**119- and 209-Pin BGA**
**Commercial Temp**
**Industrial Temp**

# 2M x 18, 1M x 36, 512K x 72 36Mb Sync NBT SRAMs

**250 MHz–133MHz**
**2.5 V or 3.3 V $V_{DD}$**
**2.5 V or 3.3 V I/O**

## Features

- NBT (No Bus Turn Around) functionality allows zero wait Read-Write-Read bus utilization; fully pin-compatible with both pipelined and flow through NtRAM™, NoBL™ and ZBT™ SRAMs
- FT pin for user-configurable flow through or pipeline operation
- IEEE 1149.1 JTAG-compatible Boundary Scan
- ZQ mode pin for user-selectable high/low output drive
- 2.5 V or 3.3 V +10%/–5% core power supply
- 2.5 V or 3.3 V I/O supply
- LBO pin for Linear or Interleaved Burst mode
- Byte Write (BW) and/or Global Write (GW) operation
- Internal self-timed write cycle
- Automatic power-down for portable applications
- JEDEC-standard 119- and 209-bump BGA package

| | | -250 | -225 | -200 | -166 | -150 | -133 | Unit |
|---|---|---|---|---|---|---|---|---|
| **Pipeline 3-1-1-1** | $t_{KQ}$ | 2.3 | 2.5 | 3.0 | 3.5 | 3.8 | 4.0 | ns |
| | tCycle | 4.0 | 4.4 | 5.0 | 6.0 | 6.6 | 7.5 | ns |
| **3.3 V** | Curr (x18) | 365 | 335 | 305 | 265 | 245 | 215 | mA |
| | Curr (x36) | 560 | 510 | 460 | 400 | 370 | 330 | mA |
| | Curr (x72) | 660 | 600 | 540 | 460 | 430 | 380 | mA |
| **2.5 V** | Curr (x18) | 360 | 330 | 305 | 260 | 240 | 215 | mA |
| | Curr (x36) | 550 | 500 | 460 | 390 | 360 | 330 | mA |
| | Curr (x72) | 640 | 590 | 530 | 450 | 420 | 370 | mA |
| **Flow Through 2-1-1-1** | $t_{KQ}$ | 6.0 | 6.5 | 7.5 | 8.5 | 10 | 11 | ns |
| | tCycle | 7.0 | 7.5 | 8.5 | 10 | 10 | 15 | ns |
| **3.3 V** | Curr (x18) | 235 | 230 | 210 | 200 | 195 | 150 | mA |
| | Curr (x36) | 300 | 300 | 270 | 270 | 270 | 200 | mA |
| | Curr (x72) | 350 | 350 | 300 | 300 | 300 | 220 | mA |
| **2.5 V** | Curr (x18) | 235 | 230 | 210 | 200 | 195 | 145 | mA |
| | Curr (x36) | 300 | 300 | 270 | 270 | 270 | 190 | mA |
| | Curr (x72) | 340 | 340 | 300 | 300 | 300 | 220 | mA |

## Functional Description

### Applications

The GS8324Z18/36/72 is a 37,748,736-bit high performance 2-die synchronous SRAM module with a 2-bit burst address counter. Although of a type originally developed for Level 2 Cache applications supporting high performance CPUs, the device now finds application in synchronous SRAM applications, ranging from DSP main store to networking chip set support.

### Controls

Addresses, data I/Os, chip enable (E1), address burst control inputs (ADSP, ADSC, ADV), and write control inputs (Bx, BW, GW) are synchronous and are controlled by a positive-edge-triggered clock input (CK). Output enable (G) and power down control (ZZ) are asynchronous inputs. Burst cycles can be initiated with either ADSP or ADSC inputs. In Burst mode, subsequent burst addresses are generated internally and are controlled by ADV. The burst address counter may be configured to count in either linear or interleave order with the Linear Burst Order (LBO) input. The Burst function need not be used. New addresses can be loaded on every cycle with no degradation of chip performance.

### Flow Through/Pipeline Reads

The function of the Data Output register can be controlled by the user via the FT mode . Holding the FT mode pin low places the RAM in Flow Through mode, causing output data to bypass the Data Output Register. Holding FT high places the RAM in Pipeline mode, activating the rising-edge-triggered Data Output Register.

### Byte Write and Global Write

Byte write operation is performed by using Byte Write enable (BW) input combined with one or more individual byte write signals (Bx). In addition, Global Write (GW) is available for writing all bytes at one time, regardless of the Byte Write control inputs.

### FLXDrive™

The ZQ pin allows selection between high drive strength (ZQ low) for multi-drop bus applications and normal drive strength (ZQ floating or high) point-to-point applications. See the Output Driver Characteristics chart for details.

### Sleep Mode

Low power (Sleep mode) is attained through the assertion (High) of the ZZ signal, or by stopping the clock (CK). Memory data is retained during Sleep mode.

### Core and Interface Voltages

The GS8324Z18/36/72 operates on a 2.5 V or 3.3 V power supply. All input are 3.3 V and 2.5 V compatible. Separate output power ($V_{DDQ}$) pins are used to decouple output noise from the internal circuits and are 3.3 V and 2.5 V compatible.

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# GS8324Z72B Pad Out
# 209-Bump BGA—Top View

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | $DQ_{G5}$ | $DQ_{G1}$ | A13 | E2 | A14 | ADV | A15 | $\overline{E3}$ | A17 | $DQ_{B1}$ | $DQ_{B5}$ | A |
| B | $DQ_{G6}$ | $DQ_{G2}$ | $\overline{BC}$ | $\overline{BG}$ | NC | $\overline{W}$ | A16 | $\overline{BB}$ | $\overline{BF}$ | $DQ_{B2}$ | $DQ_{B6}$ | B |
| C | $DQ_{G7}$ | $DQ_{G3}$ | $\overline{BH}$ | $\overline{BD}$ | NC | $\overline{E1}$ | NC | $\overline{BE}$ | $\overline{BA}$ | $DQ_{B3}$ | $DQ_{B7}$ | C |
| D | $DQ_{G8}$ | $DQ_{G4}$ | $V_{SS}$ | NC | NC | $\overline{G}$ | NC | NC | $V_{SS}$ | $DQ_{B4}$ | $DQ_{B8}$ | D |
| E | $DQP_{G9}$ | $DQP_{C9}$ | $V_{DDQ}$ | $V_{DDQ}$ | $V_{DD}$ | $V_{DD}$ | $V_{DD}$ | $V_{DDQ}$ | $V_{DDQ}$ | $DQP_{F9}$ | $DQP_{B9}$ | E |
| F | $DQ_{C4}$ | $DQ_{C8}$ | $V_{SS}$ | $V_{SS}$ | $V_{SS}$ | ZQ | $V_{SS}$ | $V_{SS}$ | $V_{SS}$ | $DQ_{F8}$ | $DQ_{F4}$ | F |
| G | $DQ_{C3}$ | $DQ_{C7}$ | $V_{DDQ}$ | $V_{DDQ}$ | $V_{DD}$ | MCH | $V_{DD}$ | $V_{DDQ}$ | $V_{DDQ}$ | $DQ_{F7}$ | $DQ_{F3}$ | G |
| H | $DQ_{C2}$ | $DQ_{C6}$ | $V_{SS}$ | $V_{SS}$ | $V_{SS}$ | MCL | $V_{SS}$ | $V_{SS}$ | $V_{SS}$ | $DQ_{F6}$ | $DQ_{F2}$ | H |
| J | $DQ_{C1}$ | $DQ_{C5}$ | $V_{DDQ}$ | $V_{DDQ}$ | $V_{DD}$ | MCH | $V_{DD}$ | $V_{DDQ}$ | $V_{DDQ}$ | $DQ_{F5}$ | $DQ_{F1}$ | J |
| K | NC | NC | CK | NC | $V_{SS}$ | MCL | $V_{SS}$ | NC | NC | NC | NC | K |
| L | $DQ_{H1}$ | $DQ_{H5}$ | $V_{DDQ}$ | $V_{DDQ}$ | $V_{DD}$ | $\overline{FT}$ | $V_{DD}$ | $V_{DDQ}$ | $V_{DDQ}$ | $DQ_{A5}$ | $DQ_{A1}$ | L |
| M | $DQ_{H2}$ | $DQ_{H6}$ | $V_{SS}$ | $V_{SS}$ | $V_{SS}$ | MCL | $V_{SS}$ | $V_{SS}$ | $V_{SS}$ | $DQ_{A6}$ | $DQ_{A2}$ | M |
| N | $DQ_{H3}$ | $DQ_{H7}$ | $V_{DDQ}$ | $V_{DDQ}$ | $V_{DD}$ | MCH | $V_{DD}$ | $V_{DDQ}$ | $V_{DDQ}$ | $DQ_{A7}$ | $DQ_{A3}$ | N |
| P | $DQ_{H4}$ | $DQ_{H8}$ | $V_{SS}$ | $V_{SS}$ | $V_{SS}$ | ZZ | $V_{SS}$ | $V_{SS}$ | $V_{SS}$ | $DQ_{A8}$ | $DQ_{A4}$ | P |
| R | $DQP_{D9}$ | $DQP_{H9}$ | $V_{DDQ}$ | $V_{DDQ}$ | $V_{DD}$ | $V_{DD}$ | $V_{DD}$ | $V_{DDQ}$ | $V_{DDQ}$ | $DQP_{A9}$ | $DQP_{E9}$ | R |
| T | $DQ_{D8}$ | $DQ_{D4}$ | $V_{SS}$ | NC | NC | $\overline{LBO}$ | $\overline{PE}$ | NC | $V_{SS}$ | $DQ_{E4}$ | $DQ_{E8}$ | T |
| U | $DQ_{D7}$ | $DQ_{D3}$ | NC | A12 | NC | A11 | **A18** | A10 | NC | $DQ_{E3}$ | $DQ_{E7}$ | U |
| V | $DQ_{D6}$ | $DQ_{D2}$ | A9 | A8 | A7 | A1 | A6 | A5 | A4 | $DQ_{E2}$ | $DQ_{E6}$ | V |
| W | $DQ_{D5}$ | $DQ_{D1}$ | TMS | TDI | A3 | A0 | A2 | TDO | TCK | $DQ_{E1}$ | $DQ_{E5}$ | W |

11 x 19 Bump BGA—14 x 22 $mm^2$ Body—1 mm Bump Pitch

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# GS8324Z36C Pad Out
## 209-Bump BGA—Top View

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | NC | NC | A13 | E2 | A14 | ADV | A15 | $\overline{E3}$ | A17 | $DQ_{B1}$ | $DQ_{B5}$ | A |
| B | NC | NC | $\overline{BC}$ | NC | **A19** | $\overline{W}$ | A16 | $\overline{BB}$ | NC | $DQ_{B2}$ | $DQ_{B6}$ | B |
| C | NC | NC | NC | $\overline{BD}$ | NC | $\overline{E1}$ | NC | NC | $\overline{BA}$ | $DQ_{B3}$ | $DQ_{B7}$ | C |
| D | NC | NC | $V_{SS}$ | NC | NC | $\overline{G}$ | NC | NC | $V_{SS}$ | $DQ_{B4}$ | $DQ_{B8}$ | D |
| E | NC | $DQP_{C9}$ | $V_{DDQ}$ | $V_{DDQ}$ | $V_{DD}$ | $V_{DD}$ | $V_{DD}$ | $V_{DDQ}$ | $V_{DDQ}$ | NC | $DQP_{B9}$ | E |
| F | $DQ_{C4}$ | $DQ_{C8}$ | $V_{SS}$ | $V_{SS}$ | $V_{SS}$ | ZQ | $V_{SS}$ | $V_{SS}$ | $V_{SS}$ | NC | NC | F |
| G | $DQ_{C3}$ | $DQ_{C7}$ | $V_{DDQ}$ | $V_{DDQ}$ | $V_{DD}$ | MCH | $V_{DD}$ | $V_{DDQ}$ | $V_{DDQ}$ | NC | NC | G |
| H | $DQ_{C2}$ | $DQ_{C6}$ | $V_{SS}$ | $V_{SS}$ | $V_{SS}$ | MCL | $V_{SS}$ | $V_{SS}$ | $V_{SS}$ | NC | NC | H |
| J | $DQ_{C1}$ | $DQ_{C5}$ | $V_{DDQ}$ | $V_{DDQ}$ | $V_{DD}$ | MCH | $V_{DD}$ | $V_{DDQ}$ | $V_{DDQ}$ | NC | NC | J |
| K | NC | NC | CK | NC | $V_{SS}$ | MCL | $V_{SS}$ | NC | NC | NC | NC | K |
| L | NC | NC | $V_{DDQ}$ | $V_{DDQ}$ | $V_{DD}$ | $\overline{FT}$ | $V_{DD}$ | $V_{DDQ}$ | $V_{DDQ}$ | $DQ_{A5}$ | $DQ_{A1}$ | L |
| M | NC | NC | $V_{SS}$ | $V_{SS}$ | $V_{SS}$ | MCL | $V_{SS}$ | $V_{SS}$ | $V_{SS}$ | $DQ_{A6}$ | $DQ_{A2}$ | M |
| N | NC | NC | $V_{DDQ}$ | $V_{DDQ}$ | $V_{DD}$ | MCH | $V_{DD}$ | $V_{DDQ}$ | $V_{DDQ}$ | $DQ_{A7}$ | $DQ_{A3}$ | N |
| P | NC | NC | $V_{SS}$ | $V_{SS}$ | $V_{SS}$ | ZZ | $V_{SS}$ | $V_{SS}$ | $V_{SS}$ | $DQ_{A8}$ | $DQ_{A4}$ | P |
| R | $DQP_{D9}$ | NC | $V_{DDQ}$ | $V_{DDQ}$ | $V_{DD}$ | $V_{DD}$ | $V_{DD}$ | $V_{DDQ}$ | $V_{DDQ}$ | $DQP_{A9}$ | NC | R |
| T | $DQ_{D8}$ | $DQ_{D4}$ | $V_{SS}$ | NC | NC | $\overline{LBO}$ | $\overline{PE}$ | NC | $V_{SS}$ | NC | NC | T |
| U | $DQ_{D7}$ | $DQ_{D3}$ | NC | A12 | NC | A11 | **A18** | A10 | NC | NC | NC | U |
| V | $DQ_{D6}$ | $DQ_{D2}$ | A9 | A8 | A7 | A1 | A6 | A5 | A4 | NC | NC | V |
| W | $DQ_{D5}$ | $DQ_{D1}$ | TMS | TDI | A3 | A0 | A2 | TDO | TCK | NC | NC | W |

