

**User's Manual**

**NEC**

# **V850E/ME2**

**32-Bit Single-Chip Microcontroller**

**Hardware**

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**μPD703111A**

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[MEMO]

**① VOLTAGE APPLICATION WAVEFORM AT INPUT PIN**

Waveform distortion due to input noise or a reflected wave may cause malfunction. If the input of the CMOS device stays in the area between  $V_{IL}$  (MAX) and  $V_{IH}$  (MIN) due to noise, etc., the device may malfunction. Take care to prevent chattering noise from entering the device when the input level is fixed, and also in the transition period when the input level passes through the area between  $V_{IL}$  (MAX) and  $V_{IH}$  (MIN).

**② HANDLING OF UNUSED INPUT PINS**

Unconnected CMOS device inputs can be cause of malfunction. If an input pin is unconnected, it is possible that an internal input level may be generated due to noise, etc., causing malfunction. CMOS devices behave differently than Bipolar or NMOS devices. Input levels of CMOS devices must be fixed high or low by using pull-up or pull-down circuitry. Each unused pin should be connected to  $V_{DD}$  or GND via a resistor if there is a possibility that it will be an output pin. All handling related to unused pins must be judged separately for each device and according to related specifications governing the device.

**③ PRECAUTION AGAINST ESD**

A strong electric field, when exposed to a MOS device, can cause destruction of the gate oxide and ultimately degrade the device operation. Steps must be taken to stop generation of static electricity as much as possible, and quickly dissipate it when it has occurred. Environmental control must be adequate. When it is dry, a humidifier should be used. It is recommended to avoid using insulators that easily build up static electricity. Semiconductor devices must be stored and transported in an anti-static container, static shielding bag or conductive material. All test and measurement tools including work benches and floors should be grounded. The operator should be grounded using a wrist strap. Semiconductor devices must not be touched with bare hands. Similar precautions need to be taken for PW boards with mounted semiconductor devices.

**④ STATUS BEFORE INITIALIZATION**

Power-on does not necessarily define the initial status of a MOS device. Immediately after the power source is turned ON, devices with reset functions have not yet been initialized. Hence, power-on does not guarantee output pin levels, I/O settings or contents of registers. A device is not initialized until the reset signal is received. A reset operation must be executed immediately after power-on for devices with reset functions.

**⑤ POWER ON/OFF SEQUENCE**

In the case of a device that uses different power supplies for the internal operation and external interface, as a rule, switch on the external power supply after switching on the internal power supply. When switching the power supply off, as a rule, switch off the external power supply and then the internal power supply. Use of the reverse power on/off sequences may result in the application of an overvoltage to the internal elements of the device, causing malfunction and degradation of internal elements due to the passage of an abnormal current.

The correct power on/off sequence must be judged separately for each device and according to related specifications governing the device.

**⑥ INPUT OF SIGNAL DURING POWER OFF STATE**

Do not input signals or an I/O pull-up power supply while the device is not powered. The current injection that results from input of such a signal or I/O pull-up power supply may cause malfunction and the abnormal current that passes in the device at this time may cause degradation of internal elements. Input of signals during the power off state must be judged separately for each device and according to related specifications governing the device.

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## INTRODUCTION

|                     |                                                                                                                                                                                                    |
|---------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Readers</b>      | This manual is intended for users who wish to understand the functions of the V850E/ME2 ( $\mu$ PD703111A) to design application systems using the V850E/ME2.                                      |
| <b>Purpose</b>      | The purpose of this manual is for users to gain an understanding of the hardware functions of the V850E/ME2.                                                                                       |
| <b>Organization</b> | The <b>V850E/ME2 User's Manual</b> is divided into two parts: Hardware (this manual) and Architecture ( <b>V850E1 Architecture User's Manual</b> ). The organization of each manual is as follows: |

| Hardware                                                                                                                                                           | Architecture                                                                                                                                                                                         |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ul style="list-style-type: none"><li>• Pin functions</li><li>• CPU function</li><li>• Internal peripheral functions</li><li>• Electrical specifications</li></ul> | <ul style="list-style-type: none"><li>• Data type</li><li>• Register set</li><li>• Instruction format and instruction set</li><li>• Interrupts and exceptions</li><li>• Pipeline operation</li></ul> |

|                                |                                                                                                                                                     |
|--------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>How to Read This Manual</b> | It is assumed that the readers of this manual have general knowledge in the fields of electrical engineering, logic circuits, and microcontrollers. |
|--------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------|

- To find the details of a register where the name is known  
→ Refer to **APPENDIX A REGISTER INDEX**.
- To understand the details of an instruction function  
→ Refer to the **V850E1 Architecture User's Manual**.

To know the electrical specifications of the V850E/ME2  
→ Refer to **CHAPTER 17 ELECTRICAL SPECIFICATIONS**.

- To understand the overall functions of the V850E/ME2  
→ Read this manual according to the **CONTENTS**.
- How to interpret the register format  
→ For a bit whose bit number is enclosed in brackets, its bit name is defined as a reserved word in the device file.

The mark <R> shows major revised points.

The revised points can be easily searched by copying an "<R>" in the PDF file and specifying it in the "Find what:" field.

## Conventions

|                                                                   |                                                                                            |
|-------------------------------------------------------------------|--------------------------------------------------------------------------------------------|
| Data significance:                                                | Higher digits on the left and lower digits on the right                                    |
| Active low representation:                                        | $\overline{\text{xxx}}$ (overscore over pin or signal name)                                |
| Memory map address:                                               | Higher addresses on the top and lower addresses on the bottom                              |
| <b>Note:</b>                                                      | Footnote for item marked with <b>Note</b> in the text                                      |
| <b>Caution:</b>                                                   | Information requiring particular attention                                                 |
| <b>Remark:</b>                                                    | Supplementary information                                                                  |
| Numeric representation:                                           | Binary ... xxxx or xxxxB<br>Decimal ... xxxx<br>Hexadecimal ... xxxxH                      |
| Prefix indicating power of 2<br>(address space, memory capacity): | K (kilo): $2^{10} = 1,024$<br>M (mega): $2^{20} = 1,024^2$<br>G (giga): $2^{30} = 1,024^3$ |
| Data type:                                                        | Word ... 32 bits<br>Halfword ... 16 bits<br>Byte ... 8 bits                                |

**Related Documents**

The related documents indicated in this publication may include preliminary versions. However, preliminary versions are not marked as such.

**Document related to V850E/ME2**

| Document Name                                                                     | Document No. |
|-----------------------------------------------------------------------------------|--------------|
| V850E1 Architecture User's Manual                                                 | U14559E      |
| V850E/ME2 Hardware User's Manual                                                  | This manual  |
| V850E/ME2 Hardware Application Note                                               | U16794E      |
| V850E/ME2 USB Function Drivers Application Note                                   | U17069E      |
| V850E/MA1, V850E/MA2, V850E/MA3, V850E/ME2 PCI Host Bridge Macro Application Note | U17121E      |

**Document related to development tools (user's manuals)**

| Document Name                                    | Document No.      |
|--------------------------------------------------|-------------------|
| CA850 Ver. 3.00 C Compiler Package               | Operation         |
|                                                  | C Language        |
|                                                  | Assembly Language |
|                                                  | Link Directives   |
| PM+ Ver. 6.00                                    | U17178E           |
| ID850 Ver. 3.00 Integrated Debugger              | U17358E           |
| ID850NW Ver. 3.00, 3.10 Integrated Debugger      | U17369E           |
| RX850 Ver. 3.20 Real-Time OS                     | Basics            |
|                                                  | Installation      |
|                                                  | Technical         |
|                                                  | Task Debugger     |
| RX850 Pro Ver. 3.20 Real-Time OS                 | Basics            |
|                                                  | Installation      |
|                                                  | Technical         |
|                                                  | Task Debugger     |
| TW850 Ver. 2.00 Performance Analysis Tuning Tool | U17241E           |

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## CHAPTER 1 INTRODUCTION

The V850E/ME2 is a product of the NEC Electronics single-chip microcontroller “V850 Series”. This chapter gives a simple outline of the V850E/ME2.

### 1.1 Outline

The V850E/ME2 is a 32-bit single-chip microcontroller that integrates the V850E1 CPU, which is a 32-bit RISC-type CPU core for ASIC, newly developed as the CPU core central to system LSI for the current age of system-on-chip. This device incorporates cache, data RAM, instruction RAM, and various peripheral functions such as memory controllers, a DMA controller, timer/counter, serial interfaces, USB function controller (USBF), and an A/D converter for realizing high-capacity data processing and sophisticated real-time control.

#### (1) V850E1 CPU

The V850E1 CPU is a CPU core that enhances the external bus interface performance of the V850 CPU, which is the CPU core integrated in the V850 Series, and has added instructions supporting high-level languages, such as C-language switch statement processing, table lookup branching, stack frame creation/deletion, and data conversion. This enhances the performance of both data processing and control. It is possible to use the software resources of the V850 CPU integrated system since the instruction codes of the V850E1 are upwardly compatible at the object code level with those of the V850 CPU.

#### (2) External memory interface function

The V850E/ME2 features various on-chip external memory interfaces including separately configured address (26 bits) and data (32 bits) buses, and SDRAM and ROM interfaces, as well as on-chip memory controllers that can be directly linked to page ROM, etc., thereby raising system performance and reducing the number of parts needed for application systems.

Also, through the DMA controller, CPU internal calculations and data transfers can be performed simultaneously with transfers to and from the external memory, so it is possible to process large volumes of image data or voice data, etc., and through high-speed execution of instructions using internal data RAM and instruction RAM, motor control, communications control and other real-time control tasks can be realized simultaneously.

#### (3) Internal instruction RAM

The instruction RAM can be accessed at high speed, in one clock, so that application programs can be executed in real time.

#### (4) A full range of middleware and development environment products

The V850E/ME2 can execute middleware such as JPEG, JBIG, MH/MR/MMR, and TCP/IP at high speed. Also, middleware that enables speech recognition, voice synthesis, and other such processing is available, and by including these middleware programs, a multimedia system can be easily realized.

A development environment system that includes an optimized C compiler, debugger, in-circuit emulator, and other elements is also available.



## 1.2 Features

- Number of instructions: 80
- Minimum instruction execution time: 10 ns/7.5 ns/6.7 ns (at internal 100 MHz/133 MHz/150 MHz operation)
- General-purpose registers: 32 bits × 32
- Instruction set: V850E1 CPU  
Signed multiplication (16 bits × 16 bits → 32 bits or 32 bits × 32 bits → 64 bits): 1 to 2 clocks  
Saturated operation instructions (with overflow/underflow detection function)  
32-bit shift instructions: 1 clock  
Bit manipulation instructions  
Load/store instructions with long/short format  
Signed load instructions
- Memory space: 256 MB linear address space (common program/data use)  
Chip select output function: 8 spaces  
Memory block division function: 2, 4, 6, 8, 64 MB/block  
Programmable wait function  
Idle state insertion function
- External bus interface: 32-bit data bus (address/data separated)  
32-/16-/8-bit bus sizing function  
External bus division function: 1/1, 1/2, 1/3, 1/4 (66 MHz MAX.)  
Bus hold function  
External wait function  
Address setup wait function  
Endian control function
- Internal memory: Instruction RAM: 128 KB  
Data RAM: 16 KB
- Instruction cache: 8 KB 2-way set associative
- Interrupts/exceptions: External interrupts: 40 (including NMI)  
Internal interrupts: 59 sources  
Exceptions: 2 sources  
Eight levels of priorities can be set.
- Memory access controller: DRAM controller (compatible with SDRAM)  
Page ROM controller  
Speculative read/write buffer function

- DMA controller:
  - 4 channels
  - Transfer unit: 8 bits/16 bits/32 bits
  - Maximum transfer count: 65,536 ( $2^{16}$ )
  - Transfer type: Flyby (1-cycle)/2-cycle
  - Transfer mode: Single/Single step/Block
  - Transfer target: Memory  $\leftrightarrow$  memory, memory  $\leftrightarrow$  I/O
  - Transfer request: External request/On-chip peripheral I/O/ Software
  - DMA transfer terminate (terminal count) output signal
  - Next address setting function
  
- I/O lines:
  - Input ports: 1
  - I/O ports: 77
  
- Timer/counter function:
  - 16-bit timer/event counter: 6 channels (no capture operation for 2 channels)
  - 16-bit timers: 6
  - 16-bit capture/compare registers: 12
  - 16-bit interval timer: 4 channels
  - Up/down counter/general-purpose timer for 16-bit 2-phase encoder input: 2 channels
  - 16-bit capture/compare registers: 4
  - 16-bit compare registers: 4
  
- Serial interfaces:
  - Asynchronous serial interface B (UARTB)
  - Clocked serial interface 3 (CSI3)
  - CSI3/UARTB: 1 channel
  - UARTB: 1 channel
  - CSI3: 1 channel
  - USB function controller (USBF): 1 channel
  - Full speed (12 Mbps)
  - Endpoint Control transfer: 64 bytes  $\times$  2
  - Interrupt transfer: 8 bytes  $\times$  2
  - Bulk transfer (IN): 64 bytes  $\times$  2 banks  $\times$  2
  - Bulk transfer (OUT): 64 bytes  $\times$  2 banks  $\times$  2
  
- A/D converter:
  - 10-bit resolution A/D converter: 8 channels
  
- PWM (Pulse Width Modulation):
  - 16-bit resolution PWM: 2 channels
  
- Clock generator:
  - $\times 8$  function using SSCG
  
- Power-save function:
  - HALT/IDLE/software STOP mode
  
- Package:
  - 176-pin plastic LQFP (fine pitch) ( $24 \times 24$ )
  - 240-pin plastic FBGA ( $16 \times 16$ )
  
- CMOS technology:
  - All static circuits

### 1.3 Applications

Servo control, NC machine tools, ink-jet printers, facsimiles, DVD players, video printers, PPC, information equipment, etc.

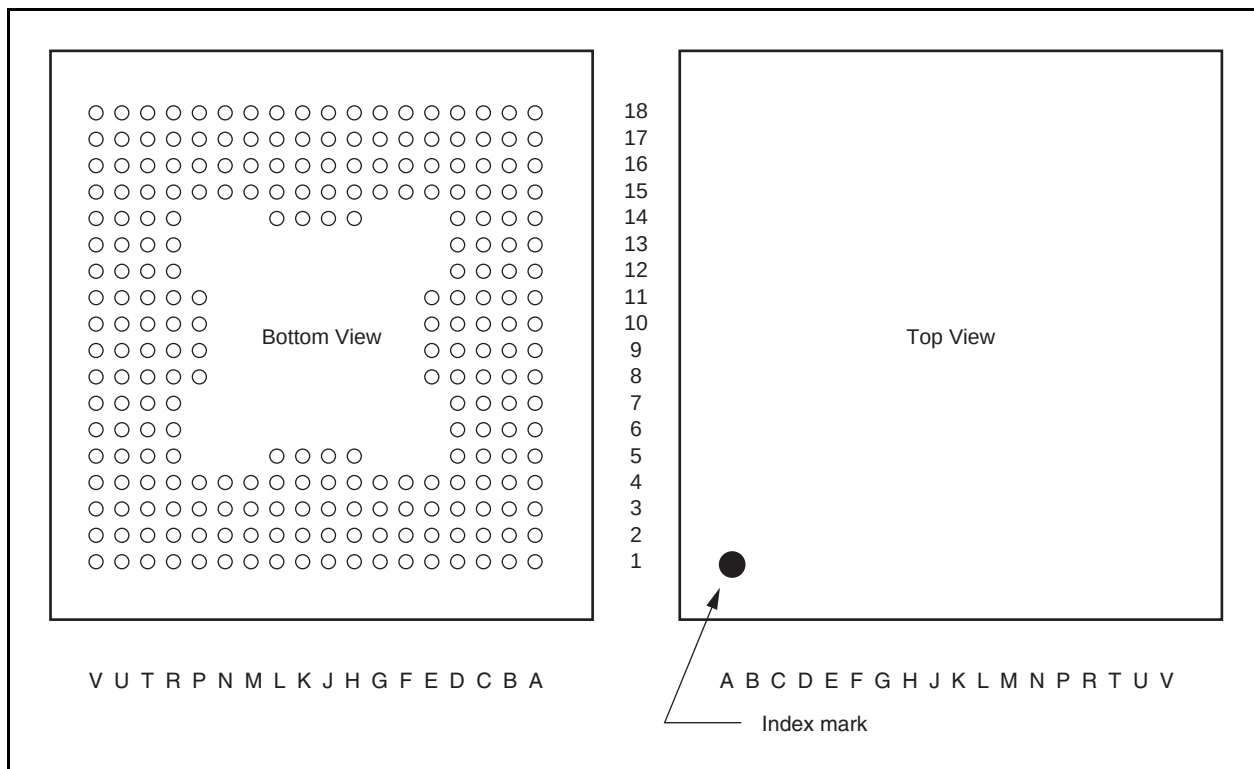
### 1.4 Ordering Information

| Part Number                | Package                                     | Maximum Operating Frequency |
|----------------------------|---------------------------------------------|-----------------------------|
| $\mu$ PD703111AGM-10-UEU   | 176-pin plastic LQFP (fine pitch) (24 × 24) | 100 MHz                     |
| $\mu$ PD703111AGM-10-UEU-A | 176-pin plastic LQFP (fine pitch) (24 × 24) | 100 MHz                     |
| $\mu$ PD703111AGM-13-UEU   | 176-pin plastic LQFP (fine pitch) (24 × 24) | 133 MHz                     |
| $\mu$ PD703111AGM-13-UEU-A | 176-pin plastic LQFP (fine pitch) (24 × 24) | 133 MHz                     |
| $\mu$ PD703111AGM-15-UEU   | 176-pin plastic LQFP (fine pitch) (24 × 24) | 150 MHz                     |
| $\mu$ PD703111AGM-15-UEU-A | 176-pin plastic LQFP (fine pitch) (24 × 24) | 150 MHz                     |
| $\mu$ PD703111AF1-13-GA3   | 240-pin plastic FBGA (16 × 16)              | 133 MHz                     |
| $\mu$ PD703111AF1-13-GA3-A | 240-pin plastic FBGA (16 × 16)              | 133 MHz                     |
| $\mu$ PD703111AF1-15-GA3   | 240-pin plastic FBGA (16 × 16)              | 150 MHz                     |
| $\mu$ PD703111AF1-15-GA3-A | 240-pin plastic FBGA (16 × 16)              | 150 MHz                     |

**Remark** Products with -A at the end of the part number are lead-free products.



- 240-pin plastic FBGA (16 × 16)  
 $\mu$ PD703111AF1-13-GA3  
 $\mu$ PD703111AF1-13-GA3-A  
 $\mu$ PD703111AF1-15-GA3  
 $\mu$ PD703111AF1-15-GA3-A



(1/2)

| Pin No. | Pin Name             | Pin No. | Pin Name             | Pin No. | Pin Name                |
|---------|----------------------|---------|----------------------|---------|-------------------------|
| A1      | –                    | C12     | IV <sub>DD</sub>     | G3      | EV <sub>SS</sub>        |
| A2      | IV <sub>SS</sub>     | C13     | PAH2/A18             | G4      | D7                      |
| A3      | PCT0/LLWR/LLBE/LLDQM | C14     | PAH4/A20             | G15     | PCM1                    |
| A4      | –                    | C15     | PAH6/A22             | G16     | PCM3/HLDRQ              |
| A5      | PCT4/RD              | C16     | –                    | G17     | PCM4/REFRQ              |
| A6      | –                    | C17     | PCS0/CS0             | G18     | PCM5/ADTRG/SELREF       |
| A7      | –                    | C18     | –                    | H1      | –                       |
| A8      | EV <sub>DD</sub>     | D1      | D0                   | H2      | D8                      |
| A9      | A9                   | D2      | EV <sub>SS</sub>     | H3      | D9                      |
| A10     | –                    | D3      | PCD0/SDCKE           | H4      | D10                     |
| A11     | A14                  | D4      | EV <sub>DD</sub>     | H5      | IV <sub>SS</sub>        |
| A12     | IV <sub>SS</sub>     | D5      | PCT1/LUWR/LUBE/LUDQM | H14     | –                       |
| A13     | EV <sub>DD</sub>     | D6      | –                    | H15     | RESET                   |
| A14     | –                    | D7      | PAL0/INTPL0/A0       | H16     | IV <sub>SS</sub>        |
| A15     | PAH5/A21             | D8      | A4                   | H17     | –                       |
| A16     | PAH7/A23             | D9      | A6                   | H18     | IV <sub>DD</sub>        |
| A17     | PAH9/A25             | D10     | –                    | J1      | –                       |
| A18     | –                    | D11     | A13                  | J2      | D11                     |
| B1      | –                    | D12     | EV <sub>SS</sub>     | J3      | D12                     |
| B2      | PCD1/BUSCLK          | D13     | PAH3/A19             | J4      | –                       |
| B3      | PCD2/SDCAS           | D14     | –                    | J5      | D13                     |
| B4      | –                    | D15     | –                    | J14     | –                       |
| B5      | PCT3/UUWR/UUBE/UUDQM | D16     | PCS2/CS2/IOWR        | J15     | P50/INTP50/DMARQ0       |
| B6      | PCT7/BCYST           | D17     | PCS3/CS3             | J16     | P51/INTP51/DMAAK0       |
| B7      | A2                   | D18     | EV <sub>DD</sub>     | J17     | P52/INTP52/TC0          |
| B8      | –                    | E1      | D3                   | J18     | P53/INTPC00/TIC0/DMARQ1 |
| B9      | A8                   | E2      | D2                   | K1      | D14                     |
| B10     | A12                  | E3      | D1                   | K2      | D15                     |
| B11     | PAH0/A16             | E4      | –                    | K3      | PDH0/D16/INTPD0         |
| B12     | –                    | E8      | A3                   | K4      | PDH1/D17/INTPD1         |
| B13     | –                    | E9      | A5                   | K5      | PDH2/D18/INTPD2/TOC4    |
| B14     | –                    | E10     | A10                  | K14     | P55/TOC0/TC1            |
| B15     | –                    | E11     | PAH1/A17             | K15     | P54/INTPC01/DMAAK1      |
| B16     | PAH8/A24             | E15     | PCS4/CS4             | K16     | P65/INTP65/INTPC10/TIC1 |
| B17     | –                    | E16     | EV <sub>SS</sub>     | K17     | P66/INTP66/INTPC11      |
| B18     | PCS1/CS1             | E17     | PCS5/CS5/IORD        | K18     | –                       |
| C1      | –                    | E18     | PCS6/CS6             | L1      | EV <sub>DD</sub>        |
| C2      | –                    | F1      | D6                   | L2      | –                       |
| C3      | PCD3/SDRAS           | F2      | D5                   | L3      | EV <sub>SS</sub>        |
| C4      | IV <sub>DD</sub>     | F3      | D4                   | L4      | PDH3/D19/INTPD3         |
| C5      | PCT2/ULWR/ULBE/ULDQM | F4      | –                    | L5      | PDH4/D20/INTPD4         |
| C6      | PCT5/WE/WR           | F15     | –                    | L14     | MODE1                   |
| C7      | PAL1/INTPL1/A1       | F16     | PCS7/CS7             | L15     | –                       |
| C8      | EV <sub>SS</sub>     | F17     | PCM0/WAIT            | L16     | MODE0                   |
| C9      | A7                   | F18     | PCM2/HLDAK           | L17     | –                       |
| C10     | A11                  | G1      | IV <sub>DD</sub>     | L18     | P67/INTP67/TOC1         |
| C11     | A15                  | G2      | EV <sub>DD</sub>     | M1      | –                       |

(2/2)

| Pin No. | Pin Name                         | Pin No. | Pin Name                | Pin No. | Pin Name                |
|---------|----------------------------------|---------|-------------------------|---------|-------------------------|
| M2      | PDH5/D21/INTPD5/TOC5             | R7      | DCK                     | U4      | –                       |
| M3      | PDH6/D22/INTPD6/INTP100/TCUD10   | R8      | EV <sub>DD</sub>        | U5      | TRCCLK                  |
| M4      | –                                | R9      | P11/INTP11/SCK0         | U6      | DRST                    |
| M15     | ANI6                             | R10     | IV <sub>SS</sub>        | U7      | P25/INTP25/SO1          |
| M16     | AV <sub>REFM</sub>               | R11     | UDM                     | U8      | P22/INTP22/TXD1         |
| M17     | ANI7                             | R12     | X2                      | U9      | EV <sub>SS</sub>        |
| M18     | AV <sub>SS</sub>                 | R13     | PLL <sub>VDD</sub>      | U10     | IV <sub>DD</sub>        |
| N1      | PDH7/D23/INTPD7/INTP101/TCLR10   | R14     | SSEL0                   | U11     | –                       |
| N2      | PDH8/D24/INTPD8/TO10             | R15     | –                       | U12     | OSCV <sub>DD</sub>      |
| N3      | PDH9/D25/INTPD9/TIUD10           | R16     | AV <sub>REFP</sub>      | U13     | –                       |
| N4      | PDH10/D26/INTPD10/INTP110/TCUD11 | R17     | AV <sub>DD</sub>        | U14     | –                       |
| N15     | ANI2                             | R18     | –                       | U15     | P76/INTPC31/DMAAK3      |
| N16     | ANI3                             | T1      | EV <sub>DD</sub>        | U16     | P73/INTPC21/DMAAK2      |
| N17     | ANI4                             | T2      | TRCDATA3                | U17     | P72/INTPC20/TIC2/DMARQ2 |
| N18     | ANI5                             | T3      | –                       | U18     | –                       |
| P1      | –                                | T4      | TRCDATA1                | V1      | –                       |
| P2      | PDH11/D27/INTPD11/INTP111/TCLR11 | T5      | TRCEND                  | V2      | TRCDATA2                |
| P3      | PDH13/D29/INTPD13/TIUD11         | T6      | DDI                     | V3      | IV <sub>SS</sub>        |
| P4      | –                                | T7      | –                       | V4      | TRCDATA0                |
| P8      | P23/INTP23/SCK1                  | T8      | P21/INTP21/RXD1         | V5      | –                       |
| P9      | P12/SIO/RXD0                     | T9      | P20/NMI                 | V6      | DMS                     |
| P10     | –                                | T10     | –                       | V7      | P24/INTP24/SI1          |
| P11     | UV <sub>DD</sub>                 | T11     | UDP                     | V8      | –                       |
| P15     | –                                | T12     | X1                      | V9      | P13/SO0/TXD0            |
| P16     | ANI0                             | T13     | OSCV <sub>SS</sub>      | V10     | PLLSEL                  |
| P17     | ANI1                             | T14     | SSEL1                   | V11     | P10/INTP10/UCLK         |
| P18     | –                                | T15     | P75/INTPC30/TIC3/DMARQ3 | V12     | –                       |
| R1      | PDH12/D28/INTPD12/TO11           | T16     | –                       | V13     | –                       |
| R2      | EV <sub>SS</sub>                 | T17     | JIT1                    | V14     | –                       |
| R3      | PDH14/D30/INTPD14/PWM0           | T18     | JIT0                    | V15     | PLL <sub>VSS</sub>      |
| R4      | IV <sub>DD</sub>                 | U1      | PDH15/D31/INTPD15/PWM1  | V16     | P77/TOC3/TC3            |
| R5      | –                                | U2      | –                       | V17     | P74/TOC2/TC2            |
| R6      | DDO                              | U3      | –                       | V18     | –                       |

**Remark** Leave the A1, A4, A6, A7, A10, A14, A18, B1, B4, B8, B12 to B15, B17, C1, C2, C16, C18, D6, D10, D14, D15, E4, F4, F15, H1, H14, H17, J1, J4, J14, K18, L2, L15, L17, M1, M4, P1, P4, P10, P15, P18, R5, R15, R18, T3, T7, T10, T16, U2 to U4, U11, U13, U14, U18, V1, V5, V8, V12 to V14, and V18 pins open.

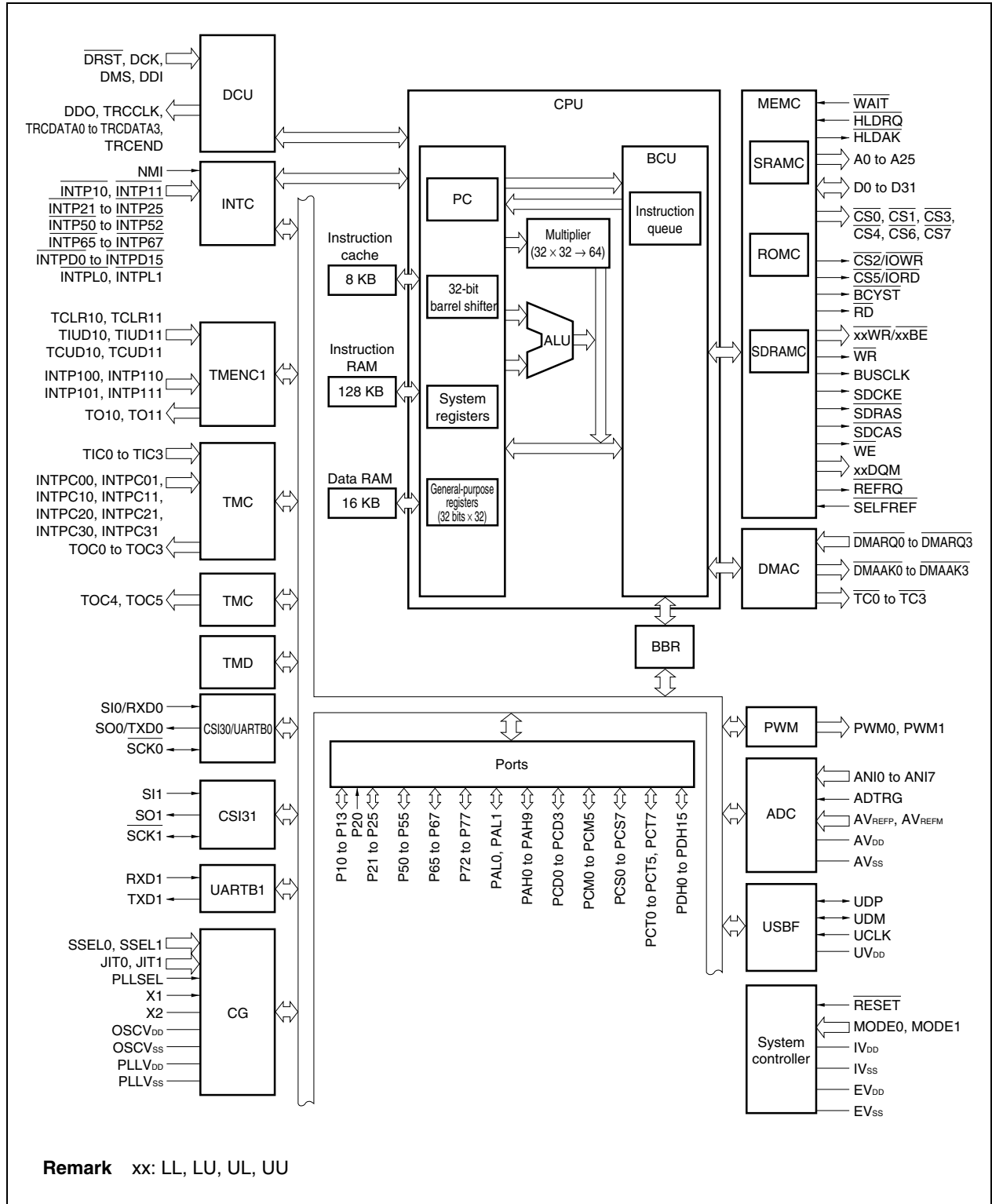
## Pin Identification

|                                                                                                                           |                                        |                              |                                         |
|---------------------------------------------------------------------------------------------------------------------------|----------------------------------------|------------------------------|-----------------------------------------|
| A0 to A25:                                                                                                                | Address bus                            | P72 to P77:                  | Port 7                                  |
| ADTRG:                                                                                                                    | A/D trigger input                      | PAH0 to PAH9:                | Port AH                                 |
| ANI0 to ANI7:                                                                                                             | Analog input                           | PAL0, PAL1:                  | Port AL                                 |
| AV <sub>DD</sub> :                                                                                                        | Analog power supply                    | PCD0 to PCD3:                | Port CD                                 |
| AV <sub>REFM</sub> :                                                                                                      | Analog reference voltage               | PCM0 to PCM5:                | Port CM                                 |
| AV <sub>REFP</sub> :                                                                                                      | Analog reference voltage               | PCS0 to PCS7:                | Port CS                                 |
| AV <sub>SS</sub> :                                                                                                        | Analog ground                          | PCT0 to PCT5, PCT7:          | Port CT                                 |
| BCYST:                                                                                                                    | Bus cycle start timing                 | PDH0 to PDH15:               | Port DH                                 |
| BUSCLK:                                                                                                                   | Bus clock output                       | PLLSEL:                      | PLL operating mode select               |
| CS0 to CS7:                                                                                                               | Chip select                            | PLL <sub>VDD</sub> :         | PLL power supply                        |
| D0 to D31:                                                                                                                | Data bus                               | PLL <sub>VSS</sub> :         | PLL ground                              |
| DCK:                                                                                                                      | Debug clock input                      | PWM0, PWM1:                  | Pulse width modulation                  |
| DDI:                                                                                                                      | Debug data input                       | RD:                          | Read strobe                             |
| DDO:                                                                                                                      | Debug data output                      | REFRQ:                       | Refresh request                         |
| DRST:                                                                                                                     | Debug reset                            | RESET:                       | Reset                                   |
| DMS:                                                                                                                      | Debug mode select                      | RXD0, RXD1:                  | Receive data                            |
| DMAAK0 to DMAAK3:                                                                                                         | DMA acknowledge                        | SCK0, SCK1:                  | Serial clock                            |
| DMARQ0 to DMARQ3:                                                                                                         | DMA request                            | SDCAS:                       | SDRAM column address strobe             |
| EV <sub>DD</sub> :                                                                                                        | Port power supply                      | SDCKE:                       | SDRAM clock enable                      |
| EV <sub>SS</sub> :                                                                                                        | Port ground                            | SDRAS:                       | SDRAM row address strobe                |
| HLDK:                                                                                                                     | Hold acknowledge                       | SELFREF:                     | Self-refresh request                    |
| HLDRQ:                                                                                                                    | Hold request                           | SI0, SI1:                    | Serial input                            |
| INTP10, INTP11,<br>INTP21 to INTP25,<br>INTP50 to INTP52,<br>INTP65 to INTP67:                                            | External interrupt input               | SO0, SO1:                    | Serial output                           |
| INTP100, INTP101,<br>INTP110, INTP111:                                                                                    | Timer capture trigger input            | SSEL0, SSEL1:                | Clock generator operating mode select   |
| INTPC00, INTPC01,<br>INTPC10, INTPC11,<br>INTPC20, INTPC21,<br>INTPC30, INTPC31,<br>INTPD0 to INTPD15,<br>INTPL0, INTPL1: | External interrupt input               | TC0 to TC3:                  | Terminal count                          |
| IORD:                                                                                                                     | I/O read strobe                        | TCLR10, TCLR11:              | Timer clear                             |
| IOWR:                                                                                                                     | I/O write strobe                       | TCUD10, TCUD11:              | Timer control pulse input               |
| IV <sub>DD</sub> :                                                                                                        | Internal unit power supply             | TIC0 to TIC3:                | Timer input                             |
| IV <sub>SS</sub> :                                                                                                        | Internal unit ground                   | TIUD10, TIUD11:              | Timer count pulse input                 |
| JIT0, JIT1:                                                                                                               | SSCG jitter select                     | TO10, TO11,<br>TOC0 to TOC5: | Timer output                            |
| LLBE:                                                                                                                     | Lower lower byte enable (D0 to D7)     | TRCCLK:                      | Trace clock                             |
| LLDQM:                                                                                                                    | Lower lower DQ mask enable (D0 to D7)  | TRCDATA0 to<br>TRCDATA3:     | Trace data output                       |
| LLWR:                                                                                                                     | Lower lower write strobe (D0 to D7)    | TRCEND:                      | Trace end status output                 |
| LUBE:                                                                                                                     | Lower upper byte enable (D8 to D15)    | TXD0, TXD1:                  | Transmit data                           |
| LUDQM:                                                                                                                    | Lower upper DQ mask enable (D8 to D15) | UCLK:                        | USB external clock input                |
| LUWR:                                                                                                                     | Lower upper write strobe (D8 to D15)   | UDM:                         | USB data input & output (–)             |
| MODE0, MODE1:                                                                                                             | Mode                                   | UDP:                         | USB data input & output (+)             |
| NMI:                                                                                                                      | Non-maskable interrupt request         | ULBE:                        | Upper lower byte enable (D16 to D23)    |
| OSC <sub>VDD</sub> :                                                                                                      | Clock generator power supply           | ULDQM:                       | Upper lower DQ mask enable (D16 to D23) |
| OSC <sub>VSS</sub> :                                                                                                      | Clock generator ground                 | ULWR:                        | Upper lower write strobe (D16 to D23)   |
| P10 to P13:                                                                                                               | Port 1                                 | UUBE:                        | Upper upper byte enable (D24 to D31)    |
| P20 to P25:                                                                                                               | Port 2                                 | UUDQM:                       | Upper upper DQ mask enable (D24 to D31) |
| P50 to P55:                                                                                                               | Port 5                                 | UUWR:                        | Upper upper write strobe (D24 to D31)   |
| P65 to P67:                                                                                                               | Port 6                                 | UV <sub>DD</sub> :           | USB power supply                        |
|                                                                                                                           |                                        | WAIT:                        | Wait                                    |
|                                                                                                                           |                                        | WE:                          | Write enable                            |
|                                                                                                                           |                                        | WR:                          | Write strobe                            |
|                                                                                                                           |                                        | X1, X2:                      | Crystal                                 |



## 1.6 Function Blocks

### 1.6.1 Internal block diagram



## 1.6.2 On-chip units

### (1) CPU

The CPU uses five-stage pipeline control to enable single-clock execution of address calculations, arithmetic logic operations, data transfers, and almost all other instruction processing.

Other dedicated on-chip hardware, such as a multiplier (16 bits  $\times$  16 bits  $\rightarrow$  32 bits or 32 bits  $\times$  32 bits  $\rightarrow$  64 bits) and a barrel shifter (32 bits), help accelerate complex processing.

### (2) Bus control unit (BCU)

The BCU starts the required external bus cycle based on the physical address obtained by the CPU. When an instruction is fetched from external memory area and the CPU does not send a bus cycle start request, the BCU generates a prefetch address and prefetches the instruction code. The prefetched instruction code is stored in an instruction queue in the CPU.

The BCU controls an SDRAM controller (SDRAMC), SRAM controller (SRAMC), page ROM controller (ROMC), and DMA controller (DMAC) and performs external memory access and DMA transfer.

#### (a) SDRAM controller (SDRAMC)

The SDRAM controller generates the  $\overline{\text{SDRAS}}$ ,  $\overline{\text{SDCAS}}$ , UUDQM, ULDQM, LUDQM, and LLDQM signals and performs access control for SDRAM.

CAS latency 1 (excluding flyby DMA transfer), 2, and 3 are supported, and the burst length is fixed to 1.

A refresh function that supports the CBR (auto) refresh cycle and a dynamic self-refresh function based on an external input are also available.

#### (b) Page ROM controller (ROMC)

This controller supports accessing ROM that includes the page access function.

It performs address comparisons with the immediately preceding bus cycle and executes wait control for normal access (off-page)/page access (on-page).

#### (c) DMA controller (DMAC)

This controller controls data transfer between memory and I/O instead of the CPU.

There are two address modes: flyby (1-cycle) transfer, and 2-cycle transfer. There are three bus modes, single transfer, single-step transfer, and block transfer.

### (3) RAM

Instruction RAM (128 KB) and data RAM (16 KB) are provided.

The instruction RAM can be accessed in one clock from the CPU when an instruction is fetched. Its write access time depends on the BUSCLK frequency to the CS0 space and the number of wait cycles. This RAM is mapped from address 00000000H.

The data RAM can be accessed in one clock from the CPU when its data is read or written. It is mapped from address FFFF8000H.

### (4) Cache

A 2-way set associative instruction cache (8 KB) is provided.

**(5) Interrupt controller (INTC)**

This controller handles hardware interrupt requests (NMI, INTP<sub>n</sub>) from on-chip peripheral hardware and external hardware. Eight levels of interrupt priorities can be specified for these interrupt requests, and multiple-interrupt servicing control can be performed (n = 10, 11, 21 to 25, 50 to 52, 65 to 67, D0 to D15, L0, L1, C00, C01, C10, C11, C20, C21, C30, C31).

**(6) Clock generator (CG)**

This clock generator supplies frequencies which are 8 times the input clock (F<sub>x</sub>) (using an on-chip PLL) as the internal system clock (f<sub>CLK</sub>). As the input clock, an external resonator is input from pins X1 and X2.

**(7) Timer/counter function**

This unit incorporates a 6-channel 16-bit timer/event counter C (TMC), 4-channel 16-bit interval timer D (TMD), and 2-channel up/down counter/general-purpose timer (TMENC1) for 16-bit 2-phase encoder input and can measure pulse widths or frequency and output a programmable pulse.

**(8) Serial interfaces**

The serial interfaces consist of 3 channels divided between an asynchronous serial interface B (UARTB) and clocked serial interface 3 (CSI3). Of these 3 channels, one is alternative with UARTB and CSI3, one is fixed to CSI3, and one is fixed to UARTB.

UARTB transfers data by using the TXD<sub>n</sub> and RXD<sub>n</sub> pins (n = 0, 1).

CSI3 transfers data by using the SOn, SIn, and  $\overline{\text{SCKn}}$  pins (n = 0, 1).

In addition, a USB function controller (USBF) is also provided.

**(9) A/D converter (ADC)**

This high-speed, high-resolution 10-bit A/D converter includes 8 analog input pins. Conversion is performed using the successive approximation method.

**(10) PWM**

Two channels for PWM signal output of 16-bit resolution have been provided. By connecting an external low-pass filter, PWM output can be used as digital to analog conversion output. PWM is ideal for actuator control signals such as those in motors.

**(11) On-chip debug function (DCU)**

An on-chip debug function via an on-chip debug emulator is provided.

**(12) Ports**

As shown below, the following ports have general-purpose port functions and control pin functions.

| Port    | I/O                       | Control Function                                                                                                                                |
|---------|---------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------|
| Port 1  | 4-bit I/O                 | Serial interface I/O, USB clock signal input, external interrupt input                                                                          |
| Port 2  | 1-bit input,<br>5-bit I/O | NMI input, serial interface I/O, external interrupt input                                                                                       |
| Port 5  | 6-bit I/O                 | DMA controller I/O, external interrupt input, timer/counter I/O                                                                                 |
| Port 6  | 3-bit I/O                 | Timer/counter I/O, external interrupt input                                                                                                     |
| Port 7  | 6-bit I/O                 | DMA controller I/O, timer/counter I/O, external interrupt input                                                                                 |
| Port AL | 2-bit I/O                 | External address bus, external interrupt input                                                                                                  |
| Port AH | 10-bit I/O                | External address bus                                                                                                                            |
| Port DH | 16-bit I/O                | External data bus, external interrupt input, PWM output, timer/counter I/O                                                                      |
| Port CS | 8-bit I/O                 | External bus interface control signal output                                                                                                    |
| Port CT | 7-bit I/O                 | External bus interface control signal output                                                                                                    |
| Port CM | 6-bit I/O                 | Wait insertion signal input, external bus interface control signal I/O, self-refresh request signal input, A/D converter external trigger input |
| Port CD | 4-bit I/O                 | External bus interface control signal output, bus clock output                                                                                  |

## CHAPTER 2 PIN FUNCTIONS

The names and functions of the pins in the V850E/ME2 are listed below. These pins can be divided into port pins and non-port pins according to their functions.

### 2.1 List of Pin Functions

#### (1) Port pins

(1/3)

| Pin Name | Pin No. |     | I/O                                     | Function                                                                                                                                                                                                                                      | Alternate Function                      |
|----------|---------|-----|-----------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------|
|          | GM      | F1  |                                         |                                                                                                                                                                                                                                               |                                         |
| P10      | 159     | V11 | I/O                                     | Port 1<br>4-bit I/O port<br>Input data can be read/output data can be written in 1-bit units.                                                                                                                                                 | $\overline{\text{INTP10/UCLK}}$         |
| P11      | 155     | R9  |                                         |                                                                                                                                                                                                                                               | $\overline{\text{INTP11/SCK0}}$         |
| P12      | 154     | P9  |                                         |                                                                                                                                                                                                                                               | SI0/RXD0                                |
| P13      | 153     | V9  |                                         |                                                                                                                                                                                                                                               | SO0/TXD0                                |
| P20      | 152     | T9  | Input                                   | Port 2<br>P20 is an input port dedicated to checking the NMI input status.<br>If a valid edge is input, it operates as an NMI input.<br>P21 to P25 are a 5-bit I/O port.<br>Input data can be read/output data can be written in 1-bit units. | NMI                                     |
| P21      | 149     | T8  | I/O                                     |                                                                                                                                                                                                                                               | $\overline{\text{INTP21/RXD1}}$         |
| P22      | 148     | U8  |                                         |                                                                                                                                                                                                                                               | $\overline{\text{INTP22/TXD1}}$         |
| P23      | 147     | P8  |                                         |                                                                                                                                                                                                                                               | $\overline{\text{INTP23/SCK1}}$         |
| P24      | 146     | V7  |                                         |                                                                                                                                                                                                                                               | $\overline{\text{INTP24/SI1}}$          |
| P25      | 145     | U7  |                                         |                                                                                                                                                                                                                                               | $\overline{\text{INTP25/SO1}}$          |
| P50      | 25      | J15 |                                         |                                                                                                                                                                                                                                               | I/O                                     |
| P51      | 24      | J16 | $\overline{\text{INTP51/DMAAK0}}$       |                                                                                                                                                                                                                                               |                                         |
| P52      | 23      | J17 | $\overline{\text{INTP52/TC0}}$          |                                                                                                                                                                                                                                               |                                         |
| P53      | 22      | J18 | $\overline{\text{INTPC00/TIC0/DMARQ1}}$ |                                                                                                                                                                                                                                               |                                         |
| P54      | 21      | K15 | $\overline{\text{INTPC01/DMAAK1}}$      |                                                                                                                                                                                                                                               |                                         |
| P55      | 20      | K14 | TOC0/ $\overline{\text{TC1}}$           |                                                                                                                                                                                                                                               |                                         |
| P65      | 19      | K16 | I/O                                     | Port 6<br>3-bit I/O port<br>Input data can be read/output data can be written in 1-bit units.                                                                                                                                                 | $\overline{\text{INTP65/INTPC10/TIC1}}$ |
| P66      | 18      | K17 |                                         |                                                                                                                                                                                                                                               | $\overline{\text{INTP66/INTPC11}}$      |
| P67      | 17      | L18 |                                         |                                                                                                                                                                                                                                               | $\overline{\text{INTP67/TOC1}}$         |
| P72      | 176     | U17 | I/O                                     | Port 7<br>6-bit I/O port<br>Input data can be read/output data can be written in 1-bit units.                                                                                                                                                 | $\overline{\text{INTPC20/TIC2/DMARQ2}}$ |
| P73      | 175     | U16 |                                         |                                                                                                                                                                                                                                               | $\overline{\text{INTPC21/DMAAK2}}$      |
| P74      | 174     | V17 |                                         |                                                                                                                                                                                                                                               | TOC2/ $\overline{\text{TC2}}$           |
| P75      | 173     | T15 |                                         |                                                                                                                                                                                                                                               | $\overline{\text{INTPC30/TIC3/DMARQ3}}$ |
| P76      | 172     | U15 |                                         |                                                                                                                                                                                                                                               | $\overline{\text{INTPC31/DMAAK3}}$      |
| P77      | 171     | V16 |                                         |                                                                                                                                                                                                                                               | TOC3/ $\overline{\text{TC3}}$           |

**Remark** GM: 176-pin plastic LQFP (fine pitch) (24 × 24)

F1: 240-pin plastic FBGA (16 × 16)

(2/3)

| Pin Name | Pin No. |     | I/O | Function                                                                                           | Alternate Function         |
|----------|---------|-----|-----|----------------------------------------------------------------------------------------------------|----------------------------|
|          | GM      | F1  |     |                                                                                                    |                            |
| PAH0     | 58      | B11 | I/O | Port AH<br>8-/10-bit I/O port<br>Input data can be read/output data can be written in 1-bit units. | A16                        |
| PAH1     | 57      | E11 |     |                                                                                                    | A17                        |
| PAH2     | 52      | C13 |     |                                                                                                    | A18                        |
| PAH3     | 51      | D13 |     |                                                                                                    | A19                        |
| PAH4     | 50      | C14 |     |                                                                                                    | A20                        |
| PAH5     | 49      | A15 |     |                                                                                                    | A21                        |
| PAH6     | 48      | C15 |     |                                                                                                    | A22                        |
| PAH7     | 47      | A16 |     |                                                                                                    | A23                        |
| PAH8     | 46      | B16 |     |                                                                                                    | A24                        |
| PAH9     | 45      | A17 |     |                                                                                                    | A25                        |
| PAL0     | 76      | D7  | I/O | Port AL<br>2-bit I/O port<br>Input data can be read/output data can be written in 1-bit units.     | INTPL0/A0                  |
| PAL1     | 75      | C7  |     |                                                                                                    | INTPL1/A1                  |
| PDH0     | 112     | K3  | I/O | Port DH<br>8-/16-bit I/O port<br>Input data can be read/output data can be written in 1-bit units. | D16/INTPD0                 |
| PDH1     | 113     | K4  |     |                                                                                                    | D17/INTPD1                 |
| PDH2     | 114     | K5  |     |                                                                                                    | D18/INTPD2/TOC4            |
| PDH3     | 117     | L4  |     |                                                                                                    | D19/INTPD3                 |
| PDH4     | 118     | L5  |     |                                                                                                    | D20/INTPD4                 |
| PDH5     | 119     | M2  |     |                                                                                                    | D21/INTPD5/TOC5            |
| PDH6     | 120     | M3  |     |                                                                                                    | D22/INTPD6/INTP100/TCUD10  |
| PDH7     | 121     | N1  |     |                                                                                                    | D23/INTPD7/INTP101/TCLR10  |
| PDH8     | 122     | N2  |     |                                                                                                    | D24/INTPD8/TO10            |
| PDH9     | 123     | N3  |     |                                                                                                    | D25/INTPD9/TIUD10          |
| PDH10    | 124     | N4  |     |                                                                                                    | D26/INTPD10/INTP110/TCUD11 |
| PDH11    | 125     | P2  |     |                                                                                                    | D27/INTPD11/INTP111/TCLR11 |
| PDH12    | 126     | R1  |     |                                                                                                    | D28/INTPD12/TO11           |
| PDH13    | 127     | P3  |     |                                                                                                    | D29/INTPD13/TIUD11         |
| PDH14    | 130     | R3  |     |                                                                                                    | D30/INTPD14/PWM0           |
| PDH15    | 131     | U1  |     |                                                                                                    | D31/INTPD15/PWM1           |
| PCD0     | 91      | D3  | I/O | Port CD<br>4-bit I/O port<br>Input data can be read/output data can be written in 1-bit units.     | SDCKE                      |
| PCD1     | 88      | B2  |     |                                                                                                    | BUSCLK                     |
| PCD2     | 87      | B3  |     |                                                                                                    | SDCAS                      |
| PCD3     | 86      | C3  |     |                                                                                                    | SDRAS                      |

**Remark** GM: 176-pin plastic LQFP (fine pitch) (24 × 24)

F1: 240-pin plastic FBGA (16 × 16)

| Pin Name | Pin No. |     | I/O | Function                                                                                       | Alternate Function                  |
|----------|---------|-----|-----|------------------------------------------------------------------------------------------------|-------------------------------------|
|          | GM      | F1  |     |                                                                                                |                                     |
| PCM0     | 34      | F17 | I/O | Port CM<br>6-bit I/O port<br>Input data can be read/output data can be written in 1-bit units. | $\overline{\text{WAIT}}$            |
| PCM1     | 33      | G15 |     |                                                                                                | —                                   |
| PCM2     | 32      | F18 |     |                                                                                                | $\overline{\text{HLDAK}}$           |
| PCM3     | 31      | G16 |     |                                                                                                | $\overline{\text{HLDRQ}}$           |
| PCM4     | 30      | G17 |     |                                                                                                | $\overline{\text{REFRQ}}$           |
| PCM5     | 29      | G18 |     |                                                                                                | $\overline{\text{ADTRG/SELFREF}}$   |
| PCS0     | 44      | C17 | I/O | Port CS<br>8-bit I/O port<br>Input data can be read/output data can be written in 1-bit units. | $\overline{\text{CS0}}$             |
| PCS1     | 43      | B18 |     |                                                                                                | $\overline{\text{CS1}}$             |
| PCS2     | 42      | D16 |     |                                                                                                | $\overline{\text{CS2/IOWR}}$        |
| PCS3     | 41      | D17 |     |                                                                                                | $\overline{\text{CS3}}$             |
| PCS4     | 40      | E15 |     |                                                                                                | $\overline{\text{CS4}}$             |
| PCS5     | 37      | E17 |     |                                                                                                | $\overline{\text{CS5/IORD}}$        |
| PCS6     | 36      | E18 |     |                                                                                                | $\overline{\text{CS6}}$             |
| PCS7     | 35      | F16 |     |                                                                                                | $\overline{\text{CS7}}$             |
| PCT0     | 83      | A3  | I/O | Port CT<br>7-bit I/O port<br>Input data can be read/output data can be written in 1-bit units. | $\overline{\text{LLWR/LLBE/LLDQM}}$ |
| PCT1     | 82      | D5  |     |                                                                                                | $\overline{\text{LUWR/LUBE/LUDQM}}$ |
| PCT2     | 81      | C5  |     |                                                                                                | $\overline{\text{ULWR/ULBE/ULDQM}}$ |
| PCT3     | 80      | B5  |     |                                                                                                | $\overline{\text{UUWR/UUBE/UUDQM}}$ |
| PCT4     | 79      | A5  |     |                                                                                                | $\overline{\text{RD}}$              |
| PCT5     | 78      | C6  |     |                                                                                                | $\overline{\text{WE/WR}}$           |
| PCT7     | 77      | B6  |     |                                                                                                | $\overline{\text{BCYST}}$           |

**Remark** GM: 176-pin plastic LQFP (fine pitch) (24 × 24)

F1: 240-pin plastic FBGA (16 × 16)

## (2) Non-port pins

(1/7)

| Pin Name | Pin No. |     | I/O    | Function                               | Alternate Function                |
|----------|---------|-----|--------|----------------------------------------|-----------------------------------|
|          | GM      | F1  |        |                                        |                                   |
| A0       | 76      | D7  | Output | 26-bit address bus for external memory | PAL0/ $\overline{\text{INTPL0}}$  |
| A1       | 75      | C7  |        |                                        | PAL1/ $\overline{\text{INTPL1}}$  |
| A2       | 74      | B7  |        |                                        | —                                 |
| A3       | 73      | E8  |        |                                        | —                                 |
| A4       | 72      | D8  |        |                                        | —                                 |
| A5       | 69      | E9  |        |                                        | —                                 |
| A6       | 68      | D9  |        |                                        | —                                 |
| A7       | 67      | C9  |        |                                        | —                                 |
| A8       | 66      | B9  |        |                                        | —                                 |
| A9       | 65      | A9  |        |                                        | —                                 |
| A10      | 64      | E10 |        |                                        | —                                 |
| A11      | 63      | C10 |        |                                        | —                                 |
| A12      | 62      | B10 |        |                                        | —                                 |
| A13      | 61      | D11 |        |                                        | —                                 |
| A14      | 60      | A11 |        |                                        | —                                 |
| A15      | 59      | C11 |        |                                        | —                                 |
| A16      | 58      | B11 |        |                                        | PAH0                              |
| A17      | 57      | E11 |        |                                        | PAH1                              |
| A18      | 52      | C13 |        |                                        | PAH2                              |
| A19      | 51      | D13 |        |                                        | PAH3                              |
| A20      | 50      | C14 |        |                                        | PAH4                              |
| A21      | 49      | A15 |        |                                        | PAH5                              |
| A22      | 48      | C15 |        |                                        | PAH6                              |
| A23      | 47      | A16 |        |                                        | PAH7                              |
| A24      | 46      | B16 |        |                                        | PAH8                              |
| A25      | 45      | A17 |        |                                        | PAH9                              |
| ADTRG    | 29      | G18 | Input  | A/D converter external trigger input   | PCM5/ $\overline{\text{SELFREF}}$ |
| ANI0     | 5       | P16 | Input  | Analog inputs to A/D converter         | —                                 |
| ANI1     | 6       | P17 |        |                                        | —                                 |
| ANI2     | 7       | N15 |        |                                        | —                                 |
| ANI3     | 8       | N16 |        |                                        | —                                 |
| ANI4     | 9       | N17 |        |                                        | —                                 |
| ANI5     | 10      | N18 |        |                                        | —                                 |
| ANI6     | 11      | M15 |        |                                        | —                                 |
| ANI7     | 12      | M17 |        |                                        | —                                 |

**Remark** GM: 176-pin plastic LQFP (fine pitch) (24 × 24)

F1: 240-pin plastic FBGA (16 × 16)



(2/7)

| Pin Name                | Pin No. |     | I/O    | Function                                                   | Alternate Function                    |
|-------------------------|---------|-----|--------|------------------------------------------------------------|---------------------------------------|
|                         | GM      | F1  |        |                                                            |                                       |
| AV <sub>DD</sub>        | 3       | R17 | –      | 3.3 V positive power supply for A/D converter              | –                                     |
| AV <sub>REFM</sub>      | 13      | M16 | Input  | Reference voltage input for A/D converter                  | –                                     |
| AV <sub>REFP</sub>      | 4       | R16 |        |                                                            | –                                     |
| AV <sub>SS</sub>        | 14      | M18 | –      | Ground potential for A/D converter                         | –                                     |
| BCYST                   | 77      | B6  | Output | Strobe signal output that shows the start of the bus cycle | PCT7                                  |
| BUSCLK                  | 88      | B2  | Output | Clock output for SDRAM                                     | PCD1                                  |
| $\overline{\text{CS0}}$ | 44      | C17 | Output | Chip select signal output                                  | PCS0                                  |
| $\overline{\text{CS1}}$ | 43      | B18 |        |                                                            | PCS1                                  |
| $\overline{\text{CS2}}$ | 42      | D16 |        |                                                            | PCS2/ $\overline{\text{IOWR}}$        |
| $\overline{\text{CS3}}$ | 41      | D17 |        |                                                            | PCS3                                  |
| $\overline{\text{CS4}}$ | 40      | E15 |        |                                                            | PCS4                                  |
| $\overline{\text{CS5}}$ | 37      | E17 |        |                                                            | PCS5/ $\overline{\text{IORD}}$        |
| $\overline{\text{CS6}}$ | 36      | E18 |        |                                                            | PCS6                                  |
| $\overline{\text{CS7}}$ | 35      | F16 |        |                                                            | PCS7                                  |
| D0                      | 92      | D1  | I/O    | 32-bit data bus for external memory                        | –                                     |
| D1                      | 93      | E3  |        |                                                            | –                                     |
| D2                      | 94      | E2  |        |                                                            | –                                     |
| D3                      | 95      | E1  |        |                                                            | –                                     |
| D4                      | 96      | F3  |        |                                                            | –                                     |
| D5                      | 97      | F2  |        |                                                            | –                                     |
| D6                      | 98      | F1  |        |                                                            | –                                     |
| D7                      | 99      | G4  |        |                                                            | –                                     |
| D8                      | 104     | H2  |        |                                                            | –                                     |
| D9                      | 105     | H3  |        |                                                            | –                                     |
| D10                     | 106     | H4  |        |                                                            | –                                     |
| D11                     | 107     | J2  |        |                                                            | –                                     |
| D12                     | 108     | J3  |        |                                                            | –                                     |
| D13                     | 109     | J5  |        |                                                            | –                                     |
| D14                     | 110     | K1  |        |                                                            | –                                     |
| D15                     | 111     | K2  |        |                                                            | –                                     |
| D16                     | 112     | K3  |        |                                                            | PDH0/ $\overline{\text{INTPD0}}$      |
| D17                     | 113     | K4  |        |                                                            | PDH1/ $\overline{\text{INTPD1}}$      |
| D18                     | 114     | K5  |        |                                                            | PDH2/ $\overline{\text{INTPD2/TOC4}}$ |
| D19                     | 117     | L4  |        |                                                            | PDH3/ $\overline{\text{INTPD3}}$      |
| D20                     | 118     | L5  |        |                                                            | PDH4/ $\overline{\text{INTPD4}}$      |

**Remark** GM: 176-pin plastic LQFP (fine pitch) (24 × 24)

F1: 240-pin plastic FBGA (16 × 16)

| Pin Name                   | Pin No. |        | I/O    | Function                                     | Alternate Function                                 |
|----------------------------|---------|--------|--------|----------------------------------------------|----------------------------------------------------|
|                            | GM      | F1     |        |                                              |                                                    |
| D21                        | 119     | M2     | I/O    | 32-bit data bus for external memory          | PDH5/ $\overline{\text{INTPD5}}$ /TOC5             |
| D22                        | 120     | M3     |        |                                              | PDH6/ $\overline{\text{INTPD6}}$ /INTP100/TCUD10   |
| D23                        | 121     | N1     |        |                                              | PDH7/ $\overline{\text{INTPD7}}$ /INTP101/TCLR10   |
| D24                        | 122     | N2     |        |                                              | PDH8/ $\overline{\text{INTPD8}}$ /TO10             |
| D25                        | 123     | N3     |        |                                              | PDH9/ $\overline{\text{INTPD9}}$ /TIUD10           |
| D26                        | 124     | N4     |        |                                              | PDH10/ $\overline{\text{INTPD10}}$ /INTP110/TCUD11 |
| D27                        | 125     | P2     |        |                                              | PDH11/ $\overline{\text{INTPD11}}$ /INTP111/TCLR11 |
| D28                        | 126     | R1     |        |                                              | PDH12/ $\overline{\text{INTPD12}}$ /TO11           |
| D29                        | 127     | P3     |        |                                              | PDH13/ $\overline{\text{INTPD13}}$ /TIUD11         |
| D30                        | 130     | R3     |        |                                              | PDH14/ $\overline{\text{INTPD14}}$ /PWM0           |
| D31                        | 131     | U1     |        |                                              | PDH15/ $\overline{\text{INTPD15}}$ /PWM1           |
| DCK                        | 144     | R7     | Input  | Debug clock input                            | –                                                  |
| DDI                        | 141     | T6     | Input  | Debug data input                             | –                                                  |
| DDO                        | 140     | R6     | Output | Debug data output                            | –                                                  |
| $\overline{\text{DMAAK0}}$ | 24      | J16    | Output | DMA acknowledge signal output                | P51/ $\overline{\text{INTP51}}$                    |
| $\overline{\text{DMAAK1}}$ | 21      | K15    |        |                                              | P54/ $\overline{\text{INTPC01}}$                   |
| $\overline{\text{DMAAK2}}$ | 175     | U16    |        |                                              | P73/ $\overline{\text{INTPC21}}$                   |
| $\overline{\text{DMAAK3}}$ | 172     | U15    |        |                                              | P76/ $\overline{\text{INTPC31}}$                   |
| $\overline{\text{DMARQ0}}$ | 25      | J15    | Input  | DMA request signal input                     | P50/ $\overline{\text{INTP50}}$                    |
| $\overline{\text{DMARQ1}}$ | 22      | J18    |        |                                              | P53/ $\overline{\text{INTPC00}}$ /TIC0             |
| $\overline{\text{DMARQ2}}$ | 176     | U17    |        |                                              | P72/ $\overline{\text{INTPC20}}$ /TIC2             |
| $\overline{\text{DMARQ3}}$ | 173     | T15    |        |                                              | P75/ $\overline{\text{INTPC30}}$ /TIC3             |
| DMS                        | 143     | V6     | Input  | Debug mode select                            | –                                                  |
| $\overline{\text{DRST}}$   | 142     | U6     | Input  | Reset input for debugging                    | –                                                  |
| EV <sub>DD</sub>           | Note 1  | Note 2 | –      | 3.3 V positive power supply for external pin | –                                                  |
| EV <sub>SS</sub>           | Note 3  | Note 4 | –      | Ground potential for external pin            | –                                                  |
| $\overline{\text{HLDK}}$   | 32      | F18    | Output | Bus hold acknowledge output                  | PCM2                                               |
| $\overline{\text{HLDRQ}}$  | 31      | G16    | Input  | Bus hold request input                       | PCM3                                               |
| $\overline{\text{INTP10}}$ | 159     | V11    | Input  | External maskable interrupt request input    | P10/ $\overline{\text{UCLK}}$                      |
| $\overline{\text{INTP11}}$ | 155     | R9     |        |                                              | P11/ $\overline{\text{SCK0}}$                      |
| $\overline{\text{INTP21}}$ | 149     | T8     |        |                                              | P21/ $\overline{\text{RXD1}}$                      |
| $\overline{\text{INTP22}}$ | 148     | U8     |        |                                              | P22/ $\overline{\text{TXD1}}$                      |

**Notes** 1. 38, 53, 70, 89, 100, 115, 128, 150

2. A8, A13, D4, D18, G2, L1, R8, T1

3. 39, 54, 71, 90, 101, 116, 129, 151

4. C8, D2, D12, E16, G3, L3, R2, U9

**Remark** GM: 176-pin plastic LQFP (fine pitch) (24 × 24)

F1: 240-pin plastic FBGA (16 × 16)

| Pin Name                    | Pin No. |     | I/O   | Function                                                                          | Alternate Function                            |
|-----------------------------|---------|-----|-------|-----------------------------------------------------------------------------------|-----------------------------------------------|
|                             | GM      | F1  |       |                                                                                   |                                               |
| $\overline{\text{INTP23}}$  | 147     | P8  | Input | External maskable interrupt request input                                         | P23/ $\overline{\text{SCK1}}$                 |
| $\overline{\text{INTP24}}$  | 146     | V7  |       |                                                                                   | P24/SI1                                       |
| $\overline{\text{INTP25}}$  | 145     | U7  |       |                                                                                   | P25/SO1                                       |
| $\overline{\text{INTP50}}$  | 25      | J15 |       |                                                                                   | P50/ $\overline{\text{DMARQ0}}$               |
| $\overline{\text{INTP51}}$  | 24      | J16 |       |                                                                                   | P51/ $\overline{\text{DMAAK0}}$               |
| $\overline{\text{INTP52}}$  | 23      | J17 |       |                                                                                   | P52/ $\overline{\text{TC0}}$                  |
| $\overline{\text{INTP65}}$  | 19      | K16 |       |                                                                                   | P65/TIC1/ $\overline{\text{INTPC10}}$         |
| $\overline{\text{INTP66}}$  | 18      | K17 |       |                                                                                   | P66/ $\overline{\text{INTPC11}}$              |
| $\overline{\text{INTP67}}$  | 17      | L18 |       |                                                                                   | P67/ $\overline{\text{TOC1}}$                 |
| $\overline{\text{INTPD0}}$  | 112     | K3  |       |                                                                                   | PDH0/D16                                      |
| $\overline{\text{INTPD1}}$  | 113     | K4  |       |                                                                                   | PDH1/D17                                      |
| $\overline{\text{INTPD2}}$  | 114     | K5  |       |                                                                                   | PDH2/ $\overline{\text{TOC4/D18}}$            |
| $\overline{\text{INTPD3}}$  | 117     | L4  |       |                                                                                   | PDH3/D19                                      |
| $\overline{\text{INTPD4}}$  | 118     | L5  |       |                                                                                   | PDH4/D20                                      |
| $\overline{\text{INTPD5}}$  | 119     | M2  |       |                                                                                   | PDH5/ $\overline{\text{TOC5/D21}}$            |
| $\overline{\text{INTPD6}}$  | 120     | M3  |       |                                                                                   | PDH6/ $\overline{\text{INTP100/TCUD10/D22}}$  |
| $\overline{\text{INTPD7}}$  | 121     | N1  |       |                                                                                   | PDH7/ $\overline{\text{INTP101/TCLR10/D23}}$  |
| $\overline{\text{INTPD8}}$  | 122     | N2  |       |                                                                                   | PDH8/ $\overline{\text{TO10/D24}}$            |
| $\overline{\text{INTPD9}}$  | 123     | N3  |       |                                                                                   | PDH9/ $\overline{\text{TIUD10/D25}}$          |
| $\overline{\text{INTPD10}}$ | 124     | N4  |       |                                                                                   | PDH10/ $\overline{\text{INTP110/TCUD11/D26}}$ |
| $\overline{\text{INTPD11}}$ | 125     | P2  |       |                                                                                   | PDH11/ $\overline{\text{INTP111/TCLR11/D27}}$ |
| $\overline{\text{INTPD12}}$ | 126     | R1  |       |                                                                                   | PDH12/ $\overline{\text{TO11/D28}}$           |
| $\overline{\text{INTPD13}}$ | 127     | P3  |       |                                                                                   | PDH13/ $\overline{\text{TIUD11/D29}}$         |
| $\overline{\text{INTPD14}}$ | 130     | R3  |       |                                                                                   | PDH14/ $\overline{\text{PWM0/D30}}$           |
| $\overline{\text{INTPD15}}$ | 131     | U1  |       |                                                                                   | PDH15/ $\overline{\text{PWM1/D31}}$           |
| $\overline{\text{INTPL0}}$  | 76      | D7  |       |                                                                                   | PAL0/A0                                       |
| $\overline{\text{INTPL1}}$  | 75      | C7  |       |                                                                                   | PAL1/A1                                       |
| $\overline{\text{INTP100}}$ | 120     | M3  | Input | Timer ENC10 external capture trigger input                                        | PDH6/ $\overline{\text{TCUD10/D22/INTPD6}}$   |
| $\overline{\text{INTP101}}$ | 121     | N1  |       |                                                                                   | PDH7/ $\overline{\text{TCLR10/D23/INTPD7}}$   |
| $\overline{\text{INTP110}}$ | 124     | N4  | Input | Timer ENC11 external capture trigger input                                        | PDH10/ $\overline{\text{TCUD11/D26/INTPD10}}$ |
| $\overline{\text{INTP111}}$ | 125     | P2  |       |                                                                                   | PDH11/ $\overline{\text{TCLR11/D27/INTPD11}}$ |
| $\overline{\text{INTPC00}}$ | 22      | J18 | Input | External maskable interrupt request input/timer C0 external capture trigger input | P53/ $\overline{\text{TIC0/DMARQ1}}$          |
| $\overline{\text{INTPC01}}$ | 21      | K15 |       |                                                                                   | P54/ $\overline{\text{DMAAK1}}$               |
| $\overline{\text{INTPC10}}$ | 19      | K16 |       | External maskable interrupt request input/timer C1 external capture trigger input | P65/ $\overline{\text{INTP65/TIC1}}$          |
| $\overline{\text{INTPC11}}$ | 18      | K17 |       |                                                                                   | P66/ $\overline{\text{INTP66}}$               |

**Remark** GM: 176-pin plastic LQFP (fine pitch) (24 × 24)

F1: 240-pin plastic FBGA (16 × 16)

| Pin Name                    | Pin No. |        | I/O    | Function                                                                          | Alternate Function                   |
|-----------------------------|---------|--------|--------|-----------------------------------------------------------------------------------|--------------------------------------|
|                             | GM      | F1     |        |                                                                                   |                                      |
| INTPC20                     | 176     | U17    | Input  | External maskable interrupt request input/timer C2 external capture trigger input | P72/TIC2/D $\overline{\text{MARQ2}}$ |
| INTPC21                     | 175     | U16    |        |                                                                                   | P73/D $\overline{\text{MAAK2}}$      |
| INTPC30                     | 173     | T15    |        | External maskable interrupt request input/timer C3 external capture trigger input | P75/TIC3/D $\overline{\text{MARQ3}}$ |
| INTPC31                     | 172     | U15    |        |                                                                                   | P76/D $\overline{\text{MAAK3}}$      |
| I $\overline{\text{ORD}}$   | 37      | E17    | Output | DMA read strobe signal output                                                     | PCS5/C $\overline{\text{S5}}$        |
| I $\overline{\text{OWR}}$   | 42      | D16    | Output | DMA write strobe signal output                                                    | PCS2/C $\overline{\text{S2}}$        |
| IV $\overline{\text{DD}}$   | Note 1  | Note 2 | –      | 1.5 V positive power supply for internal unit                                     | –                                    |
| IV $\overline{\text{SS}}$   | Note 3  | Note 4 |        | Ground potential for internal unit                                                | –                                    |
| JIT0                        | 2       | T18    | Input  | Specifying SSCG operating mode                                                    | –                                    |
| JIT1                        | 1       | T17    |        |                                                                                   | –                                    |
| LLBE                        | 83      | A3     | Output | External data bus byte enable signal output (lowest byte (D0 to D7))              | PCT0/LLDQM/LLW $\overline{\text{R}}$ |
| LLDQM                       | 83      | A3     | Output | Output disable/write mask signal output for SDRAM (lowest byte (D0 to D7))        | PCT0/LLW $\overline{\text{R}}$ /LLBE |
| LLW $\overline{\text{R}}$   | 83      | A3     | Output | External data bus write strobe signal output (lowest byte (D0 to D7))             | PCT0/LLBE/LLDQM                      |
| LUBE                        | 82      | D5     | Output | External data bus byte enable signal output (third byte (D8 to D15))              | PCT1/LUDQM/LUW $\overline{\text{R}}$ |
| LUDQM                       | 82      | D5     | Output | Output disable/write mask signal output for SDRAM (third byte (D8 to D15))        | PCT1/LUW $\overline{\text{R}}$ /LUBE |
| LUW $\overline{\text{R}}$   | 82      | D5     | Output | External data bus write strobe signal output (third byte (D8 to D15))             | PCT1/LUBE/LUDQM                      |
| MODE0                       | 16      | L16    | Input  | Specifying V850E/ME2 operating mode                                               | –                                    |
| MODE1                       | 15      | L14    |        |                                                                                   | –                                    |
| NMI                         | 152     | T9     | Input  | Non-maskable interrupt request signal input                                       | P20                                  |
| OSCV $\overline{\text{DD}}$ | 163     | U12    | –      | 3.3 V positive power supply for oscillator                                        | –                                    |
| OSCV $\overline{\text{SS}}$ | 166     | T13    |        | Ground potential for oscillator                                                   | –                                    |
| PLLSEL                      | 156     | V10    | Input  | Input specifying PLL operating mode                                               | –                                    |
| PLLV $\overline{\text{DD}}$ | 167     | R13    | –      | 1.5 V positive power supply for PLL synthesizer                                   | –                                    |
| PLLV $\overline{\text{SS}}$ | 168     | V15    |        | Ground potential for PLL synthesizer                                              | –                                    |
| PWM0                        | 130     | R3     | Output | PWM pulse signal output                                                           | PDH14/D30/INTPD14                    |
| PWM1                        | 131     | U1     |        |                                                                                   | PDH15/D31/INTPD15                    |
| R $\overline{\text{D}}$     | 79      | A5     | Output | External data bus read strobe signal output                                       | PCT4                                 |
| REFRQ                       | 30      | G17    | Output | Refresh request signal output for SDRAM                                           | PCM4                                 |

- Notes**
1. 26, 55, 84, 102, 134, 157
  2. C4, C12, G1, H18, R4, U10
  3. 27, 56, 85, 103, 135, 158
  4. A2, A12, H5, H16, R10, V3

**Remark** GM: 176-pin plastic LQFP (fine pitch) (24 × 24)  
F1: 240-pin plastic FBGA (16 × 16)

| Pin Name                    | Pin No. |     | I/O    | Function                                                        | Alternate Function                                                   |
|-----------------------------|---------|-----|--------|-----------------------------------------------------------------|----------------------------------------------------------------------|
|                             | GM      | F1  |        |                                                                 |                                                                      |
| $\overline{\text{RESET}}$   | 28      | H15 | Input  | System reset input                                              | –                                                                    |
| RXD0                        | 154     | P9  | Input  | UARTB0 and UARTB1 serial receive data input                     | P12/SI0                                                              |
| RXD1                        | 149     | T8  |        |                                                                 | P21/ $\overline{\text{INTP21}}$                                      |
| $\overline{\text{SCK0}}$    | 155     | R9  | I/O    | CSI30 and CSI31 serial clock I/O (3-wire)                       | P11/ $\overline{\text{INTP11}}$                                      |
| $\overline{\text{SCK1}}$    | 147     | P8  |        |                                                                 | P23/ $\overline{\text{INTP23}}$                                      |
| $\overline{\text{SDCAS}}$   | 87      | B3  | Output | Column address strobe signal output for SDRAM                   | PCD2                                                                 |
| SDCKE                       | 91      | D3  | Output | SDRAM clock enable signal output                                | PCD0                                                                 |
| $\overline{\text{SDRAS}}$   | 86      | C3  | Output | Row address strobe signal output for SDRAM                      | PCD3                                                                 |
| $\overline{\text{SELFREF}}$ | 29      | G18 | Input  | Self-refresh request input for SDRAM                            | PCM5/ADTRG                                                           |
| SI0                         | 154     | P9  | Input  | CSI30 and CSI31 serial receive data input (3-wire)              | P12/RXD0                                                             |
| SI1                         | 146     | V7  |        |                                                                 | P24/ $\overline{\text{INTP24}}$                                      |
| SO0                         | 153     | V9  | Output | CSI30 and CSI31 serial transmit data output (3-wire)            | P13/TXD0                                                             |
| SO1                         | 145     | U7  |        |                                                                 | P25/ $\overline{\text{INTP25}}$                                      |
| SSEL0                       | 170     | R14 | Input  | Specifying the clock generator's operating mode                 | –                                                                    |
| SSEL1                       | 169     | T14 |        |                                                                 | –                                                                    |
| $\overline{\text{TC0}}$     | 23      | J17 | Output | DMA transfer end (terminal count) signal output                 | P52/ $\overline{\text{INTP52}}$                                      |
| $\overline{\text{TC1}}$     | 20      | K14 |        |                                                                 | P55/ $\overline{\text{TOC0}}$                                        |
| $\overline{\text{TC2}}$     | 174     | V17 |        |                                                                 | P74/ $\overline{\text{TOC2}}$                                        |
| $\overline{\text{TC3}}$     | 171     | V16 |        |                                                                 | P77/ $\overline{\text{TOC3}}$                                        |
| TCLR10                      | 121     | N1  | Input  | Clear signal input to timer ENC10 and ENC11                     | PDH7/D23/ $\overline{\text{INTPD7}}$ / $\overline{\text{INTP101}}$   |
| TCLR11                      | 125     | P2  |        |                                                                 | PDH11/D27/ $\overline{\text{INTPD11}}$ / $\overline{\text{INTP111}}$ |
| TCUD10                      | 120     | M3  | Input  | Count operation switching signal input to timer ENC10 and ENC11 | PDH6/D22/ $\overline{\text{INTPD6}}$ / $\overline{\text{INTP100}}$   |
| TCUD11                      | 124     | N4  |        |                                                                 | PDH10/D26/ $\overline{\text{INTPD10}}$ / $\overline{\text{INTP110}}$ |
| TIC0                        | 22      | J18 | Input  | External count clock input of timer C0 to C3                    | P53/ $\overline{\text{DMARQ1}}$ / $\overline{\text{INTPC00}}$        |
| TIC1                        | 19      | K16 |        |                                                                 | P65/ $\overline{\text{INTP65}}$ / $\overline{\text{INTPC10}}$        |
| TIC2                        | 176     | U17 |        |                                                                 | P72/ $\overline{\text{INTPC20}}$ / $\overline{\text{DMARQ2}}$        |
| TIC3                        | 173     | T15 |        |                                                                 | P75/ $\overline{\text{INTPC30}}$ / $\overline{\text{DMARQ3}}$        |
| TIUD10                      | 123     | N3  | Input  | External count clock input to timer ENC10 and ENC11             | PDH9/D25/ $\overline{\text{INTPD9}}$                                 |
| TIUD11                      | 127     | P3  |        |                                                                 | PDH13/D29/ $\overline{\text{INTPD13}}$                               |
| TO10                        | 122     | N2  | Output | Pulse signal output of timer ENC10 and ENC11                    | PDH8/D24/ $\overline{\text{INTPD8}}$                                 |
| TO11                        | 126     | R1  |        |                                                                 | PDH12/D28/ $\overline{\text{INTPD12}}$                               |
| TOC0                        | 20      | K14 | Output | Pulse signal output of timer C0 to C5                           | P55/ $\overline{\text{TC1}}$                                         |
| TOC1                        | 17      | L18 |        |                                                                 | P67/ $\overline{\text{INTP67}}$                                      |
| TOC2                        | 174     | V17 |        |                                                                 | P74/ $\overline{\text{TC2}}$                                         |
| TOC3                        | 171     | V16 |        |                                                                 | P77/ $\overline{\text{TC3}}$                                         |

**Remark** GM: 176-pin plastic LQFP (fine pitch) (24 × 24)

F1: 240-pin plastic FBGA (16 × 16)

| Pin Name                 | Pin No. |     | I/O    | Function                                                                      | Alternate Function                                        |
|--------------------------|---------|-----|--------|-------------------------------------------------------------------------------|-----------------------------------------------------------|
|                          | GM      | F1  |        |                                                                               |                                                           |
| TOC4                     | 114     | K5  | Output | Pulse signal output of timer C0 to C5                                         | PDH2/D18/ $\overline{\text{INTPD2}}$                      |
| TOC5                     | 119     | M2  |        |                                                                               | PDH5/D21/ $\overline{\text{INTPD5}}$                      |
| TRCCLK                   | 139     | U5  | Output | Trace clock output                                                            | –                                                         |
| TRCDATA0                 | 137     | V4  | Output | Trace data output (D0 to D3)                                                  | –                                                         |
| TRCDATA1                 | 136     | T4  |        |                                                                               | –                                                         |
| TRCDATA2                 | 133     | V2  |        |                                                                               | –                                                         |
| TRCDATA3                 | 132     | T2  |        |                                                                               | –                                                         |
| TRCEND                   | 138     | T5  | Output | Trace end status output                                                       | –                                                         |
| TXD0                     | 153     | V9  | Output | UARTB0 and UARTB1 serial transmit data output                                 | P13/SO0                                                   |
| TXD1                     | 148     | U8  |        |                                                                               | P22/ $\overline{\text{INTP22}}$                           |
| UCLK <sup>Note</sup>     | 159     | V11 | Input  | USB clock signal input                                                        | P10/ $\overline{\text{INTP10}}$                           |
| UDM                      | 161     | R11 | I/O    | USB data I/O (–)                                                              | –                                                         |
| UDP                      | 160     | T11 | I/O    | USB data I/O (+)                                                              | –                                                         |
| $\overline{\text{ULBE}}$ | 81      | C5  | Output | External data bus byte enable signal output (second byte (D16 to D23))        | PCT2/ULDQM/ $\overline{\text{ULWR}}$                      |
| ULDQM                    | 81      | C5  | Output | Output disable/write mask signal output for SDRAM (second byte (D16 to D23))  | PCT2/ $\overline{\text{ULWR}}$ / $\overline{\text{ULBE}}$ |
| $\overline{\text{ULWR}}$ | 81      | C5  | Output | External data bus write strobe signal output (second byte (D16 to D23))       | PCT2/ $\overline{\text{ULBE}}$ /ULDQM                     |
| $\overline{\text{UUBE}}$ | 80      | B5  | Output | External data bus byte enable signal output (highest byte (D24 to D31))       | PCT3/ $\overline{\text{UUWR}}$ /UUDQM                     |
| UUDQM                    | 80      | B5  | Output | Output disable/write mask signal output for SDRAM (highest byte (D24 to D31)) | PCT3/ $\overline{\text{UUWR}}$ / $\overline{\text{UUBE}}$ |
| $\overline{\text{UUWR}}$ | 80      | B5  | Output | External data bus write strobe signal output (highest byte (D24 to D31))      | PCT3/UUDQM/ $\overline{\text{UUBE}}$                      |
| UV <sub>DD</sub>         | 162     | P11 | –      | 3.3 V positive power supply for USB                                           | –                                                         |
| $\overline{\text{WAIT}}$ | 34      | F17 | Input  | Control signal input that inserts a wait in the bus cycle                     | PCM0                                                      |
| $\overline{\text{WE}}$   | 78      | C6  | Output | Write enable signal output for SDRAM                                          | PCT5/ $\overline{\text{WR}}$                              |
| $\overline{\text{WR}}$   | 78      | C6  | Output | Write strobe signal output for SDRAM                                          | PCT5/ $\overline{\text{WE}}$                              |
| X1                       | 164     | T12 | Input  | Connects the crystal resonator for system clock oscillation.                  | –                                                         |
| X2                       | 165     | R12 | –      |                                                                               | –                                                         |

**Note** When using as the UCLK pin, be careful to avoid the input of a staircase waveform due to reflection, etc., or the input of noise.

**Remark** GM: 176-pin plastic LQFP (fine pitch) (24 × 24)  
F1: 240-pin plastic FBGA (16 × 16)

## 2.2 Pin Status

The status of each pin after reset, in power-save mode (software STOP, IDLE, HALT modes), and during DMA transfer, refresh, and bus hold (TH) is shown below.

| Pin \ Operating Status                                                                                                       | Reset               | IDLE Mode/<br>Software STOP<br>Mode | HALT Mode/<br>During DMA<br>Transfer/Refresh | Bus Hold<br>(TH) <sup>Note 1</sup> |
|------------------------------------------------------------------------------------------------------------------------------|---------------------|-------------------------------------|----------------------------------------------|------------------------------------|
| A0 to A1 (PAL0 to PAL1)                                                                                                      | Hi-Z                | Hi-Z                                | Operating                                    | Hi-Z                               |
| A2 to A15                                                                                                                    | Hi-Z                | Hi-Z                                | Operating                                    | Hi-Z                               |
| A16 to A25 (PAH0 to PAH9)                                                                                                    | Hi-Z                | Hi-Z                                | Operating                                    | Hi-Z                               |
| D0 to D15                                                                                                                    | Hi-Z                | Hi-Z                                | Operating                                    | Hi-Z                               |
| D16 to D31 (PDH to PDH15)                                                                                                    | Hi-Z                | Hi-Z                                | Operating                                    | Hi-Z                               |
| $\overline{\text{CS0}}$ to $\overline{\text{CS7}}$ (PCS0 to PCS7)                                                            | Hi-Z                | SELF <sup>Note 2</sup>              | Operating                                    | Hi-Z                               |
| $\overline{\text{IOWR}}$ (PCS2)                                                                                              | ×                   | H                                   | Operating                                    | Hi-Z                               |
| $\overline{\text{IORD}}$ (PCS5)                                                                                              | ×                   | H                                   | Operating                                    | Hi-Z                               |
| $\overline{\text{LLWR}}$ , $\overline{\text{LUWR}}$ , $\overline{\text{ULWR}}$ , $\overline{\text{UUWR}}$ (PCT0 to PCT3)     | Hi-Z                | H                                   | Operating                                    | Hi-Z                               |
| $\overline{\text{LLBE}}$ , $\overline{\text{LUBE}}$ , $\overline{\text{ULBE}}$ , $\overline{\text{UUBE}}$ (PCT0 to PCT3)     | ×                   | H                                   | Operating                                    | Hi-Z                               |
| $\overline{\text{LLDQM}}$ , $\overline{\text{LUDQM}}$ , $\overline{\text{ULDQM}}$ , $\overline{\text{UUDQM}}$ (PCT0 to PCT3) | ×                   | H                                   | Operating                                    | Hi-Z                               |
| $\overline{\text{RD}}$ (PCT4)                                                                                                | Hi-Z                | H                                   | Operating                                    | Hi-Z                               |
| $\overline{\text{WR}}$ (PCT5)                                                                                                | Hi-Z                | H                                   | Operating                                    | Hi-Z                               |
| $\overline{\text{WE}}$ (PCT5)                                                                                                | ×                   | H                                   | Operating                                    | Hi-Z                               |
| $\overline{\text{BCYST}}$ (PCT7)                                                                                             | Hi-Z                | H                                   | Operating                                    | Hi-Z                               |
| $\overline{\text{WAIT}}$ (PCM0)                                                                                              | Hi-Z                | —                                   | Operating                                    | —                                  |
| $\overline{\text{HLDAK}}$ (PCM2)                                                                                             | Hi-Z                | H                                   | Operating                                    | L                                  |
| $\overline{\text{HLDRQ}}$ (PCM3)                                                                                             | Hi-Z                | —                                   | Operating                                    | Operating                          |
| $\overline{\text{REFRQ}}$ (PCM4)                                                                                             | Hi-Z                | Operating <sup>Note 2</sup>         | Operating                                    | Operating                          |
| $\overline{\text{SELFREF}}$ (PCM5)                                                                                           | Hi-Z                | —                                   | Operating                                    | Operating                          |
| $\overline{\text{SDCKE}}$ (PCD0)                                                                                             | Hi-Z                | SELF <sup>Note 2</sup>              | Operating                                    | Operating                          |
| $\overline{\text{BUSCLK}}$ (PCD1)                                                                                            | Operating           | SELF <sup>Note 3</sup>              | Operating                                    | Operating                          |
| $\overline{\text{SDCAS}}$ (PCD2)                                                                                             | Hi-Z                | SELF                                | Operating                                    | Hi-Z                               |
| $\overline{\text{SDRAS}}$ (PCD3)                                                                                             | Hi-Z                | SELF                                | Operating                                    | Hi-Z                               |
| $\overline{\text{DMAAK0}}$ (P51)                                                                                             | ×                   | H                                   | Operating                                    | H                                  |
| $\overline{\text{DMAAK1}}$ (P54)                                                                                             | ×                   | H                                   | Operating                                    | H                                  |
| $\overline{\text{DMAAK2}}$ (P73)                                                                                             | ×                   | H                                   | Operating                                    | H                                  |
| $\overline{\text{DMAAK3}}$ (P76)                                                                                             | ×                   | H                                   | Operating                                    | H                                  |
| MODE0, MODE1                                                                                                                 | MODE0, MODE1 input  |                                     |                                              |                                    |
| DDI, DMS, DCK                                                                                                                | DDI, DMS, DCK input |                                     |                                              |                                    |
| NMI (P20)                                                                                                                    | NMI input           |                                     |                                              |                                    |
| SSEL0, SSEL1                                                                                                                 | SSEL0, SSEL1 input  |                                     |                                              |                                    |
| PLLSEL                                                                                                                       | PLLSEL input        |                                     |                                              |                                    |
| Peripheral function input pin other than above                                                                               | ×                   | —                                   | Operating                                    | Operating                          |
| Peripheral function output pin other than above                                                                              | ×                   | Hold                                | Operating                                    | Operating                          |
| Port input pin other than above                                                                                              | Hi-Z                | —                                   | —                                            | Operating                          |
| Port output pin other than above                                                                                             | ×                   | Hold                                | Hold                                         | Operating                          |

**Remark** Explanation on **Note** and **Remark** are given on the next page.

- Notes**
1. The pin set in the port mode holds the status immediately before.
  2. High-level output when the SDRAM controller is not used
  3. Low-level output when the SDRAM controller is not used

<R>

**Remark**

Hi-Z: High-impedance  
H: High-level output  
L: Low-level output  
—: No sampling of input  
×: No select function at reset  
SELF: Self-refresh state when pins are connected to SDRAM

#### Notes on turning on/off power

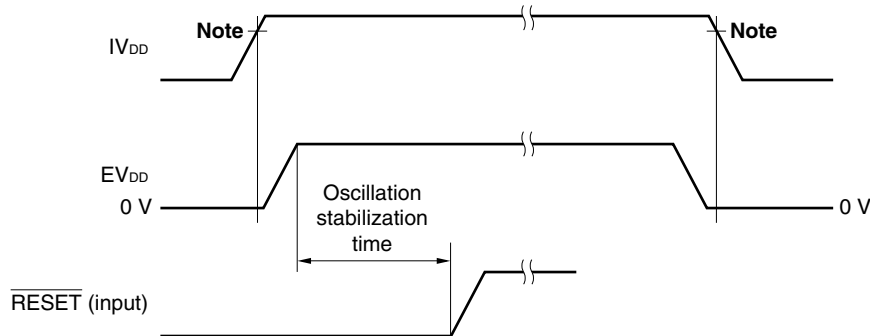
The V850E/ME2 has two power supply pins: a power supply pin for internal units (IV<sub>DD</sub>) and a power supply pin for external pins (EV<sub>DD</sub>). The I/O status of an alternate-function I/O pin may be undefined outside the range in which the operation is guaranteed. If this undefined I/O status affects the system, the pin can be made to go into a high-impedance state using the following measure.

##### • When turning on power

Keep the voltage on the EV<sub>DD</sub> pin at 0 V until the voltage on the IV<sub>DD</sub> pin reaches the operation guaranteed range (100 MHz product, 133 MHz product: 1.35 to 1.65 V, 150 MHz product: 1.40 to 1.65 V).

##### • When turning off power

Keep the voltage on the IV<sub>DD</sub> pin to within the operation guaranteed range (100 MHz product, 133 MHz product: 1.35 to 1.65 V, 150 MHz product: 1.40 to 1.65 V) until the voltage on the EV<sub>DD</sub> pin drops to 0 V.



**Note** 100 MHz product, 133 MHz product: 1.35 V  
150 MHz product: 1.40 V



## 2.3 Description of Pin Functions

### (1) P10 to P13 (Port 1) ... 3-state I/O

P10 to P13 function as a 4-bit I/O port that can read input data or write output data in 1-bit units.

Besides functioning as an I/O port, in the control mode, these pins operate as serial interface I/O (UARTB0, CSI30), USB clock signal input, and external interrupt request input.

The operation mode can be set to port or control mode in 1-bit units, specified by the PMC1 register.

#### (a) Port mode

P10 to P13 can be set to input or output in 1-bit units using the PM1 register.

#### (b) Control mode

P10 to P13 can be set to port/control mode in 1-bit units using the PMC1 register.

#### (i) $\overline{\text{INTP10}}$ , $\overline{\text{INTP11}}$ (External interrupt input) ... input

These are external interrupt request input pins.

#### (ii) SO0 (Serial output) ... output

This is a serial transmit data output pin of CSI30.

#### (iii) SI0 (Serial input) ... input

This is a serial receive data input pin of CSI30.

#### (iv) $\overline{\text{SCK0}}$ (Serial clock) ... 3-state I/O

This is a CSI30 serial clock I/O pin.

#### (v) TXD0 (Transmit data) ... output

This is a serial transmit data output pin of UARTB0.

#### (vi) RXD0 (Receive data) ... input

This is a serial receive data input pin of UARTB0.

#### (vii) UCLK (USB external clock input) ... input

This is a clock input pin of the USB.

When using as the UCLK pin, be careful to avoid the input of a staircase waveform due to reflection, etc., or the input of noise.

**(2) P20 to P25 (Port 2) ... 3-state I/O**

Port 2, except P20, which is an input pin dedicated to checking the input status of NMI, is a 5-bit I/O port that can read input data or write output data in 1-bit units.

Besides functioning as an I/O port, in the control mode, these pins operate as serial interface I/O (UARTB1/CSI31) and external interrupt request input.

The operation mode can be set to port or control mode in 1-bit units, specified by the PMC2 register.

**(a) Port mode**

P21 to P25 can be set to input or output in 1-bit units using the PM2 register. P20 is an input port dedicated to checking the NMI input status, and if a valid edge is input, it operates as an NMI input.

**(b) Control mode**

P21 to P25 can be set to port/control mode in 1-bit units using the PMC2 register.

**(i) NMI (Non-maskable interrupt request) ... input**

This is the non-maskable interrupt request input pin.

**(ii)  $\overline{\text{INTP21}}$  to  $\overline{\text{INTP25}}$  (External interrupt input) ... input**

These are external interrupt request input pins.

**(iii) SO1 (Serial output) ... output**

This is a serial transmit data output pin of CSI31.

**(iv) SI1 (Serial input) ... input**

This is a serial receive data input pin of CSI31.

**(v)  $\overline{\text{SCK1}}$  (Serial clock) ... 3-state I/O**

This is a CSI31 serial clock I/O pin.

**(vi) TXD1 (Transmit data) ... output**

This is a serial transmit data output pin of UARTB1.

**(vii) RXD1 (Receive data) ... input**

This is a serial receive data input pin of UARTB1.

**(3) P50 to P55 (Port 5) ... 3-state I/O**

P50 to P55 function as a 6-bit I/O port that can read input data or write output data in 1-bit units.

Besides functioning as an I/O port, in the control mode, these pins operate as DMA request input, DMA acknowledge output, DMA transfer termination output (terminal count), timer/counter I/O, and external interrupt request input.

The operation mode can be set to port or control mode in 1-bit units, specified by the PMC5 register.

**(a) Port mode**

P50 to P55 can be set to input or output in 1-bit units using the PM5 register.

**(b) Control mode**

P50 to P55 can be set to port/control mode in 1-bit units using the PMC5 register.

**(i)  $\overline{\text{DMARQ0}}$ ,  $\overline{\text{DMARQ1}}$  (DMA request) ... input**

These are DMA service request signal input pins. They correspond to DMA channels 0 and 1, respectively, and operate independently of each other. The priority order is fixed to  $\overline{\text{DMARQ0}} > \overline{\text{DMARQ1}} > \overline{\text{DMARQ2}} > \overline{\text{DMARQ3}}$ .

These signals are sampled at the rising edge of the BUSCLK signal. Maintain an active level until a DMA request is acknowledged.

**(ii)  $\overline{\text{DMAAK0}}$ ,  $\overline{\text{DMAAK1}}$  (DMA acknowledge) ... output**

These are acknowledge signal output pins that show a DMA service request was granted. They correspond to DMA channels 0 and 1, respectively, and operate independently of each other.

In flyby transfer, these signals become active when external memory is being accessed and internal instruction RAM (in the write mode) is being accessed. When DMA transfers are being executed between internal data RAM, internal instruction RAM (in the read mode), and on-chip peripheral I/O, they do not become active.

In 2-cycle transfer, these are used as the signals to control the  $\overline{\text{DMARQ0}}$  and  $\overline{\text{DMARQ1}}$  signals.

**(iii)  $\overline{\text{TC0}}$ ,  $\overline{\text{TC1}}$  (Terminal count) ... output**

These are terminal count signal output pins that show that the DMA transfer from the DMA controller is complete. These pins correspond to DMA channels 0 and 1 respectively, and operate independently of each other. The terminal count signals of DMA channels 0 to 3 can be commonly output from the  $\overline{\text{TC0}}$  pin.

**(iv)  $\text{INTPC00}$ ,  $\text{INTPC01}$  (External interrupt input) ... input**

These are external interrupt request input pins and the external capture trigger input pins of timer C0.

**(v)  $\text{TIC0}$  (Timer input) ... input**

This is an external count clock input pin of timer C0.

**(vi)  $\text{TOC0}$  (Timer output) ... output**

This is a pulse signal output pin of timer C0.

**(vii)  $\overline{\text{INTP50}}$  to  $\overline{\text{INTP52}}$  (External interrupt input) ... input**

These are external interrupt request input pins.

**(4) P65 to P67 (Port 6) ... 3-state I/O**

P65 to P67 function as a 3-bit I/O port that can read input data or write output data in 1-bit units.

Besides functioning as an I/O port, in the control mode, these pins operate as timer/counter I/O and external interrupt request input.

The operation mode can be set to port or control mode in 1-bit units, specified by the PMC6 register.

**(a) Port mode**

P65 to P67 can be set to input or output in 1-bit units using the PM6 register.

**(b) Control mode**

P65 to P67 can be set to port/control mode in 1-bit units using the PMC6 register.

**(i) TIC1 (Timer input) ... input**

This is the external count clock input pin for timer C1.

**(ii) TOC1 (Timer output) ... output**

This is the pulse signal output pin for timer C1.

**(iii)  $\overline{\text{INTP65}}$  to  $\overline{\text{INTP67}}$  (External interrupt input) ... input**

These are external interrupt request input pins.

**(iv)  $\overline{\text{INTPC10}}$ ,  $\overline{\text{INTPC11}}$  (External interrupt input) ... input**

These are external interrupt request input pins and the external capture trigger input pins of timer C1.

**(5) P72 to P77 (Port 7) ... 3-state I/O**

P72 to P77 function as a 6-bit I/O port that can read input data or write output data in 1-bit units.

Besides functioning as an I/O port, in the control mode, these pins operate as DMA request input, DMA acknowledge output, DMA transfer termination output (terminal count), timer/counter I/O, and external interrupt request input.

The operation mode can be set to port or control mode in 1-bit units, specified by the PMC7 register.

**(a) Port mode**

P72 to P77 can be set to input or output in 1-bit units using the PM7 register.

**(b) Control mode**

P72 to P77 can be set to port/control mode in 1-bit units using the PMC7 register.

**(i)  $\overline{\text{DMARQ2}}$ ,  $\overline{\text{DMARQ3}}$  (DMA request) ... input**

These are DMA service request signal input pins. They correspond to DMA channels 2 and 3, respectively, and operate independently of each other. The priority order is fixed to  $\overline{\text{DMARQ0}} > \overline{\text{DMARQ1}} > \overline{\text{DMARQ2}} > \overline{\text{DMARQ3}}$ .

These signals are sampled at the rising edge of the BUSCLK signal. Maintain an active level until a DMA request is acknowledged.

**(ii)  $\overline{\text{DMAAK2}}$ ,  $\overline{\text{DMAAK3}}$  (DMA acknowledge) ... output**

These are acknowledge signal output pins that show a DMA service request was granted. They correspond to DMA channels 2 and 3, respectively, and operate independently of each other.

In flyby transfer, these signals become active only when external memory is being accessed and internal instruction RAM (in the write mode) is being accessed. When DMA transfers are being executed between internal data RAM, internal instruction RAM (in the read mode), and on-chip peripheral I/O, they do not become active.

In 2-cycle transfer, these are used as the signals to control the  $\overline{\text{DMARQ2}}$  and  $\overline{\text{DMARQ3}}$  signals.

**(iii)  $\overline{\text{TC2}}$ ,  $\overline{\text{TC3}}$  (Terminal count) ... output**

These are terminal count signal output pins that show that DMA transfer from the DMA controller is complete. These pins correspond to DMA channels 2 and 3 respectively, and operate independently of each other. The terminal count signals of DMA channels 0 to 3 can be commonly output from the  $\overline{\text{TC0}}$  pin.

**(iv)  $\text{INTPC20}$ ,  $\text{INTPC21}$ ,  $\text{INTPC30}$ ,  $\text{INTPC31}$  (External interrupt input) ... input**

These are external interrupt request input pins and the external capture trigger input pins of timers C2 and C3.

**(v)  $\text{TIC2}$ ,  $\text{TIC3}$  (Timer input) ... input**

These are external count clock input pins of timers C2 and C3.

**(vi)  $\text{TOC2}$ ,  $\text{TOC3}$  (Timer output) ... output**

These are pulse signal output pins of timers C2 and C3.

**(6) PCM0 to PCM5 (Port CM) ... 3-state I/O**

PCM0 to PCM5 function as a 6-bit I/O port that can read input data or write output data in 1-bit units.

Besides functioning as a port, in the control mode, these pins operate as wait insertion signal input, bus hold control signal, refresh request signal output for SDRAM, self-refresh request signal input, and A/D converter external trigger input.

The operation mode can be set to port or control in 1-bit units, specified by the PMCCM register.

**(a) Port mode**

PCM0 to PCM5 can be set to input or output in 1-bit units using the PMCM register.

**(b) Control mode**

PCM0 to PCM5 can be set to port/control mode in 1-bit units using the PMCCM register.

**(i)  $\overline{\text{WAIT}}$  (Wait) ... input**

This is the control signal input pin at which a data wait is inserted in the bus cycle. The  $\overline{\text{WAIT}}$  signal can be input asynchronously to the BUSCLK signal. When the BUSCLK signal falls, sampling is executed. When the set/hold time is not terminated within the sampling timing, wait insertion may not be executed.

**Caution** Input to the  $\overline{\text{WAIT}}$  pin is valid immediately after reset release. If a low level is input to the  $\overline{\text{WAIT}}$  pin because an external pull-down resistor is connected to it, the external bus is placed in the bus hold status.

**(ii)  $\overline{\text{HLD}}\text{AK}$  (Hold acknowledge) ... output**

This is the acknowledge signal output pin that indicates the high impedance status for the address bus, data bus, and control bus when the V850E/ME2 receives a bus hold request.

While this signal is active, the impedance of the address bus, data bus, and control bus becomes high and the bus mastership is transferred to the external bus master.

**(iii)  $\overline{\text{HLD}}\text{RQ}$  (Hold request) ... input**

This is the input pin through which an external device requests the V850E/ME2 to release the address bus, data bus, and control bus. The  $\overline{\text{HLD}}\text{RQ}$  signal can be input asynchronously to the BUSCLK signal. When this pin is active, the address bus, data bus, and control bus are set to the high impedance status. This occurs either when the V850E/ME2 completes execution of the current bus cycle or immediately if no bus cycle is being executed, then the  $\overline{\text{HLD}}\text{AK}$  signal is set as active and the bus is released.

In order to make the bus hold state secure, keep the  $\overline{\text{HLD}}\text{RQ}$  signal active until the  $\overline{\text{HLD}}\text{AK}$  signal is output.

**Caution** Input to the  $\overline{\text{HLD}}\text{RQ}$  pin is valid immediately after reset release. If a low level is input to the  $\overline{\text{HLD}}\text{RQ}$  pin because an external pull-down resistor is connected to it, the external bus is placed in the bus hold status.

**(iv)  $\overline{\text{REFRQ}}$  (Refresh request) ... output**

This is the refresh request signal output pin for SDRAM.

This signal becomes active during the refresh cycle. Also, during bus hold, it becomes active when a refresh request is generated and notifies the external bus master that a refresh request was generated.

**(v)  $\overline{\text{SELFREF}}$  (Self-refresh request) ... input**

This is a self-refresh request signal input pin for SDRAM.

The internal data RAM and internal instruction RAM (in the read mode) can be accessed even in the self-refresh cycle. However, access to an on-chip peripheral I/O register or external device is held pending until the self-refresh cycle is cancelled.

**Caution** Input to the  $\overline{\text{SELFREF}}$  pin becomes valid immediately after the reset signal has been cleared. Consequently, if a low level is input to the  $\overline{\text{SELFREF}}$  pin by an external pull-down resistor, self refreshing is started. Note that, at this time, the normal instruction fetch cycle does not occur.

**(vi) ADTRG (A/D trigger input) ... input**

This is an external trigger input pin of the A/D converter.

**(7) PCT0 to PCT5, PCT7 (Port CT) ... 3-state I/O**

PCT0 to PCT5 and PCT7 function as a 7-bit I/O port that can read input data or write output data in 1-bit units.

Besides functioning as a port, in the control mode, these pins operate as control signal outputs for when memory is expanded externally.

The operation mode can be set to port or control mode in 1-bit units, specified by the PMCCT register.

**(a) Port mode**

PCT0 to PCT5 and PCT7 can be set to input or output in 1-bit units using the PMCT register.

**(b) Control mode**

PCT0 to PCT5 and PCT7 can be set to port/control mode in 1-bit units using the PMCCT register.

**(i)  $\overline{\text{LLWR}}$  (Lower lower byte write strobe) ... 3-state output**

This is a strobe signal output pin that shows whether the bus cycle currently being executed is a write cycle for the SRAM, external ROM, or external peripheral I/O area.

For the data bus, the lowest byte (D0 to D7) becomes valid. If the bus cycle is a lowest memory write, it becomes active at the falling edge of the BUSCLK signal in the T1 state and becomes inactive at the falling edge of the BUSCLK signal in the T2 state.

**(ii)  $\overline{\text{LUWR}}$  (Lower upper byte write strobe) ... 3-state output**

This is a strobe signal output pin that shows whether the bus cycle currently being executed is a write cycle for the SRAM, external ROM, or external peripheral I/O area.

For the data bus, the third byte (D8 to D15) becomes valid. If the bus cycle is a third byte memory write, it becomes active at the falling edge of the BUSCLK signal in the T1 state and becomes inactive at the falling edge of the BUSCLK signal in the T2 state.

**(iii)  $\overline{\text{ULWR}}$  (Upper lower byte write strobe) ... 3-state output**

This is a strobe signal output pin that shows whether the bus cycle currently being executed is a write cycle for the SRAM, external ROM, or external peripheral I/O area.

For the data bus, the second byte (D16 to D23) becomes valid. If the bus cycle is a second byte memory write, it becomes active at the falling edge of the BUSCLK signal in the T1 state and becomes inactive at the falling edge of the BUSCLK signal in the T2 state.

**(iv)  $\overline{\text{UUWR}}$  (Upper upper byte write strobe) ... 3-state output**

This is a strobe signal output pin that shows whether the bus cycle currently being executed is a write cycle for the SRAM, external ROM, or external peripheral I/O area.

For the data bus, the highest byte (D24 to D31) becomes valid. If the bus cycle is a highest memory write, it becomes active at the falling edge of the BUSCLK signal in the T1 state and becomes inactive at the falling edge of the BUSCLK signal in the T2 state.

**(v)  $\overline{\text{LLBE}}$  (Lower lower byte enable) ... 3-state output**

This is a signal output pin that enables the lowest byte (D0 to D7) of the external data bus.

**(vi)  $\overline{\text{LUBE}}$  (Lower upper byte enable) ... 3-state output**

This is a signal output pin that enables the third byte (D8 to D15) of the external data bus.



**(vii)  $\overline{\text{ULBE}}$  (Upper lower byte enable) ... 3-state output**

This is a signal output pin that enables the second byte (D16 to D23) of the external data bus.

**(viii)  $\overline{\text{UUBE}}$  (Upper upper byte enable) ... 3-state output**

This is a signal output pin that enables the highest byte (D24 to D31) of the external data bus.

**(ix)  $\overline{\text{LLDQM}}$  (Lower lower DQ mask enable) ... 3-state output**

This is a control signal output pin for the data bus to SDRAM. For the data bus, the lowest byte (D0 to D7) is valid. This signal carries out SDRAM output disable control during a read operation, and SDRAM byte mask control during a write operation.

**(x)  $\overline{\text{LUDQM}}$  (Lower upper DQ mask enable) ... 3-state output**

This is a control signal output pin for the data bus to SDRAM. For the data bus, the third byte (D8 to D15) is valid. This signal carries out SDRAM output disable control during a read operation, and SDRAM byte mask control during a write operation.

**(xi)  $\overline{\text{ULDQM}}$  (Upper lower DQ mask enable) ... 3-state output**

This is a control signal output pin for the data bus to SDRAM. For the data bus, the second byte (D16 to D23) is valid. This signal carries out SDRAM output disable control during a read operation, and SDRAM byte mask control during a write operation.

**(xii)  $\overline{\text{UUDQM}}$  (Upper upper DQ mask enable) ... 3-state output**

This is a control signal output pin for the data bus to SDRAM. For the data bus, the highest byte (D24 to D31) is valid. This signal carries out SDRAM output disable control during a read operation, and SDRAM byte mask control during a write operation.

**(xiii)  $\overline{\text{RD}}$  (Read strobe) ... 3-state output**

This is a strobe signal output pin that shows the bus cycle currently being executed is a read cycle for the SRAM, external ROM, external peripheral I/O, or page ROM area. In the idle state (T1), it becomes inactive.

**(xiv)  $\overline{\text{WR}}$  (Write strobe) ... 3-state output**

This is a strobe signal output pin that shows the bus cycle currently being executed is a write cycle for the SRAM, external ROM, or external peripheral I/O area.

It becomes active at the falling edge of the BUSCLK signal in the T1 state and becomes inactive at the falling edge of the BUSCLK signal in the T2 state.

**(xv)  $\overline{\text{WE}}$  (Write enable) ... 3-state output**

This is an enable signal output pin that shows the bus cycle currently being executed is a write cycle for the SDRAM area. In the idle state (T1), it becomes inactive.

**(xvi)  $\overline{\text{BCYST}}$  (Bus cycle start timing) ... 3-state output**

This is a status signal output pin that shows the start of the bus cycle. It becomes active for 1-clock cycle from the start of each cycle.

**(8) PCS0 to PCS7 (Port CS) ... 3-state I/O**

PCS0 to PCS7 function as an 8-bit I/O port that can read input data or write output data in 1-bit units.

Besides functioning as a port, in the control mode, these pins operate as control signal outputs for when memory and peripheral I/O are expanded externally.

The operation mode can be set to port or control mode in 1-bit units, specified by the PMCCS register.

**(a) Port mode**

PCS0 to PCS7 can be set to input or output in 1-bit units using the PMCS register.

**(b) Control mode**

PCS0 to PCS7 can be set to port/control mode in 1-bit units using the PMCCS register.

**(i)  $\overline{CS0}$  to  $\overline{CS7}$  (Chip select) ... 3-state output**

These are the chip select signal output pins for the SRAM, external ROM, external peripheral I/O, and page ROM area.

The  $\overline{CSn}$  signal is assigned to memory block n (n = 0 to 7).

It becomes active while the bus cycle that accesses the corresponding memory block is activated.

In the idle state (TI), it becomes inactive.

**(ii)  $\overline{IOWR}$  (I/O write strobe) ... 3-state output**

This is a write strobe signal output pin for external I/O during DMA flyby transfer. It indicates whether the bus cycle currently being executed is a write cycle for external I/O during DMA flyby transfer, or a write cycle for the SRAM area.

Note that if the IOEN bit of the bus cycle period control register (BCP) is set (1), this signal can be output even in the normal SRAM, external ROM, or external I/O cycle.

**(iii)  $\overline{IORD}$  (I/O read strobe) ... 3-state output**

This is a read strobe signal output pin for external I/O during DMA flyby transfer. It indicates whether the bus cycle currently being executed is a read cycle for external I/O during DMA flyby transfer, or a read cycle for the SRAM area.

Note that if the IOEN bit of the BCP register is set (1), this signal can be output even in the normal SRAM, external ROM, or external I/O cycle.

**(9) PCD0 to PCD3 (Port CD) ... 3-state I/O**

PCD0 to PCD3 function as a 4-bit I/O port that can read input data or write output data in 1-bit units.

Besides functioning as a port, in control mode, these pins operate as control signal outputs for when the memory and peripheral I/O are expanded externally.

The operation mode can be set to port or control mode in 1-bit units, specified by the PMCCD register.

**(a) Port mode**

PCD0 to PCD3 can be set to input or output in 1-bit units using the PMCD register.

**(b) Control mode**

PCD0 to PCD3 can be set to port or control mode in 1-bit units using the PMCCD register.

**(i) SDCKE (SDRAM clock enable) ... output**

This is the SDRAM clock enable output signal. It becomes inactive in self-refresh and standby mode.

**(ii) BUSCLK (Bus clock output) ... output**

This is a clock output pin for SDRAM.

**(iii)  $\overline{\text{SDCAS}}$  (SDRAM column address strobe) ... 3-state output**

This is a command output signal for SDRAM.

**(iv)  $\overline{\text{SDRAS}}$  (SDRAM row address strobe) ... 3-state output**

This is a command output signal for SDRAM.

**(10) PAH0 to PAH9 (Port AH) ... 3-state I/O**

PAH0 to PAH9 function as an 8- or 10-bit I/O port that can read input data or write output data in 1-bit units.

Besides functioning as a port, in control mode, these pins operate as an address bus (A16 to A25) for when the memory is expanded externally.

The operation mode can be set to port or control mode in 1-bit units, specified by the PMCAH register.

**(a) Port mode**

PAH0 to PAH9 can be set to input or output in 1-bit units using the PMAH register.

**(b) Control mode**

PAH0 to PAH9 can be set to function alternately as A16 to A25 using the PMCAH register.

**(i) A16 to A25 (Address bus) ... 3-state output**

These are the address output pins of the higher 10 bits of the address bus's 26-bit address when the external memory is accessed.

The output changes in synchronization with the fall of the BUSCLK signal in the T1 state. In the idle state (Tl), the address of the bus cycle immediately before is retained.

**(11) PAL0, PAL1 (Port AL) ... 3-state I/O**

PAL0 and PAL1 function as a 2-bit I/O port that can read input data or write output data in 1-bit units.

Besides functioning as a port, in control mode, these pins operate as an address bus (A0, A1) and external interrupt request input for when the memory is expanded externally.

The operation mode can be set to port or control mode in 1-bit units, specified by the PMCAL register.

**(a) Port mode**

PAL0 and PAL1 can be set to input or output in 1-bit units using the PMAL register.

**(b) Control mode**

PAL0 and PAL1 can be set to port or control mode in 1-bit units using the PMCAL register.

**(i) A0, A1 (Address bus) ... 3-state output**

These are the address output pins of the lower 2 bits of the address bus's 26-bit address when the external memory is accessed.

The output changes in synchronization with the fall of the BUSCLK signal in the T1 state. In the idle state (TI), the address of the bus cycle immediately before is retained.

**(ii)  $\overline{\text{INTPL0}}$ ,  $\overline{\text{INTPL1}}$  (External interrupt input) ... input**

These are external interrupt request input pins.

**(12) PDH0 to PDH15 (Port DH) ... 3-state I/O**

PDH0 to PDH15 function as an 8- or 16-bit I/O port that can read input data or write output data in 1-bit units. Besides functioning as a port, in control mode, these pins operate as timer/counter I/O, PWM output, data bus (D16 to D31), and external interrupt request input.

The operation mode can be set to port or control mode in 1-bit units, specified by the PMCDH register.

**(a) Port mode**

PDH0 to PDH15 can be set to input or output in 1-bit units using the PMDH register.

**(b) Control mode**

PDH0 to PDH15 can be set to port or control mode in 1-bit units using the PMCDH register.

**(i)  $\overline{\text{INTPD0}}$  to  $\overline{\text{INTPD15}}$  (External interrupt input) ... input**

These are external interrupt request input pins.

**(ii) TOC4, TOC5 (Timer output) ... output**

These are pulse signal output pins of timers C4 and C5.

**(iii) INTP100, INTP101, INTP110, INTP111 (Timer capture trigger input) ... input**

These are external capture trigger input pins of timers ENC10 and ENC11.

**(iv) TIUD10, TIUD11 (Timer count pulse input) ... input**

These are external count clock input pins of timers ENC10 and ENC11.

**(v) TCUD10, TCUD11 (Timer control pulse input) ... input**

These are external count clock input pins of timers ENC10 and ENC11.

**(vi) TCLR10, TCLR11 (Timer clear) ... input**

These are clear signal input pins of timers ENC10 and ENC11.

**(vii) TO10, TO11 (Timer output) ... output**

These are pulse signal output pins of timers ENC10 and ENC11.

**(viii) PWM0, PWM1 (Pulse width modulation) ... output**

These pins output the PWM pulse signal.

**(ix) D16 to D31 (Data bus) ... 3-state I/O**

These pins constitute a data bus for when the external memory is accessed. These are the higher 16-bit I/O bus pins of the 32-bit data.

The output changes in synchronization with the rise of the BUSCLK signal in the T1 state.

**(13) PLLSEL (PLL operating mode select) ... input**

This is an input pin used to specify the PLL operating mode. Fix the operating mode via a resistor.

**(14) PLLV<sub>DD</sub> (PLL power supply)**

This is a 1.5 V positive power supply pin for PLL synthesizer.

**(15) PLLV<sub>ss</sub> (PLL ground)**

This is a ground pin for PLL synthesizer.

**(16) SSEL0, SSEL1 (Clock generator operating mode select) ... input**

These are input pins used to specify the clock generator's operating mode. Fix the operating mode via a resistor.

**(17) J1T0, J1T1 (SSCG (spread spectrum frequency synthesizer phase locked loop) clock generator operating mode select) ... input**

These are input pins used to specify the SSCG operating mode. Fix the operating mode via a resistor.

**(18) DCK (Debug clock input) ... input**

This pin inputs a debug clock. At the rising edge of the DCK signal, the DMS and DDI signals are sampled, and data is output from the DDO pin at the falling edge of the DCK signal. Keep this pin high when the debug function is not used.

**(19) DDI (Debug data input) ... input**

This pin inputs debug data. This pin is sampled at the rising edge of the DCK signal when the debug serial interface is in the shift state. Data is input with the LSB first. Keep this pin high when the debug function is not used.

**(20) DDO (Debug data output) ... 3-state output**

This pin outputs debug data. It outputs data at the falling edge of the DCK signal when the debug serial interface is in the shift state. Data is output with the LSB first.

**(21) DMS (Debug mode select) ... input**

This input pin selects a debug mode. Depending on the level of the DMS signal, the state machine of the debug serial interface changes. This pin is sampled at the rising edge of the DCK signal. Keep this pin high when the debug function is not used.

**(22)  $\overline{\text{DRST}}$  (Debug reset) ... input**

This pin inputs a debug reset signal that is a negative-logic signal to initialize the DCU asynchronously. When this signal goes low, the DCU is reset/invalidated. Keep this pin low when the debug function is not used.

**(23) MODE0, MODE1 (Mode) ... input**

These are input pins used to specify the operating mode. Fix the operating mode via a resistor.

**(24)  $\overline{\text{RESET}}$  (Reset) ... input**

$\overline{\text{RESET}}$  is a signal that is input asynchronously and that has a constant low level width regardless of the operating clock's status. When this signal is input, a system reset is executed as the first priority ahead of all other operations.

In addition to being used for ordinary initialization/start operations, this pin can also be used to release a standby mode (HALT, IDLE, or software STOP).

**(25) X1, X2 (Crystal)**

These pins are used to connect the resonator that generates the system clock.

**(26) ANI0 to ANI7 (Analog input) ... input**

These are analog input pins for the A/D converter.

Connect a capacitor between these pins and AV<sub>SS</sub> to prevent noise-related operation faults. Also, do not apply voltage that is outside the range for AV<sub>SS</sub> and AV<sub>DD</sub> to pins that are being used as inputs for the A/D converter. If it is possible for noise above the AV<sub>DD</sub> range or below the AV<sub>SS</sub> to enter, clamp these pins using a diode that has a small V<sub>F</sub> value.

**(27) AV<sub>REFM</sub>, AV<sub>REFP</sub> (Analog reference voltage) ... input**

These are reference voltage supply pins for the A/D converter.

**(28) AV<sub>DD</sub> (Analog power supply)**

This is a 3.3 V positive power supply pin for the A/D converter.

**(29) AV<sub>SS</sub> (Analog ground)**

This is a ground pin for the A/D converter.

**(30) EV<sub>DD</sub> (Port power supply)**

This is a 3.3 V positive power supply pin for port.

**(31) EV<sub>SS</sub> (Port ground)**

This is a ground pin for port.

**(32) OSCV<sub>DD</sub> (Clock generator power supply)**

This is a 3.3 V positive power supply pin for the clock generator.

**(33) OSCV<sub>SS</sub> (Clock generator ground)**

This is a ground pin for the clock generator.

**(34) UV<sub>DD</sub> (USB power supply)**

This is a 3.3 V positive power supply pin for the USB.

**(35) UDP (USB data input & output (+)) ... I/O**

This is a data I/O pin (+) of the USB.

**(36) UDM (USB data input & output (–)) ... I/O**

This is a data I/O pin (–) of the USB.

**(37) IV<sub>DD</sub> (Internal unit power supply)**

This is a 1.5 V positive power supply pin for each internal unit. All the IV<sub>DD</sub> pins should be connected to a positive power supply.

**(38) IV<sub>SS</sub> (Internal unit ground)**

This is a ground pin. All the IV<sub>SS</sub> pins should be grounded.

**(39) A2 to A15 (Address bus) ... output**

These are the address output pins of the lower 14 bits of the address bus's 26-bit address when the external memory is accessed.

**(40) D0 to D15 (Data bus) ... 3-state I/O**

These pins constitute a data bus for when the external memory is accessed. These are the lower 16-bit I/O bus pins of the 32-bit data.

The output changes in synchronization with the rise of the BUSCLK signal in the T1 state.

**(41) TRCCLK (Trace clock) ... output**

This is a trace clock output pin.

**(42) TRCDATA0 to TRCDATA3 (Trace data output) ... output**

These are trace data output (D0 to D3) pins.

**(43) TRCEND (Trace end status output) ... output**

This is a trace end status output pin.



## 2.4 Pin I/O Circuits and Recommended Connection of Unused Pins

It is recommended that 1 to 10 kΩ resistors be used when connecting to V<sub>DD</sub> or V<sub>SS</sub> via resistors.

(1/5)

| Pin | Alternate Pin                                         | Pin No. |     | I/O Circuit Type | Recommended Connection                                                                                      |
|-----|-------------------------------------------------------|---------|-----|------------------|-------------------------------------------------------------------------------------------------------------|
|     |                                                       | GM      | F1  |                  |                                                                                                             |
| P10 | $\overline{\text{INTP10}}/\text{UCLK}$                | 159     | V11 | 5                | Input: Independently connect to EV <sub>DD</sub> or EV <sub>SS</sub> via a resistor.<br>Output: Leave open. |
| P11 | $\overline{\text{INTP11}}/\text{SCK0}$                | 155     | R9  | 8-J              |                                                                                                             |
| P12 | SI0/RXD0                                              | 154     | P9  |                  |                                                                                                             |
| P13 | SO0/TXD0                                              | 153     | V9  | 5                |                                                                                                             |
| P20 | NMI                                                   | 152     | T9  | 2                | Connect to V <sub>SS</sub> directly.                                                                        |
| P21 | $\overline{\text{INTP21}}/\text{RXD1}$                | 149     | T8  | 8-J              | Input: Independently connect to EV <sub>DD</sub> or EV <sub>SS</sub> via a resistor.<br>Output: Leave open. |
| P22 | $\overline{\text{INTP22}}/\text{TXD1}$                | 148     | U8  | 5                |                                                                                                             |
| P23 | $\overline{\text{INTP23}}/\text{SCK1}$                | 147     | P8  | 8-J              |                                                                                                             |
| P24 | $\overline{\text{INTP24}}/\text{SI1}$                 | 146     | V7  |                  |                                                                                                             |
| P25 | $\overline{\text{INTP25}}/\text{SO1}$                 | 145     | U7  | 5                | Input: Independently connect to EV <sub>DD</sub> via a resistor.<br>Output: Leave open.                     |
| P50 | $\overline{\text{INTP50}}/\text{DMARQ0}$              | 25      | J15 |                  |                                                                                                             |
| P51 | $\overline{\text{INTP51}}/\text{DMAAK0}$              | 24      | J16 |                  |                                                                                                             |
| P52 | $\overline{\text{INTP52}}/\text{TC0}$                 | 23      | J17 |                  |                                                                                                             |
| P53 | $\overline{\text{INTPC00}}/\text{TIC0}/\text{DMARQ1}$ | 22      | J18 |                  |                                                                                                             |
| P54 | $\overline{\text{INTPC01}}/\text{DMAAK1}$             | 21      | K15 |                  |                                                                                                             |
| P55 | $\text{TOC0}/\text{TC1}$                              | 20      | K14 |                  |                                                                                                             |
| P65 | $\overline{\text{INTP65}}/\text{INTPC10}/\text{TIC1}$ | 19      | K16 |                  |                                                                                                             |
| P66 | $\overline{\text{INTP66}}/\text{INTPC11}$             | 18      | K17 |                  |                                                                                                             |
| P67 | $\overline{\text{INTP67}}/\text{TOC1}$                | 17      | L18 |                  |                                                                                                             |
| P72 | $\overline{\text{INTPC20}}/\text{TIC2}/\text{DMARQ2}$ | 176     | U17 |                  |                                                                                                             |
| P73 | $\overline{\text{INTPC21}}/\text{DMAAK2}$             | 175     | U16 |                  |                                                                                                             |
| P74 | $\text{TOC2}/\text{TC2}$                              | 174     | V17 |                  |                                                                                                             |
| P75 | $\overline{\text{INTPC30}}/\text{TIC3}/\text{DMARQ3}$ | 173     | T15 |                  |                                                                                                             |
| P76 | $\overline{\text{INTPC31}}/\text{DMAAK3}$             | 172     | U15 |                  |                                                                                                             |
| P77 | $\text{TOC3}/\text{TC3}$                              | 171     | V16 |                  |                                                                                                             |

**Remark** GM: 176-pin plastic LQFP (fine pitch) (24 × 24)

F1: 240-pin plastic FBGA (16 × 16)

| Pin   | Alternate Pin                  | Pin No. |     | I/O Circuit Type | Recommended Connection                                                                                      |
|-------|--------------------------------|---------|-----|------------------|-------------------------------------------------------------------------------------------------------------|
|       |                                | GM      | F1  |                  |                                                                                                             |
| PAH0  | A16                            | 58      | B11 | 5                | Input: Independently connect to EV <sub>DD</sub> or EV <sub>SS</sub> via a resistor.<br>Output: Leave open. |
| PAH1  | A17                            | 57      | E11 |                  |                                                                                                             |
| PAH2  | A18                            | 52      | C13 |                  |                                                                                                             |
| PAH3  | A19                            | 51      | D13 |                  |                                                                                                             |
| PAH4  | A20                            | 50      | C14 |                  |                                                                                                             |
| PAH5  | A21                            | 49      | A15 |                  |                                                                                                             |
| PAH6  | A22                            | 48      | C15 |                  |                                                                                                             |
| PAH7  | A23                            | 47      | A16 |                  |                                                                                                             |
| PAH8  | A24                            | 46      | B16 |                  |                                                                                                             |
| PAH9  | A25                            | 45      | A17 |                  |                                                                                                             |
| PAL0  | INTPL0/A0                      | 76      | D7  |                  |                                                                                                             |
| PAL1  | INTPL1/A1                      | 75      | C7  |                  |                                                                                                             |
| PDH0  | D16/INTPD0                     | 112     | K3  |                  |                                                                                                             |
| PDH1  | D17/INTPD1                     | 113     | K4  |                  |                                                                                                             |
| PDH2  | D18/INTPD2/TOC4                | 114     | K5  |                  |                                                                                                             |
| PDH3  | D19/INTPD3                     | 117     | L4  |                  |                                                                                                             |
| PDH4  | D20/INTPD4                     | 118     | L5  |                  |                                                                                                             |
| PDH5  | D21/INTPD5/TOC5                | 119     | M2  |                  |                                                                                                             |
| PDH6  | D22/INTPD6/INTP100/<br>TCUD10  | 120     | M3  |                  |                                                                                                             |
| PDH7  | D23/INTPD7/INTP101/<br>TCLR10  | 121     | N1  |                  |                                                                                                             |
| PDH8  | D24/INTPD8/TO10                | 122     | N2  |                  |                                                                                                             |
| PDH9  | D25/INTPD9/TIUD10              | 123     | N3  |                  |                                                                                                             |
| PDH10 | D26/INTPD10/INTP110/<br>TCUD11 | 124     | N4  |                  |                                                                                                             |
| PDH11 | D27/INTPD11/INTP111/<br>TCLR11 | 125     | P2  |                  |                                                                                                             |
| PDH12 | D28/INTPD12/TO11               | 126     | R1  |                  |                                                                                                             |
| PDH13 | D29/INTPD13/TIUD11             | 127     | P3  |                  |                                                                                                             |
| PDH14 | D30/INTPD14/PWM0               | 130     | R3  |                  |                                                                                                             |
| PDH15 | D31/INTPD15/PWM1               | 131     | U1  |                  |                                                                                                             |
| PCS0  | CS0                            | 44      | C17 |                  |                                                                                                             |
| PCS1  | CS1                            | 43      | B18 |                  |                                                                                                             |
| PCS2  | CS2/IOWR                       | 42      | D16 |                  |                                                                                                             |
| PCS3  | CS3                            | 41      | D17 |                  |                                                                                                             |
| PCS4  | CS4                            | 40      | E15 |                  |                                                                                                             |
| PCS5  | CS5/IORD                       | 37      | E17 |                  |                                                                                                             |
| PCS6  | CS6                            | 36      | E18 |                  |                                                                                                             |
| PCS7  | CS7                            | 35      | F16 |                  |                                                                                                             |

**Remark** GM: 176-pin plastic LQFP (fine pitch) (24 × 24)  
F1: 240-pin plastic FBGA (16 × 16)

| Pin  | Alternate Pin                                                           | Pin No. |     | I/O Circuit Type | Recommended Connection                                                                                      |
|------|-------------------------------------------------------------------------|---------|-----|------------------|-------------------------------------------------------------------------------------------------------------|
|      |                                                                         | GM      | F1  |                  |                                                                                                             |
| PCT0 | $\overline{\text{LLWR}}/\overline{\text{LLBE}}/\overline{\text{LLDQM}}$ | 83      | A3  | 5                | Input: Independently connect to EV <sub>DD</sub> or EV <sub>SS</sub> via a resistor.<br>Output: Leave open. |
| PCT1 | $\overline{\text{LUWR}}/\overline{\text{LUBE}}/\overline{\text{LUDQM}}$ | 82      | D5  |                  |                                                                                                             |
| PCT2 | $\overline{\text{ULWR}}/\overline{\text{ULBE}}/\overline{\text{ULDQM}}$ | 81      | C5  |                  |                                                                                                             |
| PCT3 | $\overline{\text{UUWR}}/\overline{\text{UUBE}}/\overline{\text{UUDQM}}$ | 80      | B5  |                  |                                                                                                             |
| PCT4 | $\overline{\text{RD}}$                                                  | 79      | A5  |                  |                                                                                                             |
| PCT5 | $\overline{\text{WE}}/\overline{\text{WR}}$                             | 78      | C6  |                  |                                                                                                             |
| PCT7 | $\overline{\text{BCYST}}$                                               | 77      | B6  |                  |                                                                                                             |
| PCM0 | $\overline{\text{WAIT}}$                                                | 34      | F17 |                  |                                                                                                             |
| PCM1 | –                                                                       | 33      | G15 | 8-J              | Input: Independently connect to EV <sub>DD</sub> or EV <sub>SS</sub> via a resistor.<br>Output: Leave open. |
| PCM2 | $\overline{\text{HLDK}}$                                                | 32      | F18 |                  |                                                                                                             |
| PCM3 | $\overline{\text{HLDRQ}}$                                               | 31      | G16 |                  |                                                                                                             |
| PCM4 | $\overline{\text{REFRQ}}$                                               | 30      | G17 |                  |                                                                                                             |
| PCM5 | $\overline{\text{ADTRG}}/\overline{\text{SELFREF}}$                     | 29      | G18 |                  |                                                                                                             |
| PCD0 | $\overline{\text{SDCKE}}$                                               | 91      | D3  |                  |                                                                                                             |
| PCD1 | $\overline{\text{BUSCLK}}$                                              | 88      | B2  |                  |                                                                                                             |
| PCD2 | $\overline{\text{SDCAS}}$                                               | 87      | B3  |                  |                                                                                                             |
| PCD3 | $\overline{\text{SDRAS}}$                                               | 86      | C3  |                  |                                                                                                             |
| A2   | –                                                                       | 74      | B7  |                  |                                                                                                             |
| A3   | –                                                                       | 73      | E8  |                  |                                                                                                             |
| A4   | –                                                                       | 72      | D8  |                  |                                                                                                             |
| A5   | –                                                                       | 69      | E9  |                  |                                                                                                             |
| A6   | –                                                                       | 68      | D9  |                  |                                                                                                             |
| A7   | –                                                                       | 67      | C9  |                  |                                                                                                             |
| A8   | –                                                                       | 66      | B9  |                  |                                                                                                             |
| A9   | –                                                                       | 65      | A9  |                  |                                                                                                             |
| A10  | –                                                                       | 64      | E10 |                  |                                                                                                             |
| A11  | –                                                                       | 63      | C10 |                  |                                                                                                             |
| A12  | –                                                                       | 62      | B10 |                  |                                                                                                             |
| A13  | –                                                                       | 61      | D11 |                  |                                                                                                             |
| A14  | –                                                                       | 60      | A11 |                  |                                                                                                             |
| A15  | –                                                                       | 59      | C11 |                  |                                                                                                             |

**Remark** GM: 176-pin plastic LQFP (fine pitch) (24 × 24)

F1: 240-pin plastic FBGA (16 × 16)

(4/5)

| Pin | Alternate Pin | Pin No. |    | I/O Circuit Type | Recommended Connection                                                                                      |
|-----|---------------|---------|----|------------------|-------------------------------------------------------------------------------------------------------------|
|     |               | GM      | F1 |                  |                                                                                                             |
| D0  | –             | 92      | D1 | 5                | Input: Independently connect to EV <sub>DD</sub> or EV <sub>SS</sub> via a resistor.<br>Output: Leave open. |
| D1  | –             | 93      | E3 |                  |                                                                                                             |
| D2  | –             | 94      | E2 |                  |                                                                                                             |
| D3  | –             | 95      | E1 |                  |                                                                                                             |
| D4  | –             | 96      | F3 |                  |                                                                                                             |
| D5  | –             | 97      | F2 |                  |                                                                                                             |
| D6  | –             | 98      | F1 |                  |                                                                                                             |
| D7  | –             | 99      | G4 |                  |                                                                                                             |
| D8  | –             | 104     | H2 |                  |                                                                                                             |
| D9  | –             | 105     | H3 |                  |                                                                                                             |
| D10 | –             | 106     | H4 |                  |                                                                                                             |
| D11 | –             | 107     | J2 |                  |                                                                                                             |
| D12 | –             | 108     | J3 |                  |                                                                                                             |
| D13 | –             | 109     | J5 |                  |                                                                                                             |
| D14 | –             | 110     | K1 |                  |                                                                                                             |
| D15 | –             | 111     | K2 |                  |                                                                                                             |

**Remark** GM: 176-pin plastic LQFP (fine pitch) (24 × 24)

F1: 240-pin plastic FBGA (16 × 16)

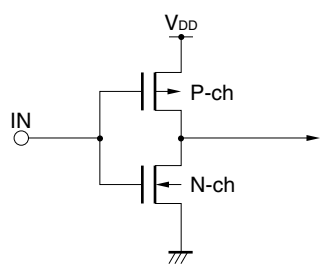
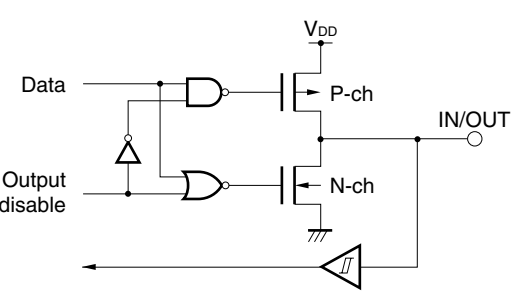
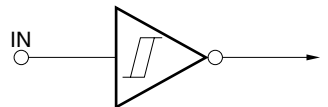
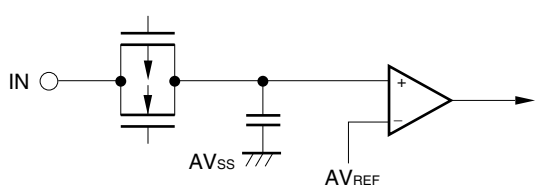
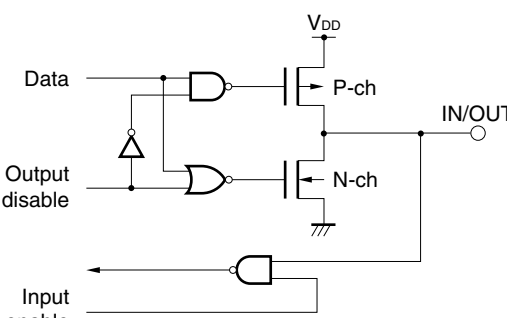
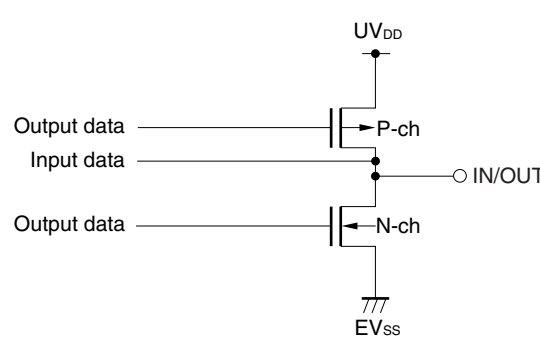
(5/5)

| Pin                      | Alternate Pin | Pin No. |     | I/O Circuit Type | Recommended Connection                      |
|--------------------------|---------------|---------|-----|------------------|---------------------------------------------|
|                          |               | GM      | F1  |                  |                                             |
| AV <sub>DD</sub>         | –             | 3       | R17 | –                | Connect to EV <sub>DD</sub> .               |
| AV <sub>SS</sub>         | –             | 14      | M18 | –                | Connect to EV <sub>SS</sub> .               |
| DCK                      | –             | 144     | R7  | 1                | Connect to EV <sub>DD</sub> via a resistor. |
| DDI                      | –             | 141     | T6  |                  |                                             |
| DMS                      | –             | 143     | V6  |                  |                                             |
| DDO                      | –             | 140     | R6  |                  | Leave open.                                 |
| $\overline{\text{DRST}}$ | –             | 142     | U6  |                  | Connect to EV <sub>SS</sub> .               |
| TRCCLK                   | –             | 139     | U5  |                  | Leave open.                                 |
| TRCDATA0                 | –             | 137     | V4  |                  |                                             |
| TRCDATA1                 | –             | 136     | T4  |                  |                                             |
| TRCDATA2                 | –             | 133     | V2  |                  |                                             |
| TRCDATA3                 | –             | 132     | T2  |                  |                                             |
| TRCEND                   | –             | 138     | T5  |                  |                                             |
| UV <sub>DD</sub>         | –             | 162     | P11 |                  | –                                           |
| UDM                      | –             | 161     | R11 | 24-A             | Connect to EV <sub>SS</sub> .               |
| UDP                      | –             | 160     | T11 |                  |                                             |
| ANI0                     | –             | 5       | P16 | 9-E              |                                             |
| ANI1                     | –             | 6       | P17 |                  |                                             |
| ANI2                     | –             | 7       | N15 |                  |                                             |
| ANI3                     | –             | 8       | N16 |                  |                                             |
| ANI4                     | –             | 9       | N17 |                  |                                             |
| ANI5                     | –             | 10      | N18 |                  |                                             |
| ANI6                     | –             | 11      | M15 |                  |                                             |
| ANI7                     | –             | 12      | M17 |                  |                                             |
| AV <sub>REFM</sub>       | –             | 13      | M16 | –                |                                             |
| AV <sub>REFP</sub>       | –             | 4       | R16 | –                | Connect to EV <sub>DD</sub> .               |

**Remark** GM: 176-pin plastic LQFP (fine pitch) (24 × 24)

F1: 240-pin plastic FBGA (16 × 16)

## 2.5 Pin I/O Circuits

|                                                                                                                                                                |                                                                                                       |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------|
| <p>Type 1</p>                                                                 | <p>Type 8-J</p>     |
| <p>Type 2</p>  <p>Schmitt-triggered input with hysteresis characteristics</p> | <p>Type 9-E</p>     |
| <p>Type 5</p>                                                               | <p>Type 24-A</p>  |

## CHAPTER 3 CPU FUNCTION

The CPU of the V850E/ME2 is based on RISC architecture and executes almost all the instructions in one clock cycle using 5-stage pipeline control.

### 3.1 Features

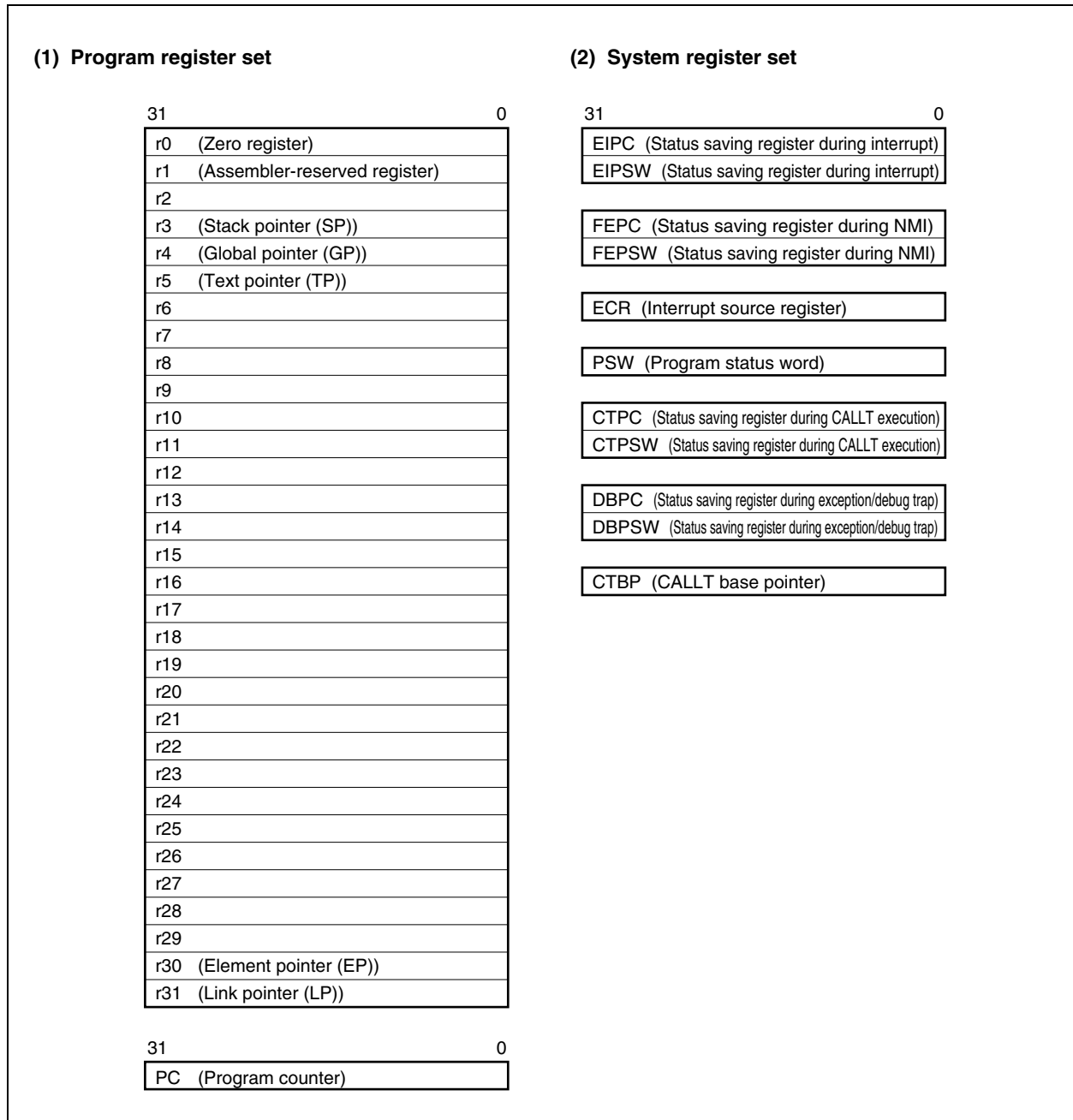
- Minimum instruction execution time: 10 ns/7.5 ns/6.7 ns (@100 MHz/133 MHz/150 MHz internal operation)
- Memory space    Program space: 64 MB linear  
                              Data space: 4 GB linear
- Thirty-two 32-bit general-purpose registers
- Internal 32-bit architecture
- Five-stage pipeline control
- Multiply/divide instructions
- Saturated operation instructions
- One-clock 32-bit shift instruction
- Load/store instruction with long/short format
- Four types of bit manipulation instructions
  - SET1
  - CLR1
  - NOT1
  - TST1

### 3.2 CPU Register Set

The registers of the V850E/ME2 can be classified into two categories: a general program register set and a dedicated system register set. All the registers have a 32-bit width.

For details, refer to **V850E1 Architecture User's Manual**.

Figure 3-1. CPU Register Set





### 3.2.1 Program register set

The program register set includes general-purpose registers and a program counter.

#### (1) General-purpose registers (r0 to r31)

Thirty-two general-purpose registers, r0 to r31, are provided. All these registers can be used for data variables or address variables.

However, care must be exercised as follows in using the r0 to r5, r30, and r31 registers.

##### (a) r0, r30

r0 and r30 are implicitly used by instructions.

r0 is a register that always holds 0, and is used for operations using 0 and offset 0 addressing.

r30 is used as a base pointer when accessing memory using the SLD and SST instructions.

##### (b) r1, r3 to r5, r31

r1, r3 to r5, and r31 are implicitly used by the assembler and C compiler.

Therefore, their contents must be saved before using these registers so that they are not lost.

The contents must be restored to the registers after the registers have been used.

##### (c) r2

r2 is sometimes used by a real-time OS. When the real-time OS to be used is not using r2, r2 can be used as an address variable register or a data variable register.

**Table 3-1. General-Purpose Registers**

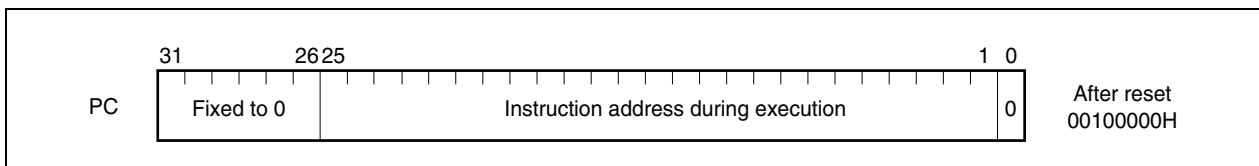
| Name      | Usage                                                                    | Operation                                                                         |
|-----------|--------------------------------------------------------------------------|-----------------------------------------------------------------------------------|
| r0        | Zero register                                                            | Always holds 0                                                                    |
| r1        | Assembler-reserved register                                              | Working register for generating 32-bit immediate data                             |
| r2        | Address/data variable register (when r2 is not used by the real-time OS) |                                                                                   |
| r3        | Stack pointer                                                            | Used to generate stack frame when function is called                              |
| r4        | Global pointer                                                           | Used to access global variable in data area                                       |
| r5        | Text pointer                                                             | Register to indicate the start of the text area (where program code is allocated) |
| r6 to r29 | Address/data variable registers                                          |                                                                                   |
| r30       | Element pointer                                                          | Base pointer when memory is accessed                                              |
| r31       | Link pointer                                                             | Used by compiler when calling function                                            |

**Remark** For detailed descriptions of r1, r3 to r5, and r31 used by an assembler or C compiler, refer to the **CA850 (C Compiler Package) Assembly Language User's Manual**.

#### (2) Program counter (PC)

This register holds the instruction address during program execution. The lower 26 bits of this register are valid, and bits 31 to 26 are fixed to 0. If a carry occurs from bit 25 to 26, it is ignored.

Bit 0 is fixed to 0, and branching to an odd address cannot be performed.



### 3.2.2 System register set

System registers control the status of the CPU and hold interrupt information.

To read/write these system registers, specify a system register number indicated below using the system register load/store instruction (LDSR or STSR instruction).

**Table 3-2. System Register Numbers**

| No.      | System Register Name                                                                                         | Operand Specification |                     |
|----------|--------------------------------------------------------------------------------------------------------------|-----------------------|---------------------|
|          |                                                                                                              | LDSR Instruction      | STSR Instruction    |
| 0        | Status saving register during interrupt (EIPC) <sup>Note 1</sup>                                             | ○                     | ○                   |
| 1        | Status saving register during interrupt (EIPSW) <sup>Note 1</sup>                                            | ○                     | ○                   |
| 2        | Status saving register during NMI (FEPC)                                                                     | ○                     | ○                   |
| 3        | Status saving register during NMI (FEPSW)                                                                    | ○                     | ○                   |
| 4        | Interrupt source register (ECR)                                                                              | ×                     | ○                   |
| 5        | Program status word (PSW)                                                                                    | ○                     | ○                   |
| 6 to 15  | Reserved for future function expansion (operations that access these register numbers cannot be guaranteed). | ×                     | ×                   |
| 16       | Status saving register during CALLT execution (CTPC)                                                         | ○                     | ○                   |
| 17       | Status saving register during CALLT execution (CTPSW)                                                        | ○                     | ○                   |
| 18       | Status saving register during exception/debug trap (DBPC)                                                    | ○ <sup>Note 2</sup>   | ○ <sup>Note 2</sup> |
| 19       | Status saving register during exception/debug trap (DBPSW)                                                   | ○ <sup>Note 2</sup>   | ○ <sup>Note 2</sup> |
| 20       | CALLT base pointer (CTBP)                                                                                    | ○                     | ○                   |
| 21 to 31 | Reserved for future function expansion (operations that access these register numbers cannot be guaranteed). | ×                     | ×                   |

**Notes 1.** Because these registers have only one set, to enable multiple interrupts, it is necessary to save these registers by program.

<R> **2.** These registers can be accessed only during the period between the execution of the DBTRAP instruction or illegal opcode and the DBRET instruction.

**Caution** Even if bit 0 of EIPC, FEPC, or CTPC is set to 1 by the LDSR instruction, bit 0 will be ignored when the program is returned to with the RETI instruction after interrupt servicing (because bit 0 of the PC is fixed to 0). When setting the value of EIPC, FEPC, and CTPC, use an even value (bit 0 = 0).

**Remark** ○: Access allowed  
×: Access prohibited

**(1) Interrupt status saving registers (EIPC, EIPSW)**

There are two interrupt status saving registers, EIPC and EIPSW.

Upon occurrence of a software exception or a maskable interrupt, the contents of the program counter (PC) are saved to EIPC and the contents of the program status word (PSW) are saved to EIPSW (upon occurrence of a non-maskable interrupt (NMI), the contents are saved to the NMI status saving registers (FEPC, FEPSW)).

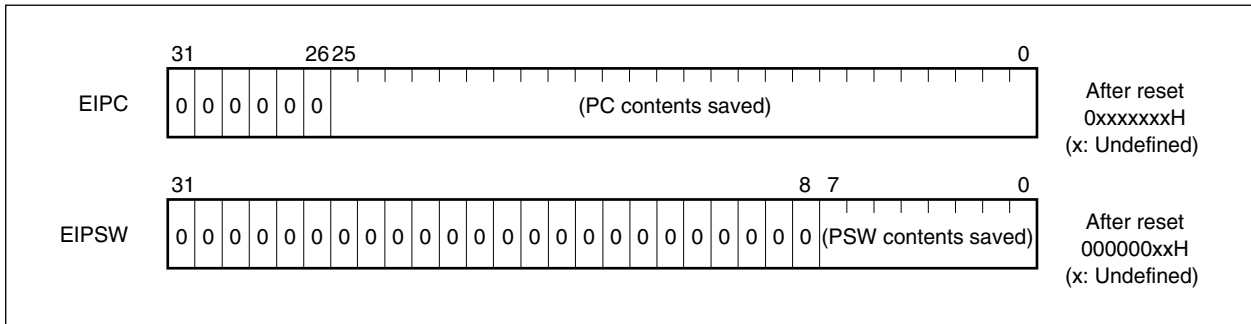
The address of the next instruction following the instruction executed when a software exception or maskable interrupt occurs is saved to EIPC, except for some instructions (see **7.8 Periods in Which CPU Does Not Acknowledge Interrupts**).

The current PSW contents are saved to EIPSW.

Since there is only one set of interrupt status saving registers, the contents of these registers must be saved by the program when multiple interrupt servicing is enabled.

Bits 31 to 26 of EIPC and bits 31 to 8 of EIPSW are reserved (fixed to 0) for future function expansion.

When the RETI instruction is executed, the values in EIPC and EIPSW are restored to the PC and PSW, respectively.



**(2) NMI status saving registers (FEPC, FEPSW)**

There are two NMI status saving registers, FEPC and FEPSW.

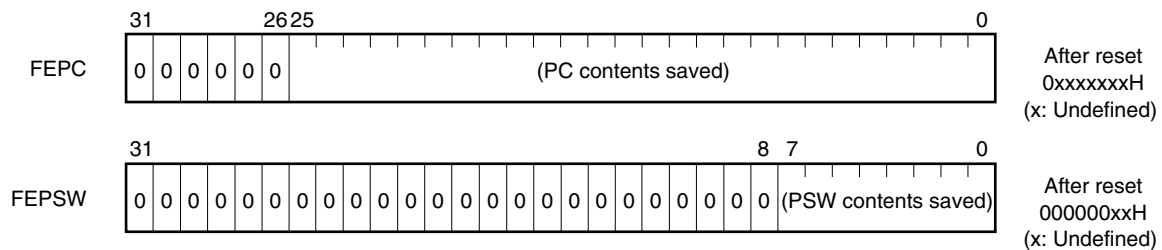
Upon occurrence of a non-maskable interrupt (NMI), the contents of the program counter (PC) are saved to FEPC and the contents of the program status word (PSW) are saved to FEPSW.

The address of the next instruction following the instruction executed when a non-maskable interrupt occurs is saved to FEPC, except for some instructions.

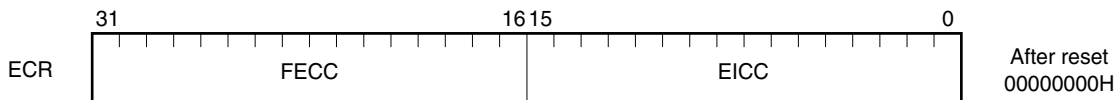
The current PSW contents are saved to FEPSW.

Bits 31 to 26 of FEPC and bits 31 to 8 of FEPSW are reserved (fixed to 0) for future function expansion.

When the RETI instruction has been executed, the values of FEPC and FEPSW are restored to the PC and PSW, respectively.

**(3) Interrupt source register (ECR)**

Upon occurrence of an interrupt or an exception, the interrupt source register (ECR) holds the source of an interrupt or an exception. The value held by ECR is the exception code coded for each interrupt source. This register is a read-only register, and thus data cannot be written to it using the LDSR instruction.



| Bit position | Bit name | Description                                  |
|--------------|----------|----------------------------------------------|
| 31 to 16     | FECC     | Non-maskable interrupt (NMI) exception code  |
| 15 to 0      | EICC     | Exception, maskable interrupt exception code |

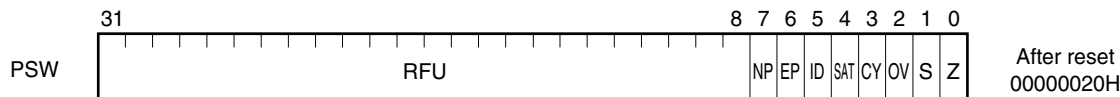
**(4) Program status word (PSW)**

The program status word (PSW) is a collection of flags that indicate the program status (instruction execution result) and the CPU status.

When the contents of this register are changed using the LDSR instruction, the new contents become valid immediately following completion of LDSR instruction execution. Interrupt request acknowledgment is held pending while a write to the PSW is being executed by the LDSR instruction.

Bits 31 to 8 are reserved (fixed to 0) for future function expansion.

(1/2)



| Bit position | Flag name           | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|--------------|---------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 31 to 8      | RFU                 | Reserved field. Fixed to 0.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| 7            | NP                  | Indicates that non-maskable interrupt (NMI) servicing is in progress. This flag is set to 1 when an NMI request is acknowledged, and disables multiple interrupts.<br>0: NMI servicing not in progress<br>1: NMI servicing in progress                                                                                                                                                                                                                                                                                                               |
| 6            | EP                  | Indicates that exception processing is in progress. This flag is set to 1 when an exception occurs. Moreover, interrupt requests can be acknowledged even when this bit is set.<br>0: Exception processing not in progress<br>1: Exception processing in progress                                                                                                                                                                                                                                                                                    |
| 5            | ID                  | Indicates whether maskable interrupt request acknowledgment is enabled.<br>0: Interrupt enabled (EI)<br>1: Interrupt disabled (DI)                                                                                                                                                                                                                                                                                                                                                                                                                   |
| 4            | SAT <sup>Note</sup> | Indicates that the result of executing a saturated operation instruction has overflowed and that the calculation result is saturated. Since this is a cumulative flag, it is set to 1 when the result of a saturated operation instruction becomes saturated, and it is not cleared to 0 even if the operation results of successive instructions do not become saturated. Use the LDSR instruction to clear this bit. This flag is neither set nor cleared when arithmetic operation instructions are executed.<br>0: Not saturated<br>1: Saturated |
| 3            | CY                  | Indicates whether carry or borrow occurred as the result of an operation.<br>0: No carry or borrow occurred<br>1: Carry or borrow occurred                                                                                                                                                                                                                                                                                                                                                                                                           |
| 2            | OV <sup>Note</sup>  | Indicates whether overflow occurred during an operation.<br>0: No overflow occurred<br>1: Overflow occurred                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| 1            | S <sup>Note</sup>   | Indicates whether the result of an operation is negative.<br>0: Operation result is positive or 0.<br>1: Operation result is negative.                                                                                                                                                                                                                                                                                                                                                                                                               |
| 0            | Z                   | Indicates whether operation result is 0.<br>0: Operation result is not 0.<br>1: Operation result is 0.                                                                                                                                                                                                                                                                                                                                                                                                                                               |

**Remark** Note is explained on the following page.

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**Note** During saturated operation, the saturated operation results are determined by the contents of the OV flag and S flag. The SAT flag is set (to 1) only when the OV flag is set (to 1) during saturated operation.

| Operation result status               | Flag status                  |    |   | Saturated operation result |
|---------------------------------------|------------------------------|----|---|----------------------------|
|                                       | SAT                          | OV | S |                            |
| Maximum positive value exceeded       | 1                            | 1  | 0 | 7FFFFFFFH                  |
| Maximum negative value exceeded       | 1                            | 1  | 1 | 80000000H                  |
| Positive (maximum value not exceeded) | Holds value before operation | 0  | 0 | Actual operation result    |
| Negative (maximum value not exceeded) |                              |    | 1 |                            |

#### (5) CALLT execution status saving registers (CTPC, CTPSW)

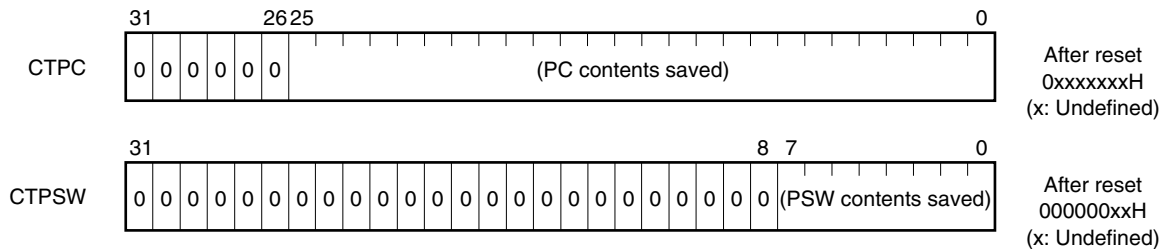
There are two CALLT execution status saving registers, CTPC and CTPSW.

When the CALLT instruction is executed, the contents of the program counter (PC) are saved to CTPC, and the program status word (PSW) contents are saved to CTPSW.

The contents saved to CTPC consist of the address of the next instruction after the CALLT instruction.

The current PSW contents are saved to CTPSW.

Bits 31 to 26 of CTPC and bits 31 to 8 of CTPSW are reserved (fixed to 0) for future function expansion.



**(6) Exception/debug trap status saving registers (DBPC, DBPSW)**

There are two exception/debug trap status saving registers, DBPC and DBPSW.

Upon occurrence of an exception trap or debug trap, the contents of the program counter (PC) are saved to DBPC, and the program status word (PSW) contents are saved to DBPSW.

The contents saved to DBPC consist of the address of the next instruction after the instruction executed when an exception trap or debug trap occurs.

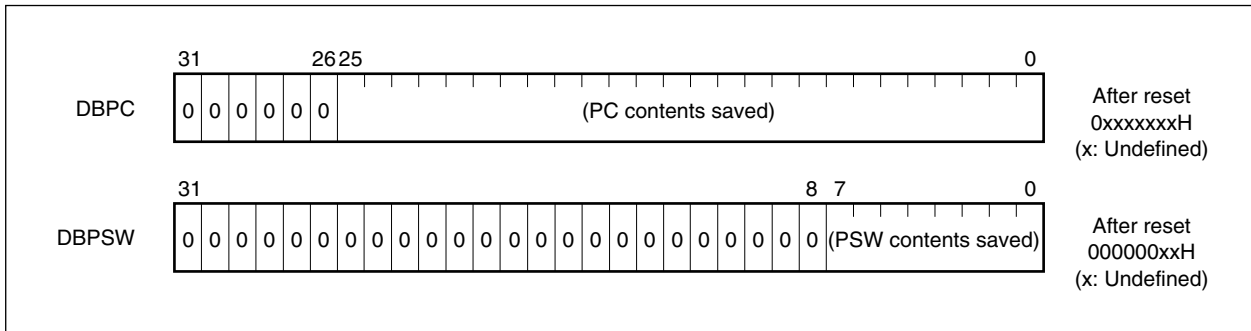
The current PSW contents are saved to DBPSW.

These registers can be read or written only during the period between the execution of the DBTRAP instruction or illegal opcode and the DBRET instruction.

Bits 31 to 26 of DBPC and bits 31 to 8 of DBPSW are reserved (fixed to 0) for future function expansion.

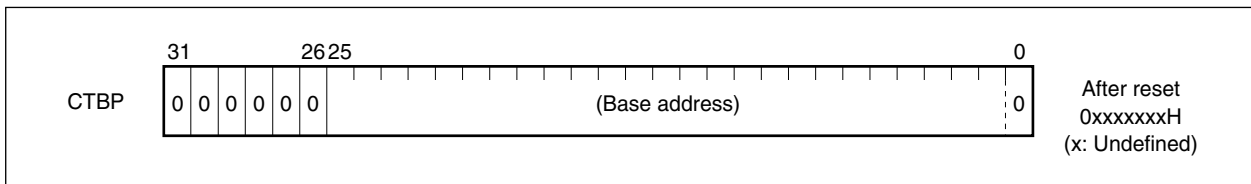
When the DBRET instruction has been executed, the values of DBPC and DBPSW are restored to the PC and PSW, respectively.

<R>

**(7) CALLT base pointer (CTBP)**

The CALLT base pointer (CTBP) is used to specify table addresses and generate target addresses (bit 0 is fixed to 0).

Bits 31 to 26 are reserved (fixed to 0) for future function expansion.



### 3.3 Operating Modes

#### 3.3.1 Operating modes

The V850E/ME2 has the following operating modes. Mode specification is carried out using the MODE0 and MODE1 pins.

##### (1) Normal operation mode

32-bit mode, 16-bit mode

After system reset is cleared, each pin related to the bus interface enters the control mode, the SRAM cycle branches to 0100000H (reset entry address) of the external device (memory), and instruction processing starts.

In the 32-bit mode, the bus interface functions as a 32-bit data bus; it functions as a 16-bit data bus in the 16-bit mode.

**Caution** Be sure to allocate external memory to address 0100000H for correct operation.

#### 3.3.2 Operating mode specification

The operating mode is specified according to the status of the MODE0 and MODE1 pins. In an application system fix the specification of these pins and do not change them during operation. Operation is not guaranteed if these pins are changed during operation.

| MODE1            | MODE0 | Operating Mode        |             | Remarks         |
|------------------|-------|-----------------------|-------------|-----------------|
| L                | L     | Normal operation mode | 32-bit mode | 32-bit data bus |
| L                | H     |                       | 16-bit mode | 16-bit data bus |
| Other than above |       | Setting prohibited    |             |                 |

**Remark** L: Low-level input

H: High-level input



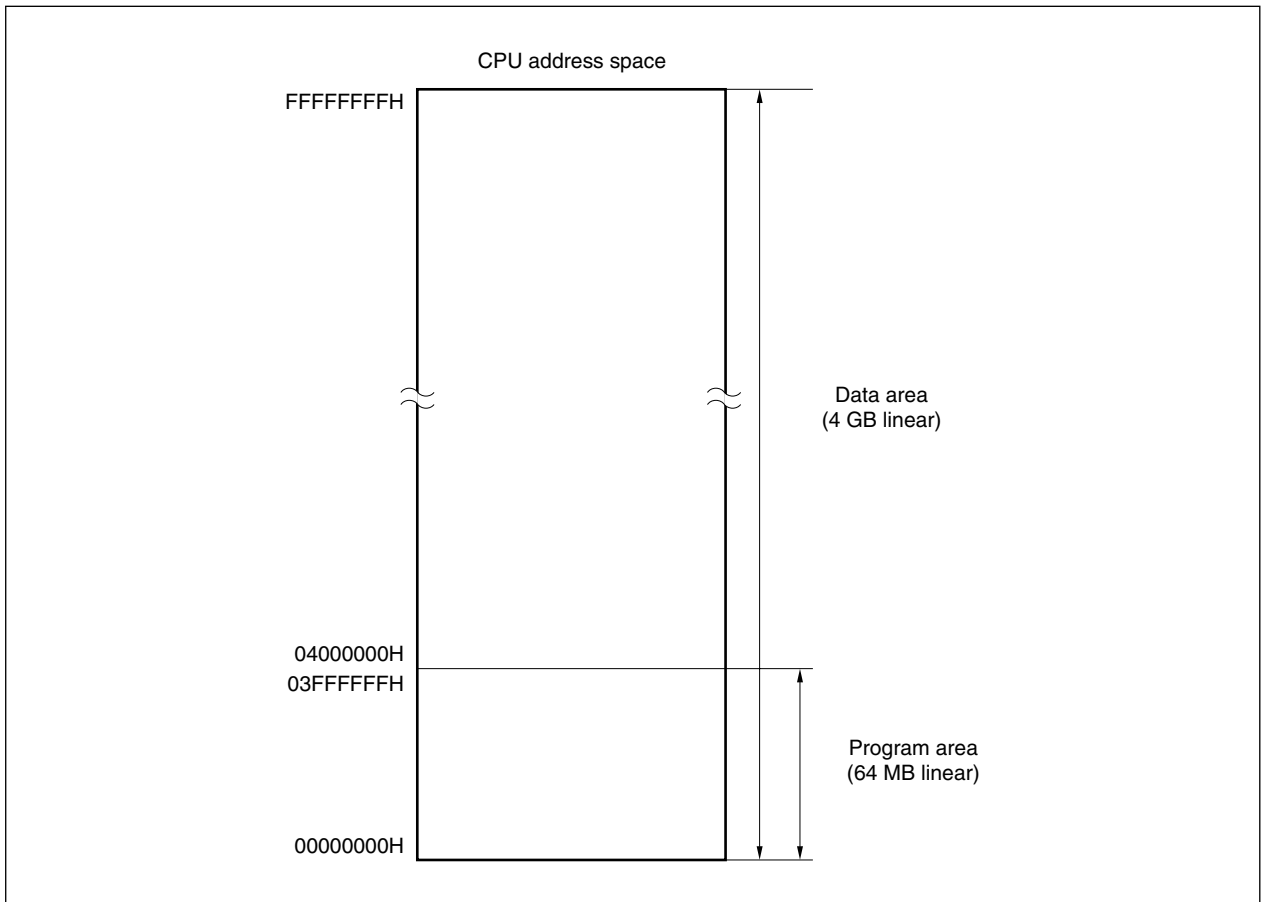
### 3.4 Address Space

#### 3.4.1 CPU address space

The CPU of the V850E/ME2 is of 32-bit architecture and supports up to 4 GB of linear address space (data space) during operand addressing (data access). Also, in instruction address addressing, a maximum of 64 MB of linear address space (program space) is supported.

Figure 3-2 shows the CPU address space.

Figure 3-2. CPU Address Space

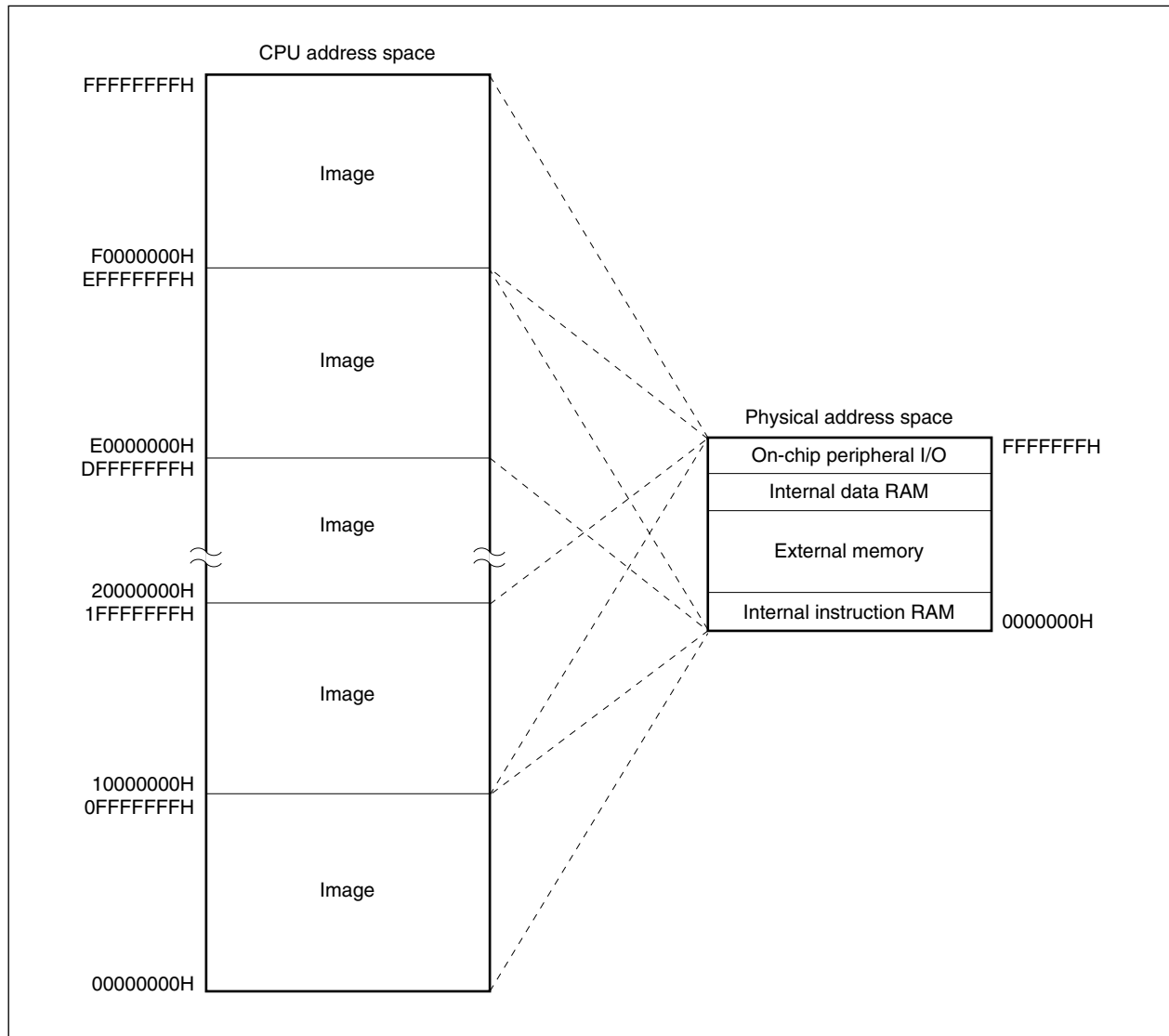


### 3.4.2 Image

A 256 MB physical address space is seen as 16 images in the 4 GB CPU address space. In actuality, the same 256 MB physical address space is accessed regardless of the values of bits 31 to 28 of the CPU address. Figure 3-3 shows the image of the virtual addressing space.

Physical address x0000000H can be seen as CPU address 00000000H, and in addition, can be seen as address 10000000H, address 20000000H, ... , address E0000000H, or address F0000000H.

Figure 3-3. Images on Address Space



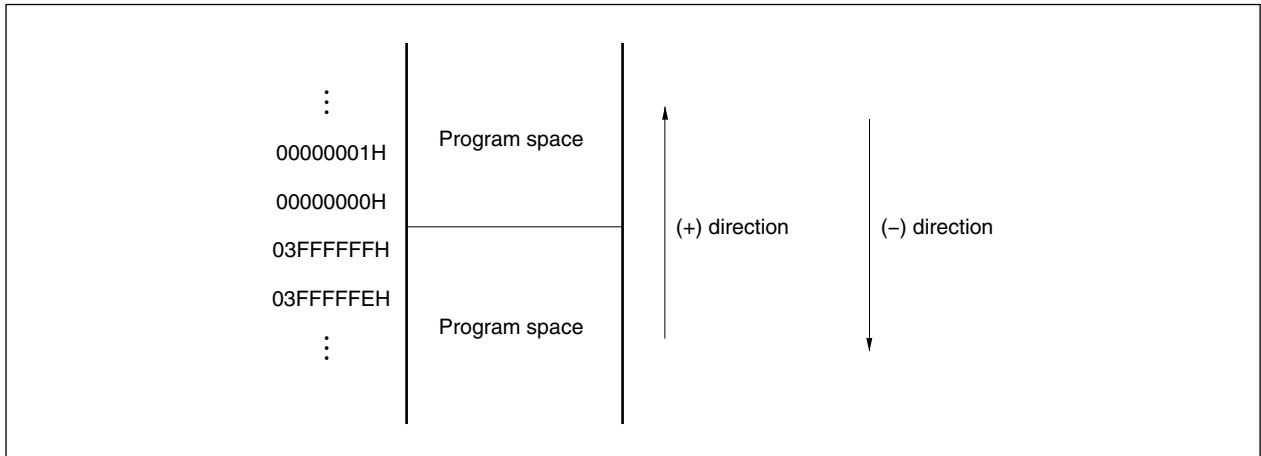
### 3.4.3 Wrap-around of CPU address space

#### (1) Program space

Of the 32 bits of the PC (program counter), the higher 6 bits are fixed to 0, and only the lower 26 bits are valid. Even if a carry or borrow occurs from bit 25 to 26 as a result of a branch address calculation, the higher 6 bits ignore the carry or borrow.

Therefore, the upper-limit address 03FFFFFFH and the lower-limit address 00000000H of the program space become contiguous addresses. Wrap-around refers to a situation like this whereby the upper-limit address and lower-limit address become contiguous.

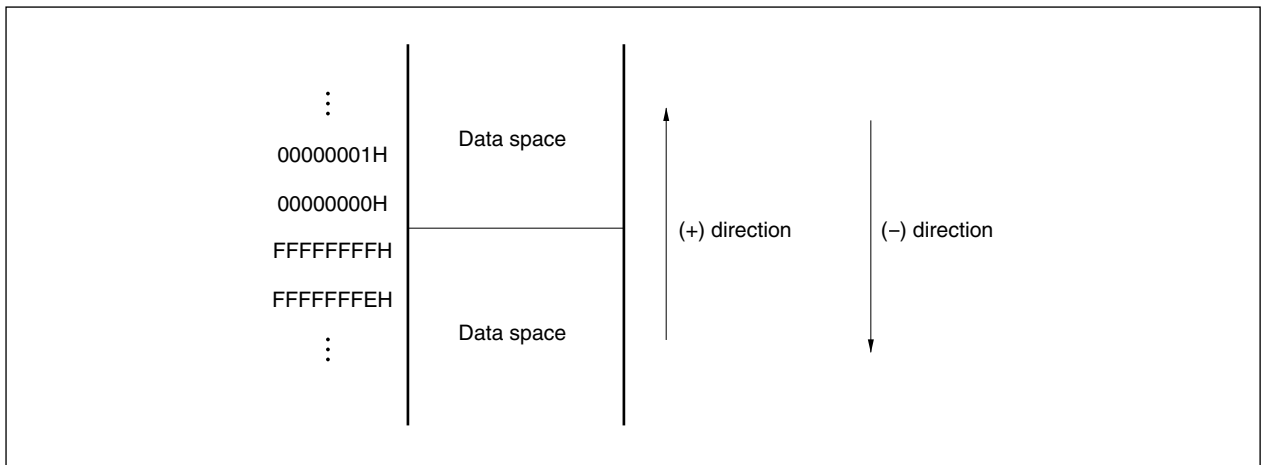
**Caution** The 32 KB area of 03FFF800H to 03FFFFFFH can be seen as an image of 0FFFF800H to 0FFFFFFFH. Instructions cannot be fetched from this area because it is an on-chip peripheral I/O area, internal data RAM area, or access-prohibited area. Therefore, do not execute any branch address calculation in which the result will reside in any part of this area.



#### (2) Data space

The result of an operand address calculation that exceeds 32 bits is ignored.

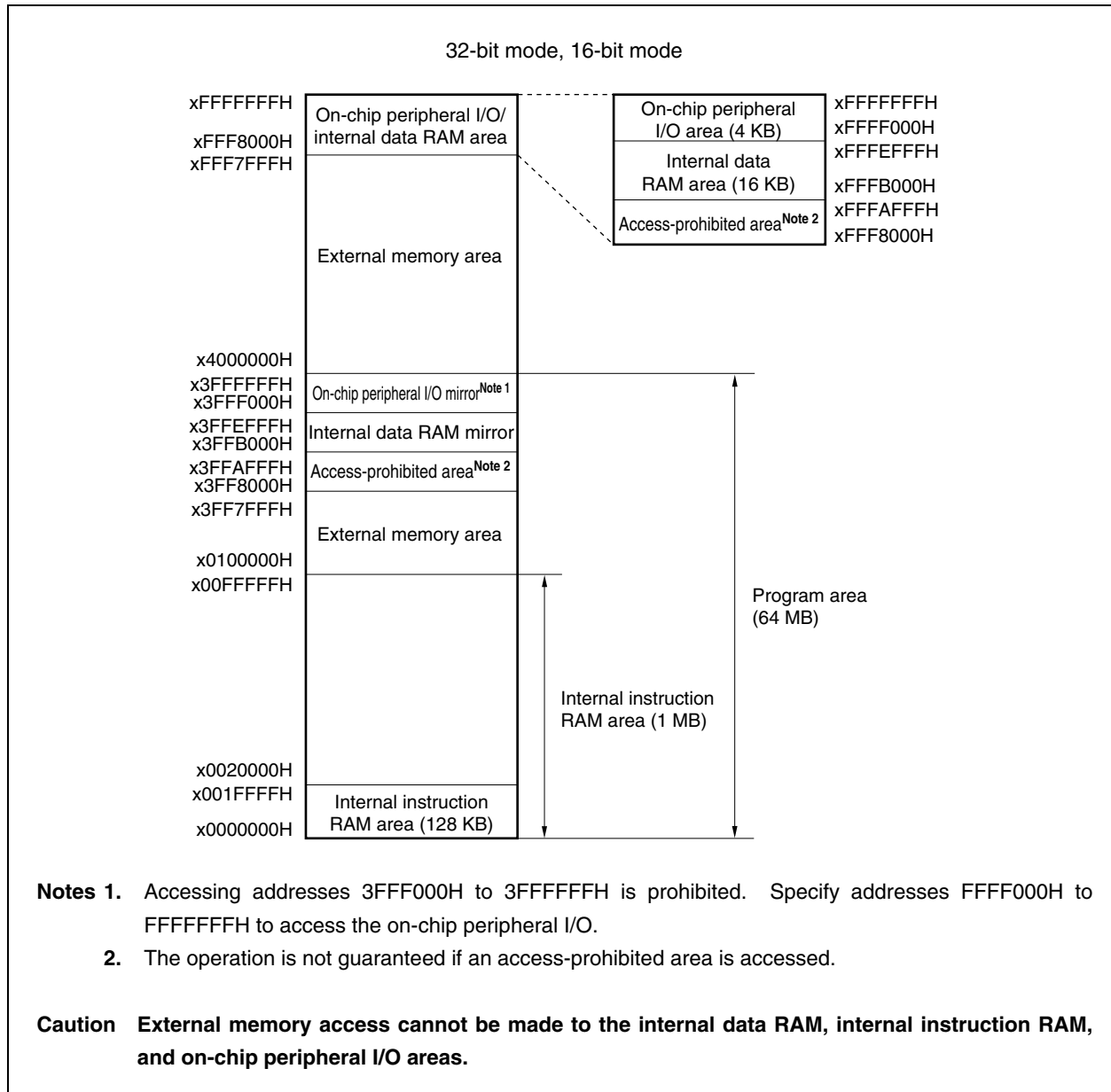
Therefore, the upper-limit address FFFFFFFFH and the lower-limit address 00000000H of the program space are contiguous addresses, and the data space is wrapped around at the boundary of these addresses.



### 3.4.4 Memory map

Areas are reserved in the V850E/ME2 as shown in Figure 3-4.

Figure 3-4. Memory Map



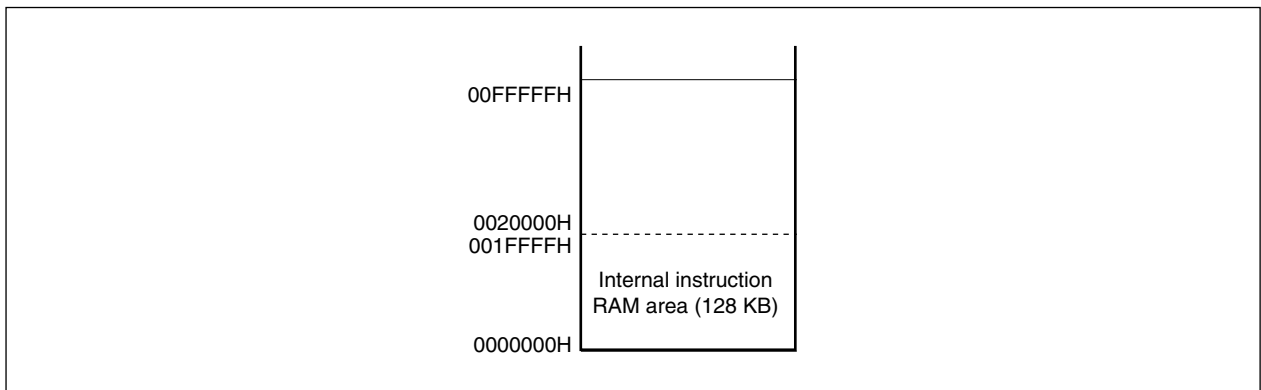
### 3.4.5 Area

#### (1) Internal instruction RAM area

##### (a) Memory map

1 MB of internal instruction RAM area, addresses 0000000H to 00FFFFFFH, is reserved. 128 KB are provided at addresses 0000000H to 001FFFFFH as physical instruction RAM.

**Caution** External memory access cannot be made to addresses 0020000H to 0FFFFFFFH. If this area is accessed, the address bus (A0 to A25) outputs a low level, the data bus (D0 to D31) goes into a high-impedance state without outputting anything, and the external bus control signal becomes inactive.



##### (b) Interrupt/exception table

The V850E/ME2 increases the interrupt response speed by assigning handler addresses corresponding to interrupts/exceptions.

The collection of these handler addresses is called an interrupt/exception table, which is allocated in the internal instruction RAM area. When an interrupt/exception request is acknowledged, execution jumps to the handler address, and the program written in that memory is executed. Table 3-3 shows the sources of interrupts/exceptions, and the corresponding addresses.

**Table 3-3. Interrupt/Exception Table (1/2)**

| Start Address of<br>Interrupt/Exception Table | Interrupt/Exception Source | Start Address of<br>Interrupt/Exception Table | Interrupt/Exception Source |
|-----------------------------------------------|----------------------------|-----------------------------------------------|----------------------------|
| 00100000H                                     | RESET                      | 000000D0H                                     | INTP24                     |
| 00000010H                                     | NMI0                       | 000000E0H                                     | INTP25                     |
| 00000040H                                     | TRAP0n (n = 0 to F)        | 000000F0H                                     | INTP50                     |
| 00000050H                                     | TRAP1n (n = 0 to F)        | 00000100H                                     | INTP51                     |
| 00000060H                                     | ILGOP/DBG0                 | 00000110H                                     | INTP52                     |
| 00000080H                                     | INTP10                     | 00000120H                                     | INTP65                     |
| 00000090H                                     | INTP11                     | 00000130H                                     | INTP66                     |
| 000000A0H                                     | INTP21                     | 00000140H                                     | INTP67                     |
| 000000B0H                                     | INTP22                     | 00000150H                                     | INTPD0                     |
| 000000C0H                                     | INTP23                     | 00000160H                                     | INTPD1                     |

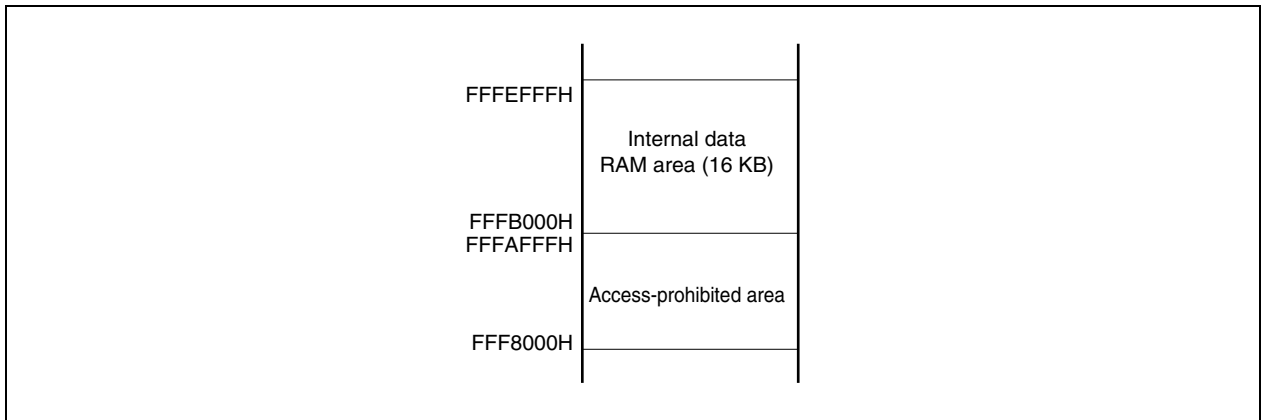
Table 3-3. Interrupt/Exception Table (2/2)

| Start Address of<br>Interrupt/Exception Table | Interrupt/Exception Source | Start Address of<br>Interrupt/Exception Table | Interrupt/Exception Source |
|-----------------------------------------------|----------------------------|-----------------------------------------------|----------------------------|
| 00000170H                                     | INTPD2                     | 000003C0H                                     | INTCMD3                    |
| 00000180H                                     | INTPD3                     | 000003D0H                                     | INTCC100                   |
| 00000190H                                     | INTPD4                     | 000003E0H                                     | INTCC101                   |
| 000001A0H                                     | INTPD5                     | 000003F0H                                     | INTCM100                   |
| 000001B0H                                     | INTPD6                     | 00000400H                                     | INTCM101                   |
| 000001C0H                                     | INTPD7                     | 00000410H                                     | INTOV10                    |
| 000001D0H                                     | INTPD8                     | 00000420H                                     | INTUD10                    |
| 000001E0H                                     | INTPD9                     | 00000430H                                     | INTCC110                   |
| 000001F0H                                     | INTPD10                    | 00000440H                                     | INTCC111                   |
| 00000200H                                     | INTPD11                    | 00000450H                                     | INTCM110                   |
| 00000210H                                     | INTPD12                    | 00000460H                                     | INTCM111                   |
| 00000220H                                     | INTPD13                    | 00000470H                                     | INTOV11                    |
| 00000230H                                     | INTPD14                    | 00000480H                                     | INTUD11                    |
| 00000240H                                     | INTPD15                    | 00000490H                                     | INTDMA0                    |
| 00000250H                                     | INTPL0                     | 000004C0H                                     | INTDMA3                    |
| 00000260H                                     | INTPL1                     | 000004D0H                                     | INTCSI30                   |
| 00000270H                                     | INTOVC0                    | 000004E0H                                     | INTCOVF30                  |
| 00000280H                                     | INTOVC1                    | 000004F0H                                     | INTCSI31                   |
| 00000290H                                     | INTOVC2                    | 00000500H                                     | INTCOVF31                  |
| 000002A0H                                     | INTOVC3                    | 00000510H                                     | UBTIRE0                    |
| 000002B0H                                     | INTOVC4                    | 00000520H                                     | UBTIR0                     |
| 000002C0H                                     | INTOVC5                    | 00000530H                                     | UBTIT0                     |
| 000002D0H                                     | INTPC00/INTCCC00           | 00000540H                                     | UBTIF0                     |
| 000002E0H                                     | INTPC01/INTCCC01           | 00000550H                                     | UBTITO0                    |
| 000002F0H                                     | INTPC10/INTCCC10           | 00000560H                                     | UBTIRE1                    |
| 00000300H                                     | INTPC11/INTCCC11           | 00000570H                                     | UBTIR1                     |
| 00000310H                                     | INTPC20/INTCCC20           | 00000580H                                     | UBTIT1                     |
| 00000320H                                     | INTPC21/INTCCC21           | 00000590H                                     | UBTIF1                     |
| 00000330H                                     | INTPC30/INTCCC30           | 000005A0H                                     | UBTITO1                    |
| 00000340H                                     | INTPC31/INTCCC31           | 000005B0H                                     | INTAD                      |
| 00000350H                                     | INTCCC40                   | 000005C0H                                     | INTUSB0B                   |
| 00000360H                                     | INTCCC41                   | 000005D0H                                     | INTUSB1B                   |
| 00000370H                                     | INTCCC50                   | 000005E0H                                     | INTUSB2B                   |
| 00000380H                                     | INTCCC51                   | 000005F0H                                     | USBSP2B                    |
| 00000390H                                     | INTCMD0                    | 00000600H                                     | USBSP4B                    |
| 000003A0H                                     | INTCMD1                    | 00000610H                                     | INTRSUM                    |
| 000003B0H                                     | INTCMD2                    |                                               |                            |

**(2) Internal data RAM area**

The 16 KB area of addresses FFFB000H to FFFEFFFFH is provided as the internal data RAM area. The 16 KB area of 3FFB000H to 3FFEFFFFH can be seen as an image of FFFB000H to FFFEFFFFH.

- Cautions**
1. External memory access cannot be made to addresses xFFF8000H to xFFFAFFFFH and x3FF8000H to x3FFAFFFFH. The operation is not guaranteed if external memory access is performed.
  2. Do not execute the program in the internal data RAM area.

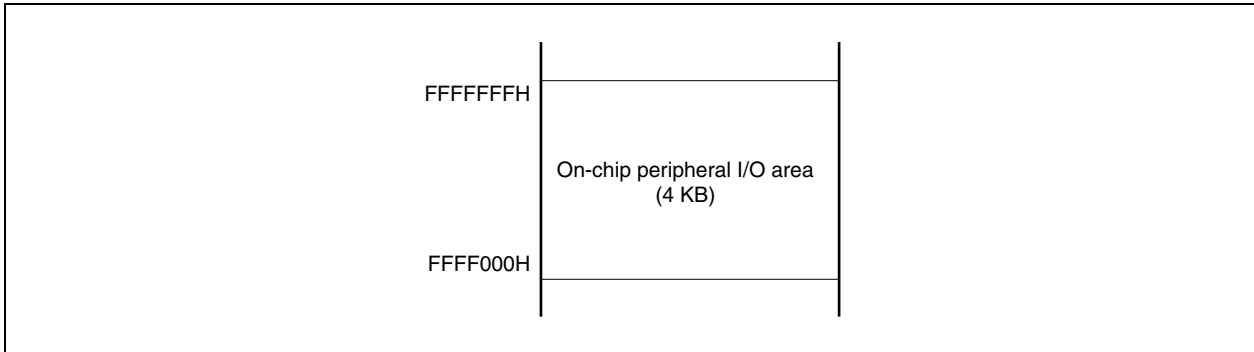


**(3) On-chip peripheral I/O area**

4 KB of memory, addresses FFFF000H to FFFFFFFFH, are provided as an on-chip peripheral I/O area.

An image of addresses FFFF000H to FFFFFFFFH can be seen at addresses 3FFF000H to 3FFFFFFFH<sup>Note</sup>.

**Note** Addresses 3FFF000H to 3FFFFFFFH are access-prohibited. To access the on-chip peripheral I/O, specify addresses FFFF000H to FFFFFFFFH.



On-chip peripheral I/O registers associated with the operating mode specification and the state monitoring for the on-chip peripheral I/O are all memory-mapped to the on-chip peripheral I/O area. Program fetches cannot be executed from this area.

**Cautions 1. For registers in which byte access is possible, if halfword access is executed, the higher 8 bits become undefined during a read operation, and the lower 8 bits of data are written to the register during a write operation.**

**Do not access an 8-bit register in halfword units.**

**2. Addresses that are not defined as registers are reserved for future expansion. If these addresses are accessed, the operation is undefined and not guaranteed.**

**Addresses 3FFF000H to 3FFFFFFFH cannot be specified as the source/destination address of DMA transfer. Be sure to use addresses FFFF000H to FFFFFFFFH for the source/destination address of DMA transfer.**

**(4) External memory area**

256 MB are available for external memory area. The lower 64 MB can be used as program/data area and the higher 192 MB as data area. The external memory area is addresses x0100000H to xDFFFFFFH.

Access to the external memory area is performed using the chip select signal assigned to each memory block (which is carried out in the CS unit set by the CSC0 and CSC1 registers).

Note that the internal instruction RAM, internal data RAM, and on-chip peripheral I/O areas cannot be used as external memory areas.



### 3.4.6 Recommended use of address space

The architecture of the V850E/ME2 requires that a register that serves as a pointer be secured for address generation in operand data accessing of data space. Operand data access from instruction can be directly executed at the address in this pointer register  $\pm 32$  KB area. However, because the general-purpose registers that can be used as a pointer register are limited, by minimizing the deterioration of address calculation performance when changing the pointer value, the number of usable general-purpose registers for handling variables is maximized, and the program size can be saved.

In connection with the memory map of the V850E/ME2, the following usage is recommended to enhance the efficiency of pointer operation.

#### (1) Program space

Of the 32 bits of the program counter (PC), the higher 6 bits are fixed to 0, and only the lower 26 bits are valid. Therefore, a contiguous 64 MB space, starting from address 00000000H, unconditionally corresponds to the memory map of the program space.

#### (2) Data space

To efficiently operate the resources using wrap-around of the data space, a consecutive 16 MB are used as a data space at each of the 4 GB CPU address spaces of 00000000H to 00FFFFFFFH and FF000000H to FFFFFFFFH. With the V850E/ME2, a 256 MB physical address space is seen as 16 images in the 4 GB CPU address space. The highest bit (bit 25) of this 26-bit address is assigned as an address sign-extended to 32 bits.

##### (a) Application of wrap-around

When R = r0 (zero register) is specified with the LD/ST disp16[R] instruction, an addressing range of 00000000H  $\pm 32$  KB can be referenced with the sign-extended disp16.

The zero register (r0) is a register fixed to 0 by the hardware, and eliminates the need for additional registers for the pointer.

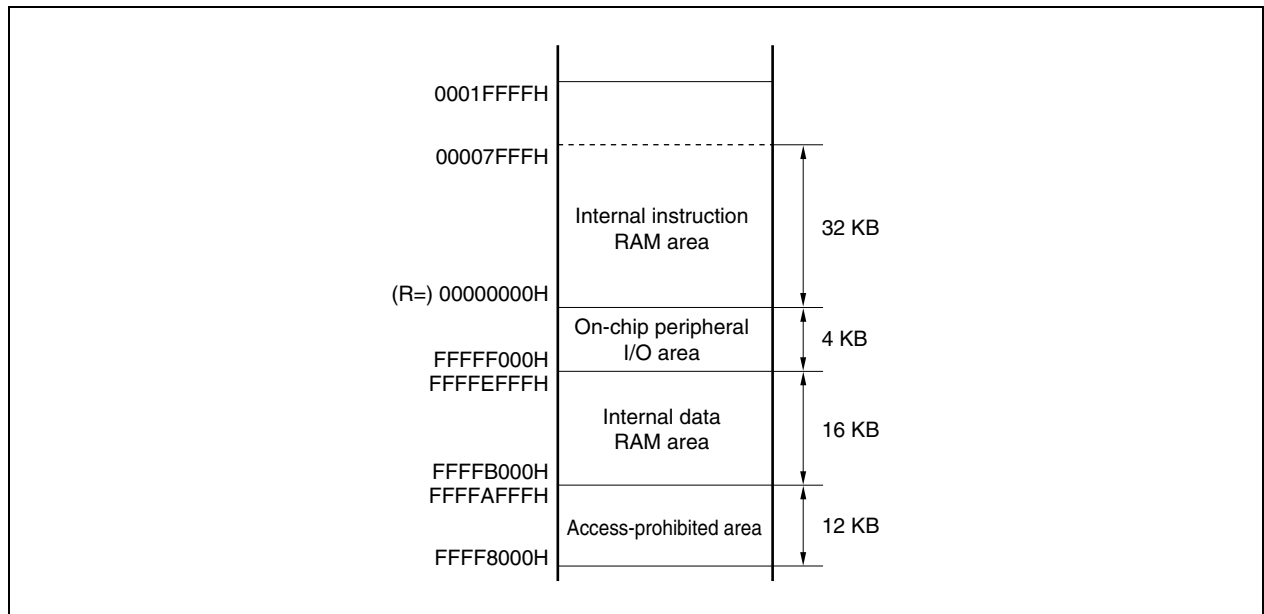
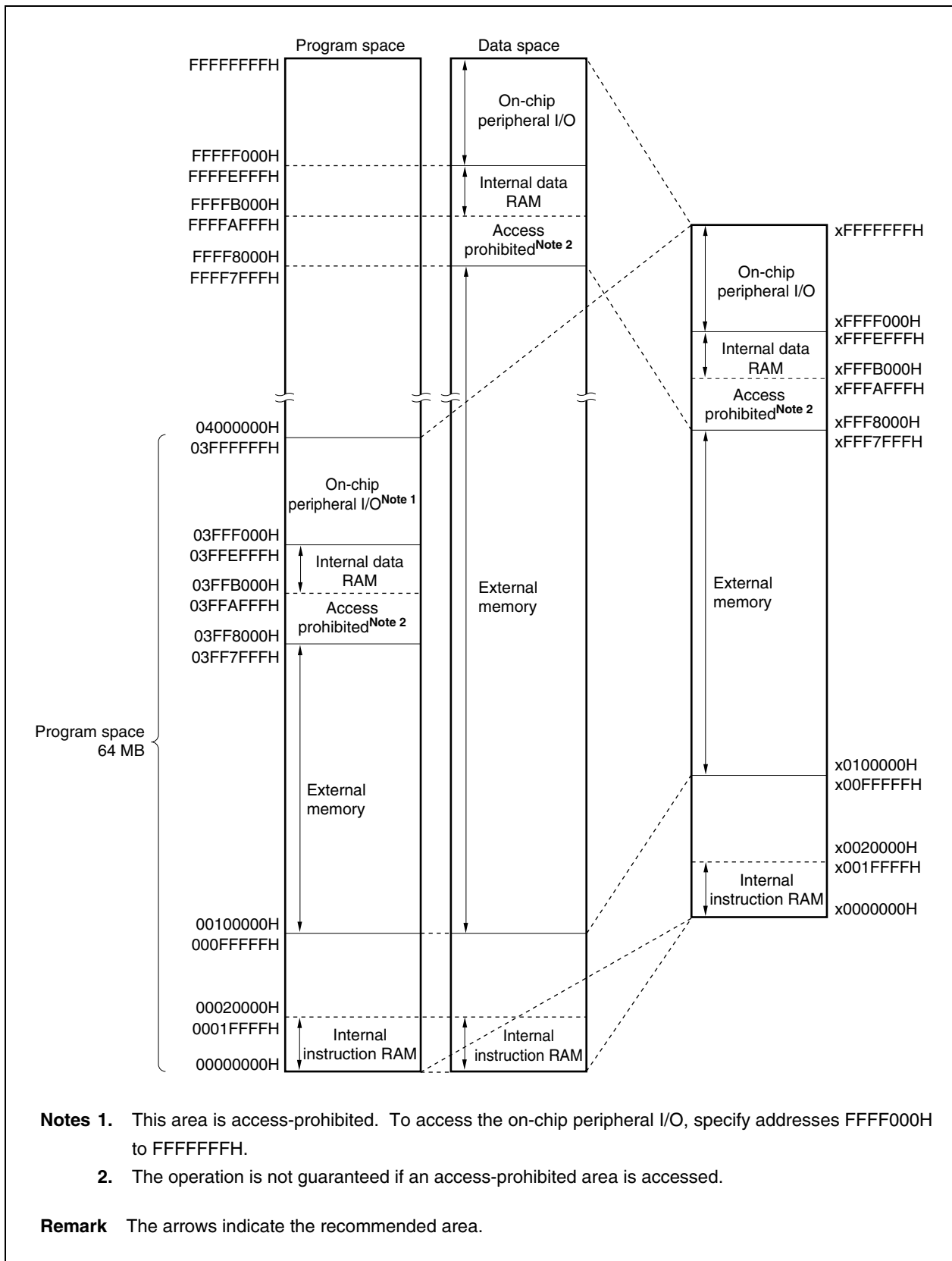


Figure 3-5. Recommended Memory Map



## 3.4.7 On-chip peripheral I/O registers

(1/26)

| Address   | Function Register Name            | Symbol | R/W | Bit Units for Manipulation |        |         | After Reset |
|-----------|-----------------------------------|--------|-----|----------------------------|--------|---------|-------------|
|           |                                   |        |     | 1 Bit                      | 8 Bits | 16 Bits |             |
| FFFFF000H | Port AL                           | PAL    | R/W |                            |        | √       | Undefined   |
| FFFFF000H | Port ALL                          | PALL   | R/W | √                          | √      |         | Undefined   |
| FFFFF001H | Port ALH                          | PALH   | R   | √                          | √      |         | 00H         |
| FFFFF002H | Port AH                           | PAH    | R/W |                            |        | √       | Undefined   |
| FFFFF002H | Port AHL                          | PAHL   | R/W | √                          | √      |         | Undefined   |
| FFFFF003H | Port AHH                          | PAHH   | R/W | √                          | √      |         | Undefined   |
| FFFFF006H | Port DH                           | PDH    | R/W |                            |        | √       | Undefined   |
| FFFFF006H | Port DHL                          | PDHL   | R/W | √                          | √      |         | Undefined   |
| FFFFF007H | Port DHH                          | PDHH   | R/W | √                          | √      |         | Undefined   |
| FFFFF008H | Port CS                           | PCS    | R/W | √                          | √      |         | Undefined   |
| FFFFF00AH | Port CT                           | PCT    | R/W | √                          | √      |         | Undefined   |
| FFFFF00CH | Port CM                           | PCM    | R/W | √                          | √      |         | Undefined   |
| FFFFF00EH | Port CD                           | PCD    | R/W | √                          | √      |         | Undefined   |
| FFFFF020H | Port AL mode register             | PMAL   | R/W |                            |        | √       | FFFFH       |
| FFFFF020H | Port AL mode register L           | PMALL  | R/W | √                          | √      |         | FFH         |
| FFFFF021H | Port AL mode register H           | PMALH  | R   | √                          | √      |         | FFH         |
| FFFFF022H | Port AH mode register             | PMAH   | R/W |                            |        | √       | FFFFH       |
| FFFFF022H | Port AH mode register L           | PMAHL  | R/W | √                          | √      |         | FFH         |
| FFFFF023H | Port AH mode register H           | PMAHH  | R/W | √                          | √      |         | FFH         |
| FFFFF026H | Port DH mode register             | PMDH   | R/W |                            |        | √       | FFFFH       |
| FFFFF026H | Port DH mode register L           | PMDHL  | R/W | √                          | √      |         | FFH         |
| FFFFF027H | Port DH mode register H           | PMDHH  | R/W | √                          | √      |         | FFH         |
| FFFFF028H | Port CS mode register             | PMCS   | R/W | √                          | √      |         | FFH         |
| FFFFF02AH | Port CT mode register             | PMCT   | R/W | √                          | √      |         | FFH         |
| FFFFF02CH | Port CM mode register             | PMCM   | R/W | √                          | √      |         | FFH         |
| FFFFF02EH | Port CD mode register             | PMCD   | R/W | √                          | √      |         | FFH         |
| FFFFF040H | Port AL mode control register     | PMCAL  | R/W |                            |        | √       | 0002H       |
| FFFFF040H | Port AL mode control register L   | PMCALL | R/W | √                          | √      |         | 02H         |
| FFFFF041H | Port AL mode control register H   | PMCALH | R   | √                          | √      |         | 00H         |
| FFFFF042H | Port AH mode control register     | PMCAH  | R/W |                            |        | √       | 03FFH       |
| FFFFF042H | Port AH mode control register L   | PMCAHL | R/W | √                          | √      |         | FFH         |
| FFFFF043H | Port AH mode control register H   | PMCAHH | R/W | √                          | √      |         | 03H         |
| FFFFF046H | Port DH mode control register     | PMCDH  | R/W |                            |        | √       | 0000H       |
| FFFFF046H | Port DH mode control register L   | PMCDHL | R/W | √                          | √      |         | 00H         |
| FFFFF047H | Port DH mode control register H   | PMCDHH | R/W | √                          | √      |         | 00H         |
| FFFFF048H | Port CS mode control register     | PMCCS  | R/W | √                          | √      |         | FFH         |
| FFFFF049H | Port CS function control register | PFCCS  | R/W | √                          | √      |         | 00H         |

(2/26)

| Address   | Function Register Name                        | Symbol | R/W | Bit Units for Manipulation |        |         | After Reset             |
|-----------|-----------------------------------------------|--------|-----|----------------------------|--------|---------|-------------------------|
|           |                                               |        |     | 1 Bit                      | 8 Bits | 16 Bits |                         |
| FFFFF04AH | Port CT mode control register                 | PMCCT  | R/W | √                          | √      |         | BFH                     |
| FFFFF04BH | Port CT function control register             | PFCCT  | R/W | √                          | √      |         | 00H                     |
| FFFFF04CH | Port CM mode control register                 | PMCCM  | R/W | √                          | √      |         | 3DH                     |
| FFFFF04DH | Port CM function control register             | PFCCM  | R/W | √                          | √      |         | 00H                     |
| FFFFF04EH | Port CD mode control register                 | PMCCD  | R/W | √                          | √      |         | 0FH                     |
| FFFFF056H | Port DH function control register             | PFCDH  | R/W |                            |        | √       | 0000H                   |
| FFFFF056H | Port DH function control register L           | PFCDHL | R/W | √                          | √      |         | 00H                     |
| FFFFF057H | Port DH function control register H           | PFCDHH | R/W | √                          | √      |         | 00H                     |
| FFFFF058H | Port AL function control register L           | PFCALL | R/W | √                          | √      |         | 03H                     |
| FFFFF060H | Chip area select control register 0           | CSC0   | R/W |                            |        | √       | 2C11H                   |
| FFFFF062H | Chip area select control register 1           | CSC1   | R/W |                            |        | √       | 2C11H                   |
| FFFFF068H | Endian configuration register                 | BEC    | R/W |                            |        | √       | 0000H                   |
| FFFFF06AH | Cache configuration register                  | BHC    | R/W |                            |        | √       | 0000H                   |
| FFFFF06EH | System wait control register                  | VSWC   | R/W | √                          | √      |         | 77H                     |
| FFFFF070H | Instruction cache control register            | ICC    | R/W |                            |        | √       | 0003H <sup>Note 1</sup> |
| FFFFF070H | Instruction cache control register L          | ICCL   | R/W | √                          | √      |         | 03H <sup>Note 2</sup>   |
| FFFFF071H | Instruction cache control register H          | ICCH   | R/W | √                          | √      |         | 00H                     |
| FFFFF074H | Instruction cache data configuration register | ICD    | R/W |                            |        | √       | Undefined               |
| FFFFF080H | DMA source address register 0L                | DSA0L  | R/W |                            |        | √       | Undefined               |
| FFFFF082H | DMA source address register 0H                | DSA0H  | R/W |                            |        | √       | Undefined               |
| FFFFF084H | DMA destination address register 0L           | DDA0L  | R/W |                            |        | √       | Undefined               |
| FFFFF086H | DMA destination address register 0H           | DDA0H  | R/W |                            |        | √       | Undefined               |
| FFFFF088H | DMA source address register 1L                | DSA1L  | R/W |                            |        | √       | Undefined               |
| FFFFF08AH | DMA source address register 1H                | DSA1H  | R/W |                            |        | √       | Undefined               |
| FFFFF08CH | DMA destination address register 1L           | DDA1L  | R/W |                            |        | √       | Undefined               |
| FFFFF08EH | DMA destination address register 1H           | DDA1H  | R/W |                            |        | √       | Undefined               |
| FFFFF090H | DMA source address register 2L                | DSA2L  | R/W |                            |        | √       | Undefined               |
| FFFFF092H | DMA source address register 2H                | DSA2H  | R/W |                            |        | √       | Undefined               |
| FFFFF094H | DMA destination address register 2L           | DDA2L  | R/W |                            |        | √       | Undefined               |
| FFFFF096H | DMA destination address register 2H           | DDA2H  | R/W |                            |        | √       | Undefined               |
| FFFFF098H | DMA source address register 3L                | DSA3L  | R/W |                            |        | √       | Undefined               |
| FFFFF09AH | DMA source address register 3H                | DSA3H  | R/W |                            |        | √       | Undefined               |
| FFFFF09CH | DMA destination address register 3L           | DDA3L  | R/W |                            |        | √       | Undefined               |

**Notes 1.** This register is set to 0003H and the tag is automatically initialized when the reset signal becomes active. When initialization of the tag is completed, the register is cleared to 0000H.

**2.** This register is set to 03H and the tag is automatically initialized when the reset signal becomes active. When initialization of the tag is completed, the register is cleared to 00H.

| Address   | Function Register Name              | Symbol | R/W | Bit Units for Manipulation |        |         | After Reset |
|-----------|-------------------------------------|--------|-----|----------------------------|--------|---------|-------------|
|           |                                     |        |     | 1 Bit                      | 8 Bits | 16 Bits |             |
| FFFFF09EH | DMA destination address register 3H | DDA3H  | R/W |                            |        | √       | Undefined   |
| FFFFF0C0H | DMA transfer count register 0       | DBC0   | R/W |                            |        | √       | Undefined   |
| FFFFF0C2H | DMA transfer count register 1       | DBC1   | R/W |                            |        | √       | Undefined   |
| FFFFF0C4H | DMA transfer count register 2       | DBC2   | R/W |                            |        | √       | Undefined   |
| FFFFF0C6H | DMA transfer count register 3       | DBC3   | R/W |                            |        | √       | Undefined   |
| FFFFF0D0H | DMA addressing control register 0   | DADC0  | R/W |                            |        | √       | 0000H       |
| FFFFF0D2H | DMA addressing control register 1   | DADC1  | R/W |                            |        | √       | 0000H       |
| FFFFF0D4H | DMA addressing control register 2   | DADC2  | R/W |                            |        | √       | 0000H       |
| FFFFF0D6H | DMA addressing control register 3   | DADC3  | R/W |                            |        | √       | 0000H       |
| FFFFF0E0H | DMA channel control register 0      | DCHC0  | R/W | √                          | √      |         | 00H         |
| FFFFF0E2H | DMA channel control register 1      | DCHC1  | R/W | √                          | √      |         | 00H         |
| FFFFF0E4H | DMA channel control register 2      | DCHC2  | R/W | √                          | √      |         | 00H         |
| FFFFF0E6H | DMA channel control register 3      | DCHC3  | R/W | √                          | √      |         | 00H         |
| FFFFF100H | Interrupt mask register 0           | IMR0   | R/W |                            |        | √       | FFFFH       |
| FFFFF100H | Interrupt mask register 0L          | IMR0L  | R/W | √                          | √      |         | FFH         |
| FFFFF101H | Interrupt mask register 0H          | IMR0H  | R/W | √                          | √      |         | FFH         |
| FFFFF102H | Interrupt mask register 1           | IMR1   | R/W |                            |        | √       | FFFFH       |
| FFFFF102H | Interrupt mask register 1L          | IMR1L  | R/W | √                          | √      |         | FFH         |
| FFFFF103H | Interrupt mask register 1H          | IMR1H  | R/W | √                          | √      |         | FFH         |
| FFFFF104H | Interrupt mask register 2           | IMR2   | R/W |                            |        | √       | FFFFH       |
| FFFFF104H | Interrupt mask register 2L          | IMR2L  | R/W | √                          | √      |         | FFH         |
| FFFFF105H | Interrupt mask register 2H          | IMR2H  | R/W | √                          | √      |         | FFH         |
| FFFFF106H | Interrupt mask register 3           | IMR3   | R/W |                            |        | √       | FFFFH       |
| FFFFF106H | Interrupt mask register 3L          | IMR3L  | R/W | √                          | √      |         | FFH         |
| FFFFF107H | Interrupt mask register 3H          | IMR3H  | R/W | √                          | √      |         | FFH         |
| FFFFF108H | Interrupt mask register 4           | IMR4   | R/W |                            |        | √       | FFFFH       |
| FFFFF108H | Interrupt mask register 4L          | IMR4L  | R/W | √                          | √      |         | FFH         |
| FFFFF109H | Interrupt mask register 4H          | IMR4H  | R/W | √                          | √      |         | FFH         |
| FFFFF10AH | Interrupt mask register 5           | IMR5   | R/W |                            |        | √       | FFFFH       |
| FFFFF10AH | Interrupt mask register 5L          | IMR5L  | R/W | √                          | √      |         | FFH         |
| FFFFF10BH | Interrupt mask register 5H          | IMR5H  | R/W | √                          | √      |         | FFH         |
| FFFFF110H | Interrupt control register 0        | P1IC0  | R/W | √                          | √      |         | 47H         |
| FFFFF112H | Interrupt control register 1        | P1IC1  | R/W | √                          | √      |         | 47H         |
| FFFFF114H | Interrupt control register 2        | P2IC1  | R/W | √                          | √      |         | 47H         |
| FFFFF116H | Interrupt control register 3        | P2IC2  | R/W | √                          | √      |         | 47H         |
| FFFFF118H | Interrupt control register 4        | P2IC3  | R/W | √                          | √      |         | 47H         |
| FFFFF11AH | Interrupt control register 5        | P2IC4  | R/W | √                          | √      |         | 47H         |
| FFFFF11CH | Interrupt control register 6        | P2IC5  | R/W | √                          | √      |         | 47H         |

| Address   | Function Register Name        | Symbol  | R/W | Bit Units for Manipulation |        |         | After Reset |
|-----------|-------------------------------|---------|-----|----------------------------|--------|---------|-------------|
|           |                               |         |     | 1 Bit                      | 8 Bits | 16 Bits |             |
| FFFFF11EH | Interrupt control register 7  | P5IC0   | R/W | √                          | √      |         | 47H         |
| FFFFF120H | Interrupt control register 8  | P5IC1   | R/W | √                          | √      |         | 47H         |
| FFFFF122H | Interrupt control register 9  | P5IC2   | R/W | √                          | √      |         | 47H         |
| FFFFF124H | Interrupt control register 10 | P6IC5   | R/W | √                          | √      |         | 47H         |
| FFFFF126H | Interrupt control register 11 | P6IC6   | R/W | √                          | √      |         | 47H         |
| FFFFF128H | Interrupt control register 12 | P6IC7   | R/W | √                          | √      |         | 47H         |
| FFFFF12AH | Interrupt control register 13 | PDIC0   | R/W | √                          | √      |         | 47H         |
| FFFFF12CH | Interrupt control register 14 | PDIC1   | R/W | √                          | √      |         | 47H         |
| FFFFF12EH | Interrupt control register 15 | PDIC2   | R/W | √                          | √      |         | 47H         |
| FFFFF130H | Interrupt control register 16 | PDIC3   | R/W | √                          | √      |         | 47H         |
| FFFFF132H | Interrupt control register 17 | PDIC4   | R/W | √                          | √      |         | 47H         |
| FFFFF134H | Interrupt control register 18 | PDIC5   | R/W | √                          | √      |         | 47H         |
| FFFFF136H | Interrupt control register 19 | PDIC6   | R/W | √                          | √      |         | 47H         |
| FFFFF138H | Interrupt control register 20 | PDIC7   | R/W | √                          | √      |         | 47H         |
| FFFFF13AH | Interrupt control register 21 | PDIC8   | R/W | √                          | √      |         | 47H         |
| FFFFF13CH | Interrupt control register 22 | PDIC9   | R/W | √                          | √      |         | 47H         |
| FFFFF13EH | Interrupt control register 23 | PDIC10  | R/W | √                          | √      |         | 47H         |
| FFFFF140H | Interrupt control register 24 | PDIC11  | R/W | √                          | √      |         | 47H         |
| FFFFF142H | Interrupt control register 25 | PDIC12  | R/W | √                          | √      |         | 47H         |
| FFFFF144H | Interrupt control register 26 | PDIC13  | R/W | √                          | √      |         | 47H         |
| FFFFF146H | Interrupt control register 27 | PDIC14  | R/W | √                          | √      |         | 47H         |
| FFFFF148H | Interrupt control register 28 | PDIC15  | R/W | √                          | √      |         | 47H         |
| FFFFF14AH | Interrupt control register 29 | PLIC0   | R/W | √                          | √      |         | 47H         |
| FFFFF14CH | Interrupt control register 30 | PLIC1   | R/W | √                          | √      |         | 47H         |
| FFFFF14EH | Interrupt control register 31 | OVCIC0  | R/W | √                          | √      |         | 47H         |
| FFFFF150H | Interrupt control register 32 | OVCIC1  | R/W | √                          | √      |         | 47H         |
| FFFFF152H | Interrupt control register 33 | OVCIC2  | R/W | √                          | √      |         | 47H         |
| FFFFF154H | Interrupt control register 34 | OVCIC3  | R/W | √                          | √      |         | 47H         |
| FFFFF156H | Interrupt control register 35 | OVCIC4  | R/W | √                          | √      |         | 47H         |
| FFFFF158H | Interrupt control register 36 | OVCIC5  | R/W | √                          | √      |         | 47H         |
| FFFFF15AH | Interrupt control register 37 | CCC0IC0 | R/W | √                          | √      |         | 47H         |
| FFFFF15CH | Interrupt control register 38 | CCC0IC1 | R/W | √                          | √      |         | 47H         |
| FFFFF15EH | Interrupt control register 39 | CCC1IC0 | R/W | √                          | √      |         | 47H         |
| FFFFF160H | Interrupt control register 40 | CCC1IC1 | R/W | √                          | √      |         | 47H         |
| FFFFF162H | Interrupt control register 41 | CCC2IC0 | R/W | √                          | √      |         | 47H         |
| FFFFF164H | Interrupt control register 42 | CCC2IC1 | R/W | √                          | √      |         | 47H         |
| FFFFF166H | Interrupt control register 43 | CCC3IC0 | R/W | √                          | √      |         | 47H         |
| FFFFF168H | Interrupt control register 44 | CCC3IC1 | R/W | √                          | √      |         | 47H         |

| Address   | Function Register Name        | Symbol   | R/W | Bit Units for Manipulation |        |         | After Reset |
|-----------|-------------------------------|----------|-----|----------------------------|--------|---------|-------------|
|           |                               |          |     | 1 Bit                      | 8 Bits | 16 Bits |             |
| FFFFF16AH | Interrupt control register 45 | CCC4IC0  | R/W | √                          | √      |         | 47H         |
| FFFFF16CH | Interrupt control register 46 | CCC4IC1  | R/W | √                          | √      |         | 47H         |
| FFFFF16EH | Interrupt control register 47 | CCC5IC0  | R/W | √                          | √      |         | 47H         |
| FFFFF170H | Interrupt control register 48 | CCC5IC1  | R/W | √                          | √      |         | 47H         |
| FFFFF172H | Interrupt control register 49 | CMDIC0   | R/W | √                          | √      |         | 47H         |
| FFFFF174H | Interrupt control register 50 | CMDIC1   | R/W | √                          | √      |         | 47H         |
| FFFFF176H | Interrupt control register 51 | CMDIC2   | R/W | √                          | √      |         | 47H         |
| FFFFF178H | Interrupt control register 52 | CMDIC3   | R/W | √                          | √      |         | 47H         |
| FFFFF17AH | Interrupt control register 53 | CC10IC0  | R/W | √                          | √      |         | 47H         |
| FFFFF17CH | Interrupt control register 54 | CC10IC1  | R/W | √                          | √      |         | 47H         |
| FFFFF17EH | Interrupt control register 55 | CM10IC0  | R/W | √                          | √      |         | 47H         |
| FFFFF180H | Interrupt control register 56 | CM10IC1  | R/W | √                          | √      |         | 47H         |
| FFFFF182H | Interrupt control register 57 | OV1IC0   | R/W | √                          | √      |         | 47H         |
| FFFFF184H | Interrupt control register 58 | UD1IC0   | R/W | √                          | √      |         | 47H         |
| FFFFF186H | Interrupt control register 59 | CC11IC0  | R/W | √                          | √      |         | 47H         |
| FFFFF188H | Interrupt control register 60 | CC11IC1  | R/W | √                          | √      |         | 47H         |
| FFFFF18AH | Interrupt control register 61 | CM11IC0  | R/W | √                          | √      |         | 47H         |
| FFFFF18CH | Interrupt control register 62 | CM11IC1  | R/W | √                          | √      |         | 47H         |
| FFFFF18EH | Interrupt control register 63 | OV1IC1   | R/W | √                          | √      |         | 47H         |
| FFFFF190H | Interrupt control register 64 | UD1IC1   | R/W | √                          | √      |         | 47H         |
| FFFFF192H | Interrupt control register 65 | DMAIC0   | R/W | √                          | √      |         | 47H         |
| FFFFF194H | Interrupt control register 66 | DMAIC1   | R/W | √                          | √      |         | 47H         |
| FFFFF196H | Interrupt control register 67 | DMAIC2   | R/W | √                          | √      |         | 47H         |
| FFFFF198H | Interrupt control register 68 | DMAIC3   | R/W | √                          | √      |         | 47H         |
| FFFFF19AH | Interrupt control register 69 | CSI3IC0  | R/W | √                          | √      |         | 47H         |
| FFFFF19CH | Interrupt control register 70 | COVF3IC0 | R/W | √                          | √      |         | 47H         |
| FFFFF19EH | Interrupt control register 71 | CSI3IC1  | R/W | √                          | √      |         | 47H         |
| FFFFF1A0H | Interrupt control register 72 | COVF3IC1 | R/W | √                          | √      |         | 47H         |
| FFFFF1A2H | Interrupt control register 73 | UREIC0   | R/W | √                          | √      |         | 47H         |
| FFFFF1A4H | Interrupt control register 74 | URIC0    | R/W | √                          | √      |         | 47H         |
| FFFFF1A6H | Interrupt control register 75 | UTIC0    | R/W | √                          | √      |         | 47H         |
| FFFFF1A8H | Interrupt control register 76 | UIFIC0   | R/W | √                          | √      |         | 47H         |
| FFFFF1AAH | Interrupt control register 77 | UTOIC0   | R/W | √                          | √      |         | 47H         |
| FFFFF1ACH | Interrupt control register 78 | UREIC1   | R/W | √                          | √      |         | 47H         |
| FFFFF1AEH | Interrupt control register 79 | URIC1    | R/W | √                          | √      |         | 47H         |
| FFFFF1B0H | Interrupt control register 80 | UTIC1    | R/W | √                          | √      |         | 47H         |
| FFFFF1B2H | Interrupt control register 81 | UIFIC1   | R/W | √                          | √      |         | 47H         |
| FFFFF1B4H | Interrupt control register 82 | UTOIC1   | R/W | √                          | √      |         | 47H         |

| Address   | Function Register Name            | Symbol | R/W | Bit Units for Manipulation |        |         | After Reset |
|-----------|-----------------------------------|--------|-----|----------------------------|--------|---------|-------------|
|           |                                   |        |     | 1 Bit                      | 8 Bits | 16 Bits |             |
| FFFFF1B6H | Interrupt control register 83     | ADIC   | R/W | √                          | √      |         | 47H         |
| FFFFF1B8H | Interrupt control register 84     | US0BIC | R/W | √                          | √      |         | 47H         |
| FFFFF1BAH | Interrupt control register 85     | US1BIC | R/W | √                          | √      |         | 47H         |
| FFFFF1BCH | Interrupt control register 86     | US2BIC | R/W | √                          | √      |         | 47H         |
| FFFFF1BEH | Interrupt control register 87     | USP2IC | R/W | √                          | √      |         | 47H         |
| FFFFF1C0H | Interrupt control register 88     | USP4IC | R/W | √                          | √      |         | 47H         |
| FFFFF1C2H | Interrupt control register 89     | RSUMIC | R/W | √                          | √      |         | 47H         |
| FFFFF1FAH | In-service priority register      | ISPR   | R   | √                          | √      |         | 00H         |
| FFFFF1FCH | Command register                  | PRCMD  | W   |                            | √      |         | Undefined   |
| FFFFF1FEH | Power-save control register       | PSC    | R/W | √                          | √      |         | 00H         |
| FFFFF200H | A/D converter mode register 0     | ADM0   | R/W | √                          | √      |         | 00H         |
| FFFFF201H | A/D converter mode register 1     | ADM1   | R/W | √                          | √      |         | 00H         |
| FFFFF202H | A/D converter mode register 2     | ADM2   | R/W | √                          | √      |         | 00H         |
| FFFFF210H | A/D conversion result register 0  | ADCR0  | R   |                            |        | √       | Undefined   |
| FFFFF211H | A/D conversion result register 0H | ADCR0H | R   |                            | √      |         | Undefined   |
| FFFFF212H | A/D conversion result register 1  | ADCR1  | R   |                            |        | √       | Undefined   |
| FFFFF213H | A/D conversion result register 1H | ADCR1H | R   |                            | √      |         | Undefined   |
| FFFFF214H | A/D conversion result register 2  | ADCR2  | R   |                            |        | √       | Undefined   |
| FFFFF215H | A/D conversion result register 2H | ADCR2H | R   |                            | √      |         | Undefined   |
| FFFFF216H | A/D conversion result register 3  | ADCR3  | R   |                            |        | √       | Undefined   |
| FFFFF217H | A/D conversion result register 3H | ADCR3H | R   |                            | √      |         | Undefined   |
| FFFFF218H | A/D conversion result register 4  | ADCR4  | R   |                            |        | √       | Undefined   |
| FFFFF219H | A/D conversion result register 4H | ADCR4H | R   |                            | √      |         | Undefined   |
| FFFFF21AH | A/D conversion result register 5  | ADCR5  | R   |                            |        | √       | Undefined   |
| FFFFF21BH | A/D conversion result register 5H | ADCR5H | R   |                            | √      |         | Undefined   |
| FFFFF21CH | A/D conversion result register 6  | ADCR6  | R   |                            |        | √       | Undefined   |
| FFFFF21DH | A/D conversion result register 6H | ADCR6H | R   |                            | √      |         | Undefined   |
| FFFFF21EH | A/D conversion result register 7  | ADCR7  | R   |                            |        | √       | Undefined   |
| FFFFF21FH | A/D conversion result register 7H | ADCR7H | R   |                            | √      |         | Undefined   |
| FFFFF220H | ADC trigger select register       | ADTS   | R/W |                            | √      |         | 00H         |
| FFFFF402H | Port 1                            | P1     | R/W | √                          | √      |         | Undefined   |
| FFFFF404H | Port 2                            | P2     | R/W | √                          | √      |         | Undefined   |
| FFFFF40AH | Port 5                            | P5     | R/W | √                          | √      |         | Undefined   |
| FFFFF40CH | Port 6                            | P6     | R/W | √                          | √      |         | Undefined   |
| FFFFF40EH | Port 7                            | P7     | R/W | √                          | √      |         | Undefined   |
| FFFFF422H | Port 1 mode register              | PM1    | R/W | √                          | √      |         | FFH         |
| FFFFF424H | Port 2 mode register              | PM2    | R/W | √                          | √      |         | FFH         |
| FFFFF42AH | Port 5 mode register              | PM5    | R/W | √                          | √      |         | FFH         |



| Address   | Function Register Name                        | Symbol | R/W | Bit Units for Manipulation |        |         | After Reset                 |
|-----------|-----------------------------------------------|--------|-----|----------------------------|--------|---------|-----------------------------|
|           |                                               |        |     | 1 Bit                      | 8 Bits | 16 Bits |                             |
| FFFFF42CH | Port 6 mode register                          | PM6    | R/W | √                          | √      |         | FFH                         |
| FFFFF42EH | Port 7 mode register                          | PM7    | R/W | √                          | √      |         | FFH                         |
| FFFFF442H | Port 1 mode control register                  | PMC1   | R/W | √                          | √      |         | 00H                         |
| FFFFF444H | Port 2 mode control register                  | PMC2   | R/W | √                          | √      |         | 01H                         |
| FFFFF44AH | Port 5 mode control register                  | PMC5   | R/W | √                          | √      |         | 00H                         |
| FFFFF44CH | Port 6 mode control register                  | PMC6   | R/W | √                          | √      |         | 00H                         |
| FFFFF44EH | Port 7 mode control register                  | PMC7   | R/W | √                          | √      |         | 00H                         |
| FFFFF462H | Port 1 function control register              | PFC1   | R/W | √                          | √      |         | 00H                         |
| FFFFF464H | Port 2 function control register              | PFC2   | R/W | √                          | √      |         | 00H                         |
| FFFFF46AH | Port 5 function control register              | PFC5   | R/W | √                          | √      |         | 00H                         |
| FFFFF46CH | Port 6 function control register              | PFC6   | R/W | √                          | √      |         | 00H                         |
| FFFFF46EH | Port 7 function control register              | PFC7   | R/W | √                          | √      |         | 00H                         |
| FFFFF480H | Bus cycle type configuration register 0       | BCT0   | R/W |                            |        | √       | 8888H                       |
| FFFFF482H | Bus cycle type configuration register 1       | BCT1   | R/W |                            |        | √       | 8888H                       |
| FFFFF484H | Data wait control register 0                  | DWC0   | R/W |                            |        | √       | 7777H                       |
| FFFFF486H | Data wait control register 1                  | DWC1   | R/W |                            |        | √       | 7777H                       |
| FFFFF488H | Bus cycle control register                    | BCC    | R/W |                            |        | √       | FFFFH                       |
| FFFFF48AH | Address setup wait control register           | ASC    | R/W |                            |        | √       | FFFFH                       |
| FFFFF48CH | Bus cycle period control register             | BCP    | R/W | √                          | √      |         | 00H                         |
| FFFFF48EH | Local bus sizing control register             | LBS    | R/W |                            |        | √       | 5555H/AAAAH <sup>Note</sup> |
| FFFFF490H | Line buffer control register 0                | LBC0   | R/W |                            |        | √       | 0000H                       |
| FFFFF492H | Line buffer control register 1                | LBC1   | R/W |                            |        | √       | 0000H                       |
| FFFFF494H | DMA flyby transfer wait control register      | FWC    | R/W |                            |        | √       | 7777H                       |
| FFFFF496H | DMA flyby transfer idle control register      | FIC    | R/W |                            |        | √       | 3333H                       |
| FFFFF498H | Bus mode control register                     | BMC    | R/W |                            | √      |         | 00H                         |
| FFFFF49AH | Page ROM configuration register               | PRC    | R/W |                            |        | √       | 7000H                       |
| FFFFF49CH | Write access synchronization control register | WAS    | W   |                            | √      |         | Undefined                   |
| FFFFF4A4H | SDRAM configuration register 1                | SCR1   | R/W |                            |        | √       | 30C0H                       |
| FFFFF4A6H | SDRAM refresh control register 1              | RFS1   | R/W |                            |        | √       | 0000H                       |
| FFFFF4ACH | SDRAM configuration register 3                | SCR3   | R/W |                            |        | √       | 30C0H                       |
| FFFFF4AEH | SDRAM refresh control register 3              | RFS3   | R/W |                            |        | √       | 0000H                       |
| FFFFF4B0H | SDRAM configuration register 4                | SCR4   | R/W |                            |        | √       | 30C0H                       |
| FFFFF4B2H | SDRAM refresh control register 4              | RFS4   | R/W |                            |        | √       | 0000H                       |
| FFFFF4B8H | SDRAM configuration register 6                | SCR6   | R/W |                            |        | √       | 30C0H                       |
| FFFFF4BAH | SDRAM refresh control register 6              | RFS6   | R/W |                            |        | √       | 0000H                       |

**Note** 32-bit mode: AAAAH

16-bit mode: 5555H

For details of 32-bit mode and 16-bit mode, see **3.3.1 Operating modes**.

| Address   | Function Register Name                      | Symbol   | R/W | Bit Units for Manipulation |        |         | After Reset |
|-----------|---------------------------------------------|----------|-----|----------------------------|--------|---------|-------------|
|           |                                             |          |     | 1 Bit                      | 8 Bits | 16 Bits |             |
| FFFFF540H | Timer D0                                    | TMD0     | R   |                            |        | √       | 0000H       |
| FFFFF542H | Compare register D0                         | CMD0     | R/W |                            |        | √       | 0000H       |
| FFFFF544H | Timer mode control register D0              | TMCD0    | R/W | √                          | √      |         | 00H         |
| FFFFF550H | Timer D1                                    | TMD1     | R   |                            |        | √       | 0000H       |
| FFFFF552H | Compare register D1                         | CMD1     | R/W |                            |        | √       | 0000H       |
| FFFFF554H | Timer mode control register D1              | TMCD1    | R/W | √                          | √      |         | 00H         |
| FFFFF560H | Timer D2                                    | TMD2     | R   |                            |        | √       | 0000H       |
| FFFFF562H | Compare register D2                         | CMD2     | R/W |                            |        | √       | 0000H       |
| FFFFF564H | Timer mode control register D2              | TMCD2    | R/W | √                          | √      |         | 00H         |
| FFFFF570H | Timer D3                                    | TMD3     | R   |                            |        | √       | 0000H       |
| FFFFF572H | Compare register D3                         | CMD3     | R/W |                            |        | √       | 0000H       |
| FFFFF574H | Timer mode control register D3              | TMCD3    | R/W | √                          | √      |         | 00H         |
| FFFFF5A0H | Timer ENC10                                 | TMENC10  | R/W |                            |        | √       | 0000H       |
| FFFFF5A2H | Compare register 100                        | CM100    | R/W |                            |        | √       | 0000H       |
| FFFFF5A4H | Compare register 101                        | CM101    | R/W |                            |        | √       | 0000H       |
| FFFFF5A6H | Capture/compare register 100                | CC100    | R/W |                            |        | √       | 0000H       |
| FFFFF5A8H | Capture/compare register 101                | CC101    | R/W |                            |        | √       | 0000H       |
| FFFFF5AAH | Capture/compare control register 10         | CCR10    | R/W | √                          | √      |         | 00H         |
| FFFFF5ABH | Timer unit mode register 10                 | TUM10    | R/W | √                          | √      |         | 00H         |
| FFFFF5ACH | Timer control register 10                   | TMC10    | R/W | √                          | √      |         | 00H         |
| FFFFF5ADH | Valid edge select register 10               | SESA10   | R/W | √                          | √      |         | 00H         |
| FFFFF5AEH | Prescaler mode register 10                  | PRM10    | R/W | √                          | √      |         | 07H         |
| FFFFF5AFH | Status register 10                          | STATUS10 | R   | √                          | √      |         | 00H         |
| FFFFF5C0H | Noise elimination width setting register 10 | NCW10    | R/W |                            | √      |         | 02H         |
| FFFFF5D0H | Timer ENC11                                 | TMENC11  | R/W |                            |        | √       | 0000H       |
| FFFFF5D2H | Compare register 110                        | CM110    | R/W |                            |        | √       | 0000H       |
| FFFFF5D4H | Compare register 111                        | CM111    | R/W |                            |        | √       | 0000H       |
| FFFFF5D6H | Capture/compare register 110                | CC110    | R/W |                            |        | √       | 0000H       |
| FFFFF5D8H | Capture/compare register 111                | CC111    | R/W |                            |        | √       | 0000H       |
| FFFFF5DAH | Capture/compare control register 11         | CCR11    | R/W | √                          | √      |         | 00H         |
| FFFFF5DBH | Timer unit mode register 11                 | TUM11    | R/W | √                          | √      |         | 00H         |
| FFFFF5DCH | Timer control register 11                   | TMC11    | R/W | √                          | √      |         | 00H         |
| FFFFF5DDH | Valid edge select register 11               | SESA11   | R/W | √                          | √      |         | 00H         |
| FFFFF5DEH | Prescaler mode register 11                  | PRM11    | R/W | √                          | √      |         | 07H         |
| FFFFF5DFH | Status register 11                          | STATUS11 | R   | √                          | √      |         | 00H         |
| FFFFF5F0H | Noise elimination width setting register 11 | NCW11    | R/W |                            | √      |         | 02H         |
| FFFFF600H | Timer C0                                    | TMC0     | R   |                            |        | √       | 0000H       |
| FFFFF602H | Capture/compare register C00                | CCC00    | R/W |                            |        | √       | 0000H       |

| Address   | Function Register Name                         | Symbol | R/W | Bit Units for Manipulation |        |         | After Reset |
|-----------|------------------------------------------------|--------|-----|----------------------------|--------|---------|-------------|
|           |                                                |        |     | 1 Bit                      | 8 Bits | 16 Bits |             |
| FFFFF604H | Capture/compare register C01                   | CCC01  | R/W |                            |        | √       | 0000H       |
| FFFFF606H | Timer mode control register C00                | TMCC00 | R/W | √                          | √      |         | 00H         |
| FFFFF608H | Timer mode control register C01                | TMCC01 | R/W |                            | √      |         | 20H         |
| FFFFF609H | Valid edge select register C0                  | SESC0  | R/W |                            | √      |         | 00H         |
| FFFFF610H | Noise elimination width setting register C0    | NCWC0  | R/W |                            | √      |         | 02H         |
| FFFFF620H | Timer C1                                       | TMC1   | R   |                            |        | √       | 0000H       |
| FFFFF622H | Capture/compare register C10                   | CCC10  | R/W |                            |        | √       | 0000H       |
| FFFFF624H | Capture/compare register C11                   | CCC11  | R/W |                            |        | √       | 0000H       |
| FFFFF626H | Timer mode control register C10                | TMCC10 | R/W | √                          | √      |         | 00H         |
| FFFFF628H | Timer mode control register C11                | TMCC11 | R/W |                            | √      |         | 20H         |
| FFFFF629H | Valid edge select register C1                  | SESC1  | R/W |                            | √      |         | 00H         |
| FFFFF630H | Noise elimination width setting register C1    | NCWC1  | R/W |                            | √      |         | 02H         |
| FFFFF640H | Timer C2                                       | TMC2   | R   |                            |        | √       | 0000H       |
| FFFFF642H | Capture/compare register C20                   | CCC20  | R/W |                            |        | √       | 0000H       |
| FFFFF644H | Capture/compare register C21                   | CCC21  | R/W |                            |        | √       | 0000H       |
| FFFFF646H | Timer mode control register C20                | TMCC20 | R/W | √                          | √      |         | 00H         |
| FFFFF648H | Timer mode control register C21                | TMCC21 | R/W |                            | √      |         | 20H         |
| FFFFF649H | Valid edge select register C2                  | SESC2  | R/W |                            | √      |         | 00H         |
| FFFFF650H | Noise elimination width setting register C2    | NCWC2  | R/W |                            | √      |         | 02H         |
| FFFFF660H | Timer C3                                       | TMC3   | R   |                            |        | √       | 0000H       |
| FFFFF662H | Capture/compare register C30                   | CCC30  | R/W |                            |        | √       | 0000H       |
| FFFFF664H | Capture/compare register C31                   | CCC31  | R/W |                            |        | √       | 0000H       |
| FFFFF666H | Timer mode control register C30                | TMCC30 | R/W | √                          | √      |         | 00H         |
| FFFFF668H | Timer mode control register C31                | TMCC31 | R/W |                            | √      |         | 20H         |
| FFFFF669H | Valid edge select register C3                  | SESC3  | R/W |                            | √      |         | 00H         |
| FFFFF670H | Noise elimination width setting register C3    | NCWC3  | R/W |                            | √      |         | 02H         |
| FFFFF680H | Timer C4                                       | TMC4   | R   |                            |        | √       | 0000H       |
| FFFFF682H | Capture/compare register C40                   | CCC40  | R/W |                            |        | √       | 0000H       |
| FFFFF684H | Capture/compare register C41                   | CCC41  | R/W |                            |        | √       | 0000H       |
| FFFFF686H | Timer mode control register C40                | TMCC40 | R/W | √                          | √      |         | 00H         |
| FFFFF688H | Timer mode control register C41                | TMCC41 | R/W |                            | √      |         | 20H         |
| FFFFF6A0H | Timer C5                                       | TMC5   | R   |                            |        | √       | 0000H       |
| FFFFF6A2H | Capture/compare register C50                   | CCC50  | R/W |                            |        | √       | 0000H       |
| FFFFF6A4H | Capture/compare register C51                   | CCC51  | R/W |                            |        | √       | 0000H       |
| FFFFF6A6H | Timer mode control register C50                | TMCC50 | R/W | √                          | √      |         | 00H         |
| FFFFF6A8H | Timer mode control register C51                | TMCC51 | R/W |                            | √      |         | 20H         |
| FFFFF6C0H | Oscillation stabilization time select register | OSTS   | R/W |                            | √      |         | 04H         |
| FFFFF80AH | Internal instruction RAM mode register         | IRAMM  | R/W | √                          | √      |         | 03H         |

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| Address   | Function Register Name                            | Symbol   | R/W | Bit Units for Manipulation |        |         | After Reset   |
|-----------|---------------------------------------------------|----------|-----|----------------------------|--------|---------|---------------|
|           |                                                   |          |     | 1 Bit                      | 8 Bits | 16 Bits |               |
| FFFFF80CH | NMI reset status register                         | NRS      | R   | √                          | √      |         | 00H           |
| FFFFF810H | DMA trigger factor register 0                     | DTFR0    | R/W | √                          | √      |         | 00H           |
| FFFFF812H | DMA trigger factor register 1                     | DTFR1    | R/W | √                          | √      |         | 00H           |
| FFFFF814H | DMA trigger factor register 2                     | DTFR2    | R/W | √                          | √      |         | 00H           |
| FFFFF816H | DMA trigger factor register 3                     | DTFR3    | R/W | √                          | √      |         | 00H           |
| FFFFF820H | Power-save mode register                          | PSMR     | R/W | √                          | √      |         | 00H           |
| FFFFF822H | Clock control register                            | CKC      | R/W |                            | √      |         | 03H           |
| FFFFF824H | Lock register                                     | LOCKR    | R   | √                          | √      |         | 01H           |
| FFFFF82CH | Clock source select register                      | CKS      | R/W | √                          | √      |         | 00H           |
| FFFFF82EH | USB clock control register                        | UCKC     | R/W | √                          | √      |         | 00H           |
| FFFFF836H | SSCG control register                             | SSCGC    | R/W |                            | √      |         | <b>Note 1</b> |
| FFFFF8A0H | DMA terminal count output control register        | DTOC     | R/W | √                          | √      |         | 01H           |
| FFFFF8A8H | DMA interface control register                    | DIFC     | R/W | √                          | √      |         | 00H           |
| FFFFFA00H | UARTB0 control register 0                         | UB0CTL0  | R/W | √                          | √      |         | 10H           |
| FFFFFA02H | UARTB0 control register 2                         | UB0CTL2  | R/W |                            |        | √       | FFFFH         |
| FFFFFA04H | UARTB0 status register                            | UB0STR   | R/W | √                          | √      |         | 00H           |
| FFFFFA06H | UARTB0 receive data register AP <sup>Note 2</sup> | UB0RXAP  | R   |                            |        | √       | 00FFH         |
| FFFFFA06H | UARTB0 receive data register                      | UB0RX    | R   |                            | √      |         | FFH           |
| FFFFFA08H | UARTB0 transmit data register                     | UB0TX    | W   |                            | √      |         | FFH           |
| FFFFFA0AH | UARTB0 FIFO control register 0                    | UB0FIC0  | R/W | √                          | √      |         | 00H           |
| FFFFFA0BH | UARTB0 FIFO control register 1                    | UB0FIC1  | R/W | √                          | √      |         | 00H           |
| FFFFFA0CH | UARTB0 FIFO control register 2                    | UB0FIC2  | R/W |                            |        | √       | 0000H         |
| FFFFFA0CH | UARTB0 FIFO control register 2L                   | UB0FIC2L | R/W |                            | √      |         | 00H           |
| FFFFFA0DH | UARTB0 FIFO control register 2H                   | UB0FIC2H | R/W |                            | √      |         | 00H           |
| FFFFFA0EH | UARTB0 FIFO status register 0                     | UB0FIS0  | R   |                            | √      |         | 00H           |
| FFFFFA0FH | UARTB0 FIFO status register 1                     | UB0FIS1  | R   |                            | √      |         | 10H           |
| FFFFFA20H | UARTB1 control register 0                         | UB1CTL0  | R/W | √                          | √      |         | 10H           |
| FFFFFA22H | UARTB1 control register 2                         | UB1CTL2  | R/W |                            |        | √       | FFFFH         |
| FFFFFA24H | UARTB1 status register                            | UB1STR   | R/W | √                          | √      |         | 00H           |
| FFFFFA26H | UARTB1 receive data register AP <sup>Note 2</sup> | UB1RXAP  | R   |                            |        | √       | 00FFH         |
| FFFFFA26H | UARTB1 receive data register                      | UB1RX    | R   |                            | √      |         | FFH           |
| FFFFFA28H | UARTB1 transmit data register                     | UB1TX    | W   |                            | √      |         | FFH           |
| FFFFFA2AH | UARTB1 FIFO control register 0                    | UB1FIC0  | R/W | √                          | √      |         | 00H           |
| FFFFFA2BH | UARTB1 FIFO control register 1                    | UB1FIC1  | R/W | √                          | √      |         | 00H           |

**Notes 1.** For details, see **8.3.3 SSCG control register (SSCGC)**.

**2.** This register can be used only in FIFO mode.

| Address   | Function Register Name                                     | Symbol   | R/W | Bit Units for Manipulation |        |         | After Reset |
|-----------|------------------------------------------------------------|----------|-----|----------------------------|--------|---------|-------------|
|           |                                                            |          |     | 1 Bit                      | 8 Bits | 16 Bits |             |
| FFFFFA2CH | UARTB1 FIFO control register 2                             | UB1FIC2  | R/W |                            |        | √       | 0000H       |
| FFFFFA2CH | UARTB1 FIFO control register 2L                            | UB1FIC2L | R/W |                            | √      |         | 00H         |
| FFFFFA2DH | UARTB1 FIFO control register 2H                            | UB1FIC2H | R/W |                            | √      |         | 00H         |
| FFFFFA2EH | UARTB1 FIFO status register 0                              | UB1FIS0  | R   |                            | √      |         | 00H         |
| FFFFFA2FH | UARTB1 FIFO status register 1                              | UB1FIS1  | R   |                            | √      |         | 10H         |
| FFFFFB00H | PWM control register 0                                     | PWMC0    | R/W | √                          | √      |         | 08H         |
| FFFFFB02H | PWM modulo register 0                                      | PWM0     | R/W |                            |        | √       | 0000H       |
| FFFFFB02H | PWM modulo register L0                                     | PWML0    | R/W |                            | √      |         | 00H         |
| FFFFFB03H | PWM modulo register H0                                     | PWMH0    | R/W |                            | √      |         | 00H         |
| FFFFFB10H | PWM control register 1                                     | PWMC1    | R/W | √                          | √      |         | 08H         |
| FFFFFB12H | PWM modulo register 1                                      | PWM1     | R/W |                            |        | √       | 0000H       |
| FFFFFB12H | PWM modulo register L1                                     | PWML1    | R/W |                            | √      |         | 00H         |
| FFFFFB13H | PWM modulo register H1                                     | PWMH1    | R/W |                            | √      |         | 00H         |
| FFFFFC02H | External interrupt falling edge specification register 1   | INTF1    | R/W | √                          | √      |         | 00H         |
| FFFFFC04H | External interrupt falling edge specification register 2   | INTF2    | R/W | √                          | √      |         | 00H         |
| FFFFFC0AH | External interrupt falling edge specification register 5   | INTF5    | R/W | √                          | √      |         | 00H         |
| FFFFFC0CH | External interrupt falling edge specification register 6   | INTF6    | R/W | √                          | √      |         | 00H         |
| FFFFFC10H | External interrupt falling edge specification register AL  | INTFAL   | R/W | √                          | √      |         | 00H         |
| FFFFFC16H | External interrupt falling edge specification register DH  | INTFDH   | R/W |                            |        | √       | 0000H       |
| FFFFFC16H | External interrupt falling edge specification register DHL | INTFDHL  | R/W | √                          | √      |         | 00H         |
| FFFFFC17H | External interrupt falling edge specification register DHH | INTFDHH  | R/W | √                          | √      |         | 00H         |
| FFFFFC22H | External interrupt rising edge specification register 1    | INTR1    | R/W | √                          | √      |         | 03H         |
| FFFFFC24H | External interrupt rising edge specification register 2    | INTR2    | R/W | √                          | √      |         | 3FH         |
| FFFFFC2AH | External interrupt rising edge specification register 5    | INTR5    | R/W | √                          | √      |         | 07H         |
| FFFFFC2CH | External interrupt rising edge specification register 6    | INTR6    | R/W | √                          | √      |         | E0H         |
| FFFFFC30H | External interrupt rising edge specification register AL   | INTRAL   | R/W | √                          | √      |         | 03H         |

| Address   | Function Register Name                                    | Symbol  | R/W | Bit Units for Manipulation |        |         | After Reset |
|-----------|-----------------------------------------------------------|---------|-----|----------------------------|--------|---------|-------------|
|           |                                                           |         |     | 1 Bit                      | 8 Bits | 16 Bits |             |
| FFFFFC36H | External interrupt rising edge specification register DH  | INTRDH  | R/W |                            |        | √       | FFFFH       |
| FFFFFC36H | External interrupt rising edge specification register DHL | INTRDHL | R/W | √                          | √      |         | FFH         |
| FFFFFC37H | External interrupt rising edge specification register DHH | INTRDHH | R/W | √                          | √      |         | FFH         |
| FFFFFD00H | Clocked serial interface mode register 30                 | CSIM30  | R/W | √                          | √      |         | 00H         |
| FFFFFD01H | Clocked serial interface clock select register 30         | CSIC30  | R/W | √                          | √      |         | 07H         |
| FFFFFD02H | Receive data buffer register 30                           | SIRB30  | R   |                            |        | √       | 0000H       |
| FFFFFD02H | Receive data buffer register 30L                          | SIRB30L | R   |                            | √      |         | 00H         |
| FFFFFD03H | Receive data buffer register 30H                          | SIRB30H | R   |                            | √      |         | 00H         |
| FFFFFD06H | Transmit data CSI buffer register 30                      | SFDB30  | R/W |                            |        | √       | 0000H       |
| FFFFFD06H | Transmit data CSI buffer register 30L                     | SFDB30L | R/W |                            | √      |         | 00H         |
| FFFFFD07H | Transmit data CSI buffer register 30H                     | SFDB30H | R/W |                            | √      |         | 00H         |
| FFFFFD08H | CSIBUF status register 30                                 | SFA30   | R/W | √                          | √      |         | 20H         |
| FFFFFD09H | Transfer data length select register 30                   | CSIL30  | R/W | √                          | √      |         | 00H         |
| FFFFFD0CH | Transfer data number specification register 30            | SFN30   | R/W | √                          | √      |         | 00H         |
| FFFFFD20H | Clocked serial interface mode register 31                 | CSIM31  | R/W | √                          | √      |         | 00H         |
| FFFFFD21H | Clocked serial interface clock select register 31         | CSIC31  | R/W | √                          | √      |         | 07H         |
| FFFFFD22H | Receive data buffer register 31                           | SIRB31  | R   |                            |        | √       | 0000H       |
| FFFFFD22H | Receive data buffer register 31L                          | SIRB31L | R   |                            | √      |         | 00H         |
| FFFFFD23H | Receive data buffer register 31H                          | SIRB31H | R   |                            | √      |         | 00H         |
| FFFFFD26H | Transmit data CSI buffer register 31                      | SFDB31  | R/W |                            |        | √       | 0000H       |
| FFFFFD26H | Transmit data CSI buffer register 31L                     | SFDB31L | R/W |                            | √      |         | 00H         |
| FFFFFD27H | Transmit data CSI buffer register 31H                     | SFDB31H | R/W |                            | √      |         | 00H         |
| FFFFFD28H | CSIBUF status register 31                                 | SFA31   | R/W | √                          | √      |         | 20H         |
| FFFFFD29H | Transfer data length select register 31                   | CSIL31  | R/W | √                          | √      |         | 00H         |
| FFFFFD2CH | Transfer data number specification register 31            | SFN31   | R/W | √                          | √      |         | 00H         |
| FFFFFDF0H | USB function 0 DMA channel select register                | UF0CS   | R/W |                            |        | √       | 0000H       |
| FFFFFDF2H | USB function 0 buffer control register                    | UF0BC   | R/W | √                          | √      |         | 00H         |
| FFFFFE00H | UF0 EP0NAK register                                       | UF0E0N  | R/W |                            | √      |         | 00H         |
| FFFFFE01H | UF0 EP0NAKALL register                                    | UF0E0NA | R/W |                            | √      |         | 00H         |
| FFFFFE02H | UF0 EPNAK register                                        | UF0EN   | R/W |                            | √      |         | 00H         |
| FFFFFE03H | UF0 EPNAK mask register                                   | UF0ENM  | R/W |                            | √      |         | 00H         |
| FFFFFE04H | UF0 SNDSIE register                                       | UF0SDS  | R/W |                            | √      |         | 00H         |
| FFFFFE05H | UF0 CLR request register                                  | UF0CLR  | R   |                            | √      |         | 00H         |
| FFFFFE06H | UF0 SET request register                                  | UF0SET  | R   |                            | √      |         | 00H         |
| FFFFFE07H | UF0 EP status 0 register                                  | UF0EPS0 | R   |                            | √      |         | 00H         |

| Address   | Function Register Name                    | Symbol  | R/W | Bit Units for Manipulation |        |         | After Reset |
|-----------|-------------------------------------------|---------|-----|----------------------------|--------|---------|-------------|
|           |                                           |         |     | 1 Bit                      | 8 Bits | 16 Bits |             |
| FFFFFE08H | UF0 EP status 1 register                  | UF0EPS1 | R   |                            | √      |         | 00H         |
| FFFFFE09H | UF0 EP status 2 register                  | UF0EPS2 | R   |                            | √      |         | 00H         |
| FFFFFE10H | UF0 INT status 0 register                 | UF0IS0  | R   |                            | √      |         | 00H         |
| FFFFFE11H | UF0 INT status 1 register                 | UF0IS1  | R   |                            | √      |         | 00H         |
| FFFFFE12H | UF0 INT status 2 register                 | UF0IS2  | R   |                            | √      |         | 00H         |
| FFFFFE13H | UF0 INT status 3 register                 | UF0IS3  | R   |                            | √      |         | 00H         |
| FFFFFE14H | UF0 INT status 4 register                 | UF0IS4  | R   |                            | √      |         | 00H         |
| FFFFFE17H | UF0 INT mask 0 register                   | UF0IM0  | R/W |                            | √      |         | 00H         |
| FFFFFE18H | UF0 INT mask 1 register                   | UF0IM1  | R/W |                            | √      |         | 00H         |
| FFFFFE19H | UF0 INT mask 2 register                   | UF0IM2  | R/W |                            | √      |         | 00H         |
| FFFFFE1AH | UF0 INT mask 3 register                   | UF0IM3  | R/W |                            | √      |         | 00H         |
| FFFFFE1BH | UF0 INT mask 4 register                   | UF0IM4  | R/W |                            | √      |         | 00H         |
| FFFFFE1EH | UF0 INT clear 0 register                  | UF0IC0  | W   |                            | √      |         | FFH         |
| FFFFFE1FH | UF0 INT clear 1 register                  | UF0IC1  | W   |                            | √      |         | FFH         |
| FFFFFE20H | UF0 INT clear 2 register                  | UF0IC2  | W   |                            | √      |         | FFH         |
| FFFFFE21H | UF0 INT clear 3 register                  | UF0IC3  | W   |                            | √      |         | FFH         |
| FFFFFE22H | UF0 INT clear 4 register                  | UF0IC4  | W   |                            | √      |         | FFH         |
| FFFFFE26H | UF0 INT & DMARQ register                  | UF0IDR  | R/W |                            | √      |         | 00H         |
| FFFFFE27H | UF0 DMA status 0 register                 | UF0DMS0 | R   |                            | √      |         | 00H         |
| FFFFFE28H | UF0 DMA status 1 register                 | UF0DMS1 | R   |                            | √      |         | 00H         |
| FFFFFE30H | UF0 FIFO clear 0 register                 | UF0FIC0 | W   |                            | √      |         | 00H         |
| FFFFFE31H | UF0 FIFO clear 1 register                 | UF0FIC1 | W   |                            | √      |         | 00H         |
| FFFFFE35H | UF0 data end register                     | UF0DEND | R/W |                            | √      |         | 00H         |
| FFFFFE37H | UF0 GPR register                          | UF0GPR  | W   |                            | √      |         | 00H         |
| FFFFFE3AH | UF0 mode control register                 | UF0MODC | R/W |                            | √      |         | 00H         |
| FFFFFE3CH | UF0 mode status register                  | UF0MODS | R   |                            | √      |         | 00H         |
| FFFFFE40H | UF0 active interface number register      | UF0AIFN | R/W |                            | √      |         | 00H         |
| FFFFFE41H | UF0 active alternative setting register   | UF0AAS  | R/W |                            | √      |         | 00H         |
| FFFFFE42H | UF0 alternative setting status register   | UF0ASS  | R   |                            | √      |         | 00H         |
| FFFFFE43H | UF0 endpoint 1 interface mapping register | UF0E1IM | R/W |                            | √      |         | 00H         |
| FFFFFE44H | UF0 endpoint 2 interface mapping register | UF0E2IM | R/W |                            | √      |         | 00H         |
| FFFFFE45H | UF0 endpoint 3 interface mapping register | UF0E3IM | R/W |                            | √      |         | 00H         |
| FFFFFE46H | UF0 endpoint 4 interface mapping register | UF0E4IM | R/W |                            | √      |         | 00H         |
| FFFFFE49H | UF0 endpoint 7 interface mapping register | UF0E7IM | R/W |                            | √      |         | 00H         |
| FFFFFE4AH | UF0 endpoint 8 interface mapping register | UF0E8IM | R/W |                            | √      |         | 00H         |
| FFFFFE80H | UF0 EP0 read register                     | UF0E0R  | R   |                            | √      |         | Undefined   |
| FFFFFE81H | UF0 EP0 length register                   | UF0E0L  | R   |                            | √      |         | 00H         |
| FFFFFE82H | UF0 EP0 setup register                    | UF0E0ST | R   |                            | √      |         | 00H         |

| Address     | Function Register Name            | Symbol  | R/W | Bit Units for Manipulation |        |         | After Reset |
|-------------|-----------------------------------|---------|-----|----------------------------|--------|---------|-------------|
|             |                                   |         |     | 1 Bit                      | 8 Bits | 16 Bits |             |
| FFFFFFE83H  | UF0 EP0 write register            | UF0E0W  | W   |                            | √      |         | Undefined   |
| FFFFFFE84H  | UF0 bulk out 1 register           | UF0BO1  | R   |                            | √      |         | Undefined   |
| FFFFFFE85H  | UF0 bulk out 1 length register    | UF0BO1L | R   |                            | √      |         | 00H         |
| FFFFFFE86H  | UF0 bulk out 2 register           | UF0BO2  | R   |                            | √      |         | Undefined   |
| FFFFFFE87H  | UF0 bulk out 2 length register    | UF0BO2L | R   |                            | √      |         | 00H         |
| FFFFFFE88H  | UF0 bulk in 1 register            | UF0BI1  | W   |                            | √      |         | Undefined   |
| FFFFFFE89H  | UF0 bulk in 2 register            | UF0BI2  | W   |                            | √      |         | Undefined   |
| FFFFFFE8AH  | UF0 interrupt 1 register          | UF0INT1 | W   |                            | √      |         | Undefined   |
| FFFFFFE8BH  | UF0 interrupt 2 register          | UF0INT2 | W   |                            | √      |         | Undefined   |
| FFFFFFEA2H  | UF0 device status register L      | UF0DSTL | R/W |                            | √      |         | 00H         |
| FFFFFFEA6H  | UF0 EP0 status register L         | UF0E0SL | R/W |                            | √      |         | 00H         |
| FFFFFFEA8H  | UF0 EP1 status register L         | UF0E1SL | R/W |                            | √      |         | 00H         |
| FFFFFFEAAH  | UF0 EP2 status register L         | UF0E2SL | R/W |                            | √      |         | 00H         |
| FFFFFFEACH  | UF0 EP3 status register L         | UF0E3SL | R/W |                            | √      |         | 00H         |
| FFFFFFEAEH  | UF0 EP4 status register L         | UF0E4SL | R/W |                            | √      |         | 00H         |
| FFFFFFEB4H  | UF0 EP7 status register L         | UF0E7SL | R/W |                            | √      |         | 00H         |
| FFFFFFEB6H  | UF0 EP8 status register L         | UF0E8SL | R/W |                            | √      |         | 00H         |
| FFFFFFEC0H  | UF0 address register              | UF0ADRS | R   |                            | √      |         | 00H         |
| FFFFFFEC1H  | UF0 configuration register        | UF0CNF  | R   |                            | √      |         | 00H         |
| FFFFFFEC2H  | UF0 interface 0 register          | UF0IF0  | R   |                            | √      |         | 00H         |
| FFFFFFEC3H  | UF0 interface 1 register          | UF0IF1  | R   |                            | √      |         | 00H         |
| FFFFFFEC4H  | UF0 interface 2 register          | UF0IF2  | R   |                            | √      |         | 00H         |
| FFFFFFEC5H  | UF0 interface 3 register          | UF0IF3  | R   |                            | √      |         | 00H         |
| FFFFFFEC6H  | UF0 interface 4 register          | UF0IF4  | R   |                            | √      |         | 00H         |
| FFFFFFED0H  | UF0 descriptor length register    | UF0DSCL | R/W |                            | √      |         | 00H         |
| FFFFFFED1H  | UF0 device descriptor register 0  | UF0DD0  | R/W |                            | √      |         | Undefined   |
| FFFFFFED2H  | UF0 device descriptor register 1  | UF0DD1  | R/W |                            | √      |         | Undefined   |
| FFFFFFED3H  | UF0 device descriptor register 2  | UF0DD2  | R/W |                            | √      |         | Undefined   |
| FFFFFFED4H  | UF0 device descriptor register 3  | UF0DD3  | R/W |                            | √      |         | Undefined   |
| FFFFFFED5H  | UF0 device descriptor register 4  | UF0DD4  | R/W |                            | √      |         | Undefined   |
| FFFFFFED6H  | UF0 device descriptor register 5  | UF0DD5  | R/W |                            | √      |         | Undefined   |
| FFFFFFED7H  | UF0 device descriptor register 6  | UF0DD6  | R/W |                            | √      |         | Undefined   |
| FFFFFFED8H  | UF0 device descriptor register 7  | UF0DD7  | R/W |                            | √      |         | Undefined   |
| FFFFFFED9H  | UF0 device descriptor register 8  | UF0DD8  | R/W |                            | √      |         | Undefined   |
| FFFFFFEDA H | UF0 device descriptor register 9  | UF0DD9  | R/W |                            | √      |         | Undefined   |
| FFFFFFEDBH  | UF0 device descriptor register 10 | UF0DD10 | R/W |                            | √      |         | Undefined   |
| FFFFFFEDCH  | UF0 device descriptor register 11 | UF0DD11 | R/W |                            | √      |         | Undefined   |
| FFFFFFEDDH  | UF0 device descriptor register 12 | UF0DD12 | R/W |                            | √      |         | Undefined   |



| Address   | Function Register Name                                          | Symbol   | R/W | Bit Units for Manipulation |        |         | After Reset |
|-----------|-----------------------------------------------------------------|----------|-----|----------------------------|--------|---------|-------------|
|           |                                                                 |          |     | 1 Bit                      | 8 Bits | 16 Bits |             |
| FFFFFEDEH | UF0 device descriptor register 13                               | UF0DD13  | R/W |                            | √      |         | Undefined   |
| FFFFFEDFH | UF0 device descriptor register 14                               | UF0DD14  | R/W |                            | √      |         | Undefined   |
| FFFFFEE0H | UF0 device descriptor register 15                               | UF0DD15  | R/W |                            | √      |         | Undefined   |
| FFFFFEE1H | UF0 device descriptor register 16                               | UF0DD16  | R/W |                            | √      |         | Undefined   |
| FFFFFEE2H | UF0 device descriptor register 17                               | UF0DD17  | R/W |                            | √      |         | Undefined   |
| FFFFFEE3H | UF0 configuration/interface/<br>endpoint descriptor register 0  | UF0CIE0  | R/W |                            | √      |         | Undefined   |
| FFFFFEE4H | UF0 configuration/interface/<br>endpoint descriptor register 1  | UF0CIE1  | R/W |                            | √      |         | Undefined   |
| FFFFFEE5H | UF0 configuration/interface/<br>endpoint descriptor register 2  | UF0CIE2  | R/W |                            | √      |         | Undefined   |
| FFFFFEE6H | UF0 configuration/interface/<br>endpoint descriptor register 3  | UF0CIE3  | R/W |                            | √      |         | Undefined   |
| FFFFFEE7H | UF0 configuration/interface/<br>endpoint descriptor register 4  | UF0CIE4  | R/W |                            | √      |         | Undefined   |
| FFFFFEE8H | UF0 configuration/interface/<br>endpoint descriptor register 5  | UF0CIE5  | R/W |                            | √      |         | Undefined   |
| FFFFFEE9H | UF0 configuration/interface/<br>endpoint descriptor register 6  | UF0CIE6  | R/W |                            | √      |         | Undefined   |
| FFFFFEEAH | UF0 configuration/interface/<br>endpoint descriptor register 7  | UF0CIE7  | R/W |                            | √      |         | Undefined   |
| FFFFFEEBH | UF0 configuration/interface/<br>endpoint descriptor register 8  | UF0CIE8  | R/W |                            | √      |         | Undefined   |
| FFFFFEECH | UF0 configuration/interface/<br>endpoint descriptor register 9  | UF0CIE9  | R/W |                            | √      |         | Undefined   |
| FFFFFEEDH | UF0 configuration/interface/<br>endpoint descriptor register 10 | UF0CIE10 | R/W |                            | √      |         | Undefined   |
| FFFFFEEEH | UF0 configuration/interface/<br>endpoint descriptor register 11 | UF0CIE11 | R/W |                            | √      |         | Undefined   |
| FFFFFEEFH | UF0 configuration/interface/<br>endpoint descriptor register 12 | UF0CIE12 | R/W |                            | √      |         | Undefined   |
| FFFFFEF0H | UF0 configuration/interface/<br>endpoint descriptor register 13 | UF0CIE13 | R/W |                            | √      |         | Undefined   |
| FFFFFEF1H | UF0 configuration/interface/<br>endpoint descriptor register 14 | UF0CIE14 | R/W |                            | √      |         | Undefined   |
| FFFFFEF2H | UF0 configuration/interface/<br>endpoint descriptor register 15 | UF0CIE15 | R/W |                            | √      |         | Undefined   |
| FFFFFEF3H | UF0 configuration/interface/<br>endpoint descriptor register 16 | UF0CIE16 | R/W |                            | √      |         | Undefined   |
| FFFFFEF4H | UF0 configuration/interface/<br>endpoint descriptor register 17 | UF0CIE17 | R/W |                            | √      |         | Undefined   |
| FFFFFEF5H | UF0 configuration/interface/<br>endpoint descriptor register 18 | UF0CIE18 | R/W |                            | √      |         | Undefined   |

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| Address    | Function Register Name                                          | Symbol   | R/W | Bit Units for Manipulation |        |         | After Reset |
|------------|-----------------------------------------------------------------|----------|-----|----------------------------|--------|---------|-------------|
|            |                                                                 |          |     | 1 Bit                      | 8 Bits | 16 Bits |             |
| FFFFFFEF6H | UF0 configuration/interface/<br>endpoint descriptor register 19 | UF0CIE19 | R/W |                            | √      |         | Undefined   |
| FFFFFFEF7H | UF0 configuration/interface/<br>endpoint descriptor register 20 | UF0CIE20 | R/W |                            | √      |         | Undefined   |
| FFFFFFEF8H | UF0 configuration/interface/<br>endpoint descriptor register 21 | UF0CIE21 | R/W |                            | √      |         | Undefined   |
| FFFFFFEF9H | UF0 configuration/interface/<br>endpoint descriptor register 22 | UF0CIE22 | R/W |                            | √      |         | Undefined   |
| FFFFFFEFAH | UF0 configuration/interface/<br>endpoint descriptor register 23 | UF0CIE23 | R/W |                            | √      |         | Undefined   |
| FFFFFFEFBH | UF0 configuration/interface/<br>endpoint descriptor register 24 | UF0CIE24 | R/W |                            | √      |         | Undefined   |
| FFFFFFEFC  | UF0 configuration/interface/<br>endpoint descriptor register 25 | UF0CIE25 | R/W |                            | √      |         | Undefined   |
| FFFFFFEFDH | UF0 configuration/interface/<br>endpoint descriptor register 26 | UF0CIE26 | R/W |                            | √      |         | Undefined   |
| FFFFFFEFEH | UF0 configuration/interface/<br>endpoint descriptor register 27 | UF0CIE27 | R/W |                            | √      |         | Undefined   |
| FFFFFFEFH  | UF0 configuration/interface/<br>endpoint descriptor register 28 | UF0CIE28 | R/W |                            | √      |         | Undefined   |
| FFFFFFF00H | UF0 configuration/interface/<br>endpoint descriptor register 29 | UF0CIE29 | R/W |                            | √      |         | Undefined   |
| FFFFFFF01H | UF0 configuration/interface/<br>endpoint descriptor register 30 | UF0CIE30 | R/W |                            | √      |         | Undefined   |
| FFFFFFF02H | UF0 configuration/interface/<br>endpoint descriptor register 31 | UF0CIE31 | R/W |                            | √      |         | Undefined   |
| FFFFFFF03H | UF0 configuration/interface/<br>endpoint descriptor register 32 | UF0CIE32 | R/W |                            | √      |         | Undefined   |
| FFFFFFF04H | UF0 configuration/interface/<br>endpoint descriptor register 33 | UF0CIE33 | R/W |                            | √      |         | Undefined   |
| FFFFFFF05H | UF0 configuration/interface/<br>endpoint descriptor register 34 | UF0CIE34 | R/W |                            | √      |         | Undefined   |
| FFFFFFF06H | UF0 configuration/interface/<br>endpoint descriptor register 35 | UF0CIE35 | R/W |                            | √      |         | Undefined   |
| FFFFFFF07H | UF0 configuration/interface/<br>endpoint descriptor register 36 | UF0CIE36 | R/W |                            | √      |         | Undefined   |
| FFFFFFF08H | UF0 configuration/interface/<br>endpoint descriptor register 37 | UF0CIE37 | R/W |                            | √      |         | Undefined   |
| FFFFFFF09H | UF0 configuration/interface/<br>endpoint descriptor register 38 | UF0CIE38 | R/W |                            | √      |         | Undefined   |
| FFFFFFF0AH | UF0 configuration/interface/<br>endpoint descriptor register 39 | UF0CIE39 | R/W |                            | √      |         | Undefined   |
| FFFFFFF0BH | UF0 configuration/interface/<br>endpoint descriptor register 40 | UF0CIE40 | R/W |                            | √      |         | Undefined   |

| Address   | Function Register Name                                          | Symbol   | R/W | Bit Units for Manipulation |        |         | After Reset |
|-----------|-----------------------------------------------------------------|----------|-----|----------------------------|--------|---------|-------------|
|           |                                                                 |          |     | 1 Bit                      | 8 Bits | 16 Bits |             |
| FFFFFF0CH | UF0 configuration/interface/<br>endpoint descriptor register 41 | UF0CIE41 | R/W |                            | √      |         | Undefined   |
| FFFFFF0DH | UF0 configuration/interface/<br>endpoint descriptor register 42 | UF0CIE42 | R/W |                            | √      |         | Undefined   |
| FFFFFF0EH | UF0 configuration/interface/<br>endpoint descriptor register 43 | UF0CIE43 | R/W |                            | √      |         | Undefined   |
| FFFFFF0FH | UF0 configuration/interface/<br>endpoint descriptor register 44 | UF0CIE44 | R/W |                            | √      |         | Undefined   |
| FFFFFF10H | UF0 configuration/interface/<br>endpoint descriptor register 45 | UF0CIE45 | R/W |                            | √      |         | Undefined   |
| FFFFFF11H | UF0 configuration/interface/<br>endpoint descriptor register 46 | UF0CIE46 | R/W |                            | √      |         | Undefined   |
| FFFFFF12H | UF0 configuration/interface/<br>endpoint descriptor register 47 | UF0CIE47 | R/W |                            | √      |         | Undefined   |
| FFFFFF13H | UF0 configuration/interface/<br>endpoint descriptor register 48 | UF0CIE48 | R/W |                            | √      |         | Undefined   |
| FFFFFF14H | UF0 configuration/interface/<br>endpoint descriptor register 49 | UF0CIE49 | R/W |                            | √      |         | Undefined   |
| FFFFFF15H | UF0 configuration/interface/<br>endpoint descriptor register 50 | UF0CIE50 | R/W |                            | √      |         | Undefined   |
| FFFFFF16H | UF0 configuration/interface/<br>endpoint descriptor register 51 | UF0CIE51 | R/W |                            | √      |         | Undefined   |
| FFFFFF17H | UF0 configuration/interface/<br>endpoint descriptor register 52 | UF0CIE52 | R/W |                            | √      |         | Undefined   |
| FFFFFF18H | UF0 configuration/interface/<br>endpoint descriptor register 53 | UF0CIE53 | R/W |                            | √      |         | Undefined   |
| FFFFFF19H | UF0 configuration/interface/<br>endpoint descriptor register 54 | UF0CIE54 | R/W |                            | √      |         | Undefined   |
| FFFFFF1AH | UF0 configuration/interface/<br>endpoint descriptor register 55 | UF0CIE55 | R/W |                            | √      |         | Undefined   |
| FFFFFF1BH | UF0 configuration/interface/<br>endpoint descriptor register 56 | UF0CIE56 | R/W |                            | √      |         | Undefined   |
| FFFFFF1CH | UF0 configuration/interface/<br>endpoint descriptor register 57 | UF0CIE57 | R/W |                            | √      |         | Undefined   |
| FFFFFF1DH | UF0 configuration/interface/<br>endpoint descriptor register 58 | UF0CIE58 | R/W |                            | √      |         | Undefined   |
| FFFFFF1EH | UF0 configuration/interface/<br>endpoint descriptor register 59 | UF0CIE59 | R/W |                            | √      |         | Undefined   |
| FFFFFF1FH | UF0 configuration/interface/<br>endpoint descriptor register 60 | UF0CIE60 | R/W |                            | √      |         | Undefined   |
| FFFFFF20H | UF0 configuration/interface/<br>endpoint descriptor register 61 | UF0CIE61 | R/W |                            | √      |         | Undefined   |
| FFFFFF21H | UF0 configuration/interface/<br>endpoint descriptor register 62 | UF0CIE62 | R/W |                            | √      |         | Undefined   |

| Address   | Function Register Name                                          | Symbol   | R/W | Bit Units for Manipulation |        |         | After Reset |
|-----------|-----------------------------------------------------------------|----------|-----|----------------------------|--------|---------|-------------|
|           |                                                                 |          |     | 1 Bit                      | 8 Bits | 16 Bits |             |
| FFFFFF22H | UF0 configuration/interface/<br>endpoint descriptor register 63 | UF0CIE63 | R/W |                            | √      |         | Undefined   |
| FFFFFF23H | UF0 configuration/interface/<br>endpoint descriptor register 64 | UF0CIE64 | R/W |                            | √      |         | Undefined   |
| FFFFFF24H | UF0 configuration/interface/<br>endpoint descriptor register 65 | UF0CIE65 | R/W |                            | √      |         | Undefined   |
| FFFFFF25H | UF0 configuration/interface/<br>endpoint descriptor register 66 | UF0CIE66 | R/W |                            | √      |         | Undefined   |
| FFFFFF26H | UF0 configuration/interface/<br>endpoint descriptor register 67 | UF0CIE67 | R/W |                            | √      |         | Undefined   |
| FFFFFF27H | UF0 configuration/interface/<br>endpoint descriptor register 68 | UF0CIE68 | R/W |                            | √      |         | Undefined   |
| FFFFFF28H | UF0 configuration/interface/<br>endpoint descriptor register 69 | UF0CIE69 | R/W |                            | √      |         | Undefined   |
| FFFFFF29H | UF0 configuration/interface/<br>endpoint descriptor register 70 | UF0CIE70 | R/W |                            | √      |         | Undefined   |
| FFFFFF2AH | UF0 configuration/interface/<br>endpoint descriptor register 71 | UF0CIE71 | R/W |                            | √      |         | Undefined   |
| FFFFFF2BH | UF0 configuration/interface/<br>endpoint descriptor register 72 | UF0CIE72 | R/W |                            | √      |         | Undefined   |
| FFFFFF2CH | UF0 configuration/interface/<br>endpoint descriptor register 73 | UF0CIE73 | R/W |                            | √      |         | Undefined   |
| FFFFFF2DH | UF0 configuration/interface/<br>endpoint descriptor register 74 | UF0CIE74 | R/W |                            | √      |         | Undefined   |
| FFFFFF2EH | UF0 configuration/interface/<br>endpoint descriptor register 75 | UF0CIE75 | R/W |                            | √      |         | Undefined   |
| FFFFFF2FH | UF0 configuration/interface/<br>endpoint descriptor register 76 | UF0CIE76 | R/W |                            | √      |         | Undefined   |
| FFFFFF30H | UF0 configuration/interface/<br>endpoint descriptor register 77 | UF0CIE77 | R/W |                            | √      |         | Undefined   |
| FFFFFF31H | UF0 configuration/interface/<br>endpoint descriptor register 78 | UF0CIE78 | R/W |                            | √      |         | Undefined   |
| FFFFFF32H | UF0 configuration/interface/<br>endpoint descriptor register 79 | UF0CIE79 | R/W |                            | √      |         | Undefined   |
| FFFFFF33H | UF0 configuration/interface/<br>endpoint descriptor register 80 | UF0CIE80 | R/W |                            | √      |         | Undefined   |
| FFFFFF34H | UF0 configuration/interface/<br>endpoint descriptor register 81 | UF0CIE81 | R/W |                            | √      |         | Undefined   |
| FFFFFF35H | UF0 configuration/interface/<br>endpoint descriptor register 82 | UF0CIE82 | R/W |                            | √      |         | Undefined   |
| FFFFFF36H | UF0 configuration/interface/<br>endpoint descriptor register 83 | UF0CIE83 | R/W |                            | √      |         | Undefined   |
| FFFFFF37H | UF0 configuration/interface/<br>endpoint descriptor register 84 | UF0CIE84 | R/W |                            | √      |         | Undefined   |

| Address   | Function Register Name                                           | Symbol    | R/W | Bit Units for Manipulation |        |         | After Reset |
|-----------|------------------------------------------------------------------|-----------|-----|----------------------------|--------|---------|-------------|
|           |                                                                  |           |     | 1 Bit                      | 8 Bits | 16 Bits |             |
| FFFFFF38H | UF0 configuration/interface/<br>endpoint descriptor register 85  | UF0CIE85  | R/W |                            | √      |         | Undefined   |
| FFFFFF39H | UF0 configuration/interface/<br>endpoint descriptor register 86  | UF0CIE86  | R/W |                            | √      |         | Undefined   |
| FFFFFF3AH | UF0 configuration/interface/<br>endpoint descriptor register 87  | UF0CIE87  | R/W |                            | √      |         | Undefined   |
| FFFFFF3BH | UF0 configuration/interface/<br>endpoint descriptor register 88  | UF0CIE88  | R/W |                            | √      |         | Undefined   |
| FFFFFF3CH | UF0 configuration/interface/<br>endpoint descriptor register 89  | UF0CIE89  | R/W |                            | √      |         | Undefined   |
| FFFFFF3DH | UF0 configuration/interface/<br>endpoint descriptor register 90  | UF0CIE90  | R/W |                            | √      |         | Undefined   |
| FFFFFF3EH | UF0 configuration/interface/<br>endpoint descriptor register 91  | UF0CIE91  | R/W |                            | √      |         | Undefined   |
| FFFFFF3FH | UF0 configuration/interface/<br>endpoint descriptor register 92  | UF0CIE92  | R/W |                            | √      |         | Undefined   |
| FFFFFF40H | UF0 configuration/interface/<br>endpoint descriptor register 93  | UF0CIE93  | R/W |                            | √      |         | Undefined   |
| FFFFFF41H | UF0 configuration/interface/<br>endpoint descriptor register 94  | UF0CIE94  | R/W |                            | √      |         | Undefined   |
| FFFFFF42H | UF0 configuration/interface/<br>endpoint descriptor register 95  | UF0CIE95  | R/W |                            | √      |         | Undefined   |
| FFFFFF43H | UF0 configuration/interface/<br>endpoint descriptor register 96  | UF0CIE96  | R/W |                            | √      |         | Undefined   |
| FFFFFF44H | UF0 configuration/interface/<br>endpoint descriptor register 97  | UF0CIE97  | R/W |                            | √      |         | Undefined   |
| FFFFFF45H | UF0 configuration/interface/<br>endpoint descriptor register 98  | UF0CIE98  | R/W |                            | √      |         | Undefined   |
| FFFFFF46H | UF0 configuration/interface/<br>endpoint descriptor register 99  | UF0CIE99  | R/W |                            | √      |         | Undefined   |
| FFFFFF47H | UF0 configuration/interface/<br>endpoint descriptor register 100 | UF0CIE100 | R/W |                            | √      |         | Undefined   |
| FFFFFF48H | UF0 configuration/interface/<br>endpoint descriptor register 101 | UF0CIE101 | R/W |                            | √      |         | Undefined   |
| FFFFFF49H | UF0 configuration/interface/<br>endpoint descriptor register 102 | UF0CIE102 | R/W |                            | √      |         | Undefined   |
| FFFFFF4AH | UF0 configuration/interface/<br>endpoint descriptor register 103 | UF0CIE103 | R/W |                            | √      |         | Undefined   |
| FFFFFF4BH | UF0 configuration/interface/<br>endpoint descriptor register 104 | UF0CIE104 | R/W |                            | √      |         | Undefined   |
| FFFFFF4CH | UF0 configuration/interface/<br>endpoint descriptor register 105 | UF0CIE105 | R/W |                            | √      |         | Undefined   |
| FFFFFF4DH | UF0 configuration/interface/<br>endpoint descriptor register 106 | UF0CIE106 | R/W |                            | √      |         | Undefined   |

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| Address   | Function Register Name                                           | Symbol    | R/W | Bit Units for Manipulation |        |         | After Reset |
|-----------|------------------------------------------------------------------|-----------|-----|----------------------------|--------|---------|-------------|
|           |                                                                  |           |     | 1 Bit                      | 8 Bits | 16 Bits |             |
| FFFFFF4EH | UF0 configuration/interface/<br>endpoint descriptor register 107 | UF0CIE107 | R/W |                            | √      |         | Undefined   |
| FFFFFF4FH | UF0 configuration/interface/<br>endpoint descriptor register 108 | UF0CIE108 | R/W |                            | √      |         | Undefined   |
| FFFFFF50H | UF0 configuration/interface/<br>endpoint descriptor register 109 | UF0CIE109 | R/W |                            | √      |         | Undefined   |
| FFFFFF51H | UF0 configuration/interface/<br>endpoint descriptor register 110 | UF0CIE110 | R/W |                            | √      |         | Undefined   |
| FFFFFF52H | UF0 configuration/interface/<br>endpoint descriptor register 111 | UF0CIE111 | R/W |                            | √      |         | Undefined   |
| FFFFFF53H | UF0 configuration/interface/<br>endpoint descriptor register 112 | UF0CIE112 | R/W |                            | √      |         | Undefined   |
| FFFFFF54H | UF0 configuration/interface/<br>endpoint descriptor register 113 | UF0CIE113 | R/W |                            | √      |         | Undefined   |
| FFFFFF55H | UF0 configuration/interface/<br>endpoint descriptor register 114 | UF0CIE114 | R/W |                            | √      |         | Undefined   |
| FFFFFF56H | UF0 configuration/interface/<br>endpoint descriptor register 115 | UF0CIE115 | R/W |                            | √      |         | Undefined   |
| FFFFFF57H | UF0 configuration/interface/<br>endpoint descriptor register 116 | UF0CIE116 | R/W |                            | √      |         | Undefined   |
| FFFFFF58H | UF0 configuration/interface/<br>endpoint descriptor register 117 | UF0CIE117 | R/W |                            | √      |         | Undefined   |
| FFFFFF59H | UF0 configuration/interface/<br>endpoint descriptor register 118 | UF0CIE118 | R/W |                            | √      |         | Undefined   |
| FFFFFF5AH | UF0 configuration/interface/<br>endpoint descriptor register 119 | UF0CIE119 | R/W |                            | √      |         | Undefined   |
| FFFFFF5BH | UF0 configuration/interface/<br>endpoint descriptor register 120 | UF0CIE120 | R/W |                            | √      |         | Undefined   |
| FFFFFF5CH | UF0 configuration/interface/<br>endpoint descriptor register 121 | UF0CIE121 | R/W |                            | √      |         | Undefined   |
| FFFFFF5DH | UF0 configuration/interface/<br>endpoint descriptor register 122 | UF0CIE122 | R/W |                            | √      |         | Undefined   |
| FFFFFF5EH | UF0 configuration/interface/<br>endpoint descriptor register 123 | UF0CIE123 | R/W |                            | √      |         | Undefined   |
| FFFFFF5FH | UF0 configuration/interface/<br>endpoint descriptor register 124 | UF0CIE124 | R/W |                            | √      |         | Undefined   |
| FFFFFF60H | UF0 configuration/interface/<br>endpoint descriptor register 125 | UF0CIE125 | R/W |                            | √      |         | Undefined   |
| FFFFFF61H | UF0 configuration/interface/<br>endpoint descriptor register 126 | UF0CIE126 | R/W |                            | √      |         | Undefined   |
| FFFFFF62H | UF0 configuration/interface/<br>endpoint descriptor register 127 | UF0CIE127 | R/W |                            | √      |         | Undefined   |
| FFFFFF63H | UF0 configuration/interface/<br>endpoint descriptor register 128 | UF0CIE128 | R/W |                            | √      |         | Undefined   |

| Address   | Function Register Name                                           | Symbol    | R/W | Bit Units for Manipulation |        |         | After Reset |
|-----------|------------------------------------------------------------------|-----------|-----|----------------------------|--------|---------|-------------|
|           |                                                                  |           |     | 1 Bit                      | 8 Bits | 16 Bits |             |
| FFFFFF64H | UF0 configuration/interface/<br>endpoint descriptor register 129 | UF0CIE129 | R/W |                            | √      |         | Undefined   |
| FFFFFF65H | UF0 configuration/interface/<br>endpoint descriptor register 130 | UF0CIE130 | R/W |                            | √      |         | Undefined   |
| FFFFFF66H | UF0 configuration/interface/<br>endpoint descriptor register 131 | UF0CIE131 | R/W |                            | √      |         | Undefined   |
| FFFFFF67H | UF0 configuration/interface/<br>endpoint descriptor register 132 | UF0CIE132 | R/W |                            | √      |         | Undefined   |
| FFFFFF68H | UF0 configuration/interface/<br>endpoint descriptor register 133 | UF0CIE133 | R/W |                            | √      |         | Undefined   |
| FFFFFF69H | UF0 configuration/interface/<br>endpoint descriptor register 134 | UF0CIE134 | R/W |                            | √      |         | Undefined   |
| FFFFFF6AH | UF0 configuration/interface/<br>endpoint descriptor register 135 | UF0CIE135 | R/W |                            | √      |         | Undefined   |
| FFFFFF6BH | UF0 configuration/interface/<br>endpoint descriptor register 136 | UF0CIE136 | R/W |                            | √      |         | Undefined   |
| FFFFFF6CH | UF0 configuration/interface/<br>endpoint descriptor register 137 | UF0CIE137 | R/W |                            | √      |         | Undefined   |
| FFFFFF6DH | UF0 configuration/interface/<br>endpoint descriptor register 138 | UF0CIE138 | R/W |                            | √      |         | Undefined   |
| FFFFFF6EH | UF0 configuration/interface/<br>endpoint descriptor register 139 | UF0CIE139 | R/W |                            | √      |         | Undefined   |
| FFFFFF6FH | UF0 configuration/interface/<br>endpoint descriptor register 140 | UF0CIE140 | R/W |                            | √      |         | Undefined   |
| FFFFFF70H | UF0 configuration/interface/<br>endpoint descriptor register 141 | UF0CIE141 | R/W |                            | √      |         | Undefined   |
| FFFFFF71H | UF0 configuration/interface/<br>endpoint descriptor register 142 | UF0CIE142 | R/W |                            | √      |         | Undefined   |
| FFFFFF72H | UF0 configuration/interface/<br>endpoint descriptor register 143 | UF0CIE143 | R/W |                            | √      |         | Undefined   |
| FFFFFF73H | UF0 configuration/interface/<br>endpoint descriptor register 144 | UF0CIE144 | R/W |                            | √      |         | Undefined   |
| FFFFFF74H | UF0 configuration/interface/<br>endpoint descriptor register 145 | UF0CIE145 | R/W |                            | √      |         | Undefined   |
| FFFFFF75H | UF0 configuration/interface/<br>endpoint descriptor register 146 | UF0CIE146 | R/W |                            | √      |         | Undefined   |
| FFFFFF76H | UF0 configuration/interface/<br>endpoint descriptor register 147 | UF0CIE147 | R/W |                            | √      |         | Undefined   |
| FFFFFF77H | UF0 configuration/interface/<br>endpoint descriptor register 148 | UF0CIE148 | R/W |                            | √      |         | Undefined   |
| FFFFFF78H | UF0 configuration/interface/<br>endpoint descriptor register 149 | UF0CIE149 | R/W |                            | √      |         | Undefined   |
| FFFFFF79H | UF0 configuration/interface/<br>endpoint descriptor register 150 | UF0CIE150 | R/W |                            | √      |         | Undefined   |

| Address   | Function Register Name                                           | Symbol    | R/W | Bit Units for Manipulation |        |         | After Reset |
|-----------|------------------------------------------------------------------|-----------|-----|----------------------------|--------|---------|-------------|
|           |                                                                  |           |     | 1 Bit                      | 8 Bits | 16 Bits |             |
| FFFFFF7AH | UF0 configuration/interface/<br>endpoint descriptor register 151 | UF0CIE151 | R/W |                            | √      |         | Undefined   |
| FFFFFF7BH | UF0 configuration/interface/<br>endpoint descriptor register 152 | UF0CIE152 | R/W |                            | √      |         | Undefined   |
| FFFFFF7CH | UF0 configuration/interface/<br>endpoint descriptor register 153 | UF0CIE153 | R/W |                            | √      |         | Undefined   |
| FFFFFF7DH | UF0 configuration/interface/<br>endpoint descriptor register 154 | UF0CIE154 | R/W |                            | √      |         | Undefined   |
| FFFFFF7EH | UF0 configuration/interface/<br>endpoint descriptor register 155 | UF0CIE155 | R/W |                            | √      |         | Undefined   |
| FFFFFF7FH | UF0 configuration/interface/<br>endpoint descriptor register 156 | UF0CIE156 | R/W |                            | √      |         | Undefined   |
| FFFFFF80H | UF0 configuration/interface/<br>endpoint descriptor register 157 | UF0CIE157 | R/W |                            | √      |         | Undefined   |
| FFFFFF81H | UF0 configuration/interface/<br>endpoint descriptor register 158 | UF0CIE158 | R/W |                            | √      |         | Undefined   |
| FFFFFF82H | UF0 configuration/interface/<br>endpoint descriptor register 159 | UF0CIE159 | R/W |                            | √      |         | Undefined   |
| FFFFFF83H | UF0 configuration/interface/<br>endpoint descriptor register 160 | UF0CIE160 | R/W |                            | √      |         | Undefined   |
| FFFFFF84H | UF0 configuration/interface/<br>endpoint descriptor register 161 | UF0CIE161 | R/W |                            | √      |         | Undefined   |
| FFFFFF85H | UF0 configuration/interface/<br>endpoint descriptor register 162 | UF0CIE162 | R/W |                            | √      |         | Undefined   |
| FFFFFF86H | UF0 configuration/interface/<br>endpoint descriptor register 163 | UF0CIE163 | R/W |                            | √      |         | Undefined   |
| FFFFFF87H | UF0 configuration/interface/<br>endpoint descriptor register 164 | UF0CIE164 | R/W |                            | √      |         | Undefined   |
| FFFFFF88H | UF0 configuration/interface/<br>endpoint descriptor register 165 | UF0CIE165 | R/W |                            | √      |         | Undefined   |
| FFFFFF89H | UF0 configuration/interface/<br>endpoint descriptor register 166 | UF0CIE166 | R/W |                            | √      |         | Undefined   |
| FFFFFF8AH | UF0 configuration/interface/<br>endpoint descriptor register 167 | UF0CIE167 | R/W |                            | √      |         | Undefined   |
| FFFFFF8BH | UF0 configuration/interface/<br>endpoint descriptor register 168 | UF0CIE168 | R/W |                            | √      |         | Undefined   |
| FFFFFF8CH | UF0 configuration/interface/<br>endpoint descriptor register 169 | UF0CIE169 | R/W |                            | √      |         | Undefined   |
| FFFFFF8DH | UF0 configuration/interface/<br>endpoint descriptor register 170 | UF0CIE170 | R/W |                            | √      |         | Undefined   |
| FFFFFF8EH | UF0 configuration/interface/<br>endpoint descriptor register 171 | UF0CIE171 | R/W |                            | √      |         | Undefined   |
| FFFFFF8FH | UF0 configuration/interface/<br>endpoint descriptor register 172 | UF0CIE172 | R/W |                            | √      |         | Undefined   |



| Address   | Function Register Name                                           | Symbol    | R/W | Bit Units for Manipulation |        |         | After Reset |
|-----------|------------------------------------------------------------------|-----------|-----|----------------------------|--------|---------|-------------|
|           |                                                                  |           |     | 1 Bit                      | 8 Bits | 16 Bits |             |
| FFFFFF90H | UF0 configuration/interface/<br>endpoint descriptor register 173 | UF0CIE173 | R/W |                            | √      |         | Undefined   |
| FFFFFF91H | UF0 configuration/interface/<br>endpoint descriptor register 174 | UF0CIE174 | R/W |                            | √      |         | Undefined   |
| FFFFFF92H | UF0 configuration/interface/<br>endpoint descriptor register 175 | UF0CIE175 | R/W |                            | √      |         | Undefined   |
| FFFFFF93H | UF0 configuration/interface/<br>endpoint descriptor register 176 | UF0CIE176 | R/W |                            | √      |         | Undefined   |
| FFFFFF94H | UF0 configuration/interface/<br>endpoint descriptor register 177 | UF0CIE177 | R/W |                            | √      |         | Undefined   |
| FFFFFF95H | UF0 configuration/interface/<br>endpoint descriptor register 178 | UF0CIE178 | R/W |                            | √      |         | Undefined   |
| FFFFFF96H | UF0 configuration/interface/<br>endpoint descriptor register 179 | UF0CIE179 | R/W |                            | √      |         | Undefined   |
| FFFFFF97H | UF0 configuration/interface/<br>endpoint descriptor register 180 | UF0CIE180 | R/W |                            | √      |         | Undefined   |
| FFFFFF98H | UF0 configuration/interface/<br>endpoint descriptor register 181 | UF0CIE181 | R/W |                            | √      |         | Undefined   |
| FFFFFF99H | UF0 configuration/interface/<br>endpoint descriptor register 182 | UF0CIE182 | R/W |                            | √      |         | Undefined   |
| FFFFFF9AH | UF0 configuration/interface/<br>endpoint descriptor register 183 | UF0CIE183 | R/W |                            | √      |         | Undefined   |
| FFFFFF9BH | UF0 configuration/interface/<br>endpoint descriptor register 184 | UF0CIE184 | R/W |                            | √      |         | Undefined   |
| FFFFFF9CH | UF0 configuration/interface/<br>endpoint descriptor register 185 | UF0CIE185 | R/W |                            | √      |         | Undefined   |
| FFFFFF9DH | UF0 configuration/interface/<br>endpoint descriptor register 186 | UF0CIE186 | R/W |                            | √      |         | Undefined   |
| FFFFFF9EH | UF0 configuration/interface/<br>endpoint descriptor register 187 | UF0CIE187 | R/W |                            | √      |         | Undefined   |
| FFFFFF9FH | UF0 configuration/interface/<br>endpoint descriptor register 188 | UF0CIE188 | R/W |                            | √      |         | Undefined   |
| FFFFFFA0H | UF0 configuration/interface/<br>endpoint descriptor register 189 | UF0CIE189 | R/W |                            | √      |         | Undefined   |
| FFFFFFA1H | UF0 configuration/interface/<br>endpoint descriptor register 190 | UF0CIE190 | R/W |                            | √      |         | Undefined   |
| FFFFFFA2H | UF0 configuration/interface/<br>endpoint descriptor register 191 | UF0CIE191 | R/W |                            | √      |         | Undefined   |
| FFFFFFA3H | UF0 configuration/interface/<br>endpoint descriptor register 192 | UF0CIE192 | R/W |                            | √      |         | Undefined   |
| FFFFFFA4H | UF0 configuration/interface/<br>endpoint descriptor register 193 | UF0CIE193 | R/W |                            | √      |         | Undefined   |
| FFFFFFA5H | UF0 configuration/interface/<br>endpoint descriptor register 194 | UF0CIE194 | R/W |                            | √      |         | Undefined   |

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| Address   | Function Register Name                                           | Symbol    | R/W | Bit Units for Manipulation |        |         | After Reset |
|-----------|------------------------------------------------------------------|-----------|-----|----------------------------|--------|---------|-------------|
|           |                                                                  |           |     | 1 Bit                      | 8 Bits | 16 Bits |             |
| FFFFFFA6H | UF0 configuration/interface/<br>endpoint descriptor register 195 | UF0CIE195 | R/W |                            | √      |         | Undefined   |
| FFFFFFA7H | UF0 configuration/interface/<br>endpoint descriptor register 196 | UF0CIE196 | R/W |                            | √      |         | Undefined   |
| FFFFFFA8H | UF0 configuration/interface/<br>endpoint descriptor register 197 | UF0CIE197 | R/W |                            | √      |         | Undefined   |
| FFFFFFA9H | UF0 configuration/interface/<br>endpoint descriptor register 198 | UF0CIE198 | R/W |                            | √      |         | Undefined   |
| FFFFFFAAH | UF0 configuration/interface/<br>endpoint descriptor register 199 | UF0CIE199 | R/W |                            | √      |         | Undefined   |
| FFFFFFABH | UF0 configuration/interface/<br>endpoint descriptor register 200 | UF0CIE200 | R/W |                            | √      |         | Undefined   |
| FFFFFFACH | UF0 configuration/interface/<br>endpoint descriptor register 201 | UF0CIE201 | R/W |                            | √      |         | Undefined   |
| FFFFFFADH | UF0 configuration/interface/<br>endpoint descriptor register 202 | UF0CIE202 | R/W |                            | √      |         | Undefined   |
| FFFFFFAEH | UF0 configuration/interface/<br>endpoint descriptor register 203 | UF0CIE203 | R/W |                            | √      |         | Undefined   |
| FFFFFFAFH | UF0 configuration/interface/<br>endpoint descriptor register 204 | UF0CIE204 | R/W |                            | √      |         | Undefined   |
| FFFFFFB0H | UF0 configuration/interface/<br>endpoint descriptor register 205 | UF0CIE205 | R/W |                            | √      |         | Undefined   |
| FFFFFFB1H | UF0 configuration/interface/<br>endpoint descriptor register 206 | UF0CIE206 | R/W |                            | √      |         | Undefined   |
| FFFFFFB2H | UF0 configuration/interface/<br>endpoint descriptor register 207 | UF0CIE207 | R/W |                            | √      |         | Undefined   |
| FFFFFFB3H | UF0 configuration/interface/<br>endpoint descriptor register 208 | UF0CIE208 | R/W |                            | √      |         | Undefined   |
| FFFFFFB4H | UF0 configuration/interface/<br>endpoint descriptor register 209 | UF0CIE209 | R/W |                            | √      |         | Undefined   |
| FFFFFFB5H | UF0 configuration/interface/<br>endpoint descriptor register 210 | UF0CIE210 | R/W |                            | √      |         | Undefined   |
| FFFFFFB6H | UF0 configuration/interface/<br>endpoint descriptor register 211 | UF0CIE211 | R/W |                            | √      |         | Undefined   |
| FFFFFFB7H | UF0 configuration/interface/<br>endpoint descriptor register 212 | UF0CIE212 | R/W |                            | √      |         | Undefined   |
| FFFFFFB8H | UF0 configuration/interface/<br>endpoint descriptor register 213 | UF0CIE213 | R/W |                            | √      |         | Undefined   |
| FFFFFFB9H | UF0 configuration/interface/<br>endpoint descriptor register 214 | UF0CIE214 | R/W |                            | √      |         | Undefined   |
| FFFFFFBAH | UF0 configuration/interface/<br>endpoint descriptor register 215 | UF0CIE215 | R/W |                            | √      |         | Undefined   |
| FFFFFFBBH | UF0 configuration/interface/<br>endpoint descriptor register 216 | UF0CIE216 | R/W |                            | √      |         | Undefined   |

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| Address   | Function Register Name                                           | Symbol    | R/W | Bit Units for Manipulation |        |         | After Reset |
|-----------|------------------------------------------------------------------|-----------|-----|----------------------------|--------|---------|-------------|
|           |                                                                  |           |     | 1 Bit                      | 8 Bits | 16 Bits |             |
| FFFFFFBCH | UF0 configuration/interface/<br>endpoint descriptor register 217 | UF0CIE217 | R/W |                            | √      |         | Undefined   |
| FFFFFFBDH | UF0 configuration/interface/<br>endpoint descriptor register 218 | UF0CIE218 | R/W |                            | √      |         | Undefined   |
| FFFFFFBEH | UF0 configuration/interface/<br>endpoint descriptor register 219 | UF0CIE219 | R/W |                            | √      |         | Undefined   |
| FFFFFFBFH | UF0 configuration/interface/<br>endpoint descriptor register 220 | UF0CIE220 | R/W |                            | √      |         | Undefined   |
| FFFFFFC0H | UF0 configuration/interface/<br>endpoint descriptor register 221 | UF0CIE221 | R/W |                            | √      |         | Undefined   |
| FFFFFFC1H | UF0 configuration/interface/<br>endpoint descriptor register 222 | UF0CIE222 | R/W |                            | √      |         | Undefined   |
| FFFFFFC2H | UF0 configuration/interface/<br>endpoint descriptor register 223 | UF0CIE223 | R/W |                            | √      |         | Undefined   |
| FFFFFFC3H | UF0 configuration/interface/<br>endpoint descriptor register 224 | UF0CIE224 | R/W |                            | √      |         | Undefined   |
| FFFFFFC4H | UF0 configuration/interface/<br>endpoint descriptor register 225 | UF0CIE225 | R/W |                            | √      |         | Undefined   |
| FFFFFFC5H | UF0 configuration/interface/<br>endpoint descriptor register 226 | UF0CIE226 | R/W |                            | √      |         | Undefined   |
| FFFFFFC6H | UF0 configuration/interface/<br>endpoint descriptor register 227 | UF0CIE227 | R/W |                            | √      |         | Undefined   |
| FFFFFFC7H | UF0 configuration/interface/<br>endpoint descriptor register 228 | UF0CIE228 | R/W |                            | √      |         | Undefined   |
| FFFFFFC8H | UF0 configuration/interface/<br>endpoint descriptor register 229 | UF0CIE229 | R/W |                            | √      |         | Undefined   |
| FFFFFFC9H | UF0 configuration/interface/<br>endpoint descriptor register 230 | UF0CIE230 | R/W |                            | √      |         | Undefined   |
| FFFFFFCAH | UF0 configuration/interface/<br>endpoint descriptor register 231 | UF0CIE231 | R/W |                            | √      |         | Undefined   |
| FFFFFFCBH | UF0 configuration/interface/<br>endpoint descriptor register 232 | UF0CIE232 | R/W |                            | √      |         | Undefined   |
| FFFFFFCCH | UF0 configuration/interface/<br>endpoint descriptor register 233 | UF0CIE233 | R/W |                            | √      |         | Undefined   |
| FFFFFFCDH | UF0 configuration/interface/<br>endpoint descriptor register 234 | UF0CIE234 | R/W |                            | √      |         | Undefined   |
| FFFFFFCEH | UF0 configuration/interface/<br>endpoint descriptor register 235 | UF0CIE235 | R/W |                            | √      |         | Undefined   |
| FFFFFFCFH | UF0 configuration/interface/<br>endpoint descriptor register 236 | UF0CIE236 | R/W |                            | √      |         | Undefined   |
| FFFFFFD0H | UF0 configuration/interface/<br>endpoint descriptor register 237 | UF0CIE237 | R/W |                            | √      |         | Undefined   |
| FFFFFFD1H | UF0 configuration/interface/<br>endpoint descriptor register 238 | UF0CIE238 | R/W |                            | √      |         | Undefined   |

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| Address   | Function Register Name                                           | Symbol    | R/W | Bit Units for Manipulation |        |         | After Reset |
|-----------|------------------------------------------------------------------|-----------|-----|----------------------------|--------|---------|-------------|
|           |                                                                  |           |     | 1 Bit                      | 8 Bits | 16 Bits |             |
| FFFFFFD2H | UF0 configuration/interface/<br>endpoint descriptor register 239 | UF0CIE239 | R/W |                            | √      |         | Undefined   |
| FFFFFFD3H | UF0 configuration/interface/<br>endpoint descriptor register 240 | UF0CIE240 | R/W |                            | √      |         | Undefined   |
| FFFFFFD4H | UF0 configuration/interface/<br>endpoint descriptor register 241 | UF0CIE241 | R/W |                            | √      |         | Undefined   |
| FFFFFFD5H | UF0 configuration/interface/<br>endpoint descriptor register 242 | UF0CIE242 | R/W |                            | √      |         | Undefined   |
| FFFFFFD6H | UF0 configuration/interface/<br>endpoint descriptor register 243 | UF0CIE243 | R/W |                            | √      |         | Undefined   |
| FFFFFFD7H | UF0 configuration/interface/<br>endpoint descriptor register 244 | UF0CIE244 | R/W |                            | √      |         | Undefined   |
| FFFFFFD8H | UF0 configuration/interface/<br>endpoint descriptor register 245 | UF0CIE245 | R/W |                            | √      |         | Undefined   |
| FFFFFFD9H | UF0 configuration/interface/<br>endpoint descriptor register 246 | UF0CIE246 | R/W |                            | √      |         | Undefined   |
| FFFFFFDAH | UF0 configuration/interface/<br>endpoint descriptor register 247 | UF0CIE247 | R/W |                            | √      |         | Undefined   |
| FFFFFFDBH | UF0 configuration/interface/<br>endpoint descriptor register 248 | UF0CIE248 | R/W |                            | √      |         | Undefined   |
| FFFFFFDCH | UF0 configuration/interface/<br>endpoint descriptor register 249 | UF0CIE249 | R/W |                            | √      |         | Undefined   |
| FFFFFFDDH | UF0 configuration/interface/<br>endpoint descriptor register 250 | UF0CIE250 | R/W |                            | √      |         | Undefined   |
| FFFFFFDEH | UF0 configuration/interface/<br>endpoint descriptor register 251 | UF0CIE251 | R/W |                            | √      |         | Undefined   |
| FFFFFFDFH | UF0 configuration/interface/<br>endpoint descriptor register 252 | UF0CIE252 | R/W |                            | √      |         | Undefined   |
| FFFFFFE0H | UF0 configuration/interface/<br>endpoint descriptor register 253 | UF0CIE253 | R/W |                            | √      |         | Undefined   |
| FFFFFFE1H | UF0 configuration/interface/<br>endpoint descriptor register 254 | UF0CIE254 | R/W |                            | √      |         | Undefined   |
| FFFFFFE2H | UF0 configuration/interface/<br>endpoint descriptor register 255 | UF0CIE255 | R/W |                            | √      |         | Undefined   |

### 3.4.8 Specific registers

Specific registers are registers that are protected from being written with illegal data due to erroneous program execution, etc. The V850E/ME2 has four specific registers, the power-save control register (PSC) (see **8.6.2 (3) Power-save control register (PSC)**), clock control register (CKC) (see **8.3.1 Clock control register (CKC)**), clock source select register (CKS) (see **8.3.2 Clock source select register (CKS)**), and SSCG control register (SSCGC) (see **8.3.3 SSCG control register (SSCGC)**). Disable DMA transfer when writing to a specific register.

There is also the command register (PRCMD), a protection register supporting write operations for specific registers to avoid an unexpected stoppage of the application system due to erroneous program execution (see **8.6.2 (2) Command register (PRCMD)**).

### 3.4.9 System wait control register (VSWC)

The VSWC register is a register that controls the bus access wait for the on-chip peripheral I/O registers.

Access to on-chip peripheral I/O registers of the V850E1 CPU core is basically made in 3 clocks; however, in the V850E/ME2, a wait is required in addition to those 3 clocks. Set the values described in the table below to the VSWC in accordance with the operation frequency used.

This register can be read or written in 1-bit or 8-bit units (address: FFFFF06EH, initial value: 77H).

| Operation Frequency (fx)             | Number of Waits | VSWC Setting Value |
|--------------------------------------|-----------------|--------------------|
| 10.00 MHz $\leq$ fx $\leq$ 25.00 MHz | 0               | 00H                |
| 25.00 MHz < fx $\leq$ 34.00 MHz      | 1               | 10H                |
| 34.00 MHz < fx $\leq$ 68.00 MHz      | 2               | 11H                |
| 68.00 MHz < fx $\leq$ 75.00 MHz      | 3               | 12H                |
| 75.00 MHz < fx $\leq$ 103.00 MHz     | 4               | 22H                |
| 103.00 MHz < fx $\leq$ 125.00 MHz    | 5               | 23H                |
| 125.00 MHz < fx $\leq$ 150.00 MHz    | 6               | 33H                |

**Remark** If the timing of changing a count value contend with the timing of accessing a register when accessing a register having status flags that indicate the status of the on-chip peripheral functions (such as UBnSTR) or a register that indicates the count value of a timer (such as TMCn), the register access is retried. As a result, it may take a longer time to access an on-chip peripheral I/O register.

### 3.4.10 Initialization sequence

Initialize the V850E/ME2 in the following sequence.

#### <1> Automatically branch to address 100000H after reset is cleared

Set the following registers that affect the external bus access performance using the program allocated at address 100000H. Execution automatically branches to 100000H when the reset signal is input in the power-on status.

- System wait control register (VSWC)  
Setting of a wait cycle for accessing the on-chip peripheral I/O
- Data wait control registers 0 and 1 (DWC0 and DWC1)  
Setting of a data wait cycle of the external bus
- Address setup wait control register (ASC)  
Setting of an address setup wait cycle of the external bus
- Bus cycle control register (BCC)  
Setting of an idle state of the external bus

As necessary, set chip area select control registers 0 and 1 (CSC0 and CSC1), bus cycle type configuration registers 0 and 1 (BCT0 and BCT1), the local bus sizing control register (LBS), the endian configuration register (BEC), line buffer control registers 0 and 1 (LBC0 and LBC1), the page ROM configuration register (PRC), port DH function control register (PFCDH), and port CS function control register (PFCCS).

- Cautions**
1. **Disable all interrupts from when the reset signal is cleared until when the program code is completely transferred to the internal instruction RAM (while steps <1> to <3> of the initialization sequence are being executed). Maskable interrupts are masked by default and do not have to be disabled.**
  2. **Set SDRAM configuration registers 1, 3, 4, and 6 (SCR1, SCR3, SCR4, and SCR6) after the processing of step <2>.**

#### <2> Checking LOCK bit of lock register (LOCKR)

After setting the registers in <1> above, check whether the LOCK bit of the LOCKR register is cleared to 0 (PLL is locked), and set the registers as follows.

- (i) System wait control register (VSWC)  
Set to x7H (x: Value set in <1>)  
For example, if 11H is set in <1>, set 17H here.
- (ii) Bus mode control register (BMC)  
Set the frequency division value of the external bus.
- (iii) System wait control register (VSWC)  
Re-set the value set in <1>.
- (iv) Clock control register (CKC)  
Set the internal system clock frequency ( $f_{CLK}$ ) division value.
- (v) Clock source select register (CKS)  
Switch from OSC output to SSCG output (switch the clock supply to the CPU from the input frequency to the X1 and X2 pins to the frequency multiplied by 8 by the PLL).

**Remark** The CKC and CKS registers must be rewritten in a special sequence because they are specific registers.

**<3> Transferring program code to internal instruction RAM**

Transfer the program code to the internal instruction RAM by program processing or using the DMA function. When using the DMA function, check the completion of DMA transfer by polling bit 7 (DMAIFn) of the DMA interrupt control register (DMAICn), without using the DMA transfer end interrupt (INTDMAn) (n = 0 to 3). After transferring the program code, set the internal instruction RAM in the read mode using the following procedure.

- (i) Set the read mode by using (clearing to 0) the IRAMM0 bit of the internal instruction RAM mode register (IRAMM). Note that the setting of the IRAMM0 bit must not be changed before it is cleared here.
- (ii) After clearing the IRAMM0 bit of the IRAMM register to 0, read the IRAMM0 bit that has been cleared to 0 to confirm that the read mode has been set (to prevent speculative instruction execution by pipeline operation).
- (iii) Branch to the internal instruction RAM area by executing a branch instruction.

**Cautions 1.** After the reset signal has been cleared, the NMI input is masked by hardware. The NMI is unmasked as soon as the IRAMM0 bit of the IRAMM register is cleared in step <3> of the initialization sequence.

2. If it is necessary to confirm NMI input immediately after the reset signal has been cleared and before the internal instruction RAM is set in the read mode, read the NMIRS bit of the NMI reset status register (NRS). If this bit is set to 1, it indicates that the NMI valid edge has been input. Execute the NMI servicing routine as necessary. The NRS register is used only to check NMI input after the reset signal has been cleared and before the internal instruction RAM is set in the read mode. This register is not cleared after the reset signal has been cleared.
3. The software exception and exception trap cannot be masked. Do not execute the TRAP and DBTRAP instructions until the program code has been transferred to the internal instruction RAM.

**Remarks 1.** The NMIRS bit of the NRS register is also set to 1 if an NMI is input after the internal instruction RAM has been set in the read mode. In this case, execution automatically branches to the NMI servicing routine and it is not necessary to confirm the status of the NMIRS bit.

2. The NMI input mask function is valid after the reset signal has been cleared and before the internal instruction RAM is set in the read mode.
3. To write data to instruction RAM bank 0 of the internal instruction RAM in the middle of program execution, set the NP bit of the PSW to 1 to disable NMI and maskable interrupts, so that the software exception and exception trap do not occur. Clear the NP bit after the program has been rewritten, and after it has been confirmed that the IRAMM0 bit of the IRAMM register has been set to 1 and the read mode has been set.
4. NMI and maskable interrupt requests that are generated while the NP bit of the PSW is set to 1 are held pending. An NMI request is acknowledged immediately after the NP bit has been cleared to 0. A maskable interrupt is acknowledged immediately after the NP bit has been cleared to 0 if interrupts are not disabled (DI status) and the interrupt request is not cleared (by clearing the xxIFn bit of the interrupt control register (xxICn) to 0) before the NP bit is cleared to 0, and if the xxMKn bit of the interrupt control register is not set to 1. However, only one of the NMI and maskable interrupt requests is held pending for each interrupt source, and only one interrupt request is acknowledged even if the same interrupt request is generated two times or more.

### 3.4.11 Restriction on conflict between sld instruction and interrupt request

#### (a) Description

If a conflict occurs between the decode operation of an instruction in <2> immediately before the sld instruction following an instruction in <1> and an interrupt request before the instruction in <1> is complete, the execution result of the instruction in <1> may not be stored in a register.

Instruction <1>

- Id instruction: ld.b, ld.h, ld.w, ld.bu, ld.hu
- sld instruction: sld.b, sld.h, sld.w, sld.bu, sld.hu
- Multiplication instruction: mul, mulh, mulhi, mulu

Instruction <2>

|                   |                   |                    |                   |
|-------------------|-------------------|--------------------|-------------------|
| mov reg1, reg2    | not reg1, reg2    | satsubr reg1, reg2 | satsub reg1, reg2 |
| satadd reg1, reg2 | satadd imm5, reg2 | or reg1, reg2      | xor reg1, reg2    |
| and reg1, reg2    | tst reg1, reg2    | subr reg1, reg2    | sub reg1, reg2    |
| add reg1, reg2    | add imm5, reg2    | cmp reg1, reg2     | cmp imm5, reg2    |
| mulh reg1, reg2   | shr imm5, reg2    | sar imm5, reg2     | shl imm5, reg2    |

<Example>

|                       |                                                                                                                                                                                                                                                                     |
|-----------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <i> ld.w [r11], r10   | If the decode operation of the mov instruction <ii> immediately before the sld instruction <iii> and an interrupt request conflict before execution of the ld instruction <i> is complete, the execution result of instruction <i> may not be stored in a register. |
| •                     |                                                                                                                                                                                                                                                                     |
| •                     |                                                                                                                                                                                                                                                                     |
| <ii> mov r10, r28     |                                                                                                                                                                                                                                                                     |
| <iii> sld.w 0x28, r10 |                                                                                                                                                                                                                                                                     |

#### (b) Countermeasure

<1> When compiler (CA850) is used

Use CA850 Ver. 2.61 or later because generation of the corresponding instruction sequence can be automatically suppressed.

<2> For assembler

When executing the sld instruction immediately after instruction <ii>, avoid the above operation using either of the following methods.

- Insert a nop instruction immediately before the sld instruction.
- Do not use the same register as the sld instruction destination register in the above instruction <ii> executed immediately before the sld instruction.



### 3.5 Cautions

Cautions concerning the CPU function are shown below.

**(1) Allocation to address 0100000H**

Be sure to allocate external memory to address 0100000H for correct operation.

**(2) Program execution in internal data RAM area**

Do not execute the program in the internal data RAM area.

<R>

**(3) Source/destination address of DMA transfer when transfer target is on-chip peripheral I/O**

Be sure to use addresses FFFF000H to FFFFFFFFH for the address when an on-chip peripheral I/O is specified as the source/destination of DMA transfer.

**(4) Initialization sequence**

Disable all interrupts from when the reset signal is released until when the program code is completely transferred to the internal instruction RAM.

**(5) Program code transfer to internal instruction RAM**

Do not execute the TRAP and DBTRAP instructions until the program code has been transferred to the internal instruction RAM.

## CHAPTER 4 BUS CONTROL FUNCTION

The V850E/ME2 is provided with an external bus interface function by which external I/O and memories, such as ROM and RAM, can be connected.

### 4.1 Features

- 32-bit/16-bit/8-bit data bus sizing function
- 8-space chip select function
- Wait function
  - Programmable wait function, through which up to 7 wait states can be inserted for each memory block
  - External wait function via  $\overline{\text{WAIT}}$  pin
- Idle state insertion function
- Bus mastership arbitration function
- Bus hold function
- External device connection enabled via bus control/port alternate function pins

### 4.2 Bus Control Pins

The following pins are used for connection to external devices.

| Bus Control Pin (Function When in Control Mode)                                                                                                                                                                                                                                                                                                                                                     | Function When in Port Mode | Register for Port/Control Mode Switching |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------|------------------------------------------|
| Data bus (D0 to D15)                                                                                                                                                                                                                                                                                                                                                                                | —                          | —                                        |
| Data bus (D16 to D31)                                                                                                                                                                                                                                                                                                                                                                               | PDH0 to PDH15 (Port DH)    | PMCDH                                    |
| Address bus (A0, A1)                                                                                                                                                                                                                                                                                                                                                                                | PAL0, PAL1 (Port AL)       | PMCAL                                    |
| Address bus (A16 to A25)                                                                                                                                                                                                                                                                                                                                                                            | PAH0 to PAH9 (Port AH)     | PMCAH                                    |
| Chip select ( $\overline{\text{CS0}}$ to $\overline{\text{CS7}}$ , $\overline{\text{IOWR}}$ , $\overline{\text{IORD}}$ )                                                                                                                                                                                                                                                                            | PCS0 to PCS7 (Port CS)     | PMCCS                                    |
| SDRAM sync control ( $\overline{\text{SDCKE}}$ )                                                                                                                                                                                                                                                                                                                                                    | PCD0 (Port CD)             | PMCCD                                    |
| Bus clock (BUSCLK)                                                                                                                                                                                                                                                                                                                                                                                  | PCD1 (Port CD)             |                                          |
| SDRAM control ( $\overline{\text{SDCAS}}$ , $\overline{\text{SDRAS}}$ )                                                                                                                                                                                                                                                                                                                             | PCD2, PCD3 (Port CD)       |                                          |
| Read/write control ( $\overline{\text{LLWR}}/\overline{\text{LLBE}}/\overline{\text{LLDQM}}$ , $\overline{\text{LUWR}}/\overline{\text{LUBE}}/\overline{\text{LUDQM}}$ , $\overline{\text{ULWR}}/\overline{\text{ULBE}}/\overline{\text{ULDQM}}$ , $\overline{\text{UUDQM}}/\overline{\text{UUBE}}/\overline{\text{UUWR}}$ , $\overline{\text{RD}}$ , $\overline{\text{WE}}/\overline{\text{WR}}$ ) | PCT0 to PCT5 (Port CT)     | PMCCT                                    |
| Bus cycle start ( $\overline{\text{BCYST}}$ )                                                                                                                                                                                                                                                                                                                                                       | PCT7 (Port CT)             |                                          |
| External wait control ( $\overline{\text{WAIT}}$ )                                                                                                                                                                                                                                                                                                                                                  | PCM0 (Port CM)             | PMCCM                                    |
| Bus hold control ( $\overline{\text{HLDRQ}}$ , $\overline{\text{HLDK}}$ )                                                                                                                                                                                                                                                                                                                           | PCM2, PCM3 (Port CM)       |                                          |
| SDRAM refresh control ( $\overline{\text{REFRQ}}$ )                                                                                                                                                                                                                                                                                                                                                 | PCM4 (Port CM)             |                                          |
| Self-refresh control ( $\overline{\text{SELFREF}}$ )                                                                                                                                                                                                                                                                                                                                                | PCM5 (Port CM)             |                                          |

**Remark** When the system is reset, each bus control pin becomes unconditionally valid. (However, D16 to D31,  $\overline{\text{ULWR}}/\overline{\text{LUBE}}/\overline{\text{ULDQM}}$ , and  $\overline{\text{UUWR}}/\overline{\text{UUBE}}/\overline{\text{UUDQM}}$  are valid only in 32-bit mode.)

**4.2.1 Pin status during internal instruction RAM, internal data RAM, and on-chip peripheral I/O access**

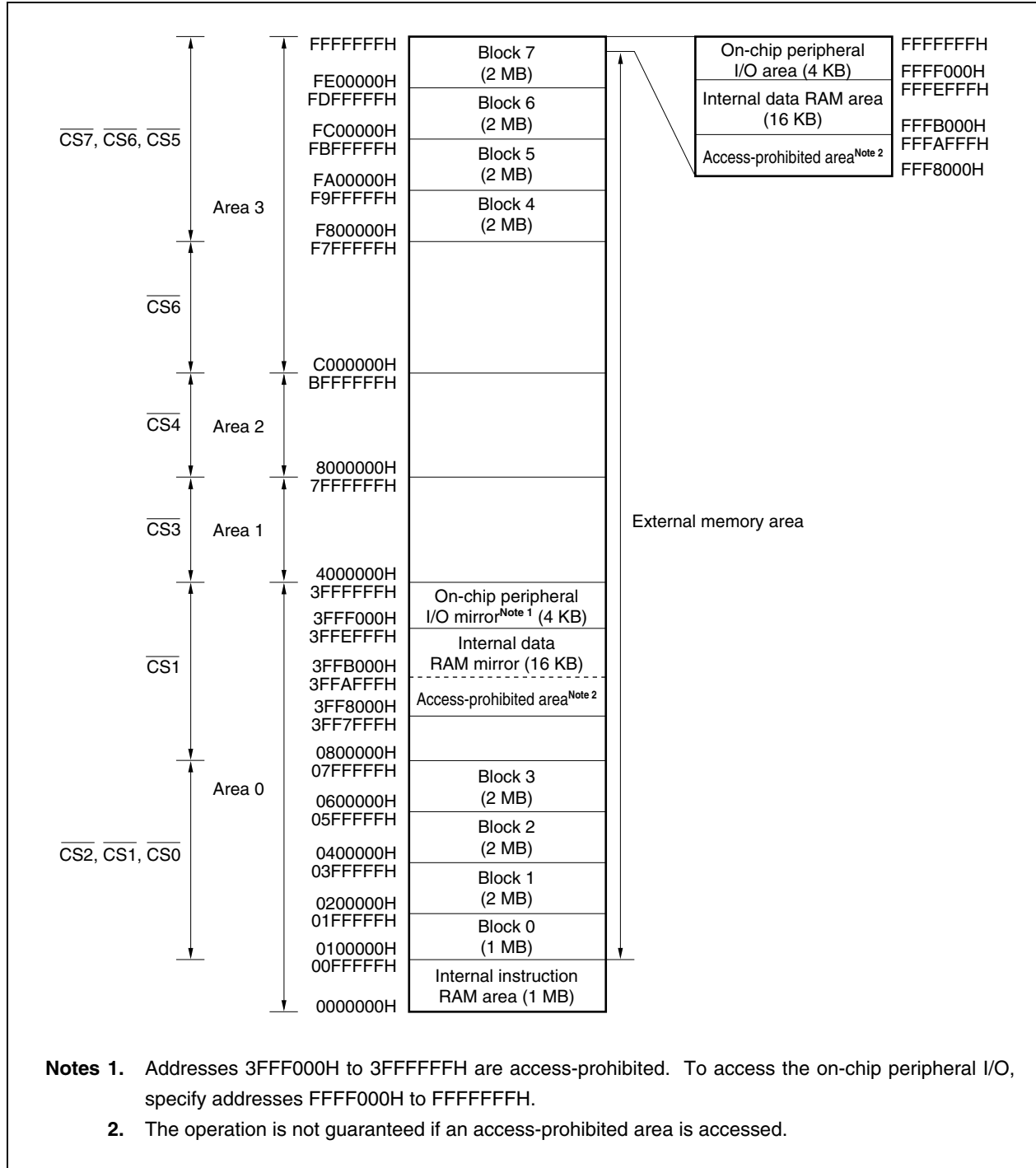
While accessing internal instruction RAM (in the read mode), internal data RAM, and on-chip peripheral I/O, the address bus outputs low level, and the data bus outputs nothing and enters the high-impedance state. The external bus control signals become inactive.

When the internal instruction RAM is accessed (in the write mode), the address bus and data bus output data. The external bus control signals other than  $\overline{\text{UUWR}}$ ,  $\overline{\text{ULWR}}$ ,  $\overline{\text{LUWR}}$ ,  $\overline{\text{LLWR}}$ , and  $\overline{\text{WR}}$  become active. If output of the  $\overline{\text{IOWR}}$  signal is enabled by setting the IOEN bit of the bus cycle period control register (BCP) to 1, the  $\overline{\text{IOWR}}$  signal becomes inactive.

### 4.3 Memory Block Function

The 256 MB memory space is divided into four areas including seven 2 MB memory blocks and one 1 MB memory block.

The area that can be used as program area is the 64 MB space of addresses 0000000H to 3FFFFFFFH.



#### 4.3.1 Chip select control function

Each memory block can be divided by the CSC0 and CSC1 registers to control the chip select signal.

The memory area can be effectively used by dividing it into memory blocks using the chip select control function. The priority order is described below.

##### (1) Chip area select control registers 0, 1 (CSC0, CSC1)

These registers can be read or written in 16-bit units and become valid by setting each bit to 1.

If different chip select signal outputs are set to the same block, the priority order is controlled as follows.

CSC0:  $\overline{CS0} > \overline{CS2} > \overline{CS1}$

CSC1:  $\overline{CS7} > \overline{CS5} > \overline{CS6}$

If the CS0n and CS2n bits of the CSC0 register are cleared to 00,  $\overline{CS1}$  is output to the corresponding block (n = 0 to 3).

Similarly, if the CS5n and CS7n bits of the CSC1 register are cleared to 00,  $\overline{CS6}$  is output to the corresponding block (n = 0 to 3).

**Caution** Write to the CSC0 and CSC1 registers after reset, and then do not change the set value.

|      |                                                                                                                                                                                                                                                                                                                                                                                                                         |      |      |      |      |      |      |      |      |      |      |      |      |      |      |   |   |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |                      |                      |
|------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|---|---|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|----------------------|----------------------|
| CSC0 | <table><tr><td>15</td><td>14</td><td>13</td><td>12</td><td>11</td><td>10</td><td>9</td><td>8</td><td>7</td><td>6</td><td>5</td><td>4</td><td>3</td><td>2</td><td>1</td><td>0</td></tr><tr><td>CS33</td><td>CS32</td><td>CS31</td><td>CS30</td><td>CS23</td><td>CS22</td><td>CS21</td><td>CS20</td><td>CS13</td><td>CS12</td><td>CS11</td><td>CS10</td><td>CS03</td><td>CS02</td><td>CS01</td><td>CS00</td></tr></table> | 15   | 14   | 13   | 12   | 11   | 10   | 9    | 8    | 7    | 6    | 5    | 4    | 3    | 2    | 1 | 0 | CS33 | CS32 | CS31 | CS30 | CS23 | CS22 | CS21 | CS20 | CS13 | CS12 | CS11 | CS10 | CS03 | CS02 | CS01 | CS00 | Address<br>FFFFF060H | After reset<br>2C11H |
| 15   | 14                                                                                                                                                                                                                                                                                                                                                                                                                      | 13   | 12   | 11   | 10   | 9    | 8    | 7    | 6    | 5    | 4    | 3    | 2    | 1    | 0    |   |   |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |                      |                      |
| CS33 | CS32                                                                                                                                                                                                                                                                                                                                                                                                                    | CS31 | CS30 | CS23 | CS22 | CS21 | CS20 | CS13 | CS12 | CS11 | CS10 | CS03 | CS02 | CS01 | CS00 |   |   |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |                      |                      |
| CSC1 | <table><tr><td>15</td><td>14</td><td>13</td><td>12</td><td>11</td><td>10</td><td>9</td><td>8</td><td>7</td><td>6</td><td>5</td><td>4</td><td>3</td><td>2</td><td>1</td><td>0</td></tr><tr><td>CS43</td><td>CS42</td><td>CS41</td><td>CS40</td><td>CS53</td><td>CS52</td><td>CS51</td><td>CS50</td><td>CS63</td><td>CS62</td><td>CS61</td><td>CS60</td><td>CS73</td><td>CS72</td><td>CS71</td><td>CS70</td></tr></table> | 15   | 14   | 13   | 12   | 11   | 10   | 9    | 8    | 7    | 6    | 5    | 4    | 3    | 2    | 1 | 0 | CS43 | CS42 | CS41 | CS40 | CS53 | CS52 | CS51 | CS50 | CS63 | CS62 | CS61 | CS60 | CS73 | CS72 | CS71 | CS70 | Address<br>FFFFF062H | After reset<br>2C11H |
| 15   | 14                                                                                                                                                                                                                                                                                                                                                                                                                      | 13   | 12   | 11   | 10   | 9    | 8    | 7    | 6    | 5    | 4    | 3    | 2    | 1    | 0    |   |   |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |                      |                      |
| CS43 | CS42                                                                                                                                                                                                                                                                                                                                                                                                                    | CS41 | CS40 | CS53 | CS52 | CS51 | CS50 | CS63 | CS62 | CS61 | CS60 | CS73 | CS72 | CS71 | CS70 |   |   |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |                      |                      |

| Bit position | Bit name                             | Function                                             |                                                |      |                                               |      |                                                |      |                                                |      |                                                |              |                         |      |                                                |      |                                                |      |                                                |      |                                                |              |                         |              |                         |      |                                                |      |                                                |      |                                                |      |                                                |              |                         |      |                                                |      |                                                |      |                                                |      |                                                |
|--------------|--------------------------------------|------------------------------------------------------|------------------------------------------------|------|-----------------------------------------------|------|------------------------------------------------|------|------------------------------------------------|------|------------------------------------------------|--------------|-------------------------|------|------------------------------------------------|------|------------------------------------------------|------|------------------------------------------------|------|------------------------------------------------|--------------|-------------------------|--------------|-------------------------|------|------------------------------------------------|------|------------------------------------------------|------|------------------------------------------------|------|------------------------------------------------|--------------|-------------------------|------|------------------------------------------------|------|------------------------------------------------|------|------------------------------------------------|------|------------------------------------------------|
| 15 to 0      | CSnm<br>(n = 0 to 7)<br>(m = 0 to 3) | Chip select is enabled by setting the CSnm bit to 1. |                                                |      |                                               |      |                                                |      |                                                |      |                                                |              |                         |      |                                                |      |                                                |      |                                                |      |                                                |              |                         |              |                         |      |                                                |      |                                                |      |                                                |      |                                                |              |                         |      |                                                |      |                                                |      |                                                |      |                                                |
|              |                                      | CSnm                                                 | CS operation                                   | CS00 | $\overline{CS0}$ output during block 0 access | CS01 | $\overline{CS0}$ output during block 1 access. | CS02 | $\overline{CS0}$ output during block 2 access. | CS03 | $\overline{CS0}$ output during block 3 access. | CS10 to CS13 | Setting has no meaning. | CS20 | $\overline{CS2}$ output during block 0 access. | CS21 | $\overline{CS2}$ output during block 1 access. | CS22 | $\overline{CS2}$ output during block 2 access. | CS23 | $\overline{CS2}$ output during block 3 access. | CS30 to CS33 | Setting has no meaning. | CS40 to CS43 | Setting has no meaning. | CS50 | $\overline{CS5}$ output during block 7 access. | CS51 | $\overline{CS5}$ output during block 6 access. | CS52 | $\overline{CS5}$ output during block 5 access. | CS53 | $\overline{CS5}$ output during block 4 access. | CS60 to CS63 | Setting has no meaning. | CS70 | $\overline{CS7}$ output during block 7 access. | CS71 | $\overline{CS7}$ output during block 6 access. | CS72 | $\overline{CS7}$ output during block 5 access. | CS73 | $\overline{CS7}$ output during block 4 access. |
|              |                                      | CSnm                                                 | CS operation                                   |      |                                               |      |                                                |      |                                                |      |                                                |              |                         |      |                                                |      |                                                |      |                                                |      |                                                |              |                         |              |                         |      |                                                |      |                                                |      |                                                |      |                                                |              |                         |      |                                                |      |                                                |      |                                                |      |                                                |
|              |                                      | CS00                                                 | $\overline{CS0}$ output during block 0 access  |      |                                               |      |                                                |      |                                                |      |                                                |              |                         |      |                                                |      |                                                |      |                                                |      |                                                |              |                         |              |                         |      |                                                |      |                                                |      |                                                |      |                                                |              |                         |      |                                                |      |                                                |      |                                                |      |                                                |
|              |                                      | CS01                                                 | $\overline{CS0}$ output during block 1 access. |      |                                               |      |                                                |      |                                                |      |                                                |              |                         |      |                                                |      |                                                |      |                                                |      |                                                |              |                         |              |                         |      |                                                |      |                                                |      |                                                |      |                                                |              |                         |      |                                                |      |                                                |      |                                                |      |                                                |
|              |                                      | CS02                                                 | $\overline{CS0}$ output during block 2 access. |      |                                               |      |                                                |      |                                                |      |                                                |              |                         |      |                                                |      |                                                |      |                                                |      |                                                |              |                         |              |                         |      |                                                |      |                                                |      |                                                |      |                                                |              |                         |      |                                                |      |                                                |      |                                                |      |                                                |
|              |                                      | CS03                                                 | $\overline{CS0}$ output during block 3 access. |      |                                               |      |                                                |      |                                                |      |                                                |              |                         |      |                                                |      |                                                |      |                                                |      |                                                |              |                         |              |                         |      |                                                |      |                                                |      |                                                |      |                                                |              |                         |      |                                                |      |                                                |      |                                                |      |                                                |
|              |                                      | CS10 to CS13                                         | Setting has no meaning.                        |      |                                               |      |                                                |      |                                                |      |                                                |              |                         |      |                                                |      |                                                |      |                                                |      |                                                |              |                         |              |                         |      |                                                |      |                                                |      |                                                |      |                                                |              |                         |      |                                                |      |                                                |      |                                                |      |                                                |
|              |                                      | CS20                                                 | $\overline{CS2}$ output during block 0 access. |      |                                               |      |                                                |      |                                                |      |                                                |              |                         |      |                                                |      |                                                |      |                                                |      |                                                |              |                         |              |                         |      |                                                |      |                                                |      |                                                |      |                                                |              |                         |      |                                                |      |                                                |      |                                                |      |                                                |
|              |                                      | CS21                                                 | $\overline{CS2}$ output during block 1 access. |      |                                               |      |                                                |      |                                                |      |                                                |              |                         |      |                                                |      |                                                |      |                                                |      |                                                |              |                         |              |                         |      |                                                |      |                                                |      |                                                |      |                                                |              |                         |      |                                                |      |                                                |      |                                                |      |                                                |
|              |                                      | CS22                                                 | $\overline{CS2}$ output during block 2 access. |      |                                               |      |                                                |      |                                                |      |                                                |              |                         |      |                                                |      |                                                |      |                                                |      |                                                |              |                         |              |                         |      |                                                |      |                                                |      |                                                |      |                                                |              |                         |      |                                                |      |                                                |      |                                                |      |                                                |
|              |                                      | CS23                                                 | $\overline{CS2}$ output during block 3 access. |      |                                               |      |                                                |      |                                                |      |                                                |              |                         |      |                                                |      |                                                |      |                                                |      |                                                |              |                         |              |                         |      |                                                |      |                                                |      |                                                |      |                                                |              |                         |      |                                                |      |                                                |      |                                                |      |                                                |
|              |                                      | CS30 to CS33                                         | Setting has no meaning.                        |      |                                               |      |                                                |      |                                                |      |                                                |              |                         |      |                                                |      |                                                |      |                                                |      |                                                |              |                         |              |                         |      |                                                |      |                                                |      |                                                |      |                                                |              |                         |      |                                                |      |                                                |      |                                                |      |                                                |
|              |                                      | CS40 to CS43                                         | Setting has no meaning.                        |      |                                               |      |                                                |      |                                                |      |                                                |              |                         |      |                                                |      |                                                |      |                                                |      |                                                |              |                         |              |                         |      |                                                |      |                                                |      |                                                |      |                                                |              |                         |      |                                                |      |                                                |      |                                                |      |                                                |
|              |                                      | CS50                                                 | $\overline{CS5}$ output during block 7 access. |      |                                               |      |                                                |      |                                                |      |                                                |              |                         |      |                                                |      |                                                |      |                                                |      |                                                |              |                         |              |                         |      |                                                |      |                                                |      |                                                |      |                                                |              |                         |      |                                                |      |                                                |      |                                                |      |                                                |
|              |                                      | CS51                                                 | $\overline{CS5}$ output during block 6 access. |      |                                               |      |                                                |      |                                                |      |                                                |              |                         |      |                                                |      |                                                |      |                                                |      |                                                |              |                         |              |                         |      |                                                |      |                                                |      |                                                |      |                                                |              |                         |      |                                                |      |                                                |      |                                                |      |                                                |
|              |                                      | CS52                                                 | $\overline{CS5}$ output during block 5 access. |      |                                               |      |                                                |      |                                                |      |                                                |              |                         |      |                                                |      |                                                |      |                                                |      |                                                |              |                         |              |                         |      |                                                |      |                                                |      |                                                |      |                                                |              |                         |      |                                                |      |                                                |      |                                                |      |                                                |
|              |                                      | CS53                                                 | $\overline{CS5}$ output during block 4 access. |      |                                               |      |                                                |      |                                                |      |                                                |              |                         |      |                                                |      |                                                |      |                                                |      |                                                |              |                         |              |                         |      |                                                |      |                                                |      |                                                |      |                                                |              |                         |      |                                                |      |                                                |      |                                                |      |                                                |
|              |                                      | CS60 to CS63                                         | Setting has no meaning.                        |      |                                               |      |                                                |      |                                                |      |                                                |              |                         |      |                                                |      |                                                |      |                                                |      |                                                |              |                         |              |                         |      |                                                |      |                                                |      |                                                |      |                                                |              |                         |      |                                                |      |                                                |      |                                                |      |                                                |
|              |                                      | CS70                                                 | $\overline{CS7}$ output during block 7 access. |      |                                               |      |                                                |      |                                                |      |                                                |              |                         |      |                                                |      |                                                |      |                                                |      |                                                |              |                         |              |                         |      |                                                |      |                                                |      |                                                |      |                                                |              |                         |      |                                                |      |                                                |      |                                                |      |                                                |
|              |                                      | CS71                                                 | $\overline{CS7}$ output during block 6 access. |      |                                               |      |                                                |      |                                                |      |                                                |              |                         |      |                                                |      |                                                |      |                                                |      |                                                |              |                         |              |                         |      |                                                |      |                                                |      |                                                |      |                                                |              |                         |      |                                                |      |                                                |      |                                                |      |                                                |
|              |                                      | CS72                                                 | $\overline{CS7}$ output during block 5 access. |      |                                               |      |                                                |      |                                                |      |                                                |              |                         |      |                                                |      |                                                |      |                                                |      |                                                |              |                         |              |                         |      |                                                |      |                                                |      |                                                |      |                                                |              |                         |      |                                                |      |                                                |      |                                                |      |                                                |
|              |                                      | CS73                                                 | $\overline{CS7}$ output during block 4 access. |      |                                               |      |                                                |      |                                                |      |                                                |              |                         |      |                                                |      |                                                |      |                                                |      |                                                |              |                         |              |                         |      |                                                |      |                                                |      |                                                |      |                                                |              |                         |      |                                                |      |                                                |      |                                                |      |                                                |

The following diagram shows the  $\overline{CS}$  signal that is enabled for area 0 when the CSC0 register is set to 0F03H.

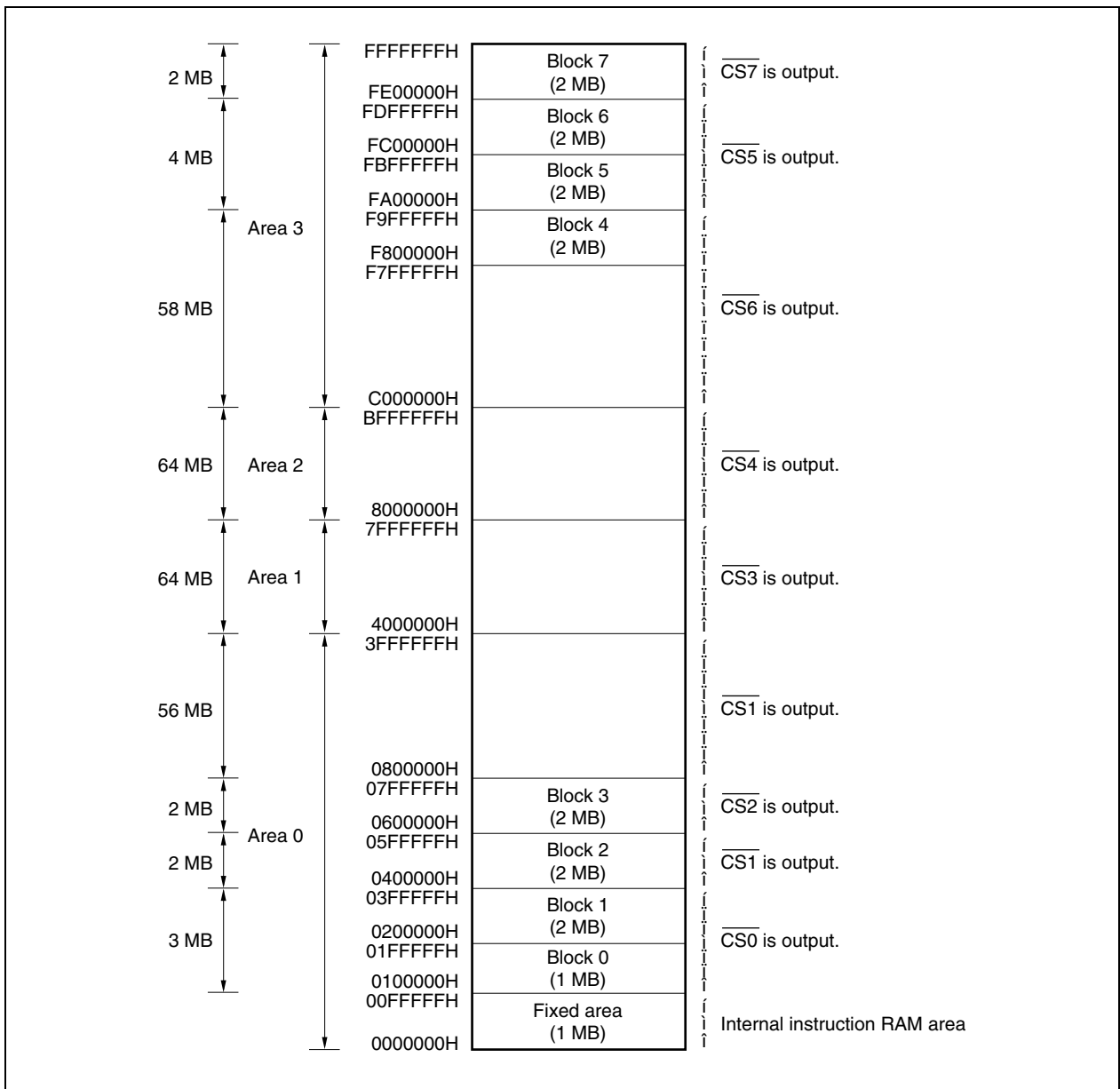
When the CSC0 register is set to 0F03H,  $\overline{CS0}$  and  $\overline{CS2}$  are output to block 0 and block 1, but since  $\overline{CS0}$  has priority over  $\overline{CS2}$ ,  $\overline{CS0}$  is output if the addresses of block 0 and block 1 are accessed.

If the addresses of block 2 and block 3 are accessed,  $\overline{CS2}$  is output.

If the addresses of area 0 other than blocks 0 to 3 are accessed,  $\overline{CS1}$  is output.

The following shows an example when the CSC0 register is set to 0803H and the CSC1 register is set to 0601H.

Figure 4-1. Example When CSC0 Register Is Set to 0803H and CSC1 Register Is Set to 0601H



## 4.4 Bus Cycle Type Control Function

In the V850E/ME2, the following external devices can be connected directly to each memory block.

- SRAM, external ROM, external I/O
- Page ROM
- SDRAM

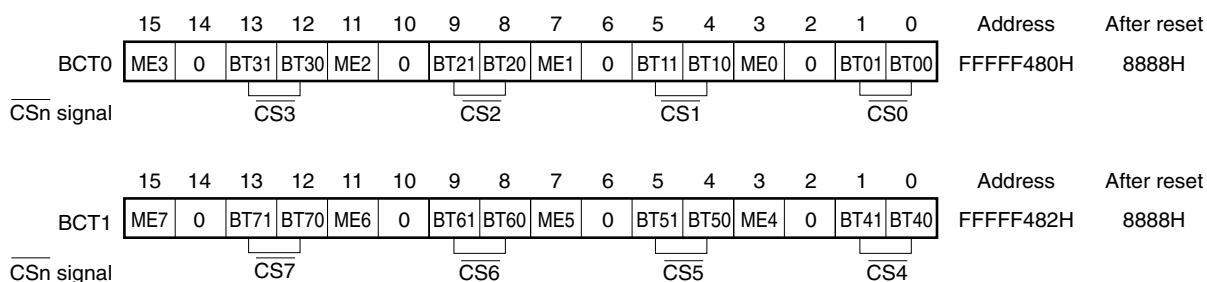
Connected external devices are specified by the BCT0 and BCT1 registers.

### (1) Bus cycle type configuration registers 0, 1 (BCT0, BCT1)

These registers can be read or written in 16-bit units.

Be sure to clear bits 14, 10, 6, and 2 to 0. If they are set to 1, the operation is not guaranteed.

**Caution** Write to the BCT0 and BCT1 registers after reset, and then do not change the set value (however, the MEn bit value can be changed). Also, do not access an external memory area other than the one for this initialization routine until the initial setting of the BCT0 and BCT1 registers is complete. However, it is possible to access external memory areas whose initialization settings are complete.



| Bit position             | Bit name   | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |      |      |                                                      |   |   |                    |   |   |          |   |   |                    |   |   |                                                             |
|--------------------------|------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|------|------------------------------------------------------|---|---|--------------------|---|---|----------|---|---|--------------------|---|---|-------------------------------------------------------------|
| 15, 11, 7, 3             | MEn        | Sets memory controller operation enable for each chip select.<br>0: Operation disabled<br>1: Operation enabled                                                                                                                                                                                                                                                                                                                                                                        |      |      |                                                      |   |   |                    |   |   |          |   |   |                    |   |   |                                                             |
| 13, 12, 9, 8, 5, 4, 1, 0 | BTn1, BTn0 | Specifies the device to be connected to the $\overline{CSn}$ signal. <table border="1"> <tr> <th>BTn1</th><th>BTn0</th><th>External device connected to <math>\overline{CSn}</math> signal</th></tr> <tr> <td>0</td><td>0</td><td>SRAM, external I/O</td></tr> <tr> <td>0</td><td>1</td><td>Page ROM</td></tr> <tr> <td>1</td><td>0</td><td>Setting prohibited</td></tr> <tr> <td>1</td><td>1</td><td>n = 1, 3, 4, 6: SDRAM<br/>n = 0, 2, 5, 7: Setting prohibited</td></tr> </table> | BTn1 | BTn0 | External device connected to $\overline{CSn}$ signal | 0 | 0 | SRAM, external I/O | 0 | 1 | Page ROM | 1 | 0 | Setting prohibited | 1 | 1 | n = 1, 3, 4, 6: SDRAM<br>n = 0, 2, 5, 7: Setting prohibited |
| BTn1                     | BTn0       | External device connected to $\overline{CSn}$ signal                                                                                                                                                                                                                                                                                                                                                                                                                                  |      |      |                                                      |   |   |                    |   |   |          |   |   |                    |   |   |                                                             |
| 0                        | 0          | SRAM, external I/O                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |      |      |                                                      |   |   |                    |   |   |          |   |   |                    |   |   |                                                             |
| 0                        | 1          | Page ROM                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |      |      |                                                      |   |   |                    |   |   |          |   |   |                    |   |   |                                                             |
| 1                        | 0          | Setting prohibited                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |      |      |                                                      |   |   |                    |   |   |          |   |   |                    |   |   |                                                             |
| 1                        | 1          | n = 1, 3, 4, 6: SDRAM<br>n = 0, 2, 5, 7: Setting prohibited                                                                                                                                                                                                                                                                                                                                                                                                                           |      |      |                                                      |   |   |                    |   |   |          |   |   |                    |   |   |                                                             |

**Remark** n = 0 to 7



## 4.5 Bus Access

### 4.5.1 Number of access clocks

The number of base clocks necessary for accessing each resource is as follows.

| Resource (Bus Width)               | Bus Cycle Configuration | Instruction Fetch | Operand Data Access |                   |
|------------------------------------|-------------------------|-------------------|---------------------|-------------------|
|                                    |                         |                   | Read                | Write             |
| Internal instruction RAM (32 bits) |                         | 1                 | 1                   | 2 <sup>Note</sup> |
| Internal data RAM (32 bits)        |                         | –                 | 1                   |                   |

**Note** Since the internal instruction RAM (in the write mode) is accessed using BUSCLK (internal instruction RAM (in the read mode) is accessed using the internal system clock ( $f_{CLK}$ )), programmable waits, address setup waits, and idle states can be inserted for the CS0 space.

**Remark** Unit: Clock/access

### 4.5.2 Bus sizing function

The bus sizing function controls the data bus width for each CS space. The data bus width is specified by using the LBS register.

#### (1) Local bus sizing control register (LBS)

This register can be read or written in 16-bit units.

**Cautions** 1. Write to the LBS register after reset, and then do not change the set value. Also, do not access an external memory area other than the one for this initialization routine until the initial setting of the LBS register is complete. However, it is possible to access external memory areas whose initialization settings are complete.

2. When the data bus width is specified as 8 bits, only the signal shown below becomes active.

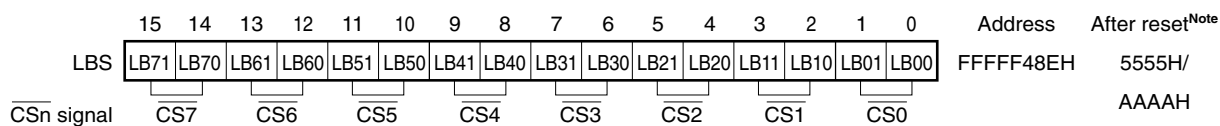
LLWR: When accessing SRAM, external ROM, or external I/O (write cycle)

3. When the data bus width is specified as 16 bits, only the signals shown below become active.

LLWR, LUWR: When accessing SRAM, external ROM, or external I/O (write cycle)

4. When starting the V850E/ME2 in the 16-bit mode and using a 32-bit bus width, set the BMODCN bit of the PFCDH register to 1 in addition to the LBS register.

<R>



**Note** When in 32-bit mode: AAAAH

When in 16-bit mode: 5555H

For details of 32-bit mode and 16-bit mode, see **3.3.1 Operating modes**.

| Bit position | Bit name   | Function                                                                                                                                                                                                                                                                                                                           |      |      |                             |   |   |        |   |   |         |   |   |         |   |   |  |
|--------------|------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|------|-----------------------------|---|---|--------|---|---|---------|---|---|---------|---|---|--|
| 15 to 0      | LBn1, LBn0 | Sets the data bus width of the CSn space. <table border="1"> <tr> <th>LBn1</th><th>LBn0</th><th>Data bus width of CSn space</th></tr> <tr> <td>0</td><td>0</td><td>8 bits</td></tr> <tr> <td>0</td><td>1</td><td>16 bits</td></tr> <tr> <td>1</td><td>0</td><td>32 bits</td></tr> <tr> <td>1</td><td>1</td><td></td></tr> </table> | LBn1 | LBn0 | Data bus width of CSn space | 0 | 0 | 8 bits | 0 | 1 | 16 bits | 1 | 0 | 32 bits | 1 | 1 |  |
| LBn1         | LBn0       | Data bus width of CSn space                                                                                                                                                                                                                                                                                                        |      |      |                             |   |   |        |   |   |         |   |   |         |   |   |  |
| 0            | 0          | 8 bits                                                                                                                                                                                                                                                                                                                             |      |      |                             |   |   |        |   |   |         |   |   |         |   |   |  |
| 0            | 1          | 16 bits                                                                                                                                                                                                                                                                                                                            |      |      |                             |   |   |        |   |   |         |   |   |         |   |   |  |
| 1            | 0          | 32 bits                                                                                                                                                                                                                                                                                                                            |      |      |                             |   |   |        |   |   |         |   |   |         |   |   |  |
| 1            | 1          |                                                                                                                                                                                                                                                                                                                                    |      |      |                             |   |   |        |   |   |         |   |   |         |   |   |  |

**Remark** n = 0 to 7

### 4.5.3 Endian control function

The endian control function can be used to set processing of word data in memory using either the big endian method or the little endian method for each CS space selected with the chip select signals ( $\overline{CS0}$  to  $\overline{CS7}$ ). Switching of the endian method is specified using the BEC register.

**Caution** In the following areas, the data processing method is fixed to little endian, so the setting of the BEC register is invalid.

- On-chip peripheral I/O area
- Internal instruction RAM area
- Internal data RAM area
- Area same as internal data RAM area of addresses 3FF8000H to 3FFBFFFFH
- Program fetch area for external memory

#### (1) Endian configuration register (BEC)

This register can be read or written in 16-bit units.

Be sure to clear bits 15, 13, 11, 9, 7, 5, 3, and 1 to 0. If they are set to 1, the operation is not guaranteed.

**Caution** Write to the BEC register after reset, and then do not change the set value.

|                         |                  |      |                  |      |                  |      |                  |      |                  |      |                  |      |                  |      |                  |      |                      |                      |
|-------------------------|------------------|------|------------------|------|------------------|------|------------------|------|------------------|------|------------------|------|------------------|------|------------------|------|----------------------|----------------------|
|                         | 15               | 14   | 13               | 12   | 11               | 10   | 9                | 8    | 7                | 6    | 5                | 4    | 3                | 2    | 1                | 0    |                      |                      |
| BEC                     | 0                | BE70 | 0                | BE60 | 0                | BE50 | 0                | BE40 | 0                | BE30 | 0                | BE20 | 0                | BE10 | 0                | BE00 | Address<br>FFFFF068H | After reset<br>0000H |
| $\overline{CSn}$ signal | $\overline{CS7}$ |      | $\overline{CS6}$ |      | $\overline{CS5}$ |      | $\overline{CS4}$ |      | $\overline{CS3}$ |      | $\overline{CS2}$ |      | $\overline{CS1}$ |      | $\overline{CS0}$ |      |                      |                      |

| Bit position                 | Bit name          | Function                                                                        |
|------------------------------|-------------------|---------------------------------------------------------------------------------|
| 14, 12, 10, 8,<br>6, 4, 2, 0 | BE <sub>n</sub> 0 | Specifies the endian method.<br>0: Little endian method<br>1: Big endian method |

**Remark** n = 0 to 7

**Figure 4-2. Big Endian Addresses Within Word**

|       |       |       |       |    |   |   |   |
|-------|-------|-------|-------|----|---|---|---|
| 31    | 24    | 23    | 16    | 15 | 8 | 7 | 0 |
| 0008H | 0009H | 000AH | 000BH |    |   |   |   |
| 0004H | 0005H | 0006H | 0007H |    |   |   |   |
| 0000H | 0001H | 0002H | 0003H |    |   |   |   |

**Figure 4-3. Little Endian Addresses Within Word**

|       |       |       |       |    |   |   |   |
|-------|-------|-------|-------|----|---|---|---|
| 31    | 24    | 23    | 16    | 15 | 8 | 7 | 0 |
| 000BH | 000AH | 0009H | 0008H |    |   |   |   |
| 0007H | 0006H | 0005H | 0004H |    |   |   |   |
| 0003H | 0002H | 0001H | 0000H |    |   |   |   |

#### 4.5.4 Big endian method usage restrictions in NEC Electronics development tools

##### (1) When using a debugger (ID850)

The big endian method is supported only in the memory window display.

##### (2) When using a compiler (CA850)

###### (a) Restrictions in C language

- (i) There are restrictions for variables allocated to/located in the big endian space, as shown below.
  - union cannot be used.
  - bitfield cannot be used.
  - Access with cast (changing access size) cannot be used.
  - Variables with initial values cannot be used.
- (ii) It is necessary to specify the following optimization inhibit options because optimization may cause a change in the access size.
  - For global optimization part (opt850)... -Wo, -XTb
  - For optimization depending on model part (impr850)... -Wi, +arg\_reg\_opt=OFF, +std\_trans\_opt=OFF

The specification of the optimization inhibit options shown above is not necessary, however, if the access is not an access with cast or with masking/shifting<sup>Note</sup>.

**Note** This is on the condition that a pattern that may cause the following optimization is not used. However, because it is very difficult for users to check the patterns completely in cases such as when several patterns are mixed (especially for optimization depending on model part), it is recommended that the optimization inhibit options shown above be specified.

**[Related global optimization part]**

- 1-bit set using bit or  
int i;  
i ^=1;
- 1-bit clear using bit and  
i &= ~1;
- 1-bit not using bit xor  
i ^= 1;
- 1-bit test using bit and  
if(i & 1);

**[Related optimization depending on model part]**

Accessing the same variable in a different size

- Cast
- Mask
- Shift

**Example**

```
int i, *ip;
char c;
:
c=*( (char*)ip);
:
c = 0xff & i;
:
i = (i<<24) >>24;
```

**(b) Restrictions in assembly language**

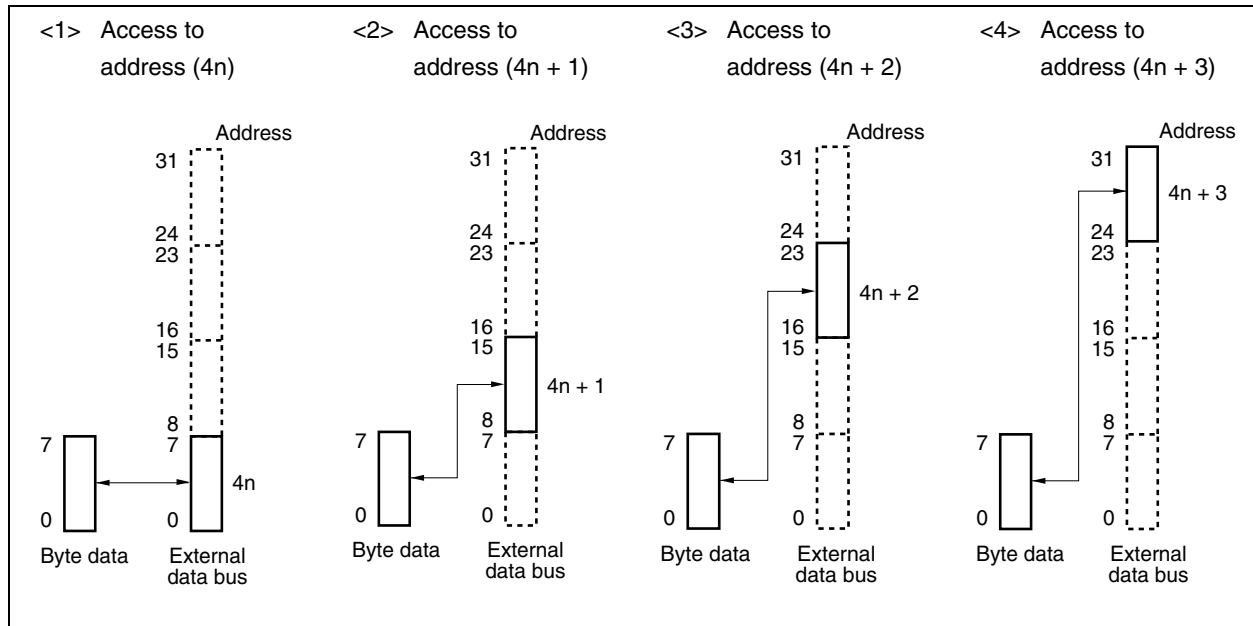
For variables allocated in the big endian space, a quasi directive that secures an area of other than byte size (.hword, .word, .float, .shword) cannot be used.

### 4.5.5 Bus width

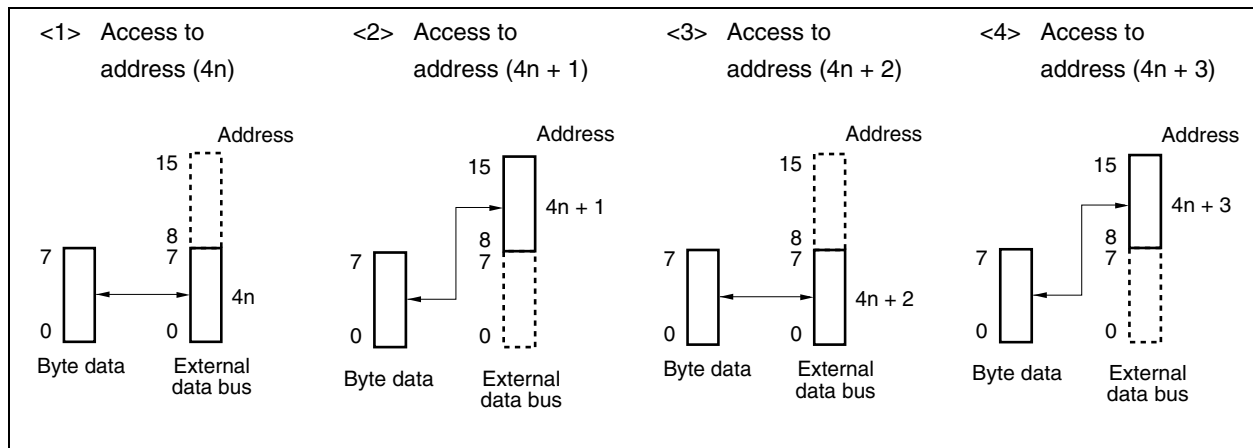
The V850E/ME2 accesses on-chip peripheral I/O and external memory in 8-bit, 16-bit, or 32-bit units. The following shows the operation for each type of access. All data is accessed in order starting from the lower order side.

