DATA SHEET

Part No.	AN32057B
Package Code No.	UBGA063-W-4040ADL

Contents

AN32057B

LED Driver with Built-in Boost (Step-up) DC-DC Converter

■ Overview

AN32057B provides LED driver for LCD back light, photo light driver, and RGB driver, and delivers voltage through built-in boost DC-DC converter. Additionally, it includes 15-V boost DC-DC converter, and LDO and GPIO pins for power supply use.

■ Features

- Boost DC-DC converter (12 V to 15 V, 30 mA)
- Boost DC-DC converter (4.2 V to 5.25 V, 300 mA)
- 8-ch LDO
- 8-ch GPIO
- 1-ch GPO
- SPI/I^2C interface (selectable)
- LED driver circuit (8-ch for back light, 2-ch for photo light, 6-ch for RGB)
- 1.2 MHz OSC (2.4 MHz for PWM control)
- Built-in 8-bit ADC and control logic for automatic light modulation control

■ Applications

- LED driver IC

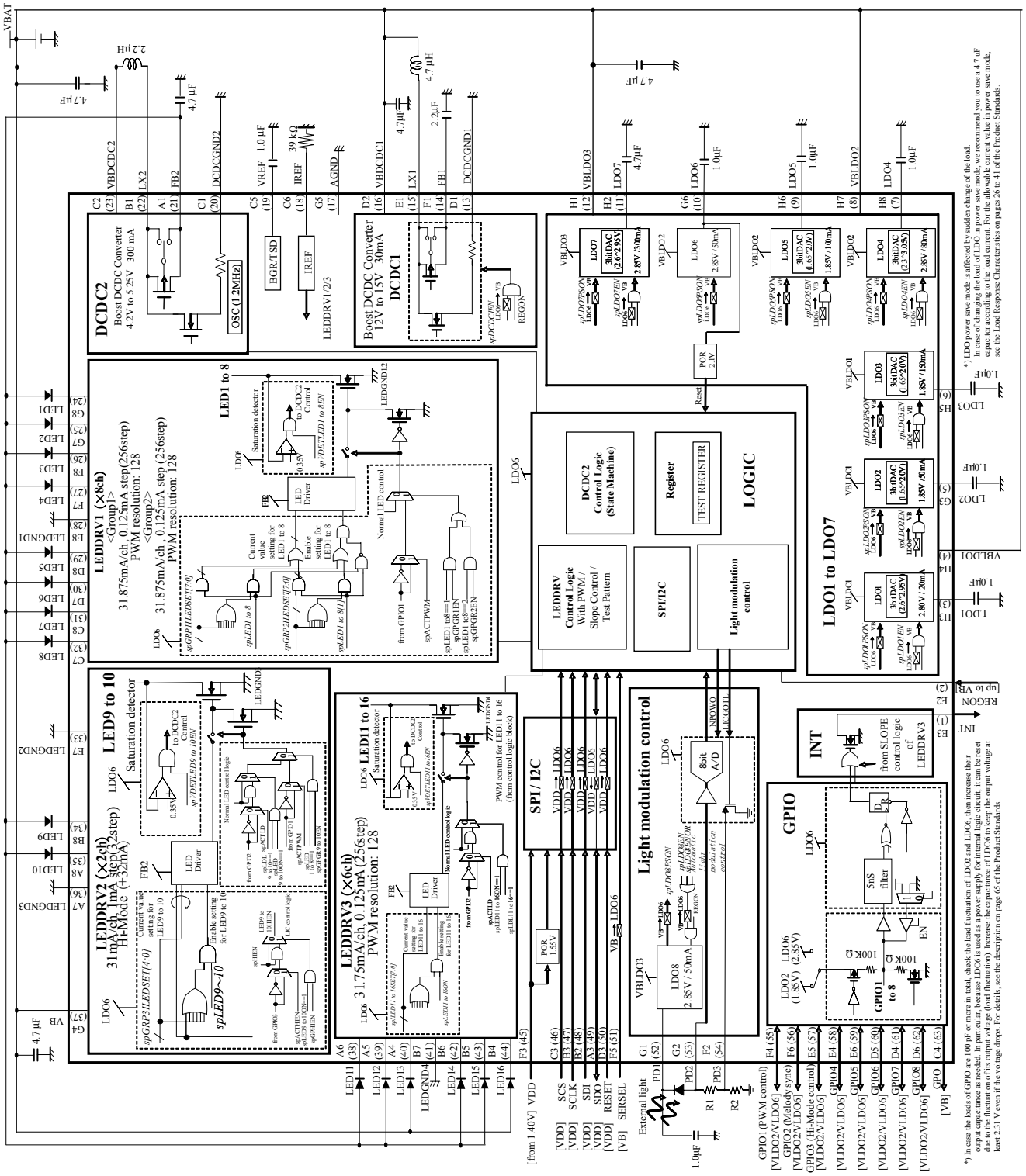
■ Package

- 63-pin wafer level chip size package (WLCSP)
  Size: 3.96 mm × 3.96 mm (0.5 mm pitch)

■ Structure

- Bi-CMOS IC

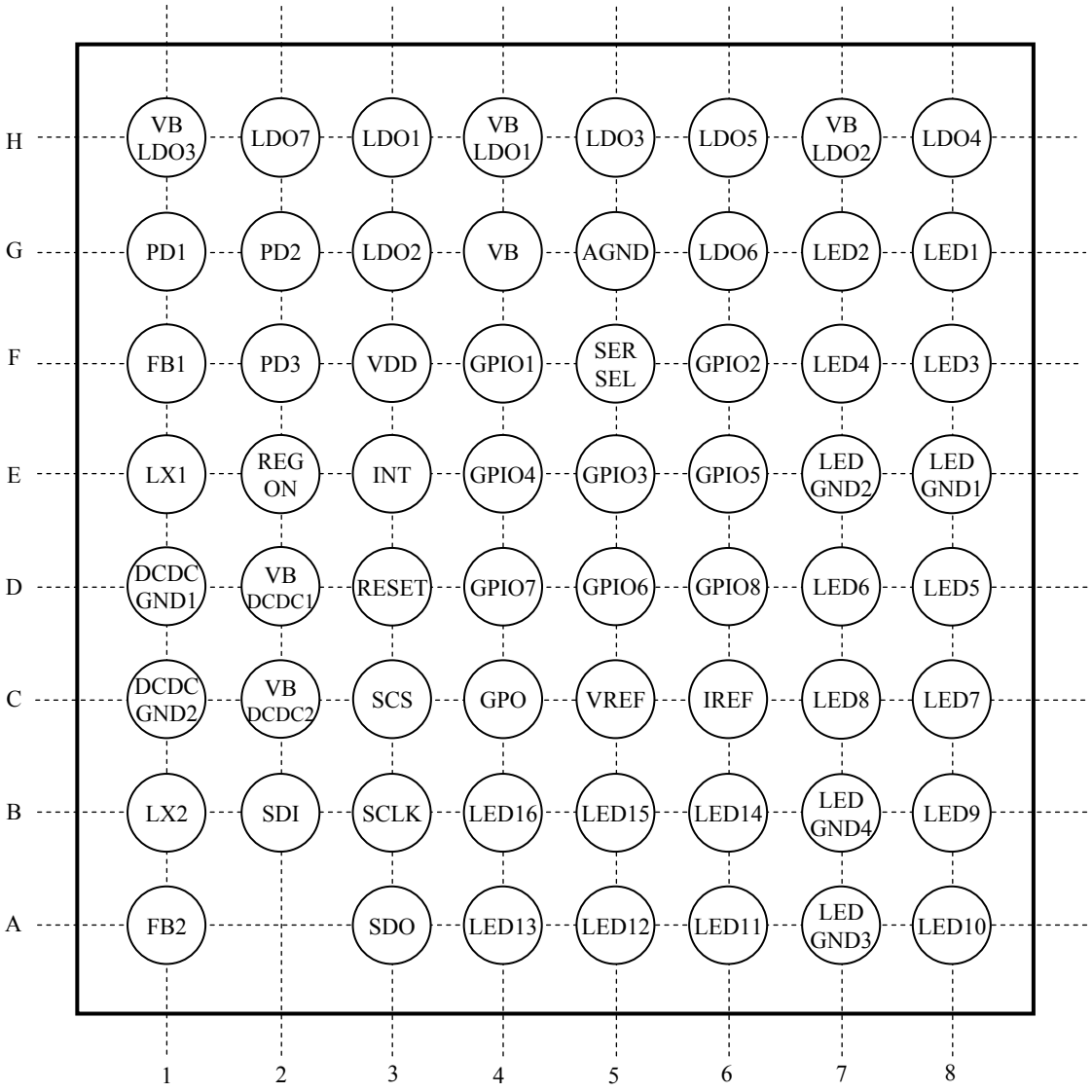
■ Application Circuit Example (Block Diagram)



Notes) • This application circuit is an example. Operation of mass production set is not guaranteed. Perform enough evaluation and verification on the design of mass production set.