11 x 19 Bump BGA—14 x 22 $mm^2$ Body—1 mm Bump Pitch

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# GS8324Z18C Pad Out
## 209-Bump BGA—Top View

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | NC | NC | A13 | **VDD** | A14 | ADV | A15 | **VSS** | A17 | NC | NC | A |
| B | NC | NC | $\overline{BB}$ | NC | **A19** | $\overline{W}$ | A16 | NC | NC | NC | NC | B |
| C | NC | NC | NC | NC | NC | $\overline{E1}$ | **A20** | NC | $\overline{BA}$ | NC | NC | C |
| D | NC | NC | $V_{SS}$ | NC | NC | $\overline{G}$ | NC | NC | $V_{SS}$ | NC | NC | D |
| E | NC | *DQP*$_{B9}$ | $V_{DDQ}$ | $V_{DDQ}$ | $V_{DD}$ | $V_{DD}$ | $V_{DD}$ | $V_{DDQ}$ | $V_{DDQ}$ | NC | NC | E |
| F | DQ$_{B4}$ | DQ$_{B8}$ | $V_{SS}$ | $V_{SS}$ | $V_{SS}$ | ZQ | $V_{SS}$ | $V_{SS}$ | $V_{SS}$ | NC | NC | F |
| G | DQ$_{B3}$ | DQ$_{B7}$ | $V_{DDQ}$ | $V_{DDQ}$ | $V_{DD}$ | MCH | $V_{DD}$ | $V_{DDQ}$ | $V_{DDQ}$ | NC | NC | G |
| H | DQ$_{B2}$ | DQ$_{B6}$ | $V_{SS}$ | $V_{SS}$ | $V_{SS}$ | MCL | $V_{SS}$ | $V_{SS}$ | $V_{SS}$ | NC | NC | H |
| J | DQ$_{B1}$ | DQ$_{B5}$ | $V_{DDQ}$ | $V_{DDQ}$ | $V_{DD}$ | MCH | $V_{DD}$ | $V_{DDQ}$ | $V_{DDQ}$ | NC | NC | J |
| K | NC | NC | CK | NC | $V_{SS}$ | MCL | $V_{SS}$ | NC | NC | NC | NC | K |
| L | NC | NC | $V_{DDQ}$ | $V_{DDQ}$ | $V_{DD}$ | $\overline{FT}$ | $V_{DD}$ | $V_{DDQ}$ | $V_{DDQ}$ | DQ$_{A5}$ | DQ$_{A1}$ | L |
| M | NC | NC | $V_{SS}$ | $V_{SS}$ | $V_{SS}$ | MCL | $V_{SS}$ | $V_{SS}$ | $V_{SS}$ | DQ$_{A6}$ | DQ$_{A2}$ | M |
| N | NC | NC | $V_{DDQ}$ | $V_{DDQ}$ | $V_{DD}$ | **VDD** | $V_{DD}$ | $V_{DDQ}$ | $V_{DDQ}$ | DQ$_{A7}$ | DQ$_{A3}$ | N |
| P | NC | NC | $V_{SS}$ | $V_{SS}$ | $V_{SS}$ | ZZ | $V_{SS}$ | $V_{SS}$ | $V_{SS}$ | DQ$_{A8}$ | DQ$_{A4}$ | P |
| R | NC | NC | $V_{DDQ}$ | $V_{DDQ}$ | $V_{DD}$ | $V_{DD}$ | $V_{DD}$ | $V_{DDQ}$ | $V_{DDQ}$ | *DQP*$_{A9}$ | NC | R |
| T | NC | NC | $V_{SS}$ | NC | NC | $\overline{LBO}$ | $\overline{PE}$ | NC | $V_{SS}$ | NC | NC | T |
| U | NC | NC | NC | A12 | NC | A11 | **A18** | A10 | NC | NC | NC | U |
| V | NC | NC | A9 | A8 | A7 | A1 | A6 | A5 | A4 | NC | NC | V |
| W | NC | NC | TMS | TDI | A3 | A0 | A2 | TDO | TCK | NC | NC | W |

11 x 19 Bump BGA—14 x 22 mm$^2$ Body—1 mm Bump Pitch

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## GS8324Z18/36/72 209-Bump BGA Pin Description

| Pin Location | Symbol | Type | Description |
|---|---|---|---|
| W6, V6 | $A_0$, $A_1$ | I | Address field LSBs and Address Counter Preset Inputs. |
| W7, W5, V9, V8, V7, V5, V4, V3, U8, U6, U4, A3, A5, A7, B7, A9, U7 | An | I | Address Inputs |
| B5 | $A_{19}$ | I | Address Inputs (x36/x18 Versions) |
| C7 | $A_{20}$ | I | Address Inputs (x18 Version) |
| L11, M11, N11, P11, L10, M10, N10, P10, R10<br>A10, B10, C10, D10, A11, B11, C11, D11, E11<br>J1, H1, G1, F1, J2, H2, G2, F2, E2<br>W2, V2, U2, T2, W1, V1, U1, T1, R1<br>W10, V10, U10, T10, W11, V11, U11, T11, R11<br>J11, H11, G11, F11, J10, H10, G10, F10, E10<br>A2, B2, C2, D2, A1, B1, C1, D1, E1<br>L1, M1, N1, P1, L2, M2, N2, P2, R2 | $DQ_{A1}$–$DQ_{A9}$<br>$DQ_{B1}$–$DQ_{B9}$<br>$DQ_{C1}$–$DQ_{C9}$<br>$DQ_{D1}$–$DQ_{D9}$<br>$DQ_{E1}$–$DQ_{E9}$<br>$DQ_{F1}$–$DQ_{F9}$<br>$DQ_{G1}$–$DQ_{G9}$<br>$DQ_{H1}$–$DQ_{H9}$ | I/O | Data Input and Output pins (x72 Version) |
| L11, M11, N11, P11, L10, M10, N10, P10, R10<br>A10, B10, C10, D10, A11, B11, C11, D11, E11<br>J1, H1, G1, F1, J2, H2, G2, F2, E2<br>W2, V2, U2, T2, W1, V1, U1, T1, R1 | $DQ_{A1}$–$DQ_{A9}$<br>$DQ_{B1}$–$DQ_{B9}$<br>$DQ_{C1}$–$DQ_{C9}$<br>$DQ_{D1}$–$DQ_{D9}$ | I/O | Data Input and Output pins (x36 Version) |
| L11, M11, N11, P11, L10, M10, N10, P10, R10<br>J1, H1, G1, F1, J2, H2, G2, F2, E2 | $DQ_{A1}$–$DQ_{A9}$<br>$DQ_{B1}$–$DQ_{B9}$ | I/O | Data Input and Output pins (x18 Version) |
| C9, B8 | $\overline{B}_A$, $\overline{B}_B$ | I | Byte Write Enable for $DQ_A$, $DQ_B$ I/Os; active low |
| B3, C4 | $\overline{B}_C$,$\overline{B}_D$ | I | Byte Write Enable for $DQ_C$, $DQ_D$ I/Os; active low (x72/x36 Versions) |
| C8, B9, B4, C3 | $\overline{B}_E$, $\overline{B}_F$, $\overline{B}_G$,$\overline{B}_H$ | I | Byte Write Enable for $DQ_E$, $DQ_F$, $DQ_G$, $DQ_H$ I/Os; active low (x72 Version) |
| B5 | NC | — | No Connect (x72 Version) |
| C7 | NC | — | No Connect (x72/x36 Versions) |
| W10, V10, U10, T10, W11, V11, U11, T11, R11<br>J11, H11, G11, F11, J10, H10, G10, F10, E10<br>A2, B2, C2, D2, A1, B1, C1, D1, E1<br>L1, M1, N1, P1, L2, M2, N2, P2, R2, C8, B9, B4, C3 | NC | — | No Connect (x36/x18 Versions) |
| B3, C4 | NC | — | No Connect (x18 Version) |
| C5, D4, D5, D7, D8, K1, K2, K4, K8, K9, K10, K11, T4, T5, T7, T8, U3, U5, U9 | NC | — | No Connect |
| K3 | CK | I | Clock Input Signal; active high |
| C6 | $\overline{E}_1$ | I | Chip Enable; active low |
| A8 | $\overline{E}_3$ | I | Chip Enable; active low (x72/x36 Versions) |
| A4 | $E_2$ | I | Chip Enable; active high (x72/x36 Versions) |
| D6 | $\overline{G}$ | I | Output Enable; active low |
| A6 | ADV | I | Burst address counter advance enable |

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## GS8324Z18/36/72 209-Bump BGA Pin Description

| Pin Location | Symbol | Type | Description |
|---|---|---|---|
| P6 | ZZ | I | Sleep Mode control; active high |
| L6 | $\overline{FT}$ | I | Flow Through or Pipeline mode; active low |
| T6 | $\overline{LBO}$ | I | Linear Burst Order mode; active low |
| G6, J6 | MCH | I | Must Connect High |
| N6 | MCH | I | Must Connect High (x72 and x36 versions) |
| H6, J6, K6, M6 | MCL | | Must Connect Low |
| A8, N6 | MCL | | Must Connect Low (x18 version) |
| B6 | $\overline{W}$ | I | Write Enable; active low |
| T7 | $\overline{PE}$ | I | Parity Bit Enable; active low (High = x16/32 Mode, Low = x18/36 Mode) |
| F6 | ZQ | I | FLXDrive Output Impedance Control (Low = Low Impedance [High Drive], High = High Impedance [Low Drive]) |
| W3 | TMS | I | Scan Test Mode Select |
| W4 | TDI | I | Scan Test Data In |
| W8 | TDO | O | Scan Test Data Out |
| W9 | TCK | I | Scan Test Clock |
| A4, N6 | $V_{DD}$ | I | Core power supply (x18 version) |
| E5, E6, E7, G5, G7, J5, J7, L5, L7, N5, N7, R5, R6, R7 | $V_{DD}$ | I | Core power supply |
| D3, D9, F3, F4, F5, F7, F8, F9, H3, H4, H5, H7, H8, H9, K5, K7, M3, M4, M5, M7, M8, M9, P3, P4, P5, P7, P8, P9, T3, T9 | $V_{SS}$ | I | I/O and Core Ground |
| E3, E4, E8, E9, G3, G4, G8, G9, J3, J4, J8, J9, L3, L4, L8, L9, N3, N4, N8, N9, R3, R4, R8, R9 | $V_{DDQ}$ | I | Output driver power supply |

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# GS8324Z36B Pad Out

## 119-Bump BGA—Top View

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | |
|---|---|---|---|---|---|---|---|---|
| A | $V_{DDQ}$ | A6 | A7 | A18 | A8 | A9 | $V_{DDQ}$ | A |
| B | NC | E2 | A4 | ADV | A15 | $\overline{E3}$ | NC | B |
| C | NC | A5 | A3 | $V_{DD}$ | A14 | A16 | NC | C |
| D | DQC | *DQPC* | $V_{SS}$ | ZQ | $V_{SS}$ | *DQPB* | DQB | D |
| E | DQC | DQC | $V_{SS}$ | $\overline{E1}$ | $V_{SS}$ | DQB | DQB | E |
| F | $V_{DDQ}$ | DQC | $V_{SS}$ | $\overline{G}$ | $V_{SS}$ | DQB | $V_{DDQ}$ | F |
| G | DQC | DQC | $\overline{BC}$ | A17 | $\overline{BB}$ | DQB | DQB | G |
| H | DQC | DQC | $V_{SS}$ | $\overline{W}$ | $V_{SS}$ | DQB | DQB | H |
| J | $V_{DDQ}$ | $V_{DD}$ | NC | $V_{DD}$ | NC | $V_{DD}$ | $V_{DDQ}$ | J |
| K | DQD | DQD | $V_{SS}$ | CK | $V_{SS}$ | DQA | DQA | K |
| L | DQD | DQD | $\overline{BD}$ | NC | $\overline{BA}$ | DQA | DQA | L |
| M | $V_{DDQ}$ | DQD | $V_{SS}$ | $\overline{CKE}$ | $V_{SS}$ | DQA | $V_{DDQ}$ | M |
| N | DQD | DQD | $V_{SS}$ | A1 | $V_{SS}$ | DQA | DQA | N |
| P | DQD | *DQPD* | $V_{SS}$ | A0 | $V_{SS}$ | *DQPA* | DQA | P |
| R | NC | A2 | $\overline{LBO}$ | $V_{DD}$ | $\overline{FT}$ | A13 | $\overline{PE}$ | R |
| T | NC | NC | A10 | A11 | A12 | **A19** | ZZ | T |
| U | $V_{DDQ}$ | TMS | TDI | TCK | TDO | NC | $V_{DDQ}$ | U |

