



36Mb DDRII CIO SRAM 4-WORD BURST

**MT57W4MH8J
MT57W4MH9J
MT57W2MH18J
MT57W1MH36J**

Features

- DLL circuitry for accurate output data placement
- Pipelined double data rate operation
- Common data input/output bus
- Fast clock to valid data times
- Full data coherency, providing most current data
- Four-tick burst counter for reduced-address latency
- Two input clocks (K and K#) for precise DDR timing at clock rising edges only
- Two output clocks (C and C#) for precise flight time and clock skew matching—clock and data delivered together to receiving device
- Optional-use echo clocks (CQ and CQ#) for flexible receive data synchronization
- Simple control logic for easy depth expansion
- Internally self-timed, registered writes
- Core V_{DD} = 1.8V (±0.1V); I/O V_{DDQ} = 1.5V to V_{DD} (±0.1V) HSTL
- Clock-stop capability with μ s restart
- 15mm x 17mm, 1mm pitch, 11 x 15 grid FBGA package
- User-programmable impedance output
- JTAG boundary scan

Options

- Clock Cycle Timing
 - 3ns (333 MHz)
 - 3.3ns (300 MHz)
 - 4ns (250 MHz)
 - 5ns (200 MHz)
 - 6ns (167 MHz)
 - 7.5ns (133 MHz)
- Configurations
 - 4 Meg x 8
 - 4 Meg x 9
 - 2 Meg x 18
 - 1 Meg x 36
- Package
 - 165-ball, 15mm x 17mm FBGA

Marking¹

| | |
|----------------------------|-------------|
| 3ns (333 MHz) | -3 |
| 3.3ns (300 MHz) | -3.3 |
| 4ns (250 MHz) | -4 |
| 5ns (200 MHz) | -5 |
| 6ns (167 MHz) | -6 |
| 7.5ns (133 MHz) | -7.5 |
| 4 Meg x 8 | MT57W4MH8J |
| 4 Meg x 9 | MT57W4MH9J |
| 2 Meg x 18 | MT57W2MH18J |
| 1 Meg x 36 | MT57W1MH36J |
| Package | |
| 165-ball, 15mm x 17mm FBGA | F |

NOTE:

1. A Part Marking Guide for the FBGA devices can be found on Micron's Web site—<http://www.micron.com/numberguide>.

Figure 1: 165-Ball FBGA

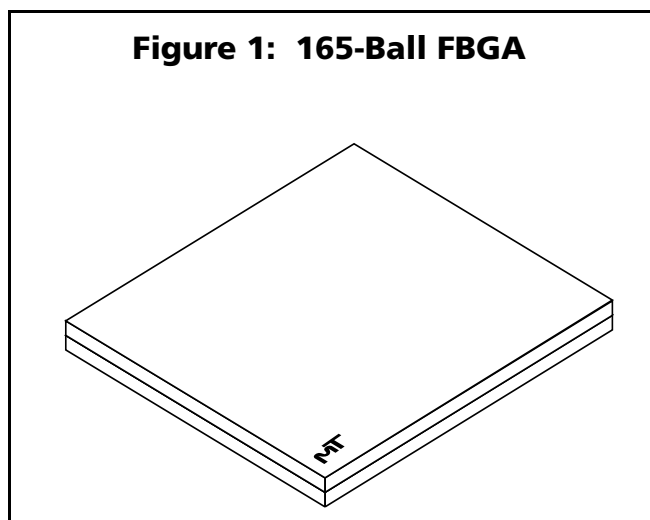


Table 1: Valid Part Numbers

| PART NUMBER | DESCRIPTION |
|-----------------|--------------------------|
| MT57W4MH8JF-xx | 4 Meg x 8, DDRIIb4 FBGA |
| MT57W4MH9JF-xx | 4 Meg x 9, DDRIIb4 FBGA |
| MT57W2MH18JF-xx | 2 Meg x 18, DDRIIb4 FBGA |
| MT57W1MH36JF-xx | 1 Meg x 36, DDRIIb4 FBGA |

General Description

The Micron[®] DDRII synchronous, pipelined burst SRAM employs high-speed, low-power CMOS designs using an advanced 6T CMOS process.

The DDR SRAM integrates an SRAM core with advanced synchronous peripheral circuitry and a two-bit burst counter. All synchronous inputs pass through registers controlled by an input clock pair (K and K#) and are latched on the rising edge of K and K#. The synchronous inputs include all addresses, all data inputs, active low load (LD#), read/write (R/W#), and active LOW byte writes or nibble writes (BWx# or NWx#). Write data is registered on the rising edges of both K and K#. Read data is driven on the rising edge of C and C#, if provided, or on the rising edge of K and K# if C and C# are not provided.



Asynchronous inputs include impedance match (ZQ). Synchronous data outputs (Q, sharing the same physical balls as the data inputs D) are tightly matched to the output data clocks C and C#, eliminating the need for separately capturing data from each individual DDR SRAM in the system design.

Additional write registers are incorporated to enhance pipelined WRITE cycles and reduce READ-to-WRITE turnaround time. WRITE cycles are self-timed.

Four balls are used to implement JTAG test capabilities: test mode select (TMS), test data-in (TDI), test clock (TCK), and test data-out (TDO). JTAG circuitry is used to serially shift data to and from the SRAM. JTAG inputs use JEDEC-standard 1.8V I/O levels to shift data during this testing mode of operation.

The device can be used in HSTL systems by supplying an appropriate reference voltage (V_{REF}). The device is ideally suited for applications requiring very rapid data transfer by operation in data-doubled mode. The device is also ideal in applications requiring the cost benefits of pipelined CMOS SRAMs and the reduced READ-to-WRITE turnaround times of late write SRAMs.

The SRAM operates from a 1.8V power supply, and all inputs and outputs are HSTL-compatible. The device is ideally suited for cache, network, telecom, DSP, and other applications that benefit from a very wide, high-speed data bus.

Please refer to Micron's Web site (www.micron.com/sramds) for the latest data sheet.

DDR Operation

The DDR SRAM enables high performance operation through high clock frequencies (achieved through pipelining) and double data rate mode of operation. At slower frequencies, the DDR SRAM requires a single no operation (NOP) cycle when transitioning from a READ to a WRITE cycle. At higher frequencies, a sec-

ond NOP cycle may be required to prevent bus contention. NOP cycles are not required when switching from a WRITE to a READ.

If a READ occurs after a WRITE cycle, address and data for the write are stored in registers. The write information must be stored because the SRAM cannot perform the last word write to the array without conflicting with the read. The data stays in this register until the next WRITE cycle occurs. On the first WRITE cycle after the READ(s), the stored data from the earlier write will be written into the SRAM array. This is called a posted write.

A read can be made immediately to an address even if that address was written in the previous cycle. During this READ cycle, the SRAM array is bypassed, and data is read instead from the data register storing the recently written data. This is transparent to the user. This feature facilitates system data coherency.

The DDR SRAM differs in some ways from its predecessor, the Claymore DDR SRAM. Single data rate operation is not supported, hence, no SD/DD# ball is provided. Only bursts of four are supported. The need for echo clocks is reduced or eliminated by the two single-ended input clocks (C and C#), although tightly controlled echo clocks (CQ and CQ#) are provided. The SRAM synchronizes its output data to these data clock rising edges, if provided. No differential clocks are used in this device. This clocking scheme provides greater system tuning capability than Claymore SRAMs and reduces the number of input clocks required by the bus master.

Partial WRITE Operations

BYTE WRITE operations are supported, except for x8 devices in which nibble write is supported. The active LOW write controls, BWx# (NWx#), are registered coincident with their corresponding data. This feature can eliminate the need for some READ-MODIFY-WRITE cycles, collapsing it to a single BYTE/NIBBLE WRITE operation in some instances.



Programmable Impedance Output Buffer

The DDR SRAM is equipped with programmable impedance output buffers. This allows a user to match the driver impedance to the system. To adjust the impedance, an external precision resistor (RQ) is connected between the ZQ ball and V_{SS}. The value of the resistor must be five times the desired impedance. For example, a 350Ω resistor is required for an output impedance of 70Ω. To ensure that output impedance is one-fifth the value of RQ (within 15 percent), the range of RQ is 175Ω to 350Ω. Alternately, the ZQ ball can be connected directly to V_{DDQ}, which will place the device in a minimum impedance mode.

Output impedance updates may be required because, over time, variations may occur in supply voltage and temperature. The device samples the value of RQ. Impedance updates are transparent to the system; they do not affect device operation, and all data sheet timing and current specifications are met during an update.

The device will power up with an output impedance set at 50Ω. To guarantee optimum output driver impedance after power-up, the SRAM needs 1,024 cycles to update the impedance. The user can operate the part with fewer than 1,024 clock cycles, but optimal output impedance is not guaranteed.

Clock Considerations

This device utilizes internal delay-locked loops for maximum output, data valid window. It can be placed into a stopped-clock state to minimize power with a modest restart time of 1,024 clock cycles. Circuitry automatically resets the DLL when the absence of the input clock is detected. See Micron Technical Note TN-54-02 for more information on clock DLL start-up procedures.

Single Clock Mode

The SRAM can be used with the single K, K# clock pair by tying C and C# HIGH. In this mode, the SRAM will use K and K# in place of C and C#. This mode provides the most rapid data output but does not compensate for system clock skew and flight times.

The output echo clocks are precise references to output data. CQ and CQ# are both rising edge and falling edge accurate and are 180° out of phase. Either or both may be used for output data capture. K or C rising edge triggers CQ rising and CQ# falling edge. CQ rising edge indicates first data response for QDRI and DDRI (version 1, non-DLL) SRAM, while CQ# rising edge indicates first data response for QDRII and DDRII (version 2, DLL) SRAM.

