

# MOS INTEGRATED CIRCUIT

## $\mu$ PD44324084-A, 44324094-A, 44324184-A, 44324364-A

### 36M-BIT DDR II SRAM

### 4-WORD BURST OPERATION

#### Description

The  $\mu$ PD44324084-A is a 4,194,304-word by 8-bit, the  $\mu$ PD44324094-A is a 4,194,304-word by 9-bit, the  $\mu$ PD44324184-A is a 2,097,152-word by 18-bit and the  $\mu$ PD44324364-A is a 1,048,576-word by 36-bit synchronous double data rate static RAM fabricated with advanced CMOS technology using full CMOS six-transistor memory cell.

The  $\mu$ PD44324084-A,  $\mu$ PD44324094-A,  $\mu$ PD44324184-A and  $\mu$ PD44324364-A integrate unique synchronous peripheral circuitry and a burst counter. All input registers controlled by an input clock pair (K and K#) are latched on the positive edge of K and K#.

These products are suitable for application which require synchronous operation, high speed, low voltage, high density and wide bit configuration.

These products are packaged in 165-pin PLASTIC BGA.

#### Features

- $1.8 \pm 0.1$  V power supply
- 165-pin PLASTIC BGA (13 x 15)
- HSTL interface
- PLL circuitry for wide output data valid window and future frequency scaling
- Pipelined double data rate operation
- Common data input/output bus
- Four-tick burst for reduced address frequency
- 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
- Internally self-timed write control
- Clock-stop capability. Normal operation is restored in 1,024 cycles after clock is resumed.
- User programmable impedance output
- Fast clock cycle time : 3.7 ns (270 MHz), 4.0 ns (250 MHz), 5.0 ns (200 MHz)
- Simple control logic for easy depth expansion
- JTAG boundary scan
- Operating ambient temperature: Commercial  $T_A = 0$  to  $+70^\circ\text{C}$  (-E37, -E40, -E50)  
Industrial  $T_A = -40$  to  $+85^\circ\text{C}$  (-E40Y, -E50Y)

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**Ordering Information**

**(1) Operating Ambient Temperature T<sub>A</sub> = 0 to +70°C**

| Part number             | Cycle Time ns | Clock Frequency MHz | Organization (word x bit) | Package                       | Operating Ambient Temperature            |
|-------------------------|---------------|---------------------|---------------------------|-------------------------------|--|
| μPD44324084F5-E37-EQ2-A | 3.7           | 270                 | 4M x 8-bit                | 165-pin PLASTIC BGA (13 x 15) | Commercial (T <sub>A</sub> = 0 to +70°C) |
| μPD44324084F5-E40-EQ2-A | 4.0           | 250                 |                           |                               |  |
| μPD44324084F5-E50-EQ2-A | 5.0           | 200                 |                           |                               |  |
| μPD44324094F5-E37-EQ2-A | 3.7           | 270                 | 4M x 9-bit                | Lead-free                     |  |
| μPD44324094F5-E40-EQ2-A | 4.0           | 250                 |                           |                               |  |
| μPD44324094F5-E50-EQ2-A | 5.0           | 200                 |                           |                               |  |
| μPD44324184F5-E37-EQ2-A | 3.7           | 270                 | 2M x 18-bit               |                               |  |
| μPD44324184F5-E40-EQ2-A | 4.0           | 250                 |                           |                               |  |
| μPD44324184F5-E50-EQ2-A | 5.0           | 200                 |                           |                               |  |
| μPD44324364F5-E37-EQ2-A | 3.7           | 270                 | 1M x 36-bit               |                               |  |
| μPD44324364F5-E40-EQ2-A | 4.0           | 250                 |                           |                               |  |
| μPD44324364F5-E50-EQ2-A | 5.0           | 200                 |                           |                               |  |

**Remarks 1.** QDR Consortium standard package size is 13 x 15 and 15 x 17.

The footprint is commonly used.

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

(2) Operating Ambient Temperature T<sub>A</sub> = -40 to +85°C

| Part number              | Cycle Time ns | Clock Frequency MHz | Organization (word x bit) | Package                       | Operating Ambient Temperature              |
|--------------------------|---------------|---------------------|---------------------------|-------------------------------|--|
| μPD44324084F5-E40Y-EQ2-A | 4.0           | 250                 | 4M x 8-bit                | 165-pin PLASTIC BGA (13 x 15) | Industrial (T <sub>A</sub> = -40 to +85°C) |
| μPD44324084F5-E50Y-EQ2-A | 5.0           | 200                 |                           |                               |  |
| μPD44324094F5-E40Y-EQ2-A | 4.0           | 250                 | 4M x 9-bit                | Lead-free                     |  |
| μPD44324094F5-E50Y-EQ2-A | 5.0           | 200                 |                           |                               |  |
| μPD44324184F5-E40Y-EQ2-A | 4.0           | 250                 | 2M x 18-bit               |                               |  |
| μPD44324184F5-E50Y-EQ2-A | 5.0           | 200                 |                           |                               |  |

**Remarks 1.** QDR Consortium standard package size is 13 x 15 and 15 x 17.

The footprint is commonly used.

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

Pin Configurations

165-pin PLASTIC BGA (13 x 15)

(Top View)

[μPD44324084-A]

4M x 8-bit

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

|            |                             |                  |                              |
|------------|-----------------------------|------------------|------------------------------|
| A          | : Address inputs            | TMS              | : IEEE 1149.1 Test input     |
| DQ0 to DQ7 | : Data inputs / outputs     | TDI              | : IEEE 1149.1 Test input     |
| LD#        | : Synchronous load          | TCK              | : IEEE 1149.1 Clock input    |
| R, W#      | : Read Write input          | TDO              | : IEEE 1149.1 Test output    |
| NW0#, NW1# | : Nibble Write data select  | V <sub>REF</sub> | : HSTL input reference input |
| K, K#      | : Input clock               | V <sub>DD</sub>  | : Power Supply               |
| C, C#      | : Output clock              | V <sub>DDQ</sub> | : Power Supply               |
| CQ, CQ#    | : Echo clock                | V <sub>SS</sub>  | : Ground                     |
| ZQ         | : Output impedance matching | NC               | : No connection              |
| DLL#       | : DLL/PLL disable           |                  |                              |

- Remarks**
1. xxx# indicates active LOW signal.
  2. Refer to **Package Drawing** for the index mark.
  3. 2A and 7A are expansion addresses: 2A for 72Mb and 7A for 144Mb.  
2A of this product can also be used as NC.

165-pin PLASTIC BGA (13 x 15)

(Top View)

[μPD44324094-A]

4M x 9-bit

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

|            |                             |                  |                              |
|------------|-----------------------------|------------------|------------------------------|
| A          | : Address inputs            | TMS              | : IEEE 1149.1 Test input     |
| DQ0 to DQ8 | : Data inputs / outputs     | TDI              | : IEEE 1149.1 Test input     |
| LD#        | : Synchronous load          | TCK              | : IEEE 1149.1 Clock input    |
| R, W#      | : Read Write input          | TDO              | : IEEE 1149.1 Test output    |
| BW0#       | : Byte Write data select    | V <sub>REF</sub> | : HSTL input reference input |
| K, K#      | : Input clock               | V <sub>DD</sub>  | : Power Supply               |
| C, C#      | : Output clock              | V <sub>DDQ</sub> | : Power Supply               |
| CQ, CQ#    | : Echo clock                | V <sub>SS</sub>  | : Ground                     |
| ZQ         | : Output impedance matching | NC               | : No connection              |
| DLL#       | : DLL/PLL disable           |                  |                              |

- Remarks**
1. xxx# indicates active LOW signal.
  2. Refer to **Package Drawing** for the index mark.
  3. 2A and 7A are expansion addresses: 2A for 72Mb and 7A for 144Mb.  
2A of this product can also be used as NC.

165-pin PLASTIC BGA (13 x 15)

(Top View)

[μPD44324184-A]

2M x 18-bit

|   | 1    | 2                | 3                | 4                | 5               | 6               | 7               | 8                | 9                | 10               | 11  |
|---|------|------------------|------------------|------------------|-----------------|-----------------|-----------------|------------------|------------------|------------------|-----|
| A | CQ#  | V <sub>SS</sub>  | A                | R, W#            | BW1#            | K#              | NC              | LD#              | A                | A                | CQ  |
| B | NC   | DQ9              | NC               | A                | NC              | K               | BW0#            | A                | NC               | NC               | DQ8 |
| C | NC   | NC               | NC               | V <sub>SS</sub>  | A               | A0              | A1              | V <sub>SS</sub>  | NC               | DQ7              | NC  |
| D | NC   | NC               | DQ10             | V <sub>SS</sub>  | V <sub>SS</sub> | V <sub>SS</sub> | V <sub>SS</sub> | V <sub>SS</sub>  | NC               | NC               | NC  |
| E | NC   | NC               | DQ11             | V <sub>DDQ</sub> | V <sub>SS</sub> | V <sub>SS</sub> | V <sub>SS</sub> | V <sub>DDQ</sub> | NC               | NC               | DQ6 |
| F | NC   | DQ12             | NC               | V <sub>DDQ</sub> | V <sub>DD</sub> | V <sub>SS</sub> | V <sub>DD</sub> | V <sub>DDQ</sub> | NC               | NC               | DQ5 |
| G | NC   | NC               | DQ13             | V <sub>DDQ</sub> | V <sub>DD</sub> | V <sub>SS</sub> | V <sub>DD</sub> | V <sub>DDQ</sub> | NC               | NC               | NC  |
| H | DLL# | V <sub>REF</sub> | V <sub>DDQ</sub> | V <sub>DDQ</sub> | V <sub>DD</sub> | V <sub>SS</sub> | V <sub>DD</sub> | V <sub>DDQ</sub> | V <sub>DDQ</sub> | V <sub>REF</sub> | ZQ  |
| J | NC   | NC               | NC               | V <sub>DDQ</sub> | V <sub>DD</sub> | V <sub>SS</sub> | V <sub>DD</sub> | V <sub>DDQ</sub> | NC               | DQ4              | NC  |
| K | NC   | NC               | DQ14             | V <sub>DDQ</sub> | V <sub>DD</sub> | V <sub>SS</sub> | V <sub>DD</sub> | V <sub>DDQ</sub> | NC               | NC               | DQ3 |
| L | NC   | DQ15             | NC               | V <sub>DDQ</sub> | V <sub>SS</sub> | V <sub>SS</sub> | V <sub>SS</sub> | V <sub>DDQ</sub> | NC               | NC               | DQ2 |
| M | NC   | NC               | NC               | V <sub>SS</sub>  | V <sub>SS</sub> | V <sub>SS</sub> | V <sub>SS</sub> | V <sub>SS</sub>  | NC               | DQ1              | NC  |
| N | NC   | NC               | DQ16             | V <sub>SS</sub>  | A               | A               | A               | V <sub>SS</sub>  | NC               | NC               | NC  |
| P | NC   | NC               | DQ17             | A                | A               | C               | A               | A                | NC               | NC               | DQ0 |
| R | TDO  | TCK              | A                | A                | A               | C#              | A               | A                | A                | TMS              | TDI |

|             |                             |                  |                              |
|-------------|-----------------------------|------------------|------------------------------|
| A0, A1, A   | : Address inputs            | TMS              | : IEEE 1149.1 Test input     |
| DQ0 to DQ17 | : Data inputs / outputs     | TDI              | : IEEE 1149.1 Test input     |
| LD#         | : Synchronous load          | TCK              | : IEEE 1149.1 Clock input    |
| R, W#       | : Read Write input          | TDO              | : IEEE 1149.1 Test output    |
| BW0#, BW1#  | : Byte Write data select    | V <sub>REF</sub> | : HSTL input reference input |
| K, K#       | : Input clock               | V <sub>DD</sub>  | : Power Supply               |
| C, C#       | : Output clock              | V <sub>DDQ</sub> | : Power Supply               |
| CQ, CQ#     | : Echo clock                | V <sub>SS</sub>  | : Ground                     |
| ZQ          | : Output impedance matching | NC               | : No connection              |
| DLL#        | : DLL/PLL disable           |                  |                              |

- Remarks**
1. xxx# indicates active LOW signal.
  2. Refer to **Package Drawing** for the index mark.
  3. 2A and 7A are expansion addresses: 2A for 72Mb and 7A for 144Mb.  
2A of this product can also be used as NC.