7 x 17 Bump BGA—14 x 22 $mm^2$ Body—1.27 mm Bump Pitch

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# GS8324Z18B Pad Out

## 119-Bump BGA—Top View

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | |
|---|---|---|---|---|---|---|---|---|
| A | $V_{DDQ}$ | A6 | A7 | A18 | A8 | A9 | $V_{DDQ}$ | A |
| B | NC | **VDD** | A4 | ADV | A15 | **VSS** | NC | B |
| C | NC | A5 | A3 | $V_{DD}$ | A14 | A16 | NC | C |
| D | DQB | NC | $V_{SS}$ | ZQ | $V_{SS}$ | *DQPA* | NC | D |
| E | NC | DQB | $V_{SS}$ | $\overline{E1}$ | $V_{SS}$ | NC | DQA | E |
| F | $V_{DDQ}$ | NC | $V_{SS}$ | $\overline{G}$ | $V_{SS}$ | DQA | $V_{DDQ}$ | F |
| G | NC | DQB | $\overline{BB}$ | A17 | NC | NC | DQA | G |
| H | DQB | NC | $V_{SS}$ | $\overline{W}$ | $V_{SS}$ | DQA | NC | H |
| J | $V_{DDQ}$ | $V_{DD}$ | NC | $V_{DD}$ | NC | $V_{DD}$ | $V_{DDQ}$ | J |
| K | NC | DQB | $V_{SS}$ | CK | $V_{SS}$ | NC | DQA | K |
| L | DQB | NC | NC | **VDD** | $\overline{BA}$ | DQA | NC | L |
| M | $V_{DDQ}$ | DQB | $V_{SS}$ | $\overline{CKE}$ | $V_{SS}$ | NC | $V_{DDQ}$ | M |
| N | DQB | NC | $V_{SS}$ | A1 | $V_{SS}$ | DQA | NC | N |
| P | NC | *DQPB* | $V_{SS}$ | A0 | $V_{SS}$ | NC | DQA | P |
| R | NC | A2 | $\overline{LBO}$ | $V_{DD}$ | $\overline{FT}$ | A13 | $\overline{PE}$ | R |
| T | NC | A10 | A11 | **A20** | A12 | A19 | ZZ | T |
| U | $V_{DDQ}$ | TMS | TDI | TCK | TDO | NC | $V_{DDQ}$ | U |

7 x 17 Bump BGA—14 x 22 $mm^2$ Body—1.27 mm Bump Pitch

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## GS8324Z18/36 119-Bump BGA Pin Description

| Pin Location | Symbol | Type | Description |
|---|---|---|---|
| P4, N4 | $A_0$, $A_1$ | I | Address field LSBs and Address Counter Preset Inputs |
| R2, C3, B3, C2, A2, A3, A5, A6, T3, T5, R6, C5, B5, C6, G4, A4 | An | I | Address Inputs |
| T4, T6 | An | | Address Input (x36 Version) |
| T2 | NC | — | No Connect (x36 Version) |
| T2, T6, T4 | An | I | Address Input (x18 Version) |
| K7, L7, N7, P7, K6, L6, M6, N6 H7, G7, E7, D7, H6, G6, F6, E6 H1, G1, E1, D1, H2, G2, F2, E2 K1, L1, N1, P1, K2, L2, M2, N2 | $DQ_{A1}$–$DQ_{A8}$ $DQ_{B1}$–$DQ_{B8}$ $DQ_{C1}$–$DQ_{C8}$ $DQ_{D1}$–$DQ_{D8}$ | I/O | Data Input and Output pins. (x36 Version) |
| P6, D6, D2, P2 | $DQ_{A9}$, $DQ_{B9}$, $DQ_{C9}$, $DQ_{D9}$ | I/O | Data Input and Output pins. (x36 Version) |
| L5, G5, G3, L3 | $\overline{B}_A$, $\overline{B}_B$, $\overline{B}_C$, $\overline{B}_D$ | I | Byte Write Enable for $DQ_A$, $DQ_B$, $DQ_C$, $DQ_D$ I/Os; active low (x36 Version) |
| P7, N6, L6, K7, H6, G7, F6, E7, D6 D1, E2, G2, H1, K2, L1, M2, N1, P2 | $DQ_{A1}$–$DQ_{A9}$ $DQ_{B1}$–$DQ_{B9}$ | I/O | Data Input and Output pins (x18 Version) |
| L5, G3 | $\overline{B}_A$, $\overline{B}_B$ | I | Byte Write Enable for $DQ_A$, $DQ_B$ I/Os; active low (x18 Version) |
| B1, C1, R1, T1, U6, B7, C7, J3, J5 | NC | — | No Connect |
| P6, N7, M6, L7, K6, H7, G6, E6, D7, D2, E1, F2, G1, H2, K1, L2, N2, P1, G5, L3 | NC | — | No Connect (x18 Version) |
| L4 | NC | — | No Connect (x36 Version) |
| K4 | CK | I | Clock Input Signal; active high |
| M4 | $\overline{CKE}$ | I | Clock Enable; active low |
| H4 | $\overline{W}$ | I | Write Enable; active low |
| E4 | $\overline{E}_1$ | I | Chip Enable; active low |
| B6 | $\overline{E}_3$ | I | Chip Enable; active low (x36 version) |
| B2 | $E_2$ | I | Chip Enable; active high (x36 version) |
| F4 | $\overline{G}$ | I | Output Enable; active low |
| B4 | ADV | I | Burst address counter advance enable |
| T7 | ZZ | I | Sleep mode control; active high |
| R5 | $\overline{FT}$ | I | Flow Through or Pipeline mode; active low |
| R3 | $\overline{LBO}$ | I | Linear Burst Order mode; active low |
| D4 | ZQ | I | FLXDrive Output Impedance Control (Low = Low Impedance [High Drive], High = High Impedance [Low Drive]) |
| R7 | $\overline{PE}$ | I | Parity Bit Enable; active low |
| U2 | TMS | I | Scan Test Mode Select |
| U3 | TDI | I | Scan Test Data In |

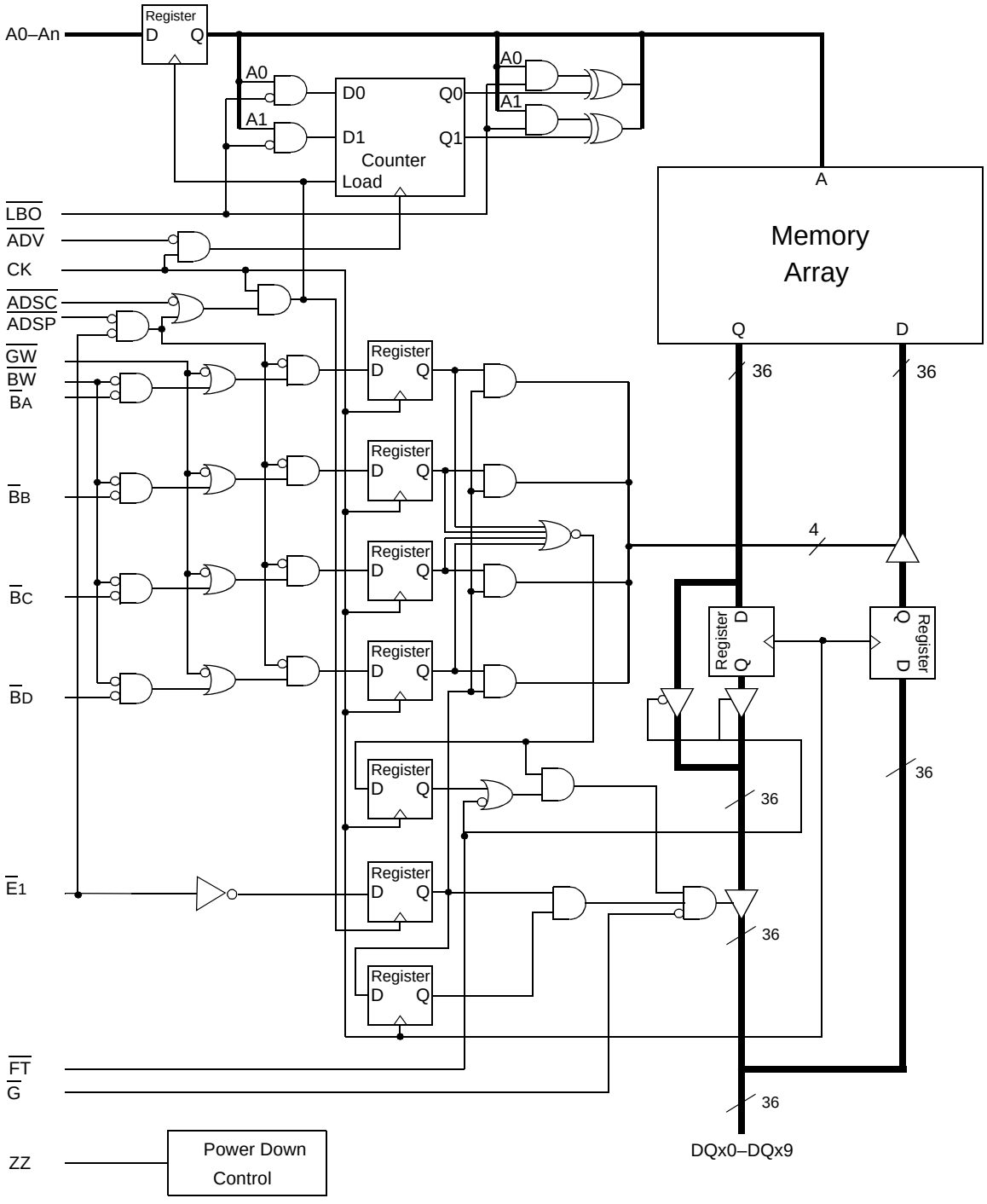
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## GS8324Z18/36 119-Bump BGA Pin Description

| Pin Location | Symbol | Type | Description |
|---|---|---|---|
| U5 | TDO | O | Scan Test Data Out |
| U4 | TCK | I | Scan Test Clock |
| J2, C4, J4, R4, J6 | $V_{DD}$ | I | Core power supply |
| B2, L4 | $V_{DD}$ | I | Core power supply (x18 version) |
| D3, E3, F3, H3, K3, M3, N3, P3, D5, E5, F5, H5, K5, M5, N5, P5 | $V_{SS}$ | I | I/O and Core Ground |
| B6 | $V_{SS}$ | I | I/O and Core Ground (x18 version) |
| A1, F1, J1, M1, U1, A7, F7, J7, M7, U7 | $V_{DDQ}$ | I | Output driver power supply |

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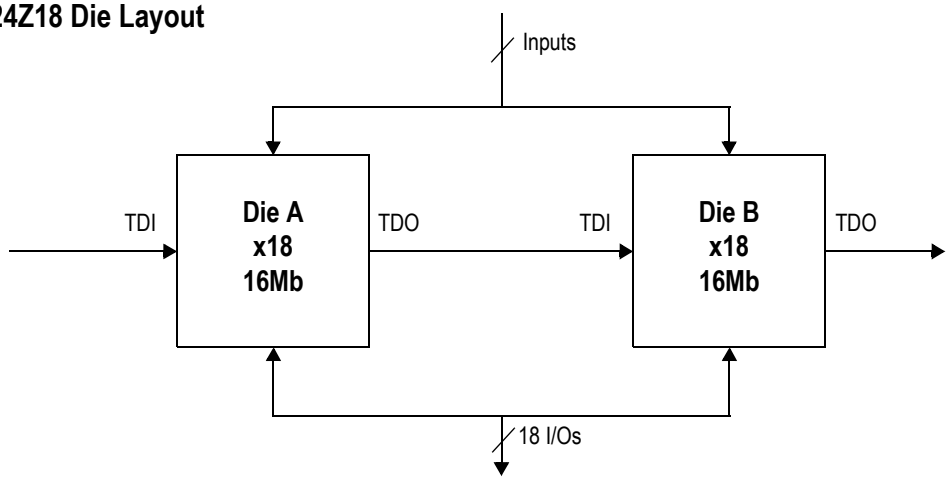
## GS8324Z18/36/72 Block Diagram



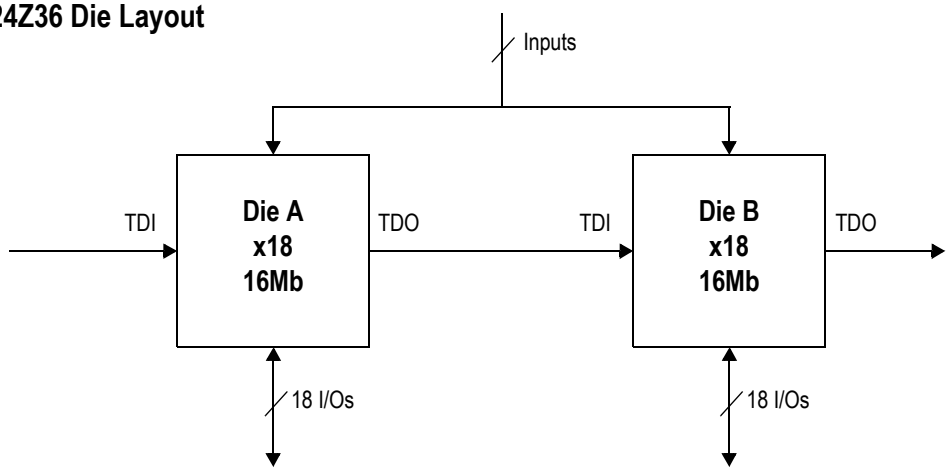

Note: Only x36 version shown for simplicity.