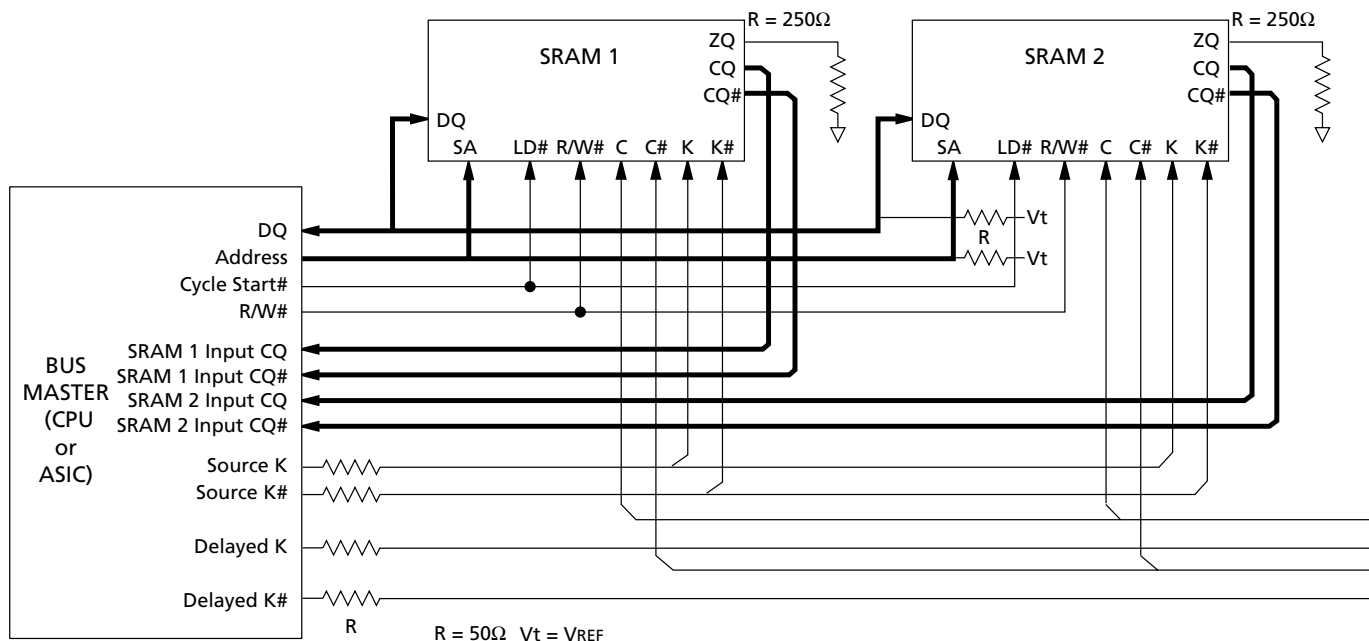
Depth Expansion

Depth expansion requires replicating the LD# control signal for each bank. All other control signals can be common between banks as appropriate.



4 MEG x 8, 4 MEG x 9, 2 MEG x 18, 1 MEG x 36
1.8V V_{DD}, HSTL, DDRIIb4 SRAM

Figure 3: Application Example



NOTE:

1. In this approach, the second clock pair drives the C and C# clocks but is delayed such that return data meets setup and hold times at the bus master.
2. Consult Micron Technical Notes for more thorough discussions of clocking schemes.
3. Data capture is possible using only one of the two signals. CQ and CQ# clocks are optional use outputs.
4. For high frequency applications (200 MHz and faster) the CQ and CQ# clocks (for data capture) are recommended over the C and C# clocks (for data alignment). The C and C# clocks are optional use inputs.


**Table 2: 4 Meg x 8 Ball Layout (Top View)
165-Ball FBGA**

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|------|----------------------------------|------------------|------------------|--------------------|-----------------|--------------------|------------------|------------------|------------------|-----|
| A | CQ# | V _{SS} /SA ¹ | SA | R/W# | NW1# ² | K# | NC/SA ³ | LD# | SA | SA | CQ |
| B | NC | NC | NC | SA | NC/SA ⁴ | K | NW0# ⁵ | SA | NC | NC | DQ3 |
| C | NC | NC | NC | V _{SS} | SA | NC | SA | V _{SS} | NC | NC | NC |
| D | NC | NC | NC | V _{SS} | V _{SS} | V _{SS} | V _{SS} | V _{SS} | NC | NC | NC |
| E | NC | NC | DQ4 | V _{DDQ} | V _{SS} | V _{SS} | V _{SS} | V _{DDQ} | NC | NC | DQ2 |
| F | NC | NC | NC | V _{DDQ} | V _{DD} | V _{SS} | V _{DD} | V _{DDQ} | NC | NC | NC |
| G | NC | NC | DQ5 | V _{DDQ} | V _{DD} | V _{SS} | V _{DD} | V _{DDQ} | NC | NC | NC |
| H | DLL# | V _{REF} | V _{DDQ} | V _{DDQ} | V _{DD} | V _{SS} | V _{DD} | V _{DDQ} | V _{DDQ} | V _{REF} | ZQ |
| J | NC | NC | NC | V _{DDQ} | V _{DD} | V _{SS} | V _{DD} | V _{DDQ} | NC | DQ1 | NC |
| K | NC | NC | NC | V _{DDQ} | V _{DD} | V _{SS} | V _{DD} | V _{DDQ} | NC | NC | NC |
| L | NC | DQ6 | NC | V _{DDQ} | V _{SS} | V _{SS} | V _{SS} | V _{DDQ} | NC | NC | DQ0 |
| M | NC | NC | NC | V _{SS} | V _{SS} | V _{SS} | V _{SS} | V _{SS} | NC | NC | NC |
| N | NC | NC | NC | V _{SS} | SA | SA | SA | V _{SS} | NC | NC | NC |
| P | NC | NC | DQ7 | SA | SA | C | SA | SA | NC | NC | NC |
| R | TDO | TCK | SA | SA | SA | C# | SA | SA | SA | TMS | TDI |

NOTE:

1. Expansion address: 2A for 72Mb
2. NW1# controls writes to DQ4:DQ7
3. Expansion address: 7A for 144Mb
4. Expansion address: 5B for 288Mb
5. NW0# controls writes to DQ0:DQ3

Note that the x8 does not permit random start address on the two least-significant address bits. SA0 and SA1 = 0 at the start of each access.


**Table 3: 4 Meg x 9 Ball Layout (Top View)
165-Ball FBGA**

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|----------|------|----------------------------------|-------------------|-------------------|--------------------|-----------------|--------------------|-------------------|-------------------|------------------|-----|
| A | CQ# | V _{SS} /SA ¹ | SA | R/W# | NC | K# | NC/SA ² | LD# | SA | SA | CQ |
| B | NC | NC | NC | SA | NC/SA ³ | K | BW0 ⁴ # | SA | NC | NC | DQ4 |
| C | NC | NC | NC | V _{SS} | SA | NC | SA | V _{SS} | NC | NC | NC |
| D | NC | NC | NC | V _{SS} | V _{SS} | V _{SS} | V _{SS} | V _{SS} | NC | NC | NC |
| E | NC | NC | DQ5 | V _{DD} Q | V _{SS} | V _{SS} | V _{SS} | V _{DD} Q | NC | NC | DQ3 |
| F | NC | NC | NC | V _{DD} Q | V _{DD} | V _{SS} | V _{DD} | V _{DD} Q | NC | NC | NC |
| G | NC | NC | DQ6 | V _{DD} Q | V _{DD} | V _{SS} | V _{DD} | V _{DD} Q | NC | NC | NC |
| H | DLL# | V _{REF} | V _{DD} Q | V _{DD} Q | V _{DD} | V _{SS} | V _{DD} | V _{DD} Q | V _{DD} Q | V _{REF} | ZQ |
| J | NC | NC | NC | V _{DD} Q | V _{DD} | V _{SS} | V _{DD} | V _{DD} Q | NC | DQ2 | NC |
| K | NC | NC | NC | V _{DD} Q | V _{DD} | V _{SS} | V _{DD} | V _{DD} Q | NC | NC | NC |
| L | NC | DQ7 | NC | V _{DD} Q | V _{SS} | V _{SS} | V _{SS} | V _{DD} Q | NC | NC | DQ1 |
| M | NC | NC | NC | V _{SS} | V _{SS} | V _{SS} | V _{SS} | V _{SS} | NC | NC | NC |
| N | NC | NC | NC | V _{SS} | SA | SA | SA | V _{SS} | NC | NC | NC |
| P | NC | NC | DQ8 | SA | SA | C | SA | SA | NC | NC | DQ0 |
| R | TDO | TCK | SA | SA | SA | C# | SA | SA | SA | TMS | TDI |

NOTE:

1. Expansion address: 2A for 72Mb
2. Expansion address: 7A for 144Mb
3. Expansion address: 5B for 288Mb
4. BW0# controls writes to DQ0:DQ8

Note that the x9 does not permit random address on the two least-significant address bits. SA0 and SA1 = 0 at the start of each access.



4 MEG x 8, 4 MEG x 9, 2 MEG x 18, 1 MEG x 36
1.8V V_{DD}, HSTL, DDRIIb4 SRAM

**Table 4: 2 Meg x 18 Ball Layout (Top View)
165-Ball FBGA**

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|----------|------|----------------------------------|-------------------|-------------------|--------------------|-----------------|--------------------|-------------------|-------------------|------------------|-----|
| A | CQ# | V _{SS} /SA ¹ | SA | R/W# | BW1# ² | K# | NC/SA ³ | LD# | SA | SA | CQ |
| B | NC | DQ9 | NC | SA | NC/SA ⁴ | K | BW0# ⁵ | SA | NC | NC | DQ8 |
| C | NC | NC | NC | V _{SS} | SA | SA0 | SA1 | V _{SS} | NC | DQ7 | NC |
| D | NC | DQ12 | DQ10 | V _{SS} | V _{SS} | V _{SS} | V _{SS} | V _{SS} | NC | NC | NC |
| E | NC | NC | DQ11 | V _{DD} Q | V _{SS} | V _{SS} | V _{SS} | V _{DD} Q | NC | NC | DQ6 |
| F | NC | NC | NC | V _{DD} Q | V _{DD} | V _{SS} | V _{DD} | V _{DD} Q | NC | NC | DQ5 |
| G | NC | NC | DQ13 | V _{DD} Q | V _{DD} | V _{SS} | V _{DD} | V _{DD} Q | NC | NC | NC |
| H | DLL# | V _{REF} | V _{DD} Q | V _{DD} Q | V _{DD} | V _{SS} | V _{DD} | V _{DD} Q | V _{DD} Q | V _{REF} | ZQ |
| J | NC | NC | NC | V _{DD} Q | V _{DD} | V _{SS} | V _{DD} | V _{DD} Q | NC | DQ4 | NC |
| K | NC | NC | DQ14 | V _{DD} Q | V _{DD} | V _{SS} | V _{DD} | V _{DD} Q | NC | NC | DQ3 |
| L | NC | DQ15 | NC | V _{DD} Q | V _{SS} | V _{SS} | V _{SS} | V _{DD} Q | NC | NC | DQ2 |
| M | NC | NC | NC | V _{SS} | V _{SS} | V _{SS} | V _{SS} | V _{SS} | NC | DQ1 | NC |
| N | NC | NC | DQ16 | V _{SS} | SA | SA | SA | V _{SS} | NC | NC | NC |
| P | NC | NC | DQ17 | SA | SA | C | SA | SA | NC | NC | DQ0 |
| R | TDO | TCK | SA | SA | SA | C# | SA | SA | SA | TMS | TDI |