165-pin PLASTIC BGA (13 x 15)

(Top View)

[μPD44324364-A]

1M x 36-bit

|   | 1    | 2                | 3                | 4                | 5               | 6               | 7               | 8                | 9                | 10               | 11   |
|---|------|------------------|------------------|------------------|-----------------|-----------------|-----------------|------------------|------------------|------------------|------|
| A | CQ#  | V <sub>SS</sub>  | A                | R, W#            | BW2#            | K#              | BW1#            | LD#              | A                | V <sub>SS</sub>  | CQ   |
| B | NC   | DQ27             | DQ18             | A                | BW3#            | K               | BW0#            | A                | NC               | NC               | DQ8  |
| C | NC   | NC               | DQ28             | V <sub>SS</sub>  | A               | A0              | A1              | V <sub>SS</sub>  | NC               | DQ17             | DQ7  |
| D | NC   | DQ29             | DQ19             | V <sub>SS</sub>  | V <sub>SS</sub> | V <sub>SS</sub> | V <sub>SS</sub> | V <sub>SS</sub>  | NC               | NC               | DQ16 |
| E | NC   | NC               | DQ20             | V <sub>DDQ</sub> | V <sub>SS</sub> | V <sub>SS</sub> | V <sub>SS</sub> | V <sub>DDQ</sub> | NC               | DQ15             | DQ6  |
| F | NC   | DQ30             | DQ21             | V <sub>DDQ</sub> | V <sub>DD</sub> | V <sub>SS</sub> | V <sub>DD</sub> | V <sub>DDQ</sub> | NC               | NC               | DQ5  |
| G | NC   | DQ31             | DQ22             | V <sub>DDQ</sub> | V <sub>DD</sub> | V <sub>SS</sub> | V <sub>DD</sub> | V <sub>DDQ</sub> | NC               | NC               | DQ14 |
| H | DLL# | V <sub>REF</sub> | V <sub>DDQ</sub> | V <sub>DDQ</sub> | V <sub>DD</sub> | V <sub>SS</sub> | V <sub>DD</sub> | V <sub>DDQ</sub> | V <sub>DDQ</sub> | V <sub>REF</sub> | ZQ   |
| J | NC   | NC               | DQ32             | V <sub>DDQ</sub> | V <sub>DD</sub> | V <sub>SS</sub> | V <sub>DD</sub> | V <sub>DDQ</sub> | NC               | DQ13             | DQ4  |
| K | NC   | NC               | DQ23             | V <sub>DDQ</sub> | V <sub>DD</sub> | V <sub>SS</sub> | V <sub>DD</sub> | V <sub>DDQ</sub> | NC               | DQ12             | DQ3  |
| L | NC   | DQ33             | DQ24             | V <sub>DDQ</sub> | V <sub>SS</sub> | V <sub>SS</sub> | V <sub>SS</sub> | V <sub>DDQ</sub> | NC               | NC               | DQ2  |
| M | NC   | NC               | DQ34             | V <sub>SS</sub>  | V <sub>SS</sub> | V <sub>SS</sub> | V <sub>SS</sub> | V <sub>SS</sub>  | NC               | DQ11             | DQ1  |
| N | NC   | DQ35             | DQ25             | V <sub>SS</sub>  | A               | A               | A               | V <sub>SS</sub>  | NC               | NC               | DQ10 |
| P | NC   | NC               | DQ26             | A                | A               | C               | A               | A                | NC               | DQ9              | DQ0  |
| R | TDO  | TCK              | A                | A                | A               | C#              | A               | A                | A                | TMS              | TDI  |

|              |                             |                  |                              |
|--------------|-----------------------------|------------------|------------------------------|
| A0, A1, A    | : Address inputs            | TMS              | : IEEE 1149.1 Test input     |
| DQ0 to DQ35  | : Data inputs / outputs     | TDI              | : IEEE 1149.1 Test input     |
| LD#          | : Synchronous load          | TCK              | : IEEE 1149.1 Clock input    |
| R, W#        | : Read Write input          | TDO              | : IEEE 1149.1 Test output    |
| BW0# to BW3# | : Byte Write data select    | V <sub>REF</sub> | : HSTL input reference input |
| K, K#        | : Input clock               | V <sub>DD</sub>  | : Power Supply               |
| C, C#        | : Output clock              | V <sub>DDQ</sub> | : Power Supply               |
| CQ, CQ#      | : Echo clock                | V <sub>SS</sub>  | : Ground                     |
| ZQ           | : Output impedance matching | NC               | : No connection              |
| DLL#         | : DLL/PLL disable           |                  |                              |

- Remarks**
1. xxx# indicates active LOW signal.
  2. Refer to **Package Drawing** for the index mark.
  3. 2A and 10A are expansion addresses: 10A for 72Mb and 2A for 144Mb.  
2A and 10A of this product can also be used as NC.

Pin Identification

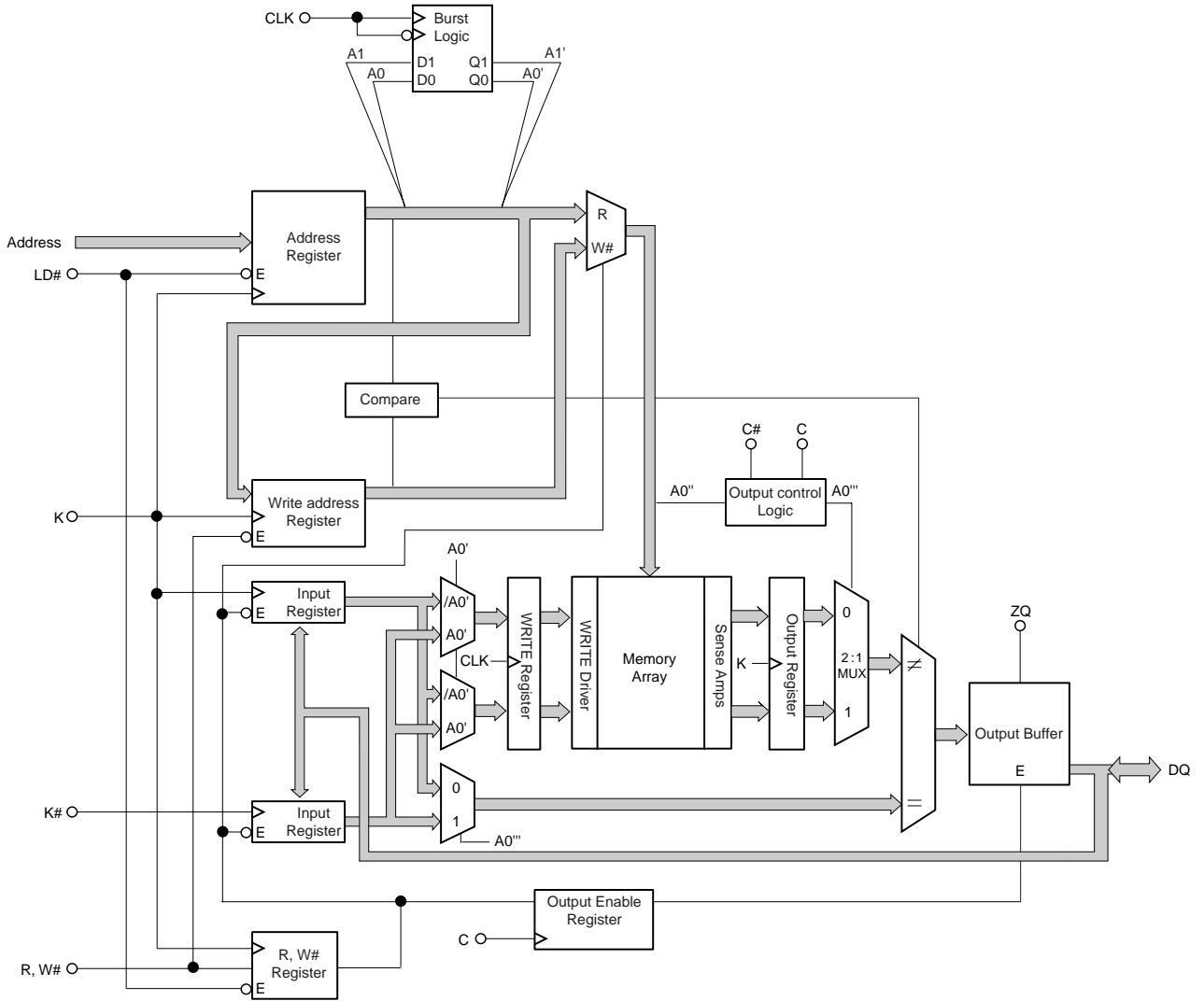
(1/2)

| Symbol        | Description  |
|---------------|--|
| A0<br>A1<br>A | Synchronous Address Inputs: These inputs are registered and must meet the setup and hold times around the rising edge of K. All transactions operate on a burst of four words (two clock periods of bus activity). A0 and A1 are used as the lowest two address bits for BURST READ and BURST WRITE operations permitting a random burst start address on x18 and x36 devices. These inputs are ignored when device is deselected, i.e., NOP (LD# = HIGH), or once BURST operation is in progress.   |
| DQ0 to DQxx   | Synchronous Data IOs: 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 to HIGH.<br>x8 device uses DQ0 to DQ7.<br>x9 device uses DQ0 to DQ8.<br>x18 device uses DQ0 to DQ17.<br>x36 device uses DQ0 to DQ35.   |
| LD#           | 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 4 data (two clock periods of bus activity).  |
| R, W#         | 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. If a synchronous load command (LD# = LOW) is input, inputs of R, W# and LD# on the subsequent rising edge of K are ignored.  |
| BWx#<br>NWx#  | Synchronous Byte Writes (Nibble Writes on x8): When LOW these inputs cause their respective byte or nibble 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 two rising edges comprising the WRITE cycle. See <b>Pin Configurations</b> for signal to data relationships.<br>x8 device uses NW0#, NW1#.<br>x9 device uses BW0#.<br>x18 device uses BW0#, BW1#.<br>x36 device uses BW0# to BW3#.<br>See <b>Byte Write Operation</b> for relation between BWx#, NWx# and Dxx. |
| K, K#         | 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.   |
| C, C#         | 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. When use of K and K# as the reference instead of C and C#, then fixed C and C# to HIGH. Operation cannot be guaranteed unless C and C# are fixed to HIGH (i.e. toggle of C and C#).   |

(2/2)

| Symbol           | Description   |
|------------------|---|
| CQ, CQ#          | Synchronous Echo Clock Outputs. The rising edges of these outputs are tightly matched to the synchronous data outputs and can be used as a data valid indication. These signals run freely and do not stop when DQ tristates. If C and C# are stopped (if K and K# are stopped in the single clock mode), CQ and CQ# will also stop.  |
| ZQ               | Output Impedance Matching Input: This input is used to tune the device outputs to the system data bus impedance. DQ, CQ and CQ# output impedance are set to $0.2 \times RQ$ , where RQ is a resistor from this bump to ground. The output impedance can be minimized by directly connect ZQ to V <sub>DDQ</sub> . This pin cannot be connected directly to GND or left unconnected. The output impedance is adjusted every 1,024 cycles upon power-up to account for drifts in supply voltage and temperature. After replacement for a resistor, the new output impedance is reset by implementing power-on sequence. |
| DLL#             | DLL/PLL Disable: When debugging the system or board, the operation can be performed at a clock frequency slower than TKHKH (MAX.) without the DLL/PLL circuit being used, if DLL# = LOW. The AC/DC characteristics cannot be guaranteed. For normal operation, DLL# must be HIGH and it can be connected to V <sub>DDQ</sub> through a 10 kΩ or less resistor.  |
| TMS<br>TDI       | IEEE 1149.1 Test Inputs: 1.8 V I/O level. These balls may be left Not Connected if the JTAG function is not used in the circuit.  |
| TCK              | IEEE 1149.1 Clock Input: 1.8 V I/O level. This pin must be tied to V <sub>SS</sub> if the JTAG function is not used in the circuit.   |
| TDO              | IEEE 1149.1 Test Output: 1.8 V I/O level.   |
| V <sub>REF</sub> | HSTL Input Reference Voltage: Nominally V <sub>DDQ</sub> /2. Provides a reference voltage for the input buffers.  |
| V <sub>DD</sub>  | Power Supply: 1.8 V nominal. See <b>Recommended DC Operating Conditions</b> and <b>DC Characteristics</b> for range.  |
| V <sub>DDQ</sub> | Power Supply: Isolated Output Buffer Supply. Nominally 1.5 V. 1.8 V is also permissible. See <b>Recommended DC Operating Conditions</b> and <b>DC Characteristics</b> for range.  |
| V <sub>SS</sub>  | Power Supply: Ground  |
| NC               | No Connect: These signals are not connected internally.   |