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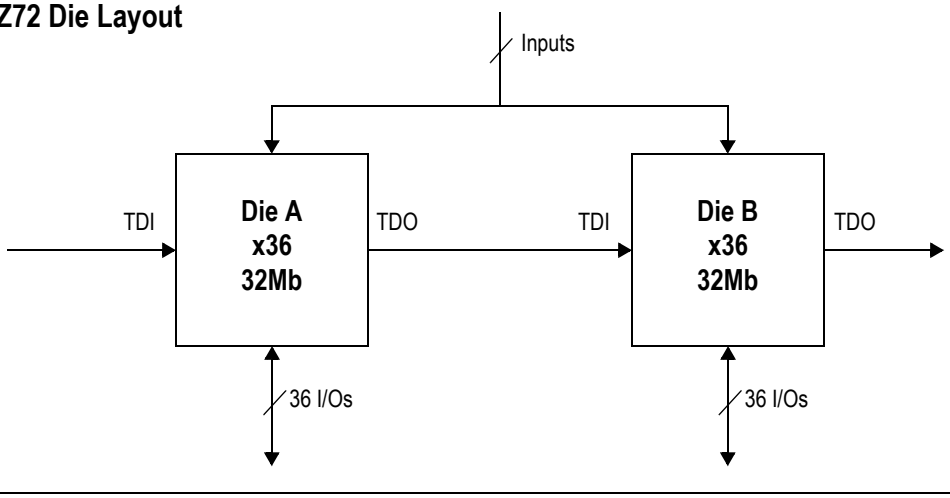
**GS8324Z18 Die Layout**




**GS8324Z36 Die Layout**




**GS8324Z72 Die Layout**




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# Functional Details

## Clocking

Deassertion of the Clock Enable ($\overline{CKE}$) input blocks the Clock input from reaching the RAM's internal circuits. It may be used to suspend RAM operations. Failure to observe Clock Enable set-up or hold requirements will result in erratic operation.

## Pipeline Mode Read and Write Operations

All inputs (with the exception of Output Enable, Linear Burst Order and Sleep) are synchronized to rising clock edges. Single cycle read and write operations must be initiated with the Advance/Load pin (ADV) held low, in order to load the new address. Device activation is accomplished by asserting all three of the Chip Enable inputs ($\overline{E}_1$, $E_2$, and $\overline{E}_3$). Deassertion of any one of the Enable inputs will deactivate the device.

| Function | $\overline{W}$ | $\overline{B}_A$ | $\overline{B}_B$ | $\overline{B}_C$ | $\overline{B}_D$ |
|---|---|---|---|---|---|
| Read | H | X | X | X | X |
| Write Byte “a” | L | L | H | H | H |
| Write Byte “b” | L | H | L | H | H |
| Write Byte “c” | L | H | H | L | H |
| Write Byte “d” | L | H | H | H | L |
| Write all Bytes | L | L | L | L | L |
| Write Abort/NOP | L | H | H | H | H |

Read operation is initiated when the following conditions are satisfied at the rising edge of clock: $\overline{CKE}$ is asserted low, all three chip enables ($\overline{E}_1$, $E_2$, and $\overline{E}_3$) are active, the write enable input signals $\overline{W}$ is deasserted high, and ADV is asserted low. The address presented to the address inputs is latched into the address register and presented to the memory core and control logic. The control logic determines that a read access is in progress and allows the requested data to propagate to the input of the output register. At the next rising edge of clock the read data is allowed to propagate through the output register and onto the output pins.

Write operation occurs when the RAM is selected, CKE is active, and the Write input is sampled low at the rising edge of clock. The Byte Write Enable inputs ($\overline{B}_A$, $\overline{B}_B$, $\overline{B}_C$, and $\overline{B}_D$) determine which bytes will be written. All or none may be activated. A write cycle with no Byte Write inputs active is a no-op cycle. The pipelined NBT SRAM provides double late write functionality, matching the write command versus data pipeline length (2 cycles) to the read command versus data pipeline length (2 cycles). At the first rising edge of clock, Enable, Write, Byte Write(s), and Address are registered. The Data In associated with that address is required at the third rising edge of clock.

## Flow Through Mode Read and Write Operations

Operation of the RAM in Flow Through mode is very similar to operations in Pipeline mode. Activation of a Read Cycle and the use of the Burst Address Counter is identical. In Flow Through mode the device may begin driving out new data immediately after new address are clocked into the RAM, rather than holding new data until the following (second) clock edge. Therefore, in Flow Through mode the read pipeline is one cycle shorter than in Pipeline mode.

Write operations are initiated in the same way, but differ in that the write pipeline is one cycle shorter as well, preserving the ability to turn the bus from reads to writes without inserting any dead cycles. While the pipelined NBT RAMs implement a double late write protocol in Flow Through mode a single late write protocol mode is observed. Therefore, in Flow Through mode, address and control are registered on the first rising edge of clock and data in is required at the data input pins at the second rising edge of clock.

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### Byte Write Truth Table

| Function | $\overline{GW}$ | $\overline{BW}$ | $\overline{B}_A$ | $\overline{B}_B$ | $\overline{B}_C$ | $\overline{B}_D$ | Notes |
|---|---|---|---|---|---|---|---|
| Read | H | H | X | X | X | X | 1 |
| Read | H | L | H | H | H | H | 1 |
| Write byte a | H | L | L | H | H | H | 2, 3 |
| Write byte b | H | L | H | L | H | H | 2, 3 |
| Write byte c | H | L | H | H | L | H | 2, 3, 4 |
| Write byte d | H | L | H | H | H | L | 2, 3, 4 |
| Write all bytes | H | L | L | L | L | L | 2, 3, 4 |
| Write all bytes | L | X | X | X | X | X | |

Notes:
1. All byte outputs are active in read cycles regardless of the state of Byte Write Enable inputs.
2. Byte Write Enable inputs $\overline{B}_A$, $\overline{B}_B$, $\overline{B}_C$, and/or $\overline{B}_D$ may be used in any combination with $\overline{BW}$ to write single or multiple bytes.
3. All byte I/Os remain High-Z during all write operations regardless of the state of Byte Write Enable inputs.
4. Bytes "C" and "D" are only available on the x36 version.

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## Synchronous Truth Table (x72 and x36 209-Bump BGA)

| Operation | Type | Address | $\overline{E}_1$ | $E_2$ | $\overline{E}_3$ | ZZ | ADV | $\overline{W}$ | $\overline{Bx}$ | $\overline{G}$ | $\overline{CKE}$ | CK | DQ | Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Deselect Cycle, Power Down | D | None | H | X | X | L | L | X | X | X | L | L-H | High-Z | |
| Deselect Cycle, Power Down | D | None | X | X | H | L | L | X | X | X | L | L-H | High-Z | |
| Deselect Cycle, Power Down | D | None | X | L | X | L | L | X | X | X | L | L-H | High-Z | |
| Deselect Cycle, Continue | D | None | X | X | X | L | H | X | X | X | L | L-H | High-Z | 1 |
| Read Cycle, Begin Burst | R | External | L | H | L | L | L | H | X | L | L | L-H | Q | |
| Read Cycle, Continue Burst | B | Next | X | X | X | L | H | X | X | L | L | L-H | Q | 1,10 |
| NOP/Read, Begin Burst | R | External | L | H | L | L | L | H | X | H | L | L-H | High-Z | 2 |
| Dummy Read, Continue Burst | B | Next | X | X | X | L | H | X | X | H | L | L-H | High-Z | 1,2,10 |
| Write Cycle, Begin Burst | W | External | L | H | L | L | L | L | L | X | L | L-H | D | 3 |
| Write Cycle, Continue Burst | B | Next | X | X | X | L | H | X | L | X | L | L-H | D | 1,3,10 |
| NOP/Write Abort, Begin Burst | W | None | L | H | L | L | L | L | H | X | L | L-H | High-Z | 2,3 |
| Write Abort, Continue Burst | B | Next | X | X | X | L | H | X | H | X | L | L-H | High-Z | 1,2,3,10 |
| Clock Edge Ignore, Stall | | Current | X | X | X | L | X | X | X | X | H | L-H | - | 4 |
| Sleep Mode | | None | X | X | X | H | X | X | X | X | X | X | High-Z | |

Notes:
1. Continue Burst cycles, whether Read or Write, use the same control inputs. A Deselect continue cycle can only be entered into if a Deselect cycle is executed first.
2. Dummy Read and Write abort can be considered NOPs because the SRAM performs no operation. A Write abort occurs when the $\overline{W}$ pin is sampled low but no Byte Write pins are active, so no write operation is performed.
3. $\overline{G}$ can be wired low to minimize the number of control signals provided to the SRAM. Output drivers will automatically turn off during write cycles.
4. If $\overline{CKE}$ High occurs during a pipelined read cycle, the DQ bus will remain active (Low Z). If $\overline{CKE}$ High occurs during a write cycle, the bus will remain in High Z.
5. X = Don't Care; H = Logic High; L = Logic Low; $\overline{Bx}$ = High = All Byte Write signals are high; $\overline{Bx}$ = Low = One or more Byte/Write signals are Low
6. All inputs, except $\overline{G}$ and ZZ must meet setup and hold times of rising clock edge.
7. Wait states can be inserted by setting $\overline{CKE}$ high.
8. This device contains circuitry that ensures all outputs are in High Z during power-up.
9. A 2-bit burst counter is incorporated.
10. The address counter is incriminated for all Burst continue cycles.

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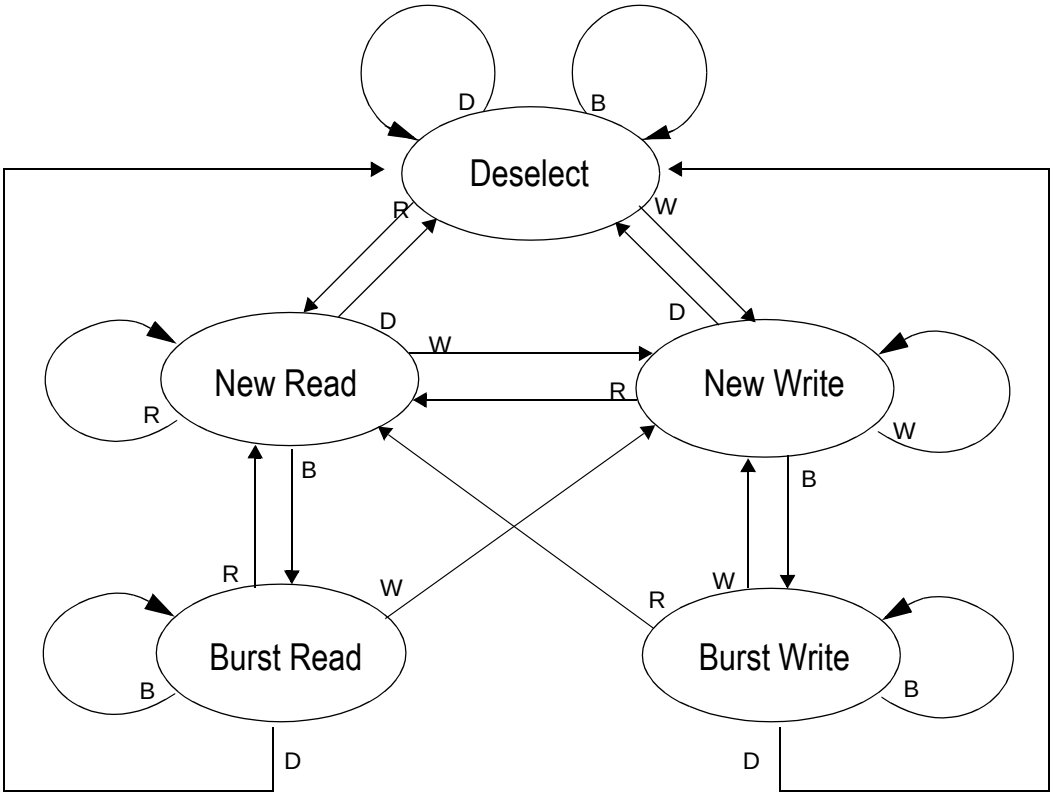
## Synchronous Truth Table (x18 209-Bump BGA and x36/x18 119-Bump BGA)

| Operation | Type | Address | $\overline{E}_1$ | ZZ | ADV | $\overline{W}$ | $\overline{Bx}$ | $\overline{G}$ | $\overline{CKE}$ | CK | DQ | Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Deselect Cycle, Power Down | D | None | H | L | L | X | X | X | L | L-H | High-Z | |
| Deselect Cycle, Power Down | D | None | X | L | L | X | X | X | L | L-H | High-Z | |
| Deselect Cycle, Power Down | D | None | X | L | L | X | X | X | L | L-H | High-Z | |
| Deselect Cycle, Continue | D | None | X | L | H | X | X | X | L | L-H | High-Z | 1 |
| Read Cycle, Begin Burst | R | External | L | L | L | H | X | L | L | L-H | Q | |
| Read Cycle, Continue Burst | B | Next | X | L | H | X | X | L | L | L-H | Q | 1,10 |
| NOP/Read, Begin Burst | R | External | L | L | L | H | X | H | L | L-H | High-Z | 2 |
| Dummy Read, Continue Burst | B | Next | X | L | H | X | X | H | L | L-H | High-Z | 1,2,10 |
| Write Cycle, Begin Burst | W | External | L | L | L | L | L | X | L | L-H | D | 3 |
| Write Cycle, Continue Burst | B | Next | X | L | H | X | L | X | L | L-H | D | 1,3,10 |
| NOP/Write Abort, Begin Burst | W | None | L | L | L | L | H | X | L | L-H | High-Z | 2,3 |
| Write Abort, Continue Burst | B | Next | X | L | H | X | H | X | L | L-H | High-Z | 1,2,3,10 |
| Clock Edge Ignore, Stall | | Current | X | L | X | X | X | X | H | L-H | - | 4 |
| Sleep Mode | | None | X | H | X | X | X | X | X | X | High-Z | |

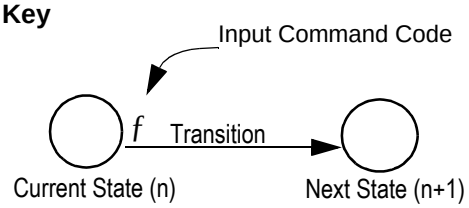
Notes:
1. Continue Burst cycles, whether Read or Write, use the same control inputs. A Deselect continue cycle can only be entered into if a Deselect cycle is executed first.
2. Dummy Read and Write abort can be considered NOPs because the SRAM performs no operation. A Write abort occurs when the $\overline{W}$ pin is sampled low but no Byte Write pins are active, so no write operation is performed.
3. $\overline{G}$ can be wired low to minimize the number of control signals provided to the SRAM. Output drivers will automatically turn off during write cycles.
4. If $\overline{CKE}$ High occurs during a pipelined read cycle, the DQ bus will remain active (Low Z). If $\overline{CKE}$ High occurs during a write cycle, the bus will remain in High Z.
5. X = Don't Care; H = Logic High; L = Logic Low; $\overline{Bx}$ = High = All Byte Write signals are high; $\overline{Bx}$ = Low = One or more Byte/ Write signals are Low
6. All inputs, except $\overline{G}$ and ZZ must meet setup and hold times of rising clock edge.
7. Wait states can be inserted by setting $\overline{CKE}$ high.
8. This device contains circuitry that ensures all outputs are in High Z during power-up.
9. A 2-bit burst counter is incorporated.
10. The address counter is incriminated for all Burst continue cycles.