• This block diagram is for explaining functions. Some circuit blocks may be omitted, or simplified.

■ Pin Descriptions



Bottom view

■ Pin Descriptions (continued)

Pin No. (Pad No.)	Name	Type (Digital/Analog)	Description	Remarks
E3(1)	INT	Output (Analog)	Interrupt output	Open drain (OFF: Hi-Z)
E2(2)	REGON	Input (Digital)	REGON input	VB level input (Hi-Z)
H3(3)	LDO1	Output (Analog)	LDO1 (2.8 V) output	—
H4(4)	VBLDO1	Power supply	Power connection to LDO1-3 circuits	—
G3(5)	LDO2	Output (Analog)	LDO2 (1.85 V) output	—
H5(6)	LDO3	Output (Analog)	LDO3 (1.85 V) output	—
H8(7)	LDO4	Output (Analog)	LDO4 (2.85 V) output	—
H7(8)	VBLDO2	Power supply	Power connection to LDO4-6 circuits	—
H6(9)	LDO5	Output (Analog)	LDO5 (1.85 V) output	—
G6(10)	LDO6	Output (Analog)	LDO6 (2.85 V) output	—
H2(11)	LDO7	Output (Analog)	LDO7 (2.85 V) output	—
H1(12)	VBLDO3	Power supply	Power connection to LDO7-8 circuits	—
D1(13)	DCDCGND1	Ground	Ground for DC-DC converter 1	—
F1(14)	FB1	Output (Analog)	DC-DC converter 1 output	—
E1(15)	LX1	Input (Analog)	Coil connection to DC-DC converter 1	—
D2(16)	VBDCDC1	Power supply	Power connection to DC-DC converter 1	—
G5(17)	AGND	Ground	Analog ground	—
C6(18)	IREF	Output (Analog)	Resistor connection for setting constant current value	—
C5(19)	VREF	Output (Analog)	Band gap circuit output	—
C1(20)	DCDCGND2	Ground	Ground for DC-DC converter 2	—
A1(21)	FB2	Output (Analog)	DC-DC converter 2 output	—
B1(22)	LX2	Input (Analog)	Coil connection to DC-DC converter 2	—
C2(23)	VBDCDC2	Power supply	Power connection to DC-DC converter 2	—
G8(24)	LED1	Output (Analog)	LED connection for LCD back light	—
G7(25)	LED2	Output (Analog)	LED connection for LCD back light	—
F8(26)	LED3	Output (Analog)	LED connection for LCD back light	—
F7(27)	LED4	Output (Analog)	LED connection for LCD back light	—
E8(28)	LEDGND1	Ground	Ground for LED1-4	—
D8(29)	LED5	Output (Analog)	LED connection for LCD back light	—
D7(30)	LED6	Output (Analog)	LED connection for LCD back light	—
C8(31)	LED7	Output (Analog)	LED connection for LCD back light	—
C7(32)	LED8	Output (Analog)	LED connection for LCD back light	—

■ Pin Descriptions (continued)

Pin No. (Pad No.)	Name	Type (Digital/Analog)	Description	Remarks
E7(33)	LEDGND2	Ground	Ground for LED5-8	—
B8(34)	LED9	Output (Analog)	LED connection for photo light	—
A8(35)	LED10	Output (Analog)	LED connection for photo light	—
A7(36)	LEDGND3	Ground	Ground for LED9-10	—
G4(37)	VB	Power supply	Power connection to band gap circuit	—
A6(38)	LED11	Output (Analog)	LED connection for incoming RGB (Blue)	—
A5(39)	LED12	Output (Analog)	LED connection for incoming RGB (Green)	—
A4(40)	LED13	Output (Analog)	LED connection for incoming RGB (Red)	—
B7(41)	LEDGND4	Ground	Ground for LED11-16	—
B6(42)	LED14	Output (Analog)	LED connection for incoming RGB (Blue)	—
B5(43)	LED15	Output (Analog)	LED connection for incoming RGB (Green)	—
B4(44)	LED16	Output (Analog)	LED connection for incoming RGB (Red)	—
F3(45)	VDD	Power supply	Power connection to output interface	—
C3(46)	SCS	Input (Digital)	Chip select input for SPI interface Slave address selection for I^2C interface	VDD level input (Hi-Z)
B3(47)	SCLK	Input (Digital)	Common clock input for SPI and I^2C interfaces	VDD level input (Hi-Z) Schmitt buffer (only for I^2C)
B2(48)	SDI	Input (Digital)	Data input for SPI interface	I^2C: VDD level input/output Hi-Z (default) for input Open drain for output
A3(49)	SDO	Input / Output (Digital)	Data output for SPI interface Data input/output for I^2C interface	SPI: VDD level output (default: Hi-Z)
D3(50)	RESET	Input (Digital)	Reset input	VDD level input (Hi-Z)
F5(51)	SERSEL	Input (Digital)	SPI/I^2C selection	VB level input (Hi-Z)
G1(52)	PD1	Output (Analog)	LDO8 (2.85 V) output Output for illuminance sensor for automatic light modulation block	—
G2(53)	PD2	Input (Analog)	8-bit A/D converter input for illuminance sensor	Hi-Z input
F2(54)	PD3	Input (Analog)	Gain selection for automatic light modulation block	Open drain (OFF: Hi-Z)

■ Pin Descriptions (continued)

Pin No. (Pad No.)	Name	Type (Digital/Analog)	Description	Remarks
F4(55)	GPIO1	Input/Output (Digital)	GPIO input/output port	Default: input I/O voltage: LDO2/LDO6 selection (default: LDO2) Input: pull-up/down selection (default: pull-down) Output: low (default); resistance: 100 kΩ (typ)
F6(56)	GPIO2	Input/Output (Digital)	GPIO input/output port	Default: input I/O voltage: LDO2/LDO6 selection (default: LDO2) Input: pull-up/down selection (default: pull-down) Output: low (default); resistance: 100 kΩ (typ)
E5(57)	GPIO3	Input/Output (Digital)	GPIO input/output port	Default: input I/O voltage: LDO2/LDO6 selection (default: LDO2) Input: pull-up/down selection (default: pull-down) Output: low (default); resistance: 100 kΩ (typ)
E4(58)	GPIO4	Input/Output (Digital)	GPIO input/output port	Default: input I/O voltage: LDO2/LDO6 selection (default: LDO2) Input: pull-up/down selection (default: pull-down) Output: low (default); resistance: 100 kΩ (typ)
E6(59)	GPIO5	Input/Output (Digital)	GPIO input/output port	Default: input I/O voltage: LDO2/LDO6 selection (default: LDO2) Input: pull-up/down selection (default: pull-down) Output: low (default); resistance: 100 kΩ (typ)
D5(60)	GPIO6	Input/Output (Digital)	GPIO input/output port	Default: input I/O voltage: LDO2/LDO6 selection (default: LDO6) Input: pull-up/down selection (default: pull-up) Output: low (default); resistance: 100 kΩ (typ)
D4(61)	GPIO7	Input/Output (Digital)	GPIO input/output port	Default: output I/O voltage: LDO2/LDO6 selection (default: LDO2) Input: pull-up/down selection (default: Hi-Z) Output: low (default); resistance: 100 kΩ (typ)
D6(62)	GPIO8	Input/Output (Digital)	GPIO input/output port	Default: output I/O voltage: LDO2/LDO6 selection (default: LDO6) Input: pull-up/down selection (default: Hi-Z) Output: low (default); resistance: 100 kΩ (typ)
C4(63)	GPO	Output (Digital)	GPO output port	VB level output (default: low)

■ Allowable Current and Voltage Ranges

Notes) • Rating voltages are voltages on each pin, with respect to the GND. GND denotes the voltage of AGND, LEDGND1, LEDGND2, LEDGND3, LEDGND4, DCDCGND1, and DCDCGND2.
(GND = AGND = LEDGND1 = LEDGND2 = LEDGND3 = LEDGND4 = DCDCGND1 = DCDCGND2)
• VVB denotes the voltage of VB, VBLDO1, VBLDO2 , VBLDO3, VBDCDC1, and VBDCDC2.
(VB = VBLDO1 = VBLDO2 = VBLDO3 = VBDCDC1 = VBDCDC2)
• Do not apply external currents or voltages to any pins except below.