Block Diagram

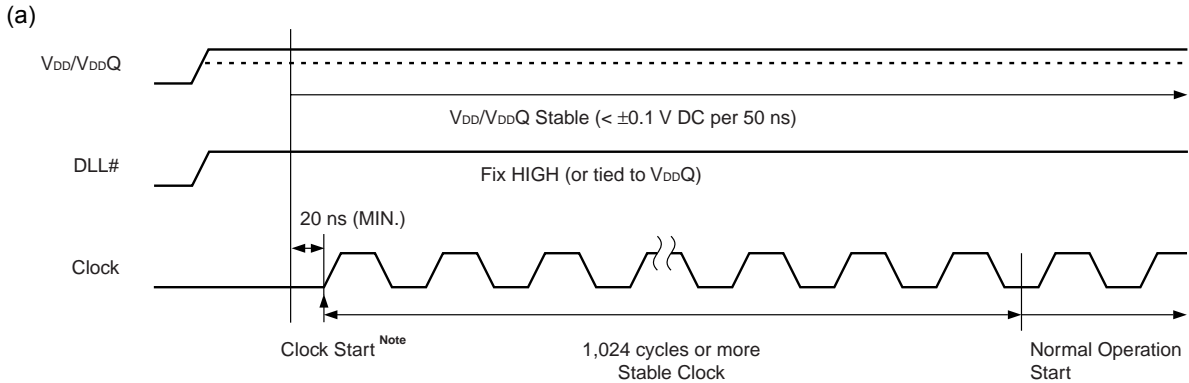


**Power-on Sequence**

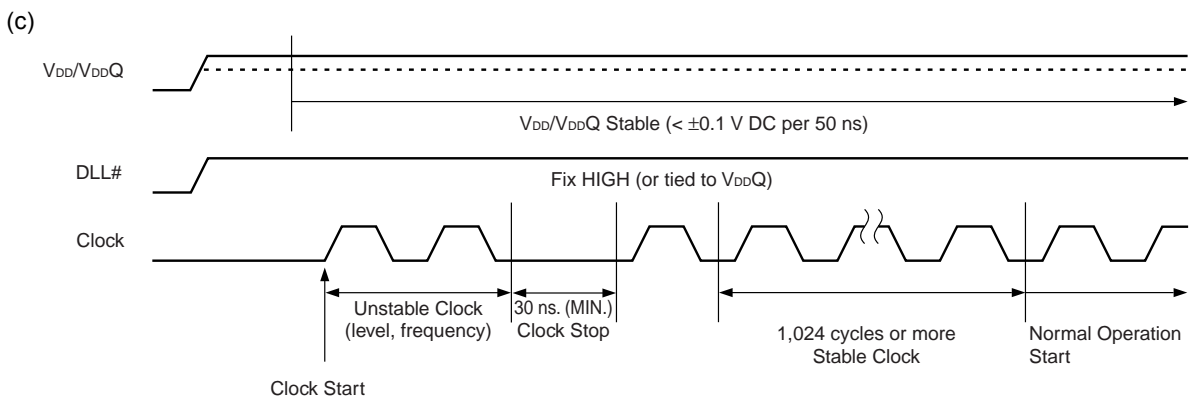
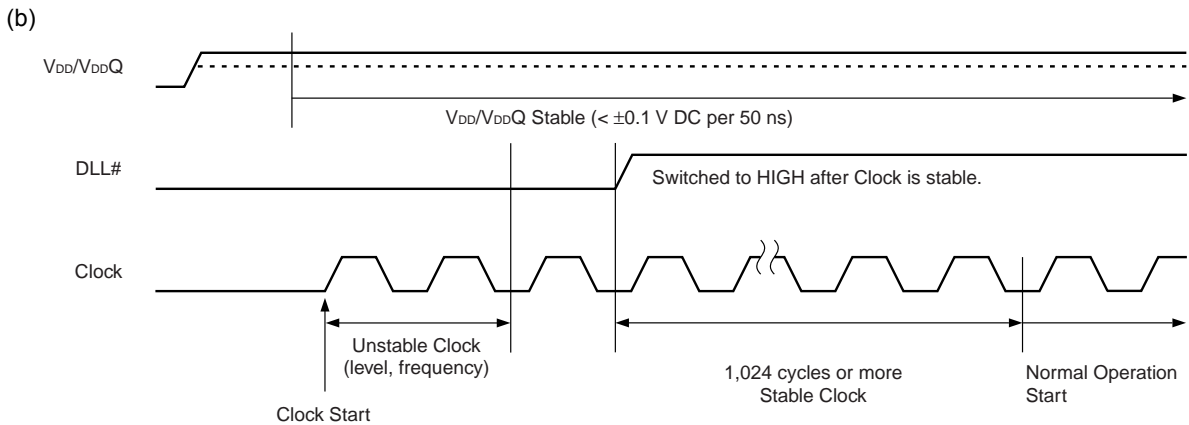
The following timing charts show the recommended power-on sequence, i.e., when starting the clock after  $V_{DD}/V_{DDQ}$  stable and when starting the clock before  $V_{DD}/V_{DDQ}$  stable.

**1. Clock starts after  $V_{DD}/V_{DDQ}$  stable**

The clock is supplied from a controller.

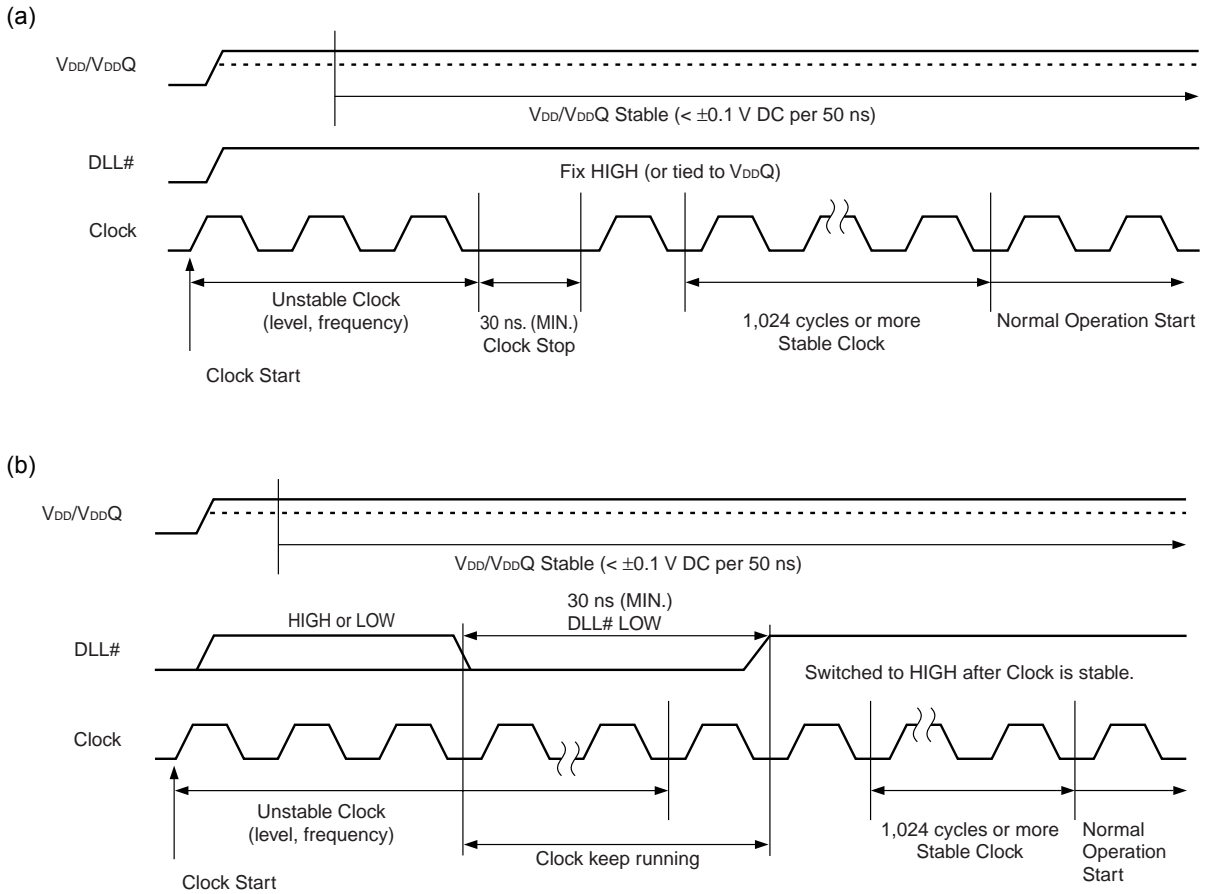


**Note** Input a stable clock from the start.



**2. Clock starts before V<sub>DD</sub>/V<sub>DDQ</sub> stable**

The clock is supplied from a clock generator.



**Burst Sequence**

**Linear Burst Sequence Table**

[μPD44324184-A, μPD44324364-A]

|                            | A1, A0 | A1, A0 | A1, A0 | A1, A0 |
|----------------------------|--------|--------|--------|--------|
| External Address           | 0, 0   | 0, 1   | 1, 0   | 1, 1   |
| 1st Internal Burst Address | 0, 1   | 1, 0   | 1, 1   | 0, 0   |
| 2nd Internal Burst Address | 1, 0   | 1, 1   | 0, 0   | 0, 1   |
| 3rd Internal Burst Address | 1, 1   | 0, 0   | 0, 1   | 1, 0   |

**Truth Table**

| Operation   | LD# | R, W# | CLK     | DQ             |           |           |           |           |
|---|-----|-------|---------|----------------|-----------|-----------|-----------|-----------|
| WRITE cycle<br>Load address, input write data on two consecutive K and K# rising edge | L   | L     | L → H   | Data in        |           |           |           |           |
|   |     |       |         | Input data     | D(A1)     | D(A2)     | D(A3)     | D(A4)     |
|   |     |       |         | Input clock    | K(t+1) ↑  | K#(t+1) ↑ | K(t+2) ↑  | K#(t+2) ↑ |
| READ cycle<br>Load address, read data on two consecutive C and C# rising edge         | L   | H     | L → H   | Data out       |           |           |           |           |
|   |     |       |         | Output data    | Q(A1)     | Q(A2)     | Q(A3)     | Q(A4)     |
|   |     |       |         | Output clock   | C#(t+1) ↑ | C(t+2) ↑  | C#(t+2) ↑ | C(t+3) ↑  |
| NOP (No operation)  | H   | X     | L → H   | High-Z         |           |           |           |           |
| Clock stop  | X   | X     | Stopped | Previous state |           |           |           |           |

**Remarks 1.** H : HIGH, L : LOW, × : don't care, ↑ : rising 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. All control inputs in the truth table must meet setup/hold times around the rising edge (LOW to HIGH) of K. All control inputs are registered during the rising edge of K.
4. This device contains circuitry that ensure the outputs to be in high impedance during power-up.
5. Refer to state diagram and timing diagrams for clarification.
6. A1 refers to the address input during a WRITE or READ cycle. A2, A3 and A4 refer to the next internal burst address in accordance with the linear burst sequence.
7. 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.

Byte Write Operation

[μPD44324084-A]

| Operation        | K     | K#    | NW0# | NW1# |
|------------------|-------|-------|------|------|
| Write DQ0 to DQ7 | L → H | –     | 0    | 0    |
|                  | –     | L → H | 0    | 0    |
| Write DQ0 to DQ3 | L → H | –     | 0    | 1    |
|                  | –     | L → H | 0    | 1    |
| Write DQ4 to DQ7 | L → H | –     | 1    | 0    |
|                  | –     | L → H | 1    | 0    |
| Write nothing    | L → H | –     | 1    | 1    |
|                  | –     | L → H | 1    | 1    |

- Remarks**
1. H : HIGH, L : LOW, → : rising edge.
  2. Assumes a WRITE cycle was initiated. NW0# and NW1# can be altered for any portion of the BURST WRITE operation provided that the setup and hold requirements are satisfied.

[μPD44324094-A]

| Operation        | K     | K#    | BW0# |
|------------------|-------|-------|------|
| Write DQ0 to DQ8 | L → H | –     | 0    |
|                  | –     | L → H | 0    |
| Write nothing    | L → H | –     | 1    |
|                  | –     | L → H | 1    |

- Remarks**
1. H : HIGH, L : LOW, → : rising edge.
  2. Assumes a WRITE cycle was initiated. BW0# can be altered for any portion of the BURST WRITE operation provided that the setup and hold requirements are satisfied.

[μPD44324184-A]

| Operation         | K     | K#    | BW0# | BW1# |
|-------------------|-------|-------|------|------|
| Write DQ0 to DQ17 | L → H | –     | 0    | 0    |
|                   | –     | L → H | 0    | 0    |
| Write DQ0 to DQ8  | L → H | –     | 0    | 1    |
|                   | –     | L → H | 0    | 1    |
| Write DQ9 to DQ17 | L → H | –     | 1    | 0    |
|                   | –     | L → H | 1    | 0    |
| Write nothing     | L → H | –     | 1    | 1    |
|                   | –     | L → H | 1    | 1    |

- Remarks**
1. H : HIGH, L : LOW, → : rising edge.
  2. 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.

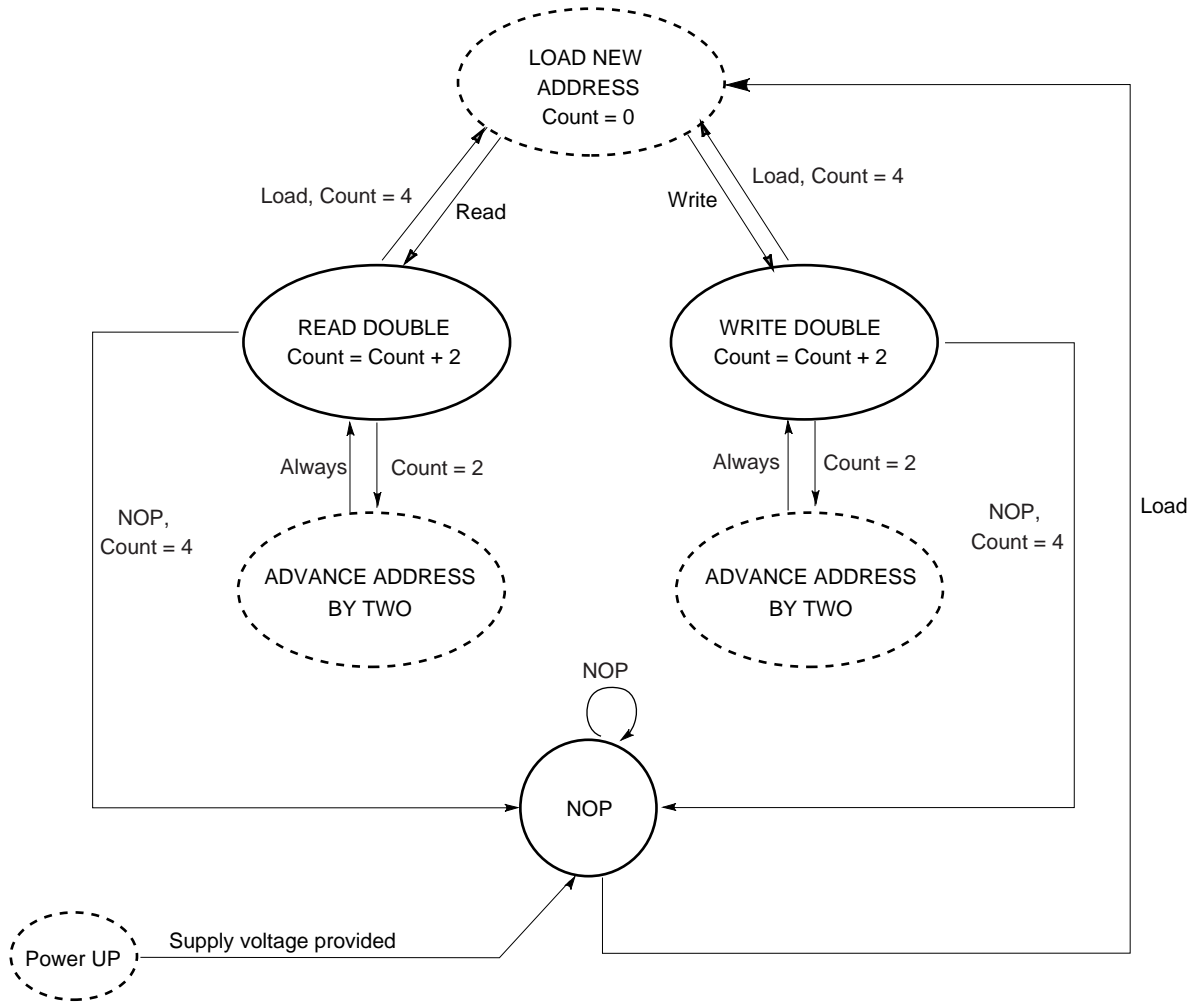
[μPD44324364-A]