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## Pipelined and Flow Through Read Write Control State Diagram

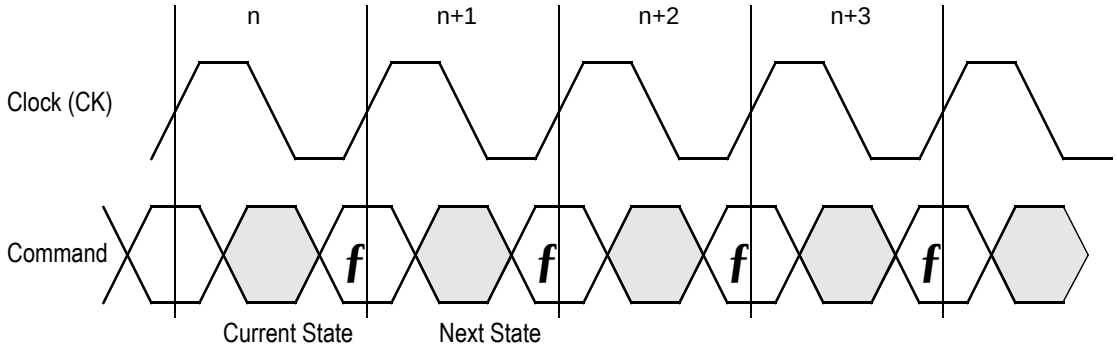



**Key**




**Notes**

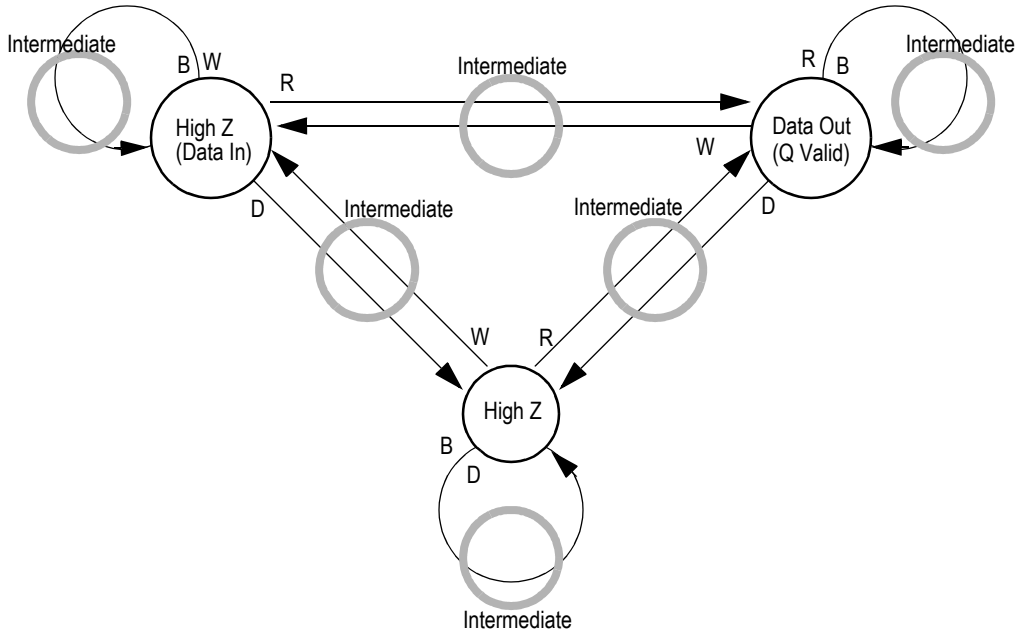
1. The Hold command ($\overline{CKE}$ Low) is not shown because it prevents any state change.
2. W, R, B, and D represent input command codes as indicated in the Synchronous Truth Table.



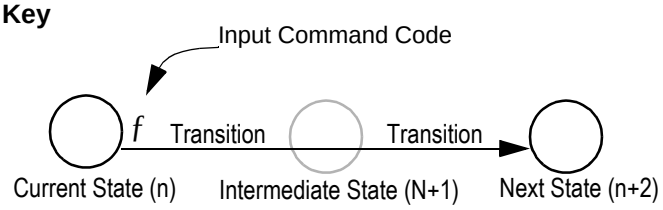

**Current State and Next State Definition for Pipelined and Flow through Read/Write Control State Diagram**

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## Pipeline Mode Data I/O State Diagram

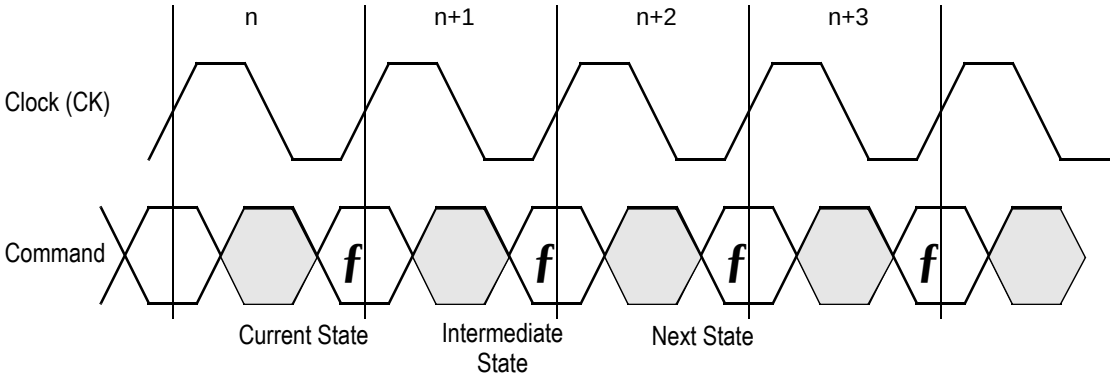



**Key**




**Notes**

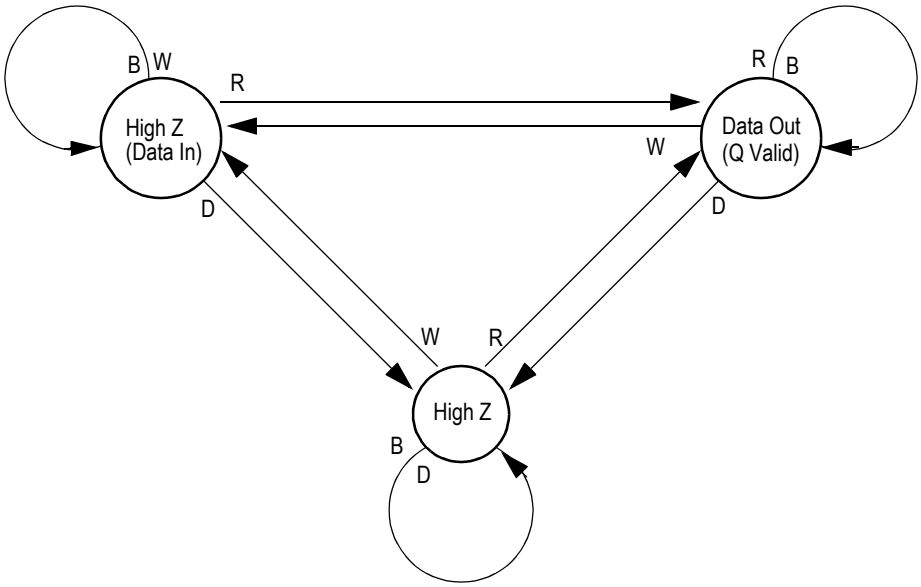
1. The Hold command ($\overline{\text{CKE}}$ Low) is not shown because it prevents any state change.
2. W, R, B, and D represent input command codes as indicated in the Truth Tables.



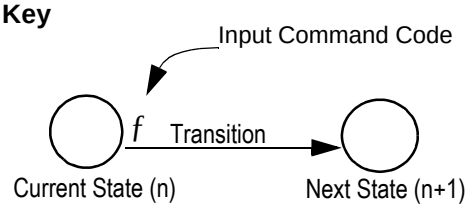

**Current State and Next State Definition for Pipeline Mode Data I/O State Diagram**

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## Flow Through Mode Data I/O State Diagram

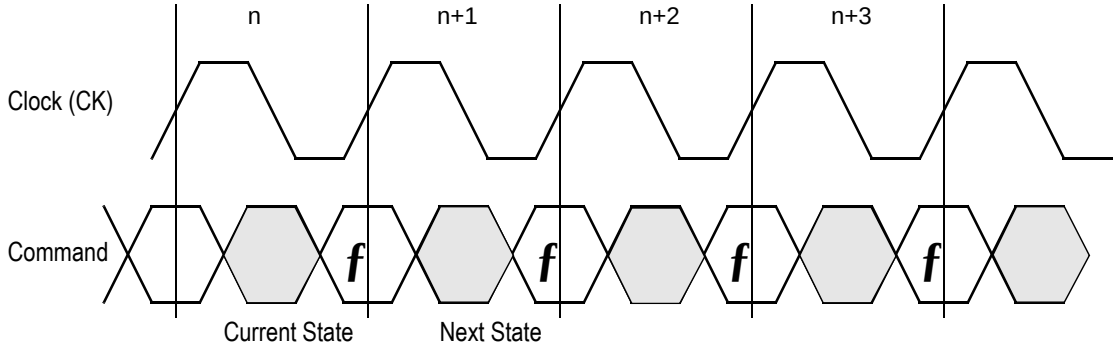



**Key**




**Notes**

1. The Hold command ($\overline{CKE}$ Low) is not shown because it prevents any state change.
2. W, R, B, and D represent input command codes as indicated in the Truth Tables.




**Current State and Next State Definition for: Pipeline and Flow Through Read Write Control State Diagram**

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## Burst Cycles

Although NBT RAMs are designed to sustain 100% bus bandwidth by eliminating turnaround cycle when there is transition from read to write, multiple back-to-back reads or writes may also be performed. NBT SRAMs provide an on-chip burst address generator that can be utilized, if desired, to further simplify burst read or write implementations. The ADV control pin, when driven high, commands the SRAM to advance the internal address counter and use the counter generated address to read or write the SRAM. The starting address for the first cycle in a burst cycle series is loaded into the SRAM by driving the ADV pin low, into Load mode.

## Burst Order

The burst address counter wraps around to its initial state after four addresses (the loaded address and three more) have been accessed. The burst sequence is determined by the state of the Linear Burst Order pin ($\overline{LBO}$). When this pin is Low, a linear burst sequence is selected. When the RAM is installed with the LBO pin tied high, Interleaved burst sequence is selected. See the tables below for details.

## Mode Pin Functions

| Mode Name | Pin Name | State | Function |
|---|---|---|---|
| Burst Order Control | $\overline{LBO}$ | L | Linear Burst |
| | | H | Interleaved Burst |
| Output Register Control | $\overline{FT}$ | L | Flow Through |
| | | H or NC | Pipeline |
| Power Down Control | ZZ | L or NC | Active |
| | | H | Standby, $I_{DD} = I_{SB}$ |
| Parity Enable | $\overline{PE}$ | L or NC | Activate 9th I/O's (x18/36 Mode) |
| | | H | Deactivate 9th I/O's (x16/32 Mode) |
| FLXDrive Output Impedance Control | ZQ | L | High Drive (Low Impedance) |
| | | H or NC | Low Drive (High Impedance) |

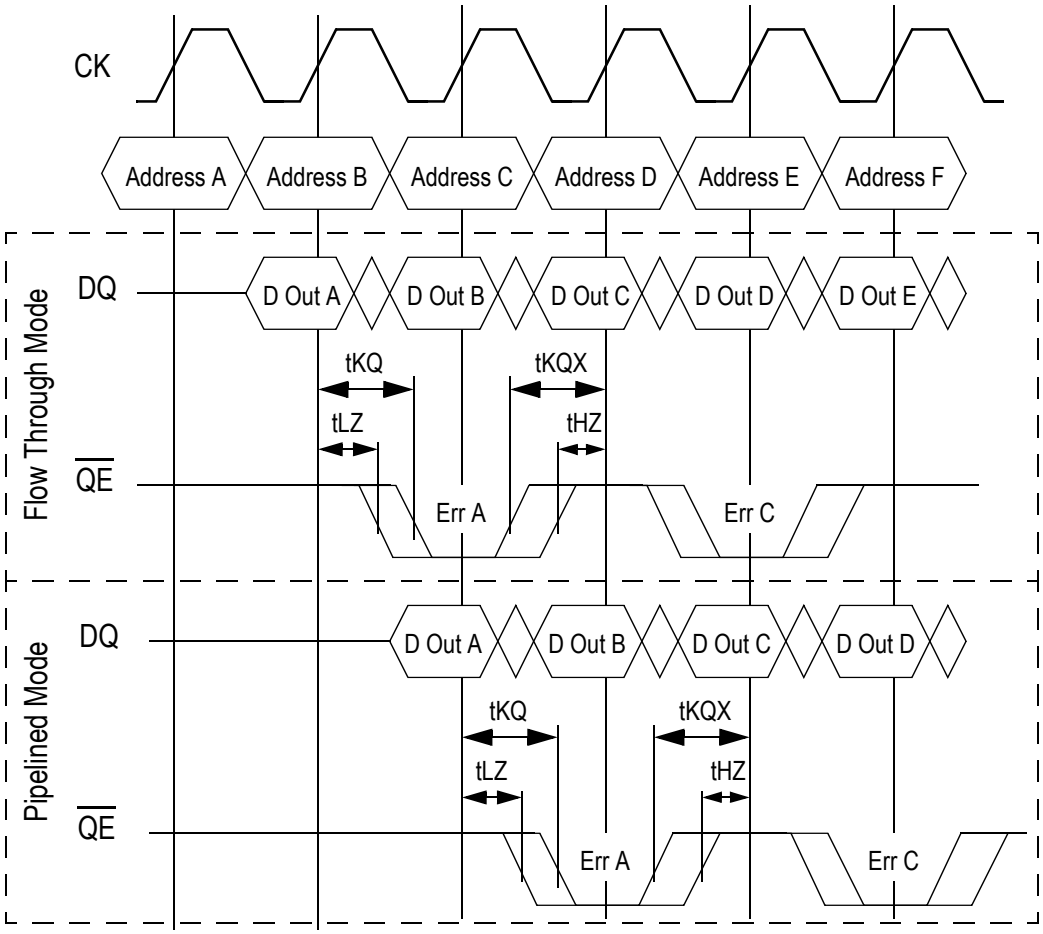
Note:
There are pull-up devices on the ZQ, SCD DP, and $\overline{FT}$ pins and a pull-down devices on the $\overline{PE}$ and ZZ pins, so those input pins can be unconnected and the chip will operate in the default states as specified in the above tables.