Pin No.	Pin Name	Rating Voltage	Unit	Notes
A1	FB2	0.0 to 6.0	V	*5
A3	SDO	–0.3 to (VVDD + 0.3)	V	*2, 5
A4	LED13	–0.3 to (VFB2 + 0.2)	V	*4
A5	LED12	–0.3 to (VFB2 + 0.2)	V	*4
A6	LED11	–0.3 to (VFB2 + 0.2)	V	*4
A8	LED10	–0.3 to (VFB2 + 0.2)	V	*4
B1	LX2	–0.3 to (VFB2 + 0.2)	V	*4
B2	SDI	–0.3 to (VVDD + 0.3)	V	*2, 5
B3	SCLK	–0.3 to (VVDD + 0.3)	V	*2
B4	LED16	–0.3 to (VFB2 + 0.2)	V	*4
B5	LED15	–0.3 to (VFB2 + 0.2)	V	*4
B6	LED14	–0.3 to (VFB2 + 0.2)	V	*4
B8	LED9	–0.3 to (VFB2 + 0.2)	V	*4
C2	VBDCDC2	0.0 to 4.6	V	—
C3	SCS	–0.3 to (VVDD + 0.3)	V	*2
C4	GPO1	–0.3 to (VVB + 0.3)	V	*1, 5
C5	VREFD	–0.3 to (VVB + 0.3)	V	*5
C6	IREF	–0.3 to (VVB + 0.3)	V	*5
C7	LED8	–0.3 to (VFB2 + 0.2)	V	*4
C8	LED7	–0.3 to (VFB2 + 0.2)	V	*4
D2	VBDCDC1	0.0 to 4.6	V	—
D3	RESET	–0.3 to (VVDD + 0.3)	V	*2
D4	GPIO7	–0.3 to (VFB2 + 0.3)	V	*1, 5
D5	GPIO6	–0.3 to (VVB + 0.3)	V	*1, 5
D6	GPIO8	–0.3 to (VVB + 0.3)	V	*1, 5
D7	LED6	–0.3 to (VFB2 + 0.2)	V	*4
D8	LED5	–0.3 to (VFB2 + 0.2)	V	*4
E1	LX1	–0.3 to (VFB1 + 0.2)	V	*3

Pin No.	Pin Name	Rating Voltage	Unit	Notes
E2	REGON	–0.3 to (VVB + 0.3)	V	*1
E3	INT	–0.3 to (VVB + 0.3)	V	*1, 5
E4	GPIO4	–0.3 to (VVB + 0.3)	V	*1, 5
E5	GPIO3	–0.3 to (VVB + 0.3)	V	*1, 5
E6	GPIO5	–0.3 to (VVB + 0.3)	V	*1, 5
F1	FB1	0.0 to 20	V	*5
F2	PD3	–0.3 to (VVB + 0.3)	V	*1
F3	VDD	0.0 to 3.2	V	—
F4	GPIO1	–0.3 to (VVB + 0.3)	V	*1, 5
F5	SERSEL	–0.3 to (VVB + 0.3)	V	*1
F6	GPIO2	–0.3 to (VVB + 0.3)	V	*1, 5
F7	LED4	–0.3 to (VFB2 + 0.2)	V	*4
F8	LED3	–0.3 to (VFB2 + 0.2)	V	*4
G1	PD1	–0.3 to (VVB + 0.3)	V	*5
G2	PD2	–0.3 to (VVB + 0.3)	V	*1
G3	LDO2	–0.3 to (VVB + 0.3)	V	*5
G4	VB	0.0 to 4.6	V	—
G6	LDO6	–0.3 to (VVB + 0.3)	V	*5
G7	LED2	–0.3 to (VFB2 + 0.2)	V	*4
G8	LED1	–0.3 to (VFB2 + 0.2)	V	*4
H1	VBLDO3	0.0 to 4.6	V	—
H2	LDO7	–0.3 to (VVB + 0.3)	V	*5
H3	LDO1	–0.3 to (VVB + 0.3)	V	*5
H4	VBLDO1	0.0 to 4.6	V	—
H5	LDO3	–0.3 to (VVB + 0.3)	V	*5
H6	LDO5	–0.3 to (VVB + 0.3)	V	*5
H7	VBLDO2	0.0 to 4.6	V	—
H8	LDO4	–0.3 to (VVB + 0.3)	V	*5

Notes) *1: The (VVB + 0.3) V must not exceed 4.6 V.
*2: The (VVDD + 0.3) V must not exceed 3.2 V.
*3: The (VFB1 + 0.2) V must not exceed 20 V.
*4: The (VFB2 + 0.2) V must not exceed 6.0 V.
*5: The values are specified for input. When using the pins as output, no external voltage or current input is allowed.

■ Absolute Maximum Ratings

Note) The absolute maximum ratings are the limit values beyond which the IC may be damaged. Operation is not guaranteed under these conditions.

A No.	Parameter	Symbol	Rating	Unit	Notes
1	Supply voltage	VB_{MAX}	6.8	V	*1
		VDD_{MAX}	4.4	V	*1
2	Supply current	I_{CC}	—	A	—
3	Power dissipation	P_D	83.1	mW	*2
4	Operating ambient temperature	T_{opr}	–30 to +85	°C	*3
5	Storage temperature	T_{stg}	–55 to +125	°C	*3

Notes) *1: VB_{MAX} = VB = VBLDO1 = VBLDO2 = VBLDO3 = VBDCDC1 = VBDCDC2
The values are defined, provided that the IC is used within all of the above absolute maximum ratings including the power dissipation.
*2: The power dissipation shown is the value at T_a = 85°C for the independent (unmounted) IC package without a heat sink.
When using this IC, refer to the P_D-T_a diagram of the Technical Data and design the heat radiation with sufficient margin not to exceed the allowable value based on the conditions of power supply voltage, load, and ambient temperature.
*3: All ratings are at T_a = 25°C except the power dissipation, operating ambient temperature, and storage temperature.

■ Operating Supply Voltage Range

Parameter	Symbol	Range	Unit	Notes
Supply voltage range	VB VBLDO1 VBLDO2 VBLDO3 VBDCDC1 VBDCDC2	3.1 to 4.6	V	*1
	VDD	1.7 to 3.2	V	*1, *2 *3

Notes) *1: The values are defined, provided that the IC is used within all of the above absolute maximum ratings including the power dissipation.
*2: The VDD voltage must not exceed the VB voltage.
*3: VDD pin requires a power supply with current capacity equal to or greater than LDO2 (in PS mode).

■ Electric Characteristics VB = VBLDO1 = VBLDO2 = VBLDO3 = VBDCDC1 = VBDCDC2 = 3.6 V, VDD = 1.85 V

Note) T_a = 25°C ± 2°C, unless otherwise specified.

B No.	Parameter	Symbol	Conditions	Limits			Unit	Notes
				Min	Typ	Max		
Consumption Current								
1	Quiescent consumption current	IOFF	VB = 3.6 V REGON = 0 V	—	0	2	µA	—
2	Operating consumption current (REGON = high)	ION	VB = 3.6 V REGON = 3.6 V spLDO2PSON = 1 spLDO6PSON = 1	—	13	20	µA	—
3	Operating consumption current (all LDOs = ON)	IALLLDO	VB = 3.6 V REGON = 3.6 V All LDOs = ON	—	300	450	µA	—
4	Operating consumption current (PS mode)	ILDOPS	VB = 3.6 V REGON = 3.6 V All LDOs = ON All LDOs, PS mode = ON	—	20	32	µA	—
5	Operating consumption current (DCDC1 = ON)	IDCDC1	VB = 3.6 V REGON = 3.6 V DCDC1 = ON spVDCDC1[3:0] = "1111" (Vout = 15.0 V)	—	12	24	mA	—
6	Operating consumption current (DCDC2 = ON)	IDCDC2	VB = 3.6 V REGON = 3.6 V DCDC2 = ON spDDSEL = 0 (Vout = 4.725 V)	—	2	4	mA	—

■ Electric Characteristics (continued) VB = VBLDO1 = VBLDO2 = VBLDO3 = VBDCDC1 = VBDCDC2 = 3.6 V, VDD = 1.85 V
Note) T_a = 25°C ± 2°C, unless otherwise specified.