#### (1) Byte access (8 bits)

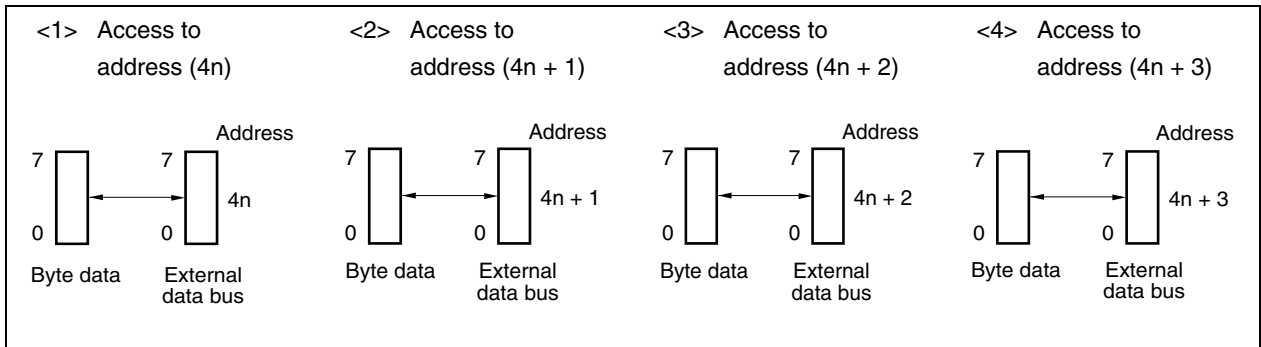
##### (a) When the data bus width is 32 bits (little endian)



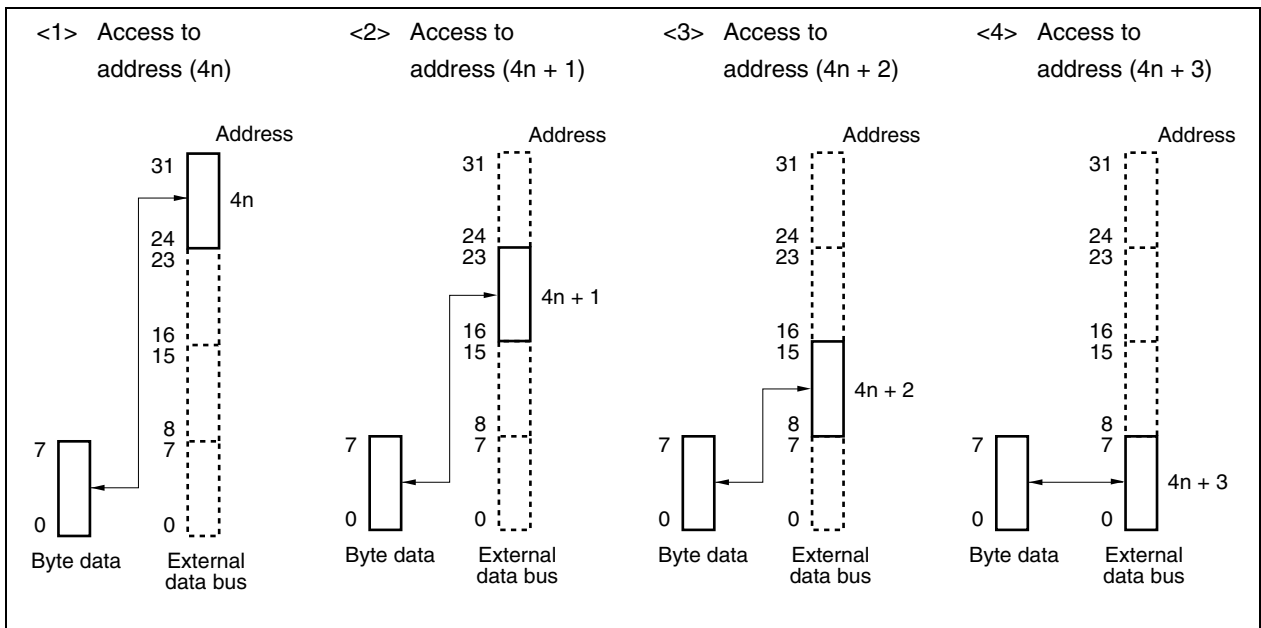
##### (b) When the data bus width is 16 bits (little endian)



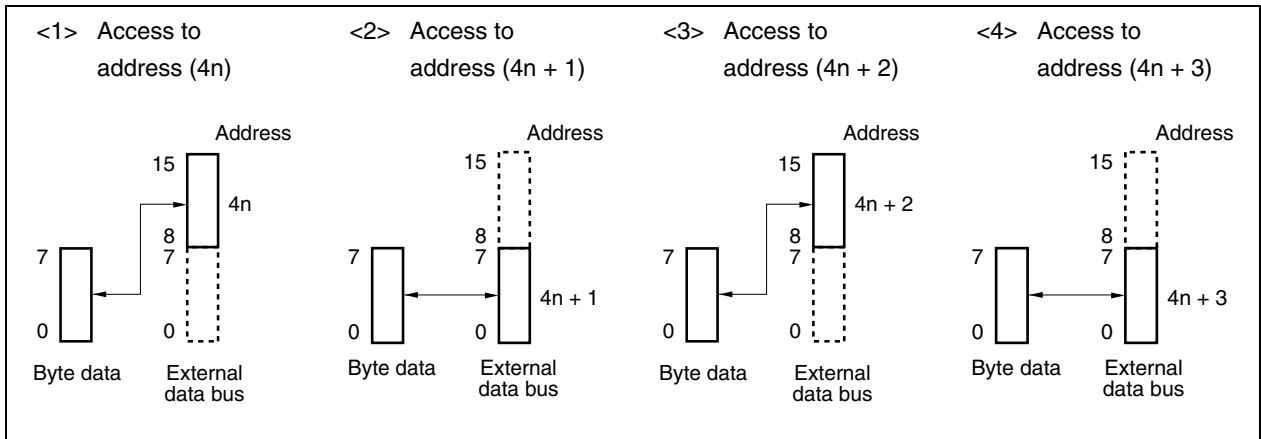
(c) When the data bus width is 8 bits (little endian)



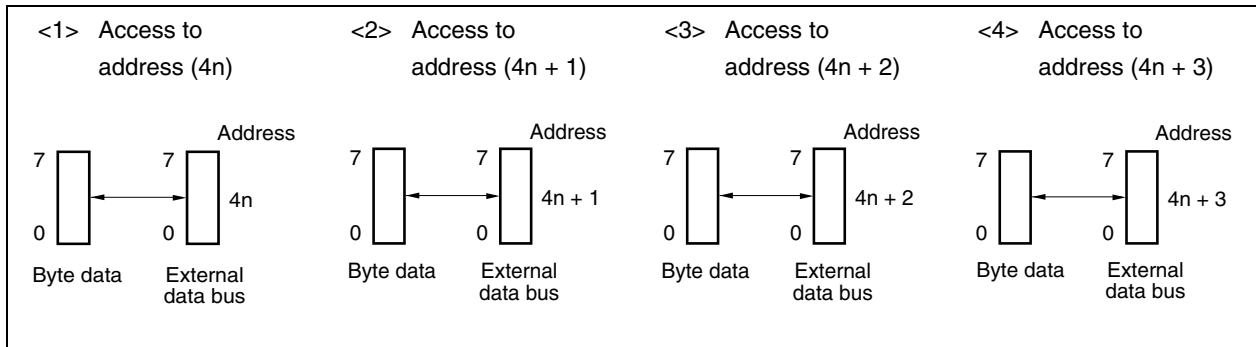
(d) When the data bus width is 32 bits (big endian)



(e) When the data bus width is 16 bits (big endian)



(f) When the data bus width is 8 bits (big endian)

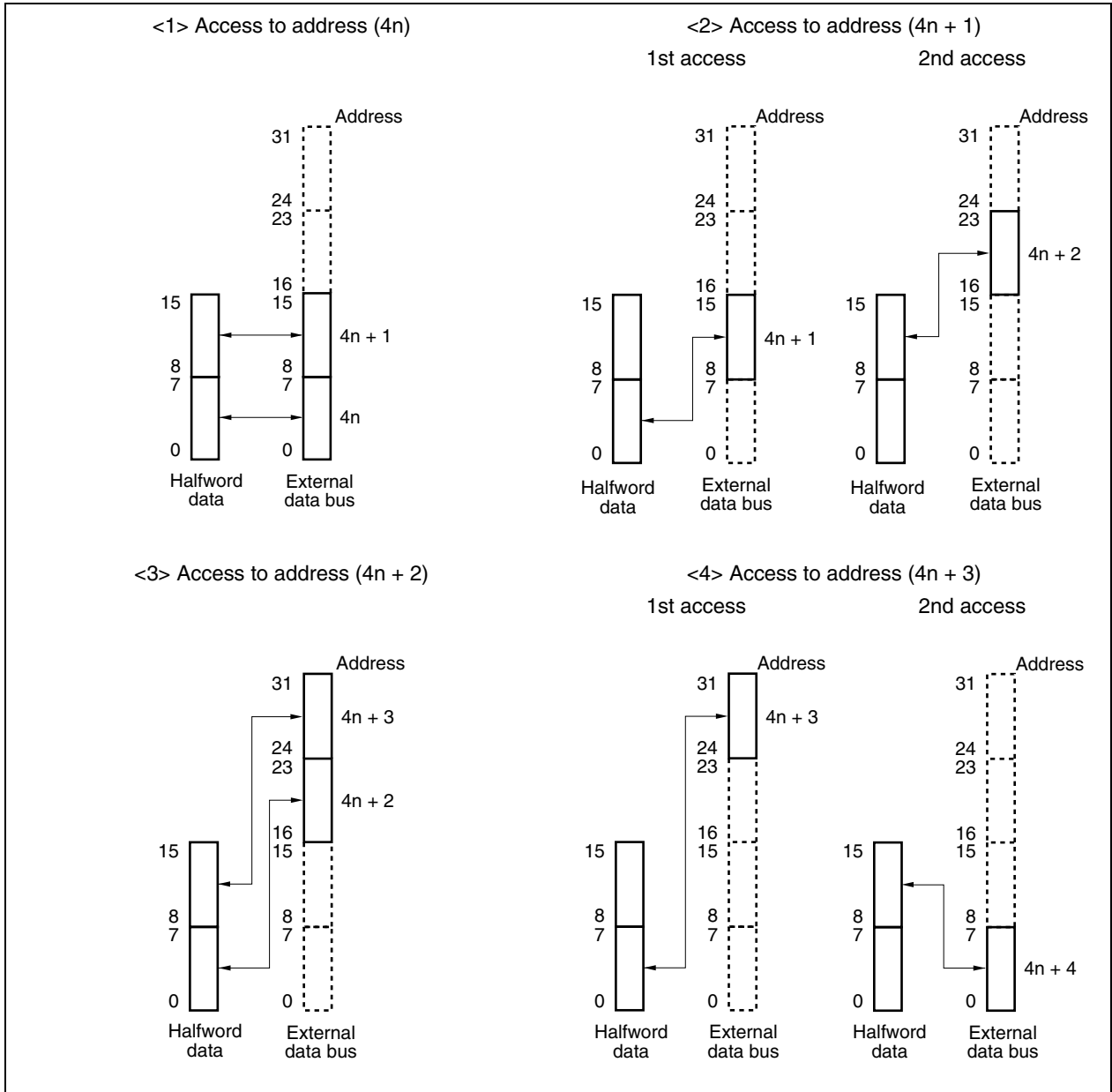




(2) Halfword access (16 bits)

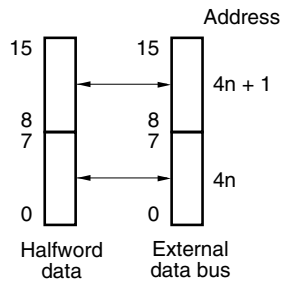
(a) When the data bus width is 32 bits (little endian)

<R>

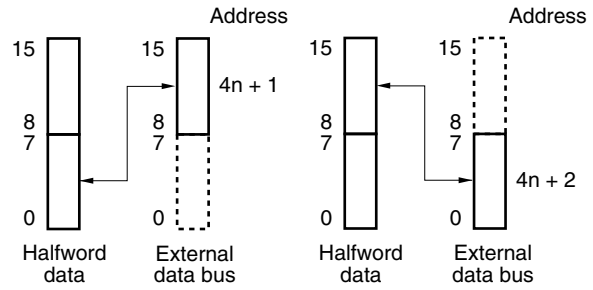


(b) When the data bus width is 16 bits (little endian)

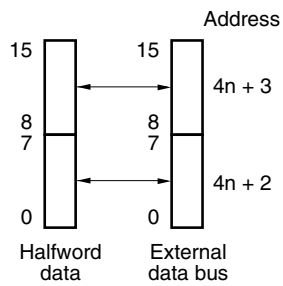
<1> Access to address ( $4n$ )



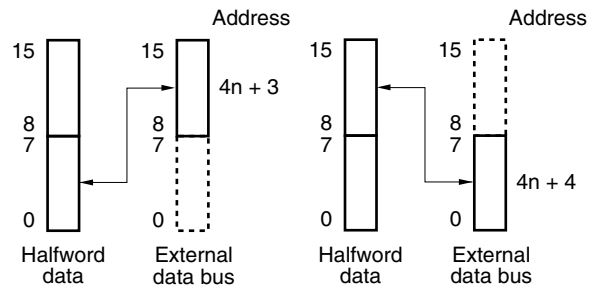
<2> Access to address ( $4n + 1$ )  
1st access 2nd access



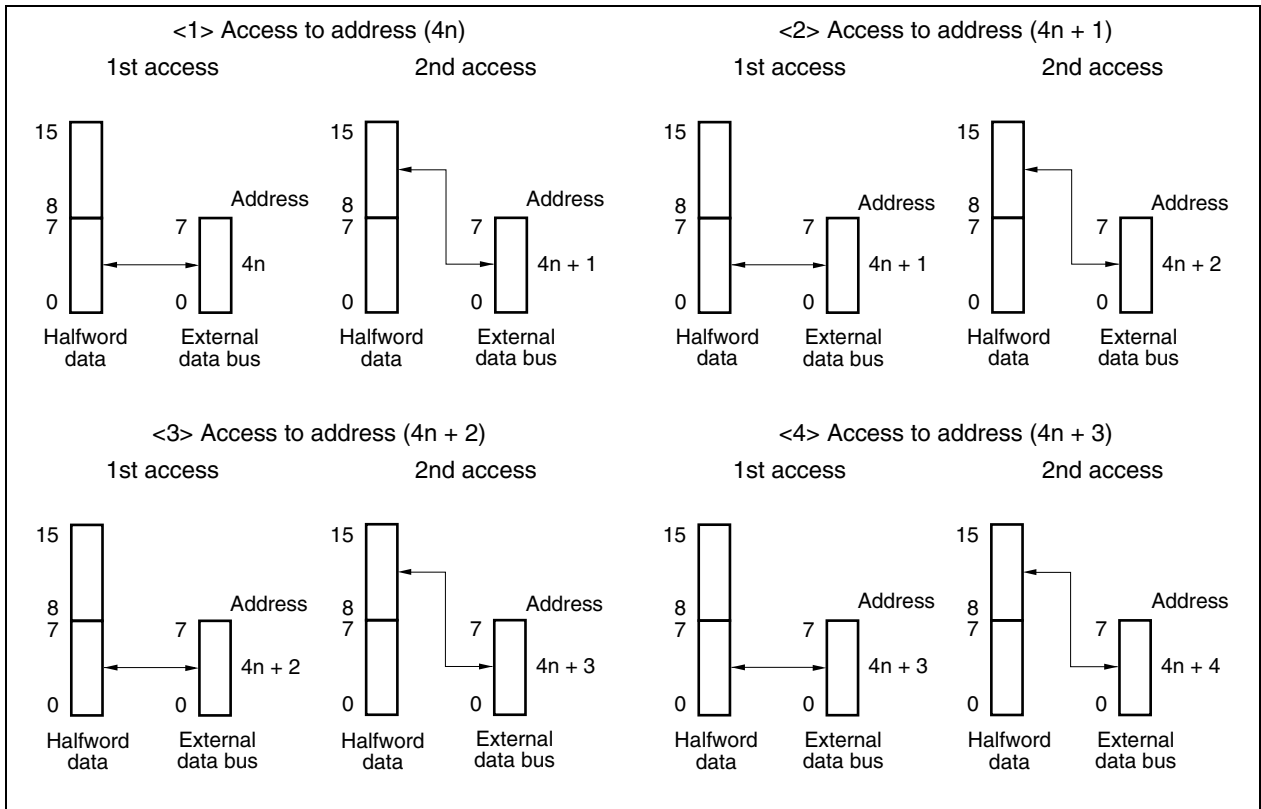
<3> Access to address ( $4n + 2$ )

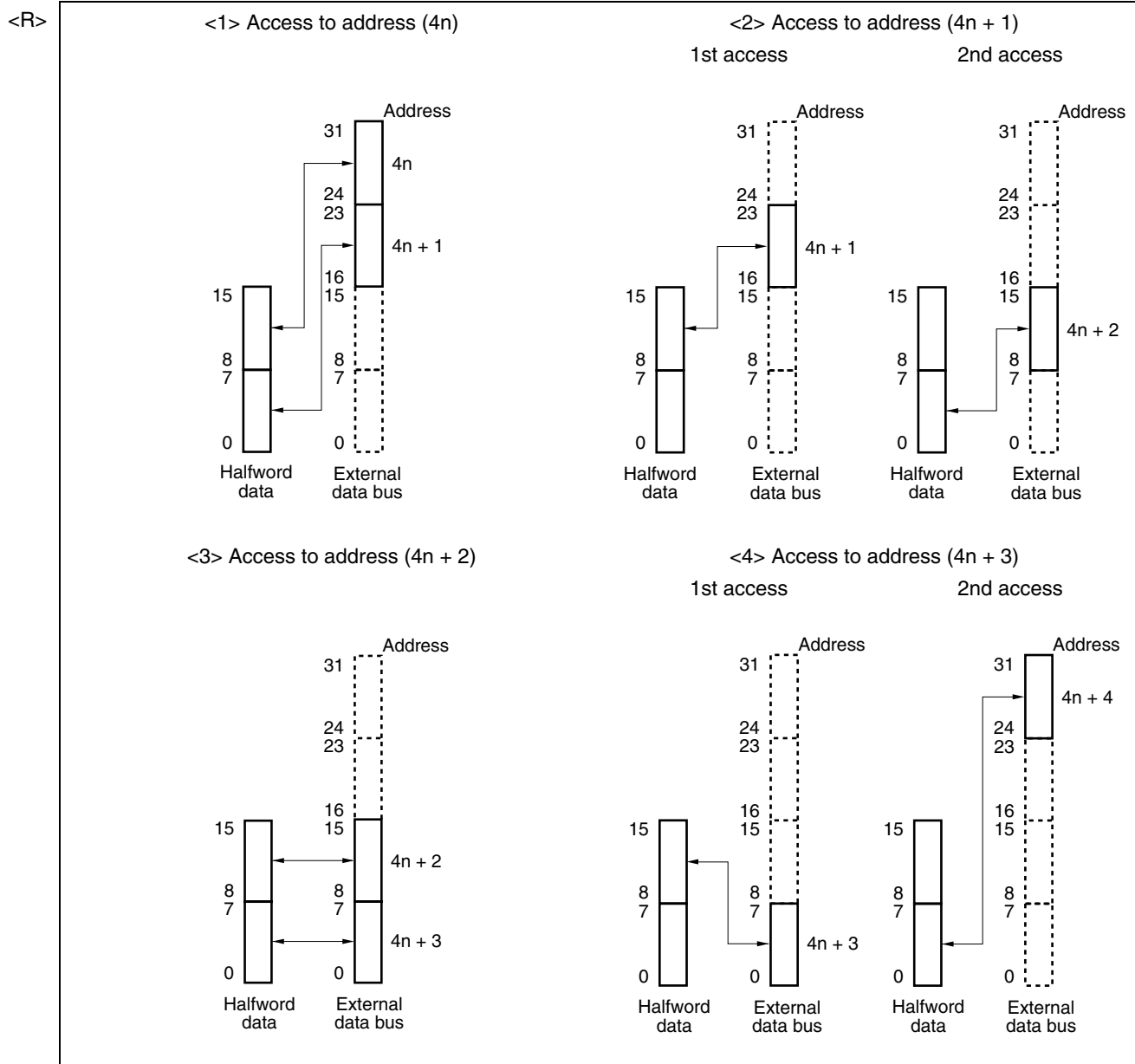


<4> Access to address ( $4n + 3$ )  
1st access 2nd access

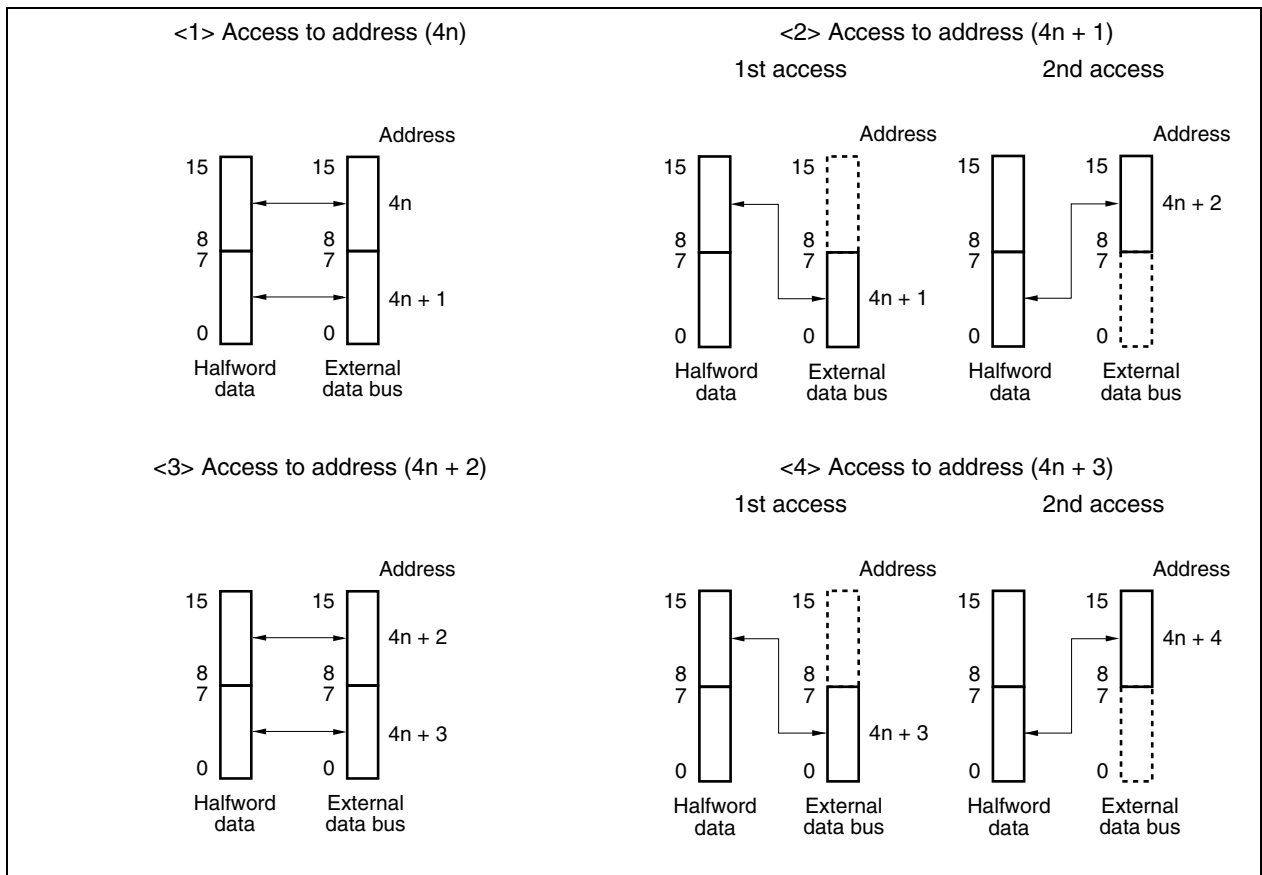


(c) When the data bus width is 8 bits (little endian)

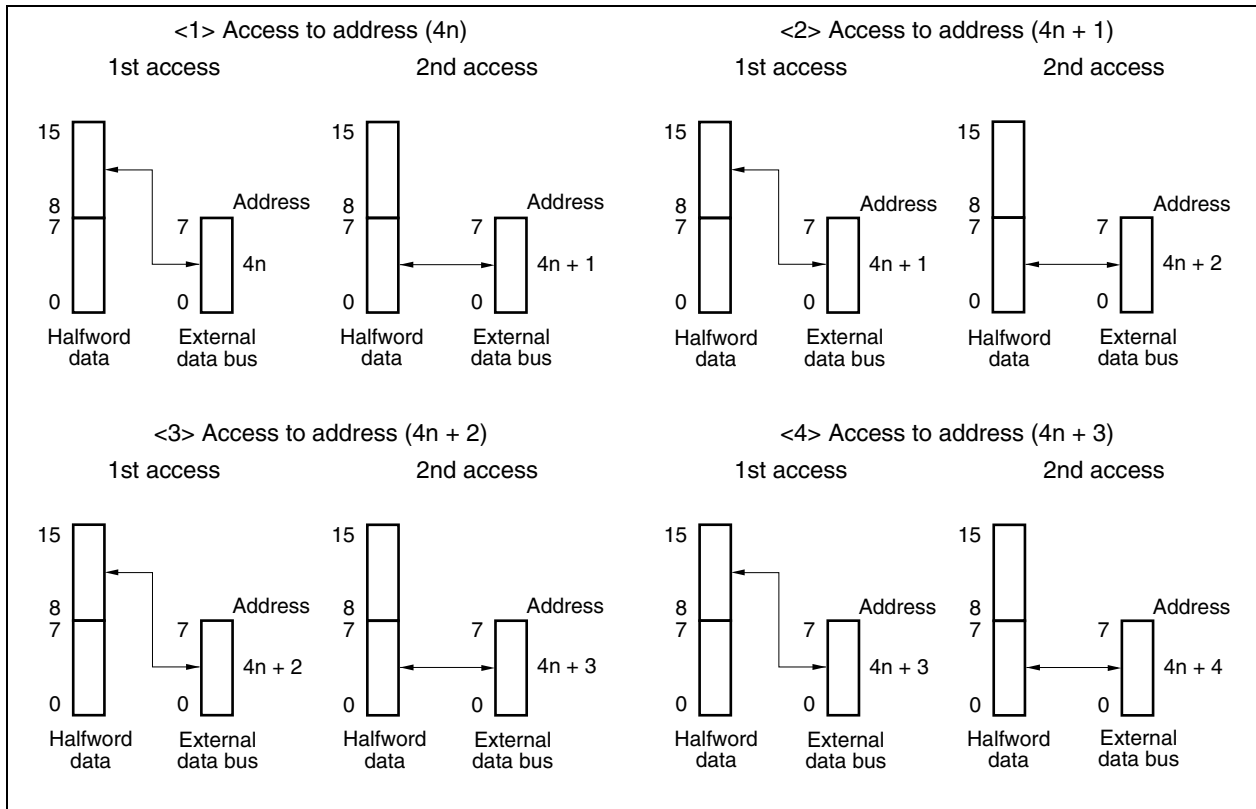


**(d) When the data bus width is 32 bits (big endian)**

(e) When the data bus width is 16 bits (big endian)



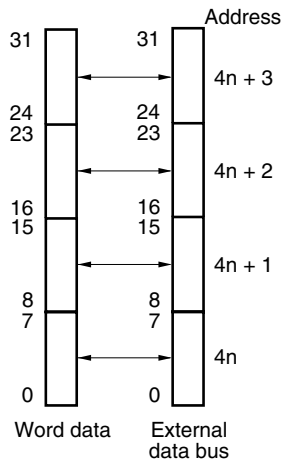
(f) When the data bus width is 8 bits (big endian)



(3) Word access (32 bits)

(a) When the data bus width is 32 bits (little endian) (1/2)

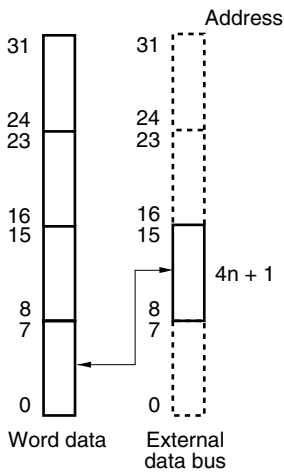
<1> Access to address ( $4n$ )



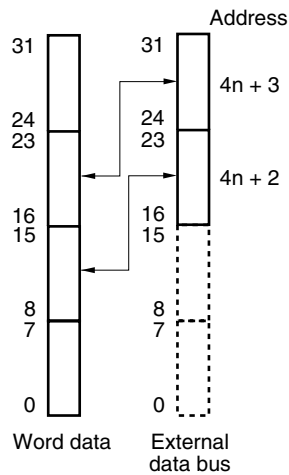
<R>

<2> Access to address ( $4n + 1$ )

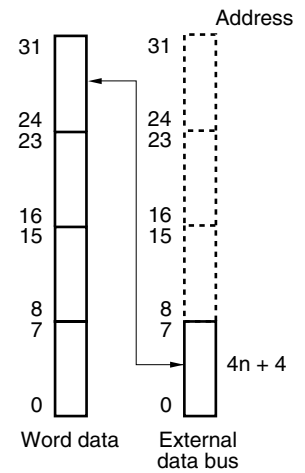
1st access



2nd access



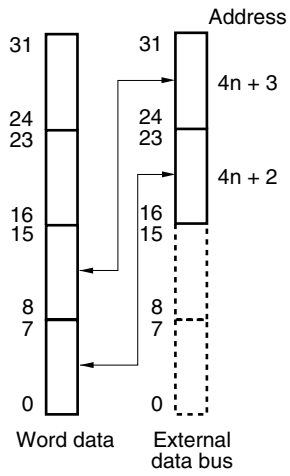
3rd access



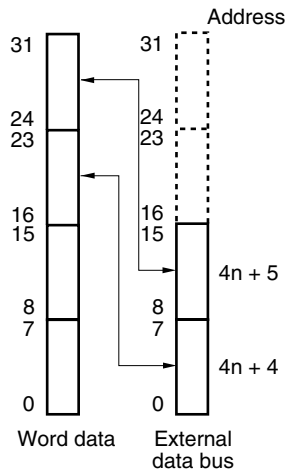
(a) When the data bus width is 32 bits (little endian) (2/2)

<3> Access to address ( $4n + 2$ )

1st access



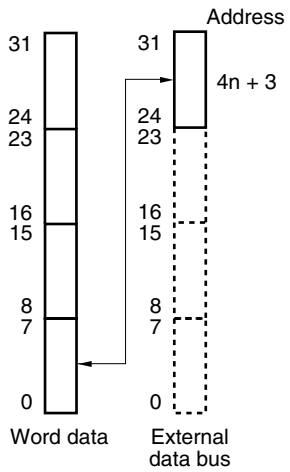
2nd access



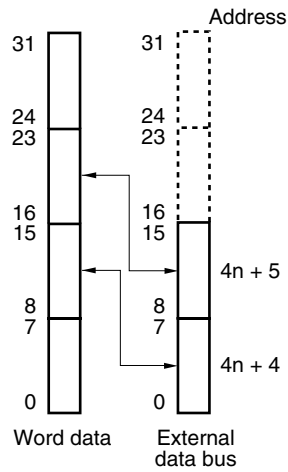
<R>

<4> Access to address ( $4n + 3$ )

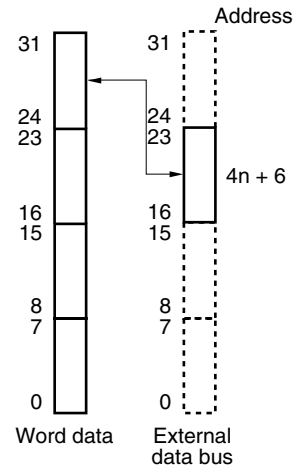
1st access



2nd access

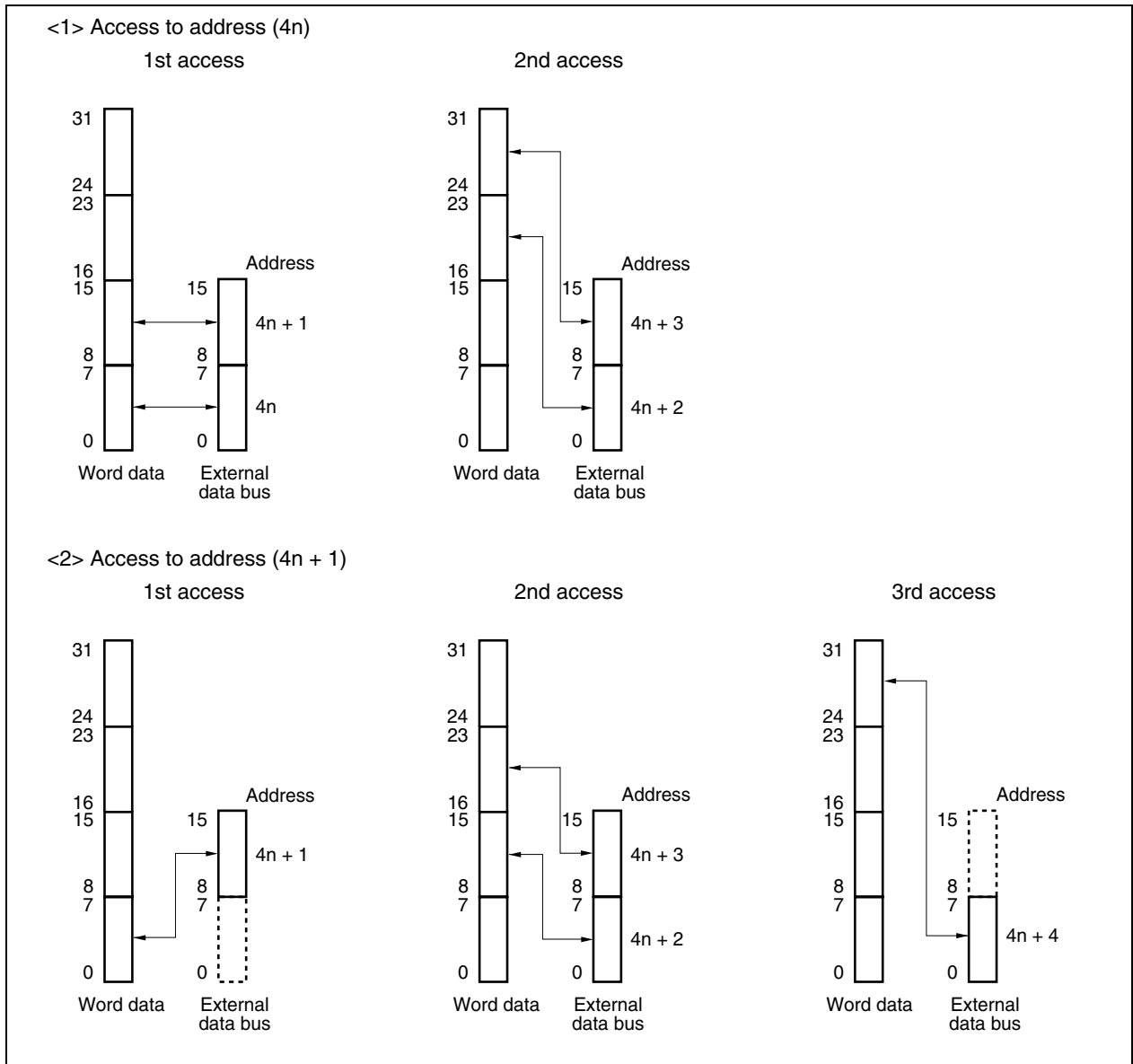


3rd access



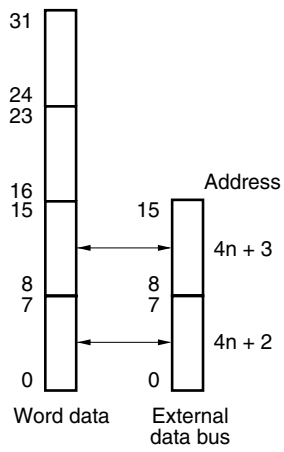


(b) When the data bus width is 16 bits (little endian) (1/2)

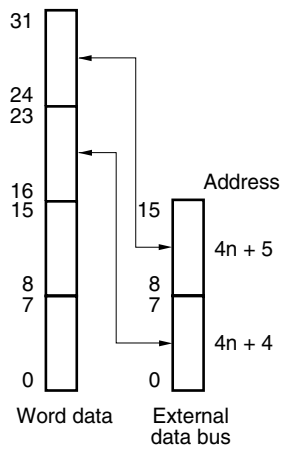


**(b) When the data bus width is 16 bits (little endian) (2/2)**<3> Access to address ( $4n + 2$ )

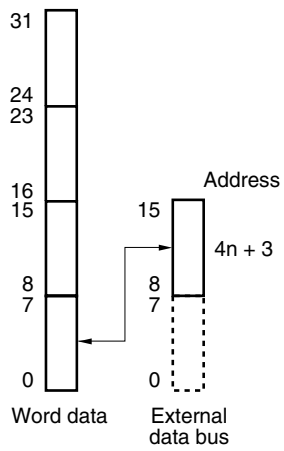
1st access



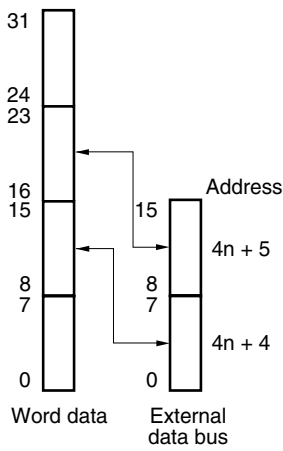
2nd access

<4> Access to address ( $4n + 3$ )

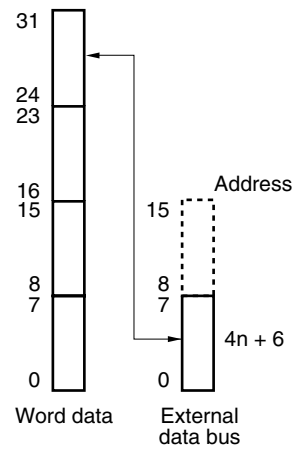
1st access



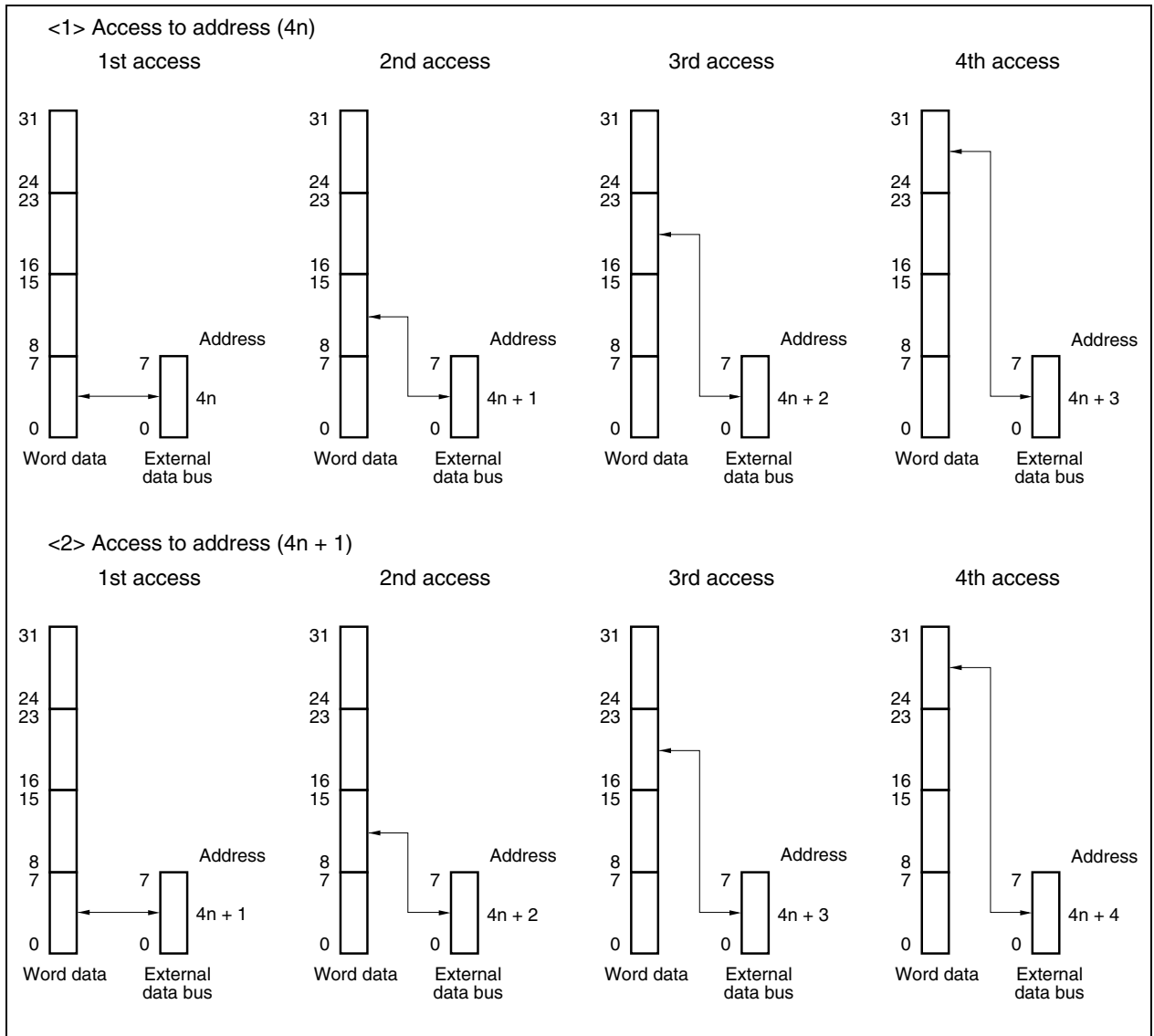
2nd access



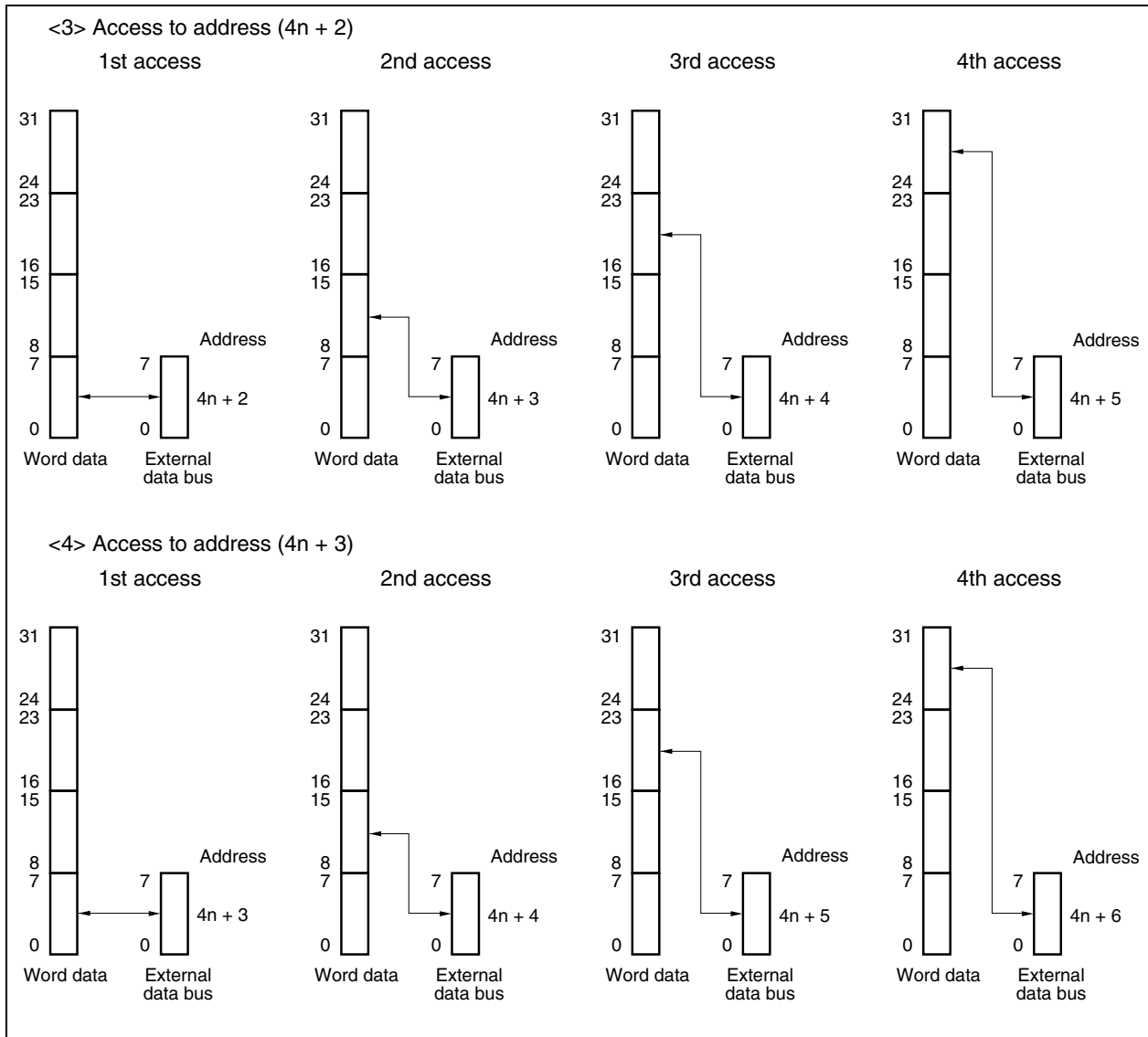
3rd access



(c) When the data bus width is 8 bits (little endian) (1/2)

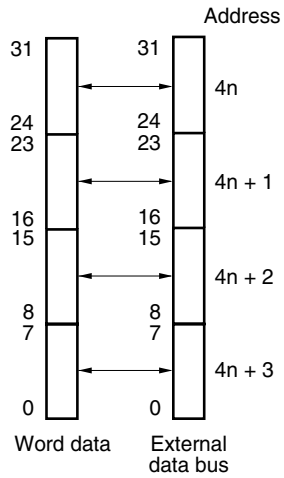


(c) When the data bus width is 8 bits (little endian) (2/2)



(d) When the data bus width is 32 bits (big endian) (1/2)

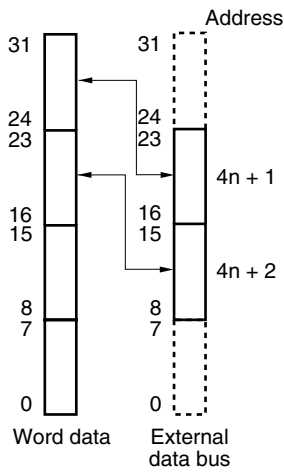
<1> Access to address (4n)



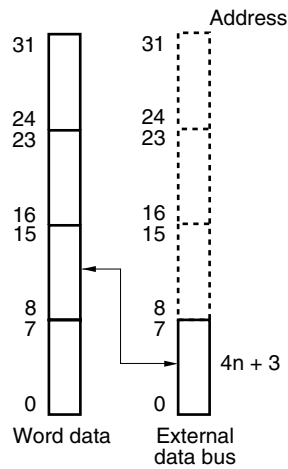
<R>

<2> Access to address ( $4n + 1$ )

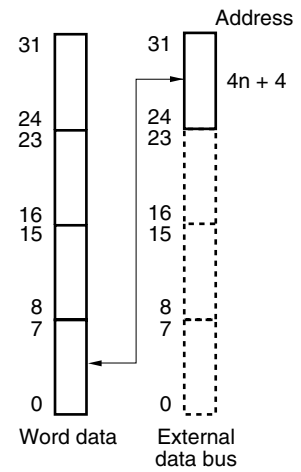
1st access



2nd access

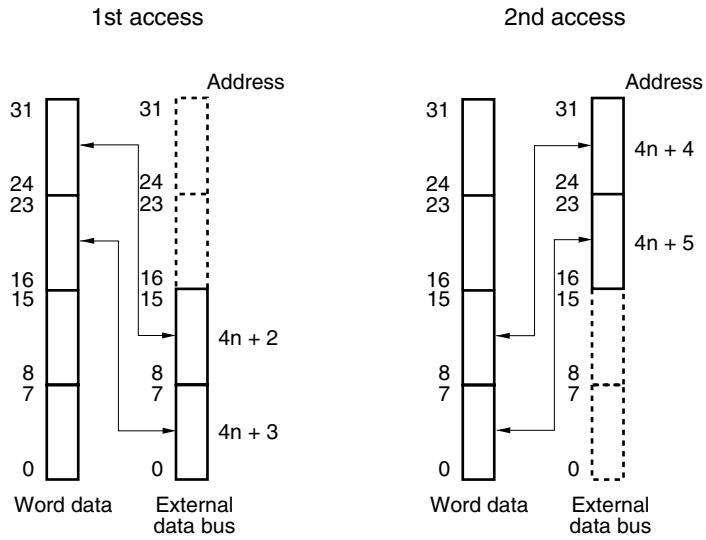


3rd access



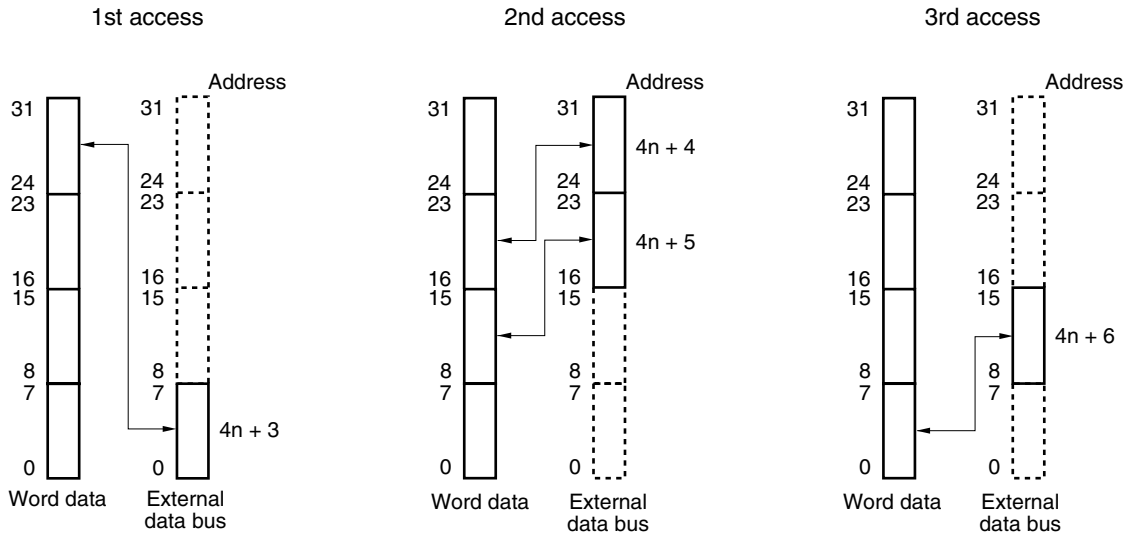
(d) When the data bus width is 32 bits (big endian) (2/2)

<3> Access to address  $(4n + 2)$

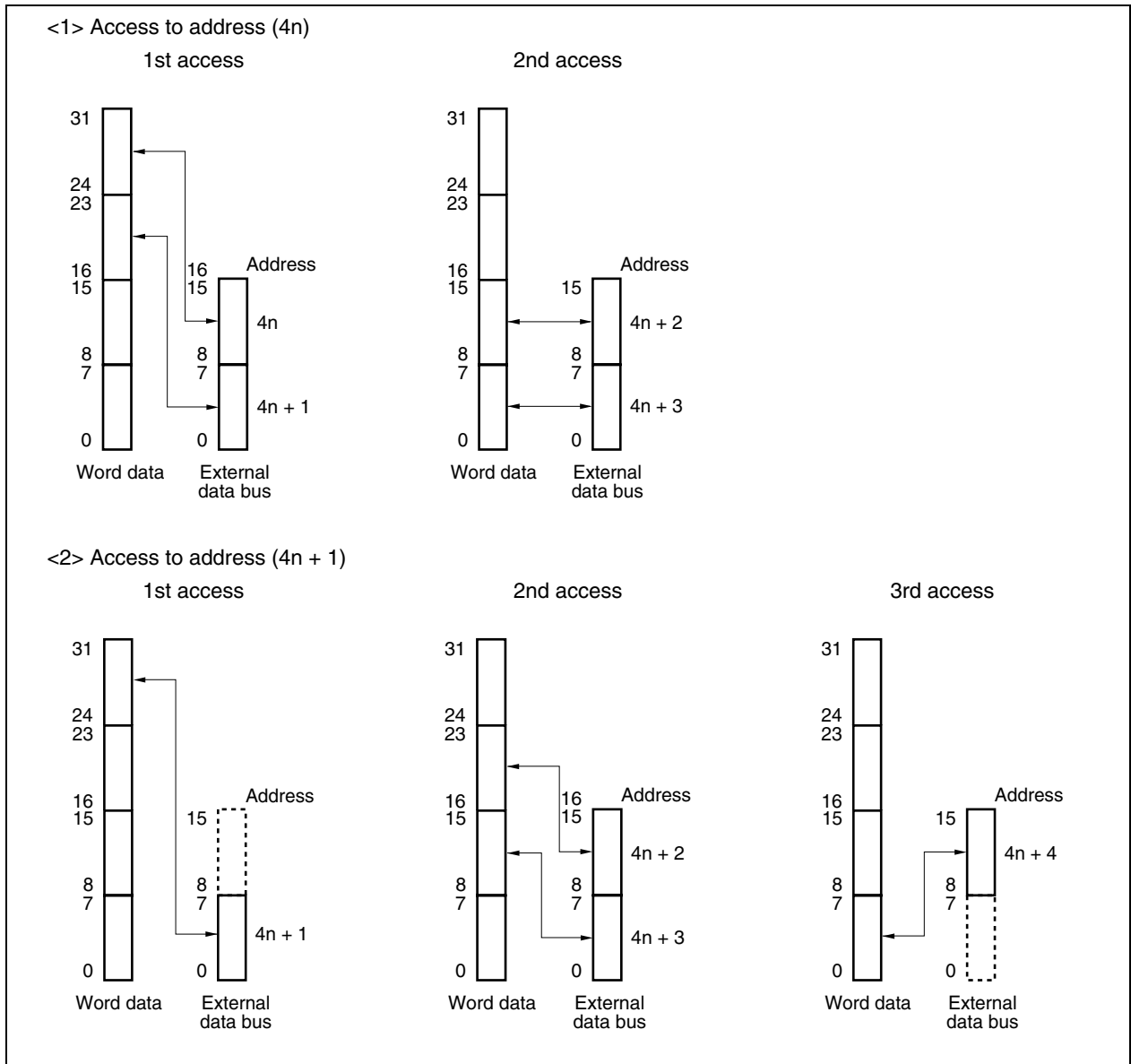


<R>

<4> Access to address  $(4n + 3)$



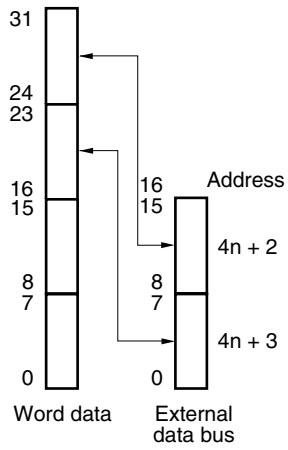
(e) When the data bus width is 16 bits (big endian) (1/2)



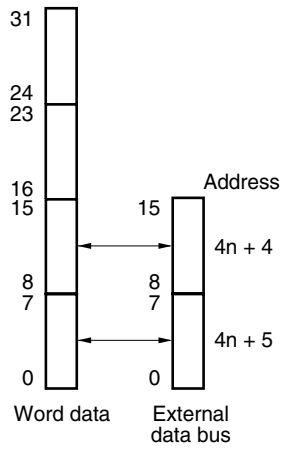
(e) When the data bus width is 16 bits (big endian) (2/2)

<3> Access to address  $(4n + 2)$

1st access

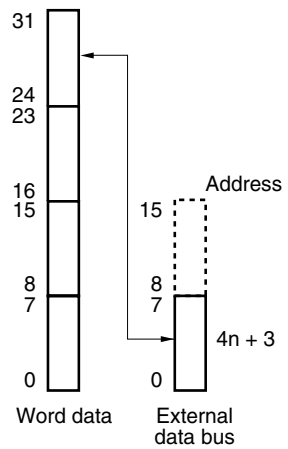


2nd access

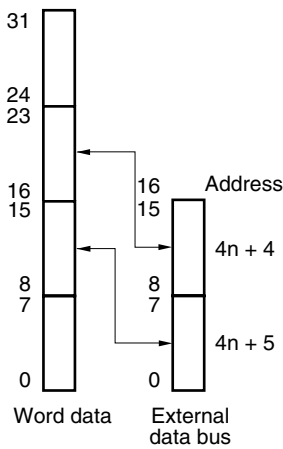


<4> Access to address  $(4n + 3)$

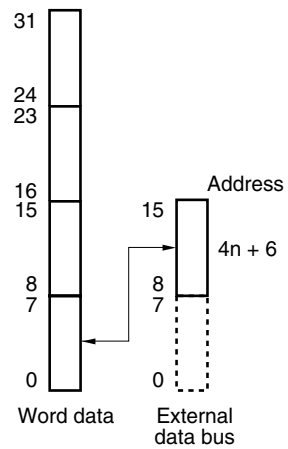
1st access



2nd access

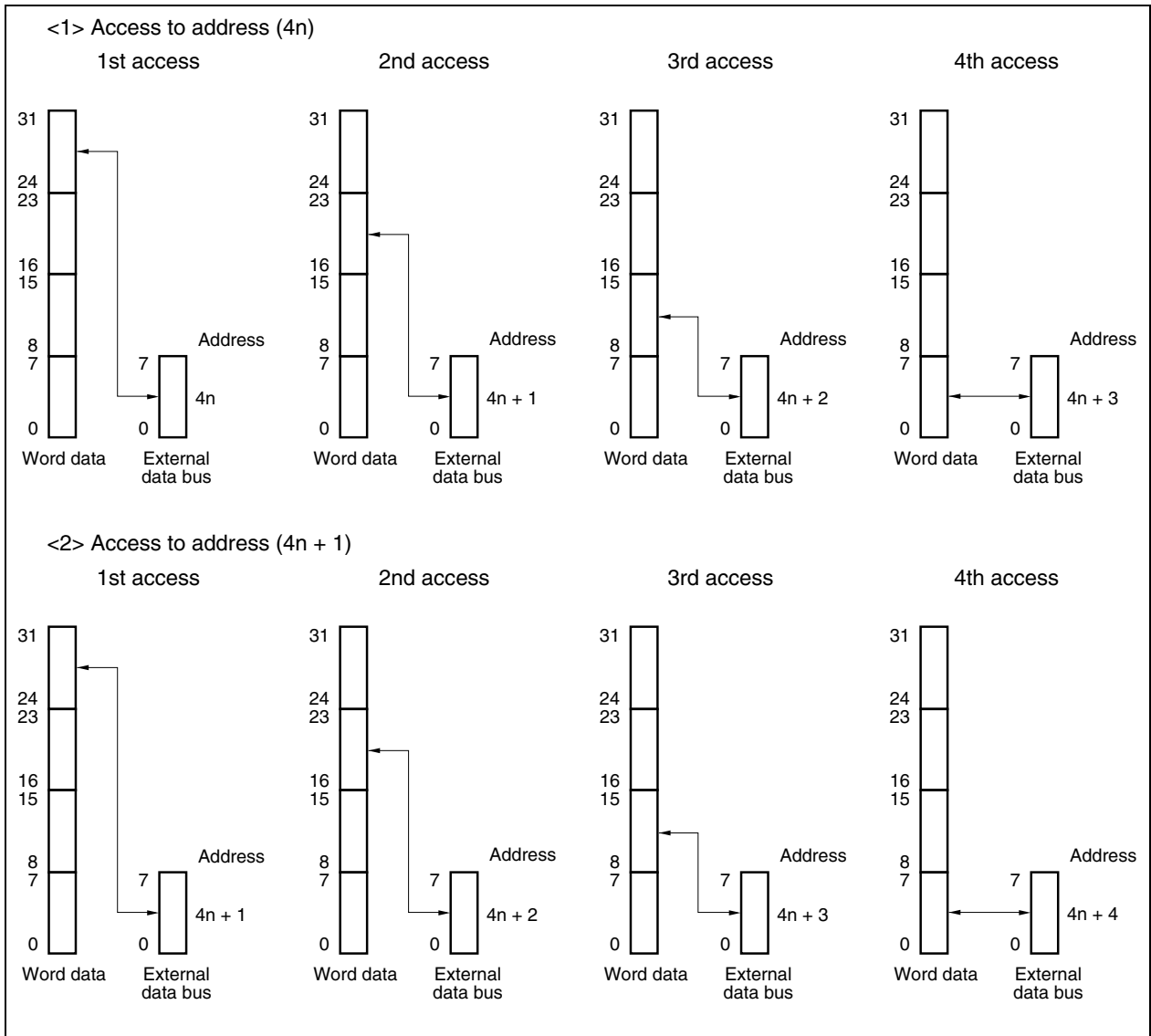


3rd access

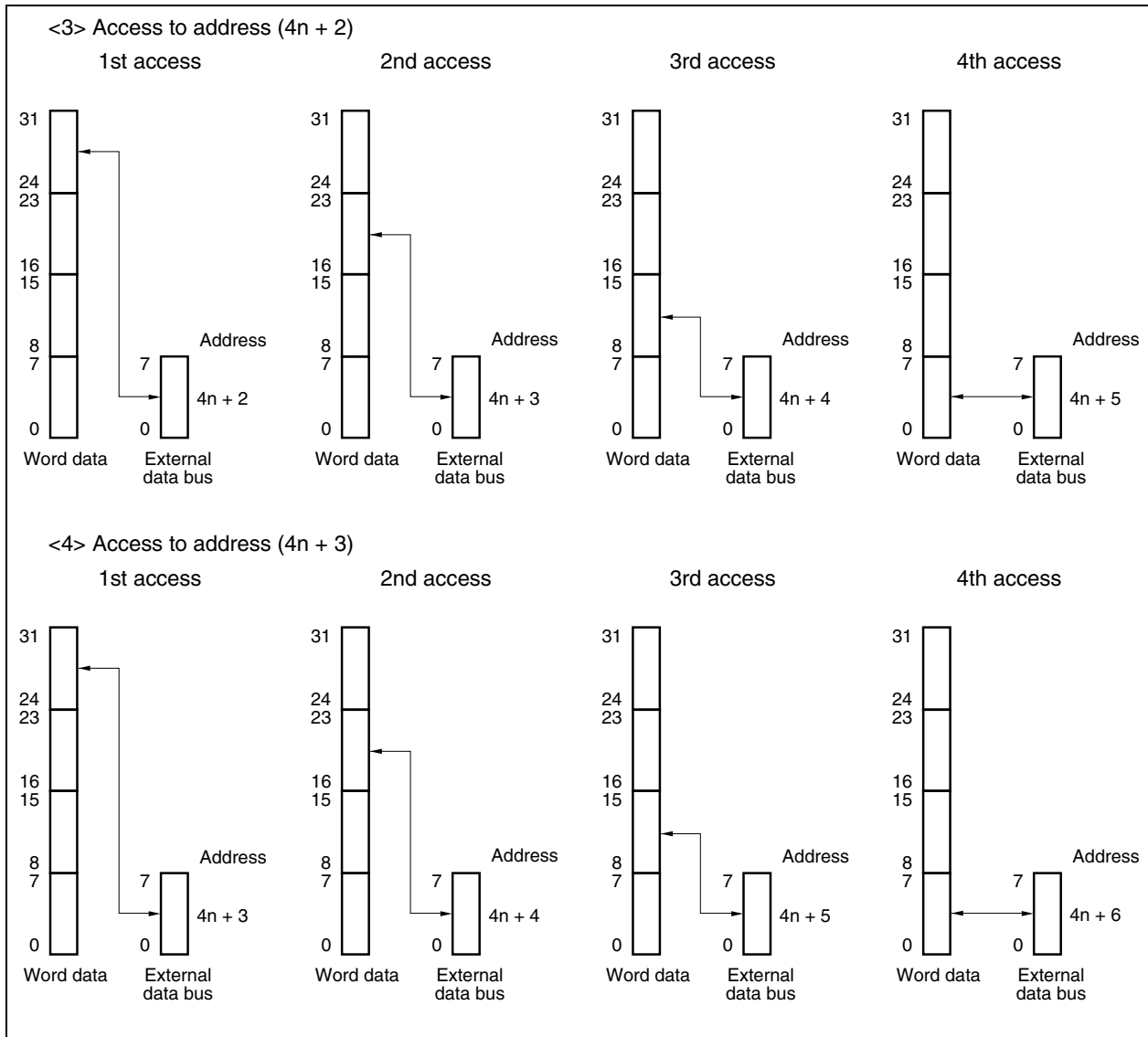




(f) When the data bus width is 8 bits (big endian) (1/2)



(f) When the data bus width is 8 bits (big endian) (2/2)



#### 4.5.6 Data read control function

##### (1) Line buffer control registers 0, 1 (LBC0, LBC1)

The V850E/ME2 has a read buffer.

The LBC0 and LBC1 registers set the operating conditions of the read buffer in each CS space.

These registers can be read or written in 16-bit units.

Be sure to clear bits 15, 14, 11, 10, 7, 6, 3, and 2 to 0. If they are set to 1, the operation is not guaranteed.

- Cautions**
1. Be sure to write data to the LBC0 and LBC1 registers after reset. After writing data to these registers, do not change their values.
  2. When the speculative read function is set for each CSn space, do not insert an idle state in the CSn space for which the speculative read function is enabled by the BCC register (n = 0 to 7). If an idle state is required to be inserted in the CSn space for which the speculative read function is enabled, enable the speculative read function for all CSn spaces (set the LBC0 and LBC1 registers to 3333H) or disable the speculative read function for all CSn spaces (set the LBC0 and LBC1 registers to 0000H).
  3. Do not enable the speculative read function for SDRAM that is accessed via a 32-bit bus.

|            |     |    |      |      |     |    |      |      |     |   |      |      |     |   |      |      |           |             |
|------------|-----|----|------|------|-----|----|------|------|-----|---|------|------|-----|---|------|------|-----------|-------------|
| LBC0       | 15  | 14 | 13   | 12   | 11  | 10 | 9    | 8    | 7   | 6 | 5    | 4    | 3   | 2 | 1    | 0    | Address   | After reset |
|            | 0   | 0  | RB31 | RB30 | 0   | 0  | RB21 | RB20 | 0   | 0 | RB11 | RB10 | 0   | 0 | RB01 | RB00 | FFFFF490H | 0000H       |
| CSn signal | CS3 |    |      |      | CS2 |    |      |      | CS1 |   |      |      | CS0 |   |      |      |           |             |
| LBC1       | 15  | 14 | 13   | 12   | 11  | 10 | 9    | 8    | 7   | 6 | 5    | 4    | 3   | 2 | 1    | 0    | Address   | After reset |
|            | 0   | 0  | RB71 | RB70 | 0   | 0  | RB61 | RB60 | 0   | 0 | RB51 | RB50 | 0   | 0 | RB41 | RB40 | FFFFF492H | 0000H       |
| CSn signal | CS7 |    |      |      | CS6 |    |      |      | CS5 |   |      |      | CS4 |   |      |      |           |             |

| Bit position             | Bit name   | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |      |      |                            |   |   |                                                                   |   |   |   |   |                    |   |   |                                       |
|--------------------------|------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|------|----------------------------|---|---|-------------------------------------------------------------------|---|---|---|---|--------------------|---|---|---------------------------------------|
| 13, 12, 9, 8, 5, 4, 1, 0 | RBn1, RBn0 | <p>These bits set the operating conditions of the read buffer (timing of speculative read) in each CSn space.</p> <table> <tr> <th>RBn1</th><th>RBn0</th><th>Timing of speculative read</th></tr> <tr> <td>0</td><td>0</td><td rowspan="2">Without speculative read (operation of read buffer is prohibited)</td></tr> <tr> <td>0</td><td>1</td></tr> <tr> <td>1</td><td>0</td><td>Setting prohibited</td></tr> <tr> <td>1</td><td>1</td><td>In all cycles (including data access)</td></tr> </table> | RBn1 | RBn0 | Timing of speculative read | 0 | 0 | Without speculative read (operation of read buffer is prohibited) | 0 | 1 | 1 | 0 | Setting prohibited | 1 | 1 | In all cycles (including data access) |
| RBn1                     | RBn0       | Timing of speculative read                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |      |      |                            |   |   |                                                                   |   |   |   |   |                    |   |   |                                       |
| 0                        | 0          | Without speculative read (operation of read buffer is prohibited)                                                                                                                                                                                                                                                                                                                                                                                                                                     |      |      |                            |   |   |                                                                   |   |   |   |   |                    |   |   |                                       |
| 0                        | 1          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |      |      |                            |   |   |                                                                   |   |   |   |   |                    |   |   |                                       |
| 1                        | 0          | Setting prohibited                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |      |      |                            |   |   |                                                                   |   |   |   |   |                    |   |   |                                       |
| 1                        | 1          | In all cycles (including data access)                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |      |      |                            |   |   |                                                                   |   |   |   |   |                    |   |   |                                       |

**Remarks**

1. n = 0 to 7
2. If the setting of the RBn1 and RBn0 bits is changed, the data in the read buffer is immediately invalidated.

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xxxxx0DH (8 bits) → xxxxx0EH (16 bits) → xxxxx10H (8 bits)

The CPU reads the following data when it stores data in the read buffer.

- Speculative read miss hit (read request to external memory area not stored in read buffer)
- Writing BCT0 or BCT1 register
- Writing LBS register
- Writing LBC0 or LBC1 register
- Generation of bus hold
- Generation of DMA flyby cycle (not dependent on CS space)
- Memory write access to speculatively read line address

If the CPU or DMA controller requests reading the data held in the read buffers, the data is transferred to the CPU or DMA controller without generating an external memory cycle.

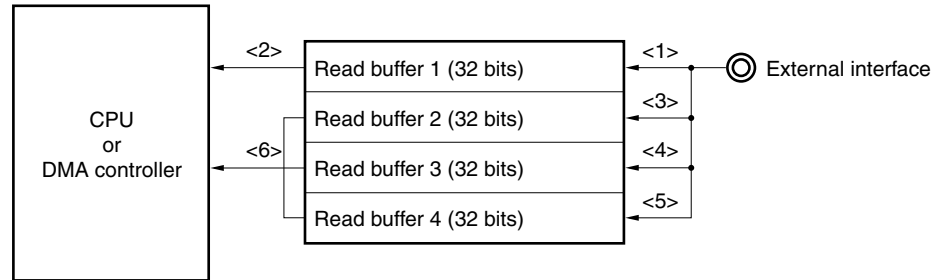
xxxxx0CH → xxxxx00H → xxxxx04H → xxxxx08H →  
Penalty cycle due to speculative reading

xxxxx10H → xxxxx14H → xxxxx18H → xxxxx1CH  
Penalty cycle due to speculative reading

The CPU reads the following data when it stores data in the read buffer.

The speculative read operation is outlined below.

**Figure 4-4. Outline of Speculative Read Operation**



- (A) A read cycle to the address requested by the CPU or DMA controller is executed (<1>).
- (B) The CPU or DMA controller reads the data loaded to read buffer 1 (<2>).
- (C) Read buffers 2 to 4 are speculatively read, and a read cycle of the remaining three words is executed (<3> to <5>).
- (D) If the CPU or DMA controller generates a read request to an address that has already been speculatively read, data is read from read buffers 2 to 4 (a read access to the external memory does not occur) (<6>).

- Remarks 1.** (B) and (C) are executed in parallel ((D) is also executed in parallel if data is stored in the read buffers).
- 2.** If the CPU or DMA controller issues a read request to an address that is not speculatively read in (C) in the cycle of (D), the operation is kept waiting until the operation of (C) is completed. After completion of the operation of (C), all data in the read buffers is discarded, and an operation in response to the next address request is executed starting from (A) (miss hit operation of the speculative read function).

#### (b) Write buffer function

The V850E/ME2 has an on-chip write buffer of 4 words (128 bits). The write buffer stores data if a write cycle cannot be executed while the external bus is occupied<sup>Note</sup>. The next instructions are speculatively executed until the write buffer becomes full. The write buffer is valid for all the external memory areas. If a write request is generated while the write buffer is full, the next instruction execution is postponed until there is a vacancy in the write buffer.

While data is being stored in the write buffer (when a write operation to the external memory has not been completed), DMA flyby and bus hold requests are not acknowledged (DMA flyby and bus hold requests are acknowledged and an enable signal is generated after all the data of the write buffers has been written to the external memory).

**Note** The external bus is occupied when there is a bus cycle currently under execution. If instruction fetch cycles are successively executed, all write cycles for the write data stored in the write buffer are always generated after the bus cycle currently under execution (instruction fetch cycle) is completed.

- Cautions**
1. Because the write buffer consists of four stages, the write buffer becomes full after 4 bytes (32 bits) when a byte write operation is executed (while a write operation to the external memory is standing by). Similarly, the conditions under which the write buffer becomes full vary due to an address miss-align access, etc.
  2. When data is written to an external device, the write operation to the external device may not be executed even when a CPU write operation has been completed by the write buffer. The CPU can access the on-chip peripheral I/O registers after the write operation has been completed even if data exist in the write buffer. Therefore, if it is necessary to change the value of an on-chip peripheral I/O register after completion of execution of an external memory cycle, write the same value as the default value to the LBC0 or LBC1 register or write 00H to the WAS register before writing the on-chip peripheral I/O register whose value is to be changed. When writing an on-chip peripheral I/O register other than the LBC0 or LBC1 register without writing the same value as the default value to the LBC0 or LBC1 register, or writing an on-chip peripheral I/O register other than the WAS register without writing 00H to the WAS register, the register value may be changed before completion of the external memory cycle. Although rewriting the LBC0 and LBC1 registers is prohibited, the same value can be rewritten to the registers in this case. However, if a value different from the default value is written to the LBC0 or LBC1 register, the operation is not guaranteed.
  3. If an read access to the external device occurs when data exist in the write buffer, reading from the external device is executed after the writing all data in the write buffer to the external device.
  4. During 2-cycle transfer that writes data to the external device, the write operation to the external device may not be completed even if TCn bit of DCHCn register = 1 (DMA transfer completion) is read by the write buffer (n = 0 to 3). If it is necessary to change the value of an on-chip peripheral I/O register after completion of DMA transfer (completion of a write operation to the external device), perform either of the following operations.
    - Monitor the  $\overline{\text{TCn}}$  signal (the  $\overline{\text{TCn}}$  signal becomes active in synchronization with a write operation to the external device).
    - After detecting setting (to 1) of the TCn bit, write 00H to the WAS register or write the same value as the default value to the LBC0 or LBC1 register, and then change the value of the on-chip peripheral I/O register. If the value of an on-chip peripheral I/O register other than the LBC0 and LBC1 registers is changed without writing the same value to LBC0 or LBC1 or the value of an on-chip peripheral I/O register other than the WAS register is changed without writing 00H to the WAS register, the value of the on-chip peripheral I/O register may be changed before completion of DMA transfer.

Although rewriting the LBC0 and LBC1 registers is prohibited, the same value can be rewritten to the registers in this case. However, if a value different from the default value is written to the LBC0 or LBC1 register, the operation is not guaranteed.

(2) Write access synchronization control register (WAS)

When an external device is written, even if the write operation by the CPU via the write buffer is complete, writing to the external device may not be complete. The WAS register is used to complete writing all data in the write buffer to the external device. See 4.5.6 (1) (b) Write buffer function for details.

This register is write-only, in 8-bit units.

|     | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | Address   | After reset |
|-----|---|---|---|---|---|---|---|---|-----------|-------------|
| WAS | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | FFFFF49CH | Undefined   |

**Caution** Be sure to write 00H to the WAS register. Operation cannot be guaranteed if value other than 00H is written.

## 4.6 Bus Clock Control Function

### (1) Bus mode control register (BMC)

This register sets the division rate of the bus clock (BUSCLK) with respect to the internal system clock ( $f_{CLK}$ ). Writing the BMC register stops BUSCLK once at low level. BUSCLK resumes operation with the set divided clock after it has been stopped. While BUSCLK is stopped, the operation of the SDRAM refresh control register (RFSn) of SDRAM is also stopped ( $n = 1, 3, 4, 6$ ).

This register can be read or written in 8-bit units.

Be sure to clear bits 7 to 2 to 0. If they are set to 1, the operation is not guaranteed.

- Cautions**
1. Write the BMC register after reset, and then do not change the value that has been written.
  2. Before writing to the BMC register, be sure to set the VSWC register to x7H (x: VSWC register value before the set value of the BMC register is changed). Even if the VSWC register value is x7H before the set value of the BMC register was changed, be sure to set the VSWC register to x7H. After changing the set value of the BMC register, re-set the value of the VSWC register to the value before the set value of the BMC register was changed (see 3.4.10 Initialization sequence).
  3. Set the number of waits (using the DWk2 to DWk0 bits of the DWCm register) or address setup waits (using the ACK1 and ACK0 bits of the ASC register) for all the CS spaces in which an SRAM or page-ROM interface cycle is activated to 1 or more when the same clock is used as the internal system clock ( $f_{CLK}$ ) and bus clock (CKM1 and CKM0 bits = 00) and the speculative read function is enabled (RBk1 and RBk0 bits of LBCm register = 11) ( $m = 0, 1, k = 0$  to 7).
  4. The maximum operating frequency of BUSCLK is 66 MHz. Set the BMC register so that BUSCLK does not exceed 66 MHz.

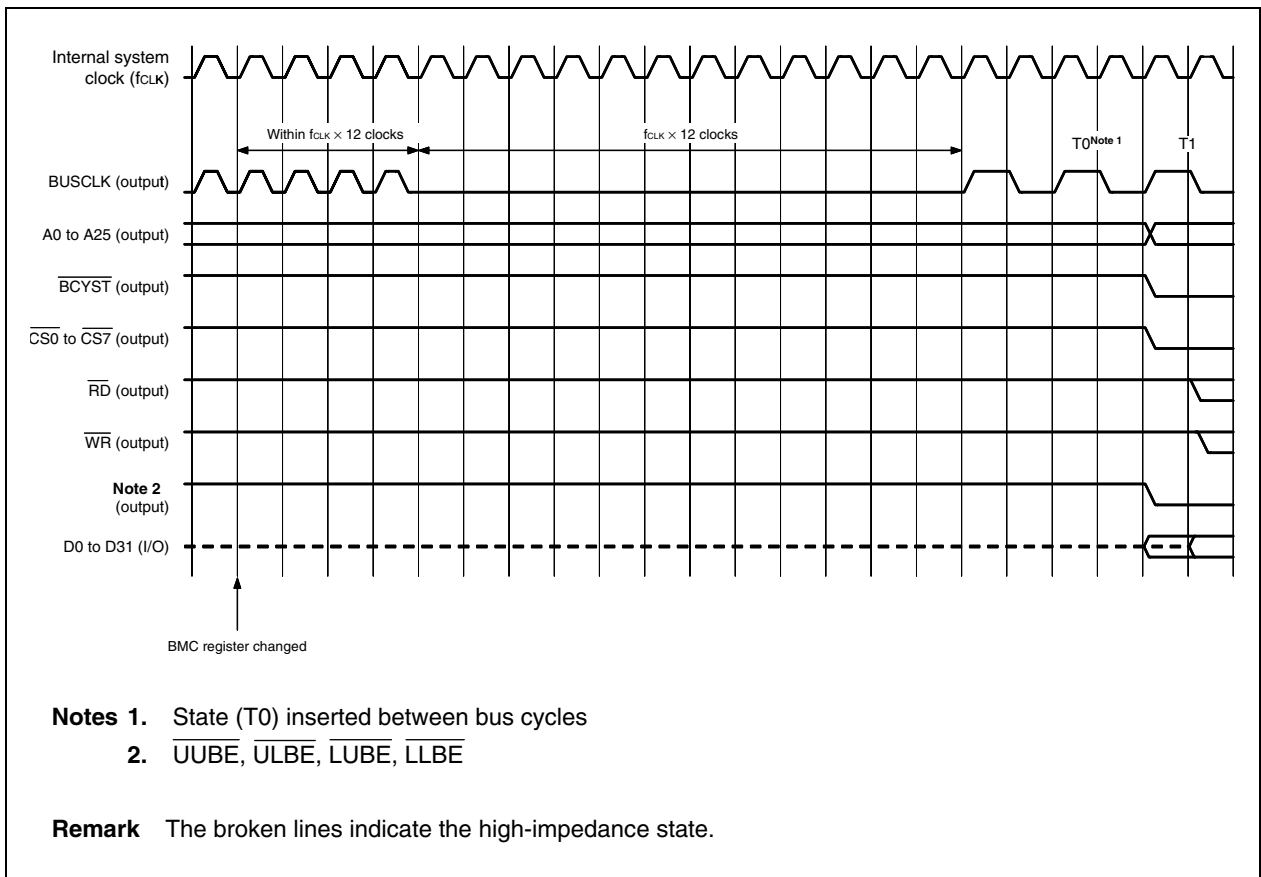
|     | 7 | 6 | 5 | 4 | 3 | 2 | 1    | 0    | Address  | After reset |
|-----|---|---|---|---|---|---|------|------|----------|-------------|
| BMC | 0 | 0 | 0 | 0 | 0 | 0 | CKM1 | CKM0 | FFFF498H | 00H         |

| Bit position | Bit name   | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |      |      |                                        |   |   |           |   |   |             |   |   |             |   |   |             |
|--------------|------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|------|----------------------------------------|---|---|-----------|---|---|-------------|---|---|-------------|---|---|-------------|
| 1, 0         | CKM1, CKM0 | <p>These bits set the division ratio of the bus clock (BUSCLK) with respect to the internal system clock (<math>f_{CLK}</math>).</p> <table> <tr> <th>CKM1</th><th>CKM0</th><th>Division ratio of BUSCLK vs. <math>f_{CLK}</math></th></tr> <tr> <td>0</td><td>0</td><td><math>f_{CLK}</math></td></tr> <tr> <td>0</td><td>1</td><td><math>f_{CLK}/2</math></td></tr> <tr> <td>1</td><td>0</td><td><math>f_{CLK}/3</math></td></tr> <tr> <td>1</td><td>1</td><td><math>f_{CLK}/4</math></td></tr> </table> | CKM1 | CKM0 | Division ratio of BUSCLK vs. $f_{CLK}$ | 0 | 0 | $f_{CLK}$ | 0 | 1 | $f_{CLK}/2$ | 1 | 0 | $f_{CLK}/3$ | 1 | 1 | $f_{CLK}/4$ |
| CKM1         | CKM0       | Division ratio of BUSCLK vs. $f_{CLK}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |      |      |                                        |   |   |           |   |   |             |   |   |             |   |   |             |
| 0            | 0          | $f_{CLK}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |      |      |                                        |   |   |           |   |   |             |   |   |             |   |   |             |
| 0            | 1          | $f_{CLK}/2$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |      |      |                                        |   |   |           |   |   |             |   |   |             |   |   |             |
| 1            | 0          | $f_{CLK}/3$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |      |      |                                        |   |   |           |   |   |             |   |   |             |   |   |             |
| 1            | 1          | $f_{CLK}/4$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |      |      |                                        |   |   |           |   |   |             |   |   |             |   |   |             |

**Remark**  $f_{CLK}$ : Internal system clock



Figure 4-5. BMC Register Switching Timing



## 4.7 Wait Function

### 4.7.1 Programmable wait function

#### (1) Data wait control registers 0, 1 (DWC0, DWC1)

To facilitate interfacing with low-speed memory and I/Os, it is possible to insert up to 7 data wait states in the starting bus cycle for each CS space.

The number of wait states can be specified by program using DWC0 and DWC1 registers. Just after system reset, all blocks have 7 data wait states inserted.

These registers can be read or written in 16-bit units.

**Cautions** 1. The internal instruction RAM area (in the read mode) and internal data RAM area are not subject to programmable waits and ordinarily no wait access is carried out.

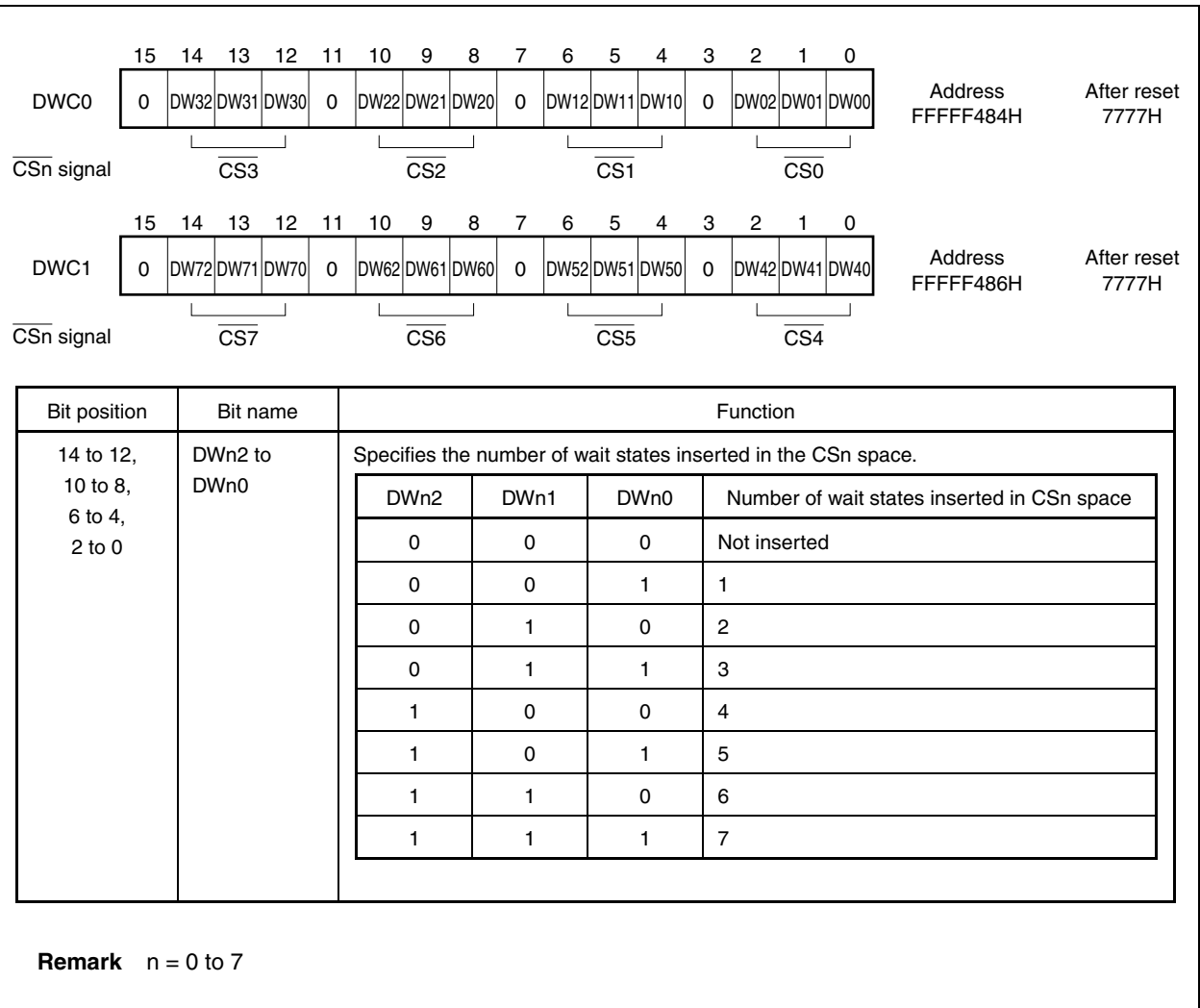
When the internal instruction RAM area is accessed (in the write mode), the programmable wait value set for the CS0 space becomes valid.

The on-chip peripheral I/O area is not subject to programmable waits, with wait control performed by each peripheral function only.

2. In the following cases, the settings of the DWC0 and DWC1 registers are invalid (wait control is performed by each memory controller).

- Page ROM on-page access
- SDRAM access

3. Write to the DWC0 and DWC1 registers after reset, and then do not change the set values. Also, do not access an external memory area other than the one for this initialization routine until the initial setting of the DWC0 and DWC1 registers is complete. However, it is possible to access external memory areas whose initialization settings are complete.



**(2) Address setup wait control register (ASC)**

The V850E/ME2 allows insertion of address setup wait states before the SRAM/page ROM cycle (the setting of the ASC register in the SDRAM cycle is invalid).

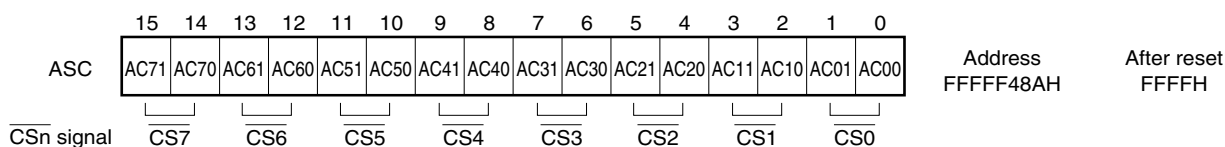
The number of address setup wait states can be set with the ASC register for each CS space.

This register can be read or written in 16-bit units.

**Cautions** 1. The internal instruction RAM area (in the read mode), internal data RAM area, and on-chip peripheral I/O area are not subject to address setup wait insertion.

When the internal instruction RAM area is accessed (in the write mode), the address setup wait value set for the CS0 space becomes valid.

2. During an address setup wait, the  $\overline{\text{WAIT}}$  pin-based external wait function is disabled.
3. Write to the ASC register after reset, and then do not change the set value.
4. Be sure to set the number of waits to 1 or more if the  $\overline{\text{CSn}}$  signal is delayed using the PFCCS register.
5. The address setup wait setting value is valid during DMA flyby transfer.



| Bit position | Bit name   | Function                                                                                                                                                                                                                                                                                                                                                                                    |      |      |                       |   |   |              |   |   |   |   |   |   |   |   |   |
|--------------|------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|------|-----------------------|---|---|--------------|---|---|---|---|---|---|---|---|---|
| 15 to 0      | ACn1, ACn0 | Specifies the number of address setup wait states inserted before the SRAM/page ROM cycle for each CSn space. <table border="1"> <tr> <th>ACn1</th><th>ACn0</th><th>Number of wait states</th></tr> <tr> <td>0</td><td>0</td><td>Not inserted</td></tr> <tr> <td>0</td><td>1</td><td>1</td></tr> <tr> <td>1</td><td>0</td><td>2</td></tr> <tr> <td>1</td><td>1</td><td>3</td></tr> </table> | ACn1 | ACn0 | Number of wait states | 0 | 0 | Not inserted | 0 | 1 | 1 | 1 | 0 | 2 | 1 | 1 | 3 |
| ACn1         | ACn0       | Number of wait states                                                                                                                                                                                                                                                                                                                                                                       |      |      |                       |   |   |              |   |   |   |   |   |   |   |   |   |
| 0            | 0          | Not inserted                                                                                                                                                                                                                                                                                                                                                                                |      |      |                       |   |   |              |   |   |   |   |   |   |   |   |   |
| 0            | 1          | 1                                                                                                                                                                                                                                                                                                                                                                                           |      |      |                       |   |   |              |   |   |   |   |   |   |   |   |   |
| 1            | 0          | 2                                                                                                                                                                                                                                                                                                                                                                                           |      |      |                       |   |   |              |   |   |   |   |   |   |   |   |   |
| 1            | 1          | 3                                                                                                                                                                                                                                                                                                                                                                                           |      |      |                       |   |   |              |   |   |   |   |   |   |   |   |   |

**Remark** n = 0 to 7

**(3) Bus cycle period control register (BCP)**

With the V850E/ME2, the operations of  $\overline{\text{IOR}}\overline{\text{D}}$  and  $\overline{\text{IOW}}\overline{\text{R}}$  can be enabled or disabled in the SRAM, external ROM, and external I/O cycles.

This register can be read or written in 8-bit or 1-bit units.

Be sure to clear bits 7 to 4 and 2 to 0 to 0. If they are set to 1, the operation is not guaranteed.

**Cautions 1.** During a flyby DMA transfer for SRAM, external ROM, or external I/O, the  $\overline{\text{IOR}}\overline{\text{D}}$  and  $\overline{\text{IOW}}\overline{\text{R}}$  signals are always output, irrespective of the IOEN bit setting.

Flyby transfer from external I/O to external memory:  $\overline{\text{IOR}}\overline{\text{D}}$  and  $\overline{\text{WR}}$  signals become active.

Flyby transfer from external memory to external I/O:  $\overline{\text{IOW}}\overline{\text{R}}$  and  $\overline{\text{RD}}$  signals become active.

In page ROM cycle, on the other hand, the IOEN bit setting has no meaning.

2. Write to the BCP register after reset, and then do not change the set values.

3. If the internal instruction RAM is accessed while the IOEN bit is set (1) (in the write mode), the  $\overline{\text{IOW}}\overline{\text{R}}$  signal becomes inactive.

|     |   |   |   |   |      |   |   |   |            |             |
|-----|---|---|---|---|------|---|---|---|------------|-------------|
|     | 7 | 6 | 5 | 4 | 3    | 2 | 1 | 0 | Address    | After reset |
| BCP | 0 | 0 | 0 | 0 | IOEN | 0 | 0 | 0 | FFFFFF48CH | 00H         |

| Bit position | Bit name                                                                                                                                                            | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |      |                                                                                                                    |   |                                                                                                                                                                     |   |                                                                                                                                                                    |
|--------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|--------------------------------------------------------------------------------------------------------------------|---|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|--------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 3            | IOEN                                                                                                                                                                | <p>Specifies whether to enable/disable the operation of <math>\overline{\text{IOR}}\overline{\text{D}}</math> and <math>\overline{\text{IOW}}\overline{\text{R}}</math> in SRAM, external ROM, and external I/O cycles.</p> <table><tr><th>IOEN</th><th>Enable/disable <math>\overline{\text{IOR}}\overline{\text{D}}</math> and <math>\overline{\text{IOW}}\overline{\text{R}}</math> operation</th></tr><tr><td>0</td><td>Disables the operation of <math>\overline{\text{IOR}}\overline{\text{D}}</math> and <math>\overline{\text{IOW}}\overline{\text{R}}</math> in SRAM, external ROM, and external I/O cycles.</td></tr><tr><td>1</td><td>Enables the operation of <math>\overline{\text{IOR}}\overline{\text{D}}</math> and <math>\overline{\text{IOW}}\overline{\text{R}}</math> in SRAM, external ROM, and external I/O cycles.</td></tr></table> | IOEN | Enable/disable $\overline{\text{IOR}}\overline{\text{D}}$ and $\overline{\text{IOW}}\overline{\text{R}}$ operation | 0 | Disables the operation of $\overline{\text{IOR}}\overline{\text{D}}$ and $\overline{\text{IOW}}\overline{\text{R}}$ in SRAM, external ROM, and external I/O cycles. | 1 | Enables the operation of $\overline{\text{IOR}}\overline{\text{D}}$ and $\overline{\text{IOW}}\overline{\text{R}}$ in SRAM, external ROM, and external I/O cycles. |
| IOEN         | Enable/disable $\overline{\text{IOR}}\overline{\text{D}}$ and $\overline{\text{IOW}}\overline{\text{R}}$ operation                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |      |                                                                                                                    |   |                                                                                                                                                                     |   |                                                                                                                                                                    |
| 0            | Disables the operation of $\overline{\text{IOR}}\overline{\text{D}}$ and $\overline{\text{IOW}}\overline{\text{R}}$ in SRAM, external ROM, and external I/O cycles. |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |      |                                                                                                                    |   |                                                                                                                                                                     |   |                                                                                                                                                                    |
| 1            | Enables the operation of $\overline{\text{IOR}}\overline{\text{D}}$ and $\overline{\text{IOW}}\overline{\text{R}}$ in SRAM, external ROM, and external I/O cycles.  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |      |                                                                                                                    |   |                                                                                                                                                                     |   |                                                                                                                                                                    |

**(4) DMA flyby transfer wait control register (FWC)**

The FWC register sets the number of data wait cycles during DMA flyby transfer for each channel  $n$  (see the timing chart in **6.5.2 Flyby transfer**) ( $n = 0$  to  $3$ ).

The set value of this register is valid during DMA flyby transfer, and the set values of the DWC0, DWC1, and PRC registers are invalid.

This register can be read or written in 16-bit units.

**Cautions** 1. The internal instruction RAM area and internal data RAM area are not subject to the programmable wait operation and are always accessed with no wait cycle. The on-chip peripheral I/O area is also not subject to the programmable wait operation, and is subject only to wait control by each peripheral function.

2. Write to the FWC register after reset, and then do not change the set values.

|     |    |      |      |      |    |      |      |      |   |      |      |      |   |      |      |      |            |             |
|-----|----|------|------|------|----|------|------|------|---|------|------|------|---|------|------|------|------------|-------------|
|     | 15 | 14   | 13   | 12   | 11 | 10   | 9    | 8    | 7 | 6    | 5    | 4    | 3 | 2    | 1    | 0    | Address    | After reset |
| FWC | 0  | FW32 | FW31 | FW30 | 0  | FW22 | FW21 | FW20 | 0 | FW12 | FW11 | FW10 | 0 | FW02 | FW01 | FW00 | FFFFFF494H | 7777H       |

| Bit position                               | Bit name        | Function                                                                                     |      |      |                                                        |
|--------------------------------------------|-----------------|----------------------------------------------------------------------------------------------|------|------|--------------------------------------------------------|
| 14 to 12,<br>10 to 8,<br>6 to 4,<br>2 to 0 | FWn2 to<br>FWn0 | These bits set the number of data wait cycles to each channel $n$ during DMA flyby transfer. |      |      |                                                        |
|                                            |                 | FWn2                                                                                         | FWn1 | FWn0 | Number of data wait cycles                             |
|                                            |                 |                                                                                              |      |      | When SDRAM is not accessed      When SDRAM is accessed |
|                                            |                 | 0                                                                                            | 0    | 0    | Not inserted      1                                    |
|                                            |                 | 0                                                                                            | 0    | 1    | 1      2                                               |
|                                            |                 | 0                                                                                            | 1    | 0    | 2      3                                               |
|                                            |                 | 0                                                                                            | 1    | 1    | 3      4                                               |
|                                            |                 | 1                                                                                            | 0    | 0    | 4      5                                               |
|                                            |                 | 1                                                                                            | 0    | 1    | 5      6                                               |
|                                            |                 | 1                                                                                            | 1    | 0    | 6      7                                               |
|                                            |                 | 1                                                                                            | 1    | 1    | 7      8                                               |

**Remark**  $n = 0$  to  $3$

#### 4.7.2 External wait function

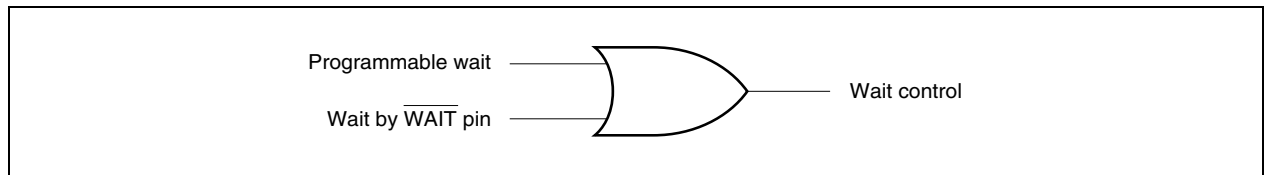
When an extremely slow memory, I/O, or asynchronous system is connected, an arbitrary number of wait states can be inserted in the bus cycle by the external wait pin ( $\overline{\text{WAIT}}$ ) for synchronization with the external device.

Just as with programmable waits, accessing internal instruction RAM (in the read mode), internal data RAM, and on-chip peripheral I/O areas cannot be controlled by external waits.

The external  $\overline{\text{WAIT}}$  signal can be input asynchronously to BUSCLK and is sampled at the rising edge of BUSCLK immediately after the T1 and TW states of a bus cycle. If the setup/hold time in the sampling timing is not satisfied, the wait state may or may not be inserted in the next state.

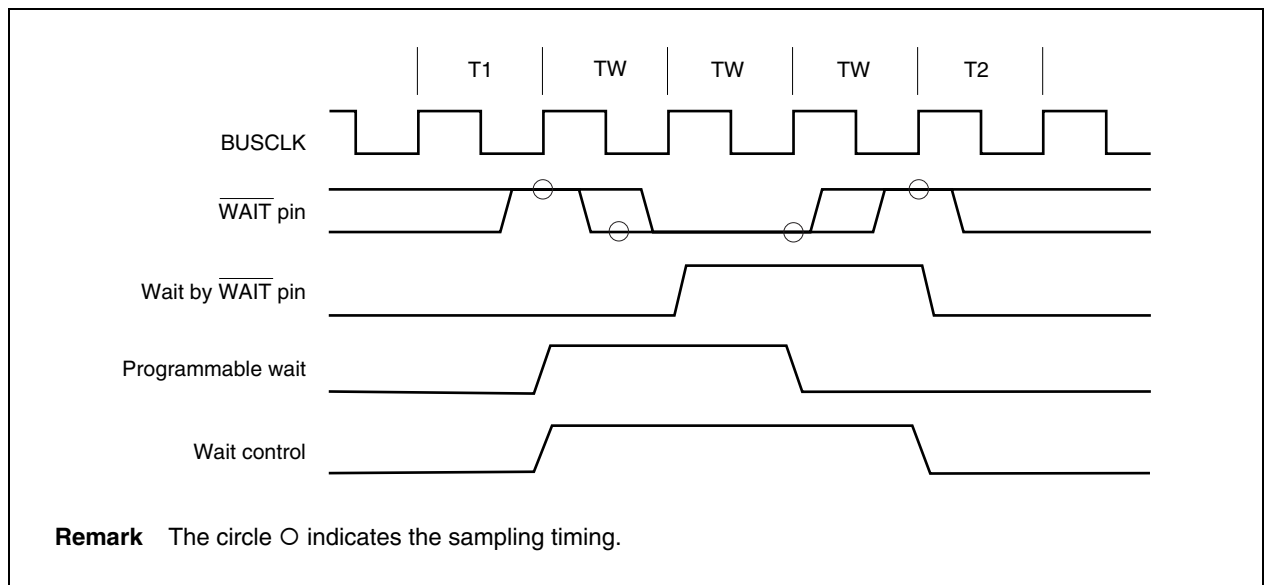
#### 4.7.3 Relationship between programmable wait and external wait

A wait cycle is inserted as the result of an OR operation between the wait cycle specified by the set value of the programmable wait and the wait cycle controlled by the  $\overline{\text{WAIT}}$  pin.



For example, if the timings of the programmable wait and the  $\overline{\text{WAIT}}$  pin signal are as illustrated below, three wait states will be inserted in the bus cycle.

Figure 4-6. Example of Wait Insertion



#### 4.7.4 Bus cycles in which wait function is valid

In the V850E/ME2, the number of waits can be specified according to the memory type specified for each memory block. The following shows the bus cycles in which the wait function is valid and the registers used for wait setting.

**Table 4-1. Bus Cycles in Which Wait Function Is Valid**

| Bus Cycle                                  |                         |          | Type of Wait          | Programmable Wait Setting |              |               | Wait by<br>WAIT Pin |           |
|--------------------------------------------|-------------------------|----------|-----------------------|---------------------------|--------------|---------------|---------------------|-----------|
|                                            |                         |          |                       | Register                  | Bit          | Wait<br>Count |                     |           |
| SRAM, external ROM, external I/O<br>cycles |                         |          | Address setup wait    | ASC                       | ACn1, ACn0   | 0 to 3        | – (invalid)         |           |
|                                            |                         |          | Data access wait      | DWC0, DWC1                | DWn2 to DWn0 | 0 to 7        | √ (valid)           |           |
| Page ROM cycle                             |                         |          | Address setup wait    | ASC                       | ACn1, ACn0   | 0 to 3        | – (invalid)         |           |
|                                            |                         |          | Off-page              | Data access wait          | DWC0, DWC1   | DWn2 to DWn0  | 0 to 7              | √ (valid) |
|                                            |                         |          | On-page               | Data access wait          | PRC          | PRW2 to PRW0  | 0 to 7              | √ (valid) |
| SDRAM cycle                                |                         |          | Row address precharge | SCRm                      | BCWm1, BCWm0 | 1 to 3        | – (invalid)         |           |
| DMA flyby<br>transfer<br>cycle             | External I/O ↔ SRAM     |          | Flyby transfer wait   | FWC                       | FWa2 to FWa0 | 0 to 7        | √ (valid)           |           |
|                                            |                         |          | Address setup wait    | ASC                       | ACn1, ACn0   | 0 to 3        | – (invalid)         |           |
|                                            | External I/O<br>→ SDRAM | Off-page | Row address precharge | SCRm                      | BCWm1, BCWm0 | 1 to 3        | – (invalid)         |           |
|                                            |                         |          | Flyby transfer wait   | FWC                       | FWa2 to FWa0 | 1 to 8        | – (invalid)         |           |
|                                            |                         | On-page  | Row address precharge | SCRm                      | BCWm1, BCWm0 | 1 to 3        | – (invalid)         |           |
|                                            |                         |          | Flyby transfer wait   | FWC                       | FWa2 to FWa0 | 1 to 8        | – (invalid)         |           |

**Remark** n = 0 to 7, m = 1, 3, 4, 6, a = 0 to 3



## 4.8 Idle State Insertion Function

### (1) Bus cycle control register (BCC)

To facilitate interfacing with low-speed memory devices, an idle state (TI) can be inserted into the current bus cycle after the T2 state to meet the data output float delay time on memory read access for each CS space. The bus cycle following the T2 state starts after the idle state is inserted.

An idle state is inserted at the timing shown below.

- After read/write cycles for SRAM, external I/O, or external ROM
- After a read cycle for page ROM
- After a read cycle for SDRAM

The idle state insertion setting can be specified by program using the BCC register.

Immediately after the system reset, idle state insertion is automatically programmed for all memory blocks.

For the timing when an idle state is inserted, see the memory access timings in Chapter 5.

This register can be read or written in 16-bit units.

**Cautions 1.** The internal instruction RAM area (in the read mode), internal data RAM area, and on-chip peripheral I/O area are not subject to idle state insertion.

When the internal instruction RAM area is accessed (in the write mode), the idle state value set for the CS0 space becomes valid.

**2.** Write to the BCC register after reset, and then do not change the set values. Also, do not access an external memory area other than the one for this initialization routine until the initial setting of the BCC register is complete. However, it is possible to access external memory areas whose initialization settings are complete.

**3.** The chip select signal ( $\overline{CSn}$ ) does not become active in the idle state ( $n = 0$  to 7).

|                                                                                                                                                                         |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|
| <div> <div>15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0</div> <div>BCC</div> <div>BC71 BC70 BC61 BC60 BC51 BC50 BC41 BC40 BC31 BC30 BC21 BC20 BC11 BC10 BC01 BC00</div> </div> |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| <div> <div>CSn signal</div> <div>CS7 CS6 CS5 CS4 CS3 CS2 CS1 CS0</div> </div>                                                                                           |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| <div> <div>Address</div> <div>FFFFF488H</div> </div>                                                                                                                    |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| <div> <div>After reset</div> <div>FFFFH</div> </div>                                                                                                                    |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

| Bit position | Bit name   | Function                                                                                                                                                                                                                                                                                                                        |      |      |                         |   |   |              |   |   |   |   |   |   |   |   |   |
|--------------|------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|------|-------------------------|---|---|--------------|---|---|---|---|---|---|---|---|---|
| 15 to 0      | BCn1, BCn0 | Specifies the insertion of an idle state in the CSn space. <table> <tr> <th>BCn1</th><th>BCn0</th><th>Idle state in CSn space</th></tr> <tr> <td>0</td><td>0</td><td>Not inserted</td></tr> <tr> <td>0</td><td>1</td><td>1</td></tr> <tr> <td>1</td><td>0</td><td>2</td></tr> <tr> <td>1</td><td>1</td><td>3</td></tr> </table> | BCn1 | BCn0 | Idle state in CSn space | 0 | 0 | Not inserted | 0 | 1 | 1 | 1 | 0 | 2 | 1 | 1 | 3 |
| BCn1         | BCn0       | Idle state in CSn space                                                                                                                                                                                                                                                                                                         |      |      |                         |   |   |              |   |   |   |   |   |   |   |   |   |
| 0            | 0          | Not inserted                                                                                                                                                                                                                                                                                                                    |      |      |                         |   |   |              |   |   |   |   |   |   |   |   |   |
| 0            | 1          | 1                                                                                                                                                                                                                                                                                                                               |      |      |                         |   |   |              |   |   |   |   |   |   |   |   |   |
| 1            | 0          | 2                                                                                                                                                                                                                                                                                                                               |      |      |                         |   |   |              |   |   |   |   |   |   |   |   |   |
| 1            | 1          | 3                                                                                                                                                                                                                                                                                                                               |      |      |                         |   |   |              |   |   |   |   |   |   |   |   |   |

**Remark** n = 0 to 7

**(2) DMA flyby transfer idle control register (FIC)**

The FIC register sets the number of idle states during DMA flyby transfer for each DMA channel  $n$  (see the timing chart in **6.5.2 Flyby transfer**) ( $n = 0$  to  $3$ ). The idle state is inserted at the end of DMA flyby transfer. During DMA flyby transfer, the set value of this register is valid, and the set value of the BCC register is invalid.

This register can be read or written in 16-bit units.

**Cautions** 1. The internal instruction RAM area, internal data RAM area, and on-chip peripheral I/O area are not subject to idle state insertion.

2. Write to the FIC register after reset, and then do not change the set values.

|     |    |    |      |      |    |    |      |      |   |   |      |      |   |   |      |      |            |             |
|-----|----|----|------|------|----|----|------|------|---|---|------|------|---|---|------|------|------------|-------------|
|     | 15 | 14 | 13   | 12   | 11 | 10 | 9    | 8    | 7 | 6 | 5    | 4    | 3 | 2 | 1    | 0    | Address    | After reset |
| FIC | 0  | 0  | FI31 | FI30 | 0  | 0  | FI21 | FI20 | 0 | 0 | FI11 | FI10 | 0 | 0 | FI01 | FI00 | FFFFFF496H | 3333H       |

| Bit position                | Bit name           | Function                                                                                                                                                                                                                                                                                                                                                                                                             |          |          |                                      |   |   |              |   |   |   |   |   |   |   |   |   |
|-----------------------------|--------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|----------|--------------------------------------|---|---|--------------|---|---|---|---|---|---|---|---|---|
| 13, 12, 9, 8,<br>5, 4, 1, 0 | FI $n$ 1, FI $n$ 0 | These bits specify the number of idle states during DMA flyby transfer for each channel $n$ . <table border="1"> <tr> <th>FI<math>n</math>1</th><th>FI<math>n</math>0</th><th>Idle state during DMA flyby transfer</th></tr> <tr> <td>0</td><td>0</td><td>Not inserted</td></tr> <tr> <td>0</td><td>1</td><td>1</td></tr> <tr> <td>1</td><td>0</td><td>2</td></tr> <tr> <td>1</td><td>1</td><td>3</td></tr> </table> | FI $n$ 1 | FI $n$ 0 | Idle state during DMA flyby transfer | 0 | 0 | Not inserted | 0 | 1 | 1 | 1 | 0 | 2 | 1 | 1 | 3 |
| FI $n$ 1                    | FI $n$ 0           | Idle state during DMA flyby transfer                                                                                                                                                                                                                                                                                                                                                                                 |          |          |                                      |   |   |              |   |   |   |   |   |   |   |   |   |
| 0                           | 0                  | Not inserted                                                                                                                                                                                                                                                                                                                                                                                                         |          |          |                                      |   |   |              |   |   |   |   |   |   |   |   |   |
| 0                           | 1                  | 1                                                                                                                                                                                                                                                                                                                                                                                                                    |          |          |                                      |   |   |              |   |   |   |   |   |   |   |   |   |
| 1                           | 0                  | 2                                                                                                                                                                                                                                                                                                                                                                                                                    |          |          |                                      |   |   |              |   |   |   |   |   |   |   |   |   |
| 1                           | 1                  | 3                                                                                                                                                                                                                                                                                                                                                                                                                    |          |          |                                      |   |   |              |   |   |   |   |   |   |   |   |   |

**Remark**  $n = 0$  to  $3$

## 4.9 Instruction Cache Function

The V850E/ME2 has an 8 KB 2-way set associative instruction cache.

This instruction cache uses an LRU (Least Recently Used) algorithm. This cache uses two ways as the cache, with the way to be replaced in case of a miss hit determined by the internal LRU bit. If the way is specified as a cacheable area, a 4-word burst sequential read cycle is issued (when the external 32-bit bus operates) (when the external 16-bit bus operates, an 8-halfword burst read cycle is issued).

Set the instruction cache using the following procedure, after system reset.

- <1> Wait until the value of the ICC register reaches "0000H" (until the tag is initialized).
- <2> Make the setting of the instruction cache cacheable by using the BHC register.

**Caution** Be sure to set the BHC register in an uncached area (instructions cannot be fetched correctly if it is set from a cacheable area).

### 4.9.1 Cache configuration register (BHC)

#### (1) Cache configuration register (BHC)

This register can set the configuration of the cache memory in each CS space selected by the chip select signals (CS0 to CS2). Setting a cacheable area becomes valid immediately after the BHC register has been set.

This register can be read or written in 16-bit units.

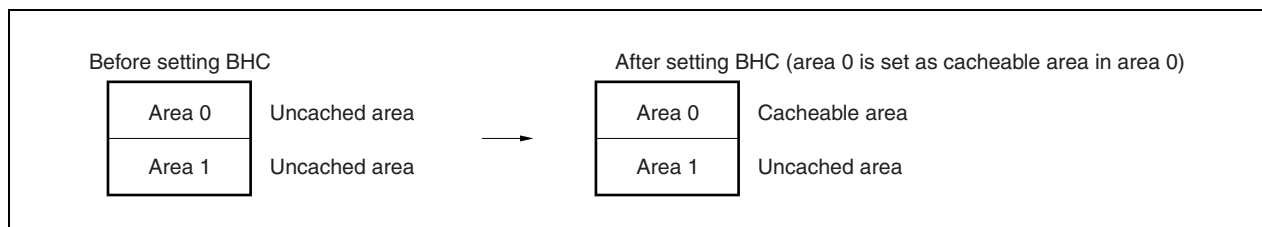
Be sure to clear bits 15 to 5 to 0. If they are set to 1, the operation is not guaranteed.

- Cautions**
1. Write the BHC register after reset, and then do not change the set values.
  2. The area that includes the instruction that sets the BHC register cannot be set from an uncached area to a cacheable area, or from a cacheable area to an uncached area; otherwise the operation is not guaranteed. In this case, branch to area 1 and then set area 0 to a cacheable area by an instruction in area 1. If necessary, branch to area 0 again.

An uncached area and a cacheable area can be set in any CS space in the internal instruction RAM area.

(Example of prohibited setting)

- If the instruction that sets the BHC register is in area 0



**Caution** 3. If adjacent memory areas are a cacheable area and an uncached area, only a branch instruction can be used to successively access this memory boundary. The operation is not guaranteed if this memory boundary is successively accessed by an instruction other than a branch instruction.

(Operation example)

- An access from area 0 to area 1 can be made only by a branch instruction.
- Successive accesses can be made from area 1 to area 2.

|        |                |
|--------|----------------|
| Area 0 | Uncached area  |
| Area 1 | Cacheable area |
| Area 2 | Cacheable area |

|            | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4    | 3 | 2    | 1 | 0    | Address   | After reset |
|------------|----|----|----|----|----|----|---|---|---|---|---|------|---|------|---|------|-----------|-------------|
| BHC        | 0  | 0  | 0  | 0  | 0  | 0  | 0 | 0 | 0 | 0 | 0 | BH20 | 0 | BH10 | 0 | BH00 | FFFFF06AH | 0000H       |
| CSn signal |    |    |    |    |    |    |   |   |   |   |   | CS2  |   | CS1  |   | CS0  |           |             |

| Bit position | Bit name | Function                                                                                     |
|--------------|----------|----------------------------------------------------------------------------------------------|
| 4, 2, 0      | BHn0     | These bits set the instruction cache placed in the CSn space.<br>0: Uncached<br>1: Cacheable |

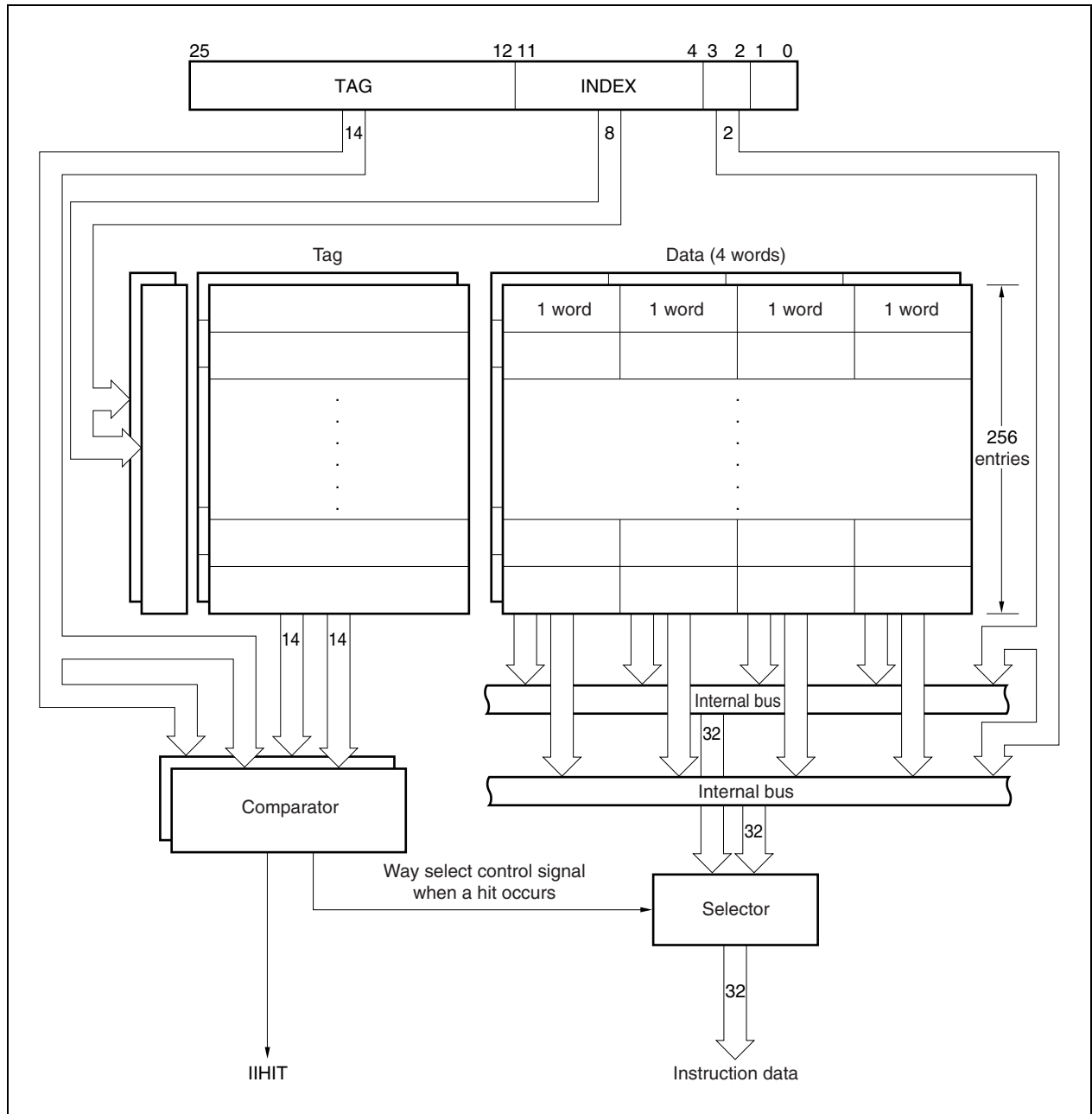
**Remark** n = 0 to 2

#### 4.9.2 8 KB 2-way set associative cache

The data memory of the 8 KB 2-way set associative cache has two ways each consisting of 4-word lines and blocks of 256 entries, and has a total capacity of 8 KB. If a cache miss occurs, the data memory is refilled in 1-line units.

Only the instructions related to data access of the cacheable area can be cached in the instruction cache.

**Figure 4-7. Configuration of 8 KB 2-Way Set Associative Instruction Cache**



#### 4.9.3 LRU algorithm

This algorithm is used to record accesses to blocks and replace the block that has not been used for the longest time, so that information that may be necessary is not discarded immediately.

## 4.9.4 Instruction cache control function

## (1) Instruction cache control register (ICC)

This register sets two types of functions, tag clear and auto fill.

This register can be read or written in 16-bit units.

If the higher 8 bits of the ICC register are used as an ICCH register, and the lower 8 bits, as an ICCL register, these registers can be read or written in 8-bit or 1-bit units.

Bit 12 can only be read and cleared.

Be sure to clear bits 15 to 13, 11 to 5, 3, and 2 to 0. If they are set to 1, the operation is not guaranteed.

**Cautions** 1. Do not forcibly clear bits 0, 1, and 4 when they are set to 1.

2. Do not set bit 4 to 1 at the same time as the other bits.

3. Do not set bit 12 to 1. This bit can only be cleared to 0.

4. Be sure to set the ICC register in an uncached area (except setting of bit 4).

|     |    |    |    |        |    |    |   |   |   |   |   |       |   |   |       |       |            |                       |
|-----|----|----|----|--------|----|----|---|---|---|---|---|-------|---|---|-------|-------|------------|-----------------------|
|     | 15 | 14 | 13 | 12     | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4     | 3 | 2 | 1     | 0     | Address    | After reset           |
| ICC | 0  | 0  | 0  | LOCKI0 | 0  | 0  | 0 | 0 | 0 | 0 | 0 | FILL0 | 0 | 0 | TCLR1 | TCLR0 | FFFFFF070H | 0003H <sup>Note</sup> |

**Note** The value of this register is 0003H when the reset signal becomes active, and initialization of the tag is automatically started. When initialization of the tag has been completed, the value of this register is cleared to 0000H.

| Bit position | Bit name | Function                                                                                                                                                                                                                                                              |
|--------------|----------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 12           | LOCKI0   | Indicates the cache lock status of way 0.<br>The cache is locked when way 0 is filled, and this bit is automatically set to 1. When this bit is cleared to 0, cache lock of way 0 is cleared.<br>0: Way 0 is not locked.<br>1: Way 0 is locked.                       |
| 4            | FILL0    | Sets auto fill of way 0.<br>When this bit is set to 1, way 0 is automatically filled. When auto fill has been completed, this bit is automatically cleared to 0.<br>0: Filling way 0 is completed.<br>1: Way 0 is being filled.                                       |
| 1            | TCLR1    | Sets tag clear of way 1.<br>When this bit is set to 1, the tag of way 1 is cleared (invalidated).<br>When clearing the tag has been completed, this bit is automatically cleared to 0.<br>0: Clearing tag of way 1 is completed.<br>1: Tag of way 1 is being cleared. |
| 0            | TCLR0    | Sets tag clear of way 0.<br>When this bit is set to 1, the tag of way 0 is cleared (invalidated).<br>When clearing the tag has been completed, this bit is automatically cleared to 0.<br>0: Clearing tag of way 0 is completed.<br>1: Tag of way 0 is being cleared. |

**(2) Instruction cache data configuration register (ICD)**

This register sets the address of the memory area that is automatically filled by the auto fill function.

This register can be read or written in 16-bit units.

Be sure to clear bit 0 to 0. If it is set to 1, the operation is not guaranteed.

- Cautions**
1. Do not rewrite the ICD register during the auto fill operation. The operation is not guaranteed if it is rewritten.
  2. Because the default value of the ICD register is undefined, be sure to set a value to the ICD register when the auto fill function is used, and then set the FILL0 bit of the ICC register to 1. If the FILL0 bit of the ICC register is set to 1 without setting a value to the ICD register, the operation is not guaranteed.

|     |    |        |        |        |        |        |       |       |       |       |       |       |       |       |       |   |            |             |
|-----|----|--------|--------|--------|--------|--------|-------|-------|-------|-------|-------|-------|-------|-------|-------|---|------------|-------------|
|     | 15 | 14     | 13     | 12     | 11     | 10     | 9     | 8     | 7     | 6     | 5     | 4     | 3     | 2     | 1     | 0 | Address    | After reset |
| ICD | 0  | ICD 14 | ICD 13 | ICD 12 | ICD 11 | ICD 10 | ICD 9 | ICD 8 | ICD 7 | ICD 6 | ICD 5 | ICD 4 | ICD 3 | ICD 2 | ICD 1 | 0 | FFFFFF074H | Undefined   |

| Bit position | Bit name      | Function                                                                                                                      |
|--------------|---------------|-------------------------------------------------------------------------------------------------------------------------------|
| 14 to 1      | ICD14 to ICD1 | Set the higher 14 bits of tag information (bits 25 to 12 of the first address of the memory area to be automatically filled). |

#### 4.9.5 Tag clear function

The tag of one way is cleared (invalidated).

After reset, all the ways, tags, and LRU are automatically cleared (invalidated).

The instruction cache tag is cleared using the following procedure.

- <1> The ICC register is read to confirm that both the TCLR0 and TCLR1 bits are cleared to 0.
- <2> The ICC register is read to confirm that the LOCKI0 bit is cleared to 0. Bit 13 of the ICC register is always cleared to 0.
- <3> The TCLR0 and TCLR1 bits of the ICC register are set as follows.

**Cautions** 1. Perform operations <1> to <3> above (tag clear) in an uncached area (the tag is not cleared from a cacheable area).

- To clear both ways 0 and 1 at the same time
  - (a) Set the TCLR0 and TCLR1 bits to 1.
  - (b) Read the TCLR0 and TCLR1 bits to confirm that they are cleared to 0.
- To clear ways 0 and 1 separately<sup>Note</sup>
  - (a) Set the TCLR0 bit to 1.
  - (b) Read the TCLR0 bit to confirm that it is cleared to 0.
  - (c) Set the TCLR1 bit to 1.
  - (d) Read the TCLR1 bit to confirm that it is cleared to 0.

**Note** The ways can be cleared separately also in the order of (c) - (d) - (a) - (b).

2. The counter for clearing the tag of ways 0 and 1 is shared.

Therefore, clear the tag (by setting the TCLR0 or TCLR1 bit of the ICC register) when the counter for clearing the tag is stopped (when TCLR0 = TCLR1 = 0). When clearing the tags of ways 0 and 1 separately, the counter stops while a tag is being cleared if the tag of one other way is cleared while the tag of the other way is being cleared (TCLR0 or TCLR1 = 1). Consequently, the tag cannot be cleared correctly because the tag of the other way is cleared with the counter indicating a midway value. Be sure to clear the tag of one other way after confirming that the tag of the other way has been cleared (TCLR0 or TCLR1 = 0).

There is no problem if both the bits are set at the same time as follows.

```

                                mov    0x3, r2
LOP0:
                                ld.h   ICC[r0], r1
                                cmp     r0, r1
                                bnz     LOP0
                                st.h    r2, ICC[r0]
LOP1:
                                ld.h   ICC[r0], r1
                                cmp     r0, r1
                                bnz     LOP1

```

3. Do not perform other processing in parallel with clearing the tag until it is confirmed by reading the TCLR0 and TCLR1 bits of the ICC register that the tag has been cleared to 0.



#### 4.9.6 Auto fill function (way 0 only)

The instruction of one way is automatically filled.

The way that has been filled automatically is automatically locked and prohibited from being written, and performs the same operation as ROM that can be accessed in one cycle. After the way is unlocked, it operates as an instruction cache again.

The instruction cache is automatically filled using the following procedure.

- <1> Clear (invalidate) the tag of way 0 (see **4.9.5 Tag clear function**).
- <2> Set information on the tag corresponding to the memory area to be automatically filled to the ICD register.
- <3> Branch to the cacheable area corresponding to the tag information set to the ICD register.
- <4> Set the FILL0 bit of the ICC register to 1.
- <5> When auto fill is completed, the LOCKI0 bit of the ICC register is automatically set to 1, and way 0 is locked.  
At this time, read the FILL0 bit of the ICC register at the same time to confirm that this bit is cleared to 0.

**Caution** Perform the above operations in the following areas.

<1>, <2>, <3> ..... **Uncached area**

<4> ..... **Cacheable area**

**If the FILL0 bit of the ICC register is set to 1 from an uncached area, auto fill cannot be executed (is invalidated).**

<5> ..... **This can be done from both an uncached area and a cacheable area.**

**Remark** To unlock the way, clear the LOCKI0 bit of the ICC register to 0.

#### 4.9.7 Cautions

When a refill read cycle is activated by the occurrence of a cache miss, the instruction read in that bus cycle may be discarded without being registered in the instruction cache. When this operation occurs for a conditional branch instruction in a program loop, for example, an illegal refill read cycle occurs in the subsequent cache line each time the program loops, which degrades the system performance. The effect of performance degradation is particularly large in a small-scale loop. However, program execution is performed normally even under this circumstance and the execution result is logically correct.

In order to make up for performance degradation due to the uncertain operation by the instruction cache, an instruction RAM is provided in the V850E/ME2, which assures certain instruction execution in a 1-clock pitch. Therefore, execute a routine that may cause this problem using the instruction RAM.

## 4.10 Internal Instruction RAM Control Function

The V850E/ME2 has 128 KB of instruction RAM (16 KB × 32 bits × 2 banks).  
While one bank is being read, the other bank can be written in parallel.

### 4.10.1 Internal instruction RAM mode register (IRAMM)

#### (1) Internal instruction RAM mode register (IRAMM)

This register specifies a mode in which the instruction RAM is accessed.  
This register can be read or written in 8-bit or 1-bit units.

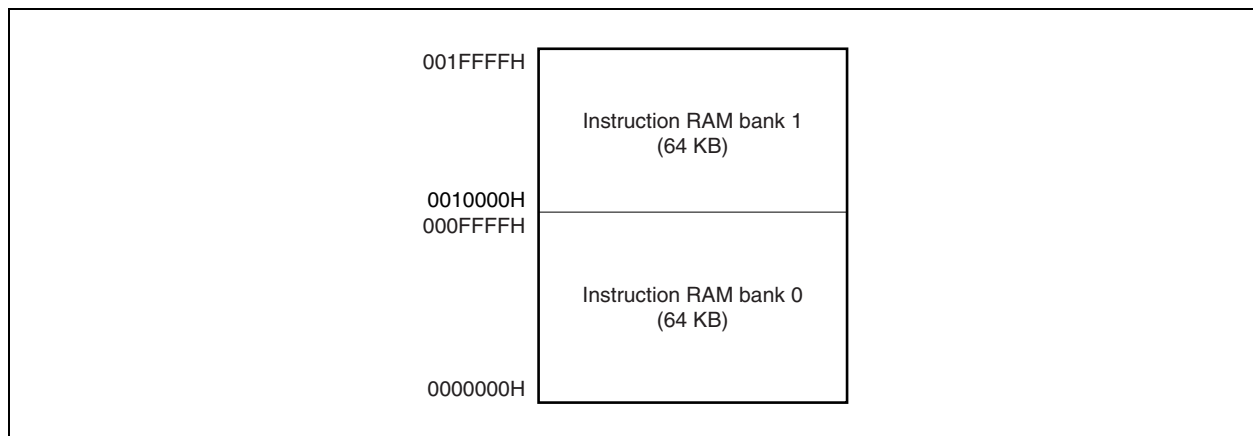
- Cautions**
1. When the setting of a mode is changed, the next access (such as code fetching) to the internal instruction RAM may be executed first because of the pipeline operation of the CPU. When the setting of the IRAMM register is changed, therefore, be sure to read the IRAMM register to confirm that writing has been executed, and then execute an access to the internal instruction RAM.
  2. Data can be written to the internal instruction RAM only by a word access.
  3. Address miss-align access to the internal instruction RAM is prohibited.

|       |   |   |   |   |   |   |        |        |            |             |
|-------|---|---|---|---|---|---|--------|--------|------------|-------------|
|       | 7 | 6 | 5 | 4 | 3 | 2 | 1      | 0      | Address    | After reset |
| IRAMM | 0 | 0 | 0 | 0 | 0 | 0 | IRAMM1 | IRAMM0 | FFFFFF80AH | 03H         |

| Bit position | Bit name | Function                                                                              |
|--------------|----------|---------------------------------------------------------------------------------------|
| 1            | IRAMM1   | Specifies the access mode of instruction RAM bank 1.<br>0: Read mode<br>1: Write mode |
| 0            | IRAMM0   | Specifies the access mode of instruction RAM bank 0.<br>0: Read mode<br>1: Write mode |

**Figure 4-8. Memory Map of Internal Instruction RAM**



#### 4.10.2 Operation

##### (1) Read operation

The internal instruction RAM can be read by normal RAM access without having to be aware of the banks if the read mode is selected by the IRAMM register.

**Cautions** 1. A bank in the write mode cannot be read.

2. The internal instruction RAM (in the read mode) is accessed using the  $\times 1$  internal system clock ( $f_{CLK}$ ).

##### (2) Write operation

The internal instruction RAM can be written by normal RAM access without having to be aware of the banks if the write mode is selected by the IRAMM register.

**Cautions** 1. A bank in the read mode cannot be written.

2. Internal instruction RAM bank 0 area is allocated to interrupt and exception tables. Disable interrupts until writing an instruction code to bank 0 of the internal instruction RAM is completed. Similarly, disable interrupts when bank 0 of the internal instruction RAM is set in the write mode.

For disabling maskable interrupts, refer to interrupt mask registers 0 to 5 (IMR0 to IMR5) (7.3.5 Interrupt mask registers 0 to 5 (IMR0 to IMR5)). To disable the non-maskable interrupt, set the NP bit of the PSW to 1 to disable multiple interrupts (see 3.2.2 (4) Program status word (PSW)). For the NMI mask operation when reset is cleared, refer to the NMI reset status register (NRS) (7.3.6 NMI reset status register (NRS)).

3. Since the internal instruction RAM (in the write mode) is accessed using BUSCLK (internal instruction RAM (in the read mode) is accessed using internal system clock ( $f_{CLK}$ )), programmable waits, address setup waits, and idle states can be inserted for the CS0 space.

## 4.10.3 Cautions

- (1) Disable all interrupts from when reset is cleared until when program codes are completely transferred to the internal instruction RAM. It is not necessary to disable maskable interrupts because they are masked by default. Because the software exception and exception trap cannot be masked, do not execute the TRAP and DBTRAP instructions until transfer of program codes to the internal instruction RAM is completed.
  - (2) After reset has been cleared, the NMI input is masked by hardware. The NMI is unmasked as soon as the IRAMM0 bit of the IRAMM register has been cleared to 0.
  - (3) To write data to instruction RAM bank 0 of the internal instruction RAM, set the NP bit of the PSW to 1 to disable the NMI and maskable interrupts and suppress occurrence of the software exception and exception trap. Clear the NP bit by setting the IRAMM0 bit of the IRAMM register to 1 and confirming that the read mode is set, after the program has been rewritten.
  - (4) NMI or maskable interrupt requests that have been generated while the NP bit of the PSW is set to 1 are held pending. An NMI request is acknowledged immediately after the NP bit has been cleared to 0. A maskable interrupt is acknowledged immediately after the NP bit has been cleared to 0, if the interrupt request is not cleared (by clearing the  $xxIFn$  bit of the interrupt control register ( $xxICn$ ) to 0), if interrupts are not disabled (DI status), and if the  $xxMKn$  bit of the interrupt control register is not set to 1 before the NP bit is cleared to 0. However, only one interrupt request, NMI request or a maskable interrupt request, can be held pending per interrupt source. Even if the same interrupt request is generated more than once, only the first interrupt request is acknowledged (xx: Peripheral unit identification name (see **Table 7-2**), n: Peripheral unit number (see **Table 7-2**)).
- <R> (5) When the internal instruction RAM is accessed (in the write mode), the  $\overline{CS0}$  signal, address bus, and data bus output data. The external bus control signals other than  $\overline{UWR}$ ,  $\overline{ULWR}$ ,  $\overline{LUWR}$ ,  $\overline{LLWR}$ ,  $\overline{WR}$ , and  $\overline{RD}$  become active. If output of the  $\overline{IOWR}$  signal is enabled by setting the IOEN bit of the BCP register to 1, the  $\overline{IOWR}$  signal becomes inactive.

## 4.11 Bus Hold Function

### 4.11.1 Function outline

If the PCM2 and PCM3 pins are specified in the control mode, the  $\overline{\text{HLDAK}}$  and  $\overline{\text{HLDRQ}}$  functions become valid.

If it is determined that the  $\overline{\text{HLDRQ}}$  pin has become active (low level) as a bus mastership request from another bus master, the external address/data bus and each strobe pin are shifted to high impedance and then released (bus hold state). If the  $\overline{\text{HLDRQ}}$  pin becomes inactive (high level) and the bus mastership request is canceled, driving of these pins begins again.

During the bus hold period, the internal operations of the V850E/ME2 continue until the external memory or an on-chip peripheral I/O register is accessed.

The bus hold state can be known by the  $\overline{\text{HLDAK}}$  pin becoming active (low level). The period from when the  $\overline{\text{HLDRQ}}$  pin becomes active (low level) to when the  $\overline{\text{HLDAK}}$  pin becomes active (low level) is at least 2 clocks.

In a multiprocessor configuration, etc., a system with multiple bus masters can be configured.

| State                                                    | Data Bus Width | Access Type                     | Timing at Which Bus Hold Request Cannot Be Acknowledged |
|----------------------------------------------------------|----------------|---------------------------------|---------------------------------------------------------|
| CPU bus lock                                             | 32 bits        | Word access for 4n+1 address    | Between first and second accesses                       |
|                                                          |                |                                 | Between second and third accesses                       |
|                                                          |                | Word access for 4n+2 address    | Between first and second accesses                       |
|                                                          |                | Word access for 4n+3 address    | Between first and second accesses                       |
|                                                          |                | Halfword access for odd address | Between second and third accesses                       |
|                                                          |                |                                 | Between first and second accesses                       |
|                                                          | 16 bits        | Word access for even address    | Between first and second accesses                       |
|                                                          |                | Word access for odd address     | Between first and second accesses                       |
|                                                          |                |                                 | Between second and third accesses                       |
|                                                          |                | Halfword access for odd address | Between first and second accesses                       |
|                                                          | 8 bits         | Word access                     | Between first and second accesses                       |
|                                                          |                |                                 | Between second and third accesses                       |
|                                                          |                |                                 | Between third and forth accesses                        |
|                                                          |                | Halfword access                 | Between first and second accesses                       |
| Read modify write access of bit manipulation instruction | —              | —                               | Between read access and write access                    |

**Cautions 1.** When an external bus master accesses SDRAM during a bus hold state, make sure that the external bus master executes the all-bank precharge command.

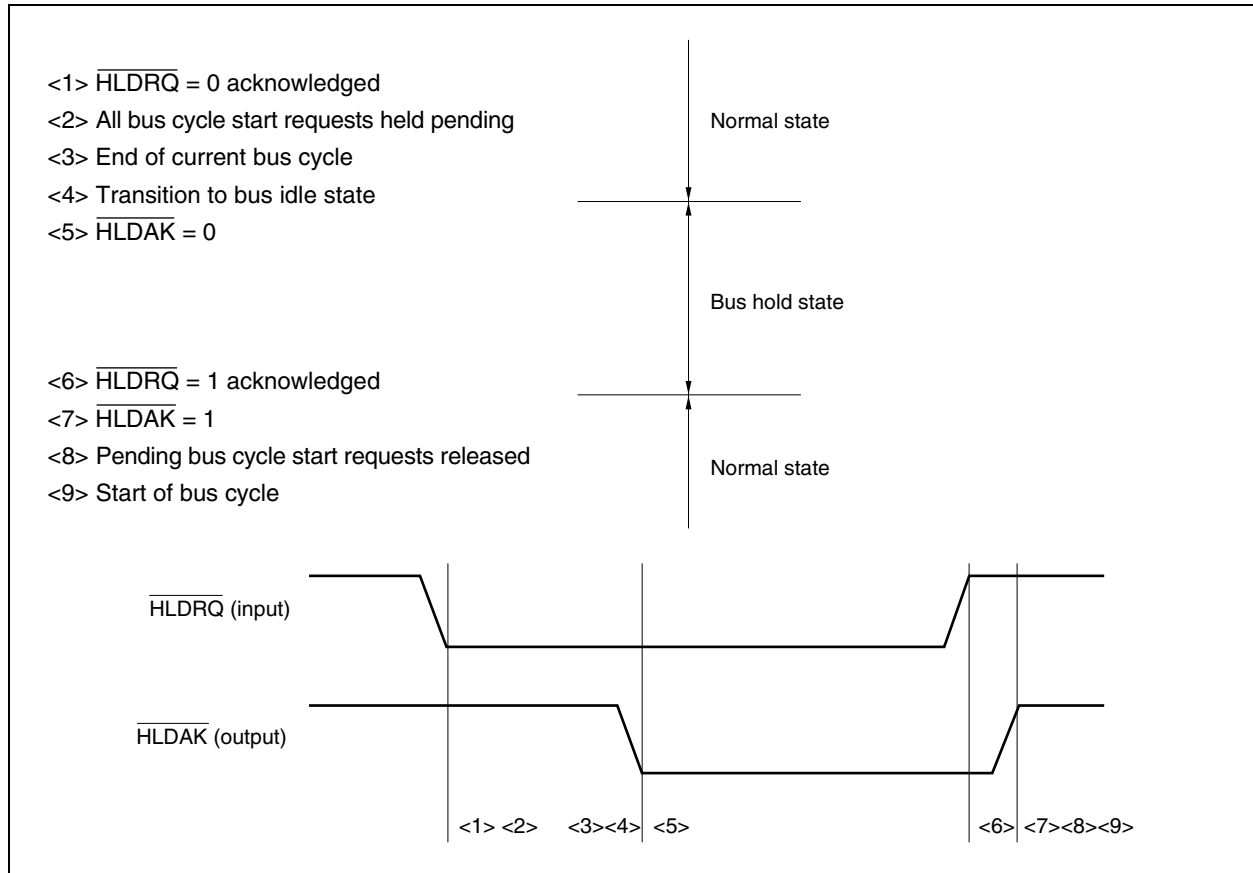
The CPU always executes the all-bank precharge command to release a bus hold state. In a bus hold state, do not allow an external bus master to change the SDRAM command register value.

**2.** The  $\overline{\text{HLDRQ}}$  function is invalid during a reset period. The  $\overline{\text{HLDAK}}$  pin becomes active either immediately after or after the insertion of a 1-clock address cycle from when the  $\overline{\text{RESET}}$  pin is set to inactive following the simultaneous activation of the  $\overline{\text{RESET}}$  and  $\overline{\text{HLDRQ}}$  pins.

When a bus master other than the V850E/ME2 is externally connected, use the  $\overline{\text{RESET}}$  signal for bus arbitration at power-on.

#### 4.11.2 Bus hold procedure

The procedure of the bus hold function is illustrated below.



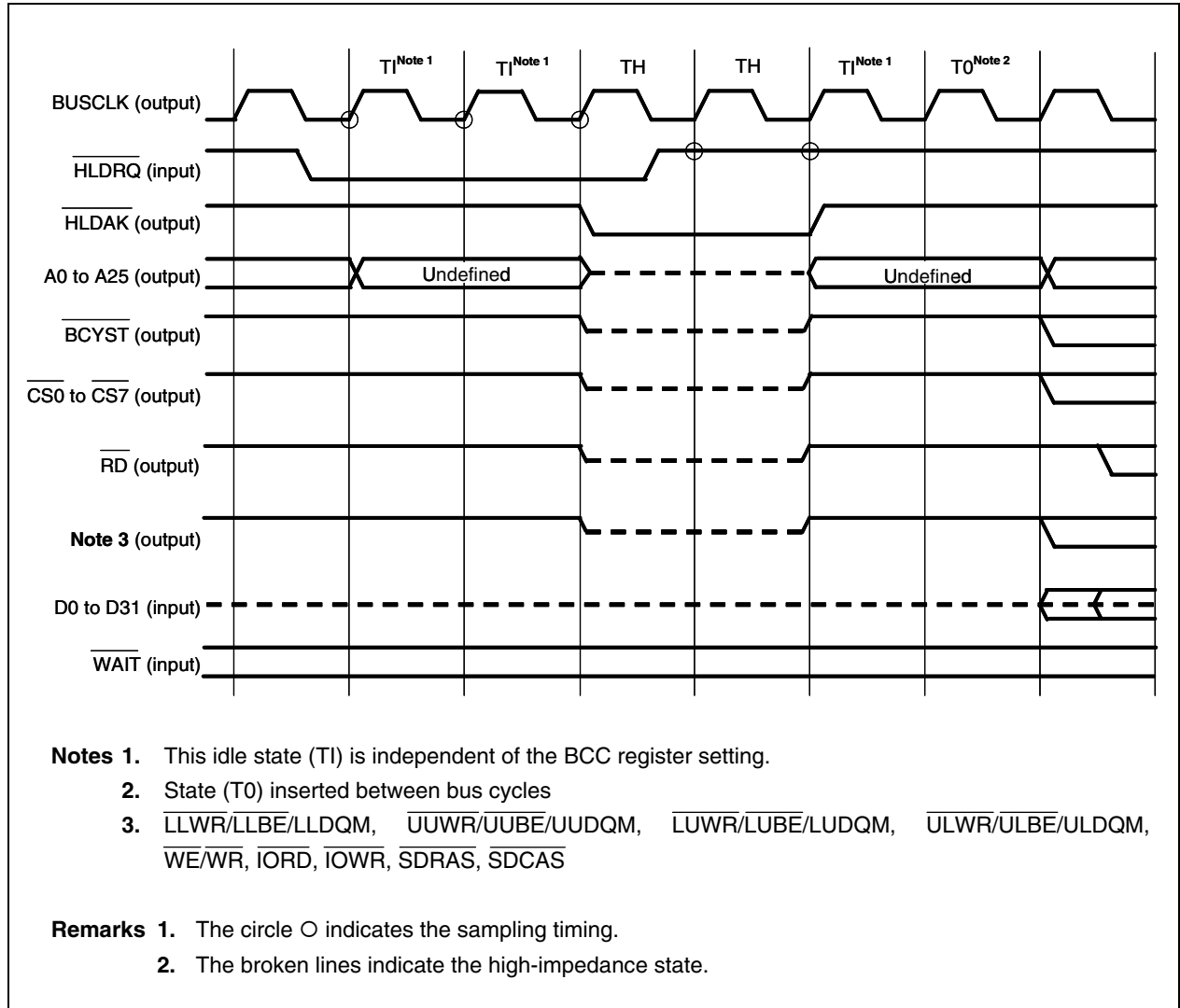
#### 4.11.3 Operation in power-save mode

In the software STOP or IDLE mode, the internal system clock ( $f_{\text{CLK}}$ ) is stopped. Consequently, the bus hold state is not set since the  $\overline{\text{HLD RQ}}$  pin cannot be acknowledged even if it becomes active.

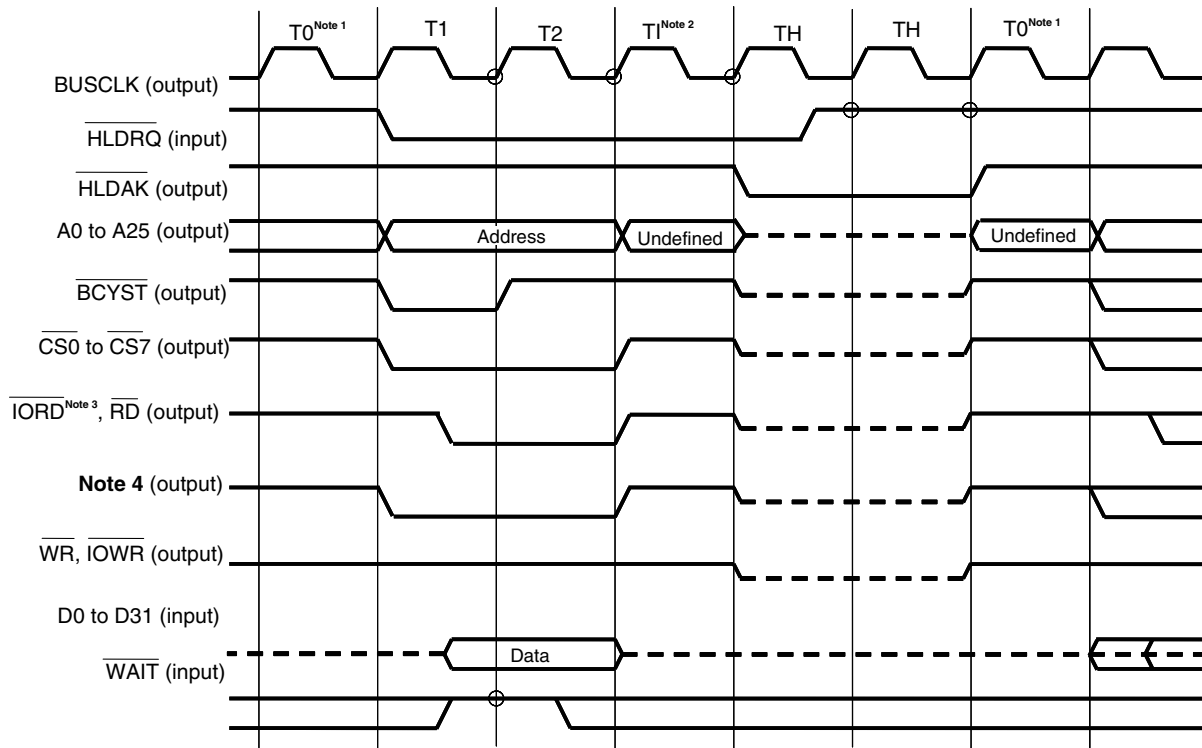
In the HALT mode, the  $\overline{\text{HLD AK}}$  pin immediately becomes active when the  $\overline{\text{HLD RQ}}$  pin becomes active, and the bus hold state is set. When the  $\overline{\text{HLD RQ}}$  pin becomes inactive after that, the  $\overline{\text{HLD AK}}$  pin also becomes inactive. As a result, the bus hold state is cleared and the HALT mode is set again.

#### 4.11.4 Bus hold timing

(1) If bus hold request is issued when bus cycle is not generated



## 4.11.5 Bus hold timing (SRAM)

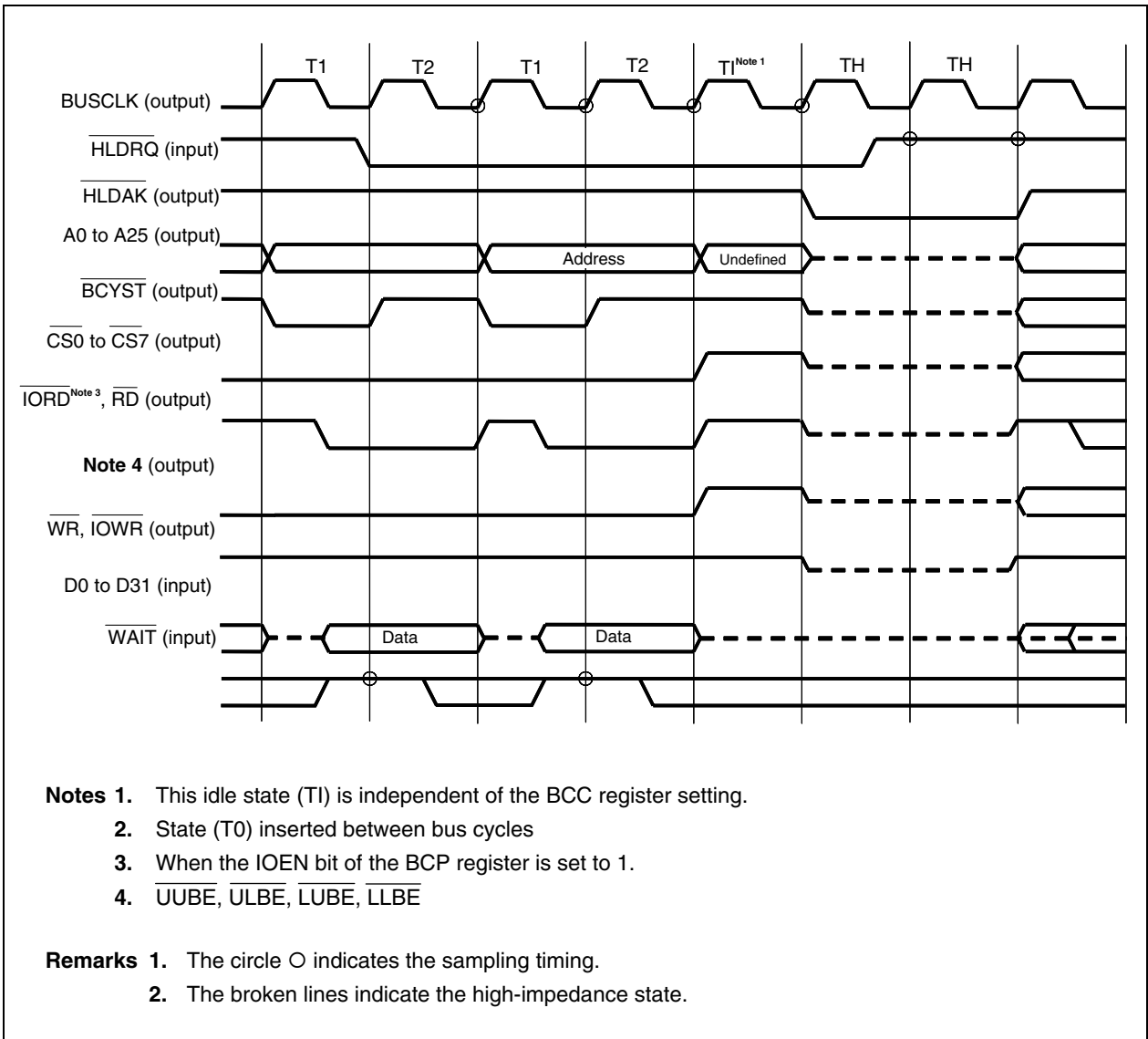
(1) SRAM (when read, without speculative read, no idle state inserted,  $BUSCLK = f_{CLK}/2$ )

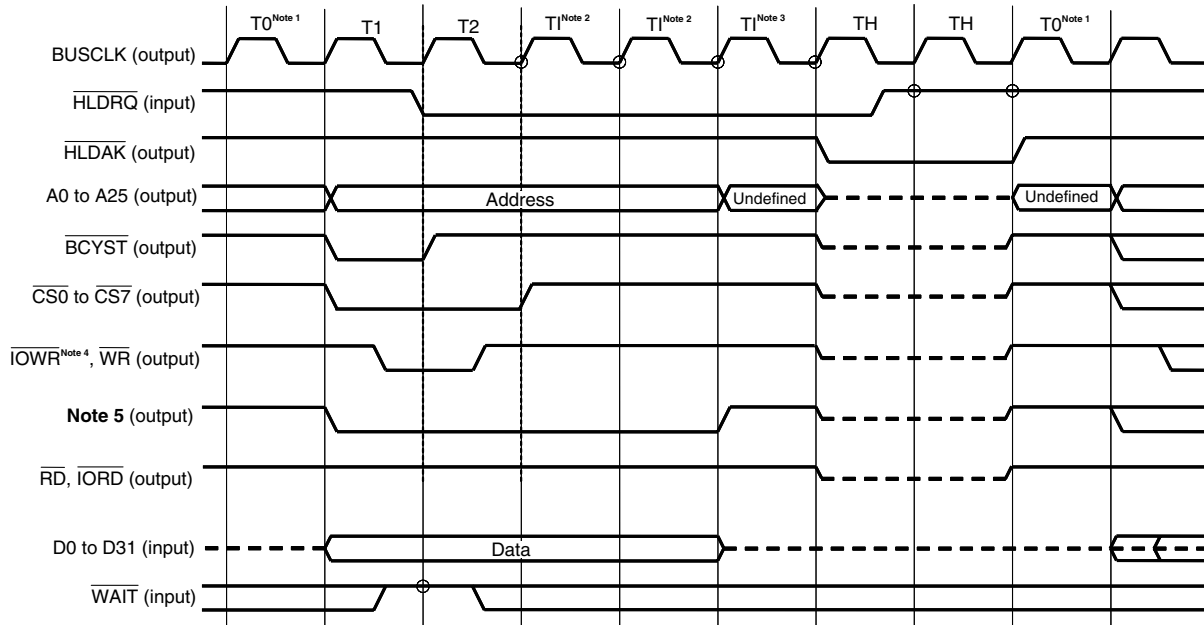
- Notes**
1. State (T0) inserted between bus cycles
  2. This idle state (T1) is independent of the BCC register setting.
  3. When the IOEN bit of the BCP register is set to 1.
  4.  $\overline{UUBE}$ ,  $\overline{ULBE}$ ,  $\overline{LUBE}$ ,  $\overline{LLBE}$

- Remarks**
1. The circle ○ indicates the sampling timing.
  2. The broken lines indicate the high-impedance state.



(2) SRAM (when read, with speculative read, no idle state inserted,  $BUSCLK = f_{CLK}/2$ )



(3) SRAM (when written, two idle states inserted,  $BUSCLK = f_{CLK}/2$ )

**Notes** 1. State (T0) inserted between bus cycles

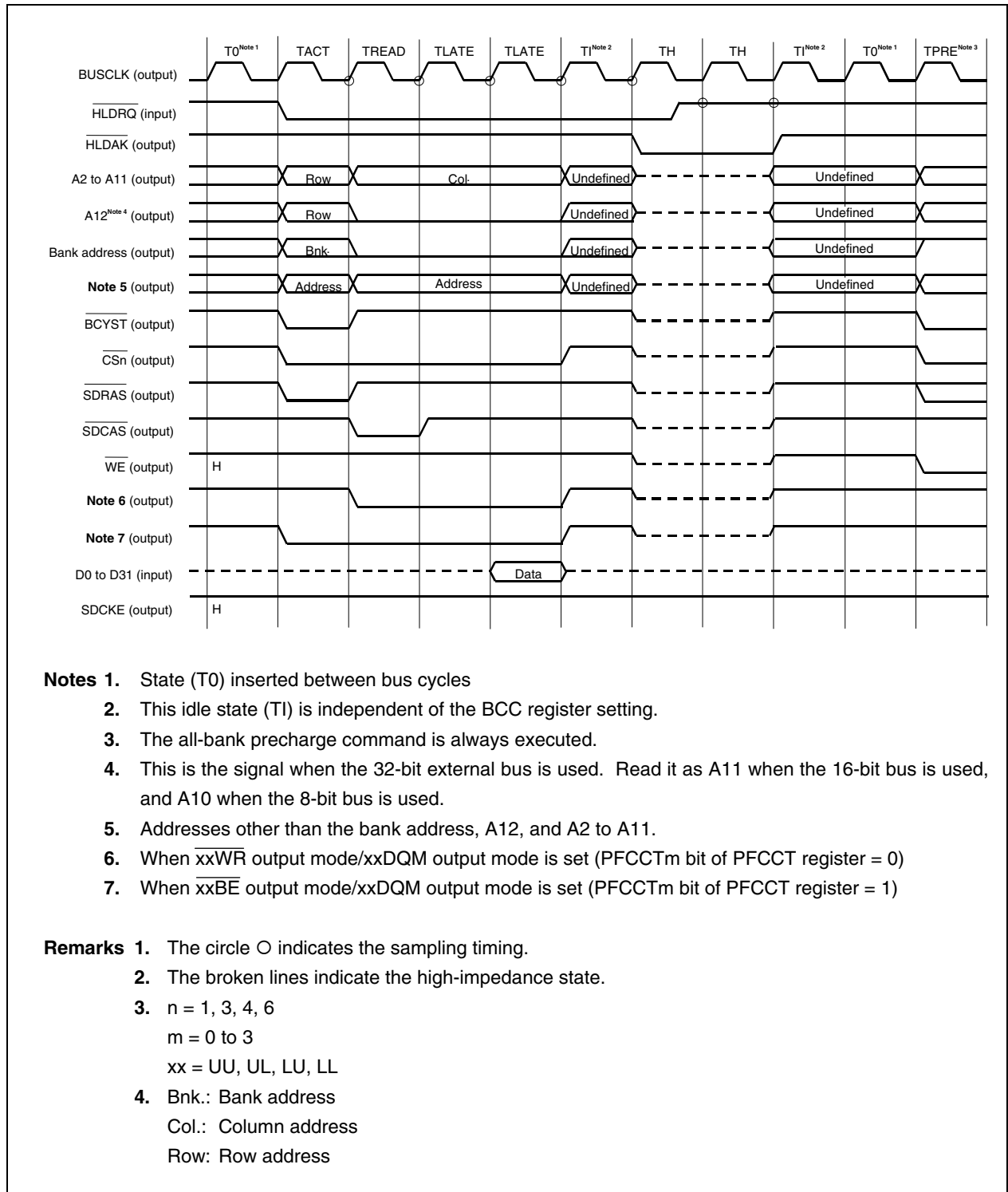
2. This idle state (T1) is inserted by means of a BCC register setting.
3. This idle state (T1) is independent of the BCC register setting.
4. When the IOEN bit of the BCP register is set to 1.
5.  $\overline{UUBE}$ ,  $\overline{ULBE}$ ,  $\overline{LUBE}$ ,  $\overline{LLBE}$

**Remarks** 1. The circle O indicates the sampling timing.

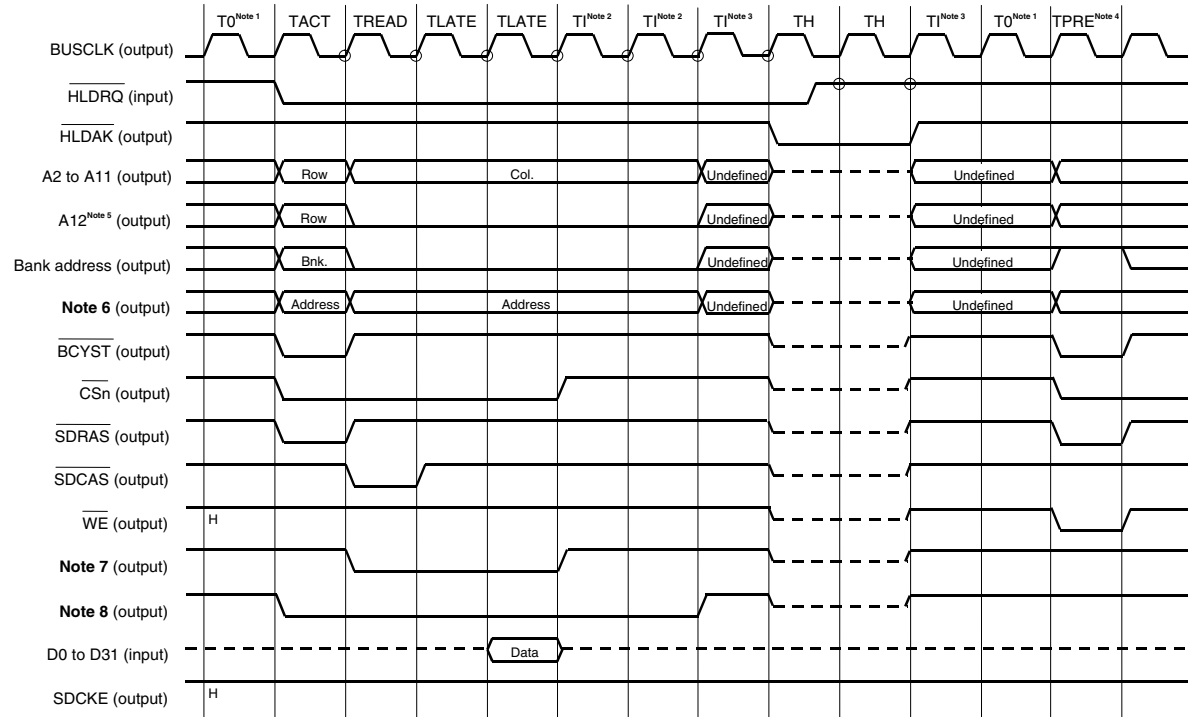
2. The broken lines indicate the high-impedance state.

## 4.11.6 Bus hold timing (SDRAM)

## (1) SDRAM (when read, latency = 2, no idle state inserted)



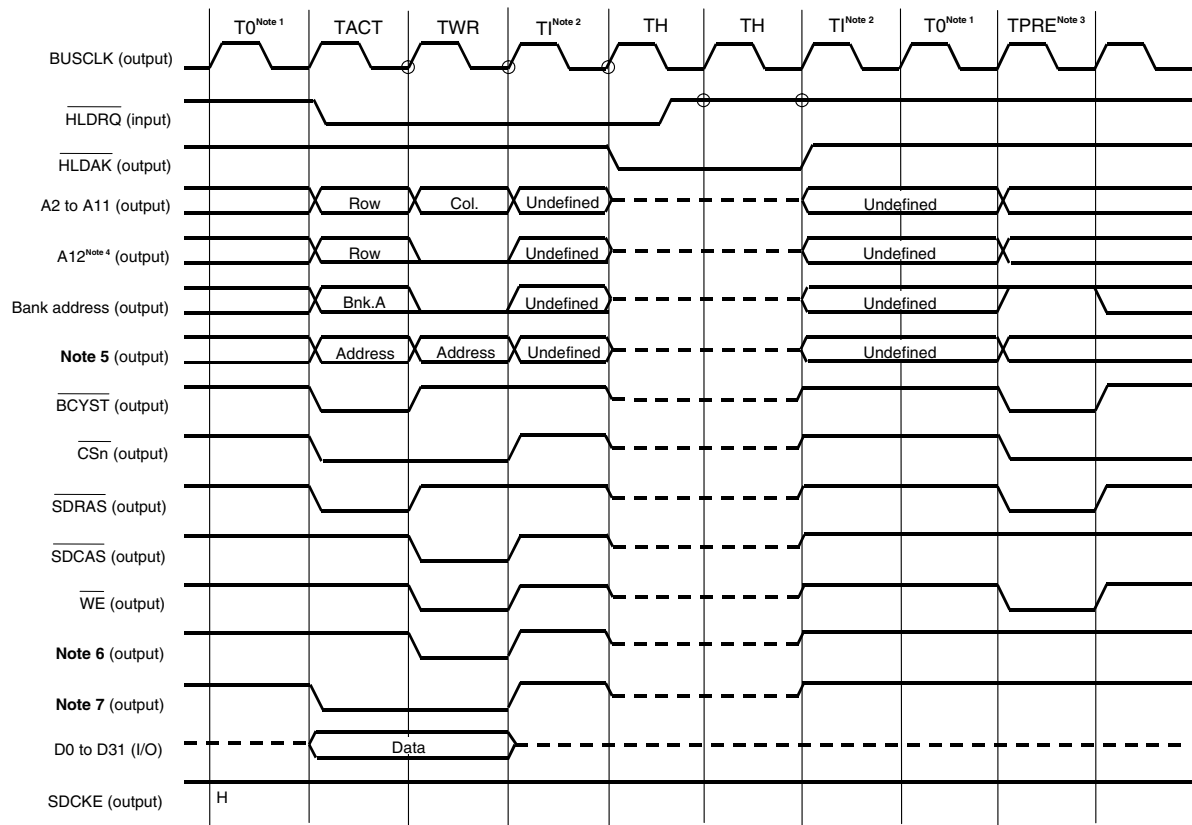
## (2) SDRAM (when read, latency = 2, two idle states inserted, 32-bit bus width)



- Notes**
1. State (T0) inserted between bus cycles
  2. This idle state (TI) is inserted by means of a BCC register setting.
  3. This idle state (TI) is independent of the BCC register setting.
  4. The all-bank precharge command is always executed.
  5. This is the signal when the 32-bit external bus is used. Read it as A11 when the 16-bit bus is used, and A10 when the 8-bit bus is used.
  6. Addresses other than the bank address, A12, and A2 to A11.
  7. When  $\overline{\text{xxWR}}$  output mode/xxDQM output mode is set (PFCCTm bit of PFCCT register = 0)
  8. When  $\overline{\text{xxBE}}$  output mode/xxDQM output mode is set (PFCCTm bit of PFCCT register = 1)

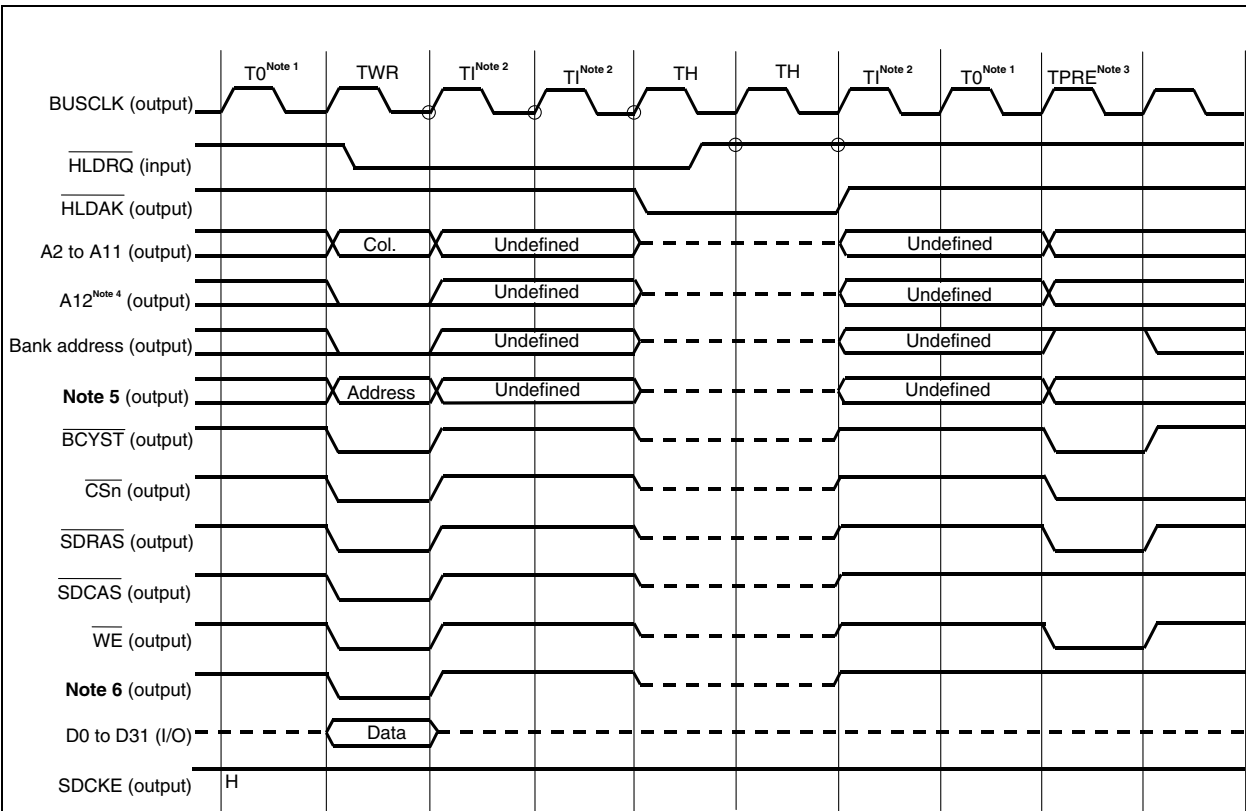
- Remarks**
1. The circle ○ indicates the sampling timing.
  2. The broken lines indicate the high-impedance state.
  3. n = 1, 3, 4, 6  
m = 0 to 3  
xx = UU, UL, LU, LL
  4. Bnk.: Bank address  
Col.: Column address  
Row: Row address

### (3) SDRAM (when written)



- Notes**
1. State (T0) inserted between bus cycles
  2. This idle state (TI) is independent of the BCC register setting.
  3. The all-bank precharge command is always executed.
  4. This is the signal when the 32-bit external bus is used. Read it as A11 when the 16-bit bus is used, and A10 when the 8-bit bus is used.
  5. Addresses other than the bank address, A12, and A2 to A11.
  6. When  $\overline{xxWR}$  output mode/ $\overline{xxDQM}$  output mode is set (PFCCTm bit of PFCCT register = 0)
  7. When  $\overline{xxBE}$  output mode/ $\overline{xxDQM}$  output mode is set (PFCCTm bit of PFCCT register = 1)

- Remarks**
1. The circle O indicates the sampling timing.
  2. The broken lines indicate the high-impedance state.
  3.  $n = 1, 3, 4, 6$   
 $m = 0 \text{ to } 3$   
 $xx = UU, UL, LU, LL$
  4. Bnk.: Bank address  
Col.: Column address  
Row: Row address

**(4) SDRAM (when written, when bus hold request acknowledged during on-page access)****Notes**

1. State (T0) inserted between bus cycles
2. This idle state (TI) is independent of the BCC register setting.
3. The all-bank precharge command is always executed.
4. This is the signal when the 32-bit external bus is used. Read it as A11 when the 16-bit bus is used, and A10 when the 8-bit bus is used.
5. Addresses other than the bank address, A12, and A2 to A11.
6. UUDQM, ULDQM, LUDQM, LLDQM

**Remarks**

1. The circle ○ indicates the sampling timing.
2. The broken lines indicate the high-impedance state.
3. n = 1, 3, 4, 6
4. Col.: Column address

## 4.12 Bus Priority Order

There are five external bus cycles: bus hold, instruction fetch, operand data access, DMA cycle, and refresh cycle.

In order of priority, bus hold is the highest, followed by the refresh cycle, DMA cycle, operand data access, and instruction fetch, in that order.

An instruction fetch may be inserted between a read access and write access during a read modify write access.

Also, an instruction fetch may be inserted between bus accesses when the CPU bus clock is used.

**Table 4-2. Bus Priority Order**

| Priority Order                                                                                   | External Bus Cycle  | Bus Master       |
|--------------------------------------------------------------------------------------------------|---------------------|------------------|
| High<br><br>Low | Bus hold            | External device  |
|                                                                                                  | Refresh cycle       | SDRAM controller |
|                                                                                                  | DMA cycle           | DMA controller   |
|                                                                                                  | Operand data access | CPU              |
|                                                                                                  | Instruction fetch   | CPU              |

## 4.13 Boundary Operation Conditions

### 4.13.1 Program space

Branching to the on-chip peripheral I/O area is prohibited. If the above is performed, undefined data is fetched, and fetching from the external memory is not performed.

### 4.13.2 Data space

The V850E/ME2 is provided with an address misalign function.

Through this function, regardless of the data format (word or halfword), data can be allocated to all addresses. However, in the case of word data and halfword data, if the data is not subject to boundary alignment, the bus cycle will be generated at least 2 times and bus efficiency will drop.

#### (1) External bus width: 16 bits

##### (a) In the case of halfword-length data access

When the address's LSB is 1, a byte-length bus cycle will be generated 2 times.

##### (b) In the case of word-length data access

(i) When the address's LSB is 1, bus cycles will be generated in the order of byte-length bus cycle, halfword-length bus cycle, and byte-length bus cycle.

(ii) When the address's lower 2 bits are 10, a halfword-length bus cycle will be generated 2 times.

#### (2) External bus width: 32 bits

##### (a) In the case of halfword-length data access

When the address's lower 2 bits are 11, a byte-length bus cycle will be generated 2 times.

##### (b) In the case of word-length data access

When the address's lower 2 bits are 10, a halfword-length bus cycle will be generated 2 times.

#### 4.14 Timing at Which T0 State Is Not Inserted

A T0 state is not inserted at the following timing.

##### (1) Read

- During a refill operation when instruction cache is used (in the second and subsequent cycles)
- During speculative reading (in the second and subsequent cycles)
- If a read request (including a read request by instruction fetch or DMA) is generated before a write operation to the external device is completed when a read operation occurs immediately after a write operation
- If a read request (including a read request by instruction fetch or DMA) that is greater than the bus width of the external device is generated (in the second and subsequent cycles)

##### [Example]

- 32-bit read access with 16-bit external bus width
- 32-bit or 16-bit read access with 8-bit external bus width

##### (2) Write

- If a write request (including a write request by DMA) is generated before a write operation to the external device is completed when a write operation occurs immediately after a write operation, and data is stored in the write buffer (a cycle in which the data stored in the write buffer is written to the external device)
- If a write request (including a write request by DMA) is generated during a speculative read operation (if data is stored in the write buffer)
- If a write request (including a write request by DMA) greater than the bus width of the external bus is generated (after the second and subsequent cycles)

##### [Example]

- 32-bit write access with external 16-bit bus width
- 32-bit or 16-bit write access with external 8-bit bus



## 4.15 Cautions

Cautions concerning the bus control function are shown below.

### (1) Access to internal instruction RAM (in write mode)

Since the internal instruction RAM (in the write mode) is accessed using BUSCLK (internal instruction RAM (in the read mode) is accessed using internal system clock (f<sub>CLK</sub>)), programmable waits, address setup waits, and idle states can be inserted in the CS0 space.

### (2) Cautions on setting LBCn register

- When the speculative read function is set for each CSn space, do not insert an idle state in the CSn space for which the speculative read function is enabled by the BCC register (n = 0 to 7). If an idle state is required to be inserted in the CSn space for which the speculative read function is enabled, enable the speculative read function for all CSn spaces (set the LBC0 and LBC1 registers to 3333H) or disable the speculative read function for all CSn spaces (set the LBC0 and LBC1 registers to 0000H).
- Do not enable the speculative read function for SDRAM that is accessed via a 32-bit bus.

### (3) Write operation to external device

When data is written to an external device, the write operation to the external device may not be executed even when a CPU write operation has been completed by the write buffer. The CPU can access the on-chip peripheral I/O registers after the write operation has been completed even if data exist in the write buffer. Therefore, if it is necessary to change the value of an on-chip peripheral I/O register after completion of execution of an external memory cycle, write the same value as the default value to the LBC0 or LBC1 register or write 00H to the WAS register before writing the on-chip peripheral I/O register whose value is to be changed. When writing an on-chip peripheral I/O register other than the LBC0 or LBC1 register without writing the same value as the default value to the LBC0 or LBC1 register, or writing an on-chip peripheral I/O register other than the WAS register without writing 00H to the WAS register, the register value may be changed before completion of the external memory cycle.

### (4) 2-cycle transfer that writes data to external device

During 2-cycle transfer that writes data to the external device, the write operation to the external device may not be completed even if TCn bit of DCHCn register = 1 (DMA transfer completion) is read by the write buffer (n = 0 to 3). If it is necessary to change the value of an on-chip peripheral I/O register after completion of DMA transfer (completion of a write operation to the external device), perform either of the following operations.

- Monitor the  $\overline{\text{TCn}}$  signal (the  $\overline{\text{TCn}}$  signal becomes active in synchronization with a write operation to the external device).
- After detecting setting (to 1) of the TCn bit, write 00H to the WAS register or write the same value as the default value to the LBC0 or LBC1 register, and then change the value of the on-chip peripheral I/O register. If the value of an on-chip peripheral I/O register other than the LBC0 and LBC1 registers is changed without writing the same value to LBC0 or LBC1 or the value of an on-chip peripheral I/O register other than the WAS register is changed without writing 00H to the WAS register, the value of the on-chip peripheral I/O register may be changed before completion of DMA transfer.

**(5) Caution on setting BMC register**

Set the number of waits (using the DWk2 to DWk0 bits of the DWCM register) or address setup waits (using the ACK1 and ACK0 bits of the ASC register) for all the CS spaces in which an SRAM or page-ROM interface cycle is activated to 1 or more when the same clock is used as the internal system clock and bus clock (CKM1 and CKM0 bits of the BMC register = 00) and the speculative read function is enabled (RBk1 and RBk0 bits of LBCM register = 11) (m = 0, 1, k = 0 to 7).

**(6) Caution on setting DWCN register**

When the internal instruction RAM area is accessed (in the write mode), the programmable wait value set for the CS0 space becomes valid.

**(7) Caution on setting ASC register**

Be sure to set the number of address setup wait states to 1 or more if the  $\overline{CSn}$  signal is delayed using the PFCCS register (n = 0 to 7).

**(8) Caution on BCP register setting**

If the internal instruction RAM is accessed while the IOEN bit of the BCP register is set (1) (in the write mode), the  $\overline{IOWR}$  signal becomes inactive.

**(9) Caution on setting BCC register**

The  $\overline{CSn}$  signal does not become active in the idle state (n = 0 to 7).

**(10) Caution on setting BHC register**

- Be sure to set the BHC register in an uncached area (instructions cannot be fetched correctly if it is set from a cacheable area).
- The area that includes the instruction that sets the BHC register cannot be set from an uncached area to a cacheable area, or from a cacheable area to an uncached area; otherwise the operation is not guaranteed. In this case, branch to area 1 and then set area 0 to a cacheable area by an instruction in area 1. If necessary, branch to area 0 again.  
An uncached area and a cacheable area can be set in any CS space in the internal instruction RAM area.
- If adjacent memory areas are a cacheable area and an uncached area, only a branch instruction can be used to successively access this memory boundary. The operation is not guaranteed if this memory boundary is successively accessed by an instruction other than a branch instruction.

**(11) Caution on setting IRAMM register**

- Data can be written to the internal instruction RAM only by a word access.
- Address miss-align access to the internal instruction RAM is prohibited.

**(12) Write operation to internal instruction RAM area**

Internal instruction RAM bank 0 area is allocated to interrupt and exception tables. Disable interrupts until writing an instruction code to bank 0 of the internal instruction RAM is completed. Similarly, disable interrupts when bank 0 of the internal instruction RAM is set in the write mode.

&lt;R&gt;

## CHAPTER 5 MEMORY ACCESS CONTROL FUNCTION

### 5.1 SRAM, External ROM, External I/O Interface

#### 5.1.1 Features

- SRAM is accessed in a minimum of 2 states.
- Up to 7 states of programmable data waits can be inserted by setting the DWC0 and DWC1 registers (DMA flyby transfer: FWC register).
- Data wait can be controlled via  $\overline{\text{WAIT}}$  pin input.
- Up to 3 idle states can be inserted after a read/write cycle by setting the BCC register (DMA flyby transfer: FIC register).
- Up to 3 address setup wait states can be inserted by setting the ASC register.
- DMA flyby transfer can be activated (SRAM → external I/O, external I/O → SRAM)

## 5.1.2 SRAM connection

Examples of connection to SRAM are shown below.

Figure 5-1. Examples of Connection to SRAM (1/2)

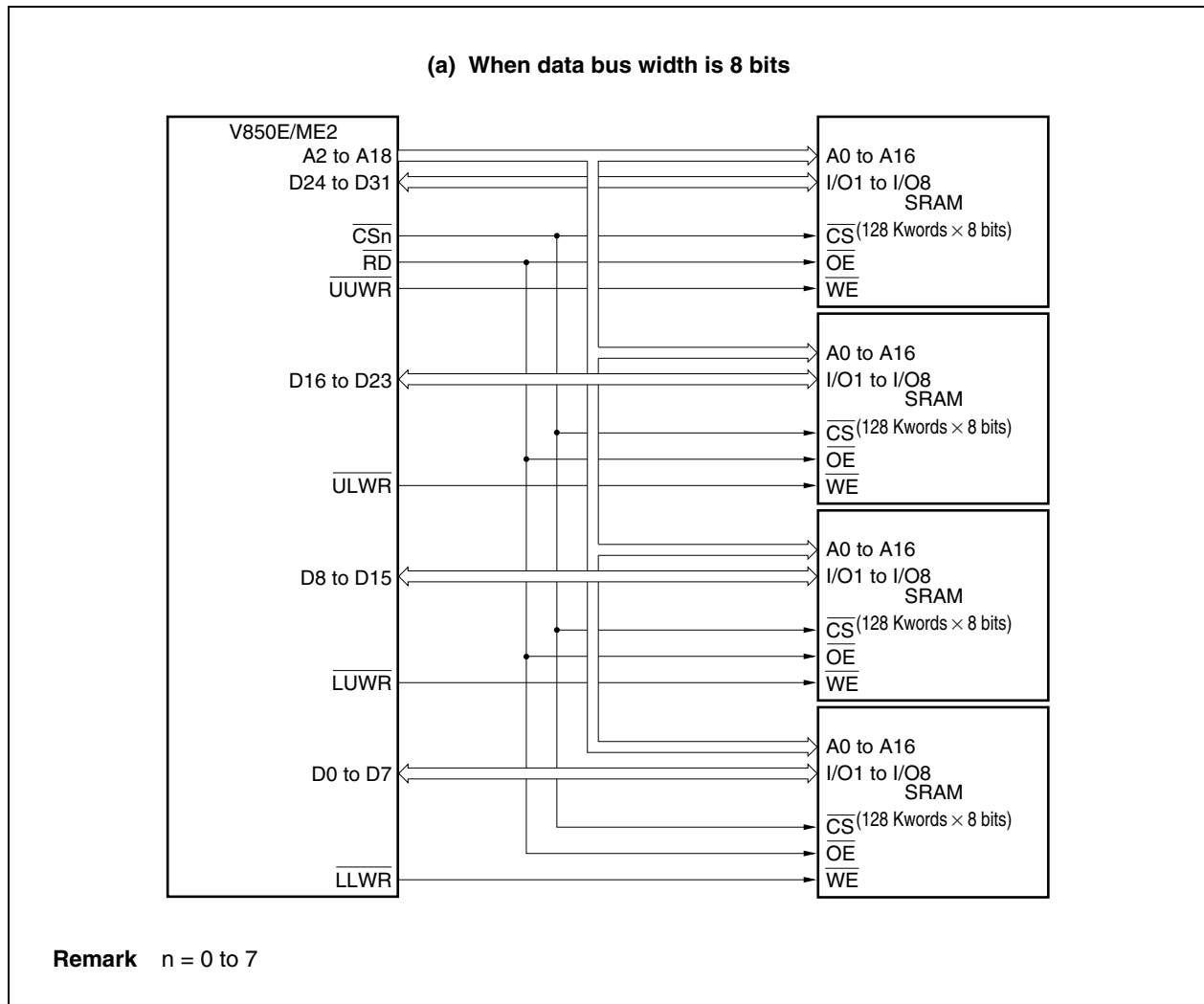
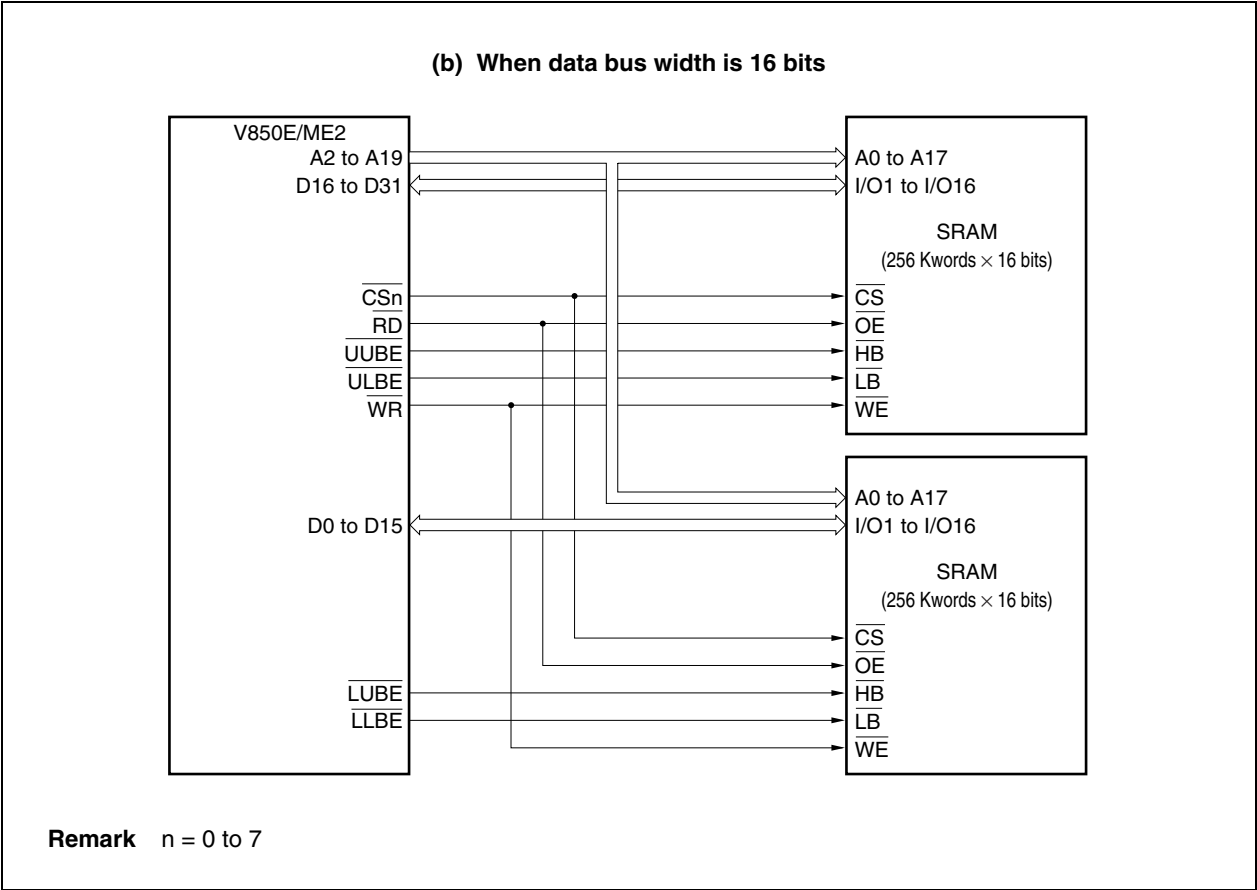


Figure 5-1. Examples of Connection to SRAM (2/2)



## 5.1.3 SRAM, external ROM, external I/O access

Figure 5-2. SRAM, External ROM, External I/O Access Timing (1/10)

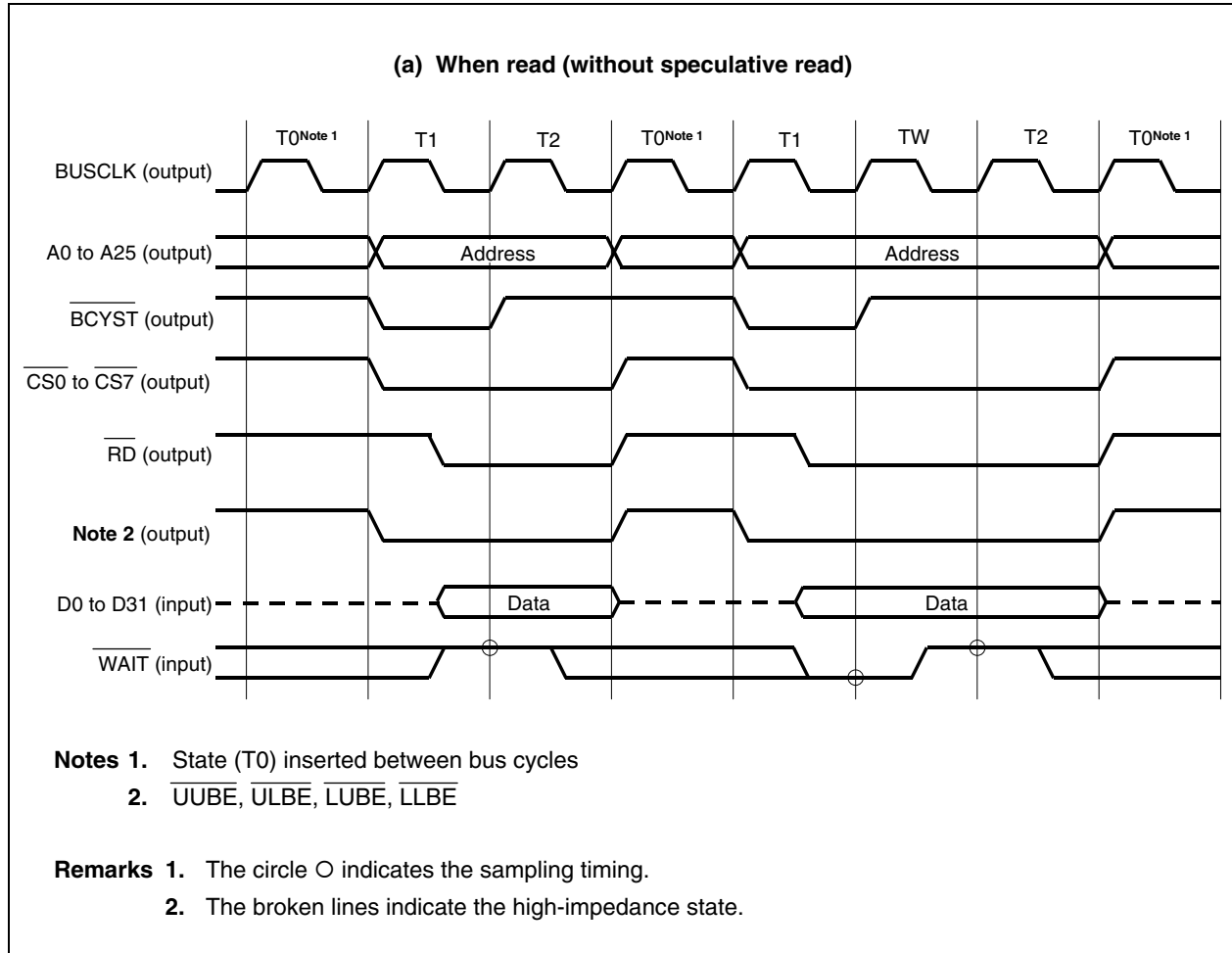


Figure 5-2. SRAM, External ROM, External I/O Access Timing (2/10)

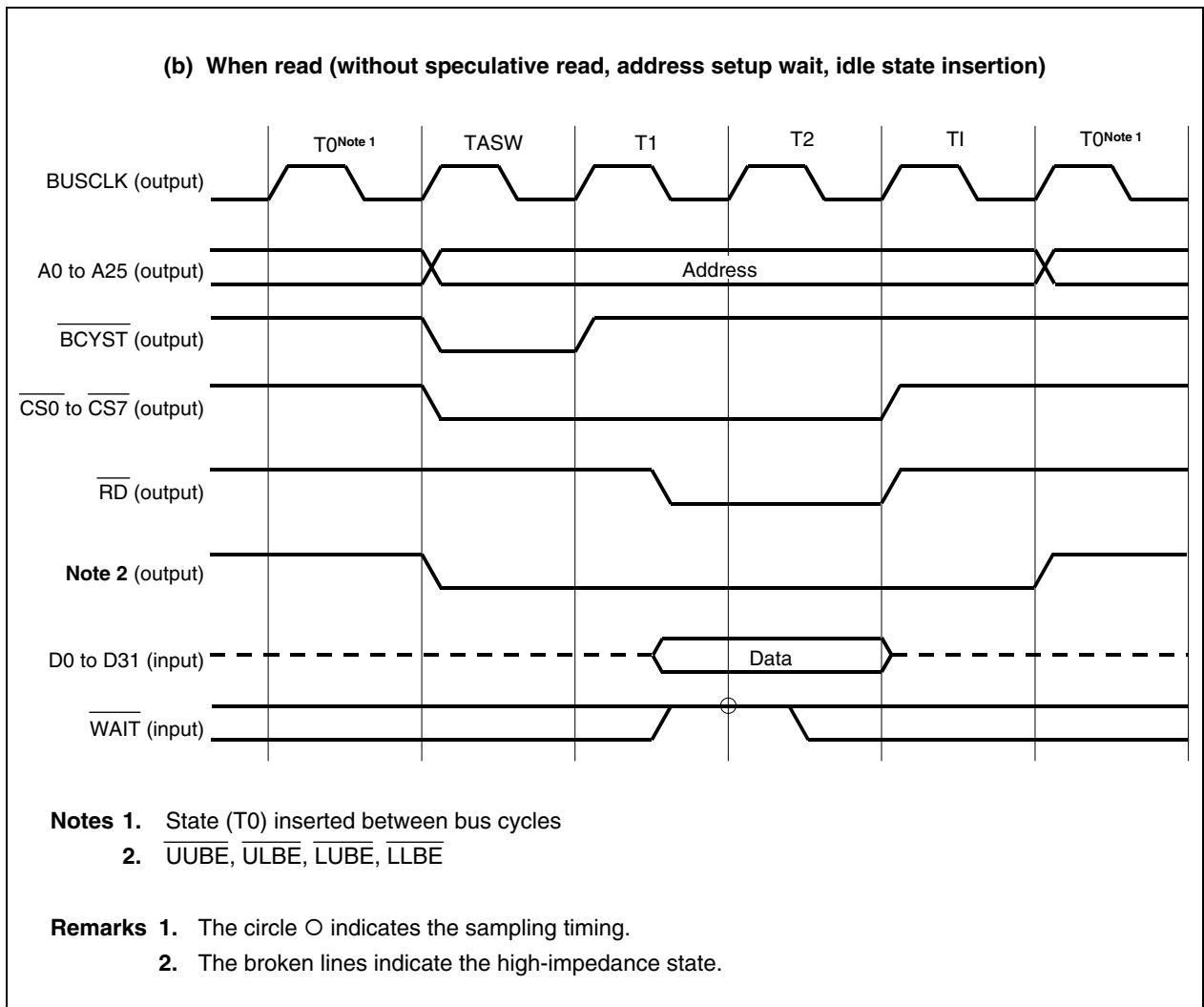


Figure 5-2. SRAM, External ROM, External I/O Access Timing (3/10)

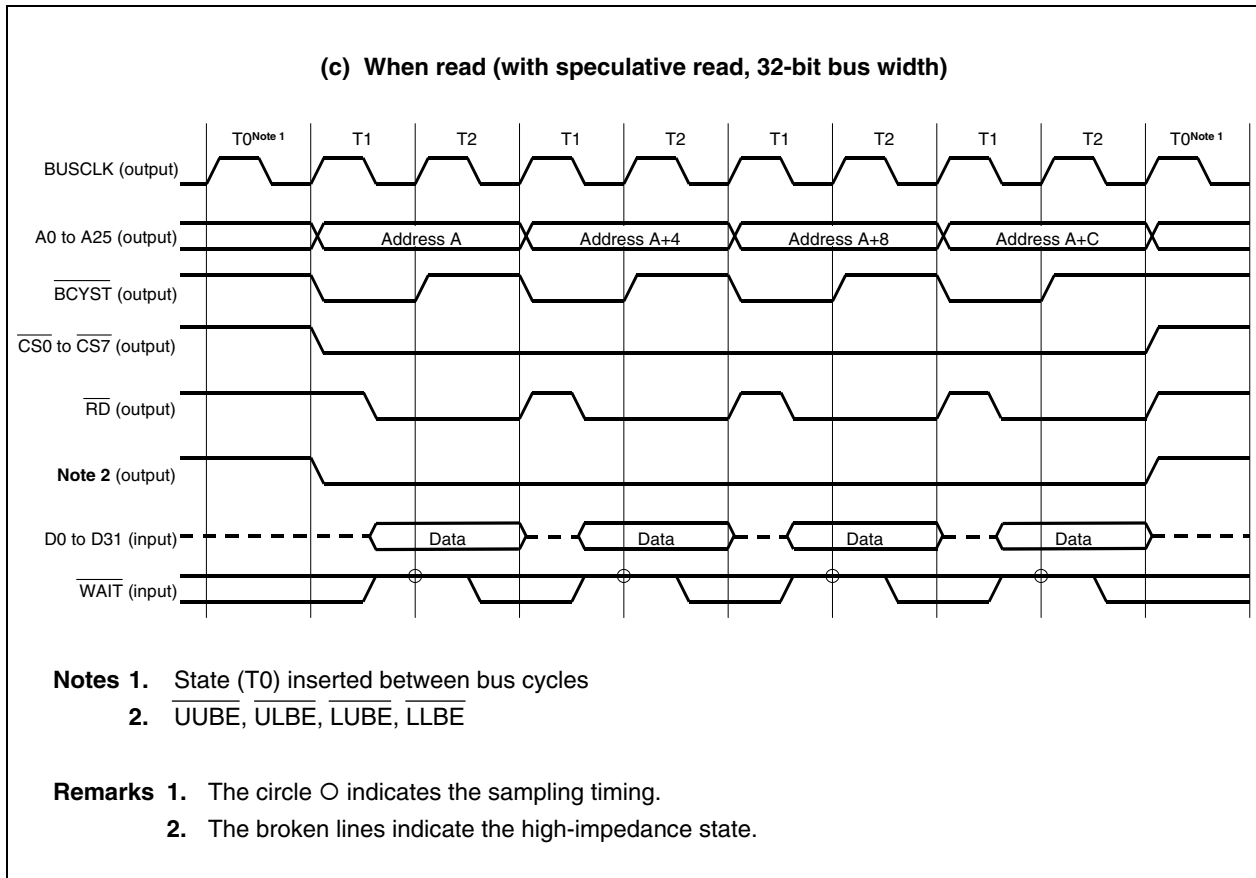




Figure 5-2. SRAM, External ROM, External I/O Access Timing (4/10)

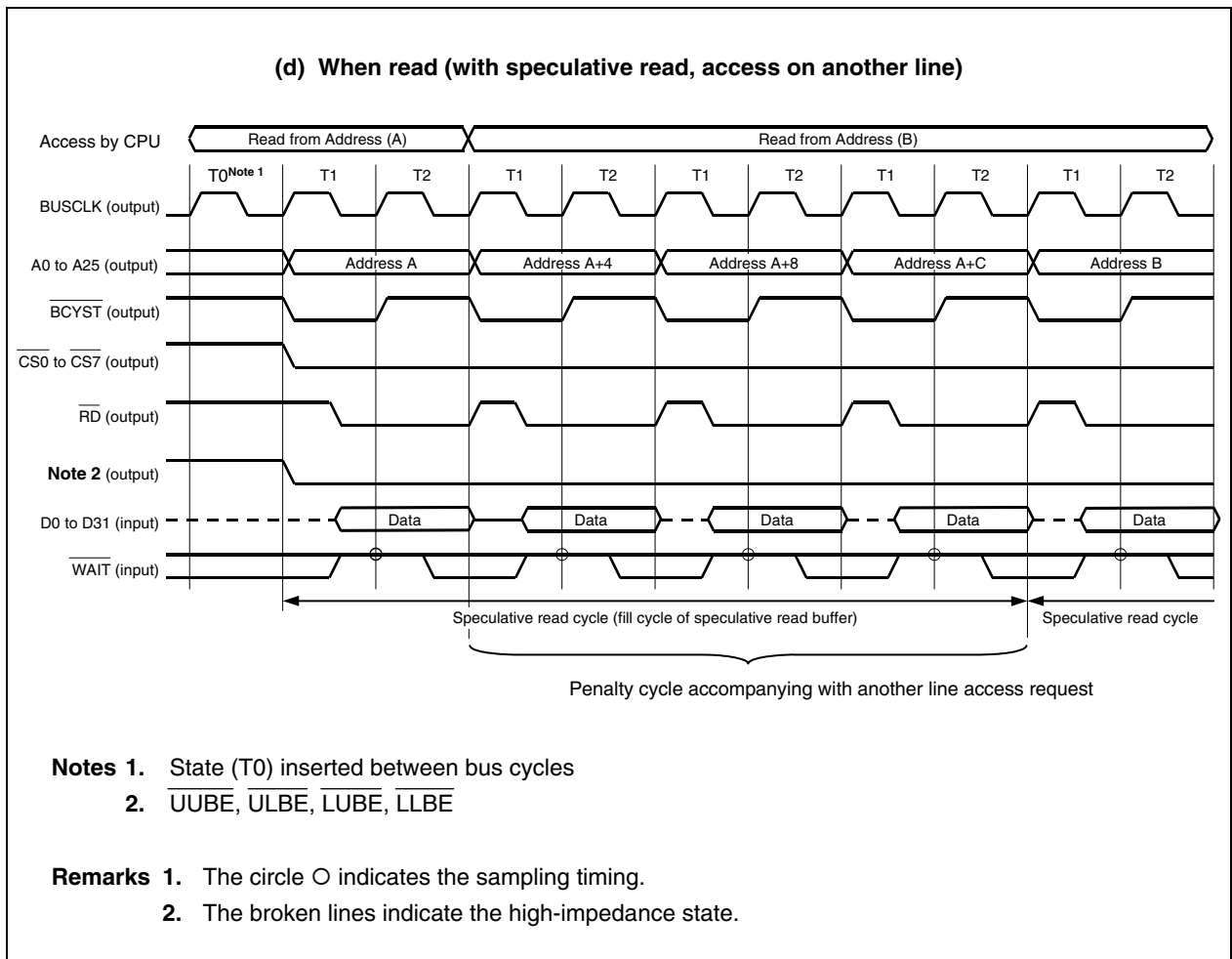
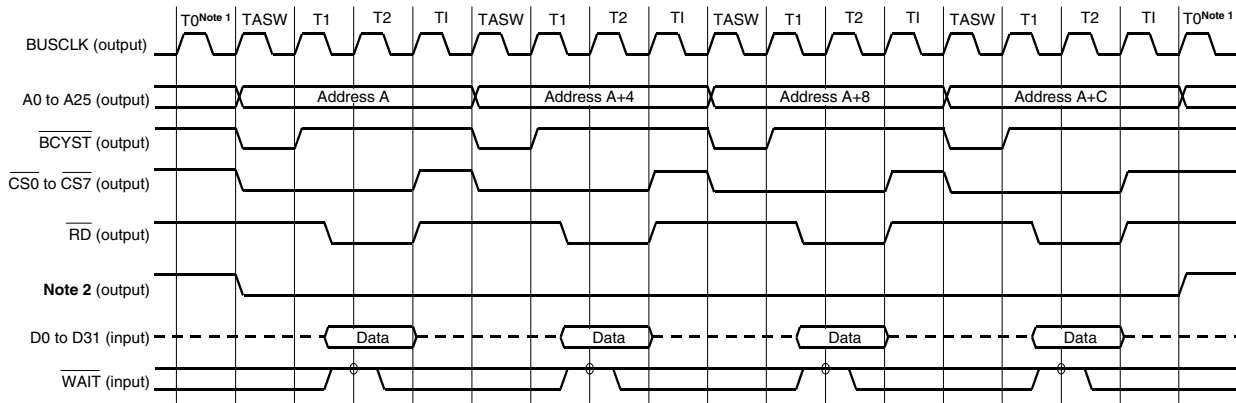


Figure 5-2. SRAM, External ROM, External I/O Access Timing (5/10)

**(e) When read (with speculative read, 32-bit bus width, address setup wait, idle state insertion)**

**Notes** 1. State (T0) inserted between bus cycles

2.  $\overline{\text{UUBE}}$ ,  $\overline{\text{ULBE}}$ ,  $\overline{\text{LUBE}}$ ,  $\overline{\text{LLBE}}$

**Remarks** 1. The circle ○ indicates the sampling timing.

2. The broken lines indicate the high-impedance state.

Figure 5-2. SRAM, External ROM, External I/O Access Timing (6/10)

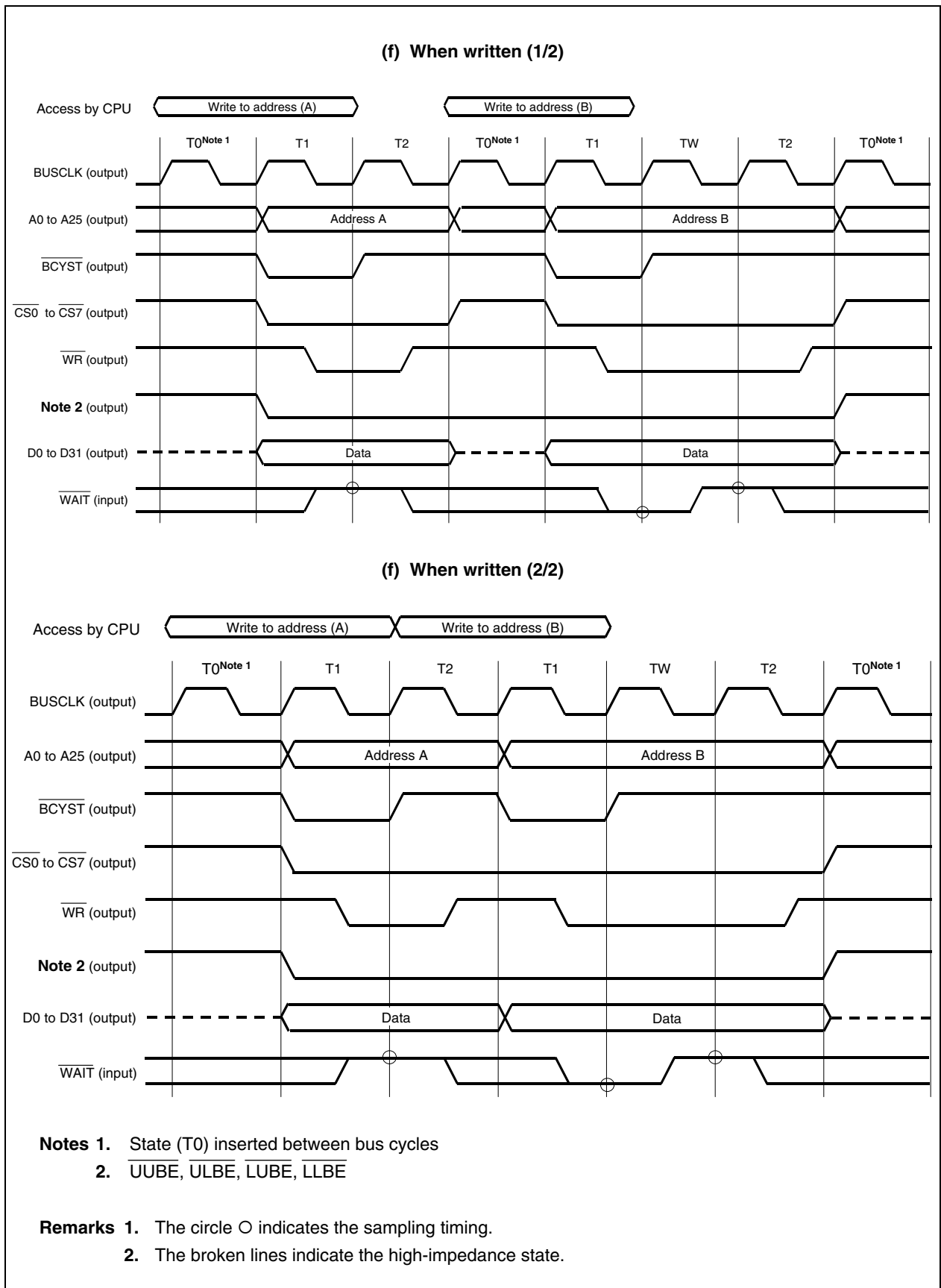


Figure 5-2. SRAM, External ROM, External I/O Access Timing (7/10)

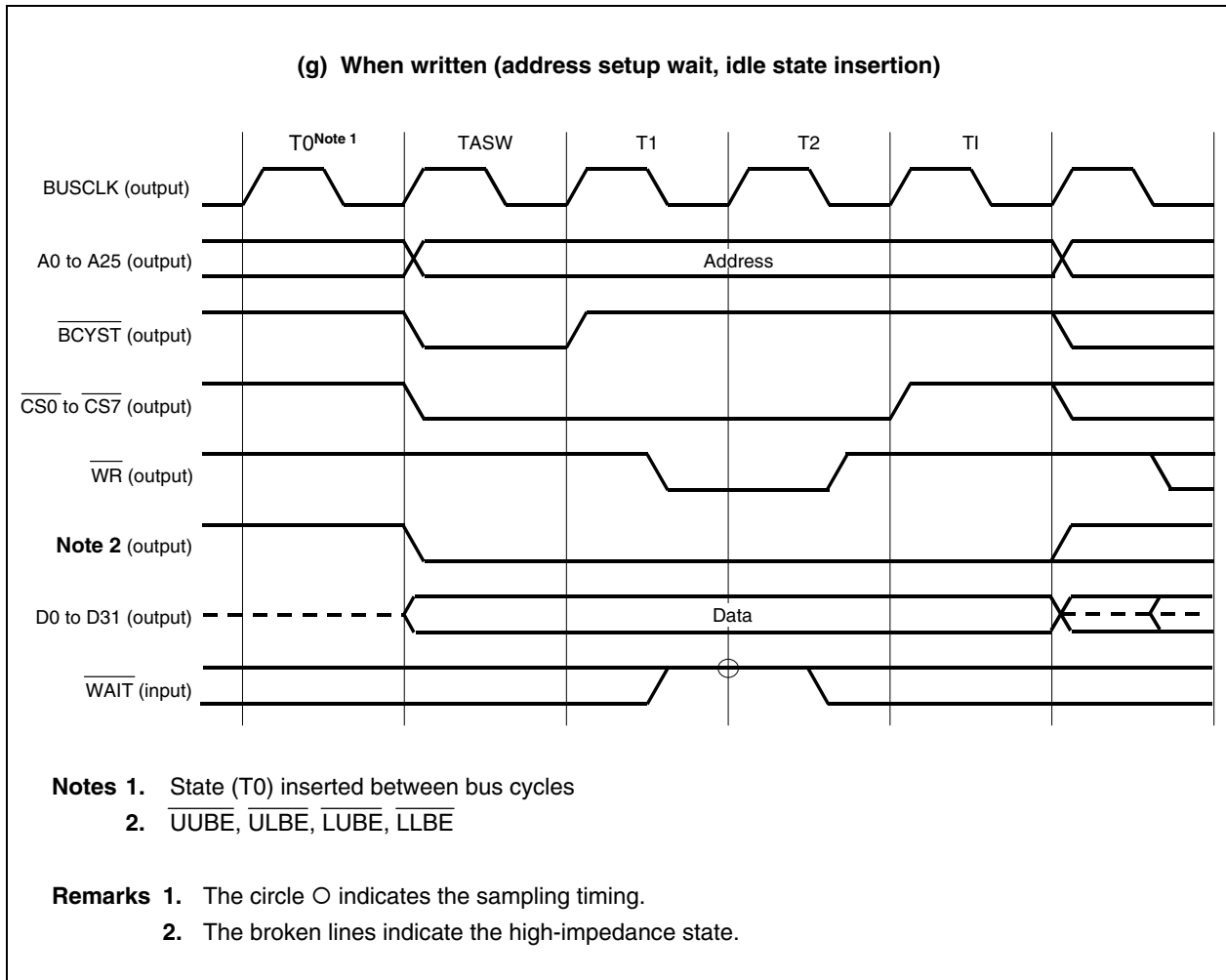


Figure 5-2. SRAM, External ROM, External I/O Access Timing (8/10)

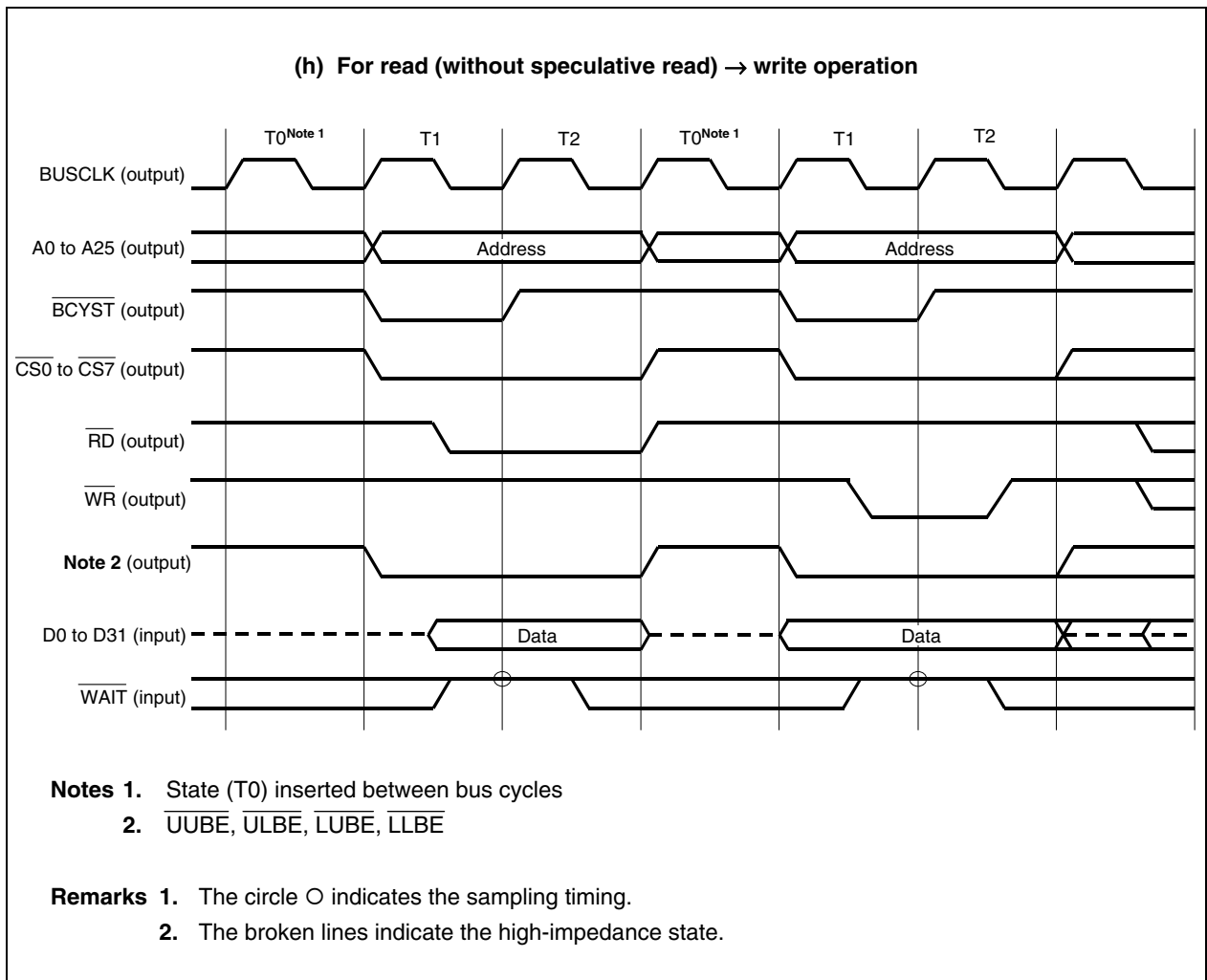


Figure 5-2. SRAM, External ROM, External I/O Access Timing (9/10)

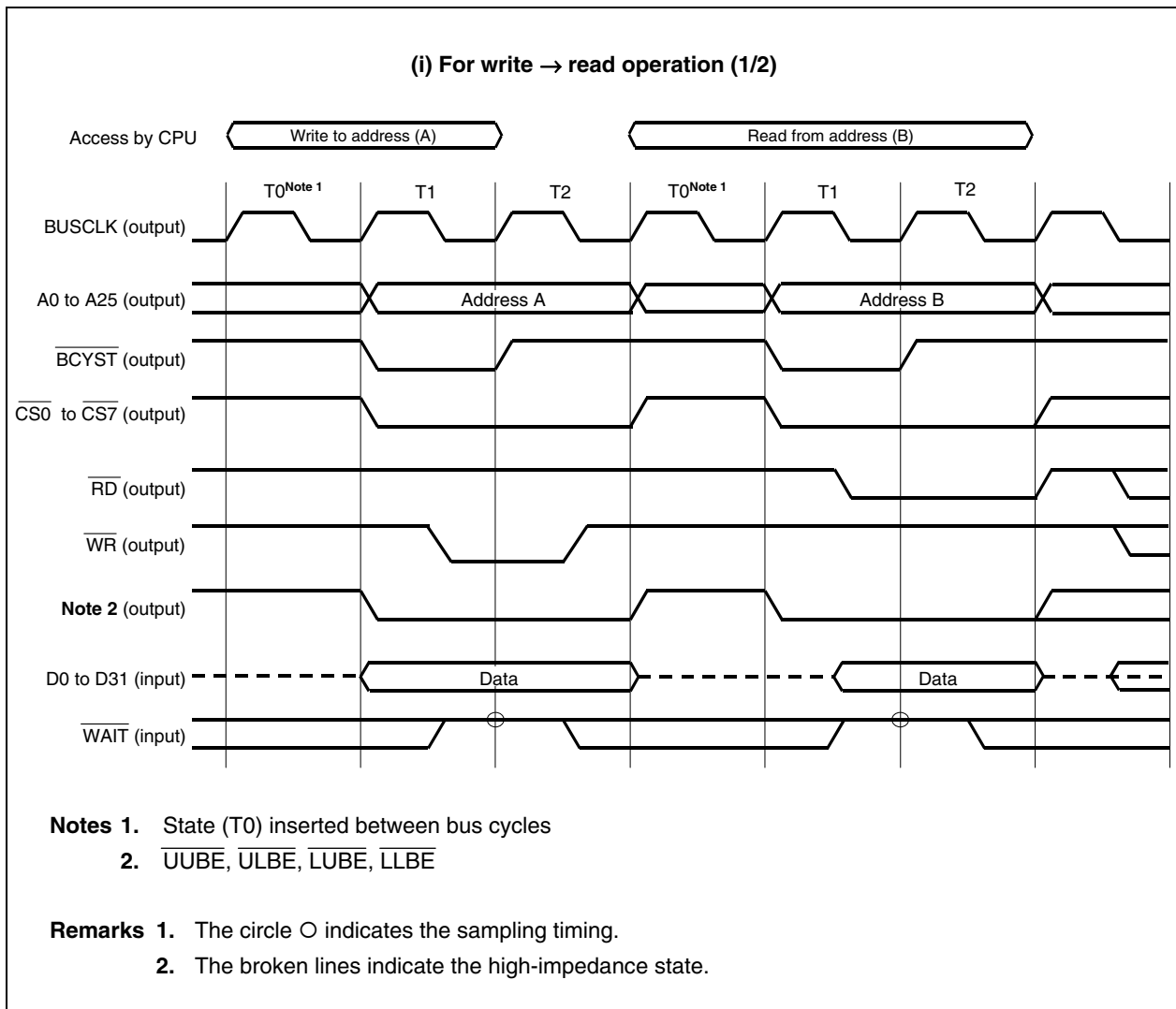
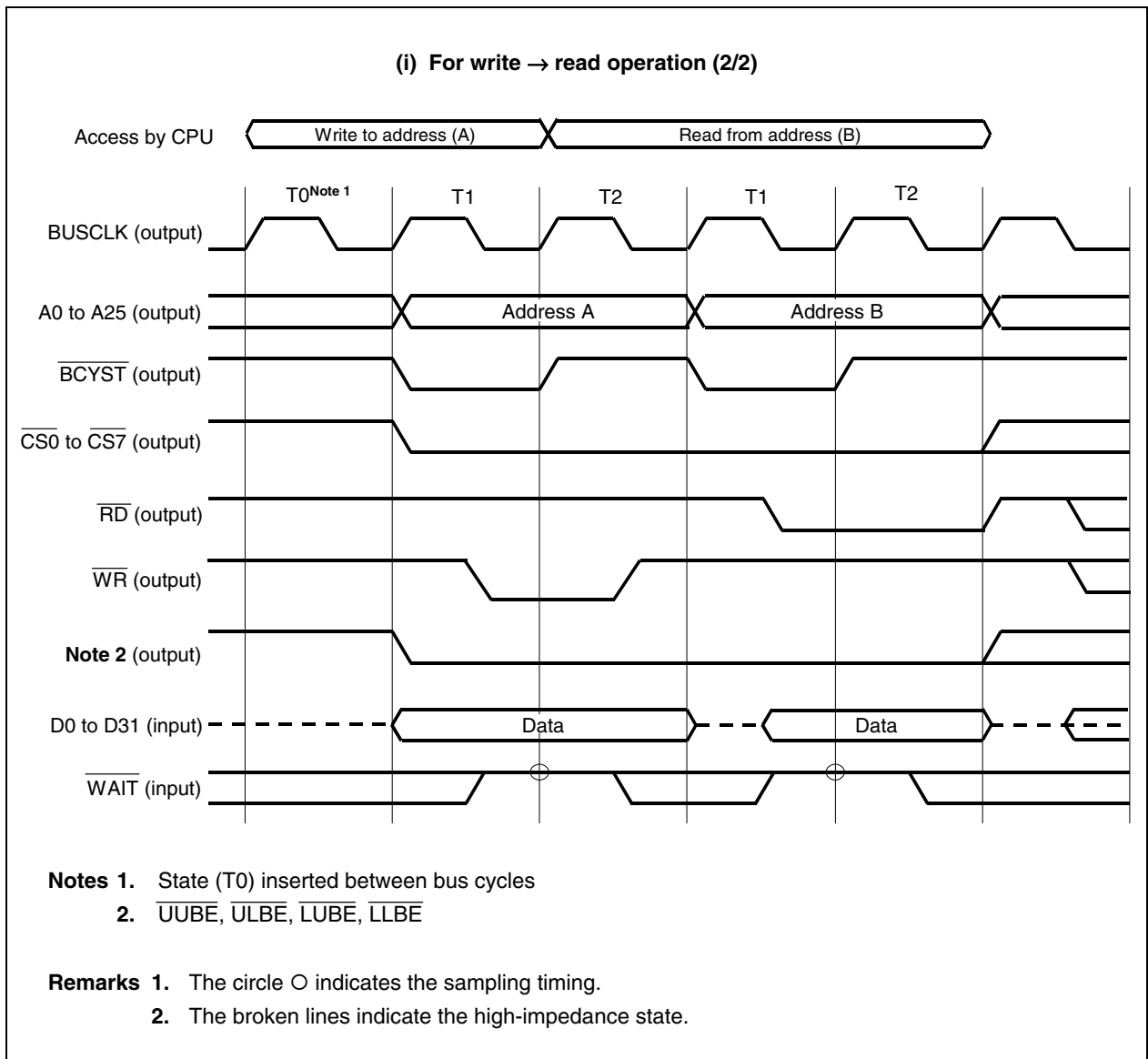


Figure 5-2. SRAM, External ROM, External I/O Access Timing (10/10)



## 5.2 Page ROM Controller (ROMC)

The page ROM controller (ROMC) is provided for accessing ROM (page ROM) with a page access function.

Addresses are compared with the immediately preceding bus cycle and wait control for normal access (off-page) and page access (on-page) is executed. This controller can handle page widths from 8 to 128 bytes.

### 5.2.1 Features

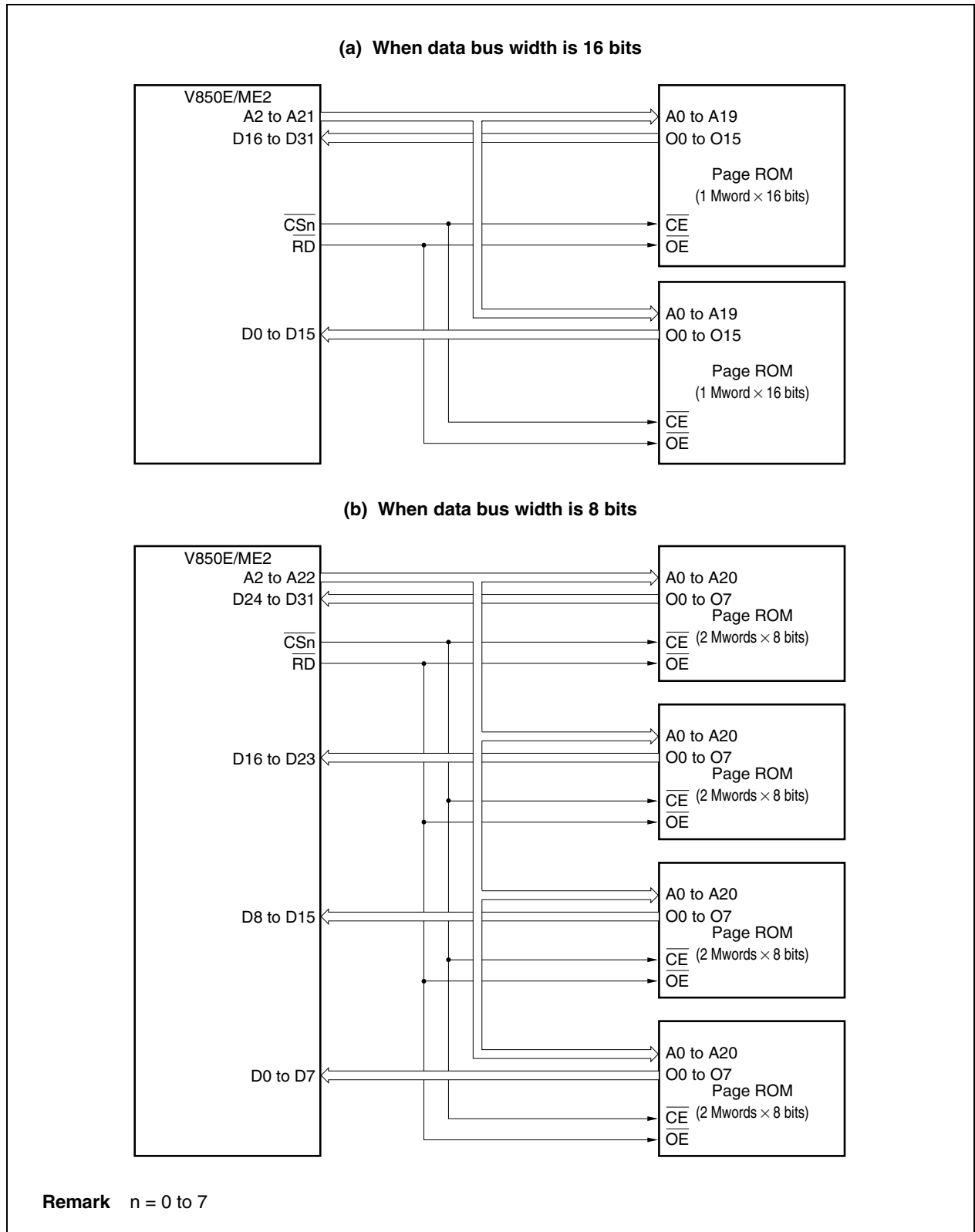
- Direct connection to 8-bit/16-bit/32-bit page ROM supported
- For 32-bit bus width: 2/4/8/16/32-word page access supported  
For 16-bit bus width: 4/8/16/32/64-word page access supported  
For 8-bit bus width: 8/16/32/64/128-word page access supported
- Page ROM is accessed in a minimum of 2 states.
- On-page judgment function
- Addresses to be compared can be changed by setting the PRC register.
- Up to 7 states of programmable data waits can be inserted by setting the following registers.
  - During on-page cycle: PRC register
  - During off-page cycle: DWC0 and DWC1 registers
  - During DMA flyby cycle: FWC register
- Waits can be controlled via  $\overline{\text{WAIT}}$  pin input.
- DMA flyby cycle can be activated (page ROM → external I/O)
- SRAM write cycle is started when a write cycle request is issued to a CSn space (n = 0 to 7) where page ROM is allocated



### 5.2.2 Page ROM connection

Examples of connection to page ROM are shown below.

**Figure 5-3. Examples of Connection to Page ROM**



### 5.2.3 On-page/off-page judgment

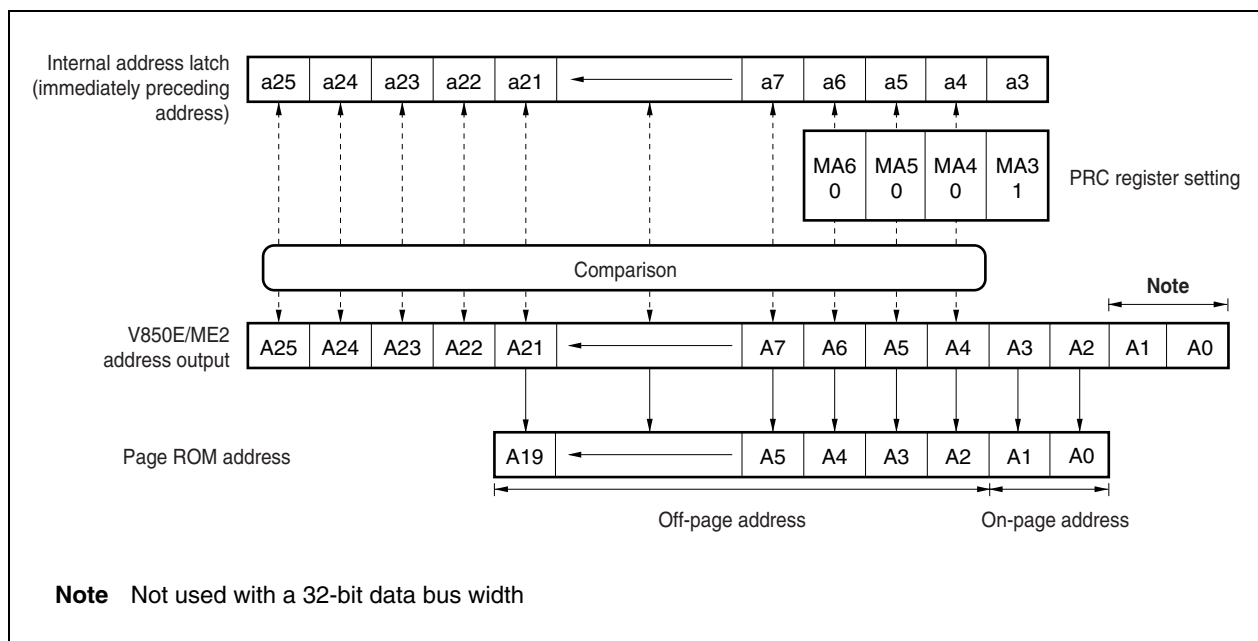
Whether a page ROM cycle is on-page or off-page is judged by latching the address of the previous cycle and comparing it with the address of the current cycle. If no speculative reading is specified (RBn1 and RBn0 bits of the LBCm register = 00, 01) or use of the instruction cache is not specified, an off-page cycle is always started, except in the following cases (m = 0, 1, n = 0 to 7).

- 16/32-bit access to 8-bit bus
- 32-bit access to 16-bit bus

One of the addresses (A3 to A6) is set as the masking address (no comparison is made) according to the configuration of the connected page ROM and the number of continuously readable bits set by the PRC register.

An example of controlling address masking when four page ROMs of 1 Mword × 8 bits are connected is shown below.

**Figure 5-4. Example of Control by MA6 to MA3 Bits of PRC Register**



### 5.2.4 Page ROM configuration register (PRC)

The masking address (no comparison is made) out of the addresses (A3 to A6) corresponding to the configuration of the connected page ROM and the number of bits that can be read continuously, as well as the number of waits corresponding to the internal system clock ( $f_{CLK}$ ), are set.

This register can be read or written in 16-bit units.

**Caution** Write to the PRC register after reset, and then do not change the set value. Also, do not access an external memory area other than the one for this initialization routine until the initial setting of the PRC register is complete. However, it is possible to access external memory areas whose initialization settings are complete.

|     |    |      |      |      |    |    |   |   |   |   |   |   |     |     |     |     |                      |                      |
|-----|----|------|------|------|----|----|---|---|---|---|---|---|-----|-----|-----|-----|----------------------|----------------------|
|     | 15 | 14   | 13   | 12   | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3   | 2   | 1   | 0   |                      |                      |
| PRC | 0  | PRW2 | PRW1 | PRW0 | 0  | 0  | 0 | 0 | 0 | 0 | 0 | 0 | MA6 | MA5 | MA4 | MA3 | Address<br>FFFFF49AH | After reset<br>7000H |

| Bit position     | Bit name     | Function                                                                                                                                                                                                                                     |      |                                                                                   |                                |                                          |   |   |   |   |                                      |   |   |   |   |                                       |   |   |   |   |                                        |   |   |   |   |                                         |   |   |   |   |                                          |                  |   |   |   |                                                                                   |   |
|------------------|--------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|-----------------------------------------------------------------------------------|--------------------------------|------------------------------------------|---|---|---|---|--------------------------------------|---|---|---|---|---------------------------------------|---|---|---|---|----------------------------------------|---|---|---|---|-----------------------------------------|---|---|---|---|------------------------------------------|------------------|---|---|---|-----------------------------------------------------------------------------------|---|
| 14 to 12         | PRW2 to PRW0 | Sets the number of waits corresponding to the internal system clock ( $f_{CLK}$ ).<br>The number of waits set by these bits is inserted only for on-page access. For off-page access, the waits set by registers DWC0 and DWC1 are inserted. |      |                                                                                   |                                |                                          |   |   |   |   |                                      |   |   |   |   |                                       |   |   |   |   |                                        |   |   |   |   |                                         |   |   |   |   |                                          |                  |   |   |   |                                                                                   |   |
|                  |              | PRW2                                                                                                                                                                                                                                         | PRW1 | PRW0                                                                              | Number of inserted wait cycles | 0                                        | 0 | 0 | 0 | 0 | 0                                    | 1 | 1 | 0 | 1 | 0                                     | 2 | 0 | 1 | 1 | 3                                      | 1 | 0 | 0 | 4 | 1                                       | 0 | 1 | 5 | 1 | 1                                        | 0                | 6 | 1 | 1 | 1                                                                                 | 7 |
|                  |              | PRW2                                                                                                                                                                                                                                         | PRW1 | PRW0                                                                              | Number of inserted wait cycles |                                          |   |   |   |   |                                      |   |   |   |   |                                       |   |   |   |   |                                        |   |   |   |   |                                         |   |   |   |   |                                          |                  |   |   |   |                                                                                   |   |
|                  |              | 0                                                                                                                                                                                                                                            | 0    | 0                                                                                 | 0                              |                                          |   |   |   |   |                                      |   |   |   |   |                                       |   |   |   |   |                                        |   |   |   |   |                                         |   |   |   |   |                                          |                  |   |   |   |                                                                                   |   |
|                  |              | 0                                                                                                                                                                                                                                            | 0    | 1                                                                                 | 1                              |                                          |   |   |   |   |                                      |   |   |   |   |                                       |   |   |   |   |                                        |   |   |   |   |                                         |   |   |   |   |                                          |                  |   |   |   |                                                                                   |   |
|                  |              | 0                                                                                                                                                                                                                                            | 1    | 0                                                                                 | 2                              |                                          |   |   |   |   |                                      |   |   |   |   |                                       |   |   |   |   |                                        |   |   |   |   |                                         |   |   |   |   |                                          |                  |   |   |   |                                                                                   |   |
|                  |              | 0                                                                                                                                                                                                                                            | 1    | 1                                                                                 | 3                              |                                          |   |   |   |   |                                      |   |   |   |   |                                       |   |   |   |   |                                        |   |   |   |   |                                         |   |   |   |   |                                          |                  |   |   |   |                                                                                   |   |
|                  |              | 1                                                                                                                                                                                                                                            | 0    | 0                                                                                 | 4                              |                                          |   |   |   |   |                                      |   |   |   |   |                                       |   |   |   |   |                                        |   |   |   |   |                                         |   |   |   |   |                                          |                  |   |   |   |                                                                                   |   |
|                  |              | 1                                                                                                                                                                                                                                            | 0    | 1                                                                                 | 5                              |                                          |   |   |   |   |                                      |   |   |   |   |                                       |   |   |   |   |                                        |   |   |   |   |                                         |   |   |   |   |                                          |                  |   |   |   |                                                                                   |   |
|                  |              | 1                                                                                                                                                                                                                                            | 1    | 0                                                                                 | 6                              |                                          |   |   |   |   |                                      |   |   |   |   |                                       |   |   |   |   |                                        |   |   |   |   |                                         |   |   |   |   |                                          |                  |   |   |   |                                                                                   |   |
| 1                | 1            | 1                                                                                                                                                                                                                                            | 7    |                                                                                   |                                |                                          |   |   |   |   |                                      |   |   |   |   |                                       |   |   |   |   |                                        |   |   |   |   |                                         |   |   |   |   |                                          |                  |   |   |   |                                                                                   |   |
| 3 to 0           | MA6 to MA3   | Each respective address (A6 to A3) corresponding to MA6 to MA3 is masked (by 1). The masked address is not subject to comparison during on/off-page judgment, and is set according to the number of continuously readable bits.              |      |                                                                                   |                                |                                          |   |   |   |   |                                      |   |   |   |   |                                       |   |   |   |   |                                        |   |   |   |   |                                         |   |   |   |   |                                          |                  |   |   |   |                                                                                   |   |
|                  |              | MA6                                                                                                                                                                                                                                          | MA5  | MA4                                                                               | MA3                            | Number of continuously readable bits     | 0 | 0 | 0 | 0 | 2 × 32 bits, 4 × 16 bits, 8 × 8 bits | 0 | 0 | 0 | 1 | 4 × 32 bits, 8 × 16 bits, 16 × 8 bits | 0 | 0 | 1 | 1 | 8 × 32 bits, 16 × 16 bits, 32 × 8 bits | 0 | 1 | 1 | 1 | 16 × 32 bits, 32 × 16 bits, 64 × 8 bits | 1 | 1 | 1 | 1 | 32 × 32 bits, 64 × 16 bits, 128 × 8 bits | Other than above |   |   |   | Setting prohibited<br>(The operation cannot be guaranteed if other bits are set.) |   |
|                  |              | MA6                                                                                                                                                                                                                                          | MA5  | MA4                                                                               | MA3                            | Number of continuously readable bits     |   |   |   |   |                                      |   |   |   |   |                                       |   |   |   |   |                                        |   |   |   |   |                                         |   |   |   |   |                                          |                  |   |   |   |                                                                                   |   |
|                  |              | 0                                                                                                                                                                                                                                            | 0    | 0                                                                                 | 0                              | 2 × 32 bits, 4 × 16 bits, 8 × 8 bits     |   |   |   |   |                                      |   |   |   |   |                                       |   |   |   |   |                                        |   |   |   |   |                                         |   |   |   |   |                                          |                  |   |   |   |                                                                                   |   |
|                  |              | 0                                                                                                                                                                                                                                            | 0    | 0                                                                                 | 1                              | 4 × 32 bits, 8 × 16 bits, 16 × 8 bits    |   |   |   |   |                                      |   |   |   |   |                                       |   |   |   |   |                                        |   |   |   |   |                                         |   |   |   |   |                                          |                  |   |   |   |                                                                                   |   |
|                  |              | 0                                                                                                                                                                                                                                            | 0    | 1                                                                                 | 1                              | 8 × 32 bits, 16 × 16 bits, 32 × 8 bits   |   |   |   |   |                                      |   |   |   |   |                                       |   |   |   |   |                                        |   |   |   |   |                                         |   |   |   |   |                                          |                  |   |   |   |                                                                                   |   |
|                  |              | 0                                                                                                                                                                                                                                            | 1    | 1                                                                                 | 1                              | 16 × 32 bits, 32 × 16 bits, 64 × 8 bits  |   |   |   |   |                                      |   |   |   |   |                                       |   |   |   |   |                                        |   |   |   |   |                                         |   |   |   |   |                                          |                  |   |   |   |                                                                                   |   |
|                  |              | 1                                                                                                                                                                                                                                            | 1    | 1                                                                                 | 1                              | 32 × 32 bits, 64 × 16 bits, 128 × 8 bits |   |   |   |   |                                      |   |   |   |   |                                       |   |   |   |   |                                        |   |   |   |   |                                         |   |   |   |   |                                          |                  |   |   |   |                                                                                   |   |
| Other than above |              |                                                                                                                                                                                                                                              |      | Setting prohibited<br>(The operation cannot be guaranteed if other bits are set.) |                                |                                          |   |   |   |   |                                      |   |   |   |   |                                       |   |   |   |   |                                        |   |   |   |   |                                         |   |   |   |   |                                          |                  |   |   |   |                                                                                   |   |

## 5.2.5 Page ROM access

Figure 5-5. Page ROM Access Timing (1/6)

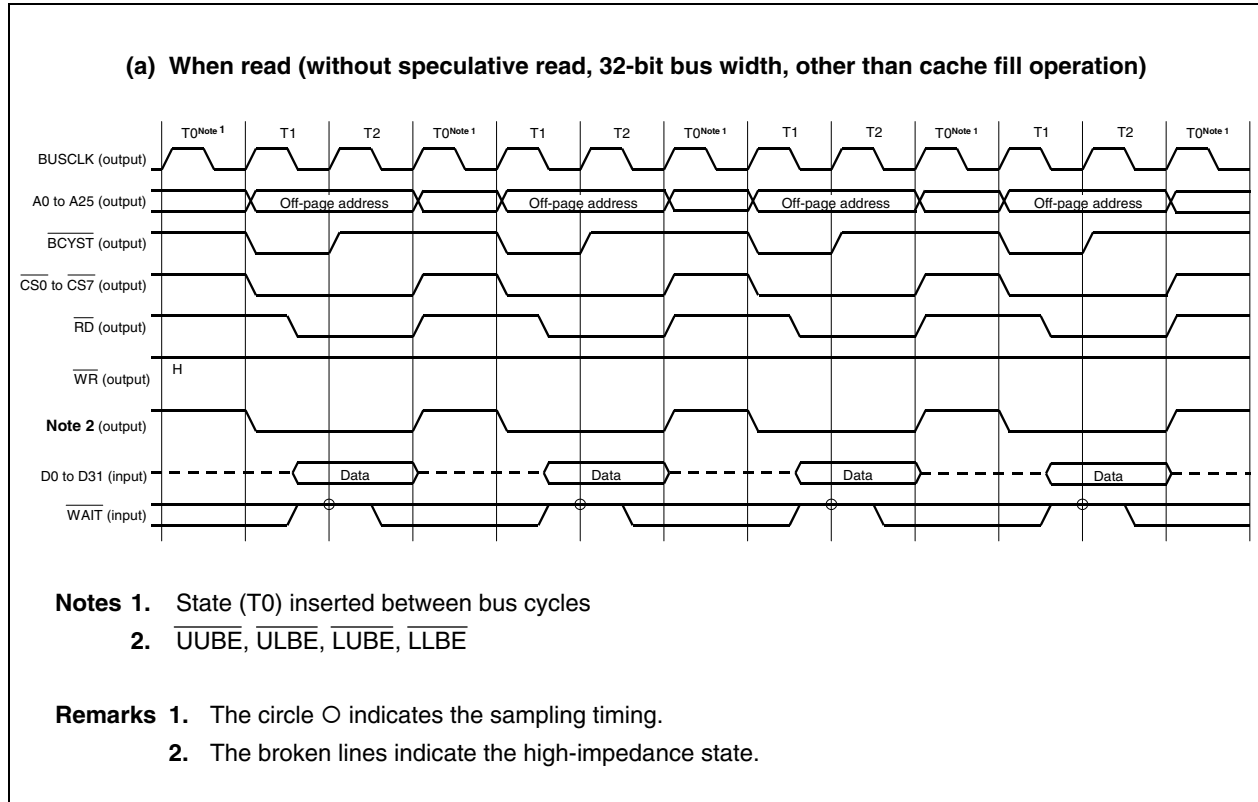


Figure 5-5. Page ROM Access Timing (2/6)

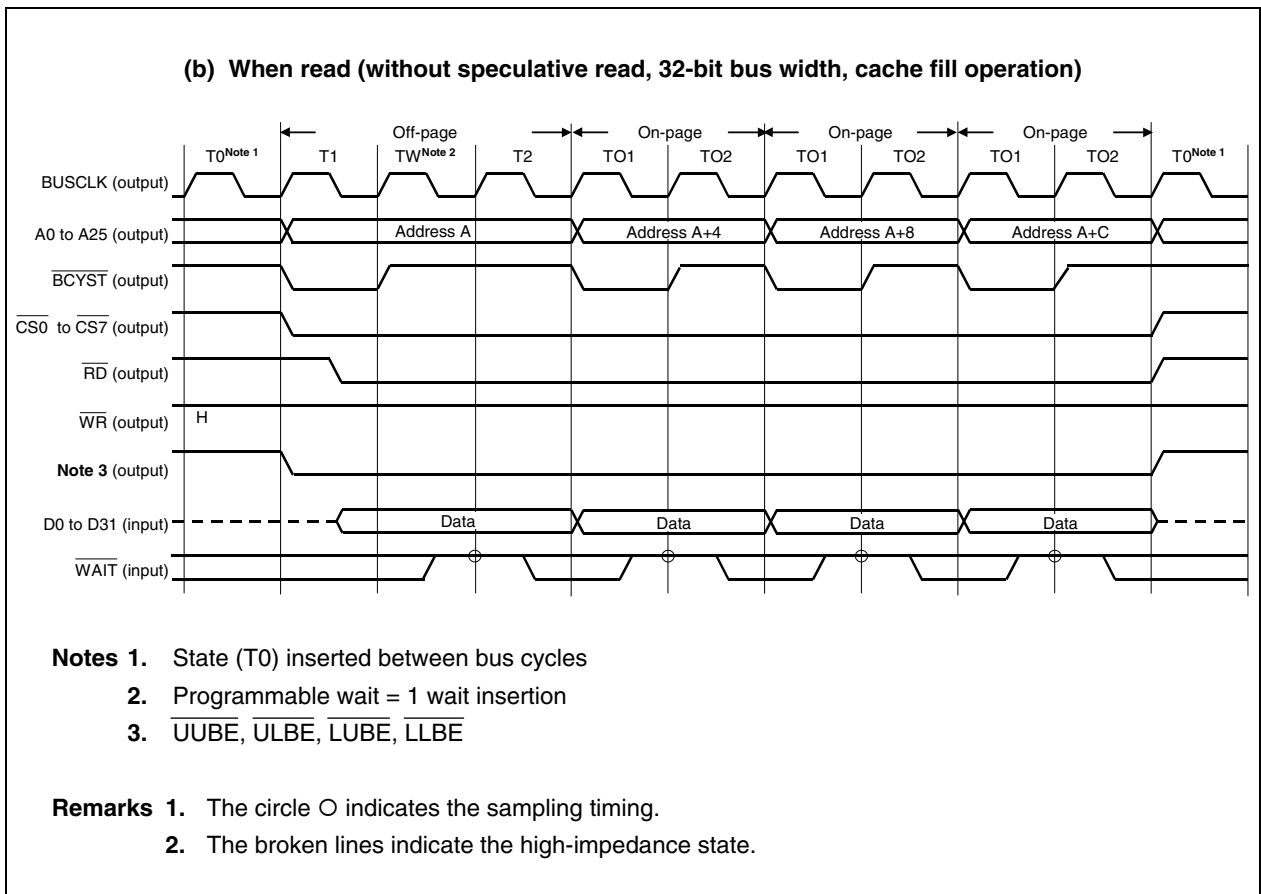


Figure 5-5. Page ROM Access Timing (3/6)

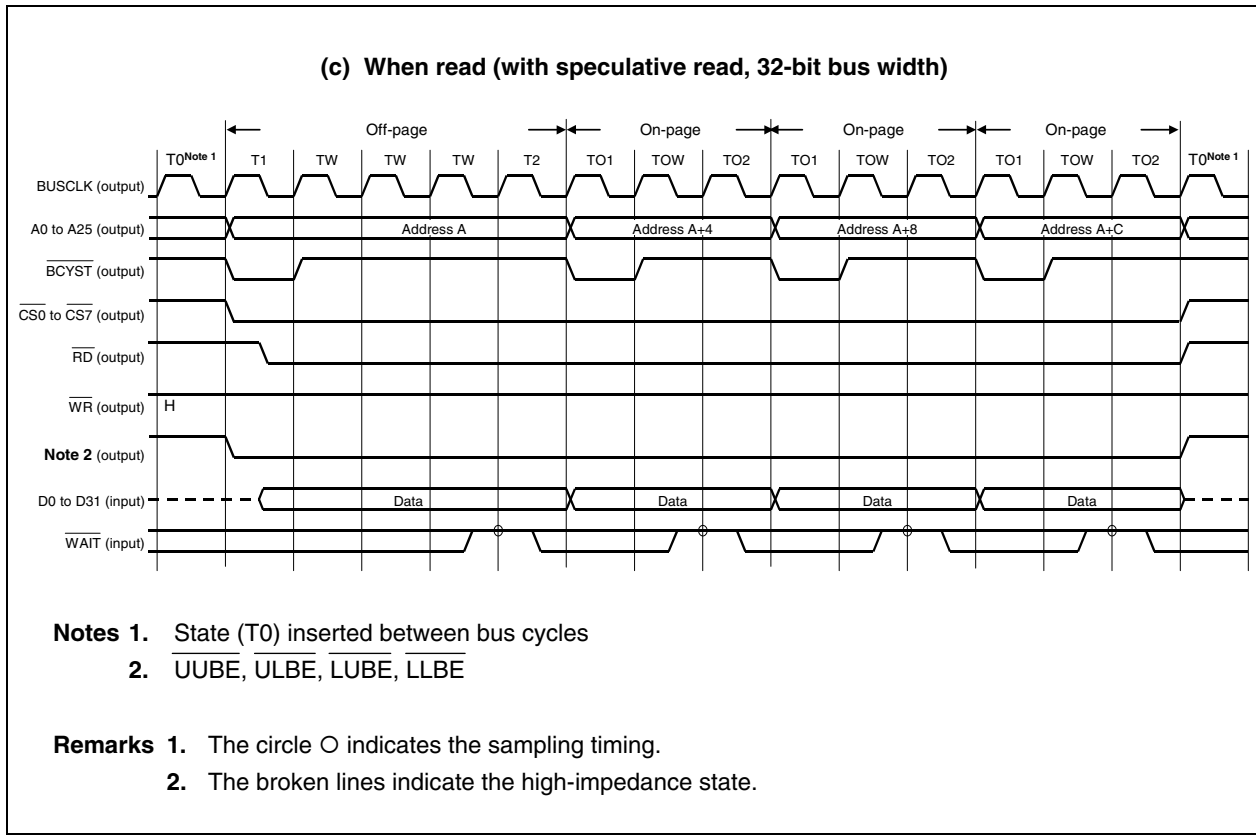


Figure 5-5. Page ROM Access Timing (4/6)

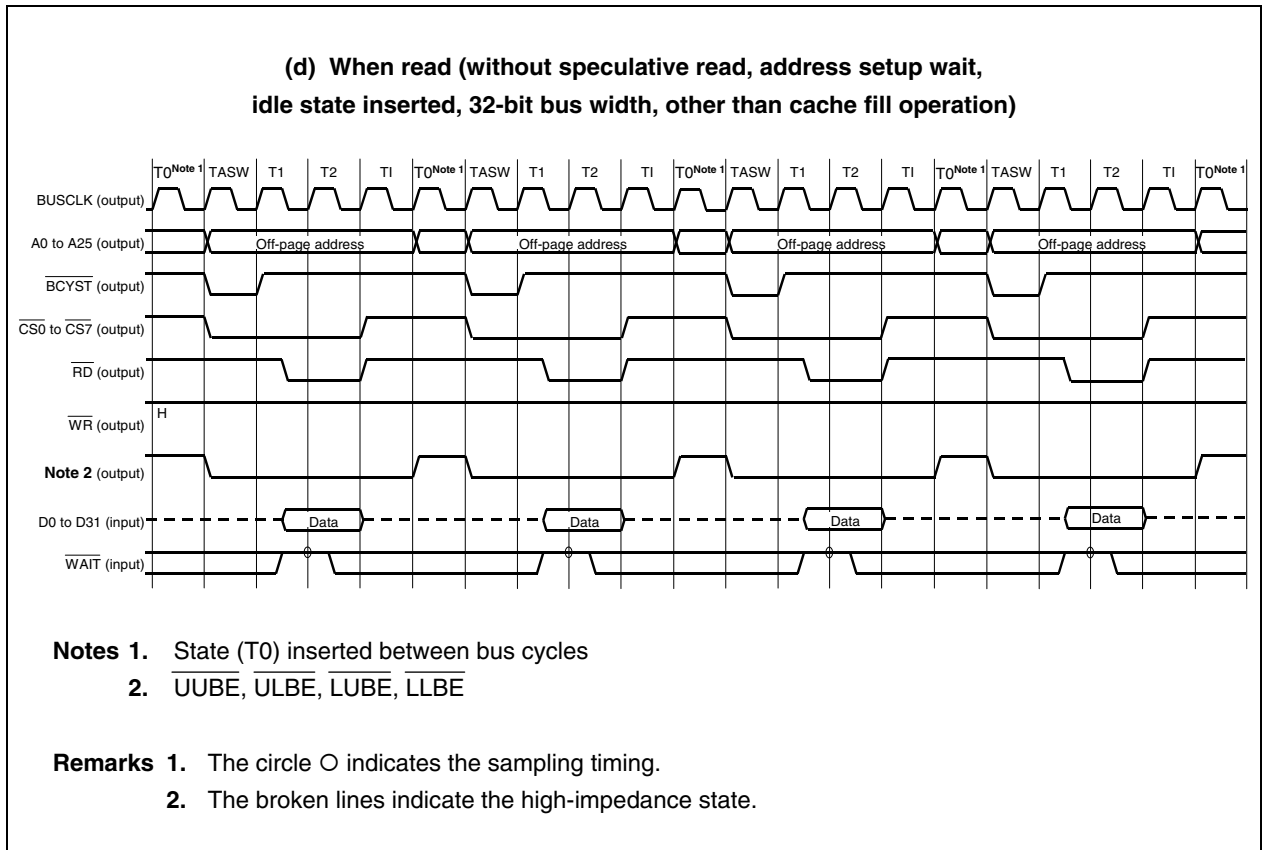
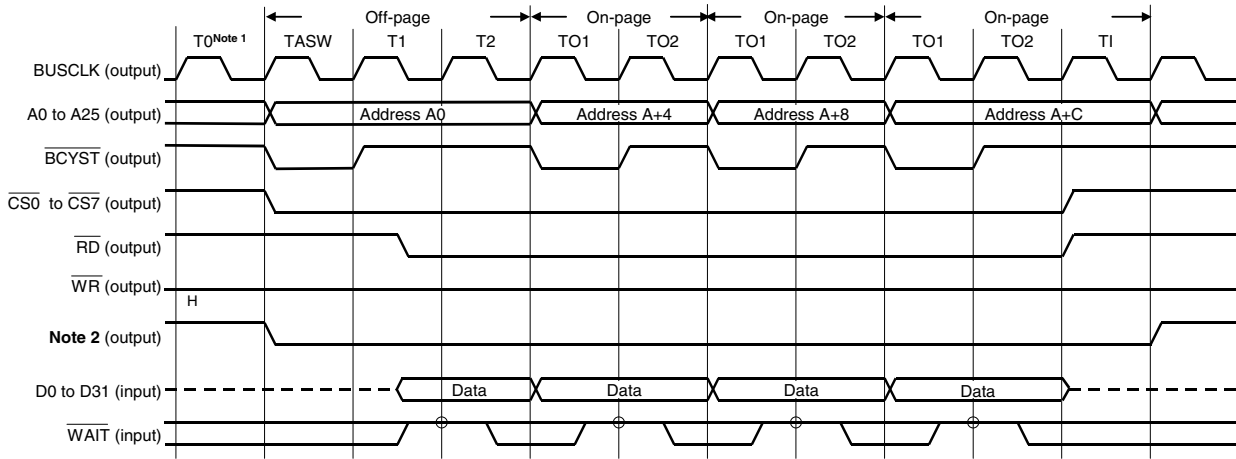


Figure 5-5. Page ROM Access Timing (5/6)

(e) When read (without speculative read,  
address setup wait, idle state inserted, 32-bit bus width, cache fill operation)



**Notes** 1. State (T0) inserted between bus cycles

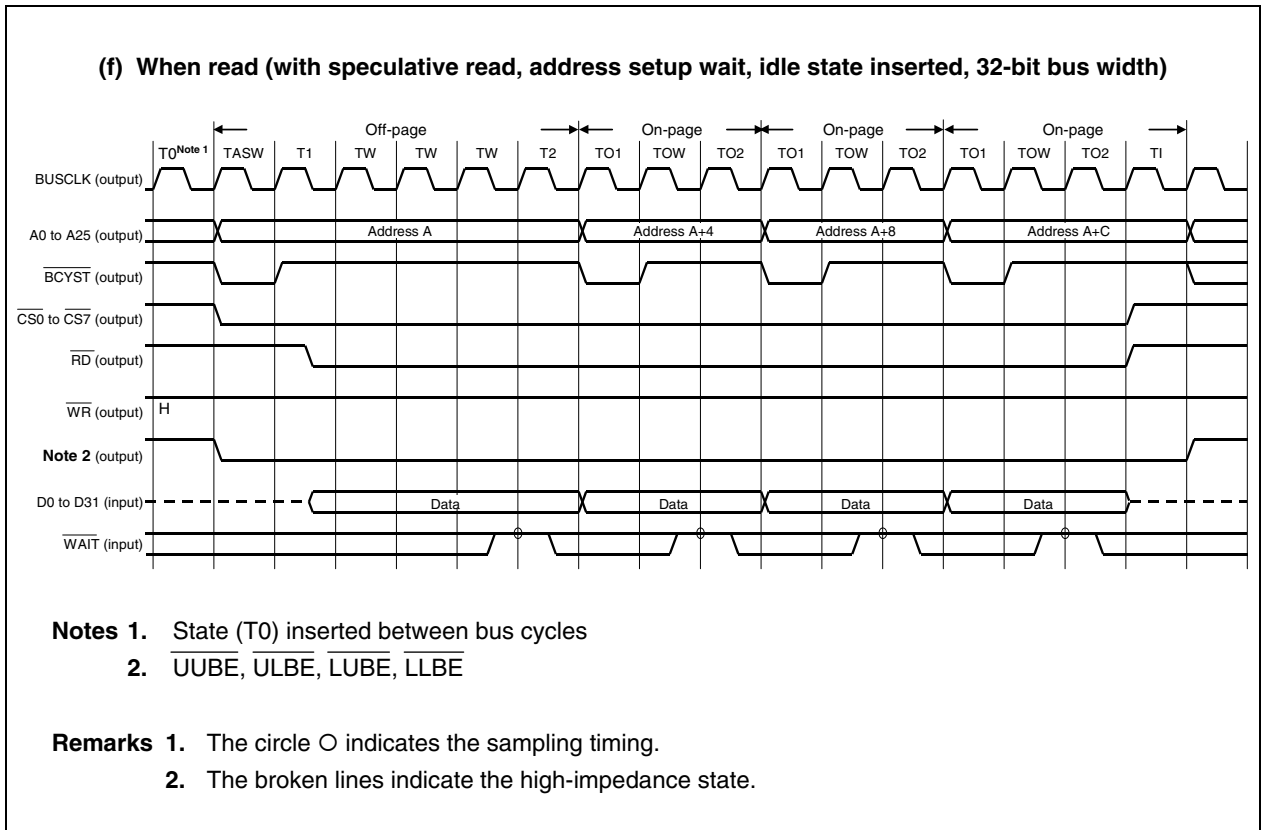
2.  $\overline{UUB\overline{E}}$ ,  $\overline{ULB\overline{E}}$ ,  $\overline{LUB\overline{E}}$ ,  $\overline{LLB\overline{E}}$

**Remarks** 1. The circle ○ indicates the sampling timing.

2. The broken lines indicate the high-impedance state.



Figure 5-5. Page ROM Access Timing (6/6)



### 5.3 SDRAM Controller (SDRAMC)

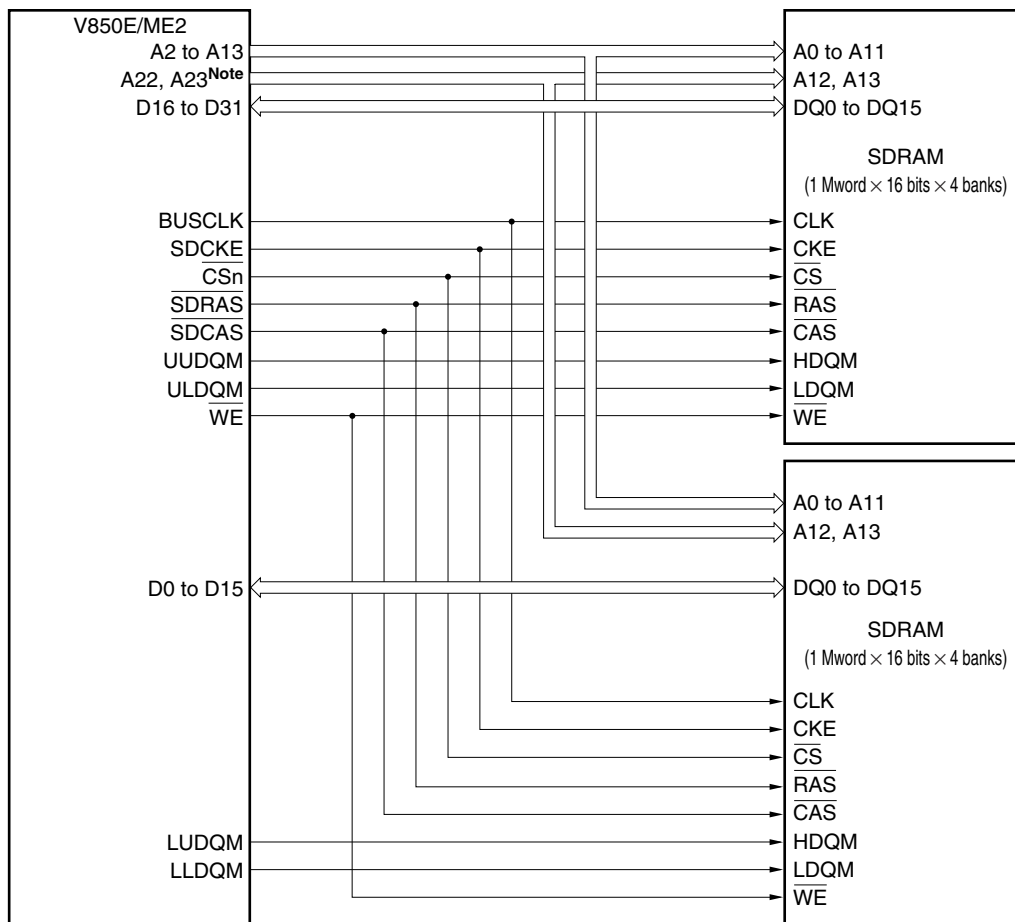
#### 5.3.1 Features

- Burst length: 1
- Wrap type: Sequential
- CAS latency: 1, 2, and 3 supported (only 2 and 3 supported during DMA flyby transfer)
- 4 types of SDRAM can be assigned to 4 memory blocks.
- Row and column address multiplex widths can be changed.
- Waits (0 to 3 waits) can be inserted between the bank active command and the read/write command.
- Supports CBR (auto) refresh and self-refresh.
- DMA flyby cycle (from external I/O to SDRAM) can be activated.

#### 5.3.2 SDRAM connection

An example of connection to SDRAM is shown below.

Figure 5-6. Example of Connection to SDRAM



**Note** The address signals to be used differ depending on the SDRAM product.

**Remark** n = 1, 3, 4, 6

### 5.3.3 Address multiplex function

Depending on the value of the SAWn0 and SAWn1 bits in the SCRn register, the row address output in the SDRAM cycle is multiplexed as shown in Figure 5-7 (a) (n = 1, 3, 4, 6). Depending on the value of the SSOOn0 and SSOOn1 bits of the SCRn register, the column address output in the SDRAM cycle is multiplexed as shown in Figure 5-7 (b) (n = 1, 3, 4, 6). In Figures 5-7 (a) and (b), a0 to a25 indicate the addresses output from the CPU, and A0 to A25 indicate the address pins of the V850E/ME2.

**Figure 5-7. Row Address/Column Address Output (1/2)**

| <b>(a) Row address output</b>                                       |                                                                                    |
|---------------------------------------------------------------------|------------------------------------------------------------------------------------|
| Address pin                                                         | A25 to A18 A17 A16 A15 A14 A13 A12 A11 A10 A9 A8 A7 A6 A5 A4 A3 A2 A1 A0           |
| Row address<br>(SAWn1, SAWn0 bits = 11)                             | a25 to a18 a17 a16 a15 a25 a24 a23 a22 a21 a20 a19 a18 a17 a16 a15 a14 a13 a12 a11 |
| Row address<br>(SAWn1, SAWn0 bits = 10)                             | a25 to a18 a17 a16 a25 a24 a23 a22 a21 a20 a19 a18 a17 a16 a15 a14 a13 a12 a11 a10 |
| Row address<br>(SAWn1, SAWn0 bits = 01)                             | a25 to a18 a17 a25 a24 a23 a22 a21 a20 a19 a18 a17 a16 a15 a14 a13 a12 a11 a10 a9  |
| Row address<br>(SAWn1, SAWn0 bits = 00)                             | a25 to a18 a25 a24 a23 a22 a21 a20 a19 a18 a17 a16 a15 a14 a13 a12 a11 a10 a9 a8   |
| <b>Remark</b> n = 1, 3, 4, 6                                        |                                                                                    |
| <b>(b) Column address output (using all-bank precharge command)</b> |                                                                                    |
| Address pin                                                         | A25 to A18 A17 A16 A15 A14 A13 A12 A11 A10 A9 A8 A7 A6 A5 A4 A3 A2 A1 A0           |
| Column address<br>(SSOOn1, SSOOn0 bits = 00)                        | a25 to a18 a17 a16 a15 a14 a13 a12 a11 1 a9 a8 a7 a6 a5 a4 a3 a2 a1 a0             |
| Column address<br>(SSOOn1, SSOOn0 bits = 01)                        | a25 to a18 a17 a16 a15 a14 a13 a12 1 a10 a9 a8 a7 a6 a5 a4 a3 a2 a1 a0             |
| Column address<br>(SSOOn1, SSOOn0 bits = 10)                        | a25 to a18 a17 a16 a15 a14 a13 1 a11 a10 a9 a8 a7 a6 a5 a4 a3 a2 a1 a0             |
| <b>Remark</b> n = 1, 3, 4, 6                                        |                                                                                    |
| <b>(c) Column address output (using register write command)</b>     |                                                                                    |
| Address pin                                                         | A25 to A18 A17 A16 A15 A14 A13 A12 A11 A10 A9 A8 A7 A6 A5 A4 A3 A2 A1 A0           |
| Column address<br>(SSOOn1, SSOOn0 bits = 00)                        | 0 0 0 0 0 0 0 0 0 0 0 0 0 LTM2 LTM1 LTM0 0 0 0 0                                   |
| Column address<br>(SSOOn1, SSOOn0 bits = 01)                        | 0 0 0 0 0 0 0 0 0 0 0 0 0 LTM2 LTM1 LTM0 0 0 0 0                                   |
| Column address<br>(SSOOn1, SSOOn0 bits = 10)                        | 0 0 0 0 0 0 0 0 0 0 0 0 0 LTM2 LTM1 LTM0 0 0 0 0                                   |
| <b>Remark</b> n = 1, 3, 4, 6                                        |                                                                                    |

Figure 5-7. Row Address/Column Address Output (2/2)

**(d) Column address output (using read/write command)**

|                                            |            |     |     |     |     |     |     |     |     |    |    |    |    |    |    |    |    |    |    |
|--------------------------------------------|------------|-----|-----|-----|-----|-----|-----|-----|-----|----|----|----|----|----|----|----|----|----|----|
| Address pin                                | A25 to A18 | A17 | A16 | A15 | A14 | A13 | A12 | A11 | A10 | A9 | A8 | A7 | A6 | A5 | A4 | A3 | A2 | A1 | A0 |
| Column address<br>(SSOn1, SSOn0 bits = 00) | a25 to a18 | a17 | a16 | a15 | a14 | a12 | a11 | a10 | 0   | a9 | a8 | a7 | a6 | a5 | a4 | a3 | a2 | a1 | a0 |
| Column address<br>(SSOn1, SSOn0 bits = 01) | a25 to a18 | a17 | a16 | a15 | a14 | a12 | a11 | 0   | a10 | a9 | a8 | a7 | a6 | a5 | a4 | a3 | a2 | a1 | a0 |
| Column address<br>(SSOn1, SSOn0 bits = 10) | a25 to a18 | a17 | a16 | a15 | a14 | a12 | 0   | a11 | a10 | a9 | a8 | a7 | a6 | a5 | a4 | a3 | a2 | a1 | a0 |

**Remark** n = 1, 3, 4, 6

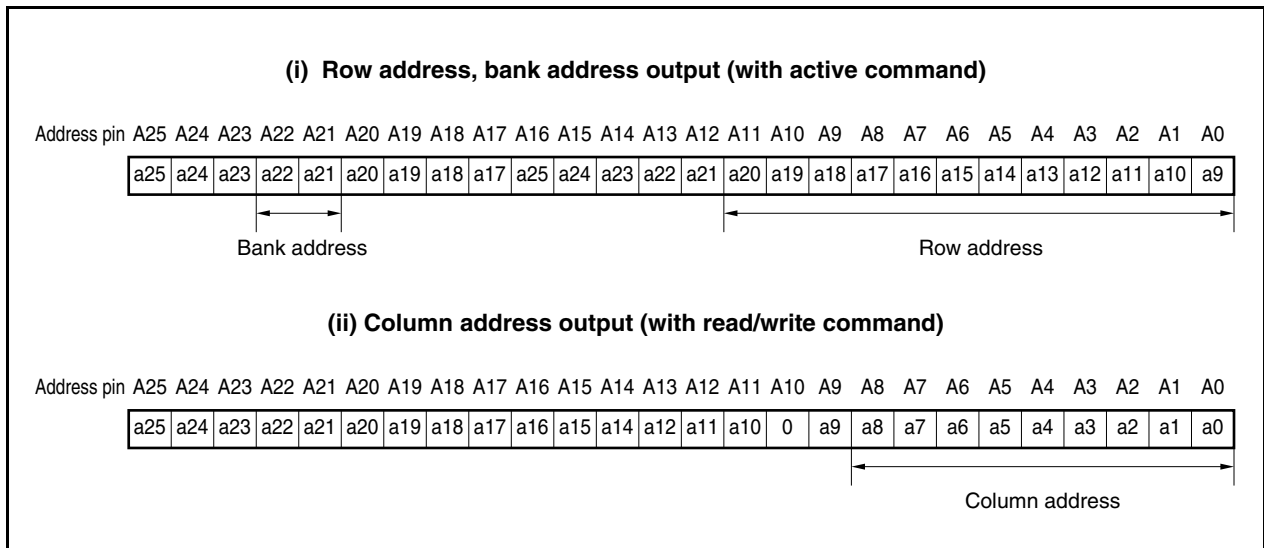
**(1) Output of each address and connection of SDRAM**

The set contents of the SCRN register, physical address, address output from the V850E/ME2, and connection between the V850E/ME2 and SDRAM at each data bus width (8 bits or 16 bits) are described below.

**(a) At 8-bit data bus width**

An example of connecting 64 Mb SDRAM (2 Mwords × 8 bits × 4 banks) at 8-bit data bus width is shown below.

- Set contents of SCRN register
  - SSOn1, SSOn0 bits = 00: Data bus width = 8 bits
  - RAWn1, RAWn0 bits = 01: Row address width = 12 bits
  - SAWn1, SAWn0 bits = 01: Column address width = 9 bits
- Physical address
  - A22, A21: Bank address
  - A20 to A9: Row address
  - A8 to A0: Column address
- Address output from V850E/ME2
  - A22, A21: Bank address
  - A11 to A0: Row address (12 bits), column address (9 bits)



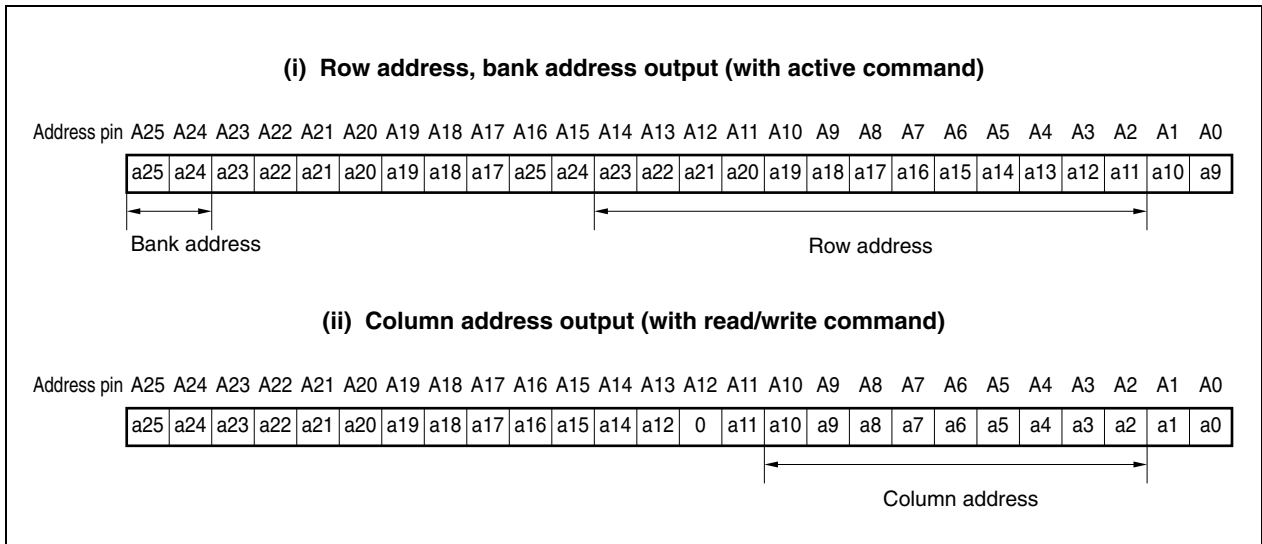
- Connection of V850E/ME2 and SDRAM
  - A22, A21 (V850E/ME2) → BA0 (A13), BA1 (A12) (SDRAM)
  - A11 to A0 (V850E/ME2) → A11 to A0 (SDRAM)



**(c) At 32-bit data bus width**

An example of connecting 512 Mb SDRAM (256 Mb SDRAM (4 Mwords × 16 bits × 4 banks) × 2) at 32-bit data bus width is shown below.

- Set contents of SCRn register  
 SSON1, SSON0 bits = 10: Data bus width = 32 bits  
 RAWn1, RAWn0 bits = 10: Row address width = 13 bits  
 SAWn1, SAWn0 bits = 01: Column address width = 9 bits
- Physical address  
 A25, A24: Bank address  
 A23 to A11: Row address  
 A10 to A2: Column address
- Address output from V850E/ME2  
 A25, A24: Bank address  
 A14 to A2: Row address (13 bits), column address (9 bits)



- Connection of V850E/ME2 and SDRAM  
 A25, A24 (V850E/ME2) → BA0 (A14), BA1 (A13) (SDRAM)  
 A14 to A2 (V850E/ME2) → A12 to A0 (SDRAM)

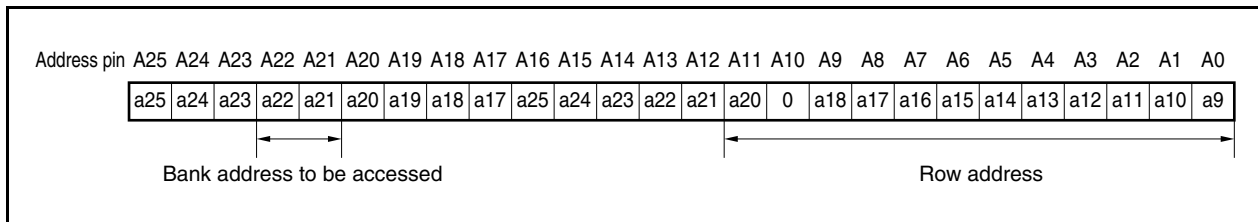
**(2) Bank address output**

The V850E/ME2 precharges a bank to access by using a bank precharge command when a row address is output immediately after page change. After bank change, it precharges the bank previously accessed when a column address is output. Therefore, a bank is precharged both when a row address is output and when a column address is output. To connect SDRAM with the contents described in 5.3.3 (1) (a) **At 8-bit data bus width**, always connect the pins (A22 and A21) of the V850E/ME2 that outputs bank addresses to the bank address pins (A13 and A12) of SDRAM.

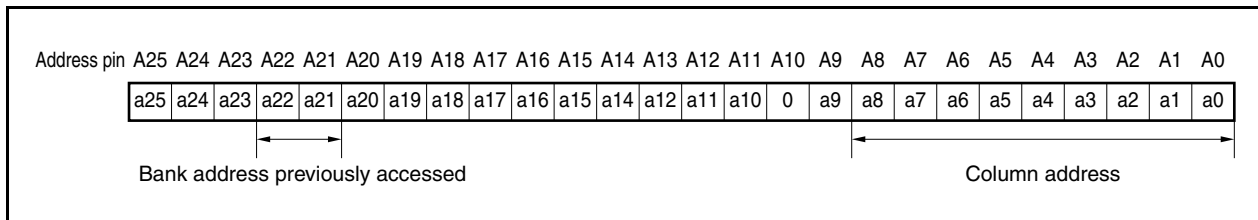
An example of address output by the bank precharge command when the page or bank is changed if SDRAM is connected with the contents described in 5.3.3 (1) (a) **At 8-bit data bus width** is shown below.

**(a) When page is changed (at 8-bit data bus width)**

When the page is changed, the precharge command outputs the physical addresses to be accessed (a20 and a18 to a9) to the A11 and A9 to A0 pins, and the bank addresses to be accessed (a22 and a21) to the A22 and A21 pins.

**(b) When bank is changed (at 8-bit data bus width)**

When the bank is changed, the bank precharge command outputs the physical addresses to be accessed (a8 to a0) to the A8 to A0 pins, and the bank addresses previously accessed (a22 and a21) to the A22 and A21 pins.



The bits that determine the precharge mode (A10: 8-bit data bus width, A11: 16-bit data bus width, A12: 32-bit data bus width) output a high level when the all bank precharge command is executed, and a low level when any other command is executed for precharging.



### 5.3.4 SDRAM configuration registers 1, 3, 4, 6 (SCR1, SCR3, SCR4, SCR6)

These registers specify the number of waits and the address multiplex width. The SCR<sub>n</sub> register corresponds to  $\overline{CS}_n$  ( $n = 1, 3, 4, 6$ ). For example, to connect SDRAM to  $\overline{CS}_1$ , set the SCR1 register. These registers can be read or written in 16-bit units.

- Cautions**
1. An SDRAM read/write cycle is not generated prior to executing a register write operation. Access SDRAM after reading the value of the SCR<sub>n</sub> register and confirming that the WCF<sub>n</sub> bit is set to 1 ( $n = 1, 3, 4, 6$ ).
  2. To write to the SCR<sub>n</sub> register again following access to SDRAM, clear the MEN bit of the BCT0 and BCT1 registers to 0, and then set it to 1 again before performing access ( $n = 1, 3, 4, 6$ ).
  3. Do not execute continuous instructions to write to the SCR<sub>n</sub> register. Be sure to insert another instruction between commands to write to the SCR<sub>n</sub> register.
  4. Start accessing SDRAM after all the SCR<sub>n</sub> registers have been set. Set the RFS<sub>n</sub> register before setting the SCR<sub>n</sub> register ( $n = 1, 3, 4, 6$ ).

(1/3)

|      | 15 | 14    | 13    | 12    | 11 | 10 | 9 | 8    | 7     | 6     | 5     | 4     | 3     | 2     | 1     | 0     | Address   | After reset |
|------|----|-------|-------|-------|----|----|---|------|-------|-------|-------|-------|-------|-------|-------|-------|-----------|-------------|
| SCR1 | 0  | LTM12 | LTM11 | LTM10 | 0  | 0  | 0 | WCF1 | BCW11 | BCW10 | SSO11 | SSO10 | RAW11 | RAW10 | SAW11 | SAW10 | FFFFF4A4H | 30C0H       |
| SCR3 | 0  | LTM32 | LTM31 | LTM30 | 0  | 0  | 0 | WCF3 | BCW31 | BCW30 | SSO31 | SSO30 | RAW31 | RAW30 | SAW31 | SAW30 | FFFFF4ACH | 30C0H       |
| SCR4 | 0  | LTM42 | LTM41 | LTM40 | 0  | 0  | 0 | WCF4 | BCW41 | BCW40 | SSO41 | SSO40 | RAW41 | RAW40 | SAW41 | SAW40 | FFFFF4B0H | 30C0H       |
| SCR6 | 0  | LTM62 | LTM61 | LTM60 | 0  | 0  | 0 | WCF6 | BCW61 | BCW60 | SSO61 | SSO60 | RAW61 | RAW60 | SAW61 | SAW60 | FFFFF4B8H | 30C0H       |

| Bit position | Bit name       | Function                                                                                                                                                                                                                                                                                                                                                      |       |       |                                                  |         |   |   |   |                                                  |   |   |   |   |   |   |   |   |                  |  |  |                    |
|--------------|----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|-------|--------------------------------------------------|---------|---|---|---|--------------------------------------------------|---|---|---|---|---|---|---|---|------------------|--|--|--------------------|
| 14 to 12     | LTMn2 to LTMn0 | Sets the CAS latency value for reading.                                                                                                                                                                                                                                                                                                                       |       |       |                                                  |         |   |   |   |                                                  |   |   |   |   |   |   |   |   |                  |  |  |                    |
|              |                | <table><tr><th>LTMn2</th><th>LTMn1</th><th>LTMn0</th><th>Latency</th></tr><tr><td>0</td><td>0</td><td>1</td><td>1 (setting prohibited during DMA flyby transfer)</td></tr><tr><td>0</td><td>1</td><td>0</td><td>2</td></tr><tr><td>0</td><td>1</td><td>1</td><td>3</td></tr><tr><td colspan="3">Other than above</td><td>Setting prohibited</td></tr></table> | LTMn2 | LTMn1 | LTMn0                                            | Latency | 0 | 0 | 1 | 1 (setting prohibited during DMA flyby transfer) | 0 | 1 | 0 | 2 | 0 | 1 | 1 | 3 | Other than above |  |  | Setting prohibited |
|              |                | LTMn2                                                                                                                                                                                                                                                                                                                                                         | LTMn1 | LTMn0 | Latency                                          |         |   |   |   |                                                  |   |   |   |   |   |   |   |   |                  |  |  |                    |
|              |                | 0                                                                                                                                                                                                                                                                                                                                                             | 0     | 1     | 1 (setting prohibited during DMA flyby transfer) |         |   |   |   |                                                  |   |   |   |   |   |   |   |   |                  |  |  |                    |
|              |                | 0                                                                                                                                                                                                                                                                                                                                                             | 1     | 0     | 2                                                |         |   |   |   |                                                  |   |   |   |   |   |   |   |   |                  |  |  |                    |
|              |                | 0                                                                                                                                                                                                                                                                                                                                                             | 1     | 1     | 3                                                |         |   |   |   |                                                  |   |   |   |   |   |   |   |   |                  |  |  |                    |
|              |                | Other than above                                                                                                                                                                                                                                                                                                                                              |       |       | Setting prohibited                               |         |   |   |   |                                                  |   |   |   |   |   |   |   |   |                  |  |  |                    |
|              |                |                                                                                                                                                                                                                                                                                                                                                               |       |       |                                                  |         |   |   |   |                                                  |   |   |   |   |   |   |   |   |                  |  |  |                    |
|              |                |                                                                                                                                                                                                                                                                                                                                                               |       |       |                                                  |         |   |   |   |                                                  |   |   |   |   |   |   |   |   |                  |  |  |                    |
|              |                |                                                                                                                                                                                                                                                                                                                                                               |       |       |                                                  |         |   |   |   |                                                  |   |   |   |   |   |   |   |   |                  |  |  |                    |
|              |                |                                                                                                                                                                                                                                                                                                                                                               |       |       |                                                  |         |   |   |   |                                                  |   |   |   |   |   |   |   |   |                  |  |  |                    |
| 8            | WCFn           | <p>Indicates that execution of a register write command on SDRAM has been completed after the SCRn register was set. This bit is set to 1 when a register write command is generated. This bit can only be read.</p> <p>0: Setting not completed</p> <p>1. Setting completed</p>                                                                              |       |       |                                                  |         |   |   |   |                                                  |   |   |   |   |   |   |   |   |                  |  |  |                    |

**Remark**  $n = 1, 3, 4, 6$

| Bit position | Bit name        | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |       |       |                                                |   |   |                                          |   |   |                                                          |   |   |                                                           |   |   |                         |
|--------------|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|-------|------------------------------------------------|---|---|------------------------------------------|---|---|----------------------------------------------------------|---|---|-----------------------------------------------------------|---|---|-------------------------|
| 7, 6         | BCWn1,<br>BCWn0 | <p>Specifies the number of wait states inserted from the bank active command to a read/write command, or from the precharge command to the bank active command.</p> <table> <tr> <th>BCWn1</th><th>BCWn0</th><th>Number of wait states inserted</th></tr> <tr> <td>0</td><td>0</td><td>Setting prohibited</td></tr> <tr> <td>0</td><td>1</td><td>1</td></tr> <tr> <td>1</td><td>0</td><td>2</td></tr> <tr> <td>1</td><td>1</td><td>3</td></tr> </table>                                                                                                                                                                                                                                                                               | BCWn1 | BCWn0 | Number of wait states inserted                 | 0 | 0 | Setting prohibited                       | 0 | 1 | 1                                                        | 1 | 0 | 2                                                         | 1 | 1 | 3                       |
| BCWn1        | BCWn0           | Number of wait states inserted                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |       |       |                                                |   |   |                                          |   |   |                                                          |   |   |                                                           |   |   |                         |
| 0            | 0               | Setting prohibited                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |       |       |                                                |   |   |                                          |   |   |                                                          |   |   |                                                           |   |   |                         |
| 0            | 1               | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |       |       |                                                |   |   |                                          |   |   |                                                          |   |   |                                                           |   |   |                         |
| 1            | 0               | 2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |       |       |                                                |   |   |                                          |   |   |                                                          |   |   |                                                           |   |   |                         |
| 1            | 1               | 3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |       |       |                                                |   |   |                                          |   |   |                                                          |   |   |                                                           |   |   |                         |
| 5, 4         | SSOn1,<br>SSOn0 | <p>Specifies the address shift width during on-page judgment.<br/>If the external data bus width is set to 16 or 32 bits, the system does not use the lower address (A0 or A1, A0). Set these bits in accordance with the contents of the LBS register corresponding to <math>\overline{CSn}</math>.</p> <table> <tr> <th>SSOn1</th><th>SSOn0</th><th>Address shift width</th></tr> <tr> <td>0</td><td>0</td><td>0 bits (external data bus width: 8 bits)</td></tr> <tr> <td>0</td><td>1</td><td>1 bit (external data bus width: 16 bits)<sup>Note</sup></td></tr> <tr> <td>1</td><td>0</td><td>2 bits (external data bus width: 32 bits)<sup>Note</sup></td></tr> <tr> <td>1</td><td>1</td><td>Setting prohibited</td></tr> </table> | SSOn1 | SSOn0 | Address shift width                            | 0 | 0 | 0 bits (external data bus width: 8 bits) | 0 | 1 | 1 bit (external data bus width: 16 bits) <sup>Note</sup> | 1 | 0 | 2 bits (external data bus width: 32 bits) <sup>Note</sup> | 1 | 1 | Setting prohibited      |
| SSOn1        | SSOn0           | Address shift width                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |       |       |                                                |   |   |                                          |   |   |                                                          |   |   |                                                           |   |   |                         |
| 0            | 0               | 0 bits (external data bus width: 8 bits)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |       |       |                                                |   |   |                                          |   |   |                                                          |   |   |                                                           |   |   |                         |
| 0            | 1               | 1 bit (external data bus width: 16 bits) <sup>Note</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |       |       |                                                |   |   |                                          |   |   |                                                          |   |   |                                                           |   |   |                         |
| 1            | 0               | 2 bits (external data bus width: 32 bits) <sup>Note</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |       |       |                                                |   |   |                                          |   |   |                                                          |   |   |                                                           |   |   |                         |
| 1            | 1               | Setting prohibited                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |       |       |                                                |   |   |                                          |   |   |                                                          |   |   |                                                           |   |   |                         |
| 3, 2         | RAWn1,<br>RAWn0 | <p>Specifies the row address width.</p> <table> <tr> <th>RAWn1</th><th>RAWn0</th><th>Row address width</th></tr> <tr> <td>0</td><td>0</td><td>11 bits</td></tr> <tr> <td>0</td><td>1</td><td>12 bits<sup>Note</sup></td></tr> <tr> <td>1</td><td>0</td><td>13 bits<sup>Note</sup></td></tr> <tr> <td>1</td><td>1</td><td>Setting prohibited</td></tr> </table>                                                                                                                                                                                                                                                                                                                                                                        | RAWn1 | RAWn0 | Row address width                              | 0 | 0 | 11 bits                                  | 0 | 1 | 12 bits <sup>Note</sup>                                  | 1 | 0 | 13 bits <sup>Note</sup>                                   | 1 | 1 | Setting prohibited      |
| RAWn1        | RAWn0           | Row address width                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |       |       |                                                |   |   |                                          |   |   |                                                          |   |   |                                                           |   |   |                         |
| 0            | 0               | 11 bits                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |       |       |                                                |   |   |                                          |   |   |                                                          |   |   |                                                           |   |   |                         |
| 0            | 1               | 12 bits <sup>Note</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |       |       |                                                |   |   |                                          |   |   |                                                          |   |   |                                                           |   |   |                         |
| 1            | 0               | 13 bits <sup>Note</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |       |       |                                                |   |   |                                          |   |   |                                                          |   |   |                                                           |   |   |                         |
| 1            | 1               | Setting prohibited                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |       |       |                                                |   |   |                                          |   |   |                                                          |   |   |                                                           |   |   |                         |
| 1, 0         | SAWn1,<br>SAWn0 | <p>Specifies the address multiplex width (column address width) during SDRAM access.</p> <table> <tr> <th>SAWn1</th><th>SAWn0</th><th>Address multiplex width (column address width)</th></tr> <tr> <td>0</td><td>0</td><td>8 bits</td></tr> <tr> <td>0</td><td>1</td><td>9 bits</td></tr> <tr> <td>1</td><td>0</td><td>10 bits<sup>Note</sup></td></tr> <tr> <td>1</td><td>1</td><td>11 bits<sup>Note</sup></td></tr> </table>                                                                                                                                                                                                                                                                                                       | SAWn1 | SAWn0 | Address multiplex width (column address width) | 0 | 0 | 8 bits                                   | 0 | 1 | 9 bits                                                   | 1 | 0 | 10 bits <sup>Note</sup>                                   | 1 | 1 | 11 bits <sup>Note</sup> |
| SAWn1        | SAWn0           | Address multiplex width (column address width)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |       |       |                                                |   |   |                                          |   |   |                                                          |   |   |                                                           |   |   |                         |
| 0            | 0               | 8 bits                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |       |       |                                                |   |   |                                          |   |   |                                                          |   |   |                                                           |   |   |                         |
| 0            | 1               | 9 bits                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |       |       |                                                |   |   |                                          |   |   |                                                          |   |   |                                                           |   |   |                         |
| 1            | 0               | 10 bits <sup>Note</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |       |       |                                                |   |   |                                          |   |   |                                                          |   |   |                                                           |   |   |                         |
| 1            | 1               | 11 bits <sup>Note</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |       |       |                                                |   |   |                                          |   |   |                                                          |   |   |                                                           |   |   |                         |

**Remarks 1.** The **Note** is described on the next page.

**2.** n = 1, 3, 4, 6

**Note** The following setting is prohibited because the upper limit of the address is exceeded.

| SSOn1 | SSOn0 | RAWn1 | RAWn0 | SAWn1 | SAWn0 | Setting                                                                                |
|-------|-------|-------|-------|-------|-------|----------------------------------------------------------------------------------------|
| 0     | 1     | 1     | 0     | 1     | 1     | Data bus width: 16 bits<br>Row address width: 13 bits<br>Column address width: 11 bits |
| 1     | 0     | 0     | 1     | 1     | 1     | Data bus width: 32 bits<br>Row address width: 12 bits<br>Column address width: 11 bits |
| 1     | 0     | 1     | 0     | 1     | 0     | Data bus width: 32 bits<br>Row address width: 13 bits<br>Column address width: 10 bits |
|       |       |       |       |       | 1     | Data bus width: 32 bits<br>Row address width: 13 bits<br>Column address width: 11 bits |

**Remark** n = 1, 3, 4, 6

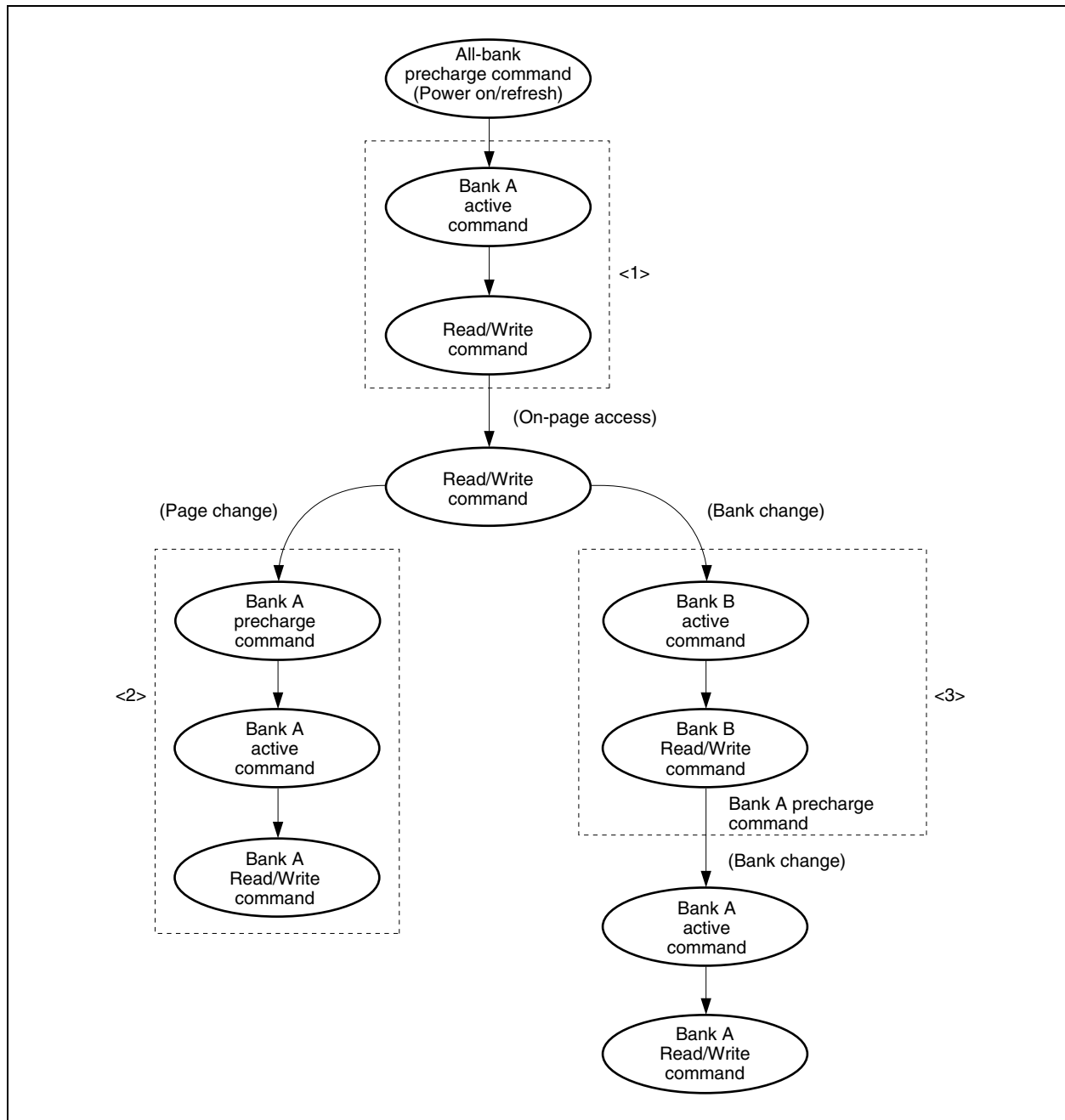
### 5.3.5 SDRAM access

During power-on or a refresh operation, the all-bank precharge command is always issued for SDRAM. When accessing SDRAM after that, therefore, the active command and read/write command are issued in that order (see <1> in Figure 5-8).

If a page change occurs following this, the precharge command, active command, and read/write command are issued in that order (see <2> in Figure 5-8).

If a bank change occurs, the active command and read/write command for the bank to be accessed next are issued in that order. Following this read/write command, the precharge command for the bank that was accessed before the bank currently being accessed will be issued (see <3> in Figure 5-8).

Figure 5-8. State Transition of SDRAM Access



**(1) SDRAM single read cycle**

The SDRAM single read cycle is a cycle for reading from SDRAM by executing a load instruction (LD) for the SDRAM area, by fetching an instruction, or by 2-cycle DMA transfer.

In the SDRAM single read cycle, the active command (ACT) and read command (RD) are issued to SDRAM in that order. During on-page access, however, only the read command is issued and the precharge command and active command are not issued. When a page change occurs in the same bank, the precharge command (PRE) is issued before the active command.

A one-state T0 cycle is always inserted immediately before all read commands activated by the CPU.

The number of idle states (TI) set by the BCC register are inserted after the read cycle (no idle states are inserted, however, if BCn1 and BCn0 are 00) (n = 1, 3, 4, 6). The timing charts of the SDRAM single read cycle are shown below.

**Caution** When executing a write access to SRAM or external I/O after read accessing SDRAM, data conflict may occur depending on the SDRAM data output float delay time. In such a case, avoid data conflict by inserting an idle state in the SDRAM space via a setting in the BCC register.

Figure 5-9. SDRAM Single Read Cycle (1/5)

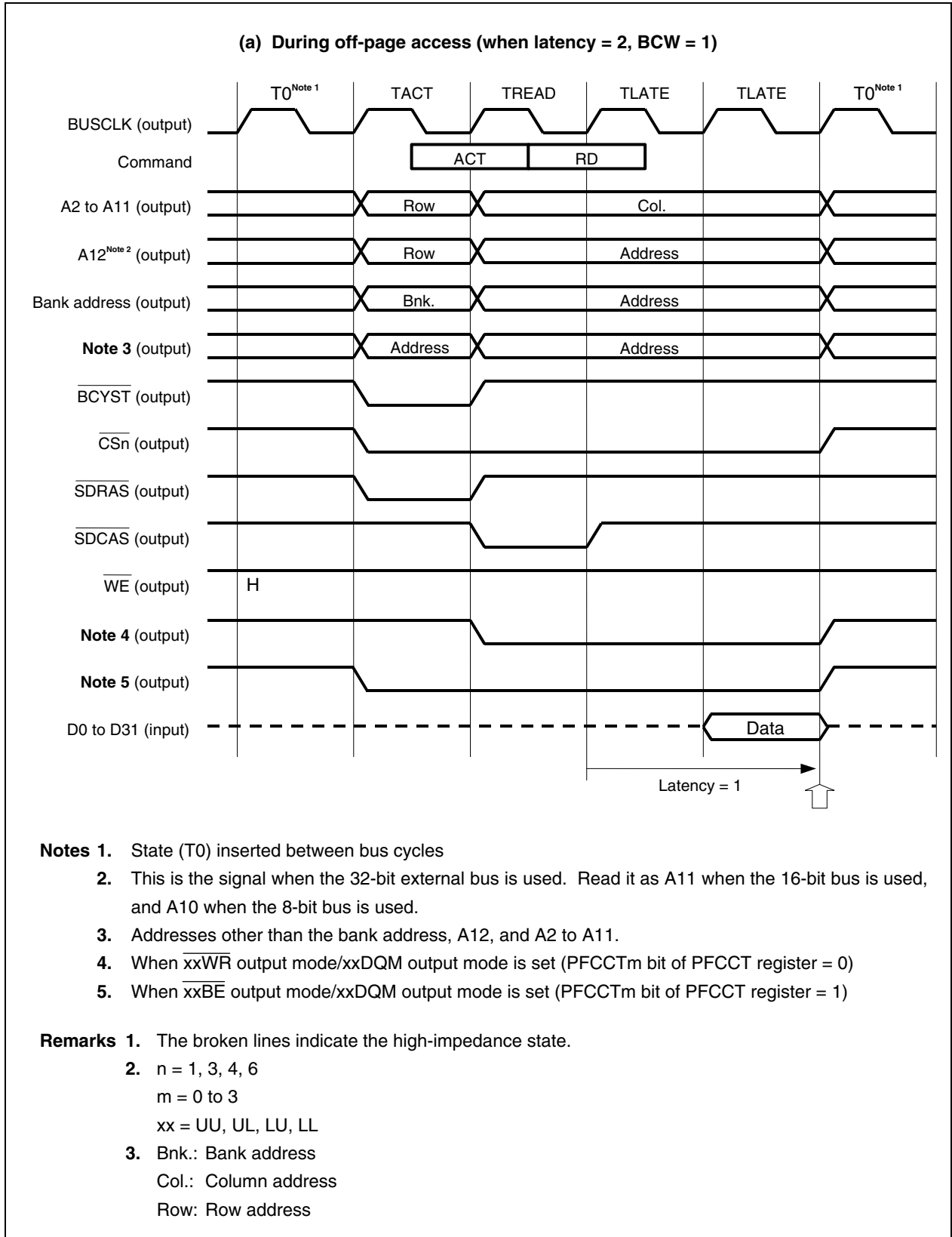


Figure 5-9. SDRAM Single Read Cycle (2/5)

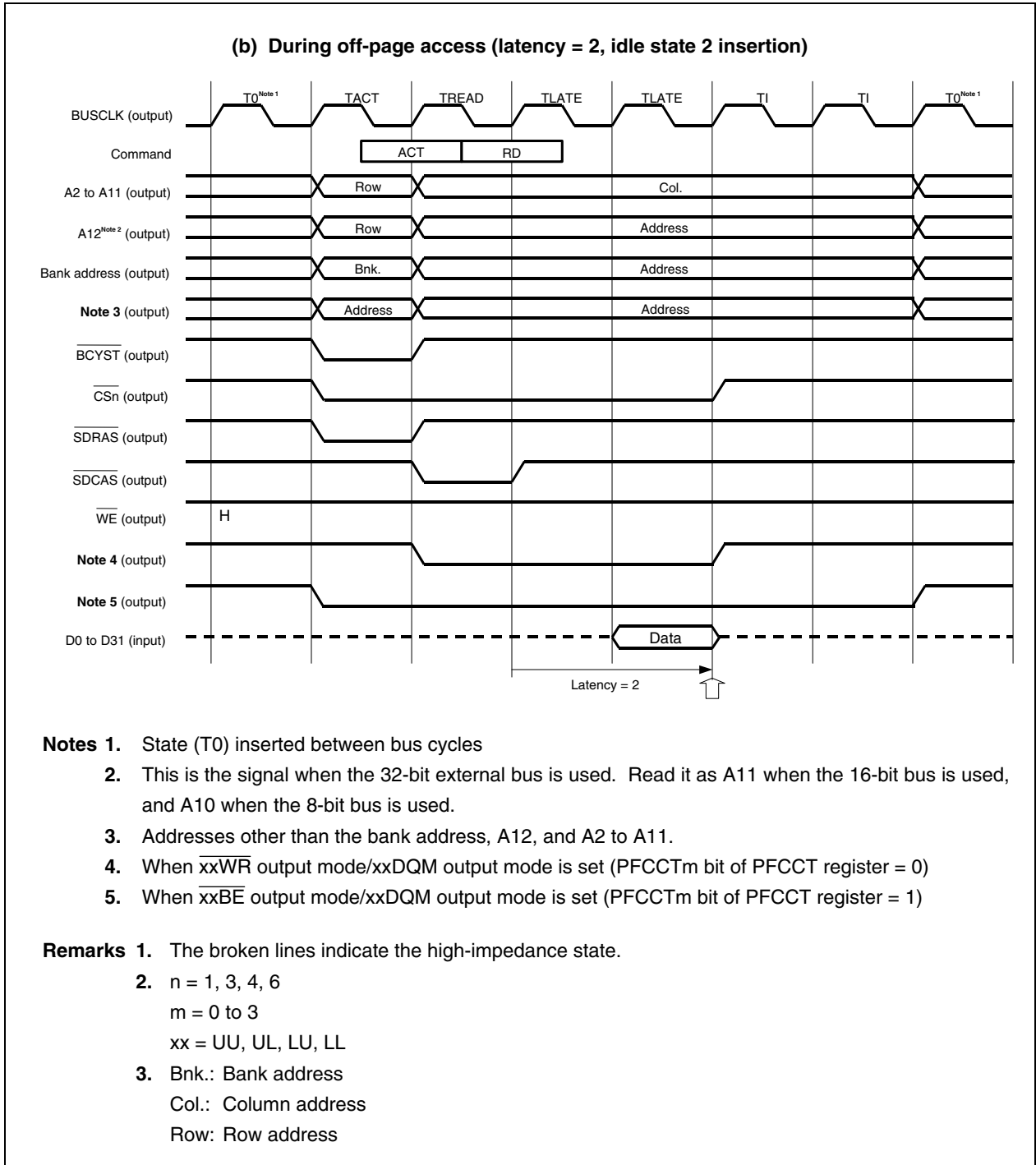


Figure 5-9. SDRAM Single Read Cycle (3/5)

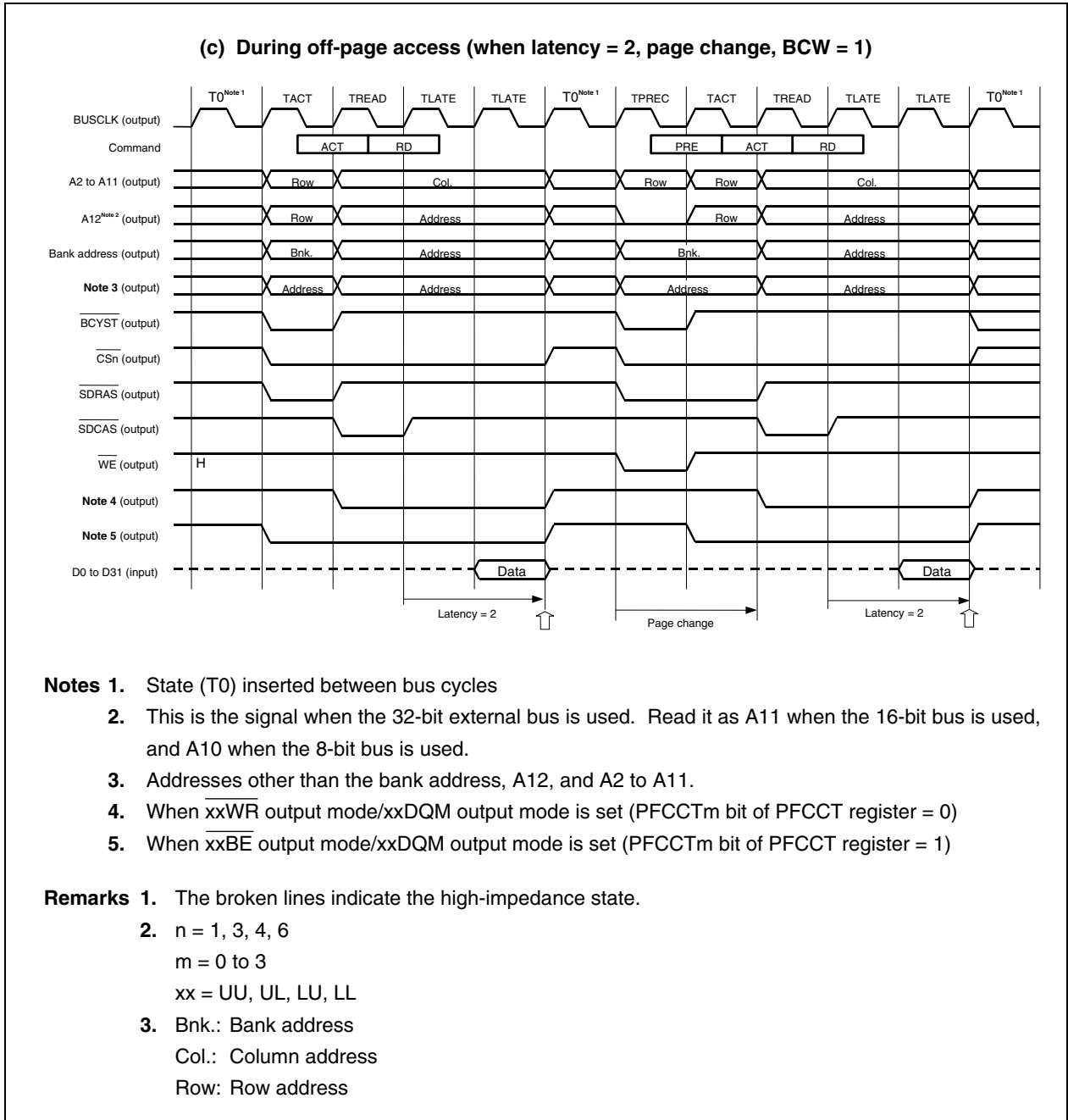




Figure 5-9. SDRAM Single Read Cycle (4/5)

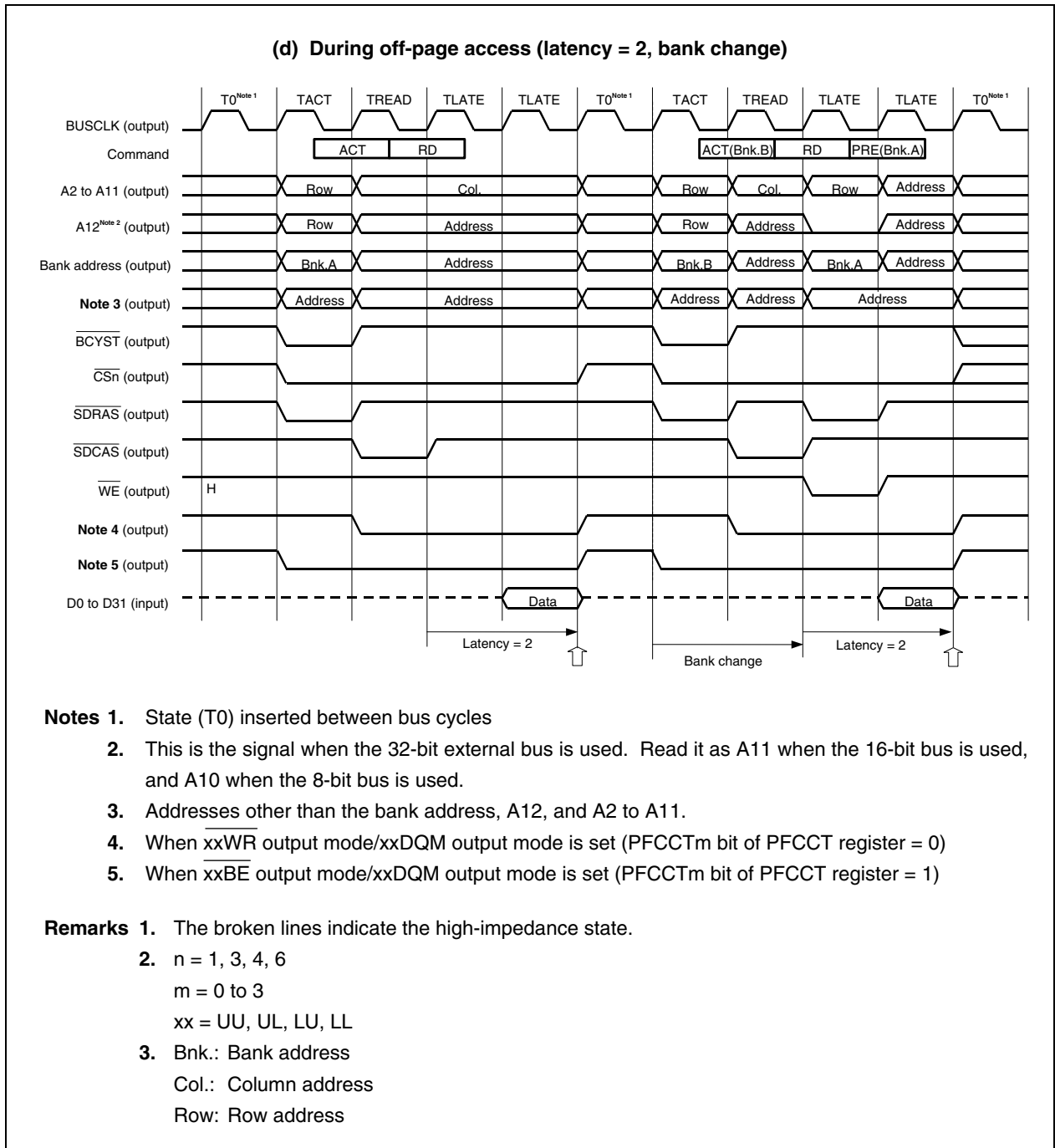
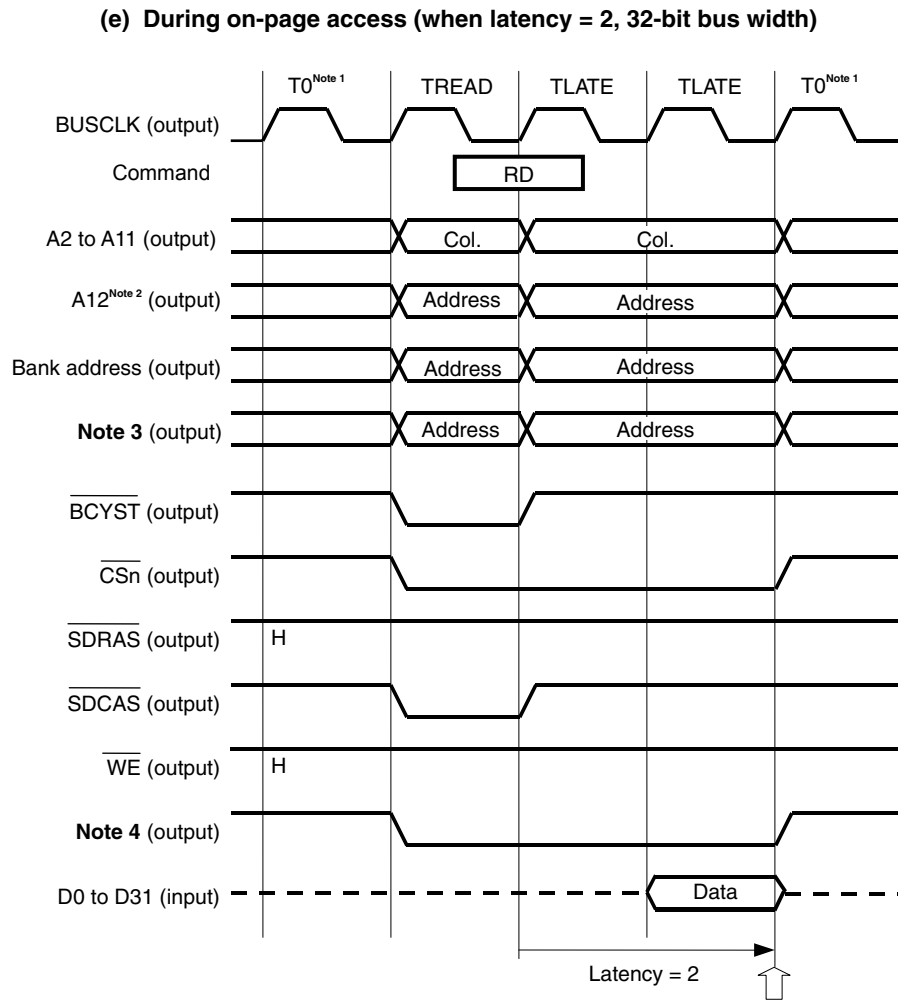


Figure 5-9. SDRAM Single Read Cycle (5/5)



- Notes**
1. State (T0) inserted between bus cycles
  2. This is the signal when the 32-bit external bus is used. Read it as A11 when the 16-bit bus is used, and A10 when the 8-bit bus is used.
  3. Addresses other than the bank address, A12, and A2 to A11.
  4. UUDQM, ULDQM, LUDQM, LLDQM

- Remarks**
1. The broken lines indicate the high-impedance state.
  2.  $n = 1, 3, 4, 6$
  3. Col.: Column address

**(2) SDRAM single write cycle**

The SDRAM single write cycle is a cycle for writing to SDRAM by executing a write instruction (ST) for the SDRAM area or by 2-cycle DMA transfer.

In the SDRAM single write cycle, the active command (ACT) and write command (WR) are issued to SDRAM in that order. During on-page access, however, only the write command is issued and the precharge command and active command are not issued. When a page change occurs in the same bank, the precharge command (PRE) is issued before the active command.

The timing charts of the SDRAM single write cycle are shown below.

Figure 5-10. SDRAM Single Write Cycle (1/6)

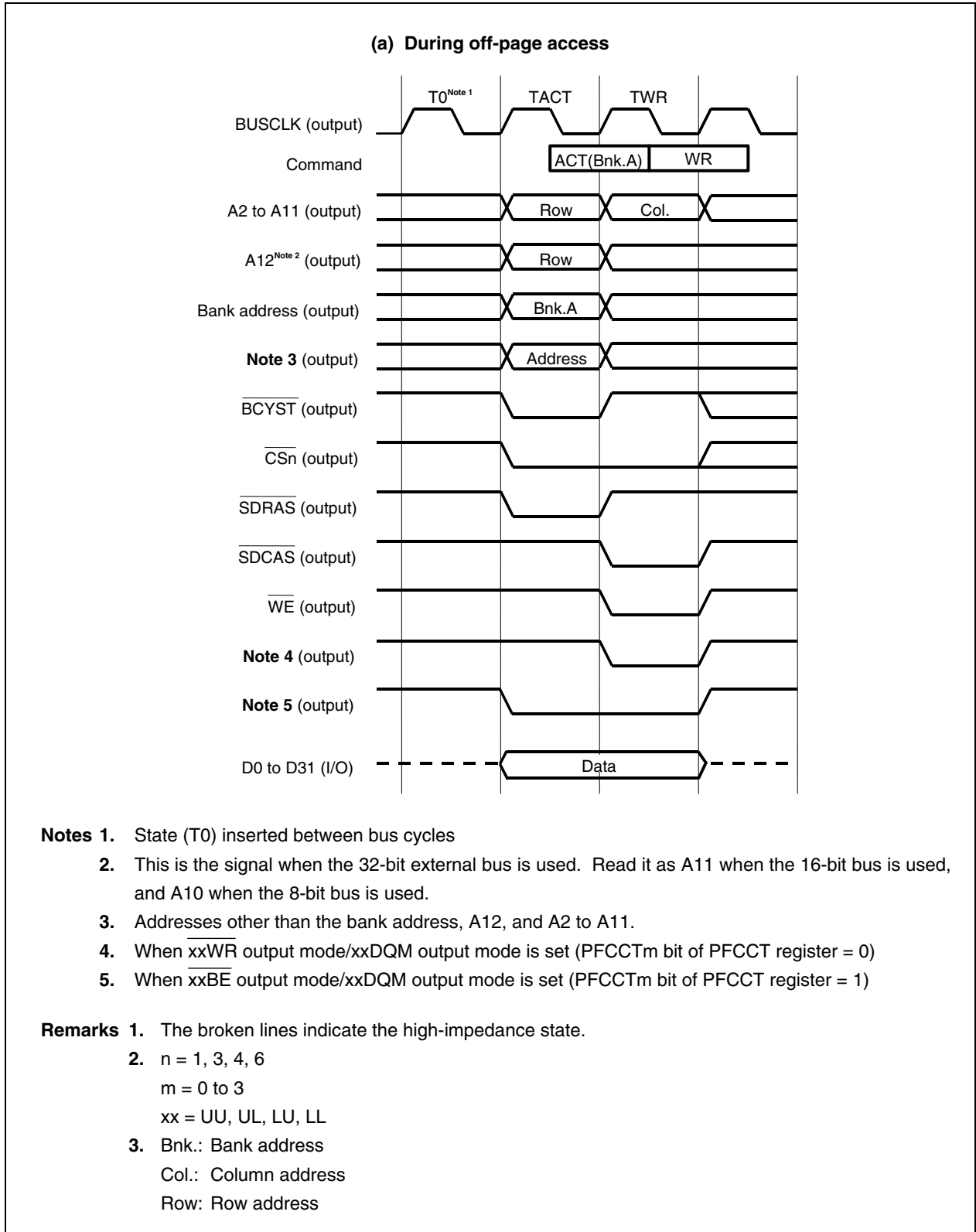


Figure 5-10. SDRAM Single Write Cycle (2/6)

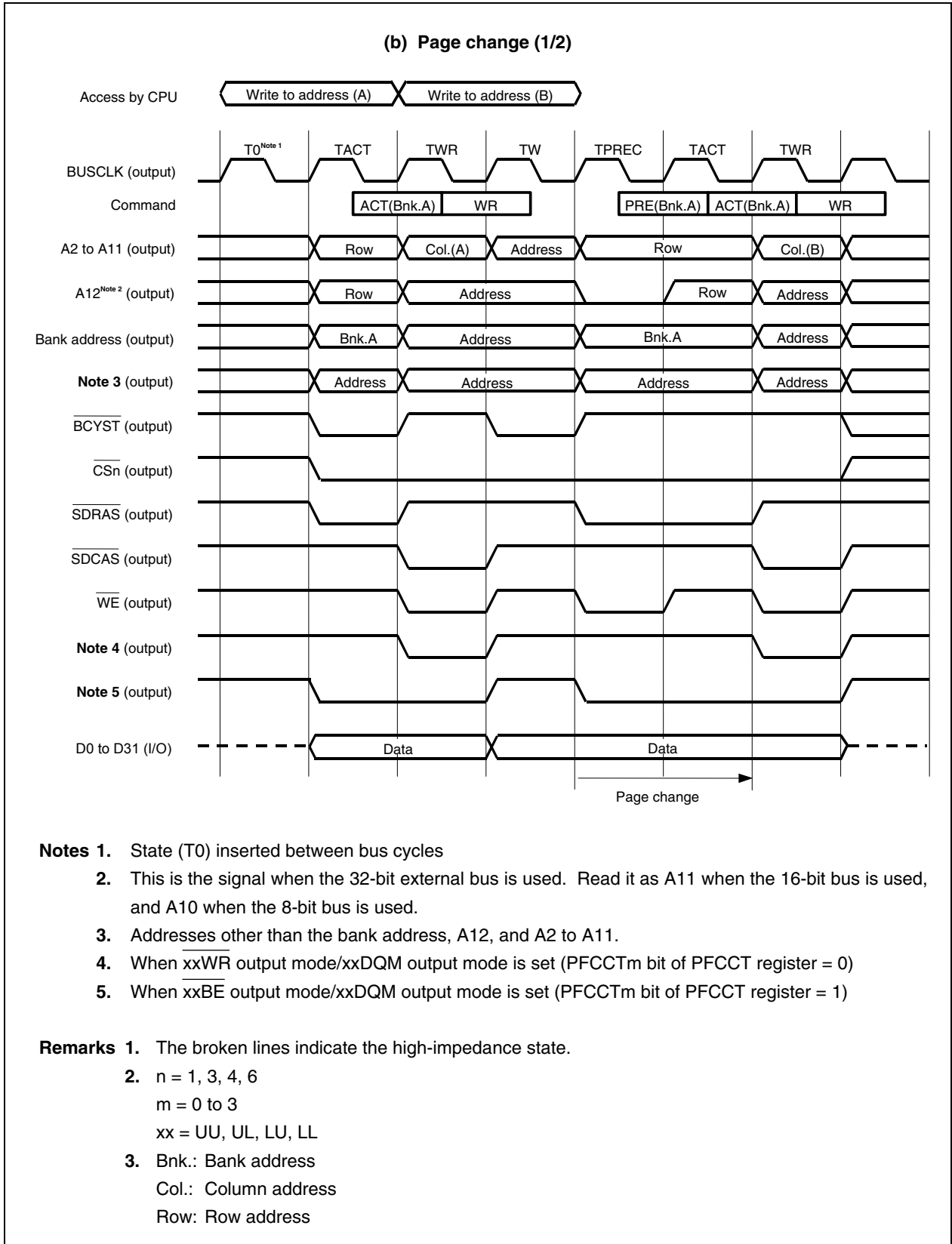


Figure 5-10. SDRAM Single Write Cycle (3/6)

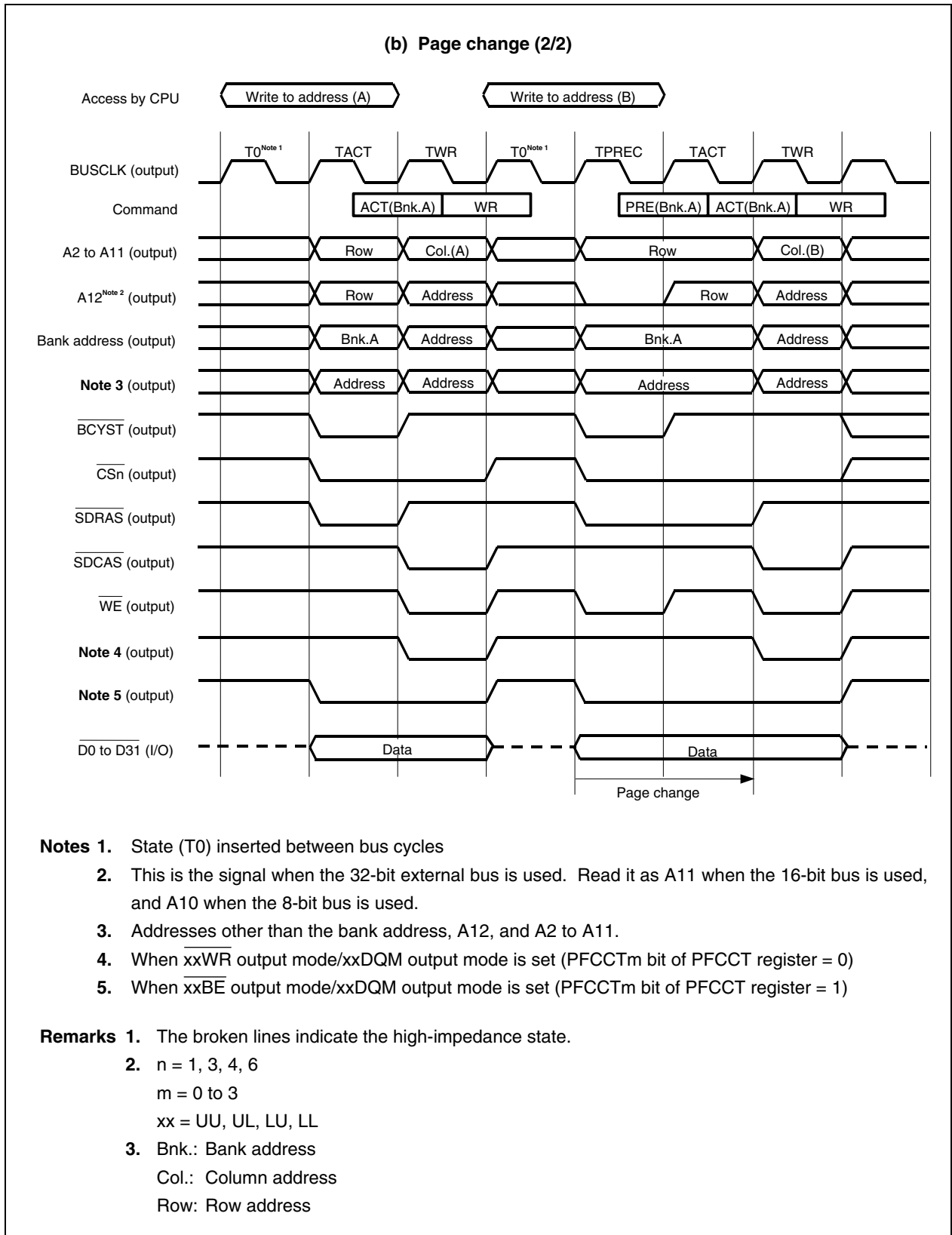


Figure 5-10. SDRAM Single Write Cycle (4/6)

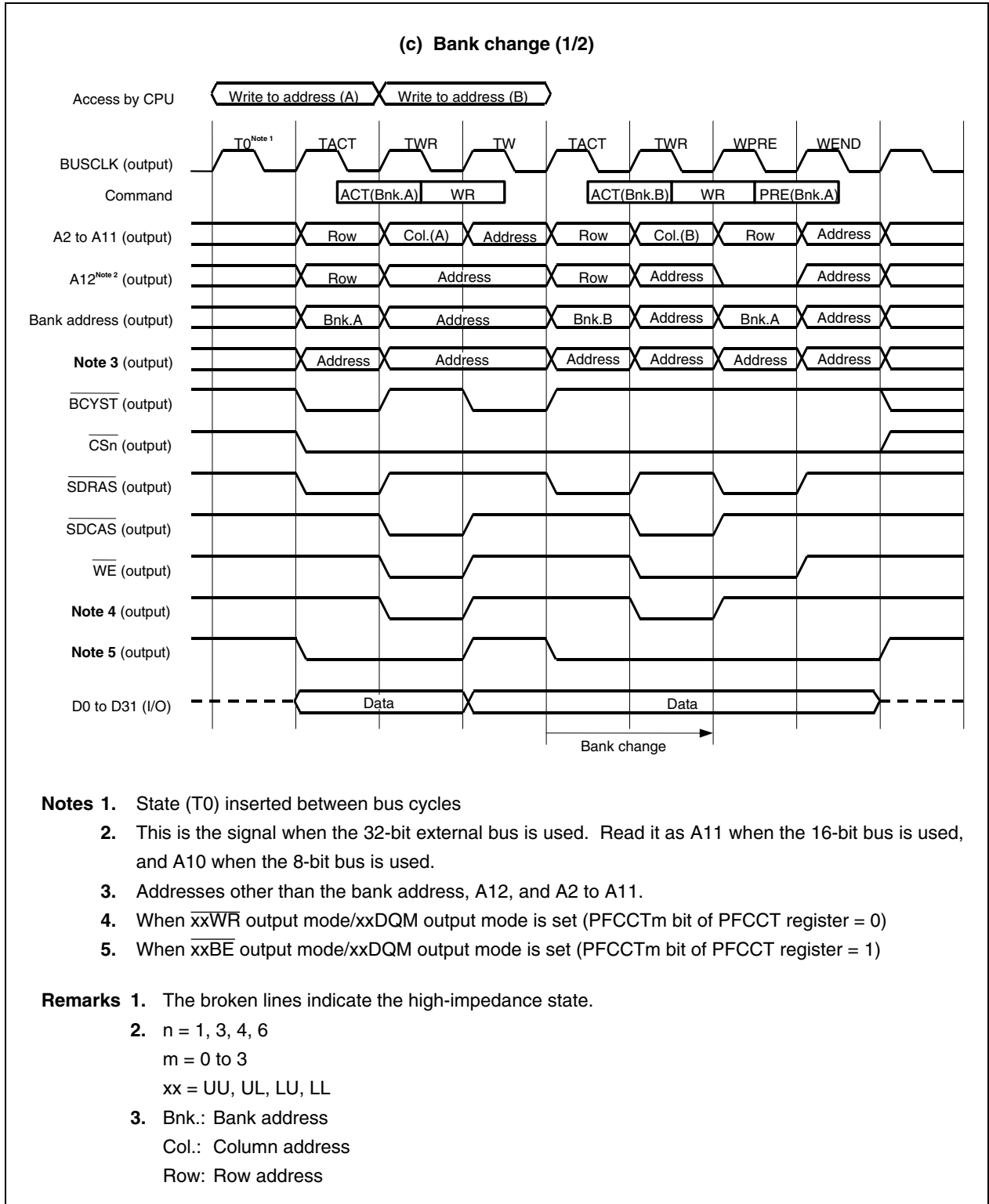


Figure 5-10. SDRAM Single Write Cycle (5/6)

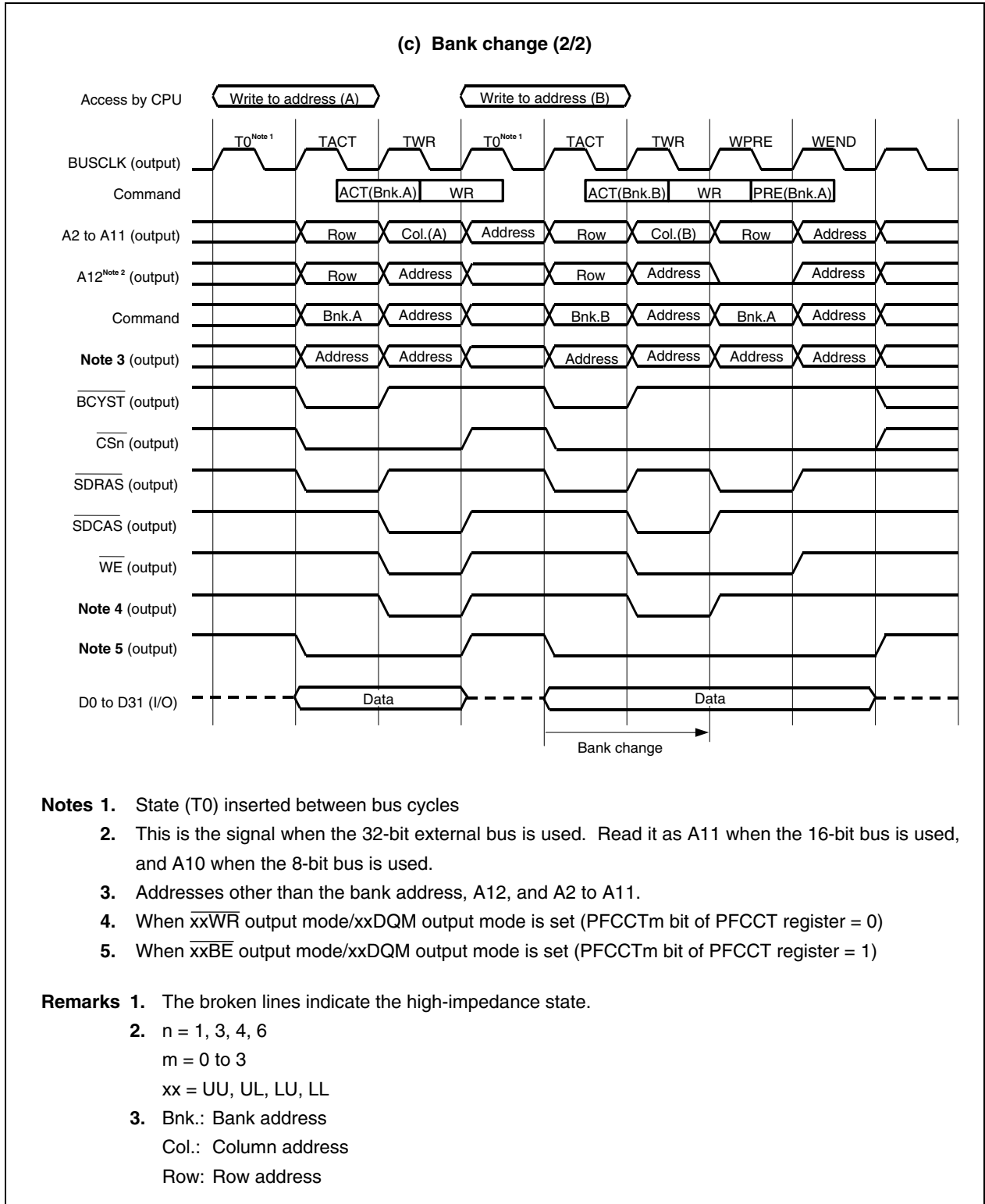
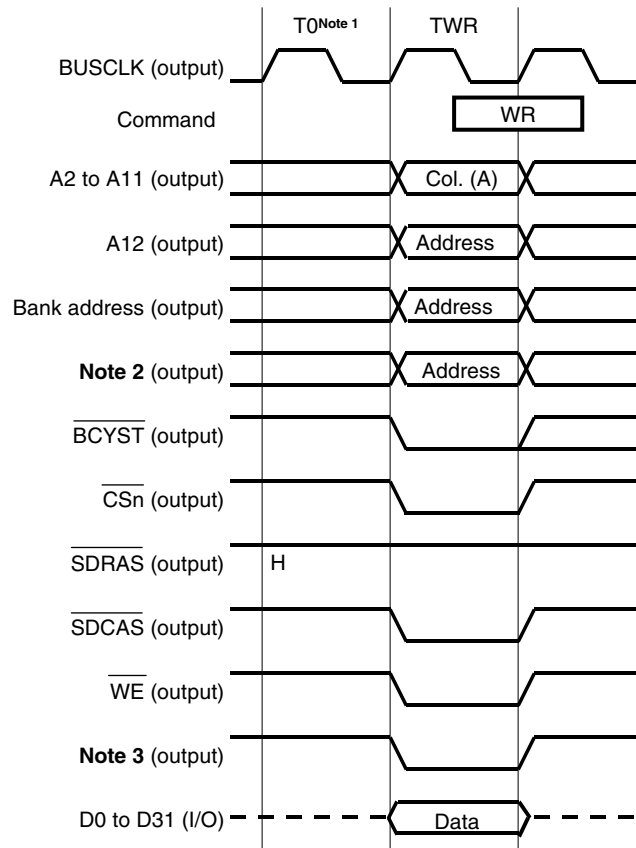




Figure 5-10. SDRAM Single Write Cycle (6/6)

## (d) During on-page access (32-bit bus width)



- Notes**
1. State ( $T_0$ ) inserted between bus cycles
  2. Addresses other than the bank address, A12, and A2 to A11.
  3. UUDQM, ULDQM, LUDQM, LLDQM

- Remarks**
1. The broken lines indicate the high-impedance state.
  2.  $n = 1, 3, 4, 6$
  3. Col.: Column address

**(3) SDRAM access timing control**

The SDRAM access timing can be controlled by the SCR<sub>n</sub> register (n = 1, 3, 4, 6). For details, see **5.3.4 SDRAM configuration registers 1, 3, 4, 6 (SCR1, SCR3, SCR4, SCR6)**.

**Caution** Wait control by the WAIT pin is not available during SDRAM access.

**(a) Number of waits from bank active command to read/write command**

The number of wait states from bank active command issue to read/write command issue can be set by setting the BCW<sub>n1</sub> and BCW<sub>n0</sub> bits of the SCR<sub>n</sub> register.

BCW<sub>n1</sub>, BCW<sub>n0</sub> bits = 01: 1 wait

BCW<sub>n1</sub>, BCW<sub>n0</sub> bits = 10: 2 waits

BCW<sub>n1</sub>, BCW<sub>n0</sub> bits = 11: 3 waits

**(b) Number of waits from precharge command to bank active command**

The number of wait states from precharge command issue to bank active command issue can be set by setting the BCW<sub>n1</sub> and BCW<sub>n0</sub> bits of the SCR<sub>n</sub> register.

BCW<sub>n1</sub>, BCW<sub>n0</sub> bits = 01: 1 wait

BCW<sub>n1</sub>, BCW<sub>n0</sub> bits = 10: 2 waits

BCW<sub>n1</sub>, BCW<sub>n0</sub> bits = 11: 3 waits

**(c) CAS latency setting when read**

The CAS latency during a read operation can be set by setting the LTM<sub>n2</sub> to LTM<sub>n0</sub> bits of the SCR<sub>n</sub> register.

LTM<sub>n2</sub> to LTM<sub>n0</sub> bits = 001: Latency = 1 (setting prohibited during DMA flyby transfer)

LTM<sub>n2</sub> to LTM<sub>n0</sub> bits = 010: Latency = 2

LTM<sub>n2</sub> to LTM<sub>n0</sub> bits = 011: Latency = 3

**(d) Number of waits from refresh command to next command**

The number of wait states from refresh command issue to next command issue can be set by setting the BCW<sub>n1</sub> and BCW<sub>n0</sub> bits of the SCR<sub>n</sub> register. The number of wait states becomes four times the value set by BCW<sub>n1</sub> and BCW<sub>n0</sub> bits.

BCW<sub>n1</sub>, BCW<sub>n0</sub> bits = 01: 4 waits

BCW<sub>n1</sub>, BCW<sub>n0</sub> bits = 10: 8 waits

BCW<sub>n1</sub>, BCW<sub>n0</sub> bits = 11: 12 waits

Figure 5-11. SDRAM Access Timing (1/9)

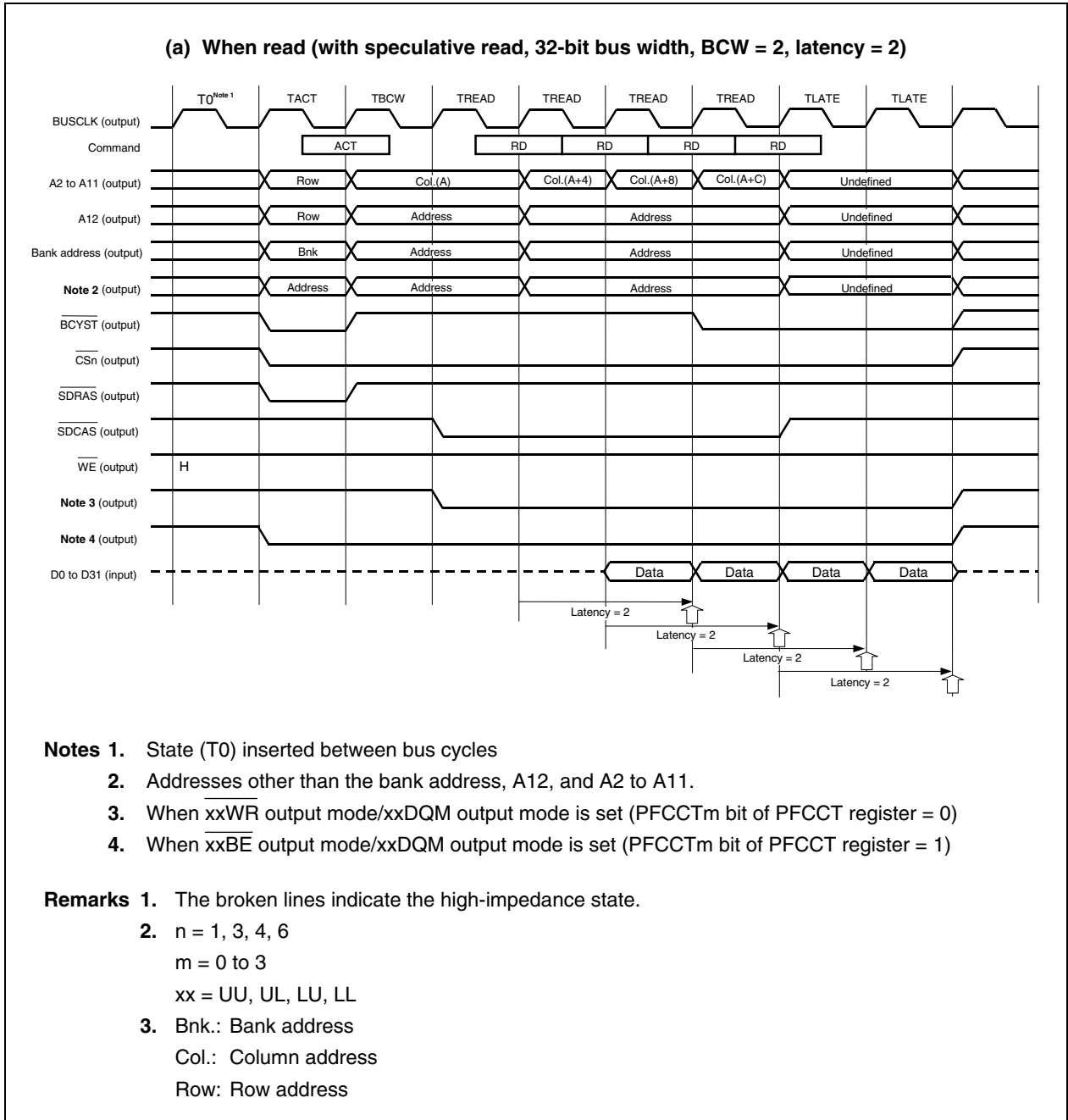
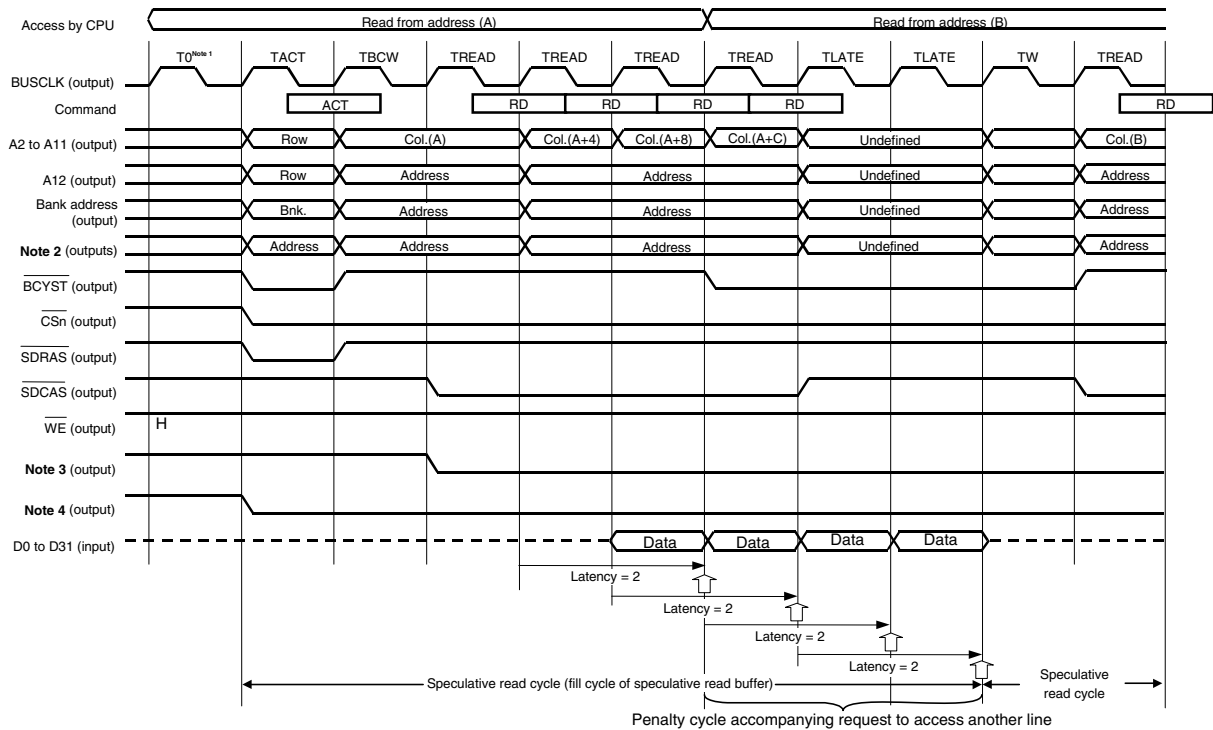


Figure 5-11. SDRAM Access Timing (2/9)

**(b) When read (with speculative read, access on another line, 32-bit bus width, BCW = 2, latency = 2)**

- Notes**
1. State (T0) inserted between bus cycles
  2. Addresses other than the bank address, A12, and A2 to A11.
  3. When  $\overline{xxWR}$  output mode/ $\overline{xxDQM}$  output mode is set (PFCCTm bit of PFCCT register = 0)
  4. When  $\overline{xxBE}$  output mode/ $\overline{xxDQM}$  output mode is set (PFCCTm bit of PFCCT register = 1)

- Remarks**
1. The broken lines indicate the high-impedance state.
  2.  $n = 1, 3, 4, 6$   
 $m = 0 \text{ to } 3$   
 $xx = UU, UL, LU, LL$
  3. Bnk.: Bank address  
Col.: Column address  
Row: Row address

Figure 5-11. SDRAM Access Timing (3/9)

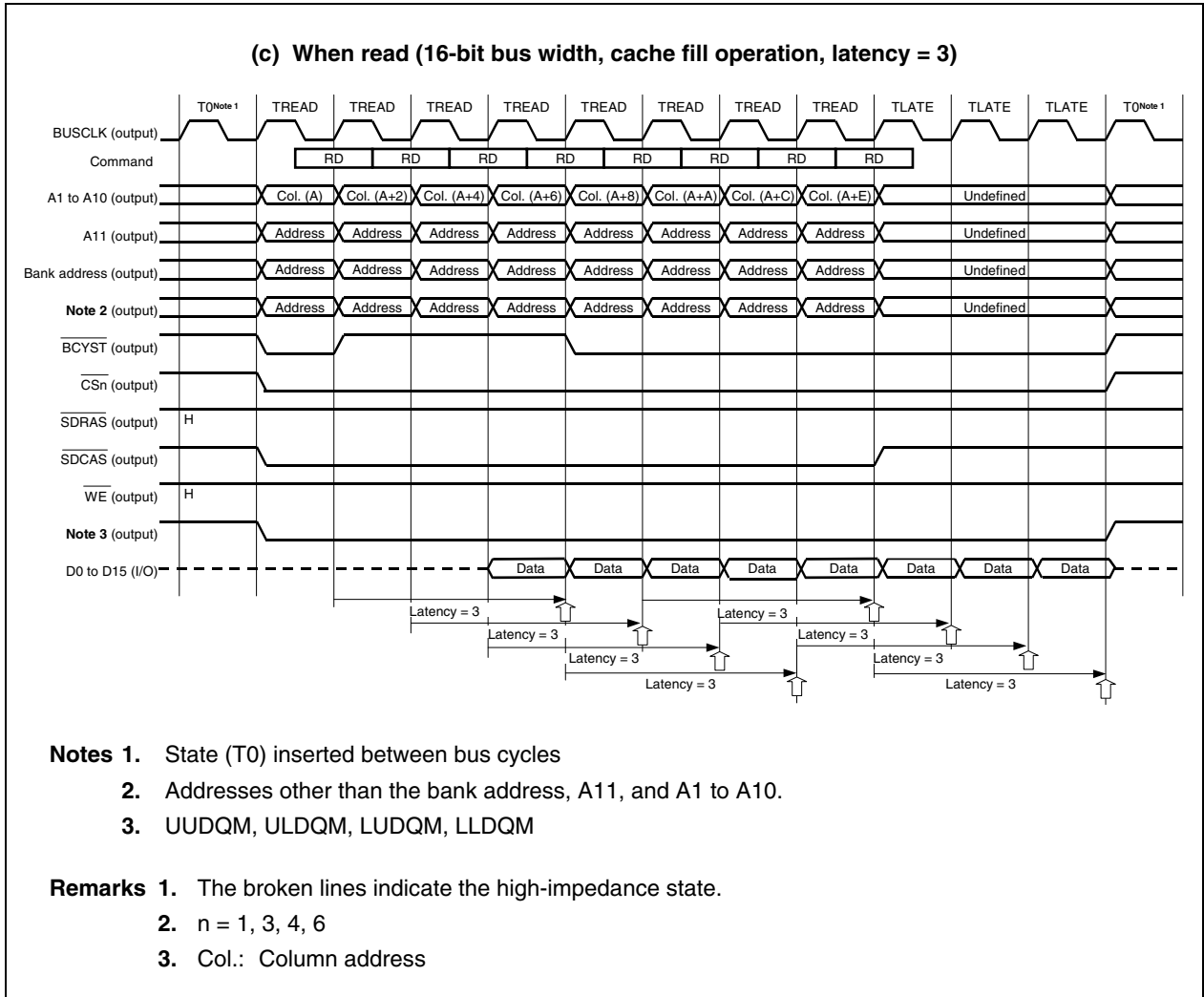


Figure 5-11. SDRAM Access Timing (4/9)

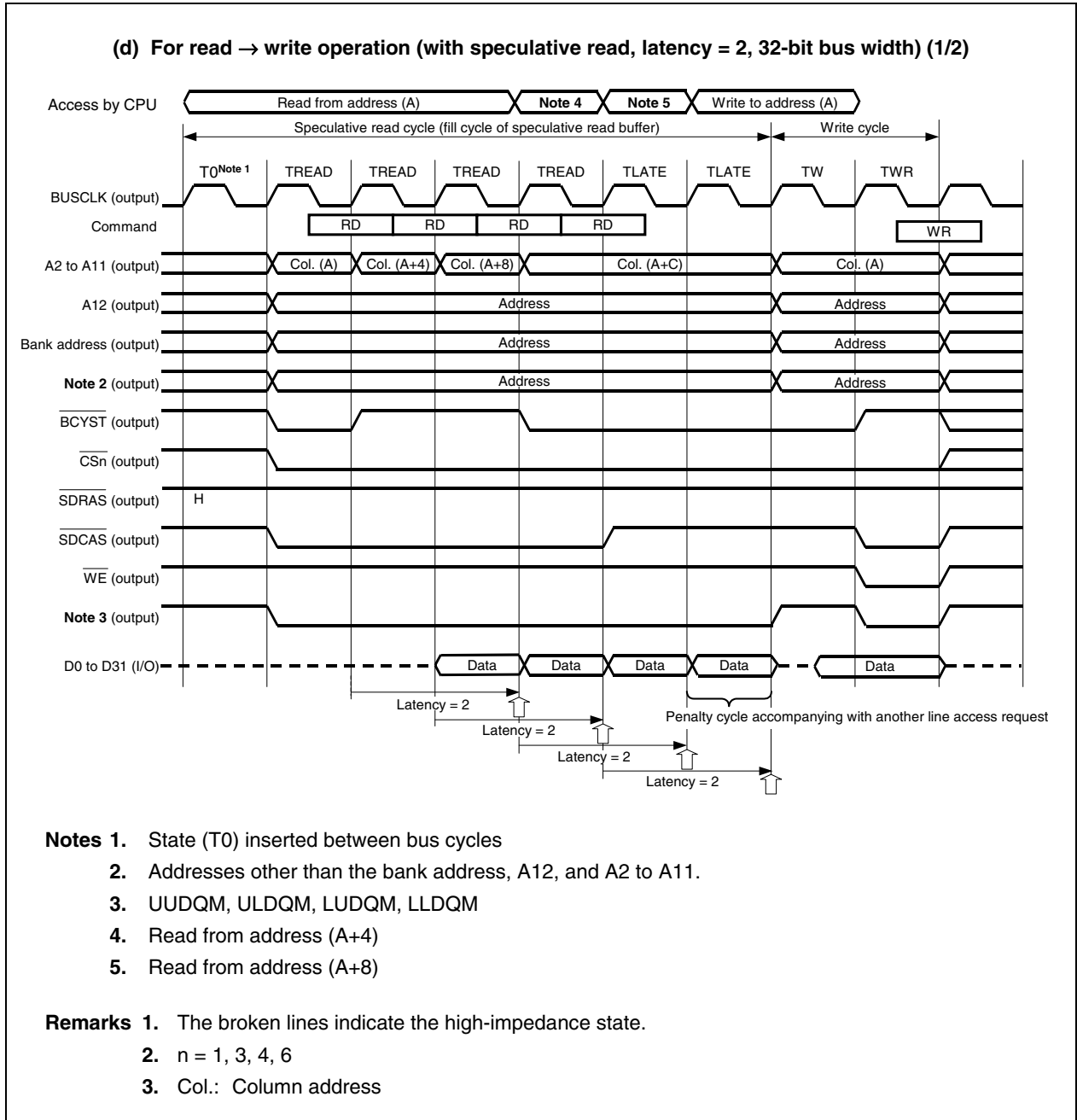


Figure 5-11. SDRAM Access Timing (5/9)

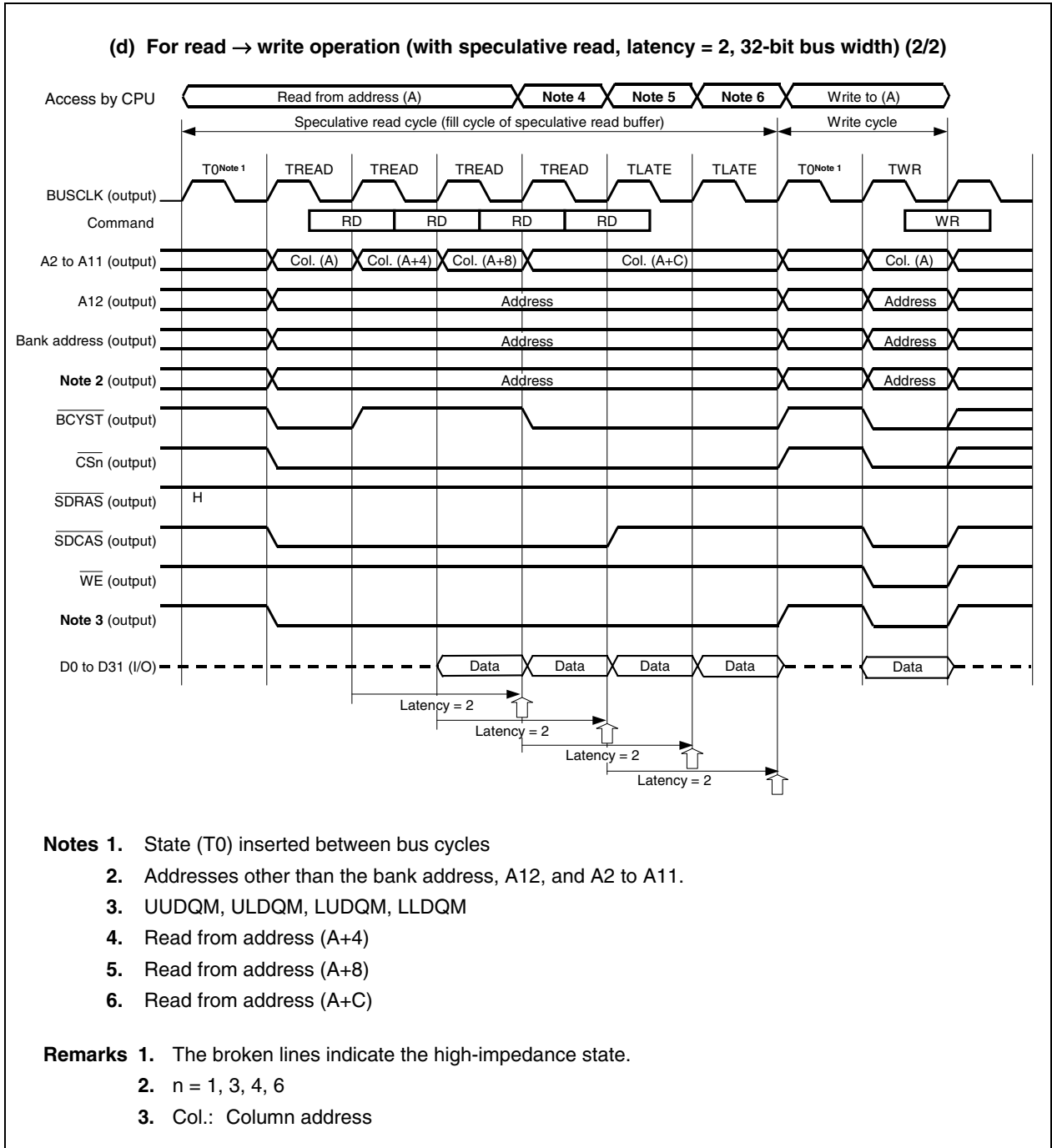
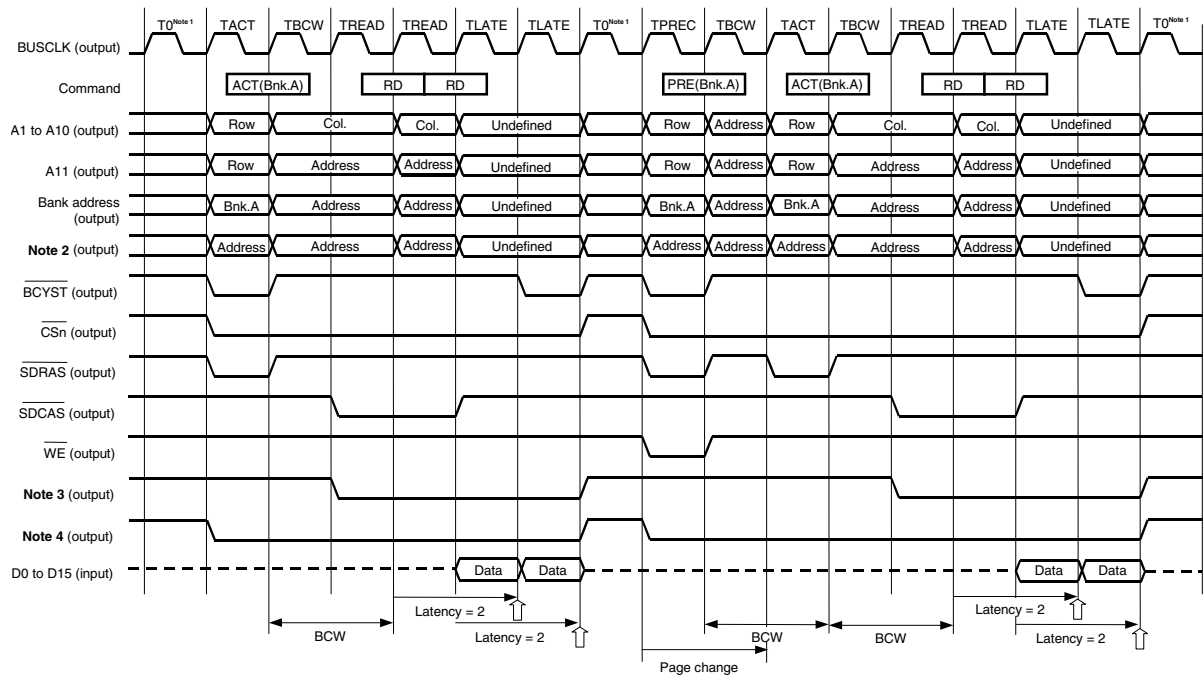


Figure 5-11. SDRAM Access Timing (6/9)

**(e) When read (without speculative read, 16-bit bus width word access, page change, BCW = 2, latency = 2)**

- Notes**
1. State (T0) inserted between bus cycles
  2. Addresses other than the bank address, A11, and A1 to A10
  3. When  $\overline{xxWR}$  output mode/ $\overline{xxDQM}$  output mode is set (PFCCTm bit of PFCCT register = 0)
  4. When  $\overline{xxBE}$  output mode/ $\overline{xxDQM}$  output mode is set (PFCCTm bit of PFCCT register = 1)

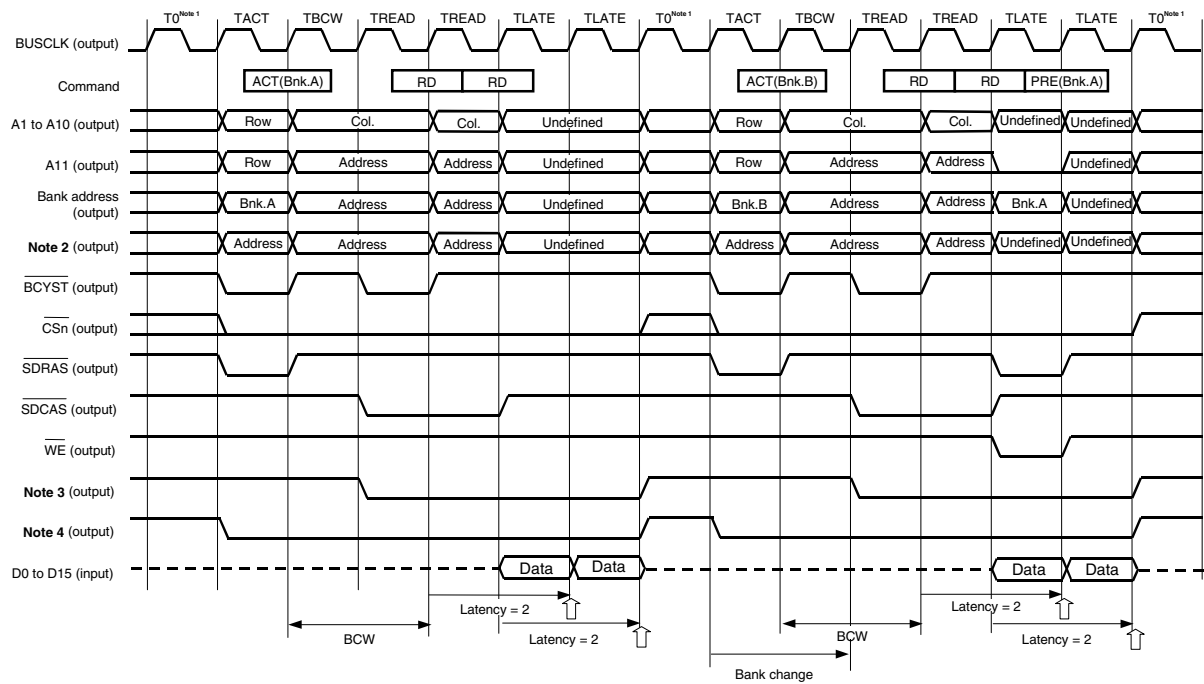
**Remarks** 1. The broken lines indicate the high-impedance state.

2.  $n = 1, 3, 4, 6$   
 $m = 0 \text{ to } 3$   
 $xx = UU, UL, LU, LL$
3. Bnk.: Bank address  
Col.: Column address  
Row: Row address



Figure 5-11. SDRAM Access Timing (7/9)

(f) When read (without speculative read, 16-bit bus width word access, bank change, BCW = 2, latency = 2)



- Notes**
1. State (T0) inserted between bus cycles
  2. Addresses other than the bank address, A12, and A2 to A11.
  3. When  $\overline{xxWR}$  output mode/ $\overline{xxDQM}$  output mode is set (PFCCTm bit of PFCCT register = 0)
  4. When  $\overline{xxBE}$  output mode/ $\overline{xxDQM}$  output mode is set (PFCCTm bit of PFCCT register = 1)

- Remarks**
1. The broken lines indicate the high-impedance state.
  2.  $n = 1, 3, 4, 6$   
 $m = 0$  to  $3$   
 $xx = UU, UL, LU, LL$
  3. Bnk.: Bank address  
 Col.: Column address  
 Row: Row address

Figure 5-11. SDRAM Access Timing (8/9)

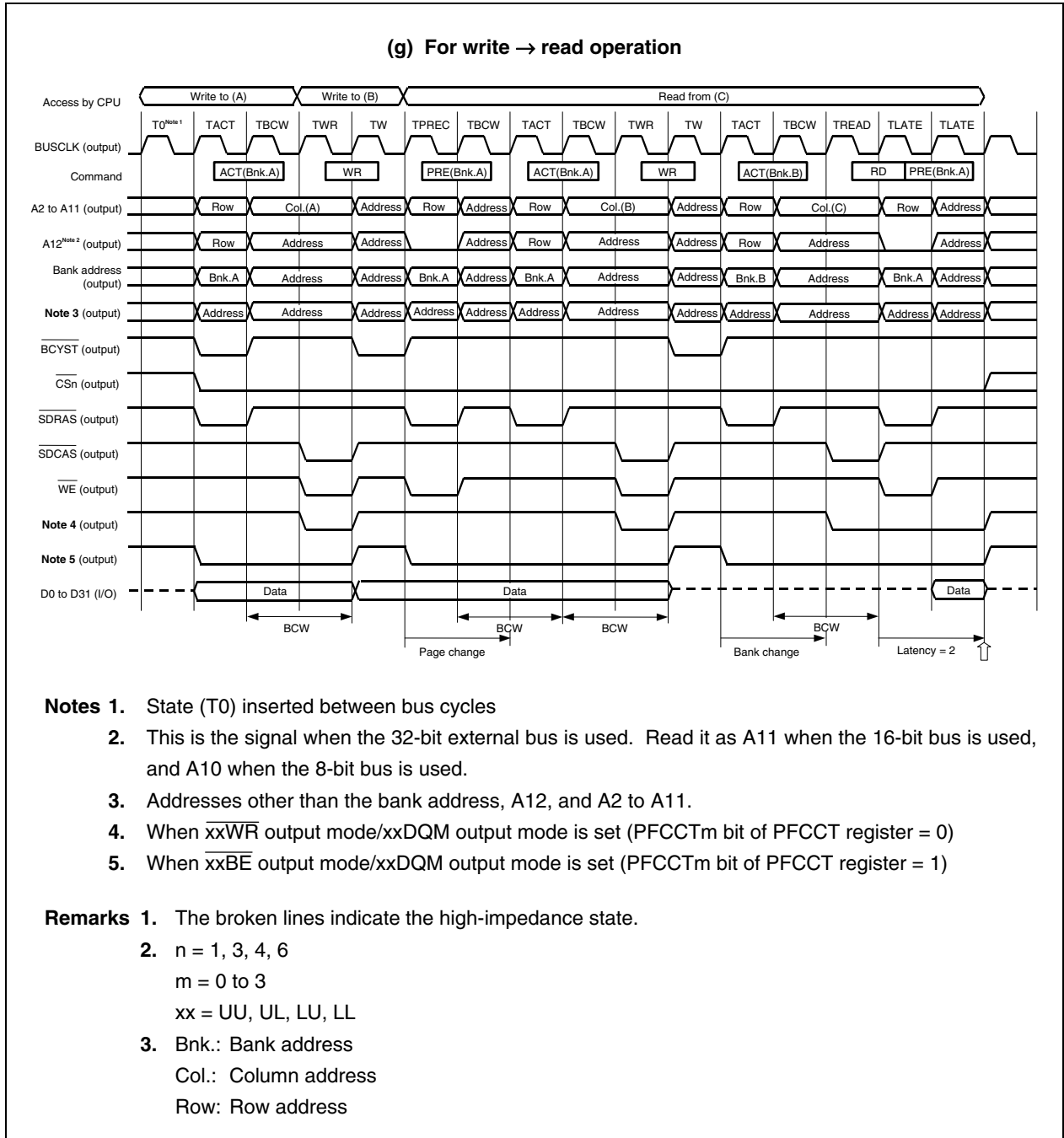
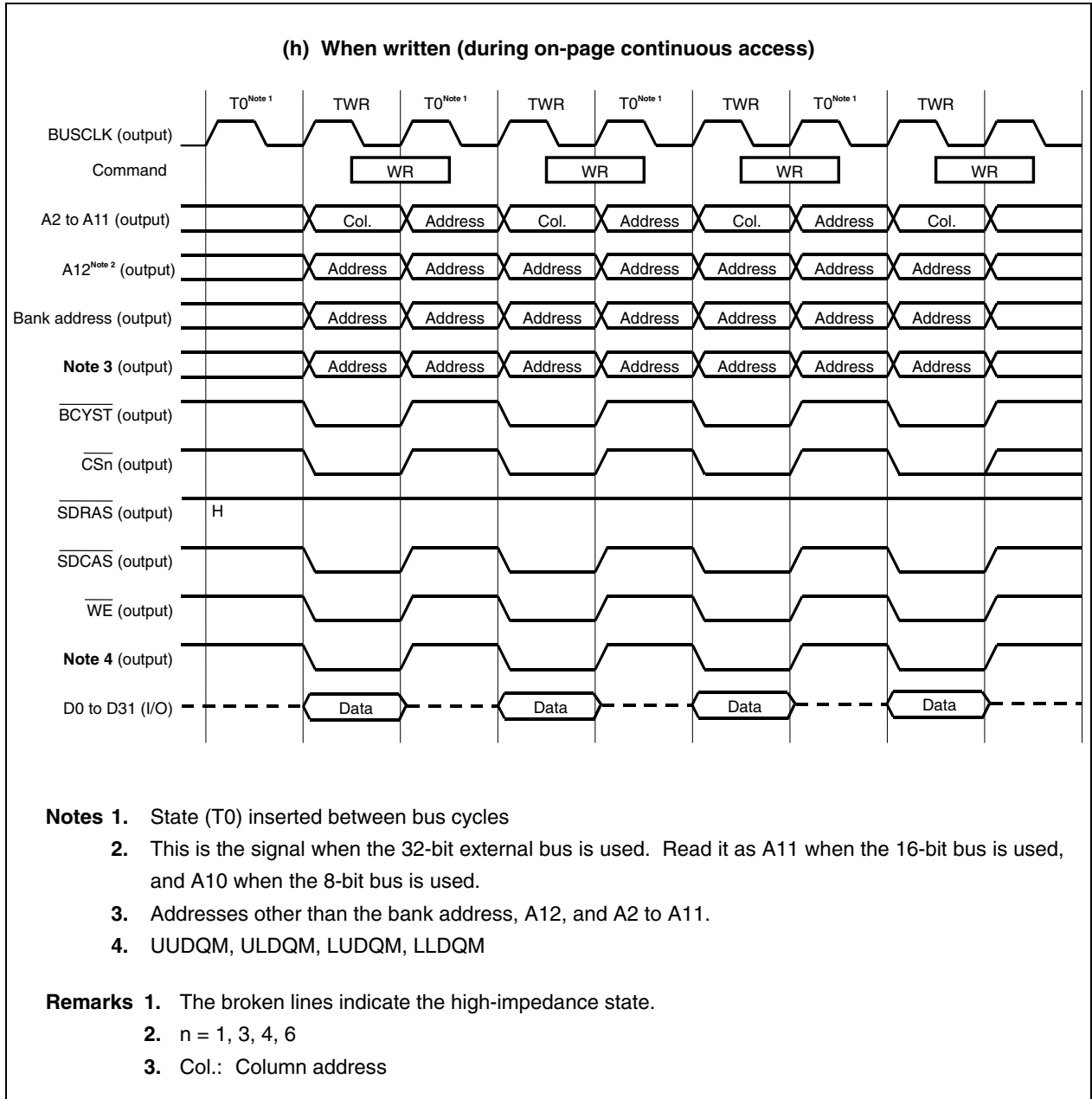


Figure 5-11. SDRAM Access Timing (9/9)



### 5.3.6 Refresh control function

The V850E/ME2 can generate a refresh cycle. The refresh cycle is set with the RFSn register ( $n = 1, 3, 4, 6$ ). The RFSn register corresponds to  $\overline{CSn}$ . For example, to connect SDRAM to  $\overline{CS1}$ , set the RFS1 register.

When another bus master occupies the external bus, the SDRAM controller cannot occupy the external bus. In this case, the SDRAM controller issues a refresh request to the bus master by changing the  $\overline{REFRQ}$  signal to active (low level).

During a refresh operation, the address bus retains the state it was in just before the refresh cycle.

#### (1) SDRAM refresh control registers 1, 3, 4, 6 (RFS1, RFS3, RFS4, RFS6)

These registers are used to enable or disable a refresh and set the refresh interval. The refresh interval is determined by the following calculation formula.

$$\text{Refresh interval } (\mu\text{s}) = \text{Refresh count clock } (T_{RCY}) \times \text{Interval factor}$$

The refresh count clock and interval factor are determined by the RCCn1 and RCCn0 bits and RIN5n to RIN0n bits, respectively.

Note that n corresponds to the register number (1, 3, 4, 6) of the SCR1, SCR3, SCR4, and SCR6 registers.

These registers can be read or written in 16-bit units.