| Operation          | K     | K#    | BW0# | BW1# | BW2# | BW3# |
|--------------------|-------|-------|------|------|------|------|
| Write DQ0 to DQ35  | L → H | -     | 0    | 0    | 0    | 0    |
|                    | -     | L → H | 0    | 0    | 0    | 0    |
| Write DQ0 to DQ8   | L → H | -     | 0    | 1    | 1    | 1    |
|                    | -     | L → H | 0    | 1    | 1    | 1    |
| Write DQ9 to DQ17  | L → H | -     | 1    | 0    | 1    | 1    |
|                    | -     | L → H | 1    | 0    | 1    | 1    |
| Write DQ18 to DQ26 | L → H | -     | 1    | 1    | 0    | 1    |
|                    | -     | L → H | 1    | 1    | 0    | 1    |
| Write DQ27 to DQ35 | L → H | -     | 1    | 1    | 1    | 0    |
|                    | -     | L → H | 1    | 1    | 1    | 0    |
| Write nothing      | L → H | -     | 1    | 1    | 1    | 1    |
|                    | -     | L → H | 1    | 1    | 1    | 1    |

**Remarks** 1. H : HIGH, L : LOW, → : rising edge.

- Assumes a WRITE cycle was initiated. BW0# to BW3# can be altered for any portion of the BURST WRITE operation provided that the setup and hold requirements are satisfied.

Bus Cycle State Diagram



- Remarks**
1. A0 and A1 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.

Electrical Specifications

Absolute Maximum Ratings

| Parameter                     | Symbol           | Conditions | MIN. | TYP. | MAX.                                | Unit |
|-------------------------------|------------------|------------|------|------|-------------------------------------|------|
| Supply voltage                | V <sub>DD</sub>  |            | -0.5 |      | +2.5                                | V    |
| Output supply voltage         | V <sub>DDQ</sub> |            | -0.5 |      | V <sub>DD</sub>                     | V    |
| Input voltage                 | V <sub>IN</sub>  |            | -0.5 |      | V <sub>DD</sub> + 0.5 (2.5 V MAX.)  | V    |
| Input / Output voltage        | V <sub>I/O</sub> |            | -0.5 |      | V <sub>DDQ</sub> + 0.5 (2.5 V MAX.) | V    |
| Operating ambient temperature | T <sub>A</sub>   | Commercial | 0    |      | +70                                 | °C   |
|                               |                  | Industrial | -40  |      | +85                                 |      |
| Storage temperature           | T <sub>stg</sub> |            | -55  |      | +125                                | °C   |

**Caution** Exposing the device to stress above those listed in Absolute Maximum Ratings could cause permanent damage. The device is not meant to be operated under conditions outside the limits described in the operational section of this specification. Exposure to Absolute Maximum Rating conditions for extended periods may affect device reliability.

Recommended DC Operating Conditions

| Parameter             | Symbol               | Conditions | MIN.                   | TYP. | MAX.                   | Unit | Note |
|-----------------------|----------------------|------------|------------------------|------|------------------------|------|------|
| Supply voltage        | V <sub>DD</sub>      |            | 1.7                    |      | 1.9                    | V    |      |
| Output supply voltage | V <sub>DDQ</sub>     |            | 1.4                    |      | V <sub>DD</sub>        | V    | 1    |
| Input HIGH voltage    | V <sub>IH</sub> (DC) |            | V <sub>REF</sub> + 0.1 |      | V <sub>DDQ</sub> + 0.3 | V    | 1, 2 |
| Input LOW voltage     | V <sub>IL</sub> (DC) |            | -0.3                   |      | V <sub>REF</sub> - 0.1 | V    | 1, 2 |
| Clock input voltage   | V <sub>IN</sub>      |            | -0.3                   |      | V <sub>DDQ</sub> + 0.3 | V    | 1, 2 |
| Reference voltage     | V <sub>REF</sub>     |            | 0.68                   |      | 0.95                   | V    |      |

- Notes**
1. During normal operation, V<sub>DDQ</sub> must not exceed V<sub>DD</sub>.
  2. Power-up: V<sub>IH</sub> ≤ V<sub>DDQ</sub> + 0.3 V and V<sub>DD</sub> ≤ 1.7 V and V<sub>DDQ</sub> ≤ 1.4 V for t ≤ 200 ms

Recommended AC Operating Conditions

| Parameter          | Symbol               | Conditions | MIN.                   | TYP. | MAX.                   | Unit | Note |
|--------------------|----------------------|------------|------------------------|------|------------------------|------|------|
| Input HIGH voltage | V <sub>IH</sub> (AC) |            | V <sub>REF</sub> + 0.2 |      | -                      | V    | 1    |
| Input LOW voltage  | V <sub>IL</sub> (AC) |            | -                      |      | V <sub>REF</sub> - 0.2 | V    | 1    |

- Note**
1. Overshoot: V<sub>IH</sub> (AC) ≤ V<sub>DD</sub> + 0.7 V (2.5 V MAX.) for t ≤ TKHKH/2  
 Undershoot: V<sub>IL</sub> (AC) ≥ -0.5 V for t ≤ TKHKH/2  
 Control input signals may not have pulse widths less than TKHKL (MIN.) or operate at cycle rates less than TKHKH (MIN.).

**DC Characteristics (V<sub>DD</sub> = 1.8 ± 0.1 V)**

| Parameter  | Symbol               | Test condition             | MIN.  | TYP.  | MAX.                     |     |       | Unit  | Note |  |
|--|----------------------|----------------------------|---|-------|--------------------------|-----|-------|-------|------|--|
|  |                      |                            |   |       | x8, x9                   | x18 | x36   |       |      |  |
| Input leakage current                                  | I <sub>LI</sub>      |                            | -2  | -     | +2                       |     |       | μA    |      |  |
| I/O leakage current                                    | I <sub>LO</sub>      |                            | -2  | -     | +2                       |     |       | μA    |      |  |
| Operating supply current<br>(Read cycle / Write cycle) | I <sub>DD</sub>      | Note1                      | Commercial<br>(T <sub>A</sub> = 0 to +70°C)   | -E37  |                          | 690 | 970   | 1,090 | mA   |  |
|  |                      |                            |   | -E40  |                          | 650 | 900   | 1,000 |      |  |
|  |                      |                            |   | -E50  |                          | 550 | 750   | 850   |      |  |
|  |                      |                            | Industrial<br>(T <sub>A</sub> = -40 to +85°C) | -E40Y |                          | 750 | 1,030 | -     |      |  |
|  |                      |                            |   | -E50Y |                          | 630 | 860   | -     |      |  |
| Standby supply current<br>(NOP)                        | I <sub>SB1</sub>     | Note1                      | Commercial<br>(T <sub>A</sub> = 0 to +70°C)   | -E37  |                          | 520 | 520   | 520   | mA   |  |
|  |                      |                            |   | -E40  |                          | 500 | 500   | 500   |      |  |
|  |                      |                            |   | -E50  |                          | 400 | 400   | 400   |      |  |
|  |                      |                            | Industrial<br>(T <sub>A</sub> = -40 to +85°C) | -E40Y |                          | 550 | 550   | -     |      |  |
|  |                      |                            |   | -E50Y |                          | 450 | 450   | -     |      |  |
| Output HIGH voltage                                    | V <sub>OH(Low)</sub> | I <sub>OH</sub>   ≤ 0.1 mA | V <sub>DDQ</sub> - 0.2                        | -     | V <sub>DDQ</sub>         |     |       | V     | 4, 5 |  |
|  | V <sub>OH</sub>      | Note2                      | V <sub>DDQ</sub> /2-0.12                      | -     | V <sub>DDQ</sub> /2+0.12 |     |       | V     | 4, 5 |  |
| Output LOW voltage                                     | V <sub>OL(Low)</sub> | I <sub>OL</sub> ≤ 0.1 mA   | V <sub>SS</sub>                               | -     | 0.2                      |     |       | V     | 4, 5 |  |
|  | V <sub>OL</sub>      | Note3                      | V <sub>DDQ</sub> /2-0.12                      | -     | V <sub>DDQ</sub> /2+0.12 |     |       | V     | 4, 5 |  |

- Notes**
1. V<sub>IN</sub> ≤ V<sub>IL</sub> or V<sub>IN</sub> ≥ V<sub>IH</sub>, I<sub>I/O</sub> = 0 mA, Cycle = MAX.
  2. Outputs are impedance-controlled. |I<sub>OH</sub>| = (V<sub>DDQ</sub>/2)/(R<sub>Q</sub>/5) ±15% for values of 175 Ω ≤ R<sub>Q</sub> ≤ 350 Ω.
  3. Outputs are impedance-controlled. I<sub>OL</sub> = (V<sub>DDQ</sub>/2)/(R<sub>Q</sub>/5) ±15% for values of 175 Ω ≤ R<sub>Q</sub> ≤ 350 Ω.
  4. AC load current is higher than the shown DC values.
  5. HSTL outputs meet JEDEC HSTL Class I standards.

**Capacitance (T<sub>A</sub> = 25°C, f = 1 MHz)**

| Parameter                                   | Symbol           | Test conditions        | MIN. | TYP. | MAX. | Unit |
|---|------------------|------------------------|------|------|------|------|
| Input capacitance (Address, Control)        | C <sub>IN</sub>  | V <sub>IN</sub> = 0 V  |      | 4    | 5    | pF   |
| Input / Output capacitance<br>(DQ, CQ, CQ#) | C <sub>I/O</sub> | V <sub>I/O</sub> = 0 V |      | 6    | 7    | pF   |
| Clock Input capacitance                     | C <sub>clk</sub> | V <sub>clk</sub> = 0 V |      | 5    | 6    | pF   |

**Remark** These parameters are periodically sampled and not 100% tested.

**Thermal Resistance**

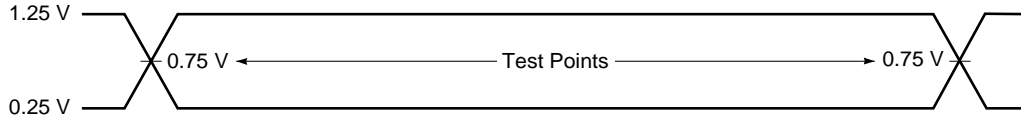
| Parameter                                  | Symbol           | Test conditions | MIN. | TYP. | MAX. | Unit |
|--|------------------|-----------------|------|------|------|------|
| Thermal resistance<br>(junction – ambient) | θ <sub>j-a</sub> |                 |      | 22.6 |      | °C/W |
| Thermal resistance<br>(junction – case)    | θ <sub>j-c</sub> |                 |      | 2.0  |      | °C/W |

**Remark** These parameters are simulated under the condition of air flow velocity = 1 m/s.

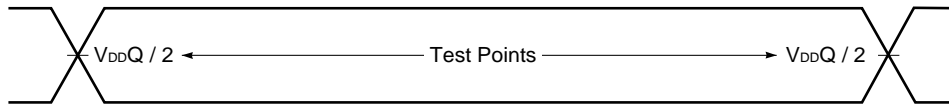
AC Characteristics ( $V_{DD} = 1.8 \pm 0.1 \text{ V}$ )

AC Test Conditions ( $V_{DD} = 1.8 \pm 0.1 \text{ V}$ ,  $V_{DDQ} = 1.4 \text{ V to } V_{DD}$ )

Input waveform (Rise / Fall time  $\leq 0.3 \text{ ns}$ )