B No.	Parameter	Symbol	Conditions	Limits			Unit	Notes
				Min	Typ	Max		
LDO1 Normal Mode with External Ceramic Capacitor Connected (1.0 µF; ESR = 0.1 Ω or less; effective value = 0.5 µF or more)								
7	Output voltage	VLDO1	Iout = –10 mA	2.79	2.85	2.91	V	—
8	Output current	IOLDO1	—	20	—	—	mA	—
9	Load fluctuation	DVLDO1	Iout = –20 mA spVLDO1 [2 : 0] : (101) ΔVLDO1 = VLDO1 – Vout	0	—	45	mV	*1
10	Minimum output voltage	VLDO1 MIN	Iout = –10 µA VLDO1MIN → spVLDO1 [2 : 0] : (000)	2.52	2.60	2.68	V	—
11	Maximum output voltage	VLDO1 MAX	Iout = –10 µA VLDO1MAX → spVLDO1 [2 : 0] : (111)	2.86	2.95	3.04	V	—
12	Standby voltage	VLDO1S	LDO OFF	–0.3	—	0.3	V	—
13	Ripple removal rate (1)	VLDO1 R1	Iout = –10 mA, FRR = 1 kHz VLDO1R1 = 20log(Vout/Vin) Vin = 0.3 V[p-p]	–130	–60	–45	dB	*2
14	Ripple removal rate (2)	VLDO1 R2	Iout = –10 mA, FRR = 10 kHz VLDO1R2 = 20log(Vout/Vin) Vin = 0.3 V[p-p]	–130	–55	–35	dB	*2
LDO1 PS Mode with External Ceramic Capacitor Connected (1.0 µF; ESR = 0.1 Ω or less; effective value = 0.5 µF or more)								
15	Output voltage	VLDO1PS	Iout = –3 mA Measurement value at Vout	2.79	2.85	2.91	V	*3
16	Minimum output voltage	VLDO1 PSMIN	Iout = –10 µA VLDO1MIN → spVLDO1 [2 : 0] : (000)	2.52	2.60	2.68	V	—
17	Maximum output voltage	VLDO1 PSMAX	Iout = –10 µA VLDO1MAX → spVLDO1 [2 : 0] : (111)	2.86	2.95	3.04	V	—
18	Standby voltage	VLDO1 PSS	LDO OFF	–0.3	—	0.3	V	—
19	Short-circuit current	ILLDO1	VLDO1 = 0 V Common to Normal and PS modes	10	50	100	mA	—

Notes) *1: See the Design Reference Manual No. 183.
*2: See the Design Reference Manual Nos. 187 and 188.
*3: The output current capacity in PS mode is 20 mA for reference.

*) "Iout" in the table refers to the output current of LDO.

■ Electric Characteristics (continued) VB = VBLDO1 = VBLDO2 = VBLDO3 = VBDCDC1 = VBDCDC2 = 3.6 V, VDD = 1.85 V
Note) T_a = 25°C ± 2°C, unless otherwise specified.

B No.	Parameter	Symbol	Conditions	Limits			Unit	Notes
				Min	Typ	Max		
LDO2 Normal Mode with External Ceramic Capacitor Connected (1.0 µF; ESR = 0.1 Ω or less; effective value = 0.5 µF or more)								
20	Output voltage	VLDO2	Iout = –20 mA	1.81	1.85	1.89	V	—
21	Output current	IOLDO2	—	50	—	—	mA	—
22	Load fluctuation	DVLDO2	Iout = –50 mA spVLDO2 [2 : 0] : (100) ΔVLDO2 = VLDO2 – Vout	0	—	45	mV	*4
23	Minimum output voltage	VLDO2 MIN	Iout = –10 µA VLDO2MIN → spVLDO2 [2 : 0] : (000)	1.60	1.65	1.70	V	—
24	Maximum output voltage	VLDO2 MAX	Iout = –10 µA VLDO2MAX → spVLDO2 [2 : 0] : (111)	1.94	2.00	2.06	V	—
25	Standby voltage	VLDO2S	LDO OFF	–0.3	—	0.3	V	—
26	Ripple removal rate (1)	VLDO2 R1	Iout = –20 mA, FRR = 1 kHz VLDO2R1 = 20log(Vout/Vin) Vin = 0.3 V[p-p]	–130	–60	–45	dB	*5
27	Ripple removal rate (2)	VLDO2 R2	Iout = –20 mA, FRR = 10 kHz VLDO2R2 = 20log(Vout/Vin) Vin = 0.3 V[p-p]	–130	–55	–35	dB	*5
LDO2 PS Mode with External Ceramic Capacitor Connected (1.0 µF; ESR = 0.1 Ω or less; effective value = 0.5 µF or more)								
28	Output voltage	VLDO2PS	Iout = –3 mA Measurement value at Vout	1.81	1.85	1.89	V	*6
29	Minimum output voltage	VLDO2 PSMIN	Iout = –10 µA VLDO2MIN → spVLDO2 [2 : 0] : (000)	1.60	1.65	—	V	—
30	Maximum output voltage	VLDO2 PSMAX	Iout = –10 µA VLDO2MAX → spVLDO2 [2 : 0] : (111)	—	2.00	2.06	V	—
31	Standby voltage	VLDO2 PSS	LDO OFF	–0.3	—	0.3	V	—
32	Short-circuit current	ILLDO2	VLDO2 = 0 V Common to Normal and PS modes	10	50	100	mA	—

Notes) *4: See the Design Reference Manual No. 215.
*5: See the Design Reference Manual Nos. 219 and 220.
*6: The output current capacity in PS mode is 50 mA for reference.

*) "Iout" in the table refers to the output current of LDO.

■ Electric Characteristics (continued) VB = VBLDO1 = VBLDO2 = VBLDO3 = VBDCDC1 = VBDCDC2 = 3.6 V, VDD = 1.85 V
Note) T_a = 25°C ± 2°C, unless otherwise specified.

B No.	Parameter	Symbol	Conditions	Limits			Unit	Notes
				Min	Typ	Max		
LDO3 Normal Mode with External Ceramic Capacitor Connected (1.0 µF; ESR = 0.1 Ω or less; effective value = 0.5 µF or more)								
33	Output voltage	VLDO3	Iout = –50 mA	1.81	1.85	1.89	V	—
34	Output current	IOLDO3	—	150	—	—	mA	—
35	Load fluctuation	DVLDO3	Iout = –150 mA spVLDO3[2 : 0] : (100) ΔVLDO3 = VLDO3 – Vout	0	—	45	mV	*7
36	Minimum output voltage	VLDO3 MIN	Iout = –10 µA VLDO3MIN → spVLDO3[2 : 0] : (000)	1.60	1.65	1.70	V	—
37	Maximum output voltage	VLDO3 MAX	Iout = –10 µA VLDO3MAX → spVLDO3[2 : 0] : (111)	1.94	2.00	2.06	V	—
38	Standby voltage	VLDO3S	LDO OFF	–0.3	—	0.3	V	—
39	Ripple removal rate (1)	VLDO3 R1	Iout = –50 mA, FRR = 1 kHz VLDO3R1 = 20log(Vout/Vin) Vin = 0.3 V[p-p]	–130	–60	–45	dB	*8
40	Ripple removal rate (2)	VLDO3 R2	Iout = –50 mA, FRR = 10 kHz VLDO3R2 = 20log(Vout/Vin) Vin = 0.3 V[p-p]	–130	–55	–35	dB	*8
LDO3 PS Mode with External Ceramic Capacitor Connected (1.0 µF; ESR = 0.1 Ω or less; effective value = 0.5 µF or more)								
41	Output voltage	VLDO3PS	Iout = –3 mA Measurement value at Vout	1.81	1.85	1.89	V	*9
42	Minimum output voltage	VLDO3 PSMIN	Iout = –10 µA VLDO3MIN → spVLDO3[2 : 0] : (000)	1.60	1.65	1.70	V	—
43	Maximum output voltage	VLDO3 PSMAX	Iout = –10 µA VLDO3MAX → spVLDO3[2 : 0] : (111)	1.94	2.00	2.06	V	—
44	Standby voltage	VLDO3 PSS	LDO OFF	–0.3	—	0.3	V	—
45	Short-circuit current	ILLDO3	VLDO3 = 0 V Common to Normal and PS modes	10	50	100	mA	—

Notes) *7: See the Design Reference Manual No. 248.
*8: See the Design Reference Manual Nos. 252 and 253.
*9: The output current capacity in PS mode is 150 mA for reference.