NOTE:

1. Expansion address: 2A for 72Mb
2. BW1# controls writes to DQ9:DQ17
3. Expansion address: 7A for 144Mb
4. Expansion address: 5B for 288Mb
5. BW0# controls writes to DQ0:DQ8


Table 5: 1 Meg x 36 Ball Layout (Top View)
165-Ball FBGA

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|----------|------|----------------------------------|------------------|------------------|-------------------|-----------------|-------------------|------------------|------------------|--------------------|------|
| A | CQ# | V _{SS} /SA ¹ | SA | R/W# | BW2# ² | K# | BW1# ³ | LD# | SA | NC/SA ⁴ | CQ |
| B | NC | DQ27 | DQ18 | SA | BW3# ⁵ | K | BW0# ⁶ | SA | NC | NC | DQ8 |
| C | NC | NC | DQ28 | V _{SS} | SA | SA0 | SA1 | V _{SS} | NC | DQ17 | DQ7 |
| D | NC | DQ29 | DQ19 | V _{SS} | V _{SS} | V _{SS} | V _{SS} | V _{SS} | NC | NC | DQ16 |
| E | NC | NC | DQ20 | V _{DDQ} | V _{SS} | V _{SS} | V _{SS} | V _{DDQ} | NC | DQ15 | DQ6 |
| F | NC | DQ30 | DQ21 | V _{DDQ} | V _{DD} | V _{SS} | V _{DD} | V _{DDQ} | NC | NC | DQ5 |
| G | NC | DQ31 | DQ22 | V _{DDQ} | V _{DD} | V _{SS} | V _{DD} | V _{DDQ} | NC | NC | DQ14 |
| H | DLL# | V _{REF} | V _{DDQ} | V _{DDQ} | V _{DD} | V _{SS} | V _{DD} | V _{DDQ} | V _{DDQ} | V _{REF} | ZQ |
| J | NC | NC | DQ32 | V _{DDQ} | V _{DD} | V _{SS} | V _{DD} | V _{DDQ} | NC | DQ13 | DQ4 |
| K | NC | NC | DQ23 | V _{DDQ} | V _{DD} | V _{SS} | V _{DD} | V _{DDQ} | NC | DQ12 | DQ3 |
| L | NC | DQ33 | DQ24 | V _{DDQ} | V _{SS} | V _{SS} | V _{SS} | V _{DDQ} | NC | NC | DQ2 |
| M | NC | NC | DQ34 | V _{SS} | V _{SS} | V _{SS} | V _{SS} | V _{SS} | NC | DQ11 | DQ1 |
| N | NC | DQ35 | DQ25 | V _{SS} | SA | SA | SA | V _{SS} | NC | NC | DQ10 |
| P | NC | NC | DQ26 | SA | SA | C | SA | SA | NC | DQ9 | DQ0 |
| R | TDO | TCK | SA | SA | SA | C# | SA | SA | SA | TMS | TDI |

NOTE:

1. Expansion address: 2A for 144Mb
2. BW2# controls writes to DQ18:DQ26
3. BW1# controls writes to DQ9:DQ17
4. Expansion address: 10A for 72Mb
5. BW3# controls writes to DQ27:DQ35
6. BW0# controls writes to DQ0:DQ8


Table 6: Ball Descriptions

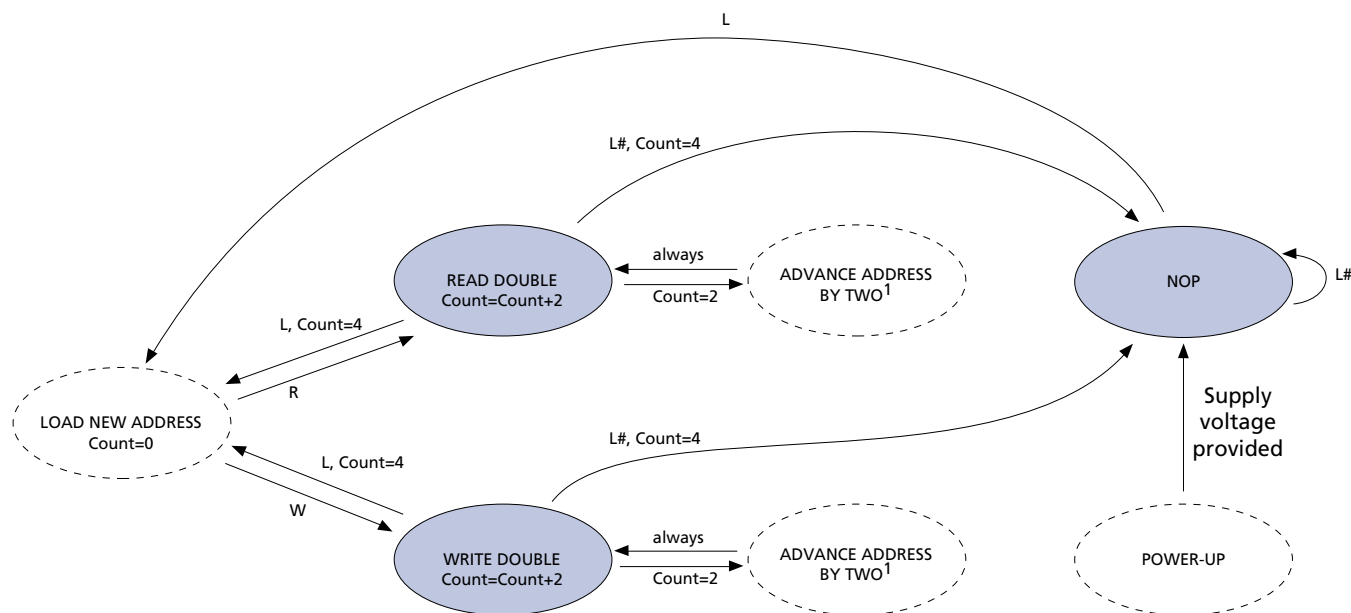
| SYMBOL | TYPE | DESCRIPTION |
|------------------|------------------|---|
| BW_# NW_# | Input | Synchronous Byte Writes (or Nibble Writes on x8): When LOW, these inputs cause their respective bytes or nibbles to be registered and written during WRITE cycles. These signals must meet setup and hold times around the rising edges of K and K# for each of the four rising edges comprising the WRITE cycle. See Ball Layout figures for signal to data relationships. |
| C C# | Input | Output Clock: This clock pair provides a user-controlled means of tuning device output data. The rising edge of C# is used as the output timing reference for first and third output data. The rising edge of C is used as the output reference for second and fourth output data. Ideally, C# is 180 degrees out of phase with C. C and C# may be tied HIGH to force the use of K and K# as the output reference clocks instead of having to provide C and C# clocks. If tied HIGH, C and C# must remain toggled during device operation. |
| DLL# | Input | DLL Disable: When LOW, this input causes the DLL to be bypassed for stable, low-frequency operation. |
| K K# | Input | Input Clock: This input clock pair registers address and control inputs on the rising edge of K and registers data on the rising edge of K and the rising edge of K#. K# is ideally 180 degrees out of phase with K. All synchronous inputs must meet setup and hold times around the clock rising edges. |
| LD# | Input | Synchronous Load: This input is brought LOW when a bus cycle sequence is to be defined. This definition includes address and read/write direction. All transactions operate on a burst of four data (two clock periods of bus activity). |
| R/W# | Input | Synchronous Read/Write Input: When LD# is LOW, this input designates the access type (READ when R/W# is HIGH; WRITE when R/W# is LOW) for the loaded address. R/W# must meet the setup and hold times around the rising edge of K. |
| SA SA0 SA1 | Input | Synchronous Address Inputs: These inputs are registered and must meet the setup and hold times around the rising edge of K. See Ball Assignment figures for address expansion inputs. All transactions operate on a burst of four words (two clock periods of bus activity). SA0 and SA1 are used as the lowest-two address bits for BURST READ and BURST WRITE operations permitting a random burst start address on the x18 and x36 devices. These inputs are ignored when the device is deselected or once BURST operation is in progress. |
| TCK | Input | IEEE 1149.1 Clock Input: 1.8V I/O levels. This ball must be tied to V _{SS} if the JTAG function is not used in the circuit. |
| TMS TDI | Input | IEEE 1149.1 Test Inputs: 1.8V I/O levels. These balls may be left as No Connects if the JTAG function is not used in the circuit. |
| VREF | Input | HSTL Input Reference Voltage: Nominally V _{DDQ} /2. Provides a reference voltage for the HSTL input buffer trip point. |
| ZQ | Input | Output Impedance Matching Input: This input is used to tune the device outputs to the system data bus impedance. DQ and CQ output impedance is set to 0.2 x R _Q , where R _Q is a resistor from this ball to ground. Alternately, this ball can be connected directly to V _{DDQ} to enable the minimum impedance mode. This ball cannot be connected directly to GND or left unconnected. |
| DQ_ | Input/ Output | Synchronous Data I/Os: Input data must meet setup and hold times around the rising edges of K and K#. Output data is synchronized to the respective C and C# data clocks or to K and K# if C and C# are tied HIGH. See Ball Layout figures for ball site location of individual signals. The x8 device uses DQ0:DQ7. Remaining signals are NC. The x9 device uses DQ0:DQ8. Remaining signals are NC. The x18 device uses DQ0:DQ17. Remaining signals are NC. The x36 device uses DQ0:DQ35. Remaining signals are NC. |
| CQ#, CQ | Output | Synchronous Echo Clock Outputs: The edges of these outputs are tightly matched to the synchronous data outputs and can be used as data valid indication. These signals run freely and do not stop when DQ tri-states. |
| TDO | Output | IEEE 1149.1 Test Output: 1.8V I/O level. |
| VDD | Supply | Power Supply: 1.8V nominal. See DC Electrical Characteristics and Operating Conditions for range. |
| VDDQ | Supply | Power Supply: Isolated Output Buffer Supply. Nominally 1.5V. 1.8V is also permissible. See DC Electrical Characteristics and Operating Conditions for range. |
| VSS | Supply | Power Supply: GND. |
| NC | – | No Connect: These balls are internally connected to the die, but have no function and may be left not connected to the board to minimize ball count. |



Table 7: Burst Address Table

| FIRST ADDRESS (EXTERNAL) | SECOND ADDRESS (INTERNAL) | THIRD ADDRESS (INTERNAL) | FOURTH ADDRESS (INTERNAL) |
|--------------------------|---------------------------|--------------------------|---------------------------|
| X ... X00 | X ... X01 | X ... X10 | X ... X11 |
| X ... X01 | X ... X10 | X ... X11 | X ... X00 |
| X ... X10 | X ... X11 | X ... X00 | X ... X01 |
| X ... X11 | X ... X00 | X ... X01 | X ... X10 |

Figure 4: Bus Cycle State Diagram



NOTE:

1. SA0 and SA1 are internally advanced in accordance with the burst order table. Bus cycle is terminated after burst count = 4.
2. State transitions: L = (LD# = LOW); L# = (LD# = HIGH); R = (R/W# = HIGH); W = (R/W# = LOW).
3. State machine, control timing sequence is controlled by K.