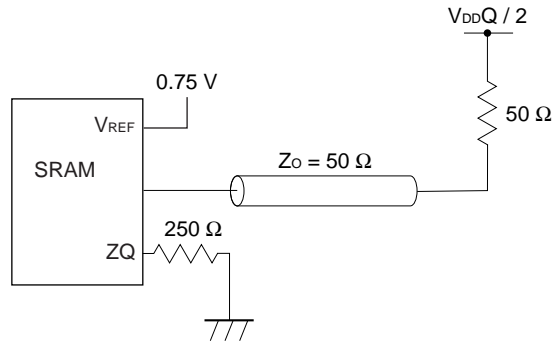


Output waveform



Output load condition

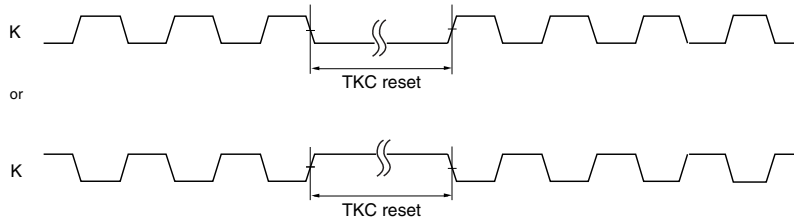
Figure 1. External load at test



Read and Write Cycle

| Parameter  | Symbol    | -E37<br>(270 MHz) |      | -E40, -E40Y<br>(250 MHz) |      | -E50, -E50Y<br>(200 MHz) |      | Unit  | Note |  |
|--|-----------|-------------------|------|--------------------------|------|--------------------------|------|-------|------|--|
|  |           | MIN.              | MAX. | MIN.                     | MAX. | MIN.                     | MAX. |       |      |  |
| <b>Clock</b>   |           |                   |      |                          |      |                          |      |       |      |  |
| Average Clock cycle time (K, K#, C, C#)  | TKHKH     | 3.7               | 8.4  | 4.0                      | 8.4  | 5.0                      | 8.4  | ns    | 1    |  |
| Clock phase jitter (K, K#, C, C#)  | TKC var   | –                 | 0.2  | –                        | 0.2  | –                        | 0.2  | ns    | 2    |  |
| Clock HIGH time (K, K#, C, C#)   | TKHKL     | 1.5               | –    | 1.6                      | –    | 2.0                      | –    | ns    |      |  |
| Clock LOW time (K, K#, C, C#)  | TKLKH     | 1.5               | –    | 1.6                      | –    | 2.0                      | –    | ns    |      |  |
| Clock HIGH to Clock# HIGH<br>(K → K#, C → C#)  | TKHK#H    | 1.7               | –    | 1.8                      | –    | 2.2                      | –    | ns    |      |  |
| Clock# HIGH to Clock HIGH<br>(K# → K, C# → C)  | TK#HKH    | 1.7               | –    | 1.8                      | –    | 2.2                      | –    | ns    |      |  |
| Clock to data clock<br>(K → C, K# → C#)  | TKHCH     | 250 to 270 MHz    | 0    | 1.65                     | –    | –                        | –    | –     | ns   |  |
|  |           | 200 to 250 MHz    | 0    | 1.8                      | 0    | 1.8                      | –    | –     |      |  |
|  |           | 167 to 200 MHz    | 0    | 2.3                      | 0    | 2.3                      | 0    | 2.3   |      |  |
|  |           | 133 to 167 MHz    | 0    | 2.8                      | 0    | 2.8                      | 0    | 2.8   |      |  |
|  |           | < 133 MHz         | 0    | 3.55                     | 0    | 3.55                     | 0    | 3.55  |      |  |
| DLL/PLL lock time (K, C)   | TKC lock  | 1,024             | –    | 1,024                    | –    | 1,024                    | –    | Cycle | 3    |  |
| K static to DLL/PLL reset  | TKC reset | 30                | –    | 30                       | –    | 30                       | –    | ns    | 4    |  |
| <b>Output Times</b>  |           |                   |      |                          |      |                          |      |       |      |  |
| C, C# HIGH to output valid   | TCHQV     | –                 | 0.45 | –                        | 0.45 | –                        | 0.45 | ns    |      |  |
| C, C# HIGH to output hold  | TCHQX     | – 0.45            | –    | – 0.45                   | –    | – 0.45                   | –    | ns    |      |  |
| C, C# HIGH to echo clock valid   | TCHCQV    | –                 | 0.45 | –                        | 0.45 | –                        | 0.45 | ns    |      |  |
| C, C# HIGH to echo clock hold  | TCHCQX    | – 0.45            | –    | – 0.45                   | –    | – 0.45                   | –    | ns    |      |  |
| CQ, CQ# HIGH to output valid   | TCQHQV    | –                 | 0.3  | –                        | 0.3  | –                        | 0.35 | ns    | 5    |  |
| CQ, CQ# HIGH to output hold  | TCQHQX    | – 0.3             | –    | – 0.3                    | –    | – 0.35                   | –    | ns    | 5    |  |
| C HIGH to output High-Z  | TCHQZ     | –                 | 0.45 | –                        | 0.45 | –                        | 0.45 | ns    |      |  |
| C HIGH to output Low-Z   | TCHQX1    | – 0.45            | –    | – 0.45                   | –    | – 0.45                   | –    | ns    |      |  |
| <b>Setup Times</b>   |           |                   |      |                          |      |                          |      |       |      |  |
| Address valid to K rising edge   | TAVKH     | 0.5               | –    | 0.5                      | –    | 0.6                      | –    | ns    | 6    |  |
| Synchronous load input (LD#),<br>read write input (R, W#) valid to<br>K rising edge    | TIVKH     | 0.5               | –    | 0.5                      | –    | 0.6                      | –    | ns    | 6    |  |
| Data inputs and write data select<br>inputs (BWx#, NWx#) valid to<br>K, K# rising edge | TDVKH     | 0.35              | –    | 0.35                     | –    | 0.4                      | –    | ns    | 6    |  |
| <b>Hold Times</b>  |           |                   |      |                          |      |                          |      |       |      |  |
| K rising edge to address hold  | TKHAX     | 0.5               | –    | 0.5                      | –    | 0.6                      | –    | ns    | 6    |  |
| K rising edge to<br>synchronous load input (LD#),<br>read write input (R, W#) hold     | TKHIX     | 0.5               | –    | 0.5                      | –    | 0.6                      | –    | ns    | 6    |  |
| K, K# rising edge to data inputs and<br>write data select inputs (BWx#, NWx#)<br>hold  | TKHDX     | 0.35              | –    | 0.35                     | –    | 0.4                      | –    | ns    | 6    |  |

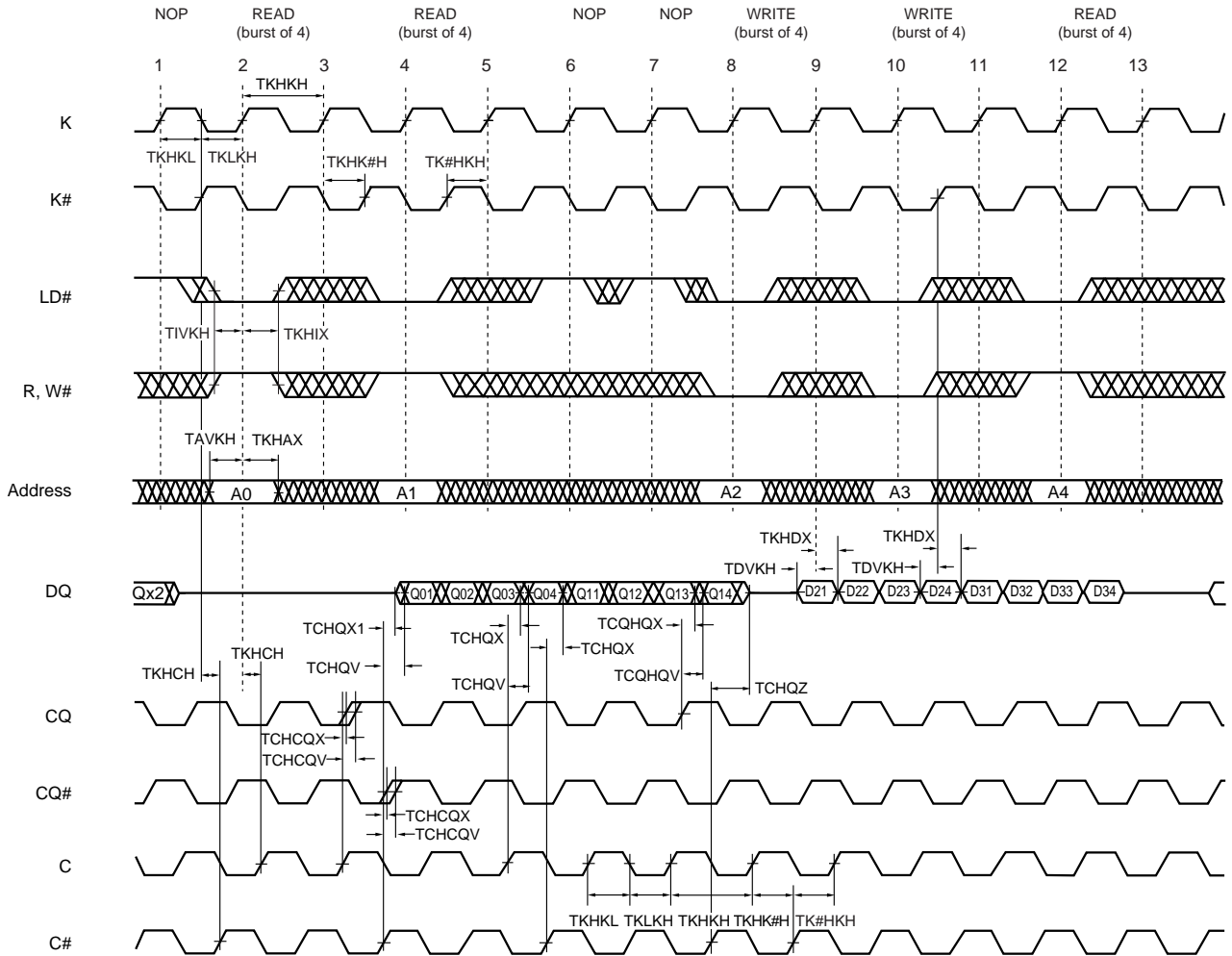
- Notes**
1. When debugging the system or board, these products can operate at a clock frequency slower than TKHKH (MAX.) without the DLL/PLL circuit being used, if DLL# = LOW. Read latency (RL) is changed to 1.5 clock in this operation. The AC/DC characteristics cannot be guaranteed, however.
  2. Clock phase jitter is the variance from clock rising edge to the next expected clock rising edge. TKC var (MAX.) indicates a peak-to-peak value.
  3. V<sub>DD</sub> slew rate must be less than 0.1 V DC per 50 ns for DLL/PLL lock retention. DLL/PLL lock time begins once V<sub>DD</sub> and input clock are stable. It is recommended that the device is kept NOP (LD# = HIGH) during these cycles.
  4. K input is monitored for this operation. See below for the timing.



5. Echo clock is very tightly controlled to data valid / data hold. By design, there is a  $\pm 0.1$  ns variation from echo clock to data. The data sheet parameters reflect tester guardbands and test setup variations.
6. This is a synchronous device. All addresses, data and control lines must meet the specified setup and hold times for all latching clock edges.

- Remarks**
1. This parameter is sampled.
  2. Test conditions as specified with the output loading as shown in AC Test Conditions unless otherwise noted.
  3. Control input signals may not be operated with pulse widths less than TKHKL (MIN.).
  4. If C, C# are tied HIGH, K, K# become the references for C, C# timing parameters.
  5. V<sub>DDQ</sub> is 1.5 V DC.

Read and Write Timing

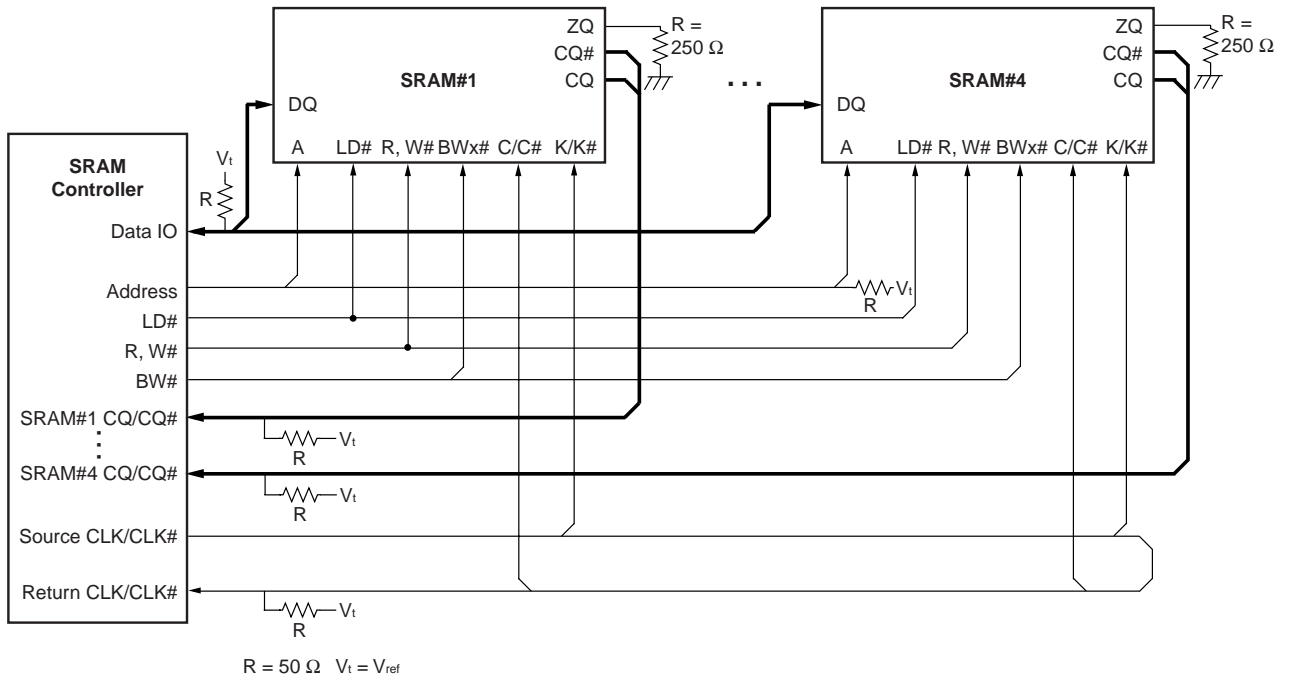


Remarks 1. Q01 refers to output from address A0.

Q02 refers to output from the next internal burst address following A0, etc.