*) "Iout" in the table refers to the output current of LDO.

■ Electric Characteristics (continued) VB = VBLDO1 = VBLDO2 = VBLDO3 = VBDCDC1 = VBDCDC2 = 3.6 V, VDD = 1.85 V
Note) T_a = 25°C ± 2°C, unless otherwise specified.

B No.	Parameter	Symbol	Conditions	Limits			Unit	Notes
				Min	Typ	Max		
LDO4 Normal Mode with External Ceramic Capacitor Connected (1.0 µF; ESR = 0.1 Ω or less; effective value = 0.5 µF or more)								
46	Output voltage	VLDO4	Iout = –30 mA	2.79	2.85	2.91	V	—
47	Output current	IOLDO4	—	80	—	—	mA	—
48	Load fluctuation	DVLDO4	Iout = –80 mA spVLDO4[3 : 0] : (1011) ΔVLDO4 = VLDO4 – Vout	0	—	45	mV	*10
49	Minimum output voltage	VLDO4 MIN	Iout = –10 µA VLDO4MIN → spVLDO4[3 : 0] : (0000)	2.23	2.30	2.37	V	—
50	Maximum output voltage	VLDO4 MAX	Iout = –10 µA VLDO4MAX → spVLDO4[3 : 0] : (1111)	2.95	3.05	3.15	V	—
51	Standby voltage	VLDO4S	LDO OFF	–0.3	—	0.3	V	—
52	Ripple removal rate (1)	VLDO4 R1	Iout = –30 mA, FRR = 1 kHz VLDO4R1 = 20log(Vout/Vin) Vin = 0.3 V[p-p]	–130	–60	–45	dB	*11
53	Ripple removal rate (2)	VLDO4 R2	Iout = –30 mA, FRR = 10 kHz VLDO4R2 = 20log(Vout/Vin) Vin = 0.3 V[p-p]	–130	–55	–35	dB	*11
LDO4 PS Mode with External Ceramic Capacitor Connected (1.0 µF; ESR = 0.1 Ω or less; effective value = 0.5 µF or more)								
54	Output voltage	VLDO4 PS	Iout = –3 mA Measurement value at Vout	2.79	2.85	2.91	V	*12
55	Minimum output voltage	VLDO4 PSMIN	Iout = –10 µA VLDO4MIN → spVLDO4[3 : 0] : (0000)	2.23	2.30	2.37	V	—
56	Maximum output voltage	VLDO4 PSMAX	Iout = –10 µA VLDO4MAX → spVLDO4[3 : 0] : (1111)	2.95	3.05	3.15	V	—
57	Standby voltage	VLDO4 PSS	LDO OFF	–0.3	—	0.3	V	—
58	Short-circuit current	ILLDO4	VLDO4 = 0 V Common to Normal and PS modes	10	50	100	mA	—

Notes) *10: See the Design Reference Manual No. 280.
*11: See the Design Reference Manual Nos. 284 and 285.
*12: The output current capacity in PS mode is 80 mA for reference.

*) "Iout" in the table refers to the output current of LDO.

■ Electric Characteristics (continued) VB = VBLDO1 = VBLDO2 = VBLDO3 = VBDCDC1 = VBDCDC2 = 3.6 V, VDD = 1.85 V
Note) T_a = 25°C ± 2°C, unless otherwise specified.

B No.	Parameter	Symbol	Conditions	Limits			Unit	Notes
				Min	Typ	Max		
LDO5 Normal Mode with External Ceramic Capacitor Connected (1.0 µF; ESR = 0.1 Ω or less; effective value = 0.5 µF or more)								
59	Output voltage	VLDO5	Iout = –50 mA	1.81	1.85	1.89	V	—
60	Output current	IOLDO5	—	100	—	—	mA	—
61	Load fluctuation	DVLDO5	Iout = –100 mA spVLDO5[2 : 0] : (100) ΔVLDO5 = VLDO5 – Vout	0	—	45	mV	*13
62	Minimum output voltage	VLDO5 MIN	Iout = –10 µA VLDO5MIN → spVLDO5[2 : 0] : (000)	1.60	1.65	1.70	V	—
63	Maximum output voltage	VLDO5 MAX	Iout = –10 µA VLDO5MAX → spVLDO5[2 : 0] : (111)	1.94	2.00	2.06	V	—
64	Standby voltage	VLDO5S	LDO OFF	–0.3	—	0.3	V	—
65	Ripple removal rate (1)	VLDO5 R1	Iout = –50 mA, FRR = 1 kHz VLDO5R1 = 20log(Vout/Vin) Vin = 0.3 V[p-p]	–130	–60	–45	dB	*14
66	Ripple removal rate (2)	VLDO5 R2	Iout = –50 mA, FRR = 10 kHz VLDO5R2 = 20log(Vout/Vin) Vin = 0.3 V[p-p]	–130	– 55	– 35	dB	*14
LDO5 PS Mode with External Ceramic Capacitor Connected (1.0 µF; ESR = 0.1 Ω or less; effective value = 0.5 µF or more)								
67	Output voltage	VLDO5PS	Iout = –3 mA Measurement value at Vout	1.81	1.85	1.89	V	*15
68	Minimum output voltage	VLDO5 PSMIN	Iout = –10 µA VLDO5MIN → spVLDO5[2 : 0] : (000)	1.60	1.65	1.70	V	—
69	Maximum output voltage	VLDO5 PSMAX	Iout = –10 µA VLDO5MAX → spVLDO5[2 : 0] : (111)	1.94	2.00	2.06	V	—
70	Standby voltage	VLDO5 PSS	LDO OFF	–0.3	—	0.3	V	—
71	Short-circuit current	ILLDO5	VLDO5 = 0 V Common to Normal and PS modes	10	50	100	mA	—

Notes) *13: See the Design Reference Manual No. 312.
*14: See the Design Reference Manual Nos. 316 and 317.
*15: The output current capacity in PS mode is 100 mA for reference.

*) "Iout" in the table refers to the output current of LDO.

■ Electric Characteristics (continued) VB = VBLDO1 = VBLDO2 = VBLDO3 = VBDCDC1 = VBDCDC2 = 3.6 V, VDD = 1.85 V
Note) T_a = 25°C ± 2°C, unless otherwise specified.

B No.	Parameter	Symbol	Conditions	Limits			Unit	Notes
				Min	Typ	Max		
LDO6 Normal Mode with External Ceramic Capacitor Connected (1.0 µF; ESR = 0.1 Ω or less; effective value = 0.5 µF or more)								
72	Output voltage	VLDO6	Iout = –20 mA	2.79	2.85	2.91	V	—
73	Output current	IOLDO6	—	50	—	—	mA	—
74	Load fluctuation	DVLDO6	Iout = –50 mA ΔVLDO6 = VLDO6 – Vout	0	—	45	mV	*16
75	Standby voltage (Voltage when REGON is off)	VLDO6S	REGON = Low	–0.3	—	0.3	V	—
76	Ripple removal rate (1)	VLDO6 R1	Iout = –20 mA, FRR = 1 kHz VLDO6R1 = 20log(Vout/Vin) Vin = 0.3 V[p-p]	–130	–60	–45	dB	*17
77	Ripple removal rate (2)	VLDO6 R2	Iout = –20 mA, FRR = 10 kHz VLDO6R2 = 20log(Vout/Vin) Vin = 0.3 V[p-p]	–130	–55	–35	dB	*17
LDO6 PS Mode with External Ceramic Capacitor Connected (1.0 µF; ESR = 0.1 Ω or less; effective value = 0.5 µF or more)								
78	Output voltage	VLDO6PS	Iout = –3 mA Measurement value at Vout	2.79	2.85	2.91	V	*18
79	Short-circuit current	ILLDO6	VLDO6 = 0 V Common to Normal and PS modes	10	50	100	mA	—
RESET Detection								
80	LDO6 pin RESET detection voltage	V6RSTL	Detection of LDO6 output voltage drop	1.89	2.1	2.31	V	*19

Notes) *16: See the Design Reference Manual No. 341.
*17: See the Design Reference Manual Nos. 345 and 346.
*18: The output current capacity in PS mode is 50 mA for reference.
*19: Activating LDO6 (i.e. returning to initial state) always clears a reset.

*) "Iout" in the table refers to the output current of LDO.

■ Electric Characteristics (continued) VB = VBLDO1 = VBLDO2 = VBLDO3 = VBDCDC1 = VBDCDC2 = 3.6 V, VDD = 1.85 V
Note) T_a = 25°C ± 2°C, unless otherwise specified.