Table 8: Truth Table

Notes 1-6

| OPERATION | LD# | R/W# | K | DQ | DQ | DQ | DQ |
|---|-----|------|---------|--------------------------|---------------------------------|----------------------------------|---------------------------------|
| WRITE Cycle: Load address, input write data on two consecutive K and K# rising edges | L | L | L→H | DIN(A0) at K(t)↑ | DIN(A0 + 1) at K#(t + 1)↑ | DIN(A0 + 2) at K(t + 2)↑ | DIN(A0 + 3) at K#(t + 3)↑ |
| READ Cycle: Load address, output data on two consecutive C and C# rising edges | L | H | L→H | QOUT(A0) at C#(t)↑ | QOUT(A0 + 1) at C(t + 1)↑ | QOUT(A0 + 2) at C#(t + 2)↑ | QOUT(A0 + 3) at C(t + 3)↑ |
| NOP: No operation | H | X | L→H | High-Z | High-Z | High-Z | High-Z |
| STANDBY: Clock stopped | X | X | Stopped | Previous State | Previous State | Previous State | Previous State |

Table 9: BYTE WRITE Operation

Notes 7, 8

| OPERATION | K | K# | BW0# | BW1# |
|---------------------------------|-----|-----|------|------|
| WRITE D0:17 at K rising edge | L→H | | 0 | 0 |
| WRITE D0:17 at K# rising edge | | L→H | 0 | 0 |
| WRITE D0:8 at K rising edge | L→H | | 0 | 1 |
| WRITE D0:8 at K# rising edge | | L→H | 0 | 1 |
| WRITE D9:17 at K rising edge | L→H | | 1 | 0 |
| WRITE D9:17 at K# rising edge | | L→H | 1 | 0 |
| WRITE nothing at K rising edge | L→H | | 1 | 1 |
| WRITE nothing at K# rising edge | | L→H | 1 | 1 |

NOTE:

1. X means "Don't Care." H means logic HIGH. L means logic LOW. ↑ means rising edge; ↓ means falling edge.
2. Data inputs are registered at K and K# rising edges. Data outputs are delivered at C and C# rising edges, except if C and C# are HIGH, then data outputs are delivered at K and K# rising edges.
3. RW# and LD# must meet setup and hold times around the rising edge (LOW to HIGH) of K and are registered at the rising edge of K.
4. This device contains circuitry that will ensure the outputs will be in High-Z during power-up.
5. Refer to state diagram and timing diagrams for clarification. A0 refers to the address input during a WRITE or READ cycle. A0 + 1 refers to the next internal burst address in accordance with the burst sequence.
6. It is recommended that K = K# = C = C# when clock is stopped. This is not essential, but permits most rapid restart by overcoming transmission line charging symmetrically.
7. Assumes a WRITE cycle was initiated. BW0# and BW1# can be altered for any portion of the BURST WRITE operation provided that the setup and hold requirements are satisfied.
8. This table illustrates operation for x18 devices. The x36 device operation is similar, except for the addition of BW2# (controls DQ18:DQ26) and BW3# (controls DQ27:DQ35). The x9 device operation is similar, except that BW1# and DQ9:DQ17 are not available. The x8 device operation is similar, except that NW0# controls DQ0:DQ3 and NW1# controls DQ4:DQ7.



4 MEG x 8, 4 MEG x 9, 2 MEG x 18, 1 MEG x 36 1.8V V_{DD}, HSTL, DDRIIb4 SRAM

Absolute Maximum Ratings

Voltage on V_{DD} Supply Relative to V_{SS}..... -0.5V to +2.8V

Voltage on V_{DDQ} Supply

Relative to V_{SS} -0.5V to +V_{DD}

V_{IN} -0.5V to V_{DD} + 0.5V

Storage Temperature -55°C to +125°C

Junction Temperature +125°C

Short Circuit Output Current ±70mA

Stresses greater than those listed under Absolute Maximum Ratings may cause permanent damage to the device. This is a stress rating only, and functional operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect reliability.

Maximum Junction Temperature depends upon package type, cycle time, loading, ambient temperature, and airflow.

Table 10: DC Electrical Characteristics and Operating Conditions

Notes appear following parameter tables on page 17; 0°C ≤ T_A ≤ +70°C; V_{DD} = 1.8V ±0.1V unless otherwise noted

| DESCRIPTION | CONDITIONS | SYMBOL | MIN | MAX | UNITS | NOTES |
|-------------------------------|--|-----------------------|----------------------------|----------------------------|-------|---------|
| Input High (Logic 1) Voltage | | V _{IH} (DC) | V _{REF} + 0.1 | V _{DDQ} + 0.3 | V | 3, 4 |
| Input Low (Logic 0) Voltage | | V _{IL} (DC) | -0.3 | V _{REF} - 0.1 | V | 3, 4 |
| Clock Input Signal Voltage | | V _{IN} | -0.3 | V _{DDQ} + 0.3 | V | 3, 4 |
| Input Leakage Current | 0V ≤ V _{IN} ≤ V _{DDQ} | I _{LI} | -5 | 5 | μA | |
| Output Leakage Current | Output(s) disabled, 0V ≤ V _{IN} ≤ V _{DDQ} (Q) | I _{LO} | -5 | 5 | μA | |
| Output High Voltage | I _{OH} ≤ 0.1mA | V _{OH} (LOW) | V _{DDQ} - 0.2 | V _{DDQ} | V | 3, 5, 6 |
| | Note 1 | V _{OH} | V _{DDQ} /2 - 0.12 | V _{DDQ} /2 + 0.12 | V | 3, 5, 6 |
| Output Low Voltage | I _{OL} ≤ 0.1mA | V _{OL} (LOW) | V _{SS} | 0.2 | V | 3, 5, 6 |
| | Note 2 | V _{OL} | V _{DDQ} /2 - 0.12 | V _{DDQ} /2 + 0.12 | V | 3, 5, 6 |
| Supply Voltage | | V _{DD} | 1.7 | 1.9 | V | 3 |
| Isolated Output Buffer Supply | | V _{DDQ} | 1.4 | V _{DD} | V | 3, 7 |
| Reference Voltage | | V _{REF} | 0.68 | 0.95 | V | 3 |

Table 11: AC Electrical Characteristics and Operating Conditions

Notes appear following parameter tables on page 17; 0°C ≤ T_A ≤ +70°C; V_{DD} = 1.8V ±0.1V unless otherwise noted

| DESCRIPTION | CONDITIONS | SYMBOL | MIN | MAX | UNITS | NOTES |
|------------------------------|------------|----------------------|------------------------|------------------------|-------|---------|
| Input High (Logic 1) Voltage | | V _{IH} (AC) | V _{REF} + 0.2 | – | V | 3, 4, 8 |
| Input Low (Logic 0) Voltage | | V _{IL} (AC) | – | V _{REF} - 0.2 | V | 3, 4, 8 |


Table 12: I_{DD} Operating Conditions and Maximum Limits

 Notes appear following parameter tables on page 17; 0°C ≤ T_A ≤ +70°C; V_{DD} = 1.8V ±0.1V unless otherwise noted

| DESCRIPTION | CONDITIONS | SYMBOL | TYP | MAX | | | | | | UNITS | NOTES |
|---|---|--|-----|-----------------|-----------------|-----------------|-----------------|----------------|----------------|-------|--------|
| | | | | -3 | -3.3 | -4 | -5 | -6 | -7.5 | | |
| Operating Supply Current: DDR | Cycle time ≥ t _{KHKH} (MIN); Outputs open; x:1 ratio for READs to WRITEs; 50% address and data bits toggling on each clock cycle | I _{DD} x8, x9, x18 x36 | TBD | 525 710 | 475 640 | 400 545 | 330 445 | 280 380 | 235 310 | mA | 9, 10 |
| Standby Supply Current: NOP | t _{KHKH} = t _{KHKH} (MIN); Device in NOP state; All addresses/data static | I _{SB1} x8, x9, x18 x36 | TBD | 255 265 | 235 240 | 200 210 | 170 180 | 150 160 | 125 135 | mA | 10, 11 |
| Output Supply Current: DDR (Information only) | C _L = 15pF | I _{DDQ} x8, x9 x18 x36 | TBD | 42 95 189 | 38 85 170 | 32 71 142 | 25 57 142 | 21 47 95 | 17 38 76 | mA | 12 |

Table 13: Capacitance

Note 13; notes appear following parameter tables on page 17

| DESCRIPTION | CONDITIONS | SYMBOL | TYP | MAX | UNITS |
|-----------------------------------|----------------------------------|-----------------|-----|-----|-------|
| Address/Control Input Capacitance | T _A = 25°C; f = 1 MHz | C _I | 4.5 | 5.5 | pF |
| Input, Output Capacitance (D, Q) | | C _O | 6 | 7 | pF |
| Clock Capacitance | | C _{CK} | 5.5 | 6.5 | pF |

Table 14: Thermal Resistance

Note 13; notes appear following parameter tables on page 17

| DESCRIPTION | CONDITIONS | SYMBOL | TYP | UNITS | NOTES |
|---------------------------------------|--|-----------------|------|-------|-------|
| Junction to Ambient (Airflow of 1m/s) | Soldered on a 4.25 x 1.125 inch, 4-layer printed circuit board | θ _{JA} | 19.4 | °C/W | 14 |
| Junction to Case (Top) | | θ _{JC} | 1.0 | °C/W | |
| Junction to Balls (Bottom) | | θ _{JB} | 9.6 | °C/W | 15 |