2. Outputs are disabled (high impedance) 3.5 clocks after the last READ (LD# = LOW, R, W# = HIGH) is input in the sequences of [READ]-[NOP].
3. The second NOP cycle at the cycle "7" is not necessary for correct device operation; however, at high clock frequencies it may be required to prevent bus contention.

Application Example



**Remark** AC specifications are defined at the condition of SRAM outputs, CQ, CQ# and DQ with termination.

**JTAG Specification**

These products support a limited set of JTAG functions as in IEEE standard 1149.1.

**Test Access Port (TAP) Pins**

| Pin name | Pin assignments | Description   |
|----------|-----------------|---|
| TCK      | 2R              | Test Clock Input. All input are captured on the rising edge of TCK and all outputs propagate from the falling edge of TCK.  |
| TMS      | 10R             | Test Mode Select. This is the command input for the TAP controller state machine.   |
| TDI      | 11R             | Test Data Input. This is the input side of the serial registers placed between TDI and TDO. The register placed between TDI and TDO is determined by the state of the TAP controller state machine and the instruction that is currently loaded in the TAP instruction. |
| TDO      | 1R              | Test Data Output. This is the output side of the serial registers placed between TDI and TDO. Output changes in response to the falling edge of TCK.  |

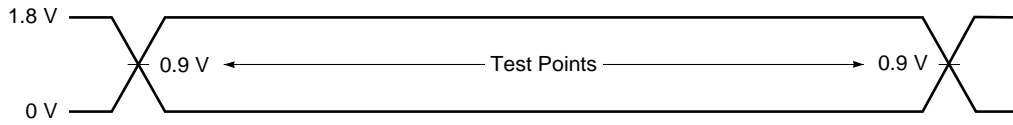
**Remark** The device does not have TRST (TAP reset). The Test-Logic Reset state is entered while TMS is held HIGH for five rising edges of TCK. The TAP controller state is also reset on the SRAM POWER-UP.

**JTAG DC Characteristics (V<sub>DD</sub> = 1.8 ± 0.1 V, unless otherwise noted)**

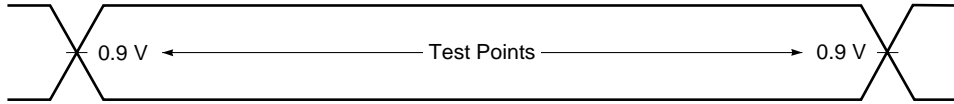
| Parameter                  | Symbol           | Conditions   | MIN. | TYP. | MAX.                 | Unit |
|----------------------------|------------------|--|------|------|----------------------|------|
| JTAG Input leakage current | I <sub>LI</sub>  | 0 V ≤ V <sub>IN</sub> ≤ V <sub>DD</sub>                        | -5.0 | -    | +5.0                 | μA   |
| JTAG I/O leakage current   | I <sub>LO</sub>  | 0 V ≤ V <sub>IN</sub> ≤ V <sub>DDQ</sub> ,<br>Outputs disabled | -5.0 | -    | +5.0                 | μA   |
| JTAG input HIGH voltage    | V <sub>IH</sub>  |  | 1.3  | -    | V <sub>DD</sub> +0.3 | V    |
| JTAG input LOW voltage     | V <sub>IL</sub>  |  | -0.3 | -    | +0.5                 | V    |
| JTAG output HIGH voltage   | V <sub>OH1</sub> | I <sub>OHC</sub>   = 100 μA                                    | 1.6  | -    | -                    | V    |
|                            | V <sub>OH2</sub> | I <sub>OHT</sub>   = 2 mA                                      | 1.4  | -    | -                    | V    |
| JTAG output LOW voltage    | V <sub>OL1</sub> | I <sub>OLC</sub> = 100 μA                                      | -    | -    | 0.2                  | V    |
|                            | V <sub>OL2</sub> | I <sub>OLT</sub> = 2 mA  | -    | -    | 0.4                  | V    |

JTAG AC Test Conditions

Input waveform (Rise / Fall time  $\leq 1$  ns)

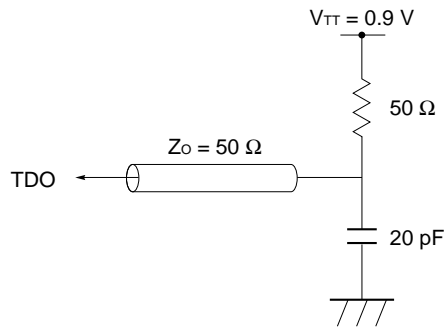


Output waveform



Output load

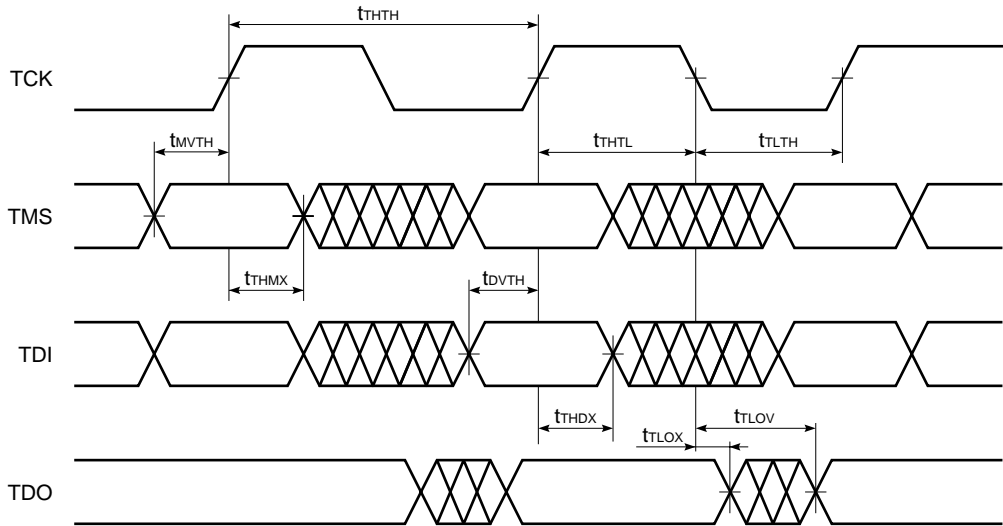
Figure 2. External load at test



JTAG AC Characteristics

| Parameter               | Symbol     | Conditions | MIN. | TYP. | MAX. | Unit |
|-------------------------|------------|------------|------|------|------|------|
| <b>Clock</b>            |            |            |      |      |      |      |
| Clock cycle time        | $t_{THTH}$ |            | 50   | –    | –    | ns   |
| Clock frequency         | $f_{TF}$   |            | –    | –    | 20   | MHz  |
| Clock HIGH time         | $t_{HTHL}$ |            | 20   | –    | –    | ns   |
| Clock LOW time          | $t_{LTH}$  |            | 20   | –    | –    | ns   |
| <b>Output time</b>      |            |            |      |      |      |      |
| TCK LOW to TDO unknown  | $t_{TLOX}$ |            | 0    | –    | –    | ns   |
| TCK LOW to TDO valid    | $t_{TLOV}$ |            | –    | –    | 10   | ns   |
| <b>Setup time</b>       |            |            |      |      |      |      |
| TMS setup time          | $t_{MVTH}$ |            | 5    | –    | –    | ns   |
| TDI valid to TCK HIGH   | $t_{DVTH}$ |            | 5    | –    | –    | ns   |
| Capture setup time      | $t_{CS}$   |            | 5    | –    | –    | ns   |
| <b>Hold time</b>        |            |            |      |      |      |      |
| TMS hold time           | $t_{THMX}$ |            | 5    | –    | –    | ns   |
| TCK HIGH to TDI invalid | $t_{THDX}$ |            | 5    | –    | –    | ns   |
| Capture hold time       | $t_{CH}$   |            | 5    | –    | –    | ns   |

JTAG Timing Diagram



**Scan Register Definition (1)**

| Register name        | Description  |
|----------------------|--|
| Instruction register | The instruction register holds the instructions that are executed by the TAP controller when it is moved into the run-test/idle or the various data register state. The register can be loaded when it is placed between the TDI and TDO pins. The instruction register is automatically preloaded with the IDCODE instruction at power-up whenever the controller is placed in test-logic-reset state.  |
| Bypass register      | The bypass register is a single bit register that can be placed between TDI and TDO. It allows serial test data to be passed through the RAMs TAP to another device in the scan chain with as little delay as possible.  |
| ID register          | The ID Register is a 32 bit register that is loaded with a device and vendor specific 32 bit code when the controller is put in capture-DR state with the IDCODE command loaded in the instruction register. The register is then placed between the TDI and TDO pins when the controller is moved into shift-DR state.  |
| Boundary register    | The boundary register, under the control of the TAP controller, is loaded with the contents of the RAMs I/O ring when the controller is in capture-DR state and then is placed between the TDI and TDO pins when the controller is moved to shift-DR state. Several TAP instructions can be used to activate the boundary register.<br><br>The Scan Exit Order tables describe which device bump connects to each boundary register location. The first column defines the bit's position in the boundary register. The second column is the name of the input or I/O at the bump and the third column is the bump number. |

**Scan Register Definition (2)**

| Register name        | Bit size | Unit |
|----------------------|----------|------|
| Instruction register | 3        | bit  |
| Bypass register      | 1        | bit  |
| ID register          | 32       | bit  |
| Boundary register    | 109      | bit  |

**ID Register Definition**

| Part number   | Organization | ID [31:28] vendor revision no. | ID [27:12] part no. | ID [11:1] vendor ID no. | ID [0] fix bit |
|---------------|--------------|--------------------------------|---------------------|-------------------------|----------------|
| μPD44324084-A | 4M x 8       | XXXX                           | 0000 0000 0100 0001 | 00000010000             | 1              |
| μPD44324094-A | 4M x 9       | XXXX                           | 0000 0000 0100 0010 | 00000010000             | 1              |
| μPD44324184-A | 2M x 18      | XXXX                           | 0000 0000 0100 0011 | 00000010000             | 1              |
| μPD44324364-A | 1M x 36      | XXXX                           | 0000 0000 0100 0100 | 00000010000             | 1              |

SCAN Exit Order

| Bit no. | Signal name |     |     |      | Bump ID |
|---------|-------------|-----|-----|------|---------|
|         | x8          | x9  | x18 | x36  |         |
| 1       | C#          |     |     |      | 6R      |
| 2       | C           |     |     |      | 6P      |
| 3       | A           |     |     |      | 6N      |
| 4       | A           |     |     |      | 7P      |
| 5       | A           |     |     |      | 7N      |
| 6       | A           |     |     |      | 7R      |
| 7       | A           |     |     |      | 8R      |
| 8       | A           |     |     |      | 8P      |
| 9       | A           |     |     |      | 9R      |
| 10      | NC          | DQ0 | DQ0 | DQ0  | 11P     |
| 11      | NC          | NC  | NC  | DQ9  | 10P     |
| 12      | NC          | NC  | NC  | NC   | 10N     |
| 13      | NC          | NC  | NC  | NC   | 9P      |
| 14      | NC          | NC  | DQ1 | DQ11 | 10M     |
| 15      | NC          | NC  | NC  | DQ10 | 11N     |
| 16      | NC          | NC  | NC  | NC   | 9M      |
| 17      | NC          | NC  | NC  | NC   | 9N      |
| 18      | DQ0         | DQ1 | DQ2 | DQ2  | 11L     |
| 19      | NC          | NC  | NC  | DQ1  | 11M     |
| 20      | NC          | NC  | NC  | NC   | 9L      |
| 21      | NC          | NC  | NC  | NC   | 10L     |
| 22      | NC          | NC  | DQ3 | DQ3  | 11K     |
| 23      | NC          | NC  | NC  | DQ12 | 10K     |
| 24      | NC          | NC  | NC  | NC   | 9J      |
| 25      | NC          | NC  | NC  | NC   | 9K      |
| 26      | DQ1         | DQ2 | DQ4 | DQ13 | 10J     |
| 27      | NC          | NC  | NC  | DQ4  | 11J     |
| 28      | ZQ          |     |     |      | 11H     |
| 29      | NC          | NC  | NC  | NC   | 10G     |
| 30      | NC          | NC  | NC  | NC   | 9G      |
| 31      | NC          | NC  | DQ5 | DQ5  | 11F     |
| 32      | NC          | NC  | NC  | DQ14 | 11G     |
| 33      | NC          | NC  | NC  | NC   | 9F      |
| 34      | NC          | NC  | NC  | NC   | 10F     |
| 35      | DQ2         | DQ3 | DQ6 | DQ6  | 11E     |
| 36      | NC          | NC  | NC  | DQ15 | 10E     |