- Cautions**
1. Write to the RFS1, RFS3, RFS4, and RFS6 registers after reset, and then do not change the set values. However, when the SDRAM refresh interval needs to be changed by changing the CKC register set value (internal system clock ( $f_{CLK}$ )), the set value of the RFS1, RFS3, RFS4, and RFS6 registers can be changed. For details, refer to Caution 2 in 8.3.1 Clock control register (CKC). Also, do not access an external memory area other than the one for this initialization routine until the initial settings of the RFS1, RFS3, RFS4, and RFS6 registers are complete. However, it is possible to access external memory areas whose initialization settings are complete.
  2. To change the refresh interval, consider and set a value at which refreshing can be performed in time even while the refresh interval is changed. For details, see 8.3.1 (1) Notes on changing refresh interval.

|      | 15   | 14 | 13 | 12 | 11 | 10 | 9     | 8     | 7 | 6 | 5     | 4     | 3     | 2     | 1     | 0     | Address    | After reset |
|------|------|----|----|----|----|----|-------|-------|---|---|-------|-------|-------|-------|-------|-------|------------|-------------|
| RFS1 | REN1 | 0  | 0  | 0  | 0  | 0  | RCC11 | RCC10 | 0 | 0 | RIN15 | RIN14 | RIN13 | RIN12 | RIN11 | RIN10 | FFFFFF4A6H | 0000H       |
| RFS3 | REN3 | 0  | 0  | 0  | 0  | 0  | RCC31 | RCC30 | 0 | 0 | RIN35 | RIN34 | RIN33 | RIN32 | RIN31 | RIN30 | FFFFFF4AEH | 0000H       |
| RFS4 | REN4 | 0  | 0  | 0  | 0  | 0  | RCC41 | RCC40 | 0 | 0 | RIN45 | RIN44 | RIN43 | RIN42 | RIN41 | RIN40 | FFFFFF4B2H | 0000H       |
| RFS6 | REN6 | 0  | 0  | 0  | 0  | 0  | RCC61 | RCC60 | 0 | 0 | RIN65 | RIN64 | RIN63 | RIN62 | RIN61 | RIN60 | FFFFFF4BAH | 0000H       |

| Bit position | Bit name          | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |       |       |                                   |                 |       |           |                 |   |            |   |   |            |   |   |                    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |    |
|--------------|-------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|-------|-----------------------------------|-----------------|-------|-----------|-----------------|---|------------|---|---|------------|---|---|--------------------|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|----|
| 15           | RENn              | Specifies whether CBR (auto) refresh is enabled or disabled.<br>0: Refresh disabled<br>1: Refresh enabled                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |       |       |                                   |                 |       |           |                 |   |            |   |   |            |   |   |                    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |    |
| 9, 8         | RCCn1,<br>RCCn0   | Specifies the refresh count clock ( $T_{RCY}$ ). <table><tr><th>RCCn1</th><th>RCCn0</th><th>Refresh count clock (<math>T_{RCY}</math>)</th></tr><tr><td>0</td><td>0</td><td>32/BUSCLK</td></tr><tr><td>0</td><td>1</td><td>128/BUSCLK</td></tr><tr><td>1</td><td>0</td><td>256/BUSCLK</td></tr><tr><td>1</td><td>1</td><td>Setting prohibited</td></tr></table>                                                                                                                                                                                                                                                                                                                                                          | RCCn1 | RCCn0 | Refresh count clock ( $T_{RCY}$ ) | 0               | 0     | 32/BUSCLK | 0               | 1 | 128/BUSCLK | 1 | 0 | 256/BUSCLK | 1 | 1 | Setting prohibited |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |    |
| RCCn1        | RCCn0             | Refresh count clock ( $T_{RCY}$ )                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |       |       |                                   |                 |       |           |                 |   |            |   |   |            |   |   |                    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |    |
| 0            | 0                 | 32/BUSCLK                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |       |       |                                   |                 |       |           |                 |   |            |   |   |            |   |   |                    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |    |
| 0            | 1                 | 128/BUSCLK                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |       |       |                                   |                 |       |           |                 |   |            |   |   |            |   |   |                    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |    |
| 1            | 0                 | 256/BUSCLK                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |       |       |                                   |                 |       |           |                 |   |            |   |   |            |   |   |                    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |    |
| 1            | 1                 | Setting prohibited                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |       |       |                                   |                 |       |           |                 |   |            |   |   |            |   |   |                    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |    |
| 5 to 0       | RINn5 to<br>RINn0 | Sets the interval factor of the interval timer for the generation of the refresh timing. <table><tr><th>RINn5</th><th>RINn4</th><th>RINn3</th><th>RINn2</th><th>RINn1</th><th>RINn0</th><th>Interval factor</th></tr><tr><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>1</td></tr><tr><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>1</td><td>2</td></tr><tr><td>0</td><td>0</td><td>0</td><td>0</td><td>1</td><td>0</td><td>3</td></tr><tr><td>0</td><td>0</td><td>0</td><td>0</td><td>1</td><td>1</td><td>4</td></tr><tr><td>:</td><td>:</td><td>:</td><td>:</td><td>:</td><td>:</td><td>:</td></tr><tr><td>1</td><td>1</td><td>1</td><td>1</td><td>1</td><td>1</td><td>64</td></tr></table> | RINn5 | RINn4 | RINn3                             | RINn2           | RINn1 | RINn0     | Interval factor | 0 | 0          | 0 | 0 | 0          | 0 | 1 | 0                  | 0 | 0 | 0 | 0 | 1 | 2 | 0 | 0 | 0 | 0 | 1 | 0 | 3 | 0 | 0 | 0 | 0 | 1 | 1 | 4 | : | : | : | : | : | : | : | 1 | 1 | 1 | 1 | 1 | 1 | 64 |
| RINn5        | RINn4             | RINn3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | RINn2 | RINn1 | RINn0                             | Interval factor |       |           |                 |   |            |   |   |            |   |   |                    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |    |
| 0            | 0                 | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 0     | 0     | 0                                 | 1               |       |           |                 |   |            |   |   |            |   |   |                    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |    |
| 0            | 0                 | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 0     | 0     | 1                                 | 2               |       |           |                 |   |            |   |   |            |   |   |                    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |    |
| 0            | 0                 | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 0     | 1     | 0                                 | 3               |       |           |                 |   |            |   |   |            |   |   |                    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |    |
| 0            | 0                 | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 0     | 1     | 1                                 | 4               |       |           |                 |   |            |   |   |            |   |   |                    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |    |
| :            | :                 | :                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | :     | :     | :                                 | :               |       |           |                 |   |            |   |   |            |   |   |                    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |    |
| 1            | 1                 | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 1     | 1     | 1                                 | 64              |       |           |                 |   |            |   |   |            |   |   |                    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |    |

**Remark** n = 1, 3, 4, 6

**Table 5-1. Example of Interval Factor Settings**

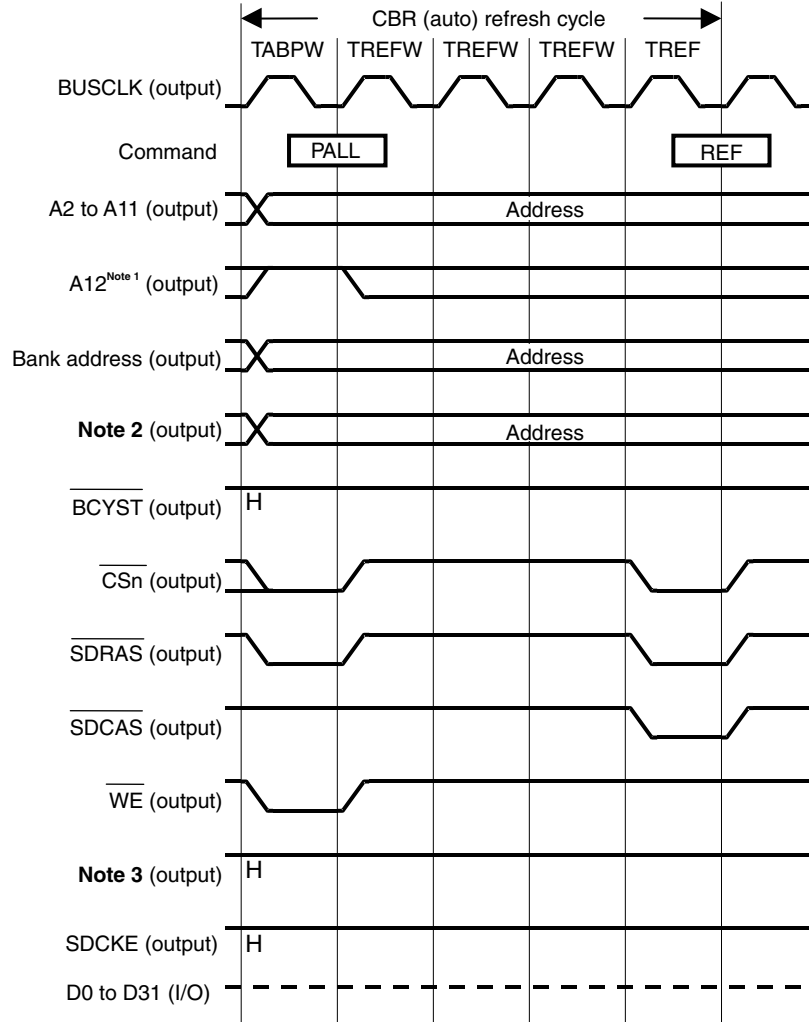
| Specified Refresh Interval Value ( $\mu$ s) | Refresh Count Clock ( $T_{RCY}$ ) | Interval Factor Value <sup>Notes 1, 2</sup> |                 |
|---------------------------------------------|-----------------------------------|---------------------------------------------|-----------------|
|                                             |                                   | BUSCLK = 66 MHz                             | BUSCLK = 50 MHz |
| 15.6                                        | 32/BUSCLK                         | 32 (15.5)                                   | 24 (15.4)       |
|                                             | 128/BUSCLK                        | 8 (15.5)                                    | 6 (15.4)        |
|                                             | 256/BUSCLK                        | 4 (15.5)                                    | 3 (15.4)        |

- Notes**
1. The interval factor is set by the RINn0 to RINn5 bits (n = 1, 3, 4, 6).
  2. The values in parentheses are the calculated values for the refresh interval ( $\mu$ s).  
Refresh interval ( $\mu$ s) = Refresh count clock ( $T_{RCY}$ )  $\times$  Interval factor

The V850E/ME2 can automatically generate a CBR (auto) refresh cycle and a self-refresh cycle.

**(2) CBR (auto) refresh cycle**

In the CBR (auto) refresh cycle, the CBR (auto) refresh command (REF) is issued four clocks after the precharge command for all banks (PALL) is issued.

**Figure 5-12. CBR (Auto) Refresh Cycle**

**Notes 1.** This is the signal when the 32-bit external bus is used. Read it as A11 when the 16-bit bus is used, and A10 when the 8-bit bus is used.

**2.** Addresses other than the bank address, A12, and A2 to A11.

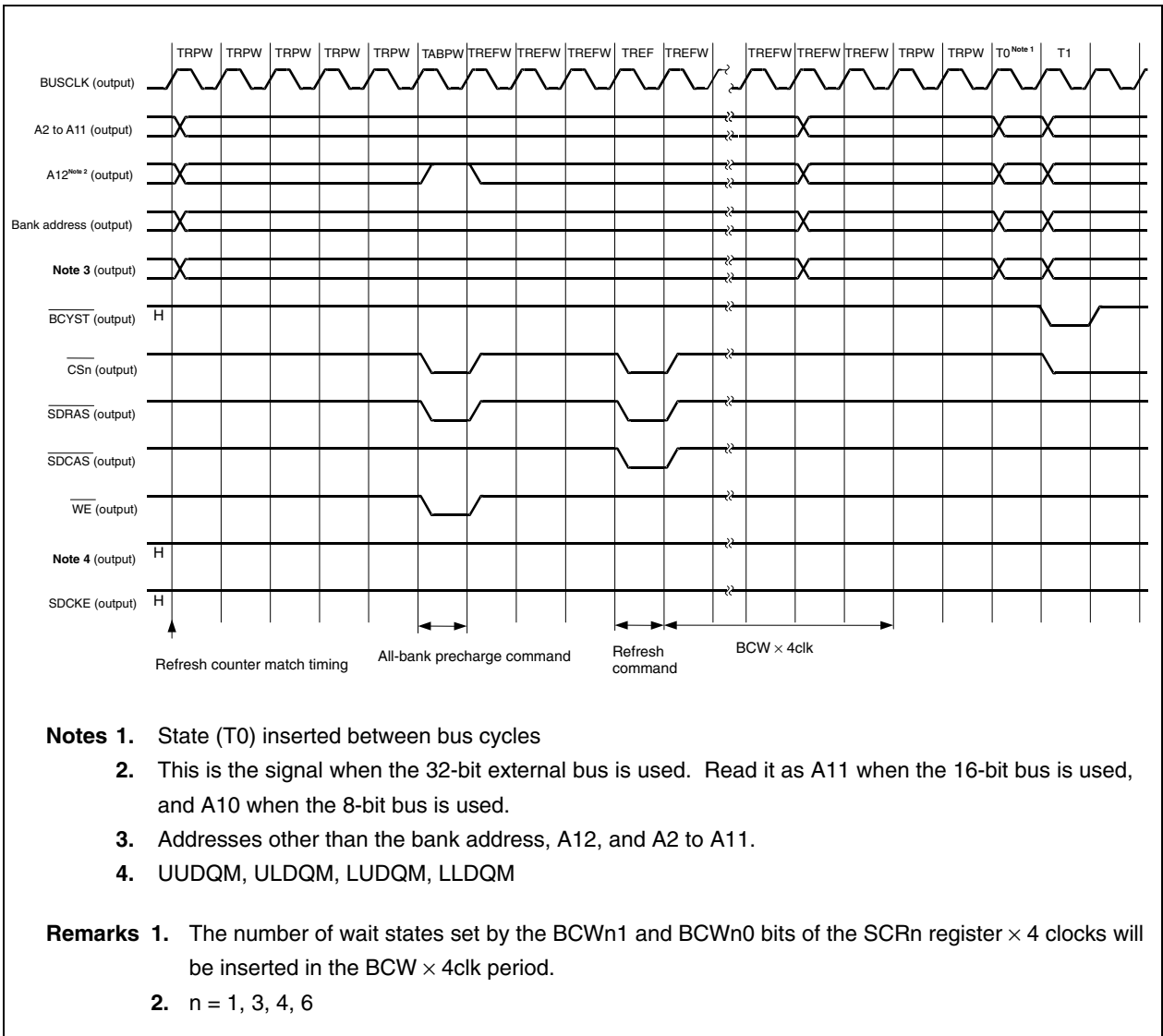
**3** UUDQM, ULDQM, LUDQM, LLDQM

**Remarks 1.** The broken lines indicate the high-impedance state.

**2.** n = 1, 3, 4, 6

### (3) CBR (auto) refresh timing

Figure 5-13. CBR (Auto) Refresh Timing (SDRAM)





### 5.3.7 Self-refresh control function

In the case of transition to the IDLE or software STOP mode, or if the  $\overline{\text{SELFREF}}$  signal becomes active, the DRAM controller generates the self-refresh cycle.

- Cautions**
1. When the transition to the self-refresh cycle is caused by  $\overline{\text{SELFREF}}$  signal input, releasing the self-refresh cycle is only possible by inputting an inactive level to the  $\overline{\text{SELFREF}}$  pin.
  2. The internal instruction RAM (only in the read mode) and internal data RAM can be accessed even in the self-refresh cycle. However, access to an on-chip peripheral I/O register or external device is held pending until the self-refresh cycle is cleared.

To release the self-refresh cycle, use one of the three methods below.

#### (1) Release by NMI input

##### (a) In the case of self-refresh cycle in IDLE mode

To release the self-refresh cycle, make the  $\overline{\text{SDRAS}}$  and  $\overline{\text{SDCAS}}$  signals inactive immediately.

##### (b) In the case of self-refresh cycle in software STOP mode

To release the self-refresh cycle, make the  $\overline{\text{SDRAS}}$  and  $\overline{\text{SDCAS}}$  signals inactive after stabilizing oscillation.

#### (2) Release by INTP0n0 and INTP0n1 inputs (n = 0 to 3)

##### (a) In the case of self-refresh cycle in IDLE mode

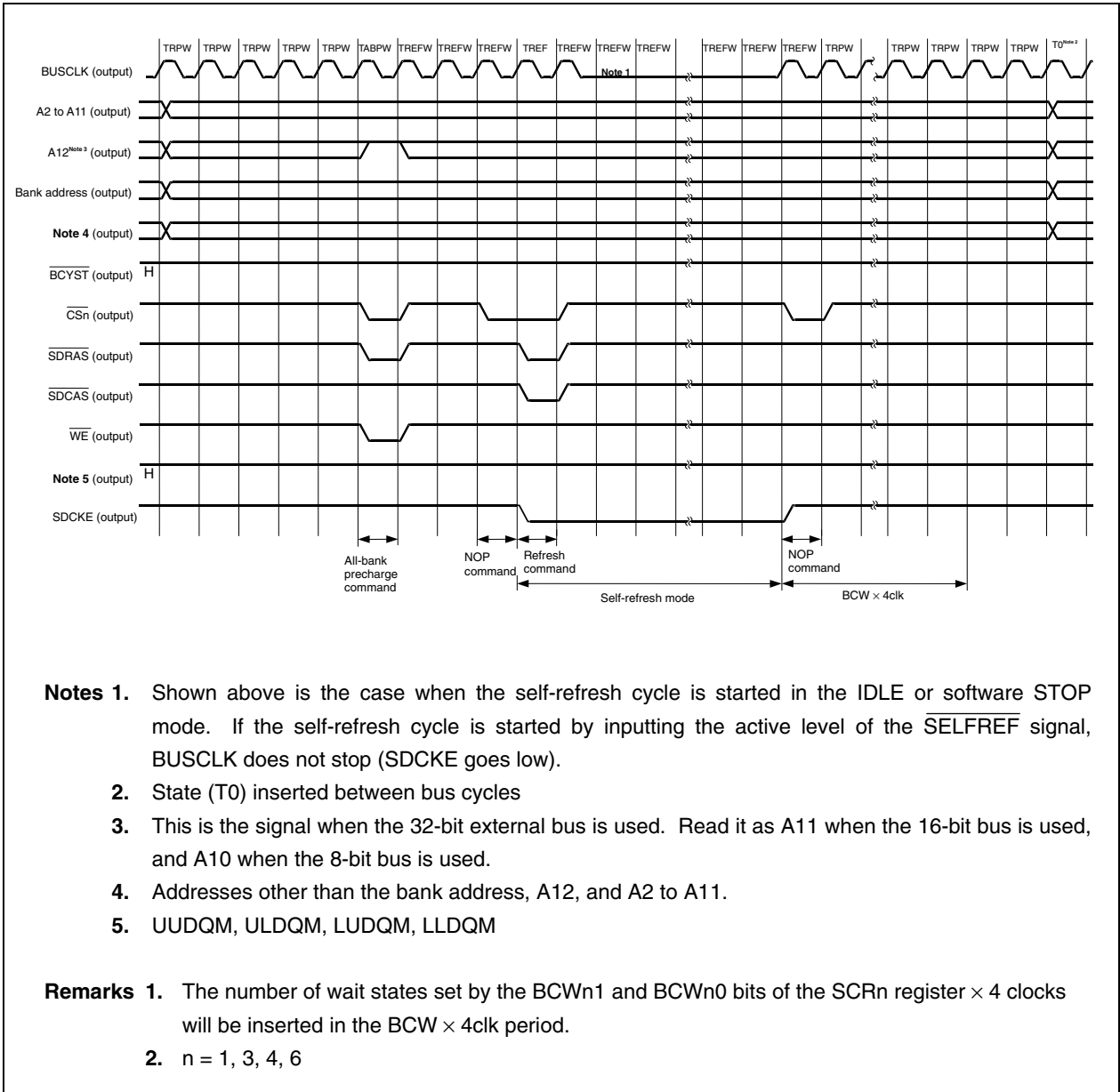
To release the self-refresh cycle, make the  $\overline{\text{SDRAS}}$  and  $\overline{\text{SDCAS}}$  signals inactive immediately.

##### (b) In the case of self-refresh cycle in software STOP mode

To release the self-refresh cycle, make the  $\overline{\text{SDRAS}}$  and  $\overline{\text{SDCAS}}$  signals inactive after stabilizing oscillation.

#### (3) Release by $\overline{\text{RESET}}$ input

Figure 5-14. Self-Refresh Timing (SDRAM)



### 5.3.8 SDRAM initialization sequence

Be sure to initialize SDRAM when applying power. Initialize SDRAM in the following procedure.

- (1) Set the registers of SDRAM (other than SDRAM configuration register n (SCRn) and SDRAM refresh control register n (RFSn)).
  - Bus cycle type configuration registers 0 and 1 (BCT0 and BCT1)
  - Bus cycle control register (BCC)
- (2) Set other than the RENn bit of SDRAM refresh control registers 1, 3, 4, 6 (RFS1, RFS3, RFS4, RFS6). Clear the RENn bit to 0.
- (3) Set SDRAM configuration registers 1, 3, 4, 6 (SCR1, SCR3, SCR4, SCR6). When writing data to the SCRn register, the following commands are issued for SDRAM in the order shown below.
  - All-bank precharge command
  - Refresh command (8 times)
  - Command that is used to set a mode register
- (4) After confirming that all the SDRAM initialization steps have been completed using the WCFn bit of the SCRn register, set the RENn bit of the RFSn register to 1. Set the value set in step (2) to other bits than the RENn bit.

- Cautions**
1. To set the SCR1, SCR3, SCR4, and SCR6 registers, confirm that the LOCK bit of the LOCKR register is set to 1, set the CKSSEL bit of the CKS register to 1, and change clock supply to the CPU to SSCG output (see 3.4.10 Initialization sequence).
  2. If it is necessary to make the input levels of the UUDQM, ULDQM, LUDQM, and LLDQM pins high until initialization of SDRAM is completed, do not change the set values of the PFCCT3 to PFCCT0 bits of the PFCCT register and do not write the external device until initialization of SDRAM is completed.

Figures 5-15 and 5-16 show examples of the SDRAM mode register setting timing.

Figure 5-15. SDRAM Mode Register Setting Cycle

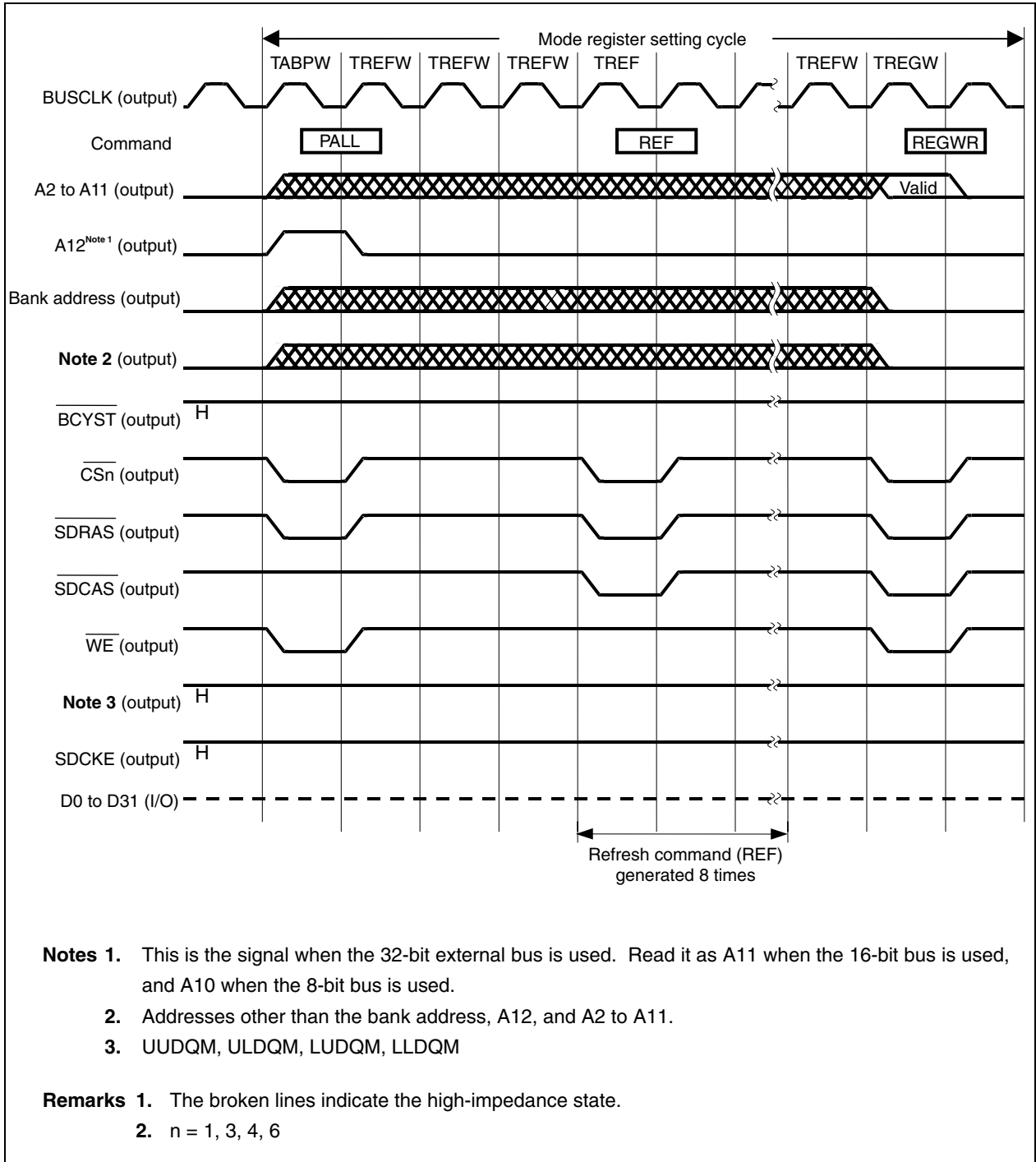
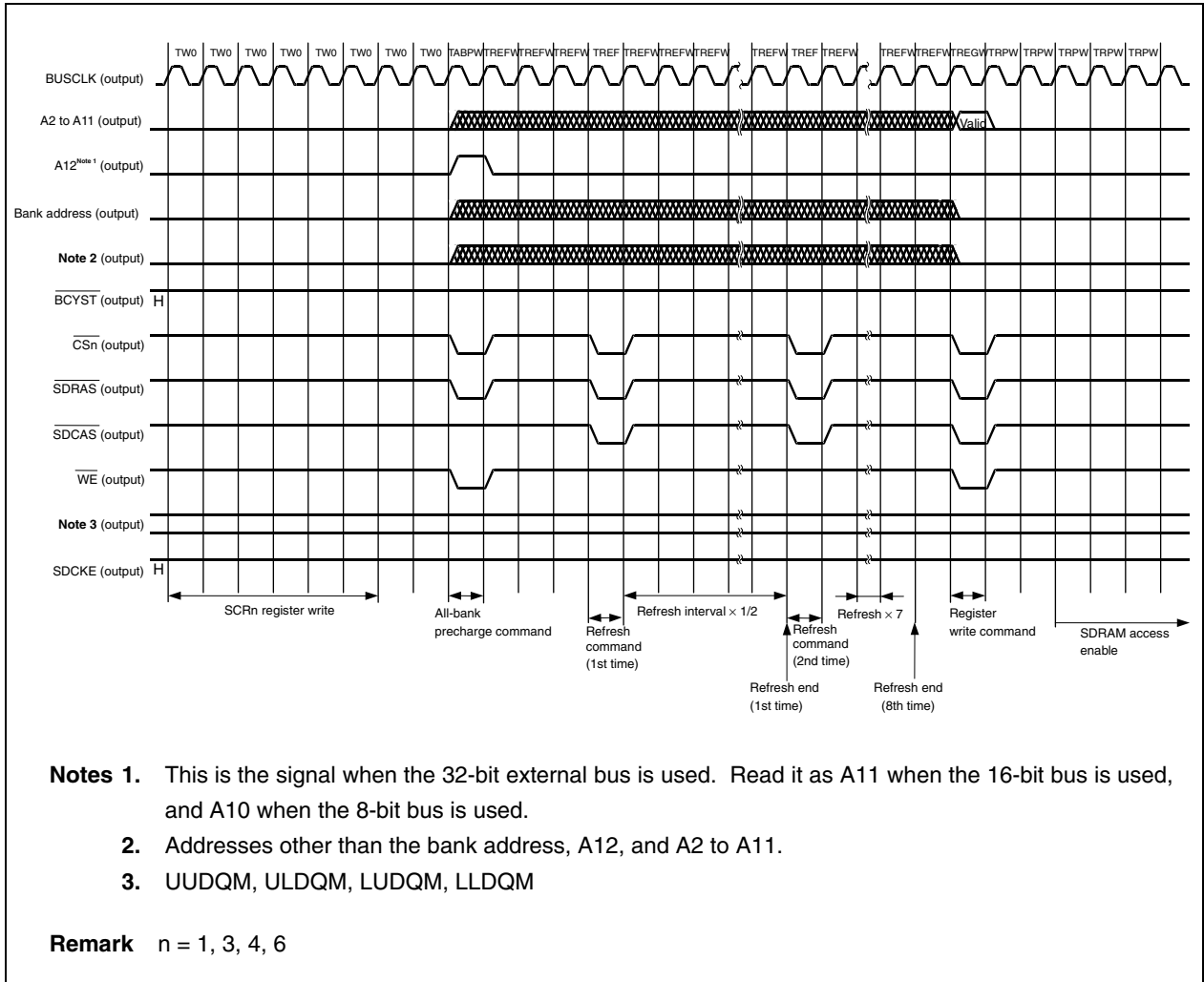


Figure 5-16. SDRAM Register Write Operation Timing



## 5.4 Cautions

Cautions concerning the memory access control function are shown below.

**(1) Write access to SRAM or external I/O after read accessing SDRAM**

When executing a write access to SRAM or external I/O after read accessing SDRAM, data conflict may occur depending on the SDRAM data output float delay time. In such a case, avoid data conflict by inserting an idle state in the SDRAM space via a setting in the BCC register.

**(2) Caution on self-refresh control function**

The internal instruction RAM (only in the read mode) and internal data RAM can be accessed even in the self-refresh cycle. However, access to an on-chip peripheral I/O register or external device is held pending until the self-refresh cycle is cleared.

## CHAPTER 6 DMA FUNCTIONS (DMA CONTROLLER)

The V850E/ME2 includes a direct memory access (DMA) controller (DMAC) that executes and controls DMA transfer.

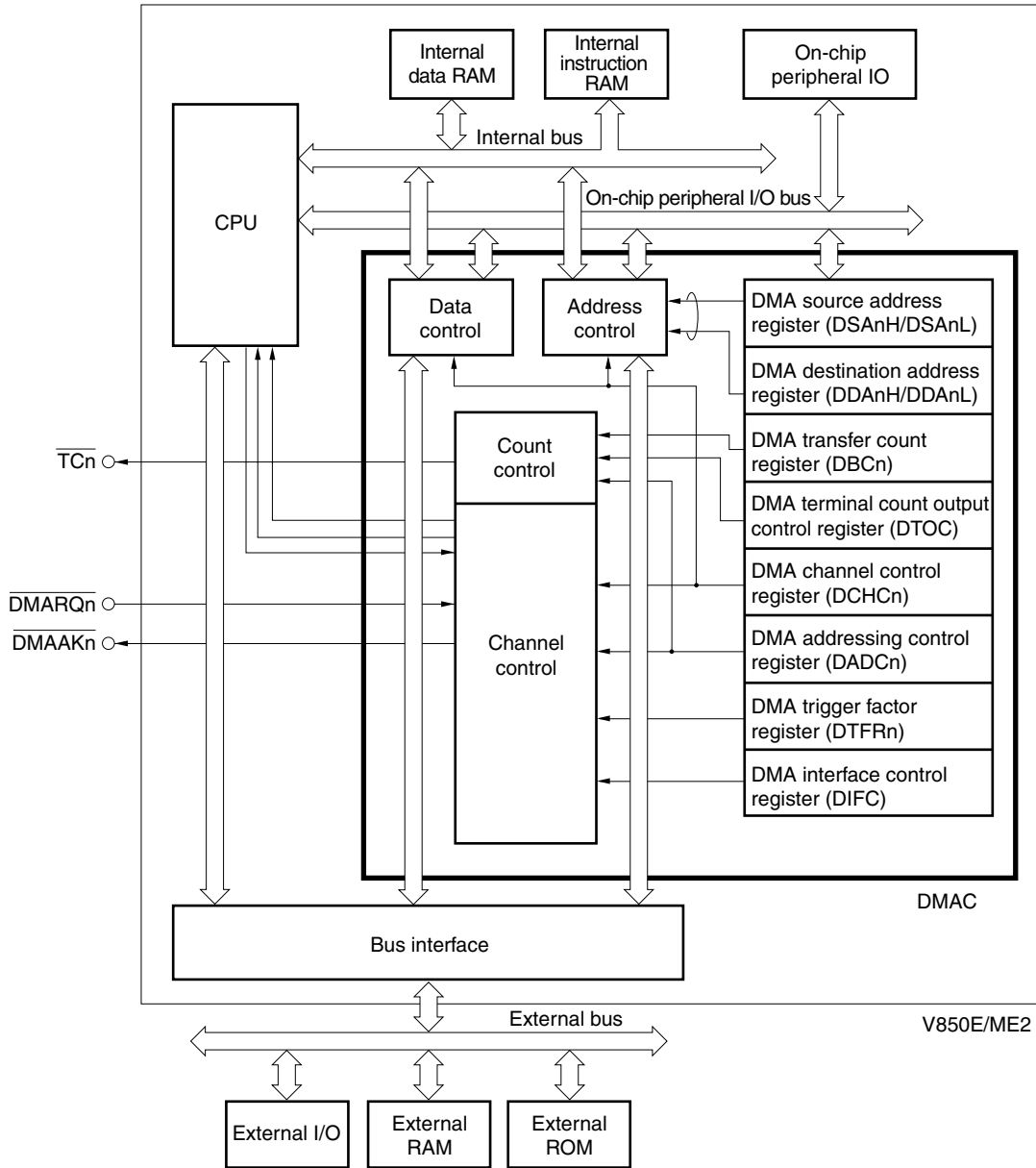
The DMAC controls data transfer between memory and I/O, or among memories, based on requests by interrupts from on-chip peripheral I/O (serial interface, timer/counter, and A/D converter) or DMA requests issued by the  $\overline{\text{DMARQ0}}$  to  $\overline{\text{DMARQ3}}$  pins, software triggers, or USB. Memory refers to the internal instruction RAM, internal data RAM, or external memory. However, the internal instruction RAM can be used only as the transfer destination.

### 6.1 Features

- 4 independent DMA channels
- Transfer unit: 8/16/32 bits
- Maximum transfer count: 65,536 ( $2^{16}$ )
- Two types of transfer
  - Flyby (1-cycle) transfer
  - 2-cycle transfer
- Three transfer modes
  - Single transfer mode
  - Single-step transfer mode
  - Block transfer mode
- Transfer requests
  - Request by interrupts from on-chip peripheral I/O (serial interface, timer/counter, A/D converter)
  - Requests via  $\overline{\text{DMARQ0}}$  to  $\overline{\text{DMARQ3}}$  pin input
  - Requests by software trigger
  - Requests by USB (only in the single transfer mode and single-step transfer mode)
- Transfer targets
  - Memory  $\leftrightarrow$  I/O
  - Memory  $\leftrightarrow$  memory
- DMA transfer end output signals ( $\overline{\text{TC0}}$  to  $\overline{\text{TC3}}$ )
- Next address setting function

<R>

## 6.2 Configuration



**Remark** n = 0 to 3



## 6.3 Control Registers

### 6.3.1 DMA source address registers 0 to 3 (DSA0 to DSA3)

These registers are used to set the DMA transfer source address (28 bits) for DMA channel n (n = 0 to 3). They are divided into two 16-bit registers, DSAnH and DSAnL.

Since these registers are buffer registers with a 2-stage FIFO format that is configured by master register and slave register, a new transfer source address for DMA transfer can be specified during DMA transfer (see **6.8 Next Address Setting Function**). In this case, the newly set value of the DSAn register is transferred to the slave register and becomes valid only when DMA transfer has been completed normally and the TCn bit of the DCHCn register is set to 1, or when the INITn bit of the DCHCn register is set to 1 (n = 0 to 3). However, the set value of the DSAn register is invalid even when the Enn bit of the DCHCn register is cleared to 0 to disable DMA transfer and then the DSAn register is set.

When flyby transfer is specified with the TTYPN bit of DMA addressing control register n (DADCn), the external memory addresses are set by the DSAn register, regardless of the transfer direction. At this time, the setting of DMA destination address register n (DDAn) is ignored (n = 0 to 3).

#### (1) DMA source address registers 0H to 3H (DSA0H to DSA3H)

These registers can be read or written in 16-bit units.

Be sure to clear bits 14 to 12 to 0. If they are set to 1, the operation is not guaranteed.

**Cautions 1. When setting an address of an on-chip peripheral I/O register for the source address, be sure to specify an address between FFFF000H and FFFFFFFH. An address of the on-chip peripheral I/O register image (3FFF000H to 3FFFFFFH) must not be specified.**

**2. Do not set the DSAnH register while DMA transfer is suspended.**

|       | 15   | 14 | 13 | 12 | 11    | 10    | 9     | 8     | 7     | 6     | 5     | 4     | 3     | 2     | 1     | 0     | Address    | After reset |
|-------|------|----|----|----|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|------------|-------------|
| DSA0H | IRS0 | 0  | 0  | 0  | SA027 | SA026 | SA025 | SA024 | SA023 | SA022 | SA021 | SA020 | SA019 | SA018 | SA017 | SA016 | FFFFFF082H | Undefined   |
| DSA1H | IRS1 | 0  | 0  | 0  | SA127 | SA126 | SA125 | SA124 | SA123 | SA122 | SA121 | SA120 | SA119 | SA118 | SA117 | SA116 | FFFFFF08AH | Undefined   |
| DSA2H | IRS2 | 0  | 0  | 0  | SA227 | SA226 | SA225 | SA224 | SA223 | SA222 | SA221 | SA220 | SA219 | SA218 | SA217 | SA216 | FFFFFF092H | Undefined   |
| DSA3H | IRS3 | 0  | 0  | 0  | SA327 | SA326 | SA325 | SA324 | SA323 | SA322 | SA321 | SA320 | SA319 | SA318 | SA317 | SA316 | FFFFFF09AH | Undefined   |

| Bit position | Bit name       | Function                                                                                                                                                                             |
|--------------|----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 15           | IRSn           | Specifies the DMA transfer source address.<br>0: External memory, on-chip peripheral I/O<br>1: Internal data RAM                                                                     |
| 11 to 0      | SAn27 to SAn16 | Sets the DMA transfer source address (A27 to A16). During DMA transfer, it stores the next DMA transfer source address. During flyby transfer, it stores an external memory address. |

**Remark** n = 0 to 3

(2) DMA source address registers 0L to 3L (DSA0L to DSA3L)

These registers can be read or written in 16-bit units.

|       |       |       |       |       |       |       |      |      |      |      |      |      |      |      |      |      |            |             |
|-------|-------|-------|-------|-------|-------|-------|------|------|------|------|------|------|------|------|------|------|------------|-------------|
|       | 15    | 14    | 13    | 12    | 11    | 10    | 9    | 8    | 7    | 6    | 5    | 4    | 3    | 2    | 1    | 0    | Address    | After reset |
| DSA0L | SA015 | SA014 | SA013 | SA012 | SA011 | SA010 | SA09 | SA08 | SA07 | SA06 | SA05 | SA04 | SA03 | SA02 | SA01 | SA00 | FFFFFF080H | Undefined   |
| DSA1L | SA115 | SA114 | SA113 | SA112 | SA111 | SA110 | SA19 | SA18 | SA17 | SA16 | SA15 | SA14 | SA13 | SA12 | SA11 | SA10 | FFFFFF088H | Undefined   |
| DSA2L | SA215 | SA214 | SA213 | SA212 | SA211 | SA210 | SA29 | SA28 | SA27 | SA26 | SA25 | SA24 | SA23 | SA22 | SA21 | SA20 | FFFFFF090H | Undefined   |
| DSA3L | SA315 | SA314 | SA313 | SA312 | SA311 | SA310 | SA39 | SA38 | SA37 | SA36 | SA35 | SA34 | SA33 | SA32 | SA31 | SA30 | FFFFFF098H | Undefined   |

| Bit position | Bit name      | Function                                                                                                                                                                            |
|--------------|---------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 15 to 0      | SAn15 to SAn0 | Sets the DMA transfer source address (A15 to A0). During DMA transfer, it stores the next DMA transfer source address. During flyby transfer, it stores an external memory address. |

**Remark**    n = 0 to 3

### 6.3.2 DMA destination address registers 0 to 3 (DDA0 to DDA3)

These registers are used to set the DMA transfer destination address (28 bits) for DMA channel  $n$  ( $n = 0$  to  $3$ ). They are divided into two 16-bit registers, DDAnH and DDAnL.

Since these registers are buffer registers with a 2-stage FIFO format that is configured by master register and slave register, a new transfer destination address for DMA transfer can be specified during DMA transfer (see **6.8 Next Address Setting Function**). In this case, the newly set value of the DDAn register is transferred to the slave register and becomes valid only when DMA transfer has been completed normally and the TCn bit of the DCHCn register is set to 1, or when the INITn bit of the DCHCn register is set to 1 ( $n = 0$  to  $3$ ). However, the set value of the DDAn register is invalid even when the Enn bit of the DCHCn register is cleared to 0 to disable DMA transfer and then the DDAn register is set.

When flyby transfer is specified with the TTYPn bit of DMA addressing control register  $n$  (DADCn), the setting of DMA destination address register  $n$  (DDAn) is ignored, regardless of the transfer direction.

#### (1) DMA destination address registers 0H to 3H (DDA0H to DDA3H)

These registers can be read or written in 16-bit units.

Be sure to clear bits 14 to 12 to 0. If they are set to 1, the operation is not guaranteed.

- Cautions 1.** When setting an address of an on-chip peripheral I/O register for the destination address, be sure to specify an address between FFFF000H and FFFFFFFH. An address of the on-chip peripheral I/O register image (3FFF000H to 3FFFFFFH) must not be specified.
- 2.** Do not set the DDAnH register while DMA transfer is suspended.
- 3.** When enabling the speculative read function is selected for the CS space at the DMA transfer destination, set the DMA transfer destination address so that the address on which a speculative read is performed and the line address to which the last DMA transfer data is written are not the same line address (the same line address means that A25 to A4 are the same in the same CS space).

|       | 15   | 14 | 13 | 12 | 11    | 10    | 9     | 8     | 7     | 6     | 5     | 4     | 3     | 2     | 1     | 0     | Address   | After reset |
|-------|------|----|----|----|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-----------|-------------|
| DDA0H | IRD0 | 0  | 0  | 0  | DA027 | DA026 | DA025 | DA024 | DA023 | DA022 | DA021 | DA020 | DA019 | DA018 | DA017 | DA016 | FFFFF086H | Undefined   |
| DDA1H | IRD1 | 0  | 0  | 0  | DA127 | DA126 | DA125 | DA124 | DA123 | DA122 | DA121 | DA120 | DA119 | DA118 | DA117 | DA116 | FFFFF08EH | Undefined   |
| DDA2H | IRD2 | 0  | 0  | 0  | DA227 | DA226 | DA225 | DA224 | DA223 | DA222 | DA221 | DA220 | DA219 | DA218 | DA217 | DA216 | FFFFF096H | Undefined   |
| DDA3H | IRD3 | 0  | 0  | 0  | DA327 | DA326 | DA325 | DA324 | DA323 | DA322 | DA321 | DA320 | DA319 | DA318 | DA317 | DA316 | FFFFF09EH | Undefined   |

| Bit position | Bit name       | Function                                                                                                                                                                         |
|--------------|----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 15           | IRDn           | Specifies the DMA transfer destination address.<br>0: External memory, on-chip peripheral I/O, internal instruction RAM<br>1: Internal data RAM                                  |
| 11 to 0      | DAn27 to DAn16 | Sets the DMA transfer destination address (A27 to A16). During DMA transfer, it stores the next DMA transfer destination address. This setting is ignored during flyby transfer. |

**Remark**  $n = 0$  to  $3$

**(2) DMA destination address registers 0L to 3L (DDA0L to DDA3L)**

These registers can be read or written in 16-bit units.

|       | 15    | 14    | 13    | 12    | 11    | 10    | 9     | 8     | 7     | 6     | 5     | 4     | 3     | 2     | 1     | 0     | Address    | After reset |
|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|------------|-------------|
| DDA0L | DA015 | DA014 | DA013 | DA012 | DA011 | DA010 | DA009 | DA008 | DA007 | DA006 | DA005 | DA004 | DA003 | DA002 | DA001 | DA000 | FFFFFF084H | Undefined   |
| DDA1L | DA115 | DA114 | DA113 | DA112 | DA111 | DA110 | DA109 | DA108 | DA107 | DA106 | DA105 | DA104 | DA103 | DA102 | DA101 | DA100 | FFFFFF08CH | Undefined   |
| DDA2L | DA215 | DA214 | DA213 | DA212 | DA211 | DA210 | DA209 | DA208 | DA207 | DA206 | DA205 | DA204 | DA203 | DA202 | DA201 | DA200 | FFFFFF094H | Undefined   |
| DDA3L | DA315 | DA314 | DA313 | DA312 | DA311 | DA310 | DA309 | DA308 | DA307 | DA306 | DA305 | DA304 | DA303 | DA302 | DA301 | DA300 | FFFFFF09CH | Undefined   |

| Bit position | Bit name      | Function                                                                                                                                                                        |
|--------------|---------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 15 to 0      | DAn15 to DAn0 | Sets the DMA transfer destination address (A15 to A0). During DMA transfer, it stores the next DMA transfer destination address. This setting is ignored during flyby transfer. |

**Remark** n = 0 to 3

### 6.3.3 DMA transfer count registers 0 to 3 (DBC0 to DBC3)

These 16-bit registers are used to set the byte transfer count for DMA channel n (n = 0 to 3). They store the remaining transfer count during DMA transfer.

Since these registers are buffer registers with a 2-stage FIFO format that is configured by master register and slave register, a new DMA byte transfer count for DMA transfer can be specified during DMA transfer (see **6.8 Next Address Setting Function**). In this case, the newly set value of the DBCn register is transferred to the slave register and becomes valid only when DMA transfer has been completed normally and the TCn bit of the DCHCn register is set to 1, or when the INITn bit of the DCHCn register is set to 1 (n = 0 to 3). However, the set value of the DBCn register is invalid even when the Enn bit of the DCHCn register is cleared to 0 to disable DMA transfer and then the DBCn register is set.

These registers are decremented by 1 for each transfer, and transfer ends when a borrow occurs.

These registers can be read or written in 16-bit units.

- Cautions**
1. If the DBCn register is read during DMA transfer after a terminal count has occurred without the register being overwritten, the value set immediately before the DMA transfer will be read out (0000H will not be read, even if DMA transfer has ended).
  2. Do not set the DBCn register while DMA transfer is suspended.

|      | 15    | 14    | 13    | 12    | 11    | 10    | 9     | 8     | 7     | 6     | 5     | 4     | 3     | 2     | 1     | 0     | Address   | After reset |
|------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-----------|-------------|
| DBC0 | BC015 | BC014 | BC013 | BC012 | BC011 | BC010 | BC009 | BC008 | BC007 | BC006 | BC005 | BC004 | BC003 | BC002 | BC001 | BC000 | FFFFF0C0H | Undefined   |
| DBC1 | BC115 | BC114 | BC113 | BC112 | BC111 | BC110 | BC109 | BC108 | BC107 | BC106 | BC105 | BC104 | BC103 | BC102 | BC101 | BC100 | FFFFF0C2H | Undefined   |
| DBC2 | BC215 | BC214 | BC213 | BC212 | BC211 | BC210 | BC209 | BC208 | BC207 | BC206 | BC205 | BC204 | BC203 | BC202 | BC201 | BC200 | FFFFF0C4H | Undefined   |
| DBC3 | BC315 | BC314 | BC313 | BC312 | BC311 | BC310 | BC309 | BC308 | BC307 | BC306 | BC305 | BC304 | BC303 | BC302 | BC301 | BC300 | FFFFF0C6H | Undefined   |

| Bit position | Bit name      | Function                                                                                       |                                                                                |       |                                                        |       |                                                        |   |   |       |                                                                                |
|--------------|---------------|------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------|-------|--------------------------------------------------------|-------|--------------------------------------------------------|---|---|-------|--------------------------------------------------------------------------------|
| 15 to 0      | BCn15 to BCn0 | Sets the byte transfer count and stores the remaining byte transfer count during DMA transfer. |                                                                                |       |                                                        |       |                                                        |   |   |       |                                                                                |
|              |               | DBCn                                                                                           | States                                                                         | 0000H | Byte transfer count 1 or remaining byte transfer count | 0001H | Byte transfer count 2 or remaining byte transfer count | : | : | FFFFH | Byte transfer count 65,536 (2 <sup>16</sup> ) or remaining byte transfer count |
|              |               | DBCn                                                                                           | States                                                                         |       |                                                        |       |                                                        |   |   |       |                                                                                |
|              |               | 0000H                                                                                          | Byte transfer count 1 or remaining byte transfer count                         |       |                                                        |       |                                                        |   |   |       |                                                                                |
|              |               | 0001H                                                                                          | Byte transfer count 2 or remaining byte transfer count                         |       |                                                        |       |                                                        |   |   |       |                                                                                |
|              |               | :                                                                                              | :                                                                              |       |                                                        |       |                                                        |   |   |       |                                                                                |
|              |               | FFFFH                                                                                          | Byte transfer count 65,536 (2 <sup>16</sup> ) or remaining byte transfer count |       |                                                        |       |                                                        |   |   |       |                                                                                |

**Remark** n = 0 to 3

**6.3.4 DMA addressing control registers 0 to 3 (DADC0 to DADC3)**

These 16-bit registers are used to control the DMA transfer mode for DMA channel  $n$  ( $n = 0$  to  $3$ ). These registers cannot be accessed during DMA operation.

These registers can be read or written in 16-bit units.

Be sure to clear bits 13 to 8 to 0. If they are set to 1, the operation is not guaranteed.

**Cautions** 1. The  $DSn1$  and  $DSn0$  bits set how many bits of data are to be transferred.

When 8-bit data is set ( $DSn1$  and  $DSn0$  bits = 00), the lower bytes of the data bus (D0 to D7) are not always used.

If the transfer data size is set to 16 bits, transfer is always started from an address with the lowest bit of the address aligned to "0". If the data size is set to 32 bits, transfer is started from an address with the lowest 2 bits of the address aligned to "0". In this case, transfer cannot be started from an odd address.

2. Set the  $DADCn$  register at the following timing while the target DMA channel is in operation or is not suspended (the operation is not guaranteed if the register is set at any other timing).

- Period from system reset to generation of the first DMA transfer request
- Period from completion of DMA transfer (after generation of terminal count) to generation of the next DMA transfer request
- Period from forced termination of DMA transfer (after the  $INITn$  bit of the  $DCHCn$  register is set to 1) to generation of the next DMA transfer request

3. Do not set flyby transfer via the  $TTYPn$  bit if all the following conditions are satisfied ( $n = 0$  to  $3$ ).

- BMC register = 00H
- $FWn2$  to  $FWn0$  bits of FWC register = 000
- $Fln1$  to  $Fln0$  bits of FIC register = 00
- $ACn1$  and  $ACn0$  bits of the  $CSn$  space subject to flyby transfer by the ASC register = 00 (during transfer to/from SRAM)

4. When the flyby transfer is set by setting the  $TTYPn$  bit to 1, the address count direction of the external memory is set using the  $SADn1$  and  $SADn0$  bits regardless of the transfer direction (the settings of the  $DADn1$  and  $DADn0$  bits are ignored).

|       | 15   | 14   | 13 | 12 | 11 | 10 | 9 | 8 | 7     | 6     | 5     | 4     | 3    | 2    | 1     | 0     | Address    | After reset |
|-------|------|------|----|----|----|----|---|---|-------|-------|-------|-------|------|------|-------|-------|------------|-------------|
| DADC0 | DS01 | DS00 | 0  | 0  | 0  | 0  | 0 | 0 | SAD01 | SAD00 | DAD01 | DAD00 | TM01 | TM00 | TTYP0 | TDIR0 | FFFFFF0D0H | 0000H       |
| DADC1 | DS11 | DS10 | 0  | 0  | 0  | 0  | 0 | 0 | SAD11 | SAD10 | DAD11 | DAD10 | TM11 | TM10 | TTYP1 | TDIR1 | FFFFFF0D2H | 0000H       |
| DADC2 | DS21 | DS20 | 0  | 0  | 0  | 0  | 0 | 0 | SAD21 | SAD20 | DAD21 | DAD20 | TM21 | TM20 | TTYP2 | TDIR2 | FFFFFF0D4H | 0000H       |
| DADC3 | DS31 | DS30 | 0  | 0  | 0  | 0  | 0 | 0 | SAD31 | SAD30 | DAD31 | DAD30 | TM31 | TM30 | TTYP3 | TDIR3 | FFFFFF0D6H | 0000H       |

| Bit position | Bit name     | Function                                                                                                                                                                                                                                                                                                                                                        |       |       |                    |   |   |           |   |   |           |   |   |         |   |   |                    |
|--------------|--------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|-------|--------------------|---|---|-----------|---|---|-----------|---|---|---------|---|---|--------------------|
| 15, 14       | DSn1, DSn0   | Sets the transfer data size for DMA transfer. <table> <tr> <th>DSn1</th><th>DSn0</th><th>Transfer data size</th></tr> <tr> <td>0</td><td>0</td><td>8 bits</td></tr> <tr> <td>0</td><td>1</td><td>16 bits</td></tr> <tr> <td>1</td><td>0</td><td>32 bits</td></tr> <tr> <td>1</td><td>1</td><td>Setting prohibited</td></tr> </table>                            | DSn1  | DSn0  | Transfer data size | 0 | 0 | 8 bits    | 0 | 1 | 16 bits   | 1 | 0 | 32 bits | 1 | 1 | Setting prohibited |
| DSn1         | DSn0         | Transfer data size                                                                                                                                                                                                                                                                                                                                              |       |       |                    |   |   |           |   |   |           |   |   |         |   |   |                    |
| 0            | 0            | 8 bits                                                                                                                                                                                                                                                                                                                                                          |       |       |                    |   |   |           |   |   |           |   |   |         |   |   |                    |
| 0            | 1            | 16 bits                                                                                                                                                                                                                                                                                                                                                         |       |       |                    |   |   |           |   |   |           |   |   |         |   |   |                    |
| 1            | 0            | 32 bits                                                                                                                                                                                                                                                                                                                                                         |       |       |                    |   |   |           |   |   |           |   |   |         |   |   |                    |
| 1            | 1            | Setting prohibited                                                                                                                                                                                                                                                                                                                                              |       |       |                    |   |   |           |   |   |           |   |   |         |   |   |                    |
| 7, 6         | SADn1, SADn0 | Sets the count direction of the source address for DMA channel n. <table> <tr> <th>SADn1</th><th>SADn0</th><th>Count direction</th></tr> <tr> <td>0</td><td>0</td><td>Increment</td></tr> <tr> <td>0</td><td>1</td><td>Decrement</td></tr> <tr> <td>1</td><td>0</td><td>Fixed</td></tr> <tr> <td>1</td><td>1</td><td>Setting prohibited</td></tr> </table>      | SADn1 | SADn0 | Count direction    | 0 | 0 | Increment | 0 | 1 | Decrement | 1 | 0 | Fixed   | 1 | 1 | Setting prohibited |
| SADn1        | SADn0        | Count direction                                                                                                                                                                                                                                                                                                                                                 |       |       |                    |   |   |           |   |   |           |   |   |         |   |   |                    |
| 0            | 0            | Increment                                                                                                                                                                                                                                                                                                                                                       |       |       |                    |   |   |           |   |   |           |   |   |         |   |   |                    |
| 0            | 1            | Decrement                                                                                                                                                                                                                                                                                                                                                       |       |       |                    |   |   |           |   |   |           |   |   |         |   |   |                    |
| 1            | 0            | Fixed                                                                                                                                                                                                                                                                                                                                                           |       |       |                    |   |   |           |   |   |           |   |   |         |   |   |                    |
| 1            | 1            | Setting prohibited                                                                                                                                                                                                                                                                                                                                              |       |       |                    |   |   |           |   |   |           |   |   |         |   |   |                    |
| 5, 4         | DADn1, DADn0 | Sets the count direction of the destination address for DMA channel n. <table> <tr> <th>DADn1</th><th>DADn0</th><th>Count direction</th></tr> <tr> <td>0</td><td>0</td><td>Increment</td></tr> <tr> <td>0</td><td>1</td><td>Decrement</td></tr> <tr> <td>1</td><td>0</td><td>Fixed</td></tr> <tr> <td>1</td><td>1</td><td>Setting prohibited</td></tr> </table> | DADn1 | DADn0 | Count direction    | 0 | 0 | Increment | 0 | 1 | Decrement | 1 | 0 | Fixed   | 1 | 1 | Setting prohibited |
| DADn1        | DADn0        | Count direction                                                                                                                                                                                                                                                                                                                                                 |       |       |                    |   |   |           |   |   |           |   |   |         |   |   |                    |
| 0            | 0            | Increment                                                                                                                                                                                                                                                                                                                                                       |       |       |                    |   |   |           |   |   |           |   |   |         |   |   |                    |
| 0            | 1            | Decrement                                                                                                                                                                                                                                                                                                                                                       |       |       |                    |   |   |           |   |   |           |   |   |         |   |   |                    |
| 1            | 0            | Fixed                                                                                                                                                                                                                                                                                                                                                           |       |       |                    |   |   |           |   |   |           |   |   |         |   |   |                    |
| 1            | 1            | Setting prohibited                                                                                                                                                                                                                                                                                                                                              |       |       |                    |   |   |           |   |   |           |   |   |         |   |   |                    |

**Remark** n = 0 to 3

(2/2)

| Bit position | Bit name   | Function                                                                                                                                                                                                                                                                                                           |      |                           |               |   |   |                      |   |   |                           |   |   |                    |   |   |                     |
|--------------|------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|---------------------------|---------------|---|---|----------------------|---|---|---------------------------|---|---|--------------------|---|---|---------------------|
| 3, 2         | TMn1, TMn0 | Sets the transfer mode during DMA transfer.                                                                                                                                                                                                                                                                        |      |                           |               |   |   |                      |   |   |                           |   |   |                    |   |   |                     |
|              |            | <table><tr><td>TMn1</td><td>TMn0</td><td>Transfer mode</td></tr><tr><td>0</td><td>0</td><td>Single transfer mode</td></tr><tr><td>0</td><td>1</td><td>Single-step transfer mode</td></tr><tr><td>1</td><td>0</td><td>Setting prohibited</td></tr><tr><td>1</td><td>1</td><td>Block transfer mode</td></tr></table> | TMn1 | TMn0                      | Transfer mode | 0 | 0 | Single transfer mode | 0 | 1 | Single-step transfer mode | 1 | 0 | Setting prohibited | 1 | 1 | Block transfer mode |
|              |            | TMn1                                                                                                                                                                                                                                                                                                               | TMn0 | Transfer mode             |               |   |   |                      |   |   |                           |   |   |                    |   |   |                     |
|              |            | 0                                                                                                                                                                                                                                                                                                                  | 0    | Single transfer mode      |               |   |   |                      |   |   |                           |   |   |                    |   |   |                     |
|              |            | 0                                                                                                                                                                                                                                                                                                                  | 1    | Single-step transfer mode |               |   |   |                      |   |   |                           |   |   |                    |   |   |                     |
|              |            | 1                                                                                                                                                                                                                                                                                                                  | 0    | Setting prohibited        |               |   |   |                      |   |   |                           |   |   |                    |   |   |                     |
|              |            | 1                                                                                                                                                                                                                                                                                                                  | 1    | Block transfer mode       |               |   |   |                      |   |   |                           |   |   |                    |   |   |                     |
| 1            | TTYPn      | Sets the DMA transfer type.<br>0: 2-cycle transfer<br>1: Flyby transfer                                                                                                                                                                                                                                            |      |                           |               |   |   |                      |   |   |                           |   |   |                    |   |   |                     |
| 0            | TDIRn      | Sets the transfer direction during transfer between I/O and memory. The setting is valid during flyby transfer only and ignored during 2-cycle transfer.<br>0: Memory → I/O (read)<br>1: I/O → memory (write)                                                                                                      |      |                           |               |   |   |                      |   |   |                           |   |   |                    |   |   |                     |

**Remark** n = 0 to 3



### 6.3.5 DMA channel control registers 0 to 3 (DCHC0 to DCHC3)

These 8-bit registers are used to control the DMA transfer operating mode for DMA channel n (n = 0 to 3).

These registers can be read or written in 8-bit or 1-bit units. (However, bit 7 is read only and bits 2 and 1 are write only. If bits 2 and 1 are read, the read value is always 0.)

Be sure to clear bits 6 to 4 to 0. If they are set to 1, the operation is not guaranteed.

**Cautions** 1. During a 2-cycle transfer that performs a write operation on the external device, the write operation on the external device may not be completed even if the TCn bit of the DCHCn register is set to 1 (DMA transfer completion) by the write buffer function. Recognize completion of the write operation on the external device as follows, if necessary.

- Monitor the signal of the  $\overline{\text{TCn}}$  pin (the  $\overline{\text{TCn}}$  pin becomes active in synchronization with a write operation to the external device).
  - After it has been detected that the TCn bit of the DCHCn register is set to 1, write 00H to the WAS register or write the same value as that set to the LBC0 or LBC1 register. When this write is completed, completion of an access from the write buffer to the external device can be recognized. If the set value of the LBC0 or LBC1 register is rewritten when a dummy write to the LBC0 or LBC1 register is executed, the operation is not guaranteed.
2. Setting the MLEn bit to 1 is valid only when DMA transfer (hardware DMA) is started by  $\overline{\text{DMARQn}}$  pin input or an interrupt from the on-chip peripheral I/O. To start DMA transfer by setting the STGn bit to 1 (software DMA), read the TCn bit and confirm that it is set to 1, and then set the STGn bit to 1.
  3. Set the MLEn bit at the following timing while the target DMA channel is in operation or is not suspended (the operation is not guaranteed if the register is set at any other timing).
    - Period from system reset to generation of the first DMA transfer request
    - Period from completion of DMA transfer (after generation of terminal count) to generation of the next DMA transfer request
    - Period from forced termination of DMA transfer (after the INITn bit is set to 1) to generation of the next DMA transfer request
  4. If DMA transfer is forcibly terminated in the last transfer cycle with the MLEn bit set to 1, the same operation as that performed when transfer is completed is performed (the TCn bit is set to 1). (The Enn bit is cleared to 0 on completion of forced termination, regardless of the value of the MLEn bit.)  
In this case, the TCn bit must be read (cleared to 0) in addition to setting the Enn bit when the next DMA transfer is requested.
  5. Do not set the STGn bit to 1 while DMA is suspended.
  6. Each bit is updated upon completion of DMA transfer (at terminal count) with the Enn bit cleared to 0 and the TCn bit set to 1 in that order. While the statuses of the TCn and Enn bits are being polled, therefore, values indicating the status of “transfer not completed and prohibited” (TCn bit = 0 and Enn bit = 0) may be read if the DCHCn register is read while each bit is being updated.

**Cautions 7.** The TCn bit does not have to be read (cleared to 0) on completion of DMA transfer (on generation of the terminal count) only if the following two conditions are satisfied. If either of the conditions is not satisfied, be sure to read the TCn bit (cleared to 0) before the next DMA transfer request is generated.

- If the MLEn bit is set to 1 upon completion of DMA transfer (at terminal count)
- If the source that starts the next DMA transfer is an external pin (DMARQn)

If these two conditions are not satisfied, the operation is not guaranteed if the next DMA transfer request is generated with the TCn bit set to 1.

|       | <7> | 6 | 5 | 4 | <3>  | <2>   | <1>  | <0> | Address   | After reset |
|-------|-----|---|---|---|------|-------|------|-----|-----------|-------------|
| DCHC0 | TC0 | 0 | 0 | 0 | MLE0 | INIT0 | STG0 | E00 | FFFFF0E0H | 00H         |
| DCHC1 | TC1 | 0 | 0 | 0 | MLE1 | INIT1 | STG1 | E11 | FFFFF0E2H | 00H         |
| DCHC2 | TC2 | 0 | 0 | 0 | MLE2 | INIT2 | STG2 | E22 | FFFFF0E4H | 00H         |
| DCHC3 | TC3 | 0 | 0 | 0 | MLE3 | INIT3 | STG3 | E33 | FFFFF0E6H | 00H         |

| Bit position | Bit name | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|--------------|----------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 7            | TCn      | <p>This status bit indicates whether DMA transfer through DMA channel n is complete or not.</p> <p>This bit is read-only. It is set to 1 during the last DMA transfer and cleared to 0 when it is read.</p> <p>0: DMA transfer is not complete.<br/>1: DMA transfer is complete.</p> <p><b>Caution</b> To read the TCn bit on completion of a DMA transfer that transfers data to/from the internal data RAM, first read the status in which the TCn bit was set to 1, and then insert two dummy reads of the DCHCn register in a row.</p>                                                                                                                                                                                                                                                                                                                  |
| 3            | MLEn     | <p>If this bit is set to 1 when DMA transfer is complete (at terminal count output), the Enn bit is not cleared to 0 and the DMA transfer enable state is retained.</p> <p>If the next DMA transfer startup factor is input from the <u>DMARQn</u> pin or is an interrupt from the on-chip peripheral I/O (hardware DMA), the DMA transfer request is acknowledged even if the TCn bit is not read.</p> <p>If the next DMA transfer startup factor is input by setting the STGn bit to 1 (software DMA), the DMA transfer request is acknowledged if the TCn bit is read and cleared to 0.</p> <p>If this bit is cleared to 0 when DMA transfer is complete (at terminal count output), the Enn bit is cleared to 0 and the DMA transfer disable state is entered. At the next DMA transfer request, the Enn bit must be set to 1 and the TCn bit read.</p> |
| 2            | INITn    | <p>If this bit is set to 1 during DMA transfer or after DMA is forcibly suspended by NMI input, DMA transfer is forcibly terminated.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| 1            | STGn     | <p>If this bit is set to 1 in the DMA transfer enable state (TCn bit = 0, Enn bit = 1), DMA transfer is started.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| 0            | Enn      | <p>Specifies whether DMA transfer through DMA channel n is to be enabled or disabled. This bit is cleared to 0 when DMA transfer ends. It is also cleared to 0 when DMA transfer is forcibly interrupted or forcibly terminated by setting the INITn bit to 1 or by NMI input.</p> <p>0: DMA transfer disabled<br/>1: DMA transfer enabled</p> <p><b>Caution</b> If the Enn bit is set to 1, forcibly terminate DMA transfer using the INITn bit after the number of DMA transfers set by the DBCn register is complete or the Enn bit is cleared to 0 (if the Enn bit is cleared to 0 during DMA transfer, do not re-set the Enn bit to 1).</p>                                                                                                                                                                                                            |

**Remark** n = 0 to 3

### 6.3.6 DMA terminal count output control register (DTCO)

The DMA terminal count output control register (DTCO) is an 8-bit register that controls the terminal count output from each DMA channel and DMA transfer during NMI input. Terminal count signals from each DMA channel can be brought together and output from the  $\overline{TC0}$  pin.

This register can be read or written in 8-bit or 1-bit units.

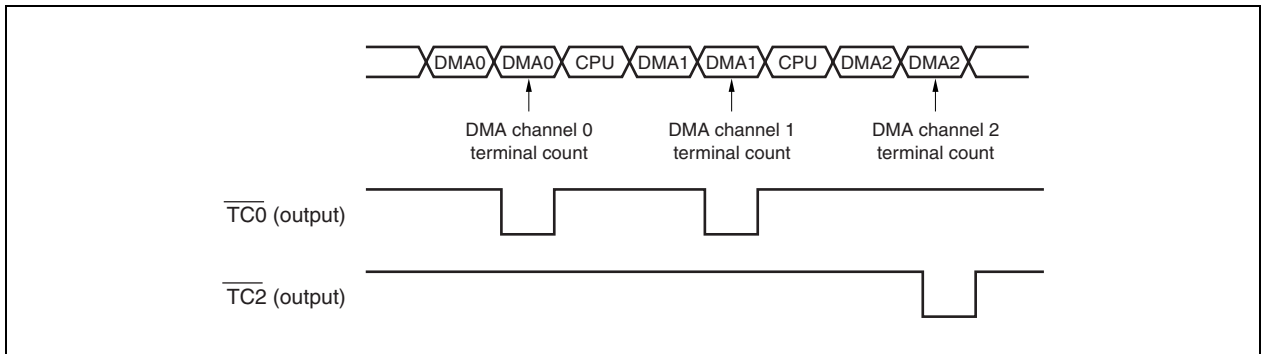
Be sure to clear bits 5 and 4 to 0, and set bit 0 to 1. Otherwise, the operation is not guaranteed.

|      |        |        |   |   |      |      |      |   |           |             |
|------|--------|--------|---|---|------|------|------|---|-----------|-------------|
|      | 7      | 6      | 5 | 4 | <3>  | <2>  | <1>  | 0 | Address   | After reset |
| DTCO | DMSTPM | DAKEBC | 0 | 0 | TCO3 | TCO2 | TCO1 | 1 | FFFFF8A0H | 01H         |

| Bit position | Bit name     | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|--------------|--------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 7            | DMSTPM       | <p>Controls DMA transfer when NMI is input.</p> <p>0: Forcibly aborts DMA transfer when NMI is input.</p> <p>1: Does not abort DMA transfer when NMI is input.</p> <p><b>Cautions</b></p> <ol style="list-style-type: none"> <li>1. When DMSTPM bit = 0, NMI servicing can be executed immediately after completion of the DMA cycle currently under execution. Before executing the aborted DMA transfer, however, be sure to re-initialize it.</li> <li>2. When DMSTPM bit = 1, NMI servicing is held pending in the block transfer mode until DMA transfer has been completed the preset number of times. In the single transfer mode and single-step transfer mode, NMI servicing is executed after the DMA cycle currently under execution is completed. As necessary, forcibly terminate DMA transfer by setting the INITn bit of the DCHCn register to 1 (n = 0 to 3).</li> <li>3. Be sure to change the value of the DMSTPM bit when DMA is not used.</li> </ol> <p>The operation is not guaranteed if the value of the DMSTPM bit is changed after registers related to DMAC have been set or during DMA transfer.</p> |
| 6            | DAKEBC       | <p>Specifies extension of the active width of the <math>\overline{DMAAKn}</math> signal while the DAKEn bit of the DIFC register = 1.</p> <p>0: Active width extended by <math>4 \times f_{CLK}</math>.</p> <p>1: Active width extended by 6 to <math>7 \times f_{CLK}</math>.</p> <p><b>Remark</b> For details of the function to extend the active width of the <math>\overline{DMAAKn}</math> signal, see 6.3.8 DMA interface control register (DIFC) or 6.5.1 (2) <math>\overline{DMAAKn}</math> signal active width extension function.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| 3 to 1       | TCO3 to TCO1 | <p>Indicates the state of the <math>\overline{TC0}</math> pin.</p> <p>0: Channel n terminal count signal not output from <math>\overline{TC0}</math> pin.</p> <p>1: Channel n terminal count signal output from <math>\overline{TC0}</math> pin.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |

**Remark**  $f_{CLK}$ : Internal system clock

The following shows an example of the case when the DTOC register is set to 03H.



### 6.3.7 DMA trigger factor registers 0 to 3 (DTFR0 to DTFR3)

These 8-bit registers are used to control the DMA transfer start trigger through interrupt requests from on-chip peripheral I/O.

The interrupt requests set by these registers serve as DMA transfer startup factors.

These registers can be read or written in 8-bit or 1-bit units. However, only bit 7 (DFn) can be read or written in 1-bit units.

- Cautions**
1. To change the setting of the DTFRn register, be sure to stop the DMA operation of all channels.
  2. An interrupt request from an on-chip peripheral I/O input in the standby mode (IDLE or software STOP mode) is held pending as a DMA transfer start factor. The held DMA start factor is executed following return to the normal operation mode.
  3. If the factor of starting DMA transfer is changed by using the IFCn6 to IFCn0 bits, be sure to clear the DFn bit of all channels to 0 using the instruction immediately after. When in single-step transfer, clear the DFn bit to 0 and then set the DCHCn.FCLRn bit of all channels to 1.
  4. When a transmission completion interrupt request signal (UBTIT0 or UBTIT1) of UARTB is used as the factor of starting DMA transfer, the factor of starting DMA transfer that is triggered by the interrupt request signal generated when the last transmission was completed is retained. In this case, clear the DFn bit to 0 to clear the DMA transfer request.
  5. Do not start two or more DMA channels with the same factor. If two or more DMA channels are started with the same factor, the DMA channel with the lower priority may be accepted before the DMA channel with the higher priority.

|       | <7> | 6     | 5     | 4     | 3     | 2     | 1     | 0     | Address    | After reset |
|-------|-----|-------|-------|-------|-------|-------|-------|-------|------------|-------------|
| DTFR0 | DF0 | IFC06 | IFC05 | IFC04 | IFC03 | IFC02 | IFC01 | IFC00 | FFFFFF810H | 00H         |
| DTFR1 | DF1 | IFC16 | IFC15 | IFC14 | IFC13 | IFC12 | IFC11 | IFC10 | FFFFFF812H | 00H         |
| DTFR2 | DF2 | IFC26 | IFC25 | IFC24 | IFC23 | IFC22 | IFC21 | IFC20 | FFFFFF814H | 00H         |
| DTFR3 | DF3 | IFC36 | IFC35 | IFC34 | IFC33 | IFC32 | IFC31 | IFC30 | FFFFFF816H | 00H         |

| Bit position | Bit name       | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |       |       |       |       |                                                                                                                 |       |       |                  |   |   |   |   |   |   |   |                                                                                                                 |   |   |   |   |   |   |   |                                                                                                                |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |        |
|--------------|----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|-------|-------|-------|-----------------------------------------------------------------------------------------------------------------|-------|-------|------------------|---|---|---|---|---|---|---|-----------------------------------------------------------------------------------------------------------------|---|---|---|---|---|---|---|----------------------------------------------------------------------------------------------------------------|---|---|---|---|---|---|---|--------|---|---|---|---|---|---|---|--------|---|---|---|---|---|---|---|--------|---|---|---|---|---|---|---|--------|---|---|---|---|---|---|---|--------|---|---|---|---|---|---|---|--------|---|---|---|---|---|---|---|--------|
| 7            | DFn            | <p>This is a DMA transfer request flag.<br/>Only 0 can be written to this flag.<br/>0: DMA transfer not requested<br/>1: DMA transfer requested</p> <p>If the interrupt specified as the DMA transfer startup trigger occurs and it is necessary to clear the DMA transfer request while DMA transfer is disabled (including when it is aborted by NMI or forcibly terminated by software), stop the operation of the source causing the interrupt, and then clear the DFn bit to 0 (for example, disable reception in the case of serial reception). If it is clear that the interrupt will not occur until DMA transfer is resumed next, it is not necessary to stop the operation of the source causing the interrupt.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |       |       |       |       |                                                                                                                 |       |       |                  |   |   |   |   |   |   |   |                                                                                                                 |   |   |   |   |   |   |   |                                                                                                                |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |        |
| 6 to 0       | IFCn6 to IFCn0 | <p>This code is used to set the interrupt sources serving as DMA transfer startup factors.</p> <table><tr><th>IFCn6</th><th>IFCn5</th><th>IFCn4</th><th>IFCn3</th><th>IFCn2</th><th>IFCn1</th><th>IFCn0</th><th>Interrupt source</th></tr><tr><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>Level detection mode of <math>\overline{\text{DMARQn}}</math> pin input (DMA request from on-chip peripheral I/O disabled)</td></tr><tr><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>1</td><td>Edge detection mode of <math>\overline{\text{DMARQn}}</math> pin input (DMA request from on-chip peripheral I/O disabled)</td></tr><tr><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>1</td><td>0</td><td>INTP10</td></tr><tr><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>1</td><td>1</td><td>INTP11</td></tr><tr><td>0</td><td>0</td><td>0</td><td>0</td><td>1</td><td>0</td><td>0</td><td>INTP21</td></tr><tr><td>0</td><td>0</td><td>0</td><td>0</td><td>1</td><td>0</td><td>1</td><td>INTP22</td></tr><tr><td>0</td><td>0</td><td>0</td><td>0</td><td>1</td><td>1</td><td>0</td><td>INTP23</td></tr><tr><td>0</td><td>0</td><td>0</td><td>0</td><td>1</td><td>1</td><td>1</td><td>INTP24</td></tr><tr><td>0</td><td>0</td><td>0</td><td>1</td><td>0</td><td>0</td><td>0</td><td>INTP25</td></tr></table> | IFCn6 | IFCn5 | IFCn4 | IFCn3 | IFCn2                                                                                                           | IFCn1 | IFCn0 | Interrupt source | 0 | 0 | 0 | 0 | 0 | 0 | 0 | Level detection mode of $\overline{\text{DMARQn}}$ pin input (DMA request from on-chip peripheral I/O disabled) | 0 | 0 | 0 | 0 | 0 | 0 | 1 | Edge detection mode of $\overline{\text{DMARQn}}$ pin input (DMA request from on-chip peripheral I/O disabled) | 0 | 0 | 0 | 0 | 0 | 1 | 0 | INTP10 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | INTP11 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | INTP21 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | INTP22 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | INTP23 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | INTP24 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | INTP25 |
| IFCn6        | IFCn5          | IFCn4                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | IFCn3 | IFCn2 | IFCn1 | IFCn0 | Interrupt source                                                                                                |       |       |                  |   |   |   |   |   |   |   |                                                                                                                 |   |   |   |   |   |   |   |                                                                                                                |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |        |
| 0            | 0              | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 0     | 0     | 0     | 0     | Level detection mode of $\overline{\text{DMARQn}}$ pin input (DMA request from on-chip peripheral I/O disabled) |       |       |                  |   |   |   |   |   |   |   |                                                                                                                 |   |   |   |   |   |   |   |                                                                                                                |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |        |
| 0            | 0              | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 0     | 0     | 0     | 1     | Edge detection mode of $\overline{\text{DMARQn}}$ pin input (DMA request from on-chip peripheral I/O disabled)  |       |       |                  |   |   |   |   |   |   |   |                                                                                                                 |   |   |   |   |   |   |   |                                                                                                                |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |        |
| 0            | 0              | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 0     | 0     | 1     | 0     | INTP10                                                                                                          |       |       |                  |   |   |   |   |   |   |   |                                                                                                                 |   |   |   |   |   |   |   |                                                                                                                |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |        |
| 0            | 0              | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 0     | 0     | 1     | 1     | INTP11                                                                                                          |       |       |                  |   |   |   |   |   |   |   |                                                                                                                 |   |   |   |   |   |   |   |                                                                                                                |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |        |
| 0            | 0              | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 0     | 1     | 0     | 0     | INTP21                                                                                                          |       |       |                  |   |   |   |   |   |   |   |                                                                                                                 |   |   |   |   |   |   |   |                                                                                                                |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |        |
| 0            | 0              | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 0     | 1     | 0     | 1     | INTP22                                                                                                          |       |       |                  |   |   |   |   |   |   |   |                                                                                                                 |   |   |   |   |   |   |   |                                                                                                                |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |        |
| 0            | 0              | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 0     | 1     | 1     | 0     | INTP23                                                                                                          |       |       |                  |   |   |   |   |   |   |   |                                                                                                                 |   |   |   |   |   |   |   |                                                                                                                |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |        |
| 0            | 0              | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 0     | 1     | 1     | 1     | INTP24                                                                                                          |       |       |                  |   |   |   |   |   |   |   |                                                                                                                 |   |   |   |   |   |   |   |                                                                                                                |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |        |
| 0            | 0              | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 1     | 0     | 0     | 0     | INTP25                                                                                                          |       |       |                  |   |   |   |   |   |   |   |                                                                                                                 |   |   |   |   |   |   |   |                                                                                                                |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |        |   |   |   |   |   |   |   |        |

**Remark** n = 0 to 3

| Bit position | Bit name       | Function |       |       |       |       |                  |       |                  |
|--------------|----------------|----------|-------|-------|-------|-------|------------------|-------|------------------|
| 6 to 0       | IFCn6 to IFCn0 |          |       |       |       |       |                  |       |                  |
|              |                | IFCn6    | IFCn5 | IFCn4 | IFCn3 | IFCn2 | IFCn1            | IFCn0 | Interrupt source |
|              |                | 0        | 0     | 0     | 1     | 0     | 0                | 1     | INTP50           |
|              |                | 0        | 0     | 0     | 1     | 0     | 1                | 0     | INTP51           |
|              |                | 0        | 0     | 0     | 1     | 0     | 1                | 1     | INTP52           |
|              |                | 0        | 0     | 0     | 1     | 1     | 0                | 0     | INTP65           |
|              |                | 0        | 0     | 0     | 1     | 1     | 0                | 1     | INTP66           |
|              |                | 0        | 0     | 0     | 1     | 1     | 1                | 0     | INTP67           |
|              |                | 0        | 0     | 0     | 1     | 1     | 1                | 1     | INTPD0           |
|              |                | 0        | 0     | 1     | 0     | 0     | 0                | 0     | INTPD1           |
|              |                | 0        | 0     | 1     | 0     | 0     | 0                | 1     | INTPD2           |
|              |                | 0        | 0     | 1     | 0     | 0     | 1                | 0     | INTPD3           |
|              |                | 0        | 0     | 1     | 0     | 0     | 1                | 1     | INTPD4           |
|              |                | 0        | 0     | 1     | 0     | 1     | 0                | 0     | INTPD5           |
|              |                | 0        | 0     | 1     | 0     | 1     | 0                | 1     | INTPD6           |
|              |                | 0        | 0     | 1     | 0     | 1     | 1                | 0     | INTPD7           |
|              |                | 0        | 0     | 1     | 0     | 1     | 1                | 1     | INTPD8           |
|              |                | 0        | 0     | 1     | 1     | 0     | 0                | 0     | INTPD9           |
|              |                | 0        | 0     | 1     | 1     | 0     | 0                | 1     | INTPD10          |
|              |                | 0        | 0     | 1     | 1     | 0     | 1                | 0     | INTPD11          |
|              |                | 0        | 0     | 1     | 1     | 0     | 1                | 1     | INTPD12          |
|              |                | 0        | 0     | 1     | 1     | 1     | 0                | 0     | INTPD13          |
|              |                | 0        | 0     | 1     | 1     | 1     | 0                | 1     | INTPD14          |
|              |                | 0        | 0     | 1     | 1     | 1     | 1                | 0     | INTPD15          |
|              |                | 0        | 0     | 1     | 1     | 1     | 1                | 1     | INTPL0           |
|              |                | 0        | 1     | 0     | 0     | 0     | 0                | 0     | INTPL1           |
|              |                | 0        | 1     | 0     | 0     | 0     | 0                | 1     | INTPC00/INTCCC00 |
|              |                | 0        | 1     | 0     | 0     | 0     | 1                | 0     | INTPC01/INTCCC01 |
|              |                | 0        | 1     | 0     | 0     | 0     | 1                | 1     | INTPC10/INTCCC10 |
|              |                | 0        | 1     | 0     | 0     | 1     | 0                | 0     | INTPC11/INTCCC11 |
|              |                | 0        | 1     | 0     | 0     | 1     | 0                | 1     | INTPC20/INTCCC20 |
|              |                | 0        | 1     | 0     | 0     | 1     | 1                | 0     | INTPC21/INTCCC21 |
|              |                | 0        | 1     | 0     | 0     | 1     | 1                | 1     | INTPC30/INTCCC30 |
| 0            | 1              | 0        | 1     | 0     | 0     | 0     | INTPC31/INTCCC31 |       |                  |

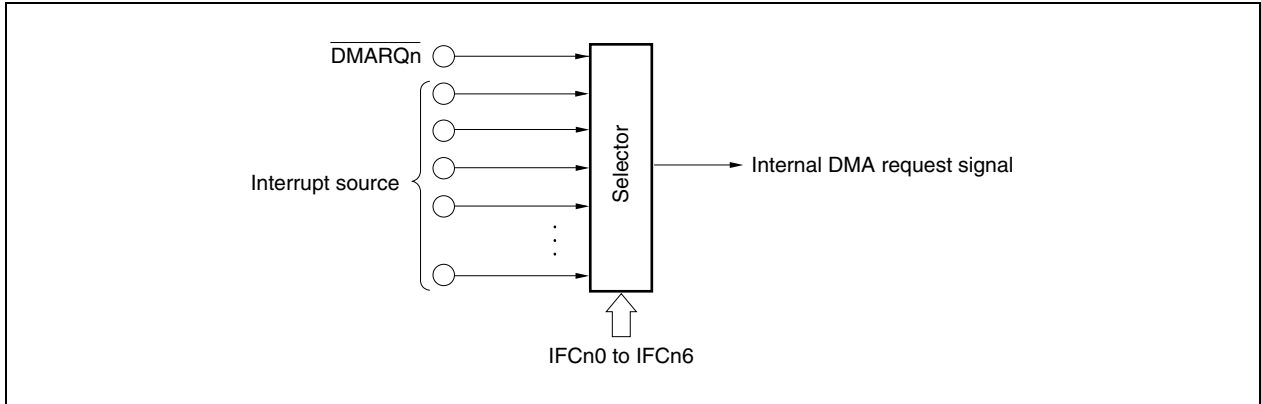
**Remark** n = 0 to 3

| Bit position                                                                                                                                                                        | Bit name       | Function         |       |       |       |       |       |       |                    |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------|------------------|-------|-------|-------|-------|-------|-------|--------------------|
| 6 to 0                                                                                                                                                                              | IFCn6 to IFCn0 |                  |       |       |       |       |       |       |                    |
|                                                                                                                                                                                     |                | IFCn6            | IFCn5 | IFCn4 | IFCn3 | IFCn2 | IFCn1 | IFCn0 | Interrupt source   |
|                                                                                                                                                                                     |                | 0                | 1     | 0     | 1     | 0     | 0     | 1     | INTCCC40           |
|                                                                                                                                                                                     |                | 0                | 1     | 0     | 1     | 0     | 1     | 0     | INTCCC41           |
|                                                                                                                                                                                     |                | 0                | 1     | 0     | 1     | 0     | 1     | 1     | INTCCC50           |
|                                                                                                                                                                                     |                | 0                | 1     | 0     | 1     | 1     | 0     | 0     | INTCCC51           |
|                                                                                                                                                                                     |                | 0                | 1     | 0     | 1     | 1     | 0     | 1     | INTCMD0            |
|                                                                                                                                                                                     |                | 0                | 1     | 0     | 1     | 1     | 1     | 0     | INTCMD1            |
|                                                                                                                                                                                     |                | 0                | 1     | 0     | 1     | 1     | 1     | 1     | INTCMD2            |
|                                                                                                                                                                                     |                | 0                | 1     | 1     | 0     | 0     | 0     | 0     | INTCMD3            |
|                                                                                                                                                                                     |                | 0                | 1     | 1     | 0     | 0     | 0     | 1     | INTCC100           |
|                                                                                                                                                                                     |                | 0                | 1     | 1     | 0     | 0     | 1     | 0     | INTCC101           |
|                                                                                                                                                                                     |                | 0                | 1     | 1     | 0     | 0     | 1     | 1     | INTCM100           |
|                                                                                                                                                                                     |                | 0                | 1     | 1     | 0     | 1     | 0     | 0     | INTCM101           |
|                                                                                                                                                                                     |                | 0                | 1     | 1     | 0     | 1     | 0     | 1     | INTCC110           |
|                                                                                                                                                                                     |                | 0                | 1     | 1     | 0     | 1     | 1     | 0     | INTCC111           |
|                                                                                                                                                                                     |                | 0                | 1     | 1     | 0     | 1     | 1     | 1     | INTCM110           |
|                                                                                                                                                                                     |                | 0                | 1     | 1     | 1     | 0     | 0     | 0     | INTCM111           |
|                                                                                                                                                                                     |                | 0                | 1     | 1     | 1     | 0     | 0     | 1     | INTCSI30           |
|                                                                                                                                                                                     |                | 0                | 1     | 1     | 1     | 0     | 1     | 0     | INTCSI31           |
|                                                                                                                                                                                     |                | 0                | 1     | 1     | 1     | 0     | 1     | 1     | UBTIR0             |
|                                                                                                                                                                                     |                | 0                | 1     | 1     | 1     | 1     | 0     | 0     | UBTIT0             |
|                                                                                                                                                                                     |                | 0                | 1     | 1     | 1     | 1     | 0     | 1     | UBTIR1             |
|                                                                                                                                                                                     |                | 0                | 1     | 1     | 1     | 1     | 1     | 0     | UBTIT1             |
|                                                                                                                                                                                     |                | 0                | 1     | 1     | 1     | 1     | 1     | 1     | INTAD              |
|                                                                                                                                                                                     |                | 1                | 1     | 1     | 1     | 1     | 1     | 1     | UFDRQn             |
|                                                                                                                                                                                     |                | Other than above |       |       |       |       |       |       | Setting prohibited |
| <b>Caution</b> When using an external interrupt (when IFCn6 to IFCn0 bits = 0000010B to 0100000B) as a DMA trigger source, be sure to specify an edge (do not use level detection). |                |                  |       |       |       |       |       |       |                    |

**Remark** n = 0 to 3



The relationship between the  $\overline{\text{DMARQn}}$  signal and the interrupt source that serves as a DMA transfer trigger is as follows ( $n = 0$  to 3).



**Remark** If an interrupt request is specified as the DMA transfer start factor, an interrupt request will be generated if DMA transfer starts. To prevent an interrupt from being generated, mask the interrupt by setting the interrupt request control register. DMA transfer starts even if an interrupt is masked.

For the level detection mode (IFCn6 to IFCn0 bits = 0000000) and edge detection mode (IFCn6 to IFCn0 bits = 0000001) of the  $\overline{\text{DMARQn}}$  pin input, see **Figures 6-8 to 6-10** ( $n = 0$  to 3).

**(1) DMA request detection function**

The V850E/ME2 has a level detection mode and an edge detection mode as functions to sample the  $\overline{\text{DMARQn}}$  pin ( $n = 0$  to 3). The level detection mode also has a mask mode in which sampling the DMA request is masked.

**(a) Level detection mode (IFCn6 to IFCn0 bits = 0000000)**

In this mode, handshaking of the  $\overline{\text{DMARQn}}$  and  $\overline{\text{DMAAKn}}$  signals can be executed at high speeds. In the single transfer mode, deassert the  $\overline{\text{DMARQn}}$  signal for the duration of  $2 \times f_{\text{CLK}}$  from the rising edge of the  $\overline{\text{DMAAKn}}$  signal, in order not to start the DMA transfer cycle next to that currently under execution. If the  $\overline{\text{DMARQn}}$  signal is active for the duration of  $2 \times f_{\text{CLK}}$ , the next DMA request is recognized. In the 2-cycle transfer mode, however, the active period of the  $\overline{\text{DMAAKn}}$  signal may be shortened depending on the combination of the transfer source and transfer destination (Min.:  $2 \times f_{\text{CLK}}$ ). Consequently, if the inactive timing of the  $\overline{\text{DMARQn}}$  signal is generated from the falling edge of the  $\overline{\text{DMAAKn}}$  signal, for example, the timing may be  $4 \times f_{\text{CLK}}$  at the shortest.

For the active width of the  $\overline{\text{DMAAKn}}$  signal for 2-cycle transfer, see **Table 6-4 Minimum Value of Active Width of  $\overline{\text{DMAAKn}}$  Signal for 2-Cycle Transfer**.

**Remark**  $f_{\text{CLK}}$ : Internal system clock

**<1> Mask mode (IFCn6 to IFCn0 bits = 0000000 and DRMKn bit of DIFC register = 1)**

This mode is used to establish handshaking of the  $\overline{\text{DMARQn}}$  and  $\overline{\text{DMAAKn}}$  signals in synchronization with BUSCLK in the level detection mode. In the single transfer mode, deassert the  $\overline{\text{DMARQn}}$  signal within  $3 \times \text{BUSCLK}$  after sampling the rising edge of the  $\overline{\text{DMAAKn}}$  signal, in order not to start the DMA transfer cycle next to that currently under execution. When the mask mode is set, sampling the DMA request is always masked for the duration of  $3 \times \text{BUSCLK}$  period from the rising edge of the  $\overline{\text{DMARQn}}$  signal, regardless of the division ratio of BUSCLK (set by the BMC register).

**(b) Edge detection mode (IFCn6 to IFCn0 bits = 0000001)**

This mode uses the falling edge of the  $\overline{\text{DMARQn}}$  signal as a DMA request. It realizes handshaking of the  $\overline{\text{DMARQn}}$  and  $\overline{\text{DMAAKn}}$  signals at a speed much lower than that when the mask mode is used. However, note that the falling edge of the  $\overline{\text{DMARQn}}$  signal is ignored, even if input, while the  $\overline{\text{DMAAKn}}$  signal is active.

For the detailed timing in each mode, see **CHAPTER 17 ELECTRICAL SPECIFICATIONS**.

### 6.3.8 DMA interface control register (DIFC)

This 8-bit register controls the active extension width of the  $\overline{\text{DMAAKn}}$  signal of each DMA channel and controls the mask function (DMA mask mode) of the  $\overline{\text{DMARQn}}$  signal (n = 0 to 3).

This register can be read or written in 8-bit or 1-bit units.

|      | 7     | 6     | 5     | 4     | 3     | 2     | 1     | 0     | Address   | After reset |
|------|-------|-------|-------|-------|-------|-------|-------|-------|-----------|-------------|
| DIFC | DAKE3 | DAKE2 | DAKE1 | DAKE0 | DRMK3 | DRMK2 | DRMK1 | DRMK0 | FFFFF8A8H | 00H         |

| Bit position | Bit name          | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|--------------|-------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 7 to 4       | DAKE <sub>n</sub> | <p>These bits specify the active extension width of the <math>\overline{\text{DMAAKn}}</math> signal.</p> <p>0: Active width of <math>\overline{\text{DMAAKn}}</math> signal output from DMAC</p> <p>1: Active width of <math>\overline{\text{DMAAKn}}</math> signal + active extension width<sup>Note</sup> output from DMAC</p> <p><b>Note</b> The active width is extended by the DAKE<sub>n</sub> bit as follows.</p> <ul style="list-style-type: none"> <li>• <math>4 \times f_{\text{CLK}}</math> when DAKEBC bit of DTOC register = 0</li> <li>• <math>6</math> to <math>7 \times f_{\text{CLK}}</math> when DAKEBC bit of DTOC register = 1</li> </ul> <p>For details of the function to extend the active width of the <math>\overline{\text{DMAAKn}}</math> signal, see <b>6.3.8 DMA interface control register (DIFC)</b> or <b>6.5.1 (2) <math>\overline{\text{DMAAKn}}</math> signal active width extension function</b>.</p> <p><b>Cautions</b></p> <ol style="list-style-type: none"> <li>1. Do not set the DAKE<sub>n</sub> bits to 1 during flyby transfer.</li> <li>2. If either of the following conditions is satisfied when the function to extend the active width of the <math>\overline{\text{DMAAKn}}</math> signal is used, the next <math>\overline{\text{DMAAKn}}</math> signal is asserted while the active width of the preceding <math>\overline{\text{DMAAKn}}</math> signal is extended. As a result, the active cycles of more than one <math>\overline{\text{DMAAKn}}</math> signal combine into one <math>\overline{\text{DMAAKn}}</math> signal, and the number of times the <math>\overline{\text{DMAAKn}}</math> signal is asserted is less than the actual number of DMA cycles.</li> </ol> <ul style="list-style-type: none"> <li>• During block transfer or single-step transfer</li> <li>• When the <math>\overline{\text{DMARQn}}</math> signal is kept active (including when the next DMA request is generated while the <math>\overline{\text{DMAAKn}}</math> signal is active or immediately after it has been deasserted in the pending mode of UARTB)</li> </ul> |
| 3 to 0       | DRMK <sub>n</sub> | <p>These are mask bits of the <math>\overline{\text{DMARQn}}</math> signal. They specify the DMA mask mode.</p> <p>0: Do not mask the <math>\overline{\text{DMARQn}}</math> signal.</p> <p>1: Mask input of the <math>\overline{\text{DMARQn}}</math> signal for the duration of 3 bus clocks from the rising edge of the <math>\overline{\text{DMAAKn}}</math> signal.</p> <p><b>Caution</b> The period masked by the DRMK<sub>n</sub> bit is three bus clocks (BUSCLK) from the rising edge of the <math>\overline{\text{DMAAKn}}</math> signal. If the rising edge of the <math>\overline{\text{DMAAKn}}</math> signal is sampled with DRMK<sub>n</sub> bit = 1, the DMA controller does not recognize the next DMA transfer request if the <math>\overline{\text{DMARQn}}</math> signal is deasserted within 3 bus clocks (BUSCLK) after the rising edge (high level) of the <math>\overline{\text{DMAAKn}}</math> signal has been sampled with BUSCLK.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |

**Remarks**

1. n = 0 to 3
2. f<sub>CLK</sub>: Internal system clock

## 6.4 Transfer Modes

### 6.4.1 Single transfer mode

In single transfer mode, the DMAC releases the bus at each byte/halfword/word transfer. If there is a subsequent DMA transfer request, transfer is performed again once. This operation continues until a terminal count occurs.

When the DMAC has released the bus, if another higher priority DMA transfer request is issued, the higher priority DMA request always takes precedence. If other DMA transfer request with the lower priority occurs one clock after single transfer has been completed, however, this request does not take precedence even if the previous DMA transfer request signal with the higher priority remains active. DMA transfer with the lower priority newly request is executed after the CPU bus has been released.

Figures 6-1 to 6-4 show examples of single transfer.

**Figure 6-1. Single Transfer Example 1**

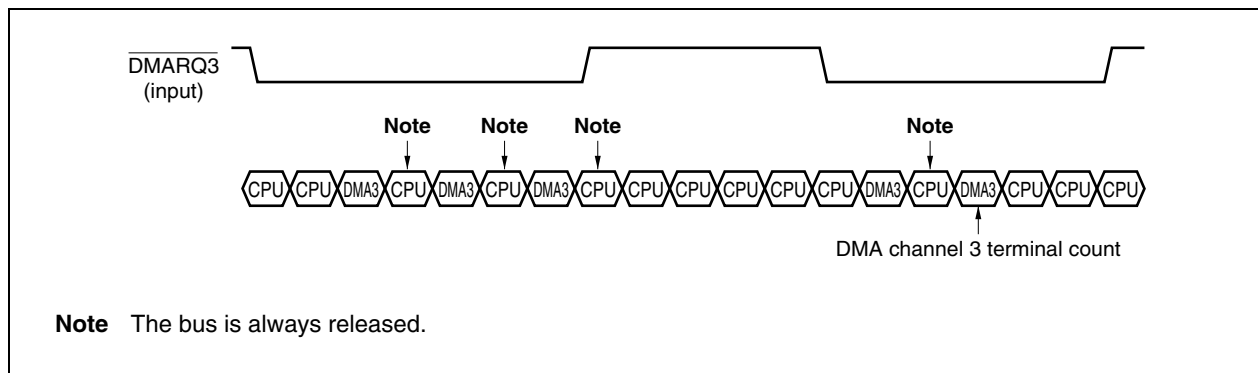


Figure 6-2 shows an example of a single transfer in which a higher priority DMA request is issued. DMA channels 0 to 2 are in the block transfer mode and channel 3 is in the single transfer mode.

**Figure 6-2. Single Transfer Example 2**

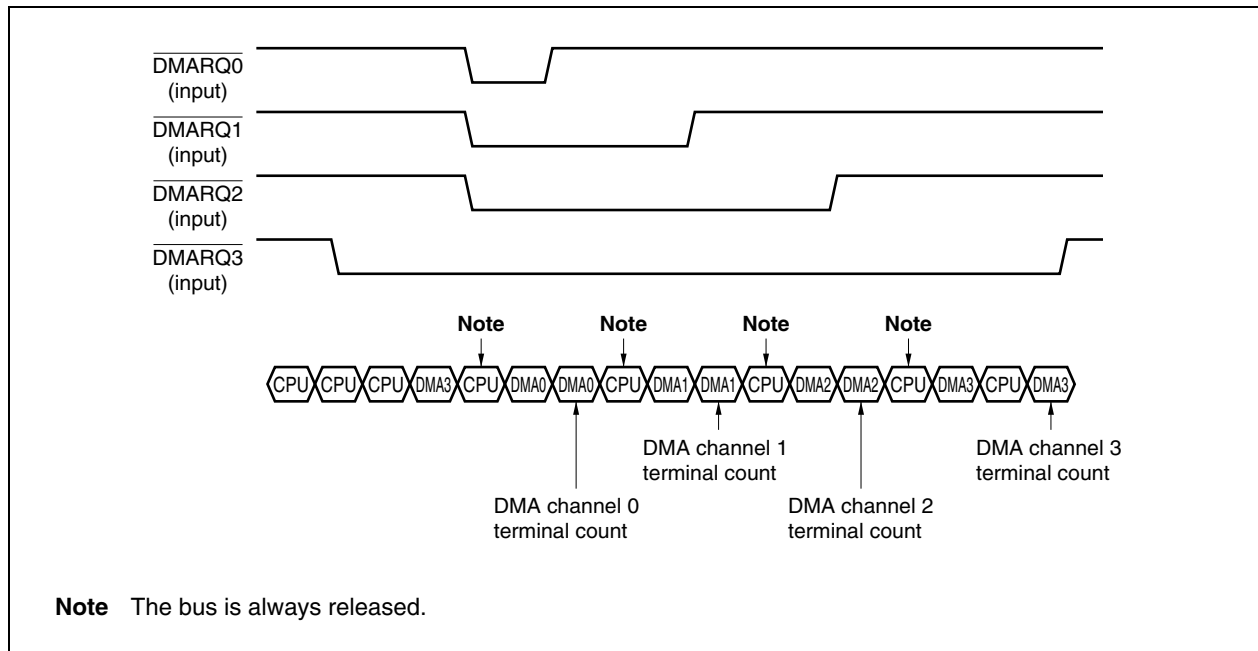


Figure 6-3 is an example of single transfer where a DMA transfer request with the lower priority is issued one clock after single transfer has been completed. DMA channels 0 and 3 are used for single transfer. If two DMA transfer request signals become active at the same time, two DMA transfer operations are alternately executed.

**Figure 6-3. Single Transfer Example 3**

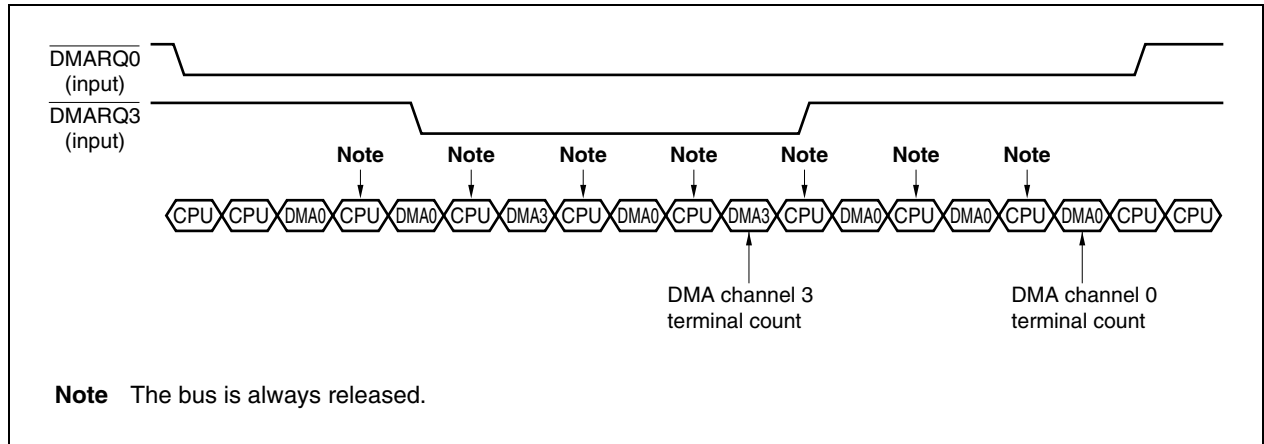
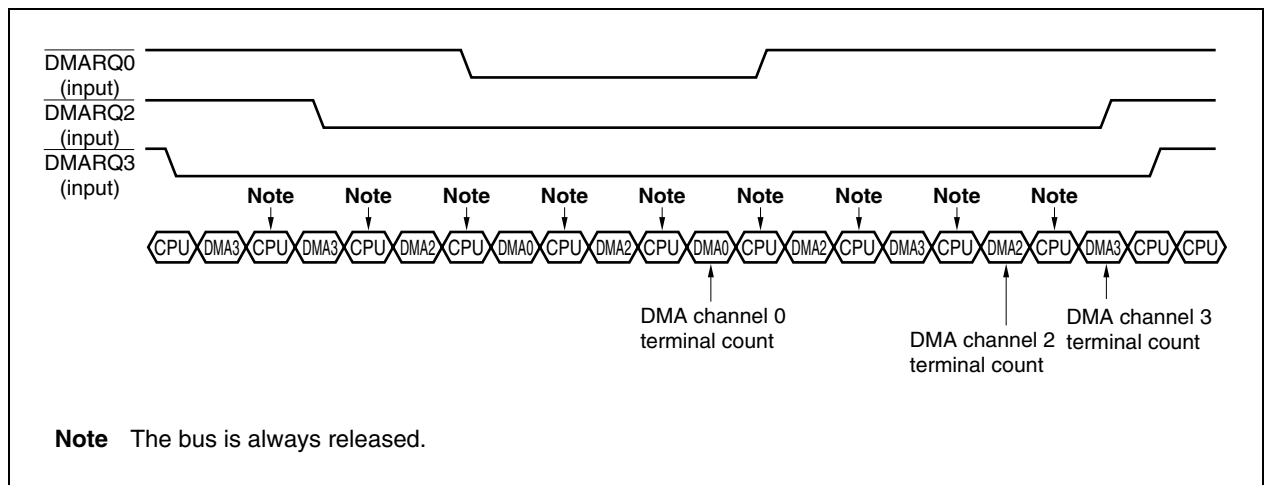


Figure 6-4 is an example of single transfer where two or more DMA transfer requests with the lower priority are issued one clock after single transfer has been completed. DMA channels 0, 2, and 3 are used for single transfer. If three or more DMA transfer request signals become active at the same time, two DMA transfer operations are alternately executed, always starting from the one with the highest priority.

**Figure 6-4. Single Transfer Example 4**



6.4.2 Single-step transfer mode

In single-step transfer mode, the DMAC releases the bus at each byte/halfword/word transfer. If there is a subsequent DMA transfer request signal ( $\overline{\text{DMARQ0}}$  to  $\overline{\text{DMARQ3}}$ ), transfer is performed again. This operation continues until a terminal count occurs.

When the DMAC has released the bus, if another higher priority DMA transfer request is issued, the higher priority DMA request always takes precedence.

The following shows an example of a single-step transfer. Figure 6-6 shows an example of single-step transfer made in which a higher priority DMA request is issued. DMA channels 0 and 1 are in the single-step transfer mode.

Figure 6-5. Single-Step Transfer Example 1

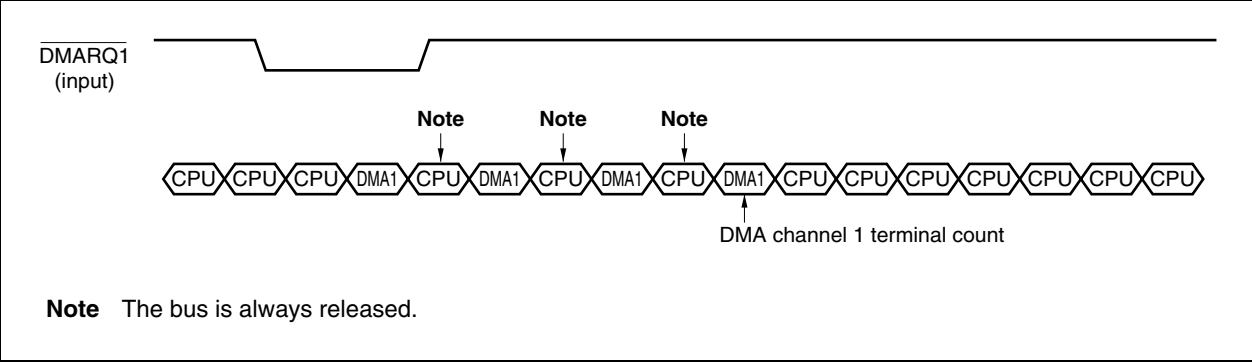
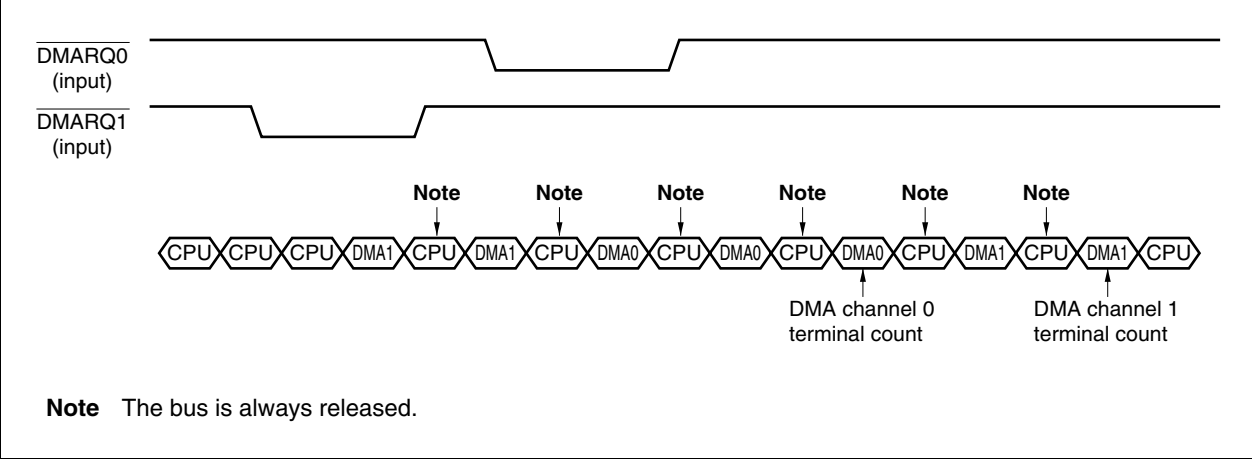


Figure 6-6. Single-Step Transfer Example 2



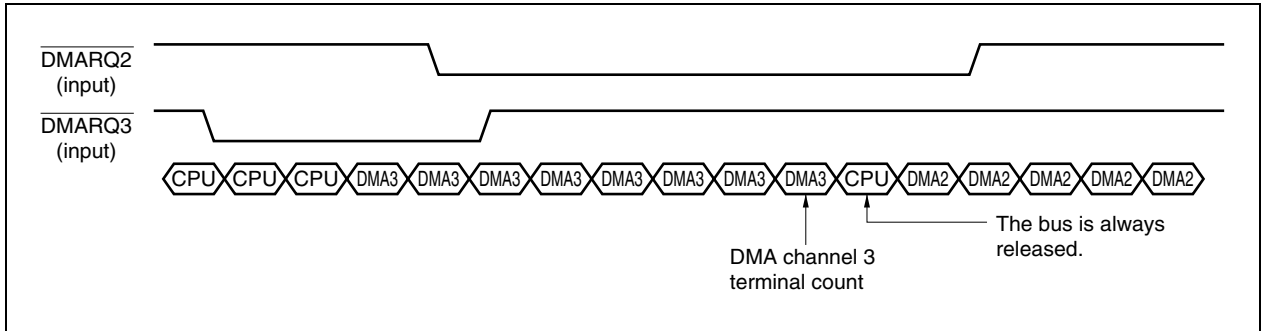
### 6.4.3 Block transfer mode

In the block transfer mode, once transfer starts, the DMAC continues the transfer operation without releasing the bus until a terminal count occurs. No other DMA requests are acknowledged during block transfer.

After the block transfer ends and the DMAC releases the bus, another DMA transfer can be acknowledged. The bus cycle of the CPU is not inserted during block transfer, but bus hold and refresh cycles are inserted in between DMA transfer operations.

The following shows an example of block transfer in which a higher priority DMA request is issued. DMA channels 2 and 3 are in the block transfer mode.

**Figure 6-7. Block Transfer Example**



## 6.5 Transfer Types

### 6.5.1 2-cycle transfer

In 2-cycle transfer, data transfer is performed in two cycles, a read cycle (source to DMAC) and a write cycle (DMAC to destination).

In the first cycle, the source address is output and reading is performed from the source to the DMAC. In the second cycle, the destination address is output and writing is performed from the DMAC to the destination.

- Cautions**
1. An idle cycle of 1 to 2 clocks is always inserted between a read cycle and a write cycle.
  2. See 6.15 (8) Restriction on 2-cycle DMA transfer for restrictions on 2-cycle DMA transfer.

Figure 6-8. Timing of 2-Cycle DMA Transfer (SRAM → External I/O) (1/2)

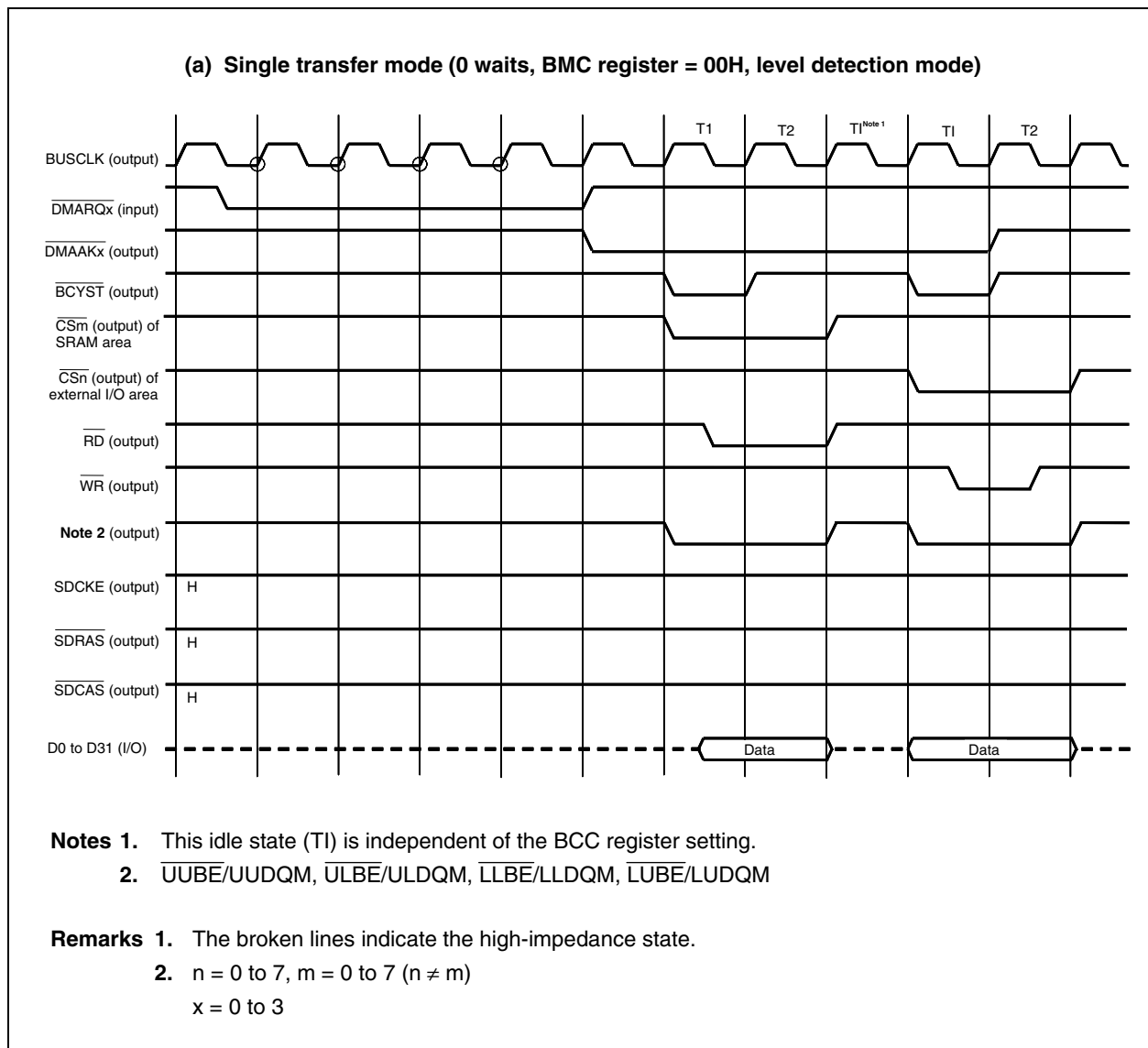




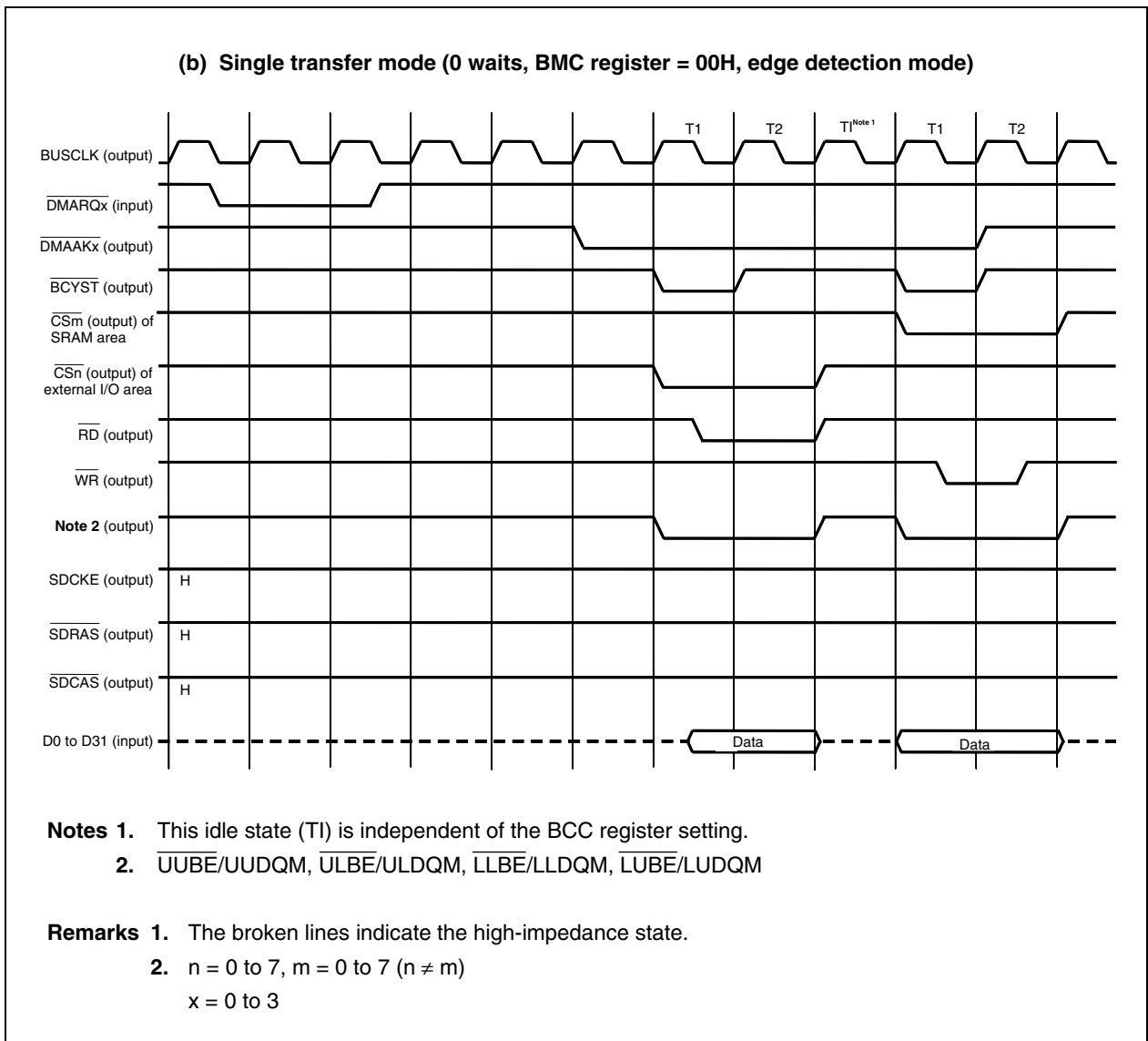
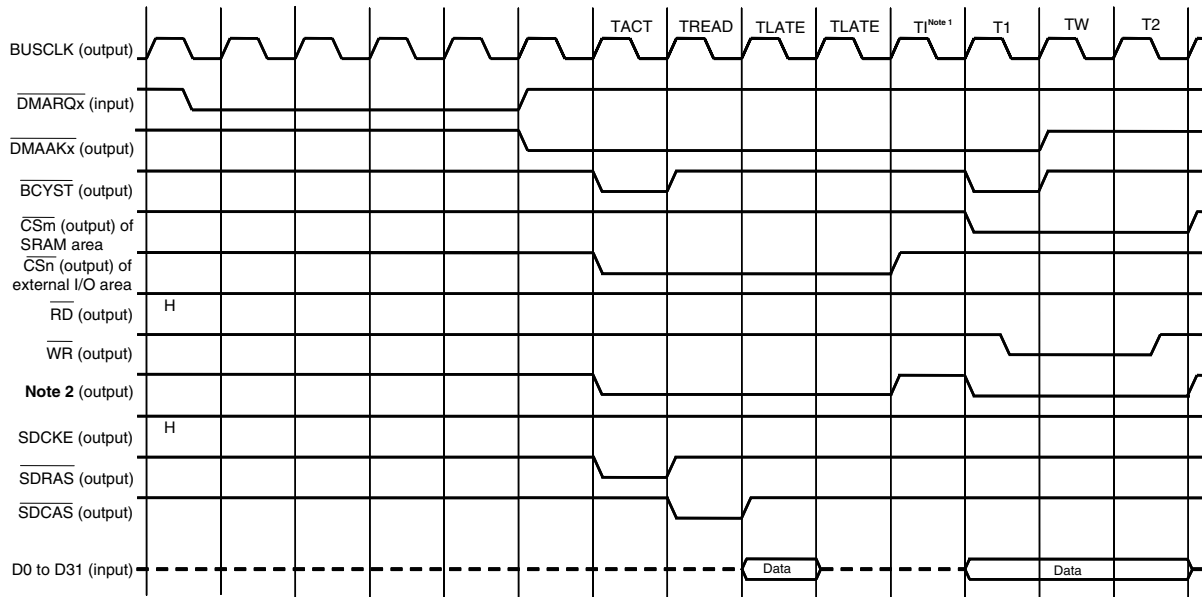
**Figure 6-8. Timing of 2-Cycle DMA Transfer (SRAM → External I/O) (2/2)**

**Figure 6-9. Timing of 2-Cycle DMA Transfer (SDRAM → SRAM):**  
**Single Transfer Mode (SRAM Data 1 Wait, SDRAM Latency = 2,**  
**BMC Register = 00H, Level Detection Mode)**



- Notes** 1. This idle state (TI) is independent of the BCC register setting.  
 2.  $\overline{UUBE}/\overline{UUDQM}$ ,  $\overline{ULBE}/\overline{ULDQM}$ ,  $\overline{LLBE}/\overline{LLDQM}$ ,  $\overline{LUBE}/\overline{LUDQM}$

- Remarks** 1. The broken lines indicate the high-impedance state.  
 2.  $m = 0$  to 7  
 $n = 1, 3, 4, 6$   
 $x = 0$  to 3

**Figure 6-10. Timing of 2-Cycle DMA Transfer (SRAM → SDRAM):**  
**Single Transfer Mode (SRAM Data 1 Wait, BMC Register = 00H,**  
**Edge Detection Mode)**

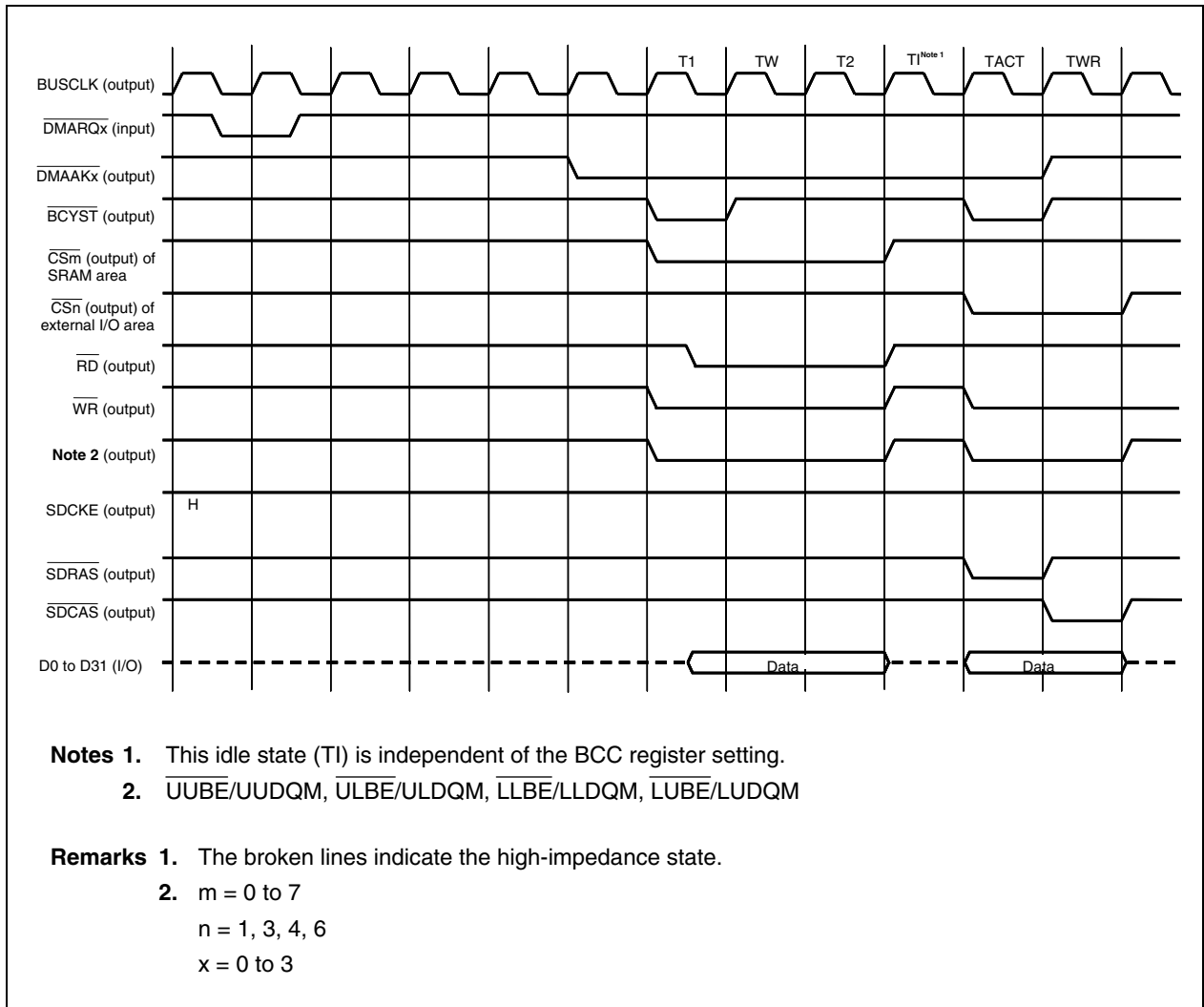
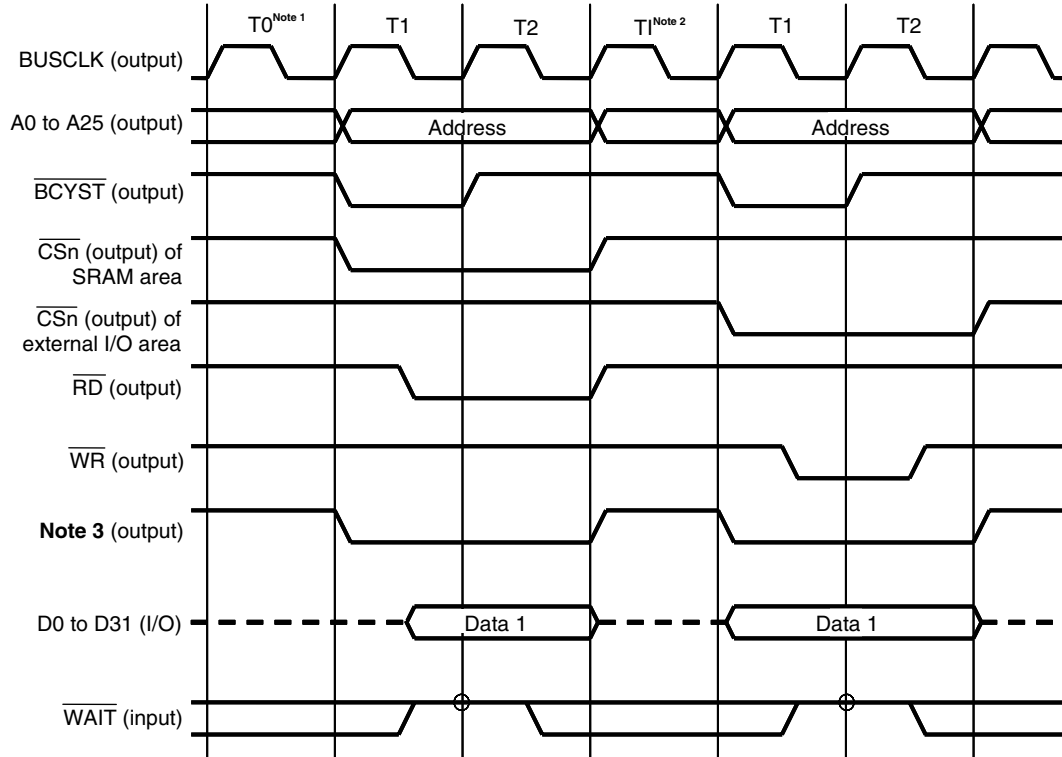


**Figure 6-11. Timing of 2-Cycle DMA Transfer (SRAM → External I/O): Without Speculative Read**

- Notes**
1. State (T0) inserted between bus cycles
  2. This idle state (T1) is independent of the BCC register setting.
  3.  $\overline{UUBE}$ ,  $\overline{ULBE}$ ,  $\overline{LUBE}$ ,  $\overline{LLBE}$

- Remarks**
1. The circle O indicates the sampling timing.
  2. The broken lines indicate the high-impedance state.
  3.  $n = 0$  to  $7$

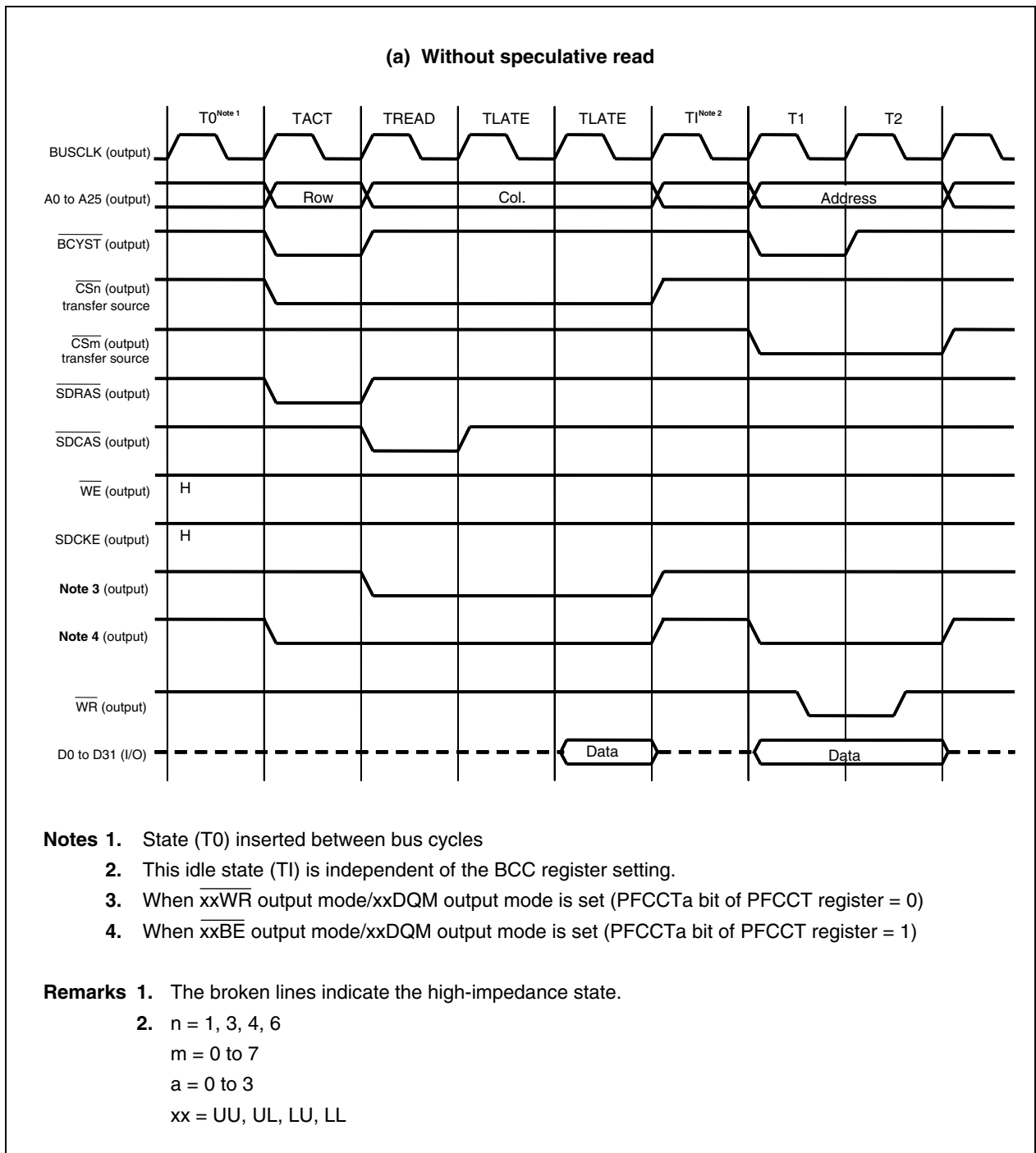
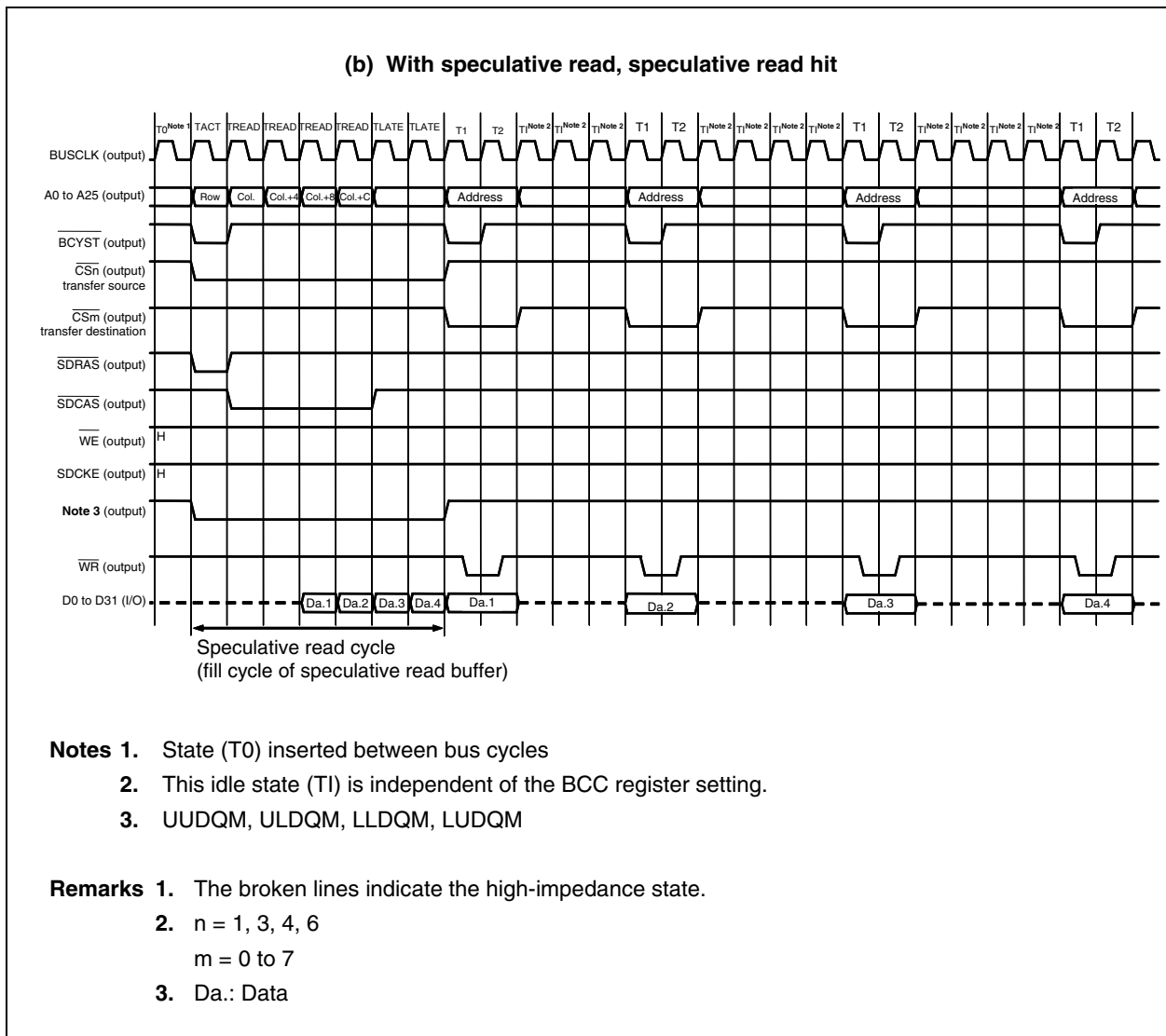
**Figure 6-12. Timing of 2-Cycle DMA Transfer (SDRAM → SRAM) (1/2)**

Figure 6-12. Timing of 2-Cycle DMA Transfer (SDRAM → SRAM) (2/2)



**(1) Timing of  $\overline{\text{DMARQn}}$  and  $\overline{\text{DMAAKn}}$  signals for 2-cycle transfer**

The targets of 2-cycle transfer are as follows.

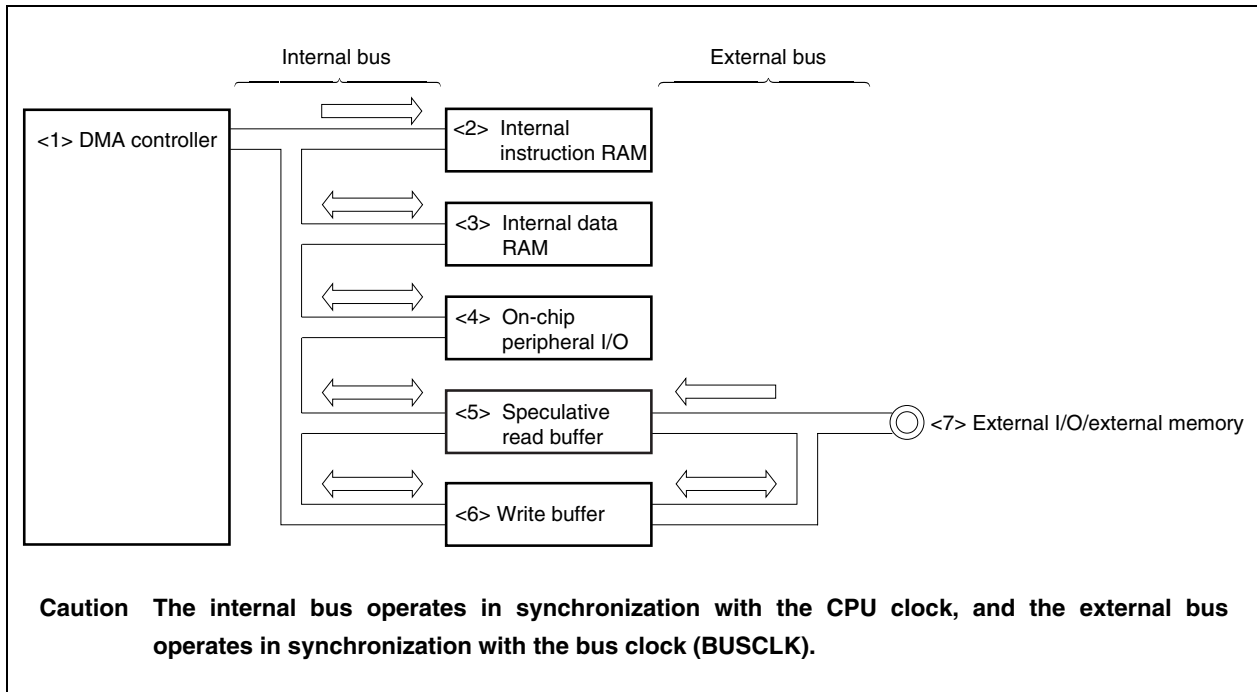
**Table 6-1. Targets of 2-Cycle Transfer**

|                 |                              | Transfer Destination         |                        |                   |                          |
|-----------------|------------------------------|------------------------------|------------------------|-------------------|--------------------------|
|                 |                              | External I/O/External Memory | On-Chip Peripheral I/O | Internal Data RAM | Internal Instruction RAM |
| Transfer source | External I/O/external memory | √                            | √                      | √                 | √                        |
|                 | On-chip peripheral I/O       | √                            | √                      | √                 | √                        |
|                 | Internal data RAM            | √                            | √                      | ×                 | √                        |

**Remarks 1.** √: Can be transferred, ×: Cannot be transferred

**2.** For details, see **Table 6-4 Minimum Value of Active Width of  $\overline{\text{DMAAKn}}$  Signal for 2-Cycle Transfer.**

The bus configuration is as shown below.

**Figure 6-13. Bus Configuration**

The active width of the  $\overline{\text{DMAAKn}}$  signal output by the DMA controller is from the beginning of a read operation by the DMA controller to the end of a write operation ( $n = 0$  to 3). The  $\overline{\text{DMAAKn}}$  signal is not asserted in a cycle used to write/read the internal data RAM.

The active width of the  $\overline{\text{DMAAKn}}$  signal for each DMA transfer is shown below.

**Table 6-2. Active Width of  $\overline{\text{DMAAKn}}$  Signal for 2-Cycle Transfer**

|                 |                              | Transfer Destination         |                        |                   |                          |
|-----------------|------------------------------|------------------------------|------------------------|-------------------|--------------------------|
|                 |                              | External I/O/External Memory | On-Chip Peripheral I/O | Internal Data RAM | Internal Instruction RAM |
| Transfer source | External I/O/external memory | <5> (<7>) → <1> → <6>        | <5> (<7>) → <1> → <4>  | <5> (<7>) → <1>   | <5> (<7>) → <1> → <2>    |
|                 | On-chip peripheral I/O       | <4> → <1> → <6>              | <4> → <1> → <4>        | <4> → <1>         | <4> → <1> → <2>          |
|                 | Internal data RAM            | <1> → <6>                    | <1> → <4>              | –                 | <1> → <2>                |

**Remark** ( ): Cycle without speculative reading or in case of speculative read miss-hit

Therefore, the correlation between external access during 2-cycle transfer (execution to external I/O/external memory) and the active width of the  $\overline{\text{DMAAKn}}$  signal is as follows.

**Table 6-3. Correlation Between External Access (Execution to External I/O/External Memory) and Active Width of  $\overline{\text{DMAAKn}}$  Signal**

|                 |                              | Speculative Read Function | Transfer Destination          |                        |                   |                          |
|-----------------|------------------------------|---------------------------|-------------------------------|------------------------|-------------------|--------------------------|
|                 |                              |                           | External I/O/ External Memory | On-Chip Peripheral I/O | Internal Data RAM | Internal Instruction RAM |
| Transfer source | External I/O/external memory | None                      | √                             | √                      | √                 | √                        |
|                 | On-chip peripheral I/O       |                           | × (a)                         | –                      | –                 | –                        |
|                 | Internal data RAM            |                           | × (a)                         | –                      | –                 | –                        |
|                 | External I/O/external memory | Provided                  | × (b)                         | × (c)                  | × (c)             | × (c)                    |
|                 | On-chip peripheral I/O       |                           | × (a)                         | –                      | –                 | –                        |
|                 | Internal data RAM            |                           | × (a)                         | –                      | –                 | –                        |

**Remarks** √: The  $\overline{\text{DMAAKn}}$  signal is asserted while DMA access to/from external I/O/external memory is being executed.

×: The  $\overline{\text{DMAAKn}}$  signal may not be asserted while DMA access to/from external I/O/external memory is being executed.

(a): As soon as data has been transferred to the write buffer (<4> → <1> → <6> or <1> → <6>), assertion of the  $\overline{\text{DMAAKn}}$  signal ends. Therefore, handshaking of the  $\overline{\text{DMARQn}}$  and  $\overline{\text{DMAAKn}}$  signals may be completed before a write operation to the external I/O or external memory is executed. If data of three buffers has already been stored in the write buffer separately, data transferred by DMA is stored in the fourth buffer and the  $\overline{\text{DMAAKn}}$  signal is deasserted. Subsequently, when a write operation of the stored data has taken place three times, transfer to the external I/O or external memory targeted by the last  $\overline{\text{DMAAKn}}$  signal (already deasserted) is executed (<6> → <7>).



- (b): Handshaking of the  $\overline{\text{DMARQn}}$  and  $\overline{\text{DMAAKn}}$  signals may be completed if a read operation from the external I/O or external memory (DMA access) has been completed before handshaking of the  $\overline{\text{DMARQn}}$  and  $\overline{\text{DMAAKn}}$  signals is completed, or before a write operation to the external I/O or external memory is executed.

The active state of the  $\overline{\text{DMAAKn}}$  signal ends as soon as data has been transferred to the write buffer ( $\langle 5 \rangle \rightarrow \langle 1 \rangle \rightarrow \langle 6 \rangle$ ). If speculative reading hits, data is read from the external I/O or external memory when speculative reading has been completed. Therefore, a read operation from the external I/O or external memory ( $\langle 7 \rangle \rightarrow \langle 5 \rangle$ ) is executed before the  $\overline{\text{DMAAKn}}$  signal. While data is being transferred from the speculative read buffer to the write buffer ( $\langle 5 \rangle \rightarrow \langle 1 \rangle \rightarrow \langle 6 \rangle$ ) after that, the  $\overline{\text{DMAAKn}}$  signal is asserted. For example, if data of three buffers has already been stored in the write buffer, data transferred by DMA is stored in the fourth buffer. After that, transfer to the external I/O or external memory ( $\langle 6 \rangle \rightarrow \langle 7 \rangle$ ) targeted by the last  $\overline{\text{DMAAKn}}$  signal is executed when a write operation of the stored data has taken place three times.

- (c): A read operation from the external I/O or external memory (DMA access) may be completed before handshaking of the  $\overline{\text{DMARQn}}$  and  $\overline{\text{DMAAKn}}$  signals is completed.

If speculative reading hits, because the data has already been transferred from the external I/O or external memory to the speculative read buffer ( $\langle 7 \rangle \rightarrow \langle 5 \rangle$ ), execution to the external I/O or external memory (DMA access) will have already been completed while the  $\overline{\text{DMAAKn}}$  signal was asserted ( $\langle 5 \rangle \rightarrow \langle 1 \rangle \rightarrow (\langle 2 \rangle, \langle 3 \rangle \text{ or } \langle 4 \rangle)$ ).

## (2) $\overline{\text{DMAAKn}}$ signal active width extension function

The  $\overline{\text{DMAAKn}}$  signal is output in synchronization with the internal bus cycle during 2-cycle transfer, and is not synchronized with the external bus cycle ( $n = 0$  to 3). The DMA cycle differs depending on the configuration subject to DMA transfer (see 6.5.1 (1) **Timing of  $\overline{\text{DMARQn}}$  and  $\overline{\text{DMAAKn}}$  signals for 2-cycle transfer**).

Depending on the target of DMA transfer, the configuration may allow the  $\overline{\text{DMAAKn}}$  signal to be asserted only for the duration of  $2 \times f_{\text{CLK}}$ . In this case, assertion of the  $\overline{\text{DMAAKn}}$  signal may not be sampled with BUSCLK if the internal system clock ( $f_{\text{CLK}}$ ) is divided and the bus clock (BUSCLK) is used (e.g., BMC register = 02H: internal system clock divided by three).

To sample assertion of the  $\overline{\text{DMAAKn}}$  signal with BUSCLK, extend the active width of the  $\overline{\text{DMAAKn}}$  signal by using the DAKEBC bit of the DTOC register and DAKEn bit of the DIFC register.

The minimum value of the active width of the  $\overline{\text{DMAAKn}}$  during 2-cycle transfer is shown in the table below.

**Table 6-4. Minimum Value of Active Width of  $\overline{\text{DMAAKn}}$  Signal During 2-Cycle Transfer**

|                 |                              | Speculative Read Function | Transfer Destination                         |                                                  |                               |                                                                                              |
|-----------------|------------------------------|---------------------------|----------------------------------------------|--------------------------------------------------|-------------------------------|----------------------------------------------------------------------------------------------|
|                 |                              |                           | External I/O/<br>External Memory             | On-Chip Peripheral<br>I/O                        | Internal Data RAM             | Internal Instruction<br>RAM                                                                  |
| Transfer source | External I/O/external memory | None                      | Read cycle<br>+<br>$3 \times f_{\text{CLK}}$ | Read cycle<br>+<br>$(4+i) \times f_{\text{CLK}}$ | Read cycle                    | Read cycle<br>+<br>internal instruction<br>RAM write cycle<br>+<br>$1 \times f_{\text{CLK}}$ |
|                 | On-chip peripheral I/O       |                           | $(6+i) \times f_{\text{CLK}}$                | $(7+2i) \times f_{\text{CLK}}$                   | $(3+i) \times f_{\text{CLK}}$ | Internal instruction<br>RAM write cycle<br>+<br>$(4+i) \times f_{\text{CLK}}$                |
|                 | Internal data RAM            |                           | $2 \times f_{\text{CLK}}$                    | $(3+i) \times f_{\text{CLK}}$                    | –                             | Internal instruction<br>RAM write cycle                                                      |
|                 | External I/O/external memory | Provided                  | $5 \times f_{\text{CLK}}$                    | $(6+i) \times f_{\text{CLK}}$                    | $2 \times f_{\text{CLK}}$     | Internal instruction<br>RAM write cycle<br>+<br>$3 \times f_{\text{CLK}}$                    |
|                 | On-chip peripheral I/O       |                           | $(6+i) \times f_{\text{CLK}}$                | $(7+2i) \times f_{\text{CLK}}$                   | $(3+i) \times f_{\text{CLK}}$ | Internal instruction<br>RAM write cycle<br>+<br>$(4+i) \times f_{\text{CLK}}$                |
|                 | Internal data RAM            |                           | $2 \times f_{\text{CLK}}$                    | $(3+i) \times f_{\text{CLK}}$                    | –                             | Internal instruction<br>RAM write cycle                                                      |

**Caution** The function to extend the active width of the  $\overline{\text{DMAAKn}}$  signal can be used only during 2-cycle transfer ( $n = 0$  to  $3$ ). It cannot be used during flyby transfer. The operation is not guaranteed if it is used during flyby transfer. During flyby transfer, the  $\overline{\text{DMAAKn}}$  signal synchronized with the bus cycle is output.

**Remark** i: Number of wait cycles set by VSWC register  
 $f_{\text{CLK}}$ : Internal system clock

### 6.5.2 Flyby transfer

Since data is transferred in 1 cycle during a flyby transfer, a memory address is always output irrespective whether it is a source address or a destination address, and read/write signals of the memory and on-chip peripheral I/O become active at the same time. Therefore, the external I/O is selected by the  $\overline{\text{DMAAK0}}$  to  $\overline{\text{DMAAK3}}$  signals.

To perform a normal access to the external I/O by means other than DMA transfer, externally AND the  $\overline{\text{CSm}}$  and  $\overline{\text{DMAAKx}}$  signals ( $m = 0$  to  $7$ ,  $x = 0$  to  $3$ ), and connect the resultant signal to the chip select signal of the external I/O. A circuit example of a normal access, other than DMA transfer, to external I/O is shown below.

**Caution** Flyby transfer to SDRAM is possible only from external I/O.

Figure 6-14. Circuit Example When Flyby Transfer Is Performed Between External I/O and SRAM

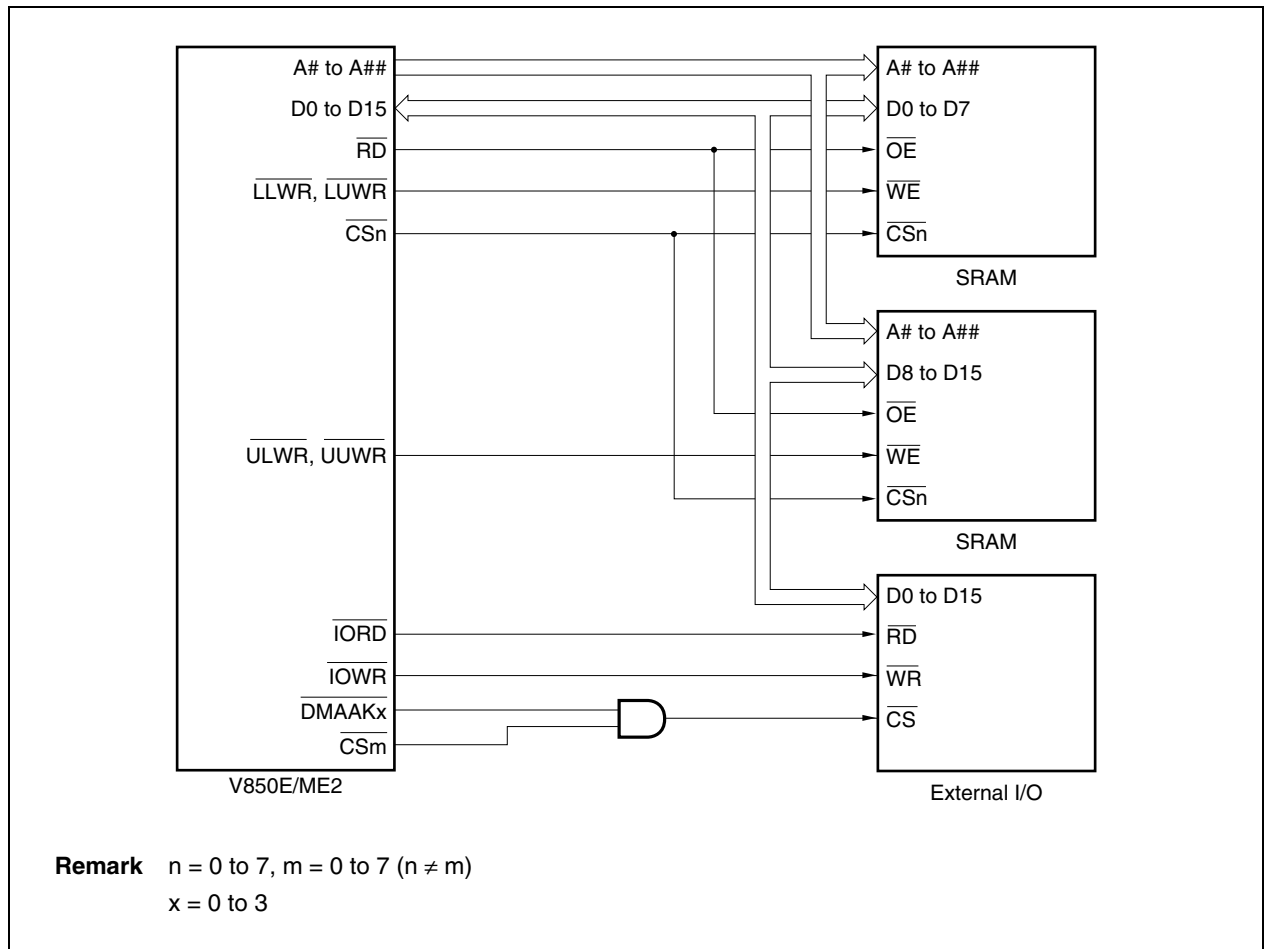
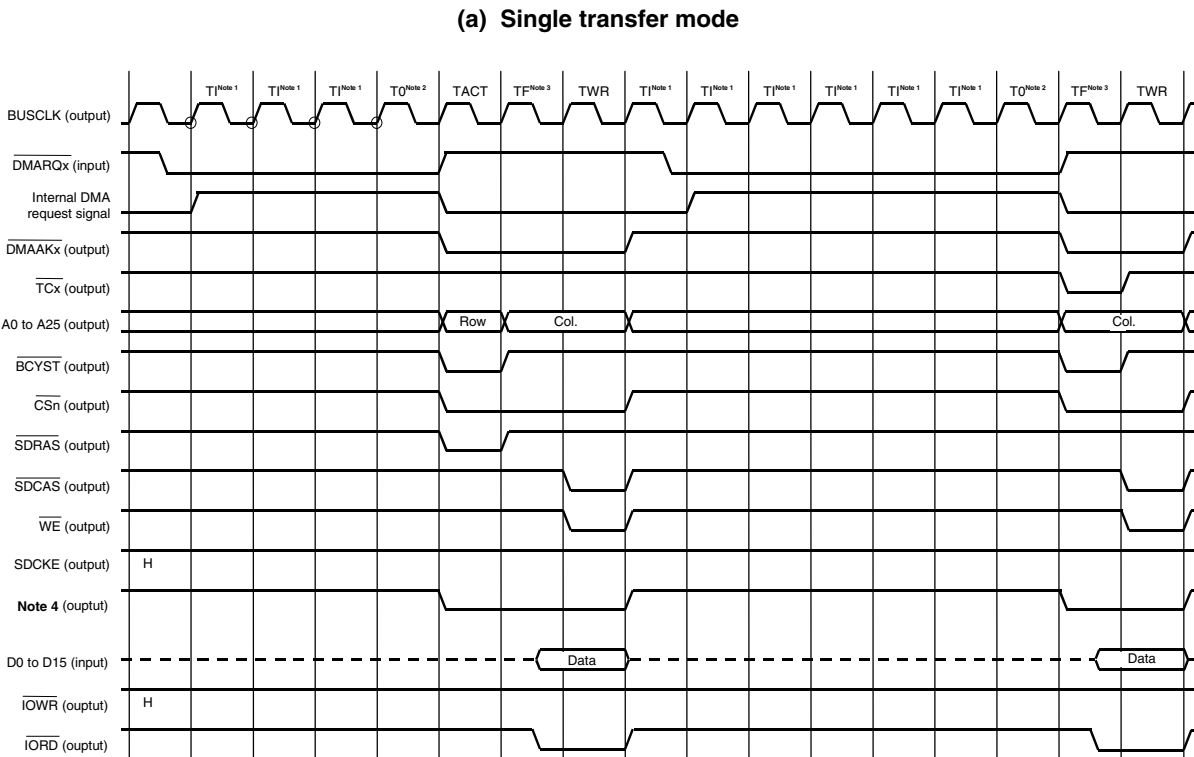


**Figure 6-15. Timing of DMA Flyby Transfer (External I/O → SDRAM) (1/3)**



- Notes**
1. This idle state (TI) is independent of the BCC register setting.
  2. State (T0) inserted between bus cycles
  3. This wait (TF) is inserted by means of the FWC register setting.
  4. UUDQM, ULDQM, LLDQM, LUDQM

**Caution** In the TF state during SDRAM flyby transfer, wait cycles of the set value of the FWC register + 1 are always inserted (one wait cycle is inserted when the set value is 0 (the case where the set value is 0 is shown above)).

- Remarks**
1. The circle O indicates the sampling timing.
  2. The broken lines indicate the high-impedance state.
  3.  $x = 0$  to 3  
 $n = 1, 3, 4, 6$
  4. Col.: Column address  
Row: Row address

Figure 6-15. Timing of DMA Flyby Transfer (External I/O → SDRAM) (2/3)

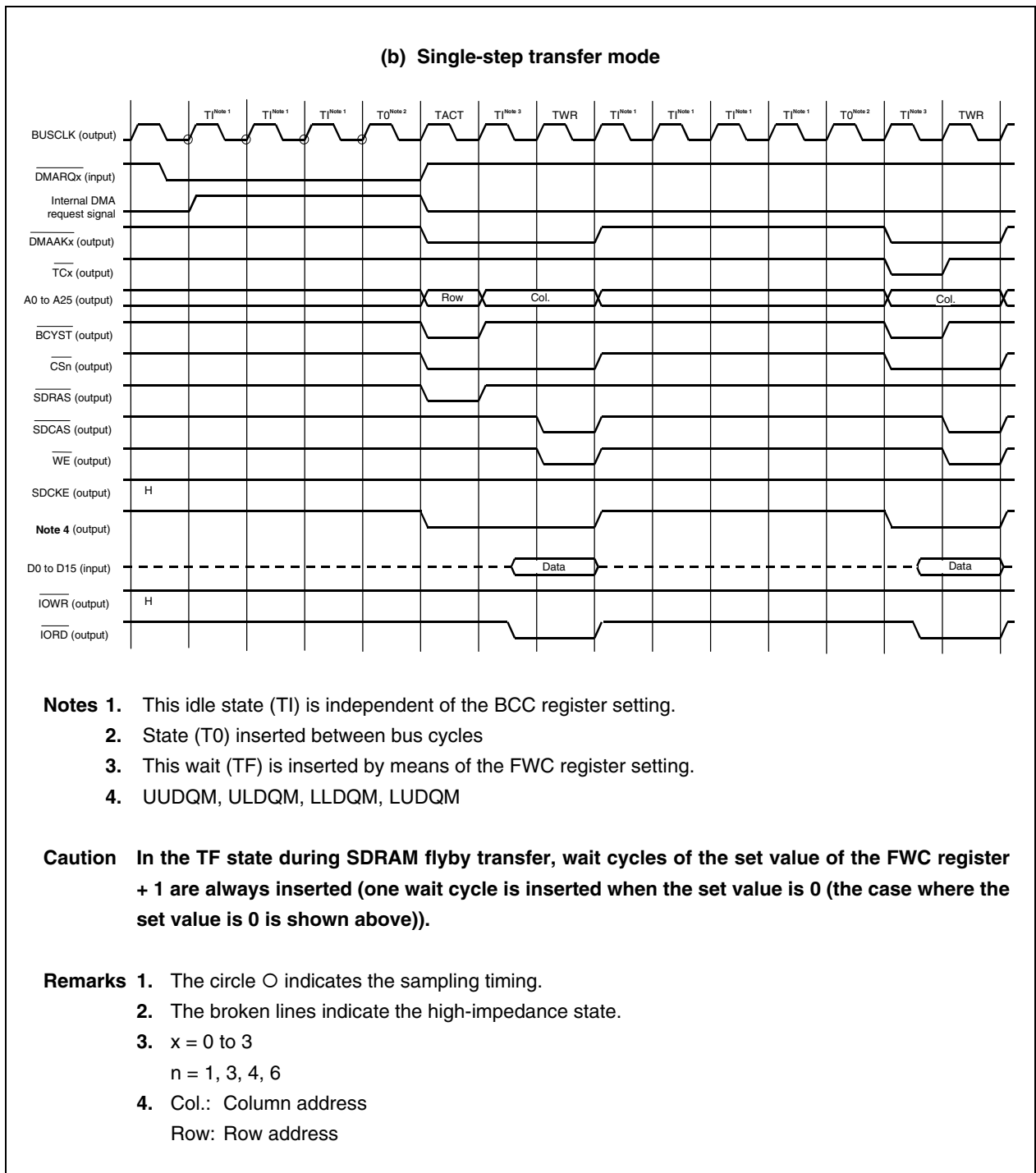


**Figure 6-15. Timing of DMA Flyby Transfer (External I/O → SDRAM) (3/3)**

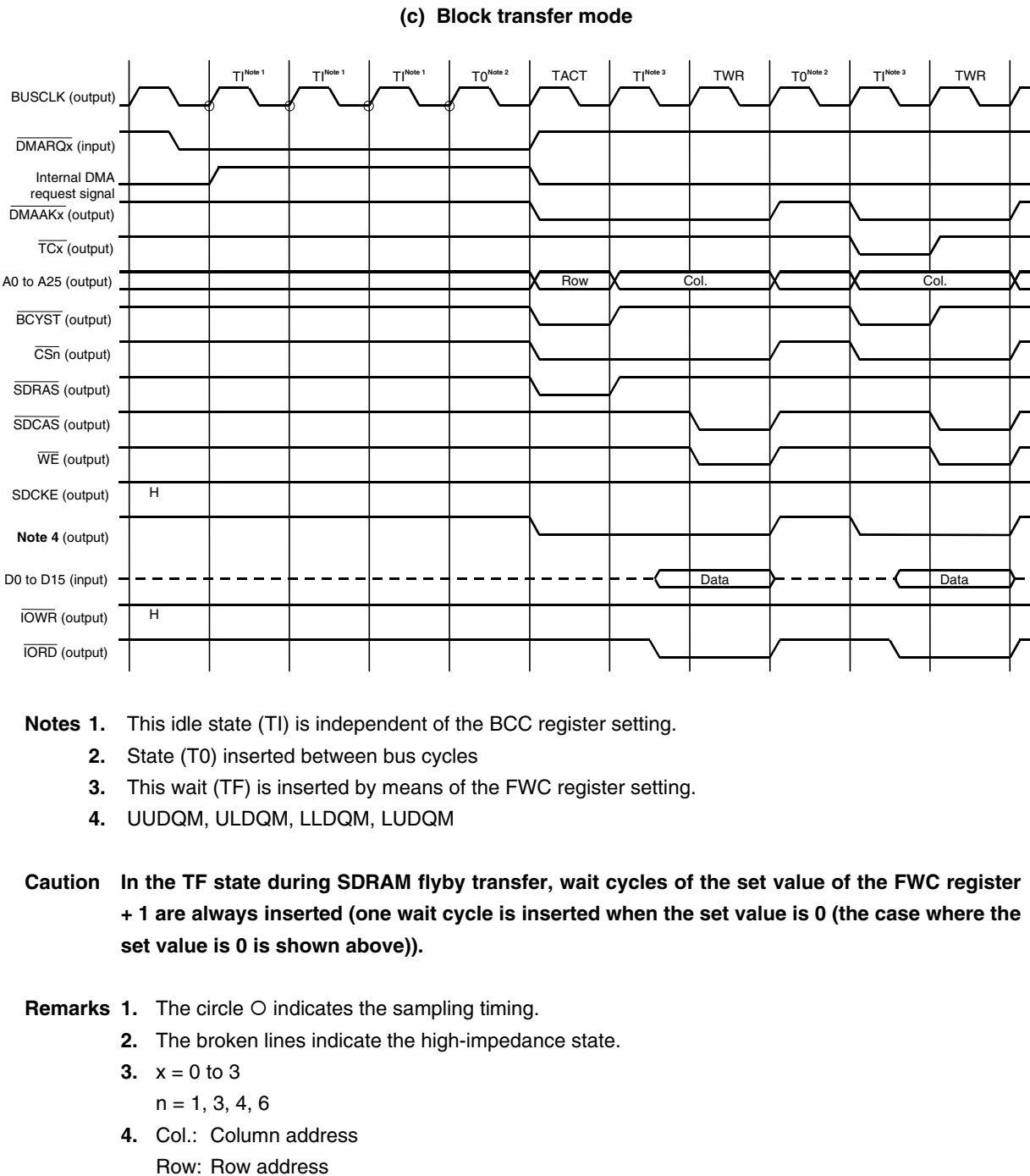


Figure 6-16. Timing of DMA Flyby Transfer (SRAM → External I/O) (1/2)

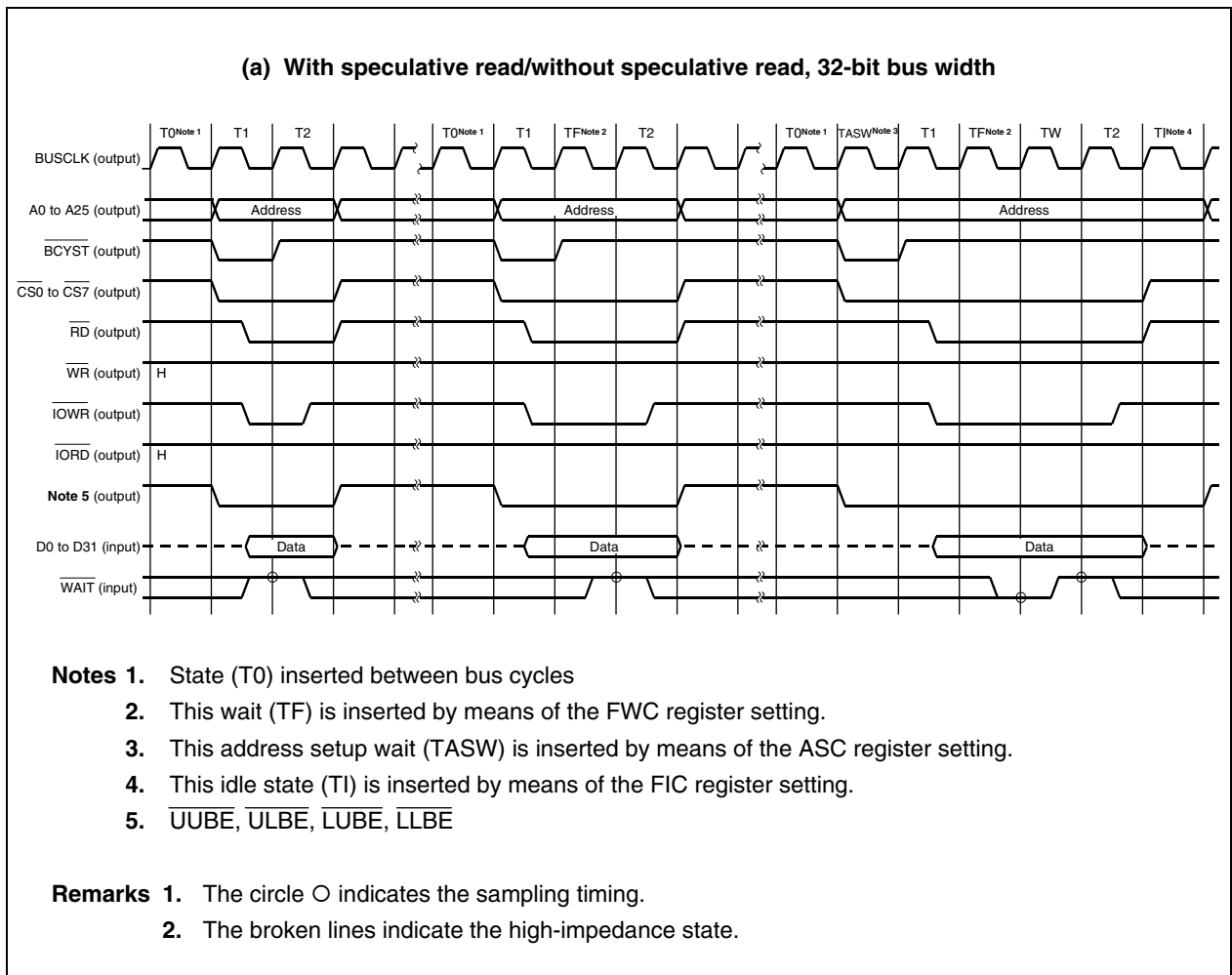
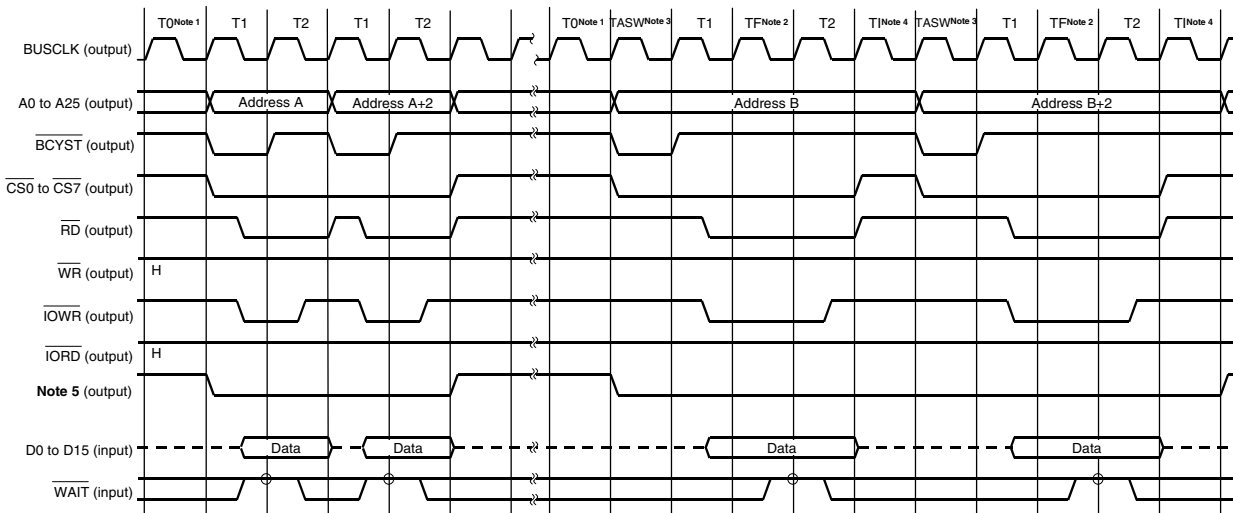


Figure 6-16. Timing of DMA Flyby Transfer (SRAM → External I/O) (2/2)

**(b) With speculative read/without speculative read, 16-bit bus width, 32-bit data transfer**

- Notes**
1. State (T0) inserted between bus cycles
  2. This wait (TF) is inserted by means of the FWC register setting.
  3. This address setup wait (TASW) is inserted by means of the ASC register setting.
  4. This idle state (TI) is inserted by means of the FIC register setting.
  5.  $\overline{UUBE}$ ,  $\overline{ULBE}$ ,  $\overline{LUBE}$ ,  $\overline{LLBE}$

- Remarks**
1. The circle ○ indicates the sampling timing.
  2. The broken lines indicate the high-impedance state.



Figure 6-17. Timing of DMA Flyby Transfer (External I/O → SRAM) (1/2)

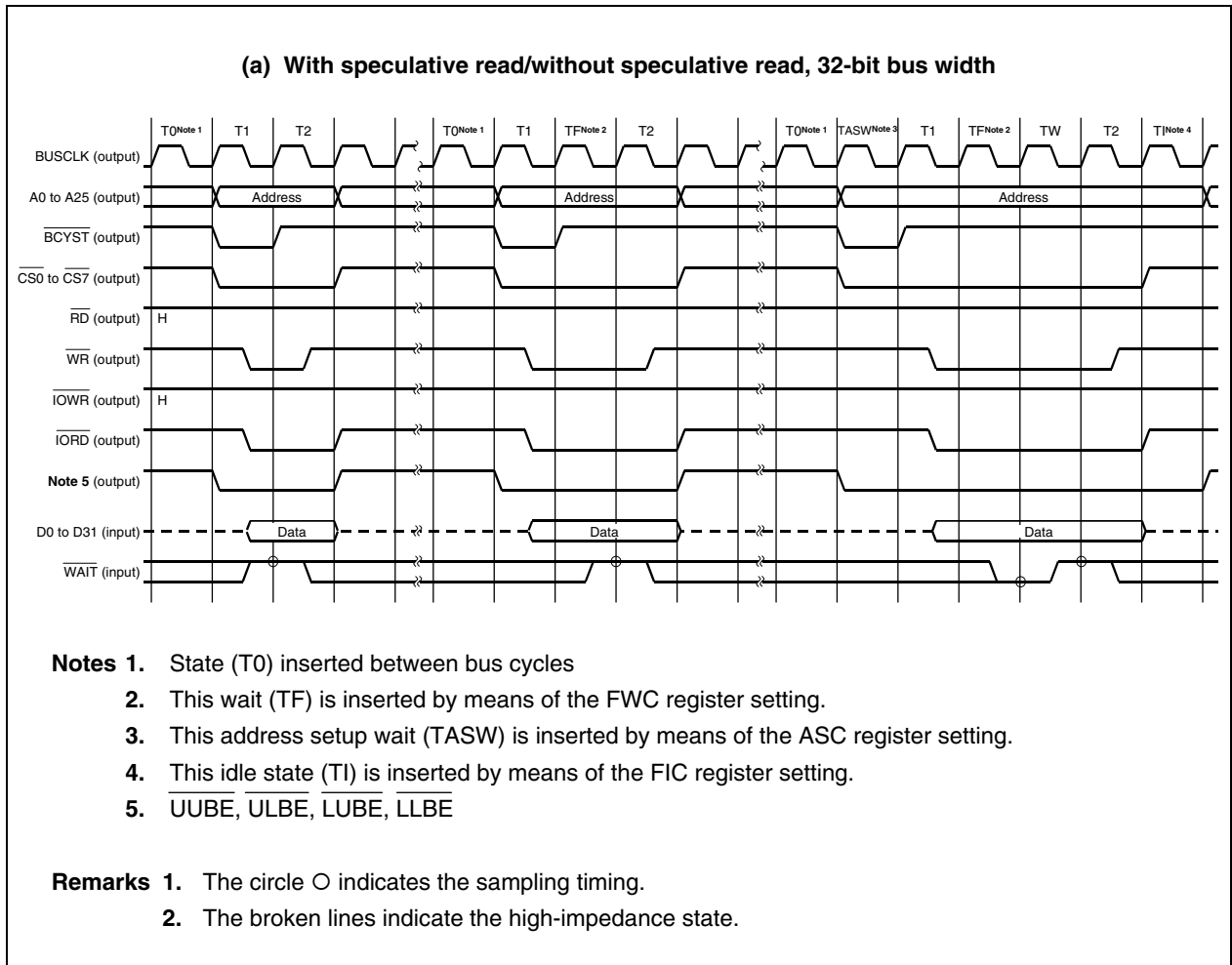
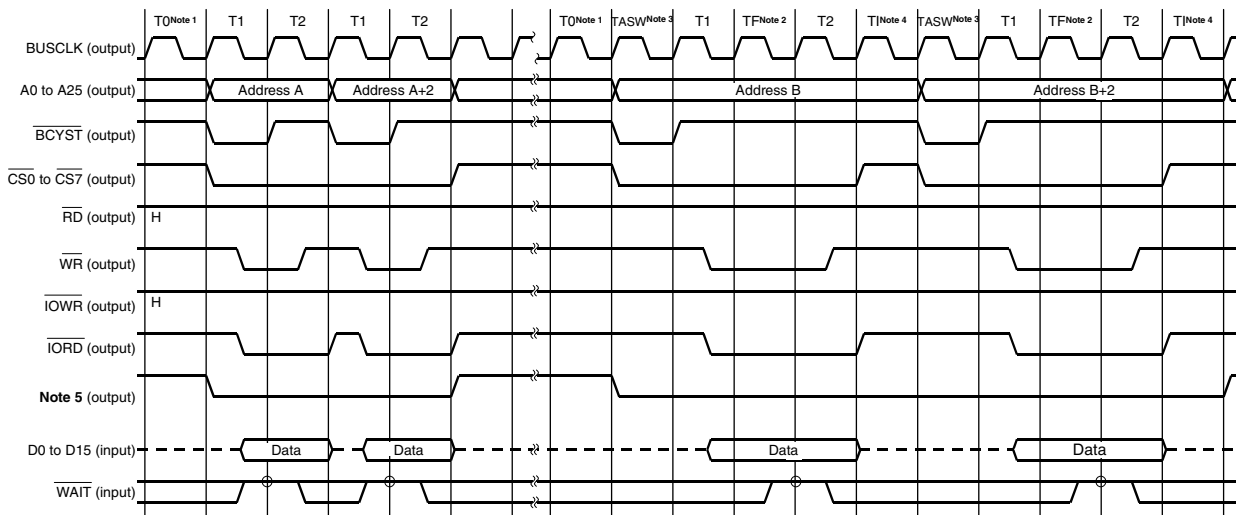


Figure 6-17. Timing of DMA Flyby Transfer (External I/O → SRAM) (2/2)

**(b) With speculative read/without speculative read, 16-bit bus width, 32-bit data transfer**

- Notes**
1. State (T0) inserted between bus cycles
  2. This wait (TF) is inserted by means of the FWC register setting.
  3. This address setup wait (TASW) is inserted by means of the ASC register setting.
  4. This idle state (TI) is inserted by means of the FIC register setting.
  5.  $\overline{UUBE}$ ,  $\overline{ULBE}$ ,  $\overline{LUBE}$ ,  $\overline{LLBE}$

- Remarks**
1. The circle ○ indicates the sampling timing.
  2. The broken lines indicate the high-impedance state.

Figure 6-18. Timing of DMA Flyby Transfer (Page ROM → External I/O) (1/2)

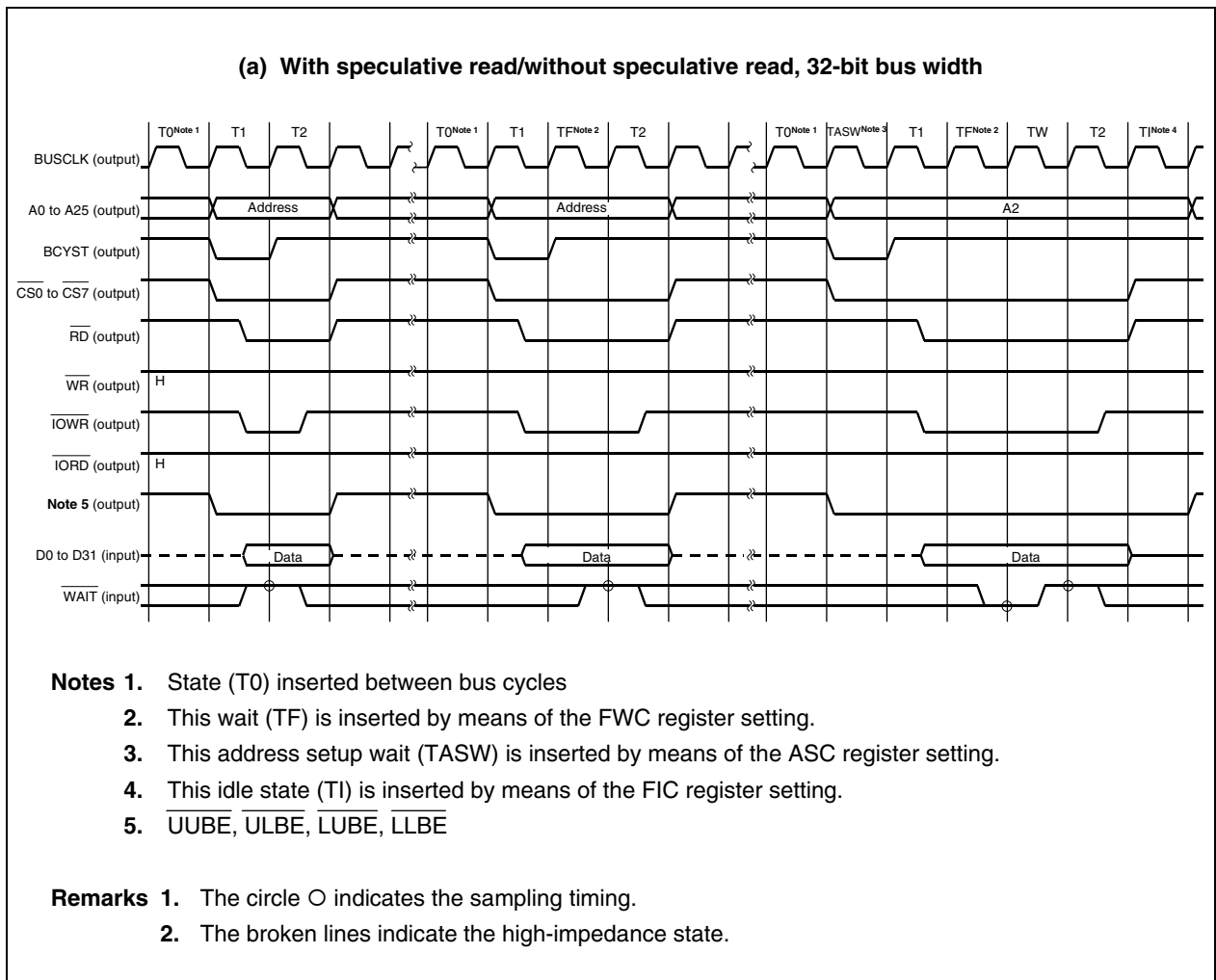
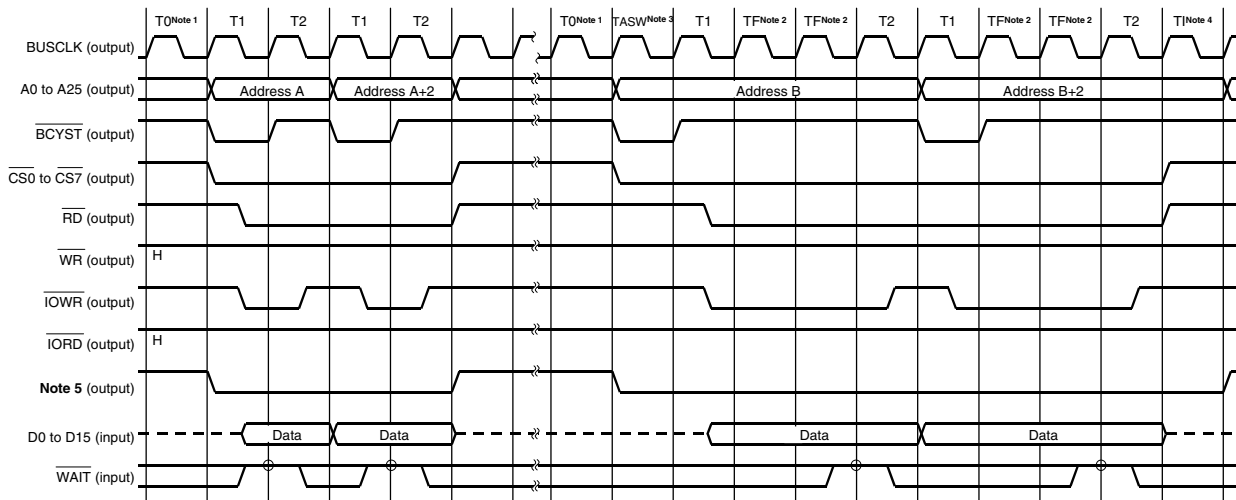


**Figure 6-18. Timing of DMA Flyby Transfer (Page ROM → External I/O) (2/2)****(b) With speculative read/without speculative read, 16-bit bus width, 32-bit data transfer**

- Notes**
1. State (T0) inserted between bus cycles
  2. This wait (TF) is inserted by means of the FWC register setting.
  3. This address setup wait (TASW) is inserted by means of the ASC register setting.
  4. This idle state (TI) is inserted by means of the FIC register setting.
  5.  $\overline{UUBE}$ ,  $\overline{ULBE}$ ,  $\overline{LUBE}$ ,  $\overline{LLBE}$

- Remarks**
1. The circle ○ indicates the sampling timing.
  2. The broken lines indicate the high-impedance state.

Figure 6-19. Timing of DMA Flyby Transfer (External I/O → SDRAM) (1/2)

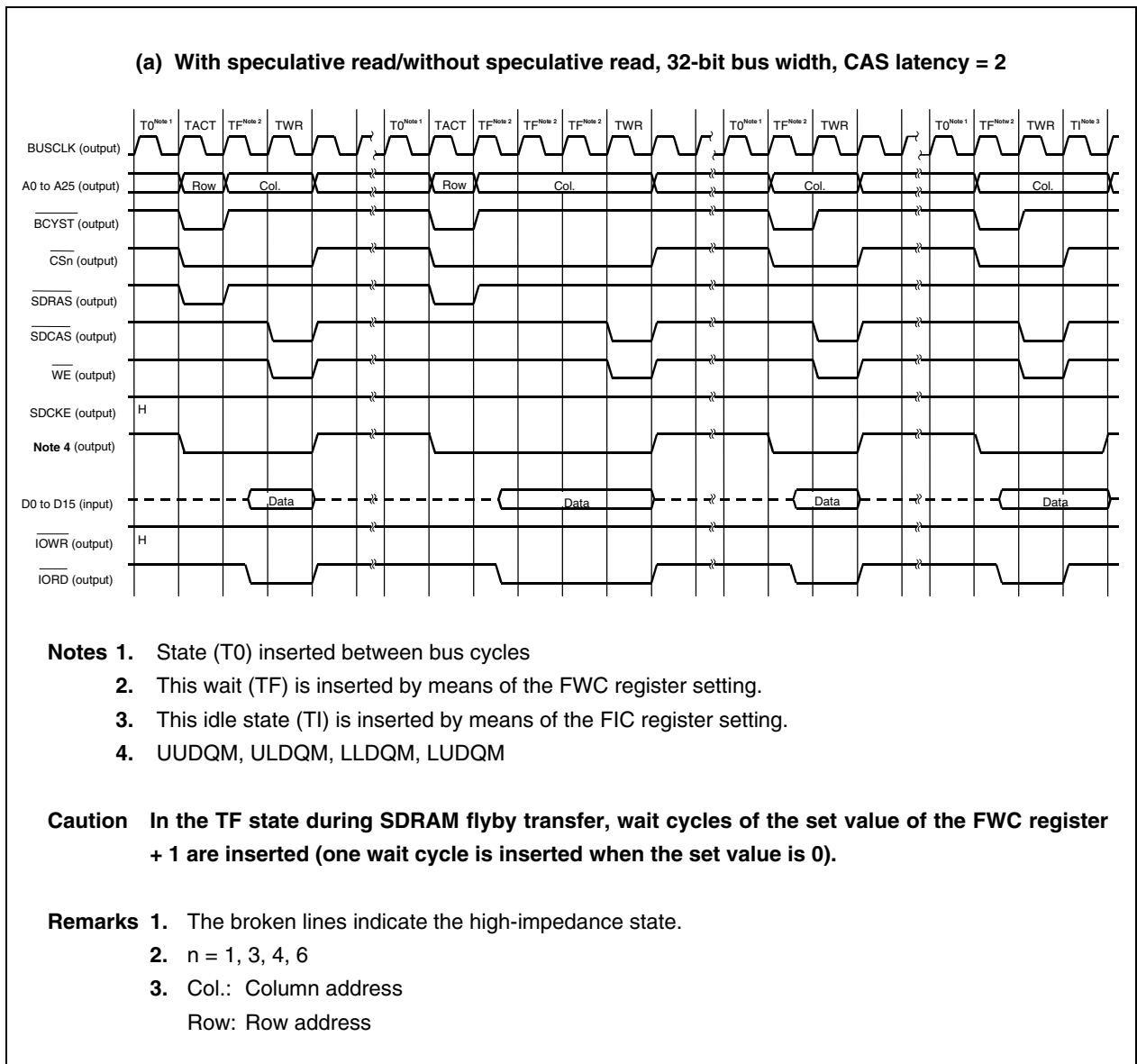
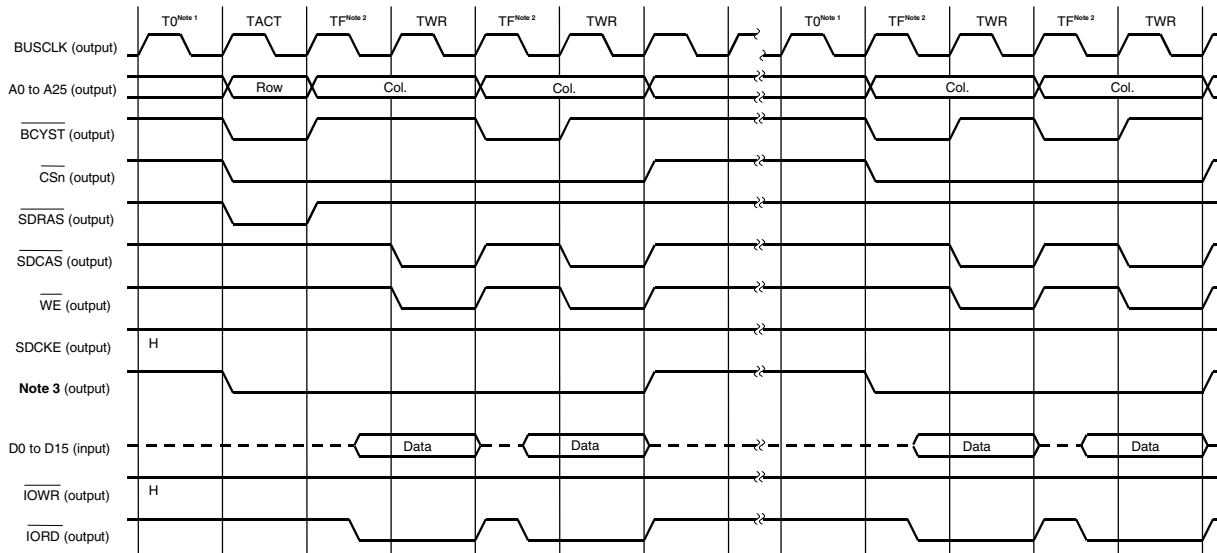


Figure 6-19. Timing of DMA Flyby Transfer (External I/O → SDRAM) (2/2)

(b) With speculative read/without speculative read, 16-bit bus width, 32-bit data transfer, CAS latency = 2



- Notes**
1. State (T0) inserted between bus cycles
  2. This wait (TF) is inserted by means of the FWC register setting.
  3. UUDQM, ULDQM, LLDQM, LUDQM

**Caution** In the TF state during SDRAM flyby transfer, wait cycles of the set value of the FWC register + 1 are inserted (one wait cycle is inserted when the set value is 0).

- Remarks**
1. The broken lines indicate the high-impedance state.
  2.  $n = 1, 3, 4, 6$
  3. Col.: Column address  
Row: Row address

## 6.6 Transfer Target

### 6.6.1 Transfer type and transfer target

Table 6-1 lists the relationships between transfer type and transfer target. The mark “√” means “transfer possible”, and the mark “x” means “transfer impossible”.

**Table 6-5. Relationship Between Transfer Type and Transfer Target**

|                 |                                          | Transfer Destination                     |              |                     |                          |                     |                        |                     |                   |                          |                 |
|-----------------|------------------------------------------|------------------------------------------|--------------|---------------------|--------------------------|---------------------|------------------------|---------------------|-------------------|--------------------------|-----------------|
|                 |                                          | 2-Cycle Transfer                         |              |                     |                          |                     | Flyby Transfer         |                     |                   |                          |                 |
|                 |                                          | On-chip Peripheral I/O <sup>Note 1</sup> | External I/O | Internal Data RAM   | Internal Instruction RAM | External Memory     | On-Chip Peripheral I/O | External I/O        | Internal Data RAM | Internal Instruction RAM | External Memory |
| Transfer source | On-chip peripheral I/O <sup>Note 1</sup> | √                                        | √            | √ <sup>Note 3</sup> | √ <sup>Note 4</sup>      | √ <sup>Note 2</sup> | x                      | x                   | x                 | x                        | x               |
|                 | External I/O                             | √                                        | √            | √                   | √ <sup>Note 4</sup>      | √                   | x                      | x                   | x                 | x                        | √               |
|                 | Internal data RAM                        | √                                        | √            | x                   | √ <sup>Note 4</sup>      | √                   | x                      | x                   | x                 | x                        | x               |
|                 | External memory                          | √ <sup>Note 2</sup>                      | √            | √ <sup>Note 3</sup> | √ <sup>Note 4</sup>      | √ <sup>Note 2</sup> | x                      | √ <sup>Note 5</sup> | x                 | x                        | x               |

<R>

- Notes**
1. If the transfer source is the on-chip peripheral I/O, only the single transfer mode can be used. However, if the start factor of the transfer is a request from the USB, the single transfer mode and single-step transfer mode can be used.
  2. Transfer can also be executed between a little-endian area and a big-endian area.
  3. See **6.15 (8) Restriction on 2-cycle DMA transfer** for restrictions on 2-cycle DMA transfer.
  4. When the internal instruction RAM is in the write mode (IRAMMn bit of IRAMM register = 1), it can be used only as a transfer destination.
  5. Flyby transfer to SDRAM is possible only from external I/O. The reverse direction is not possible.

- Cautions**
1. The operation is not guaranteed for combinations of transfer destination and source marked with “x” in Table 6-5.
  2. In the case of flyby transfer, make the data bus width the same for the source and destination.
  3. Addresses between 3FFF000H and 3FFFFFFH cannot be specified for the source and destination address of DMA transfer. Be sure to specify an address between FFFF000H and FFFFFFFH.
  4. Do not use DMA transfer to set on-chip peripheral I/O registers and to read the set values.

- Remarks**
1. During 2-cycle DMA transfer, if the data bus width of the transfer source and that of the transfer destination are different, the operation becomes as follows.  
If DMA transfer is executed to transfer data of an on-chip peripheral I/O register (as a transfer source or destination), be sure to specify the same transfer size as the register size. For example, to execute DMA transfer of an 8-bit register, be sure to specify byte (8-bit) transfer.

<32-bit transfer>

- Transfer from a 32-bit bus to a 16-bit bus

A read cycle (32 bits) is generated and then a write cycle (16 bits) is generated twice consecutively.

- Transfer from a 32-bit bus to an 8-bit bus  
A read cycle (32 bits) is generated and then a write cycle (8 bits) is generated 4 times consecutively.
- Transfer from a 16-bit bus to an 8-bit bus  
A read cycle (16 bits) is generated twice consecutively and then a write cycle (8 bits) is generated 4 times consecutively.
- Transfer from a 16-bit bus to a 32-bit bus  
A read cycle (16 bits) is generated twice consecutively and then a write cycle (32 bits) is generated. For how to write data to the transfer destination, see **Remark 2** below.
- Transfer from an 8-bit bus to a 32-bit bus  
A read cycle (8 bits) is generated 4 times consecutively and then a write cycle (32 bits) is generated. For how to write data to the transfer destination, see **Remark 2** below.
- Transfer from an 8-bit bus to a 16-bit bus  
A read cycle (8 bits) is generated 4 times consecutively and then a write cycle (16 bits) is generated twice consecutively. For how to write data to the transfer destination, see **Remark 2** below.

## &lt;16-bit transfer&gt;

- Transfer from a 32-bit bus to a 16-bit bus  
A read cycle (the higher 16 bits are high impedance) is generated and then a write cycle (16 bits) is generated.
- Transfer from a 32-bit bus to an 8-bit bus  
A read cycle (the higher 16 bits are high impedance) is generated and then a write cycle (8 bits) is generated twice consecutively.
- Transfer from a 16-bit bus to an 8-bit bus  
A read cycle (16 bits) is generated and then a write cycle (8 bits) is generated twice consecutively.
- Transfer from a 16-bit bus to a 32-bit bus  
A read cycle (16 bits) is generated and then a write cycle (the higher 16 bits are high impedance) is generated. For how to write data to the transfer destination, see **Remark 2** below.
- Transfer from an 8-bit bus to a 32-bit bus  
A read cycle (8 bits) is generated twice consecutively and then a write cycle (the higher 16 bits are high impedance) is generated. For how to write data to the transfer destination, see **Remark 2** below.
- Transfer from an 8-bit bus to a 16-bit bus  
A read cycle (8 bits) is generated twice consecutively and then a write cycle (16 bits) is generated. For how to write data to the transfer destination, see **Remark 2** below.

## &lt;8-bit transfer&gt;

- Transfer from a 32-bit bus to a 16-bit bus  
A read cycle (the higher 24 bits are high impedance) is generated and then a write cycle (the higher 8 bits are high impedance) is generated.
- Transfer from a 32-bit bus to an 8-bit bus  
A read cycle (the higher 24 bits are high impedance) is generated and then a write cycle (8 bits) is generated.
- Transfer from a 16-bit bus to an 8-bit bus  
A read cycle (the higher 8 bits are high impedance) is generated and then a write cycle (8 bits) is generated.



- Transfer from a 16-bit bus to a 32-bit bus

A read cycle (the higher 8 bits are high impedance) is generated and then a write cycle (the higher 24 bits are high impedance) is generated. For how to write data to the transfer destination, see **Remark 2** below.

- Transfer from an 8-bit bus to a 32-bit bus

A read cycle (8 bits) is generated and then a write cycle (the higher 24 bits are high impedance) is generated. For how to write data to the transfer destination, see **Remark 2** below.

- Transfer from an 8-bit bus to a 16-bit bus

A read cycle (8 bits) is generated and then a write cycle (the higher 8 bits are high impedance) is generated. For how to write data to the transfer destination, see **Remark 2** below.

**Remarks 2.** Under the following conditions, data is written to the lower byte and then the higher byte of the transfer destination in the little-endian mode, and to the higher byte and lower byte of the destination in the big-endian mode.

- Transfer from a 16-bit bus to a 32-bit bus
- Transfer from an 8-bit bus to a 32-bit bus
- Transfer from an 8-bit bus to a 16-bit bus

### 6.6.2 External bus cycles during DMA transfer

The external bus cycles during DMA transfer are shown below.

**Table 6-6. External Bus Cycles During DMA Transfer**

| Transfer Type    | Transfer Target                                                     | External Bus Cycle |                                                                                              |
|------------------|---------------------------------------------------------------------|--------------------|----------------------------------------------------------------------------------------------|
| 2-cycle transfer | On-chip peripheral I/O, internal data RAM, internal instruction RAM | None               | —                                                                                            |
|                  | External I/O                                                        | Yes                | SRAM cycle                                                                                   |
|                  | External memory                                                     | Yes                | Memory access cycle set by the BCT register                                                  |
| Flyby transfer   | Between external memory and external I/O                            | Yes                | DMA flyby transfer cycle accessing memory that is set as external memory by the BCT register |

## 6.7 DMA Channel Priorities

The DMA channel priorities are fixed as follows.

DMA channel 0 > DMA channel 1 > DMA channel 2 > DMA channel 3

In the block transfer mode, the channel used for transfer is never switched.

In the single-step transfer mode, if a higher priority DMA transfer request is issued while the bus is released, the higher priority DMA transfer request is acknowledged.

**Caution** If DMA is started by inputting the same signal to more than one  $\overline{\text{DMARQn}}$  pin ( $n = 0$  to 3), a DMA channel with a lower priority may be acknowledged before a DMA channel with a higher priority.

## 6.8 Next Address Setting Function

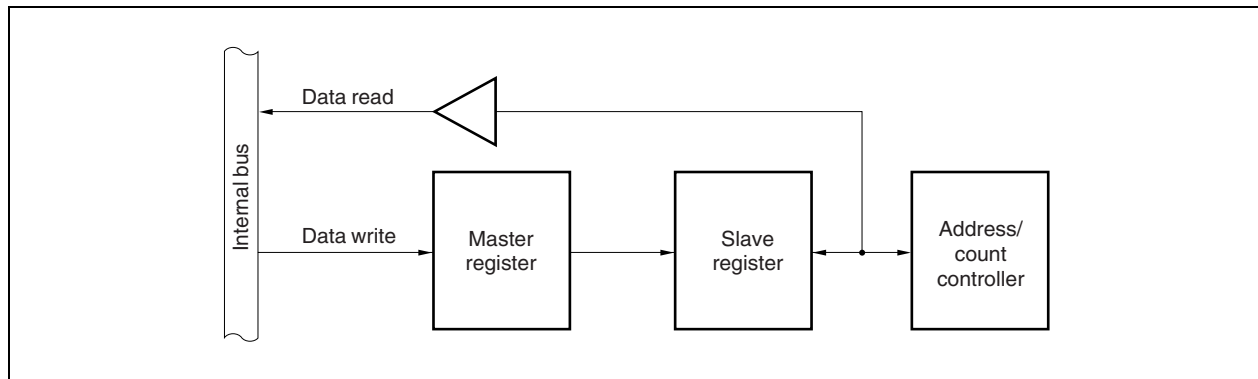
The DSAnH, DSAnL, DDAnH, DDAnL, and DBCn registers are buffer registers with a 2-stage FIFO format (n = 0 to 3).

When the terminal count is issued, these registers are automatically rewritten with the value that was set immediately before.

Therefore, during DMA transfer, transfer is automatically started when a new DMA transfer setting is made for these registers and the Enn bit of the DCHCn register, and MLEn bit is set to 1 (however, the DMA transfer end interrupt may be issued even if DMA transfer is automatically started).

The configuration of the buffer register is shown below.

**Figure 6-20. Buffer Register Configuration**



The actual DMA transfer is executed in accordance with the contents of the slave register.

The set values that are reflected in the master register and slave register differ as follows, depending on the timing (period) of setting the registers.

**(1) Period from system reset to the beginning of the first DMA transfer**

The set value is reflected in both the master register and slave register.

**(2) During DMA transfer (period from the beginning to the end of DMA transfer)**

The set value is reflected only in the master register and not in the slave register (the slave register holds the set value for the next DMA transfer).

However, the contents of the master register are automatically overwritten to the slave register after completion of DMA transfer. If the value of each register is read during this period, the value of the slave register is read.

**(3) Period from the end of DMA transfer to the beginning of the next DMA transfer**

The set value is reflected in both the master register and slave register.

**Remark** “The end of DMA transfer” means either of the following.

- Completion of DMA transfer (terminal count)
- Forced termination of DMA transfer (setting the INITn bit of the DMA channel control register (DCHCn) to 1)

If the setting of a new DMA transfer is made using the DSA<sub>n</sub>H, DSA<sub>n</sub>L, DDA<sub>n</sub>L, and DBC<sub>n</sub> registers during DMA transfer, the values of the registers are automatically updated after completion of transfer<sup>Note</sup>.

**Note** Before setting a new DMA transfer, confirm the start of the preceding DMA transfer.

If the setting of the new DMA transfer is made before the start of the preceding DMA transfer, the new set value is overwritten to both the master register and slave register, and DMA transfer according to the preceding set value cannot be executed.

## 6.9 DMA Transfer Start Factors

There are 4 types of DMA transfer start factors, as shown below.

- Cautions**
1. Do not use two or more start factors ((1) to (4)) in combination for the same channel (if two or more start factors are generated at the same time, only one of them is valid, but the valid start factor cannot be identified).

The operation is not guaranteed if two or more start factors are used in combination.

2. If DMA transfer is started via software and if the software does not correctly detect whether the expected DMA transfer operation has been completed through manipulation (setting to 1) of the STGn bit of the DCHCn register, it cannot be guaranteed whether the next (second) manipulation of the STGn bit corresponds to the start of “the next DMA transfer expected by software” (n = 0 to 3).

For example, suppose single transfer is started by manipulating the STGn bit. Even if the STGn bit is manipulated next (the second time) without checking by software whether the single transfer has actually been executed, the next (second) DMA transfer is not always executed. This is because the STGn bit may be manipulated the second time before the first DMA transfer is started or completed because, for example, DMA transfer with a higher priority had already been started when the STGn bit was manipulated for the first time.

It is therefore necessary to manipulate the STGn bit next time (the second time) after checking whether DMA transfer started by the first manipulation of the STGn bit has been completed.

Completion of DMA transfer can be checked in the following ways.

- Detecting the acknowledge signal ( $\overline{\text{DMAAKn}}$ ) or terminal count signal ( $\overline{\text{TCn}}$ ) by using a peripheral port or interrupt
- Checking the contents of the DBCn register

&lt;R&gt;

**(1) Request from an external pin ( $\overline{\text{DMARQn}}$ )**

Requests from the  $\overline{\text{DMARQn}}$  pin are sampled each time the BUSCLK signal rises ( $n = 0$  to  $3$ ).

Hold the request from  $\overline{\text{DMARQn}}$  pin until the corresponding  $\overline{\text{DMAAKn}}$  signal becomes active.

If a state whereby the Enn bit of the DCHCn register = 1 and the TCn bit = 0 is set, the  $\overline{\text{DMARQn}}$  signal becomes valid. If the  $\overline{\text{DMARQn}}$  signal set by the DTFRn register becomes active in this status, DMA transfer starts.

**(2) Request from software**

If the STGn, Enn, and TCn bits of the DCHCn register are set as follows, DMA transfer starts ( $n = 0$  to  $3$ ).

- STGn bit = 1
- Enn bit = 1
- TCn bit = 0

**(3) Request from on-chip peripheral I/O**

If, when the Enn and TCn bits of the DCHCn register are set as shown below, an interrupt request is issued from the on-chip peripheral I/O that is set in the DTFRn register, DMA transfer starts ( $n = 0$  to  $3$ ).

- Enn bit = 1
- TCn bit = 0

&lt;R&gt;

**(4) Request by USB (enabled only in single transfer mode and single-step transfer mode)**

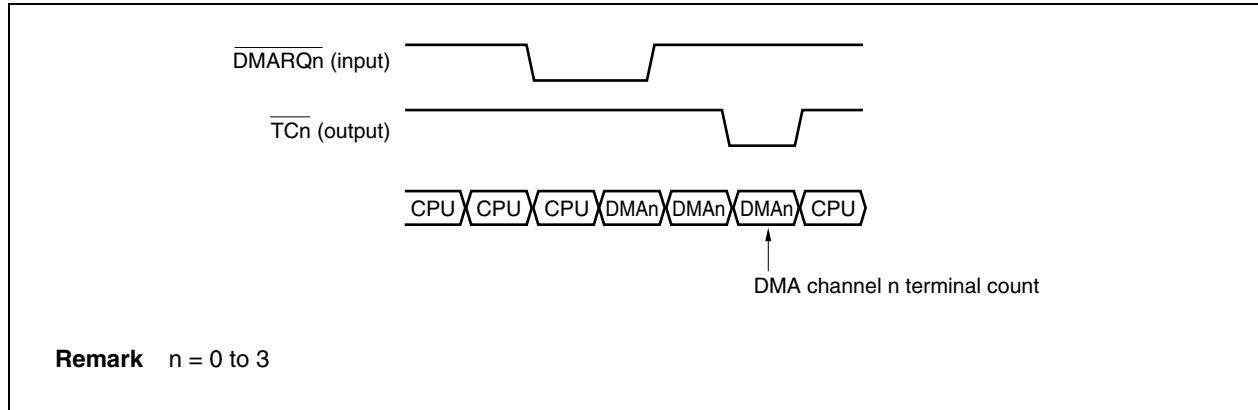
If a request is generated from the USB set to the DTFRn register when the Enn and TCn bits of the DCHCn register are set as follows, DMA transfer starts ( $n = 0$  to  $3$ ).

- Enn bit = 1
- TCn bit = 0

## 6.10 Terminal Count Output upon DMA Transfer End

The terminal count signal ( $\overline{TCn}$ ) becomes active for one clock of BUSCLK during the last DMA transfer cycle ( $n = 3$  to 0).

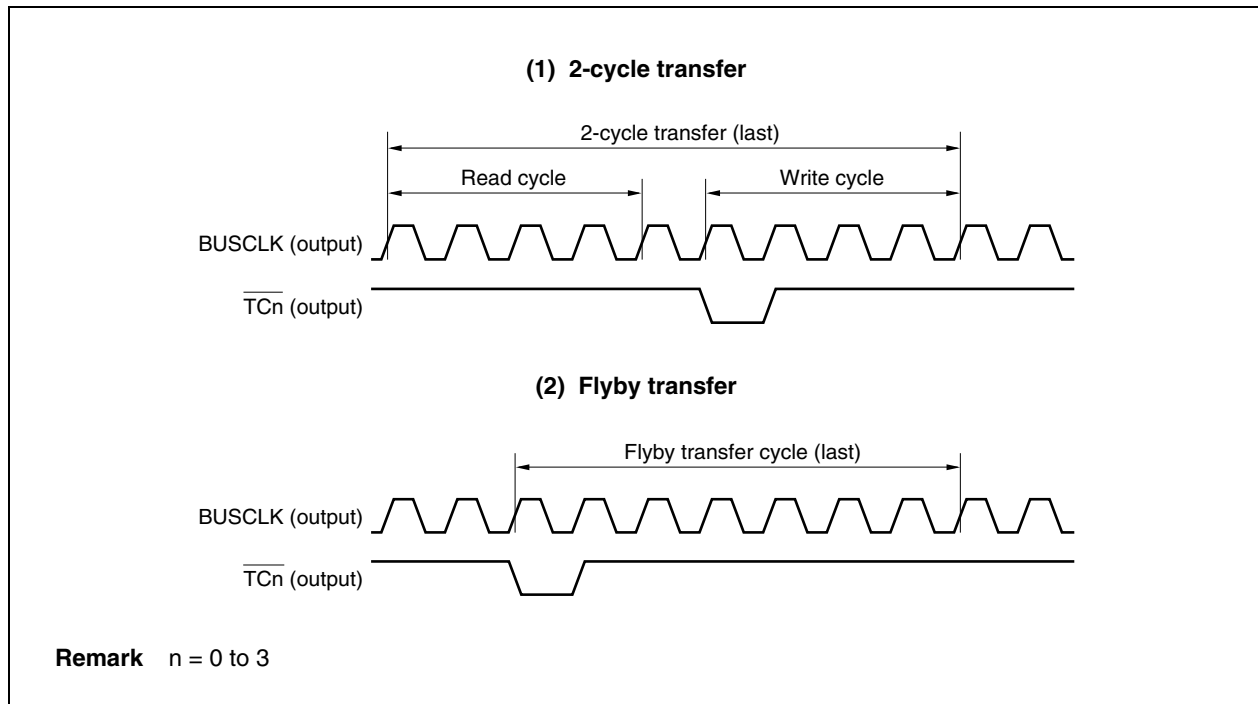
**Figure 6-21. Terminal Count Signal ( $\overline{TCn}$ ) Timing Example (1)**



The  $\overline{TCn}$  signal becomes active for one clock in any clock, from which the  $\overline{DMAAKn}$  signal of the last DMA transfer is output when 2-cycle transfer is executed. If the transfer destination is the internal data RAM, however, the  $\overline{TCn}$  signal is not output.

When flyby transfer is executed, the  $\overline{TCn}$  signal becomes active for one clock at the clock in which the  $\overline{BCYST}$  signal of the last DMA transfer cycle becomes active.

**Figure 6-22. Terminal Count Signal ( $\overline{TCn}$ ) Timing Example (2)**



### 6.11 Forcible Interruption

DMA transfer can be forcibly interrupted by NMI input during DMA transfer.

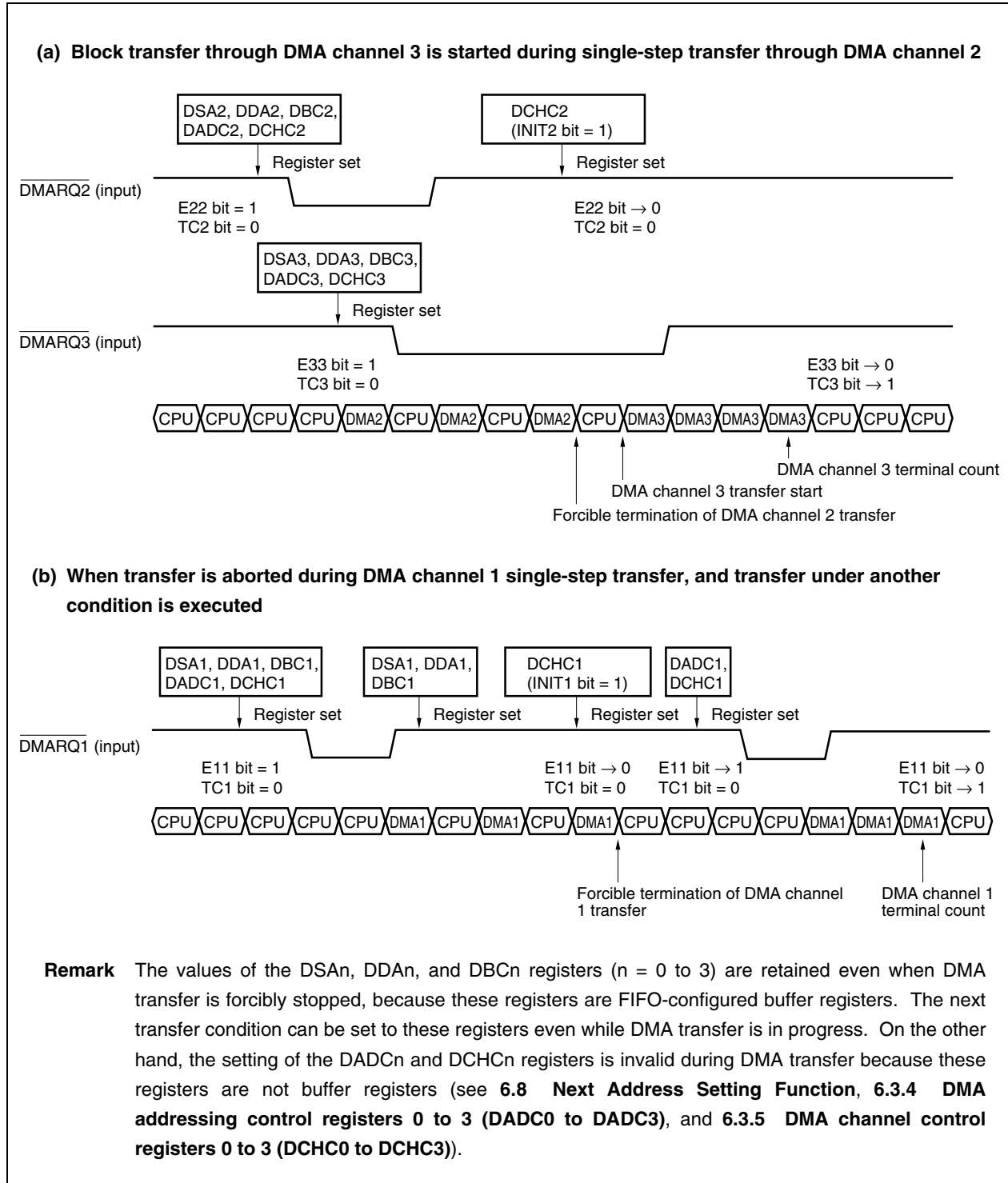
At such a time, the DMAC resets the Enn bit of the DCHCn register of all channels to 0 and the DMA transfer disabled state is entered. An NMI request can then be acknowledged after the DMA transfer that was being executed when the NMI was input is complete (n = 0 to 3).

## 6.12 Forcible Termination

DMA transfer can be forcibly terminated by the INITn bit of the DCHCn register, in addition to the forcible interruption operation by means of NMI input (n = 0 to 3).

An example of forcible termination by the INITn bit of the DCHCn register is illustrated below (n = 0 to 3).

Figure 6-23. Example of Forcible Termination of DMA Transfer





### 6.13 Times Related to DMA Transfer

The overhead before and after DMA transfer and minimum execution clock for DMA transfer are shown below. In the case of external memory access, the time depends on the type of external memory connected.

**Table 6-7. Number of Minimum Execution Clocks in DMA Cycle**

| DMA Cycle                          |                                                                  | Number of Minimum Execution Clocks                          |
|------------------------------------|------------------------------------------------------------------|-------------------------------------------------------------|
| <1> Time to respond to DMA request |                                                                  | 4 clocks <sup>Note 1</sup>                                  |
| <2> Memory access                  | External memory access                                           | Differs depending on the memory connected                   |
|                                    | Internal data RAM or internal instruction RAM (read mode) access | 2 clocks <sup>Note 2</sup>                                  |
|                                    | On-chip peripheral I/O register access                           | 3 clocks + Number of wait cycles specified by VSWC register |

**Notes** 1. If an external interrupt (INTP<sub>n</sub>) is specified as a factor of starting DMA transfer, noise elimination time is added (n = 10, 11, 21 to 25, 50 to 52, 65 to 67, D0 to D15, L0, or L1).

2. Two clocks are required for the DMA cycle.

The minimum execution clock in the DMA cycle in each transfer mode is as follows.

#### 2-cycle transfer

- Single transfer: DMA response time (<1>) + Transfer source memory access (<2>) + 1<sup>Note</sup> + Transfer destination memory access (<2>)
- Block transfer: DMA response time (<1>) + (Transfer source memory access (<2>) + 1<sup>Note</sup> + Transfer destination memory access (<2>)) × Number of transfers

**Note** One clock is always inserted between the read cycle and write cycle of DMA transfer. However, two clocks are inserted when the undivided external bus clock is used.

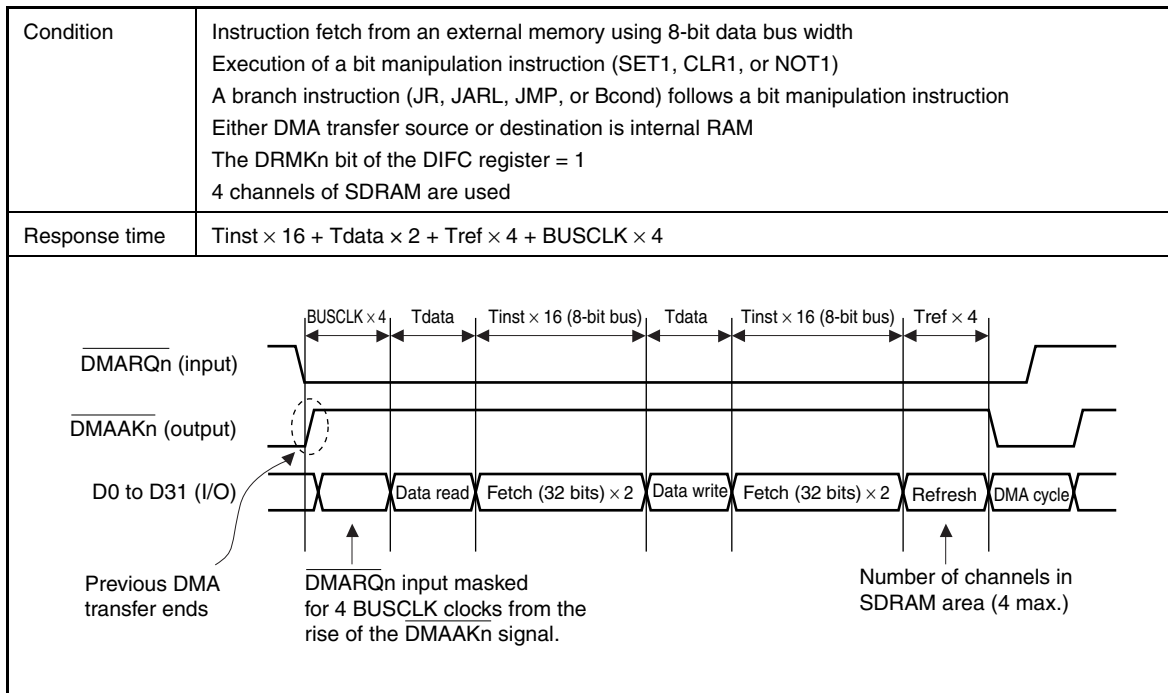
Flyby transfer: DMA response time (<1>) + External memory access (<2>)

### 6.14 Maximum Response Time for DMA Transfer Request

The response time for a DMA transfer request becomes the longest under the following conditions (state in which all the refresh cycles for the SDRAM are enabled).

**Caution** The wait time caused by the following conditions is not included.

- DMA transfer with a higher priority occurs
- When DMA transfer triggered by other than the  $\overline{\text{DMARQn}}$  pin input occurs
- External bus hold
- Speculative read buffer
- Cache miss-hit



**Remarks 1.**  $T_{\text{inst}}$ : Number of clocks per bus cycle during instruction fetch

$T_{\text{data}}$ : Number of clocks per bus cycle during data access

$T_{\text{ref}}$ : Number of clocks per refresh cycle

$\text{BUSCLK} \times 4$ : Time for masking  $\overline{\text{DMARQn}}$  input

2.  $n = 0$  to 3

## 6.15 Cautions

Cautions concerning the DMA function are shown below.

### (1) Memory boundary

The transfer operation is not guaranteed if the source or the destination address exceeds the area of DMA objects (external memory, internal data RAM, internal instruction RAM, or on-chip peripheral I/O) during DMA transfer.

### (2) Transfer of misaligned data

DMA transfer of 32-/16-bit bus width misaligned data is not supported. If the source or the destination address is set to an odd address, the LSB of the address is forcibly handled as "0".

### (3) Bus arbitration for CPU

When DMA transfer is executed to transfer data to/from an external device, the CPU can access internal data RAM and internal instruction RAM<sup>Note</sup> not being used for DMA transfer.

Because the DMA controller has a priority higher than the CPU acquiring bus mastership, a CPU access that takes place during DMA transfer is kept waiting until the preceding DMA transfer is completed and the bus is released to the CPU. If DMA transfer is executed between the external memory and on-chip peripheral I/O, however, the CPU can access the internal data RAM and internal instruction RAM<sup>Note</sup>.

**Note** When the IRAMMn bit of the IRAMM register = 0 (n = 0, 1)

### (4) Holding $\overline{\text{DMARQn}}$ signal

Be sure to keep the  $\overline{\text{DMARQn}}$  signal active until the  $\overline{\text{DMAAKn}}$  signal becomes active (n = 0 to 3).

### (5) $\overline{\text{DMAAKn}}$ signal output

When the transfer target is internal data RAM, the  $\overline{\text{DMAAKn}}$  signal is not output during a DMA cycle for internal data RAM (for example, if 2-cycle transfer is performed from internal data RAM to an external memory, the  $\overline{\text{DMAAKn}}$  signal is output only during a DMA write cycle for the external memory).

If the transfer target is the on-chip peripheral I/O or internal instruction RAM, the  $\overline{\text{DMAAKn}}$  signal is output even in the DMA cycle executed on the on-chip peripheral I/O or internal instruction RAM.

The  $\overline{\text{DMAAKn}}$  signal maintains the active state during the TI state of flyby transfer.

### (6) DMA start factors

Do not start two or more DMA channels with the same factor. If two or more DMA channels are started with the same factor, the DMA channel with the lower priority may be accepted before the DMA channel with the higher priority.

**(7) Read values of DSAn and DDAn registers**

If the values of the DSAn and DDAn registers are read during DMA transfer, the values in the middle of being updated may be read (n = 0 to 3).

For example, if the DSAnH register and the DSAnL register are read in that order when the value of the DMA transfer source address (DSAn register) is "0000FFFFH" and the counting direction is incremental (when the SADn1 and SADn0 bits of the DADn register = 00), the value of the DSAnL register differs as follows depending on whether DMA transfer is executed immediately after the DSAnH register has been read.

**(a) If DMA transfer does not occur while the DSAn register is being read**

<1> Reading DSAnH register: DSAnH = 0000H

<2> Reading DSAnL register: DSAnL = FFFFH

**(b) If DMA transfer occurs while the DSAn register is being read**

<1> Reading DSAnH register: DSAnH = 0000H

<2> Occurrence of DMA transfer

<3> Incrementing DSAn register : DSAn = 00010000H

<4> Reading DSAnL register: DSAnL = 0000H

**(8) Restriction on 2-cycle DMA transfer**

When performing any of the following 2-cycle DMA transfers, the TC signal output may become active twice (normally it becomes active once) and the DMA transfer end interrupt may occur twice (normally it occurs once) when the last data has been transferred. However, the DMA transfer itself is completed normally.

This bug does not occur during flyby transfer.

- The speculative read function (set by the LBC0 or LBC1 register) is enabled for a CS space and 2-cycle DMA transfer from external memory to internal data RAM is executed.
- 2-cycle DMA transfer from on-chip peripheral I/O to internal data RAM is executed (regardless of the speculative read function setting).

**[Countermeasures]**

- In the case of 2-cycle DMA transfer from external memory to internal data RAM  
Disable the speculative read function for the CS space in the DMA transfer source (side to be read).
- In the case of 2-cycle DMA transfer from on-chip peripheral I/O to internal data RAM  
Do not use the TC signal. In addition, execute the processing of <1> and <2> below consecutively for the excessive DMA transfer end interrupt in the DMA transfer end interrupt servicing routine. After the processing of <2> is executed, by executing the application processing that should be performed in the normal operation and restoring from the interrupt, occurrence of the second DMA transfer end interrupt can be suppressed.

<1> Clear the WAS register to 00H.

<2> Clear bit 7 (DMAIFn) of the interrupt control register (DMAICn) of the same channel as the DMA transfer end interrupt currently being serviced to 0 (n = 0 to 3).

**(9) Caution on setting DSAnH register**

When setting an address of an on-chip peripheral I/O register for the source address, be sure to specify an address between FFFF000H and FFFFFFFFH. An address of the on-chip peripheral I/O register image (3FFF000H to 3FFFFFFFH) must not be specified.

**(10) Cautions on setting DDAnH register**

- When setting an address of an on-chip peripheral I/O register for the destination address, be sure to specify an address between FFFF000H and FFFFFFFFH. An address of the on-chip peripheral I/O register image (3FFF000H to 3FFFFFFFH) must not be specified.
- When enabling the speculative read function is selected for the CS space at the DMA transfer destination, set the DMA transfer destination address so that the address on which a speculative read is performed and the line address to which the last DMA transfer data is written are not the same line address (the same line address means that A25 to A4 are the same in the same CS space).

**(11) Cautions on setting DADCn register**

Do not set flyby transfer via the TYPn bit of the DADCn register if all the following conditions are satisfied (n = 0 to 3).

- BMC register = 00H
- FWn2 to FWn0 bits of FWC register = 000
- Fln1 and Fln0 bits of FIC register = 00
- ACn1 and ACn0 bits of the CSn space subject to flyby transfer by the ASC register = 00 (during transfer to/from SRAM)

**(12) Cautions on setting DCHCn register**

- During a 2-cycle transfer that performs a write operation on the external device, the write operation on the external device may not be completed even if the TCn bit of the DCHCn register is set to 1 (DMA transfer completion) by the write buffer function. Recognize completion of the write operation on the external device as follows, if necessary.
  - (a) Monitor the signal of the  $\overline{\text{TCn}}$  pin (the  $\overline{\text{TCn}}$  pin becomes active in synchronization with a write operation to the external device).
  - (b) After it has been detected that the TCn bit of the DCHCn register is set to 1, write 00H to the WAS register or write the same value as that set to the LBC0 or LBC1 register. When this write is completed, completion of an access from the write buffer to the external device can be recognized. If the set value of the LBC0 or LBC1 register is rewritten when a dummy write to the LBC0 or LBC1 register is executed, the operation is not guaranteed.

<R>

- The TCn bit does not have to be read (cleared to 0) on completion of DMA transfer (on generation of the terminal count) only if the following two conditions are satisfied. If either of the conditions is not satisfied, be sure to read the TCn bit (cleared to 0) before the next DMA transfer request is generated.
  - (a) If the MLEn bit of the DCHCn register is set to 1 upon completion of DMA transfer (at terminal count)
  - (b) If the next DMA transfer start factor is an external pin ( $\overline{\text{DMARQn}}$ )

If these two conditions are not satisfied, the operation is not guaranteed if the next DMA transfer request is generated with the TCn bit set to 1.

**(13) Caution on setting DTFRn register**

An interrupt request from an on-chip peripheral I/O input in the standby mode (IDLE or software STOP mode) is held pending as a DMA transfer start factor. The held DMA start factor is executed following return to the normal operation mode.

**(14) DMAAKn signal active width extension function**

The function to extend the active width of the DMAAKn signal can be used only during 2-cycle transfer ( $n = 0$  to 3). It cannot be used during flyby transfer. The operation is not guaranteed if it is used during flyby transfer.

**(15) SDRAM flyby transfer**

Flyby transfer to SDRAM is possible only from external I/O.

**6.15.1 Interrupt factors**

DMA transfer is interrupted if the following factors are issued.

- Bus hold
- Refresh cycle

If the factor that is interrupting DMA transfer disappears, DMA transfer promptly restarts.

**6.16 DMA Transfer End**

When DMA transfer ends and the TCn bit of the DCHCn register is set to 1, a DMA transfer end interrupt (INTDMAn) is issued to the interrupt controller (INTC) ( $n = 0$  to 3).

## CHAPTER 7 INTERRUPT/EXCEPTION PROCESSING FUNCTION

The V850E/ME2 is provided with a dedicated interrupt controller (INTC) for interrupt servicing and can process a total of 91 interrupt requests.

An interrupt is an event that occurs independently of program execution, and an exception is an event whose occurrence is dependent on program execution.

The V850E/ME2 can process interrupt requests from the on-chip peripheral hardware and external sources. Moreover, exception processing can be started by the TRAP instruction (software exception) or by generation of an exception event (i.e. fetching of an illegal opcode) (exception trap).

### 7.1 Features

#### ○ Interrupts

- Non-maskable interrupts: 1 source

**Caution** P20 is fixed to NMI input. The level of the NMI pin is read when the P20 bit of the P2 register is read, regardless of the value of the PM2 and PMC2 registers.

Set the valid edge of the NMI pin by using the NMIR0 bit of the INTR2 register and the NMIF0 bit of the INTF2 register (default value: both rising/falling edges detection).

- Maskable interrupts:  
External: 39 sources, Internal: 59 sources
- 8 levels of programmable priorities (maskable interrupts)
- Multiple interrupt control according to priority
- Masks can be specified for each maskable interrupt request.
- Noise elimination<sup>Note</sup>, edge detection, and valid edge specification for external interrupt request signals.

**Note** For details of the noise eliminator, see 14.6 Noise Eliminator.

#### ○ Exceptions

- Software exceptions: 32 sources
- Exception traps: 2 sources (illegal opcode exception and debug trap)

Interrupt sources are listed in Table 7-1.

Table 7-1. Interrupt Source List (1/3)

| Type               | Classification | Interrupt/Exception Source |                      |                                       |                 | Default Priority | Exception Code        | Handler Address | Restored PC |
|--------------------|----------------|----------------------------|----------------------|---------------------------------------|-----------------|------------------|-----------------------|-----------------|-------------|
|                    |                | Name                       | Controlling Register | Generating Source                     | Generating Unit |                  |                       |                 |             |
| Reset              | Interrupt      | RESET                      | –                    | Reset input                           | –               | –                | 0000H                 | 00100000H       | Undefined   |
| Non-maskable       | Interrupt      | NMI0                       | –                    | NMI input                             | –               | –                | 0010H                 | 00000010H       | nextPC      |
| Software exception | Exception      | TRAP0 <sup>Note</sup>      | –                    | TRAP instruction                      | –               | –                | 004nH <sup>Note</sup> | 00000040H       | nextPC      |
|                    | Exception      | TRAP1n <sup>Note</sup>     | –                    | TRAP instruction                      | –               | –                | 005nH <sup>Note</sup> | 00000050H       | nextPC      |
| Exception trap     | Exception      | ILGOP/<br>DBG0             | –                    | Illegal opcode/<br>DBTRAP instruction | –               | –                | 0060H                 | 00000060H       | nextPC      |
| Maskable           | Interrupt      | INTP10                     | P1IC0                | $\overline{\text{INTP10}}$ pin        | Pin             | 0                | 0080H                 | 00000080H       | nextPC      |
|                    | Interrupt      | INTP11                     | P1IC1                | $\overline{\text{INTP11}}$ pin        | Pin             | 1                | 0090H                 | 00000090H       | nextPC      |
|                    | Interrupt      | INTP21                     | P2IC1                | $\overline{\text{INTP21}}$ pin        | Pin             | 2                | 00A0H                 | 000000A0H       | nextPC      |
|                    | Interrupt      | INTP22                     | P2IC2                | $\overline{\text{INTP22}}$ pin        | Pin             | 3                | 00B0H                 | 000000B0H       | nextPC      |
|                    | Interrupt      | INTP23                     | P2IC3                | $\overline{\text{INTP23}}$ pin        | Pin             | 4                | 00C0H                 | 000000C0H       | nextPC      |
|                    | Interrupt      | INTP24                     | P2IC4                | $\overline{\text{INTP24}}$ pin        | Pin             | 5                | 00D0H                 | 000000D0H       | nextPC      |
|                    | Interrupt      | INTP25                     | P2IC5                | $\overline{\text{INTP25}}$ pin        | Pin             | 6                | 00E0H                 | 000000E0H       | nextPC      |
|                    | Interrupt      | INTP50                     | P5IC0                | $\overline{\text{INTP50}}$ pin        | Pin             | 7                | 00F0H                 | 000000F0H       | nextPC      |
|                    | Interrupt      | INTP51                     | P5IC1                | $\overline{\text{INTP51}}$ pin        | Pin             | 8                | 0100H                 | 00000100H       | nextPC      |
|                    | Interrupt      | INTP52                     | P5IC2                | $\overline{\text{INTP52}}$ pin        | Pin             | 9                | 0110H                 | 00000110H       | nextPC      |
|                    | Interrupt      | INTP65                     | P6IC5                | $\overline{\text{INTP65}}$ pin        | Pin             | 10               | 0120H                 | 00000120H       | nextPC      |
|                    | Interrupt      | INTP66                     | P6IC6                | $\overline{\text{INTP66}}$ pin        | Pin             | 11               | 0130H                 | 00000130H       | nextPC      |
|                    | Interrupt      | INTP67                     | P6IC7                | $\overline{\text{INTP67}}$ pin        | Pin             | 12               | 0140H                 | 00000140H       | nextPC      |
|                    | Interrupt      | INTPD0                     | PDIC0                | $\overline{\text{INTPD0}}$ pin        | Pin             | 13               | 0150H                 | 00000150H       | nextPC      |
|                    | Interrupt      | INTPD1                     | PDIC1                | $\overline{\text{INTPD1}}$ pin        | Pin             | 14               | 0160H                 | 00000160H       | nextPC      |
|                    | Interrupt      | INTPD2                     | PDIC2                | $\overline{\text{INTPD2}}$ pin        | Pin             | 15               | 0170H                 | 00000170H       | nextPC      |
|                    | Interrupt      | INTPD3                     | PDIC3                | $\overline{\text{INTPD3}}$ pin        | Pin             | 16               | 0180H                 | 00000180H       | nextPC      |
|                    | Interrupt      | INTPD4                     | PDIC4                | $\overline{\text{INTPD4}}$ pin        | Pin             | 17               | 0190H                 | 00000190H       | nextPC      |
|                    | Interrupt      | INTPD5                     | PDIC5                | $\overline{\text{INTPD5}}$ pin        | Pin             | 18               | 01A0H                 | 000001A0H       | nextPC      |
|                    | Interrupt      | INTPD6                     | PDIC6                | $\overline{\text{INTPD6}}$ pin        | Pin             | 19               | 01B0H                 | 000001B0H       | nextPC      |
|                    | Interrupt      | INTPD7                     | PDIC7                | $\overline{\text{INTPD7}}$ pin        | Pin             | 20               | 01C0H                 | 000001C0H       | nextPC      |
|                    | Interrupt      | INTPD8                     | PDIC8                | $\overline{\text{INTPD8}}$ pin        | Pin             | 21               | 01D0H                 | 000001D0H       | nextPC      |
|                    | Interrupt      | INTPD9                     | PDIC9                | $\overline{\text{INTPD9}}$ pin        | Pin             | 22               | 01E0H                 | 000001E0H       | nextPC      |
|                    | Interrupt      | INTPD10                    | PDIC10               | $\overline{\text{INTPD10}}$ pin       | Pin             | 23               | 01F0H                 | 000001F0H       | nextPC      |
|                    | Interrupt      | INTPD11                    | PDIC11               | $\overline{\text{INTPD11}}$ pin       | Pin             | 24               | 0200H                 | 00000200H       | nextPC      |
|                    | Interrupt      | INTPD12                    | PDIC12               | $\overline{\text{INTPD12}}$ pin       | Pin             | 25               | 0210H                 | 00000210H       | nextPC      |
|                    | Interrupt      | INTPD13                    | PDIC13               | $\overline{\text{INTPD13}}$ pin       | Pin             | 26               | 0220H                 | 00000220H       | nextPC      |
|                    | Interrupt      | INTPD14                    | PDIC14               | $\overline{\text{INTPD14}}$ pin       | Pin             | 27               | 0230H                 | 00000230H       | nextPC      |
|                    | Interrupt      | INTPD15                    | PDIC15               | $\overline{\text{INTPD15}}$ pin       | Pin             | 28               | 0240H                 | 00000240H       | nextPC      |
|                    | Interrupt      | INTPL0                     | PLIC0                | $\overline{\text{INTPL0}}$ pin        | Pin             | 29               | 0250H                 | 00000250H       | nextPC      |
|                    | Interrupt      | INTPL1                     | PLIC1                | $\overline{\text{INTPL1}}$ pin        | Pin             | 30               | 0260H                 | 00000260H       | nextPC      |
|                    | Interrupt      | INTOVC0                    | OVCIC0               | Timer C0 overflow                     | TMC0            | 31               | 0270H                 | 00000270H       | nextPC      |
|                    | Interrupt      | INTOVC1                    | OVCIC1               | Timer C1 overflow                     | TMC1            | 32               | 0280H                 | 00000280H       | nextPC      |
|                    | Interrupt      | INTOVC2                    | OVCIC2               | Timer C2 overflow                     | TMC2            | 33               | 0290H                 | 00000290H       | nextPC      |
|                    | Interrupt      | INTOVC3                    | OVCIC3               | Timer C3 overflow                     | TMC3            | 34               | 02A0H                 | 000002A0H       | nextPC      |
|                    | Interrupt      | INTOVC4                    | OVCIC4               | Timer C4 overflow                     | TMC4            | 35               | 02B0H                 | 000002B0H       | nextPC      |

**Note** n = 0H to FH



Table 7-1. Interrupt Source List (2/3)

| Type     | Classification | Interrupt/Exception Source |                      |                                             |                 | Default Priority | Exception Code | Handler Address | Restored PC |
|----------|----------------|----------------------------|----------------------|---------------------------------------------|-----------------|------------------|----------------|-----------------|-------------|
|          |                | Name                       | Controlling Register | Generating Source                           | Generating Unit |                  |                |                 |             |
| Maskable | Interrupt      | INTOVC5                    | OVCIC5               | Timer C5 overflow                           | TMC5            | 36               | 02C0H          | 000002C0H       | nextPC      |
|          | Interrupt      | INTPC00/<br>INTCCC00       | CCC0IC0              | Match of<br>INTPC00 pin/CCC00               | Pin/TMC0        | 37               | 02D0H          | 000002D0H       | nextPC      |
|          | Interrupt      | INTPC01/<br>INTCCC01       | CCC0IC1              | Match of<br>INTPC01 pin/CCC01               | Pin/TMC0        | 38               | 02E0H          | 000002E0H       | nextPC      |
|          | Interrupt      | INTPC10/<br>INTCCC10       | CCC1IC0              | Match of<br>INTPC10 pin/CCC10               | Pin/TMC1        | 39               | 02F0H          | 000002F0H       | nextPC      |
|          | Interrupt      | INTPC11/<br>INTCCC11       | CCC1IC1              | Match of<br>INTPC11 pin/CCC11               | Pin/TMC1        | 40               | 0300H          | 00000300H       | nextPC      |
|          | Interrupt      | INTPC20/<br>INTCCC20       | CCC2IC0              | Match of<br>INTPC20 pin/CCC20               | Pin/TMC2        | 41               | 0310H          | 00000310H       | nextPC      |
|          | Interrupt      | INTPC21/<br>INTCCC21       | CCC2IC1              | Match of<br>INTPC21 pin/CCC21               | Pin/TMC2        | 42               | 0320H          | 00000320H       | nextPC      |
|          | Interrupt      | INTPC30/<br>INTCCC30       | CCC3IC0              | Match of<br>INTPC30 pin/CCC30               | Pin/TMC3        | 43               | 0330H          | 00000330H       | nextPC      |
|          | Interrupt      | INTPC31/<br>INTCCC31       | CCC3IC1              | Match of<br>INTPC31 pin/CCC31               | Pin/TMC3        | 44               | 0340H          | 00000340H       | nextPC      |
|          | Interrupt      | INTCCC40                   | CCC4IC0              | CCC40 match                                 | TMC4            | 45               | 0350H          | 00000350H       | nextPC      |
|          | Interrupt      | INTCCC41                   | CCC4IC1              | CCC41 match                                 | TMC4            | 46               | 0360H          | 00000360H       | nextPC      |
|          | Interrupt      | INTCCC50                   | CCC5IC0              | CCC50 match                                 | TMC5            | 47               | 0370H          | 00000370H       | nextPC      |
|          | Interrupt      | INTCCC51                   | CCC5IC1              | CCC51 match                                 | TMC5            | 48               | 0380H          | 00000380H       | nextPC      |
|          | Interrupt      | INTCMD0                    | CMDIC0               | CMD0 match                                  | TMD0            | 49               | 0390H          | 00000390H       | nextPC      |
|          | Interrupt      | INTCMD1                    | CMDIC1               | CMD1 match                                  | TMD1            | 50               | 03A0H          | 000003A0H       | nextPC      |
|          | Interrupt      | INTCMD2                    | CMDIC2               | CMD2 match                                  | TMD2            | 51               | 03B0H          | 000003B0H       | nextPC      |
|          | Interrupt      | INTCMD3                    | CMDIC3               | CMD3 match                                  | TMD3            | 52               | 03C0H          | 000003C0H       | nextPC      |
|          | Interrupt      | INTCC100                   | CC10IC0              | CC100 match                                 | TMENC10         | 53               | 03D0H          | 000003D0H       | nextPC      |
|          | Interrupt      | INTCC101                   | CC10IC1              | CC101 match                                 | TMENC10         | 54               | 03E0H          | 000003E0H       | nextPC      |
|          | Interrupt      | INTCM100                   | CM10IC0              | CM100 match                                 | TMENC10         | 55               | 03F0H          | 000003F0H       | nextPC      |
|          | Interrupt      | INTCM101                   | CM10IC1              | CM101 match                                 | TMENC10         | 56               | 0400H          | 00000400H       | nextPC      |
|          | Interrupt      | INTOV10                    | OV1IC0               | Timer ENC10 overflow                        | TMENC10         | 57               | 0410H          | 00000410H       | nextPC      |
|          | Interrupt      | INTUD10                    | UD1IC0               | Timer ENC10 underflow                       | TMENC10         | 58               | 0420H          | 00000420H       | nextPC      |
|          | Interrupt      | INTCC110                   | CC11IC0              | CC110 match                                 | TMENC11         | 59               | 0430H          | 00000430H       | nextPC      |
|          | Interrupt      | INTCC111                   | CC11IC1              | CC111 match                                 | TMENC11         | 60               | 0440H          | 00000440H       | nextPC      |
|          | Interrupt      | INTCM110                   | CM11IC0              | CM110 match                                 | TMENC11         | 61               | 0450H          | 00000450H       | nextPC      |
|          | Interrupt      | INTCM111                   | CM11IC1              | CM111 match                                 | TMENC11         | 62               | 0460H          | 00000460H       | nextPC      |
|          | Interrupt      | INTOV11                    | OV1IC1               | Timer ENC11 overflow                        | TMENC11         | 63               | 0470H          | 00000470H       | nextPC      |
|          | Interrupt      | INTUD11                    | UD1IC1               | Timer ENC11 underflow                       | TMENC11         | 64               | 0480H          | 00000480H       | nextPC      |
|          | Interrupt      | INTDMA0                    | DMAIC0               | End of DMA0 transfer                        | DMA             | 65               | 0490H          | 00000490H       | nextPC      |
|          | Interrupt      | INTDMA1                    | DMAIC1               | End of DMA1 transfer                        | DMA             | 66               | 04A0H          | 000004A0H       | nextPC      |
|          | Interrupt      | INTDMA2                    | DMAIC2               | End of DMA2 transfer                        | DMA             | 67               | 04B0H          | 000004B0H       | nextPC      |
|          | Interrupt      | INTDMA3                    | DMAIC3               | End of DMA3 transfer                        | DMA             | 68               | 04C0H          | 000004C0H       | nextPC      |
|          | Interrupt      | INTCSI30                   | CSI3IC0              | CSI30 transmission/<br>reception completion | CSI30           | 69               | 04D0H          | 000004D0H       | nextPC      |
|          | Interrupt      | INTCOVF30                  | COVF3IC0             | CSI30BUF overflow                           | CSI30           | 70               | 04E0H          | 000004E0H       | nextPC      |
|          | Interrupt      | INTCSI31                   | CSI3IC1              | CSI31 transmission/<br>reception completion | CSI31           | 71               | 04F0H          | 000004F0H       | nextPC      |
|          | Interrupt      | INTCOVF31                  | COVF3IC1             | CSI31BUF overflow                           | CSI31           | 72               | 0500H          | 00000500H       | nextPC      |

Table 7-1. Interrupt Source List (3/3)

| Type     | Classification | Interrupt/Exception Source |                      |                                      |                 | Default Priority | Exception Code | Handler Address | Restored PC |
|----------|----------------|----------------------------|----------------------|--------------------------------------|-----------------|------------------|----------------|-----------------|-------------|
|          |                | Name                       | Controlling Register | Generating Source                    | Generating Unit |                  |                |                 |             |
| Maskable | Interrupt      | UBTIRE0                    | UREIC0               | UARTB0 reception error               | UARTB0          | 73               | 0510H          | 00000510H       | nextPC      |
|          | Interrupt      | UBTIR0                     | URIC0                | UARTB0 reception completion          | UARTB0          | 74               | 0520H          | 00000520H       | nextPC      |
|          | Interrupt      | UBTIT0                     | UTIC0                | UARTB0 transmission completion       | UARTB0          | 75               | 0530H          | 00000530H       | nextPC      |
|          | Interrupt      | UBTIF0                     | UIFIC0               | UARTB0 FIFO transmission completion  | UARTB0          | 76               | 0540H          | 00000540H       | nextPC      |
|          | Interrupt      | UBTITO0                    | UTOIC0               | UARTB0 reception timeout             | UARTB0          | 77               | 0550H          | 00000550H       | nextPC      |
|          | Interrupt      | UBTIRE1                    | UREIC1               | UARTB1 reception error               | UARTB1          | 78               | 0560H          | 00000560H       | nextPC      |
|          | Interrupt      | UBTIR1                     | URIC1                | UARTB1 reception completion          | UARTB1          | 79               | 0570H          | 00000570H       | nextPC      |
|          | Interrupt      | UBTIT1                     | UTIC1                | UARTB1 transmission completion       | UARTB1          | 80               | 0580H          | 00000580H       | nextPC      |
|          | Interrupt      | UBTIF1                     | UIFIC1               | UARTB1 FIFO transmission completion  | UARTB1          | 81               | 0590H          | 00000590H       | nextPC      |
|          | Interrupt      | UBTITO1                    | UTOIC1               | UARTB1 reception timeout             | UARTB1          | 82               | 05A0H          | 000005A0H       | nextPC      |
|          | Interrupt      | INTAD                      | ADIC                 | End of A/D conversion                | ADC             | 83               | 05B0H          | 000005B0H       | nextPC      |
|          | Interrupt      | INTUSB0B                   | US0BIC               | USB function status 0                | USBF            | 84               | 05C0H          | 000005C0H       | nextPC      |
|          | Interrupt      | INTUSB1B                   | US1BIC               | USB function status 1                | USBF            | 85               | 05D0H          | 000005D0H       | nextPC      |
|          | Interrupt      | INTUSB2B                   | US2BIC               | USB function status 2                | USBF            | 86               | 05E0H          | 000005E0H       | nextPC      |
|          | Interrupt      | USBSP2B                    | USP2IC               | Forcible end of USB function EP2 DMA | USBF            | 87               | 05F0H          | 000005F0H       | nextPC      |
|          | Interrupt      | USBSP4B                    | USP4IC               | Forcible end of USB function EP4 DMA | USBF            | 88               | 0600H          | 00000600H       | nextPC      |
|          | Interrupt      | INTRSUM                    | RSUMIC               | USB Resume signal detection          | SIE             | 89               | 0610H          | 00000610H       | nextPC      |

**Remarks 1.** Default Priority: The priority order when two or more maskable interrupt request signals are generated at the same time. The highest priority is 0.

Restored PC: The value of the program counter (PC) saved to EIPC, FEPC, or DBPC of the CPU when interrupt servicing is started. Note, however, that the restored PC when a non-maskable or maskable interrupt is acknowledged while one of the following instructions is being executed does not become the nextPC. (If an interrupt is acknowledged during interrupt execution, execution stops, and then resumes after the interrupt servicing has finished. In this case, the address of the aborted instruction is the restored PC.)

- Load instructions (SLD.B, SLD.BU, SLD.H, SLD.HU, SLD.W)
- Division instructions (DIV, DIVH, DIVU, DIVHU)
- PREPARE, DISPOSE instructions (only if an interrupt is generated before the stack pointer is updated)

nextPC: The PC value from which the processing starts following interrupt/exception processing.

**2.** The execution address of the illegal instruction when an illegal opcode exception occurs is calculated by (Restored PC – 4).

## 7.2 Non-Maskable Interrupts

A non-maskable interrupt request signal is acknowledged unconditionally, even when interrupts are in the interrupt disabled (DI) status. An NMI request signal is not subject to priority control and takes precedence over all the other interrupt request signals.

A non-maskable interrupt request signal is input from the NMI pin. When the valid edge specified by bit 0 (NMIR0) of external interrupt rising edge specification register 2 (INTR2) or bit 0 (NMIF0) of external interrupt falling edge specification register 2 (INTF2) is detected at the NMI pin, the interrupt occurs.

While the service program of the non-maskable interrupt is being executed, the acknowledgment of another non-maskable interrupt request signal is held pending. The pending NMI is acknowledged after the original service program of the non-maskable interrupt under execution has been terminated (by the RETI instruction). Note that if two or more NMI request signals are input during the execution of the service program for an NMI, the number of NMIs that will be acknowledged after the RETI instruction is executed is cleared to 0 is only one.

### 7.2.1 Operation

If a non-maskable interrupt request signal is generated, the CPU performs the following processing, and transfers control to the handler routine:

- <1> Saves the restored PC to FEPC.
- <2> Saves the current PSW to FEPSW.
- <3> Writes exception code 0010H to the higher halfword (FECC) of ECR.
- <4> Sets the NP and ID bits of the PSW to 1 and clears the EP bit of the PSW to 0.
- <5> Sets the handler address (00000010H) corresponding to the non-maskable interrupt to the PC, and transfers control.

The servicing configuration of a non-maskable interrupt is shown in Figure 7-1.

**Figure 7-1. Servicing Configuration of Non-Maskable Interrupt**

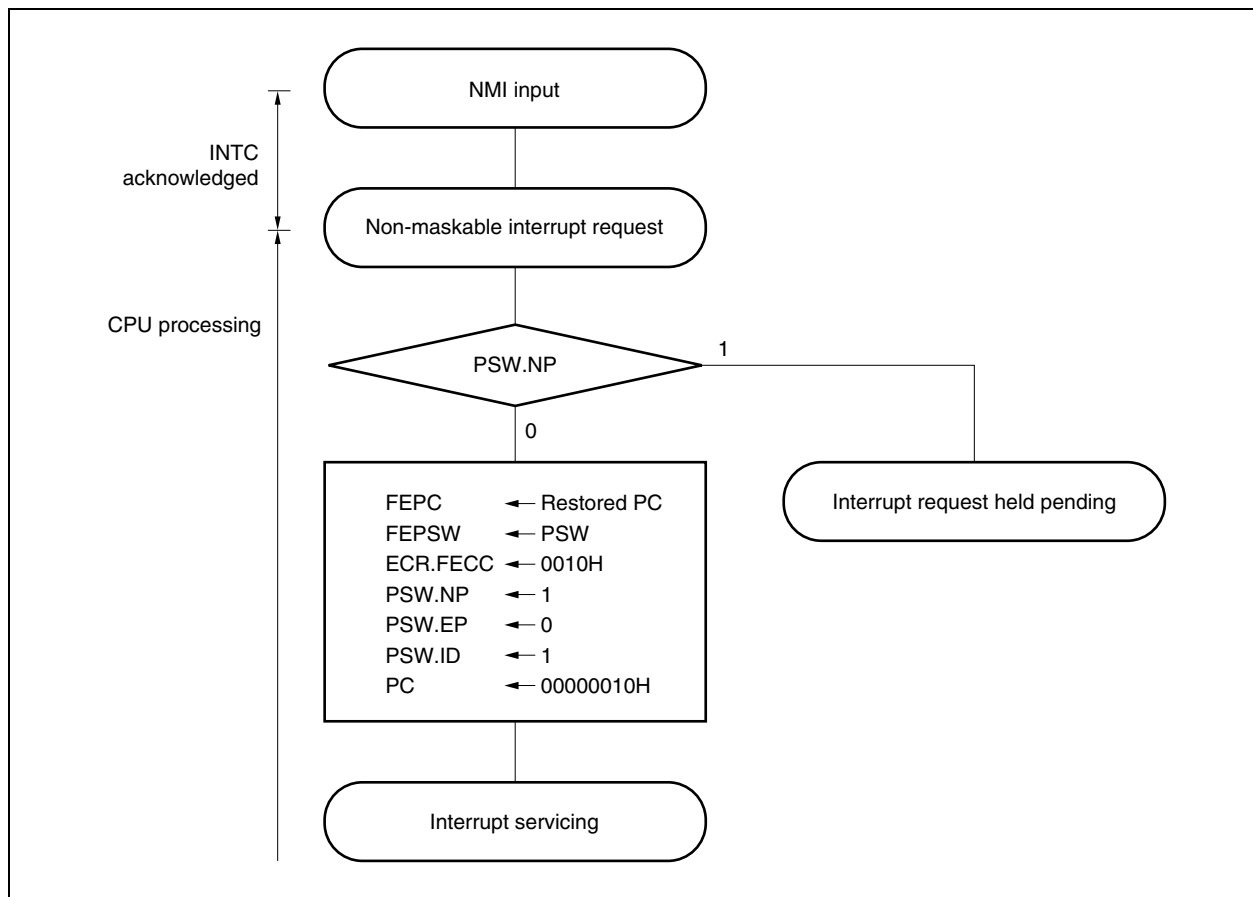
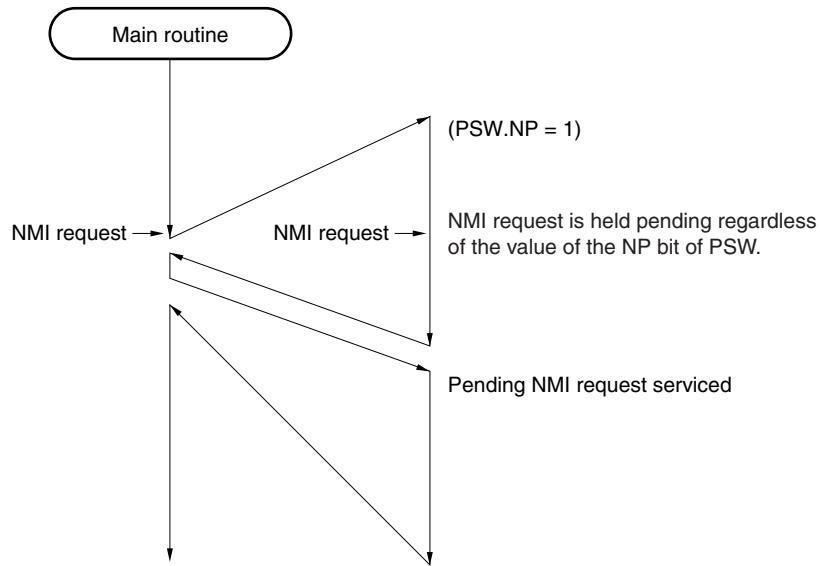
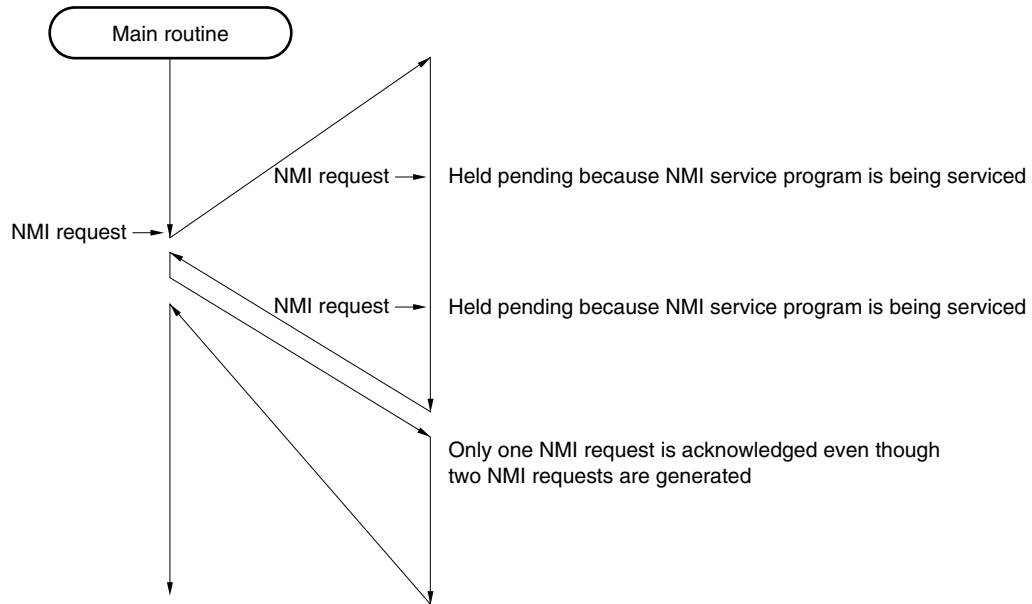


**Figure 7-2. Acknowledging Non-Maskable Interrupt Request**

**(a) If a new NMI request is generated while an NMI service program is being executed**



**(b) If a new NMI request is generated twice while an NMI service program is being executed**



### 7.2.2 Restore

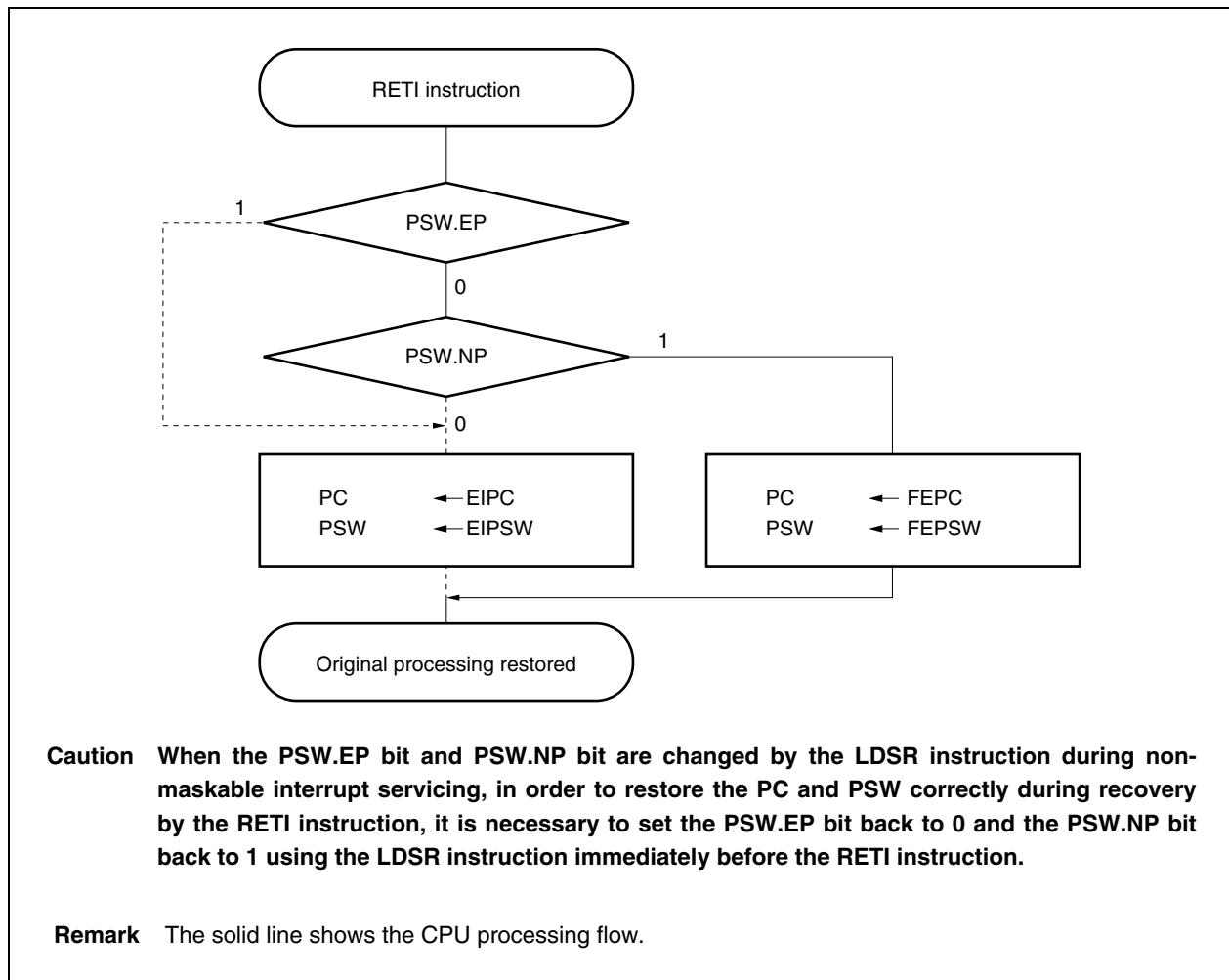
Execution is restored from the non-maskable interrupt servicing by the RETI instruction.

When the RETI instruction is executed, the CPU performs the following processing, and transfers control to the address of the restored PC.

- <1> Restores the values of the PC and the PSW from FEPC and FEPSW, respectively, because the EP bit of the PSW is 0 and the NP bit of the PSW is 1.
- <2> Transfers control back to the address of the restored PC and PSW.

Figure 7-3 illustrates how the RETI instruction is processed.

**Figure 7-3. RETI Instruction Processing**



### 7.2.3 Non-maskable interrupt status flag (NP)

The NP flag is a status flag that indicates that non-maskable interrupt (NMI) servicing is under execution.

This flag is set to 1 when an NMI interrupt request signal has been acknowledged, and masks NMI interrupt requests to prohibit multiple interrupts from being acknowledged.

31

8 7 6 5 4 3 2 1 0

PSW

0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

NP

EP

ID

SAT

CY

OV

S

Z

After reset

00000020H

| Bit position | Bit name | Function                                                                                                                                                                                  |
|--------------|----------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 7            | NP       | <div>NMI Pending</div> <div>Indicates whether NMI interrupt servicing is in progress.</div> <div>0: No NMI interrupt servicing</div> <div>1: NMI interrupt currently being serviced</div> |

### 7.2.4 Edge detection function

#### (1) External interrupt rising edge specification register 2 (INTR2), external interrupt falling edge specification register 2 (INTF2)

These registers are used to specify the valid edge of the non-maskable interrupt (NMI). The NMIR0 bit of the INTR2 register and NMIF0 bit of the INTF2 register specify the rising edge, falling edge, or both the rising and falling edges of the NMI as the valid edge.

These registers can be read or written in 8-bit or 1-bit units.

|       |   |   |        |        |        |        |        |       |           |             |
|-------|---|---|--------|--------|--------|--------|--------|-------|-----------|-------------|
|       | 7 | 6 | 5      | 4      | 3      | 2      | 1      | 0     | Address   | After reset |
| INTR2 | 0 | 0 | INTR25 | INTR24 | INTR23 | INTR22 | INTR21 | NMIR0 | FFFFFC24H | 3FH         |
| INTF2 | 0 | 0 | INTF25 | INTF24 | INTF23 | INTF22 | INTF21 | NMIF0 | FFFFFC04H | 00H         |

| Bit position | Bit name                                       | Function                                                                                                                                                                                                                                                                                                                                                         |       |       |           |   |   |              |   |   |             |   |   |                    |   |   |                               |
|--------------|------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|-------|-----------|---|---|--------------|---|---|-------------|---|---|--------------------|---|---|-------------------------------|
| 0            | NMIR0 (INTR2 register), NMIF0 (INTF2 register) | Specify the NMI pin's valid edge. <table> <tr> <th>NMIF0</th> <th>NMIR0</th> <th>Operation</th> </tr> <tr> <td>0</td> <td>0</td> <td>Falling edge</td> </tr> <tr> <td>0</td> <td>1</td> <td>Rising edge</td> </tr> <tr> <td>1</td> <td>0</td> <td>Setting prohibited</td> </tr> <tr> <td>1</td> <td>1</td> <td>Both rising and falling edges</td> </tr> </table> | NMIF0 | NMIR0 | Operation | 0 | 0 | Falling edge | 0 | 1 | Rising edge | 1 | 0 | Setting prohibited | 1 | 1 | Both rising and falling edges |
| NMIF0        | NMIR0                                          | Operation                                                                                                                                                                                                                                                                                                                                                        |       |       |           |   |   |              |   |   |             |   |   |                    |   |   |                               |
| 0            | 0                                              | Falling edge                                                                                                                                                                                                                                                                                                                                                     |       |       |           |   |   |              |   |   |             |   |   |                    |   |   |                               |
| 0            | 1                                              | Rising edge                                                                                                                                                                                                                                                                                                                                                      |       |       |           |   |   |              |   |   |             |   |   |                    |   |   |                               |
| 1            | 0                                              | Setting prohibited                                                                                                                                                                                                                                                                                                                                               |       |       |           |   |   |              |   |   |             |   |   |                    |   |   |                               |
| 1            | 1                                              | Both rising and falling edges                                                                                                                                                                                                                                                                                                                                    |       |       |           |   |   |              |   |   |             |   |   |                    |   |   |                               |

**Remark** For bits 5 to 1, see 7.3.9 (2) External interrupt rising edge specification register 2 (INTR2), external interrupt falling edge specification register 2 (INTF2).

### 7.3 Maskable Interrupts

Maskable interrupt request signals can be masked by interrupt control registers. The V850E/ME2 has 90 maskable interrupt sources.

If two or more maskable interrupt request signals are generated at the same time, they are acknowledged according to the default priority. In addition to the default priority, eight levels of priorities can be specified by using the interrupt control registers (programmable priority control).

When an interrupt request signal has been acknowledged, the acknowledgment of other maskable interrupt request signals is disabled and the interrupt disabled (DI) status is set.

When the EI instruction is executed in an interrupt service routine, the interrupt enabled (EI) status is set, which enables servicing of interrupt signals having a higher priority than the interrupt request signal in progress (specified by the interrupt control register). Note that only interrupts with a higher priority will have this capability; interrupts with the same priority level cannot be nested.

To enable multiple interrupt servicing, however, save EIPC and EIPSW to memory or registers before executing the EI instruction, and execute the DI instruction before the RETI instruction to restore EIPC and EIPSW to the original values.

#### 7.3.1 Operation

If a maskable interrupt occurs, the CPU performs the following processing, and transfers control to a handler routine:

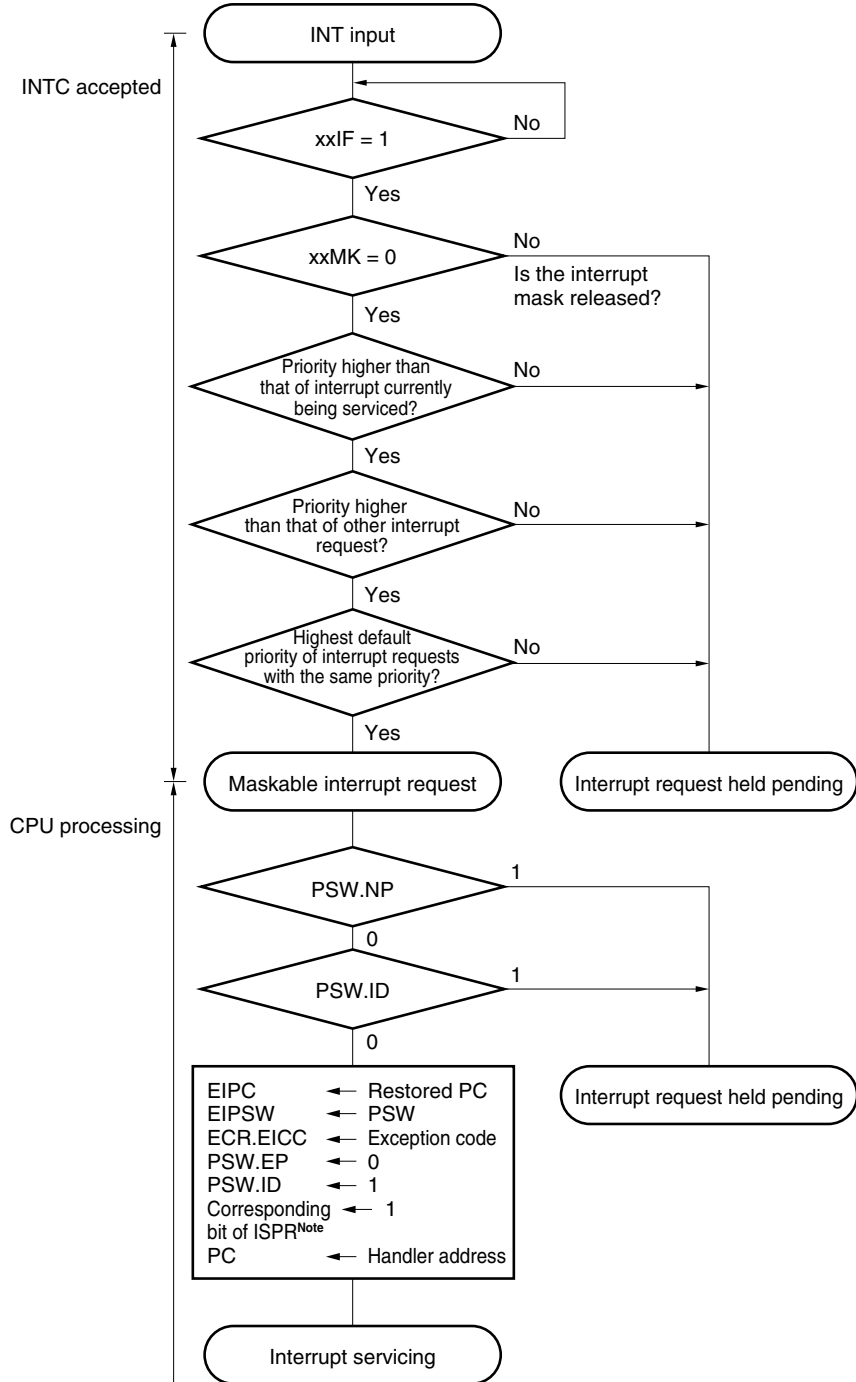
- <1> Saves the restored PC to EIPC.
- <2> Saves the current PSW to EIPSW.
- <3> Writes an exception code to the lower halfword of ECR (EICC).
- <4> Sets the ID bit of the PSW to 1 and clears the EP bit of the PSW to 0.
- <5> Sets the handler address corresponding to each interrupt to the PC, and transfers control.

The maskable interrupt request signal masked by the interrupt controller (INTC) and the maskable interrupt request signal generated while another interrupt is being serviced (while the PSW.NP bit = 1 or the PSW.ID bit = 1) are held pending inside the INTC. In this case, servicing a new maskable interrupt is started in accordance with the priority of the pending maskable interrupt request signal if either the maskable interrupt is unmasked or the NP and ID bits are cleared to 0 by using the RETI or LDSR instruction.

The servicing configuration of a maskable interrupt is shown in Figure 7-4.



Figure 7-4. Maskable Interrupt Servicing



**Note** For the `ISPR` register, see 7.3.7 In-service priority register (ISPR).

### 7.3.2 Restore

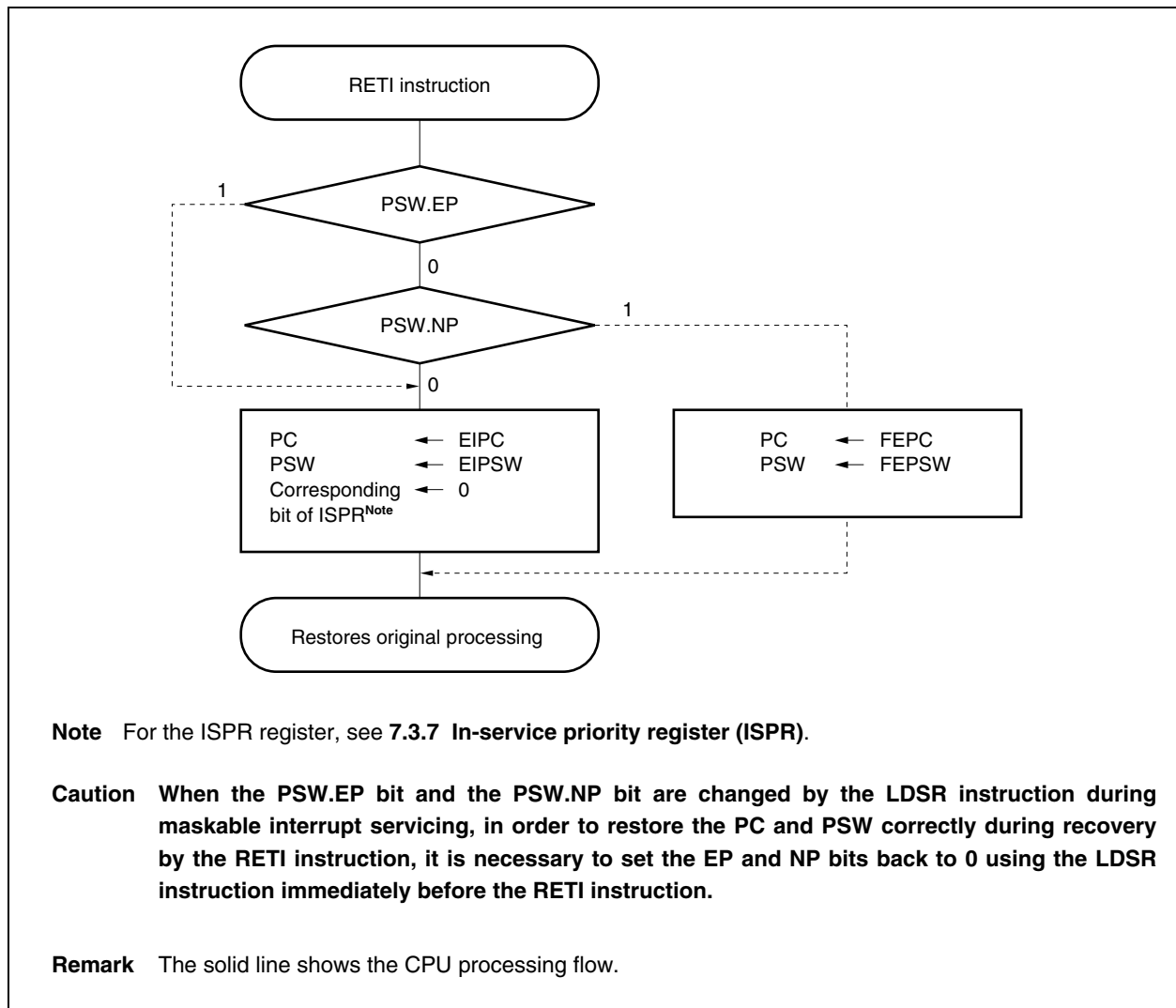
Recovery from maskable interrupt servicing is carried out by the RETI instruction.

When the RETI instruction is executed, the CPU performs the following steps, and transfers control to the address of the restored PC.

- <1> Restores the values of the PC and the PSW from EIPC and EIPSW because the EP bit of the PSW is 0 and the NP bit of the PSW is 0.
- <2> Transfers control to the address of the restored PC and PSW.

Figure 7-5 illustrates the processing of the RETI instruction.

**Figure 7-5. RETI Instruction Processing**



### 7.3.3 Priorities of maskable interrupts

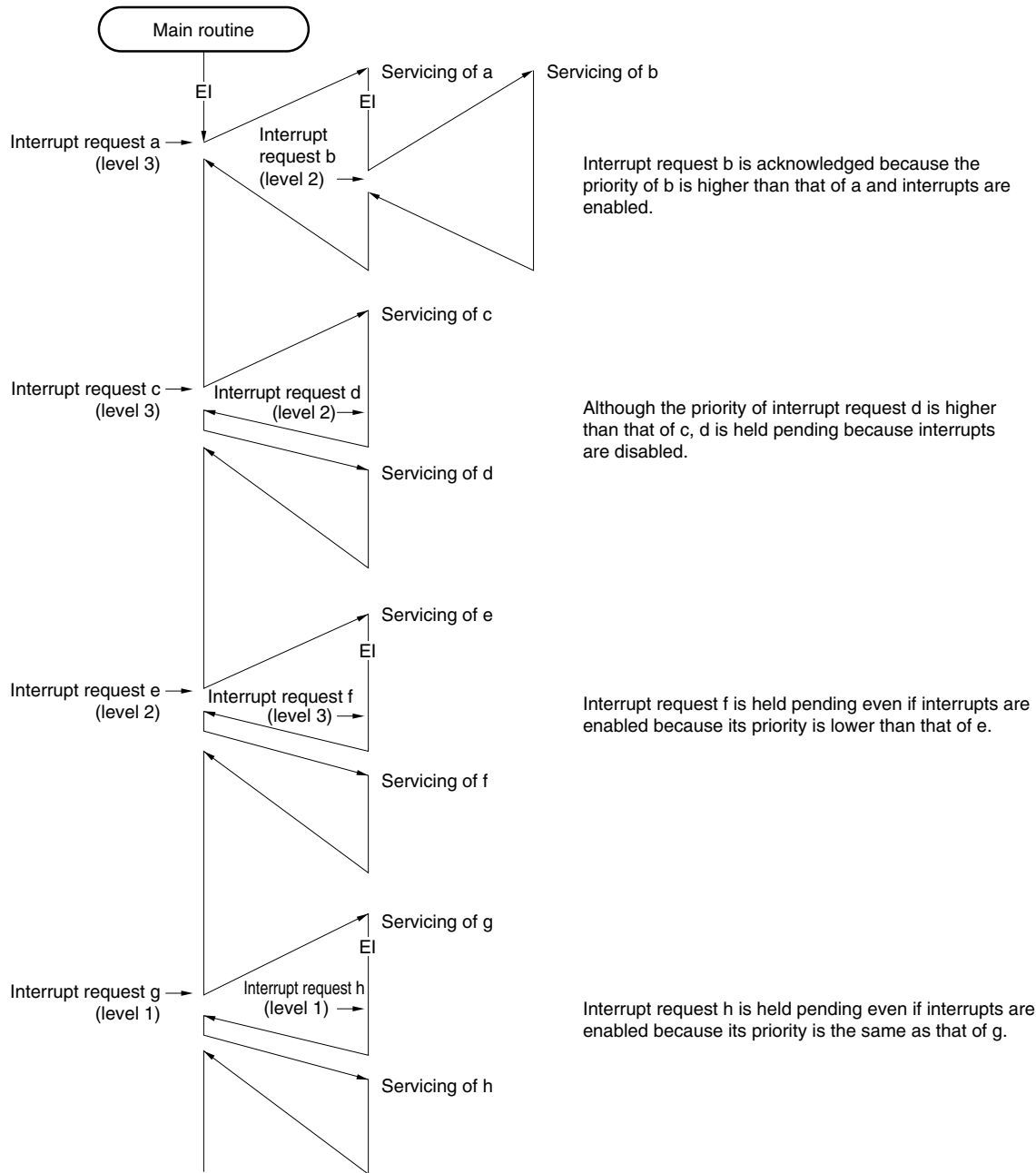
The V850E/ME2 provides multiple interrupt servicing in which an interrupt is acknowledged while another interrupt is being serviced. Multiple interrupts can be controlled by priority levels.

There are two types of priority level control: control based on the default priority levels, and control based on the programmable priority levels that are specified by the interrupt priority level specification bit (xxPRn) of the interrupt control register (xxICn). When two or more interrupts having the same priority level specified by the xxPRn bit are generated at the same time, interrupts are serviced in order depending on the priority level allocated to each interrupt request signal type (default priority level) beforehand. For more information, see **Table 7-1 Interrupt Source List**. The programmable priority control customizes interrupt request signals into eight levels by setting the priority level specification flag.

Note that when an interrupt request signal is acknowledged, the ID flag of PSW is automatically set to 1. Therefore, when multiple interrupts are to be used, clear the ID flag to 0 beforehand (for example, by placing the EI instruction in the interrupt service program) to set the interrupt enable mode.

**Remark** xx: Identification name of each peripheral unit (see **Table 7-2**)  
n: Peripheral unit number (see **Table 7-2**)

**Figure 7-6. Example of Processing in Which Another Interrupt Request Signal Is Issued While an Interrupt Is Being Serviced (1/2)**



**Caution** To perform multiple interrupt servicing, the values of the EIPC and EIPSW registers must be saved before executing the EI instruction. When returning from multiple interrupt servicing, restore the values of EIPC and EIPSW after executing the DI instruction.

**Remarks**

1. a to u in the figure are provisional interrupt request signal names shown for the sake of explanation.
2. The default priority in the figure indicates the relative priority between two interrupt request signals.

**Figure 7-6. Example of Processing in Which Another Interrupt Request Signal Is Issued While an Interrupt Is Being Serviced (2/2)**

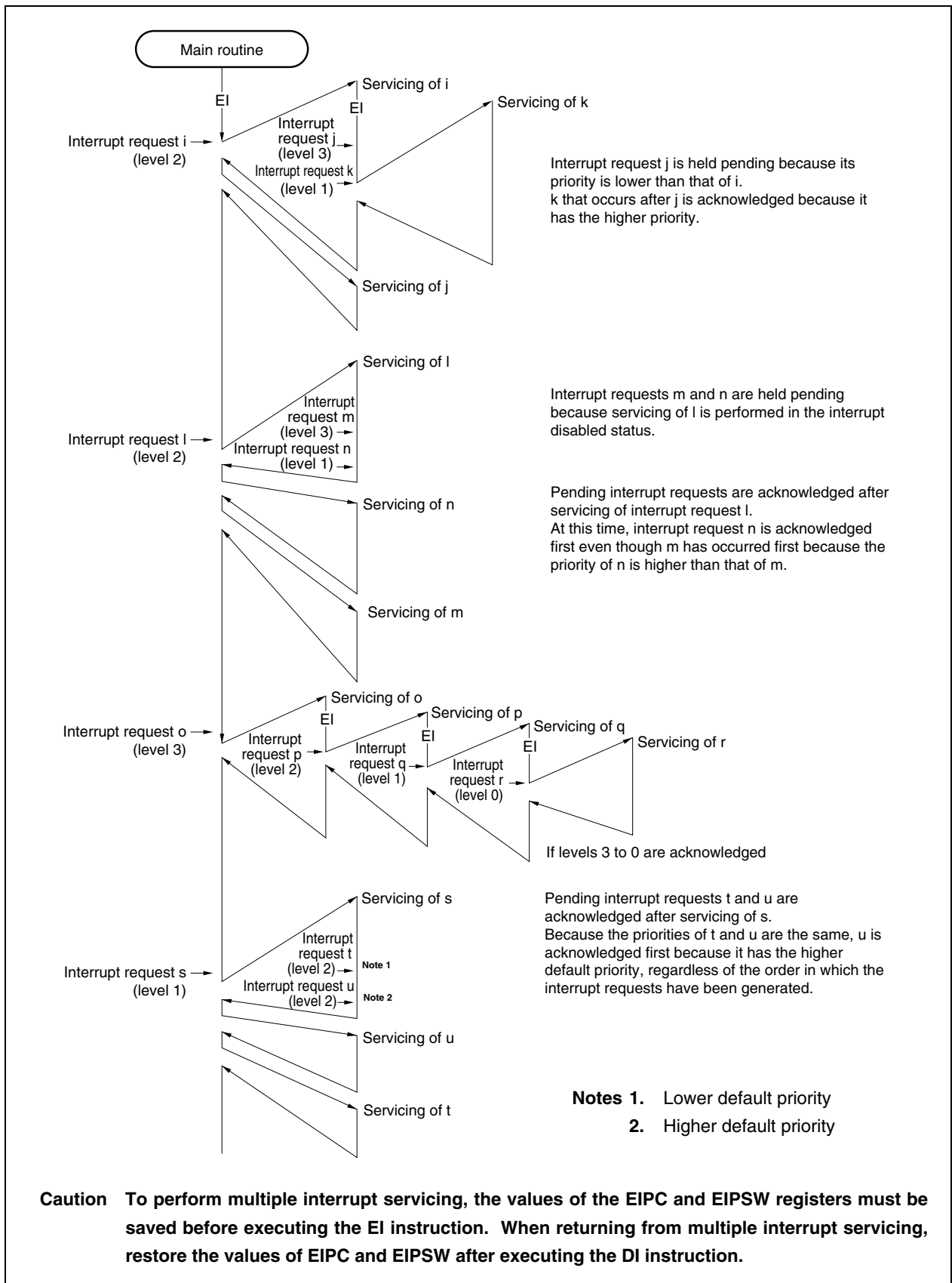
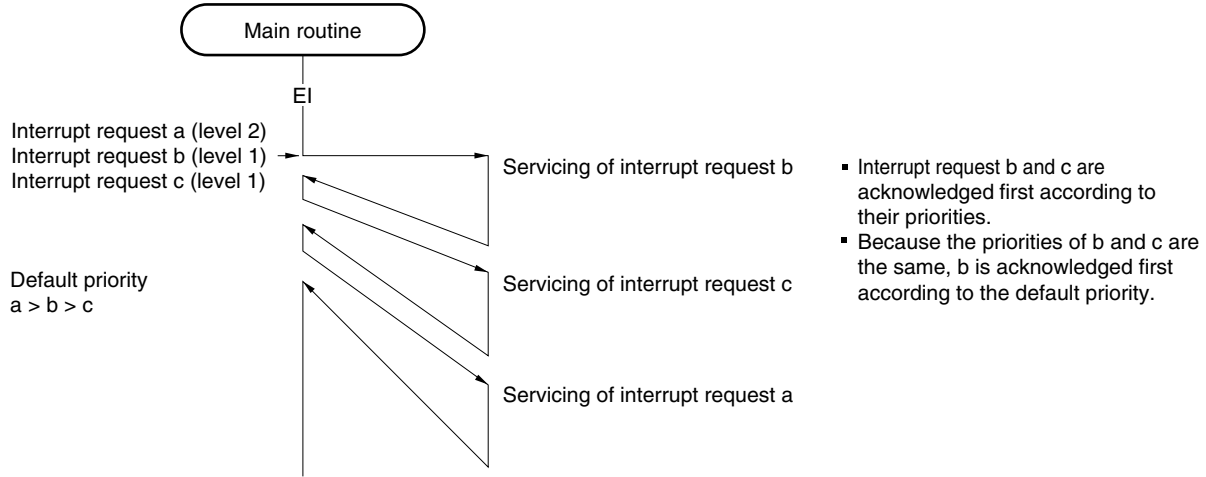


**Figure 7-7. Example of Servicing Interrupt Request Signals Simultaneously Generated**

**Caution** To perform multiple interrupt servicing, the values of the EIPC and EIPSW registers must be saved before executing the EI instruction. When returning from multiple interrupt servicing, restore the values of EIPC and EIPSW after executing the DI instruction.

**Remarks**

1. a to c in the figure are provisional interrupt request signal names shown for the sake of explanation.
2. The default priority in the figure indicates the relative priority between two interrupt request signals.

### 7.3.4 Interrupt control register (xxICn)

An interrupt control register is assigned to each interrupt request signal (maskable interrupt) and sets the control conditions for each maskable interrupt request.

This register can be read or written in 8-bit or 1-bit units.

**Caution** Disable interrupts (DI) to read the xxIFn bit of the xxICn register. If the xxIFn bit is read while interrupts are enabled (EI), the correct value may not be read if there is a conflict between acknowledging an interrupt and reading the bit.

|       |       |       |   |   |   |        |        |        |                           |             |
|-------|-------|-------|---|---|---|--------|--------|--------|---------------------------|-------------|
|       | <7>   | <6>   | 5 | 4 | 3 | 2      | 1      | 0      | Address                   | After reset |
| xxICn | xxIFn | xxMKn | 0 | 0 | 0 | xxPRn2 | xxPRn1 | xxPRn0 | FFFFF110H to<br>FFFFF1C2H | 47H         |

| Bit position | Bit name            | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                      |        |        |                                      |   |   |   |                              |   |   |   |                    |   |   |   |                    |   |   |   |                    |   |   |   |                    |   |   |   |                    |   |   |   |                    |   |   |   |                             |
|--------------|---------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------|--------|--------|--------------------------------------|---|---|---|------------------------------|---|---|---|--------------------|---|---|---|--------------------|---|---|---|--------------------|---|---|---|--------------------|---|---|---|--------------------|---|---|---|--------------------|---|---|---|-----------------------------|
| 7            | xxIFn               | This is an interrupt request flag.<br>0: Interrupt request signal not issued<br>1: Interrupt request signal issued<br><br>The flag xxIFn is reset automatically by the hardware if an interrupt request signal is acknowledged.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                      |        |        |                                      |   |   |   |                              |   |   |   |                    |   |   |   |                    |   |   |   |                    |   |   |   |                    |   |   |   |                    |   |   |   |                    |   |   |   |                             |
| 6            | xxMKn               | This is an interrupt mask flag.<br>0: Interrupt servicing enabled<br>1: Interrupt servicing disabled (pending)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                      |        |        |                                      |   |   |   |                              |   |   |   |                    |   |   |   |                    |   |   |   |                    |   |   |   |                    |   |   |   |                    |   |   |   |                    |   |   |   |                             |
| 2 to 0       | xxPRn2 to<br>xxPRn0 | 8 levels of priority order are specified for each interrupt. <table><tr><th>xxPRn2</th><th>xxPRn1</th><th>xxPRn0</th><th>Interrupt priority specification bit</th></tr><tr><td>0</td><td>0</td><td>0</td><td>Specifies level 0 (highest).</td></tr><tr><td>0</td><td>0</td><td>1</td><td>Specifies level 1.</td></tr><tr><td>0</td><td>1</td><td>0</td><td>Specifies level 2.</td></tr><tr><td>0</td><td>1</td><td>1</td><td>Specifies level 3.</td></tr><tr><td>1</td><td>0</td><td>0</td><td>Specifies level 4.</td></tr><tr><td>1</td><td>0</td><td>1</td><td>Specifies level 5.</td></tr><tr><td>1</td><td>1</td><td>0</td><td>Specifies level 6.</td></tr><tr><td>1</td><td>1</td><td>1</td><td>Specifies level 7 (lowest).</td></tr></table> | xxPRn2                               | xxPRn1 | xxPRn0 | Interrupt priority specification bit | 0 | 0 | 0 | Specifies level 0 (highest). | 0 | 0 | 1 | Specifies level 1. | 0 | 1 | 0 | Specifies level 2. | 0 | 1 | 1 | Specifies level 3. | 1 | 0 | 0 | Specifies level 4. | 1 | 0 | 1 | Specifies level 5. | 1 | 1 | 0 | Specifies level 6. | 1 | 1 | 1 | Specifies level 7 (lowest). |
| xxPRn2       | xxPRn1              | xxPRn0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Interrupt priority specification bit |        |        |                                      |   |   |   |                              |   |   |   |                    |   |   |   |                    |   |   |   |                    |   |   |   |                    |   |   |   |                    |   |   |   |                    |   |   |   |                             |
| 0            | 0                   | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Specifies level 0 (highest).         |        |        |                                      |   |   |   |                              |   |   |   |                    |   |   |   |                    |   |   |   |                    |   |   |   |                    |   |   |   |                    |   |   |   |                    |   |   |   |                             |
| 0            | 0                   | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Specifies level 1.                   |        |        |                                      |   |   |   |                              |   |   |   |                    |   |   |   |                    |   |   |   |                    |   |   |   |                    |   |   |   |                    |   |   |   |                    |   |   |   |                             |
| 0            | 1                   | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Specifies level 2.                   |        |        |                                      |   |   |   |                              |   |   |   |                    |   |   |   |                    |   |   |   |                    |   |   |   |                    |   |   |   |                    |   |   |   |                    |   |   |   |                             |
| 0            | 1                   | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Specifies level 3.                   |        |        |                                      |   |   |   |                              |   |   |   |                    |   |   |   |                    |   |   |   |                    |   |   |   |                    |   |   |   |                    |   |   |   |                    |   |   |   |                             |
| 1            | 0                   | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Specifies level 4.                   |        |        |                                      |   |   |   |                              |   |   |   |                    |   |   |   |                    |   |   |   |                    |   |   |   |                    |   |   |   |                    |   |   |   |                    |   |   |   |                             |
| 1            | 0                   | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Specifies level 5.                   |        |        |                                      |   |   |   |                              |   |   |   |                    |   |   |   |                    |   |   |   |                    |   |   |   |                    |   |   |   |                    |   |   |   |                    |   |   |   |                             |
| 1            | 1                   | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Specifies level 6.                   |        |        |                                      |   |   |   |                              |   |   |   |                    |   |   |   |                    |   |   |   |                    |   |   |   |                    |   |   |   |                    |   |   |   |                    |   |   |   |                             |
| 1            | 1                   | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Specifies level 7 (lowest).          |        |        |                                      |   |   |   |                              |   |   |   |                    |   |   |   |                    |   |   |   |                    |   |   |   |                    |   |   |   |                    |   |   |   |                    |   |   |   |                             |

**Remark** xx: Identification name of each peripheral unit (see **Table 7-2**)  
n: Peripheral unit number (see **Table 7-2**)

The addresses and bits of the interrupt control registers are as follows:

Table 7-2. Addresses and Bits of Interrupt Control Registers (1/3)

| Address   | Register | Bit     |         |   |   |   |          |          |          |
|-----------|----------|---------|---------|---|---|---|----------|----------|----------|
|           |          | <7>     | <6>     | 5 | 4 | 3 | 2        | 1        | 0        |
| FFFFF110H | P1IC0    | P1IF0   | P1MK0   | 0 | 0 | 0 | P1PR02   | P1PR01   | P1PR00   |
| FFFFF112H | P1IC1    | P1IF1   | P1MK1   | 0 | 0 | 0 | P1PR12   | P1PR11   | P1PR10   |
| FFFFF114H | P2IC1    | P2IF1   | P2MK1   | 0 | 0 | 0 | P2PR12   | P2PR11   | P2PR10   |
| FFFFF116H | P2IC2    | P2IF2   | P2MK2   | 0 | 0 | 0 | P2PR22   | P2PR21   | P2PR20   |
| FFFFF118H | P2IC3    | P2IF3   | P2MK3   | 0 | 0 | 0 | P2PR32   | P2PR31   | P2PR30   |
| FFFFF11AH | P2IC4    | P2IF4   | P2MK4   | 0 | 0 | 0 | P2PR42   | P2PR41   | P2PR40   |
| FFFFF11CH | P2IC5    | P2IF5   | P2MK5   | 0 | 0 | 0 | P2PR52   | P2PR51   | P2PR50   |
| FFFFF11EH | P5IC0    | P5IF0   | P5MK0   | 0 | 0 | 0 | P5PR02   | P5PR01   | P5PR00   |
| FFFFF120H | P5IC1    | P5IF1   | P5MK1   | 0 | 0 | 0 | P5PR12   | P5PR11   | P5PR10   |
| FFFFF122H | P5IC2    | P5IF2   | P5MK2   | 0 | 0 | 0 | P5PR22   | P5PR21   | P5PR20   |
| FFFFF124H | P6IC5    | P6IF5   | P6MK5   | 0 | 0 | 0 | P6PR52   | P6PR51   | P6PR50   |
| FFFFF126H | P6IC6    | P6IF6   | P6MK6   | 0 | 0 | 0 | P6PR62   | P6PR61   | P6PR60   |
| FFFFF128H | P6IC7    | P6IF7   | P6MK7   | 0 | 0 | 0 | P6PR72   | P6PR71   | P6PR70   |
| FFFFF12AH | PDIC0    | PDIF0   | PDMK0   | 0 | 0 | 0 | PDPR02   | PDPR01   | PDPR00   |
| FFFFF12CH | PDIC1    | PDIF1   | PDMK1   | 0 | 0 | 0 | PDPR12   | PDPR11   | PDPR10   |
| FFFFF12EH | PDIC2    | PDIF2   | PDMK2   | 0 | 0 | 0 | PDPR22   | PDPR21   | PDPR20   |
| FFFFF130H | PDIC3    | PDIF3   | PDMK3   | 0 | 0 | 0 | PDPR32   | PDPR31   | PDPR30   |
| FFFFF132H | PDIC4    | PDIF4   | PDMK4   | 0 | 0 | 0 | PDPR42   | PDPR41   | PDPR40   |
| FFFFF134H | PDIC5    | PDIF5   | PDMK5   | 0 | 0 | 0 | PDPR52   | PDPR51   | PDPR50   |
| FFFFF136H | PDIC6    | PDIF6   | PDMK6   | 0 | 0 | 0 | PDPR62   | PDPR61   | PDPR60   |
| FFFFF138H | PDIC7    | PDIF7   | PDMK7   | 0 | 0 | 0 | PDPR72   | PDPR71   | PDPR70   |
| FFFFF13AH | PDIC8    | PDIF8   | PDMK8   | 0 | 0 | 0 | PDPR82   | PDPR81   | PDPR80   |
| FFFFF13CH | PDIC9    | PDIF9   | PDMK9   | 0 | 0 | 0 | PDPR92   | PDPR91   | PDPR90   |
| FFFFF13EH | PDIC10   | PDIF10  | PDMK10  | 0 | 0 | 0 | PDPR102  | PDPR101  | PDPR100  |
| FFFFF140H | PDIC11   | PDIF11  | PDMK11  | 0 | 0 | 0 | PDPR112  | PDPR111  | PDPR110  |
| FFFFF142H | PDIC12   | PDIF12  | PDMK12  | 0 | 0 | 0 | PDPR122  | PDPR121  | PDPR120  |
| FFFFF144H | PDIC13   | PDIF13  | PDMK13  | 0 | 0 | 0 | PDPR132  | PDPR131  | PDPR130  |
| FFFFF146H | PDIC14   | PDIF14  | PDMK14  | 0 | 0 | 0 | PDPR142  | PDPR141  | PDPR140  |
| FFFFF148H | PDIC15   | PDIF15  | PDMK15  | 0 | 0 | 0 | PDPR152  | PDPR151  | PDPR150  |
| FFFFF14AH | PLIC0    | PLIF0   | PLMK0   | 0 | 0 | 0 | PLPR02   | PLPR01   | PLPR00   |
| FFFFF14CH | PLIC1    | PLIF1   | PLMK1   | 0 | 0 | 0 | PLPR12   | PLPR11   | PLPR10   |
| FFFFF14EH | OVCIC0   | OVCIF0  | OVCMK0  | 0 | 0 | 0 | OVCPR02  | OVCPR01  | OVCPR00  |
| FFFFF150H | OVCIC1   | OVCIF1  | OVCMK1  | 0 | 0 | 0 | OVCPR12  | OVCPR11  | OVCPR10  |
| FFFFF152H | OVCIC2   | OVCIF2  | OVCMK2  | 0 | 0 | 0 | OVCPR22  | OVCPR21  | OVCPR20  |
| FFFFF154H | OVCIC3   | OVCIF3  | OVCMK3  | 0 | 0 | 0 | OVCPR32  | OVCPR31  | OVCPR30  |
| FFFFF156H | OVCIC4   | OVCIF4  | OVCMK4  | 0 | 0 | 0 | OVCPR42  | OVCPR41  | OVCPR40  |
| FFFFF158H | OVCIC5   | OVCIF5  | OVCMK5  | 0 | 0 | 0 | OVCPR52  | OVCPR51  | OVCPR50  |
| FFFFF15AH | CCC0IC0  | CCC0IF0 | CCC0MK0 | 0 | 0 | 0 | CCC0PR02 | CCC0PR01 | CCC0PR00 |
| FFFFF15CH | CCC0IC1  | CCC0IF1 | CCC0MK1 | 0 | 0 | 0 | CCC0PR12 | CCC0PR11 | CCC0PR10 |
| FFFFF15EH | CCC1IC0  | CCC1IF0 | CCC1MK0 | 0 | 0 | 0 | CCC1PR02 | CCC1PR01 | CCC1PR00 |
| FFFFF160H | CCC1IC1  | CCC1IF1 | CCC1MK1 | 0 | 0 | 0 | CCC1PR12 | CCC1PR11 | CCC1PR10 |



Table 7-2. Addresses and Bits of Interrupt Control Registers (2/3)

| Address   | Register | Bit      |          |   |   |   |           |           |           |
|-----------|----------|----------|----------|---|---|---|-----------|-----------|-----------|
|           |          | <7>      | <6>      | 5 | 4 | 3 | 2         | 1         | 0         |
| FFFFF162H | CCC2IC0  | CCC2IF0  | CCC2MK0  | 0 | 0 | 0 | CCC2PR02  | CCC2PR01  | CCC2PR00  |
| FFFFF164H | CCC2IC1  | CCC2IF1  | CCC2MK1  | 0 | 0 | 0 | CCC2PR12  | CCC2PR11  | CCC2PR10  |
| FFFFF166H | CCC3IC0  | CCC3IF0  | CCC3MK0  | 0 | 0 | 0 | CCC3PR02  | CCC3PR01  | CCC3PR00  |
| FFFFF168H | CCC3IC1  | CCC3IF1  | CCC3MK1  | 0 | 0 | 0 | CCC3PR12  | CCC3PR11  | CCC3PR10  |
| FFFFF16AH | CCC4IC0  | CCC4IF0  | CCC4MK0  | 0 | 0 | 0 | CCC4PR02  | CCC4PR01  | CCC4PR00  |
| FFFFF16CH | CCC4IC1  | CCC4IF1  | CCC4MK1  | 0 | 0 | 0 | CCC4PR12  | CCC4PR11  | CCC4PR10  |
| FFFFF16EH | CCC5IC0  | CCC5IF0  | CCC5MK0  | 0 | 0 | 0 | CCC5PR02  | CCC5PR01  | CCC5PR00  |
| FFFFF170H | CCC5IC1  | CCC5IF1  | CCC5MK1  | 0 | 0 | 0 | CCC5PR12  | CCC5PR11  | CCC5PR10  |
| FFFFF172H | CMDIC0   | CMDIF0   | CMDMK0   | 0 | 0 | 0 | CMDPR02   | CMDPR01   | CMDPR00   |
| FFFFF174H | CMDIC1   | CMDIF1   | CMDMK1   | 0 | 0 | 0 | CMDPR12   | CMDPR11   | CMDPR10   |
| FFFFF176H | CMDIC2   | CMDIF2   | CMDMK2   | 0 | 0 | 0 | CMDPR22   | CMDPR21   | CMDPR20   |
| FFFFF178H | CMDIC3   | CMDIF3   | CMDMK3   | 0 | 0 | 0 | CMDPR32   | CMDPR31   | CMDPR30   |
| FFFFF17AH | CC10IC0  | CC10IF0  | CC10MK0  | 0 | 0 | 0 | CC10PR02  | CC10PR01  | CC10PR00  |
| FFFFF17CH | CC10IC1  | CC10IF1  | CC10MK1  | 0 | 0 | 0 | CC10PR12  | CC10PR11  | CC10PR10  |
| FFFFF17EH | CM10IC0  | CM10IF0  | CM10MK0  | 0 | 0 | 0 | CM10PR02  | CM10PR01  | CM10PR00  |
| FFFFF180H | CM10IC1  | CM10IF1  | CM10MK1  | 0 | 0 | 0 | CM10PR12  | CM10PR11  | CM10PR10  |
| FFFFF182H | OV1IC0   | OV1IF0   | OV1MK0   | 0 | 0 | 0 | OV1PR02   | OV1PR01   | OV1PR00   |
| FFFFF184H | UD1IC0   | UD1IF0   | UD1MK0   | 0 | 0 | 0 | UD1PR02   | UD1PR01   | UD1PR00   |
| FFFFF186H | CC11IC0  | CC11IF0  | CC11MK0  | 0 | 0 | 0 | CC11PR02  | CC11PR01  | CC11PR00  |
| FFFFF188H | CC11IC1  | CC11IF1  | CC11MK1  | 0 | 0 | 0 | CC11PR12  | CC11PR11  | CC11PR10  |
| FFFFF18AH | CM11IC0  | CM11IF0  | CM11MK0  | 0 | 0 | 0 | CM11PR02  | CM11PR01  | CM11PR00  |
| FFFFF18CH | CM11IC1  | CM11IF1  | CM11MK1  | 0 | 0 | 0 | CM11PR12  | CM11PR11  | CM11PR10  |
| FFFFF18EH | OV1IC1   | OV1IF1   | OV1MK1   | 0 | 0 | 0 | OV1PR12   | OV1PR11   | OV1PR10   |
| FFFFF190H | UD1IC1   | UD1IF1   | UD1MK1   | 0 | 0 | 0 | UD1PR12   | UD1PR11   | UD1PR10   |
| FFFFF192H | DMAIC0   | DMAIF0   | DMAMK0   | 0 | 0 | 0 | DMAPR02   | DMAPR01   | DMAPR00   |
| FFFFF194H | DMAIC1   | DMAIF1   | DMAMK1   | 0 | 0 | 0 | DMAPR12   | DMAPR11   | DMAPR10   |
| FFFFF196H | DMAIC2   | DMAIF2   | DMAMK2   | 0 | 0 | 0 | DMAPR22   | DMAPR21   | DMAPR20   |
| FFFFF198H | DMAIC3   | DMAIF3   | DMAMK3   | 0 | 0 | 0 | DMAPR32   | DMAPR31   | DMAPR30   |
| FFFFF19AH | CSI3IC0  | CSI3IF0  | CSI3MK0  | 0 | 0 | 0 | CSI3PR02  | CSI3PR01  | CSI3PR00  |
| FFFFF19CH | COVF3IC0 | COVF3IF0 | COVF3MK0 | 0 | 0 | 0 | COVF3PR02 | COVF3PR01 | COVF3PR00 |
| FFFFF19EH | CSI3IC1  | CSI3IF1  | CSI3MK1  | 0 | 0 | 0 | CSI3PR12  | CSI3PR11  | CSI3PR10  |
| FFFFF1A0H | COVF3IC1 | COVF3IF1 | COVF3MK1 | 0 | 0 | 0 | COVF3PR12 | COVF3PR11 | COVF3PR10 |
| FFFFF1A2H | UREIC0   | UREIF0   | UREMK0   | 0 | 0 | 0 | UREPR02   | UREPR01   | UREPR00   |
| FFFFF1A4H | URIC0    | URIF0    | URMK0    | 0 | 0 | 0 | URPR02    | URPR01    | URPR00    |
| FFFFF1A6H | UTIC0    | UTIF0    | UTMK0    | 0 | 0 | 0 | UTPR02    | UTPR01    | UTPR00    |
| FFFFF1A8H | UIFIC0   | UIFIF0   | UIFMK0   | 0 | 0 | 0 | UIFPR02   | UIFPR01   | UIFPR00   |
| FFFFF1AAH | UTOIC0   | UTOIF0   | UTOMK0   | 0 | 0 | 0 | UTOPR02   | UTOPR01   | UTOPR00   |
| FFFFF1ACH | UREIC1   | UREIF1   | UREMK1   | 0 | 0 | 0 | UREPR12   | UREPR11   | UREPR10   |
| FFFFF1AEH | URIC1    | URIF1    | URMK1    | 0 | 0 | 0 | URPR12    | URPR11    | URPR10    |
| FFFFF1B0H | UTIC1    | UTIF1    | UTMK1    | 0 | 0 | 0 | UTPR12    | UTPR11    | UTPR10    |
| FFFFF1B2H | UIFIC1   | UIFIF1   | UIFMK1   | 0 | 0 | 0 | UIFPR12   | UIFPR11   | UIFPR10   |

Table 7-2. Addresses and Bits of Interrupt Control Registers (3/3)

| Address   | Register | Bit    |        |   |   |   |         |         |         |
|-----------|----------|--------|--------|---|---|---|---------|---------|---------|
|           |          | <7>    | <6>    | 5 | 4 | 3 | 2       | 1       | 0       |
| FFFFF1B4H | UTOIC1   | UTOIF1 | UTOMK1 | 0 | 0 | 0 | UTOPR12 | UTOPR11 | UTOPR10 |
| FFFFF1B6H | ADIC     | ADIF   | ADMK   | 0 | 0 | 0 | ADPR2   | ADPR1   | ADPR0   |
| FFFFF1B8H | US0BIC   | US0BIF | US0BMK | 0 | 0 | 0 | US0BPR2 | US0BPR1 | US0BPR0 |
| FFFFF1BAH | US1BIC   | US1BIF | US1BMK | 0 | 0 | 0 | US1BPR2 | US1BPR1 | US1BPR0 |
| FFFFF1BCH | US2BIC   | US2BIF | US2BMK | 0 | 0 | 0 | US2BPR2 | US2BPR1 | US2BPR0 |
| FFFFF1BEH | USP2IC   | USP2IF | USP2MK | 0 | 0 | 0 | USP2PR2 | USP2PR1 | USP2PR0 |
| FFFFF1C0H | USP4IC   | USP4IF | USP4MK | 0 | 0 | 0 | USP4PR2 | USP4PR1 | USP4PR0 |
| FFFFF1C2H | RSUMIC   | RSUMIF | RSUMMK | 0 | 0 | 0 | RSUMPR2 | RSUMPR1 | RSUMPR0 |

### 7.3.5 Interrupt mask registers 0 to 5 (IMR0 to IMR5)

These registers set the interrupt mask state for the maskable interrupts. The xxMKn bit of the IMR0 to IMR5 registers is equivalent to the xxMKn bit of the xxCn register.

The IMRm register (m = 0 to 5) can be read or written in 16-bit units.

If the higher 8 bits of the IMRm register are used as an IMRmH register and the lower 8 bits as an IMRmL register, these registers can be read or written in 8-bit or 1-bit units.

Set bits 15 to 10 of the IMR5 register (bits 7 to 2 of the IMR5H register) to 1. If these bits are not 1, the operation cannot be guaranteed.

**Caution** The device file defines the xxMKn bit of the xxCn register as a reserved word. If a bit is manipulated using the name of xxMKn, the contents of the xxCn register, instead of the IMRm register, are rewritten (as a result, the contents of the IMRm register are also rewritten).

|      |         |          |         |         |         |         |         |          |         |             |
|------|---------|----------|---------|---------|---------|---------|---------|----------|---------|-------------|
| IMR0 | 15      | 14       | 13      | 12      | 11      | 10      | 9       | 8        | Address | After reset |
|      | PDMK2   | PDMK1    | PDMK0   | P6MK7   | P6MK6   | P6MK5   | P5MK2   | P5MK1    |         |             |
|      | 7       | 6        | 5       | 4       | 3       | 2       | 1       | 0        |         |             |
|      | P5MK0   | P2MK5    | P2MK4   | P2MK3   | P2MK2   | P2MK1   | P1MK1   | P1MK0    |         |             |
| IMR1 | 15      | 14       | 13      | 12      | 11      | 10      | 9       | 8        | Address | After reset |
|      | OVCMK0  | PLMK1    | PLMK0   | PDMK15  | PDMK14  | PDMK13  | PDMK12  | PDMK11   |         |             |
|      | 7       | 6        | 5       | 4       | 3       | 2       | 1       | 0        |         |             |
|      | PDMK10  | PDMK9    | PDMK8   | PDMK7   | PDMK6   | PDMK5   | PDMK4   | PDMK3    |         |             |
| IMR2 | 15      | 14       | 13      | 12      | 11      | 10      | 9       | 8        | Address | After reset |
|      | CCC5MK0 | CCC4MK1  | CCC4MK0 | CCC3MK1 | CCC3MK0 | CCC2MK1 | CCC2MK0 | CCC1MK1  |         |             |
|      | 7       | 6        | 5       | 4       | 3       | 2       | 1       | 0        |         |             |
|      | CCC1MK0 | CCC0MK1  | CCC0MK0 | OVCMK5  | OVCMK4  | OVCMK3  | OVCMK2  | OVCMK1   |         |             |
| IMR3 | 15      | 14       | 13      | 12      | 11      | 10      | 9       | 8        | Address | After reset |
|      | OV1MK1  | CM11MK1  | CM11MK0 | CC11MK1 | CC11MK0 | UD1MK0  | OV1MK0  | CM10MK1  |         |             |
|      | 7       | 6        | 5       | 4       | 3       | 2       | 1       | 0        |         |             |
|      | CM10MK0 | CC10MK1  | CC10MK0 | CMDMK3  | CMDMK2  | CMDMK1  | CMDMK0  | CCC5MK1  |         |             |
| IMR4 | 15      | 14       | 13      | 12      | 11      | 10      | 9       | 8        | Address | After reset |
|      | URMK1   | UREMK1   | UTOMK0  | UIFMK0  | UTMK0   | URMK0   | UREMK0  | COVF3MK1 |         |             |
|      | 7       | 6        | 5       | 4       | 3       | 2       | 1       | 0        |         |             |
|      | CSI3MK1 | COVF3MK0 | CSI3MK0 | DMAMK3  | DMAMK2  | DMAMK1  | DMAMK0  | UD1MK1   |         |             |
| IMR5 | 15      | 14       | 13      | 12      | 11      | 10      | 9       | 8        | Address | After reset |
|      | 1       | 1        | 1       | 1       | 1       | 1       | RSUMMK  | USP4MK   |         |             |
|      | 7       | 6        | 5       | 4       | 3       | 2       | 1       | 0        |         |             |
|      | USP2MK  | US2BMK   | US1BMK  | US0BMK  | ADMK    | UTOMK1  | UIFMK1  | UTMK1    |         |             |

| Bit position | Bit name | Function                                                                                           |
|--------------|----------|----------------------------------------------------------------------------------------------------|
| 15 to 0      | xxMKn    | Interrupt mask flag<br>0: Interrupt servicing enabled<br>1: Interrupt servicing disabled (pending) |

**Remark** xx: Identification name of each peripheral unit (see **Table 7-2**)  
n: Peripheral unit number (see **Table 7-2**)

### 7.3.6 NMI reset status register (NRS)

This register holds the valid edge input status of the NMI after the reset signal has been cleared.

This register is read-only, in 8-bit or 1-bit units.

- Cautions**
1. The NMIRS bit of the NRS register is set to 1 if an NMI occurs after the internal instruction RAM has been set in the read mode (IRAMM0 bit of IRAMM register = 0). In this case, the status of the NMIRS bit does not have to be checked because execution automatically branches to the NMI servicing routine.
  2. The mask function of NMI input is valid after the reset signal has been cleared and before the internal instruction RAM is set in the read mode (IRAMM0 bit of IRAMM register = 0).

|     |   |   |   |   |   |   |   |       |           |             |
|-----|---|---|---|---|---|---|---|-------|-----------|-------------|
|     | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0     | Address   | After reset |
| NRS | 0 | 0 | 0 | 0 | 0 | 0 | 0 | NMIRS | FFFFF80CH | 00H         |

| Bit position | Bit name | Function                                                                         |
|--------------|----------|----------------------------------------------------------------------------------|
| 0            | NMIRS    | Indicates the valid edge input status of NMI.<br>0: No NMI input<br>1: NMI input |

With the V850E/ME2, the NMI is masked after the reset signal has been cleared. It is unmasked if the mode of the internal instruction RAM is changed from the write mode (IRAMM0 bit of IRAMM register = 1) to the read mode (IRAMM0 bit of IRAMM register = 0) after the program has been downloaded to internal instruction RAM bank 0. (The NRS register is controlled to prohibit a jump to the interrupt vector before the program is stored in the interrupt vector table.)

If the NMI valid edge is input while the NMI is masked, the NMI input can be recognized by reading the NRS register.

### 7.3.7 In-service priority register (ISPR)

This register holds the priority level of the maskable interrupt currently acknowledged. When an interrupt request signal is acknowledged, the bit of this register corresponding to the priority level of that interrupt request signal is set to 1 and remains set while the interrupt is serviced.

When the RETI instruction is executed, the bit corresponding to the interrupt request signal having the highest priority is automatically cleared to 0 by hardware. However, it is not cleared to 0 when execution is returned from non-maskable interrupt servicing or exception processing.

This register is read-only, in 8-bit or 1-bit units.

**Caution** If an interrupt is acknowledged while the ISPR register is being read in the interrupt enabled (EI) status, the value of the ISPR register after the bits of the register have been set to 1 by acknowledging the interrupt may be read. To accurately read the value of the ISPR register before an interrupt is acknowledged, read the register while interrupts are disabled (DI status).

|                                                                                                                                                                             |       |       |       |       |       |       |       |         |             |     |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|-------|-------|-------|-------|-------|-------|---------|-------------|-----|
| <div><div>&lt;7&gt;</div><div>&lt;6&gt;</div><div>&lt;5&gt;</div><div>&lt;4&gt;</div><div>&lt;3&gt;</div><div>&lt;2&gt;</div><div>&lt;1&gt;</div><div>&lt;0&gt;</div></div> |       |       |       |       |       |       |       | Address | After reset |     |
| ISPR                                                                                                                                                                        | ISPR7 | ISPR6 | ISPR5 | ISPR4 | ISPR3 | ISPR2 | ISPR1 | ISPR0   | FFFF1FAH    | 00H |

| Bit position | Bit name       | Function                                                                                                                                                                           |
|--------------|----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 7 to 0       | ISPR7 to ISPR0 | Indicates priority of interrupt currently acknowledged<br>0: Interrupt request signal with priority n not acknowledged<br>1: Interrupt request signal with priority n acknowledged |

**Remark** n = 0 to 7 (priority level)

### 7.3.8 Maskable interrupt status flag (ID)

The ID flag controls the maskable interrupt's operating state and stores control information regarding enabling or disabling of interrupt requests. The ID flag is allocated to the PSW.

| <div style="display: flex; align-items: center;"> <div style="margin-right: 10px;">PSW</div> <div style="display: flex; align-items: center;"> <div style="text-align: center; margin-right: 5px;">31</div> <div style="border: 1px solid black; padding: 2px; display: flex; justify-content: space-between; width: 100%;"> <div style="display: flex; justify-content: space-between; width: 100%;"> <span>0</span><span>1</span><span>2</span><span>3</span><span>4</span><span>5</span><span>6</span><span>7</span><span>8</span><span>9</span><span>10</span><span>11</span><span>12</span><span>13</span><span>14</span><span>15</span><span>16</span><span>17</span><span>18</span><span>19</span><span>20</span><span>21</span><span>22</span><span>23</span><span>24</span><span>25</span><span>26</span><span>27</span><span>28</span><span>29</span><span>30</span><span>31</span> </div> <div style="display: flex; justify-content: space-between; width: 100%;"> NP EP ID SAT CY OV S Z </div> </div> </div> <div style="text-align: right; margin-left: 10px;"> After reset: 00000020H </div> </div> |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Bit position                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Bit name | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| 5                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | ID       | Indicates whether maskable interrupt servicing is enabled or disabled.<br>0: Maskable interrupt request signal acknowledgment enabled<br>1: Maskable interrupt request signal acknowledgment disabled (pending)<br>This bit is set to 1 by the DI instruction and cleared to 0 by the EI instruction. Its value is also modified by the RETI instruction or LDSR instruction when referencing the PSW.<br>Non-maskable interrupt request signals and exceptions are acknowledged regardless of this flag. When a maskable interrupt signal is acknowledged, the ID flag is automatically set to 1 by hardware.<br>The interrupt request signal generated during the acknowledgment disabled period (ID flag = 1) is acknowledged when the xxIFn bit of xxICn is set to 1, and the ID flag is cleared to 0. |

### 7.3.9 Selecting interrupt trigger mode

The valid edge of the  $\overline{\text{INTPn}}$ ,  $\text{INTPCm}$ ,  $\text{TIC0}$  to  $\text{TIC3}$ ,  $\text{INTPx}$ ,  $\text{TIUD10}$ ,  $\text{TIUD11}$ ,  $\text{TCUD10}$ ,  $\text{TCUD11}$ ,  $\text{TCLR10}$ , and  $\text{TCLR11}$  pins can be selected by program ( $n = 10, 11, 21$  to  $25, 50$  to  $52, 65$  to  $67, L0, L1$ , or  $D0$  to  $D15, m = 00, 01, 10, 11, 20, 21, 30$ , or  $31, x = 100, 101, 110$ , or  $111$ ). A trigger level can also be selected for the  $\overline{\text{INTPn}}$  pin. The following valid edges can be selected.

- Rising edge
- Falling edge
- Both rising and falling edges

The  $\text{INTPn}$ ,  $\text{INTPCm}$ ,  $\text{TIC0}$  to  $\text{TIC3}$ ,  $\text{INTPx}$ ,  $\text{TIUD10}$ ,  $\text{TIUD11}$ ,  $\text{TCUD10}$ ,  $\text{TCUD11}$ ,  $\text{TCLR10}$ , and  $\text{TCLR11}$  signals detected by the edge are used as interrupt sources, to input a capture trigger, or to input an external count signal to the timers.

The valid edge of these signals is specified by external interrupt rising edge specification registers 1, 2, 5, 6, AL, and DH ( $\text{INTR1}$ ,  $\text{INTR2}$ ,  $\text{INTR5}$ ,  $\text{INTR6}$ ,  $\text{INTRAL}$ , and  $\text{INTRDH}$ ), external interrupt falling edge specification registers 1, 2, 5, 6, AL, and DH ( $\text{INTF1}$ ,  $\text{INTF2}$ ,  $\text{INTF5}$ ,  $\text{INTF6}$ ,  $\text{INTFAL}$ , and  $\text{INTFDH}$ ), valid edge select registers C0 to C3 ( $\text{SESC0}$  to  $\text{SESC3}$ ), and valid edge select registers 10 and 11 ( $\text{SESA10}$  and  $\text{SESA11}$ ). The trigger level is specified by external interrupt rising edge specification registers 1, 2, 5, 6, AL, and DH ( $\text{INTR1}$ ,  $\text{INTR2}$ ,  $\text{INTR5}$ ,  $\text{INTR6}$ ,  $\text{INTRAL}$ , and  $\text{INTRDH}$ ) and external interrupt falling edge specification registers 1, 2, 5, 6, AL, and DH ( $\text{INTF1}$ ,  $\text{INTF2}$ ,  $\text{INTF5}$ ,  $\text{INTF6}$ ,  $\text{INTFAL}$ , and  $\text{INTFDH}$ ).

#### (1) External interrupt rising edge specification register 1 ( $\text{INTR1}$ ), external interrupt falling edge specification register 1 ( $\text{INTF1}$ )

These registers are used to specify the trigger mode of the external interrupt requests ( $\text{INTP10}$  and  $\text{INTP11}$ ) input from external pins. The correspondence between each bit of this register and the external interrupt request controlled by that bit is as follows.

- $\text{INTF10}$  and  $\text{INTR10}$  bits:  $\text{INTP10}$
- $\text{INTF11}$  and  $\text{INTR11}$  bits:  $\text{INTP11}$

The rising edge, falling edge, or both the rising and falling edges can be independently specified as the valid edge.

Each of these registers can be read or written in 8-bit or 1-bit units.

**Caution** Set the  $\text{PMC1}$  register before setting the trigger mode of the  $\overline{\text{INTP10}}$  and  $\overline{\text{INTP11}}$  pins.

If the  $\text{PMC1}$  register is set after the  $\text{INTR1}$  and  $\text{INTF1}$  registers have been set, an illegal interrupt may occur when the  $\text{PMC1}$  register is set.

|       | 7 | 6 | 5 | 4 | 3 | 2 | 1      | 0      | Address   | After reset |
|-------|---|---|---|---|---|---|--------|--------|-----------|-------------|
| INTR1 | 0 | 0 | 0 | 0 | 0 | 0 | INTR11 | INTR10 | FFFFFC22H | 03H         |
| INTF1 | 0 | 0 | 0 | 0 | 0 | 0 | INTF11 | INTF10 | FFFFFC02H | 00H         |

| Bit position | Bit name                        | Function                                                                                                                                                                                                                                                                                                                                       |        |                                                             |           |   |   |              |   |   |             |   |   |                                                             |   |   |                               |
|--------------|---------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|-------------------------------------------------------------|-----------|---|---|--------------|---|---|-------------|---|---|-------------------------------------------------------------|---|---|-------------------------------|
| 1, 0         | INTF1n,<br>INTR1n<br>(n = 0, 1) | Specify the trigger mode of the $\overline{\text{INTP10}}$ and $\overline{\text{INTP11}}$ pins.                                                                                                                                                                                                                                                |        |                                                             |           |   |   |              |   |   |             |   |   |                                                             |   |   |                               |
|              |                                 | <table><tr><th>INTF1n</th><th>INTR1n</th><th>Operation</th></tr><tr><td>0</td><td>0</td><td>Falling edge</td></tr><tr><td>0</td><td>1</td><td>Rising edge</td></tr><tr><td>1</td><td>0</td><td>Level detection (low-level detection)<sup>Notes 1, 2</sup></td></tr><tr><td>1</td><td>1</td><td>Both rising and falling edges</td></tr></table> | INTF1n | INTR1n                                                      | Operation | 0 | 0 | Falling edge | 0 | 1 | Rising edge | 1 | 0 | Level detection (low-level detection) <sup>Notes 1, 2</sup> | 1 | 1 | Both rising and falling edges |
|              |                                 | INTF1n                                                                                                                                                                                                                                                                                                                                         | INTR1n | Operation                                                   |           |   |   |              |   |   |             |   |   |                                                             |   |   |                               |
|              |                                 | 0                                                                                                                                                                                                                                                                                                                                              | 0      | Falling edge                                                |           |   |   |              |   |   |             |   |   |                                                             |   |   |                               |
|              |                                 | 0                                                                                                                                                                                                                                                                                                                                              | 1      | Rising edge                                                 |           |   |   |              |   |   |             |   |   |                                                             |   |   |                               |
|              |                                 | 1                                                                                                                                                                                                                                                                                                                                              | 0      | Level detection (low-level detection) <sup>Notes 1, 2</sup> |           |   |   |              |   |   |             |   |   |                                                             |   |   |                               |
| 1            | 1                               | Both rising and falling edges                                                                                                                                                                                                                                                                                                                  |        |                                                             |           |   |   |              |   |   |             |   |   |                                                             |   |   |                               |
|              |                                 |                                                                                                                                                                                                                                                                                                                                                |        |                                                             |           |   |   |              |   |   |             |   |   |                                                             |   |   |                               |
|              |                                 |                                                                                                                                                                                                                                                                                                                                                |        |                                                             |           |   |   |              |   |   |             |   |   |                                                             |   |   |                               |
|              |                                 |                                                                                                                                                                                                                                                                                                                                                |        |                                                             |           |   |   |              |   |   |             |   |   |                                                             |   |   |                               |
|              |                                 |                                                                                                                                                                                                                                                                                                                                                |        |                                                             |           |   |   |              |   |   |             |   |   |                                                             |   |   |                               |

- Notes 1.** The level of the  $\overline{\text{INTP1n}}$  pin is sampled each time the main clock (fx) is divided by four. When the low level of this pin is detected, an interrupt request is latched as the P1IFn bit (n = 0, 1). Consequently, even when the CPU acknowledges the interrupt and the P1IFn bit of the interrupt control register (P1ICn) is automatically cleared to 0, the P1IFn bit is immediately set to 1 and interrupts occur consecutively. To avoid this status, make the  $\overline{\text{INTP1n}}$  pin of the external device inactive in the interrupt servicing routine, and forcibly clear the P1IFn bit to 0.
- 2.** If a level-detected interrupt request (INTP1n) with a lower priority occurs while an interrupt is being serviced and if this level-detected interrupt request (INTP1n) that has newly occurred becomes inactive before the current interrupt has been serviced, the interrupt request of the new interrupt (INTP1n) is held pending (n = 0, 1). To not acknowledge the interrupt request of INTP1n, clear the P1IFn bit of the interrupt control register.

**(2) External interrupt rising edge specification register 2 (INTR2), external interrupt falling edge specification register 2 (INTF2)**

These registers are used to specify the trigger mode of the external interrupt requests (INTP2n) input from external pins and the non-maskable interrupt (NMI) (n = 1 to 5). For the trigger mode of the NMI, see 7.2.4

**(1) External interrupt rising edge specification register 2 (INTR2), external interrupt falling edge specification register 2 (INTF2).**

The correspondence between each bit and the external interrupt request and non-maskable interrupt that are controlled by that bit is as follows.

- INTF21 and INTR21 bits: INTP21
- INTF22 and INTR22 bits: INTP22
- INTF23 and INTR23 bits: INTP23
- INTF24 and INTR24 bits: INTP24
- INTF25 and INTR25 bits: INTP25

The rising edge, falling edge, or both the rising and falling edges can be independently specified as the valid edge of the  $\overline{\text{INTP2n}}$  pin.

Each of these registers can be read or written in 8-bit or 1-bit units.

**Caution** Set the PMC2 register before setting the trigger mode of the  $\overline{\text{INTP2n}}$  pin (n = 1 to 5).

If the PMC2 register is set after the INTR2 and INTF2 registers have been set, an illegal interrupt may occur when the PMC2 register is set.



|       | 7 | 6 | 5      | 4      | 3      | 2      | 1      | 0     | Address   | After reset |
|-------|---|---|--------|--------|--------|--------|--------|-------|-----------|-------------|
| INTR2 | 0 | 0 | INTR25 | INTR24 | INTR23 | INTR22 | INTR21 | NMIR0 | FFFFFC24H | 3FH         |
| INTF2 | 0 | 0 | INTF25 | INTF24 | INTF23 | INTF22 | INTF21 | NMIF0 | FFFFFC04H | 00H         |

| Bit position | Bit name                          | Function                                                                                                                                                                                                                                                                                                                                       |        |                                                             |           |   |   |              |   |   |             |   |   |                                                             |   |   |                               |
|--------------|-----------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|-------------------------------------------------------------|-----------|---|---|--------------|---|---|-------------|---|---|-------------------------------------------------------------|---|---|-------------------------------|
| 5 to 1       | INTF2n,<br>INTR2n<br>(n = 1 to 5) | Specify the trigger mode of the $\overline{\text{INTP2n}}$ pin.                                                                                                                                                                                                                                                                                |        |                                                             |           |   |   |              |   |   |             |   |   |                                                             |   |   |                               |
|              |                                   | <table><tr><th>INTF2n</th><th>INTR2n</th><th>Operation</th></tr><tr><td>0</td><td>0</td><td>Falling edge</td></tr><tr><td>0</td><td>1</td><td>Rising edge</td></tr><tr><td>1</td><td>0</td><td>Level detection (low-level detection)<sup>Notes 1, 2</sup></td></tr><tr><td>1</td><td>1</td><td>Both rising and falling edges</td></tr></table> | INTF2n | INTR2n                                                      | Operation | 0 | 0 | Falling edge | 0 | 1 | Rising edge | 1 | 0 | Level detection (low-level detection) <sup>Notes 1, 2</sup> | 1 | 1 | Both rising and falling edges |
|              |                                   | INTF2n                                                                                                                                                                                                                                                                                                                                         | INTR2n | Operation                                                   |           |   |   |              |   |   |             |   |   |                                                             |   |   |                               |
|              |                                   | 0                                                                                                                                                                                                                                                                                                                                              | 0      | Falling edge                                                |           |   |   |              |   |   |             |   |   |                                                             |   |   |                               |
|              |                                   | 0                                                                                                                                                                                                                                                                                                                                              | 1      | Rising edge                                                 |           |   |   |              |   |   |             |   |   |                                                             |   |   |                               |
|              |                                   | 1                                                                                                                                                                                                                                                                                                                                              | 0      | Level detection (low-level detection) <sup>Notes 1, 2</sup> |           |   |   |              |   |   |             |   |   |                                                             |   |   |                               |
| 1            | 1                                 | Both rising and falling edges                                                                                                                                                                                                                                                                                                                  |        |                                                             |           |   |   |              |   |   |             |   |   |                                                             |   |   |                               |
|              |                                   |                                                                                                                                                                                                                                                                                                                                                |        |                                                             |           |   |   |              |   |   |             |   |   |                                                             |   |   |                               |
|              |                                   |                                                                                                                                                                                                                                                                                                                                                |        |                                                             |           |   |   |              |   |   |             |   |   |                                                             |   |   |                               |
|              |                                   |                                                                                                                                                                                                                                                                                                                                                |        |                                                             |           |   |   |              |   |   |             |   |   |                                                             |   |   |                               |
|              |                                   |                                                                                                                                                                                                                                                                                                                                                |        |                                                             |           |   |   |              |   |   |             |   |   |                                                             |   |   |                               |

**Notes 1.** The level of the  $\overline{\text{INTP2n}}$  pin is sampled each time the main clock (fx) is divided by four. When the low level of this pin is detected, an interrupt request is latched as the P2IFn bit (n = 1 to 5). Consequently, even when the CPU acknowledges the interrupt and the P2IFn bit of the interrupt control register (P2ICn) is automatically cleared to 0, the P2IFn bit is immediately set to 1 and interrupts occur consecutively. To avoid this status, make the  $\overline{\text{INTP2n}}$  pin of the external device inactive in the interrupt servicing routine, and forcibly clear the P2IFn bit to 0.

- 2.** If a level-detected interrupt request (INTP2n) with a lower priority occurs while an interrupt is being serviced and if this level-detected interrupt request (INTP2n) that has newly occurred becomes inactive before the current interrupt has been serviced, the interrupt request of the new interrupt (INTP2n) is held pending (n = 1 to 5). To not acknowledge the interrupt request of INTP2n, clear the P2IFn bit of the interrupt control register.

**Remark** For the bit 0 (NMIR0) of the INTR2 register and bit 0 (NMIF0) of the INTF2 register, see **7.2.4 (1) External interrupt rising edge specification register 2 (INTR2), external interrupt falling edge specification register 2 (INTF2)**.

**(3) External interrupt rising edge specification register 5 (INTR5), external interrupt falling edge specification register 5 (INTF5)**

These registers are used to specify the trigger mode of the external interrupt requests (INTP5n) input from external pins (n = 0 to 2). The correspondence between each bit of this register and the external interrupt request controlled by that bit is as follows.

- INTF50 and INTR50 bits: INTP50
- INTF51 and INTR51 bits: INTP51
- INTF52 and INTR52 bits: INTP52

The rising edge, falling edge, or both the rising and falling edges can be independently specified as the valid edge.

Each of these registers can be read or written in 8-bit or 1-bit units.

**Caution** Set the PMC5 register before setting the trigger mode.

If the PMC5 register is set after the INTR5 and INTF5 registers have been set, an illegal interrupt may occur when the PMC5 register is set.

|       | 7 | 6 | 5 | 4 | 3 | 2      | 1      | 0      | Address   | After reset |
|-------|---|---|---|---|---|--------|--------|--------|-----------|-------------|
| INTR5 | 0 | 0 | 0 | 0 | 0 | INTR52 | INTR51 | INTR50 | FFFFFC2AH | 07H         |
| INTF5 | 0 | 0 | 0 | 0 | 0 | INTF52 | INTF51 | INTF50 | FFFFC0AH  | 00H         |

| Bit position | Bit name                          | Function                                                        |        |                                                             |   |   |              |   |   |             |   |   |                                                             |   |   |                               |
|--------------|-----------------------------------|-----------------------------------------------------------------|--------|-------------------------------------------------------------|---|---|--------------|---|---|-------------|---|---|-------------------------------------------------------------|---|---|-------------------------------|
| 2 to 0       | INTF5n,<br>INTR5n<br>(n = 0 to 2) | Specify the trigger mode of the $\overline{\text{INTP5n}}$ pin. |        |                                                             |   |   |              |   |   |             |   |   |                                                             |   |   |                               |
|              |                                   | INTF5n                                                          | INTR5n | Operation                                                   | 0 | 0 | Falling edge | 0 | 1 | Rising edge | 1 | 0 | Level detection (low-level detection) <sup>Notes 1, 2</sup> | 1 | 1 | Both rising and falling edges |
|              |                                   | INTF5n                                                          | INTR5n | Operation                                                   |   |   |              |   |   |             |   |   |                                                             |   |   |                               |
|              |                                   | 0                                                               | 0      | Falling edge                                                |   |   |              |   |   |             |   |   |                                                             |   |   |                               |
|              |                                   | 0                                                               | 1      | Rising edge                                                 |   |   |              |   |   |             |   |   |                                                             |   |   |                               |
|              |                                   | 1                                                               | 0      | Level detection (low-level detection) <sup>Notes 1, 2</sup> |   |   |              |   |   |             |   |   |                                                             |   |   |                               |
| 1            | 1                                 | Both rising and falling edges                                   |        |                                                             |   |   |              |   |   |             |   |   |                                                             |   |   |                               |

- Notes 1.** The level of the  $\overline{\text{INTP5n}}$  pin is sampled each time the main clock (fx) is divided by four. When the low level of this pin is detected, an interrupt request is latched as the P5IFn bit (n = 0 to 2). Consequently, even when the CPU acknowledges the interrupt and the P5IFn bit of the interrupt control register (P5ICn) is automatically cleared to 0, the P5IFn bit is immediately set to 1 and interrupts occur consecutively. To avoid this status, make the  $\overline{\text{INTP5n}}$  pin of the external device inactive in the interrupt servicing routine, and forcibly clear the P5IFn bit to 0.
- 2.** If a level-detected interrupt request (INTP5n) with a lower priority occurs while an interrupt is being serviced and if this level-detected interrupt request (INTP5n) that has newly occurred becomes inactive before the current interrupt has been serviced, the interrupt request of the new interrupt (INTP5n) is held pending (n = 0 to 2). To not acknowledge the interrupt request of INTP5n, clear the P5IFn bit of the interrupt control register.

**(4) External interrupt rising edge specification register 6 (INTR6), external interrupt falling edge specification register 6 (INTF6)**

These registers are used to specify the trigger mode of the external interrupt requests (INTP6n) input from external pins (n = 5 to 7). The correspondence between each bit of this register and the external interrupt request controlled by that bit is as follows.

- INTF65 and INTR65 bits: INTP65
- INTF66 and INTR66 bits: INTP66
- INTF67 and INTR67 bits: INTP67

The rising edge, falling edge, or both the rising and falling edges can be independently specified as the valid edge.

Each of these registers can be read or written in 8-bit or 1-bit units.

**Caution** Set the PMC6 register before setting the trigger mode.

If the PMC6 register is set after the INTR6 and INTF6 registers have been set, an illegal interrupt may occur when the PMC6 register is set.

|       | 7      | 6      | 5      | 4 | 3 | 2 | 1 | 0 | Address   | After reset |
|-------|--------|--------|--------|---|---|---|---|---|-----------|-------------|
| INTR6 | INTR67 | INTR66 | INTR65 | 0 | 0 | 0 | 0 | 0 | FFFFFC2CH | E0H         |
| INTF6 | INTF67 | INTF66 | INTF65 | 0 | 0 | 0 | 0 | 0 | FFFFFC0CH | 00H         |

| Bit position | Bit name                          | Function                                                        |        |                                                             |   |   |              |   |   |             |   |   |                                                             |   |   |                               |
|--------------|-----------------------------------|-----------------------------------------------------------------|--------|-------------------------------------------------------------|---|---|--------------|---|---|-------------|---|---|-------------------------------------------------------------|---|---|-------------------------------|
| 7 to 5       | INTF6n,<br>INTR6n<br>(n = 7 to 5) | Specify the trigger mode of the $\overline{\text{INTP6n}}$ pin. |        |                                                             |   |   |              |   |   |             |   |   |                                                             |   |   |                               |
|              |                                   | INTF6n                                                          | INTR6n | Operation                                                   | 0 | 0 | Falling edge | 0 | 1 | Rising edge | 1 | 0 | Level detection (low-level detection) <sup>Notes 1, 2</sup> | 1 | 1 | Both rising and falling edges |
|              |                                   | INTF6n                                                          | INTR6n | Operation                                                   |   |   |              |   |   |             |   |   |                                                             |   |   |                               |
|              |                                   | 0                                                               | 0      | Falling edge                                                |   |   |              |   |   |             |   |   |                                                             |   |   |                               |
|              |                                   | 0                                                               | 1      | Rising edge                                                 |   |   |              |   |   |             |   |   |                                                             |   |   |                               |
|              |                                   | 1                                                               | 0      | Level detection (low-level detection) <sup>Notes 1, 2</sup> |   |   |              |   |   |             |   |   |                                                             |   |   |                               |
| 1            | 1                                 | Both rising and falling edges                                   |        |                                                             |   |   |              |   |   |             |   |   |                                                             |   |   |                               |

- Notes 1.** The level of the  $\overline{\text{INTP6n}}$  pin is sampled each time the main clock (fx) is divided by four. When the low level of this pin is detected, an interrupt request is latched as the P6IFn bit (n = 5 to 7). Consequently, even when the CPU acknowledges the interrupt and the P6IFn bit of the interrupt control register (P6ICn) is automatically cleared to 0, the P6IFn bit is immediately set to 1 and interrupts occur consecutively. To avoid this status, make the  $\overline{\text{INTP6n}}$  pin of the external device inactive in the interrupt servicing routine, and forcibly clear the P6IFn bit to 0.
- 2.** If a level-detected interrupt request (INTP6n) with a lower priority occurs while an interrupt is being serviced and if this level-detected interrupt request (INTP6n) that has newly occurred becomes inactive before the current interrupt has been serviced, the interrupt request of the new interrupt (INTP6n) is held pending (n = 5 to 7). To not acknowledge the interrupt request of INTP6n, clear the P6IFn bit of the interrupt control register.

**(5) External interrupt rising edge specification register AL (INTRAL), external interrupt falling edge specification register AL (INTFAL)**

These registers are used to specify the trigger mode of the external interrupt requests (INTPL<sub>n</sub>) input from external pins (n = 0, 1). The correspondence between each bit of this register and the external interrupt request controlled by that bit is as follows.

- INTFAL0 and INTRAL0 bits: INTPL0
- INTFAL1 and INTRAL1 bits: INTPL1

The rising edge, falling edge, or both the rising and falling edges can be independently specified as the valid edge.

Each of these registers can be read or written in 8-bit or 1-bit units.

**Caution** Set the PMCAL register before setting the trigger mode.

If the PMCAL register is set after the INTRAL and INTFAL registers have been set, an illegal interrupt may occur when the PMCAL register is set.

|        | 7 | 6 | 5 | 4 | 3 | 2 | 1       | 0       | Address   | After reset |
|--------|---|---|---|---|---|---|---------|---------|-----------|-------------|
| INTRAL | 0 | 0 | 0 | 0 | 0 | 0 | INTRAL1 | INTRAL0 | FFFFFC30H | 03H         |
| INTFAL | 0 | 0 | 0 | 0 | 0 | 0 | INTFAL1 | INTFAL0 | FFFFFC10H | 00H         |

| Bit position        | Bit name                                                   | Function                                                                                                                                                                                                                                                                                                                                                                                                                                             |                     |                     |           |   |   |              |   |   |             |   |   |                                                             |   |   |                               |
|---------------------|------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|---------------------|-----------|---|---|--------------|---|---|-------------|---|---|-------------------------------------------------------------|---|---|-------------------------------|
| 1, 0                | INTFAL <sub>n</sub> ,<br>INTRAL <sub>n</sub><br>(n = 0, 1) | Specify the trigger mode of the INTPL <sub>n</sub> pin. <table border="1"> <tr> <th>INTFAL<sub>n</sub></th><th>INTRAL<sub>n</sub></th><th>Operation</th></tr> <tr> <td>0</td><td>0</td><td>Falling edge</td></tr> <tr> <td>0</td><td>1</td><td>Rising edge</td></tr> <tr> <td>1</td><td>0</td><td>Level detection (low-level detection)<sup>Notes 1, 2</sup></td></tr> <tr> <td>1</td><td>1</td><td>Both rising and falling edges</td></tr> </table> | INTFAL <sub>n</sub> | INTRAL <sub>n</sub> | Operation | 0 | 0 | Falling edge | 0 | 1 | Rising edge | 1 | 0 | Level detection (low-level detection) <sup>Notes 1, 2</sup> | 1 | 1 | Both rising and falling edges |
| INTFAL <sub>n</sub> | INTRAL <sub>n</sub>                                        | Operation                                                                                                                                                                                                                                                                                                                                                                                                                                            |                     |                     |           |   |   |              |   |   |             |   |   |                                                             |   |   |                               |
| 0                   | 0                                                          | Falling edge                                                                                                                                                                                                                                                                                                                                                                                                                                         |                     |                     |           |   |   |              |   |   |             |   |   |                                                             |   |   |                               |
| 0                   | 1                                                          | Rising edge                                                                                                                                                                                                                                                                                                                                                                                                                                          |                     |                     |           |   |   |              |   |   |             |   |   |                                                             |   |   |                               |
| 1                   | 0                                                          | Level detection (low-level detection) <sup>Notes 1, 2</sup>                                                                                                                                                                                                                                                                                                                                                                                          |                     |                     |           |   |   |              |   |   |             |   |   |                                                             |   |   |                               |
| 1                   | 1                                                          | Both rising and falling edges                                                                                                                                                                                                                                                                                                                                                                                                                        |                     |                     |           |   |   |              |   |   |             |   |   |                                                             |   |   |                               |

**Notes 1.** The level of the INTPL<sub>n</sub> pin is sampled each time the main clock (fx) is divided by four. When the low level of this pin is detected, an interrupt request is latched as the PLIF<sub>n</sub> bit (n = 0, 1). Consequently, even when the CPU acknowledges the interrupt and the PLIF<sub>n</sub> bit of the interrupt control register (PLIC<sub>n</sub>) is automatically cleared to 0, the PLIF<sub>n</sub> bit is immediately set to 1 and interrupts occur consecutively. To avoid this status, make the INTPL<sub>n</sub> pin of the external device inactive in the interrupt servicing routine, and forcibly clear the PLIF<sub>n</sub> bit to 0.

**2.** If a level-detected interrupt request (INTPL<sub>n</sub>) with a lower priority occurs while an interrupt is being serviced and if this level-detected interrupt request (INTPL<sub>n</sub>) that has newly occurred becomes inactive before the current interrupt has been serviced, the interrupt request of the new interrupt (INTPL<sub>n</sub>) is held pending (n = 0, 1). To not acknowledge the interrupt request of INTPL<sub>n</sub>, clear the PLIF<sub>n</sub> bit of the interrupt control register.

**(6) External interrupt rising edge specification register DH (INTRDH), external interrupt falling edge specification register DH (INTFDH)**

These registers are used to specify the trigger mode of the external interrupt requests (INTPDn) input from external pins (n = 0 to 15). The correspondence between each bit of this register and the external interrupt request controlled by that bit is as follows.

- |                                    |                                       |
|------------------------------------|---------------------------------------|
| • INTFDH0 and INTRDH0 bits: INTPD0 | • INTFDH8 and INTRDH8 bits: INTPD8    |
| • INTFDH1 and INTRDH1 bits: INTPD1 | • INTFDH9 and INTRDH9 bits: INTPD9    |
| • INTFDH2 and INTRDH2 bits: INTPD2 | • INTFDH10 and INTRDH10 bits: INTPD10 |
| • INTFDH3 and INTRDH3 bits: INTPD3 | • INTFDH11 and INTRDH11 bits: INTPD11 |
| • INTFDH4 and INTRDH4 bits: INTPD4 | • INTFDH12 and INTRDH12 bits: INTPD12 |
| • INTFDH5 and INTRDH5 bits: INTPD5 | • INTFDH13 and INTRDH13 bits: INTPD13 |
| • INTFDH6 and INTRDH6 bits: INTPD6 | • INTFDH14 and INTRDH14 bits: INTPD14 |
| • INTFDH7 and INTRDH7 bits: INTPD7 | • INTFDH15 and INTRDH15 bits: INTPD15 |

The rising edge, falling edge, or both the rising and falling edges can be independently specified as the valid edge.

The INTRDH and INTFDH registers can be read or written in 16-bit units.

If the higher 8 bits of the INTRDH and INTFDH registers are used as the INTRDHH and INTFDHH registers, and the lower 8 bits as the INTRDHL and INTFDHL registers, these registers can be read or written in 8-bit or 1-bit units.

**Caution** Set the PMCDH register before setting the trigger mode.

If the PMCDH register is set after the INTRDH and INTFDH registers have been set, an illegal interrupt may occur when the PMCDH register is set.

|        | 15   | 14   | 13   | 12   | 11   | 10   | 9    | 8    | 7    | 6    | 5    | 4    | 3    | 2    | 1    | 0    | Address    | After reset |
|--------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------------|-------------|
| INTRDH | INTR | INTR | INTR | INTR | INTR | INTR | INTR | INTR | INTR | INTR | INTR | INTR | INTR | INTR | INTR | INTR | FFFFFFC36H | FFFFH       |
|        | DH15 | DH14 | DH13 | DH12 | DH11 | DH10 | DH9  | DH8  | DH7  | DH6  | DH5  | DH4  | DH3  | DH2  | DH1  | DH0  |            |             |
| INTFDH | INTF | INTF | INTF | INTF | INTF | INTF | INTF | INTF | INTF | INTF | INTF | INTF | INTF | INTF | INTF | INTF | FFFFFFC16H | 0000H       |
|        | DH15 | DH14 | DH13 | DH12 | DH11 | DH10 | DH9  | DH8  | DH7  | DH6  | DH5  | DH4  | DH3  | DH2  | DH1  | DH0  |            |             |

| Bit position | Bit name                             | Function                                                                                                                                                                                                                                                                                                                                                                                                                    |         |         |           |   |   |              |   |   |             |   |   |                                                             |   |   |                               |
|--------------|--------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|---------|-----------|---|---|--------------|---|---|-------------|---|---|-------------------------------------------------------------|---|---|-------------------------------|
| 15 to 0      | INTFDHn,<br>INTRDHn<br>(n = 0 to 15) | Specify the trigger mode of the $\overline{\text{INTPDn}}$ pin. <table> <tr> <th>INTFDHn</th><th>INTRDHn</th><th>Operation</th></tr> <tr> <td>0</td><td>0</td><td>Falling edge</td></tr> <tr> <td>0</td><td>1</td><td>Rising edge</td></tr> <tr> <td>1</td><td>0</td><td>Level detection (low-level detection)<sup>Notes 1, 2</sup></td></tr> <tr> <td>1</td><td>1</td><td>Both rising and falling edges</td></tr> </table> | INTFDHn | INTRDHn | Operation | 0 | 0 | Falling edge | 0 | 1 | Rising edge | 1 | 0 | Level detection (low-level detection) <sup>Notes 1, 2</sup> | 1 | 1 | Both rising and falling edges |
| INTFDHn      | INTRDHn                              | Operation                                                                                                                                                                                                                                                                                                                                                                                                                   |         |         |           |   |   |              |   |   |             |   |   |                                                             |   |   |                               |
| 0            | 0                                    | Falling edge                                                                                                                                                                                                                                                                                                                                                                                                                |         |         |           |   |   |              |   |   |             |   |   |                                                             |   |   |                               |
| 0            | 1                                    | Rising edge                                                                                                                                                                                                                                                                                                                                                                                                                 |         |         |           |   |   |              |   |   |             |   |   |                                                             |   |   |                               |
| 1            | 0                                    | Level detection (low-level detection) <sup>Notes 1, 2</sup>                                                                                                                                                                                                                                                                                                                                                                 |         |         |           |   |   |              |   |   |             |   |   |                                                             |   |   |                               |
| 1            | 1                                    | Both rising and falling edges                                                                                                                                                                                                                                                                                                                                                                                               |         |         |           |   |   |              |   |   |             |   |   |                                                             |   |   |                               |

- Notes 1.** The level of the  $\overline{\text{INTPDn}}$  pin is sampled each time the main clock (fx) is divided by four. When the low level of this pin is detected, an interrupt request is latched as the PDIFn bit (n = 0 to 15). Consequently, even when the CPU acknowledges the interrupt and the PDIFn bit of the interrupt control register (PDICn) is automatically cleared to 0, the PDIFn bit is immediately set to 1 and interrupts occur consecutively. To avoid this status, make the  $\overline{\text{INTPDn}}$  pin of the external device inactive in the interrupt servicing routine, and forcibly clear the PDIFn bit to 0.
- 2.** If a level-detected interrupt request (INTPDn) with a lower priority occurs while an interrupt is being serviced and if this level-detected interrupt request (INTPDn) that has newly occurred becomes inactive before the current interrupt has been serviced, the interrupt request of the new interrupt (INTPDn) is held pending (n = 0 to 15). To not acknowledge the interrupt request of INTPDn, clear the PDIFn bit of the interrupt control register.



**(7) Valid edge select registers C0 to C3 (SESC0 to SESC3)**

These registers are used to specify the valid edge of the external interrupt requests (INTPC00, INTPC01, INTPC10, INTPC11, INTPC20, INTPC21, INTPC30, INTPC31, or TIC0 to TIC3) input from external pins to TMCn (n = 0 to 3).

The rising edge, falling edge, or both the rising and falling edges can be independently specified as the valid edge.

Each of these registers can be read or written in 8-bit units.

Be sure to clear bits 5 and 4 to 0. If they are set to 1, the operation is not guaranteed.

- Cautions**
- 1. Do not change each bit of the SESCn register while the timer is operating (n = 0 to 3).**  
To change a bit, clear the CECn bit of the TMCCn0 register to 0. The operation is not guaranteed if the SESCn register is rewritten during timer operation.
  - 2. Even when the INTPC00/TIC0, INTPC10/TIC1, INTPC20/TIC2, and INTPC30/TIC3 pins are used as INTPC00, INTPC10, INTPC20, and INTPC30, respectively, without using timer C, be sure to set the CAECn and CECn bits of timer mode control registers C00 to C03 (TMCC00 to TMCC30) to 1.**
  - 3. Set the PMCx register before setting the trigger mode of the INTPC00, INTPC01, INTPC10, INTPC11, INTPC20, INTPC21, INTPC30, INTPC31, and TIC0 to TIC3 pins (x = 5 to 7), then set the CAECn and CECn bits of the TMCCn0 register to 1 (n = 0 to 3).**  
If the PMCx register is set after the SESCn register has been set, an illegal interrupt, incorrect count, or incorrect clear may occur depending on the timing of setting the PMCx register (n = 0 to 3, x = 5 to 7).

|       |        |        |   |   |         |         |         |         |           |             |
|-------|--------|--------|---|---|---------|---------|---------|---------|-----------|-------------|
| SESC0 | 7      | 6      | 5 | 4 | 3       | 2       | 1       | 0       | Address   | After reset |
|       | TESC01 | TESC00 | 0 | 0 | IESC101 | IESC100 | IESC001 | IESC000 | FFFFF609H | 00H         |
|       | TIC0   |        |   |   | INTPC01 |         | INTPC00 |         |           |             |
| SESC1 | 7      | 6      | 5 | 4 | 3       | 2       | 1       | 0       | Address   | After reset |
|       | TESC11 | TESC10 | 0 | 0 | IESC111 | IESC110 | IESC011 | IESC010 | FFFFF629H | 00H         |
|       | TIC1   |        |   |   | INTPC11 |         | INTPC10 |         |           |             |
| SESC2 | 7      | 6      | 5 | 4 | 3       | 2       | 1       | 0       | Address   | After reset |
|       | TESC21 | TESC20 | 0 | 0 | IESC121 | IESC120 | IESC021 | IESC020 | FFFFF649H | 00H         |
|       | TIC2   |        |   |   | INTPC21 |         | INTPC20 |         |           |             |
| SESC3 | 7      | 6      | 5 | 4 | 3       | 2       | 1       | 0       | Address   | After reset |
|       | TESC31 | TESC30 | 0 | 0 | IESC131 | IESC130 | IESC031 | IESC030 | FFFFF669H | 00H         |
|       | TIC3   |        |   |   | INTPC31 |         | INTPC30 |         |           |             |

| Bit position | Bit name                            | Function                                                                                                                                                                                                                                                                                                          |        |        |           |   |   |              |   |   |             |   |   |                    |   |   |                               |
|--------------|-------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|--------|-----------|---|---|--------------|---|---|-------------|---|---|--------------------|---|---|-------------------------------|
| 7, 6         | TESCn1,<br>TESCn0<br>(n = 0 to 3)   | Specify the valid edge of the INTPCm0, INTPCm1, and TICm pins (m = 0 to 3).                                                                                                                                                                                                                                       |        |        |           |   |   |              |   |   |             |   |   |                    |   |   |                               |
| 3, 2         | IESCn1,<br>IESCn0<br>(n = 10 to 13) |                                                                                                                                                                                                                                                                                                                   |        |        |           |   |   |              |   |   |             |   |   |                    |   |   |                               |
| 1, 0         | IESCn1,<br>IESCn0<br>(n = 00 to 03) |                                                                                                                                                                                                                                                                                                                   |        |        |           |   |   |              |   |   |             |   |   |                    |   |   |                               |
|              |                                     |                                                                                                                                                                                                                                                                                                                   |        |        |           |   |   |              |   |   |             |   |   |                    |   |   |                               |
|              |                                     |                                                                                                                                                                                                                                                                                                                   |        |        |           |   |   |              |   |   |             |   |   |                    |   |   |                               |
|              |                                     | <table> <tr> <th>xESCn1</th><th>xESCn0</th><th>Operation</th></tr> <tr> <td>0</td><td>0</td><td>Falling edge</td></tr> <tr> <td>0</td><td>1</td><td>Rising edge</td></tr> <tr> <td>1</td><td>0</td><td>Setting prohibited</td></tr> <tr> <td>1</td><td>1</td><td>Both rising and falling edges</td></tr> </table> | xESCn1 | xESCn0 | Operation | 0 | 0 | Falling edge | 0 | 1 | Rising edge | 1 | 0 | Setting prohibited | 1 | 1 | Both rising and falling edges |
| xESCn1       | xESCn0                              | Operation                                                                                                                                                                                                                                                                                                         |        |        |           |   |   |              |   |   |             |   |   |                    |   |   |                               |
| 0            | 0                                   | Falling edge                                                                                                                                                                                                                                                                                                      |        |        |           |   |   |              |   |   |             |   |   |                    |   |   |                               |
| 0            | 1                                   | Rising edge                                                                                                                                                                                                                                                                                                       |        |        |           |   |   |              |   |   |             |   |   |                    |   |   |                               |
| 1            | 0                                   | Setting prohibited                                                                                                                                                                                                                                                                                                |        |        |           |   |   |              |   |   |             |   |   |                    |   |   |                               |
| 1            | 1                                   | Both rising and falling edges                                                                                                                                                                                                                                                                                     |        |        |           |   |   |              |   |   |             |   |   |                    |   |   |                               |

**(8) Valid edge select registers 10, 11 (SESA10, SESA11)**

These registers are used to specify the valid edge of the external interrupt requests (TIUD10, TIUD11, TCUD10, TCUD11, TCLR10, or TCLR11) input from external pins and the external capture trigger inputs to timer ENC1 (INTP100, INTP101, INTP110, or INTP111).

The rising edge, falling edge, or both the rising and falling edges can be independently specified as the valid edge.

Each of these registers can be read or written in 8-bit or 1-bit units.

**Cautions 1.** Changing each bit of the SESA1n register is prohibited while TMENC1n is operating (CE1n1 bit = 1).

**2.** Set the PMCDH register before setting the trigger mode of the INTP100, INTP101, INTP110, INTP111, TIUD10, TIUD11, TCUD10, TCUD11, TCLR10, and TCLR11 pins. If the PMCDH register is set after the SESA1n register has been set, an illegal interrupt, incorrect count, or incorrect clear may occur depending on the timing of setting the PMCDH register.

(1/2)

|        | 7              | 6       | 5       | 4       | 3       | 2      | 1       | 0      | Address   | After reset |
|--------|----------------|---------|---------|---------|---------|--------|---------|--------|-----------|-------------|
| SESA10 | TESUD01        | TESUD00 | CESUD01 | CESUD00 | IES101  | IES100 | IES001  | IES000 | FFFFF5ADH | 00H         |
|        | TIUD10, TCUD10 |         | TCLR10  |         | INTP101 |        | INTP100 |        |           |             |
| SESA11 | TESUD11        | TESUD10 | CESUD11 | CESUD10 | IES111  | IES110 | IES011  | IES010 | FFFFF5DDH | 00H         |
|        | TIUD11, TCUD11 |         | TCLR11  |         | INTP111 |        | INTP110 |        |           |             |

| Bit position | Bit name         | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |         |         |            |   |   |              |   |   |             |   |   |                    |   |   |                               |
|--------------|------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|---------|------------|---|---|--------------|---|---|-------------|---|---|--------------------|---|---|-------------------------------|
| 7, 6         | TESUDn1, TESUDn0 | <p>Specify the valid edge of the TIUD1n and TCUD1n pins.</p> <table> <tr> <th>TESUDn1</th><th>TESUDn0</th><th>Valid edge</th></tr> <tr> <td>0</td><td>0</td><td>Falling edge</td></tr> <tr> <td>0</td><td>1</td><td>Rising edge</td></tr> <tr> <td>1</td><td>0</td><td>Setting prohibited</td></tr> <tr> <td>1</td><td>1</td><td>Both rising and falling edges</td></tr> </table> <p><b>Cautions 1.</b> The set values of the TESUDn1 and TESUDn0 bits are valid only in UDC mode A and UDC mode B.</p> <p><b>2.</b> If mode 4 is specified for the operation of TMENC1n (specified by the PRM1n2 to PRM1n0 bits of the PRM1n register), specifying the valid edge for the TIUD1n and TCUD1n pins (TESUDn1 and TESUDn0 bits) is invalid.</p> | TESUDn1 | TESUDn0 | Valid edge | 0 | 0 | Falling edge | 0 | 1 | Rising edge | 1 | 0 | Setting prohibited | 1 | 1 | Both rising and falling edges |
| TESUDn1      | TESUDn0          | Valid edge                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |         |         |            |   |   |              |   |   |             |   |   |                    |   |   |                               |
| 0            | 0                | Falling edge                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |         |         |            |   |   |              |   |   |             |   |   |                    |   |   |                               |
| 0            | 1                | Rising edge                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |         |         |            |   |   |              |   |   |             |   |   |                    |   |   |                               |
| 1            | 0                | Setting prohibited                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |         |         |            |   |   |              |   |   |             |   |   |                    |   |   |                               |
| 1            | 1                | Both rising and falling edges                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |         |         |            |   |   |              |   |   |             |   |   |                    |   |   |                               |

**Remark** n = 0, 1

| Bit position | Bit name            | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |         |         |            |   |   |              |   |   |             |   |   |                    |   |   |                               |
|--------------|---------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|---------|------------|---|---|--------------|---|---|-------------|---|---|--------------------|---|---|-------------------------------|
| 5, 4         | CESUDn1,<br>CESUDn0 | <p>Specify the valid edge of the TCLR1n pin.</p> <table> <tr> <th>CESUDn1</th><th>CESUDn0</th><th>Valid edge</th></tr> <tr> <td>0</td><td>0</td><td>Falling edge</td></tr> <tr> <td>0</td><td>1</td><td>Rising edge</td></tr> <tr> <td>1</td><td>0</td><td>Low-level</td></tr> <tr> <td>1</td><td>1</td><td>High-level</td></tr> </table> <p>The relationship between the set values of the CESUDn1 and CESUDn0 bits and the operation of TMENC1n is as follows.</p> <p>00: TMENC1n cleared after the rising edge of TCLR1n has been detected.</p> <p>01: TMENC1n cleared after the falling edge of TCLR1n has been detected.</p> <p>10: TMENC1n stays cleared while TCLR1n input is low.</p> <p>11: TMENC1n stays cleared while TCLR1n input is high.</p> <p><b>Caution</b> The set values of the CESUDn1 and CESUDn0 bits are valid only in UDC mode A.</p> | CESUDn1 | CESUDn0 | Valid edge | 0 | 0 | Falling edge | 0 | 1 | Rising edge | 1 | 0 | Low-level          | 1 | 1 | High-level                    |
| CESUDn1      | CESUDn0             | Valid edge                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |         |         |            |   |   |              |   |   |             |   |   |                    |   |   |                               |
| 0            | 0                   | Falling edge                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |         |         |            |   |   |              |   |   |             |   |   |                    |   |   |                               |
| 0            | 1                   | Rising edge                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |         |         |            |   |   |              |   |   |             |   |   |                    |   |   |                               |
| 1            | 0                   | Low-level                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |         |         |            |   |   |              |   |   |             |   |   |                    |   |   |                               |
| 1            | 1                   | High-level                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |         |         |            |   |   |              |   |   |             |   |   |                    |   |   |                               |
| 3, 2         | IES1n1,<br>IES1n0   | <p>Specify the valid edge of the INTP1n1 pin.</p> <table> <tr> <th>IES1n1</th><th>IES1n0</th><th>Valid edge</th></tr> <tr> <td>0</td><td>0</td><td>Falling edge</td></tr> <tr> <td>0</td><td>1</td><td>Rising edge</td></tr> <tr> <td>1</td><td>0</td><td>Setting prohibited</td></tr> <tr> <td>1</td><td>1</td><td>Both rising and falling edges</td></tr> </table>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | IES1n1  | IES1n0  | Valid edge | 0 | 0 | Falling edge | 0 | 1 | Rising edge | 1 | 0 | Setting prohibited | 1 | 1 | Both rising and falling edges |
| IES1n1       | IES1n0              | Valid edge                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |         |         |            |   |   |              |   |   |             |   |   |                    |   |   |                               |
| 0            | 0                   | Falling edge                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |         |         |            |   |   |              |   |   |             |   |   |                    |   |   |                               |
| 0            | 1                   | Rising edge                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |         |         |            |   |   |              |   |   |             |   |   |                    |   |   |                               |
| 1            | 0                   | Setting prohibited                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |         |         |            |   |   |              |   |   |             |   |   |                    |   |   |                               |
| 1            | 1                   | Both rising and falling edges                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |         |         |            |   |   |              |   |   |             |   |   |                    |   |   |                               |
| 1, 0         | IES0n1,<br>IES0n0   | <p>Specify the valid edge of the INTP1n0 pin.</p> <table> <tr> <th>IES0n1</th><th>IES0n0</th><th>Valid edge</th></tr> <tr> <td>0</td><td>0</td><td>Falling edge</td></tr> <tr> <td>0</td><td>1</td><td>Rising edge</td></tr> <tr> <td>1</td><td>0</td><td>Setting prohibited</td></tr> <tr> <td>1</td><td>1</td><td>Both rising and falling edges</td></tr> </table>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | IES0n1  | IES0n0  | Valid edge | 0 | 0 | Falling edge | 0 | 1 | Rising edge | 1 | 0 | Setting prohibited | 1 | 1 | Both rising and falling edges |
| IES0n1       | IES0n0              | Valid edge                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |         |         |            |   |   |              |   |   |             |   |   |                    |   |   |                               |
| 0            | 0                   | Falling edge                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |         |         |            |   |   |              |   |   |             |   |   |                    |   |   |                               |
| 0            | 1                   | Rising edge                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |         |         |            |   |   |              |   |   |             |   |   |                    |   |   |                               |
| 1            | 0                   | Setting prohibited                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |         |         |            |   |   |              |   |   |             |   |   |                    |   |   |                               |
| 1            | 1                   | Both rising and falling edges                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |         |         |            |   |   |              |   |   |             |   |   |                    |   |   |                               |

**Remark** n = 0, 1

## 7.4 Software Exception

A software exception is generated when the CPU executes the TRAP instruction, and can always be acknowledged.

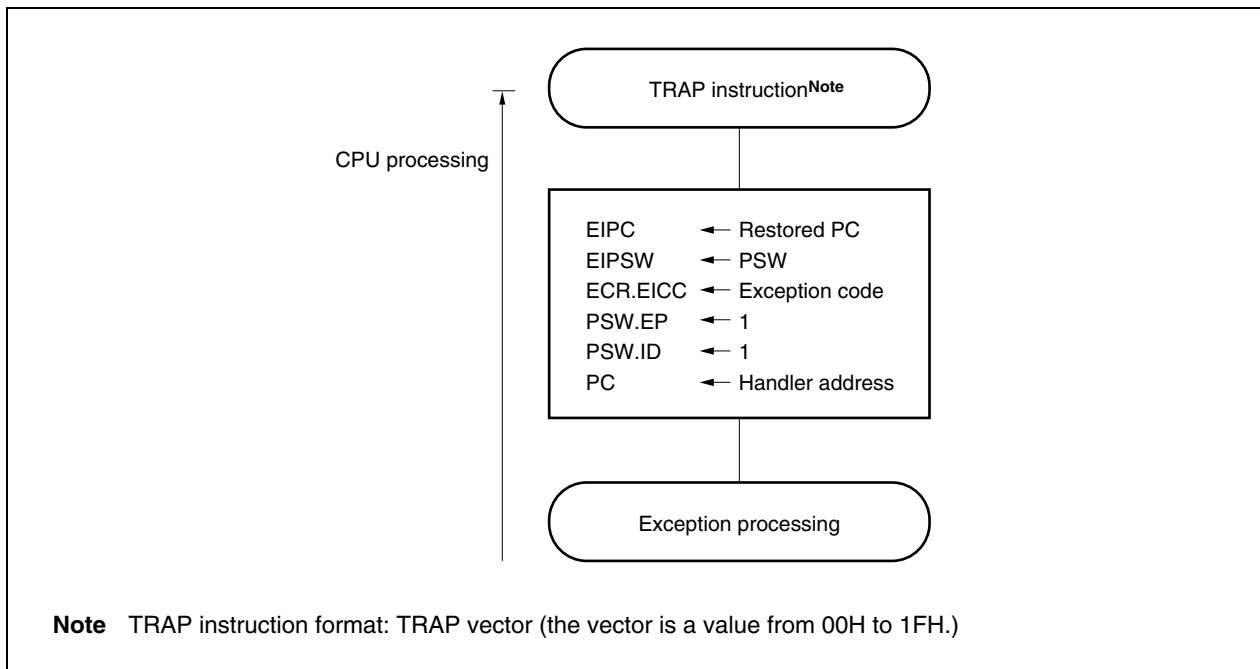
### 7.4.1 Operation

If a software exception occurs, the CPU performs the following processing, and transfers control to the handler routine:

- <1> Saves the restored PC to EIPC.
- <2> Saves the current PSW to EIPSW.
- <3> Writes an exception code to the lower 16 bits (EICC) of ECR (interrupt source).
- <4> Sets the EP and ID bits of the PSW to 1.
- <5> Sets the handler address (00000040H or 00000050H) corresponding to the software exception to the PC, and transfers control.

Figure 7-8 illustrates the processing of a software exception.

**Figure 7-8. Software Exception Processing**



The handler address is determined by the TRAP instruction's operand (vector). If the vector is 00H to 0FH, it becomes 00000040H, and if the vector is 10H to 1FH, it becomes 00000050H.

### 7.4.2 Restore

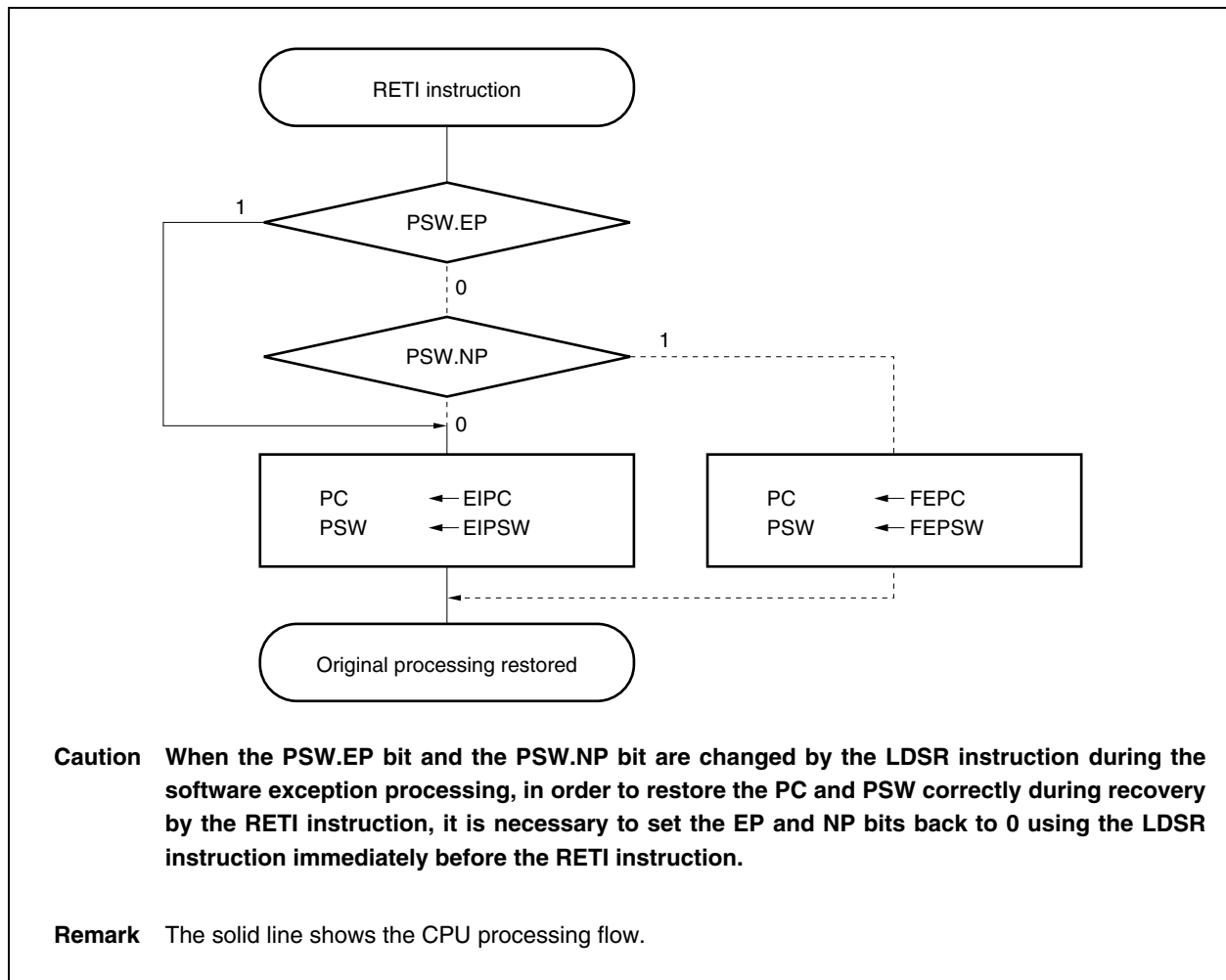
Recovery from software exception processing is carried out by the RETI instruction.