Table 15: AC Electrical Characteristics and Recommended Operating Conditions

 Notes 16-19; 22; notes appear following parameter tables on page 17; 0°C ≤ T_A ≤ +70°C; T_J ≤ +95°C; V_{DD} = 1.8V ±0.1V

| DESCRIPTION | SYM | -3 | | -3.3 | | -4 | | -5 | | -6 | | -7.5 | | UNITS | NOTES |
|---|-----------------------|-------|------|-------|------|-------|------|-------|------|-------|------|-------|------|--------|-------|
| | | MIN | MAX | MIN | MAX | MIN | MAX | MIN | MAX | MIN | MAX | MIN | MAX | | |
| Clock | | | | | | | | | | | | | | | |
| Clock cycle time (K, K#, C, C#) | t _{KHKH} | 3.00 | 3.47 | 3.30 | 4.20 | 4.00 | 5.25 | 5.00 | 6.30 | 6.00 | 7.88 | 7.50 | 8.40 | ns | 20 |
| Clock phase jitter (K, K#, C, C#) | t _{KC var} | | 0.20 | | 0.20 | | 0.20 | | 0.20 | | 0.20 | | 0.20 | ns | 21 |
| Clock HIGH time (K, K#, C, C#) | t _{KHKL} | 1.20 | | 1.32 | | 1.60 | | 2.00 | | 2.40 | | 3.00 | | ns | |
| Clock LOW time (K, K#, C, C#) | t _{KLKH} | 1.20 | | 1.32 | | 1.60 | | 2.00 | | 2.40 | | 3.00 | | ns | |
| Clock to clock# (K↑→K#↑, C↑→C#↑) at t _{KHKH} minimum | t _{KHK#H} | 1.35 | | 1.49 | | 1.80 | | 2.20 | | 2.70 | | 3.38 | | ns | |
| Clock# to clock (K#↑→K↑, C#↑→C↑) at t _{KHKH} minimum | t _{K#HKH} | 1.35 | | 1.49 | | 1.80 | | 2.20 | | 2.70 | | 3.38 | | ns | |
| Clock to data clock (K↑→C↑, K#↑→C#↑) | t _{KHCH} | 0.00 | 1.30 | 0.00 | 1.45 | 0.00 | 1.80 | 0.00 | 2.30 | 0.00 | 2.80 | 0.00 | 3.55 | ns | |
| DLL lock time (K, C) | t _{KC lock} | 1,024 | | 1,024 | | 1,024 | | 1,024 | | 1,024 | | 1,024 | | cycles | 22 |
| K static to DLL reset | t _{KC reset} | 30 | | 30 | | 30 | | 30 | | 30 | | 30 | | ns | |
| Output Times | | | | | | | | | | | | | | | |
| C, C# HIGH to output valid | t _{CHQV} | | 0.45 | | 0.45 | | 0.45 | | 0.45 | | 0.50 | | 0.50 | ns | |
| C, C# HIGH to output hold | t _{CHQX} | -0.45 | | -0.45 | | -0.45 | | -0.45 | | -0.50 | | -0.50 | | ns | |
| C, C# HIGH to echo clock valid | t _{CHCQV} | | 0.45 | | 0.45 | | 0.45 | | 0.45 | | 0.50 | | 0.50 | ns | |
| C, C# HIGH to echo clock hold | t _{CHCQX} | -0.45 | | -0.45 | | -0.45 | | -0.45 | | -0.50 | | -0.50 | | ns | |


**Table 15: AC Electrical Characteristics and Recommended Operating Conditions
(Continued)**

| DESCRIPTION | SYM | -3 | | -3.3 | | -4 | | -5 | | -6 | | -7.5 | | UNITS | NOTES |
|--|--------------------|-------|------|-------|------|-------|------|-------|------|-------|------|-------|------|-------|-------|
| | | MIN | MAX | MIN | MAX | MIN | MAX | MIN | MAX | MIN | MAX | MIN | MAX | | |
| CQ, CQ# HIGH to output valid | t _{CQHQV} | | 0.25 | | 0.27 | | 0.30 | | 0.35 | | 0.40 | | 0.40 | ns | 23 |
| CQ, CQ# HIGH to output hold | t _{CQHQX} | -0.25 | | -0.27 | | -0.30 | | -0.35 | | -0.40 | | -0.40 | | ns | 23 |
| C HIGH to output High-Z | t _{CHQZ} | | 0.45 | | 0.45 | | 0.45 | | 0.45 | | 0.50 | | 0.50 | ns | |
| C HIGH to output Low- Z | t _{CHQX1} | -0.45 | | -0.45 | | -0.45 | | -0.45 | | -0.50 | | -0.50 | | ns | |
| Setup Times | | | | | | | | | | | | | | | |
| Address valid to K rising edge | t _{AVKH} | 0.40 | | 0.40 | | 0.50 | | 0.60 | | 0.70 | | 0.70 | | ns | 16 |
| Control inputs valid to K rising edge | t _{IVKH} | 0.40 | | 0.40 | | 0.50 | | 0.60 | | 0.70 | | 0.70 | | ns | 16 |
| Data-in valid to K, K# rising edge | t _{DVKH} | 0.28 | | 0.30 | | 0.35 | | 0.40 | | 0.50 | | 0.50 | | ns | 16 |
| Hold Times | | | | | | | | | | | | | | | |
| K rising edge to address hold | t _{KHAX} | 0.40 | | 0.40 | | 0.50 | | 0.60 | | 0.70 | | 0.70 | | ns | 16 |
| K rising edge to control inputs hold | t _{KHIX} | 0.40 | | 0.40 | | 0.50 | | 0.60 | | 0.70 | | 0.70 | | ns | 16 |
| K, K# rising edge to data-in hold | t _{KHDX} | 0.28 | | 0.30 | | 0.35 | | 0.40 | | 0.50 | | 0.50 | | ns | 16 |



Notes

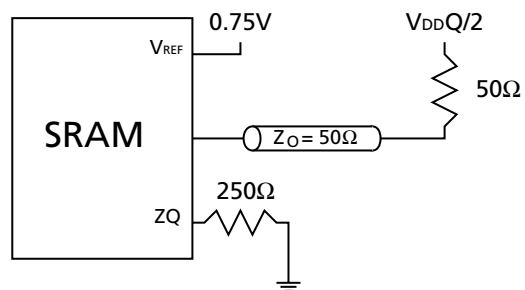
1. Outputs are impedance-controlled. $|I_{OH}| = (V_{DDQ}/2)/(RQ/5)$ for values of $175\Omega \leq RQ \leq 350\Omega$.
2. Outputs are impedance-controlled. $I_{OL} = (V_{DDQ}/2)/(RQ/5)$ for values of $175\Omega \leq RQ \leq 350\Omega$.
3. All voltages referenced to V_{SS} (GND).
4. Overshoot: $V_{IH(AC)} \leq V_{DD} + 0.7V$ for $t \leq t_{KHKH}/2$
Undershoot: $V_{IL(AC)} \geq -0.5V$ for $t \leq t_{KHKH}/2$
Power-up: $V_{IH} \leq V_{DDQ} + 0.3V$ and $V_{DD} \leq 1.7V$ and $V_{DDQ} \leq 1.4V$ for $t \leq 200ms$
During normal operation, V_{DDQ} must not exceed V_{DD}. Control input signals may not have pulse widths less than t_{KHKL} (MIN) or operate at cycle rates less than t_{KHKH} (MIN).
5. AC load current is higher than the shown DC values. AC I/O curves are available upon request.
6. HSTL outputs meet JEDEC HSTL Class I and Class II standards.
7. The nominal value of V_{DDQ} may be set within the range of 1.5V to 1.8V DC, and the variation of V_{DDQ} must be limited to $\pm 0.1V$ DC.
8. To maintain a valid level, the transitioning edge of the input must:
 - a. Sustain a constant slew rate from the current AC level through the target AC level, $V_{IL(AC)}$ or $V_{IH(AC)}$.
 - b. Reach at least the target AC level.
 - c. After the AC target level is reached, continue to maintain at least the target DC level, $V_{IL(DC)}$ or $V_{IH(DC)}$.
9. IDD is specified with no output current. IDD is linear with frequency. Typical value is measured at 6ns cycle time.
10. Typical values are measured at V_{DD} = 1.8V, V_{DDQ} = 1.5V, and temperature = 25°C.
11. NOP currents are valid when entering NOP after all pending READ and WRITE cycles are completed.
12. Average I/O current and power is provided for informational purposes only and is not tested. Calculation assumes that all outputs are loaded with C_L (in farads), f = input clock frequency, half of outputs toggle at each transition (n = 18 for the x36), C_O = 6pF, V_{DDQ} = 1.5V and uses the equations: Average I/O Power as dissipated by the SRAM is: $P = 0.5 \times n \times f \times V_{DDQ}^2 \times (C_L + 2C_O)$. Average IDDQ = $n \times f \times V_{DDQ} \times (C_L + C_O)$.
13. This parameter is sampled.
14. Average thermal resistance between the die and the case top surface per MIL SPEC 883 Method 1012.1.
15. Junction temperature is a function of total device power dissipation and device mounting environment. Measured per SEMI G38-87.
16. This is a synchronous device. All addresses, data, and control lines must meet the specified setup and hold times for all latching clock edges.
17. Test conditions as specified with the output loading as shown in Figure 5 unless otherwise noted.
18. Control input signals may not be operated with pulse widths less than t_{KHKL} (MIN).
19. If C and C# are tied HIGH, then K and K# become the references for C and C# timing parameters.
20. The device will operate at clock frequencies slower than t_{KHKH} (MAX). See Micron Technical Note TN-54-02 for more information.
21. Clock phase jitter is the variance from clock rising edge to the next expected clock rising edge.
22. V_{DD} slew rate must be less than 0.1V DC per 50ns for DLL lock retention. DLL lock time begins once V_{DD} and input clock are stable.
23. Echo clock is tightly controlled to data valid/data hold. By design, there is a $\pm 0.1ns$ variation from echo clock to data. The data sheet parameters reflect tester guardbands and test setup variations.