| Bit no. | Signal name     |      |      |                 | Bump ID |
|---------|-----------------|------|------|-----------------|---------|
|         | x8              | x9   | x18  | x36             |         |
| 37      | NC              | NC   | NC   | NC              | 10D     |
| 38      | NC              | NC   | NC   | NC              | 9E      |
| 39      | NC              | NC   | DQ7  | DQ17            | 10C     |
| 40      | NC              | NC   | NC   | DQ16            | 11D     |
| 41      | NC              | NC   | NC   | NC              | 9C      |
| 42      | NC              | NC   | NC   | NC              | 9D      |
| 43      | DQ3             | DQ4  | DQ8  | DQ8             | 11B     |
| 44      | NC              | NC   | NC   | DQ7             | 11C     |
| 45      | NC              | NC   | NC   | NC              | 9B      |
| 46      | NC              | NC   | NC   | NC              | 10B     |
| 47      | CQ              |      |      |                 | 11A     |
| 48      | A               | A    | A    | V <sub>ss</sub> | 10A     |
| 49      | A               |      |      |                 | 9A      |
| 50      | A               |      |      |                 | 8B      |
| 51      | A               | A    | A1   | A1              | 7C      |
| 52      | NC              | NC   | A0   | A0              | 6C      |
| 53      | LD#             |      |      |                 | 8A      |
| 54      | NC              | NC   | NC   | BW1#            | 7A      |
| 55      | NW0#            | BW0# | BW0# | BW0#            | 7B      |
| 56      | K               |      |      |                 | 6B      |
| 57      | K#              |      |      |                 | 6A      |
| 58      | NC              | NC   | NC   | BW3#            | 5B      |
| 59      | NW1#            | NC   | BW1# | BW2#            | 5A      |
| 60      | R, W#           |      |      |                 | 4A      |
| 61      | A               |      |      |                 | 5C      |
| 62      | A               |      |      |                 | 4B      |
| 63      | A               |      |      |                 | 3A      |
| 64      | V <sub>ss</sub> |      |      |                 | 2A      |
| 65      | CQ#             |      |      |                 | 1A      |
| 66      | NC              | NC   | DQ9  | DQ27            | 2B      |
| 67      | NC              | NC   | NC   | DQ18            | 3B      |
| 68      | NC              | NC   | NC   | NC              | 1C      |
| 69      | NC              | NC   | NC   | NC              | 1B      |
| 70      | NC              | NC   | DQ10 | DQ19            | 3D      |
| 71      | NC              | NC   | NC   | DQ28            | 3C      |
| 72      | NC              | NC   | NC   | NC              | 1D      |

| Bit no. | Signal name |     |      |      | Bump ID  |
|---------|-------------|-----|------|------|----------|
|         | x8          | x9  | x18  | x36  |          |
| 73      | NC          | NC  | NC   | NC   | 2C       |
| 74      | DQ4         | DQ5 | DQ11 | DQ20 | 3E       |
| 75      | NC          | NC  | NC   | DQ29 | 2D       |
| 76      | NC          | NC  | NC   | NC   | 2E       |
| 77      | NC          | NC  | NC   | NC   | 1E       |
| 78      | NC          | NC  | DQ12 | DQ30 | 2F       |
| 79      | NC          | NC  | NC   | DQ21 | 3F       |
| 80      | NC          | NC  | NC   | NC   | 1G       |
| 81      | NC          | NC  | NC   | NC   | 1F       |
| 82      | DQ5         | DQ6 | DQ13 | DQ22 | 3G       |
| 83      | NC          | NC  | NC   | DQ31 | 2G       |
| 84      | DLL#        |     |      |      | 1H       |
| 85      | NC          | NC  | NC   | NC   | 1J       |
| 86      | NC          | NC  | NC   | NC   | 2J       |
| 87      | NC          | NC  | DQ14 | DQ23 | 3K       |
| 88      | NC          | NC  | NC   | DQ32 | 3J       |
| 89      | NC          | NC  | NC   | NC   | 2K       |
| 90      | NC          | NC  | NC   | NC   | 1K       |
| 91      | DQ6         | DQ7 | DQ15 | DQ33 | 2L       |
| 92      | NC          | NC  | NC   | DQ24 | 3L       |
| 93      | NC          | NC  | NC   | NC   | 1M       |
| 94      | NC          | NC  | NC   | NC   | 1L       |
| 95      | NC          | NC  | DQ16 | DQ25 | 3N       |
| 96      | NC          | NC  | NC   | DQ34 | 3M       |
| 97      | NC          | NC  | NC   | NC   | 1N       |
| 98      | NC          | NC  | NC   | NC   | 2M       |
| 99      | DQ7         | DQ8 | DQ17 | DQ26 | 3P       |
| 100     | NC          | NC  | NC   | DQ35 | 2N       |
| 101     | NC          | NC  | NC   | NC   | 2P       |
| 102     | NC          | NC  | NC   | NC   | 1P       |
| 103     | A           |     |      |      | 3R       |
| 104     | A           |     |      |      | 4R       |
| 105     | A           |     |      |      | 4P       |
| 106     | A           |     |      |      | 5P       |
| 107     | A           |     |      |      | 5N       |
| 108     | A           |     |      |      | 5R       |
| 109     | -           |     |      |      | Internal |

**Remark** Bump ID 10A of bit no. 48 can also be used as NC if the product is x36.  
 Bump ID 2A of bit no. 64 can also be used as NC.  
 The register always indicates LOW, however.

**JTAG Instructions**

| Instructions     | Description  |
|------------------|--|
| 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 the ID ROM to be loaded into the ID register when the controller is in capture-DR mode and places the ID register between the TDI and TDO pins in shift-DR mode. The IDCODE instruction is the default instruction loaded in at power up and any time the controller is placed in the test-logic-reset state.  |
| BYPASS           | When the BYPASS instruction is loaded in the instruction register, the bypass register is placed between TDI and TDO. This occurs when the TAP controller is moved to the shift-DR state. This allows the board level scan path to be shortened to facilitate testing of other devices in the scan path.   |
| SAMPLE / PRELOAD | SAMPLE / PRELOAD is a Standard 1149.1 mandatory public instruction. When the SAMPLE / PRELOAD instruction is loaded in the instruction register, moving the TAP controller into the capture-DR state loads the data in the RAMs input and DQ pins into the boundary scan register. Because the RAM clock(s) are independent from the TAP clock (TCK) it is possible for the TAP to attempt to capture the I/O ring contents while the input buffers are in transition (i.e., in a metastable state). Although allowing the TAP to sample metastable input will not harm the device, repeatable results cannot be expected. RAM input signals must be stabilized for long enough to meet the TAPs input data capture setup plus hold time ( $t_{cs}$ plus $t_{ch}$ ). The RAMs clock inputs need not be paused for any other TAP operation except capturing the I/O ring contents into the boundary scan register. Moving the controller to shift-DR state then places the boundary scan register between the TDI and TDO pins. |
| SAMPLE-Z         | If the SAMPLE-Z instruction is loaded in the instruction register, all RAM DQ pins are forced to an inactive drive state (high impedance) and the boundary register is connected between TDI and TDO when the TAP controller is moved to the shift-DR state.   |

**JTAG Instruction Coding**

| IR2 | IR1 | IR0 | Instruction      | Note |
|-----|-----|-----|------------------|------|
| 0   | 0   | 0   | EXTEST           |      |
| 0   | 0   | 1   | IDCODE           |      |
| 0   | 1   | 0   | SAMPLE-Z         | 1    |
| 0   | 1   | 1   | RESERVED         | 2    |
| 1   | 0   | 0   | SAMPLE / PRELOAD |      |
| 1   | 0   | 1   | RESERVED         | 2    |
| 1   | 1   | 0   | RESERVED         | 2    |
| 1   | 1   | 1   | BYPASS           |      |

- Notes**
1. TRISTATE all DQ pins and CAPTURE the pad values into a SERIAL SCAN LATCH.
  2. Do not use this instruction code because the vendor uses it to evaluate this product.

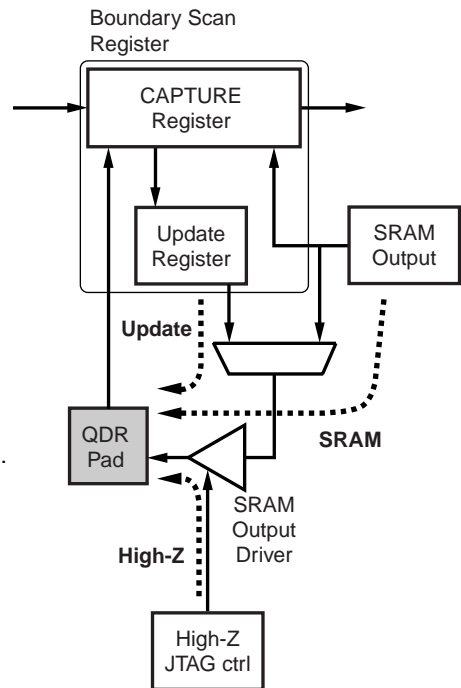
Output Pin States of CQ, CQ# and DQ

| Instructions | Control-Register Status | Output Pin Status |        |
|--------------|-------------------------|-------------------|--------|
|              |                         | CQ,CQ#            | DQ     |
| EXTEST       | 0                       | Update            | High-Z |
|              | 1                       | Update            | Update |
| IDCODE       | 0                       | SRAM              | SRAM   |
|              | 1                       | SRAM              | SRAM   |
| SAMPLE-Z     | 0                       | High-Z            | High-Z |
|              | 1                       | High-Z            | High-Z |
| SAMPLE       | 0                       | SRAM              | SRAM   |
|              | 1                       | SRAM              | SRAM   |
| BYPASS       | 0                       | SRAM              | SRAM   |
|              | 1                       | SRAM              | SRAM   |

**Remark** The output pin statuses during each instruction vary according to the Control-Register status (value of Boundary Scan Register, bit no. 109). There are three statuses:

- Update : Contents of the "Update Register" are output to the output pin (QDR Pad).
- SRAM : Contents of the SRAM internal output "SRAM Output" are output to the output pin (QDR Pad).
- High-Z : The output pin (QDR Pad) becomes high impedance by controlling of the "High-Z JTAG ctrl".

The Control-Register status is set during Update-DR at the EXTEST or SAMPLE instruction.



Boundary Scan Register Status of Output Pins CQ, CQ# and DQ

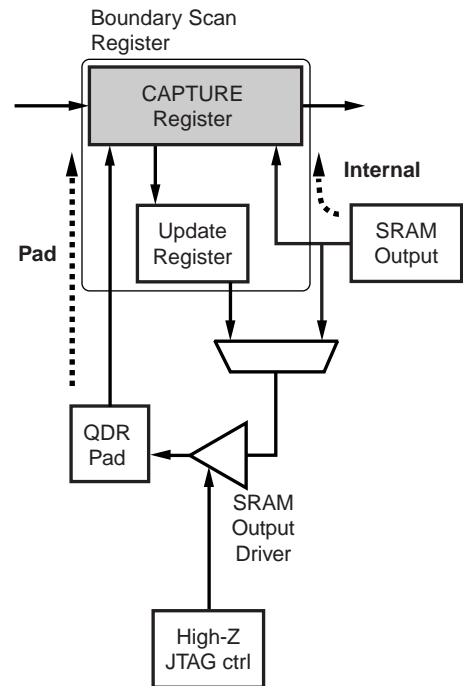
| Instructions | SRAM Status  | Boundary Scan Register Status |          | Note          |
|--------------|--------------|-------------------------------|----------|---------------|
|              |              | CQ, CQ#                       | DQ       |               |
| EXTEST       | READ (Low-Z) | Pad                           | Pad      |               |
|              | NOP (High-Z) | Pad                           | Pad      |               |
| IDCODE       | READ (Low-Z) | -                             | -        | No definition |
|              | NOP (High-Z) | -                             | -        |               |
| SAMPLE-Z     | READ (Low-Z) | Pad                           | Pad      |               |
|              | NOP (High-Z) | Pad                           | Pad      |               |
| SAMPLE       | READ (Low-Z) | Internal                      | Internal |               |
|              | NOP (High-Z) | Internal                      | Pad      |               |
| BYPASS       | READ (Low-Z) | -                             | -        | No definition |
|              | NOP (High-Z) | -                             | -        |               |

**Remark** The Boundary Scan Register statuses during execution each instruction vary according to the instruction code and SRAM operation mode.

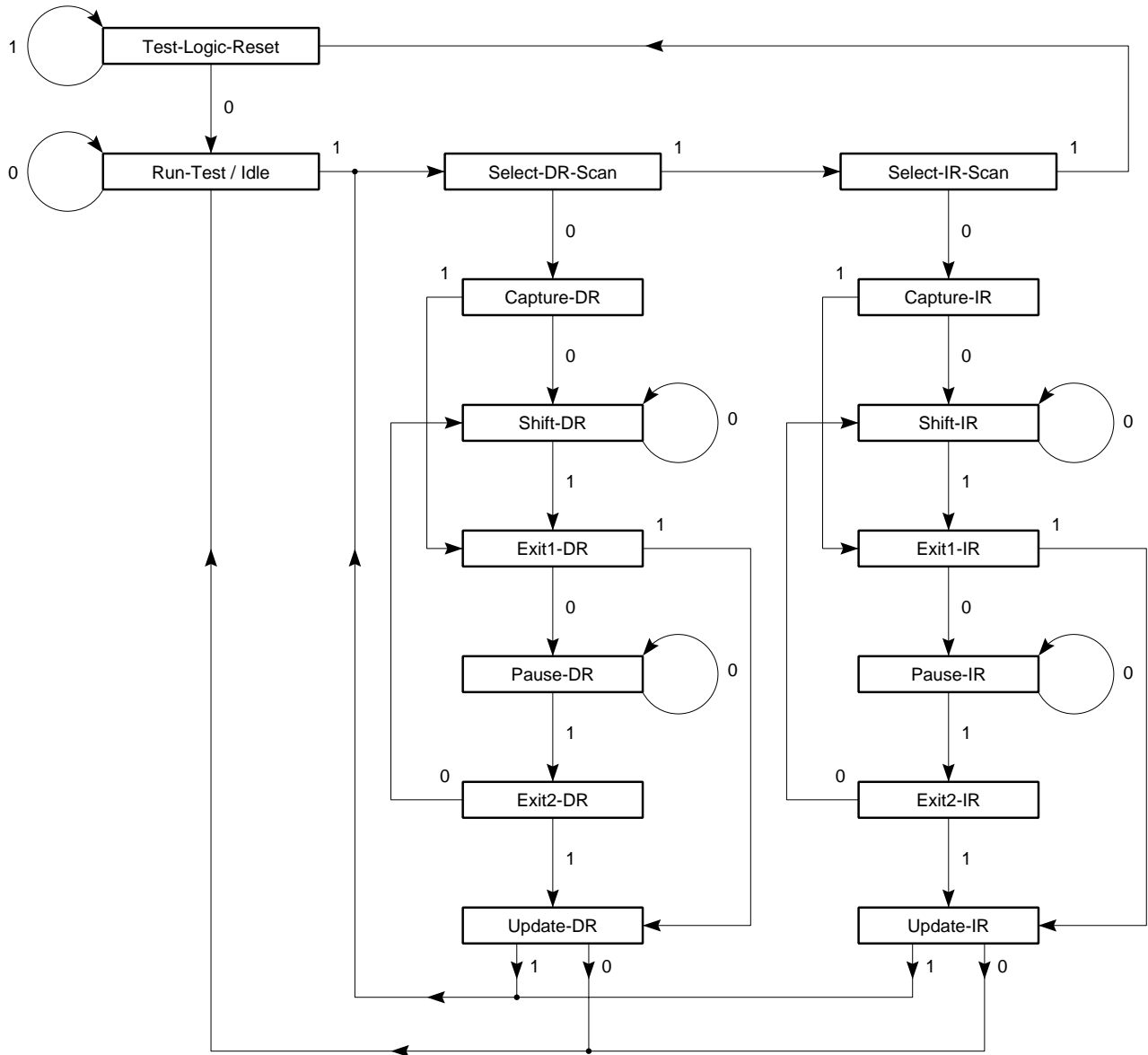
There are two statuses:

**Pad** : Contents of the output pin (QDR Pad) are captured in the "CAPTURE Register" in the Boundary Scan Register.

**Internal** : Contents of the SRAM internal output "SRAM Output" are captured in the "CAPTURE Register" in the Boundary Scan Register.