By executing the RETI instruction, the CPU carries out the following processing and shifts control to the restored PC's address.

- <1> Loads the restored PC and PSW from EIPC and EIPSW because the EP bit of the PSW is 1.
- <2> Transfers control to the address of the restored PC and PSW.

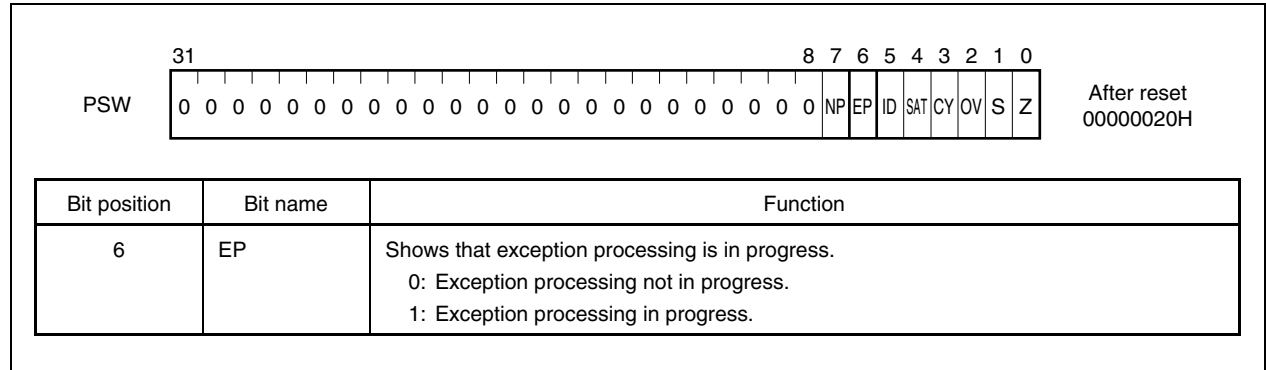
Figure 7-9 illustrates the processing of the RETI instruction.

**Figure 7-9. RETI Instruction Processing**



### 7.4.3 Exception status flag (EP)

The EP flag is a status flag used to indicate that exception processing is in progress. It is set to 1 when an exception occurs. The EP flag is allocated to the PSW.

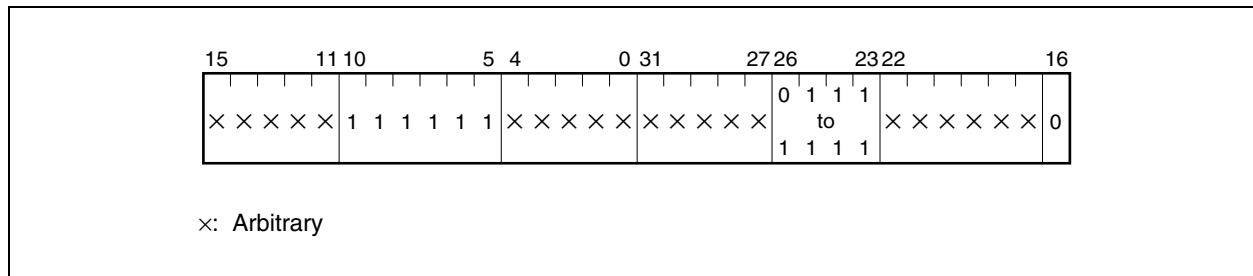


## 7.5 Exception Trap

An exception trap is an interrupt that is requested when the illegal execution of an instruction takes place. In the V850E/ME2, an illegal opcode exception (ILGOP: Illegal Opcode Trap) is considered as an exception trap.

### 7.5.1 Illegal opcode definition

The illegal instruction has an opcode (bits 10 to 5) of 111111B, a sub-opcode (bits 26 to 23) of 0111B to 1111B, and a sub-opcode (bit 16) of 0B. An exception trap is generated when an instruction applicable to this illegal instruction is executed.



**Caution** Since it is possible to assign this instruction to an illegal opcode in the future, it is recommended that it not be used.

#### (1) Operation

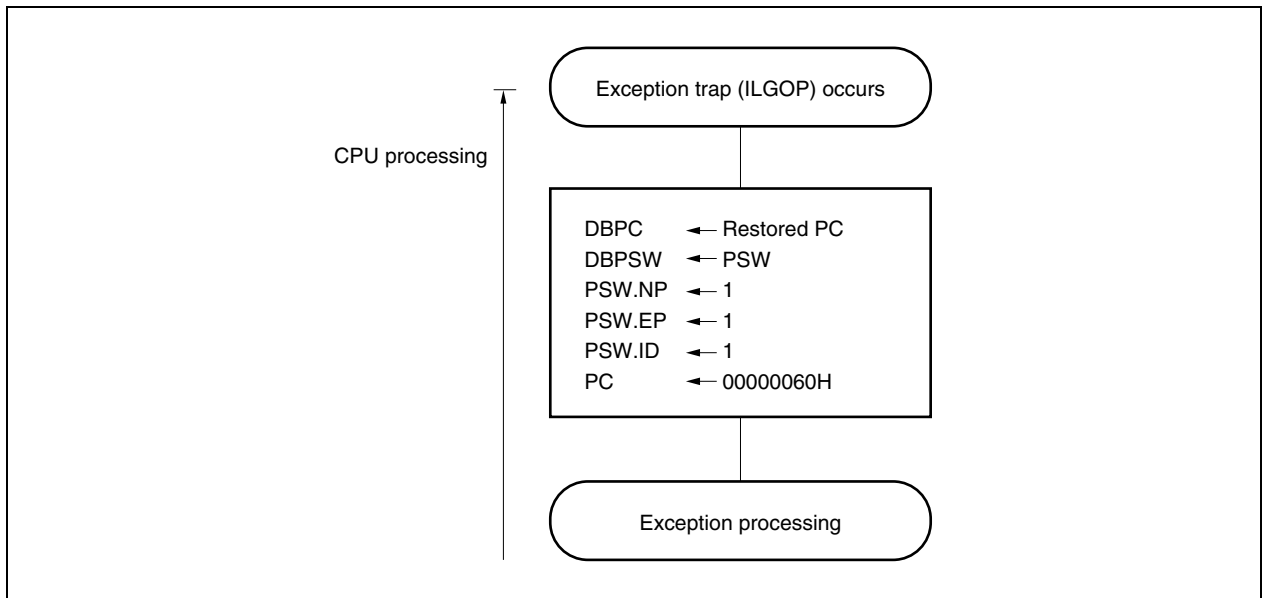
If an exception trap occurs, the CPU performs the following processing, and transfers control to the handler routine:

- <1> Saves the restored PC to DBPC.
- <2> Saves the current PSW to DBPSW.
- <3> Sets the NP, EP, and ID bits of the PSW to 1.
- <4> Sets the handler address (00000060H) corresponding to the exception trap to the PC, and transfers control.

Figure 7-10 illustrates the processing of the exception trap.



Figure 7-10. Exception Trap Processing

**(2) Restore**

Recovery from an exception trap is carried out by the DBRET instruction. By executing the DBRET instruction, the CPU carries out the following processing and controls the address of the restored PC.

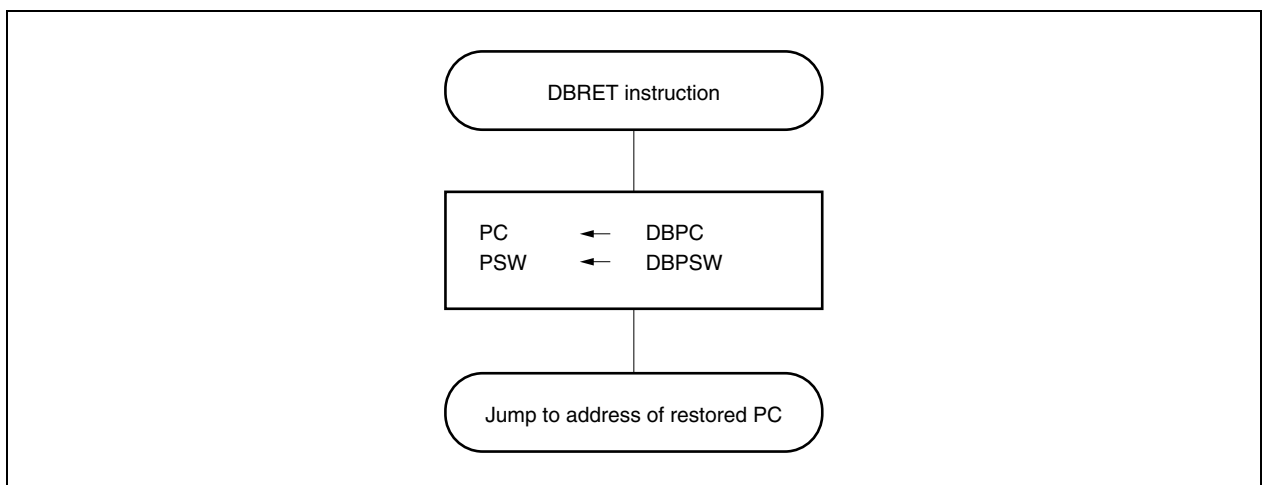
- <1> Loads the restored PC and PSW from DBPC and DBPSW.
- <2> Transfers control to the address indicated by the restored PC and PSW.

&lt;R&gt;

**Caution** DBPC and DBPSW can be accessed only during the period between when the illegal opcode is executed and when the DBRET instruction is executed.

Figure 7-11 illustrates the restore processing from an exception trap.

Figure 7-11. Restore Processing from Exception Trap



### 7.5.2 Debug trap

The debug trap is an exception that can be acknowledged every time and is generated by execution of the DBTRAP instruction.

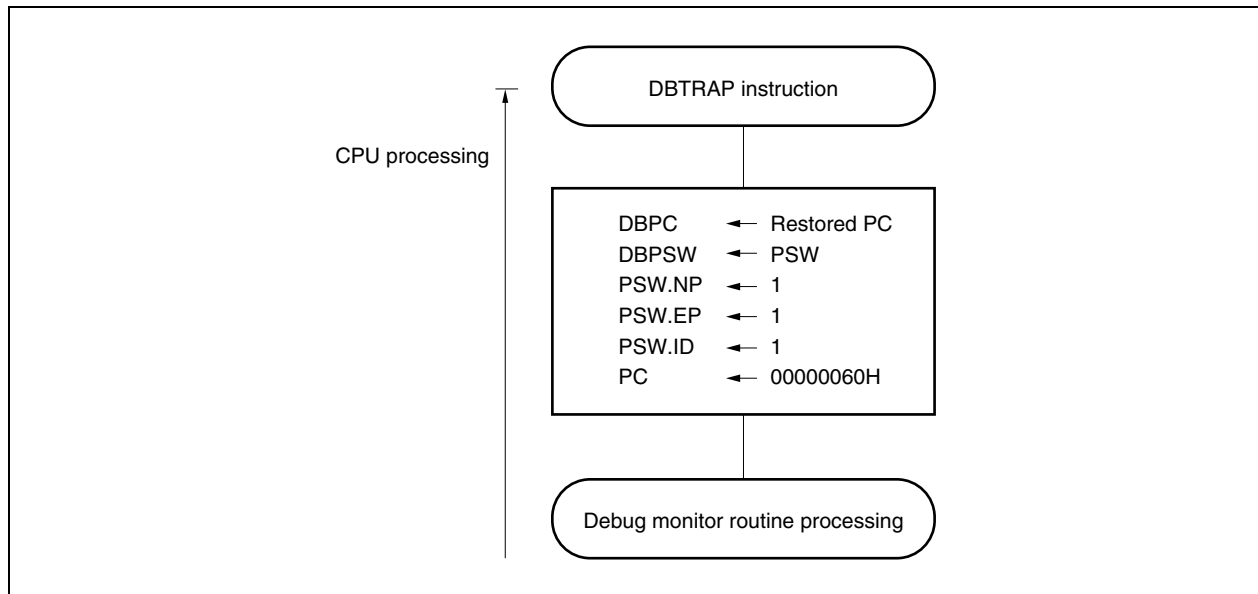
When the debug trap is generated, the CPU performs the following processing.

#### (1) Operation

- <1> Saves the restored PC to DBPC.
- <2> Saves the current PSW to DBPSW.
- <3> Sets the NP, EP and ID bits of the PSW to 1.
- <4> Sets the handler address (00000060H) corresponding to the debug trap to the PC and transfers control.

Figure 7-12 illustrates the processing of the debug trap.

**Figure 7-12. Debug Trap Processing**



**(2) Restore**

Recovery from a debug trap is carried out by the DBRET instruction. By executing the DBRET instruction, the CPU carries out the following processing and controls the address of the restored PC.

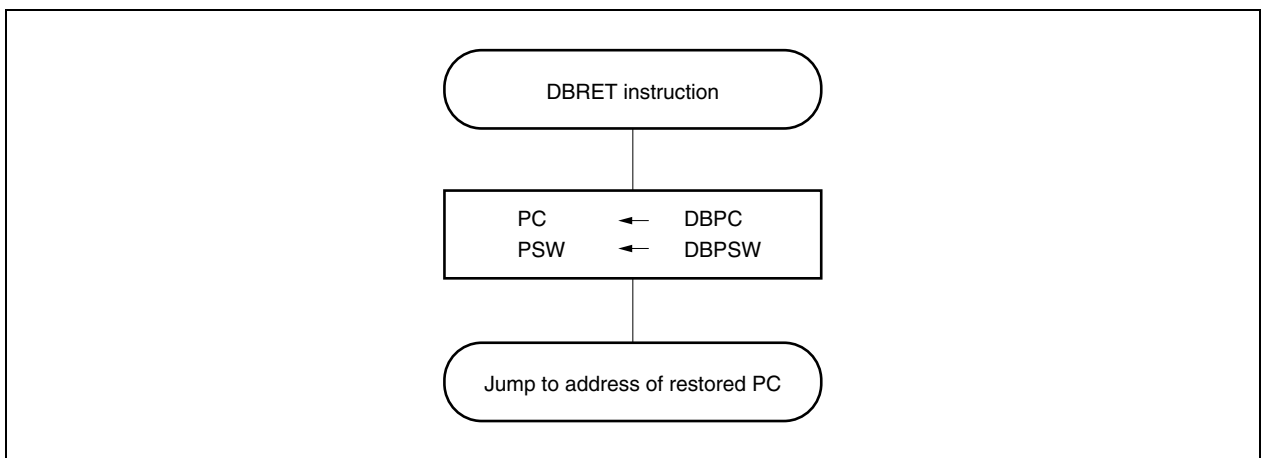
<1> Loads the restored PC and PSW from DBPC and DBPSW.

<2> Transfers control to the address indicated by the restored PC and PSW.

**Caution** DBPC and DBPSW can be accessed only during the period between when the DBTRAP instruction is executed and when the DBRET instruction is executed.

Figure 7-13 illustrates the restore processing from a debug trap.

**Figure 7-13. Restore Processing from Debug Trap**



## 7.6 Multiple Interrupt Servicing Control

Multiple interrupt servicing control is a process by which an interrupt request that is currently being serviced can be interrupted during servicing if there is an interrupt request signal with a higher priority level, and the higher priority interrupt request signal is acknowledged and serviced first.

If there is an interrupt request signal with a lower priority level than the interrupt request currently being serviced, that interrupt request signal is held pending.

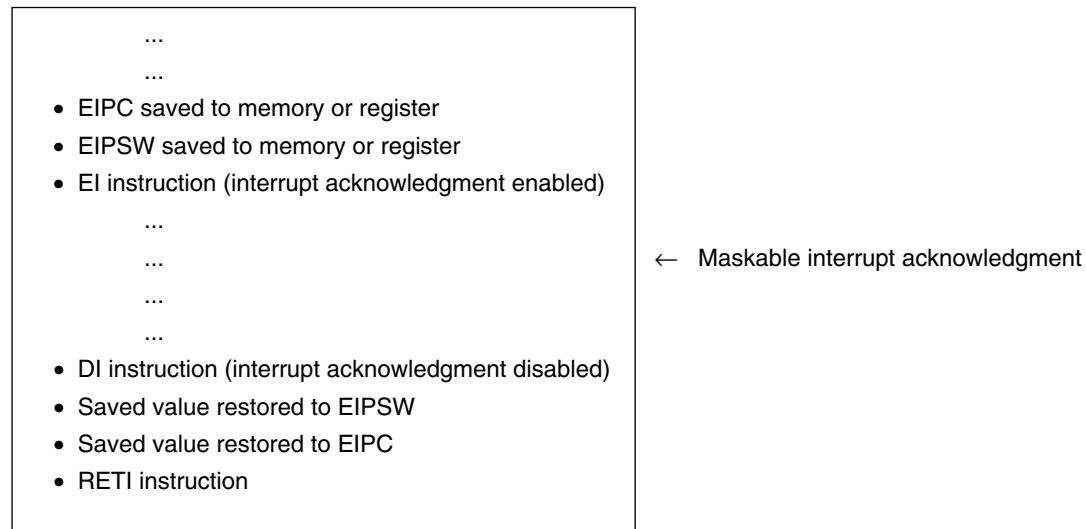
Multiple interrupt servicing control of maskable interrupts is executed when interrupts are enabled (ID bit of PSW = 0). Thus, to execute multiple interrupts, it is necessary to set the interrupt enabled state (ID bit = 0) even for an interrupt service routine.

If maskable interrupts are enabled or a software exception is generated in a maskable interrupt or software exception service program, it is necessary to save EIPC and EIPSW.

This is accomplished by the following procedure.

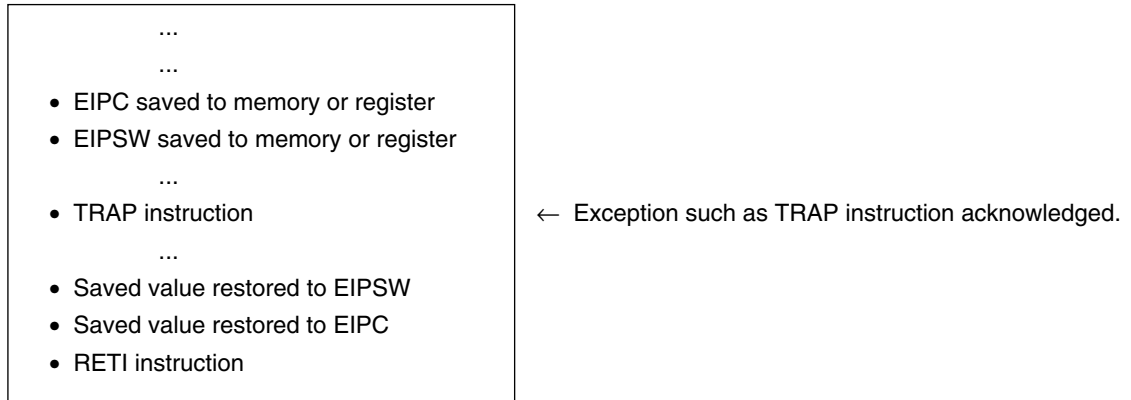
### (1) Acknowledgment of maskable interrupt request signals in service program

Service program of maskable interrupt or exception



**(2) Generation of exception in service program**

Service program of maskable interrupt or exception



The priority order for multiple interrupt servicing control has 8 levels, from 0 to 7 for each maskable interrupt request signal (0 is the highest priority), but it can be set as desired via software. The priority order is set using the xxPRn0 to xxPRn2 bits of the interrupt control request register (xxICn), provided for each maskable interrupt request signal. After system reset, an interrupt request signal is masked by the xxMKn bit and the priority order is set to level 7 by the xxPRn0 to xxPRn2 bits.

The priority order of maskable interrupts is as follows.

(High)    Level 0 > Level 1 > Level 2 > Level 3 > Level 4 > Level 5 > Level 6 > Level 7    (Low)

Interrupt servicing that has been suspended as a result of multiple servicing control is resumed after the servicing of the higher priority interrupt has been completed and the RETI instruction has been executed.

A pending interrupt request signal is acknowledged after the current interrupt servicing has been completed and the RETI instruction has been executed.

**Caution** In a non-maskable interrupt servicing routine (time until the RETI instruction is executed), maskable interrupts are held pending and not acknowledged.

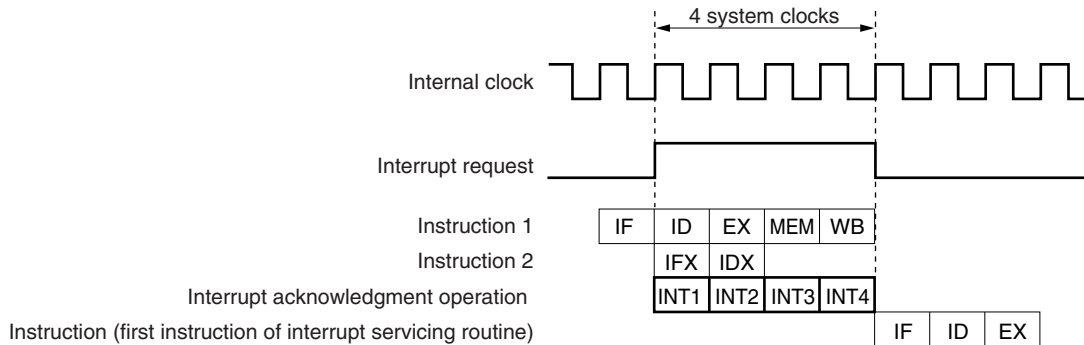
**Remark** xx: Identification name of each peripheral unit (see **Table 7-2**)

n: Peripheral unit number (see **Table 7-2**)

## 7.7 Interrupt Latency Time

The V850E/ME2 interrupt latency time (from interrupt request generation to start of interrupt servicing) is described below.

**Figure 7-14. Pipeline Operation at Interrupt Request Acknowledgment (Outline)**



**Remark** INT1 to INT4: Interrupt acknowledgment processing

IFX: Invalid instruction fetch

IDX: Invalid instruction decode

| Interrupt latency (internal system clock ( $f_{CLK}$ )) |                    |                           |                          | Condition                                                                                                                                                                                                                                                                                     |
|---------------------------------------------------------|--------------------|---------------------------|--------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                         | Internal interrupt | External interrupt        |                          |                                                                                                                                                                                                                                                                                               |
|                                                         |                    | INTP <sub>m</sub>         | INTP <sub>n</sub>        |                                                                                                                                                                                                                                                                                               |
| Minimum                                                 | 4                  | 7 +<br>Digital delay time | 4 +<br>Analog delay time | The following cases are exceptions. <ul style="list-style-type: none"><li>• In IDLE/software STOP mode</li><li>• External bus access</li><li>• Two or more interrupt request non-sample instructions are executed in succession</li><li>• Access to on-chip peripheral I/O register</li></ul> |
| Maximum                                                 | 6 <sup>Note</sup>  | 9 +<br>Digital delay time | 6 +<br>Analog delay time |                                                                                                                                                                                                                                                                                               |

**Note** The interrupt latency is the maximum value when executing any of the following instructions.

DIV instruction, PREPARE instruction, DISPOSE instruction, SWITCH instruction, SET1 instruction, CLR1 instruction, NOT1 instruction, LD instruction for internal instruction RAM, misalign access

**Remark**  $m = C00, C01, C10, C11, C20, C21, C30, C31$

$n = 10, 11, 21 \text{ to } 25, 50 \text{ to } 52, 65 \text{ to } 67, L0, L1, D0 \text{ to } D15$

## 7.8 Periods in Which CPU Does Not Acknowledge Interrupts

The CPU acknowledges an interrupt while an instruction is being executed. However, no interrupt will be acknowledged between an interrupt request non-sample instruction and the next instruction (interrupt is held pending).

The interrupt request non-sample instructions are as follows.

- EI instruction
- DI instruction
- LDSR reg2, 0x5 instruction (for PSW)
- The store instruction for the command register (PRCMD)
- The store and bit manipulation instructions of SET1, NOT1, and CLR1 for the following registers.
  - Interrupt-related registers:
    - Interrupt control register (xxICn), interrupt mask registers 0 to 5 (IMR0 to IMR5)
  - Power-save control register (PSC)

**Remark** xx: Identification name of each peripheral unit (see **Table 7-2**)  
 n: Peripheral unit number (see **Table 7-2**)

## 7.9 Cautions

Cautions concerning the interrupt/exception processing function are shown below.

### (1) Setting trigger mode of $\overline{\text{INTPn}}$ pin

Set the PMCM register before setting the trigger mode of the  $\overline{\text{INTPn}}$  pin.

If the PMCM register is set after the INTRm and INTFm registers have been set, an illegal interrupt may occur when the PMCM register is set (n = 10, 11, 21 to 25, 50 to 52, 65 to 67, L0, L1, D0 to D15, m = 1, 2, 5, 6, AL, DH).

### (2) Multiple interrupt servicing control

In a non-maskable interrupt servicing routine (time until the RETI instruction is executed), maskable interrupts are held pending and not acknowledged.

## CHAPTER 8 CLOCK GENERATION FUNCTION

The clock generator (CG) consists of a spread spectrum frequency synthesizer phase locked loop (SSCG) and a divider circuit, and generates and controls the clock supplied to the internal units as well as the CPU.

The SSCG is a spread spectrum clock generator used to suppress noise, and is effective in reducing the peak value of electromagnetic interference (EMI) noise.

### 8.1 Features

- SSCG output is used fixed to  $\times 8$ .
- Selection of SSCG output by PLLSEL pin

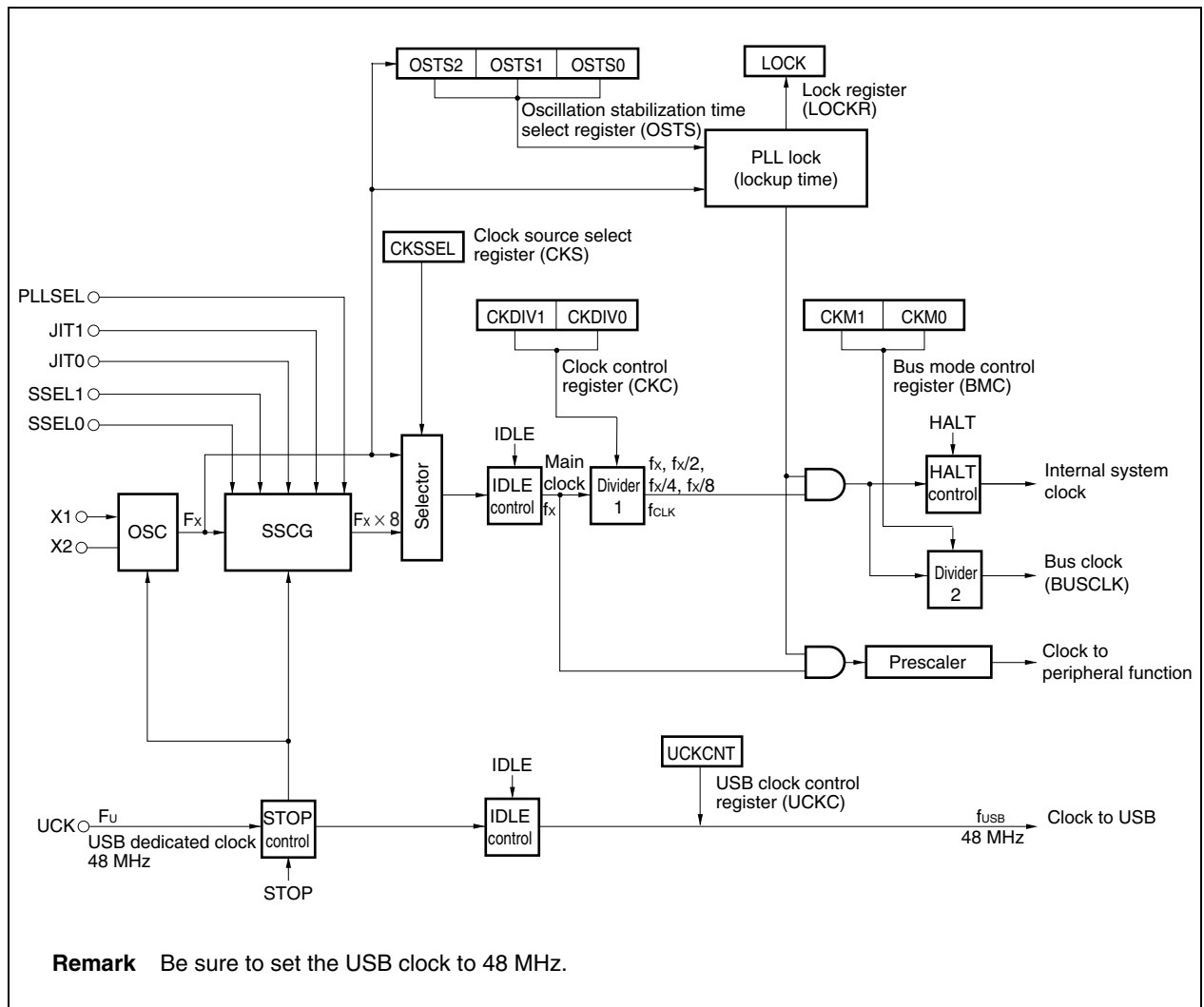
Set the PLLSEL pin as follows according to the value of  $f_x$  = Input frequency to X1 and X2 pins ( $F_x$ )  $\times 8$

| PLLSEL Pin | SSCG Output ( $f_x$ )                          |
|------------|------------------------------------------------|
| 0          | $96 \text{ MHz} \leq f_x \leq 150 \text{ MHz}$ |
| 1          | $80 \text{ MHz} \leq f_x < 96 \text{ MHz}$     |

- Selection of frequency modulation rate ( $f_{\text{DMT}}$ ) of SSCG output  
The following two setting methods are available.
  - Selection by J1T0 and J1T1 pins (without modulation (frequency fixed),  $-1\%$ ,  $-3\%$ ,  $-5\%$ )
  - Selection by SSCGC register (without modulation (frequency fixed),  $-0.5\%$ ,  $-1\%$ ,  $-2\%$ ,  $-3\%$ ,  $-4\%$ ,  $-5\%$ )
- MDL-Selector Table (modulation period)  
Selection by SSCGC register (13 to 27 kHz, 23 to 37 kHz, 32 to 48 kHz)
- Division function by register setting ( $1/1$ ,  $1/2$ ,  $1/4$ ,  $1/8$ )
- Clock sources  
Oscillation by connecting a resonator
- Operation mode selection by register setting  
The clock to be supplied to each unit is selected from the following by register setting.
  - Clock output by SSCG
  - Clock from OSC without passing through SSCG
- USB-dedicated clock input
- Power-save control
  - HALT mode
  - IDLE mode
  - Software STOP mode



## 8.2 Configuration



## 8.3 Control Registers

### 8.3.1 Clock control register (CKC)

The clock control register is an 8-bit register that controls the internal system clock ( $f_{CLK}$ ) in PLL mode. It can be written to only by a specific sequence so that it cannot easily be overwritten by mistake due to an inadvertent program loop.

This register can be read or written in 8-bit units.

Be sure to clear bits 7 to 2 to 0. If they are set to 1, the operation is not guaranteed.

|     |   |   |   |   |   |   |        |        |            |             |
|-----|---|---|---|---|---|---|--------|--------|------------|-------------|
|     | 7 | 6 | 5 | 4 | 3 | 2 | 1      | 0      | Address    | After reset |
| CKC | 0 | 0 | 0 | 0 | 0 | 0 | CKDIV1 | CKDIV0 | FFFFFF822H | 03H         |

| Bit position | Bit name          | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |        |        |                                     |   |   |         |   |   |         |   |   |         |   |   |       |
|--------------|-------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|--------|-------------------------------------|---|---|---------|---|---|---------|---|---|---------|---|---|-------|
| 1, 0         | CKDIV1,<br>CKDIV0 | <p>Sets the internal system clock (<math>f_{CLK}</math>) when PLL mode is used.</p> <table> <tr> <th>CKDIV1</th><th>CKDIV0</th><th>Internal system clock (<math>f_{CLK}</math>)</th></tr> <tr> <td>0</td><td>0</td><td><math>f_x/8</math></td></tr> <tr> <td>0</td><td>1</td><td><math>f_x/4</math></td></tr> <tr> <td>1</td><td>0</td><td><math>f_x/2</math></td></tr> <tr> <td>1</td><td>1</td><td><math>f_x</math></td></tr> </table> <p>To change the internal system clock frequency in the middle of an operation, be sure to set it to <math>f_x</math> first, and then change the frequency as desired.</p> | CKDIV1 | CKDIV0 | Internal system clock ( $f_{CLK}$ ) | 0 | 0 | $f_x/8$ | 0 | 1 | $f_x/4$ | 1 | 0 | $f_x/2$ | 1 | 1 | $f_x$ |
| CKDIV1       | CKDIV0            | Internal system clock ( $f_{CLK}$ )                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |        |        |                                     |   |   |         |   |   |         |   |   |         |   |   |       |
| 0            | 0                 | $f_x/8$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |        |        |                                     |   |   |         |   |   |         |   |   |         |   |   |       |
| 0            | 1                 | $f_x/4$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |        |        |                                     |   |   |         |   |   |         |   |   |         |   |   |       |
| 1            | 0                 | $f_x/2$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |        |        |                                     |   |   |         |   |   |         |   |   |         |   |   |       |
| 1            | 1                 | $f_x$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |        |        |                                     |   |   |         |   |   |         |   |   |         |   |   |       |

**Remark**  $f_x$ : Main clock

- Cautions**
- Note that if the internal system clock ( $f_{CLK}$ ) is changed, the frequency of the bus clock (BUSCLK) is also changed.
  - If it necessary to change the refresh interval of the SDRAM as a result of changing the internal system clock ( $f_{CLK}$ ), follow this procedure.

<1> Mask all interrupts. Disable DMA operations.

For how to disable maskable interrupts, refer to the description of interrupt mask registers 0 to 5 (IMR0 to IMR5) (7.3.5 Interrupt mask registers 0 to 5 (IMR0 to IMR5)). For how to disable non-maskable interrupts, disable multiple interrupts by setting the NP bit of the PSW to 1 (see 3.2.2 (4) Program status word (PSW)).

<2> Clear the MEa bit of the BCTm register to 0.

<3> Clear the RENn bit of the RFSn register to 0 ( $n = 1, 3, 4$ , or 6).

<4> Change the values of the CKDIV0 and CKDIV1 bits of the CKC register (see 8.3.1 (2) Setting data to clock control register (CKC) for how to change the values).

<5> Set the MEa bit of the BCTm register to 1.

<6> Set a new refresh interval to the RFSn register, and clear the RENn bit to 0 ( $n = 1, 3, 4$ , or 6).

<7> Write the same value currently set to the SCRn register to the SCRn register ( $n = 1, 3, 4$ , or 6).

<8> Confirm that the WCFn bit of the SCRn register is set to 1, then set the RENn bit of the RFSn register to 1. Do not change any other bits except for the RENn bit ( $n = 1, 3, 4$ , or 6).

<9> Enable DMA operations as necessary.

<10> Access SDRAM.

**Remarks** 1.  $f_x$ : Main clock

- $a = 0$  to 3 when  $m = 0$   
 $a = 4$  to 7 when  $m = 1$

To change the refresh interval, set a value at which refresh can be made in time even while the interval is changed (see 8.3.1 (1) Notes on changing refresh interval). If the refresh interval is correctly secured with the interrupt servicing time taken into consideration, the processing in <1> above may be skipped. The RFSn and BCTm registers are prohibited from being rewritten, but they can be rewritten when the refreshing interval is re-set by changing the value of the CKC register.

A register write cycle of SDRAM is generated as a result of rewriting the SCRn register (processing in <6> above), but the value of SDRAM before the RFSn and SCRn registers are re-set is retained.

**(1) Notes on changing refresh interval**

Figure 8-1 shows the internal state and the external bus state when the refresh interval is changed when the SDRAM is connected to the CS1 and CS3 areas. In such a case, the SDRAM that is connected to CS1 is not refreshed during a <1> and <3> period, and the SDRAM that is connected to CS3 is not refreshed during a <2> period.

The time for <1> may be increased or decreased depending on factors such as the use status of the internal system bus or a bus hold request from the external bus. Moreover, the time for <2> and <3> may be increased or decreased depending on the value set to the RFSn register.

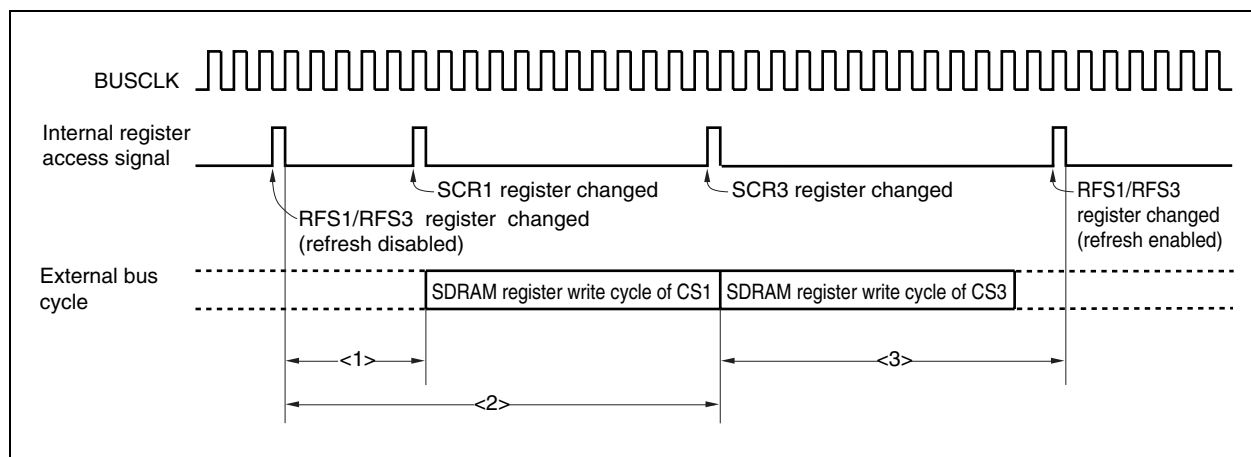
When changing the refresh interval, therefore, the value must be set by making allowances for periods <1> to <3> in which a refresh is not performed.

When the SDRAM is connected to only one CS area, the refresh interval value must be changed by making allowances for period <1>.

- Cautions**
1. The refresh command is issued eight times in the register write cycle regardless of the setting of the RENn bit of the RFSn register.
  2. The  $\overline{\text{REFRQ}}$  signal does not operate while the RENn bit is set to 0, so care must be exercised when the external bus master references the  $\overline{\text{REFRQ}}$  signal.
  3. Input to the  $\overline{\text{SELFREF}}$  signal is ignored while the MEa bit of the BCTm register is set to 0, so the operation does not shift to the self-refresh state.

- Remarks**
1. n = 1, 3, 4, or 6
  2. a = 0 to 3 when m = 0  
a = 4 to 7 when m = 1

**Figure 8-1. Internal State and External Bus State When Refresh Interval Is Changed**



&lt;R&gt;

**(2) Setting data to clock control register (CKC)**

Set data to the CKC register in the following sequence.

- <1> Prepare data in any one of the general-purpose registers to set in the specific register.
- <2> Write data to the command register (PRCMD).
- <3> Set the clock control register (CKC) (with the following instruction).
  - Store instruction (ST/SST instruction)
- <4> Insert the NOP instructions (5 instructions (<4> to <8>)).

[Sample coding]

```

<1> MOV      0x02, r10
<2> ST.B     r10, PRCMD[r0]
<3> ST.B     r10, CKC[r0]
<4> NOP
<5> NOP
<6> NOP
<7> NOP
<8> NOP

```

No special sequence is required to read the specific register.

- Cautions**
1. Although the data written to the PRCMD register is dummy data, use the same register as the general-purpose register used in specific register setting (<3>) for writing to the PRCMD register (<2>). The same method should be applied when using a general-purpose register for addressing.
  2. Be sure to terminate all DMA transfers prior to the execution of the above sequence.

**<R> 8.3.2 Clock source select register (CKS)**

This 8-bit register controls supply of the main clock ( $f_x$ ). It can be written to only by a specific sequence so that it cannot easily be overwritten by mistake due to an inadvertent program loop.

This register can be read or written in 8-bit or 1-bit units.

Be sure to clear bits 7 to 1 to 0. If they are set to 1, the operation is not guaranteed.

- Cautions**
1. With the V850E/ME2, it is not assumed that the CPU operates with the OSC output always supplied as the main clock (CKSSEL bit = 0). Therefore, be sure to confirm in the initialization sequence that the LOCK bit of the LOCKR register is 0, and then supply the main clock from the SSCG output (CKSSEL bit = 1); otherwise the operation will not be guaranteed.
  2. If the software STOP mode is released by a non-maskable interrupt request (NMI) or an unmasked maskable interrupt request, the system operates on the SSCG output clock after PLL frequency stabilization time (about 2 ms) after the count time (oscillation stabilization time set by the OSTS register) of the time base counter (TBC) has elapsed. Therefore, it is not necessary to re-set the CKS register. If the software STOP mode is released by RESET pin input, set the CKS register in accordance with the initialization sequence (see 3.4.10 Initialization sequence).

|     |   |   |   |   |   |   |   |        |           |             |
|-----|---|---|---|---|---|---|---|--------|-----------|-------------|
|     | 7 | 6 | 5 | 4 | 3 | 2 | 1 | <0>    | Address   | After reset |
| CKS | 0 | 0 | 0 | 0 | 0 | 0 | 0 | CKSSEL | FFFFF82CH | 00H         |

| Bit position | Bit name | Function                                                                                                                 |
|--------------|----------|--------------------------------------------------------------------------------------------------------------------------|
| 0            | CKSSEL   | Controls supply of the main clock ( $f_x$ ).<br>0: OSC output clock ( $F_x$ )<br>1: SSCG output clock ( $F_x \times 8$ ) |

Set data in the clock source select register (CKS) in the following sequence.

- <1> Prepare data in any one of the general-purpose registers to set in the specific register.
- <2> Write data to the command register (PRCMD).
- <3> Set the clock source select register (CKS) (with the following instruction).
  - Store instruction (ST/SST instruction)
- <4> Insert the NOP instructions (5 instructions (<4> to <8>)).

[Sample coding]

|     |      |                |
|-----|------|----------------|
| <1> | MOV  | 0x01, r10      |
| <2> | ST.B | r10, PRCMD[r0] |
| <3> | ST.B | r10, CKS[r0]   |
| <4> | NOP  |                |
| <5> | NOP  |                |
| <6> | NOP  |                |
| <7> | NOP  |                |
| <8> | NOP  |                |

No special sequence is required to read the specific register.

- Cautions**
1. Although the data written to the PRCMD register is dummy data, use the same register as the general-purpose register used in specific register setting (<3>) for writing to the PRCMD register (<2>). The same method should be applied when using a general-purpose register for addressing.
  2. Be sure to terminate all DMA transfers prior to the execution of the above sequence.

## &lt;R&gt; 8.3.3 SSCG control register (SSCGC)

This is an 8-bit register that controls the frequency modulation rate and modulation period of SSCG output. It modulates the frequency by the frequency modulation rate (Down Spread) set by the ADJ2 to ADJ0 bits within the modulation period set by the SMDLn bit. This is effective in reducing the peak value of EMI noise. It can be written to only by a specific sequence so that it cannot easily be overwritten by mistake due to an inadvertent program loop.

This register can be read or written in 8-bit units.

**Caution** The SSCGC register can be set only when OSC output is supplied as the main clock (CKSSEL bit of CKS register = 0). If the setting of the SSCGC register is changed, the SSCG is unlocked (LOCK bit of LOCKR register = 1). Be sure to confirm that the LOCK bit = 0 before starting to supply SSCG output as the main clock (CKSSEL bit = 1); otherwise the operation will not be guaranteed.

(1/2)

|       | 7 | 6 | 5     | 4     | 3     | 2    | 1    | 0    | Address   | After reset |
|-------|---|---|-------|-------|-------|------|------|------|-----------|-------------|
| SSCGC | 0 | 0 | SMDL1 | SMDL0 | ADJON | ADJ2 | ADJ1 | ADJ0 | FFFFF836H | <b>Note</b> |

**Note** The default value is as follows.

SMDL1 bit = 0, SMDL0 bit = 1

The ADJON and ADJ2 to ADJ0 bits are set as follows by the JIT1 and JIT0 pins.

| JIT1 pin | JIT0 pin | Reset value |          |          |          |
|----------|----------|-------------|----------|----------|----------|
|          |          | ADJON bit   | ADJ2 bit | ADJ1 bit | ADJ0 bit |
| 0        | 0        | 0           | 0        | 0        | 0        |
| 0        | 1        | 1           | 0        | 0        | 1        |
| 1        | 0        | 1           | 0        | 1        | 1        |
| 1        | 1        | 1           | 1        | 0        | 1        |

| Bit position | Bit name        | Function                                                                                                                                                                                                                                                                                                    |       |                                  |                                  |   |   |              |   |   |              |   |   |              |   |   |                    |
|--------------|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|----------------------------------|----------------------------------|---|---|--------------|---|---|--------------|---|---|--------------|---|---|--------------------|
| 5, 4         | SMDL1,<br>SMDL0 | Set the modulation period of SSCG output.                                                                                                                                                                                                                                                                   |       |                                  |                                  |   |   |              |   |   |              |   |   |              |   |   |                    |
|              |                 | <table><tr><th>SMDL1</th><th>SMDL0</th><th>Modulation period of SSCG output</th></tr><tr><td>0</td><td>0</td><td>13 to 27 kHz</td></tr><tr><td>0</td><td>1</td><td>23 to 37 kHz</td></tr><tr><td>1</td><td>0</td><td>32 to 48 kHz</td></tr><tr><td>1</td><td>1</td><td>Setting prohibited</td></tr></table> | SMDL1 | SMDL0                            | Modulation period of SSCG output | 0 | 0 | 13 to 27 kHz | 0 | 1 | 23 to 37 kHz | 1 | 0 | 32 to 48 kHz | 1 | 1 | Setting prohibited |
|              |                 | SMDL1                                                                                                                                                                                                                                                                                                       | SMDL0 | Modulation period of SSCG output |                                  |   |   |              |   |   |              |   |   |              |   |   |                    |
|              |                 | 0                                                                                                                                                                                                                                                                                                           | 0     | 13 to 27 kHz                     |                                  |   |   |              |   |   |              |   |   |              |   |   |                    |
|              |                 | 0                                                                                                                                                                                                                                                                                                           | 1     | 23 to 37 kHz                     |                                  |   |   |              |   |   |              |   |   |              |   |   |                    |
|              |                 | 1                                                                                                                                                                                                                                                                                                           | 0     | 32 to 48 kHz                     |                                  |   |   |              |   |   |              |   |   |              |   |   |                    |
|              |                 | 1                                                                                                                                                                                                                                                                                                           | 1     | Setting prohibited               |                                  |   |   |              |   |   |              |   |   |              |   |   |                    |
|              |                 |                                                                                                                                                                                                                                                                                                             |       |                                  |                                  |   |   |              |   |   |              |   |   |              |   |   |                    |
|              |                 |                                                                                                                                                                                                                                                                                                             |       |                                  |                                  |   |   |              |   |   |              |   |   |              |   |   |                    |
|              |                 |                                                                                                                                                                                                                                                                                                             |       |                                  |                                  |   |   |              |   |   |              |   |   |              |   |   |                    |
|              |                 |                                                                                                                                                                                                                                                                                                             |       |                                  |                                  |   |   |              |   |   |              |   |   |              |   |   |                    |



| Bit position                                                                                                                                                                                                                                                                                                                                                                                                                                          | Bit name               | Function                                          |      |      |      |                                          |        |        |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|---------------------------------------------------|------|------|------|------------------------------------------|--------|--------|
| 3 to 0                                                                                                                                                                                                                                                                                                                                                                                                                                                | ADJON,<br>ADJ2 to ADJ0 | Set the frequency modulation rate of SSCG output. |      |      |      |                                          |        |        |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                        | ADJON                                             | ADJ2 | ADJ1 | ADJ0 | Frequency modulation rate of SSCG output |        |        |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                        |                                                   |      |      |      | Min.                                     | Typ.   | Max.   |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                        | 0                                                 | ×    | ×    | ×    | No modulation (frequency fixed)          |        |        |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                        | 1                                                 | 0    | 0    | 0    | −0.31%                                   | −0.50% | −1.28% |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                        | 1                                                 | 0    | 0    | 1    | −0.67%                                   | −1.00% | −1.75% |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                        | 1                                                 | 0    | 1    | 0    | −1.23%                                   | −2.00% | −3.10% |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                        | 1                                                 | 0    | 1    | 1    | −1.74%                                   | −3.00% | −4.33% |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                        | 1                                                 | 1    | 0    | 0    | −2.48%                                   | −4.00% | −5.83% |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                        | 1                                                 | 1    | 0    | 1    | −3.27%                                   | −5.00% | −7.28% |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                        | Other than above                                  |      |      |      | Setting prohibited                       |        |        |
| <b>Cautions</b>                                                                                                                                                                                                                                                                                                                                                                                                                                       |                        |                                                   |      |      |      |                                          |        |        |
| 1. If the frequency modulation rate of SSCG output is set to other than “No modulation (frequency fixed)” (ADJON bit = 0), the internal system clock ( $f_{CLK}$ ), bus clock (BUSCLK), and clock supplied to the on-chip peripheral functions all operate at the frequency that accords with the frequency modulation rate set by the ADJ2 to ADJ0 bits (see 8.5 Operating Clock Provisions). Therefore, thoroughly evaluate and confirm the system. |                        |                                                   |      |      |      |                                          |        |        |
| 2. An overshoot/undershoot of the frequency modulation rate occurs.                                                                                                                                                                                                                                                                                                                                                                                   |                        |                                                   |      |      |      |                                          |        |        |

Set data in the SSCG control register (SSCGC) in the following sequence.

- <1> Prepare data in any one of the general-purpose registers to set in the specific register.
- <2> Write data to the command register (PRCMD).
- <3> Set the SSCG control register (SSCGC) (with the following instruction).
  - Store instruction (ST/SST instruction)
- <4> Insert the NOP instructions (5 instructions (<4> to <8>)).

[Sample coding]

```

<1> MOV    0x08, r10
<2> ST.B   r10, PRCMD[r0]
<3> ST.B   r10, SSCGC[r0]
<4> NOP
<5> NOP
<6> NOP
<7> NOP
<8> NOP

```

No special sequence is required to read the specific register.

- Cautions**
1. Although the data written to the PRCMD register is dummy data, use the same register as the general-purpose register used in specific register setting (<3>) for writing to the PRCMD register (<2>). The same method should be applied when using a general-purpose register for addressing.
  2. Be sure to terminate all DMA transfers prior to the execution of the above sequence.

#### 8.3.4 USB clock control register (UCKC)

This register is used to select the clock source of the USB clock. Be sure to input fusb at 48 MHz.

This register can be read or written in 8-bit or 1-bit units.

Be sure to clear the bits of this register other than bit 7 to 0. If they are set to 1, the operation is not guaranteed.

**Caution** When using the USB function, be sure to set (1) the UCKCNT bit.  
If the registers related to the USB function are read while the UCKCNT bit is 0, 0 is read.

|      |        |   |   |   |   |   |   |   |           |             |
|------|--------|---|---|---|---|---|---|---|-----------|-------------|
|      | <7>    | 6 | 5 | 4 | 3 | 2 | 1 | 0 | Address   | After reset |
| UCKC | UCKCNT | 0 | 0 | 0 | 0 | 0 | 0 | 0 | FFFFF82EH | 00H         |

| Bit position | Bit name | Function                                                                                    |
|--------------|----------|---------------------------------------------------------------------------------------------|
| 7            | UCKCNT   | Controls clock supply to USB.<br>0: Stops clock supply to USB.<br>1: Supplies clock to USB. |

### 8.3.5 Lock register (LOCKR)

The lockup time (frequency stabilization time: approx. 2 ms) is the time from when the power is turned on or software STOP mode is released until the phase locks at the prescribed frequency. The state until this stabilization occurs is called the lockup state, and the stabilized state is called the locked state.

The lock register (LOCKR) has a LOCK flag that indicates that the PLL is in the lock wait state.

This register is read-only, in 8-bit or 1-bit units.

**Caution** If the phase is locked, the LOCK flag is cleared to 0. If it is unlocked later because of a standby status, writing to SSCGC register, or  $\overline{\text{RESET}}$  input, the LOCK flag is set to 1. If the phase is unlocked by a cause other than these, however, the LOCK flag is not affected (LOCK = 0).

|       |   |   |   |   |   |   |   |      |           |             |
|-------|---|---|---|---|---|---|---|------|-----------|-------------|
|       | 7 | 6 | 5 | 4 | 3 | 2 | 1 | <0>  | Address   | After reset |
| LOCKR | 0 | 0 | 0 | 0 | 0 | 0 | 0 | LOCK | FFFFF824H | 01H         |

| Bit position | Bit name | Function                                                                                                                                                                                                                                                                 |
|--------------|----------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 0            | LOCK     | <p>This is a read-only flag that indicates the PLL lock wait state.</p> <p>This flag holds the value 0 as long as a lockup state is maintained.</p> <p>0: Indicates that the PLL is locked.</p> <p>1: Indicates that the PLL is waiting to be locked (unlock state).</p> |

If some other factor operates to cause an unlock state to occur, for control processing that depends on software execution speed, such as real-time processing, be sure to judge the LOCK flag by software immediately after operation begins and start processing after the PLL is locked.

On the other hand, static processing such as the setting of internal hardware or the initialization of register data or memory data can be executed without waiting for the LOCK flag to be reset to 0.

### 8.3.6 Oscillation stabilization time select register (OSTS)

This is an 8-bit register that specifies the oscillation stabilization time.

The OSTS register is used to make sure that the oscillation stabilization time of the oscillator elapses when the software STOP mode is released. After the software STOP mode is released, the oscillation stabilization time is counted by the time base counter (TBC), and program execution is started about 2 ms later.

This register can be read or written in 8-bit units.

|      |   |   |   |   |   |       |       |       |            |             |
|------|---|---|---|---|---|-------|-------|-------|------------|-------------|
|      | 7 | 6 | 5 | 4 | 3 | 2     | 1     | 0     | Address    | After reset |
| OSTS | 0 | 0 | 0 | 0 | 0 | OSTS2 | OSTS1 | OSTS0 | FFFFFF6C0H | 04H         |

| Bit position | Bit name       | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |              |       |                                |                                |   |   |   |              |   |   |   |              |   |   |   |              |   |   |   |              |   |   |   |              |   |   |   |              |   |   |   |              |   |   |   |              |
|--------------|----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|-------|--------------------------------|--------------------------------|---|---|---|--------------|---|---|---|--------------|---|---|---|--------------|---|---|---|--------------|---|---|---|--------------|---|---|---|--------------|---|---|---|--------------|---|---|---|--------------|
| 2 to 0       | OSTS2 to OSTS0 | Specify the oscillation stabilization time.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |              |       |                                |                                |   |   |   |              |   |   |   |              |   |   |   |              |   |   |   |              |   |   |   |              |   |   |   |              |   |   |   |              |   |   |   |              |
|              |                | <table><tr><th>OSTS2</th><th>OSTS1</th><th>OSTS0</th><th>Oscillation stabilization time</th></tr><tr><td>0</td><td>0</td><td>0</td><td><math>F_x/2^{13}</math></td></tr><tr><td>0</td><td>0</td><td>1</td><td><math>F_x/2^{15}</math></td></tr><tr><td>0</td><td>1</td><td>0</td><td><math>F_x/2^{16}</math></td></tr><tr><td>0</td><td>1</td><td>1</td><td><math>F_x/2^{17}</math></td></tr><tr><td>1</td><td>0</td><td>0</td><td><math>F_x/2^{18}</math></td></tr><tr><td>1</td><td>0</td><td>1</td><td><math>F_x/2^{19}</math></td></tr><tr><td>1</td><td>1</td><td>0</td><td><math>F_x/2^{20}</math></td></tr><tr><td>1</td><td>1</td><td>1</td><td><math>F_x/2^{21}</math></td></tr></table> | OSTS2        | OSTS1 | OSTS0                          | Oscillation stabilization time | 0 | 0 | 0 | $F_x/2^{13}$ | 0 | 0 | 1 | $F_x/2^{15}$ | 0 | 1 | 0 | $F_x/2^{16}$ | 0 | 1 | 1 | $F_x/2^{17}$ | 1 | 0 | 0 | $F_x/2^{18}$ | 1 | 0 | 1 | $F_x/2^{19}$ | 1 | 1 | 0 | $F_x/2^{20}$ | 1 | 1 | 1 | $F_x/2^{21}$ |
|              |                | OSTS2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | OSTS1        | OSTS0 | Oscillation stabilization time |                                |   |   |   |              |   |   |   |              |   |   |   |              |   |   |   |              |   |   |   |              |   |   |   |              |   |   |   |              |   |   |   |              |
|              |                | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 0            | 0     | $F_x/2^{13}$                   |                                |   |   |   |              |   |   |   |              |   |   |   |              |   |   |   |              |   |   |   |              |   |   |   |              |   |   |   |              |   |   |   |              |
|              |                | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 0            | 1     | $F_x/2^{15}$                   |                                |   |   |   |              |   |   |   |              |   |   |   |              |   |   |   |              |   |   |   |              |   |   |   |              |   |   |   |              |   |   |   |              |
|              |                | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 1            | 0     | $F_x/2^{16}$                   |                                |   |   |   |              |   |   |   |              |   |   |   |              |   |   |   |              |   |   |   |              |   |   |   |              |   |   |   |              |   |   |   |              |
|              |                | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 1            | 1     | $F_x/2^{17}$                   |                                |   |   |   |              |   |   |   |              |   |   |   |              |   |   |   |              |   |   |   |              |   |   |   |              |   |   |   |              |   |   |   |              |
|              |                | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 0            | 0     | $F_x/2^{18}$                   |                                |   |   |   |              |   |   |   |              |   |   |   |              |   |   |   |              |   |   |   |              |   |   |   |              |   |   |   |              |   |   |   |              |
|              |                | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 0            | 1     | $F_x/2^{19}$                   |                                |   |   |   |              |   |   |   |              |   |   |   |              |   |   |   |              |   |   |   |              |   |   |   |              |   |   |   |              |   |   |   |              |
|              |                | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 1            | 0     | $F_x/2^{20}$                   |                                |   |   |   |              |   |   |   |              |   |   |   |              |   |   |   |              |   |   |   |              |   |   |   |              |   |   |   |              |   |   |   |              |
| 1            | 1              | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | $F_x/2^{21}$ |       |                                |                                |   |   |   |              |   |   |   |              |   |   |   |              |   |   |   |              |   |   |   |              |   |   |   |              |   |   |   |              |   |   |   |              |
|              |                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |              |       |                                |                                |   |   |   |              |   |   |   |              |   |   |   |              |   |   |   |              |   |   |   |              |   |   |   |              |   |   |   |              |   |   |   |              |
|              |                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |              |       |                                |                                |   |   |   |              |   |   |   |              |   |   |   |              |   |   |   |              |   |   |   |              |   |   |   |              |   |   |   |              |   |   |   |              |
|              |                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |              |       |                                |                                |   |   |   |              |   |   |   |              |   |   |   |              |   |   |   |              |   |   |   |              |   |   |   |              |   |   |   |              |   |   |   |              |
|              |                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |              |       |                                |                                |   |   |   |              |   |   |   |              |   |   |   |              |   |   |   |              |   |   |   |              |   |   |   |              |   |   |   |              |   |   |   |              |
|              |                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |              |       |                                |                                |   |   |   |              |   |   |   |              |   |   |   |              |   |   |   |              |   |   |   |              |   |   |   |              |   |   |   |              |   |   |   |              |
|              |                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |              |       |                                |                                |   |   |   |              |   |   |   |              |   |   |   |              |   |   |   |              |   |   |   |              |   |   |   |              |   |   |   |              |   |   |   |              |
|              |                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |              |       |                                |                                |   |   |   |              |   |   |   |              |   |   |   |              |   |   |   |              |   |   |   |              |   |   |   |              |   |   |   |              |   |   |   |              |
|              |                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |              |       |                                |                                |   |   |   |              |   |   |   |              |   |   |   |              |   |   |   |              |   |   |   |              |   |   |   |              |   |   |   |              |   |   |   |              |

**Caution** When the software STOP mode is released by  $\overline{\text{RESET}}$  pin input, the oscillation stabilization time does not elapse. Secure the oscillation stabilization time by the low-level width of the  $\overline{\text{RESET}}$  pin input.

**Remark**  $F_x$ : OSC output clock

## 8.4 Operation

### 8.4.1 Operation status of each clock

The following table shows the operation status of each clock.

**Table 8-1. Operation Status of Each Clock**

| Clock Source |                                  | OSC | PLL | Main Clock (fx)                             |                                           | USB Clock (f <sub>USB</sub> ) | BUSCLK              |
|--------------|----------------------------------|-----|-----|---------------------------------------------|-------------------------------------------|-------------------------------|---------------------|
|              |                                  |     |     | Clock Supply to On-Chip Peripheral Function | Internal System Clock (f <sub>CLK</sub> ) |                               |                     |
| PLL mode     | Normal operation                 | √   | √   | √                                           | √                                         | √                             | √                   |
|              | HALT mode                        | √   | √   | √                                           | ×                                         | √                             | √                   |
|              | IDLE mode                        | √   | √   | ×                                           | ×                                         | ×                             | ×                   |
|              | Software STOP mode               | ×   | ×   | ×                                           | ×                                         | ×                             | ×                   |
|              | Oscillation stabilization period | √   | √   | ×                                           | √ <sup>Note 1</sup>                       | ×                             | √ <sup>Note 1</sup> |
|              | Reset period                     | √   | ×   | ×                                           | √ <sup>Note 2</sup>                       | ×                             | √ <sup>Note 2</sup> |

**Remark** √: Operates  
 ×: Stops

- Notes** 1. The system operates on the OSC output clock at power application. It stops when the operation is restored from the software STOP mode by an interrupt.  
 2. Operates on the OSC output clock.

### 8.4.2 Setting of input clock (Fx)

This table lists the frequencies supplied to the V850E/ME2.

**Table 8-2. Frequency List**

| Multiple | PLLSEL Pin | SSEL1 Pin | SSEL0 Pin | Input Frequency (MHz)<br>(Target Values) | Main Clock (fx) Frequency<br>(MHz) |
|----------|------------|-----------|-----------|------------------------------------------|------------------------------------|
| 8        | 1          | 0         | 1         | Setting prohibited                       | Setting prohibited                 |
|          |            | 1         | 0         | 10.00 to 10.19                           | 80.00 to 81.59                     |
|          |            | 1         | 1         | 10.20 to 11.99                           | 81.60 to 95.99                     |
|          | 0          | 0         | 0         | 12.00 to 14.39                           | 96.00 to 115.19                    |
|          |            | 0         | 1         | 14.40 to 17.39                           | 115.20 to 139.19                   |
|          |            | 1         | 0         | 17.40 to 18.75                           | 139.20 to 150.00                   |
|          |            | 1         | 1         | Setting prohibited                       | Setting prohibited                 |

**Caution** The MAX. value of f<sub>CLK</sub> of a 100 MHz version is 100 MHz, that of a 133 MHz version is 133 MHz, and that of a 150 MHz version is 150 MHz.

The operation is not guaranteed if f<sub>CLK</sub> (MAX.) < fx.

Make sure that fx does not exceed the guaranteed operating frequency of each product.

## 8.5 Operating Clock Provisions

SSCG consists of a multiplier that multiplies the OSC clock by eight and a modulation circuit for frequency diffusion. The multiplier that multiplies the OSC clock by eight generates an output error of up to  $\pm 150$  ps in the output period because of its circuit characteristics.

The modulation circuit adds the modulation error with respect to the set modulation rate, which varies depending on the modulation rate.

Therefore, the output frequency ( $f_{CLK}$ ) of BUSCLK, which outputs a clock via SSCG, and the operating frequency of the on-chip peripheral I/O (main clock ( $f_x$ ) of timers C, D, and ENC1, PWM unit, CSI3, UARTB, and A/D converter) are affected by this error. When calculating the frequency of each signal, therefore, be sure to take this error into consideration.

The methods of calculating the output period and output frequency at each modulation rate are shown below.

### (1) Minimum value of operating frequency ( $f_{MIN}$ )

| Modulation Rate of SSCG Output (%) | Parameter | Output Period: $T_{MAX}$ (ns)                   | Output Frequency (MHz)    |
|------------------------------------|-----------|-------------------------------------------------|---------------------------|
| No modulation                      | 1.00000   | $(1/f_x) \times 10^3 + 0.15$                    | $(1/T_{MAX}) \times 10^3$ |
| -0.50                              | 0.99110   | $\{1/(0.99110 \times f_x)\} \times 10^3 + 0.15$ | $(1/T_{MAX}) \times 10^3$ |
| -1.00                              | 0.98625   | $\{1/(0.98625 \times f_x)\} \times 10^3 + 0.15$ | $(1/T_{MAX}) \times 10^3$ |
| -2.00                              | 0.97450   | $\{1/(0.97450 \times f_x)\} \times 10^3 + 0.15$ | $(1/T_{MAX}) \times 10^3$ |
| -3.00                              | 0.96335   | $\{1/(0.96335 \times f_x)\} \times 10^3 + 0.15$ | $(1/T_{MAX}) \times 10^3$ |
| -4.00                              | 0.95085   | $\{1/(0.95085 \times f_x)\} \times 10^3 + 0.15$ | $(1/T_{MAX}) \times 10^3$ |
| -5.00                              | 0.93860   | $\{1/(0.93860 \times f_x)\} \times 10^3 + 0.15$ | $(1/T_{MAX}) \times 10^3$ |

### (2) Maximum value of operating frequency ( $f_{MAX}$ )

| Modulation Rate of SSCG Output (%) | Parameter | Output Period: $T_{MAX}$ (ns)                   | Output Frequency (MHz)    |
|------------------------------------|-----------|-------------------------------------------------|---------------------------|
| No modulation                      | 1.00000   | $(1/f_x) \times 10^3 - 0.15$                    | $(1/T_{MIN}) \times 10^3$ |
| -0.50                              | 1.00390   | $\{1/(1.00390 \times f_x)\} \times 10^3 - 0.15$ | $(1/T_{MIN}) \times 10^3$ |
| -1.00                              | 1.00375   | $\{1/(1.00375 \times f_x)\} \times 10^3 - 0.15$ | $(1/T_{MIN}) \times 10^3$ |
| -2.00                              | 1.00550   | $\{1/(1.00550 \times f_x)\} \times 10^3 - 0.15$ | $(1/T_{MIN}) \times 10^3$ |
| -3.00                              | 1.00665   | $\{1/(1.00665 \times f_x)\} \times 10^3 - 0.15$ | $(1/T_{MIN}) \times 10^3$ |
| -4.00                              | 1.00915   | $\{1/(1.00915 \times f_x)\} \times 10^3 - 0.15$ | $(1/T_{MIN}) \times 10^3$ |
| -5.00                              | 1.01140   | $\{1/(1.01140 \times f_x)\} \times 10^3 - 0.15$ | $(1/T_{MIN}) \times 10^3$ |

### (3) Average operating frequency ( $f_{AVE}$ )

The average operating frequency can be calculated by this expression.

$$\text{Average operating frequency } (f_{AVE}) = (f_{MIN} + f_{MAX})/2$$

The average operating frequency is in one period of the modulation period set by the SMDL1 and SMDL0 bits of the SSCGC register. The operating frequency in a period shorter than the modulation period may have a relatively larger error than the result of the above expression.

### 8.5.1 Calculating BUSCLK frequency

If the modulation function of SSCG is used, the internal system clock frequency ( $f_{CLK}$ ) from which BUSCLK is generated fluctuates. Exercise care in calculating the frequency of BUSCLK.

The following table shows the frequency fluctuation of BUSCLK.

**Table 8-3. Frequency Fluctuation of BUSCLK**

| BMC Register |      | BUSCLK Frequency (MHz) |             |             |
|--------------|------|------------------------|-------------|-------------|
| CKM1         | CKM1 | Min.                   | Typ.        | Max.        |
| 0            | 0    | $f_{MIN}$              | $f_{AVE}$   | $f_{MAX}$   |
| 0            | 1    | $f_{MIN}/2$            | $f_{AVE}/2$ | $f_{MAX}/2$ |
| 1            | 0    | $f_{MIN}/3$            | $f_{AVE}/3$ | $f_{MAX}/3$ |
| 1            | 1    | $f_{MIN}/4$            | $f_{AVE}/4$ | $f_{MAX}/4$ |

### 8.5.2 Calculating operating clock frequency of each on-chip peripheral function

When the modulation function of SSCG is used, the main clock ( $f_x$ ) from which the operating clock of each on-chip peripheral function is generated fluctuates. Note (1) to (8) below.

(1) Count period of timer C:

Period of count clock frequency (set by the CSCn2 to CSCn0 bits of the TMCCn0 register) when input clock is specified (ETICn bit of the TMCCn1 register = 0) ( $n = 0$  to 5)

The count period can be calculated from the average operating frequency.

However, the average operating frequency is in one period of the modulation period set by the SMDL1 and SMDL0 bits of the SSCGC register. Note that the average operating frequency may have a relatively larger error than the result of calculation during a count operation in a period shorter than the modulation period.

If it is necessary to guarantee an absolute value for the count operation, it is recommended to set appropriate counts during operation at  $f_{MIN}$  if the counting operation is performed within a specific time and during operation at  $f_{MAX}$  if the operation is performed for longer than a specific time.

Do not use the modulation function of SSCG if a high-accuracy count operation is necessary.

(2) Count period of timer D:

Period of count clock frequency (set by CSDn2 to CSDn0 bits of the TMCDn register) ( $n = 0$  to 3)

The count period can be calculated from the average operating frequency.

However, the average operating frequency is in one period of the modulation period set by the SMDL1 and SMDL0 bits of the SSCGC register. Note that the average operating frequency may have a relatively larger error than the result of calculation during a count operation in a period shorter than the modulation period.

If it is necessary to guarantee an absolute value for the count operation, it is recommended to set appropriate counts during operation at  $f_{MIN}$  if the counting operation is performed within a specific time and during operation at  $f_{MAX}$  if the operation is performed for longer than a specific time.

Do not use the modulation function of SSCG if a high-accuracy count operation is necessary.

## (3) Count period of timer ENC1:

Period of count clock frequency (set by PRM1n2 to PRM1n0 bits of the PRM1n register) when general-purpose timer mode is specified (T1CMDn bit of the TUM1n register = 0) (n = 0, 1)

The count period can be calculated from the average operating frequency.

However, the average operating frequency is in one period of the modulation period set by the SMDL1 and SMDL0 bits of the SSCGC register. Note that the average operating frequency may have a relatively larger error than the result of calculation during a count operation in a period shorter than the modulation period.

If it is necessary to guarantee an absolute value for the count operation, it is recommended to set appropriate counts during operation at  $f_{\text{MIN}}$  if the counting operation is performed within a specific time and during operation at  $f_{\text{MAX}}$  if the operation is performed for longer than a specific time. Duty setting is guaranteed during either high level output or low level output when timer output is performed.

Do not use the modulation function of SSCG if a high-accuracy count operation is necessary.

## (4) Pulse output period of PWM unit:

Period of operating clock frequency (set by the CKSPn1 and CKSPn0 bits of the PWMCn register) (n = 0, 1)

The pulse output period can be calculated from the average operating frequency.

However, the average operating frequency is in one period of the modulation period set by the SMDL1 and SMDL0 bits of the SSCGC register. Note that the average operating frequency may have a relatively larger error than the result of calculation when a pulse with a period shorter than the modulation period is output.

If it is necessary to guarantee an absolute value for the pulse output, it is recommended to set appropriate counts during operation at  $f_{\text{MIN}}$  if the counting operation is performed within a specific time and during operation at  $f_{\text{MAX}}$  if the operation is performed for longer than a specific time. Duty setting is guaranteed during either high level output or low level output when PWM output is performed.

Do not use the modulation function of SSCG if a high-accuracy pulse output is necessary.

## (5) Serial communication (transmission, reception, or transmission/reception) transfer rate of CSI3:

Period of base clock frequency (CKS3n2 to CKS3n0 of the CSIC3n register = other than 111) (n = 0, 1) with master mode specified

The transfer rate can be calculated from the average operating frequency.

However, the average operating frequency is in one period of the modulation period set by the SMDL1 and SMDL0 bits of the SSCGC register. Note that the average operating frequency may have a relatively larger error than the result of calculation at a transfer rate shorter than the modulation period.

If it is necessary to guarantee an absolute value for the transfer rate, it is recommended to set an appropriate transfer rate during operation at  $f_{\text{MIN}}$  for the minimum transfer rate and during operation at  $f_{\text{MAX}}$  for the maximum transfer rate.



(6) Serial communication (transmission or reception) transfer rate of UARTB:

Period of serial transfer speed (set by the UBnBRS15 to UBnBRS0 bits of the UBnCTL2 register) ( $n = 0, 1$ )

Set the value of the transfer rate (set value ( $k$ ) of the UBnCTL2 register) so that the permissible maximum and minimum baud rate errors are satisfied at both  $f_{\text{MIN}}$  and  $f_{\text{MAX}}$ .

Here is a calculation example.

<1> Determine the set value ( $k$ ) of the UBnCTL2 register from the calculation result of the expression “Target baud rate  $\times 8/f_{\text{AVE}}$  (Hz)”.

<2> Calculate the actual baud rate value at  $f_{\text{MAX}}$  and  $f_{\text{MIN}}$ , by using the set value ( $k$ ) calculated in <1> above.

<3> Check that the result of calculation in <2> above satisfies the allowable maximum/minimum baud rate error.

<4> Calculate the set value of the transfer rate using <1> to <3> (set value ( $k$ ) of the UBnCTL2 register).

**Caution** Change the modulation rate of SSCG if the set value (set value ( $k$ ) of the UBnCTL2 register) of the transfer rate that satisfies the above calculation method cannot be obtained. The more the transfer rate is raised, the smaller the selectable modulation rate becomes.

**(Example)**

**$f_x = 150$  MHz: Setting of modulation rates of 4% and 5% is prohibited.**

**$f_x = 133$  MHz: Setting of modulation rates of 4% and 5% is prohibited.**

**$f_x = 100$  MHz: Setting of modulation rate of 5% is prohibited.**

(7) A/D converter:

Conversion time

Calculate the set value (2 to 10  $\mu\text{s}$ ) of the A/D conversion time (set by the FR3 to FR0 bits of the ADM1 register) by  $f_{\text{AVE}}$  (calculation by  $f_{\text{MIN}}$  and  $f_{\text{MAX}}$  is not necessary).

(8) Digital noise elimination time

Calculate the minimum noise elimination time set by the NCWC $n$  and NCW1 $m$  registers at  $f_{\text{MAX}}$  and the maximum noise elimination time at  $f_{\text{MIN}}$  ( $n = 0$  to 3,  $m = 0, 1$ ).

## 8.6 Power-Save Control

### 8.6.1 Overview

The power-save function has the following three modes.

#### (1) HALT mode

In this mode, the clock generator (oscillator (OSC, SSCG) and PLL synthesizer) continues to operate, but the CPU's operation clock stops. Since the supply of clocks to on-chip peripheral functions other than the CPU continues, operation continues. The power consumption of the overall system can be reduced by intermittent operation using a combination of the HALT mode and the normal operation mode.

The system is switched to HALT mode by a specific instruction (the HALT instruction).

#### (2) IDLE mode

In this mode, the clock generator (oscillator (OSC, SSCG) and PLL synthesizer) continues to operate, but the supply of internal system clocks ( $f_{CLK}$ ) is stopped, which causes the overall system to stop.

When the system is released from IDLE mode, it can be switched to normal operation mode quickly because the oscillator's oscillation stabilization time does not need to be secured.

The system is switched to IDLE mode by a PSMR register setting.

IDLE mode is located midway between software STOP mode and HALT mode in relation to the clock stabilization time and power consumption. It is used for situations in which a low-power-consumption mode is to be used and the clock stabilization time is to be eliminated after the mode is released.

#### (3) Software STOP mode

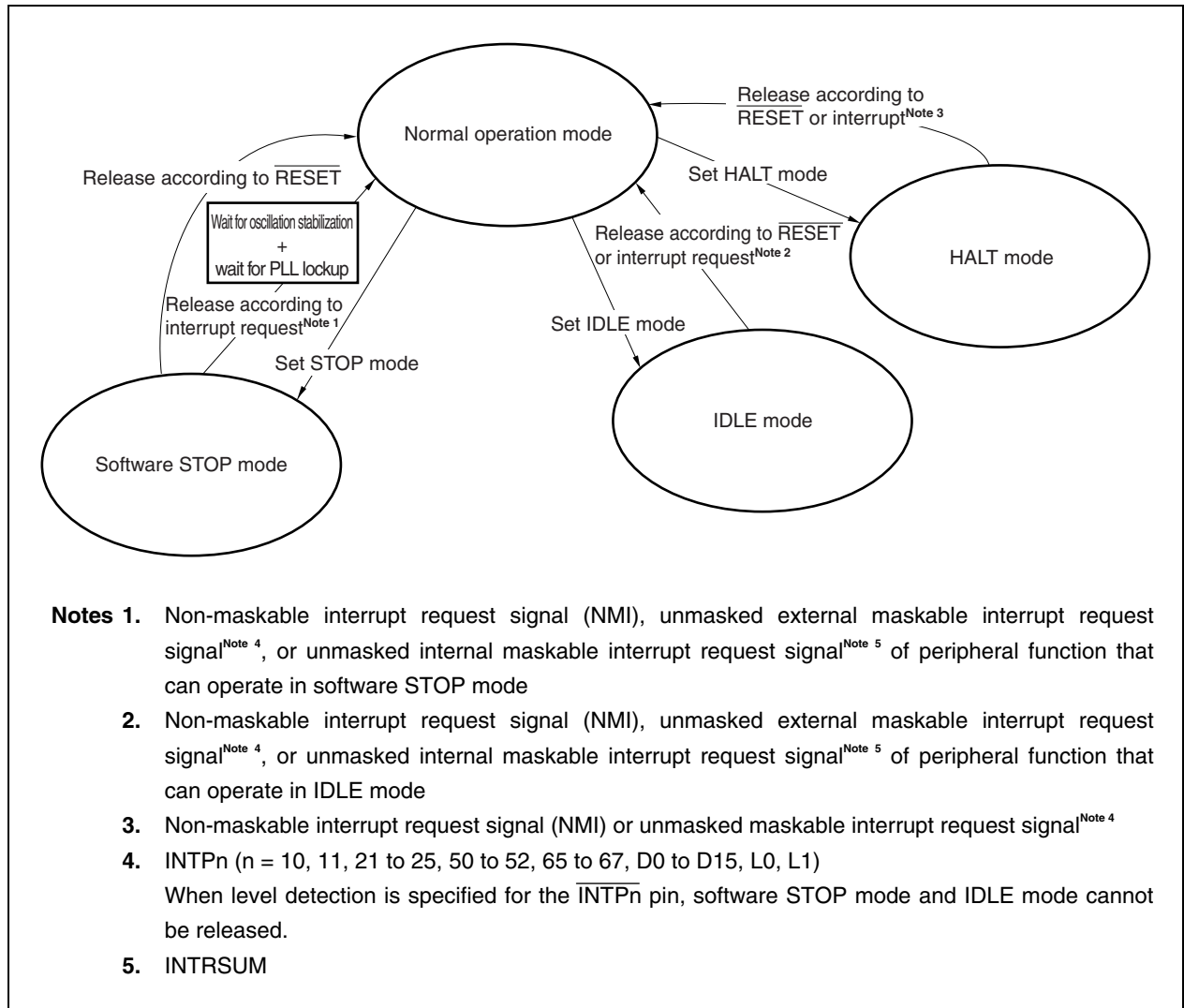
In this mode, the overall system is stopped by stopping the clock generator (oscillator (OSC, SSCG) and PLL synthesizer). The system enters an ultra-low-power-consumption state in which only leakage current is lost.

The system is switched to software STOP mode by a PSMR register setting. The PLL synthesizer's clock output is stopped at the same time the oscillator is stopped. After software STOP mode is released by  $\overline{RESET}$  input, the oscillator's oscillation stabilization time must be secured until the system clock stabilizes. When the software STOP mode is released by the non-maskable interrupt request (NMI) or an unmasked maskable interrupt request, program execution is started about 2 ms after the count time of the time base counter (TBC) elapses.

Table 8-1 shows the operation of the clock generator in normal operation mode, HALT mode, IDLE mode, and software STOP mode.

An effective low power consumption system can be realized by combining these modes and switching modes according to the required use.

**Figure 8-2. Power-Save Mode State Transition Diagram**



## 8.6.2 Control registers

## (1) Power-save mode register (PSMR)

This is an 8-bit register that controls power-save mode. It is effective only when the STP bit of the PSC register is set to 1.

Writing to the PSMR register is executed by the store instruction (ST/SST instruction) and a bit manipulation instruction (SET1/CLR1/NOT1 instruction).

This register can be read or written in 8-bit or 1-bit units.

Be sure to clear bits 7, 5, and 4 to 0. If they are set to 1, the operation is not guaranteed.

|      | 7 | 6 | 5 | 4 | 3 | 2 | 1 | <0> | Address   | After reset |
|------|---|---|---|---|---|---|---|-----|-----------|-------------|
| PSMR | 0 | 0 | 0 | 0 | 0 | 0 | 0 | PSM | FFFFF820H | 00H         |

| Bit position | Bit name | Function                                                                                                                          |
|--------------|----------|-----------------------------------------------------------------------------------------------------------------------------------|
| 0            | PSM      | Specifies IDLE mode or software STOP mode.<br>0: Switches the system to IDLE mode<br>1: Switches the system to software STOP mode |

## (2) Command register (PRCMD)

This is an 8-bit register that is used to set protection for write operations to registers that can significantly affect the system so that the application system is not halted unexpectedly due to an inadvertent program loop.

Writing to the first specific register (power-save control register (PSC), etc.) is only valid after first writing to the PRCMD register. Because of this, the register value can be overwritten only by the specified sequence, preventing an illegal write operation from being performed.

This register is write-only, in 8-bit units (when it is read, undefined data is read out).

|       | 7     | 6     | 5     | 4     | 3     | 2     | 1     | 0     | Address   | After reset |
|-------|-------|-------|-------|-------|-------|-------|-------|-------|-----------|-------------|
| PRCMD | RREG7 | RREG6 | RREG5 | RREG4 | RREG3 | RREG2 | RREG1 | RREG0 | FFFFF1FCH | Undefined   |

| Bit position | Bit name       | Function                                                                                                                                                                                                                                                                                                       |
|--------------|----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 7 to 0       | RREG7 to RREG0 | Registration code (arbitrary 8-bit data)<br>The specific register targeted is as follows. <ul style="list-style-type: none"> <li>• Power-save control register (PSC)</li> <li>• Clock control register (CKC)</li> <li>• Clock source select register (CKS)</li> <li>• SSCG control register (SSCGC)</li> </ul> |

**(3) Power-save control register (PSC)**

This is an 8-bit register that controls the power-save function.

<R> If interrupts are enabled by the setting of the NMIM and INTM bits, the IDLE mode or software STOP mode can be released by an interrupt request (except when interrupt servicing is disabled by the interrupt mask registers (IMR0 to IMR5)).

<R> The IDLE mode or software STOP mode is specified by the setting of the STP bit.

This register, which is one of the specific registers, is valid only when accessed in a specific sequence during a write operation.

This register can be read or written in 8-bit or 1-bit units.

Be sure to clear bits 7 and 6 to 0. If they are set to 1, the operation is not guaranteed.

**Cautions 1. It is impossible to set the STP bit and the NMIM or INTM bit at the same time. Be sure to set the STP bit after setting the NMIM or INTM bit.**

<R> **2. The IDLE mode or software STOP mode cannot be released by either a non-maskable interrupt request signal or an unmasked maskable interrupt request signal for which the NMIM and INTM bits are set to 1 because these interrupt requests are invalid (they are not held pending).**

|     | 7 | 6 | <5>  | <4>  | 3 | 2 | <1> | 0 | Address    | After reset |
|-----|---|---|------|------|---|---|-----|---|------------|-------------|
| PSC | 0 | 0 | NMIM | INTM | 0 | 0 | STP | 0 | FFFFFF1FEH | 00H         |

| Bit position | Bit name | Function                                                                                                                                                                                                                                                                                                      |
|--------------|----------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 5            | NMIM     | This is the enable/disable setting bit for standby mode release using the valid edge input of NMI <sup>Note</sup> .<br>0: Release by NMI enabled<br>1: Release by NMI disabled                                                                                                                                |
| 4            | INTM     | This is the enable/disable setting bit for standby mode release using the valid edge input of an unmasked maskable interrupt (INTPn) (n = 10, 11, 21 to 25, 50 to 52, 65 to 67, D0 to D15, L0, L1) <sup>Note</sup> .<br>0: Release by maskable interrupt enabled<br>1: Release by maskable interrupt disabled |
| 1            | STP      | Indicates the standby mode status.<br>If 1 is written to this bit, the system enters IDLE or software STOP mode (set by the PSM bit of the PSMR register). When standby mode is released, this bit is automatically reset to 0.<br>0: Standby mode is released<br>1: Standby mode is in effect                |

**Note** Setting these bits is valid only in the IDLE/software STOP mode.

Set data in the power-save control register (PSC) in the following sequence.

- <1> Set the power-save mode register (PSMR) (with the following instructions).
  - Store instruction (ST/SST instruction)
  - Bit manipulation instruction (SET1/CLR1/NOT1 instruction)
- <2> Prepare data in any one of the general-purpose registers to set to the specific register.
- <3> Write data to the command register (PRCMD).
- <4> Set the power-save control register (PSC) (with the following instructions).
  - Store instruction (ST/SST instruction)
  - Bit manipulation instruction (SET1/CLR1/NOT1 instruction)
- <5> Insert the NOP instructions (5 instructions (<5> to <9>).

[Sample coding]

```

<1> ST.B  r11, PSMR[r0]    ; Set PSMR register
<2> MOV   0x02, r10
<3> ST.B  r10, PRCMD[r0]   ; Write PRCMD register
<4> ST.B  r10, PSC[r0]     ; Set PSC register
<5> NOP                                ; Dummy instruction
<6> NOP                                ; Dummy instruction
<7> NOP                                ; Dummy instruction
<8> NOP                                ; Dummy instruction
<9> NOP                                ; Dummy instruction
(next instruction)          ; Execution routine after software STOP mode and IDLE mode release

```

No special sequence is required to read the specific register.

- Cautions**
1. A store instruction for the command register does not acknowledge interrupts. This coding is made on assumption that <3> and <4> above are executed by the program with consecutive store instructions. If another instruction is set between <3> and <4>, the above sequence may become ineffective when the interrupt is acknowledged by that instruction, and a malfunction of the program may result.
  2. Although the data written to the PRCMD register is dummy data, use the same register as the general-purpose register used in specific register setting (<4>) for writing to the PRCMD register (<3>). The same method should be applied when using a general-purpose register for addressing.
  3. At least 5 NOP instructions must be inserted after executing a store instruction to the PSC register to set software STOP or IDLE mode.
  4. Be sure to terminate all DMA transfers prior to the execution of the above sequence.

### 8.6.3 HALT mode

#### (1) Setting and operation status

In HALT mode, the clock generator (oscillator (OSC, SSCG) and PLL synthesizer) continues to operate, but the operation clock of the CPU is stopped. Since the supply of clocks to on-chip peripheral functions other than the CPU continues, operation continues. The power consumption of the overall system can be reduced by setting the system to HALT mode while the CPU is idle.

The system is switched to HALT mode by the HALT instruction.

Although program execution stops in HALT mode, the contents of all registers, internal data RAM, internal instruction RAM, and ports are maintained in the state they were in immediately before HALT mode began. Also, operation continues for all on-chip peripheral functions (other than ports) that do not depend on CPU instruction processing. The following shows the status of each hardware unit in HALT mode.

- Cautions**
1. If the HALT instruction is executed while an interrupt request signal is being held pending, the HALT mode is set once but it is immediately released by the pending interrupt request signal.
  2. At least 5 NOP instructions must be inserted after executing a HALT instruction.

Table 8-4. Operation Status in HALT Mode

| Function                                                                                                              | Operation Status                                                                                                                                                                                         |
|-----------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Clock generator                                                                                                       | Operating                                                                                                                                                                                                |
| Main clock (fx)                                                                                                       | Operating                                                                                                                                                                                                |
| CPU                                                                                                                   | Stopped                                                                                                                                                                                                  |
| Internal data                                                                                                         | All internal data such as CPU registers, statuses, data, and the contents of internal data RAM and internal instruction RAM are maintained in the state they were in immediately before HALT mode began. |
| DMAC                                                                                                                  | Operating                                                                                                                                                                                                |
| INTC                                                                                                                  | Operating                                                                                                                                                                                                |
| TMC0 to TMC5                                                                                                          | Operating                                                                                                                                                                                                |
| TMD0 to TMD3                                                                                                          | Operating                                                                                                                                                                                                |
| TMENC10, TMENC11                                                                                                      | Operating                                                                                                                                                                                                |
| UARTB0, UARTB1                                                                                                        | Operating                                                                                                                                                                                                |
| CSI30, CSI31                                                                                                          | Operating                                                                                                                                                                                                |
| A/D converter                                                                                                         | Operating                                                                                                                                                                                                |
| Ports                                                                                                                 | Maintained the state before HALT mode set                                                                                                                                                                |
| USB function controller                                                                                               | Operating                                                                                                                                                                                                |
| D0 to D31                                                                                                             | Operating                                                                                                                                                                                                |
| A0 to A25                                                                                                             |                                                                                                                                                                                                          |
| $\overline{RD}$ , $\overline{WE/WR}$ , $\overline{BCYST}$                                                             |                                                                                                                                                                                                          |
| $\overline{ULWR}$ , $\overline{UUWR}$ , $\overline{LLWR}$ , $\overline{LUWR}$ , $\overline{IORD}$ , $\overline{IOWR}$ |                                                                                                                                                                                                          |
| $\overline{LLDQM}$ , $\overline{LUDQM}$ , $\overline{ULDQM}$ , $\overline{UUDQM}$                                     |                                                                                                                                                                                                          |
| $\overline{LLBE}$ , $\overline{LUBE}$ , $\overline{ULBE}$ , $\overline{UUBE}$                                         |                                                                                                                                                                                                          |
| $\overline{CS0}$ to $\overline{CS7}$                                                                                  |                                                                                                                                                                                                          |
| $\overline{SDRAS}$                                                                                                    |                                                                                                                                                                                                          |
| $\overline{SDCAS}$                                                                                                    |                                                                                                                                                                                                          |
| $\overline{REFRQ}$                                                                                                    |                                                                                                                                                                                                          |
| $\overline{HLDK}$                                                                                                     |                                                                                                                                                                                                          |
| $\overline{HLDRQ}$                                                                                                    |                                                                                                                                                                                                          |
| $\overline{WAIT}$                                                                                                     |                                                                                                                                                                                                          |
| $\overline{SELFREF}$                                                                                                  |                                                                                                                                                                                                          |
| $\overline{SDCKE}$                                                                                                    |                                                                                                                                                                                                          |
| BUSCLK                                                                                                                | Clock output                                                                                                                                                                                             |



**(2) Release of HALT mode**

HALT mode is released by a non-maskable interrupt request signal, an unmasked maskable interrupt request signal (INTP<sub>n</sub>), or  $\overline{\text{RESET}}$  pin input (n = 10, 11, 21 to 25, 50 to 52, 65 to 67, D0 to D15, L0, L1).

**(a) Release according to a non-maskable interrupt request signal or an unmasked maskable interrupt request signal**

HALT mode is released by a non-maskable interrupt request signal or by an unmasked maskable interrupt request signal regardless of the priority. The operation after release is as follows.

**Table 8-5. Operation After HALT Mode Is Released by Interrupt Request Signal**

| Release Source                             | Enable Interrupt (EI) Status                          | Disable Interrupt (DI) Status |
|--------------------------------------------|-------------------------------------------------------|-------------------------------|
| Non-maskable interrupt request signal      | Branch to handler address                             |                               |
| Unmasked maskable interrupt request signal | Branch to handler address or execute next instruction | Execute next instruction      |

However, if the system is set to HALT mode during an interrupt servicing routine, operation will differ as follows.

- (i) If an interrupt request signal is generated with a lower priority than that of the maskable interrupt request signal that is currently being serviced, HALT mode is released, but the newly generated interrupt request signal is not acknowledged. The new interrupt request signal is held pending.
- (ii) If an interrupt request signal (including non-maskable interrupt request signals) is generated with a higher priority than that of the maskable interrupt request signal that is currently being serviced, HALT mode is released and the newly generated interrupt request signal is acknowledged.

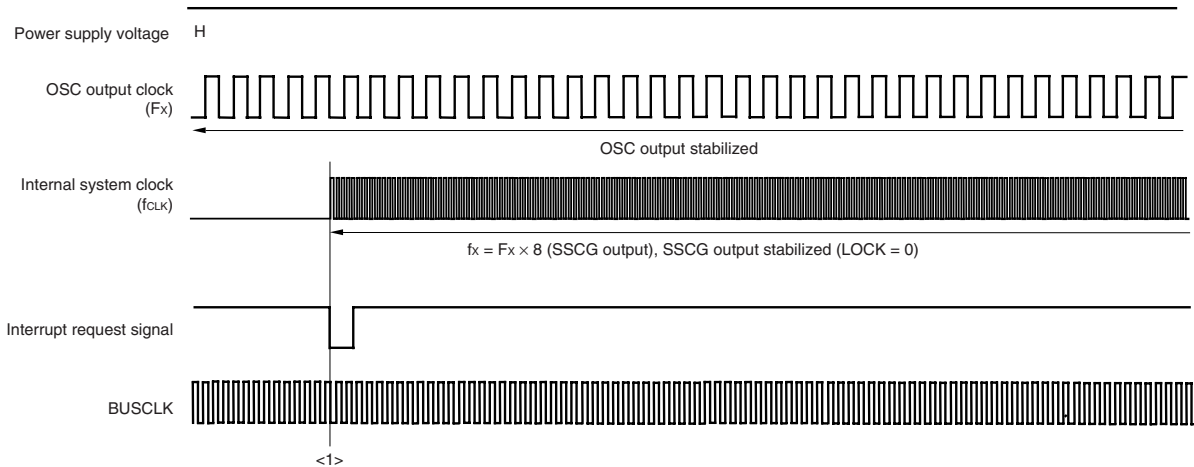
**(b) Release according to  $\overline{\text{RESET}}$  pin input**

This is the same as a normal reset operation.

The BUSCLK operation when the HALT mode is released is illustrated below.

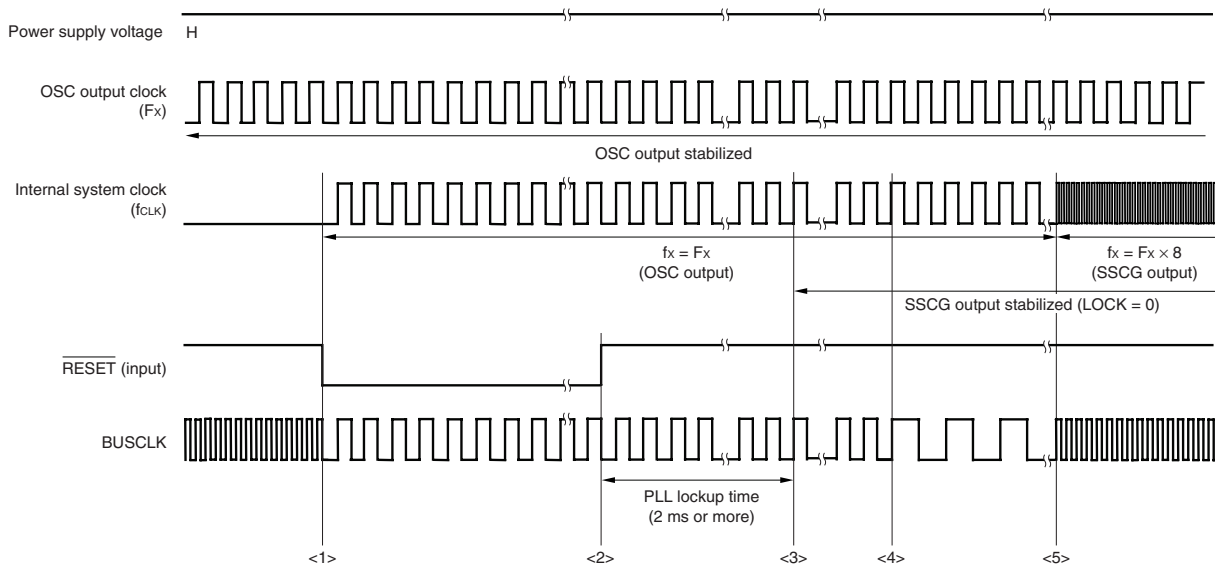
Figure 8-3. BUSCLK Operation When HALT Mode Is Released

## (a) When HALT mode is released by non-maskable interrupt request signal or unmasked external maskable interrupt request signal



- Remarks**
1. <1>: Interrupt signal (active) input
  2. BUSCLK is output normally in the HALT mode.

## (b) When HALT mode is released by RESET pin input



- Remarks**
1. <1>: RESET input
  - <2>: RESET cleared (counting PLL lockup time starts)
  - <3>: PLL lock status (LOCK bit of LOCKR register = 0)
  - <4>: BUSCLK = f<sub>CLK</sub>/2 (CKM1 and CKM0 bits of BMC register = 01)
  - <5>: f<sub>x</sub> = F<sub>x</sub> × 8 (CKSSEL bit of CKS register = 1)
  2. The above operation is performed if BUSCLK operates with half the period of the internal system clock (f<sub>CLK</sub>).

#### 8.6.4 IDLE mode

##### (1) Setting and operation status

In this mode, the entire system is stopped with the clock generator (oscillator (OSC, SSCG) and PLL synthesizer) continuing to operate and clock supply to the CPU and other on-chip peripheral functions stopped.

When IDLE mode is released, the system can be switched to normal operation mode quickly because the oscillator's oscillation stabilization time or the PLL lockup time does not need to be secured.

The system is switched to IDLE mode by setting the PSC or PSMR register using a store instruction (ST or SST instruction) or a bit manipulation instruction (SET1, CLR1, or NOT1 instruction) (see **8.6.2 Control registers**).

In IDLE mode, program execution is stopped, and the contents of all registers, internal data RAM, internal instruction RAM, and ports are maintained in the state they were in immediately before execution stopped.

The operation of CPU and other on-chip peripheral functions is stopped.

The following shows the status of each hardware unit in IDLE mode.

**Caution** Insert at least 5 NOP instructions after the instruction that stores data in the PSC register to set the IDLE mode.

Table 8-6. Operation Status in IDLE Mode

| Function                                                                                                              | Operation Status                                                                                                                                                                                         |
|-----------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Clock generator                                                                                                       | Operating                                                                                                                                                                                                |
| Main clock (fx)                                                                                                       | Stopped                                                                                                                                                                                                  |
| CPU                                                                                                                   | Stopped                                                                                                                                                                                                  |
| Internal data                                                                                                         | All internal data such as CPU registers, statuses, data, and the contents of internal data RAM and internal instruction RAM are maintained in the state they were in immediately before IDLE mode began. |
| DMAC                                                                                                                  | Stopped                                                                                                                                                                                                  |
| INTC                                                                                                                  | Stopped                                                                                                                                                                                                  |
| TMC0 to TMC5                                                                                                          | Stopped                                                                                                                                                                                                  |
| TMD0 to TMD3                                                                                                          | Stopped                                                                                                                                                                                                  |
| TMENC10, TMENC11                                                                                                      | Stopped                                                                                                                                                                                                  |
| UARTB0, UARTB1                                                                                                        | Stopped                                                                                                                                                                                                  |
| CSI30, CSI31                                                                                                          | Stopped                                                                                                                                                                                                  |
| A/D converter                                                                                                         | Stopped                                                                                                                                                                                                  |
| Ports                                                                                                                 | Maintained the state before IDLE mode set                                                                                                                                                                |
| USB function controller                                                                                               | Stopped                                                                                                                                                                                                  |
| D0 to D31                                                                                                             | High impedance                                                                                                                                                                                           |
| A0 to A25                                                                                                             |                                                                                                                                                                                                          |
| $\overline{RD}$ , $\overline{WE}/\overline{WR}$ , $\overline{BCYST}$                                                  | High-level output                                                                                                                                                                                        |
| $\overline{ULWR}$ , $\overline{UUWR}$ , $\overline{LLWR}$ , $\overline{LUWR}$ , $\overline{IORD}$ , $\overline{IOWR}$ |                                                                                                                                                                                                          |
| $\overline{LLDQM}$ , $\overline{LUDQM}$ , $\overline{ULDQM}$ , $\overline{UUDQM}$                                     |                                                                                                                                                                                                          |
| $\overline{LLBE}$ , $\overline{LUBE}$ , $\overline{ULBE}$ , $\overline{UUBE}$                                         |                                                                                                                                                                                                          |
| $\overline{CS0}$ to $\overline{CS7}$                                                                                  |                                                                                                                                                                                                          |
| $\overline{SDRAS}$                                                                                                    | Self-refresh status when connected to SDRAM                                                                                                                                                              |
| $\overline{SDCAS}$                                                                                                    |                                                                                                                                                                                                          |
| $\overline{REFRQ}$                                                                                                    | Operating (outputs high level when SDRAM controller is not used)                                                                                                                                         |
| $\overline{HLDK}$                                                                                                     | High-level output                                                                                                                                                                                        |
| $\overline{HLDRQ}$                                                                                                    | Input (no sampling)                                                                                                                                                                                      |
| $\overline{WAIT}$                                                                                                     |                                                                                                                                                                                                          |
| $\overline{SELFREF}$                                                                                                  |                                                                                                                                                                                                          |
| SDCKE                                                                                                                 | Low-level output (outputs high level when SDRAM controller is not used)                                                                                                                                  |
| BUSCLK                                                                                                                | Low-level output                                                                                                                                                                                         |

**(2) Release of IDLE mode**

The IDLE mode is released by a non-maskable interrupt request signal, an unmasked external maskable interrupt request signal (INTPn)<sup>Note</sup>, an unmasked internal maskable interrupt request signal of a peripheral function that can operate in the IDLE mode (INTRSUM), and RESET pin input (n = 10, 11, 21 to 25, 50 to 52, 65 to 67, D0 to D15, L0, or L1).

**Note** When level detection is set, the IDLE mode cannot be released.

**(a) Release according to a non-maskable interrupt request signal or an unmasked maskable interrupt request signal**

IDLE mode can be released by an interrupt request signal only when it has been set with the INTM and NMIM bits of the PSC register cleared to 0.

IDLE mode is released by a non-maskable interrupt request signal, an unmasked external maskable interrupt request signal (INTPn), or an unmasked internal maskable interrupt request signal of a peripheral function that can operate in the IDLE mode (INTRSUM) regardless of the priority (n = 10, 11, 21 to 25, 50 to 52, 65 to 67, D0 to D15, L0, or L1). The operation after release is as follows.

**Caution** When the INTM bit of the PSC register = 1, the IDLE mode cannot be released by the unmasked maskable interrupt request signal.

**Table 8-7. Operation After IDLE Mode Is Released by Interrupt Request Signal**

| Release Source                             | Enable Interrupt (EI) Status                          | Disable Interrupt (DI) Status |
|--------------------------------------------|-------------------------------------------------------|-------------------------------|
| Non-maskable interrupt request signal      | Branch to handler address                             |                               |
| Unmasked maskable interrupt request signal | Branch to handler address or execute next instruction | Execute next instruction      |

However, if the system is set to IDLE mode during an interrupt servicing routine, operation will differ as follows.

- (i) If an interrupt request signal is generated with a lower priority than that of the maskable interrupt request signal that is currently being serviced, IDLE mode is released, but the newly generated interrupt request signal is not acknowledged. The new interrupt request signal is held pending.
- (ii) If an interrupt request signal (including non-maskable interrupt request signals) is generated with a higher priority than that of the maskable interrupt request signal that is currently being serviced, IDLE mode is released and the newly generated interrupt request signal is acknowledged.

If the system is set to IDLE mode during an NMI servicing routine, IDLE mode is released, but the interrupt is not acknowledged (interrupt is held pending).

Interrupt servicing that is started when IDLE mode is released by NMI pin input is handled in the same way as normal NMI interrupt servicing that occurs during an emergency (because the NMI interrupt handler address is unique). Therefore, when a program must be able to distinguish between these two situations, a software status must be prepared in advance and that status must be set before setting the PSMR register using a store instruction or a bit manipulation instruction. By checking for this status during NMI interrupt servicing, an ordinary NMI can be distinguished from the processing that is started when IDLE mode is released by NMI pin input.

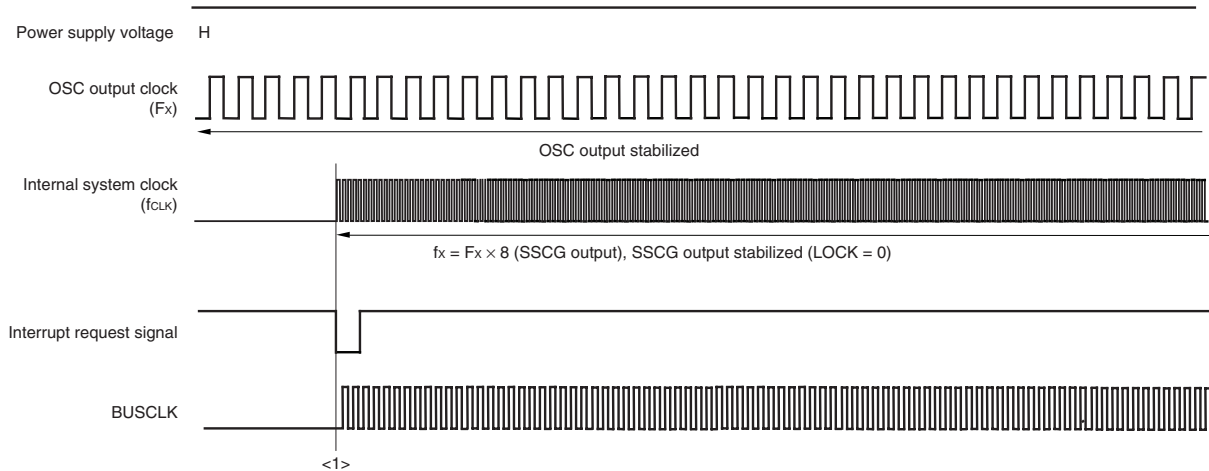
**(b) Release according to RESET pin input**

This is the same as a normal reset operation.

The BUSCLK operation when the IDLE mode is released is illustrated below.

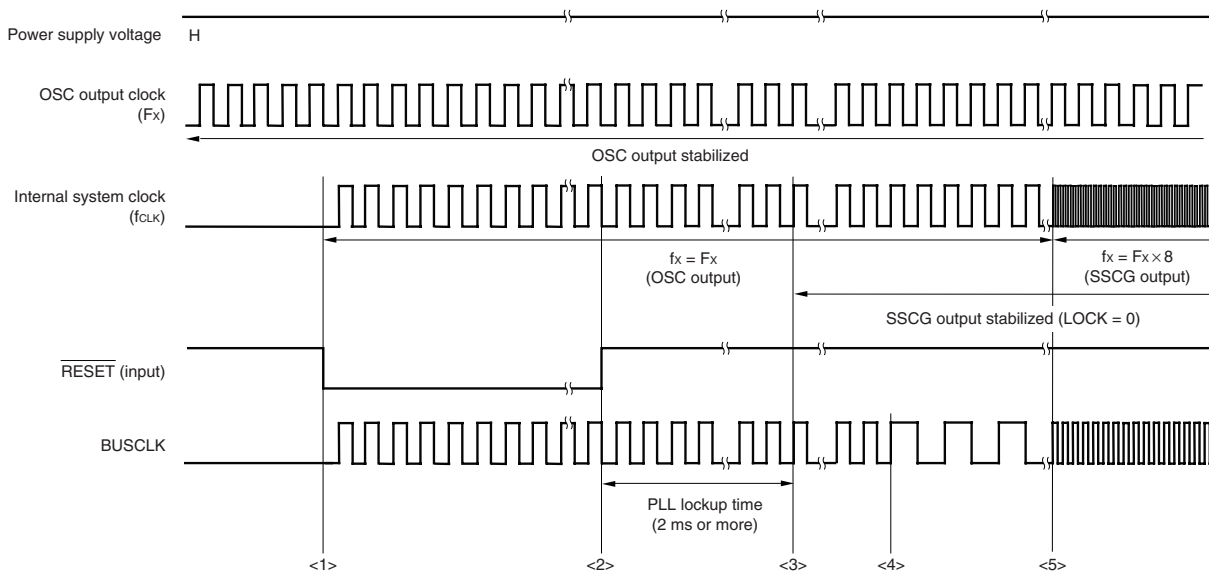
**Figure 8-4. BUSCLK Operation When IDLE Mode Is Released**

**(a) When IDLE mode is released by non-maskable interrupt request signal or unmasked external maskable interrupt request signal**



**Remark** <1>: Interrupt signal (active) input

**(b) When IDLE mode is released by RESET pin input**



**Remarks 1.** <1>: RESET input

<2>: RESET cleared (counting PLL lockup time starts)

<3>: PLL lock status (LOCK bit of LOCKR register = 0)

<4>: BUSCLK = f<sub>CLK</sub>/2 (CKM1 and CKM0 bits of BMC register = 01)

<5>: f<sub>x</sub> = F<sub>x</sub> × 8 (CKSSEL bit of CKS register = 1)

**2.** The above operation is performed if BUSCLK operates with half the period of the internal system clock (f<sub>CLK</sub>).

### 8.6.5 Software STOP mode

#### (1) Setting and operation status

In software STOP mode, the clock generator (oscillator (OSC, SSCG) and PLL synthesizer) is stopped. The overall system is stopped, and ultra-low power consumption is achieved in which only leakage current is lost. The system is switched to software STOP mode by using a store instruction (ST or SST instruction) or bit manipulation instruction (SET1, CLR1, or NOT1 instruction) to set the PSC and PSMR registers (see **8.6.2 Control registers**).

The oscillator's oscillation stabilization time and PLL frequency stabilization time must be secured after software STOP mode is released.

If the software STOP mode is released by an unmasked maskable interrupt request signal<sup>Note</sup>, program execution is started after the PLL lockup time (about 2 ms) has elapsed after the count time of the time base counter (TBC) (time set by the OSTS register) elapses.

Although program execution stops in software STOP mode, the contents of all registers, internal data RAM, internal instruction RAM, and ports are maintained in the state they were in immediately before software STOP mode began. The operation of CPU and other on-chip peripheral functions is stopped.

The following shows the status of each hardware unit in software STOP mode.

**Note** INTP10, INTP11, INTP21 to INTP25, INTP50 to INTP52, INTP65 to INTP67, INTPD0 to INTPD15, INTPL0, INTPL1, INTRSUM

- Cautions**
1. Insert at least 5 NOP instructions after the instruction that stores data in the PSC register to set the software STOP mode.
  2. If the software STOP mode is released by an unmasked maskable interrupt request signal, the external bus continues to operate in the same status as in the software STOP mode during the count time (time set by the OSTS register) of the time base counter (TBC) and the PLL lockup time.
  3. Before setting software STOP mode, set (1) the xxICn interrupt mask flag corresponding to the interrupt that can be used as a release source for software STOP mode but is not used for that purpose. If the timing at which such an interrupt occurs and the shift to software STOP mode conflict, the software STOP mode may be released.

Table 8-8. Operation Status in Software STOP Mode

| Function                                                                                                              | Operation Status                                                                                                                                                                                                  |
|-----------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Clock generator                                                                                                       | Stopped                                                                                                                                                                                                           |
| Main clock (fx)                                                                                                       | Stopped                                                                                                                                                                                                           |
| CPU                                                                                                                   | Stopped                                                                                                                                                                                                           |
| Internal data                                                                                                         | All internal data such as CPU registers, statuses, data, and the contents of internal data RAM and internal instruction RAM are maintained in the state they were in immediately before software STOP mode began. |
| DMAC                                                                                                                  | Stopped                                                                                                                                                                                                           |
| INTC                                                                                                                  | Stopped                                                                                                                                                                                                           |
| TMC0 to TMC5                                                                                                          | Stopped                                                                                                                                                                                                           |
| TMD0 to TMD3                                                                                                          | Stopped                                                                                                                                                                                                           |
| TMENC10, TMENC11                                                                                                      | Stopped                                                                                                                                                                                                           |
| UARTB0, UARTB1                                                                                                        | Stopped                                                                                                                                                                                                           |
| CSI30, CSI31                                                                                                          | Stopped                                                                                                                                                                                                           |
| A/D converter                                                                                                         | Stopped                                                                                                                                                                                                           |
| Ports                                                                                                                 | Maintained the state before software STOP mode set                                                                                                                                                                |
| USB function controller                                                                                               | Stopped                                                                                                                                                                                                           |
| D0 to D31                                                                                                             | High impedance                                                                                                                                                                                                    |
| A0 to A25                                                                                                             |                                                                                                                                                                                                                   |
| $\overline{RD}$ , $\overline{WE}/\overline{WR}$ , $\overline{BCYST}$                                                  | High-level output                                                                                                                                                                                                 |
| $\overline{ULWR}$ , $\overline{UUWR}$ , $\overline{LLWR}$ , $\overline{LUWR}$ , $\overline{IORD}$ , $\overline{IOWR}$ |                                                                                                                                                                                                                   |
| $\overline{LLDQM}$ , $\overline{LUDQM}$ , $\overline{ULDQM}$ , $\overline{UUDQM}$                                     |                                                                                                                                                                                                                   |
| $\overline{LLBE}$ , $\overline{LUBE}$ , $\overline{ULBE}$ , $\overline{UUBE}$                                         |                                                                                                                                                                                                                   |
| $\overline{CS0}$ to $\overline{CS7}$                                                                                  |                                                                                                                                                                                                                   |
| $\overline{SDRAS}$                                                                                                    | Self-refresh status when connected to SDRAM                                                                                                                                                                       |
| $\overline{SDCAS}$                                                                                                    |                                                                                                                                                                                                                   |
| $\overline{REFRQ}$                                                                                                    | Operating (outputs high level when SDRAM controller is not used)                                                                                                                                                  |
| $\overline{HLDK}$                                                                                                     | High-level output                                                                                                                                                                                                 |
| $\overline{HLDRQ}$                                                                                                    | Input (no sampling)                                                                                                                                                                                               |
| $\overline{WAIT}$                                                                                                     |                                                                                                                                                                                                                   |
| $\overline{SELFREF}$                                                                                                  |                                                                                                                                                                                                                   |
| SDCKE                                                                                                                 | Low-level output (outputs high level when SDRAM controller is not used)                                                                                                                                           |
| BUSCLK                                                                                                                | Low-level output                                                                                                                                                                                                  |



**(2) Release of software STOP mode**

The software STOP mode is released by a non-maskable interrupt signal input, an unmasked external maskable interrupt request signal (INTPn)<sup>Note</sup>, an unmasked internal maskable interrupt request signal of a peripheral function that can operate in the software STOP mode (INTRSUM), or  $\overline{\text{RESET}}$  pin input (n = 10, 11, 21 to 25, 50 to 52, 65 to 67, D0 to D15, L0, or L1). When the software STOP mode is released by  $\overline{\text{RESET}}$  pin input, it is necessary to make sure that the oscillation stabilization time of the oscillator elapses. When the software STOP mode is released by the non-maskable interrupt request signal or an unmasked maskable interrupt request signal, program execution starts after about 2 ms after the count time of the time base counter (TBC) elapses.

**Note** When level detection is set, the software STOP mode cannot be released.

**(a) Release according to a non-maskable interrupt request signal or an unmasked maskable interrupt request signal**

The software STOP mode can be released by an interrupt request signal only when it has been set with the INTM and NMIM bits of the PCS register cleared to 0.

Software STOP mode is released by a non-maskable interrupt request signal, an unmasked external maskable interrupt request signal (INTPn), or an unmasked internal maskable interrupt request signal of a peripheral function that can operate in the software STOP mode (INTRSUM) regardless of the priority (n = 10, 11, 21 to 25, 50 to 52, 65 to 67, D0 to D15, L0, or L1). The operation after release is as follows.

**Caution** When the INTM bit of the PSC register = 1, the software STOP mode cannot be released by the unmasked maskable interrupt request signal.

**Table 8-9. Operation After Software STOP Mode Is Released by Interrupt Request Signal**

| Release Source                             | Enable Interrupt (EI) Status                          | Disable Interrupt (DI) Status |
|--------------------------------------------|-------------------------------------------------------|-------------------------------|
| Non-maskable interrupt request signal      | Branch to handler address                             |                               |
| Unmasked maskable interrupt request signal | Branch to handler address or execute next instruction | Execute next instruction      |

The operation is performed as shown below if the software STOP mode is set in an interrupt servicing routine.

**Table 8-10. Operation If Software STOP Mode Is Set in Interrupt Servicing Routine**

| Type of Interrupt Servicing Routine<br>When Software STOP Mode Is Set | Releasing Cause                       |                                 | Operation                                                                                               |
|-----------------------------------------------------------------------|---------------------------------------|---------------------------------|---------------------------------------------------------------------------------------------------------|
|                                                                       | Releasing Source                      | Priority <sup>Note 1</sup>      |                                                                                                         |
| Maskable interrupt                                                    | Maskable interrupt request signal     | Low                             | Only software STOP mode is released and interrupt request signal is not acknowledged (is held pending). |
|                                                                       |                                       | Same                            |                                                                                                         |
|                                                                       |                                       | High (ID = 1) <sup>Note 2</sup> |                                                                                                         |
|                                                                       | Non-maskable interrupt request signal | High (ID = 0) <sup>Note 3</sup> | Interrupt request signal is acknowledged when software STOP mode is released.                           |
| Non-maskable interrupt                                                | Maskable interrupt request signal     | —                               | Only software STOP mode is released and interrupt request signal is not acknowledged (is held pending). |
|                                                                       | Non-maskable interrupt request signal | Low                             |                                                                                                         |
|                                                                       |                                       | Same                            | Interrupt request signal is acknowledged when software STOP mode is released.                           |
|                                                                       |                                       | High                            |                                                                                                         |

- Notes**
1. Priority of interrupt (being serviced) when software STOP mode is set
  2. When the ID bit of the PSW is 1 (disabling acknowledging interrupt)
  3. When the ID bit of the PSW is 0 (enabling acknowledging interrupt)

**Remark** The software STOP mode is released by NMI regardless of the value of the NP bit of the PSW.

If the system is set to software STOP mode during an NMI servicing routine, software STOP mode is released, but the interrupt is not acknowledged (interrupt is held pending).

Interrupt servicing that is started when software STOP mode is released by NMI pin input is handled in the same way as normal NMI interrupt servicing that occurs during an emergency (because the NMI interrupt handler address is unique). Therefore, when a program must be able to distinguish between these two situations, a software status must be prepared in advance and that status must be set before setting the PSMR register using a store instruction or a bit manipulation instruction.

By checking for this status during NMI interrupt servicing, an ordinary NMI can be distinguished from the servicing that is started when software STOP mode is released by NMI pin input.

**(b) Release according to  $\overline{\text{RESET}}$  pin input**

This is the same as a normal reset operation.

The BUSCLK operation when the software STOP mode is released is illustrated below.

Figure 8-5. BUSCLK Operation When Software STOP Mode Is Released (1/2)

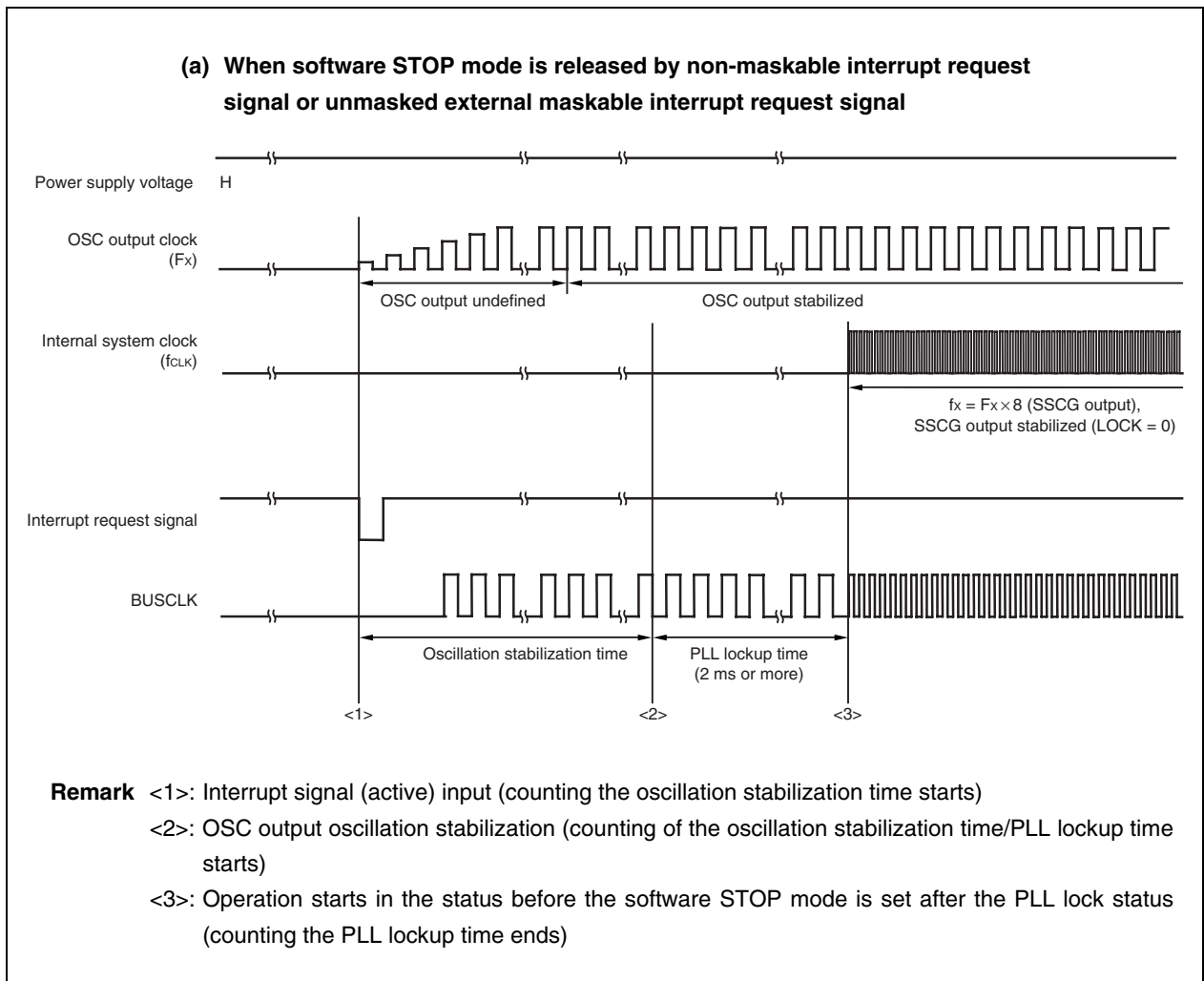
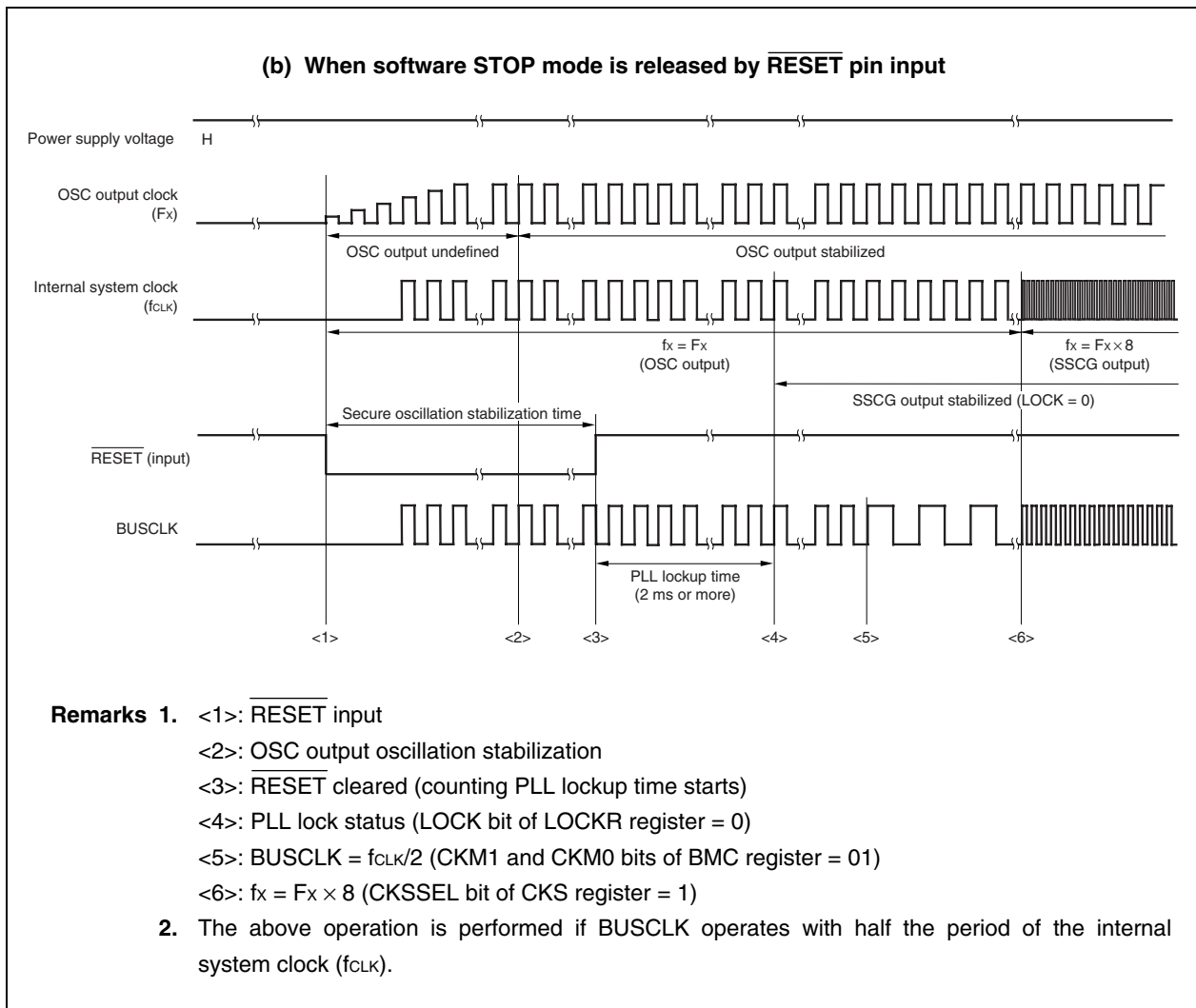


Figure 8-5. BUSCLK Operation When Software STOP Mode Is Released (2/2)



## 8.7 Securing Oscillation Stabilization Time

### 8.7.1 Oscillation stabilization time security specification

When the software STOP mode is released by a non-maskable interrupt request signal, an unmasked external maskable interrupt request signal (INTPn)<sup>Note</sup> (n = 10, 11, 21 to 25, 50 to 52, 65 to 67, D0 to D15, L0, or L1), or an unmasked internal maskable interrupt request signal of a peripheral function that can operate in the software STOP mode (INTRSUM), the oscillation stabilization time set by the OSTS register is secured (see **Figure 8-5 (a)**). About 2 ms after that, program execution is started. When the software STOP mode is released by  $\overline{\text{RESET}}$  pin input, the oscillation stabilization time does not elapse. Therefore, secure the oscillation stabilization time by the low-active width of  $\overline{\text{RESET}}$  (see **Figure 8-5 (b)**).

The internal time base counter (TBC) is used as a timer that counts and secures the oscillation stabilization time.

Oscillation stabilization time = Count time of TBC

**Note** When level detection is set, the software STOP mode cannot be released.

### 8.7.2 Time base counter (TBC)

The time base counter (TBC) is used to secure the oscillator's oscillation stabilization time when software STOP mode is released.

The TBC counts the oscillation stabilization time after software STOP mode is released, and program execution begins after the count is completed.

The TBC count clock is selected according to the OSTS2 to OSTS0 bits of the OSTS register, and the next counting time can be set.

**Table 8-11. Counting Time Examples**

| OSTS2 to OSTS0 Bits |   |   | Oscillation Stabilization Time | Counting Time            |                          |
|---------------------|---|---|--------------------------------|--------------------------|--------------------------|
|                     |   |   |                                | $F_x = 16.6 \text{ MHz}$ | $f_x = 12.5 \text{ MHz}$ |
| 0                   | 0 | 0 | $F_x/2^{13}$                   | 0.49 ms                  | 0.66 ms                  |
| 0                   | 0 | 1 | $F_x/2^{15}$                   | 1.97 ms                  | 2.62 ms                  |
| 0                   | 1 | 0 | $F_x/2^{16}$                   | 3.95 ms                  | 5.24 ms                  |
| 0                   | 1 | 1 | $F_x/2^{17}$                   | 7.90 ms                  | 10.49 ms                 |
| 1                   | 0 | 0 | $F_x/2^{18}$                   | 15.79 ms                 | 20.97 ms                 |
| 1                   | 0 | 1 | $F_x/2^{19}$                   | 31.58 ms                 | 41.94 ms                 |
| 1                   | 1 | 0 | $F_x/2^{20}$                   | 63.17 ms                 | 83.89 ms                 |
| 1                   | 1 | 1 | $F_x/2^{21}$                   | 126.33 ms                | 167.77 ms                |

**Remark**  $F_x$ : OSC output clock

## 8.8 Cautions

Cautions concerning the clock generation function are shown below.

### (1) Caution on setting CKC register

Note that if the internal system clock ( $f_{CLK}$ ) is changed, the frequency of the bus clock (BUSCLK) is also changed.

### (2) Caution on setting CKS register

With the V850E/ME2, it is not assumed that the CPU operates with the OSC output always supplied as the main clock (CKSSEL bit of CKS register = 0). Therefore, be sure to confirm in the initialization sequence that the LOCK bit of the LOCKR register is 0, and then supply the main clock from the SSCG output (CKSSEL bit = 1); otherwise the operation will not be guaranteed.

### (3) Caution on setting SSCGC register

The SSCGC register can be set only when OSC output is supplied as the main clock (CKSSEL bit of CKS register = 0). If the setting of the SSCGC register is changed, the SSCG is unlocked (LOCK bit of LOCKR register = 1). Be sure to confirm that the LOCK bit = 0 before starting to supply SSCG output as the main clock (CKSSEL bit = 1); otherwise the operation will not be guaranteed.

## CHAPTER 9 TIMER/COUNTER FUNCTION

### 9.1 Timer C

#### 9.1.1 Features

Timer C is a 16-bit timer/counter that can perform the following operations.

- Interval timer function
- PWM output
- External signal cycle measurement

#### 9.1.2 Function overview

- 16-bit timer/counter: 6 channels (no capture operation for 2 channels)
- Capture/compare common registers: 12 sources
- Interrupt request sources
  - Capture/match interrupt requests: 12 sources
    - Capture register: Generates INTCCm0 or INTCCm1 at INTPCm0 or INTPCm1 input
    - Compare register: Generates INTCCn0 or INTCCn1 at match signal of CCn0 or CCn1
  - Overflow interrupt requests: 6 sources
- Timer/counter count clock sources: 2 types  
(Selection of external pulse input or main clock division)
- Either free-running mode or overflow stop mode can be selected as the operation mode when the timer/counter overflows
- Timer/counter can be cleared by a match of the timer/counter and a compare register
- External pulse outputs: 6

**Remark** m = 0 to 3, n = 0 to 5

## 9.1.3 Basic configuration

Table 9-1. Timer C Configuration

| Timer   | Count Clock                                                          | Register | Read/Write | Generated Interrupt Signal | Capture Trigger | Timer Output S/R | Other Functions              |
|---------|----------------------------------------------------------------------|----------|------------|----------------------------|-----------------|------------------|------------------------------|
| Timer C | fx/8, fx/16,<br>fx/32, fx/64,<br>fx/128, fx/256,<br>fx/512, fx/1,024 | TMC0     | Read       | INTOVC0                    | –               | –                |                              |
|         |                                                                      | CCC00    | Read/write | INTCCC00                   | INTPC00         | TOC0 (S)         |                              |
|         |                                                                      | CCC01    | Read/write | INTCCC01                   | INTPC01         | TOC0 (R)         |                              |
|         |                                                                      | TMC1     | Read       | INTOVC1                    | –               | –                |                              |
|         |                                                                      | CCC10    | Read/write | INTCCC10                   | INTPC10         | TOC1 (S)         |                              |
|         |                                                                      | CCC11    | Read/write | INTCCC11                   | INTPC11         | TOC1 (R)         |                              |
|         |                                                                      | TMC2     | Read       | INTOVC2                    | –               | –                |                              |
|         |                                                                      | CCC20    | Read/write | INTCCC20                   | INTPC20         | TOC2 (S)         |                              |
|         |                                                                      | CCC21    | Read/write | INTCCC21                   | INTPC21         | TOC2 (R)         |                              |
|         |                                                                      | TMC3     | Read       | INTOVC3                    | –               | –                |                              |
|         |                                                                      | CCC30    | Read/write | INTCCC30                   | INTPC30         | TOC3 (S)         |                              |
|         |                                                                      | CCC31    | Read/write | INTCCC31                   | INTPC31         | TOC3 (R)         |                              |
|         |                                                                      | TMC4     | Read       | INTOVC4                    | –               | –                |                              |
|         |                                                                      | CCC40    | Read/write | INTCCC40                   | –               | TOC4 (S)         | A/D conversion start trigger |
|         |                                                                      | CCC41    | Read/write | INTCCC41                   | –               | TOC4 (R)         | A/D conversion start trigger |
|         |                                                                      | TMC5     | Read       | INTOVC5                    | –               | –                |                              |
|         |                                                                      | CCC50    | Read/write | INTCCC50                   | –               | TOC5 (S)         | A/D conversion start trigger |
|         |                                                                      | CCC51    | Read/write | INTCCC51                   | –               | TOC5 (R)         | A/D conversion start trigger |

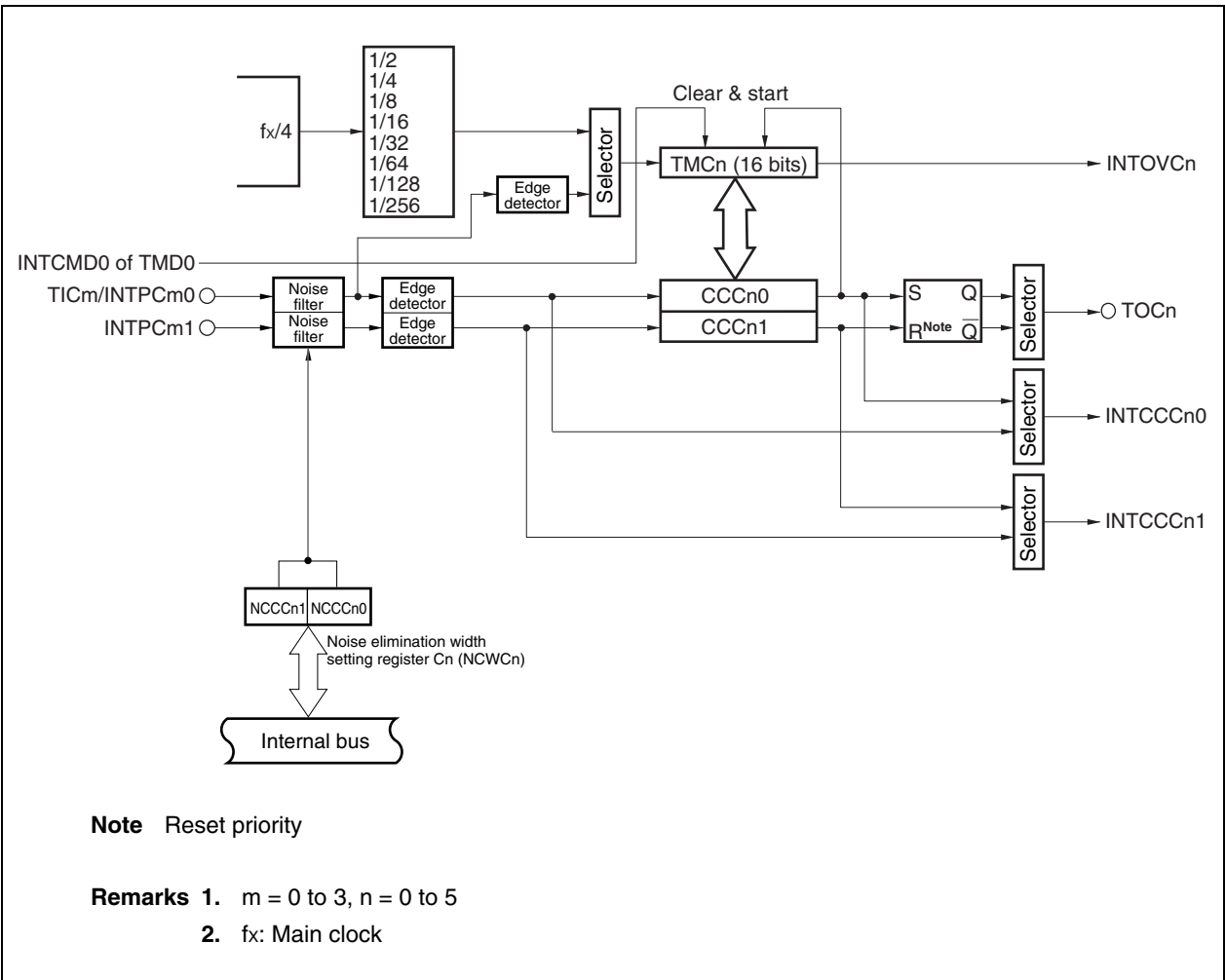
**Remark** fx: Main clock

S/R: Set/reset



**(1) Timer C (16-bit timer/counter)**

**Figure 9-1. Timer C Block Diagram**



## 9.1.4 Timer C

## (1) Timers C0 to C5 (TMC0 to TMC5)

TMCn functions as a 16-bit free-running timer or as an event counter for an external signal. Besides being mainly used for cycle measurement, TMCn can be used as pulse output ( $n = 0$  to  $5$ ).

TMCn is read-only, in 16-bit units.

- Cautions**
1. The TMCn register can only be read. If the TMCn register is written, the subsequent operation is undefined.
  2. If the CAECn bit of the TMCCn0 register is cleared to 0, a reset is performed asynchronously.

|      | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | Address    | After reset |
|------|----|----|----|----|----|----|---|---|---|---|---|---|---|---|---|---|------------|-------------|
| TMC0 |    |    |    |    |    |    |   |   |   |   |   |   |   |   |   |   | FFFFFF600H | 0000H       |
| TMC1 |    |    |    |    |    |    |   |   |   |   |   |   |   |   |   |   | FFFFFF620H | 0000H       |
| TMC2 |    |    |    |    |    |    |   |   |   |   |   |   |   |   |   |   | FFFFFF640H | 0000H       |
| TMC3 |    |    |    |    |    |    |   |   |   |   |   |   |   |   |   |   | FFFFFF660H | 0000H       |
| TMC4 |    |    |    |    |    |    |   |   |   |   |   |   |   |   |   |   | FFFFFF680H | 0000H       |
| TMC5 |    |    |    |    |    |    |   |   |   |   |   |   |   |   |   |   | FFFFFF6A0H | 0000H       |

TMCn performs the count-up operations of an internal count clock or external count clock. Timer start and stop are controlled by the CECn bit of timer mode control register Cn0 (TMCCn0) ( $n = 0$  to  $5$ ).

The internal or external count clock is selected by the ETICn bit of timer mode control register Cn1 (TMCCn1) ( $n = 0$  to  $5$ ).

**(a) Selection of the external count clock**

TMCn operates as an event counter.

When the ETICn bit of timer mode control register Cn1 (TMCCn1) is set to 1, TMCm counts the valid edges of the external clock input (TICm), synchronized with the internal count clock. The valid edge is specified by valid edge select register Cm (SESCm) (m = 0 to 3, n = 0 to 5).

**Caution** When the INTPCm0/TICm pin is used as TICm (external clock input pin), disable the INTPCm0 interrupt or set CCCm0 to compare mode (m = 0 to 3, n = 0 to 5).

**(b) Selection of the internal count clock**

TMCn operates as a free-running timer.

When an internal clock is specified as the count clock by timer mode control register Cn1 (TMCCn1), TMCn is counted up for each input clock cycle specified by the CSCn0 to CSCn2 bits of the TMCCn0 register (n = 0 to 5).

Division by the prescaler can be selected for the count clock from among fx/8, fx/16, fx/32, fx/64, fx/128, fx/256, fx/512, and fx/1,024 by the TMCCn0 register (fx: main clock).

An overflow interrupt can be generated if the timer overflows. Also, the timer can be stopped following an overflow by setting the OSTCn bit of the TMCCn1 register to 1.

**Caution** The count clock cannot be changed while the timer is operating.

The conditions when the TMCn register becomes 0000H are shown below.

**(a) Asynchronous reset**

- CAECn bit of TMCCn0 register = 0
- Reset input

**(b) Synchronous reset**

- CECn bit of TMCCn0 register = 0
- The CCCn0 register is used as a compare register, and the TMCn and CCCn0 registers match when clearing the TMCn register is enabled (CCLRCn bit of the TMCCn1 register = 1)

**(2) Capture/compare registers Cn0 and Cn1 (CCCN0 and CCCn1) (n = 0 to 5)**

These capture/compare registers (Cn0 and Cn1) are 16-bit registers.

They can be used as capture registers or compare registers according to the CMSCn0 and CMSCn1 bit specifications of timer mode control register Cn1 (TMCCn1) (n = 0 to 5).

These registers can be read or written in 16-bit units. (However, write operations can only be performed in compare mode.)

**Caution** The CCC40, CCC41, CCC50, and CCC51 registers can only be used as compare registers. They cannot be used as capture registers.

|       | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | Address                 | After reset |
|-------|----|----|----|----|----|----|---|---|---|---|---|---|---|---|---|---|-------------------------|-------------|
| CCC0n |    |    |    |    |    |    |   |   |   |   |   |   |   |   |   |   | FFFFF602H,<br>FFFFF604H | 0000H       |
| CCC1n |    |    |    |    |    |    |   |   |   |   |   |   |   |   |   |   | FFFFF622H,<br>FFFFF624H | 0000H       |
| CCC2n |    |    |    |    |    |    |   |   |   |   |   |   |   |   |   |   | FFFFF642H,<br>FFFFF644H | 0000H       |
| CCC3n |    |    |    |    |    |    |   |   |   |   |   |   |   |   |   |   | FFFFF662H,<br>FFFFF664H | 0000H       |
| CCC4n |    |    |    |    |    |    |   |   |   |   |   |   |   |   |   |   | FFFFF682H,<br>FFFFF684H | 0000H       |
| CCC5n |    |    |    |    |    |    |   |   |   |   |   |   |   |   |   |   | FFFFF6A2H,<br>FFFFF6A4H | 0000H       |

**Remark** n = 0, 1

**(a) Setting these registers as capture registers (CMSCn0 and CMSCn1 bits of TMCCn1 register = 0)**

When these registers are set as capture registers, the valid edges of the corresponding external interrupt signals INTPCm0 and INTPCm1 are detected as capture triggers. The timer TMCm is synchronized with the capture trigger, and the value of TMCm is latched in the CCCm0 and CCCm1 registers (capture operation) ( $m = 0$  to 3,  $n = 0$  to 5).

The valid edge of the INTPCm0 pin is specified (rising edge, falling edge, or both rising and falling edges) according to the IESC0m1 and IESC0m0 bits of the SESCm register, and the valid edge of the INTPCm1 pin is specified according to the IESC1m1 and IESC1m0 bits of the SESCm register.

The capture operation is performed asynchronously to the count clock. The latched value is held in the capture register until another capture operation is performed.

When the CAECn bit of timer mode control register Cn0 (TMCCn0) is 0, 0000H is read.

If these registers are specified as capture registers, an interrupt is generated by detecting the valid edge of signals INTPCm0 and INTPCm1.

**Caution** If the capture operation contends with the timing of disabling the TMCm register from counting (when the CECn bit of the TMCCn0 register = 0), the captured data becomes undefined. In addition, the INTCCm0 and INTCCm1 interrupts do not occur ( $m = 0$  to 3,  $n = 0$  to 5).

**(b) Setting these registers as compare registers (CMSCn0 and CMSCn1 bits of TMCCn1 register = 1)**

When these registers are set as compare registers, the TMCn and register values are compared for each count clock, and an interrupt is generated by a match. If the CCLRCn bit of timer mode control register Cn1 (TMCCn1) is set to 1, the TMCn value is cleared to 0 at the same time as a match with the CCCn0 register (it is not cleared to 0 by a match with the CCCn1 register) ( $n = 0$  to 5).

A compare register is equipped with a set/reset function. The corresponding timer output (TOCn) is set or reset, in synchronization with the generation of a match signal.

The interrupt selection source differs according to the function of the selected register.

- Cautions**
1. To write to capture/compare registers Cn0 and Cn1, always set the CAECn bit to 1 first. If the CAECn bit is 0, the data that is written will be invalid.
  2. Write to capture/compare registers Cn0 and Cn1 after setting them as compare registers via TMCCn0 and TMCCn1 register settings. If they are set as capture registers (CMSCn0 and CMSCn1 bits of TMCCn1 register = 0), no data is written even if a write operation is performed to CCCm0 and CCCm1 ( $m = 0$  to 3,  $n = 0$  to 5).
  3. When these registers are set as compare registers, INTPCn0 and INTPCn1 cannot be used ( $n = 0$  to 5).

When using these registers as an external interrupt input pin, use the  $\overline{\text{INTP65}}$  and  $\overline{\text{INTP66}}$  pins.

## 9.1.5 Control registers

## (1) Timer mode control registers C00 to C50 (TMCC00 to TMCC50)

The TMCCn0 registers control the operation of TMCn (n = 0 to 5).

These registers can be read or written in 8-bit or 1-bit units.

Be sure to clear bits 3 and 2 to 0. If they are set to 1, the operation is not guaranteed.

**Cautions 1. The CAECn and other bits cannot be set at the same time. The other bits and the registers of the other TMCn unit should always be set after the CAECn bit has been set. Also, to use external pins related to the timer function when timer C is used, be sure to set the CAECn bit to 1 after setting the external pins to control mode.**

**2. When conflict occurs between an overflow and a TMCCn0 register write, the OVFCn bit value becomes the value written during the TMCCn0 register write (n = 0 to 5).**

(1/2)

|        | <7>   | 6     | 5     | 4     | 3 | 2 | <1>  | <0>   | Address    | After reset |
|--------|-------|-------|-------|-------|---|---|------|-------|------------|-------------|
| TMCC00 | OVFC0 | CSC02 | CSC01 | CSC00 | 0 | 0 | CEC0 | CAEC0 | FFFFFF606H | 00H         |
| TMCC10 | OVFC1 | CSC12 | CSC11 | CSC10 | 0 | 0 | CEC1 | CAEC1 | FFFFFF626H | 00H         |
| TMCC20 | OVFC2 | CSC22 | CSC21 | CSC20 | 0 | 0 | CEC2 | CAEC2 | FFFFFF646H | 00H         |
| TMCC30 | OVFC3 | CSC32 | CSC31 | CSC30 | 0 | 0 | CEC3 | CAEC3 | FFFFFF666H | 00H         |
| TMCC40 | OVFC4 | CSC42 | CSC41 | CSC40 | 0 | 0 | CEC4 | CAEC4 | FFFFFF686H | 00H         |
| TMCC50 | OVFC5 | CSC52 | CSC51 | CSC50 | 0 | 0 | CEC5 | CAEC5 | FFFFFF6A6H | 00H         |

| Bit position | Bit name | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|--------------|----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 7            | OVFCn    | <p>This is a flag that indicates TMCn overflow.</p> <p>0: No overflow occurs<br/>1: Overflow occurs</p> <p>When TMCn has counted up from FFFFH to 0000H, the OVFCn bit becomes 1 and an overflow interrupt request (INTOVFn) is generated at the same time. However, if TMCn is cleared to 0000H after a match at FFFFH when the CCCn0 register is set to compare mode (CMSCn0 bit of TMCCn1 register = 1) and clearing is enabled for a match when TMCn and CCCn0 are compared (CCLRCn bit of TMCCn1 register = 1), then TMCn is considered to be cleared and the OVFCn bit does not become 1. Also, no INTOVFn interrupt is generated.</p> <p>The OVFCn bit retains the value 1 until 0 is written directly or until an asynchronous reset is performed because the CAECn bit is 0. An interrupt operation due to an overflow is independent of the OVFCn bit, and the interrupt request flag (OVCIFn) for INTOVFn is not affected even if the OVFCn bit is manipulated. If an overflow occurs while the OVFCn bit is being read, the flag value changes, and the change is reflected when the next read operation occurs.</p> |

**Remark** n = 0 to 5

| Bit position                                                                                                                                                                                                                                              | Bit name       | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |          |       |             |             |   |   |   |      |   |   |   |       |   |   |   |       |   |   |   |       |   |   |   |        |   |   |   |        |   |   |   |        |   |   |   |          |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|-------|-------------|-------------|---|---|---|------|---|---|---|-------|---|---|---|-------|---|---|---|-------|---|---|---|--------|---|---|---|--------|---|---|---|--------|---|---|---|----------|
| 6 to 4                                                                                                                                                                                                                                                    | CSCn2 to CSCn0 | Selects the TMCn internal count clock.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |          |       |             |             |   |   |   |      |   |   |   |       |   |   |   |       |   |   |   |       |   |   |   |        |   |   |   |        |   |   |   |        |   |   |   |          |
|                                                                                                                                                                                                                                                           |                | <table><tr><th>CSCn2</th><th>CSCn1</th><th>CSCn0</th><th>Count cycle</th></tr><tr><td>0</td><td>0</td><td>0</td><td>fx/8</td></tr><tr><td>0</td><td>0</td><td>1</td><td>fx/16</td></tr><tr><td>0</td><td>1</td><td>0</td><td>fx/32</td></tr><tr><td>0</td><td>1</td><td>1</td><td>fx/64</td></tr><tr><td>1</td><td>0</td><td>0</td><td>fx/128</td></tr><tr><td>1</td><td>0</td><td>1</td><td>fx/256</td></tr><tr><td>1</td><td>1</td><td>0</td><td>fx/512</td></tr><tr><td>1</td><td>1</td><td>1</td><td>fx/1,024</td></tr></table>                                                       | CSCn2    | CSCn1 | CSCn0       | Count cycle | 0 | 0 | 0 | fx/8 | 0 | 0 | 1 | fx/16 | 0 | 1 | 0 | fx/32 | 0 | 1 | 1 | fx/64 | 1 | 0 | 0 | fx/128 | 1 | 0 | 1 | fx/256 | 1 | 1 | 0 | fx/512 | 1 | 1 | 1 | fx/1,024 |
|                                                                                                                                                                                                                                                           |                | CSCn2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | CSCn1    | CSCn0 | Count cycle |             |   |   |   |      |   |   |   |       |   |   |   |       |   |   |   |       |   |   |   |        |   |   |   |        |   |   |   |        |   |   |   |          |
|                                                                                                                                                                                                                                                           |                | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 0        | 0     | fx/8        |             |   |   |   |      |   |   |   |       |   |   |   |       |   |   |   |       |   |   |   |        |   |   |   |        |   |   |   |        |   |   |   |          |
|                                                                                                                                                                                                                                                           |                | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 0        | 1     | fx/16       |             |   |   |   |      |   |   |   |       |   |   |   |       |   |   |   |       |   |   |   |        |   |   |   |        |   |   |   |        |   |   |   |          |
|                                                                                                                                                                                                                                                           |                | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 1        | 0     | fx/32       |             |   |   |   |      |   |   |   |       |   |   |   |       |   |   |   |       |   |   |   |        |   |   |   |        |   |   |   |        |   |   |   |          |
|                                                                                                                                                                                                                                                           |                | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 1        | 1     | fx/64       |             |   |   |   |      |   |   |   |       |   |   |   |       |   |   |   |       |   |   |   |        |   |   |   |        |   |   |   |        |   |   |   |          |
|                                                                                                                                                                                                                                                           |                | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 0        | 0     | fx/128      |             |   |   |   |      |   |   |   |       |   |   |   |       |   |   |   |       |   |   |   |        |   |   |   |        |   |   |   |        |   |   |   |          |
|                                                                                                                                                                                                                                                           |                | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 0        | 1     | fx/256      |             |   |   |   |      |   |   |   |       |   |   |   |       |   |   |   |       |   |   |   |        |   |   |   |        |   |   |   |        |   |   |   |          |
|                                                                                                                                                                                                                                                           |                | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 1        | 0     | fx/512      |             |   |   |   |      |   |   |   |       |   |   |   |       |   |   |   |       |   |   |   |        |   |   |   |        |   |   |   |        |   |   |   |          |
| 1                                                                                                                                                                                                                                                         | 1              | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | fx/1,024 |       |             |             |   |   |   |      |   |   |   |       |   |   |   |       |   |   |   |       |   |   |   |        |   |   |   |        |   |   |   |        |   |   |   |          |
| <b>Caution</b> The CSCn2 to CSCn0 bits must not be changed during timer operation. If they are to be changed, they must be changed after setting the CECn bit to 0. If these bits are overwritten during timer operation, operation cannot be guaranteed. |                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |          |       |             |             |   |   |   |      |   |   |   |       |   |   |   |       |   |   |   |       |   |   |   |        |   |   |   |        |   |   |   |        |   |   |   |          |
| <b>Remark</b> fx: Main clock                                                                                                                                                                                                                              |                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |          |       |             |             |   |   |   |      |   |   |   |       |   |   |   |       |   |   |   |       |   |   |   |        |   |   |   |        |   |   |   |        |   |   |   |          |
| 1                                                                                                                                                                                                                                                         | CECn           | Controls the operation of TMCn.<br>0: Count disabled (stops at 0000H and does not operate)<br>1: Counting operation is performed<br><br><b>Caution</b> When CECn = 0, the external pulse output (TOCn) becomes inactive (the active level of TOCn output is set by the ALVCn bit of the TMCCn1 register).                                                                                                                                                                                                                                                                                 |          |       |             |             |   |   |   |      |   |   |   |       |   |   |   |       |   |   |   |       |   |   |   |        |   |   |   |        |   |   |   |        |   |   |   |          |
| 0                                                                                                                                                                                                                                                         | CAECn          | Controls the internal count clock.<br>0: The entire TMCn unit is asynchronously reset. The supply of clocks to the TMCn unit stops.<br>1: Clocks are supplied to the TMCn unit<br><br><b>Cautions</b><br>1. When the CAECn bit is cleared to 0, the TMCn unit can be asynchronously reset.<br>2. When CAECn = 0, the TMCn unit is in a reset state. Therefore, to operate TMCn, the CAECn bit must be set to 1.<br>3. When the CAECn bit is changed from 1 to 0, all registers of the TMCn unit are initialized. When CAECn is set to 1 again, the TMCn unit registers must be set again. |          |       |             |             |   |   |   |      |   |   |   |       |   |   |   |       |   |   |   |       |   |   |   |        |   |   |   |        |   |   |   |        |   |   |   |          |

**Remark** n = 0 to 5

**(2) Timer mode control registers C01 to C51 (TMCC01 to TMCC51)**

The TMCCn1 registers control the operation of TMCn (n = 0 to 5).

These registers can be read or written in 8-bit units.

- Cautions**
1. The various bits of the TMCCn1 register must not be changed during timer operation. If they are to be changed, they must be changed after setting the CECn bit of the TMCCn0 register to 0. If these bits are overwritten during timer operation, operation cannot be guaranteed (n = 0 to 5).
  2. If the ENTOCn and ALVCn bits are changed at the same time, a glitch (spike shaped noise) may be generated in the TOCn pin output. Either create a circuit configuration that will not malfunction even if a glitch is generated or make sure that the ENTOCn and ALVCn bits do not change at the same time (n = 0 to 5).
  3. TOCn output is not changed by an external interrupt signal (INTPCm0 or INTPCm1). To use the TOCn signal, specify that the capture/compare registers are compare registers (CMSCn0 and CMSCn1 bits of TMCCn1 register = 1) (m = 0 to 3, n = 0 to 5).
  4. The TMCC41 and TMCC51 registers can be used only when the CCC40, CCC41, CCC50, and CCC51 registers are used as compare registers. They cannot be used when the CCC40, CCC41, CCC50, and CCC51 registers are used as capture registers.
  5. To clear the external interrupt signal by setting the ECLRCn bit, be sure to make the following setting.

Count clock period of TMD0 > Count clock period of TMCn

If this setting is not made, the falling edge of the INTCMD0 interrupt signal may not be detected.

Correct example (if count clock of TMD0 is slow)

CSD02 to CSD00 bits of TMCD0 register = 011: fx/64

CSCn2 to CSCn0 bits of TMCC0 register = 001: fx/16

**Remark** Resetting the flip-flop of the TOCn output takes precedence (n = 0 to 5).



|        | 7     | 6      | 5     | 4     | 3      | 2      | 1      | 0      | Address    | After reset |
|--------|-------|--------|-------|-------|--------|--------|--------|--------|------------|-------------|
| TMCC01 | OSTC0 | ENTOC0 | ALVC0 | ETIC0 | CCLRC0 | ECLRC0 | CMSC01 | CMSC00 | FFFFFF608H | 20H         |
| TMCC11 | OSTC1 | ENTOC1 | ALVC1 | ETIC1 | CCLRC1 | ECLRC1 | CMSC11 | CMSC10 | FFFFFF628H | 20H         |
| TMCC21 | OSTC2 | ENTOC2 | ALVC2 | ETIC2 | CCLRC2 | ECLRC2 | CMSC21 | CMSC20 | FFFFFF648H | 20H         |
| TMCC31 | OSTC3 | ENTOC3 | ALVC3 | ETIC3 | CCLRC3 | ECLRC3 | CMSC31 | CMSC30 | FFFFFF668H | 20H         |
| TMCC41 | OSTC4 | ENTOC4 | ALVC4 | ETIC4 | CCLRC4 | ECLRC4 | CMSC41 | CMSC40 | FFFFFF688H | 20H         |
| TMCC51 | OSTC5 | ENTOC5 | ALVC5 | ETIC5 | CCLRC5 | ECLRC5 | CMSC51 | CMSC50 | FFFFFF6A8H | 20H         |

| Bit position | Bit name | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|--------------|----------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 7            | OSTCn    | <p>Sets the operation when TMCn has overflowed.</p> <p>0: After the overflow, counting continues (free-running mode)</p> <p>1: After the overflow, the timer maintains the value 0000H, and counting stops (overflow stop mode). Counting is resumed by the following operation.</p> <p>When ECLRCn bit = 0: Writing 1 to CECn bit</p> <p>When ECLRCn bit = 1: Inputting valid edge to INTCMD0</p>                                                                                                                                                                                                                                                                                                        |
| 6            | ENTOCn   | <p>External pulse output is enabled/disabled (TOCn).</p> <p>0: External pulse output is disabled. Output of the ALVCn bit inactive level to the TOCn pin is fixed. The TOCn pin level is not changed even if a match signal from the corresponding compare register is generated.</p> <p>1: External pulse output is enabled. A compare register match causes TOCn output to change. However, if capture mode is set, TOCn output does not change. The ALVCn bit inactive level is output from the time when timer output is enabled until a match signal is first generated.</p> <p><b>Caution</b> If either CCCn0 or CCCn1 is specified as a capture register, the ENTOCn bit must be cleared to 0.</p> |
| 5            | ALVCn    | <p>Specifies the active level for external pulse output (TOCn).</p> <p>0: Active level is low level</p> <p>1: Active level is high level</p> <p><b>Caution</b> The initial value of the ALVCn bit is 1.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| 4            | ETICn    | <p>Specifies a switch between the external and internal count clock.</p> <p>0: Specifies the input clock (internal). The count clock can be selected according to the CSCn2 to CSCn0 bits of TMCCn0.</p> <p>1: Specifies the external clock (TICm). The valid edge can be selected according to the TESCm1 and TESCm0 bit specifications of SESCm.</p>                                                                                                                                                                                                                                                                                                                                                    |

**Remark** m = 0 to 3  
n = 0 to 5

| Bit position | Bit name | Function                                                                                                                                                                                                                                                                                                                                                                           |
|--------------|----------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 3            | CCLRCn   | Sets whether the clearing of TMCn is enabled or disabled during a compare operation.<br>0: Clearing is disabled<br>1: Clearing is enabled (if CCCn0 and TMCn match during a compare operation, TMCn is cleared)                                                                                                                                                                    |
| 2            | ECLRCn   | Enables/disables clearing TMCn by INTCMD0 (TMD0).<br>0: Disables clearing by INTCMD0.<br>1: Enables clearing by INTCMD0. After TMCn has been cleared, it resumes counting.<br><br><b>Caution</b> When the ECLRCn bit = 1, unless a compare match interrupt (INTCMD0) is generated by TMD0, timer counting does not start (even if the CECn bit of the TMCCn0 register is set (1)). |
| 1            | CMSCn1   | Selects the operation mode of the capture/compare register (CCcn1).<br>0: The register operates as a capture register (CCcn1)<br>1: The register operates as a compare register (CCcn1)                                                                                                                                                                                            |
| 0            | CMSCn0   | Selects the operation mode of the capture/compare register (CCcn0).<br>0: The register operates as a capture register (CCcn0)<br>1: The register operates as a compare register (CCcn0)                                                                                                                                                                                            |

**Remark** m = 0 to 3  
n = 0 to 5

**(3) Valid edge select registers C0 to C3 (SESC0 to SESC3)**

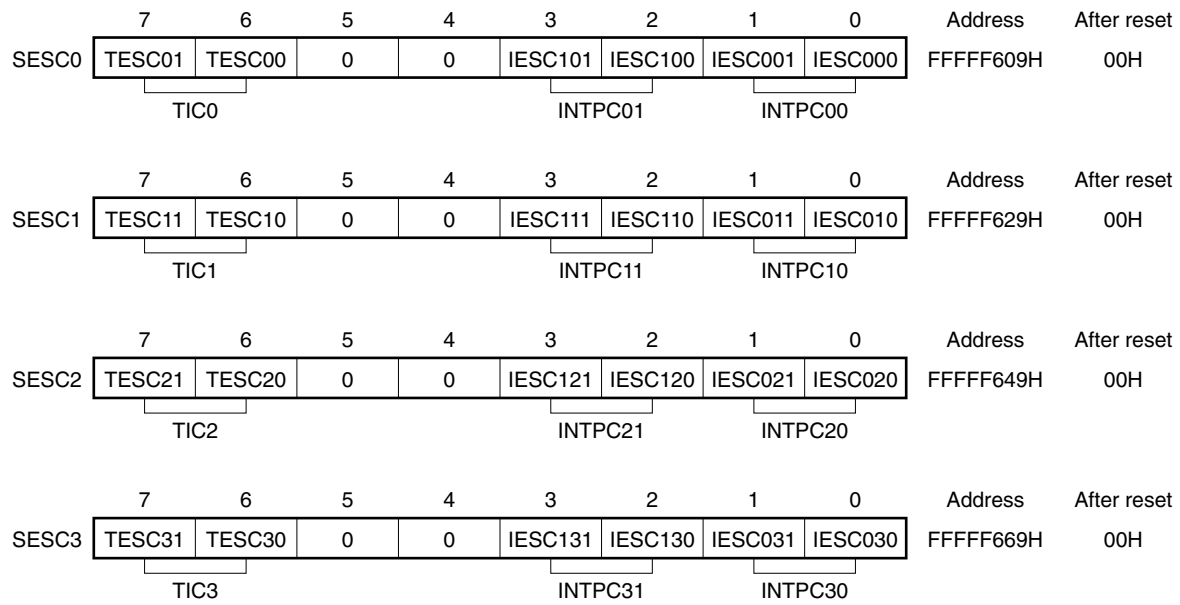
These registers specify the valid edge of an external interrupt request (INTPC00, INTPC01, INTPC10, INTPC11, INTPC20, INTPC21, INTPC30, INTPC31, and TIC0 to TIC3) from an external pin of TMCn (n = 0 to 3).

The rising edge, the falling edge, or both rising and falling edges can be specified as the valid edge independently for each pin.

Each of these registers can be read or written in 8-bit units.

Be sure to clear bits 5 and 4 to 0. If they are set to 1, the operation is not guaranteed.

- Cautions**
1. The various bits of the SESCn register must not be changed during timer operation (n = 0 to 3). If they are to be changed, they must be changed after setting the CECn bit of the TMCCn0 register to 0. If the SESCn register is overwritten during timer operation, operation cannot be guaranteed.
  2. Even when using the INTPC00/TIC0, INTPC10/TIC1, INTPC20/TIC2, and INTPC30/TIC3 pins as INTPC00, INTPC10, INTPC20, and INTPC30, respectively, without using timer C, be sure to set the CAECn and CECn bits of timer mode control registers C00 to C03 (TMCC00 to TMCC30) to 1.
  3. Set the PMCx register before setting the trigger mode of the INTPC00, INTPC01, INTPC10, INTPC11, INTPC20, INTPC21, INTPC30, INTPC31, and TIC0 to TIC3 pins (x = 5 to 7). Then set the CAECn and CECn bits of the TMCCn0 register to 1 (n = 0 to 3).  
If the PMCx register is set after the SESCn register has been set, an illegal interrupt, incorrect counting, and incorrect clearing may occur depending on the timing of setting the PMCx register (n = 0 to 3, x = 5 to 7).



| Bit position | Bit name                            | Function                                                                                                                                                                                                                                                                                                                                                                             |        |        |           |   |   |              |   |   |             |   |   |                    |   |   |                               |
|--------------|-------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|--------|-----------|---|---|--------------|---|---|-------------|---|---|--------------------|---|---|-------------------------------|
| 7, 6         | TESCn1,<br>TESCn0<br>(n = 0 to 3)   | Specifies the valid edge of the INTPCm0, INTPCm1, and TICm pins (m = 0 to 3). <table><tr><th>xESCn1</th><th>xESCn0</th><th>Operation</th></tr><tr><td>0</td><td>0</td><td>Falling edge</td></tr><tr><td>0</td><td>1</td><td>Rising edge</td></tr><tr><td>1</td><td>0</td><td>Setting prohibited</td></tr><tr><td>1</td><td>1</td><td>Both rising and falling edges</td></tr></table> | xESCn1 | xESCn0 | Operation | 0 | 0 | Falling edge | 0 | 1 | Rising edge | 1 | 0 | Setting prohibited | 1 | 1 | Both rising and falling edges |
| xESCn1       | xESCn0                              | Operation                                                                                                                                                                                                                                                                                                                                                                            |        |        |           |   |   |              |   |   |             |   |   |                    |   |   |                               |
| 0            | 0                                   | Falling edge                                                                                                                                                                                                                                                                                                                                                                         |        |        |           |   |   |              |   |   |             |   |   |                    |   |   |                               |
| 0            | 1                                   | Rising edge                                                                                                                                                                                                                                                                                                                                                                          |        |        |           |   |   |              |   |   |             |   |   |                    |   |   |                               |
| 1            | 0                                   | Setting prohibited                                                                                                                                                                                                                                                                                                                                                                   |        |        |           |   |   |              |   |   |             |   |   |                    |   |   |                               |
| 1            | 1                                   | Both rising and falling edges                                                                                                                                                                                                                                                                                                                                                        |        |        |           |   |   |              |   |   |             |   |   |                    |   |   |                               |
| 3, 2         | IESCn1,<br>IESCn0<br>(n = 10 to 13) |                                                                                                                                                                                                                                                                                                                                                                                      |        |        |           |   |   |              |   |   |             |   |   |                    |   |   |                               |
| 1, 0         | IESCn1,<br>IESCn0<br>(n = 00 to 03) |                                                                                                                                                                                                                                                                                                                                                                                      |        |        |           |   |   |              |   |   |             |   |   |                    |   |   |                               |

**(4) Noise elimination width setting registers C0 to C3 (NCWC0 to NCWC3)**

The NCWCn registers are used to set the noise elimination width of the digital noise filter of the timer C input pin (n = 0 to 3).

These registers can be read or written in 8-bit units.

Be sure to clear bits 7 to 2 to 0. If they are set to 1, the operation is not guaranteed.

In addition, do not overwrite this register during timer operation.

|       | 7 | 6 | 5 | 4 | 3 | 2 | 1      | 0      | Address   | After reset |
|-------|---|---|---|---|---|---|--------|--------|-----------|-------------|
| NCWC0 | 0 | 0 | 0 | 0 | 0 | 0 | NCCC01 | NCCC00 | FFFFF610H | 02H         |
| NCWC1 | 0 | 0 | 0 | 0 | 0 | 0 | NCCC11 | NCCC10 | FFFFF630H | 02H         |
| NCWC2 | 0 | 0 | 0 | 0 | 0 | 0 | NCCC21 | NCCC20 | FFFFF650H | 02H         |
| NCWC3 | 0 | 0 | 0 | 0 | 0 | 0 | NCCC31 | NCCC30 | FFFFF670H | 02H         |

| Bit position | Bit name          | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                |        |        |                                                     |   |   |                   |   |   |   |   |   |   |   |   |   |
|--------------|-------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|--------|-----------------------------------------------------|---|---|-------------------|---|---|---|---|---|---|---|---|---|
| 1, 0         | NCCCN1,<br>NCCCN0 | <p>Specifies the number of clocks by which noise is to be eliminated.</p> <table> <tr> <th>NCCCN1</th><th>NCCCN0</th><th>Number of clocks by which noise is to be eliminated</th></tr> <tr> <td>0</td><td>0</td><td>0 (through input)</td></tr> <tr> <td>0</td><td>1</td><td>2</td></tr> <tr> <td>1</td><td>0</td><td>3</td></tr> <tr> <td>1</td><td>1</td><td>5</td></tr> </table> <p><b>Remark</b> 1 clock = <math>f_x/4</math><br/> <math>f_x</math>: Main clock</p> | NCCCN1 | NCCCN0 | Number of clocks by which noise is to be eliminated | 0 | 0 | 0 (through input) | 0 | 1 | 2 | 1 | 0 | 3 | 1 | 1 | 5 |
| NCCCN1       | NCCCN0            | Number of clocks by which noise is to be eliminated                                                                                                                                                                                                                                                                                                                                                                                                                     |        |        |                                                     |   |   |                   |   |   |   |   |   |   |   |   |   |
| 0            | 0                 | 0 (through input)                                                                                                                                                                                                                                                                                                                                                                                                                                                       |        |        |                                                     |   |   |                   |   |   |   |   |   |   |   |   |   |
| 0            | 1                 | 2                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |        |        |                                                     |   |   |                   |   |   |   |   |   |   |   |   |   |
| 1            | 0                 | 3                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |        |        |                                                     |   |   |                   |   |   |   |   |   |   |   |   |   |
| 1            | 1                 | 5                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |        |        |                                                     |   |   |                   |   |   |   |   |   |   |   |   |   |

**Remark** n = 0 to 3

## 9.1.6 Operation

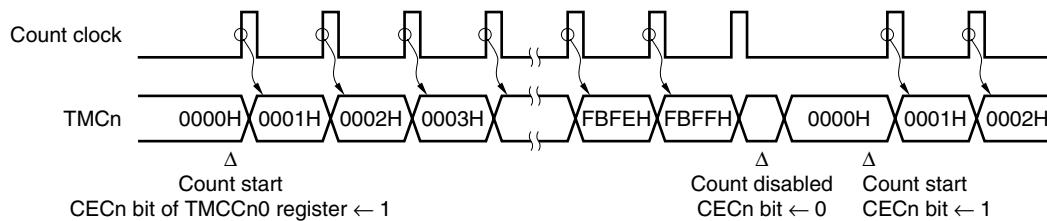
## (1) Count operation

Timer C can function as a 16-bit free-running timer or as an external signal event counter. The setting for the type of operation is specified by timer mode control registers Cn0 and Cn1 (TMCCn0 and TMCCn1) (n = 0 to 5).

When it operates as a free-running timer, if the CCCn0 or CCCn1 register and the TMCn count value match, an interrupt signal is generated and the timer output signal (TOCn) can be set or reset. Also, a capture operation that holds the TMCm count value in the CCCm0 or CCCm1 register is performed, in synchronization with the valid edge that was detected from the external interrupt request input pin as an external trigger (m = 0 to 3). The capture value is held until the next capture trigger is generated.

**Caution** When using the INTPCm0/TICm pin as TICm (external clock input pin), be sure to disable the INTPCm0 interrupt or set the CCCm0 register to compare mode (m = 0 to 3).

Figure 9-2. Basic Operation of Timer C



**Remark** n = 0 to 5

**(2) Overflow**

When the TMCn register has counted the count clock from FFFFH to 0000H, the OVFCn bit of the TMCCn0 register is set to 1, and an overflow interrupt (INTOVCn) is generated at the same time. However, if the CCCn0 register is set to compare mode (CMSCn0 bit of the TMCCn1 register = 1) and to the value FFFFH when match clearing is enabled (CCLRCn bit of the TMCCn1 register = 1), then the TMCn register is considered to be cleared and the OVFCn bit is not set to 1 when the TMCn register changes from FFFFH to 0000H. Also, the overflow interrupt (INTOVCn) is not generated.

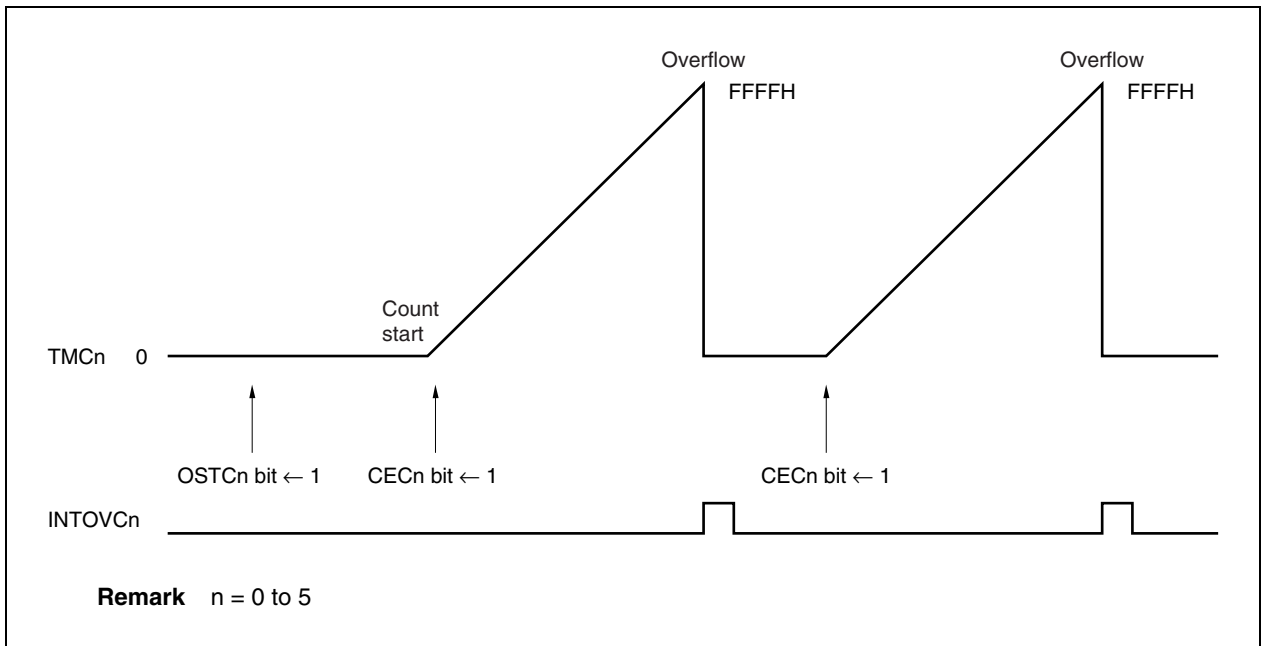
When the TMCn register is changed from FFFFH to 0000H because the CECn bit of the TMCCn0 register changes from 1 to 0, the TMCn register is considered to be cleared, but the OVFCn bit is not set to 1 and no INTOVCn interrupt is generated.

Also, timer operation can be stopped after an overflow by setting the OSTCn bit of the TMCCn1 register to 1. When the timer is stopped due to an overflow, the count operation is not restarted until the CECn bit is set to 1.

Operation is not affected even if the CECn bit is set to 1 during a count operation.

**Remark** n = 0 to 5

**Figure 9-3. Operation After Overflow (When OSTCn Bit = 1)**



**(3) Capture operation**

The TMCn register has two capture/compare registers. These are the CCCn0 register and the CCCn1 register. A capture operation or a compare operation is performed according to the settings of both the CMSCn1 and CMSCn0 bits of the TMCCn1 register. If the CMSCn1 and CMSCn0 bits of the TMCCn1 register are cleared to 0, the register operates as a capture register.

A capture operation that captures and holds the TMCm count value asynchronously relative to the count clock is performed in synchronization with an external trigger. The valid edge that is detected from an external interrupt request input pin (INTPCm0 or INTPCm1) is used as an external trigger (capture trigger). The TMCm count value during counting is captured and held in the capture register, in synchronization with that capture trigger signal. The capture register value is held until the next capture trigger is generated.

Also, an interrupt request (INTCCm0 or INTCCm1) is generated by INTPCm0 or INTPCm1 signal input.

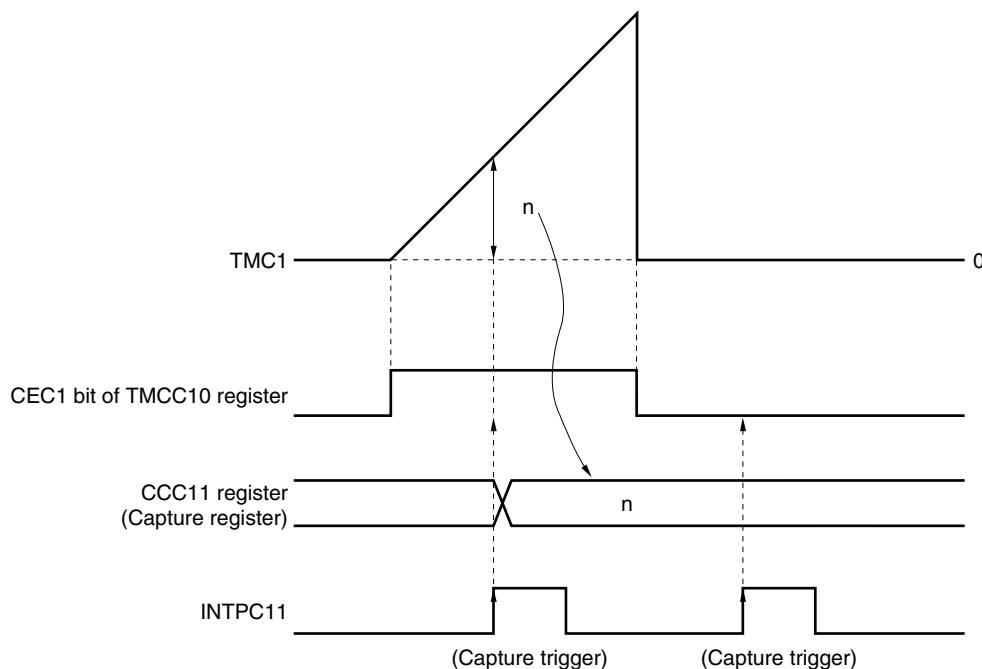
The valid edge of the capture trigger is set by valid edge select register Cm (SESCm).

If both the rising and falling edges are set as capture triggers, the input pulse width from an external source can be measured. Also, if only one of the edges is set as the capture trigger, the input pulse cycle can be measured.

**Remark** m = 0 to 3

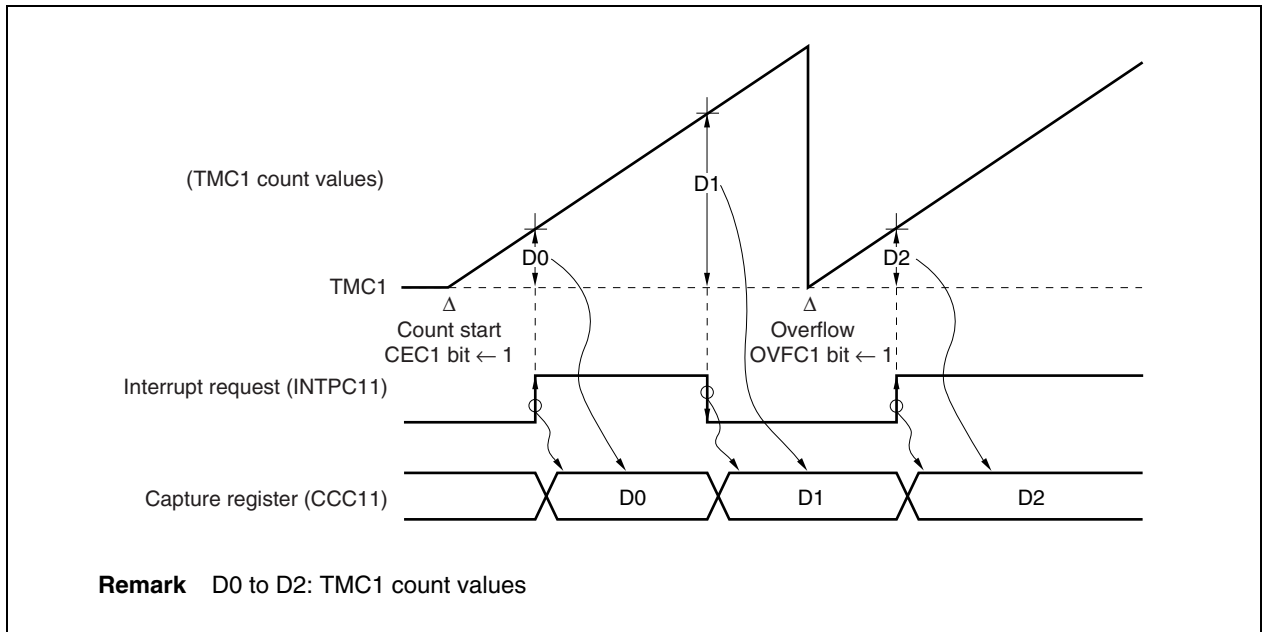
n = 0 to 5

**Figure 9-4. Capture Operation Example**



- Remarks**
1. When the CEC1 bit is 0, no capture operation is performed even if INTPC11 is input.
  2. Valid edge of INTPC11: Rising edge



**Figure 9-5. TMC1 Capture Operation Example (When Both Edges Are Specified)**

**(4) Compare operation**

The TMCn register has two capture/compare registers. These are the CCCn0 register and the CCCn1 register. A capture operation or a compare operation is performed according to the settings of both the CMSCn1 and CMSCn0 bits of the TMCCn1 register. If the CMSCn1 and CMSCn0 bits of the TMCCn1 register are set to 1, the register operates as a compare register.

A compare operation that compares the value that was set in the compare register and the TMCn count value is performed.

If the TMCn count value matches the value of the compare register, which had been set in advance, a match signal is sent to the output controller. The match signal causes the timer output pin (TOCn) to change and an interrupt request signal (INTCCn0 or INTCCn1) to be generated at the same time.

If the CCCn0 or CCCn1 registers are cleared to 0000H, the 0000H after the TMCn register counts up from FFFFH to 0000H is judged as a match. In this case, the TMCn register value is cleared to 0 at the next count timing, however, this 0000H is not judged as a match. Also, the 0000H when the TMCn register begins counting is not judged as a match.

If match clearing is enabled (CCLRCn bit of the TMCCn1 register = 1) for the CCCn0 register, the TMCn register is cleared when a match with the TMCn register occurs during a compare operation.

**Remark** n = 0 to 5

**Figure 9-6. Compare Operation Example (1/2)**

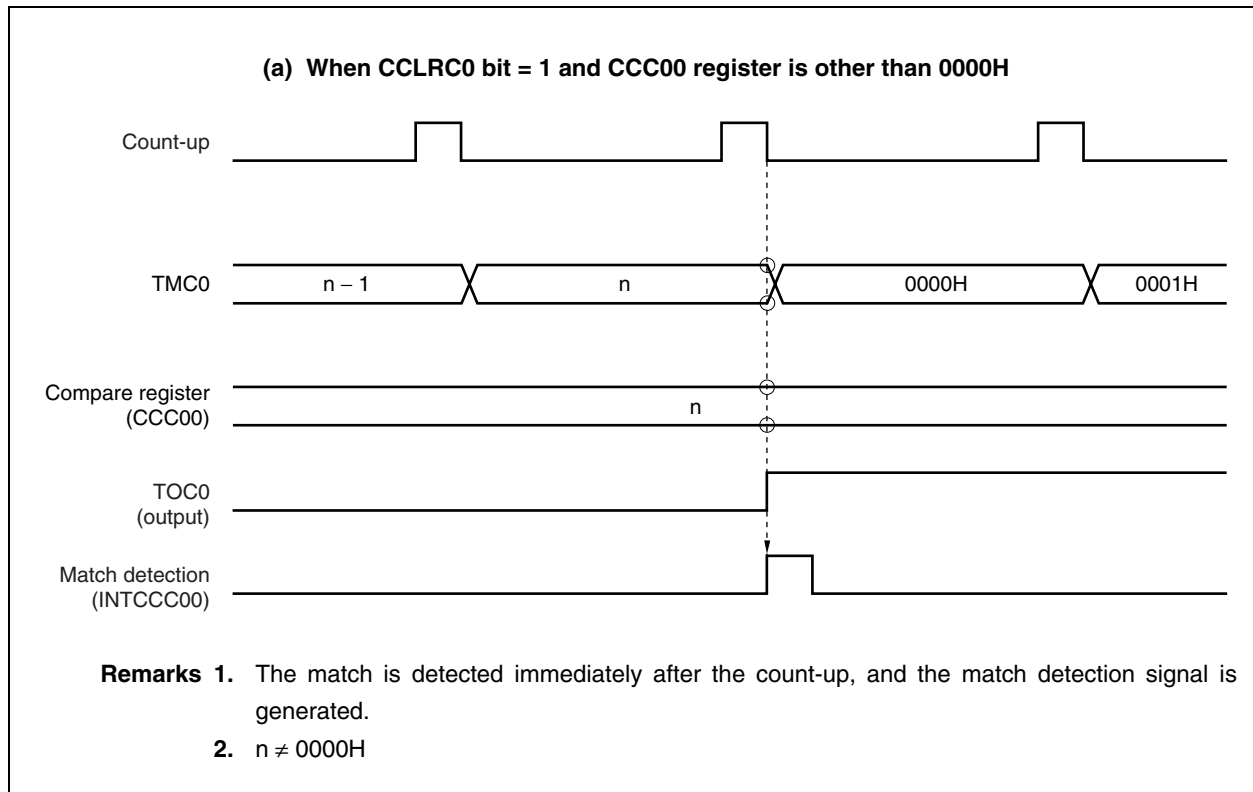
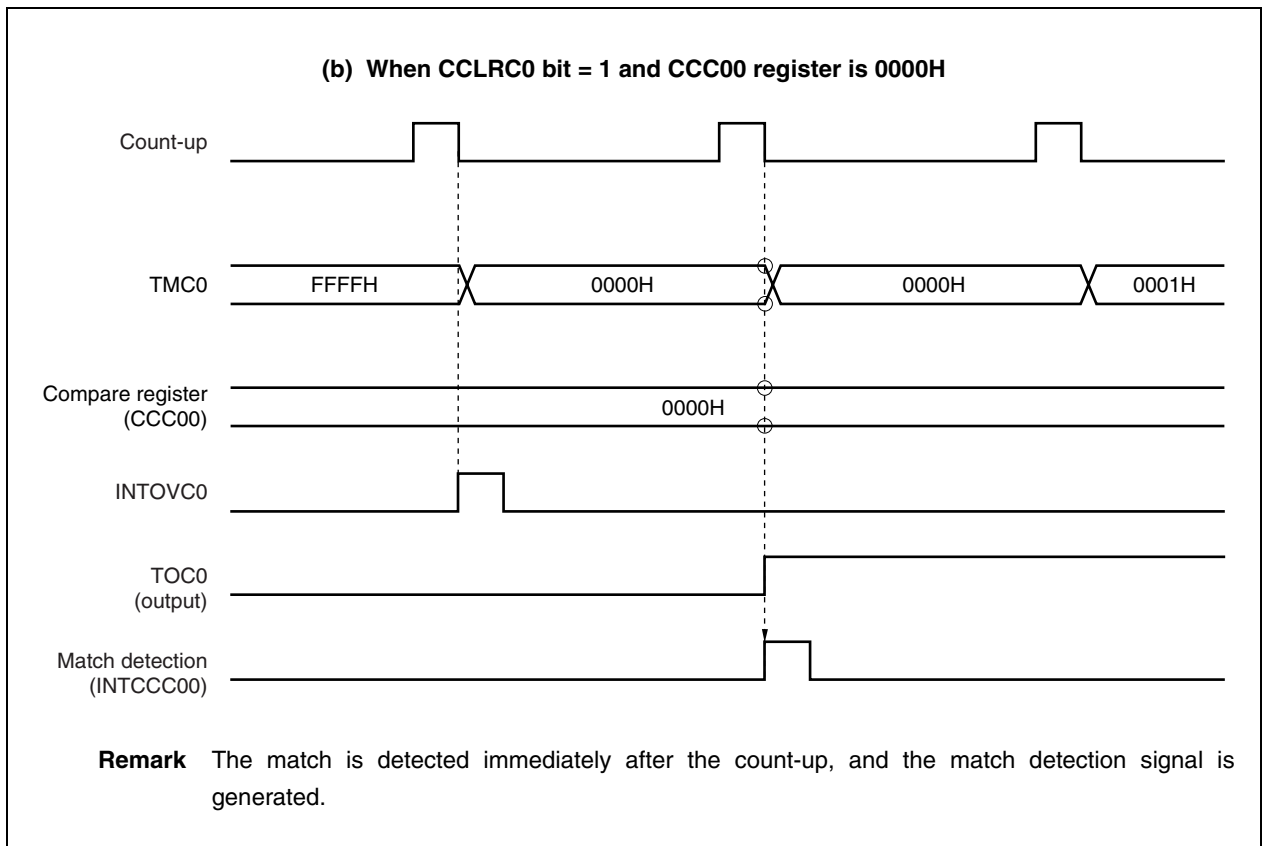


Figure 9-6. Compare Operation Example (2/2)



**(5) External pulse output**

Timer C has six timer output pins (TOCn).

An external pulse output (TOCn) is generated when a match of the two compare registers (CCCN0 and CCCn1) and the TMCn register is detected.

If a match is detected when the TMCn count value and the CCCn0 register value are compared, the output level of the TOCn pin is set. Also, if a match is detected when the TMCn count value and the CCCn1 register value are compared, the output level of the TOCn pin is reset.

The output level of the TOCn pin can be specified by the TMCCn1 register.

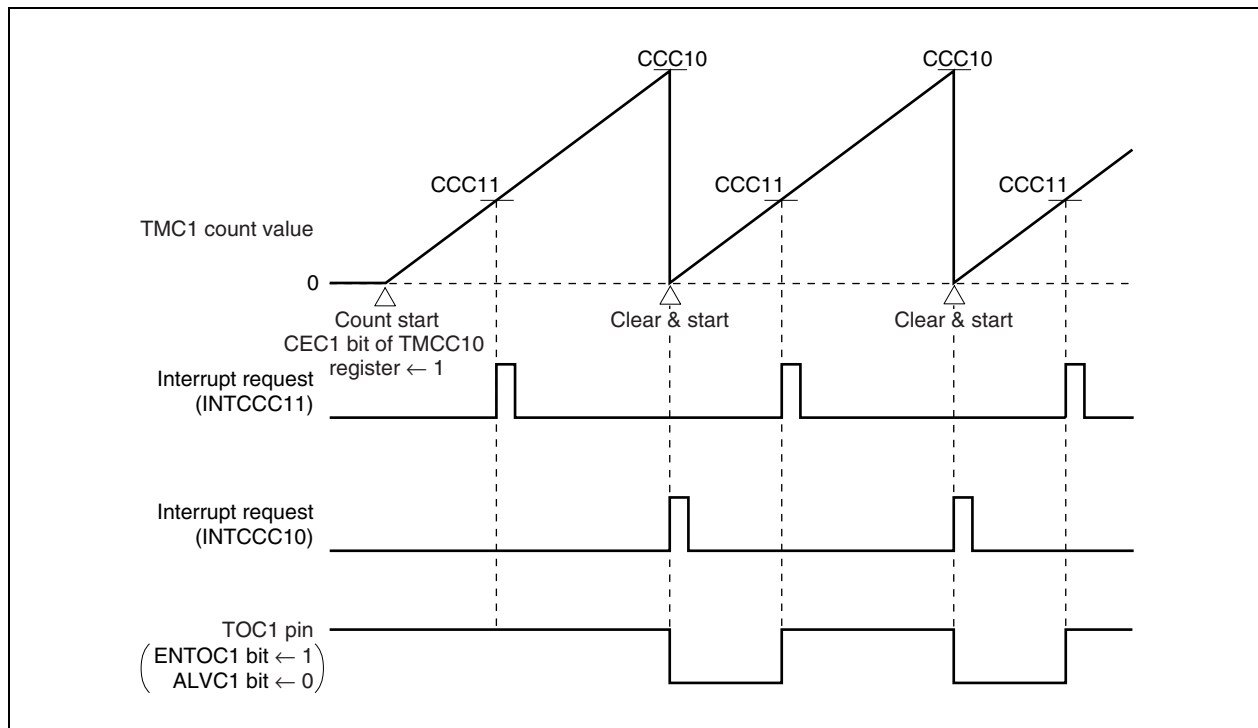
**Remark** n = 0 to 5

**Table 9-2. TOCn Output Control**

| TMCCn1 Register |           | TOCn Output           |                                                                                                 |
|-----------------|-----------|-----------------------|-------------------------------------------------------------------------------------------------|
| ENTOCn Bit      | ALVCn Bit | External Pulse Output | Output Level                                                                                    |
| 0               | 0         | Disable               | High level                                                                                      |
| 0               | 1         | Disable               | Low level                                                                                       |
| 1               | 0         | Enable                | When the CCCn0 register is matched: low level<br>When the CCCn1 register is matched: high level |
| 1               | 1         | Enable                | When the CCCn0 register is matched: high level<br>When the CCCn1 register is matched: low level |

**Remark** n = 0 to 5

**Figure 9-7. TMC1 Compare Operation Example (Set/Reset Output Mode)**



## 9.1.7 Application examples

## (1) Interval timer

By setting the TMCCn0 and TMCCn1 registers as shown in Figure 9-8, timer C operates as an interval timer that repeatedly generates interrupt requests with the value that was preset in the CCCn0 register as the interval.

When the counter value of the TMCn register matches the setting value of the CCCn0 register, the TMCn register is cleared to 0000H and an interrupt request signal (INTCCCN0) is generated at the same time that the count operation resumes.

**Remark** n = 0 to 5

**Figure 9-8. Contents of Register Settings When Timer C Is Used as Interval Timer**

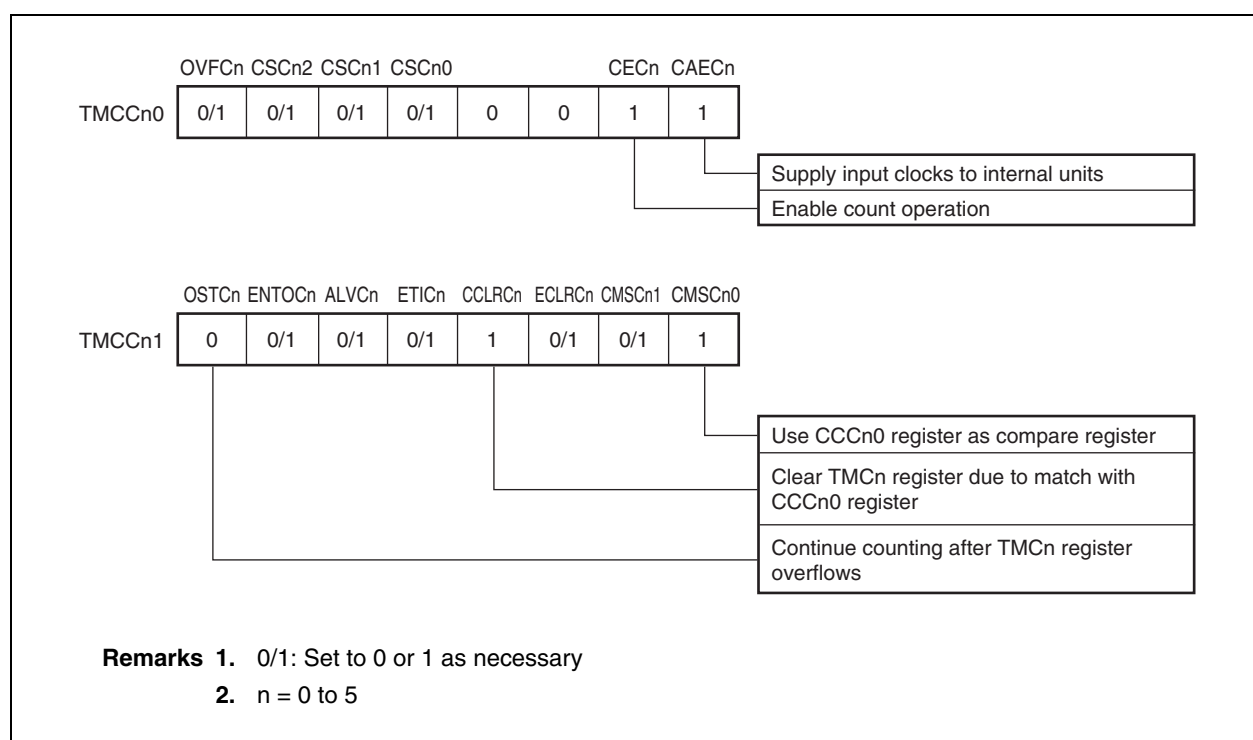
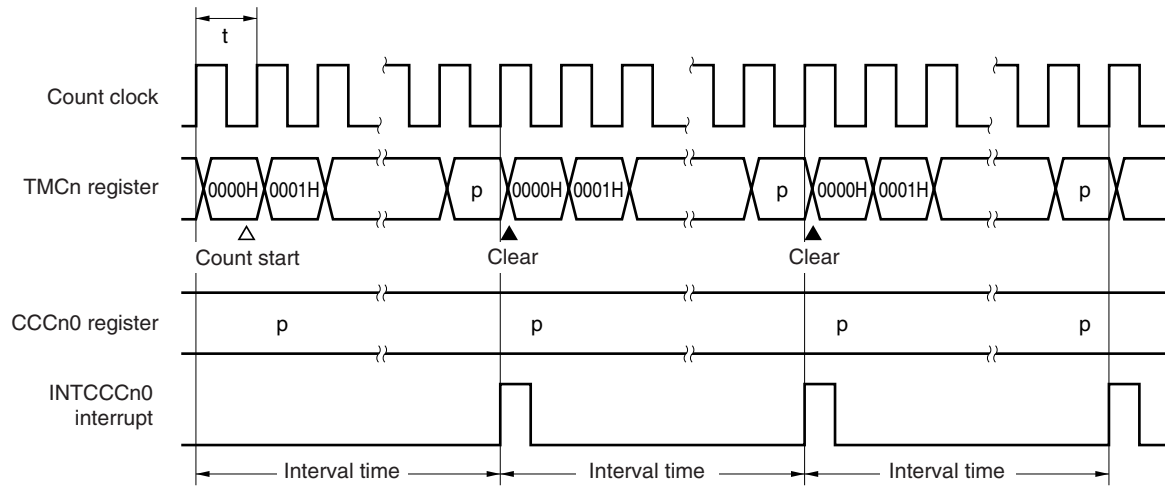


**Figure 9-9. Interval Timer Operation Timing Example**

**Remarks 1.** p: Setting value of CCCn0 register (0000H to FFFFH)

t: Count clock cycle

$$\text{Interval time} = (p + 1) \times t$$

**2.** n = 0 to 5

**(2) PWM output**

By setting the TMCCn0 and TMCCn1 registers as shown in Figure 9-10, timer C can output a PWM signal, whose frequency is determined according to the setting of the CSCn2 to CSCn0 bits of the TMCCn0 register, with the values that were preset in the CCCn0 and CCCn1 registers determining the intervals.

When the counter value of the TMCn register matches the setting value of the CCCn0 register, the TOCn output becomes active. Then, when the counter value of the TMCn register matches the setting value of the CCCn1 register, the TOCn output becomes inactive. The TMCn register continues counting. When it overflows, its count value is cleared to 0000H, and the register continues counting. In this way, a PWM signal whose frequency is determined according to the setting of the CSCn2 to CSCn0 bits of the TMCCn0 register can be output. When the setting value of the CCCn0 register and the setting value of the CCCn1 register are the same, the TOCn output remains inactive and does not change.

The active level of the TOCn output can be set by the ALVCn bit of the TMCCn1 register.

**Remark** n = 0 to 5

**Figure 9-10. Contents of Register Settings When Timer C Is Used for PWM Output**

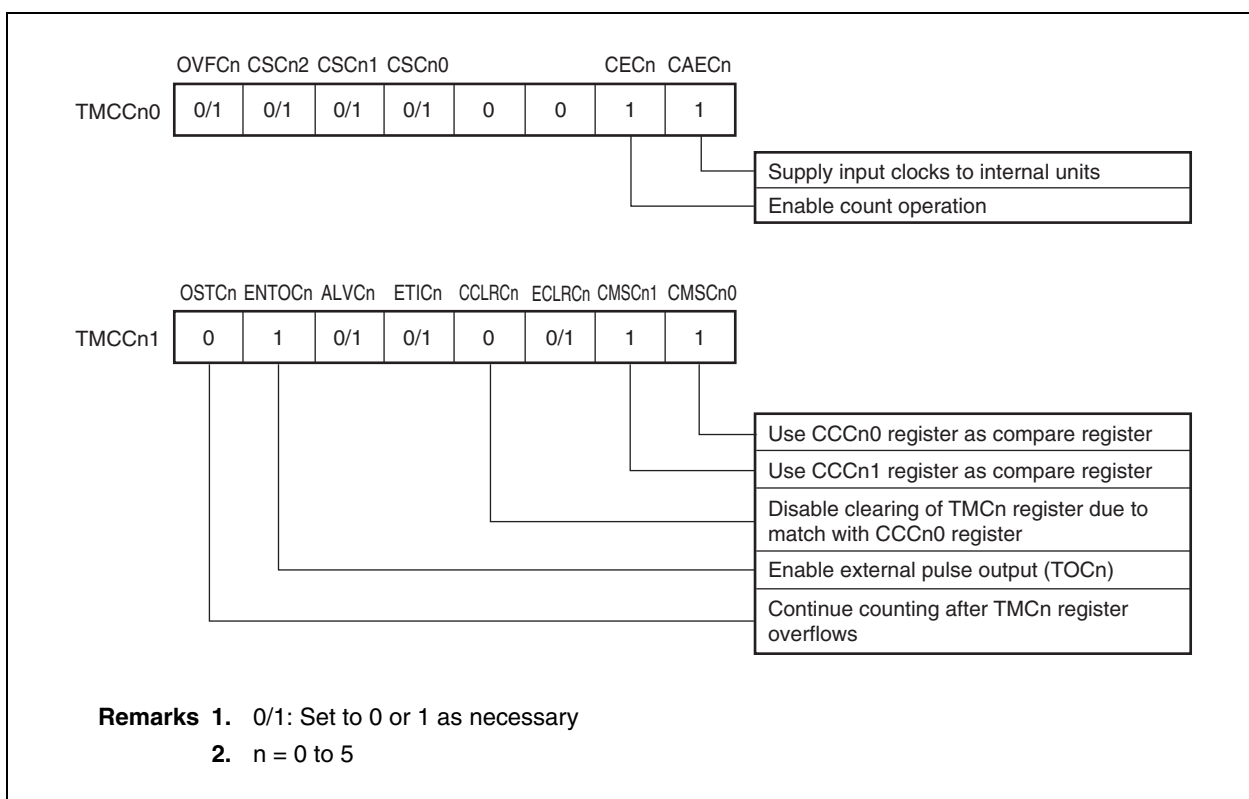
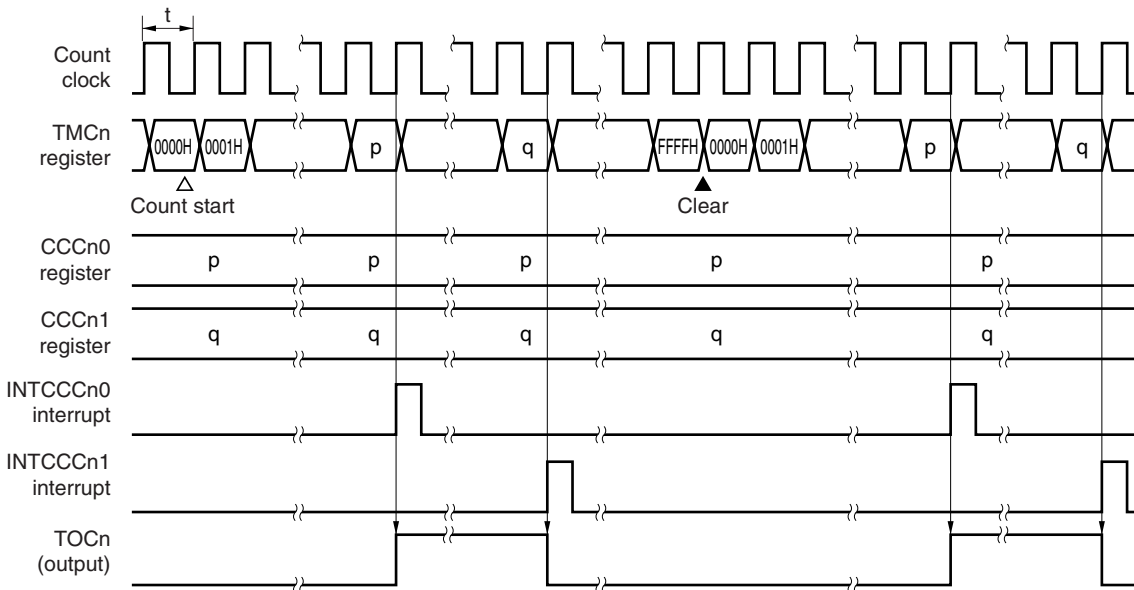


Figure 9-11. PWM Output Operation Timing Example



**Remarks 1.** p: Setting value of CCCn0 register (0000H to FFFFH)

q: Setting value of CCCn1 register (0000H to FFFFH)

$p \neq q$

t: Count clock cycle

PWM cycle =  $65,536 \times t$

$$\text{Duty} = \frac{q - p}{65,536}$$

2. In this example, the active level of the TOCn output is set to the high level.

3.  $n = 0$  to 5



**(3) Cycle measurement**

By setting the TMCCn0 and TMCCn1 registers as shown in Figure 9-12, timer C can measure the cycle of signals input to the INTPCm0 or INTPCm1 pin.

The valid edge of the INTPCm0 pin is selected according to the IESC0m1 and IESC0m0 bits of the SESCm register, and the valid edge of the INTPCm1 pin is selected according to the IESC1m1 and IESC1m0 bits of the SESCm register. Either the rising edge, the falling edge, or both edges can be selected as the valid edges of both pins.

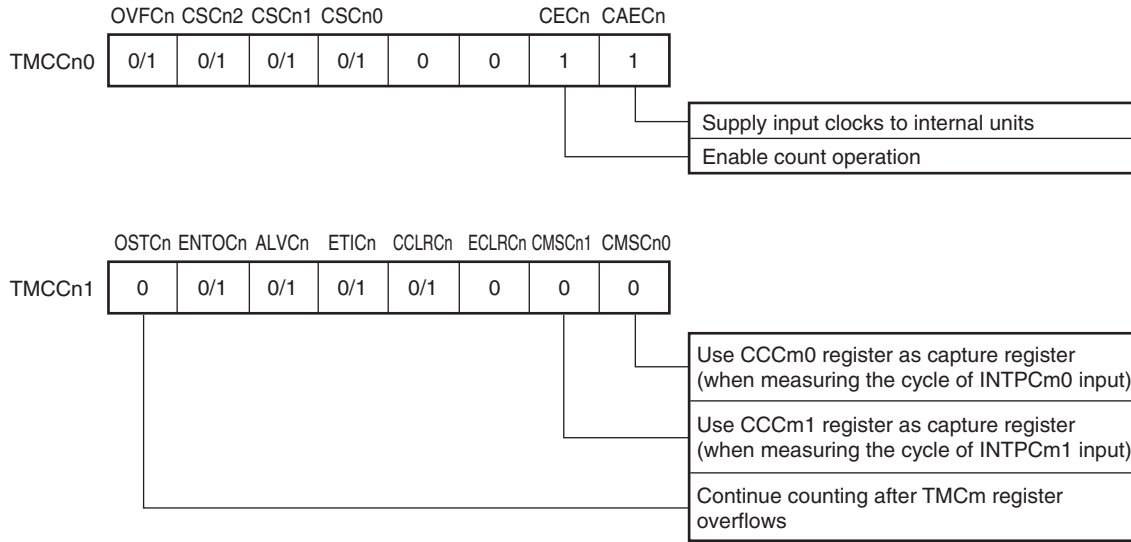
If the CCCm0 register is set as a capture register, the valid edge input of the INTPCm0 pin is set as the trigger for capturing the TMCm register value in the CCCm0 register. When this value is captured, an INTCCm0 interrupt is generated.

Similarly, if the CCCm1 register is set as a capture register, the valid edge input of the INTPCm1 pin is set as the trigger for capturing the TMCm register value in the CCCm1 register. When this value is captured, an INTCCm1 interrupt is generated.

The cycle of signals input to the INTPCm0 pin is calculated by obtaining the difference between the TMCm register's count value ( $D_x$ ) that was captured in the CCCm0 register according to the  $x$ -th valid edge input of the INTPCm0 pin and the TMCm register's count value ( $D_{(x+1)}$ ) that was captured in the CCCm0 register according to the  $(x+1)$ -th valid edge input of the INTPCm0 pin and multiplying the value of this difference by the cycle of the clock control signal.

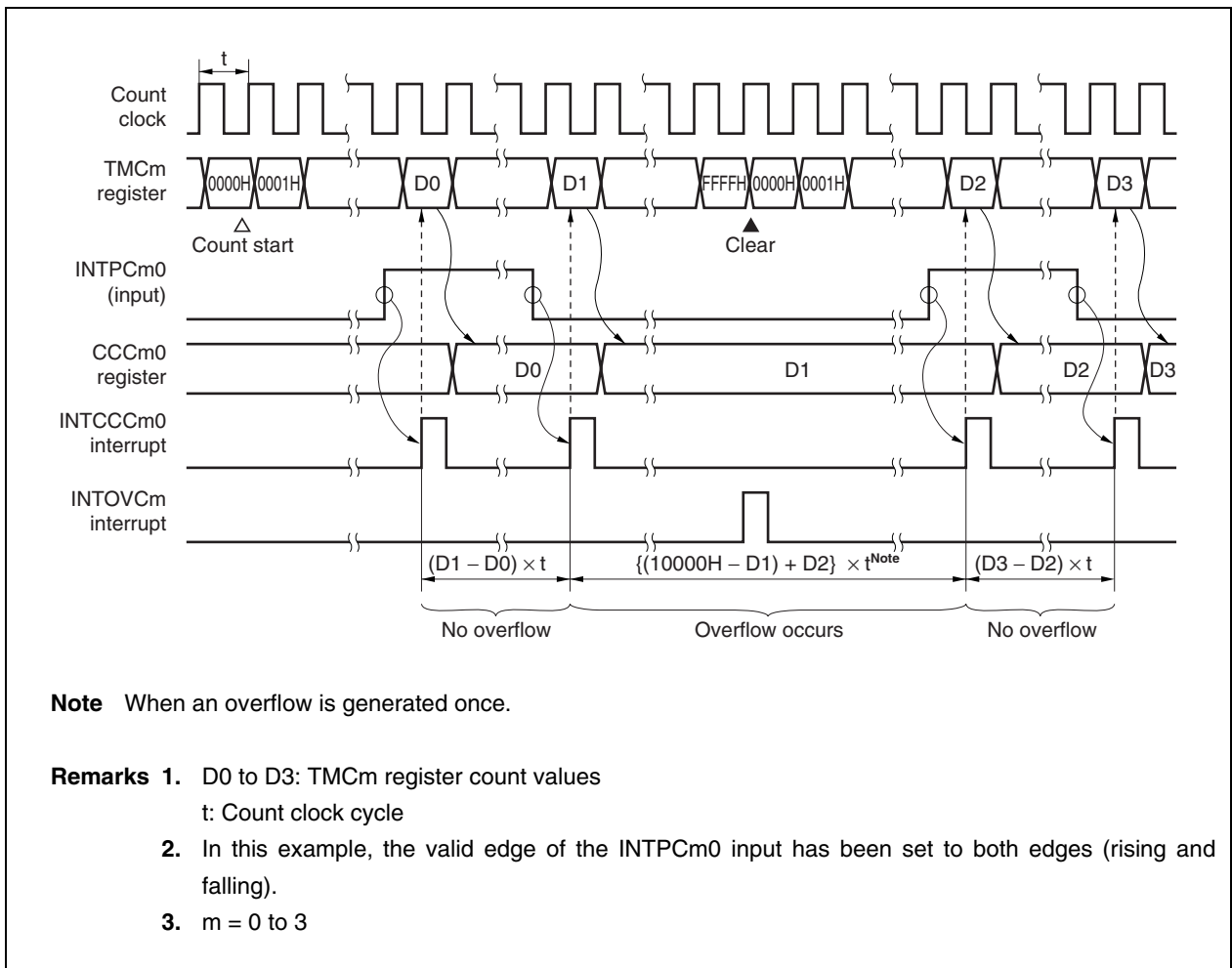
The cycle of signals input to the INTPCm1 pin is calculated by obtaining the difference between the TMCm register's count value ( $D_x$ ) that was captured in the CCCm1 register according to the  $x$ -th valid edge input of the INTPCm1 pin and the TMCm register's count value ( $D_{(x+1)}$ ) that was captured in the CCCm1 register according to the  $(x+1)$ -th valid edge input of the INTPCm1 pin and multiplying the value of this difference by the cycle of the clock control signal.

**Remark**     $m = 0 \text{ to } 3$   
                   $n = 0 \text{ to } 5$

**Figure 9-12. Contents of Register Settings When Timer C Is Used for Cycle Measurement**

- Remarks**
1. 0/1: Set to 0 or 1 as necessary
  2. m = 0 to 3  
n = 0 to 5

Figure 9-13. Cycle Measurement Operation Timing Example



### 9.1.8 Cautions

Cautions concerning the timer C are shown below.

**(1) Conflict between reading CCCm0 register and capture operation**

If a conflict occurs between the reading of the CCCm0 register and a capture operation when the CCCm0 register is used in capture mode, an external trigger (INTPCm0) valid edge is detected and an external interrupt request (INTCCm0) is generated, however, the timer value is not stored in the CCCm0 register.

**(2) Conflict between reading CCCm1 register and capture operation**

If a conflict occurs between the reading of the CCCm1 register and a capture operation when the CCCm1 register is used in capture mode, an external trigger (INTPCm1) valid edge is detected and an external interrupt request (INTCCm1) is generated, however, the timer value is not stored in the CCCm1 register.

**(3) Rewriting during timer operation**

The following bits and registers must not be rewritten during timer operation (CECn bit of TMCCn0 register = 1).

- CSCn2 to CSCn0 bits of TMCCn0 register
- TMCCn1 register
- SESCm register

**(4) Register setting when Timer C used**

The CAECn bit of the TMCCn0 register is a TMCn reset signal. To use TMCn, first set the CAECn bit to 1.

**(5) Valid edge detection of external interrupt request signals (INTPCm0, INTPCm1), external clock input (TICm)**

The digital noise elimination time  $(0 \text{ to } 5) \times f_x/4$  are required to detect the valid edge of the external interrupt request signal (INTPCm0 or INTPCm1) or the external clock input (TICm). Therefore, edge detection will not be performed normally for changes that are less than the digital noise elimination time. For details of digital noise elimination, see **14.6.3 Timer C and timer ENC1 input pins**.

**(6) Operation of external interrupt request signals (INTCCn0, INTCCn1)**

The operation of an external interrupt request signal (INTCCn0 or INTCCn1) is automatically determined according to the operating state of the capture/compare register. When the capture/compare register is used for a capture operation, the external interrupt request signal is used for valid edge detection. When the capture/compare register is used for a compare operation, the external interrupt request signal is used for an interrupt indicating a match with the TMCn register.

**(7) Glitch generation**

If the ENTOCn and ALVCn bits of the TMCCn1 register are changed at the same time, a glitch (spike shaped noise) may be generated in the TOCn pin output. Either create a circuit configuration that will not malfunction even if a glitch is generated or make sure that the ENTOCn and ALVCn bits are not changed at the same time.

**(8) Alternate-function pins when timer C not used**

Even when using the INTPC00/TIC0, INTPC10/TIC1, INTPC20/TIC2, and INTPC30/TIC3 pins as INTPC00, INTPC10, INTPC20, and INTPC30, respectively, without using timer C, be sure to set the CAECn and CECn bits of timer mode control registers C00 to C03 (TMCC00 to TMCC30) to 1.

**(9) When used as TICm (external clock input pin)**

When the INTPCm0/TICm pin is used as TICm (external clock input pin), disable the INTPCm0 interrupt or set CCCm0 to compare mode ( $m = 0$  to 3).

**(10) Count clock**

The count clock cannot be changed while the timer is operating.

**(11) CCC40, CCC41, CCC50, and CCC51 registers**

The CCC40, CCC41, CCC50, and CCC51 registers can only be used as compare registers. They cannot be used as capture registers.

**(12) INTPCn0 and INTPCn1 pins when CCCn0 and CCCn1 registers set as compare registers**

When the CCCn0 and CCCn1 registers are set as compare registers, INTPCn0 and INTPCn1 cannot be used as an external interrupt input pin ( $n = 0$  to 5).

When using these registers as an external interrupt input pin, use the  $\overline{\text{INTP65}}$  and  $\overline{\text{INTP66}}$  pins.

**(13) Setting trigger mode**

Set the PMCx register before setting the trigger mode of the INTPCm0, INTPCm1, and TICm pins ( $m = 0$  to 3,  $x = 5$  to 7). Then set the CAECm and CECm bits of the TMCCm0 register to 1.

If the PMCx register is set after the SESCm register has been set, an illegal interrupt, incorrect counting, and incorrect clearing may occur depending on the timing of setting the PMCx register.

**Remark**     $m = 0$  to 3  
               $n = 0$  to 5

## 9.2 Timer D

### 9.2.1 Features

Timer D functions as a 16-bit interval timer.

### 9.2.2 Function overview

- 16-bit interval timer: 4 channels
- Compare registers: 4
- Interrupt request sources: 4 sources
- Count clock selected from divisions of main clock

### 9.2.3 Basic configuration

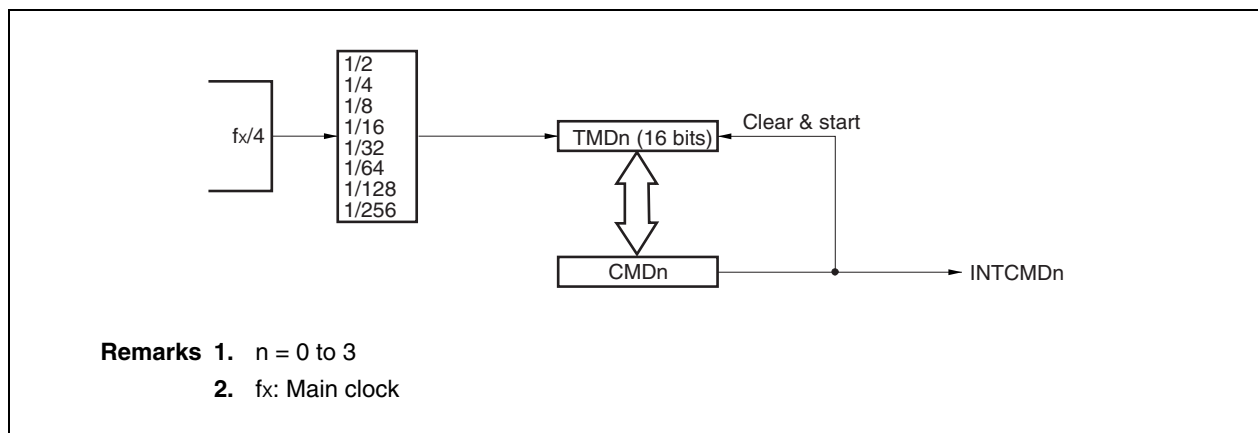
**Table 9-3. Timer D Configuration**

| Timer   | Count Clock                                                 | Register | Read/Write | Generated Interrupt Signal | Capture Trigger | Timer Output S/R | Other Functions          |
|---------|-------------------------------------------------------------|----------|------------|----------------------------|-----------------|------------------|--------------------------|
| Timer D | fx/8, fx/16, fx/32, fx/64, fx/128, fx/256, fx/512, fx/1,024 | TMD0     | Read       | —                          | —               | —                | —                        |
|         |                                                             | CMD0     | Read/write | INTCMD0                    | —               | —                | Clear & start of timer C |
|         |                                                             | TMD1     | Read       | —                          | —               | —                | —                        |
|         |                                                             | CMD1     | Read/write | INTCMD1                    | —               | —                | —                        |
|         |                                                             | TMD2     | Read       | —                          | —               | —                | —                        |
|         |                                                             | CMD2     | Read/write | INTCMD2                    | —               | —                | —                        |
|         |                                                             | TMD3     | Read       | —                          | —               | —                | —                        |
|         |                                                             | CMD3     | Read/write | INTCMD3                    | —               | —                | —                        |

**Remark** fx: Main clock  
S/R: Set/reset

#### (1) Timer D (16-bit timer/counter)

**Figure 9-14. Timer D Block Diagram**



## 9.2.4 Timer D

## (1) Timers D0 to D3 (TMD0 to TMD3)

TMDn is a 16-bit timer. It is mainly used as an interval timer for software (n = 0 to 3).

Starting and stopping TMDn is controlled by the CEDn bit of the timer mode control register Dn (TMCDn) (n = 0 to 3).

Division by the prescaler can be selected for the count clock from among  $f_x/8$ ,  $f_x/16$ ,  $f_x/32$ ,  $f_x/64$ ,  $f_x/128$ ,  $f_x/256$ ,  $f_x/512$ , and  $f_x/1,024$  by the CSDn0 to CSDn2 bits of the TMCDn register ( $f_x$ : main clock).

TMDn is read-only, in 16-bit units.

|      | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | Address    | After reset |
|------|----|----|----|----|----|----|---|---|---|---|---|---|---|---|---|---|------------|-------------|
| TMD0 |    |    |    |    |    |    |   |   |   |   |   |   |   |   |   |   | FFFFFF540H | 0000H       |
| TMD1 |    |    |    |    |    |    |   |   |   |   |   |   |   |   |   |   | FFFFFF550H | 0000H       |
| TMD2 |    |    |    |    |    |    |   |   |   |   |   |   |   |   |   |   | FFFFFF560H | 0000H       |
| TMD3 |    |    |    |    |    |    |   |   |   |   |   |   |   |   |   |   | FFFFFF570H | 0000H       |

The conditions for which the TMDn register becomes 0000H are shown below (n = 0 to 3).

- Reset input
- CAEDn bit of TMCDn register = 0
- CEDn bit of TMCDn register = 0
- Match of TMDn register and CMDn register
- Overflow

**Cautions 1.** If the CAEDn bit of the TMCDn register is cleared to 0, a reset is performed asynchronously.

2. If the CEDn bit of the TMCDn register is cleared to 0, a reset is performed, in synchronization with the internal clock. Similarly, a synchronized reset is performed after a match with the CMDn register and after an overflow.

3. The count clock must not be changed during a timer operation. If it is to be overwritten, it should be overwritten after the CEDn bit is cleared to 0.

4. Up to 8 main clocks are required after a value is set in the CEDn bit until the set value is transferred to internal units. When a count operation begins, the count cycle from 0000H to 0001H differs from subsequent cycles.

5. After a compare match is generated, the timer is cleared at the next count clock. Therefore, if the division ratio is large, the timer value may not be zero even if the timer value is read immediately after a match interrupt is generated.

6. To initialize the TMDn register and start counting again, set the CEDn bit of the TMCDn register to 1 after 8 main clocks.

**(2) Compare registers D0 to D3 (CMD0 to CMD3)**

The CMDn register value and the TMDn register count value are compared, and an interrupt request signal (INTCMDn) is generated when a match occurs. TMDn is cleared, in synchronization with this match. If the CAEDn bit of the TMCDn register is cleared to 0, a reset is performed asynchronously, and the registers are initialized (n = 0 to 3).

The CMDn registers are configured with a master/slave configuration. When the CMDn register is written, data is first written to the master register and then the master register data is transferred to the slave register. In a compare operation, the slave register value is compared with the count value of the TMDn register. When the CMDn register is read, data in the master side is read out.

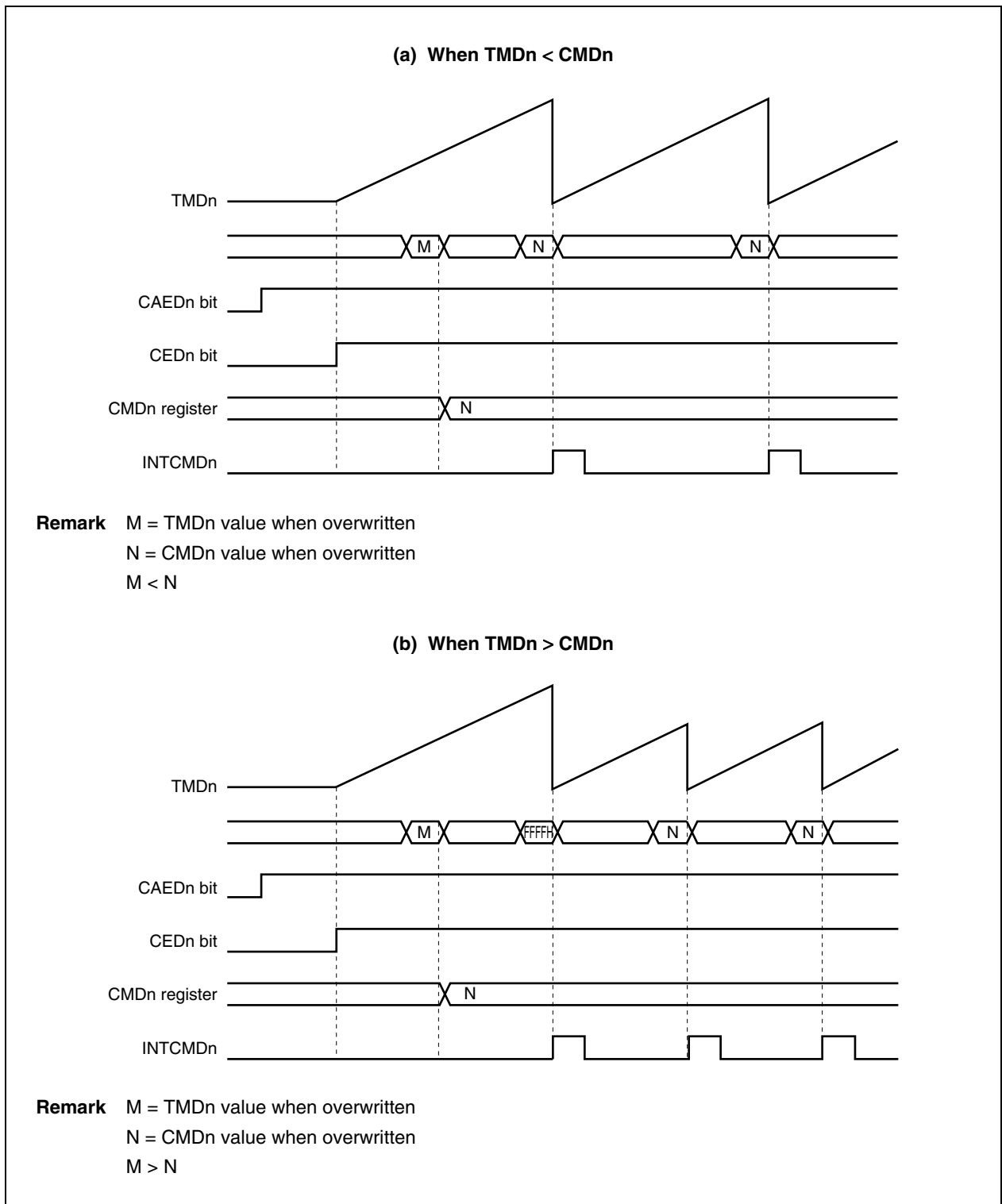
The CMDn register can be read or written in 16-bit units.

- Cautions**
1. A write operation to the CMDn register requires 8 main clocks until the value that was set in the CMDn register is transferred to internal units. When writing continuously to the CMDn register, be sure to secure a time interval of at least 8 main clocks.
  2. The CMDn register can be overwritten only once in a single TMDn register cycle (from 0000H until an INTCMDn interrupt is generated due to a match of the TMDn register and CMDn register). If this cannot be secured by the application, make sure that the CMDn register is not overwritten during timer operation.
  3. Note that an INTCMDn interrupt will be generated after an overflow if a value less than the counter value is written in the CMDn register during TMDn register operation (Figure 9-15).

|      | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | Address    | After reset |
|------|----|----|----|----|----|----|---|---|---|---|---|---|---|---|---|---|------------|-------------|
| CMD0 |    |    |    |    |    |    |   |   |   |   |   |   |   |   |   |   | FFFFFF542H | 0000H       |
| CMD1 |    |    |    |    |    |    |   |   |   |   |   |   |   |   |   |   | FFFFFF552H | 0000H       |
| CMD2 |    |    |    |    |    |    |   |   |   |   |   |   |   |   |   |   | FFFFFF562H | 0000H       |
| CMD3 |    |    |    |    |    |    |   |   |   |   |   |   |   |   |   |   | FFFFFF572H | 0000H       |



Figure 9-15. Example of Timing During TMDn Operation



## 9.2.5 Control registers

## (1) Timer mode control registers D0 to D3 (TMCD0 to TMCD3)

The TMCDn registers control the operation of timer Dn (n = 0 to 3).

These registers can be read or written in 8-bit or 1-bit units.

**Caution** The CAEDn and other bits cannot be set at the same time. The other bits and the registers of the other TMDn units should always be set after the CAEDn bit has been set.

(1/2)

|       | 7 | 6     | 5     | 4     | 3 | 2 | <1>  | <0>   | Address   | After reset |
|-------|---|-------|-------|-------|---|---|------|-------|-----------|-------------|
| TMCD0 | 0 | CSD02 | CSD01 | CSD00 | 0 | 0 | CED0 | CAED0 | FFFFF544H | 00H         |
| TMCD1 | 0 | CSD12 | CSD11 | CSD10 | 0 | 0 | CED1 | CAED1 | FFFFF554H | 00H         |
| TMCD2 | 0 | CSD22 | CSD21 | CSD20 | 0 | 0 | CED2 | CAED2 | FFFFF564H | 00H         |
| TMCD3 | 0 | CSD32 | CSD31 | CSD30 | 0 | 0 | CED3 | CAED3 | FFFFF574H | 00H         |

| Bit position                                                                                                                                                                                                                                              | Bit name       | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |          |       |             |             |   |   |   |      |   |   |   |       |   |   |   |       |   |   |   |       |   |   |   |        |   |   |   |        |   |   |   |        |   |   |   |          |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|-------|-------------|-------------|---|---|---|------|---|---|---|-------|---|---|---|-------|---|---|---|-------|---|---|---|--------|---|---|---|--------|---|---|---|--------|---|---|---|----------|
| 6 to 4                                                                                                                                                                                                                                                    | CSDn2 to CSDn0 | Selects the TMDn internal count clock cycle.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |          |       |             |             |   |   |   |      |   |   |   |       |   |   |   |       |   |   |   |       |   |   |   |        |   |   |   |        |   |   |   |        |   |   |   |          |
|                                                                                                                                                                                                                                                           |                | <table><tr><th>CSDn2</th><th>CSDn1</th><th>CSDn0</th><th>Count cycle</th></tr><tr><td>0</td><td>0</td><td>0</td><td>fx/8</td></tr><tr><td>0</td><td>0</td><td>1</td><td>fx/16</td></tr><tr><td>0</td><td>1</td><td>0</td><td>fx/32</td></tr><tr><td>0</td><td>1</td><td>1</td><td>fx/64</td></tr><tr><td>1</td><td>0</td><td>0</td><td>fx/128</td></tr><tr><td>1</td><td>0</td><td>1</td><td>fx/256</td></tr><tr><td>1</td><td>1</td><td>0</td><td>fx/512</td></tr><tr><td>1</td><td>1</td><td>1</td><td>fx/1,024</td></tr></table> | CSDn2    | CSDn1 | CSDn0       | Count cycle | 0 | 0 | 0 | fx/8 | 0 | 0 | 1 | fx/16 | 0 | 1 | 0 | fx/32 | 0 | 1 | 1 | fx/64 | 1 | 0 | 0 | fx/128 | 1 | 0 | 1 | fx/256 | 1 | 1 | 0 | fx/512 | 1 | 1 | 1 | fx/1,024 |
|                                                                                                                                                                                                                                                           |                | CSDn2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | CSDn1    | CSDn0 | Count cycle |             |   |   |   |      |   |   |   |       |   |   |   |       |   |   |   |       |   |   |   |        |   |   |   |        |   |   |   |        |   |   |   |          |
|                                                                                                                                                                                                                                                           |                | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 0        | 0     | fx/8        |             |   |   |   |      |   |   |   |       |   |   |   |       |   |   |   |       |   |   |   |        |   |   |   |        |   |   |   |        |   |   |   |          |
|                                                                                                                                                                                                                                                           |                | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 0        | 1     | fx/16       |             |   |   |   |      |   |   |   |       |   |   |   |       |   |   |   |       |   |   |   |        |   |   |   |        |   |   |   |        |   |   |   |          |
|                                                                                                                                                                                                                                                           |                | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 1        | 0     | fx/32       |             |   |   |   |      |   |   |   |       |   |   |   |       |   |   |   |       |   |   |   |        |   |   |   |        |   |   |   |        |   |   |   |          |
|                                                                                                                                                                                                                                                           |                | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 1        | 1     | fx/64       |             |   |   |   |      |   |   |   |       |   |   |   |       |   |   |   |       |   |   |   |        |   |   |   |        |   |   |   |        |   |   |   |          |
|                                                                                                                                                                                                                                                           |                | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 0        | 0     | fx/128      |             |   |   |   |      |   |   |   |       |   |   |   |       |   |   |   |       |   |   |   |        |   |   |   |        |   |   |   |        |   |   |   |          |
|                                                                                                                                                                                                                                                           |                | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 0        | 1     | fx/256      |             |   |   |   |      |   |   |   |       |   |   |   |       |   |   |   |       |   |   |   |        |   |   |   |        |   |   |   |        |   |   |   |          |
|                                                                                                                                                                                                                                                           |                | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 1        | 0     | fx/512      |             |   |   |   |      |   |   |   |       |   |   |   |       |   |   |   |       |   |   |   |        |   |   |   |        |   |   |   |        |   |   |   |          |
| 1                                                                                                                                                                                                                                                         | 1              | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | fx/1,024 |       |             |             |   |   |   |      |   |   |   |       |   |   |   |       |   |   |   |       |   |   |   |        |   |   |   |        |   |   |   |        |   |   |   |          |
| <b>Caution</b> The CSDn2 to CSDn0 bits must not be changed during timer operation. If they are to be changed, they must be changed after setting the CEDn bit to 0. If these bits are overwritten during timer operation, operation cannot be guaranteed. |                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |          |       |             |             |   |   |   |      |   |   |   |       |   |   |   |       |   |   |   |       |   |   |   |        |   |   |   |        |   |   |   |        |   |   |   |          |
| <b>Remark</b> fx: Main clock                                                                                                                                                                                                                              |                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |          |       |             |             |   |   |   |      |   |   |   |       |   |   |   |       |   |   |   |       |   |   |   |        |   |   |   |        |   |   |   |        |   |   |   |          |
| 1                                                                                                                                                                                                                                                         | CEDn           | Controls the operation of TMDn.<br>0: Count disabled (stops at 0000H and does not operate)<br>1: Counting operation is performed                                                                                                                                                                                                                                                                                                                                                                                                    |          |       |             |             |   |   |   |      |   |   |   |       |   |   |   |       |   |   |   |       |   |   |   |        |   |   |   |        |   |   |   |        |   |   |   |          |
|                                                                                                                                                                                                                                                           |                | <b>Caution</b> The CEDn bit is not cleared even if a match is detected by the compare operation. To stop the count operation, clear the CEDn bit.                                                                                                                                                                                                                                                                                                                                                                                   |          |       |             |             |   |   |   |      |   |   |   |       |   |   |   |       |   |   |   |       |   |   |   |        |   |   |   |        |   |   |   |        |   |   |   |          |

**Remark** n = 0 to 3

| Bit position | Bit name | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|--------------|----------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 0            | CAEDn    | <p>Controls the internal count clock.</p> <p>0: The entire TMDn unit is reset asynchronously. The supply of input clocks to the TMDn unit stops.</p> <p>1: Input clocks are supplied to the TMDn unit.</p> <p><b>Cautions</b></p> <ol style="list-style-type: none"><li>1. When the CAEDn bit is cleared to 0, the TMDn unit can be asynchronously reset.</li><li>2. When the CAEDn bit = 0, the TMDn unit is in a reset state. To operate TMDn, therefore, the CAEDn bit must be set to 1.</li><li>3. If the CAEDn bit is cleared to 0, all the registers of the TMDn unit are initialized. If the CAEDn bit is set to 1 again, be sure to set all the registers of the TMDn unit again after setting the CAEDn bit to 1.</li></ol> |

**Remark** n = 0 to 3

## 9.2.6 Operation

## (1) Compare operation

TMDn can be used for a compare operation in which the value that was set in a compare register (CMDn) is compared with the TMDn count value ( $n = 0$  to 3).

If a match is detected by the compare operation, an interrupt (INTCMDn) is generated. The generation of the interrupt causes TMDn to be cleared to 0 at the next count timing. This function enables timer D to be used as an interval timer.

The CMDn register can also be cleared to 0. In this case, when an overflow occurs and TMDn becomes 0, a match is detected and INTCMDn is generated. Although the TMDn value is cleared to 0 at the next count timing, INTCMDn is not generated by this match.

Figure 9-16. TMD0 Compare Operation Example (1/2)

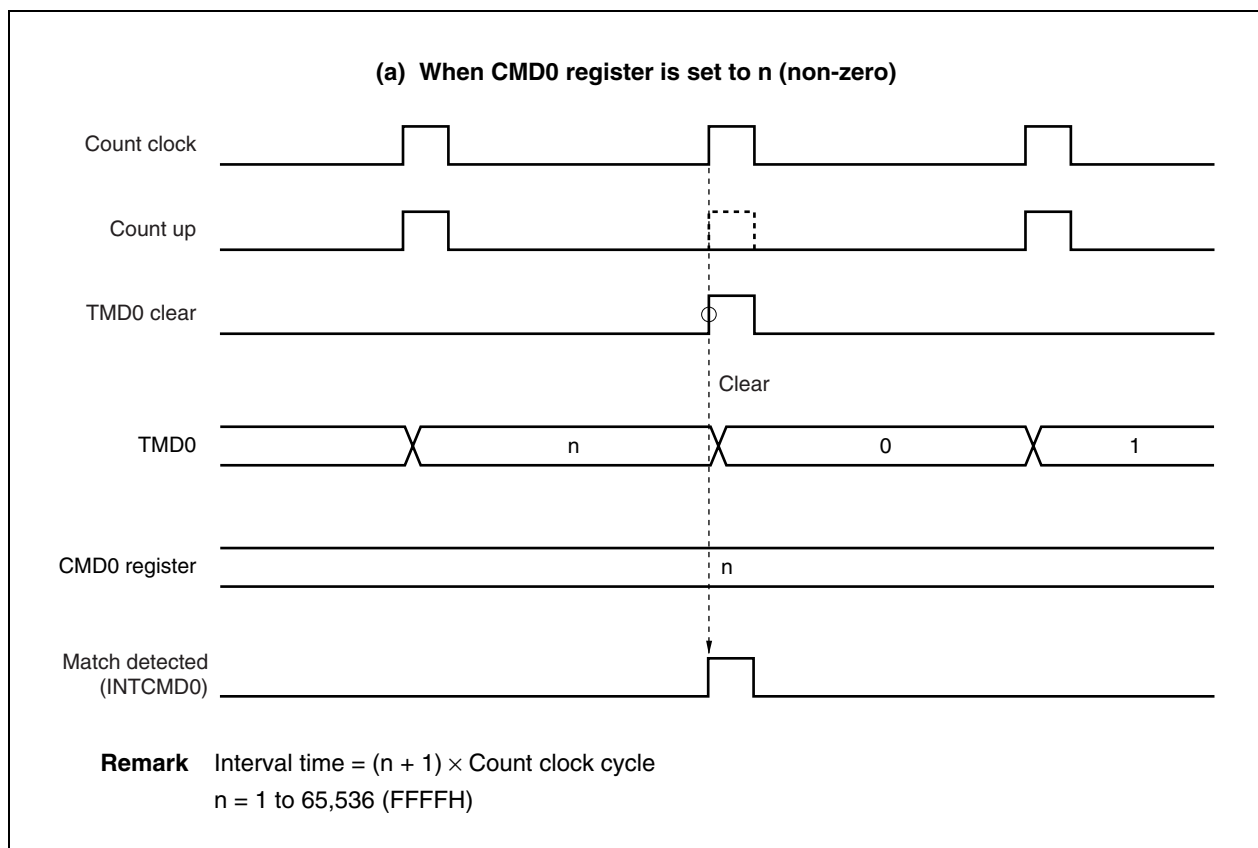
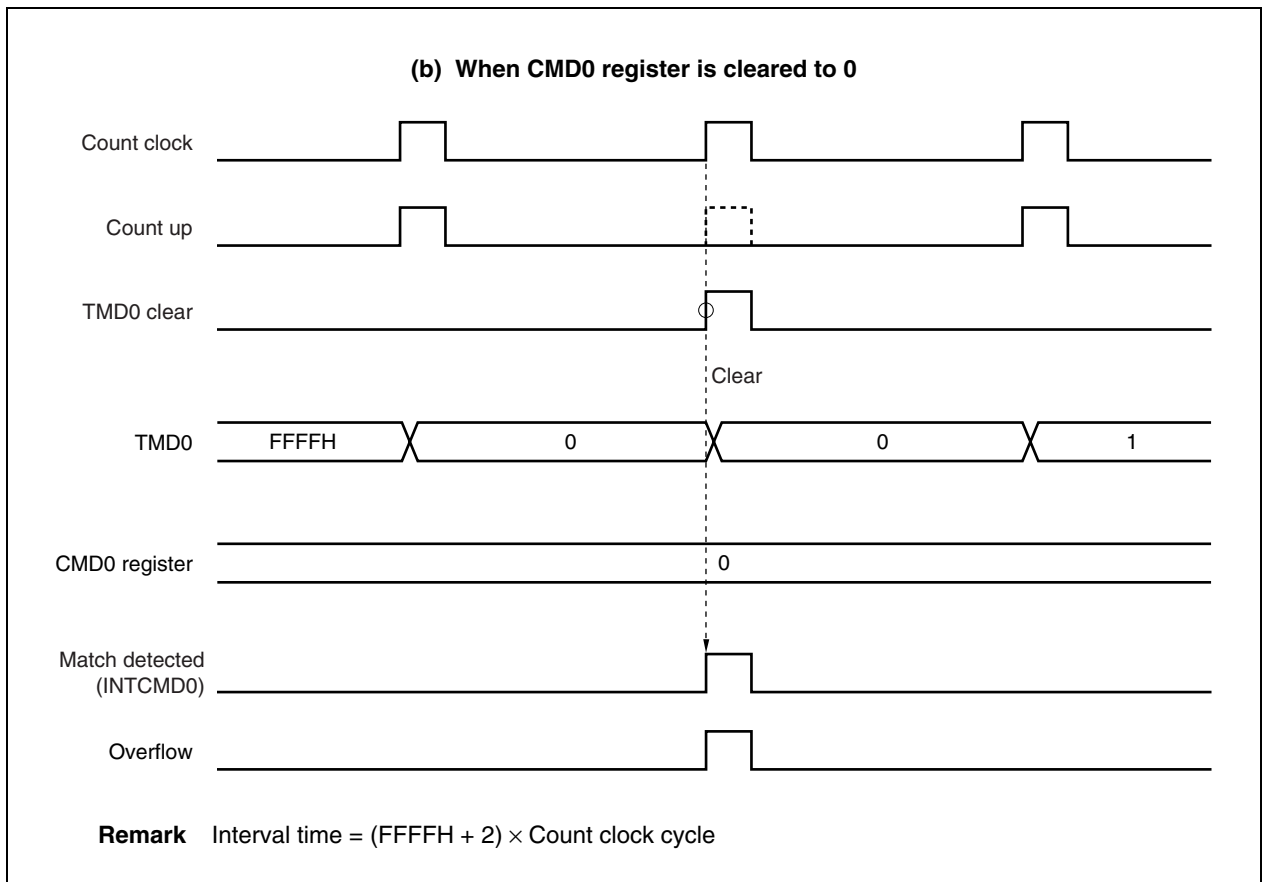


Figure 9-16. TMD0 Compare Operation Example (2/2)



### 9.2.7 Application examples

#### (1) Interval timer

This section explains an example in which timer D is used as an interval timer with 16-bit precision. Interrupt requests (INTCMDn) are output at equal intervals (see **Figure 9-16 TMD0 Compare Operation Example**). The setup procedure is shown below (n = 0 to 3).

- <1> Set the CAEDn bit of the TMCDn register to 1.
- <2> Set each register.
  - Select the count clock using the CSDn0 to CSDn2 bits of the TMCDn register.
  - Set the compare value in the CMDn register.
- <3> Start counting by setting the CEDn bit of the TMCDn register to 1.
- <4> If the TMDn register and CMDn register values match, an INTCMDn interrupt is generated.
- <5> INTCMDn interrupts are generated thereafter at equal intervals.

**Remark** n = 0 to 3

### 9.2.8 Cautions

Cautions concerning the timer D are shown below.

#### (1) Starting timer D operation

To operate TMDn, first set the CAEDn bit of the TMCDn register to 1.

#### (2) Caution on setting TMCDn register

Up to 8 main clocks are required after a value is set in the CEDn bit until the set value is transferred to internal units. When a count operation begins, the count cycle from 0000H to 0001H differs from subsequent cycles.

#### (3) Recount after TMDn register initialization

To initialize the TMDn register status and start counting again, clear the CEDn bit to 0 and then set the CEDn bit to 1 after an interval of 8 main clocks has elapsed.

#### (4) Caution on setting CMDn register

Up to 8 main locks are required until the value that was set in the CMDn register is transferred to internal units. When writing continuously to the CMDn register, be sure to secure a time interval of at least 8 main clocks.

- The CMDn register can be overwritten only once during a timer/counter operation (from 0000H until an INTCMDn interrupt is generated due to a match of the TMDn register and CMDn register). If this cannot be secured, make sure that the CMDn register is not overwritten during a timer/counter operation.

#### (5) Count clock

The count clock must not be changed during a timer operation. If it is to be overwritten, it should be overwritten after the CEDn bit is cleared to 0. If the count clock is overwritten during a timer operation, operation cannot be guaranteed.

#### (6) Writing to CMDn register

A match signal will be generated after an overflow if a value less than the counter value is written in the CMDn register during TMDn register operation.

**Remark** n = 0 to 3

### 9.3 16-Bit 2-Phase Encoder Input Up/Down Counter/General-Purpose Timer (Timer ENC1)

#### 9.3.1 Functions

Timers ENC10 and ENC11 (TMENC10, TMENC11) perform the following operations.

- General-purpose timer mode (See **9.3.6 (1) Operation in general-purpose timer mode.**)
  - Free-running timer
  - Timer output
- Up/down counter mode (See **9.3.6 (2) Operation in UDC mode.**)
  - UDC mode A (mode 1, mode 2, mode 3, mode 4)
  - UDC mode B (mode 1, mode 2, mode 3, mode 4)

#### 9.3.2 Features

- Timers ENC10 and ENC11: 2 channels
- Compare registers: 4
- Capture/compare registers: 4
- Interrupt request sources
  - Capture/compare match interrupt: 4 sources
  - Compare match interrupt request: 4 sources
- Capture request signal: 4 sources
  - The TMENC1n value can be latched using the valid edge of the INTP1n0 and INTP1n1 pins corresponding to the capture/compare register as the capture trigger.
- Count clock selectable through division by prescaler
- Timer output function
 

In the general-purpose timer mode, 16-bit resolution timer can be output from the TO1n pin.
- Timer clear
 

The following timer clear operations are performed according to the mode that is used.

  - (a) General-purpose timer mode: Timer clear operation is possible upon occurrence of match with the CM1n0 register set value.
  - (b) Up/down counter mode: The timer clear operation can be selected from among the following four conditions.
    - (i) Timer clear performed upon occurrence of match with the CM1n0 register set value during TMENC1n up-count operation, and timer clear performed upon occurrence of match with the CM1n1 register set value during TMENC1n down-count operation.
    - (ii) Timer clear performed only by external input.
    - (iii) Timer clear performed upon occurrence of match between TMENC1n count value and the CM1n0 register set value.
    - (iv) Timer clear performed upon occurrence of external input and match between TMENC1n count value and the CM1n0 register set value.
- External pulse output (TO1n): 2

## 9.3.3 Basic configuration

Table 9-4. Timer ENC1 Configuration

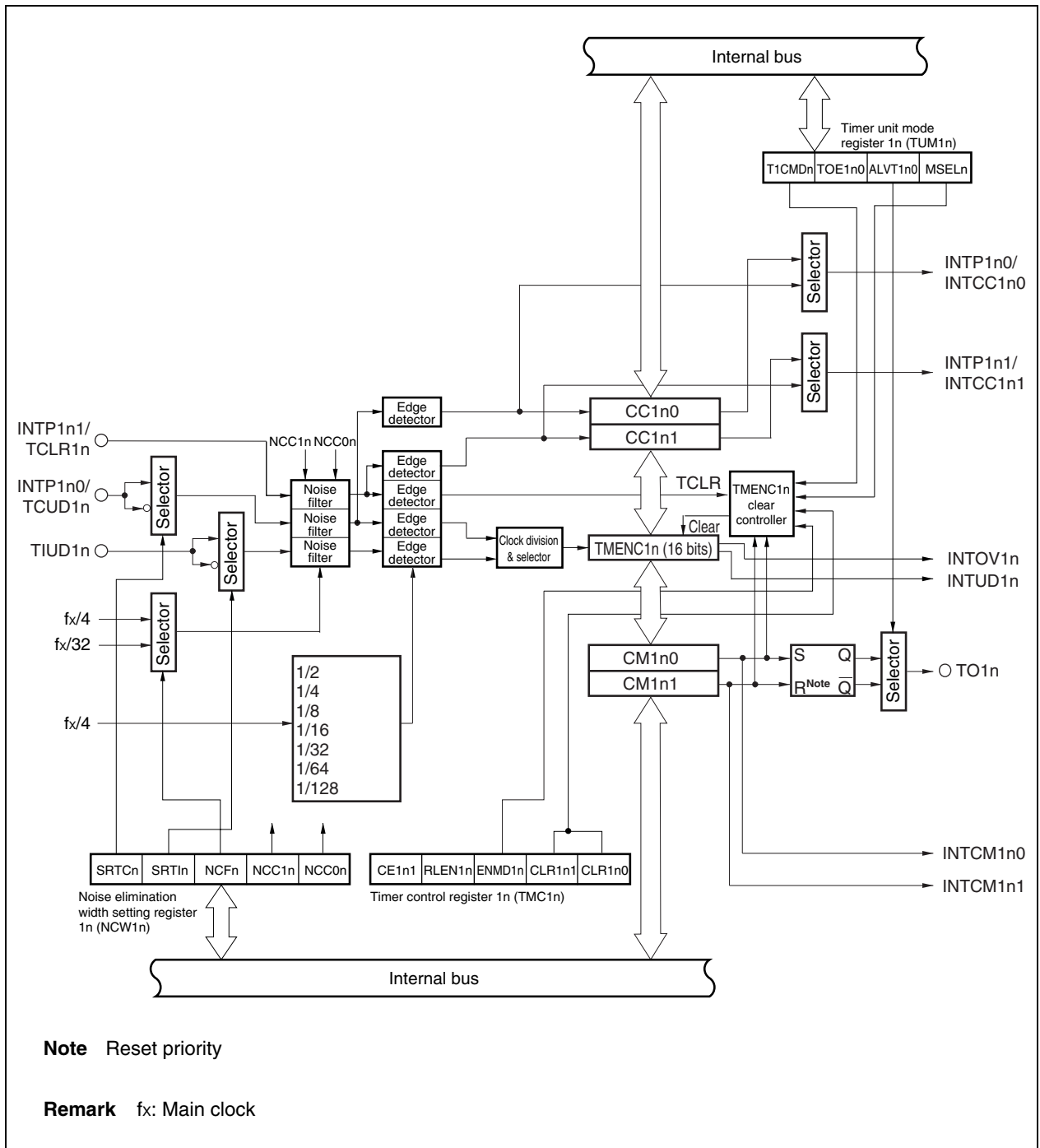
| Timer      | Count Clock                                       | Register | Read/Write | Generated Interrupt Request Signal | Capture Trigger |
|------------|---------------------------------------------------|----------|------------|------------------------------------|-----------------|
| Timer ENC1 | fx/8, fx/16, fx/32, fx/64, fx/128, fx/256, fx/512 | TMENC10  | Read/write | —                                  | —               |
|            |                                                   | CM100    | Read/write | INTCM100                           | —               |
|            |                                                   | CM101    | Read/write | INTCM101                           | —               |
|            |                                                   | CC100    | Read/write | INTCC100                           | INTP100         |
|            |                                                   | CC101    | Read/write | INTCC101                           | INTP101         |
|            |                                                   | TMENC11  | Read/write | —                                  | —               |
|            |                                                   | CM110    | Read/write | INTCM110                           | —               |
|            |                                                   | CM111    | Read/write | INTCM111                           | —               |
|            |                                                   | CC110    | Read/write | INTCC110                           | INTP110         |
|            |                                                   | CC111    | Read/write | INTCC111                           | INTP111         |

**Remark** fx: Main clock



## (1) Timer ENC1 (16-bit up/down counter)

Figure 9-17. Timer ENC1 Block Diagram



## 9.3.4 Timer ENC1

## (1) Timers ENC10, ENC11 (TMENC10, TMENC11)

TMENC1n is a general-purpose timer (in general-purpose mode) and 2-phase encoder input up/down counter (in UDC mode).

This timer counts up in the general-purpose operation mode and counts up/down in the UDC mode.

It can be read or written in 16-bit units.

- Cautions**
1. Writing to TMENC1n is enabled only when the CE1n1 bit of the TMC1n register is 0 (count operation disabled).
  2. Continuous reading of TMENC1n is prohibited. If TMENC1n is continuously read, the second read value may differ from the actual value. If TMENC1n must be read twice, be sure to read another register between the first and the second read operation.
  3. Writing the same value to the TMENC1n register is prohibited.

|         | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | Address   | After reset |
|---------|----|----|----|----|----|----|---|---|---|---|---|---|---|---|---|---|-----------|-------------|
| TMENC10 |    |    |    |    |    |    |   |   |   |   |   |   |   |   |   |   | FFFFF5A0H | 0000H       |
| TMENC11 |    |    |    |    |    |    |   |   |   |   |   |   |   |   |   |   | FFFFF5D0H | 0000H       |

TMENC1n start and stop is controlled by the CE1n1 bit of timer control register 1n (TMC1n).

The TMENC1n operation consists of the following two modes.

## (a) General-purpose timer mode

In the general-purpose timer mode, TMENC1n operates as a 16-bit interval timer, free-running timer, or timer output.

Counting is performed based on the count clock selected by software. Division by the prescaler can be selected for the count clock from among  $fx/8$ ,  $fx/16$ ,  $fx/32$ ,  $fx/64$ ,  $fx/128$ ,  $fx/256$ , or  $fx/512$  using the PRM1n2 to PRM1n0 bits of prescaler mode register 1n (PRM1n) (fx: main clock).

**(b) Up/down counter mode (UDC mode)**

In the UDC mode, TMENC1n functions as a 16-bit up/down counter that performs counting based on the TCUD1n and TIUD1n input signals. This mode is divided into the UDC A mode and UDC B mode, depending on the condition of clearing TMENC1n.

- Cautions 1.** The TCUD1n and INTP1n0 pins function alternately. Therefore, because the TCUD1n pin is used in the UDC mode, the external capture function of the INTP1n0 pin cannot be used.
- 2.** The TCLR1n and INTP1n1 pins function alternately. Therefore, when the TCLR1n input is used in UDC mode A, the external capture function of the INTP1n1 pin cannot be used.

The conditions for clearing TMENC1n are as follows, depending on the operation mode.

**Table 9-5. Timer ENC1 (TMENC1n) Clear Conditions**

| Operation Mode             | TUM1n Register |           | TMC1n Register |            |            | TMENC1n Clear                                                                                                                    |
|----------------------------|----------------|-----------|----------------|------------|------------|----------------------------------------------------------------------------------------------------------------------------------|
|                            | T1CMDn Bit     | MSELn Bit | ENMD1n Bit     | CLR1n1 Bit | CLR1n0 Bit |                                                                                                                                  |
| General-purpose timer mode | 0              | 0         | 0              | ×          | ×          | Clearing not performed (free-running timer)                                                                                      |
|                            |                |           | 1              | ×          | ×          | Cleared upon match with CM1n0 set value                                                                                          |
| UDC mode A                 | 1              | 0         | ×              | 0          | 0          | Cleared only by TCLR1n input                                                                                                     |
|                            |                |           | ×              | 0          | 1          | Cleared upon match with CM1n0 set value during up-count operation                                                                |
|                            |                |           | ×              | 1          | 0          | Cleared by TCLR1n input or upon match with CM1n0 set value during up-count operation                                             |
|                            |                |           | ×              | 1          | 1          | Clearing not performed                                                                                                           |
| UDC mode B                 | 1              | 1         | ×              | ×          | ×          | Cleared upon match with CM1n0 set value during up-count operation or upon match with CM1n1 set value during down-count operation |
| Other than the above       |                |           |                |            |            | Setting prohibited                                                                                                               |

**Remark** ×: Indicates that the set value of that bit is ignored.

## 9.3.5 Control registers

## (1) Timer unit mode registers 10, 11 (TUM10, TUM11)

The TUM1n register is an 8-bit register used to specify the TMENC1n operation mode or to control the operation of the timer output pin.

TUM1n can be read or written in 8-bit or 1-bit units.

- Cautions**
1. Changing the value of the TUM1n register during TMENC1n operation (CE1n1 bit of TMC1n register = 1) is prohibited.
  2. It is prohibited to set the MSELn bit (UDC mode B) to 1 when the T1CMDn bit is cleared to 0 (general-purpose timer mode).
  3. Writing the same value to the TUM1n register is permitted (writing the same value is guaranteed even during a count operation).

|       | 7      | 6 | 5 | 4 | 3      | 2       | 1 | 0     | Address   | After reset |
|-------|--------|---|---|---|--------|---------|---|-------|-----------|-------------|
| TUM10 | T1CMD0 | 0 | 0 | 0 | TOE100 | ALVT100 | 0 | MSEL0 | FFFFF5ABH | 00H         |
| TUM11 | T1CMD1 | 0 | 0 | 0 | TOE110 | ALVT110 | 0 | MSEL1 | FFFFF5DBH | 00H         |

| Bit position | Bit name | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|--------------|----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 7            | T1CMDn   | Specifies TMENC1n operation mode.<br>0: General-purpose timer mode (up count)<br>1: UDC mode (up/down count)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| 3            | TOE1n0   | Specifies timer output (TO1n) enable.<br>0: Timer output disabled<br>1: Timer output enabled<br><br><b>Caution</b> When T1CMDn bit = 1 (UDC mode), timer output is not performed regardless of the setting of the TOE1n0 bit. At this time, timer output consists of the negative phase level of the level set by the ALVT1n0 bit.                                                                                                                                                                                                                                                                                                                                   |
| 2            | ALVT1n0  | Specifies active level of timer output (TO1n).<br>0: Active level is high level<br>1: Active level is low level<br><br><b>Caution</b> When T1CMDn bit = 1 (UDC mode), timer output is not performed regardless of the setting of the TOE1n0 bit. At this time, timer output consists of the negative phase level of the level set by the ALVT1n0 bit.                                                                                                                                                                                                                                                                                                                |
| 0            | MSELn    | Specifies operation in UDC mode (up/down count)<br>0: UDC mode A<br>TMENC1n can be cleared by setting the CLR1n1 and CLR1n0 bits of the TMC1n register.<br>1: UDC mode B<br>TMENC1n is cleared in the following cases.<br><ul style="list-style-type: none"> <li>• Upon match with the CM1n0 register during TMENC1n up-count operation</li> <li>• Upon match with the CM1n1 register during TMENC1n down-count operation</li> </ul> <b>Caution</b> When the T1CMDn bit = 0 (general-purpose timer mode), setting MSELn bit = 1 (UDC mode B) is prohibited.<br><br>When UDC mode B is set, the ENMD1n, CLR1n1, and CLR1n0 bits of the TMC1n register become invalid. |

**Remark** n = 0, 1

**(2) Timer control registers 10, 11 (TMC10, TMC11)**

The TMC1n register is used to enable/disable TMENC1n operation and to set transfer and timer clear operations.

TMC1n can be read or written in 8-bit or 1-bit units.

- Cautions**
1. Changing the values of the TMC1n register bits other than the CE1n1 bit during TMENC1n operation (CE1n1 bit = 1) is prohibited.
  2. Writing the same value to the TMC1n register is permitted (writing the same value is guaranteed even during a count operation).

(1/2)

|       | 7 | <6>   | 5 | 4 | 3      | 2      | 1      | 0      | Address   | After reset |
|-------|---|-------|---|---|--------|--------|--------|--------|-----------|-------------|
| TMC10 | 0 | CE101 | 0 | 0 | RLEN10 | ENMD10 | CLR101 | CLR100 | FFFFF5ACH | 00H         |
| TMC11 | 0 | CE111 | 0 | 0 | RLEN11 | ENMD11 | CLR111 | CLR110 | FFFFF5DCH | 00H         |

| Bit position | Bit name | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|--------------|----------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 6            | CE1n1    | Enables/disables TMENC1n operation.<br>0: TMENC1n count operation disabled<br>1: TMENC1n count operation enabled                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| 3            | RLEN1n   | Enables/disables transfer from the CM1n0 register to TMENC1n in UDC mode A.<br>0: Transfer disabled<br>1: Transfer enabled<br><br><b>Cautions</b> 1. When the RLEN1n bit = 1, the value set to the CM1n0 register is transferred to TMENC1n upon occurrence of a TMENC1n underflow.<br>2. The RLEN1n bit is valid only in UDC mode A (TUM1n register's T1CMDn bit = 1, MSELn bit = 0). In the general-purpose timer mode (T1CMDn bit = 0) and in UDC mode B (T1CMDn bit = 1, MSELn bit = 1), a transfer operation is not performed even the RLEN1n bit is set to 1. |
| 2            | ENMD1n   | Enables/disables clearing of TMENC1n in general-purpose timer mode (T1CMDn bit of TUM1n register = 0).<br>0: Clear disabled (free-running mode)<br>Clearing is not performed even when the TMENC1n and CM1n0 register values match.<br>1: Clear enabled<br>Clearing is performed when the TMENC1n and CM1n0 register values match.<br><br><b>Caution</b> The ENMD1n bit setting becomes invalid in UDC mode (T1CMDn bit of TUM1n register = 1).                                                                                                                     |

**Remark** n = 0, 1

| Bit position                                                                                                                                                                                       | Bit name          | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |        |                                                                                               |                                |   |   |                                         |   |   |                                                                            |   |   |                                                                                               |   |   |             |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|-----------------------------------------------------------------------------------------------|--------------------------------|---|---|-----------------------------------------|---|---|----------------------------------------------------------------------------|---|---|-----------------------------------------------------------------------------------------------|---|---|-------------|
| 1, 0                                                                                                                                                                                               | CLR1n1,<br>CLR1n0 | Controls TMENC1n clear operation in UDC mode A.                                                                                                                                                                                                                                                                                                                                                                                                                                |        |                                                                                               |                                |   |   |                                         |   |   |                                                                            |   |   |                                                                                               |   |   |             |
|                                                                                                                                                                                                    |                   | <table><tr><th>CLR1n1</th><th>CLR1n0</th><th>Specifies TMENC1n clear source</th></tr><tr><td>0</td><td>0</td><td>Cleared only by external input (TCLR1n)</td></tr><tr><td>0</td><td>1</td><td>Cleared upon match of TMENC1n count value and the CM1n0 register set value</td></tr><tr><td>1</td><td>0</td><td>Cleared by TCLR1n input or upon match of TMENC1n count value and the CM1n0 register set value</td></tr><tr><td>1</td><td>1</td><td>Not cleared</td></tr></table> | CLR1n1 | CLR1n0                                                                                        | Specifies TMENC1n clear source | 0 | 0 | Cleared only by external input (TCLR1n) | 0 | 1 | Cleared upon match of TMENC1n count value and the CM1n0 register set value | 1 | 0 | Cleared by TCLR1n input or upon match of TMENC1n count value and the CM1n0 register set value | 1 | 1 | Not cleared |
|                                                                                                                                                                                                    |                   | CLR1n1                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | CLR1n0 | Specifies TMENC1n clear source                                                                |                                |   |   |                                         |   |   |                                                                            |   |   |                                                                                               |   |   |             |
|                                                                                                                                                                                                    |                   | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 0      | Cleared only by external input (TCLR1n)                                                       |                                |   |   |                                         |   |   |                                                                            |   |   |                                                                                               |   |   |             |
|                                                                                                                                                                                                    |                   | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 1      | Cleared upon match of TMENC1n count value and the CM1n0 register set value                    |                                |   |   |                                         |   |   |                                                                            |   |   |                                                                                               |   |   |             |
|                                                                                                                                                                                                    |                   | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 0      | Cleared by TCLR1n input or upon match of TMENC1n count value and the CM1n0 register set value |                                |   |   |                                         |   |   |                                                                            |   |   |                                                                                               |   |   |             |
|                                                                                                                                                                                                    |                   | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 1      | Not cleared                                                                                   |                                |   |   |                                         |   |   |                                                                            |   |   |                                                                                               |   |   |             |
| <b>Cautions</b>                                                                                                                                                                                    |                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |        |                                                                                               |                                |   |   |                                         |   |   |                                                                            |   |   |                                                                                               |   |   |             |
| 1. Clearing by match of the TMENC1n count value and the CM1n0 register set value is valid only during a TMENC1n up-count operation (TMENC1n is not cleared during a TMENC1n down-count operation). |                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |        |                                                                                               |                                |   |   |                                         |   |   |                                                                            |   |   |                                                                                               |   |   |             |
| 2. The CLR1n1 and CLR1n0 bit settings are invalid in general-purpose timer mode (T1CMDn bit of TUM1n register = 0).                                                                                |                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |        |                                                                                               |                                |   |   |                                         |   |   |                                                                            |   |   |                                                                                               |   |   |             |
| 3. The CLR1n1 and CLR1n0 bit settings are invalid in UDC mode B (MSELn bit of TUM1n register = 1).                                                                                                 |                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |        |                                                                                               |                                |   |   |                                         |   |   |                                                                            |   |   |                                                                                               |   |   |             |
| 4. When clearing by TCLR1n has been enabled by the CLR1n1 and CLR1n0 bits, clearing is performed whether the value of the CE1n1 bit is 1 or 0.                                                     |                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |        |                                                                                               |                                |   |   |                                         |   |   |                                                                            |   |   |                                                                                               |   |   |             |

**Remark** n = 0, 1

**(3) Capture/compare control registers 10, 11 (CCR10, CCR11)**

The CCR1n register specifies the operation mode of the CC1n0 and CC1n1 registers.

CCR1n can be read or written in 8-bit or 1-bit units.

- Cautions**
1. Overwriting the CCR1n register during TMENC1n operation (CE1n1 bit of TMC1n register = 1) is prohibited.
  2. The TCUD1n and INTP1n0 pins function alternately. Therefore, because the TCUD1n pin is used in the UDC mode, the external capture function of the INTP1n0 pin cannot be used.
  3. The TCLR1n and INTP1n1 pins function alternately. Therefore, when the TCLR1n input is used in UDC mode A, the external capture function of the INTP1n1 pin cannot be used.
  4. Writing the same value to the CCR1n register is permitted (writing the same value is guaranteed even during a count operation).

|       |   |   |   |   |   |   |       |       |           |             |
|-------|---|---|---|---|---|---|-------|-------|-----------|-------------|
|       | 7 | 6 | 5 | 4 | 3 | 2 | 1     | 0     | Address   | After reset |
| CCR10 | 0 | 0 | 0 | 0 | 0 | 0 | CMS01 | CMS00 | FFFFF5AAH | 00H         |
| CCR11 | 0 | 0 | 0 | 0 | 0 | 0 | CMS11 | CMS10 | FFFFF5DAH | 00H         |

| Bit position | Bit name | Function                                                                                      |
|--------------|----------|-----------------------------------------------------------------------------------------------|
| 1            | CMSn1    | Specifies operation mode of the CC1n1 register.<br>0: Capture register<br>1: Compare register |
| 0            | CMSn0    | Specifies operation mode of the CC1n0 register.<br>0: Capture register<br>1: Compare register |

**Remark** n = 0, 1

#### (4) Valid edge select registers 10, 11 (SESA10, SESA11)

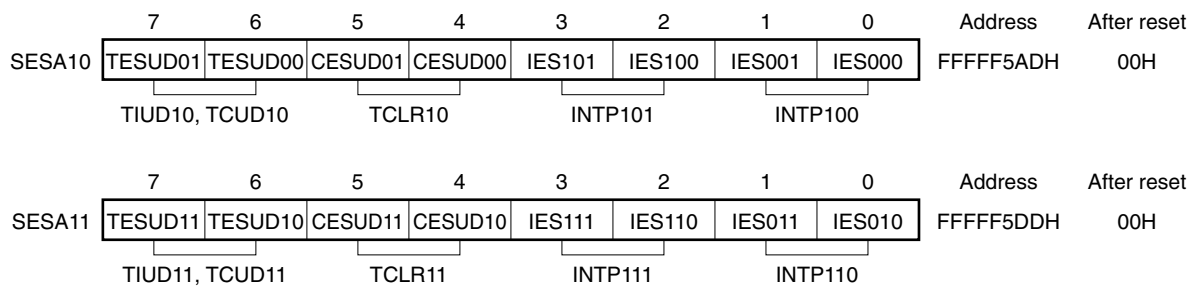
The SESA1n register is used to specify the valid edge of external interrupt request signals from external pins (INTP100, INTP101, INTP110, INTP111, TIUD10, TIUD11, TCUD10, TCUD11, TCLR10, TCLR11).

The valid edge (rising edge, falling edge, or both rising and falling edges) can be specified independently for each pin.

SESA1n can be read or written in 8-bit or 1-bit units.

- Cautions**
1. Changing the values of the SESA1n register bits during TMENC1n operation (CE1n1 bit of TMC1n register = 1) is prohibited.
  2. Set the PMCDH register before setting the trigger mode of the INTP100, INTP101, INTP110, INTP111, TIUD10, TIUD11, TCUD10, TCUD11, TCLR10, and TCLR11 pins. If the PMCDH register is set after the SESA1n register has been set, an illegal interrupt, incorrect counting, and incorrect clearing may occur depending on the timing of setting the PMCDH register.
  3. Writing the same value to the SESA1n register is permitted (writing the same value is guaranteed even during a count operation).

(1/2)



| Bit position                                                                                                                                                                                                                      | Bit name            | Function                                                                                                                                                                                                                                                                                                  |         |                               |            |   |   |              |   |   |             |   |   |                    |   |   |                               |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|-------------------------------|------------|---|---|--------------|---|---|-------------|---|---|--------------------|---|---|-------------------------------|
| 7, 6                                                                                                                                                                                                                              | TESUDn1,<br>TESUDn0 | Specifies valid edge of pins TIUD1n, TCUD1n.                                                                                                                                                                                                                                                              |         |                               |            |   |   |              |   |   |             |   |   |                    |   |   |                               |
|                                                                                                                                                                                                                                   |                     | <table><tr><th>TESUDn1</th><th>TESUDn0</th><th>Valid edge</th></tr><tr><td>0</td><td>0</td><td>Falling edge</td></tr><tr><td>0</td><td>1</td><td>Rising edge</td></tr><tr><td>1</td><td>0</td><td>Setting prohibited</td></tr><tr><td>1</td><td>1</td><td>Both rising and falling edges</td></tr></table> | TESUDn1 | TESUDn0                       | Valid edge | 0 | 0 | Falling edge | 0 | 1 | Rising edge | 1 | 0 | Setting prohibited | 1 | 1 | Both rising and falling edges |
|                                                                                                                                                                                                                                   |                     | TESUDn1                                                                                                                                                                                                                                                                                                   | TESUDn0 | Valid edge                    |            |   |   |              |   |   |             |   |   |                    |   |   |                               |
|                                                                                                                                                                                                                                   |                     | 0                                                                                                                                                                                                                                                                                                         | 0       | Falling edge                  |            |   |   |              |   |   |             |   |   |                    |   |   |                               |
|                                                                                                                                                                                                                                   |                     | 0                                                                                                                                                                                                                                                                                                         | 1       | Rising edge                   |            |   |   |              |   |   |             |   |   |                    |   |   |                               |
|                                                                                                                                                                                                                                   |                     | 1                                                                                                                                                                                                                                                                                                         | 0       | Setting prohibited            |            |   |   |              |   |   |             |   |   |                    |   |   |                               |
|                                                                                                                                                                                                                                   |                     | 1                                                                                                                                                                                                                                                                                                         | 1       | Both rising and falling edges |            |   |   |              |   |   |             |   |   |                    |   |   |                               |
| <b>Cautions</b>                                                                                                                                                                                                                   |                     |                                                                                                                                                                                                                                                                                                           |         |                               |            |   |   |              |   |   |             |   |   |                    |   |   |                               |
| 1. The setting of the TESUDn1 and TESUDn0 bits are only valid in UDC mode A and UDC mode B.                                                                                                                                       |                     |                                                                                                                                                                                                                                                                                                           |         |                               |            |   |   |              |   |   |             |   |   |                    |   |   |                               |
| 2. If mode 4 is specified as the operation mode of TMENC1n (specified by the PRM1n2 to PRM1n0 bits of the PRM1n register), the valid edge specifications for the TIUD1n and TCUD1n pins (bits TESUDn1 and TESUDn0) are not valid. |                     |                                                                                                                                                                                                                                                                                                           |         |                               |            |   |   |              |   |   |             |   |   |                    |   |   |                               |
|                                                                                                                                                                                                                                   |                     |                                                                                                                                                                                                                                                                                                           |         |                               |            |   |   |              |   |   |             |   |   |                    |   |   |                               |

**Remark** n = 0, 1



| Bit position                  | Bit name            | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |         |         |            |   |   |              |   |   |             |   |   |                    |   |   |                               |
|-------------------------------|---------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|---------|------------|---|---|--------------|---|---|-------------|---|---|--------------------|---|---|-------------------------------|
| 5, 4                          | CESUDn1,<br>CESUDn0 | <p>Specifies valid edge of TCLR1n pin.</p> <table> <tr> <th>CESUDn1</th><th>CESUDn0</th><th>Valid edge</th></tr> <tr> <td>0</td><td>0</td><td>Falling edge</td></tr> <tr> <td>0</td><td>1</td><td>Rising edge</td></tr> <tr> <td>1</td><td>0</td><td>Low level</td></tr> <tr> <td>1</td><td>1</td><td>High level</td></tr> </table> <p>The set values of bits CESUDn1 and CESUDn0 and the TMENC1n operation are related as follows.</p> <p>00: TMENC1n cleared after detection of rising edge of TCLR1n<br/> 01: TMENC1n cleared after detection of falling edge of TCLR1n<br/> 10: TMENC1n cleared status held while TCLR1n input is low level<br/> 11: TMENC1n cleared status held while TCLR1n input is high level</p> <p><b>Caution</b> The setting of the CESUDn1 and CESUDn0 bits are valid only in UDC mode A.</p> | CESUDn1 | CESUDn0 | Valid edge | 0 | 0 | Falling edge | 0 | 1 | Rising edge | 1 | 0 | Low level          | 1 | 1 | High level                    |
| CESUDn1                       | CESUDn0             | Valid edge                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |         |         |            |   |   |              |   |   |             |   |   |                    |   |   |                               |
| 0                             | 0                   | Falling edge                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |         |         |            |   |   |              |   |   |             |   |   |                    |   |   |                               |
| 0                             | 1                   | Rising edge                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |         |         |            |   |   |              |   |   |             |   |   |                    |   |   |                               |
| 1                             | 0                   | Low level                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |         |         |            |   |   |              |   |   |             |   |   |                    |   |   |                               |
| 1                             | 1                   | High level                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |         |         |            |   |   |              |   |   |             |   |   |                    |   |   |                               |
| 3, 2                          | IES1n1,<br>IES1n0   | <p>Specifies valid edge of INTP1n1 pin.</p> <table> <tr> <th>IES1n1</th><th>IES1n0</th><th>Valid edge</th></tr> <tr> <td>0</td><td>0</td><td>Falling edge</td></tr> <tr> <td>0</td><td>1</td><td>Rising edge</td></tr> <tr> <td>1</td><td>0</td><td>Setting prohibited</td></tr> <tr> <td>1</td><td>1</td><td>Both rising and falling edges</td></tr> </table>                                                                                                                                                                                                                                                                                                                                                                                                                                                            | IES1n1  | IES1n0  | Valid edge | 0 | 0 | Falling edge | 0 | 1 | Rising edge | 1 | 0 | Setting prohibited | 1 | 1 | Both rising and falling edges |
| IES1n1                        | IES1n0              | Valid edge                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |         |         |            |   |   |              |   |   |             |   |   |                    |   |   |                               |
| 0                             | 0                   | Falling edge                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |         |         |            |   |   |              |   |   |             |   |   |                    |   |   |                               |
| 0                             | 1                   | Rising edge                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |         |         |            |   |   |              |   |   |             |   |   |                    |   |   |                               |
| 1                             | 0                   | Setting prohibited                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |         |         |            |   |   |              |   |   |             |   |   |                    |   |   |                               |
| 1                             | 1                   | Both rising and falling edges                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |         |         |            |   |   |              |   |   |             |   |   |                    |   |   |                               |
| 1, 0                          | IES0n1,<br>IES0n0   | <p>Specifies valid edge of INTP1n0 pin.</p> <table> <tr> <th>IES0n1</th><th>IES0n0</th><th>Valid edge</th></tr> <tr> <td>0</td><td>0</td><td>Falling edge</td></tr> <tr> <td>0</td><td>1</td><td>Rising edge</td></tr> <tr> <td>1</td><td>0</td><td>Setting prohibited</td></tr> <tr> <td>1</td><td>1</td><td>Both rising and falling edges</td></tr> </table>                                                                                                                                                                                                                                                                                                                                                                                                                                                            | IES0n1  | IES0n0  | Valid edge | 0 | 0 | Falling edge | 0 | 1 | Rising edge | 1 | 0 | Setting prohibited | 1 | 1 | Both rising and falling edges |
| IES0n1                        | IES0n0              | Valid edge                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |         |         |            |   |   |              |   |   |             |   |   |                    |   |   |                               |
| 0                             | 0                   | Falling edge                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |         |         |            |   |   |              |   |   |             |   |   |                    |   |   |                               |
| 0                             | 1                   | Rising edge                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |         |         |            |   |   |              |   |   |             |   |   |                    |   |   |                               |
| 1                             | 0                   | Setting prohibited                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |         |         |            |   |   |              |   |   |             |   |   |                    |   |   |                               |
| 1                             | 1                   | Both rising and falling edges                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |         |         |            |   |   |              |   |   |             |   |   |                    |   |   |                               |
| <p><b>Remark</b> n = 0, 1</p> |                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |         |         |            |   |   |              |   |   |             |   |   |                    |   |   |                               |

**(5) Prescaler mode registers 10, 11 (PRM10, PRM11)**

The PRM1n register is used to perform the following selections.

- Selection of count clock in general-purpose timer mode (T1CMDn bit of TUM1n register = 0)
- Selection of count operation mode in UDC mode (T1CMDn bit = 1)

PRM1n can be read or written in 8-bit or 1-bit units.

- Cautions**
1. Overwriting the PRM1n register during TMENC1n operation (CE1n1 bit of TMC1n register = 1) is prohibited.
  2. Clearing the PRM1n2 bit to 0 is prohibited in UDC mode (T1CMDn bit of TUM1n register = 1).
  3. When TMENC1n is in mode 4, specification of the valid edge for the TIUD1n and TCUD1n pins is invalid.
  4. Writing the same value to the PRM1n register is permitted (writing the same value is guaranteed even during a count operation).

|       | 7 | 6 | 5 | 4 | 3 | 2      | 1      | 0      | Address   | After reset |
|-------|---|---|---|---|---|--------|--------|--------|-----------|-------------|
| PRM10 | 0 | 0 | 0 | 0 | 0 | PRM102 | PRM101 | PRM100 | FFFFF5AEH | 07H         |
| PRM11 | 0 | 0 | 0 | 0 | 0 | PRM112 | PRM111 | PRM110 | FFFFF5DEH | 07H         |

| Bit position | Bit name         | Function                                                                                                                                                            |        |        |                    |                    |          |  |
|--------------|------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|--------|--------------------|--------------------|----------|--|
| 2 to 0       | PRM1n2 to PRM1n0 | Specifies the up-/down-count operation mode during input of the clock rate when the internal clock of the TMENC1n is used, or during external clock (TIUD1n) input. |        |        |                    |                    |          |  |
|              |                  | PRM1n2                                                                                                                                                              | PRM1n1 | PRM1n0 | T1CMDn = 0         | T1CMDn = 1         |          |  |
|              |                  |                                                                                                                                                                     |        |        | Count clock        | Count clock        | UDC mode |  |
|              |                  | 0                                                                                                                                                                   | 0      | 0      | Setting prohibited | Setting prohibited |          |  |
|              |                  | 0                                                                                                                                                                   | 0      | 1      | fx/8               |                    |          |  |
|              |                  | 0                                                                                                                                                                   | 1      | 0      | fx/16              |                    |          |  |
|              |                  | 0                                                                                                                                                                   | 1      | 1      | fx/32              |                    |          |  |
|              |                  | 1                                                                                                                                                                   | 0      | 0      | fx/64              | TIUD1n             | Mode 1   |  |
|              |                  | 1                                                                                                                                                                   | 0      | 1      | fx/128             |                    | Mode 2   |  |
|              |                  | 1                                                                                                                                                                   | 1      | 0      | fx/256             |                    | Mode 3   |  |
|              |                  | 1                                                                                                                                                                   | 1      | 1      | fx/512             |                    | Mode 4   |  |
|              |                  | <b>Remark</b> fx: Main clock                                                                                                                                        |        |        |                    |                    |          |  |

**Remark**    n = 0, 1

**(a) In general-purpose timer mode (T1CMDn bit of TUM1n register = 0)**

The count clock is specified by the PRM1n2 to PRM1n0 bits.

**(b) UDC mode (T1CMDn bit of TUM1n register = 1)**

The TMENC1n count triggers in the UDC mode are as follows.

| Operation Mode | TMENC1n Operation                                                                                                                                                 |
|----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Mode 1         | Down count upon detection of valid edge of TIUD1n input when TCUD1n = high level<br>Up count upon detection of valid edge of TIUD1n input when TCUD1n = low level |
| Mode 2         | Up count upon detection of valid edge of TIUD1n input<br>Down count upon detection of valid edge of TCUD1n input                                                  |
| Mode 3         | Up count upon detection of valid edge of TIUD1n input when TCUD1n = high level<br>Down count upon detection of valid edge of TIUD1n input when TCUD1n = low level |
| Mode 4         | Automatic judgment upon detection of both edges of TIUD1n input and both edges of TCUD1n input                                                                    |

**(6) Status registers 10, 11 (STATUS10, STATUS11)**

The STATUS1n register indicates the operating status of TMENC1n.

STATUS1n is read-only, in 8-bit or 1-bit units.

**Caution** Writing the same value to the STATUS1n register is prohibited.

|          | 7 | 6 | 5 | 4 | 3 | <2>   | <1>   | <0>   | Address   | After reset |
|----------|---|---|---|---|---|-------|-------|-------|-----------|-------------|
| STATUS10 | 0 | 0 | 0 | 0 | 0 | UDF10 | OVF10 | UBD10 | FFFFF5AFH | 00H         |
| STATUS11 | 0 | 0 | 0 | 0 | 0 | UDF11 | OVF11 | UBD11 | FFFFF5DFH | 00H         |

| Bit position | Bit name | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|--------------|----------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 2            | UDF1n    | TMENC1n underflow flag<br>0: No TMENC1n count underflow<br>1: TMENC1n count underflow<br><br><b>Caution</b> The UDF1n bit is cleared to 0 upon completion of a read access to the STATUS1n register from the CPU.                                                                                                                                                                                                                                                                                   |
| 1            | OVF1n    | TMENC1n overflow flag<br>0: No TMENC1n count overflow<br>1: TMENC1n count overflow<br><br><b>Caution</b> The OVF1n bit is cleared to 0 upon completion of a read access to the STATUS1n register from the CPU.                                                                                                                                                                                                                                                                                      |
| 0            | UBD1n    | Indicates the operating status of TMENC1n up/down count.<br>0: TMENC1n up count in progress<br>1: TMENC1n down count in progress<br><br><b>Caution</b> The state of the UBD1n bit differs according to the mode as follows. <ul style="list-style-type: none"> <li>• The UBD1n bit is fixed to 0 in general-purpose timer mode (T1CMDn bit of TUM1n register = 0).</li> <li>• The UBD1n bit indicates the TMENC1n up-/down-count status in UDC mode B (MSELn bit of TUM1n register = 1).</li> </ul> |

**Remark** n = 0, 1

**(7) Noise elimination width setting registers 10, 11 (NCW10, NCW11)**

The NCW1n register is used to set the noise elimination width of the digital noise filter of the timer ENC1 input pin.

NCW1n can be read or written in 8-bit units.

- Cautions**
- Whether the signal is input through or inverted can be specified for each of the INTP1n0/TCUD1n and TIUD1n pins. The setting of the noise elimination width by the NCFn, NCC1n, and NCC0n bits is for each timer and cannot be changed for each pin.
  - The setting of the SRTCn bit is valid even when the INTP1n0/TCUD1n pin is used as a capture trigger (INTP1n0).

|       | 7 | 6 | 5     | 4     | 3 | 2    | 1     | 0     | Address   | After reset |
|-------|---|---|-------|-------|---|------|-------|-------|-----------|-------------|
| NCW10 | 0 | 0 | SRTC0 | SRTI0 | 0 | NCF0 | NCC10 | NCC00 | FFFFF5C0H | 02H         |
| NCW11 | 0 | 0 | SRTC1 | SRTI1 | 0 | NCF1 | NCC11 | NCC01 | FFFFF5F0H | 02H         |

| Bit position            | Bit name                | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                         |                         |                                                     |   |   |                                     |   |   |   |   |   |   |   |   |   |
|-------------------------|-------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|-------------------------|-----------------------------------------------------|---|---|-------------------------------------|---|---|---|---|---|---|---|---|---|
| 5                       | SRTCn                   | Sets the input mode of the INTP1n0/TCUD1n pin.<br>0: Through input<br>1: Inverted<br>This bit specifies whether the signal input from the INTP1n0/TCUD1n pin is input through to TMENC1n or inverted.                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                         |                         |                                                     |   |   |                                     |   |   |   |   |   |   |   |   |   |
| 4                       | SRTIn                   | Sets the input mode of the TIUD1n pin.<br>0: Through input<br>1: Inverted<br>This bit specifies whether the signal input from the TIUD1n pin is input through to TMENC1n or inverted.                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                         |                         |                                                     |   |   |                                     |   |   |   |   |   |   |   |   |   |
| 2                       | NCFn                    | Specifies the clock frequency for noise elimination.<br>0: $f_x/4$<br>1: $f_x/32$<br>This bit selects the clock source of the noise filter.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                         |                         |                                                     |   |   |                                     |   |   |   |   |   |   |   |   |   |
| 1, 0                    | NCC1n,<br>NCC0n         | Specify the number of clocks by which noise is to be eliminated.<br><table border="1"> <tr> <th>NCC1n<sup>Note 1</sup></th><th>NCC0n<sup>Note 1</sup></th><th>Number of clocks by which noise is to be eliminated</th></tr> <tr> <td>0</td><td>0</td><td>0 (through input)<sup>Note 2</sup></td></tr> <tr> <td>0</td><td>1</td><td>2</td></tr> <tr> <td>1</td><td>0</td><td>3</td></tr> <tr> <td>1</td><td>1</td><td>7</td></tr> </table> <p><b>Notes</b></p> <p>1. Do not overwrite this bit during a count operation.</p> <p>2. Clear the NCFn bit to 0 for through input.</p> <p>These bits select the number of clocks by which noise is to be eliminated.</p> | NCC1n <sup>Note 1</sup> | NCC0n <sup>Note 1</sup> | Number of clocks by which noise is to be eliminated | 0 | 0 | 0 (through input) <sup>Note 2</sup> | 0 | 1 | 2 | 1 | 0 | 3 | 1 | 1 | 7 |
| NCC1n <sup>Note 1</sup> | NCC0n <sup>Note 1</sup> | Number of clocks by which noise is to be eliminated                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                         |                         |                                                     |   |   |                                     |   |   |   |   |   |   |   |   |   |
| 0                       | 0                       | 0 (through input) <sup>Note 2</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                         |                         |                                                     |   |   |                                     |   |   |   |   |   |   |   |   |   |
| 0                       | 1                       | 2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                         |                         |                                                     |   |   |                                     |   |   |   |   |   |   |   |   |   |
| 1                       | 0                       | 3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                         |                         |                                                     |   |   |                                     |   |   |   |   |   |   |   |   |   |
| 1                       | 1                       | 7                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                         |                         |                                                     |   |   |                                     |   |   |   |   |   |   |   |   |   |

**Remark** n = 0, 1

## (a) Relationship between NCW1n register set value and noise elimination width

Table 9-6. Relationship Between NCW1n Register Set Value and Noise Elimination Width

| NCW1n Register |           |           | Noise Elimination Width (ns) |                         |                         | Remark                  |
|----------------|-----------|-----------|------------------------------|-------------------------|-------------------------|-------------------------|
| NCFn Bit       | NCC1n Bit | NCC0n Bit | $f_x = 150 \text{ MHz}$      | $f_x = 133 \text{ MHz}$ | $f_x = 100 \text{ MHz}$ |                         |
| 0              | 0         | 0         | 0                            | 0                       | 0                       | Through                 |
| 0              | 0         | 1         | 53.3 to 80.0                 | 60.2 to 90.2            | 80 to 120               | $(1/(f_x/4)) \times 2$  |
| 0              | 1         | 0         | 80.0 to 106.7                | 90.2 to 120.3           | 120 to 160              | $(1/(f_x/4)) \times 3$  |
| 0              | 1         | 1         | 133.3 to 160.0               | 150.4 to 180.5          | 200 to 240              | $(1/(f_x/4)) \times 5$  |
| 1              | 0         | 1         | 426.7 to 640.0               | 481.2 to 721.8          | 640 to 960              | $(1/(f_x/32)) \times 2$ |
| 1              | 1         | 0         | 640.0 to 853.3               | 721.8 to 962.9          | 960 to 1,280            | $(1/(f_x/32)) \times 3$ |
| 1              | 1         | 1         | 1,066.7 to 1,280.0           | 1,203.0 to 1,443.6      | 1,600 to 1,920          | $(1/(f_x/32)) \times 5$ |

- Remarks**
1.  $n = 0, 1$
  2.  $f_x$ : Main clock

## (8) Compare registers 100, 110 (CM100, CM110)

The CM1n0 register is a 16-bit register that always compares its value with the value of TMENC1n. When the value of a compare register matches the value of TMENC1n, an interrupt request signal is generated. The CM1n0 register can be read or written in 16-bit units. The interrupt request signal generation timing in the various modes is described below.

- In the general-purpose timer mode (T1CMDn bit of TUM1n register = 0) and UDC mode A (MSELn bit of TUM1n register = 0), an interrupt request signal (INTCM1n0) is generated upon occurrence of a match.
- In UDC mode B (MSELn bit of TUM1n register = 1), an interrupt request signal (INTCM1n0) is generated only upon occurrence of a match during an up-count operation.

- Cautions**
1. When the CE1n1 bit of the TMC1n register is 1, it is prohibited to overwrite the value of the CM1n0 register.
  2. Writing the same value to the CM1n0 register is permitted (writing the same value is guaranteed even during a count operation).

|       | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | Address   | After reset |
|-------|----|----|----|----|----|----|---|---|---|---|---|---|---|---|---|---|-----------|-------------|
| CM100 |    |    |    |    |    |    |   |   |   |   |   |   |   |   |   |   | FFFFF5A2H | 0000H       |
| CM110 |    |    |    |    |    |    |   |   |   |   |   |   |   |   |   |   | FFFFF5D2H | 0000H       |

**(9) Compare registers 101, 111 (CM101, CM111)**

The CM1n1 register is a 16-bit register that always compares its value with the value of TMENC1n. When the value of the compare register matches the value of TMENC1n, an interrupt request signal is generated. The CM1n1 register can be read or written in 16-bit units. The interrupt request signal generation timing in the various modes is described below.

- In the general-purpose timer mode (T1CMDn bit of TUM1n register = 0) and UDC mode A (MSELn bit of TUM1n register = 0), an interrupt request signal (INTCM1n1) is generated upon occurrence of a match.
- In UDC mode B (MSELn bit of TUM1n register = 1), an interrupt request signal (INTCM1n1) is generated only upon occurrence of a match during a down-count operation.

- Cautions**
1. When the CE1n1 bit of the TMC1n register is 1, it is prohibited to overwrite the value of the CM1n1 register.
  2. Writing the same value to the CM1n1 register is permitted (writing the same value is guaranteed even during a count operation).

|       | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | Address   | After reset |
|-------|----|----|----|----|----|----|---|---|---|---|---|---|---|---|---|---|-----------|-------------|
| CM101 |    |    |    |    |    |    |   |   |   |   |   |   |   |   |   |   | FFFFF5A4H | 0000H       |
| CM111 |    |    |    |    |    |    |   |   |   |   |   |   |   |   |   |   | FFFFF5D4H | 0000H       |

**(10) Capture/compare registers 100, 110 (CC100, CC110)**

The CC1n0 register is a 16-bit register. It can be specified as a capture register or as a compare register using the CCR1n register. CC1n0 can be read or written in 16-bit units.

- Cautions**
1. When used as a capture register (CMSn0 bit of CCR1n register = 0), write access is prohibited.
  2. When used as a compare register (CMSn0 bit of CCR1n register = 1) during TMENC1n operation (CE1n1 bit of TMC1n register = 1), overwriting the CC1n0 register values is prohibited.
  3. When TMENC1n has been stopped (CE1n1 bit of TMC1n register = 0), the capture trigger is disabled.
  4. When the operation mode is changed from capture register to compare register, set a new compare value.
  5. Continuous reading of the CC1n0 register is prohibited. If the CC1n0 register is continuously read, the second read value may differ from the actual value. If the CC1n0 register must be read twice, be sure to read another register between the first and the second read operation.
  6. Writing the same value to the CC1n0 register is prohibited.

|       | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | Address   | After reset |
|-------|----|----|----|----|----|----|---|---|---|---|---|---|---|---|---|---|-----------|-------------|
| CC100 |    |    |    |    |    |    |   |   |   |   |   |   |   |   |   |   | FFFFF5A6H | 0000H       |
| CC110 |    |    |    |    |    |    |   |   |   |   |   |   |   |   |   |   | FFFFF5D6H | 0000H       |

**(a) When set as a capture register**

When the CC1n0 register is set as a capture register, the valid edge of the corresponding external interrupt request signal (INTP1n0) is detected as the capture trigger. TMENC1n latches the count value in synchronization with the capture trigger (capture operation). The latched value is held in the capture register until the next capture operation.

The valid edge of external interrupt request signals (rising edge, falling edge, both rising and falling edges) is selected by the SESA1n register.

When the CC1n0 register is specified as a capture register, interrupt request signals are generated upon detection of the valid edge of the INTP1n0 signal.

**Caution** The TCUD1n and INTP1n0 pins function alternately. Therefore, because the TCUD1n pin is used in the UDC mode, the external capture function of the INTP1n0 pin cannot be used.

**(b) When set as a compare register**

When the CC1n0 register is set as a compare register, it always compares its own value with the value of the TMENC1n register. If the value of the CC1n0 register matches the value of the TMENC1n register, the CC1n0 register generates an interrupt request signal (INTCC1n0).



**(11) Capture/compare registers 101, 111 (CC101, CC111)**

The CC1n1 register is a 16-bit register. It can be specified as a capture register or as a compare register using the CCR1n register. The CC1n1 register can be read or written in 16-bit units.

- Cautions**
1. When used as a capture register (CMSn1 bit of CCR1n register = 0), write access is prohibited.
  2. When used as a compare register (CMSn1 bit of CCR1n register = 1) during TMENC1n operation (CE1n1 bit of TMC1n register = 1), overwriting the CC1n1 register values is prohibited.
  3. When TMENC1n has been stopped (CE1n1 bit of TMC1n register = 0), the capture trigger is disabled.
  4. When the operation mode is changed from capture register to compare register, newly set a compare value.
  5. Continuous reading of the CC1n1 register is prohibited. If the CC1n1 register is continuously read, the second read value may differ from the actual value. If the CC1n1 register must be read twice, be sure to read another register between the first and the second read operation.
  6. Writing the same value to the CC1n1 register is prohibited.

|       | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | Address   | After reset |
|-------|----|----|----|----|----|----|---|---|---|---|---|---|---|---|---|---|-----------|-------------|
| CC101 |    |    |    |    |    |    |   |   |   |   |   |   |   |   |   |   | FFFFF5A8H | 0000H       |
| CC111 |    |    |    |    |    |    |   |   |   |   |   |   |   |   |   |   | FFFFF5D8H | 0000H       |

**(a) When set as a capture register**

When the CC1n1 register is set as a capture register, the valid edge of the corresponding external interrupt request signal (INTP1n1) is detected as the capture trigger. TMENC1n latches the count value in synchronization with the capture trigger (capture operation). The latched value is held in the capture register until the next capture operation.

The valid edge of external interrupt request signals (rising edge, falling edge, both rising and falling edges) is selected by the SESA1n register.

When the CC1n1 register is specified as a capture register, interrupts are generated upon detection of the valid edge of the INTP1n1 signal.

**Caution** The TCLR1n and INTP1n1 pins function alternately. Therefore, when the TCLR1n input is used in UDC mode A, the external capture function of the INTP1n1 pin cannot be used.

**(b) When set as a compare register**

When the CC1n1 register is set as a compare register, it always compares its own value with the value of the TMENC1n register. If the value of the CC1n1 register matches the value of the TMENC1n register, the CC1n1 register generates an interrupt request signal (INTCC1n1).

### 9.3.6 Operation

#### (1) Operation in general-purpose timer mode

TMENC1n can perform the following operations in the general-purpose timer mode.

##### (a) Interval operation (when TMC1n.ENMD1n0 bit = 1)

TMENC1n and the CM1n0 register always compare their values and the INTCM1n0 interrupt request signal is generated upon occurrence of a match. TMENC1n is cleared to 0000H at the count clock following the match. Furthermore, when one more count clock is input, TMENC1n counts up to 0001H. The interval time can be calculated with the following formula.

$$\text{Interval time} = (\text{CM1n0 register value} + 1) \times \text{TMENC1n count clock rate}$$

##### (b) Free-running operation (when TMC1n.ENMD1n0 bit = 0)

TMENC1n fully counts from 0000H to FFFFH, is cleared to 0000H at the next count clock after the STATUS1n.OVF1n bit has been set (1), and continues counting. The free-running cycle can be calculated by the following formula.

$$\text{Free-running cycle} = 65,536 \times \text{TMENC1n count clock rate}$$

##### (c) Compare function

TMENC1n connects two compare register (CM1n0, CM1n1) channels and two capture/compare register (CC1n0, CC1n1) channels.

When the TMENC1n count value and the set value of one of the compare registers match, a match interrupt request signal (INTCM1n0, INTCM1n1, INTCC1n0<sup>Note</sup>, INTCC1n1<sup>Note</sup>) is output. Particularly in the case of interval operation, TMENC1n is cleared upon generation of the INTCM1n0 interrupt.

**Note** This match interrupt request signal is generated when the CC1n0 and CC1n1 registers are set to the compare register mode.

##### (d) Capture function

TMENC1n connects two capture/compare register (CC1n0, CC1n1) channels.

When the CC1n0 and CC1n1 registers are set to the capture register mode, the value of TMENC1n is captured in synchronization with the corresponding capture trigger signal (INTP1n0, INTP1n1).

Furthermore, an interrupt request signal (INTCC1n0, INTCC1n1) is generated by the valid edge of the INTP1n0, INTP1n1 input signals specified as the capture trigger signals.

**Table 9-7. Capture Trigger Signal (TMENC1n) to 16-Bit Capture Register**

|                  |                        |
|------------------|------------------------|
| Capture Register | Capture Trigger Signal |
| CC1n0            | INTP1n0                |
| CC1n1            | INTP1n1                |

**Remark** The CC1n0 and CC1n1 registers are capture/compare registers. Which of these registers is used is specified by the CCR1n register.

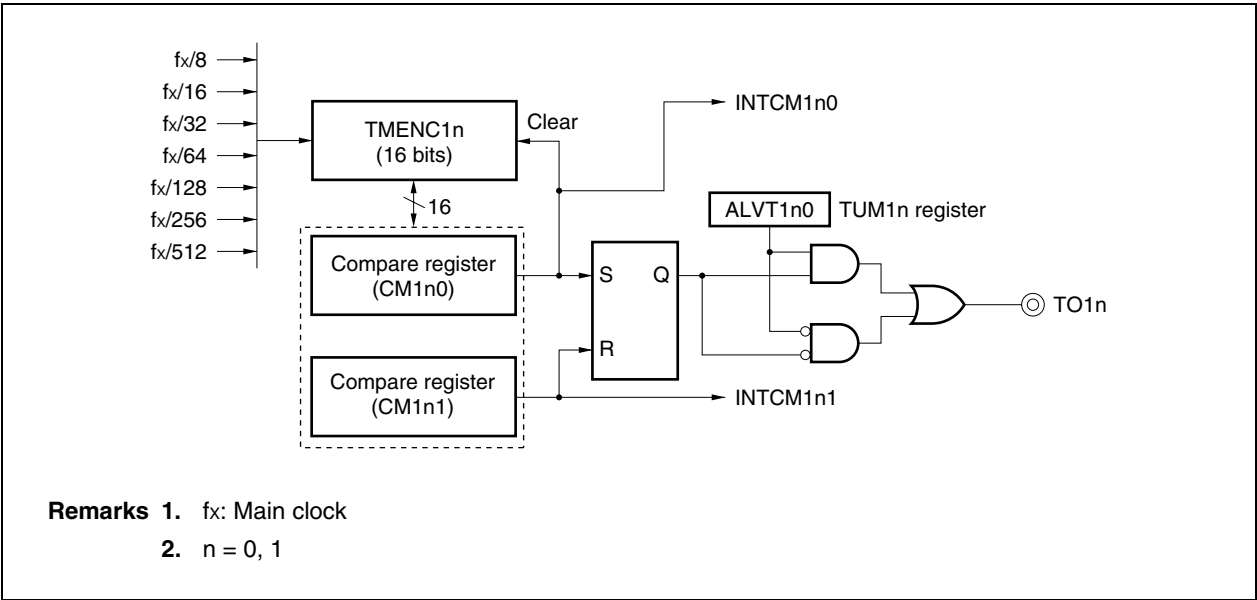
The valid edge of the capture trigger is specified by the SESA1n register. If both the rising edge and the falling edge are selected as the capture triggers, it is possible to measure the input pulse width externally. If a single edge is selected as the capture trigger, the input pulse cycle can be measured.

### (e) Timer output operation

Timer output operation is performed from the TO1n pin by setting TMENC1n to the general-purpose timer mode (T1CMDn bit = 0) using the TUM1n register.

During the timer output operation, the cycle and duty (CM1n0 and CM1n1 registers) cannot be rewritten. The resolution is 16 bits, and the count clock can be selected from among seven internal clocks (fx/8, fx/16, fx/32, fx/64, fx/128, fx/256, fx/512).

**Figure 9-18. TMENC1n Block Diagram (During Timer Output Operation)**

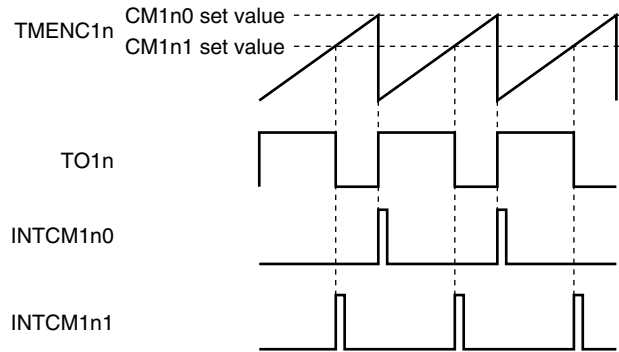


**(i) Description of operation**

The CM1n0 register is a compare register used to set the timer output cycle. When the value of this register matches the value of TMENC1n, the INTCM1n0 interrupt request signal is generated. The compare match is saved by hardware, and TMENC1n is cleared at the next count clock after the match.

The CM1n1 register is a compare register used to set the timer output duty. Set the duty required for the timer cycle.

**Figure 9-19. Timer Output Example (When ALVT1n0 Bit = 0 Is Set)**



- Cautions**
1. Changing the values of the CM1n0 and CM1n1 registers is prohibited during TMENC1n operation (CE1n1 bit of TMC1n register = 1).
  2. Changing the value of the ALVT1n0 bit of the TUM1n register is prohibited during TMENC1n operation.
  3. Timer output is performed from the second timer cycle after the CE1n1 bit is set to 1.

**Remark** n = 0, 1

**(2) Operation in UDC mode****(a) Overview of operation in UDC mode**

The count clock input to TMENC1n in the UDC mode (T1CMDn bit of TUM1n register = 1) can only be externally input from the TIUD1n and TCUD1n pins. Up-/down-count judgment in the UDC mode is determined based on the phase difference of the TIUD1n and TCUD1n pin inputs according to the PRM1n register setting (there is a total of four choices).

**Table 9-8. List of Count Operations in UDC Mode**

| PRM1n Register |        |        | Operation Mode | TMENC1n Operation                                                                                                                                                 |
|----------------|--------|--------|----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| PRM1n2         | PRM1n1 | PRM1n0 |                |                                                                                                                                                                   |
| 1              | 0      | 0      | Mode 1         | Down count upon detection of valid edge of TIUD1n input when TCUD1n = high level<br>Up count upon detection of valid edge of TIUD1n input when TCUD1n = low level |
| 1              | 0      | 1      | Mode 2         | Up count upon detection of valid edge of TIUD1n input<br>Down count upon detection of valid edge of TCUD1n input                                                  |
| 1              | 1      | 0      | Mode 3         | Up count upon detection of valid edge of TIUD1n input when TCUD1n = high level<br>Down count upon detection of valid edge of TIUD1n input when TCUD1n = low level |
| 1              | 1      | 1      | Mode 4         | Automatic judgment upon detection of both edges of TIUD1n input and both edges of TCUD1n input                                                                    |

**Remark** n = 0, 1

The UDC mode is further divided into two modes according to the TMENC1n clear conditions (a count operation is performed only with TIUD1n and TCUD1n input in both modes).

- **UDC mode A (TUM1n.T1CMDn bit = 1, TUM1n.MSELn bit = 0)**

The TMENC1n clear source can be selected as only external clear input (TCLR1n), a match signal between the TMENC1n count value and the CM1n0 register set value during up-count operation, or the logical sum (OR) of the two signals, using bits CLR1n1 and CLR1n0 of the TMC1n register. TMENC1n can transfer the value of the CM1n0 register upon occurrence of a TMENC1n underflow.

- **UDC mode B (TUM1n.T1CMDn bit = 1, TUM1n.MSELn bit = 1)**

The status of TMENC1n after a match of the TMENC1n count value and the CM1n0 register set value is as follows.

<1> In the case of an up-count operation, TMENC1n is cleared to 0000H, and the INTCM1n0 interrupt request signal is generated.

<2> In the case of a down-count operation, the TMENC1n count value is decremented by 1.

The status of TMENC1n after a match of the TMENC1n count value and the CM1n1 register set value is as follows.

<1> In the case of an up-count operation, the TMENC1n count value is incremented by 1.

<2> In the case of a down-count operation, TMENC1n is cleared to 0000H, and the INTCM1n1 interrupt request signal is generated.

**(b) Up-/down-count operation in UDC mode**

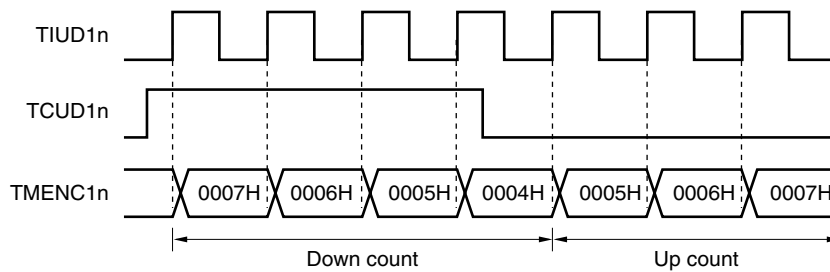
TMENC1n up-/down-count judgment in the UDC mode is determined based on the phase difference of the TIUD1n and TCUD1n pin inputs according to the PRM1n register setting.

**(i) Mode 1 (PRM1n.PRM1n2 bit = 1, PRM1n.PRM1n1 bit = 0, PRM1n.PRM1n0 bit = 0)**

In mode 1, the following count operations are performed based on the level of the TCUD1n pin upon detection of the valid edge of the TIUD1n pin.

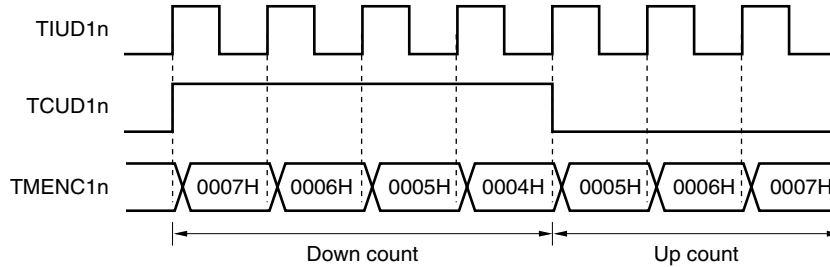
- TMENC1n down-count operation when TCUD1n pin = high level
- TMENC1n up-count operation when TCUD1n pin = low level

**Figure 9-20. Mode 1 (When Rising Edge Is Specified as Valid Edge of TIUD1n Pin)**



**Remark** n = 0, 1

**Figure 9-21. Mode 1 (When Rising Edge Is Specified as Valid Edge of TIUD1n Pin):  
In Case of Simultaneous TIUD1n, TCUD1n Pin Edge Timing**



**Remark** n = 0, 1

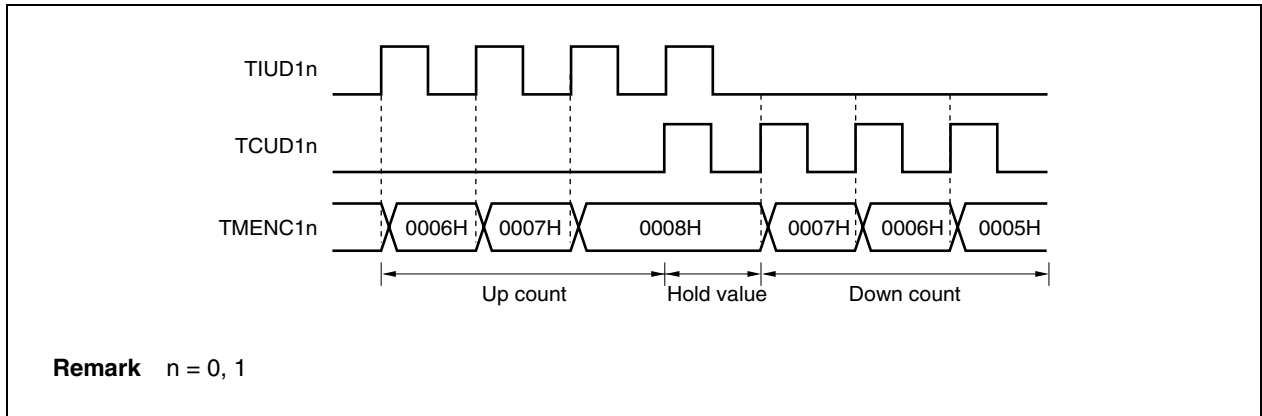
**(ii) Mode 2 (PRM1n.PRM1n2 bit = 1, PRM1n.PRM1n1 bit = 0, PRM1n.PRM1n0 bit = 1)**

The count conditions in mode 2 are as follows.

- TMENC1n up count upon detection of valid edge of TIUD1n pin
- TMENC1n down count upon detection of valid edge of TCUD1n pin

**Caution** If the count clock is simultaneously input to the TIUD1n pin and the TCUD1n pin, count operation is not performed and the immediately preceding value is held.

**Figure 9-22. Mode 2 (When Rising Edge Is Specified as Valid Edge of TIUD1n, TCUD1n Pins)**

**(iii) Mode 3 (PRM1n.PRM1n2 = 1, PRM1n.PRM1n1 = 1, PRM1n.PRM1n0 = 0)**

In mode 3, when two signals 90 degrees out of phase are input to the TIUD1n and TCUD1n pins, the level of the TCUD1n pin is sampled at the input of the valid edge of the TIUD1n pin (see **Figure 9-23**).

If the TCUD1n pin level sampled at the valid edge input to the TIUD1n pin is low, TMENC1n counts down when the valid edge is input to the TIUD1n pin.

If the TCUD1n pin level sampled at the valid edge input to the TIUD1n pin is high, TMENC1n counts up when the valid edge is input to the TIUD1n pin.

**Figure 9-23. Mode 3 (When Rising Edge Is Specified as Valid Edge of TIUD1n Pin)**

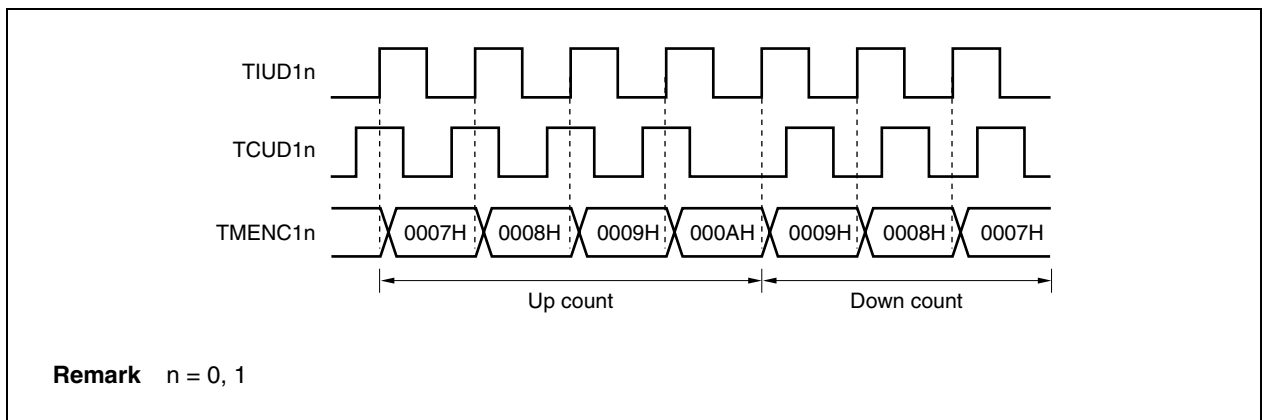
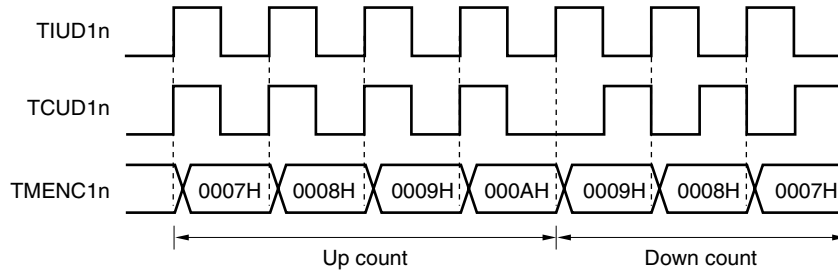


**Figure 9-24. Mode 3 (When Rising Edge Is Specified as Valid Edge of TIUD1n Pin):  
In Case of Simultaneous TIUD1n, TCUD1n Pin Edge Timing**



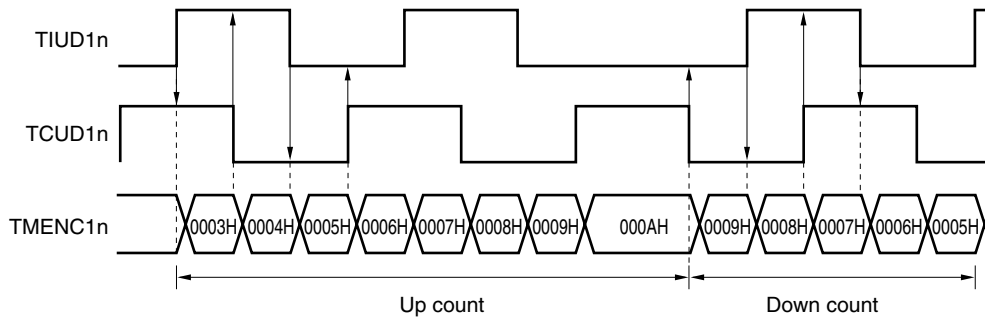
**Remark** n = 0, 1

**(iv) Mode 4 (PRM1n.PRM1n2 = 1, PRM1n.PRM1n1 = 1, PRM1n.PRM1n0 = 1)**

In mode 4, when two signals out of phase are input to the TIUD1n and TCUD1n pins, up/down operation is automatically judged and counting is performed according to the timing shown in **Figure 9-25**.

In mode 4, counting is executed at both the rising and falling edges of the two signals input to the TIUD1n and TCUD1n pins. Therefore, TMENC1n counts four times per cycle of an input signal ( $\times 4$  count).

**Figure 9-25. Mode 4**



**Cautions** 1. When mode 4 is specified as the operation mode of TMENC1n, the valid edge specifications for the TIUD1n and TCUD1n pins are not valid.

2. If the TIUD1n pin edge and TCUD1n pin edge are input simultaneously in mode 4, TMENC1n continues the same count operation (up or down) it was performing immediately before the input.

**Remark** n = 0, 1



**(c) Operation in UDC mode A****(i) Interval operation**

The operations at the count clock following a match of the TMENC1n count value and the CM1n0 register set value are as follows.

- In case of up-count operation: TMENC1n is cleared to 0000H and the INTCM1n0 interrupt request signal is generated.
- In case of down-count operation: The TMENC1n count value is decremented by 1 and the INTCM1n0 interrupt request signal is generated.

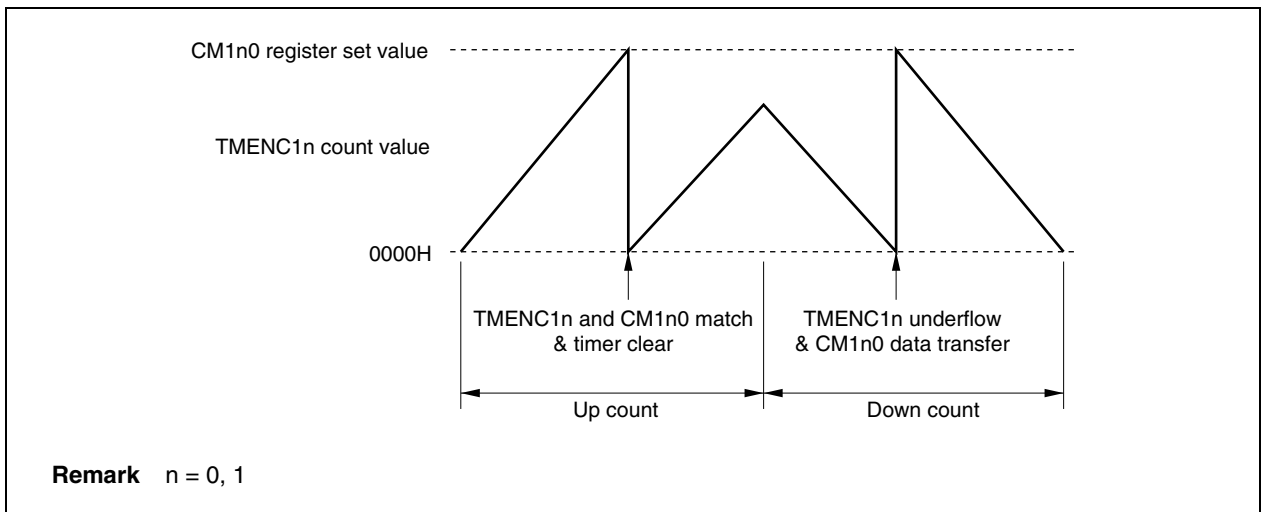
**Remark** The interval operation can be combined with the transfer operation.

**(ii) Transfer operation**

If TMENC1n = 0000H during down counting when the TMC1n.RLEN1n bit = 1, the CM1n0 register set value is transferred to TMENC1n at the next count clock.

- Remarks**
1. Transfer enable/disable can be set using the RLEN1n bit of the TMC1n register.
  2. The transfer operation can be combined with the interval operation.

**Figure 9-26. Example of TMENC1n Operation When Interval Operation and Transfer Operation Are Combined**

**(iii) Compare function**

TMENC1n connects two compare register (CM1n0, CM1n1) channels and two capture/compare register (CC1n0, CC1n1) channels.

When the TMENC1n count value and the set value of one of the compare registers match, a match interrupt request signal (INTCM1n0, INTCM1n1, INTCC1n0<sup>Note</sup>, INTCC1n1<sup>Note</sup>) is output.

**Note** This match interrupt request signal is generated when the CC1n0 and CC1n1 registers are set to the compare register mode.

**(iv) Capture function**

TMENC1n connects two capture/compare register (CC1n0, CC1n1) channels.

When the CC1n0 and CC1n1 registers are set to the capture register mode, the value of TMENC1n is captured in synchronization with the corresponding capture trigger signal.

A capture interrupt request signal (INTCC1n0, INTCC1n1) is generated upon detection of the valid edge.

**(d) Operation in UDC mode B****(i) Basic operation**

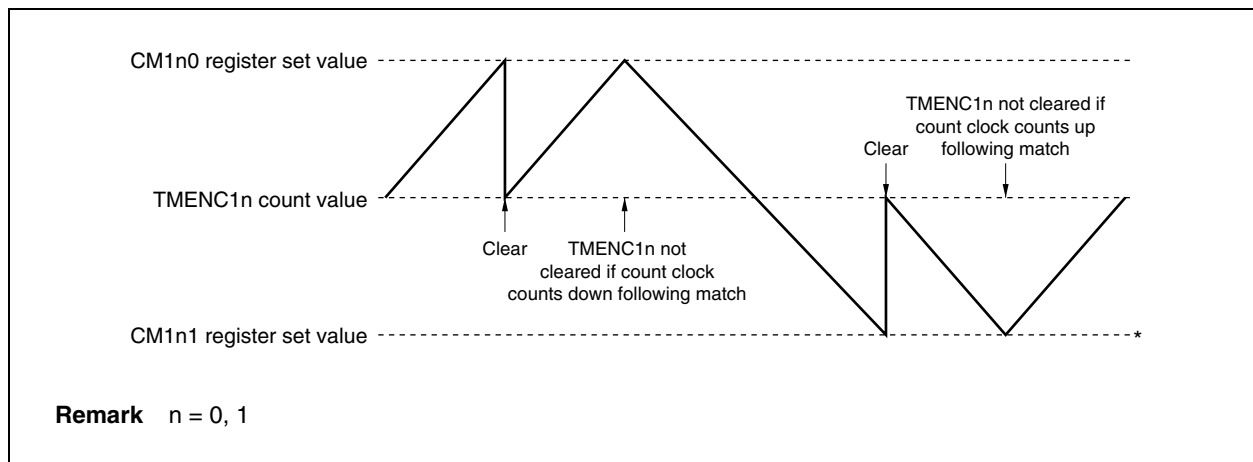
The operations at the next count clock after the count value of TMENC1n and the CM1n0 register set value match when TMENC1n is in UDC mode B are as follows.

- In case of up-count operation: TMENC1n is cleared to 0000H and the INTCM1n0 interrupt request signal is generated.
- In case of down-count operation: The TMENC1n count value is decremented by 1.

The operations at the next count clock after the count value of TMENC1n and the CM1n1 register set value match when TMENC1n is in UDC mode B are as follows.

- In case of up-count operation: The TMENC1n count value is incremented by 1.
- In case of down-count operation: TMENC1n is cleared to 0000H and the INTCM1n1 interrupt request signal is generated.

**Figure 9-27. Example of TMENC1n Operation in UDC Mode**

**(ii) Compare function**

TMENC1n connects two compare register (CM1n0, CM1n1) channels and two capture/compare register (CC1n0, CC1n1) channels.

When the TMENC1n count value and the set value of one of the compare registers match, a match interrupt request signal (INTCM1n0 (only during up-count operation), INTCM1n1 (only during down-count operation), INTCC1n0<sup>Note</sup>, INTCC1n1<sup>Note</sup>) is output.

**Note** This match interrupt request signal is generated when the CC1n0 and CC1n1 registers are set to the compare register mode.

**(iii) Capture function**

TMENC1n connects two capture/compare register (CC1n0, CC1n1) channels.

When the CC1n0 and CC1n1 registers are set to the capture register mode, the value of TMENC1n is captured in synchronization with the corresponding capture trigger signal. A capture interrupt request signal (INTCC1n0, INTCC1n1) is generated upon detection of the valid edge.

## 9.3.7 Supplementary description of internal operation

## (1) Clearing of count value in UDC mode B

When TMENC1n is in UDC mode B, the conditions to clear the count value are as follows.

- In case of TMENC1n up-count operation: TMENC1n count value is cleared upon match with the CM1n0 register
- In case of TMENC1n down-count operation: TMENC1n count value is cleared upon match with the CM1n1 register

Figure 9-28. Clear Operation After Match of CM1n0 Register Set Value and TMENC1n Count Value

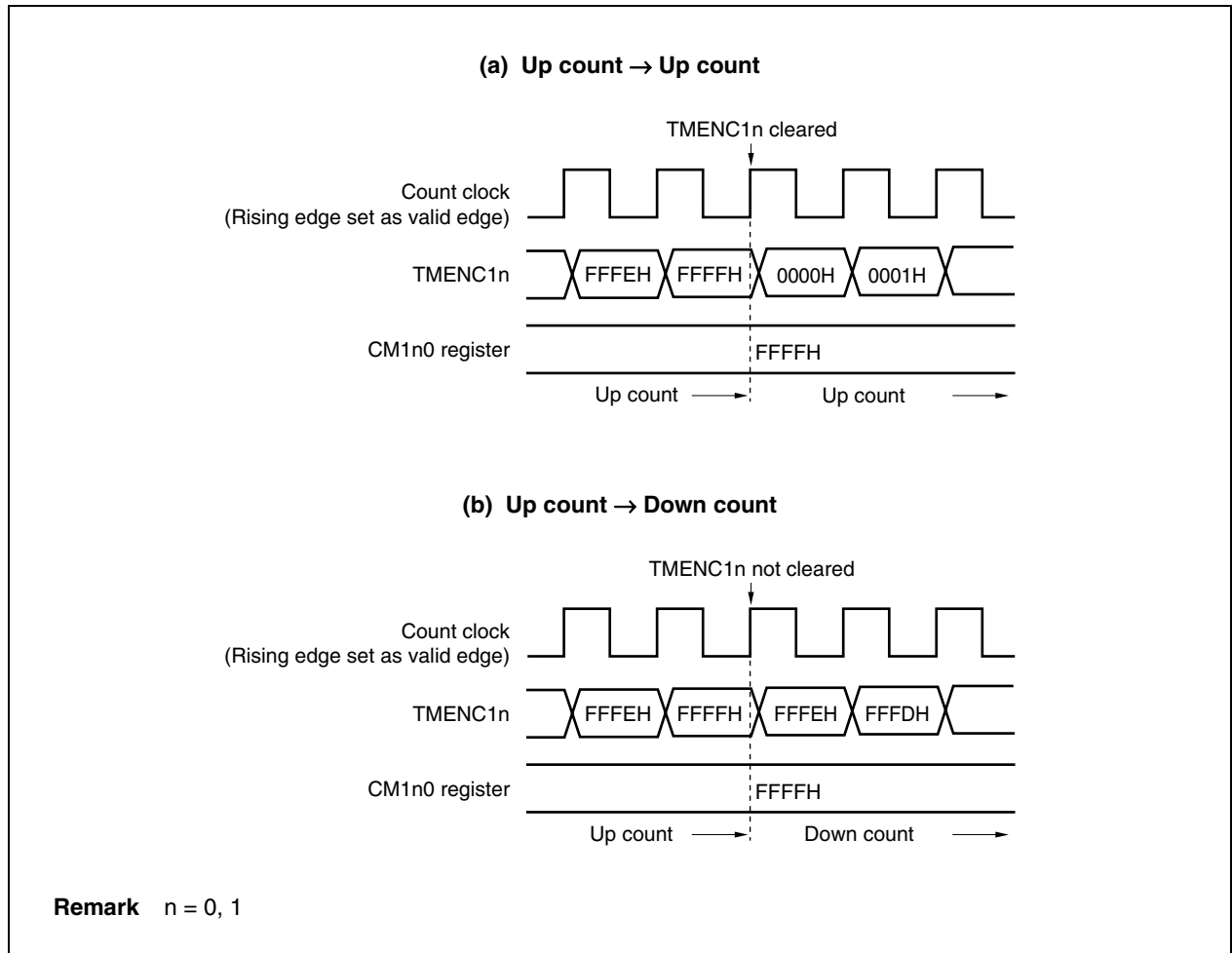
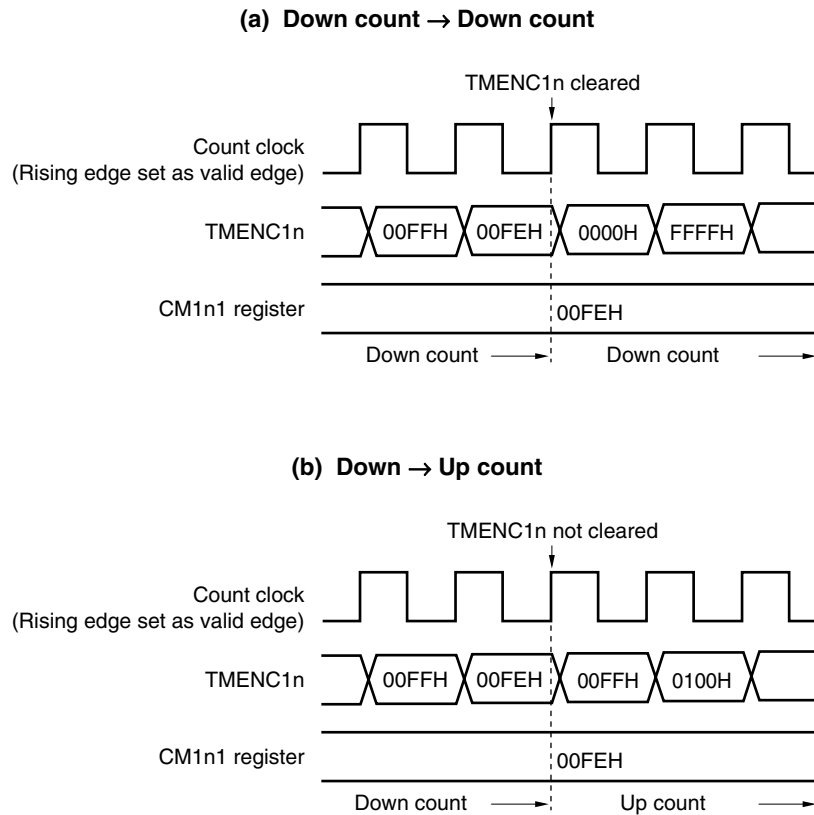
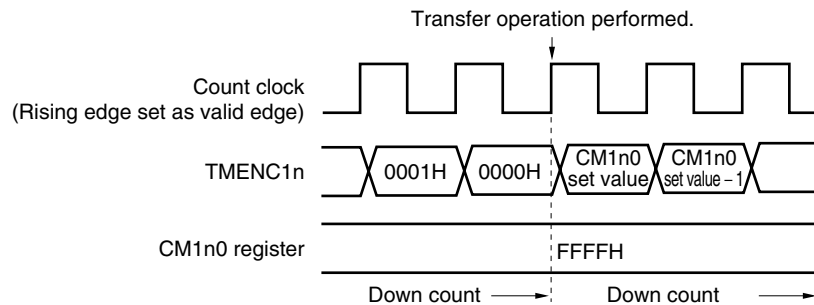


**Figure 9-29. Clear Operation After Match of CM1n1 Register Set Value and TMENC1n Count Value**

**Remark**  $n = 0, 1$

## (2) Transfer operation

If  $TMENC1n = 0000H$  during down counting when the  $RLEN1n$  bit of the  $TMC1n$  register = 1 in UDC mode A, the  $CM1n0$  register set value is transferred to  $TMENC1n$  at the next count clock. The transfer operation is not performed during up counting.

**Figure 9-30. Internal Operation During Transfer Operation**

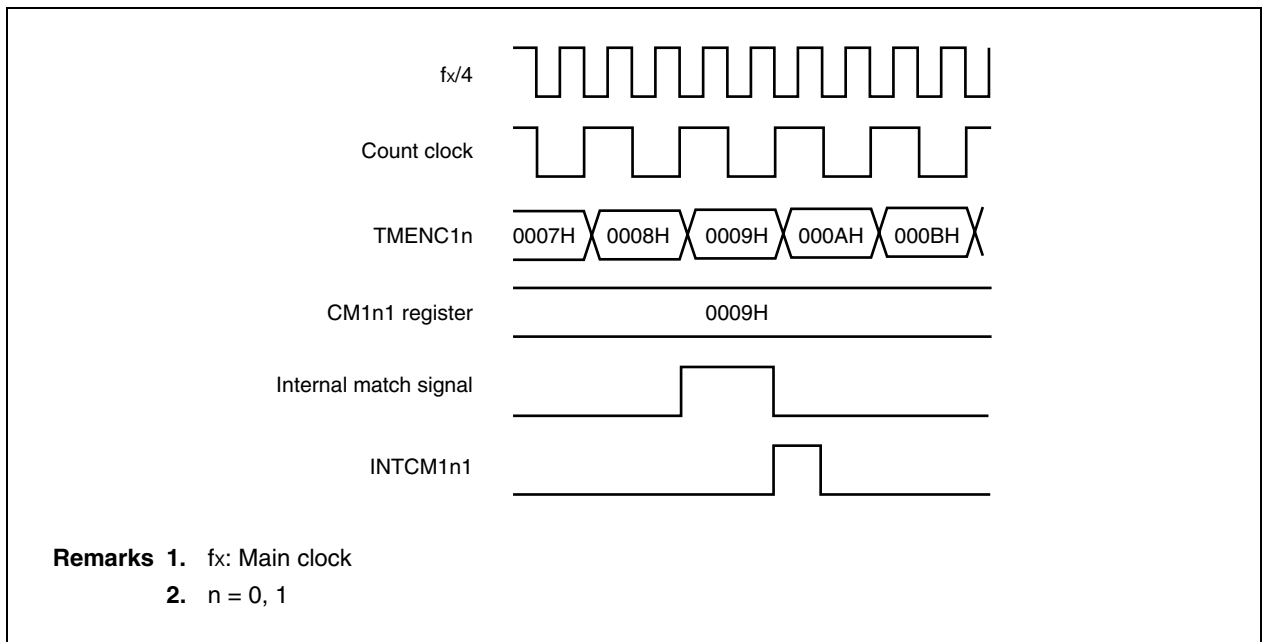
**Remark**  $n = 0, 1$

**(3) Interrupt request signal output upon compare match**

An interrupt request signal is output when the count value of TMENC1n matches the set value of the CM1n0, CM1n1, CC1n0<sup>Note</sup>, or CC1n1<sup>Note</sup> register. The interrupt generation timing is as follows.

**Note** When the CC1n0 and CC1n1 registers are set to the compare register mode.

**Figure 9-31. Interrupt Request Signal Output upon Compare Match**  
(CM1n1 with Operation Mode Set to General-Purpose Timer Mode and Count Clock Set to fx/8)

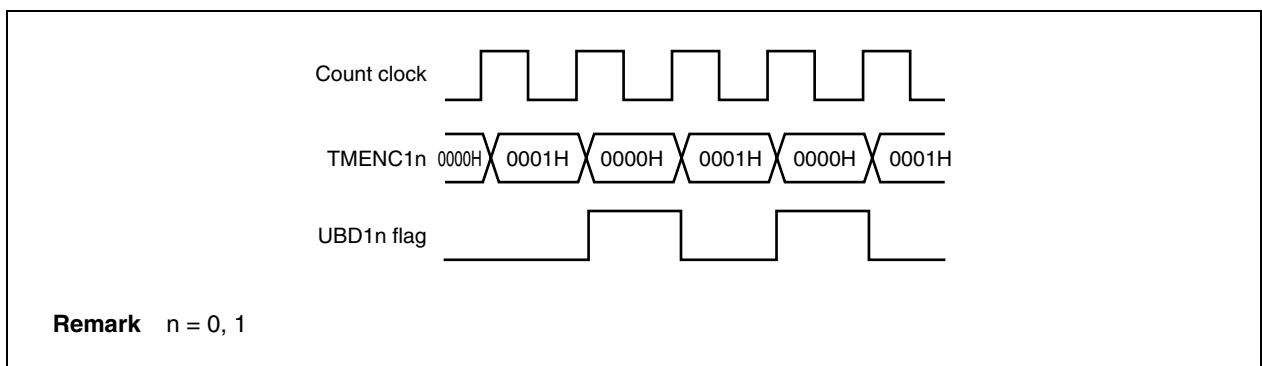


An interrupt request signal such as the one illustrated in Figure 9-31 is output at the next count clock following a match of the TMENC1n count value and the set value of the corresponding compare register.

**(4) UBD1n flag (bit 0 of STATUS1n register) operation**

In the UDC mode (T1CMDn bit of TUM1n register = 1), the UBD1n flag changes as follows during TMENC1n up-/down-count operation at every internal operation clock.

**Figure 9-32. UBD1n Flag Operation**



**(5) Overflow interrupt request signal (INTOV1n) and underflow interrupt request signal (INTUD1n)**

- (a) The overflow interrupt request signal (INTOV1n) is generated when the count value of TMENC1n has reached FFFFH and the next count operation is an up-count.
- (b) The underflow interrupt request signal (INTUD1n) is generated when the count value of TMENC1n has reached 0000H and the next count operation is a down-count.
- (c) TMENC1n continues counting even after occurrence of an overflow or underflow, if a count edge is detected. If the condition of the underflow (0000H → FFFFH) is satisfied when the RLEN1n bit of the TMC1n register is 1 (enabling transfer), however, the CM1n0 register set value is transferred.
- (d) If the condition of the underflow (0000H → FFFFH) is satisfied with the CM1n0 register set value = FFFFH when the RLEN1n bit of the TMC1n register is cleared to 0 (disabling transfer), the INTCM1n0 interrupt and INTUD1n interrupt occur simultaneously.

**9.3.8 Cautions**

Cautions concerning timer ENC1 are shown below.

**(1) INTP1n0 pin in UDC mode**

The TCUD1n and INTP1n0 pins function alternately. Therefore, because the TCUD1n pin is used in the UDC mode, the external capture function of the INTP1n0 pin cannot be used.

**(2) INTP1n1 pin in UDC mode A**

The TCLR1n and INTP1n1 pins function alternately. Therefore, when the TCLR1n input is used in UDC mode A, the external capture function of the INTP1n1 pin cannot be used.

**(3) Setting trigger mode**

Set the PMCDH register before setting the trigger mode of the INTP1n0, INTP1n1, TIUD1n, TCUD1n, and TCLR1n pins. If the PMCDH register is set after the SESA1n register has been set, an illegal interrupt, incorrect counting, and incorrect clearing may occur depending on the timing of setting the PMCDH register.

**(4) Caution on setting NCW1n register**

Whether the signal is input through or inverted can be specified for each of the INTP1n0/TCUD1n and TIUD1n pins by the SRTCn and SRTIn bits of the NCW1n register. The setting of the noise elimination width by the NCFn, NCC1n, and NCC0n bits is for each timer and cannot be changed for each pin.

## CHAPTER 10 SERIAL INTERFACE FUNCTION

### 10.1 Features

The serial interface function provides three types of serial interfaces equipped with five transmit/receive channels of which four channels can be used simultaneously.

The following three interface formats are available.

- (1) Asynchronous serial interfaces B0 and B1 (UARTB0 and UARTB1): 2 channels
- (2) Clocked serial interfaces 30 and 31 (CSI30 and CSI31): 2 channels
- (3) USB function controller (USBF): 1 channel

**Remark** For details of the USB function, see **CHAPTER 11 USB FUNCTION CONTROLLER (USBF)**.

UARTB0 and UARTB1, which use the method of transmitting/receiving one byte of serial data following a start bit, enable full-duplex communication to be performed.

CSI30 and CSI31 transfer data according to three types of signals (3-wire serial I/O). These signals are the serial clock ( $\overline{\text{SCK0}}$  and  $\overline{\text{SCK1}}$ ), serial input (SI0 and SI1), and serial output (SO0 and SO1) signals.

The USB supports full-speed transfer of 12 Mbps and consists of seven endpoints.

#### 10.1.1 Switching between UARTB0 and CSI30 modes

In the V850E/ME2, since UARTB0 and CSI30 are alternate function pins, they cannot be used at the same time. The registers must be set in advance.

## 10.2 Asynchronous Serial Interfaces B0, B1 (UARTB0, UARTB1)

### 10.2.1 Features

- Transfer rate: Maximum 1.5 Mbps (using a dedicated baud rate generator)
- Full-duplex communications
- Single mode and FIFO mode selectable
  - Single mode: 8-bit  $\times$  1-stage data register (UBnTX register or UBnRX register) is used for each of transmission and reception.
  - FIFO mode
    - Transmit FIFO: UBnTX register (8 bits  $\times$  16 stages).
    - Receive FIFO: UBnRXAP register (16 bits  $\times$  16 stages)  
2 bits of the higher 8 bits of the UBnRXAP register are for an error flag.
- Two-pin configuration
  - TXDn: Transmit data output pin
  - RXDn: Receive data input pin
- Reception error detection function
  - Overflow error (FIFO mode only)
  - Parity error
  - Framing error
  - Overrun error (single mode only)
- Interrupt sources: 5 types
  - Reception error interrupt (UBTIREn)
  - Reception completion interrupt (UBTIRn)
  - Transmission completion interrupt (UBTITn)
  - FIFO transmission completion interrupt (UBTIFn) (FIFO mode only)
  - Reception timeout interrupt (UBTITOn) (FIFO mode only)
- The character length of transmit/receive data is specified according to the UBnCTL0 register
- Character length: 7 or 8 bits
- Parity functions: Odd, even, 0, or none
- Transmission stop bits: 1 or 2 bits
- MSB first/LSB first selectable for transfer data
- On-chip dedicated baud rate generator

**Remark** n = 0, 1



### 10.2.2 Configuration

UARTBn is controlled by UARTBn control register 0 (UBnCTL0), the UARTBn status register (UBnSTR), UARTBn control register 2 (UBnCTL2), UARTBn FIFO control register 0 (UBnFIC0), UARTBn FIFO control register 1 (UBnFIC1), UARTBn FIFO control register 2 (UBnFIC2), UARTBn FIFO status register 0 (UBnFIS0), and UARTBn FIFO status register 1 (UBnFIS1) ( $n = 0, 1$ ). Receive data is stored in a receive data register (the UBnRX register in the single mode or receive FIFO in the FIFO mode (the UBnRXAP register)) and transmit data is written to a transmit data register (the UBnTX register in the single mode or transmit FIFO in the FIFO mode). If a reception error (such as a parity error or a framing error) occurs in the FIFO mode, the error data can be identified by reading UARTBn receive data register AP (UBnRXAP) in 16-bit (halfword) units.

Figure 10-1 shows the configuration of the asynchronous serial interface.

**(1) UARTBn control register 0 (UBnCTL0) ( $n = 0, 1$ )**

This register controls the transfer operation of UARTBn.

**(2) UARTBn status register (UBnSTR) ( $n = 0, 1$ )**

This register indicates the transfer status during transmission and the contents of a reception error. The status flag of this register, which indicates the transfer status during transmission, indicates the data retention status of transmit shift register  $n$  and transmit data register  $n$  (the UBnTX register in the single mode or transmit FIFO in the FIFO mode). Each reception error flag is set to 1 when a reception error occurs, and cleared to 0 when 0 is written to the UBnSTR register.

**(3) UARTBn control register 2 (UBnCTL2) ( $n = 0, 1$ )**

This register is used to specify the division rate by which to control the baud rate (serial transfer speed) of UARTBn.

**(4) UARTBn FIFO control register 0 (UBnFIC0) ( $n = 0, 1$ )**

This register is used to select the operation mode of UARTBn, clear the transmit FIFO/receive FIFO that becomes valid in the FIFO mode, and specify the timing mode in which the transmission completion interrupt (UBTITn)/reception completion interrupt (UBTIRn) occurs.

**(5) UARTBn FIFO control register 1 (UBnFIC1) ( $n = 0, 1$ )**

This register is valid in the FIFO mode. It generates a reception timeout interrupt request (UBTITOn) if data is stored in the receive FIFO when the next data does not come (start bit is not detected) even after the reception wait time of the next data has elapsed.

**(6) UARTBn FIFO control register 2 (UBnFIC2) ( $n = 0, 1$ )**

This register is valid in the FIFO mode. It is used to set the timing to generate the transmission completion interrupt (UBTITn)/reception completion interrupt (UBTIRn), using the number of data transmitted or received as a trigger.

**(7) UARTBn FIFO status register 0 (UBnFIS0) ( $n = 0, 1$ )**

This register is valid in the FIFO mode. The number of bytes of data stored in the receive FIFO can be read from this register.

**(8) UARTBn FIFO status register 1 (UBnFIS1) ( $n = 0, 1$ )**

This register is valid in the FIFO mode. The number of vacant bytes of the transmit FIFO can be read from this register.

**(9) Receive shift register n (n = 0, 1)**

This is a shift register that converts the serial data that was input to the RXDn pin into parallel data. One byte of data is received, and if a stop bit is detected, the received data is transferred to receive data register n. This register cannot be directly manipulated.

**(10) UARTBn receive data register AP (UBnRXAP), UARTBn receive data register (UBnRX) (n = 0, 1)**

Receive data register n holds receive data. In the single mode, the 8-bit × 1-stage UBnRX register is used. The 16-bit × 16-stage receive FIFO (UBnRXAP register) is used in the FIFO mode.

The receive data is stored in the lower 8 bits of the receive FIFO (UBnRXAP register) and the error information of the received data is stored in the higher 8 bits (bit 8 and bit 9). If a reception error (such as a parity error or a framing error) occurs in the FIFO mode, the error data can be identified by reading the UBnRXAP register in 16-bit (halfword) units (error information is appended as UBnPEF bit = 1 or UBnFEF bit = 1). When the lower 8 bits of the UBnRXAP register are read in 8-bit (byte) units, the higher 8 bits are discarded. Therefore, if no error has occurred, the receive data of the UBnRXAP register can be read consecutively by being read in 8-bit (byte) units in the same way as the UBnRX register.

When 7-bit length data is received with the LSB first, the received data is transferred to bits 6 to 0 of receive data register n from the LSB (bit 0), with the MSB (bit 7) always being 0. When data is received with the MSB first, the received data is transferred to bits 7 to 1 of receive data register n from the MSB (bit 7), with the LSB (bit 0) always being 0. If an overrun error occurs, the receive data at that time is not transferred to receive data register n.

While reception is enabled, the received data is transferred from receive shift register n to receive data register n, in synchronization with the shift-in processing of one frame.

A reception completion interrupt request (UBTIRn) is generated by transferring the data to the UBnRX register in the single mode, or transferring the number of receive data set as the trigger by the UBnRT3 to UBnRT0 bits of the UBnFIC2 register to receive FIFO in the FIFO mode. If data is stored in receive FIFO when the next data does not come (start bit is not detected) after the next data reception wait time specified by the UBnTC4 to UBnTC0 bits of the UBnFIC1 register has elapsed in the FIFO mode, a reception timeout interrupt request (UBTITOn) is generated.

**(11) Transmit shift register n (n = 0, 1)**

This is a shift register that converts the parallel data that was transferred from transmit data register n into serial data.

When one byte of data is transferred from transmit data register n, transmit shift register n data is output from the TXDn pin.

This register cannot be directly manipulated.

**(12) UARTBn transmit data register n (UBnTX) (n = 0, 1)**

Transmit data register n is a buffer for transmit data. The 8-bit  $\times$  1-stage UBnTX register is used as this buffer in the single mode. In the FIFO mode, the 8-bit  $\times$  16-stage transmit FIFO is used.

When 7-bit length data is transmitted with the LSB first, bits 6 to 0 of transmit data register n are transmitted as the transmit data from the LSB (bit 0) with the MSB (bit 7) always being 0. When data is transmitted with the MSB first, bits 7 to 1 of transmit data register n are transmitted as the transmit data from the MSB (bit 7) with the LSB (bit 0) always being 0.

In the single mode, transmission is started by writing transmit data to the UBnTX register while transmission is enabled (UBnTXE bit = 1 in the UBnCTL0 register). When writing the transmit data to the UBnTX register is enabled (when 1-byte data is transferred from the UBnTX register to transmit shift register n), a transmission completion interrupt request (UBTITn) is generated.

In the FIFO mode, transmission is started by writing at least the number of transmit data set as the trigger by the UBnTT3 to UBnTT0 bits of the UBnFIC2 register and 16 bytes or less to transmit FIFO and then enabling transmission (UBnTXE bit = 1). When the number of transmit data set as the trigger by the UBnTT3 to UBnTT0 bits of the UBnFIC2 register have been transferred from transmit FIFO to transmit shift register n (transmit data of the number set as the trigger can be written), a transmission completion interrupt request (UBTITn) is generated. In the FIFO mode, a FIFO transmission completion interrupt request (UBTIFn) is generated when there is no more data in transmit FIFO and transmit shift register n (when FIFO and the register become empty).

**(13) Timeout counter**

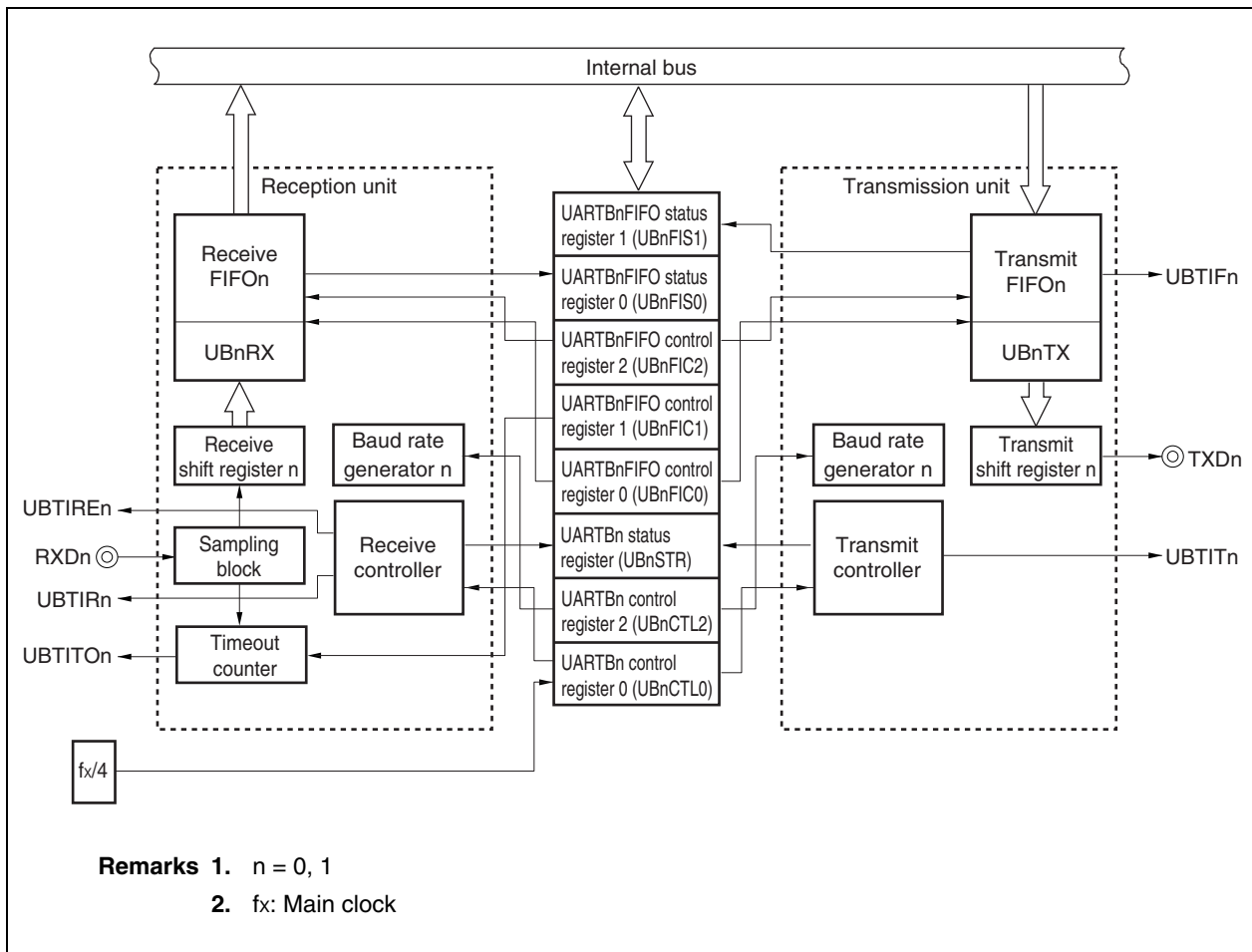
This counter is used to recognize that data exists (remains) in receive FIFO when the number of received data does not reach the number set as the trigger by the UBnRT3 to UBnRT0 bits of the UBnFIC2 register, and is valid only in the FIFO mode.

If data is stored in receive FIFO when the next data does not come (start bit is not detected) after the next data reception wait time specified by the UBnTC4 to UBnTC0 bits of the UBnFIC1 register has elapsed after the stop bit has been received, a reception timeout interrupt request (UBTITOn) is generated.

**(14) Sampling block**

This block samples the RXDn signal at the rising edge of the input clock ( $f_x/4$ ) ( $f_x$ : main clock). If the same sampling value is detected two times, output of the match detector changes, and the value is sampled as input data. Data of less than one clock width is judged as noise and is not transmitted to the internal circuitry.

Figure 10-1. Block Diagram of Asynchronous Serial Interfaces B0 and B1



## 10.2.3 Control registers

## (1) UARTBn control register 0 (UBnCTL0) (n = 0, 1)

The UBnCTL0 register controls the transfer operations of UARTBn.

This register can be read or written in 8-bit or 1-bit units.

- Cautions**
1. When using UARTBn, set the external pins related to the UARTBn function in the control mode, and set UARTBn control register 2 (UBnCTL2). Then set the UBnPWR bit to 1 before setting the other bits.
  2. Be sure to input a high level to the RXDn pin when setting the external pins related to the UARTBn function in the control mode. If a low level is input, it is judged that a falling edge is input after the UBnRXE bit has been set to 1, and reception may be started.

(1/3)

|         | 7      | 6      | 5      | 4      | 3      | 2      | 1     | 0     | Address   | After reset |
|---------|--------|--------|--------|--------|--------|--------|-------|-------|-----------|-------------|
| UB0CTL0 | UB0PWR | UB0TXE | UB0RXE | UB0DIR | UB0PS1 | UB0PS0 | UB0CL | UB0SL | FFFFFA00H | 10H         |
| UB1CTL0 | UB1PWR | UB1TXE | UB1RXE | UB1DIR | UB1PS1 | UB1PS0 | UB1CL | UB1SL | FFFFFA20H | 10H         |

| Bit position | Bit name | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|--------------|----------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 7            | UBnPWR   | <p>Controls the operation clock.</p> <p>0: Stops supply of clocks to UARTBn<br/>1: Supplies clocks to UARTBn</p> <p><b>Cautions</b></p> <ol style="list-style-type: none"> <li>1. When the UBnPWR bit is cleared to 0, the UARTBn can be asynchronously reset.</li> <li>2. When the UBnPWR bit = 0, the UARTBn is in a reset state. Therefore, to operate UARTBn, the UBnPWR bit must be set to 1.</li> <li>3. When the UBnPWR bit is changed from 1 to 0, all registers of the UARTBn are initialized. When the UBnPWR bit is set to 1 again, the UARTBn registers must be set again.</li> </ol> <p>The TXDn pin output is high level when the UBnPWR bit is cleared to 0.</p> |
| 6            | UBnTXE   | <p>Specifies whether transmission is enabled or disabled.</p> <p>0: Transmission is disabled<br/>1: Transmission is enabled</p> <p><b>Cautions</b></p> <ol style="list-style-type: none"> <li>1. On startup, set the UBnPWR bit to 1 and then set the UBnTXE bit to 1. To stop transmission, clear the UBnTXE bit to 0 and then the UBnPWR bit to 0.</li> <li>2. When the transmission unit status is to be initialized, the transmission status may not be able to be initialized unless the UBnTXE bit is set to 1 again after an interval of two cycles of <math>f_x/4</math> (<math>f_x</math>: main clock) has elapsed since the UBnTXE bit was cleared to 0.</li> </ol>   |

**Remark** n = 0, 1

| Bit position | Bit name          | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                        |        |                    |                   |   |   |                            |                        |   |   |                 |                     |   |   |                   |                     |   |   |                    |                      |
|--------------|-------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|--------|--------------------|-------------------|---|---|----------------------------|------------------------|---|---|-----------------|---------------------|---|---|-------------------|---------------------|---|---|--------------------|----------------------|
| 5            | UBnRXE            | <p>Specifies whether reception is enabled or disabled.</p> <p>0: Reception is disabled</p> <p>1: Reception is enabled</p> <p><b>Cautions</b></p> <p><b>1. On startup, set the UBnPWR bit to 1 and then set the UBnRXE bit to 1. To stop reception, clear the UBnRXE bit to 0 and then the UBnPWR bit to 0.</b></p> <p><b>2. When the reception unit status is to be initialized, the reception status may not be able to be initialized unless the UBnRXE bit is set to 1 again after an interval of two cycles of <math>f_x/4</math> (<math>f_x</math>: main clock) has elapsed since the UBnRXE bit was cleared to 0.</b></p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                        |        |                    |                   |   |   |                            |                        |   |   |                 |                     |   |   |                   |                     |   |   |                    |                      |
| 4            | UBnDIR            | <p>Specifies the transfer direction mode (MSB/LSB).</p> <p>0: The first bit of transfer data is the MSB.</p> <p>1: The first bit of transfer data is the LSB.</p> <p><b>Caution</b> Clear the UBnPWR bit or UBnTXE and UBnRXE bits to 0 before changing the setting of the UBnDIR bit.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                        |        |                    |                   |   |   |                            |                        |   |   |                 |                     |   |   |                   |                     |   |   |                    |                      |
| 3, 2         | UBnPS1,<br>UBnPS0 | <p>Controls the parity bit.</p> <table><tr><th>UBnPS1</th><th>UBnPS0</th><th>Transmit operation</th><th>Receive operation</th></tr><tr><td>0</td><td>0</td><td>Do not output a parity bit</td><td>Receive with no parity</td></tr><tr><td>0</td><td>1</td><td>Output 0 parity</td><td>Receive as 0 parity</td></tr><tr><td>1</td><td>0</td><td>Output odd parity</td><td>Judge as odd parity</td></tr><tr><td>1</td><td>1</td><td>Output even parity</td><td>Judge as even parity</td></tr></table> <p><b>Cautions</b></p> <p><b>1. Clear the UBnTXE and UBnRXE bits to 0 before overwriting the UBnPS1 and UBnPS0 bits.</b></p> <p><b>2. If “0 parity” is selected for reception, no parity judgment is made. Therefore, no error interrupt is generated because the UBnPE bit of the UBnSTR register is not set to 1.</b></p> <ul style="list-style-type: none"><li>• Even parity<br/>If the transmit data contains an odd number of bits with the value “1”, the parity bit is set to 1. If it contains an even number of bits with the value “1”, the parity bit is cleared to 0. This controls the number of bits with the value “1” contained in the transmit data and the parity bit so that it is an even number.<br/>During reception, the number of bits with the value “1” contained in the receive data and the parity bit is counted, and if the number is odd, a parity error is generated.</li><li>• Odd parity<br/>In contrast to even parity, odd parity controls the number of bits with the value “1” contained in the transmit data and the parity bit so that it is an odd number.<br/>During reception, the number of bits with the value “1” contained in the receive data and the parity bit is counted, and if the number is even, a parity error is generated.</li></ul> | UBnPS1                 | UBnPS0 | Transmit operation | Receive operation | 0 | 0 | Do not output a parity bit | Receive with no parity | 0 | 1 | Output 0 parity | Receive as 0 parity | 1 | 0 | Output odd parity | Judge as odd parity | 1 | 1 | Output even parity | Judge as even parity |
| UBnPS1       | UBnPS0            | Transmit operation                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Receive operation      |        |                    |                   |   |   |                            |                        |   |   |                 |                     |   |   |                   |                     |   |   |                    |                      |
| 0            | 0                 | Do not output a parity bit                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Receive with no parity |        |                    |                   |   |   |                            |                        |   |   |                 |                     |   |   |                   |                     |   |   |                    |                      |
| 0            | 1                 | Output 0 parity                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Receive as 0 parity    |        |                    |                   |   |   |                            |                        |   |   |                 |                     |   |   |                   |                     |   |   |                    |                      |
| 1            | 0                 | Output odd parity                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Judge as odd parity    |        |                    |                   |   |   |                            |                        |   |   |                 |                     |   |   |                   |                     |   |   |                    |                      |
| 1            | 1                 | Output even parity                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Judge as even parity   |        |                    |                   |   |   |                            |                        |   |   |                 |                     |   |   |                   |                     |   |   |                    |                      |

**Remark** n = 0, 1

| Bit position | Bit name          | Function                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|--------------|-------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 3, 2         | UBnPS1,<br>UBnPS0 | <ul style="list-style-type: none"> <li>• 0 parity<br/>During transmission, the parity bit is cleared to 0 regardless of the transmit data.<br/>During reception, no parity error is generated because no parity bit is checked.</li> <li>• No parity<br/>No parity bit is added to transmit data.<br/>During reception, the receive data is considered to have no parity bit. No parity error is generated because there is no parity bit.</li> </ul> |
| 1            | UBnCL             | Specifies the character length of the transmit/receive data.<br>0: 7 bits<br>1: 8 bits<br><br><b>Caution</b> Clear the UBnTXE and UBnRXE bits to 0 before overwriting the UBnCL bit.                                                                                                                                                                                                                                                                  |
| 0            | UBnSL             | Specifies the stop bit length of the transmit data.<br>0: 1 bit<br>1: 2 bits<br><br><b>Cautions</b> 1. Clear the UBnTXE bit to 0 before overwriting the UBnSL bit.<br>2. Since reception always operates by using a single stop bit length, the UBnSL bit setting does not affect receive operations.                                                                                                                                                 |

**Remarks 1.** When reception is disabled, receive shift register n does not detect a start bit. No shift-in processing or transfer processing to receive data register n is performed, and the contents of receive data register n are retained.

When reception is enabled, the receive shift operation starts, in synchronization with the detection of the start bit, and when the reception of one frame is completed, the contents of receive shift register n are transferred to receive data register n. A reception completion interrupt (UBTIRn) is also generated, in synchronization with the transfer to receive data register n (in FIFO mode, transfer triggered by reaching set number of receive data).

If data is stored in receive FIFO n when the next data does not come (start bit is not detected) after the next data reception wait time specified by the UBnTC4 to UBnTC0 bits of the UBnFIC1 register has elapsed in the FIFO mode, a reception timeout interrupt request (UBTITOn) is generated.

2. n = 0, 1

**(2) UARTBn status register (UBnSTR) (n = 0, 1)**

The UBnSTR register indicates the transfer status and reception error contents while UARTBn is transmitting data.

The status flag that indicates the transfer status during transmission indicates the data retention status of transmit shift register n and transmit data register n (the UBnTX register in the single mode or transmit FIFO in the FIFO mode). The status flag that indicates a reception error holds its status until it is cleared to 0.

This register can be read or written in 8-bit or 1-bit units.

**Caution** When the UBnPWR bit or UBnRXE bit of the UBnCTL0 register is cleared to 0, or when 0 is written to the UBnSTR register, the UBnOVF, UBnPE, UBnFE, and UBnOVE bits of the UBnSTR register are cleared to 0.

(1/2)

|        | 7      | 6 | 5 | 4 | 3      | 2     | 1     | 0      | Address   | After reset |
|--------|--------|---|---|---|--------|-------|-------|--------|-----------|-------------|
| UB0STR | UB0TSF | 0 | 0 | 0 | UB0OVF | UB0PE | UB0FE | UB0OVE | FFFFFA04H | 00H         |
| UB1STR | UB1TSF | 0 | 0 | 0 | UB1OVF | UB1PE | UB1FE | UB1OVE | FFFFFA24H | 00H         |

| Bit position | Bit name | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|--------------|----------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 7            | UBnTSF   | <p>This is a status flag indicating the transfer status.</p> <ul style="list-style-type: none"> <li>In single mode (UBnMOD bit = 0 in the UBnFIC0 register)           <ul style="list-style-type: none"> <li>0: Data to be transferred to transmit shift register n and UBnTX register does not exist (cleared (0) when UBnPWR bit = 0 or UBnTXE bit = 0 in the UBnCTL0 register).</li> <li>1: Data to be transferred to transmit shift register n or UBnTX register exists (transmission in progress).</li> </ul> </li> <li>In FIFO mode (UBnMOD bit = 1 in the UBnFIC0 register)           <ul style="list-style-type: none"> <li>0: Data to be transferred to transmit shift register n and transmit FIFO n does not exist (cleared (0) when UBnPWR bit = 0 or UBnTXE bit = 0 in the UBnCTL0 register).</li> <li>1: Data to be transferred to transmit shift register n and transmit FIFO n exists (transmission in progress).</li> </ul> </li> </ul> <p><b>Caution</b> The value of the UBnTSF bit is reflected after two periods of <math>f_x/4</math> (<math>f_x</math>: main clock) have elapsed, after the transmit data is written to the UBnTX register. Therefore, exercise care when referencing the UBnTSF bit after transmit data has been written to the UBnTX register.</p> |
| 3            | UBnOVF   | <p>This is a status flag indicating an overflow. The setting of this flag is valid only in the FIFO mode (when UBnMOD bit = 1 in the UBnFIC0 register), and invalid in the single mode (when UBnMOD bit = 0 in the UBnFIC0 register).</p> <ul style="list-style-type: none"> <li>0: Overflow did not occur.</li> <li>1: Overflow occurred (during reception).</li> </ul> <p><b>Caution</b> If an overflow occurs, the received data is not written to receive FIFO n but discarded.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |

**Remark** n = 0, 1



| Bit position | Bit name | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|--------------|----------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 2            | UBnPE    | <p>This is a status flag that indicates a parity error. The setting of this flag is valid only in the single mode (when UBnMOD bit = 0 in the UBnFIC0 register), and invalid in the FIFO mode (when UBnMOD bit = 1 in the UBnFIC0 register).</p> <p>0: Parity error did not occur.<br/>1: Parity error occurred (during reception).</p> <p><b>Caution</b> The operation of the UBnPE bit differs according to the settings of the UBnPS1 and UBnPS0 bits of the UBnCTL0 register.</p>       |
| 1            | UBnFE    | <p>This is a status flag that indicates a framing error. The setting of this flag is valid only in the single mode (when UBnMOD bit = 0 in the UBnFIC0 register), and invalid in the FIFO mode (when UBnMOD bit = 1 in the UBnFIC0 register).</p> <p>0: Framing error did not occur.<br/>1: Framing error occurred (during reception).</p> <p><b>Caution</b> Only the first bit of the stop bits of the receive data is checked, regardless of the stop bit length.</p>                     |
| 0            | UBnOVE   | <p>This is a status flag that indicates an overrun error. The setting of this flag is valid only in the single mode (when UBnMOD bit = 0 in the UBnFIC0 register), and invalid in the FIFO mode (when UBnMOD bit = 1 in the UBnFIC0 register).</p> <p>0: Overrun error did not occur.<br/>1: Overrun error occurred (during reception).</p> <p><b>Caution</b> When an overrun error occurs, the next receive data value is not written to the UBnRX register and the data is discarded.</p> |

**Remark** n = 0, 1

### (3) UARTBn control register 2 (UBnCTL2) (n = 0, 1)

The UBnCTL2 register is used to specify the division ratio by which to control the baud rate (serial transfer speed) of UARTBn.

This register can be read or written in 16-bit units.

**Caution** When rewriting the UBnBRS15 to UBnBRS0 bits of this register, clear the UBnTXE and UBnRXE bits of the UBnCTL0 register to 0 or clear the UBnPWR bit (n = 0, 1).

|         | 15  | 14  | 13  | 12  | 11  | 10  | 9   | 8   | 7   | 6   | 5   | 4   | 3   | 2   | 1   | 0   | Address   | After reset |
|---------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----------|-------------|
| UB0CTL2 | UB0 | UB0 | UB0 | UB0 | UB0 | UB0 | UB0 | UB0 | UB0 | UB0 | UB0 | UB0 | UB0 | UB0 | UB0 | UB0 | FFFFFA02H | FFFFH       |
|         | BRS | BRS | BRS | BRS | BRS | BRS | BRS | BRS | BRS | BRS | BRS | BRS | BRS | BRS | BRS | BRS |           |             |
|         | 15  | 14  | 13  | 12  | 11  | 10  | 9   | 8   | 7   | 6   | 5   | 4   | 3   | 2   | 1   | 0   |           |             |
| UB1CTL2 | UB1 | UB1 | UB1 | UB1 | UB1 | UB1 | UB1 | UB1 | UB1 | UB1 | UB1 | UB1 | UB1 | UB1 | UB1 | UB1 | FFFFFA22H | FFFFH       |
|         | BRS | BRS | BRS | BRS | BRS | BRS | BRS | BRS | BRS | BRS | BRS | BRS | BRS | BRS | BRS | BRS |           |             |
|         | 15  | 14  | 13  | 12  | 11  | 10  | 9   | 8   | 7   | 6   | 5   | 4   | 3   | 2   | 1   | 0   |           |             |

| Bit position | Bit name            | Function                                                                   |
|--------------|---------------------|----------------------------------------------------------------------------|
| 15 to 0      | UBnBRS15 to UBnBRS0 | Specify the division value of the 16-bit counter (see <b>Table 10-1</b> ). |

**Remark** n = 0, 1

**Table 10-1. Division Value of 16-Bit Counter**

| UBnB RS15 | UBnB RS14 | UBnB RS13 | UBnB RS12 | UBnB RS11 | UBnB RS10 | UBnB RS9 | UBnB RS8 | UBnB RS7 | UBnB RS6 | UBnB RS5 | UBnB RS4 | UBnB RS3 | UBnB RS2 | UBnB RS1 | UBnB RS0 | k      | Output Clock Selected |
|-----------|-----------|-----------|-----------|-----------|-----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|--------|-----------------------|
| 0         | 0         | 0         | 0         | 0         | 0         | 0        | 0        | 0        | 0        | 0        | 0        | 0        | 0        | x        | x        | 4      | $fx/(4 \times k)$     |
| 0         | 0         | 0         | 0         | 0         | 0         | 0        | 0        | 0        | 0        | 0        | 0        | 0        | 1        | 0        | 0        | 4      | $fx/(4 \times k)$     |
| 0         | 0         | 0         | 0         | 0         | 0         | 0        | 0        | 0        | 0        | 0        | 0        | 0        | 1        | 0        | 1        | 5      | $fx/(4 \times k)$     |
| 0         | 0         | 0         | 0         | 0         | 0         | 0        | 0        | 0        | 0        | 0        | 0        | 0        | 1        | 1        | 0        | 6      | $fx/(4 \times k)$     |
| •         | •         | •         | •         | •         | •         | •        | •        | •        | •        | •        | •        | •        | •        | •        | •        | •      | •                     |
| •         | •         | •         | •         | •         | •         | •        | •        | •        | •        | •        | •        | •        | •        | •        | •        | •      | •                     |
| •         | •         | •         | •         | •         | •         | •        | •        | •        | •        | •        | •        | •        | •        | •        | •        | •      | •                     |
| 1         | 1         | 1         | 1         | 1         | 1         | 1        | 1        | 1        | 1        | 1        | 1        | 1        | 1        | 0        | 0        | 65,532 | $fx/(4 \times k)$     |
| 1         | 1         | 1         | 1         | 1         | 1         | 1        | 1        | 1        | 1        | 1        | 1        | 1        | 1        | 0        | 1        | 65,533 | $fx/(4 \times k)$     |
| 1         | 1         | 1         | 1         | 1         | 1         | 1        | 1        | 1        | 1        | 1        | 1        | 1        | 1        | 1        | 0        | 65,534 | $fx/(4 \times k)$     |
| 1         | 1         | 1         | 1         | 1         | 1         | 1        | 1        | 1        | 1        | 1        | 1        | 1        | 1        | 1        | 1        | 65,535 | $fx/(4 \times k)$     |

**Remarks** 1. fx: Main clock

2. k: Value set by UBnBRS15 to UBnBRS0 bits of UBnCTL2 register (k = 4, 5, 6, ..., 65,535)

3. x: Don't care

**(4) UARTBn transmit data register (UBnTX) (n = 0, 1)**

The UBnTX register is used to set transmit data. It functions as the 8-bit × 1-stage UBnTX register, in the single mode (UBnMOD bit = 0 in the UBnFIC0 register), and as the 8-bit × 16-stage transmit FIFO in the FIFO mode (UBnMOD bit = 1 in the UBnFIC0 register).