AC Test Conditions

| | |
|------------------------------------|---------------------|
| Input pulse levels | 0.25V to 1.25V |
| Input rise and fall times | 0.7ns |
| Input timing reference levels..... | 0.75V |
| Output reference levels..... | V _{DDQ} /2 |
| ZQ for 50Ω impedance..... | 250Ω |
| Output load..... | See Figure 5 |

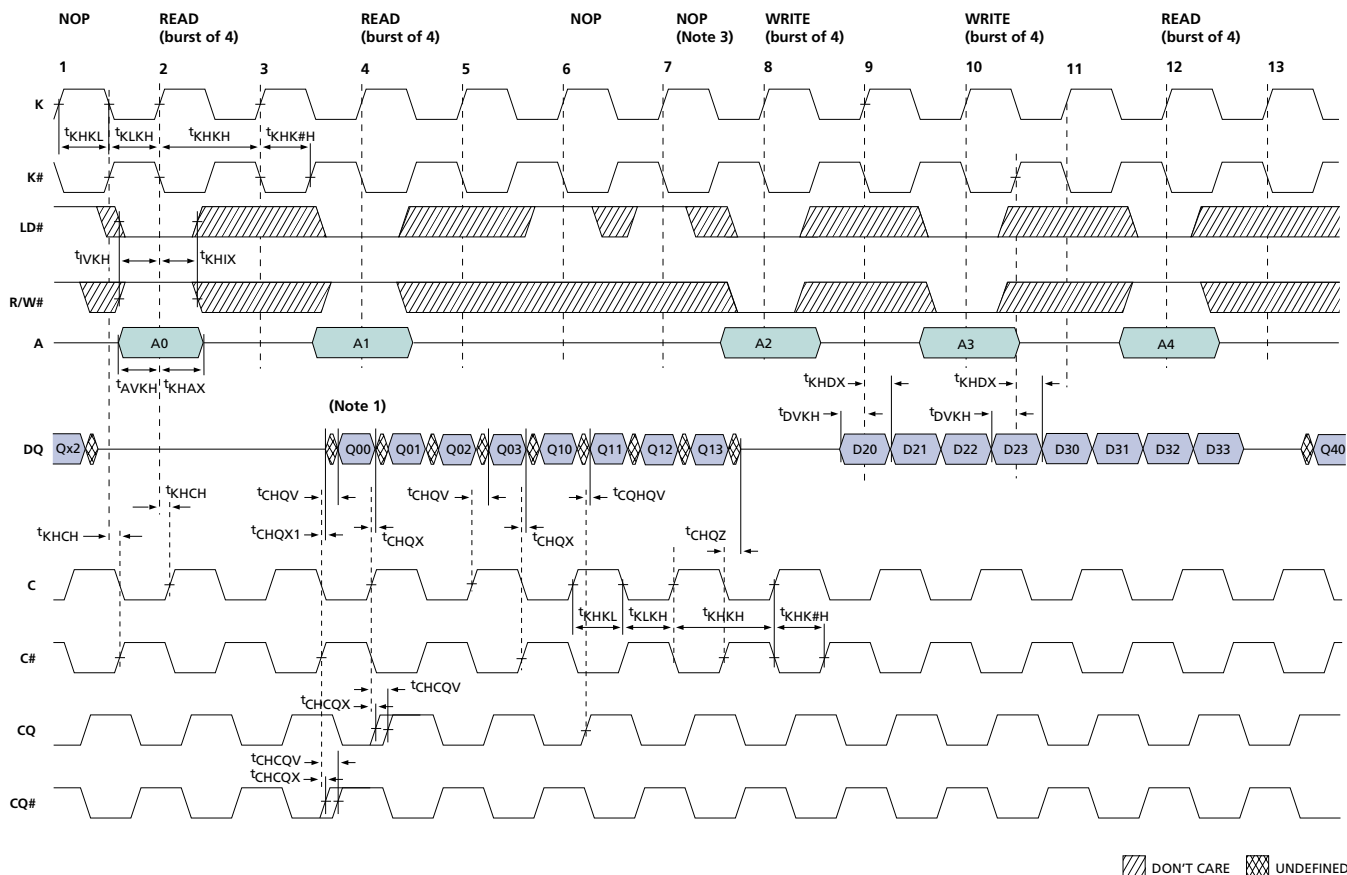
**Figure 5:
Output Load Equivalent**





4 MEG x 8, 4 MEG x 9, 2 MEG x 18, 1 MEG x 36
1.8V V_{DD}, HSTL, DDRIIb4 SRAM

**Figure 6:
READ/WRITE Timing**



NOTE:

1. Q00 refers to output from address A0. Q01 refers to output from the next internal burst address following A0, etc.
2. Outputs are disabled (High-Z) one clock cycle after a NOP.
3. The second NOP cycle is not necessary for correct device operation; however, at high clock frequencies it may be required to prevent bus contention.



IEEE 1149.1 Serial Boundary Scan (JTAG)

The SRAM incorporates a serial boundary scan test access port (TAP). This port operates in accordance with IEEE Standard 1149.1-2001. The TAP operates using JEDEC-standard 1.8V I/O logic levels.

The SRAM contains a TAP controller, instruction register, boundary scan register, bypass register, and ID register.

Disabling The JTAG Feature

It is possible to operate the SRAM without using the JTAG feature. To disable the TAP controller, TCK must be tied LOW (V_{SS}) to prevent clocking of the device. TDI and TMS are internally pulled up and may be unconnected. Alternately, they may be connected to V_{DD} through a pull-up resistor. TDO should be left unconnected. Upon power-up, the device will come up in a reset state, which will not interfere with the operation of the device.

Test Access Port (TAP)

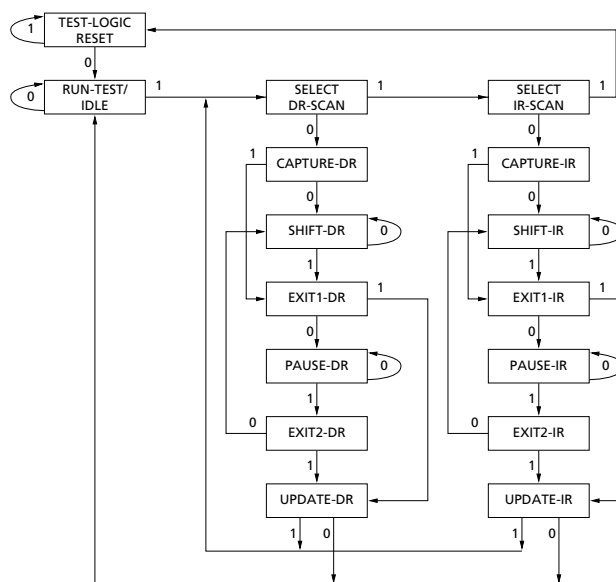
Test Clock (TCK)

The test clock is used only with the TAP controller. All inputs are captured on the rising edge of TCK. All outputs are driven from the falling edge of TCK.

Test Mode Select (TMS)

The TMS input is used to give commands to the TAP controller and is sampled on the rising edge of TCK. It is allowable to leave this ball unconnected if the TAP is not used. The ball is pulled up internally, resulting in a logic HIGH level.

**Figure 7:
TAP Controller State Diagram**



NOTE:

The 0/1 next to each state represents the value of TMS at the rising edge of TCK.

Test Data-in (TDI)

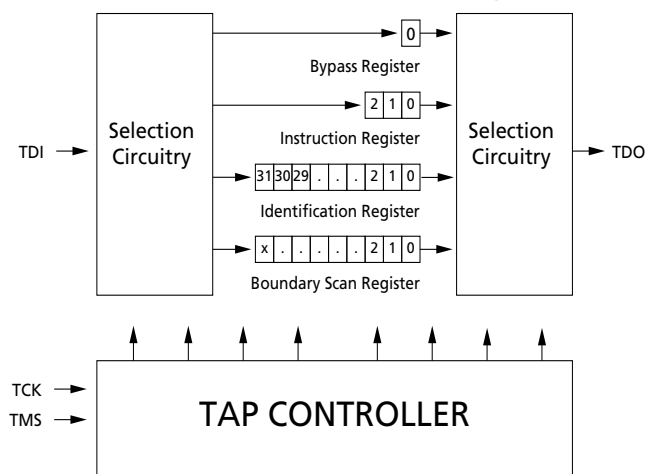
The TDI ball is used to serially input information into the registers and can be connected to the input of any of the registers. The register between TDI and TDO is chosen by the instruction that is loaded into the TAP instruction register. For information on loading the instruction register, see Figure 7. TDI is internally pulled up and can be unconnected if the TAP is unused in an application. TDI is connected to the most-significant bit (MSB) of any register, as illustrated in Figure 8.

Test Data-out (TDO)

The TDO output ball is used to serially clock data-out from the registers. The output is active depending upon the current state of the TAP state machine illustrated in Figure 7. The output changes on the falling edge of TCK. TDO is connected to the least-significant bit (LSB) of any register, as depicted in Figure 8.



**Figure 8:
TAP Controller Block Diagram**



NOTE:

X = 108 for all configurations.

Performing A TAP Reset

A RESET is performed by forcing TMS HIGH (V_{DD}) for five rising edges of TCK. This RESET does not affect the operation of the SRAM and may be performed while the SRAM is operating.

At power-up, the TAP is reset internally to ensure that TDO comes up in a High-Z state.

TAP Registers

Registers are connected between the TDI and TDO balls and allow data to be scanned into and out of the SRAM test circuitry. Only one register can be selected at a time through the instruction register. Data is serially loaded into the TDI ball on the rising edge of TCK. Data is output on the TDO ball on the falling edge of TCK.

Instruction Register

Three-bit instructions can be serially loaded into the instruction register. This register is loaded when it is placed between the TDI and TDO balls, as shown in Figure 8. Upon power-up, the instruction register is loaded with the IDCODE instruction. It is also loaded with the IDCODE instruction if the controller is placed in a reset state, as described in the previous section.

When the TAP controller is in the Capture-IR state, the two LSBs are loaded with a binary “01” pattern to allow for fault isolation of the board-level serial test data path.

Bypass Register

To save time when serially shifting data through registers, it is sometimes advantageous to skip certain chips. The bypass register is a single-bit register that can be placed between the TDI and TDO balls. This allows data to be shifted through the SRAM with minimal delay. The bypass register is set LOW (V_{SS}) when the BYPASS instruction is executed.

Boundary Scan Register

The boundary scan register is connected to all the input and bidirectional balls on the SRAM. Several no connect (NC) balls are also included in the scan register to reserve balls. The SRAM has a 109-bit-long register.