## Enable/Disable Parity I/O Pins

This SRAM allows the user to configure the device to operate in Parity I/O active (x18, x36, or x72) or in Parity I/O inactive (x16, x32, or x64) mode. Holding the $\overline{PE}$ bump low or letting it float will activate the 9th I/O on each byte of the RAM. Grounding $\overline{PE}$ deactivates the 9th I/O of each byte, although the bit in each byte of the memory array remains active to store and recall parity bits generated and read into the ByteSafe parity circuits.

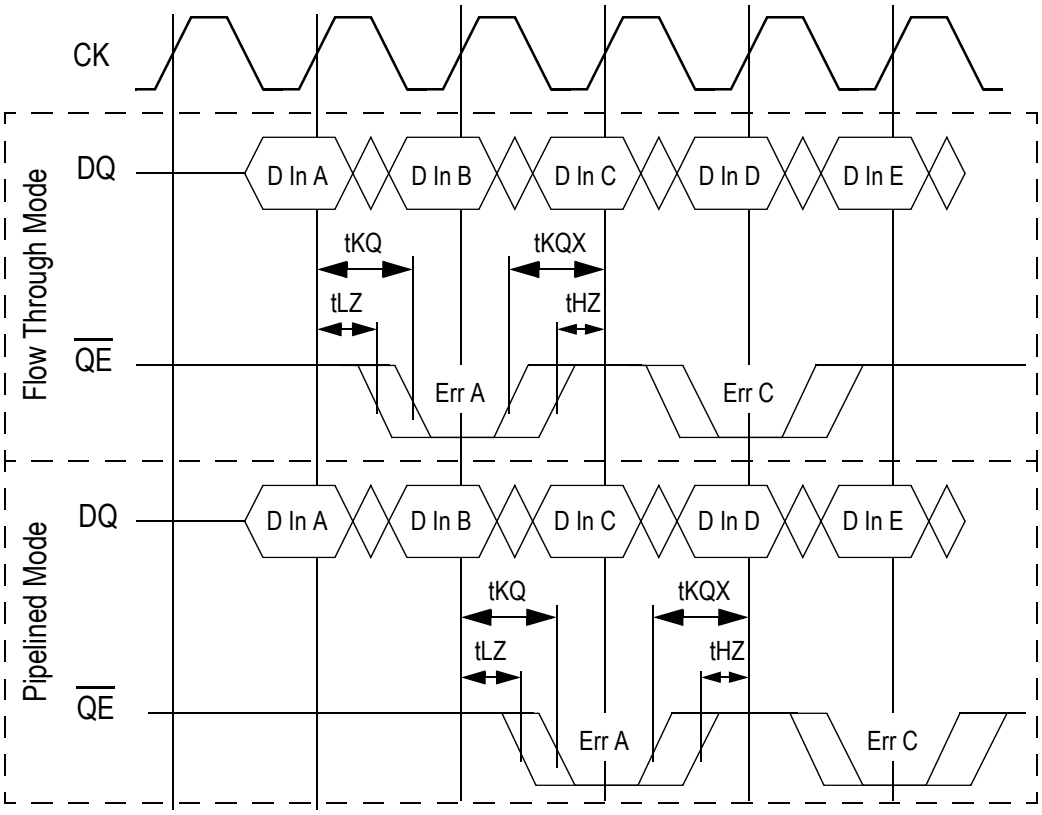
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**x16/32/64 Mode ($\overline{PE}$ = 0) Read Parity Error Output Timing Diagram**




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**x18/x36 Mode ($\overline{PE}$ = 1) Write Parity Error Output Timing Diagram**




BPR 1999.05.18

## Burst Counter Sequences

### Linear Burst Sequence

| | A[1:0] | A[1:0] | A[1:0] | A[1:0] |
|---|---|---|---|---|
| 1st address | 00 | 01 | 10 | 11 |
| 2nd address | 01 | 10 | 11 | 00 |
| 3rd address | 10 | 11 | 00 | 01 |
| 4th address | 11 | 00 | 01 | 10 |

Note: The burst counter wraps to initial state on the 5th clock.

### Interleaved Burst Sequence

| | A[1:0] | A[1:0] | A[1:0] | A[1:0] |
|---|---|---|---|---|
| 1st address | 00 | 01 | 10 | 11 |
| 2nd address | 01 | 00 | 11 | 10 |
| 3rd address | 10 | 11 | 00 | 01 |
| 4th address | 11 | 10 | 01 | 00 |

Note: The burst counter wraps to initial state on the 5th clock.

BPR 1999.05.18

## Sleep Mode

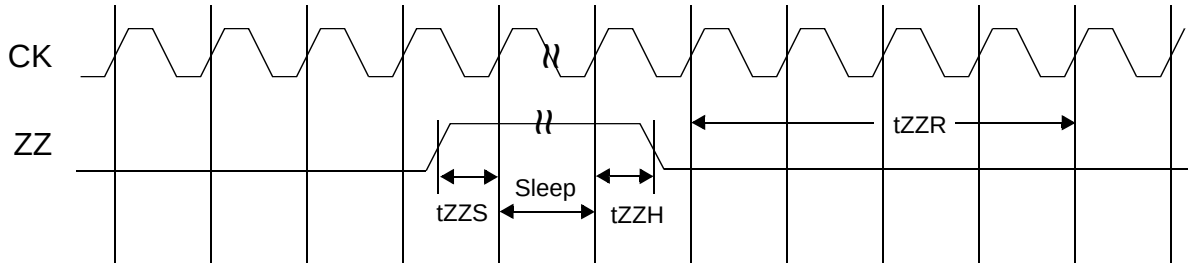
During normal operation, ZZ must be pulled low, either by the user or by its internal pull down resistor. When ZZ is pulled high, the SRAM will enter a Power Sleep mode after 2 cycles. At this time, internal state of the SRAM is preserved. When ZZ returns to low, the SRAM operates normally after 2 cycles of wake up time.

Sleep mode is a low current, power-down mode in which the device is deselected and current is reduced to $I_{SB}2$. The duration of

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Sleep mode is dictated by the length of time the ZZ is in a High state. After entering Sleep mode, all inputs except ZZ become disabled and all outputs go to High-Z The ZZ pin is an asynchronous, active high input that causes the device to enter Sleep mode. When the ZZ pin is driven high, $I_{SB}2$ is guaranteed after the time tZZI is met. Because ZZ is an asynchronous input, pending operations or operations in progress may not be properly completed if ZZ is asserted. Therefore, Sleep mode must not be initiated until valid pending operations are completed. Similarly, when exiting Sleep mode during tZZR, only a Deselect or Read commands may be applied while the SRAM is recovering from Sleep mode.

### Sleep Mode Timing Diagram




### Designing for Compatibility

The GSI NBT SRAMs offer users a configurable selection between Flow Through mode and Pipeline mode via the $\overline{FT}$ signal found on . Not all vendors offer this option, however most mark as $V_{DD}$ or $V_{DDQ}$ on pipelined parts and $V_{SS}$ on flow through parts. GSI NBT SRAMs are fully compatible with these sockets.

### Absolute Maximum Ratings

(All voltages reference to $V_{SS}$)

| Symbol | Description | Value | Unit |
|---|---|---|---|
| $V_{DD}$ | Voltage on $V_{DD}$ Pins | –0.5 to 4.6 | V |
| $V_{DDQ}$ | Voltage in $V_{DDQ}$ Pins | –0.5 to 4.6 | V |
| $V_{CK}$ | Voltage on Clock Input Pin | –0.5 to 6 | V |
| $V_{I/O}$ | Voltage on I/O Pins | –0.5 to $V_{DDQ}$ +0.5 (≤ 4.6 V max.) | V |
| $V_{IN}$ | Voltage on Other Input Pins | –0.5 to $V_{DD}$ +0.5 (≤ 4.6 V max.) | V |
| $I_{IN}$ | Input Current on Any Pin | +/–20 | mA |
| $I_{OUT}$ | Output Current on Any I/O Pin | +/–20 | mA |
| $P_D$ | Package Power Dissipation | 1.5 | W |
| $T_{STG}$ | Storage Temperature | –55 to 125 | °C |
| $T_{BIAS}$ | Temperature Under Bias | –55 to 125 | °C |

Note:

Permanent damage to the device may occur if the Absolute Maximum Ratings are exceeded. Operation should be restricted to Recommended Operating Conditions. Exposure to conditions exceeding the Absolute Maximum Ratings, for an extended period of time, may affect reliability of this component.

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## Power Supply Voltage Ranges

| Parameter | Symbol | Min. | Typ. | Max. | Unit | Notes |
|---|---|---|---|---|---|---|
| 3.3 V Supply Voltage | $V_{DD3}$ | 3.0 | 3.3 | 3.6 | V | |
| 2.5 V Supply Voltage | $V_{DD2}$ | 2.3 | 2.5 | 2.7 | V | |
| 3.3 V $V_{DDQ}$ I/O Supply Voltage | $V_{DDQ3}$ | 3.0 | 3.3 | 3.6 | V | |
| 2.5 V $V_{DDQ}$ I/O Supply Voltage | $V_{DDQ2}$ | 2.4 | 2.5 | 2.7 | V | |

Notes:
1. The part numbers of Industrial Temperature Range versions end the character "I". Unless otherwise noted, all performance specifications quoted are evaluated for worst case in the temperature range marked on the device.
2. Input Under/overshoot voltage must be –2 V > Vi < $V_{DDn}$+2 V not to exceed 4.6 V maximum, with a pulse width not to exceed 20% tKC.

## $V_{DDQ3}$ Range Logic Levels

| Parameter | Symbol | Min. | Typ. | Max. | Unit | Notes |
|---|---|---|---|---|---|---|
| $V_{DD}$ Input High Voltage | $V_{IH}$ | 1.7 | — | $V_{DD}$ + 0.3 | V | 1 |
| $V_{DD}$ Input Low Voltage | $V_{IL}$ | –0.3 | — | 0.8 | V | 1 |
| $V_{DDQ}$ I/O Input High Voltage | $V_{IHQ}$ | 1.7 | — | $V_{DDQ}$ + 0.3 | V | 1,3 |
| $V_{DDQ}$ I/O Input Low Voltage | $V_{ILQ}$ | –0.3 | — | 0.8 | V | 1,3 |

Notes:
1. The part numbers of Industrial Temperature Range versions end the character "I". Unless otherwise noted, all performance specifications quoted are evaluated for worst case in the temperature range marked on the device.
2. Input Under/overshoot voltage must be –2 V > Vi < $V_{DDn}$+2 V not to exceed 4.6 V maximum, with a pulse width not to exceed 20% tKC.
3. $V_{IHQ}$ (max) is voltage on $V_{DDQ}$ pins plus 0.3 V.

## $V_{DDQ2}$ Range Logic Levels

| Parameter | Symbol | Min. | Typ. | Max. | Unit | Notes |
|---|---|---|---|---|---|---|
| $V_{DD}$ Input High Voltage | $V_{IH}$ | 0.6*$V_{DD}$ | — | $V_{DD}$ + 0.3 | V | 1 |
| $V_{DD}$ Input Low Voltage | $V_{IL}$ | –0.3 | — | 0.3*$V_{DD}$ | V | 1 |
| $V_{DDQ}$ I/O Input High Voltage | $V_{IHQ}$ | 0.6*$V_{DD}$ | — | $V_{DDQ}$ + 0.3 | V | 1,3 |
| $V_{DDQ}$ I/O Input Low Voltage | $V_{ILQ}$ | –0.3 | — | 0.3*$V_{DD}$ | V | 1,3 |

Notes:
1. The part numbers of Industrial Temperature Range versions end the character "I". Unless otherwise noted, all performance specifications quoted are evaluated for worst case in the temperature range marked on the device.
2. Input Under/overshoot voltage must be –2 V > Vi < $V_{DDn}$+2 V not to exceed 4.6 V maximum, with a pulse width not to exceed 20% tKC.
3. $V_{IHQ}$ (max) is voltage on $V_{DDQ}$ pins plus 0.3 V.