In the single mode, transmission is started by writing transmit data to the UBnTX register when transmission is enabled (the UBnTXE bit = 1 in the UBnCTL0 register). When data can be written to the UBnTX register (when 1 byte of data is transferred from the UBnTX register to transmit shift register n), a transmission completion interrupt request (UBTITn) is generated.

In the FIFO mode, transmission is started by enabling transmission (UBnTXE bit = 1) after writing at least the number of transmit data set as the trigger by the UBnTT3 to UBnTT0 bits of the UBnFIC2 register and 16 bytes or less to transmit FIFO. When the number of transmit data set as the trigger by the UBnTT3 to UBnTT0 bits of the UBnFIC2 register have been transferred from transmit FIFO to transmit shift register n (transmit data of the number set as the trigger can be written to transmit FIFO), a transmission completion interrupt request (UBTITn) is generated. In the FIFO mode, a FIFO transmission completion interrupt request (UBTIFn) is generated when there is no more data in transmit FIFO and transmit shift register n (when the FIFO and register become empty).

For the generation timing of the interrupt, see **10.2.4 Interrupt requests**.

When 7-bit length data is transmitted with the LSB first, bits 6 to 0 of transmit data register n are transmitted as the transmit data from the LSB (bit 0) with the MSB (bit 7) always being 0. When data is transmitted with the MSB first, bits 7 to 1 of transmit data register n are transmitted as the transmit data from the MSB (bit 7) with the LSB (bit 0) always being 0.

This register is write-only, in 8-bit units. Data is written to transmit data register n.

|       | 7      | 6      | 5      | 4      | 3      | 2      | 1      | 0      | Address   | After reset |
|-------|--------|--------|--------|--------|--------|--------|--------|--------|-----------|-------------|
| UB0TX | UB0TD7 | UB0TD6 | UB0TD5 | UB0TD4 | UB0TD3 | UB0TD2 | UB0TD1 | UB0TD0 | FFFFFA08H | FFH         |
| UB1TX | UB1TD7 | UB1TD6 | UB1TD5 | UB1TD4 | UB1TD3 | UB1TD2 | UB1TD1 | UB1TD0 | FFFFFA28H | FFH         |

| Bit position | Bit name         | Function             |
|--------------|------------------|----------------------|
| 7 to 0       | UBnTD7 to UBnTD0 | Write transmit data. |

**Remark** n = 0, 1

**(5) UARTBn receive data register AP (UBnRXAP), UARTBn receive data register (UBnRX) (n = 0, 1)**

These registers store parallel data converted by receive shift register n. They function as the 8-bit  $\times$  1-stage UBnRX register, in the single mode (UBnMOD bit = 0 in the UBnFIC0 register), and as the 16-bit  $\times$  16-stage receive FIFO (UBnRXAP register) in the FIFO mode (UBnMOD bit = 1 in the UBnFIC0 register).

The receive data is stored in the lower 8 bits of the receive FIFO (UBnRXAP register) and the error information of the received data is stored in the higher 8 bits (bit 8 and bit 9). If a reception error (such as a parity error or a framing error) occurs in the FIFO mode, the UBnRXAP register is read in 16-bit (halfword) units. In this way, the flag of the data stored in receive FIFO can be checked (error information is appended as UBnPEF bit = 1 or UBnFEF bit = 1), so that the error data can be recognized (when the lower 8 bits of the UBnRXAP register are read in 8-bit (byte) units, the higher 8 bits are discarded. Therefore, if no error has occurred, the receive data of the UBnRXAP register can be read consecutively by being read in 8-bit (byte) units in the same way as the UBnRX register).

If reception is enabled (UBnRXE bit = 1 in the UBnCTL0 register), the receive data is transferred from receive shift register n to receive data register n, in synchronization with the completion of the shift-in processing of one frame.

By transferring the receive data to the UBnRX register in the single mode or by transferring the number of receive data set as the trigger by the UBnRT3 to UBnRT0 bits of the UBnFIC2 register to the receive FIFO in the FIFO mode, a reception completion interrupt request (UBnIRn) is generated. If data is stored in receive FIFO when the next data does not come (start bit is not detected) even after the next data reception wait time specified by the UBnTC4 to UBnTC0 bits of the UBnFIC1 register has elapsed in the FIFO mode, a reception timeout interrupt request (UBnITOn) is generated.

For information about the timing for generating these interrupt requests, see **10.2.4 Interrupt requests**.

If data is received with the LSB first when the data length is specified as 7 bits, the received data is transferred to bits 6 to 0 of receive data register n from the LSB (bit 0), with the MSB (bit 7) always being 0. If data is received with the MSB first, it is transferred to bits 7 to 1 of receive data register n from the MSB (bit 7) with the LSB (bit 0) always being 0. However, if an overrun error occurs, the receive data at that time is not transferred to receive data register n.

The UBnRXAP register is read-only, in 16-bit units. However, the lower 8 bits of the UBnRXAP register are read-only, in 8-bit units.

The UBnRX register is read-only, in 8-bit units.

In addition to reset input, the value of these registers can be set to FFH in the single mode or to 00FFH in the FIFO mode, by clearing the UBnPWR bit of the UBnCTL0 register to 0.

**Cautions 1. The UBnPEF and UBnFEF bits cannot be read because these registers serve as 8-bit registers in the single mode.**

- 2. When no reception error has occurred in the FIFO mode, the receive data of the UBnRXAP register can be read consecutively by reading the lower 8 bits of the UBnRXAP register in 8-bit (byte) units. An 8-bit access to the higher 8 bits is prohibited. If they are accessed, the operation is not guaranteed.**

**Caution 3.** Do not perform the following operations when debugging a system that uses the single mode.

- Setting a break for an instruction immediately after the UBnRX register is read
- Setting a break before DMA transfer with the UBnRX register specified as the transfer source is completed
- Setting a break before completion of reception of the next data after reception of data and reading the UBnRX register, and checking the UBnRX register in the I/O register window of the debugger

If any of these operations is performed, an overrun error may occur during the subsequent reception.

[UARTBn receive data register AP]

|         | 15 | 14 | 13 | 12 | 11 | 10 | 9          | 8          | 7          | 6          | 5          | 4          | 3          | 2          | 1          | 0          | Address    | After reset |
|---------|----|----|----|----|----|----|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|-------------|
| UB0RXAP | 0  | 0  | 0  | 0  | 0  | 0  | UB0<br>PEF | UB0<br>FEF | UB0<br>RD7 | UB0<br>RD6 | UB0<br>RD5 | UB0<br>RD4 | UB0<br>RD3 | UB0<br>RD2 | UB0<br>RD1 | UB0<br>RD0 | FFFFFFA06H | 00FFH       |
| UB1RXAP | 0  | 0  | 0  | 0  | 0  | 0  | UB1<br>PEF | UB1<br>FEF | UB1<br>RD7 | UB1<br>RD6 | UB1<br>RD5 | UB1<br>RD4 | UB1<br>RD3 | UB1<br>RD2 | UB1<br>RD1 | UB1<br>RD0 | FFFFFFA26H | 00FFH       |

[UARTBn receive data register]

|       | 7          | 6          | 5          | 4          | 3          | 2          | 1          | 0          | Address    | After reset |
|-------|------------|------------|------------|------------|------------|------------|------------|------------|------------|-------------|
| UB0RX | UB0<br>RD7 | UB0<br>RD6 | UB0<br>RD5 | UB0<br>RD4 | UB0<br>RD3 | UB0<br>RD2 | UB0<br>RD1 | UB0<br>RD0 | FFFFFFA06H | FFH         |
| UB1RX | UB1<br>RD7 | UB1<br>RD6 | UB1<br>RD5 | UB1<br>RD4 | UB1<br>RD3 | UB1<br>RD2 | UB1<br>RD1 | UB1<br>RD0 | FFFFFFA26H | FFH         |

| Bit position   | Bit name            | Function                                                                                                                                                                                                                                                                                                                                                                                                                              |
|----------------|---------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 9<br>(UBnRXAP) | UBnPEF              | This is a status flag that indicates a parity error. Status is valid only in the FIFO mode (UBnMOD bit = 1 in the UBnFIC0 register), and is invalid in the single mode (UBnMOD bit = 0 in the UBnFIC0 register).<br>0: No parity error<br>1: Parity error occurs (during reception).<br><br><b>Caution</b> The operation of the UBnPEF bit differs depending on the set values of the UBnPS1 and UBnPS0 bits of the UBnCTL0 register. |
| 8<br>(UBnRXAP) | UBnFEF              | This is a status flag indicating a framing error. Status is valid only in the FIFO mode (UBnMOD bit = 1 in the UBnFIC0 register), and is invalid in the single mode (UBnMOD bit = 0 in the UBnFIC0 register).<br>0: No framing error<br>1: Framing error occurs (during reception).<br><br><b>Caution</b> Only the first bit of the stop bits of the receive data is checked, regardless of the stop bit length.                      |
| 7 to 0         | UBnRD7 to<br>UBnRD0 | Stores receive data.                                                                                                                                                                                                                                                                                                                                                                                                                  |

**Remark** n = 0, 1

**(6) UARTBn FIFO control register 0 (UBnFIC0) (n = 0, 1)**

The UBnFIC0 register is used to select the operation mode of UARTBn and the functions that become valid in the FIFO mode (UBnMOD bit = 1). In the FIFO mode, it clears transmit FIFO/receive FIFO and specifies the timing mode in which the transmission completion interrupt (UBTITn)/reception completion interrupt (UBTIRn) is generated.

This register can be read or written in 8-bit or 1-bit units.

(1/2)

|         | 7      | 6 | 5 | 4 | 3      | 2      | 1      | 0      | Address   | After reset |
|---------|--------|---|---|---|--------|--------|--------|--------|-----------|-------------|
| UB0FIC0 | UB0MOD | 0 | 0 | 0 | UB0TFC | UB0RFC | UB0ITM | UB0IRM | FFFFFA0AH | 00H         |
| UB1FIC0 | UB1MOD | 0 | 0 | 0 | UB1TFC | UB1RFC | UB1ITM | UB1IRM | FFFFFA2AH | 00H         |

| Bit position | Bit name | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|--------------|----------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 7            | UBnMOD   | Specifies an operation mode of UARTBn.<br>0: Single mode<br>1: FIFO mode                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| 3            | UBnTFC   | <p>This is a transmit FIFO clear trigger bit. The setting of this bit is valid only in the FIFO mode (UBnMOD bit = 1) and invalid in the single mode (UBnMOD bit = 0).</p> <p>0: Normal status<br/>1: Clear (This bit automatically returns to 0 after transmit FIFO is cleared.)</p> <p>When 1 is written to the UBnTFC bit, the pointer to transmit FIFO is cleared to 0. In the pending mode (UBnITM bit = 0), the interrupt request (UBTITn) held pending is cleared<sup>Note</sup>. However, bit 7 (UTIFn) of the interrupt control register (UTICn) is not cleared to 0. Clear this bit to 0 as necessary.</p> <p>When 0 is written to the UBnTFC bit, the status is retained. No operation, such as clearing or setting, is executed.</p> <p><b>Note</b> After transmit FIFO is cleared (UBnTFC bit = 1), accessing the registers related to UARTB is prohibited for the duration of four cycles of <math>f_x/4</math> (<math>f_x</math>: main clock) or until clearing the UBnTFC bit (automatic recovery) is confirmed by reading the UBnFIC0 register. If these registers are accessed, the operation is not guaranteed.</p> <p><b>Caution</b> When writing 1 to the UBnTFC bit, be sure to clear the UBnTXE bit of the UBnCTL0 register to 0 (disabling transmission). If 1 is written to the UBnTFC bit when the UBnTXE bit is 1 (transmission enabled), the operation is not guaranteed.</p> |

**Remark** n = 0, 1

| Bit position | Bit name | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|--------------|----------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 2            | UBnRFC   | <p>This is a receive FIFO (UBnRXAP) clear trigger bit. The setting of this bit is valid only in the FIFO mode (UBnMOD bit = 1) and invalid in the single mode (UBnMOD bit = 0).</p> <p>0: Normal status<br/>1: Clear (This bit automatically returns to 0 after receive FIFO is cleared.)</p> <p>When 1 is written to the UBnRFC bit, the pointer to receive FIFO is cleared to 0. In the pending mode (UBnIRM bit = 0), the interrupt request (UBTIRn) held pending is cleared<sup>Note</sup>. However, bit 7 (URIFn) of the interrupt control register (URICn) is not cleared to 0. Clear this bit to 0 as necessary.</p> <p>When 0 is written to the UBnRFC bit, the status is retained. No operation, such as clearing or setting, is executed.</p> <p><b>Note</b> After receive FIFO (UBnRXAP) is cleared (UBnRFC bit = 1), accessing the registers related to UARTB is prohibited for the duration of four cycles of <math>f_x/4</math> (<math>f_x</math>: main clock) or until clearing the UBnRFC bit (automatic recovery) is confirmed by reading the UBnFIC0 register. If these registers are accessed, the operation is not guaranteed.</p> <p><b>Caution</b> When writing 1 to the UBnRFC bit, be sure to clear the UBnRXE bit of the UBnCTL0 register to 0 (disabling reception). If 1 is written to the UBnRFC bit when the UBnRXE bit is 1 (reception enabled), the operation is not guaranteed.</p> |
| 1            | UBnITM   | <p>This bit specifies the timing mode in which the UBTITn interrupt is generated in FIFO mode.</p> <p>0: Pending mode<br/>1: Pointer mode</p> <p>In the FIFO mode, the UBTITn interrupt is generated as soon as transmit data of the number set as the trigger by the UBnTT3 to UBnTT0 bits of the UBnFIC2 register have been transferred from transmit FIFO to transmit shift register n. After the UBTITn interrupt request has been generated, specify the timing of actually generating the UBTITn interrupt as the pending mode or pointer mode. For details, see <b>10.2.5 (2) Pending mode/pointer mode</b>.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| 0            | UBnIRM   | <p>This bit specifies the timing mode in which the UBTIRn interrupt is generated in FIFO mode.</p> <p>0: Pending mode<br/>1: Pointer mode</p> <p>In the FIFO mode, the UBTIRn interrupt is generated as soon as receive data of the number set as the trigger by the UBnRT3 to UBnRT0 bits of the UBnFIC2 register have been transferred from receive shift register n to receive FIFO. After the UBTIRn interrupt request has been generated, specify the timing of actually generating the UBTIRn interrupt as the pending mode or pointer mode. For details, see <b>10.2.5 (2) Pending mode/pointer mode</b>.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |

**Remark** n = 0, 1

**(7) UARTBn FIFO control register 1 (UBnFIC1) (n = 0, 1)**

The UBnFIC1 register is valid in the FIFO mode (UBnMOD bit = 1 in the UBnFIC0 register). It generates a reception timeout interrupt request (UBTITOn) if data is stored in receive FIFO<sub>n</sub> when the next data does not come (start bit is not detected) after the lapse of the time set by the UBnTC4 to UBnTC0 bits (next data reception wait time), after the stop bit has been received.

This register can be read or written in 8-bit or 1-bit units.

|         | 7      | 6 | 5 | 4      | 3      | 2      | 1      | 0      | Address   | After reset |
|---------|--------|---|---|--------|--------|--------|--------|--------|-----------|-------------|
| UB0FIC1 | UB0TCE | 0 | 0 | UB0TC4 | UB0TC3 | UB0TC2 | UB0TC1 | UB0TC0 | FFFFFA0BH | 00H         |
| UB1FIC1 | UB1TCE | 0 | 0 | UB1TC4 | UB1TC3 | UB1TC2 | UB1TC1 | UB1TC0 | FFFFFA2BH | 00H         |

| Bit position | Bit name         | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |        |        |                               |        |        |                               |   |   |   |   |   |                               |   |   |   |   |   |                               |   |   |   |   |   |                               |   |   |   |   |   |                               |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |                             |   |   |   |   |   |                             |   |   |   |   |   |                             |   |   |   |   |   |                            |
|--------------|------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|--------|-------------------------------|--------|--------|-------------------------------|---|---|---|---|---|-------------------------------|---|---|---|---|---|-------------------------------|---|---|---|---|---|-------------------------------|---|---|---|---|---|-------------------------------|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|-----------------------------|---|---|---|---|---|-----------------------------|---|---|---|---|---|-----------------------------|---|---|---|---|---|----------------------------|
| 7            | UBnTCE           | Specifies the timeout counter function.<br>0: Disable use of timeout counter function.<br>1: Enable use of timeout counter function.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |        |        |                               |        |        |                               |   |   |   |   |   |                               |   |   |   |   |   |                               |   |   |   |   |   |                               |   |   |   |   |   |                               |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |                             |   |   |   |   |   |                             |   |   |   |   |   |                             |   |   |   |   |   |                            |
| 4 to 0       | UBnTC4 to UBnTC0 | <div>Specify the time to wait for the next data reception.<table><tr><th>UBnTC4</th><th>UBnTC3</th><th>UBnTC2</th><th>UBnTC1</th><th>UBnTC0</th><th>Next data reception wait time</th></tr><tr><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>32 bytes (32 × 8 / baud rate)</td></tr><tr><td>0</td><td>0</td><td>0</td><td>0</td><td>1</td><td>31 bytes (31 × 8 / baud rate)</td></tr><tr><td>0</td><td>0</td><td>0</td><td>1</td><td>0</td><td>30 bytes (30 × 8 / baud rate)</td></tr><tr><td>0</td><td>0</td><td>0</td><td>1</td><td>1</td><td>29 bytes (29 × 8 / baud rate)</td></tr><tr><td>•</td><td>•</td><td>•</td><td>•</td><td>•</td><td>•</td></tr><tr><td>•</td><td>•</td><td>•</td><td>•</td><td>•</td><td>•</td></tr><tr><td>•</td><td>•</td><td>•</td><td>•</td><td>•</td><td>•</td></tr><tr><td>1</td><td>1</td><td>1</td><td>0</td><td>0</td><td>4 bytes (4 × 8 / baud rate)</td></tr><tr><td>1</td><td>1</td><td>1</td><td>0</td><td>1</td><td>3 bytes (3 × 8 / baud rate)</td></tr><tr><td>1</td><td>1</td><td>1</td><td>1</td><td>0</td><td>2 bytes (2 × 8 / baud rate)</td></tr><tr><td>1</td><td>1</td><td>1</td><td>1</td><td>1</td><td>1 byte (1 × 8 / baud rate)</td></tr></table></div> <div>Caution When the count set by the UBnTC4 to UBnTC0 bits is up, the count value of the timeout counter is cleared to 0, regardless of the status of the data stored in receive FIFO<sub>n</sub>. When the next start bit is later detected, counting is started again from the stop bit of that data.</div> | UBnTC4 | UBnTC3 | UBnTC2                        | UBnTC1 | UBnTC0 | Next data reception wait time | 0 | 0 | 0 | 0 | 0 | 32 bytes (32 × 8 / baud rate) | 0 | 0 | 0 | 0 | 1 | 31 bytes (31 × 8 / baud rate) | 0 | 0 | 0 | 1 | 0 | 30 bytes (30 × 8 / baud rate) | 0 | 0 | 0 | 1 | 1 | 29 bytes (29 × 8 / baud rate) | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | 1 | 1 | 1 | 0 | 0 | 4 bytes (4 × 8 / baud rate) | 1 | 1 | 1 | 0 | 1 | 3 bytes (3 × 8 / baud rate) | 1 | 1 | 1 | 1 | 0 | 2 bytes (2 × 8 / baud rate) | 1 | 1 | 1 | 1 | 1 | 1 byte (1 × 8 / baud rate) |
| UBnTC4       | UBnTC3           | UBnTC2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | UBnTC1 | UBnTC0 | Next data reception wait time |        |        |                               |   |   |   |   |   |                               |   |   |   |   |   |                               |   |   |   |   |   |                               |   |   |   |   |   |                               |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |                             |   |   |   |   |   |                             |   |   |   |   |   |                             |   |   |   |   |   |                            |
| 0            | 0                | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 0      | 0      | 32 bytes (32 × 8 / baud rate) |        |        |                               |   |   |   |   |   |                               |   |   |   |   |   |                               |   |   |   |   |   |                               |   |   |   |   |   |                               |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |                             |   |   |   |   |   |                             |   |   |   |   |   |                             |   |   |   |   |   |                            |
| 0            | 0                | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 0      | 1      | 31 bytes (31 × 8 / baud rate) |        |        |                               |   |   |   |   |   |                               |   |   |   |   |   |                               |   |   |   |   |   |                               |   |   |   |   |   |                               |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |                             |   |   |   |   |   |                             |   |   |   |   |   |                             |   |   |   |   |   |                            |
| 0            | 0                | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 1      | 0      | 30 bytes (30 × 8 / baud rate) |        |        |                               |   |   |   |   |   |                               |   |   |   |   |   |                               |   |   |   |   |   |                               |   |   |   |   |   |                               |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |                             |   |   |   |   |   |                             |   |   |   |   |   |                             |   |   |   |   |   |                            |
| 0            | 0                | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 1      | 1      | 29 bytes (29 × 8 / baud rate) |        |        |                               |   |   |   |   |   |                               |   |   |   |   |   |                               |   |   |   |   |   |                               |   |   |   |   |   |                               |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |                             |   |   |   |   |   |                             |   |   |   |   |   |                             |   |   |   |   |   |                            |
| •            | •                | •                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | •      | •      | •                             |        |        |                               |   |   |   |   |   |                               |   |   |   |   |   |                               |   |   |   |   |   |                               |   |   |   |   |   |                               |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |                             |   |   |   |   |   |                             |   |   |   |   |   |                             |   |   |   |   |   |                            |
| •            | •                | •                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | •      | •      | •                             |        |        |                               |   |   |   |   |   |                               |   |   |   |   |   |                               |   |   |   |   |   |                               |   |   |   |   |   |                               |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |                             |   |   |   |   |   |                             |   |   |   |   |   |                             |   |   |   |   |   |                            |
| •            | •                | •                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | •      | •      | •                             |        |        |                               |   |   |   |   |   |                               |   |   |   |   |   |                               |   |   |   |   |   |                               |   |   |   |   |   |                               |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |                             |   |   |   |   |   |                             |   |   |   |   |   |                             |   |   |   |   |   |                            |
| 1            | 1                | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 0      | 0      | 4 bytes (4 × 8 / baud rate)   |        |        |                               |   |   |   |   |   |                               |   |   |   |   |   |                               |   |   |   |   |   |                               |   |   |   |   |   |                               |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |                             |   |   |   |   |   |                             |   |   |   |   |   |                             |   |   |   |   |   |                            |
| 1            | 1                | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 0      | 1      | 3 bytes (3 × 8 / baud rate)   |        |        |                               |   |   |   |   |   |                               |   |   |   |   |   |                               |   |   |   |   |   |                               |   |   |   |   |   |                               |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |                             |   |   |   |   |   |                             |   |   |   |   |   |                             |   |   |   |   |   |                            |
| 1            | 1                | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 1      | 0      | 2 bytes (2 × 8 / baud rate)   |        |        |                               |   |   |   |   |   |                               |   |   |   |   |   |                               |   |   |   |   |   |                               |   |   |   |   |   |                               |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |                             |   |   |   |   |   |                             |   |   |   |   |   |                             |   |   |   |   |   |                            |
| 1            | 1                | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 1      | 1      | 1 byte (1 × 8 / baud rate)    |        |        |                               |   |   |   |   |   |                               |   |   |   |   |   |                               |   |   |   |   |   |                               |   |   |   |   |   |                               |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |                             |   |   |   |   |   |                             |   |   |   |   |   |                             |   |   |   |   |   |                            |

**Remark** n = 0, 1



**(8) UARTBn FIFO control register 2 (UBnFIC2) (n = 0, 1)**

The UBnFIC2 register is valid in the FIFO mode (UBnMOD bit = 1 in the UBnFIC0 register). It sets the timing of generating an interrupt, using the number of transmit/receive data as a trigger. When data is transmitted, the number of data transferred from transmit FIFO is specified as the condition of generating the interrupt. When data is received, the number of data stored in receive FIFO is specified as the interrupt generation condition.

This register can be read or written in 16-bit units.

When the higher 8 bits of the UBnFIC2 register can be used as the UBnFIC2H register and the lower 8 bits, as the UBnFIC2L register, these registers can be read or written in 8-bit units.

**Caution** Be sure to clear the UBnTXE bit (to disable transmission) and UBnRXE bit (to disable reception) of the UBnCTL0 register to 0 before writing data to the UBnFIC2 register. If data is written to the UBnFIC2 register with the UBnTXE or UBnRXE bit set to 1, the operation is not guaranteed.

|         | 15 | 14 | 13 | 12 | 11         | 10         | 9          | 8          | 7 | 6 | 5 | 4 | 3          | 2          | 1          | 0          | Address    | After reset |
|---------|----|----|----|----|------------|------------|------------|------------|---|---|---|---|------------|------------|------------|------------|------------|-------------|
| UB0FIC2 | 0  | 0  | 0  | 0  | UB0<br>TT3 | UB0<br>TT2 | UB0<br>TT1 | UB0<br>TT0 | 0 | 0 | 0 | 0 | UB0<br>RT3 | UB0<br>RT2 | UB0<br>RT1 | UB0<br>RT0 | FFFFFFA0CH | 0000H       |
| UB1FIC2 | 0  | 0  | 0  | 0  | UB1<br>TT3 | UB1<br>TT2 | UB1<br>TT1 | UB1<br>TT0 | 0 | 0 | 0 | 0 | UB1<br>RT3 | UB1<br>RT2 | UB1<br>RT1 | UB1<br>RT0 | FFFFFFA2CH | 0000H       |

| Bit position | Bit name            | Function                                                                                                                                                                                                                                                                                                                                                    |            |            |            |                                                      |                       |                 |   |   |   |   |        |          |          |   |   |   |   |         |                       |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |          |   |   |   |   |          |   |   |   |   |          |   |   |   |   |          |   |   |   |   |          |   |   |   |   |          |   |   |   |   |          |
|--------------|---------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|------------|------------|------------------------------------------------------|-----------------------|-----------------|---|---|---|---|--------|----------|----------|---|---|---|---|---------|-----------------------|---|---|---|---|---------|---|---|---|---|---------|---|---|---|---|---------|---|---|---|---|---------|---|---|---|---|---------|---|---|---|---|---------|---|---|---|---|---------|---|---|---|---|----------|---|---|---|---|----------|---|---|---|---|----------|---|---|---|---|----------|---|---|---|---|----------|---|---|---|---|----------|---|---|---|---|----------|
| 11 to 8      | UBnTT3 to<br>UBnTT0 | Set the number of transmit FIFO transmit data to be the trigger.<br>Each time data of the specified number has shifted out from transmit FIFO to transmit shift register n, the UBTITn interrupt is generated.<br>In the pending mode (UBnITM bit = 0 in the UBnFIC0 register), the UBTITn interrupt is generated under the conditions of the pending mode. |            |            |            |                                                      |                       |                 |   |   |   |   |        |          |          |   |   |   |   |         |                       |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |          |   |   |   |   |          |   |   |   |   |          |   |   |   |   |          |   |   |   |   |          |   |   |   |   |          |   |   |   |   |          |
|              |                     | UBn<br>TT3                                                                                                                                                                                                                                                                                                                                                  | UBn<br>TT2 | UBn<br>TT1 | UBn<br>TT0 | Number of data of<br>transmit FIFO set<br>as trigger | Pointer<br>mode       | Pending<br>mode | 0 | 0 | 0 | 0 | 1 byte | Settable | Settable | 0 | 0 | 0 | 1 | 2 bytes | Setting<br>prohibited | 0 | 0 | 1 | 0 | 3 bytes | 0 | 0 | 1 | 1 | 4 bytes | 0 | 1 | 0 | 0 | 5 bytes | 0 | 1 | 0 | 1 | 6 bytes | 0 | 1 | 1 | 0 | 7 bytes | 0 | 1 | 1 | 1 | 8 bytes | 1 | 0 | 0 | 0 | 9 bytes | 1 | 0 | 0 | 1 | 10 bytes | 1 | 0 | 1 | 0 | 11 bytes | 1 | 0 | 1 | 1 | 12 bytes | 1 | 1 | 0 | 0 | 13 bytes | 1 | 1 | 0 | 1 | 14 bytes | 1 | 1 | 1 | 0 | 15 bytes | 1 | 1 | 1 | 1 | 16 bytes |
|              |                     | UBn<br>TT3                                                                                                                                                                                                                                                                                                                                                  | UBn<br>TT2 | UBn<br>TT1 | UBn<br>TT0 | Number of data of<br>transmit FIFO set<br>as trigger | Pointer<br>mode       | Pending<br>mode |   |   |   |   |        |          |          |   |   |   |   |         |                       |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |          |   |   |   |   |          |   |   |   |   |          |   |   |   |   |          |   |   |   |   |          |   |   |   |   |          |   |   |   |   |          |
|              |                     | 0                                                                                                                                                                                                                                                                                                                                                           | 0          | 0          | 0          | 1 byte                                               | Settable              | Settable        |   |   |   |   |        |          |          |   |   |   |   |         |                       |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |          |   |   |   |   |          |   |   |   |   |          |   |   |   |   |          |   |   |   |   |          |   |   |   |   |          |   |   |   |   |          |
|              |                     | 0                                                                                                                                                                                                                                                                                                                                                           | 0          | 0          | 1          | 2 bytes                                              | Setting<br>prohibited |                 |   |   |   |   |        |          |          |   |   |   |   |         |                       |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |          |   |   |   |   |          |   |   |   |   |          |   |   |   |   |          |   |   |   |   |          |   |   |   |   |          |   |   |   |   |          |
|              |                     | 0                                                                                                                                                                                                                                                                                                                                                           | 0          | 1          | 0          | 3 bytes                                              |                       |                 |   |   |   |   |        |          |          |   |   |   |   |         |                       |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |          |   |   |   |   |          |   |   |   |   |          |   |   |   |   |          |   |   |   |   |          |   |   |   |   |          |   |   |   |   |          |
|              |                     | 0                                                                                                                                                                                                                                                                                                                                                           | 0          | 1          | 1          | 4 bytes                                              |                       |                 |   |   |   |   |        |          |          |   |   |   |   |         |                       |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |          |   |   |   |   |          |   |   |   |   |          |   |   |   |   |          |   |   |   |   |          |   |   |   |   |          |   |   |   |   |          |
|              |                     | 0                                                                                                                                                                                                                                                                                                                                                           | 1          | 0          | 0          | 5 bytes                                              |                       |                 |   |   |   |   |        |          |          |   |   |   |   |         |                       |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |          |   |   |   |   |          |   |   |   |   |          |   |   |   |   |          |   |   |   |   |          |   |   |   |   |          |   |   |   |   |          |
|              |                     | 0                                                                                                                                                                                                                                                                                                                                                           | 1          | 0          | 1          | 6 bytes                                              |                       |                 |   |   |   |   |        |          |          |   |   |   |   |         |                       |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |          |   |   |   |   |          |   |   |   |   |          |   |   |   |   |          |   |   |   |   |          |   |   |   |   |          |   |   |   |   |          |
|              |                     | 0                                                                                                                                                                                                                                                                                                                                                           | 1          | 1          | 0          | 7 bytes                                              |                       |                 |   |   |   |   |        |          |          |   |   |   |   |         |                       |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |          |   |   |   |   |          |   |   |   |   |          |   |   |   |   |          |   |   |   |   |          |   |   |   |   |          |   |   |   |   |          |
|              |                     | 0                                                                                                                                                                                                                                                                                                                                                           | 1          | 1          | 1          | 8 bytes                                              |                       |                 |   |   |   |   |        |          |          |   |   |   |   |         |                       |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |          |   |   |   |   |          |   |   |   |   |          |   |   |   |   |          |   |   |   |   |          |   |   |   |   |          |   |   |   |   |          |
|              |                     | 1                                                                                                                                                                                                                                                                                                                                                           | 0          | 0          | 0          | 9 bytes                                              |                       |                 |   |   |   |   |        |          |          |   |   |   |   |         |                       |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |          |   |   |   |   |          |   |   |   |   |          |   |   |   |   |          |   |   |   |   |          |   |   |   |   |          |   |   |   |   |          |
|              |                     | 1                                                                                                                                                                                                                                                                                                                                                           | 0          | 0          | 1          | 10 bytes                                             |                       |                 |   |   |   |   |        |          |          |   |   |   |   |         |                       |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |          |   |   |   |   |          |   |   |   |   |          |   |   |   |   |          |   |   |   |   |          |   |   |   |   |          |   |   |   |   |          |
|              |                     | 1                                                                                                                                                                                                                                                                                                                                                           | 0          | 1          | 0          | 11 bytes                                             |                       |                 |   |   |   |   |        |          |          |   |   |   |   |         |                       |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |          |   |   |   |   |          |   |   |   |   |          |   |   |   |   |          |   |   |   |   |          |   |   |   |   |          |   |   |   |   |          |
|              |                     | 1                                                                                                                                                                                                                                                                                                                                                           | 0          | 1          | 1          | 12 bytes                                             |                       |                 |   |   |   |   |        |          |          |   |   |   |   |         |                       |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |          |   |   |   |   |          |   |   |   |   |          |   |   |   |   |          |   |   |   |   |          |   |   |   |   |          |   |   |   |   |          |
|              |                     | 1                                                                                                                                                                                                                                                                                                                                                           | 1          | 0          | 0          | 13 bytes                                             |                       |                 |   |   |   |   |        |          |          |   |   |   |   |         |                       |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |          |   |   |   |   |          |   |   |   |   |          |   |   |   |   |          |   |   |   |   |          |   |   |   |   |          |   |   |   |   |          |
|              |                     | 1                                                                                                                                                                                                                                                                                                                                                           | 1          | 0          | 1          | 14 bytes                                             |                       |                 |   |   |   |   |        |          |          |   |   |   |   |         |                       |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |          |   |   |   |   |          |   |   |   |   |          |   |   |   |   |          |   |   |   |   |          |   |   |   |   |          |   |   |   |   |          |
|              |                     | 1                                                                                                                                                                                                                                                                                                                                                           | 1          | 1          | 0          | 15 bytes                                             |                       |                 |   |   |   |   |        |          |          |   |   |   |   |         |                       |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |          |   |   |   |   |          |   |   |   |   |          |   |   |   |   |          |   |   |   |   |          |   |   |   |   |          |   |   |   |   |          |
|              |                     | 1                                                                                                                                                                                                                                                                                                                                                           | 1          | 1          | 1          | 16 bytes                                             |                       |                 |   |   |   |   |        |          |          |   |   |   |   |         |                       |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |          |   |   |   |   |          |   |   |   |   |          |   |   |   |   |          |   |   |   |   |          |   |   |   |   |          |   |   |   |   |          |
|              |                     | <b>Caution</b> In the pointer mode (UBnITM bit = 1 in the UBnFIC0 register), the number of transmit data set as the trigger can be only 1 byte (UBnTT3 to UBnTT0 bits = 0000), and other settings are prohibited. If a setting of other than 1 byte is made, the operation is not guaranteed.                                                               |            |            |            |                                                      |                       |                 |   |   |   |   |        |          |          |   |   |   |   |         |                       |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |          |   |   |   |   |          |   |   |   |   |          |   |   |   |   |          |   |   |   |   |          |   |   |   |   |          |   |   |   |   |          |

**Remark** n = 0, 1

| Bit position | Bit name            | Function                                                                                                                                                                                                                                                                                                                                               |            |            |            |                                                     |                       |                 |
|--------------|---------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|------------|------------|-----------------------------------------------------|-----------------------|-----------------|
| 3 to 0       | UBnRT3 to<br>UBnRT0 | Set the number of receive FIFO receive data to be the trigger.<br>Each time data of the specified number has been stored from receive shift register n to receive FIFO, the UBTIR interrupt is generated.<br>In the pending mode (UBnITM bit = 0 in the UBnFIC0 register), the UBTIRn interrupt is generated under the conditions of the pending mode. |            |            |            |                                                     |                       |                 |
|              |                     | UBn<br>RT3                                                                                                                                                                                                                                                                                                                                             | UBn<br>RT2 | UBn<br>RT1 | UBn<br>RT0 | Number of data of<br>receive FIFO set<br>as trigger | Pointer<br>mode       | Pending<br>mode |
|              |                     | 0                                                                                                                                                                                                                                                                                                                                                      | 0          | 0          | 0          | 1 byte                                              | Settable              | Settable        |
|              |                     | 0                                                                                                                                                                                                                                                                                                                                                      | 0          | 0          | 1          | 2 bytes                                             | Setting<br>prohibited |                 |
|              |                     | 0                                                                                                                                                                                                                                                                                                                                                      | 0          | 1          | 0          | 3 bytes                                             |                       |                 |
|              |                     | 0                                                                                                                                                                                                                                                                                                                                                      | 0          | 1          | 1          | 4 bytes                                             |                       |                 |
|              |                     | 0                                                                                                                                                                                                                                                                                                                                                      | 1          | 0          | 0          | 5 bytes                                             |                       |                 |
|              |                     | 0                                                                                                                                                                                                                                                                                                                                                      | 1          | 0          | 1          | 6 bytes                                             |                       |                 |
|              |                     | 0                                                                                                                                                                                                                                                                                                                                                      | 1          | 1          | 0          | 7 bytes                                             |                       |                 |
|              |                     | 0                                                                                                                                                                                                                                                                                                                                                      | 1          | 1          | 1          | 8 bytes                                             |                       |                 |
|              |                     | 1                                                                                                                                                                                                                                                                                                                                                      | 0          | 0          | 0          | 9 bytes                                             |                       |                 |
|              |                     | 1                                                                                                                                                                                                                                                                                                                                                      | 0          | 0          | 1          | 10 bytes                                            |                       |                 |
|              |                     | 1                                                                                                                                                                                                                                                                                                                                                      | 0          | 1          | 0          | 11 bytes                                            |                       |                 |
|              |                     | 1                                                                                                                                                                                                                                                                                                                                                      | 0          | 1          | 1          | 12 bytes                                            |                       |                 |
|              |                     | 1                                                                                                                                                                                                                                                                                                                                                      | 1          | 0          | 0          | 13 bytes                                            |                       |                 |
|              |                     | 1                                                                                                                                                                                                                                                                                                                                                      | 1          | 0          | 1          | 14 bytes                                            |                       |                 |
|              |                     | 1                                                                                                                                                                                                                                                                                                                                                      | 1          | 1          | 0          | 15 bytes                                            |                       |                 |
|              |                     | 1                                                                                                                                                                                                                                                                                                                                                      | 1          | 1          | 1          | 16 bytes                                            |                       |                 |
|              |                     | <b>Caution</b> In the pointer mode (UBnIRM bit = 1 in the UBnFIC0 register), the number of receive data set as the trigger can be only 1 byte (UBnRT3 to UBnRT0 bits = 0000), and other settings are prohibited. If a setting of other than 1 byte is made, the operation is not guaranteed.                                                           |            |            |            |                                                     |                       |                 |

**Remark** n = 0, 1

**(9) UARTBn FIFO status register 0 (UBnFIS0) (n = 0, 1)**

The UBnFIS0 register is valid in the FIFO mode (UBnMOD bit = 1 in the UBnFIC0 register). It is used to read the number of bytes of the data stored in receive FIFO.

This register is read-only, in 8-bit units.

|         | 7 | 6 | 5 | 4      | 3      | 2      | 1      | 0      | Address   | After reset |
|---------|---|---|---|--------|--------|--------|--------|--------|-----------|-------------|
| UB0FIS0 | 0 | 0 | 0 | UB0RB4 | UB0RB3 | UB0RB2 | UB0RB1 | UB0RB0 | FFFFFA0EH | 00H         |
| UB1FIS0 | 0 | 0 | 0 | UB1RB4 | UB1RB3 | UB1RB2 | UB1RB1 | UB1RB0 | FFFFFA2EH | 00H         |

| Bit position     | Bit name         | Function                                                                                                     |            |            |            |            |                      |   |   |   |   |   |         |   |   |   |   |   |        |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |                  |  |  |  |  |         |
|------------------|------------------|--------------------------------------------------------------------------------------------------------------|------------|------------|------------|------------|----------------------|---|---|---|---|---|---------|---|---|---|---|---|--------|---|---|---|---|---|---------|---|---|---|---|---|---------|---|---|---|---|---|---------|---|---|---|---|---|---------|---|---|---|---|---|---------|---|---|---|---|---|---------|---|---|---|---|---|---------|---|---|---|---|---|---------|---|---|---|---|---|----------|---|---|---|---|---|----------|---|---|---|---|---|----------|---|---|---|---|---|----------|---|---|---|---|---|----------|---|---|---|---|---|----------|---|---|---|---|---|----------|------------------|--|--|--|--|---------|
| 4 to 0           | UBnRB4 to UBnRB0 | Indicates the number of bytes (readable bytes) of the data stored in receive FIFO as a receive FIFO pointer. |            |            |            |            |                      |   |   |   |   |   |         |   |   |   |   |   |        |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |                  |  |  |  |  |         |
|                  |                  | UBn<br>RB4                                                                                                   | UBn<br>RB3 | UBn<br>RB2 | UBn<br>RB1 | UBn<br>RB0 | Receive FIFO pointer | 0 | 0 | 0 | 0 | 0 | 0 bytes | 0 | 0 | 0 | 0 | 1 | 1 byte | 0 | 0 | 0 | 1 | 0 | 2 bytes | 0 | 0 | 0 | 1 | 1 | 3 bytes | 0 | 0 | 1 | 0 | 0 | 4 bytes | 0 | 0 | 1 | 0 | 1 | 5 bytes | 0 | 0 | 1 | 1 | 0 | 6 bytes | 0 | 0 | 1 | 1 | 1 | 7 bytes | 0 | 1 | 0 | 0 | 0 | 8 bytes | 0 | 1 | 0 | 0 | 1 | 9 bytes | 0 | 1 | 0 | 1 | 0 | 10 bytes | 0 | 1 | 0 | 1 | 1 | 11 bytes | 0 | 1 | 1 | 0 | 0 | 12 bytes | 0 | 1 | 1 | 0 | 1 | 13 bytes | 0 | 1 | 1 | 1 | 0 | 14 bytes | 0 | 1 | 1 | 1 | 1 | 15 bytes | 1 | 0 | 0 | 0 | 0 | 16 bytes | Other than above |  |  |  |  | Invalid |
|                  |                  | UBn<br>RB4                                                                                                   | UBn<br>RB3 | UBn<br>RB2 | UBn<br>RB1 | UBn<br>RB0 | Receive FIFO pointer |   |   |   |   |   |         |   |   |   |   |   |        |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |                  |  |  |  |  |         |
|                  |                  | 0                                                                                                            | 0          | 0          | 0          | 0          | 0 bytes              |   |   |   |   |   |         |   |   |   |   |   |        |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |                  |  |  |  |  |         |
|                  |                  | 0                                                                                                            | 0          | 0          | 0          | 1          | 1 byte               |   |   |   |   |   |         |   |   |   |   |   |        |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |                  |  |  |  |  |         |
|                  |                  | 0                                                                                                            | 0          | 0          | 1          | 0          | 2 bytes              |   |   |   |   |   |         |   |   |   |   |   |        |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |                  |  |  |  |  |         |
|                  |                  | 0                                                                                                            | 0          | 0          | 1          | 1          | 3 bytes              |   |   |   |   |   |         |   |   |   |   |   |        |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |                  |  |  |  |  |         |
|                  |                  | 0                                                                                                            | 0          | 1          | 0          | 0          | 4 bytes              |   |   |   |   |   |         |   |   |   |   |   |        |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |                  |  |  |  |  |         |
|                  |                  | 0                                                                                                            | 0          | 1          | 0          | 1          | 5 bytes              |   |   |   |   |   |         |   |   |   |   |   |        |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |                  |  |  |  |  |         |
|                  |                  | 0                                                                                                            | 0          | 1          | 1          | 0          | 6 bytes              |   |   |   |   |   |         |   |   |   |   |   |        |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |                  |  |  |  |  |         |
|                  |                  | 0                                                                                                            | 0          | 1          | 1          | 1          | 7 bytes              |   |   |   |   |   |         |   |   |   |   |   |        |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |                  |  |  |  |  |         |
|                  |                  | 0                                                                                                            | 1          | 0          | 0          | 0          | 8 bytes              |   |   |   |   |   |         |   |   |   |   |   |        |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |                  |  |  |  |  |         |
|                  |                  | 0                                                                                                            | 1          | 0          | 0          | 1          | 9 bytes              |   |   |   |   |   |         |   |   |   |   |   |        |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |                  |  |  |  |  |         |
|                  |                  | 0                                                                                                            | 1          | 0          | 1          | 0          | 10 bytes             |   |   |   |   |   |         |   |   |   |   |   |        |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |                  |  |  |  |  |         |
|                  |                  | 0                                                                                                            | 1          | 0          | 1          | 1          | 11 bytes             |   |   |   |   |   |         |   |   |   |   |   |        |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |                  |  |  |  |  |         |
|                  |                  | 0                                                                                                            | 1          | 1          | 0          | 0          | 12 bytes             |   |   |   |   |   |         |   |   |   |   |   |        |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |                  |  |  |  |  |         |
|                  |                  | 0                                                                                                            | 1          | 1          | 0          | 1          | 13 bytes             |   |   |   |   |   |         |   |   |   |   |   |        |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |                  |  |  |  |  |         |
|                  |                  | 0                                                                                                            | 1          | 1          | 1          | 0          | 14 bytes             |   |   |   |   |   |         |   |   |   |   |   |        |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |                  |  |  |  |  |         |
|                  |                  | 0                                                                                                            | 1          | 1          | 1          | 1          | 15 bytes             |   |   |   |   |   |         |   |   |   |   |   |        |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |                  |  |  |  |  |         |
|                  |                  | 1                                                                                                            | 0          | 0          | 0          | 0          | 16 bytes             |   |   |   |   |   |         |   |   |   |   |   |        |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |                  |  |  |  |  |         |
| Other than above |                  |                                                                                                              |            |            | Invalid    |            |                      |   |   |   |   |   |         |   |   |   |   |   |        |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |                  |  |  |  |  |         |

**Remark** n = 0, 1

**(10)UARTBn FIFO status register 1 (UBnFIS1) (n = 0, 1)**

The UBnFIS1 register is valid in the FIFO mode (UBnMOD bit = 1 in the UBnFIC0 register). This register can be used to read the number of vacant bytes of transmit FIFO.

This register is read-only, in 8-bit units.

**Caution** The values of the UBnTB4 to UBnTB0 bits are reflected after transmit data has been written to the UBnTX register and then time of two cycles of  $f_x/4$  ( $f_x$ : main clock) has passed. Therefore, care must be exercised when referencing the UBnFIS1 register after transmit data has been written to the UBnTX register.

|         | 7 | 6 | 5 | 4      | 3      | 2      | 1      | 0      | Address  | After reset |
|---------|---|---|---|--------|--------|--------|--------|--------|----------|-------------|
| UB0FIS1 | 0 | 0 | 0 | UB0TB4 | UB0TB3 | UB0TB2 | UB0TB1 | UB0TB0 | FFFFA0FH | 10H         |
| UB1FIS1 | 0 | 0 | 0 | UB1TB4 | UB1TB3 | UB1TB2 | UB1TB1 | UB1TB0 | FFFFA2FH | 10H         |

| Bit position | Bit name         | Function                                                                                                      |        |        |        |        |                       |   |   |   |   |   |         |   |   |   |   |   |        |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |                  |  |  |  |  |         |
|--------------|------------------|---------------------------------------------------------------------------------------------------------------|--------|--------|--------|--------|-----------------------|---|---|---|---|---|---------|---|---|---|---|---|--------|---|---|---|---|---|---------|---|---|---|---|---|---------|---|---|---|---|---|---------|---|---|---|---|---|---------|---|---|---|---|---|---------|---|---|---|---|---|---------|---|---|---|---|---|---------|---|---|---|---|---|---------|---|---|---|---|---|----------|---|---|---|---|---|----------|---|---|---|---|---|----------|---|---|---|---|---|----------|---|---|---|---|---|----------|---|---|---|---|---|----------|---|---|---|---|---|----------|------------------|--|--|--|--|---------|
| 4 to 0       | UBnTB4 to UBnTB0 | Indicates the number of vacant bytes of transmit FIFO (bytes that can be written) as a transmit FIFO pointer. |        |        |        |        |                       |   |   |   |   |   |         |   |   |   |   |   |        |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |                  |  |  |  |  |         |
|              |                  | UBnTB4                                                                                                        | UBnTB3 | UBnTB2 | UBnTB1 | UBnTB0 | Transmit FIFO pointer | 0 | 0 | 0 | 0 | 0 | 0 bytes | 0 | 0 | 0 | 0 | 1 | 1 byte | 0 | 0 | 0 | 1 | 0 | 2 bytes | 0 | 0 | 0 | 1 | 1 | 3 bytes | 0 | 0 | 1 | 0 | 0 | 4 bytes | 0 | 0 | 1 | 0 | 1 | 5 bytes | 0 | 0 | 1 | 1 | 0 | 6 bytes | 0 | 0 | 1 | 1 | 1 | 7 bytes | 0 | 1 | 0 | 0 | 0 | 8 bytes | 0 | 1 | 0 | 0 | 1 | 9 bytes | 0 | 1 | 0 | 1 | 0 | 10 bytes | 0 | 1 | 0 | 1 | 1 | 11 bytes | 0 | 1 | 1 | 0 | 0 | 12 bytes | 0 | 1 | 1 | 0 | 1 | 13 bytes | 0 | 1 | 1 | 1 | 0 | 14 bytes | 0 | 1 | 1 | 1 | 1 | 15 bytes | 1 | 0 | 0 | 0 | 0 | 16 bytes | Other than above |  |  |  |  | Invalid |
|              |                  | UBnTB4                                                                                                        | UBnTB3 | UBnTB2 | UBnTB1 | UBnTB0 | Transmit FIFO pointer |   |   |   |   |   |         |   |   |   |   |   |        |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |                  |  |  |  |  |         |
|              |                  | 0                                                                                                             | 0      | 0      | 0      | 0      | 0 bytes               |   |   |   |   |   |         |   |   |   |   |   |        |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |                  |  |  |  |  |         |
|              |                  | 0                                                                                                             | 0      | 0      | 0      | 1      | 1 byte                |   |   |   |   |   |         |   |   |   |   |   |        |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |                  |  |  |  |  |         |
|              |                  | 0                                                                                                             | 0      | 0      | 1      | 0      | 2 bytes               |   |   |   |   |   |         |   |   |   |   |   |        |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |                  |  |  |  |  |         |
|              |                  | 0                                                                                                             | 0      | 0      | 1      | 1      | 3 bytes               |   |   |   |   |   |         |   |   |   |   |   |        |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |                  |  |  |  |  |         |
|              |                  | 0                                                                                                             | 0      | 1      | 0      | 0      | 4 bytes               |   |   |   |   |   |         |   |   |   |   |   |        |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |                  |  |  |  |  |         |
|              |                  | 0                                                                                                             | 0      | 1      | 0      | 1      | 5 bytes               |   |   |   |   |   |         |   |   |   |   |   |        |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |                  |  |  |  |  |         |
|              |                  | 0                                                                                                             | 0      | 1      | 1      | 0      | 6 bytes               |   |   |   |   |   |         |   |   |   |   |   |        |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |                  |  |  |  |  |         |
|              |                  | 0                                                                                                             | 0      | 1      | 1      | 1      | 7 bytes               |   |   |   |   |   |         |   |   |   |   |   |        |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |                  |  |  |  |  |         |
|              |                  | 0                                                                                                             | 1      | 0      | 0      | 0      | 8 bytes               |   |   |   |   |   |         |   |   |   |   |   |        |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |                  |  |  |  |  |         |
|              |                  | 0                                                                                                             | 1      | 0      | 0      | 1      | 9 bytes               |   |   |   |   |   |         |   |   |   |   |   |        |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |                  |  |  |  |  |         |
|              |                  | 0                                                                                                             | 1      | 0      | 1      | 0      | 10 bytes              |   |   |   |   |   |         |   |   |   |   |   |        |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |                  |  |  |  |  |         |
|              |                  | 0                                                                                                             | 1      | 0      | 1      | 1      | 11 bytes              |   |   |   |   |   |         |   |   |   |   |   |        |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |                  |  |  |  |  |         |
|              |                  | 0                                                                                                             | 1      | 1      | 0      | 0      | 12 bytes              |   |   |   |   |   |         |   |   |   |   |   |        |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |                  |  |  |  |  |         |
|              |                  | 0                                                                                                             | 1      | 1      | 0      | 1      | 13 bytes              |   |   |   |   |   |         |   |   |   |   |   |        |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |                  |  |  |  |  |         |
|              |                  | 0                                                                                                             | 1      | 1      | 1      | 0      | 14 bytes              |   |   |   |   |   |         |   |   |   |   |   |        |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |                  |  |  |  |  |         |
|              |                  | 0                                                                                                             | 1      | 1      | 1      | 1      | 15 bytes              |   |   |   |   |   |         |   |   |   |   |   |        |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |                  |  |  |  |  |         |
|              |                  | 1                                                                                                             | 0      | 0      | 0      | 0      | 16 bytes              |   |   |   |   |   |         |   |   |   |   |   |        |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |                  |  |  |  |  |         |
|              |                  | Other than above                                                                                              |        |        |        |        | Invalid               |   |   |   |   |   |         |   |   |   |   |   |        |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |   |   |   |   |   |          |                  |  |  |  |  |         |

**Remark** n = 0, 1

### 10.2.4 Interrupt requests

The following five types of interrupt requests are generated from UARTBn (n = 0, 1).

- Reception error interrupt (UBTIREn)
- Reception completion interrupt (UBTIRn)
- Transmission completion interrupt (UBTITn)
- FIFO transmission completion interrupt (UBTIFn)
- Reception timeout interrupt (UBTITOn)

The default priorities among these five types of interrupt requests is, from high to low, reception error interrupt, reception completion interrupt, transmission completion interrupt, FIFO transmission completion interrupt, and reception timeout interrupt.

**Table 10-2. Generated Interrupts and Default Priorities**

| Interrupt                    | Priority |
|------------------------------|----------|
| Reception error              | 1        |
| Reception completion         | 2        |
| Transmission completion      | 3        |
| FIFO transmission completion | 4        |
| Reception timeout            | 5        |

#### (1) Reception error interrupt (UBTIREn)

##### (a) Single mode

When reception is enabled, a reception error interrupt is generated according to the logical OR of the three types of reception errors (parity error, framing error, overrun error) explained for the UBnSTR register.

When reception is disabled, no reception error interrupt is generated.

##### (b) FIFO mode

When reception is enabled, a reception error interrupt is generated according to the logical OR of the three types of reception errors (parity error, framing error, overflow error) explained for the UBnSTR register.

When reception is disabled, no reception error interrupt is generated.

**(2) Reception completion interrupt (UBTIRn)****(a) Single mode**

When reception is enabled, a reception completion interrupt is generated if data is shifted into receive shift register n and stored in the UBnRX register (if the receive data can be read).

When reception is disabled, no reception completion interrupt is generated.

**(b) FIFO mode**

When reception is enabled, a reception completion interrupt is generated if data is shifted into receive shift register n and receive data of the number set as the trigger by the UBnRT3 to UBnRT0 bits of the UBnFIC2 register is transferred to receive FIFO n (if receive data of the specified number can be read).

When reception is disabled, no reception completion interrupt is generated.

**(3) Transmission completion interrupt (UBTITn)****(a) Single mode**

The transmission completion interrupt is generated if transmit data of one frame, including 7 or 8 bits of characters, is shifted out from transmit shift register n and the UBnTX register becomes vacant (if transmit data can be written).

**(b) FIFO mode**

The transmission completion interrupt is generated if transmit data of the number set as the trigger by the UBnTT3 to UBnTT0 bits of the UBnFIC2 register is transferred to transmit shift register n from transmit FIFO n (if transmit data of the specified number can be written).

**(4) FIFO transmission completion interrupt (UBTIFn)****(a) Single mode**

Cannot be used.

**(b) FIFO mode**

The FIFO transmission completion interrupt is generated when no more data is in transmit FIFO n and transmit shift register n (when the FIFO and register become empty). After the FIFO transmission completion interrupt has occurred, clear the interrupt held pending (UBTITn) in the pending mode (UBnITM bit = 0 in the UBnFIC0 register) by clearing the FIFO (UBnTFC bit = 1 in the UBnFIC0 register).

**Caution** If the FIFO transmission completion interrupt is generated (all transmit data are not transmitted) because writing the next transmit data to transmit FIFO n is delayed, do not clear the FIFO.

**(5) Reception timeout interrupt (UBTITOn)****(a) Single mode**

Cannot be used.

**(b) FIFO mode**

The reception timeout interrupt is generated if data is stored in receive FIFO when the next data does not come (start bit is not detected) even after the next data reception wait time specified by the UBnTC4 to UBnTC0 bits of the UBnFIC1 register has elapsed, when the timeout counter function is used (UBnTCE bit = 1 in the UBnFIC1 register).

The reception timeout interrupt is not generated while reception is disabled.

If receive data of the number set as the trigger by the UBnRT3 to UBnRT0 bits of the UBnFIC2 register is not received, the timing of reading the number of receive data less than the specified number can be set by the reception timeout interrupt.

Since the timeout counter starts counting at start bit detection, a receive timeout interrupt does not occur if data of 1 character has not been received.



### 10.2.5 Control method

#### (1) Single mode/FIFO mode

The single mode or FIFO mode can be selected by using the UBnMOD bit of the UBnFIC0 register.

##### (a) Single mode

- Each of the UBnRX and UBnTX registers consists of 8 bits  $\times$  1 stage.
- When 1 byte of data is received, the UBTIRn interrupt is generated.
- If the next reception operation of UARTBn is completed before the receive data of the UBnRX register is read after the UBTIRn interrupt has been generated, the UBTIREn interrupt is generated and an overrun error occurs.

##### (b) FIFO mode

- Receive FIFO (UBnRXAP register) consists of 16 bits  $\times$  16 stages and transmit FIFO consists of 8 bits  $\times$  16 stages.
- Receive FIFO can recognize error data by reading the 16-bit UBnRXAP register only when a reception error (parity error or framing error) occurs.
- Transmission is started when transmission is enabled (UBnTXE bit = 1 in the UBnCTL0 register) after transmit data of at least the number set as the trigger by the UBnTT3 to UBnTT0 bits of the UBnFIC2 register and 16 bytes or less are written to transmit FIFO.
- The pending mode or pointer mode can be selected for the generation timing of the UBTITn and UBTIRn interrupts.

**(2) Pending mode/pointer mode**

The pending mode or pointer mode can be selected by using the UBnITM and UBnIRM bits of the UBnFIC0 register in the FIFO mode (UBnMOD bit = 1 in the UBnFIC0 register).

If transmission is started by writing data of more than double the amount set as the trigger by the UBnTT3 to UBnTT0 bits of the UBnFIC2 register to transmit FIFO, the transmission completion interrupt (UBTITn) may occur more than once. The reception completion interrupt (UBTIRn) may also occur more than once if the number of receive data set as the trigger by the UBnRT3 to UBnRT0 bits of the UBnFIC2 register is 8 bytes or less in receive FIFO. In the pending or pointer mode, it can be specified how an interrupt is handled after it has been held pending.

**(a) Pending mode****(i) During transmission (writing to transmit FIFO)**

- If the data of the first transmission completion interrupt (UBTITn) is not written to transmit FIFO after the interrupt has occurred, the second UBTITn interrupt does not occur (is held pending) even if the generation condition of the second UBTITn interrupt is satisfied (when transmit data of the number set as the trigger by the UBnTT3 to UBnTT0 bits of the UBnFIC2 register is transferred from transmit FIFO to the transmit shift register).

When data for the first UBTITn interrupt is later written to transmit FIFO, the pending UBTITn interrupt is generated<sup>Note</sup>.

**Note** The number of pending interrupts is as follows.

When trigger is set to 1 byte (UBnTT3 to UBnTT0 bits of UBnFIC2 register = 0000): 15 times max.

When trigger is set to 2 bytes (UBnTT3 to UBnTT0 bits of UBnFIC2 register = 0001): 7 times max.

:

When trigger is set to 6 bytes (UBnTT3 to UBnTT0 bits of UBnFIC2 register = 0101): 1 time max.

When trigger is set to 7 bytes (UBnTT3 to UBnTT0 bits of UBnFIC2 register = 0110): 1 time max.

When trigger is set to 8 bytes (UBnTT3 to UBnTT0 bits of UBnFIC2 register = 0111): 1 time max.

- In the pending mode, transmit data of the number set as the trigger by the UBnTT3 to UBnTT0 bits of the UBnFIC2 register is always written to transmit FIFO when the transmission completion interrupt (UBTITn) occurs. Writing data to transmit FIFO is prohibited if the data is more or less than the specified number. If data more or less than the specified number is written, the operation is not guaranteed.
- Fix the UBnTT3 to UBnTT0 bits of the UBnFIC2 register to 0000 (set number of transmit data: 1 byte) to write transmit data to transmit FIFO by DMA. If any other setting is made, the operation is not guaranteed.

**(ii) During reception (reading from receive FIFO)**

- If data for the first reception completion interrupt (UBTIRn) is not read from receive FIFO, the second UBTIRn interrupt does not occur (is held pending) even if the generation condition of the second UBTIRn is satisfied (if receive data of the number set as the trigger by the UBnRT3 to UBnRT0 bits of the UBnFIC2 register can be read from receive FIFO). When data for the first UBTIRn interrupt is later read from the receive FIFO, the pending UBTIRn interrupt is generated<sup>Note</sup>.

**Note** The number of pending interrupts is as follows.

When trigger is set to 1 byte (UBnRT3 to UBnRT0 bits of UBnFIC2 register = 0000): 15 times max.

When trigger is set to 2 bytes (UBnRT3 to UBnRT0 bits of UBnFIC2 register = 0001): 7 times max.

:

When trigger is set to 6 bytes (UBnRT3 to UBnRT0 bits of UBnFIC2 register = 0101): 1 time max.

When trigger is set to 7 bytes (UBnRT3 to UBnRT0 bits of UBnFIC2 register = 0110): 1 time max.

When trigger is set to 8 bytes (UBnRT3 to UBnRT0 bits of UBnFIC2 register = 0111): 1 time max.

- In the pending mode, receive data of the number set as the trigger by the UBnRT3 to UBnRT0 bits of the UBnFIC2 register is always read from receive FIFO when the reception completion interrupt (UBTIRn) occurs. Reading data from receive FIFO is prohibited if the data is more or less than the specified number. If data more or less than the specified number is read, the operation is not guaranteed.
- Fix the UBnRT3 to UBnRT0 bits of the UBnFIC2 register to 0000 (set number of receive data: 1 byte) to read receive data from receive FIFO by DMA. If any other setting is made, the operation is not guaranteed.

**(b) Pointer mode****(i) During transmission (writing to transmit FIFO)**

- Each time the data of 1 byte is transferred to transmit shift register n from transmit FIFO, a transmission completion interrupt (UBTITn) occurs.
- In the pointer mode, be sure to fix the UBnTT3 to UBnTT0 bits of the UBnFIC2 register to 0000 (set number of transmit data: 1 byte) as the number of transmit data set as the trigger for transmit FIFO when the transmission completion interrupt (UBTITn) occurs. If any other setting is made, the operation is not guaranteed.
- Writing transmit data to transmit FIFO by DMA is prohibited. The operation is not guaranteed if DMA control is used.
- After the transmission completion interrupt (UBTITn) has been acknowledged, data of the number of vacant bytes of transmit FIFO can be written to transmit FIFO by referencing the UBnFIS1 register.

**(ii) During reception (reading from receive FIFO)**

- Each time the data of 1 byte is transferred to receive FIFO from receive shift register n, a reception completion interrupt (UBTIRn) occurs.
- In the pointer mode, be sure to fix the UBnRT3 to UBnRT0 bits of the UBnFIC2 register to 0000 (set number of receive data: 1 byte) as the number of receive data set as the trigger for receive FIFO when the reception completion interrupt (UBTIRn) occurs. If any other setting is made, the operation is not guaranteed.
- Reading receive data from receive FIFO by DMA is prohibited. The operation is not guaranteed if DMA control is used.
- After the reception completion interrupt (UBTIRn) has been acknowledged, data of the number of bytes stored in receive FIFO can be read from receive FIFO by referencing the UBnFIS0 register. In some cases, however, data is not stored in receive FIFO even though the UBTIRn interrupt is generated (UBnRB4 to UBnRB0 bits = 00000 in the UBnFIS0 register). In these cases, do not read data from receive FIFO. Always read data from receive FIFO when the number of bytes stored in receive FIFO is 1 byte or more (UBnRB4 to UBnRB0 bits = other than 00000).

**10.2.6 Operation****(1) Data format**

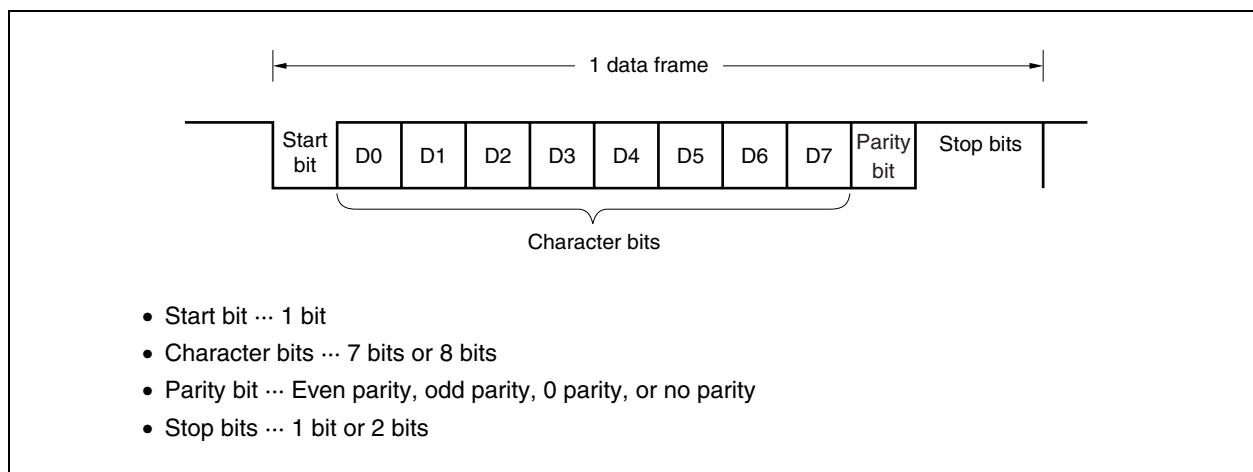
Full-duplex serial data transmission and reception can be performed.

The transmit/receive data format consists of one data frame containing a start bit, character bits, a parity bit, and stop bits as shown in Figure 10-2.

The character bit length within one data frame, the type of parity, and the stop bit length are specified by the UARTBn control register 0 (UBnCTL0) (n = 0, 1).

Also, data is transferred with LSB first/MSB first.

**Figure 10-2. Asynchronous Serial Interface Transmit/Receive Data Format (LSB-First Transfer)**



**(2) Transmit operation**

In the single mode (UBnMOD bit = 0 in the UBnFIC0 register), transmission is enabled when the UBnTXE bit of the UBnCTL0 register is set to 1, and transmission is started when transmit data is written to the UBnTX register (n = 0, 1).

In the FIFO mode (UBnMOD bit = 1 in the UBnFIC0 register), transmission is started when transmit data of at least the number set as the trigger by the UBnTT3 to UBnTT0 bits of the UBnFIC2 register and 16 bytes or less is written to transmit FIFO and then the UBnTXE bit is set to 1.

**Caution** Setting the UBnTXE bit of the UBnCTL0 register to 1 before writing transmit data to transmit FIFO in the FIFO mode is prohibited. The operation is not guaranteed if this setting is made.

**(a) Transmission enabled state**

This state is set by the UBnTXE bit in the UBnCTL0 register (n = 0, 1).

- UBnTXE = 1: Transmission enabled state
- UBnTXE = 0: Transmission disabled state

However, when the transmission enabled state is set, to use UARTB0, which shares pins with clocked serial interface 30 (CSI30), the CSICAE0 bit of clocked serial interface mode register 30 (CSIM30) should be cleared to 0.

Since UARTBn does not have a CTS (transmission enabled signal) input pin, a port should be used to confirm whether the destination is in the reception enabled state.

**(b) Starting a transmit operation**

- **In single mode (UBnMOD bit = 0 in UBnFIC0 register)**

In the single mode, transmission is started when transmit data is written to the UBnTX register while transmission is enabled (n = 0, 1).

- **In FIFO mode (UBnMOD bit = 1 in UBnFIC0 register)**

In the FIFO mode, transmission is started when transmit data of at least the number set as the trigger by the UBnTT3 to UBnTT0 bits of the UBnFIC2 register and 16 bytes or less is written to transmit FIFO and then transmission is enabled (UBnTXE bit = 1).

Data in transmit data register n (UBnTX register in single mode or transmit FIFO in the FIFO mode) is transferred to transmit shift register n when transmission is started. Then, transmit shift register n outputs data to the TXDn pin sequentially beginning with the LSB (the transmit data is transferred sequentially starting with the start bit). The start bit, parity bit, and stop bits are added automatically (n = 0, 1).

**(c) Transmission interrupt request****(i) Transmission completion interrupt (UBTITn)**

- **In single mode (UBnMOD bit = 0 in UBnFIC0 register)**

In the single mode, the transmission completion interrupt (UBTITn) occurs when transmit data can be written to the UBnTX register (when 1 byte of data is transferred from the UBnTX register to transmit shift register n) (n = 0, 1).

- **In FIFO mode (UBnMOD bit = 1 in UBnFIC0 register)**

In the FIFO mode, the UBTITn interrupt occurs when transmit data of the number set as the trigger specified by the UBnTT3 to UBnTT0 bits of the UBnFIC2 register is transferred from transmit FIFO to transmit shift register n (if transmit data of the number set as the trigger can be written) (n = 0, 1).

- **If pending mode is specified (UBnITM bit = 0 in UBnFIC0 register) in FIFO mode**

If the pending mode is specified in the FIFO mode, the second UBTITn interrupt is held pending after the first UBTITn interrupt has occurred, until as many transmit data as the number set as the trigger by the UBnTT3 to UBnTT0 bits of the UBnFIC2 register are written to transmit FIFO, even if the generation condition of the second UBTITn interrupt is satisfied. When as many transmit data as the number set as the trigger are written to transmit FIFO in response to the first UBTITn interrupt, the second pending UBTITn interrupt is generated (n = 0, 1).

- **If pointer mode is specified (UBnITM bit = 1 in UBnFIC0 register) in FIFO mode**

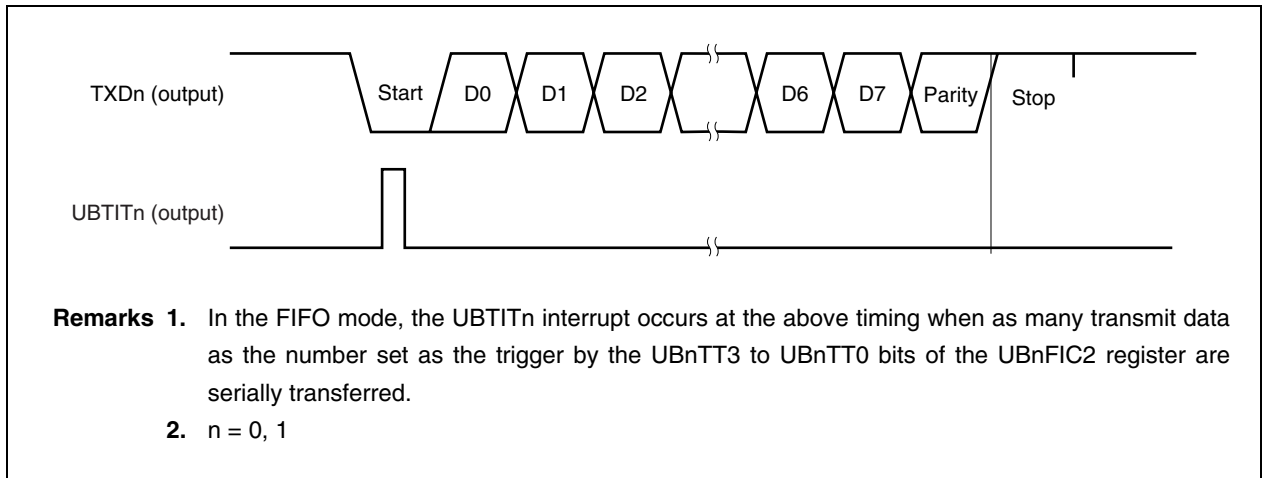
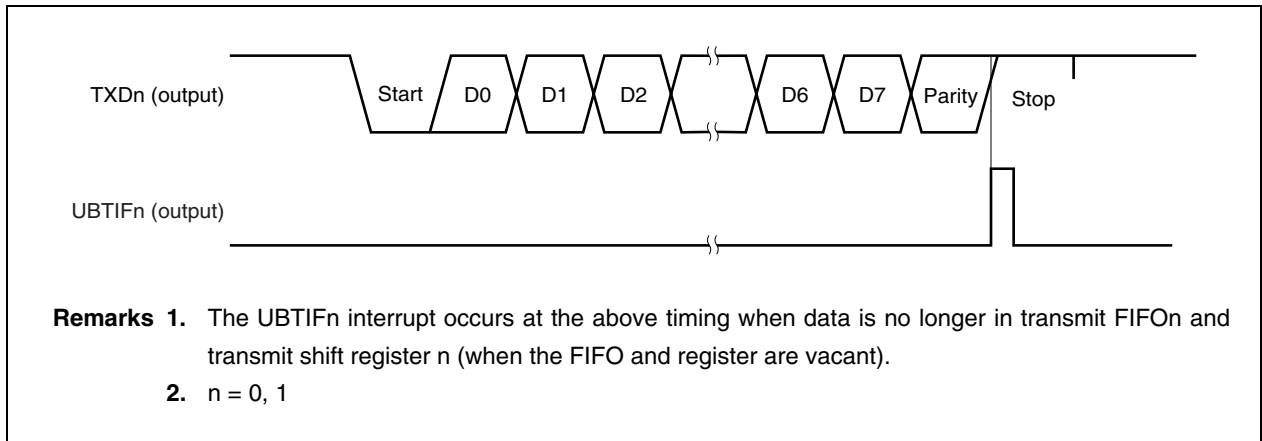
If the pointer mode is specified in the FIFO mode, the second UBTITn interrupt occurs when the generation condition of the second UBTITn interrupt is satisfied even if as many transmit data as the number set as the trigger by the UBnTT3 to UBnTT0 bits of the UBnFIC2 register are not written to transmit FIFO when the first UBTITn interrupt occurs (n = 0, 1).

**(ii) FIFO transmission completion interrupt (UBTIFn)**

The FIFO transmission completion interrupt (UBTIFn) occurs when no more data is in transmit FIFO and transmit shift register n in the FIFO mode (UBnMOD bit = 1 in the UBnFIC0 register) (n = 0, 1). After the UBTIFn interrupt has occurred, clear the pending UBTITn interrupt in the pending mode (UBnITM bit = 0 in the UBnFIC0 register) by clearing the FIFO (UBnTFC bit = 1 in the UBnFIC0 register). If the UBTIFn interrupt occurs because writing the next transmit data to transmit FIFO is delayed (if all transmit data have not been transmitted), do not clear the FIFO.

If the data to be transmitted next has not been written to transmit data register n, the transmit operation is suspended.

**Caution** In the single mode, the transmission completion interrupt (UBTITn) occurs when the UBnTX register becomes empty (when 1 byte of data is transferred from the UBnTX register to transmit shift register n). In the FIFO mode, the FIFO transmission completion interrupt (UBTIFn) occurs when data is no longer in transmit FIFO and transmit shift register n (when the FIFO and register are vacant). However, the UBTITn interrupt or UBTIFn interrupt is not generated if transmit data register n becomes empty due to RESET input.

**Figure 10-3. Timing of Asynchronous Serial Interface Transmission Completion Interrupt (UBTITn)****Figure 10-4. Timing of Asynchronous Serial Interface FIFO Transmission Completion Interrupt (UBTIFn)**

**(3) Continuous transmission operation**

- **In single mode (UBnMOD bit = 0 in UBnFIC0 register)**

In the single mode, the next data can be written to the UBnTX register as soon as transmit shift register n has started a shift operation ( $n = 0, 1$ ). The timing of transfer can be identified by the transmission completion interrupt (UBTITn). By writing the next transmit data to the UBnTX register via the UBTITn interrupt within one data frame transmission period, data can be transmitted without an interval and an efficient communication rate can be realized.

**Caution** Confirm that the UBnTSF bit of the UBnSTR register is 0 before executing initialization during transmission processing. If initialization is executed while the UBnTSF bit is 1, the transmit data is not guaranteed.

- **If pending mode is specified (UBnITM bit = 0 in UBnFIC0 register) in FIFO mode**

If transmit data of at least the number set as the transmit trigger by UBnTT3 to UBnTT0 bits of the UBnFIC2 register and 16 bytes or less is written to transmit FIFO, transmission starts.

If the pending mode is specified in the FIFO mode, as many of the next transmit data as the number set as the trigger by the UBnTT3 to UBnTT0 bits of the UBnFIC2 register can be written to transmit FIFO as soon as transmit shift register n has started shifting the last data of the specified number of data. The timing of transfer can be identified by the UBTITn interrupt. By writing as many of the next transmit data as the number set as the trigger to transmit FIFO or writing the data to the FIFO within the transmission period of the data in transmit FIFO via the UBTITn interrupt, data can be transmitted without an interval and an efficient communication rate can be realized.

**Caution** Confirm that the UBnTSF bit of the UBnSTR register is 0 before executing initialization during transmission processing (this can also be done by the FIFO transmission completion interrupt (UBTIFn)). If initialization is executed while the UBnTSF bit is 1, the transmit data is not guaranteed. To write transmit data to transmit FIFO by DMA control, set the number of transmit data specified as the trigger by the UBnTT3 to UBnTT0 bits of the UBnFIC2 register to 1 byte; otherwise the operation will not be guaranteed.

- **If pointer mode is specified (UBnITM bit = 1 in UBnFIC0 register) in FIFO mode**

If the pointer mode is specified in the FIFO mode, a UBTITn interrupt occurs and the next data can be written to transmit FIFO as soon as transmit shift register n has started shifting the number of transmit data set as the trigger. At this time, as many data as the number of vacant bytes of transmit FIFO can be written by referencing the UBnFIS1 register. The timing of transfer can be identified by the UBTITn interrupt. By writing as many of the next transmit data as the number specified as the trigger to transmit FIFO (= 1 byte) or writing the data to the FIFO within the transmission period of the data in transmit FIFO via the UBTITn interrupt, data can be transmitted without an interval and an efficient communication rate can be realized.

**Caution** Confirm that the UBnTSF bit of the UBnSTR register is 0 before executing initialization during transmission processing (this can also be done by the FIFO transmission completion interrupt (UBTIFn)). If initialization is executed while the UBnTSF bit is 1, the transmit data is not guaranteed.



**(4) Receive operation**

The awaiting reception state is set by setting the UBnPWR bit to 1 in the UBnCTL0 register and then setting the UBnRXE bit to 1 in the UBnCTL0 register ( $n = 0, 1$ ). RXDn pin sampling begins and a start bit is detected. When the start bit is detected, the receive operation begins, and data is stored sequentially in receive shift register n according to the baud rate that was set.

In the single mode (UBnMOD bit = 0 in the UBnFIC0 register), a reception completion interrupt (UBTIRn) is generated each time the reception of one frame of data is completed. Normally, the receive data is transferred from the UBnRX register to memory by this interrupt servicing.

In the FIFO mode (UBnMOD bit = 1 in the UBnFIC0 register), the UBTIRn interrupt occurs when as many receive data as the number set as the trigger by the UBnRT3 to UBnRT0 bits of the UBnFIC2 register are transferred to receive FIFO n.

If the pending mode is specified (UBnIRM bit = 0 in the UBnFIC0 register) in the FIFO mode, as many receive data as the number set as the trigger by the UBnRT3 to UBnRT0 bits of the UBnFIC2 register can be read from receive FIFO n.

If the pointer mode is specified (UBnIRM bit = 1 in the UBnFIC0 register) in the FIFO mode, as many data as the number of bytes stored in receive FIFO n (0 bytes or more) can be read from receive FIFO n by referencing the number of receive data specified as the trigger by the UBnRT3 to UBnRT0 bits (1 byte) or the UBnFIS0 register.

**Caution** If the pointer mode is specified in the FIFO mode and if as many data as the number of bytes stored in receive FIFO n are read by referencing the UBnFIS0 register, no data may be stored in receive FIFO n (UBnRB4 to UBnRB0 bits = 00000 in the UBnFIS0 register) even though the reception completion interrupt (UBTIRn) has occurred. In this case, do not read data from receive FIFO n. Be sure to read data from receive FIFO n after confirming that the number of bytes stored in receive FIFO n = 1 byte or more (UBnRB4 to UBnRB0 bits = other than 00000).

**(a) Reception enabled state**

This state is set by the UBnRXE bit in the UBnCTL0 register ( $n = 0, 1$ ).

- UBnRXE = 1: Reception enabled state
- UBnRXE = 0: Reception disabled state

However, when the reception enabled state is set, to use UARTB0, which shares pins with clocked serial interface 30 (CSI30), the operation of CSI30 must be disabled by clearing the CSICAE0 bit of clocked serial interface mode register 30 (CSIM30) to 0 ( $n = 0, 1$ ).

In the reception disabled state, the reception hardware stands by in the initial state. At this time, the reception completion interrupt or reception error interrupt does not occur, and the contents of receive data register n (UBnRX register in the single mode or receive FIFO n in the FIFO mode (UBnRXAP register)) are retained.

**(b) Starting a receive operation**

A receive operation is started by the detection of a start bit.

The RXDn pin is sampled using the serial clock from UARTBn control register 2 (UBnCTL2) ( $n = 0, 1$ ).

**(c) Reception completion interrupt****(i) Reception completion interrupt (UBTIRn)****• In single mode (UBnMOD bit = 0 in UBnFIC0 register)**

When the UBnRXE bit = 1 in the UBnCTL0 register and the reception of one frame of data is completed (the stop bit is detected) in the single mode, a reception completion interrupt request (UBTIRn) is generated and the receive data in receive shift register n is transferred to the UBnRX register at the same time (n = 0, 1).

Also, if an overrun error occurs, the receive data at that time is not transferred to the UBnRX register, and a reception error interrupt (UBTIREn) is generated.

If a parity error or framing error occurs during the reception operation, the reception operation continues up to the position at which the stop bit is received. After completion of reception, an UBTIREn interrupt occurs (the receive data in receive shift register n is transferred to the UBnRX register).

If the UBnRXE bit is reset (0) during a receive operation, the receive operation is immediately stopped. At this time, the contents of the UBnRX register remain unchanged, the contents of the UARTBn status register (UBnSTR) are cleared, and the UBTIRn and UBTIREn interrupts do not occur.

No UBTIRn interrupt is generated when the UBnRXE bit = 0 (reception is disabled).

**• In FIFO mode (UBnMOD bit = 1 in UBnFIC0 register)**

In the FIFO mode, the reception completion interrupt (UBTIRn) occurs when data of one frame has been received (stop bit is detected) and when as many receive data as the number specified as the trigger by the UBnRT3 to UBnRT0 bits of the UBnFIC2 register are transferred from receive shift register n to receive FIFO n (n = 0, 1).

If an overflow error occurs, the receive data is not transferred to receive FIFO n and the reception error interrupt (UBTIREn) occurs.

If a parity error or framing error occurs during reception, reception continues up to the reception position of the stop bit. After reception has been completed, the UBTIREn interrupt occurs and the receive data in receive shift register n is transferred to receive FIFO n. At this time, error information is appended as the UBnPEF or UBnFEF bit = 1 in the UBnRXAP register. If the UBTIREn interrupt occurs, the error data can be recognized by reading receive FIFO n as a 16-bit register, UBnRXAP.

**(ii) Reception timeout interrupt (UBTITOn) (in FIFO mode only)**

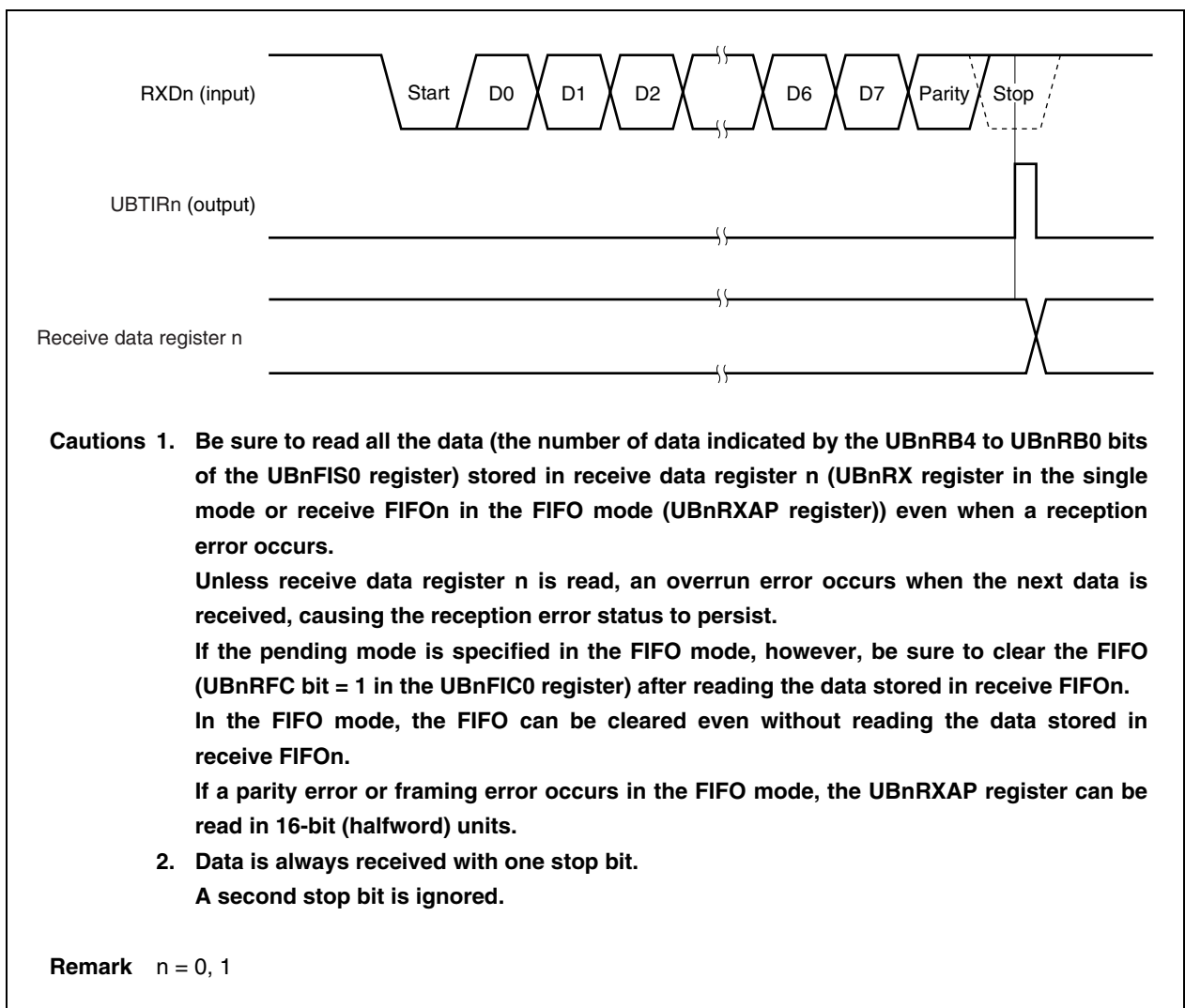
When the timeout counter function (UBnTCE bit = 1 in the UBnFIC1 register) is used in the FIFO mode, the reception timeout interrupt (UBTITOn) occurs if the next data does not come even after the next data reception wait time specified by the UBnTC4 to UBnTC0 bits of the UBnFIC1 register has elapsed and if data is stored in receive FIFO<sub>n</sub> (n = 0, 1).

The UBTITOn interrupt does not occur while reception is disabled.

If as many receive data as the number set as the trigger by the UBnRT3 to UBnRT0 bits of the UBnFIC2 register are not received, the timing of reading less receive data than the specified number can be set by the UBTITOn interrupt.

Since the timeout counter starts counting at start bit detection, a receive timeout interrupt does not occur if data of 1 character has not been received.

**Figure 10-5. Timing of Asynchronous Serial Interface Reception Completion Interrupt (UBTIRn)**



**(5) Reception error**

In the single mode (UBnMOD bit = 0 in the UBnFIC0 register), the three types of errors that can occur during a receive operation are a parity error, framing error, and overrun error. In the FIFO mode (UBnMOD bit = 1 in the UBnFIC0 register), the three types of errors that can occur during a receive operation are a parity error, framing error, and overflow error.

As a result of data reception, the UBnPE, UBnFE, or UBnOVE bit of the UBnSTR register is set to 1 if a parity error, framing error, or overrun error occurs in the single mode. The UBnOVF bit of the UBnSTR register is set to 1 if an overflow error occurs in the FIFO mode. The UBnPEF or UBnFEF bit of the UBnRXAP register is set to 1 if a parity error or framing error occurs in the FIFO mode. At the same time, a reception error interrupt (UBTIREn) occurs. The contents of the error can be detected by reading the contents of the UBnSTR or UBnRXAP register.

The contents of the UBnSTR register are reset when 0 is written to the UBnOVF, UBnPE, UBnFE, or UBnOVE bit, or the UBnPWR or UBnRXE bit of the UBnCTL0 register. The contents of the UBnRXAP register are reset when 0 is written to the UBnPWR bit of the UBnCTL0 register.

**Table 10-3. Reception Error Causes**

| Error Flag | Valid Operation Mode | Error Flag | Reception Error | Cause                                                                                              |
|------------|----------------------|------------|-----------------|----------------------------------------------------------------------------------------------------|
| UBnPE      | Single mode          | UBnPE      | Parity error    | The parity specification during transmission does not match the parity of the receive data         |
| UBnFE      |                      | UBnFE      | Framing error   | No stop bit detected                                                                               |
| UBnOVE     |                      | UBnOVE     | Overrun error   | The reception of the next data is completed before data is read from the UBnRX register            |
| UBnOVF     | FIFO mode            | UBnOVF     | Overflow error  | The reception of the next data is completed while receive FIFO is full and before data is read.    |
| UBnPEF     |                      | UBnPEF     | Parity error    | The parity specification during transmission does not match the parity of the data to be received. |
| UBnFEF     |                      | UBnFEF     | Framing error   | The stop bit is not detected when the target data is loaded.                                       |

**Remark** n = 0, 1

**(6) Parity types and corresponding operation**

A parity bit is used to detect a bit error in communication data. Normally, the same type of parity bit is used at the transmission and reception sides.

**(a) Even parity****(i) During transmission**

The parity bit is controlled so that the number of bits with the value “1” within the transmit data including the parity bit is even. The parity bit value is as follows.

- If the number of bits with the value “1” within the transmit data is odd: 1
- If the number of bits with the value “1” within the transmit data is even: 0

**(ii) During reception**

The number of bits with the value “1” within the receive data including the parity bit is counted, and a parity error is generated if this number is odd.

**(b) Odd parity****(i) During transmission**

In contrast to even parity, the parity bit is controlled so that the number of bits with the value “1” within the transmit data including the parity bit is odd. The parity bit value is as follows.

- If the number of bits with the value “1” within the transmit data is odd: 0
- If the number of bits with the value “1” within the transmit data is even: 1

**(ii) During reception**

The number of bits with the value “1” within the receive data including the parity bit is counted, and a parity error is generated if this number is even.

**(c) 0 parity**

During transmission the parity bit is set to “0” regardless of the transmit data.

During reception, no parity bit check is performed. Therefore, no parity error is generated regardless of whether the parity bit is “0” or “1”.

**(d) No parity**

No parity bit is added to the transmit data.

During reception, the receive operation is performed as if there were no parity bit. Since there is no parity bit, no parity error is generated.

### (7) Receive data noise filter

The RXDn signal is sampled at the rising edge of the input clock ( $f_x/4$ ) ( $f_x$ : main clock). If the same sampling value is obtained twice, the match detector output changes, and this output is sampled as input data. Therefore, data not exceeding one clock width is judged to be noise and is not delivered to the internal circuit (see **Figure 10-7**).

Also, since the circuit is configured as shown in Figure 10-6, internal processing during a receive operation is delayed by up to 2 clocks according to the external signal status.

**Figure 10-6. Noise Filter Circuit**

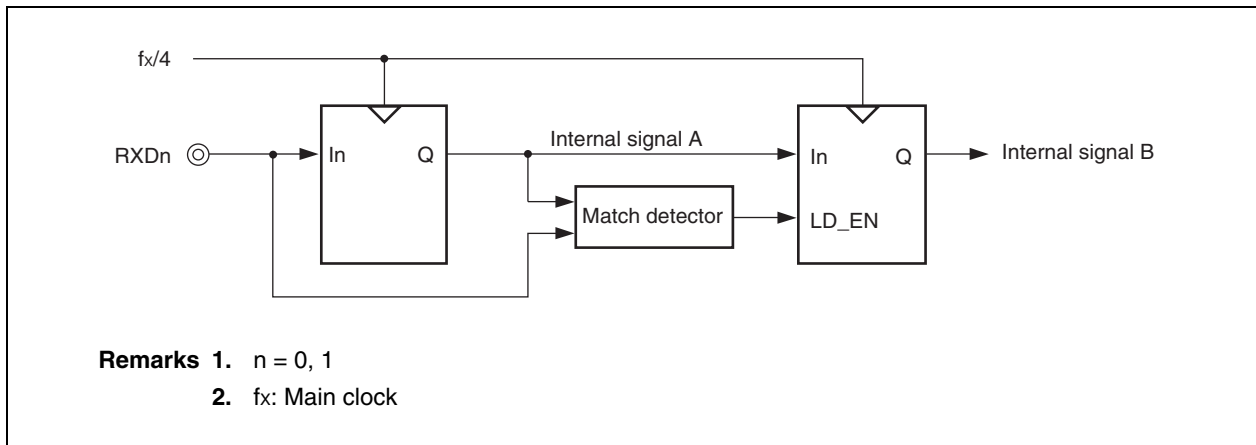
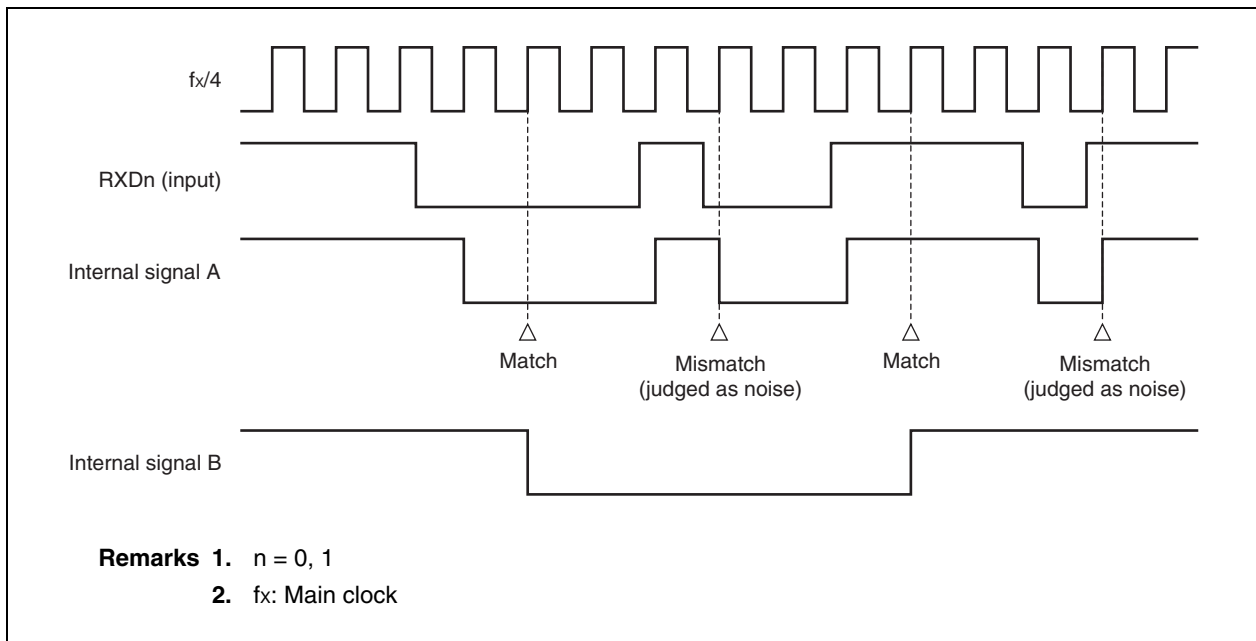


**Figure 10-7. Timing of RXDn Signal Judged as Noise**



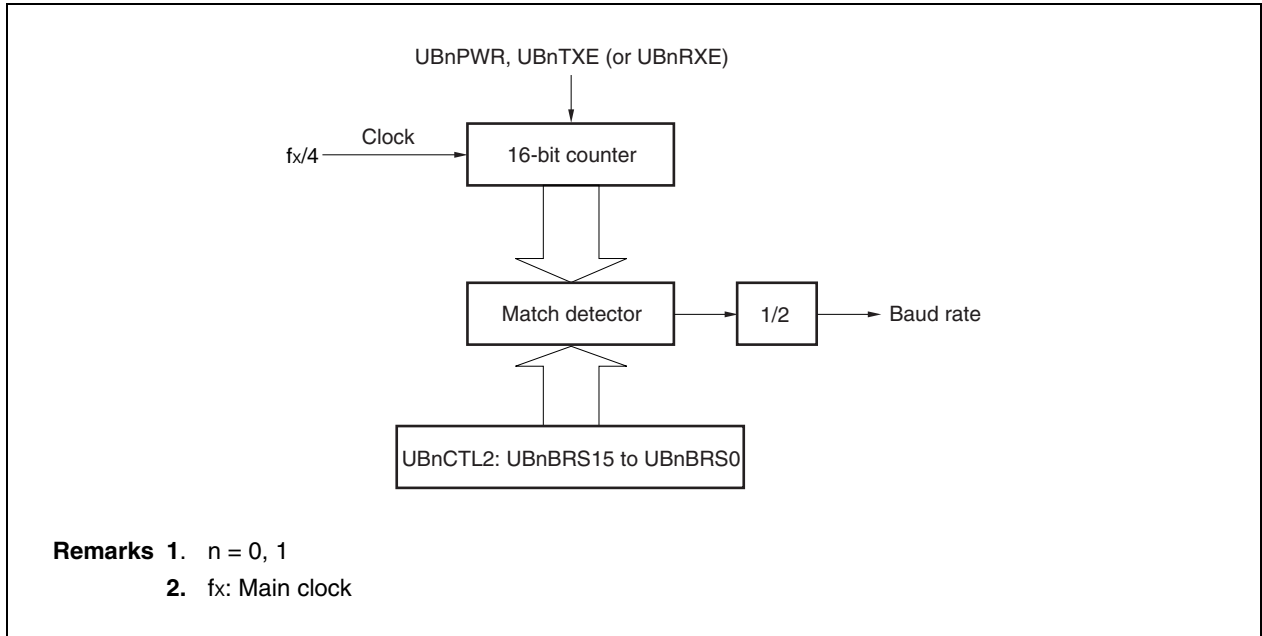
### 10.2.7 Dedicated baud rate generators 0, 1 (BRG0, BRG1)

A dedicated baud rate generator, which consists of a 16-bit programmable counter, generates serial clocks during transmission/reception in UARTBn. The dedicated baud rate generator output can be selected as the serial clock for each channel.

Separate 16-bit counters exist for transmission and for reception. The baud rate for transmission/reception is the same at the same channel.

#### (1) Baud rate generator configuration

Figure 10-8. Baud Rate Generator Configuration



#### (a) Base clock (Clock)

When the UBnPWR bit = 1 in the UBnCTL0 register, the input clock ( $f_x/4$ ) is supplied to the transmission/reception unit ( $f_x$ : main clock). This clock is called the base clock. When the UBnPWR bit = 0, the clock signal is fixed at low level.

**(2) Serial clock generation**

A serial clock can be generated according to the settings of the UBnCTL2 register (n = 0, 1).

The 16-bit counter divisor value can be selected according to the UBnBRS15 to UBnBRS0 bits of the UBnCTL2 register.

**(a) Baud rate**

The baud rate is the value obtained according to the following formula.

$$\text{Baud rate} = \frac{\text{Base clock frequency}}{2 \times k} \text{ [bps]}$$

Base clock frequency =  $f_x/4$  ( $f_x$ : main clock)

k = Value set according to UBnBRS15 to UBnBRS0 bits of UBnCTL2 register (k = 4, 5, 6, ..., 65,535)

**(b) Baud rate error**

The baud rate error is obtained according to the following formula.

$$\text{Error (\%)} = \left( \frac{\text{Actual baud rate (baud rate with error)}}{\text{Desired baud rate (normal baud rate)}} - 1 \right) \times 100 \text{ [\%]}$$

**Cautions 1. Make sure that the baud rate error during transmission does not exceed the allowable error of the reception destination.**

**2. Make sure that the baud rate error during reception is within the allowable baud rate range during reception, which is described in paragraph (4).**

**Example:** Main clock ( $f_x$ ) = 150 MHz = 150,000,000 Hz

Settings of UBnBRS15 to UBnBRS0 bits in UBnCTL2 register = 0000000001111010B

(k = 122)

Target baud rate = 153,600 bps

Baud rate =  $150 \text{ M}/4/(2 \times 122)$   
 $= 150,000,000/4/(2 \times 122) = 153,689 \text{ [bps]}$

Error =  $(153,689/153,600 - 1) \times 100$   
 $= 0.058 \text{ [\%]}$



## (3) Baud rate setting example

Table 10-4. Baud Rate Generator Setting Data

| Baud Rate<br>(bps) | fx = 150 MHz |        | fx = 133 MHz |        | fx = 100 MHz |        | fx = 80 MHz |        |
|--------------------|--------------|--------|--------------|--------|--------------|--------|-------------|--------|
|                    | k            | ERR    | k            | ERR    | k            | ERR    | k           | ERR    |
| 300                | 62,500       | 0.000  | 55,417       | -0.001 | 41,667       | -0.001 | 33,333      | 0.001  |
| 600                | 31,250       | 0.000  | 27,708       | 0.001  | 20,833       | 0.002  | 16,667      | -0.002 |
| 1,200              | 15,625       | 0.000  | 13,854       | 0.001  | 10,417       | -0.003 | 8,333       | 0.004  |
| 2,400              | 7,813        | -0.006 | 6,927        | 0.001  | 5,208        | 0.006  | 4,167       | -0.008 |
| 4,800              | 3,906        | 0.006  | 3,464        | -0.013 | 2,604        | 0.006  | 2,083       | 0.016  |
| 9,600              | 1,953        | 0.006  | 1,732        | -0.013 | 1,302        | 0.006  | 1,042       | -0.032 |
| 19,200             | 977          | -0.045 | 866          | -0.013 | 651          | 0.006  | 521         | -0.032 |
| 31,250             | 600          | 0.000  | 532          | 0.000  | 400          | 0.000  | 320         | 0.000  |
| 38,400             | 488          | 0.058  | 433          | -0.013 | 326          | -0.147 | 260         | 0.160  |
| 76,800             | 244          | 0.058  | 216          | 0.218  | 163          | -0.147 | 130         | 0.160  |
| 153,600            | 122          | 0.058  | 108          | 0.218  | 81           | 0.469  | 65          | 0.160  |
| 312,500            | 60           | 0.000  | 53           | 0.377  | 40           | 0.000  | 32          | 0.000  |

**Caution** The maximum allowable frequency of the main clock (fx) is 150 MHz.

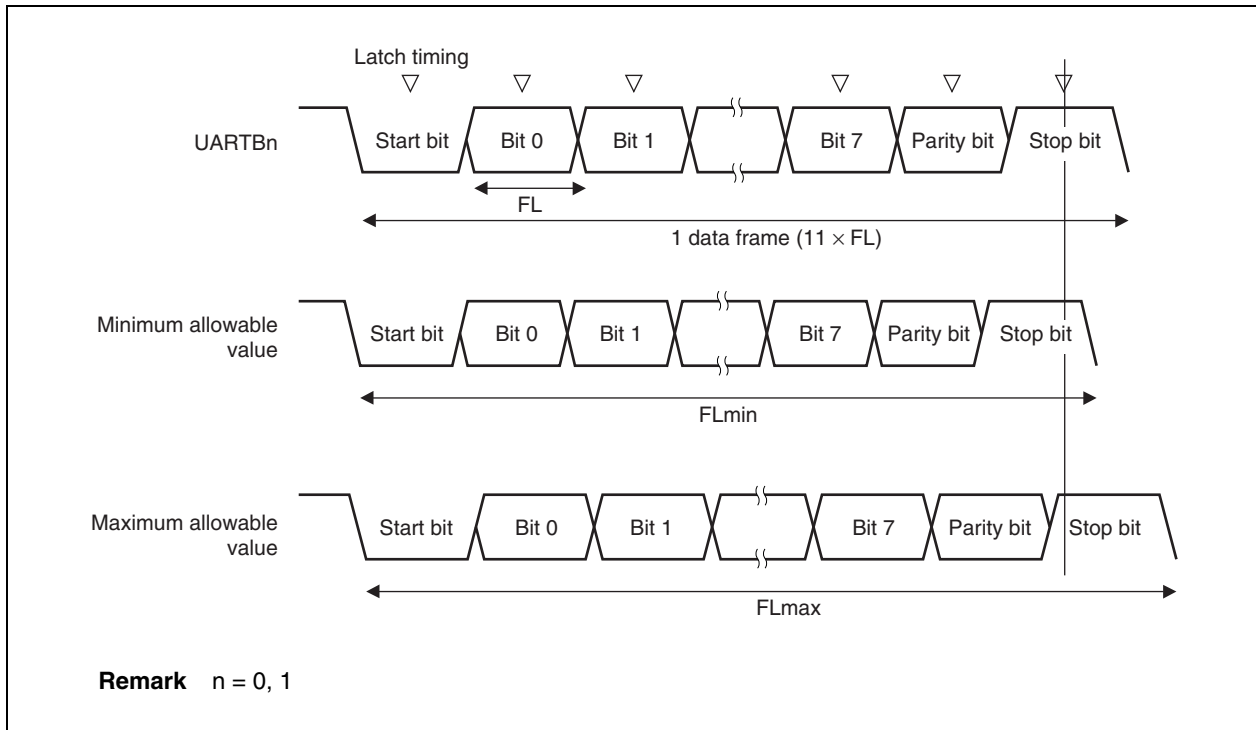
**Remark** fx: Main clock  
k: Settings of UBnBRS15 to UBnBRS0 bits in UBnCTL2 register (n = 0, 1)  
ERR: Baud rate error [%]

#### (4) Allowable baud rate range during reception

The degree to which a discrepancy from the transmission destination's baud rate is allowed during reception is shown below.

**Caution** The equations described below should be used to set the baud rate error during reception so that it always is within the allowable error range.

**Figure 10-9. Allowable Baud Rate Range During Reception**



As shown in Figure 10-9, after the start bit is detected, the receive data latch timing is determined according to the counter that was set by the UBnCTL2 register. If all data up to the final data (stop bit) is in time for this latch timing, the data can be received normally.

Applying this to 11-bit reception is, theoretically, as follows.

$$FL = (Brate)^{-1}$$

Brate: UARTBn baud rate ( $n = 0, 1$ )

k: UBnCTL2 setting value ( $n = 0, 1$ )

FL: 1-bit data length

Latch timing margin: 2 clocks

$$\text{Minimum allowable value: } FL_{\min} = 11 \times FL - \frac{k - 2}{2k} \times FL = \frac{21k + 2}{2k} FL$$

Therefore, the maximum baud rate that can be received at the transfer destination is as follows.

$$BR_{\max} = (FL_{\min}/11)^{-1} = \frac{22k}{21k + 2} \text{ Brate}$$

Similarly, the maximum allowable value can be obtained as follows.

$$\begin{aligned} \frac{10}{11} \times FL_{\max} &= 11 \times FL - \frac{k + 2}{2 \times k} \times FL = \frac{21k - 2}{2 \times k} FL \\ FL_{\max} &= \frac{21k - 2}{20k} FL \times 11 \end{aligned}$$

Therefore, the minimum baud rate that can be received at the transfer destination is as follows.

$$BR_{\min} = (FL_{\max}/11)^{-1} = \frac{20k}{21k - 2} \text{ Brate}$$

The allowable baud rate error of UARTBn and the transfer destination can be obtained as follows from the expressions described above for computing the minimum and maximum baud rate values.

**Table 10-5. Maximum and Minimum Allowable Baud Rate Error**

| Division Ratio (k) | Maximum Allowable Baud Rate Error | Minimum Allowable Baud Rate Error |
|--------------------|-----------------------------------|-----------------------------------|
| 4                  | +2.33 %                           | -2.44                             |
| 8                  | +3.53 %                           | -3.61                             |
| 16                 | +4.14 %                           | -4.19                             |
| 32                 | +4.45 %                           | -4.48                             |
| 64                 | +4.61 %                           | -4.62                             |
| 128                | +4.68 %                           | -4.69                             |
| 256                | +4.72 %                           | -4.73                             |
| 512                | +4.74 %                           | -4.74                             |
| 1,024              | +4.75 %                           | -4.75                             |
| 2,048              | +4.76 %                           | -4.76                             |
| 4,096              | +4.76 %                           | -4.76                             |
| 8,192              | +4.76 %                           | -4.76                             |
| 16,384             | +4.76 %                           | -4.76                             |
| 32,768             | +4.76 %                           | -4.76                             |
| 65,535             | +4.76 %                           | -4.76                             |

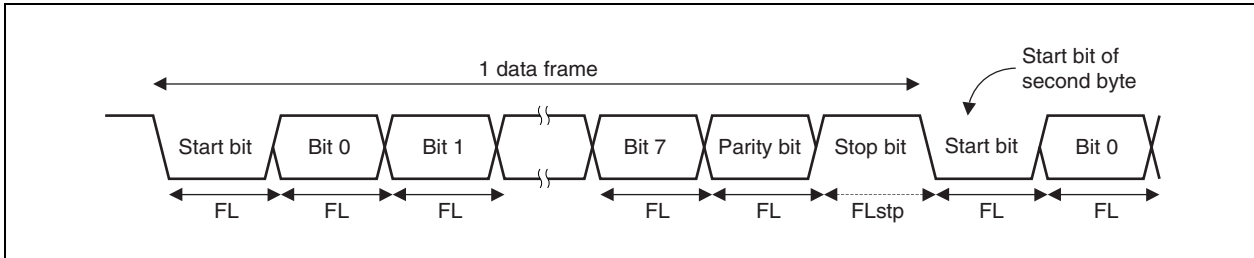
**Remarks 1.** The reception precision depends on the number of bits in one frame, the base clock frequency, and the division ratio (k). The higher the base clock frequency and the larger the division ratio (k), the higher the precision.

2. k: UBnCTL2 setting value (n = 0, 1)

**(5) Transfer rate during continuous transmission**

During continuous transmission, the transfer rate from a stop bit to the next start bit is extended two clocks longer than normal. However, on the reception side, the transfer result is not affected since the timing is initialized by the detection of the start bit.

**Figure 10-10. Transfer Rate During Continuous Transmission**



Representing the 1-bit data length by FL, the stop bit length by FLstp, and the base clock frequency by  $f_x/4$  ( $f_x$ : main clock) yields the following equation.

$$FL_{stp} = FL + 2/(f_x/4)$$

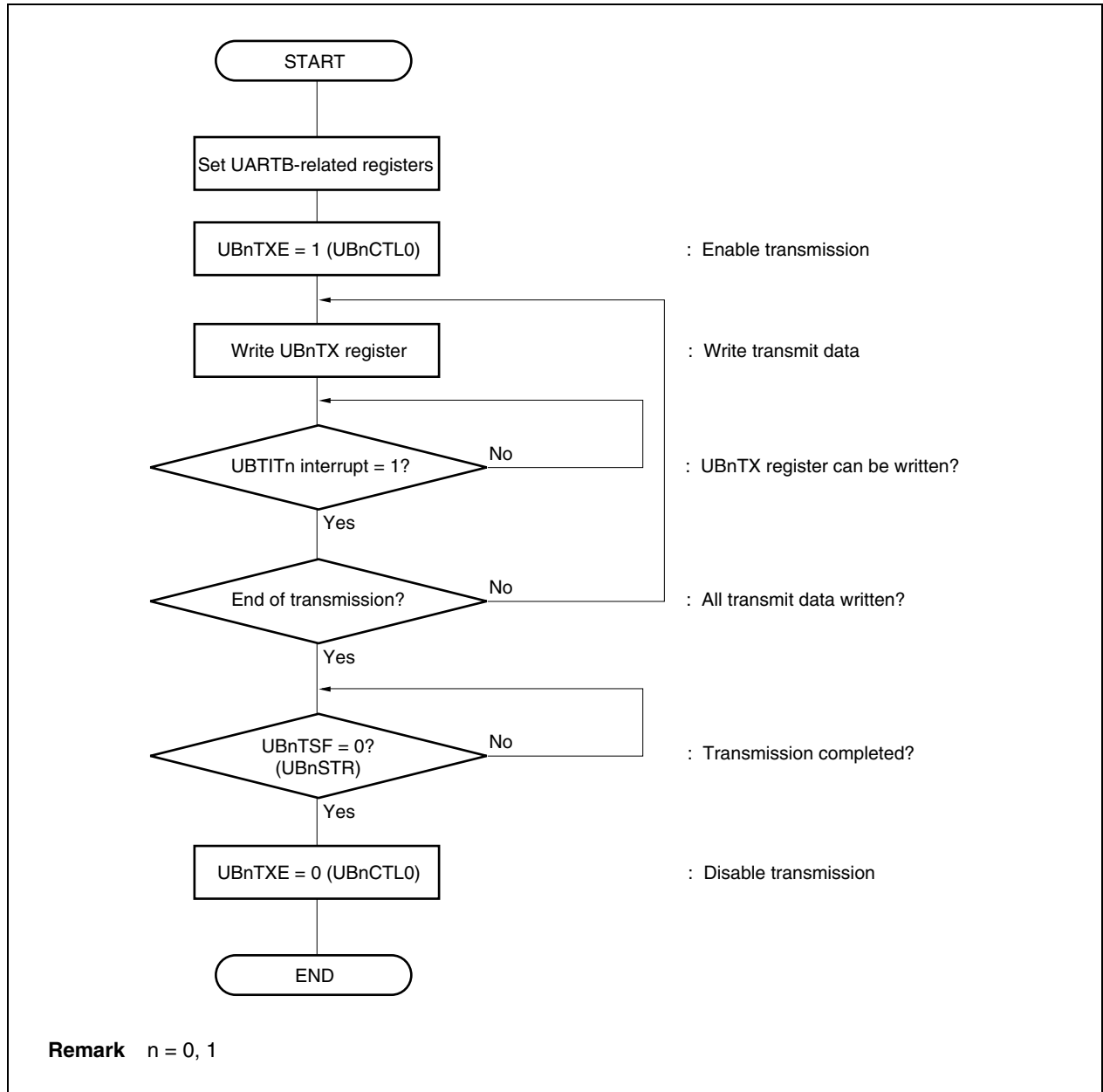
Therefore, the transfer rate during continuous transmission is as follows.

$$\text{Transfer rate} = 11 \times FL + 2/(f_x/4)$$

## 10.2.8 Control flow

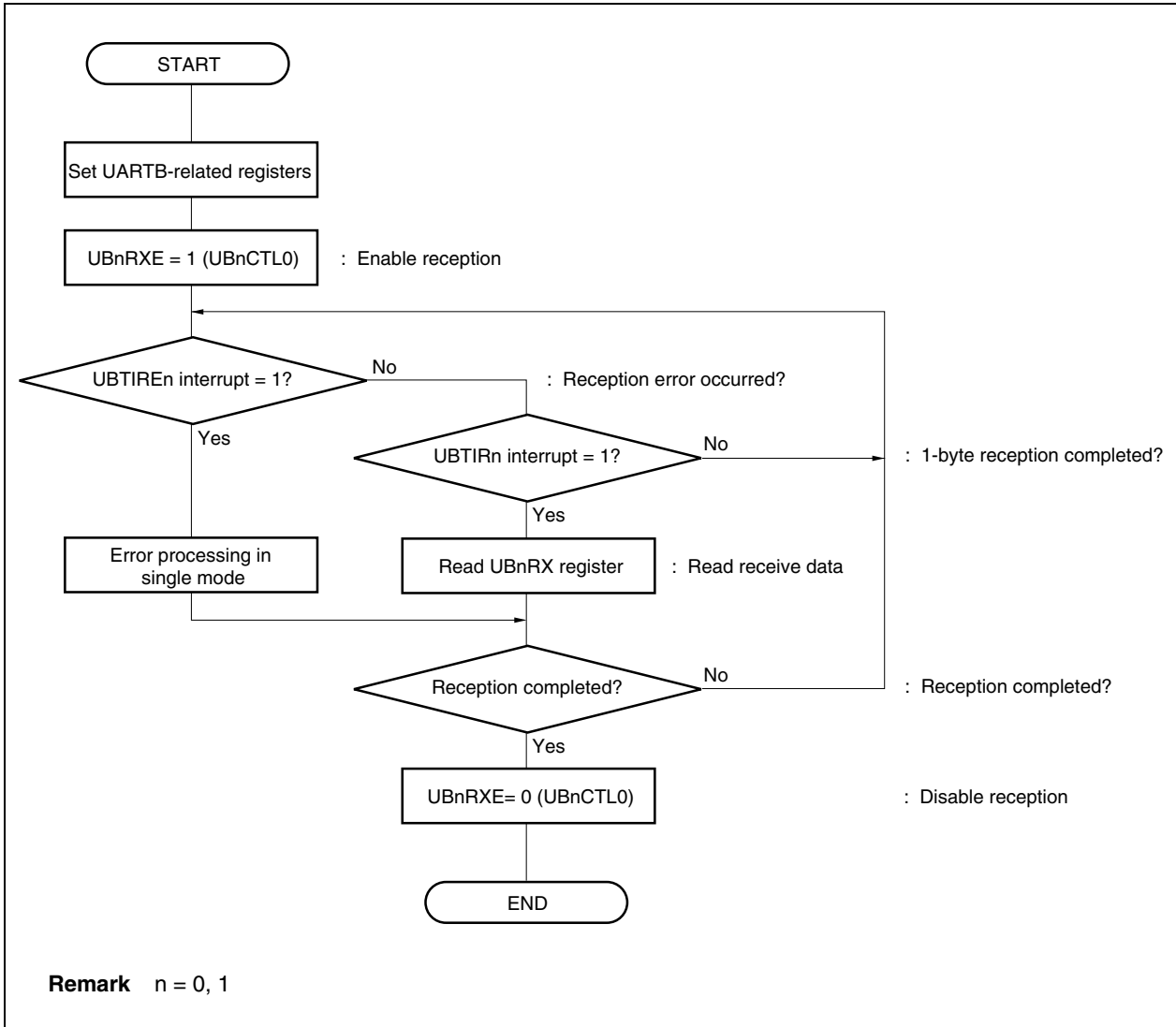
## (1) Example of continuous transmission processing flow in single mode (CPU control)

Figure 10-11. Example of Continuous Transmission Processing Flow in Single Mode (CPU Control)



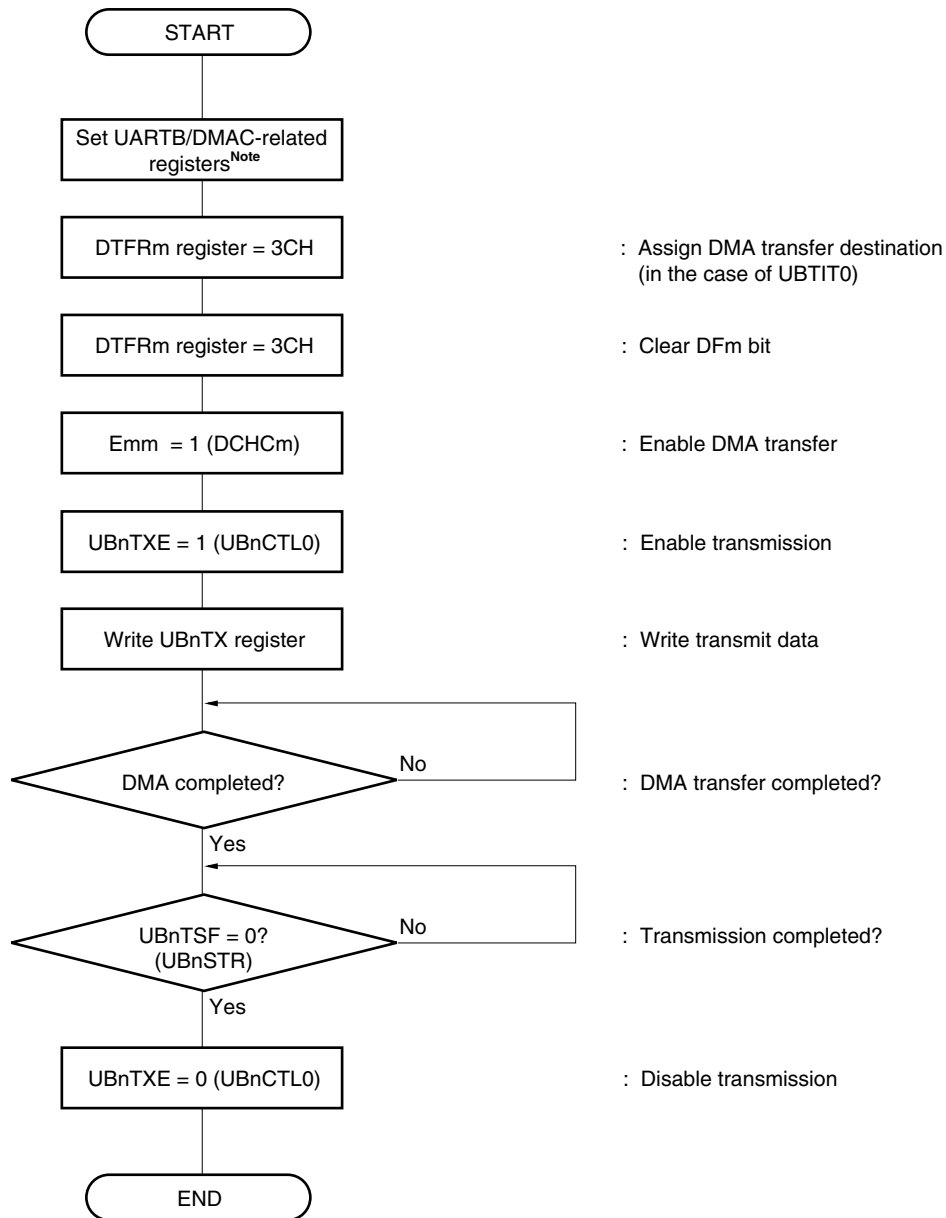
## (2) Example of continuous reception processing flow in single mode (CPU control)

Figure 10-12. Example of Continuous Reception Processing Flow in Single Mode (CPU Control)



## (3) Example of continuous transmission processing flow in single mode (DMA control)

Figure 10-13. Example of Continuous Transmission Processing Flow in Single Mode (DMA Control)

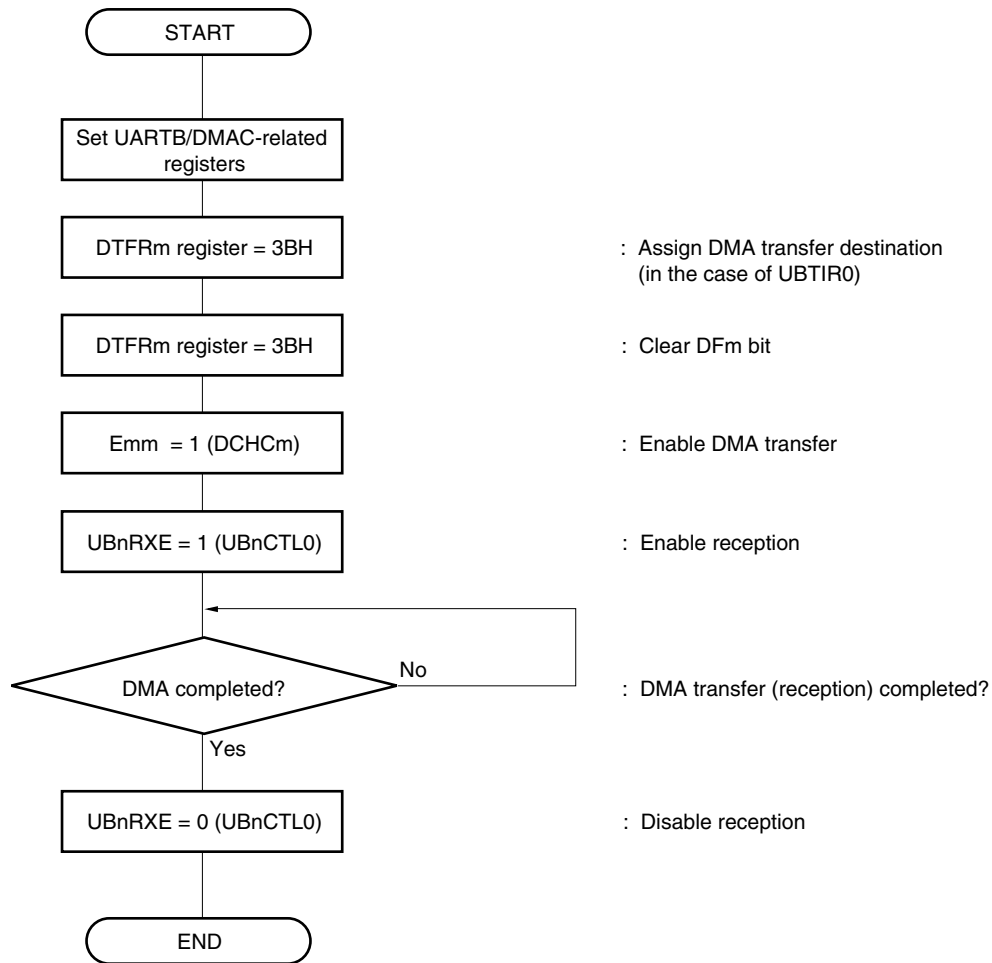


**Note** In this control flow example, transmission of the first byte of the data is executed by a CPU write operation. Exercise care in setting the number of data for DMA transfer (DBCm register) and the source address (DSAmH and DSAmL registers).

**Remark** n = 0, 1  
m = 0 to 3

## (4) Example of continuous reception processing flow in single mode (DMA control)

Figure 10-14. Example of Continuous Reception Processing Flow in Single Mode (DMA Control)

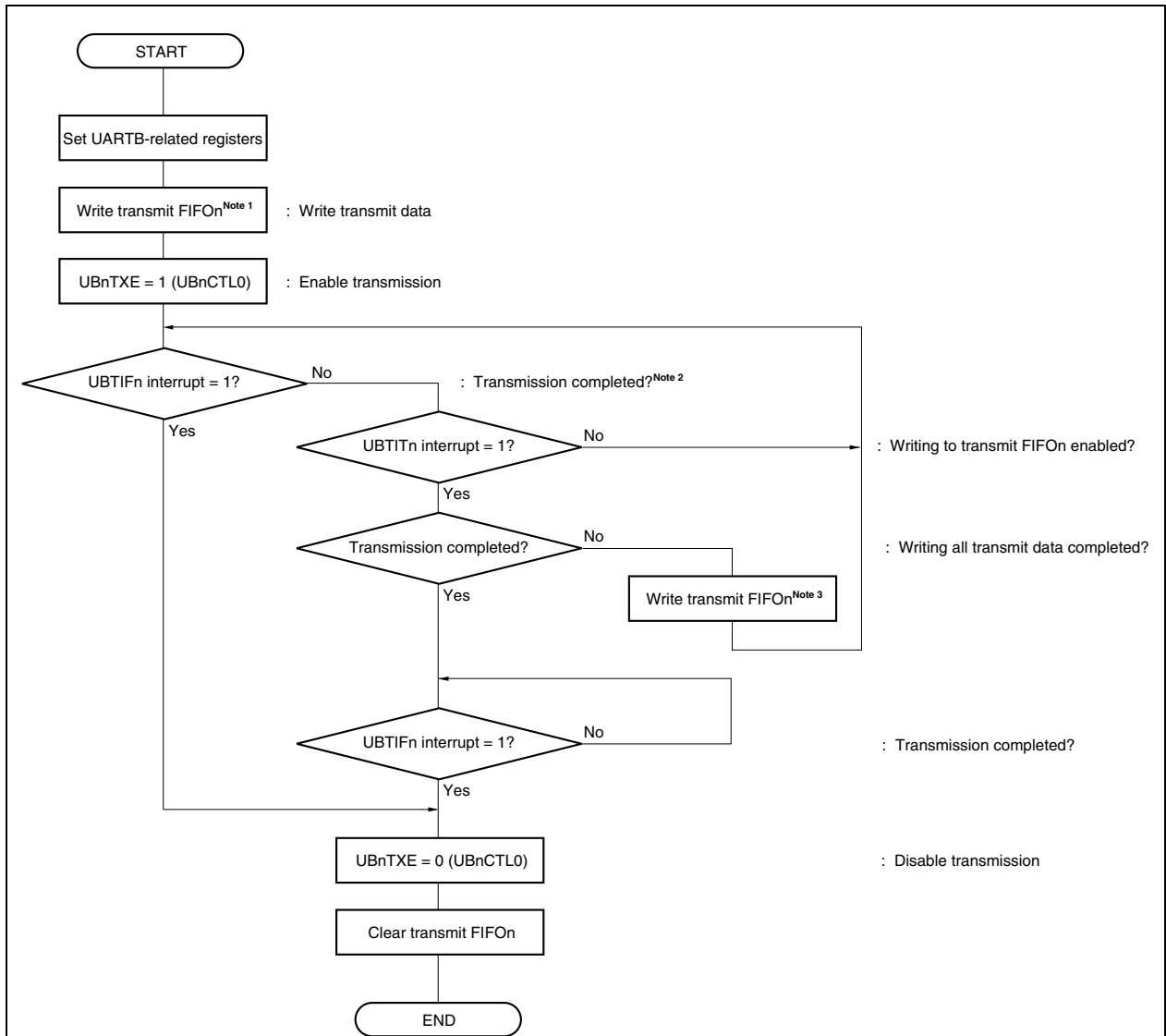


**Remark** n = 0, 1  
m = 0 to 3



## (5) Example of continuous transmission processing flow in FIFO mode (CPU control)

Figure 10-15. Example of Continuous Transmission Processing Flow in FIFO Mode (CPU Control)



**Notes 1.** Write more transmit data than the number set as the trigger by the UBnTT3 to UBnTT0 bits of the UBnFIC2 register to transmit FIFO.

**2.** This is the case where transmission is completed (transmit FIFO and transmit shift register n become empty) before the next transmit data is written. To continue data transmission, clear the UBTIFn and UBTITn interrupts and write the next data to transmit FIFO.

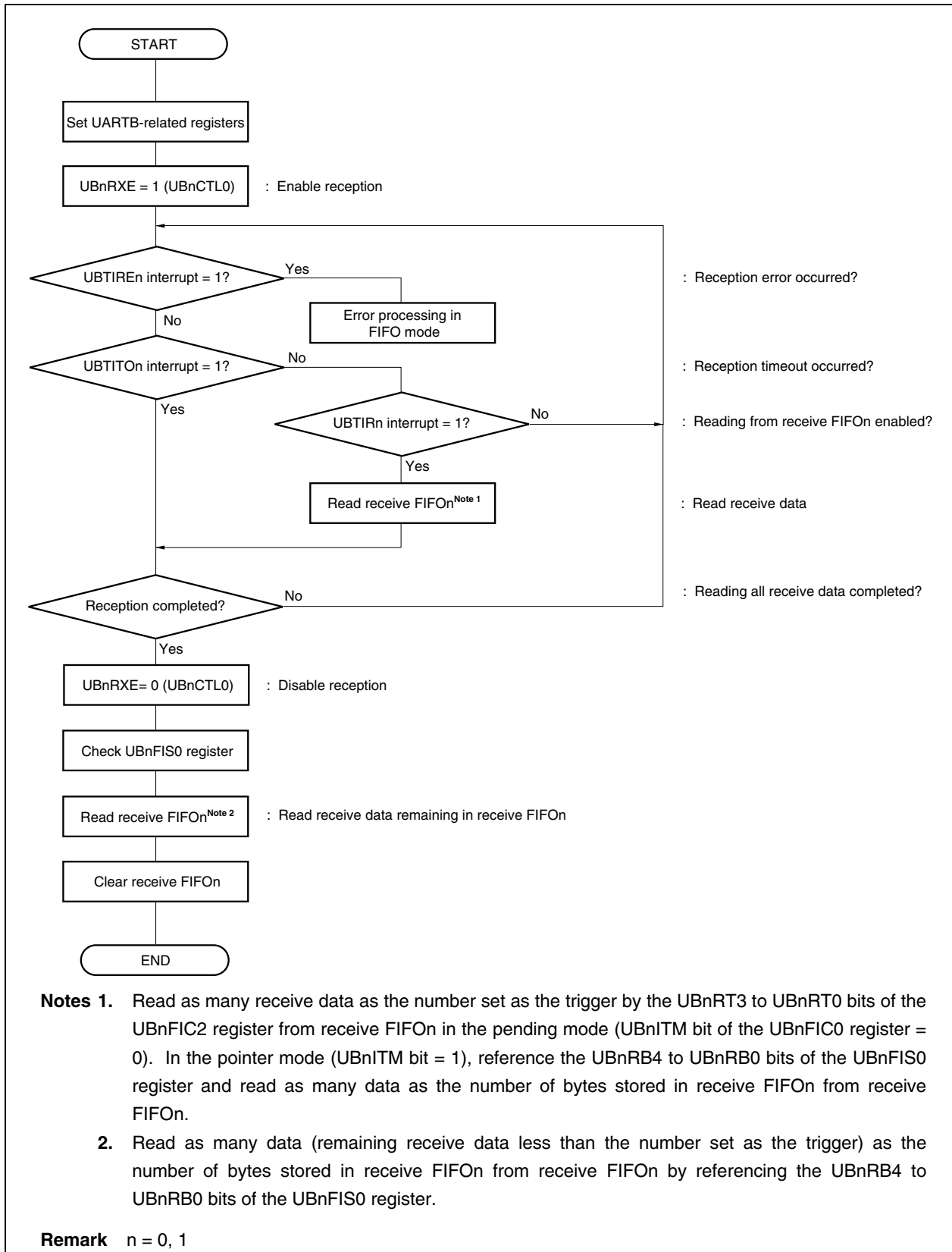
**3.** In the pending mode (UBnITM bit of the UBnFIC0 register = 0), write as many transmit data as the number set as the trigger by the UBnTT3 to UBnTT0 bits of the UBnFIC2 register to transmit FIFO. In the pointer mode (UBnITM bit = 1), reference the UBnTB4 to UBnTB0 bits of the UBnFIS1 register and write as many data as the number of vacant bytes in transmit FIFO to transmit FIFO.

Write 16-byte data to fully use the 8-bit × 16-stage FIFO function.

**Remark** n = 0, 1

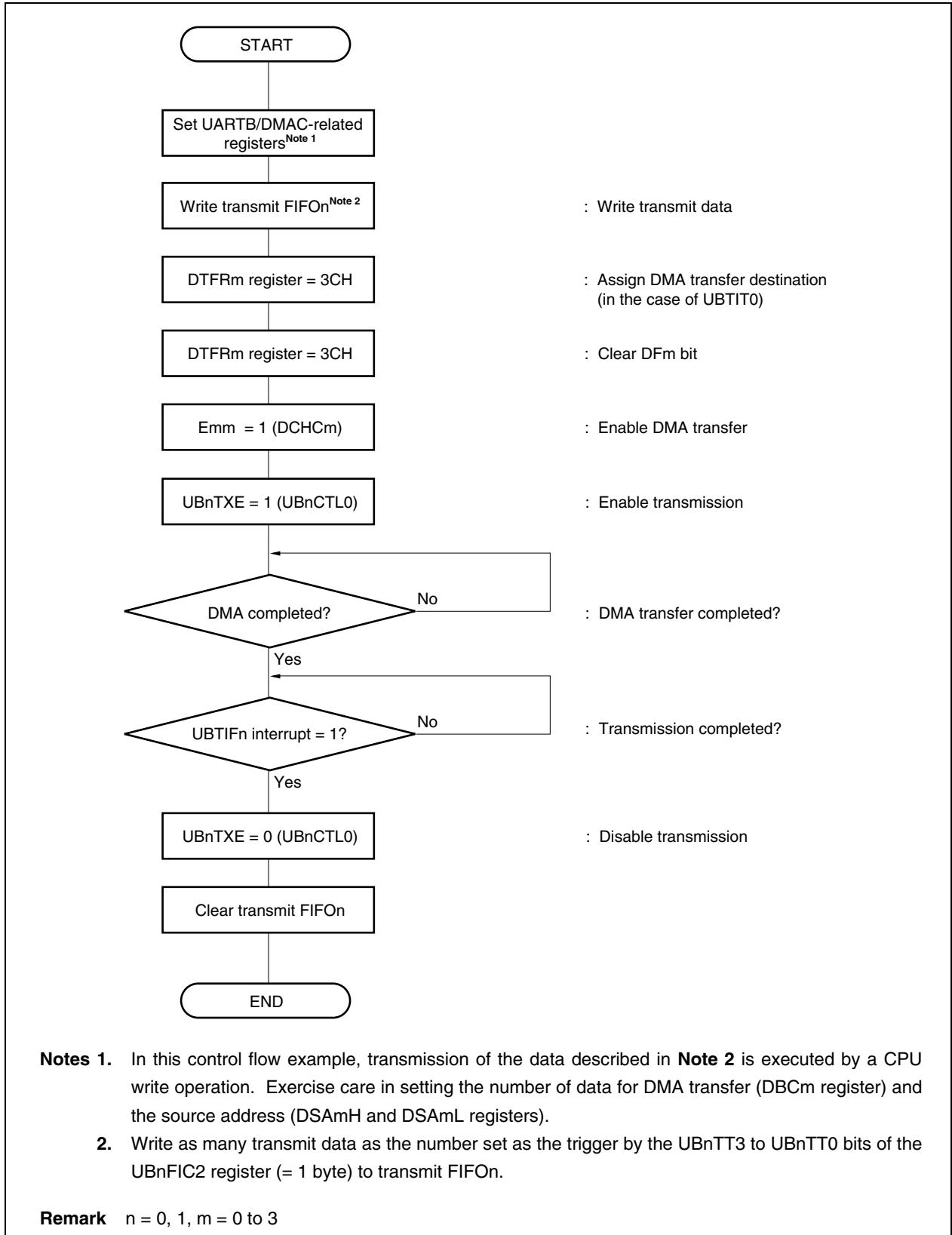
## (6) Example of continuous reception processing in FIFO mode (CPU control)

Figure 10-16. Example of Continuous Reception Processing in FIFO Mode (CPU Control)



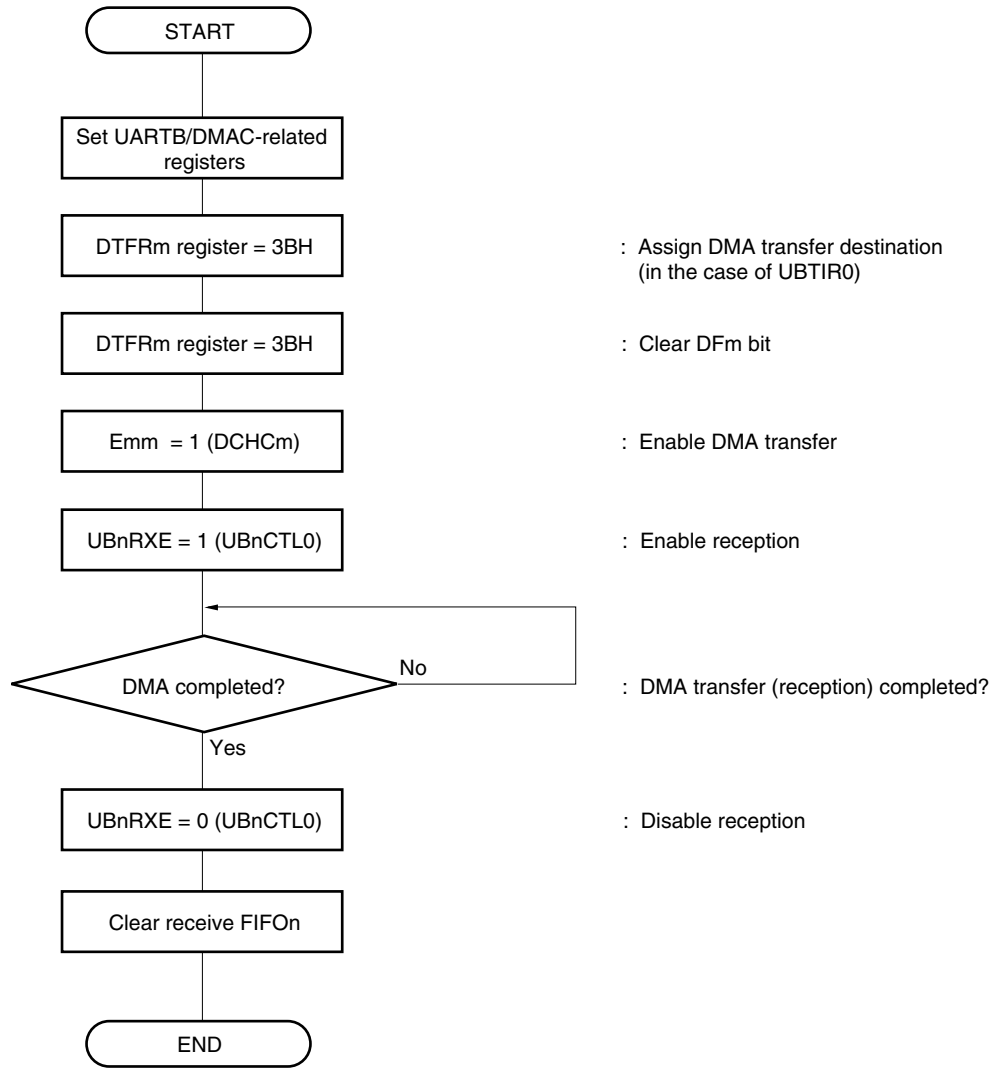
## (7) Example of continuous transmission (pending mode) processing in FIFO mode (DMA control)

Figure 10-17. Example of Continuous Transmission (Pending Mode) Processing in FIFO Mode (DMA Control)



## (8) Example of continuous reception (pending mode) processing flow in FIFO mode (DMA control)

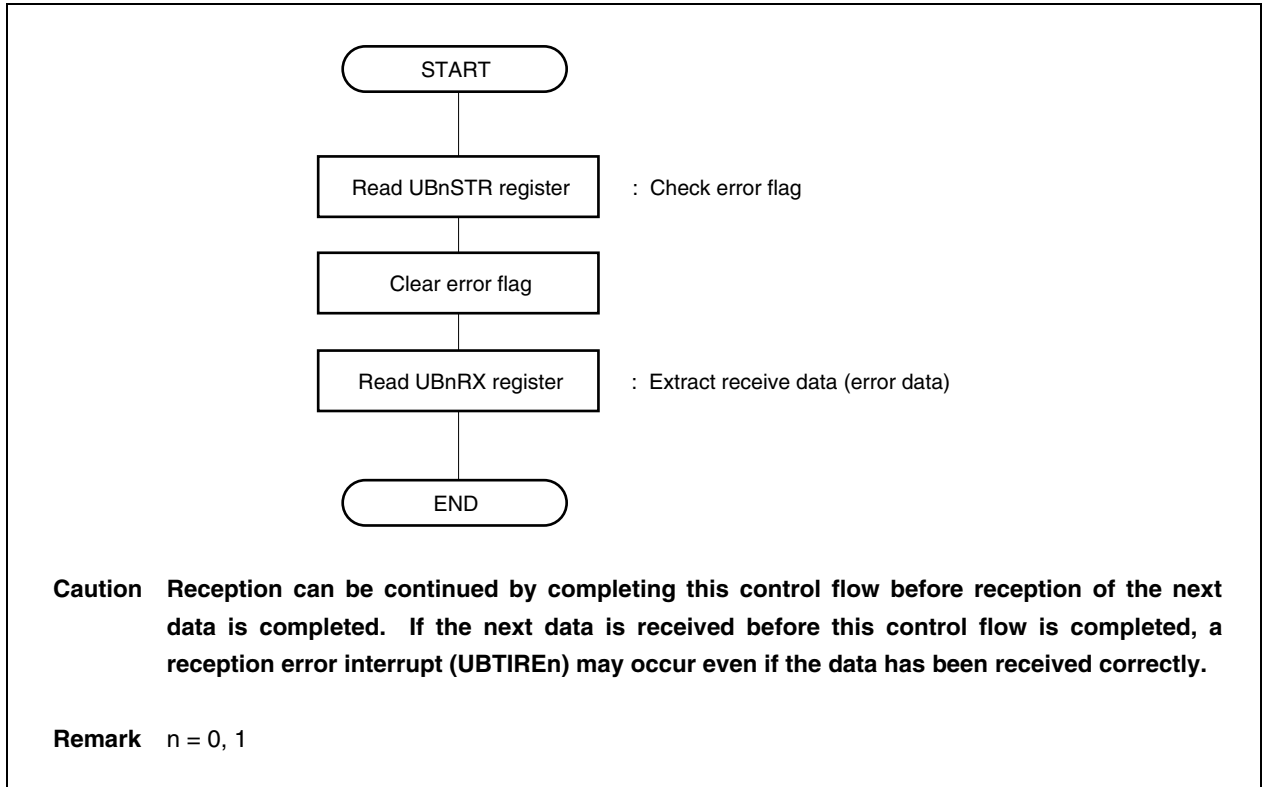
Figure 10-18. Example of Continuous Reception (Pending Mode) Processing Flow in FIFO Mode (DMA Control)



**Remark** n = 0, 1  
m = 0 to 3

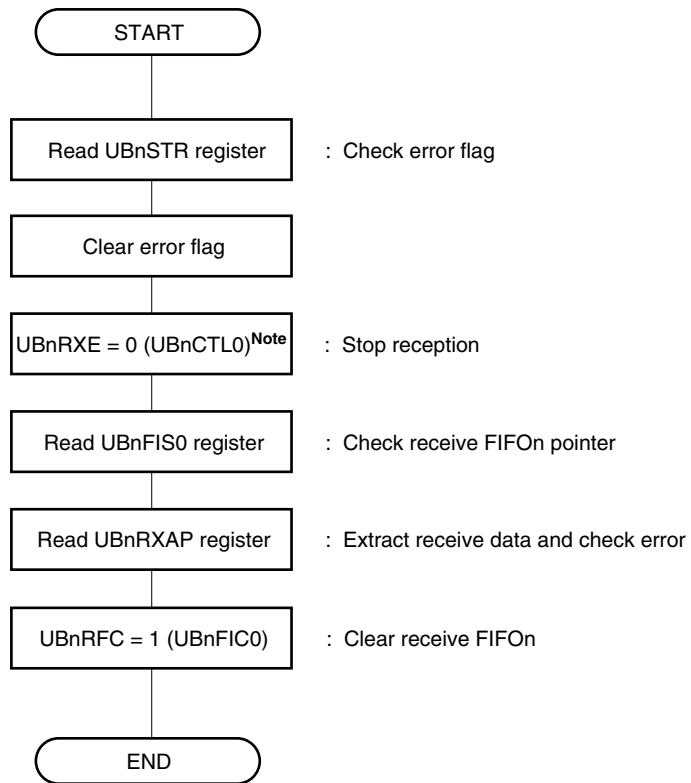
## (9) Example of reception error processing in single mode

Figure 10-19. Example of Reception Error Processing in Single Mode



## (10) Example of reception error processing flow in FIFO mode (1)

Figure 10-20. Example of Reception Error Processing Flow in FIFO Mode (1)

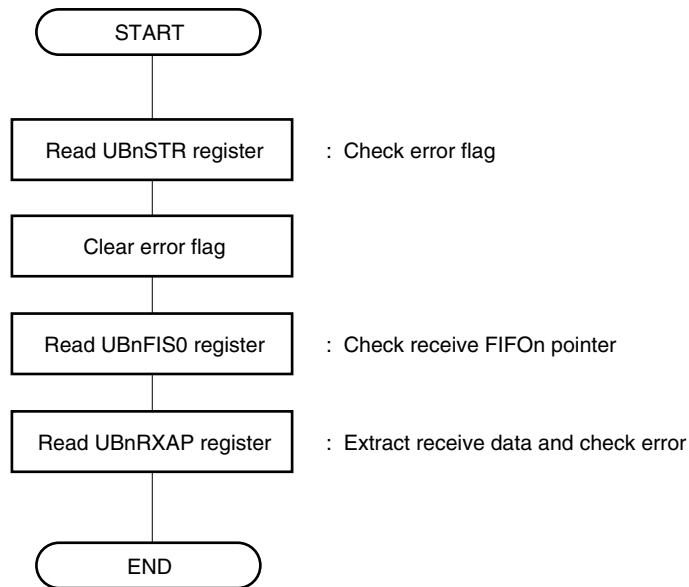


**Note** If the error flag is cleared when UBnRXE bit = 0, the UBnCTL0 register does not have to be set.

**Remark** n = 0, 1

## (11) Example of reception error processing flow in FIFO mode (2)

Figure 10-21. Example of Reception Error Processing Flow in FIFO Mode (2)



**Note** Reception can be continued by completing this control flow before reception of the next data is completed. Extract the receive data and check if a reception error has occurred before receive FIFO becomes empty. Note that this control flow is valid only when a parity error or a framing error occurs. If an overflow error occurs, receive FIFO must be cleared (UBnRFC bit of the UBnFIC0 register = 1). If the next data is received before this control flow is completed, a reception error interrupt (UBTIREn) may occur even if the data has been received correctly.

**Remark** n = 0, 1

### 10.2.9 Cautions

Cautions concerning UARTB are shown below.

#### (1) When supply clock to UARTBn is stopped

When the supply of clocks to UARTBn is stopped (for example, IDLE or STOP mode), operation stops with each register retaining the value it had immediately before the supply of clocks was stopped. The TXDn pin output also holds and outputs the value it had immediately before the supply of clocks was stopped. However, operation is not guaranteed after the supply of clocks is restarted. Therefore, after the supply of clocks is restarted, the circuits should be initialized by setting the UBnPWR bit = 0, UBnRXE bit = 0, and UBnTXE bit = 0.

#### (2) Caution on setting UBnCTL0 register

- When using UARTBn, set the external pins related to the UARTBn function to the control mode and set the UBnCTL2 register. Then set the UBnPWR bit of the UBnCTL0 register to 1 before setting the other bits.
- Be sure to input a high level to the RXDn pin when setting the external pins related to the UARTBn function to the control mode. If a low level is input, it is judged that a falling edge is input after the UBnRXE bit of the UBnCTL0 register has been set to 1, and reception may be started.

#### (3) Caution on setting UBnFIC2 register

Be sure to clear the UBnTXE bit (to disable transmission) and UBnRXE bit (to disable reception) of the UBnCTL0 register to 0 before writing data to the UBnFIC2 register. If data is written to the UBnFIC2 register with the UBnTXE or UBnRXE bit set to 1, the operation is not guaranteed.

#### (4) Transmission interrupt request signal

In the single mode, the transmission completion interrupt (UBTITn) occurs when the UBnTX register becomes empty (when 1 byte of data is transferred from the UBnTX register to transmit shift register n). In the FIFO mode, the FIFO transmission completion interrupt (UBTIFn) occurs when data is no longer in transmit FIFO n and transmit shift register n (when the FIFO and register are vacant). However, the UBTITn interrupt or UBTIFn interrupt does not occur if transmit data register n becomes empty due to  $\overline{\text{RESET}}$  input.

#### (5) Initialization during continuous transmission in single mode

Confirm that the UBnTSF bit of the UBnSTR register is 0 before executing initialization during transmission processing. If initialization is executed while the UBnTSF bit is 1, the transmit data is not guaranteed.

#### (6) Initialization during continuous transmission (pending mode) in FIFO mode

Confirm that the UBnTSF bit of the UBnSTR register is 0 before executing initialization during transmission processing (this can also be done by checking the FIFO transmission completion interrupt (UBTIFn)). If initialization is executed while the UBnTSF bit is 1, the transmit data is not guaranteed.

To write transmit data to transmit FIFO n by DMA control, set the number of transmit data specified as the trigger by the UBnTT3 to UBnTT0 bits of the UBnFIC2 register to 1 byte; otherwise the operation will not be guaranteed.

#### (7) Initialization during continuous transmission (pointer mode) in FIFO mode

Confirm that the UBnTSF bit of the UBnSTR register is 0 before executing initialization during transmission processing (this can also be done by checking the FIFO transmission completion interrupt (UBTIFn)). If initialization is executed while the UBnTSF bit is 1, the transmit data is not guaranteed.



**(8) Receive operation in FIFO mode (pointer mode specified)**

If the pointer mode is specified in the FIFO mode and if as many data as the number of bytes stored in receive FIFO<sub>n</sub> are read by referencing the UBnFIS0 register, no data may be stored in receive FIFO<sub>n</sub> (UBnRB4 to UBnRB0 bits = 00000 in the UBnFIS0 register) even though the reception completion interrupt (UBTIR<sub>n</sub>) has occurred. In this case, do not read data from receive FIFO<sub>n</sub>. Be sure to read data from receive FIFO<sub>n</sub> after confirming that the number of bytes stored in receive FIFO<sub>n</sub> = 1 byte or more (UBnRB4 to UBnRB0 bits = other than 00000).

### 10.3 Clocked Serial Interfaces 30, 31 (CSI30, CSI31)

#### 10.3.1 Features

- Transfer rate: Master mode/slave mode: Maximum 5.5 Mbps
- Half-duplex communications
- Master mode and slave mode can be selected
- Transmission data length: 8 to 16 bits (selectable in 1-bit units)
- Transfer data direction can be switched between MSB first and LSB first
- 3-wire mode
  - SOn: Serial data output
  - SIn: Serial data input
  - SCKn: Serial clock I/O
- Bit rate
  - In master mode: BRG output (selected by the CKS3n2 to CKS3n0 bits and MDLn2 to MDLn0 bits of clocked serial interface clock select register n (CSIC3n))
  - In slave mode: Clock input from master (when CKS3n2 to CKS3n0 bits = 111 in the CSIC3n register)
- Interrupt sources: 2 types
  - Transmission/reception completion interrupt (INTCSI3n)
  - CSIBUFn overflow interrupt (INTCOVF3n)
- Transmission mode, reception mode, or transmission/reception mode can be selected
  - Transmission mode: Transmission is started by writing transmit data to transmit data CSI buffer register 3n (SFDB3n) while transmission is enabled (see **10.3.5 (11) Transmission mode**).
  - Reception mode: Reception is started by using processing that writes dummy data to transmit data CSI buffer register 3n (SFDB3n) as a trigger while reception is enabled (see **10.3.5 (12) Reception mode**).
  - Transmission/reception mode: Transmission/reception is started by using processing that writes transmit data to transmit data CSI buffer register 3n (SFDB3n) while transmission/reception is enabled (see **10.3.5 (13) Transmission/reception mode**).
- Sixteen on-chip 16-bit transmit/receive buffers (CSIBUFn)
- On-chip dedicated baud rate generator

**Remark** n = 0, 1

### 10.3.2 Configuration

CSI3n is controlled by the clocked serial interface mode register 3n (CSIM3n) (n = 0, 1).

**(1) Clocked serial interface mode registers 30, 31 (CSIM30, CSIM31)**

The CSIM3n register is an 8-bit register for specifying the operation of CSI3n.

**(2) Clocked serial interface clock select registers 30, 31 (CSIC30, CSIC31)**

The CSIC3n register is an 8-bit register for controlling the operation clock and operating mode of CSI3n.

**(3) Serial I/O shift registers 0, 1 (SIO0, SIO1)**

The SIO<sub>n</sub> register is an 8-bit register for converting between serial data and parallel data. SIO<sub>n</sub> is used for both transmission and reception.

Data is shifted in (reception) or shifted out (transmission) beginning at either the MSB side or the LSB side.

**(4) Receive data buffer registers 30, 31 (SIRB30, SIRB31)**

The SIRB3n register is a 16-bit buffer register that stores receive data. This register is also divided into two registers: the higher 8 bits (SIRB3nH) and lower 8 bits (SIRB3nL).

**(5) Transmit data CSI buffer registers 30, 31 (SFDB30, SFDB31)**

The SFDB3n register is a 16-bit buffer register that stores transmit data. This register is also divided into two registers: the higher 8 bits (SFDB3nH) and lower 8 bits (SFDB3nL).

**(6) CSIBUF status registers 30, 31 (SFA30, SFA31)**

The SFA3n register is an 8-bit register that indicates the status of CSI data buffer register n (CSIBUF<sub>n</sub>) or the transfer status.

**(7) Transfer data length select registers 30, 31 (CSIL30, CSIL31)**

The CSIL3n register is an 8-bit register that selects the CSI3n transfer data length.

**(8) Transfer data number specification registers 30, 31 (SFN30, SFN31)**

The SFN3n register is an 8-bit register that sets the number of CSI3n transfer data in continuous mode.

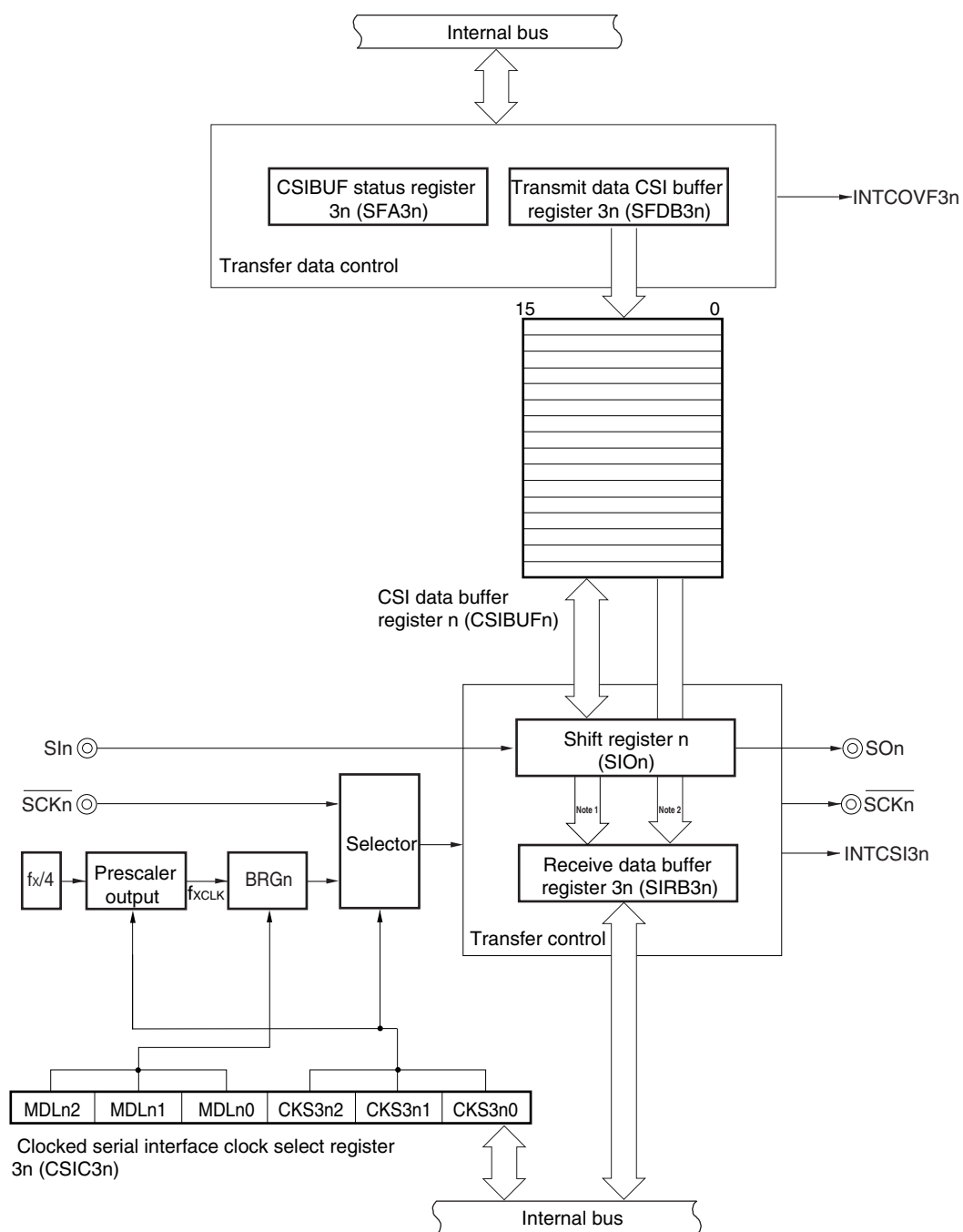
**(9) CSI data buffer registers 0, 1 (CSIBUF0, CSIBUF1)**

By consecutively writing transmit data to the SFDB3n register from where it is transferred, the data can be stored in the CSIBUF<sub>n</sub> register while the CSIBUF<sub>n</sub> pointer for writing is automatically incremented (CSIBUF<sub>n</sub>).

The CSIBUF<sub>n</sub> is a 16-bit buffer register.

In the continuous mode, the data received in the CSIBUF<sub>n</sub> register can be sequentially read while the read CSIBUF<sub>n</sub> pointer is automatically incremented, by continuously reading the receive data from the SIRB3n register.

Figure 10-22. Block Diagram of Clocked Serial Interfaces 30 and 31



- Notes**
1. In single mode
  2. In continuous mode

- Remarks**
1.  $n = 0, 1$
  2.  $f_x$ : Main clock  
 $f_{xCLK}$ : Base clock selected by  $CKS3n2$  to  $CKS3n0$  bits of  $CSIC3n$  register

### 10.3.3 Control registers

Because CSI30 shares pins with UARTB0, the CSI30 mode must be set in advance by using the PMC1 and PFC1 registers (see 10.1.1 Switching between UARTB0 and CSI30 modes).

#### (1) Clocked serial interface mode registers 30, 31 (CSIM30, CSIM31)

The CSIM3n register controls the operation of CSI3n (n = 0, 1).

These registers can be read or written in 8-bit or 1-bit units.

Be sure to clear bit 0 to 0. If it is set to 1, the operation is not guaranteed.

**Cautions 1.** Writing the TRMDn, DIRn, CSITn, and CSWEn bits is enabled only when CTXEn bit = 0 and CRXEn bit = 0.

**2** Be sure to set the external pins related to the CSI3n function to control the mode before using CSI3n. Then set the CSICAEn bit to 1 before setting the other bits.

(1/2)

|        |         |       |       |       |      |       |       |   |           |             |
|--------|---------|-------|-------|-------|------|-------|-------|---|-----------|-------------|
|        | 7       | 6     | 5     | 4     | 3    | 2     | 1     | 0 | Address   | After reset |
| CSIM30 | CSICAE0 | CTXE0 | CRXE0 | TRMD0 | DIR0 | CSIT0 | CSWE0 | 0 | FFFFFD00H | 00H         |
| CSIM31 | CSICAE1 | CTXE1 | CRXE1 | TRMD1 | DIR1 | CSIT1 | CSWE1 | 0 | FFFFFD20H | 00H         |

| Bit position | Bit name | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|--------------|----------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 7            | CSICAEn  | <p>Controls the operating clock.</p> <p>0: Stop clock supply to CSI3n.</p> <p>1: Supply clock to CSI3n.</p> <p><b>Cautions 1.</b> The CSI3n unit is reset when the CSICAEn bit = 0, and CSI3n is stopped. To operate CSI3n, first set the CSICAEn bit to 1.</p> <p><b>2.</b> When rewriting the CSICAEn bit from 0 to 1 or from 1 to 0, simultaneously rewriting the bits other than the CSICAEn bit of the CSIM3n register is prohibited.</p> <p>When the CSICAEn bit = 0, rewriting the bits other than the CSICAEn bit of the CSIM3n register, and the SFDB3n, SFDB3nL, and SFA3n registers is prohibited.</p> |
| 6            | CTXEn    | <p>Enables or disables transmission.</p> <p>1: Disables transmission.</p> <p>0: Enables transmission.</p> <p><b>Caution</b> The CTXEn bit is reset when the CSICAEn bit is cleared to 0.</p>                                                                                                                                                                                                                                                                                                                                                                                                                      |

**Remark** n = 0, 1

| Bit position | Bit name | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|--------------|----------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 5            | CRXEn    | Enables or disables reception.<br>1: Disables reception.<br>0: Enables reception.<br><br><b>Caution</b> The CRXEn bit is reset when the CSICAEn bit is cleared to 0.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| 4            | TRMDn    | Specifies the transfer mode.<br>0: Single mode<br>1: Continuous mode                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| 3            | DIRn     | Specifies the transfer direction when data is written from the SFDB3n register to the CSIBUFn register or read from the SIRB3n and CSIBUFn registers.<br>0: The first bit of transfer data is the MSB.<br>1: The first bit of transfer data is the LSB.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| 2            | CSITn    | Controls delay of the transmission completion interrupt signal (INTCSI3n) (see <b>10.3.5 (14) Delay control of transmission/reception completion interrupt (INTCSI3n)</b> ).<br>0: No delay<br>1: Delay mode (In the continuous mode (TRMDn = 1), the next data transfer is delayed half a cycle because a delay of half a cycle is inserted when transfer of 1-bit data is complete.)<br><br><b>Cautions</b><br>1. The delay mode (CSIT bit = 1) is valid only in the master mode (when the CKS3n2 to CKS3n0 bits of the CSIC3n register are other than 111). In the slave mode (when the CKS3n2 to CKS3n0 bits are 111), do not set the delay mode. Even if the delay mode is set, INTCSI3n is not affected by the CSITn bit.<br>2. If the CSITn bit is set to 1 in the continuous mode (TRMDn bit = 1), the INTCSI3n interrupt is not output except when the last data set by the SFNn3 to SFNn0 bits of the SFN3n register is transferred, but a delay of half a clock can be inserted between each data transfer. |
| 1            | CSWEn    | Enables or disables transfer wait.<br>0: Disables transfer wait (1 wait cycle not inserted on starting transfer).<br>1: Enables transfer wait (1 wait cycle inserted on starting transfer).<br><br><b>Caution</b> Inserting a transfer wait cycle (CSWEn bit = 1) is valid only in the master mode (CKS3n2 to CKS3n0 bits = other than 111 in the CSIC3n register). In the slave mode (CKS3n2 to CKS3n0 bits = 111), do not insert a transfer wait cycle. Even if set, a transfer wait cycle is not inserted.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |

**Remark** n = 0, 1

**(2) Clocked serial interface clock select registers 30, 31 (CSIC30, CSIC31)**

The CSIC3n register is an 8-bit register that controls the operation clock and operating mode of CSI3n. These registers can be read or written in 8-bit or 1-bit units.

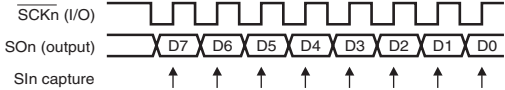
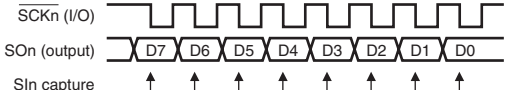
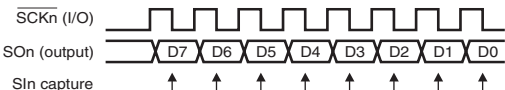
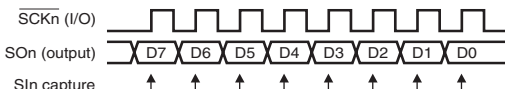
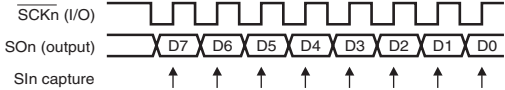
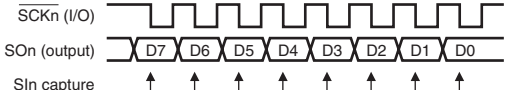
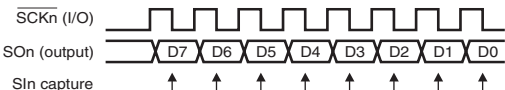
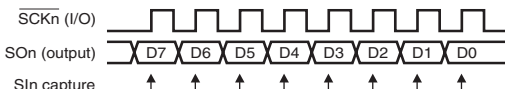
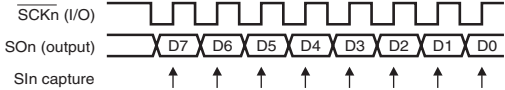
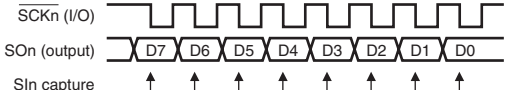
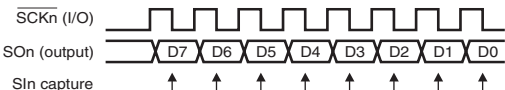
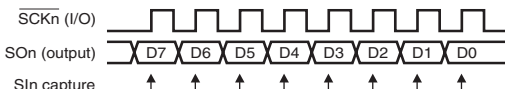
**Caution** Data can be written to the CSIC3n register only when the CTXEn bit = 0 and CRXEn bit = 0 in the CSIM3n register.

(1/3)

|        | 7     | 6     | 5     | 4    | 3    | 2      | 1      | 0      | Address   | After reset |
|--------|-------|-------|-------|------|------|--------|--------|--------|-----------|-------------|
| CSIC30 | MDL02 | MDL01 | MDL00 | CKP0 | DAP0 | CKS302 | CKS301 | CKS300 | FFFFFD01H | 07H         |
| CSIC31 | MDL12 | MDL11 | MDL10 | CKP1 | DAP1 | CKS312 | CKS311 | CKS310 | FFFFFD21H | 07H         |

| Bit position | Bit name       | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |       |       |               |                                     |                                     |   |   |   |   |                             |   |   |   |   |                      |   |   |   |   |                      |   |   |   |   |                      |   |   |   |   |                      |   |   |   |   |                       |   |   |   |   |                       |   |   |   |   |                       |
|--------------|----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|-------|---------------|-------------------------------------|-------------------------------------|---|---|---|---|-----------------------------|---|---|---|---|----------------------|---|---|---|---|----------------------|---|---|---|---|----------------------|---|---|---|---|----------------------|---|---|---|---|-----------------------|---|---|---|---|-----------------------|---|---|---|---|-----------------------|
| 7 to 5       | MDLn2 to MDLn0 | Specify the transfer clock (BRGn output signal).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |       |       |               |                                     |                                     |   |   |   |   |                             |   |   |   |   |                      |   |   |   |   |                      |   |   |   |   |                      |   |   |   |   |                      |   |   |   |   |                       |   |   |   |   |                       |   |   |   |   |                       |
|              |                | <table><tr><th>MDLn2</th><th>MDLn1</th><th>MDLn0</th><th>Set value (N)</th><th>Transfer clock (BRGn output signal)</th></tr><tr><td>0</td><td>0</td><td>0</td><td>–</td><td>BRGn stop mode (power save)</td></tr><tr><td>0</td><td>0</td><td>1</td><td>1</td><td>f<sub>XCLK</sub>/2</td></tr><tr><td>0</td><td>1</td><td>0</td><td>2</td><td>f<sub>XCLK</sub>/4</td></tr><tr><td>0</td><td>1</td><td>1</td><td>3</td><td>f<sub>XCLK</sub>/6</td></tr><tr><td>1</td><td>0</td><td>0</td><td>4</td><td>f<sub>XCLK</sub>/8</td></tr><tr><td>1</td><td>0</td><td>1</td><td>5</td><td>f<sub>XCLK</sub>/10</td></tr><tr><td>1</td><td>1</td><td>0</td><td>6</td><td>f<sub>XCLK</sub>/12</td></tr><tr><td>1</td><td>1</td><td>1</td><td>7</td><td>f<sub>XCLK</sub>/14</td></tr></table> | MDLn2 | MDLn1 | MDLn0         | Set value (N)                       | Transfer clock (BRGn output signal) | 0 | 0 | 0 | – | BRGn stop mode (power save) | 0 | 0 | 1 | 1 | f <sub>XCLK</sub> /2 | 0 | 1 | 0 | 2 | f <sub>XCLK</sub> /4 | 0 | 1 | 1 | 3 | f <sub>XCLK</sub> /6 | 1 | 0 | 0 | 4 | f <sub>XCLK</sub> /8 | 1 | 0 | 1 | 5 | f <sub>XCLK</sub> /10 | 1 | 1 | 0 | 6 | f <sub>XCLK</sub> /12 | 1 | 1 | 1 | 7 | f <sub>XCLK</sub> /14 |
|              |                | MDLn2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | MDLn1 | MDLn0 | Set value (N) | Transfer clock (BRGn output signal) |                                     |   |   |   |   |                             |   |   |   |   |                      |   |   |   |   |                      |   |   |   |   |                      |   |   |   |   |                      |   |   |   |   |                       |   |   |   |   |                       |   |   |   |   |                       |
|              |                | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 0     | 0     | –             | BRGn stop mode (power save)         |                                     |   |   |   |   |                             |   |   |   |   |                      |   |   |   |   |                      |   |   |   |   |                      |   |   |   |   |                      |   |   |   |   |                       |   |   |   |   |                       |   |   |   |   |                       |
|              |                | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 0     | 1     | 1             | f <sub>XCLK</sub> /2                |                                     |   |   |   |   |                             |   |   |   |   |                      |   |   |   |   |                      |   |   |   |   |                      |   |   |   |   |                      |   |   |   |   |                       |   |   |   |   |                       |   |   |   |   |                       |
|              |                | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 1     | 0     | 2             | f <sub>XCLK</sub> /4                |                                     |   |   |   |   |                             |   |   |   |   |                      |   |   |   |   |                      |   |   |   |   |                      |   |   |   |   |                      |   |   |   |   |                       |   |   |   |   |                       |   |   |   |   |                       |
|              |                | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 1     | 1     | 3             | f <sub>XCLK</sub> /6                |                                     |   |   |   |   |                             |   |   |   |   |                      |   |   |   |   |                      |   |   |   |   |                      |   |   |   |   |                      |   |   |   |   |                       |   |   |   |   |                       |   |   |   |   |                       |
|              |                | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 0     | 0     | 4             | f <sub>XCLK</sub> /8                |                                     |   |   |   |   |                             |   |   |   |   |                      |   |   |   |   |                      |   |   |   |   |                      |   |   |   |   |                      |   |   |   |   |                       |   |   |   |   |                       |   |   |   |   |                       |
|              |                | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 0     | 1     | 5             | f <sub>XCLK</sub> /10               |                                     |   |   |   |   |                             |   |   |   |   |                      |   |   |   |   |                      |   |   |   |   |                      |   |   |   |   |                      |   |   |   |   |                       |   |   |   |   |                       |   |   |   |   |                       |
|              |                | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 1     | 0     | 6             | f <sub>XCLK</sub> /12               |                                     |   |   |   |   |                             |   |   |   |   |                      |   |   |   |   |                      |   |   |   |   |                      |   |   |   |   |                      |   |   |   |   |                       |   |   |   |   |                       |   |   |   |   |                       |
|              |                | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 1     | 1     | 7             | f <sub>XCLK</sub> /14               |                                     |   |   |   |   |                             |   |   |   |   |                      |   |   |   |   |                      |   |   |   |   |                      |   |   |   |   |                      |   |   |   |   |                       |   |   |   |   |                       |   |   |   |   |                       |
|              |                | <b>Caution</b> In the slave mode (CKS3n2 to CKS3n0 bits = 111), it is recommended to clear the MDLn2 to MDLn0 bits to 000 (BRGn stop mode).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |       |       |               |                                     |                                     |   |   |   |   |                             |   |   |   |   |                      |   |   |   |   |                      |   |   |   |   |                      |   |   |   |   |                      |   |   |   |   |                       |   |   |   |   |                       |   |   |   |   |                       |
|              |                | <b>Remark</b> f <sub>XCLK</sub> : Base clock selected by CKS3n2 to CKS3n0 bits                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |       |       |               |                                     |                                     |   |   |   |   |                             |   |   |   |   |                      |   |   |   |   |                      |   |   |   |   |                      |   |   |   |   |                      |   |   |   |   |                       |   |   |   |   |                       |   |   |   |   |                       |
|              |                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |       |       |               |                                     |                                     |   |   |   |   |                             |   |   |   |   |                      |   |   |   |   |                      |   |   |   |   |                      |   |   |   |   |                      |   |   |   |   |                       |   |   |   |   |                       |   |   |   |   |                       |
|              |                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |       |       |               |                                     |                                     |   |   |   |   |                             |   |   |   |   |                      |   |   |   |   |                      |   |   |   |   |                      |   |   |   |   |                      |   |   |   |   |                       |   |   |   |   |                       |   |   |   |   |                       |
|              |                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |       |       |               |                                     |                                     |   |   |   |   |                             |   |   |   |   |                      |   |   |   |   |                      |   |   |   |   |                      |   |   |   |   |                      |   |   |   |   |                       |   |   |   |   |                       |   |   |   |   |                       |
|              |                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |       |       |               |                                     |                                     |   |   |   |   |                             |   |   |   |   |                      |   |   |   |   |                      |   |   |   |   |                      |   |   |   |   |                      |   |   |   |   |                       |   |   |   |   |                       |   |   |   |   |                       |
|              |                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |       |       |               |                                     |                                     |   |   |   |   |                             |   |   |   |   |                      |   |   |   |   |                      |   |   |   |   |                      |   |   |   |   |                      |   |   |   |   |                       |   |   |   |   |                       |   |   |   |   |                       |
|              |                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |       |       |               |                                     |                                     |   |   |   |   |                             |   |   |   |   |                      |   |   |   |   |                      |   |   |   |   |                      |   |   |   |   |                      |   |   |   |   |                       |   |   |   |   |                       |   |   |   |   |                       |
|              |                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |       |       |               |                                     |                                     |   |   |   |   |                             |   |   |   |   |                      |   |   |   |   |                      |   |   |   |   |                      |   |   |   |   |                      |   |   |   |   |                       |   |   |   |   |                       |   |   |   |   |                       |
|              |                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |       |       |               |                                     |                                     |   |   |   |   |                             |   |   |   |   |                      |   |   |   |   |                      |   |   |   |   |                      |   |   |   |   |                      |   |   |   |   |                       |   |   |   |   |                       |   |   |   |   |                       |

**Remark** n = 0, 1

| Bit position      | Bit name   | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |      |                                                                                    |                |   |   |                                                                                    |   |   |                                                                                    |                   |   |                                                                                    |                   |   |                                                                                    |
|-------------------|------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|------------------------------------------------------------------------------------|----------------|---|---|------------------------------------------------------------------------------------|---|---|------------------------------------------------------------------------------------|-------------------|---|------------------------------------------------------------------------------------|-------------------|---|------------------------------------------------------------------------------------|
| 4, 3              | CKPn, DAPn | Specify the data transmission/reception timing for $\overline{\text{SCKn}}$ .                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |      |                                                                                    |                |   |   |                                                                                    |   |   |                                                                                    |                   |   |                                                                                    |                   |   |                                                                                    |
|                   |            | <table><tr><th>CKPn</th><th>DAPn</th><th>Operation mode</th></tr><tr><td>0</td><td>0</td><td></td></tr><tr><td>0</td><td>1</td><td></td></tr><tr><td>1<sup>Note</sup></td><td>0</td><td></td></tr><tr><td>1<sup>Note</sup></td><td>1</td><td></td></tr></table> | CKPn | DAPn                                                                               | Operation mode | 0 | 0 |  | 0 | 1 |  | 1 <sup>Note</sup> | 0 |  | 1 <sup>Note</sup> | 1 |  |
|                   |            | CKPn                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | DAPn | Operation mode                                                                     |                |   |   |                                                                                    |   |   |                                                                                    |                   |   |                                                                                    |                   |   |                                                                                    |
|                   |            | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 0    |  |                |   |   |                                                                                    |   |   |                                                                                    |                   |   |                                                                                    |                   |   |                                                                                    |
|                   |            | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 1    |  |                |   |   |                                                                                    |   |   |                                                                                    |                   |   |                                                                                    |                   |   |                                                                                    |
| 1 <sup>Note</sup> | 0          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |      |                                                                                    |                |   |   |                                                                                    |   |   |                                                                                    |                   |   |                                                                                    |                   |   |                                                                                    |
| 1 <sup>Note</sup> | 1          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |      |                                                                                    |                |   |   |                                                                                    |   |   |                                                                                    |                   |   |                                                                                    |                   |   |                                                                                    |
|                   |            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |      |                                                                                    |                |   |   |                                                                                    |   |   |                                                                                    |                   |   |                                                                                    |                   |   |                                                                                    |
|                   |            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |      |                                                                                    |                |   |   |                                                                                    |   |   |                                                                                    |                   |   |                                                                                    |                   |   |                                                                                    |
|                   |            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |      |                                                                                    |                |   |   |                                                                                    |   |   |                                                                                    |                   |   |                                                                                    |                   |   |                                                                                    |
|                   |            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |      |                                                                                    |                |   |   |                                                                                    |   |   |                                                                                    |                   |   |                                                                                    |                   |   |                                                                                    |

**Note** If the CKPn bit is set to 1 in the master mode (CKS3n2 to CKS3n0 bits are other than 111), the  $\overline{\text{SCKn}}$  pin outputs a low level when it is inactive. If the CTXEn bit of the CSIM3n register is cleared to 0 (disabling transmission) and CRXEn bit is cleared to 0 (disabling reception), the  $\overline{\text{SCKn}}$  pin outputs a high level.

Therefore, take the following measures to fix the  $\overline{\text{SCKn}}$  pin to low level when CSI3n is not used.

#### [ $\overline{\text{SCK0}}$ pin ( $\overline{\text{SCK1}}$ pin)]

- <1> Clearing the P11 bit of the P1 register to 0 (clearing the P23 bit of the P2 register to 0):  
The port output level is set to low.
- <2> Clearing the PM11 bit of the PM1 register to 0 (clearing the PM23 bit of the PM2 register to 0):  
The port is set in the output mode.
- <3> Clearing the PMC11 bit of the PMC1 register to 0 (clearing the PMC23 bit of the PMC2 register to 0):  
The pin is set in the port mode (fixed to low-level output).
- <4> Clearing the CTXE0 and CRXE0 bits of the CSIM30 register to 0 (clearing the CTXE1 and CRXE1 bits of the CSIM31 register to 0):  
Transmission and reception are disabled.
- <5> Setting the CTXE0 or CRXE0 bit of the CSIM30 register to 1 (setting the CTXE1 or CRXE1 bit of the CSIM31 register to 1):  
Transmission or reception is enabled (both transmission and reception can also be enabled).
- <6> Setting the PMC11 bit of the PMC1 register to 1 (setting the PMC23 bit of the PMC2 register to 1):  
The pin is set in the control mode ( $\overline{\text{SCK0}}$  and  $\overline{\text{SCK1}}$  pin output).

Because the register set values <1> and <2> are retained, control can be performed only by <3> to <6> once they have been set.

**Remark** n = 0, 1



| Bit position                                                                                                                                                        | Bit name         | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |        |                                    |               |                                |                                |      |   |   |   |   |                   |             |   |   |   |   |                   |             |   |   |   |   |                    |             |   |   |   |   |                    |             |   |   |   |   |                    |             |   |   |   |   |                     |             |   |   |   |   |                     |             |   |   |   |   |                                    |            |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|------------------------------------|---------------|--------------------------------|--------------------------------|------|---|---|---|---|-------------------|-------------|---|---|---|---|-------------------|-------------|---|---|---|---|--------------------|-------------|---|---|---|---|--------------------|-------------|---|---|---|---|--------------------|-------------|---|---|---|---|---------------------|-------------|---|---|---|---|---------------------|-------------|---|---|---|---|------------------------------------|------------|
| 2 to 0                                                                                                                                                              | CKS3n2 to CSK3n0 | Specify the base clock (prescaler output).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |        |                                    |               |                                |                                |      |   |   |   |   |                   |             |   |   |   |   |                   |             |   |   |   |   |                    |             |   |   |   |   |                    |             |   |   |   |   |                    |             |   |   |   |   |                     |             |   |   |   |   |                     |             |   |   |   |   |                                    |            |
|                                                                                                                                                                     |                  | <table><tr><th>CKS3n2</th><th>CKS3n1</th><th>CKS3n0</th><th>Set value (k)</th><th>Base clock (f<sub>CLK</sub>)</th><th>Mode</th></tr><tr><td>0</td><td>0</td><td>0</td><td>0</td><td>f<sub>x</sub>/4</td><td>Master mode</td></tr><tr><td>0</td><td>0</td><td>1</td><td>1</td><td>f<sub>x</sub>/8</td><td>Master mode</td></tr><tr><td>0</td><td>1</td><td>0</td><td>2</td><td>f<sub>x</sub>/16</td><td>Master mode</td></tr><tr><td>0</td><td>1</td><td>1</td><td>3</td><td>f<sub>x</sub>/32</td><td>Master mode</td></tr><tr><td>1</td><td>0</td><td>0</td><td>4</td><td>f<sub>x</sub>/64</td><td>Master mode</td></tr><tr><td>1</td><td>0</td><td>1</td><td>5</td><td>f<sub>x</sub>/128</td><td>Master mode</td></tr><tr><td>1</td><td>1</td><td>0</td><td>6</td><td>f<sub>x</sub>/256</td><td>Master mode</td></tr><tr><td>1</td><td>1</td><td>1</td><td>7</td><td>External clock (SCK<sub>n</sub>)</td><td>Slave mode</td></tr></table> | CKS3n2 | CKS3n1                             | CKS3n0        | Set value (k)                  | Base clock (f <sub>CLK</sub> ) | Mode | 0 | 0 | 0 | 0 | f <sub>x</sub> /4 | Master mode | 0 | 0 | 1 | 1 | f <sub>x</sub> /8 | Master mode | 0 | 1 | 0 | 2 | f <sub>x</sub> /16 | Master mode | 0 | 1 | 1 | 3 | f <sub>x</sub> /32 | Master mode | 1 | 0 | 0 | 4 | f <sub>x</sub> /64 | Master mode | 1 | 0 | 1 | 5 | f <sub>x</sub> /128 | Master mode | 1 | 1 | 0 | 6 | f <sub>x</sub> /256 | Master mode | 1 | 1 | 1 | 7 | External clock (SCK <sub>n</sub> ) | Slave mode |
|                                                                                                                                                                     |                  | CKS3n2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | CKS3n1 | CKS3n0                             | Set value (k) | Base clock (f <sub>CLK</sub> ) | Mode                           |      |   |   |   |   |                   |             |   |   |   |   |                   |             |   |   |   |   |                    |             |   |   |   |   |                    |             |   |   |   |   |                    |             |   |   |   |   |                     |             |   |   |   |   |                     |             |   |   |   |   |                                    |            |
|                                                                                                                                                                     |                  | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | 0      | 0                                  | 0             | f <sub>x</sub> /4              | Master mode                    |      |   |   |   |   |                   |             |   |   |   |   |                   |             |   |   |   |   |                    |             |   |   |   |   |                    |             |   |   |   |   |                    |             |   |   |   |   |                     |             |   |   |   |   |                     |             |   |   |   |   |                                    |            |
|                                                                                                                                                                     |                  | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | 0      | 1                                  | 1             | f <sub>x</sub> /8              | Master mode                    |      |   |   |   |   |                   |             |   |   |   |   |                   |             |   |   |   |   |                    |             |   |   |   |   |                    |             |   |   |   |   |                    |             |   |   |   |   |                     |             |   |   |   |   |                     |             |   |   |   |   |                                    |            |
|                                                                                                                                                                     |                  | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | 1      | 0                                  | 2             | f <sub>x</sub> /16             | Master mode                    |      |   |   |   |   |                   |             |   |   |   |   |                   |             |   |   |   |   |                    |             |   |   |   |   |                    |             |   |   |   |   |                    |             |   |   |   |   |                     |             |   |   |   |   |                     |             |   |   |   |   |                                    |            |
|                                                                                                                                                                     |                  | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | 1      | 1                                  | 3             | f <sub>x</sub> /32             | Master mode                    |      |   |   |   |   |                   |             |   |   |   |   |                   |             |   |   |   |   |                    |             |   |   |   |   |                    |             |   |   |   |   |                    |             |   |   |   |   |                     |             |   |   |   |   |                     |             |   |   |   |   |                                    |            |
|                                                                                                                                                                     |                  | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | 0      | 0                                  | 4             | f <sub>x</sub> /64             | Master mode                    |      |   |   |   |   |                   |             |   |   |   |   |                   |             |   |   |   |   |                    |             |   |   |   |   |                    |             |   |   |   |   |                    |             |   |   |   |   |                     |             |   |   |   |   |                     |             |   |   |   |   |                                    |            |
|                                                                                                                                                                     |                  | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | 0      | 1                                  | 5             | f <sub>x</sub> /128            | Master mode                    |      |   |   |   |   |                   |             |   |   |   |   |                   |             |   |   |   |   |                    |             |   |   |   |   |                    |             |   |   |   |   |                    |             |   |   |   |   |                     |             |   |   |   |   |                     |             |   |   |   |   |                                    |            |
|                                                                                                                                                                     |                  | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | 1      | 0                                  | 6             | f <sub>x</sub> /256            | Master mode                    |      |   |   |   |   |                   |             |   |   |   |   |                   |             |   |   |   |   |                    |             |   |   |   |   |                    |             |   |   |   |   |                    |             |   |   |   |   |                     |             |   |   |   |   |                     |             |   |   |   |   |                                    |            |
| 1                                                                                                                                                                   | 1                | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | 7      | External clock (SCK <sub>n</sub> ) | Slave mode    |                                |                                |      |   |   |   |   |                   |             |   |   |   |   |                   |             |   |   |   |   |                    |             |   |   |   |   |                    |             |   |   |   |   |                    |             |   |   |   |   |                     |             |   |   |   |   |                     |             |   |   |   |   |                                    |            |
| <b>Caution</b> If the CKS3n2 to CKS3n0 bits of the CSIC3n register are cleared to 000, setting the MDLn2 to MDLn0 bits of the CSIC3n register to 001 is prohibited. |                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |        |                                    |               |                                |                                |      |   |   |   |   |                   |             |   |   |   |   |                   |             |   |   |   |   |                    |             |   |   |   |   |                    |             |   |   |   |   |                    |             |   |   |   |   |                     |             |   |   |   |   |                     |             |   |   |   |   |                                    |            |
| <b>Remark</b> f <sub>x</sub> : Main clock                                                                                                                           |                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |        |                                    |               |                                |                                |      |   |   |   |   |                   |             |   |   |   |   |                   |             |   |   |   |   |                    |             |   |   |   |   |                    |             |   |   |   |   |                    |             |   |   |   |   |                     |             |   |   |   |   |                     |             |   |   |   |   |                                    |            |

**Remark** n = 0, 1

**(3) Receive data buffer registers 30, 31 (SIRB30, SIRB31)**

The SIRB3n register is a 16-bit buffer register that stores receive data.

By consecutively reading this register in the continuous mode (TRMDn bit = 1 in the CSIM3n register), the received data in the CSIBUFn register can be sequentially read while the CSIBUFn pointer for reading is incremented.

In the single mode (TRMDn bit = 0 in the CSIM3n register), received data is read by reading the SIRB3n register and it is judged that the SIRB3n register has become empty.

The SIRB3n register is read-only, in 16-bit units.

When the higher 8 bits of the SIRB3n register are used as the SIRB3nH register and the lower 8 bits as the SIRB3nL register, these registers are read-only, in 8-bit units. When reading in 8-bit units, be sure to read the SIRB3nH register and SIRB3nL register in that order.

|        | 15          | 14          | 13          | 12          | 11          | 10          | 9           | 8           | 7           | 6           | 5           | 4           | 3           | 2           | 1           | 0           | Address   | After reset <sup>Note</sup> |
|--------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-----------|-----------------------------|
| SIRB30 | SIRB<br>015 | SIRB<br>014 | SIRB<br>013 | SIRB<br>012 | SIRB<br>011 | SIRB<br>010 | SIRB<br>009 | SIRB<br>008 | SIRB<br>007 | SIRB<br>006 | SIRB<br>005 | SIRB<br>004 | SIRB<br>003 | SIRB<br>002 | SIRB<br>001 | SIRB<br>000 | FFFFFD02H | 0000H                       |
| SIRB31 | SIRB<br>115 | SIRB<br>114 | SIRB<br>113 | SIRB<br>112 | SIRB<br>111 | SIRB<br>110 | SIRB<br>109 | SIRB<br>108 | SIRB<br>107 | SIRB<br>106 | SIRB<br>105 | SIRB<br>104 | SIRB<br>103 | SIRB<br>102 | SIRB<br>101 | SIRB<br>100 | FFFFFD22H | 0000H                       |

**Note** In continuous mode (TRMDn bit = 1 in the CSIM3n register): Undefined

| Bit position | Bit name             | Function            |
|--------------|----------------------|---------------------|
| 15 to 0      | SIRBn15 to<br>SIRBn0 | Store receive data. |

**Remarks 1.** n = 0, 1

**2.** The SIRB3n register is cleared to 0000H when the CSICAEn bit of the CSIM3n register is cleared to 0.

**(4) Transmit data CSI buffer registers 30, 31 (SFDB30, SFDB31)**

The SFDB3n register is a 16-bit buffer register that stores transmit data.

When transmit data is written to this register, the data is sequentially stored in the CSIBUFn register while the CSIBUFn pointer for writing is incremented.

When the data of this register is read, the value of the transmit data written last is read.

The SFDB3n register can be read or written in 16-bit units.

When the higher 8 bits of the SFDB3n register are used as the SFDB3nH register, and the lower 8 bits as the SFDB3nL register, these registers can be read or written in 8-bit units. When reading in 8-bit units, be sure to read the SFDB3nH register and SFDB3nL register in that order.

|        | 15   | 14   | 13   | 12   | 11   | 10   | 9    | 8    | 7    | 6    | 5    | 4    | 3    | 2    | 1    | 0    | Address   | After reset |
|--------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|-----------|-------------|
| SFDB30 | SFDB | SFDB | SFDB | SFDB | SFDB | SFDB | SFDB | SFDB | SFDB | SFDB | SFDB | SFDB | SFDB | SFDB | SFDB | SFDB | FFFFFD06H | 0000H       |
|        | 015  | 014  | 013  | 012  | 011  | 010  | 09   | 08   | 07   | 06   | 05   | 04   | 03   | 02   | 01   | 00   |           |             |
| SFDB31 | SFDB | SFDB | SFDB | SFDB | SFDB | SFDB | SFDB | SFDB | SFDB | SFDB | SFDB | SFDB | SFDB | SFDB | SFDB | SFDB | FFFFFD26H | 0000H       |
|        | 115  | 114  | 113  | 112  | 111  | 110  | 19   | 18   | 17   | 16   | 15   | 14   | 13   | 12   | 11   | 10   |           |             |

| Bit position | Bit name          | Function             |
|--------------|-------------------|----------------------|
| 15 to 0      | SFDBn15 to SFDBn0 | Store transmit data. |

**Remark** n = 0, 1

**(5) CSIBUF status registers 30, 31 (SFA30, SFA31)**

These registers indicate the status of the CSIBUF<sub>n</sub> register or the transfer status.

These registers can be read or written in 8-bit or 1-bit units (however, bits 6 to 0 can only be read. They do not change even if they are written).

- Cautions**
1. Reading the SFA3<sub>n</sub> register is prohibited when the CSICAEn bit of the CSIM3<sub>n</sub> register is 1 and when the main clock (fx) is stopped.
  2. Because the values of the SFFUL<sub>n</sub>, SFEMP<sub>n</sub>, CSOT<sub>n</sub>, and SFP<sub>n</sub>3 to SFP<sub>n</sub>0 bits may change at any time during transfer, their values during transfer may differ from the actual values. Especially, use the CSOT<sub>n</sub> bit independently (do not use this bit in relation with the other bits). To detect the end of transfer by the SFA3<sub>n</sub> register, check to see if the SFEMP<sub>n</sub> bit is 1 after the data to be transferred has been written to the CSIBUF<sub>n</sub> register.
  3. If the SFA3<sub>n</sub> register is read immediately after data has been written to the SFDB3<sub>n</sub> and SFDB3<sub>n</sub>L registers when the main clock (fx) is 84 MHz or lower, the values of the SFFUL<sub>n</sub>, SFEMP<sub>n</sub>, and SFP<sub>n</sub>3 to SFP<sub>n</sub>0 bits do not change in time.
  4. If the SFA3<sub>n</sub> register is read before the SFFUL<sub>n</sub> bit is set to 1 and the 17th data is written, the CSIBUF<sub>n</sub> overflow interrupt (INTCOVF3<sub>n</sub>) is generated.

(1/3)

|       | 7      | 6      | 5      | 4     | 3     | 2     | 1     | 0     | Address   | After reset |
|-------|--------|--------|--------|-------|-------|-------|-------|-------|-----------|-------------|
| SFA30 | FPCLR0 | SFFUL0 | SFEMP0 | CSOT0 | SFP03 | SFP02 | SFP01 | SFP00 | FFFFFD08H | 20H         |
| SFA31 | FPCLR1 | SFFUL1 | SFEMP1 | CSOT1 | SFP13 | SFP12 | SFP11 | SFP10 | FFFFFD28H | 20H         |

| Bit position | Bit name           | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|--------------|--------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 7            | FPCLR <sub>n</sub> | <p>Specifies clearing of the CSIBUF<sub>n</sub> pointer.</p> <p>0: No operation<br/>1: Clear all CSIBUF<sub>n</sub> pointers to 0.</p> <p><b>Cautions</b></p> <ol style="list-style-type: none"> <li>1. This bit is always 0 when it is read.</li> <li>2. If 1 is written to the FPCLR<sub>n</sub> bit in the middle of transfer, transfer is aborted. Because all the CSIBUF<sub>n</sub> pointers are cleared to 0, the remaining data in the CSIBUF<sub>n</sub> register is ignored. If 1 is written to the FPCLR<sub>n</sub> bit, be sure to read the SFA3<sub>n</sub> register to check to see if all the CSIBUF<sub>n</sub> pointers have been correctly cleared to 0 (SFFUL<sub>n</sub> bit = 0, SFEMP<sub>n</sub> bit = 1, SFP<sub>n</sub>3 to SFP<sub>n</sub>0 bits = 0000). Nothing happens even if 0 is written to the FPCLR<sub>n</sub> bit.</li> </ol> |

**Remarks** 1. n = 0, 1

2. The SFA3<sub>n</sub> register is set to 20H when the CSICAEn bit of the CSIM3<sub>n</sub> register is cleared to 0.

| Bit position | Bit name | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|--------------|----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 6            | SFFULn   | <p>This flag indicates the full status of the CSIBUFn register.</p> <p>0: CSIBUFn register has a vacancy.<br/>1: CSIBUFn register is full.</p> <p><b>Cautions</b></p> <ol style="list-style-type: none"> <li>1. This bit is cleared to 0 when the CSICAEn bit of the CSIM3n register is cleared to 0 and the FPCLR bit is set to 1.</li> <li>2. If transfer of 16 data is specified in the continuous mode (TRMDn bit = 1 in the CSIM3n register) (SFNn3 to SFNn0 bits = 0000 in the SFN3n register), the SFFULn bit is set to 1 in the same way as in the single mode (TRMDn bit = 0 in the CSIM3n register) when 16 data are in the CSIBUFn register. If even one of the data has been completely transferred, the SFFULn bit is cleared to 0. However, this does not mean that the CSIBUFn register has a vacancy.</li> </ol> |
| 5            | SFEMPn   | <p>This flag indicates the empty status of the CSIBUFn register.</p> <p>0: Data is in CSIBUFn register.<br/>1: CSIBUFn register is empty.</p> <p><b>Cautions</b></p> <ol style="list-style-type: none"> <li>1. This flag is set to 1 when the CSICAEn bit of the CSIM3n register is cleared to 0 and the FPCLR bit is set to 1.</li> <li>2. If the data written to the CSIBUFn register has been transferred, the SFEMPn bit is set to 1 (even if receive data is stored in the CSIBUFn register).</li> </ol>                                                                                                                                                                                                                                                                                                                    |
| 4            | CSOTn    | <p>This flag indicates transfer status.</p> <p>0: Idle status<br/>1: Transfer or transfer start processing in progress</p> <p><b>Cautions</b></p> <ol style="list-style-type: none"> <li>1. This flag is cleared to 0 when the CSICAEn bit of the CSIM3n register is cleared to 0 and the FPCLRn bit is set to 1, or when the CTXEn and CRXEn bits of the CSIM3n register are cleared to 0.</li> <li>2. This flag is "1" from when transfer is started until there is no more transfer data in the CSIBUFn register in the single mode (TRMDn bit = 0 in the CSIM3n register) or until the specified number of data has been transferred in the continuous mode (TRMDn bit = 1 in the CSIM3n register).</li> </ol>                                                                                                               |

**Remark** n = 0, 1

| Bit position | Bit name       | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|--------------|----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 3 to 0       | SFPn3 to SFPn0 | <ul style="list-style-type: none"> <li>In the single mode (TRMDn bit = 0 in the CSIM3n register), the “number of transfer data remaining in CSIBUFn register (CSIBUFn pointer value for writing – CSIBUFn pointer value for SIO n loading)” can be read.</li> <li>In the continuous mode (TRMDn bit = 1 in the CSIM3n register), the “number of data completely transferred (value of CSIBUFn pointer for SIO n loading/storing)” can be read. If the SFPn3 to SFPn0 bits are 0H, however, the number of transferred data is as follows, depending on the setting of the SFEMPn bit. <ul style="list-style-type: none"> <li>When SFEMPn bit = 0: Number of transferred data = 0</li> <li>When SFEMPn bit = 1: Number of transferred data = 16 or status before starting transfer (before writing transfer data)</li> </ul> </li> </ul> <p><b>Caution</b> These bits are cleared to 0 in synchronization with the operating clock when the FPCLRn bit = 1. However, the values of these bits are held until the CSICAEn bit of the CSIM3n register is cleared to 0 or the FPCLRn bit is set to 1.</p> |

**Remark** n = 0, 1

### (6) Transfer data length select registers 30, 31 (CSIL30, CSIL31)

The CSIL3n register is used to select the transfer data length of CSI3n.

These registers can be read or written in 8-bit or 1-bit units.

Be sure to clear bits 7 to 4 to 0. If they are set to 1, the operation is not guaranteed.

**Caution** The CSIL3n register may be transferring data when the CTXEn or CRXEn bit of the CSIM3n register is 1. Be sure to clear the CTXEn and CRXEn bits to 0 before writing data to the CSIL3n register.

|        | 7 | 6 | 5 | 4 | 3     | 2     | 1     | 0     | Address   | After reset |
|--------|---|---|---|---|-------|-------|-------|-------|-----------|-------------|
| CSIL30 | 0 | 0 | 0 | 0 | CCL03 | CCL02 | CCL01 | CCL00 | FFFFFD09H | 00H         |
| CSIL31 | 0 | 0 | 0 | 0 | CCL13 | CCL12 | CCL11 | CCL10 | FFFFFD29H | 00H         |

| Bit position                                                                                                                                                                                                                                                     | Bit name       | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |       |       |       |                      |                      |   |   |   |   |         |   |   |   |   |        |   |   |   |   |        |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |                  |  |  |  |                    |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|-------|-------|----------------------|----------------------|---|---|---|---|---------|---|---|---|---|--------|---|---|---|---|--------|---|---|---|---|---------|---|---|---|---|---------|---|---|---|---|---------|---|---|---|---|---------|---|---|---|---|---------|---|---|---|---|---------|------------------|--|--|--|--------------------|
| 3 to 0                                                                                                                                                                                                                                                           | CCLn3 to CCLn0 | Specifies a transfer data length.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |       |       |       |                      |                      |   |   |   |   |         |   |   |   |   |        |   |   |   |   |        |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |                  |  |  |  |                    |
|                                                                                                                                                                                                                                                                  |                | <table><tr><th>CCLn3</th><th>CCLn2</th><th>CCLn1</th><th>CCLn0</th><th>Transfer data length</th></tr><tr><td>0</td><td>0</td><td>0</td><td>0</td><td>16 bits</td></tr><tr><td>1</td><td>0</td><td>0</td><td>0</td><td>8 bits</td></tr><tr><td>1</td><td>0</td><td>0</td><td>1</td><td>9 bits</td></tr><tr><td>1</td><td>0</td><td>1</td><td>0</td><td>10 bits</td></tr><tr><td>1</td><td>0</td><td>1</td><td>1</td><td>11 bits</td></tr><tr><td>1</td><td>1</td><td>0</td><td>0</td><td>12 bits</td></tr><tr><td>1</td><td>1</td><td>0</td><td>1</td><td>13 bits</td></tr><tr><td>1</td><td>1</td><td>1</td><td>0</td><td>14 bits</td></tr><tr><td>1</td><td>1</td><td>1</td><td>1</td><td>15 bits</td></tr><tr><td colspan="4">Other than above</td><td>Setting prohibited</td></tr></table> | CCLn3 | CCLn2 | CCLn1 | CCLn0                | Transfer data length | 0 | 0 | 0 | 0 | 16 bits | 1 | 0 | 0 | 0 | 8 bits | 1 | 0 | 0 | 1 | 9 bits | 1 | 0 | 1 | 0 | 10 bits | 1 | 0 | 1 | 1 | 11 bits | 1 | 1 | 0 | 0 | 12 bits | 1 | 1 | 0 | 1 | 13 bits | 1 | 1 | 1 | 0 | 14 bits | 1 | 1 | 1 | 1 | 15 bits | Other than above |  |  |  | Setting prohibited |
|                                                                                                                                                                                                                                                                  |                | CCLn3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | CCLn2 | CCLn1 | CCLn0 | Transfer data length |                      |   |   |   |   |         |   |   |   |   |        |   |   |   |   |        |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |                  |  |  |  |                    |
|                                                                                                                                                                                                                                                                  |                | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 0     | 0     | 0     | 16 bits              |                      |   |   |   |   |         |   |   |   |   |        |   |   |   |   |        |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |                  |  |  |  |                    |
|                                                                                                                                                                                                                                                                  |                | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 0     | 0     | 0     | 8 bits               |                      |   |   |   |   |         |   |   |   |   |        |   |   |   |   |        |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |                  |  |  |  |                    |
|                                                                                                                                                                                                                                                                  |                | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 0     | 0     | 1     | 9 bits               |                      |   |   |   |   |         |   |   |   |   |        |   |   |   |   |        |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |                  |  |  |  |                    |
|                                                                                                                                                                                                                                                                  |                | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 0     | 1     | 0     | 10 bits              |                      |   |   |   |   |         |   |   |   |   |        |   |   |   |   |        |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |                  |  |  |  |                    |
|                                                                                                                                                                                                                                                                  |                | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 0     | 1     | 1     | 11 bits              |                      |   |   |   |   |         |   |   |   |   |        |   |   |   |   |        |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |                  |  |  |  |                    |
|                                                                                                                                                                                                                                                                  |                | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 1     | 0     | 0     | 12 bits              |                      |   |   |   |   |         |   |   |   |   |        |   |   |   |   |        |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |                  |  |  |  |                    |
|                                                                                                                                                                                                                                                                  |                | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 1     | 0     | 1     | 13 bits              |                      |   |   |   |   |         |   |   |   |   |        |   |   |   |   |        |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |                  |  |  |  |                    |
|                                                                                                                                                                                                                                                                  |                | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 1     | 1     | 0     | 14 bits              |                      |   |   |   |   |         |   |   |   |   |        |   |   |   |   |        |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |                  |  |  |  |                    |
|                                                                                                                                                                                                                                                                  |                | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 1     | 1     | 1     | 15 bits              |                      |   |   |   |   |         |   |   |   |   |        |   |   |   |   |        |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |                  |  |  |  |                    |
|                                                                                                                                                                                                                                                                  |                | Other than above                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |       |       |       | Setting prohibited   |                      |   |   |   |   |         |   |   |   |   |        |   |   |   |   |        |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |                  |  |  |  |                    |
| <b>Caution</b> If a transfer data length other than 16 bits is specified (CCLn3 to CCLn0 bits = 0000), an undefined value is read to the higher excess bits of the SIRB3n and CSIBUFn registers (see 10.3.5 (3) Data transfer direction specification function). |                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |       |       |       |                      |                      |   |   |   |   |         |   |   |   |   |        |   |   |   |   |        |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |   |   |   |   |         |                  |  |  |  |                    |

**Remark** n = 0, 1

**(7) Transfer data number specification registers 30, 31 (SFN30, SFN31)**

The SFN3n register is used to set the number of transfer data of CSI3n in the continuous mode (TRMDn bit = 1 in the CSIM3n register).

These registers can be read or written in 8-bit or 1-bit units.

|       | 7 | 6 | 5 | 4 | 3     | 2     | 1     | 0     | Address   | After reset |
|-------|---|---|---|---|-------|-------|-------|-------|-----------|-------------|
| SFN30 | — | — | — | — | SFN03 | SFN02 | SFN01 | SFN00 | FFFFFD0CH | 00H         |
| SFN31 | — | — | — | — | SFN13 | SFN12 | SFN11 | SFN10 | FFFFFD2CH | 00H         |

| Bit position | Bit name       | Function                                                                                                                                                                                |       |       |       |                         |   |   |   |   |    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |    |   |   |   |   |    |   |   |   |   |    |   |   |   |   |    |   |   |   |   |    |   |   |   |   |    |
|--------------|----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|-------|-------|-------------------------|---|---|---|---|----|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|----|---|---|---|---|----|---|---|---|---|----|---|---|---|---|----|---|---|---|---|----|---|---|---|---|----|
| 3 to 0       | SFNn3 to SFNn0 | Specify the number of transfer data.                                                                                                                                                    |       |       |       |                         |   |   |   |   |    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |    |   |   |   |   |    |   |   |   |   |    |   |   |   |   |    |   |   |   |   |    |   |   |   |   |    |
|              |                | SFNn3                                                                                                                                                                                   | SFNn2 | SFNn1 | SFNn0 | Number of transfer data | 0 | 0 | 0 | 0 | 16 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 2 | 0 | 0 | 1 | 1 | 3 | 0 | 1 | 0 | 0 | 4 | 0 | 1 | 0 | 1 | 5 | 0 | 1 | 1 | 0 | 6 | 0 | 1 | 1 | 1 | 7 | 1 | 0 | 0 | 0 | 8 | 1 | 0 | 0 | 1 | 9 | 1 | 0 | 1 | 0 | 10 | 1 | 0 | 1 | 1 | 11 | 1 | 1 | 0 | 0 | 12 | 1 | 1 | 0 | 1 | 13 | 1 | 1 | 1 | 0 | 14 | 1 | 1 | 1 | 1 | 15 |
|              |                | SFNn3                                                                                                                                                                                   | SFNn2 | SFNn1 | SFNn0 | Number of transfer data |   |   |   |   |    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |    |   |   |   |   |    |   |   |   |   |    |   |   |   |   |    |   |   |   |   |    |   |   |   |   |    |
|              |                | 0                                                                                                                                                                                       | 0     | 0     | 0     | 16                      |   |   |   |   |    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |    |   |   |   |   |    |   |   |   |   |    |   |   |   |   |    |   |   |   |   |    |   |   |   |   |    |
|              |                | 0                                                                                                                                                                                       | 0     | 0     | 1     | 1                       |   |   |   |   |    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |    |   |   |   |   |    |   |   |   |   |    |   |   |   |   |    |   |   |   |   |    |   |   |   |   |    |
|              |                | 0                                                                                                                                                                                       | 0     | 1     | 0     | 2                       |   |   |   |   |    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |    |   |   |   |   |    |   |   |   |   |    |   |   |   |   |    |   |   |   |   |    |   |   |   |   |    |
|              |                | 0                                                                                                                                                                                       | 0     | 1     | 1     | 3                       |   |   |   |   |    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |    |   |   |   |   |    |   |   |   |   |    |   |   |   |   |    |   |   |   |   |    |   |   |   |   |    |
|              |                | 0                                                                                                                                                                                       | 1     | 0     | 0     | 4                       |   |   |   |   |    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |    |   |   |   |   |    |   |   |   |   |    |   |   |   |   |    |   |   |   |   |    |   |   |   |   |    |
|              |                | 0                                                                                                                                                                                       | 1     | 0     | 1     | 5                       |   |   |   |   |    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |    |   |   |   |   |    |   |   |   |   |    |   |   |   |   |    |   |   |   |   |    |   |   |   |   |    |
|              |                | 0                                                                                                                                                                                       | 1     | 1     | 0     | 6                       |   |   |   |   |    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |    |   |   |   |   |    |   |   |   |   |    |   |   |   |   |    |   |   |   |   |    |   |   |   |   |    |
|              |                | 0                                                                                                                                                                                       | 1     | 1     | 1     | 7                       |   |   |   |   |    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |    |   |   |   |   |    |   |   |   |   |    |   |   |   |   |    |   |   |   |   |    |   |   |   |   |    |
|              |                | 1                                                                                                                                                                                       | 0     | 0     | 0     | 8                       |   |   |   |   |    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |    |   |   |   |   |    |   |   |   |   |    |   |   |   |   |    |   |   |   |   |    |   |   |   |   |    |
|              |                | 1                                                                                                                                                                                       | 0     | 0     | 1     | 9                       |   |   |   |   |    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |    |   |   |   |   |    |   |   |   |   |    |   |   |   |   |    |   |   |   |   |    |   |   |   |   |    |
|              |                | 1                                                                                                                                                                                       | 0     | 1     | 0     | 10                      |   |   |   |   |    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |    |   |   |   |   |    |   |   |   |   |    |   |   |   |   |    |   |   |   |   |    |   |   |   |   |    |
|              |                | 1                                                                                                                                                                                       | 0     | 1     | 1     | 11                      |   |   |   |   |    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |    |   |   |   |   |    |   |   |   |   |    |   |   |   |   |    |   |   |   |   |    |   |   |   |   |    |
|              |                | 1                                                                                                                                                                                       | 1     | 0     | 0     | 12                      |   |   |   |   |    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |    |   |   |   |   |    |   |   |   |   |    |   |   |   |   |    |   |   |   |   |    |   |   |   |   |    |
|              |                | 1                                                                                                                                                                                       | 1     | 0     | 1     | 13                      |   |   |   |   |    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |    |   |   |   |   |    |   |   |   |   |    |   |   |   |   |    |   |   |   |   |    |   |   |   |   |    |
|              |                | 1                                                                                                                                                                                       | 1     | 1     | 0     | 14                      |   |   |   |   |    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |    |   |   |   |   |    |   |   |   |   |    |   |   |   |   |    |   |   |   |   |    |   |   |   |   |    |
|              |                | 1                                                                                                                                                                                       | 1     | 1     | 1     | 15                      |   |   |   |   |    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |    |   |   |   |   |    |   |   |   |   |    |   |   |   |   |    |   |   |   |   |    |   |   |   |   |    |
|              |                | <b>Caution</b> Writing data exceeding the value set by the SFNn3 to SFNn0 bits (number of CSI3n transfer data) to the CSIBUFn register is prohibited (data is ignored even if written). |       |       |       |                         |   |   |   |   |    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |    |   |   |   |   |    |   |   |   |   |    |   |   |   |   |    |   |   |   |   |    |   |   |   |   |    |

**Remark** n = 0, 1



### 10.3.4 Dedicated baud rate generators 0, 1 (BRG0, BRG1)

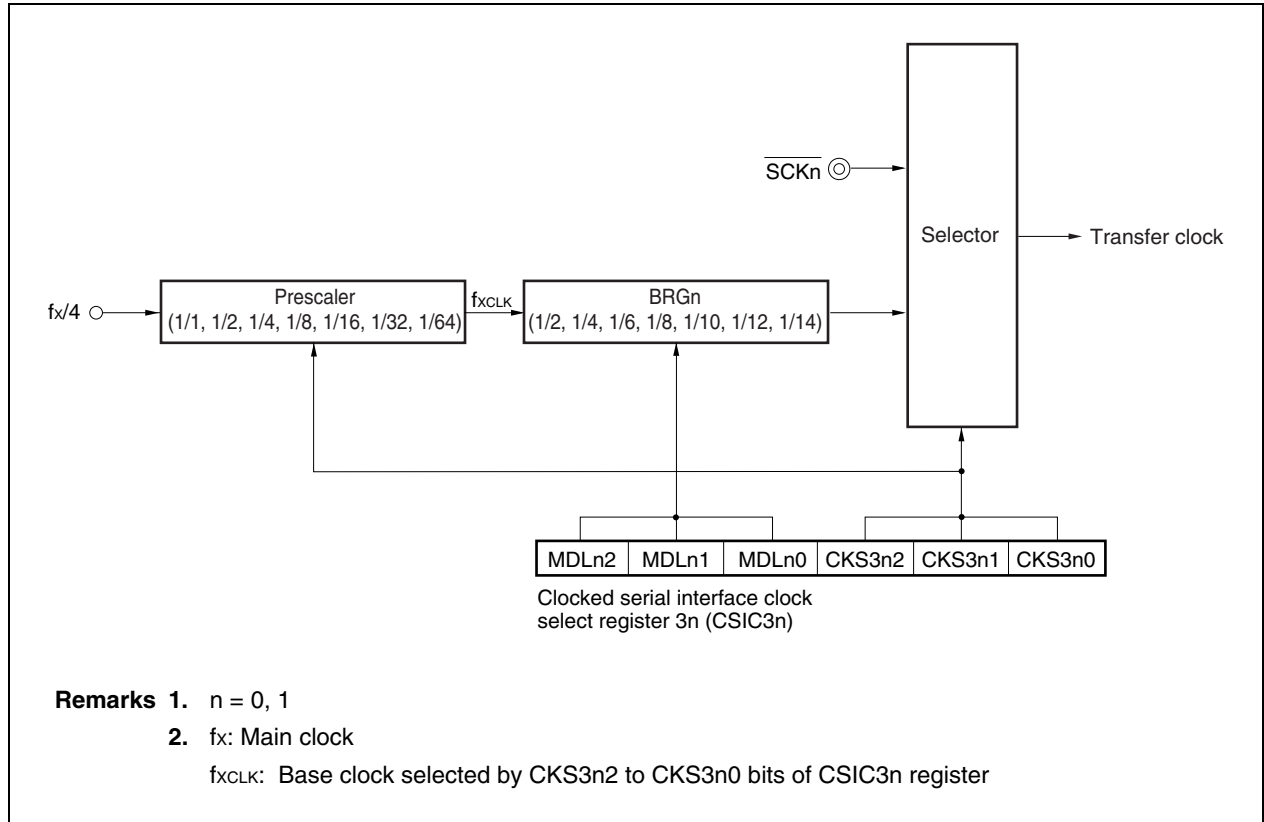
The transfer clock of CSI3n can be selected from the output of a dedicated baud rate generator or external clock ( $n = 0, 1$ ).

The serial clock source is specified by the CSIC3n register.

In the master mode (CKS3n2 to CKS3n0 bits = other than 111 in the CSIC3n register), BRGn is selected as the clock source.

#### (1) Transfer clock

Figure 10-23. Transfer Clock of CSI3n



**(2) Baud rate**

The baud rate is calculated by the following expression.

$$\text{Baud rate} = \frac{F}{N \times 2^{(K+1)}} [\text{bps}]$$

F = fx/4 (fx: main clock)

K = Value set by CKS3n2 to CKS3n0 bits of CSIC3n register (K = 0, 1, 2, ..., 6)

N = Value set by MDLn2 to MDLn0 bits of CSIC3n register (N = 1, 2, 3, ..., 7)

**Cautions** 1. If the CKS3n2 to CKS3n0 bits of the CSIC3n register are cleared to 000, setting the MDLn2 to MDLn0 bits of the CSIC3n register to 001 is prohibited.

2. Because the maximum transfer rate in the master mode (CKS3n2 to CKS3n0 bits = other than 111 in the CSIC3n register) is 5.5 Mbps, do not exceed this value.

**Example:** When CSI3n operates at 133 MHz, the maximum transfer rate is set when the CKS3n2 to CKS3n0 bits = 000 and the MDLn2 to MDLn0 bits = 011, and at 150 MHz, when the CKS3n2 to CKS3n0 bits = 000 and MDLn2 to MDLn0 bits = 100, in the CSIC3n register.

## 10.3.5 Operation

## (1) Operation modes

Table 10-6. Operation Modes

| TRMDn Bit        | CKS3n2 to CKS3n0 Bits | CTXEn and CRXEn Bits                                  | DIRn Bit         | CSITn Bit                               | CSWEn Bit              |
|------------------|-----------------------|-------------------------------------------------------|------------------|-----------------------------------------|------------------------|
| Single mode      | Master mode           | Transmission/reception/<br>transmission and reception | MSB/LSB<br>first | Enables/disables<br>INTCSI3n delay mode | Disables transfer wait |
|                  | Slave mode            |                                                       |                  | –                                       | Enables transfer wait  |
| Consecutive mode | Master mode           |                                                       |                  | Enables/disables<br>INTCSI3n delay mode | Disables transfer wait |
|                  | Slave mode            |                                                       |                  | –                                       | Enables transfer wait  |

- Remarks 1.** CTXEn bit: Bit 6 of CSIM3n register  
 CRXEn bit: Bit 5 of CSIM3n register  
 TRMDn bit: Bit 4 of CSIM3n register  
 DIRn bit: Bit 3 of CSIM3n register  
 CSITn bit: Bit 2 of CSIM3n register  
 CSWEn bit: Bit 1 of CSIM3n register  
 CKS3n2 to CKS3n0 bits: Bits 2 to 0 of CSIC3n register
- 2.** n = 0, 1

## (2) Function of CSI data buffer registers 0, 1 (CSIBUF0, CSIBUF1)

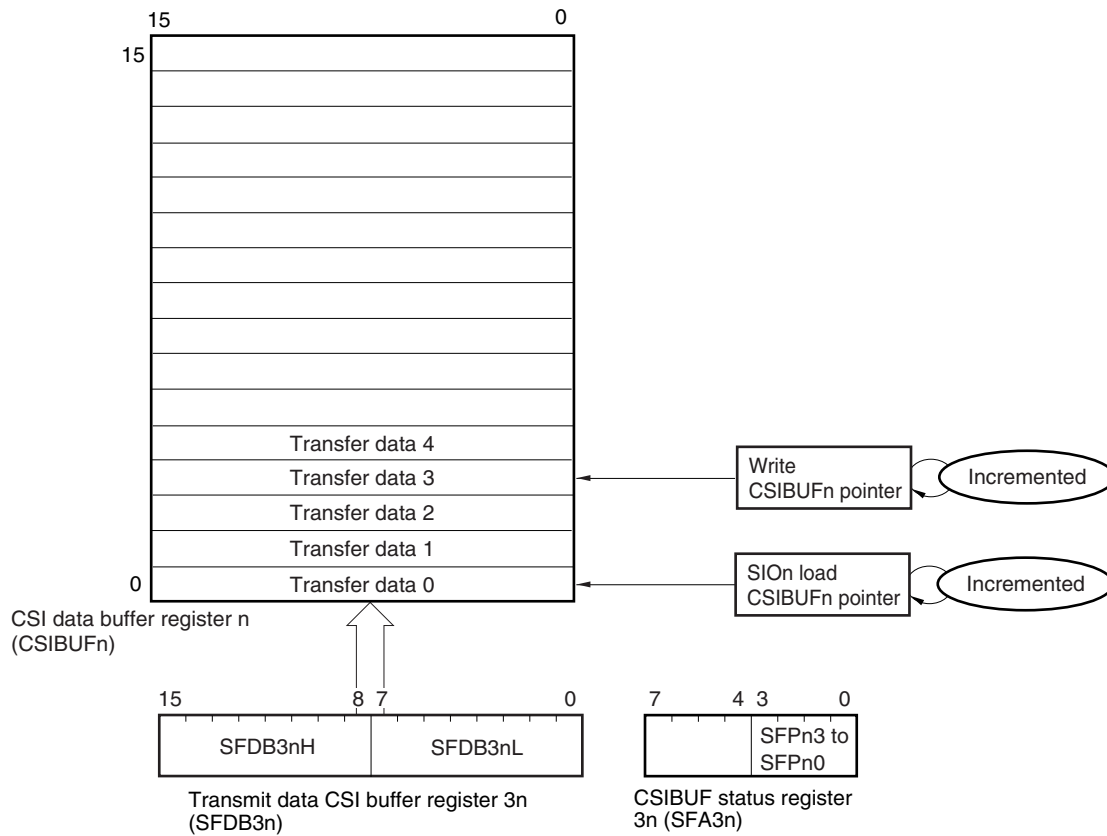
By consecutively writing the transmit data to the SFDB3n register from where it is transferred, the data can be stored in the CSIBUFn register while the CSIBUFn pointer for writing is automatically incremented (the CSIBUFn register size is 16 bits  $\times$  16) (n = 0, 1).

The condition under which transfer is to be started (SFEMPn bit = 0 in the SFA3n register) is satisfied when data is written to the lower 8 bits (SFDB3nL register) of the SFDB3n register. If a transfer data length of 9 bits or more is specified (CCLn3 to CCLn0 bits = 0000 or 1001 to 1111 in the CSIL3n register), data must be written to the SFDB3n register in 16-bit units or to the SFDB3nH and SFDB3nL registers, in that order, in 8-bit units. If the transfer data length is set to 8 bits (CCLn3 to CCLn0 bits = 1000 in the CSIL3n register), data must be written to the SFDB3nL register in 8-bit units or to the SFDB3n register in 16-bit units. (If data is written to the SFDB3nL register in 16-bit units, however, the higher 8 bits of the data (of the SFDB3nH register) are ignored and not transferred).

The SFFULn bit of the SFA3n register is set to 1 when 16 data exist in the CSIBUFn register and outputs a CSIBUFn overflow interrupt (INTCOVF3n) when the SFFULn bit = 1 and when the 17th transfer data is written (17th transfer data is not written and ignored).

Sixteen data exist in the CSIBUFn register in the single mode (TRMDn bit = 0 in the CSIM3n register) when “CSIBUFn pointer value for writing = CSIBUFn pointer value for SIO loading, and SFFULn bit = 1 in the SFA3n register”. When the CSIBUFn pointer for SIO loading is incremented after completion of transfer, the CSIBUFn register has a vacancy of one data (in the continuous mode (TRMDn bit = 1 in the CSIM3n register), the CSIBUFn register does not have a vacancy even if one data has been transferred).

**Figure 10-24. Function of CSI Data Buffer Register n (CSIBUFn)**



**Remark**  $n = 0, 1$

**(3) Data transfer direction specification function**

The data transfer direction can be changed by using the DIRn bit of the CSIM3n register (n = 0, 1).

**(a) MSB first (DIRn bit = 0)**

**Figure 10-25. Transfer Data Length: 8 Bits (CCLn3 to CCLn0 Bits = 1000 in CSIL3n Register),  
Transfer Direction: MSB First (DIRn Bit = 0 in CSIM3n Register) (1/2)**

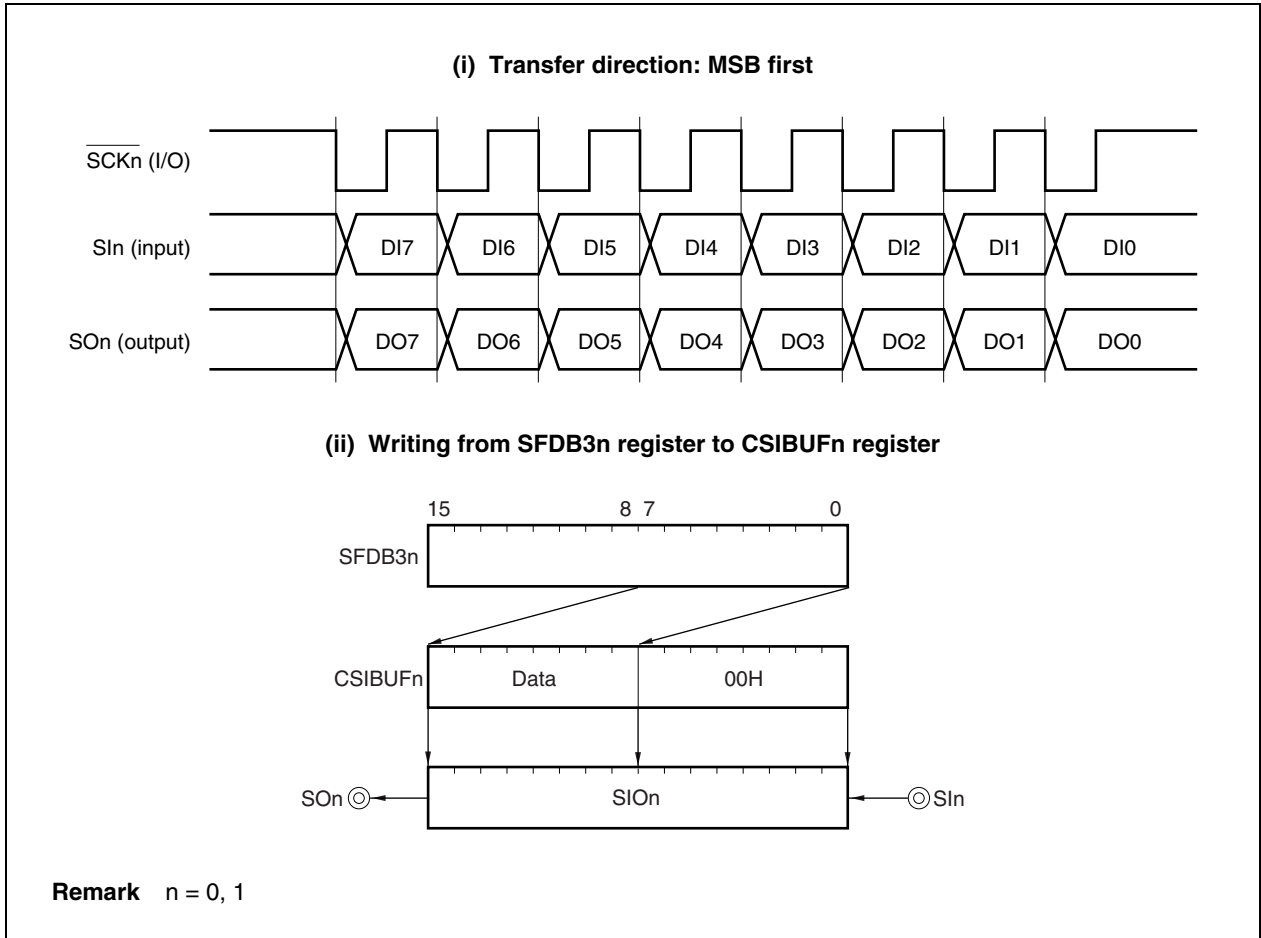
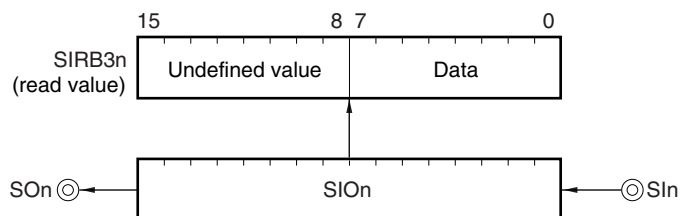
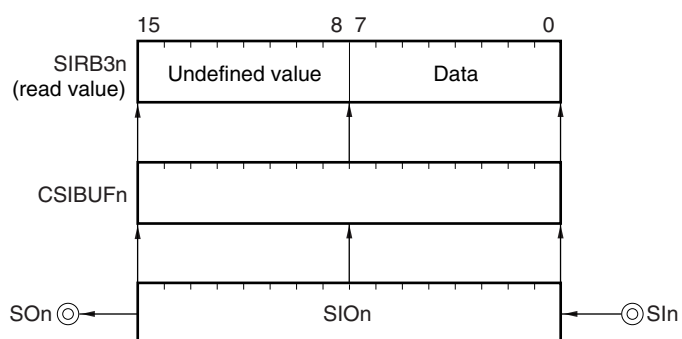


**Figure 10-25. Transfer Data Length: 8 Bits (CCLn3 to CCLn0 Bits = 1000 in CSIL3n Register),  
Transfer Direction: MSB First (DIRn Bit = 0 in CSIM3n Register) (2/2)**

**(iii) Reading from SIRB3n register (in single mode (TRMDn bit of CSIM3n register = 0))**



**(iv) Reading from SIRB3n register (in continuous mode (TRMDn bit of CSIM3n register = 1))**



**Remark** n = 0, 1

(b) LSB first (DIRn bit = 1)

**Figure 10-26. Transfer Data Length: 8 Bits (CCLn3 to CCLn0 Bits = 1000 in CSIL3n Register),  
Transfer Direction: LSB First (DIRn Bit = 1 in CSIM3n Register) (1/2)**

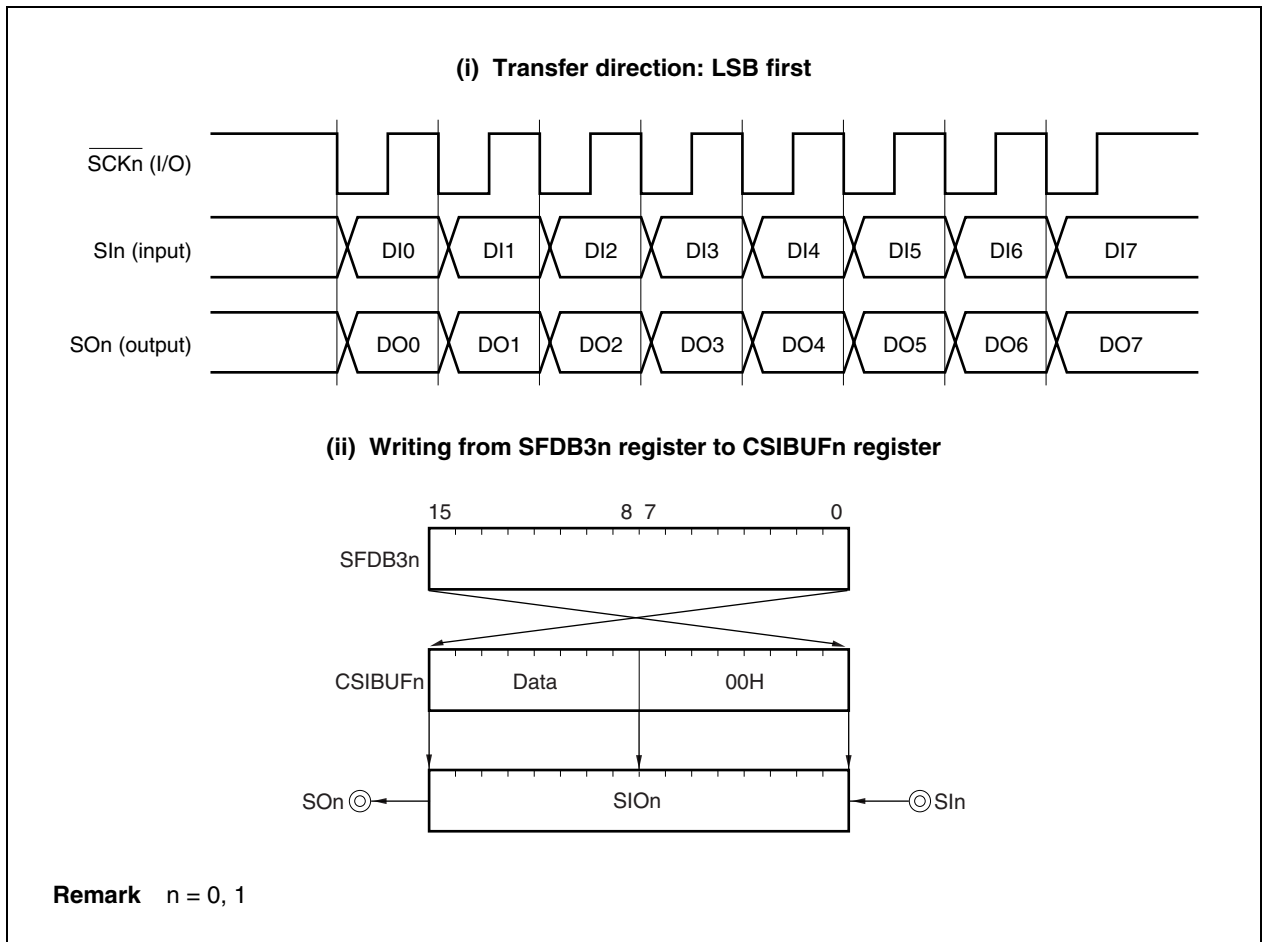
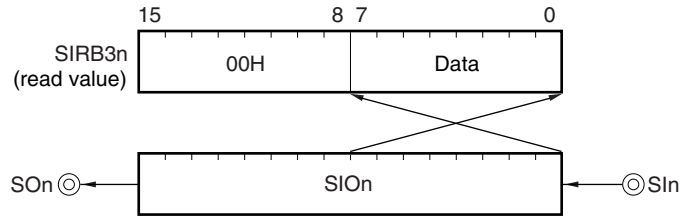
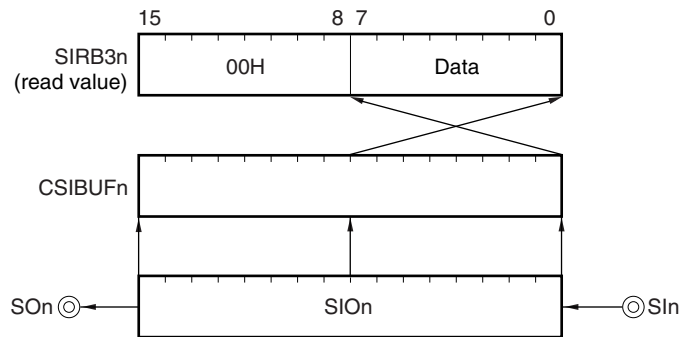


**Figure 10-26. Transfer Data Length: 8 Bits (CCLn3 to CCLn0 Bits = 1000 in CSIL3n Register),  
Transfer Direction: LSB First (DIRn Bit = 1 in CSIM3n Register) (2/2)**

**(iii) Reading from SIRB3n register (in single mode (TRMDn bit of CSIM3n register = 0))**



**(iv) Reading from SIRB3n register (in continuous mode (TRMDn bit of CSIM3n register = 1))**



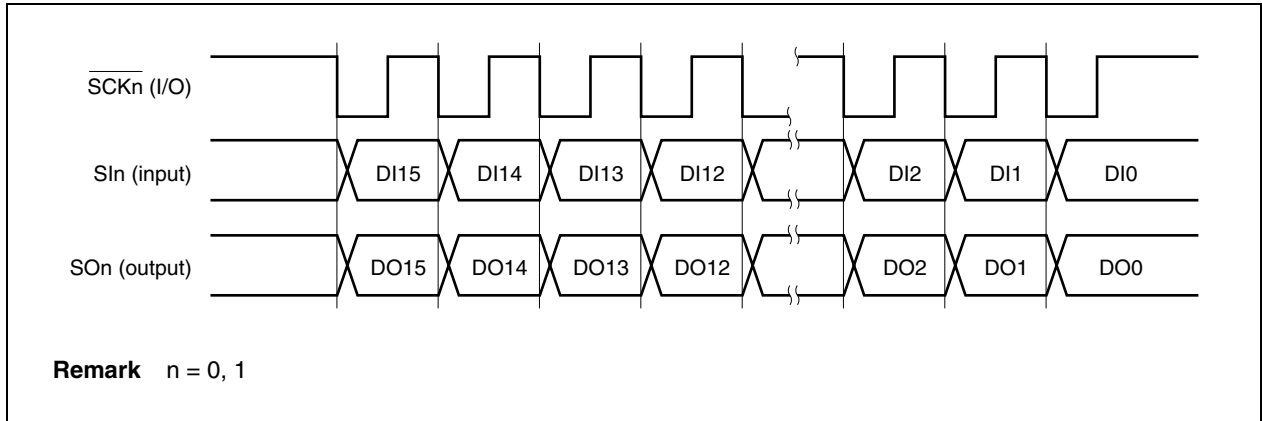
**Remark** n = 0, 1



**(4) Transfer data length changing function**

The transfer data length can be set from 8 to 16 bits in 1-bit units, by using the CCLn3 to CCLn0 bits of the CSIL3n register (n = 1, 0).

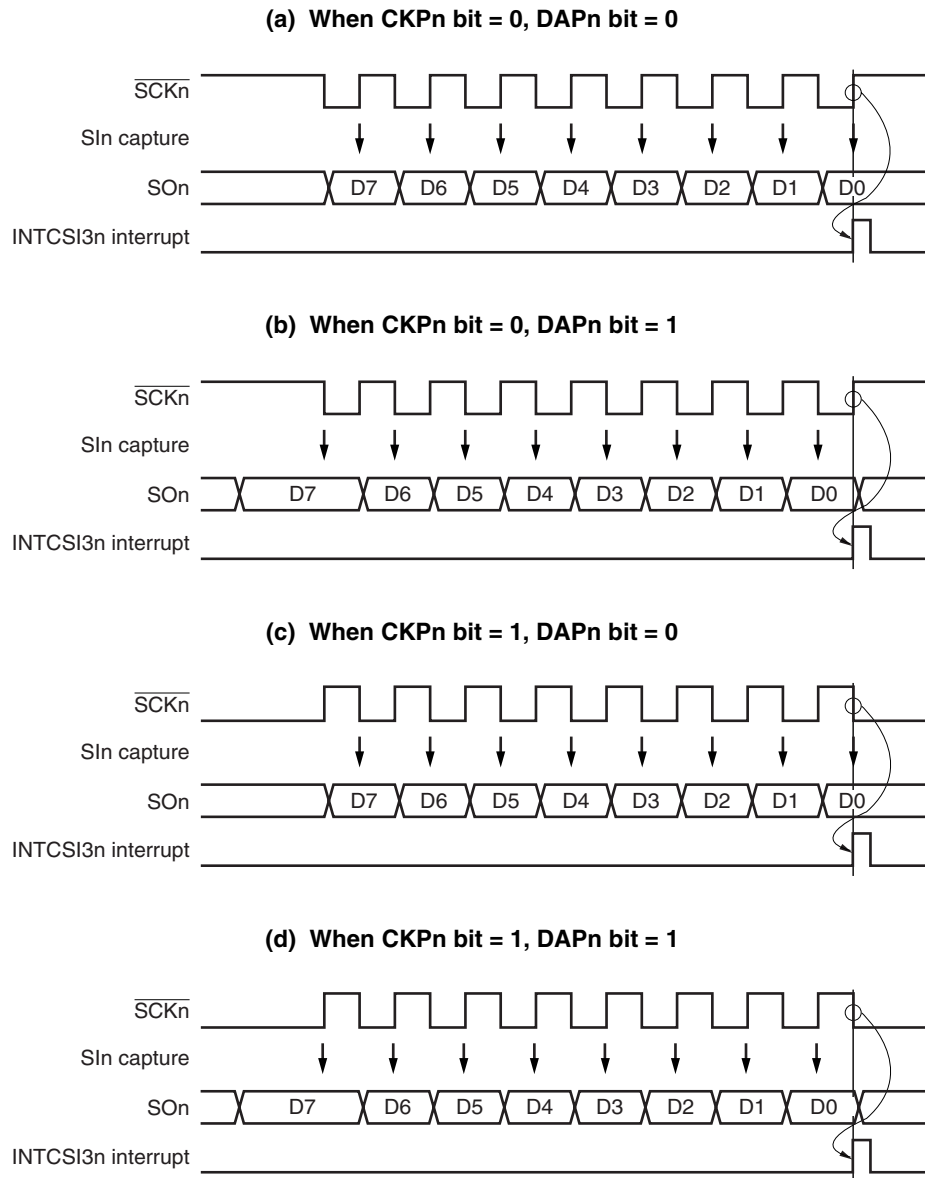
**Figure 10-27. Transfer Data Length: 16 Bits (CCLn3 to CCLn0 Bits = 0000 in CSIL3n Register),  
Transfer Direction: MSB First (DIRn Bit = 0 in CSIM3n Register)**



(5) Function to select serial clock and data phase

The serial clock and data phase can be changed by using the CKPn and DAPn bits of the CSIC3n register (n = 0, 1).

Figure 10-28. Clock Timing



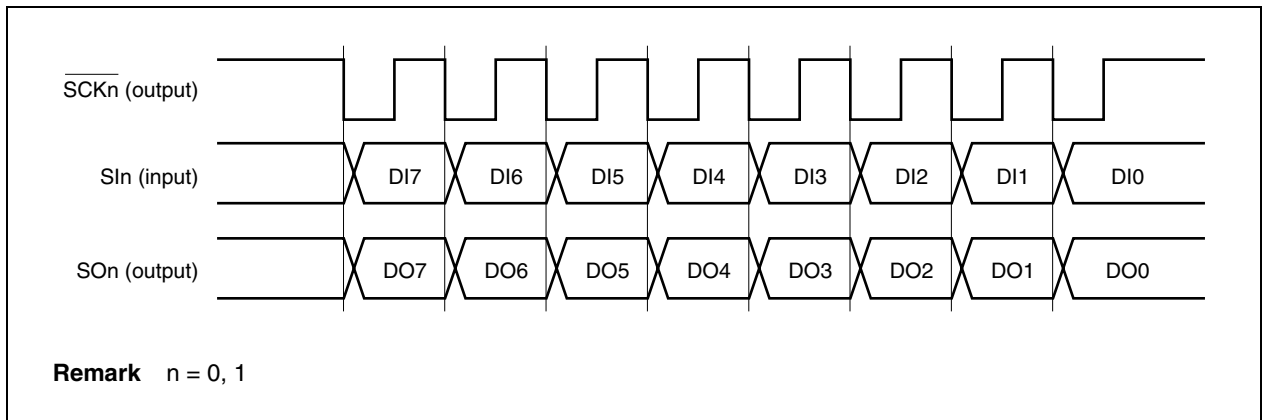
**Remark** n = 0, 1

**(6) Master mode**

The master mode is set and data is transferred with the transfer clock output to the  $\overline{\text{SCKn}}$  pin when the CKS3n2 to CKS3n0 bits of the CSIC3n register are set to a value other than 111 ( $\overline{\text{SCKn}}$  pin input is invalid) ( $n = 0, 1$ ).

The default output level of the  $\overline{\text{SCKn}}$  pin is high when the CKPn bit of the CSIC3n register is 0, and low when the CKPn bit is 1.

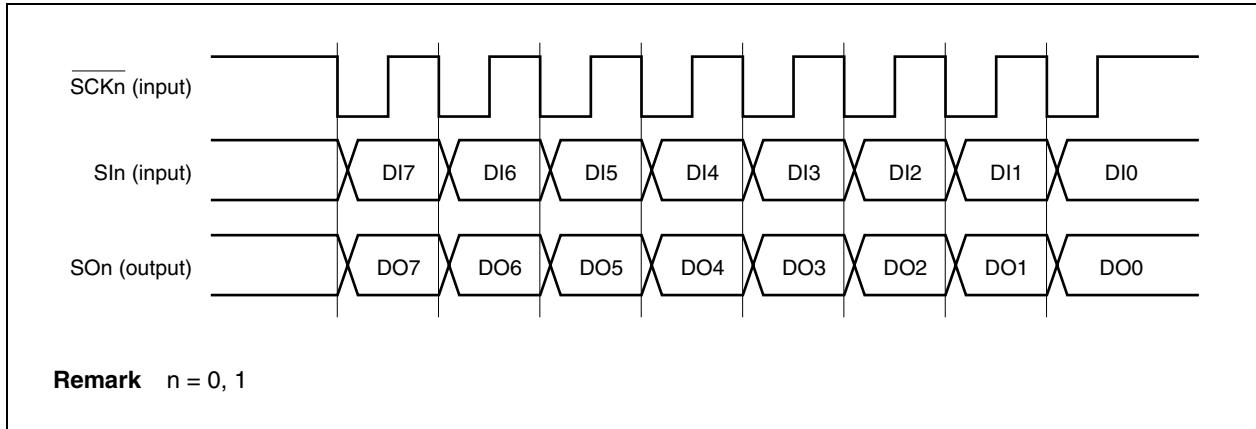
**Figure 10-29. Master Mode (CKPn and DAPn Bits = 00 in CSIC3n Register,  
CCLn3 to CCLn0 Bits = 1000 in CSIL3n Register (Transfer Data Length: 8 Bits))**



### (7) Slave mode

The slave mode is set when the CKS3n2 to CKS3n0 bits of the CSIC3n register are set to 111, and data is transferred with the transfer clock input to the  $\overline{\text{SCKn}}$  pin (in the slave mode, it is recommended to set the MDL2n to MDL2n0 bits of the CSIC3n register to 000 and set the BRGn stop mode) (n = 0, 1).

**Figure 10-30. Slave Mode (CKPn and DAPn Bits = 00 in CSIC3n Register, CCLn3 to CCLn0 Bits = 1000 in CSIL3n Register (Transfer Data Length: 8 Bits))**



The conditions under which data can be transferred in the slave mode are listed in the table below.

**Table 10-7. Conditions Under Which Data Can Be Transferred in Slave Mode**

| Transfer Mode    |                             | CTXEn Bit | CRXEn Bit | CSIBUFn Register                                    | SIRB3n Register and SIOOn Register          |
|------------------|-----------------------------|-----------|-----------|-----------------------------------------------------|---------------------------------------------|
| Single mode      | Transmission mode           | 1         | 0         | Data is in CSIBUFn register (SFEMPn bit = 0).       | —                                           |
|                  | Reception mode              | 0         | 1         | Dummy data is in CSIBUFn register (SFEMPn bit = 0). | SIRB3n register or SIOOn register is empty. |
|                  | Transmission/reception mode | 1         | 1         | Data is in CSIBUFn register (SFEMPn bit = 0).       |                                             |
| Consecutive mode | Transmission mode           | 1         | 0         | Data is in CSIBUFn register (SFEMPn bit = 0).       | —                                           |
|                  | Reception mode              | 0         | 1         | Dummy data is in CSIBUFn register (SFEMPn bit = 0). | —                                           |
|                  | Transmission/reception mode | 1         | 1         | Data is in CSIBUFn register (SFEMPn bit = 0).       | —                                           |

**Caution** Transfer is not performed normally while data transfer is not enabled, even if the transfer clock is input from the master.

**Remarks**

- CTXEn bit: Bit 6 of CSIM3n register  
CRXEn bit: Bit 5 of CSIM3n register  
SFEMPn bit: Bit 5 of SFA3n register

2. n = 0, 1

**(8) Transfer clock selection function**

In the master mode (CKS3n2 to CKS3n0 bits = other than 111 in the CSIC3n register), the bit transfer rate can be selected by setting the CKS3n2 to CKS3n0 and MDLn2 to MDLn0 bits of the CSIC3n register (see 10.3.3 (2) **Clocked serial interface clock select registers 30, 31 (CSIC30, CSIC31)**).

**(9) Single mode**

The single mode is set when the TRMDn bit of the CSIM3n register is 0 (n = 0, 1).

In this mode, transfer is started when the CTXEn bit or CRXEn bit is set to 1 and when data is in the CSIBUFn register (SFEMPn bit = 0 in the SFA3n register).

If no data is in the CSIBUFn register (SFEMPn bit = 1), transfer is kept waiting until transmit data or dummy data is written to the SFDB3n register.

When data is transferred to the CSIBUFn register while transmission or reception is enabled (CTXEn or CRXEn bit is 1), the CSOTn bit of the SFA3n register (transfer status flag) is set to 1. If transfer is not in the wait status, the transfer data indicated by the SIOOn load CSIBUFn pointer is loaded from the CSIBUFn register to the SIOOn register, and transfer processing is started.

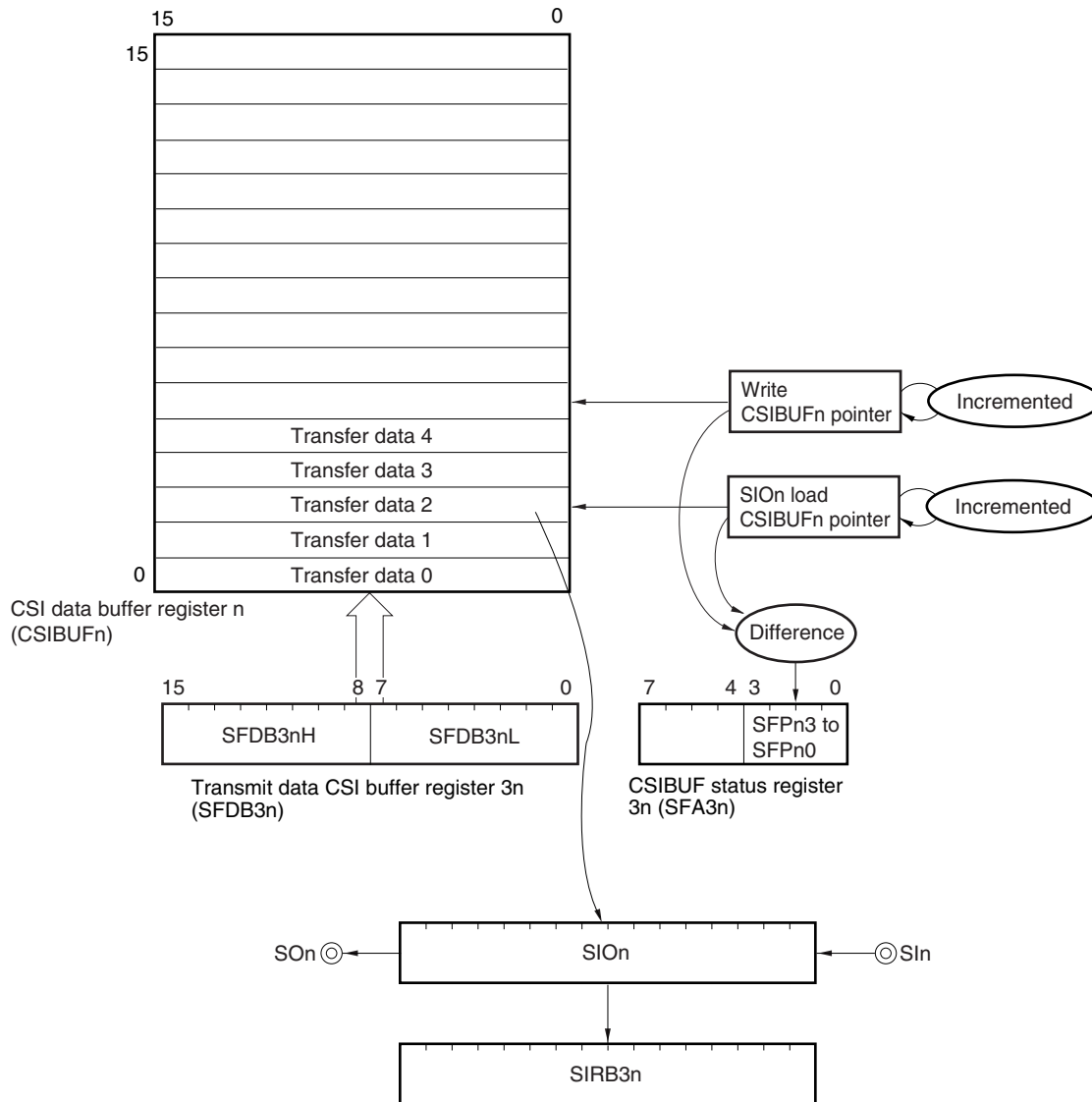
If the SIRB3n register is empty when one data has been transferred in the reception mode or transmission/reception mode, the received data is stored from the SIOOn register to the SIRB3n register, the transmission/reception completion interrupt (INTCSI3n) is output, and the SIOOn load CSIBUFn pointer is incremented. If transmit data or dummy data is stored in the CSIBUFn register, the next transfer processing is started. However, storing the receive data in the SIRB3n register, outputting the INTCSI3n interrupt, and incrementing the SIOOn load CSIBUFn pointer are held pending, until the previously received data is read from the SIRB3n register and the SIRB3n register becomes empty.

In the transmission mode, the INTCSI3n interrupt is output and the SIOOn load pointer is incremented when transfer processing of one data has been completed (the SIRB3n register is always empty because no data is stored from the SIOOn register to the SIRB3n register).

In all modes (transmission, reception, and transmission/reception modes), if the CSIBUFn register is empty (write CSIBUFn pointer value = SIOOn load CSIBUFn pointer value) when transfer processing of one data has been completed, the CSOTn bit is cleared to 0. The value of the “number of remaining data in the CSIBUFn register (write CSIBUFn pointer – SIOOn load pointer)” can always be read from the SFPn3 to SFPn0 bits of the SFA3n register.

**Caution** Be sure to confirm that the SFFULn bit of the SFA3n register is 0 when writing data to the SFDB3n register. Even if data is written to this register when SFFULn bit is 1, the CSIBUFn overflow interrupt (INTCOVF3n) is output, and the written data is ignored.

Figure 10-31. Single Mode



**Remark**  $n = 0, 1$

**(10)Continuous mode**

The continuous mode is set when the TRMDn bit of the CSIM3n register is 1 (n = 0, 1).

In this mode, transfer is started when the CTXEn bit or CRXEn bit is 1 and when data is in the CSIBUFn register (SFEMPn bit = 0 in the SFA3n register). At this time, set the number of transfer data in advance by using the SFNn3 to SFNn0 bits of the SFN3n register. If data exceeding the number of transfer data specified by the SFNn3 to SFNn0 bits of the SFN3n register are written to the CSIBUFn register, the excess data are ignored and not transferred.

If no data is in the CSIBUFn register (SFEMPn bit = 1), transfer is kept waiting until transmit data or dummy data is written to the SFDB3n register.

If data is transferred to the CSIBUFn register when transmission or reception is enabled (CTXEn or CRXEn bit is 1), the CSOTn bit (transfer status flag) of the SFA3n register is set to 1 and the transfer data indicated by the SIOn load/store CSIBUFn pointer is loaded from the CSIBUFn register to SIOn register. Then transfer processing is started.

When transfer processing of one data is completed in the reception mode or transmission/reception mode, the received data is overwritten from the SIOn register to the transfer data in the CSIBUFn register indicated by the SIOn load/store CSIBUFn pointer, and then the pointer is incremented. By consecutively reading the transfer data from the SIRB3n register after all data in the CSIBUFn register have been transferred (when the INTCSI3n interrupt has occurred), the receive data can be sequentially read while the read CSIBUFn pointer is incremented.

In the transmission mode, the SIOn load/store CSIBUFn pointer is incremented when transfer processing of one data has been completed.

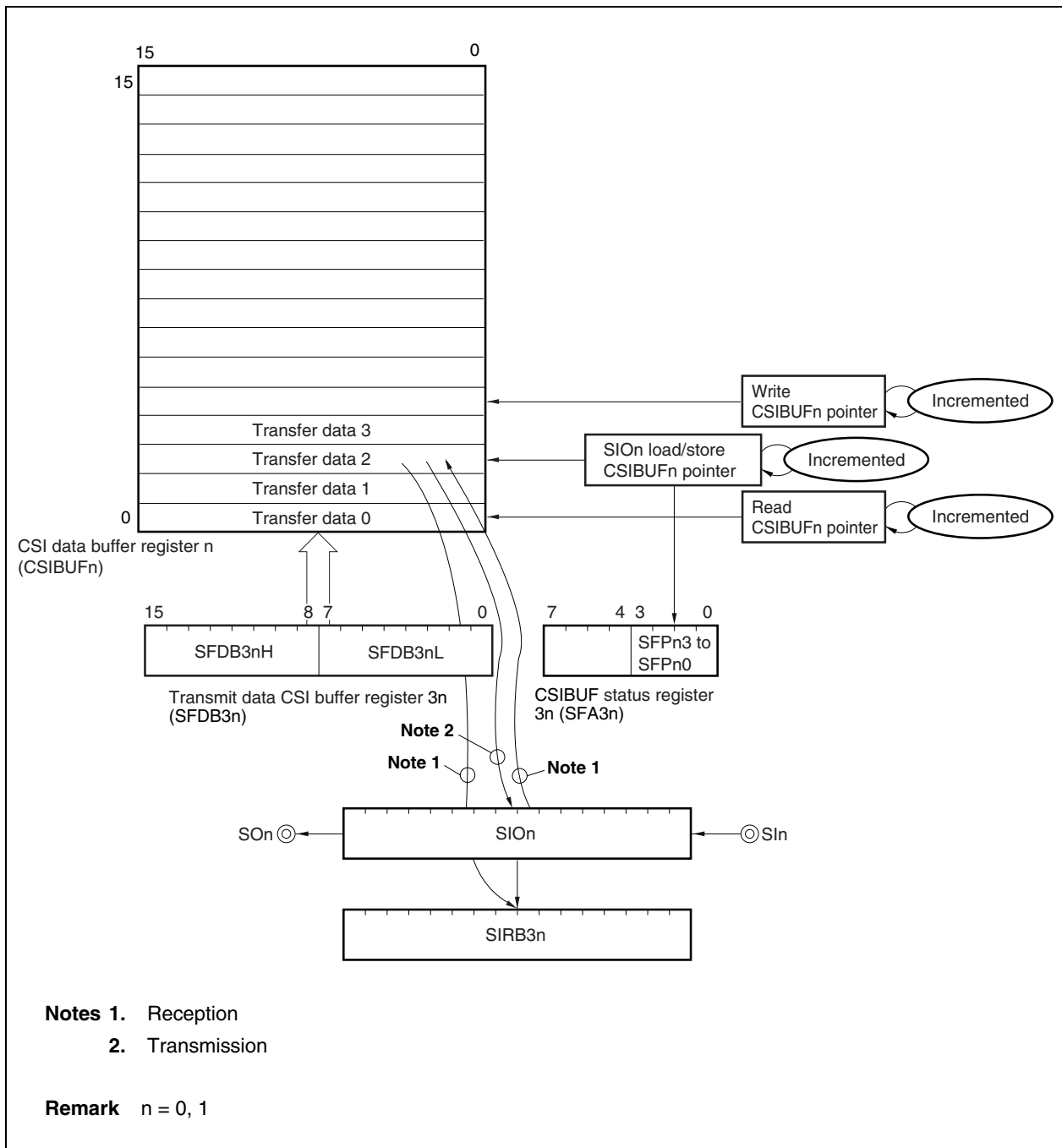
In all modes (transmission, reception, and transmission/reception modes), when data has been transferred by the value set by the SFNn3 to SFNn0 bits of the SFN3n register, the CSOTn bit is cleared to 0 and the transmission/reception completion interrupt (INTCSI3n) is output.

To transfer the next data, be sure to write 1 to the FPCLRn bit of the SFA3n register and clear all the CSIBUFn pointers to 0.

The “number of transferred data (SIOn load/store CSIBUFn pointer value)” can always be read from the SFPn3 to SFPn0 bits of the SFA3n register.

**Caution** The SFA3n register is in the same status when transfer data is written (before start of transfer) after the CSIBUFn pointer is cleared (FPCLRn bit = 1 in the SFA3n register) and when 16 data have been transferred (SFFULn bit = 0, SFEMPn bit = 1, SFPn3 to SFPn0 bits = 0000 in the SFA3n register).

Figure 10-32. Continuous Mode





**(11) Transmission mode**

The transmission mode is set when the CTXEn bit of the CSIM3n register is set to 1 and the CRXEn bit is cleared to 0. In this mode, transmission is started by a trigger that writes transmit data to the SFDB3n register or sets the CTXEn bit to 1 when transmit data is in the CSIBUFn register (n = 0, 1). Even in the single mode (TRMDn bit = 0 in the CSIM3n register), whether the SIRB3n or SION register is empty has nothing to do with starting transmission. The value input to the SIn pin during transmission is latched in the shift register (SION) but is not transferred to the SIRB3n and CSIBUFn registers at the end of transmission.

The transmission/reception completion interrupt (INTCSI3n) occurs immediately after data is sent out from the SION register.

**(12) Reception mode**

The reception mode is set when the CTXEn bit of the CSIM3n register is cleared to 0 and CRXEn bit is set to 1. In this mode, reception is started by using the processing of writing dummy data to the SFDB3n register as a trigger (n = 0, 1). In the single mode (TRMDn bit = 0 in the CSIM3n register), however, the condition of starting reception includes that the SIRB3n or SION register is empty. (If reception to the SION register is completed when the previously received data is held in the SIRB3n register without being read, the previously received data is read from the SIRB3n register and the wait status continues until the SIRB3n register becomes empty.) In the continuous mode, reception starts by writing dummy data of the number of receive data to the SFDB3n register with the first dummy data write processing taken as a trigger.

The SOn pin outputs a low level.

The transmission/reception completion interrupt (INTCSI3n) occurs immediately after receive data is transferred from the SION register to the SIRB3n register.

**(13) Transmission/reception mode**

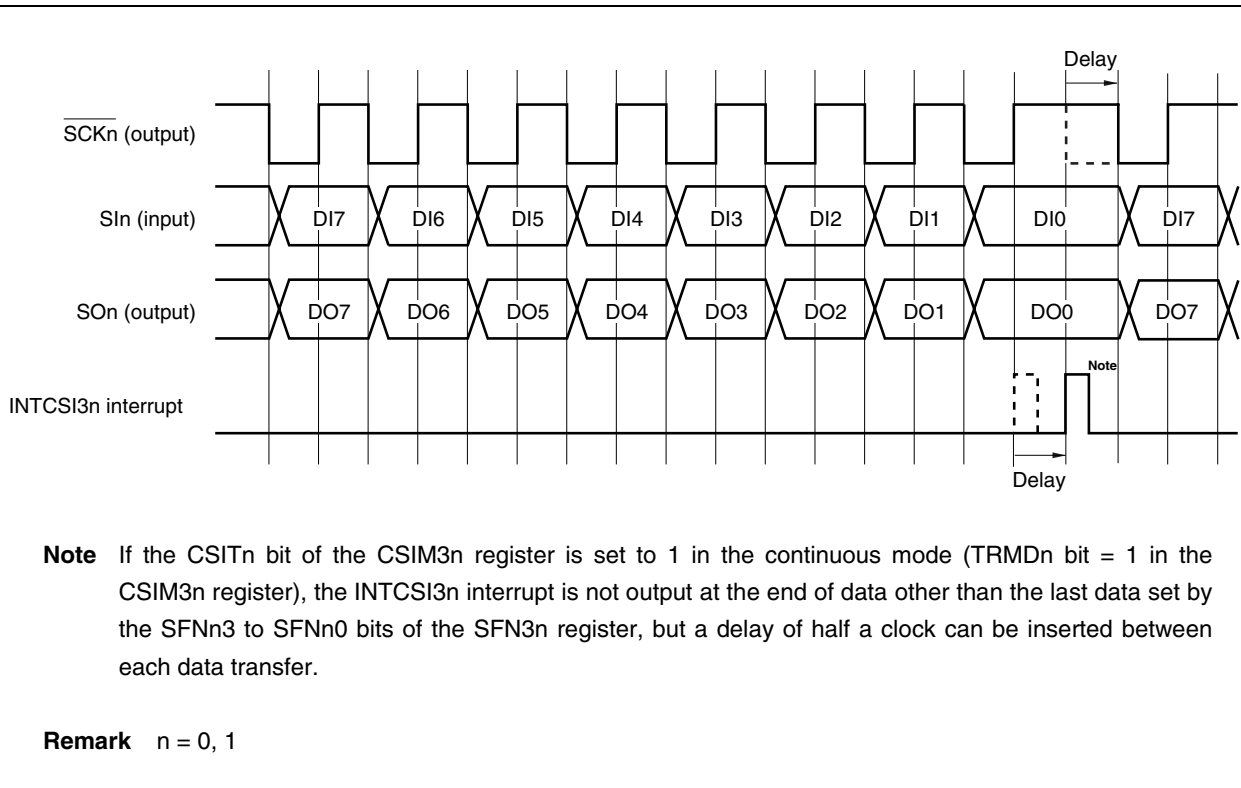
The transmission/reception mode is set when both the CTXEn and CRXEn bits of the CSIM3n register are set to 1. In this mode, transmission/reception is started by using the processing to write transmit data to the SFDB3n register as a trigger (n = 0, 1). In the single mode (TRMDn bit = 0 in the CSIM3n register), however, the condition of starting transmission/reception includes that the SIRB3n or SION register is empty. (If reception to the SION register is completed when the previously received data is held in the SIRB3n register without being read, the previously received data is read from the SIRB3n register and the wait status continues until the SIRB3n register becomes empty.)

**(14) Delay control of transmission/reception completion interrupt (INTCSI3n)**

In the master mode (CKS3n2 to CKS3n0 bits = other than 111 in the CSIC3n register), occurrence of the transmission/reception completion interrupt (INTCSI3n) can be delayed by half a clock (1/2 serial clock), depending on the setting (1) of the CSITn bit of the CSIM3n register. The CSITn bit is valid only in the master mode. In the slave mode (CKS3n2 to CKS3n0 bits = 111 in the CSIC3n register), setting the CSITn bit to 1 is prohibited (even if set, the INTCSI3n interrupt is not affected).

**Caution** If the CSITn bit of the CSIM3n register is set to 1 in the continuous mode (TRMDn bit = 1 in the CSIM3n register), the INTCSI3n interrupt is not output at the end of data other than the last data set by the SFNn3 to SFNn0 bits of the SFN3n register, but a delay of half a clock can be inserted between each data transfer.

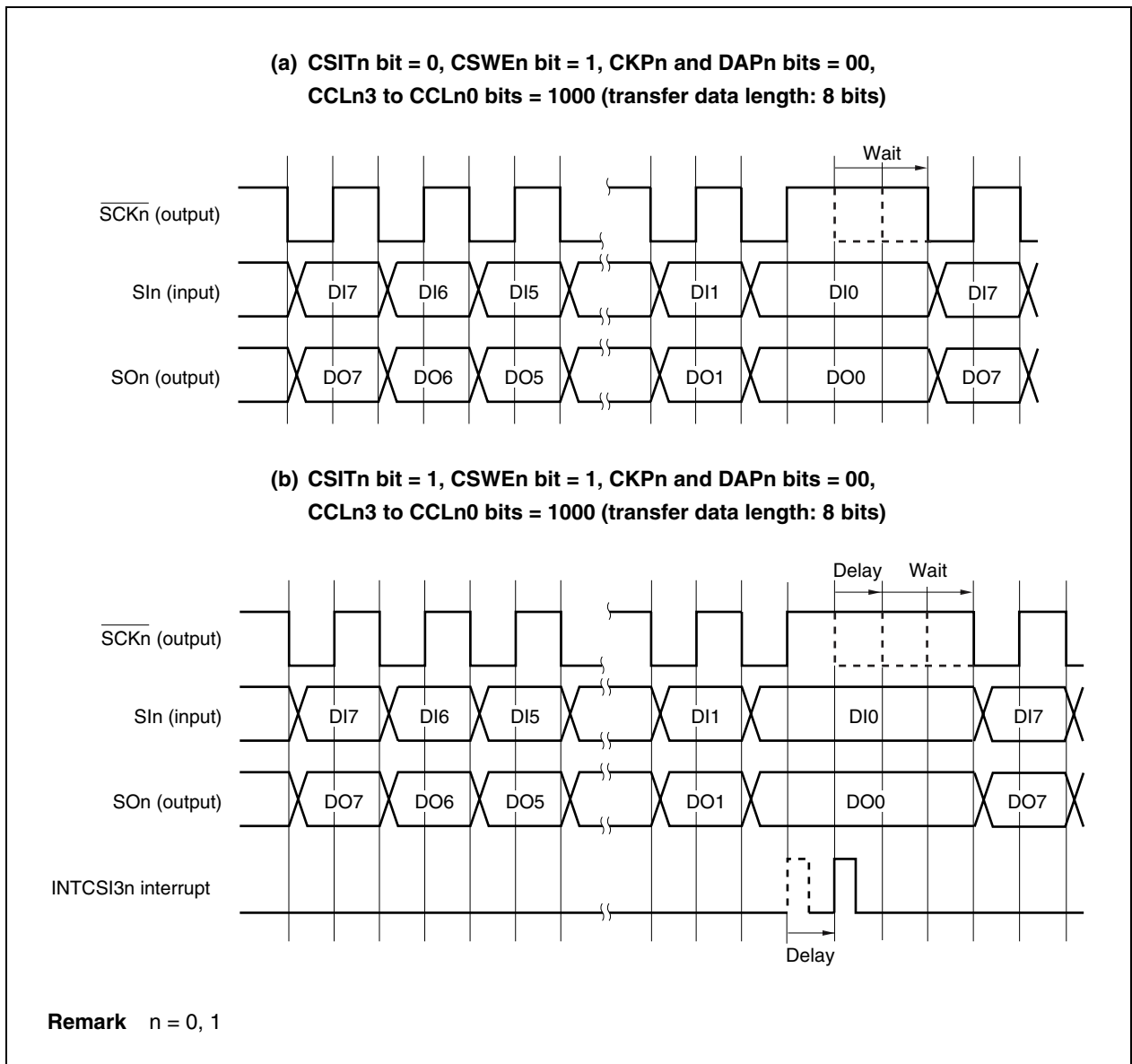
**Figure 10-33. Delay Control of Transmission/Reception Completion Interrupt (INTCSI3n):**  
**CSITn Bit = 1 in CSIC3n Register, CSWEEn Bit = 0, CKPn and DAPn Bits = 00,**  
**CCLn3 to CCLn0 Bits = 1000 in CSIL3n Register (Transfer Data Length: 8 Bits)**



### (15) Enabling/disabling transfer wait

In the master mode (CKS3n2 to CKS3n0 bits = other than 111 in the CSIC3n register), starting transfer can be delayed by one clock for each time 1-bit data transfer is started, depending on the setting (1) of the CSWEn bit of the CSIM3n register (CSWEn bit = 1 (transfer wait inserted)). The CSWEn bit is valid only in the master mode. In the slave mode (CKS3n2 to CKS3n0 bits = 111 in the CSIC3n register), setting the CSWEn bit to 1 is prohibited (even if set, transfer wait is not inserted).

Figure 10-34. Enabling/Disabling Transfer Wait



**(16) Output pins****(a)  $\overline{\text{SCKn}}$  pin**

The  $\overline{\text{SCKn}}$  pin outputs a high level when both the CTXEn and CRXEn bits of the CSIM3n register are 0 ( $n = 0, 1$ ).

In the master mode (CKS3n2 to CKS3n0 bits = other than 111 in the CSIC3n register), this pin outputs the default level when the FPCLRn bit of the SFA3n register is set to 1.

**Table 10-8. Default Output Level of  $\overline{\text{SCKn}}$  Pin**

| CKPn Bit | CKS3n2 to CKS3n0 Bits        | Default Output Level of $\overline{\text{SCKn}}$ Pin |
|----------|------------------------------|------------------------------------------------------|
| 0        | 111 (slave mode)             | High level <sup>Note</sup>                           |
|          | Other than 111 (master mode) | High level                                           |
| 1        | 111 (slave mode)             | – (input)                                            |
|          | Other than 111 (master mode) | Low level                                            |

**Note** Default value after reset or value when CSICAEn bit = 0 in the CSIM3n register

**Remarks** 1. The output of the  $\overline{\text{SCKn}}$  pin changes if the CKPn bit is rewritten in the master mode.  
2.  $n = 0, 1$

**(b) SOn pin**

The SOn pin outputs a low level when both the CTXEn and CRXEn bits of the CSIM3n register are 0 ( $n = 0, 1$ ).

This pin outputs a low level when the FPCLRn bit of the SFA3n register is 1 (the previous value is retained only in the slave mode (CKS3n2 to CKS3n0 bits = 111 in the CSIC3n register) and when the DAPn bit = 0 in the CSIC3n register).

**Table 10-9. Default Output Level of SOn Pin**

| Default Output Level of SOn Pin |
|---------------------------------|
| Low level <sup>Note</sup>       |

**Note** Default value after reset or value when CSICAEn bit = 0 in the CSIM3n register

**Remark**  $n = 0, 1$

**(17) CSIBUFn overflow interrupt signal (INTCOVF3n)**

The INTCOVF3n interrupt is output when 16 data exist in the CSIBUFn register and when the 17th data is written (to the SFDB3n or SFDB3nL register) (the 17th data is not written but ignored).

In the single mode (TRMDn bit = 0 in the CSIM3n register), 16 data exist in the CSIBUFn register when “write CSIBUFn pointer value = SIOOn load CSIBUFn pointer value and SFFULn bit = 1 in the SFA3n register”. When transfer is completed and the SIOOn load CSIBUFn pointer is incremented, the CSIBUFn register has one vacancy (the CSIBUFn register has no vacancy even when transfer of one data has been completed in the continuous mode (TRMDn bit = 1 in the CSIM3n register)).

## 10.3.6 Usage

## (1) Single mode (in master mode and transmission mode)

- <1> Set the external pins related to the CSI3n function to control mode.
- <2> When the CSICAEn bit of the CSIM3n register is set to 1, supplying the operating clock is enabled.
- <3> Specify the transfer mode by setting the CSIC3n and CSIL3n registers.
- <4> Write 1 to the FPCLRn bit of the SFA3n register to clear all the CSIBUFn pointers to 0.
- <5> Confirm that the SFFULn bit = 0, SFEMPn bit = 1, and SFPn3 to SFPn0 bits = 0000 in the SFA3n register.
- <6> Specify the transfer mode by using the TRMDn, DIRn, CSITn, and CSWEn bits of the CSIM3n register and, at the same time, enable transmission by setting the CTXEn bit to 1.
- <7> Confirm that the SFFULn bit of the SFA3n register is 0, and then write transfer data to the SFDB3n register. If it is clearly known that the SFFULn bit is 0 because transfer data is written to that bit by the interrupt servicing routine of INTCSI3n, it is not always necessary to confirm that the SFFULn bit is 0.
- <8> Confirm that the INTCSI3n interrupt has occurred and the SFEMPn bit of the SFA3n register is 1, and disable transmission by clearing the CTXEn bit of the CSIM3n register to 0 (end of transmission).

**Caution** To execute further transfer, repeat <7> before <8>.

## (2) Single mode (in master mode and reception mode)

- <1> Set the external pins related to the CSI3n function to control mode.
- <2> When the CSICAEn bit of the CSIM3n register is set to 1, supplying the operating clock is enabled.
- <3> Specify the transfer mode by setting the CSIC3n and CSIL3n registers.
- <4> Write 1 to the FPCLRn bit of the SFA3n register to clear all the CSIBUFn pointers to 0.
- <5> Confirm that the SFFULn bit = 0, SFEMPn bit = 1, and SFPn3 to SFPn0 bits = 0000 in the SFA3n register.
- <6> Specify the transfer mode by using the TRMDn, DIRn, CSITn, and CSWEn bits of the CSIM3n register and, at the same time, enable reception by setting the CRXEn bit to 1.
- <7> Confirm that the SFFULn bit of the SFA3n register is 0, and then write dummy transfer data to the SFDB3n register (reception start trigger). If it is clearly known that the SFFULn bit is 0 because dummy transfer data is written to that bit by the interrupt servicing routine of INTCSI3n, it is not always necessary to confirm that the SFFULn bit is 0.
- <8> Confirm that the INTCSI3n interrupt has occurred, and then read the SIRB3n register.
- <9> Confirm that the INTCSI3n interrupt has occurred and the SFEMPn bit is 1, and disable reception by clearing the CRXEn bit of the CSIM3n register to 0 (end of reception).

**Cautions** 1. To execute further transfer, repeat <7> and <8> before <9>.

2. The SOn pin outputs a low level but this is invalid.

**(3) Single mode (in master mode and transmission/reception mode)**

- <1> Set the external pins related to the CSI3n function to control mode.
- <2> When the CSICAEn bit of the CSIM3n register is set to 1, supplying the operating clock is enabled.
- <3> Specify the transfer mode by setting the CSIC3n and CSIL3n registers.
- <4> Write 1 to the FPCLRN bit of the SFA3n register to clear all the CSIBUFn pointers to 0.
- <5> Confirm that the SFFULn bit = 0, SFEMPn bit = 1, and SFPn3 to SFPn0 bits = 0000 in the SFA3n register.
- <6> Specify the transfer mode by using the TRMDn, DIRn, CSITn, and CSWEn bits of the CSIM3n register and, at the same time, enable transmission/reception by setting the CTXEn and CRXEn bits to 1.
- <7> Confirm that the SFFULn bit of the SFA3n register is 0, and then write transfer data to the SFDB3n register. If it is clearly known that the SFFULn bit is 0 because transfer data is written to that bit by the interrupt servicing routine of INTCSI3n, it is not always necessary to confirm that the SFFULn bit is 0.
- <8> Confirm that the INTCSI3n interrupt has occurred, and then read the SIRB3n register.
- <9> Confirm that the INTCSI3n interrupt has occurred and the SFEMPn bit is 1, and disable transmission/reception by clearing the CTXEn and CRXEn bits of the CSIM3n register to 0 (end of transmission/reception).

**Caution** To execute further transfer, repeat <7> and <8> before <9>.

**(4) Single mode (in slave mode and transmission mode)**

- <1> Set the external pins related to the CSI3n function to control mode.
- <2> When the CSICAEn bit of the CSIM3n register is set to 1, supplying the operating clock is enabled.
- <3> Specify the transfer mode by setting the CSIC3n and CSIL3n registers.
- <4> Write 1 to the FPCLRN bit of the SFA3n register to clear all the CSIBUFn pointers to 0.
- <5> Confirm that the SFFULn bit = 0, SFEMPn bit = 1, and SFPn3 to SFPn0 bits = 0000 in the SFA3n register.
- <6> Specify the transfer mode by using the TRMDn, DIRn, CSITn, and CSWEn bits of the CSIM3n register and, at the same time, enable transmission by setting the CTXEn bit to 1.
- <7> Confirm that the SFFULn bit of the SFA3n register is 0, and then write transfer data to the SFDB3n register. If it is clearly known that the SFFULn bit is 0 because transfer data is written to that bit by the interrupt servicing routine of INTCSI3n, it is not always necessary to confirm that the SFFULn bit is 0.
- <8> Confirm that the INTCSI3n interrupt has occurred and the SFEMPn bit is 1, and disable transmission by clearing the CTXEn bit of the CSIM3n register to 0 (end of transmission).

**Caution** To execute further transfer, repeat <7> before <8>.

**(5) Single mode (in slave mode and reception mode)**

- <1> Set the external pins related to the CSI3n function to control mode.
- <2> When the CSICAEn bit of the CSIM3n register is set to 1, supplying the operating clock is enabled.
- <3> Specify the transfer mode by setting the CSIC3n and CSIL3n registers.
- <4> Write 1 to the FPCLRn bit of the SFA3n register to clear all the CSIBUFn pointers to 0.
- <5> Confirm that the SFFULn bit = 0, SFEMPn bit = 1, and SFPn3 to SFPn0 bits = 0000 in the SFA3n register.
- <6> Specify the transfer mode by using the TRMDn, DIRn, CSITn, and CSWEn bits of the CSIM3n register and, at the same time, enable reception by setting the CRXEn bit to 1.
- <7> Confirm that the SFFULn bit of the SFA3n register is 0, and then write dummy transfer data to the SFDB3n register (reception start trigger). If it is clearly known that the SFFULn bit is 0 because dummy transfer data is written to that bit by the interrupt servicing routine of INTCSI3n, it is not always necessary to confirm that the SFFULn bit is 0.
- <8> Confirm that the INTCSI3n interrupt has occurred, and then read the SIRB3n register.
- <9> Confirm that the INTCSI3n interrupt has occurred and the SFEMPn bit is 1, and disable reception by clearing the CRXEn bit of the CSIM3n register to 0 (end of reception).

**Cautions** 1. To execute further transfer, repeat <7> and <8> before <9>.  
 2. The SOn pin outputs a low level but this is invalid.

**(6) Single mode (in slave mode and transmission/reception mode)**

- <1> Set the external pins related to the CSI3n function to control mode.
- <2> When the CSICAEn bit of the CSIM3n register is set to 1, supplying the operating clock is enabled.
- <3> Specify the transfer mode by setting the CSIC3n and CSIL3n registers.
- <4> Write 1 to the FPCLRn bit of the SFA3n register to clear all the CSIBUFn pointers to 0.
- <5> Confirm that the SFFULn bit = 0, SFEMPn bit = 1, and SFPn3 to SFPn0 bits = 0000 in the SFA3n register.
- <6> Specify the transfer mode by using the TRMDn, DIRn, CSITn, and CSWEn bits of the CSIM3n register and, at the same time, enable transmission/reception by setting the CTXEn and CRXEn bits to 1.
- <7> Confirm that the SFFULn bit of the SFA3n register is 0, and then write transfer data to the SFDB3n register. If it is clearly known that the SFFULn bit is 0 because transfer data is written to that bit by the interrupt servicing routine of INTCSI3n, it is not always necessary to confirm that the SFFULn bit is 0.
- <8> Confirm that the INTCSI3n interrupt has occurred, and then read the SIRB3n register.
- <9> Confirm that the INTCSI3n interrupt has occurred and the SFEMPn bit is 1, and disable transmission/reception by clearing the CTXEn and CRXEn bits of the CSIM3n register to 0 (end of transmission/reception).

**Caution** To execute further transfer, repeat <7> and <8> before <9>.

**(7) Continuous mode (in master mode and transmission mode)**

- <1> Set the external pins related to the CSI3n function to control mode.
- <2> When the CSICAEn bit of the CSIM3n register is set to 1, supplying the operating clock is enabled.
- <3> Specify the transfer mode by setting the CSIC3n and CSIL3n registers.
- <4> Write 1 to the FPCLRn bit of the SFA3n register to clear all the CSIBUFn pointers to 0.
- <5> Confirm that the SFFULn bit = 0, SFEMPn bit = 1, and SFPn3 to SFPn0 bits = 0000 in the SFA3n register.
- <6> Specify the transfer mode by using the TRMDn, DIRn, CSITn, and CSWEn bits of the CSIM3n register and, at the same time, enable transmission by setting the CTXEn bit to 1.
- <7> Set the amount of data to be transmitted by using the SFNn3 to SFNn0 bits of the SFN3n register.
- <8> Write the amount of data to be transmitted to the SFDB3n register as transfer data. Writing data exceeding the set value of the SFN3n register is prohibited.
- <9> Confirm that the INTCSI3n interrupt has occurred and the SFEMPn bit is 1. Then write 1 to the FPCLRn bit of the SFA3n register, and clear all the CSIBUFn pointers to 0 in preparation for the next transfer.
- <10> Confirm that the SFFULn bit = 0, SFEMPn bit = 1, and SFPn3 to SFPn0 bits = 0000 in the SFA3n register.
- <11> Disable transmission by clearing the CTXEn bit of the CSIM3n register to 0 (end of transmission).

**Caution** To execute further transfer, repeat <7> to <10> before <11>.

**(8) Continuous mode (in master mode and reception mode)**

- <1> Set the external pins related to the CSI3n function to control mode.
- <2> When the CSICAEn bit of the CSIM3n register is set to 1, supplying the operating clock is enabled.
- <3> Specify the transfer mode by setting the CSIC3n and CSIL3n registers.
- <4> Write 1 to the FPCLRn bit of the SFA3n register to clear all the CSIBUFn pointers to 0.
- <5> Confirm that the SFFULn bit = 0, SFEMPn bit = 1, and SFPn3 to SFPn0 bits = 0000 in the SFA3n register.
- <6> Specify the transfer mode by using the TRMDn, DIRn, CSITn, and CSWEn bits of the CSIM3n register and, at the same time, enable reception by setting the CRXEn bit to 1.
- <7> Set the amount of data to be received by using the SFNn3 to SFNn0 bits of the SFN3n register.
- <8> Write dummy transfer data of the number of receive data to the SFDB3n register. The first dummy transfer data write is the trigger to start reception. Writing dummy data exceeding the set value of the SFN3n register is prohibited.
- <9> Confirm that the INTCSI3n interrupt has occurred and the SFEMPn bit is 1. Then read the receive data from the SIRB3n register (sequentially read the receive data stored in the CSIBUFn register).
- <10> Write 1 to the FPCLRn bit of the SFA3n register, and clear all the CSIBUFn pointers to 0 in preparation for the next transfer.
- <11> Confirm that the SFFULn bit = 0, SFEMPn bit = 1, and SFPn3 to SFPn0 bits = 0000 in the SFA3n register.
- <12> Disable reception by clearing the CRXEn bit of the CSIM3n register to 0 (end of reception).

**Cautions 1.** To execute further transfer, repeat <7> to <11> before <12>.

**2.** The SOn pin outputs a low level.



**(9) Continuous mode (in master mode and transmission/reception mode)**

- <1> Set the external pins related to the CSI3n function to control mode.
- <2> When the CSICAEn bit of the CSIM3n register is set to 1, supplying the operating clock is enabled.
- <3> Specify the transfer mode by setting the CSIC3n and CSIL3n registers.
- <4> Write 1 to the FPCLRN bit of the SFA3n register to clear all the CSIBUFn pointers to 0.
- <5> Confirm that the SFFULn bit = 0, SFEMPn bit = 1, and SFPn3 to SFPn0 bits = 0000 in the SFA3n register.
- <6> Specify the transfer mode by using the TRMDn, DIRn, CSITn, and CSWEn bits of the CSIM3n register and, at the same time, enable transmission/reception by setting both the CTXEn and CRXEn bits to 1.
- <7> Set the amount of data to be transmitted/received by using the SFNn3 to SFNn0 bits of the SFN3n register.
- <8> Write the amount of data to be transmitted to the SFDB3n register as transfer data. Writing data exceeding the set value of the SFN3n register is prohibited.
- <9> Confirm that the INTCSI3n interrupt has occurred and the SFEMPn bit is 1. Then read the receive data from the SIRB3n register (sequentially read the receive data stored in the CSIBUFn register).
- <10> Write 1 to the FPCLRN bit of the SFA3n register, and clear all the CSIBUFn pointers to 0 in preparation for the next transfer.
- <11> Confirm that the SFFULn bit = 0, SFEMPn bit = 1, and SFPn3 to SFPn0 bits = 0000 in the SFA3n register.
- <12> Disable transmission/reception by clearing the CTXEn and CRXEn bits of the CSIM3n register to 0 (end of transmission/reception).

**Caution** To execute further transfer, repeat <7> to <11> before <12>.

**(10) Continuous mode (in slave mode and transmission mode)**

- <1> Set the external pins related to the CSI3n function to control mode.
- <2> When the CSICAEn bit of the CSIM3n register is set to 1, supplying the operating clock is enabled.
- <3> Specify the transfer mode by setting the CSIC3n and CSIL3n registers.
- <4> Write 1 to the FPCLRN bit of the SFA3n register to clear all the CSIBUFn pointers to 0.
- <5> Confirm that the SFFULn bit = 0, SFEMPn bit = 1, and SFPn3 to SFPn0 bits = 0000 in the SFA3n register.
- <6> Specify the transfer mode by using the TRMDn, DIRn, CSITn, and CSWEn bits of the CSIM3n register and, at the same time, enable transmission by setting the CTXEn bit to 1.
- <7> Set the amount of data to be transmitted by using the SFNn3 to SFNn0 bits of the SFN3n register.
- <8> Write the amount of data to be transmitted to the SFDB3n register as transfer data. Writing data exceeding the set value of the SFN3n register is prohibited.
- <9> Confirm that the INTCSI3n interrupt has occurred and the SFEMPn bit is 1. Then write 1 to the FPCLRN bit of the SFA3n register, and clear all the CSIBUFn pointers to 0 in preparation for the next transfer.
- <10> Confirm that the SFFULn bit = 0, SFEMPn bit = 1, and SFPn3 to SFPn0 bits = 0000 in the SFA3n register.
- <11> Disable transmission by clearing the CTXEn bit of the CSIM3n register to 0 (end of transmission).

**Caution** To execute further transfer, repeat <7> to <10> before <11>.

**(11) Continuous mode (in slave mode and reception mode)**

- <1> Set the external pins related to the CSI3n function to control mode.
- <2> When the CSICAEn bit of the CSIM3n register is set to 1, supplying the operating clock is enabled.
- <3> Specify the transfer mode by setting the CSIC3n and CSIL3n registers.
- <4> Write 1 to the FPCLRn bit of the SFA3n register to clear all the CSIBUFn pointers to 0.
- <5> Confirm that the SFFULn bit = 0, SFEMPn bit = 1, and SFPn3 to SFPn0 bits = 0000 in the SFA3n register.
- <6> Specify the transfer mode by using the TRMDn, DIRn, CSITn, and CSWEn bits of the CSIM3n register and, at the same time, enable reception by setting the CRXEn bit to 1.
- <7> Set the amount of data to be received by using the SFNn3 to SFNn0 bits of the SFN3n register.
- <8> Write dummy transfer data of the number of receive data to the SFDB3n register. The first dummy transfer data write is the trigger to start reception. Writing dummy data exceeding the set value of the SFN3n register is prohibited.
- <9> Confirm that the INTCSI3n interrupt has occurred and the SFEMPn bit is 1. Then read the receive data from the SIRB3n register (sequentially read the receive data stored in the CSIBUFn register).
- <10> Write 1 to the FPCLRn bit of the SFA3n register, and clear all the CSIBUFn pointers to 0 in preparation for the next transfer.
- <11> Confirm that the SFFULn bit = 0, SFEMPn bit = 1, and SFPn3 to SFPn0 bits = 0000 in the SFA3n register.
- <12> Disable reception by clearing the CRXEn bit of the CSIM3n register to 0 (end of reception).

**Cautions 1. To execute further transfer, repeat <7> to <11> before <12>.**

**2. The SOn pin outputs a low level.**

**(12) Continuous mode (in slave mode and transmission/reception mode)**

- <1> Set the external pins related to the CSI3n function to control mode.
- <2> When the CSICAEn bit of the CSIM3n register is set to 1, supplying the operating clock is enabled.
- <3> Specify the transfer mode by setting the CSIC3n and CSIL3n registers.
- <4> Write 1 to the FPCLRn bit of the SFA3n register to clear all the CSIBUFn pointers to 0.
- <5> Confirm that the SFFULn bit = 0, SFEMPn bit = 1, and SFPn3 to SFPn0 bits = 0000 in the SFA3n register.
- <6> Specify the transfer mode by using the TRMDn, DIRn, CSITn, and CSWEn bits of the CSIM3n register and, at the same time, enable transmission/reception by setting both the CTXEn and CRXEn bits to 1.
- <7> Set the number of data to be transmitted/received by using the SFNn3 to SFNn0 bits of the SFN3n register.
- <8> Write the amount of data to be transmitted to the SFDB3n register as transfer data. Writing data exceeding the set value of the SFN3n register is prohibited.
- <9> Confirm that the INTCSI3n interrupt has occurred and the SFEMPn bit is 1. Then read the receive data from the SIRB3n register (sequentially read the receive data stored in the CSIBUFn register).
- <10> Write 1 to the FPCLRn bit of the SFA3n register, and clear all the CSIBUFn pointers to 0 in preparation for the next transfer.
- <11> Confirm that the SFFULn bit = 0, SFEMPn bit = 1, and SFPn3 to SFPn0 bits = 0000 in the SFA3n register.
- <12> Disable transmission/reception by clearing the CTXEn and CRXEn bits of the CSIM3n register to 0 (end of transmission/reception).

**Caution To execute further transfer, repeat <7> to <11> before <12>.**

### 10.3.7 Cautions

Cautions concerning CSI3n are shown below (n = 0, 1).

#### (1) Stopping CSI3n

The CSI3n unit is reset and CSI3n is stopped when the CSICAEn bit of the CSIM3n register is cleared to 0. To operate CSI3n, first set the CSICAEn bit to 1.

Usually, before clearing the CSICAEn bit to 0, clear both the CTXEn and CRXEn bits to 0 (after the end of transfer).

#### (2) Enabling transfer

Be sure to write 1 to the FPCLRn bit of the SFA3n register to clear all the CSIBUFn pointers to 0 before enabling transfer by setting the CTXEn or CRXEn bit of the CSIM3n register to 1. If the CTXEn or CRXEn bit is set to 1 without clearing the pointers, and if the previously transferred data remains in the CSIBUFn register, transferring that data is immediately started.

If transfer data is set to the CSIBUFn register before transfer is enabled, transfer is started as soon as the CTXEn or CRXEn bit is set to 1.

#### (3) Caution on setting SFA3n register

If the SFA3n register is read immediately after data has been written to the SFDB3n and SFDB3nL registers when the main clock (fx) is used at 84 MHz or lower, the SFFULn, SFEMPn, and SFPn3 to SFPn0 bits of the SFA3n register may not change their values in time.

If the SFA3n register is read before the SFFULn bit is set to 1 and the 17th data is written, the CSIBUFn overflow interrupt (INTCOVF3n) occurs.

#### (4) Caution on setting CSIM3n register

Be sure to set the external pins related to the CSI3n function to the control mode before using CSI3n. Then set the CSICAEn bit to 1 before setting the other bits.

#### (5) Maximum transfer rate in master mode

Because the maximum transfer rate in the master mode (CKS3n2 to CKS3n0 bits = other than 111 in the CSIC3n register) is 5.5 Mbps, do not exceed this value.

#### (6) Writing data to SFDB3n register in single mode

Be sure to confirm that the SFFULn bit of the SFA3n register is 0 when writing data to the SFDB3n register. Even if data is written to this register when the SFFULn bit is 1, the CSIBUFn overflow interrupt (INTCOVF3n) is issued, and the written data is ignored.

#### (7) SFA3n register status in continuous mode

The SFA3n register is in the same status when transfer data is written (before start of transfer) after the CSIBUFn pointer is cleared (FPCLRn bit = 1 in the SFA3n register) and when 16 data have been transferred (SFFULn bit = 0, SFEMPn bit = 1, SFPn3 to SFPn0 bits = 0000 in the SFA3n register).

## CHAPTER 11 USB FUNCTION CONTROLLER (USBF)

The V850E/ME2 has an internal USB function controller (USBF) conforming to the Universal Serial Bus Specification.

### 11.1 Overview

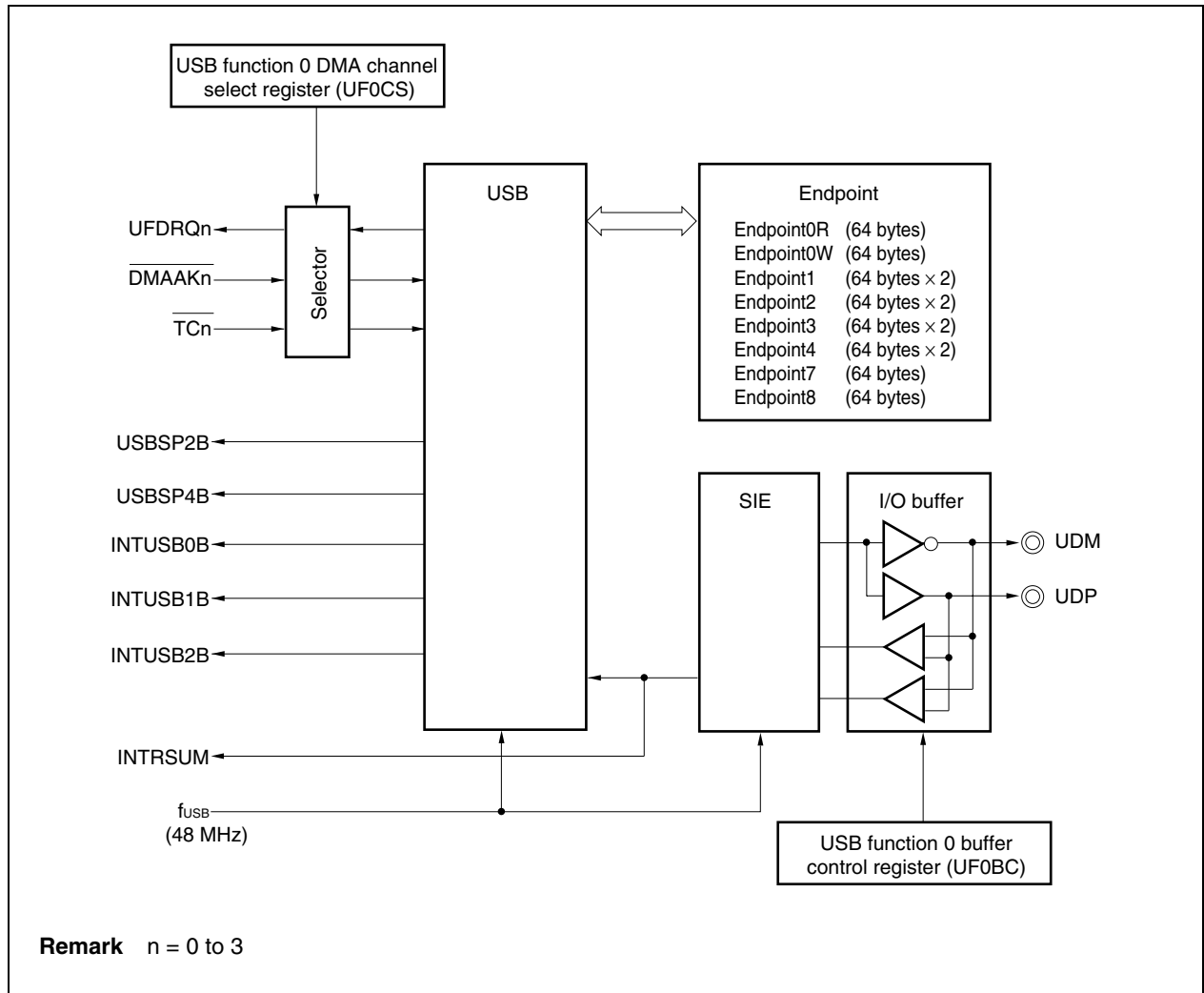
- Conforms to the Universal Serial Bus Specification.
- Supports 12 Mbps (full-speed) transfer
- Endpoint for transfer incorporated

| Endpoint Name   | FIFO Size (Bytes) | Transfer Type         | Remark                 |
|-----------------|-------------------|-----------------------|------------------------|
| Endpoint0 Read  | 64                | Control transfer      | –                      |
| Endpoint0 Write | 64                | Control transfer      | –                      |
| Endpoint1       | 64 × 2            | Bulk 1 transfer (IN)  | 2-buffer configuration |
| Endpoint2       | 64 × 2            | Bulk 1 transfer (OUT) | 2-buffer configuration |
| Endpoint3       | 64 × 2            | Bulk 2 transfer (IN)  | 2-buffer configuration |
| Endpoint4       | 64 × 2            | Bulk 2 transfer (OUT) | 2-buffer configuration |
| Endpoint7       | 8                 | Interrupt 1 transfer  | –                      |
| Endpoint8       | 8                 | Interrupt 2 transfer  | –                      |

- Clock: Clock input from UCK pin ( $f_{\text{USB}} = 48 \text{ MHz}$ )

**Caution** When using the USB function, be sure to set (1) the UCKCNT bit of the UCKC register.  
If the registers related to the USB function while the UCKCNT bit is 0, 0 is read.

## 11.2 Configuration



## 11.3 Requests

### 11.3.1 Automatic requests

#### (1) Decode

The following tables show the request formats and correspondence between requests and decoded values.

**Table 11-1. Request Format**

| Offset | Field Name    |             |
|--------|---------------|-------------|
| 0      | bmRequestType |             |
| 1      | bRequest      |             |
| 2      | wValue        | Lower side  |
| 3      |               | Higher side |
| 4      | wIndex        | Lower side  |
| 5      |               | Higher side |
| 6      | wLength       | Lower side  |
| 7      |               | Higher side |

Table 11-2. Correspondence Between Requests and Decoded Values

| Request \ Offset                              | Decoded Value |          |        |            |        |            |         |                       | Response   |            |            | Data Stage |
|-----------------------------------------------|---------------|----------|--------|------------|--------|------------|---------|-----------------------|------------|------------|------------|------------|
|                                               | bmRequestType | bRequest | wValue |            | wIndex |            | wLength |                       | Df         | Ad         | Cf         |            |
|                                               | 0             | 1        | 3      | 2          | 5      | 4          | 7       | 6                     |            |            |            |            |
| GET_INTERFACE                                 | 81H           | 0AH      | 00H    | 00H        | 00H    | 0nH        | 00H     | 01H                   | STALL      | STALL      | ACK<br>NAK | √          |
| GET_CONFIGURATION                             | 80H           | 08H      | 00H    | 00H        | 00H    | 00H        | 00H     | 01H                   | ACK<br>NAK | ACK<br>NAK | ACK<br>NAK | √          |
| GET_DESCRIPTOR<br>Device                      | 80H           | 06H      | 01H    | 00H        | 00H    | 00H        | XXH     | XXH <sup>Note 1</sup> | ACK<br>NAK | ACK<br>NAK | ACK<br>NAK | √          |
| GET_DESCRIPTOR<br>Configuration               | 80H           | 06H      | 02H    | 00H        | 00H    | 00H        | XXH     | XXH <sup>Note 1</sup> | ACK<br>NAK | ACK<br>NAK | ACK<br>NAK | √          |
| GET_STATUS<br>Device                          | 80H           | 00H      | 00H    | 00H        | 00H    | 00H        | 00H     | 02H                   | ACK<br>NAK | ACK<br>NAK | ACK<br>NAK | √          |
| GET_STATUS<br>Endpoint 0                      | 82H           | 00H      | 00H    | 00H        | 00H    | 00H<br>80H | 00H     | 02H                   | ACK<br>NAK | ACK<br>NAK | ACK<br>NAK | √          |
| GET_STATUS<br>Endpoint X                      | 82H           | 00H      | 00H    | 00H        | 00H    | \$\$H      | 00H     | 02H                   | STALL      | STALL      | ACK<br>NAK | √          |
| CLEAR_FEATURE<br>Device <sup>Note 2</sup>     | 00H           | 01H      | 00H    | 01H        | 00H    | 00H        | 00H     | 00H                   | ACK<br>NAK | ACK<br>NAK | ACK<br>NAK | ×          |
| CLEAR_FEATURE<br>Endpoint 0 <sup>Note 2</sup> | 02H           | 01H      | 00H    | 00H        | 00H    | 00H<br>80H | 00H     | 00H                   | ACK<br>NAK | ACK<br>NAK | ACK<br>NAK | ×          |
| CLEAR_FEATURE<br>Endpoint X <sup>Note 2</sup> | 02H           | 01H      | 00H    | 00H        | 00H    | \$\$H      | 00H     | 00H                   | STALL      | STALL      | ACK<br>NAK | ×          |
| SET_FEATURE<br>Device <sup>Note 3</sup>       | 00H           | 03H      | 00H    | 01H        | 00H    | 00H        | 00H     | 00H                   | ACK<br>NAK | ACK<br>NAK | ACK<br>NAK | ×          |
| SET_FEATURE<br>Endpoint 0 <sup>Note 3</sup>   | 02H           | 03H      | 00H    | 00H        | 00H    | 00H<br>80H | 00H     | 00H                   | ACK<br>NAK | ACK<br>NAK | ACK<br>NAK | ×          |
| SET_FEATURE<br>Endpoint X <sup>Note 3</sup>   | 02H           | 03H      | 00H    | 00H        | 00H    | \$\$H      | 00H     | 00H                   | STALL      | STALL      | ACK<br>NAK | ×          |
| SET_INTERFACE                                 | 01H           | 0BH      | 00H    | 0#H        | 00H    | 0?H        | 00H     | 00H                   | STALL      | STALL      | ACK<br>NAK | ×          |
| SET_CONFIGURATION <sup>Note 4</sup>           | 00H           | 09H      | 00H    | 00H<br>01H | 00H    | 00H        | 00H     | 00H                   | ACK<br>NAK | ACK<br>NAK | ACK<br>NAK | ×          |
| SET_ADDRESS                                   | 00H           | 05H      | XXH    | XXH        | 00H    | 00H        | 00H     | 00H                   | ACK<br>NAK | ACK<br>NAK | ACK<br>NAK | ×          |

**Remark**    √: Data stage is provided  
                  ×: Data stage is not provided

**Notes 1.** If the wLength value is less than the prepared value, the wLength value is returned; if the wLength value is greater than the prepared value, the prepared value is returned.

**2.** The CLEAR\_FEATURE request clears UF0 device status register L (UF0DSTL) and UF0 EPn status register L (UF0EnSL) (n = 0 to 4, 7, 8) when ACK is received in the status stage.

**Notes 3.** The SET\_FEATURE request sets the UF0 device status register L (UF0DSTL) and UF0 EPn status register L (UF0EnSL) (n = 0 to 4, 7, 8) when ACK is received in the status stage. If the E0HALT bit of the UF0E0SL register is set, a STALL response is made in the status stage or data stage of control transfer for a request other than the GET\_STATUS Endpoint0 request, SET\_FEATURE Endpoint0 request, and a request generated by the CPUDEC interrupt request, until the CLEAR\_FEATURE Endpoint0 request is received. A STALL response to an unsupported request does not set the E0HALT bit of the UF0E0SL register to 1, and the STALL response is cleared as soon as the next SETUP token has been received.

4. If the wValue is not the default value, an automatic STALL response is made.

**Cautions 1.** The sequence of control transfer defined by the Universal Serial Bus Specification is not satisfied under the following conditions. The operation is not guaranteed under these conditions.

- If an IN/OUT token is suddenly received without a SETUP stage
  - If DATA PID1 is sent in the data phase of the SETUP stage
  - If a token of 128 addresses or more is received
  - If the request data transmitted in the SETUP stage is of less than 8 bytes
2. An ACK response is made even when the host transmits data other than a Null packet in the status stage.
3. If the wLength value is 00H during control transfer (read) of FW processing, a Null packet is automatically transmitted for control transfer (without data). The FW request does not automatically transmit a Null packet.

**Remarks 1.** Df: Default state, Ad: Addressed state, Cf: Configured state

2. n = 0 to 4

It is determined by the setting of the UF0 active interface number register (UF0AIFN) whether a request with Interface number 1 to 4 is correctly responded to, depending on whether the Interface number of the target is valid or not.

3. \$\$: Valid endpoint number including transfer direction

The valid endpoint is determined by the currently set Alternate Setting number (see 11.4.1 (36) **UF0 active alternative setting register (UF0AAS)**, (38) **UF0 endpoint 1 interface mapping register (UF0E1IM)** to (43) **UF0 endpoint 8 interface mapping register (UF0E8IM)**).

4. ? and #: Value transmitted from host (information on Interface numbers 0 to 4)

It is determined by the UF0 active interface number register (UF0AIFN) and UF0 active alternative setting register (UF0AAS) whether an Alternate Setting request corresponding to each Interface number is correctly responded to or not, depending on whether the Interface number and Alternate Setting of the target are valid or not.



**(2) Processing**

The processing of an automatic request in the Default state, Addressed state, and Configured state is described below.

**Remark** Default state: State in which an operation is performed with the Default address

Addressed state: State after an address has been allocated

Configured state: State after SET\_CONFIGURATION wValue = 1 has been correctly received

**(a) CLEAR\_FEATURE() request**

A STALL response is made in the status stage if the CLEAR\_FEATURE() request cannot be cleared, if FEATURE does not exist, or if the target is an interface or an endpoint that does not exist. A STALL response is also made if the wLength value is other than 0.

- Default state: The correct response is made when the CLEAR\_FEATURE() request has been received only if the target is a device or a request for Endpoint0; otherwise a STALL response is made in the status stage.
- Addressed state: The correct response is made when the CLEAR\_FEATURE() request has been received only if the target is a device or a request for Endpoint0; otherwise a STALL response is made in the status stage.
- Configured state: The correct response is made when the CLEAR\_FEATURE() request has been received only if the target is a device or a request for an endpoint that exists; otherwise a STALL response is made in the status stage.

When the CLEAR\_FEATURE() request has been correctly processed, the corresponding bit of the UF0 CLR request register (UF0CLR) is set to 1, the EnHALT bit of the UF0 EPn status register L (UF0EnSL) is cleared to 0, and an interrupt is issued (n = 0 to 4, 7, 8). If the CLEAR\_FEATURE() request is received when the subject is an endpoint, the toggle bit (that controls switching between DATA0 and DATA1) of the corresponding endpoint is always re-set to DATA0.

**(b) GET\_CONFIGURATION() request**

A STALL response is made in the data stage if any of wValue, wIndex, or wLength is other than the values shown in Table 11-2.

- Default state: The value stored in the UF0 configuration register (UF0CNF) is returned when the GET\_CONFIGURATION() request has been received.
- Addressed state: The value stored in the UF0CNF register is returned when the GET\_CONFIGURATION() request has been received.
- Configured state: The value stored in the UF0CNF register is returned when the GET\_CONFIGURATION() request has been received.

**(c) GET\_DESCRIPTOR() request**

If the subject descriptor has a length that is a multiple of wMaxPacketSize, a Null packet is returned to indicate the end of the data stage. If the length of the descriptor at this time is less than the wLength value, the entire descriptor is returned; if the length of the descriptor is greater than the wLength value, the descriptor up to the wLength value is returned.

- **Default state:** The value stored in UF0 device descriptor register n (UF0DDn) and UF0 configuration/interface/endpoint descriptor register m (UF0CIEm) is returned (n = 0 to 17, m = 0 to 255) when the GET\_DESCRIPTOR() request has been received.
- **Addressed state:** The value stored in the UF0DDn register and UF0CIEm register is returned when the GET\_DESCRIPTOR() request has been received.
- **Configured state:** The value stored in the UF0DDn register and UF0CIEm register is returned when the GET\_DESCRIPTOR() request has been received.

A descriptor of up to 256 bytes can be stored in the UF0CIEm register. To return a descriptor of more than 256 bytes, set the CDCGDST bit of the UF0MODC register to 1 and process the GET\_DESCRIPTOR() request by FW.

Store the value of the total number of bytes of the descriptor set by the UF0CIEm register – 1 in the UF0 descriptor length register (UF0DSCL). The transfer data is controlled by the value of this data + 1 and wLength.

**(d) GET\_INTERFACE() request**

If either of wValue and wLength is other than that shown in Table 11-2, or if wIndex is other than that set by the UF0 active interface number register (UF0AIFN), a STALL response is made in the data stage.

- **Default state:** A STALL response is made in the data stage when the GET\_INTERFACE() request has been received.
- **Addressed state:** A STALL response is made in the data stage when the GET\_INTERFACE() request has been received.
- **Configured state:** The value stored in the UF0 interface n register (UF0IFn) corresponding to the wIndex value is returned (n = 0 to 4) when the GET\_INTERFACE() request has been received.

**(e) GET\_STATUS() request**

A STALL response is made in the data stage if any of wValue, wIndex, or wLength is other than the values shown in Table 11-2. A STALL response is also made in the data stage if the target is an interface or an endpoint that does not exist.

- **Default state:** The value stored in the target status register<sup>Note</sup> is returned only when the GET\_STATUS() request has been received and when the request is for a device or Endpoint0; otherwise a STALL response is made in the data stage.
- **Addressed state:** The value stored in the target status register<sup>Note</sup> is returned only when the GET\_STATUS() request has been received and when the request is for a device or Endpoint0; otherwise a STALL response is made in the data stage.
- **Configured state:** The value stored in the target status register<sup>Note</sup> is returned only when the GET\_STATUS() request has been received and when the request is for a device or an endpoint that exists; otherwise a STALL response is made in the data stage.

**Note** The target status register is as follows.

- If the target is a device: UF0 device status register L (UF0DSTL)
- If the target is endpoint 0: UF0 EP0 status register L (UF0E0SL)
- If the target is endpoint n: UF0 EPn status register L (UF0EnSL) (n = 1 to 4, 7, 8)

**(f) SET\_ADDRESS() request**

A STALL response is made in the status stage if either of wIndex or wLength is other than the values shown in Table 11-2. A STALL response is also made if the specified device address is greater than 127.

- **Default state:** The device enters the Addressed state and changes the USB Address value to be input to SIE into a specified address value if the specified address is other than 0 when the SET\_ADDRESS() request has been received. If the specified address is 0, the device remains in the Default state.
- **Addressed state:** The device enters the Default state and returns the USB Address value to be input to SIE to the default address if the specified address is 0 when the SET\_ADDRESS() request has been received. If the specified address is other than 0, the device remains in the Addressed state, and changes the USB Address value to be input to SIE into a specified new address value.
- **Configured state:** The device remains in the Configured state and returns the USB Address value to be input to SIE to the default address if the specified address is 0 when the SET\_ADDRESS() request has been received. In this case, the endpoints other than endpoint 0 remain valid, and control transfer (IN), control transfer (OUT), bulk transfer and interrupt transfer for an endpoint other than endpoint 0 are also acknowledged. If the specified address is other than 0, the device remains in the Configured state and changes the USB Address value to be input to SIE into a specified new address value.

**(g) SET\_CONFIGURATION() request**

If any of wValue, wIndex, or wLength is other than the values shown in Table 11-2, a STALL response is made in the status stage.

- **Default state:** The CONF bit of the UF0 mode status register (UF0MODS) and the UF0 configuration register (UF0CNF) are set to 1 if the specified configuration value is 1 when the SET\_CONFIGURATION() request has been received. If the specified configuration value is 0, the CONF bit of the UF0MODS register and UF0CNF register are cleared to 0. In other words, the device skips the Addressed state and moves to the Configured state in which it responds to the Default address.
- **Addressed state:** The CONF bit of the UF0MODS register and UF0CNF register are set to 1 and the device enters the Configured state if the specified configuration value is 1 when the SET\_CONFIGURATION() request has been received. If the specified configuration value is 0, the device remains in the Addressed state.
- **Configured state:** The CONF bit of the UF0MODS register and UF0CNF register are set to 1 and the device returns to the Addressed state if the specified configuration value is 0 when the SET\_CONFIGURATION() request has been received. If the specified configuration value is 1, the device remains in the Configured state.

If the SET\_CONFIGURATION() request has been correctly processed, the target bit of the UF0 SET request register (UF0SET) is set to 1, and an interrupt is issued. All Halt Features are cleared after the SET\_CONFIGURATION() request has been completed even if the specified configuration value is the same as the current configuration value. If the SET\_CONFIGURATION() request has been correctly processed, the data toggle of all endpoints is always initialized to DATA0 again (it is defined that the default status, Alternative Setting 0, is set from when the SET\_CONFIGURATION request is received to when the SET\_INTERFACE request is received).

**(h) SET\_FEATURE() request**

A STALL response is made in the status stage if the SET\_FEATURE() request is for a Feature that cannot be set or does not exist, or if the target is an interface or an endpoint that does not exist. A STALL response is also made if the wLength value is other than 0.

- **Default state:** The correct response is made when the SET\_FEATURE() request has been received, only if the request is for a device or Endpoint0; otherwise a STALL response is made in the status stage.
- **Addressed state:** The correct response is made when the SET\_FEATURE() request has been received, only if the request is for a device or Endpoint0; otherwise a STALL response is made in the status stage.
- **Configured state:** The correct response is made when the SET\_FEATURE() request has been received, only if the request is for a device or an endpoint that exists; otherwise a STALL response is made in the status stage.

When the SET\_FEATURE() request has been correctly processed, the target bit of the UF0 SET request register (UF0SET) and the EnHALT bit of the UF0 EPn status register L (UF0EnSL) are set to 1, and an interrupt is issued (n = 0 to 4, 7, 8).

**(i) SET\_INTERFACE() request**

If wLength is other than the values shown in Table 11-2, if wIndex is other than the value set to the UF0 active interface number register (UF0AIFN), or if wValue is other than the value set to the UF0 active alternative setting register (UF0AAS), a STALL response is made in the status stage.

- Default state: A STALL response is made in the status stage when the SET\_INTERFACE() request has been received.
- Addressed state: A STALL response is made in the status stage when the SET\_INTERFACE() request has been received.
- Configured state: Null packet is transmitted in the status stage when the SET\_INTERFACE() request has been received.

When the SET\_INTERFACE() request has been correctly processed, an interrupt is issued. All the Halt Features of the endpoint linked to the target Interface are cleared after the SET\_INTERFACE() request has been cleared. The data toggle of all the endpoints related to the target Interface number is always initialized again to DATA0. When the currently selected Alternative Setting is to be changed by correctly processing the SET\_INTERFACE() request, the FIFO of the endpoint that is affected is completely cleared, and all the related interrupt sources are also initialized.

When the SET\_INTERFACE() request has been completed, the FIFO of all the endpoints linked to the target Interface are cleared. At the same time, Halt Feature and Data PID are initialized, and the related UF0 INT status n register (UF0ISn) is cleared to 0 (n = 0 to 4). (Only Halt Feature and Data PID are cleared when the SET\_CONFIGURATION request has been completed.)

If the target Endpoint is not supported by the SET\_INTERFACE() request during DMA transfer, the DMA request signal is immediately deasserted, and the FIFO of the Endpoint that has been linked when the SET\_INTERFACE() request has been completed is completely cleared. As a result of this clearing of the FIFO, data transferred by DMA is not correctly processed.

**11.3.2 Other requests****(1) Response and processing**

The following table shows how other requests are responded to and processed.

**Table 11-3. Response and Processing of Other Requests**

| Request                 | Response and Processing                |
|-------------------------|----------------------------------------|
| GET_DESCRIPTOR String   | Generation of CPUDEC interrupt request |
| GET_STATUS Interface    | Automatic STALL response               |
| CLEAR_FEATURE Interface | Automatic STALL response               |
| SET_FEATURE Interface   | Automatic STALL response               |
| all SET_DESCRIPTOR      | Generation of CPUDEC interrupt request |
| All other requests      | Generation of CPUDEC interrupt request |

## 11.4 Register Configuration

### 11.4.1 Control registers

#### (1) UF0 EP0NAK register (UF0E0N)

This register controls NAK of Endpoint0 (except an automatically executed request).

This register can be read or written in 8-bit units (however, bit 0 can only be read).

It takes five USB clocks to reflect the status on this register after the UF0FIC0 and UF0FIC1 registers have been set. If it is necessary to read the status correctly, therefore, separate a write signal that accesses the UF0FIC0 and UF0FIC1 registers from a read signal that accesses the UF0EPS0, UF0EPS1, UF0EPS2, UF0E0N, and UF0EN registers by at least four USB clocks.

While NAK is being transmitted to Endpoint0 Read, Endpoint2, and Endpoint4, a write access to the EP0NKR bit is ignored.

|        | 7 | 6 | 5 | 4 | 3 | 2 | 1      | 0      | Address    | After reset |
|--------|---|---|---|---|---|---|--------|--------|------------|-------------|
| UF0E0N | 0 | 0 | 0 | 0 | 0 | 0 | EP0NKR | EP0NKR | FFFFFFE00H | 00H         |

| Bit position | Bit name | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|--------------|----------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1            | EP0NKR   | <p>This bit controls NAK to the OUT token to Endpoint0 (except an automatically executed request). It is automatically set to 1 by hardware when Endpoint0 has correctly received data. It is also cleared to 0 by hardware when the data of the UF0E0R register has been read by FW (counter value = 0).</p> <p>1: Transmit NAK.<br/>0: Do not transmit NAK (default value).</p> <p>Set this bit to 1 by FW when data should not be received from the USB bus for some reason even when USBF is ready for receiving data. In this case, USBF continues transmitting NAK until this bit is cleared to 0 by FW. This bit is also cleared to 0 as soon as the UF0E0R register has been cleared.</p>                                                                                                                                                                                                                                                                                                                                                                                                    |
| 0            | EP0NKR   | <p>This bit indicates how NAK to the IN token to Endpoint0 is controlled (except an automatically executed request). This bit is automatically cleared to 0 by hardware when the data of Endpoint0 is transmitted and the host correctly receives the transmitted data. The data of the UF0E0W register is retained until this bit is cleared. Therefore, it is not necessary to rewrite this bit even in the case of a retransmission request that is made if the host could not receive data correctly. To send a short packet, be sure to set the E0DED bit of the UF0DEND register to 1. This bit is automatically set to 1 when the FIFO is full. As soon as the E0DED bit of the UF0DEND register is set to 1, the EP0NKR bit is automatically set to 1 at the same time.</p> <p>1: Do not transmit NAK.<br/>0: Transmit NAK (default value).</p> <p>If control transfer enters the status stage while ACK cannot be correctly received in the data stage, this bit is cleared to 0 as soon as the UF0E0W register is cleared. This bit is also cleared to 0 when UF0E0W is cleared by FW.</p> |

Next, the procedure of a SETUP transaction that uses IN/OUT tokens is explained below.

**(a) When IN token is used (except a request automatically executed by hardware)**

FW should be used to clear the PROT bit of the UF0IS1 register to 0 after receiving the CPUDEC interrupt and before reading data from the UF0E0ST register. Next, perform processing in accordance with the request and, if it is necessary to return data by an IN token, write data to the UF0E0W register. Confirm that the PROT bit of the UF0IS1 register is 0 after writing has been completed, and set the E0DED bit of the UF0DEND register to 1. The hardware sends out data at the first IN token after the EP0NKW bit has been set to 1. If the PROT bit of the UF0IS1 register is 1, it indicates that a SETUP transaction has occurred again before completion of control transfer. In this case, clear the PROT bit of the UF0IS1 register to 0 by clearing the PROTC bit of the UF0IC1 register to 0, and then read data from the UF0E0ST register again. A request received later can be read.

**(b) When OUT token is used (except a request automatically executed by hardware)**

FW should be used to clear the PROT bit of the UF0IS1 register after receiving the CPUDEC interrupt and before reading data from the UF0E0ST register. Confirm that the PROT bit of the UF0IS1 register is 0 before reading data from the UF0E0R register. If the PROT bit is 1, it means that invalid data is retained. Clear the FIFO by FW (the EP0NKR bit is automatically cleared to 0). If the PROT bit of the UF0IS1 register is 0, read the data of the UF0E0L register and read as many data from the UF0E0R register as set. When reading data from the UF0E0R register has been completed (when the counter of the UF0E0R register has been cleared to 0), the hardware automatically clears the EP0NKR bit to 0.

**(2) UF0 EP0NAKALL register (UF0E0NA)**

This register controls NAK to all the requests of Endpoint0. It is also valid for automatically executed requests.

This register can be read or written in 8-bit units.

|         | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0      | Address    | After reset |
|---------|---|---|---|---|---|---|---|--------|------------|-------------|
| UF0E0NA | 0 | 0 | 0 | 0 | 0 | 0 | 0 | EP0NKA | FFFFFFE01H | 00H         |

| Bit position | Bit name | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|--------------|----------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 0            | EP0NKA   | <p>This bit controls NAK to a transaction other than a SETUP transaction to Endpoint0 (including an automatically executed request). This bit is manipulated by FW.</p> <p>1: Transmit NAK.<br/>0: Do not transmit NAK (default value).</p> <p>This register is used to prevent a conflict between a write access by FW and a read access from SIE when the data used for an automatically executed request is to be changed. It postpones reflecting a write access on this bit from FW while an access from SIE is being made. Before rewriting the request data register from FW, confirm that this bit has been correctly set to 1.</p> <p>Setting this bit to 1 is reflected only in the following cases.</p> <ul style="list-style-type: none"> <li>Immediately after USBF has been reset and a SETUP token has never been received</li> <li>Immediately after reception of Bus Reset and a SETUP token has never been received</li> <li>PID of a SETUP token has been detected</li> <li>The stage has been changed to the status stage</li> </ul> <p>Clearing this bit to 0 is reflected immediately, except while an IN token is being received and a NAK response is being made.</p> <p>Setting the EP0NKA bit to 1 is reflected in the above four cases during Endpoint0 transfer, but it is reflected immediately after data has been written to the bit while Endpoint0 is transferring no data.</p> |



**(3) UF0 EPNAK register (UF0EN)**

This register controls NAK of endpoints other than Endpoint0.

This register can be read or written in 8-bit units (however, bits 5, 4, 1, and 0 can only be read).

The BKO2NK bit can be written only when the BKO2NKM bit of the UF0ENM register is 1 and the BKO1NK bit can be written only when the BKO1NKM bit of the UF0ENM register is 1.

The related bits are invalid if each endpoint is not supported by the setting of the UF0EnIM register (n = 1 to 4, 7, 8) and the current setting of the interface.

It takes five USB clocks to reflect the status on this register after the UF0FIC0 and UF0FIC1 registers have been set. If it is necessary to read the status correctly, therefore, separate a write signal that accesses the UF0FIC0 and UF0FIC1 registers from a read signal that accesses the UF0EPS0, UF0EPS1, UF0EPS2, UF0E0N, and UF0EN registers by at least four USB clocks.

While NAK is being transmitted to Endpoint0 Read, Endpoint2, and Endpoint4, a write access to the BKO1NK and BKO2NK bits is ignored.

Be sure to clear bits 7 and 6 to 0. If it is set to 1, the operation is not guaranteed.

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|       |  |  |  |  |  |  |  | Address   | After reset |
|-------|--|--|--|--|--|--|--|-----------|-------------|
|       |  |  |  |  |  |  |  | 7         | 6           |
|       |  |  |  |  |  |  |  | 5         | 4           |
|       |  |  |  |  |  |  |  | 3         | 2           |
|       |  |  |  |  |  |  |  | 1         | 0           |
| UF0EN |  |  |  |  |  |  |  | FFFFFE02H | 00H         |
|       |  |  |  |  |  |  |  | IT2NK     | IT1NK       |
|       |  |  |  |  |  |  |  | BKO2NK    | BKO1NK      |
|       |  |  |  |  |  |  |  | BKI2NK    | BKI1NK      |

| Bit position | Bit name | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|--------------|----------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 5            | IT2NK    | <p>This bit controls NAK to Endpoint8 (interrupt 2 transfer).<br/> It is automatically set to 1 and transmission is started when the UF0INT2 register has become full as a result of writing data to it. To send a short packet that does not make the FIFO full, set the IT2DEND bit of the UF0DEND register to 1. As soon as the IT2DEND bit has been set to 1, this bit is automatically set to 1.</p> <p>1: Do not transmit NAK.<br/> 0: Transmit NAK (default value).</p> <p>This bit is also cleared to 0 when the UF0INT2 register has been cleared.</p> |
| 4            | IT1NK    | <p>This bit controls NAK to Endpoint7 (interrupt 1 transfer).<br/> It is automatically set to 1 and transmission is started when the UF0INT1 register has become full as a result of writing data to it. To send a short packet that does not make the FIFO full, set the IT1DEND bit of the UF0DEND register to 1. As soon as the IT1DEND bit has been set to 1, this bit is automatically set to 1.</p> <p>1: Do not transmit NAK.<br/> 0: Transmit NAK (default value).</p> <p>This bit is also cleared to 0 when the UF0INT1 register has been cleared.</p> |

| Bit position | Bit name | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|--------------|----------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 3            | BKO2NK   | <p>This bit controls NAK to Endpoint4 (bulk 2 transfer (OUT)).</p> <p>1: Transmit NAK.<br/>0: Do not transmit NAK (default value).</p> <p>This bit is set to 1 only when the FIFO connected to the SIE side of the UF0BO2 register (64-byte FIFO of bank configuration) cannot receive data. It is cleared to 0 when a toggle operation is performed. The bank is changed (toggle operation) when the following conditions are satisfied.</p> <ul style="list-style-type: none"> <li>• Data correctly received is stored in the FIFO connected to the SIE side.</li> <li>• The value of the FIFO counter connected to the CPU side is 0 (completion of reading).</li> </ul> <p>FW should be used to read data of the UF0BO2L register when it has received the BLKO2DT interrupt request and read as many data from the UF0BO2 register as the value of that data. To not receive data from the USB bus for some reason even if USBF is ready to receive data, set this bit to 1 by FW. In this case, USBF keeps transmitting NAK until the FW clears this bit to 0. This bit is also cleared to 0 as soon as the UF0BO2 register has been cleared.</p> |
| 2            | BKO1NK   | <p>This bit controls NAK to Endpoint2 (bulk 1 transfer (OUT)).</p> <p>1: Transmit NAK.<br/>0: Do not transmit NAK (default value).</p> <p>This bit is set to 1 only when the FIFO connected to the SIE side of the UF0BO1 register (64-byte FIFO of bank configuration) cannot receive data. It is cleared to 0 when a toggle operation is performed. The bank is changed (toggle operation) when the following conditions are satisfied.</p> <ul style="list-style-type: none"> <li>• Data correctly received is stored in the FIFO connected to the SIE side.</li> <li>• The value of the FIFO counter connected to the CPU side is 0 (completion of reading).</li> </ul> <p>FW should be used to read data of the UF0BO1L register when it has received the BLKO1DT interrupt request and read as many data from the UF0BO1 register as the value of that data. To not receive data from the USB bus for some reason even if USBF is ready to receive data, set this bit to 1 by FW. In this case, USBF keeps transmitting NAK until the FW clears this bit to 0. This bit is also cleared to 0 as soon as the UF0BO1 register has been cleared.</p> |

- Cautions**
1. If DMA is enabled while data is being read from the UF0BO2 register in the PIO mode, a DMA request is immediately issued.
  2. If the last data of the FIFO on the CPU side is read in the DMA transfer mode, the DMA request signal becomes inactive.
  3. If the TC signal is received in the DMA transfer mode, the DMA request signal becomes inactive.

| Bit position | Bit name | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|--------------|----------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1            | BKI2NK   | <p>This bit controls NAK to Endpoint3 (bulk 2 transfer (IN)).</p> <p>1: Do not transmit NAK.<br/>0: Transmit NAK (default value).</p> <p>This bit is cleared to 0 only when the FIFO connected to the SIE side of the UF0BI2 register (64-byte FIFO of bank configuration) cannot receive data. It is set to 1 when a toggle operation is performed (the data of the UF0BI2 register is retained until transmission has been correctly completed). The bank is changed (toggle operation) when the following conditions are satisfied.</p> <ul style="list-style-type: none"> <li>• Data is correctly written to the FIFO connected to the CPU bus side (writing has been completed and the FIFO is full or the UF0DEND register is set).</li> <li>• The value of the FIFO counter connected to the SIE side is 0.</li> </ul> <p>This bit is automatically set to 1 and data transmission is started when the FIFO on the CPU side becomes full and a FIFO toggle operation is performed as a result of writing data to the FIFO. However, if the FIFO on the CPU side becomes full as a result of writing data to it by DMA while the BKI2T bit of the UF0DEND register is cleared to 0, the toggle operation is not performed because the condition of the toggle operation is not satisfied until the BKI2DED bit of the UF0DEND register is set to 1. To send a short packet that does not make the FIFO on the CPU side full, set the BKI2DED bit to 1 after completing writing data. When the BKI2DED bit is set to 1, a toggle operation is performed and at the same time, this bit is automatically set to 1. This bit is also cleared to 0 as soon as the UF0BI2 register has been cleared.</p> |

- Cautions**
1. If DMA is enabled while data is being written to the UF0BI2 register in the PIO mode, a DMA request is immediately issued.
  2. If 64-byte data is written in the DMA transfer mode, the DMA request signal becomes inactive. If the BKI2NK bit is then set to 1, data is transmitted in synchronization with an IN token. The DMA request signal becomes active again as long as the DMA request is not masked as soon as the FIFO is toggled. If the BKI2NK bit is not set, data is not transmitted even if an IN token has been received. In this case, set the BKI2DED bit of the UF0DEND register to 1.
  3. If the TC signal is received in the DMA transfer mode, the DMA request signal becomes inactive. At the same time, the DMA request is masked. If the BKI2NK bit is not set to 1, data is not transmitted even if an IN token is received. When the BKI2DED bit of the UF0DEND register is set to 1 by FW, data is transmitted in synchronization with the IN token. To execute DMA transfer again, unmask the DMA request.

| Bit position | Bit name | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
|--------------|----------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 0            | BK11NK   | <p>This bit controls NAK to Endpoint1 (bulk 1 transfer (IN)).</p> <p>1: Do not transmit NAK.</p> <p>0: Transmit NAK (default value).</p> <p>This bit is cleared to 0 only when the FIFO connected to the SIE side of the UF0BI1 register (64-byte FIFO of bank configuration) cannot receive data. It is set to 1 when a toggle operation is performed (the data of the UF0BI1 register is retained until transmission has been correctly completed). The bank is changed (toggle operation) when the following conditions are satisfied.</p> <ul style="list-style-type: none"> <li>• Data is correctly written to the FIFO connected to the CPU bus side (writing has been completed and the FIFO is full or the UF0DEND register is set).</li> <li>• The value of the FIFO counter connected to the SIE side is 0.</li> </ul> <p>This bit is automatically set to 1 and data transmission is started when the FIFO on the CPU side becomes full and a FIFO toggle operation is performed as a result of writing data to the FIFO. However, if the FIFO on the CPU side becomes full as a result of writing data to it by DMA while the BK11T bit of the UF0DEND register is cleared to 0, the toggle operation is not performed because the condition of the toggle operation is not satisfied until the BK11DED bit of the UF0DEND register is set to 1. To send a short packet that does not make the FIFO on the CPU side full, set the BK11DED bit to 1 after completing writing data. When the BK11DED bit is set to 1, a toggle operation is performed and at the same time, this bit is automatically set to 1. This bit is also cleared to 0 as soon as the UF0BI1 register has been cleared.</p> |

- Cautions**
1. If DMA is enabled while data is being written to the UF0BI1 register in the PIO mode, a DMA request is immediately issued.
  2. If 64-byte data is written in the DMA transfer mode, the DMA request signal becomes inactive. If the BK11NK bit is then set to 1, data is transmitted in synchronization with an IN token. The DMA request signal becomes active again as long as the DMA request is not masked as soon as the FIFO is toggled. If the BK11NK bit is not set, data is not transmitted even if an IN token has been received. In this case, set the BK11DED bit of the UF0DEND register to 1.
  3. If the TC signal is received in the DMA transfer mode, the DMA request signal becomes inactive. At the same time, the DMA request is masked. If the BK11NK bit is not set to 1, data is not transmitted even if an IN token is received. When the BK11DED bit of the UF0DEND register is set to 1 by FW, data is transmitted in synchronization with the IN token. To execute DMA transfer again, unmask the DMA request.

**(4) UF0 EPNACK mask register (UF0ENM)**

This register controls masking a write access to the UF0EN register.

This register can be read or written in 8-bit units.

Be sure to clear bits 7 to 4, 1, and 0. If it is set to 1, the operation is not guaranteed.

|        |   |   |   |   |         |         |   |   |           |             |
|--------|---|---|---|---|---------|---------|---|---|-----------|-------------|
|        | 7 | 6 | 5 | 4 | 3       | 2       | 1 | 0 | Address   | After reset |
| UF0ENM | 0 | 0 | 0 | 0 | BKO2NKM | BKO1NKM | 0 | 0 | FFFFFE03H | 00H         |

| Bit position | Bit name | Function                                                                                                                                           |
|--------------|----------|----------------------------------------------------------------------------------------------------------------------------------------------------|
| 3            | BKO2NKM  | This bit specifies whether a write access to bit 3 (BKO2NK) of the UF0EN register is masked or not.<br>1: Do not mask.<br>0: Mask (default value). |
| 2            | BKO1NKM  | This bit specifies whether a write access to bit 2 (BKO1NK) of the UF0EN register is masked or not.<br>1: Do not mask.<br>0: Mask (default value). |

**(5) UF0 SNDSIE register (UF0SDS)**

This register performs manipulation such as no handshake. It can directly manipulate the pins of SIE.

This register can be read or written in 8-bit units.

Be sure to clear bit 2 to 0. If it is set to 1, the operation is not guaranteed.

|        | 7 | 6 | 5 | 4 | 3      | 2 | 1 | 0      | Address    | After reset |
|--------|---|---|---|---|--------|---|---|--------|------------|-------------|
| UF0SDS | 0 | 0 | 0 | 0 | SNDSTL | 0 | 0 | RSUMIN | FFFFFFE04H | 00H         |

| Bit position | Bit name | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|--------------|----------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 3            | SNDSTL   | <p>This bit makes Endpoint0 issue a STALL handshake. Setting this bit to 1 if a request for CPUDEC processing is not supported by the system results in a STALL handshake response. If an unsupported wValue is sent by the SET_CONFIGURATION or SET_INTERFACE request, the hardware sets this bit to 1. If a problem occurs in Endpoint0 due to overrun of an automatically executed request, this bit is also set to 1. However, the E0HALT bit of the UF0E0SL register is not set to 1.</p> <p>1: Respond with STALL handshake.<br/>0: Do not respond with STALL handshake (default value).</p> <p>This bit is cleared to 0 and the handshake response to the bus is other than STALL when the next SETUP token is received. To set the SNDSTL bit to 1 by FW, do not write data to the UF0E0W register. Depending on the timing of setting this bit, the STALL response is not made in time, and it may be made to the next transfer after a NAK response has been made.</p> <p>Setting this bit is valid only while an FW-executed request is under execution when this bit is set to 1. It is automatically cleared to 0 when the next SETUP token is received.</p> <p><b>Remark</b> The SNDSTL bit is valid only for an FW-executed request.</p> |
| 0            | RSUMIN   | <p>This bit outputs the Resume signal onto the USB bus. Writing this bit is invalid unless the RMWK bit of the UF0DSTL register is set to 1.</p> <p>1: Generate the Resume signal.<br/>0: Do not generate the Resume signal (default value).</p> <p>While this bit is set to 1, the Resume signal continues to be generated. Clear this bit to 0 by FW after a specific time has elapsed. Because the signal is internally sampled at the clock, the operation is guaranteed only while CLK is supplied. Care must be exercised when CLK of the system is stopped.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |

**(6) UF0 CLR request register (UF0CLR)**

This register indicates the target of the received CLEAR\_FEATURE request.

This register is read-only, in 8-bit units.

This register is meaningful only when an interrupt request is generated. Each bit is set to 1 after completion of the status stage, and automatically cleared to 0 when this register is read.

The related bits are invalid if each endpoint is not supported by the setting of the UF0EnIM register (n = 1 to 4, 7, 8) and the current setting of the interface.

|        |        |        |        |        |        |        |        |        |           |             |
|--------|--------|--------|--------|--------|--------|--------|--------|--------|-----------|-------------|
|        | 7      | 6      | 5      | 4      | 3      | 2      | 1      | 0      | Address   | After reset |
| UF0CLR | CLREP8 | CLREP7 | CLREP4 | CLREP3 | CLREP2 | CLREP1 | CLREP0 | CLRDEV | FFFFFE05H | 00H         |

| Bit position | Bit name | Function                                                                                                                                                                             |
|--------------|----------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 7 to 1       | CLREPN   | These bits indicate that a CLEAR_FEATURE Endpoint n request is received and automatically processed.<br>1: Automatically processed<br>0: Not automatically processed (default value) |
| 0            | CLRDEV   | This bit indicates that a CLEAR_FEATURE Device request is received and automatically processed.<br>1: Automatically processed<br>0: Not automatically processed (default value)      |

**Remark** n = 0 to 4, 7, 8

**(7) UF0 SET request register (UF0SET)**

This register indicates the target of the automatically processed SET\_XXXX (except SET\_INTERFACE) request.

This register is read-only, in 8-bit units.

This register is meaningful only when an interrupt request is generated. Each bit is set to 1 after completion of the status stage, and automatically cleared to 0 when this register is read.

|        | 7      | 6 | 5 | 4 | 3 | 2     | 1 | 0      | Address    | After reset |
|--------|--------|---|---|---|---|-------|---|--------|------------|-------------|
| UF0SET | SETCON | 0 | 0 | 0 | 0 | SETEP | 0 | SETDEV | FFFFFFE06H | 00H         |

| Bit position | Bit name | Function                                                                                                                                                                                             |
|--------------|----------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 7            | SETCON   | This bit indicates that a SET_CONFIGURATION request is received and automatically processed.<br>1: Automatically processed<br>0: Not automatically processed (default value)                         |
| 2            | SETEP    | This bit indicates that a SET_FEATURE Endpoint n request (n = 0 to 4, 7, 8) is received and automatically processed.<br>1: Automatically processed<br>0: Not automatically processed (default value) |
| 0            | SETDEV   | This bit indicates that a SET_FEATURE Device request is received and automatically processed.<br>1: Automatically processed<br>0: Not automatically processed (default value)                        |



**(8) UF0 EP status 0 register (UF0EPS0)**

This register indicates the USB bus status and the presence or absence of register data.

This register is read-only, in 8-bit units.

The related bits are invalid if each endpoint is not supported by the setting of the UF0EnIM register (n = 1 to 4, 7, 8) and the current setting of the interface.

It takes five USB clocks to reflect the status on this register after the UF0FIC0 and UF0FIC1 registers have been set. If it is necessary to read the status correctly, therefore, separate writing to the UF0FIC0 and UF0FIC1 registers from reading from the UF0EPS0, UF0EPS1, UF0EPS2, UF0E0N, and UF0EN registers by at least four USB clocks.

(1/2)

|         | 7   | 6   | 5      | 4      | 3     | 2     | 1    | 0    | Address    | After reset |
|---------|-----|-----|--------|--------|-------|-------|------|------|------------|-------------|
| UF0EPS0 | IT2 | IT1 | BKOUT2 | BKOUT1 | BKIN2 | BKIN1 | EP0W | EP0R | FFFFFFE07H | 00H         |

| Bit position | Bit name | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|--------------|----------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 7, 6         | ITn      | <p>These bits indicate that data is in the UF0INTn register (FIFO). By setting the ITnDED bit of the UF0DEND register to 1, the status in which data is in the UF0INTn register can be created even if data is not written to the register (Null data transmission). As soon as the ITnDED bit of the UF0DEND register is set to 1 even when the counter of the UF0INTn register is 0, this bit is set to 1 by hardware. It is cleared to 0 after correct transmission.</p> <p>1: Data is in the register.<br/>0: No data is in the register (default value).</p>                                      |
| 5, 4         | BKOUTn   | <p>These bits indicate that data is in the UF0BOn register (FIFO) connected to the CPU side. When the FIFO configuring the UF0BOn register is toggled, this bit is automatically set to 1 by hardware. It is automatically cleared to 0 by hardware when reading the UF0BOn register (FIFO) connected to the CPU side has been completed (counter value = 0). It is not set to 1 when Null data is received (toggling the FIFO does not take place either).</p> <p>1: Data is in the register.<br/>0: No data is in the register (default value).</p>                                                  |
| 3, 2         | BKINn    | <p>These bits indicate that data is in the UF0BIn register (FIFO) connected to the CPU side. By setting the BKInDED bit of the UF0DEND register to 1, the status in which data is in the UF0BIn register can be created even if data is not written to the register (Null data transmission). As soon as the BKInDED bit of the UF0DEND register has been set to 1 while the counter of the UF0BIn register is 0, this bit is set to 1 by hardware. It is cleared to 0 when a toggle operation is performed.</p> <p>1: Data is in the register.<br/>0: No data is in the register (default value).</p> |

**Remark** n = 1, 2

(2/2)

| Bit position | Bit name | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|--------------|----------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1            | EP0W     | <p>This bit indicates that data is in the UF0E0W register (FIFO). By setting the E0DED bit of the UF0DEND register to 1, the status in which data is in the UF0E0W register can be created even if data is not written to the register (Null data transmission). As soon as the E0DED bit of the UF0DEND register is set to 1 even when the counter of the UF0E0W register is 0, this bit is set to 1 by hardware. It is cleared to 0 after correct transmission.</p> <p>1: Data is in the register.<br/>0: No data is in the register (default value).</p> |
| 0            | EP0R     | <p>This bit indicates that data is in the UF0E0R register (FIFO). It is automatically cleared to 0 by hardware when reading the UF0E0R register (FIFO) has been completed (counter value = 0). It is not set to 1 if Null data is received.</p> <p>1: Data is in the register.<br/>0: No data is in the register (default value).</p>                                                                                                                                                                                                                       |

**(9) UF0 EP status 1 register (UF0EPS1)**

This register indicates the USB bus status and the presence or absence of register data.

This register is read-only, in 8-bit units.

|         | 7    | 6 | 5 | 4 | 3 | 2 | 1 | 0 | Address    | After reset |
|---------|------|---|---|---|---|---|---|---|------------|-------------|
| UF0EPS1 | RSUM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | FFFFFFE08H | 00H         |

| Bit position | Bit name | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|--------------|----------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 7            | RSUM     | <p>This bit indicates that the USB bus is in the Resume status. This bit is meaningful only when an interrupt request is generated.</p> <p>1: Suspend status<br/>0: Resume status (default value)</p> <p>Because sampling is internally performed with the clock, the operation is guaranteed only when CLK is supplied. Care must be exercised when CLK of the system is stopped. The INTRSUM signal of SIE operates even when CLK is stopped. It can therefore be supported by making the interrupt control register (RSUMIC) valid or lowering the frequency of CLK to the USBF.</p> <p>This bit is automatically cleared to 0 when it is read.</p> |

**(10) UF0 EP status 2 register (UF0EPS2)**

This register indicates the USB bus status and the presence or absence of register data.

This register is read-only, in 8-bit units.

The related bits are invalid if each endpoint is not supported by the setting of the UF0EnIM register (n = 1 to 4, 7, 8) and the current setting of the interface.

|         | 7 | 6     | 5     | 4     | 3     | 2     | 1     | 0     | Address    | After reset |
|---------|---|-------|-------|-------|-------|-------|-------|-------|------------|-------------|
| UF0EPS2 | 0 | HALT8 | HALT7 | HALT4 | HALT3 | HALT2 | HALT1 | HALT0 | FFFFFFE09H | 00H         |

| Bit position | Bit name | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|--------------|----------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 6 to 0       | HALTn    | <p>These bits indicate that Endpoint n is currently stalled. They are set to 1 when a stall condition, such as occurrence of an overrun and reception of an undefined request, is satisfied. These bits are automatically set to 1 by hardware.</p> <p>1: Endpoint is stalled.<br/>0: Endpoint is not stalled (default value).</p> <p>The SNDSTL bit is set to 1 as soon as the HALT0 bit has been set to 1 as a result of occurrence of an overrun or reception of an undefined request. If the next SETUP token is received in this status, the SNDSTL bit is cleared to 0 and, therefore, the HALT0 bit is also cleared to 0. If Endpoint0 is stalled by the SET_FEATURE Endpoint0 request, this bit is not cleared to 0 until the CLEAR_FEATURE Endpoint0 request is received or Halt Feature is cleared by FW. If the GET_STATUS Endpoint0, CLEAR_FEATURE Endpoint0, or SET_FEATURE Endpoint0 request is received, or if a request to be processed by FW is received due to the CPUDEC interrupt request, the HALT0 bit is masked and cleared to 0, until the next SETUP token is received.</p> <p>The HALTn bit is not cleared to 0 until Endpoint n receives the CLEAR_FEATURE Endpoint request, Halt Feature is cleared by the SET_INTERFACE or SET_CONFIGURATION request to the interface to which the endpoint is linked, or Halt Feature is cleared by FW. When the SET_INTERFACE or SET_CONFIGURATION request is correctly processed, the Halt Feature of all the target endpoints, except Endpoint0, is cleared after the request has been processed, even if the wValue is the same as the currently set value, and these bits are also cleared to 0. Halt Feature of Endpoint0 cannot be cleared if it is set because the STALL response is made in response to the SET_INTERFACE and SET_CONFIGURATION requests.</p> |

**Remark** n = 0 to 4, 7, 8

**(11) UF0 INT status 0 register (UF0IS0)**

This register indicates the interrupt source. If the contents of this register are changed, the INTUSB0B signal becomes active.

This register is read-only, in 8-bit units.

If an interrupt request (INTUSB0B) is generated from USBF, the FW must read this register to identify the interrupt source.

Each bit of this register is forcibly cleared to 0 when 0 is written to the corresponding bit of the UF0IC0 register.

(1/2)

|        |        |        |   |       |       |       |       |        |            |             |
|--------|--------|--------|---|-------|-------|-------|-------|--------|------------|-------------|
|        | 7      | 6      | 5 | 4     | 3     | 2     | 1     | 0      | Address    | After reset |
| UF0IS0 | BUSRST | RSUSPD | 0 | SHORT | DMAED | SETRQ | CLRRQ | EPHALT | FFFFFFE10H | 00H         |

| Bit position | Bit name | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|--------------|----------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 7            | BUSRST   | This bit indicates that Bus Reset has occurred.<br>1: Bus Reset has occurred (interrupt request is generated).<br>0: Not Bus Reset status (default value)                                                                                                                                                                                                                                                                                                                                                   |
| 6            | RSUSPD   | This bit indicates that the Resume or Suspend status has occurred. Reference bit 7 of the UF0EPS1 register by FW.<br>1: Resume or Suspend status has occurred (interrupt request is generated).<br>0: Resume or Suspend status has not occurred (default value).                                                                                                                                                                                                                                            |
| 4            | SHORT    | This bit indicates that data is read from the FIFO of either the UF0BO1 or UF0BO2 register and that the USBSPnB signal (n = 2, 4) is active. It is valid only when the FIFO is full in the DMA mode.<br>1: USBSPnB signal is active (interrupt request is generated).<br>0: USBSPnB signal is not active (default value).<br>Identify on which endpoint the operation is performed, by using the UF0DMS1 register. This bit is not automatically cleared to 0 even when the UF0DMS1 register is read by FW. |

| Bit position | Bit name | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|--------------|----------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 3            | DMAED    | <p>This bit indicates that the DMA end (TC) signal for Endpoint n (n = 1 to 4, 7, 8) is active.</p> <p>1: DMA end signal for Endpoint n has been input (interrupt request is generated).</p> <p>0: DMA end signal for Endpoint n has not been input (default value).</p> <p>When this bit is set to 1, the DMA request signal for Endpoint n becomes inactive. The DMA request signal for Endpoint n does not become active unless FW enables DMA transfer.</p> <p>Use the UF0DMS0 register to confirm on which endpoint the operation is actually performed. However, this bit is not automatically cleared to 0 even if the UF0DMS0 register is read by FW.</p>                                                                                                                                                                                                                                                                                                        |
| 2            | SETRQ    | <p>This bit indicates that the SET_XXXX request to be automatically processed has been received and automatically processed (XXXX = CONFIGURATION or FEATURE).</p> <p>1: SET_XXXX request to be automatically processed has been received (interrupt request is generated).</p> <p>0: SET_XXXX request to be automatically processed has not been received (default value).</p> <p>This bit is set to 1 after completion of the status stage. Reference the UF0SET register to identify what is the target of the request. This bit is not automatically cleared to 0 even if the UF0SET register is read by FW.</p> <p>The EPHALT bit is also set to 1 when the SET_FEATURE Endpoint request has been received.</p>                                                                                                                                                                                                                                                     |
| 1            | CLRRQ    | <p>This bit indicates that the CLEAR_FEATURE request has been received and automatically processed.</p> <p>1: CLEAR_FEATURE request has been received (interrupt request is generated).</p> <p>0: CLEAR_FEATURE request has not been received (default value).</p> <p>This bit is set to 1 after completion of the status stage. Reference the UF0CLR register to identify what is the target of the request. This bit is not automatically cleared to 0 even if the UF0CLR register is read by FW.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| 0            | EPHALT   | <p>This bit indicates that an endpoint has stalled.</p> <p>1: Endpoint has stalled (interrupt request is generated).</p> <p>0: Endpoint has not stalled (default value).</p> <p>This bit is also set to 1 when an endpoint has stalled by setting FW.</p> <p>Identify the endpoint that has stalled, by referencing the UF0EPS2 register. This bit is not automatically cleared to 0 even when the CLEAR_FEATURE Endpoint, SET_INTERFACE, or SET_CONFIGURATION request is received. It is not automatically cleared to 0, either, if the next SETUP token is received in case of overrun of Endpoint0.</p> <p><b>Caution</b> Even if Halt Feature of Endpoint0 is set and this interrupt request is generated, bit 0 of the UF0EPS2 register is masked and cleared to 0 between when a SET_FEATURE Endpoint0, CLEAR_FEATURE Endpoint0, or GET_STATUS Endpoint0 request, or FW-processed request is received and when a SETUP token other than the above is received.</p> |

**(12) UF0 INT status 1 register (UF0IS1)**

This register indicates the interrupt source. If the contents of this register are changed, the INTUSB0B signal becomes active.

This register is read-only, in 8-bit units.

If an interrupt request (INTUSB0B) is generated from USBF, the FW must read this register to identify the interrupt source.

Each bit of this register is forcibly cleared to 0 when 0 is written to the corresponding bit of the UF0IC1 register. However, the SUCES and STG bits of the UF0IS1 register are automatically cleared to 0 when the next SETUP token has been received.

(1/2)

| UF0IS1 | 7 | 6    | 5      | 4     | 3     | 2   | 1    | 0          | Address   | After reset |
|--------|---|------|--------|-------|-------|-----|------|------------|-----------|-------------|
|        | 0 | E0IN | E0INDT | E0ODT | SUCES | STG | PROT | CPU<br>DEC | FFFFFE11H | 00H         |

| Bit position | Bit name | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|--------------|----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 6            | E0IN     | This bit indicates that an IN token for Endpoint0 has been received and that the hardware has automatically transmitted NAK.<br>1: IN token is received and NAK is transmitted (interrupt request is generated).<br>0: IN token is not received (default value).                                                                                                                                                                                                                                                                                                                                                                                         |
| 5            | E0INDT   | This bit indicates that data has been correctly transmitted from the UF0E0W register.<br>1: Transmission from UF0E0W register is completed (interrupt request is generated).<br>0: Transmission from UF0E0W register is not completed (default value).<br>Data is transmitted in synchronization with the IN token next to the one that set the EP0NKW bit of the UF0E0N register to 1. This bit is automatically set to 1 by hardware when the host correctly receives that data. It is also set to 1 even if the data is a Null packet. This bit is automatically cleared to 0 by hardware when the first write access is made to the UF0E0W register. |
| 4            | E0ODT    | This bit indicates that data has been correctly received in the UF0E0R register.<br>1: Data is in UF0E0R register (interrupt request is generated).<br>0: Data is not in UF0E0R register (default value).<br>This bit is automatically set to 1 by hardware when data has been correctly received. At the same time, the EP0R bit of the UF0EPS0 register is also set to 1. If a Null packet has been received, this bit is not set to 1. It is automatically cleared to 0 by hardware when the FW reads the UF0E0R register and the value of the UF0E0L register becomes 0.                                                                             |
| 3            | SUCES    | This bit indicates that either an FW-processed or hardware-processed request has been received and that the status stage has been correctly completed.<br>1: Control transfer has been correctly processed (interrupt request is generated).<br>0: Control transfer has not been processed correctly (default value).<br>This bit is set to 1 upon completion of the status stage. It is automatically cleared to 0 by hardware when the next SETUP token is received.<br>This bit is also set to 1 when data with Data PID of 0 (Null data) is received in the status stage of control transfer.                                                        |

| Bit position | Bit name | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|--------------|----------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 2            | STG      | <p>This bit is set to 1 when the stage of control transfer has changed to the status stage. It is valid for both FW-processed and hardware-processed requests. This bit is also set to 1 when the stage of control transfer (without data) has changed to the status stage.</p> <p>1: Status stage (interrupt request is generated)<br/>0: Not status stage (default value)</p> <p>This bit is automatically cleared to 0 by hardware when the next SETUP token is received.</p> <p>It is also set to 1 when the stage of control transfer has changed to the status stage while ACK cannot be correctly received in the data stage. In this case, the EPONKW bit of the UF0E0N register is also cleared to 0 as soon as the UF0E0W register has been cleared, if the FW is processing control transfer (read).</p>                                                                                   |
| 1            | PROT     | <p>This bit indicates that a SETUP token has been received. It is valid for both FW-processed and hardware-processed requests.</p> <p>1: SETUP token is correctly received (interrupt request is generated).<br/>0: SETUP token is not received (default value).</p> <p>This bit is set to 1 when data has been correctly received in the UF0E0ST register. Clear this bit to 0 by FW when the first read access is made to the UF0E0ST register. If it is not cleared to 0 by FW, reception of the next SETUP token cannot be correctly recognized.</p> <p>This bit is used to accurately recognize that a SETUP transaction has been executed again during control transfer. If the SETUP transaction is re-executed during control transfer and if a second request is executed by hardware, the CPUDEC bit is not set to 1, but the PROT bit can be used for recognition of the re-execution.</p> |
| 0            | CPUDEC   | <p>This bit indicates that the UF0E0ST register has a request that is to be decoded by FW.</p> <p>1: Data is in UF0E0ST register (interrupt request is generated).<br/>0: Data is not in UF0E0ST register (default value).</p> <p>This bit is automatically cleared to 0 by hardware when all the data of the UF0E0ST register is read.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |



**(13) UF0 INT status 2 register (UF0IS2)**

This register indicates the interrupt source. If the contents of this register are changed, the INTUSB1B signal becomes active.

This register is read-only, in 8-bit units.

If an interrupt request (INTUSB1B) is generated from USBF, the FW must read this register to identify the interrupt source.

Each bit of this register is forcibly cleared to 0 when 0 is written to the corresponding bit of the UF0IC2 register.

The related bits are invalid if each endpoint is not supported by the setting of the UF0EnIM register ( $n = 1, 3, 7, 8$ ) and the current setting of the interface.

|        |        |        |        |        |   |   |       |       |           |             |
|--------|--------|--------|--------|--------|---|---|-------|-------|-----------|-------------|
|        | 7      | 6      | 5      | 4      | 3 | 2 | 1     | 0     | Address   | After reset |
| UF0IS2 | BKI2IN | BKI2DT | BKI1IN | BKI1DT | 0 | 0 | IT2DT | IT1DT | FFFFFE12H | 00H         |

| Bit position | Bit name | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|--------------|----------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 7, 5         | BKInIN   | These bits indicate that an IN token has been received in the UF0BIn register (Endpoint m) and that NAK has been returned.<br>1: IN token is received and NAK is transmitted (interrupt request is generated).<br>0: IN token is not received (default value).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| 6, 4         | BKInDT   | These bits indicate that the FIFO of the UF0BIn register (Endpoint m) has been toggled. This means that data can be written to Endpoint m.<br>1: FIFO has been toggled (interrupt request is generated).<br>0: FIFO has not been toggled (default value).<br>The data written to Endpoint m is transmitted in synchronization with the IN token next to the one that set the BKInNK bit of the UF0EN register to 1. When the FIFO has been toggled and then data can be written from the CPU, this bit is automatically set to 1 by hardware. It is also set to 1 when the FIFO has been toggled, even if the data is a Null packet. This bit is automatically cleared to 0 by hardware when the first write access is made to the UF0BIn register. |
| 1, 0         | ITnDT    | These bits indicate that data has been correctly received from the UF0INTn register (Endpoint x).<br>1: Transmission is completed (interrupt request is generated).<br>0: Transmission is not completed (default value).<br>Data is transmitted in synchronization with the IN token next to the one that set the ITnNK bit of the UF0EN register to 1. This bit is automatically set to 1 by hardware when the host has correctly received that data. It is automatically cleared to 0 by hardware when the first write access is made to the UF0INTn register. This bit is also set to 1 even when the data is a Null packet.                                                                                                                     |

**Remark**  $n = 1, 2$

$m = 1$  and  $x = 7$  where  $n = 1$

$m = 3$  and  $x = 8$  where  $n = 2$

**(14) UF0 INT status 3 register (UF0IS3)**

This register indicates the interrupt source. If the contents of this register are changed, the INTUSB1B signal becomes active.

This register is read-only, in 8-bit units.

If an interrupt request (INTUSB1B) is generated from USBF, the FW must read this register to identify the interrupt source.

Each bit of this register is forcibly cleared to 0 when 0 is written to the corresponding bit of the UF0IC3 register.

The related bits are invalid if each endpoint is not supported by the setting of the UF0EnIM register ( $n = 2, 4$ ) and the current setting of the interface.

(1/2)

|        | 7      | 6      | 5           | 4      | 3      | 2      | 1           | 0      | Address    | After reset |
|--------|--------|--------|-------------|--------|--------|--------|-------------|--------|------------|-------------|
| UF0IS3 | BKO2FL | BKO2NL | BKO2<br>NAK | BKO2DT | BKO1FL | BKO1NL | BKO1<br>NAK | BKO1DT | FFFFFFE13H | 00H         |

| Bit position | Bit name | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|--------------|----------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 7, 3         | BKOnFL   | These bits indicate that data has been correctly received in the UF0BOn register (Endpoint m) and that both the FIFOs of the CPU and SIE hold the data.<br>1: Received data is in both the FIFOs of the UF0BOn register (interrupt request is generated).<br>0: Received data is not in the FIFO on the SIE side of the UF0BOn register (default value).<br>If data is held in both the FIFOs of the CPU and SIE, these bits are automatically set to 1 by hardware. They are automatically cleared to 0 by hardware when the FIFO is toggled. |
| 6, 2         | BKOnNL   | These bits indicate that a Null packet (packet with a length of 0) has been received in the UF0BOn register (Endpoint m).<br>1: Null packet is received (interrupt request is generated).<br>0: Null packet is not received (default value).<br>These bits are set to 1 immediately after reception of a Null packet when the FIFO is empty. They are set to 1 when the FIFO on the CPU side has been completely read if data is in that FIFO.                                                                                                 |
| 5, 1         | BKOnNAK  | These bits indicate that an OUT token has been received to the UF0BOn register (Endpoint m) and that NAK has been returned.<br>1: OUT token is received and NAK is transmitted (interrupt request is generated).<br>0: OUT token is not received (default value).                                                                                                                                                                                                                                                                              |

**Remark**  $n = 1, 2$   
 $m = 2$  where  $n = 1$   
 $m = 4$  where  $n = 2$

| Bit position | Bit name | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|--------------|----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 4, 0         | BKOnDT   | <p>These bits indicate that data has been correctly received in the UF0BOn register (Endpoint m).</p> <p>1: Reception has been completed correctly (interrupt request is generated).</p> <p>0: Reception has not been completed (default value).</p> <p>These bits are automatically set to 1 by hardware when data has been correctly received and the FIFO has been toggled. At the same time, the corresponding bits of the UF0EPS0 register are also set to 1. They are not set to 1 when the data is a Null packet.</p> <p>These bits are automatically cleared to 0 by hardware when the value of the UF0BOnL register becomes 0 as a result of reading the UF0BOn register by FW.</p> <p>These bits are automatically cleared to 0 when all the contents of the FIFO on the CPU side have been read. However, the interrupt request is not cleared if data is in the FIFO on the SIE side at this time, and the INTUSB1B signal does not become inactive. The signal is kept active if data is successively received.</p> |

**Remark**    n = 1, 2  
                   m = 2 where n = 1  
                   m = 4 where n = 2

**(15) UF0 INT status 4 register (UF0IS4)**

This register indicates the interrupt source. If the contents of this register are changed, the INTUSB2B signal becomes active.

This register is read-only, in 8-bit units.

If an interrupt request (INTUSB2B) is generated from USBF, the FW must read this register to identify the interrupt source.

Each bit of this register is forcibly cleared to 0 when 0 is written to the corresponding bit of the UF0IC4 register.

The related bits are invalid if each endpoint is not supported by the setting of the UF0EnIM register (n = 1 to 4, 7, 8) and the current setting of the interface.

|        |   |   |        |   |   |   |   |   |            |             |
|--------|---|---|--------|---|---|---|---|---|------------|-------------|
|        | 7 | 6 | 5      | 4 | 3 | 2 | 1 | 0 | Address    | After reset |
| UF0IS4 | 0 | 0 | SETINT | 0 | 0 | 0 | 0 | 0 | FFFFFFE14H | 00H         |

| Bit position | Bit name | Function                                                                                                                                                                                                                                                                                                                                                                                     |
|--------------|----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 5            | SETINT   | <p>This bit indicates that the SET_INTERFACE request has been received and automatically processed.</p> <p>1: The request has been automatically processed (interrupt request is generated).</p> <p>0: The request has not been automatically processed (default value).</p> <p>The current setting of this bit can be identified by reading the UF0ASS or UF0IFn register (n = 0 to 4).</p> |

**(16) UF0 INT mask 0 register (UF0IM0)**

This register controls masking of the interrupt sources indicated by the UF0IS0 register.

This register can be read or written in 8-bit units.

FW can mask occurrence of an interrupt request from USBF (INTUSB0B) by writing 1 to the corresponding bit of this register.

|        | 7           | 6           | 5 | 4      | 3          | 2          | 1          | 0           | Address   | After reset |
|--------|-------------|-------------|---|--------|------------|------------|------------|-------------|-----------|-------------|
| UF0IM0 | BUS<br>RSTM | RSU<br>SPDM | 0 | SHORTM | DMA<br>EDM | SET<br>RQM | CLR<br>RQM | EP<br>HALTM | FFFFFE17H | 00H         |

| Bit position | Bit name | Function                                                                                  |
|--------------|----------|-------------------------------------------------------------------------------------------|
| 7            | BUSRSTM  | This bit masks the Bus Reset interrupt.<br>1: Mask<br>0: Do not mask (default value)      |
| 6            | RSUSPDM  | This bit masks the Resume/Suspend interrupt.<br>1: Mask<br>0: Do not mask (default value) |
| 4            | SHORTM   | This bit masks the Short interrupt.<br>1: Mask<br>0: Do not mask (default value)          |
| 3            | DMAEDM   | This bit masks the DMA_END interrupt.<br>1: Mask<br>0: Do not mask (default value)        |
| 2            | SETRQM   | This bit masks the SET_RQ interrupt.<br>1: Mask<br>0: Do not mask (default value)         |
| 1            | CLRRQM   | This bit masks the CLR_RQ interrupt.<br>1: Mask<br>0: Do not mask (default value)         |
| 0            | EPHALTM  | This bit masks the EP_Halt interrupt.<br>1: Mask<br>0: Do not mask (default value)        |

**(17) UF0 INT mask 1 register (UF0IM1)**

This register controls masking of the interrupt sources indicated by the UF0IS1 register.

This register can be read or written in 8-bit units.

FW can mask occurrence of an interrupt request from USBF (INTUSB0B) by writing 1 to the corresponding bit of this register.

|        | 7 | 6     | 5           | 4          | 3      | 2    | 1     | 0           | Address    | After reset |
|--------|---|-------|-------------|------------|--------|------|-------|-------------|------------|-------------|
| UF0IM1 | 0 | E0INM | E0<br>INDTM | E0<br>ODTM | SUCESM | STGM | PROTM | CPU<br>DECM | FFFFFFE18H | 00H         |

| Bit position | Bit name | Function                                                                            |
|--------------|----------|-------------------------------------------------------------------------------------|
| 6            | E0INM    | This bit masks the EP0IN interrupt.<br>1: Mask<br>0: Do not mask (default value)    |
| 5            | E0INDTM  | This bit masks the EP0INDT interrupt.<br>1: Mask<br>0: Do not mask (default value)  |
| 4            | E0ODTM   | This bit masks the EP0OUTDT interrupt.<br>1: Mask<br>0: Do not mask (default value) |
| 3            | SUCESM   | This bit masks the Success interrupt.<br>1: Mask<br>0: Do not mask (default value)  |
| 2            | STGM     | This bit masks the Stg interrupt.<br>1: Mask<br>0: Do not mask (default value)      |
| 1            | PROTM    | This bit masks the Protect interrupt.<br>1: Mask<br>0: Do not mask (default value)  |
| 0            | CPUDECM  | This bit masks the CPUDEC interrupt.<br>1: Mask<br>0: Do not mask (default value)   |

**(18) UF0 INT mask 2 register (UF0IM2)**

This register controls masking of the interrupt sources indicated by the UF0IS2 register.

This register can be read or written in 8-bit units.

FW can mask occurrence of an interrupt request from USBF (INTUSB1B) by writing 1 to the corresponding bit of this register.

The related bits are invalid if each endpoint is not supported by the setting of the UF0EnIM register (n = 1, 3, 7, 8) and the current setting of the interface.

|        |         |             |         |             |   |   |        |        |           |             |
|--------|---------|-------------|---------|-------------|---|---|--------|--------|-----------|-------------|
| UF0IM2 | 7       | 6           | 5       | 4           | 3 | 2 | 1      | 0      | Address   | After reset |
|        | BKI2INM | BKI2<br>DTM | BKI1INM | BKI1<br>DTM | 0 | 0 | IT2DTM | IT1DTM | FFFFFE19H | 00H         |

| Bit position | Bit name | Function                                                                            |
|--------------|----------|-------------------------------------------------------------------------------------|
| 7, 5         | BKInINM  | These bits mask the BLKInIN interrupt.<br>1: Mask<br>0: Do not mask (default value) |
| 6, 4         | BKInDTM  | These bits mask the BLKInDT interrupt.<br>1: Mask<br>0: Do not mask (default value) |
| 1, 0         | ITnDTM   | These bits mask the INTnDT interrupt.<br>1: Mask<br>0: Do not mask (default value)  |

**Remark** n = 1, 2

**(19) UF0 INT mask 3 register (UF0IM3)**

This register controls masking of the interrupt sources indicated by the UF0IS3 register.

This register can be read or written in 8-bit units.

FW can mask occurrence of an interrupt request from USBF (INTUSB1B) by writing 1 to the corresponding bit of this register.

The related bits are invalid if each endpoint is not supported by the setting of the UF0EnIM register ( $n = 2, 4$ ) and the current setting of the interface.

|        | 7           | 6           | 5            | 4           | 3           | 2           | 1            | 0           | Address    | After reset |
|--------|-------------|-------------|--------------|-------------|-------------|-------------|--------------|-------------|------------|-------------|
| UF0IM3 | BKO2<br>FLM | BKO2<br>NLM | BKO2<br>NAKM | BKO2<br>DTM | BKO1<br>FLM | BKO1<br>NLM | BKO1<br>NAKM | BKO1<br>DTM | FFFFFFE1AH | 00H         |

| Bit position | Bit name | Function                                                                            |
|--------------|----------|-------------------------------------------------------------------------------------|
| 7, 3         | BKOnFLM  | These bits mask the BLKOnFL interrupt.<br>1: Mask<br>0: Do not mask (default value) |
| 6, 2         | BKOnNLM  | These bits mask the BLKOnNL interrupt.<br>1: Mask<br>0: Do not mask (default value) |
| 5, 1         | BKOnNAKM | These bits mask the BLKOnNK interrupt.<br>1: Mask<br>0: Do not mask (default value) |
| 4, 0         | BKOnDTM  | These bits mask the BLKOnDT interrupt.<br>1: Mask<br>0: Do not mask (default value) |

**Remark**  $n = 1, 2$



**(20) UF0 INT mask 4 register (UF0IM4)**

This register controls masking of the interrupt sources indicated by the UF0IS4 register.

This register can be read or written in 8-bit units.