The boundary scan register is loaded with the contents of the RAM I/O ring when the TAP controller is in the Capture-DR state and is then placed between the TDI and TDO balls when the controller is moved to the Shift-DR state.

The Boundary Scan Order table shows the order in which the bits are connected. Each bit corresponds to one of the balls on the SRAM package. The MSB of the register is connected to TDI, and the LSB is connected to TDO.

Identification (ID) Register

The ID register is loaded with a vendor-specific, 32-bit code during the Capture-DR state when the IDCODE command is loaded in the instruction register. The IDCODE is hardwired into the SRAM and can be shifted out when the TAP controller is in the Shift-DR state. The ID register has a vendor code and other information described in the Identification Register Definitions table.

Tap Instruction Set Overview

Eight different instructions are possible with the three-bit instruction register. All combinations are listed in the Instruction Codes table. Three of these instructions are listed as RESERVED and should not be used. The other five instructions are described below in detail.

The TAP controller used in this SRAM is fully compliant to the 1149.1 convention.

Instructions are loaded into the TAP controller during the Shift-IR state when the instruction register is placed between TDI and TDO. During this state, instructions are shifted through the instruction regis-



ter, and through the TDI and TDO balls. To execute the instruction once it is shifted in, the TAP controller needs to be moved into the Update-IR state.

EXTEST

The EXTEST instruction allows circuitry external to the component package to be tested. Boundary scan register cells at output pins are used to apply test vectors, while those at input pins capture test results. Typically, the first test vector to be applied using the EXTEST instruction will be shifted into the boundary scan register using the PRELOAD instruction. Thus, during the Update-IR state of EXTEST, the output drive is turned on and the PRELOAD data is driven onto the output pins.

IDCODE

The IDCODE instruction causes a vendor-specific, 32-bit code to be loaded into the instruction register. It also places the instruction register between the TDI and TDO balls and allows the IDCODE to be shifted out of the device when the TAP controller enters the Shift-DR state.

The IDCODE instruction is loaded into the instruction register upon power-up or whenever the TAP controller is given a test logic reset state.

SAMPLE Z

The SAMPLE Z instruction causes the boundary scan register to be connected between the TDI and TDO balls when the TAP controller is in a Shift-DR state. It also places all SRAM outputs into a High-Z state, including CQ and CQ#.

SAMPLE/PRELOAD

When the SAMPLE/PRELOAD instruction is loaded into the instruction register and the TAP controller is in the Capture-DR state, a snapshot of data on the inputs and bidirectional balls is captured in the boundary scan register.

The user must be aware that the TAP controller clock can only operate at a frequency up to 10 MHz, while the SRAM clock operates more than an order of magnitude faster. Because there is a large difference in the clock frequencies, it is possible that during the Capture-DR state, an input or output will undergo a transition. The TAP may then try to capture a signal while in transition (metastable state). This will not harm the device, but there is no guarantee as to the value that will be captured. Repeatable results may not be possible.

To guarantee that the boundary scan register will capture the correct value of a signal, the SRAM signal must be stabilized long enough to meet the TAP controller's capture setup plus hold time (t_{CS} plus t_{CH}). The SRAM clock input might not be captured correctly if there is no way in a design to stop (or slow) the clock during a SAMPLE/PRELOAD instruction. If this is an issue, it is still possible to capture all other signals and simply ignore the value of the K, K# and C, C# captured in the boundary scan register.

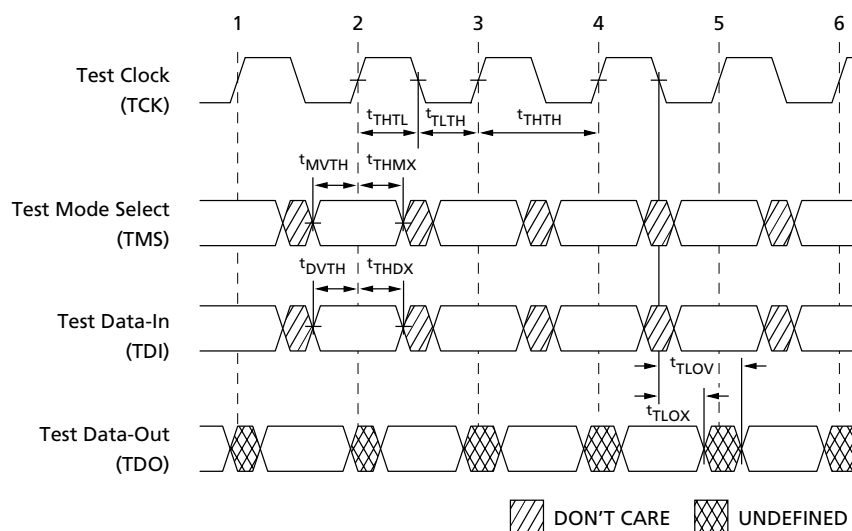
Once the data is captured, it is possible to shift out the data by putting the TAP into the Shift-DR state. This places the boundary scan register between the TDI and TDO balls.

BYPASS

When the BYPASS instruction is loaded in the instruction register and the TAP is placed in a Shift-DR state, the bypass register is placed between the TDI and TDO balls. The advantage of the BYPASS instruction is that it shortens the boundary scan path when multiple devices are connected together on a board.

RESERVED

These instructions are not implemented but are reserved for future use. Do not use these instructions.


Figure 9: TAP Timing

NOTE:

Timing for SRAM inputs and outputs is congruent with TDI and TDO, respectively, as shown in Figure 9.

Table 16: TAP AC Characteristics

Notes 1, 2; 0°C ≤ T_A ≤ +70°C; V_{DD} = 1.8V ±0.1V

| DESCRIPTION | SYMBOL | MIN | MAX | UNITS |
|-------------------------|-------------------|-----|-----|-------|
| Clock | | | | |
| Clock cycle time | t _{THTH} | 100 | | ns |
| Clock frequency | f _{TF} | | 10 | MHz |
| Clock HIGH time | t _{THTL} | 40 | | ns |
| Clock LOW time | t _{TLTH} | 40 | | ns |
| Output Times | | | | |
| TCK LOW to TDO unknown | t _{TLOX} | 0 | | ns |
| TCK LOW to TDO valid | t _{TLOV} | | 20 | ns |
| TDI valid to TCK HIGH | t _{DVTH} | 10 | | ns |
| TCK HIGH to TDI invalid | t _{THDX} | 10 | | ns |
| Setup Times | | | | |
| TMS setup | t _{MVTH} | 10 | | ns |
| Capture setup | t _{CS} | 10 | | ns |
| Hold Times | | | | |
| TMS hold | t _{THMX} | 10 | | ns |
| Capture hold | t _{CH} | 10 | | ns |

NOTE:

1. t_{CS} and t_{CH} refer to the setup and hold time requirements of latching data from the boundary scan register.
2. Test conditions are specified using the load in Figure 10.



TAP AC Test Conditions

Input pulse levels V_{SS} to 1.8V
 Input rise and fall times 1ns
 Input timing reference levels 0.9V
 Output reference levels..... 0.9V
 Test load termination supply voltage 0.9V

**Figure 10:
TAP AC Output Load Equivalent**

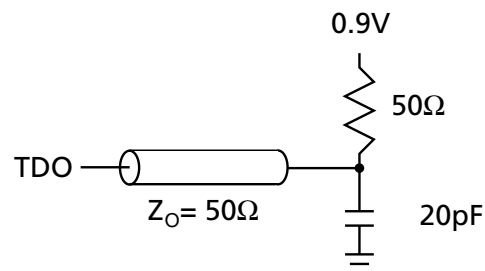


Table 17: TAP DC Electrical Characteristics and Operating Conditions

Note 3; 0°C ≤ T_A ≤ +70°C; V_{DD} = 1.8V ±0.1V unless otherwise noted

| DESCRIPTION | CONDITIONS | SYMBOL | MIN | MAX | UNITS | NOTES |
|------------------------------|---|------------------|------|-----------------------|-------|-------|
| Input High (Logic 1) Voltage | | V _{IH} | 1.3 | V _{DD} + 0.3 | V | 1, 2 |
| Input Low (Logic 0) Voltage | | V _{IL} | -0.3 | 0.5 | V | 1, 2 |
| Input Leakage Current | 0V ≤ V _{IN} ≤ V _{DD} | I _{LI} | -5.0 | 5.0 | μA | |
| Output Leakage Current | Output(s) disabled, 0V ≤ V _{IN} ≤ V _{DD} | I _{LO} | -5.0 | 5.0 | μA | |
| Output Low Voltage | I _{OLC} = 100μA | V _{OL1} | | 0.2 | V | 1 |
| Output Low Voltage | I _{OLT} = 2mA | V _{OL2} | | 0.4 | V | 1 |
| Output High Voltage | I _{OHc} = 100μA | V _{OH1} | 1.6 | | V | 1 |
| Output High Voltage | I _{OHt} = 2mA | V _{OH2} | 1.4 | | V | 1 |

NOTE:

- All voltages referenced to V_{SS} (GND).
- Overshoot: V_{IH(AC)} ≤ V_{DD} + 0.7V for t ≤ ^tKHKH/2
 Undershoot: V_{IL(AC)} ≥ -0.5V for t ≤ ^tKHKH/2
 Power-up: V_{IH} ≤ +1.9V and V_{DD} ≤ +1.7V for t ≤ 200ms
 During normal operation, V_{DDQ} must not exceed V_{DD}. Control input signals (LD#, R/W#, etc.) may not have pulse widths less than ^tKHKL (MIN) or operate at frequencies exceeding ^fKF (MAX).
- This table defines DC values for TAP control and data balls only. The DQ SRAM balls used in JTAG operation will have the DC values as defined in Table 10, "DC Electrical Characteristics and Operating Conditions," on page 13.