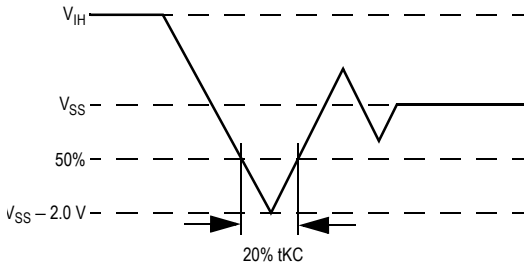
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## Recommended Operating Temperatures

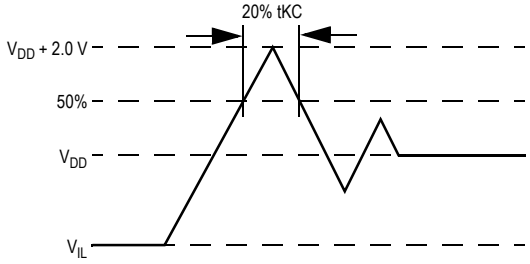
| Parameter | Symbol | Min. | Typ. | Max. | Unit | Notes |
|---|---|---|---|---|---|---|
| Ambient Temperature (Commercial Range Versions) | $T_A$ | 0 | 25 | 70 | °C | 2 |
| Ambient Temperature (Industrial Range Versions) | $T_A$ | –40 | 25 | 85 | °C | 2 |

Note:
1. The part numbers of Industrial Temperature Range versions end the character "I". Unless otherwise noted, all performance specifications quoted are evaluated for worst case in the temperature range marked on the device.
2. Input Under/overshoot voltage must be –2 V > Vi < $V_{DDn}$+2 V not to exceed 4.6 V maximum, with a pulse width not to exceed 20% tKC.

### Undershoot Measurement and Timing




### Overshoot Measurement and Timing




## Capacitance

($T_A$ = 25°C, f = 1 MHz, $V_{DD}$ = 2.5 V)

| Parameter | Symbol | Test conditions | Typ. | Max. | Unit |
|---|---|---|---|---|---|
| Input Capacitance | $C_{IN}$ | $V_{IN}$ = 0 V | 6.5 | 7.5 | pF |
| Input/Output Capacitance (x36/x72) | $C_{I/O}$ | $V_{OUT}$ = 0 V | 6 | 7 | pF |
| Input/Output Capacitance (x18) | $C_{I/O}$ | $V_{OUT}$ = 0 V | 8.5 | 9.5 | pF |

Note: These parameters are sample tested.

## Package Thermal Characteristics

| Rating | Layer Board | Symbol | Max | Unit | Notes |
|---|---|---|---|---|---|
| Junction to Ambient (at 200 lfm) | single | $R_{\Theta JA}$ | 40 | °C/W | 1,2 |
| Junction to Ambient (at 200 lfm) | four | $R_{\Theta JA}$ | 24 | °C/W | 1,2 |
| Junction to Case (TOP) | — | $R_{\Theta JC}$ | 9 | °C/W | 3 |

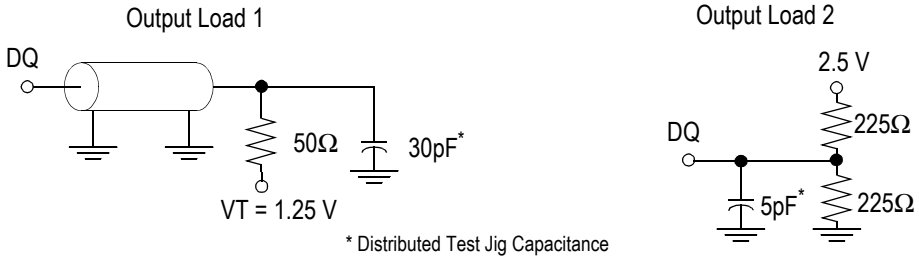
Notes:
1. Junction temperature is a function of SRAM power dissipation, package thermal resistance, mounting board temperature, ambient. Temperature air flow, board density, and PCB thermal resistance.
2. SCMI G-38-87
3. Average thermal resistance between die and top surface, MIL SPEC-883, Method 1012.1

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## AC Test Conditions

| Parameter | Conditions |
|---|---|
| Input high level | 2.3 V |
| Input low level | 0.2 V |
| Input slew rate | 1 V/ns |
| Input reference level | 1.25 V |
| Output reference level | 1.25 V |
| Output load | **Fig. 1& 2** |

Notes:
1. Include scope and jig capacitance.
2. Test conditions as specified with output loading as shown in **Fig. 1** unless otherwise noted.
3. Output Load 2 for $t_{LZ}$, $t_{HZ}$, $t_{OLZ}$ and $t_{OHZ}$
4. Device is deselected as defined by the Truth Table.




## DC Electrical Characteristics

| Parameter | Symbol | Test Conditions | Min | Max |
|---|---|---|---|---|
| Input Leakage Current (except mode pins) | $I_{IL}$ | $V_{IN}$ = 0 to $V_{DD}$ | –2 uA | 2 uA |
| ZZ and $\overline{PE}$ Input Current | $I_{IN1}$ | $V_{DD} \geq V_{IN} \geq V_{IH}$<br>0 V ≤ $V_{IN} \leq V_{IH}$ | –1 uA<br>–1 uA | 1 uA<br>100 uA |
| $\overline{FT}$, SCD, ZQ, DP Input Current | $I_{IN2}$ | $V_{DD} \geq V_{IN} \geq V_{IL}$<br>0 V ≤ $V_{IN} \leq V_{IL}$ | –100 uA<br>–1 uA | 1 uA<br>1 uA |
| Output Leakage Current (x36/x72) | $I_{OL}$ | Output Disable, $V_{OUT}$ = 0 to $V_{DD}$ | –1 uA | 1 uA |
| Output Leakage Current (x18) | $I_{OL}$ | Output Disable, $V_{OUT}$ = 0 to $V_{DD}$ | –2 uA | 2 uA |
| Output High Voltage | $V_{OH2}$ | $I_{OH}$ = –8 mA, $V_{DDQ}$ = 2.375 V | 1.7 V | — |
| Output High Voltage | $V_{OH3}$ | $I_{OH}$ = –8 mA, $V_{DDQ}$ = 3.135 V | 2.4 V | — |
| Output Low Voltage | $V_{OL}$ | $I_{OL}$ = 8 mA | — | 0.4 V |

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## Operating Currents

| Parameter | Test Conditions | Mode | | Symbol | -250 | | -225 | | -200 | | -166 | | -150 | | -133 | | Unit |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 0 to 70°C | –40 to 85°C | 0 to 70°C | –40 to 85°C | 0 to 70°C | –40 to 85°C | 0 to 70°C | –40 to 85°C | 0 to 70°C | –40 to 85°C | 0 to 70°C | –40 to 85°C | |
| Operating Current **3.3 V** | Device Selected; All other inputs ≥$V_{IH}$ or ≤ $V_{IL}$ Output open | **(x72)** | Pipeline | $I_{DD}$<br>$I_{DDQ}$ | 580<br>80 | 560<br>80 | 530<br>70 | 550<br>70 | 480<br>60 | 500<br>60 | 410<br>50 | 430<br>50 | 380<br>50 | 400<br>50 | 340<br>40 | 360<br>40 | mA |
| | | | Flow Through | $I_{DD}$<br>$I_{DDQ}$ | 310<br>40 | 330<br>40 | 340<br>40 | 330<br>40 | 270<br>30 | 290<br>30 | 270<br>30 | 290<br>30 | 270<br>30 | 290<br>30 | 200<br>20 | 220<br>20 | mA |
| | | **(x36)** | Pipeline | $I_{DD}$<br>$I_{DDQ}$ | 520<br>40 | 540<br>40 | 470<br>40 | 490<br>40 | 430<br>30 | 450<br>30 | 370<br>30 | 390<br>30 | 340<br>30 | 360<br>30 | 310<br>20 | 330<br>20 | mA |
| | | | Flow Through | $I_{DD}$<br>$I_{DDQ}$ | 280<br>20 | 300<br>20 | 280<br>20 | 300<br>20 | 250<br>20 | 270<br>20 | 350<br>20 | 270<br>20 | 250<br>20 | 270<br>20 | 180<br>20 | 200<br>20 | mA |
| | | **(x18)** | Pipeline | $I_{DD}$<br>$I_{DDQ}$ | 345<br>20 | 360<br>20 | 315<br>20 | 330<br>20 | 290<br>15 | 305<br>15 | 250<br>15 | 265<br>15 | 230<br>15 | 245<br>15 | 205<br>10 | 220<br>10 | mA |
| | | | Flow Through | $I_{DD}$<br>$I_{DDQ}$ | 200<br>10 | 215<br>10 | 200<br>10 | 215<br>10 | 175<br>10 | 190<br>10 | 175<br>10 | 190<br>10 | 175<br>10 | 190<br>10 | 135<br>10 | 150<br>10 | mA |
| Operating Current **2.5 V** | Device Selected; All other inputs ≥$V_{IH}$ or ≤ $V_{IL}$ Output open | **(x72)** | Pipeline | $I_{DD}$<br>$I_{DDQ}$ | 580<br>60 | 600<br>60 | 530<br>60 | 550<br>60 | 480<br>50 | 500<br>50 | 410<br>40 | 430<br>40 | 380<br>40 | 400<br>40 | 340<br>30 | 360<br>30 | mA |
| | | | Flow Through | $I_{DD}$<br>$I_{DDQ}$ | 310<br>30 | 330<br>30 | 310<br>30 | 330<br>30 | 270<br>30 | 290<br>30 | 270<br>30 | 290<br>30 | 270<br>30 | 290<br>30 | 200<br>20 | 220<br>20 | mA |
| | | **(x36)** | Pipeline | $I_{DD}$<br>$I_{DDQ}$ | 520<br>30 | 540<br>30 | 470<br>30 | 490<br>30 | 430<br>30 | 450<br>30 | 370<br>20 | 390<br>20 | 340<br>20 | 360<br>20 | 310<br>20 | 330<br>20 | mA |
| | | | Flow Through | $I_{DD}$<br>$I_{DDQ}$ | 280<br>20 | 300<br>20 | 280<br>20 | 300<br>20 | 250<br>20 | 270<br>20 | 250<br>20 | 270<br>20 | 250<br>20 | 270<br>20 | 180<br>10 | 200<br>10 | mA |
| | | **(x18)** | Pipeline | $I_{DD}$<br>$I_{DDQ}$ | 345<br>15 | 360<br>15 | 315<br>15 | 330<br>15 | 290<br>15 | 305<br>15 | 250<br>10 | 265<br>10 | 230<br>10 | 245<br>10 | 205<br>10 | 220<br>10 | mA |
| | | | Flow Through | $I_{DD}$<br>$I_{DDQ}$ | 200<br>10 | 215<br>10 | 200<br>10 | 215<br>10 | 175<br>10 | 190<br>10 | 175<br>10 | 190<br>10 | 175<br>10 | 190<br>10 | 135<br>5 | 150<br>5 | mA |
| Standby Current | ZZ ≥ $V_{DD}$ – 0.2 V | — | Pipeline | $I_{SB}$ | 40 | 60 | 40 | 60 | 40 | 60 | 40 | 60 | 40 | 60 | 40 | 60 | mA |
| | | | Flow Through | $I_{SB}$ | 40 | 60 | 40 | 60 | 40 | 60 | 40 | 60 | 40 | 60 | 40 | 60 | mA |
| Deselect Current | Device Deselected; All other inputs ≥ $V_{IH}$ or ≤ $V_{IL}$ | — | Pipeline | $I_{DD}$ | 170 | 180 | 160 | 170 | 150 | 160 | 130 | 140 | 120 | 130 | 100 | 110 | mA |
| | | | Flow Through | $I_{DD}$ | 120 | 130 | 120 | 130 | 100 | 110 | 100 | 110 | 100 | 110 | 90 | 100 | mA |

Notes:
1. $I_{DD}$ and $I_{DDQ}$ apply to any combination of $V_{DD3}$, $V_{DD2}$, $V_{DDQ3}$, and $V_{DDQ2}$ operation.
2. All parameters listed are worst case scenario.