FW can mask occurrence of an interrupt request from USBF (INTUSB2B) by writing 1 to the corresponding bit of this register.

The related bits are invalid if each endpoint is not supported by the setting of the UF0EnIM register (n = 1 to 4, 7, 8) and the current setting of the interface.

|        |   |   |         |   |   |   |   |   |           |             |
|--------|---|---|---------|---|---|---|---|---|-----------|-------------|
|        | 7 | 6 | 5       | 4 | 3 | 2 | 1 | 0 | Address   | After reset |
| UF0IM4 | 0 | 0 | SETINTM | 0 | 0 | 0 | 0 | 0 | FFFFFE1BH | 00H         |

| Bit position | Bit name | Function                                                                           |
|--------------|----------|------------------------------------------------------------------------------------|
| 5            | SETINTM  | This bit masks the SET_INT interrupt.<br>1: Mask<br>0: Do not mask (default value) |

**(21) UF0 INT clear 0 register (UF0IC0)**

This register controls clearing the interrupt sources indicated by the UF0IS0 register.

This register is write-only, in 8-bit units. If this register is read, the value FFH is read.

FW can clear an interrupt source by writing 0 to the corresponding bit of this register. Even a bit that is automatically cleared to 0 by hardware can be cleared by FW before it is cleared by hardware. Writing 0 to a bit of this register automatically sets the bit to 1. Writing 1 is invalid.

|        | 7           | 6           | 5 | 4      | 3          | 2          | 1          | 0           | Address    | After reset |
|--------|-------------|-------------|---|--------|------------|------------|------------|-------------|------------|-------------|
| UF0IC0 | BUS<br>RSTC | RSU<br>SPDC | 1 | SHORTC | DMA<br>EDC | SET<br>RQC | CLR<br>RQC | EP<br>HALTC | FFFFFFE1EH | FFH         |

| Bit position | Bit name | Function                                                  |
|--------------|----------|-----------------------------------------------------------|
| 7            | BUSRSTC  | This bit clears the Bus Reset interrupt.<br>0: Clear      |
| 6            | RSUSPDC  | This bit clears the Resume/Suspend interrupt.<br>0: Clear |
| 4            | SHORTC   | This bit clears the Short interrupt.<br>0: Clear          |
| 3            | DMAEDC   | This bit clears the DMA_END interrupt.<br>0: Clear        |
| 2            | SETRQC   | This bit clears the SET_RQ interrupt.<br>0: Clear         |
| 1            | CLRRQC   | This bit clears the CLR_RQ interrupt.<br>0: Clear         |
| 0            | EPHALTC  | This bit clears the EP_Halt interrupt.<br>0: Clear        |

**(22) UF0 INT clear 1 register (UF0IC1)**

This register controls clearing the interrupt sources indicated by the UF0IS1 register.

This register is write-only, in 8-bit units. If this register is read, the value FFH is read.

FW can clear an interrupt source by writing 0 to the corresponding bit of this register. Even a bit that is automatically cleared to 0 by hardware can be cleared by FW before it is cleared by hardware. Writing 0 to a bit of this register automatically sets the bit to 1. Writing 1 is invalid.

|        | 7 | 6     | 5           | 4      | 3      | 2    | 1     | 0           | Address   | After reset |
|--------|---|-------|-------------|--------|--------|------|-------|-------------|-----------|-------------|
| UF0IC1 | 1 | E0INC | E0<br>INDTC | E0ODTC | SUCESC | STGC | PROTC | CPU<br>DECC | FFFFFE1FH | FFH         |

| Bit position | Bit name | Function                                            |
|--------------|----------|-----------------------------------------------------|
| 6            | E0INC    | This bit clears the EP0IN interrupt.<br>0: Clear    |
| 5            | E0INDTC  | This bit clears the EP0INDT interrupt.<br>0: Clear  |
| 4            | E0ODTC   | This bit clears the EP0OUTDT interrupt.<br>0: Clear |
| 3            | SUCESC   | This bit clears the Success interrupt.<br>0: Clear  |
| 2            | STGC     | This bit clears the Stg interrupt.<br>0: Clear      |
| 1            | PROTC    | This bit clears the Protect interrupt.<br>0: Clear  |
| 0            | CPUDECC  | This bit clears the CPUDEC interrupt.<br>0: Clear   |

**(23) UF0 INT clear 2 register (UF0IC2)**

This register controls clearing the interrupt sources indicated by the UF0IS2 register.

This register is write-only, in 8-bit units. If this register is read, the value FFH is read.

FW can clear an interrupt source by writing 0 to the corresponding bit of this register. Even a bit that is automatically cleared to 0 by hardware can be cleared by FW before it is cleared by hardware. Writing 0 to a bit of this register automatically sets the bit to 1. Writing 1 is invalid.

The related bits are invalid if each endpoint is not supported by the setting of the UF0EnIM register (n = 1, 3, 7, 8) and the current setting of the interface.

|        | 7       | 6           | 5       | 4           | 3 | 2 | 1      | 0      | Address   | After reset |
|--------|---------|-------------|---------|-------------|---|---|--------|--------|-----------|-------------|
| UF0IC2 | BKI2INC | BKI2<br>DTC | BKI1INC | BKI1<br>DTC | 1 | 1 | IT2DTC | IT1DTC | FFFFFE20H | FFH         |

| Bit position | Bit name | Function                                            |
|--------------|----------|-----------------------------------------------------|
| 7, 5         | BKInINC  | These bits clear the BLKInIN interrupt.<br>0: Clear |
| 6, 4         | BKInDTC  | These bits clear the BLKInDT interrupt.<br>0: Clear |
| 1, 0         | ITnDTC   | These bits clear the INTnDT interrupt.<br>0: Clear  |

**Remark** n = 1, 2

**(24) UF0 INT clear 3 register (UF0IC3)**

This register controls clearing the interrupt sources indicated by the UF0IS3 register.

This register is write-only, in 8-bit units. If this register is read, the value FFH is read.

FW can clear an interrupt source by writing 0 to the corresponding bit of this register. Even a bit that is automatically cleared to 0 by hardware can be cleared by FW before it is cleared by hardware. Writing 0 to a bit of this register automatically sets the bit to 1. Writing 1 is invalid.

The related bits are invalid if each endpoint is not supported by the setting of the UF0EnIM register ( $n = 2, 4$ ) and the current setting of the interface.

|        |             |             |              |             |             |             |              |             |           |             |
|--------|-------------|-------------|--------------|-------------|-------------|-------------|--------------|-------------|-----------|-------------|
| UF0IC3 | 7           | 6           | 5            | 4           | 3           | 2           | 1            | 0           | Address   | After reset |
|        | BKO2<br>FLC | BKO2<br>NLC | BKO2<br>NAKC | BKO2<br>DTC | BKO1<br>FLC | BKO1<br>NLC | BKO1<br>NAKC | BKO1<br>DTC | FFFFFE21H | FFH         |

| Bit position | Bit name | Function                                            |
|--------------|----------|-----------------------------------------------------|
| 7, 3         | BKOnFLC  | These bits clear the BLKOnFL interrupt.<br>0: Clear |
| 6, 2         | BKOnNLC  | These bits clear the BLKOnNL interrupt.<br>0: Clear |
| 5, 1         | BKOnNAKC | These bits clear the BLKOnNK interrupt.<br>0: Clear |
| 4, 0         | BKOnDTC  | These bits clear the BLKOnDT interrupt.<br>0: Clear |

**Remark**  $n = 1, 2$

**(25) UF0 INT clear 4 register (UF0IC4)**

This register controls clearing the interrupt sources indicated by the UF0IS4 register.

This register is write-only, in 8-bit units. If this register is read, the value FFH is read.

FW can clear an interrupt source by writing 0 to the corresponding bit of this register. Even a bit that is automatically cleared to 0 by hardware can be cleared by FW before it is cleared by hardware. Writing 0 to a bit of this register automatically sets the bit to 1. Writing 1 is invalid.

The related bits are invalid if each endpoint is not supported by the setting of the UF0EnIM register (n = 1 to 4, 7, 8) and the current setting of the interface.

|        | 7 | 6 | 5       | 4 | 3 | 2 | 1 | 0 | Address   | After reset |
|--------|---|---|---------|---|---|---|---|---|-----------|-------------|
| UF0IC4 | 1 | 1 | SETINTC | 1 | 1 | 1 | 1 | 1 | FFFFFE22H | FFH         |

| Bit position | Bit name | Function                                           |
|--------------|----------|----------------------------------------------------|
| 5            | SETINTC  | This bit clears the SET_INT interrupt.<br>0: Clear |

**(26) UF0 INT & DMARQ register (UF0IDR)**

This register selects reporting via an interrupt request or starting DMA.

This register can be read or written in 8-bit units.

If data exists in either the UF0BO1 or UF0BO1 register, or if data can be written to the UF0BI1 or UF0BI2 register, this register selects whether it is reported to the FW by an interrupt request, or whether starting DMA is requested. If starting DMA is requested, the DMA transfer mode can be selected according to the setting of bits 0 and 1.

The related bits are invalid if each endpoint is not supported by the setting of the UF0EnIM register ( $n = 1$  to 4) and the current setting of the interface.

Be sure to clear bits 3 and 2 to 0. If they are set to 1, the operation is not guaranteed.

**Caution** If the target endpoint is not supported by the SET\_INTERFACE request under DMA transfer, the DMA request signal becomes inactive immediately, and the corresponding bit is automatically cleared to 0 by hardware.

(1/2)

|        |             |             |             |             |   |   |       |       |           |             |
|--------|-------------|-------------|-------------|-------------|---|---|-------|-------|-----------|-------------|
| UF0IDR | 7           | 6           | 5           | 4           | 3 | 2 | 1     | 0     | Address   | After reset |
|        | DQBI2<br>MS | DQBI1<br>MS | DQBO2<br>MS | DQBO1<br>MS | 0 | 0 | MODE1 | MODE0 | FFFFFE26H | 00H         |

| Bit position | Bit name | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|--------------|----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 7, 6         | DQBInMS  | <p>These bits enable (mask) a write DMA transfer request (DMA request signal for Endpoint m) to the UF0BIn register. When these bits are set to 1, the DMA request signal for Endpoint m becomes active while writing data can be acknowledged. If the DMA end signal for Endpoint m is input (if the DMA controller issues TC), these bits are automatically cleared to 0 by hardware. To continue DMA transfer, re-set these bits to 1 by FW.</p> <p>1: Enables active DMA request signal for Endpoint m (masks BKInDT interrupt).<br/>0: Disables active DMA request signal for Endpoint m (default value).</p>                                                                                 |
| 5, 4         | DQBOOnMS | <p>These bits enable (mask) a read DMA transfer request (DMA request signal for Endpoint x) to the UF0BOn register. When these bits are set to 1, the DMA request signal for Endpoint x becomes active if the data to be read is prepared in the UF0BOn register. If the DMA end signal for Endpoint x is input (if the DMA controller issues TC), these bits are automatically cleared to 0 by hardware. They are also cleared to 0 when the USBSPxB signal is active. To continue DMA transfer, re-set these bits to 1 by FW.</p> <p>1: Enables active DMA request signal for Endpoint x (masks BKOnDT interrupt).<br/>0: Disables active DMA request signal for Endpoint x (default value).</p> |

**Remark**  $n = 1, 2$   
 $m = 1$  and  $x = 2$  where  $n = 1$   
 $m = 3$  and  $x = 4$  where  $n = 2$

&lt;R&gt;

| Bit position | Bit name        | Function                                                                                                                                                                                                                                                                                          |       |                    |                                                                                                           |
|--------------|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|--------------------|-----------------------------------------------------------------------------------------------------------|
| 1, 0         | MODE1,<br>MODE0 | These bits select the DMA transfer mode.                                                                                                                                                                                                                                                          |       |                    |                                                                                                           |
|              |                 | MODE1                                                                                                                                                                                                                                                                                             | MODE0 | Mode               | Remark                                                                                                    |
|              |                 | 1                                                                                                                                                                                                                                                                                                 | 1     | Setting prohibited | Operation cannot be guaranteed.                                                                           |
|              |                 | 1                                                                                                                                                                                                                                                                                                 | 0     | Demand mode        | DMA request signal becomes active as long as there is data. It becomes inactive if there is no more data. |
|              |                 | 0                                                                                                                                                                                                                                                                                                 | X     | Single mode        | DMA request signal becomes inactive each time DMA transfer has been executed.                             |
|              |                 | <b>Remarks</b> 1. X: Don't care<br>2. When performing DMA transfer using the USB, transfer is possible only in the single transfer mode or single-step transfer mode. Therefore, operation does not differ regardless whether the MODE1 and MODE0 bits are set to the demand mode or single mode. |       |                    |                                                                                                           |



**(27) UF0 DMA status 0 register (UF0DMS0)**

This register indicates the DMA status of Endpoint1 to Endpoint4.

This register is read-only, in 8-bit units.

The related bits are invalid if each endpoint is not supported by the setting of the UF0EnIM register (n = 1 to 4) and the current setting of the interface.

|         | 7 | 6 | 5    | 4    | 3    | 2    | 1 | 0 | Address    | After reset |
|---------|---|---|------|------|------|------|---|---|------------|-------------|
| UF0DMS0 | 0 | 0 | DQE4 | DQE3 | DQE2 | DQE1 | 0 | 0 | FFFFFFE27H | 00H         |

| Bit position | Bit name | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|--------------|----------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 5            | DQE4     | This bit indicates that a DMA read request is being issued from Endpoint4 to memory.<br>1: DMA read request from Endpoint4 is being issued.<br>0: DMA read request from Endpoint4 is not being issued (default value).                                                                                                                                                                                                                                                             |
| 4            | DQE3     | This bit indicates that a DMA write request is being issued from memory to Endpoint3.<br>Note that, even if data is in Endpoint3 (when the FIFO is not full and after the BK12DED bit has been set to 1), the DMA request signal becomes active immediately and DMA transfer is started when the DQBI2MS bit of the UF0IDR register is set to 1.<br>1: DMA write request for Endpoint3 is being issued.<br>0: DMA write request for Endpoint3 is not being issued (default value). |
| 3            | DQE2     | This bit indicates that a DMA read request is being issued from Endpoint2 to memory.<br>1: DMA read request from Endpoint2 is being issued.<br>0: DMA read request from Endpoint2 is not being issued (default value).                                                                                                                                                                                                                                                             |
| 2            | DQE1     | This bit indicates that a DMA write request is being issued from memory to Endpoint1.<br>Note that, even if data is in Endpoint1 (when the FIFO is not full and after the BK11DED bit has been set to 1), the DMA request signal becomes active immediately and DMA transfer is started when the DQBI1MS bit of the UF0IDR register is set to 1.<br>1: DMA write request for Endpoint1 is being issued.<br>0: DMA write request for Endpoint1 is not being issued (default value). |

**(28) UF0 DMA status 1 register (UF0DMS1)**

This register indicates the DMA status of Endpoint1 to Endpoint4.

This register is read-only, in 8-bit units.

The related bits are invalid if each endpoint is not supported by the setting of the UF0EnIM register (n = 1 to 4) and the current setting of the interface.

Each bit is automatically cleared to 0 when this register is read. Even when this register is read, however, bits 4 and 3 of the UF0IS0 register are not cleared to 0. If the target endpoint is no longer supported by the SET\_INTERFACE request, each bit is automatically cleared to 0 by hardware (however, the DMA\_END interrupt request and Short interrupt request are not cleared).

|         | 7     | 6     | 5     | 4     | 3     | 2     | 1 | 0 | Address   | After reset |
|---------|-------|-------|-------|-------|-------|-------|---|---|-----------|-------------|
| UF0DMS1 | DEDE4 | DSPE4 | DEDE3 | DEDE2 | DSPE2 | DEDE1 | 0 | 0 | FFFFFE28H | 00H         |

| Bit position | Bit name | Function                                                                                                                                                                                                                                                                                          |
|--------------|----------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 7, 5, 4, 2   | DEDEn    | These bits indicate that the DMA end (TC) signal for Endpoint n becomes active and DMA is stopped while a DMA read request is being issued from Endpoint n to memory.<br>1: DMA end signal for Endpoint n is active.<br>0: DMA end signal for Endpoint n is inactive (default value).             |
| 6, 3         | DSPEm    | These bits indicate that, although a DMA read request was being issued from Endpoint m to memory, DMA has been stopped because the received data is a short packet and there is no more data to be transferred.<br>1: USBSPmB signal is active.<br>0: USBSPmB signal is inactive (default value). |

**Remark** n = 1 to 4  
m = 2, 4

**(29) UF0 FIFO clear 0 register (UF0FIC0)**

This register clears each FIFO.

This register is write-only, in 8-bit units. If this register is read, 00H is read.

FW can clear the target FIFO by writing 1 to the corresponding bit of this register. The bit to which 1 has been written is automatically cleared to 0. Writing 0 to the bit is invalid.

The related bits are invalid if each endpoint is not supported by the setting of the UF0EnIM register (n = 1, 3, 7, 8) and the current setting of the interface.

|         |        |        |        |        |       |       |       |       |           |             |
|---------|--------|--------|--------|--------|-------|-------|-------|-------|-----------|-------------|
|         | 7      | 6      | 5      | 4      | 3     | 2     | 1     | 0     | Address   | After reset |
| UF0FIC0 | BKI2SC | BKI2CC | BKI1SC | BKI1CC | ITR2C | ITR1C | EP0WC | EP0RC | FFFFFE30H | 00H         |

| Bit position | Bit name | Function                                                                                                                                                                                                                                                                                                                                                                   |
|--------------|----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 7, 5         | BKInSC   | These bits clear only the FIFO on the SIE side of the UF0BIn register (reset the counter).<br>1: Clear<br>Writing these bits is invalid while an IN token for Endpoint m is being processed with the BKInNK bit set to 1.<br>The BKInNK bit is automatically cleared to 0 by clearing the FIFO. Make sure that the FIFO on the CPU side is empty when these bits are used. |
| 6, 4         | BKInCC   | These bits clear only the FIFO on the CPU side of the UF0BIn register (reset the counter).<br>1: Clear                                                                                                                                                                                                                                                                     |
| 3, 2         | ITRnC    | These bits clear the UF0INTn register (reset the counter).<br>1: Clear<br>Writing these bits is invalid while an IN token for Endpoint x is being processed with the ITnNK bit set to 1.<br>The ITnNK bit is automatically cleared to 0 by clearing the FIFO.                                                                                                              |
| 1            | EP0WC    | This bit clears the UF0E0W register (resets the counter).<br>1: Clear<br>Writing this bit is invalid while an IN token for Endpoint0 is being processed with the EP0NKW bit set to 1.<br>The EP0NKW bit is automatically cleared to 0 by clearing the FIFO.                                                                                                                |
| 0            | EP0RC    | This bit clears the UF0E0R register (resets the counter).<br>1: Clear<br>When the EP0NKR bit is set to 1 (except when it has been set by FW), the EP0NKR bit is automatically cleared to 0 by clearing the FIFO.                                                                                                                                                           |

**Remark** n = 1, 2  
m = 1 and x = 7 where n = 1  
m = 3 and x = 8 where n = 2

**(30) UF0 FIFO clear 1 register (UF0FIC1)**

This register clears each FIFO.

This register is write-only, in 8-bit units. If this register is read, 00H is read.

FW can clear the target FIFO by writing 1 to the corresponding bit of this register. The bit to which 1 has been written is automatically cleared to 0. Writing 0 to the bit is invalid.

The related bits are invalid if each endpoint is not supported by the setting of the UF0EnIM register ( $n = 2, 4$ ) and the current setting of the interface.

|         | 7 | 6 | 5 | 4 | 3     | 2      | 1     | 0      | Address    | After reset |
|---------|---|---|---|---|-------|--------|-------|--------|------------|-------------|
| UF0FIC1 | 0 | 0 | 0 | 0 | BKO2C | BKO2CC | BKO1C | BKO1CC | FFFFFFE31H | 00H         |

| Bit position | Bit name | Function                                                                                                                                                                                                                                                    |
|--------------|----------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 3, 1         | BKOnC    | These bits clear the FIFOs on both the SIE and CPU sides of the UF0BOn register (reset the counter).<br>1: Clear<br>When the BKOnNK bit is set to 1 (except when it has been set by FW), the BKOnNK bit is automatically cleared to 0 by clearing the FIFO. |
| 2, 0         | BKOnCC   | These bits clear only the FIFO on the CPU side of the UF0BOn register (reset the counter).<br>1: Clear<br>When the BKOnNK bit is set to 1 (except when it has been set by FW), the BKOnNK bit is automatically cleared to 0 by clearing the FIFO.           |

**Remark**  $n = 1, 2$

**(31) UF0 data end register (UF0DEND)**

This register reports the end of writing to the transmission system.

This register is write-only, in 8-bit units (however, bits 7 and 6 can be read and written). If this register is read, 00H is read.

FW can start data transfer of the target endpoint by writing 1 to the corresponding bit of this register. The bit to which 1 has been written is automatically cleared to 0. Writing 0 to the bit is invalid.

The related bits are invalid if each endpoint is not supported by the setting of the UF0EnIM register (n = 1, 3, 7, 8) and the current setting of the interface.

(1/2)

|         | 7     | 6     | 5 | 4       | 3       | 2       | 1       | 0     | Address    | After reset |
|---------|-------|-------|---|---------|---------|---------|---------|-------|------------|-------------|
| UF0DEND | BKI2T | BKI1T | 0 | IT2DEND | IT1DEND | BKI2DED | BKI1DED | E0DED | FFFFFFE35H | 00H         |

| Bit position | Bit name | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|--------------|----------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 7, 6         | BKInT    | <p>These bits specify whether toggling the FIFO is automatically executed if the FIFO on the CPU side of the UF0BIn register becomes full as a result of DMA.</p> <p>1: Automatically execute a toggle operation of the FIFO as soon as the FIFO has become full.</p> <p>0: Do not automatically execute a toggle operation of the FIFO even if the FIFO becomes full (default value).</p>                                                                                                                                                                                                                                                                                                                                                                                                        |
| 4, 3         | ITnDEND  | <p>Set these bits to 1 to transmit the data of the UF0INTn register. When these bits are set to 1, the ITnNK bit is set to 1 and data transfer is executed.</p> <p>1: Transmit a short packet.</p> <p>0: Do not transmit a short packet (default value).</p> <p>If the ITRnC bit of the UF0FIC0 register is set to 1 and then these bits are set to 1 (counter of UF0INTn register = 0 and the corresponding bit of the UF0EPS0 register = 1), a Null packet (with a data length of 0) is transmitted.</p> <p>If data exists in the UF0INTn register and if these bits are set to 1 (counter of UF0INTn register ≠ 0 and the corresponding bit of the UF0EPS0 register = 1), a short packet is transmitted.</p> <p>These bits are automatically controlled by hardware when the FIFO is full.</p> |

**Remark** n = 1, 2

(2/2)

| Bit position | Bit name | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|--------------|----------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 2, 1         | BKInDED  | <p>Set these bits to 1 when writing transmit data to the UF0BIn register has been completed. When these bits are set to 1, the FIFO is toggled as soon as possible, the BKInNK bit is set to 1, and data is transferred.</p> <p>1: Transmit a short packet.<br/>0: Do not transmit a short packet (default value).</p> <p>These bits control the FIFO on the CPU side.</p> <p>If the BKInCC bit of the UF0FIC0 register is set to 1 and then these bits are set to 1 (counter of UF0BIn register = 0), a Null packet (with a data length of 0) is transmitted.</p> <p>If data exists in the UF0BIn register and if these bits are set to 1 (counter of UF0BIn register ≠ 0), and if the FIFO is not full, a short packet is transmitted.</p> <p>If the FIFO on the CPU side of the UF0BIn register becomes full as a result of DMA, with the PIO or BKInT bit set to 1, the hardware starts data transmission even if these bits are not set to 1.</p> <p>If the FIFO on the CPU side of the UF0BIn register becomes full as a result of DMA, with the BKInT bit cleared to 0, be sure to set these bits to 1 (see <b>11.4.1 (3) UF0 EPNACK register (UF0EN)</b>).</p> |
| 0            | E0DED    | <p>Set this bit to 1 to transmit data of the UF0E0W register. When this bit is set to 1, the EPONKW bit is set to 1 and data is transferred.</p> <p>1: Transmit a short packet.<br/>0: Do not transmit a short packet (default value).</p> <p>If the EP0WC bit of the UF0FIC0 register is set to 1 and if this bit is set to 1 (counter of UF0E0W register = 0 and bit 1 of UF0EPS0 register = 1), a Null packet (with a data length of 0) is transmitted.</p> <p>If data exists in the UF0E0W register and if this bit is set to 1 (counter of UF0E0W register ≠ 0 and bit 1 of the UF0EPS0 register = 1), and if the FIFO is not full, a short packet is transmitted.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |

**Remark** n = 1, 2

**(32) UF0 GPR register (UF0GPR)**

This register controls USBF and the USB interface.

This register is write-only, in 8-bit units. If this register is read, 00H is read. Be sure to clear bits 7 to 1 to 0.

FW can reset the USBF by writing 1 to bit 0 of this register. This bit is automatically cleared to 0 after 1 has been written to it. Writing 0 to this bit is invalid.

|        | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0    | Address   | After reset |
|--------|---|---|---|---|---|---|---|------|-----------|-------------|
| UF0GPR | 0 | 0 | 0 | 0 | 0 | 0 | 0 | MRST | FFFFFE37H | 00H         |

| Bit position | Bit name | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|--------------|----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 0            | MRST     | <p>Set this bit to 1 to reset USBF.</p> <p>1: Reset</p> <p>Actually, USBF is reset two USB clocks after this bit has been set to 1 by FW and the write signal has become inactive.</p> <p>Resetting USBF by the MRST bit while the system clock is operating has the same result as resetting by the RESET pin (hardware reset) (register value back to default value).</p> <p>However, the UF0CS and UF0BC registers are not reset by the MRST bit.</p> |

**(33) UF0 mode control register (UF0MODC)**

This register controls CPUDEC processing.

This register can be read or written in 8-bit units.

By setting each bit of this register, the setting of the UF0MODS register can be changed. The bit of this register is automatically cleared to 0 only at hardware reset and when the MRST bit of the UF0GRP register has been set to 1.

Even if the bit of this register has automatically been set to 1 by hardware, the setting by FW takes precedence.

Be sure to clear bits 7 and 5 to 2 to 0. If they are set to 1, the operation is not guaranteed.

**Caution** This register is provided for debugging purposes. Usually, do not set this register except for verifying the operation or when a special mode is used.

|         | 7 | 6           | 5 | 4 | 3 | 2 | 1 | 0 | Address   | After reset |
|---------|---|-------------|---|---|---|---|---|---|-----------|-------------|
| UF0MODC | 0 | CDC<br>GDST | 0 | 0 | 0 | 0 | 0 | 0 | FFFFFE3AH | 00H         |

| Bit position | Bit name | Function                                                                                                                                                                                                                                                                                                                                                                                                                         |
|--------------|----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 6            | CDCGDST  | <p>Set this bit to 1 to switch the GET_DESCRIPTOR Configuration request to CPUDEC processing. By setting this bit to 1, the CDCGD bit of the UF0MODS register can be forcibly set to 1.</p> <p>1: Forcibly change the GET_DESCRIPTOR Configuration request to CPUDEC processing (sets the CDCGD bit of the UF0MODS register to 1).</p> <p>0: Automatically process the GET_DESCRIPTOR Configuration request (default value).</p> |



**(34) UF0 mode status register (UF0MODS)**

This register indicates the configuration status.

This register is read-only, in 8-bit units.

|         | 7 | 6     | 5 | 4     | 3    | 2    | 1 | 0 | Address   | After reset |
|---------|---|-------|---|-------|------|------|---|---|-----------|-------------|
| UF0MODS | 0 | CDCGD | 0 | MPACK | DFLT | CONF | 0 | 0 | FFFFFE3CH | 00H         |

| Bit position | Bit name | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
|--------------|----------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 6            | CDCGD    | <p>This bit specifies whether CPUDEC processing is performed for the GET_DESCRIPTOR Configuration request.</p> <p>1: Forcibly change the GET_DESCRIPTOR Configuration request to CPUDEC processing.</p> <p>0: Automatically process the GET_DESCRIPTOR Configuration request (default value).</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| 4            | MPACK    | <p>This bit indicates the transmit packet size of Endpoint0.</p> <p>1: Transmit a packet of other than 8 bytes.</p> <p>0: Transmit a packet of 8 bytes (default value).</p> <p>This bit is automatically set to 1 by hardware after the GET_DESCRIPTOR Device request has been processed (on normal completion of the status stage). It is not cleared to 0 until the USBF has been reset (it is not cleared to 0 by Bus Reset).</p> <p>If this bit is not set to 1, the hardware transfers only the automatically-executed request in 8-byte units. Therefore, even if data of more than 8 bytes is sent by the OUT token to be processed by FW before completion of the GET_DESCRIPTOR Device request, the data is correctly received.</p> <p>This bit is ignored if the size of Endpoint0 is 8 bytes.</p> |
| 3            | DFLT     | <p>This bit indicates the default status (DFLT bit = 1).</p> <p>1: Enables response.</p> <p>0: Disables response (always no response) (default value).</p> <p>This bit is automatically set to 1 by Bus Reset. The transaction for all the endpoints is not responded to until this bit is set to 1.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| 2            | CONF     | <p>This bit indicates whether the SET_CONFIGURATION request has been completed.</p> <p>1: SET_CONFIGURATION request has been completed.</p> <p>0: SET_CONFIGURATION request has not been completed (default value).</p> <p>This bit is set to 1 when Configuration value = 1 is received by the SET_CONFIGURATION request.</p> <p>Unless this bit is set to 1, access to an endpoint other than Endpoint0 is ignored.</p> <p>This bit is cleared to 0 when Configuration value = 0 is received by the SET_CONFIGURATION request. It is also cleared to 0 when Bus Reset is detected.</p>                                                                                                                                                                                                                     |

**(35) UF0 active interface number register (UF0AIFN)**

This register sets the valid Interface number that correctly responds to the GET/SET\_INTERFACE request. Because Interface 0 is always valid, Interfaces 1 to 4 can be selected.

This register can be read or written in 8-bit units.

|         |       |   |   |   |   |   |       |       |            |             |
|---------|-------|---|---|---|---|---|-------|-------|------------|-------------|
|         | 7     | 6 | 5 | 4 | 3 | 2 | 1     | 0     | Address    | After reset |
| UF0AIFN | ADDIF | 0 | 0 | 0 | 0 | 0 | IFNO1 | IFNO0 | FFFFFFE40H | 00H         |

| Bit position | Bit name        | Function                                                                                                                                                                                                                                                                                                                                                                   |       |       |                     |   |   |               |   |   |            |   |   |         |   |   |      |
|--------------|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|-------|---------------------|---|---|---------------|---|---|------------|---|---|---------|---|---|------|
| 7            | ADDIF           | <p>This bit allows use of Interfaces numbered other than 0.</p> <p>1: Support up to the Interface number specified by the IFNO1 and IFNO0 bits.</p> <p>0: Support only Interface 0 (default value).</p> <p>Setting bits 1 and 0 of this register is invalid when this bit is not set to 1.</p>                                                                             |       |       |                     |   |   |               |   |   |            |   |   |         |   |   |      |
| 1, 0         | IFNO1,<br>IFNO0 | <p>These bits specify the range of Interface numbers to be supported.</p> <table border="1"> <tr> <th>IFNO1</th><th>IFNO0</th><th>Valid Interface No.</th></tr> <tr> <td>1</td><td>1</td><td>0, 1, 2, 3, 4</td></tr> <tr> <td>1</td><td>0</td><td>0, 1, 2, 3</td></tr> <tr> <td>0</td><td>1</td><td>0, 1, 2</td></tr> <tr> <td>0</td><td>0</td><td>0, 1</td></tr> </table> | IFNO1 | IFNO0 | Valid Interface No. | 1 | 1 | 0, 1, 2, 3, 4 | 1 | 0 | 0, 1, 2, 3 | 0 | 1 | 0, 1, 2 | 0 | 0 | 0, 1 |
| IFNO1        | IFNO0           | Valid Interface No.                                                                                                                                                                                                                                                                                                                                                        |       |       |                     |   |   |               |   |   |            |   |   |         |   |   |      |
| 1            | 1               | 0, 1, 2, 3, 4                                                                                                                                                                                                                                                                                                                                                              |       |       |                     |   |   |               |   |   |            |   |   |         |   |   |      |
| 1            | 0               | 0, 1, 2, 3                                                                                                                                                                                                                                                                                                                                                                 |       |       |                     |   |   |               |   |   |            |   |   |         |   |   |      |
| 0            | 1               | 0, 1, 2                                                                                                                                                                                                                                                                                                                                                                    |       |       |                     |   |   |               |   |   |            |   |   |         |   |   |      |
| 0            | 0               | 0, 1                                                                                                                                                                                                                                                                                                                                                                       |       |       |                     |   |   |               |   |   |            |   |   |         |   |   |      |

**(36) UF0 active alternative setting register (UF0AAS)**

This register specifies a link between the Interface number and Alternative Setting.

This register can be read or written in 8-bit units.

USBF of the V850E/ME2 can set a five-series Alternative Setting (Alternate Setting 0, 1, 2, 3, and 4 can be defined) and a two-series Alternative Setting (Alternative Setting 0 and 1 can be defined) for one Interface.

|        | 7    | 6      | 5      | 4      | 3    | 2      | 1      | 0      | Address   | After reset |
|--------|------|--------|--------|--------|------|--------|--------|--------|-----------|-------------|
| UF0AAS | ALT2 | IFAL21 | IFAL20 | ALT2EN | ALT5 | IFAL51 | IFAL50 | ALT5EN | FFFFFE41H | 00H         |

| Bit position  | Bit name          | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |        |        |                               |   |   |                    |   |   |                    |   |   |                    |   |   |                    |
|---------------|-------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|--------|-------------------------------|---|---|--------------------|---|---|--------------------|---|---|--------------------|---|---|--------------------|
| 7, 3          | ALTn              | These bits specify whether an n-series Alternative Setting is linked with Interface 0.<br>When these bits are set to 1, the setting of the IFALn1 and IFALn0 bits is invalid.<br>1: Link n-series Alternative Setting with Interface 0.<br>0: Do not link n-series Alternative Setting with Interface 0 (default value).                                                                                                                                                                                                                                                                                                                                                                                                  |        |        |                               |   |   |                    |   |   |                    |   |   |                    |   |   |                    |
| 6, 5,<br>2, 1 | IFALn1,<br>IFALn0 | These bits specify the Interface number to be linked with the n-series Alternative Setting.<br>If the linked Interface number is outside the range specified by the UF0AIFN register, the n-series Alternative Setting is invalid (ALTnEN bit = 0). <table border="1"> <tr> <th>IFALn1</th><th>IFALn0</th><th>Interface number to be linked</th></tr> <tr> <td>1</td><td>1</td><td>Links Interface 4.</td></tr> <tr> <td>1</td><td>0</td><td>Links Interface 3.</td></tr> <tr> <td>0</td><td>1</td><td>Links Interface 2.</td></tr> <tr> <td>0</td><td>0</td><td>Links Interface 1.</td></tr> </table> Do not link a five-series Alternative Setting and a two-series Alternative Setting with the same Interface number. | IFALn1 | IFALn0 | Interface number to be linked | 1 | 1 | Links Interface 4. | 1 | 0 | Links Interface 3. | 0 | 1 | Links Interface 2. | 0 | 0 | Links Interface 1. |
| IFALn1        | IFALn0            | Interface number to be linked                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |        |        |                               |   |   |                    |   |   |                    |   |   |                    |   |   |                    |
| 1             | 1                 | Links Interface 4.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |        |        |                               |   |   |                    |   |   |                    |   |   |                    |   |   |                    |
| 1             | 0                 | Links Interface 3.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |        |        |                               |   |   |                    |   |   |                    |   |   |                    |   |   |                    |
| 0             | 1                 | Links Interface 2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |        |        |                               |   |   |                    |   |   |                    |   |   |                    |   |   |                    |
| 0             | 0                 | Links Interface 1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |        |        |                               |   |   |                    |   |   |                    |   |   |                    |   |   |                    |
| 4, 0          | ALTnEN            | These bits validate the n-series Alternative Setting. Unless these bits are set to 1, the setting of the ALTn, IFALn1, and IFALn0 bits is invalid.<br>1: Validate the n-series Alternative Setting.<br>0: Do not validate the n-series Alternative Setting (default value).                                                                                                                                                                                                                                                                                                                                                                                                                                               |        |        |                               |   |   |                    |   |   |                    |   |   |                    |   |   |                    |

**Remark** n = 2, 5

For example, when the UF0AIFN register is set to 82H and the UF0AAS register is set to 15H, Interfaces 0, 1, 2, and 3 are valid. Interfaces 0 and 2 support only Alternative Setting 0. Interface 1 supports Alternative Setting 0 and 1, and Interface 3 supports Alternative Setting 0, 1, 2, 3, and 4. With this setting, requests GET\_INTERFACE wIndex = 0/1/2/3, SET\_INTERFACE wValue = 0 & wIndex = 0/2, SET\_INTERFACE wValue = 0/1 & wIndex = 1, and SET\_INTERFACE wValue = 0/1/2/3/4 & wIndex = 3 are automatically responded to, and a STALL response is made to the other GET/SET\_INTERFACE requests.

**(37) UF0 alternative setting status register (UF0ASS)**

This register indicates the current status of the Alternative Setting.

This register is read-only, in 8-bit units.

Check this register when the SET\_INT interrupt request has been issued. The value received by the SET\_INTERFACE request is reflected on the UF0IFn register (n = 0 to 4) as well as on this register.

|        |   |   |   |   |        |        |        |       |            |             |
|--------|---|---|---|---|--------|--------|--------|-------|------------|-------------|
|        | 7 | 6 | 5 | 4 | 3      | 2      | 1      | 0     | Address    | After reset |
| UF0ASS | 0 | 0 | 0 | 0 | AL5ST3 | AL5ST2 | AL5ST1 | AL2ST | FFFFFFE42H | 00H         |

| Bit position | Bit name         | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |        |        |                                     |                                     |   |   |   |                       |   |   |   |                       |   |   |   |                       |   |   |   |                       |   |   |   |                       |
|--------------|------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|--------|-------------------------------------|-------------------------------------|---|---|---|-----------------------|---|---|---|-----------------------|---|---|---|-----------------------|---|---|---|-----------------------|---|---|---|-----------------------|
| 3 to 1       | AL5ST3 to AL5ST1 | These bits indicate the current status of the five-series Alternative Setting.                                                                                                                                                                                                                                                                                                                                                                                             |        |        |                                     |                                     |   |   |   |                       |   |   |   |                       |   |   |   |                       |   |   |   |                       |   |   |   |                       |
|              |                  | <table><tr><th>AL5ST3</th><th>AL5ST2</th><th>AL5ST1</th><th>Selected Alternative Setting number</th></tr><tr><td>1</td><td>0</td><td>0</td><td>Alternative Setting 4</td></tr><tr><td>0</td><td>1</td><td>1</td><td>Alternative Setting 3</td></tr><tr><td>0</td><td>1</td><td>0</td><td>Alternative Setting 2</td></tr><tr><td>0</td><td>0</td><td>1</td><td>Alternative Setting 1</td></tr><tr><td>0</td><td>0</td><td>0</td><td>Alternative Setting 0</td></tr></table> | AL5ST3 | AL5ST2 | AL5ST1                              | Selected Alternative Setting number | 1 | 0 | 0 | Alternative Setting 4 | 0 | 1 | 1 | Alternative Setting 3 | 0 | 1 | 0 | Alternative Setting 2 | 0 | 0 | 1 | Alternative Setting 1 | 0 | 0 | 0 | Alternative Setting 0 |
|              |                  | AL5ST3                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | AL5ST2 | AL5ST1 | Selected Alternative Setting number |                                     |   |   |   |                       |   |   |   |                       |   |   |   |                       |   |   |   |                       |   |   |   |                       |
|              |                  | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 0      | 0      | Alternative Setting 4               |                                     |   |   |   |                       |   |   |   |                       |   |   |   |                       |   |   |   |                       |   |   |   |                       |
|              |                  | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 1      | 1      | Alternative Setting 3               |                                     |   |   |   |                       |   |   |   |                       |   |   |   |                       |   |   |   |                       |   |   |   |                       |
|              |                  | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 1      | 0      | Alternative Setting 2               |                                     |   |   |   |                       |   |   |   |                       |   |   |   |                       |   |   |   |                       |   |   |   |                       |
|              |                  | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 0      | 1      | Alternative Setting 1               |                                     |   |   |   |                       |   |   |   |                       |   |   |   |                       |   |   |   |                       |   |   |   |                       |
|              |                  | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 0      | 0      | Alternative Setting 0               |                                     |   |   |   |                       |   |   |   |                       |   |   |   |                       |   |   |   |                       |   |   |   |                       |
|              |                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |        |        |                                     |                                     |   |   |   |                       |   |   |   |                       |   |   |   |                       |   |   |   |                       |   |   |   |                       |
|              |                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |        |        |                                     |                                     |   |   |   |                       |   |   |   |                       |   |   |   |                       |   |   |   |                       |   |   |   |                       |
|              |                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |        |        |                                     |                                     |   |   |   |                       |   |   |   |                       |   |   |   |                       |   |   |   |                       |   |   |   |                       |
|              |                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |        |        |                                     |                                     |   |   |   |                       |   |   |   |                       |   |   |   |                       |   |   |   |                       |   |   |   |                       |
|              |                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |        |        |                                     |                                     |   |   |   |                       |   |   |   |                       |   |   |   |                       |   |   |   |                       |   |   |   |                       |
|              |                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |        |        |                                     |                                     |   |   |   |                       |   |   |   |                       |   |   |   |                       |   |   |   |                       |   |   |   |                       |
| 0            | AL2ST            | <p>This bit indicates the current status of the two-series Alternative Setting (selected Alternative Setting number).</p> <p>1: Alternative Setting 1</p> <p>0: Alternative Setting 0</p>                                                                                                                                                                                                                                                                                  |        |        |                                     |                                     |   |   |   |                       |   |   |   |                       |   |   |   |                       |   |   |   |                       |   |   |   |                       |

**(38) UF0 endpoint 1 interface mapping register (UF0E1IM)**

This register specifies for which Interface and Alternative Setting Endpoint1 is valid.

This register can be read or written in 8-bit units.

The setting of this register and the Alternative Setting selected by the SET\_INTERFACE request indicate whether Endpoint1 is currently valid, and the hardware determines how the GET\_STATUS/CLEAR\_FEATURE/SET\_FEATURE Endpoint1 request and the IN transaction to Endpoint1 are responded to, and whether the related bits are valid or invalid.

|         |       |       |       |        |        |        |        |        |           |             |
|---------|-------|-------|-------|--------|--------|--------|--------|--------|-----------|-------------|
|         | 7     | 6     | 5     | 4      | 3      | 2      | 1      | 0      | Address   | After reset |
| UF0E1IM | E1EN2 | E1EN1 | E1EN0 | E12AL1 | E15AL4 | E15AL3 | E15AL2 | E15AL1 | FFFFFE43H | 00H         |

| Bit position                                                                                                       | Bit name       | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |       |       |                                                   |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
|--------------------------------------------------------------------------------------------------------------------|----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|-------|---------------------------------------------------|-------------|---|---|---|---------------------------|---|---|---|---|---|---|---------------------------------------------------|---|---|---|---------------------------------------------------|---|---|---|---------------------------------------------------|---|---|---|---------------------------------------------------|---|---|---|---------------------------------------------------|---|---|---|-------------------------------------------|
| 7 to 5                                                                                                             | E1EN2 to E1EN0 | These bits set a link between the Interface of Endpoint1 and the two-/five-series Alternative Setting. The endpoint is linked with Alternative Setting 0. The endpoint linked with Alternative Setting 0 cannot be excluded from Alternative Setting 1 to 4.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |       |       |                                                   |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
|                                                                                                                    |                | <table><tr><th>E1EN2</th><th>E1EN1</th><th>E1EN0</th><th>Link status</th></tr><tr><td>1</td><td>1</td><td>1</td><td rowspan="2">Not linked with Interface</td></tr><tr><td>1</td><td>1</td><td>0</td></tr><tr><td>1</td><td>0</td><td>1</td><td>Linked with Interface 4 and Alternative Setting 0</td></tr><tr><td>1</td><td>0</td><td>0</td><td>Linked with Interface 3 and Alternative Setting 0</td></tr><tr><td>0</td><td>1</td><td>1</td><td>Linked with Interface 2 and Alternative Setting 0</td></tr><tr><td>0</td><td>1</td><td>0</td><td>Linked with Interface 1 and Alternative Setting 0</td></tr><tr><td>0</td><td>0</td><td>1</td><td>Linked with Interface 0 and Alternative Setting 0</td></tr><tr><td>0</td><td>0</td><td>0</td><td>Not linked with Interface (default value)</td></tr></table> | E1EN2 | E1EN1 | E1EN0                                             | Link status | 1 | 1 | 1 | Not linked with Interface | 1 | 1 | 0 | 1 | 0 | 1 | Linked with Interface 4 and Alternative Setting 0 | 1 | 0 | 0 | Linked with Interface 3 and Alternative Setting 0 | 0 | 1 | 1 | Linked with Interface 2 and Alternative Setting 0 | 0 | 1 | 0 | Linked with Interface 1 and Alternative Setting 0 | 0 | 0 | 1 | Linked with Interface 0 and Alternative Setting 0 | 0 | 0 | 0 | Not linked with Interface (default value) |
|                                                                                                                    |                | E1EN2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | E1EN1 | E1EN0 | Link status                                       |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
|                                                                                                                    |                | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 1     | 1     | Not linked with Interface                         |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
|                                                                                                                    |                | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 1     | 0     |                                                   |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
|                                                                                                                    |                | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 0     | 1     | Linked with Interface 4 and Alternative Setting 0 |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
|                                                                                                                    |                | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 0     | 0     | Linked with Interface 3 and Alternative Setting 0 |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
|                                                                                                                    |                | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 1     | 1     | Linked with Interface 2 and Alternative Setting 0 |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
|                                                                                                                    |                | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 1     | 0     | Linked with Interface 1 and Alternative Setting 0 |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
|                                                                                                                    |                | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 0     | 1     | Linked with Interface 0 and Alternative Setting 0 |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
|                                                                                                                    |                | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 0     | 0     | Not linked with Interface (default value)         |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
| When these bits are set to 110 or 111, they are invalid even if the E12AL1 bit is cleared to 0.                    |                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |       |       |                                                   |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
| If the endpoint is linked, setting of the CONF bit of the UF0MODS register to 1 indicates that Endpoint1 is valid. |                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |       |       |                                                   |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
|                                                                                                                    |                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |       |       |                                                   |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
|                                                                                                                    |                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |       |       |                                                   |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
|                                                                                                                    |                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |       |       |                                                   |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
|                                                                                                                    |                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |       |       |                                                   |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
|                                                                                                                    |                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |       |       |                                                   |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
|                                                                                                                    |                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |       |       |                                                   |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
|                                                                                                                    |                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |       |       |                                                   |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
| 4                                                                                                                  | E12AL1         | <p>This bit validates Endpoint1 when the two-series Alternative Setting and the Alternative Setting of the linked Interface are set to 1.</p> <p>1: Validate the endpoint when Alternative Setting 1 is set with CONF bit = 1.</p> <p>0: Do not validate the endpoint even when Alternative Setting 1 is set with CONF bit = 1 (default value).</p> <p>This bit is valid when the E15AL4 to E15AL1 bits are 0000.</p>                                                                                                                                                                                                                                                                                                                                                                                            |       |       |                                                   |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
| 3 to 0                                                                                                             | E15ALn         | <p>These bits validate Endpoint1 when the five-series Alternative Setting and the Alternative Setting of the linked Interface are set to n.</p> <p>1: Validate the endpoint when Alternative Setting n is set with CONF bit = 1.</p> <p>0: Do not validate the endpoint even when Alternative Setting n is set with CONF bit = 1 (default value).</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                            |       |       |                                                   |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |

**Remark** n = 1 to 4

**(39) UF0 endpoint 2 interface mapping register (UF0E2IM)**

This register specifies for which Interface and Alternative Setting Endpoint2 is valid.

This register can be read or written in 8-bit units.

The setting of this register and the Alternative Setting selected by the SET\_INTERFACE request indicate whether Endpoint2 is currently valid, and the hardware determines how the GET\_STATUS/CLEAR\_FEATURE/SET\_FEATURE Endpoint2 request and the OUT transaction to Endpoint2 are responded to, and whether the related bits are valid or invalid.

|         |       |       |       |        |        |        |        |        |           |             |
|---------|-------|-------|-------|--------|--------|--------|--------|--------|-----------|-------------|
|         | 7     | 6     | 5     | 4      | 3      | 2      | 1      | 0      | Address   | After reset |
| UF0E2IM | E2EN2 | E2EN1 | E2EN0 | E22AL1 | E25AL4 | E25AL3 | E25AL2 | E25AL1 | FFFFFE44H | 00H         |

| Bit position                                                                                                       | Bit name       | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                           |       |                                                   |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
|--------------------------------------------------------------------------------------------------------------------|----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------|-------|---------------------------------------------------|-------------|---|---|---|---------------------------|---|---|---|---|---|---|---------------------------------------------------|---|---|---|---------------------------------------------------|---|---|---|---------------------------------------------------|---|---|---|---------------------------------------------------|---|---|---|---------------------------------------------------|---|---|---|-------------------------------------------|
| 7 to 5                                                                                                             | E2EN2 to E2EN0 | These bits set a link between the Interface of Endpoint2 and the two-/five-series Alternative Setting. The endpoint is linked with Alternative Setting 0. The endpoint linked with Alternative Setting 0 cannot be excluded from Alternative Setting 1 to 4.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                           |       |                                                   |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
|                                                                                                                    |                | <table><tr><th>E2EN2</th><th>E2EN1</th><th>E2EN0</th><th>Link status</th></tr><tr><td>1</td><td>1</td><td>1</td><td rowspan="2">Not linked with Interface</td></tr><tr><td>1</td><td>1</td><td>0</td></tr><tr><td>1</td><td>0</td><td>1</td><td>Linked with Interface 4 and Alternative Setting 0</td></tr><tr><td>1</td><td>0</td><td>0</td><td>Linked with Interface 3 and Alternative Setting 0</td></tr><tr><td>0</td><td>1</td><td>1</td><td>Linked with Interface 2 and Alternative Setting 0</td></tr><tr><td>0</td><td>1</td><td>0</td><td>Linked with Interface 1 and Alternative Setting 0</td></tr><tr><td>0</td><td>0</td><td>1</td><td>Linked with Interface 0 and Alternative Setting 0</td></tr><tr><td>0</td><td>0</td><td>0</td><td>Not linked with Interface (default value)</td></tr></table> | E2EN2                                     | E2EN1 | E2EN0                                             | Link status | 1 | 1 | 1 | Not linked with Interface | 1 | 1 | 0 | 1 | 0 | 1 | Linked with Interface 4 and Alternative Setting 0 | 1 | 0 | 0 | Linked with Interface 3 and Alternative Setting 0 | 0 | 1 | 1 | Linked with Interface 2 and Alternative Setting 0 | 0 | 1 | 0 | Linked with Interface 1 and Alternative Setting 0 | 0 | 0 | 1 | Linked with Interface 0 and Alternative Setting 0 | 0 | 0 | 0 | Not linked with Interface (default value) |
|                                                                                                                    |                | E2EN2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | E2EN1                                     | E2EN0 | Link status                                       |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
|                                                                                                                    |                | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 1                                         | 1     | Not linked with Interface                         |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
|                                                                                                                    |                | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 1                                         | 0     |                                                   |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
|                                                                                                                    |                | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 0                                         | 1     | Linked with Interface 4 and Alternative Setting 0 |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
|                                                                                                                    |                | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 0                                         | 0     | Linked with Interface 3 and Alternative Setting 0 |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
|                                                                                                                    |                | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 1                                         | 1     | Linked with Interface 2 and Alternative Setting 0 |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
|                                                                                                                    |                | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 1                                         | 0     | Linked with Interface 1 and Alternative Setting 0 |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
|                                                                                                                    |                | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 0                                         | 1     | Linked with Interface 0 and Alternative Setting 0 |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
| 0                                                                                                                  | 0              | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Not linked with Interface (default value) |       |                                                   |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
| When these bits are set to 110 or 111, they are invalid even if the E22AL1 bit is cleared to 0.                    |                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                           |       |                                                   |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
| If the endpoint is linked, setting of the CONF bit of the UF0MODS register to 1 indicates that Endpoint2 is valid. |                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                           |       |                                                   |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
| 4                                                                                                                  | E22AL1         | This bit validates Endpoint2 when the two-series Alternative Setting and the Alternative Setting of the linked Interface are set to 1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                           |       |                                                   |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
|                                                                                                                    |                | 1: Validate the endpoint when Alternative Setting 1 is set with CONF bit = 1.<br>0: Do not validate the endpoint even when Alternative Setting 1 is set with CONF bit = 1 (default value).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                           |       |                                                   |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
|                                                                                                                    |                | This bit is valid when the E25AL4 to E25AL1 bits are 0000.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                           |       |                                                   |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
| 3 to 0                                                                                                             | E25ALn         | These bits validate Endpoint2 when the five-series Alternative Setting and the Alternative Setting of the linked Interface are set to n.<br>1: Validate the endpoint when Alternative Setting n is set with CONF bit = 1.<br>0: Do not validate the endpoint even when Alternative Setting n is set with CONF bit = 1 (default value).                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                           |       |                                                   |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |

**Remark** n = 1 to 4

**(40) UF0 endpoint 3 interface mapping register (UF0E3IM)**

This register specifies for which Interface and Alternative Setting Endpoint3 is valid.

This register can be read or written in 8-bit units.

The setting of this register and the Alternative Setting selected by the SET\_INTERFACE request indicate whether Endpoint3 is currently valid, and the hardware determines how the GET\_STATUS/CLEAR\_FEATURE/SET\_FEATURE Endpoint3 request and the IN transaction to Endpoint3 are responded to, and whether the related bits are valid or invalid.

|         |       |       |       |        |        |        |        |        |           |             |
|---------|-------|-------|-------|--------|--------|--------|--------|--------|-----------|-------------|
|         | 7     | 6     | 5     | 4      | 3      | 2      | 1      | 0      | Address   | After reset |
| UF0E3IM | E3EN2 | E3EN1 | E3EN0 | E32AL1 | E35AL4 | E35AL3 | E35AL2 | E35AL1 | FFFFFE45H | 00H         |

| Bit position                                                                                                       | Bit name       | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                           |       |                                                   |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
|--------------------------------------------------------------------------------------------------------------------|----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------|-------|---------------------------------------------------|-------------|---|---|---|---------------------------|---|---|---|---|---|---|---------------------------------------------------|---|---|---|---------------------------------------------------|---|---|---|---------------------------------------------------|---|---|---|---------------------------------------------------|---|---|---|---------------------------------------------------|---|---|---|-------------------------------------------|
| 7 to 5                                                                                                             | E3EN2 to E3EN0 | These bits set a link between the Interface of Endpoint3 and the two-/five-series Alternative Setting. The endpoint is linked with Alternative Setting 0. The endpoint linked with Alternative Setting 0 cannot be excluded from Alternative Setting 1 to 4.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                           |       |                                                   |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
|                                                                                                                    |                | <table><tr><th>E3EN2</th><th>E3EN1</th><th>E3EN0</th><th>Link status</th></tr><tr><td>1</td><td>1</td><td>1</td><td rowspan="2">Not linked with Interface</td></tr><tr><td>1</td><td>1</td><td>0</td></tr><tr><td>1</td><td>0</td><td>1</td><td>Linked with Interface 4 and Alternative Setting 0</td></tr><tr><td>1</td><td>0</td><td>0</td><td>Linked with Interface 3 and Alternative Setting 0</td></tr><tr><td>0</td><td>1</td><td>1</td><td>Linked with Interface 2 and Alternative Setting 0</td></tr><tr><td>0</td><td>1</td><td>0</td><td>Linked with Interface 1 and Alternative Setting 0</td></tr><tr><td>0</td><td>0</td><td>1</td><td>Linked with Interface 0 and Alternative Setting 0</td></tr><tr><td>0</td><td>0</td><td>0</td><td>Not linked with Interface (default value)</td></tr></table> | E3EN2                                     | E3EN1 | E3EN0                                             | Link status | 1 | 1 | 1 | Not linked with Interface | 1 | 1 | 0 | 1 | 0 | 1 | Linked with Interface 4 and Alternative Setting 0 | 1 | 0 | 0 | Linked with Interface 3 and Alternative Setting 0 | 0 | 1 | 1 | Linked with Interface 2 and Alternative Setting 0 | 0 | 1 | 0 | Linked with Interface 1 and Alternative Setting 0 | 0 | 0 | 1 | Linked with Interface 0 and Alternative Setting 0 | 0 | 0 | 0 | Not linked with Interface (default value) |
|                                                                                                                    |                | E3EN2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | E3EN1                                     | E3EN0 | Link status                                       |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
|                                                                                                                    |                | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 1                                         | 1     | Not linked with Interface                         |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
|                                                                                                                    |                | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 1                                         | 0     |                                                   |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
|                                                                                                                    |                | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 0                                         | 1     | Linked with Interface 4 and Alternative Setting 0 |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
|                                                                                                                    |                | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 0                                         | 0     | Linked with Interface 3 and Alternative Setting 0 |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
|                                                                                                                    |                | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 1                                         | 1     | Linked with Interface 2 and Alternative Setting 0 |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
|                                                                                                                    |                | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 1                                         | 0     | Linked with Interface 1 and Alternative Setting 0 |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
|                                                                                                                    |                | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 0                                         | 1     | Linked with Interface 0 and Alternative Setting 0 |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
| 0                                                                                                                  | 0              | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Not linked with Interface (default value) |       |                                                   |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
| When these bits are set to 110 or 111, they are invalid even if the E32AL1 bit is cleared to 0.                    |                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                           |       |                                                   |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
| If the endpoint is linked, setting of the CONF bit of the UF0MODS register to 1 indicates that Endpoint3 is valid. |                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                           |       |                                                   |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
| 4                                                                                                                  | E32AL1         | This bit validates Endpoint3 when the two-series Alternative Setting and the Alternative Setting of the linked Interface are set to 1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                           |       |                                                   |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
|                                                                                                                    |                | 1: Validate the endpoint when Alternative Setting 1 is set with CONF bit = 1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                           |       |                                                   |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
|                                                                                                                    |                | 0: Do not validate the endpoint even when Alternative Setting 1 is set with CONF bit = 1 (default value).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                           |       |                                                   |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
|                                                                                                                    |                | This bit is valid when the E35AL4 to E35AL1 bits are 0000.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                           |       |                                                   |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
| 3 to 0                                                                                                             | E35ALn         | These bits validate Endpoint3 when the five-series Alternative Setting and the Alternative Setting of the linked Interface are set to n.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                           |       |                                                   |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
|                                                                                                                    |                | 1: Validate the endpoint when Alternative Setting n is set with CONF bit = 1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                           |       |                                                   |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
|                                                                                                                    |                | 0: Do not validate the endpoint even when Alternative Setting n is set with CONF bit = 1 (default value).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                           |       |                                                   |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |

**Remark** n = 1 to 4

**(41) UF0 endpoint 4 interface mapping register (UF0E4IM)**

This register specifies for which Interface and Alternative Setting Endpoint4 is valid.

This register can be read or written in 8-bit units.

The setting of this register and the Alternative Setting selected by the SET\_INTERFACE request indicate whether Endpoint4 is currently valid, and the hardware determines how the GET\_STATUS/CLEAR\_FEATURE/SET\_FEATURE Endpoint4 request and the OUT transaction to Endpoint4 are responded to, and whether the related bits are valid or invalid.

|         |       |       |       |        |        |        |        |        |           |             |
|---------|-------|-------|-------|--------|--------|--------|--------|--------|-----------|-------------|
|         | 7     | 6     | 5     | 4      | 3      | 2      | 1      | 0      | Address   | After reset |
| UF0E4IM | E4EN2 | E4EN1 | E4EN0 | E42AL1 | E45AL4 | E45AL3 | E45AL2 | E45AL1 | FFFFFE46H | 00H         |

| Bit position                                                                                                       | Bit name       | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                           |       |                                                   |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
|--------------------------------------------------------------------------------------------------------------------|----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------|-------|---------------------------------------------------|-------------|---|---|---|---------------------------|---|---|---|---|---|---|---------------------------------------------------|---|---|---|---------------------------------------------------|---|---|---|---------------------------------------------------|---|---|---|---------------------------------------------------|---|---|---|---------------------------------------------------|---|---|---|-------------------------------------------|
| 7 to 5                                                                                                             | E4EN2 to E4EN0 | These bits set a link between the Interface of Endpoint4 and the two-/five-series Alternative Setting. The endpoint is linked with Alternative Setting 0. The endpoint linked with Alternative Setting 0 cannot be excluded from Alternative Setting 1 to 4.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                           |       |                                                   |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
|                                                                                                                    |                | <table><tr><th>E4EN2</th><th>E4EN1</th><th>E4EN0</th><th>Link status</th></tr><tr><td>1</td><td>1</td><td>1</td><td rowspan="2">Not linked with Interface</td></tr><tr><td>1</td><td>1</td><td>0</td></tr><tr><td>1</td><td>0</td><td>1</td><td>Linked with Interface 4 and Alternative Setting 0</td></tr><tr><td>1</td><td>0</td><td>0</td><td>Linked with Interface 3 and Alternative Setting 0</td></tr><tr><td>0</td><td>1</td><td>1</td><td>Linked with Interface 2 and Alternative Setting 0</td></tr><tr><td>0</td><td>1</td><td>0</td><td>Linked with Interface 1 and Alternative Setting 0</td></tr><tr><td>0</td><td>0</td><td>1</td><td>Linked with Interface 0 and Alternative Setting 0</td></tr><tr><td>0</td><td>0</td><td>0</td><td>Not linked with Interface (default value)</td></tr></table> | E4EN2                                     | E4EN1 | E4EN0                                             | Link status | 1 | 1 | 1 | Not linked with Interface | 1 | 1 | 0 | 1 | 0 | 1 | Linked with Interface 4 and Alternative Setting 0 | 1 | 0 | 0 | Linked with Interface 3 and Alternative Setting 0 | 0 | 1 | 1 | Linked with Interface 2 and Alternative Setting 0 | 0 | 1 | 0 | Linked with Interface 1 and Alternative Setting 0 | 0 | 0 | 1 | Linked with Interface 0 and Alternative Setting 0 | 0 | 0 | 0 | Not linked with Interface (default value) |
|                                                                                                                    |                | E4EN2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | E4EN1                                     | E4EN0 | Link status                                       |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
|                                                                                                                    |                | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 1                                         | 1     | Not linked with Interface                         |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
|                                                                                                                    |                | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 1                                         | 0     |                                                   |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
|                                                                                                                    |                | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 0                                         | 1     | Linked with Interface 4 and Alternative Setting 0 |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
|                                                                                                                    |                | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 0                                         | 0     | Linked with Interface 3 and Alternative Setting 0 |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
|                                                                                                                    |                | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 1                                         | 1     | Linked with Interface 2 and Alternative Setting 0 |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
|                                                                                                                    |                | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 1                                         | 0     | Linked with Interface 1 and Alternative Setting 0 |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
|                                                                                                                    |                | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 0                                         | 1     | Linked with Interface 0 and Alternative Setting 0 |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
| 0                                                                                                                  | 0              | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Not linked with Interface (default value) |       |                                                   |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
| When these bits are set to 110 or 111, they are invalid even if the E42AL1 bit is cleared to 0.                    |                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                           |       |                                                   |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
| If the endpoint is linked, setting of the CONF bit of the UF0MODS register to 1 indicates that Endpoint4 is valid. |                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                           |       |                                                   |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
| 4                                                                                                                  | E42AL1         | This bit validates Endpoint4 when the two-series Alternative Setting and the Alternative Setting of the linked Interface are set to 1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                           |       |                                                   |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
|                                                                                                                    |                | 1: Validate the endpoint when Alternative Setting 1 is set with CONF bit = 1.<br>0: Do not validate the endpoint even when Alternative Setting 1 is set with CONF bit = 1 (default value).<br>This bit is valid when the E45AL4 to E45AL1 bits are 0000.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                           |       |                                                   |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
| 3 to 0                                                                                                             | E45ALn         | These bits validate Endpoint4 when the five-series Alternative Setting and the Alternative Setting of the linked Interface are set to n.<br>1: Validate the endpoint when Alternative Setting n is set with CONF bit = 1.<br>0: Do not validate the endpoint even when Alternative Setting n is set with CONF bit = 1 (default value).                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                           |       |                                                   |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |

**Remark** n = 1 to 4



**(42) UF0 endpoint 7 interface mapping register (UF0E7IM)**

This register specifies for which Interface and Alternative Setting Endpoint7 is valid.

This register can be read or written in 8-bit units.

The setting of this register and the Alternative Setting selected by the SET\_INTERFACE request indicate whether Endpoint7 is currently valid, and the hardware determines how the GET\_STATUS/CLEAR\_FEATURE/SET\_FEATURE Endpoint7 request and the IN transaction to Endpoint7 are responded to, and whether the related bits are valid or invalid.

|         |       |       |       |        |        |        |        |        |           |             |
|---------|-------|-------|-------|--------|--------|--------|--------|--------|-----------|-------------|
|         | 7     | 6     | 5     | 4      | 3      | 2      | 1      | 0      | Address   | After reset |
| UF0E7IM | E7EN2 | E7EN1 | E7EN0 | E72AL1 | E75AL4 | E75AL3 | E75AL2 | E75AL1 | FFFFFE49H | 00H         |

| Bit position                                                                                                       | Bit name       | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                           |       |                                                   |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
|--------------------------------------------------------------------------------------------------------------------|----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------|-------|---------------------------------------------------|-------------|---|---|---|---------------------------|---|---|---|---|---|---|---------------------------------------------------|---|---|---|---------------------------------------------------|---|---|---|---------------------------------------------------|---|---|---|---------------------------------------------------|---|---|---|---------------------------------------------------|---|---|---|-------------------------------------------|
| 7 to 5                                                                                                             | E7EN2 to E7EN0 | These bits set a link between the Interface of Endpoint7 and the two-/five-series Alternative Setting. The endpoint is linked with Alternative Setting 0. The endpoint linked with Alternative Setting 0 cannot be excluded from Alternative Setting 1 to 4.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                           |       |                                                   |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
|                                                                                                                    |                | <table><tr><th>E7EN2</th><th>E7EN1</th><th>E7EN0</th><th>Link status</th></tr><tr><td>1</td><td>1</td><td>1</td><td rowspan="2">Not linked with Interface</td></tr><tr><td>1</td><td>1</td><td>0</td></tr><tr><td>1</td><td>0</td><td>1</td><td>Linked with Interface 4 and Alternative Setting 0</td></tr><tr><td>1</td><td>0</td><td>0</td><td>Linked with Interface 3 and Alternative Setting 0</td></tr><tr><td>0</td><td>1</td><td>1</td><td>Linked with Interface 2 and Alternative Setting 0</td></tr><tr><td>0</td><td>1</td><td>0</td><td>Linked with Interface 1 and Alternative Setting 0</td></tr><tr><td>0</td><td>0</td><td>1</td><td>Linked with Interface 0 and Alternative Setting 0</td></tr><tr><td>0</td><td>0</td><td>0</td><td>Not linked with Interface (default value)</td></tr></table> | E7EN2                                     | E7EN1 | E7EN0                                             | Link status | 1 | 1 | 1 | Not linked with Interface | 1 | 1 | 0 | 1 | 0 | 1 | Linked with Interface 4 and Alternative Setting 0 | 1 | 0 | 0 | Linked with Interface 3 and Alternative Setting 0 | 0 | 1 | 1 | Linked with Interface 2 and Alternative Setting 0 | 0 | 1 | 0 | Linked with Interface 1 and Alternative Setting 0 | 0 | 0 | 1 | Linked with Interface 0 and Alternative Setting 0 | 0 | 0 | 0 | Not linked with Interface (default value) |
|                                                                                                                    |                | E7EN2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | E7EN1                                     | E7EN0 | Link status                                       |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
|                                                                                                                    |                | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 1                                         | 1     | Not linked with Interface                         |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
|                                                                                                                    |                | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 1                                         | 0     |                                                   |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
|                                                                                                                    |                | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 0                                         | 1     | Linked with Interface 4 and Alternative Setting 0 |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
|                                                                                                                    |                | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 0                                         | 0     | Linked with Interface 3 and Alternative Setting 0 |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
|                                                                                                                    |                | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 1                                         | 1     | Linked with Interface 2 and Alternative Setting 0 |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
|                                                                                                                    |                | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 1                                         | 0     | Linked with Interface 1 and Alternative Setting 0 |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
|                                                                                                                    |                | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 0                                         | 1     | Linked with Interface 0 and Alternative Setting 0 |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
| 0                                                                                                                  | 0              | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Not linked with Interface (default value) |       |                                                   |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
| When these bits are set to 110 or 111, they are invalid even if the E72AL1 bit is cleared to 0.                    |                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                           |       |                                                   |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
| If the endpoint is linked, setting of the CONF bit of the UF0MODS register to 1 indicates that Endpoint7 is valid. |                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                           |       |                                                   |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
| 4                                                                                                                  | E72AL1         | This bit validates Endpoint7 when the two-series Alternative Setting and the Alternative Setting of the linked Interface are set to 1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                           |       |                                                   |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
|                                                                                                                    |                | 1: Validate the endpoint when Alternative Setting 1 is set with CONF bit = 1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                           |       |                                                   |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
|                                                                                                                    |                | 0: Do not validate the endpoint even when Alternative Setting 1 is set with CONF bit = 1 (default value).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                           |       |                                                   |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
|                                                                                                                    |                | This bit is valid when the E75AL4 to E75AL1 bits are 0000.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                           |       |                                                   |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
| 3 to 0                                                                                                             | E75ALn         | These bits validate Endpoint7 when the five-series Alternative Setting and the Alternative Setting of the linked Interface are set to n.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                           |       |                                                   |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
|                                                                                                                    |                | 1: Validate the endpoint when Alternative Setting n is set with CONF bit = 1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                           |       |                                                   |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
|                                                                                                                    |                | 0: Do not validate the endpoint even when Alternative Setting n is set with CONF bit = 1 (default value).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                           |       |                                                   |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |

**Remark** n = 1 to 4

**(43) UF0 endpoint 8 interface mapping register (UF0E8IM)**

This register specifies for which Interface and Alternative Setting Endpoint8 is valid.

This register can be read or written in 8-bit units.

The setting of this register and the Alternative Setting selected by the SET\_INTERFACE request indicate whether Endpoint8 is currently valid, and the hardware determines how the GET\_STATUS/CLEAR\_FEATURE/SET\_FEATURE Endpoint8 request and the IN transaction to Endpoint8 are responded to, and whether the related bits are valid or invalid.

|         |       |       |       |        |        |        |        |        |           |             |
|---------|-------|-------|-------|--------|--------|--------|--------|--------|-----------|-------------|
|         | 7     | 6     | 5     | 4      | 3      | 2      | 1      | 0      | Address   | After reset |
| UF0E8IM | E8EN2 | E8EN1 | E8EN0 | E82AL1 | E85AL4 | E85AL3 | E85AL2 | E85AL1 | FFFFFE4AH | 00H         |

| Bit position                                                                                                       | Bit name       | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                           |       |                                                   |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
|--------------------------------------------------------------------------------------------------------------------|----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------|-------|---------------------------------------------------|-------------|---|---|---|---------------------------|---|---|---|---|---|---|---------------------------------------------------|---|---|---|---------------------------------------------------|---|---|---|---------------------------------------------------|---|---|---|---------------------------------------------------|---|---|---|---------------------------------------------------|---|---|---|-------------------------------------------|
| 7 to 5                                                                                                             | E8EN2 to E8EN0 | These bits set a link between the Interface of Endpoint8 and the two-/five-series Alternative Setting. The endpoint is linked with Alternative Setting 0. The endpoint linked with Alternative Setting 0 cannot be excluded from Alternative Setting 1 to 4.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                           |       |                                                   |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
|                                                                                                                    |                | <table><tr><th>E8EN2</th><th>E8EN1</th><th>E8EN0</th><th>Link status</th></tr><tr><td>1</td><td>1</td><td>1</td><td rowspan="2">Not linked with Interface</td></tr><tr><td>1</td><td>1</td><td>0</td></tr><tr><td>1</td><td>0</td><td>1</td><td>Linked with Interface 4 and Alternative Setting 0</td></tr><tr><td>1</td><td>0</td><td>0</td><td>Linked with Interface 3 and Alternative Setting 0</td></tr><tr><td>0</td><td>1</td><td>1</td><td>Linked with Interface 2 and Alternative Setting 0</td></tr><tr><td>0</td><td>1</td><td>0</td><td>Linked with Interface 1 and Alternative Setting 0</td></tr><tr><td>0</td><td>0</td><td>1</td><td>Linked with Interface 0 and Alternative Setting 0</td></tr><tr><td>0</td><td>0</td><td>0</td><td>Not linked with Interface (default value)</td></tr></table> | E8EN2                                     | E8EN1 | E8EN0                                             | Link status | 1 | 1 | 1 | Not linked with Interface | 1 | 1 | 0 | 1 | 0 | 1 | Linked with Interface 4 and Alternative Setting 0 | 1 | 0 | 0 | Linked with Interface 3 and Alternative Setting 0 | 0 | 1 | 1 | Linked with Interface 2 and Alternative Setting 0 | 0 | 1 | 0 | Linked with Interface 1 and Alternative Setting 0 | 0 | 0 | 1 | Linked with Interface 0 and Alternative Setting 0 | 0 | 0 | 0 | Not linked with Interface (default value) |
|                                                                                                                    |                | E8EN2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | E8EN1                                     | E8EN0 | Link status                                       |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
|                                                                                                                    |                | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 1                                         | 1     | Not linked with Interface                         |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
|                                                                                                                    |                | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 1                                         | 0     |                                                   |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
|                                                                                                                    |                | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 0                                         | 1     | Linked with Interface 4 and Alternative Setting 0 |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
|                                                                                                                    |                | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 0                                         | 0     | Linked with Interface 3 and Alternative Setting 0 |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
|                                                                                                                    |                | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 1                                         | 1     | Linked with Interface 2 and Alternative Setting 0 |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
|                                                                                                                    |                | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 1                                         | 0     | Linked with Interface 1 and Alternative Setting 0 |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
|                                                                                                                    |                | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 0                                         | 1     | Linked with Interface 0 and Alternative Setting 0 |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
| 0                                                                                                                  | 0              | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Not linked with Interface (default value) |       |                                                   |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
| When these bits are set to 110 or 111, they are invalid even if the E82AL1 bit is cleared to 0.                    |                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                           |       |                                                   |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
| If the endpoint is linked, setting of the CONF bit of the UF0MODS register to 1 indicates that Endpoint8 is valid. |                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                           |       |                                                   |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
| 4                                                                                                                  | E82AL1         | This bit validates Endpoint8 when the two-series Alternative Setting and the Alternative Setting of the linked Interface are set to 1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                           |       |                                                   |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
|                                                                                                                    |                | 1: Validate the endpoint when Alternative Setting 1 is set with CONF bit = 1.<br>0: Do not validate the endpoint even when Alternative Setting 1 is set with CONF bit = 1 (default value).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                           |       |                                                   |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
|                                                                                                                    |                | This bit is valid when the E85AL4 to E85AL1 bits are 0000.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                           |       |                                                   |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |
| 3 to 0                                                                                                             | E85ALn         | These bits validate Endpoint8 when the five-series Alternative Setting and the Alternative Setting of the linked Interface are set to n.<br>1: Validate the endpoint when Alternative Setting n is set with CONF bit = 1.<br>0: Do not validate the endpoint even when Alternative Setting n is set with CONF bit = 1 (default value).                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                           |       |                                                   |             |   |   |   |                           |   |   |   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                                   |   |   |   |                                           |

**Remark** n = 1 to 4

### 11.4.2 Data hold registers

#### (1) UF0 EP0 read register (UF0E0R)

The UF0E0R register is a 64-byte FIFO that stores the OUT data sent from the host in the data stage of control transfer to/from Endpoint0.

This register is read-only, in 8-bit units. A write access to this register is ignored.

The hardware automatically transfers data to the UF0E0R register when it has received the data from the host. When the data has been correctly received, the E0ODT bit of the UF0IS1 register is set to 1. The UF0E0L register holds the quantity of the received data, and an interrupt request (INTUSB0B) is issued. The UF0E0L register always updates the length of the received data while it is receiving data. If the final transfer is correct reception, the interrupt request is generated. If the reception is abnormal, the UF0E0L register is cleared to 0 and the interrupt request is not generated.

The data held by the UF0E0R register must be read by FW up to the value of the amount of data read by the UF0E0L register. Check that all data has been read by using the EP0R bit of the UF0EPS0 register (EP0R bit = 0 when all data has been read). If the value of the UF0E0L register is 0, the EP0NKR bit of the UF0E0N register is cleared to 0, and the UF0E0R register is ready for reception. The UF0E0R register is cleared when the next SETUP token has been received.

**Caution** Read all the data stored. Clear the FIFO to discard some data.

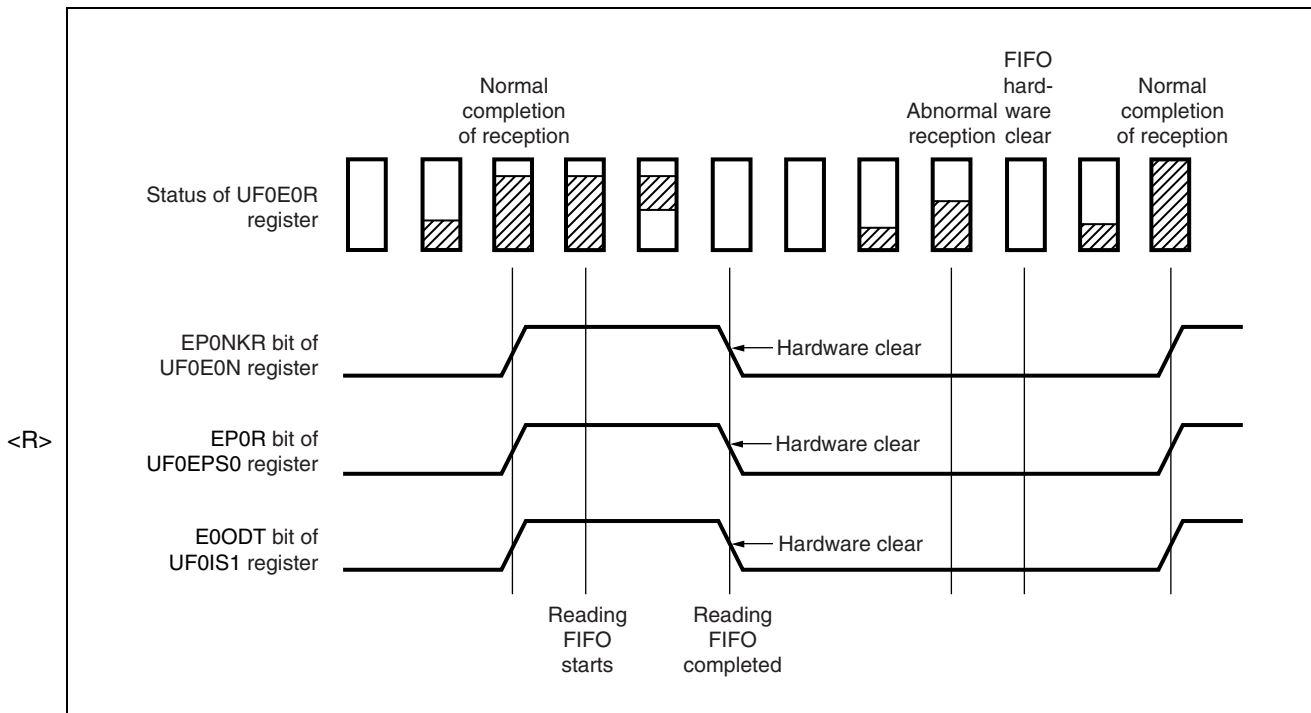
|        | 7    | 6    | 5    | 4    | 3    | 2    | 1    | 0    | Address   | After reset |
|--------|------|------|------|------|------|------|------|------|-----------|-------------|
| UF0E0R | E0R7 | E0R6 | E0R5 | E0R4 | E0R3 | E0R2 | E0R1 | E0R0 | FFFFFE80H | Undefined   |

| Bit position | Bit name     | Function                                                                                                  |
|--------------|--------------|-----------------------------------------------------------------------------------------------------------|
| 7 to 0       | E0R7 to E0R0 | These bits store the OUT data sent from the host in the data stage of control transfer to/from Endpoint0. |

The operation of the UF0E0R register is illustrated below.

Figure 11-1. Operation of UF0E0R Register

**(2) UF0 EP0 length register (UF0E0L)**

The UF0E0L register stores the data length held by the UF0E0R register.

This register is read-only, in 8-bit units. A write access to this register is ignored.

The UF0E0L register always updates the length of the received data while it is receiving data. If the final transfer is abnormal reception, the UF0E0L register is cleared to 0 and the interrupt request is not generated.

The interrupt request is generated only when the reception is normal, and the FW can read as many data from the UF0E0R register as the value read from the UF0E0L register. The value of the UF0E0L register is decremented each time the UF0E0R register has been read.

|        | 7    | 6    | 5    | 4    | 3    | 2    | 1    | 0    | Address    | After reset |
|--------|------|------|------|------|------|------|------|------|------------|-------------|
| UF0E0L | E0L7 | E0L6 | E0L5 | E0L4 | E0L3 | E0L2 | E0L1 | E0L0 | FFFFFFE81H | 00H         |

| Bit position | Bit name     | Function                                                      |
|--------------|--------------|---------------------------------------------------------------|
| 7 to 0       | E0L7 to E0L0 | These bits store the data length held by the UF0E0R register. |

**(3) UF0 EP0 setup register (UF0E0ST)**

The UF0E0ST register holds the SETUP data sent from the host.

This register is read-only, in 8-bit units. A write access to this register is ignored.

The UF0E0ST register always writes data when a SETUP transaction has been received. The hardware sets the PROT bit of the UF0IS1 register when it has correctly received the SETUP transaction. It sets the CPUDEC bit of the UF0IS1 register in the case of an FW-processed request. Then an interrupt request (INTUSB0B) is issued. In the case of an FW-processed request, be sure to read the request in 8-byte units. If it is not read in 8-byte units, the subsequent requests cannot be correctly decoded. The read counter of the UF0E0ST register is not cleared even when Bus Reset is received. Always read this counter in 8-byte units regardless of whether Bus Reset is received or not.

Because the UF0E0ST register always enables writing, the hardware overwrites data to this register even if a SETUP transaction is received while the data of the register is being read. Even if the SETUP transaction cannot be correctly received, the CPUDEC interrupt request and Protect interrupt request are not generated, but the previous data is discarded. If a SETUP token of less than 8 bytes is received, however, the received SETUP token is discarded, and the previously received SETUP data is retained. If the SETUP token is received more than once when control transfer is executed once, be sure to check the PROT bit of the UF0IS1 register under the conditions below. If PROT bit = 1, read the UF0E0ST register again because the SETUP transaction has been received more than once.

<1> If a request is decoded by FW and the UF0E0R register is read or the UF0E0W register is written

<2> When preparing for a STALL response for the request to which the decode result does not correspond

**Caution** Be sure to read all the stored data. The UF0E0ST register is always updated by the request in the SETUP transaction.

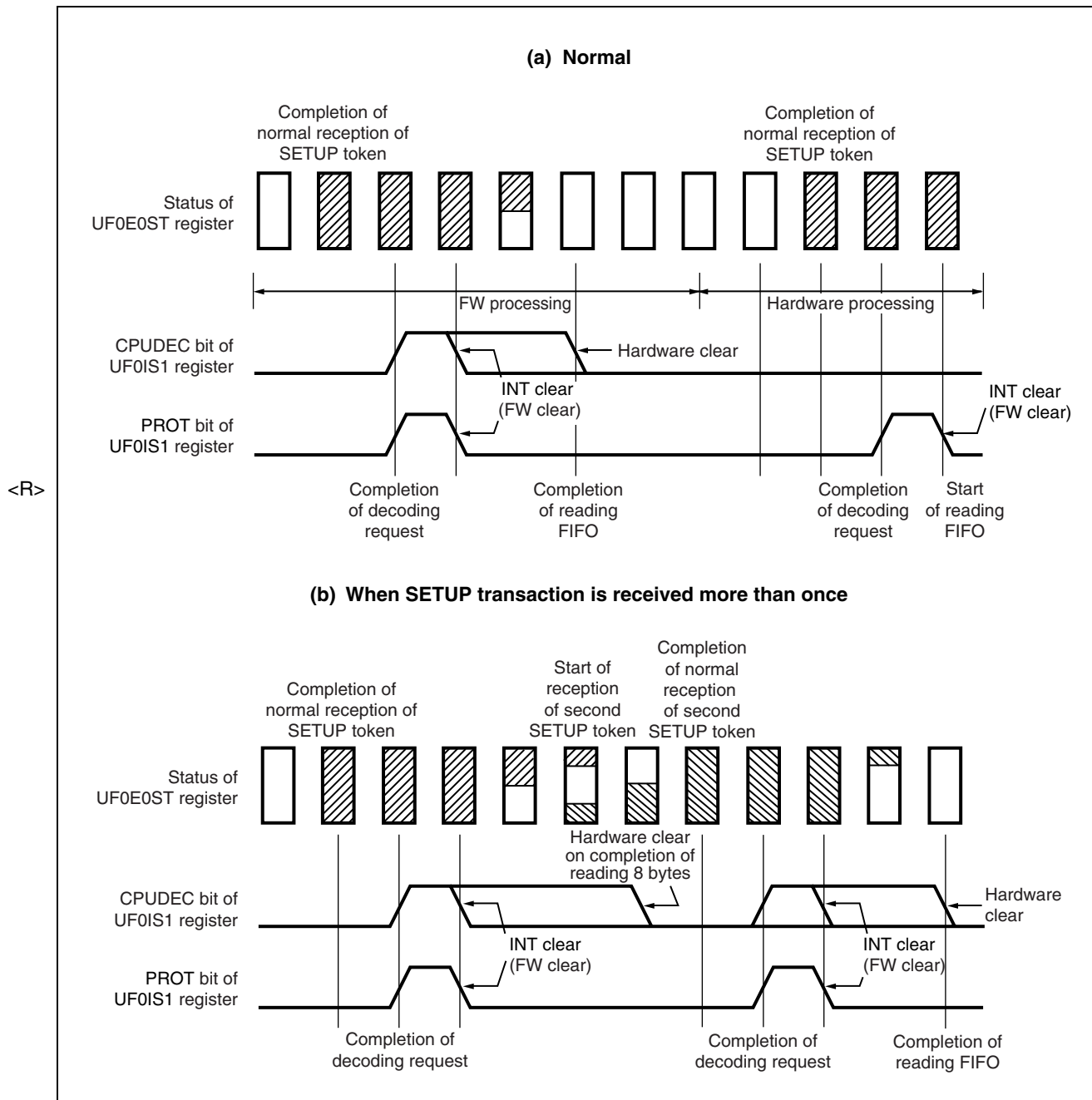
|         | 7    | 6    | 5    | 4    | 3    | 2    | 1    | 0    | Address   | After reset |
|---------|------|------|------|------|------|------|------|------|-----------|-------------|
| UF0E0ST | E0S7 | E0S6 | E0S5 | E0S4 | E0S3 | E0S2 | E0S1 | E0S0 | FFFFFE82H | 00H         |

| Bit position | Bit name     | Function                                           |
|--------------|--------------|----------------------------------------------------|
| 7 to 0       | E0S7 to E0S0 | These bits hold the SETUP data sent from the host. |

The operation of the UF0E0ST register is illustrated below.

Figure 11-2. Operation of UF0E0ST Register



**(4) UF0 EP0 write register (UF0E0W)**

The UF0E0W register is a 64-byte FIFO that stores the IN data (passes it to SIE) sent to the host in the data stage to Endpoint0.

This register is write-only, in 8-bit units. When this register is read, 00H is read.

The hardware transmits data to the USB bus in synchronization with an IN token only when the EP0NKW bit of the UF0E0N register is set to 1 (when NAK is not transmitted). When data is transmitted and when the host correctly receives the data, the EP0NKW bit of the UF0E0N register is automatically cleared to 0 by hardware. A short packet is transmitted when data is written to the UF0E0W register and the E0DED bit of the UF0DEND register is set to 1 (EP0W bit of the UF0EPS0 register = 1 (data exists)). A Null packet is transmitted when the UF0E0W register is cleared and the E0DED bit of the UF0DEND register is set to 1 (EP0W bit of the UF0EPS0 register = 1 (data exists)).

The UF0E0W register is cleared to 0 when the next SETUP token is received while transmission has not been completed yet. If the stage of control transfer (read) changes to the status stage while ACK has not been correctly received in the data stage, the UF0E0W register is automatically cleared to 0. At the same time, it is also cleared to 0 if the EP0NKW bit of the UF0E0N register is 1.

If the UF0E0W register is read while no data is in it, 00H is read.

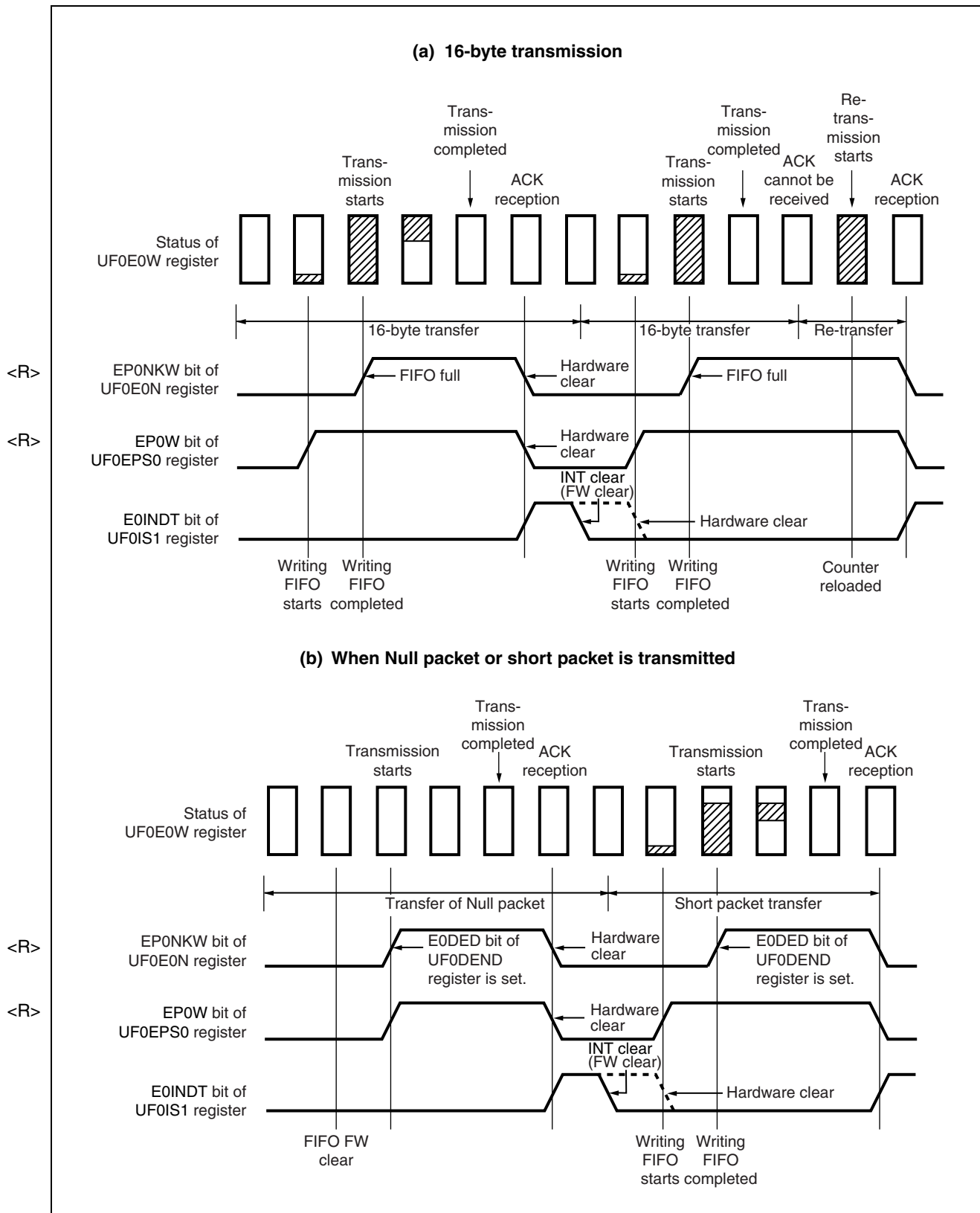
|        |      |      |      |      |      |      |      |      |           |             |
|--------|------|------|------|------|------|------|------|------|-----------|-------------|
|        | 7    | 6    | 5    | 4    | 3    | 2    | 1    | 0    | Address   | After reset |
| UF0E0W | E0W7 | E0W6 | E0W5 | E0W4 | E0W3 | E0W2 | E0W1 | E0W0 | FFFFFE83H | Undefined   |

| Bit position | Bit name     | Function                                                                      |
|--------------|--------------|-------------------------------------------------------------------------------|
| 7 to 0       | E0W7 to E0W0 | These bits store the IN data sent to the host in the data stage to Endpoint0. |

The operation of the UF0E0W register is illustrated below.

Figure 11-3. Operation of UF0E0W Register





**(5) UF0 bulk out 1 register (UF0BO1)**

The UF0BO1 register is a 64-byte  $\times$  2 FIFO that stores data for Endpoint2. This register consists of two banks of 64-byte FIFOs each of which performs a toggle operation and repeatedly connects the buses on the SIE and CPU sides. The toggle operation takes place when data is in the FIFO on the SIE side and when no data is in the FIFO on the CPU side (counter value = 0).

This register is read-only, in 8-bit units. A write access to this register is ignored.

When the hardware receives data for Endpoint2 from the host, it automatically transfers the data to the UF0BO1 register. When the register correctly receives the data, a FIFO toggle operation occurs. As a result, the BKO1DT bit of the UF0IS3 register is set to 1, the quantity of the received data is held by the UF0BO1L register, and an interrupt request or DMA request is issued to the CPU. Whether the interrupt request or DMA request is issued can be selected by using the DQBO1MS bit of the UF0IDR register.

Read the data held by the UF0BO1 register by FW, up to the value of the amount of data read by the UF0BO1L register. When the correct received data is held by the FIFO connected to the SIE side and the value of the UF0BO1L register reaches 0, the toggle operation of the FIFO occurs, and the BKO1NK bit of the UF0EN register is automatically cleared to 0. If data greater than the value of the UF0BO1L register is read and if the FIFO toggle condition is satisfied, the toggle operation of the FIFO occurs. As a result, the next packet may be read by mistake. Note that, if the toggle condition is not satisfied, the first data is repeatedly read.

If overrun data is received while data is held by the FIFO connected to the CPU side, Endpoint2 stalls, and the FIFO on the CPU side is cleared.

When the UF0BO1 register is read while no data is in it, an undefined value is read.

**Caution** Be sure to read all the data stored in this register.

|        |       |       |       |       |       |       |       |       |           |             |
|--------|-------|-------|-------|-------|-------|-------|-------|-------|-----------|-------------|
|        | 7     | 6     | 5     | 4     | 3     | 2     | 1     | 0     | Address   | After reset |
| UF0BO1 | BKO17 | BKO16 | BKO15 | BKO14 | BKO13 | BKO12 | BKO11 | BKO10 | FFFFFE84H | Undefined   |

| Bit position | Bit name       | Function                             |
|--------------|----------------|--------------------------------------|
| 7 to 0       | BKO17 to BKO10 | These bits store data for Endpoint2. |

The operation of the UF0BO1 register is illustrated below.

Figure 11-4. Operation of UF0BO1 Register (1/2)

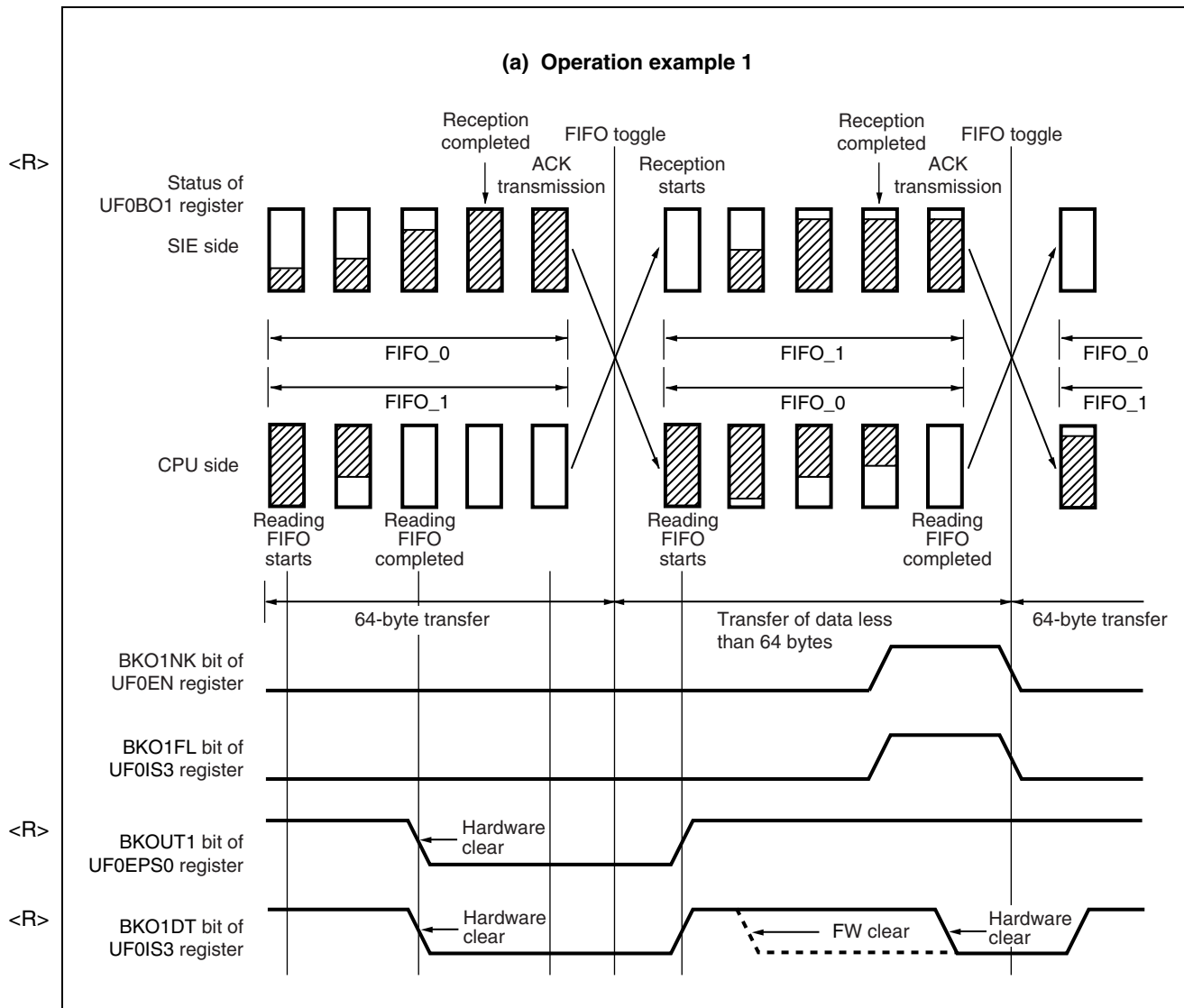
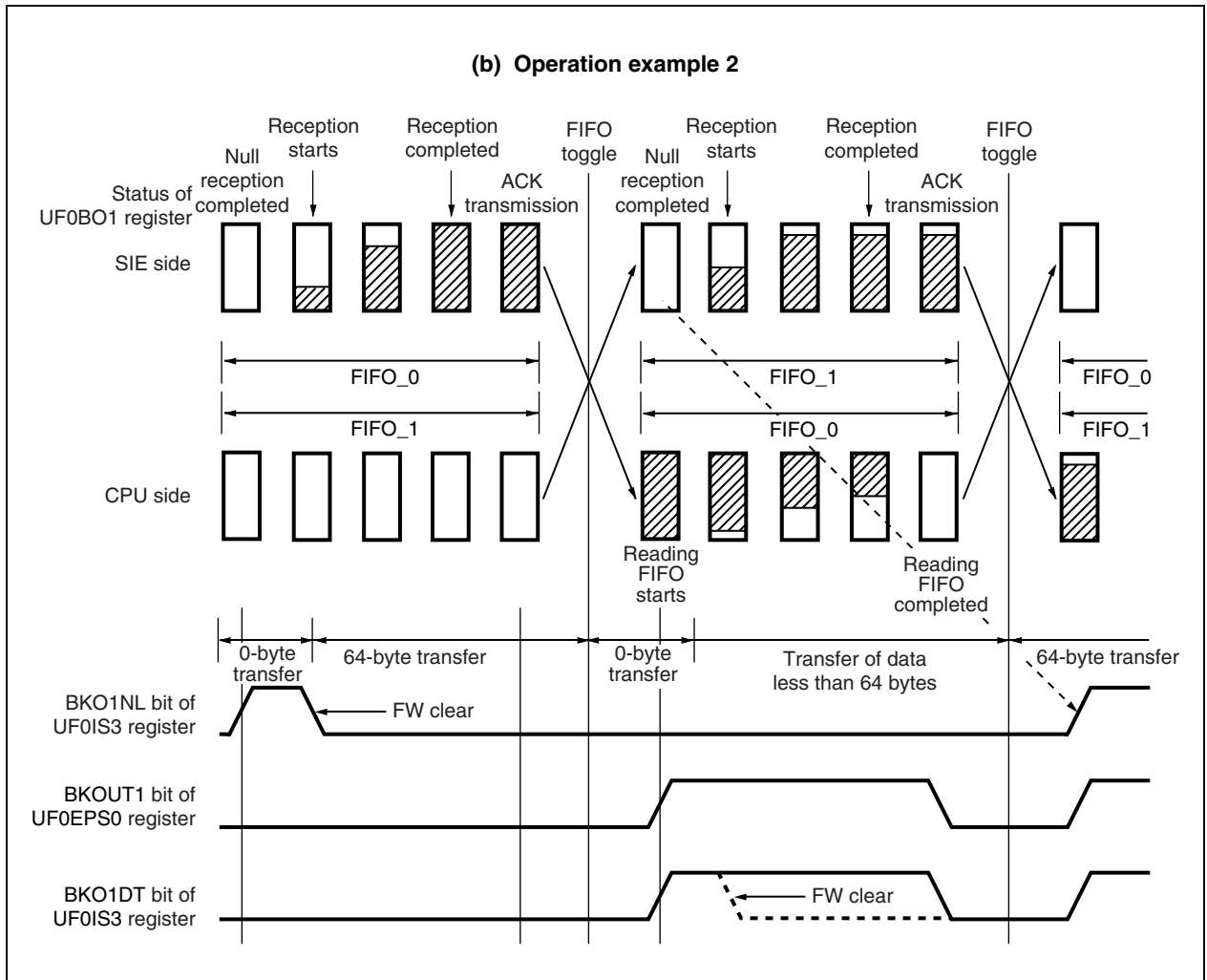


Figure 11-4. Operation of UF0BO1 Register (2/2)

<R>



<R>

**(6) UF0 bulk out 1 length register (UF0BO1L)**

The UF0BO1L register stores the length of the data held by the UF0BO1 register.

This register is read-only, in 8-bit units. A write access to this register is ignored.

The UF0BO1L register always updates the received data length while it is receiving data. If the final transfer is abnormal reception, the UF0BO1L register is cleared to 00H, and an interrupt request is not generated. Only if the reception is normal, the interrupt request is generated, and FW can read as much data from the UF0BO1 register as the value read from the UF0BO1L register. The value of the UF0BO1L register is decremented each time the UF0BO1 register has been read.

|         |        |        |        |        |        |        |        |        |           |             |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|-----------|-------------|
|         | 7      | 6      | 5      | 4      | 3      | 2      | 1      | 0      | Address   | After reset |
| UF0BO1L | BKO1L7 | BKO1L6 | BKO1L5 | BKO1L4 | BKO1L3 | BKO1L2 | BKO1L1 | BKO1L0 | FFFFFE85H | 00H         |

| Bit position | Bit name         | Function                                                             |
|--------------|------------------|----------------------------------------------------------------------|
| 7 to 0       | BKO1L7 to BKO1L0 | These bits store the length of the data held by the UF0BO1 register. |

**(7) UF0 bulk out 2 register (UF0BO2)**

The UF0BO2 register is a 64-byte  $\times$  2 FIFO that stores data for Endpoint4. This register consists of two banks of 64-byte FIFOs each of which performs a toggle operation and repeatedly connects the buses on the SIE and CPU sides. The toggle operation takes place when data is in the FIFO on the SIE side and when no data is in the FIFO on the CPU side (counter value = 0).

This register is read-only, in 8-bit units. A write access to this register is ignored.

When the hardware receives data for Endpoint4 from the host, it automatically transfers the data to the UF0BO2 register. When the register correctly receives the data, a FIFO toggle operation occurs. As a result, the BKO2DT bit of the UF0IS3 register is set to 1, the quantity of the received data is held by the UF0BO2L register, and an interrupt request or DMA request is issued to the CPU. Whether the interrupt request or DMA request is issued can be selected by using the DQBO2MS bit of the UF0IDR register.

Read the data held by the UF0BO2 register by FW, up to the value of the amount of data read by the UF0BO2L register. When the correct received data is held by the FIFO connected to the SIE side and the value of the UF0BO2L register reaches 0, the toggle operation of the FIFO occurs, and the BKO2NK bit of the UF0EN register is automatically cleared to 0. If data greater than the value of the UF0BO2L register is read and if the FIFO toggle condition is satisfied, the toggle operation of the FIFO occurs. As a result, the next packet may be read by mistake. Note that, if the toggle condition is not satisfied, the first data is repeatedly read.

If overrun data is received while data is held by the FIFO connected to the CPU side, Endpoint4 stalls, and the FIFO on the CPU side is cleared.

When the UF0BO2 register is read while no data is in it, an undefined value is read.

**Caution** Be sure to read all the data stored in this register.

|        |       |       |       |       |       |       |       |       |           |             |
|--------|-------|-------|-------|-------|-------|-------|-------|-------|-----------|-------------|
|        | 7     | 6     | 5     | 4     | 3     | 2     | 1     | 0     | Address   | After reset |
| UF0BO2 | BKO27 | BKO26 | BKO25 | BKO24 | BKO23 | BKO22 | BKO21 | BKO20 | FFFFFE86H | Undefined   |

| Bit position | Bit name       | Function                             |
|--------------|----------------|--------------------------------------|
| 7 to 0       | BKO27 to BKO20 | These bits store data for Endpoint4. |

The operation of the UF0BO2 register is illustrated below.

Figure 11-5. Operation of UF0BO2 Register (1/2)

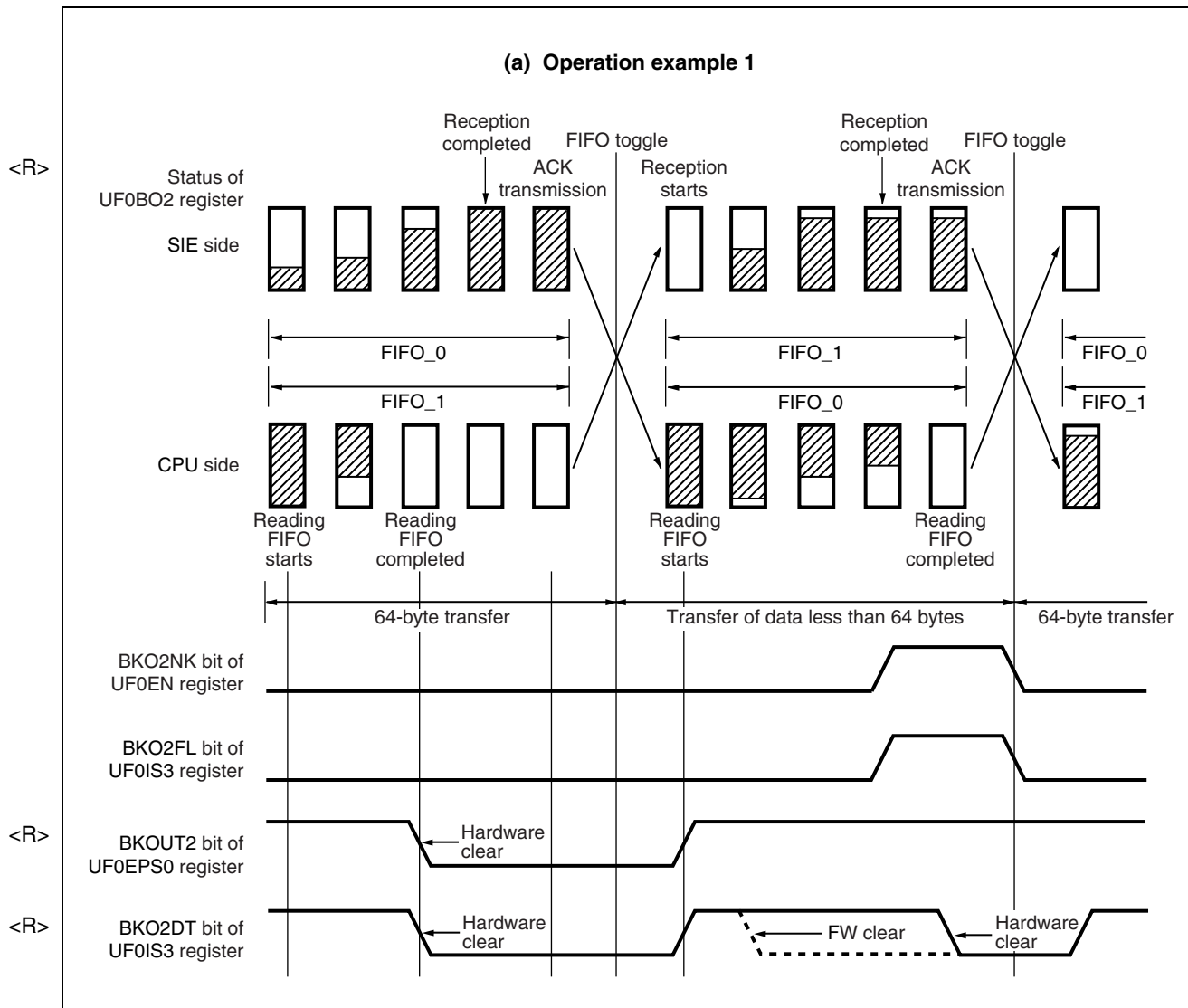
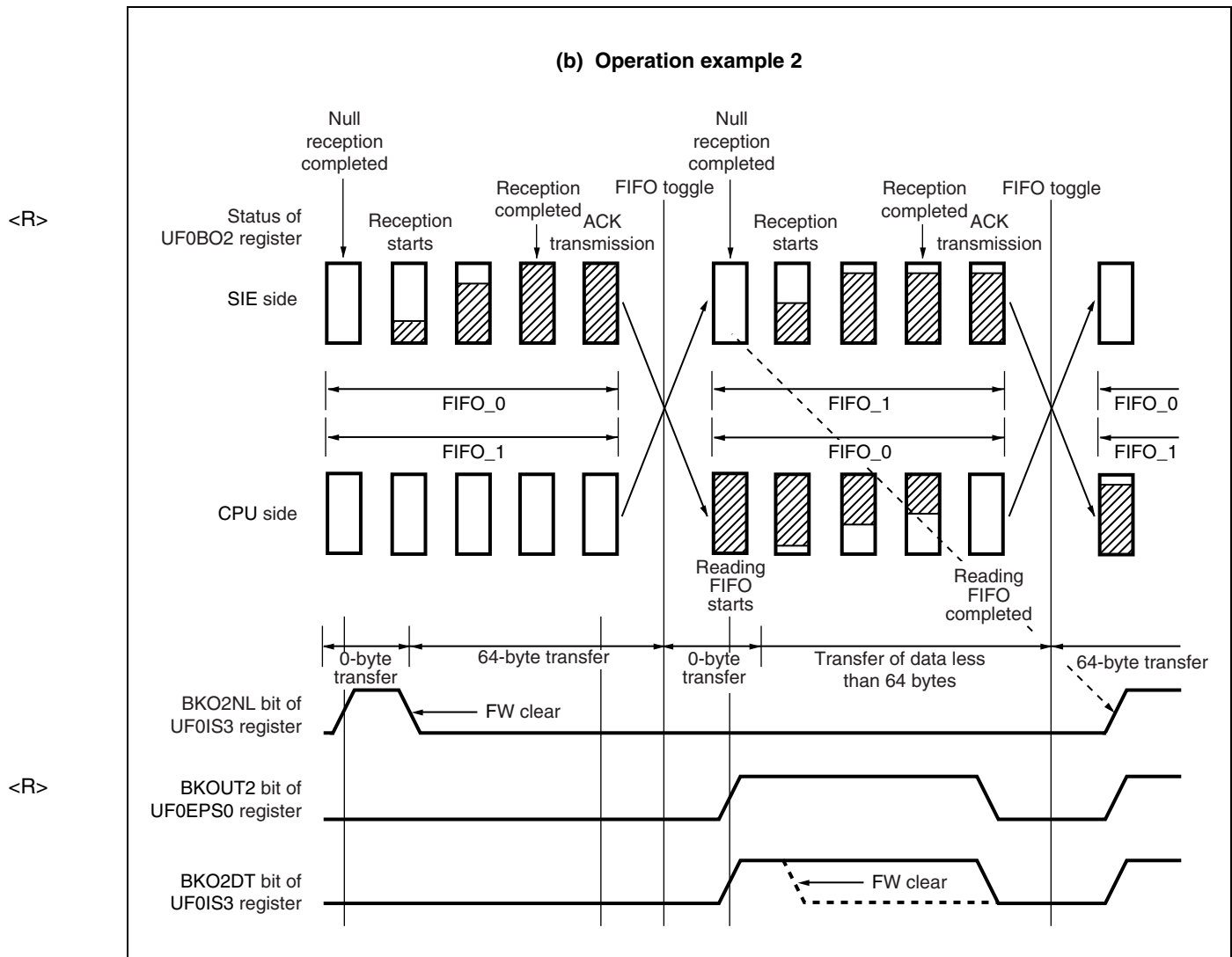


Figure 11-5. Operation of UF0BO2 Register (2/2)



**(8) UF0 bulk out 2 length register (UF0BO2L)**

The UF0BO2L register stores the length of the data held by the UF0BO2 register.

This register is read-only, in 8-bit units. A write access to this register is ignored.

The UF0BO2L register always updates the received data length while it is receiving data. If the final transfer is abnormal reception, the UF0BO2L register is cleared to 00H, and an interrupt request is not generated. Only if the reception is normal, the interrupt request is generated, and FW can read as much data from the UF0BO2 register as the value read from the UF0BO2L register. The value of the UF0BO2L register is decremented each time the UF0BO2 register has been read.

|         | 7      | 6      | 5      | 4      | 3      | 2      | 1      | 0      | Address   | After reset |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|-----------|-------------|
| UF0BO2L | BKO2L7 | BKO2L6 | BKO2L5 | BKO2L4 | BKO2L3 | BKO2L2 | BKO2L1 | BKO2L0 | FFFFFE87H | 00H         |

| Bit position | Bit name         | Function                                                             |
|--------------|------------------|----------------------------------------------------------------------|
| 7 to 0       | BKO2L7 to BKO2L0 | These bits store the length of the data held by the UF0BO2 register. |

**(9) UF0 bulk in 1 register (UF0BI1)**

The UF0BI1 register is a 64-byte × 2 FIFO that stores data for Endpoint1. This register consists of two banks of 64-byte FIFOs each of which performs a toggle operation and repeatedly connects the buses on the SIE and CPU sides. The toggle operation takes place when no data is in the FIFO on the SIE side (counter value = 0) and when the FIFO on the CPU side is correctly written (FIFO full or BKI1DED bit = 1).

This register is write-only, in 8-bit units. When this register is read, 00H is read.

The hardware transmits data to the USB bus in synchronization with the IN token for Endpoint1 only when the BKI1NK bit of the UF0EN register is set to 1 (when NAK is not transmitted). The address at which data is to be written or read is managed by the hardware. Therefore, FW can transmit data to the host only by writing the data to the UF0BI1 register sequentially. A short packet is transmitted when data is written to the UF0BI1 register and the BKI1DED bit of the UF0DEND register is set to 1 (BKIN1 bit of UF0EPS0 register = 1 (data exists)). A Null packet is transmitted when the UF0BI1 register is cleared and the BKI1DED bit of the UF0DEND register is set to 1 (BKIN1 bit of the UF0EPS0 register = 1 (data exists)). When the data is transmitted correctly, a FIFO toggle operation occurs. The BKI1DT bit of the UF0IS2 register is set to 1, and an interrupt request is generated for the CPU. An interrupt request or DMA request can be selected by using the DQBI1MS bit of the UF0IDR register.

**Caution** To execute DMA transfer to or from the UF0BI1 register, do not perform block transfer. If block transfer is performed, the transferred data cannot be guaranteed.

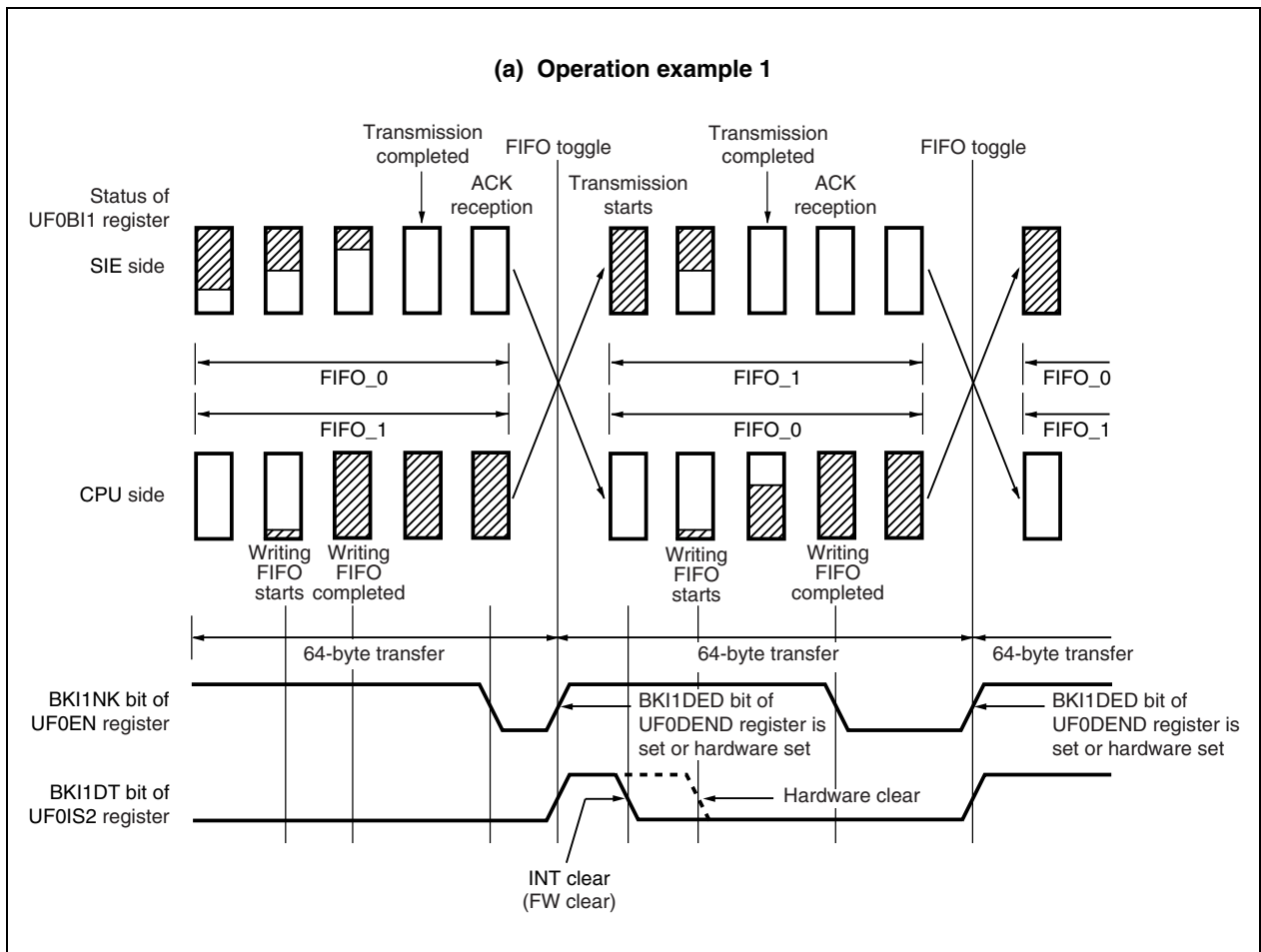
|        | 7     | 6     | 5     | 4     | 3     | 2     | 1     | 0     | Address   | After reset |
|--------|-------|-------|-------|-------|-------|-------|-------|-------|-----------|-------------|
| UF0BI1 | BKI17 | BKI16 | BKI15 | BKI14 | BKI13 | BKI12 | BKI11 | BKI10 | FFFFFE88H | Undefined   |

| Bit position | Bit name       | Function                             |
|--------------|----------------|--------------------------------------|
| 7 to 0       | BKI17 to BKI10 | These bits store data for Endpoint1. |

The operation of the UF0BI1 register is illustrated below.



Figure 11-6. Operation of UF0BI1 Register (1/3)



### Figure 11-6. Operation of UF0BI1 Register (2/3)

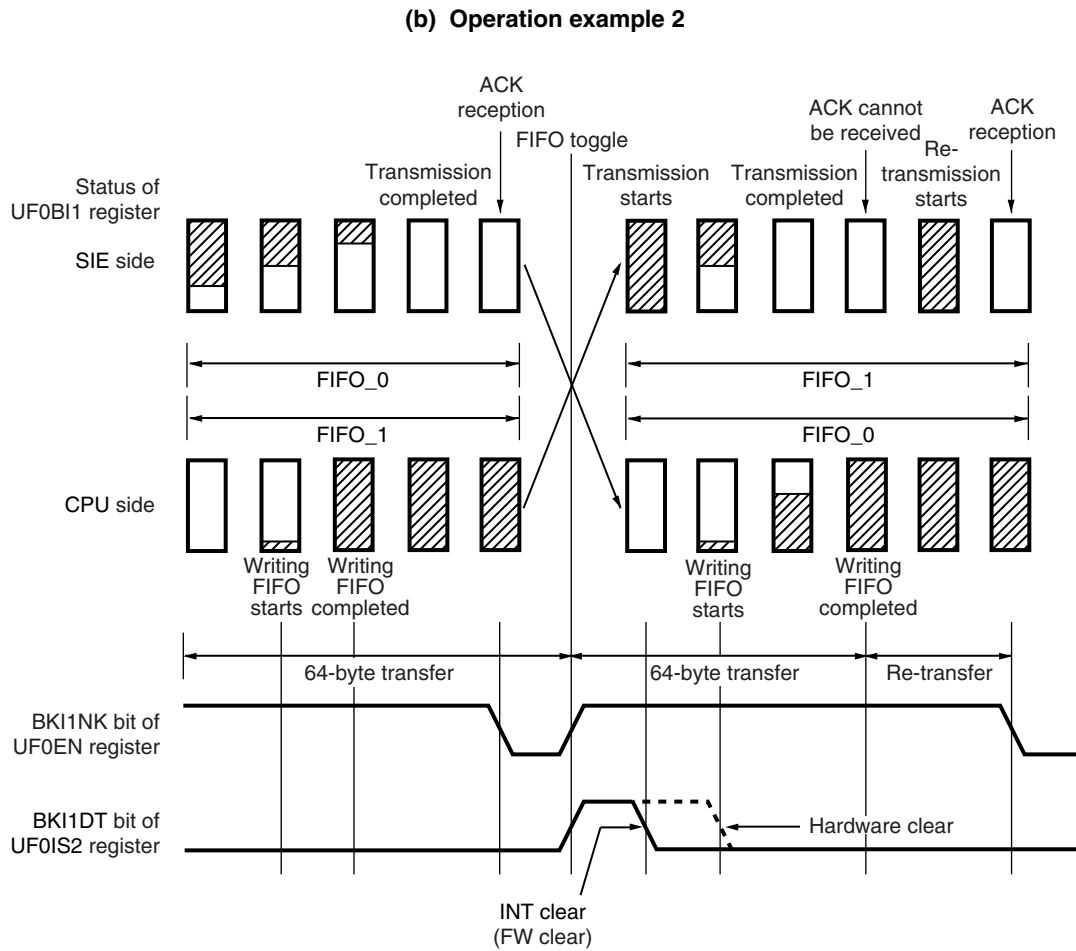
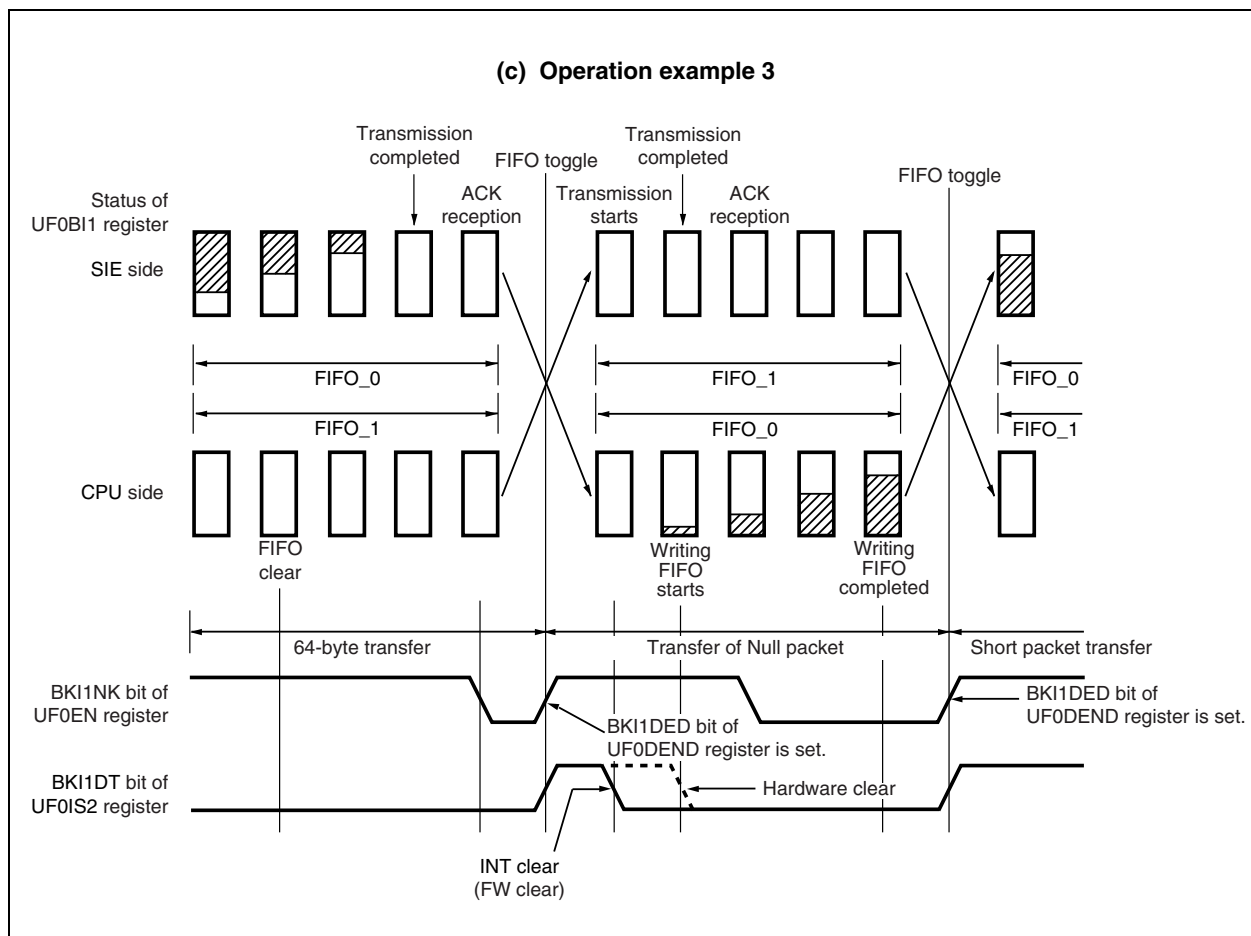


Figure 11-6. Operation of UF0BI1 Register (3/3)



**(10) UF0BI2 bulk in 2 register (UF0BI2)**

The UF0BI2 register is a 64-byte × 2 FIFO that stores data for Endpoint3. This register consists of two banks of 64-byte FIFOs each of which performs a toggle operation and repeatedly connects the buses on the SIE and CPU sides. The toggle operation takes place when no data is in the FIFO on the SIE side (counter value = 0) and when the FIFO on the CPU side is correctly written (FIFO full or BKI2DED bit = 1).

This register is write-only, in 8-bit units. When this register is read, 00H is read.

The hardware transmits data to the USB bus in synchronization with the IN token for Endpoint3 only when the BKI2NK bit of the UF0EN register is set to 1 (when NAK is not transmitted). The address at which data is to be written or read is managed by the hardware. Therefore, FW can transmit data to the host only by writing the data to the UF0BI2 register sequentially. A short packet is transmitted when data is written to the UF0BI2 register and the BKI2DED bit of the UF0DEND register is set to 1 (BKIN2 bit of UF0EPS0 register = 1 (data exists)). A Null packet is transmitted when the UF0BI2 register is cleared and the BKI2DED bit of the UF0DEND register is set to 1 (BKIN2 bit of the UF0EPS0 register = 1 (data exists)). When the data is transmitted correctly, a FIFO toggle operation occurs. The BKI2DT bit of the UF0IS2 register is set to 1, and an interrupt request is generated for the CPU. An interrupt request or DMA request can be selected by using the DQBI2MS bit of the UF0IDR register.

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**Caution** To execute DMA transfer to or from the UF0BI2 register, do not perform block transfer. If block transfer is performed, the transferred data cannot be guaranteed.

|        | 7     | 6     | 5     | 4     | 3     | 2     | 1     | 0     | Address    | After reset |
|--------|-------|-------|-------|-------|-------|-------|-------|-------|------------|-------------|
| UF0BI2 | BKI27 | BKI26 | BKI25 | BKI24 | BKI23 | BKI22 | BKI21 | BKI20 | FFFFFFE89H | Undefined   |

| Bit position | Bit name       | Function                             |
|--------------|----------------|--------------------------------------|
| 7 to 0       | BKI27 to BKI20 | These bits store data for Endpoint3. |

The operation of the UF0BI2 register is illustrated below.

Figure 11-7. Operation of UF0BI2 Register (1/3)

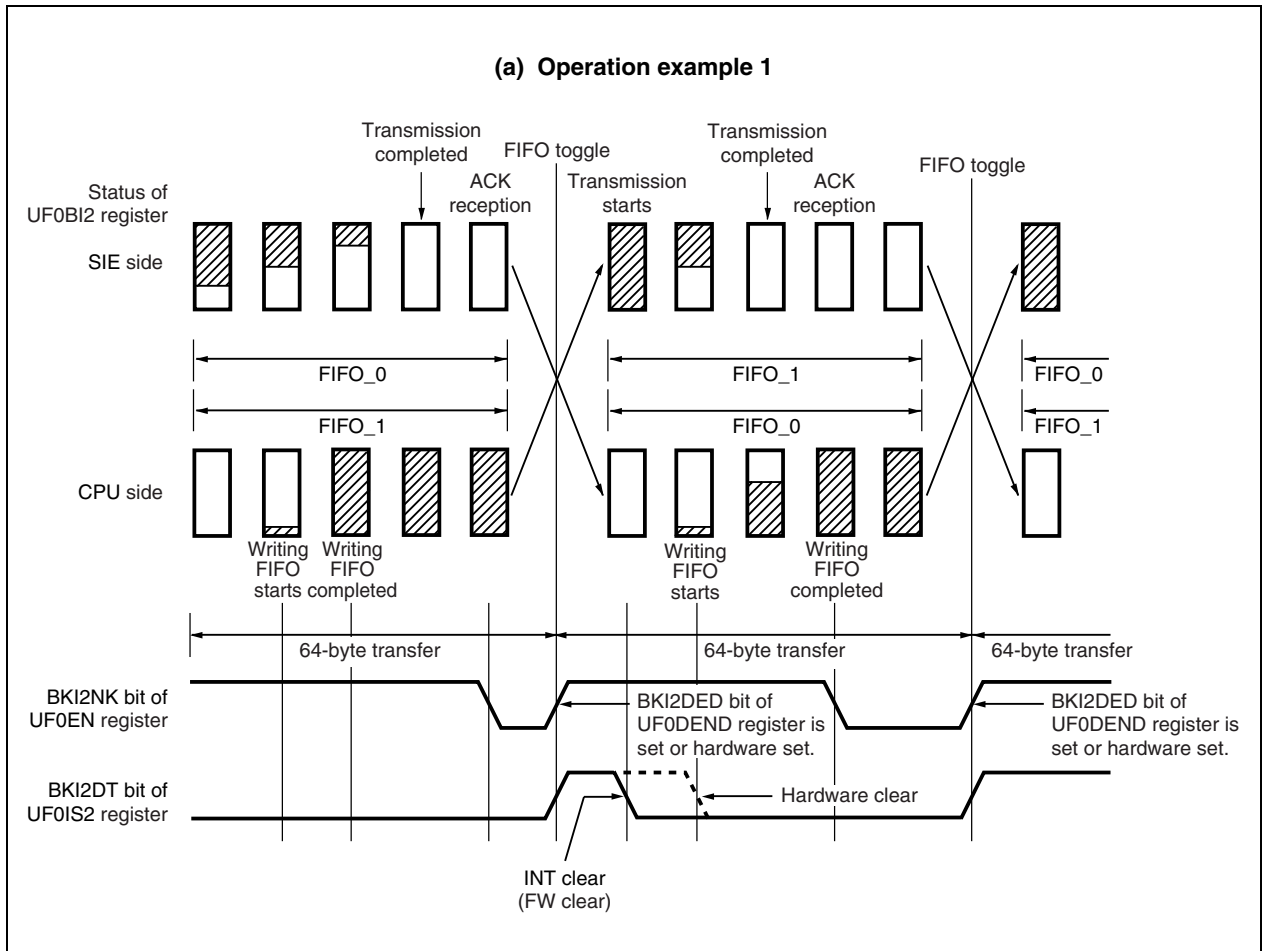


Figure 11-7. Operation of UF0BI2 Register (2/3)

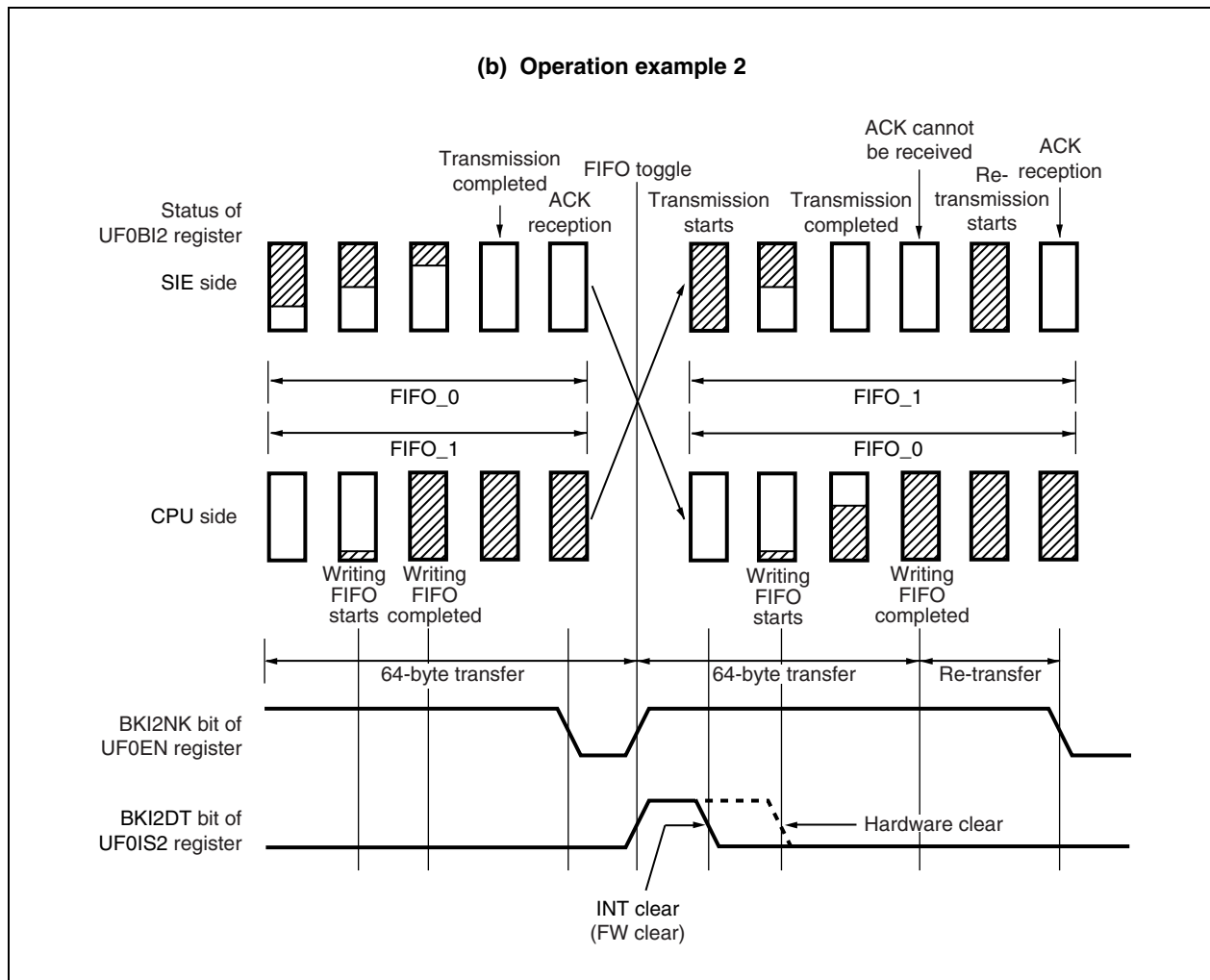
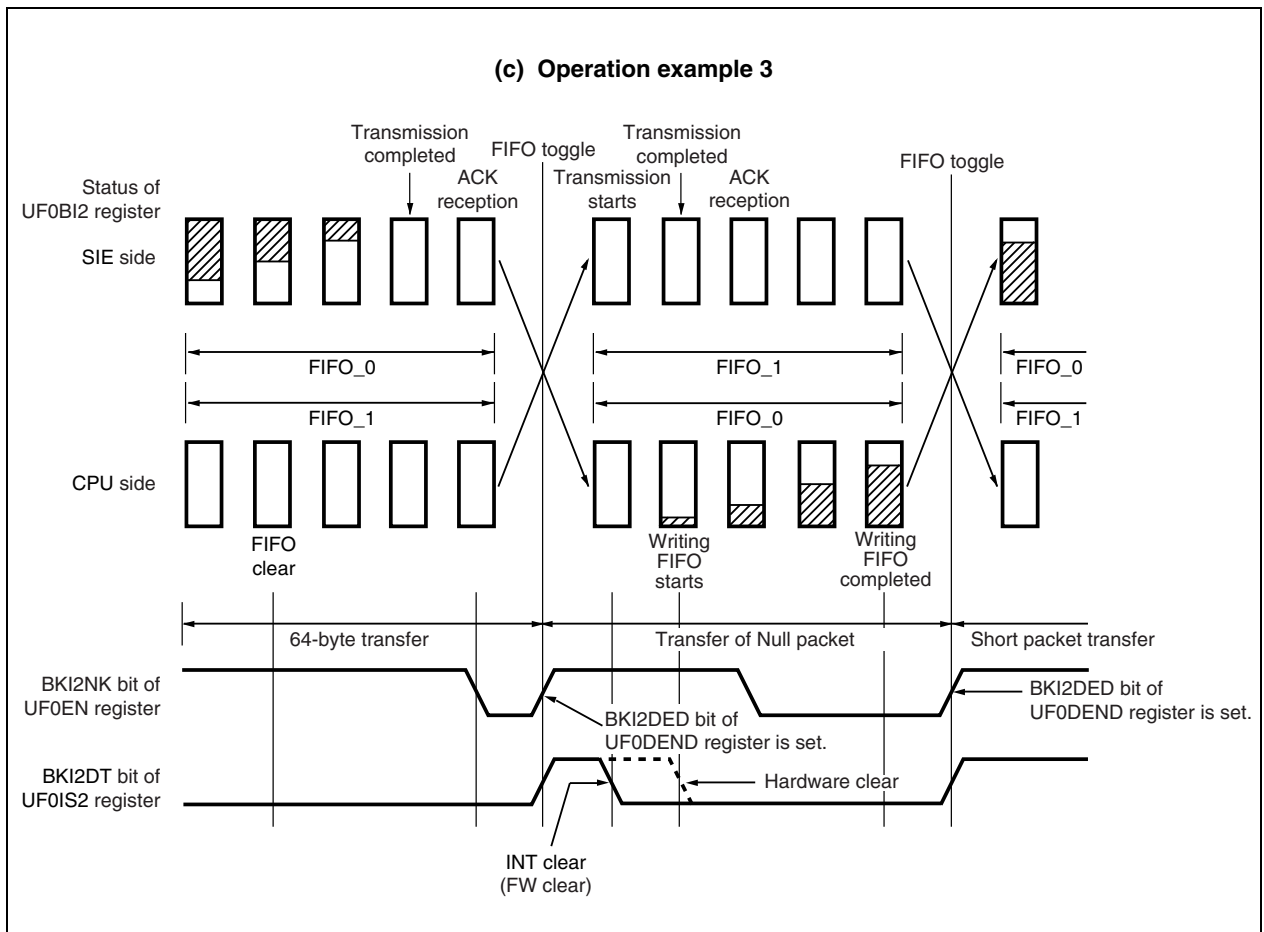


Figure 11-7. Operation of UF0BI2 Register (3/3)



**(11) UF0 interrupt 1 register (UF0INT1)**

The UF0INT1 register is an 8-byte FIFO that stores data for Endpoint7 (to be passed to SIE).

This register is write-only, in 8-bit units. When this register is read, 00H is read.

The hardware transmits data to the USB bus in synchronization with the IN token for Endpoint7 only when the IT1NK bit of the UF0EN register is set to 1 (when NAK is not transmitted). When the data is transmitted and the host correctly receives it, the IT1NK bit of the UF0EN register is automatically cleared to 0 by hardware. A short packet is transmitted when data is written to the UF0INT1 register and the IT1DEND bit of the UF0DEND register is set to 1 (IT1 bit of the UF0EPS0 register = 1 (data exists)). A Null packet is transmitted when the UF0INT1 register is cleared and the IT1DEND bit of the UF0DEND register is set to 1 (IT1 bit of the UF0EPS0 register = 1 (data exists)).

|         |      |      |      |      |      |      |      |      |           |             |
|---------|------|------|------|------|------|------|------|------|-----------|-------------|
|         | 7    | 6    | 5    | 4    | 3    | 2    | 1    | 0    | Address   | After reset |
| UF0INT1 | IT17 | IT16 | IT15 | IT14 | IT13 | IT12 | IT11 | IT10 | FFFFFE8AH | Undefined   |

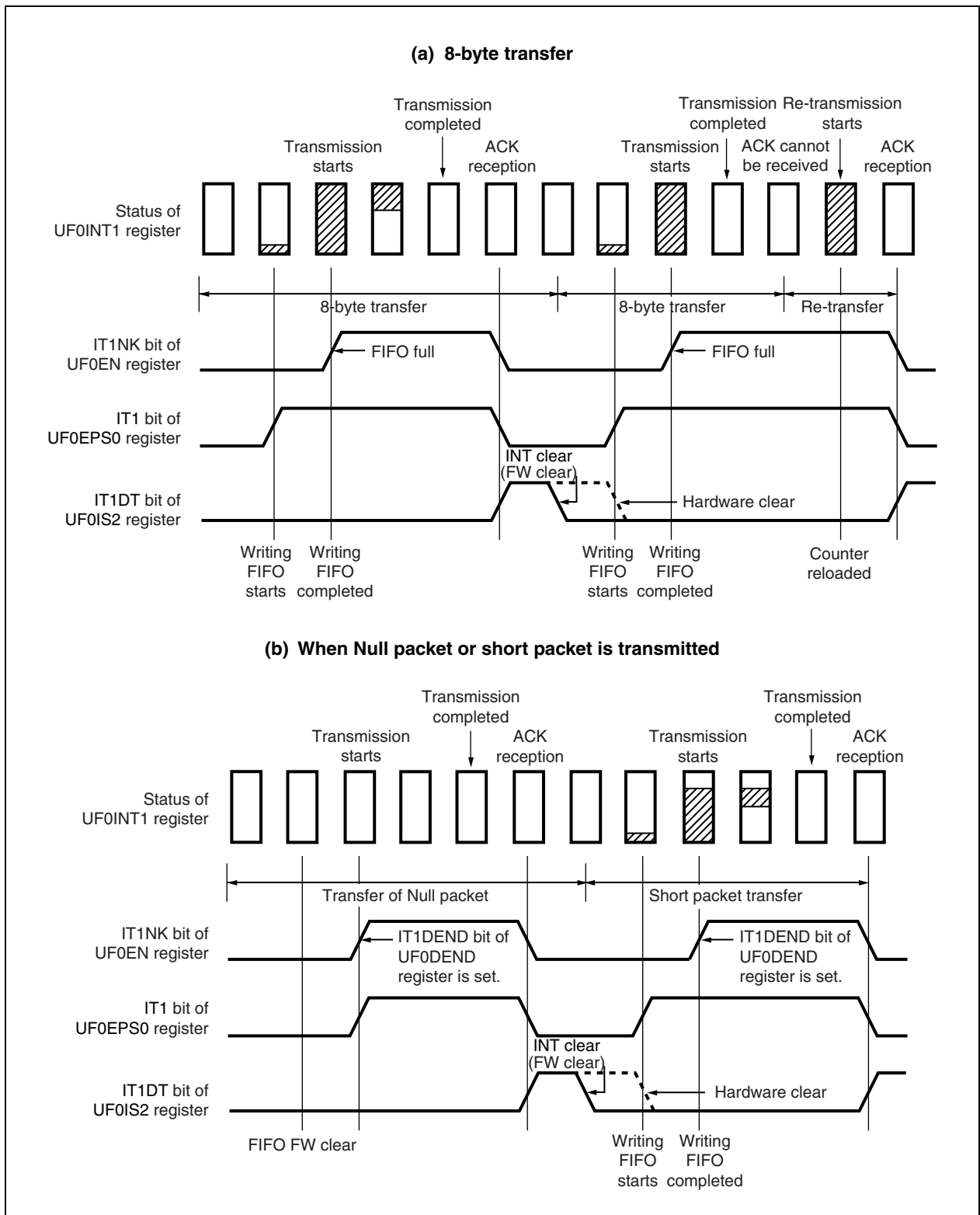
  

| Bit position | Bit name     | Function                             |
|--------------|--------------|--------------------------------------|
| 7 to 0       | IT17 to IT10 | These bits store data for Endpoint7. |

The operation of the UF0INT1 register is illustrated below.



Figure 11-8. Operation of UF0INT1 Register



**(12) UF0 interrupt 2 register (UF0INT2)**

The UF0INT2 register is an 8-byte FIFO that stores data for Endpoint8 (to be passed to SIE).

This register is write-only, in 8-bit units. When this register is read, 00H is read.

The hardware transmits data to the USB bus in synchronization with the IN token for Endpoint8 only when the IT2NK bit of the UF0EN register is set to 1 (when NAK is not transmitted). When the data is transmitted and the host correctly receives it, the IT2NK bit of the UF0EN register is automatically cleared to 0 by hardware. A short packet is transmitted when data is written to the UF0INT2 register and the IT2DEND bit of the UF0DEND register is set to 1 (IT2 bit of the UF0EPS0 register = 1 (data exists)). A Null packet is transmitted when the UF0INT2 register is cleared and the IT2DEND bit of the UF0DEND register is set to 1 (IT2 bit of the UF0EPS0 register = 1 (data exists)).

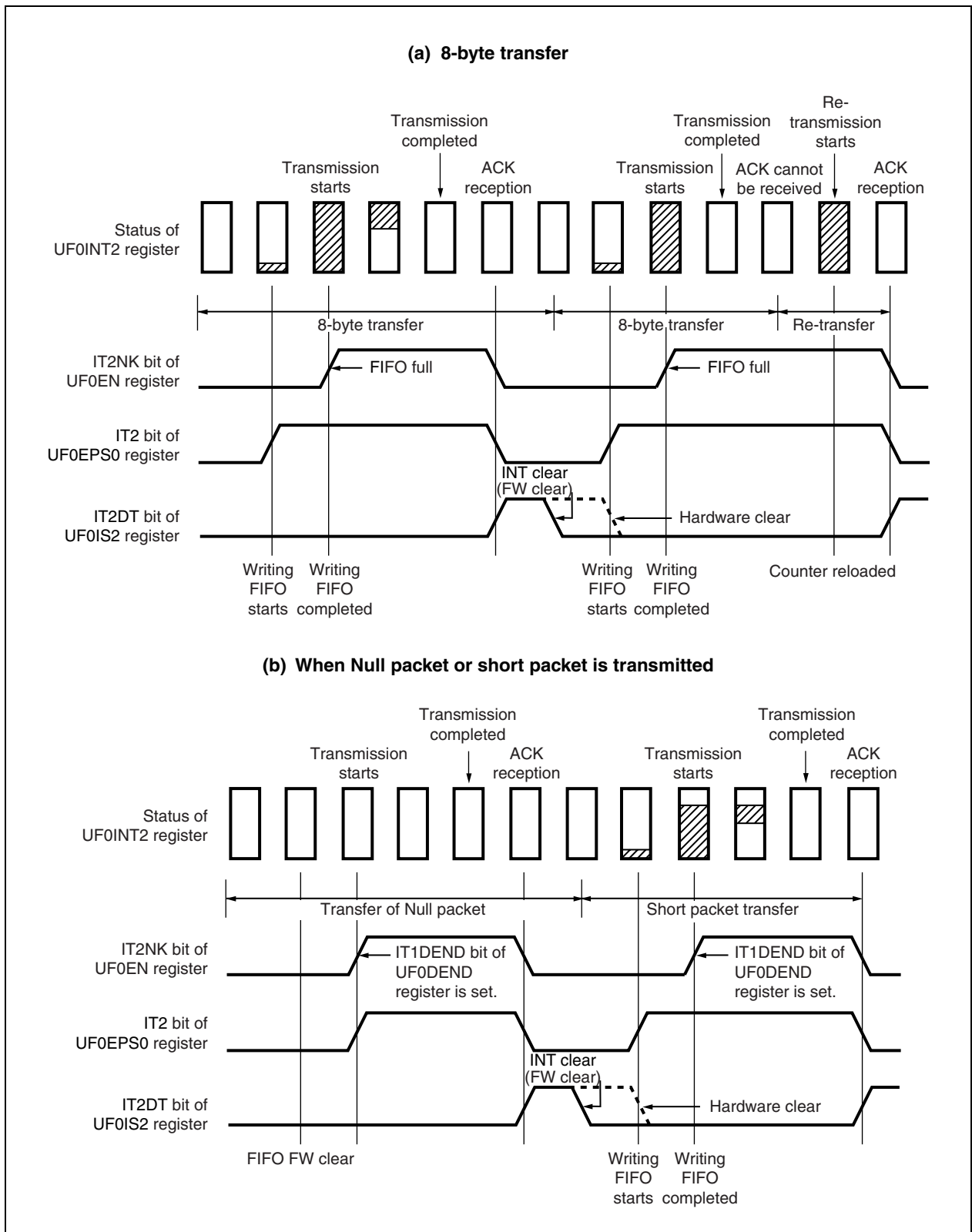
|         |      |      |      |      |      |      |      |      |           |             |
|---------|------|------|------|------|------|------|------|------|-----------|-------------|
|         | 7    | 6    | 5    | 4    | 3    | 2    | 1    | 0    | Address   | After reset |
| UF0INT2 | IT27 | IT26 | IT25 | IT24 | IT23 | IT22 | IT21 | IT20 | FFFFFE8BH | Undefined   |

| Bit position | Bit name     | Function                             |
|--------------|--------------|--------------------------------------|
| 7 to 0       | IT27 to IT20 | These bits store data for Endpoint8. |

The operation of the UF0INT2 register is illustrated below.

Figure 11-9. Operation of UF0INT2 Register



### 11.4.3 Request data registers

#### (1) UF0 device status register L (UF0DSTL)

This register stores the value that is to be returned in response to the GET\_STATUS Device request.

This register can be read or written in 8-bit units.

The hardware automatically transmits the contents of this register to the host when it has received the GET\_STATUS Device request.

**Caution** To rewrite this register, set the EP0NKA bit to 1 before reading the register contents, and rewrite the register contents after confirming that the bit has been set, in order to prevent conflict between a read access and a write access.

|         | 7 | 6 | 5 | 4 | 3 | 2 | 1    | 0    | Address   | After reset |
|---------|---|---|---|---|---|---|------|------|-----------|-------------|
| UF0DSTL | 0 | 0 | 0 | 0 | 0 | 0 | RMWK | SFPW | FFFFFEA2H | 00H         |

| Bit position | Bit name | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|--------------|----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1            | RMWK     | <p>This bit specifies whether the remote wakeup function of the device is used.</p> <p>1: Enabled<br/>0: Disabled</p> <p>If the device supports a remote wakeup function, this bit is set to 1 by hardware when the SET_FEATURE Device request has been received, and is cleared to 0 by hardware when the CLEAR_FEATURE Device request has been received. If the device does not support a remote wakeup function, make sure that the SET_FEATURE Device request is not issued from the host.</p> |
| 0            | SFPW     | <p>This bit indicates whether the device is self-powered or bus-powered.</p> <p>1: Self-powered<br/>0: Bus-powered</p>                                                                                                                                                                                                                                                                                                                                                                             |

**(2) UF0 EP0 status register L (UF0E0SL)**

This register stores the value that is to be returned in response to the GET\_STATUS Endpoint0 request.

This register can be read or written in 8-bit units. Note, however, that data can be written to this register only when the EP0NKA bit is set to 1.

If an error occurs in USBF, the E0HALT bit is set to 1 by FW. A write access to this register is ignored while a USB-side access to Endpoint0 is being received.

When the E0HALT bit is set to 1 by FW, it is not reflected until the next SETUP token is received if the control transfer immediately before is for the SET\_FEATURE Endpoint0, CLEAR\_FEATURE Endpoint0, GET\_STATUS Endpoint0 request, or an FW-processed request.

The hardware automatically transmits the contents of this register to the host when it has received the GET\_STATUS Endpoint0 request. If Endpoint0 has stalled, the UF0E0W and UF0E0R registers are cleared, and the EP0NKW and EP0NKR bits of the UF0E0N register are cleared to 0.

**Caution** To rewrite this register, set the EP0NKA bit to 1 before reading the register contents, and rewrite the register contents after confirming that the bit has been set, in order to prevent conflict between a read access and a write access.

|         | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0      | Address    | After reset |
|---------|---|---|---|---|---|---|---|--------|------------|-------------|
| UF0E0SL | 0 | 0 | 0 | 0 | 0 | 0 | 0 | E0HALT | FFFFFFEA6H | 00H         |

| Bit position | Bit name | Function                                                                                                                                                                                                                                                                                                                |
|--------------|----------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 0            | E0HALT   | <p>This bit indicates the status of Endpoint0.</p> <p>1: Stalled</p> <p>0: Not stalled</p> <p>This bit is set to 1 by hardware when the SET_FEATURE Endpoint0 request has been received, and cleared to 0 by hardware when the CLEAR_FEATURE Endpoint0 request has been received. DATA PID is initialized to DATA0.</p> |

**(3) UF0 EP1 status register L (UF0E1SL)**

This register stores the value that is to be returned in response to the GET\_STATUS Endpoint1 request.

This register can be read or written in 8-bit units. Note, however, that data can be written to this register only when the EP0NKA bit is set to 1.

If an error occurs in Endpoint1, the E1HALT bit is set to 1. A write access to this register is ignored while a USB-side access to Endpoint1 is being received.

The hardware automatically transmits the contents of this register to the host when it has received the GET\_STATUS Endpoint1 request. If Endpoint1 has stalled, the UF0BI1 register is cleared and the BKI1NK bit is cleared to 0.

Because writing this register is always masked when transfer to Endpoint1, rather than control transfer, is executed, be sure to check this register to see if data has been correctly written to it.

**Caution** To rewrite this register, set the EP0NKA bit to 1 before reading the register contents, and rewrite the register contents after confirming that the bit has been set, in order to prevent conflict between a read access and a write access.

|         | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0      | Address  | After reset |
|---------|---|---|---|---|---|---|---|--------|----------|-------------|
| UF0E1SL | 0 | 0 | 0 | 0 | 0 | 0 | 0 | E1HALT | FFFFEA8H | 00H         |

| Bit position | Bit name | Function                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|--------------|----------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 0            | E1HALT   | <p>This bit indicates the status of Endpoint1.</p> <p>1: Stalled<br/>0: Not stalled</p> <p>This bit is set to 1 by hardware when the SET_FEATURE Endpoint1 request has been received. It is cleared to 0 by hardware when the CLEAR_FEATURE Endpoint1 request, SET_CONFIGURATION request, or the SET_INTERFACE request for the Interface to which Endpoint1 is linked has correctly been received. DATA PID is initialized to DATA0.</p> |

**(4) UF0 EP2 status register L (UF0E2SL)**

This register stores the value that is to be returned in response to the GET\_STATUS Endpoint2 request.

This register can be read or written in 8-bit units. Note, however, that data can be written to this register only when the EP0NKA bit is set to 1.

If an error occurs in Endpoint2, the E2HALT bit is set to 1. A write access to this register is ignored while a USB-side access to Endpoint2 is being received.

The hardware automatically transmits the contents of this register to the host when it has received the GET\_STATUS Endpoint2 request. If Endpoint2 has stalled, the UF0BO1 register is cleared and the BKO1NK bit is cleared to 0.

Because writing this register is always masked when transfer to Endpoint2, rather than control transfer, is executed, be sure to check this register to see if data has been correctly written to it.

**Caution** To rewrite this register, set the EP0NKA bit to 1 before reading the register contents, and rewrite the register contents after confirming that the bit has been set, in order to prevent conflict between a read access and a write access.

|         | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0      | Address    | After reset |
|---------|---|---|---|---|---|---|---|--------|------------|-------------|
| UF0E2SL | 0 | 0 | 0 | 0 | 0 | 0 | 0 | E2HALT | FFFFFFEAAH | 00H         |

| Bit position | Bit name | Function                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|--------------|----------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 0            | E2HALT   | <p>This bit indicates the status of Endpoint2.</p> <p>1: Stalled</p> <p>0: Not stalled</p> <p>This bit is set to 1 by hardware when the SET_FEATURE Endpoint2 request has been received. It is cleared to 0 by hardware when the CLEAR_FEATURE Endpoint2 request, SET_CONFIGURATION request, or the SET_INTERFACE request for the Interface to which Endpoint2 is linked has correctly been received. DATA PID is initialized to DATA0.</p> |

**(5) UF0 EP3 status register L (UF0E3SL)**

This register stores the value that is to be returned in response to the GET\_STATUS Endpoint3 request.

This register can be read or written in 8-bit units. Note, however, that data can be written to this register only when the EP0NKA bit is set to 1.

If an error occurs in Endpoint3, the E3HALT bit is set to 1. A write access to this register is ignored while a USB-side access to Endpoint3 is being received.

The hardware automatically transmits the contents of this register to the host when it has received the GET\_STATUS Endpoint3 request. If Endpoint3 has stalled, the UF0BI2 register is cleared and the BKI2NK bit is cleared to 0.

Because writing this register is always masked when transfer to Endpoint3, rather than control transfer, is executed, be sure to check this register to see if data has been correctly written to it.

**Caution** To rewrite this register, set the EP0NKA bit to 1 before reading the register contents, and rewrite the register contents after confirming that the bit has been set, in order to prevent conflict between a read access and a write access.

|         | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0      | Address   | After reset |
|---------|---|---|---|---|---|---|---|--------|-----------|-------------|
| UF0E3SL | 0 | 0 | 0 | 0 | 0 | 0 | 0 | E3HALT | FFFFFEACH | 00H         |

| Bit position | Bit name | Function                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|--------------|----------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 0            | E3HALT   | <p>This bit indicates the status of Endpoint3.</p> <p>1: Stalled<br/>0: Not stalled</p> <p>This bit is set to 1 by hardware when the SET_FEATURE Endpoint3 request has been received. It is cleared to 0 by hardware when the CLEAR_FEATURE Endpoint3 request, SET_CONFIGURATION request, or the SET_INTERFACE request for the Interface to which Endpoint3 is linked has correctly been received. DATA PID is initialized to DATA0.</p> |



**(6) UF0 EP4 status register L (UF0E4SL)**

This register stores the value that is to be returned in response to the GET\_STATUS Endpoint4 request.

This register can be read or written in 8-bit units. Note, however, that data can be written to this register only when the EP0NKA bit is set to 1.

If an error occurs in Endpoint4, the E4HALT bit is set to 1. A write access to this register is ignored while a USB-side access to Endpoint4 is being received.

The hardware automatically transmits the contents of this register to the host when it has received the GET\_STATUS Endpoint4 request. If Endpoint4 has stalled, the UF0BO2 register is cleared and the BKO2NK bit is cleared to 0.

Because writing this register is always masked when transfer to Endpoint4, rather than control transfer, is executed, be sure to check this register to see if data has been correctly written to it.

**Caution** To rewrite this register, set the EP0NKA bit to 1 before reading the register contents, and rewrite the register contents after confirming that the bit has been set, in order to prevent conflict between a read access and a write access.

|         | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0      | Address   | After reset |
|---------|---|---|---|---|---|---|---|--------|-----------|-------------|
| UF0E4SL | 0 | 0 | 0 | 0 | 0 | 0 | 0 | E4HALT | FFFFFFAEH | 00H         |

| Bit position | Bit name | Function                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|--------------|----------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 0            | E4HALT   | <p>This bit indicates the status of Endpoint4.</p> <p>1: Stalled</p> <p>0: Not stalled</p> <p>This bit is set to 1 by hardware when the SET_FEATURE Endpoint4 request has been received. It is cleared to 0 by hardware when the CLEAR_FEATURE Endpoint4 request, SET_CONFIGURATION request, or the SET_INTERFACE request for the Interface to which Endpoint4 is linked has correctly been received. DATA PID is initialized to DATA0.</p> |

**(7) UF0 EP7 status register L (UF0E7SL)**

This register stores the value that is to be returned in response to the GET\_STATUS Endpoint7 request.

This register can be read or written in 8-bit units. Note, however, that data can be written to this register only when the EP0NKA bit is set to 1.

If an error occurs in Endpoint7, the E7HALT bit is set to 1. A write access to this register is ignored while a USB-side access to Endpoint7 is being received.

The hardware automatically transmits the contents of this register to the host when it has received the GET\_STATUS Endpoint7 request. If Endpoint7 has stalled, the UF0INT1 register is cleared and the IT1NK bit is cleared to 0.

Because writing this register is always masked when transfer to Endpoint7, rather than control transfer, is executed, be sure to check this register to see if data has been correctly written to it.

**Caution** To rewrite this register, set the EP0NKA bit to 1 before reading the register contents, and rewrite the register contents after confirming that the bit has been set, in order to prevent conflict between a read access and a write access.

|         | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0      | Address  | After reset |
|---------|---|---|---|---|---|---|---|--------|----------|-------------|
| UF0E7SL | 0 | 0 | 0 | 0 | 0 | 0 | 0 | E7HALT | FFFFEB4H | 00H         |

| Bit position | Bit name | Function                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|--------------|----------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 0            | E7HALT   | <p>This bit indicates the status of Endpoint7.</p> <p>1: Stalled</p> <p>0: Not stalled</p> <p>This bit is set to 1 by hardware when the SET_FEATURE Endpoint7 request has been received. It is cleared to 0 by hardware when the CLEAR_FEATURE Endpoint7 request, SET_CONFIGURATION request, or the SET_INTERFACE request for the Interface to which Endpoint7 is linked has correctly been received. DATA PID is initialized to DATA0.</p> |

**(8) UF0 EP8 status register L (UF0E8SL)**

This register stores the value that is to be returned in response to the GET\_STATUS Endpoint8 request.

This register can be read or written in 8-bit units. Note, however, that data can be written to this register only when the EP0NKA bit is set to 1.

If an error occurs in Endpoint8, the E8HALT bit is set to 1. A write access to this register is ignored while a USB-side access to Endpoint8 is being received.

The hardware automatically transmits the contents of this register to the host when it has received the GET\_STATUS Endpoint8 request. If Endpoint8 has stalled, the UF0INT2 register is cleared and the IT2NK bit is cleared to 0.

Because writing this register is always masked when transfer to Endpoint8, rather than control transfer, is executed, be sure to check this register to see if data has been correctly written to it.

**Caution** To rewrite this register, set the EP0NKA bit to 1 before reading the register contents, and rewrite the register contents after confirming that the bit has been set, in order to prevent conflict between a read access and a write access.

|         | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0      | Address    | After reset |
|---------|---|---|---|---|---|---|---|--------|------------|-------------|
| UF0E8SL | 0 | 0 | 0 | 0 | 0 | 0 | 0 | E8HALT | FFFFFFEB6H | 00H         |

| Bit position | Bit name | Function                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|--------------|----------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 0            | E8HALT   | <p>This bit indicates the status of Endpoint8.</p> <p>1: Stalled</p> <p>0: Not stalled</p> <p>This bit is set to 1 by hardware when the SET_FEATURE Endpoint8 request has been received. It is cleared to 0 by hardware when the CLEAR_FEATURE Endpoint8 request, SET_CONFIGURATION request, or the SET_INTERFACE request for the Interface to which Endpoint8 is linked has correctly been received. DATA PID is initialized to DATA0.</p> |

**(9) UF0 address register (UF0ADRS)**

This register stores the device address.

This register is read-only, in 8-bit units.

The device address sent by the SET\_ADDRESS request is analyzed and the resultant value is automatically written to this register. If the SET\_ADDRESS request is processed by FW, the value of this register is reflected as the device address when the SUCCESS signal is received in the status stage.

<R> **Caution** Do not execute a write access to this register. If written, the operation is not guaranteed.

|         | 7 | 6     | 5     | 4     | 3     | 2     | 1     | 0     | Address    | After reset |
|---------|---|-------|-------|-------|-------|-------|-------|-------|------------|-------------|
| UF0ADRS | 0 | ADRS6 | ADRS5 | ADRS4 | ADRS3 | ADRS2 | ADRS1 | ADRS0 | FFFFFFEC0H | 00H         |

| Bit position | Bit name       | Function                                   |
|--------------|----------------|--------------------------------------------|
| 6 to 0       | ADRS6 to ADRS0 | These bits hold the device address of SIE. |

&lt;R&gt;

**(10) UF0 configuration register (UF0CNF)**

This register stores the value that is to be returned in response to the GET\_CONFIGURATION request.

This register is read-only, in 8-bit units.

When the SET\_CONFIGURATION request is received, its wValue is automatically written to this register.

When a change of the value of this register from 00H to other than 00H is detected, the CONF bit of the UF0MODS register is set to 1. If the SET\_CONFIGURATION request is processed by FW, the status of this register is immediately reflected on the UF0MODS register as soon as data has been written to this register (CONF bit = 1 before completion of the status stage).

**Caution** Do not execute a write access to this register. If written, the operation is not guaranteed.

|        |   |   |   |   |   |   |       |       |           |             |
|--------|---|---|---|---|---|---|-------|-------|-----------|-------------|
|        | 7 | 6 | 5 | 4 | 3 | 2 | 1     | 0     | Address   | After reset |
| UF0CNF | 0 | 0 | 0 | 0 | 0 | 0 | CONF1 | CONF0 | FFFFFEC1H | 00H         |

| Bit position | Bit name        | Function                                                                              |
|--------------|-----------------|---------------------------------------------------------------------------------------|
| 1, 0         | CONF1,<br>CONF0 | These bits hold the data to be returned in response to the GET_CONFIGURATION request. |

**(11) UF0 interface 0 register (UF0IF0)**

This register stores the value that is to be returned in response to the GET\_INTERFACE wIndex = 0 request.

This register is read-only, in 8-bit units.

When the SET\_INTERFACE request is received, its wValue is automatically written to this register.

If the SET\_INTERFACE request is processed by FW, wIndex and wValue are decoded, and the setting of endpoint is automatically changed. At this time, the status bit of the target endpoint and DPID are automatically cleared to 0, depending on the setting. The FIFO is not cleared automatically.

<R> **Caution** Do not execute a write access to this register. If written, the operation is not guaranteed.

|        | 7 | 6 | 5 | 4 | 3 | 2    | 1    | 0    | Address   | After reset |
|--------|---|---|---|---|---|------|------|------|-----------|-------------|
| UF0IF0 | 0 | 0 | 0 | 0 | 0 | IF02 | IF01 | IF00 | FFFFFEC2H | 00H         |

| Bit position | Bit name     | Function                                                                                 |
|--------------|--------------|------------------------------------------------------------------------------------------|
| 2 to 0       | IF02 to IF00 | These bits hold the data to be returned in response to GET_INTERFACE wIndex = 0 request. |

**(12) UF0 interface 1 to 4 registers (UF0IF1 to UF0IF4)**

These registers store the value that is to be returned in response to the GET\_INTERFACE wIndex = n request (n = 1 to 4).

These registers are read-only, in 8-bit units.

When the SET\_INTERFACE request is received, its wValue is automatically written to these registers.

These registers are invalidated according to the setting of the UF0AIFN and UF0AAS registers.

If the SET\_INTERFACE request is processed by FW, wIndex and wValue are decoded, and the setting of endpoint is automatically changed. At this time, the status bit of the target endpoint and DPID are automatically cleared to 0, depending on the setting. The FIFO is not cleared automatically.

<R>

**Caution** Do not execute a write access to this register. If written, the operation is not guaranteed.

|        | 7 | 6 | 5 | 4 | 3 | 2    | 1    | 0    | Address   | After reset |
|--------|---|---|---|---|---|------|------|------|-----------|-------------|
| UF0IF1 | 0 | 0 | 0 | 0 | 0 | IF12 | IF11 | IF10 | FFFFFEC3H | 00H         |
| UF0IF2 | 0 | 0 | 0 | 0 | 0 | IF22 | IF21 | IF20 | FFFFFEC4H | 00H         |
| UF0IF3 | 0 | 0 | 0 | 0 | 0 | IF32 | IF31 | IF30 | FFFFFEC5H | 00H         |
| UF0IF4 | 0 | 0 | 0 | 0 | 0 | IF42 | IF41 | IF40 | FFFFFEC6H | 00H         |

| Bit position | Bit name     | Function                                                                                 |
|--------------|--------------|------------------------------------------------------------------------------------------|
| 2 to 0       | IFn2 to IFn0 | These bits hold the data to be returned in response to GET_INTERFACE wIndex = n request. |

**Remark** n = 1 to 4

**(13) UF0 descriptor length register (UF0DSCL)**

This register stores the length of the value that is to be returned in response to the GET\_DESCRIPTOR Configuration request. The value of this register is the number of bytes of all the descriptors set by the UF0CIEn register minus 1 ( $n = 0$  to 255). The total descriptor length that is to be returned in response to the GET\_DESCRIPTOR Configuration request is determined according to the value of this register.

This register can be read or written in 8-bit units. However, data can be written to this register only when the EP0NKA bit is set to 1.

Processing of wLength is automatically controlled. If this register is set to 00H, it means that the descriptor to be returned is 1 byte long. If the register is set to FFH, a descriptor length of 256 bytes is returned. When a descriptor exceeding 256 bytes in length is used, set the CDCGDST bit of the UF0MODC register to 1 and process the GET\_DESCRIPTOR request by FW (at this time, the CDCGD bit of the UF0MODS register is also set to 1).

**Caution** To rewrite this register, set the EP0NKA bit to 1 before reading the register contents, and rewrite the register contents after confirming that the bit has been set, in order to prevent conflict between a read access and a write access.

|         | 7    | 6    | 5    | 4    | 3    | 2    | 1    | 0    | Address   | After reset |
|---------|------|------|------|------|------|------|------|------|-----------|-------------|
| UF0DSCL | DPL7 | DPL6 | DPL5 | DPL4 | DPL3 | DPL2 | DPL1 | DPL0 | FFFFFFD0H | 00H         |

| Bit position | Bit name     | Function                                                                                                                                               |
|--------------|--------------|--------------------------------------------------------------------------------------------------------------------------------------------------------|
| 7 to 0       | DPL7 to DPL0 | These bits set the value of the number of bytes of all the descriptors to be returned in response to the GET_DESCRIPTOR Configuration request minus 1. |



**(14) UF0 device descriptor registers 0 to 17 (UF0DD0 to UF0DD17)**

These registers store the value to be returned in response to the GET\_DESCRIPTOR Device request.

These registers can be read or written in 8-bit units. However, data can be written to these registers only when the EP0NKA bit is set to 1.

- Cautions**
1. To rewrite these registers, set the EP0NKA bit to 1 before reading the register contents, and rewrite the register contents after confirming that the bit has been set, in order to prevent conflict between a read access and a write access.
  2. Use the value defined by USB Specification Ver. 2.0 and the latest Class Specification as the set value.

|                         |   |   |   |   |   |   |   |   |                 |             |
|-------------------------|---|---|---|---|---|---|---|---|-----------------|-------------|
|                         | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | Address         | After reset |
| UF0DDn<br>(n = 0 to 17) |   |   |   |   |   |   |   |   | See Table 11-4. | Undefined   |

**Table 11-4. Mapping and Data of UF0 Device Descriptor Registers**

| Symbol  | Address    | Field Name         | Contents                                                      |
|---------|------------|--------------------|---------------------------------------------------------------|
| UF0DD0  | FFFFFED1H  | bLength            | Size of this descriptor                                       |
| UF0DD1  | FFFFFED2H  | bDescriptorType    | Device descriptor type                                        |
| UF0DD2  | FFFFFED3H  | bcdUSB             | Value below decimal point of Rev. number of USB specification |
| UF0DD3  | FFFFFED4H  |                    | Value above decimal point of Rev. number of USB specification |
| UF0DD4  | FFFFFED5H  | bDeviceClass       | Class code                                                    |
| UF0DD5  | FFFFFED6H  | bDeviceSubClass    | Subclass code                                                 |
| UF0DD6  | FFFFFED7H  | bDeviceProtocol    | Protocol code                                                 |
| UF0DD7  | FFFFFED8H  | bMaxPacketSize0    | Maximum packet size of Endpoint0                              |
| UF0DD8  | FFFFFED9H  | idVendor           | Lower value of vendor ID                                      |
| UF0DD9  | FFFFFEDA H |                    | Higher value of vendor ID                                     |
| UF0DD10 | FFFFFEDBH  | idProduct          | Lower value of product ID                                     |
| UF0DD11 | FFFFFEDCH  |                    | Higher value of product ID                                    |
| UF0DD12 | FFFFFEDDH  | bcdDevice          | Lower value of device release number                          |
| UF0DD13 | FFFFFEDEH  |                    | Higher value of device release number                         |
| UF0DD14 | FFFFFEDFH  | iManufacturer      | Index of string descriptor describing manufacturer            |
| UF0DD15 | FFFFFEE0H  | iProduct           | Index of string descriptor describing product                 |
| UF0DD16 | FFFFFEE1H  | iSerialNumber      | Index of string descriptor describing device serial number    |
| UF0DD17 | FFFFFEE2H  | BNumConfigurations | Number of settable configurations                             |

**(15) UF0 configuration/interface/endpoint descriptor registers 0 to 255 (UF0CIE0 to UF0CIE255)**

These registers store the value to be returned in response to the GET\_DESCRIPTOR Configuration request.

These registers can be read or written in 8-bit units. However, data can be written to these registers only when the EP0NKA bit is set to 1.

Descriptor information of up to 256 bytes can be stored in these registers. Store each descriptor in the order of Configuration, Interface, and Endpoint (see **Table 11-5**). If there are two or more Interfaces, repeatedly store the data following the Interface descriptor.

**Table 11-5. Mapping of UF0CIEn Register**

| Address      | Descriptor Stored                  |
|--------------|------------------------------------|
| FFFFFFEE3H   | Configuration descriptor (9 bytes) |
| FFFFFFEECH   | Interface descriptor (9 bytes)     |
| FFFFFFEF5H   | Endpoint1 descriptor (7 bytes)     |
| FFFFFFEFCH   | Endpoint2 descriptor (7 bytes)     |
| FFFFFFF03H   | Endpoint3 descriptor (7 bytes)     |
| :            | :                                  |
| FFFFFFxxH    | Interface descriptor (9 bytes)     |
| FFFFFFxxH+9  | Endpoint1 descriptor (7 bytes)     |
| FFFFFFxxH+16 | Endpoint2 descriptor (7 bytes)     |
| FFFFFFxxH+23 | Endpoint3 descriptor (7 bytes)     |
| :            | :                                  |

The range of the valid data that can be set to these registers varies according to the setting of the UF0DSDL register. In addition to the descriptors listed in Table 11-6, descriptors peculiar to classes and vendors can also be stored.

If all the values are fixed, they can be stored in ROM.

- Cautions**
- 1. To rewrite these registers, set the EP0NKA bit to 1 before reading the register contents, and rewrite the register contents after confirming that the bit has been set, in order to prevent conflict between a read access and a write access.**
  - 2. Use the value defined by USB Specification Ver. 2.0 and the latest Class Specification as the set value.**

|                           |   |   |   |   |   |   |   |   |                            |             |
|---------------------------|---|---|---|---|---|---|---|---|----------------------------|-------------|
|                           | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | Address                    | After reset |
| UF0CIEn<br>(n = 0 to 255) |   |   |   |   |   |   |   |   | FFFFFFEE3H to<br>FFFFFFE2H | Undefined   |

**Table 11-6. Data of UF0CIEn Register****(a) Configuration descriptor (9 bytes)**

| Offset | Field Name          | Contents                                                                                                |
|--------|---------------------|---------------------------------------------------------------------------------------------------------|
| 0      | bLength             | Size of this descriptor                                                                                 |
| 1      | bDescriptorType     | Descriptor type                                                                                         |
| 2      | wTotalLength        | Lower value of the total number of bytes of Configuration, all Interface, and all Endpoint descriptors  |
| 3      |                     | Higher value of the total number of bytes of Configuration, all Interface, and all Endpoint descriptors |
| 4      | bNumInterface       | Number of Interfaces                                                                                    |
| 5      | bConfigurationValue | Value to select this Configuration                                                                      |
| 6      | iConfiguration      | Index of string descriptor describing this Configuration                                                |
| 7      | bmAttributes        | Features of this Configuration (self-powered, without remote wakeup)                                    |
| 8      | MaxPower            | Maximum power consumption of this Configuration (unit: mA)                                              |

**(b) Interface descriptor (9 bytes)**

| Offset | Field Name         | Contents                                             |
|--------|--------------------|------------------------------------------------------|
| 0      | bLength            | Size of this descriptor                              |
| 1      | bDescriptorType    | Descriptor type                                      |
| 2      | bInterfaceNumber   | Value of this Interface                              |
| 3      | bAlternateSetting  | Value to select alternative setting of Interface     |
| 4      | bNumEndpoints      | Number of usable Endpoints                           |
| 5      | bInterfaceClass    | Class code                                           |
| 6      | bInterfaceSubClass | Subclass code                                        |
| 7      | bInterfaceProtocol | Protocol code                                        |
| 8      | Interface          | Index of string descriptor describing this Interface |

**(c) Endpoint descriptor (7 bytes)**

| Offset | Field Name       | Contents                                        |
|--------|------------------|-------------------------------------------------|
| 0      | bLength          | Size of this descriptor                         |
| 1      | bDescriptorType  | Descriptor type                                 |
| 2      | bEndpointAddress | Address/transfer direction of this Endpoint     |
| 3      | bmAttributes     | Transfer type                                   |
| 4      | wMaxPaketSize    | Lower value of maximum number of transfer data  |
| 5      |                  | Higher value of maximum number of transfer data |
| 6      | bInterval        | Transfer interval                               |

## 11.4.4 Peripheral control registers

## (1) USB function 0 DMA channel select register (UF0CS)

This register allocates each DMA service of the USB function to a DMA channel.

This register can be read or written in 16-bit units.

To allocate the service of a USB function to a DMA channel by using this register, set this register in advance, set the DTFRn register (n = 0 to 3) of the DMA controller to 7FH, and enable USB\_DMA in advance.

**Caution** Setting the same DMA service to different DMA channels and setting different DMA services to the same DMA channel are prohibited.

|       | 15 | 14  | 13  | 12  | 11 | 10  | 9   | 8   | 7 | 6   | 5   | 4   | 3 | 2   | 1   | 0   | Address    | After reset |
|-------|----|-----|-----|-----|----|-----|-----|-----|---|-----|-----|-----|---|-----|-----|-----|------------|-------------|
| UF0CS | 0  | UFD | UFD | UFD | 0  | UFD | UFD | UFD | 0 | UFD | UFD | UFD | 0 | UFD | UFD | UFD | FFFFFFDF0H | 0000H       |
|       |    | C32 | C31 | C30 |    | C22 | C21 | C20 |   | C12 | C11 | C10 |   | C02 | C01 | C00 |            |             |

| Bit position                            | Bit name            | Function                                                                           |                              |        |                         |   |   |   |         |   |   |   |         |   |   |   |         |   |   |   |         |   |   |   |                              |
|-----------------------------------------|---------------------|------------------------------------------------------------------------------------|------------------------------|--------|-------------------------|---|---|---|---------|---|---|---|---------|---|---|---|---------|---|---|---|---------|---|---|---|------------------------------|
| 14 to 12,<br>10 to 8,<br>6 to 4, 2 to 0 | UFDCn2 to<br>UFDCn0 | These bits set the DMA service of a USB function to be allocated to DMA channel n. |                              |        |                         |   |   |   |         |   |   |   |         |   |   |   |         |   |   |   |         |   |   |   |                              |
|                                         |                     | UFDCn2                                                                             | UFDCn1                       | UFDCn0 | Service to be allocated | 1 | 1 | 1 | EP4_DMA | 1 | 1 | 0 | EP3_DMA | 1 | 0 | 1 | EP2_DMA | 1 | 0 | 0 | EP1_DMA | 0 | X | X | No allocation (DMA not used) |
|                                         |                     | UFDCn2                                                                             | UFDCn1                       | UFDCn0 | Service to be allocated |   |   |   |         |   |   |   |         |   |   |   |         |   |   |   |         |   |   |   |                              |
|                                         |                     | 1                                                                                  | 1                            | 1      | EP4_DMA                 |   |   |   |         |   |   |   |         |   |   |   |         |   |   |   |         |   |   |   |                              |
|                                         |                     | 1                                                                                  | 1                            | 0      | EP3_DMA                 |   |   |   |         |   |   |   |         |   |   |   |         |   |   |   |         |   |   |   |                              |
|                                         |                     | 1                                                                                  | 0                            | 1      | EP2_DMA                 |   |   |   |         |   |   |   |         |   |   |   |         |   |   |   |         |   |   |   |                              |
|                                         |                     | 1                                                                                  | 0                            | 0      | EP1_DMA                 |   |   |   |         |   |   |   |         |   |   |   |         |   |   |   |         |   |   |   |                              |
| 0                                       | X                   | X                                                                                  | No allocation (DMA not used) |        |                         |   |   |   |         |   |   |   |         |   |   |   |         |   |   |   |         |   |   |   |                              |
| <b>Remark</b> X: Don't care             |                     |                                                                                    |                              |        |                         |   |   |   |         |   |   |   |         |   |   |   |         |   |   |   |         |   |   |   |                              |

**Remark** X: Don't care

**Remark** n = 0 to 3

**(2) USB function 0 buffer control register (UF0BC)**

This register performs enable control and floating control on the input buffer of the USB function.

This register can be read or written in 8-bit or 1-bit units.

|       |   |   |   |   |   |   |        |        |          |             |
|-------|---|---|---|---|---|---|--------|--------|----------|-------------|
| UF0BC | 7 | 6 | 5 | 4 | 3 | 2 | 1      | 0      | Address  | After reset |
|       | 0 | 0 | 0 | 0 | 0 | 0 | UBFIEN | UBFIOR | FFFFDF2H | 00H         |

| Bit position | Bit name | Function                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|--------------|----------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1            | UBFIEN   | <p>This bit controls use of the USB buffer.</p> <p>1: Buffer valid<br/>0: Buffer invalid</p> <p><b>Caution</b> Clear this bit to 0 when the USB is not used. If this bit is set to 1, a current of 3 mA (TYP.) constantly flows, regardless of whether the USB is used or not.</p>                                                                                                                                                       |
| 0            | UBFIOR   | <p>This bit controls use of floating measures of the USB buffer.</p> <p>1: Disables floating measures<br/>0: Enables floating measures</p> <p>This bit prevents erroneous recognition of Bus Reset, Suspend, and Resume due to an undefined value when a cable is not connected (when data input is floated). When this bit is set to 1, control the processing for floating by the VBUS signal (which recognizes cable connection).</p> |

The following flowcharts illustrate the program execution when the host is disconnected and then reconnected, and the program execution when power is supplied.

**Figure 11-10. Flowchart of Program When Host Is Disconnected and Then Reconnected**

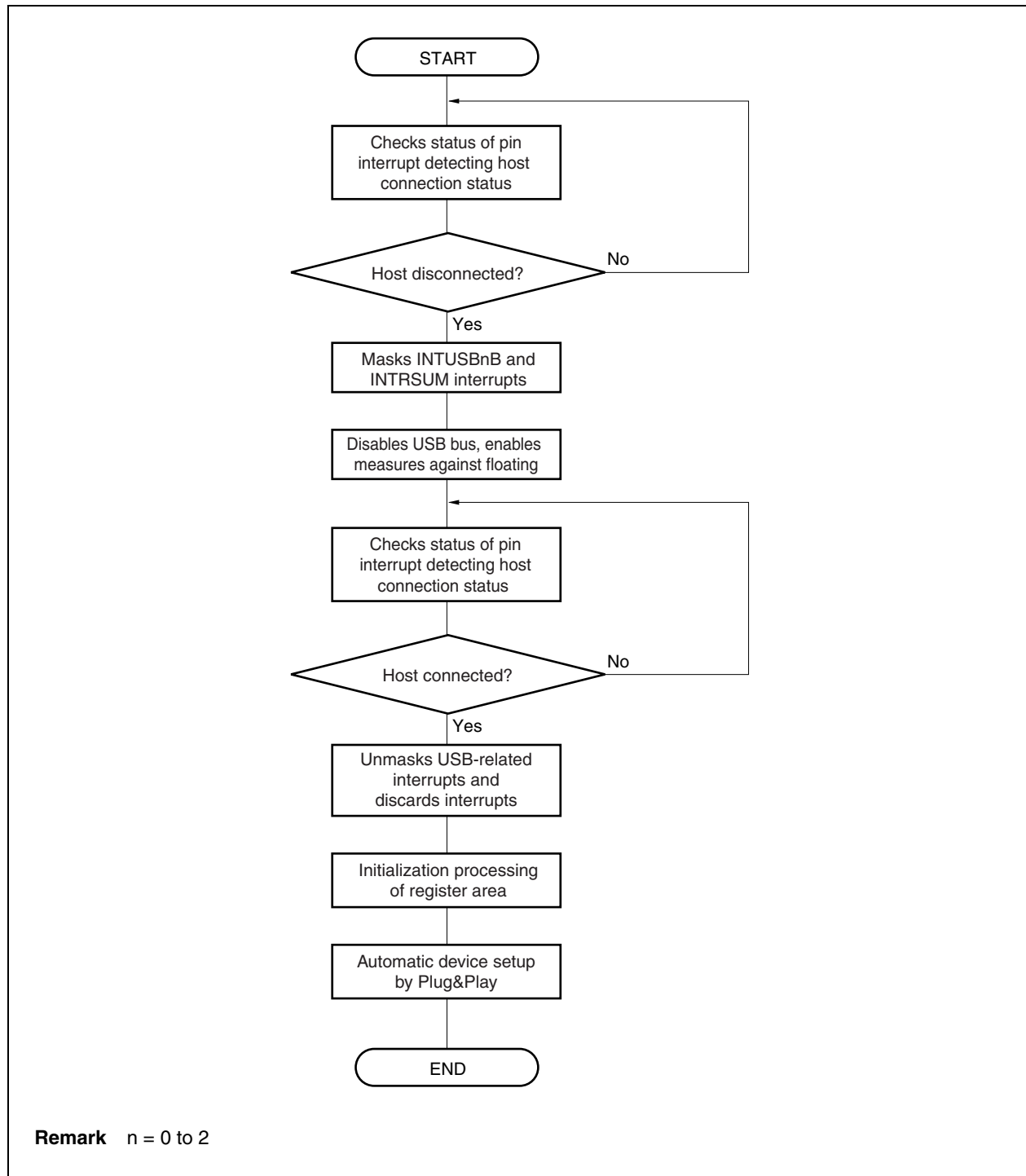
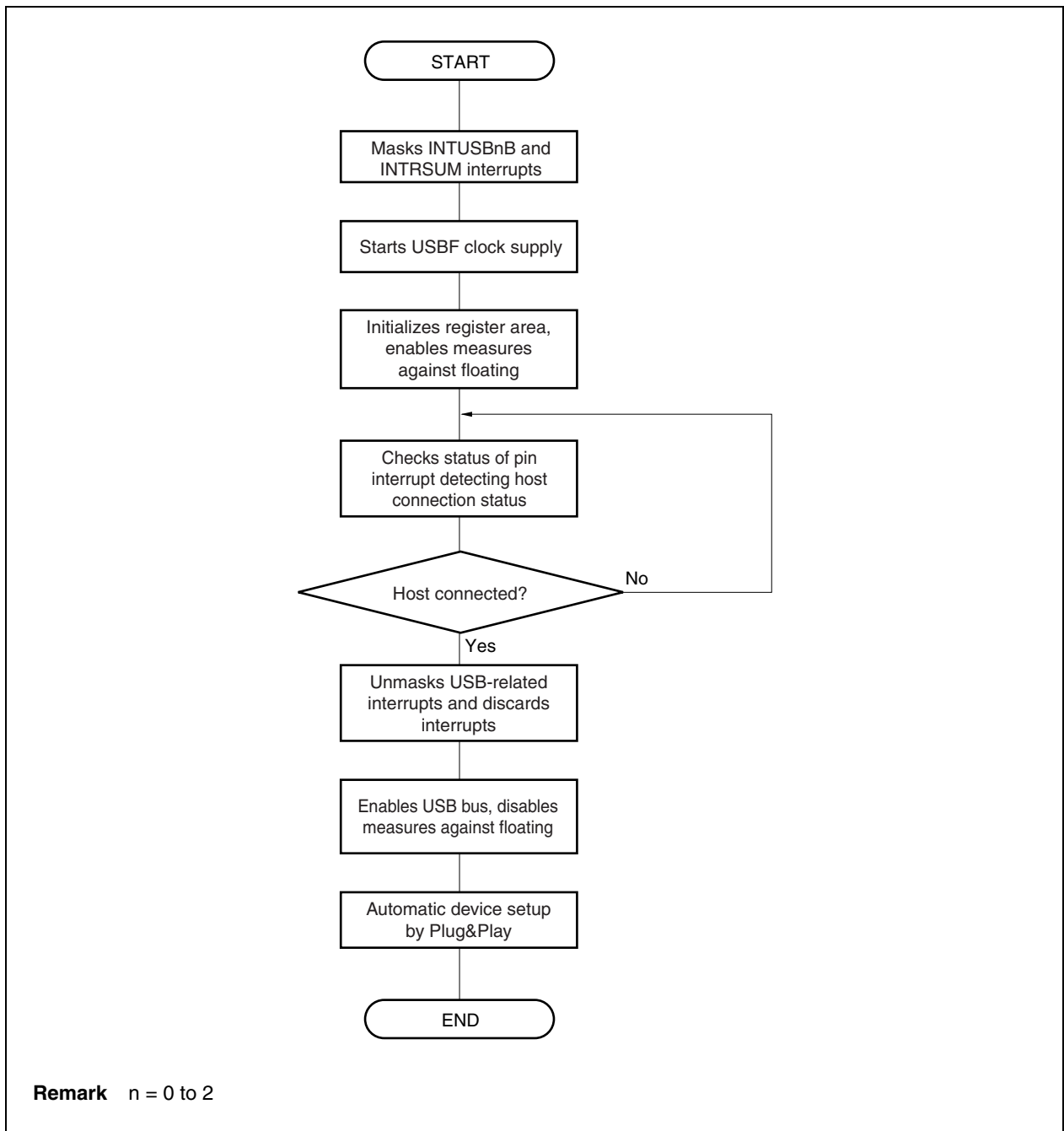


Figure 11-11. Flowchart of Program When Power Is Supplied



## 11.5 STALL Handshake or No Handshake

Errors of USBF are defined to be handled as follows.

| Transfer Type                                             | Transaction  | Target Packet | Error Type                            | Function Response                    | Processing                                                       |
|-----------------------------------------------------------|--------------|---------------|---------------------------------------|--------------------------------------|------------------------------------------------------------------|
| Control transfer/<br>bulk transfer/<br>interrupt transfer | IN/OUT/SETUP | Token         | Endpoint not supported                | No response                          | None                                                             |
|                                                           |              |               | Endpoint transfer direction mismatch  | No response                          | None                                                             |
|                                                           |              |               | CRC error                             | No response                          | None                                                             |
|                                                           |              |               | Bit stuffing error                    | No response                          | None                                                             |
| Control transfer/<br>bulk transfer                        | OUT/SETUP    | Data          | Timeout                               | No response                          | None                                                             |
|                                                           |              |               | PID check error                       | No response                          | None                                                             |
|                                                           |              |               | Unsupported PID (other than Data PID) | No response                          | None                                                             |
|                                                           |              |               | CRC error                             | No response                          | Discard received data                                            |
|                                                           |              |               | Bit stuffing error                    | No response                          | Discard received data                                            |
|                                                           | OUT          | Data          | Data PID mismatch                     | ACK                                  | Discard received data                                            |
| Control transfer (SETUP stage)                            | SETUP        | Data          | Overrun                               | No response                          | Discard received data                                            |
| Control transfer (data stage)                             | OUT          | Data          | Overrun                               | No response <sup>Note 1</sup>        | Set SNDSTL bit of UF0SDS register to 1 and discard received data |
| Control transfer (status stage)                           | OUT          | Data          | Overrun                               | ACK or no response <sup>Note 2</sup> | Set SNDSTL bit of UF0SDS register to 1 and discard received data |
| Bulk transfer                                             | OUT          | Data          | Overrun                               | No response <sup>Note 1</sup>        | Set EnHALT bit of UF0EnSL register (n = 0 to 4, 7, 8) to 1       |
| Control transfer/<br>bulk transfer/<br>interrupt transfer | IN           | Handshake     | PID check error                       | –                                    | Hold transferred data and re-transfer data <sup>Note 3</sup>     |
|                                                           |              |               | Unsupported PID (other than ACK PID)  | –                                    | Hold transferred data and re-transfer data <sup>Note 3</sup>     |
|                                                           |              |               | Timeout                               | –                                    | Hold transferred data and re-transfer data <sup>Note 3</sup>     |

**Notes 1.** A STALL response is made to re-transfer by the host.

2. An ACK response is made if the transfer data is of less than MaxPacketSize and the data received in the status stage is discarded. If MaxPacketSize is exceeded, no response is made, the SNDSTL bit of the UF0SDS register is set to 1, and the received data is discarded.
3. If an OUT transaction indicating a change from the data stage to the status stage is received during control transfer, an error is not handled and it is assumed that reception has been correctly completed.

**Cautions 1.** It is judged by the Alternative Setting number currently set whether the target Endpoint is valid or invalid.

2. For the response to the request included in control transfer to/from Endpoint0, see 11.3 Requests.



## 11.6 Register Values in Specific Status

Table 11-7. Register Values in Specific Status (1/2)

| Register Name    | After CPU Reset ( $\overline{\text{RESET}}$ ) | After Bus Reset                                          |
|------------------|-----------------------------------------------|----------------------------------------------------------|
| UF0E0N register  | 00H                                           | Value is held.                                           |
| UF0E0NA register | 00H                                           | Value is held.                                           |
| UF0EN register   | 00H                                           | Value is held.                                           |
| UF0ENM register  | 00H                                           | Value is held.                                           |
| UF0SDS register  | 00H                                           | Value is held.                                           |
| UF0CLR register  | 00H                                           | Value is held.                                           |
| UF0SET register  | 00H                                           | Value is held.                                           |
| UF0EPS0 register | 00H                                           | Value is held.                                           |
| UF0EPS1 register | 00H                                           | Value is held.                                           |
| UF0EPS2 register | 00H                                           | Value is held.                                           |
| UF0IS0 register  | 00H                                           | Value is held.                                           |
| UF0IS1 register  | 00H                                           | Value is held.                                           |
| UF0IS2 register  | 00H                                           | Value is held.                                           |
| UF0IS3 register  | 00H                                           | Value is held.                                           |
| UF0IS4 register  | 00H                                           | Value is held.                                           |
| UF0IM0 register  | 00H                                           | Value is held.                                           |
| UF0IM1 register  | 00H                                           | Value is held.                                           |
| UF0IM2 register  | 00H                                           | Value is held.                                           |
| UF0IM3 register  | 00H                                           | Value is held.                                           |
| UF0IM4 register  | 00H                                           | Value is held.                                           |
| UF0IC0 register  | FFH                                           | Value is held.                                           |
| UF0IC1 register  | FFH                                           | Value is held.                                           |
| UF0IC2 register  | FFH                                           | Value is held.                                           |
| UF0IC3 register  | FFH                                           | Value is held.                                           |
| UF0IC4 register  | FFH                                           | Value is held.                                           |
| UF0IDR register  | 00H                                           | Value is held.                                           |
| UF0DMS0 register | 00H                                           | Value is held.                                           |
| UF0DMS1 register | 00H                                           | Value is held.                                           |
| UF0FIC0 register | 00H                                           | Value is held.                                           |
| UF0FIC1 register | 00H                                           | Value is held.                                           |
| UF0DEND register | 00H                                           | Value is held.                                           |
| UF0GPR register  | 00H                                           | Value is held.                                           |
| UF0MODC register | 00H                                           | Value is held.                                           |
| UF0MODS register | 00H                                           | Bit 2 (CONF): Cleared (0),<br>Other bits: Value is held. |
| UF0AIFN register | 00H                                           | Value is held.                                           |
| UF0AAS register  | 00H                                           | Value is held.                                           |
| UF0ASS register  | 00H                                           | 00H                                                      |
| UF0E1IM register | 00H                                           | Value is held.                                           |
| UF0E2IM register | 00H                                           | Value is held.                                           |

Table 11-7. Register Values in Specific Status (2/2)

| Register Name                   | After CPU Reset ( $\overline{\text{RESET}}$ ) | After Bus Reset |
|---------------------------------|-----------------------------------------------|-----------------|
| UF0E3IM register                | 00H                                           | Value is held.  |
| UF0E4IM register                | 00H                                           | Value is held.  |
| UF0E7IM register                | 00H                                           | Value is held.  |
| UF0E8IM register                | 00H                                           | Value is held.  |
| UF0E0R register                 | Undefined <sup>Note 1</sup>                   | Value is held.  |
| UF0E0L register                 | 00H                                           | Value is held.  |
| UF0E0ST register                | 00H                                           | 00H             |
| UF0E0W register                 | Undefined <sup>Note 1</sup>                   | Value is held.  |
| UF0BO1 register                 | Undefined <sup>Note 1</sup>                   | Value is held.  |
| UF0BO1L register                | 00H                                           | Value is held.  |
| UF0BO2 register                 | Undefined <sup>Note 1</sup>                   | Value is held.  |
| UF0BO2L register                | 00H                                           | Value is held.  |
| UF0BI1 register                 | Undefined <sup>Note 1</sup>                   | Value is held.  |
| UF0BI2 register                 | Undefined <sup>Note 1</sup>                   | Value is held.  |
| UF0INT1 register                | Undefined                                     | Value is held.  |
| UF0INT2 register                | Undefined                                     | Value is held.  |
| UF0DSTL register                | 00H                                           | 00H             |
| UF0E0SL register                | 00H                                           | 00H             |
| UF0E1SL register                | 00H                                           | 00H             |
| UF0E2SL register                | 00H                                           | 00H             |
| UF0E3SL register                | 00H                                           | 00H             |
| UF0E4SL register                | 00H                                           | 00H             |
| UF0E7SL register                | 00H                                           | 00H             |
| UF0E8SL register                | 00H                                           | 00H             |
| UF0ADRS register                | 00H                                           | 00H             |
| UF0CNF register                 | 00H                                           | 00H             |
| UF0IF0 register                 | 00H                                           | 00H             |
| UF0IF1 register                 | 00H                                           | 00H             |
| UF0IF2 register                 | 00H                                           | 00H             |
| UF0IF3 register                 | 00H                                           | 00H             |
| UF0IF4 register                 | 00H                                           | 00H             |
| UF0DSCL register                | 00H                                           | Value is held.  |
| UF0DDn register (n = 0 to 17)   | <b>Note 2</b>                                 | <b>Note 2</b>   |
| UF0CIEn register (n = 0 to 255) | <b>Note 2</b>                                 | <b>Note 2</b>   |

**Notes 1.** This register can be cleared to 0 by the  $\overline{\text{RESET}}$  signal because its write pointer, counter, and read pointer are cleared to 0 when the  $\overline{\text{RESET}}$  signal becomes active, in the same manner as clearing by the UF0FICn register, as the register is controlled by FIFO.

- 2.** This register cannot be cleared to 0. Because data can be written to it by FW, however, any value can be written to the register (before doing so, however, be sure to set the EP0NKA bit of the UF0E0NA register to 1).

## 11.7 FW Processing

The following FW processing is performed.

- Setting processing on device side for the SET\_CONFIGURATION, SET\_INTERFACE, SET\_FEATURE, and CLEAR\_FEATURE requests during enumeration processing
- Analysis and processing of XXXXStandard, XXXXClass, and XXXXVendor requests not subject to automatic processing
- Reading data following bulk-transferred OUT token from receive buffer
- Writing data to be returned in response to bulk-transferred IN token
- Writing data to be returned in response to interrupt-transferred token

The following table lists the requests supported by FW.

Table 11-8. FW-Supported Standard Requests

| Request        | Reception Side | Processing/<br>Frequency    | Explanation                                                                                                                                                                                                                                                                                                                           |
|----------------|----------------|-----------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| CLEAR_FEATURE  | Interface      | Automatic<br>STALL response | It is considered that this request does not come to Interface because there is no function selector value, though it is reserved for bmRequestType.<br>When this request is received, the hardware makes an automatic STALL response.                                                                                                 |
| SET_FEATURE    | Interface      | Automatic<br>STALL response | It is considered that this request does not come to Interface because there is no function selector value, though it is reserved for bmRequestType.<br>When this request is received, the hardware makes an automatic STALL response.                                                                                                 |
| GET_DESCRIPTOR | String         | FW                          | Returns the string descriptor.<br>When this request is received by the SETUP token, the hardware generates the CPUDEC interrupt request for FW. FW decodes the contents of the request from the CPUDEC interrupt request, and writes the data to be returned to the host, to the UF0E0W register.                                     |
| SET_DESCRIPTOR | Device         | FW                          | Rewrites the device descriptor.<br>When this request is received by the SETUP token, the hardware generates the CPUDEC interrupt request for FW. FW decodes the contents of the request from the CPUDEC interrupt request, and the writes the data for the next control transfer (OUT) to the UF0DDn register (n = 0 to 17).          |
| SET_DESCRIPTOR | Configuration  | FW                          | Rewrites the configuration descriptor.<br>When this request is received by the SETUP token, the hardware generates the CPUDEC interrupt request for FW. FW decodes the contents of the request from the CPUDEC interrupt request, and the writes the data for the next control transfer (OUT) to the UF0CIEn register (n = 0 to 255). |
| SET_DESCRIPTOR | String         | FW                          | Rewrites the string descriptor.<br>When this request is received by the SETUP token, the hardware generates the CPUDEC interrupt request for FW. FW decodes the contents of the request from the CPUDEC interrupt request, and loads the data for the next control transfer (OUT).                                                    |
| Other          | NA             | FW                          | When this request is received by the SETUP token, the hardware generates the CPUDEC interrupt request for FW. FW decodes the contents of the request from the CPUDEC interrupt request, and performs the necessary processing.                                                                                                        |

### 11.7.1 Initialization processing

Initialization processing is executed in the following two ways.

- Initialization of request data register
- Setting of interrupt

When a request data register is initialized, data for the GET\_XXXX request to which a value is to be automatically returned is written and an endpoint is allocated to an interface. In the interrupt settings, the interrupt sources that do not have to be checked can be masked by using the UF0IMn register (n = 0 to 4).

The following flowcharts illustrate the above processing.

**Figure 11-12. Initializing Request Data Register**

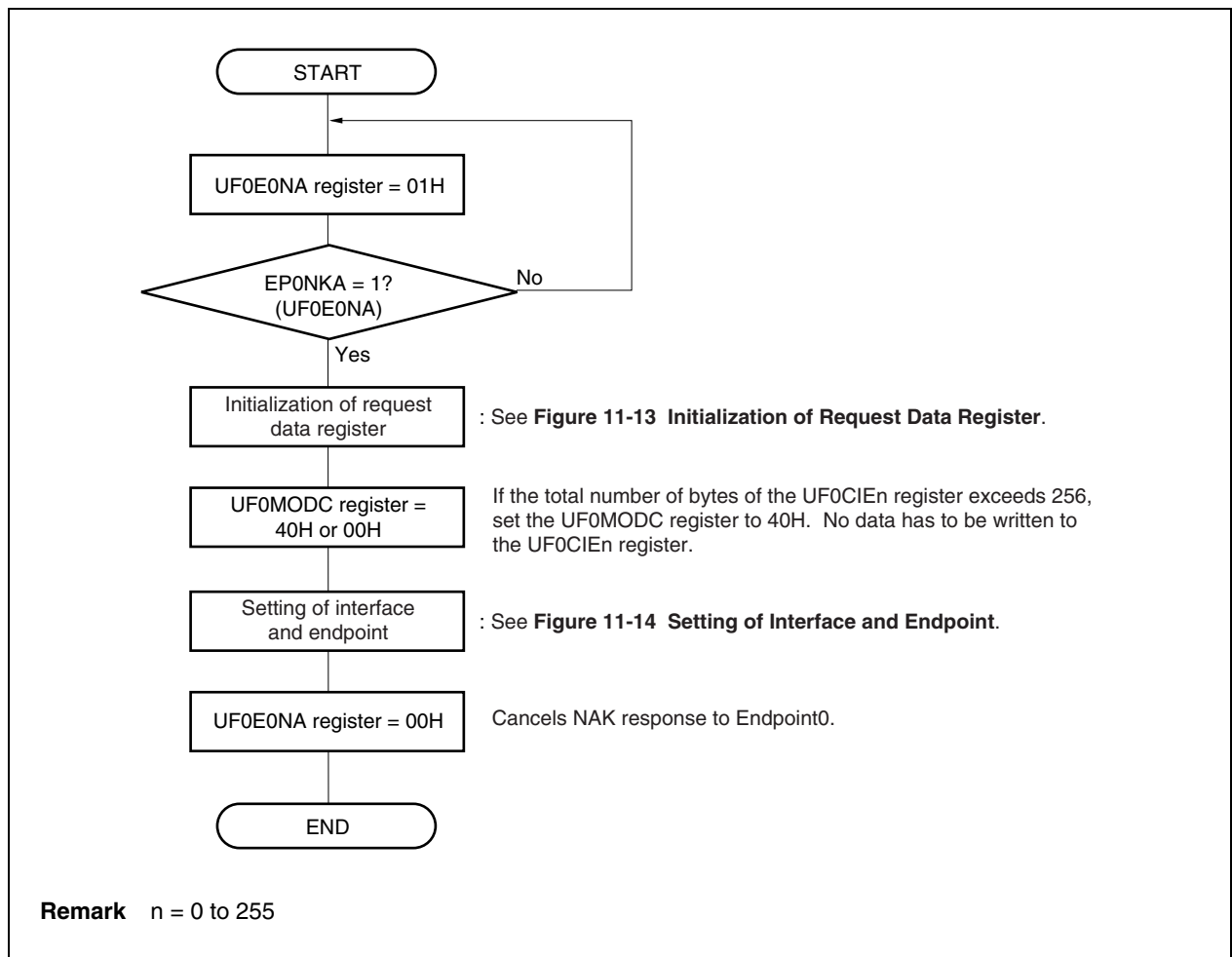


Figure 11-13. Initialization of Request Data Register

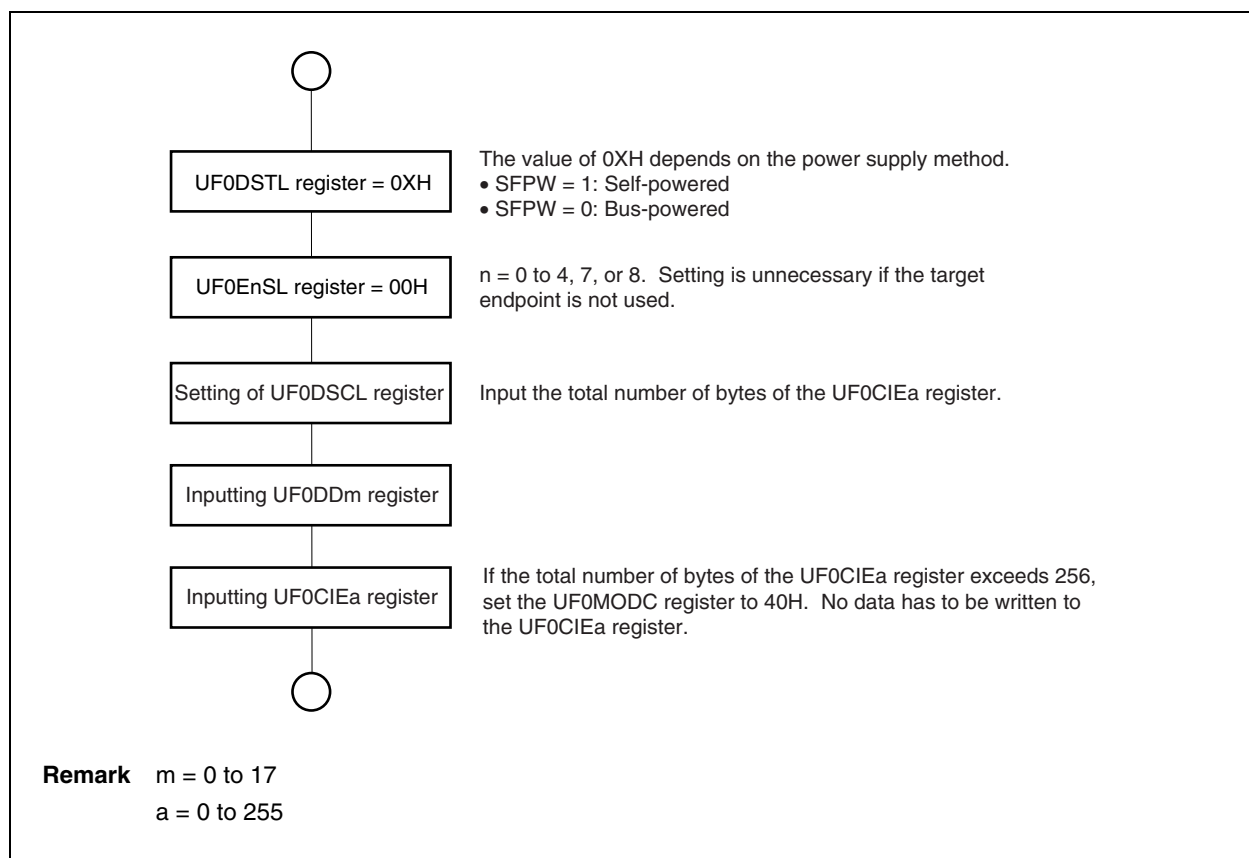


Figure 11-14. Setting of Interface and Endpoint

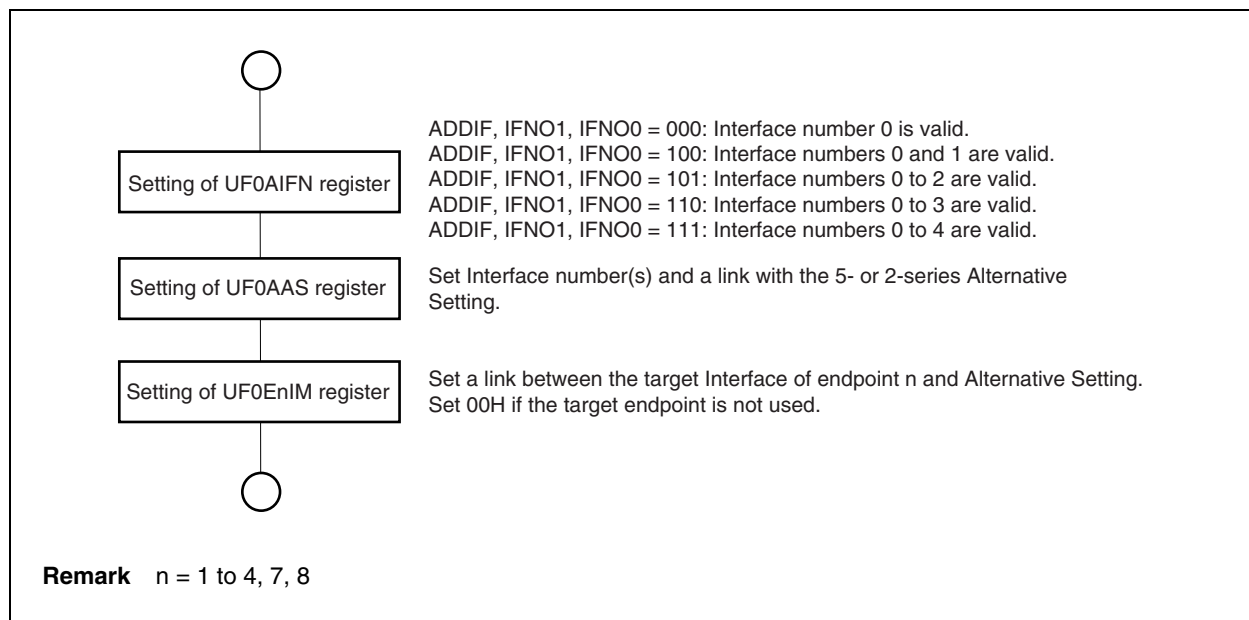
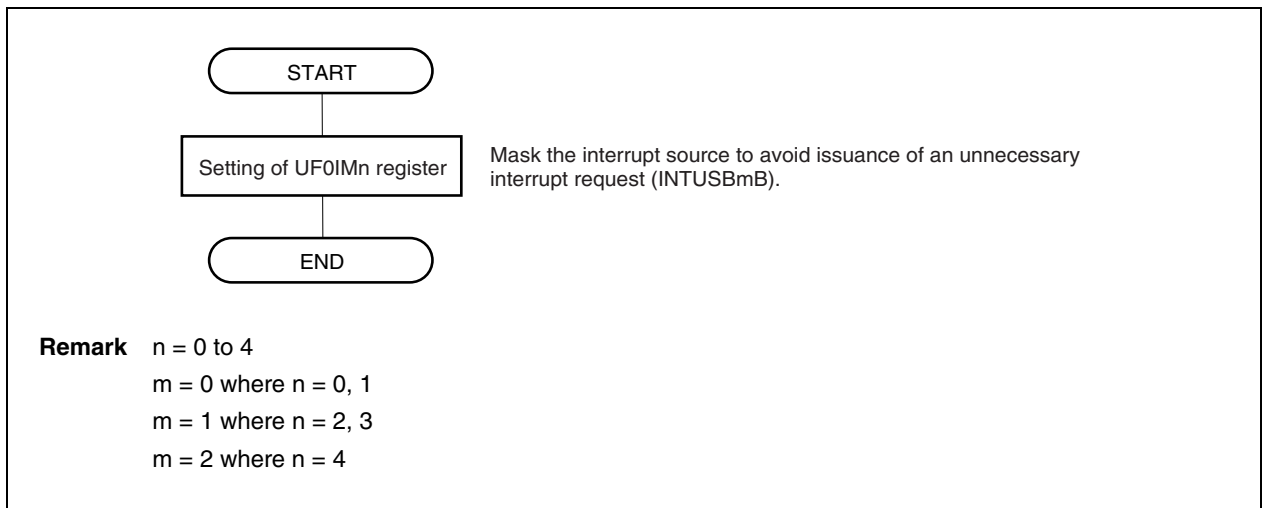


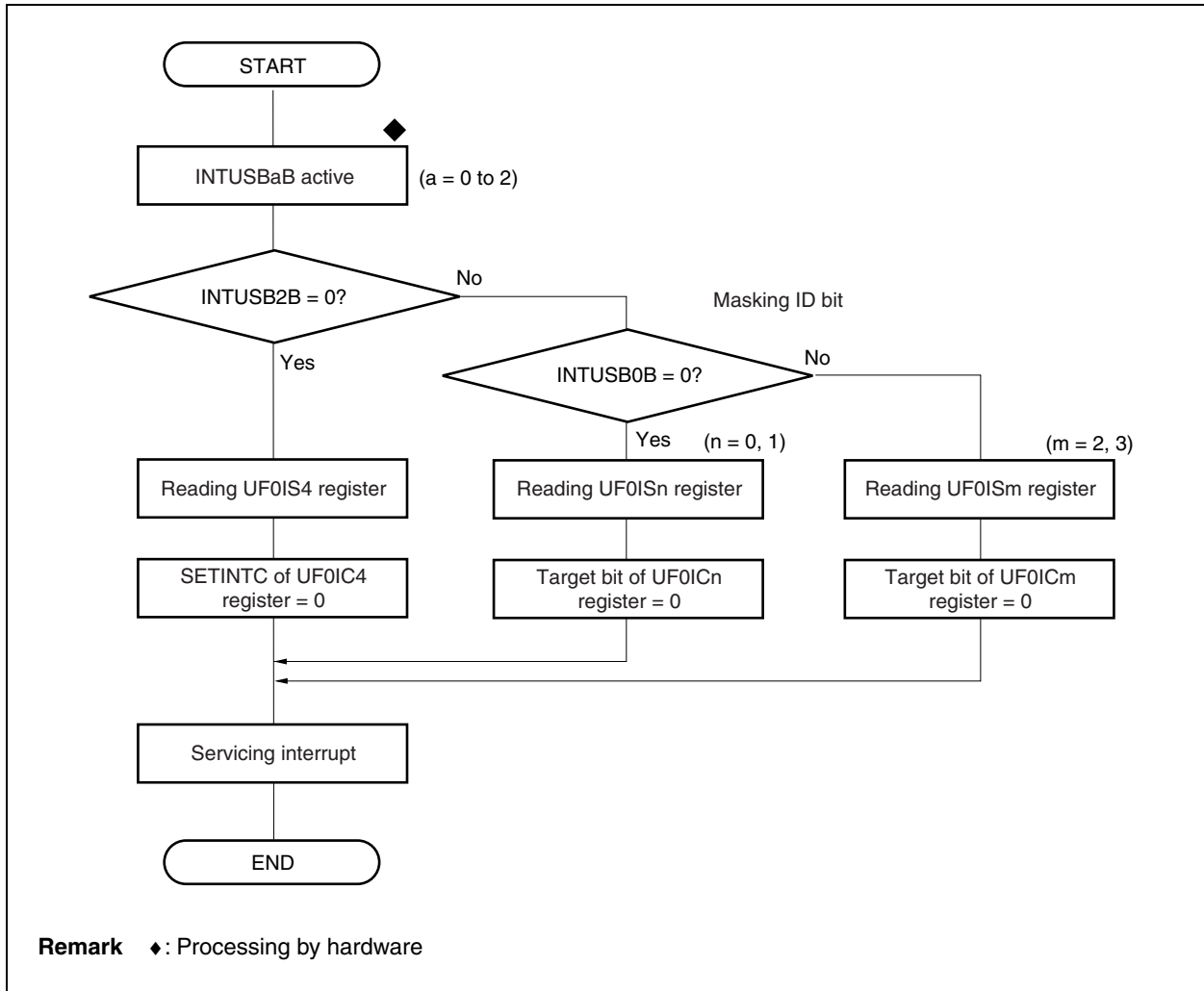
Figure 11-15. Setting of Interrupt



### 11.7.2 Interrupt servicing

The following flowchart illustrates how an interrupt is serviced.

**Figure 11-16. Interrupt Servicing**



The following bits of the UF0ISn register are automatically cleared by hardware when a given condition is satisfied (n = 1 to 4).

- E0INDT, E0ODT, SUCES, STG, and CPUDEC bits of UF0IS1 register
- BKI2DT, BKI1DT, IT2DT, and IT1DT bits of UF0IS2 register
- BKO2FL, BKO2DT, BKO1FL, and BKO1DT bits of UF0IS3 register

Because clearing an interrupt source by the UF0ICn register is given a lower priority than setting an interrupt source by hardware, the interrupt source may not be cleared depending on the timing (n = 0 to 4).



### 11.7.3 USB main processing

USB main processing involves processing USB transactions. The types of transactions to be processed are as follows.

- Fully automatically processed request for control transfer
- Automatically processed requests for control transfer  
(SET\_CONFIGURATION, SET\_INTERFACE, SET\_FEATURE, CLEAR\_FEATURE)
- CPUDEC request for control transfer
- Processing for bulk transfer (IN)
- Processing for bulk transfer (OUT)
- Processing for interrupt transfer (IN)

Processing for endpoint n involves writing or reading for data transfer. The flowchart shown below is for PIO.

#### (1) Fully automatically processed request for control transfer

Because the fully automatically processed request for control transfer is executed by hardware, it cannot be referenced by FW. Therefore, FW does not have to perform any special processing for this request.

#### (2) Automatically processed requests for control transfer

(SET\_CONFIGURATION, SET\_INTERFACE, SET\_FEATURE, CLEAR\_FEATURE)

Processing to write a register for automatically processed requests for control transfer, such as SET\_CONFIGURATION, SET\_INTERFACE, SET\_FEATURE, and CLEAR\_FEATURE requests, is automatically executed by hardware, but an interrupt request is issued for recognition on the device side. This processing may be ignored if there is no special processing to be executed.

The flowcharts are shown below.

Figure 11-17. Automatically Processed Requests for Control Transfer

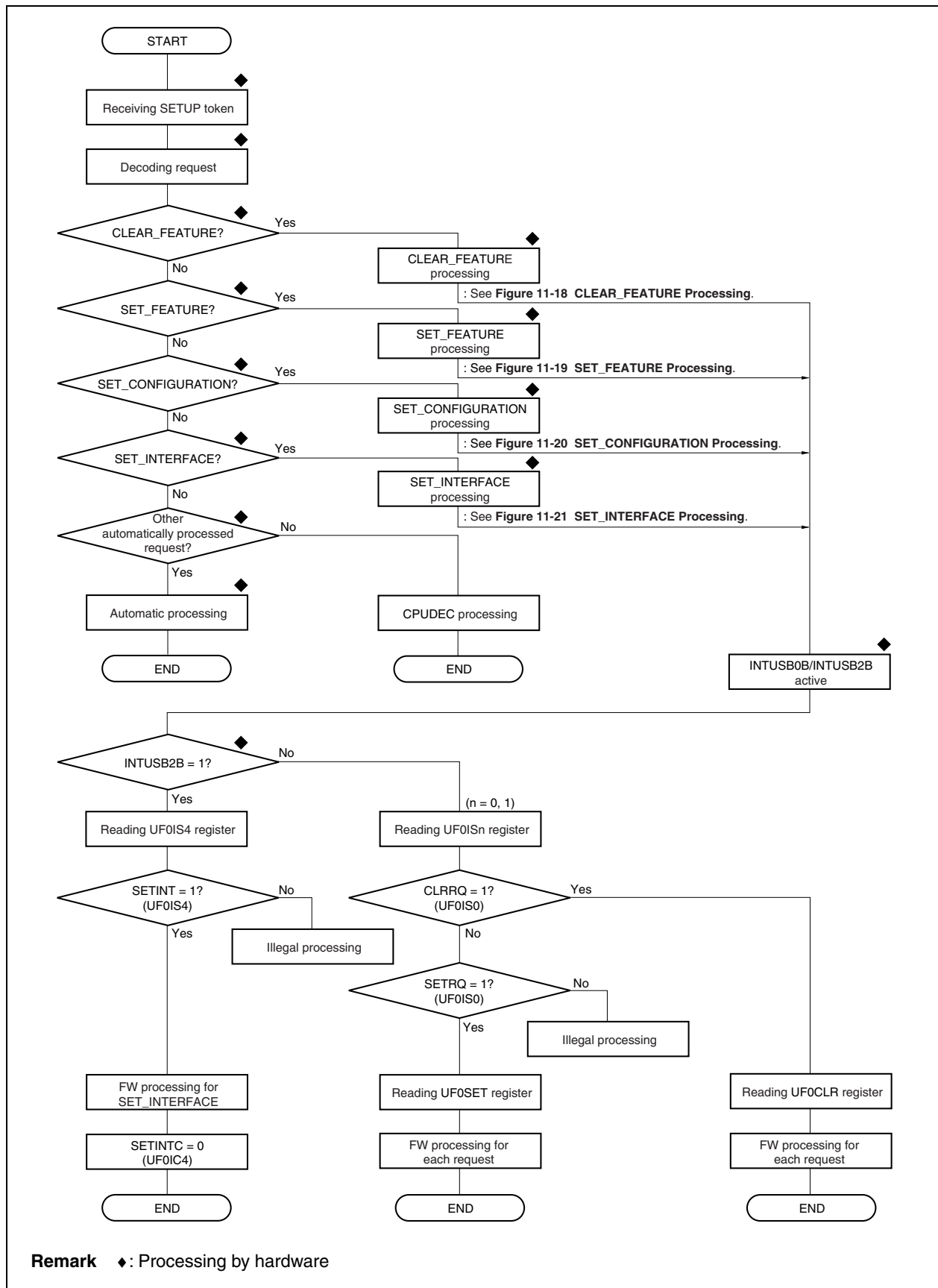


Figure 11-18. CLEAR\_FEATURE Processing

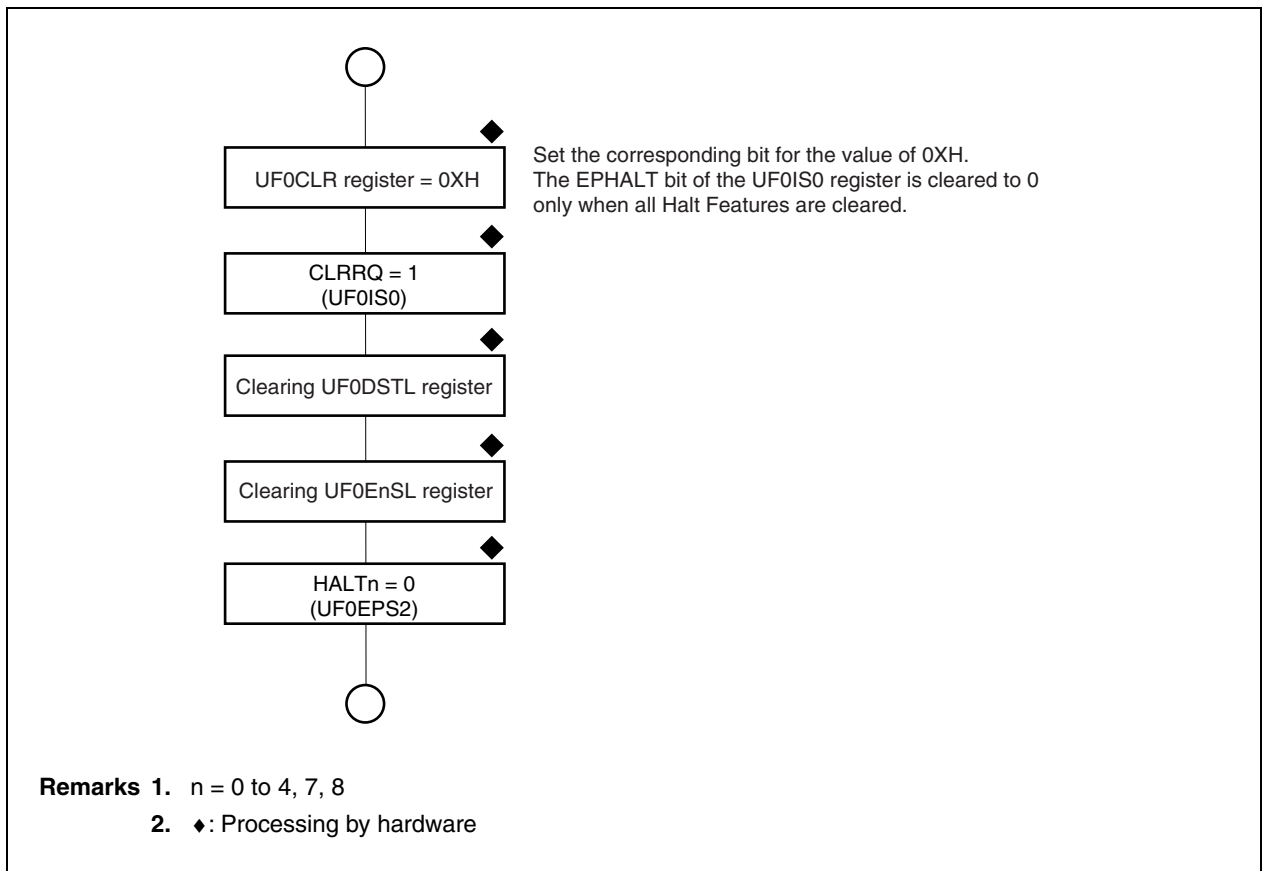
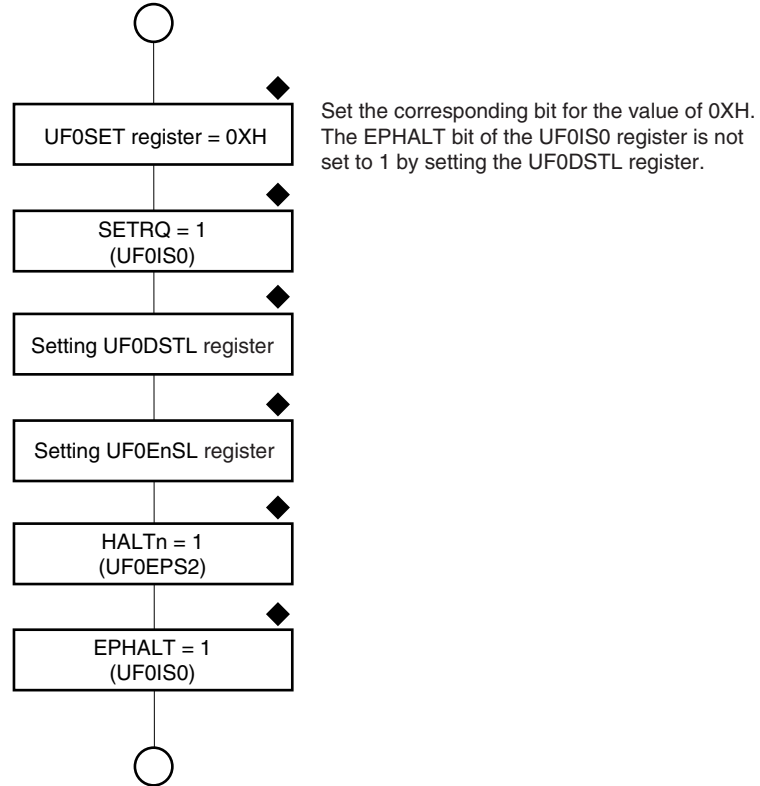


Figure 11-19. SET\_FEATURE Processing



- Remarks**
1.  $n = 0$  to 4, 7, 8
  2. ♦: Processing by hardware

Figure 11-20. SET\_CONFIGURATION Processing

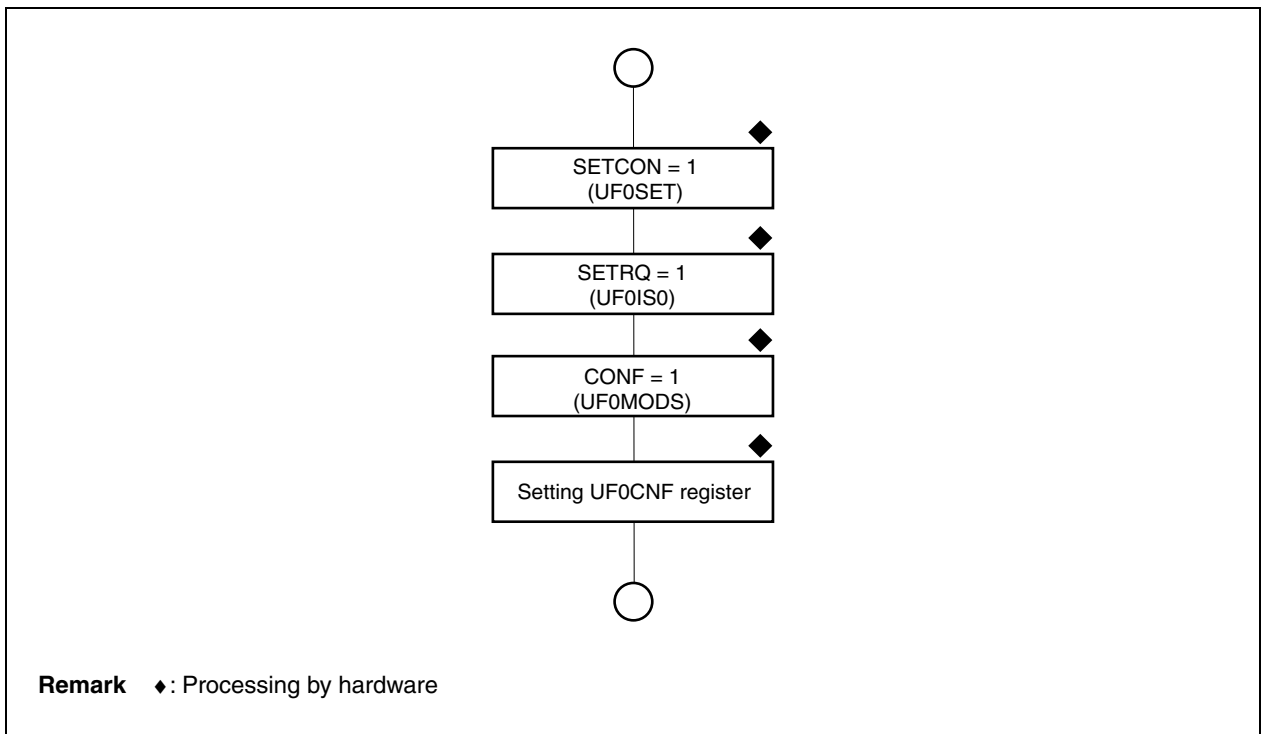
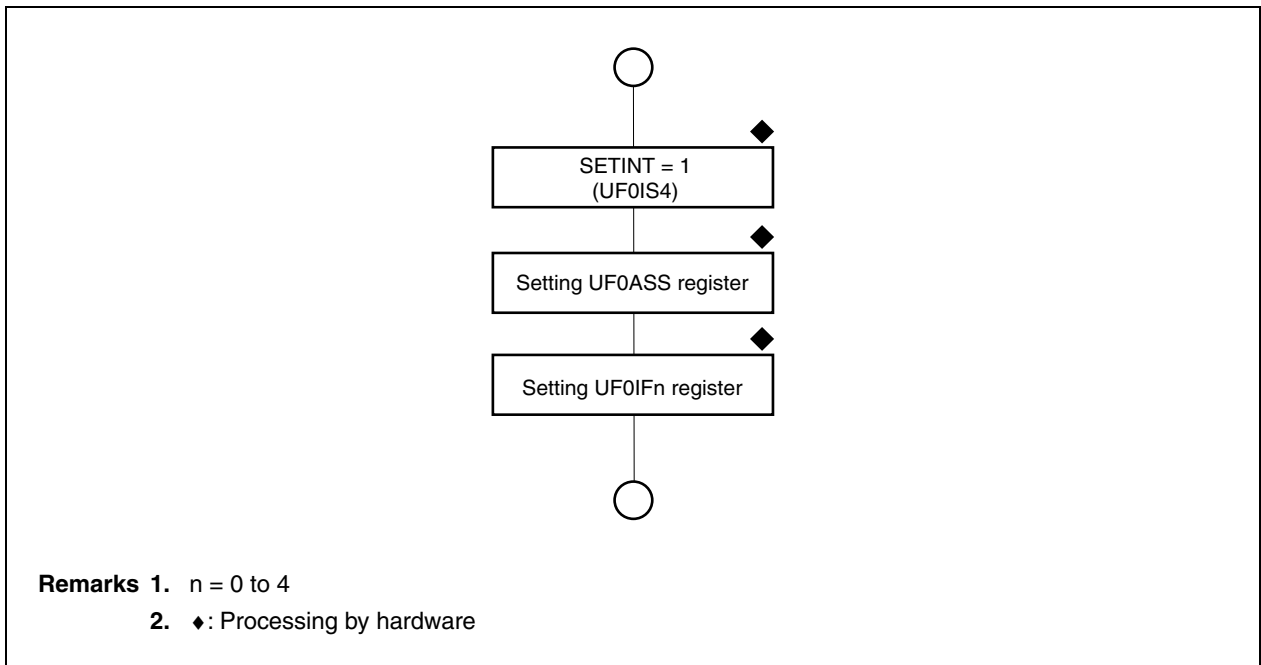


Figure 11-21. SET\_INTERFACE Processing



**(3) CPUDEC request for control transfer**

The CPUDEC request can be classified into three types of processing: control transfer (write), control transfer (read), and control transfer (without data). Control transfer (write) indicates a request that uses the OUT transaction in the data stage (e.g., SET\_DESCRIPTOR), and control transfer (read) indicates a request that uses the IN transaction in the data stage (e.g., GET\_DESCRIPTOR). Control transfer (without data) indicates a request that has no data stage (e.g., SET\_CONFIGURATION).

The flowcharts are shown below.

**Figure 11-22. CPUDEC Request for Control Transfer (1/12)**

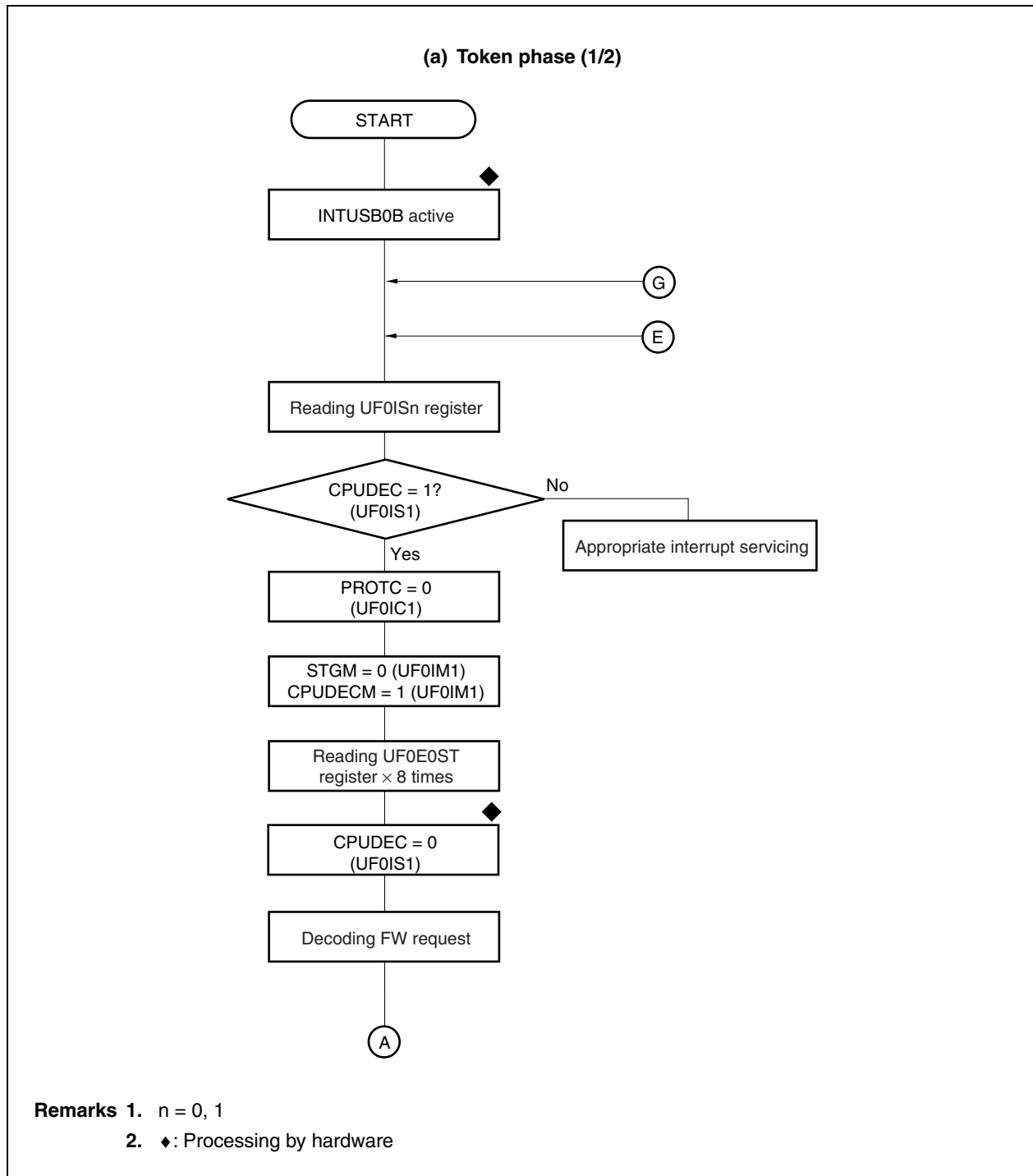


Figure 11-22. CPUDEC Request for Control Transfer (2/12)

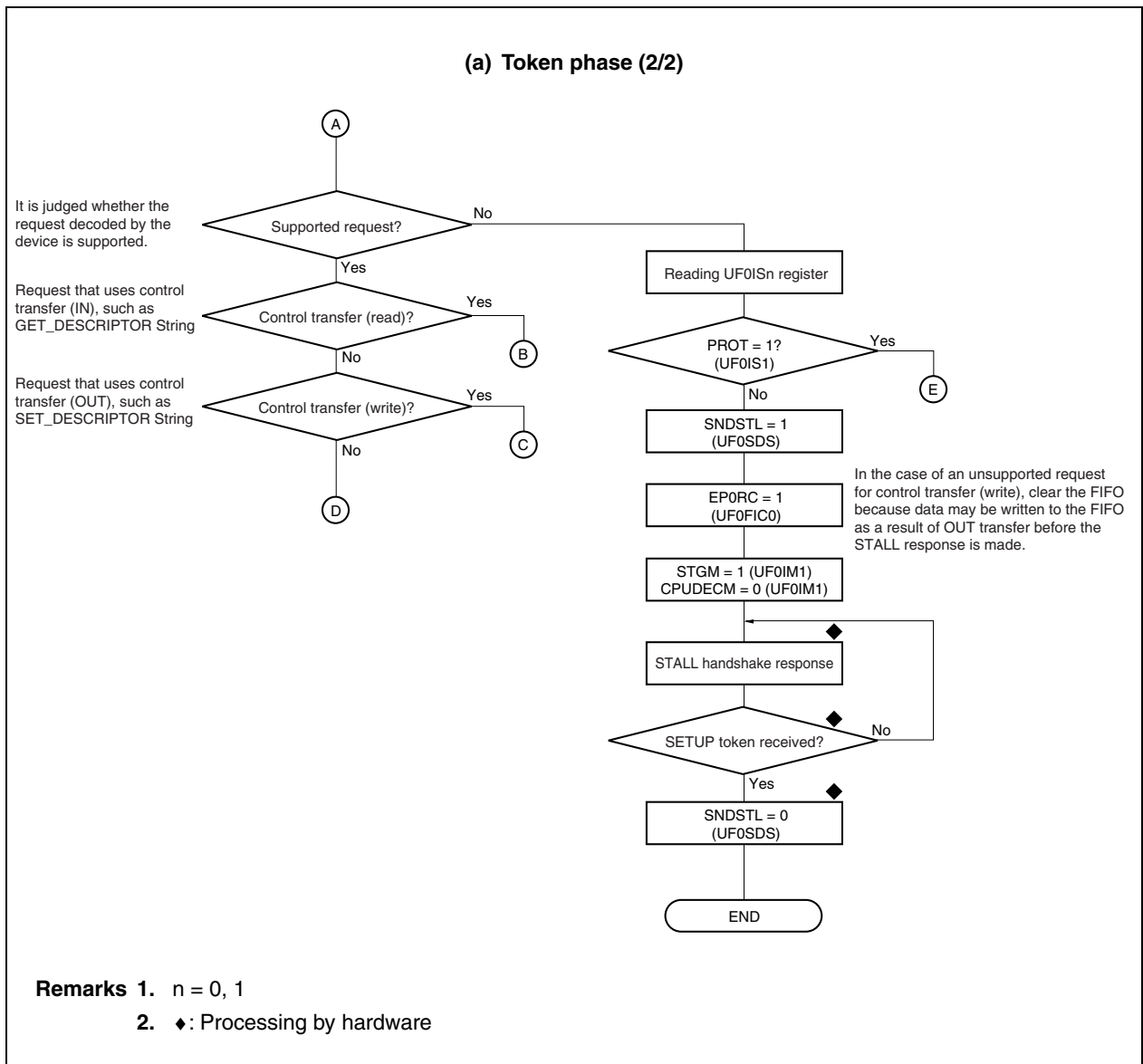


Figure 11-22. CPUDEC Request for Control Transfer (3/12)

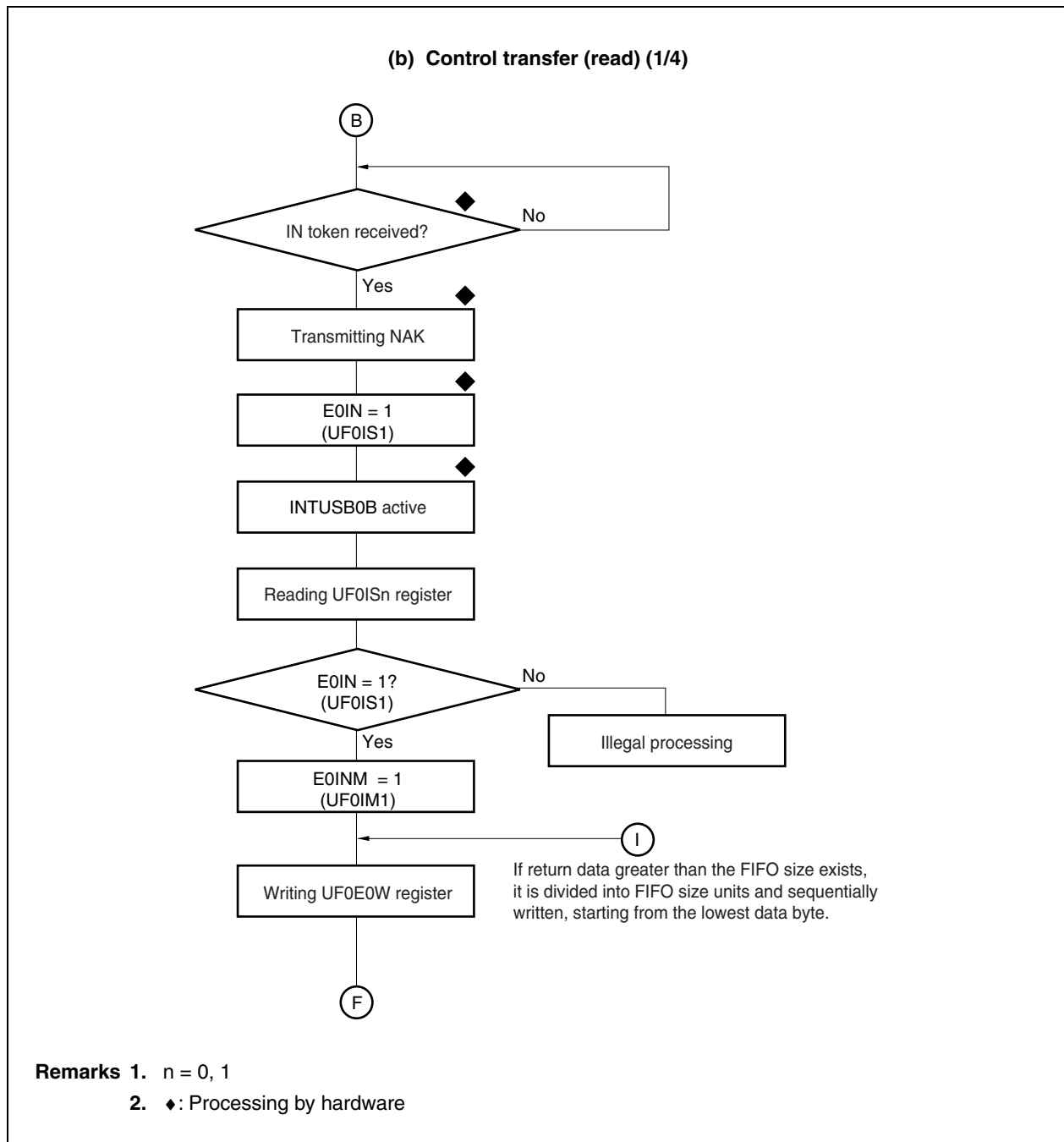




Figure 11-22. CPUDEC Request for Control Transfer (4/12)

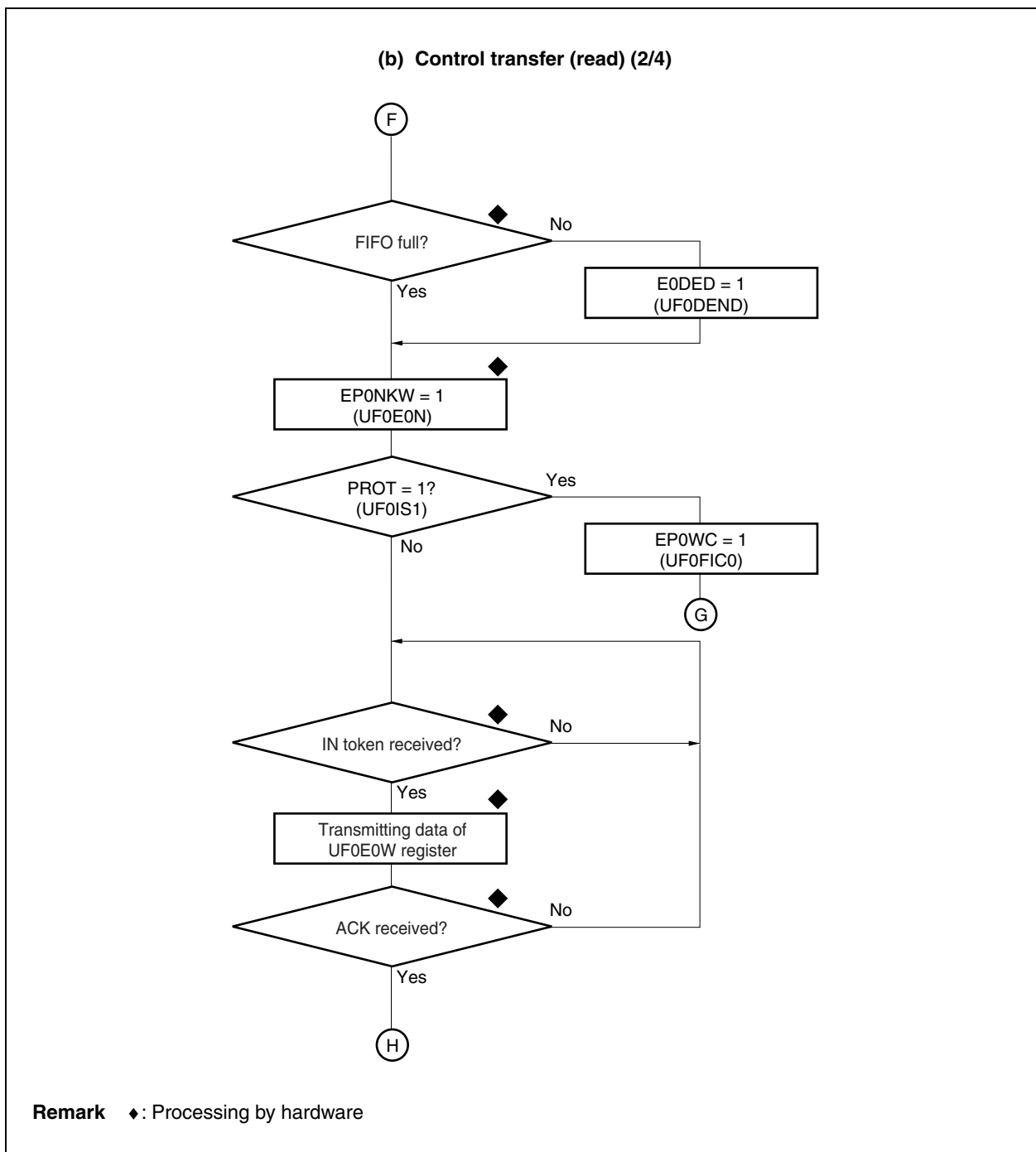
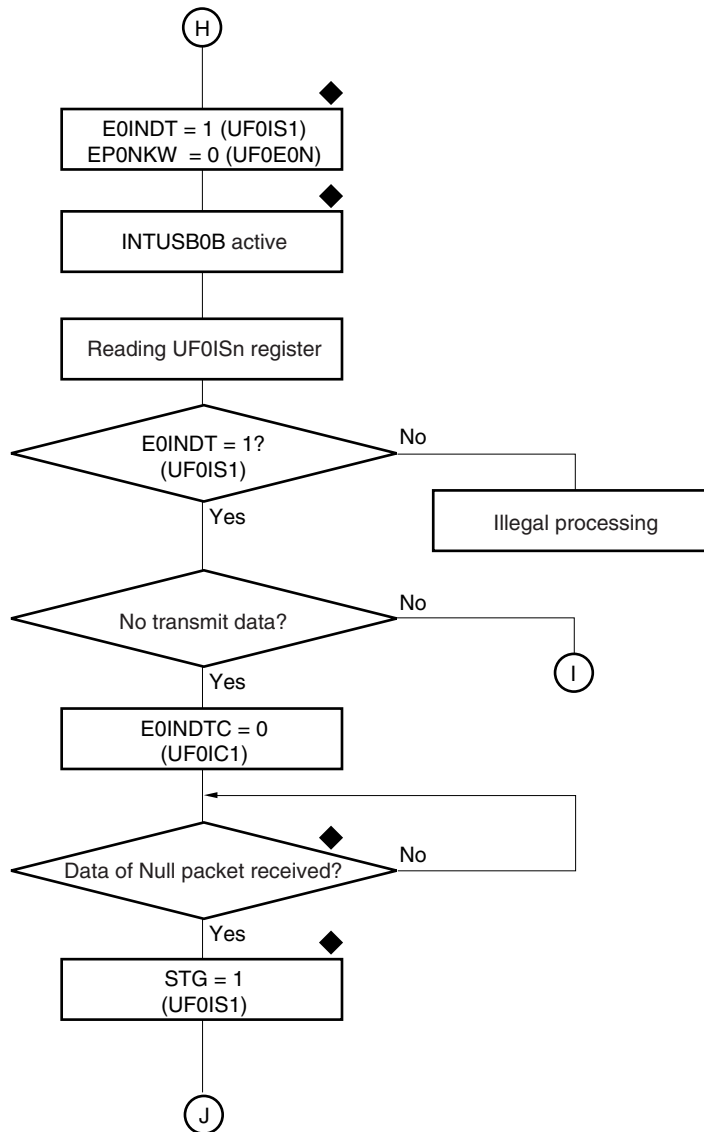


Figure 11-22. CPUDEC Request for Control Transfer (5/12)

## (b) Control transfer (read) (3/4)



**Remarks 1.** n = 0, 1

**2.** ◆: Processing by hardware

Figure 11-22. CPUDEC Request for Control Transfer (6/12)

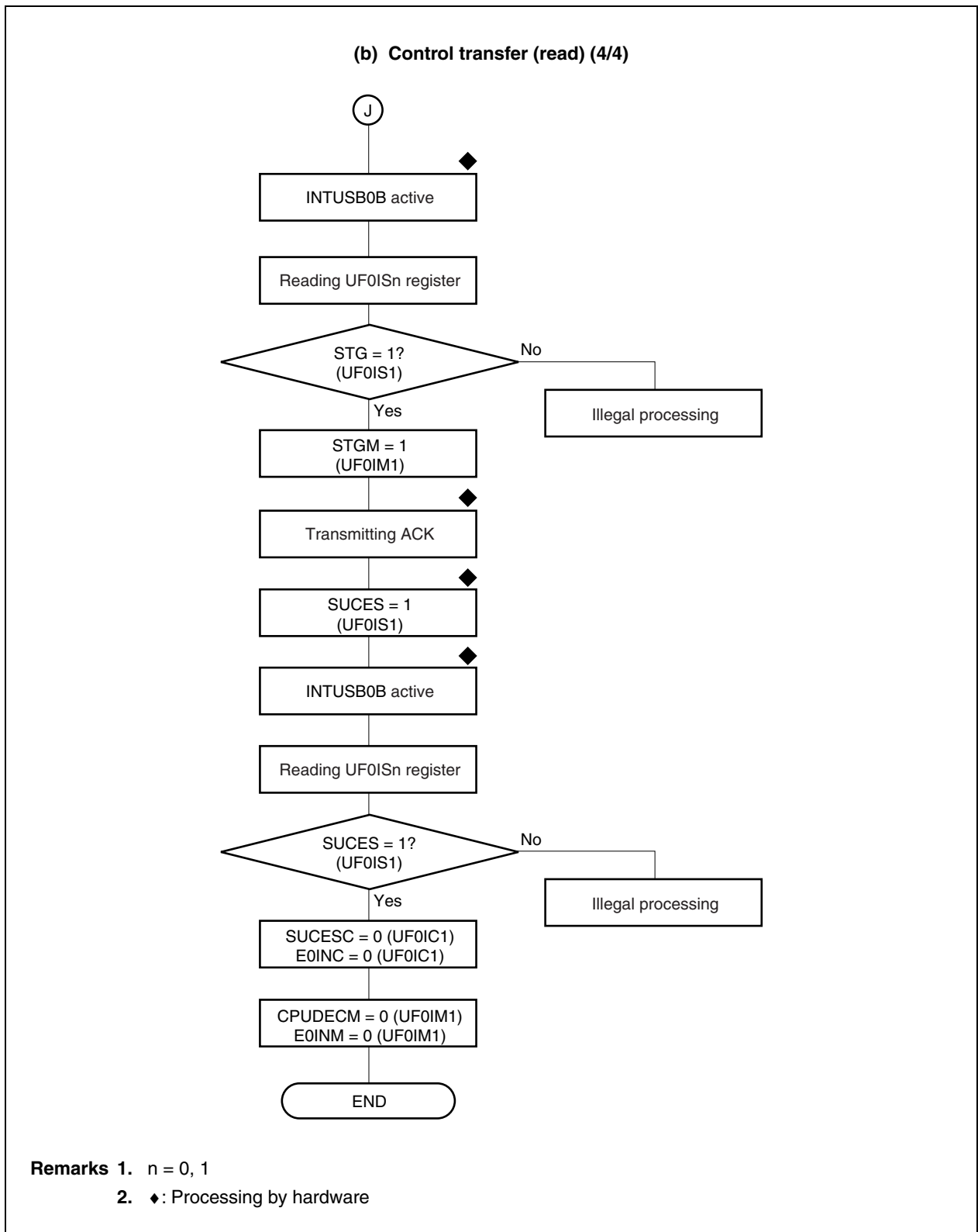
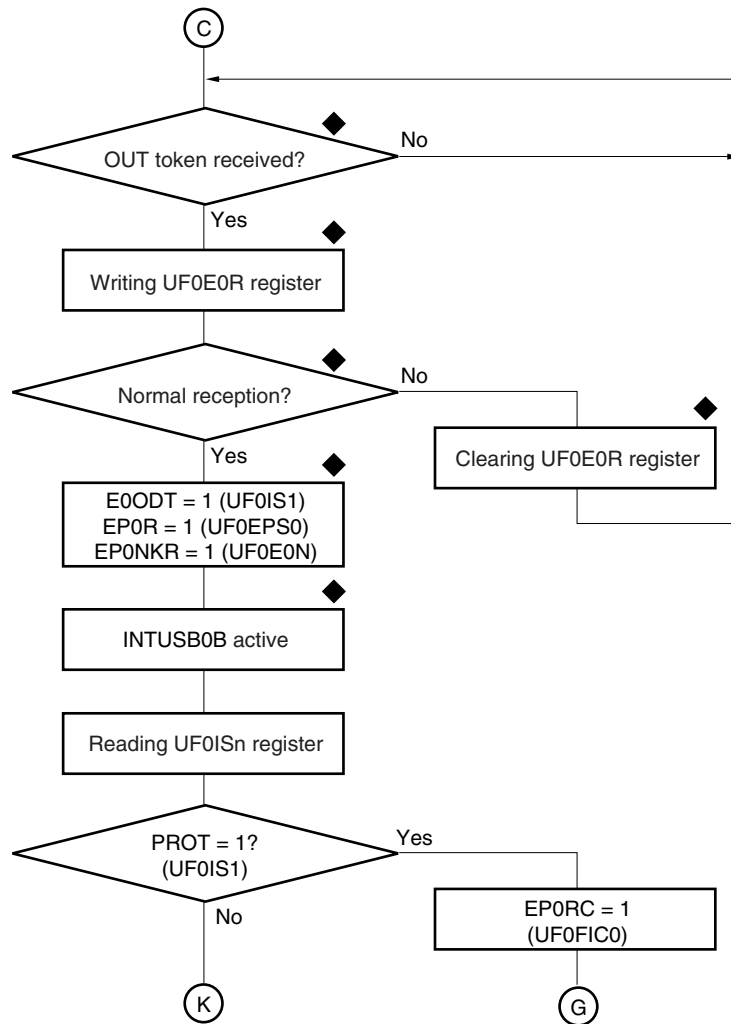


Figure 11-22. CPUDEC Request for Control Transfer (7/12)

## (c) Control transfer (write) (1/4)



**Remarks** 1.  $n = 0, 1$

2. ♦: Processing by hardware

Figure 11-22. CPUDEC Request for Control Transfer (8/12)

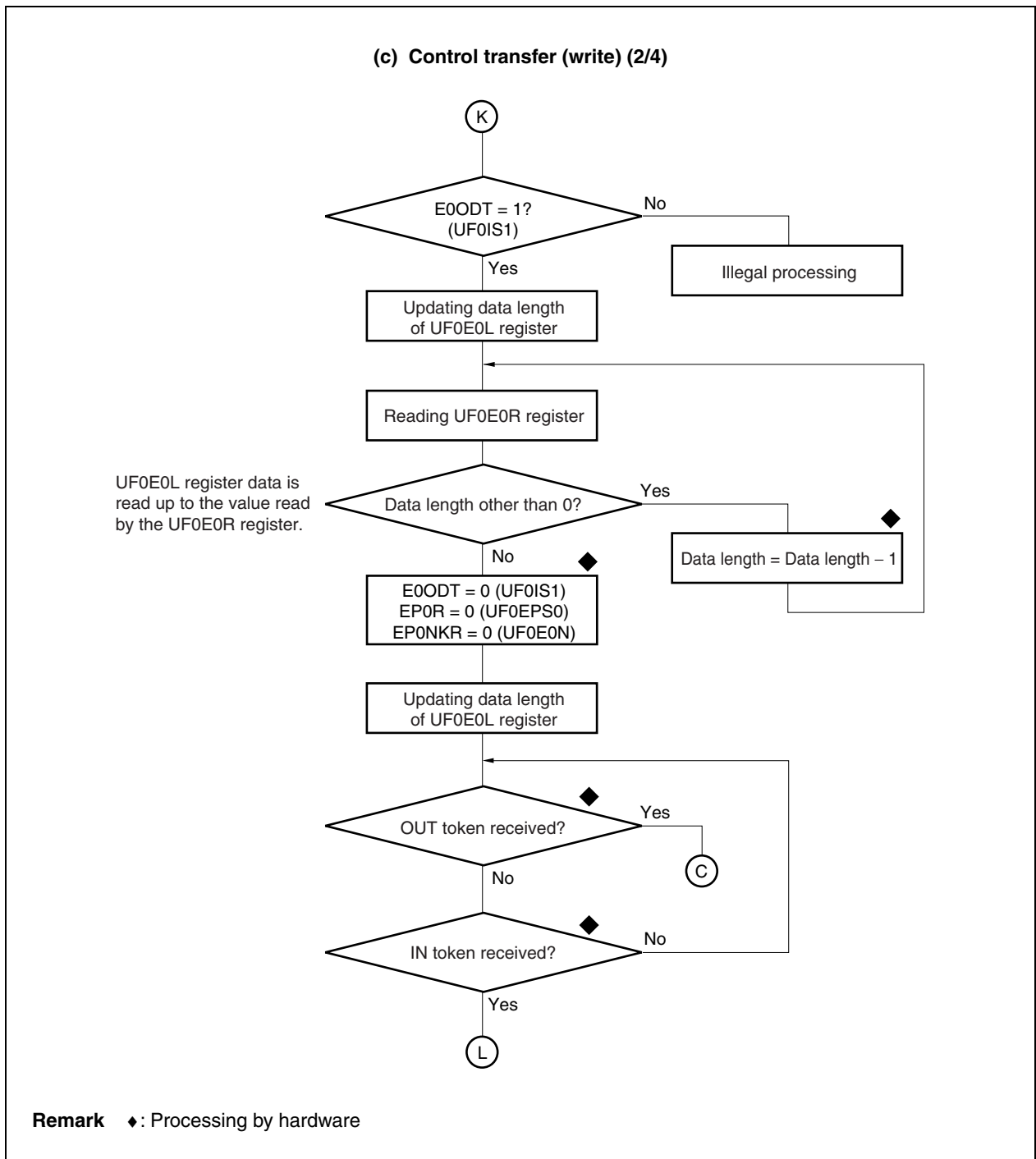
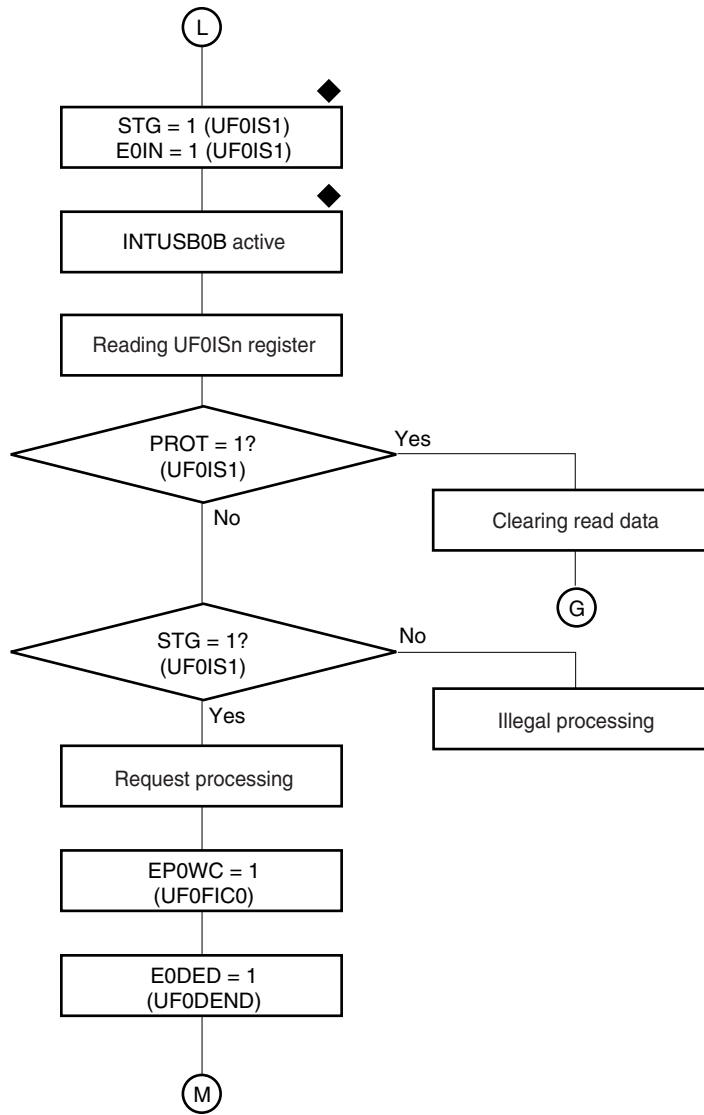


Figure 11-22. CPUDEC Request for Control Transfer (9/12)

## (c) Control transfer (write) (3/4)

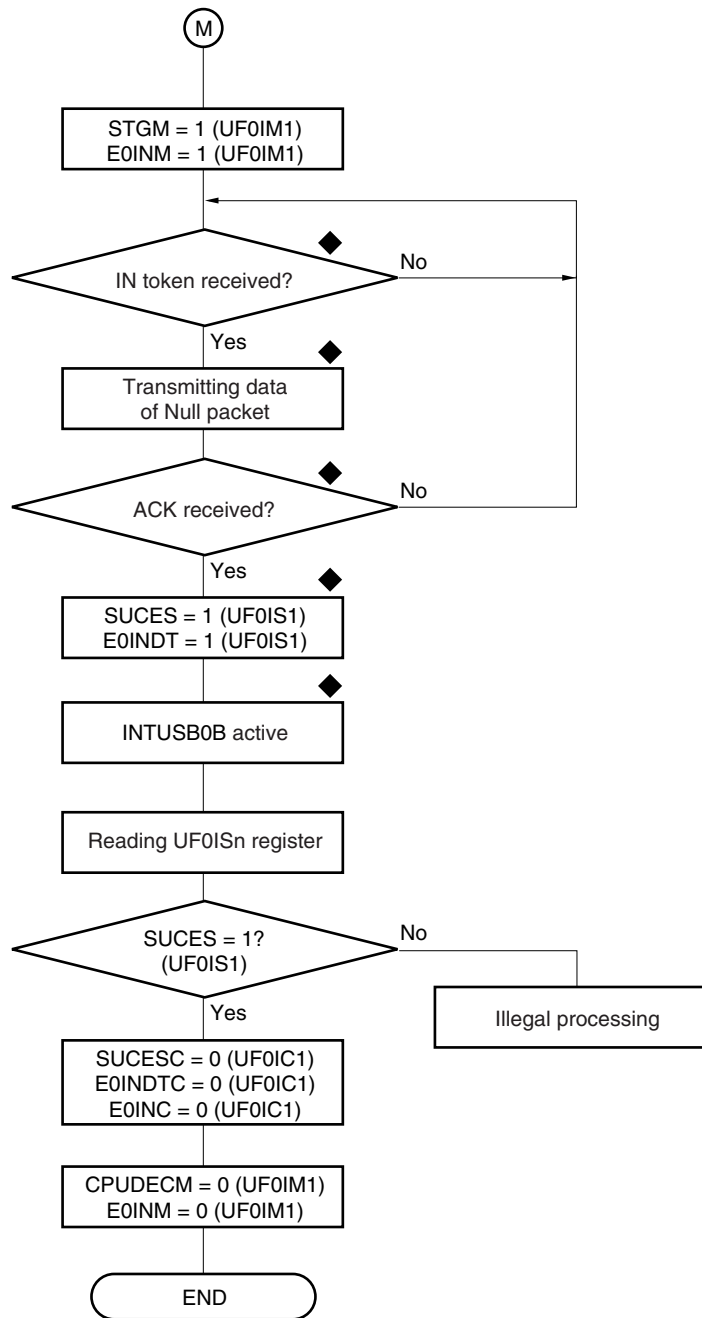


**Remarks** 1.  $n = 0, 1$

2. ♦: Processing by hardware

Figure 11-22. CPUDEC Request for Control Transfer (10/12)

## (c) Control transfer (write) (4/4)

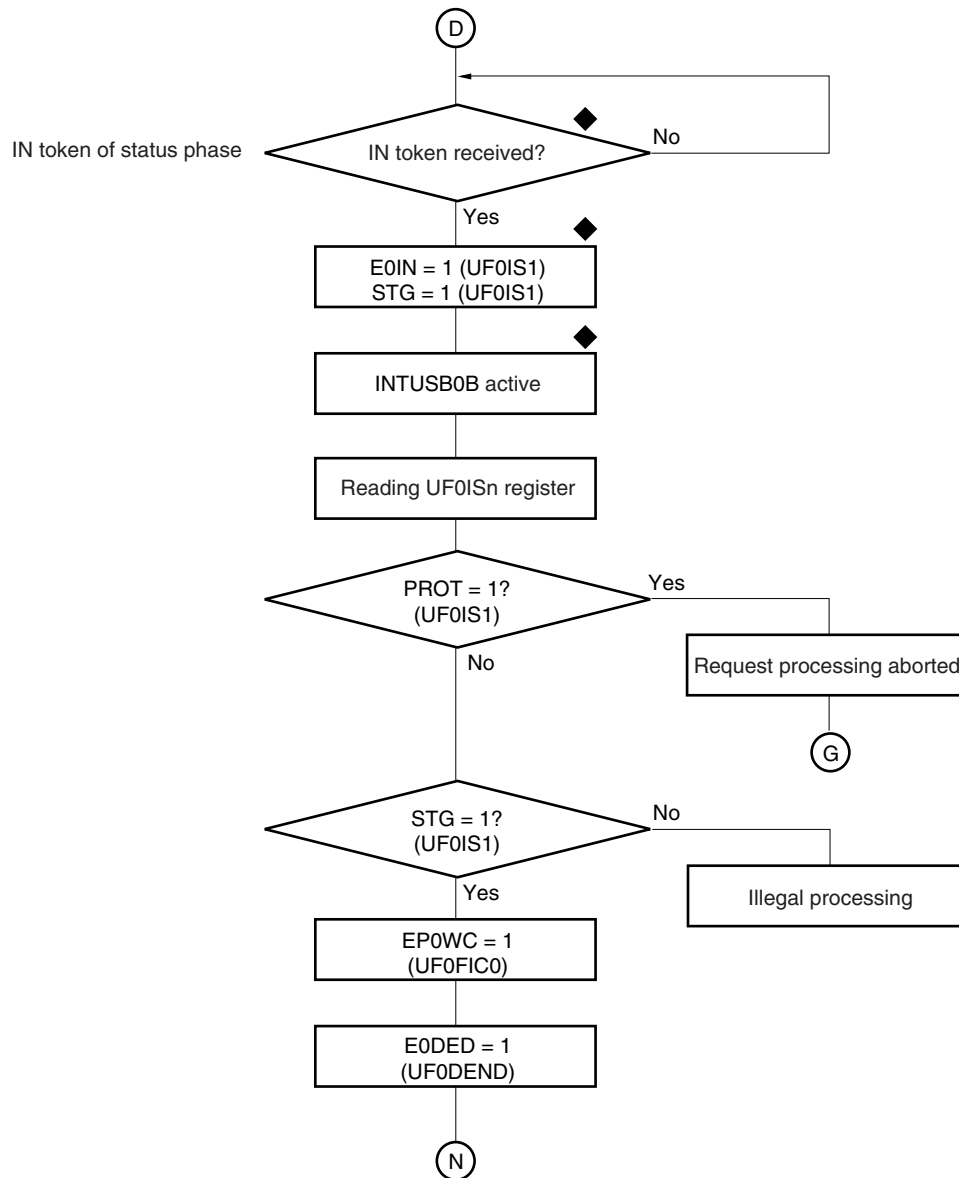


Remarks 1.  $n = 0, 1$

2. ♦: Processing by hardware

Figure 11-22. CPUDEC Request for Control Transfer (11/12)

## (d) Control transfer (without data stage) (1/2)

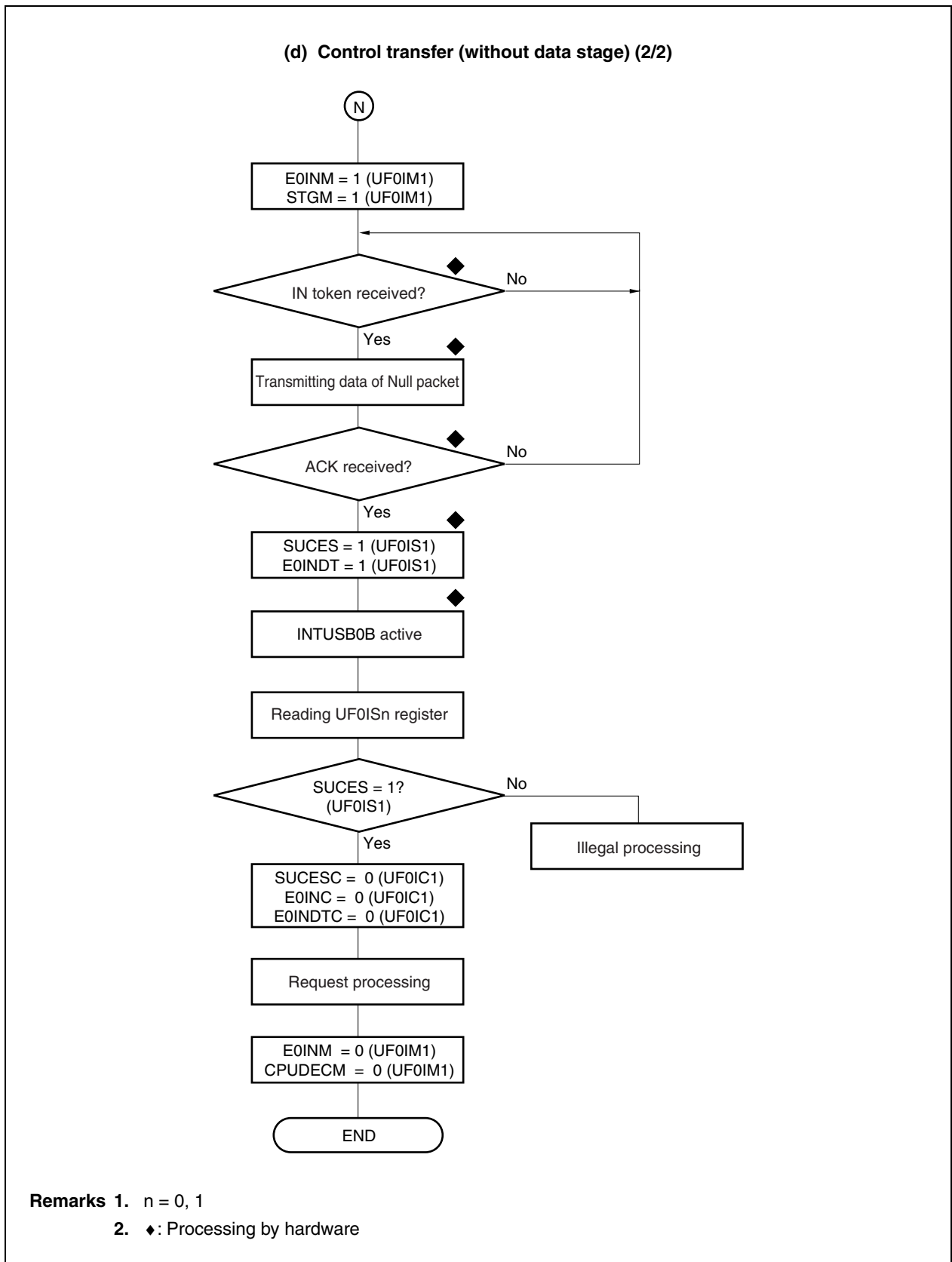


**Remarks 1.** n = 0, 1

**2.** ♦: Processing by hardware



Figure 11-22. CPUDEC Request for Control Transfer (12/12)

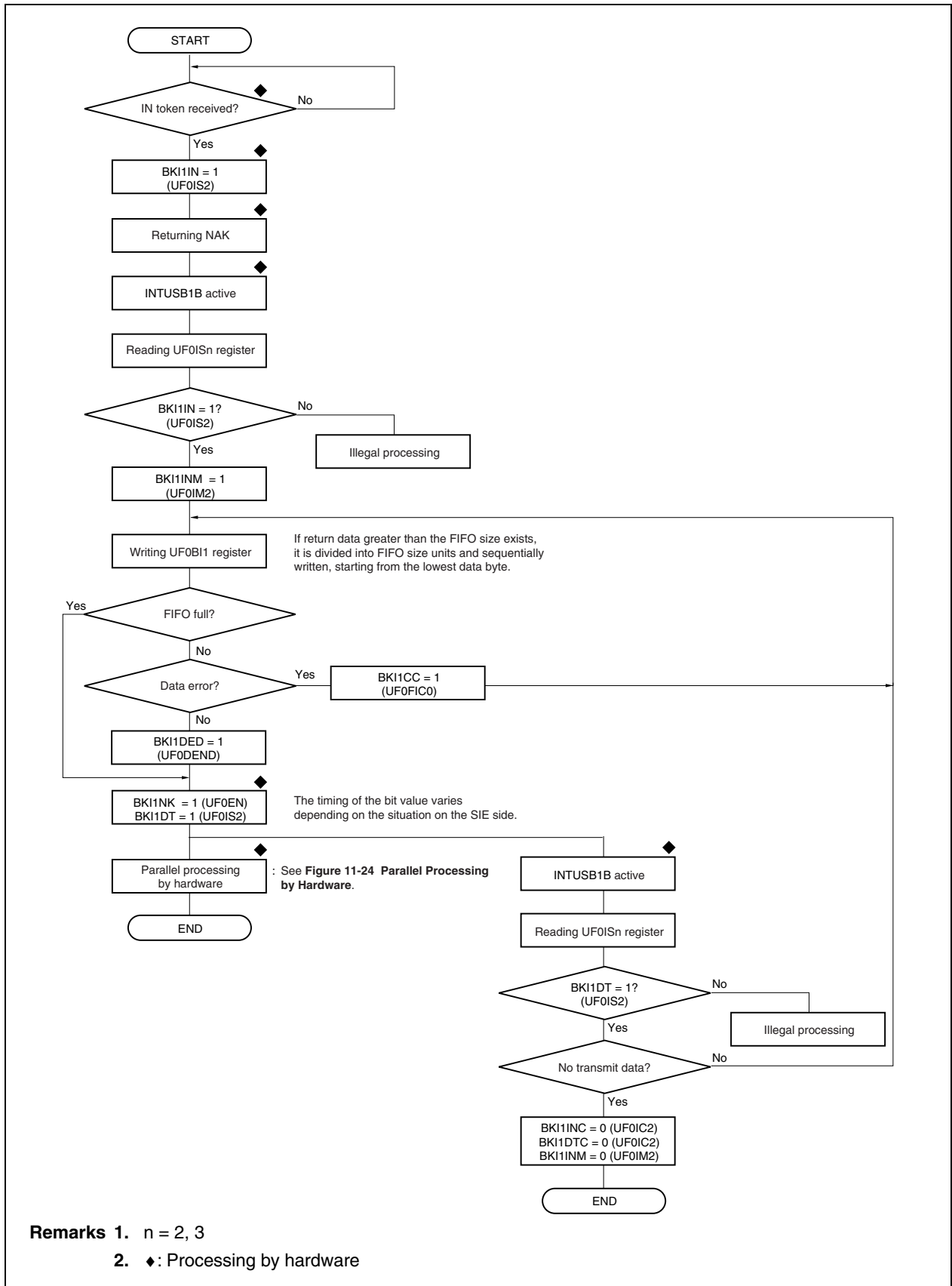


&lt;R&gt;

**(4) Processing for bulk transfer (IN)**

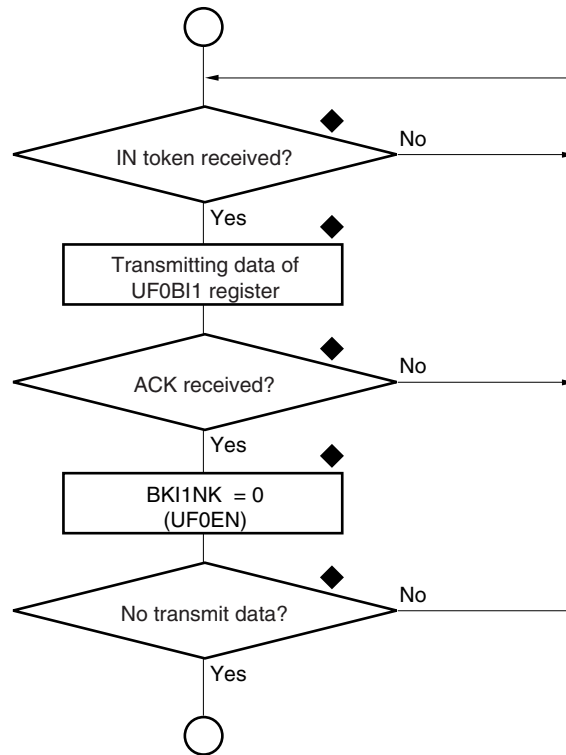
Bulk transfer (IN) is allocated to Endpoint1 and Endpoint3. The flowchart shown below illustrates how Endpoint1 is controlled. Endpoint3 can also be controlled in the same sequence. To use this flowchart as the control flow of Endpoint3, therefore, read the bit names of Endpoint1 in the flowchart as those of Endpoint3.

Figure 11-23. Processing for Bulk Transfer (IN) (Endpoint1)



&lt;R&gt;

Figure 11-24. Parallel Processing by Hardware

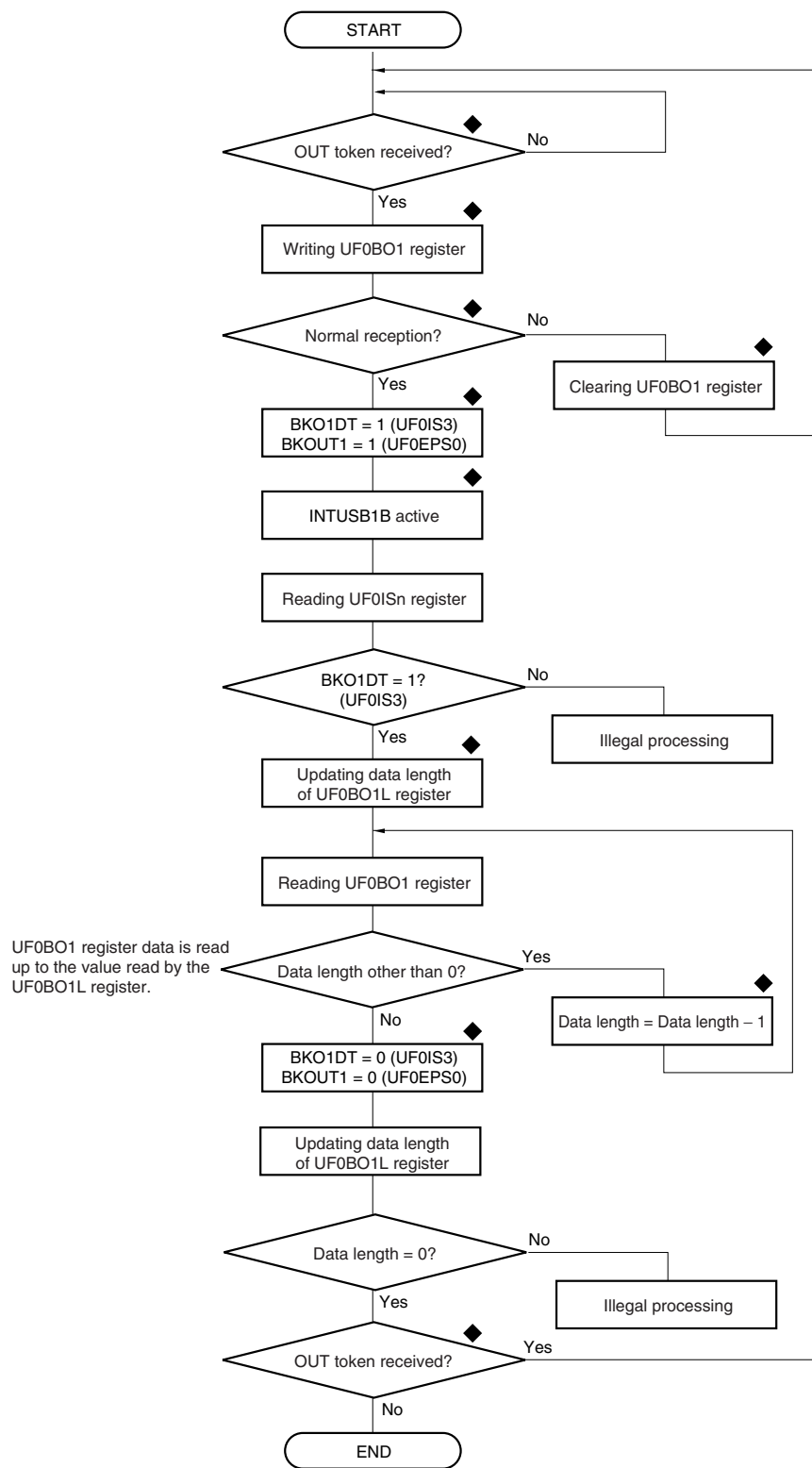


**Remark** ♦: Processing by hardware

**(5) Processing for bulk transfer (OUT)**

Bulk transfer (OUT) is allocated to Endpoint2 and Endpoint4. The flowchart shown below illustrates how Endpoint2 is controlled. Endpoint4 can also be controlled in the same sequence. To use this flowchart as the control flow of Endpoint4, therefore, read the bit names of Endpoint2 in the flowchart as those of Endpoint4.

Figure 11-25. Normal Processing for Bulk Transfer (OUT) (Endpoint2)

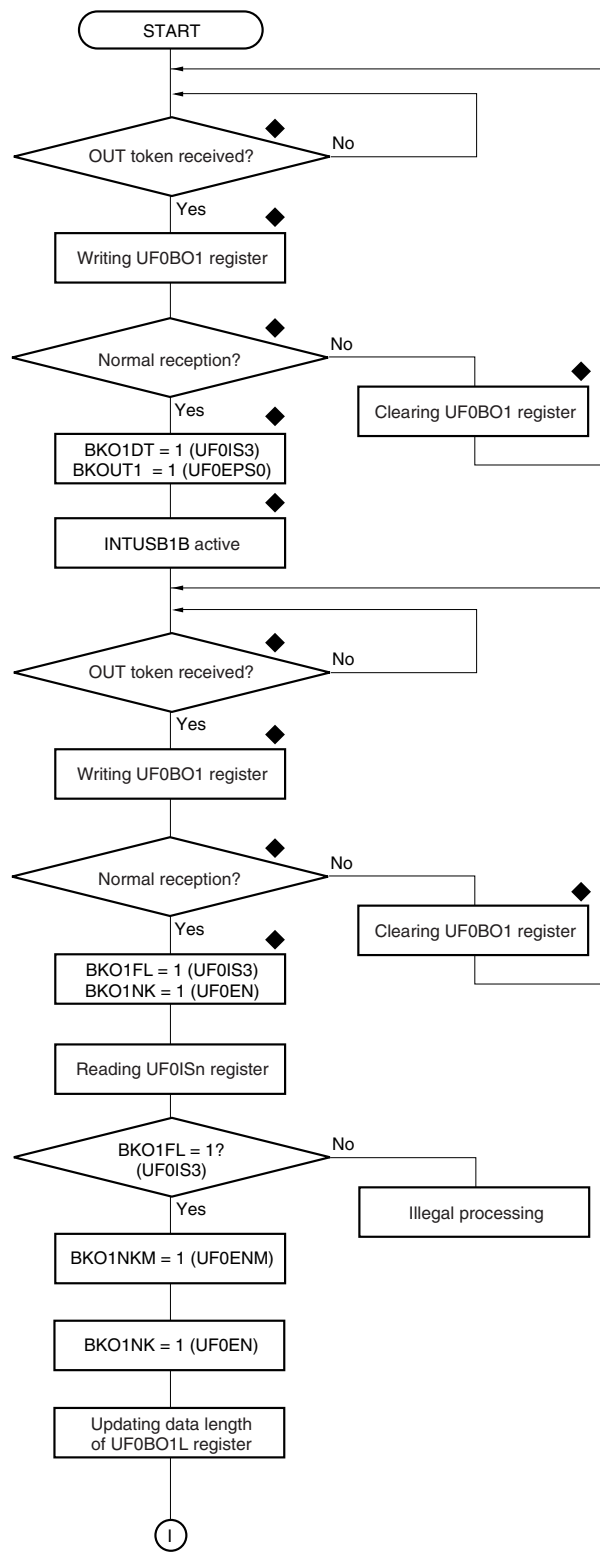


**Remarks 1.** n = 2, 3

**2.** ♦: Processing by hardware

During bulk transfer (OUT), more data may be transmitted from the host than expected by the system. Endpoint2 and Endpoint4 for bulk transfer (OUT) of the V850E/ME2 consist of two 64-byte buffers so that NAK responses are suppressed as much as possible and data can be read from the CPU side even while the bus side is being accessed as the transfer rate of the USB bus increases. Consequently, if the host sends more data than expected by the system, up to 128 bytes of extra data may be automatically received in the worst case. In this case, change the control flow from that of the normal processing of Endpoint2 and Endpoint4 to the flow illustrated below when the quantity of data expected by the system has decreased to two packets. This flowchart illustrates how Endpoint2 is controlled. Endpoint4 can also be controlled in the same sequence. To use this flowchart as the control flow of Endpoint4, therefore, read the bit names of Endpoint2 in the flowchart as those of Endpoint4.

Figure 11-26. Processing If More Data Than Expected by System Is Transmitted (Endpoint2) (1/2)

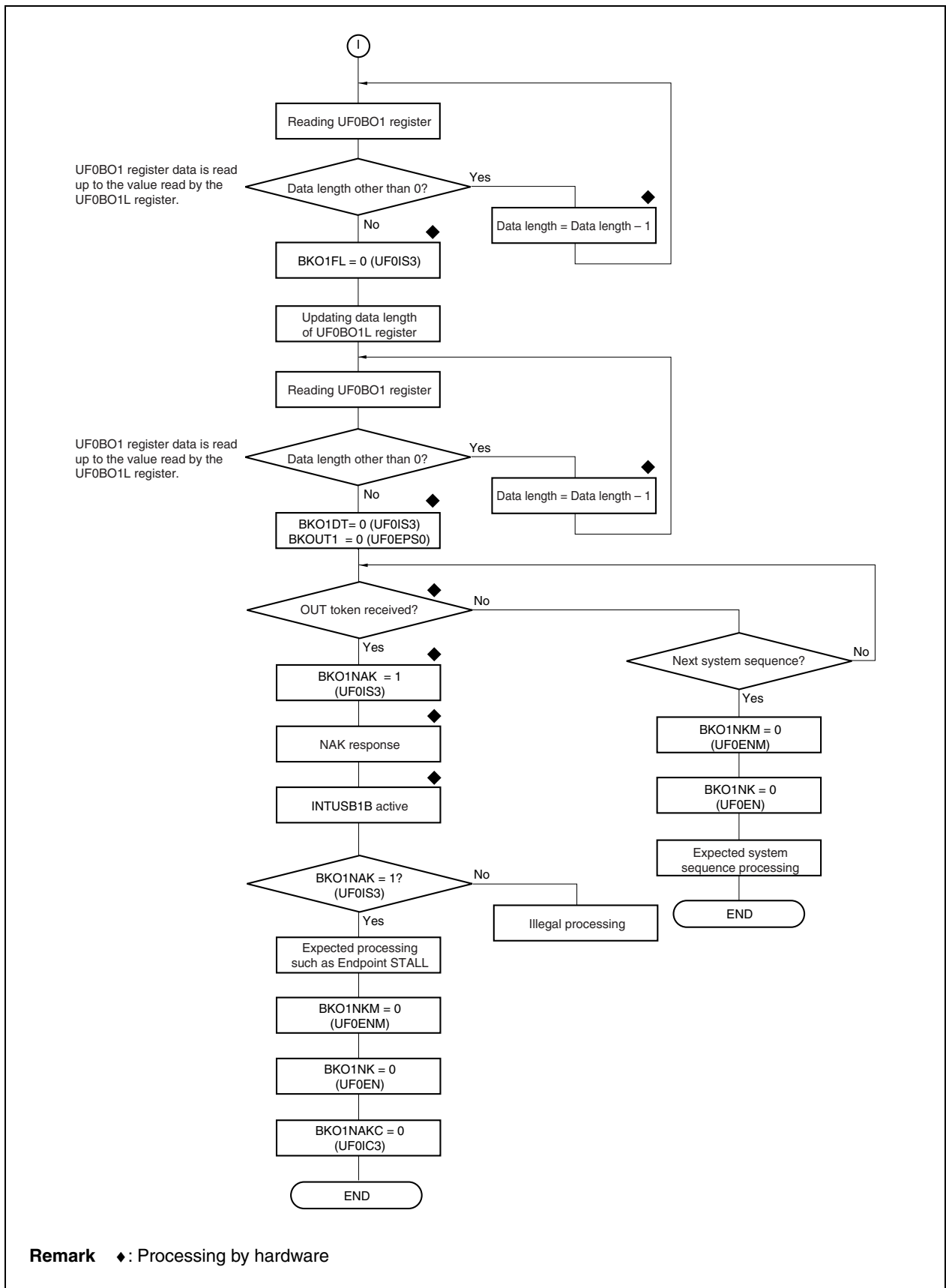


**Remarks 1.** n = 2, 3

**2.** ♦: Processing by hardware



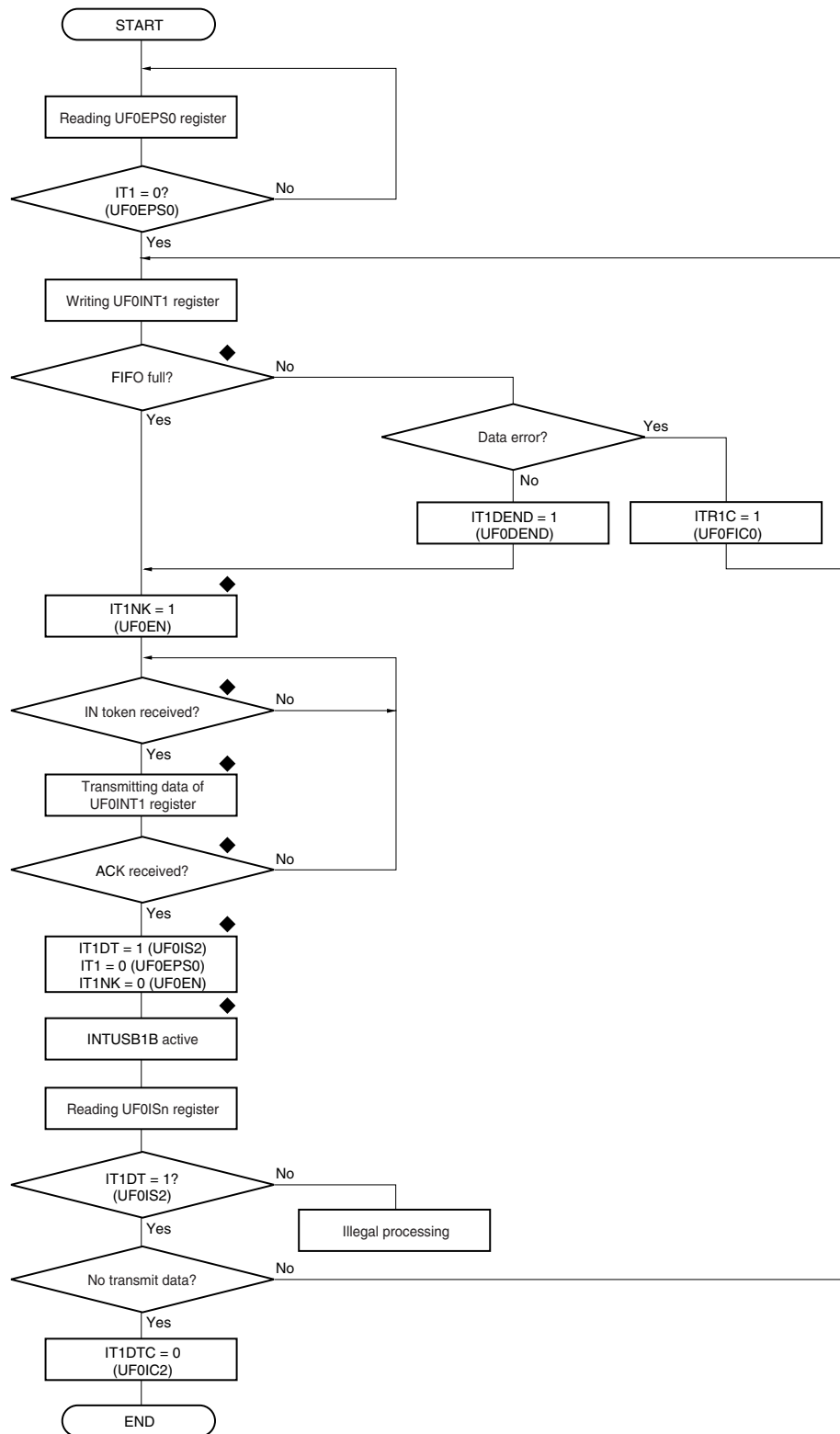
Figure 11-26. Processing If More Data Than Expected by System Is Transmitted (Endpoint2) (2/2)



**(6) Processing for interrupt transfer (IN)**

Interrupt transfer (IN) is allocated to Endpoint7 and Endpoint8. The flowchart shown below illustrates how Endpoint7 is controlled. Endpoint8 can also be controlled in the same sequence. To use this flowchart as the control flow of Endpoint8, therefore, read the bit names of Endpoint7 in the flowchart as those of Endpoint8.

Figure 11-27. Processing for Interrupt Transfer (IN) (Endpoint7)



**Remarks 1.** n = 2, 3

**2.** ♦: Processing by hardware

### 11.7.4 Suspend/Resume processing

How Suspend/Resume processing is performed differs depending on the configuration of the system. One example is given below.

**Figure 11-28. Example of Suspend/Resume Processing (1/3)**

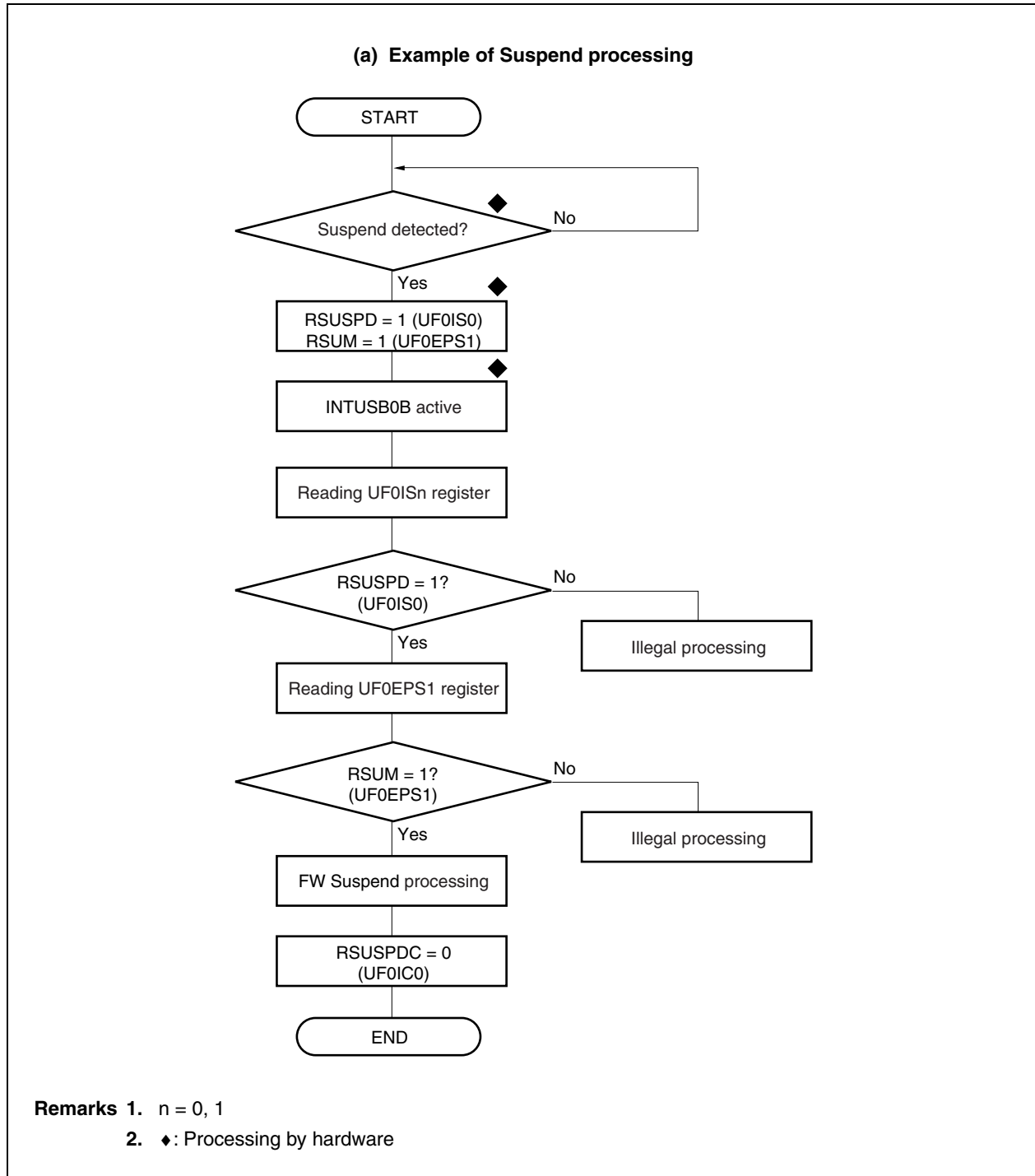


Figure 11-28. Example of Suspend/Resume Processing (2/3)

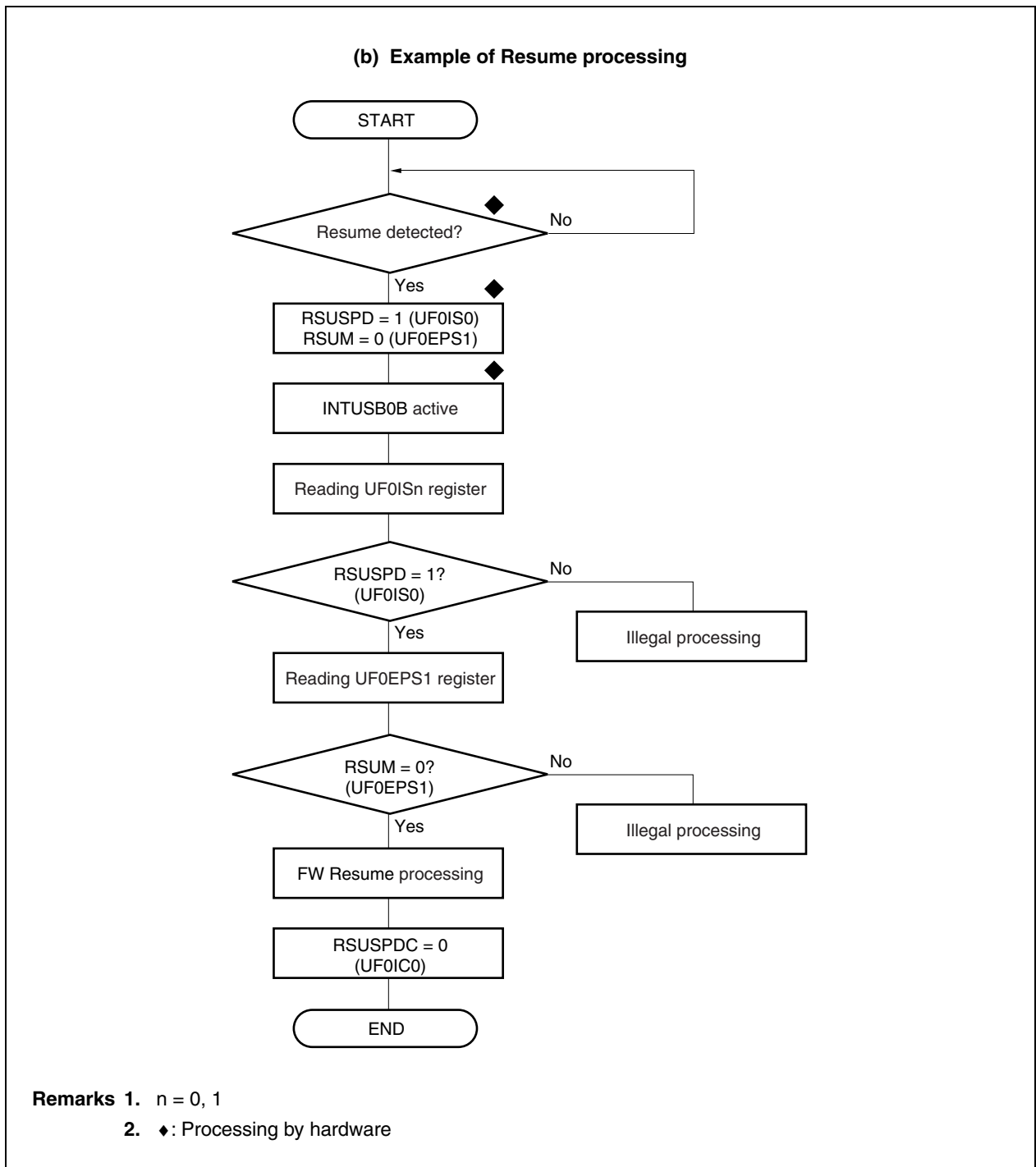
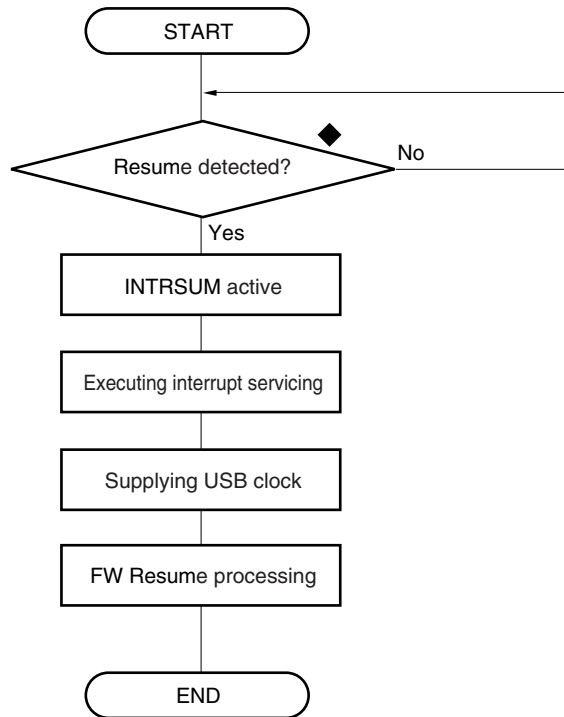


Figure 11-28. Example of Suspend/Resume Processing (3/3)

## (c) Example of Resume processing (when supply of USB clock to USBF is stopped)



**Remark** ♦: Processing by hardware

### 11.7.5 Processing after power application

The processing to be performed after power application differs depending on the configuration of the system. One example is given below.

**Figure 11-29. Example of Processing After Power Application/Power Failure (1/3)**

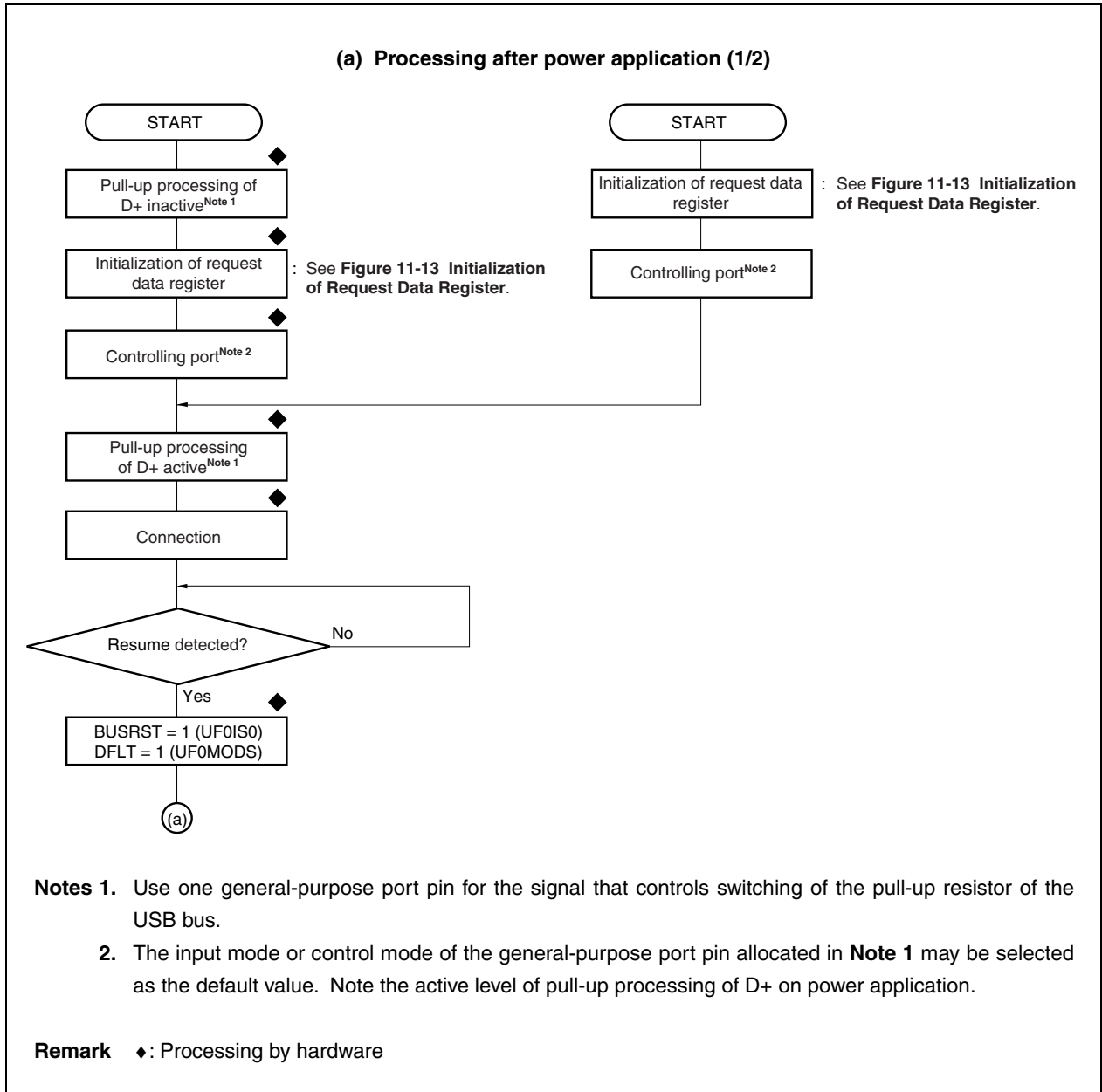
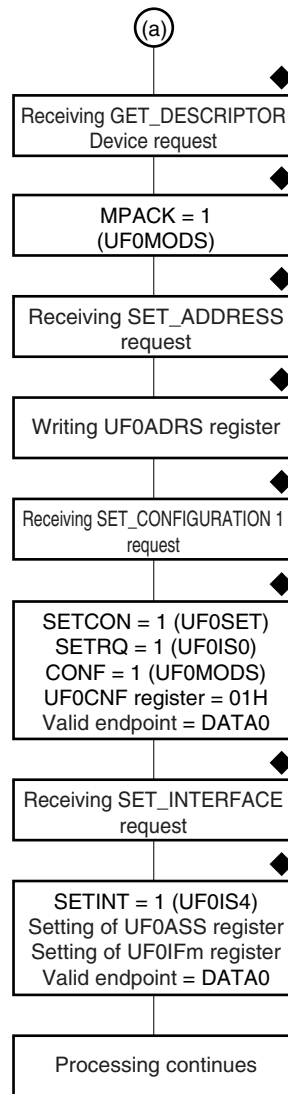


Figure 11-29. Example of Processing After Power Application/Power Failure (2/3)

## (a) Processing after power application (2/2)

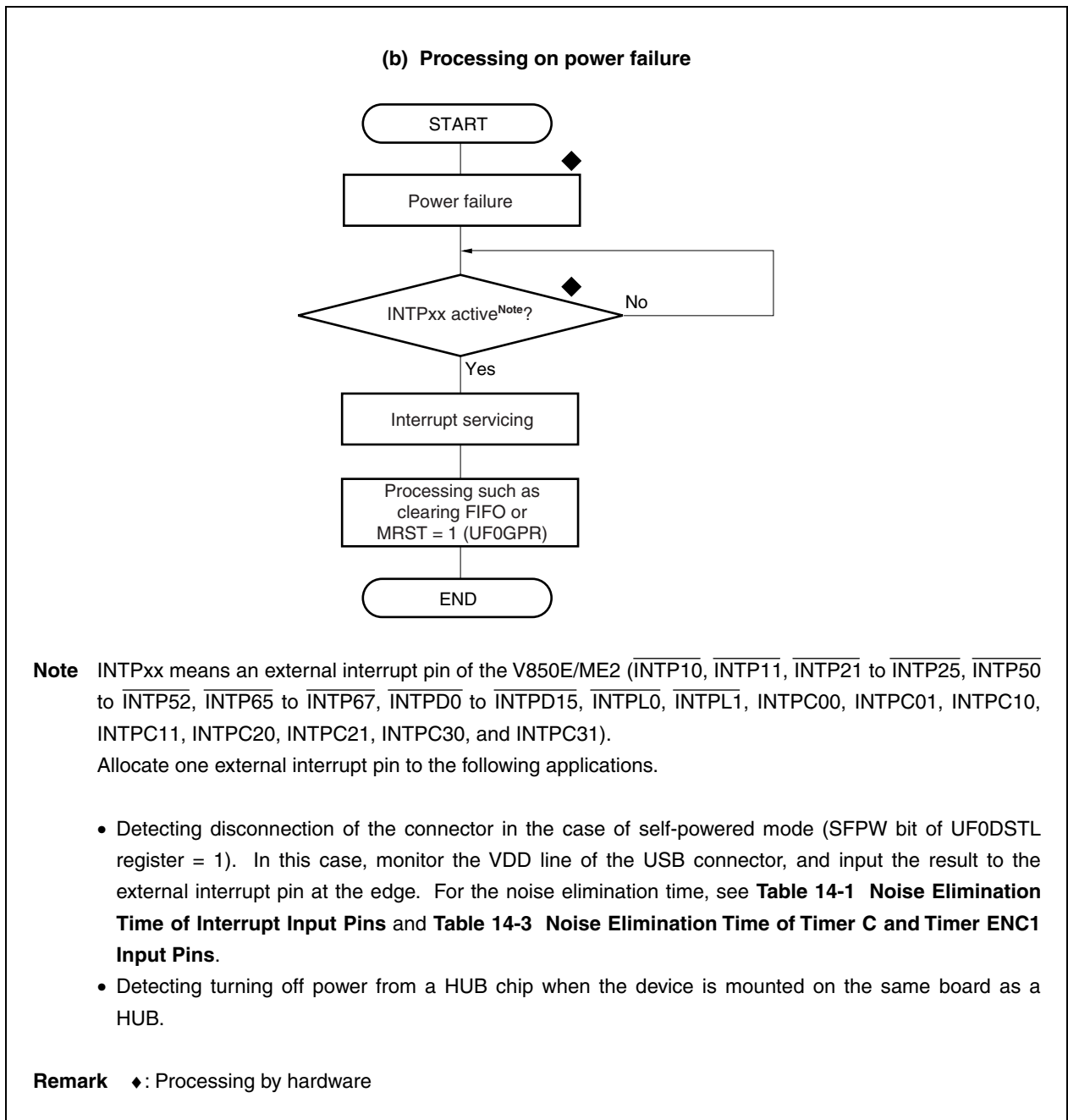


**Remarks 1.** m = 0 to 4

**2.** ♦: Processing by hardware



Figure 11-29. Example of Processing After Power Application/Power Failure (3/3)



### 11.7.6 Receiving data for bulk transfer (OUT) in DMA mode

Bulk transfer (OUT) is allocated to Endpoint2 and Endpoint4. The flowchart shown below illustrates how Endpoint2 is controlled when DMA is used. Endpoint4 can also be controlled in the same sequence. To use this flowchart as the control flow of Endpoint4, therefore, read the bit names of Endpoint2 in the flowchart as those of Endpoint4. The control flowchart shown below illustrates how remaining data is read by the CPU.

If data for bulk transfer (OUT) has been correctly received by setting the DQBO1MS bit of the UF0IDR register to 1, the DMA request signal for Endpoint2, instead of an interrupt request (INTUSB1B), becomes active. This DMA request signal for Endpoint2 operates according to the setting of the MODEn bit of the UF0IDR register ( $n = 0, 1$ ). If all the data stored in the UF0BO1 register has been read by DMA, the DMA request signal for Endpoint2 becomes inactive. In this status, if data for the next bulk transfer (OUT) has been correctly received, the DMA request signal for Endpoint2 becomes active again. If the data for bulk transfer (OUT) that has been received is equal to or less than the FIFO size, a Short interrupt request is issued and the USBSP2B signal becomes active, as soon as reading the data by DMA is completed. As a result, the DQBO1MS bit of the UF0IDR register is cleared to 0, and the DMA request signal for Endpoint2 becomes inactive. To read data by DMA again, set the DQBO1MS bit to 1 again. If DMA is completed by the DMA end signal for Endpoint2, the DQBO1MS bit of the UF0IDR register is cleared to 0, and the DMA request signal for Endpoint2 becomes inactive. At the same time, the DMA\_END interrupt request is issued. If data remains in the UF0BO1 register at this time, DMA can be started again by setting the DQBO1MS bit of the UF0IDR register again. However, the data for bulk transfer (OUT) is always equal to or less than the FIFO size. Consequently, a Short interrupt request is issued, the USBSP2B signal becomes active, the DQBO1MS bit is cleared, and the DMA request signal for Endpoint2 becomes inactive, as soon as the data is read by DMA.

- Cautions**
1. The DMA request signal for Endpoint  $n$  ( $n = 2, 4$ ) becomes active in the demand mode (MODE1 and MODE0 bits of the UF0IDR register = 10), as long as there is data to be transferred.
  2. The DMA request signal for Endpoint  $n$  ( $n = 2, 4$ ) becomes active in the single mode (MODE1 and MODE0 bits of the UF0IDR register = 0X (X: don't care)) if there is data to be transferred, but this signal becomes inactive each time one byte has been transferred. This operation is repeated until there is no more data to be transferred.

Figure 11-30. DMA Processing by Bulk Transfer (OUT) (1/3)

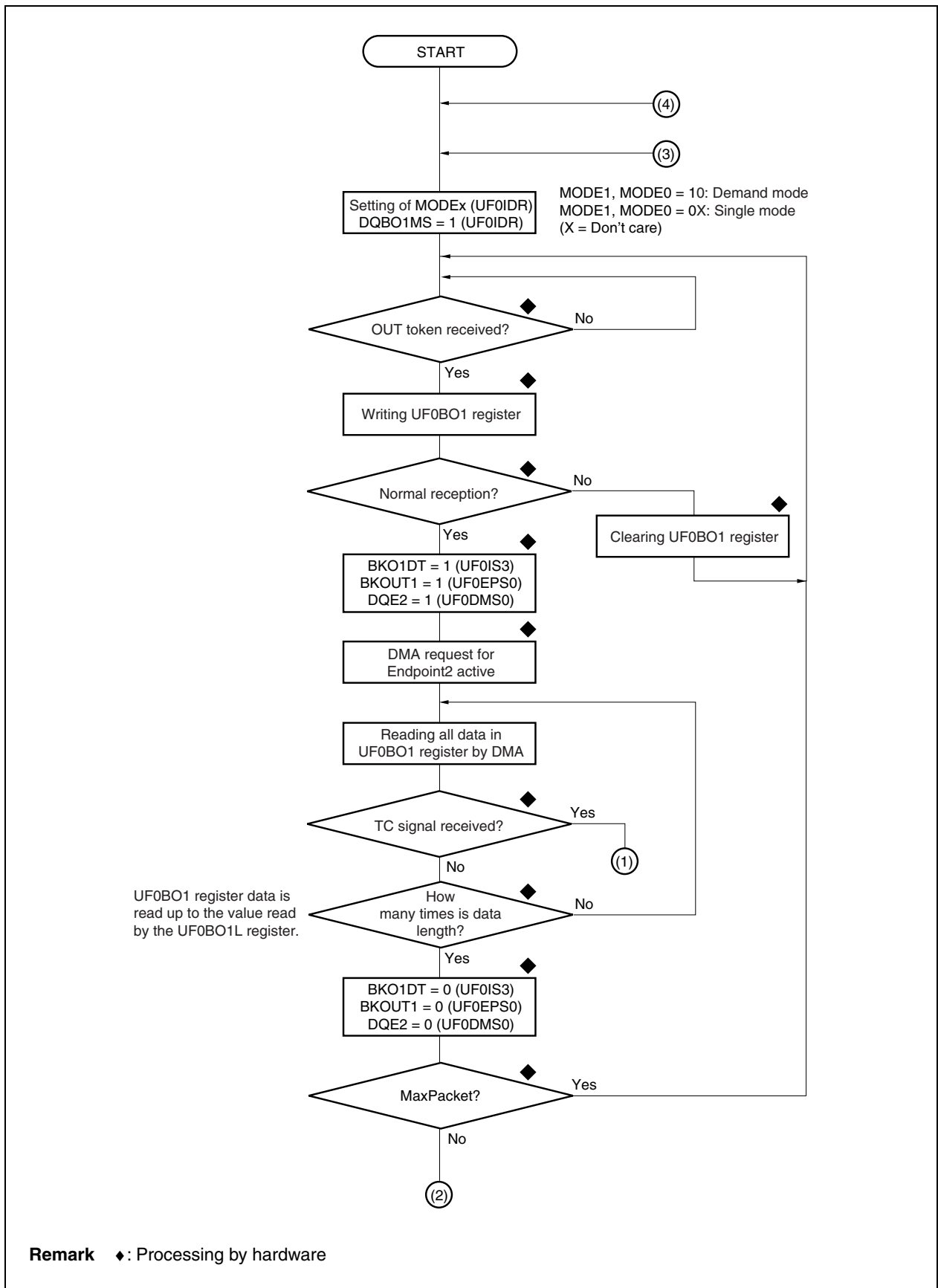
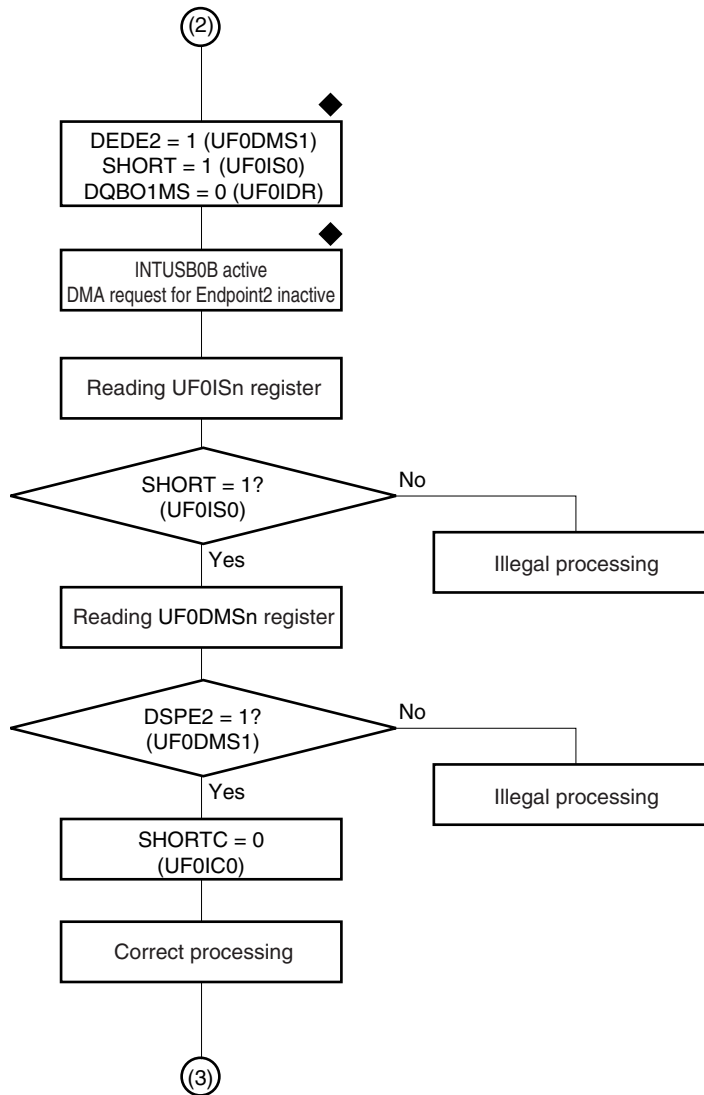


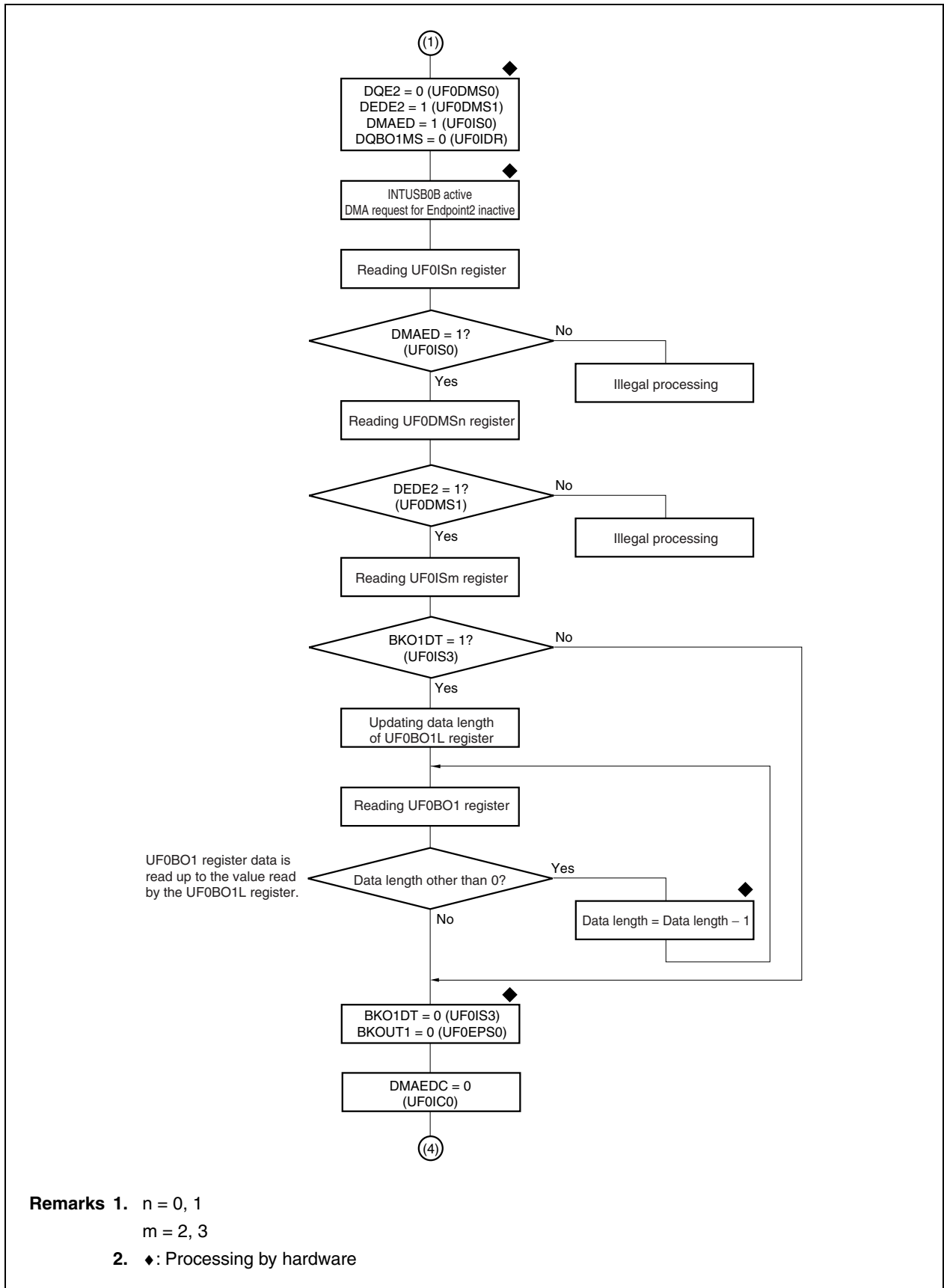
Figure 11-30. DMA Processing by Bulk Transfer (OUT) (2/3)



**Remarks 1.** n = 0, 1

**2.** ◆: Processing by hardware

Figure 11-30. DMA Processing by Bulk Transfer (OUT) (3/3)



### 11.7.7 Transmitting data for bulk transfer (IN) in DMA mode

Bulk transfer (IN) is allocated to Endpoint1 and Endpoint3. The flowchart shown below illustrates how Endpoint1 is controlled when DMA is used. Endpoint3 can also be controlled in the same sequence. To use this flowchart as the control flow of Endpoint3, therefore, read the bit names of Endpoint1 in the flowchart as those of Endpoint3.

If data for bulk transfer (IN) can be written by setting the DQBI1MS bit of the UF0IDR register to 1, the DMA request signal for Endpoint1, instead of an interrupt request (INTUSB1B), becomes active. This DMA request signal for Endpoint1 operates according to the setting of the MODEn bit of the UF0IDR register ( $n = 0, 1$ ). If all the data that can be written to the UF0BI1 register has been written by DMA, the DMA request signal for Endpoint1 becomes inactive. In this status, the toggle operation of the FIFO takes place and, if data for bulk transfer (IN) can be written, the DMA request signal for Endpoint1 becomes active again. The automatic toggle operation of the FIFO is not executed even if the FIFO has become full as a result of DMA transfer, unless the BK11T bit of the UF0DEND register is set to 1. Therefore, be sure to set the BK11DED bit of the UF0DEND register to 1 to transfer data. If DMA is completed by the DMA end signal for Endpoint1, the DQBI1MS bit of the UF0IDR register is cleared to 0, and the DMA request signal for Endpoint1 becomes inactive. At the same time, the DMA\_END interrupt request is issued. To transmit a short packet at this time when the FIFO is not full, set the BK11DED bit of the UF0DEND register to 1.

- Cautions**
1. The DMA request signal for Endpoint  $n$  ( $n = 1, 3$ ) becomes active in the demand mode (MODE1 and MODE0 bits of the UF0IDR register = 10), as long as data can be transferred.
  2. The DMA request signal for Endpoint  $n$  ( $n = 1, 3$ ) becomes active in the single mode (MODE1 and MODE0 bits of the UF0IDR register = 0X (X: don't care)) if data can be transferred, but this signal becomes inactive each time one byte has been transferred. This operation is repeated until there is no more data to be transferred.

Figure 11-31. DMA Processing by Bulk Transfer (IN) (1/4)

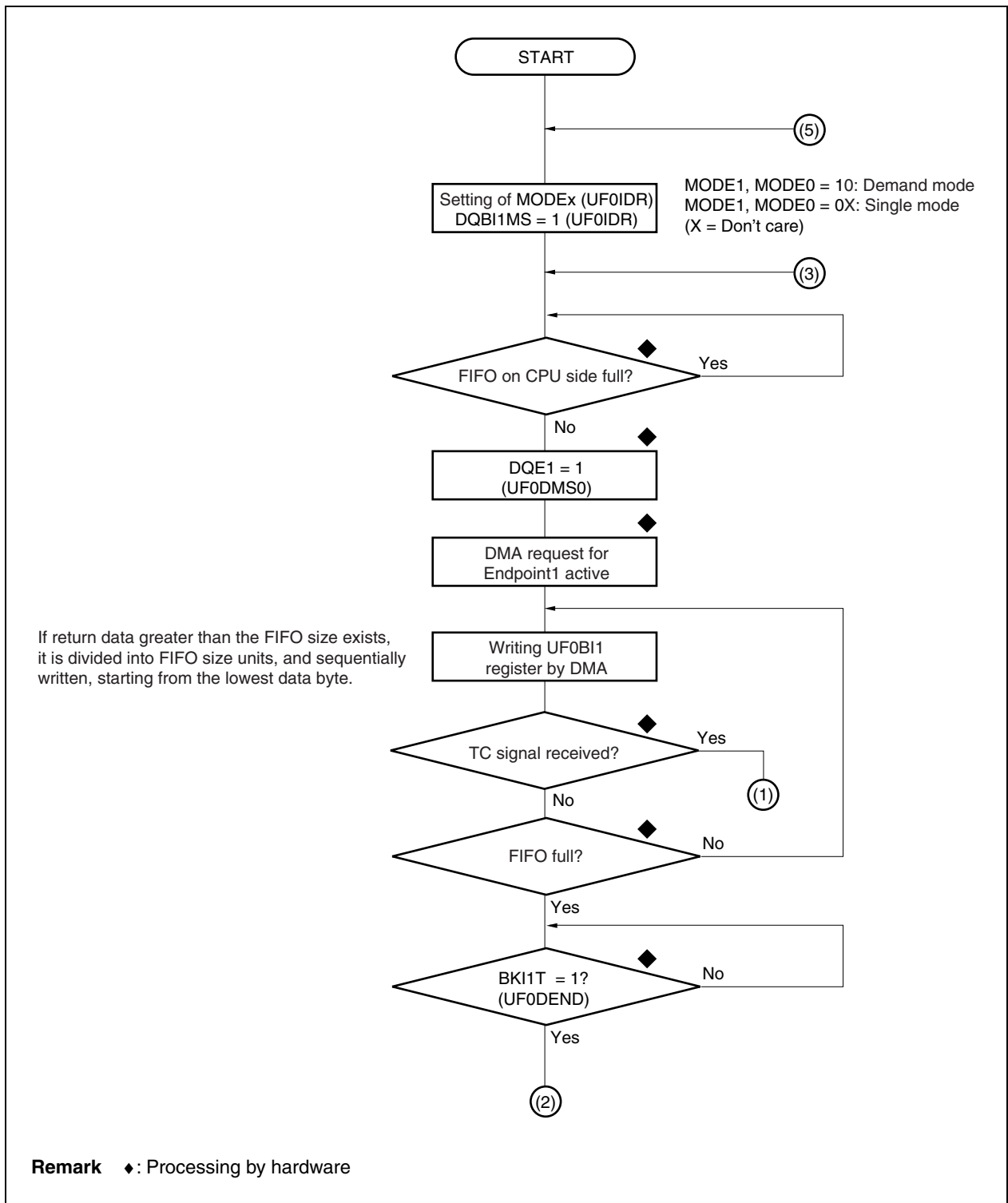
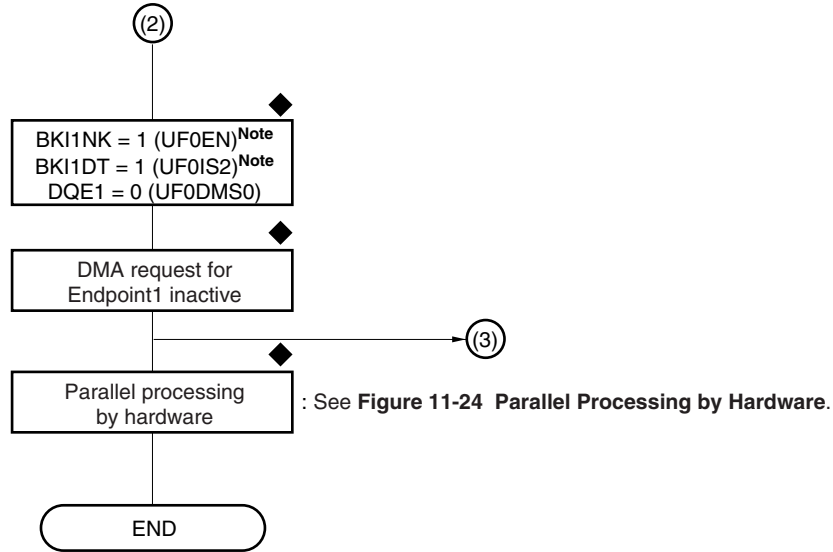


Figure 11-31. DMA Processing by Bulk Transfer (IN) (2/4)



**Note** The timing of the bit value changes depending on the status on the SIE side.

**Remark** ♦: Processing by hardware



Figure 11-31. DMA Processing by Bulk Transfer (IN) (3/4)

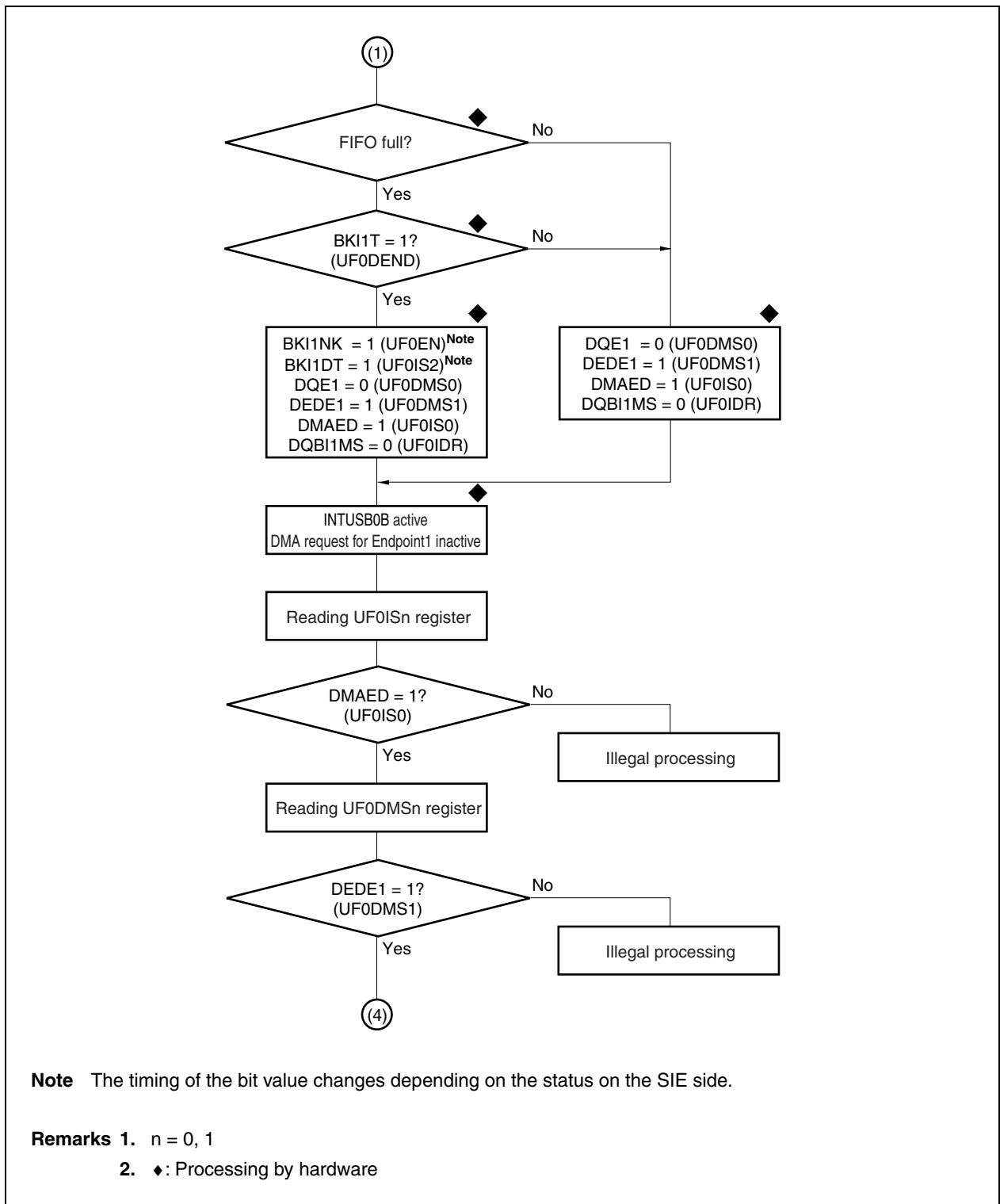
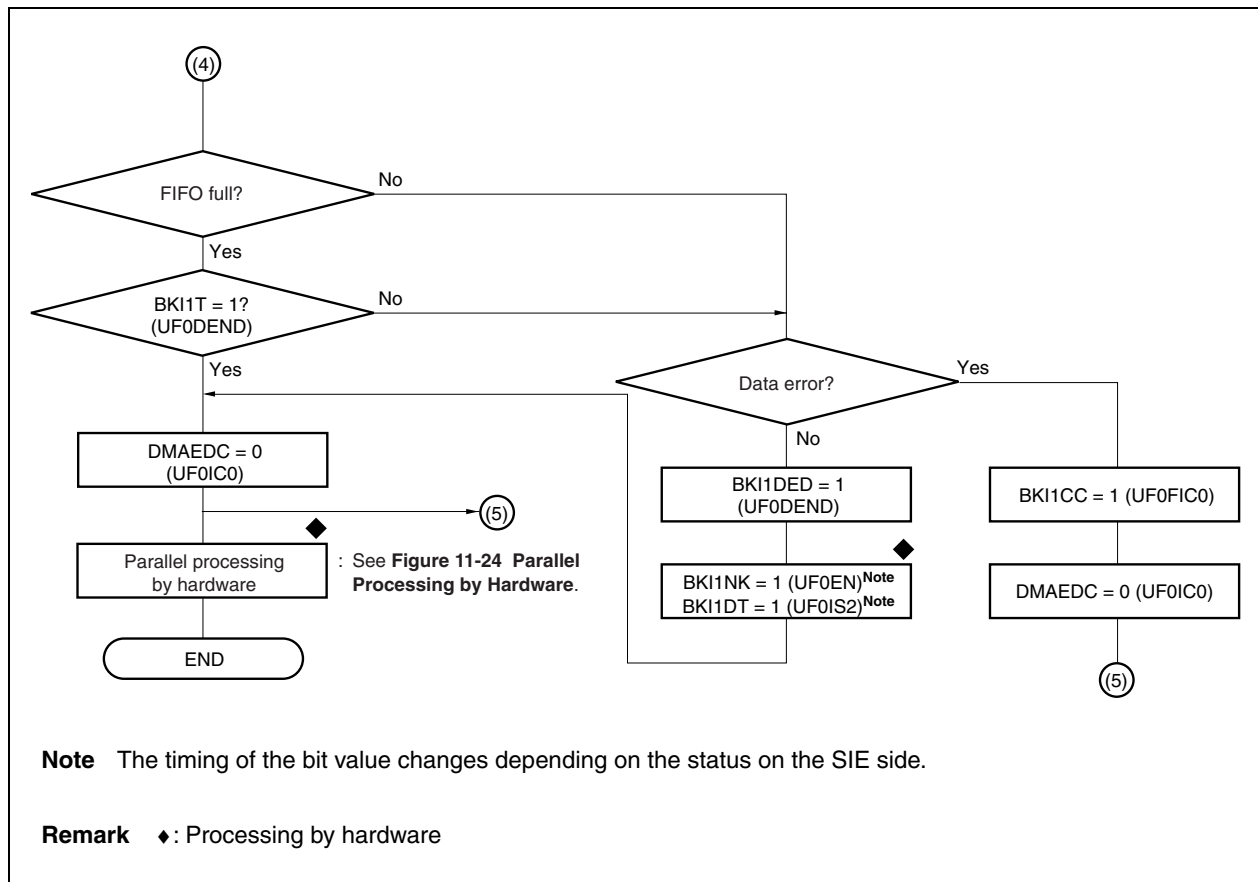
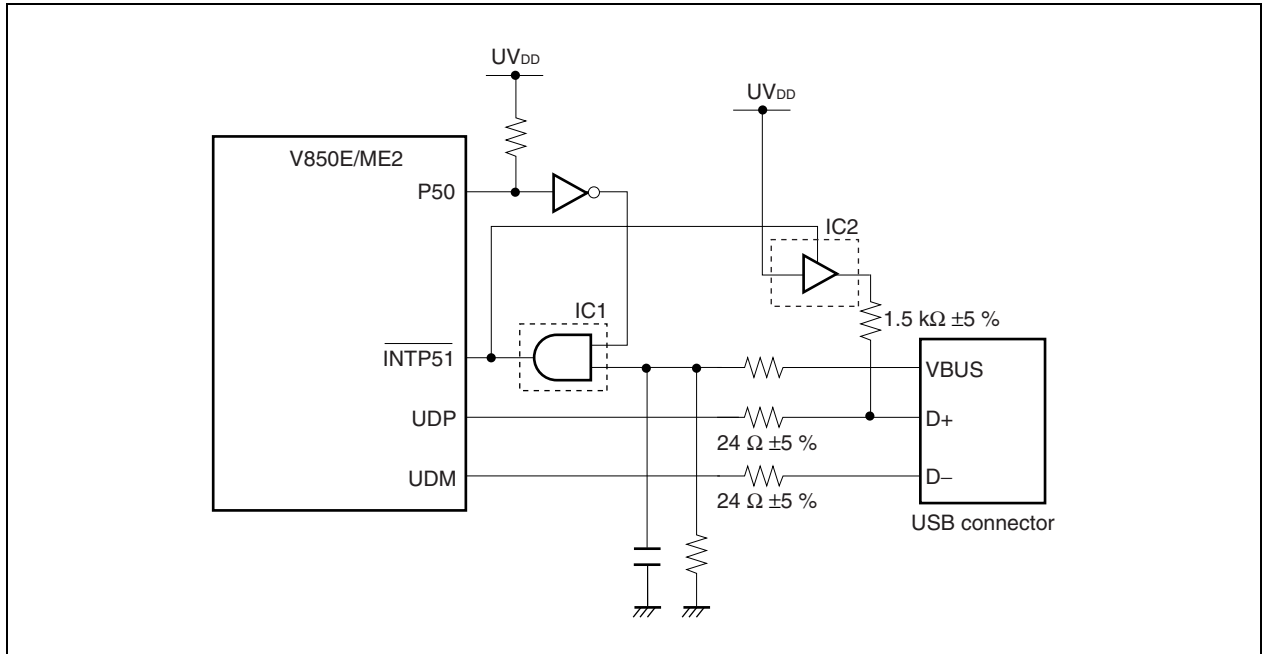


Figure 11-31. DMA Processing by Bulk Transfer (IN) (4/4)



## 11.7.8 USB connection example

Figure 11-32. USB Connection Example

**(1) Pull-up control of D+**

To prohibit connection report (D+ pull-up) to the USB host/HUB (such as while higher priority processing or initialization processing is under execution), the system must control pulling up of D+ via a general-purpose port. As shown in the circuit example in Figure 11-32, control the pull-up control signal of D+ and VBUS input signal by using a general-purpose port and USB cable VBUS (AND circuit). In Figure 11-32, pulling up D+ is prohibited when the general-purpose port is high level (secure the high level of the general-purpose port pin by pulling it up because the port pin is in the input mode by default). Use an IC to which power can be applied when the system power supply is off as IC2 shown in Figure 11-32.

**(2) Detecting USB cable connection/disconnection**

The USB function controller (USBF) requires a VBUS input signal that recognizes connection and disconnection, because the state of USBF is managed by hardware. Voltage (5 V) is applied from the USB host/HUB as the VBUS input signal if the USB cable VBUS is connected to the USB host/HUB when power to the USBF is turned off. Therefore, use an IC to which power can be applied when the system power supply is off as IC1 shown in Figure 11-32. When disconnecting the USB cable in the circuit example in Figure 11-32, a signal input to INT $\overline{\text{P51}}$  may be unstable while the VBUS voltage is dropping. Therefore, it is recommended to use a Schmitt buffer for IC1.

## CHAPTER 12 A/D CONVERTER

### 12.1 Features

- Analog input: 8 channels
- 10-bit A/D converter
- On-chip A/D conversion result register (ADCR0 to ADCR7)  
10 bits × 8
- A/D conversion trigger mode
  - A/D trigger mode
  - Timer trigger mode
  - External trigger mode
- Successive approximation method

## 12.2 Configuration

The A/D converter of the V850E/ME2 adopts the successive approximation method, and uses A/D converter mode registers 0, 1, 2 (ADM0, ADM1, ADM2), and the A/D conversion result register (ADCR0 to ADCR7) to perform A/D conversion operations.

### (1) Input circuit

The input circuit selects the analog input (ANI0 to ANI7) according to the mode set by the ADM0, ADM1, and ADM2 registers.

### (2) C-Array

Holds the charge of the differential voltage between the voltage input from the analog input pins (ANI0 to ANI7) and the reference voltage ( $1/2 AV_{DD}$ ), and redistributes the sampled charges.

### (3) C-Dummy

This block holds the reference voltage ( $1/2 AV_{DD}$ ) and assigns the reference of the comparator input.

### (4) Voltage comparator

The voltage comparator compares the C-Array comparison potential with the C-Dummy reference potential.

### (5) A/D conversion result register n (ADCRn), A/D conversion result register nH (ADCRnH)

ADCRn is a 10-bit register that holds A/D conversion results. Each time A/D conversion is completed, the conversion results are loaded from the successive approximation register (SAR).

$\overline{\text{RESET}}$  input makes this register undefined.

### (6) ANI0 to ANI7 pins

These are 8-channel analog input pins for the A/D converter. They input the analog signals to be A/D converted.

**Caution** Make sure that the voltages input to ANI0 to ANI7 do not exceed the rated values. If a voltage higher than  $AV_{DD}$  or lower than  $AV_{SS}$  (even within the range of the absolute maximum ratings) is input to a channel, the conversion value of the channel is undefined, and the conversion values of the other channels may also be affected.

### (7) $AV_{REFM}$ and $AV_{REFP}$ pins

This is the pin for inputting the reference voltage of the A/D converter. It converts signals input to the ANI0 to ANI7 pins to digital signals based on the voltage applied between  $AV_{REFM}$  and  $AV_{REFP}$ .

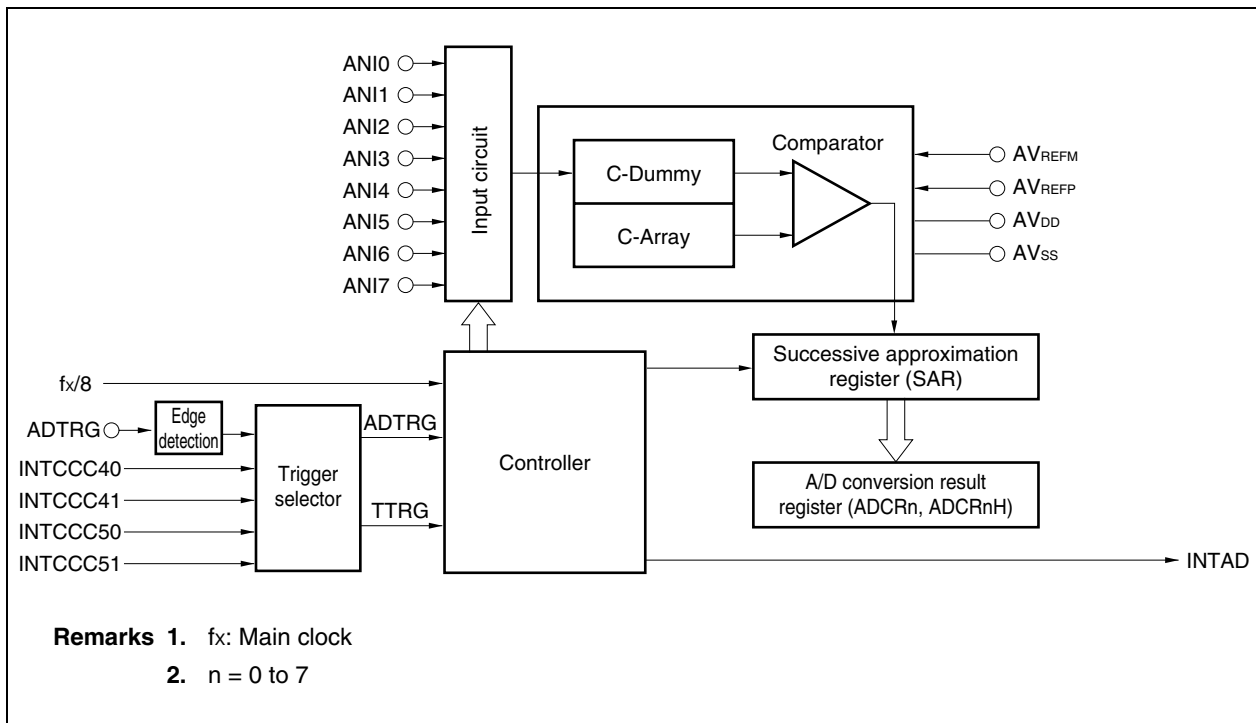
### (8) $AV_{SS}$ pin

This is the ground pin of the A/D converter. Always use this pin at the same potential as that of the  $EV_{SS}$  pin even when the A/D converter is not used.

### (9) $AV_{DD}$ pin

This is the analog power supply pin of the A/D converter. Always use this pin at the same potential as that of the  $EV_{DD}$  pin even when the A/D converter is not used.

Figure 12-1. Block Diagram of A/D Converter



**Cautions**

1. If there is noise at the analog input pins (ANI0 to ANI7) or at the reference voltage input pin (AVREFP, AVREFM), that noise may generate an illegal conversion result. Software processing will be needed to avoid a negative effect on the system from this illegal conversion result. An example of this software processing is shown below.

- Take the average result of a number of A/D conversions and use that as the A/D conversion result.
- Execute a number of A/D conversions consecutively and use those results, omitting any exceptional results that may have been obtained.
- If an A/D conversion result which can be judged that a system abnormality has occurred is obtained, do not attempt to overcome the abnormality right away, but handle the abnormality after checking the abnormality occurrence again.

2. Do not apply a voltage outside the AVREFM to AVREFP range to the pins that are used as A/D converter input pins.

&lt;R&gt;

## 12.3 Control Registers

### (1) A/D converter mode register 0 (ADM0)

The ADM0 register is an 8-bit register that specifies the operation mode, and executes conversion operations. This register can be read or written in 8-bit or 1-bit units. However, bit 6 can only be read. Writing this bit is ignored.

**Cautions 1.** When the ADCE bit is 1 in the timer trigger mode and external trigger mode, the trigger signal standby state is set. To clear the ADCE bit, write 0 or reset.

In the A/D trigger mode, the conversion trigger is set by writing 1 to the ADCE bit. After the operation, when the mode is changed to the timer trigger mode or external trigger mode without clearing the ADCE bit, the trigger input standby state is set immediately after changing the register.

2. Changing the setting of the BS and MS bits is prohibited while A/D conversion is enabled (ADCE bit = 1).
3. When data is written to the ADM0 register during an A/D conversion operation, the conversion operation is initialized and conversion is executed from the beginning.

|      | <7>  | <6>  | 5  | 4  | 3 | 2 | 1 | 0 | Address   | After reset |
|------|------|------|----|----|---|---|---|---|-----------|-------------|
| ADM0 | ADCE | ADCS | BS | MS | 0 | 0 | 0 | 0 | FFFFF200H | 00H         |

| Bit position | Bit name | Function                                                                                    |
|--------------|----------|---------------------------------------------------------------------------------------------|
| 7            | ADCE     | Enables or disables A/D conversion operation.<br>0: Disabled<br>1: Enabled                  |
| 6            | ADCS     | Indicates the status of A/D converter. This bit is read only.<br>0: Stopped<br>1: Operating |
| 5            | BS       | Specifies buffer mode in the select mode.<br>0: 1-buffer mode<br>1: 4-buffer mode           |
| 4            | MS       | Specifies operation mode of A/D converter.<br>0: Scan mode<br>1: Select mode                |

**(2) A/D converter mode register 1 (ADM1)**

The ADM1 register is an 8-bit register that specifies the conversion operation time and trigger mode. This register can be read or written in 8-bit or 1-bit units.

- Cautions**
1. Changing the setting of the EGA1, EGA0, and FR3 to FR0 bits is prohibited while A/D conversion is enabled (ADCE bit = 1 in the ADM0 register).
  2. When data is written to the ADM1 register during an A/D conversion operation, the conversion operation is initialized and conversion is executed from the beginning.

|      | 7    | 6    | 5    | 4    | 3   | 2   | 1   | 0   | Address    | After reset |
|------|------|------|------|------|-----|-----|-----|-----|------------|-------------|
| ADM1 | EGA1 | EGA0 | TRG1 | TRG0 | FR3 | FR2 | FR1 | FR0 | FFFFFF201H | 00H         |

| Bit position | Bit name   | Function                                                                                                                                                                                                                                                                                                                                                             |      |                                                         |                                |   |   |                                                         |   |   |                       |   |   |                       |   |   |                     |
|--------------|------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|---------------------------------------------------------|--------------------------------|---|---|---------------------------------------------------------|---|---|-----------------------|---|---|-----------------------|---|---|---------------------|
| 7, 6         | EGA1, EGA0 | Specify valid edge of ADTRG.                                                                                                                                                                                                                                                                                                                                         |      |                                                         |                                |   |   |                                                         |   |   |                       |   |   |                       |   |   |                     |
|              |            | <table><tr><th>EGA1</th><th>EGA0</th><th>ADTRG valid edge specification</th></tr><tr><td>0</td><td>0</td><td>No edge detected (does not operate as external trigger)</td></tr><tr><td>0</td><td>1</td><td>Falling edge detected</td></tr><tr><td>1</td><td>0</td><td>Rising edge detected</td></tr><tr><td>1</td><td>1</td><td>Both edges detected</td></tr></table> | EGA1 | EGA0                                                    | ADTRG valid edge specification | 0 | 0 | No edge detected (does not operate as external trigger) | 0 | 1 | Falling edge detected | 1 | 0 | Rising edge detected  | 1 | 1 | Both edges detected |
|              |            | EGA1                                                                                                                                                                                                                                                                                                                                                                 | EGA0 | ADTRG valid edge specification                          |                                |   |   |                                                         |   |   |                       |   |   |                       |   |   |                     |
|              |            | 0                                                                                                                                                                                                                                                                                                                                                                    | 0    | No edge detected (does not operate as external trigger) |                                |   |   |                                                         |   |   |                       |   |   |                       |   |   |                     |
|              |            | 0                                                                                                                                                                                                                                                                                                                                                                    | 1    | Falling edge detected                                   |                                |   |   |                                                         |   |   |                       |   |   |                       |   |   |                     |
|              |            | 1                                                                                                                                                                                                                                                                                                                                                                    | 0    | Rising edge detected                                    |                                |   |   |                                                         |   |   |                       |   |   |                       |   |   |                     |
|              |            | 1                                                                                                                                                                                                                                                                                                                                                                    | 1    | Both edges detected                                     |                                |   |   |                                                         |   |   |                       |   |   |                       |   |   |                     |
| 5, 4         | TRG1, TRG0 | Specify the trigger mode.                                                                                                                                                                                                                                                                                                                                            |      |                                                         |                                |   |   |                                                         |   |   |                       |   |   |                       |   |   |                     |
|              |            | <table><tr><th>TRG1</th><th>TRG0</th><th>Trigger mode</th></tr><tr><td>0</td><td>0</td><td>A/D trigger mode</td></tr><tr><td>0</td><td>1</td><td>Timer trigger mode</td></tr><tr><td>1</td><td>0</td><td>External trigger mode</td></tr><tr><td>1</td><td>1</td><td>Setting prohibited</td></tr></table>                                                             | TRG1 | TRG0                                                    | Trigger mode                   | 0 | 0 | A/D trigger mode                                        | 0 | 1 | Timer trigger mode    | 1 | 0 | External trigger mode | 1 | 1 | Setting prohibited  |
|              |            | TRG1                                                                                                                                                                                                                                                                                                                                                                 | TRG0 | Trigger mode                                            |                                |   |   |                                                         |   |   |                       |   |   |                       |   |   |                     |
|              |            | 0                                                                                                                                                                                                                                                                                                                                                                    | 0    | A/D trigger mode                                        |                                |   |   |                                                         |   |   |                       |   |   |                       |   |   |                     |
|              |            | 0                                                                                                                                                                                                                                                                                                                                                                    | 1    | Timer trigger mode                                      |                                |   |   |                                                         |   |   |                       |   |   |                       |   |   |                     |
|              |            | 1                                                                                                                                                                                                                                                                                                                                                                    | 0    | External trigger mode                                   |                                |   |   |                                                         |   |   |                       |   |   |                       |   |   |                     |
|              |            | 1                                                                                                                                                                                                                                                                                                                                                                    | 1    | Setting prohibited                                      |                                |   |   |                                                         |   |   |                       |   |   |                       |   |   |                     |

**Remark** Sets A/D conversion operation time by using bits FR3 to FR0. For details, see **Table 12-1**.



Table 12-1. Setting of A/D Conversion Operation Time

| FR3 | FR2 | FR1 | FR0 | Number of Conversion Clocks | Conversion Operation Time <sup>Note 1</sup> |                         |                         |                        |                                          |
|-----|-----|-----|-----|-----------------------------|---------------------------------------------|-------------------------|-------------------------|------------------------|------------------------------------------|
|     |     |     |     |                             | $f_x = 150 \text{ MHz}$                     | $f_x = 133 \text{ MHz}$ | $f_x = 100 \text{ MHz}$ | $f_x = 80 \text{ MHz}$ | A/D Stabilization Time <sup>Note 2</sup> |
| 0   | 0   | 0   | 0   | 128                         | Setting prohibited                          | Setting prohibited      | Setting prohibited      | Setting prohibited     | $64/f_x$                                 |
| 0   | 0   | 0   | 1   | 256                         | Setting prohibited                          | Setting prohibited      | $2.56 \mu\text{s}$      | $3.20 \mu\text{s}$     | $128/f_x$                                |
| 0   | 0   | 1   | 0   | 384                         | $2.56 \mu\text{s}$                          | $2.89 \mu\text{s}$      | $3.84 \mu\text{s}$      | $4.80 \mu\text{s}$     | $160/f_x$                                |
| 0   | 0   | 1   | 1   | 512                         | $3.42 \mu\text{s}$                          | $3.85 \mu\text{s}$      | $5.12 \mu\text{s}$      | $6.40 \mu\text{s}$     | $160/f_x$                                |
| 0   | 1   | 0   | 0   | 640                         | $4.27 \mu\text{s}$                          | $4.82 \mu\text{s}$      | $6.40 \mu\text{s}$      | $8.00 \mu\text{s}$     | $160/f_x$                                |
| 0   | 1   | 0   | 1   | 768                         | $5.12 \mu\text{s}$                          | $5.78 \mu\text{s}$      | $7.68 \mu\text{s}$      | $9.60 \mu\text{s}$     | $160/f_x$                                |
| 0   | 1   | 1   | 0   | 896                         | $5.98 \mu\text{s}$                          | $6.74 \mu\text{s}$      | $8.96 \mu\text{s}$      | Setting prohibited     | $160/f_x$                                |
| 0   | 1   | 1   | 1   | 1,024                       | $6.83 \mu\text{s}$                          | $7.70 \mu\text{s}$      | Setting prohibited      | Setting prohibited     | $160/f_x$                                |
| 1   | 0   | 0   | 0   | 1,152                       | $7.68 \mu\text{s}$                          | $8.67 \mu\text{s}$      | Setting prohibited      | Setting prohibited     | $160/f_x$                                |
| 1   | 0   | 0   | 1   | 1,280                       | $8.54 \mu\text{s}$                          | $9.63 \mu\text{s}$      | Setting prohibited      | Setting prohibited     | $160/f_x$                                |
| 1   | 0   | 1   | 0   | 1,408                       | $9.39 \mu\text{s}$                          | Setting prohibited      | Setting prohibited      | Setting prohibited     | $160/f_x$                                |
| 1   | 0   | 1   | 1   | 1,536                       | Setting prohibited                          | Setting prohibited      | Setting prohibited      | Setting prohibited     | –                                        |
| 1   | 1   | 0   | 0   | 1,664                       | Setting prohibited                          | Setting prohibited      | Setting prohibited      | Setting prohibited     | –                                        |
| 1   | 1   | 0   | 1   | 1,792                       | Setting prohibited                          | Setting prohibited      | Setting prohibited      | Setting prohibited     | –                                        |
| 1   | 1   | 1   | 0   | 1,920                       | Setting prohibited                          | Setting prohibited      | Setting prohibited      | Setting prohibited     | –                                        |
| 1   | 1   | 1   | 1   | 2,048                       | Setting prohibited                          | Setting prohibited      | Setting prohibited      | Setting prohibited     | –                                        |

**Notes 1.** Set the conversion operation time in the range of 2 to  $10 \mu\text{s}$  (target value).

- 2.** After the ADCE bit is set to “1” from “0” to secure the stabilization time of the A/D converter, conversion is started after the A/D stabilization time has elapsed only before the first A/D conversion is executed.

**Cautions 1.** Do not change the set value of the A/D conversion time (FR3 to FR0 bits) during an A/D conversion operation (ADCE bit = 1). To change the value, clear the ADCE bit to 0.

- 2.** When the trigger mode (TRG1 and TGR0 bits) is changed midway, A/D conversion can be started immediately without having to secure the A/D stabilization time by re-setting the ADCE bit to “1”.

**Remark**  $f_x$ : Main clock

**(3) A/D converter mode register 2 (ADM2)**

The ADM2 register is an 8-bit register that specifies the analog input pin of the A/D converter.

This register can be read or written in 8-bit or 1-bit units.

- Cautions**
1. If a channel for which no analog input pin exists is specified, the result of A/D conversion is undefined.
  2. Changing the setting of the ANIS2 to ANIS0 bits is prohibited while A/D conversion is enabled (ADCE bit = 1 in the ADM0 register).
  3. When data is written to the ADM2 register during an A/D conversion operation, the conversion operation is initialized and conversion is executed from the beginning.

|      |   |   |   |   |   |       |       |       |            |             |
|------|---|---|---|---|---|-------|-------|-------|------------|-------------|
|      | 7 | 6 | 5 | 4 | 3 | 2     | 1     | 0     | Address    | After reset |
| ADM2 | 0 | 0 | 0 | 0 | 0 | ANIS2 | ANIS1 | ANIS0 | FFFFFF202H | 00H         |

| Bit position | Bit name       | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |             |           |       |                                         |       |                                         |           |   |   |   |      |      |   |   |   |      |            |   |   |   |      |              |   |   |   |      |              |   |   |   |      |              |   |   |   |      |              |   |   |   |      |              |   |   |   |      |              |
|--------------|----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|-----------|-------|-----------------------------------------|-------|-----------------------------------------|-----------|---|---|---|------|------|---|---|---|------|------------|---|---|---|------|--------------|---|---|---|------|--------------|---|---|---|------|--------------|---|---|---|------|--------------|---|---|---|------|--------------|---|---|---|------|--------------|
| 2 to 0       | ANIS2 to ANIS0 | Specify the analog input pin for A/D conversion.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |             |           |       |                                         |       |                                         |           |   |   |   |      |      |   |   |   |      |            |   |   |   |      |              |   |   |   |      |              |   |   |   |      |              |   |   |   |      |              |   |   |   |      |              |   |   |   |      |              |
|              |                | <table><tr><th rowspan="2">ANIS2</th><th rowspan="2">ANIS1</th><th rowspan="2">ANIS0</th><th colspan="2">Specification of pin for A/D conversion</th></tr><tr><th>Select mode</th><th>Scan mode</th></tr><tr><td>0</td><td>0</td><td>0</td><td>ANI0</td><td>ANI0</td></tr><tr><td>0</td><td>0</td><td>1</td><td>ANI1</td><td>ANI0, ANI1</td></tr><tr><td>0</td><td>1</td><td>0</td><td>ANI2</td><td>ANI0 to ANI2</td></tr><tr><td>0</td><td>1</td><td>1</td><td>ANI3</td><td>ANI0 to ANI3</td></tr><tr><td>1</td><td>0</td><td>0</td><td>ANI4</td><td>ANI0 to ANI4</td></tr><tr><td>1</td><td>0</td><td>1</td><td>ANI5</td><td>ANI0 to ANI5</td></tr><tr><td>1</td><td>1</td><td>0</td><td>ANI6</td><td>ANI0 to ANI6</td></tr><tr><td>1</td><td>1</td><td>1</td><td>ANI7</td><td>ANI0 to ANI7</td></tr></table> | ANIS2       | ANIS1     | ANIS0 | Specification of pin for A/D conversion |       | Select mode                             | Scan mode | 0 | 0 | 0 | ANI0 | ANI0 | 0 | 0 | 1 | ANI1 | ANI0, ANI1 | 0 | 1 | 0 | ANI2 | ANI0 to ANI2 | 0 | 1 | 1 | ANI3 | ANI0 to ANI3 | 1 | 0 | 0 | ANI4 | ANI0 to ANI4 | 1 | 0 | 1 | ANI5 | ANI0 to ANI5 | 1 | 1 | 0 | ANI6 | ANI0 to ANI6 | 1 | 1 | 1 | ANI7 | ANI0 to ANI7 |
|              |                | ANIS2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |             |           |       | ANIS1                                   | ANIS0 | Specification of pin for A/D conversion |           |   |   |   |      |      |   |   |   |      |            |   |   |   |      |              |   |   |   |      |              |   |   |   |      |              |   |   |   |      |              |   |   |   |      |              |   |   |   |      |              |
|              |                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Select mode | Scan mode |       |                                         |       |                                         |           |   |   |   |      |      |   |   |   |      |            |   |   |   |      |              |   |   |   |      |              |   |   |   |      |              |   |   |   |      |              |   |   |   |      |              |   |   |   |      |              |
|              |                | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 0           | 0         | ANI0  | ANI0                                    |       |                                         |           |   |   |   |      |      |   |   |   |      |            |   |   |   |      |              |   |   |   |      |              |   |   |   |      |              |   |   |   |      |              |   |   |   |      |              |   |   |   |      |              |
|              |                | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 0           | 1         | ANI1  | ANI0, ANI1                              |       |                                         |           |   |   |   |      |      |   |   |   |      |            |   |   |   |      |              |   |   |   |      |              |   |   |   |      |              |   |   |   |      |              |   |   |   |      |              |   |   |   |      |              |
|              |                | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 1           | 0         | ANI2  | ANI0 to ANI2                            |       |                                         |           |   |   |   |      |      |   |   |   |      |            |   |   |   |      |              |   |   |   |      |              |   |   |   |      |              |   |   |   |      |              |   |   |   |      |              |   |   |   |      |              |
|              |                | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 1           | 1         | ANI3  | ANI0 to ANI3                            |       |                                         |           |   |   |   |      |      |   |   |   |      |            |   |   |   |      |              |   |   |   |      |              |   |   |   |      |              |   |   |   |      |              |   |   |   |      |              |   |   |   |      |              |
|              |                | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 0           | 0         | ANI4  | ANI0 to ANI4                            |       |                                         |           |   |   |   |      |      |   |   |   |      |            |   |   |   |      |              |   |   |   |      |              |   |   |   |      |              |   |   |   |      |              |   |   |   |      |              |   |   |   |      |              |
|              |                | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 0           | 1         | ANI5  | ANI0 to ANI5                            |       |                                         |           |   |   |   |      |      |   |   |   |      |            |   |   |   |      |              |   |   |   |      |              |   |   |   |      |              |   |   |   |      |              |   |   |   |      |              |   |   |   |      |              |
|              |                | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 1           | 0         | ANI6  | ANI0 to ANI6                            |       |                                         |           |   |   |   |      |      |   |   |   |      |            |   |   |   |      |              |   |   |   |      |              |   |   |   |      |              |   |   |   |      |              |   |   |   |      |              |   |   |   |      |              |
|              |                | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 1           | 1         | ANI7  | ANI0 to ANI7                            |       |                                         |           |   |   |   |      |      |   |   |   |      |            |   |   |   |      |              |   |   |   |      |              |   |   |   |      |              |   |   |   |      |              |   |   |   |      |              |   |   |   |      |              |

**(4) ADC trigger select register (ADTS)**

This is an 8-bit register that specifies the timer trigger signal in the timer trigger mode.