Table 18: Identification Register Definitions

| INSTRUCTION FIELD | ALL DEVICES | DESCRIPTION |
|---------------------------------------|-------------------|--|
| REVISION NUMBER (31:29) | 000 | Revision number. |
| DEVICE ID (28:12) | 00def0wx0t0q0b0s0 | def = 010 for 36Mb density wx = 11 for x36 width wx = 10 for x18 width wx = 00 for x9 width wx = 01 for x8 width t = 1 for DLL version t = 0 for non-DLL version q = 1 for QDR q = 0 for DDR b = 1 for 4-word burst b = 0 for 2-word burst s = 1 for separate I/O s = 0 for common I/O |
| MICRON JEDEC ID CODE (11:1) | 00000101100 | Allows unique identification of SRAM vendor. |
| ID Register Presence Indicator (0) | 1 | Indicates the presence of an ID register. |

Table 19: Scan Register Size

| REGISTER NAME | BIT SIZE |
|---------------|----------|
| Instruction | 3 |
| Bypass | 1 |
| ID | 32 |
| Boundary Scan | 109 |

Table 20: Instruction Codes

| INSTRUCTION | CODE | DESCRIPTION | NOTES |
|--------------------|------|--|-------|
| EXTEST | 000 | Captures I/O ring contents. Places the boundary scan register between TDI and TDO. | 1, 2 |
| IDCODE | 001 | Loads the ID register with the vendor ID code and places the register between TDI and TDO. This operation does not affect SRAM operations. | |
| SAMPLE Z | 010 | Captures I/O ring contents. Places the boundary scan register between TDI and TDO. Forces all SRAM output drivers to a High-Z state. | |
| RESERVED | 011 | Do Not Use: This instruction is reserved for future use. | |
| SAMPLE/ PRELOAD | 100 | Captures I/O ring contents. Places the boundary scan register between TDI and TDO. | |
| RESERVED | 101 | Do Not Use: This instruction is reserved for future use. | |
| RESERVED | 110 | Do Not Use: This instruction is reserved for future use. | |
| BYPASS | 111 | Places the bypass register between TDI and TDO. This operation does not affect SRAM operations. | |

NOTE:

1. Data in output register is not guaranteed if EXTEST instruction is loaded.
2. After performing EXTEST, power-up conditions are required in order to return part to normal operation.


Table 21: Boundary Scan (Exit) Order

| BIT# | FBGA BALL |
|------|-----------|
| 1 | 6R |
| 2 | 6P |
| 3 | 6N |
| 4 | 7P |
| 5 | 7N |
| 6 | 7R |
| 7 | 8R |
| 8 | 8P |
| 9 | 9R |
| 10 | 11P |
| 11 | 10P |
| 12 | 10N |
| 13 | 9P |
| 14 | 10M |
| 15 | 11N |
| 16 | 9M |
| 17 | 9N |
| 18 | 11L |
| 19 | 11M |
| 20 | 9L |
| 21 | 10L |
| 22 | 11K |
| 23 | 10K |
| 24 | 9J |
| 25 | 9K |
| 26 | 10J |
| 27 | 11J |
| 28 | 11H |
| 29 | 10G |
| 30 | 9G |
| 31 | 11F |
| 32 | 11G |
| 33 | 9F |
| 34 | 10F |
| 35 | 11E |
| 36 | 10E |

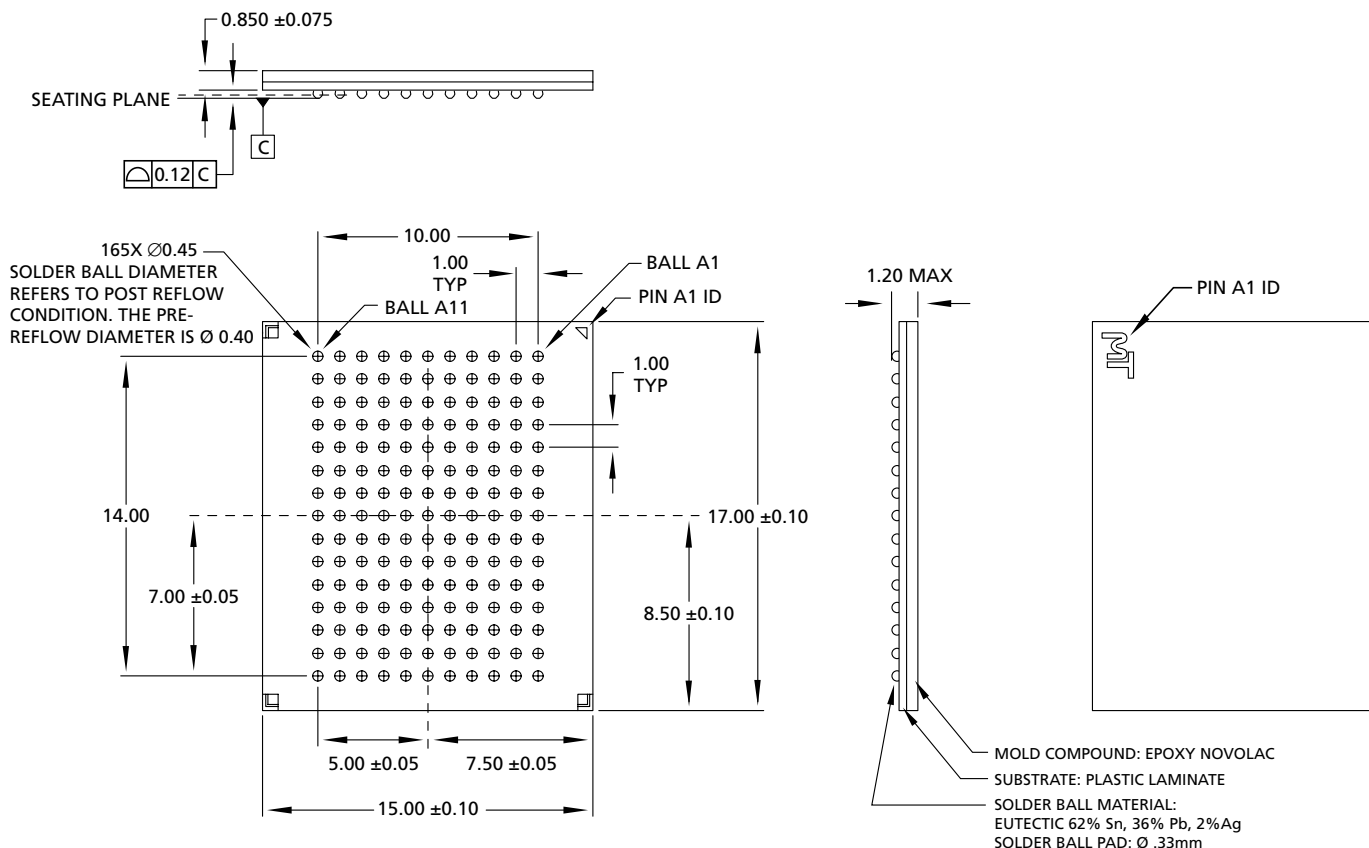
| BIT# | FBGA BALL |
|------|-----------|
| 37 | 10D |
| 38 | 9E |
| 39 | 10C |
| 40 | 11D |
| 41 | 9C |
| 42 | 9D |
| 43 | 11B |
| 44 | 11C |
| 45 | 9B |
| 46 | 10B |
| 47 | 11A |
| 48 | 10A |
| 49 | 9A |
| 50 | 8B |
| 51 | 7C |
| 52 | 6C |
| 53 | 8A |
| 54 | 7A |
| 55 | 7B |
| 56 | 6B |
| 57 | 6A |
| 58 | 5B |
| 59 | 5A |
| 60 | 4A |
| 61 | 5C |
| 62 | 4B |
| 63 | 3A |
| 64 | 2A |
| 65 | 1A |
| 66 | 2B |
| 67 | 3B |
| 68 | 1C |
| 69 | 1B |
| 70 | 3D |
| 71 | 3C |
| 72 | 1D |

| BIT# | FBGA BALL |
|------|-----------|
| 73 | 2C |
| 74 | 3E |
| 75 | 2D |
| 76 | 2E |
| 77 | 1E |
| 78 | 2F |
| 79 | 3F |
| 80 | 1G |
| 81 | 1F |
| 82 | 3G |
| 83 | 2G |
| 84 | 1H |
| 85 | 1J |
| 86 | 2J |
| 87 | 3K |
| 88 | 3J |
| 89 | 2K |
| 90 | 1K |
| 91 | 2L |
| 92 | 3L |
| 93 | 1M |
| 94 | 1L |
| 95 | 3N |
| 96 | 3M |
| 97 | 1N |
| 98 | 2M |
| 99 | 3P |
| 100 | 2N |
| 101 | 2P |
| 102 | 1P |
| 103 | 3R |
| 104 | 4R |
| 105 | 4P |
| 106 | 5P |
| 107 | 5N |
| 108 | 5R |
| 109 | INTERNAL |



4 MEG x 8, 4 MEG x 9, 2 MEG x 18, 1 MEG x 36
1.8V V_{DD}, HSTL, DDRIIb4 SRAM

**Figure 11:
165-Ball FBGA**



NOTE:

1. All dimensions are in millimeters.

DATA SHEET DESIGNATION

Advance: This data sheet contains initial descriptions of products still under development.



8000 S. Federal Way, P.O. Box 6, Boise, ID 83707-0006, Tel: 208-368-3900

E-mail: prodmgmt@micron.com, Internet: <http://www.micron.com>, Customer Comment Line: 800-932-4992

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Document Revision History

| | |
|--|------|
| Rev. G, Pub 2/03..... | 2/03 |
| <ul style="list-style-type: none"> • Added definitive notes to Figure 3 • Added definitive note to Table 9 • Updated AC Timing specifications with new codevelopment values • Added definitive note concerning bit# 64 to Table 19 • Removed Errata specifications • Updated AC timing values with new codevelopment values • Removed all references of device not being 1149.1 JTAG compliant • Added definitive note concerning SRAM (DQ) I/O balls used for JTAG DC values and timing • Changed process information in header to die revision indicator • Updated Thermal Resistance Values to Table 12: C_I = 4.5 TYP; 5.5 MAX C_O = 6 TYP; 7 MAX C_{CK} = 5.5 TYP; 6.5 MAX • Updated Thermal Resistance values to Table 12: J_A = 19.4 TYP J_C = 1.0 TYP J_B = 9.6 TYP • Added T_J ≤ +95°C to Table 13 • Modified Figure 2 regarding depth, configuration, and byte controls • Added definitive notes regarding I/O behavior during JTAG operation • Added definitive notes regarding IDD test conditions for read to write ratio • Removed note regarding AC derating information for full I/O range • Remove references to JTAG scan chain logic levels being at logic zero for NC pins in Tables 5 and 19 • Revised ball description for NC balls: These balls are internally connected to the die, but have no function and may be left not connected to the board to minimize ball count. | |
| Rev. A, Pub. 9/02 | 9/02 |
| <ul style="list-style-type: none"> • New ADVANCE data sheet | |