B No.	Parameter	Symbol	Conditions	Limits			Unit	Notes
				Min	Typ	Max		
LDO7 Normal Mode with External Ceramic Capacitor Connected (4.7 µF; ESR = 0.1 Ω or less; effective value = 2.35 µF or more)								
81	Output voltage	VLDO7	Iout = –50 mA	2.79	2.85	2.91	V	—
82	Output current	IOLDO7	—	300	—	—	mA	—
83	Load fluctuation	DVLDO7	Iout = –300 mA spVLDO7[2 : 0] : (101) ΔVLDO7 = VLDO7 – Vout	0	—	45	mV	*20 *21
84	Minimum output voltage	VLDO7 MIN	Iout = –10 µA VLDO7MIN → spVLDO7[2 : 0] : (000)	2.52	2.60	2.68	V	—
85	Maximum output voltage	VLDO7 MAX	Iout = –10 µA VLDO7MAX → spVLDO7[2 : 0] : (111)	2.86	2.95	3.04	V	—
86	Standby voltage	VLDO7S	LDO OFF	–0.3	—	0.3	V	—
87	Ripple removal rate (1)	VLDO7 R1	Iout = –50 mA, FRR = 1 kHz VLDO7R1 = 20log(Vout/Vin) Vin = 0.3 V[p-p]	–130	–60	–45	dB	*22
88	Ripple removal rate (2)	VLDO7 R2	Iout = –50 mA, FRR = 10 kHz VLDO7R2 = 20log(Vout/Vin) Vin = 0.3 V[p-p]	–130	–55	–35	dB	*22
LDO7 PS Mode with External Ceramic Capacitor Connected (4.7 µF; ESR = 0.1 Ω or less; effective value = 2.35 µF or more)								
89	Output voltage	VLDO7PS	Iout = –3 mA Measurement value at Vout	2.79	2.85	2.91	V	*23
90	Minimum output voltage	VLDO7 PSMIN	Iout = –10 µA VLDO7MIN → spVLDO7[2 : 0] : (000)	2.52	2.60	2.68	V	—
91	Maximum output voltage	VLDO7 PSMAX	Iout = –10 µA VLDO7MAX → spVLDO7[2 : 0] : (111)	2.86	2.95	3.04	V	—
92	Standby voltage	VLDO7 PSS	LDO OFF	–0.3	—	0.3	V	—
93	Short-circuit current	ILLDO7	VLDO7 = 0 V Common to Normal and PS modes	10	50	120	mA	—

Notes) *20: See the Design Reference Manual No. 370.
*21: The operating supply voltage range with maximum load is 3.2 V to 4.7 V.
*22: See the Design Reference Manual Nos. 375 and 376.
*23: The output current capacity in PS mode is 150 mA for reference.

*) "Iout" in the table refers to the output current of LDO.

■ Electric Characteristics (continued) VB = VBLDO1 = VBLDO2 = VBLDO3 = VBDCDC1 = VBDCDC2 = 3.6 V, VDD = 1.85 V

Note) T_a = 25°C ± 2°C, unless otherwise specified.

B No.	Parameter	Symbol	Conditions	Limits			Unit	Notes
				Min	Typ	Max		
LDO8 Normal Mode with External Ceramic Capacitor Connected (1.0 μF; ESR = 0.1 Ω or less; effective value = 0.5 μF or more)								
94	Output voltage	VLDO8	Iout = –20 mA	2.79	2.85	2.91	V	—
95	Output current	IOLDO8	—	50	—	—	mA	—
96	Load fluctuation	DVLDO8	Iout = –50 mA ΔVLDO8 = VLDO8 – Vout	0	—	45	mV	*24
97	Standby voltage	VLDO8S	LDO OFF	– 0.3	—	0.3	V	—
98	Ripple removal rate (1)	VLDO8 R1	Iout = –20 mA, FRR = 1 kHz VLDO8R1 = 20log(Vout/Vin) Vin = 0.3 V[p-p]	–130	–60	–45	dB	*25
99	Ripple removal rate (2)	VLDO8 R2	Iout = –20 mA, FRR = 10 kHz VLDO8R2 = 20log(Vout/Vin) Vin = 0.3 V[p-p]	–130	–55	–35	dB	*25
LDO8 PS Mode with External Ceramic Capacitor Connected (1.0 μF; ESR = 0.1 Ω or less; effective value = 0.5 μF or more)								
100	Output voltage	VLDO8PS	Iout = –3 mA Measurement value at Vout	2.79	2.85	2.91	V	*26
101	Standby voltage	VLDO8 PSS	LDO OFF	– 0.3	—	0.3	V	—
102	Short-circuit current	ILLDO8	VLDO8 = 0 V Common to Normal and PS modes	10	50	100	mA	—

Notes) *24: See the Design Reference Manual No. 400.

*25: See the Design Reference Manual Nos. 404 and 405.

*26: The output current capacity in PS mode is 50 mA for reference.

*) "Iout" in the table refers to the output current of LDO.

■ Electric Characteristics (continued) VB = VBLDO1 = VBLDO2 = VBLDO3 = VBDCDC1 = VBDCDC2 = 3.6 V, VDD = 1.85 V

Note) T_a = 25°C ± 2°C, unless otherwise specified.

B No.	Parameter	Symbol	Conditions	Limits			Unit	Notes
				Min	Typ	Max		
DCDC1 (Reference for Design: Vout = 15 V, Iout = –30 mA) with Coil (MIPSA2520D4R7) and External Ceramic Capacitor (TMK316BJ225KD-T) Connected								
103	Output voltage (1)	VDD1	Vout = 15.0 V Iout = –15 mA spVDCDC1[3:0] : (1111)	14.45	15.0	15.55	V	*27
104	Output voltage (2)	VDD1 MIN	Vout = 12.0 V Iout = –15 mA VDCDC1MIN → spVDCDC1[3:0] : (0000)	11.4	12.0	12.6	V	*27
105	OVLO detection voltage	OVP1	—	16.0	17. 0	18.0	V	—
106	GND short detection voltage	GCP1	—	5.5	8	10.5	V	—
OSC (DCDC Oscillation Frequency: 1.2 MHz, LED-PWM Control: 2.4 MHz)								
107	Oscillation frequency 1	FDD1	—	1.08	1.2	1.32	MHz	—
108	Oscillation frequency 2	FDD2	—	2.16	2.4	2.64	MHz	—
DCDC2 (Reference for Design: Vout = 5.25 V, Iout = –300 mA) with Coil (MIPSA2520D2R2) and External Ceramic Capacitor (PSLA21A475M) Connected								
109	Output voltage (1)	VDD21	Vout = 4.2 V Iout = –150 mA	4.03	4.20	4.41	V	*28
110	Output voltage (2)	VDD22	Vout = 4.725 V Iout = –150 mA	4.48	4.725	4.97	V	*28
111	Output voltage (3)	VDD23	Vout = 5.25 V Iout = –150 mA	4.98	5.25	5.51	V	*28
112	OVLO detection voltage	OVP2	—	5.52	5.75	5.98	V	—
113	GND short detection voltage	GCP2	Vin = 3.6 V	2.84	3.15	3.34	V	—
On Resistance in Through Mode (DCDC2)								
114	Resistance in switch mode	RVBS	Vin = 3.1 V Iin = 100 mA	—	0.3	1	Ω	*29
VDD RESET Detection								
115	VDD pin RESET detection voltage	VDDRST	Detection of VDD input voltage drop	1.395	1.55	1.695	V	—

Notes) *27: Load conditions are within the voltage range listed above for up to I_{out} = -30 mA. (reference for design)

*28: Load conditions are within the voltage range listed above for up to I_{out} = -300 mA. (reference for design)

*29: On resistance in through mode is within the resistance range listed above for up to I_{in} = 300 mA. (reference for design)

*) For the efficiency or protection function of DCDC1/DCDC2, see the reference values for design and technical data.

■ Electric Characteristics (continued) VB = VBLDO1 = VBLDO2 = VBLDO3 = VBDCDC1 = VBDCDC2 = 3.6 V, VDD = 1.85 V
Note) T_a = 25°C ± 2°C, unless otherwise specified.