This register can be read or written in 8-bit units.

Be sure to clear bits 7 to 4 to 0. If they are set to 1, the operation is not guaranteed.

**Caution** Stop the A/D conversion operation (by clearing the ADCE bit of the ADM0 register to 0) before changing the setting of the ADTS register. The operation is not guaranteed if the setting of the ADTS register is changed while A/D conversion is enabled (ADCE bit = 1).

|      | 7 | 6 | 5 | 4 | <3>  | <2>  | <1>  | <0>  | Address   | After reset |
|------|---|---|---|---|------|------|------|------|-----------|-------------|
| ADTS | 0 | 0 | 0 | 0 | TMS3 | TMS2 | TMS1 | TMS0 | FFFFF220H | 00H         |

| Bit position | Bit name | Function                                                                                                                              |
|--------------|----------|---------------------------------------------------------------------------------------------------------------------------------------|
| 3            | TMS3     | Controls connection of a timer trigger signal (INTCCC51).<br>0: Timer trigger of ADC is invalid.<br>1: Timer trigger of ADC is valid. |
| 2            | TMS2     | Controls connection of a timer trigger signal (INTCCC50).<br>0: Timer trigger of ADC is invalid.<br>1: Timer trigger of ADC is valid. |
| 1            | TMS1     | Controls connection of a timer trigger signal (INTCCC41).<br>0: Timer trigger of ADC is invalid.<br>1: Timer trigger of ADC is valid. |
| 0            | TMS0     | Controls connection of a timer trigger signal (INTCCC40).<br>0: Timer trigger of ADC is invalid.<br>1: Timer trigger of ADC is valid. |

**(5) A/D conversion result registers 0 to 7, 0H to 7H (ADCR0 to ADCR7, ADCR0H to ADCR7H)**

The ADCRn register is a 10-bit register holding the A/D conversion results. There are eight 10-bit registers. These registers are read-only, in 16-bit or 8-bit units. During 16-bit access, the ADCRn register is specified, and during higher 8-bit access, the ADCRnH register is specified (n = 0 to 7).

When reading the 10-bit data of the A/D conversion results from the ADCRn register, only the higher 10 bits are valid and the lower 6 bits are always read as 0.

|        |      |      |      |      |      |      |      |      |      |      |   |   |   |   |   |   |                           |             |
|--------|------|------|------|------|------|------|------|------|------|------|---|---|---|---|---|---|---------------------------|-------------|
|        | 15   | 14   | 13   | 12   | 11   | 10   | 9    | 8    | 7    | 6    | 5 | 4 | 3 | 2 | 1 | 0 | Address                   | After reset |
| ADCRn  | ADn9 | ADn8 | ADn7 | ADn6 | ADn5 | ADn4 | ADn3 | ADn2 | ADn1 | ADn0 | 0 | 0 | 0 | 0 | 0 | 0 | FFFFF210H to<br>FFFFF21EH | Undefined   |
|        | 7    | 6    | 5    | 4    | 3    | 2    | 1    | 0    |      |      |   |   |   |   |   |   | Address                   | After reset |
| ADCRnH | ADn9 | ADn8 | ADn7 | ADn6 | ADn5 | ADn4 | ADn3 | ADn2 |      |      |   |   |   |   |   |   | FFFFF211H to<br>FFFFF21FH | Undefined   |

**Remark** n = 0 to 7

The correspondence between each analog input pin and the ADCRn register is shown below.

| Analog Input Pin | ADCRn Register                     |                                     |
|------------------|------------------------------------|-------------------------------------|
|                  | Select 1 Buffer Mode/<br>Scan Mode | Select 4 Buffer Mode                |
| ANI0             | ADCR0, ADCR0H                      | ADCR0 to ADCR3,<br>ADCR0H to ADCR3H |
| ANI1             | ADCR1, ADCR1H                      |                                     |
| ANI2             | ADCR2, ADCR2H                      |                                     |
| ANI3             | ADCR3, ADCR3H                      |                                     |
| ANI4             | ADCR4, ADCR4H                      | ADCR4 to ADCR7,<br>ADCR4H to ADCR7H |
| ANI5             | ADCR5, ADCR5H                      |                                     |
| ANI6             | ADCR6, ADCR6H                      |                                     |
| ANI7             | ADCR7, ADCR7H                      |                                     |

The relationship between the analog voltage input to the analog input pins (ANI0 to ANI7) and the A/D conversion result (of the A/D conversion result register n (ADCRn)) is as follows:

$$\text{SAR} = \text{INT} \left( \frac{V_{\text{IN}}}{\text{AV}_{\text{REF}}} \times 1,024 + 0.5 \right)$$

$$\text{ADCR}^{\text{Note}} = \text{SAR} \times 64$$

or,

$$(\text{SAR} - 0.5) \times \frac{\text{AV}_{\text{REF}}}{1,024} \leq V_{\text{IN}} < (\text{SAR} + 0.5) \times \frac{\text{AV}_{\text{REF}}}{1,024}$$

INT( ): Function that returns the integer of the value in ( )

V<sub>IN</sub>: Analog input voltage

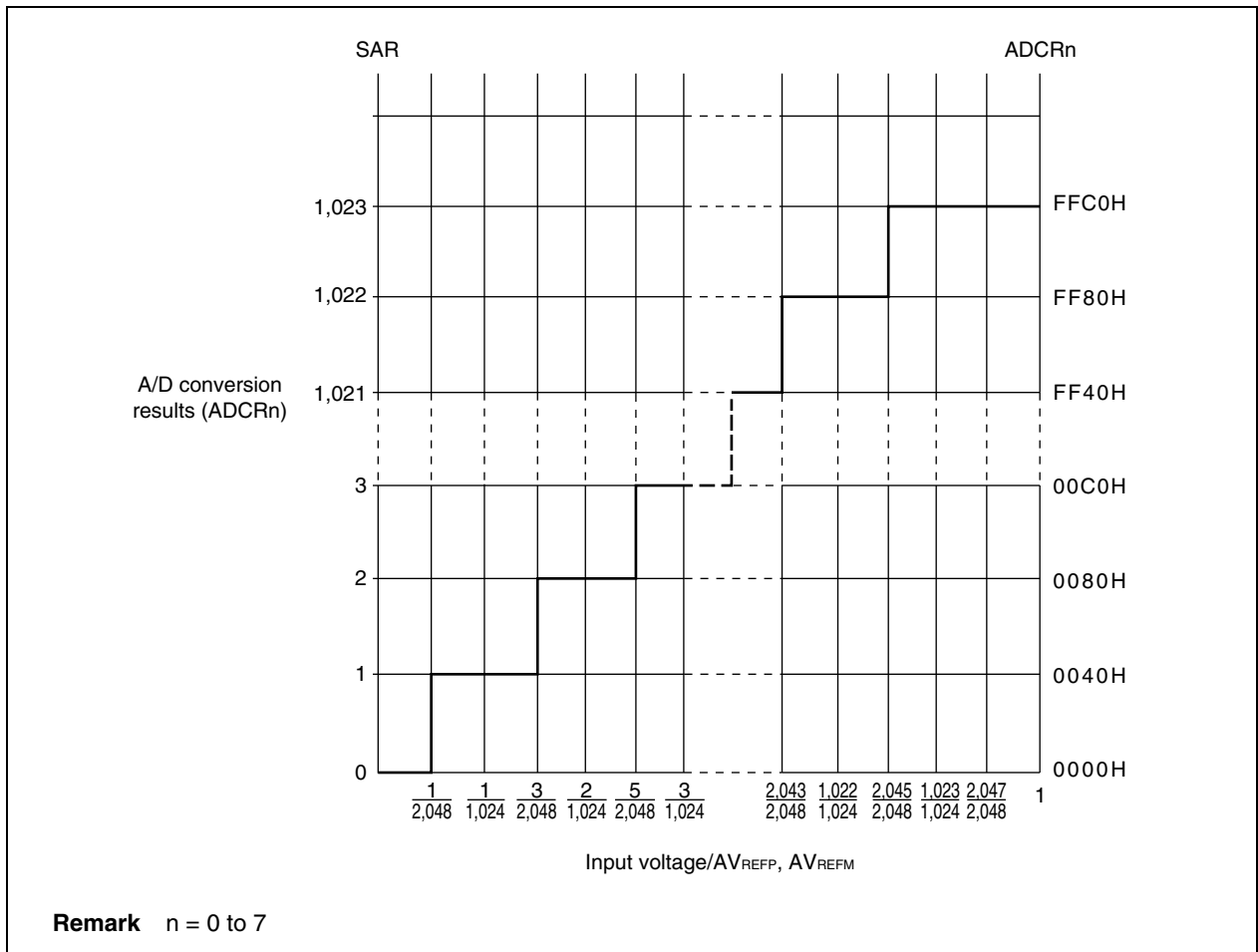
AV<sub>REF</sub>: AV<sub>REFM</sub>, AV<sub>REFP</sub> pin voltage

ADCR: Value of A/D conversion result register n (ADCRn)

**Note** The lower 6 bits of the ADCRn registers are fixed to 0.

Figure 12-2 shows the relationship between the analog input voltage and the A/D conversion results.

**Figure 12-2. Relationship Between Analog Input Voltage and A/D Conversion Results**



## 12.4 Operation

### 12.4.1 Basic operation

A/D conversion is executed by the following procedure.

- (1) The selection of the analog input and specification of the operation mode, trigger mode, etc. should be specified using the ADMn register<sup>Note 1</sup> (n = 0 to 2).  
When the ADCE bit of the ADM0 register is set to 1, A/D conversion starts in the A/D trigger mode. In the timer trigger mode and external trigger mode, the trigger standby state<sup>Note 2</sup> is set.
- (2) When A/D conversion is started, the C array voltage on the analog input side and the C array voltage on the reference side are compared by the comparator.
- (3) When the comparison of the 10 bits ends, the conversion results are stored in the ADCRn register. When A/D conversion has been performed the specified number of times, the A/D conversion end interrupt (INTAD) is generated (n = 0 to 7).

**Notes 1.** If the setting of the ADMn register (n = 0 to 2) is changed during A/D conversion, the operation immediately before is stopped, and the result of the conversion is not stored in the ADCRn register (n = 0 to 7). The A/D conversion operation is then initialized, and conversion is executed from the beginning again.

2. During the timer trigger mode and external trigger mode, if the ADCE bit of the ADM0 register is set to 1, the mode changes to the trigger standby state. The A/D conversion operation is started by the trigger signal (ADCS bit = 1 in the ADM0 register), and the trigger standby state (ADCS bit = 0) is returned when the A/D conversion operation ends.

### 12.4.2 Operation mode and trigger mode

Various conversion operations can be specified for the A/D converter by specifying the operation mode and trigger mode. The operation mode and trigger mode are set by the ADM0 to ADM2 registers.

The following shows the relationship between the operation mode and trigger mode.

**Table 12-2. Relationship Between Operation Mode and Trigger Mode**

| Trigger Mode     | Operation Mode |           | Set Value |           |           | Analog Input |
|------------------|----------------|-----------|-----------|-----------|-----------|--------------|
|                  |                |           | ADM0      | ADM1      | ADM2      |              |
| A/D trigger      | Select         | 1 buffer  | xx010000B | 00000xxxB | 00000xxxB | ANI0 to ANI7 |
|                  |                | 4 buffers | xx110000B |           | 00000xxxB | ANI0 to ANI7 |
|                  | Scan           |           | xxx00000B |           | 00000xxxB | ANI0 to ANI7 |
| Timer trigger    | Select         | 1 buffer  | xx010000B | 00001xxxB | 00000xxxB | ANI0 to ANI7 |
|                  |                | 4 buffers | xx110000B |           | 00000xxxB | ANI0 to ANI7 |
|                  | Scan           |           | xxx00000B |           | 00000xxxB | ANI0 to ANI7 |
| External trigger | Select         | 1 buffer  | xx010000B | xx10xxxxB | 00000xxxB | ANI0 to ANI7 |
|                  |                | 4 buffers | xx110000B |           | 00000xxxB | ANI0 to ANI7 |
|                  | Scan           |           | xxx00000B |           | 00000xxxB | ANI0 to ANI7 |

#### (1) Trigger mode

There are three types of trigger modes that serve as the start timing of A/D conversion processing: A/D trigger mode, timer trigger mode, and external trigger mode. These trigger modes are set by the TRG1 and TRG0 bits of the ADM1 register.

##### (a) A/D trigger mode

This mode starts the conversion timing of the analog input set to the ANI0 to ANI7 pins, and by setting the ADCE bit of the ADM0 register to 1, starts A/D conversion. Unless the ADCE bit is cleared to 0 after conversion, the next conversion operation is repeated. If data is written to the ADM0 to ADM2 registers during conversion, conversion is stopped and then executed from the beginning again.

##### (b) Timer trigger mode

This mode specifies the conversion timing of the analog input set for the ANI0 to ANI7 pins using the values set to the timer C capture/compare register.

This register creates the analog input conversion timing by generating the compare match interrupts of the four capture/compare registers (CCC40, CCC41, CCC50, CCC51) connected to the 16-bit timer C (TMC4, TMC5).

If the ADCE bit of the ADM0 register is set to 1, the A/D converter waits for an interrupt (INTCCC40, INTCCC41, INTCCC50, or INTCCC51), and starts conversion when INTCCC40, INTCCC41, INTCCC50, or INTCCC51 occurs (ADCS bit = 1 in the ADM0 register). When conversion has finished, the converter waits for an interrupt again (ADCS = 0). If data is written to the ADM0 to ADM2 registers during conversion, conversion is stopped and then executed from the beginning again.

**(c) External trigger mode**

This mode specifies the conversion timing of the analog input to the ANI0 to ANI7 pins using the ADTRG pin.

The EGA1 and EGA0 bits of the ADM1 register are used to specify the valid edge to be input to the ADTRG pin.

When the ADCE bit of the ADM0 register is set to 1, the A/D converter waits for an external trigger (ADTRG), and starts conversion when the valid edge of ADTRG is detected (ADCS bit = 1 in the ADM0 register). When the converter has completed its conversion operation, it waits for an external trigger again (ADCS bit = 0).

If the valid edge is detected at the ADTRG pin during conversion, conversion is executed from the beginning again.

If data is written to the ADM0 to ADM2 registers during conversion, conversion is stopped and then executed from the beginning again.

**(2) Operation mode**

There are two operation modes that set the ANI0 to ANI7 pins: select mode and scan mode. The select mode has sub-modes that consist of 1-buffer mode and 4-buffer mode. These modes are set by the BS and MS bits of the ADM0 register.

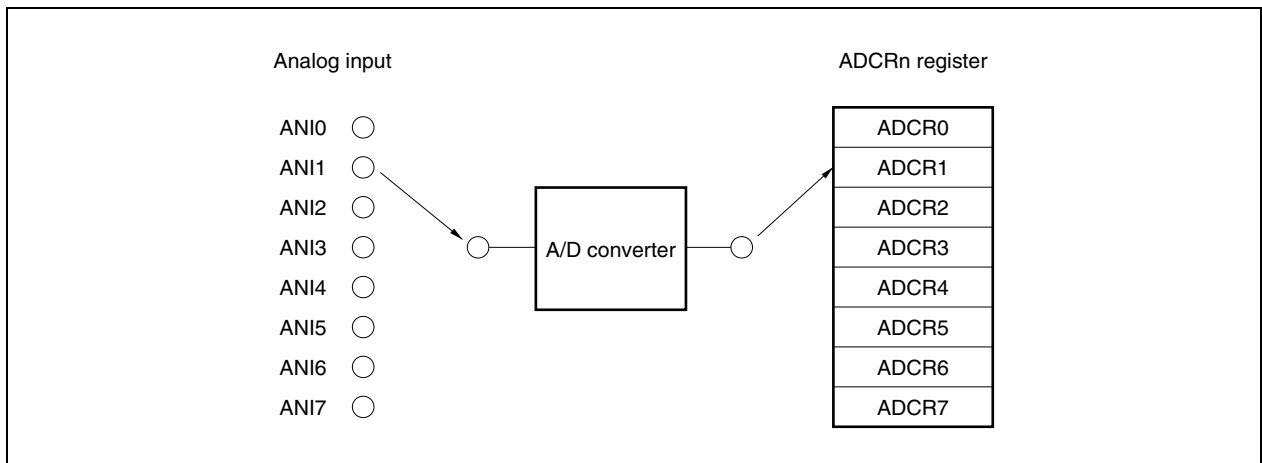
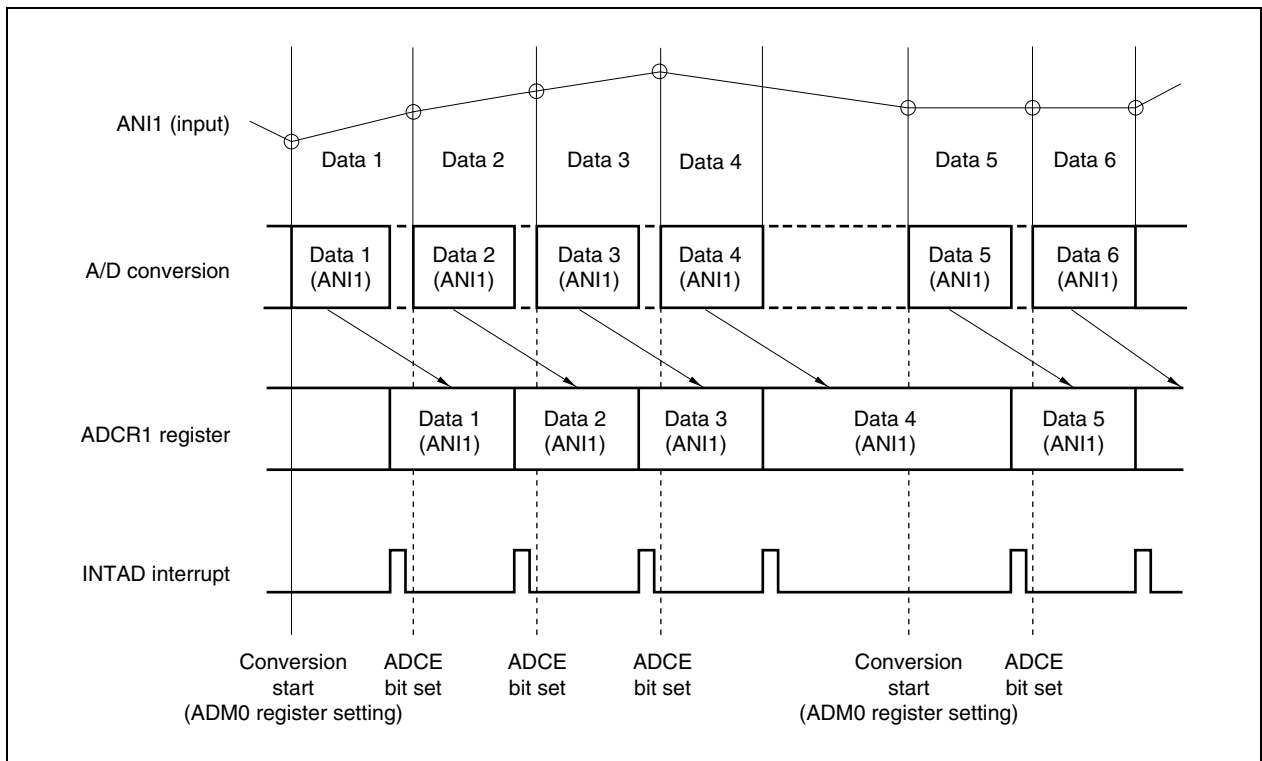
**(a) Select mode**

In this mode, one analog input specified by the ADM2 register is A/D converted. The conversion results are stored in the ADCRn register corresponding to the analog input (ANIn). For this mode, the 1-buffer mode and 4-buffer mode are provided for storing the A/D conversion results (n = 0 to 7).

- **1-buffer mode**

In this mode, one analog input specified by the ADM2 register is A/D converted. The conversion results are stored in the ADCRn register corresponding to the analog input (ANIn) (n = 0 to 7). The ANIn and ADCRn register correspond one to one, and an A/D conversion end interrupt (INTAD) is generated each time one A/D conversion ends. After conversion has finished, the next conversion operation is repeated, unless the ADCE bit of the ADM0 register is cleared to 0.



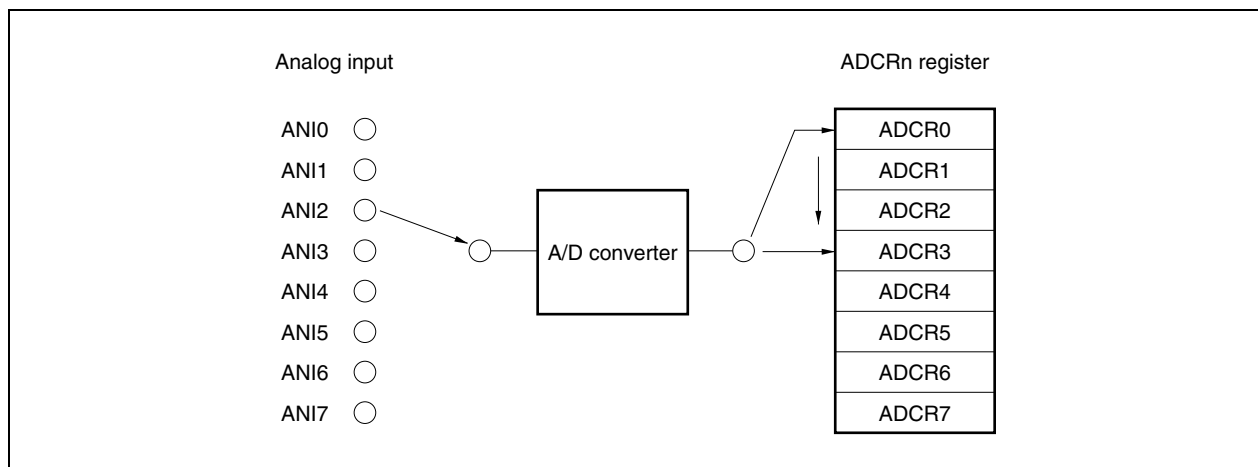
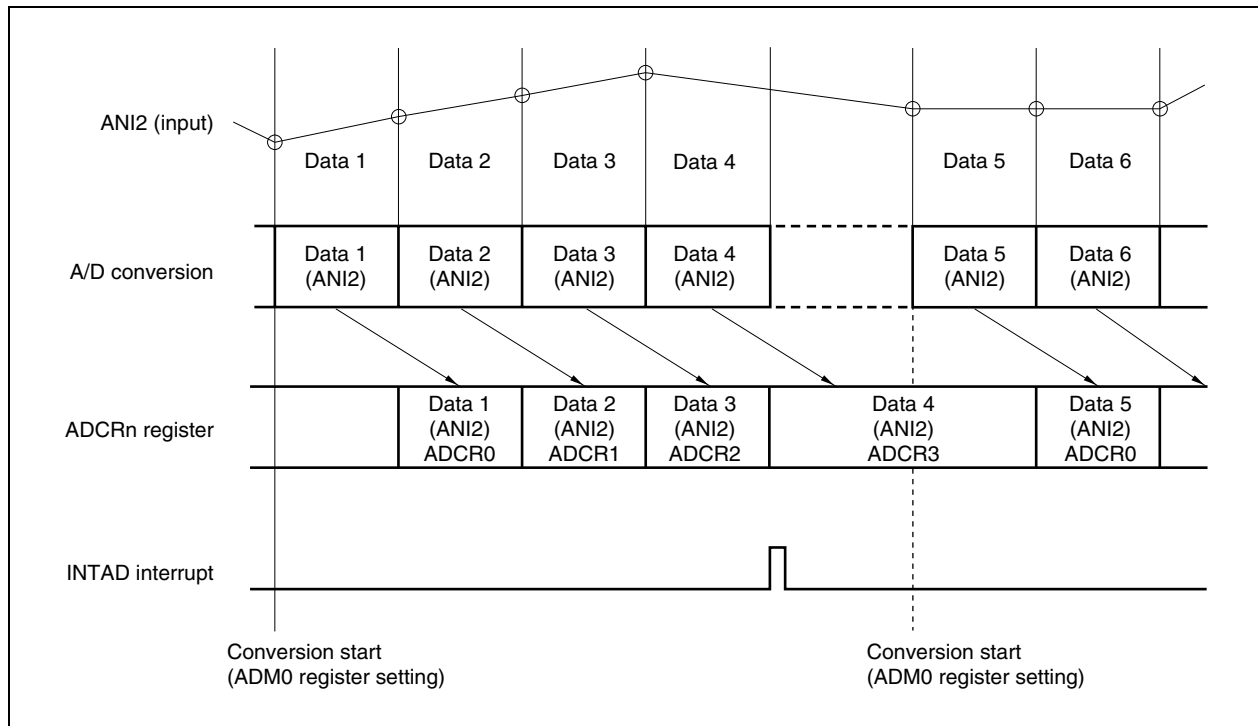
**Figure 12-3. Select Mode Operation Timing: 1-Buffer Mode (ANI1)**

- **4-buffer mode**

In this mode, one analog input is A/D converted four times and the results are stored in the ADCRn register. The A/D conversion end interrupt (INTAD) is generated when the four A/D conversions end ( $n = 0$  to  $3$  when the lower analog input channel is specified and  $n = 4$  to  $7$  when the higher analog input channel is specified).

After conversion has finished, the next conversion operation is repeated, unless the ADCE bit of the ADM0 register is cleared to 0.

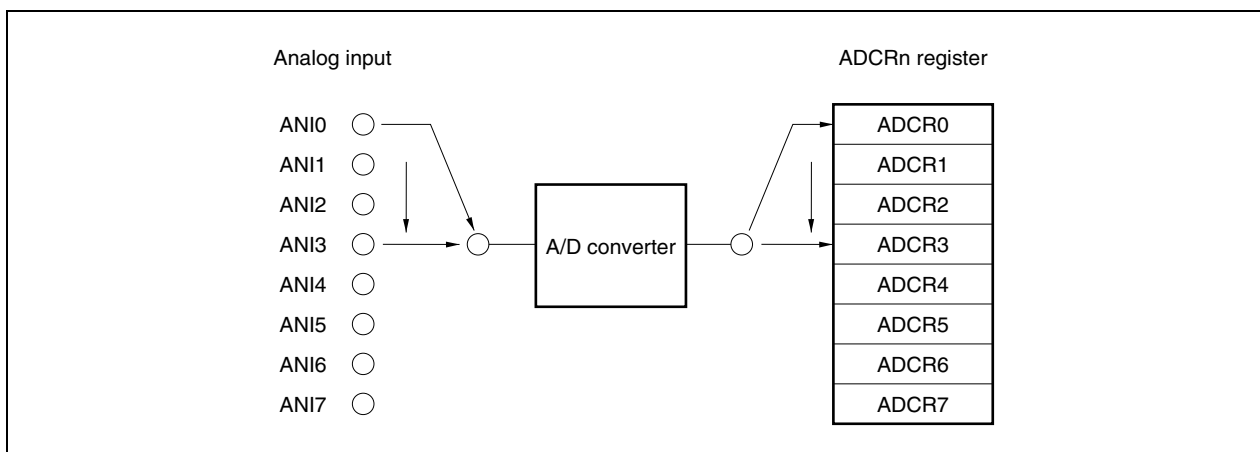
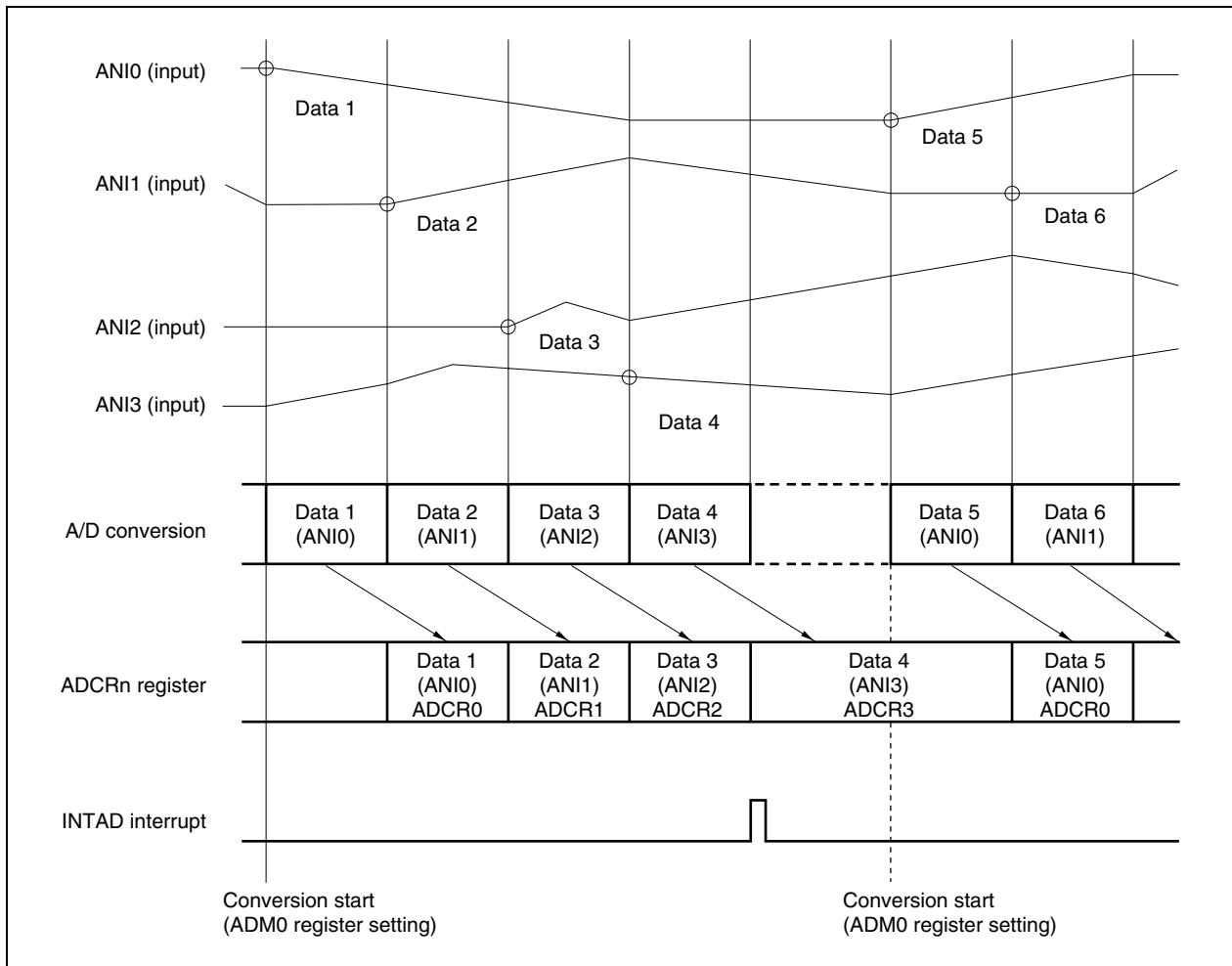
**Figure 12-4. Select Mode Operation Timing: 4-Buffer Mode (ANI2)**



**(b) Scan mode**

In this mode, the analog inputs specified by the ADM2 register are selected sequentially from the ANI0 pin, and A/D conversion is executed. The A/D conversion results are stored in the ADCRn register corresponding to the analog input ( $n = 0$  to 7). When the conversion of the specified analog input ends, the A/D conversion end interrupt (INTAD) is generated. After conversion has finished, the next conversion operation is repeated, unless the ADCE bit of the ADM0 register is cleared to 0.

**Figure 12-5. Scan Mode Operation Timing: 4-Channel Scan (ANI0 to ANI3)**



## 12.5 Operation in A/D Trigger Mode

When the ADCE bit of the ADM0 register is set to 1, A/D conversion is started.

### 12.5.1 Select mode operation

In this mode, the analog input specified by the ADM2 register is A/D converted. The conversion results are stored in the ADCRn register corresponding to the analog input. In the select mode, the 1-buffer mode and 4-buffer mode are supported according to the storing method of the A/D conversion results ( $n = 0$  to 7).

#### (1) 1-buffer mode (A/D trigger select: 1 buffer)

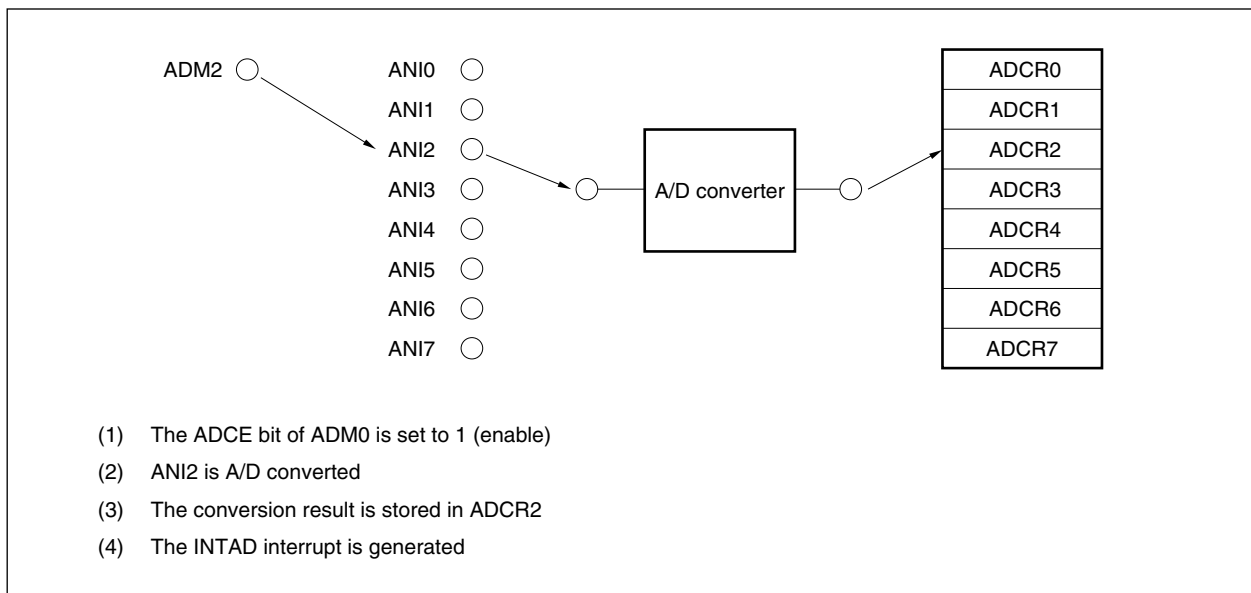
In this mode, one analog input is A/D converted once. The conversion results are stored in one ADCRn register. The analog input and ADCRn register correspond one to one.

Each time an A/D conversion is executed, an A/D conversion end interrupt (INTAD) is generated and A/D conversion ends. The next conversion operation is repeated, unless the ADCE bit of the ADM0 register is cleared to 0.

| Analog Input | A/D Conversion Result Register |
|--------------|--------------------------------|
| ANIn         | ADCRn                          |

This mode is most appropriate for applications in which the results of each first-time A/D conversion are read.

**Figure 12-6. Example of 1-Buffer Mode Operation (A/D Trigger Select: 1 Buffer)**



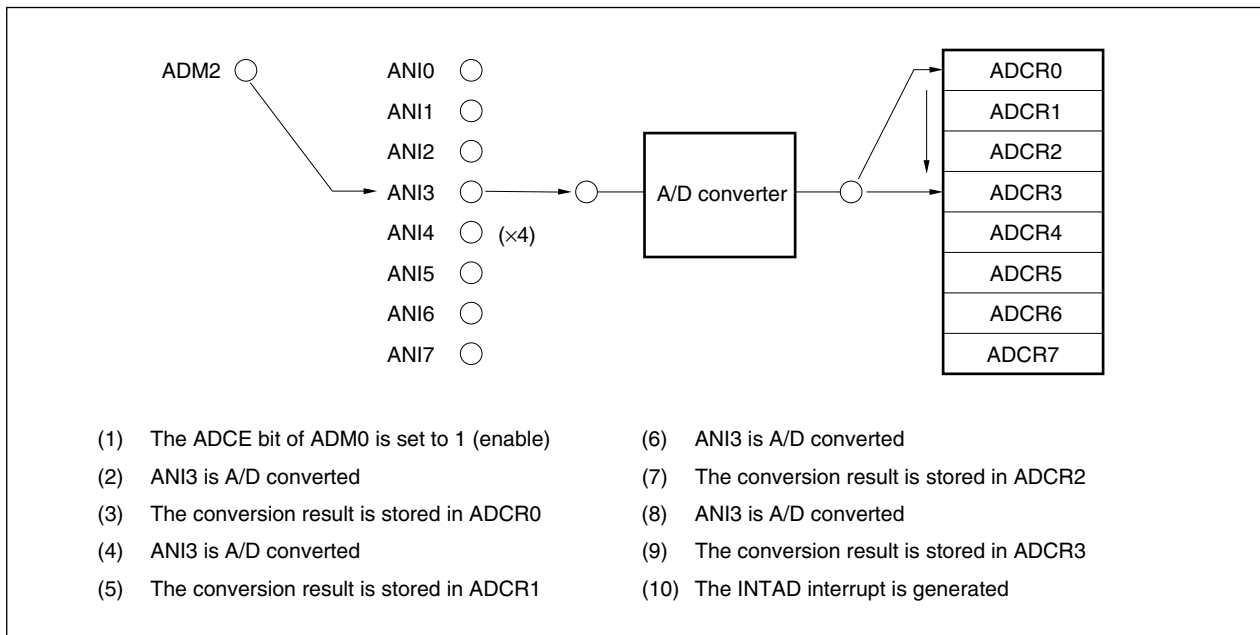
**(2) 4-buffer mode (A/D trigger select: 4 buffers)**

In this mode, one analog input is A/D converted four times and the results are stored in the ADCRn register. When the 4th A/D conversion ends, an A/D conversion end interrupt (INTAD) is generated and the A/D conversion is stopped. The next conversion operation is repeated, unless the ADCE bit of the ADM0 register is cleared to 0.

| Analog Input | A/D Conversion Result Register |
|--------------|--------------------------------|
| ANI0 to ANI3 | ADCR0 (1st time)               |
|              | ADCR1 (2nd time)               |
|              | ADCR2 (3rd time)               |
|              | ADCR3 (4th time)               |
| ANI4 to ANI7 | ADCR4 (1st time)               |
|              | ADCR5 (2nd time)               |
|              | ADCR6 (3rd time)               |
|              | ADCR7 (4th time)               |

This mode is suitable for applications in which the average of the A/D conversion results is calculated.

**Figure 12-7. Example of 4-Buffer Mode Operation (A/D Trigger Select: 4 Buffers)**



### 12.5.2 Scan mode operations

In this mode, the analog inputs specified by the ADM2 register are selected sequentially from the ANI0 pin, and A/D conversion is executed. The A/D conversion results are stored in the ADCRn register corresponding to the analog input (n = 0 to 7).

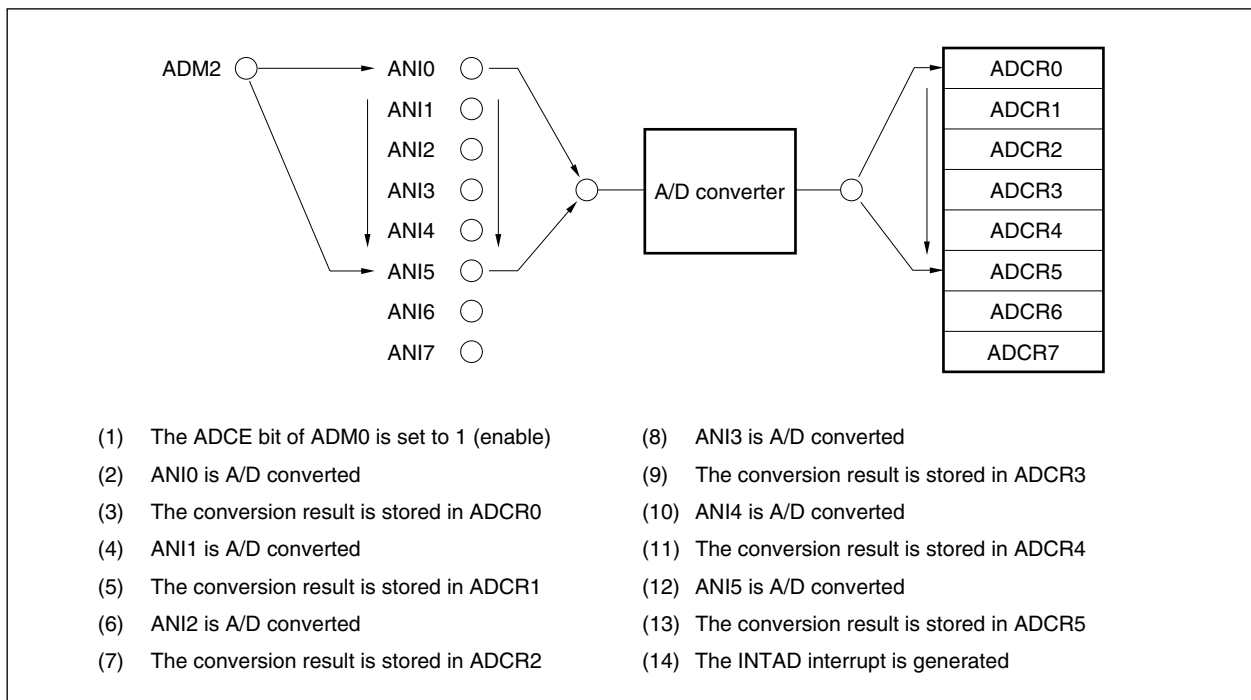
When conversion of all the specified analog input ends, the A/D conversion end interrupt (INTAD) is generated, and A/D conversion is stopped. The next conversion operation is repeated, unless the ADCE bit of the ADM0 register is cleared to 0.

| Analog Input         | A/D Conversion Result Register |
|----------------------|--------------------------------|
| ANI0                 | ADCR0                          |
| ⋮                    | ⋮                              |
| ANIn <sup>Note</sup> | ADCRn                          |

**Note** Set by the ANIS2 to ANIS0 bits of the ADM2 register.

This mode is most appropriate for applications in which multiple analog inputs are constantly monitored.

**Figure 12-8. Example of Scan Mode Operation (A/D Trigger Scan)**



## 12.6 Operation in Timer Trigger Mode

In this mode, the conversion timing of the analog input signal set by the ANI0 to ANI7 pins is defined by the value set to the capture/compare registers of timers C4 and C5.

The analog input conversion timing is generated when a compare match interrupt (INTCCC40, INTCCC41, INTCCC50, or INTCCC51) is generated by the capture/compare register connected to 16-bit timer C4 or C5 (TMC4 or TMC5).

When the ADCE bit of the ADM0 register is set to 1, the A/D converter waits for the interrupt (INTCCC40, INTCCC41, INTCCC50, or INTCCC51), and starts conversion when INTCCC40, INTCCC41, INTCCC50, or INTCCC51 occurs (ADCS bit = 1 in the ADM0 register). When conversion is finished, the converter waits for an interrupt again (ADCS bit = 0).

If INTCCC40, INTCCC41, INTCCC50, or INTCCC51 occurs during conversion, the conversion operation is executed from the beginning again.

If data is written to the ADM0 to ADM2 registers during conversion, the conversion operation is stopped and executed from the beginning again.

### 12.6.1 Select mode operation

In this mode, an analog input (ANI0 to ANI7) specified by the ADM2 register is A/D converted. The conversion results are stored in the ADCRn register corresponding to the analog input. In the select mode, the 1-buffer mode and 4-buffer mode are provided according to the storing method of the A/D conversion results.

#### (1) 1-buffer mode (timer trigger select: 1 buffer)

In this mode, one analog input is A/D converted once and the conversion results are stored in one ADCRn register.

One analog input is A/D converted once using the trigger of the match interrupt signals (INTCCC40, INTCCC41, INTCCC50, INTCCC51) and the results are stored in one ADCRn register. An A/D conversion end interrupt (INTAD) is generated for each A/D conversion.

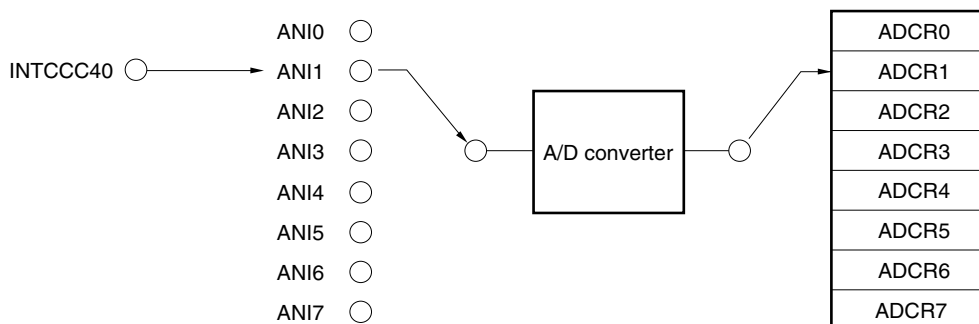
Unless the ADCE bit of the ADM0 register is cleared to 0, A/D conversion is repeated each time a timer match interrupt is generated.

**Table 12-3. Correspondence Between Analog Input Pins and ADCRn Register  
(1-Buffer Mode (Timer Trigger Select: 1 Buffer))**

| Trigger           | Analog Input | A/D Conversion Result Register |
|-------------------|--------------|--------------------------------|
| INTCCCN interrupt | ANI0         | ADCR0                          |
| INTCCCN interrupt | ANI1         | ADCR1                          |
| INTCCCN interrupt | ANI2         | ADCR2                          |
| INTCCCN interrupt | ANI3         | ADCR3                          |
| INTCCCN interrupt | ANI4         | ADCR4                          |
| INTCCCN interrupt | ANI5         | ADCR5                          |
| INTCCCN interrupt | ANI6         | ADCR6                          |
| INTCCCN interrupt | ANI7         | ADCR7                          |

**Remark** n = 40, 41, 50, 51

**Figure 12-9. Example of 1-Buffer Mode Operation (Timer Trigger Select: 1 Buffer) (ANI1)**



- (1) The ADCE bit of ADM0 is set to 1 (enable)
- (2) The CCC40 compare is generated
- (3) ANI1 is A/D converted
- (4) The conversion result is stored in ADCR1
- (5) The INTAD interrupt is generated



**(2) 4-buffer mode (timer trigger select: 4 buffers)**

In this mode, A/D conversion of one analog input is executed four times, and the results are stored in the ADCRn register.

One analog input is A/D converted four times using the match interrupt signals (INTCCC40, INTCCC41, INTCCC50, INTCCC51) as a trigger, and the results are stored in four ADCRn registers. The A/D conversion end interrupt (INTAD) is generated when the four A/D conversions end.

After conversion has finished, the next conversion is repeated, unless the ADCE bit of the ADM0 register is cleared to 0.

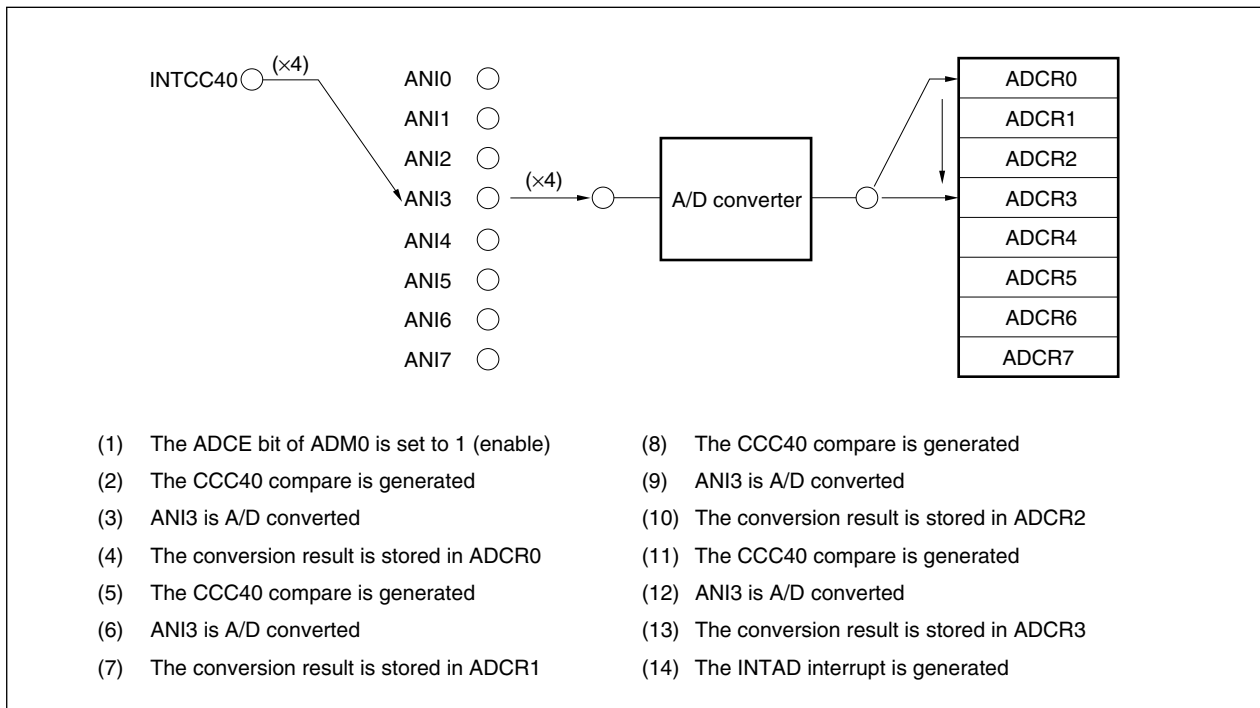
This mode is suitable for applications in which the average of the A/D conversion results is calculated.

**Table 12-4. Correspondence Between Analog Input Pins and ADCRn Register  
(4-Buffer Mode (Timer Trigger Select: 4 Buffers))**

| Trigger          | Analog Input | A/D Conversion Result Register                                               |
|------------------|--------------|------------------------------------------------------------------------------|
| INTCCn interrupt | ANI0 to ANI3 | ADCR0 (1st time)<br>ADCR1 (2nd time)<br>ADCR2 (3rd time)<br>ADCR3 (4th time) |
|                  | ANI4 to ANI7 | ADCR4 (1st time)<br>ADCR5 (2nd time)<br>ADCR6 (3rd time)<br>ADCR7 (4th time) |

**Remark** n = 40, 41, 50, 51

**Figure 12-10. Example of 4-Buffer Mode Operation (Timer Trigger Select: 4 Buffers) (ANI3)**



### 12.6.2 Scan mode operation

In this mode, the analog inputs specified by the ADM2 register are selected sequentially from the ANI0 pin and are A/D converted the specified number of times using the timer match interrupt signal as a trigger.

The result of conversion is stored in the ADCRn register corresponding to the analog input. When all the specified analog input signals have been converted, an A/D conversion end interrupt (INTAD) occurs.

After conversion has finished, the A/D converter waits for a trigger unless the ADCE bit of the ADM0 register is cleared to 0. When a timer match interrupt occurs again, the converter starts A/D conversion again, starting from the ANI0 input.

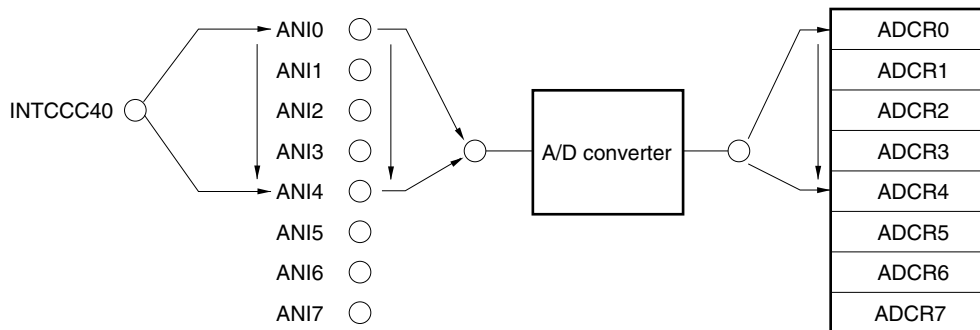
This mode is most appropriate for applications in which multiple analog inputs are constantly monitored.

**Table 12-5. Correspondence Between Analog Input Pins and ADCRn Register  
(Scan Mode (Timer Trigger Scan))**

| Trigger           | Analog Input | A/D Conversion Result Register |
|-------------------|--------------|--------------------------------|
| INTCCCN interrupt | ANI0         | ADCR0                          |
|                   | ANI1         | ADCR1                          |
|                   | ANI2         | ADCR2                          |
|                   | ANI3         | ADCR3                          |
|                   | ANI4         | ADCR4                          |
|                   | ANI5         | ADCR5                          |
|                   | ANI6         | ADCR6                          |
|                   | ANI7         | ADCR7                          |

**Remark** n = 40, 41, 50, 51

**Figure 12-11. Example of Scan Mode Operation (Timer Trigger Scan) (ANI0 to ANI4)**



- (1) The ADCE bit of ADM0 is set to 1 (enable)
- (2) The CCC40 compare is generated
- (3) ANI0 is A/D converted
- (4) The conversion result is stored in ADCR0
- (5) ANI1 is A/D converted
- (6) The conversion result is stored in ADCR1
- (7) ANI2 is A/D converted
- (8) The conversion result is stored in ADCR2
- (9) ANI3 is A/D converted
- (10) The conversion result is stored in ADCR3
- (11) ANI4 is A/D converted
- (12) The conversion result is stored in ADCR4
- (13) The INTAD interrupt is generated

## 12.7 Operation in External Trigger Mode

In this mode, the conversion timing of the analog signals input to the ANI0 to ANI7 pins is specified by the ADTRG pin.

Detection of the valid edge at the ADTRG input pin is specified by using the EGA1 and EGA0 bits of the ADM1 register.

When the ADCE bit of the ADM0 register is set to 1, the A/D converter waits for an external trigger (ADTRG), and starts conversion when the valid edge of ADTRG is detected (ADCS bit = 1 in the ADM0 register). When the converter has ended conversion, it waits for the external trigger again (ADCS bit = 0).

If the valid edge is detected at the ADTRG pin during conversion, conversion is executed from the beginning again.

If data is written to the ADM0 to ADM2 registers during conversion, conversion is stopped and executed from the beginning again.

### 12.7.1 Select mode operations

In this mode, one analog input (ANI0 to ANI7) specified by the ADM2 register is A/D converted. The conversion results are stored in the ADCRn register corresponding to the analog input. In the select mode, there are two select modes: 1-buffer mode and 4-buffer mode, according to the storing method of the conversion results.

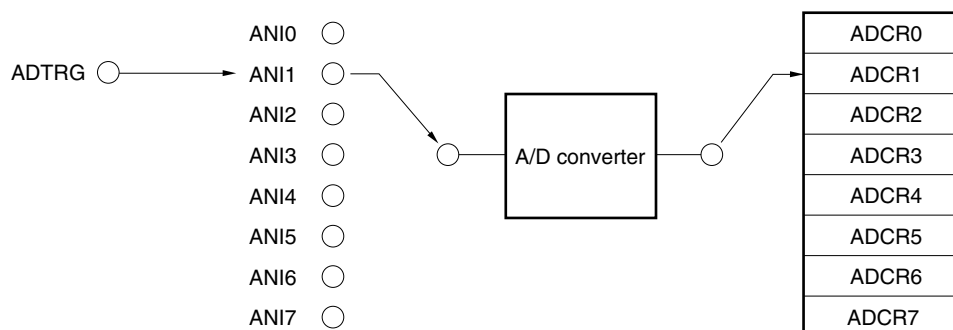
#### (1) 1-buffer mode (external trigger select: 1-buffer)

In this mode, one analog input is A/D converted using the ADTRG signal as a trigger. The conversion results are stored in one ADCRn register. The analog input and the A/D conversion results register correspond one to one. The A/D conversion end interrupt (INTAD) is generated for each A/D conversion, and A/D conversion is stopped.

| Trigger      | Analog Input | A/D Conversion Result Register |
|--------------|--------------|--------------------------------|
| ADTRG signal | ANIn         | ADCRn                          |

While the ADCE bit of the ADM0 register is 1, A/D conversion is repeated every time a trigger is input from the ADTRG pin.

This mode is most appropriate for applications in which the results are read after each A/D conversion.

**Figure 12-12. Example of 1-Buffer Mode Operation (External Trigger Select: 1 Buffer) (ANI1)**

- (1) The ADCE bit of ADM0 is set to 1 (enable)
- (2) The external trigger is generated
- (3) ANI1 is A/D converted
- (4) The conversion result is stored in ADCR1
- (5) The INTAD interrupt is generated

**(2) 4-buffer mode (external trigger select: 4 buffers)**

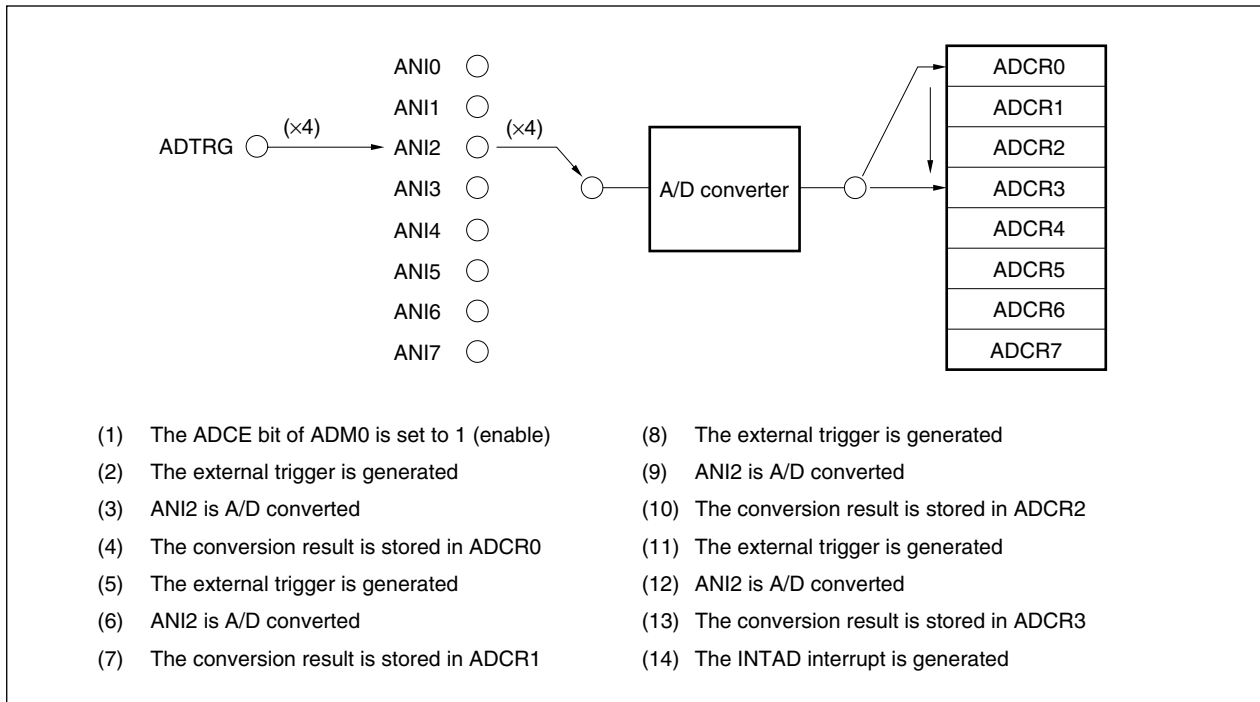
In this mode, one analog input is A/D converted four times using the ADTRG signal as a trigger and the results are stored in the ADCRn register. The A/D conversion end interrupt (INTAD) is generated and A/D conversion is stopped after the 4th A/D conversion.

| Trigger      | Analog Input | A/D Conversion Result Register |
|--------------|--------------|--------------------------------|
| ADTRG signal | ANI0 to ANI3 | ADCR0 (1st time)               |
|              |              | ADCR1 (2nd time)               |
|              |              | ADCR2 (3rd time)               |
|              |              | ADCR3 (4th time)               |
|              | ANI4 to ANI7 | ADCR4 (1st time)               |
|              |              | ADCR5 (2nd time)               |
|              |              | ADCR6 (3rd time)               |
|              |              | ADCR7 (4th time)               |

While the ADCE bit of the ADM0 register is 1, A/D conversion is repeated every time a trigger is input from the ADTRG pin.

This mode is suitable for applications in which the average of the A/D conversion results is calculated.

**Figure 12-13. Example of 4-Buffer Mode Operation (External Trigger Select: 4 Buffers) (ANI2)**



### 12.7.2 Scan mode operation

In this mode, the analog inputs specified by the ADM2 register are selected sequentially from the ANI0 pin using the ADTRG signal as a trigger, and A/D converted. The A/D conversion results are stored in the ADCRn register corresponding to the analog input ( $n = 0$  to  $7$ ).

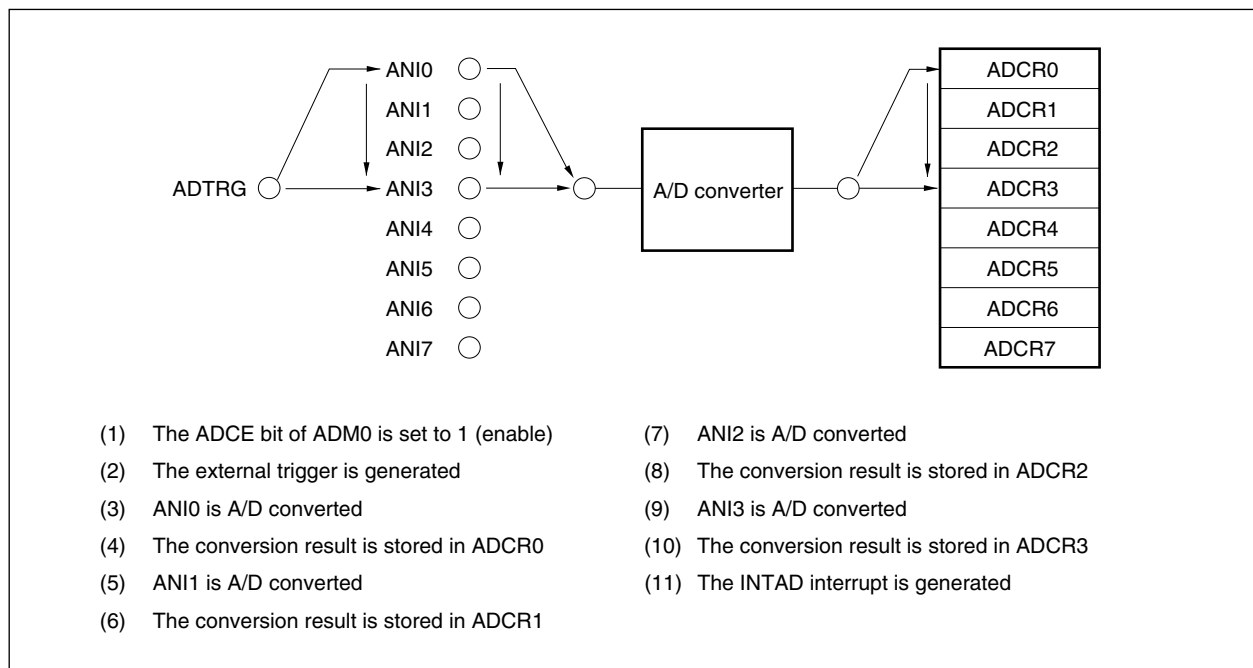
When conversion of all the specified analog inputs has ended, the A/D conversion end interrupt (INTAD) is generated. Unless the ADCE bit of the ADM0 register is cleared to 0 after end of conversion, the A/D converter waits for a trigger. The converter starts A/D conversion from the ANI0 input when a trigger is input to the ADTRG pin again.

| Trigger      | Analog Input | A/D Conversion Result Register |
|--------------|--------------|--------------------------------|
| ADTRG signal | ANI0         | ADCR0                          |
|              | ANI1         | ADCR1                          |
|              | ANI2         | ADCR2                          |
|              | ANI3         | ADCR3                          |
|              | ANI4         | ADCR4                          |
|              | ANI5         | ADCR5                          |
|              | ANI6         | ADCR6                          |
|              | ANI7         | ADCR7                          |

When a trigger is input to the ADTRG pin while the ADCE bit of the ADM0 register is 1, A/D conversion is started again.

This is most appropriate for applications in which multiple analog inputs are constantly monitored.

**Figure 12-14. Example of Scan Mode Operation (External Trigger Scan) (ANI0 to ANI3)**



## 12.8 Cautions

Cautions concerning the A/D converter are shown below.

### (1) Stopping conversion operation

When the ADCE bit of the ADM0 register is cleared to 0 during a conversion operation, the conversion operation stops and the conversion results are not stored in the ADCRn register (n = 0 to 7).

### (2) External/timer trigger interval

Set the interval (input time interval) of the trigger in the external or timer trigger mode longer than the conversion time specified by the FR3 to FR0 bits of the ADM1 register.

#### When $0 < \text{interval} \leq \text{conversion operation time}$

When the following external trigger or timer trigger is input during a conversion operation, the conversion operation is aborted and the conversion starts according to the last external trigger input or timer trigger input.

When conversion operations are aborted, the conversion results are not stored in the ADCRn register (n = 0 to 7). However, the number of times the trigger has been input is counted. When an interrupt occurs, the values that have been converted are stored in the ADCRn register.

### (3) Operation in standby mode

#### <1> HALT mode

In this mode, A/D conversion continues. When this mode is released by NMI input or unmasked maskable interrupt input (see **8.6.3 (2) Release of HALT mode**), the ADM0, ADM1, and ADM2 registers and ADCRn register hold the value (n = 0 to 7).

#### <2> IDLE mode, software STOP mode

As clock supply to the A/D converter is stopped, no conversion operations are performed.

When these modes are released by NMI input, the ADM0, ADM1, and ADM2 registers and the ADCRn register hold the value (n = 0 to 7). However, when the IDLE or software STOP mode is set during a conversion operation, the conversion operation is stopped. At this time, if the mode released by NMI input or unmasked maskable interrupt input (see **8.6.4 (2) Release of IDLE mode**, **8.6.5 (2) Release of software STOP mode**), the conversion operation resumes, but the conversion result written to the ADCRn register will become undefined.

### (4) Compare match interrupt in timer trigger mode

The compare register's match interrupt becomes an A/D conversion start trigger and starts the conversion operation. When this happens, the compare register's match interrupt also functions as a compare register match interrupt for the CPU. In order to prevent match interrupts from the compare register for the CPU, disable interrupts using the interrupt mask bits (CCC4MK0, CCC4MK1, CCC5MK0, CCC5MK1) of the interrupt control register (CCC4IC0, CCC4IC1, CCC5IC0, CCC5IC1).

### (5) Input range of ANI0 to ANI7

Use the input voltage at ANI0 to ANI7 within the specified range. If a voltage outside the range of  $AV_{REFP}$  and  $AV_{REFM}$  is input to any of these pins (even within the absolute maximum rating range), the converted value of the channel is undefined. In addition, the converted value of the other channels may also be affected.

**(6) Conflict****<1> Conflict between writing A/D conversion result registers (ADCRn, ADCRnH) at end of conversion and reading ADCRn and ADCRnH registers by instruction**

Reading the ADCRn and ADCRnH registers takes precedence. After these registers have been read, the new conversion result is written to the ADCRn and ADCRnH registers.

**<2> Conflict between writing ADCRn and ADCRnH at end of conversion and input of external trigger signal**

The external trigger signal is not accepted during A/D conversion. Therefore, it is not accepted while ADCRn and ADCRnH are being written.

**<3> Conflict between writing ADCRn and ADCRnH at end of conversion and writing A/D converter mode register 1 (ADM1) or A/D converter mode register 2 (ADM2)**

If ADM1 or ADM2 is written immediately after ADCRn and ADCRnH have been written on completion of A/D conversion, the conversion result is written to the ADCRn and ADCRnH registers, but the A/D conversion end interrupt (INTAD) may not occur depending on the timing.

**<R> (7) Absolute precision**

The specified value of absolute precision is an attribute of microcontroller units, and is a value which is not effected by the setup environment (e.g., effects of noise, board wiring). In order to suppress degradation of absolute precision due to the setup environment, sufficient attention should be paid to board layouts, such as by isolating AV<sub>DD</sub> and AV<sub>SS</sub> from digital power supplies and by ensuring that the analog input pins (ANI0 to ANI7) are not effected by digital signals.

**<R> (8) Conversion results when a fixed A/D converter input voltage is subjected to A/D conversion more than once in the same channel**

When a fixed A/D converter input voltage is subjected to A/D conversion more than once in the same channel, although the same conversion results can theoretically be obtained in an ideal environment (in which the power supply voltage, analog input voltage, ambient temperature, etc. are stable), in reality, since there are influences such as changes in the power supply voltage, analog input voltage, ambient temperature, etc. due to noise, conversion results are not the same.

This phenomenon is particularly appeared due to extremely minute environment influences occurring when an analog input voltage is near the change point of a digital value.

**<R> (9) Noise countermeasures**

If there is noise at the analog input pins (ANI0 to ANI7) or at the reference voltage input pins (AV<sub>REFP</sub>, AV<sub>REFM</sub>), an illegal conversion result may be generated due to that noise.

Software processing will be needed to avoid a negative effect on the system from this illegal conversion result.

An example of this software processing is shown below.

- Take the average value of multiple A/D conversion results and use this value as the A/D conversion result.
- If exceptional results are obtained after the continuous multiple A/D conversions, use the conversion results omitting these exceptional results.
- If an A/D conversion result which can be judged that a system abnormality has occurred is obtained, do not attempt to overcome the abnormality right away, but handle the abnormality after checking the abnormality occurrence again.



&lt;R&gt;

**(10) Coupling noise**

When digital pulses are applied to the pins or pins are used as digital buffer output pins during A/D conversion, A/D conversion values may not be obtained as expected, due to coupling noise.

&lt;R&gt;

**(11) Cautions on board design**

As a constraint derived from electric potential fluctuations due to common impedance and inductance, digital and analog signals should be isolated as much as possible as the circuit board design. Crossing and bringing into close proximity of digital and analog signals should also be avoided as much as possible.

Connect the AV<sub>SS</sub> pin at one point to a stable ground.

&lt;R&gt;

**(12) AV<sub>REFP</sub> and AV<sub>REFM</sub> pins**

When the impedance of the unit supplying power to the AV<sub>REFP</sub> and AV<sub>REFM</sub> pins is high or the capacity to supply current from the power supply is low, there is a risk of the reference voltage changing and the conversion accuracy deteriorating. Connecting a capacitor between the AV<sub>REFP</sub> and AV<sub>SS</sub> pins and between the AV<sub>REFM</sub> and AV<sub>SS</sub> pins is recommended to avoid this problem.

&lt;R&gt;

**(13) Bypass capacitor connection**

The bypass capacitor to be connected to the AV<sub>DD</sub>, AV<sub>REFP</sub>, and AV<sub>REFM</sub> pins should be connected as closely as possible to the device, using a capacitor with high-frequency characteristics, such as a chip capacitor.

&lt;R&gt;

**(14) Stabilization time for re-conversion operations**

If the A/D control register is written or the external/timer trigger is input during A/D stabilization, the time needed for re-conversion operations to stabilize may increase.

## 12.9 How to Read A/D Converter Characteristics Table

Here, special terms unique to the A/D converter are explained.

### (1) Resolution

This is the minimum analog input voltage that can be identified. That is, the percentage of the analog input voltage per bit of digital output is called 1LSB (Least Significant Bit). The percentage of 1LSB with respect to the full scale is expressed by %FSR (Full Scale Range). %FSR indicates the ratio of analog input voltage that can be converted as a percentage, and is always represented by the following formula regardless of the resolution.

$$\begin{aligned} 1\%FSR &= (\text{Max. value of analog input voltage that can be converted} - \text{Min. value of analog input voltage that can be converted})/100 \\ &= (AV_{REFP} - AV_{REFM})/100 \end{aligned}$$

1LSB is as follows when the resolution is 10 bits.

$$\begin{aligned} 1\text{LSB} &= 1/2^{10} = 1/1024 \\ &= 0.098\%FSR \end{aligned}$$

Accuracy has no relation to resolution, but is determined by overall error.

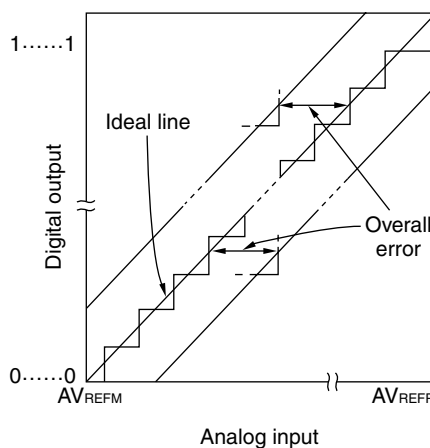
### (2) Overall error

This shows the maximum error value between the actual measured value and the theoretical value.

Zero-scale error, full-scale error, linearity error and errors that are combinations of these express the overall error.

Note that the quantization error is not included in the overall error in the characteristics table.

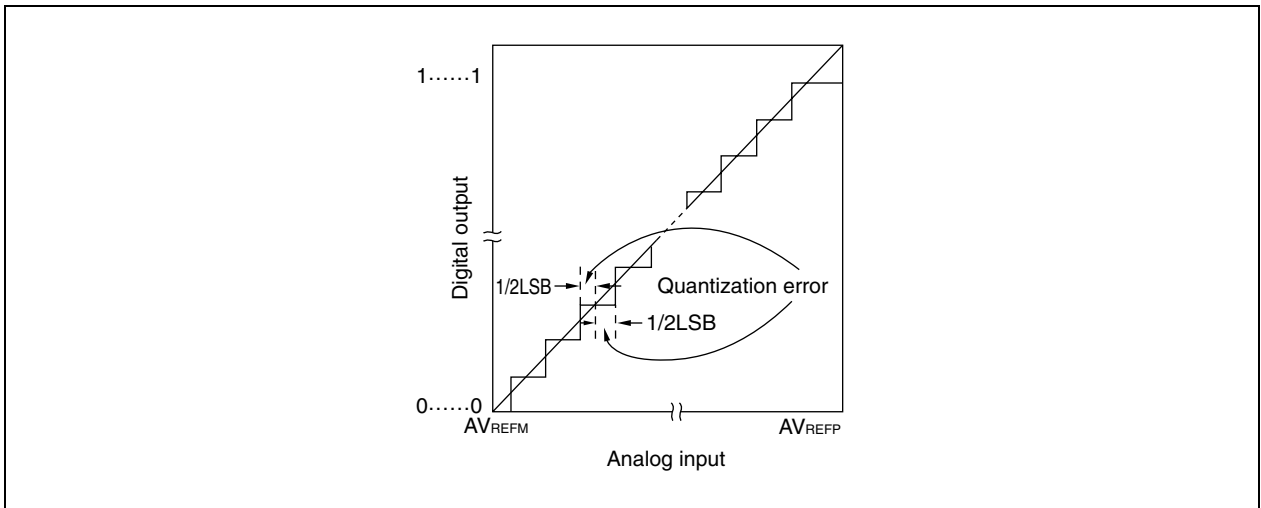
Figure 12-15. Overall Error



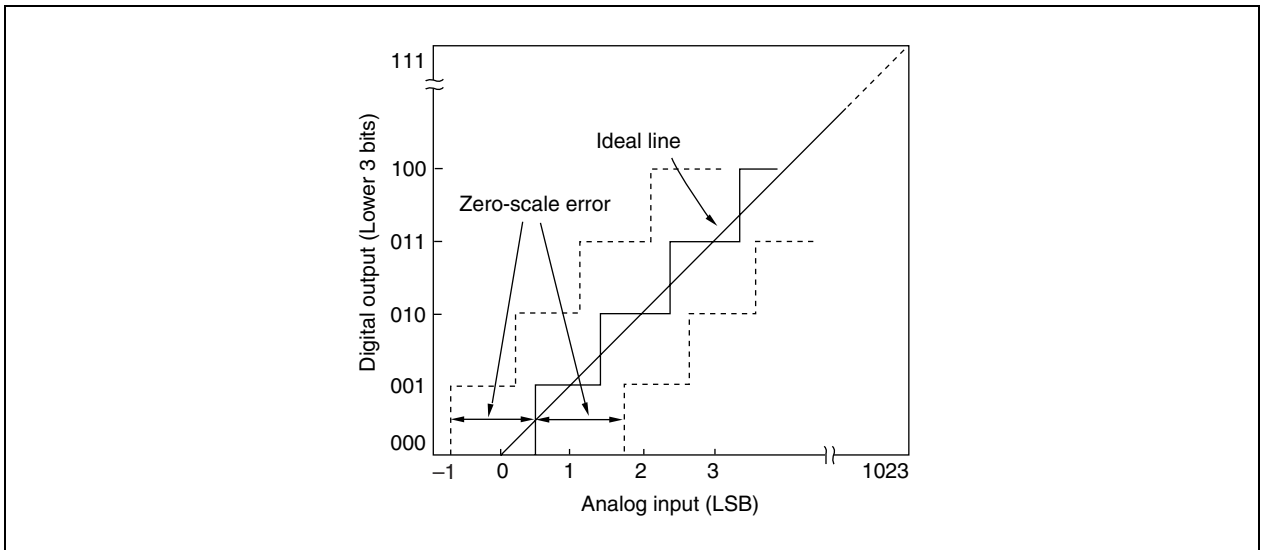
**(3) Quantization error**

When analog values are converted to digital values, a  $\pm 1/2\text{LSB}$  error naturally occurs. In an A/D converter, an analog input voltage in a range of  $\pm 1/2\text{LSB}$  is converted to the same digital code, so a quantization error cannot be avoided.

Note that the quantization error is not included in the overall error, zero-scale error, full-scale error, integral linearity error, and differential linearity error in the characteristics table.

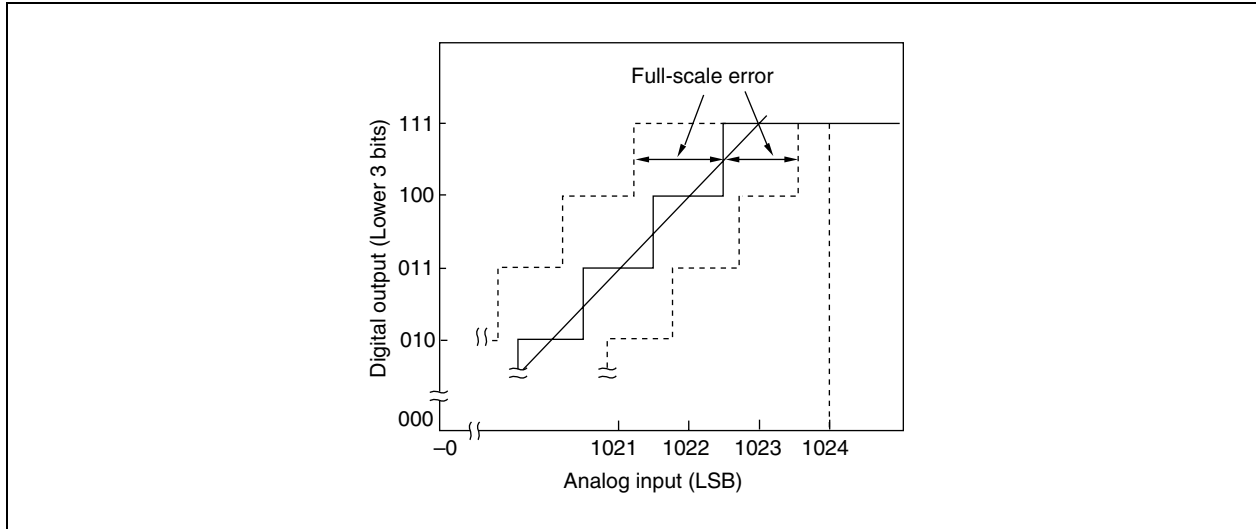
**Figure 12-16. Quantization Error****(4) Zero-scale error**

This shows the difference between the actual measurement value of the analog input voltage and the theoretical value ( $1/2\text{LSB}$ ) when the digital output changes from 0.....000 to 0.....001.

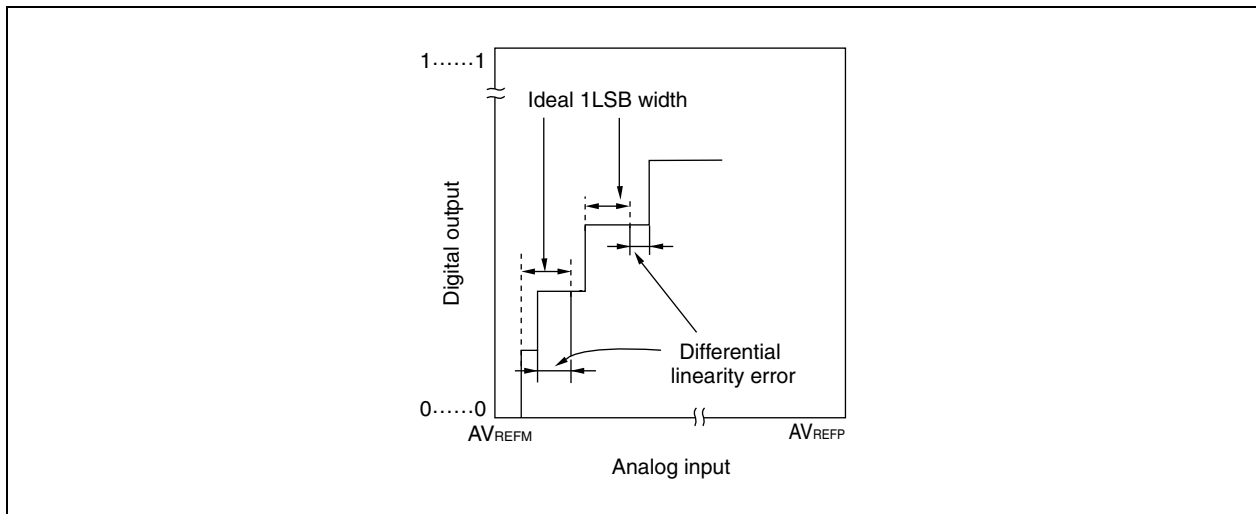
**Figure 12-17. Zero-Scale Error**

**(5) Full-scale error**

This shows the difference between the actual measurement value of the analog input voltage and the theoretical value ( $3/2\text{LSB}$ ) when the digital output changes from 1.....110 to 1.....111.

**Figure 12-18. Full-Scale Error****(6) Differential linearity error**

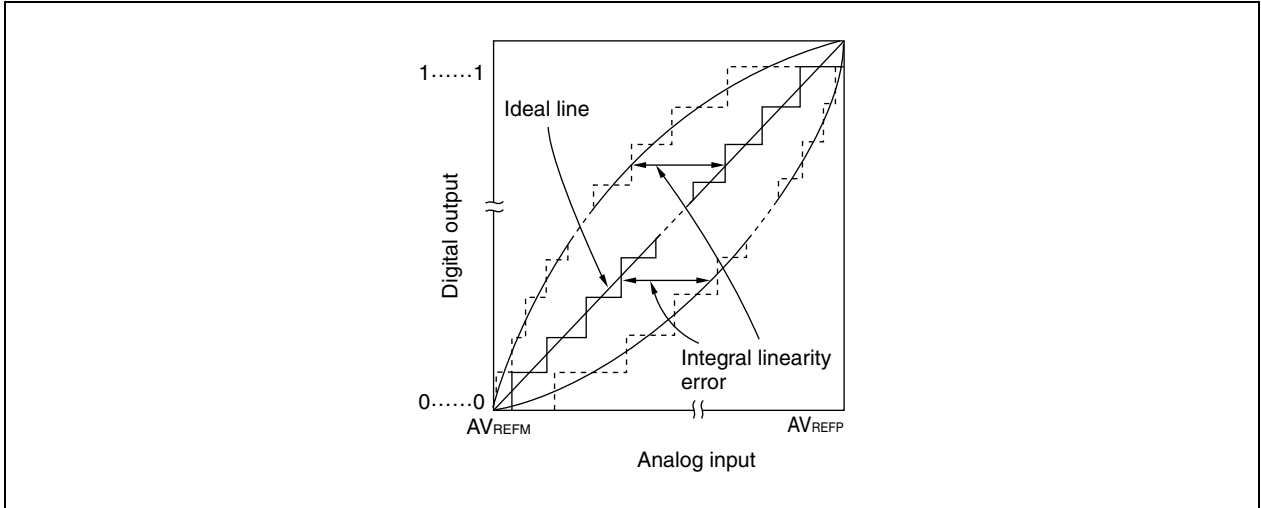
While the ideal width of code output is 1LSB, this indicates the difference between the actual measurement value and the ideal value.

**Figure 12-19. Differential Linearity Error**

**(7) Integral linearity error**

This shows the degree to which the conversion characteristics deviate from the ideal linear relationship. It expresses the maximum value of the difference between the actual measurement value and the ideal straight line when the zero-scale error and full-scale error are 0.

**Figure 12-20. Integral Linearity Error**



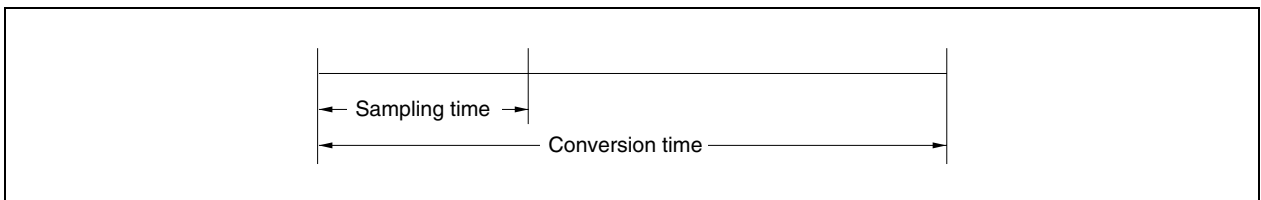
**(8) Conversion time**

This expresses the time from when a trigger was generated to the time when the digital output was obtained. The sampling time is included in the conversion time in the characteristics table.

**(9) Sampling time**

This is the time the analog switch is turned on for the analog voltage to be sampled by the sample & hold circuit.

**Figure 12-21. Sampling Time**



## CHAPTER 13 PWM UNIT

### 13.1 Features

- PWMn: 2 channels
- 12- to 16-bit accuracy selectable
- Minimization of low-pass filter size due to main pulse + ancillary pulse configuration
  - Main pulse 4/5/6/7/8 bits
  - Ancillary pulse 8 bits
- Repeat frequency: 129 kHz to 2 MHz ( $f_{\text{PWMC}} = 33 \text{ MHz}$ )
- Selecting pulse width rewrite period: Every 1 pulse/256 pulses
- Active level of PWM output pulse selectable
- PWM operating clock ( $f_{\text{PWMC}}$ ):  $f_x/4$ ,  $f_x/8$ ,  $f_x/16$ , or  $f_x/32$  selectable

**Remarks 1.**  $n = 0, 1$

**2.**  $f_{\text{PWMC}}$ : PWM operating clock

$f_x$ : Main clock

### 13.2 Configuration

PWMn has a PWM output configuration of 256 main pulses and sets the active-level width using modulo H register n.

#### (1) Prescaler

The prescaler divides  $f_x$  to generate the PWM operating clock ( $f_{\text{PWMC}}$ ). The output frequency of the prescaler can be selected from  $f_x/4$ ,  $f_x/8$ ,  $f_x/16$ , and  $f_x/32$ , by using the CKSPn1 and CKSPn0 bits of the PWMCn register ( $n = 0, 1$ ).

#### (2) Reload controller

The reload controller controls reloading of the modulo register value.

The reload timing (PWM pulse width rewrite period) can be selected from  $2^x/f_{\text{PWMC}}$  or  $2^{x+8}/f_{\text{PWMC}}$  by using the SYNn bit of the PWMCn register ( $n = 0, 1$ ,  $x = 4$  to 8 (main pulse bit length)).

#### (3) Main pulse generator/output controller

This circuit controls the output timing of the main pulse.

It generates the main pulse from the reload signal generated by the reload controller, according to the value of modulo H register n ( $n = 0, 1$ ).

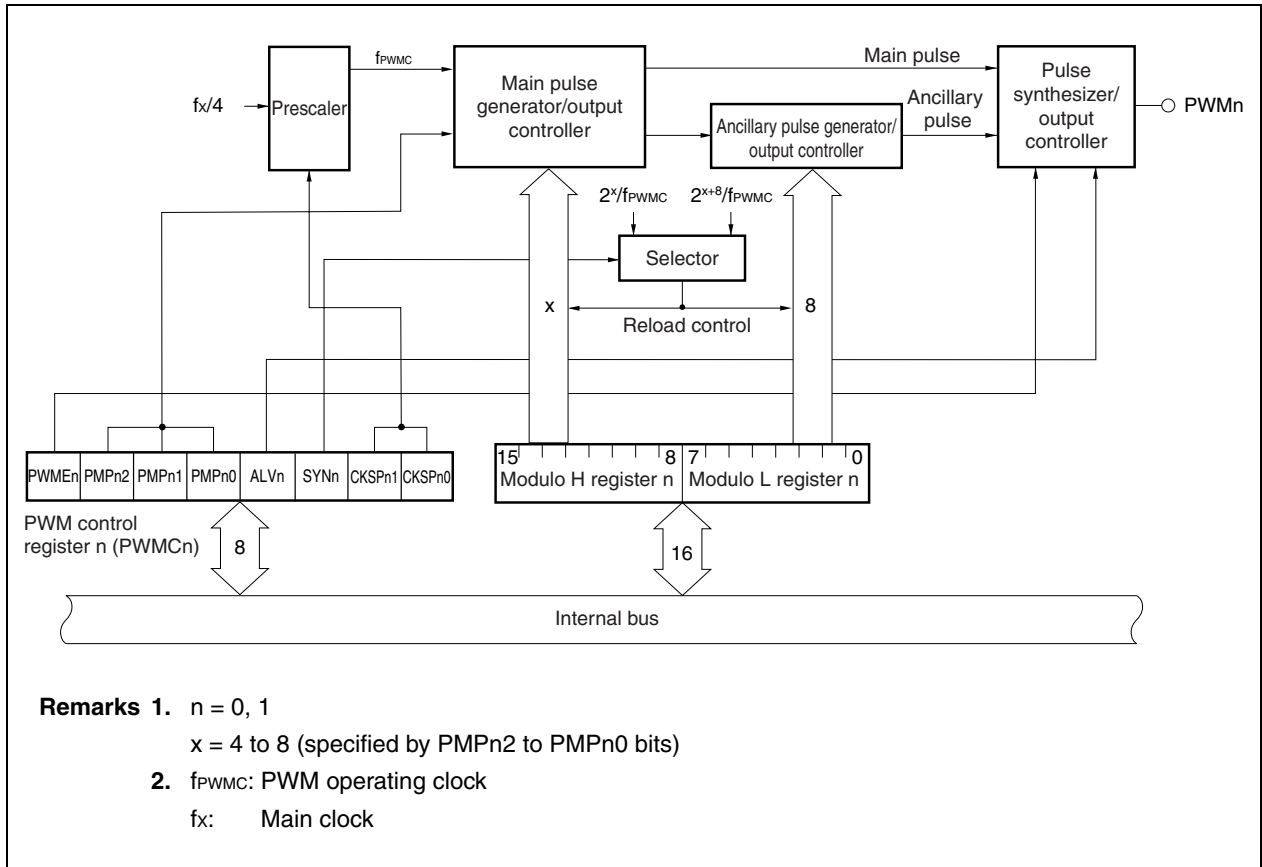
#### (4) Ancillary pulse generator/output controller

This circuit controls the output timing of the ancillary pulse.

It generates an ancillary pulse from the reload signal generated by the reload controller, according to the value of modulo L register n ( $n = 0, 1$ ).

**(5) Pulse synthesizer/output controller**

This circuit controls the timing of the PWM pulse signal output by synthesizing the main pulse and ancillary pulse.

**Figure 13-1. Block Diagram of PWM Unit**

### 13.3 Control Registers

#### (1) PWM control registers 0 and 1 (PWMC0 and PWMC1)

PWMCn is a register that controls PWMn (n = 0, 1).

These registers can be read or written in 8-bit or 1-bit units.

- Cautions**
1. Do not change the setting of the PMPn2 to PMPn0, SYNn, CKSPn1, and CKSPn0 bits during PWM operation (when PWMCn bit = 1); otherwise the operation cannot be guaranteed.
  2. Note that, if the setting of the ALVn bit is changed during PWM operation (when PWMCn bit = 1), noise may be generated.



|       |       |       |       |       |      |      |        |        |           |             |
|-------|-------|-------|-------|-------|------|------|--------|--------|-----------|-------------|
|       | 7     | 6     | 5     | 4     | 3    | 2    | 1      | 0      | Address   | After reset |
| PWMC0 | PWME0 | PMP02 | PMP01 | PMP00 | ALV0 | SYN0 | CKSP01 | CKSP00 | FFFFFB00H | 08H         |
| PWMC1 | PWME1 | PMP12 | PMP11 | PMP10 | ALV1 | SYN1 | CKSP11 | CKSP10 | FFFFFB10H | 08H         |

| Bit position     | Bit name       | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                |                           |                                      |                                                |                       |                   |   |   |                   |                           |   |                    |   |        |                           |   |   |   |        |                          |   |   |   |        |                          |   |   |   |        |                          |                  |  |  |                    |  |
|------------------|----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------|---------------------------|--------------------------------------|------------------------------------------------|-----------------------|-------------------|---|---|-------------------|---------------------------|---|--------------------|---|--------|---------------------------|---|---|---|--------|--------------------------|---|---|---|--------|--------------------------|---|---|---|--------|--------------------------|------------------|--|--|--------------------|--|
| 7                | PWMEn          | This bit enables or disables the operation of PWMn.<br>0: Disables PWM operation.<br>Outputs the inactive level as PWM output (PWMn).<br>1: Enables PWM operation.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                |                           |                                      |                                                |                       |                   |   |   |                   |                           |   |                    |   |        |                           |   |   |   |        |                          |   |   |   |        |                          |   |   |   |        |                          |                  |  |  |                    |  |
| 6 to 4           | PMPn2 to PMPn0 | <div>These bits specify the number of main pulse length specification bits and the main pulse length.</div> <table><tr><th>PMPn2</th><th>PMPn1</th><th>PMPn0</th><th>Number of main pulse length specification bits</th><th>Main pulse bit length</th></tr><tr><td>0</td><td>0</td><td>0</td><td>8 bits</td><td>2<sup>8</sup> (256 bits)</td></tr><tr><td>0</td><td>0</td><td>1</td><td>7 bits</td><td>2<sup>7</sup> (128 bits)</td></tr><tr><td>0</td><td>1</td><td>0</td><td>6 bits</td><td>2<sup>6</sup> (64 bits)</td></tr><tr><td>0</td><td>1</td><td>1</td><td>5 bits</td><td>2<sup>5</sup> (32 bits)</td></tr><tr><td>1</td><td>0</td><td>0</td><td>4 bits</td><td>2<sup>4</sup> (16 bits)</td></tr><tr><td colspan="3">Other than above</td><td colspan="2">Setting prohibited</td></tr></table> | PMPn2                                          | PMPn1                     | PMPn0                                | Number of main pulse length specification bits | Main pulse bit length | 0                 | 0 | 0 | 8 bits            | 2 <sup>8</sup> (256 bits) | 0 | 0                  | 1 | 7 bits | 2 <sup>7</sup> (128 bits) | 0 | 1 | 0 | 6 bits | 2 <sup>6</sup> (64 bits) | 0 | 1 | 1 | 5 bits | 2 <sup>5</sup> (32 bits) | 1 | 0 | 0 | 4 bits | 2 <sup>4</sup> (16 bits) | Other than above |  |  | Setting prohibited |  |
| PMPn2            | PMPn1          | PMPn0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Number of main pulse length specification bits | Main pulse bit length     |                                      |                                                |                       |                   |   |   |                   |                           |   |                    |   |        |                           |   |   |   |        |                          |   |   |   |        |                          |   |   |   |        |                          |                  |  |  |                    |  |
| 0                | 0              | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 8 bits                                         | 2 <sup>8</sup> (256 bits) |                                      |                                                |                       |                   |   |   |                   |                           |   |                    |   |        |                           |   |   |   |        |                          |   |   |   |        |                          |   |   |   |        |                          |                  |  |  |                    |  |
| 0                | 0              | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 7 bits                                         | 2 <sup>7</sup> (128 bits) |                                      |                                                |                       |                   |   |   |                   |                           |   |                    |   |        |                           |   |   |   |        |                          |   |   |   |        |                          |   |   |   |        |                          |                  |  |  |                    |  |
| 0                | 1              | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 6 bits                                         | 2 <sup>6</sup> (64 bits)  |                                      |                                                |                       |                   |   |   |                   |                           |   |                    |   |        |                           |   |   |   |        |                          |   |   |   |        |                          |   |   |   |        |                          |                  |  |  |                    |  |
| 0                | 1              | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 5 bits                                         | 2 <sup>5</sup> (32 bits)  |                                      |                                                |                       |                   |   |   |                   |                           |   |                    |   |        |                           |   |   |   |        |                          |   |   |   |        |                          |   |   |   |        |                          |                  |  |  |                    |  |
| 1                | 0              | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 4 bits                                         | 2 <sup>4</sup> (16 bits)  |                                      |                                                |                       |                   |   |   |                   |                           |   |                    |   |        |                           |   |   |   |        |                          |   |   |   |        |                          |   |   |   |        |                          |                  |  |  |                    |  |
| Other than above |                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Setting prohibited                             |                           |                                      |                                                |                       |                   |   |   |                   |                           |   |                    |   |        |                           |   |   |   |        |                          |   |   |   |        |                          |   |   |   |        |                          |                  |  |  |                    |  |
| 3                | ALVn           | This bit specifies the active level of PWMn.<br>0: Active low<br>1: Active high<br>At reset, the inactive level of the ALVn bit (low level) is output as PWM output.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                |                           |                                      |                                                |                       |                   |   |   |                   |                           |   |                    |   |        |                           |   |   |   |        |                          |   |   |   |        |                          |   |   |   |        |                          |                  |  |  |                    |  |
| 2                | SYNn           | This bit specifies the period during which the pulse width of PWMn is to be rewritten.<br>0: Long period (every 256 PWM cycles (2 <sup>x+8</sup> /f <sub>PWMC</sub> ))<br>1: Short period (every 1 PWM cycle (2 <sup>x</sup> /f <sub>PWMC</sub> ))                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                |                           |                                      |                                                |                       |                   |   |   |                   |                           |   |                    |   |        |                           |   |   |   |        |                          |   |   |   |        |                          |   |   |   |        |                          |                  |  |  |                    |  |
| 1, 0             | CKSPn1, CKSPn0 | <div>These bits specify the operating clock of PWMn (f<sub>PWMC</sub>).</div> <table><tr><th>CKSPn1</th><th>CKSPn0</th><th>Operating clock (f<sub>PWMC</sub>)</th></tr><tr><td>0</td><td>0</td><td>f<sub>x</sub>/4</td></tr><tr><td>0</td><td>1</td><td>f<sub>x</sub>/8</td></tr><tr><td>1</td><td>0</td><td>f<sub>x</sub>/16</td></tr><tr><td>1</td><td>1</td><td>f<sub>x</sub>/32</td></tr></table>                                                                                                                                                                                                                                                                                                                                                                                                    | CKSPn1                                         | CKSPn0                    | Operating clock (f <sub>PWMC</sub> ) | 0                                              | 0                     | f <sub>x</sub> /4 | 0 | 1 | f <sub>x</sub> /8 | 1                         | 0 | f <sub>x</sub> /16 | 1 | 1      | f <sub>x</sub> /32        |   |   |   |        |                          |   |   |   |        |                          |   |   |   |        |                          |                  |  |  |                    |  |
| CKSPn1           | CKSPn0         | Operating clock (f <sub>PWMC</sub> )                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                |                           |                                      |                                                |                       |                   |   |   |                   |                           |   |                    |   |        |                           |   |   |   |        |                          |   |   |   |        |                          |   |   |   |        |                          |                  |  |  |                    |  |
| 0                | 0              | f <sub>x</sub> /4                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                |                           |                                      |                                                |                       |                   |   |   |                   |                           |   |                    |   |        |                           |   |   |   |        |                          |   |   |   |        |                          |   |   |   |        |                          |                  |  |  |                    |  |
| 0                | 1              | f <sub>x</sub> /8                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                |                           |                                      |                                                |                       |                   |   |   |                   |                           |   |                    |   |        |                           |   |   |   |        |                          |   |   |   |        |                          |   |   |   |        |                          |                  |  |  |                    |  |
| 1                | 0              | f <sub>x</sub> /16                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                |                           |                                      |                                                |                       |                   |   |   |                   |                           |   |                    |   |        |                           |   |   |   |        |                          |   |   |   |        |                          |   |   |   |        |                          |                  |  |  |                    |  |
| 1                | 1              | f <sub>x</sub> /32                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                |                           |                                      |                                                |                       |                   |   |   |                   |                           |   |                    |   |        |                           |   |   |   |        |                          |   |   |   |        |                          |   |   |   |        |                          |                  |  |  |                    |  |

- Remarks**
- $n = 0, 1$   
 $x = 4$  to 8 (specified by PMPn2 to PMPn0 bits)
  - $f_x$ : Main clock

**(2) PWM modulo registers 0 and 1 (PWM0 and PWM1)**

These 16-bit registers determine the pulse width of the PWM pulse.

These registers can be read or written in 16-bit units.

If the higher 8 bits of the PWMn register are used as a PWMHn register and the lower 8 bits are used as a PWMLn register, these registers can be read or written in 8-bit units.

**<1> Modulo H register n (PWMHn): Bits 15 to 8**

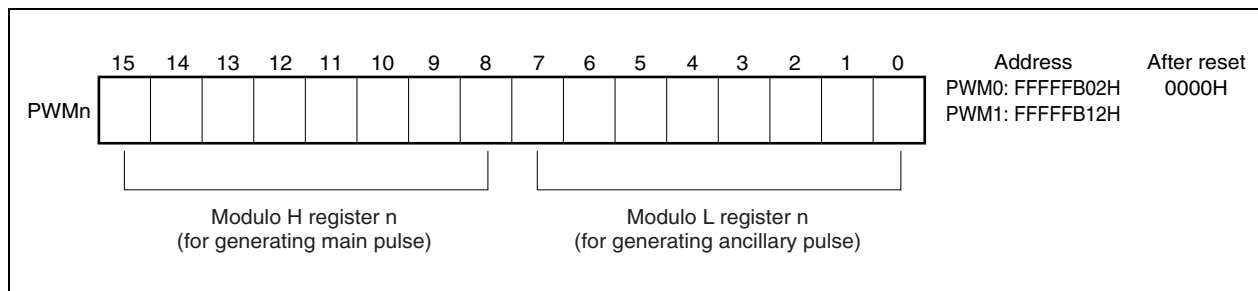
This register specifies the active level of the main pulse.

The data of the active level width of only the bit length specified by the PMPn2 to PMPn0 bits of the PWMCn register is valid. If the counter length is set to 4 to 7 bits by the PMPn2 to PMPn0 bits, data input to the higher bits is invalid.

**<2> Modulo L register n (PWMLn): Bits 7 to 0**

This register adjusts the timing of the ancillary pulse for fine tuning (see **Figure 13-2**).

A value of 0000H to FFFFH can be set to the PWMn register, and the PWM output changed linearly. If a value of 0000H is set, the inactive level is held. If the value is FFFFH, the PWM output becomes inactive for one ancillary pulse ( $1/f_{PWM}$ ) in one rewrite cycle ( $2^{16}/f_{PWM}$ ) (see **Figure 13-3**).



## 13.4 Operation

### 13.4.1 PWM basic operation

PWMn is divided into 256 parts, each of which is called a main pulse. Each main pulse has 4- to 8-bit accuracy. PWMn realizes a signal with an accuracy of 12 to 16 bits by synthesizing the required number of main pulses and an ancillary pulse with a pulse width of one clock.

The main pulse is set by the PMPn2 to PMPn0 bits of PWM control register n (PWMCn), and the pulse width is determined by the value of modulo H register n (valid number of bits). The repeat cycle of the PWM pulse output is the operating clock cycle ( $f_{PWMC}$ ) of PWMn specified by the CKSPn1 and CKSPn0 bits of the PWMCn register divided by  $2^x$  ( $f_{PWMC}/2^x$ ).

Of the 256 main pulses, the ancillary pulses are generated only for the main pulses of the set number specified by modulo L register n. The pulse width is  $1/f_{PWMC}$ .

The logical sum of the main pulse and the ancillary pulse is output as the PWM pulse signal. Therefore, the average value of 256 PWM pulse signals is the PWM pulse signal with a resolution of 12 to 16 bits.

The duty factor of the output PWM pulse is determined as follows, by the value set to modulo H register n of PWM modulo register n (PWM0 or PWM1).

#### (1) If ancillary pulse is not generated

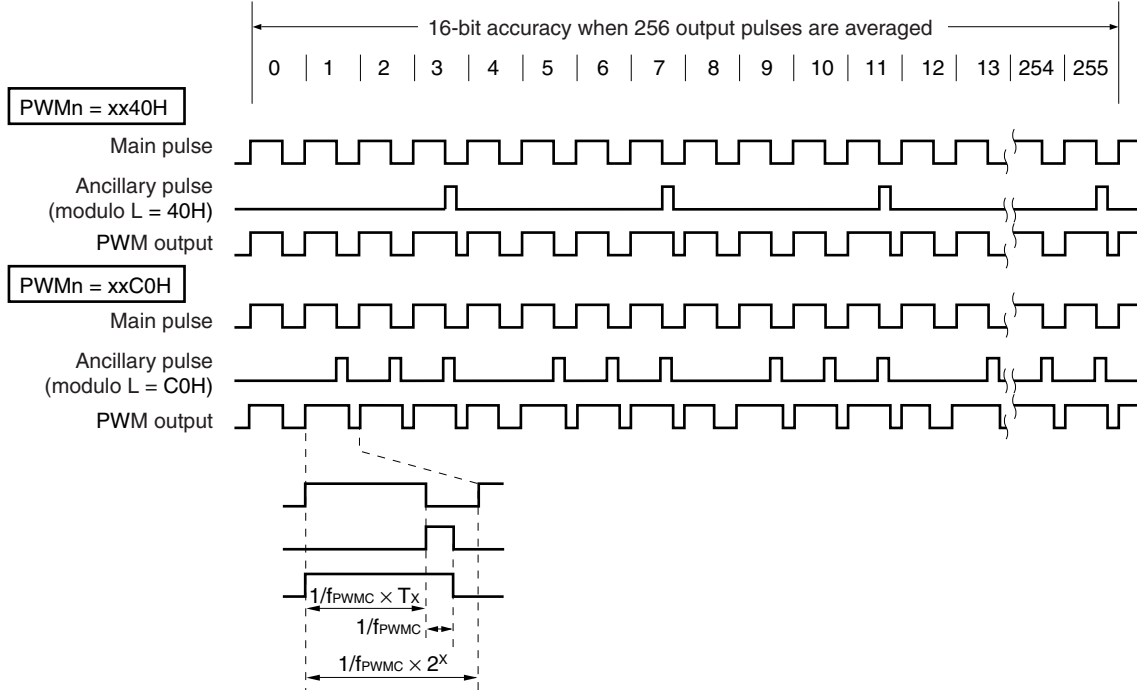
$$\text{Duty of output PWM pulse} = \frac{(\text{Value of modulo H register n})}{2^x}$$

#### (2) If ancillary pulse is generated

$$\text{Duty of output PWM pulse} = \frac{(\text{Value of modulo H register n}) + 1}{2^x}$$

**Remark**  $x = 4$  to  $8$  (bit length of main pulse)

Figure 13-2. Example of PWM Output with Main Pulse and Ancillary Pulse



**Remarks 1.**  $n = 0, 1$

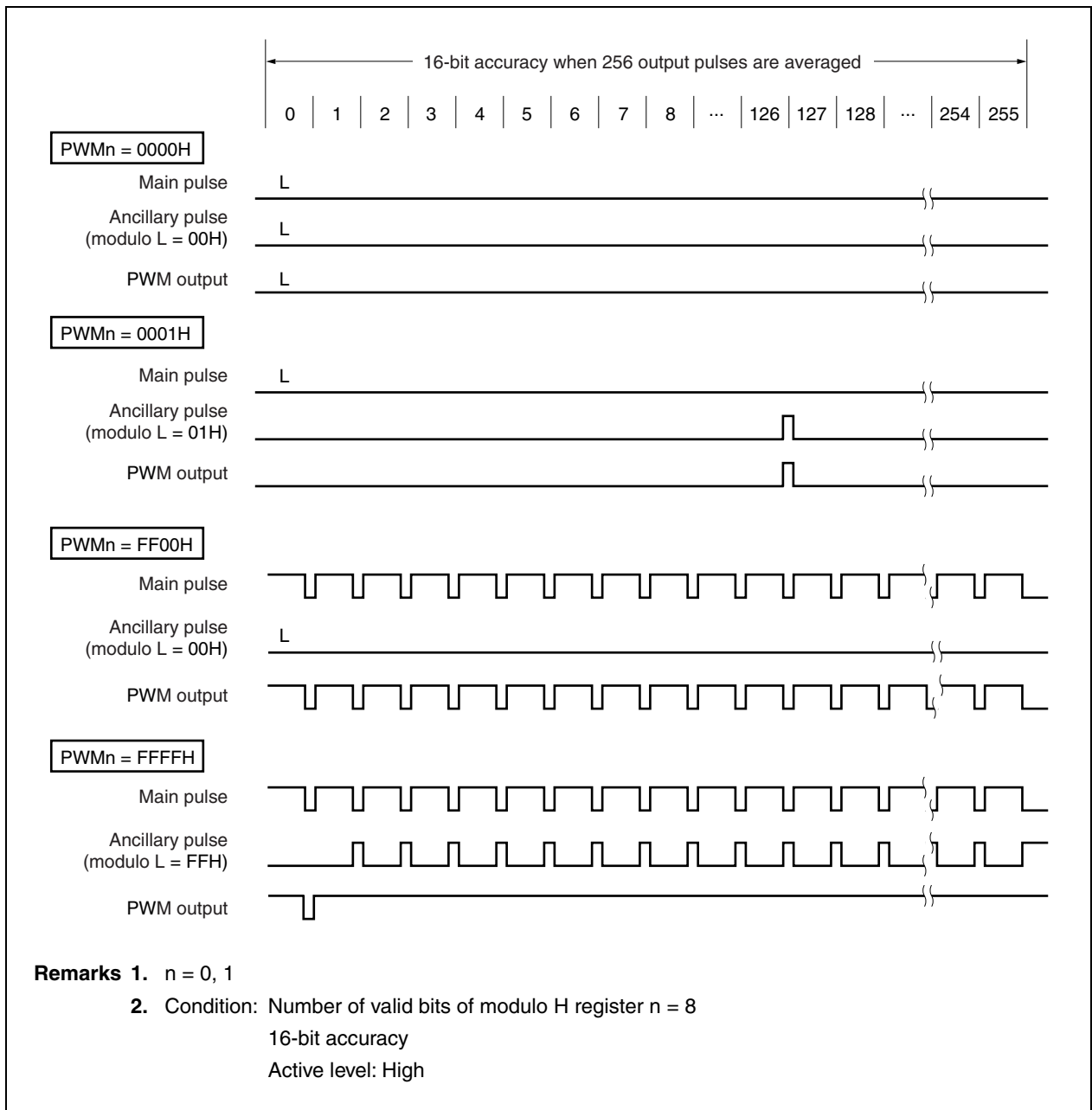
**2.**  $f_{PWMC}$ : PWM operating clock

$T_x$ : Value of modulo H register n

$x$ : Number of valid bits of modulo H register n (specified by PMPn2 to PMPn0 bits of PWMCn register)

Active level: High

Figure 13-3. Example of PWM Output Operation



### 13.4.2 Starting/stopping PWM operation

To output a PWM pulse, set data to PWM modulo register  $n$  (PWM $n$ ) and then set the PWME $n$  bit of PWM control register  $n$  (PWMC $n$ ) to 1 ( $n = 0, 1$ ).

As a result, the PWM output pin outputs a PWM pulse of the active level specified by the ALV $n$  bit of the PWMC $n$  register.

When the PWME $n$  bit of the PWMC $n$  register is cleared to 0, the PWM output unit immediately stops the PWM output operation, and the PWM output pin becomes inactive.

#### (1) Setting for starting PWM operation

Before starting the operation of PWM $n$  (when PWME $n$  bit of PWMC $n$  register = 0), be sure to initialize the following registers.

- PMCDH, PFCDH registers: Set the control mode.
- PWM $n$  register: Set the pulse width.
- PWMC $n$  register:
  - CKSP $n$ 1 and CKSP $n$ 0 bits: Specify the operating clock ( $f_{\text{PWMC}}$ ) ( $f_x/4$ ,  $f_x/8$ ,  $f_x/16$ ,  $f_x/32$ )
  - PMP $n$ 2 to PMP $n$ 0 bits: Specify the bit length ( $x$ ) of the main pulse.
  - ALV $n$  bit: Specify the active level of the PWM pulse.
  - SYN $n$  bit: Specify the PWM pulse width rewrite period.

**Cautions 1.** Do not change the setting of the PMP $n$ 2 to PMP $n$ 0, SYN $n$ , CKSP $n$ 1, and CKSP $n$ 0 bits when PWME $n$  bit of the PWMC $n$  register = 1; otherwise the operation cannot be guaranteed.

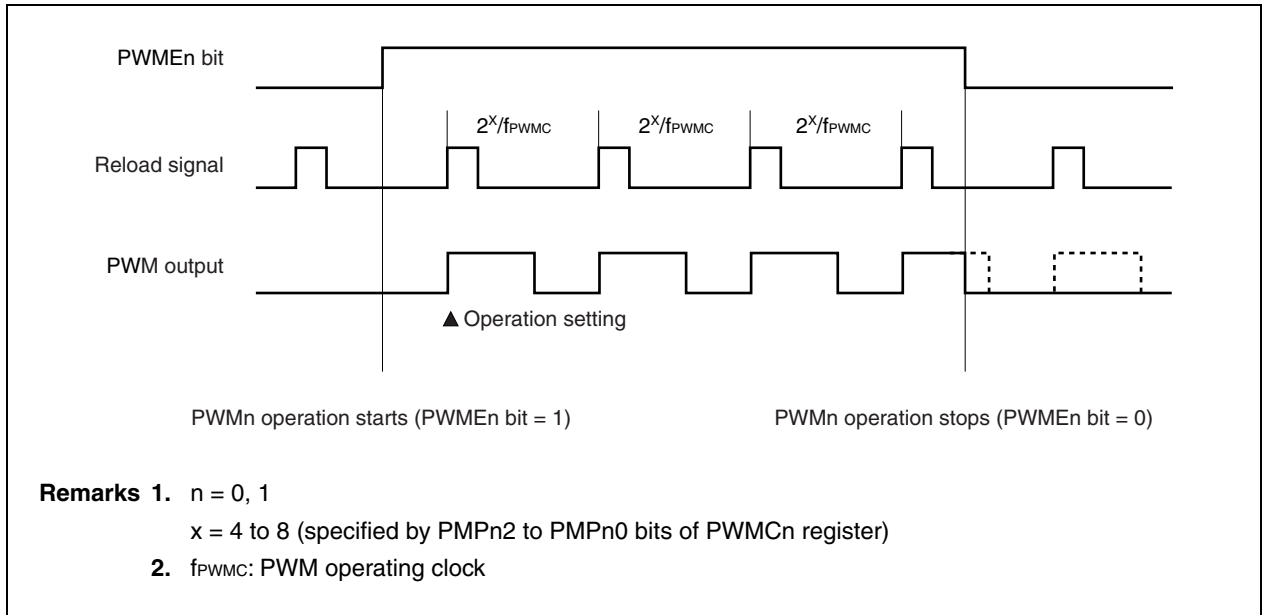
**2.** Note that, if the setting of the ALV $n$  bit is changed during PWM operation (when PWME $n$  bit = 1), noise may be generated.

**Remark**  $n = 0, 1$

When the PWME $n$  bit of the PWMC $n$  register is set, PWM $n$  starts operating. Immediately after PWM $n$  has started operating, however, the PWM pin maintains the status of the port mode (inactive level) until the reload signal of the PWM $n$  register is generated. After the operation has been started, the PWM output becomes active when the reload signal is generated, regardless of the setting of the SYN $n$  bit (PWM $n$  = other than 00xxH). If the timing of rewriting the pulse width is set to  $2^{x+8}$  (long period: SYN $n$  bit = 0), the operation is started up to  $2^{x+8}/f_{\text{PWMC}}$  after the PWME $n$  bit has been set. The PWM $n$  register can be rewritten even during PWM output.

**(2) Setting for stopping PWM operation**

When the PWME<sub>n</sub> bit of the PWMC<sub>n</sub> register ( $n = 0, 1$ ) is cleared to 0, the PWM operation is immediately stopped, and the PWM output becomes inactive immediately.

**Figure 13-4. PWM Operation Timing**

### 13.4.3 Setting active level of PWM pulse

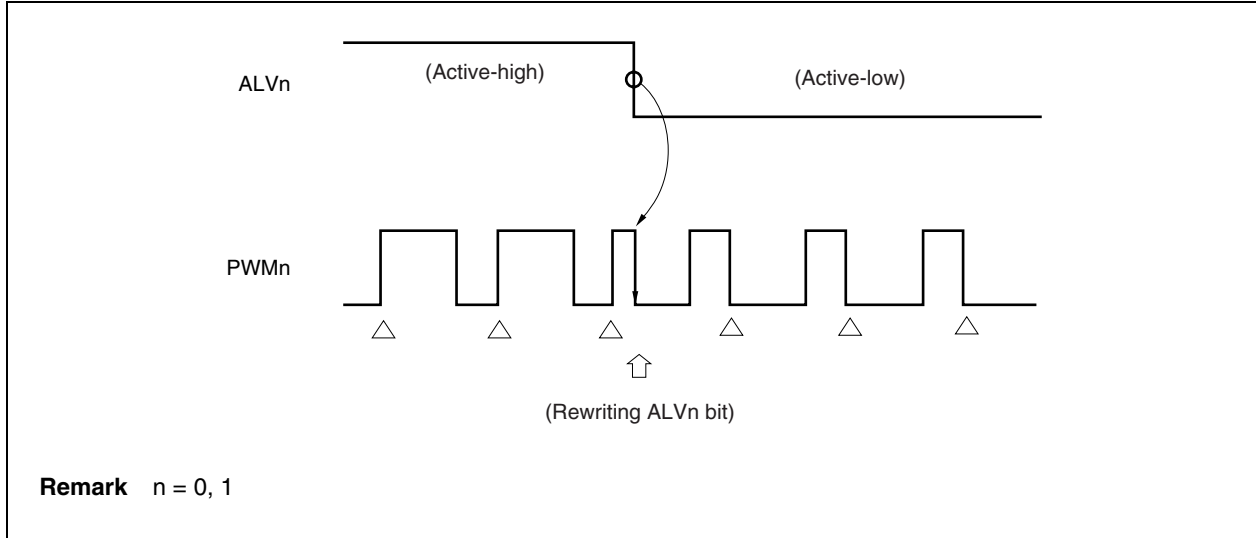
The ALVn bit of PWM control register n (PWMCn) specifies the active level of the PWM pulse output from the PWM output pin (n = 0, 1).

If the ALVn bit is set to 1, an active-high pulse is output; if it is cleared to 0, an active-low pulse is output.

If the ALVn bit is rewritten, the active level of PWM output is immediately changed. The figure below shows the setting of the active level of PWM output and pin status.

Regardless of the setting of the PWME<sub>n</sub> bit (which enables or disables PWM), the active level of PWM output can be changed by manipulating the ALVn bit.

**Figure 13-5. Setting Active Level of PWM Output**





#### 13.4.4 Specifying PWM pulse width rewrite period

PWM output is started and the pulse width is changed every 256 cycles of the PWM pulse ( $2^{x+8}/f_{\text{PWM}}$ ) or every one PWM cycle ( $2^x/f_{\text{PWM}}$ ). This PWM pulse width rewrite period is specified by the SYNn bit of the PWMnCn register (n = 0, 1).

When the SYNn bit is cleared to 0, the pulse width is changed every 256 PWM pulse cycles ( $2^{x+8}/f_{\text{PWM}}$ ) (long period). Therefore, it takes up to  $2^{x+8}$  clocks to output a pulse of the width corresponding to the data written to the PWMn register.

An example of the PWM output timing at this time is shown in Figure 13-6.

When the SYNn bit is set to 1, the pulse width is changed every one PWM pulse cycle ( $2^x/f_{\text{PWM}}$ ) (short period). In this case, it takes up to  $2^x$  clocks to output a pulse of the width corresponding to the data written to the PWMn register.

If the PWM pulse rewrite period is specified to be every  $2^x/f_{\text{PWM}}$  (if the SYNn bit is set to 1), the accuracy of the PWM pulse is x bits or more and (x+8) bits or less, or is lower than the accuracy when the rewrite cycle is set to  $2^{x+8}/f_{\text{PWM}}$ . However, the response speed improves because the repeat cycle increases.

Figure 13-7 shows an example of the PWM output timing where the rewrite timing is  $2^x/f_{\text{PWM}}$ .

**Figure 13-6. PWM Output Timing Example 1 (PWM Pulse Width Rewrite Period:  $2^{x+8}/f_{\text{PWM}}$ )**

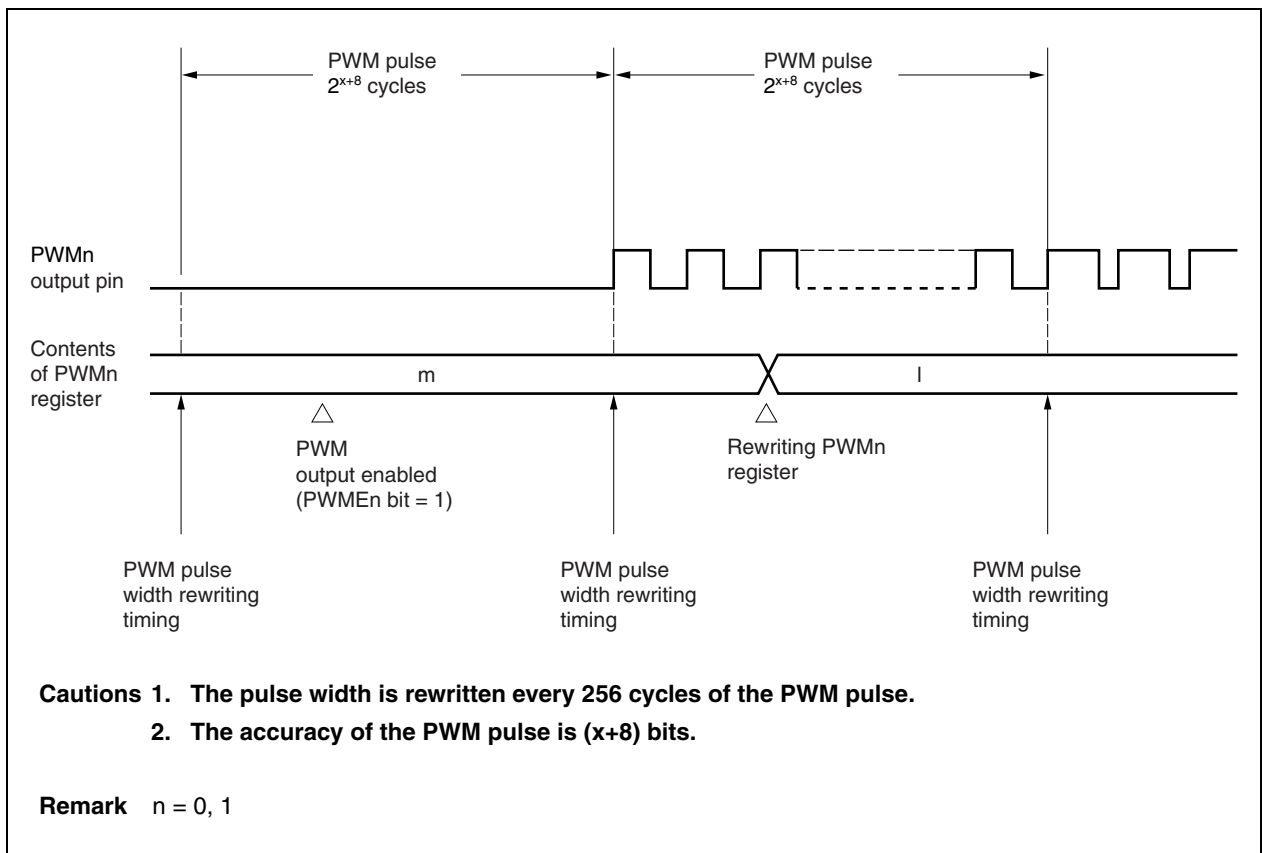
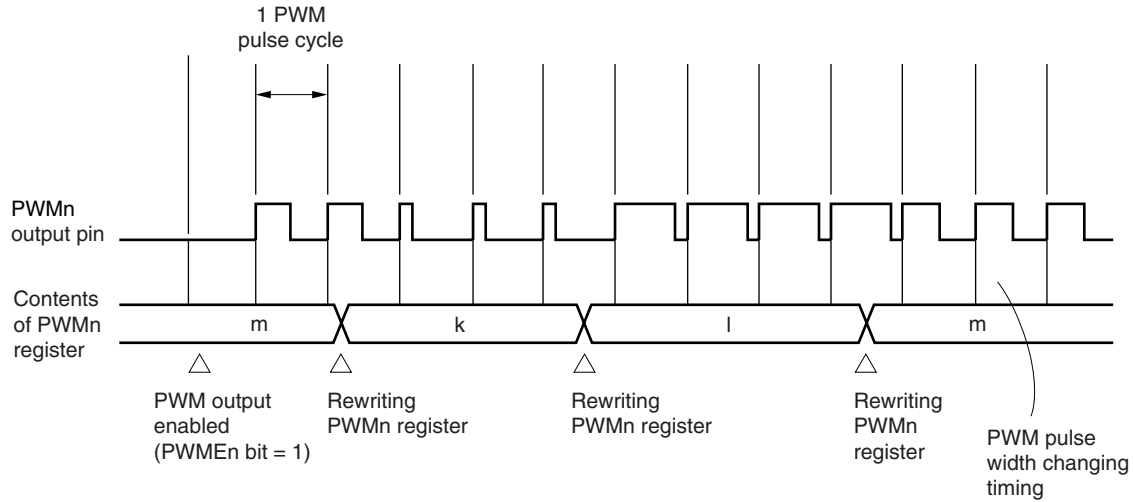


**Figure 13-7. PWM Output Timing Example 2 (PWM Pulse Width Rewrite Period:  $2^x/f_{PWMC}$ )**

- Cautions**
1. The pulse width is rewritten every one PWM pulse cycle.
  2. The accuracy of the PWM pulse is  $x$  bits or more and  $(x+8)$  bits or less.

- Remarks**
1.  $k$ ,  $l$ , and  $m$  indicate the contents of the PWMn register.
  2.  $n = 0, 1$

#### 13.4.5 Repeat cycle

The following table shows the repeat cycle of PWMn ( $n = 0, 1$ ).

**Table 13-1. Repeat Cycle of PWMn**

| Main Pulse Accuracy | Ancillary Pulse Accuracy | Repeat Cycle   | Pulse Width Rewrite Period |                             |
|---------------------|--------------------------|----------------|----------------------------|-----------------------------|
|                     |                          |                | Long Period (SYNn Bit = 0) | Short Period (SYNn Bit = 1) |
| 4 bits              | 8 bits                   | $16/f_{PWMC}$  | $2^{12}/f_{PWMC}$          | $2^4/f_{PWMC}$              |
| 5 bits              | 8 bits                   | $32/f_{PWMC}$  | $2^{13}/f_{PWMC}$          | $2^5/f_{PWMC}$              |
| 6 bits              | 8 bits                   | $64/f_{PWMC}$  | $2^{14}/f_{PWMC}$          | $2^6/f_{PWMC}$              |
| 7 bits              | 8 bits                   | $128/f_{PWMC}$ | $2^{15}/f_{PWMC}$          | $2^7/f_{PWMC}$              |
| 8 bits              | 8 bits                   | $256/f_{PWMC}$ | $2^{16}/f_{PWMC}$          | $2^8/f_{PWMC}$              |

- Remarks**
1.  $n = 0, 1$
  2.  $f_{PWMC}$ : PWM operating clock

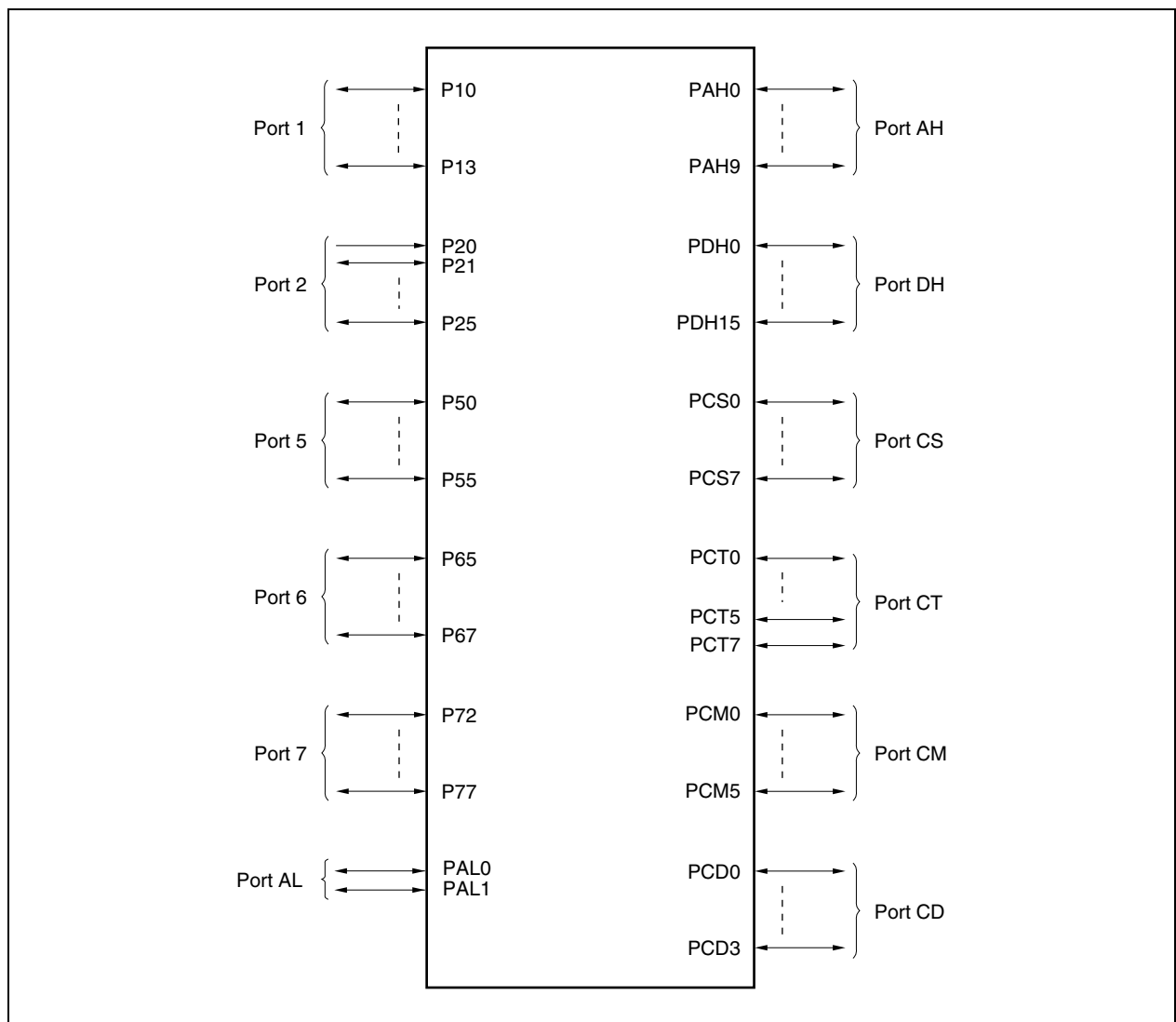
## CHAPTER 14 PORT FUNCTIONS

### 14.1 Features

- Input-only ports: 1  
I/O ports: 77
- Function alternately as other peripheral I/O pins.
- It is possible to specify input and output in 1-bit units.

### 14.2 Port Configuration

The V850E/ME2 incorporates a total of 78 input/output ports (including 1 input-only port) labeled ports 1, 2, 5 to 7, AL, AH, DH, CS, CT, CM, and CD. The port configuration is shown below.



**(1) Function of each port**

The port functions of this product are shown below.

8-bit and 1-bit operations are possible on all ports, allowing various kinds of control to be performed. In addition to their port functions, these pins also function as on-chip peripheral I/O input/output pins in the control mode. For the block types of each port, see **(3) Block diagram of port**.

| Port Name | Pin Name           | Port Function             | Function in Control Mode                                                                                                                              | Block Type              |
|-----------|--------------------|---------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|
| Port 1    | P10 to P13         | 4-bit I/O                 | Serial interface I/O (CSI30, UARTB0)<br>External interrupt input<br>USB clock signal input                                                            | F-1, F-3, H-1, J-1      |
| Port 2    | P20 to P25         | 1-bit input,<br>5-bit I/O | NMI input<br>Serial interface I/O (CSI31, UARTB1)<br>External interrupt input                                                                         | A-1, F-4, G-2, H-1      |
| Port 5    | P50 to P55         | 6-bit I/O                 | DMA controller I/O<br>External interrupt input<br>Timer/counter I/O                                                                                   | F-2, F-3, G-1, G-2, J-1 |
| Port 6    | P65 to P67         | 3-bit I/O                 | Timer/counter I/O<br>External interrupt input                                                                                                         | L-3, L-5                |
| Port 7    | P72 to P77         | 6-bit I/O                 | DMA controller I/O<br>Timer/counter I/O<br>External interrupt input                                                                                   | L-1, L-2, L-4           |
| Port AL   | PAL0, PAL1         | 2-bit I/O                 | External address bus (A0, A1)<br>External interrupt input                                                                                             | G-3                     |
| Port AH   | PAH0 to PAH9       | 10-bit input              | External address bus (A16 to A25)                                                                                                                     | D-2                     |
| Port DH   | PDH0 to PDH15      | 16-bit I/O                | External data bus (D16 to D31)<br>External interrupt input<br>PWM output<br>Timer/counter I/O                                                         | M-1, M-2, M-3           |
| Port CS   | PCS0 to PCS7       | 8-bit I/O                 | External bus interface control signal output                                                                                                          | D-2, J-2                |
| Port CT   | PCT0 to PCT5, PCT7 | 7-bit I/O                 | External bus interface control signal output                                                                                                          | D-2, J-3                |
| Port CM   | PCM0 to PCM5       | 6-bit I/O                 | Wait insertion signal input<br>External bus interface control signal I/O<br>Self-refresh request signal input<br>A/D converter external trigger input | C-1, D-1, D-2, F-5      |
| Port CD   | PCD0 to PCD3       | 4-bit I/O                 | External bus interface control signal output<br>Bus clock output                                                                                      | D-1, D-2                |

**Cautions** 1. When switching the mode of a port that functions as an output or I/O pin to control mode, be sure to follow the procedure below.

<1> Set the inactive level of the signals output in control mode to the appropriate bits in port n (n = 1, 2, 5 to 7, AL, AH, DH, CS, CT, CM, and CD).

<2> The mode is switched to control mode by the port n mode control register (PMCn).

If <1> above is not performed, the contents of port n may be output for a moment when the mode is switched from port mode to control mode.

2. To manipulate a port by using a bit manipulation instruction (SET1, CLR1, or NOT1), read the port in byte units, process the data of only the bit to be manipulated, and then write back the byte data to the port after conversion. In the case of a port having a mixture of input and output pins, the contents of the output latch are written over bits other than the bit to be manipulated. Consequently, the output latch of the input pin is undefined (in the input mode, however, the pin status does not change because the output buffer is turned off).

To change the port mode from the input to the output mode, therefore, set an expected output value to the corresponding bits, and then change the mode to the output mode. The same applies to a port that has both a control mode and an output mode.

## (2) Function when each port's pins are reset and registers that set the port/control mode

(1/3)

| Port Name | Pin Name                                                                                 | Pin Function After Reset | Register That Sets the Mode |
|-----------|------------------------------------------------------------------------------------------|--------------------------|-----------------------------|
| Port 1    | P10/ $\overline{\text{INTP10}}$ /UCLK                                                    | P10 (input mode)         | PMC1, PFC1                  |
|           | P11/ $\overline{\text{INTP11}}$ / $\overline{\text{SCK0}}$                               | P11 (input mode)         |                             |
|           | P12/SI0/RXD0                                                                             | P12 (input mode)         |                             |
|           | P13/SO0/TXD0                                                                             | P13 (input mode)         |                             |
| Port 2    | P20/NMI                                                                                  | NMI                      | PMC2, PFC2                  |
|           | P21/ $\overline{\text{INTP21}}$ /RXD1                                                    | P21 (input mode)         |                             |
|           | P22/ $\overline{\text{INTP22}}$ /TXD1                                                    | P22 (input mode)         |                             |
|           | P23/ $\overline{\text{INTP23}}$ / $\overline{\text{SCK1}}$                               | P23 (input mode)         |                             |
|           | P24/ $\overline{\text{INTP24}}$ /SI1                                                     | P24 (input mode)         |                             |
|           | P25/ $\overline{\text{INTP25}}$ /SO1                                                     | P25 (input mode)         |                             |
| Port 5    | P50/ $\overline{\text{INTP50}}$ / $\overline{\text{DMARQ0}}$                             | P50 (input mode)         | PMC5, PFC5                  |
|           | P51/ $\overline{\text{INTP51}}$ / $\overline{\text{DMAAK0}}$                             | P51 (input mode)         |                             |
|           | P52/ $\overline{\text{INTP52}}$ / $\overline{\text{TC0}}$                                | P52 (input mode)         |                             |
|           | P53/ $\overline{\text{INTPC00}}$ / $\overline{\text{TIC0}}$ / $\overline{\text{DMARQ1}}$ | P53 (input mode)         |                             |
|           | P54/ $\overline{\text{INTPC01}}$ / $\overline{\text{DMAAK1}}$                            | P54 (input mode)         |                             |
|           | P55/ $\overline{\text{TOC0}}$ / $\overline{\text{TC1}}$                                  | P55 (input mode)         |                             |
| Port 6    | P65/ $\overline{\text{INTP65}}$ / $\overline{\text{INTPC10}}$ / $\overline{\text{TIC1}}$ | P65 (input mode)         | PMC6, PFC6                  |
|           | P66/ $\overline{\text{INTP66}}$ / $\overline{\text{INTPC11}}$                            | P66 (input mode)         |                             |
|           | P67/ $\overline{\text{INTP67}}$ / $\overline{\text{TOC1}}$                               | P67 (input mode)         |                             |
| Port 7    | P72/ $\overline{\text{INTPC20}}$ / $\overline{\text{TIC2}}$ / $\overline{\text{DMARQ2}}$ | P72 (input mode)         | PMC7, PFC7                  |
|           | P73/ $\overline{\text{INTPC21}}$ / $\overline{\text{DMAAK2}}$                            | P73 (input mode)         |                             |
|           | P74/ $\overline{\text{TOC2}}$ / $\overline{\text{TC2}}$                                  | P74 (input mode)         |                             |
|           | P75/ $\overline{\text{INTPC30}}$ / $\overline{\text{TIC3}}$ / $\overline{\text{DMARQ3}}$ | P75 (input mode)         |                             |
|           | P76/ $\overline{\text{INTPC31}}$ / $\overline{\text{DMAAK3}}$                            | P76 (input mode)         |                             |
|           | P77/ $\overline{\text{TOC3}}$ / $\overline{\text{TC3}}$                                  | P77 (input mode)         |                             |
| Port AL   | PAL0/ $\overline{\text{INTPL0}}$ /A0                                                     | A0                       | PMCAL, PFCALL               |
|           | PAL1/ $\overline{\text{INTPL1}}$ /A1                                                     | A1                       |                             |
| Port AH   | PAH0/A16 to PAH9/A25                                                                     | A16 to A25               | PMCAH                       |

(2/3)

| Port Name | Pin Name                                                                              | Pin Function After Reset                             | Register That Sets the Mode |
|-----------|---------------------------------------------------------------------------------------|------------------------------------------------------|-----------------------------|
| Port CS   | PCS0/ $\overline{\text{CS0}}$                                                         | $\overline{\text{CS0}}$                              | PMCCS                       |
|           | PCS1/ $\overline{\text{CS1}}$                                                         | $\overline{\text{CS1}}$                              |                             |
|           | PCS2/ $\overline{\text{CS2}}$ / $\overline{\text{IOWR}}$                              | $\overline{\text{CS2}}$                              | PMCCS, PFCCS                |
|           | PCS3/ $\overline{\text{CS3}}$                                                         | $\overline{\text{CS3}}$                              | PMCCS                       |
|           | PCS4/ $\overline{\text{CS4}}$                                                         | $\overline{\text{CS4}}$                              |                             |
|           | PCS5/ $\overline{\text{CS5}}$ / $\overline{\text{IORD}}$                              | $\overline{\text{CS5}}$                              | PMCCS, PFCCS                |
|           | PCS6/ $\overline{\text{CS6}}$                                                         | $\overline{\text{CS6}}$                              | PMCCS                       |
|           | PCS7/ $\overline{\text{CS7}}$                                                         | $\overline{\text{CS7}}$                              |                             |
| Port CT   | PCT0/ $\overline{\text{LLWR}}$ / $\overline{\text{LLBE}}$ / $\overline{\text{LLDQM}}$ | $\overline{\text{LLWR}}$ / $\overline{\text{LLDQM}}$ | PMCCT, PFCCT                |
|           | PCT1/ $\overline{\text{LUWR}}$ / $\overline{\text{LUBE}}$ / $\overline{\text{LUDQM}}$ | $\overline{\text{LUWR}}$ / $\overline{\text{LUDQM}}$ |                             |
|           | PCT2/ $\overline{\text{ULWR}}$ / $\overline{\text{ULBE}}$ / $\overline{\text{ULDQM}}$ | $\overline{\text{ULWR}}$ / $\overline{\text{ULDQM}}$ |                             |
|           | PCT3/ $\overline{\text{UUWR}}$ / $\overline{\text{UUBE}}$ / $\overline{\text{UUDQM}}$ | $\overline{\text{UUWR}}$ / $\overline{\text{UUDQM}}$ |                             |
|           | PCT4/ $\overline{\text{RD}}$                                                          | $\overline{\text{RD}}$                               | PMCCT                       |
|           | PCT5/ $\overline{\text{WE}}$ / $\overline{\text{WR}}$                                 | $\overline{\text{WE}}$ / $\overline{\text{WR}}$      |                             |
|           | PCT7/ $\overline{\text{BCYST}}$                                                       | $\overline{\text{BCYST}}$                            |                             |
| Port CM   | PCM0/ $\overline{\text{WAIT}}$                                                        | $\overline{\text{WAIT}}$                             | PMCCM                       |
|           | PCM1                                                                                  | —                                                    | —                           |
|           | PCM2/ $\overline{\text{HLDK}}$                                                        | $\overline{\text{HLDK}}$                             | PMCCM                       |
|           | PCM3/ $\overline{\text{HLDRQ}}$                                                       | $\overline{\text{HLDRQ}}$                            |                             |
|           | PCM4/ $\overline{\text{REFRQ}}$                                                       | $\overline{\text{REFRQ}}$                            |                             |
|           | PCM5/ $\overline{\text{SELFREF}}$ / $\overline{\text{ADTRG}}$                         | $\overline{\text{SELFREF}}$                          | PMCCM, PFCCM                |
| Port CD   | PCD0/ $\overline{\text{SDCKE}}$                                                       | $\overline{\text{SDCKE}}$                            | PMCCD                       |
|           | PCD1/ $\overline{\text{BUSCLK}}$                                                      | $\overline{\text{BUSCLK}}$                           |                             |
|           | PCD2/ $\overline{\text{SDCAS}}$                                                       | $\overline{\text{SDCAS}}$                            |                             |
|           | PCD3/ $\overline{\text{SDRAS}}$                                                       | $\overline{\text{SDRAS}}$                            |                             |

(3/3)

| Port Name | Pin Name                                                                     | Pin Function After Reset    |                             | Register That Sets the Mode |
|-----------|------------------------------------------------------------------------------|-----------------------------|-----------------------------|-----------------------------|
|           |                                                                              | 16-Bit Mode <sup>Note</sup> | 32-Bit Mode <sup>Note</sup> |                             |
| Port DH   | PDH0/D16/ $\overline{\text{INTPD0}}$                                         | PDH0 (input mode)           | D16                         | PMCDH                       |
|           | PDH1/D17/ $\overline{\text{INTPD1}}$                                         | PDH1 (input mode)           | D17                         |                             |
|           | PDH2/D18/ $\overline{\text{INTPD2}}$ /TOC4                                   | PDH2 (input mode)           | D18                         | PMCDH, PFCDH                |
|           | PDH3/D19/ $\overline{\text{INTPD3}}$                                         | PDH3 (input mode)           | D19                         | PMCDH                       |
|           | PDH4/D20/ $\overline{\text{INTPD4}}$                                         | PDH4 (input mode)           | D20                         |                             |
|           | PDH5/D21/ $\overline{\text{INTPD5}}$ /TOC5                                   | PDH5 (input mode)           | D21                         | PMCDH, PFCDH                |
|           | PDH6/D22/ $\overline{\text{INTPD6}}$ / $\overline{\text{INTP100}}$ /TCUD10   | PDH6 (input mode)           | D22                         |                             |
|           | PDH7/D23/ $\overline{\text{INTPD7}}$ / $\overline{\text{INTP101}}$ /TCLR10   | PDH7 (input mode)           | D23                         |                             |
|           | PDH8/D24/ $\overline{\text{INTPD8}}$ /TO10                                   | PDH8 (input mode)           | D24                         |                             |
|           | PDH9/D25/ $\overline{\text{INTPD9}}$ /TIUD10                                 | PDH9 (input mode)           | D25                         |                             |
|           | PDH10/D26/ $\overline{\text{INTPD10}}$ / $\overline{\text{INTP110}}$ /TCUD11 | PDH10 (input mode)          | D26                         |                             |
|           | PDH11/D27/ $\overline{\text{INTPD11}}$ / $\overline{\text{INTP111}}$ /TCLR11 | PDH11 (input mode)          | D27                         |                             |
|           | PDH12/D28/ $\overline{\text{INTPD12}}$ /TO11                                 | PDH12 (input mode)          | D28                         |                             |
|           | PDH13/D29/ $\overline{\text{INTPD13}}$ /TIUD11                               | PDH13 (input mode)          | D29                         |                             |
|           | PDH14/D30/ $\overline{\text{INTPD14}}$ /PWM0                                 | PDH14 (input mode)          | D30                         |                             |
|           | PDH15/D31/ $\overline{\text{INTPD15}}$ /PWM1                                 | PDH15 (input mode)          | D31                         |                             |

**Note** For details of the operating modes, refer to **3.3.2 Operating mode specification**.



## (3) Block diagram of port

Figure 14-1. Block Diagram of Type A-1

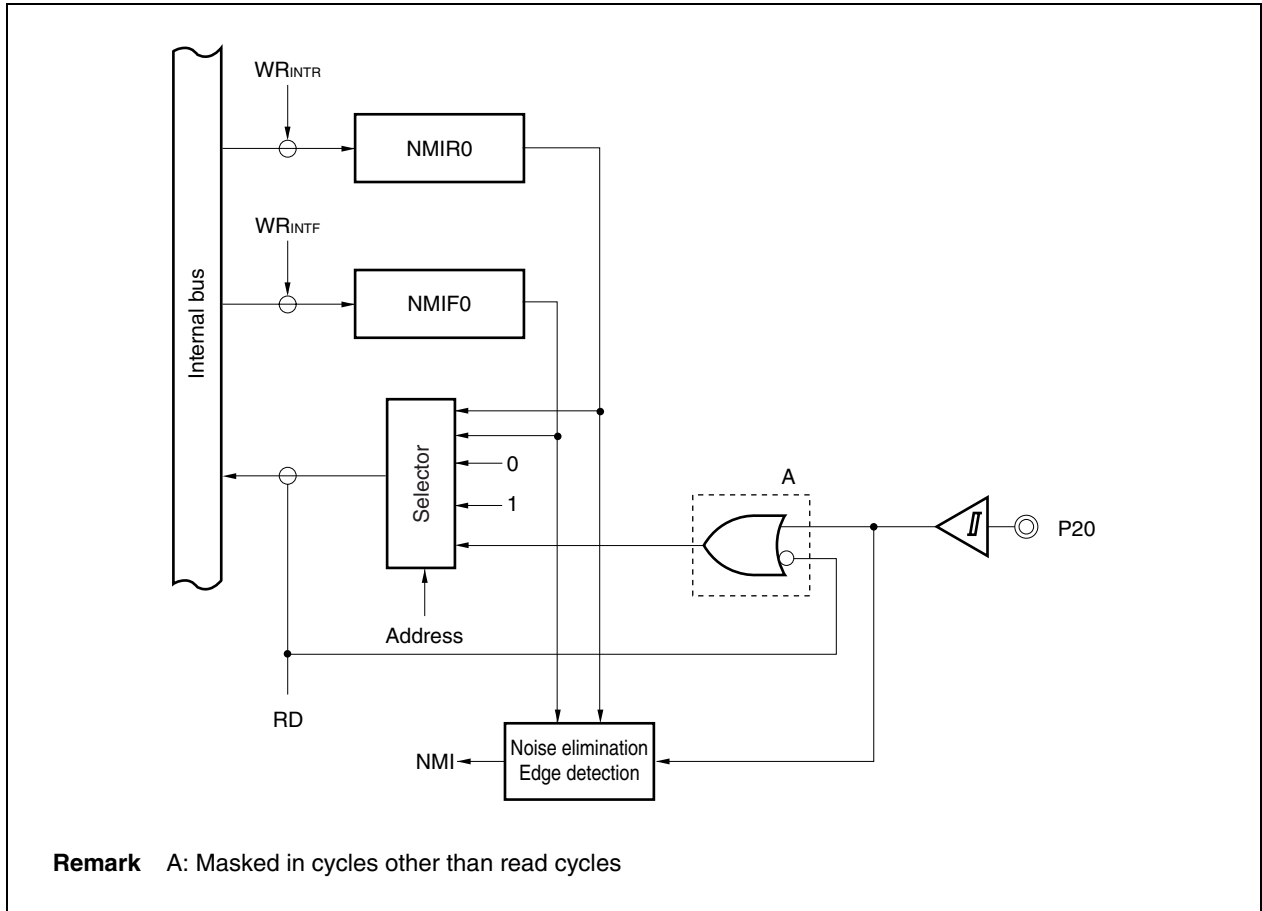
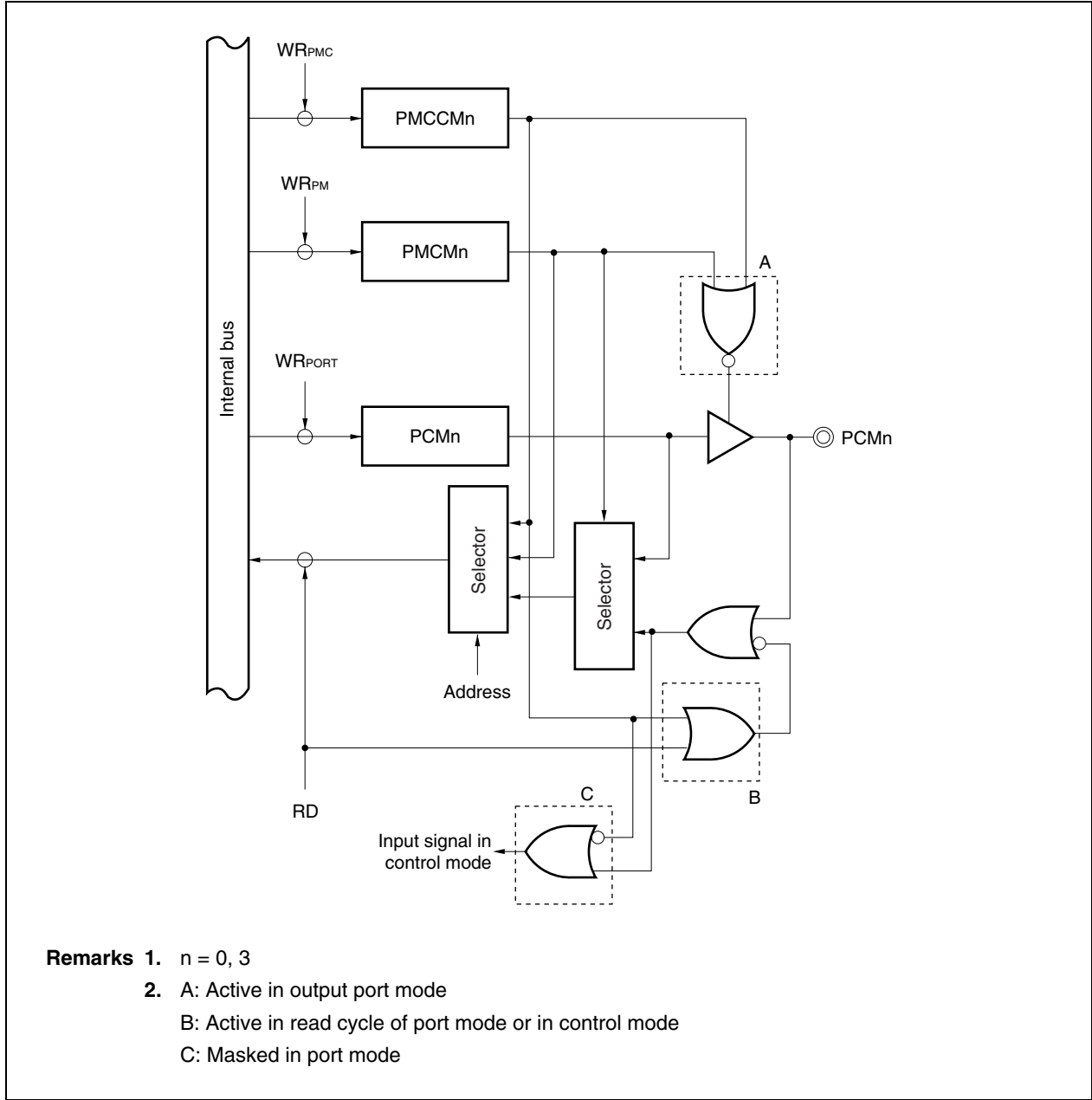


**Figure 14-2. Block Diagram of Type C-1**



**Remarks**

1.  $n = 0, 3$
2. A: Active in output port mode  
B: Active in read cycle of port mode or in control mode  
C: Masked in port mode

Figure 14-3. Block Diagram of Type D-1

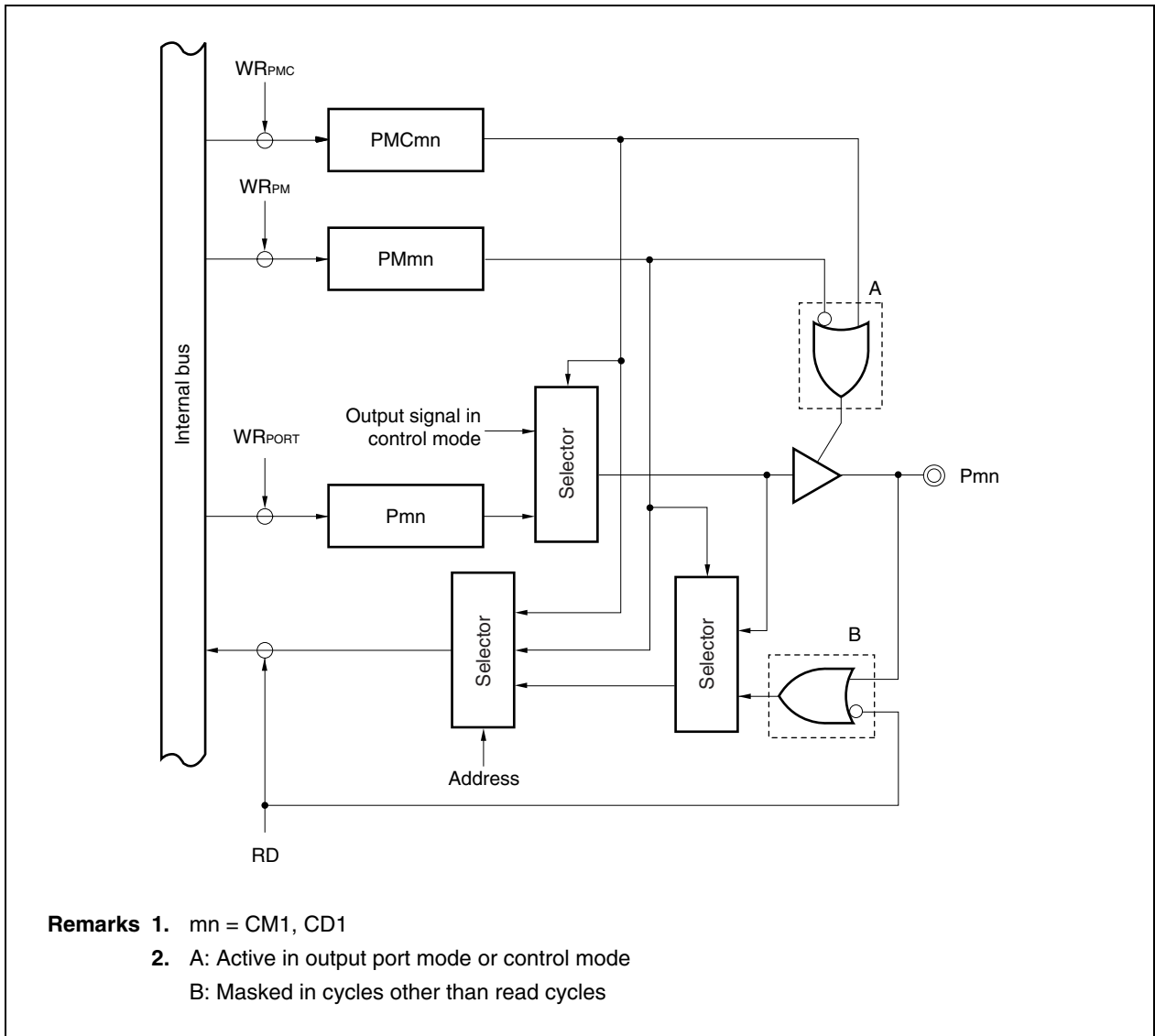
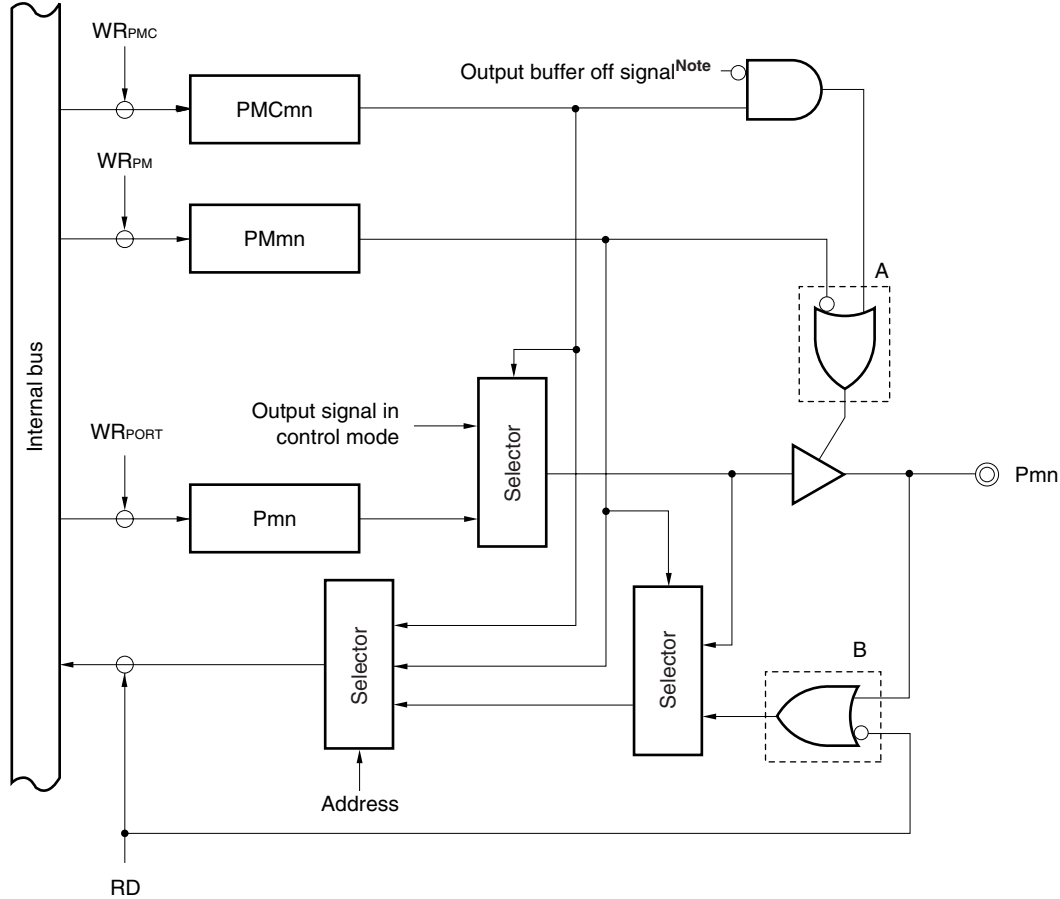


Figure 14-4. Block Diagram of Type D-2

**Note** PAH0 to PAH9:

These signals become active in the IDLE mode and software STOP mode, and by bus hold and reset.

PCS0, PCS1, PCS3, PCS4, PCS6, PCS7, PCD2, PCD3, PCT4, PCT5, PCT7:

These signals become active by bus hold and reset.

PCM2, PCM4, PCD0:

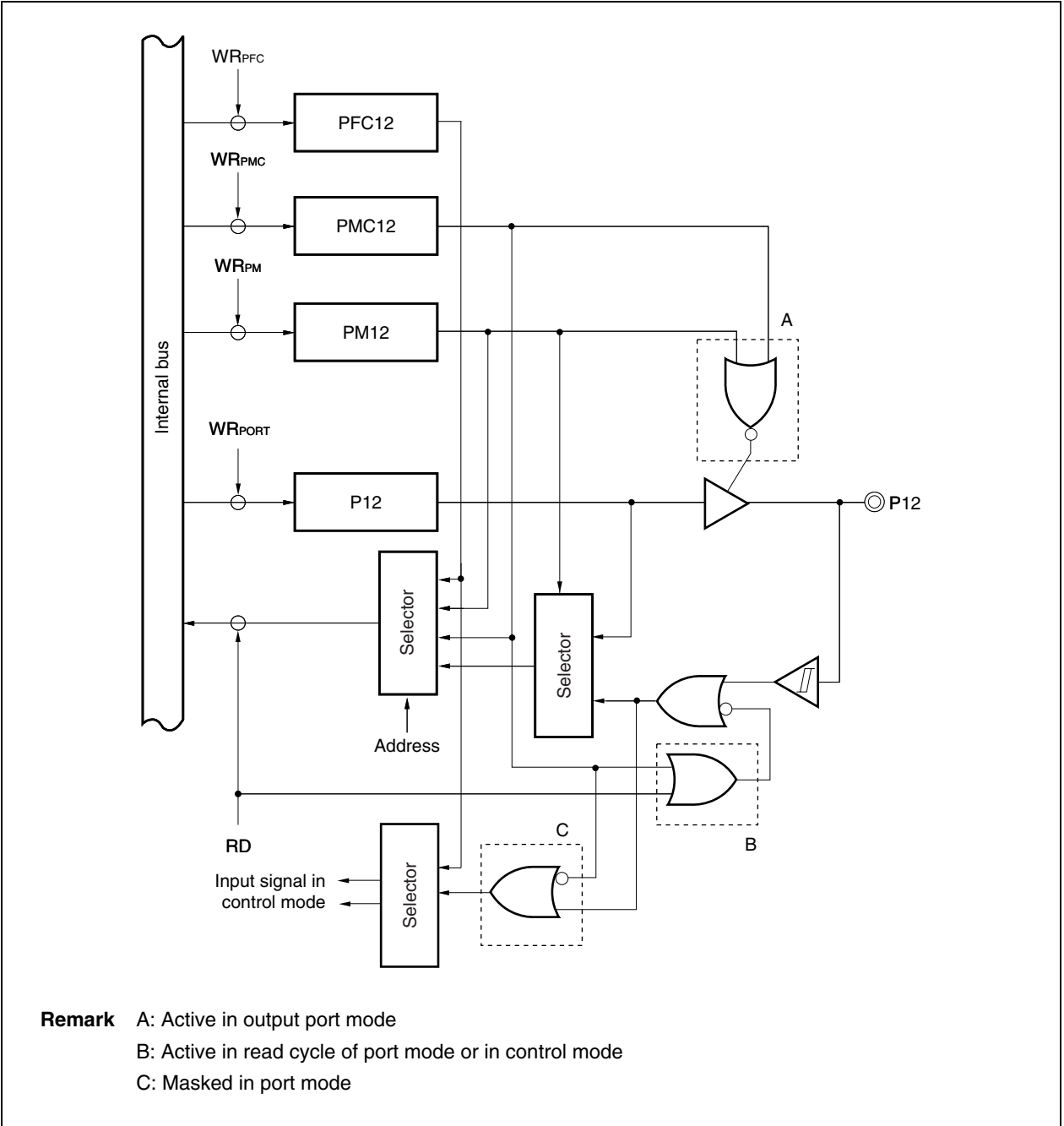
These signals become active at reset.

**Remarks 1.** mn = AH0 to AH9, CS0, CS1, CS3, CS4, CS6, CS7, CT4, CT5, CT7, CM2, CM4, CD0, CD2, CD3

**2.** A: Active in output port mode or control mode

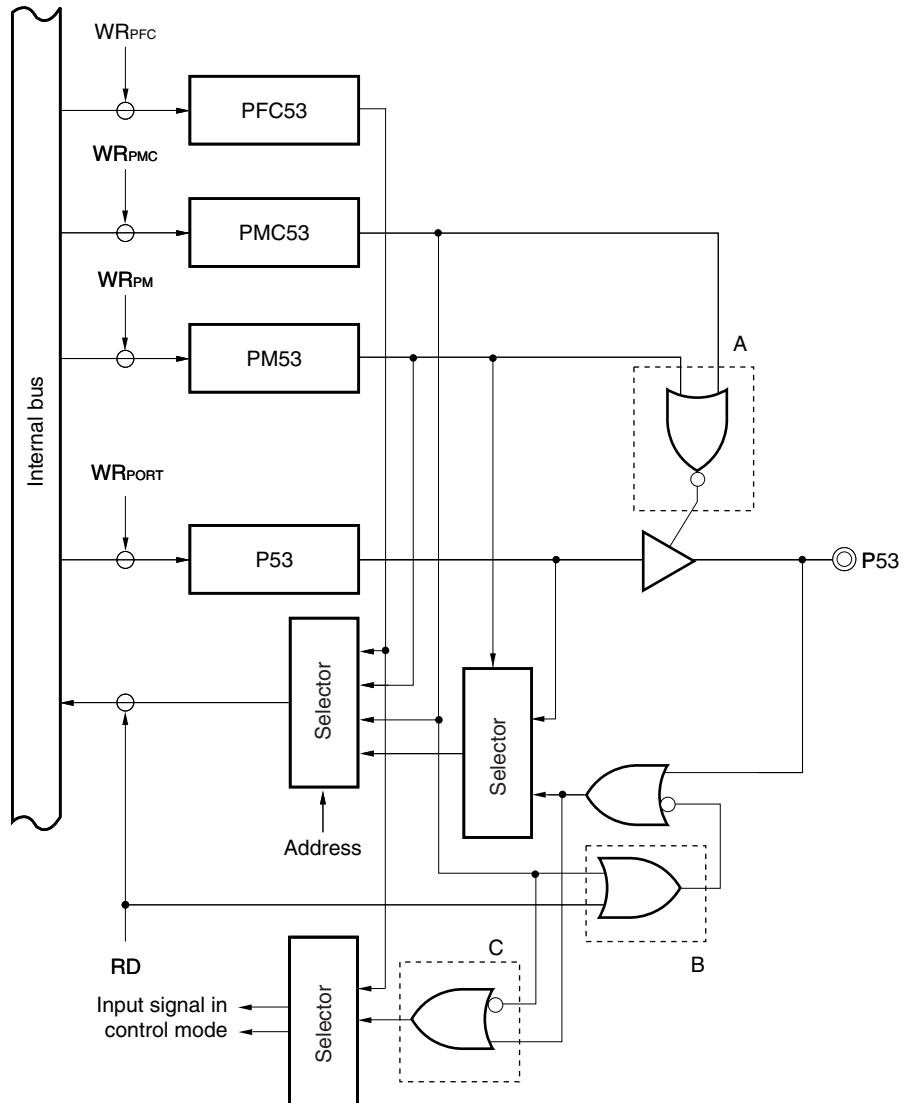
B: Masked in cycles other than read cycles

**Figure 14-5. Block Diagram of Type F-1**



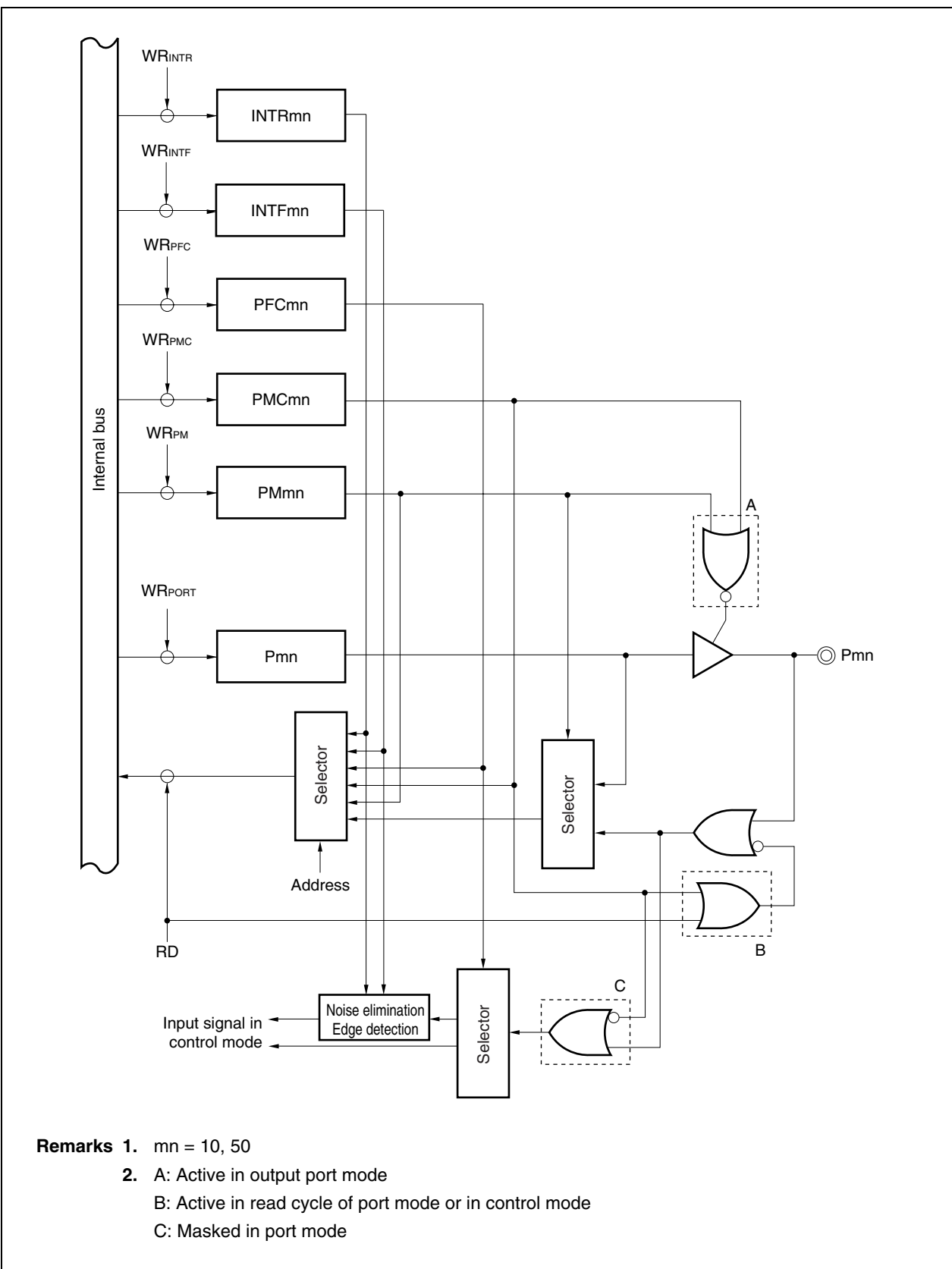
**Remark** A: Active in output port mode  
B: Active in read cycle of port mode or in control mode  
C: Masked in port mode

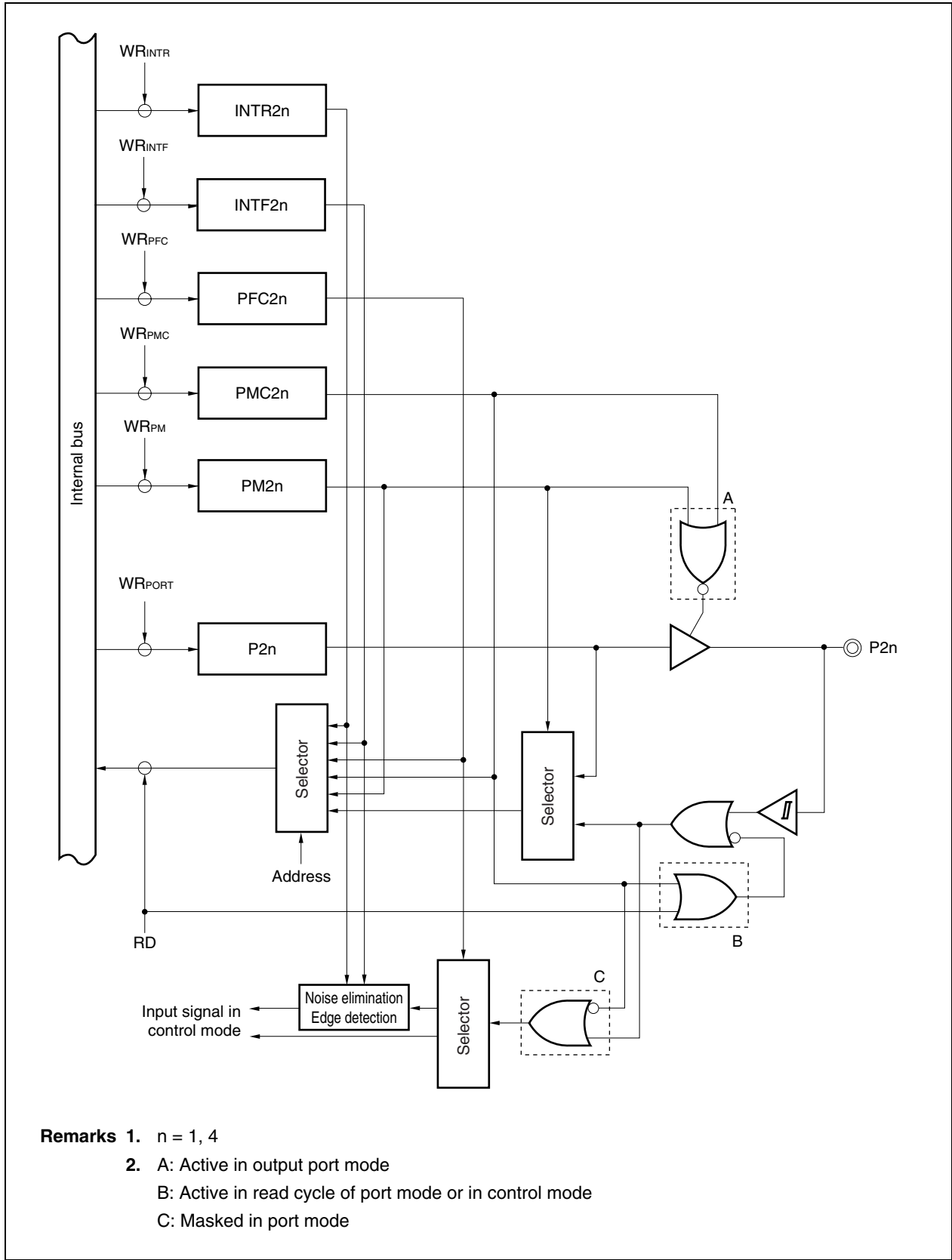
Figure 14-6. Block Diagram of Type F-2



**Remark** A: Active in output port mode  
 B: Active in read cycle of port mode or in control mode  
 C: Masked in port mode

**Figure 14-7. Block Diagram of Type F-3**





**Remarks 1.**  $n = 1, 4$

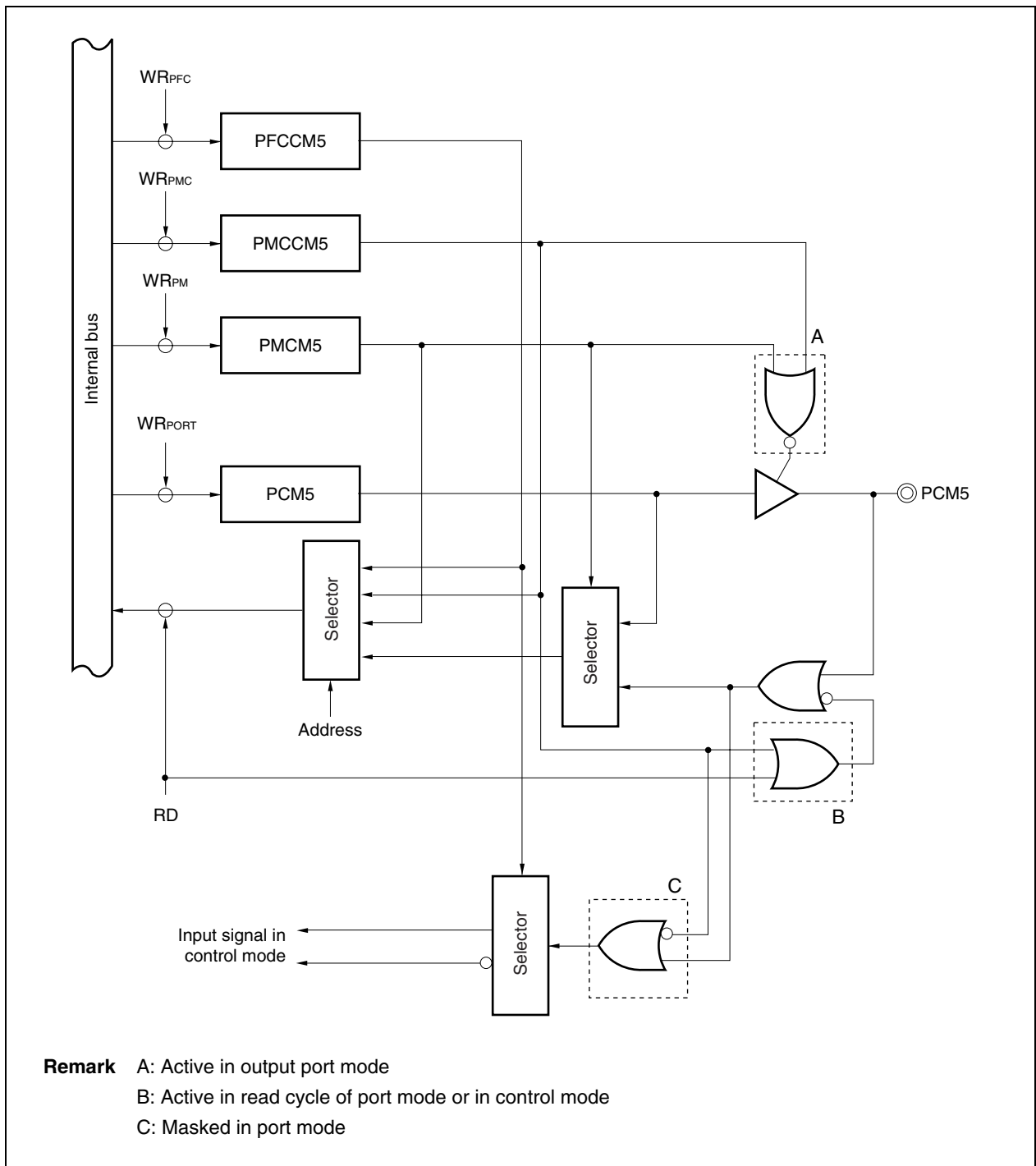
**2. A: Active in output port mode**

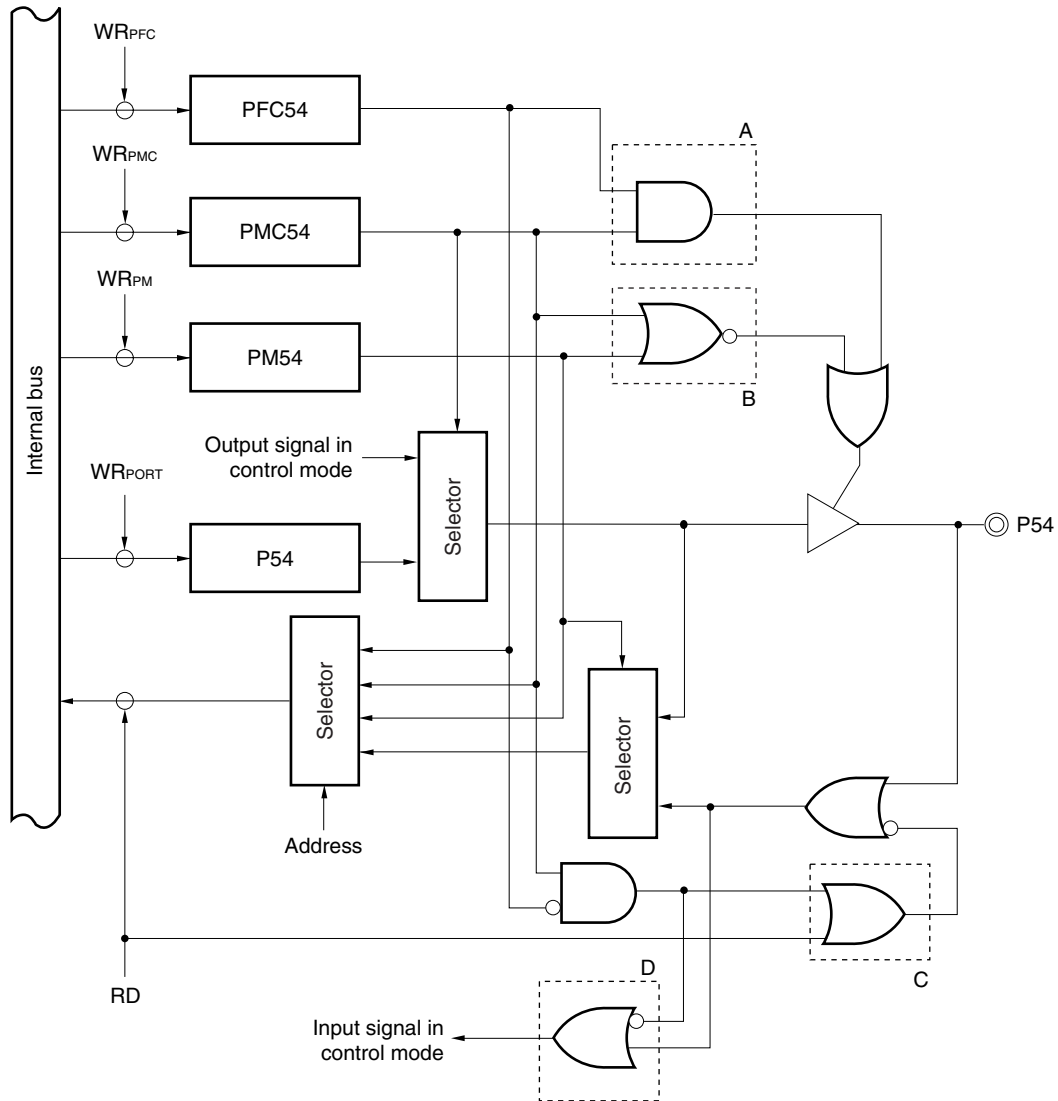
**B:** Active in read cycle of port mode or in control mode

C: Masked in port mode



Figure 14-9. Block Diagram of Type F-5





**Remark** A: Active in output control mode  
B: Active in output port mode  
C: Active in read cycle of port mode or in input control mode  
D: Masked in port mode or output control mode

Figure 14-11. Block Diagram of Type G-2

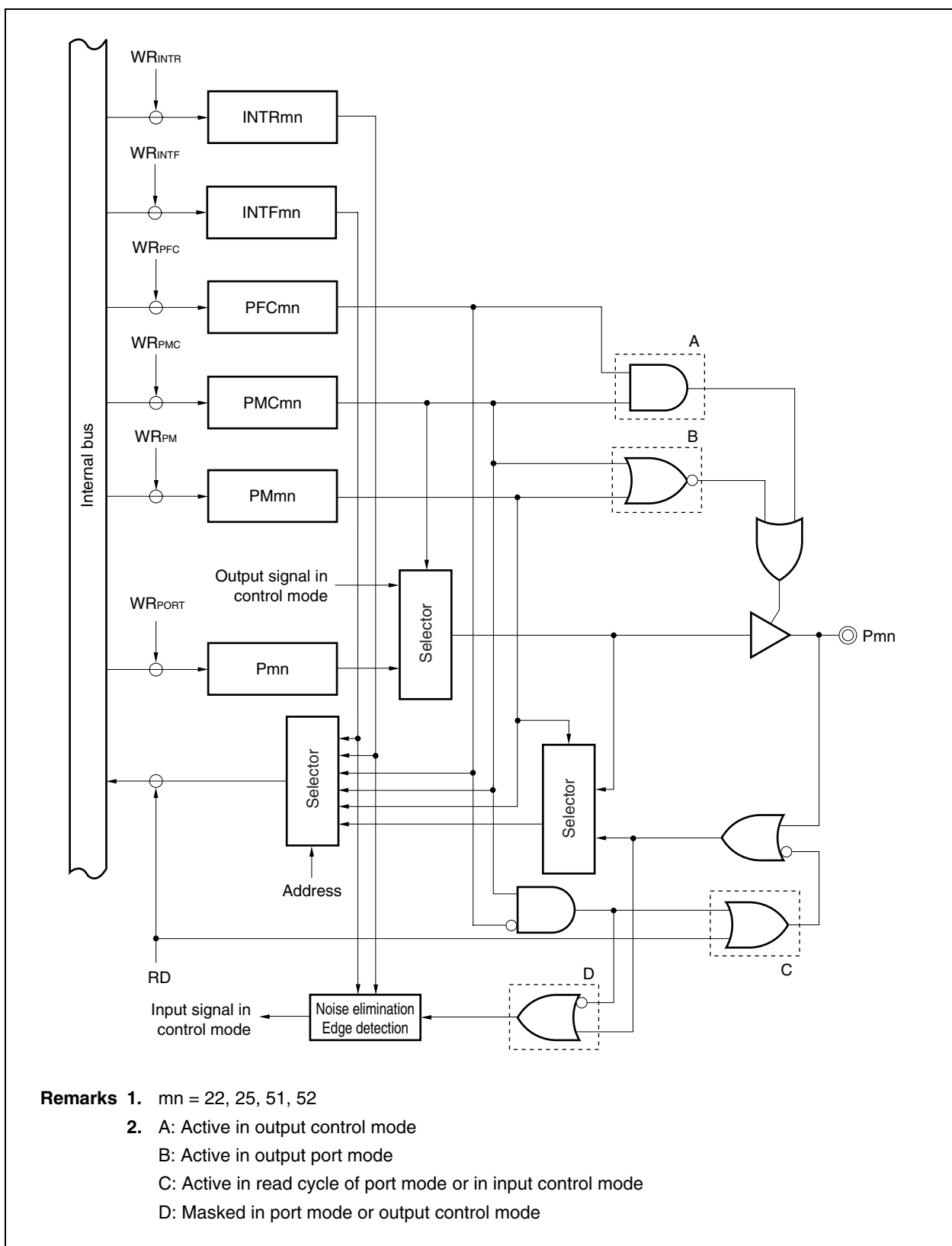
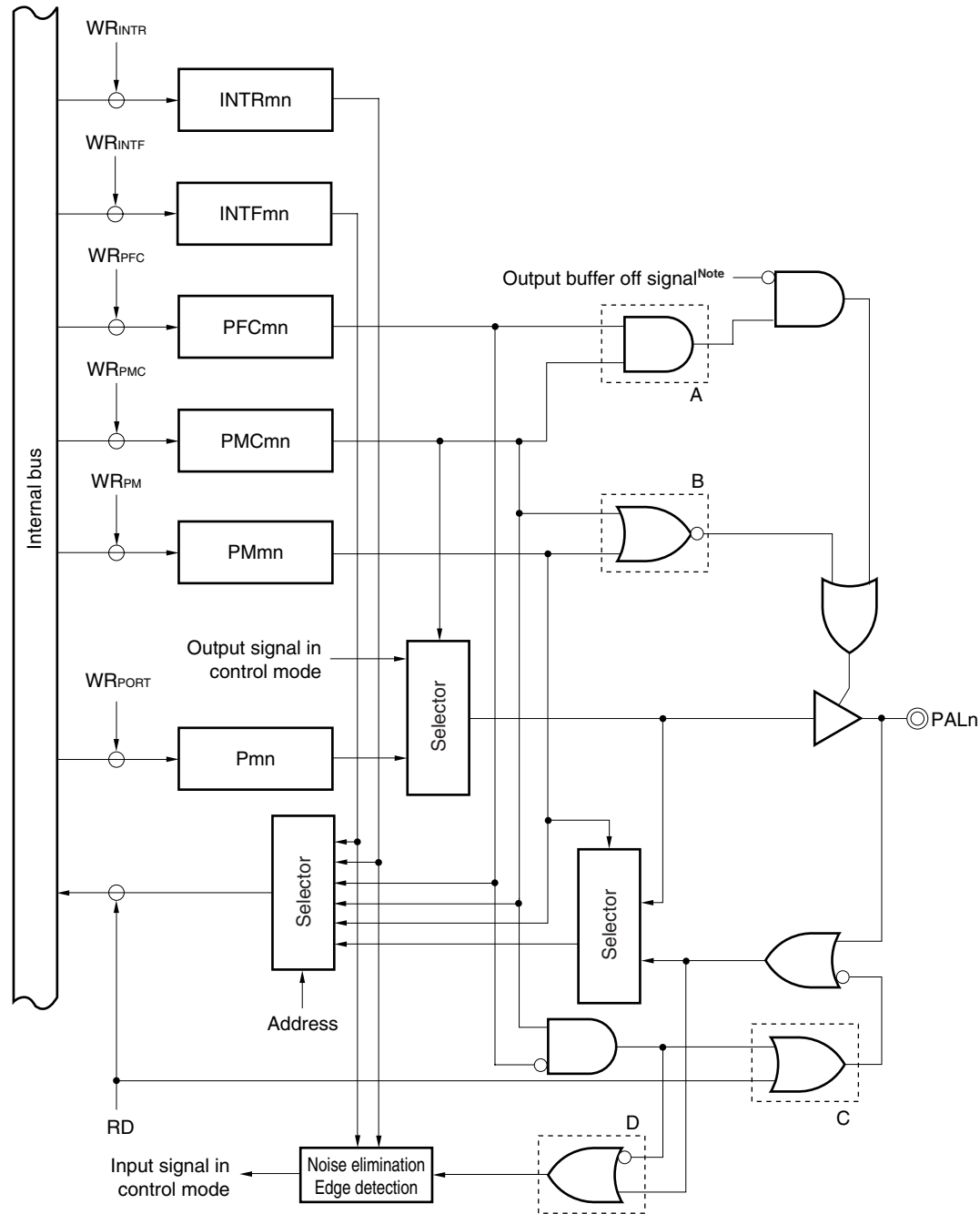


Figure 14-12. Block Diagram of Type G-3



**Note** Signal that becomes active in IDLE mode and software STOP mode, and by bus hold and reset

**Remarks 1.**  $n = 0, 1$

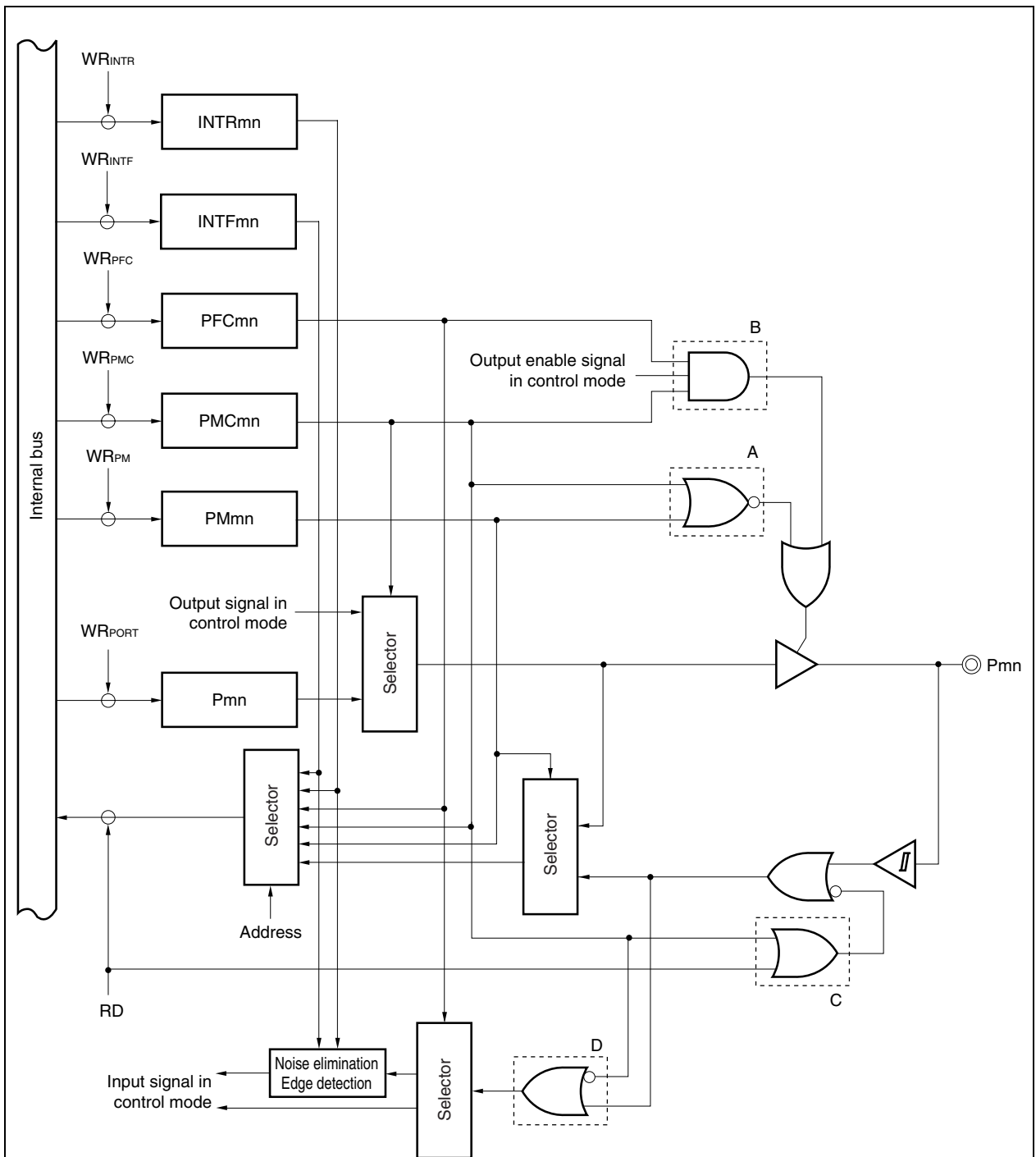
**2.** A: Active in output control mode

B: Active in output port mode

C: Active in read cycle of port mode or in input control mode

D: Masked in port mode or output control mode

Figure 14-13. Block Diagram of Type H-1



**Remarks 1.** mn = 11, 23

**2.** A: Active in output port mode

B: Bidirectional control mode (DIR control): Active in output direction

C: Active in read cycle of port mode or in input control mode

D: Masked in port mode

Figure 14-14. Block Diagram of Type J-1

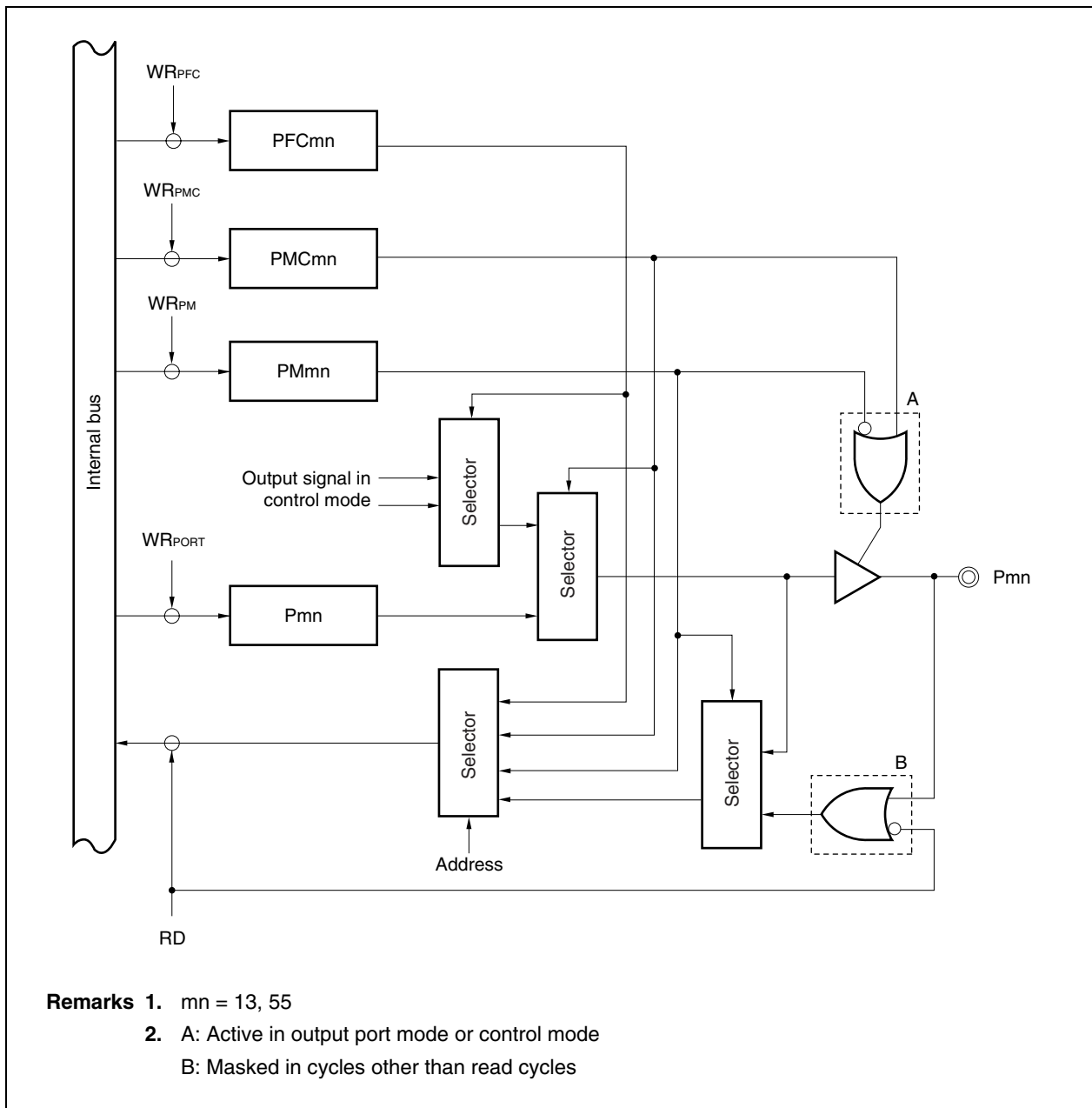
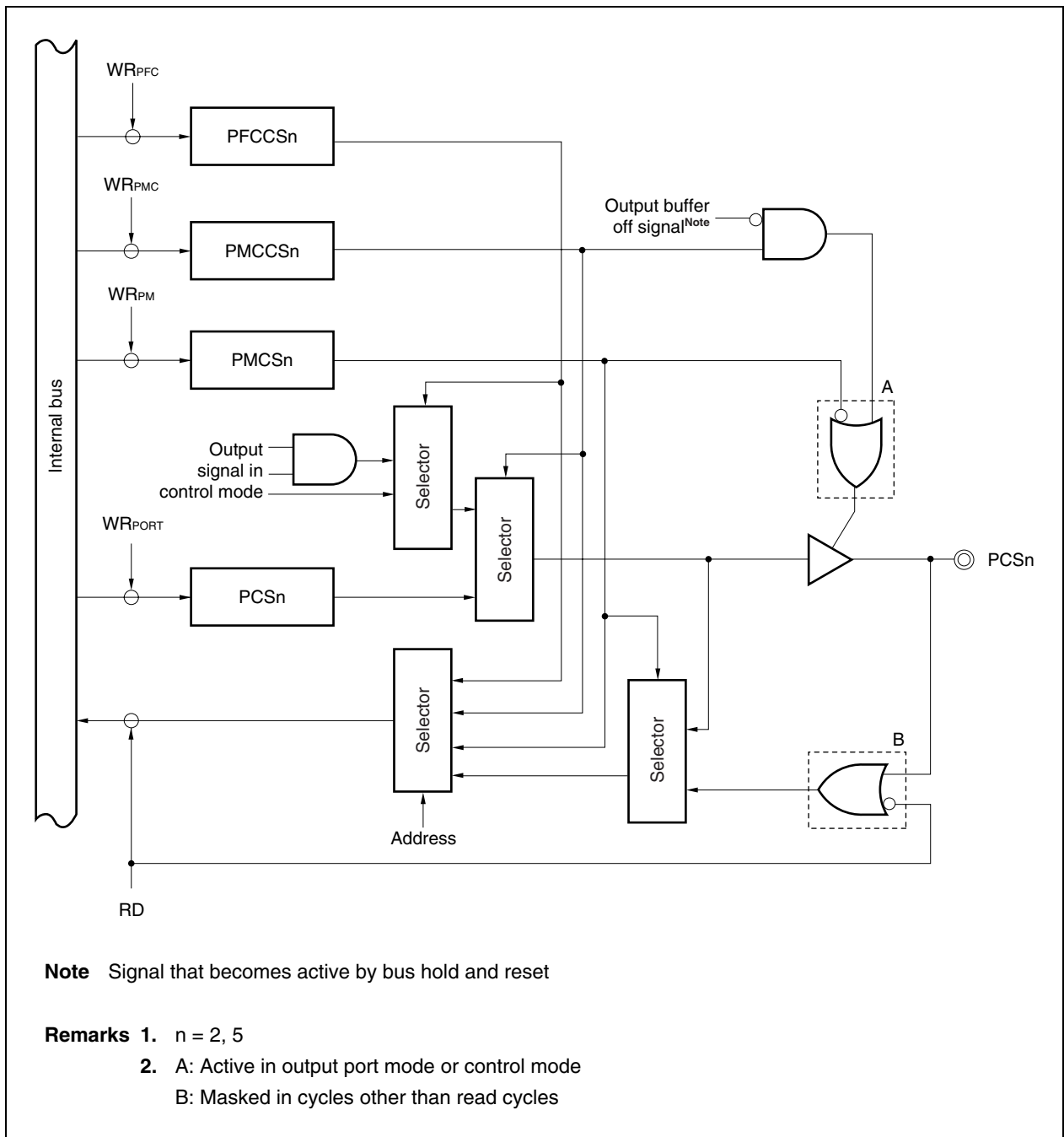


Figure 14-15. Block Diagram of Type J-2



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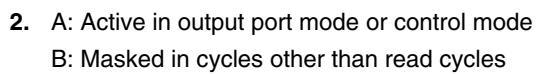




Figure 14-17. Block Diagram of Type L-1

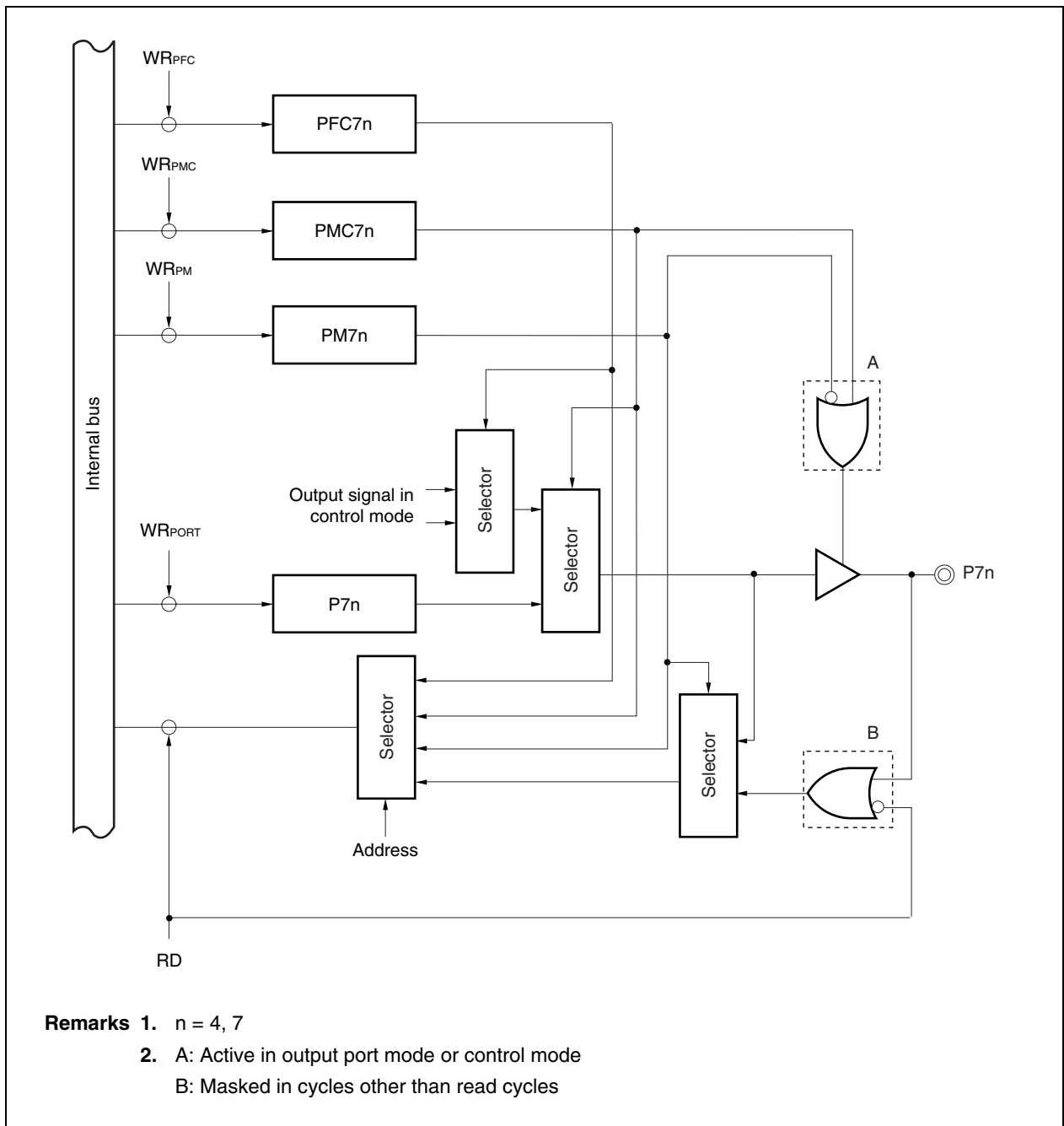
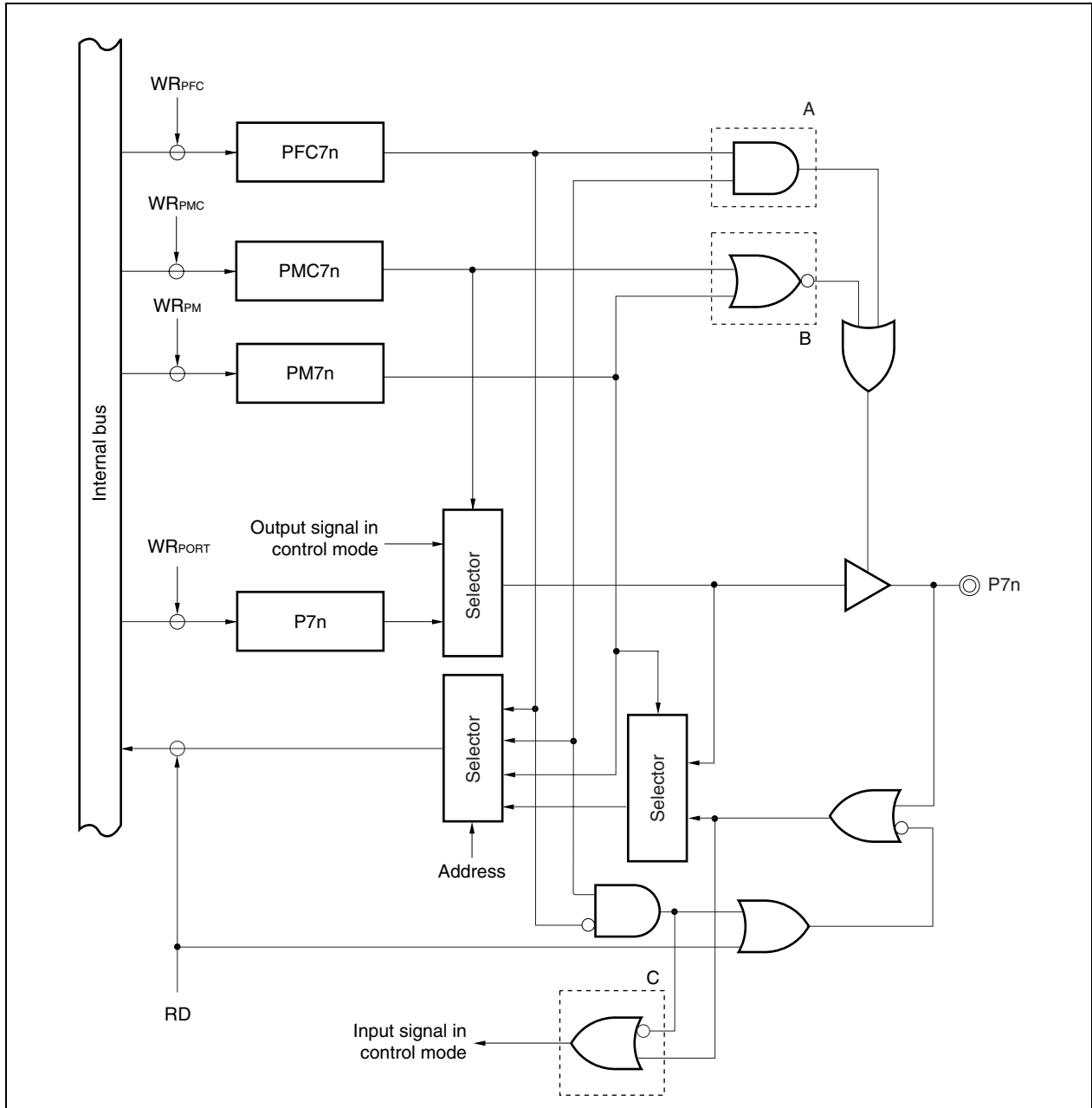


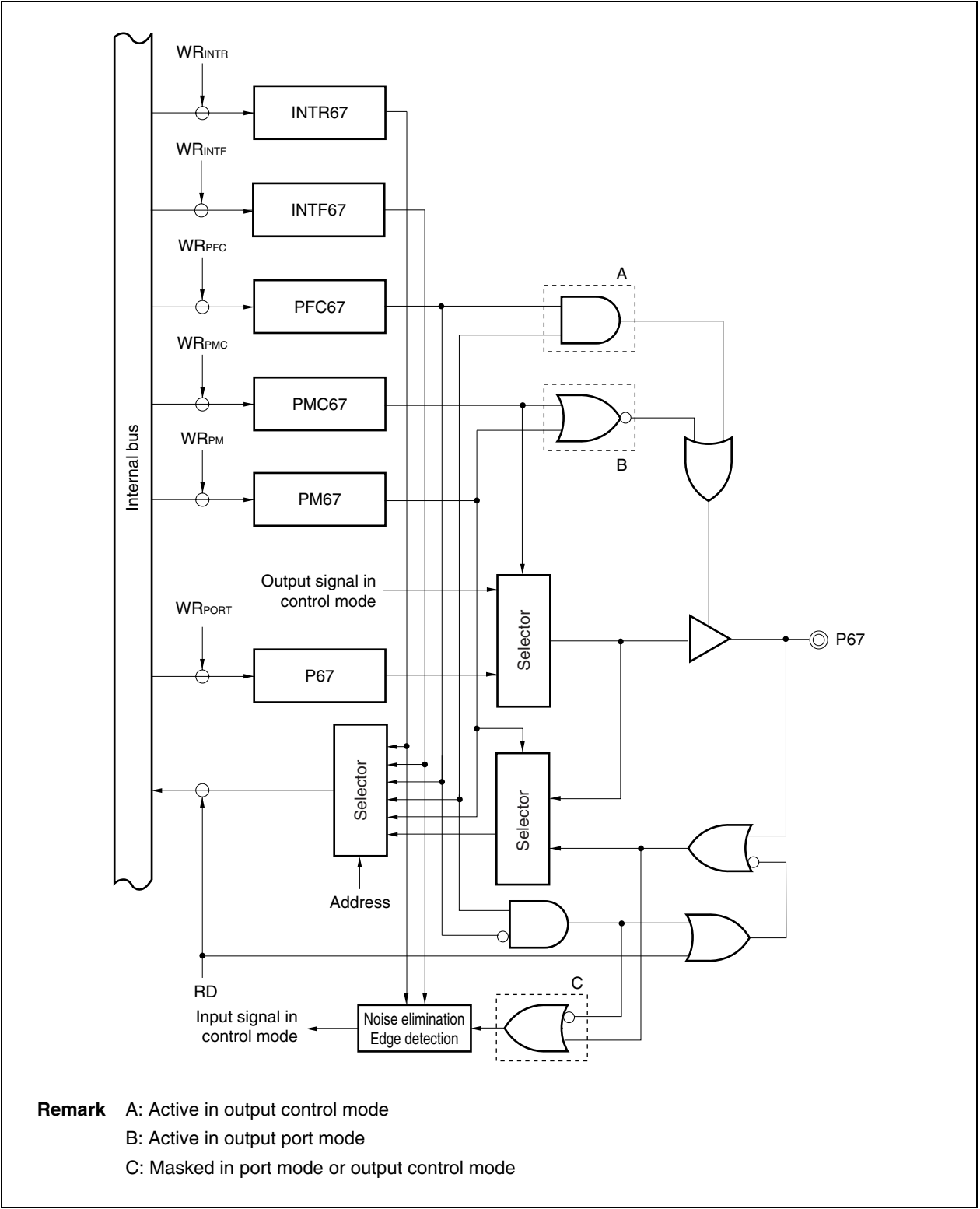
**Figure 14-18. Block Diagram of Type L-2**



**Remarks**

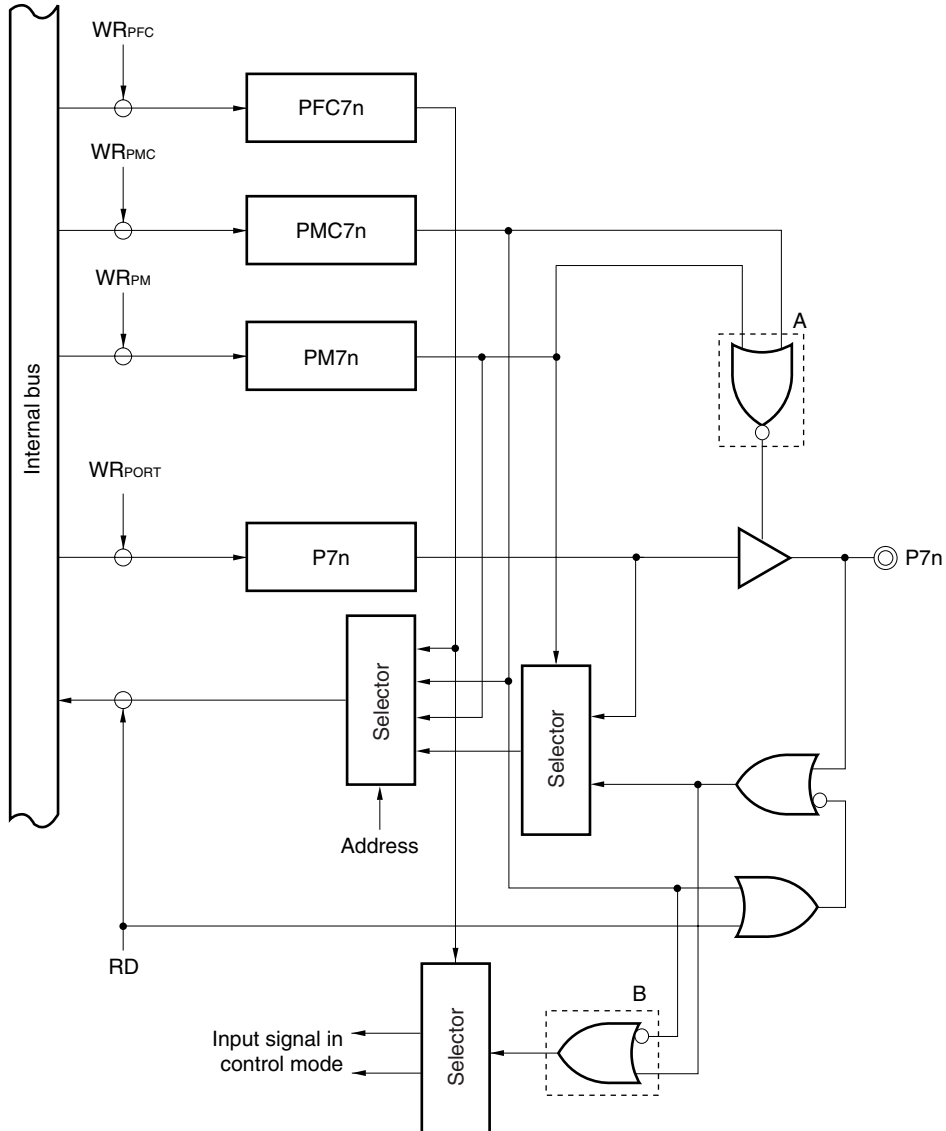
1.  $n = 3, 6$
2. A: Active in output control mode  
B: Active in output port mode  
C: Masked in port mode or output control mode

**Figure 14-19. Block Diagram of Type L-3**



**Remark** A: Active in output control mode  
B: Active in output port mode  
C: Masked in port mode or output control mode

Figure 14-20. Block Diagram of Type L-4



- Remarks**
1.  $n = 2, 5$
  2. A: Active in output port mode  
B: Masked in port mode

Figure 14-21. Block Diagram of Type L-5

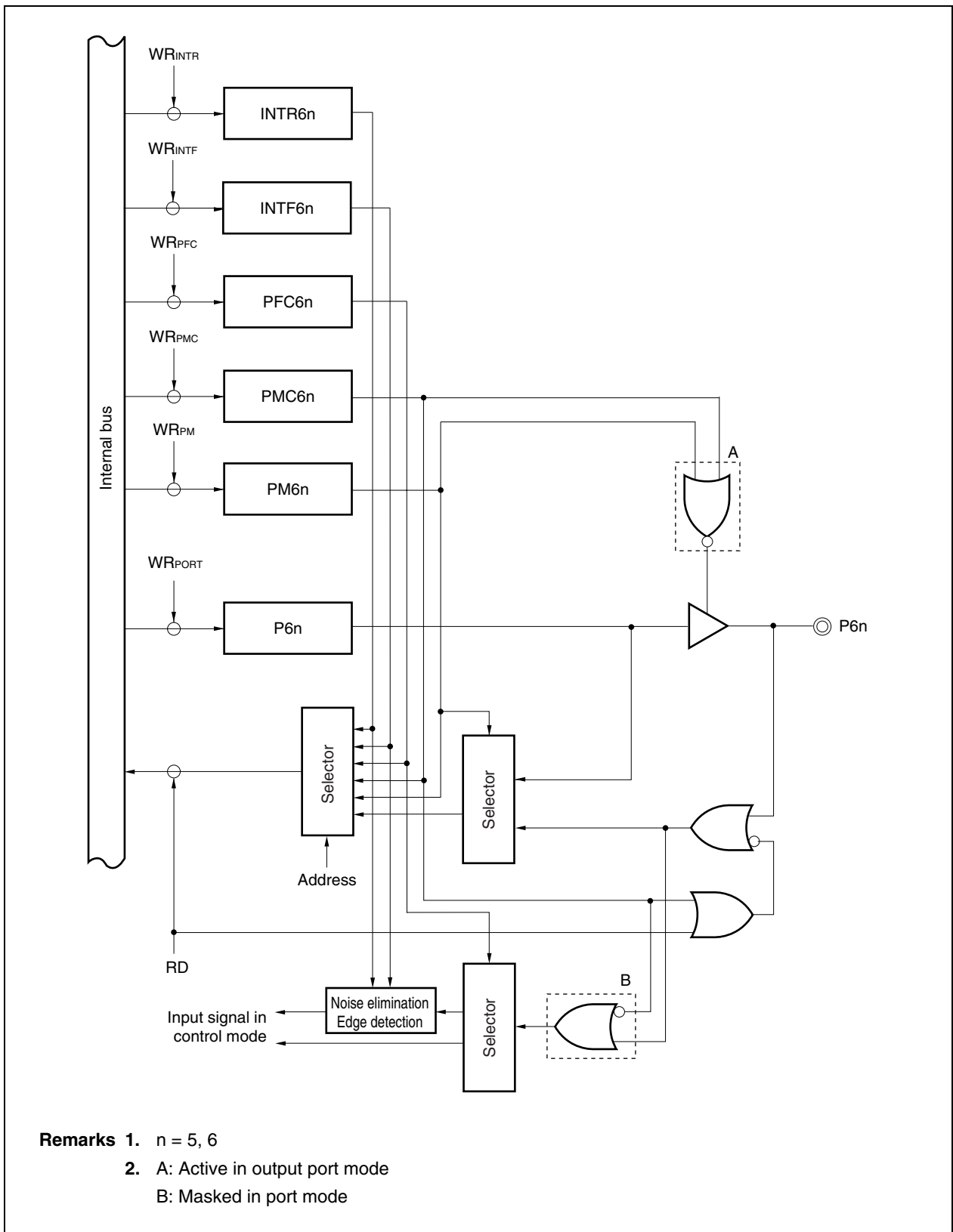


Figure 14-22. Block Diagram of Type M-1

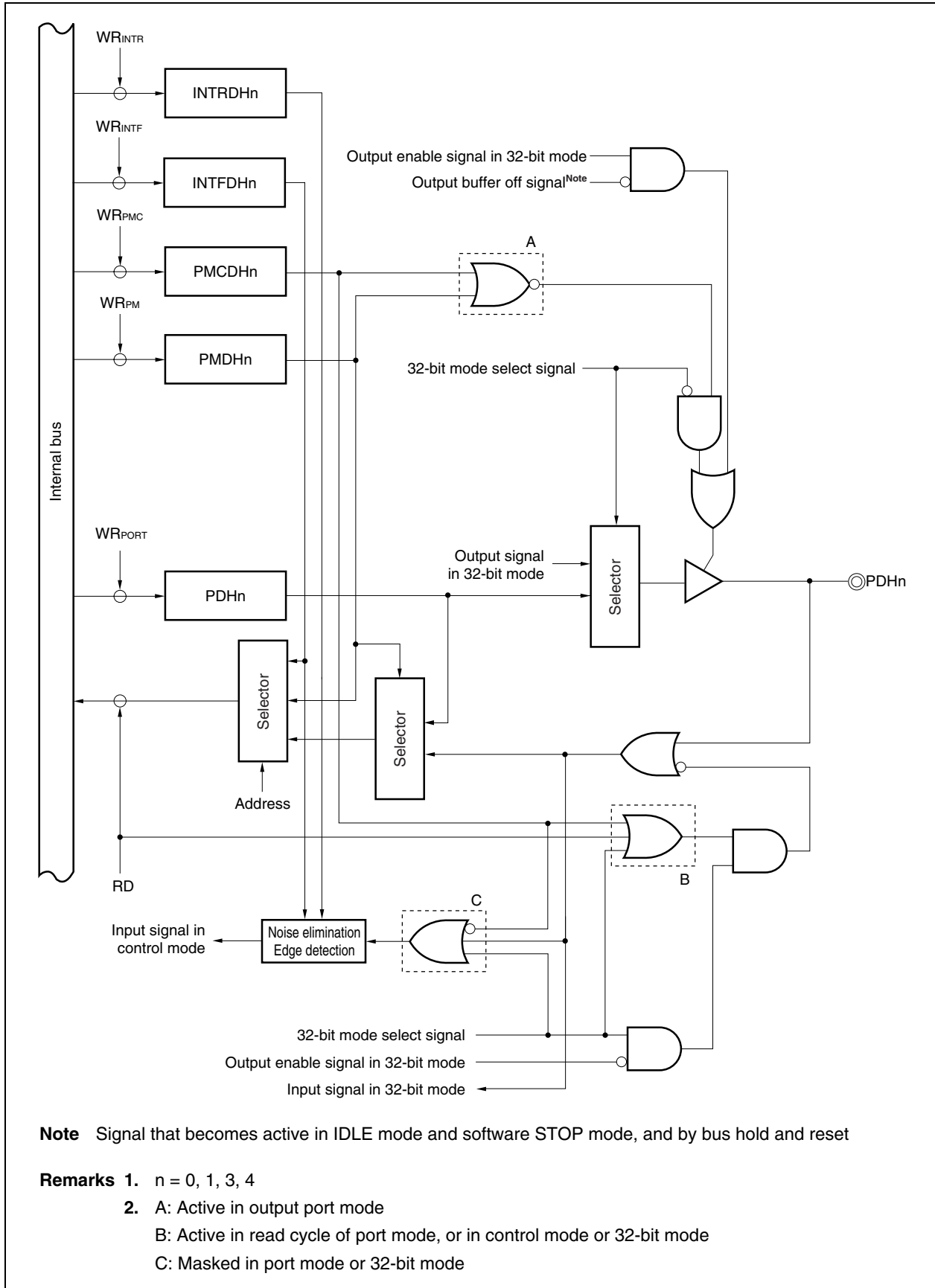


Figure 14-23. Block Diagram of Type M-2

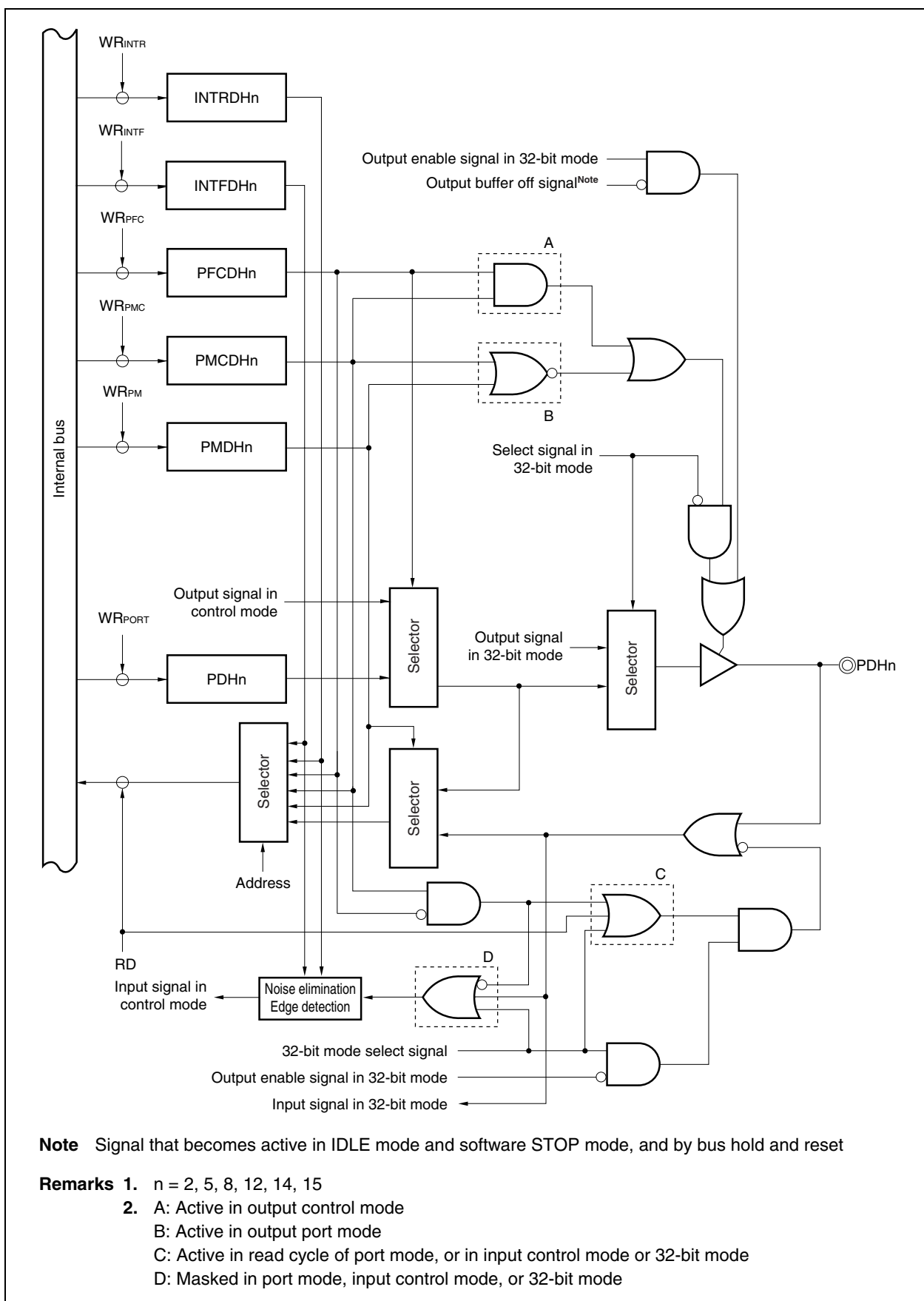
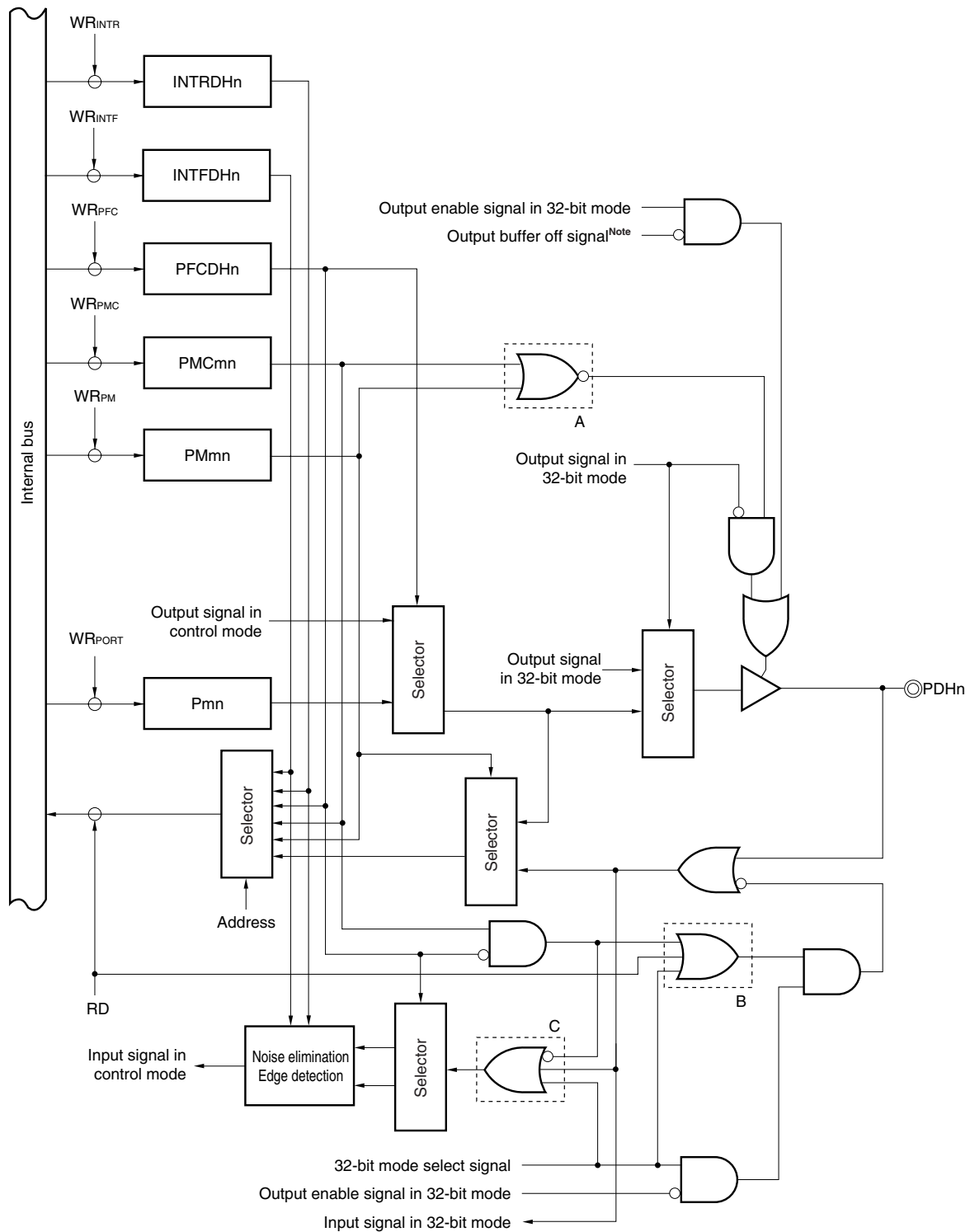


Figure 14-24. Block Diagram of Type M-3



**Note** Signal that becomes active in IDLE mode and software STOP mode, and by bus hold and reset

**Remarks 1.**  $n = 6, 7, 9, 10, 11, 13$

**2.** A: Active in output port mode

B: Active in read cycle of port mode, or in control mode or 32-bit mode

C: Masked in port mode or 32-bit mode



### 14.3 Port Pin Functions

#### 14.3.1 Port 1

Port 1 is a 4-bit I/O port that can be set to the input or output mode in 1-bit units.

|    |   |   |   |   |     |     |     |     |            |             |
|----|---|---|---|---|-----|-----|-----|-----|------------|-------------|
| P1 | 7 | 6 | 5 | 4 | 3   | 2   | 1   | 0   | Address    | After reset |
|    | 0 | 0 | 0 | 0 | P13 | P12 | P11 | P10 | FFFFFF402H | Undefined   |

| Bit position | Bit name            | Function |
|--------------|---------------------|----------|
| 3 to 0       | P1n<br>(n = 3 to 0) | I/O port |

**Remark** For reading/writing of the I/O port, see **14.5 Operation of Port Function**.

In addition to their function as port pins, the port 1 pins can also operate as serial interface I/O (CSI30, UARTB0), USB clock signal input, and external interrupt request input in the control mode.

#### (1) Operation in control mode

| Pin Name | Pin No. |     | Alternate Function              | Remark                                                            | Block Type |
|----------|---------|-----|---------------------------------|-------------------------------------------------------------------|------------|
|          | GM      | F1  |                                 |                                                                   |            |
| P10      | 159     | V11 | $\overline{\text{INTP10/UCLK}}$ | External interrupt input/USB clock signal input                   | F-3        |
| P11      | 155     | R9  | $\overline{\text{INTP11/SCK0}}$ | External interrupt request input/<br>serial interface (CSI30) I/O | H-1        |
| P12      | 154     | P9  | SI0/RXD0                        | Serial interface (CSI30) I/O/<br>serial interface (UARTB0) I/O    | F-1        |
| P13      | 153     | V9  | SO0/TXD0                        |                                                                   | J-1        |

**Remark** GM: 176-pin plastic LQFP (fine pitch) (24 × 24)

F1: 240-pin plastic FBGA (16 × 16)

**(2) I/O mode/control mode setting**

The port 1 I/O mode setting is performed by the port 1 mode register (PM1), and the control mode setting is performed by the port 1 mode control register (PMC1) and port 1 function control register (PFC1).

**(a) Port 1 mode register (PM1)**

This register can be read or written in 8-bit or 1-bit units.

|     |   |   |   |   |      |      |      |      |            |             |
|-----|---|---|---|---|------|------|------|------|------------|-------------|
|     | 7 | 6 | 5 | 4 | 3    | 2    | 1    | 0    | Address    | After reset |
| PM1 | 1 | 1 | 1 | 1 | PM13 | PM12 | PM11 | PM10 | FFFFFF422H | FFH         |

| Bit position | Bit name             | Function                                                                                                           |
|--------------|----------------------|--------------------------------------------------------------------------------------------------------------------|
| 3 to 0       | PM1n<br>(n = 3 to 0) | Specifies input/output mode for P1n pin.<br>0: Output mode (output buffer on)<br>1: Input mode (output buffer off) |

**(b) Port 1 mode control register (PMC1)**

This register can be read or written in 8-bit or 1-bit units.

<R> **Caution** When using the USB function, be sure to set the PFC10 bit of the PFC1 register to 1, and then set the PMC10 bit of the PMC1 register to 1. If the registers related to the USB function are read while these bits are 0, 0 is read.

|      |   |   |   |   |       |       |       |       |            |             |
|------|---|---|---|---|-------|-------|-------|-------|------------|-------------|
|      | 7 | 6 | 5 | 4 | 3     | 2     | 1     | 0     | Address    | After reset |
| PMC1 | 0 | 0 | 0 | 0 | PMC13 | PMC12 | PMC11 | PMC10 | FFFFFF442H | 00H         |

| Bit position | Bit name | Function                                                                                                                                                                                                     |
|--------------|----------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 3            | PMC13    | Specifies operation mode of P13 pin in combination with the PFC1 register.<br>0: I/O port mode<br>1: SO0 output mode/TXD0 output mode                                                                        |
| 2            | PMC12    | Specifies operation mode of P12 pin in combination with the PFC1 register.<br>0: I/O port mode<br>1: SI0 input mode/RXD0 input mode                                                                          |
| 1            | PMC11    | Specifies operation mode of P11 pin in combination with the PFC1 register.<br>0: I/O port mode<br>1: External interrupt request ( $\overline{\text{INTP11}}$ ) input mode/ $\overline{\text{SCK0}}$ I/O mode |
| 0            | PMC10    | Specifies operation mode of P10 pin in combination with the PFC1 register.<br>0: I/O port mode<br>1: External interrupt request ( $\overline{\text{INTP10}}$ ) input mode/UCLK input mode                    |

**(c) Port 1 function control register (PFC1)**

This register can be read or written in 8-bit or 1-bit units.

**Cautions** 1. When the port mode is specified by the port 1 mode control register (PMC1), the setting of this register becomes invalid.

2. When using the USB function, be sure to set the PFC10 bit of the PFC1 register to 1, and then set the PMC10 bit of the PMC1 register to 1. If the registers related to the USB function are read while these bits are 0, 0 is read.

<R>

|      |   |   |   |   |       |       |       |       |            |             |
|------|---|---|---|---|-------|-------|-------|-------|------------|-------------|
|      | 7 | 6 | 5 | 4 | 3     | 2     | 1     | 0     | Address    | After reset |
| PFC1 | 0 | 0 | 0 | 0 | PFC13 | PFC12 | PFC11 | PFC10 | FFFFFF462H | 00H         |

| Bit position | Bit name | Function                                                                                                                                                                |
|--------------|----------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 3            | PFC13    | Specifies operation mode of P13 pin in control mode.<br>0: SO0 output mode<br>1: TXD0 output mode                                                                       |
| 2            | PFC12    | Specifies operation mode of P12 pin in control mode.<br>0: SI0 input mode<br>1: RXD0 input mode                                                                         |
| 1            | PFC11    | Specifies operation mode of P11 pin in control mode.<br>0: External interrupt request ( $\overline{\text{INTP11}}$ ) input mode<br>1: $\overline{\text{SCK0}}$ I/O mode |
| 0            | PFC10    | Specifies operation mode of P10 pin in control mode.<br>0: External interrupt request ( $\overline{\text{INTP10}}$ ) input mode<br>1: UCLK input mode                   |

**(3) Selecting interrupt trigger mode**

The valid edges of the  $\overline{\text{INTP10}}$  and  $\overline{\text{INTP11}}$  pins can be selected by program. The levels to be detected can also be selected.

External interrupt rising edge specification register 1 (INTR1) and external interrupt falling edge specification register 1 (INTF1) are used to specify the valid edge and level detection.

**(a) External interrupt rising edge specification register 1 (INTR1) and external interrupt falling edge specification register 1 (INTF1)**

These registers are used to specify the trigger mode of the external interrupt requests (INTP10 and INTP11) from external pins.

The correspondence between each bit of this register and the external interrupt request controlled by that bit is as follows.

- INTF10 and INTR10 bits: INTP10
- INTF11 and INTR11 bits: INTP11

The valid edge can be independently selected from the rising edge, falling edge, and both rising and falling edges.

Both the registers can be read or written in 8-bit or 1-bit units.

**Caution** Set the PMC1 register before setting the trigger mode of the  $\overline{\text{INTP10}}$  and  $\overline{\text{INTP11}}$  pins.  
If the PMC1 register is set after the INTR1 and INTF1 registers have been set, an illegal interrupt may occur when the PMC1 register is set.

|       | 7 | 6 | 5 | 4 | 3 | 2 | 1      | 0      | Address   | After reset |
|-------|---|---|---|---|---|---|--------|--------|-----------|-------------|
| INTR1 | 0 | 0 | 0 | 0 | 0 | 0 | INTR11 | INTR10 | FFFFFC22H | 03H         |
| INTF1 | 0 | 0 | 0 | 0 | 0 | 0 | INTF11 | INTF10 | FFFFFC02H | 00H         |

| Bit position | Bit name                        | Function                                                                                                                                                                                                                                                                                                                                       |        |                                                             |           |   |   |              |   |   |             |   |   |                                                             |   |   |                               |
|--------------|---------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|-------------------------------------------------------------|-----------|---|---|--------------|---|---|-------------|---|---|-------------------------------------------------------------|---|---|-------------------------------|
| 1, 0         | INTF1n,<br>INTR1n<br>(n = 0, 1) | Specify trigger mode of $\overline{\text{INTP10}}$ and $\overline{\text{INTP11}}$ pins.                                                                                                                                                                                                                                                        |        |                                                             |           |   |   |              |   |   |             |   |   |                                                             |   |   |                               |
|              |                                 | <table><tr><th>INTF1n</th><th>INTR1n</th><th>Operation</th></tr><tr><td>0</td><td>0</td><td>Falling edge</td></tr><tr><td>0</td><td>1</td><td>Rising edge</td></tr><tr><td>1</td><td>0</td><td>Level detection (low-level detection)<sup>Notes 1, 2</sup></td></tr><tr><td>1</td><td>1</td><td>Both rising and falling edges</td></tr></table> | INTF1n | INTR1n                                                      | Operation | 0 | 0 | Falling edge | 0 | 1 | Rising edge | 1 | 0 | Level detection (low-level detection) <sup>Notes 1, 2</sup> | 1 | 1 | Both rising and falling edges |
|              |                                 | INTF1n                                                                                                                                                                                                                                                                                                                                         | INTR1n | Operation                                                   |           |   |   |              |   |   |             |   |   |                                                             |   |   |                               |
|              |                                 | 0                                                                                                                                                                                                                                                                                                                                              | 0      | Falling edge                                                |           |   |   |              |   |   |             |   |   |                                                             |   |   |                               |
|              |                                 | 0                                                                                                                                                                                                                                                                                                                                              | 1      | Rising edge                                                 |           |   |   |              |   |   |             |   |   |                                                             |   |   |                               |
|              |                                 | 1                                                                                                                                                                                                                                                                                                                                              | 0      | Level detection (low-level detection) <sup>Notes 1, 2</sup> |           |   |   |              |   |   |             |   |   |                                                             |   |   |                               |
| 1            | 1                               | Both rising and falling edges                                                                                                                                                                                                                                                                                                                  |        |                                                             |           |   |   |              |   |   |             |   |   |                                                             |   |   |                               |
|              |                                 |                                                                                                                                                                                                                                                                                                                                                |        |                                                             |           |   |   |              |   |   |             |   |   |                                                             |   |   |                               |
|              |                                 |                                                                                                                                                                                                                                                                                                                                                |        |                                                             |           |   |   |              |   |   |             |   |   |                                                             |   |   |                               |
|              |                                 |                                                                                                                                                                                                                                                                                                                                                |        |                                                             |           |   |   |              |   |   |             |   |   |                                                             |   |   |                               |
|              |                                 |                                                                                                                                                                                                                                                                                                                                                |        |                                                             |           |   |   |              |   |   |             |   |   |                                                             |   |   |                               |

- Notes 1.** The level of the  $\overline{\text{INTP1n}}$  pin is sampled each time the main clock (fx) is divided by four. When the low level of this pin is detected, an interrupt request is latched as the P1IFn bit (n = 0, 1). Consequently, even when the CPU acknowledges the interrupt and the P1IFn bit of the interrupt control register (P1ICn) is automatically cleared to 0, the P1IFn bit is immediately set to 1 and interrupts occur consecutively. To avoid this status, make the  $\overline{\text{INTP1n}}$  pin of the external device inactive in the interrupt servicing routine, and forcibly clear the P1IFn bit to 0.
- 2.** If a level-detected interrupt request ( $\overline{\text{INTP1n}}$ ) with a lower priority occurs while an interrupt is being serviced and if this level-detected interrupt request ( $\overline{\text{INTP1n}}$ ) that has newly occurred becomes inactive before the current interrupt has been serviced, the interrupt request of the new interrupt ( $\overline{\text{INTP1n}}$ ) is held pending (n = 0, 1). To not acknowledge the interrupt request of  $\overline{\text{INTP1n}}$ , clear the P1IFn bit of the interrupt control register.

### 14.3.2 Port 2

Port 2 is an I/O port that can be set to the input or output mode in 1-bit units except for P20, which is an input-only pin.

P20 always functions as an NMI pin. The level of the NMI pin can be read by reading the P20 bit of the P2 register.

|    |   |   |     |     |     |     |     |     |           |             |
|----|---|---|-----|-----|-----|-----|-----|-----|-----------|-------------|
|    | 7 | 6 | 5   | 4   | 3   | 2   | 1   | 0   | Address   | After reset |
| P2 | 0 | 0 | P25 | P24 | P23 | P22 | P21 | P20 | FFFFF404H | Undefined   |

| Bit position | Bit name            | Function |
|--------------|---------------------|----------|
| 5 to 0       | P2n<br>(n = 5 to 0) | I/O port |

**Remark** For reading/writing of the I/O port, see **14.5 Operation of Port Function**.

In addition to their function as port pins, the port 2 pins can also operate as the serial interface (CSI31, UARTB1) I/O and external interrupt request input in the control mode.

#### (1) Operation in control mode

| Pin Name | Pin No. |    | Alternate Function                     | Remark                                                             | Block Type |
|----------|---------|----|----------------------------------------|--------------------------------------------------------------------|------------|
|          | GM      | F1 |                                        |                                                                    |            |
| P20      | 152     | T9 | NMI                                    | Non-maskable interrupt request input                               | A-1        |
| P21      | 149     | T8 | $\overline{\text{INTP21}}/\text{RXD1}$ | External interrupt request input/<br>serial interface (UARTB1) I/O | F-4        |
| P22      | 148     | U8 | $\overline{\text{INTP22}}/\text{TXD1}$ |                                                                    | G-2        |
| P23      | 147     | P8 | $\overline{\text{INTP23}}/\text{SCK1}$ | External interrupt request input/<br>serial interface (CSI31) I/O  | H-1        |
| P24      | 146     | V7 | $\overline{\text{INTP24}}/\text{SI1}$  |                                                                    | F-4        |
| P25      | 145     | U7 | $\overline{\text{INTP25}}/\text{SO1}$  |                                                                    | G-2        |

**Remark** GM: 176-pin plastic LQFP (fine pitch) (24 × 24)

F1: 240-pin plastic FBGA (16 × 16)

**(2) I/O mode/control mode setting**

The port 2 I/O mode setting is performed by the port 2 mode register (PM2), and the control mode setting is performed by the port 2 mode control register (PMC2) and the port 2 function control register (PFC2).

**(a) Port 2 mode register (PM2)**

This register can be read or written in 8-bit or 1-bit units.

|     |   |   |      |      |      |      |      |   |            |             |
|-----|---|---|------|------|------|------|------|---|------------|-------------|
|     | 7 | 6 | 5    | 4    | 3    | 2    | 1    | 0 | Address    | After reset |
| PM2 | 1 | 1 | PM25 | PM24 | PM23 | PM22 | PM21 | 1 | FFFFFF424H | FFH         |

| Bit position | Bit name             | Function                                                                                                           |
|--------------|----------------------|--------------------------------------------------------------------------------------------------------------------|
| 5 to 1       | PM2n<br>(n = 5 to 1) | Specifies input/output mode for P2n pin.<br>0: Output mode (output buffer on)<br>1: Input mode (output buffer off) |

**(b) Port 2 mode control register (PMC2)**

This register can be read or written in 8-bit or 1-bit units.

|      |   |   |       |       |       |       |       |   |            |             |
|------|---|---|-------|-------|-------|-------|-------|---|------------|-------------|
|      | 7 | 6 | 5     | 4     | 3     | 2     | 1     | 0 | Address    | After reset |
| PMC2 | 0 | 0 | PMC25 | PMC24 | PMC23 | PMC22 | PMC21 | 1 | FFFFFF444H | 01H         |

| Bit position | Bit name | Function                                                                                                                                                                                                     |
|--------------|----------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 5            | PMC25    | Specifies operation mode of P25 pin in combination with the PFC2 register.<br>0: I/O port mode<br>1: External interrupt request ( $\overline{\text{INTP25}}$ ) input mode/SO1 output mode                    |
| 4            | PMC24    | Specifies operation mode of P24 pin in combination with the PFC2 register.<br>0: I/O port mode<br>1: External interrupt request ( $\overline{\text{INTP24}}$ ) input mode/SI1 input mode                     |
| 3            | PMC23    | Specifies operation mode of P23 pin in combination with the PFC2 register.<br>0: I/O port mode<br>1: External interrupt request ( $\overline{\text{INTP23}}$ ) input mode/ $\overline{\text{SCK1}}$ I/O mode |
| 2            | PMC22    | Specifies operation mode of P22 pin in combination with the PFC2 register.<br>0: I/O port mode<br>1: External interrupt request ( $\overline{\text{INTP22}}$ ) input mode/TXD1 output mode                   |
| 1            | PMC21    | Specifies operation mode of P21 pin in combination with the PFC2 register.<br>0: I/O port mode<br>1: External interrupt request ( $\overline{\text{INTP21}}$ ) input mode/RXD1 input mode                    |

**(c) Port 2 function control register (PFC2)**

This register can be read or written in 8-bit or 1-bit units.

**Caution** When the port mode is specified by the port 2 mode control register (PMC2), the PFC2 setting becomes invalid.

|      |   |   |       |       |       |       |       |   |            |             |
|------|---|---|-------|-------|-------|-------|-------|---|------------|-------------|
|      | 7 | 6 | 5     | 4     | 3     | 2     | 1     | 0 | Address    | After reset |
| PFC2 | 0 | 0 | PFC25 | PFC24 | PFC23 | PFC22 | PFC21 | 0 | FFFFFF464H | 00H         |

| Bit position | Bit name | Function                                                                                                                                                     |
|--------------|----------|--------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 5            | PFC25    | Specifies operation mode of P25 pin in control mode.<br>0: External interrupt request ( $\overline{\text{INTP25}}$ ) input mode<br>1: SO1 output mode        |
| 4            | PFC24    | Specifies operation mode of P24 pin in control mode.<br>0: External interrupt request ( $\overline{\text{INTP24}}$ ) input mode<br>1: SI1 input mode         |
| 3            | PFC23    | Specifies operation mode of P23 pin in control mode.<br>0: External interrupt request ( $\overline{\text{INTP23}}$ ) input mode<br>1: $\text{SCK1}$ I/O mode |
| 2            | PFC22    | Specifies operation mode of P22 pin in control mode.<br>0: External interrupt request ( $\overline{\text{INTP22}}$ ) input mode<br>1: TXD1 output mode       |
| 1            | PFC21    | Specifies operation mode of P21 pin in control mode.<br>0: External interrupt request ( $\overline{\text{INTP21}}$ ) input mode<br>1: RXD1 input mode        |



**(3) Selecting interrupt trigger mode**

The valid edges of the  $\overline{\text{INTP2n}}$  and NMI pins can be selected by program ( $n = 1$  to 5). The level detection of the  $\overline{\text{INTP2n}}$  pin can also be selected.

External interrupt rising edge specification register 2 (INTR2) and external interrupt falling edge specification register 2 (INTF2) are used to specify the valid edge and level detection.

**(a) External interrupt rising edge specification register 2 (INTR2) and external interrupt falling edge specification register 2 (INTF2)**

These registers are used to specify the trigger mode of an external interrupt request ( $\overline{\text{INTP2n}}$ ) from an external pin and the non-maskable interrupt (NMI) ( $n = 1$  to 5). The correspondence between each bit of this register and the external interrupt request and non-maskable interrupt controlled by that bit is as follows.

- NMIF0 and NMIR0 bits: NMI
- INTF21 and INTR21 bits: INTP21
- INTF22 and INTR22 bits: INTP22
- INTF23 and INTR23 bits: INTP23
- INTF24 and INTR24 bits: INTP24
- INTF25 and INTR25 bits: INTP25

The rising edge, falling edge, or both the rising and falling edges can be specified as the valid edge of the  $\overline{\text{INTP2n}}$  pin and the rising or falling edge can be specified as the valid edge of the NMI pin, independently for each pin.

Both the registers can be read or written in 8-bit or 1-bit units.

**Caution** Set the PMC2 register before setting the trigger mode of the  $\overline{\text{INTP2n}}$  pin ( $n = 1$  to 5).  
If the PMC2 register is set after the INTR2 and INTF2 registers have been set, an illegal interrupt may occur when the PMC2 register is set.

|       |   |   |        |        |        |        |        |       |           |             |
|-------|---|---|--------|--------|--------|--------|--------|-------|-----------|-------------|
|       | 7 | 6 | 5      | 4      | 3      | 2      | 1      | 0     | Address   | After reset |
| INTR2 | 0 | 0 | INTR25 | INTR24 | INTR23 | INTR22 | INTR21 | NMIR0 | FFFFFC24H | 3FH         |
| INTF2 | 0 | 0 | INTF25 | INTF24 | INTF23 | INTF22 | INTF21 | NMIF0 | FFFFFC04H | 00H         |

| Bit position | Bit name                          | Function                                                                                                                                                                                                                                                                                                                                                                                                          |        |        |           |   |   |              |   |   |             |   |   |                                                             |   |   |                               |
|--------------|-----------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|--------|-----------|---|---|--------------|---|---|-------------|---|---|-------------------------------------------------------------|---|---|-------------------------------|
| 5 to 1       | INTF2n,<br>INTR2n<br>(n = 1 to 5) | Specify trigger mode of $\overline{\text{INTP2n}}$ pin. <table> <tr> <th>INTF2n</th><th>INTR2n</th><th>Operation</th></tr> <tr> <td>0</td><td>0</td><td>Falling edge</td></tr> <tr> <td>0</td><td>1</td><td>Rising edge</td></tr> <tr> <td>1</td><td>0</td><td>Level detection (low-level detection)<sup>Notes 1, 2</sup></td></tr> <tr> <td>1</td><td>1</td><td>Both rising and falling edges</td></tr> </table> | INTF2n | INTR2n | Operation | 0 | 0 | Falling edge | 0 | 1 | Rising edge | 1 | 0 | Level detection (low-level detection) <sup>Notes 1, 2</sup> | 1 | 1 | Both rising and falling edges |
| INTF2n       | INTR2n                            | Operation                                                                                                                                                                                                                                                                                                                                                                                                         |        |        |           |   |   |              |   |   |             |   |   |                                                             |   |   |                               |
| 0            | 0                                 | Falling edge                                                                                                                                                                                                                                                                                                                                                                                                      |        |        |           |   |   |              |   |   |             |   |   |                                                             |   |   |                               |
| 0            | 1                                 | Rising edge                                                                                                                                                                                                                                                                                                                                                                                                       |        |        |           |   |   |              |   |   |             |   |   |                                                             |   |   |                               |
| 1            | 0                                 | Level detection (low-level detection) <sup>Notes 1, 2</sup>                                                                                                                                                                                                                                                                                                                                                       |        |        |           |   |   |              |   |   |             |   |   |                                                             |   |   |                               |
| 1            | 1                                 | Both rising and falling edges                                                                                                                                                                                                                                                                                                                                                                                     |        |        |           |   |   |              |   |   |             |   |   |                                                             |   |   |                               |
| 0            | NMIF0,<br>NMIR0                   | Specify trigger mode of NMI pin. <table> <tr> <th>NMIF0</th><th>NMIR0</th><th>Operation</th></tr> <tr> <td>0</td><td>0</td><td>Falling edge</td></tr> <tr> <td>0</td><td>1</td><td>Rising edge</td></tr> <tr> <td>1</td><td>0</td><td>Setting prohibited</td></tr> <tr> <td>1</td><td>1</td><td>Both rising and falling edges</td></tr> </table>                                                                  | NMIF0  | NMIR0  | Operation | 0 | 0 | Falling edge | 0 | 1 | Rising edge | 1 | 0 | Setting prohibited                                          | 1 | 1 | Both rising and falling edges |
| NMIF0        | NMIR0                             | Operation                                                                                                                                                                                                                                                                                                                                                                                                         |        |        |           |   |   |              |   |   |             |   |   |                                                             |   |   |                               |
| 0            | 0                                 | Falling edge                                                                                                                                                                                                                                                                                                                                                                                                      |        |        |           |   |   |              |   |   |             |   |   |                                                             |   |   |                               |
| 0            | 1                                 | Rising edge                                                                                                                                                                                                                                                                                                                                                                                                       |        |        |           |   |   |              |   |   |             |   |   |                                                             |   |   |                               |
| 1            | 0                                 | Setting prohibited                                                                                                                                                                                                                                                                                                                                                                                                |        |        |           |   |   |              |   |   |             |   |   |                                                             |   |   |                               |
| 1            | 1                                 | Both rising and falling edges                                                                                                                                                                                                                                                                                                                                                                                     |        |        |           |   |   |              |   |   |             |   |   |                                                             |   |   |                               |

- Notes 1.** The level of the  $\overline{\text{INTP2n}}$  pin is sampled each time the main clock (fx) is divided by four. When the low level of this pin is detected, an interrupt request is latched as the P2IFn bit (n = 1 to 5). Consequently, even when the CPU acknowledges the interrupt and the P2IFn bit of the interrupt control register (P2ICn) is automatically cleared to 0, the P2IFn bit is immediately set to 1 and interrupts occur consecutively. To avoid this status, make the  $\overline{\text{INTP2n}}$  pin of the external device inactive in the interrupt servicing routine, and forcibly clear the P2IFn bit to 0.
- 2.** If a level-detected interrupt request (INTP2n) with a lower priority occurs while an interrupt is being serviced and if this level-detected interrupt request (INTP2n) that has newly occurred becomes inactive before the current interrupt has been serviced, the interrupt request of the new interrupt (INTP2n) is held pending (n = 1 to 5). To not acknowledge the interrupt request of INTP2n, clear the P2IFn bit of the interrupt control register.

### 14.3.3 Port 5

Port 5 is a 6-bit I/O port that can be set to the input or output mode in 1-bit units.

|    |   |   |     |     |     |     |     |     |            |             |
|----|---|---|-----|-----|-----|-----|-----|-----|------------|-------------|
|    | 7 | 6 | 5   | 4   | 3   | 2   | 1   | 0   | Address    | After reset |
| P5 | 0 | 0 | P55 | P54 | P53 | P52 | P51 | P50 | FFFFFF40AH | Undefined   |

| Bit position | Bit name            | Function |
|--------------|---------------------|----------|
| 5 to 0       | P5n<br>(n = 5 to 0) | I/O port |

**Remark** For reading/writing of the I/O port, see **14.5 Operation of Port Function**.

In addition to their function as port pins, the port 5 pins can also operate as the DMA controller I/O, timer/counter I/O, and external interrupt request input in the control mode.

#### (1) Operation in control mode

| Pin Name | Pin No. |     | Alternate Function                      | Remark                                                                                                       | Block Type |
|----------|---------|-----|-----------------------------------------|--------------------------------------------------------------------------------------------------------------|------------|
|          | GM      | F1  |                                         |                                                                                                              |            |
| P50      | 25      | J15 | $\overline{\text{INTP50/DMARQ0}}$       | External interrupt request input/DMA request input                                                           | F-3        |
| P51      | 24      | J16 | $\overline{\text{INTP51/DMAAK0}}$       | External interrupt request input/<br>DMA acknowledge signal output                                           | G-2        |
| P52      | 23      | J17 | $\overline{\text{INTP52/TC0}}$          | External interrupt request input/DMA end signal output                                                       |            |
| P53      | 22      | J18 | $\overline{\text{INTPC00/TIC0/DMARQ1}}$ | External interrupt request and timer C0 external capture trigger input/timer/counter input/DMA request input | F-2        |
| P54      | 21      | K15 | $\overline{\text{INTPC01/DMAAK1}}$      | External interrupt request and timer C0 external capture trigger input/DMA acknowledge signal output         | G-1        |
| P55      | 20      | K14 | $\overline{\text{TOC0/TC1}}$            | Timer/counter output/DMA end signal output                                                                   | J-1        |

**Remark** GM: 176-pin plastic LQFP (fine pitch) (24 × 24)

F1: 240-pin plastic FBGA (16 × 16)

**(2) I/O mode/control mode setting**

The port 5 I/O mode setting is performed by the port 5 mode register (PM5), and the control mode setting is performed by the port 5 mode control register (PMC5) and port 5 function control register (PFC5).

**(a) Port 5 mode register (PM5)**

This register can be read or written in 8-bit or 1-bit units.

|     |   |   |      |      |      |      |      |      |          |             |
|-----|---|---|------|------|------|------|------|------|----------|-------------|
|     | 7 | 6 | 5    | 4    | 3    | 2    | 1    | 0    | Address  | After reset |
| PM5 | 1 | 1 | PM55 | PM54 | PM53 | PM52 | PM51 | PM50 | FFFF42AH | FFH         |

| Bit position | Bit name             | Function                                                                                                           |
|--------------|----------------------|--------------------------------------------------------------------------------------------------------------------|
| 5 to 0       | PM5n<br>(n = 5 to 0) | Specifies input/output mode for P5n pin.<br>0: Output mode (output buffer on)<br>1: Input mode (output buffer off) |

**(b) Port 5 mode control register (PMC5)**

This register can be read or written in 8-bit or 1-bit units.

|      |   |   |       |       |       |       |       |       |          |             |
|------|---|---|-------|-------|-------|-------|-------|-------|----------|-------------|
|      | 7 | 6 | 5     | 4     | 3     | 2     | 1     | 0     | Address  | After reset |
| PMC5 | 0 | 0 | PMC55 | PMC54 | PMC53 | PMC52 | PMC51 | PMC50 | FFFF44AH | 00H         |

| Bit position | Bit name | Function                                                                                                                                                                                                                                                  |
|--------------|----------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 5            | PMC55    | Specifies operation mode of P55 pin in combination with the PFC5 register.<br>0: I/O port mode<br>1: TOC0 output mode/DMA end signal ( $\overline{TC1}$ ) output mode                                                                                     |
| 4            | PMC54    | Specifies operation mode of P54 pin in combination with the PFC5 register.<br>0: I/O port mode<br>1: External interrupt request and timer C0 external capture trigger (INTPC01) input mode/DMA acknowledge signal ( $\overline{DMAAK1}$ ) output mode     |
| 3            | PMC53    | Specifies operation mode of P53 pin in combination with the PFC5 register.<br>0: I/O port mode<br>1: External interrupt request and timer C0 external capture trigger (INTPC00) input mode/TIC0 input mode/DMA request ( $\overline{DMARQ1}$ ) input mode |
| 2            | PMC52    | Specifies operation mode of P52 pin in combination with the PFC5 register.<br>0: I/O port mode<br>1: External interrupt request ( $\overline{INTP52}$ ) input mode/DMA end signal ( $\overline{TC0}$ ) output mode                                        |
| 1            | PMC51    | Specifies operation mode of P51 pin in combination with the PFC5 register.<br>0: I/O port mode<br>1: External interrupt request ( $\overline{INTP51}$ ) input mode/DMA acknowledge signal ( $\overline{DMAAK0}$ ) output mode                             |
| 0            | PMC50    | Specifies operation mode of P50 pin in combination with the PFC5 register.<br>0: I/O port mode<br>1: External interrupt request ( $\overline{INTP50}$ ) input mode/DMA request ( $\overline{DMARQ0}$ ) input mode                                         |

**(c) Port 5 function control register (PFC5)**

This register can be read or written in 8-bit or 1-bit units.

**Caution** When the port mode is specified by the port 5 mode control register (PMC5), the setting of this register becomes invalid.

|      |   |   |       |       |       |       |       |       |           |             |
|------|---|---|-------|-------|-------|-------|-------|-------|-----------|-------------|
|      | 7 | 6 | 5     | 4     | 3     | 2     | 1     | 0     | Address   | After reset |
| PFC5 | 0 | 0 | PFC55 | PFC54 | PFC53 | PFC52 | PFC51 | PFC50 | FFFFF46AH | 00H         |

| Bit position | Bit name | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|--------------|----------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 5            | PFC55    | Specifies operation mode of P55 pin in control mode.<br>0: TOC0 output mode<br>1: DMA end signal ( $\overline{\text{TC1}}$ ) output mode                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| 4            | PFC54    | Specifies operation mode of P54 pin in control mode.<br>0: External interrupt request and timer C0 external capture trigger (INTPC01) input mode<br>1: DMA acknowledge signal ( $\overline{\text{DMAAK1}}$ ) output                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| 3            | PFC53    | Specifies operation mode of P53 pin in control mode.<br>0: External interrupt request and timer C0 external capture trigger (INTPC01) input mode/TIC0 input mode<br>1: DMA request ( $\overline{\text{DMARQ1}}$ ) input mode<br>There is no register that selects an external interrupt request and timer C0 external capture trigger (INTPC00) input mode or TIC0 input mode.<br><ul style="list-style-type: none"><li>To use TIC0 input mode:<br/>Mask the external interrupt request and external capture trigger (INTPC00) of timer C0, or use the CCC00 register as a compare register.</li><li>To use external interrupt request and external capture trigger (INTPC00) of timer C0:<br/>Clear the ETIC0 bit of the TMCC01 register to 0.</li></ul> |
| 2            | PFC52    | Specifies operation mode of P52 pin.<br>0: External interrupt request ( $\overline{\text{INTP52}}$ ) input mode<br>1: DMA end signal ( $\overline{\text{TC0}}$ ) output mode                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| 1            | PFC51    | Specifies operation mode of P51 pin.<br>0: External interrupt request ( $\overline{\text{INTP51}}$ ) input mode<br>1: DMA acknowledge signal ( $\overline{\text{DMAAK0}}$ ) output                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| 0            | PFC50    | Specifies operation mode of P50 pin in control mode.<br>0: External interrupt request ( $\overline{\text{INTP50}}$ ) input mode<br>1: DMA request ( $\overline{\text{DMARQ0}}$ ) input mode                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |

**(3) Selecting interrupt trigger mode**

The valid edges of the  $\overline{\text{INTP5n}}$  pin can be selected by program ( $n = 0$  to  $2$ ). The level detection of the  $\overline{\text{INTP5n}}$  pin can also be selected.

External interrupt rising edge specification register 5 (INTR5) and external interrupt falling edge specification register 5 (INTF5) are used to specify the valid edge and level detection.

**(a) External interrupt rising edge specification register 5 (INTR5) and external interrupt falling edge specification register 5 (INTF5)**

These registers are used to specify the trigger mode of an external interrupt request ( $\text{INTP5n}$ ) from an external pin ( $n = 0$  to  $2$ ). The correspondence between each bit of this register and the external interrupt request controlled by that bit is as follows.

- INTF50 and INTR50 bits:  $\text{INTP50}$
- INTF51 and INTR51 bits:  $\text{INTP51}$
- INTF52 and INTR52 bits:  $\text{INTP52}$

The rising edge, falling edge, or both the rising and falling edges can be specified as the valid edge of the  $\overline{\text{INTP5n}}$  pin, independently for each pin.

Both the registers can be read or written in 8-bit or 1-bit units.

**Caution** Set the PMC5 register before setting the trigger mode.

**If the PMC5 register is set after the INTR5 and INTF5 registers have been set, an illegal interrupt may occur when the PMC5 register is set.**

|       | 7 | 6 | 5 | 4 | 3 | 2      | 1      | 0      | Address   | After reset |
|-------|---|---|---|---|---|--------|--------|--------|-----------|-------------|
| INTR5 | 0 | 0 | 0 | 0 | 0 | INTR52 | INTR51 | INTR50 | FFFFFC2AH | 07H         |
| INTF5 | 0 | 0 | 0 | 0 | 0 | INTF52 | INTF51 | INTF50 | FFFFFC0AH | 00H         |

| Bit position | Bit name                          | Function                                                |        |                                                             |   |   |              |   |   |             |   |   |                                                             |   |   |                               |
|--------------|-----------------------------------|---------------------------------------------------------|--------|-------------------------------------------------------------|---|---|--------------|---|---|-------------|---|---|-------------------------------------------------------------|---|---|-------------------------------|
| 2 to 0       | INTF5n,<br>INTR5n<br>(n = 0 to 2) | Specify trigger mode of $\overline{\text{INTP5n}}$ pin. |        |                                                             |   |   |              |   |   |             |   |   |                                                             |   |   |                               |
|              |                                   | INTF5n                                                  | INTR5n | Operation                                                   | 0 | 0 | Falling edge | 0 | 1 | Rising edge | 1 | 0 | Level detection (low-level detection) <sup>Notes 1, 2</sup> | 1 | 1 | Both rising and falling edges |
|              |                                   | INTF5n                                                  | INTR5n | Operation                                                   |   |   |              |   |   |             |   |   |                                                             |   |   |                               |
|              |                                   | 0                                                       | 0      | Falling edge                                                |   |   |              |   |   |             |   |   |                                                             |   |   |                               |
|              |                                   | 0                                                       | 1      | Rising edge                                                 |   |   |              |   |   |             |   |   |                                                             |   |   |                               |
|              |                                   | 1                                                       | 0      | Level detection (low-level detection) <sup>Notes 1, 2</sup> |   |   |              |   |   |             |   |   |                                                             |   |   |                               |
| 1            | 1                                 | Both rising and falling edges                           |        |                                                             |   |   |              |   |   |             |   |   |                                                             |   |   |                               |

- Notes 1.** The level of the  $\overline{\text{INTP5n}}$  pin is sampled each time the main clock (fx) is divided by four. When the low level of this pin is detected, an interrupt request is latched as the P5IFn bit (n = 0 to 2). Consequently, even when the CPU acknowledges the interrupt and the P5IFn bit of the interrupt control register (P5ICn) is automatically cleared to 0, the P5IFn bit is immediately set to 1 and interrupts occur consecutively. To avoid this status, make the  $\overline{\text{INTP5n}}$  pin of the external device inactive in the interrupt servicing routine, and forcibly clear the P5IFn bit to 0.
- 2.** If a level-detected interrupt request ( $\overline{\text{INTP5n}}$ ) with a lower priority occurs while an interrupt is being serviced and if this level-detected interrupt request ( $\overline{\text{INTP5n}}$ ) that has newly occurred becomes inactive before the current interrupt has been serviced, the interrupt request of the new interrupt ( $\overline{\text{INTP5n}}$ ) is held pending (n = 0 to 2). To not acknowledge the interrupt request of  $\overline{\text{INTP5n}}$ , clear the P5IFn bit of the interrupt control register.

### 14.3.4 Port 6

Port 6 is a 3-bit I/O port that can be set to the input or output mode in 1-bit units.

|    |     |     |     |   |   |   |   |   |            |             |
|----|-----|-----|-----|---|---|---|---|---|------------|-------------|
|    | 7   | 6   | 5   | 4 | 3 | 2 | 1 | 0 | Address    | After reset |
| P6 | P67 | P66 | P65 | 0 | 0 | 0 | 0 | 0 | FFFFFF40CH | Undefined   |

| Bit position | Bit name            | Function |
|--------------|---------------------|----------|
| 7 to 5       | P6n<br>(n = 7 to 5) | I/O port |

**Remark** For reading/writing of the I/O port, see **14.5 Operation of Port Function**.

In addition to their function as port pins, the port 6 pins can also operate as the timer/counter I/O and external interrupt request input in the control mode.

#### (1) Operation in control mode

| Pin Name | Pin No. |     | Alternate Function                                    | Remark                                                                                         | Block Type |
|----------|---------|-----|-------------------------------------------------------|------------------------------------------------------------------------------------------------|------------|
|          | GM      | F1  |                                                       |                                                                                                |            |
| P65      | 19      | K16 | $\overline{\text{INTP65}}/\text{INTPC10}/\text{TIC1}$ | External interrupt request and timer C1 external capture trigger input/<br>timer/counter input | L-5        |
| P66      | 18      | K17 | $\overline{\text{INTP66}}/\text{INTPC11}$             | External interrupt request and timer C1 external capture trigger input                         |            |
| P67      | 17      | L18 | $\overline{\text{INTP67}}/\text{TOC1}$                | External interrupt request input/<br>timer/counter output                                      | L-3        |

**Remark** GM: 176-pin plastic LQFP (fine pitch) (24 × 24)  
F1: 240-pin plastic FBGA (16 × 16)



**(2) I/O mode/control mode setting**

The port 6 I/O mode setting is performed by the port 6 mode register (PM6), and the control mode setting is performed by the port 6 mode control register (PMC6) and port 6 function control register (PFC6).

**(a) Port 6 mode register (PM6)**

This register can be read or written in 8-bit or 1-bit units.

|     |      |      |      |   |   |   |   |   |            |             |
|-----|------|------|------|---|---|---|---|---|------------|-------------|
|     | 7    | 6    | 5    | 4 | 3 | 2 | 1 | 0 | Address    | After reset |
| PM6 | PM67 | PM66 | PM65 | 1 | 1 | 1 | 1 | 1 | FFFFFF42CH | FFH         |

| Bit position | Bit name             | Function                                                                                                           |
|--------------|----------------------|--------------------------------------------------------------------------------------------------------------------|
| 7 to 5       | PM6n<br>(n = 7 to 5) | Specifies input/output mode for P6n pin.<br>0: Output mode (output buffer on)<br>1: Input mode (output buffer off) |

**(b) Port 6 mode control register (PMC6)**

This register can be read or written in 8-bit or 1-bit units.

|      |       |       |       |   |   |   |   |   |            |             |
|------|-------|-------|-------|---|---|---|---|---|------------|-------------|
|      | 7     | 6     | 5     | 4 | 3 | 2 | 1 | 0 | Address    | After reset |
| PMC6 | PMC67 | PMC66 | PMC65 | 0 | 0 | 0 | 0 | 0 | FFFFFF44CH | 00H         |

| Bit position | Bit name | Function                                                                                                                                                                                                                                  |
|--------------|----------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 7            | PMC67    | Specifies operation mode of P67 pin.<br>0: I/O port mode<br>1: External interrupt request ( $\overline{\text{INTP67}}$ ) input mode/TOC1 output mode                                                                                      |
| 6            | PMC66    | Specifies operation mode of P66 pin.<br>0: I/O port mode<br>1: External interrupt request ( $\overline{\text{INTP66}}$ ) input mode/external interrupt request and timer C1 external capture trigger (INTPC11) input mode                 |
| 5            | PMC65    | Specifies operation mode of P65 pin.<br>0: I/O port mode<br>1: External interrupt request ( $\overline{\text{INTP65}}$ ) input mode/external interrupt request and timer C1 external capture trigger (INTPC10) input mode/TIC1 input mode |

**(c) Port 6 function control register (PFC6)**

This register can be read or written in 8-bit or 1-bit units.

**Caution** When the port mode is specified by the port 6 mode control register (PMC6), the setting of this register becomes invalid.

|      |       |       |       |   |   |   |   |   |            |             |
|------|-------|-------|-------|---|---|---|---|---|------------|-------------|
|      | 7     | 6     | 5     | 4 | 3 | 2 | 1 | 0 | Address    | After reset |
| PFC6 | PFC67 | PFC66 | PFC65 | 0 | 0 | 0 | 0 | 0 | FFFFFF46CH | 00H         |

| Bit position | Bit name | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|--------------|----------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 7            | PFC67    | Specifies operation mode of P67 pin in control mode.<br>0: External interrupt request (INTP67) input mode<br>1: TOC1 output mode                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| 6            | PFC66    | Specifies operation mode of P66 pin in control mode.<br>0: External interrupt request (INTP66) input mode<br>1: External interrupt request and timer C1 external capture trigger (INTPC11) input mode                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| 5            | PFC65    | Specifies operation mode of P65 pin in control mode.<br>0: External interrupt request (INTP65) input mode<br>1: External interrupt request and timer C1 external capture trigger (INTPC10) input mode/TIC1 input mode<br><br>There is no register that selects an external interrupt request and timer C1 external capture trigger (INTPC10) input mode or TIC1 input mode.<br><br><ul style="list-style-type: none"> <li>To use TIC1 input mode:<br/>Mask the external interrupt request and external capture trigger (INTPC10) of timer C1, or use the CCC10 register as a compare register.</li> <li>To use external interrupt request and external capture trigger (INTPC10) of timer C1:<br/>Clear the ETIC1 bit of the TMCC11 register to 0.</li> </ul> |

**(3) Selecting interrupt trigger mode**

The valid edges of the  $\overline{\text{INTP6n}}$  pin can be selected by program ( $n = 5$  to  $7$ ). The level detection of the  $\overline{\text{INTP6n}}$  pin can also be selected.

External interrupt rising edge specification register 6 (INTR6) and external interrupt falling edge specification register 6 (INTF6) are used to specify the valid edge and level detection.

**(a) External interrupt rising edge specification register 6 (INTR6) and external interrupt falling edge specification register 6 (INTF6)**

These registers are used to specify the trigger mode of an external interrupt request ( $\text{INTP6n}$ ) from an external pin ( $n = 5$  to  $7$ ). The correspondence between each bit of this register and the external interrupt request controlled by that bit is as follows.

- INTF65 and INTR65 bits:  $\text{INTP65}$
- INTF66 and INTR66 bits:  $\text{INTP66}$
- INTF67 and INTR67 bits:  $\text{INTP67}$

The rising edge, falling edge, or both the rising and falling edges can be specified as the valid edge of the  $\overline{\text{INTP6n}}$  pin, independently for each pin.

Both the registers can be read or written in 8-bit or 1-bit units.

**Caution** Set the PMC6 register before setting the trigger mode.

If the PMC6 register is set after the INTR6 and INTF6 registers have been set, an illegal interrupt may occur when the PMC6 register is set.

|       | 7      | 6      | 5      | 4 | 3 | 2 | 1 | 0 | Address   | After reset |
|-------|--------|--------|--------|---|---|---|---|---|-----------|-------------|
| INTR6 | INTR67 | INTR66 | INTR65 | 0 | 0 | 0 | 0 | 0 | FFFFFC2CH | E0H         |
| INTF6 | INTF67 | INTF66 | INTF65 | 0 | 0 | 0 | 0 | 0 | FFFFFC0CH | 00H         |

| Bit position | Bit name                          | Function                                                                                                                                                                                                                                                                                                                                       |        |                                                             |           |   |   |              |   |   |             |   |   |                                                             |   |   |                               |
|--------------|-----------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|-------------------------------------------------------------|-----------|---|---|--------------|---|---|-------------|---|---|-------------------------------------------------------------|---|---|-------------------------------|
| 7 to 5       | INTF6n,<br>INTR6n<br>(n = 7 to 5) | Specify trigger mode of $\overline{\text{INTP6n}}$ pin.                                                                                                                                                                                                                                                                                        |        |                                                             |           |   |   |              |   |   |             |   |   |                                                             |   |   |                               |
|              |                                   | <table><tr><th>INTF6n</th><th>INTR6n</th><th>Operation</th></tr><tr><td>0</td><td>0</td><td>Falling edge</td></tr><tr><td>0</td><td>1</td><td>Rising edge</td></tr><tr><td>1</td><td>0</td><td>Level detection (low-level detection)<sup>Notes 1, 2</sup></td></tr><tr><td>1</td><td>1</td><td>Both rising and falling edges</td></tr></table> | INTF6n | INTR6n                                                      | Operation | 0 | 0 | Falling edge | 0 | 1 | Rising edge | 1 | 0 | Level detection (low-level detection) <sup>Notes 1, 2</sup> | 1 | 1 | Both rising and falling edges |
|              |                                   | INTF6n                                                                                                                                                                                                                                                                                                                                         | INTR6n | Operation                                                   |           |   |   |              |   |   |             |   |   |                                                             |   |   |                               |
|              |                                   | 0                                                                                                                                                                                                                                                                                                                                              | 0      | Falling edge                                                |           |   |   |              |   |   |             |   |   |                                                             |   |   |                               |
|              |                                   | 0                                                                                                                                                                                                                                                                                                                                              | 1      | Rising edge                                                 |           |   |   |              |   |   |             |   |   |                                                             |   |   |                               |
|              |                                   | 1                                                                                                                                                                                                                                                                                                                                              | 0      | Level detection (low-level detection) <sup>Notes 1, 2</sup> |           |   |   |              |   |   |             |   |   |                                                             |   |   |                               |
| 1            | 1                                 | Both rising and falling edges                                                                                                                                                                                                                                                                                                                  |        |                                                             |           |   |   |              |   |   |             |   |   |                                                             |   |   |                               |
|              |                                   |                                                                                                                                                                                                                                                                                                                                                |        |                                                             |           |   |   |              |   |   |             |   |   |                                                             |   |   |                               |
|              |                                   |                                                                                                                                                                                                                                                                                                                                                |        |                                                             |           |   |   |              |   |   |             |   |   |                                                             |   |   |                               |
|              |                                   |                                                                                                                                                                                                                                                                                                                                                |        |                                                             |           |   |   |              |   |   |             |   |   |                                                             |   |   |                               |
|              |                                   |                                                                                                                                                                                                                                                                                                                                                |        |                                                             |           |   |   |              |   |   |             |   |   |                                                             |   |   |                               |

- Notes 1.** The level of the  $\overline{\text{INTP6n}}$  pin is sampled each time the main clock (fx) is divided by four. When the low level of this pin is detected, an interrupt request is latched as the P6IFn bit (n = 5 to 7). Consequently, even when the CPU acknowledges the interrupt and the P6IFn bit of the interrupt control register (P6ICn) is automatically cleared to 0, the P6IFn bit is immediately set to 1 and interrupts occur consecutively. To avoid this status, make the  $\overline{\text{INTP6n}}$  pin of the external device inactive in the interrupt servicing routine, and forcibly clear the P6IFn bit to 0.
- 2.** If a level-detected interrupt request (INTP6n) with a lower priority occurs while an interrupt is being serviced and if this level-detected interrupt request (INTP6n) that has newly occurred becomes inactive before the current interrupt has been serviced, the interrupt request of the new interrupt (INTP6n) is held pending (n = 5 to 7). To not acknowledge the interrupt request of INTP6n, clear the P6IFn bit of the interrupt control register.

### 14.3.5 Port 7

Port 7 is a 6-bit I/O port that can be set to the input or output mode in 1-bit units.

|    |     |     |     |     |     |     |   |   |            |             |
|----|-----|-----|-----|-----|-----|-----|---|---|------------|-------------|
|    | 7   | 6   | 5   | 4   | 3   | 2   | 1 | 0 | Address    | After reset |
| P7 | P77 | P76 | P75 | P74 | P73 | P72 | 0 | 0 | FFFFFF40EH | Undefined   |

| Bit position | Bit name            | Function |
|--------------|---------------------|----------|
| 7 to 2       | P7n<br>(n = 7 to 2) | I/O port |

**Remark** For reading/writing of the I/O port, see **14.5 Operation of Port Function**.

In addition to their function as port pins, the port 7 pins can also operate as the DMA controller I/O, timer/counter I/O, and external interrupt request input in the control mode.

#### (1) Operation in control mode

| Pin Name | Pin No. |     | Alternate Function      | Remark                                                                                                           | Block Type |
|----------|---------|-----|-------------------------|------------------------------------------------------------------------------------------------------------------|------------|
|          | GM      | F1  |                         |                                                                                                                  |            |
| P72      | 176     | U17 | INTPC20/TIC2/<br>DMARQ2 | External interrupt request and timer C2 external capture trigger input/<br>timer/counter input/DMA request input | L-4        |
| P73      | 175     | U16 | INTPC21/DMAAK2          | External interrupt request and timer C2 external capture trigger input/DMA acknowledge signal output             | L-2        |
| P74      | 174     | V17 | TOC2/TC2                | Timer/counter output/DMA end signal output                                                                       | L-1        |
| P75      | 173     | T15 | INTPC30/TIC3/<br>DMARQ3 | External interrupt request and timer C3 external capture trigger input/<br>timer/counter input/DMA request input | L-4        |
| P76      | 172     | U15 | INTPC31/DMAAK3          | External interrupt request and timer C3 external capture trigger input/DMA acknowledge signal output             | L-2        |
| P77      | 171     | V16 | TOC3/TC3                | Timer/counter output/DMA end signal output                                                                       | L-1        |

**Remark** GM: 176-pin plastic LQFP (fine pitch) (24 × 24)

F1: 240-pin plastic FBGA (16 × 16)

**(2) I/O mode/control mode setting**

The port 7 I/O mode setting is performed by the port 7 mode register (PM7), and the control mode setting is performed by the port 7 mode control register (PMC7) and port 7 function control register (PFC7).

**(a) Port 7 mode register (PM7)**

This register can be read or written in 8-bit or 1-bit units.

|     |      |      |      |      |      |      |   |   |           |             |
|-----|------|------|------|------|------|------|---|---|-----------|-------------|
|     | 7    | 6    | 5    | 4    | 3    | 2    | 1 | 0 | Address   | After reset |
| PM7 | PM77 | PM76 | PM75 | PM74 | PM73 | PM72 | 1 | 1 | FFFFF42EH | FFH         |

| Bit position | Bit name             | Function                                                                                                           |
|--------------|----------------------|--------------------------------------------------------------------------------------------------------------------|
| 7 to 2       | PM7n<br>(n = 7 to 2) | Specifies input/output mode for P7n pin.<br>0: Output mode (output buffer on)<br>1: Input mode (output buffer off) |

**(b) Port 7 mode control register (PMC7)**

This register can be read or written in 8-bit or 1-bit units.

|      |       |       |       |       |       |       |   |   |           |             |
|------|-------|-------|-------|-------|-------|-------|---|---|-----------|-------------|
|      | 7     | 6     | 5     | 4     | 3     | 2     | 1 | 0 | Address   | After reset |
| PMC7 | PMC77 | PMC76 | PMC75 | PMC74 | PMC73 | PMC72 | 0 | 0 | FFFFF44EH | 00H         |

| Bit position | Bit name | Function                                                                                                                                                                                                                                                  |
|--------------|----------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 7            | PMC77    | Specifies operation mode of P77 pin in combination with the PFC7 register.<br>0: I/O port mode<br>1: TOC3 output mode/DMA end signal ( $\overline{TC3}$ ) output mode                                                                                     |
| 6            | PMC76    | Specifies operation mode of P76 pin in combination with the PFC7 register.<br>0: I/O port mode<br>1: External interrupt request and time C3 external capture trigger (INTPC31) input mode/DMA acknowledge signal ( $\overline{DMAAK3}$ ) output mode      |
| 5            | PMC75    | Specifies operation mode of P75 pin in combination with the PFC7 register.<br>0: I/O port mode<br>1: External interrupt request and timer C3 external capture trigger (INTPC30) input mode/TIC3 input mode/DMA request ( $\overline{DMARQ3}$ ) input mode |
| 4            | PMC74    | Specifies operation mode of P74 pin in combination with the PFC7 register.<br>0: I/O port mode<br>1: TOC2 output mode/DMA end signal ( $\overline{TC2}$ ) output mode                                                                                     |
| 3            | PMC73    | Specifies operation mode of P73 pin in combination with the PFC7 register.<br>0: I/O port mode<br>1: External interrupt request and time C2 external capture trigger (INTPC21) input mode/DMA acknowledge signal ( $\overline{DMAAK2}$ ) output mode      |
| 2            | PMC72    | Specifies operation mode of P72 pin in combination with the PFC7 register.<br>0: I/O port mode<br>1: External interrupt request and timer C2 external capture trigger (INTPC20) input mode/TIC2 input mode/DMA request ( $\overline{DMARQ2}$ ) input mode |

**(c) Port 7 function control register (PFC7)**

This register can be read or written in 8-bit or 1-bit units.

**Caution** When the port mode is specified by the port 7 mode control register (PMC7), the setting of this register becomes invalid.

|      | 7     | 6     | 5     | 4     | 3     | 2     | 1 | 0 | Address   | After reset |
|------|-------|-------|-------|-------|-------|-------|---|---|-----------|-------------|
| PFC7 | PFC77 | PFC76 | PFC75 | PFC74 | PFC73 | PFC72 | 0 | 0 | FFFFF46EH | 00H         |

| Bit position | Bit name | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|--------------|----------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 7            | PFC77    | Specifies operation mode of P77 pin in control mode.<br>0: TOC3 output mode<br>1: DMA end signal ( $\overline{\text{TC3}}$ ) output mode                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| 6            | PFC76    | Specifies operation mode of P76 pin in control mode.<br>0: External interrupt request and timer C3 external capture trigger (INTPC31) input mode<br>1: DMA acknowledge signal ( $\overline{\text{DMAAK3}}$ ) output                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| 5            | PFC75    | Specifies operation mode of P75 pin in control mode.<br>0: External interrupt request and timer C3 external capture trigger (INTPC30) input mode/TIC3 input mode<br>1: DMA request ( $\overline{\text{DMARQ3}}$ ) input mode<br>There is no register that selects an external interrupt request and timer C3 external capture trigger (INTPC30) input mode or TIC3 input mode.<br><ul style="list-style-type: none"><li>To use TIC3 input mode:<br/>Mask the external interrupt request and external capture trigger (INTPC30) of timer C3, or use the CCC30 register as a compare register.</li><li>To use external interrupt request and external capture trigger (INTPC30) of timer C3:<br/>Clear the ETIC3 bit of the TMCC31 register to 0.</li></ul> |
| 4            | PFC74    | Specifies operation mode of P74 pin.<br>0: TOC2 output mode<br>1: DMA end signal ( $\overline{\text{TC2}}$ ) output mode                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| 3            | PFC73    | Specifies operation mode of P73 pin.<br>0: External interrupt request and timer C2 external capture trigger (INTPC21) input mode<br>1: DMA acknowledge signal ( $\overline{\text{DMAAK2}}$ ) output                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| 2            | PFC72    | Specifies operation mode of P72 pin in control mode.<br>0: External interrupt request and timer C2 external capture trigger (INTPC20) input mode/TIC2 input mode<br>1: DMA request ( $\overline{\text{DMARQ2}}$ ) input mode<br>There is no register that selects an external interrupt request and timer C2 external capture trigger (INTPC20) input mode or TIC2 input mode.<br><ul style="list-style-type: none"><li>To use TIC2 input mode:<br/>Mask the external interrupt request and external capture trigger (INTPC20) of timer C2, or use the CCC20 register as a compare register.</li><li>To use external interrupt request and external capture trigger (INTPC20) of timer C2:<br/>Clear the ETIC2 bit of the TMCC21 register to 0.</li></ul> |

### 14.3.6 Port AL

Port AL (PAL) is a 16-bit I/O port that can be set to the input or output mode in 1-bit units.

When the higher 8 bits of port AL are used as port ALH (PALH) and the lower 8 bits as port ALL (PALL), port AL becomes two 8-bit ports that can be set in the input or output mode in 1-bit units.

|     |    |    |    |    |    |    |      |      |           |             |
|-----|----|----|----|----|----|----|------|------|-----------|-------------|
|     | 15 | 14 | 13 | 12 | 11 | 10 | 9    | 8    | Address   | After reset |
| PAL | 0  | 0  | 0  | 0  | 0  | 0  | 0    | 0    | FFFFF001H | Undefined   |
|     | 7  | 6  | 5  | 4  | 3  | 2  | 1    | 0    | Address   |             |
|     | 0  | 0  | 0  | 0  | 0  | 0  | PAL1 | PAL0 | FFFFF000H |             |

| Bit position | Bit name           | Function |
|--------------|--------------------|----------|
| 1, 0         | PALn<br>(n = 1, 0) | I/O port |

**Remark** For reading/writing of the I/O port, see **14.5 Operation of Port Function**.

In addition to their functions as port pins, in the control mode, the port AL pins operate as an address bus for when the memory is externally expanded and external interrupt request input.

#### (1) Operation in control mode

| Pin Name | Pin No. |    | Alternate Function                   | Remark                                                                | Block Type |
|----------|---------|----|--------------------------------------|-----------------------------------------------------------------------|------------|
|          | GM      | F1 |                                      |                                                                       |            |
| PAL0     | 76      | D7 | $\overline{\text{INTPL0}}/\text{A0}$ | Address bus when memory expanded/<br>external interrupt request input | G-3        |
| PAL1     | 75      | C7 | $\overline{\text{INTPL1}}/\text{A1}$ |                                                                       |            |

**Remark** GM: 176-pin plastic LQFP (fine pitch) (24 × 24)

F1: 240-pin plastic FBGA (16 × 16)



**(2) I/O mode/control mode setting**

The port AL I/O mode setting is performed by the port AL mode register (PMAL), and control mode setting is performed by port AL mode control register L (PMCALL) and the port AL function control register (PFCAL).

**(a) Port AL mode register (PMAL)**

The port AL mode register (PMAL) can be read or written in 16-bit units.

When using the higher 8 bits of PMAL as port AL mode register H (PMALH) and the lower 8 bits as port AL mode register L (PMALL), the PMALH register is read-only, in 8-bit or 1-bit units, and the PMALL register can be read or written in 8-bit or 1-bit units.

|      |    |    |    |    |    |    |       |       |            |             |
|------|----|----|----|----|----|----|-------|-------|------------|-------------|
| PMAL | 15 | 14 | 13 | 12 | 11 | 10 | 9     | 8     | Address    | After reset |
|      | 1  | 1  | 1  | 1  | 1  | 1  | 1     | 1     | FFFFFF021H | FFFFH       |
|      | 7  | 6  | 5  | 4  | 3  | 2  | 1     | 0     | Address    |             |
|      | 1  | 1  | 1  | 1  | 1  | 1  | PMAL1 | PMAL0 | FFFFFF020H |             |

| Bit position | Bit name            | Function                                                                                                            |
|--------------|---------------------|---------------------------------------------------------------------------------------------------------------------|
| 1, 0         | PMALn<br>(n = 1, 0) | Specifies input/output mode for PALn pin.<br>0: Output mode (output buffer on)<br>1: Input mode (output buffer off) |

**(b) Port AL mode control register (PMCAL)**

The port AL mode control register (PMCAL) can be read or written in 16-bit units.

When using the higher 8 bits of PMCAL as port AL mode control register H (PMCALH) and the lower 8 bits as port AL mode control register L (PMCALL), the PMCALH register is read-only, in 8-bit or 1-bit units, and the PMCALL register can be read or written in 8-bit or 1-bit units.

|       |    |    |    |    |    |    |        |        |           |             |
|-------|----|----|----|----|----|----|--------|--------|-----------|-------------|
| PMCAL | 15 | 14 | 13 | 12 | 11 | 10 | 9      | 8      | Address   | After reset |
|       | 0  | 0  | 0  | 0  | 0  | 0  | 0      | 0      | FFFFF041H | 0002H       |
|       | 7  | 6  | 5  | 4  | 3  | 2  | 1      | 0      | Address   |             |
|       | 0  | 0  | 0  | 0  | 0  | 0  | PMCAL1 | PMCAL0 | FFFFF040H |             |

| Bit position | Bit name | Function                                                                                         |
|--------------|----------|--------------------------------------------------------------------------------------------------|
| 1            | PMCAL1   | Specifies operation mode of PAL1 pin.<br>0: I/O port mode<br>1: INTPL1 input mode/A1 output mode |
| 0            | PMCAL0   | Specifies operation mode of PAL0 pin.<br>0: I/O port mode<br>1: INTPL0 input mode/A0 output mode |

**(c) Port AL function control register L (PFCALL)**

This register can be read or written in 8-bit or 1-bit units.

**Caution** When the port mode is specified by the port AL mode control register (PMCAL), the setting of this register becomes invalid.

|        |   |   |   |   |   |   |        |        |            |             |
|--------|---|---|---|---|---|---|--------|--------|------------|-------------|
|        | 7 | 6 | 5 | 4 | 3 | 2 | 1      | 0      | Address    | After reset |
| PFCALL | 0 | 0 | 0 | 0 | 0 | 0 | PFCAL1 | PFCAL0 | FFFFFF058H | 03H         |

| Bit position | Bit name | Function                                                                                                                                              |
|--------------|----------|-------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1            | PFCAL1   | Specifies operation mode of PAL1 pin in control mode.<br>0: External interrupt request ( $\overline{\text{INTPL1}}$ ) input mode<br>1: A1 output mode |
| 0            | PFCAL0   | Specifies operation mode of PAL0 pin in control mode.<br>0: External interrupt request ( $\overline{\text{INTPL0}}$ ) input mode<br>1: A0 output mode |

**(3) Selecting interrupt trigger mode**

The valid edges of the  $\overline{\text{INTPLn}}$  pin can be selected by program ( $n = 0, 1$ ). The level detection of the  $\overline{\text{INTPLn}}$  pin can also be selected.

External interrupt rising edge specification register AL (INTRAL) and external interrupt falling edge specification register AL (INTFAL) are used to specify the valid edge and level detection.

**(a) External interrupt rising edge specification register AL (INTRAL) and external interrupt falling edge specification register AL (INTFAL)**

These registers are used to specify the trigger mode of an external interrupt request ( $\overline{\text{INTPLn}}$ ) from an external pin ( $n = 0, 1$ ). The correspondence between each bit of this register and the external interrupt request controlled by that bit is as follows.

- INTFAL0 and INTRAL0 bits: INTPL0
- INTFAL1 and INTRAL1 bits: INTPL1

The rising edge, falling edge, or both the rising and falling edges can be specified as the valid edge of the  $\overline{\text{INTPLn}}$  pin, independently for each pin.

Both the registers can be read or written in 8-bit or 1-bit units.

**Caution** Before setting the trigger mode, set the PMCAL register.

If the PMCAL register is set after the INTRAL and INTFAL registers have been set, an illegal interrupt may occur when the PMCAL register is set.

|        | 7 | 6 | 5 | 4 | 3 | 2 | 1       | 0       | Address    | After reset |
|--------|---|---|---|---|---|---|---------|---------|------------|-------------|
| INTRAL | 0 | 0 | 0 | 0 | 0 | 0 | INTRAL1 | INTRAL0 | FFFFFFC30H | 03H         |
| INTFAL | 0 | 0 | 0 | 0 | 0 | 0 | INTFAL1 | INTFAL0 | FFFFFFC10H | 00H         |

| Bit position | Bit name                          | Function                                                                                                                                                                                                                                                                                                                                         |         |                                                             |           |   |   |              |   |   |             |   |   |                                                             |   |   |                               |
|--------------|-----------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|-------------------------------------------------------------|-----------|---|---|--------------|---|---|-------------|---|---|-------------------------------------------------------------|---|---|-------------------------------|
| 1, 0         | INTFALn,<br>INTRALn<br>(n = 0, 1) | Specify trigger mode of $\overline{\text{INTPLn}}$ pin.                                                                                                                                                                                                                                                                                          |         |                                                             |           |   |   |              |   |   |             |   |   |                                                             |   |   |                               |
|              |                                   | <table><tr><th>INTFALn</th><th>INTRALn</th><th>Operation</th></tr><tr><td>0</td><td>0</td><td>Falling edge</td></tr><tr><td>0</td><td>1</td><td>Rising edge</td></tr><tr><td>1</td><td>0</td><td>Level detection (low-level detection)<sup>Notes 1, 2</sup></td></tr><tr><td>1</td><td>1</td><td>Both rising and falling edges</td></tr></table> | INTFALn | INTRALn                                                     | Operation | 0 | 0 | Falling edge | 0 | 1 | Rising edge | 1 | 0 | Level detection (low-level detection) <sup>Notes 1, 2</sup> | 1 | 1 | Both rising and falling edges |
|              |                                   | INTFALn                                                                                                                                                                                                                                                                                                                                          | INTRALn | Operation                                                   |           |   |   |              |   |   |             |   |   |                                                             |   |   |                               |
|              |                                   | 0                                                                                                                                                                                                                                                                                                                                                | 0       | Falling edge                                                |           |   |   |              |   |   |             |   |   |                                                             |   |   |                               |
|              |                                   | 0                                                                                                                                                                                                                                                                                                                                                | 1       | Rising edge                                                 |           |   |   |              |   |   |             |   |   |                                                             |   |   |                               |
|              |                                   | 1                                                                                                                                                                                                                                                                                                                                                | 0       | Level detection (low-level detection) <sup>Notes 1, 2</sup> |           |   |   |              |   |   |             |   |   |                                                             |   |   |                               |
|              |                                   | 1                                                                                                                                                                                                                                                                                                                                                | 1       | Both rising and falling edges                               |           |   |   |              |   |   |             |   |   |                                                             |   |   |                               |
|              |                                   |                                                                                                                                                                                                                                                                                                                                                  |         |                                                             |           |   |   |              |   |   |             |   |   |                                                             |   |   |                               |
|              |                                   |                                                                                                                                                                                                                                                                                                                                                  |         |                                                             |           |   |   |              |   |   |             |   |   |                                                             |   |   |                               |
|              |                                   |                                                                                                                                                                                                                                                                                                                                                  |         |                                                             |           |   |   |              |   |   |             |   |   |                                                             |   |   |                               |
|              |                                   |                                                                                                                                                                                                                                                                                                                                                  |         |                                                             |           |   |   |              |   |   |             |   |   |                                                             |   |   |                               |

- Notes 1.** The level of the  $\overline{\text{INTPLn}}$  pin is sampled each time the main clock (fx) is divided by four. When the low level of this pin is detected, an interrupt request is latched as the PLIFn bit (n = 0, 1). Consequently, even when the CPU acknowledges the interrupt and the PLIFn bit of the interrupt control register (PLICn) is automatically cleared to 0, the PLIFn bit is immediately set to 1 and interrupts occur consecutively. To avoid this status, make the  $\overline{\text{INTPLn}}$  pin of the external device inactive in the interrupt servicing routine, and forcibly clear the PLIFn bit to 0.
- 2.** If a level-detected interrupt request (INTPLn) with a lower priority occurs while an interrupt is being serviced and if this level-detected interrupt request (INTPLn) that has newly occurred becomes inactive before the current interrupt has been serviced, the interrupt request of the new interrupt (INTPLn) is held pending (n = 0, 1). To not acknowledge the interrupt request of INTPLn, clear the PLIFn bit of the interrupt control register.

### 14.3.7 Port AH

Port AH (PAH) is a 10-bit I/O port that can be set in the input or output mode in 1-bit units.

When the higher 8 bits of port AH are used as port AHH (PAHH) and the lower 8 bits as port AHL (PAHL), port AH becomes two 8-bit ports that can be set in the input or output mode in 1-bit units.

|     |      |      |      |      |      |      |      |      |            |             |
|-----|------|------|------|------|------|------|------|------|------------|-------------|
| PAH | 15   | 14   | 13   | 12   | 11   | 10   | 9    | 8    | Address    | After reset |
|     | 0    | 0    | 0    | 0    | 0    | 0    | PAH9 | PAH8 | FFFFFF003H | Undefined   |
|     | 7    | 6    | 5    | 4    | 3    | 2    | 1    | 0    | Address    |             |
|     | PAH7 | PAH6 | PAH5 | PAH4 | PAH3 | PAH2 | PAH1 | PAH0 | FFFFFF002H |             |

| Bit position | Bit name             | Function |
|--------------|----------------------|----------|
| 9 to 0       | PAHn<br>(n = 9 to 0) | I/O port |

**Remark** For reading/writing of the I/O port, see **14.5 Operation of Port Function**.

In addition to their functions as port pins, in the control mode, the port AH pins operate as an address bus for when the memory is externally expanded.

#### (1) Operation in control mode

| Pin Name | Pin No. |     | Alternate Function | Remark                           | Block Type |
|----------|---------|-----|--------------------|----------------------------------|------------|
|          | GM      | F1  |                    |                                  |            |
| PAH0     | 58      | B11 | A16                | Address bus when memory expanded | D-2        |
| PAH1     | 57      | E11 | A17                |                                  |            |
| PAH2     | 52      | C13 | A18                |                                  |            |
| PAH3     | 51      | D13 | A19                |                                  |            |
| PAH4     | 50      | C14 | A20                |                                  |            |
| PAH5     | 49      | A15 | A21                |                                  |            |
| PAH6     | 48      | C15 | A22                |                                  |            |
| PAH7     | 47      | A16 | A23                |                                  |            |
| PAH8     | 46      | B16 | A24                |                                  |            |
| PAH9     | 45      | A17 | A25                |                                  |            |

**Remark** GM: 176-pin plastic LQFP (fine pitch) (24 × 24)

F1: 240-pin plastic FBGA (16 × 16)

**(2) I/O mode/control mode setting**

The port AH I/O mode setting is performed by the port AH mode register (PMAH), and the control mode setting is performed by the port AH mode control register (PMCAH).

**(a) Port AH mode register (PMAH)**

The port AH mode register (PMAH) can be read or written in 16-bit units.

If the higher 8 bits of PMAH are used as port AH mode register H (PMAHH), and the lower 8 bits as port AH mode register L (PMAHL), these two 8-bit port mode registers can be read or written in 8-bit or 1-bit units.

|      |       |       |       |       |       |       |       |       |           |             |
|------|-------|-------|-------|-------|-------|-------|-------|-------|-----------|-------------|
|      | 15    | 14    | 13    | 12    | 11    | 10    | 9     | 8     | Address   | After reset |
| PMAH | 1     | 1     | 1     | 1     | 1     | 1     | PMAH9 | PMAH8 | FFFFF023H | FFFFH       |
|      | 7     | 6     | 5     | 4     | 3     | 2     | 1     | 0     | Address   |             |
|      | PMAH7 | PMAH6 | PMAH5 | PMAH4 | PMAH3 | PMAH2 | PMAH1 | PMAH0 | FFFFF022H |             |

| Bit position | Bit name              | Function                                                                                                            |
|--------------|-----------------------|---------------------------------------------------------------------------------------------------------------------|
| 9 to 0       | PMAHn<br>(n = 9 to 0) | Specifies input/output mode for PAHn pin.<br>0: Output mode (output buffer on)<br>1: Input mode (output buffer off) |

**(b) Port AH mode control register (PMCAH)**

The port AH mode control register (PMCAH) can be read or written in 16-bit units.

If the higher 8 bits of PMCAH are used as port AH mode control register H (PMCAHH), and the lower 8 bits as port AH mode control register L (PMCAHL), these two 8-bit port mode registers can be read or written in 8-bit or 1-bit units.

|       |        |        |        |        |        |        |        |        |           |             |
|-------|--------|--------|--------|--------|--------|--------|--------|--------|-----------|-------------|
|       | 15     | 14     | 13     | 12     | 11     | 10     | 9      | 8      | Address   | After reset |
| PMCAH | 0      | 0      | 0      | 0      | 0      | 0      | PMCAH9 | PMCAH8 | FFFFF043H | 03FFH       |
|       | 7      | 6      | 5      | 4      | 3      | 2      | 1      | 0      | Address   |             |
|       | PMCAH7 | PMCAH6 | PMCAH5 | PMCAH4 | PMCAH3 | PMCAH2 | PMCAH1 | PMCAH0 | FFFFF042H |             |

| Bit position | Bit name               | Function                                                                               |
|--------------|------------------------|----------------------------------------------------------------------------------------|
| 9 to 0       | PMCAHn<br>(n = 9 to 0) | Specifies operation mode of PAHn pin.<br>0: I/O port mode<br>1: A25 to A16 output mode |

### 14.3.8 Port DH

Port DH (PDH) is a 16-bit I/O port that can be set in the input or output mode in 1-bit units.

When the higher 8 bits of port DH are used as port DHH (PDHH), and the lower 8 bits as port DHL (PDHL), port DH becomes two 8-bit ports that can be set in the input or output mode in 1-bit units.

**Caution** In the 32-bit mode (MODE1 and MODE0 pins = 00) and when the BMODCN bit of the PFCDH register is set, all the register functions of port DH (see 14.3.8) become invalid.

|     |       |       |       |       |       |       |      |      |           |             |
|-----|-------|-------|-------|-------|-------|-------|------|------|-----------|-------------|
| PDH | 15    | 14    | 13    | 12    | 11    | 10    | 9    | 8    | Address   | After reset |
|     | PDH15 | PDH14 | PDH13 | PDH12 | PDH11 | PDH10 | PDH9 | PDH8 | FFFFFF07H | Undefined   |
|     | 7     | 6     | 5     | 4     | 3     | 2     | 1    | 0    | Address   |             |
|     | PDH7  | PDH6  | PDH5  | PDH4  | PDH3  | PDH2  | PDH1 | PDH0 | FFFFFF06H |             |

| Bit position | Bit name              | Function |
|--------------|-----------------------|----------|
| 15 to 0      | PDHn<br>(n = 15 to 0) | I/O port |

**Remark** For reading/writing of the I/O port, see **14.5 Operation of Port Function**.

In addition to their functions as port pins, in the control mode, the port DH pins operate as a data bus for when the memory is externally expanded, timer/counter I/O, PWM output, and external interrupt request input.

## (1) Operation in control mode

| Pin Name | Pin No. |    | Alternate Function                              | Remark                                                                                                                                    | Block Type |
|----------|---------|----|-------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------|------------|
|          | GM      | F1 |                                                 |                                                                                                                                           |            |
| PDH0     | 112     | K3 | D16/ $\overline{\text{INTPD0}}$                 | Data bus when memory expanded/<br>external interrupt request input                                                                        | M-1        |
| PDH1     | 113     | K4 | D17/ $\overline{\text{INTPD1}}$                 | Data bus when memory expanded/<br>external interrupt request input                                                                        |            |
| PDH2     | 114     | K5 | D18/ $\overline{\text{INTPD2/TOC4}}$            | Data bus when memory expanded/<br>external interrupt request input/<br>timer/counter output                                               | M-2        |
| PDH3     | 117     | L4 | D19/ $\overline{\text{INTPD3}}$                 | Data bus when memory expanded/<br>external interrupt request input                                                                        | M-1        |
| PDH4     | 118     | L5 | D20/ $\overline{\text{INTPD4}}$                 | Data bus when memory expanded/<br>external interrupt request input                                                                        |            |
| PDH5     | 119     | M2 | D21/ $\overline{\text{INTPD5/TOC5}}$            | Data bus when memory expanded/<br>external interrupt request input/<br>timer/counter output                                               | M-2        |
| PDH6     | 120     | M3 | D22/ $\overline{\text{INTPD6/INTP100/TCUD10}}$  | Data bus when memory expanded/<br>external interrupt request input/<br>timer ENC10 external capture trigger input/<br>timer/counter input | M-3        |
| PDH7     | 121     | N1 | D23/ $\overline{\text{INTPD7/INTP101/TCLR10}}$  | Data bus when memory expanded/<br>external interrupt request input/<br>timer ENC10 external capture trigger input/<br>timer/counter input |            |
| PDH8     | 122     | N2 | D24/ $\overline{\text{INTPD8/TO10}}$            | Data bus when memory expanded/<br>external interrupt request input/<br>timer/counter output                                               | M-2        |
| PDH9     | 123     | N3 | D25/ $\overline{\text{INTPD9/TIUD10}}$          | Data bus when memory expanded/<br>external interrupt request input/<br>timer/counter input                                                | M-3        |
| PDH10    | 124     | N4 | D26/ $\overline{\text{INTPD10/INTP110/TCUD11}}$ | Data bus when memory expanded/<br>external interrupt request input/<br>timer ENC11 external capture trigger input/<br>timer/counter input |            |
| PDH11    | 125     | P2 | D27/ $\overline{\text{INTPD11/INTP111/TCLR11}}$ | Data bus when memory expanded/<br>external interrupt request input/<br>timer ENC11 external capture trigger input/<br>timer/counter input |            |
| PDH12    | 126     | R1 | D28/ $\overline{\text{INTPD12/TO11}}$           | Data bus when memory expanded/<br>external interrupt request input/<br>timer/counter output                                               | M-2        |
| PDH13    | 127     | P3 | D29/ $\overline{\text{INTPD13/TIUD11}}$         | Data bus when memory expanded/<br>external interrupt request input/<br>timer/counter input                                                | M-3        |
| PDH14    | 130     | R3 | D30/ $\overline{\text{INTPD14/PWM0}}$           | Data bus when memory expanded/<br>external interrupt request input/PWM output                                                             | M-2        |
| PDH15    | 131     | U1 | D31/ $\overline{\text{INTPD15/PWM1}}$           | Data bus when memory expanded/<br>external interrupt request input/PWM output                                                             |            |

**Remark** GM: 176-pin plastic LQFP (fine pitch) (24 × 24)

F1: 240-pin plastic FBGA (16 × 16)



**(2) I/O mode/control mode setting**

The port DH I/O mode setting is performed by the port DH mode register (PMDH), and the control mode setting is performed by the port DH mode control register (PMCDH) and port DH function control register (PFCDH).

**(a) Port DH mode register (PMDH)**

The port DH mode register (PMDH) can be read or written in 16-bit units.

If the higher 8 bits of PMDH are used as port DH mode register H (PMDHH), and the lower 8 bits as port DH mode register L (PMDHL), these two 8-bit port mode registers can be read or written in 8-bit or 1-bit units.

|      |        |        |        |        |        |        |       |       |           |             |
|------|--------|--------|--------|--------|--------|--------|-------|-------|-----------|-------------|
|      | 15     | 14     | 13     | 12     | 11     | 10     | 9     | 8     | Address   | After reset |
| PMDH | PMDH15 | PMDH14 | PMDH13 | PMDH12 | PMDH11 | PMDH10 | PMDH9 | PMDH8 | FFFFF027H | FFFFH       |
|      | 7      | 6      | 5      | 4      | 3      | 2      | 1     | 0     | Address   |             |
|      | PMDH7  | PMDH6  | PMDH5  | PMDH4  | PMDH3  | PMDH2  | PMDH1 | PMDH0 | FFFFF026H |             |

| Bit position | Bit name               | Function                                                                                                            |
|--------------|------------------------|---------------------------------------------------------------------------------------------------------------------|
| 15 to 0      | PMDHn<br>(n = 15 to 0) | Specifies input/output mode for PDHn pin.<br>0: Output mode (output buffer on)<br>1: Input mode (output buffer off) |

**(b) Port DH mode control register (PMCDH)**

The port DH mode control register (PMCDH) can be read or written in 16-bit units.

If the higher 8 bits of PMCDH are used as port DH mode control register H (PMCDHH), and the lower 8 bits as port DH mode control register L (PMCDHL), these two 8-bit port mode registers can be read or written in 8-bit or 1-bit units.

(1/2)

|       |         |         |         |         |         |         |        |        |           |             |
|-------|---------|---------|---------|---------|---------|---------|--------|--------|-----------|-------------|
|       | 15      | 14      | 13      | 12      | 11      | 10      | 9      | 8      | Address   | After reset |
| PMCDH | PMCDH15 | PMCDH14 | PMCDH13 | PMCDH12 | PMCDH11 | PMCDH10 | PMCDH9 | PMCDH8 | FFFFF047H | 0000H       |
|       | 7       | 6       | 5       | 4       | 3       | 2       | 1      | 0      | Address   |             |
|       | PMCDH7  | PMCDH6  | PMCDH5  | PMCDH4  | PMCDH3  | PMCDH2  | PMCDH1 | PMCDH0 | FFFFF046H |             |

| Bit position | Bit name | Function                                                                                                                                                                                        |
|--------------|----------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 15           | PMCDH15  | Specifies operation mode of PDH15 pin in combination with the PFCDH register.<br>0: I/O port mode<br>1: External interrupt request ( $\overline{\text{INTPD15}}$ ) input mode/PWM1 output mode  |
| 14           | PMCDH14  | Specifies operation mode of PDH14 pin in combination with the PFCDH register.<br>0: I/O port mode<br>1: External interrupt request ( $\overline{\text{INTPD14}}$ ) input mode/PWM0 output mode  |
| 13           | PMCDH13  | Specifies operation mode of PDH13 pin in combination with the PFCDH register.<br>0: I/O port mode<br>1: External interrupt request ( $\overline{\text{INTPD13}}$ ) input mode/TIUD11 input mode |

| Bit position | Bit name | Function                                                                                                                                                                                                                                                  |
|--------------|----------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 12           | PMCDH12  | Specifies operation mode of PDH12 pin in combination with the PFCDH register.<br>0: I/O port mode<br>1: External interrupt request ( $\overline{\text{INTPD12}}$ ) input mode/TO11 output mode                                                            |
| 11           | PMCDH11  | Specifies operation mode of PDH11 pin in combination with the PFCDH register.<br>0: I/O port mode<br>1: External interrupt request ( $\overline{\text{INTPD11}}$ ) input mode/timer ENC11 external capture trigger (INTP111) input mode/TCLR11 input mode |
| 10           | PMCDH10  | Specifies operation mode of PDH10 pin in combination with the PFCDH register.<br>0: I/O port mode<br>1: External interrupt request ( $\overline{\text{INTPD10}}$ ) input mode/timer ENC11 external capture trigger (INTP110) input mode/TCUD11 input mode |
| 9            | PMCDH9   | Specifies operation mode of PDH9 pin in combination with the PFCDH register.<br>0: I/O port mode<br>1: External interrupt request ( $\overline{\text{INTPD9}}$ ) input mode/TIUD10 input mode                                                             |
| 8            | PMCDH8   | Specifies operation mode of PDH8 pin in combination with the PFCDH register.<br>0: I/O port mode<br>1: External interrupt request ( $\overline{\text{INTPD8}}$ ) input mode/TO10 output mode                                                              |
| 7            | PMCDH7   | Specifies operation mode of PDH7 pin in combination with the PFCDH register.<br>0: I/O port mode<br>1: External interrupt request ( $\overline{\text{INTPD7}}$ ) input mode/timer ENC10 external capture trigger (INTP101) input mode/TCLR10 input mode   |
| 6            | PMCDH6   | Specifies operation mode of PDH6 pin in combination with the PFCDH register.<br>0: I/O port mode<br>1: External interrupt request ( $\overline{\text{INTPD6}}$ ) input mode/timer ENC10 external capture trigger (INTP100) input mode/TCUD10 input mode   |
| 5            | PMCDH5   | Specifies operation mode of PDH5 pin in combination with the PFCDH register.<br>0: I/O port mode<br>1: External interrupt request ( $\overline{\text{INTPD5}}$ ) input mode/TOC5 output mode                                                              |
| 4            | PMCDH4   | Specifies operation mode of PDH4 pin in combination with the PFCDH register.<br>0: I/O port mode<br>1: External interrupt request ( $\overline{\text{INTPD4}}$ ) input mode                                                                               |
| 3            | PMCDH3   | Specifies operation mode of PDH3 pin in combination with the PFCDH register.<br>0: I/O port mode<br>1: External interrupt request ( $\overline{\text{INTPD3}}$ ) input mode                                                                               |
| 2            | PMCDH2   | Specifies operation mode of PDH2 pin in combination with the PFCDH register.<br>0: I/O port mode<br>1: External interrupt request ( $\overline{\text{INTPD2}}$ ) input mode/TOC4 output mode                                                              |
| 1            | PMCDH1   | Specifies operation mode of PDH1 pin in combination with the PFCDH register.<br>0: I/O port mode<br>1: External interrupt request ( $\overline{\text{INTPD1}}$ ) input mode                                                                               |
| 0            | PMCDH0   | Specifies operation mode of PDH0 pin in combination with the PFCDH register.<br>0: I/O port mode<br>1: External interrupt request ( $\overline{\text{INTPD0}}$ ) input mode                                                                               |

**(c) Port DH function control register (PFCDH)**

This register can be read or written in 16-bit units.

If the higher 8 bits of the PFCDH are used as port DH function control register H (PFCDHH), and the lower 8 bits as port DH function control register L (PFCDHL), these registers can be read or written in 8-bit or 1-bit units.

**Caution** When the port mode is specified by the port DH mode control register (PMCDH), the setting of this register becomes invalid. However, bit 0 is independent of the setting of the PMCDH0 bit of the PMCDH register.

(1/3)

|       |         |         |         |         |         |         |        |        |           |             |
|-------|---------|---------|---------|---------|---------|---------|--------|--------|-----------|-------------|
|       | 15      | 14      | 13      | 12      | 11      | 10      | 9      | 8      | Address   | After reset |
| PFCDH | PFCDH15 | PFCDH14 | PFCDH13 | PFCDH12 | PFCDH11 | PFCDH10 | PFCDH9 | PFCDH8 | FFFFF057H | 0000H       |
|       | 7       | 6       | 5       | 4       | 3       | 2       | 1      | 0      | Address   |             |
|       | PFCDH7  | PFCDH6  | PFCDH5  | 0       | 0       | PFCDH2  | 0      | BMODCN | FFFFF056H |             |

| Bit position | Bit name | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|--------------|----------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 15           | PFCDH15  | Specifies operation mode of PDH15 pin in control mode.<br>0: External interrupt request ( $\overline{\text{INTPD15}}$ ) input mode<br>1: PWM1 output mode                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| 14           | PFCDH14  | Specifies operation mode of PDH14 pin in control mode.<br>0: External interrupt request ( $\overline{\text{INTPD14}}$ ) input mode<br>1: PWM0 output mode                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| 13           | PFCDH13  | Specifies operation mode of PDH13 pin in control mode.<br>0: External interrupt request ( $\overline{\text{INTPD13}}$ ) input mode<br>1: TIUD11 input mode                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| 12           | PFCDH12  | Specifies operation mode of PDH12 pin in control mode.<br>0: External interrupt request ( $\overline{\text{INTPD12}}$ ) input mode<br>1: TO11 output mode                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| 11           | PFCDH11  | Specifies operation mode of PDH11 pin in control mode.<br>0: External interrupt request ( $\overline{\text{INTPD11}}$ ) input mode<br>1: Timer ENC11 external capture trigger (INTP111) input mode/TCLR11 input mode<br>There is no register that selects a timer ENC11 external capture trigger (INTP111) input mode or TCLR11 input mode.<br><br><ul style="list-style-type: none"> <li>To use TCLR11 input mode:<br/>Mask the external capture trigger (INTP111) of timer ENC11, or use the CC111 register as a compare register.</li> <li>To use external capture trigger (INTP111) of timer ENC11:<br/>Set the CLR111 and CLR110 bits of the TMC11 register to other than 00.</li> </ul> |

| Bit position | Bit name | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|--------------|----------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 10           | PFCDH10  | <p>Specifies operation mode of PDH10 pin in control mode.</p> <p>0: External interrupt request (INTPD10) input mode<br/>1: Timer ENC11 external capture trigger (INTP110) input mode/TCUD10 input mode</p> <p>There is no register that selects a timer ENC11 external capture trigger (INTP110) input mode or TCUD11 input mode.</p> <ul style="list-style-type: none"> <li>To use TUCD11 input mode:<br/>Mask the external capture trigger (INTP110) of timer ENC11, or use the CC110 register as a compare register.</li> <li>To use external capture trigger (INTP110) of timer ENC11:<br/>Set the T1CMD1 bit of the TUM11 register to 0.</li> </ul>                       |
| 9            | PFCDH9   | <p>Specifies operation mode of PDH9 pin in control mode.</p> <p>0: External interrupt request (INTPD9) input mode<br/>1: TIUD10 input mode</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| 8            | PFCDH8   | <p>Specifies operation mode of PDH8 pin in control mode.</p> <p>0: External interrupt request (INTPD8) input mode<br/>1: TO10 output mode</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| 7            | PFCDH7   | <p>Specifies operation mode of PDH7 pin in control mode.</p> <p>0: External interrupt request (INTPD7) input mode<br/>1: Timer ENC10 external capture trigger (INTP101) input mode/TCLR10 input mode</p> <p>There is no register that selects a timer ENC10 external capture trigger (INTP101) input mode or TCLR10 input mode.</p> <ul style="list-style-type: none"> <li>To use TCLR10 input mode:<br/>Mask the external capture trigger (INTP101) of timer ENC10, or use the CC101 register as a compare register.</li> <li>To use external capture trigger (INTP101) of timer ENC10:<br/>Set the CLR101 and CLR100 bits of the TMC10 register to other than 00.</li> </ul> |
| 6            | PFCDH6   | <p>Specifies operation mode of PDH6 pin in control mode.</p> <p>0: External interrupt request (INTPD6) input mode<br/>1: Timer ENC10 external capture trigger (INTP100) input mode/TCUD10 input mode</p> <p>There is no register that selects a timer ENC10 external capture trigger (INTP100) input mode or TCUD10 input mode.</p> <ul style="list-style-type: none"> <li>To use TUCD10 input mode:<br/>Mask the external capture trigger (INTP100) of timer ENC10, or use the CC100 register as a compare register.</li> <li>To use external capture trigger (INTP100) of timer ENC10:<br/>Set the T1CMD0 bit of the TUM10 register to 0.</li> </ul>                         |
| 5            | PFCDH5   | <p>Specifies operation mode of PDH5 pin in control mode.</p> <p>0: External interrupt request (INTPD5) input mode<br/>1: TOC5 output mode</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| 2            | PFCDH2   | <p>Specifies operation mode of PDH2 pin in control mode.</p> <p>0: External interrupt request (INTPD2) input mode<br/>1: TOC4 output mode</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |

| Bit position | Bit name | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|--------------|----------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 0            | BMODCN   | <p>Specifies the operation mode of the D16 to D31 pins in the 16-bit mode (16-bit data bus). However, changing the value of the BMODCN bit from 0 to 1 is not reflected in the LBS register.</p> <p>0: The D16 to D31 pins are not used for starting in the 16-bit mode (data bus width: 16/8 bits).</p> <p>1: The D16 to D31 pins are not used for starting in the 16-bit mode (data bus width: 32/16/8 bits).</p> <p><b>Caution</b> The BMODCN bit is valid only when the 16-bit mode is specified in accordance with the status of the MODE0 and MODE1 pins. This bit is invalid if the 32-bit mode is specified.</p> <p>The BMODCN bit can be rewritten only once. If it is rewritten twice or more, the operation is not guaranteed.</p> <p>When the BMODCN bit = 1, the operation is the same as when the 32-bit mode is specified in accordance with the status of the MODE0 and MODE1 pins.</p> |

**(3) Selecting interrupt trigger mode**

The valid edges of the  $\overline{\text{INTPDn}}$  pin can be selected by program ( $n = 0$  to 15). The level detection of the  $\overline{\text{INTPDn}}$  pin can also be selected.

External interrupt rising edge specification register DH (INTRDH) and external interrupt falling edge specification register DH (INTFDH) are used to specify the valid edge and level detection.

**(a) External interrupt rising edge specification register DH (INTRDH) and external interrupt falling edge specification register DH (INTFDH)**

These registers are used to specify the trigger mode of an external interrupt request ( $\overline{\text{INTPDn}}$ ) from an external pin ( $n = 0$  to 15). The correspondence between each bit of this register and the external interrupt request controlled by that bit is as follows.

- INTFDH0 and INTRDH0 bits: INTPD0
- INTFDH1 and INTRDH1 bits: INTPD1
- INTFDH2 and INTRDH2 bits: INTPD2
- INTFDH3 and INTRDH3 bits: INTPD3
- INTFDH4 and INTRDH4 bits: INTPD4
- INTFDH5 and INTRDH5 bits: INTPD5
- INTFDH6 and INTRDH6 bits: INTPD6
- INTFDH7 and INTRDH7 bits: INTPD7
- INTFDH8 and INTRDH8 bits: INTPD8
- INTFDH9 and INTRDH9 bits: INTPD9
- INTFDH10 and INTRDH10 bits: INTPD10
- INTFDH11 and INTRDH11 bits: INTPD11
- INTFDH12 and INTRDH12 bits: INTPD12
- INTFDH13 and INTRDH13 bits: INTPD13
- INTFDH14 and INTRDH14 bits: INTPD14
- INTFDH15 and INTRDH15 bits: INTPD15

The rising edge, falling edge, or both the rising and falling edges can be specified as the valid edge of the  $\overline{\text{INTPDn}}$  pin, independently for each pin.

INTRDH and INTFDH registers can be read or written in 16-bit units.

When the higher 8 bits of the INTRDH and INTFDH registers are used as INTRDHH and INTFDHH registers, and the lower 8 bits as INTRDHL and INTFDHL registers, these registers can be read or written in 8-bit or 1-bit units.

**Caution** Set the PMCDH register before setting the trigger mode.

If the PMCDH register is set after the INTRDH and INTFDH registers have been set, an illegal interrupt may occur when the PMCDH register is set.

|        | 15   | 14   | 13   | 12   | 11   | 10   | 9    | 8    | 7    | 6    | 5    | 4    | 3    | 2    | 1    | 0    | Address   | After reset |
|--------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|-----------|-------------|
| INTRDH | INTR | INTR | INTR | INTR | INTR | INTR | INTR | INTR | INTR | INTR | INTR | INTR | INTR | INTR | INTR | INTR | FFFFFC36H | FFFFH       |
|        | DH15 | DH14 | DH13 | DH12 | DH11 | DH10 | DH9  | DH8  | DH7  | DH6  | DH5  | DH4  | DH3  | DH2  | DH1  | DH0  |           |             |
| INTFDH | INTF | INTF | INTF | INTF | INTF | INTF | INTF | INTF | INTF | INTF | INTF | INTF | INTF | INTF | INTF | INTF | FFFFFC16H | 0000H       |
|        | DH15 | DH14 | DH13 | DH12 | DH11 | DH10 | DH9  | DH8  | DH7  | DH6  | DH5  | DH4  | DH3  | DH2  | DH1  | DH0  |           |             |

| Bit position | Bit name                             | Function                                                                                                                                                                                                                                                                                                                                         |         |                                                             |           |   |   |              |   |   |             |   |   |                                                             |   |   |                               |
|--------------|--------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|-------------------------------------------------------------|-----------|---|---|--------------|---|---|-------------|---|---|-------------------------------------------------------------|---|---|-------------------------------|
| 15 to 0      | INTFDHn,<br>INTRDHn<br>(n = 0 to 15) | Specify trigger mode of $\overline{\text{INTPDn}}$ pin.                                                                                                                                                                                                                                                                                          |         |                                                             |           |   |   |              |   |   |             |   |   |                                                             |   |   |                               |
|              |                                      | <table><tr><th>INTFDHn</th><th>INTRDHn</th><th>Operation</th></tr><tr><td>0</td><td>0</td><td>Falling edge</td></tr><tr><td>0</td><td>1</td><td>Rising edge</td></tr><tr><td>1</td><td>0</td><td>Level detection (low-level detection)<sup>Notes 1, 2</sup></td></tr><tr><td>1</td><td>1</td><td>Both rising and falling edges</td></tr></table> | INTFDHn | INTRDHn                                                     | Operation | 0 | 0 | Falling edge | 0 | 1 | Rising edge | 1 | 0 | Level detection (low-level detection) <sup>Notes 1, 2</sup> | 1 | 1 | Both rising and falling edges |
|              |                                      | INTFDHn                                                                                                                                                                                                                                                                                                                                          | INTRDHn | Operation                                                   |           |   |   |              |   |   |             |   |   |                                                             |   |   |                               |
|              |                                      | 0                                                                                                                                                                                                                                                                                                                                                | 0       | Falling edge                                                |           |   |   |              |   |   |             |   |   |                                                             |   |   |                               |
|              |                                      | 0                                                                                                                                                                                                                                                                                                                                                | 1       | Rising edge                                                 |           |   |   |              |   |   |             |   |   |                                                             |   |   |                               |
|              |                                      | 1                                                                                                                                                                                                                                                                                                                                                | 0       | Level detection (low-level detection) <sup>Notes 1, 2</sup> |           |   |   |              |   |   |             |   |   |                                                             |   |   |                               |
|              |                                      | 1                                                                                                                                                                                                                                                                                                                                                | 1       | Both rising and falling edges                               |           |   |   |              |   |   |             |   |   |                                                             |   |   |                               |
|              |                                      |                                                                                                                                                                                                                                                                                                                                                  |         |                                                             |           |   |   |              |   |   |             |   |   |                                                             |   |   |                               |
|              |                                      |                                                                                                                                                                                                                                                                                                                                                  |         |                                                             |           |   |   |              |   |   |             |   |   |                                                             |   |   |                               |
|              |                                      |                                                                                                                                                                                                                                                                                                                                                  |         |                                                             |           |   |   |              |   |   |             |   |   |                                                             |   |   |                               |
|              |                                      |                                                                                                                                                                                                                                                                                                                                                  |         |                                                             |           |   |   |              |   |   |             |   |   |                                                             |   |   |                               |
|              |                                      |                                                                                                                                                                                                                                                                                                                                                  |         |                                                             |           |   |   |              |   |   |             |   |   |                                                             |   |   |                               |

- Notes 1.** The level of the  $\overline{\text{INTPDn}}$  pin is sampled each time the main clock (fx) is divided by four. When the low level of this pin is detected, an interrupt request is latched as the PDIFn bit (n = 0 to 15). Consequently, even when the CPU acknowledges the interrupt and the PDIFn bit of the interrupt control register (PDICn) is automatically cleared to 0, the PDIFn bit is immediately set to 1 and interrupts occur consecutively. To avoid this status, make the  $\overline{\text{INTPDn}}$  pin of the external device inactive in the interrupt servicing routine, and forcibly clear the PDIFn bit to 0.
- 2.** If a level-detected interrupt request (INTPDn) with a lower priority occurs while an interrupt is being serviced and if this level-detected interrupt request (INTPDn) that has newly occurred becomes inactive before the current interrupt has been serviced, the interrupt request of the new interrupt (INTPDn) is held pending (n = 0 to 15). To not acknowledge the interrupt request of INTPDn, clear the PDIFn bit of the interrupt control register.

### 14.3.9 Port CS

Port CS (PCS) is an 8-bit I/O port that can be set to the input or output mode in 1-bit units.

|     |      |      |      |      |      |      |      |      |            |             |
|-----|------|------|------|------|------|------|------|------|------------|-------------|
|     | 7    | 6    | 5    | 4    | 3    | 2    | 1    | 0    | Address    | After reset |
| PCS | PCS7 | PCS6 | PCS5 | PCS4 | PCS3 | PCS2 | PCS1 | PCS0 | FFFFFF008H | Undefined   |

| Bit position | Bit name             | Function |
|--------------|----------------------|----------|
| 7 to 0       | PCSn<br>(n = 7 to 0) | I/O port |

**Remark** For reading/writing of the I/O port, see **14.5 Operation of Port Function**.

In addition to their function as port pins, in the control mode, the port pins can also operate as the chip select signal outputs when memory is externally expanded and the read/write strobe signal output to an external I/O.

#### (1) Operation in control mode

| Pin Name | Pin No. |     | Alternate Function           | Remark                                               | Block Type |
|----------|---------|-----|------------------------------|------------------------------------------------------|------------|
|          | GM      | F1  |                              |                                                      |            |
| PCS0     | 44      | C17 | $\overline{\text{CS0}}$      | Chip select signal output                            | D-2        |
| PCS1     | 43      | B18 | $\overline{\text{CS1}}$      | Chip select signal output                            |            |
| PCS2     | 42      | D16 | $\overline{\text{CS2/IOWR}}$ | Chip select signal output/write strobe signal output | J-2        |
| PCS3     | 41      | D17 | $\overline{\text{CS3}}$      | Chip select signal output                            | D-2        |
| PCS4     | 40      | E15 | $\overline{\text{CS4}}$      | Chip select signal output                            |            |
| PCS5     | 37      | E17 | $\overline{\text{CS5/IORD}}$ | Chip select signal output/read strobe signal output  | J-2        |
| PCS6     | 36      | E18 | $\overline{\text{CS6}}$      | Chip select signal output                            | D-2        |
| PCS7     | 35      | F16 | $\overline{\text{CS7}}$      | Chip select signal output                            |            |

**Remark** GM: 176-pin plastic LQFP (fine pitch) (24 × 24)

F1: 240-pin plastic FBGA (16 × 16)



## (2) I/O mode/control mode setting

The port CS I/O mode setting is performed by the port CS mode register (PMCS), and the control mode setting is performed by the port CS mode control register (PMCCS) and the port CS function control register (PFCCS).

### (a) Port CS mode register (PMCS)

This register can be read or written in 8-bit or 1-bit units.

|      |       |       |       |       |       |       |       |       |           |             |
|------|-------|-------|-------|-------|-------|-------|-------|-------|-----------|-------------|
|      | 7     | 6     | 5     | 4     | 3     | 2     | 1     | 0     | Address   | After reset |
| PMCS | PMCS7 | PMCS6 | PMCS5 | PMCS4 | PMCS3 | PMCS2 | PMCS1 | PMCS0 | FFFFF028H | FFH         |

| Bit position | Bit name              | Function                                                                                                            |
|--------------|-----------------------|---------------------------------------------------------------------------------------------------------------------|
| 7 to 0       | PMCSn<br>(n = 7 to 0) | Specifies input/output mode for PCSn pin.<br>0: Output mode (output buffer on)<br>1: Input mode (output buffer off) |

### (b) Port CS mode control register (PMCCS)

This register can be read or written in 8-bit or 1-bit units.

|       |        |        |        |        |        |        |        |        |           |             |
|-------|--------|--------|--------|--------|--------|--------|--------|--------|-----------|-------------|
|       | 7      | 6      | 5      | 4      | 3      | 2      | 1      | 0      | Address   | After reset |
| PMCCS | PMCCS7 | PMCCS6 | PMCCS5 | PMCCS4 | PMCCS3 | PMCCS2 | PMCCS1 | PMCCS0 | FFFFF048H | FFH         |

| Bit position | Bit name | Function                                                                                                                    |
|--------------|----------|-----------------------------------------------------------------------------------------------------------------------------|
| 7            | PMCCS7   | Specifies operation mode of PCS7 pin.<br>0: I/O port mode<br>1: $\overline{CS7}$ output mode                                |
| 6            | PMCCS6   | Specifies operation mode of PCS6 pin.<br>0: I/O port mode<br>1: $\overline{CS6}$ output mode                                |
| 5            | PMCCS5   | Specifies operation mode of PCS5 pin.<br>0: I/O port mode<br>1: $\overline{CS5}$ output mode/ $\overline{IORD}$ output mode |
| 4            | PMCCS4   | Specifies operation mode of PCS4 pin.<br>0: I/O port mode<br>1: $\overline{CS4}$ output mode                                |
| 3            | PMCCS3   | Specifies operation mode of PCS3 pin.<br>0: I/O port mode<br>1: $\overline{CS3}$ output mode                                |
| 2            | PMCCS2   | Specifies operation mode of PCS2 pin.<br>0: I/O port mode<br>1: $\overline{CS2}$ output mode/ $\overline{IOWR}$ output mode |
| 1            | PMCCS1   | Specifies operation mode of PCS1 pin.<br>0: I/O port mode<br>1: $\overline{CS1}$ output mode                                |
| 0            | PMCCS0   | Specifies operation mode of PCS0 pin.<br>0: I/O port mode<br>1: $\overline{CS0}$ output mode                                |

**(c) Port CS function control register (PFCCS)**

This register can be read or written in 8-bit or 1-bit units.

The  $\overline{\text{LLWR}}$ ,  $\overline{\text{LUWR}}$ ,  $\overline{\text{ULWR}}$ , and  $\overline{\text{UUWR}}$  signals (hereafter referred to as the  $\overline{\text{xxWR}}$  signal) and LLDQM, LUDQM, ULDQM, and UUDQM signals (hereafter referred to as the  $\overline{\text{xxDQM}}$  signal) are alternate-function pins ( $\overline{\text{xxWR}}$ / $\overline{\text{xxDQM}}$ ), and the  $\overline{\text{WR}}$  signal and  $\overline{\text{WE}}$  signal are alternate-function pins ( $\overline{\text{WR}}$ / $\overline{\text{WE}}$ ). When an access to the SRAM interface device occurs immediately after an access to the SDRAM occurs, the rise of the  $\overline{\text{xxDQM}}$  ( $\overline{\text{xxWR}}$ ) signal or the rise (inactive timing) of the  $\overline{\text{WE}}$  ( $\overline{\text{WR}}$ ) signal overlaps the SRAM interface device cycle, which may cause erroneous write. To prevent this, set the CSDCn bit to 1 to delay the timing at which the  $\overline{\text{CSn}}$  signal falls by one clock.

**Caution** When the port mode is specified by the port CS mode control register (PMCCS), the PFCCS setting becomes invalid.

|       | 7     | 6     | 5      | 4     | 3                   | 2      | 1                   | 0     | Address   | After reset |
|-------|-------|-------|--------|-------|---------------------|--------|---------------------|-------|-----------|-------------|
| PFCCS | CSDC7 | CSDC6 | PFCCS5 | CSDC4 | 0 <sup>Note 1</sup> | PFCCS2 | 0 <sup>Note 1</sup> | CSDC0 | FFFFF049H | 00H         |

| Bit position | Bit name                          | Function                                                                                                                                                                                                                                                                                                                                                  |
|--------------|-----------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 7, 6, 4, 0   | CSDCn <sup>Notes 2, 3, 4, 5</sup> | Specifies chip select signal ( $\overline{\text{CSn}}$ ) output timing.<br>0: No delay function<br>1: Delay function<br>When this bit is set (1), the timing at which the corresponding chip select signal ( $\overline{\text{CSn}}$ ) falls is delayed by one clock.<br>The output timing of signals other than $\overline{\text{CSn}}$ is not affected. |
| 5            | PFCCS5                            | Specifies operation mode of PCS5 pin in control mode.<br>0: $\overline{\text{CS5}}$ output mode<br>1: $\overline{\text{IORD}}$ output mode <sup>Note 6</sup>                                                                                                                                                                                              |
| 2            | PFCCS2                            | Specifies operation mode of PCS2 pin in control mode.<br>0: CS2 output mode<br>1: $\overline{\text{IOWR}}$ output mode <sup>Note 6</sup>                                                                                                                                                                                                                  |

**Notes 1.** Be sure to clear bits 3 and 1 to 0.

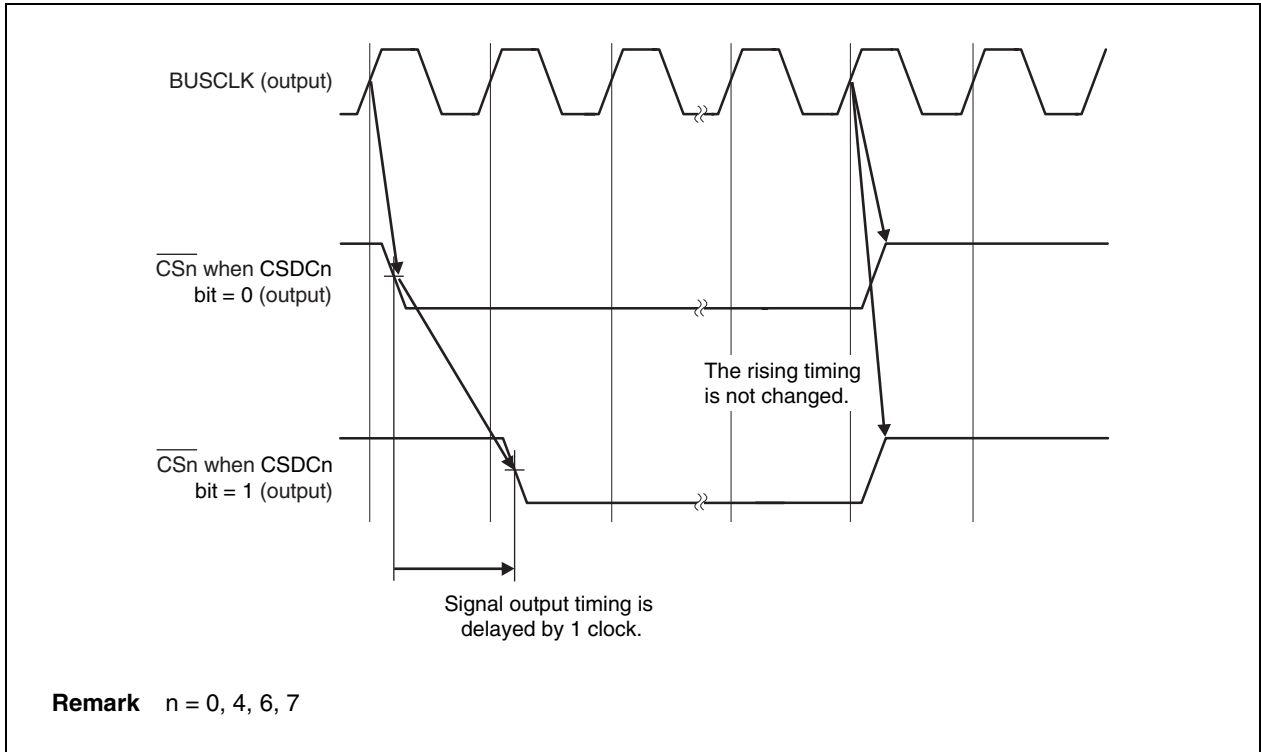
- Be sure to set the BTn0 and BTn1 bits of the BCT0 and BCT1 registers to 00 or 01 so that the device to which erroneous write may occur is connected to the CS space to which the CSDCn bit is set to 1.
- Do not change the value of the CSDCn bit for the CS space where the program under execution is allocated.
- Be sure to insert one or more address setup waits (required number of waits + 1) in the CS space for which the CSDCn bit is set to 1 using the ASC register.
- The CSDCn bit can be set to 1 only in the initialization sequence.
- To output the  $\overline{\text{IORD}}$  and  $\overline{\text{IOWR}}$  signals during access to the external I/O other than by a DMA flyby transfer, the IOEN bit of the BCP register must be set.

**Remark** n = 0, 4, 6, 7

An example of a timing chart where the CSDCn bit is set to 1 is shown below.

<R>

**Figure 14-25. Timing When CSDCn Bit Is Set to 1**



### 14.3.10 Port CT

Port CT (PCT) is a 6-bit I/O port that can be set to input or output mode in 1-bit units.

|     |      |   |      |      |      |      |      |      |            |             |
|-----|------|---|------|------|------|------|------|------|------------|-------------|
|     | 7    | 6 | 5    | 4    | 3    | 2    | 1    | 0    | Address    | After reset |
| PCT | PCT7 | 0 | PCT5 | PCT4 | PCT3 | PCT2 | PCT1 | PCT0 | FFFFFF00AH | Undefined   |

| Bit position | Bit name                | Function |
|--------------|-------------------------|----------|
| 7, 5 to 0    | PCTn<br>(n = 7, 5 to 0) | I/O port |

**Remark** For reading/writing of the I/O port, see **14.5 Operation of Port Function**.

In addition to the port function, this port outputs, in the control mode, control signals to externally expand the memory and byte enable signals when SDRAM is accessed in byte units.

#### (1) Operation in control mode

| Pin Name | Pin No. |    | Alternate Function                                           | Remark                                                                                        | Block Type |
|----------|---------|----|--------------------------------------------------------------|-----------------------------------------------------------------------------------------------|------------|
|          | GM      | F1 |                                                              |                                                                                               |            |
| PCT0     | 83      | A3 | $\overline{\text{LLWR}}/\overline{\text{LLBE}}/\text{LLDQM}$ | Write strobe signal output/<br>byte enable signal output/<br>output disable/write mask signal | J-3        |
| PCT1     | 82      | D5 | $\overline{\text{LUWR}}/\overline{\text{LUBE}}/\text{LUDQM}$ | Write strobe signal output/<br>byte enable signal output/<br>output disable/write mask signal |            |
| PCT2     | 81      | C5 | $\overline{\text{ULWR}}/\overline{\text{ULBE}}/\text{ULDQM}$ | Write strobe signal output/<br>byte enable signal output/<br>output disable/write mask signal |            |
| PCT3     | 80      | B5 | $\overline{\text{UUWR}}/\overline{\text{UUBE}}/\text{UUDQM}$ | Write strobe signal output/<br>byte enable signal output/<br>output disable/write mask signal |            |
| PCT4     | 79      | A5 | $\overline{\text{RD}}$                                       | Read strobe signal output                                                                     | D-2        |
| PCT5     | 78      | C6 | $\overline{\text{WE}}/\overline{\text{WR}}$                  | Write enable signal output/<br>write strobe signal output                                     |            |
| PCT7     | 77      | B6 | $\overline{\text{BCYST}}$                                    | Bus cycle status signal output                                                                |            |

**Remark** GM: 176-pin plastic LQFP (fine pitch) (24 × 24)

F1: 240-pin plastic FBGA (16 × 16)

**(2) I/O mode/control mode setting**

The port CT I/O mode setting is performed by the port CT mode register (PMCT), and the control mode setting is performed by the port CT mode control register (PMCCT) and port CT function control register (PFCCT).

**(a) Port CT mode register (PMCT)**

This register can be read or written in 8-bit or 1-bit units.

|      |       |   |       |       |       |       |       |       |           |             |
|------|-------|---|-------|-------|-------|-------|-------|-------|-----------|-------------|
|      | 7     | 6 | 5     | 4     | 3     | 2     | 1     | 0     | Address   | After reset |
| PMCT | PMCT7 | 1 | PMCT5 | PMCT4 | PMCT3 | PMCT2 | PMCT1 | PMCT0 | FFFFF02AH | FFH         |

| Bit position | Bit name                 | Function                                                                                                            |
|--------------|--------------------------|---------------------------------------------------------------------------------------------------------------------|
| 7, 5 to 0    | PMCTn<br>(n = 7, 5 to 0) | Specifies input/output mode for PCTn pin.<br>0: Output mode (output buffer on)<br>1: Input mode (output buffer off) |

**(b) Port CT mode control register (PMCCT)**

This register can be read or written in 8-bit or 1-bit units.

|       |        |   |        |        |        |        |        |        |           |             |
|-------|--------|---|--------|--------|--------|--------|--------|--------|-----------|-------------|
|       | 7      | 6 | 5      | 4      | 3      | 2      | 1      | 0      | Address   | After reset |
| PMCCT | PMCCT7 | 0 | PMCCT5 | PMCCT4 | PMCCT3 | PMCCT2 | PMCCT1 | PMCCT0 | FFFFF04AH | BFH         |

| Bit position | Bit name | Function                                                                                                                                                                                                                                                                                     |
|--------------|----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 7            | PMCCT7   | Specifies operation mode of PCT7 pin.<br>0: I/O port mode<br>1: $\overline{\text{BCYST}}$ output mode                                                                                                                                                                                        |
| 5            | PMCCT5   | Specifies operation mode of PCT5 pin.<br>0: I/O port mode<br>1: $\overline{\text{WE}}/\overline{\text{WR}}$ output mode<br>The $\overline{\text{WE}}$ output mode and $\overline{\text{WR}}$ output mode are automatically selected by accessing the memory for which each mode is targeted. |
| 4            | PMCCT4   | Specifies operation mode of PCT4 pin.<br>0: I/O port mode<br>1: $\overline{\text{RD}}$ output mode                                                                                                                                                                                           |
| 3            | PMCCT3   | Specifies operation mode of PCT3 pin.<br>0: I/O port mode<br>1: $\overline{\text{UWR}}$ output mode/ $\overline{\text{UBE}}$ output mode/ $\overline{\text{UDQM}}$ output mode                                                                                                               |
| 2            | PMCCT2   | Specifies operation mode of PCT2 pin.<br>0: I/O port mode<br>1: $\overline{\text{ULWR}}$ output mode/ $\overline{\text{ULBE}}$ output mode/ $\overline{\text{ULDQM}}$ output mode                                                                                                            |
| 1            | PMCCT1   | Specifies operation mode of PCT1 pin.<br>0: I/O port mode<br>1: $\overline{\text{LUWR}}$ output mode/ $\overline{\text{LUBE}}$ output mode/ $\overline{\text{LUDQM}}$ output mode                                                                                                            |
| 0            | PMCCT0   | Specifies operation mode of PCT0 pin.<br>0: I/O port mode<br>1: $\overline{\text{LLWR}}$ output mode/ $\overline{\text{LLBE}}$ output mode/ $\overline{\text{LLDQM}}$ output mode                                                                                                            |

**(c) Port CT function control register (PFCCT)**

This register can be read or written in 8-bit or 1-bit units.

**Cautions** 1. When the port mode is specified by the port CT mode control register (PMCCT), the setting of this register becomes invalid.

2. The timing of the  $\overline{\text{xxDQM}}$  signal differs between when the  $\overline{\text{xxWR}}$  output mode/ $\overline{\text{xxDQM}}$  output mode is selected and when the  $\overline{\text{xxBE}}$  output mode/ $\overline{\text{xxDQM}}$  output mode is selected. However, if either mode is selected, no problems occur when connecting to SDRAM. For the output timing of the  $\overline{\text{xxDQM}}$  signal, refer to the timing diagrams (Figures 5-9 to 5-11) in 5.3.5 SDRAM access (xx = UU, UL, LU, LL).

|       |   |   |   |   |        |        |        |        |            |             |
|-------|---|---|---|---|--------|--------|--------|--------|------------|-------------|
|       | 7 | 6 | 5 | 4 | 3      | 2      | 1      | 0      | Address    | After reset |
| PFCCT | 0 | 0 | 0 | 0 | PFCCT3 | PFCCT2 | PFCCT1 | PFCCT0 | FFFFFF04BH | 00H         |

| Bit position | Bit name | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|--------------|----------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 3            | PFCCT3   | Specifies operation mode of PCT3 pin in control mode.<br>0: $\overline{\text{UWR}}$ output mode/ $\overline{\text{UDQM}}$ output mode<br>1: $\overline{\text{UBE}}$ output mode/ $\overline{\text{UDQM}}$ output mode<br>The $\overline{\text{UWR}}$ output mode and $\overline{\text{UDQM}}$ output mode, and the $\overline{\text{UBE}}$ output mode and $\overline{\text{UDQM}}$ output mode are automatically selected by accessing the memory for which each mode is targeted.         |
| 2            | PFCCT2   | Specifies operation mode of PCT2 pin in control mode.<br>0: $\overline{\text{ULWR}}$ output mode/ $\overline{\text{ULDQM}}$ output mode<br>1: $\overline{\text{ULBE}}$ output mode/ $\overline{\text{ULDQM}}$ output mode<br>The $\overline{\text{ULWR}}$ output mode and $\overline{\text{ULDQM}}$ output mode, and the $\overline{\text{ULBE}}$ output mode and $\overline{\text{ULDQM}}$ output mode are automatically selected by accessing the memory for which each mode is targeted. |
| 1            | PFCCT1   | Specifies operation mode of PCT1 pin in control mode.<br>0: $\overline{\text{LWR}}$ output mode/ $\overline{\text{LUDQM}}$ output mode<br>1: $\overline{\text{LBE}}$ output mode/ $\overline{\text{LUDQM}}$ output mode<br>The $\overline{\text{LWR}}$ output mode and $\overline{\text{LUDQM}}$ output mode, and the $\overline{\text{LBE}}$ output mode and $\overline{\text{LUDQM}}$ output mode are automatically selected by accessing the memory for which each mode is targeted.     |
| 0            | PFCCT0   | Specifies operation mode of PCT0 pin in control mode.<br>0: $\overline{\text{LLWR}}$ output mode/ $\overline{\text{LLDQM}}$ output mode<br>1: $\overline{\text{LLBE}}$ output mode/ $\overline{\text{LUDQM}}$ output mode<br>The $\overline{\text{LLWR}}$ output mode and $\overline{\text{LLDQM}}$ output mode, and the $\overline{\text{LLBE}}$ output mode and $\overline{\text{LUDQM}}$ output mode are automatically selected by accessing the memory for which each mode is targeted. |

### 14.3.11 Port CM

Port CM (PCM) is a 6-bit I/O port that can be set to the input or output mode in 1-bit units.

|     |   |   |      |      |      |      |      |      |           |             |
|-----|---|---|------|------|------|------|------|------|-----------|-------------|
|     | 7 | 6 | 5    | 4    | 3    | 2    | 1    | 0    | Address   | After reset |
| PCM | 0 | 0 | PCM5 | PCM4 | PCM3 | PCM2 | PCM1 | PCM0 | FFFFF00CH | Undefined   |

| Bit position | Bit name             | Function |
|--------------|----------------------|----------|
| 5 to 0       | PCMn<br>(n = 5 to 0) | I/O port |

**Remark** For reading/writing of the I/O port, see **14.5 Operation of Port Function**.

In addition to their function as port pins, in the control mode, the port CM pins operate as the wait insertion signal input, bus hold control signal output, refresh request signal output from SDRAM, and A/D converter external trigger input.

#### (1) Operation in control mode

| Pin Name | Pin No. |     | Alternate Function         | Remark                             | Block Type |
|----------|---------|-----|----------------------------|------------------------------------|------------|
|          | GM      | F1  |                            |                                    |            |
| PCM0     | 34      | F17 | WAIT                       | Wait insertion signal input        | C-1        |
| PCM1     | 33      | G15 | –                          | –                                  | D-1        |
| PCM2     | 32      | F18 | HLD $\overline{\text{AK}}$ | Bus hold acknowledge signal output | D-2        |
| PCM3     | 31      | G16 | HLD $\overline{\text{RQ}}$ | Bus hold request signal input      | C-1        |
| PCM4     | 30      | G17 | REF $\overline{\text{RQ}}$ | Refresh request signal output      | D-2        |
| PCM5     | 29      | G18 | SELFREF/ADTRG              | Self-refresh request signal input  | F-5        |

**Remark** GM: 176-pin plastic LQFP (fine pitch) (24 × 24)

F1: 240-pin plastic FBGA (16 × 16)

**(2) I/O mode/control mode setting**

The port CM I/O mode setting is performed by the port CM mode register (PMCM), and the control mode setting is performed by the port CM mode control register (PMCCM) and the port CM function control register (PFCCM).

**(a) Port CM mode register (PMCM)**

This register can be read or written in 8-bit or 1-bit units.

|      |   |   |       |       |       |       |       |       |            |             |
|------|---|---|-------|-------|-------|-------|-------|-------|------------|-------------|
|      | 7 | 6 | 5     | 4     | 3     | 2     | 1     | 0     | Address    | After reset |
| PMCM | 1 | 1 | PMCM5 | PMCM4 | PMCM3 | PMCM2 | PMCM1 | PMCM0 | FFFFFF02CH | FFH         |

| Bit position | Bit name              | Function                                                                                                            |
|--------------|-----------------------|---------------------------------------------------------------------------------------------------------------------|
| 5 to 0       | PMCMn<br>(n = 5 to 0) | Specifies input/output mode for PCMn pin.<br>0: Output mode (output buffer on)<br>1: Input mode (output buffer off) |

**(b) Port CM mode control register (PMCCM)**

This register can be read or written in 8-bit or 1-bit units.

Be sure to clear bit 1 to 0. If it is set to 1, the operation is not guaranteed.

|       |   |   |        |        |        |        |   |        |            |             |
|-------|---|---|--------|--------|--------|--------|---|--------|------------|-------------|
|       | 7 | 6 | 5      | 4      | 3      | 2      | 1 | 0      | Address    | After reset |
| PMCCM | 0 | 0 | PMCCM5 | PMCCM4 | PMCCM3 | PMCCM2 | 0 | PMCCM0 | FFFFFF04CH | 3DH         |

| Bit position | Bit name | Function                                                                                                                             |
|--------------|----------|--------------------------------------------------------------------------------------------------------------------------------------|
| 5            | PMCCM5   | Specifies operation mode of PCM5 pin.<br>0: I/O port mode<br>1: SELFREF input mode/A/D converter external trigger (ADTRG) input mode |
| 4            | PMCCM4   | Specifies operation mode of PCM4 pin.<br>0: I/O port mode<br>1: REFRQ output mode                                                    |
| 3            | PMCCM3   | Specifies operation mode of PCM3 pin.<br>0: I/O port mode<br>1: HLDRQ input mode                                                     |
| 2            | PMCCM2   | Specifies operation mode of PCM2 pin.<br>0: I/O port mode<br>1: HLDAR output mode                                                    |
| 0            | PMCCM0   | Specifies operation mode of PCM0 pin.<br>0: I/O port mode<br>1: WAIT input mode                                                      |



**(c) Port CM function control register (PFCCM)**

This register can be read or written in 8-bit or 1-bit units.

**Caution** When the port mode is specified by the port CM mode control register (PMCCM), the PFCCM setting becomes invalid.

|       |   |   |        |   |   |   |   |   |           |             |
|-------|---|---|--------|---|---|---|---|---|-----------|-------------|
|       | 7 | 6 | 5      | 4 | 3 | 2 | 1 | 0 | Address   | After reset |
| PFCCM | 0 | 0 | PFCCM5 | 0 | 0 | 0 | 0 | 0 | FFFFF04DH | 00H         |

| Bit position | Bit name | Function                                                                                                                               |
|--------------|----------|----------------------------------------------------------------------------------------------------------------------------------------|
| 5            | PFCCM5   | Specifies operation mode of PCM5 pin in control mode.<br>0: SELFREF input mode<br>1: A/D converter external trigger (ADTRG) input mode |

### 14.3.12 Port CD

Port CD (PCD) is a 4-bit I/O port that can be set to the input or output mode in 1-bit units.

|     |   |   |   |   |      |      |      |      |            |             |
|-----|---|---|---|---|------|------|------|------|------------|-------------|
|     | 7 | 6 | 5 | 4 | 3    | 2    | 1    | 0    | Address    | After reset |
| PCD | 0 | 0 | 0 | 0 | PCD3 | PCD2 | PCD1 | PCD0 | FFFFFF00EH | Undefined   |

| Bit position | Bit name             | Function |
|--------------|----------------------|----------|
| 3 to 0       | PCDn<br>(n = 3 to 0) | I/O port |

**Remark** For reading/writing of the I/O port, see **14.5 Operation of Port Function**.

In addition to their function as port pins, the port CD pins operate as the clock enable signal output, bus clock output, column address strobe signal output, and row address strobe signal output in the control mode.

#### (1) Operation in control mode

| Pin Name | Pin No. |    | Alternate Function | Remark                              | Block Type |
|----------|---------|----|--------------------|-------------------------------------|------------|
|          | GM      | F1 |                    |                                     |            |
| PCD0     | 91      | D3 | SDCKE              | Clock enable signal output          | D-2        |
| PCD1     | 88      | B2 | BUSCLK             | Bus clock output                    | D-1        |
| PCD2     | 87      | B3 | SDCAS              | Column address strobe signal output | D-2        |
| PCD3     | 86      | C3 | SDRAS              | Row address strobe signal output    |            |

**Remark** GM: 176-pin plastic LQFP (fine pitch) (24 × 24)  
F1: 240-pin plastic FBGA (16 × 16)

**(2) I/O mode/control mode setting**

The port CD I/O mode setting is performed by the port CD mode register (PMCD), and the control mode setting is performed by the port CD mode control register (PMCCD).

**(a) Port CD mode register (PMCD)**

This register can be read or written in 8-bit or 1-bit units.

|      |   |   |   |   |       |       |       |       |           |             |
|------|---|---|---|---|-------|-------|-------|-------|-----------|-------------|
|      | 7 | 6 | 5 | 4 | 3     | 2     | 1     | 0     | Address   | After reset |
| PMCD | 1 | 1 | 1 | 1 | PMCD3 | PMCD2 | PMCD1 | PMCD0 | FFFFF02EH | FFH         |

| Bit position | Bit name              | Function                                                                                                            |
|--------------|-----------------------|---------------------------------------------------------------------------------------------------------------------|
| 3 to 0       | PMCDn<br>(n = 3 to 0) | Specifies input/output mode for PCDn pin.<br>0: Output mode (output buffer on)<br>1: Input mode (output buffer off) |

**(b) Port CD mode control register (PMCCD)**

This register can be read or written in 8-bit or 1-bit units.

|       |   |   |   |   |        |        |        |        |           |             |
|-------|---|---|---|---|--------|--------|--------|--------|-----------|-------------|
|       | 7 | 6 | 5 | 4 | 3      | 2      | 1      | 0      | Address   | After reset |
| PMCCD | 0 | 0 | 0 | 0 | PMCCD3 | PMCCD2 | PMCCD1 | PMCCD0 | FFFFF04EH | 0FH         |

| Bit position | Bit name | Function                                                                                              |
|--------------|----------|-------------------------------------------------------------------------------------------------------|
| 3            | PMCCD3   | Specifies operation mode of PCD3 pin.<br>0: I/O port mode<br>1: $\overline{\text{SDRAS}}$ output mode |
| 2            | PMCCD2   | Specifies operation mode of PCD2 pin.<br>0: I/O port mode<br>1: $\overline{\text{SDCAS}}$ output mode |
| 1            | PMCCD1   | Specifies operation mode of PCD1 pin.<br>0: I/O port mode<br>1: BUSCLK output mode                    |
| 0            | PMCCD0   | Specifies operation mode of PCD0 pin.<br>0: I/O port mode<br>1: SDCKE output mode                     |

## 14.4 Configuration of $\overline{\text{RESET}}$ , A2 to A15, and D0 to D15 Pins

The  $\overline{\text{RESET}}$ , A2 to A15, and D0 to D15 pins are not alternative function pins. Their configuration is as follows.

### (1) Configuration of $\overline{\text{RESET}}$ , A2 to A15, and D0 to D15 pins

| Pin Function              | Remark                                    | Block Type |
|---------------------------|-------------------------------------------|------------|
| $\overline{\text{RESET}}$ | Schmitt buffer                            | N-1        |
| A2 to A15                 | Output buffer off control                 | N-2        |
| D0 to D15                 | Output buffer off control and DIR control | N-3        |

### (2) Block diagram of $\overline{\text{RESET}}$ , A2 to A15, and D0 to D15 pins

Figure 14-26. Block Diagram of Type N-1

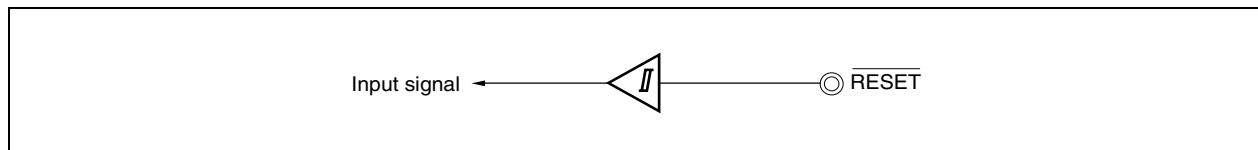


Figure 14-27. Block Diagram of Type N-2

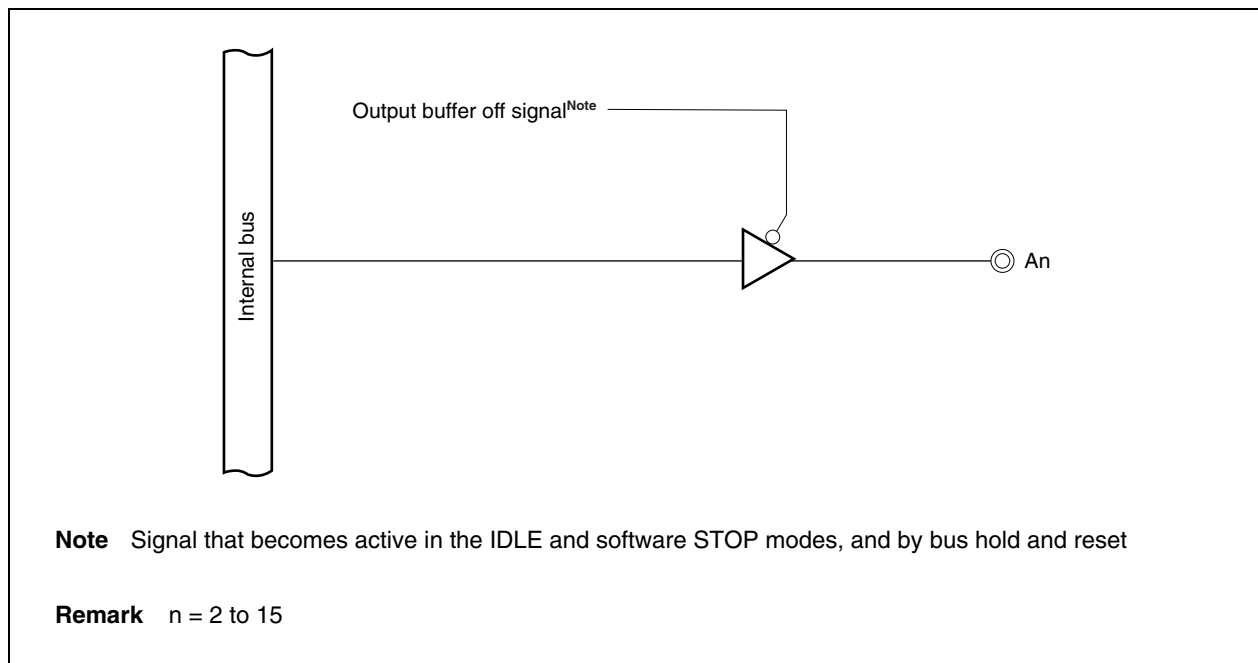
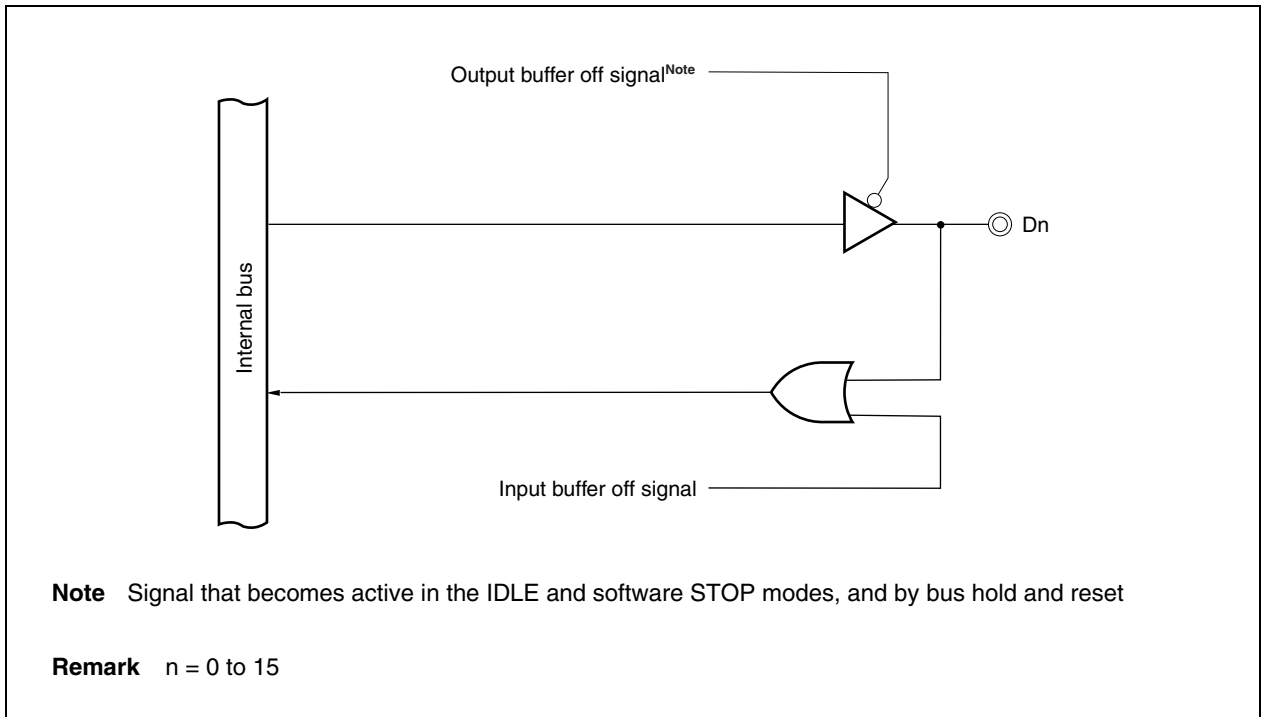


Figure 14-28. Block Diagram of Type N-3



## 14.5 Operation of Port Function

The operation of a port differs depending on whether it is set in the input or output mode, as follows.