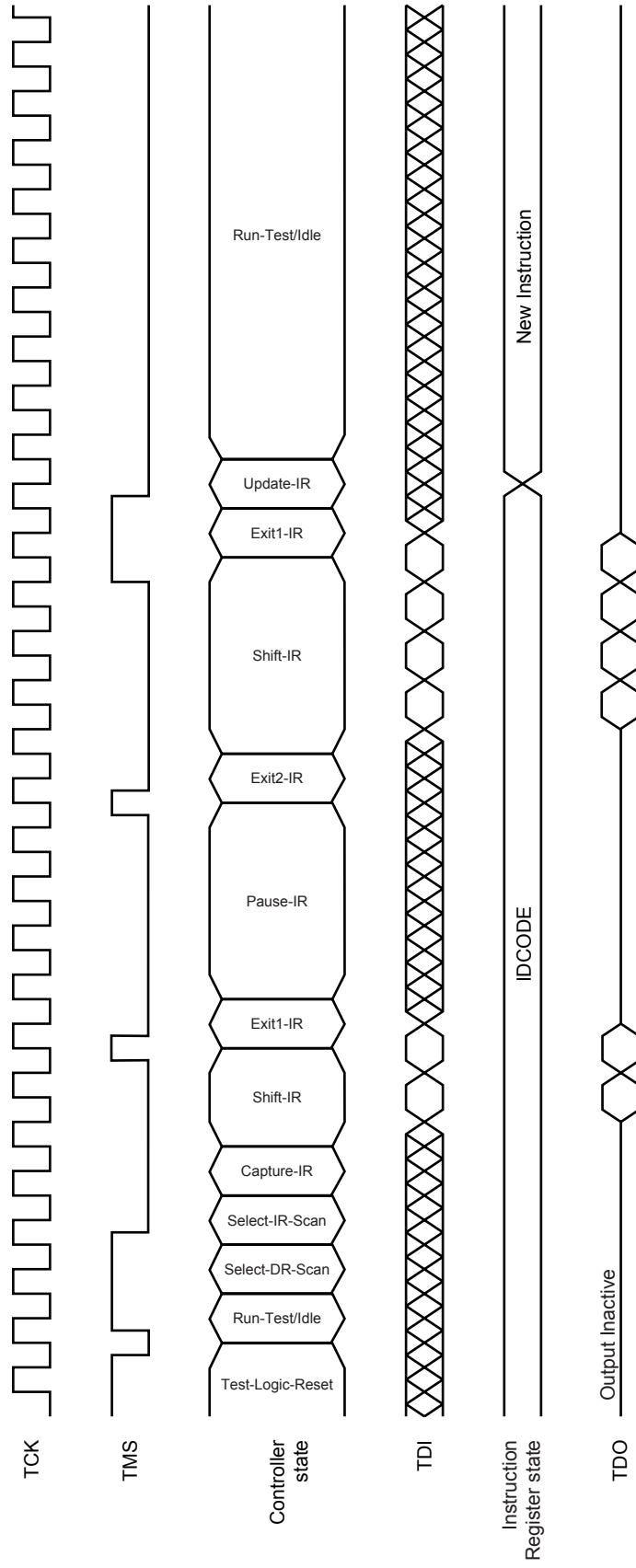
TAP Controller State Diagram



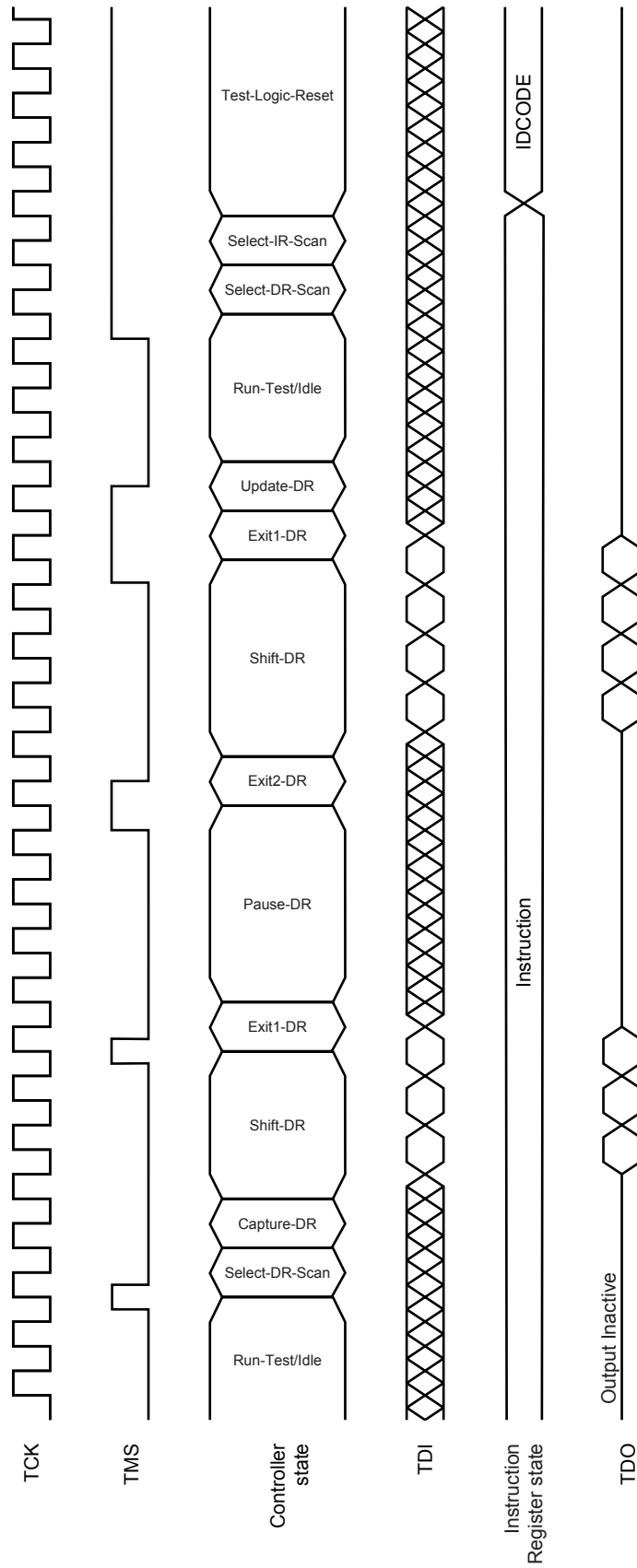
**Disabling the Test Access Port**

It is possible to use this device without utilizing the TAP. To disable the TAP Controller without interfering with normal operation of the device, TCK must be tied to V<sub>SS</sub> to preclude mid level inputs. TDI and TMS may be left open but fix them to V<sub>DD</sub> via a resistor of about 1 kΩ when the TAP controller is not used. TDO should be left unconnected also when the TAP controller is not used.

Test Logic Operation (Instruction Scan)

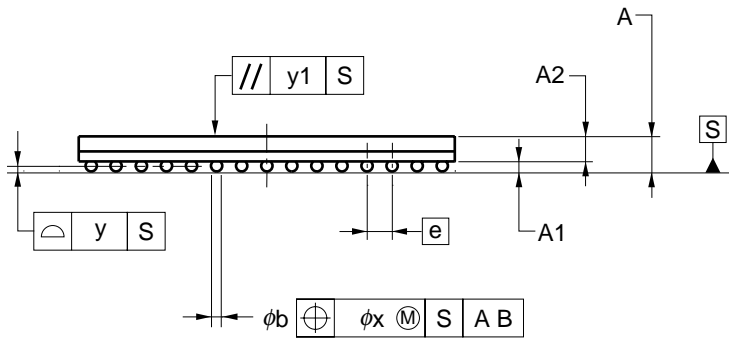
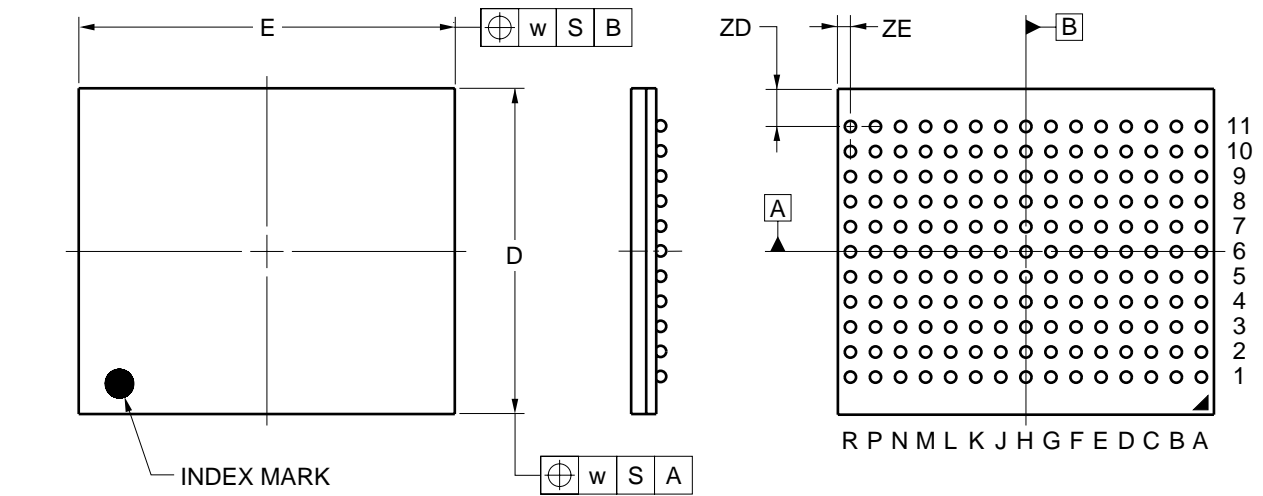


Test Logic (Data Scan)



Package Drawing

165-PIN PLASTIC BGA (13x15)



(UNIT:mm)

| ITEM | DIMENSIONS |
|------|------------|
| D    | 13.00±0.10 |
| E    | 15.00±0.10 |
| w    | 0.15       |
| e    | 1.00       |
| A    | 1.40±0.11  |
| A1   | 0.40±0.05  |
| A2   | 1.00       |
| b    | 0.50±0.05  |
| x    | 0.08       |
| y    | 0.10       |
| y1   | 0.20       |
| ZD   | 1.50       |
| ZE   | 0.50       |

P165F5-100-EQ2

**Recommended Soldering Condition**

Please consult with our sales offices for soldering conditions of these products.

**Types of Surface Mount Devices**

$\mu$ PD44324084F5-EQ2-A : 165-pin PLASTIC BGA (13 x 15)

$\mu$ PD44324094F5-EQ2-A : 165-pin PLASTIC BGA (13 x 15)

$\mu$ PD44324184F5-EQ2-A : 165-pin PLASTIC BGA (13 x 15)

$\mu$ PD44324364F5-EQ2-A : 165-pin PLASTIC BGA (13 x 15)

**Quality Grade**

- A quality grade of the products is "Standard".
- Anti-radioactive design is not implemented in the products.
- Semiconductor devices have the possibility of unexpected defects by affection of cosmic ray that reach to the ground and so forth.

[ MEMO ]

[ MEMO ]

## NOTES FOR CMOS DEVICES

**① VOLTAGE APPLICATION WAVEFORM AT INPUT PIN**

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

**② HANDLING OF UNUSED INPUT PINS**

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

**③ PRECAUTION AGAINST ESD**

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

**④ STATUS BEFORE INITIALIZATION**

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

**⑤ POWER ON/OFF SEQUENCE**

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

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

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

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

- **The information in this document is current as of July, 2009. The information is subject to change without notice. For actual design-in, refer to the latest publications of NEC Electronics data sheets, etc., for the most up-to-date specifications of NEC Electronics products. Not all products and/or types are available in every country. Please check with an NEC Electronics sales representative for availability and additional information.**
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"Special": Transportation equipment (automobiles, trains, ships, etc.), traffic control systems, anti-disaster systems, anti-crime systems, safety equipment and medical equipment (not specifically designed for life support).

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