B No.	Parameter	Symbol	Conditions	Limits			Unit	Notes
				Min	Typ	Max		
LED1 - 8 for LCD Back Light								
116	Off leakage current	Ileak1	—	−1.0	—	1.0	µA	—
117	Minimum current value 1	Imin11	Accuracy: ± 10% (Imin < 1 mA)	0.112	0.125	0.138	mA	—
118	Minimum current value 2	Imin12	Accuracy: ± 4% (Imin ≥ 1 mA)	0.96	1.00	1.04	mA	—
119	Maximum current value	Imax1	—	30.60	31.875	33.15	mA	—
120	Current step	Istep1	—	0.000	0.125	0.225	mA	*30
121	Saturation voltage	Vsat1	—	—	0.33	0.4	V	—
LED9 -10 for Photo Light								
122	Off leakage current	Ileak2	—	−1.0	—	1.0	µA	—
123	Minimum current value	Imin21	Accuracy: ± 10% (Imin < 1 mA)	0.96	1.00	1.04	mA	—
124	Maximum current value	Imax21	Accuracy: ± 4% (Imax ≥ 1 mA)	30.60	31.875	33.15	mA	—
125	Maximum current value	Imax22	Enhanced emission mode	60.48	63.00	65.52	mA	—
126	Current step	Istep21	—	0.20	1.00	1.80	mA	—
127	Saturation voltage	Vsat21	—	—	0.33	0.4	V	—
LED11 - 16 for Incoming RGB								
128	Off leakage current	Ileak3	—	−1.0	—	1.0	µA	—
129	Minimum current value 1	Imin31	Accuracy: ± 10% (Imin < 1 mA)	0.112	0.125	0.138	mA	—
130	Minimum current value 2	Imin32	Accuracy: ± 4% (Imin ≥ 1 mA)	0.96	1.00	1.04	mA	—
131	Maximum current value	Imax3	—	30.60	31.875	33.15	mA	—
132	Current step	Istep3	—	0.000	0.125	0.225	mA	*31
133	Saturation voltage (LED11, 12, 14, 15)	Vsat31	—	—	0.33	0.45	V	—
134	Saturation voltage (LED13, 16)	Vsat32	—	—	0.33	0.5	V	—

Notes) *30: See the Design Reference Manual No. 453.
*31: See the Design Reference Manual No. 465.

■ Electric Characteristics (continued) VB = VBLDO1 = VBLDO2 = VBLDO3 = VBDCDC1 = VBDCDC2 = 3.6 V, VDD = 1.85 V
Note) T_a = 25°C ± 2°C, unless otherwise specified.

B No.	Parameter	Symbol	Conditions	Limits			Unit	Notes
				Min	Typ	Max		
SCS, SCLK, SDI, RESET								
135	High-level input voltage range	VIH1	—	VDD × 0.7	—	VDD + 0.2	V	—
136	Low-level input voltage range	VIL1	—	– 0.2	—	VDD × 0.3	V	—
GPIO1 to 8								
137	High-level input voltage range (1) at 1.85-V mode operation	VIH2	IOVDDSEL = 0	LDO2 × 0.7	—	LDO2 + 0.2	V	—
138	Low-level input voltage range (1) at 1.85-V mode operation	VIL2	IOVDDSEL = 0	– 0.2	—	LDO2 × 0.3	V	—
139	High-level input voltage range (2) at 2.85-V mode operation	VIH3	IOVDDSEL = 1	LDO6 × 0.7	—	LDO6 + 0.2	V	—
140	Low-level input voltage range (2) at 2.85-V mode operation	VIL3	IOVDDSEL = 1	– 0.2	—	LDO6 × 0.3	V	—
141	High-level output voltage (1)	VOH1	IOVDDSEL = 0 Iout = –2 mA	LDO2 × 0.8	—	LDO2 + 0.2	V	*32
142	Low-level output voltage (1)	VOL1	IOVDDSEL = 0 Iout = 2 mA	– 0.2	—	LDO2 × 0.2	V	*32
143	High-level output voltage (2)	VOH2	IOVDDSEL = 1 Iout = –2 mA	LDO6 × 0.8	—	LDO6 + 0.2	V	*32
144	Low-level output voltage (2)	VOL2	IOVDDSEL = 1 Iout = 2 mA	– 0.2	—	LDO6 × 0.2	V	*32
145	High-level input current	IIH	IOVDDSEL = 1 Vin = 2.85 V	−1.0	0	1.0	µA	—
146	Low-level input current	IIL	IOVDDSEL = 1 Vin = 0 V	−1.0	0	1.0	µA	—
GPO								
147	High-level output voltage	VOH3	Iout = –2 mA	VB × 0.8	—	VB + 0.2	V	—
148	Low-level output voltage	VOL3	Iout = 2 mA	– 0.2	—	VB × 0.2	V	—

Note) *32: For information about the allowable value of capacitor connected to GPIO pin, see the block diagram on page 64 of the Product Standards.

■ Electric Characteristics (continued) VB = VBLDO1 = VBLDO2 = VBLDO3 = VBDCDC1 = VBDCDC2 = 3.6 V, VDD = 1.85 V
Note) T_a = 25°C ± 2°C, unless otherwise specified.

B No.	Parameter	Symbol	Conditions	Limits			Unit	Notes
				Min	Typ	Max		
SERSEL								
149	High-level input voltage range	VIH4	—	VB × 0.7	—	VB + 0.2	V	—
150	Low-level input voltage range	VIL4	—	– 0.2	—	VB × 0.3	V	—
REGON								
151	High-level input voltage range	VIH5	—	1.6	—	VB +0.2	V	—
152	Low-level input voltage range	VIL5	—	– 0.2	—	0.4	V	—
SDO								
153	High-level output voltage	VOH4	Iout = –2 mA	VDD × 0.8	—	VDD + 0.2	V	—
154	Low-level output voltage	VOL4	Iout = 2 mA	– 0.2	—	VDD × 0.2	V	—
GPIO1 to 8								
155	Pull-up resistance	RPL	IOPLU = 1 IOPLD = 0	50	100	150	kΩ	*33
156	Pull-down resistance	RPD1	IOPLD = 1	50	100	150	kΩ	*33
INT								
157	On resistance at INT pin	RINTON	—	—	20	50	Ω	—
Automatic Light Modulation Control Block								
158	On resistance at PD3 pin	RPD3ON	—	—	20	50	Ω	—
159	A/D conversion value (1)	AD1	Vin = VLDO6 × 1/255 Read value of the ADC_DATA[7:0] register	0	1	5	—	—
160	A/D conversion value (2)	AD2	Vin = VLDO6 × 64/255 Read value of the ADC_DATA[7:0] register	60	64	68	—	—
161	A/D conversion value (3)	AD3	Vin = VLDO6 × 128/255 Read value of the ADC_DATA[7:0] register	124	128	132	—	—
162	A/D conversion value (4)	AD4	Vin = VLDO6 × 192/255 Read value of the ADC_DATA[7:0] register	188	192	196	—	—
163	A/D conversion value (5)	AD5	Vin = VLDO6 × 255/255 Read value of the ADC_DATA[7:0] register	251	255	255	—	—

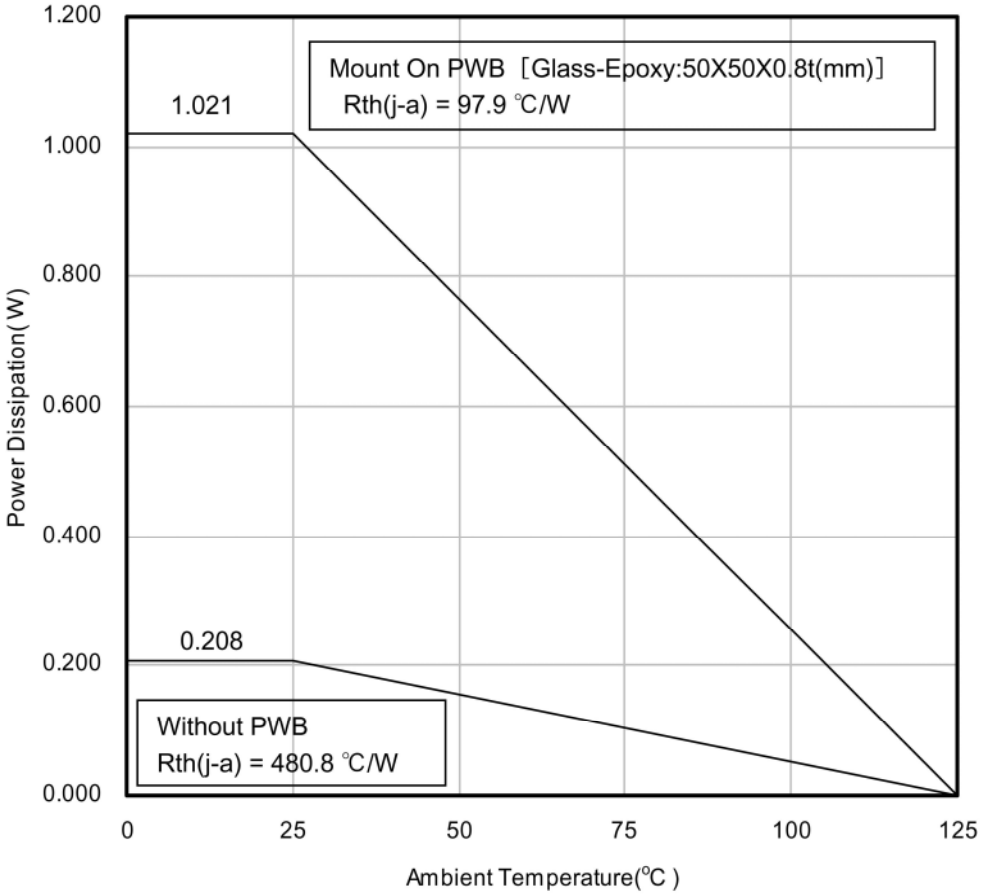
Note) *33: When pull-up and pull-down resistors of GPIO block are both turned ON at the same time, only pull-down resistor is effective.