### 14.5.1 Writing to I/O port

#### (1) In output mode

A value can be written to the output latch (Pn) by writing it to the port n register (Pn). The contents of the output latch are output from the pin.

Once data is written to the output latch, it is held until new data is written to the output latch.

#### (2) In input mode

A value can be written to the output latch (Pn) by writing it to the port n register (Pn). However, the status of the pin does not change because the output buffer is off.

Once data is written to the output latch, it is held until new data is written to the output latch.

**Caution** A bit manipulation instruction (CLR1, SET1, NOT1) manipulates 1 bit but accesses a port in 8-bit units. If this instruction is executed to manipulate a port with a mixture of input and output bits, the contents of the output latch of a pin set in the input mode, in addition to the bit to be manipulated, are overwritten to the current input pin status and become undefined.

### 14.5.2 Reading from I/O port

#### (1) In output mode

The contents of the output latch (Pn) can be read by reading the port n register (Pn). The contents of the output latch do not change.

#### (2) In input mode

The status of the pin can be read by reading the port n register (Pn). The contents of the output latch (Pn) do not change.

### 14.5.3 Output status of alternate function in control mode

The status of a port pin is not dependent upon the setting of the PMcN register and can be read by setting the port n mode register (PMn) to the input mode. If the PMn register is set to the output mode, the value of the port n register (Pn) can be read in the port mode, and the output status of the alternate function can be read in the control mode.

## 14.6 Noise Eliminator

### 14.6.1 Interrupt input pin

The following timing controller used to secure the noise elimination time is provided for the NMI and port pins that operate in the control mode when the valid edge is input. Input signals that change within the noise elimination time are not internally acknowledged.

**Table 14-1. Noise Elimination Time of Interrupt Input Pins**

| Pin     | Noise Elimination Time    |
|---------|---------------------------|
| NMI     | Analog delay (80 ns typ.) |
| INTP10  |                           |
| INTP11  |                           |
| INTP21  |                           |
| INTP22  |                           |
| INTP23  |                           |
| INTP24  |                           |
| INTP25  |                           |
| INTP50  |                           |
| INTP51  |                           |
| INTP52  |                           |
| INTP65  |                           |
| INTP66  |                           |
| INTP67  |                           |
| INTPL0  |                           |
| INTPL1  |                           |
| INTPD0  |                           |
| INTPD1  |                           |
| INTPD2  |                           |
| INTPD3  |                           |
| INTPD4  |                           |
| INTPD5  |                           |
| INTPD6  |                           |
| INTPD7  |                           |
| INTPD8  |                           |
| INTPD9  |                           |
| INTPD10 |                           |
| INTPD11 |                           |
| INTPD12 |                           |
| INTPD13 |                           |
| INTPD14 |                           |
| INTPD15 |                           |

- Cautions**
1. The above non-maskable and maskable interrupt pins are used to release the standby mode. A timing circuit that controls the clock is not employed because the internal system clock ( $f_{CLK}$ ) is stopped in the standby mode.
  2. The noise eliminator is valid only in the control mode.

### 14.6.2 A/D converter input pin

The following timing controller used to secure the noise elimination time is provided for the ADTRG pin. An input signal that changes within the noise elimination time is not internally acknowledged.

**Table 14-2. Noise Elimination Time of A/D Converter Input Pin**

| Pin                | Noise Elimination Time    |
|--------------------|---------------------------|
| PCM5/ADTRG/SELFREF | Analog delay (80 ns typ.) |

**Caution** The noise eliminator is valid only in the control mode.

### 14.6.3 Timer C and timer ENC1 input pins

The following noise filter that operates via clock sampling is provided for the pins of timers C and ENC1 that operate when the valid edge is input. Input signals that change within the noise elimination time are not internally acknowledged.

**Table 14-3. Noise Elimination Time of Timer C and Timer ENC1 Input Pins**

| Pin                                                                                                      | Noise Elimination Time             |
|----------------------------------------------------------------------------------------------------------|------------------------------------|
| INTPC00/TIC0<br>INTPC01<br>INTPC10/TIC1<br>INTPC11<br>INTPC20/TIC2<br>INTPC21<br>INTPC30/TIC3<br>INTPC31 | Selected from 0, 2, 3, or 5 clocks |
| INTP100/TCUD10<br>INTP101/TCLR10<br>TIUD10<br>INTP110/TCUD11<br>INTP111/TCLR11<br>TIUD11                 |                                    |

- Cautions**
1. The noise filter of the above pins cannot acknowledge an input signal when the CPU clock is stopped because it uses clock sampling.
  2. The noise eliminator is valid only in the control mode.



**(1) Noise elimination width setting registers C0 to C3 (NCWC0 to NCWC3)**

These registers are used to set the noise elimination width of the digital noise filter of the timer C input pins.

These registers can be read or written in 8-bit units.

Be sure to clear bits 7 to 2 to 0. If they are set to 1, the operation is not guaranteed.

Do not overwrite this register during a count operation.

|       | 7 | 6 | 5 | 4 | 3 | 2 | 1      | 0      | Address   | After reset |
|-------|---|---|---|---|---|---|--------|--------|-----------|-------------|
| NCWC0 | 0 | 0 | 0 | 0 | 0 | 0 | NCCC01 | NCCC00 | FFFFF610H | 02H         |
| NCWC1 | 0 | 0 | 0 | 0 | 0 | 0 | NCCC11 | NCCC10 | FFFFF630H | 02H         |
| NCWC2 | 0 | 0 | 0 | 0 | 0 | 0 | NCCC21 | NCCC20 | FFFFF650H | 02H         |
| NCWC3 | 0 | 0 | 0 | 0 | 0 | 0 | NCCC31 | NCCC30 | FFFFF670H | 02H         |

| Bit position | Bit name          | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                          |        |        |                                                       |   |   |                   |   |   |   |   |   |   |   |   |   |
|--------------|-------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|--------|-------------------------------------------------------|---|---|-------------------|---|---|---|---|---|---|---|---|---|
| 1, 0         | NCCCN1,<br>NCCCN0 | Specify number of clocks from which noise is to be eliminated.<br><table> <tr> <th>NCCCN1</th><th>NCCCN0</th><th>Number of clocks from which noise is to be eliminated</th></tr> <tr> <td>0</td><td>0</td><td>0 (through input)</td></tr> <tr> <td>0</td><td>1</td><td>2</td></tr> <tr> <td>1</td><td>0</td><td>3</td></tr> <tr> <td>1</td><td>1</td><td>5</td></tr> </table> <p><b>Remark</b> 1 clock = <math>f_x/4</math><br/> <math>f_x</math>: Main clock</p> | NCCCN1 | NCCCN0 | Number of clocks from which noise is to be eliminated | 0 | 0 | 0 (through input) | 0 | 1 | 2 | 1 | 0 | 3 | 1 | 1 | 5 |
| NCCCN1       | NCCCN0            | Number of clocks from which noise is to be eliminated                                                                                                                                                                                                                                                                                                                                                                                                             |        |        |                                                       |   |   |                   |   |   |   |   |   |   |   |   |   |
| 0            | 0                 | 0 (through input)                                                                                                                                                                                                                                                                                                                                                                                                                                                 |        |        |                                                       |   |   |                   |   |   |   |   |   |   |   |   |   |
| 0            | 1                 | 2                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |        |        |                                                       |   |   |                   |   |   |   |   |   |   |   |   |   |
| 1            | 0                 | 3                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |        |        |                                                       |   |   |                   |   |   |   |   |   |   |   |   |   |
| 1            | 1                 | 5                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |        |        |                                                       |   |   |                   |   |   |   |   |   |   |   |   |   |

**Remark** n = 0 to 3

## (2) Noise elimination width setting registers 10, 11 (NCW10, NCW11)

These registers are used to set the noise elimination width of the digital noise filter of the timer ENC1 input pins.

These registers can be read or written in 8-bit units.

**Cautions** 1. Whether the signal is input through or inverted can be specified for each of the INTp1n0/TCUD1n and TIUD1n pins. The noise elimination width set by the NCFn, NCC1n, and NCC0n bits is for each timer and cannot be changed for each pin.

2. The setting of the SRTCn bit is valid even when the INTp1n0/TCUD1n pin is used as a capture trigger (INTp1n0).

|       | 7 | 6 | 5     | 4     | 3 | 2    | 1     | 0     | Address   | After reset |
|-------|---|---|-------|-------|---|------|-------|-------|-----------|-------------|
| NCW10 | 0 | 0 | SRTC0 | SRTI0 | 0 | NCF0 | NCC10 | NCC00 | FFFFF5C0H | 02H         |
| NCW11 | 0 | 0 | SRTC1 | SRTI1 | 0 | NCF1 | NCC11 | NCC01 | FFFFF5F0H | 02H         |

| Bit position            | Bit name                | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                         |                         |                                                       |   |   |                                     |   |   |   |   |   |   |   |   |   |
|-------------------------|-------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|-------------------------|-------------------------------------------------------|---|---|-------------------------------------|---|---|---|---|---|---|---|---|---|
| 5                       | SRTCn                   | Specifies the input mode of the INTp1n0/TCUD1n pin.<br>0: Through input<br>1: Inverted<br>This bit specifies whether the signal input from the INTp1n0/TCUD1n pin is input through to TMENC1n, or inverted.                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                         |                         |                                                       |   |   |                                     |   |   |   |   |   |   |   |   |   |
| 4                       | SRTIn                   | Specifies the input mode of the TIUD1n pin.<br>0: Through input<br>1: Inverted<br>This bit specifies whether the signal input from the TIUD1n pin is input through to TMENC1n, or inverted.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                         |                         |                                                       |   |   |                                     |   |   |   |   |   |   |   |   |   |
| 2                       | NCFn                    | Specifies the clock frequency for noise elimination.<br>0: $f_x/4$<br>1: $f_x/32$<br>This bit selects a clock source for the noise filter.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                         |                         |                                                       |   |   |                                     |   |   |   |   |   |   |   |   |   |
| 1, 0                    | NCC1n,<br>NCC0n         | Specify the number of clocks from which noise is to be eliminated. <table border="1"> <tr> <th>NCC1n<sup>Note 1</sup></th><th>NCC0n<sup>Note 1</sup></th><th>Number of clocks from which noise is to be eliminated</th></tr> <tr> <td>0</td><td>0</td><td>0 (through input)<sup>Note 2</sup></td></tr> <tr> <td>0</td><td>1</td><td>2</td></tr> <tr> <td>1</td><td>0</td><td>3</td></tr> <tr> <td>1</td><td>1</td><td>5</td></tr> </table> <p><b>Notes</b> 1. Do not overwrite this bit during a count operation.<br/>2. Clear the NCFn bit to 0 to input the signal through.</p> <p>These bits are used to select the number of clocks from which noise is to be eliminated.</p> | NCC1n <sup>Note 1</sup> | NCC0n <sup>Note 1</sup> | Number of clocks from which noise is to be eliminated | 0 | 0 | 0 (through input) <sup>Note 2</sup> | 0 | 1 | 2 | 1 | 0 | 3 | 1 | 1 | 5 |
| NCC1n <sup>Note 1</sup> | NCC0n <sup>Note 1</sup> | Number of clocks from which noise is to be eliminated                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                         |                         |                                                       |   |   |                                     |   |   |   |   |   |   |   |   |   |
| 0                       | 0                       | 0 (through input) <sup>Note 2</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                         |                         |                                                       |   |   |                                     |   |   |   |   |   |   |   |   |   |
| 0                       | 1                       | 2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                         |                         |                                                       |   |   |                                     |   |   |   |   |   |   |   |   |   |
| 1                       | 0                       | 3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                         |                         |                                                       |   |   |                                     |   |   |   |   |   |   |   |   |   |
| 1                       | 1                       | 5                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                         |                         |                                                       |   |   |                                     |   |   |   |   |   |   |   |   |   |

**Remark** n = 0, 1

## (a) Relationship between NCW1n register set value and noise elimination width

Table 14-4. Relationship Between NCW1n Register Set Value and Noise Elimination Width

| NCW1n Register |           |           | Noise Elimination Width (ns) |                         |                         | Remark                  |
|----------------|-----------|-----------|------------------------------|-------------------------|-------------------------|-------------------------|
| NCFn Bit       | NCC1n Bit | NCC0n Bit | $f_x = 150 \text{ MHz}$      | $f_x = 133 \text{ MHz}$ | $f_x = 100 \text{ MHz}$ |                         |
| 0              | 0         | 0         | 0                            | 0                       | 0                       | Through                 |
| 0              | 0         | 1         | 53.3 to 80.0                 | 60.2 to 90.2            | 80 to 120               | $(1/(f_x/4)) \times 2$  |
| 0              | 1         | 0         | 80.0 to 106.7                | 90.2 to 120.3           | 120 to 160              | $(1/(f_x/4)) \times 3$  |
| 0              | 1         | 1         | 133.3 to 160.0               | 150.4 to 180.5          | 200 to 240              | $(1/(f_x/4)) \times 5$  |
| 1              | 0         | 1         | 426.7 to 640.0               | 481.2 to 721.8          | 640 to 960              | $(1/(f_x/32)) \times 2$ |
| 1              | 1         | 0         | 640.0 to 853.3               | 721.8 to 962.9          | 960 to 1,280            | $(1/(f_x/32)) \times 3$ |
| 1              | 1         | 1         | 1,066.7 to 1,280.0           | 1,203.0 to 1,443.6      | 1,600 to 1,920          | $(1/(f_x/32)) \times 5$ |

- Remarks**
1.  $n = 0, 1$
  2.  $f_x$ : Main clock

## 14.7 Cautions

### 14.7.1 Cautions on setting port pins

#### (1) Procedure to change mode from port mode to control mode

Change the mode of a port pin that functions as an output or I/O pin in the control mode to the control mode using the following procedure.

- <1> Set the inactive level of the signal to be output in the control mode to the corresponding bit of port n (n = 1, 2, 5 to 7, AH, AL, CD, CM, CS, CT, DH).
- <2> Select the control mode by using the port n mode control register (PMCn).

If <1> is not performed, the contents of port n may be momentarily output when the mode is changed from the port mode to the control mode.

### 14.7.2 Cautions on bit manipulation instruction for port n register (Pn)

When a 1-bit manipulation instruction is executed on a port that provides both input and output functions, the value of the output latch of an input port that is not subject to manipulation may be written in addition to the targeted bit.

<R>

Therefore, it is recommended to rewrite the output latch using the ST/SST instruction before switching any port from input mode to output mode (including switching from control mode to port mode).

<Example> When PCS0 pin is an output port, PCS1 to PCS7 pins are input ports (all pin statuses are high level), and the value of the port latch is 00H, if the output of PCS0 pin is changed from low level to high level via a bit manipulation instruction, the value of the port latch is FFH.

Explanation: The targets of writing to and reading from the Pn register of a port whose PMnm bit is 1 are the output latch and pin status, respectively.

A bit manipulation instruction is executed in the following order in the V850E/ME2.

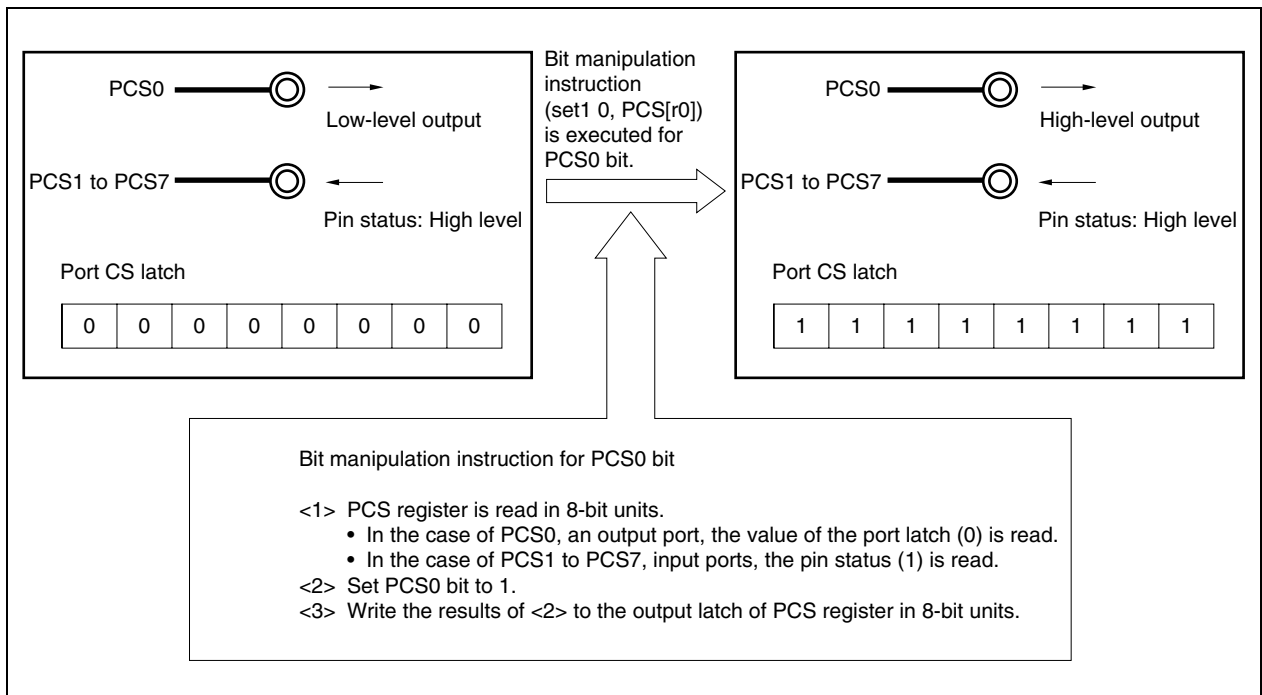
- <1> The Pn register is read in 8-bit units.
- <2> The targeted one bit is manipulated.
- <3> The Pn register is written in 8-bit units.

In step <1>, the value of the output latch (0) is read from the PCS0 pin, which is an output port, while the pin statuses are read from the PCS1 to PCS7 pins, which are input ports. If the pin statuses of PCS1 to PCS7 pins are high level at this time, the read value is FEH.

The value is changed to FFH by the manipulation in <2>.

FFH is written to the output latch by the manipulation in <3>.

**Figure 14-29. Bit Manipulation Instruction (PCS0 Pin)**

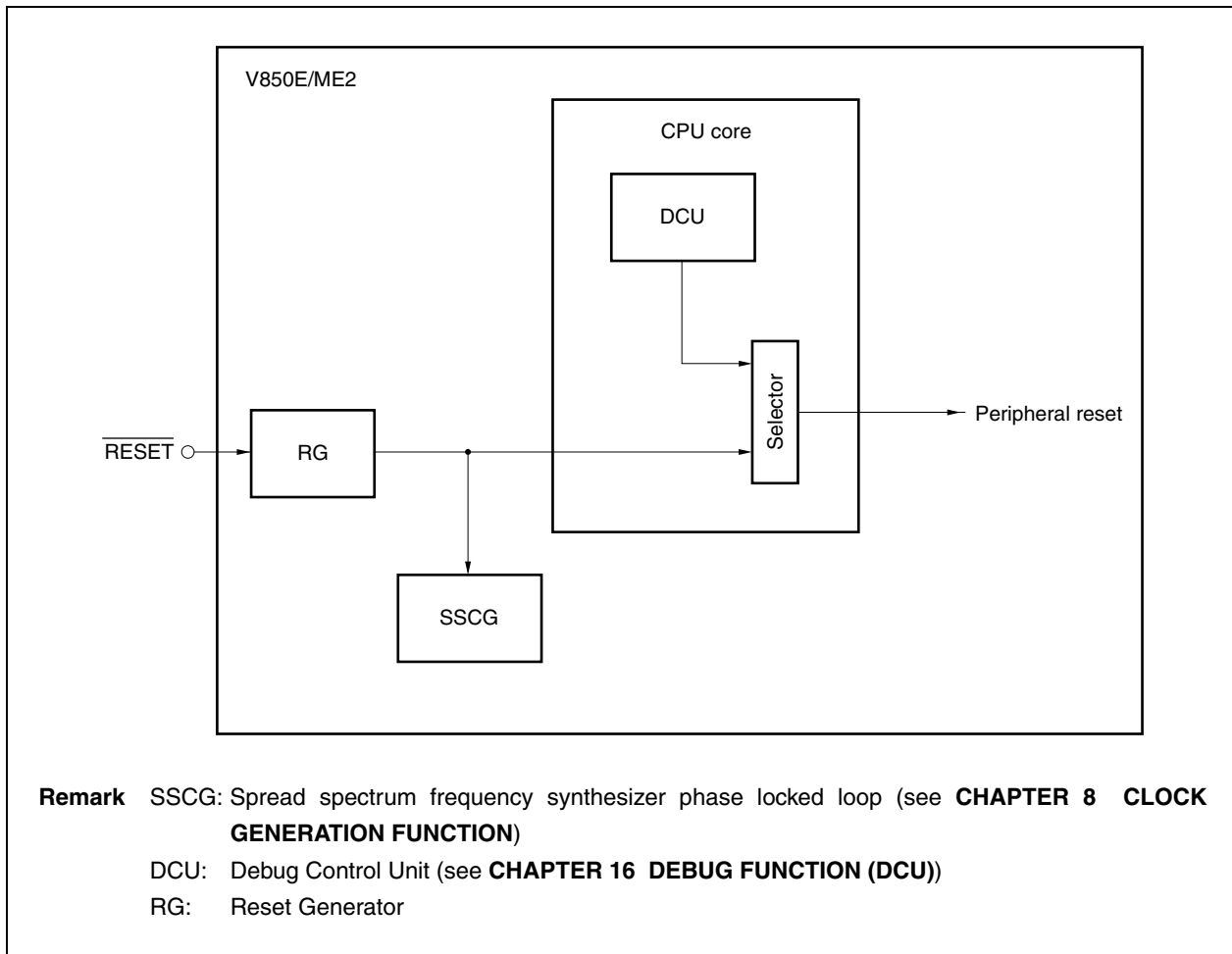


## CHAPTER 15 RESET FUNCTIONS

### 15.1 Overview

- Reset function by  $\overline{\text{RESET}}$  input
- Forced reset function by DCU (See **CHAPTER 16 DEBUG FUNCTION (DCU)**.)
- Low level is input to the  $\overline{\text{RESET}}$  pin for 100  $\mu\text{s}$  min. If an oscillation stabilization time of 100  $\mu\text{s}$  or longer is necessary, secure the low level for as long as the necessary oscillation stabilization time.
- Reset generator (RG) eliminates noise from the  $\overline{\text{RESET}}$  pin.

### 15.2 Configuration



During a system reset, most pins (all excluding the BUSCLK,  $\overline{\text{RESET}}$ , X2, EV<sub>DD</sub>, EV<sub>SS</sub>, IV<sub>DD</sub>, IV<sub>SS</sub>, PLLV<sub>DD</sub>, PLLV<sub>SS</sub>, OSCV<sub>DD</sub>, OSCV<sub>SS</sub>, UV<sub>DD</sub>, AV<sub>DD</sub>, AV<sub>REFP</sub>, AV<sub>REFM</sub>, and AV<sub>SS</sub> pins) enter the high-impedance state.

Therefore, a pull-up (or pull-down) resistor must be connected to each pin of the address bus, data bus, and external bus control signals. If no resistor is connected, external memory may be destroyed when these pins enter the high-impedance state.

For the same reason, the output signals of the on-chip peripheral I/O functions and other output ports should be handled in the same manner.

### 15.3 Operation

When a low-level signal is input to the  $\overline{\text{RESET}}$  pin, a system reset is effected and each on-chip hardware is initialized.

When the  $\overline{\text{RESET}}$  pin level changes from low to high, the reset state is released and the CPU starts program execution using OSC output clock ( $F_x$ ). Register contents must be initialized as required in the program.

When the reset signal is cleared, the oscillation stabilization time is not inserted. When the  $\overline{\text{RESET}}$  signal is to be input (reset input on power application or reset input when the software STOP mode is released) while the clock oscillator is stopped, therefore, a low-level width longer than the oscillation stabilization time (100  $\mu\text{s}$  min.) must be secured at the  $\overline{\text{RESET}}$  pin. When the  $\overline{\text{RESET}}$  signal is to be input (reset input when the IDLE mode is released) while the clock oscillator is not stopped, a low level of 100  $\mu\text{s}$  min. must be secured at the  $\overline{\text{RESET}}$  pin.

**Table 15-1. Hardware Status After Reset**

| Hardware                                      | During Reset Period                                                                                                                                                 | After Reset Is Cleared                                                                                                                                                          |
|-----------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| OSC                                           | Oscillation/supply continues                                                                                                                                        |                                                                                                                                                                                 |
| Clock generator                               | <ul style="list-style-type: none"> <li>• Outputs OSC clock (<math>F_x</math>)</li> <li>• Output is not guaranteed before oscillation stabilization time.</li> </ul> | <ul style="list-style-type: none"> <li>• Outputs OSC clock (<math>F_x</math>)</li> <li>• Operable at <math>f_x = F_x \times 8</math> by controlling the CKS register</li> </ul> |
| CPU                                           | Stops operating                                                                                                                                                     | Starts operating                                                                                                                                                                |
| Internal instruction RAM, internal data RAM   | Undefined                                                                                                                                                           |                                                                                                                                                                                 |
| Debug function                                | Stops operating                                                                                                                                                     | Operable                                                                                                                                                                        |
| On-chip peripheral I/O registers              | Initialized to specific status                                                                                                                                      |                                                                                                                                                                                 |
| On-chip peripheral functions other than above | Stops operating                                                                                                                                                     | Can start operating                                                                                                                                                             |
| Pin function                                  | See <b>2.2 Pin Status</b> .                                                                                                                                         |                                                                                                                                                                                 |

The reset operation when the  $\overline{\text{RESET}}$  pin is input is illustrated below.

**Figure 15-1. Reset Operation with  $\overline{\text{RESET}}$  Pin Input (1/2)**

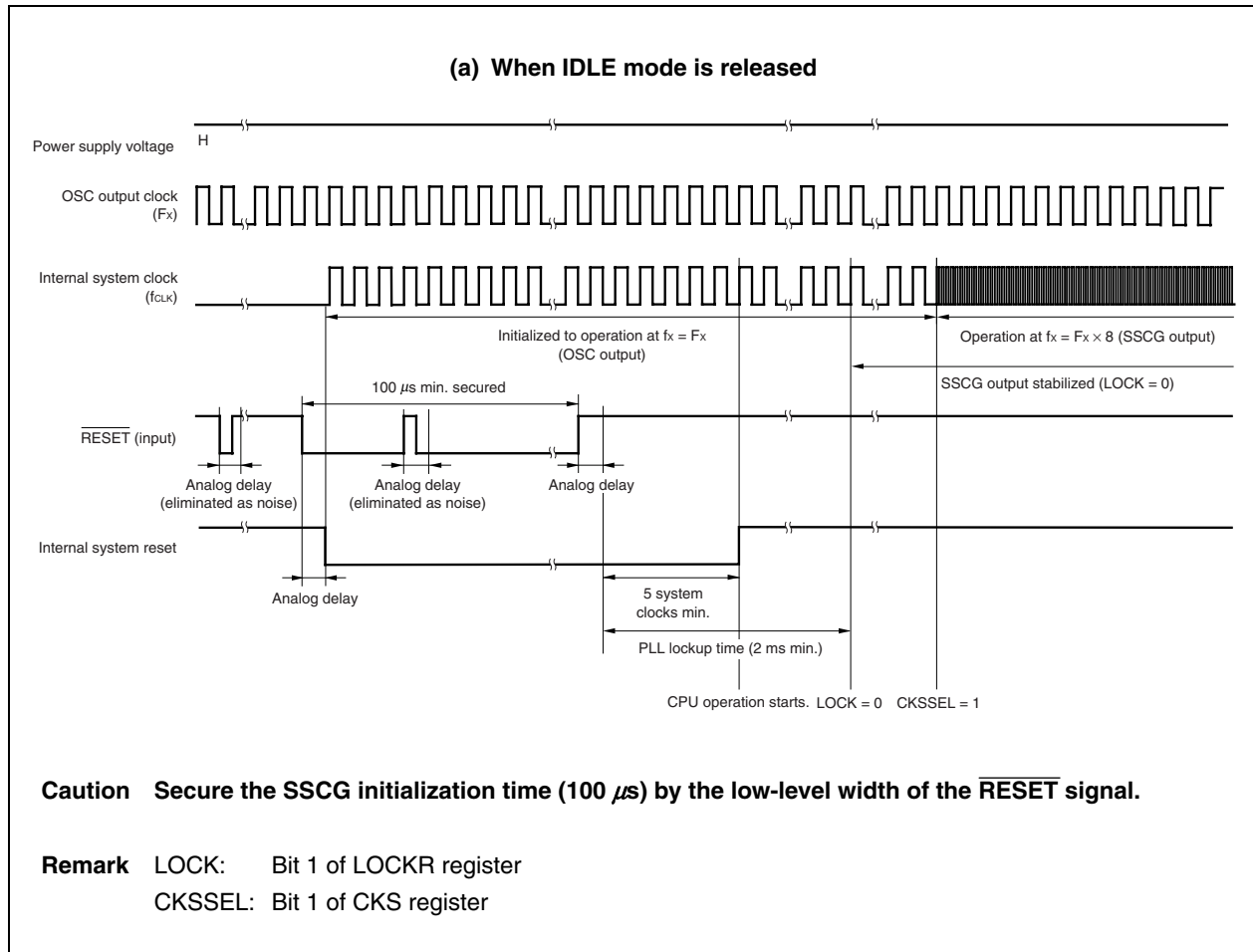
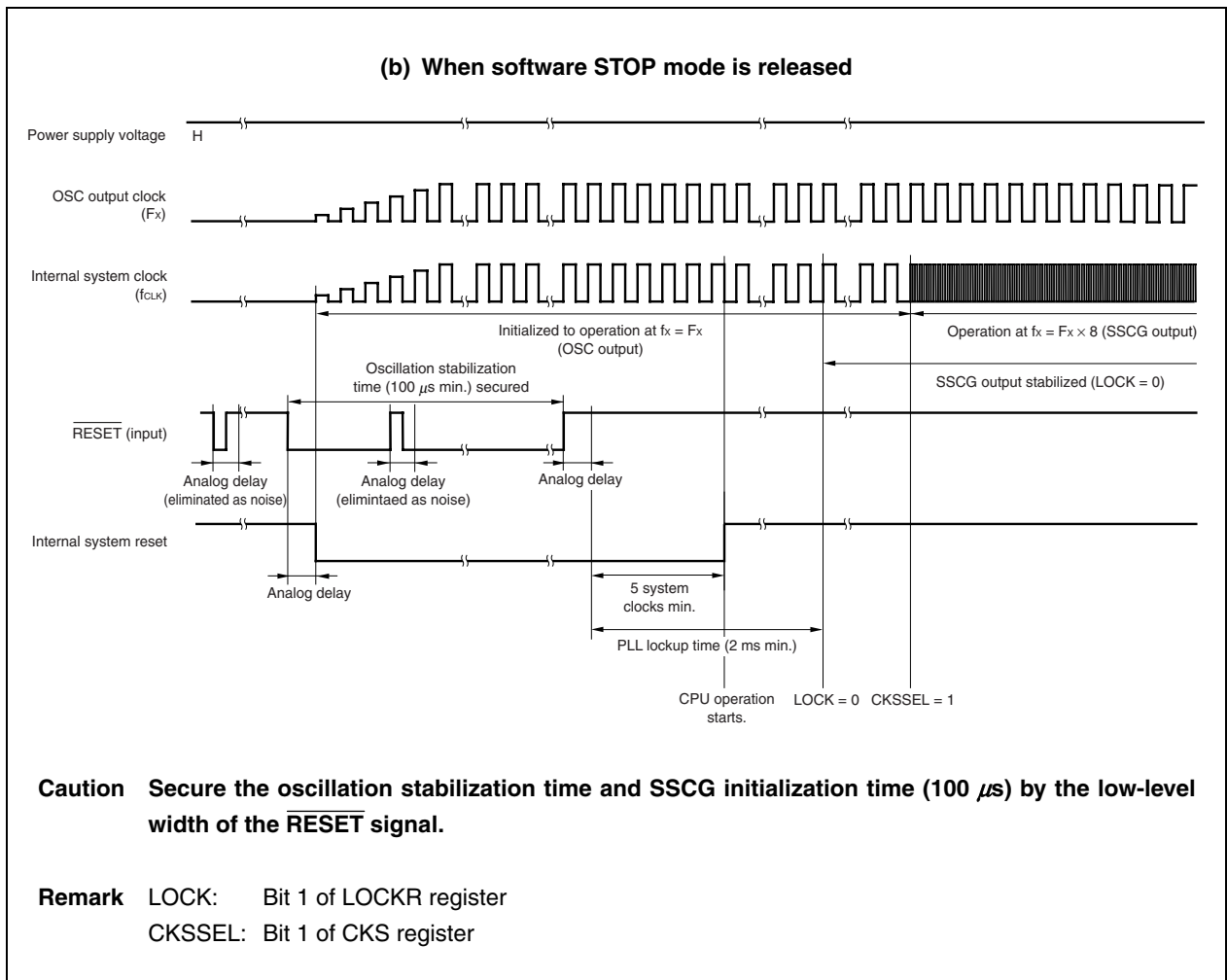
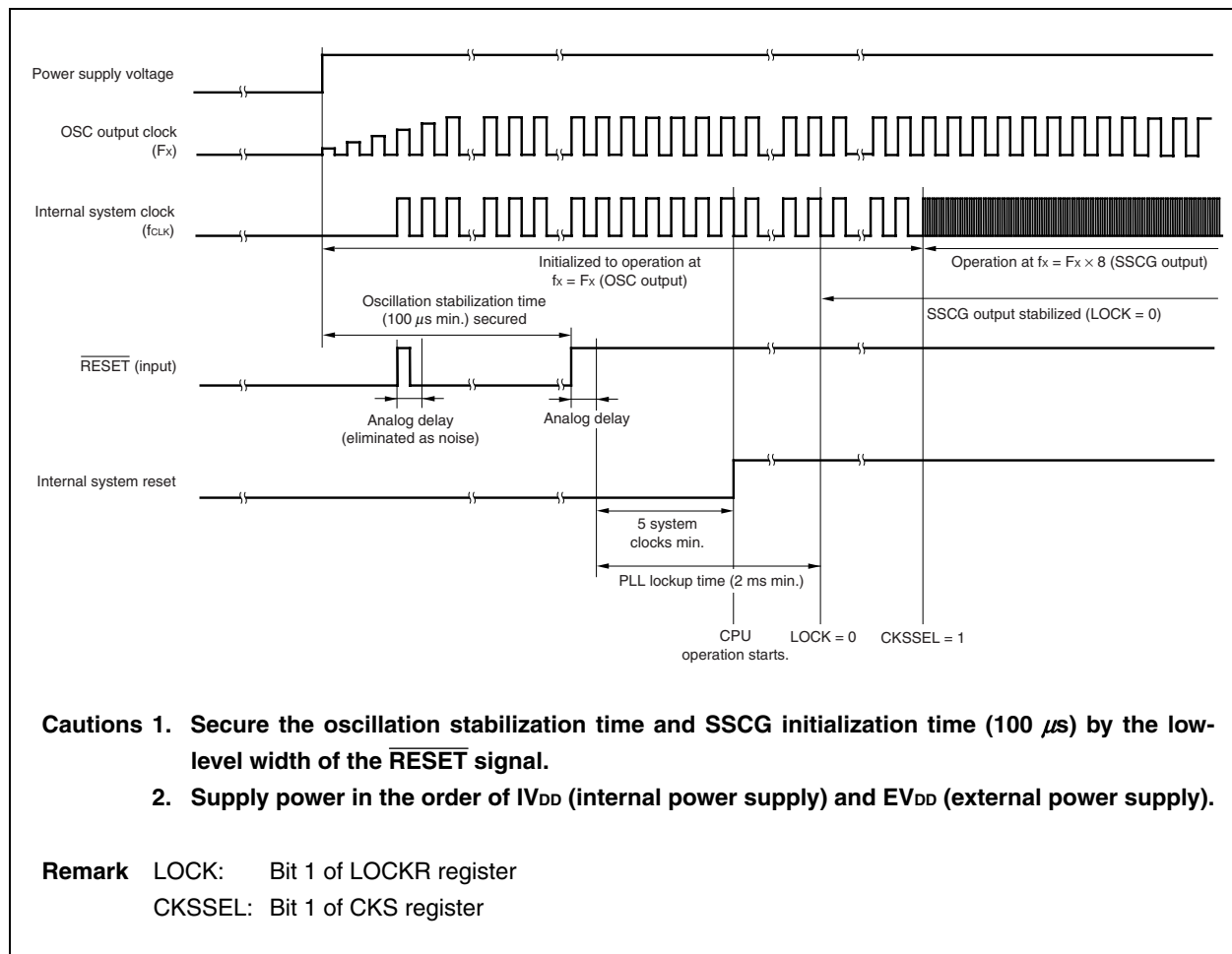




Figure 15-1. Reset Operation with  $\overline{\text{RESET}}$  Pin Input (2/2)

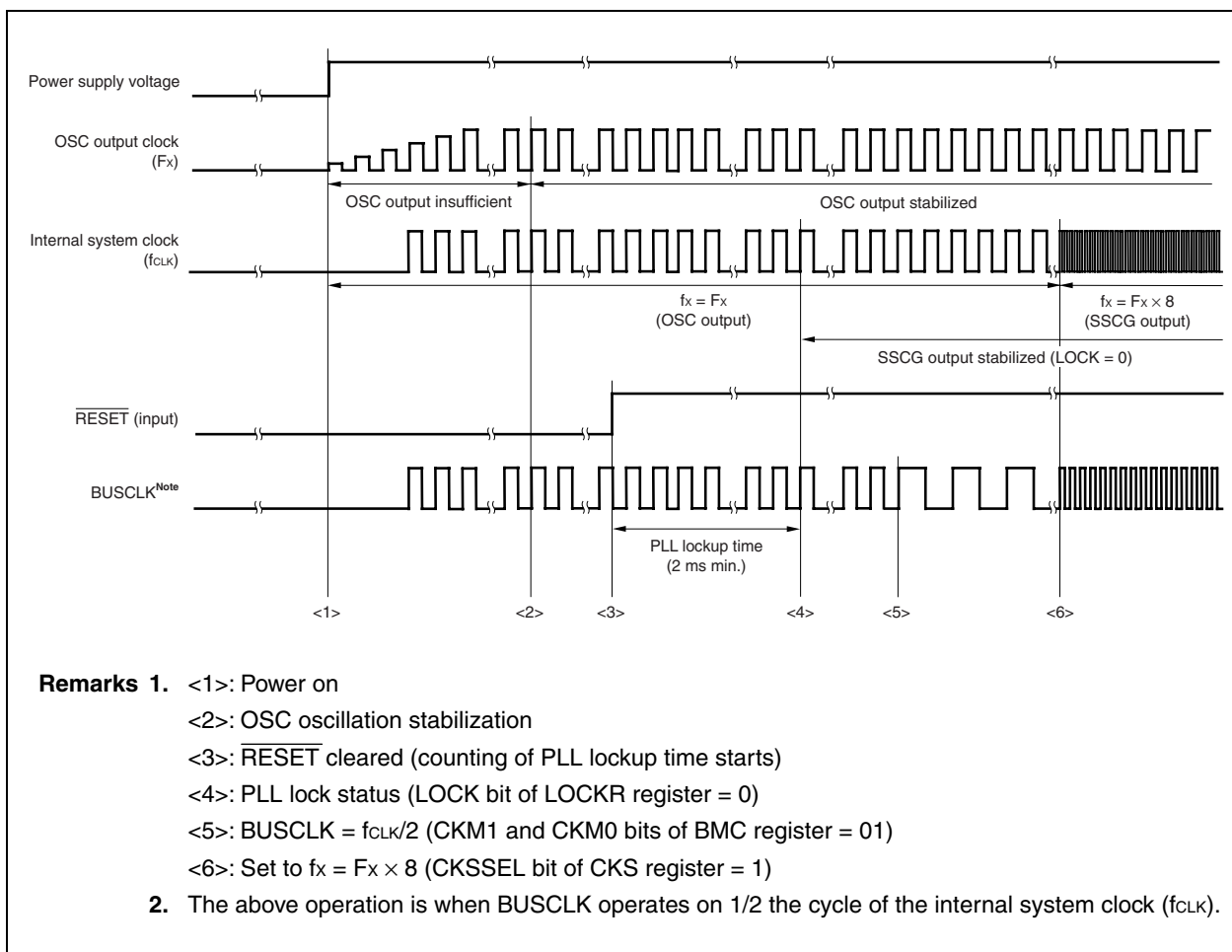
The power-on reset operation is illustrated below.

**Figure 15-2. Power-on Reset Operation**



The BUSCLK operation at power-on reset is illustrated below.

**Figure 15-3. BUSCLK Operation at Power-on Reset**



## 15.4 Initialization

Initialize the contents of each register as necessary while programming.

The initial values of the CPU, internal data RAM, internal instruction RAM, and on-chip peripheral I/O after a reset are shown below.

**Table 15-2. Initial Value of CPU, Internal Data RAM, Internal Instruction RAM, and On-Chip Peripheral I/O After Reset (1/6)**

| Internal Hardware                           |                          | Register Name                                                     | Initial Value After Reset     |
|---------------------------------------------|--------------------------|-------------------------------------------------------------------|-------------------------------|
| CPU                                         | Program registers        | General-purpose register (r0)                                     | 00000000H                     |
|                                             |                          | General-purpose register (r1 to r31)                              | Undefined                     |
|                                             |                          | Program counter (PC)                                              | 00100000H                     |
|                                             | System registers         | Status saving registers during interrupt (EIPC, EIPSW)            | Undefined                     |
|                                             |                          | Status saving registers during NMI (FEPC, FEPSW)                  | Undefined                     |
|                                             |                          | Interrupt source register (ECR)                                   | 00000000H                     |
|                                             |                          | Program status word (PSW)                                         | 00000020H                     |
|                                             |                          | Status saving registers during CALLT execution (CTPC, CTPSW)      | Undefined                     |
|                                             |                          | Status saving registers during exception/debug trap (DBPC, DBPSW) | Undefined                     |
|                                             |                          | CALLT base pointer (CTBP)                                         | Undefined                     |
| Internal instruction RAM, internal data RAM |                          | –                                                                 | Undefined                     |
| On-chip peripheral I/O                      | Bus control functions    | Chip area select control register n (CSCn) (n = 0, 1)             | 2C11H                         |
|                                             |                          | Bus cycle type configuration register n (BCTn) (n = 0, 1)         | 8888H                         |
|                                             |                          | Local bus sizing control register (LBS)                           | 5555H/AAAAH <sup>Note 1</sup> |
|                                             |                          | Endian configuration register (BEC)                               | 0000H                         |
|                                             |                          | Line buffer control register n (LBCn) (n = 0, 1)                  | 0000H                         |
|                                             |                          | Write access synchronization control register (WAS)               | Undefined                     |
|                                             |                          | Bus mode control register (BMC)                                   | 00H                           |
|                                             |                          | Data wait control register n (DWCn) (n = 0, 1)                    | 7777H                         |
|                                             |                          | Address setup wait control register (ASC)                         | FFFFH                         |
|                                             |                          | Bus cycle period control register (BCP)                           | 00H                           |
|                                             |                          | DMA flyby transfer wait control register (FWC)                    | 7777H                         |
|                                             |                          | Bus cycle control register (BCC)                                  | FFFFH                         |
|                                             |                          | DMA flyby transfer idle control register (FIC)                    | 3333H                         |
|                                             |                          | Cache configuration register (BHC)                                | 0000H                         |
|                                             |                          | Instruction cache control register (ICC)                          | 0003H <sup>Note 2</sup>       |
|                                             |                          | Instruction cache control register L (ICCL)                       | 03H <sup>Note 2</sup>         |
|                                             |                          | Instruction cache control register H (ICCH)                       | 00H                           |
|                                             |                          | Instruction cache data configuration register (ICD)               | Undefined                     |
|                                             |                          | Internal instruction RAM mode register (IRAMM)                    | 03H                           |
|                                             |                          | System wait control register (VSWC)                               | 77H                           |
|                                             | Memory control functions | Page ROM configuration register (PRC)                             | 7000H                         |
|                                             |                          | SDRAM configuration register n (SCRn) (n = 1, 3, 4, 6)            | 30C0H                         |
|                                             |                          | SDRAM refresh control register n (RFSn) (n = 1, 3, 4, 6)          | 0000H                         |

**Notes 1.** For details, see 4.5.2 (1) **Local bus sizing control register (LBS)**.

**2.** For details, see 4.9.4 (1) **Instruction cache control register (ICC)**.

**Table 15-2. Initial Value of CPU, Internal Data RAM, Internal Instruction RAM, and On-Chip Peripheral I/O After Reset (2/6)**

| Internal Hardware      |                                       | Register Name                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Initial Value After Reset |
|------------------------|---------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------|
| On-chip peripheral I/O | DMA functions                         | DMA source address register nH (DSAnH) (n = 0 to 3)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Undefined                 |
|                        |                                       | DMA source address register nL (DSAnL) (n = 0 to 3)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Undefined                 |
|                        |                                       | DMA destination address register nH (DDAnH) (n = 0 to 3)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Undefined                 |
|                        |                                       | DMA destination address register nL (DDAnL) (n = 0 to 3)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Undefined                 |
|                        |                                       | DMA transfer count register n (DBCn) (n = 0 to 3)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Undefined                 |
|                        |                                       | DMA addressing control register n (DADCn) (n = 0 to 3)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 0000H                     |
|                        |                                       | DMA channel control register n (DCHCn) (n = 0 to 3)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 00H                       |
|                        |                                       | DMA terminal count output control register (DTCO)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 01H                       |
|                        |                                       | DMA trigger factor register n (DTFRn) (n = 0 to 3)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 00H                       |
|                        |                                       | DMA interface control register (DIFC)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 00H                       |
|                        | Interrupt/exception control functions | Interrupt control registers (P1IC0, P1C1, P2IC1 to P2IC5, P5IC0 to P5IC2, P6IC5 to P6IC7, PDIC0 to PDIC15, PLIC0, PLIC1, OVCIC0 to OVCIC5, CCC0IC0, CCC0IC1, CCC1IC0, CCC1IC1, CCC2IC0, CCC2IC1, CCC3IC0, CCC3IC1, CCC4IC0, CCC4IC1, CCC5IC0, CCC5IC1, CMDIC0 to CMDIC3, CC10IC0, CC10IC1, CC11IC0, CC11IC1, CM10IC0, CM10IC1, CM11IC0, CM11IC1, OV1IC0, OV1IC1, UD1IC0, UD1IC1, DMAIC0 to DMAIC3, CSI3IC0, CSI3IC1, COVF3IC0, COVF3IC1, UREIC0, UREIC1, URIC0, URIC1, UTIC0, UTIC1, UIFIC0, UIFIC1, UTOIC0, UTOIC1, ADIC, US0BIC to US2BIC, USP2IC, USP4IC, RSUMIC) | 47H                       |
|                        |                                       | Interrupt mask register n (IMRn) (n = 0 to 5)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | FFFFH                     |
|                        |                                       | Interrupt mask register nL (IMRnL) (n = 0 to 5)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | FFH                       |
|                        |                                       | Interrupt mask register nH (IMRnH) (n = 0 to 5)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | FFH                       |
|                        |                                       | NMI reset status register (NRS)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 00H                       |
|                        |                                       | In-service priority register (ISPR)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 00H                       |
|                        |                                       | External interrupt falling edge specification register n (INTFn) (n = 1, 2, 5, 6, AL)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 00H                       |
|                        |                                       | External interrupt falling edge specification register DH (INTFDH)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 0000H                     |
|                        |                                       | External interrupt falling edge specification register DHL (INTFDHL)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 00H                       |
|                        |                                       | External interrupt falling edge specification register DHH (INTFDHH)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 00H                       |
|                        |                                       | External interrupt rising edge specification register n (INTRn) (n = 1, AL)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 03H                       |
|                        |                                       | External interrupt rising edge specification register 2 (INTR2)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 3FH                       |
|                        |                                       | External interrupt rising edge specification register 5 (INTR5)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 07H                       |
|                        |                                       | External interrupt rising edge specification register 6 (INTR6)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | E0H                       |
|                        |                                       | External interrupt rising edge specification register DH (INTRDH)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | FFFFH                     |
|                        |                                       | External interrupt rising edge specification register DHL (INTRDHL)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | FFH                       |
|                        |                                       | External interrupt rising edge specification register DHH (INTRDHH)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | FFH                       |
|                        |                                       | Valid edge select register Cn (SESCn) (n = 0 to 3)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 00H                       |
|                        |                                       | Valid edge select register 1n (SESA1n) (n = 0, 1)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 00H                       |

**Table 15-2. Initial Value of CPU, Internal Data RAM, Internal Instruction RAM, and On-Chip Peripheral I/O After Reset (3/6)**

| Internal Hardware      |                                      | Register Name                                                    | Initial Value After Reset |
|------------------------|--------------------------------------|------------------------------------------------------------------|---------------------------|
| On-chip peripheral I/O | Clock generation functions           | Clock control register (CKC)                                     | 03H                       |
|                        |                                      | Clock source select register (CKS)                               | 00H                       |
|                        |                                      | SSCG control register (SSCGC)                                    | See 8.3.3                 |
|                        |                                      | USB clock control register (UCKC)                                | 00H                       |
|                        |                                      | Lock register (LOCKR)                                            | 01H                       |
|                        |                                      | Oscillation stabilization time select register (OSTS)            | 04H                       |
|                        |                                      | Power-save mode register (PSMR)                                  | 00H                       |
|                        |                                      | Power-save control register (PSC)                                | 00H                       |
|                        | System control                       | Command register (PRCMD)                                         | Undefined                 |
|                        | Timer/counter functions (timer C)    | Timer Cn (TMCn) (n = 0 to 5)                                     | 0000H                     |
|                        |                                      | Capture/compare registers Cn0, Cn1 (CCn0, CCn1) (n = 0 to 5)     | 0000H                     |
|                        |                                      | Timer mode control register Cn0 (TMCCn0) (n = 0 to 5)            | 00H                       |
|                        |                                      | Timer mode control register Cn1 (TMCCn1) (n = 0 to 5)            | 20H                       |
|                        |                                      | Valid edge select register Cn (SESCn) (n = 0 to 3)               | 00H                       |
|                        |                                      | Noise elimination width setting register Cn (NCWCn) (n = 0 to 3) | 02H                       |
|                        | Timer/counter functions (timer D)    | Timer Dn (TMDn) (n = 0 to 3)                                     | 0000H                     |
|                        |                                      | Compare register Dn (CMDn) (n = 0 to 3)                          | 0000H                     |
|                        |                                      | Timer mode control register Dn (n = 0 to 3)                      | 00H                       |
|                        | Timer/counter functions (timer ENC1) | Timer ENC1n (TMENC1n) (n = 0, 1)                                 | 0000H                     |
|                        |                                      | Compare register 1n (CM1n) (n = 00, 01, 10, 11)                  | 0000H                     |
|                        |                                      | Capture/compare register 1n (CC1n) (n = 00, 01, 10, 11)          | 0000H                     |
|                        |                                      | Timer unit mode register 1n (TUM1n) (n = 0, 1)                   | 00H                       |
|                        |                                      | Timer control register 1n (TMC1n) (n = 0, 1)                     | 00H                       |
|                        |                                      | Capture/compare control register 1n (CCR1n) (n = 0, 1)           | 00H                       |
|                        |                                      | Valid edge select register 1n (SESA1n) (n = 0, 1)                | 00H                       |
|                        |                                      | Prescaler mode register 1n (PRM1n) (n = 0, 1)                    | 07H                       |
|                        |                                      | Status register 1n (STATUS1n) (n = 0, 1)                         | 00H                       |
|                        |                                      | Noise elimination width setting register 1n (NCW1n) (n = 0, 1)   | 02H                       |
|                        | Serial interface functions (USBF)    | UF0 EP0NAK register (UF0E0N)                                     | 00H                       |
|                        |                                      | UF0 EP0NAKALL register (UF0E0NA)                                 | 00H                       |
|                        |                                      | UF0 EPNAK register (UF0EN)                                       | 00H                       |
|                        |                                      | UF0 EPNAK mask register (UF0ENM)                                 | 00H                       |
|                        |                                      | UF0 SNDSIE register (UF0SDS)                                     | 00H                       |
|                        |                                      | UF0 CLR request register (UF0CLR)                                | 00H                       |
|                        |                                      | UF0 SET request register (UF0SET)                                | 00H                       |
|                        |                                      | UF0 EP status n register (UF0EPSn) (n = 0 to 2)                  | 00H                       |
|                        |                                      | UF0 INT status n register (UF0ISn) (n = 0 to 4)                  | 00H                       |
|                        |                                      | UF0 INT mask n register (UF0IMn) (n = 0 to 4)                    | 00H                       |
|                        |                                      | UF0 INT clear n register (UF0ICn) (n = 0 to 4)                   | FFH                       |
|                        |                                      | UF0 INT & DMARQ register (UF0IDR)                                | 00H                       |
|                        |                                      | UF0 DMA status n register (UF0DMSn) (n = 0, 1)                   | 00H                       |
|                        |                                      | UF0 FIFO clear n register (UF0FICn) (n = 0, 1)                   | 00H                       |

**Table 15-2. Initial Value of CPU, Internal Data RAM, Internal Instruction RAM, and On-Chip Peripheral I/O After Reset (4/6)**

| Internal Hardware      |                                    | Register Name                                                                       | Initial Value After Reset |
|------------------------|------------------------------------|-------------------------------------------------------------------------------------|---------------------------|
| On-chip peripheral I/O | Serial interface functions (USBF)  | UF0 data end register (UF0DEND)                                                     | 00H                       |
|                        |                                    | UF0 GPR register (UF0GPR)                                                           | 00H                       |
|                        |                                    | UF0 mode control register (UF0MODC)                                                 | 00H                       |
|                        |                                    | UF0 mode status register (UF0MODS)                                                  | 00H                       |
|                        |                                    | UF0 active interface number register (UF0AIFN)                                      | 00H                       |
|                        |                                    | UF0 active alternative setting register (UF0AAS)                                    | 00H                       |
|                        |                                    | UF0 alternative setting status register (UF0ASS)                                    | 00H                       |
|                        |                                    | UF0 endpoint n interface mapping register (UF0EnIM) (n = 1 to 4, 7, 8)              | 00H                       |
|                        |                                    | UF0 EP0 read register (UF0E0R)                                                      | Undefined                 |
|                        |                                    | UF0 EP0 length register (UF0E0L)                                                    | 00H                       |
|                        |                                    | UF0 EP0 setup register (UF0E0ST)                                                    | 00H                       |
|                        |                                    | UF0 EP0 write register (UF0E0W)                                                     | Undefined                 |
|                        |                                    | UF0 bulk out n register (UF0BOn) (n = 1, 2)                                         | Undefined                 |
|                        |                                    | UF0 bulk out n length register (UF0BO1L) (n = 1, 2)                                 | 00H                       |
|                        |                                    | UF0 bulk in n register (UF0BI n) (n = 1, 2)                                         | Undefined                 |
|                        |                                    | UF0 interrupt n register (UF0INTn) (n = 1, 2)                                       | Undefined                 |
|                        |                                    | UF0 device status register L (UF0DSTL)                                              | 00H                       |
|                        |                                    | UF0 EPn status register L (UF0EnSL) (n = 0 to 4, 7, 8)                              | 00H                       |
|                        |                                    | UF0 address register (UF0ADRS)                                                      | 00H                       |
|                        |                                    | UF0 configuration register (UF0CNF)                                                 | 00H                       |
|                        |                                    | UF0 interface n register (UF0IFn) (n = 0 to 4)                                      | 00H                       |
|                        |                                    | UF0 descriptor length register (UF0DSCL)                                            | 00H                       |
|                        |                                    | UF0 device descriptor register n (UF0DDn) (n = 0 to 17)                             | 00H                       |
|                        |                                    | UF0 configuration/interface/endpoint descriptor register n (UF0CIEn) (n = 0 to 255) | Undefined                 |
|                        |                                    | USB function 0 DMA channel select register (UF0CS)                                  | 0000H                     |
|                        |                                    | USB function 0 buffer control register (UF0BC)                                      | 00H                       |
|                        | Serial interface functions (UARTB) | UARTBn control register 0 (UBnCTL0) (n = 0, 1)                                      | 10H                       |
|                        |                                    | UARTBn control register 2 (UBnCTL2) (n = 0, 1)                                      | FFFFH                     |
|                        |                                    | UARTBn status register (UBnSTR) (n = 0, 1)                                          | 00H                       |
|                        |                                    | UARTBn transmit data register (UBnTX) (n = 0, 1)                                    | FFH                       |
|                        |                                    | UARTBn receive data register AP (UBnRXAP) (n = 0, 1)                                | 00FFH                     |
|                        |                                    | UARTBn receive data register (UBnRX) (n = 0, 1)                                     | FFH                       |
|                        |                                    | UARTBn FIFO control register 0 (UBnFIC0) (n = 0, 1)                                 | 00H                       |
|                        |                                    | UARTBn FIFO control register 1 (UBnFIC1) (n = 0, 1)                                 | 00H                       |
|                        |                                    | UARTBn FIFO control register 2 (UBnFIC2) (n = 0, 1)                                 | 0000H                     |
|                        |                                    | UARTBn FIFO control register 2L (UBnFIC2L) (n = 0, 1)                               | 00H                       |
|                        |                                    | UARTBn FIFO control register 2H (UBnFIC2H) (n = 0, 1)                               | 00H                       |
|                        |                                    | UARTBn FIFO status register 0 (UBnFIS0) (n = 0, 1)                                  | 00H                       |
|                        |                                    | UARTBn FIFO status register 1 (UBnFIS1) (n = 0, 1)                                  | 10H                       |

**Table 15-2. Initial Value of CPU, Internal Data RAM, Internal Instruction RAM, and On-Chip Peripheral I/O After Reset (5/6)**

| Internal Hardware      |                                   | Register Name                                                         | Initial Value After Reset |
|------------------------|-----------------------------------|-----------------------------------------------------------------------|---------------------------|
| On-chip peripheral I/O | Serial interface functions (CSI3) | Clocked serial interface mode register 3n (CSIM3n) (n = 0, 1)         | 00H                       |
|                        |                                   | Clocked serial interface clock select register 3n (CSIC3n) (n = 0, 1) | 07H                       |
|                        |                                   | Receive data buffer register 3n (SIRB3n) (n = 0, 1)                   | 0000H                     |
|                        |                                   | Receive data buffer register 3nL (SIRB3nL) (n = 0, 1)                 | 00H                       |
|                        |                                   | Receive data buffer register 3nH (SIRB3nH) (n = 0, 1)                 | 00H                       |
|                        |                                   | Transmit data CSI buffer register 3n (SFDB3n)                         | 0000H                     |
|                        |                                   | Transmit data CSI buffer register 3nL (SFDB3nL)                       | 00H                       |
|                        |                                   | Transmit data CSI buffer register 3nH (SFDB3nH)                       | 00H                       |
|                        |                                   | CSIBUF status register 3n (SFA3n) (n = 0, 1)                          | 20H                       |
|                        |                                   | Transfer data length select register 3n (CSIL3n) (n = 0, 1)           | 00H                       |
|                        |                                   | Transfer data number specification register 3n (SFN3n) (n = 0, 1)     | 00H                       |
|                        | A/D converter                     | A/D converter mode register n (ADMn) (n = 0 to 2)                     | 00H                       |
|                        |                                   | ADC trigger select register (ADTS)                                    | 00H                       |
|                        |                                   | A/D conversion result register n (ADCRn) (10 bits) (n = 0 to 7)       | Undefined                 |
|                        |                                   | A/D conversion result register nH (ADCRnH) (8 bits) (n = 0 to 7)      | Undefined                 |
|                        | PWM                               | PWM control register n (PWMCn) (n = 0, 1)                             | 08H                       |
|                        |                                   | PWM modulo register n (PWMn) (n = 0, 1)                               | 0000H                     |
|                        |                                   | PWM modulo register Ln (PWMLn) (n = 0, 1)                             | 00H                       |
|                        |                                   | PWM modulo register Hn (PWHn) (n = 0, 1)                              | 00H                       |
|                        | Port functions                    | Ports (P1, P2, P5 to P7, PCS, PCT, PCM, PCD)                          | Undefined                 |
|                        |                                   | Port (PAL)                                                            | Undefined                 |
|                        |                                   | Port (PALL)                                                           | Undefined                 |
|                        |                                   | Port (PALH)                                                           | Undefined                 |
|                        |                                   | Port (PAH)                                                            | Undefined                 |
|                        |                                   | Port (PAHL)                                                           | Undefined                 |
|                        |                                   | Port (PAHH)                                                           | Undefined                 |
|                        |                                   | Port (PDH)                                                            | Undefined                 |
|                        |                                   | Port (PDHL)                                                           | Undefined                 |
|                        |                                   | Port (PDHH)                                                           | Undefined                 |
|                        |                                   | Mode register (PM1, PM2, PM5 to PM7, PMCS, PMCT, PMCM, PMCD)          | FFH                       |
|                        |                                   | Mode register (PMAL)                                                  | FFFFH                     |
|                        |                                   | Mode register (PMALL)                                                 | FFH                       |
|                        |                                   | Mode register (PMALH)                                                 | FFH                       |
|                        |                                   | Mode register (PMAH)                                                  | FFFFH                     |
|                        |                                   | Mode register (PMAHL)                                                 | FFH                       |
|                        |                                   | Mode register (PMAHH)                                                 | FFH                       |
|                        |                                   | Mode register (PMDH)                                                  | FFFFH                     |
|                        |                                   | Mode register (PMDHL)                                                 | FFH                       |
|                        |                                   | Mode register (PMDHH)                                                 | FFH                       |
|                        |                                   | Mode control register (PMC1, PMC5 to PMC7)                            | 00H                       |
|                        |                                   | Mode control register (PMC2)                                          | 01H                       |
|                        |                                   | Mode control register (PMCCS)                                         | FFH                       |



**Table 15-2. Initial Value of CPU, Internal Data RAM, Internal Instruction RAM, and On-Chip Peripheral I/O After Reset (6/6)**

| Internal Hardware      |                | Register Name                                                                            | Initial Value After Reset |
|------------------------|----------------|------------------------------------------------------------------------------------------|---------------------------|
| On-chip peripheral I/O | Port functions | Mode control register (PMCCT)                                                            | BFH                       |
|                        |                | Mode control register (PMCCM)                                                            | 3DH                       |
|                        |                | Mode control register (PMCCD)                                                            | 0FH                       |
|                        |                | Mode control register (PMCAL)                                                            | 0002H                     |
|                        |                | Mode control register (PMCALL)                                                           | 02H                       |
|                        |                | Mode control register (PMCALH)                                                           | 00H                       |
|                        |                | Mode control register (PMCAH)                                                            | 03FFH                     |
|                        |                | Mode control register (PMCAHL)                                                           | FFH                       |
|                        |                | Mode control register (PMCAHH)                                                           | 03H                       |
|                        |                | Mode control register (PMCDH)                                                            | 0000H                     |
|                        |                | Mode control register (PMCDHL)                                                           | 00H                       |
|                        |                | Mode control register (PMCDHH)                                                           | 00H                       |
|                        |                | Function control registers (PFC1, PFC2, PFC5 to PFC7, PFCCS, PFCCT, PFCCM)               | 00H                       |
|                        |                | Function control register L (PFCALL)                                                     | 03H                       |
|                        |                | Function control register (PFCDH)                                                        | 0000H                     |
|                        |                | Function control register (PFCDHL)                                                       | 00H                       |
|                        |                | Function control register (PFCDHH)                                                       | 00H                       |
|                        |                | External interrupt falling edge specification register n (INTFn)<br>(n = 1, 2, 5, 6, AL) | 00H                       |
|                        |                | External interrupt falling edge specification register DH (INTFDH)                       | 0000H                     |
|                        |                | External interrupt falling edge specification register DHL (INTFDHL)                     | 00H                       |
|                        |                | External interrupt falling edge specification register DHH (INTFDHH)                     | 00H                       |
|                        |                | External interrupt rising edge specification register n (INTRn)<br>(n = 1, AL)           | 03H                       |
|                        |                | External interrupt rising edge specification register 2 (INTR2)                          | 3FH                       |
|                        |                | External interrupt rising edge specification register 5 (INTR5)                          | 07H                       |
|                        |                | External interrupt rising edge specification register 6 (INTR6)                          | E0H                       |
|                        |                | External interrupt rising edge specification register DH (INTRDH)                        | FFFFH                     |
|                        |                | External interrupt rising edge specification register DHL (INTRDHL)                      | FFH                       |
|                        |                | External interrupt rising edge specification register DHH (INTRDHH)                      | FFH                       |
|                        |                | Noise elimination width setting register Cn (NCWCn) (n = 0 to 3)                         | 02H                       |
|                        |                | Noise elimination width setting register 1n (NCW1n) (n = 0, 1)                           | 02H                       |

**Caution** “Undefined” in the above table is undefined after power-on-reset, or undefined as a result of data destruction when  $\overline{\text{RESET}}\downarrow$  is input and the data write timing has been synchronized.  
For other  $\overline{\text{RESET}}\downarrow$  signals, data is held in the same state it was in before the  $\overline{\text{RESET}}$  operation.

## CHAPTER 16 DEBUG FUNCTION (DCU)

The debug control unit (DCU) consists of three function units: an execution control unit (RCU) that realizes communication with JTAG and execution of debug processing, a trace control unit (TRCU) that implements trace functions, and a trigger event unit (TEU) that implements event detection functions. On-chip debugging of the V850E/ME2 can be executed by connecting an on-chip debug emulator.

**Caution** The debug function is supported by the V850E/ME2, but whether this function can be used or not depends on the debugger used.

### 16.1 Functional Outline

#### 16.1.1 Debug function

##### (1) Debug interface

This interface establishes communication with the host machine by using the  $\overline{\text{DRST}}$ , DCK, DMS, DDI, and DDO signals, via an on-chip debug emulator. The communication specifications of JTAG are used for this interface. It does not support a boundary scan function.

##### (2) On-chip debugging

On-chip debugging can be performed if wiring and connectors for debugging are provided on the target system.

Connect an on-chip debug emulator to the connector for debugging.

##### (3) Forced reset function

The V850E/ME2 can be forcibly reset.

##### (4) Forced break function

Execution of the user program can be forcibly stopped (however, the handler of the illegal instruction code exception (first address: 00000060H) cannot be used).

##### (5) Debug monitor function

During debugging, a memory space for debugging, different from the user memory space, is used (background monitor format). The user program can be executed starting from any address.

While execution of the user program is stopped, the user resources (such as memory and I/O) can be read/written, and the user program can be downloaded.

##### (6) Mask function

(a) NMI and all maskable interrupt request signals can be masked.

(b) When the debugger is connected, the  $\overline{\text{RESET}}$  pin input on the target board is masked by default (the  $\overline{\text{RESET}}$  pin input is masked when the debugger is started after power application to the V850E/ME2).

The  $\overline{\text{RESET}}$  pin input can be unmasked from the debugger. If a signal is input to the  $\overline{\text{RESET}}$  pin during debugging (during RUN execution), however, the following problems may occur.

- The break function may malfunction. If this happens, restart.
- Trace data may be illegal before and after  $\overline{\text{RESET}}$  pin input. Recovery will occur after the  $\overline{\text{RESET}}$  signal has been released.

### 16.1.2 Trace function

#### (1) PC trace (branch trace) function

All branches (transition of processing) that occur during user program execution can be traced.

The trace sources can be selected from 12 types of branch sources that are classified by function, and PC trace can be started from execution of an instruction at any address, and the trace source can be changed.

Two trace start triggers are available.

#### (2) Data trace function

A data access issued by the CPU to any address can be traced in a range of 1 KB to 4 bytes.

Read or written data can be traced, and two data trace points are available.

However, a data access issued by the DMAC cannot be traced.

#### (3) Real-time trace mode

Branch and data access can be traced during real-time execution of the user program.

The trace packet of the trace source detected is stored in a trace buffer, and output from trace interface pins (TRCCLK, TRCDATA0 to TRCDATA3, and TRCEND) (some trace packets may not be traced if no more trace packets can be stored in the trace buffer).

#### (4) Full trace mode (non-real-time trace mode)

All branches and data accesses of the user program can be traced.

In the full trace mode, the pipeline of the CPU is temporarily held and instruction execution is stopped to secure the time of trace data output from trace interface pins, so that all trace packets can be correctly traced.

### 16.1.3 Event function

#### (1) Instruction event detection function

Event detection (10 events) via size comparison by the execution PC and range event detection (up to four pairs with each pair consisting of two events) of the execution PC can be executed.

If an instruction event source is used as a break source, two breakpoints before execution of the instruction at which an event is detected and eight breakpoints after instruction execution can be detected.

#### (2) Access event detection function

Events can be detected as follows.

- Comparison of access addresses (4 addresses)
- Range of access address (up to two pairs with each pair consisting of two addresses)
- Match or mismatch of access data
- Data of specific bit by masking data
- Access size

An access event source is detected after access. If an access event source is used as a break source, a break occurs after several instructions have been executed after the instruction that issued the access that caused event detection.

#### (3) Sequential event detection function

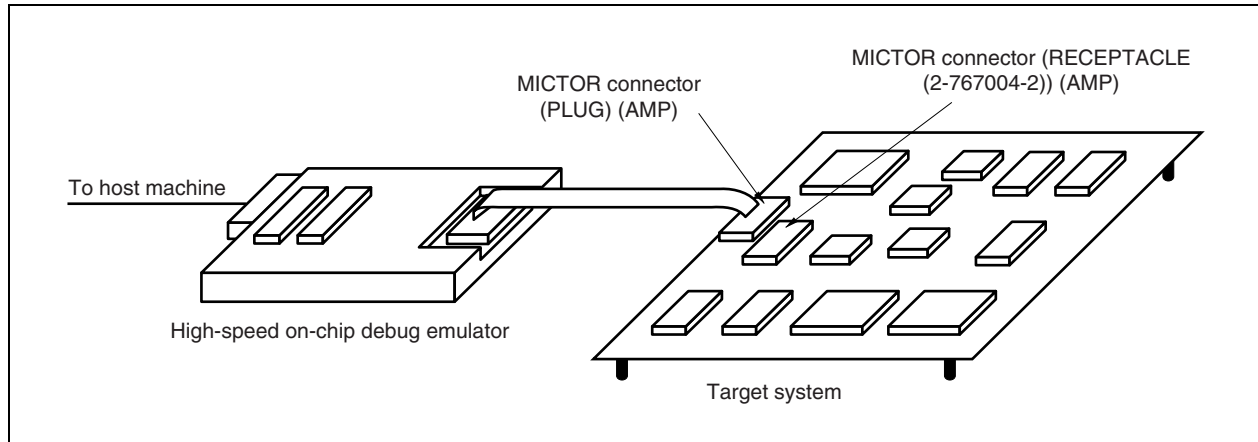
An event can be detected when up to four stages of events have successively occurred or an event that clears successive occurrence of events can be detected.

Sequential events can be counted by using a 12-bit pass counter.

## 16.2 Connection with On-Chip Debug Emulator

A connector for the emulator and a connection circuit must be provided on the target system.

**Figure 16-1. Connecting On-Chip Debug Emulator**



### 16.2.1 Emulator connector

The following table shows the pin functions of the emulator connector.

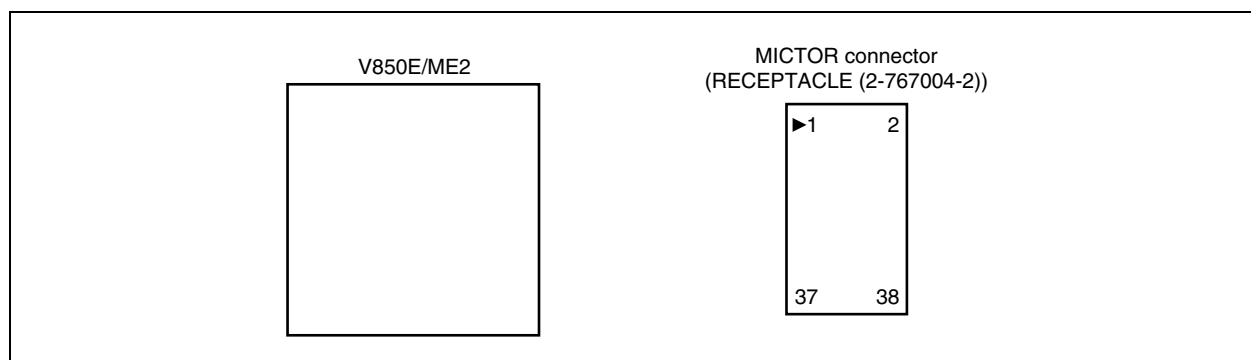
**Table 16-1. Emulator Connector Pin Function**

| Pin No. | Pin Name                 | I/O Direction        | Pin Function                                                           |
|---------|--------------------------|----------------------|------------------------------------------------------------------------|
| 1       | GND                      | –                    | –                                                                      |
| 2       | GND                      | –                    | –                                                                      |
| 3       | DCK                      | Emulator → V850E/ME2 | Clock for debug serial interface (Emulator → V850E/ME2)                |
| 4       | V <sub>DD</sub>          | –                    | +3.3 V (V850E/ME2 → Emulator) (for monitoring power to target)         |
| 5       | DMS                      | Emulator → V850E/ME2 | Transfer mode select for debug serial interface (Emulator → V850E/ME2) |
| 6       | $\overline{\text{DRST}}$ | Emulator → V850E/ME2 | DCU reset (Emulator → V850E/ME2)                                       |
| 7       | DDI                      | Emulator → V850E/ME2 | Data for debug serial interface (Emulator → V850E/ME2)                 |
| 8       | PORT0_OUT                | Emulator → V850E/ME2 | General-purpose control signal 0 (Emulator → V850E/ME2)                |
| 9       | DDO                      | V850E/ME2 → Emulator | Data for debug serial interface (V850E/ME2 → Emulator)                 |
| 10      | PORT1_OUT                | Emulator → V850E/ME2 | General-purpose control signal 1 (Emulator → V850E/ME2)                |
| 11      | (Reserved 1)             | –                    | (Leave this pin open)                                                  |
| 12      | PORT2_OUT                | Emulator → V850E/ME2 | General-purpose control signal 2 (Emulator → V850E/ME2)                |
| 13      | (Reserved 2)             | –                    | (Leave this pin open)                                                  |
| 14      | PORT0_IN                 | V850E/ME2 → Emulator | General-purpose control signal 0 (V850E/ME2 → Emulator)                |
| 15      | (Reserved 3)             | –                    | (Leave this pin open)                                                  |
| 16      | PORT1_IN                 | V850E/ME2 → Emulator | General-purpose control signal 1 (V850E/ME2 → Emulator)                |
| 17      | TRCCLK                   | V850E/ME2 → Emulator | Trace clock (V850E/ME2 → Emulator)                                     |
| 18      | PORT2_IN                 | V850E/ME2 → Emulator | General-purpose control signal 2 (V850E/ME2 → Emulator)                |
| 19      | TRCEND                   | V850E/ME2 → Emulator | Trace data end (V850E/ME2 → Emulator)                                  |
| 20      | TRCCE                    | V850E/ME2 → Emulator | Trace packet compression enable signal (V850E/ME2 → Emulator)          |
| 21      | TRCDATA0                 | V850E/ME2 → Emulator | Trace data 0 (V850E/ME2 → Emulator)                                    |
| 22      | TRCDATA8                 | V850E/ME2 → Emulator | Trace data 8 (V850E/ME2 → Emulator)                                    |
| 23      | TRCDATA1                 | V850E/ME2 → Emulator | Trace data 1 (V850E/ME2 → Emulator)                                    |
| 24      | TRCDATA9                 | V850E/ME2 → Emulator | Trace data 9 (V850E/ME2 → Emulator)                                    |
| 25      | TRCDATA2                 | V850E/ME2 → Emulator | Trace data 2 (V850E/ME2 → Emulator)                                    |
| 26      | TRCDATA10                | V850E/ME2 → Emulator | Trace data 10 (V850E/ME2 → Emulator)                                   |
| 27      | TRCDATA3                 | V850E/ME2 → Emulator | Trace data 3 (V850E/ME2 → Emulator)                                    |
| 28      | TRCDATA11                | V850E/ME2 → Emulator | Trace data 11 (V850E/ME2 → Emulator)                                   |
| 29      | TRCDATA4                 | V850E/ME2 → Emulator | Trace data 4 (V850E/ME2 → Emulator)                                    |
| 30      | TRCDATA12                | V850E/ME2 → Emulator | Trace data 12 (V850E/ME2 → Emulator)                                   |
| 31      | TRCDATA5                 | V850E/ME2 → Emulator | Trace data 5 (V850E/ME2 → Emulator)                                    |
| 32      | TRCDATA13                | V850E/ME2 → Emulator | Trace data 13 (V850E/ME2 → Emulator)                                   |
| 33      | TRCDATA6                 | V850E/ME2 → Emulator | Trace data 6 (V850E/ME2 → Emulator)                                    |
| 34      | TRCDATA14                | V850E/ME2 → Emulator | Trace data 14 (V850E/ME2 → Emulator)                                   |
| 35      | TRCDATA7                 | V850E/ME2 → Emulator | Trace data 7 (V850E/ME2 → Emulator)                                    |
| 36      | TRCDATA15                | V850E/ME2 → Emulator | Trace data 15 (V850E/ME2 → Emulator)                                   |
| 37      | GND                      | –                    | –                                                                      |
| 38      | GND                      | –                    | –                                                                      |

**Remark** Cautions are given on the next page.

- Cautions**
1. The connection of pins not supported by the V850E/ME2 depends on the emulator used.
  2. The pattern on the target board must satisfy the following conditions to support high-speed interfacing.

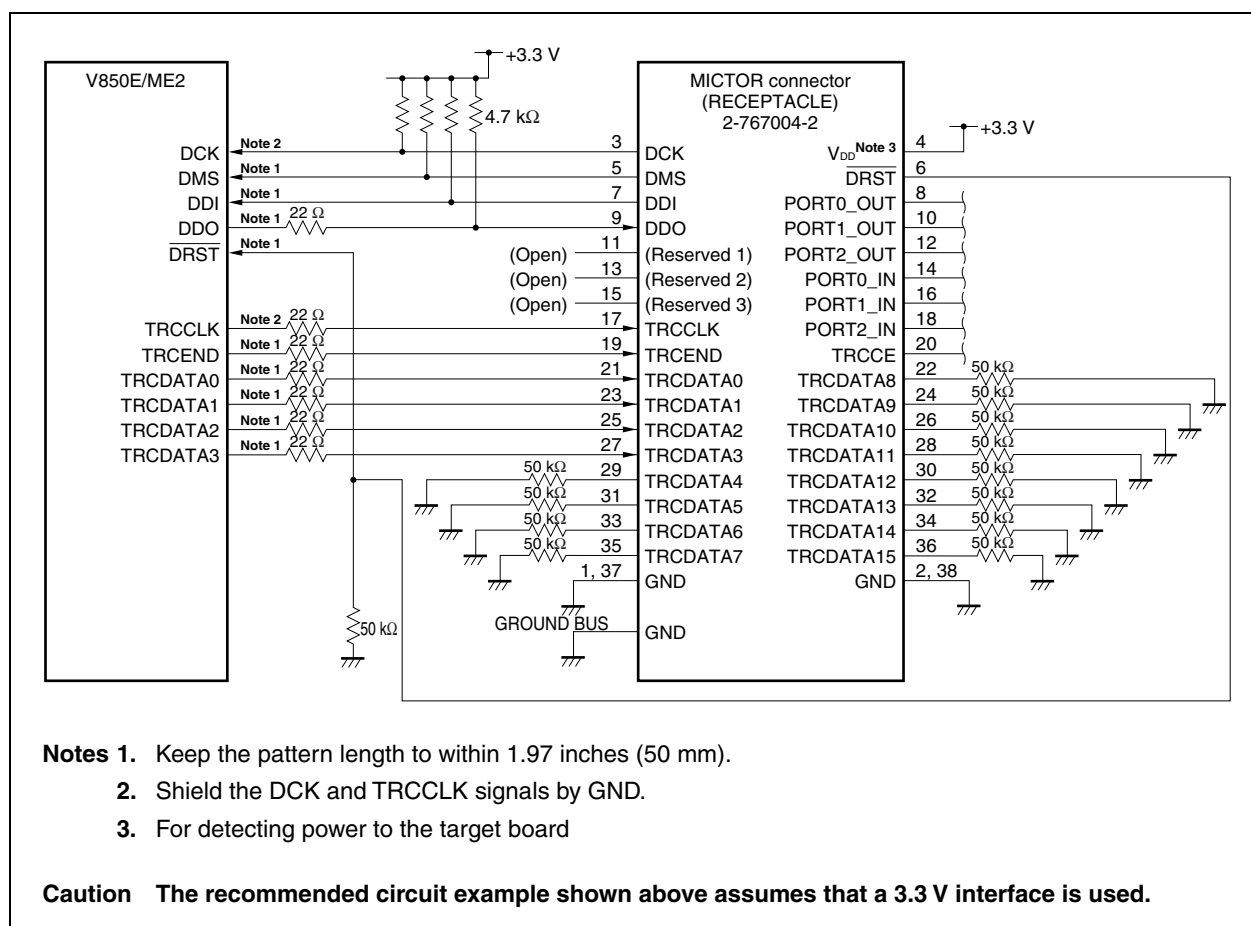
- Lay out the pattern with the odd pins facing the device (V850E/ME2).
- Keep the pattern length to within 1.97 inches (50 mm).
- Shield the clock signal with GND.



### 16.2.2 Recommended circuit example

The following figure shows an example of the recommended circuit of the emulator connector (on the target system side).

**Figure 16-2. Example of Recommended Emulator Connection Circuit**



## CHAPTER 17 ELECTRICAL SPECIFICATIONS

### Absolute Maximum Ratings (T<sub>A</sub> = 25°C)

| Parameter                             | Symbol             | Conditions                                                       | Ratings                                          | Unit |
|---------------------------------------|--------------------|------------------------------------------------------------------|--------------------------------------------------|------|
| Supply voltage                        | IV <sub>DD</sub>   | IV <sub>DD</sub> pin                                             | −0.5 to +2.0                                     | V    |
|                                       | IV <sub>SS</sub>   | IV <sub>SS</sub> pin                                             | −0.5 to +0.5                                     | V    |
|                                       | EV <sub>DD</sub>   | EV <sub>DD</sub> pin, EV <sub>DD</sub> ≥ IV <sub>DD</sub>        | −0.5 to +4.6                                     | V    |
|                                       | EV <sub>SS</sub>   | EV <sub>SS</sub> pin                                             | −0.5 to +0.5                                     | V    |
|                                       | OSCV <sub>DD</sub> | OSCV <sub>DD</sub> pin                                           | −0.5 to +4.6                                     | V    |
|                                       | OSCV <sub>SS</sub> | OSCV <sub>SS</sub> pin                                           | −0.5 to +0.5                                     | V    |
|                                       | PLLV <sub>DD</sub> | PLLV <sub>DD</sub> pin                                           | −0.5 to +2.0                                     | V    |
|                                       | PLLV <sub>SS</sub> | PLLV <sub>SS</sub> pin                                           | −0.5 to +0.5                                     | V    |
|                                       | UV <sub>DD</sub>   | UV <sub>DD</sub> pin                                             | −0.5 to +4.6                                     | V    |
|                                       | AV <sub>DD</sub>   | AV <sub>DD</sub> pin, AV <sub>DD</sub> < EV <sub>DD</sub> ±0.5 V | −0.5 to +4.6                                     | V    |
|                                       | AV <sub>SS</sub>   | AV <sub>SS</sub> pin                                             | −0.5 to +0.5                                     | V    |
| Input voltage                         | V <sub>I</sub>     | Except for X1 pin, V <sub>I</sub> < EV <sub>DD</sub> + 0.3 V     | −0.5 to +4.6                                     | V    |
| Clock input voltage                   | V <sub>K</sub>     | X1 pin                                                           | −0.5 to OSCV <sub>DD</sub> + 0.5 <sup>Note</sup> | V    |
| Output current, low                   | I <sub>OL</sub>    | Per pin                                                          | 4.0                                              | mA   |
|                                       |                    | Total of all pins                                                | 100                                              | mA   |
| Output current, high                  | I <sub>OH</sub>    | Per pin                                                          | −4.0                                             | mA   |
|                                       |                    | Total of all pins                                                | −100                                             | mA   |
| Output voltage                        | V <sub>O</sub>     | EV <sub>DD</sub> = 3.3 V ±0.3 V                                  | −0.5 to EV <sub>DD</sub> + 0.5 <sup>Note</sup>   | V    |
| Analog input voltage                  | V <sub>WASN</sub>  | ANI0 to ANI7 pins, AV <sub>DD</sub> = 3.3 V ±0.3 V               | −0.3 to AV <sub>DD</sub> + 0.3 <sup>Note</sup>   | V    |
| A/D converter reference input voltage | AV <sub>REFP</sub> |                                                                  | −0.3 to AV <sub>DD</sub> + 0.3 <sup>Note</sup>   | V    |
|                                       | AV <sub>REFM</sub> |                                                                  | −0.3 to +0.3                                     | V    |
| Operating ambient temperature         | T <sub>A</sub>     | 30 pF < output pin load capacitance ≤ 50 pF                      | −40 to +70                                       | °C   |
|                                       |                    | Output pin load capacitance ≤ 30 pF                              | −40 to +85                                       | °C   |
| Storage temperature                   | T <sub>stg</sub>   |                                                                  | −60 to +150                                      | °C   |

**Note** Be sure not to exceed the absolute maximum ratings (MAX. value) of each supply voltage.

- Cautions**
1. Do not directly connect the output (or I/O) pins of IC products to each other, or to IV<sub>DD</sub>, EV<sub>DD</sub>, and GND. Direct connection of the output pins between an IC product and an external circuit is possible, if the output pins can be set to the high-impedance state and the output timing of the external circuit is designed to avoid output conflict.
  2. Product quality may suffer if the absolute maximum rating is exceeded even momentarily for any parameter. That is, the absolute maximum ratings are rated values at which the product is on the verge of suffering physical damage, and therefore the product must be used under conditions that ensure that the absolute maximum ratings are not exceeded.  
The ratings and conditions indicated for DC Characteristics and AC Characteristics represent the quality assurance range during normal operation.

**Capacitance** ( $T_A = 25^\circ\text{C}$ ,  $IV_{DD} = IV_{SS} = EV_{DD} = EV_{SS} = OSCV_{DD} = OSCV_{SS} = PLLV_{DD} = PLLV_{SS} = UV_{DD} = AV_{DD} = AV_{SS} = 0\text{ V}$ )

| Parameter          | Symbol   | Conditions                                              | MIN. | TYP. | MAX. | Unit |
|--------------------|----------|---------------------------------------------------------|------|------|------|------|
| Input capacitance  | $C_i$    | $f_c = 1\text{ MHz}$<br>Unmeasured pins returned to 0 V |      |      | 15   | pF   |
| I/O capacitance    | $C_{io}$ |                                                         |      |      | 15   | pF   |
| Output capacitance | $C_o$    |                                                         |      |      | 15   | pF   |

### Operating Conditions

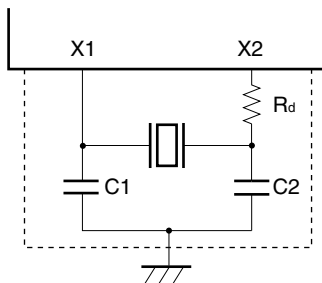
| Part Number                                                        | Internal Operation Clock Frequency ( $f_x$ ) | Operating Ambient Temperature ( $T_A$ )                                                | Supply Voltage ( $V_{DD}$ )                                                                                                                                                                                                                                                      |
|--------------------------------------------------------------------|----------------------------------------------|----------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| $\mu\text{PD7030111AGM-10-UEU}$                                    | 10 to 100 MHz                                | When external pin load capacitance $C_L = 50\text{ pF}$ , $-40$ to $+70^\circ\text{C}$ | $IV_{DD} = 1.5\text{ V} \pm 0.15\text{ V}$<br>$PLLV_{DD} = 1.5\text{ V} \pm 0.15\text{ V}$<br>$EV_{DD} = 3.3\text{ V} \pm 0.3\text{ V}$<br>$OSCV_{DD} = 3.3\text{ V} \pm 0.3\text{ V}$<br>$UV_{DD} = 3.3\text{ V} \pm 0.3\text{ V}$<br>$AV_{DD} = 3.3\text{ V} \pm 0.3\text{ V}$ |
|                                                                    |                                              | When external pin load capacitance $C_L = 30\text{ pF}$ , $-40$ to $+85^\circ\text{C}$ |                                                                                                                                                                                                                                                                                  |
| $\mu\text{PD7030111AGM-13-UEU}$<br>$\mu\text{PD7030111AF1-13-GA3}$ | 10 to 133 MHz                                | When external pin load capacitance $C_L = 50\text{ pF}$ , $-40$ to $+70^\circ\text{C}$ |                                                                                                                                                                                                                                                                                  |
|                                                                    |                                              | When external pin load capacitance $C_L = 30\text{ pF}$ , $-40$ to $+85^\circ\text{C}$ |                                                                                                                                                                                                                                                                                  |
| $\mu\text{PD7030111AGM-15-UEU}$<br>$\mu\text{PD7030111AF1-15-GA3}$ | 10 to 150 MHz                                | When external pin load capacitance $C_L = 50\text{ pF}$ , $-40$ to $+70^\circ\text{C}$ | $IV_{DD} = 1.4$ to $1.65\text{ V}$<br>$PLLV_{DD} = 1.4$ to $1.65\text{ V}$<br>$EV_{DD} = 3.3\text{ V} \pm 0.3\text{ V}$<br>$OSCV_{DD} = 3.3\text{ V} \pm 0.3\text{ V}$<br>$UV_{DD} = 3.3\text{ V} \pm 0.3\text{ V}$<br>$AV_{DD} = 3.3\text{ V} \pm 0.3\text{ V}$                 |



## Recommended Oscillator

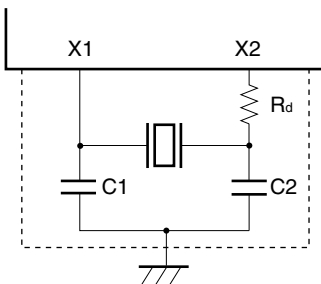
### (a) Ceramic resonator

#### (i) Murata Mfg. Co., Ltd. ( $T_A = -40$ to $+85^\circ\text{C}$ )



| Type             | Part Number     | Oscillation Frequency<br>$f_x$ (MHz) | Recommended Circuit Constant |         |                     | Oscillation Voltage Range |          | Oscillation Stabilization Time (MAX.)<br>$T_{OST}$ (ms) |
|------------------|-----------------|--------------------------------------|------------------------------|---------|---------------------|---------------------------|----------|---------------------------------------------------------|
|                  |                 |                                      | C1 (pF)                      | C2 (pF) | $R_d$ (k $\Omega$ ) | MIN. (V)                  | MAX. (V) |                                                         |
| Surface mounting | CSTCE10M0G55-R0 | 10.000                               | On-chip                      | On-chip | 0                   | 3.0                       | 3.6      | 0.07                                                    |
|                  | CSTCE12M5G55-R0 | 12.500                               | On-chip                      | On-chip | 0                   | 3.0                       | 3.6      | 0.08                                                    |
|                  | CSTCE16M6V53-R0 | 16.625                               | On-chip                      | On-chip | 0                   | 3.0                       | 3.6      | 0.04                                                    |
|                  | CSTCE18M0V53-R0 | 18.000                               | On-chip                      | On-chip | 0                   | 3.0                       | 3.6      | 0.03                                                    |
|                  | CSTCE18M7V53-R0 | 18.750                               | On-chip                      | On-chip | 0                   | 3.0                       | 3.6      | 0.03                                                    |

- Cautions**
1. Connect the oscillator as close as possible to the X1 and X2 pins.
  2. Do not route the wiring near broken lines.
  3. Sufficiently evaluate the matching between the  $\mu\text{PD703111A}$  and the resonator.

(ii) TDK ( $T_A = -40$  to  $+85^\circ\text{C}$ )

| Type             | Part Number | Oscillation Frequency<br>$f_x$ (MHz) | Recommended Circuit Constant |         |                     | Oscillation Voltage Range |          | Oscillation Stabilization Time (MAX.)<br>$T_{OST}$ (ms) |
|------------------|-------------|--------------------------------------|------------------------------|---------|---------------------|---------------------------|----------|---------------------------------------------------------|
|                  |             |                                      | C1 (pF)                      | C2 (pF) | $R_d$ (k $\Omega$ ) | MIN. (V)                  | MAX. (V) |                                                         |
| Lead             | FCR10.0MC5  | 10.0                                 | On-chip                      | On-chip | 0                   | 3.0                       | 3.6      | 0.076                                                   |
| Surface mounting | CCR18.0MXC7 | 18.0                                 | On-chip                      | On-chip | 0                   | 3.0                       | 3.6      | 0.9                                                     |

- Cautions**
1. Connect the oscillator as close as possible to the X1 and X2 pins.
  2. Do not route the wiring near broken lines.
  3. Sufficiently evaluate the matching between the  $\mu\text{PD703111A}$  and the resonator.

**DC Characteristics ( $T_A = -40$  to  $+85^\circ\text{C}$ ,  $E_{VDD} = 3.3\text{ V} \pm 0.3\text{ V}$ ,  $E_{VSS} = 0\text{ V}$ )**

| Parameter                                 | Symbol            | Conditions                                                           | MIN.                       | TYP.                        | MAX.                                          | Unit          |
|-------------------------------------------|-------------------|----------------------------------------------------------------------|----------------------------|-----------------------------|-----------------------------------------------|---------------|
| Input voltage, high                       | $V_{IH}$          | Except for <b>Notes 1, 2</b>                                         | 2.0                        |                             | $E_{VDD} + 0.3$                               | V             |
|                                           |                   | <b>Note 1</b>                                                        | $0.75E_{VDD}$              |                             | $E_{VDD} + 0.3$                               | V             |
|                                           |                   | <b>Note 2</b>                                                        | 2.0                        |                             | $UV_{DD} + 0.3$                               | V             |
| Input voltage, low                        | $V_{IL}$          | Except for <b>Notes 1, 2</b>                                         | -0.5                       |                             | 0.8                                           | V             |
|                                           |                   | <b>Note 1</b>                                                        | -0.5                       |                             | $0.2E_{VDD}$                                  | V             |
|                                           |                   | <b>Note 2</b>                                                        | -0.5                       |                             | 0.8                                           | V             |
| Schmitt-triggered input threshold voltage | $V_{T+}$          | <b>Note 1</b> , rising edge                                          |                            | 1.9                         |                                               | V             |
|                                           | $V_{T-}$          | <b>Note 1</b> , falling edge                                         |                            | 1.3                         |                                               | V             |
| Schmitt-triggered input hysteresis width  | $V_{T+} - V_{T-}$ | <b>Note 1</b>                                                        | 0.3                        | 0.6                         |                                               | V             |
| Output voltage, high                      | $V_{OH}$          | Except for <b>Note 2</b><br>$I_{OH} = -2.5\text{ mA}$                | $0.8E_{VDD}$               |                             |                                               | V             |
|                                           |                   | $I_{OH} = -100\text{ }\mu\text{A}$                                   | $E_{VDD} - 0.4$            |                             |                                               | V             |
|                                           |                   | <b>Note 2</b> , $R_L = 15\text{ k}\Omega$<br>( $E_{VSS}$ connection) | 2.8                        |                             |                                               | V             |
| Output voltage, low                       | $V_{OL}$          | Except for <b>Note 2</b> ,<br>$I_{OL} = 2.5\text{ mA}$               |                            |                             | 0.45                                          | V             |
|                                           |                   | <b>Note 2</b> , $R_L = 15\text{ k}\Omega$<br>( $UV_{DD}$ connection) |                            |                             | 0.3                                           | V             |
| Input leakage current, high               | $I_{LH}$          | $V_I = E_{VDD}$ , except for <b>Note 3</b>                           |                            |                             | 10                                            | $\mu\text{A}$ |
| Input leakage current, low                | $I_{LIL}$         | $V_I = 0\text{ V}$ , except for <b>Note 3</b>                        |                            |                             | -10                                           | $\mu\text{A}$ |
| Output leakage current, high              | $I_{LOH}$         | $V_O = E_{VDD}$                                                      |                            |                             | 10                                            | $\mu\text{A}$ |
| Output leakage current, low               | $I_{LOL}$         | $V_O = 0\text{ V}$                                                   |                            |                             | -10                                           | $\mu\text{A}$ |
| Analog pin input leakage current          | $I_{LWASN}$       | <b>Note 3</b>                                                        |                            |                             | $\pm 10$                                      | $\mu\text{A}$ |
| Supply current                            | Normal            | $I_{DD1}$                                                            | $IV_{DD} + PLLV_{DD}$ pins | $0.82 \times f_x + 10$      | $0.90 \times f_x + 117$                       | mA            |
|                                           |                   | $E_{VDD}$ pin <sup>Note 4</sup>                                      |                            | $0.33 \times F_{BUS} + 3.2$ | $0.66 \times F_{BUS} + 6.4$ <sup>Note 5</sup> | mA            |
|                                           | HALT              | $I_{DD2}$                                                            | $IV_{DD} + PLLV_{DD}$ pins | $0.82 \times f_x + 4$       | $0.85 \times f_x + 114$                       | mA            |
|                                           |                   | $E_{VDD}$ pin <sup>Note 4</sup>                                      |                            | $0.33 \times F_{BUS} + 3.2$ | $0.66 \times F_{BUS} + 6.4$ <sup>Note 5</sup> | mA            |
|                                           | IDLE              | $I_{DD3}$                                                            | $IV_{DD} + PLLV_{DD}$ pins | $0.015 \times f_x + 10$     |                                               | mA            |
|                                           |                   | $E_{VDD}$ pin <sup>Note 4</sup>                                      |                            | 500                         |                                               | $\mu\text{A}$ |
| STOP                                      | $I_{DD4}$         | $IV_{DD} + PLLV_{DD}$ pins                                           |                            | 4                           |                                               | mA            |
|                                           |                   | $E_{VDD}$ pin <sup>Note 4</sup>                                      |                            | 500                         |                                               | $\mu\text{A}$ |

**Notes 1.** P11/SCK0/INTP11, P12/RXD0/SI0, P20/NMI, P21/RXD1/INTP21, P23/SCK1/INTP23, P24/SI1/INTP24, PCM1, RESET

**2.** UDM, UDP

**3.** ANI0 to ANI7

**4.** Current value with no load

**5.** Calculate the current value with a load using the following expression.

$$\text{Current value per pin } (\mu\text{A}) = 3.63 \times C_L \times F$$

$C_L$ : Load capacitance (pF)  $F$ : Pin average operating frequency

**Remarks 1.** TYP. values are reference values for when  $T_A = 25^\circ\text{C}$ ,  $E_{VDD} = 3.3\text{ V}$ . The current that flows through pull-up resistors is not included.

**2.**  $f_x$ : Main clock frequency (MHz)

$F_{BUS}$ : BUSCLK frequency (MHz)

**AC Characteristics**

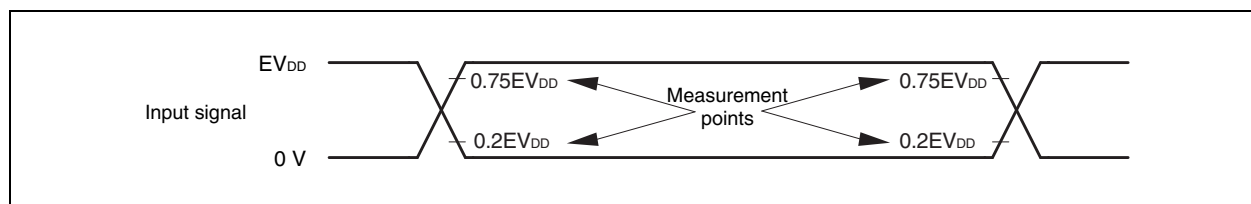
( $T_A = -40$  to  $+85^\circ\text{C}$ ,  $I_{VDD} = PLLV_{DD} = 1.5\text{ V} \pm 0.15\text{ V}^{\text{Note}}$ ,  $EV_{DD} = OSCV_{DD} = 3.3\text{ V} \pm 0.3\text{ V}$ ,  $IV_{SS} = EV_{SS} = PLLV_{SS} = OSCV_{SS} = 0\text{ V}$ , output pin load capacitance:  $C_L = 30\text{ pF}$ )

( $T_A = -40$  to  $+70^\circ\text{C}$ ,  $I_{VDD} = PLLV_{DD} = 1.5\text{ V} \pm 0.15\text{ V}^{\text{Note}}$ ,  $EV_{DD} = OSCV_{DD} = 3.3\text{ V} \pm 0.3\text{ V}$ ,  $IV_{SS} = EV_{SS} = PLLV_{SS} = OSCV_{SS} = 0\text{ V}$ , output pin load capacitance:  $C_L = 50\text{ pF}$ )

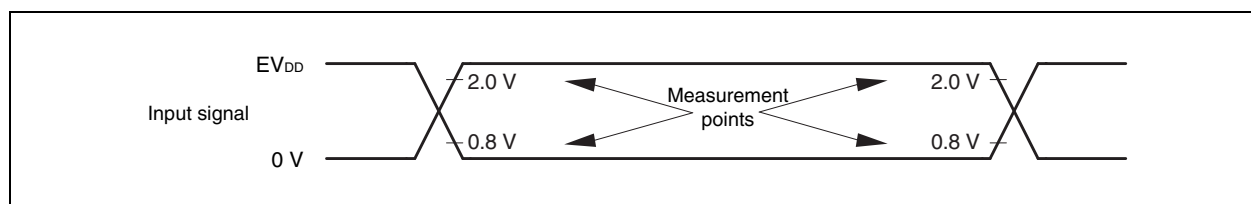
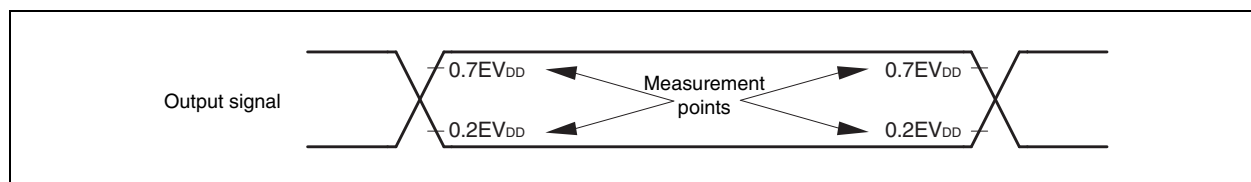
**Note** Consider the operation conditions when operating at 133.34 to 150 MHz.

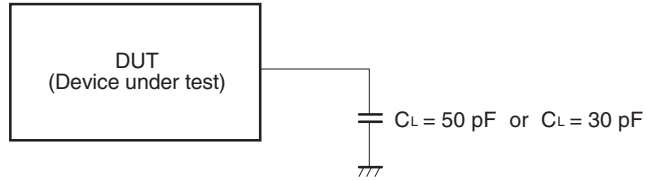
**AC test input measurement points**

- (a) P11/ $\overline{\text{SCK0}}/\overline{\text{INTP11}}$ , P12/RXD0/SIO, P20/NMI, P21/RXD1/ $\overline{\text{INTP21}}$ , P23/ $\overline{\text{SCK1}}/\overline{\text{INTP23}}$ , P24/SI1/ $\overline{\text{INTP24}}$ , PCM1,  $\overline{\text{RESET}}$



- (b) Other than (a)

**AC test output measurement points**

**Load conditions****Caution At –40 to +70°C:**

If the load capacitance exceeds 50 pF due to the circuit configuration, make the load capacitance of this device 50 pF or lower by inserting a buffer, etc.

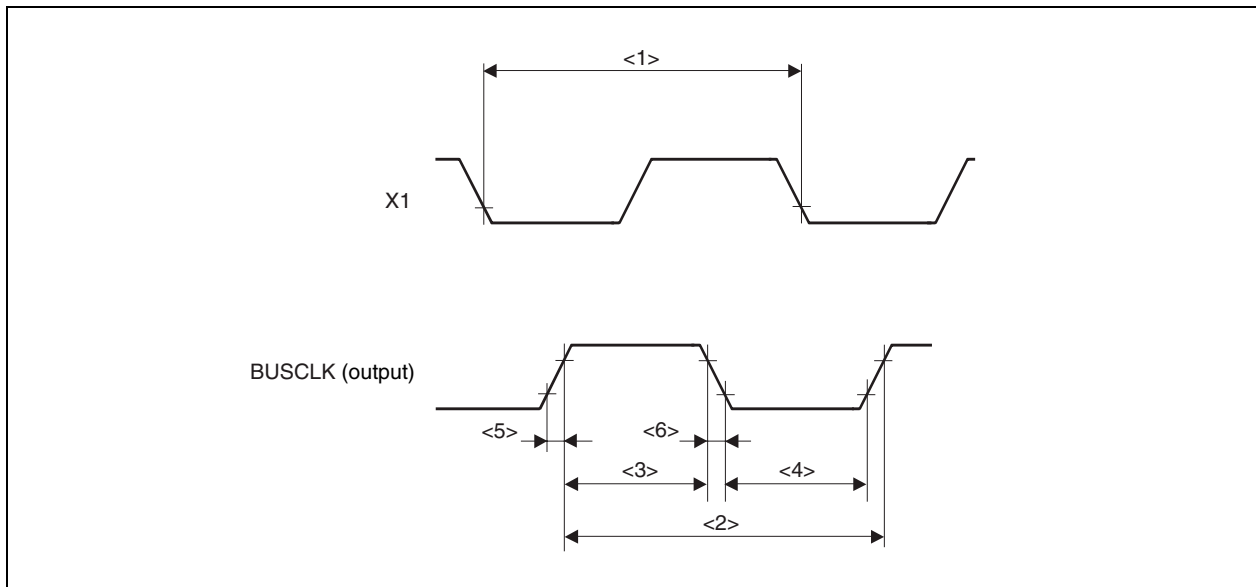
**At –40 to +85°C:**

If the load capacitance exceeds 30 pF due to the circuit configuration, make the load capacitance of this device 30 pF or lower by inserting a buffer, etc.

(1) Clock timing

| Parameter               | Symbol         | Conditions                                                                            | MIN.       | MAX.       | Unit |
|-------------------------|----------------|---------------------------------------------------------------------------------------|------------|------------|------|
| X1 input cycle          | <1> $t_{CYX}$  | Including resonator error                                                             | 52.5       | 100        | ns   |
| <R> BUSCLK output cycle | <2> $t_{CYK}$  | Output load capacitance $\leq 30$ pF,<br>$T_A = -40$ to $+85^\circ\text{C}$           | 14.3       | 40         | ns   |
|                         |                | $30$ pF < output load capacitance $\leq 50$ pF,<br>$T_A = -40$ to $+70^\circ\text{C}$ | 19.0       | 40         | ns   |
| BUSCLK high-level width | <3> $t_{WKH1}$ |                                                                                       | $0.5T - 2$ | $0.5T + 2$ | ns   |
| BUSCLK low-level width  | <4> $t_{WKL1}$ |                                                                                       | $0.5T - 2$ | $0.5T + 2$ | ns   |
| BUSCLK rise time        | <5> $t_{KR1}$  |                                                                                       |            | 3          | ns   |
| BUSCLK fall time        | <6> $t_{KF1}$  |                                                                                       |            | 3          | ns   |

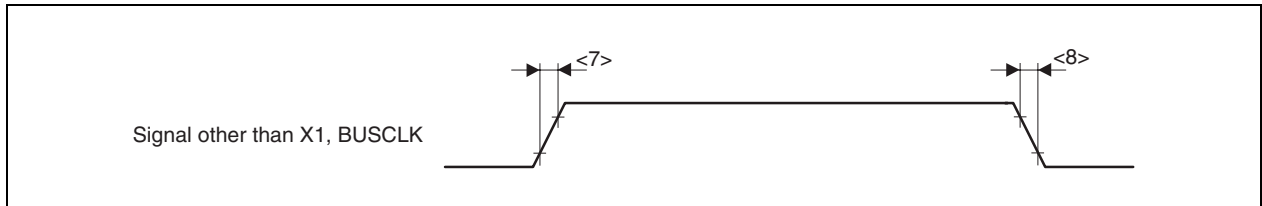
**Remark**  $T = t_{CYK}$



## (2) Output waveform (other than X1, BUSCLK)

| Parameter        | Symbol |          | Conditions             | MIN. | MAX. | Unit |
|------------------|--------|----------|------------------------|------|------|------|
| Output rise time | <7>    | $t_{OR}$ | Other than <b>Note</b> |      | 6    | ns   |
|                  |        |          | <b>Note</b>            |      | 8    | ns   |
| Output fall time | <8>    | $t_{OF}$ | Other than <b>Note</b> |      | 6    | ns   |
|                  |        |          | <b>Note</b>            |      | 8    | ns   |

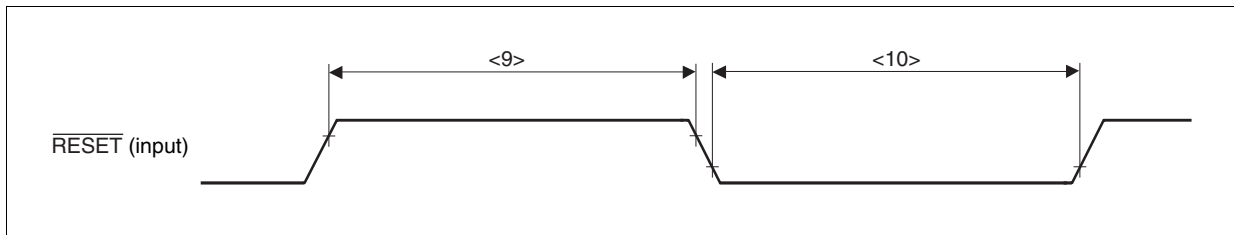
**Note** P10/UCLK/INTP10, P12/RXD0/SIO, P20/NMI, P21/RXD1/INTP21, P22/TXD1/INTP22, P24/SI1/INTP24, P50/DMARQ0/INTP50, P51/DMAAK0/INTP51, P52/TC0/INTP52, P53/DMARQ1/TIC0/INTPC00, P54/DMAAK1/INTPC01, P55/TC1/TOC0, P65/INTPC10/TIC1/INTP65, P66/INTPC11/INTP66, P67/TOC1/INTP67, P72/DMARQ2/INTPC20/TIC2, P73/DMAAK2/INTPC21, P74/TC2/TOC2, P75/DMARQ3/INTPC30/TIC3, P76/DMAAK3/INTPC31, P77/TC3/TOC3



## (3) Reset timing

| Parameter                  | Symbol |            | Conditions                                                                                                                                                                                             | MIN. | MAX. | Unit    |
|----------------------------|--------|------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|------|---------|
| RESET pin high-level width | <9>    | $t_{WRSH}$ |                                                                                                                                                                                                        | 500  |      | ns      |
| RESET pin low-level width  | <10>   | $t_{WRSL}$ | Including oscillation stabilization time at power on and STOP mode release. However, when the oscillation stabilization time exceeds 100 $\mu$ s, secure the necessary oscillation stabilization time. | 100  |      | $\mu$ s |
|                            |        |            | Excluding at power on and STOP mode release.                                                                                                                                                           | 100  |      | $\mu$ s |

**Caution** Sufficiently evaluate the oscillation stabilization time.



## (4) SRAM, external ROM, external I/O access timing

## (a) Access timing (SRAM, external ROM, external I/O) (1/2)

| Parameter                                                                                                           | Symbol           | Conditions | MIN. | MAX. | Unit |
|---------------------------------------------------------------------------------------------------------------------|------------------|------------|------|------|------|
| Address, $\overline{\text{CSn}}$ output delay time (from BUSCLK $\uparrow$ )                                        | <11> $t_{DKA}$   |            | 2    | 11   | ns   |
| Address, $\overline{\text{CSn}}$ output hold time (from BUSCLK $\uparrow$ )                                         | <12> $t_{HKA}$   |            | 2    | 11   | ns   |
| $\overline{\text{RD}}$ , $\overline{\text{IORD}}$ delay time (from BUSCLK $\downarrow$ )                            | <13> $t_{DKRDL}$ |            | 1    | 11   | ns   |
| $\overline{\text{RD}}$ , $\overline{\text{IORD}}$ delay time (from BUSCLK $\uparrow$ )                              | <14> $t_{DKRDH}$ |            | 2    | 11   | ns   |
| $\overline{\text{xxWR}}$ , $\overline{\text{IOWR}}$ , $\overline{\text{WR}}$ delay time (from BUSCLK $\downarrow$ ) | <15> $t_{DKWRL}$ |            | 2    | 11   | ns   |
| $\overline{\text{xxWR}}$ , $\overline{\text{IOWR}}$ , $\overline{\text{WR}}$ delay time (from BUSCLK $\uparrow$ )   | <16> $t_{DKWRH}$ |            | 1    | 11   | ns   |
| $\overline{\text{BCYST}}$ delay time (from BUSCLK $\uparrow$ )                                                      | <17> $t_{DKBSL}$ |            | 2    | 11   | ns   |
| $\overline{\text{BCYST}}$ delay time (from BUSCLK $\uparrow$ )                                                      | <18> $t_{DKBSH}$ |            | 2    | 11   | ns   |
| $\overline{\text{WAIT}}$ setup time (to BUSCLK $\uparrow$ )                                                         | <19> $t_{SWK}$   |            | 6    |      | ns   |
| $\overline{\text{WAIT}}$ hold time (from BUSCLK $\uparrow$ )                                                        | <20> $t_{HKW}$   |            | 2    |      | ns   |
| Data input setup time (to BUSCLK $\uparrow$ )                                                                       | <21> $t_{SKID}$  |            | 6    |      | ns   |
| Data input hold time (from BUSCLK $\uparrow$ )                                                                      | <22> $t_{HKID}$  |            | 2    |      | ns   |
| Data output delay time (from BUSCLK $\downarrow$ )                                                                  | <23> $t_{DKOD1}$ |            | 2    | 11   | ns   |
| Data float delay time (from BUSCLK $\uparrow$ )                                                                     | <24> $t_{HKOD}$  |            | 2    | 11   | ns   |

**Remarks** 1. Observe at least one of the data input hold times  $t_{HRDID}$  and  $t_{HKID}$ .

2.  $n = 0$  to 7

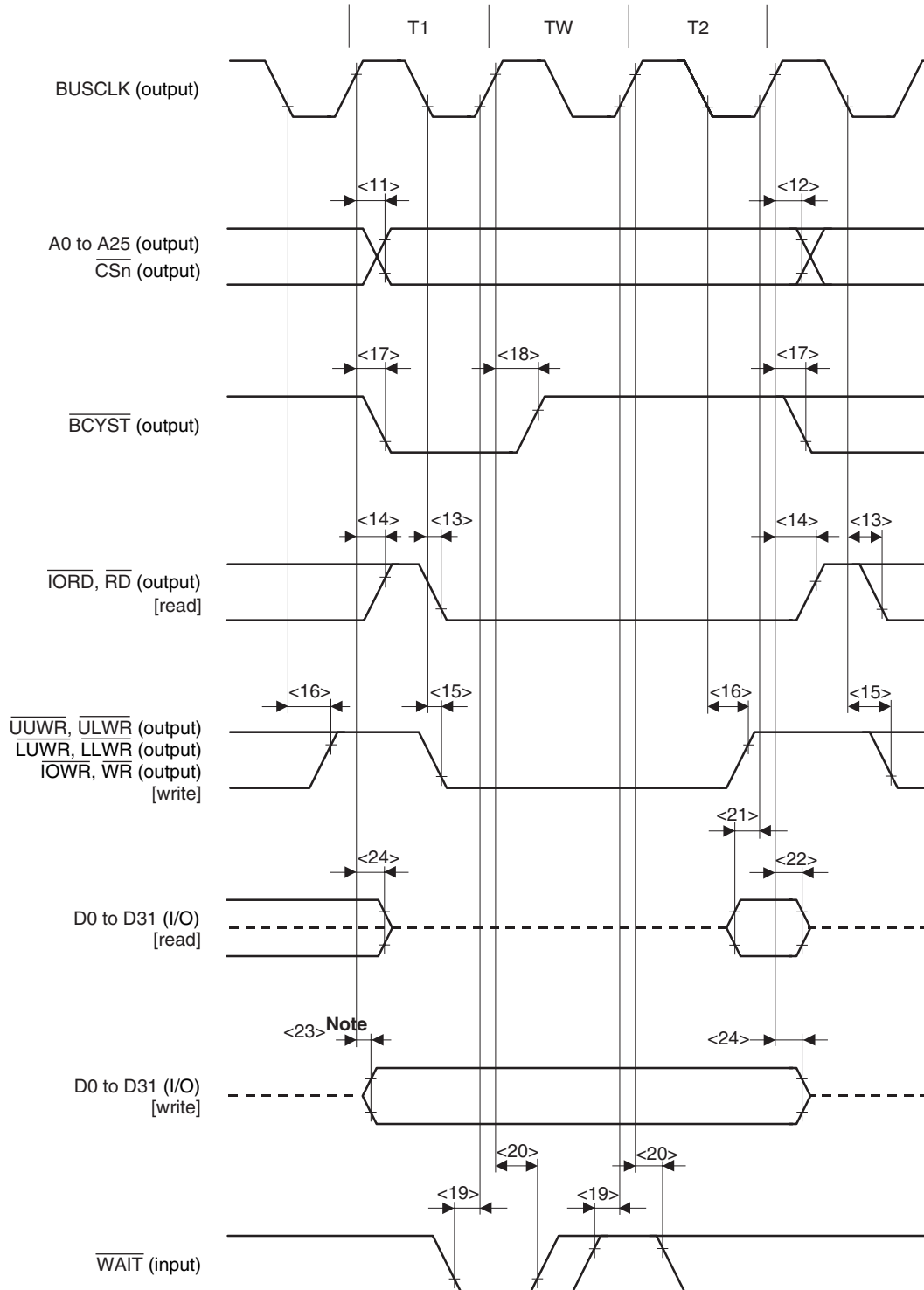
xx = UU, UL, LU, LL



(a) Access timing (SRAM, external ROM, external I/O) (2/2)

<R>

<R>



**Note** When a write cycle is executed without inserting a T0 state immediately after a read cycle, the data output timing is delayed by a half clock (in synchronization with the falling edge of BUSCLK).

**Remarks 1.** Timing when the number of waits set by the DWC0 and DWC1 registers is 0.

**2.** Broken lines indicate high impedance.

**3.** n = 0 to 7

**(b) Read timing (SRAM, external ROM, external I/O) (1/2)**

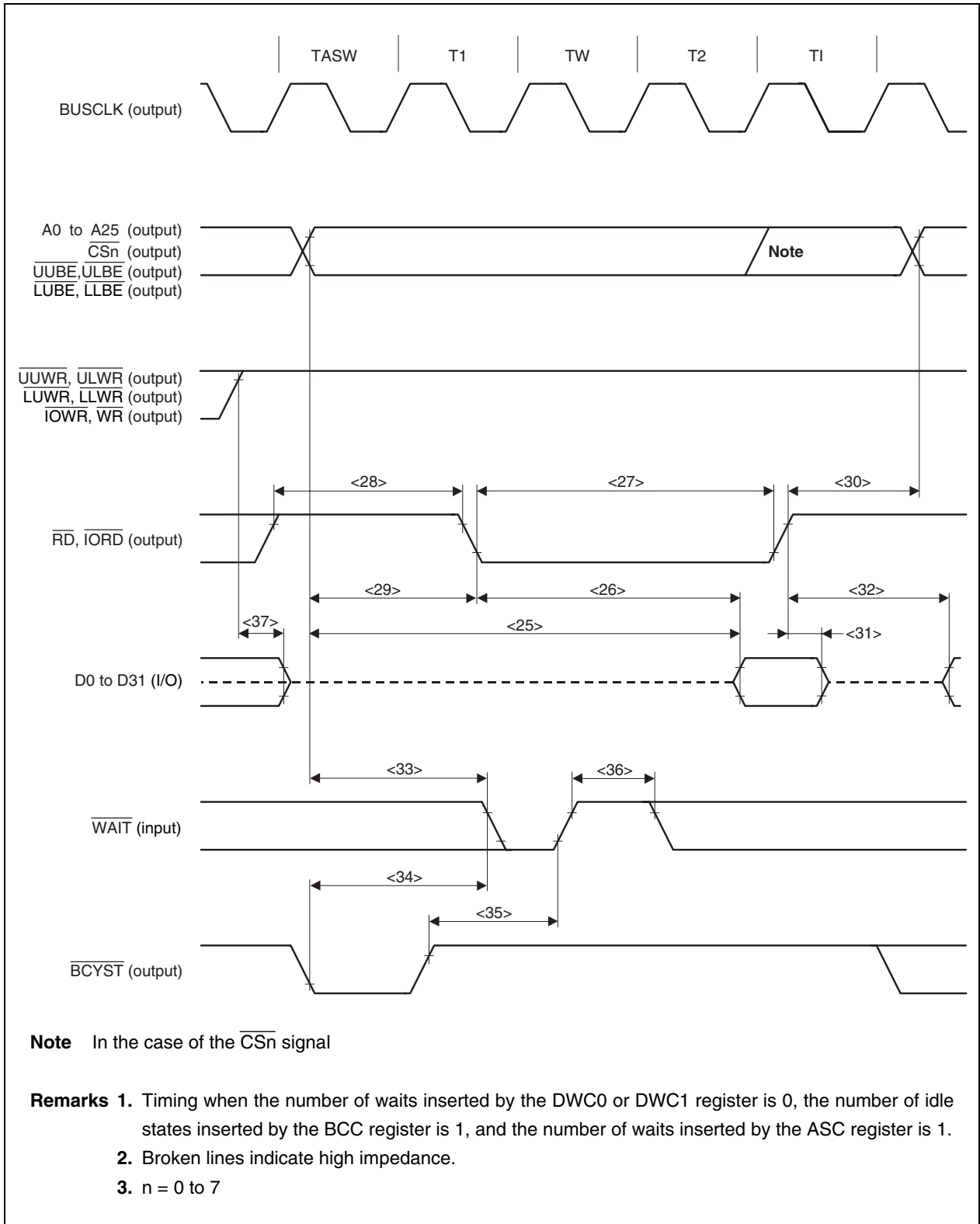
| Parameter                                                                                     | Symbol           | Conditions    | MIN.                       | MAX.                            | Unit |
|-----------------------------------------------------------------------------------------------|------------------|---------------|----------------------------|---------------------------------|------|
| Data input setup time (to address)                                                            | <25> $t_{SAID}$  |               |                            | $(2 + w + w_D + w_{AS}) T - 17$ | ns   |
| Data input setup time (to $\overline{RD}$ )                                                   | <26> $t_{SRDID}$ |               |                            | $(1.5 + w + w_D) T - 17$        | ns   |
| $\overline{RD}$ , $\overline{IORD}$ low-level width                                           | <27> $t_{WRDL}$  |               | $(1.5 + w + w_D) T - 6$    |                                 | ns   |
| $\overline{RD}$ , $\overline{IORD}$ high-level width                                          | <28> $t_{WRDH}$  |               | $(0.5 + w_{AS} + i) T - 6$ |                                 | ns   |
| Delay time from address, $\overline{CSn}$ to $\overline{RD}$ , $\overline{IORD}\downarrow$    | <29> $t_{DARD}$  |               | $(0.5 + w_{AS}) T - 7.5$   |                                 | ns   |
| Delay time from $\overline{RD}$ , $\overline{IORD}\uparrow$ to address                        | <30> $t_{DRDA}$  |               | $iT - 2$                   |                                 | ns   |
| Data input hold time (from $\overline{RD}$ , $\overline{IORD}\uparrow$ )                      | <31> $t_{HRDID}$ |               | 0                          |                                 | ns   |
| Delay time from $\overline{RD}$ , $\overline{IORD}\uparrow$ to data output                    | <32> $t_{DRDOD}$ |               | $(0.5 + i) T - 6$          |                                 | ns   |
| $\overline{WAIT}$ setup time (to address)                                                     | <33> $t_{SAW}$   | <b>Note 1</b> |                            | $(1 + w_{AS}) T - 17$           | ns   |
| $\overline{WAIT}$ setup time (to $\overline{BCYST}\downarrow$ )                               | <34> $t_{SBSW}$  | <b>Note 1</b> |                            | $(1 + w_{AS}) T - 17$           | ns   |
| $\overline{WAIT}$ hold time (from $\overline{BCYST}\uparrow$ )                                | <35> $t_{HBSW}$  | <b>Note 1</b> | $(w_{AS} + w_D) T + 2$     |                                 | ns   |
| $\overline{WAIT}$ high-level width                                                            | <36> $t_{WWH}$   | <b>Note 2</b> | $T + 2$                    |                                 | ns   |
| Data output hold time (from $\overline{xxWR}$ , $\overline{IOWR}$ , $\overline{WR}\uparrow$ ) | <37> $t_{HWROD}$ |               | $(0.5 + i) T - 5.5$        |                                 | ns   |

- Notes**
1. At the first  $\overline{WAIT}$  sampling
  2. Time necessary for releasing the wait state

**Remarks** 1.  $T = t_{CYK}$ 

2.  $w$ : Number of waits inserted due to  $\overline{WAIT}$
3.  $w_D$ : Number of waits inserted by DWC0 and DWC1 registers
4. Observe at least one of the data input hold times  $t_{HRDID}$  and  $t_{HKID}$ .
5.  $n = 0$  to  $7$   
 $xx = UU, UL, LU, LL$
6.  $i$ : Number of idle states
7.  $w_{AS}$ : Number of address setup waits inserted by ASC register
8. For the number of  $w$  and  $w_D$  to be inserted, refer to **4.7.3 Relationship between programmable wait and external wait**.

## (b) Read timing (SRAM, external ROM, external I/O) (2/2)



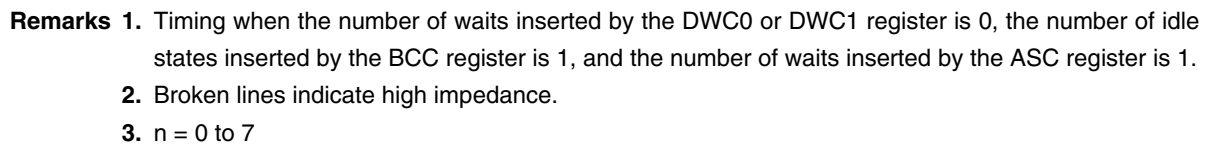
**(c) Write timing (SRAM, external ROM, external I/O) (1/2)**

| Parameter                                                                                                                                  | Symbol                  | Conditions    | MIN.                                              | MAX.                         | Unit |
|--------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|---------------|---------------------------------------------------|------------------------------|------|
| $\overline{\text{WAIT}}$ setup time (to address)                                                                                           | <33> $t_{\text{SAW}}$   | <b>Note 1</b> |                                                   | $(1 + w_{\text{AS}}) T - 17$ | ns   |
| $\overline{\text{WAIT}}$ setup time (to $\overline{\text{BCYST}}\downarrow$ )                                                              | <34> $t_{\text{BSW}}$   | <b>Note 1</b> |                                                   | $(1 + w_{\text{AS}}) T - 17$ | ns   |
| $\overline{\text{WAIT}}$ hold time (from $\overline{\text{BCYST}}\uparrow$ )                                                               | <35> $t_{\text{BSW}}$   | <b>Note 1</b> | $(w_{\text{AS}} + w_{\text{D}}) T + 2$            |                              | ns   |
| $\overline{\text{WAIT}}$ high-level width                                                                                                  | <36> $t_{\text{WWH}}$   | <b>Note 2</b> | $T + 2$                                           |                              | ns   |
| Delay time from address, $\overline{\text{CSn}}$ to $\overline{\text{xxWR}}$ , $\overline{\text{IOWR}}$ , $\overline{\text{WR}}\downarrow$ | <38> $t_{\text{DAWR}}$  |               | $(0.5 + w_{\text{AS}}) T - 7$                     |                              | ns   |
| Address setup time (to $\overline{\text{xxWR}}$ , $\overline{\text{IOWR}}$ , $\overline{\text{WR}}\uparrow$ )                              | <39> $t_{\text{SAWR}}$  |               | $(1.5 + w + w_{\text{D}} + w_{\text{AS}}) T - 10$ |                              | ns   |
| Delay time from $\overline{\text{xxWR}}$ , $\overline{\text{IOWR}}$ , $\overline{\text{WR}}\uparrow$ to address                            | <40> $t_{\text{DWRA}}$  |               | $(0.5 + i) T - 5$                                 |                              | ns   |
| $\overline{\text{xxWR}}$ , $\overline{\text{IOWR}}$ , $\overline{\text{WR}}$ high-level width                                              | <41> $t_{\text{WWRH}}$  |               | $(1 + i + w_{\text{AS}}) T - 5$                   |                              | ns   |
| $\overline{\text{xxWR}}$ , $\overline{\text{IOWR}}$ , $\overline{\text{WR}}$ low-level width                                               | <42> $t_{\text{WWRL}}$  |               | $(1 + w + w_{\text{D}}) T - 5$                    |                              | ns   |
| Data output setup time (to $\overline{\text{xxWR}}$ , $\overline{\text{IOWR}}$ , $\overline{\text{WR}}\uparrow$ )                          | <43> $t_{\text{SODWR}}$ |               | $(1.5 + w_{\text{AS}} + w + w_{\text{D}}) T - 5$  |                              | ns   |
| Data output hold time (from $\overline{\text{xxWR}}$ , $\overline{\text{IOWR}}$ , $\overline{\text{WR}}\uparrow$ )                         | <37> $t_{\text{HWROD}}$ |               | $(0.5 + i) T - 5.5$                               |                              | ns   |

- Notes**
1. At the first  $\overline{\text{WAIT}}$  sampling
  2. Time necessary for releasing the wait state

**Remarks** 1.  $T = t_{\text{CYK}}$

2.  $w$ : Number of waits inserted due to  $\overline{\text{WAIT}}$
3.  $w_{\text{D}}$ : Number of waits inserted by DWC0 and DWC1 registers
4.  $n = 0$  to 7  
 $\text{xx} = \text{UU}, \text{UL}, \text{LU}, \text{LL}$
5.  $i$ : Number of idle states
6.  $w_{\text{AS}}$ : Number of address setup waits inserted by ASC register
7. For the number of  $w$  and  $w_{\text{D}}$  to be inserted, refer to **4.7.3 Relationship between programmable wait and external wait.**



## (d) DMA flyby transfer timing (transfer from SRAM to external I/O) (1/2)

| Parameter                                                                                  | Symbol                   | Conditions  | MIN.                                               | MAX.                                         | Unit |
|--------------------------------------------------------------------------------------------|--------------------------|-------------|----------------------------------------------------|----------------------------------------------|------|
| $\overline{\text{WAIT}}$ setup time (to $\text{BUSCLK}\uparrow$ )                          | <19> $t_{\text{SWK}}$    |             | 6                                                  |                                              | ns   |
| $\overline{\text{WAIT}}$ hold time (from $\text{BUSCLK}\uparrow$ )                         | <20> $t_{\text{HKW}}$    |             | 2                                                  |                                              | ns   |
| $\overline{\text{RD}}$ low-level width                                                     | <27> $t_{\text{WRDL}}$   |             | $(1.5 + w + w_{\text{FW}}) T - 6$                  |                                              | ns   |
| $\overline{\text{RD}}$ high-level width                                                    | <28> $t_{\text{WRDH}}$   |             | $(0.5 + w_{\text{AS}} + i) T - 6$                  |                                              | ns   |
| Delay time from address, $\overline{\text{CSn}}$ to $\overline{\text{RD}}\downarrow$       | <29> $t_{\text{DARD}}$   |             | $(0.5 + w_{\text{AS}}) T - 7.5$                    |                                              | ns   |
| Delay time from $\overline{\text{RD}}\uparrow$ to address                                  | <30> $t_{\text{DRDA}}$   |             | $iT - 2$                                           |                                              | ns   |
| Delay time from $\overline{\text{RD}}\uparrow$ to data output                              | <32> $t_{\text{DRDOD}}$  |             | $(0.5 + i) T - 6$                                  |                                              | ns   |
| $\overline{\text{WAIT}}$ setup time (to address)                                           | <33> $t_{\text{SAW}}$    | <b>Note</b> |                                                    | $(1 + w_{\text{AS}} + w_{\text{FW}}) T - 17$ | ns   |
| $\overline{\text{WAIT}}$ setup time (to $\overline{\text{BCYST}}\downarrow$ )              | <34> $t_{\text{BSW}}$    | <b>Note</b> |                                                    | $(1 + w_{\text{AS}} + w_{\text{FW}}) T - 17$ | ns   |
| $\overline{\text{WAIT}}$ hold time (from $\overline{\text{BCYST}}\uparrow$ )               | <35> $t_{\text{BSW}}$    | <b>Note</b> | $(w_{\text{AS}} + w_{\text{FW}}) T + 2$            |                                              | ns   |
| $\overline{\text{WAIT}}$ high-level width                                                  | <36> $t_{\text{WWH}}$    |             | $T + 2$                                            |                                              | ns   |
| Delay time from address to $\overline{\text{IOWR}}\downarrow$                              | <38> $t_{\text{DAWR}}$   |             | $(0.5 + w_{\text{AS}}) T - 7$                      |                                              | ns   |
| Address setup time (to $\overline{\text{IOWR}}\uparrow$ )                                  | <39> $t_{\text{SAWR}}$   |             | $(1.5 + w + w_{\text{FW}} + w_{\text{AS}}) T - 10$ |                                              | ns   |
| Delay time from $\overline{\text{IOWR}}\uparrow$ to address                                | <40> $t_{\text{DWRA}}$   |             | $(0.5 + i) T - 5$                                  |                                              | ns   |
| $\overline{\text{IOWR}}$ high-level width                                                  | <41> $t_{\text{WWRH}}$   |             | $(0.5 + i + w_{\text{AS}}) T - 5$                  |                                              | ns   |
| $\overline{\text{IOWR}}$ low-level width                                                   | <42> $t_{\text{WWRL}}$   |             | $(1 + w + w_{\text{FW}}) T - 5$                    |                                              | ns   |
| Delay time from $\overline{\text{IOWR}}\uparrow$ to $\overline{\text{RD}}\uparrow$         | <44> $t_{\text{DIWRRD}}$ |             | $0.5T - 4$                                         |                                              | ns   |
| Delay time from $\overline{\text{DMAAKm}}\downarrow$ to $\overline{\text{IOWR}}\downarrow$ | <45> $t_{\text{DDAWR}}$  |             | $(0.5 + w_{\text{AS}}) T - 7.5$                    |                                              | ns   |
| Delay time from $\overline{\text{IOWR}}\uparrow$ to $\overline{\text{DMAAKm}}\uparrow$     | <46> $t_{\text{DWRDA}}$  |             | $(1.5 + i) T - 10$                                 |                                              | ns   |

**Note** At the second and subsequent  $\overline{\text{WAIT}}$  sampling

**Remarks 1.**  $T = t_{\text{CYK}}$

2.  $w$ : Number of waits inserted due to  $\overline{\text{WAIT}}$

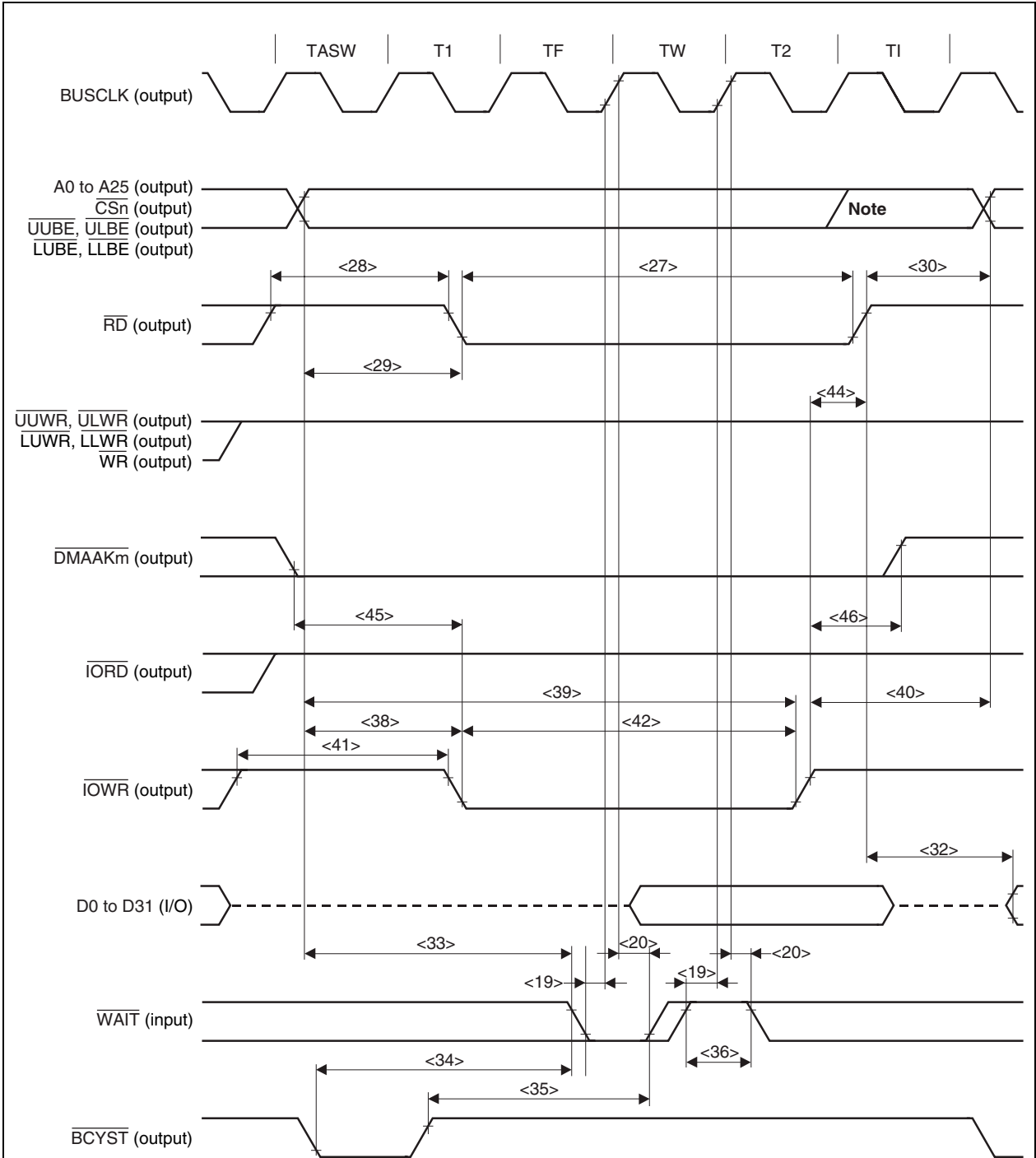
3.  $w_{\text{FW}}$ : Number of waits inserted by FWC register

4.  $n = 0$  to 7,  $m = 0$  to 3

5.  $i$ : Number of idle states

6.  $w_{\text{AS}}$ : Number of address setup waits inserted by ASC register

## (d) DMA flyby transfer timing (transfer from SRAM to external I/O) (2/2)



**Note** In the case of the CSn signal

**Remarks 1.** Timing when the number of waits inserted by the FWC register is 1, the number of idle states inserted by the FIC register is 1, and the number of waits inserted by the ASC register is 1.

**2.** Broken lines indicate high impedance.

**3.** n = 0 to 7, m = 0 to 3

## (e) DMA flyby transfer timing (transfer from external I/O to SRAM) (1/2)

| Parameter                                                                                                     | Symbol                   | Conditions  | MIN.                                               | MAX.                                         | Unit |
|---------------------------------------------------------------------------------------------------------------|--------------------------|-------------|----------------------------------------------------|----------------------------------------------|------|
| $\overline{\text{WAIT}}$ setup time (to $\text{BUSCLK}\uparrow$ )                                             | <19> $t_{\text{SWK}}$    |             | 6                                                  |                                              | ns   |
| $\overline{\text{WAIT}}$ hold time (from $\text{BUSCLK}\uparrow$ )                                            | <20> $t_{\text{HKW}}$    |             | 2                                                  |                                              | ns   |
| $\overline{\text{IORD}}$ low-level width                                                                      | <27> $t_{\text{WRDL}}$   |             | $(2 + w + w_{\text{FW}}) T - 6$                    |                                              | ns   |
| $\overline{\text{IORD}}$ high-level width                                                                     | <28> $t_{\text{WRDH}}$   |             | $(1 + w_{\text{AS}} + i) T - 6$                    |                                              | ns   |
| Delay time from address, $\overline{\text{CSn}}$ to $\overline{\text{IORD}}\downarrow$                        | <29> $t_{\text{DARD}}$   |             | $(0.5 + w_{\text{AS}}) T - 7.5$                    |                                              | ns   |
| Delay time from $\overline{\text{IORD}}\uparrow$ to address                                                   | <30> $t_{\text{DRDA}}$   |             | $iT - 2$                                           |                                              | ns   |
| Delay time from $\overline{\text{IORD}}\uparrow$ to data output                                               | <32> $t_{\text{DRDOD}}$  |             | $(0.5 + i) T - 6$                                  |                                              | ns   |
| $\overline{\text{WAIT}}$ setup time (to address)                                                              | <33> $t_{\text{SAW}}$    | <b>Note</b> |                                                    | $(1 + w_{\text{AS}} + w_{\text{FW}}) T - 17$ | ns   |
| $\overline{\text{WAIT}}$ setup time (to $\overline{\text{BCYST}}\downarrow$ )                                 | <34> $t_{\text{SBSW}}$   | <b>Note</b> |                                                    | $(1 + w_{\text{AS}} + w_{\text{FW}}) T - 17$ | ns   |
| $\overline{\text{WAIT}}$ hold time (from $\overline{\text{BCYST}}\uparrow$ )                                  | <35> $t_{\text{HBSW}}$   | <b>Note</b> | $(w_{\text{AS}} + w_{\text{FW}}) T + 2$            |                                              | ns   |
| $\overline{\text{WAIT}}$ high-level width                                                                     | <36> $t_{\text{WWH}}$    |             | $T + 2$                                            |                                              | ns   |
| Delay time from address to $\overline{\text{xxWR}}$ , $\overline{\text{WR}}\downarrow$                        | <38> $t_{\text{DAWR}}$   |             | $(0.5 + w_{\text{AS}}) T - 7$                      |                                              | ns   |
| Address setup time (to $\overline{\text{xxWR}}$ , $\overline{\text{WR}}\uparrow$ )                            | <39> $t_{\text{SAWR}}$   |             | $(1.5 + w + w_{\text{FW}} + w_{\text{AS}}) T - 10$ |                                              | ns   |
| Delay time from $\overline{\text{xxWR}}$ , $\overline{\text{WR}}\uparrow$ to address                          | <40> $t_{\text{DWRA}}$   |             | $(0.5 + i) T - 5$                                  |                                              | ns   |
| $\overline{\text{xxWR}}$ , $\overline{\text{WR}}$ high-level width                                            | <41> $t_{\text{WWRH}}$   |             | $(1 + i + w_{\text{AS}}) T - 5$                    |                                              | ns   |
| $\overline{\text{xxWR}}$ , $\overline{\text{WR}}$ low-level width                                             | <42> $t_{\text{WWRL}}$   |             | $(1 + w + w_{\text{FW}}) T - 5$                    |                                              | ns   |
| Delay time from $\overline{\text{xxWR}}$ , $\overline{\text{WR}}\uparrow$ to $\overline{\text{IORD}}\uparrow$ | <47> $t_{\text{DWRIRD}}$ |             | $0.5T - 4$                                         |                                              | ns   |
| Delay time from $\overline{\text{DMAAKm}}\downarrow$ to $\overline{\text{IORD}}\downarrow$                    | <48> $t_{\text{DDARD}}$  |             | $(0.5 + w_{\text{AS}}) T - 7.5$                    |                                              | ns   |
| Delay time from $\overline{\text{IORD}}\uparrow$ to $\overline{\text{DMAAKm}}\uparrow$                        | <49> $t_{\text{DRDDA}}$  |             | $(0.5 + i) T - 7.5$                                |                                              | ns   |

**Note** At the second and subsequent  $\overline{\text{WAIT}}$  sampling

**Remarks 1.**  $T = t_{\text{CYK}}$

**2.**  $w$ : Number of waits inserted due to  $\overline{\text{WAIT}}$

**3.**  $w_{\text{FW}}$ : Number of waits inserted by FWC register

**4.**  $n = 0$  to 7,  $m = 0$  to 3

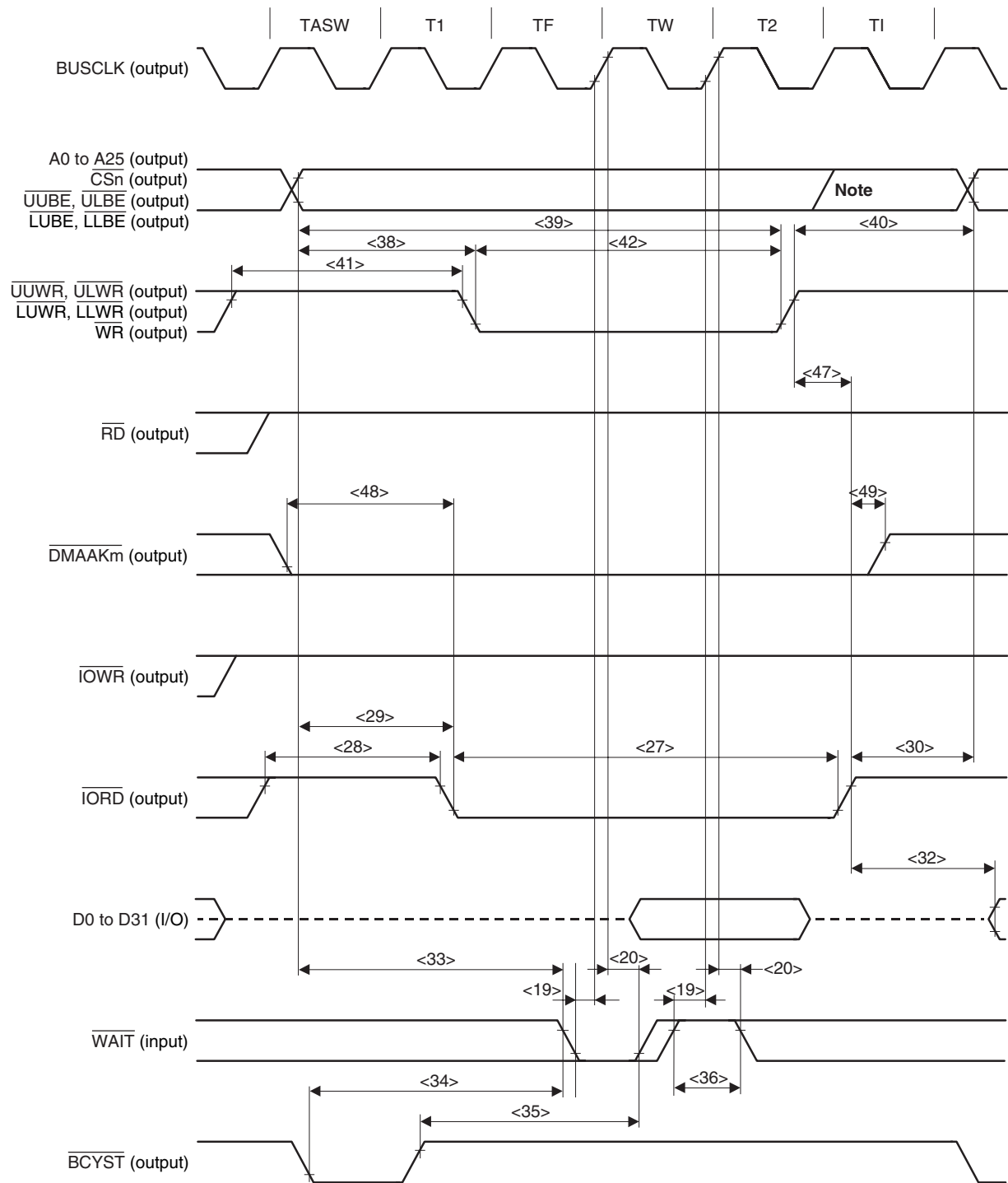
$\text{xx} = \text{UU}, \text{UL}, \text{LU}, \text{LL}$

**5.**  $i$ : Number of idle states inserted when a write cycle is inserted after a read cycle

**6.**  $w_{\text{AS}}$ : Number of address setup waits inserted by ASC register



## (e) DMA flyby transfer timing (transfer from external I/O to SRAM) (2/2)



**Note** In the case of the  $\overline{\text{CSn}}$  signal

**Remarks 1.** Timing when the number of waits inserted by the FWC register is 1, the number of idle states inserted by the FIC register is 1, and the number of waits inserted by the ASC register is 1.

**2.** Broken lines indicate high impedance.

**3.**  $n = 0$  to 7,  $m = 0$  to 3

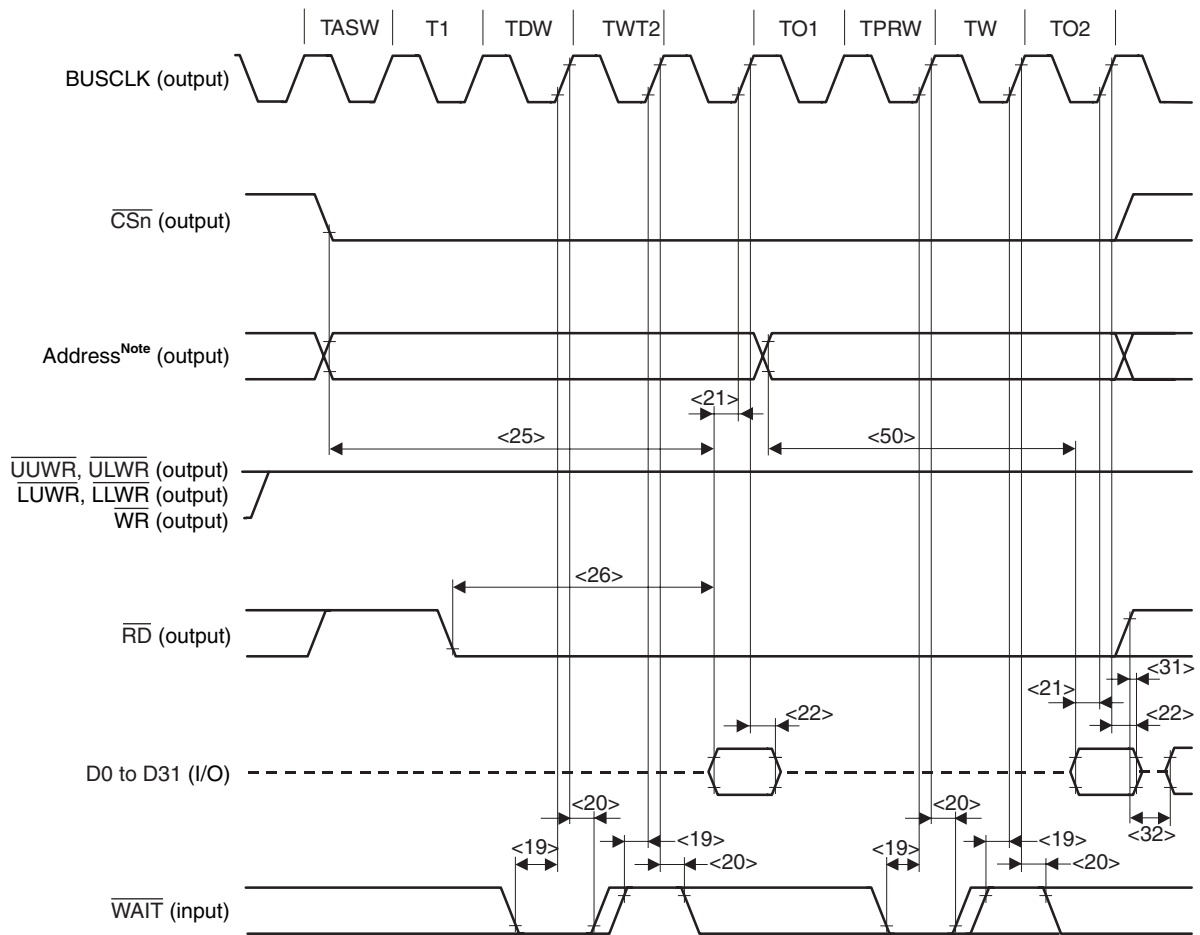
**(5) Page ROM access timing (1/2)**

| Parameter                                                     | Symbol                  | Conditions | MIN.              | MAX.                            | Unit |
|---------------------------------------------------------------|-------------------------|------------|-------------------|---------------------------------|------|
| $\overline{\text{WAIT}}$ setup time (to BUSCLK $\uparrow$ )   | <19> $t_{\text{SWK}}$   |            | 6                 |                                 | ns   |
| $\overline{\text{WAIT}}$ hold time (from BUSCLK $\uparrow$ )  | <20> $t_{\text{HKW}}$   |            | 2                 |                                 | ns   |
| Data input setup time (to BUSCLK $\uparrow$ )                 | <21> $t_{\text{SKID}}$  |            | 6                 |                                 | ns   |
| Data input hold time (from BUSCLK $\uparrow$ )                | <22> $t_{\text{HKID}}$  |            | 2                 |                                 | ns   |
| Off-page data input setup time (to address)                   | <25> $t_{\text{SAID}}$  |            |                   | $(2 + w + w_D + w_{AS}) T - 17$ | ns   |
| Off-page data input setup time (to $\overline{\text{RD}}$ )   | <26> $t_{\text{SRDID}}$ |            |                   | $(1.5 + w + w_D) T - 17$        | ns   |
| Data input hold time (from $\overline{\text{RD}}\uparrow$ )   | <31> $t_{\text{HRDID}}$ |            | 2                 |                                 | ns   |
| Delay time from $\overline{\text{RD}}\uparrow$ to data output | <32> $t_{\text{DRDOD}}$ |            | $(0.5 + i) T - 6$ |                                 | ns   |
| On-page data input setup time (to address)                    | <50> $t_{\text{SOAID}}$ |            |                   | $(2 + w + w_{PR}) T - 17$       | ns   |

**Remarks** 1.  $T = t_{\text{CYK}}$

2.  $w$ : Number of waits inserted due to  $\overline{\text{WAIT}}$
3.  $w_D$ : Number of waits inserted by DWC0 and DWC1 registers
4.  $w_{PR}$ : Number of waits inserted by PRC register
5.  $i$ : Number of idle states inserted when a write cycle is inserted after a read cycle
6.  $w_{AS}$ : Number of address setup waits inserted by ASC register
7. Observe at least one of the data input hold times  $t_{\text{HRDID}}$  and  $t_{\text{HKID}}$ .
8. For the number of  $w$  and  $w_D$  to be inserted, refer to **4.7.3 Relationship between programmable wait and external wait**.

(5) Page ROM access timing (2/2)



**Note** On-page addresses and off-page addresses are shown below.

| PRC register |     |     |     | On-page address | Off-page address |
|--------------|-----|-----|-----|-----------------|------------------|
| MA6          | MA5 | MA4 | MA3 |                 |                  |
| 0            | 0   | 0   | 0   | A0 to A2        | A3 to A25        |
| 0            | 0   | 0   | 1   | A0 to A3        | A4 to A25        |
| 0            | 0   | 1   | 1   | A0 to A4        | A5 to A25        |
| 0            | 1   | 1   | 1   | A0 to A5        | A6 to A25        |
| 1            | 1   | 1   | 1   | A0 to A6        | A7 to A25        |

**Remarks 1.** Timing in the following case.

Number of waits inserted by DWC0 or DWC1 register (TDW): 1

Number of waits inserted by PRC register (TPRW): 1

Number of waits inserted by ASC register (TASW): 1

**2.** Broken lines indicate high impedance.

**3.** n = 0 to 7

## (6) SDRAM access timing

## (a) Read timing (SDRAM access) (1/2)

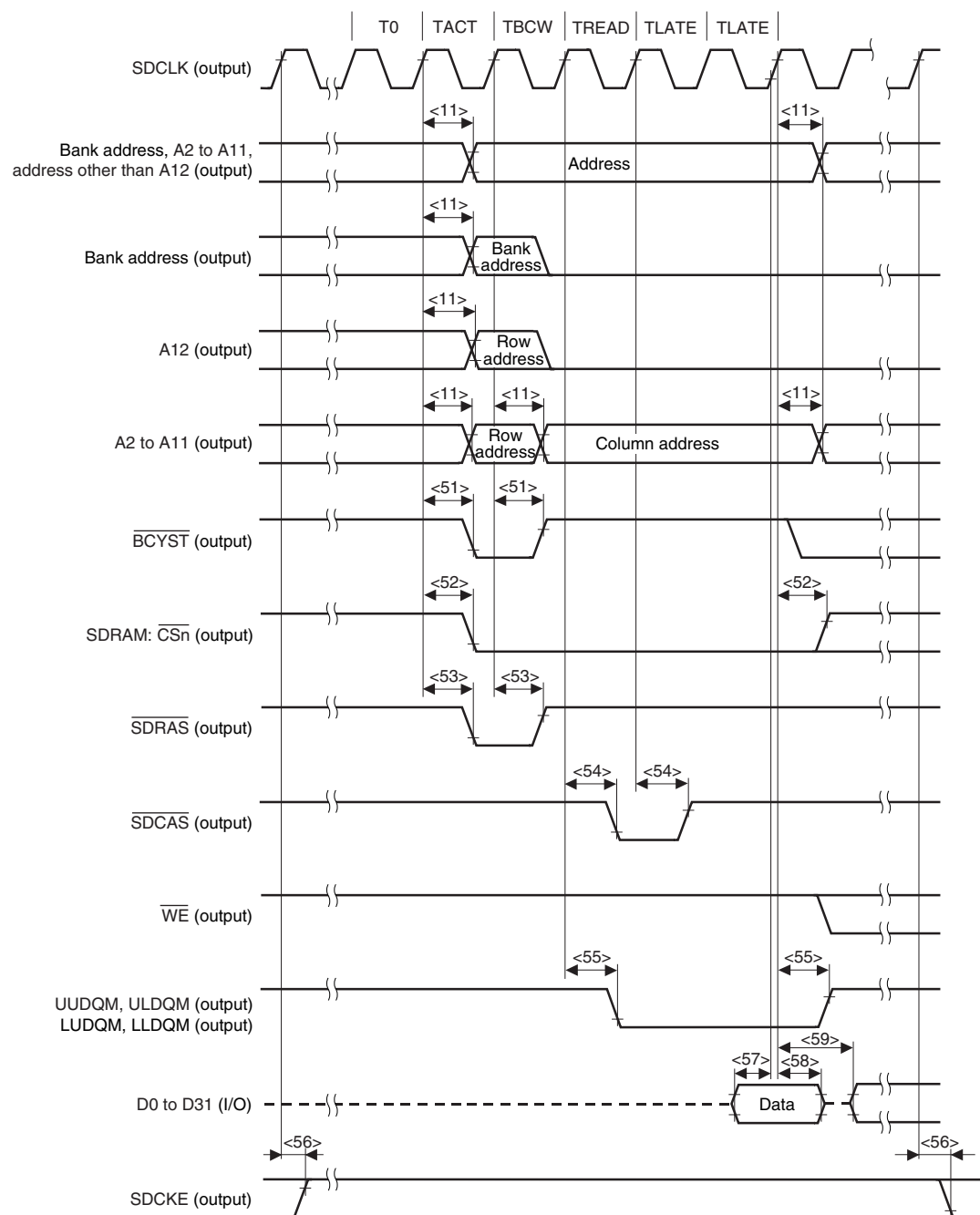
| Parameter                                           | Symbol           | Conditions | MIN.          | MAX. | Unit |
|-----------------------------------------------------|------------------|------------|---------------|------|------|
| Address delay time (from BUSCLK↑)                   | <11> $t_{DKA}$   |            | 2             | 11   | ns   |
| $\overline{BCYST}$ delay time (from BUSCLK↑)        | <51> $t_{DKBC}$  |            | 2             | 11   | ns   |
| $\overline{CSn}$ delay time (from BUSCLK↑)          | <52> $t_{DKCS}$  |            | 2             | 11   | ns   |
| $\overline{SDRAS}$ delay time (from BUSCLK↑)        | <53> $t_{DKRAS}$ |            | 2             | 11   | ns   |
| $\overline{SDCAS}$ delay time (from BUSCLK↑)        | <54> $t_{DKCAS}$ |            | 2             | 11   | ns   |
| xxDQM delay time (from BUSCLK↑)                     | <55> $t_{DKDQM}$ |            | 2             | 11   | ns   |
| SDCKE delay time (from BUSCLK↑)                     | <56> $t_{DKCKE}$ |            | 2             | 11   | ns   |
| Data input setup time<br>(SDRAM read, from BUSCLK↑) | <57> $t_{SDRMK}$ |            | 6             |      | ns   |
| Data input hold time<br>(SDRAM read, from BUSCLK↑)  | <58> $t_{HKDRM}$ |            | 2             |      | ns   |
| Delay time from BUSCLK↑ to data<br>output           | <59> $t_{DSDOD}$ |            | $(0.5 + i) T$ |      | ns   |

**Caution** If an SRAM (external I/O) cycle that uses the  $\overline{xxWR}$  signal is generated immediately after a read cycle to SDRAM, an SRAM (external I/O) writing error may occur. In this case, set the BCC register to insert an idle state in the SDRAM space or execute a countermeasure using external circuits. However, no writing error occurs in a synchronization design in which the  $\overline{xxWR}$  signal is sampled using BUSCLK.

**Remarks**

1.  $T = t_{CYK}$
2. i: Number of idle states
3.  $n = 1, 3, 4, 6$   
xx = UU, UL, LU, LL

## (a) Read timing (SDRAM access) (2/2)



- Remarks**
1. Number of waits inserted by BCW1n and BCW0n bits of the SCRn register (TBCW): 2
  2. Broken lines indicate high impedance.
  3. n = 1, 3, 4, 6

**(b) Write timing (SDRAM access) (1/2)**

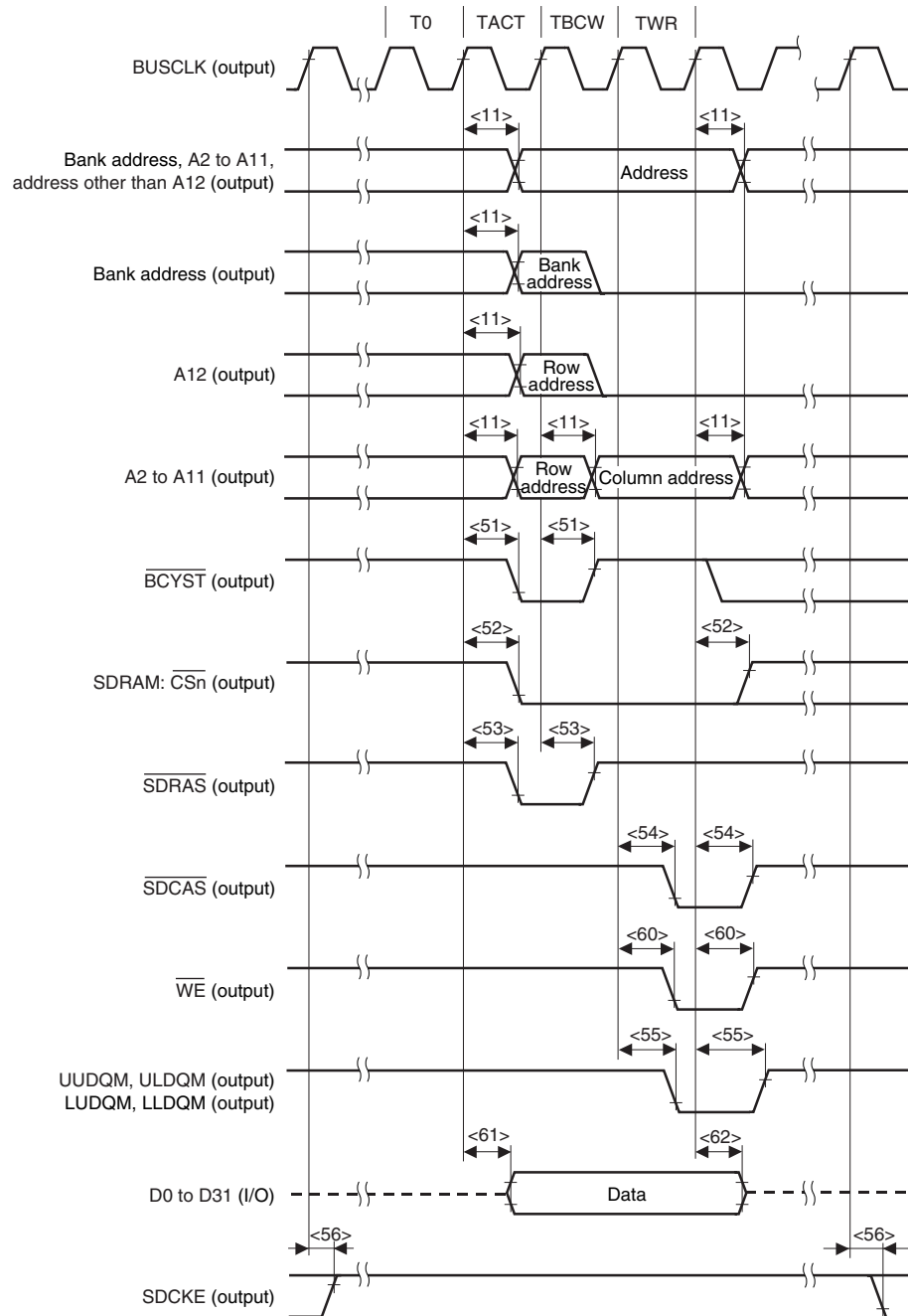
| Parameter                                    | Symbol           | Conditions | MIN. | MAX. | Unit |
|----------------------------------------------|------------------|------------|------|------|------|
| Address delay time (from BUSCLK↑)            | <11> $t_{DKA}$   |            | 2    | 11   | ns   |
| $\overline{BCYST}$ delay time (from BUSCLK↑) | <51> $t_{DKBC}$  |            | 2    | 11   | ns   |
| $\overline{CSn}$ delay time (from BUSCLK↑)   | <52> $t_{DKCS}$  |            | 2    | 11   | ns   |
| $\overline{SDRAS}$ delay time (from BUSCLK↑) | <53> $t_{DKRAS}$ |            | 2    | 11   | ns   |
| $\overline{SDCAS}$ delay time (from BUSCLK↑) | <54> $t_{DKCAS}$ |            | 2    | 11   | ns   |
| xxDQM delay time (from BUSCLK↑)              | <55> $t_{DKDQM}$ |            | 2    | 11   | ns   |
| SDCKE delay time (from BUSCLK↑)              | <56> $t_{DKCKE}$ |            | 2    | 11   | ns   |
| $\overline{WE}$ delay time (from BUSCLK↑)    | <60> $t_{DKWE}$  |            | 2    | 11   | ns   |
| Data output delay time<br>(from BUSCLK↑)     | <61> $t_{DKDT}$  |            | 2    | 11   | ns   |
| Data float delay time<br>(from BUSCLK↑)      | <62> $t_{HZKDT}$ |            | 2    | 11   | ns   |

**Caution** If an SRAM (external I/O) cycle that uses the  $\overline{xxWR}$  signal is generated immediately after a read cycle to SDRAM, an SRAM (external I/O) writing error may occur. In this case, execute a countermeasure using external circuits.

However, no writing error occurs in a synchronization design in which the  $\overline{xxWR}$  signal is sampled using BUSCLK.

**Remark** n = 1, 3, 4, 6  
xx = UU, UL, LU, LL

(b) Write timing (SDRAM access) (2/2)



- Remarks**
1. Number of waits inserted by BCW1n and BCW0n bits of SCRn register (TBCW): 2
  2. Broken lines indicate high impedance.
  3. n = 1, 3, 4, 6

## (c) DMA flyby transfer timing (transfer from external I/O to SDRAM) (1/2)

| Parameter                                            | Symbol            | Conditions | MIN.                       | MAX. | Unit |
|------------------------------------------------------|-------------------|------------|----------------------------|------|------|
| Address delay time (from BUSCLK↑)                    | <11> $t_{DKA}$    |            | 2                          | 11   | ns   |
| $\overline{IORD}$ ↓ delay time (from BUSCLK↓)        | <13> $t_{DKRDL}$  |            | 1                          | 11   | ns   |
| $\overline{IORD}$ ↑ delay time (from BUSCLK↑)        | <14> $t_{HKRDH}$  |            | 2                          | 11   | ns   |
| $\overline{BCYST}$ delay time (from BUSCLK↑)         | <51> $t_{DKBC}$   |            | 2                          | 11   | ns   |
| $\overline{CSn}$ delay time (from BUSCLK↑)           | <52> $t_{DKCS}$   |            | 2                          | 11   | ns   |
| $\overline{SDRAS}$ delay time (from BUSCLK↑)         | <53> $t_{DKRAS}$  |            | 2                          | 11   | ns   |
| $\overline{SDCAS}$ delay time (from BUSCLK↑)         | <54> $t_{DKCAS}$  |            | 2                          | 11   | ns   |
| xxDQM delay time (from BUSCLK↑)                      | <55> $t_{DKDQM}$  |            | 2                          | 11   | ns   |
| SDCKE delay time (from BUSCLK↑)                      | <56> $t_{DKCKE}$  |            | 2                          | 11   | ns   |
| $\overline{WE}$ delay time (from BUSCLK↑)            | <60> $t_{DKWE}$   |            | 2                          | 11   | ns   |
| $\overline{DMAAKx}$ output delay time (from BUSCLK↑) | <65> $t_{DKDA}$   |            | 0                          | 13   | ns   |
| $\overline{DMAAKx}$ output hold time (from BUSCLK↑)  | <66> $t_{HKDA}$   |            | 0                          | 13   | ns   |
| $\overline{IORD}$ low-level width                    | <102> $t_{WRDL}$  |            | $(1.5 + w_{FW}) T - 6$     |      | ns   |
| $\overline{IORD}$ high-level width                   | <103> $t_{WRDH}$  |            | $(1.5 + w_{AS} + i) T - 6$ |      | ns   |
| Delay time from $\overline{IORD}$ ↑ to data output   | <104> $t_{DRDOD}$ |            | $(1 + i) T - 6$            |      | ns   |

**Remarks** 1.  $T = t_{CYK}$

2.  $i$ : Number of idle states

3.  $w_{AS}$ : Number of address setup waits inserted by ASC register

4.  $w_{FW}$ : Number of data waits inserted by FWC register

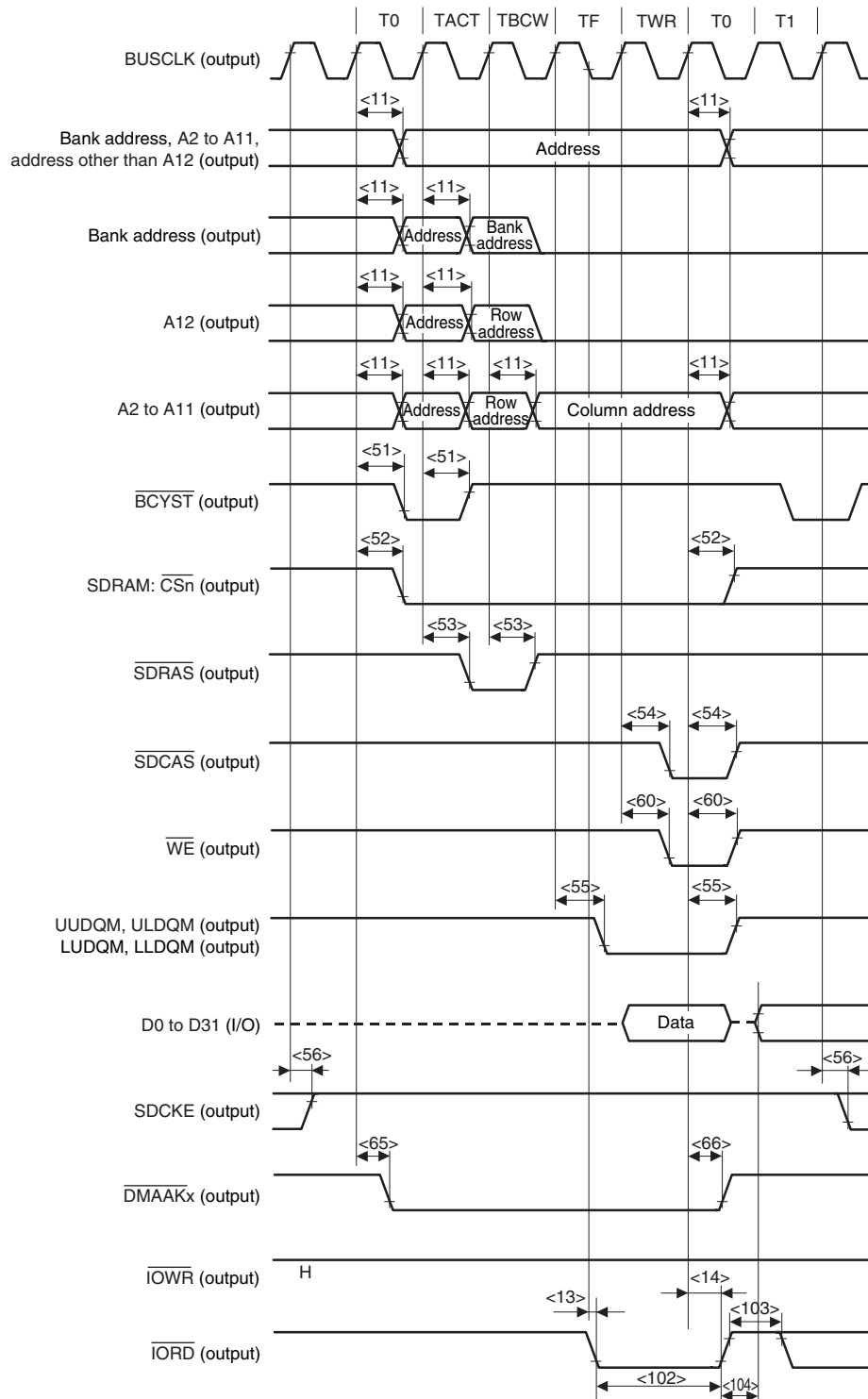
5.  $n = 1, 3, 4, 6$

xx = UU, UL, LU, LL

x = 0 to 3



(c) DMA flyby transfer timing (transfer from external I/O to SDRAM) (2/2)



**Remarks 1.** Broken lines indicate high impedance.

**2.** n = 1, 3, 4, 6

x = 0 to 3

## (7) DMAC timing

## (a) Level mode (1/3)

| Parameter                                                                         | Symbol | Conditions        | MIN.                   | MAX. | Unit                                                                                     |
|-----------------------------------------------------------------------------------|--------|-------------------|------------------------|------|------------------------------------------------------------------------------------------|
| $\overline{\text{DMARQn}}$ setup time (to $\text{BUSCLK}\uparrow$ )               | <63>   | $t_{\text{SDRK}}$ | 2-cycle/flyby transfer | 8    | ns                                                                                       |
| $\overline{\text{DMARQn}}$ hold time (from $\overline{\text{DMAAKn}}\downarrow$ ) | <64>   | $t_{\text{HKDR}}$ | 2-cycle transfer       | 0    | $4T_{\text{CPU}} - 20^{\text{Note 1}}$                                                   |
|                                                                                   |        |                   |                        |      | $6T_{\text{CPU}} - 20^{\text{Note 2}}$                                                   |
|                                                                                   |        |                   | Flyby transfer         | 0    | $2T_{\text{BUS}} + W_{\text{AS}} + W_{\text{FW}} + W_{\text{IC}} + 2T_{\text{CPU}} - 20$ |
| $\overline{\text{DMAAKn}}$ output delay time (from $\text{BUSCLK}\uparrow$ )      | <65>   | $t_{\text{DKDA}}$ | 2-cycle transfer       | 0    | $nT_{\text{CPU}} + 13^{\text{Note 3}}$                                                   |
|                                                                                   |        |                   | Flyby transfer         | 0    | 13                                                                                       |
| $\overline{\text{DMAAKn}}$ output hold time (from $\text{BUSCLK}\uparrow$ )       | <66>   | $t_{\text{HKDA}}$ | 2-cycle transfer       | 0    | $nT_{\text{CPU}} + 13^{\text{Note 3}}$                                                   |
|                                                                                   |        |                   | Flyby transfer         | 0    | 13                                                                                       |

**Notes** 1. Second DMA transfer request disable timing in single transfer.

The accesses are as follows.

| Transfer Source   | Transfer Destination                            | Speculative Read Function                                                                                                                                                                                                                                                                      |
|-------------------|-------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Internal data RAM | External memory/<br>internal instruction<br>RAM | Provided/none                                                                                                                                                                                                                                                                                  |
| External memory   | Internal data RAM                               | Provided/none<br>However, when the speculative read function is not provided, the following conditions apply.<br><ul style="list-style-type: none"> <li><math>\text{BUSCLK} = \text{Internal system clock (f}_{\text{CLK}})</math></li> <li>External memory access wait setting = 0</li> </ul> |

2. Second DMA transfer request disable timing in single transfer.

The access is other than that shown in the table in **Note 1**.

3. n is as follows.

| CKM1 | CKM0 | BUSCLK Division Ratio with Respect to Internal System Clock ( $f_{\text{CLK}}$ ) | n |
|------|------|----------------------------------------------------------------------------------|---|
| 0    | 0    | $f_{\text{CLK}}/1$                                                               | 1 |
| 0    | 1    | $f_{\text{CLK}}/2$                                                               | 2 |
| 1    | 0    | $f_{\text{CLK}}/3$                                                               | 3 |
| 1    | 1    | $f_{\text{CLK}}/4$                                                               | 4 |

**Remarks** 1.  $n = 0$  to 3

2.  $T_{\text{BUS}} = 1 \times \text{BUSCLK cycle}$

3.  $T_{\text{CPU}} = 1 \times \text{internal system clock (f}_{\text{CLK}}) \text{ cycle}$

4.  $W_{\text{AS}} = \text{Number of address setup waits inserted by ASC register}$

$W_{\text{FW}} = \text{Number of data waits inserted by FWC register}$

$W_{\text{IC}} = \text{Number of idle states inserted by FIC register}$

**(a) Level mode (2/3)**

| Parameter                                                | Symbol |       | Conditions             |               | MIN.                                                         | MAX. | Unit |
|----------------------------------------------------------|--------|-------|------------------------|---------------|--------------------------------------------------------------|------|------|
| $\overline{\text{DMAAKn}}$ low-level width               | <67>   | tWDAL | 2-cycle transfer       | <b>Note 1</b> | $2T_{\text{CPU}} - 8^{\text{Note 2}}$                        |      | ns   |
|                                                          |        |       |                        | <b>Note 3</b> | $6T_{\text{CPU}} - 8^{\text{Note 2}}$                        |      | ns   |
|                                                          |        |       | Flyby transfer         |               | $2T_{\text{BUS}} + \text{WAS} + \text{WFW} + \text{WIC} - 8$ |      |      |
| $\overline{\text{TCn}}$ output delay time (from BUSCLK↑) | <68>   | tDKTC | 2-cycle/flyby transfer |               | 2                                                            | 13   | ns   |
| $\overline{\text{TCn}}$ output hold time (from BUSCLK↑)  | <69>   | tHKTC | 2-cycle/flyby transfer |               | 2                                                            | 13   | ns   |

- Notes**
1. Normal operation ( $\overline{\text{DMAAKn}}$  output width = memory controller output)
  2. The access is as follows.

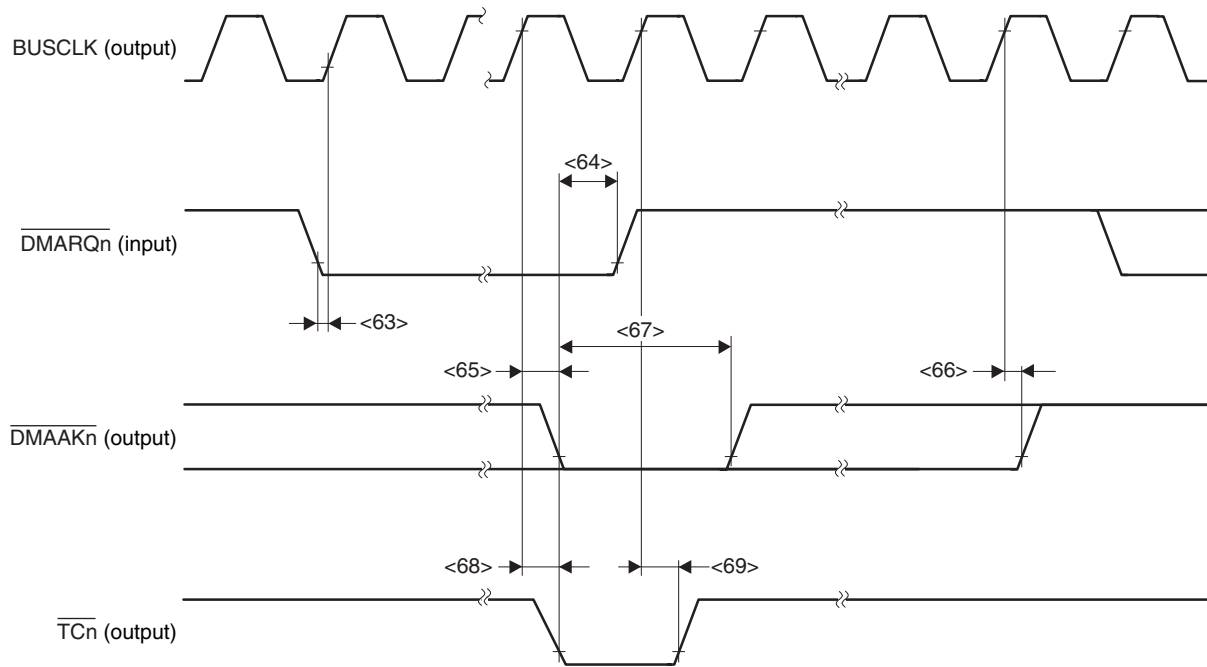
| Transfer Source   | Transfer Destination                            | Speculative Read Function                                                                                                                                                                                                                                                         |
|-------------------|-------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Internal data RAM | External memory/<br>internal instruction<br>RAM | Provided/none                                                                                                                                                                                                                                                                     |
| External memory   | Internal data RAM                               | Provided/none<br>However, when the speculative read function is not provided, the following conditions apply. <ul style="list-style-type: none"> <li>• BUSCLK = Internal system clock (<math>f_{\text{CLK}}</math>)</li> <li>• External memory access wait setting = 0</li> </ul> |

3. When selecting a mode in which  $\overline{\text{DMAAKn}}$  output width = memory controller output +  $4T_{\text{CPU}}$

**Remarks** 1.  $n = 0$  to 3

2.  $T_{\text{BUS}} = 1 \times \text{BUSCLK cycle}$
3.  $T_{\text{CPU}} = 1 \times \text{internal system clock } (f_{\text{CLK}}) \text{ cycle}$
4.  $\text{WAS} = \text{Number of address setup waits inserted by ASC register}$   
 $\text{WFW} = \text{Number of data waits inserted by FWC register}$   
 $\text{WIC} = \text{Number of idle states inserted by FIC register}$

## (a) Level mode (3/3)



**Remarks 1.** The minimum  $\overline{\text{DMAACKn}}$  inactive time is as follows.

| Transfer mode                            | Transfer source                                            | Transfer destination                                                                    | Inactive time     |
|------------------------------------------|------------------------------------------------------------|-----------------------------------------------------------------------------------------|-------------------|
| Single transfer,<br>single-step transfer | External memory/<br>external I/O<br>on-chip peripheral I/O | External memory/<br>external I/O<br>on-chip peripheral I/O/<br>internal instruction RAM | $4T_{\text{CPU}}$ |
|                                          | Internal data RAM                                          | Internal data RAM                                                                       | $5T_{\text{CPU}}$ |
|                                          | Internal data RAM                                          | External memory/<br>external I/O<br>on-chip peripheral I/O/<br>internal instruction RAM | $9T_{\text{CPU}}$ |
|                                          | External memory/<br>external I/O<br>on-chip peripheral I/O | Internal data RAM                                                                       | $9T_{\text{CPU}}$ |
| Block transfer                           | —                                                          | —                                                                                       | $T_{\text{CPU}}$  |

2.  $n = 0$  to 3

(b) Mask mode (1/3)

| Parameter                                                                                                                                   | Symbol                  | Conditions             | MIN.                                    | MAX.                                     | Unit |
|---------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|------------------------|-----------------------------------------|------------------------------------------|------|
| $\overline{\text{DMARQn}}$ setup time (to $\text{BUSCLK}\uparrow$ )                                                                         | <63> $t_{\text{SDRK}}$  | 2-cycle/flyby transfer | 8                                       |                                          | ns   |
| $\overline{\text{DMAAKn}}$ hold time 1<br>(from $\overline{\text{DMAAKn}}\downarrow$ )                                                      | <70> $t_{\text{HKDR1}}$ | 2-cycle/flyby transfer | To $\overline{\text{DMAAKn}}\downarrow$ |                                          | ns   |
| $\overline{\text{DMARQn}}$ hold time 2<br>(from $\text{BUSCLK}\downarrow$ ) <sup>Note 2</sup><br>( $\overline{\text{DMAAKn}}$ = "H" sample) | <71> $t_{\text{HKDR2}}$ | 2-cycle transfer       | 0                                       | $3T_{\text{BUS}} - 8$ <sup>Note 1</sup>  | ns   |
|                                                                                                                                             |                         | Flyby transfer         | 0                                       | $4T_{\text{BUS}} - 8$ <sup>Note 3</sup>  | ns   |
| $\overline{\text{DMAAKn}}$ output delay time<br>(from $\text{BUSCLK}\uparrow$ )                                                             | <65> $t_{\text{DKDA}}$  | 2-cycle transfer       | 0                                       | $nT_{\text{CPU}} + 13$ <sup>Note 4</sup> | ns   |
|                                                                                                                                             |                         | Flyby transfer         | 0                                       | 13                                       | ns   |
| $\overline{\text{DMAAKn}}$ output hold time<br>(from $\text{BUSCLK}\uparrow$ )                                                              | <66> $t_{\text{HKDA}}$  | 2-cycle transfer       | 0                                       | $nT_{\text{CPU}} + 13$ <sup>Note 4</sup> | ns   |
|                                                                                                                                             |                         | Flyby transfer         | 0                                       | 13                                       | ns   |

**Notes** 1. The second transfer request disable timing in single transfer.

To  $\text{BUSCLK}\uparrow$ : Since the  $\overline{\text{DMAAKn}}$  is output asynchronously with  $\text{BUSCLK}$ , in accordance with the  $\overline{\text{DMAAKn}}$  rising "H" sample prescription, if  $\overline{\text{DMAAKn}}$  = "H" is output at the timing in which it cannot be sampled at the  $\text{BUSCLK}$  (setup time < 8 ns),  $+1T_{\text{BUS}}$  is added.

2. Time to  $\overline{\text{DMAAKn}}$  high level from  $\text{BUSCLK}\uparrow$  after  $\overline{\text{DMAAKn}}$  rises
3. The second DMA transfer request disable timing in single transfer.
4. n is as follows.

| CKM1 | CKM0 | BUSCLK Division Ratio to Internal System Clock ( $f_{\text{CLK}}$ ) | n |
|------|------|---------------------------------------------------------------------|---|
| 0    | 0    | $f_{\text{CLK}}/1$                                                  | 1 |
| 0    | 1    | $f_{\text{CLK}}/2$                                                  | 2 |
| 1    | 0    | $f_{\text{CLK}}/3$                                                  | 3 |
| 1    | 1    | $f_{\text{CLK}}/4$                                                  | 4 |

**Remarks** 1. n = 0 to 3

2.  $T_{\text{BUS}} = 1 \times \text{BUSCLK cycle}$
3.  $T_{\text{CPU}} = 1 \times \text{internal system clock } (f_{\text{CLK}}) \text{ cycle}$

(b) Mask mode (2/3)

| Parameter                                                | Symbol |                   | Conditions             |               | MIN.                                    | MAX.                                    | Unit |
|----------------------------------------------------------|--------|-------------------|------------------------|---------------|-----------------------------------------|-----------------------------------------|------|
| $\overline{\text{DMAAKn}}$ low-level width               | <67>   | t <sub>WDAL</sub> | 2-cycle transfer       | <b>Note 1</b> | 2T <sub>CPU</sub> – 8 <sup>Note 2</sup> |                                         | ns   |
|                                                          |        |                   |                        | <b>Note 3</b> | 6T <sub>CPU</sub> – 8 <sup>Note 2</sup> |                                         | ns   |
|                                                          |        |                   | Flyby transfer         |               |                                         | 2T <sub>BUS</sub> + WAS + WFW + WIC – 8 |      |
| $\overline{\text{TCn}}$ output delay time (from BUSCLK↑) | <68>   | t <sub>DKTC</sub> | 2-cycle/flyby transfer |               | 2                                       | 13                                      | ns   |
| $\overline{\text{TCn}}$ output hold time (from BUSCLK↑)  | <69>   | t <sub>HKTC</sub> | 2-cycle/flyby transfer |               | 2                                       | 13                                      | ns   |

**Notes** 1. Normal operation ( $\overline{\text{DMAAKn}}$  output width = memory controller output)

2. The access is as follows.

| Transfer Source   | Transfer Destination                            | Speculative Read Function                                                                                                                                                                                                                                                        |
|-------------------|-------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Internal data RAM | External memory/<br>internal instruction<br>RAM | Provided/none                                                                                                                                                                                                                                                                    |
| External memory   | Internal data RAM                               | Provided/none<br>However, when the speculative read function is not provided, the following conditions apply.<br><ul style="list-style-type: none"> <li>BUSCLK = Internal system clock (<math>f_{\text{CLK}}</math>)</li> <li>External memory access wait setting = 0</li> </ul> |

3. When selecting a mode in which  $\overline{\text{DMAAKn}}$  output width = memory controller output +  $4T_{\text{CPU}}$

**Remarks** 1.  $n = 0$  to 3

2.  $T_{\text{BUS}} = 1 \times \text{BUSCLK cycle}$

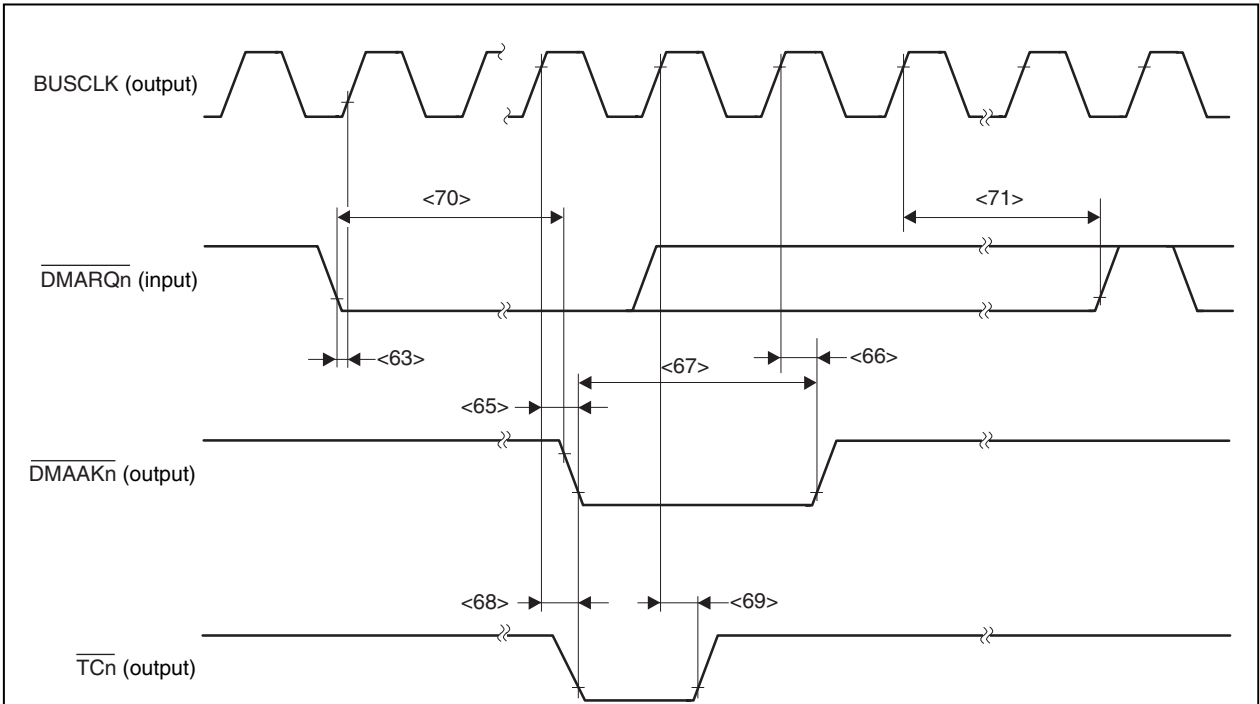
3.  $T_{\text{CPU}} = 1 \times \text{internal system clock } (f_{\text{CLK}}) \text{ cycle}$

4. WAS = Number of address setup waits inserted by ASC register

WFW = Number of data waits inserted by FWC register

WIC = Number of idle states inserted by FIC register

(b) Masks mode (3/3)



**Remarks 1.** The minimum  $\overline{\text{DMAAKn}}$  inactive time is as follows.

| Transfer mode                            | Transfer source                                            | Transfer destination                                                                    | Inactive time     |
|------------------------------------------|------------------------------------------------------------|-----------------------------------------------------------------------------------------|-------------------|
| Single transfer,<br>Single-step transfer | External memory/<br>external I/O<br>on-chip peripheral I/O | External memory/<br>external I/O<br>on-chip peripheral I/O/<br>internal instruction RAM | $4T_{\text{CPU}}$ |
|                                          | Internal data RAM                                          | Internal data RAM                                                                       | $5T_{\text{CPU}}$ |
|                                          | Internal data RAM                                          | External memory/<br>external I/O<br>on-chip peripheral I/O/<br>internal instruction RAM | $9T_{\text{CPU}}$ |
|                                          | External memory/<br>external I/O<br>on-chip peripheral I/O | Internal data RAM                                                                       | $9T_{\text{CPU}}$ |
| Block transfer                           | —                                                          | —                                                                                       | $T_{\text{CPU}}$  |

2.  $n = 0$  to 3

(c) Edge mode (1/3)

| Parameter                                                                                  | Symbol                   | Conditions             | MIN.              | MAX.                                 | Unit |
|--------------------------------------------------------------------------------------------|--------------------------|------------------------|-------------------|--------------------------------------|------|
| $\overline{\text{DMARQn}}$ hold time 3                                                     | <107> $t_{\text{HKDR3}}$ | 2-cycle/flyby transfer | $2T_{\text{CPU}}$ |                                      | ns   |
| $\overline{\text{DMARQn}}$ high-level time 1<br>(from $\overline{\text{DMARQn}}\uparrow$ ) | <72> $t_{\text{WDRH1}}$  | 2-cycle/flyby transfer | $2T_{\text{CPU}}$ |                                      | ns   |
| $\overline{\text{DMARQn}}$ high-level time 2<br>(from $\overline{\text{DMAAKn}}\uparrow$ ) | <73> $t_{\text{WDRH2}}$  | 2-cycle/flyby transfer | 0                 |                                      | ns   |
| $\overline{\text{DMAAKn}}$ output delay time<br>(from $\text{BUSCLK}\uparrow$ )            | <65> $t_{\text{DKDA}}$   | 2-cycle transfer       | 0                 | $nT_{\text{CPU}} + 13^{\text{Note}}$ | ns   |
|                                                                                            |                          | Flyby transfer         | 0                 | 13                                   | ns   |
| $\overline{\text{DMAAKn}}$ output hold time<br>(from $\text{BUSCLK}\uparrow$ )             | <66> $t_{\text{HKDA}}$   | 2-cycle transfer       | 0                 | $nT_{\text{CPU}} + 13^{\text{Note}}$ | ns   |
|                                                                                            |                          | Flyby transfer         | 0                 | 13                                   | ns   |

**Note** n is as follows.

| CKM1 | CKM0 | BUSCLK Ratio to Internal System Clock ( $f_{\text{CLK}}$ ) | n |
|------|------|------------------------------------------------------------|---|
| 0    | 0    | $f_{\text{CLK}}/1$                                         | 1 |
| 0    | 1    | $f_{\text{CLK}}/2$                                         | 2 |
| 1    | 0    | $f_{\text{CLK}}/3$                                         | 3 |
| 1    | 1    | $f_{\text{CLK}}/4$                                         | 4 |

**Remarks 1.**  $n = 0$  to 3

**2.**  $T_{\text{CPU}} = 1 \times$  internal system clock ( $f_{\text{CLK}}$ ) cycle



**(c) Edge mode (2/3)**

| Parameter                                                | Symbol |       | Conditions             |               | MIN.                                                         | MAX. | Unit |
|----------------------------------------------------------|--------|-------|------------------------|---------------|--------------------------------------------------------------|------|------|
| $\overline{\text{DMAAKn}}$ low-level width               | <67>   | tWDAL | 2-cycle transfer       | <b>Note 1</b> | $2T_{\text{CPU}} - 8^{\text{Note 2}}$                        |      | ns   |
|                                                          |        |       |                        | <b>Note 3</b> | $6T_{\text{CPU}} - 8^{\text{Note 2}}$                        |      | ns   |
|                                                          |        |       | Flyby transfer         |               | $2T_{\text{BUS}} + \text{WAS} + \text{WFW} + \text{WIC} - 8$ |      |      |
| $\overline{\text{TCn}}$ output delay time (from BUSCLK↑) | <68>   | tDKTC | 2-cycle/flyby transfer |               | 2                                                            | 13   | ns   |
| $\overline{\text{TCn}}$ output hold time (from BUSCLK↑)  | <69>   | tHKTC | 2-cycle/flyby transfer |               | 2                                                            | 13   | ns   |

- Notes**
1. Time to  $\overline{\text{DMAAKn}}$  high level from  $\text{BUSCLK}\uparrow$  after  $\overline{\text{DMAAKn}}$  rises
  2. The access is as follows.

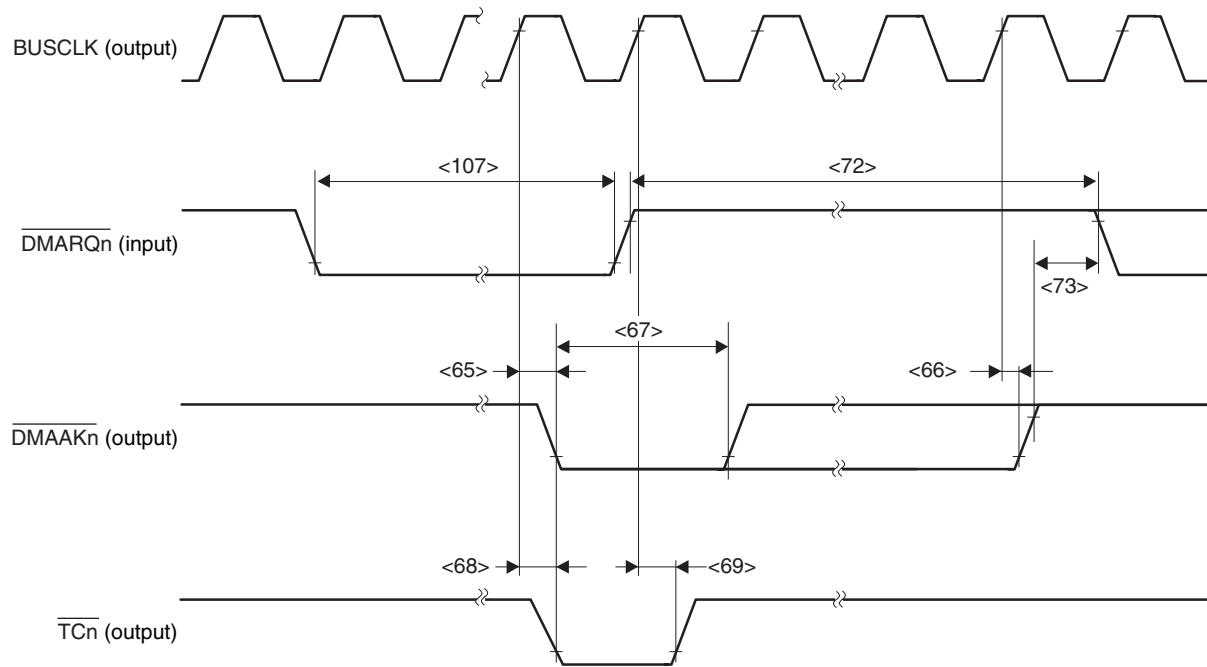
| Transfer Source   | Transfer Destination                            | Speculative Read Function                                                                                                                                                                                                                                                                             |
|-------------------|-------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Internal data RAM | External memory/<br>internal instruction<br>RAM | Provided/none                                                                                                                                                                                                                                                                                         |
| External memory   | Internal data RAM                               | Provided/none<br>However, when the speculative read function is not provided, the following conditions apply. <ul style="list-style-type: none"> <li>• <math>\text{BUSCLK}</math> = Internal system clock (<math>f_{\text{CLK}}</math>)</li> <li>• External memory access wait setting = 0</li> </ul> |

3. Normal operation ( $\overline{\text{DMAAKn}}$  output width = memory controller output)

**Remarks** 1.  $n = 0$  to 3

2.  $T_{\text{BUS}} = 1 \times \text{BUSCLK cycle}$
3.  $T_{\text{CPU}} = 1 \times \text{internal system clock } (f_{\text{CLK}}) \text{ cycle}$
4.  $\text{WAS}$  = Number of address setup waits inserted by ASC register  
 $\text{WFW}$  = Number of data waits inserted by FWC register  
 $\text{WIC}$  = Number of idle states inserted by FIC register

## (c) Edge mode (3/3)



**Remarks 1.** The minimum  $\overline{\text{DMAACKn}}$  inactive time is as follows.

| Transfer mode                            | Transfer source                                            | Transfer destination                                                                    | Inactive time     |
|------------------------------------------|------------------------------------------------------------|-----------------------------------------------------------------------------------------|-------------------|
| Single transfer,<br>Single-step transfer | External memory/<br>external I/O<br>on-chip peripheral I/O | External memory/<br>external I/O<br>on-chip peripheral I/O/<br>internal instruction RAM | $4T_{\text{CPU}}$ |
|                                          | Internal data RAM                                          | Internal data RAM                                                                       | $5T_{\text{CPU}}$ |
|                                          | Internal data RAM                                          | External memory/<br>external I/O<br>on-chip peripheral I/O/<br>internal instruction RAM | $9T_{\text{CPU}}$ |
|                                          | External memory/<br>external I/O<br>on-chip peripheral I/O | Internal data RAM                                                                       | $9T_{\text{CPU}}$ |
| Block transfer                           | —                                                          | —                                                                                       | $T_{\text{CPU}}$  |

2.  $n = 0$  to 3

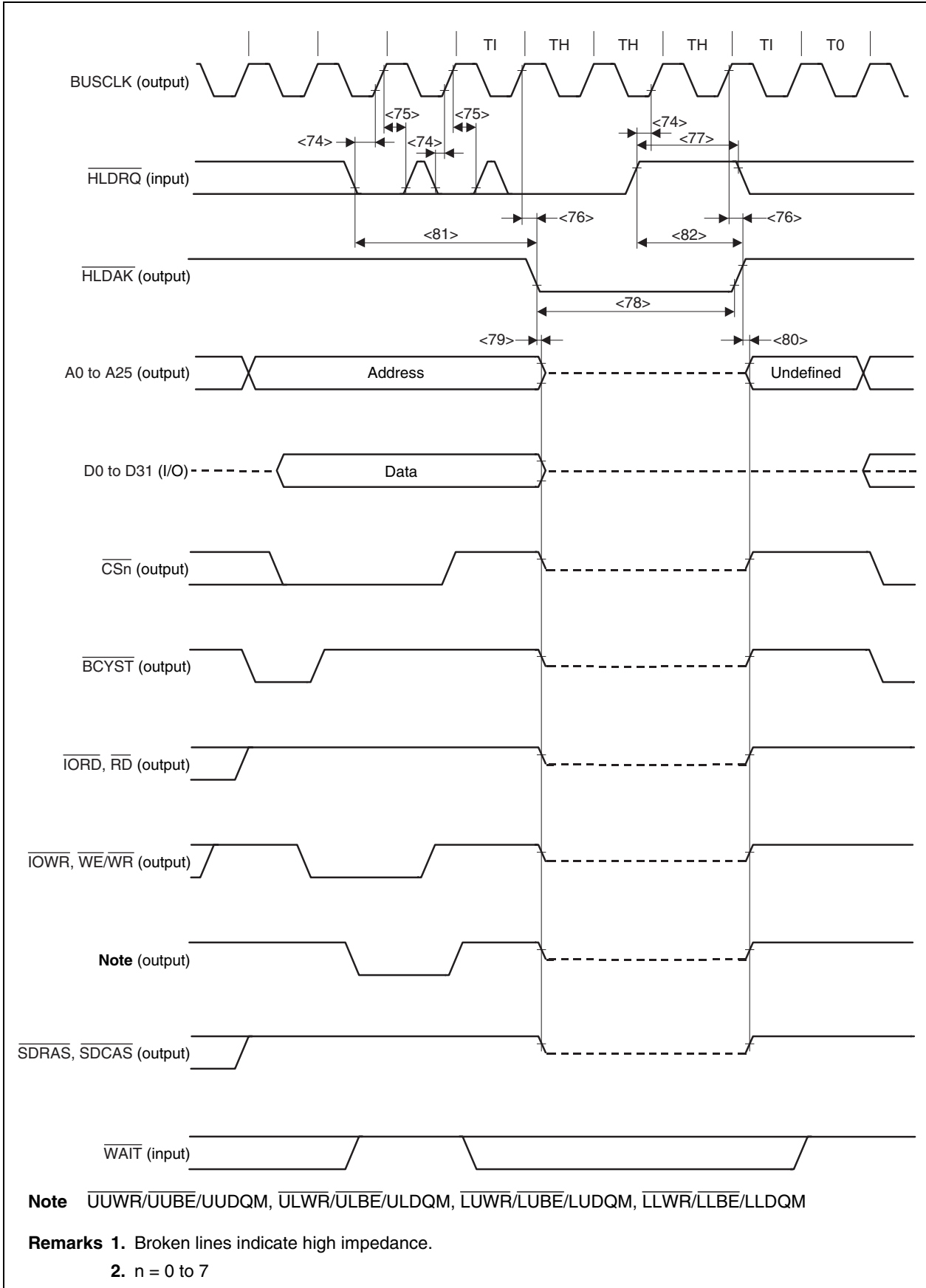
**(8) Bus hold timing (1/2)**

| Parameter                                                                                         | Symbol                   | Conditions    | MIN.     | MAX.      | Unit |
|---------------------------------------------------------------------------------------------------|--------------------------|---------------|----------|-----------|------|
| $\overline{\text{HLDRQ}}$ setup time (to $\text{BUSCLK}\uparrow$ )                                | <74> $t_{\text{SHRK}}$   |               | 10       |           | ns   |
| $\overline{\text{HLDRQ}}$ hold time (from $\text{BUSCLK}\uparrow$ )                               | <75> $t_{\text{HKHR}}$   |               | 2        |           | ns   |
| Delay time from $\text{BUSCLK}\uparrow$ to $\text{HLD}\overline{\text{AK}}$                       | <76> $t_{\text{DKHA}}$   |               | 2        | 11        | ns   |
| $\overline{\text{HLDRQ}}$ high-level width                                                        | <77> $t_{\text{WHQH}}$   |               | $T + 12$ |           | ns   |
| $\text{HLD}\overline{\text{AK}}$ low-level width                                                  | <78> $t_{\text{WHAL}}$   |               | $T - 11$ |           | ns   |
| Delay time from $\text{HLD}\overline{\text{AK}}\downarrow$ to bus float                           | <79> $t_{\text{DKCF}}$   |               | 0        |           | ns   |
| Delay time from $\text{HLD}\overline{\text{AK}}\uparrow$ to bus output                            | <80> $t_{\text{DHAC}}$   |               | 0        | 11        | ns   |
| Delay time from $\overline{\text{HLDRQ}}\downarrow$ to $\text{HLD}\overline{\text{AK}}\downarrow$ | <81> $t_{\text{DHQHA1}}$ | <b>Note 1</b> | 4T       |           | ns   |
|                                                                                                   |                          | <b>Note 2</b> | 3T       |           | ns   |
|                                                                                                   |                          | <b>Note 3</b> | 3T       |           | ns   |
| Delay time from $\overline{\text{HLDRQ}}\uparrow$ to $\text{HLD}\overline{\text{AK}}\uparrow$     | <82> $t_{\text{DHQHA2}}$ |               | T        | $2T + 12$ | ns   |

- Notes**
1.  $\text{BUSCLK}$  divided by 2
  2.  $\text{BUSCLK}$  divided by 3
  3.  $\text{BUSCLK}$  divided by 4

**Remark**  $T = t_{\text{CYK}}$

(8) Bus hold timing (2/2)



## (9) Interrupt timing (1/2)

| Parameter                                          | Symbol           | Conditions                                      | MIN.                                               | MAX.                                                | Unit |
|----------------------------------------------------|------------------|-------------------------------------------------|----------------------------------------------------|-----------------------------------------------------|------|
| NMI high-level width                               | <83> $t_{WNIH}$  |                                                 | 500                                                |                                                     | ns   |
| NMI low-level width                                | <84> $t_{WNIL}$  |                                                 | 500                                                |                                                     | ns   |
| INTPCm0, INTPCm1 pin (m = 0 to 3) high-level width | <85> $t_{WITCH}$ | When noise elimination has been set             | (Number of set elimination clocks + 1)/(fx/4) + 10 |                                                     | ns   |
|                                                    |                  | When clock-through has been set                 | $1/(fx/4) \times 2 + 10$                           |                                                     | ns   |
| INTPCm0, INTPCm1 pin (m = 0 to 3) low-level width  | <86> $t_{WITCL}$ | When noise elimination has been set             | (Number of set elimination clocks + 1)/(fx/4) + 10 |                                                     | ns   |
|                                                    |                  | When clock-through has been set                 | $1/(fx/4) \times 2 + 10$                           |                                                     | ns   |
| INTPa pin high-level width                         | <87> $t_{WIT1H}$ | When noise elimination has been set             | Noise elimination clock = fx/4 selected            | (Number of set elimination clocks + 1)/(fx/4) + 10  | ns   |
|                                                    |                  |                                                 | Noise elimination clock = fx/32 selected           | (Number of set elimination clocks + 1)/(fx/32) + 10 | ns   |
|                                                    |                  | When clock-through has been set <sup>Note</sup> | Noise elimination clock = fx/4 selected            | $1/(fx/4) \times 2 + 10$                            | ns   |
| INTPa pin low-level width                          | <88> $t_{WIT1L}$ | When noise elimination has been set             | Noise elimination clock = fx/4 selected            | (Number of set elimination clocks + 1)/(fx/4) + 10  | ns   |
|                                                    |                  |                                                 | Noise elimination clock = fx/32 selected           | (Number of set elimination clocks + 1)/(fx/32) + 10 | ns   |
|                                                    |                  | When clock-through has been set <sup>Note</sup> | Noise elimination clock = fx/4 selected            | $1/(fx/4) \times 2 + 10$                            | ns   |
| INTPb high-level width                             | <89> $t_{WITPH}$ | Both edge and level detection                   | $500 + 1/(fx/4) + 10$                              |                                                     | ns   |
| INTPb low-level width                              | <90> $t_{WITPL}$ | Both edge and level detection                   | $500 + 1/(fx/4) + 10$                              |                                                     | ns   |

**Note** When clock-through has been set, do not select a noise elimination clock of fx/32.

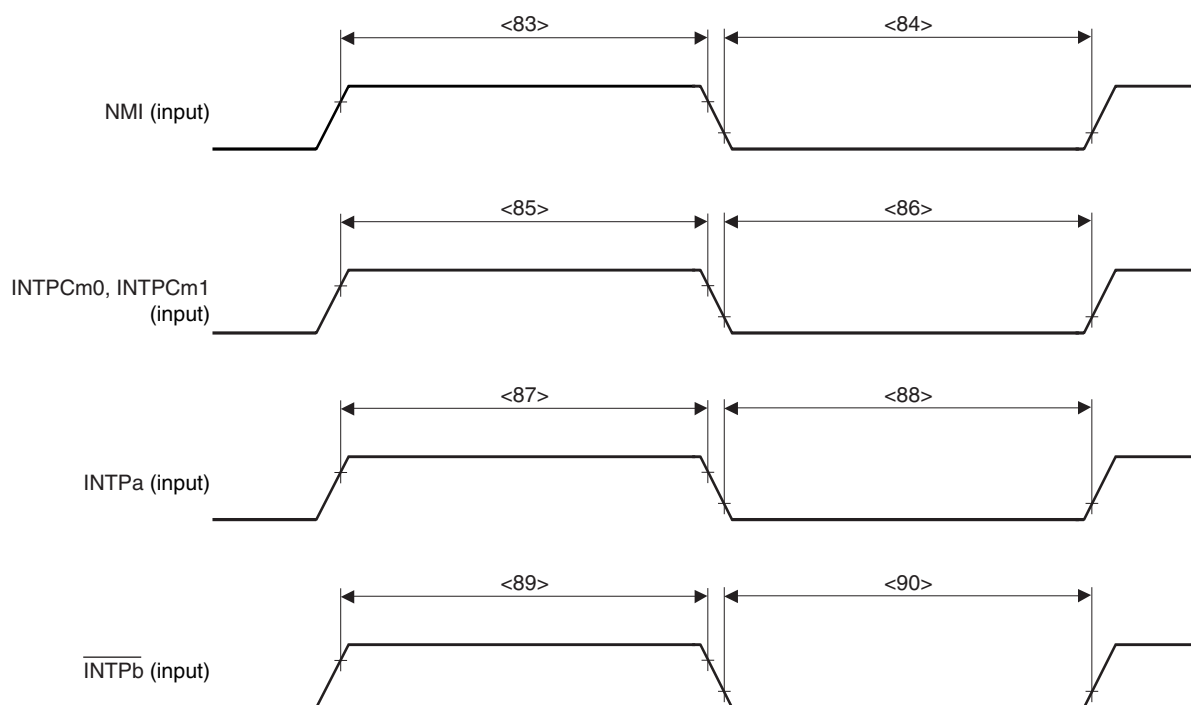
**Remarks 1.** The noise elimination clock and clock-through are set values of the NCWC0 to NCWC3, NCW10, and NCW11 registers.

**2.** fx: Main clock

**3.** a = 100, 101, 110, 111

b = 10, 11, 21 to 25, 50 to 52, 65 to 67, D0 to D15, L0, L1

## (9) Interrupt timing (2/2)

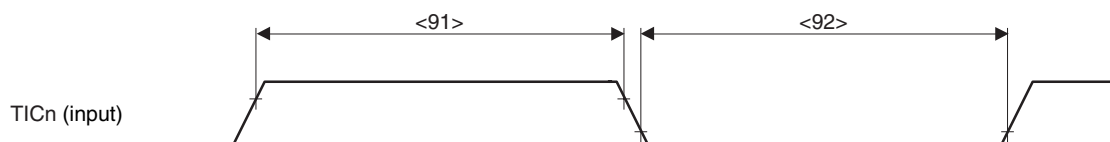


**Remark** m = 0 to 3  
a = 100, 101, 110, 111  
b = 10, 11, 21 to 25, 50 to 52, 65 to 67, D0 to D15, L0, L1

## (10) Timer C timing

| Parameter             | Symbol | Conditions        | MIN.                                | MAX.                                                      | Unit |
|-----------------------|--------|-------------------|-------------------------------------|-----------------------------------------------------------|------|
| TICn high-level width | <91>   | $t_{\text{WTH}}$  | When noise elimination has been set | (Number of set elimination clocks + 1)/<br>$(f_x/4) + 10$ | ns   |
|                       |        |                   | When clock-through has been set     | $1/(f_x/4) \times 2 + 10$                                 | ns   |
| TICn low-level width  | <92>   | $t_{\text{WTCL}}$ | When noise elimination has been set | (Number of set elimination clocks + 1)/<br>$(f_x/4) + 10$ | ns   |
|                       |        |                   | When clock-through has been set     | $1/(f_x/4) \times 2 + 10$                                 | ns   |

- Remarks** 1. n = 0 to 3  
2. The noise elimination clock and clock-through are set values of the NCWC0 to NCWC3 registers.



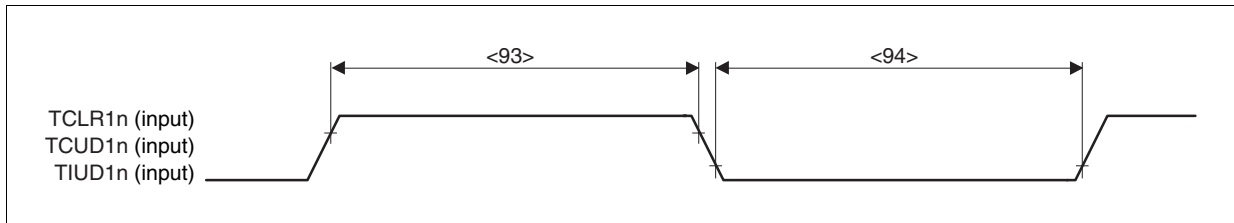
(11) Timer ENC1 timing

| Parameter                                   | Symbol | Conditions                                      |                                            | MIN.                                        | MAX.                                                     | Unit |
|---------------------------------------------|--------|-------------------------------------------------|--------------------------------------------|---------------------------------------------|----------------------------------------------------------|------|
| TCLR1n, TCUD1n, TIUD1n pin high-level width | <93>   | twTENCH                                         | When noise elimination has been set        | Noise elimination clock = $f_x/4$ selected  | (Number of set elimination clocks + 1)/( $f_x/4$ ) + 10  | ns   |
|                                             |        |                                                 |                                            | Noise elimination clock = $f_x/32$ selected | (Number of set elimination clocks + 1)/( $f_x/32$ ) + 10 | ns   |
|                                             |        | When clock-through has been set <sup>Note</sup> | Noise elimination clock = $f_x/4$ selected | $1/(f_x/4) \times 2 + 10$                   |                                                          | ns   |
| TCLR1n, TCUD1n, TIUD1n pin low-level width  | <94>   | twTENCL                                         | When noise elimination has been set        | Noise elimination clock = $f_x/4$ selected  | (Number of set elimination clocks + 1)/( $f_x/4$ ) + 10  | ns   |
|                                             |        |                                                 |                                            | Noise elimination clock = $f_x/32$ selected | (Number of set elimination clocks + 1)/( $f_x/32$ ) + 10 | ns   |
|                                             |        | When clock-through has been set <sup>Note</sup> | Noise elimination clock = $f_x/4$ selected | $1/(f_x/4) \times 2 + 10$                   |                                                          | ns   |

**Note** When clock-through has been set, do not select a noise elimination clock of  $f_x/32$ .

**Remarks** 1.  $n = 0, 1$

2. The noise elimination clock and clock-through are the set values of the NCW10 and NCW11 registers.



## (12) CSI30, CSI31 timing (1/3)

## (a) Master mode

| Parameter                                                        | Symbol                   | Conditions | MIN.                       | MAX. | Unit |
|------------------------------------------------------------------|--------------------------|------------|----------------------------|------|------|
| $\overline{\text{SCKn}}$ cycle                                   | <95> $t_{\text{CYSK1}}$  | Output     | 182                        |      | ns   |
| $\overline{\text{SCKn}}$ high-level width                        | <96> $t_{\text{WSK1H}}$  | Output     | $0.5t_{\text{CYSK1}} - 12$ |      | ns   |
| $\overline{\text{SCKn}}$ low-level width                         | <97> $t_{\text{WSK1L}}$  | Output     | $0.5t_{\text{CYSK1}} - 12$ |      | ns   |
| SIn setup time (to $\overline{\text{SCKn}}\uparrow$ )            | <98> $t_{\text{SSISK}}$  |            | 12                         |      | ns   |
| SIn setup time (to $\overline{\text{SCKn}}\downarrow$ )          |                          |            | 12                         |      | ns   |
| SIn hold time (from $\overline{\text{SCKn}}\uparrow$ )           | <99> $t_{\text{HSKSI}}$  |            | 5                          |      | ns   |
| SIn hold time (from $\overline{\text{SCKn}}\downarrow$ )         |                          |            | 5                          |      | ns   |
| SOn output delay time (from $\overline{\text{SCKn}}\downarrow$ ) | <100> $t_{\text{DSKSO}}$ |            |                            | 7    | ns   |
| SOn output delay time (from $\overline{\text{SCKn}}\uparrow$ )   |                          |            |                            | 7    | ns   |
| SOn output hold time (from $\overline{\text{SCKn}}\uparrow$ )    | <101> $t_{\text{HSKSO}}$ |            | $0.5t_{\text{CYSK1}} - 5$  |      | ns   |
| SOn output hold time (from $\overline{\text{SCKn}}\downarrow$ )  |                          |            | $0.5t_{\text{CYSK1}} - 5$  |      | ns   |

**Remark** n = 0, 1

## (b) Slave mode

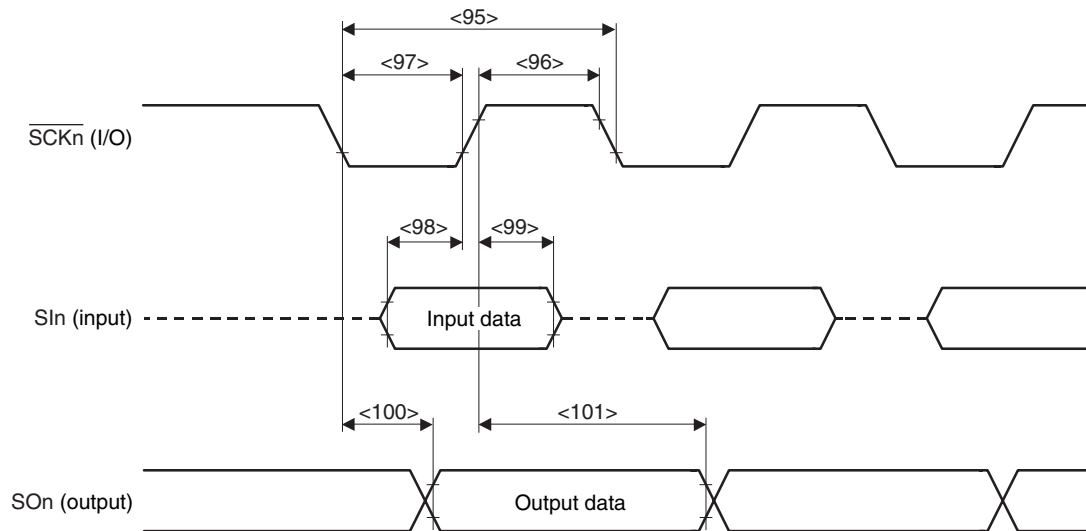
| Parameter                                                        | Symbol                   | Conditions | MIN.                       | MAX. | Unit |
|------------------------------------------------------------------|--------------------------|------------|----------------------------|------|------|
| $\overline{\text{SCKn}}$ cycle                                   | <95> $t_{\text{CYSK1}}$  | Input      | 182                        |      | ns   |
| $\overline{\text{SCKn}}$ high-level width                        | <96> $t_{\text{WSK1H}}$  | Input      | $0.5t_{\text{CYSK1}} - 20$ |      | ns   |
| $\overline{\text{SCKn}}$ low-level width                         | <97> $t_{\text{WSK1L}}$  | Input      | $0.5t_{\text{CYSK1}} - 20$ |      | ns   |
| SIn setup time (to $\overline{\text{SCKn}}\uparrow$ )            | <98> $t_{\text{SSISK}}$  |            | 30                         |      | ns   |
| SIn setup time (to $\overline{\text{SCKn}}\downarrow$ )          |                          |            | 30                         |      | ns   |
| SIn hold time (from $\overline{\text{SCKn}}\uparrow$ )           | <99> $t_{\text{HSKSI}}$  |            | $1.5T + 10$                |      | ns   |
| SIn hold time (from $\overline{\text{SCKn}}\downarrow$ )         |                          |            | $1.5T + 10$                |      | ns   |
| SOn output delay time (from $\overline{\text{SCKn}}\downarrow$ ) | <100> $t_{\text{DSKSO}}$ |            |                            | 12   | ns   |
| SOn output delay time (from $\overline{\text{SCKn}}\uparrow$ )   |                          |            |                            | 12   | ns   |
| SOn output hold time (from $\overline{\text{SCKn}}\uparrow$ )    | <101> $t_{\text{HSKSO}}$ |            | $t_{\text{WSK1H}}$         |      | ns   |
| SOn output hold time (from $\overline{\text{SCKn}}\downarrow$ )  |                          |            | $t_{\text{WSK1H}}$         |      | ns   |

**Remarks** 1. n = 0, 12.  $T = f_x/4$



(12) CSI30, CSI31 timing (2/3)

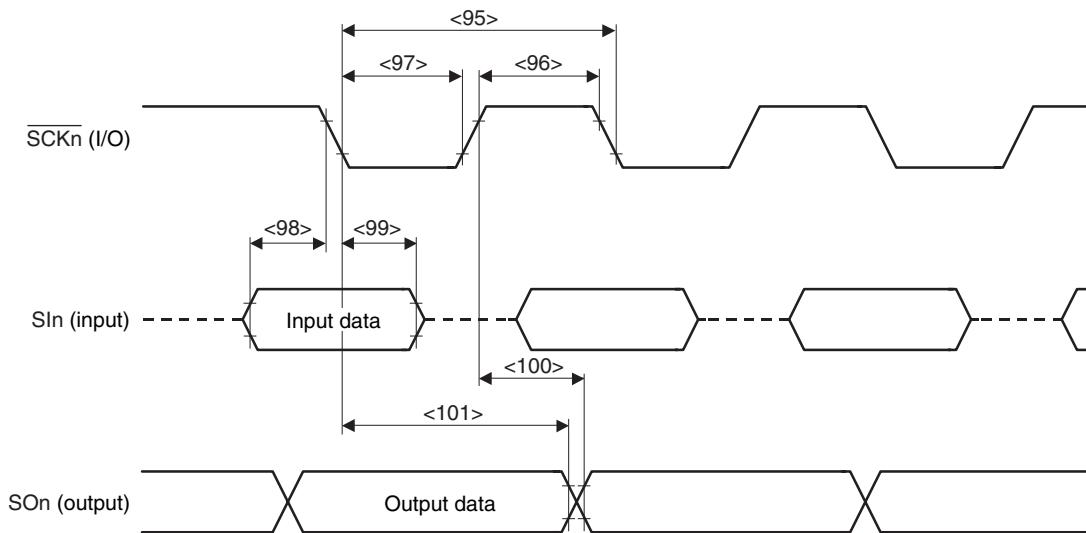
(c) Timing when CKPn and DAPn bits of CSIC3n register = 00



**Remarks** 1. Broken lines indicate high impedance.

2. n = 0, 1

(d) Timing when CKPn and DAPn bits of CSIC3n register = 01

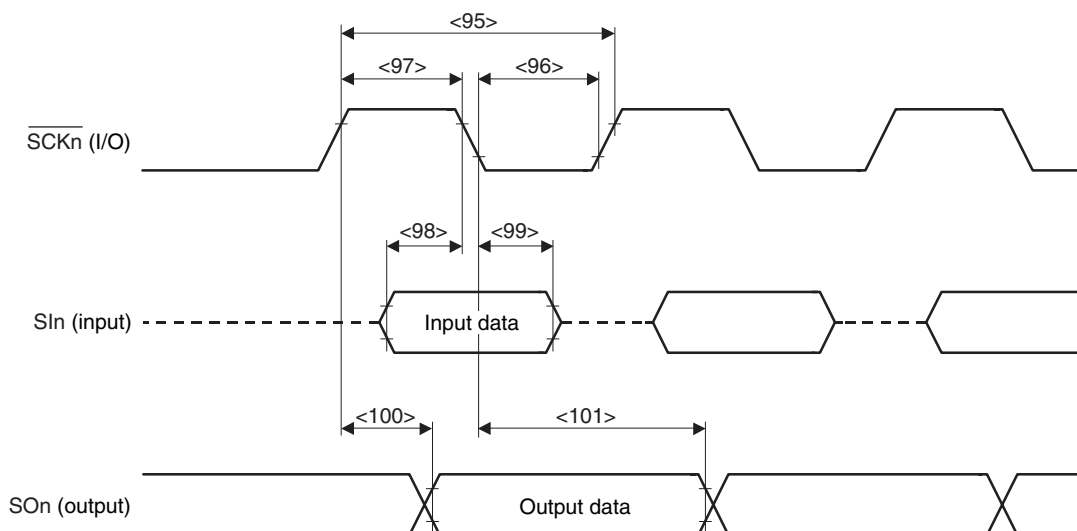


**Remarks** 1. Broken lines indicate high impedance.

2. n = 0, 1

## (12) CSI30, CSI31 timing (3/3)

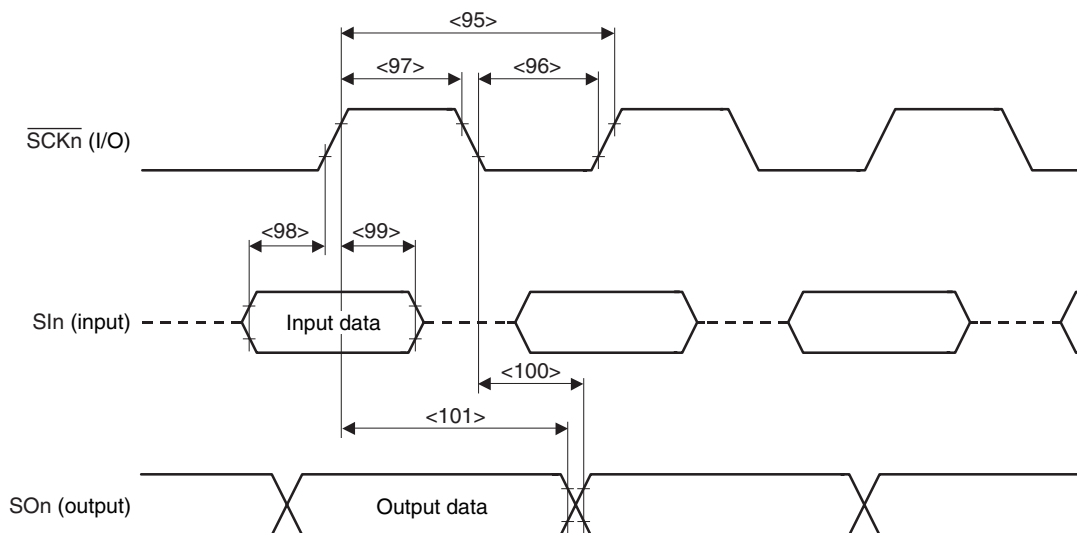
## (e) Timing when CKPn and DAPn bits of CSIC3n register = 10



**Remarks** 1. Broken lines indicate high impedance.

2. n = 0, 1

## (f) Timing when CKPn and DAPn bits of CSIC3n register = 11



**Remarks** 1. Broken lines indicate high impedance.

2. n = 0, 1

**A/D Converter Characteristics (EV<sub>DD</sub> = AV<sub>DD</sub> = AV<sub>REFP</sub> = 3.0 to 3.6 V, EV<sub>SS</sub> = AV<sub>SS</sub> = AV<sub>REFM</sub> = 0 V)**

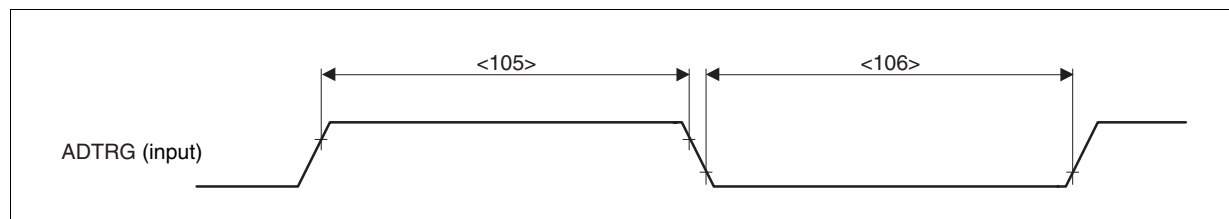
| Parameter                                      | Symbol | Conditions        | MIN.                                       | TYP. | MAX.               | Unit |
|------------------------------------------------|--------|-------------------|--------------------------------------------|------|--------------------|------|
| Resolution                                     | –      | –                 | 10                                         |      |                    | bit  |
| Overall error <sup>Note 1</sup>                | –      | –                 |                                            |      | ±0.49              | %FSR |
| Quantization error                             | –      | –                 |                                            |      | ±1/2               | LSB  |
| Conversion time                                | –      | t <sub>CONV</sub> | 2.00                                       |      | 10                 | μs   |
| Sampling time                                  | –      | t <sub>SAMP</sub> | 3 × conversion clock <sup>Note 2</sup> /16 |      |                    | ns   |
| Zero-scale error <sup>Note 1</sup>             | –      | –                 |                                            |      | ±0.49              | %FSR |
| Full-scale error <sup>Note 1</sup>             | –      | –                 |                                            |      | ±0.49              | %FSR |
| Integral linearity error <sup>Note 3</sup>     | –      | –                 |                                            |      | ±4                 | LSB  |
| Differential linearity error <sup>Note 3</sup> | –      | –                 |                                            |      | ±4                 | LSB  |
| Analog input voltage                           | –      | V <sub>WASN</sub> | AV <sub>REFM</sub>                         |      | AV <sub>REFP</sub> | V    |
| AV <sub>DD</sub> power supply current          | –      | A <sub>IDD</sub>  |                                            |      | 10                 | mA   |
| ADTRG high-level width                         | <105>  | t <sub>WAIH</sub> | 500                                        |      |                    | ns   |
| ADTRG low-level width                          | <106>  | t <sub>WAIL</sub> | 500                                        |      |                    | ns   |

- Notes**
1. Excluding quantization error (±0.05 %FSR).
  2. The conversion clock indicates the number of clocks set by the ADM1 register.
  3. Excluding quantization error (±0.5 LSB).

**Remark** LSB: Least Significant Bit

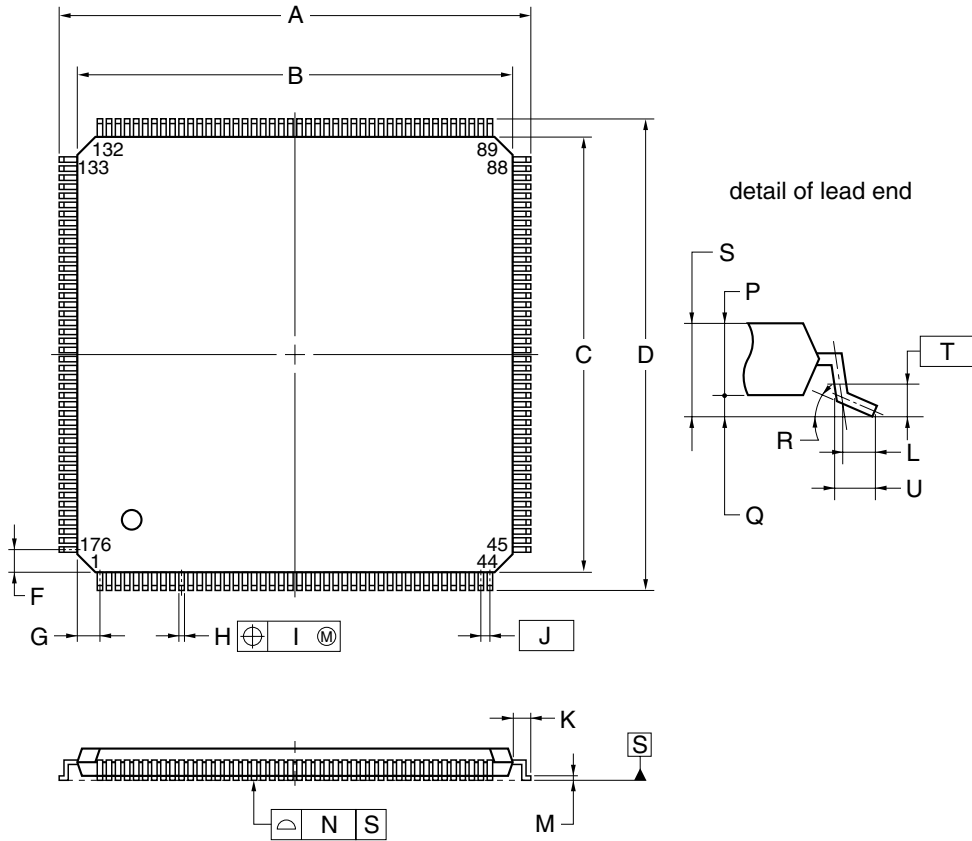
FSR: Full Scale Range

%FSR indicates the ratio to the full-scale value.



## CHAPTER 18 PACKAGE DRAWINGS

### 176-PIN PLASTIC LQFP (FINE PITCH) (24x24)



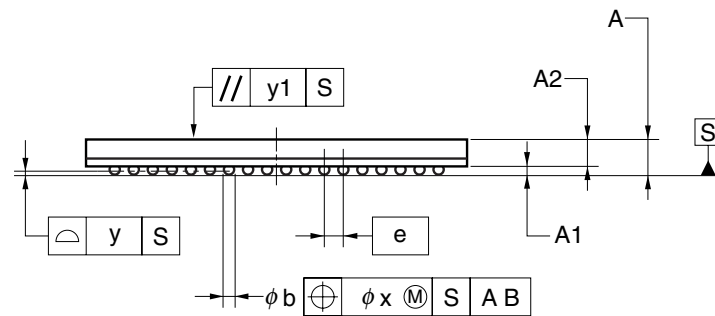
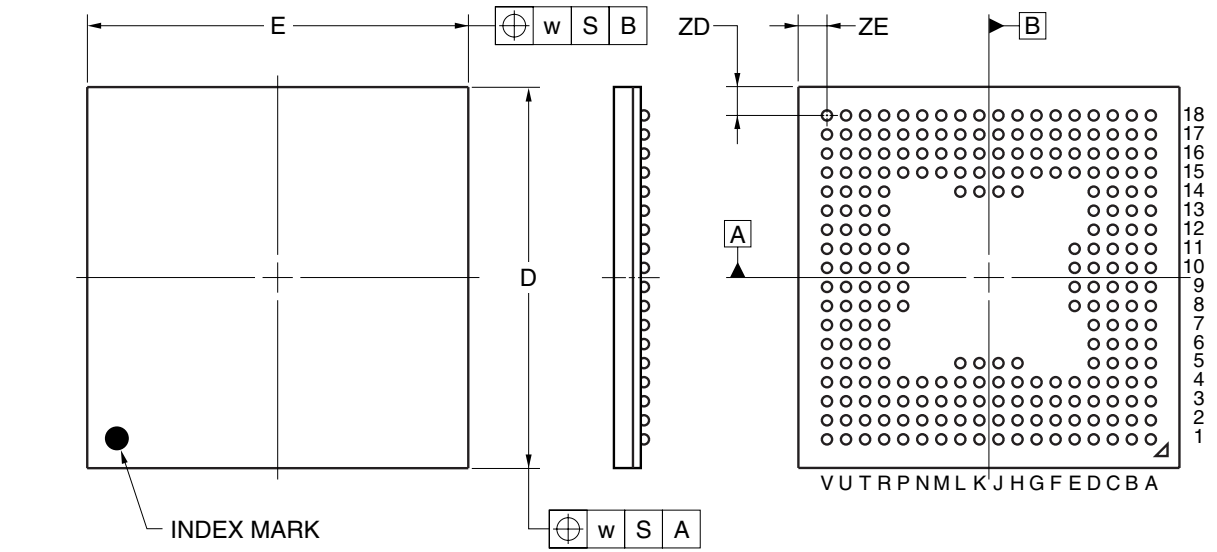
#### NOTE

Each lead centerline is located within 0.10 mm of its true position (T.P.) at maximum material condition.

| ITEM | MILLIMETERS                            |
|------|----------------------------------------|
| A    | 26.0±0.2                               |
| B    | 24.0±0.2                               |
| C    | 24.0±0.2                               |
| D    | 26.0±0.2                               |
| F    | 1.25                                   |
| G    | 1.25                                   |
| H    | 0.22±0.05                              |
| I    | 0.08                                   |
| J    | 0.5 (T.P.)                             |
| K    | 1.0±0.2                                |
| L    | 0.5                                    |
| M    | 0.17 <sup>+0.03</sup> <sub>-0.07</sub> |
| N    | 0.08                                   |
| P    | 1.4                                    |
| Q    | 0.1±0.05                               |
| R    | 3° <sup>+4°</sup> <sub>-3°</sub>       |
| S    | 1.5±0.1                                |
| T    | 0.25                                   |
| U    | 0.60±0.15                              |

S176GM-50-UEU-1

## 240-PIN PLASTIC FBGA (16x16)



(UNIT:mm)

| ITEM | DIMENSIONS                             |
|------|----------------------------------------|
| D    | 16.00±0.10                             |
| E    | 16.00±0.10                             |
| w    | 0.20                                   |
| A    | 1.48±0.10                              |
| A1   | 0.35±0.06                              |
| A2   | 1.13                                   |
| e    | 0.80                                   |
| b    | 0.50 <sup>+0.05</sup> <sub>-0.10</sub> |
| x    | 0.08                                   |
| y    | 0.10                                   |
| y1   | 0.20                                   |
| ZD   | 1.20                                   |
| ZE   | 1.20                                   |

P240F1-80-GA3

## CHAPTER 19 RECOMMENDED SOLDERING CONDITIONS

The V850E/ME2 should be soldered and mounted under the following recommended conditions.  
For technical information, see the following website.

Semiconductor Device Mount Manual (<http://www.necel.com/pkg/en/mount/index.html>)

<R> **Caution** The recommended soldering conditions for the following products are undetermined.

- $\mu$ PD703111AF1-13-GA3
- $\mu$ PD703111AF1-13-GA3-A
- $\mu$ PD703111AF1-15-GA3
- $\mu$ PD703111AF1-15-GA3-A

**Remark** Products with -A at the end of the part number are lead-free products.

Table 19-1. Surface Mounting Type Soldering Conditions

- $\mu$ PD703111AGM-10-UEU: 176-pin plastic LQFP (fine pitch) (24 × 24)
- <R>  $\mu$ PD703111AGM-10-UEU-A: 176-pin plastic LQFP (fine pitch) (24 × 24)
- $\mu$ PD703111AGM-13-UEU: 176-pin plastic LQFP (fine pitch) (24 × 24)
- <R>  $\mu$ PD703111AGM-13-UEU-A: 176-pin plastic LQFP (fine pitch) (24 × 24)
- $\mu$ PD703111AGM-15-UEU: 176-pin plastic LQFP (fine pitch) (24 × 24)
- <R>  $\mu$ PD703111AGM-15-UEU-A: 176-pin plastic LQFP (fine pitch) (24 × 24)

| Soldering Method | Soldering Conditions                                                                                                                                                                         | Recommended Condition Symbol |
|------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------|
| Infrared reflow  | Package peak temperature: 250°C, Time: 30 seconds max. (at 210°C or higher), Count: Three times or less<br>Exposure limit: 3days <sup>Note</sup> (after that, prebake at 125°C for 20 hours) | IR50-203-3                   |
| Partial heating  | Pin temperature: 350°C max., Time: 3 seconds max. (per pin row)                                                                                                                              | —                            |

**Note** After opening the dry pack, store it at 25°C or less and 65% RH or less for the allowable storage period.

**Remark** For soldering methods and conditions other than those recommended above, consult an NEC Electronics sales representative.

## APPENDIX A REGISTER INDEX

(1/13)

| Symbol           | Name                                     | Unit  | Page |
|------------------|------------------------------------------|-------|------|
| ADCR0 to ADCR7   | A/D conversion result registers 0 to 7   | ADC   | 748  |
| ADCR0H to ADCR7H | A/D conversion result registers 0H to 7H | ADC   | 748  |
| ADIC             | Interrupt control register 83            | ADC   | 338  |
| ADM0             | A/D converter mode register 0            | ADC   | 743  |
| ADM1             | A/D converter mode register 1            | ADC   | 744  |
| ADM2             | A/D converter mode register 2            | ADC   | 746  |
| ADTS             | ADC trigger select register              | ADC   | 747  |
| ASC              | Address setup wait control register      | BCU   | 156  |
| BCC              | Bus cycle control register               | BCU   | 161  |
| BCP              | Bus cycle period control register        | BCU   | 157  |
| BCT0             | Bus cycle type configuration register 0  | BCU   | 120  |
| BCT1             | Bus cycle type configuration register 1  | BCU   | 120  |
| BEC              | Endian configuration register            | BCU   | 123  |
| BHC              | Cache configuration register             | BCU   | 163  |
| BMC              | Bus mode control register                | BCU   | 152  |
| CC100            | Capture/compare register 100             | Timer | 464  |
| CC101            | Capture/compare register 101             | Timer | 465  |
| CC10IC0          | Interrupt control register 53            | INTC  | 337  |
| CC10IC1          | Interrupt control register 54            | INTC  | 337  |
| CC110            | Capture/compare register 110             | Timer | 464  |
| CC111            | Capture/compare register 111             | Timer | 465  |
| CC11IC0          | Interrupt control register 59            | INTC  | 337  |
| CC11IC1          | Interrupt control register 60            | INTC  | 337  |
| CCC00            | Capture/compare register C00             | Timer | 412  |
| CCC01            | Capture/compare register C01             | Timer | 412  |
| CCC0IC0          | Interrupt control register 37            | INTC  | 336  |
| CCC0IC1          | Interrupt control register 38            | INTC  | 336  |
| CCC10            | Capture/compare register C10             | Timer | 412  |
| CCC11            | Capture/compare register C11             | Timer | 412  |
| CCC1IC0          | Interrupt control register 39            | INTC  | 336  |
| CCC1IC1          | Interrupt control register 40            | INTC  | 336  |
| CCC20            | Capture/compare register C20             | Timer | 412  |
| CCC21            | Capture/compare register C21             | Timer | 412  |
| CCC2IC0          | Interrupt control register 41            | INTC  | 337  |
| CCC2IC1          | Interrupt control register 42            | INTC  | 337  |

| Symbol   | Name                                              | Unit  | Page |
|----------|---------------------------------------------------|-------|------|
| CCC30    | Capture/compare register C30                      | Timer | 412  |
| CCC31    | Capture/compare register C31                      | Timer | 412  |
| CCC3IC0  | Interrupt control register 43                     | INTC  | 337  |
| CCC3IC1  | Interrupt control register 44                     | INTC  | 337  |
| CCC40    | Capture/compare register C40                      | Timer | 412  |
| CCC41    | Capture/compare register C41                      | Timer | 412  |
| CCC4IC0  | Interrupt control register 45                     | INTC  | 337  |
| CCC4IC1  | Interrupt control register 46                     | INTC  | 337  |
| CCC50    | Capture/compare register C50                      | Timer | 412  |
| CCC51    | Capture/compare register C51                      | Timer | 412  |
| CCC5IC0  | Interrupt control register 47                     | INTC  | 337  |
| CCC5IC1  | Interrupt control register 48                     | INTC  | 337  |
| CCR10    | Capture/compare control register 10               | Timer | 455  |
| CCR11    | Capture/compare control register 11               | Timer | 455  |
| CKC      | Clock control register                            | CG    | 369  |
| CKS      | Clock source select register                      | CG    | 374  |
| CM100    | Compare register 100                              | Timer | 462  |
| CM101    | Compare register 101                              | Timer | 463  |
| CM10IC0  | Interrupt control register 55                     | INTC  | 337  |
| CM10IC1  | Interrupt control register 56                     | INTC  | 337  |
| CM110    | Compare register 110                              | Timer | 462  |
| CM111    | Compare register 111                              | Timer | 463  |
| CM11IC0  | Interrupt control register 61                     | INTC  | 337  |
| CM11IC1  | Interrupt control register 62                     | INTC  | 337  |
| CMD0     | Compare register D0                               | Timer | 440  |
| CMD1     | Compare register D1                               | Timer | 440  |
| CMD2     | Compare register D2                               | Timer | 440  |
| CMD3     | Compare register D3                               | Timer | 440  |
| CMDIC0   | Interrupt control register 49                     | INTC  | 337  |
| CMDIC1   | Interrupt control register 50                     | INTC  | 337  |
| CMDIC2   | Interrupt control register 51                     | INTC  | 337  |
| CMDIC3   | Interrupt control register 52                     | INTC  | 337  |
| COVF3IC0 | Interrupt control register 70                     | INTC  | 337  |
| COVF3IC1 | Interrupt control register 72                     | INTC  | 337  |
| CSC0     | Chip area select control register 0               | BCU   | 117  |
| CSC1     | Chip area select control register 1               | BCU   | 117  |
| CSI3IC0  | Interrupt control register 69                     | INTC  | 337  |
| CSI3IC1  | Interrupt control register 71                     | INTC  | 337  |
| CSIC30   | Clocked serial interface clock select register 30 | CSI30 | 543  |



| Symbol | Name                                              | Unit  | Page |
|--------|---------------------------------------------------|-------|------|
| CSIC31 | Clocked serial interface clock select register 31 | CSI31 | 543  |
| CSIL30 | Transfer data length select register 30           | CSI30 | 551  |
| CSIL31 | Transfer data length select register 31           | CSI31 | 551  |
| CSIM30 | Clocked serial interface mode register 30         | CSI30 | 541  |
| CSIM31 | Clocked serial interface mode register 31         | CSI31 | 541  |
| DADC0  | DMA addressing control register 0                 | DMAC  | 262  |
| DADC1  | DMA addressing control register 1                 | DMAC  | 262  |
| DADC2  | DMA addressing control register 2                 | DMAC  | 262  |
| DADC3  | DMA addressing control register 3                 | DMAC  | 262  |
| DBC0   | DMA transfer count register 0                     | DMAC  | 261  |
| DBC1   | DMA transfer count register 1                     | DMAC  | 261  |
| DBC2   | DMA transfer count register 2                     | DMAC  | 261  |
| DBC3   | DMA transfer count register 3                     | DMAC  | 261  |
| DCHC0  | DMA channel control register 0                    | DMAC  | 265  |
| DCHC1  | DMA channel control register 1                    | DMAC  | 265  |
| DCHC2  | DMA channel control register 2                    | DMAC  | 265  |
| DCHC3  | DMA channel control register 3                    | DMAC  | 265  |
| DDA0H  | DMA destination address register 0H               | DMAC  | 259  |
| DDA0L  | DMA destination address register 0L               | DMAC  | 260  |
| DDA1H  | DMA destination address register 1H               | DMAC  | 259  |
| DDA1L  | DMA destination address register 1L               | DMAC  | 260  |
| DDA2H  | DMA destination address register 2H               | DMAC  | 259  |
| DDA2L  | DMA destination address register 2L               | DMAC  | 260  |
| DDA3H  | DMA destination address register 3H               | DMAC  | 259  |
| DDA3L  | DMA destination address register 3L               | DMAC  | 260  |
| DIFC   | DMA interface control register                    | DMAC  | 275  |
| DMAIC0 | Interrupt control register 65                     | INTC  | 337  |
| DMAIC1 | Interrupt control register 66                     | INTC  | 337  |
| DMAIC2 | Interrupt control register 67                     | INTC  | 337  |
| DMAIC3 | Interrupt control register 68                     | INTC  | 337  |
| DSA0H  | DMA source address register 0H                    | DMAC  | 257  |
| DSA0L  | DMA source address register 0L                    | DMAC  | 258  |
| DSA1H  | DMA source address register 1H                    | DMAC  | 257  |
| DSA1L  | DMA source address register 1L                    | DMAC  | 258  |
| DSA2H  | DMA source address register 2H                    | DMAC  | 257  |
| DSA2L  | DMA source address register 2L                    | DMAC  | 258  |
| DSA3H  | DMA source address register 3H                    | DMAC  | 257  |
| DSA3L  | DMA source address register 3L                    | DMAC  | 258  |
| DTFR0  | DMA trigger factor register 0                     | DMAC  | 269  |

| Symbol  | Name                                                       | Unit | Page          |
|---------|------------------------------------------------------------|------|---------------|
| DTFR1   | DMA trigger factor register 1                              | DMAC | 269           |
| DTFR2   | DMA trigger factor register 2                              | DMAC | 269           |
| DTFR3   | DMA trigger factor register 3                              | DMAC | 269           |
| DTOC    | DMA terminal count output control register                 | DMAC | 268           |
| DWC0    | Data wait control register 0                               | BCU  | 154           |
| DWC1    | Data wait control register 1                               | BCU  | 154           |
| FIC     | DMA flyby transfer idle control register                   | BCU  | 162           |
| FWC     | DMA flyby transfer wait control register                   | BCU  | 158           |
| ICC     | Instruction cache control register                         | BCU  | 166           |
| ICCH    | Instruction cache control register H                       | BCU  | 166           |
| ICCL    | Instruction cache control register L                       | BCU  | 166           |
| ICD     | Instruction cache data configuration register              | BCU  | 167           |
| IMR0    | Interrupt mask register 0                                  | INTC | 338           |
| IMR0H   | Interrupt mask register 0H                                 | INTC | 338           |
| IMR0L   | Interrupt mask register 0L                                 | INTC | 338           |
| IMR1    | Interrupt mask register 1                                  | INTC | 338           |
| IMR1H   | Interrupt mask register 1H                                 | INTC | 338           |
| IMR1L   | Interrupt mask register 1L                                 | INTC | 338           |
| IMR2    | Interrupt mask register 2                                  | INTC | 338           |
| IMR2H   | Interrupt mask register 2H                                 | INTC | 338           |
| IMR2L   | Interrupt mask register 2L                                 | INTC | 338           |
| IMR3    | Interrupt mask register 3                                  | INTC | 338           |
| IMR3H   | Interrupt mask register 3H                                 | INTC | 338           |
| IMR3L   | Interrupt mask register 3L                                 | INTC | 338           |
| IMR4    | Interrupt mask register 4                                  | INTC | 338           |
| IMR4H   | Interrupt mask register 4H                                 | INTC | 338           |
| IMR4L   | Interrupt mask register 4L                                 | INTC | 338           |
| IMR5    | Interrupt mask register 5                                  | INTC | 338           |
| IMR5H   | Interrupt mask register 5H                                 | INTC | 338           |
| IMR5L   | Interrupt mask register 5L                                 | INTC | 338           |
| INTF1   | External interrupt falling edge specification register 1   | INTC | 342, 820      |
| INTF2   | External interrupt falling edge specification register 2   | INTC | 327, 344, 825 |
| INTF5   | External interrupt falling edge specification register 5   | INTC | 346, 830      |
| INTF6   | External interrupt falling edge specification register 6   | INTC | 348, 835      |
| INTFAL  | External interrupt falling edge specification register AL  | INTC | 350, 843      |
| INTFDH  | External interrupt falling edge specification register DH  | INTC | 351, 854      |
| INTFDHH | External interrupt falling edge specification register DHH | INTC | 351, 854      |
| INTFDHL | External interrupt falling edge specification register DHL | INTC | 351, 854      |

| Symbol  | Name                                                      | Unit  | Page          |
|---------|-----------------------------------------------------------|-------|---------------|
| INTR1   | External interrupt rising edge specification register 1   | INTC  | 342, 820      |
| INTR2   | External interrupt rising edge specification register 2   | INTC  | 327, 344, 825 |
| INTR5   | External interrupt rising edge specification register 5   | INTC  | 346, 830      |
| INTR6   | External interrupt rising edge specification register 6   | INTC  | 348, 835      |
| INTRAL  | External interrupt rising edge specification register AL  | INTC  | 350, 843      |
| INTRDH  | External interrupt rising edge specification register DH  | INTC  | 351, 854      |
| INTRDHH | External interrupt rising edge specification register DHH | INTC  | 351, 854      |
| INTRDHL | External interrupt rising edge specification register DHL | INTC  | 351, 854      |
| IRAMM   | Internal instruction RAM mode register                    | BCU   | 170           |
| ISPR    | In-service priority register                              | INTC  | 341           |
| LBC0    | Line buffer control register 0                            | BCU   | 147           |
| LBC1    | Line buffer control register 1                            | BCU   | 147           |
| LBS     | Local bus sizing control register                         | BCU   | 122           |
| LOCKR   | Lock register                                             | CPU   | 379           |
| NCW10   | Noise elimination width setting register 10               | Timer | 461, 874      |
| NCW11   | Noise elimination width setting register 11               | Timer | 461, 874      |
| NCWC0   | Noise elimination width setting register C0               | Timer | 421, 873      |
| NCWC1   | Noise elimination width setting register C1               | Timer | 421, 873      |
| NCWC2   | Noise elimination width setting register C2               | Timer | 421, 873      |
| NCWC3   | Noise elimination width setting register C3               | Timer | 421, 873      |
| NRS     | NMI reset status register                                 | INTC  | 340           |
| OSTS    | Oscillation stabilization time select register            | CG    | 380           |
| OV1IC0  | Interrupt control register 57                             | INTC  | 337           |
| OV1IC1  | Interrupt control register 63                             | INTC  | 337           |
| OVCIC0  | Interrupt control register 31                             | INTC  | 336           |
| OVCIC1  | Interrupt control register 32                             | INTC  | 336           |
| OVCIC2  | Interrupt control register 33                             | INTC  | 336           |
| OVCIC3  | Interrupt control register 34                             | INTC  | 336           |
| OVCIC4  | Interrupt control register 35                             | INTC  | 336           |
| OVCIC5  | Interrupt control register 36                             | INTC  | 336           |
| P1      | Port 1                                                    | Port  | 817           |
| P1IC0   | Interrupt control register 0                              | INTC  | 336           |
| P1IC1   | Interrupt control register 1                              | INTC  | 336           |
| P2      | Port 2                                                    | Port  | 822           |
| P2IC1   | Interrupt control register 2                              | INTC  | 336           |
| P2IC2   | Interrupt control register 3                              | INTC  | 336           |
| P2IC3   | Interrupt control register 4                              | INTC  | 336           |
| P2IC4   | Interrupt control register 5                              | INTC  | 336           |

| Symbol | Name                          | Unit | Page |
|--------|-------------------------------|------|------|
| P2IC5  | Interrupt control register 6  | INTC | 336  |
| P5     | Port 5                        | Port | 827  |
| P5IC0  | Interrupt control register 7  | INTC | 336  |
| P5IC1  | Interrupt control register 8  | INTC | 336  |
| P5IC2  | Interrupt control register 9  | INTC | 336  |
| P6     | Port 6                        | Port | 832  |
| P6IC5  | Interrupt control register 10 | INTC | 336  |
| P6IC6  | Interrupt control register 11 | INTC | 336  |
| P6IC7  | Interrupt control register 12 | INTC | 336  |
| P7     | Port 7                        | Port | 837  |
| PAH    | Port AH                       | Port | 845  |
| PAHH   | Port AHH                      | Port | 845  |
| PAHL   | Port AHL                      | Port | 845  |
| PAL    | Port AL                       | Port | 840  |
| PALH   | Port ALH                      | Port | 840  |
| PALL   | Port ALL                      | Port | 840  |
| PCD    | Port CD                       | Port | 866  |
| PCM    | Port CM                       | Port | 863  |
| PCS    | Port CS                       | Port | 856  |
| PCT    | Port CT                       | Port | 860  |
| PDH    | Port DH                       | Port | 847  |
| PDHH   | Port DHH                      | Port | 847  |
| PDHL   | Port DHL                      | Port | 847  |
| PDIC0  | Interrupt control register 13 | INTC | 336  |
| PDIC1  | Interrupt control register 14 | INTC | 336  |
| PDIC2  | Interrupt control register 15 | INTC | 336  |
| PDIC3  | Interrupt control register 16 | INTC | 336  |
| PDIC4  | Interrupt control register 17 | INTC | 336  |
| PDIC5  | Interrupt control register 18 | INTC | 336  |
| PDIC6  | Interrupt control register 19 | INTC | 336  |
| PDIC7  | Interrupt control register 20 | INTC | 336  |
| PDIC8  | Interrupt control register 21 | INTC | 336  |
| PDIC9  | Interrupt control register 22 | INTC | 336  |
| PDIC10 | Interrupt control register 23 | INTC | 336  |
| PDIC11 | Interrupt control register 24 | INTC | 336  |
| PDIC12 | Interrupt control register 25 | INTC | 336  |
| PDIC13 | Interrupt control register 26 | INTC | 336  |
| PDIC14 | Interrupt control register 27 | INTC | 336  |
| PDIC15 | Interrupt control register 28 | INTC | 336  |

| Symbol | Name                                | Unit | Page |
|--------|-------------------------------------|------|------|
| PFC1   | Port 1 function control register    | Port | 819  |
| PFC2   | Port 2 function control register    | Port | 824  |
| PFC5   | Port 5 function control register    | Port | 829  |
| PFC6   | Port 6 function control register    | Port | 834  |
| PFC7   | Port 7 function control register    | Port | 839  |
| PFCALL | Port AL function control register L | Port | 842  |
| PFCCM  | Port CM function control register   | Port | 865  |
| PFCCS  | Port CS function control register   | Port | 858  |
| PFCCT  | Port CT function control register   | Port | 862  |
| PFCDH  | Port DH function control register   | Port | 851  |
| PFCDHH | Port DH function control register H | Port | 851  |
| PFCDHL | Port DH function control register L | Port | 851  |
| PLIC0  | Interrupt control register 29       | INTC | 336  |
| PLIC1  | Interrupt control register 30       | INTC | 336  |
| PM1    | Port 1 mode register                | Port | 818  |
| PM2    | Port 2 mode register                | Port | 823  |
| PM5    | Port 5 mode register                | Port | 828  |
| PM6    | Port 6 mode register                | Port | 833  |
| PM7    | Port 7 mode register                | Port | 838  |
| PMAH   | Port AH mode register               | Port | 846  |
| PMAHH  | Port AH mode register H             | Port | 846  |
| PMAHL  | Port AH mode register L             | Port | 846  |
| PMAL   | Port AL mode register               | Port | 841  |
| PMALH  | Port AL mode register H             | Port | 841  |
| PMALL  | Port AL mode register L             | Port | 841  |
| PMC1   | Port 1 mode control register        | Port | 818  |
| PMC2   | Port 2 mode control register        | Port | 823  |
| PMC5   | Port 5 mode control register        | Port | 828  |
| PMC6   | Port 6 mode control register        | Port | 833  |
| PMC7   | Port 7 mode control register        | Port | 838  |
| PMCAH  | Port AH mode control register       | Port | 846  |
| PMCAHH | Port AH mode control register H     | Port | 846  |
| PMCAHL | Port AH mode control register L     | Port | 846  |
| PMCAL  | Port AL mode control register       | Port | 841  |
| PMCALH | Port AL mode control register H     | Port | 841  |
| PMCALL | Port AL mode control register L     | Port | 841  |
| PMCCD  | Port CD mode control register       | Port | 867  |
| PMCCM  | Port CM mode control register       | Port | 864  |
| PMCCS  | Port CS mode control register       | Port | 857  |

| Symbol | Name                             | Unit  | Page     |
|--------|----------------------------------|-------|----------|
| PMCCT  | Port CT mode control register    | Port  | 861      |
| PMCD   | Port CD mode register            | Port  | 867      |
| PMCDH  | Port DH mode control register    | Port  | 849      |
| PMCDHH | Port DH mode control register H  | Port  | 849      |
| PMCDHL | Port DH mode control register L  | Port  | 849      |
| PMCM   | Port CM mode register            | Port  | 864      |
| PMCS   | Port CS mode register            | Port  | 857      |
| PMCT   | Port CT mode register            | Port  | 861      |
| PMDH   | Port DH mode register            | Port  | 849      |
| PMDHH  | Port DH mode register H          | Port  | 849      |
| PMDHL  | Port DH mode register L          | Port  | 849      |
| PRC    | Page ROM configuration register  | MEMC  | 203      |
| PRCMD  | Command register                 | CPU   | 388      |
| PRM10  | Prescaler mode register 10       | Timer | 458      |
| PRM11  | Prescaler mode register 11       | Timer | 458      |
| PSC    | Power-save control register      | CPU   | 389      |
| PSMR   | Power-save mode register         | CPU   | 388      |
| PWM0   | PWM modulo register 0            | PWM   | 778      |
| PWM1   | PWM modulo register 1            | PWM   | 778      |
| PWMC0  | PWM control register 0           | PWM   | 776      |
| PWMC1  | PWM control register 1           | PWM   | 776      |
| PWMH0  | PWM modulo register H0           | PWM   | 778      |
| PWMH1  | PWM modulo register H1           | PWM   | 778      |
| PWML0  | PWM modulo register L0           | PWM   | 778      |
| PWML1  | PWM modulo register L1           | PWM   | 778      |
| RFS1   | SDRAM refresh control register 1 | MEMC  | 244      |
| RFS3   | SDRAM refresh control register 3 | MEMC  | 244      |
| RFS4   | SDRAM refresh control register 4 | MEMC  | 244      |
| RFS6   | SDRAM refresh control register 6 | MEMC  | 244      |
| RSUMIC | Interrupt control register 89    | INTC  | 338      |
| SCR1   | SDRAM configuration register 1   | MEMC  | 217      |
| SCR3   | SDRAM configuration register 3   | MEMC  | 217      |
| SCR4   | SDRAM configuration register 4   | MEMC  | 217      |
| SCR6   | SDRAM configuration register 6   | MEMC  | 217      |
| SESA10 | Valid edge select register 10    | INTC  | 355, 456 |
| SESA11 | Valid edge select register 11    | INTC  | 355, 456 |
| SESC0  | Valid edge select register C0    | INTC  | 353, 419 |
| SESC1  | Valid edge select register C1    | INTC  | 353, 419 |
| SESC2  | Valid edge select register C2    | INTC  | 353, 419 |

| Symbol   | Name                                           | Unit  | Page     |
|----------|------------------------------------------------|-------|----------|
| SESC3    | Valid edge select register C3                  | INTC  | 353, 419 |
| SFA30    | CSIBUF status register 30                      | CSI30 | 548      |
| SFA31    | CSIBUF status register 31                      | CSI31 | 548      |
| SFDB30   | Transmit data CSI buffer register 30           | CSI30 | 547      |
| SFDB30H  | Transmit data CSI buffer register 30H          | CSI30 | 547      |
| SFDB30L  | Transmit data CSI buffer register 30L          | CSI30 | 547      |
| SFDB31   | Transmit data CSI buffer register 31           | CSI31 | 547      |
| SFDB31H  | Transmit data CSI buffer register 31H          | CSI31 | 547      |
| SFDB31L  | Transmit data CSI buffer register 31L          | CSI31 | 547      |
| SFN30    | Transfer data number specification register 30 | CSI30 | 552      |
| SFN31    | Transfer data number specification register 31 | CSI31 | 552      |
| SIRB30   | Receive data buffer register 30                | CSI30 | 546      |
| SIRB30H  | Receive data buffer register 30H               | CSI31 | 546      |
| SIRB30L  | Receive data buffer register 30L               | CSI30 | 546      |
| SIRB31   | Receive data buffer register 31                | CSI31 | 546      |
| SIRB31H  | Receive data buffer register 31H               | CSI31 | 546      |
| SIRB31L  | Receive data buffer register 31L               | CSI31 | 546      |
| SSCGC    | SSCG control register                          | CG    | 376      |
| STATUS10 | Status register 10                             | Timer | 460      |
| STATUS11 | Status register 11                             | Timer | 460      |
| TMC0     | Timer C0                                       | Timer | 410      |
| TMC1     | Timer C1                                       | Timer | 410      |
| TMC10    | Timer control register 10                      | Timer | 453      |
| TMC11    | Timer control register 11                      | Timer | 453      |
| TMC2     | Timer C2                                       | Timer | 410      |
| TMC3     | Timer C3                                       | Timer | 410      |
| TMC4     | Timer C4                                       | Timer | 410      |
| TMC5     | Timer C5                                       | Timer | 410      |
| TMCC00   | Timer mode control register C00                | Timer | 414      |
| TMCC01   | Timer mode control register C01                | Timer | 416      |
| TMCC10   | Timer mode control register C10                | Timer | 414      |
| TMCC11   | Timer mode control register C11                | Timer | 416      |
| TMCC20   | Timer mode control register C20                | Timer | 414      |
| TMCC21   | Timer mode control register C21                | Timer | 416      |
| TMCC30   | Timer mode control register C30                | Timer | 414      |
| TMCC31   | Timer mode control register C31                | Timer | 416      |
| TMCC40   | Timer mode control register C40                | Timer | 414      |
| TMCC41   | Timer mode control register C41                | Timer | 416      |
| TMCC50   | Timer mode control register C50                | Timer | 414      |

| Symbol   | Name                            | Unit  | Page |
|----------|---------------------------------|-------|------|
| TMCC51   | Timer mode control register C51 | Timer | 416  |
| TMCD0    | Timer mode control register D0  | Timer | 442  |
| TMCD1    | Timer mode control register D1  | Timer | 442  |
| TMCD2    | Timer mode control register D2  | Timer | 442  |
| TMCD3    | Timer mode control register D3  | Timer | 442  |
| TMD0     | Timer D0                        | Timer | 439  |
| TMD1     | Timer D1                        | Timer | 439  |
| TMD2     | Timer D2                        | Timer | 439  |
| TMD3     | Timer D3                        | Timer | 439  |
| TMENC10  | Timer ENC10                     | Timer | 450  |
| TMENC11  | Timer ENC11                     | Timer | 450  |
| TUM10    | Timer unit mode register 10     | Timer | 452  |
| TUM11    | Timer unit mode register 11     | Timer | 452  |
| UB0CTL0  | UARTB0 control register 0       | UARTB | 485  |
| UB0CTL2  | UARTB0 control register 2       | UARTB | 490  |
| UB0FIC0  | UARTB0 FIFO control register 0  | UARTB | 494  |
| UB0FIC1  | UARTB0 FIFO control register 1  | UARTB | 496  |
| UB0FIC2  | UARTB0 FIFO control register 2  | UARTB | 497  |
| UB0FIC2H | UARTB0 FIFO control register 2H | UARTB | 497  |
| UB0FIC2L | UARTB0 FIFO control register 2L | UARTB | 497  |
| UB0FIS0  | UARTB0 FIFO status register 0   | UARTB | 500  |
| UB0FIS1  | UARTB0 FIFO status register 1   | UARTB | 501  |
| UB0RX    | UARTB0 receive data register    | UARTB | 492  |
| UB0RXAP  | UARTB0 receive data register AP | UARTB | 492  |
| UB0STR   | UARTB0 status register          | UARTB | 488  |
| UB0TX    | UARTB0 transmit data register   | UARTB | 491  |
| UB1CTL0  | UARTB1 control register 0       | UARTB | 485  |
| UB1CTL2  | UARTB1 control register 2       | UARTB | 490  |
| UB1FIC0  | UARTB1 FIFO control register 0  | UARTB | 494  |
| UB1FIC1  | UARTB1 FIFO control register 1  | UARTB | 496  |
| UB1FIC2  | UARTB1 FIFO control register 2  | UARTB | 497  |
| UB1FIC2H | UARTB1 FIFO control register 2H | UARTB | 497  |
| UB1FIC2L | UARTB1 FIFO control register 2L | UARTB | 497  |
| UB1FIS0  | UARTB1 FIFO status register 0   | UARTB | 500  |
| UB1FIS1  | UARTB1 FIFO status register 1   | UARTB | 501  |
| UB1RX    | UARTB1 receive data register    | UARTB | 492  |
| UB1RXAP  | UARTB1 receive data register AP | UARTB | 492  |
| UB1STR   | UARTB1 status register          | UARTB | 488  |
| UB1TX    | UARTB1 transmit data register   | UARTB | 491  |



| Symbol                  | Name                                                               | Unit | Page |
|-------------------------|--------------------------------------------------------------------|------|------|
| UCKC                    | USB clock control register                                         | CG   | 378  |
| UD1IC0                  | Interrupt control register 58                                      | INTC | 337  |
| UD1IC1                  | Interrupt control register 64                                      | INTC | 337  |
| UF0AAS                  | UF0 active alternative setting register                            | USBF | 635  |
| UF0ADRS                 | UF0 address register                                               | USBF | 676  |
| UF0AIFN                 | UF0 active interface number register                               | USBF | 634  |
| UF0ASS                  | UF0 alternative setting status register                            | USBF | 636  |
| UF0BC                   | USB function 0 buffer control register                             | USBF | 685  |
| UF0BI1                  | UF0 bulk in 1 register                                             | USBF | 656  |
| UF0BI2                  | UF0 bulk in 2 register                                             | USBF | 660  |
| UF0BO1                  | UF0 bulk out 1 register                                            | USBF | 649  |
| UF0BO1L                 | UF0 bulk out 1 length register                                     | USBF | 652  |
| UF0BO2                  | UF0 bulk out 2 register                                            | USBF | 653  |
| UF0BO2L                 | UF0 bulk out 2 length register                                     | USBF | 656  |
| UF0CIE0 to<br>UF0CIE255 | UF0 configuration/interface/endpoint descriptor registers 0 to 255 | USBF | 682  |
| UF0CLR                  | UF0 CLR request register                                           | USBF | 599  |
| UF0CNF                  | UF0 configuration register                                         | USBF | 677  |
| UF0CS                   | USB function 0 DMA channel select register                         | USBF | 684  |
| UF0DD0 to<br>UF0DD17    | UF0 device descriptor registers 0 to 17                            | USBF | 681  |
| UF0DEND                 | UF0 data end register                                              | USBF | 629  |
| UF0DMS0                 | UF0 DMA status 0 register                                          | USBF | 625  |
| UF0DMS1                 | UF0 DMA status 1 register                                          | USBF | 626  |
| UF0DSCL                 | UF0 descriptor length register                                     | USBF | 680  |
| UF0DSTL                 | UF0 device status register L                                       | USBF | 668  |
| UF0E0L                  | UF0 EP0 length register                                            | USBF | 644  |
| UF0E0N                  | UF0 EP0NAK register                                                | USBF | 590  |
| UF0E0NA                 | UF0 EP0NAKALL register                                             | USBF | 592  |
| UF0E0R                  | UF0 EP0 read register                                              | USBF | 643  |
| UF0E0SL                 | UF0 EP0 status register L                                          | USBF | 669  |
| UF0E0ST                 | UF0 EP0 setup register                                             | USBF | 645  |
| UF0E0W                  | UF0 EP0 write register                                             | USBF | 647  |
| UF0E1IM                 | UF0 endpoint 1 interface mapping register                          | USBF | 637  |
| UF0E1SL                 | UF0 EP1 status register L                                          | USBF | 670  |
| UF0E2IM                 | UF0 endpoint 2 interface mapping register                          | USBF | 638  |
| UF0E2SL                 | UF0 EP2 status register L                                          | USBF | 671  |
| UF0E3IM                 | UF0 endpoint 3 interface mapping register                          | USBF | 639  |
| UF0E3SL                 | UF0 EP3 status register L                                          | USBF | 672  |

| Symbol  | Name                                      | Unit | Page |
|---------|-------------------------------------------|------|------|
| UF0E4IM | UF0 endpoint 4 interface mapping register | USBF | 640  |
| UF0E4SL | UF0 EP4 status register L                 | USBF | 673  |
| UF0E7IM | UF0 endpoint 7 interface mapping register | USBF | 641  |
| UF0E7SL | UF0 EP7 status register L                 | USBF | 674  |
| UF0E8IM | UF0 endpoint 8 interface mapping register | USBF | 642  |
| UF0E8SL | UF0 EP8 status register L                 | USBF | 675  |
| UF0EN   | UF0 EPNAK register                        | USBF | 593  |
| UF0ENM  | UF0 EPNAK mask register                   | USBF | 597  |
| UF0EPS0 | UF0 EP status 0 register                  | USBF | 601  |
| UF0EPS1 | UF0 EP status 1 register                  | USBF | 603  |
| UF0EPS2 | UF0 EP status 2 register                  | USBF | 604  |
| UF0FIC0 | UF0 FIFO clear 0 register                 | USBF | 627  |
| UF0FIC1 | UF0 FIFO clear 1 register                 | USBF | 628  |
| UF0GPR  | UF0 GPR register                          | USBF | 631  |
| UF0IC0  | UF0 INT clear 0 register                  | USBF | 618  |
| UF0IC1  | UF0 INT clear 1 register                  | USBF | 619  |
| UF0IC2  | UF0 INT clear 2 register                  | USBF | 620  |
| UF0IC3  | UF0 INT clear 3 register                  | USBF | 621  |
| UF0IC4  | UF0 INT clear 4 register                  | USBF | 622  |
| UF0IDR  | UF0 INT & DMARQ register                  | USBF | 623  |
| UF0IF0  | UF0 interface 0 register                  | USBF | 678  |
| UF0IF1  | UF0 interface 1 register                  | USBF | 679  |
| UF0IF2  | UF0 interface 2 register                  | USBF | 679  |
| UF0IF3  | UF0 interface 3 register                  | USBF | 679  |
| UF0IF4  | UF0 interface 4 register                  | USBF | 679  |
| UF0IM0  | UF0 INT mask 0 register                   | USBF | 613  |
| UF0IM1  | UF0 INT mask 1 register                   | USBF | 614  |
| UF0IM2  | UF0 INT mask 2 register                   | USBF | 615  |
| UF0IM3  | UF0 INT mask 3 register                   | USBF | 616  |
| UF0IM4  | UF0 INT mask 4 register                   | USBF | 617  |
| UF0INT1 | UF0 interrupt 1 register                  | USBF | 664  |
| UF0INT2 | UF0 interrupt 2 register                  | USBF | 666  |
| UF0IS0  | UF0 INT status 0 register                 | USBF | 605  |
| UF0IS1  | UF0 INT status 1 register                 | USBF | 607  |
| UF0IS2  | UF0 INT status 2 register                 | USBF | 609  |
| UF0IS3  | UF0 INT status 3 register                 | USBF | 610  |
| UF0IS4  | UF0 INT status 4 register                 | USBF | 612  |
| UF0MODC | UF0 mode control register                 | USBF | 632  |
| UF0MODS | UF0 mode status register                  | USBF | 633  |

| Symbol | Name                                          | Unit | Page |
|--------|-----------------------------------------------|------|------|
| UF0SDS | UF0 SNDSIE register                           | USBF | 598  |
| UF0SET | UF0 SET request register                      | USBF | 600  |
| UIFIC0 | Interrupt control register 76                 | INTC | 337  |
| UIFIC1 | Interrupt control register 81                 | INTC | 337  |
| UREIC0 | Interrupt control register 73                 | INTC | 337  |
| UREIC1 | Interrupt control register 78                 | INTC | 337  |
| URIC0  | Interrupt control register 74                 | INTC | 337  |
| URIC1  | Interrupt control register 79                 | INTC | 337  |
| US0BIC | Interrupt control register 84                 | INTC | 338  |
| US1BIC | Interrupt control register 85                 | INTC | 338  |
| US2BIC | Interrupt control register 86                 | INTC | 338  |
| USP2IC | Interrupt control register 87                 | INTC | 338  |
| USP4IC | Interrupt control register 88                 | INTC | 338  |
| UTIC0  | Interrupt control register 75                 | INTC | 337  |
| UTIC1  | Interrupt control register 80                 | INTC | 337  |
| UTOIC0 | Interrupt control register 77                 | INTC | 337  |
| UTOIC1 | Interrupt control register 82                 | INTC | 338  |
| VSWC   | System wait control register                  | BCU  | 109  |
| WAS    | Write access synchronization control register | BCU  | 151  |

## APPENDIX B INSTRUCTION SET LIST

### B.1 Conventions

#### (1) Register symbols used to describe operands

| Register Symbol | Explanation                                                                                                                                |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------|
| reg1            | General-purpose registers: Used as source registers.                                                                                       |
| reg2            | General-purpose registers: Used mainly as destination registers. Also used as source register in some instructions.                        |
| reg3            | General-purpose registers: Used mainly to store the remainders of division results and the higher order 32 bits of multiplication results. |
| bit#3           | 3-bit data for specifying the bit number                                                                                                   |
| immX            | X bit immediate data                                                                                                                       |
| dispX           | X bit displacement data                                                                                                                    |
| regID           | System register number                                                                                                                     |
| vector          | 5-bit data that specifies the trap vector (00H to 1FH)                                                                                     |
| cccc            | 4-bit data that shows the conditions code                                                                                                  |
| sp              | Stack pointer (SP)                                                                                                                         |
| ep              | Element pointer (r30)                                                                                                                      |
| listX           | X item register list                                                                                                                       |

#### (2) Register symbols used to describe opcodes

| Register Symbol | Explanation                                                        |
|-----------------|--------------------------------------------------------------------|
| R               | 1-bit data of a code that specifies reg1 or regID                  |
| r               | 1-bit data of the code that specifies reg2                         |
| w               | 1-bit data of the code that specifies reg3                         |
| d               | 1-bit displacement data                                            |
| l               | 1-bit immediate data (indicates the higher bits of immediate data) |
| i               | 1-bit immediate data                                               |
| cccc            | 4-bit data that shows the condition codes                          |
| CCCC            | 4-bit data that shows the condition codes of Bcond instruction     |
| bbb             | 3-bit data for specifying the bit number                           |
| L               | 1-bit data that specifies a program register in the register list  |
| S               | 1-bit data that specifies a system register in the register list   |

**(3) Register symbols used in operations**

| Register Symbol               | Explanation                                                                                                                                                                  |
|-------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| ←                             | Input for                                                                                                                                                                    |
| GR [ ]                        | General-purpose register                                                                                                                                                     |
| SR [ ]                        | System register                                                                                                                                                              |
| zero-extend (n)               | Expand n with zeros until word length.                                                                                                                                       |
| sign-extend (n)               | Expand n with signs until word length.                                                                                                                                       |
| load-memory (a, b)            | Read size b data from address a.                                                                                                                                             |
| store-memory (a, b, c)        | Write data b into address a in size c.                                                                                                                                       |
| load-memory-bit (a, b)        | Read bit b of address a.                                                                                                                                                     |
| store-memory-bit (a, b, c)    | Write c to bit b of address a.                                                                                                                                               |
| saturated (n)                 | Execute saturated processing of n (n is a 2's complement).<br>If, as a result of calculations,<br>n ≥ 7FFFFFFFH, let it be 7FFFFFFFH.<br>n ≤ 80000000H, let it be 80000000H. |
| result                        | Reflects the results in a flag.                                                                                                                                              |
| Byte                          | Byte (8 bits)                                                                                                                                                                |
| Halfword                      | Half word (16 bits)                                                                                                                                                          |
| Word                          | Word (32 bits)                                                                                                                                                               |
| +                             | Addition                                                                                                                                                                     |
| −                             | Subtraction                                                                                                                                                                  |
|                               | Bit concatenation                                                                                                                                                            |
| ×                             | Multiplication                                                                                                                                                               |
| ÷                             | Division                                                                                                                                                                     |
| %                             | Remainder from division results                                                                                                                                              |
| AND                           | Logical product                                                                                                                                                              |
| OR                            | Logical sum                                                                                                                                                                  |
| XOR                           | Exclusive OR                                                                                                                                                                 |
| NOT                           | Logical negation                                                                                                                                                             |
| logically shift left by       | Logical shift left                                                                                                                                                           |
| logically shift right by      | Logical shift right                                                                                                                                                          |
| arithmetically shift right by | Arithmetic shift right                                                                                                                                                       |

**(4) Register symbols used in execution clock**

| Register Symbol | Explanation                                                                                                 |
|-----------------|-------------------------------------------------------------------------------------------------------------|
| i               | If executing another instruction immediately after executing the first instruction (issue).                 |
| r               | If repeating execution of the same instruction immediately after executing the first instruction (repeat).  |
| l               | If using the results of instruction execution in the instruction immediately after the execution (latency). |

**(5) Register symbols used in flag operations**

| Identifier | Explanation                                    |
|------------|------------------------------------------------|
| (Blank)    | No change                                      |
| 0          | Clear to 0                                     |
| X          | Set or cleared in accordance with the results. |
| R          | Previously saved values are restored.          |

**(6) Condition codes**

| Condition Name<br>(cond) | Condition Code<br>(cccc) | Condition Formula                         | Explanation                                   |
|--------------------------|--------------------------|-------------------------------------------|-----------------------------------------------|
| V                        | 0 0 0 0                  | $OV = 1$                                  | Overflow                                      |
| NV                       | 1 0 0 0                  | $OV = 0$                                  | No overflow                                   |
| C/L                      | 0 0 0 1                  | $CY = 1$                                  | Carry<br>Lower (Less than)                    |
| NC/NL                    | 1 0 0 1                  | $CY = 0$                                  | No carry<br>Not lower (Greater than or equal) |
| Z/E                      | 0 0 1 0                  | $Z = 1$                                   | Zero<br>Equal                                 |
| NZ/NE                    | 1 0 1 0                  | $Z = 0$                                   | Not zero<br>Not equal                         |
| NH                       | 0 0 1 1                  | $(CY \text{ or } Z) = 1$                  | Not higher (Less than or equal)               |
| H                        | 1 0 1 1                  | $(CY \text{ or } Z) = 0$                  | Higher (Greater than)                         |
| N                        | 0 1 0 0                  | $S = 1$                                   | Negative                                      |
| P                        | 1 1 0 0                  | $S = 0$                                   | Positive                                      |
| T                        | 0 1 0 1                  | –                                         | Always (Unconditional)                        |
| SA                       | 1 1 0 1                  | $SAT = 1$                                 | Saturated                                     |
| LT                       | 0 1 1 0                  | $(S \text{ xor } OV) = 1$                 | Less than signed                              |
| GE                       | 1 1 1 0                  | $(S \text{ xor } OV) = 0$                 | Greater than or equal signed                  |
| LE                       | 0 1 1 1                  | $((S \text{ xor } OV) \text{ or } Z) = 1$ | Less than or equal signed                     |
| GT                       | 1 1 1 1                  | $((S \text{ xor } OV) \text{ or } Z) = 0$ | Greater than signed                           |

## B.2 Instruction Set (in Alphabetical Order)

(1/6)

| Mnemonic | Operand             | Opcode                                | Operation                                                                                                                                    | Execution Clock |               |               | Flags |    |   |   |     |
|----------|---------------------|---------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------|-----------------|---------------|---------------|-------|----|---|---|-----|
|          |                     |                                       |                                                                                                                                              | i               | r             | l             | CY    | OV | S | Z | SAT |
| ADD      | reg1,reg2           | rrrrr001110RRRRR                      | GR[reg2]←GR[reg2]+GR[reg1]                                                                                                                   | 1               | 1             | 1             | ×     | ×  | × | × |     |
|          | imm5,reg2           | rrrrr010010iiii                       | GR[reg2]←GR[reg2]+sign-extend(imm5)                                                                                                          | 1               | 1             | 1             | ×     | ×  | × | × |     |
| ADDI     | imm16,reg1,reg2     | rrrrr110000RRRRR<br>iiiiiiiiiiiiiiii  | GR[reg2]←GR[reg1]+sign-extend(imm16)                                                                                                         | 1               | 1             | 1             | ×     | ×  | × | × |     |
| AND      | reg1,reg2           | rrrrr001010RRRRR                      | GR[reg2]←GR[reg2]AND GR[reg1]                                                                                                                | 1               | 1             | 1             |       | 0  | × | × |     |
| ANDI     | imm16,reg1,reg2     | rrrrr110110RRRRR<br>iiiiiiiiiiiiiiii  | GR[reg2]←GR[reg1]AND zero-extend(imm16)                                                                                                      | 1               | 1             | 1             |       | 0  | 0 | × |     |
| Bcond    | disp9               | ddddd1011dddcccc<br><b>Note 1</b>     | if conditions are satisfied<br>then PC←PC+sign-extend(disp9)                                                                                 | 3               | 3             | 3             |       |    |   |   |     |
|          |                     |                                       | When conditions are satisfied                                                                                                                | <b>Note 2</b>   | <b>Note 2</b> | <b>Note 2</b> |       |    |   |   |     |
|          |                     |                                       | When conditions are not satisfied                                                                                                            | 1               | 1             | 1             |       |    |   |   |     |
| BSH      | reg2,reg3           | rrrrr11111100000<br>wwwwww01101000010 | GR[reg3]←GR[reg2] (23 : 16)    GR[reg2] (31 : 24)   <br>GR[reg2] (7 : 0)    GR[reg2] (15 : 8)                                                | 1               | 1             | 1             | ×     | 0  | × | × |     |
| BSW      | reg2,reg3           | rrrrr11111100000<br>wwwwww01101000000 | GR[reg3]←GR[reg2] (7 : 0)    GR[reg2] (15 : 8)    GR<br>[reg2] (23 : 16)    GR[reg2] (31 : 24)                                               | 1               | 1             | 1             | ×     | 0  | × | × |     |
| CALLT    | imm6                | 0000001000iiii                        | CTPC←PC+2(return PC)<br>CTPSW←PSW<br>adr←CTBP+zero-extend(imm6 logically shift left by 1)<br>PC←CTBP+zero-extend(Load-memory(adrs,Halfword)) | 5               | 5             | 5             |       |    |   |   |     |
| CLR1     | bit#3, disp16[reg1] | 10bbb111110RRRRR<br>dddddddddddddd    | adr←GR[reg1]+sign-extend(disp16)<br>Z flag←Not(Load-memory-bit(adrs,bit#3))<br>Store-memory-bit(adrs,bit#3,0)                                | 3               | 3             | 3             |       |    |   | × |     |
|          | reg2,[reg1]         | rrrrr111111RRRRR<br>0000000011100100  | adr←GR[reg1]<br>Z flag←Not(Load-memory-bit(adrs,reg2))<br>Store-memory-bit(adrs,reg2,0)                                                      | 3               | 3             | 3             |       |    |   | × |     |
| CMOV     | cccc,imm5,reg2,reg3 | rrrrr111111iiii<br>wwwwww01100cccc0   | if conditions are satisfied<br>then GR[reg3]←sign-extended(imm5)<br>else GR[reg3]←GR[reg2]                                                   | 1               | 1             | 1             |       |    |   |   |     |
|          | cccc,reg1,reg2,reg3 | rrrrr111111RRRRR<br>wwwwww011001cccc0 | if conditions are satisfied<br>then GR[reg3]←GR[reg1]<br>else GR[reg3]←GR[reg2]                                                              | 1               | 1             | 1             |       |    |   |   |     |
| CMP      | reg1,reg2           | rrrrr001111RRRRR                      | result←GR[reg2]−GR[reg1]                                                                                                                     | 1               | 1             | 1             | ×     | ×  | × | × |     |
|          | imm5,reg2           | rrrrr010011iiii                       | result←GR[reg2]−sign-extend(imm5)                                                                                                            | 1               | 1             | 1             | ×     | ×  | × | × |     |
| CTRET    |                     | 0000011111100000<br>0000000101000100  | PC←CTPC<br>PSW←CTPSW                                                                                                                         | 4               | 4             | 4             | R     | R  | R | R | R   |
| DBRET    |                     | 0000011111100000<br>0000000101000110  | PC←DBPC<br>PSW←DBPSW                                                                                                                         | 4               | 4             | 4             | R     | R  | R | R | R   |

(2/6)

| Mnemonic | Operand            | Opcode                                             | Operation                                                                                                                                                                        | Execution Clock |               |               | Flags |    |   |   |     |
|----------|--------------------|----------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|---------------|---------------|-------|----|---|---|-----|
|          |                    |                                                    |                                                                                                                                                                                  | i               | r             | l             | CY    | OV | S | Z | SAT |
| DBTRAP   |                    | 1111100001000000                                   | DBPC←PC+2 (returned PC)<br>DBPSW←PSW<br>PSW.NP←1<br>PSW.EP←1<br>PSW.ID←1<br>PC←00000060H                                                                                         | 4               | 4             | 4             |       |    |   |   |     |
| DI       |                    | 0000011111100000<br>0000000101100000               | PSW.ID←1                                                                                                                                                                         | 1               | 1             | 1             |       |    |   |   |     |
| DISPOSE  | imm5,list12        | 0000011001iiiiL<br>LLLLLLLLLLL00000                | sp←sp+zero-extend(imm5 logically shift left by 2)<br>GR[reg in list12]←Load-memory(sp,Word)<br>sp←sp+4<br>repeat 2 steps above until all regs in list12 is loaded                | n+1<br>Note 4   | n+1<br>Note 4 | n+1<br>Note 4 |       |    |   |   |     |
|          | imm5,list12,[reg1] | 0000011001iiiiL<br>LLLLLLLLLLLRRRRR<br>Note 5      | sp←sp+zero-extend(imm5 logically shift left by 2)<br>GR[reg in list12]←Load-memory(sp,Word)<br>sp←sp+4<br>repeat 2 steps above until all regs in list12 is loaded<br>PC←GR[reg1] | n+3<br>Note 4   | n+3<br>Note 4 | n+3<br>Note 4 |       |    |   |   |     |
| DIV      | reg1,reg2,reg3     | rrrrr11111RRRRR<br>wwwwww01011000000               | GR[reg2]←GR[reg2]÷GR[reg1]<br>GR[reg3]←GR[reg2]%GR[reg1]                                                                                                                         | 35              | 35            | 35            |       | ×  | × | × |     |
| DIVH     | reg1,reg2          | rrrrr000010RRRRR                                   | GR[reg2]←GR[reg2]÷GR[reg1] <sup>Note 6</sup>                                                                                                                                     | 35              | 35            | 35            |       | ×  | × | × |     |
|          | reg1,reg2,reg3     | rrrrr11111RRRRR<br>wwwwww01010000000               | GR[reg2]←GR[reg2]÷GR[reg1] <sup>Note 6</sup><br>GR[reg3]←GR[reg2]%GR[reg1]                                                                                                       | 35              | 35            | 35            |       | ×  | × | × |     |
| DIVHU    | reg1,reg2,reg3     | rrrrr11111RRRRR<br>wwwwww01010000010               | GR[reg2]←GR[reg2]÷GR[reg1] <sup>Note 6</sup><br>GR[reg3]←GR[reg2]%GR[reg1]                                                                                                       | 34              | 34            | 34            |       | ×  | × | × |     |
| DIVU     | reg1,reg2,reg3     | rrrrr11111RRRRR<br>wwwwww01011000010               | GR[reg2]←GR[reg2]÷GR[reg1]<br>GR[reg3]←GR[reg2]%GR[reg1]                                                                                                                         | 34              | 34            | 34            |       | ×  | × | × |     |
| EI       |                    | 1000011111100000<br>0000000101100000               | PSW.ID←0                                                                                                                                                                         | 1               | 1             | 1             |       |    |   |   |     |
| HALT     |                    | 0000011111100000<br>0000000100100000               | Stop                                                                                                                                                                             | 1               | 1             | 1             |       |    |   |   |     |
| HSW      | reg2,reg3          | rrrrr11111100000<br>wwwwww01101000100              | GR[reg3]←GR[reg2](15 : 0)    GR[reg2] (31 : 16)                                                                                                                                  | 1               | 1             | 1             | ×     | 0  | × | × |     |
| JARL     | disp22,reg2        | rrrrr11110ddddd<br>dddddddddddddd0<br>Note 7       | GR[reg2]←PC+4<br>PC←PC+sign-extend(disp22)                                                                                                                                       | 3               | 3             | 3             |       |    |   |   |     |
| JMP      | [reg1]             | 00000000011RRRRR                                   | PC←GR[reg1]                                                                                                                                                                      | 4               | 4             | 4             |       |    |   |   |     |
| JR       | disp22             | 0000011110ddddd<br>dddddddddddddd0<br>Note 7       | PC←PC+sign-extend(disp22)                                                                                                                                                        | 3               | 3             | 3             |       |    |   |   |     |
| LD.B     | disp16[reg1],reg2  | rrrrr111000RRRRR<br>ddddddddddddddd                | adr←GR[reg1]+sign-extend(disp16)<br>GR[reg2]←sign-extend(Load-memory(adr,Byte))                                                                                                  | 1               | 1             | Note 11       |       |    |   |   |     |
| LD.BU    | disp16[reg1],reg2  | rrrrr11110bRRRRR<br>dddddddddddddd1<br>Notes 8, 10 | adr←GR[reg1]+sign-extend(disp16)<br>GR[reg2]←zero-extend(Load-memory(adr,Byte))                                                                                                  | 1               | 1             | Note 11       |       |    |   |   |     |



| Mnemonic                | Operand            | Opcode                                                   | Operation                                                                                                          | Execution Clock |   |                | Flags |    |   |   |     |
|-------------------------|--------------------|----------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------|-----------------|---|----------------|-------|----|---|---|-----|
|                         |                    |                                                          |                                                                                                                    | i               | r | l              | CY    | OV | S | Z | SAT |
| LD.H                    | disp16[reg1],reg2  | rrrrr111001RRRRR<br>dddddddddddddd0<br><b>Note 8</b>     | adr←GR[reg1]+sign-extend(displ6)<br>GR[reg2]←sign-extend(Load-memory(adrr,Halfword))                               | 1               | 1 | <b>Note 11</b> |       |    |   |   |     |
| LDSR                    | reg2,regID         | rrrrr111111RRRRR<br>0000000000100000<br><b>Note 12</b>   | SR[regID]←GR[reg2]                                                                                                 | 1               | 1 | 1              |       |    |   |   |     |
|                         |                    |                                                          | Other than regID = PSW<br>regID = PSW                                                                              | 1               | 1 | 1              | ×     | ×  | × | × | ×   |
| LD.HU                   | disp16[reg1],reg2  | rrrrr111111RRRRR<br>dddddddddddddd1<br><b>Note 8</b>     | adr←GR[reg1]+sign-extend(displ6)<br>GR[reg2]←zero-extend(Load-memory(adrr,Halfword))                               | 1               | 1 | <b>Note 11</b> |       |    |   |   |     |
| LD.W                    | disp16[reg1],reg2  | rrrrr111001RRRRR<br>dddddddddddddd1<br><b>Note 8</b>     | adr←GR[reg1]+sign-extend(displ6)<br>GR[reg2]←Load-memory(adrr,Word)                                                | 1               | 1 | <b>Note 11</b> |       |    |   |   |     |
| MOV                     | reg1,reg2          | rrrrr000000RRRRR                                         | GR[reg2]←GR[reg1]                                                                                                  | 1               | 1 | 1              |       |    |   |   |     |
|                         | imm5,reg2          | rrrrr010000iiii                                          | GR[reg2]←sign-extend(imm5)                                                                                         | 1               | 1 | 1              |       |    |   |   |     |
|                         | imm32,reg1         | 00000110001RRRRR<br>iiiiiiiiiiiiiiii<br>iiiiiiiiiiiiiiii | GR[reg1]←imm32                                                                                                     | 2               | 2 | 2              |       |    |   |   |     |
| MOVEA                   | imm16,reg1,reg2    | rrrrr110001RRRRR<br>iiiiiiiiiiiiiiii                     | GR[reg2]←GR[reg1]+sign-extend(imm16)                                                                               | 1               | 1 | 1              |       |    |   |   |     |
| MOVHI                   | imm16,reg1,reg2    | rrrrr110010RRRRR<br>iiiiiiiiiiiiiiii                     | GR[reg2]←GR[reg1]+(imm16 ll 0 <sup>16</sup> )                                                                      | 1               | 1 | 1              |       |    |   |   |     |
| MUL <sup>Note 22</sup>  | reg1,reg2,reg3     | rrrrr111111RRRRR<br>wwwww01000100000                     | GR[reg3] ll GR[reg2]←GR[reg2]xGR[reg1]                                                                             | 1               | 2 | 2              |       |    |   |   |     |
|                         | imm9,reg2,reg3     | rrrrr111111iiii<br>wwwww01001111100<br><b>Note 13</b>    | GR[reg3] ll GR[reg2]←GR[reg2]xsign-extend(imm9)                                                                    | 1               | 2 | 2              |       |    |   |   |     |
| MULH                    | reg1,reg2          | rrrrr000111RRRRR                                         | GR[reg2]←GR[reg2] <sup>Note 6</sup> xGR[reg1] <sup>Note 6</sup>                                                    | 1               | 1 | 2              |       |    |   |   |     |
|                         | imm5,reg2          | rrrrr010111iiii                                          | GR[reg2]←GR[reg2] <sup>Note 6</sup> xsign-extend(imm5)                                                             | 1               | 1 | 2              |       |    |   |   |     |
| MULHI                   | imm16,reg1,reg2    | rrrrr110111RRRRR<br>iiiiiiiiiiiiiiii                     | GR[reg2]←GR[reg1] <sup>Note 6</sup> ximm16                                                                         | 1               | 1 | 2              |       |    |   |   |     |
| MULU <sup>Note 22</sup> | reg1,reg2,reg3     | rrrrr111111RRRRR<br>wwwww01000100010                     | GR[reg3] ll GR[reg2]←GR[reg2]xGR[reg1]                                                                             | 1               | 2 | 2              |       |    |   |   |     |
|                         | imm9,reg2,reg3     | rrrrr111111iiii<br>wwwww01001111110<br><b>Note 13</b>    | GR[reg3] ll GR[reg2]←GR[reg2]xzero-extend(imm9)                                                                    | 1               | 2 | 2              |       |    |   |   |     |
| NOP                     |                    | 0000000000000000                                         | Pass at least one clock cycle doing nothing.                                                                       | 1               | 1 | 1              |       |    |   |   |     |
| NOT                     | reg1,reg2          | rrrrr000001RRRRR                                         | GR[reg2]←NOT(GR[reg1])                                                                                             | 1               | 1 | 1              |       | 0  | × | × |     |
| NOT1                    | bit#3,disp16[reg1] | 01bbb111110RRRRR<br>dddddddddddddd                       | adr←GR[reg1]+sign-extend(displ6)<br>Z flag←Not(Load-memory-bit(adrr,bit#3))<br>Store-memory-bit(adrr,bit#3,Z flag) | 3               | 3 | 3              |       |    |   | × |     |
|                         | reg2,[reg1]        | rrrrr111111RRRRR<br>0000000011100010                     | adr←GR[reg1]<br>Z flag←Not(Load-memory-bit(adrr,reg2))<br>Store-memory-bit(adrr,reg2,Z flag)                       | 3               | 3 | 3              |       |    |   | × |     |

| Mnemonic | Operand                                   | Opcode                                                                | Operation                                                                                                                                                                | Execution Clock |               |               | Flags |    |   |   |     |
|----------|-------------------------------------------|-----------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|---------------|---------------|-------|----|---|---|-----|
|          |                                           |                                                                       |                                                                                                                                                                          | i               | r             | l             | CY    | OV | S | Z | SAT |
| OR       | reg1,reg2                                 | rrrrr001000RRRRR                                                      | GR[reg2]←GR[reg2]OR GR[reg1]                                                                                                                                             | 1               | 1             | 1             |       | 0  | × | × |     |
| ORI      | imm16,reg1,reg2                           | rrrrr110100RRRRR<br>iiiiiiiiiiiiiiii                                  | GR[reg2]←GR[reg1]OR zero-extend(imm16)                                                                                                                                   | 1               | 1             | 1             |       | 0  | × | × |     |
| PREPARE  | list12,imm5                               | 0000011110iiiiL<br>LLLLLLLLLLLL00001                                  | Store-memory(sp−4,GR[reg in list12],Word)<br>sp←sp−4<br>repeat 1 step above until all regs in list12 is stored<br>sp←sp-zero-extend(imm5)                                | n+1<br>Note 4   | n+1<br>Note 4 | n+1<br>Note 4 |       |    |   |   |     |
|          | list12,imm5,<br>sp/imm <sup>Note 15</sup> | 0000011110iiiiL<br>LLLLLLLLLLLLff011<br>imm16/imm32<br><b>Note 16</b> | Store-memory(sp−4,GR[reg in list12],Word)<br>GR[reg in list 12]←Load-memory(sp,Word)<br>sp←sp+4<br>repeat 2 step above until all regs in list12 is loaded<br>PC←GR[reg1] | n+2<br>Note 4   | n+2<br>Note 4 | n+2<br>Note 4 |       |    |   |   |     |
| RETI     |                                           | 000001111100000<br>0000000101000000                                   | if PSW.EP=1<br>then PC ←EIPC<br>PSW ←EIPSW<br>else if PSW.NP=1<br>then PC ←FEPC<br>PSW ←FEPSW<br>else PC ←EIPC<br>PSW ←EIPSW                                             | 4               | 4             | 4             | R     | R  | R | R | R   |
| SAR      | reg1,reg2                                 | rrrrr11111RRRRR<br>0000000010100000                                   | GR[reg2]←GR[reg2]arithmetically shift right<br>by GR[reg1]                                                                                                               | 1               | 1             | 1             | ×     | 0  | × | × |     |
|          | imm5,reg2                                 | rrrrr010101iiii                                                       | GR[reg2]←GR[reg2]arithmetically shift right<br>by zero-extend (imm5)                                                                                                     | 1               | 1             | 1             | ×     | 0  | × | × |     |
| SASF     | cccc,reg2                                 | rrrrr111110cccc<br>0000001000000000                                   | if conditions are satisfied<br>then GR[reg2]←(GR[reg2]Logically shift left by 1)<br>OR 00000001H<br>else GR[reg2]←(GR[reg2]Logically shift left by 1)<br>OR 00000000H    | 1               | 1             | 1             |       |    |   |   |     |
| SATADD   | reg1,reg2                                 | rrrrr000110RRRRR                                                      | GR[reg2]←saturated(GR[reg2]+GR[reg1])                                                                                                                                    | 1               | 1             | 1             | ×     | ×  | × | × | ×   |
|          | imm5,reg2                                 | rrrrr010001iiii                                                       | GR[reg2]←saturated(GR[reg2]+sign-extend(imm5))                                                                                                                           | 1               | 1             | 1             | ×     | ×  | × | × | ×   |
| SATSUB   | reg1,reg2                                 | rrrrr000101RRRRR                                                      | GR[reg2]←saturated(GR[reg2]−GR[reg1])                                                                                                                                    | 1               | 1             | 1             | ×     | ×  | × | × | ×   |
| SATSUBI  | imm16,reg1,reg2                           | rrrrr110011RRRRR<br>iiiiiiiiiiiiiiii                                  | GR[reg2]←saturated(GR[reg1]−sign-extend(imm16))                                                                                                                          | 1               | 1             | 1             | ×     | ×  | × | × | ×   |
| SATSUBR  | reg1,reg2                                 | rrrrr000100RRRRR                                                      | GR[reg2]←saturated(GR[reg1]−GR[reg2])                                                                                                                                    | 1               | 1             | 1             | ×     | ×  | × | × | ×   |
| SETF     | cccc,reg2                                 | rrrrr111110cccc<br>0000000000000000                                   | If conditions are satisfied<br>then GR[reg2]←00000001H<br>else GR[reg2]←00000000H                                                                                        | 1               | 1             | 1             |       |    |   |   |     |

| Mnemonic | Operand            | Opcode                                        | Operation                                                                                                    | Execution Clock |             |             | Flags |    |   |   |     |
|----------|--------------------|-----------------------------------------------|--------------------------------------------------------------------------------------------------------------|-----------------|-------------|-------------|-------|----|---|---|-----|
|          |                    |                                               |                                                                                                              | i               | r           | l           | CY    | OV | S | Z | SAT |
| SET1     | bit#3,disp16[reg1] | 00bbb11110RRRRR<br>dddddddddddddd             | adr←GR[reg1]+sign-extend(disp16)<br>Z flag←Not (Load-memory-bit(adr,bit#3))<br>Store-memory-bit(adr,bit#3,1) | 3<br>Note 3     | 3<br>Note 3 | 3<br>Note 3 |       |    |   | × |     |
|          | reg2,[reg1]        | rrrr111111RRRRR<br>0000000011100000           | adr←GR[reg1]<br>Z flag←Not(Load-memory-bit(adr,reg2))<br>Store-memory-bit(adr,reg2,1)                        | 3<br>Note 3     | 3<br>Note 3 | 3<br>Note 3 |       |    |   | × |     |
| SHL      | reg1,reg2          | rrrr111111RRRRR<br>0000000011000000           | GR[reg2]←GR[reg2] logically shift left by GR[reg1]                                                           | 1               | 1           | 1           | ×     | 0  | × | × |     |
|          | imm5,reg2          | rrrrr010110iiii                               | GR[reg2]←GR[reg2] logically shift left<br>by zero-extend(imm5)                                               | 1               | 1           | 1           | ×     | 0  | × | × |     |
| SHR      | reg1,reg2          | rrrr111111RRRRR<br>0000000010000000           | GR[reg2]←GR[reg2] logically shift right by GR[reg1]                                                          | 1               | 1           | 1           | ×     | 0  | × | × |     |
|          | imm5,reg2          | rrrrr010100iiii                               | GR[reg2]←GR[reg2] logically shift right<br>by zero-extend(imm5)                                              | 1               | 1           | 1           | ×     | 0  | × | × |     |
| SLD.B    | disp7[ep],reg2     | rrrrr0110dddddd                               | adr←ep+zero-extend(disp7)<br>GR[reg2]←sign-extend(Load-memory(adr,Byte))                                     | 1               | 1           | Note 9      |       |    |   |   |     |
| SLD.BU   | disp4[ep],reg2     | rrrrr0000110dddd<br>Note 18                   | adr←ep+zero-extend(disp4)<br>GR[reg2]←zero-extend(Load-memory(adr,Byte))                                     | 1               | 1           | Note 9      |       |    |   |   |     |
| SLD.H    | disp8[ep],reg2     | rrrrr1000dddddd<br>Note 19                    | adr←ep+zero-extend(disp8)<br>GR[reg2]←sign-extend(Load-memory(adr,Halfword))                                 | 1               | 1           | Note 9      |       |    |   |   |     |
| SLD.HU   | disp5[ep],reg2     | rrrrr0000111dddd<br>Notes 18, 20              | adr←ep+zero-extend(disp5)<br>GR[reg2]←zero-extend(Load-memory(adr,Halfword))                                 | 1               | 1           | Note 9      |       |    |   |   |     |
| SLD.W    | disp8[ep],reg2     | rrrrr1010dddddd0<br>Note 21                   | adr←ep+zero-extend(disp8)<br>GR[reg2]←Load-memory(adr,Word)                                                  | 1               | 1           | Note 9      |       |    |   |   |     |
| SST.B    | reg2,disp7[ep]     | rrrrr0111dddddd                               | adr←ep+zero-extend(disp7)<br>Store-memory(adr,GR[reg2],Byte)                                                 | 1               | 1           | 1           |       |    |   |   |     |
| SST.H    | reg2,disp8[ep]     | rrrrr1001dddddd<br>Note 19                    | adr←ep+zero-extend(disp8)<br>Store-memory(adr,GR[reg2],Halfword)                                             | 1               | 1           | 1           |       |    |   |   |     |
| SST.W    | reg2,disp8[ep]     | rrrrr1010dddddd1<br>Note 21                   | adr←ep+zero-extend(disp8)<br>Store-memory(adr,GR[reg2],Word)                                                 | 1               | 1           | 1           |       |    |   |   |     |
| ST.B     | reg2,disp16[reg1]  | rrrrr111010RRRRR<br>dddddddddddddd            | adr←GR[reg1]+sign-extend(disp16)<br>Store-memory(adr,GR[reg2],Byte)                                          | 1               | 1           | 1           |       |    |   |   |     |
| ST.H     | reg2,disp16[reg1]  | rrrrr111011RRRRR<br>dddddddddddddd0<br>Note 8 | adr←GR[reg1]+sign-extend(disp16)<br>Store-memory (adr,GR[reg2], Halfword)                                    | 1               | 1           | 1           |       |    |   |   |     |
| ST.W     | reg2,disp16[reg1]  | rrrrr111011RRRRR<br>dddddddddddddd1<br>Note 8 | adr←GR[reg1]+sign-extend(disp16)<br>Store-memory (adr,GR[reg2], Word)                                        | 1               | 1           | 1           |       |    |   |   |     |
| STSR     | regID,reg2         | rrrrr111111RRRRR<br>0000000001000000          | GR[reg2]←SR[regID]                                                                                           | 1               | 1           | 1           |       |    |   |   |     |

| Mnemonic | Operand            | Opcode                               | Operation                                                                                                                                                                                                                                                                 | Execution Clock |   | Flags |        |        |        |   |     |
|----------|--------------------|--------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|---|-------|--------|--------|--------|---|-----|
|          |                    |                                      |                                                                                                                                                                                                                                                                           | i               | r | l     | CY     | OV     | S      | Z | SAT |
| SUB      | reg1,reg2          | rrrrr001101RRRRR                     | GR[reg2]←GR[reg2]−GR[reg1]                                                                                                                                                                                                                                                | 1               | 1 | 1     | ×      | ×      | ×      | × |     |
| SUBR     | reg1,reg2          | rrrrr001100RRRRR                     | GR[reg2]←GR[reg1]−GR[reg2]                                                                                                                                                                                                                                                | 1               | 1 | 1     | ×      | ×      | ×      | × |     |
| SWITCH   | reg1               | 0000000010RRRRR                      | adr←(PC+2) + (GR[reg1] logically shift left by 1)<br>PC←(PC+2) + (sign-extend (Load-memory (adr,Halfword)) logically shift left by 1                                                                                                                                      | 5               | 5 | 5     |        |        |        |   |     |
| SXB      | reg1               | 00000000101RRRRR                     | GR[reg1]←sign-extend (GR[reg1] (7 : 0))                                                                                                                                                                                                                                   | 1               | 1 | 1     |        |        |        |   |     |
| SXH      | reg1               | 00000000111RRRRR                     | GR[reg1]←sign-extend (GR[reg1] (15 : 0))                                                                                                                                                                                                                                  | 1               | 1 | 1     |        |        |        |   |     |
| TRAP     | vector             | 0000011111111111<br>0000000100000000 | EIPC ←PC+4 (Return PC)<br>EIPSW ←PSW<br>ECR.EICC ←Exception code (40H to 4FH, 50H to 5FH)<br>PSW.EP ←1<br>PSW.ID ←1<br>PC ←00000040H<br>(when vector is 00H to 0FH (exception code: 40H to 4FH))<br>00000050H<br>(when vector is 10H to 1FH (exception code: 50H to 5FH)) | 4               | 4 | 4     |        |        |        |   |     |
| TST      | reg1,reg2          | rrrrr001011RRRRR                     | result←GR[reg2] AND GR[reg1]                                                                                                                                                                                                                                              | 1               | 1 | 1     |        | 0      | ×      | × |     |
| TST1     | bit#3,disp16[reg1] | 11bbb111110RRRRR<br>dddddddddddddd   | adr←GR[reg1]+sign-extend(disp16)<br>Z flag←Not (Load-memory-bit (adr,bit#3))                                                                                                                                                                                              | 3               | 3 | 3     | Note 3 | Note 3 | Note 3 | × |     |
|          | reg2, [reg1]       | rrrrr111111RRRRR<br>0000000011100110 | adr←GR[reg1]<br>Z flag←Not (Load-memory-bit (adr,reg2))                                                                                                                                                                                                                   | 3               | 3 | 3     | Note 3 | Note 3 | Note 3 | × |     |
| XOR      | reg1,reg2          | rrrrr001001RRRRR                     | GR[reg2]←GR[reg2] XOR GR[reg1]                                                                                                                                                                                                                                            | 1               | 1 | 1     |        | 0      | ×      | × |     |
| XORI     | imm16,reg1,reg2    | rrrrr110101RRRRR<br>iiiiiiiiiiiiiiii | GR[reg2]←GR[reg1] XOR zero-extend (imm16)                                                                                                                                                                                                                                 | 1               | 1 | 1     |        | 0      | ×      | × |     |
| ZXB      | reg1               | 00000000100RRRRR                     | GR[reg1]←zero-extend (GR[reg1] (7 : 0))                                                                                                                                                                                                                                   | 1               | 1 | 1     |        |        |        |   |     |
| ZXH      | reg1               | 00000000110RRRRR                     | GR[reg1]←zero-extend (GR[reg1] (15 : 0))                                                                                                                                                                                                                                  | 1               | 1 | 1     |        |        |        |   |     |

- Notes**
1. dddddddd: Higher 8 bits of disp9.
  2. 4 if there is an instruction that rewrites the contents of the PSW immediately before.
  3. If there is no wait state (3 + the number of read access wait states).
  4. n is the total number of list12 load registers. (According to the number of wait states. Also, if there are no wait states, n is the total number of list12 registers. If n = 0, same operation as when n = 1)
  5. RRRRRR: other than 00000.
  6. The lower halfword data only are valid.
  7. dddddddddddddddddd: The higher 21 bits of disp22.
  8. dddddddddddddd: The higher 15 bits of disp16.
  9. According to the number of wait states (1 if there are no wait states).
  10. b: bit 0 of disp16.
  11. According to the number of wait states (2 if there are no wait states).

**Notes 12.** In this instruction, for convenience of mnemonic description, the source register is made reg2, but the reg1 field is used in the opcode. Therefore, the meaning of register specification in the mnemonic description and in the opcode differs from other instructions.

rrrrr = regID specification

RRRRR = reg2 specification

**13.** iiii: Lower 5 bits of imm9.

IIII: Higher 4 bits of imm9.

**14.** In the case of reg2 = reg3 (the lower 32 bits of the results are not written in the register) or reg3 = r0 (the higher 32 bits of the results are not written in the register), shortened by 1 clock.

**15.** sp/imm: specified by bits 19 and 20 of the sub-opcode.

**16.** ff = 00: Load sp in ep.

01: Load sign expanded 16-bit immediate data (bits 47 to 32) in ep.

10: Load 16-bit logically left shifted 16-bit immediate data (bits 47 to 32) in ep.

11: Load 32-bit immediate data (bits 63 to 32) in ep.

**17.** If imm = imm32, n + 3 clocks.

**18.** rrrrr: Other than 00000.

**19.** ddddddd: Higher 7 bits of disp8.

**20.** dddd: Higher 4 bits of disp5.

**21.** ddddddd: Higher 6 bits of disp8.

**22.** Do not make a combination that satisfies all the following conditions when using the “MUL reg1, reg2, reg3” instruction and “MULU reg1, reg2, reg3” instruction. Operation is not guaranteed when an instruction that satisfies the following conditions is executed.

- Reg1 = reg3
- Reg1 ≠ reg2
- Reg1 ≠ r0
- Reg3 ≠ r0

## APPENDIX C REVISION HISTORY

### C.1 Major Revisions in This Edition

(1/2)

| Page         | Description                                                                                                                             |
|--------------|-----------------------------------------------------------------------------------------------------------------------------------------|
| pp. 39, 40   | Addition of <b>Note</b> to <b>2.2 Pin Status</b>                                                                                        |
| p. 66        | Modification of <b>Note</b> in <b>Table 3-2 System Register Numbers</b>                                                                 |
| p. 71        | Modification of description in <b>3.2.2 (6) Exception/debug trap status saving registers (DBPC, DBPSW)</b>                              |
| p. 113       | Modification of description in <b>3.5 (3) Source/destination address of DMA transfer when transfer target is on-chip peripheral I/O</b> |
| p. 122       | Addition of <b>Caution</b> to <b>4.5.2 (1) Local bus sizing control register (LBS)</b>                                                  |
| p. 129       | Modification of description in <b>4.5.5 (2) (a) &lt;2&gt; Access to address (4n + 1)</b>                                                |
| p. 132       | Modification of description in <b>4.5.5 (2) (d) &lt;2&gt; Access to address (4n + 1)</b>                                                |
| p. 135       | Modification of description in <b>4.5.5 (3) (a) &lt;2&gt; Access to address (4n + 1)</b>                                                |
| p. 136       | Modification of description in <b>4.5.5 (3) (a) &lt;4&gt; Access to address (4n + 3)</b>                                                |
| p. 141       | Modification of description in <b>4.5.5 (3) (d) &lt;2&gt; Access to address (4n + 1)</b>                                                |
| p. 142       | Modification of description in <b>4.5.5 (3) (d) &lt;4&gt; Access to address (4n + 3)</b>                                                |
| p. 163       | Addition of description to <b>Caution</b> in <b>4.9.1 (1) Cache configuration register (BHC)</b>                                        |
| p. 172       | Modification of description in <b>4.10.3 Cautions</b>                                                                                   |
| p. 186       | Addition of description to <b>4.15 (10) Caution on setting BHC register</b>                                                             |
| p. 223       | Modification of <b>Figure 5-9 SDRAM Single Read Cycle</b>                                                                               |
| p. 255       | Modification of description in <b>6.1 Features</b>                                                                                      |
| p. 269       | Addition and modification of <b>Caution</b> in <b>6.3.7 DMA trigger factor registers 0 to 3 (DTFR0 to DTFR3)</b>                        |
| p. 303       | Modification of <b>Note</b> in <b>Table 6-5 Relationship Between Transfer Type and Transfer Target</b>                                  |
| p. 309       | Deletion of <b>Remark</b> from <b>6.9 (1) Request from an external pin (DMARQn)</b>                                                     |
| p. 309       | Modification of description in <b>6.9 (4) Request by USB (enabled only in single transfer mode and single-step transfer mode)</b>       |
| p. 317       | Addition of description to <b>6.15 (12) Cautions on setting DCHCn register</b>                                                          |
| p. 361       | Addition of <b>Caution</b> to <b>7.5.1 (2) Restore</b>                                                                                  |
| p. 373       | Modification of description in <b>8.3.1 (2) Setting data to clock control register (CKC)</b>                                            |
| p. 375       | Modification of description in <b>8.3.2 Clock source select register (CKS)</b>                                                          |
| pp. 377, 378 | Modification of description in <b>8.3.3 SSCG control register (SSCGC)</b>                                                               |
| p. 389       | Modification of description in <b>8.6.2 (3) Power-save control register (PSC)</b>                                                       |
| p. 624       | Addition of <b>Remark</b> to <b>11.4.1 (26) UF0 INT &amp; DMARQ register (UF0IDR)</b>                                                   |
| p. 644       | Modification of <b>Figure 11-1 Operation of UF0E0R Register</b>                                                                         |
| p. 646       | Modification of <b>Figure 11-2 Operation of UF0E0ST Register</b>                                                                        |
| p. 648       | Modification of <b>Figure 11-3 Operation of UF0E0W Register</b>                                                                         |
| pp. 650, 651 | Modification of <b>Figure 11-4 Operation of UF0BO1 Register</b>                                                                         |
| pp. 654, 655 | Modification of <b>Figure 11-5 Operation of UF0BO2 Register</b>                                                                         |
| p. 656       | Modification of description and addition of <b>Caution</b> in <b>11.4.2 (9) UF0 bulk in 1 register (UF0BI1)</b>                         |
| p. 660       | Modification of description and addition of <b>Caution</b> in <b>11.4.2 (10) UF0 bulk in 2 register (UF0BI2)</b>                        |

| Page         | Description                                                                                                                                                 |
|--------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------|
| p. 676       | Modification of <b>Caution</b> in 11.4.3 (9) UF0 address register (UF0ADRS)                                                                                 |
| p. 677       | Modification of description in 11.4.3 (10) UF0 configuration register (UF0CNF)                                                                              |
| p. 678       | Modification of <b>Caution</b> in 11.4.3 (11) UF0 interface 0 register (UF0IF0)                                                                             |
| p. 679       | Modification of <b>Caution</b> in 11.4.3 (12) UF0 interface 1 to 4 registers (UF0IF1 to UF0IF4)                                                             |
| pp. 711, 713 | Modification of description in <b>Figure 11-22 CPUDEC Request for Control Transfer</b>                                                                      |
| p. 715       | Addition of description to <b>Figure 11-23 Processing for Bulk Transfer (IN) (Endpoint1)</b>                                                                |
| p. 718       | Modification of description in <b>Figure 11-25 Normal Processing for Bulk Transfer (OUT) (Endpoint2)</b>                                                    |
| p. 728       | Modification of description in <b>Figure 11-29 Example of Processing After Power Application/Power Failure</b>                                              |
| p. 742       | Addition of description to <b>Caution</b> in <b>Figure 12-1 Block Diagram of A/D Converter</b>                                                              |
| pp. 768, 769 | Addition of description to <b>12.8 Cautions</b>                                                                                                             |
| p. 818       | Addition of <b>Caution</b> to 14.3.1 (2) (b) Port 1 mode control register (PMC1)                                                                            |
| p. 819       | Addition of <b>Caution</b> to 14.3.1 (2) (c) Port 1 function control register (PFC1)                                                                        |
| p. 859       | Modification of <b>Figure 14-25 Timing When CSDCn Bit Is Set to 1</b>                                                                                       |
| p. 877       | Modification of description in <b>14.7.2 Cautions on bit manipulation instruction for port n register (Pn)</b>                                              |
| p. 902       | Modification of description in <b>AC Characteristics (1) Clock timing</b> in <b>CHAPTER 17 ELECTRICAL SPECIFICATIONS</b>                                    |
| p. 905       | Modification of figure in <b>AC Characteristics (4) (a) Access timing (SRAM, external ROM, external I/O)</b> in <b>CHAPTER 17 ELECTRICAL SPECIFICATIONS</b> |
| p. 942       | Modification of description in <b>CHAPTER 19 RECOMMENDED SOLDERING CONDITIONS</b>                                                                           |

## C.2 Revision History up to Previous Edition

The following table shows the revision history up to this edition. The “Applied to:” column indicates the chapters of each edition in which the revision was applied.

(1/11)

| Edition | Major Revision from Previous Edition                                                                                                                                                                                                                                                                              | Applied to:                                     |
|---------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------|
| 2nd     | <ul style="list-style-type: none"> <li>Addition of the following product.<br/>μPD703111GM-15-UEU</li> <li>Deletion of indication “under development” for the following products (developed)<br/>μPD703111GM-10-UEU, 703111GM-13-UEU</li> <li>Change of the following register name.<br/>PFCAL → PFCALL</li> </ul> | Throughout                                      |
|         | Addition of execution time of 150 MHz products to minimum instruction execution time in <b>1.2 Features</b>                                                                                                                                                                                                       | <b>CHAPTER 1 INTRODUCTION</b>                   |
|         | Addition of <b>Note</b> in <b>2.1 (2) Non-port pins</b>                                                                                                                                                                                                                                                           | <b>CHAPTER 2 PIN FUNCTIONS</b>                  |
|         | Addition of description in <b>2.3 (1) (b) (vii) UCLK (USB clock)</b>                                                                                                                                                                                                                                              |                                                 |
|         | Modification of description in <b>2.3 (3) (b) (ii) DMAAK0, DMAAK1 (DMA acknowledge)</b>                                                                                                                                                                                                                           |                                                 |
|         | Modification of description in <b>2.3 (5) (b) (ii) DMAAK2, DMAAK3 (DMA acknowledge)</b>                                                                                                                                                                                                                           |                                                 |
|         | Addition of execution time of 150 MHz products to minimum instruction execution time in <b>3.1 Features</b>                                                                                                                                                                                                       | <b>CHAPTER 3 CPU FUNCTION</b>                   |
|         | Modification of default value in <b>3.2.1 (2) Program counter (PC)</b>                                                                                                                                                                                                                                            |                                                 |
|         | Modification of description in <b>3.4.7 Peripheral I/O registers</b>                                                                                                                                                                                                                                              |                                                 |
|         | Change of table of VSWC setting values in <b>3.4.9 System wait control register (VSWC)</b>                                                                                                                                                                                                                        |                                                 |
|         | Modification of description in <b>4.2.1 Pin status during internal instruction RAM, internal data RAM, and peripheral I/O access</b>                                                                                                                                                                              | <b>CHAPTER 4 BUS CONTROL FUNCTION</b>           |
|         | Modification of description when BTn1 and BTn0 bits are set to 11 in <b>4.4.1 (1) Bus cycle type configuration registers 0, 1 (BCT0, BCT1)</b>                                                                                                                                                                    |                                                 |
|         | Modification of table of number of access clocks in <b>4.5.1 Number of access clocks</b>                                                                                                                                                                                                                          |                                                 |
|         | Addition to <b>Cautions</b> and modification of description in <b>4.5.6 (1) Line buffer control registers 0, 1 (LBC0, LBC1)</b>                                                                                                                                                                                   |                                                 |
|         | Addition of <b>Remark</b> in <b>4.5.6 (1) (a) Speculative read function (read buffer function)</b>                                                                                                                                                                                                                |                                                 |
|         | Modification of description, addition of <b>Note</b> , and addition to <b>Cautions</b> in <b>4.5.6 (1) (b) Write buffer function</b>                                                                                                                                                                              |                                                 |
|         | Addition to <b>Cautions</b> in <b>4.7.1 (3) Bus cycle period control register (BCP)</b>                                                                                                                                                                                                                           |                                                 |
|         | Modification of <b>Cautions</b> in <b>4.9.1 (1) Cache configuration register (BHC)</b>                                                                                                                                                                                                                            |                                                 |
|         | Addition of <b>(5)</b> in <b>4.10.3 Cautions</b>                                                                                                                                                                                                                                                                  |                                                 |
|         | Addition of timing and modification of <b>Notes</b> in <b>4.11.6 (1) SDRAM (when read, latency = 2, no idle state insertion)</b>                                                                                                                                                                                  |                                                 |
|         | Addition of timing and modification of <b>Notes</b> in <b>4.11.6 (2) SDRAM (when read, latency = 2, two idle states inserted, 32-bit bus width)</b>                                                                                                                                                               |                                                 |
|         | Addition of timing and modification of <b>Notes</b> in <b>4.11.6 (3) SDRAM (when written)</b>                                                                                                                                                                                                                     |                                                 |
|         | Addition of <b>4.14 Timing at Which T0 State Is Not Inserted</b>                                                                                                                                                                                                                                                  |                                                 |
|         | Addition of timing and modification of <b>Notes</b> in <b>Figure 5-9 SDRAM Single Read Cycle</b>                                                                                                                                                                                                                  | <b>CHAPTER 5 MEMORY ACCESS CONTROL FUNCTION</b> |
|         | Addition of timing and modification of <b>Notes</b> in <b>Figure 5-10 SDRAM Single Write Cycle</b>                                                                                                                                                                                                                |                                                 |



| Edition | Major Revision from Previous Edition                                                                                                                | Applied to:                                              |
|---------|-----------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------|
| 2nd     | Addition of timing and modification of <b>Notes</b> in <b>Figure 5-11 SDRAM Access Timing</b>                                                       | <b>CHAPTER 5 MEMORY ACCESS CONTROL FUNCTION</b>          |
|         | Modification of <b>Caution</b> in <b>5.3.6 (1) SDRAM refresh control registers 1, 3, 4, 6 (RFS1, RFS3, RFS4, RFS6)</b>                              |                                                          |
|         | Modification of description in <b>Table 5-1 Example of Interval Factor Settings</b>                                                                 |                                                          |
|         | Addition of internal instruction RAM in block diagram in <b>6.2 Configuration</b>                                                                   | <b>CHAPTER 6 DMA FUNCTIONS (DMA CONTROLLER)</b>          |
|         | Addition to <b>Cautions</b> in <b>6.3.1 (1) DMA source address registers 0H to 3H (DSA0H to DSA3H)</b>                                              |                                                          |
|         | Addition to <b>Cautions</b> in <b>6.3.2 (1) DMA destination address registers 0H to 3H (DDA0H to DDA3H)</b>                                         |                                                          |
|         | Addition to <b>Cautions</b> in <b>6.3.3 DMA transfer count registers 0 to 3 (DBC0 to DBC3)</b>                                                      |                                                          |
|         | Addition to <b>Cautions</b> in <b>6.3.4 DMA addressing control registers 0 to 3 (DADC0 to DADC3)</b>                                                |                                                          |
|         | Addition to <b>Cautions</b> and description in <b>6.3.5 DMA channel control registers 0 to 3 (DCHC0 to DCHC3)</b>                                   |                                                          |
|         | Addition to <b>Cautions</b> and description in <b>6.3.6 DMA terminal count output control register (DTC)</b>                                        |                                                          |
|         | Addition to <b>Cautions</b> in <b>6.3.7 DMA trigger factor registers 0 to 3 (DTFR0 to DTFR3)</b>                                                    |                                                          |
|         | Addition of <b>6.3.7 (1) DMA request detection function</b>                                                                                         |                                                          |
|         | Addition of <b>Caution</b> and <b>Note</b> and modification of description in <b>6.3.8 DMA interface control register (DIFC)</b>                    |                                                          |
|         | Addition of timing and modification of <b>Notes</b> in <b>Figure 6-12 Timing of 2-Cycle DMA Transfer (SDRAM → SRAM)</b>                             |                                                          |
|         | Addition of <b>6.5.1 (1) Timing of <math>\overline{\text{DMARQn}}</math> and <math>\overline{\text{DMAAKn}}</math> signals for 2-cycle transfer</b> |                                                          |
|         | Addition of <b>6.5.1 (2) <math>\overline{\text{DMAAKn}}</math> signal active width extension function</b>                                           |                                                          |
|         | Addition of <b>6.5.1 (3) Outline of 2-cycle transfer timing</b>                                                                                     |                                                          |
|         | Modification of timing in <b>Figure 6-19 Timing of DMA Flyby Transfer (External I/O → SDRAM)</b>                                                    |                                                          |
|         | Modification of timing in <b>Figure 6-23 Timing of DMA Flyby Transfer (SDRAM → External I/O)</b>                                                    |                                                          |
|         | Modification of timing in <b>Figure 6-24 Timing of DMA Flyby Transfer (External I/O → SDRAM)</b>                                                    |                                                          |
|         | Modification of description and addition to <b>Caution</b> in <b>Table 6-5 Relationship Between Transfer Type and Transfer Object</b>               |                                                          |
|         | Addition of description in <b>6.8 Next Address Setting Function</b>                                                                                 |                                                          |
|         | Addition of <b>Cautions</b> in <b>6.9 DMA Transfer Start Factors</b>                                                                                |                                                          |
|         | Modification of description in <b>6.13 Times Related to DMA Transfer</b>                                                                            |                                                          |
|         | Modification of description in <b>6.15 (3) Bus arbitration for CPU</b>                                                                              |                                                          |
|         | Addition of <b>6.15 (7) Read values of DSA<sub>n</sub> and DDAn registers</b>                                                                       |                                                          |
|         | Modification of <b>Note</b> in <b>Figure 7-14 Pipeline Operation at Interrupt Request Acknowledgment (Outline)</b>                                  | <b>CHAPTER 7 INTERRUPT/EXCEPTION PROCESSING FUNCTION</b> |

| Edition | Major Revision from Previous Edition                                                                                                                   | Applied to:                                                    |
|---------|--------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------|
| 2nd     | Modification of selection of SSCG output by PLLSEL pin and MDL-Selector Table (modulation period) in <b>8.1 Features</b>                               | <b>CHAPTER 8 CLOCK GENERATION FUNCTION</b>                     |
|         | Addition to <b>Cautions</b> and modification of description in <b>8.3.1 Clock control register (CKC)</b>                                               |                                                                |
|         | Modification of sample coding <2> for data setting sequence of clock source select register (CKS) in <b>8.3.2 Clock source select register (CKS)</b>   |                                                                |
|         | Modification of description in <b>8.3.3 SSCG control register (SSCGC)</b>                                                                              |                                                                |
|         | Addition of <b>Caution</b> in <b>8.3.4 USB clock control register (UCKC)</b>                                                                           |                                                                |
|         | Modification of oscillation stabilization time in <b>8.3.6 Oscillation stabilization time select register (OSTS)</b>                                   |                                                                |
|         | Addition to <b>Notes</b> in <b>Table 8-1 Operation Status of Each Clock</b>                                                                            |                                                                |
|         | Modification of description in <b>Table 8-2 Frequency List</b>                                                                                         |                                                                |
|         | Addition of <b>8.5 Operating Clock Provisions</b>                                                                                                      |                                                                |
|         | Modification of oscillation stabilization time in <b>Table 8-11 Counting Time Examples</b>                                                             |                                                                |
|         | Addition to <b>Caution</b> in <b>9.1.5 (2) Timer mode control registers C01 to C51 (TMCC01 to TMCC51)</b>                                              | <b>CHAPTER 9 TIMER/COUNTER FUNCTION (REAL-TIME PULSE UNIT)</b> |
|         | Modification of <b>Figure 9-7 TMC1 Compare Operation Example (Set/Reset Output Mode)</b>                                                               |                                                                |
|         | Addition of noise elimination width when $f_x = 150$ MHz in <b>Table 9-6 Relationship Between NCW1n Register Set Value and Noise Elimination Width</b> |                                                                |
|         | Addition of <b>9.3.7 (6) Overflow interrupt signal (INTOV1n) and underflow interrupt signal (INTUD1n)</b>                                              |                                                                |
|         | Modification of transfer rate in <b>10.2.1 Features</b>                                                                                                | <b>CHAPTER 10 SERIAL INTERFACE FUNCTION</b>                    |
|         | Modification of description in <b>10.2.2 (10) UARTBn receive data register AP (UBnRXAP), UARTBn receive data register (UBnRX) (n = 0, 1)</b>           |                                                                |
|         | Addition of description in <b>10.2.2 (12) UARTBn transmit data register n (UBnTX) (n = 0, 1)</b>                                                       |                                                                |
|         | Modification of <b>Caution</b> in <b>10.2.3 (3) UARTBn control register 2 (UBnCTL2) (n = 0, 1)</b>                                                     |                                                                |
|         | Addition of description in <b>10.2.3 (4) UARTBn transmit data register (UBnTX) (n = 0, 1)</b>                                                          |                                                                |
|         | Modification of description in <b>10.2.3 (5) UARTBn receive data register AP (UBnRXAP), UARTBn receive data register (UBnRX) (n = 0, 1)</b>            |                                                                |
|         | Addition and modification of description in <b>10.2.3 (6) UARTBn FIFO control register 0 (UBnFIC0) (n = 0, 1)</b>                                      |                                                                |
|         | Modification of description in <b>10.2.3 (7) UARTBn FIFO control register 1 (UBnFIC1) (n = 0, 1)</b>                                                   |                                                                |
|         | Addition of description in <b>10.2.4 (5) (b) FIFO mode</b>                                                                                             |                                                                |
|         | Addition of description in <b>10.2.5 (2) Pending mode/pointer mode</b>                                                                                 |                                                                |
|         | Addition of <b>Note</b> in <b>10.2.5 (2) (a) (i) During transmission (writing to transmit FIFO)</b>                                                    |                                                                |
|         | Addition of <b>Note</b> in <b>10.2.5 (2) (a) (ii) During reception (reading from receive FIFO)</b>                                                     |                                                                |
|         | Addition of description in <b>10.2.6 (4) (c) (ii) Reception timeout interrupt (UBTITOn) (in FIFO mode only)</b>                                        |                                                                |
|         | Addition of value when $f_x = 150$ MHz in <b>Table 10-4 Baud Rate Generator Setting Data</b>                                                           |                                                                |

| Edition | Major Revision from Previous Edition                                                                                                                                                             | Applied to:                                      |
|---------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------|
| 2nd     | Addition of <b>10.2.8 Control flow</b>                                                                                                                                                           | <b>CHAPTER 10 SERIAL INTERFACE FUNCTION</b>      |
|         | Modification of description in <b>Figure 10-22 Block Diagram of Clocked Serial Interfaces 30 and 31</b>                                                                                          |                                                  |
|         | Modification of description of <b>Caution 2</b> in <b>10.3.3 (1) Clocked serial interface mode registers 30, 31 (CSIM30, CSIM31)</b>                                                             |                                                  |
|         | Modification of description in <b>10.3.3 (2) Clocked serial interface clock select registers 30, 31 (CSIC30, CSIC31)</b>                                                                         |                                                  |
|         | Addition of description in <b>10.3.3 (3) Receive data buffer registers 30, 31 (SIRB30, SIRB31)</b>                                                                                               |                                                  |
|         | Addition of description in <b>10.3.3 (4) Transmit data CSI buffer registers 30, 31 (SFDB30, SFDB31)</b>                                                                                          |                                                  |
|         | Modification of description in <b>10.3.3 (5) CSIBUF status registers 30, 31 (SFA30, SFA31)</b>                                                                                                   |                                                  |
|         | Modification of example in <b>Caution 2</b> in <b>10.3.4 (2) Baud rate</b>                                                                                                                       |                                                  |
|         | Modification of description in <b>Figure 10-25 Transfer Data Length: 8 Bits (CCLn3 to CCLn0 Bits = 1000 in CSIL3n Register), Transfer Direction: MSB First (DIRn Bit = 0 in CSIM3n Register)</b> |                                                  |
|         | Modification of description in <b>Figure 10-26 Transfer Data Length: 8 Bits (CCLn3 to CCLn0 Bits = 1000 in CSIL3n Register), Transfer Direction: LSB First (DIRn Bit = 1 in CSIM3n Register)</b> |                                                  |
|         | Deletion of description of <b>10.3.5 (7) Slave mode</b>                                                                                                                                          |                                                  |
|         | Modification of <b>Figure 10-30 Slave Mode (CKPn and DAPn Bits = 00 in CSIC3n Register, CCLn3 to CCLn0 Bits = 1000 in CSIL3n Register (Transfer Data Length: 8 Bits))</b>                        |                                                  |
|         | Modification of description in <b>Figure 10-32 Continuous Mode</b>                                                                                                                               |                                                  |
|         | Modification of description in <b>10.3.5 (11) Transmission mode</b>                                                                                                                              |                                                  |
|         | Addition of description in <b>10.3.5 (12) Reception mode</b>                                                                                                                                     |                                                  |
|         | Deletion of description in <b>10.3.5 (16) (a) SCKn pin</b>                                                                                                                                       |                                                  |
|         | Modification of description in <b>Table 10-8 Default Output Level of SCKn Pin</b>                                                                                                                |                                                  |
|         | Modification of description of (1) to (12) in <b>10.3.6 Usage</b>                                                                                                                                |                                                  |
|         | Addition of <b>Caution</b> in <b>11.1 Overview</b>                                                                                                                                               | <b>CHAPTER 11 USB FUNCTION CONTROLLER (USBF)</b> |
|         | Addition of items in <b>Table 11-2 Correspondence Between Requests and Decoded Values</b>                                                                                                        |                                                  |
|         | Addition of description in <b>11.4.1 (3) UF0 EPNAK register (UF0EN)</b>                                                                                                                          |                                                  |
|         | Deletion of description in <b>11.4.1 (9) UF0 EP status 1 register (UF0EPS1)</b>                                                                                                                  |                                                  |
|         | Modification of description in <b>11.4.1 (11) UF0 INT status 0 register (UF0IS0)</b>                                                                                                             |                                                  |
|         | Modification of description in <b>11.4.1 (34) UF0 mode status register (UF0MODS)</b>                                                                                                             |                                                  |
|         | Modification of description in <b>11.4.3 (2) UF0 EP0 status register L (UF0E0SL)</b>                                                                                                             |                                                  |
|         | Modification of description in <b>11.4.3 (9) UF0 address register (UF0ADRS)</b>                                                                                                                  |                                                  |
|         | Modification of description in <b>11.4.3 (10) UF0 configuration register (UF0CNF)</b>                                                                                                            |                                                  |
|         | Modification of description in <b>11.4.3 (11) UF0 interface 0 register (UF0IF0)</b>                                                                                                              |                                                  |
|         | Modification of description in <b>11.4.3 (12) UF0 interface 1 to 4 registers (UF0IF1 to UF0IF4)</b>                                                                                              |                                                  |

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|---------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------|
| 2nd     | Modification of <b>Caution 2</b> in 11.4.3 (14) UF0 device descriptor registers 0 to 17 (UF0DD0 to UF0DD17)                                                                       | <b>CHAPTER 11 USB FUNCTION CONTROLLER (USBF)</b>   |
|         | Modification of <b>Caution 2</b> in 11.4.3 (15) UF0 configuration/interface/endpoint descriptor registers 0 to 255 (UF0CIE0 to UF0CIE255)                                         |                                                    |
|         | Modification of <b>Caution</b> in 11.4.4 (1) USB function 0 DMA channel select register (UF0CS)                                                                                   |                                                    |
|         | Deletion of <b>Caution</b> in Table 11-8 FW-Supported Standard Requests                                                                                                           |                                                    |
|         | Modification of description in Figure 11-15 Automatically Processed Requests for Control Transfer                                                                                 |                                                    |
|         | Modification of description in Figure 11-20 CPUDEC Request for Control Transfer                                                                                                   |                                                    |
|         | Modification of description in Figure 11-30 USB Connection Example                                                                                                                |                                                    |
|         | Addition of value when $f_x = 150$ MHz in Table 12-1 Setting of A/D Conversion Operation Time                                                                                     | <b>CHAPTER 12 A/D CONVERTER</b>                    |
|         | Addition of 12.9 How to Read A/D Converter Characteristics Table                                                                                                                  |                                                    |
|         | Modification of repeat frequency in 13.1 Features                                                                                                                                 | <b>CHAPTER 13 PWM UNIT</b>                         |
|         | Modification of description in Figure 13-1 Block Diagram of PWM Unit                                                                                                              |                                                    |
|         | Modification of description in 13.3 (1) PWM control registers 0 and 1 (PWMC0 and PWMC1)                                                                                           |                                                    |
|         | Modification of description in 13.4.2 (1) Setting for starting PWM operation                                                                                                      |                                                    |
|         | Modification of description in Table 13-1 Repeat Cycle of PWMn                                                                                                                    |                                                    |
|         | Modification of <b>Caution</b> in 14.3.8 Port DH                                                                                                                                  | <b>CHAPTER 14 PORT FUNCTIONS</b>                   |
|         | Modification of <b>Caution</b> and description on bit 0 in 14.3.8 (2) (c) Port DH function control register (PFCDH)                                                               |                                                    |
|         | Addition to <b>Caution</b> in 14.3.10 (2) (c) Port CT function control register (PFCCT)                                                                                           |                                                    |
|         | Addition of noise elimination width when $f_x = 150$ MHz in Table 14-4 Relationship Between NCW1n Register Set Value and Noise Elimination Width                                  |                                                    |
|         | Modification of value of program counter (PC) after reset in Table 15-2 Initial Value of CPU, Internal Data RAM, Internal Instruction RAM, and On-Chip Peripheral I/O After Reset | <b>CHAPTER 15 RESET FUNCTIONS</b>                  |
|         | Modification of description in 16.1.1 (7) Mask function                                                                                                                           | <b>CHAPTER 16 DEBUG FUNCTION (DCU)</b>             |
|         | Addition of <b>CHAPTER 17 ELECTRICAL SPECIFICATIONS (TARGET VALUES)</b>                                                                                                           | <b>CHAPTER 17 ELECTRICAL SPECIFICATIONS</b>        |
|         | Addition of <b>CHAPTER 18 PACKAGE DRAWING</b>                                                                                                                                     | <b>CHAPTER 18 PACKAGE DRAWING</b>                  |
|         | Addition of <b>CHAPTER 19 RECOMMENDED SOLDERING CONDITIONS</b>                                                                                                                    | <b>CHAPTER 19 RECOMMENDED SOLDERING CONDITIONS</b> |
|         | Addition to <b>Note</b> in B.2 Instruction Set (in Alphabetical Order)                                                                                                            | <b>APPENDIX B INSTRUCTION SET LIST</b>             |
|         | Addition of <b>APPENDIX C REVISION HISTORY</b>                                                                                                                                    | <b>APPENDIX C REVISION HISTORY</b>                 |

| Edition | Major Revision from Previous Edition                                                                                                        | Applied to:                                             |
|---------|---------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------|
| 3rd     | Deletion of the following product<br>$\mu$ PD703111<br>Addition of the following product<br>$\mu$ PD703111A                                 | Throughout                                              |
|         | Addition of 240-pin plastic FBGA to <b>1.2 Features</b>                                                                                     | <b>CHAPTER 1<br/>INTRODUCTION</b>                       |
|         | Addition of 240-pin plastic FBGA to <b>1.5 Pin Configuration</b>                                                                            |                                                         |
|         | Addition of <b>Caution</b> to <b>2.3 (6) (b) (i) WAIT</b>                                                                                   | <b>CHAPTER 2 PIN<br/>FUNCTIONS</b>                      |
|         | Addition of <b>Caution</b> to <b>2.3 (6) (b) (iii) HLDRQ</b>                                                                                |                                                         |
|         | Modification of description in <b>2.3 (6) (b) (iv) REFRQ</b>                                                                                |                                                         |
|         | Modification of <b>Figure 3-1 CPU Register Set</b>                                                                                          | <b>CHAPTER 3 CPU<br/>FUNCTION</b>                       |
|         | Modification of <b>Table 3-2 System Register Numbers</b>                                                                                    |                                                         |
|         | Modification of <b>3.2.2 (2) Program status word (PSW)</b>                                                                                  |                                                         |
|         | Addition of write access synchronization control register, modification of description of R/W in <b>3.4.7 Peripheral I/O registers</b>      |                                                         |
|         | Addition of description to <b>3.4.10 &lt;1&gt; Automatically branch to address 100000H after reset is cleared</b>                           |                                                         |
|         | Addition of <b>Caution 3</b> to <b>4.5.6 (1) Line buffer control registers 0, 1 (LBC0, LBC1)</b>                                            | <b>CHAPTER 4 BUS<br/>CONTROL FUNCTION</b>               |
|         | Modification of <b>Cautions 2 and 3</b> in <b>4.5.6 (1) (b) Write buffer function</b>                                                       |                                                         |
|         | Addition of <b>4.5.6 (2) Write access synchronization control register (WAS)</b>                                                            |                                                         |
|         | Addition of <b>Caution 3</b> to <b>4.6 (1) Bus mode control register (BMC)</b>                                                              |                                                         |
|         | Addition of <b>Caution 4</b> to <b>4.7.1 (2) Address setup wait control register (ASC)</b>                                                  |                                                         |
|         | Modification of <b>Caution 3</b> in <b>4.7.1 (3) Bus cycle period control register (BCP)</b>                                                |                                                         |
|         | Modification of <b>Figure 4-6 Example of Wait Insertion</b>                                                                                 |                                                         |
|         | Modification of <b>Table 4-1 Bus Cycles in Which Wait Function Is Valid</b>                                                                 |                                                         |
|         | Addition of <b>4.9.7 Cautions</b>                                                                                                           |                                                         |
|         | Modification of description in <b>4.10.3 Cautions (5)</b>                                                                                   |                                                         |
|         | Modification of <b>4.11.5 (1) SRAM (when read, without speculative read, no idle state insertion, BUSCLK = f<sub>CLK</sub>/2)</b>           |                                                         |
|         | Modification of <b>4.11.5 (2) SRAM (when read, with speculative read, no idle state insertion, BUSCLK = f<sub>CLK</sub>/2)</b>              |                                                         |
|         | Modification of <b>4.11.5 (3) SRAM (when written, two idle states inserted, BUSCLK = f<sub>CLK</sub>/2)</b>                                 |                                                         |
|         | Addition of description to <b>5.2.3 On-page/off-page judgment</b>                                                                           | <b>CHAPTER 5 MEMORY<br/>ACCESS CONTROL<br/>FUNCTION</b> |
|         | Addition of item to <b>5.3.1 Features</b>                                                                                                   |                                                         |
|         | Addition of <b>Caution 3</b> to <b>6.3.2 (1) DMA destination address registers 0H to 3H (DDA0H to DDA3H)</b>                                | <b>CHAPTER 6 DMA<br/>FUNCTIONS (DMA<br/>CONTROLLER)</b> |
|         | Addition of <b>Caution 4</b> to <b>6.3.4 DMA addressing control registers 0 to 3 (DADC0 to DADC3)</b>                                       |                                                         |
|         | Modification of <b>Cautions 1 and 5</b> and <b>Caution</b> on Enn bit in <b>6.3.5 DMA channel control registers 0 to 3 (DCHC0 to DCHC3)</b> |                                                         |
|         | Addition of <b>Caution 2</b> to <b>6.5.1 2-cycle transfer</b>                                                                               |                                                         |
|         | Modification of <b>Figure 6-8 Timing of 2-Cycle DMA Transfer (SRAM → External I/O)</b>                                                      |                                                         |

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| 3rd     | Modification of <b>Figure 6-9 Timing of 2-Cycle DMA Transfer (SDRAM → SRAM)</b>                                                                   | <b>CHAPTER 6 DMA FUNCTIONS (DMA CONTROLLER)</b>                |
|         | Modification of <b>Figure 6-10 Timing of 2-Cycle DMA Transfer (SRAM → SDRAM)</b>                                                                  |                                                                |
|         | Modification of <b>Figure 6-11 Timing of 2-Cycle DMA Transfer (SRAM → External I/O): Without Speculative Read</b>                                 |                                                                |
|         | Modification of <b>Figure 6-12 Timing of 2-Cycle DMA Transfer (SDRAM → SRAM) (a) Without speculative read</b>                                     |                                                                |
|         | Modification of <b>Figure 6-12 Timing of 2-Cycle DMA Transfer (SDRAM → SRAM) (b) With speculative read, speculative read hit</b>                  |                                                                |
|         | Addition of <b>Caution</b> to <b>6.5.2 Flyby transfer</b>                                                                                         |                                                                |
|         | Addition of <b>Notes 3 and 5</b> to <b>Table 6-5 Relationship Between Transfer Type and Transfer Target</b>                                       |                                                                |
|         | Modification of description in <b>6.10 Terminal Count Output upon DMA Transfer End</b>                                                            |                                                                |
|         | Modification of <b>Figure 6-23 Example of Forcible Termination of DMA Transfer</b>                                                                |                                                                |
|         | Modification of description in <b>6.13 Times Related to DMA Transfer</b>                                                                          |                                                                |
|         | Modification of <b>6.14 Maximum Response Time for DMA Transfer Request</b>                                                                        |                                                                |
|         | Addition of description to <b>6.15 (5) DMAAKn signal output</b>                                                                                   |                                                                |
|         | Addition of <b>Caution 3</b> to <b>8.6.5 (1) Setting and operation status</b>                                                                     | <b>CHAPTER 8 CLOCK GENERATION FUNCTION</b>                     |
|         | Addition of description to <b>9.1.5 (4) Noise elimination width setting registers C0 to C3 (NCWC0 to NCWC3)</b>                                   | <b>CHAPTER 9 TIMER/COUNTER FUNCTION (REAL-TIME PULSE UNIT)</b> |
|         | Modification of <b>Figure 9-17 Timer ENC1 Block Diagram</b>                                                                                       |                                                                |
|         | Addition of <b>Caution 2</b> to <b>9.3.4 (2) Compare registers 100, 110 (CM100, CM110)</b>                                                        |                                                                |
|         | Addition of <b>Caution 2</b> to <b>9.3.4 (3) Compare registers 101, 111 (CM101, CM111)</b>                                                        |                                                                |
|         | Addition of <b>Caution 6</b> to <b>9.3.4 (4) Capture/compare registers 100, 110 (CC100, CC110)</b>                                                |                                                                |
|         | Addition of <b>Caution 6</b> to <b>9.3.4 (5) Capture/compare registers 101, 111 (CC101, CC111)</b>                                                |                                                                |
|         | Addition of <b>Cautions 2 and 3</b> to <b>9.3.5 (1) Timer unit mode registers 10, 11 (TUM10, TUM11)</b>                                           |                                                                |
|         | Addition of <b>Caution</b> to description of MSELn bit in <b>9.3.5 (1) Timer unit mode registers 10, 11 (TUM10, TUM11)</b>                        |                                                                |
|         | Addition of <b>Caution 2</b> to <b>9.3.5 (2) Timer control registers 10, 11 (TMC10, TMC11)</b>                                                    |                                                                |
|         | Deletion of a part of <b>Caution</b> on RLEN1n bit in <b>9.3.5 (2) Timer control registers 10, 11 (TMC10, TMC11)</b>                              |                                                                |
|         | Addition of <b>Caution 4</b> to <b>9.3.5 (3) Capture/compare control registers 10, 11 (CCR10, CCR11)</b>                                          |                                                                |
|         | Addition of <b>Caution 3</b> to <b>9.3.5 (4) Valid edge select registers 10, 11 (SESA10, SESA11)</b>                                              |                                                                |
|         | Addition of <b>Caution 4</b> to <b>9.3.5 (5) Prescaler mode registers 10, 11 (PRM10, PRM11)</b>                                                   |                                                                |
|         | Modification of <b>Caution</b> in <b>9.3.5 (6) Status registers 10, 11 (STATUS10, STATUS11)</b>                                                   |                                                                |
|         | Addition of <b>Note 1</b> to description on NCC1n, NCC0n bits in <b>9.3.5 (7) Noise elimination width setting registers 10, 11 (NCW10, NCW11)</b> |                                                                |
|         | Modification of <b>Table 9-6 Relationship Between NCW1n Register Set Value and Noise Elimination Width</b>                                        |                                                                |
|         | Modification of <b>Figure 9-18 TMENC1n Block Diagram (During PWM Output Operation)</b>                                                            |                                                                |

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| 3rd     | Modification of <b>Caution</b> in 10.2.3 (3) <b>UARTBn control register 2 (UBnCTL2) (n = 0, 1)</b>                                                                                                           | <b>CHAPTER 10 SERIAL INTERFACE FUNCTION</b>        |
|         | Addition of <b>Caution 3</b> to 10.2.3 (5) <b>UARTBn receive data register AP (UBnRXAP), UARTBn receive data register (UBnRX) (n = 0, 1)</b>                                                                 |                                                    |
|         | Modification of description of CSITn bit in 10.3.3 (1) <b>Clocked serial interface mode registers 30, 31 (CSIM30, CSIM31)</b>                                                                                |                                                    |
|         | Addition of <b>Caution</b> to description on CKS3n2 to CKS3n0 bits in 10.3.3 (2) <b>Clocked serial interface clock select registers 30, 31 (CSIC30, CSIC31)</b>                                              |                                                    |
|         | Addition of <b>Caution</b> to <b>Table 10-7 Conditions Under Which Data Can Be Transferred in Slave Mode</b>                                                                                                 |                                                    |
|         | Modification of description in 11.4.1 (4) <b>UF0 EPNACK mask register (UF0ENM)</b>                                                                                                                           | <b>CHAPTER 11 USB FUNCTION CONTROLLER (USBF)</b>   |
|         | Modification of description in 11.4.1 (32) <b>UF0 GPR register (UF0GPR)</b>                                                                                                                                  |                                                    |
|         | Modification of <b>Figure 11-21 Processing for Bulk Transfer (IN) (Endpoint1)</b>                                                                                                                            |                                                    |
|         | Modification of <b>Figure 11-30 USB Connection Example</b>                                                                                                                                                   |                                                    |
|         | Addition of description to 11.7.8 (2) <b>Detecting USB cable connection/disconnection</b>                                                                                                                    |                                                    |
|         | Change of 14.3.9 (2) (c) <b>Port CS function control register (PFCCS)</b>                                                                                                                                    | <b>CHAPTER 14 PORT FUNCTIONS</b>                   |
|         | Addition of description to 14.6.3 (1) <b>Noise elimination width setting registers C0 to C3 (NCWC0 to NCWC3)</b>                                                                                             |                                                    |
|         | Addition of <b>Note 1</b> to description on NCC1n, NCC0n bits in 14.6.3 (2) <b>Noise elimination width setting registers 10, 11 (NCW10, NCW11)</b>                                                           |                                                    |
|         | Modification of <b>Table 14-4 Relationship Between NCW1n Register Set Value and Noise Elimination Width</b>                                                                                                  |                                                    |
|         | Modification of <b>Table 15-2 Initial Value of CPU, Internal Instruction RAM, Internal Data RAM, and On-Chip Peripheral I/O After Reset</b>                                                                  | <b>CHAPTER 15 RESET FUNCTIONS</b>                  |
|         | Modification of <b>Table 16-1 Emulator Connector Pin Function</b>                                                                                                                                            | <b>CHAPTER 16 DEBUG FUNCTION (DCU)</b>             |
|         | Modification of <b>twwrh</b> in <b>CHAPTER 17 (4) (c) Write timing (SRAM, external ROM, external I/O)</b>                                                                                                    | <b>CHAPTER 17 ELECTRICAL SPECIFICATIONS</b>        |
|         | Modification of <b>tsaw</b> , <b>tsbsw</b> , and <b>tdwrrd</b> , <b>Note</b> , and timing diagram in <b>CHAPTER 17 (4) (d) DMA flyby transfer timing (transfer from SRAM to external I/O)</b>                |                                                    |
|         | Modification of <b>tsaw</b> , <b>tsbsw</b> , <b>twwrh</b> , and <b>tdwrrd</b> , <b>Note</b> , and timing diagram in <b>CHAPTER 17 (4) (e) DMA flyby transfer timing (transfer from external I/O to SRAM)</b> |                                                    |
|         | Modification of <b>CHAPTER 17 (6) (a) Read timing (SDRAM access)</b>                                                                                                                                         |                                                    |
|         | Modification of <b>CHAPTER 17 (6) (b) Write timing (SDRAM access)</b>                                                                                                                                        |                                                    |
|         | Addition of <b>CHAPTER 17 (6) (c) DMA flyby transfer timing (transfer from external I/O to SDRAM)</b>                                                                                                        |                                                    |
|         | Modification of <b>thkdr</b> in <b>CHAPTER 17 (7) (a) Level mode</b>                                                                                                                                         |                                                    |
|         | Modification of <b>tdhqa1</b> and <b>tdhqa2</b> , and addition of <b>Notes 1, 2, and 3</b> in <b>CHAPTER 17 (8) Bus hold timing</b>                                                                          |                                                    |
|         | Addition of 240-pin plastic FBGA (16 × 16) package drawing to <b>CHAPTER 18 PACKAGE DRAWINGS</b>                                                                                                             | <b>CHAPTER 18 PACKAGE DRAWINGS</b>                 |
|         | Addition of <b>Caution</b> to <b>CHAPTER 19 RECOMMENDED SOLDERING CONDITIONS</b>                                                                                                                             | <b>CHAPTER 19 RECOMMENDED SOLDERING CONDITIONS</b> |
|         | Addition of <b>APPENDIX A NOTES</b>                                                                                                                                                                          | <b>APPENDIX A NOTES</b>                            |

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|---------|-------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------|
| 4th     | Deletion of $\mu$ PD703111AF1-10-GA3                                                                                          | Throughout                                              |
|         | Modification of the number of instructions in <b>1.2 Features</b>                                                             | <b>CHAPTER 1<br/>INTRODUCTION</b>                       |
|         | Modification of description in <b>1.6.2 (3) RAM</b>                                                                           |                                                         |
|         | Addition of <b>1.6.2 (11) On-chip debug function (DCU)</b>                                                                    |                                                         |
|         | Modification of description in <b>2.2 Pin Status</b>                                                                          | <b>CHAPTER 2<br/>PIN FUNCTIONS</b>                      |
|         | Deletion of a part of description in <b>2.3 (6) (b) (iv) REFRQ (Refresh request)</b>                                          |                                                         |
|         | Addition and change of <b>Note</b> in <b>Table 3-2 System Register Numbers</b>                                                | <b>CHAPTER 3<br/>CPU FUNCTION</b>                       |
|         | Addition of <b>3.2.2 (1) Interrupt status saving registers (EIPC, EIPSW)</b>                                                  |                                                         |
|         | Addition of <b>3.2.2 (2) NMI status saving registers (FEPC, FEPSW)</b>                                                        |                                                         |
|         | Addition of <b>3.2.2 (5) CALLT execution status saving registers (CTPC, CTPSW)</b>                                            |                                                         |
|         | Addition of <b>3.2.2 (6) Exception/debug trap status saving registers (DBPC, DBPSW)</b>                                       |                                                         |
|         | Addition of <b>3.2.2 (7) CALLT base pointer (CTBP)</b>                                                                        |                                                         |
|         | Addition of items to <b>3.4.9 System wait control register (VSWC)</b>                                                         |                                                         |
|         | Addition of <b>3.4.11 Restriction on conflict between sld instruction and interrupt request</b>                               |                                                         |
|         | Addition of <b>3.5 Cautions</b>                                                                                               |                                                         |
|         | Addition of description to <b>Caution</b> in <b>4.4 (1) Bus cycle type configuration registers 0, 1 (BCT0, BCT1)</b>          | <b>CHAPTER 4<br/>BUS CONTROL<br/>FUNCTION</b>           |
|         |                                                                                                                               |                                                         |
|         | Modification of <b>Note</b> in <b>4.5.1 Number of access clocks</b>                                                           |                                                         |
|         | Modification of <b>Caution 2</b> and addition of <b>Caution 3</b> in <b>4.5.6 (1) (b) Write buffer function</b>               |                                                         |
|         | Addition of <b>Caution</b> to <b>4.5.6 (2) Write access synchronization control register (WAS)</b>                            |                                                         |
|         | Modification of <b>Caution 2</b> and addition of <b>Caution 4</b> in <b>4.6 (1) Bus mode control register (BMC)</b>           |                                                         |
|         | Addition of <b>Caution</b> to <b>4.7.1 (2) Address setup wait control register (ASC)</b>                                      |                                                         |
|         | Deletion of <b>Caution</b> in <b>4.7.2 External wait function</b>                                                             |                                                         |
|         | Modification of description in <b>Table 4-1 Bus Cycles in Which Wait Function Is Valid</b>                                    |                                                         |
|         | Modification of <b>Caution 3</b> in <b>4.10.2 (2) Write operation</b>                                                         |                                                         |
|         | Addition of description to (5) in <b>4.10.3 Cautions</b>                                                                      |                                                         |
|         | Addition of <b>4.15 Cautions</b>                                                                                              |                                                         |
|         | Addition of <b>5.3.3 (1) Output of each address and connection of SDRAM</b>                                                   | <b>CHAPTER 5<br/>MEMORY ACCESS<br/>CONTROL FUNCTION</b> |
|         | Addition of <b>5.3.3 (2) Bank address output</b>                                                                              |                                                         |
|         | Addition of description to <b>Caution 4</b> in <b>5.3.4 SDRAM configuration registers 1, 3, 4, 6 (SCR1, SCR3, SCR4, SCR6)</b> |                                                         |
|         | Deletion of a part of description to <b>5.3.5 (2) SDRAM single write cycle</b>                                                |                                                         |
|         | Addition of <b>Caution 2</b> to <b>5.3.6 (1) SDRAM refresh control registers 1, 3, 4, 6 (RFS1, RFS3, RFS4, RFS6)</b>          |                                                         |
|         | Modification of description in <b>5.3.8 SDRAM initialization sequence</b>                                                     |                                                         |
|         | Addition of <b>5.4 Cautions</b>                                                                                               |                                                         |



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| 4th     | Modification of description in <b>6.3.5 DMA channel control registers 0 to 3 (DCHC0 to DCHC3)</b>                                                                             | <b>CHAPTER 6<br/>DMA FUNCTIONS<br/>(DMA CONTROLLER)</b>          |
|         | Modification of description in <b>6.3.6 DMA terminal count output control register (DTC)</b>                                                                                  |                                                                  |
|         | Modification of <b>Caution 2</b> in <b>6.3.7 DMA trigger factor registers 0 to 3 (DTFR0 to DTFR3)</b>                                                                         |                                                                  |
|         | Modification of description of (a) in <b>6.5.1 (1) Timing of <math>\overline{\text{DMARQn}}</math> and <math>\overline{\text{DMAAKn}}</math> signals for 2-cycle transfer</b> |                                                                  |
|         | Addition of description to <b>Caution</b> in <b>6.14 Maximum Response Time for DMA Transfer Request</b>                                                                       |                                                                  |
|         | Addition of descriptions to <b>6.15 Cautions</b>                                                                                                                              |                                                                  |
|         | Addition of <b>Caution</b> to <b>7.1 Features</b>                                                                                                                             | <b>CHAPTER 7<br/>INTERRUPT/EXCEPTION<br/>PROCESSING FUNCTION</b> |
|         | Modification of <b>Remark 1</b> in <b>Table 7-1 Interrupt Source List</b>                                                                                                     |                                                                  |
|         | Addition of <b>Caution</b> to <b>7.5.2 (2) Restore</b>                                                                                                                        |                                                                  |
|         | Modification of description in <b>7.8 Periods in Which CPU Does Not Acknowledge Interrupts</b>                                                                                |                                                                  |
|         | Addition of <b>7.9 Cautions</b>                                                                                                                                               |                                                                  |
|         | Modification of <b>Caution 2</b> in <b>8.3.1 Clock control register (CKC)</b>                                                                                                 | <b>CHAPTER 8<br/>CLOCK GENERATION<br/>FUNCTION</b>               |
|         | Addition of <b>8.3.1 (1) Notes on changing refresh interval</b>                                                                                                               |                                                                  |
|         | Addition of description to <b>8.3.2 Clock source select register (CKS)</b>                                                                                                    |                                                                  |
|         | Addition of <b>Caution</b> to <b>8.3.6 Oscillation stabilization time select register (OSTS)</b>                                                                              |                                                                  |
|         | Modification of description in <b>8.5.2 (6) Serial communication (transmission or reception) transfer rate of UARTB</b>                                                       |                                                                  |
|         | Addition of description to <b>Note 3</b> to <b>Figure 8-2 Power-Save Mode State Transition Diagram</b>                                                                        |                                                                  |
|         | Addition of <b>Note</b> to <b>8.6.2 (3) Power-save control register (PSC)</b>                                                                                                 |                                                                  |
|         | Addition of description to <b>8.6.3 (2) Release of HALT mode</b>                                                                                                              |                                                                  |
|         | Deletion of a part of description in <b>8.6.4 (1) Setting and operation status</b>                                                                                            |                                                                  |
|         | Deletion of a part of description in <b>Table 8-6 Operation Status in IDLE Mode</b>                                                                                           |                                                                  |
|         | Addition of <b>Caution</b> to <b>8.6.4 (2) (a) Release according to a non-maskable interrupt request signal or an unmasked maskable interrupt request signal</b>              |                                                                  |
|         | Deletion of a part of description in <b>Table 8-8 Operation Status in Software STOP Mode</b>                                                                                  |                                                                  |
|         | Addition of <b>Caution</b> to <b>8.6.5 (2) (a) Release according to a non-maskable interrupt request signal or an unmasked maskable interrupt request signal</b>              |                                                                  |
|         | Addition of <b>8.8 Cautions</b>                                                                                                                                               |                                                                  |
|         | Addition of description to <b>9.1.8 Cautions</b>                                                                                                                              | <b>CHAPTER 9<br/>TIMER/COUNTER<br/>FUNCTION</b>                  |
|         | Modification of description in <b>9.3.5 (5) Prescaler mode registers 10, 11 (PRM10, PRM11)</b>                                                                                |                                                                  |
|         | Modification of description in <b>9.3.5 (5) (b) UDC mode (T1CMDn bit of TUM1n register = 1)</b>                                                                               |                                                                  |
|         | Addition of a part of description to <b>9.3.6 (1) (e) Timer output operation</b>                                                                                              |                                                                  |

| Edition                       | Major Revision from Previous Edition                                                                                                                                                                                                                                                  | Applied to:                                                |
|-------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------|
| 4th                           | Modification of description in <b>Table 9-8 List of Count Operations in UDC Mode</b>                                                                                                                                                                                                  | <b>CHAPTER 9<br/>TIMER/COUNTER<br/>FUNCTION</b>            |
|                               | Addition of <b>9.3.8 Cautions</b>                                                                                                                                                                                                                                                     |                                                            |
|                               | Modification of <b>Caution 3</b> in <b>10.2.3 (5) UARTBn receive data register AP (UBnRXAP), UARTBn receive data register (UBnRX) (n = 0, 1)</b>                                                                                                                                      | <b>CHAPTER 10<br/>SERIAL INTERFACE<br/>FUNCTION</b>        |
|                               | Addition of description to <b>10.2.9 Cautions</b>                                                                                                                                                                                                                                     |                                                            |
|                               | Addition of description to <b>10.3.7 Cautions</b>                                                                                                                                                                                                                                     |                                                            |
|                               | Addition of description to <b>11.3.1 (2) (i) SET_INTERFACE() request</b>                                                                                                                                                                                                              | <b>CHAPTER 11<br/>USB FUNCTION<br/>CONTROLLER (USBF)</b>   |
|                               | Modification of description in <b>11.4.1 (32) UF0 GPR register (UF0GPR)</b>                                                                                                                                                                                                           |                                                            |
|                               | Addition of <b>Figure 11-10 Flowchart of Program When Host Is Disconnected and Then Reconnected</b>                                                                                                                                                                                   |                                                            |
|                               | Addition of <b>Figure 11-11 Flowchart of Program When Power Is Supplied</b>                                                                                                                                                                                                           |                                                            |
|                               | Modification of description in <b>14.2 (2) Function when each port's pins are reset and registers that set the port/control mode</b>                                                                                                                                                  | <b>CHAPTER 14<br/>PORT FUNCTIONS</b>                       |
|                               | Addition of description to <b>14.3.2 Port 2</b>                                                                                                                                                                                                                                       |                                                            |
|                               | Addition of description to <b>14.3.9 (2) (c) Port CS function control register (PFCCS)</b>                                                                                                                                                                                            |                                                            |
|                               | Addition of <b>Figure 14-25 Timing When CSDCn Bit Is Set to 1</b>                                                                                                                                                                                                                     |                                                            |
|                               | Addition of <b>14.7 Cautions</b>                                                                                                                                                                                                                                                      |                                                            |
|                               | Deletion of a part of description in <b>16.1.1 Debug function</b>                                                                                                                                                                                                                     | <b>CHAPTER 16<br/>DEBUG FUNCTION (DCU)</b>                 |
|                               | Modification of the MIN. value of the delay time from $\overline{\text{IOWR}}\uparrow$ to address <40> ( $t_{\text{DWRA}}$ ) in <b>AC Characteristics (4) (d) DMA flyby transfer timing (transfer from SRAM to external I/O) (1/2)</b> in <b>CHAPTER 17 ELECTRICAL SPECIFICATIONS</b> | <b>CHAPTER 17<br/>ELECTRICAL<br/>SPECIFICATIONS</b>        |
|                               | Addition of items ADTRG high-level width <105> ( $t_{\text{WAH}}$ ) and ADTRG low-level width <106> ( $t_{\text{WAL}}$ ), and timing chart to <b>A/D Converter Characteristics</b> in <b>CHAPTER 17 ELECTRICAL SPECIFICATIONS</b>                                                     |                                                            |
| 4th<br>(corrected<br>version) | Modification of <b>1.4 Ordering Information</b>                                                                                                                                                                                                                                       | <b>CHAPTER 1<br/>INTRODUCTION</b>                          |
|                               | Addition of description to <b>1.5 Pin Configuration</b>                                                                                                                                                                                                                               |                                                            |
|                               | Addition of description to <b>CHAPTER 19 RECOMMENDED SOLDERING CONDITIONS</b>                                                                                                                                                                                                         | <b>CHAPTER 19<br/>RECOMMENDED<br/>SOLDERING CONDITIONS</b> |

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