■ Electric Characteristics (continued) VB = VBLDO1 = VBLDO2 = VBLDO3 = VBDCDC1 = VBDCDC2 = 3.6 V, VDD = 1.85 V
Note) T_a = 25°C ± 2°C, unless otherwise specified.

B No.	Parameter	Symbol	Conditions	Limits			Unit	Notes
				Min	Typ	Max		
I²C Interface (SERSEL = High)								
164	High-level input voltage range	VIH6	A voltage detected as High level by SCLK and SDI	VDD × 0.7	—	VDD + 0.5	V	—
165	Low-level input voltage range	VIL6	A voltage detected as Low level by SCLK and SDI	– 0.5	—	VDD × 0.3	V	—
166	Low-level output voltage (1)	VOL5	VDD > 2 V Iin = 3 mA	0	—	0.4	V	—
167	Low-level output voltage (2)	VOL6	VDD < 2 V Iin = 3 mA	0	—	VDD × 0.2	V	—
168	Input current 1	Ii1	SCLI, SDI: Vin = 1.85 V	–10	0	10	µA	—
169	Input current 2	Ii2	SCLI, SDI: Vin = 0 V	–10	0	10	µA	—
170	SCL clock frequency	f_{SCL}	—	0	—	400	kHz	—

■ Technical Data

• P_D — T_a Characteristic Diagram



■ Usage Notes

• Special Attention and Precaution in Using the IC

1. This IC is intended to be used for general electronic equipment [LED driver for mobile devices].
   Consult our sales staff in advance for information on the following applications:
   - Special applications in which exceptional quality and reliability are required, or if the failure or malfunction of this IC may directly jeopardize life or harm the human body.
   - Any applications other than the standard applications intended.

   (1) Space appliance (such as artificial satellite, and rocket)
   (2) Traffic control equipment (such as for automobile, airplane, train, and ship)
   (3) Medical equipment for life support
   (4) Submarine transponder
   (5) Control equipment for power plant
   (6) Disaster prevention and security device
   (7) Weapon
   (8) Others: Applications requiring reliability, equivalent to that of (1) to (7).
   Otherwise, we will not be liable for any defect which may arise later in your equipment.
2. This IC might smoke or ignite if it is mounted in the wrong direction onto the PCB (printed circuit board). Pay attention to the direction of it.
3. Pay attention to the pattern layout of PCB in order to prevent damage due to pin-to-pin short. For pin configuration, see the Pin Descriptions.
4. Conduct a visual inspection on PCBs sufficiently prior to supplying power to the IC, to prevent damage due to pin-to-pin solder-bridge. Also, conduct a technical verification to the mounting quality sufficiently, to prevent damage due to adhering conductive foreign substance such as solder scrap during transportation.
5. Since this IC might be damaged or occasionally smoke if abnormal state occurs, such as output-VCC short (power supply fault), output-GND short (ground fault), output-to-output short (load short), or pin-to-pin leakage, care must be taken in the use of the IC. Safety measures, such as fuse installation, are recommended in order to avoid such risks.
6. When designing your equipment, comply with the range of absolute maximum ratings and the guaranteed operating conditions (operating power supply voltage and environment, etc.). Especially, please be careful not to exceed the range of absolute maximum rating on the transient state, such as power-on, power-off, and mode-switching. Otherwise, we will not be liable for any defect which may arise later in your equipment.
   Even when the IC is used within the guaranteed values, take into the consideration of incidence of break down and failure mode, possible to occur to semiconductor products. Measures on the systems such as redundant design, arresting the spread of fire, or preventing glitch are recommended in order to prevent physical injury, fire, social damages, for example, by using the IC.
7. When designing your equipment with this IC, conduct safety checks including the long-term reliability for each equipment.
8. When designing application systems with this IC, read the Usage Notes described in this document thoroughly.
9. This IC has a structure that the chip is exposed to external. In case of using it in the light, functions and characteristics are not guaranteed. Please treat this IC not to be exposed to light during operation or testing process.
10. Since the chip surface is basically at ground potential, avoid the chip surface being in contact with metal shielding and others when designing your equipment.
11. Make sure the surge withstand voltage in using the IC.

	Surge withstand voltage	Pins
MM (0 Ω, 200 pF)	± 150 V or more	LED6(D7), IREF(C6), GPO(C4), LED13(A4), INT(E3), LDO2(G3), LED2(G7), LED8(C7), LED14(B6), LED16(B4), LDO3(H5), LED4(F7)
	± 170 V or more	RESET(D3), SCLK(B3), SCS(C3), SDO(A3), SDI(B2), REGON(E2), SERSEL(F5)
	± 180 V or more	LED10(A8), LED15(B5)
	± 200 V or more	Pins except the above
HBM (1.5 kΩ, 100 pF)	± 2000 V or more	All pins
CDM	± 500 V or more	All pins

Request for your special attention and precautions in using the technical information and semiconductors described in this book

(1) If any of the products or technical information described in this book is to be exported or provided to non-residents, the laws and regulations of the exporting country, especially, those with regard to security export control, must be observed.

(2) The technical information described in this book is intended only to show the main characteristics and application circuit examples of the products. No license is granted in and to any intellectual property right or other right owned by Panasonic Corporation or any other company. Therefore, no responsibility is assumed by our company as to the infringement upon any such right owned by any other company which may arise as a result of the use of technical information described in this book.

(3) The products described in this book are intended to be used for general applications (such as office equipment, communications equipment, measuring instruments and household appliances), or for specific applications as expressly stated in this book.
Consult our sales staff in advance for information on the following applications:
- Special applications (such as for airplanes, aerospace, automotive equipment, traffic signaling equipment, combustion equipment, life support systems and safety devices) in which exceptional quality and reliability are required, or if the failure or malfunction of the products may directly jeopardize life or harm the human body.

It is to be understood that our company shall not be held responsible for any damage incurred as a result of or in connection with your using the products described in this book for any special application, unless our company agrees to your using the products in this book for any special application.

(4) The products and product specifications described in this book are subject to change without notice for modification and/or improvement. At the final stage of your design, purchasing, or use of the products, therefore, ask for the most up-to-date Product Standards in advance to make sure that the latest specifications satisfy your requirements.

(5) When designing your equipment, comply with the range of absolute maximum rating and the guaranteed operating conditions (operating power supply voltage and operating environment etc.). Especially, please be careful not to exceed the range of absolute maximum rating on the transient state, such as power-on, power-off and mode-switching. Otherwise, we will not be liable for any defect which may arise later in your equipment.
Even when the products are used within the guaranteed values, take into the consideration of incidence of break down and failure mode, possible to occur to semiconductor products. Measures on the systems such as redundant design, arresting the spread of fire or preventing glitch are recommended in order to prevent physical injury, fire, social damages, for example, by using the products.

(6) Comply with the instructions for use in order to prevent breakdown and characteristics change due to external factors (ESD, EOS, thermal stress and mechanical stress) at the time of handling, mounting or at customer's process. When using products for which damp-proof packing is required, satisfy the conditions, such as shelf life and the elapsed time since first opening the packages.

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