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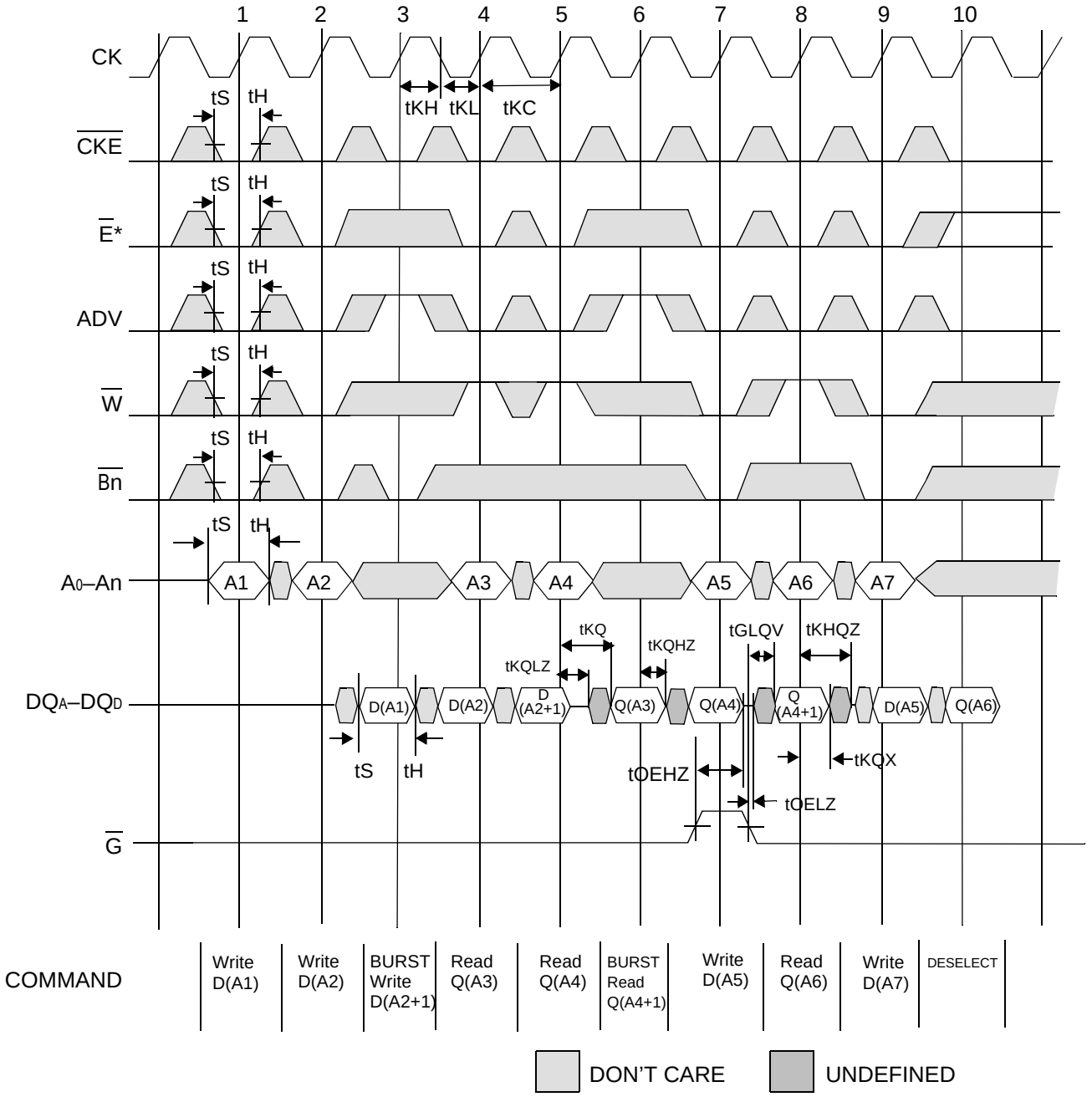
## AC Electrical Characteristics

| | Parameter | Symbol | -250 | | -225 | | -200 | | -166 | | -150 | | -133 | | Unit |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Min | Max | Min | Max | Min | Max | Min | Max | Min | Max | Min | Max | |
| **Pipeline** | Clock Cycle Time | tKC | 4.0 | — | 4.4 | — | 5.0 | — | 6.0 | — | 6.7 | — | 7.5 | — | ns |
| | Clock to Output Valid | tKQ | — | 2.3 | — | 2.5 | — | 3.0 | — | 3.4 | — | 3.8 | — | 4.0 | ns |
| | Clock to Output Invalid | tKQX | 1.5 | — | 1.5 | — | 1.5 | — | 1.5 | — | 1.5 | — | 1.5 | — | ns |
| | Clock to Output in Low-Z | tLZ[1] | 1.5 | — | 1.5 | — | 1.5 | — | 1.5 | — | 1.5 | — | 1.5 | — | ns |
| **Flow Through** | Clock Cycle Time | tKC | 7.0 | — | 7.5 | — | 8.5 | — | 10.0 | — | 10.0 | — | 15.0 | — | ns |
| | Clock to Output Valid | tKQ | — | 6.0 | — | 6.0 | — | 7.5 | — | 8.5 | — | 10.0 | — | 10.0 | ns |
| | Clock to Output Invalid | tKQX | 3.0 | — | 3.0 | — | 3.0 | — | 3.0 | — | 3.0 | — | 3.0 | — | ns |
| | Clock to Output in Low-Z | tLZ[1] | 3.0 | — | 3.0 | — | 3.0 | — | 3.0 | — | 3.0 | — | 3.0 | — | ns |
| | Clock HIGH Time | tKH | 1.3 | — | 1.3 | — | 1.3 | — | 1.3 | — | 1.5 | — | 1.7 | — | ns |
| | Clock LOW Time | tKL | 1.5 | — | 1.5 | — | 1.5 | — | 1.5 | — | 1.7 | — | 2 | — | ns |
| | Clock to Output in High-Z | tHZ[1] | 1.5 | 2.3 | 1.5 | 2.5 | 1.5 | 3.0 | 1.5 | 3.5 | 1.5 | 3.8 | 1.5 | 4.0 | ns |
| | $\overline{G}$ to Output Valid | tOE | — | 2.3 | — | 2.5 | — | 3.2 | — | 3.5 | — | 3.8 | — | 4.0 | ns |
| | $\overline{G}$ to output in Low-Z | tOLZ[1] | 0 | — | 0 | — | 0 | — | 0 | — | 0 | — | 0 | — | ns |
| | $\overline{G}$ to output in High-Z | tOHZ[1] | — | 2.3 | — | 2.5 | — | 3.0 | — | 3.5 | — | 3.8 | — | 4.0 | ns |
| | Setup time | tS | 1.5 | — | 1.5 | — | 1.5 | — | 1.5 | — | 1.5 | — | 1.5 | — | ns |
| | Hold time | tH | 0.5 | — | 0.5 | — | 0.5 | — | 0.5 | — | 0.5 | — | 0.5 | — | ns |
| | ZZ setup time | tZZS[2] | 5 | — | 5 | — | 5 | — | 5 | — | 5 | — | 5 | — | ns |
| | ZZ hold time | tZZH[2] | 1 | — | 1 | — | 1 | — | 1 | — | 1 | — | 1 | — | ns |
| | ZZ recovery | tZZR | 100 | — | 100 | — | 100 | — | 100 | — | 100 | — | 100 | — | ns |

Notes:
1. These parameters are sampled and are not 100% tested.
2. ZZ is an asynchronous signal. However, in order to be recognized on any given clock cycle, ZZ must meet the specified setup and hold times as specified above.

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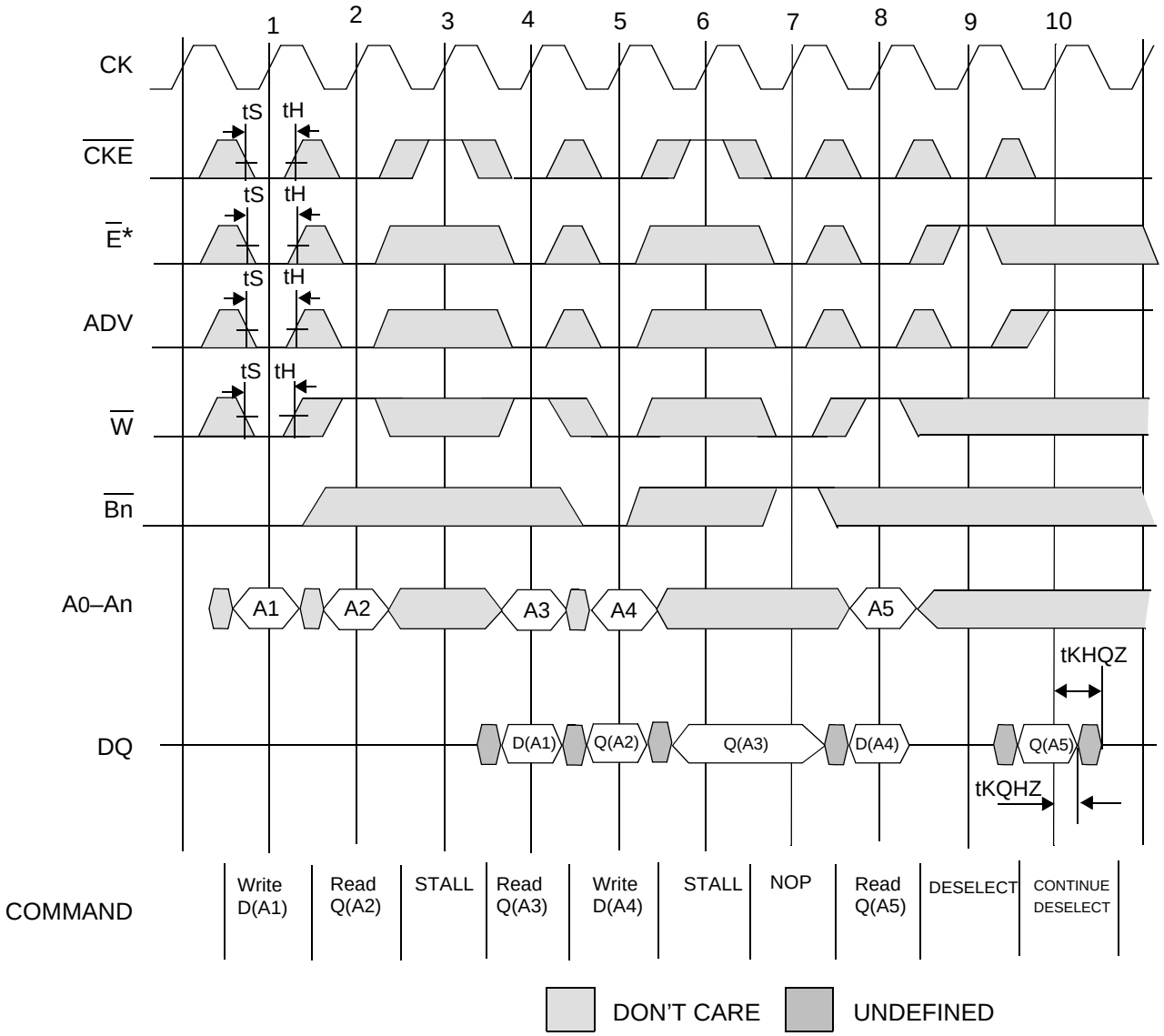
## Pipeline Mode Read/Write Cycle Timing




*Note: $\overline{E}$ = High (False) if $\overline{E}_1$ = 1 or $E_2$ = 0 or $\overline{E}_3$ = 1

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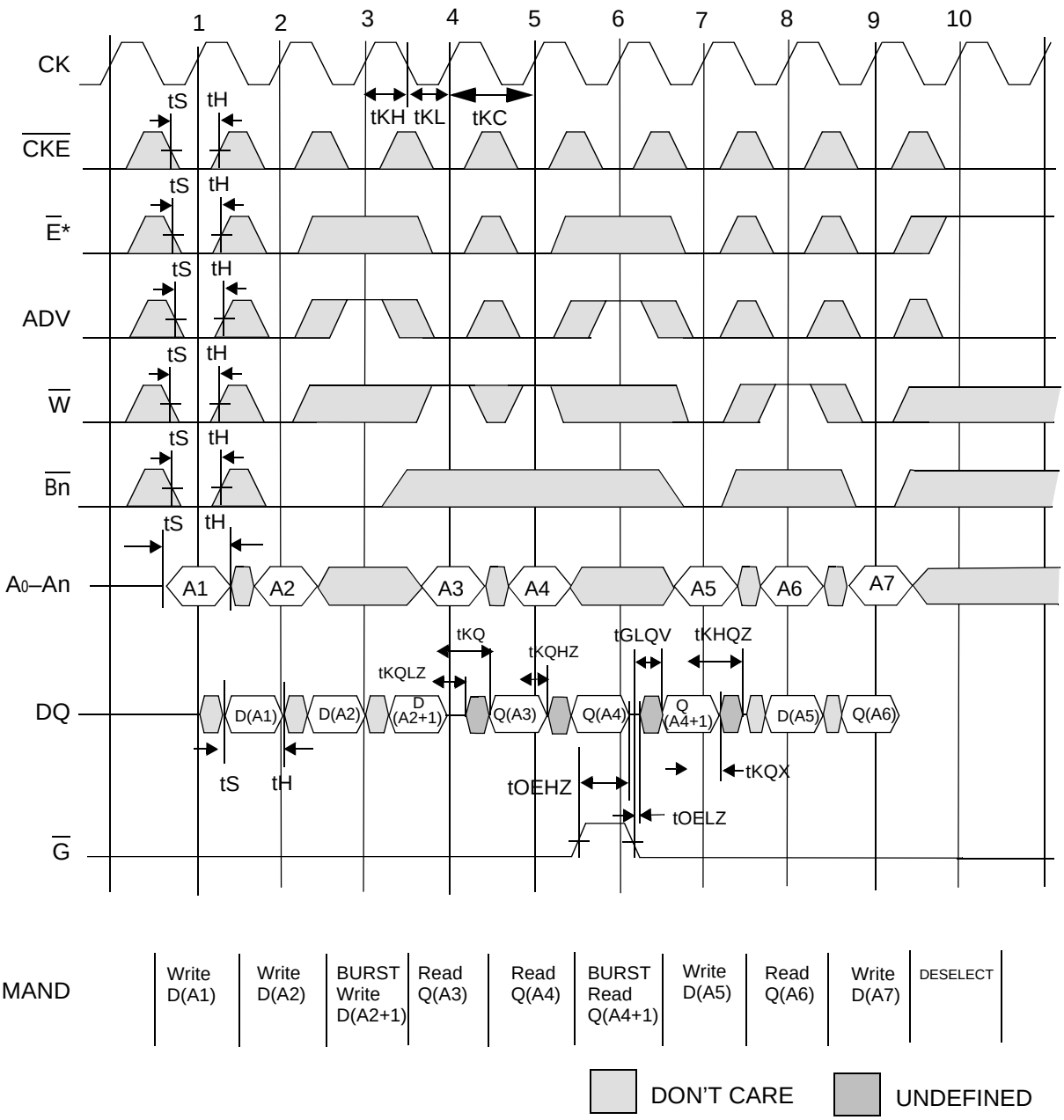
## Pipeline Mode No-Op, Stall and Deselect Timing




*Note: $\overline{E}$ = High (False) if $\overline{E}_1$ = 1 or $E_2$ = 0 or $\overline{E}_3$ = 1

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## Flow Through Mode Read/Write Cycle Timing



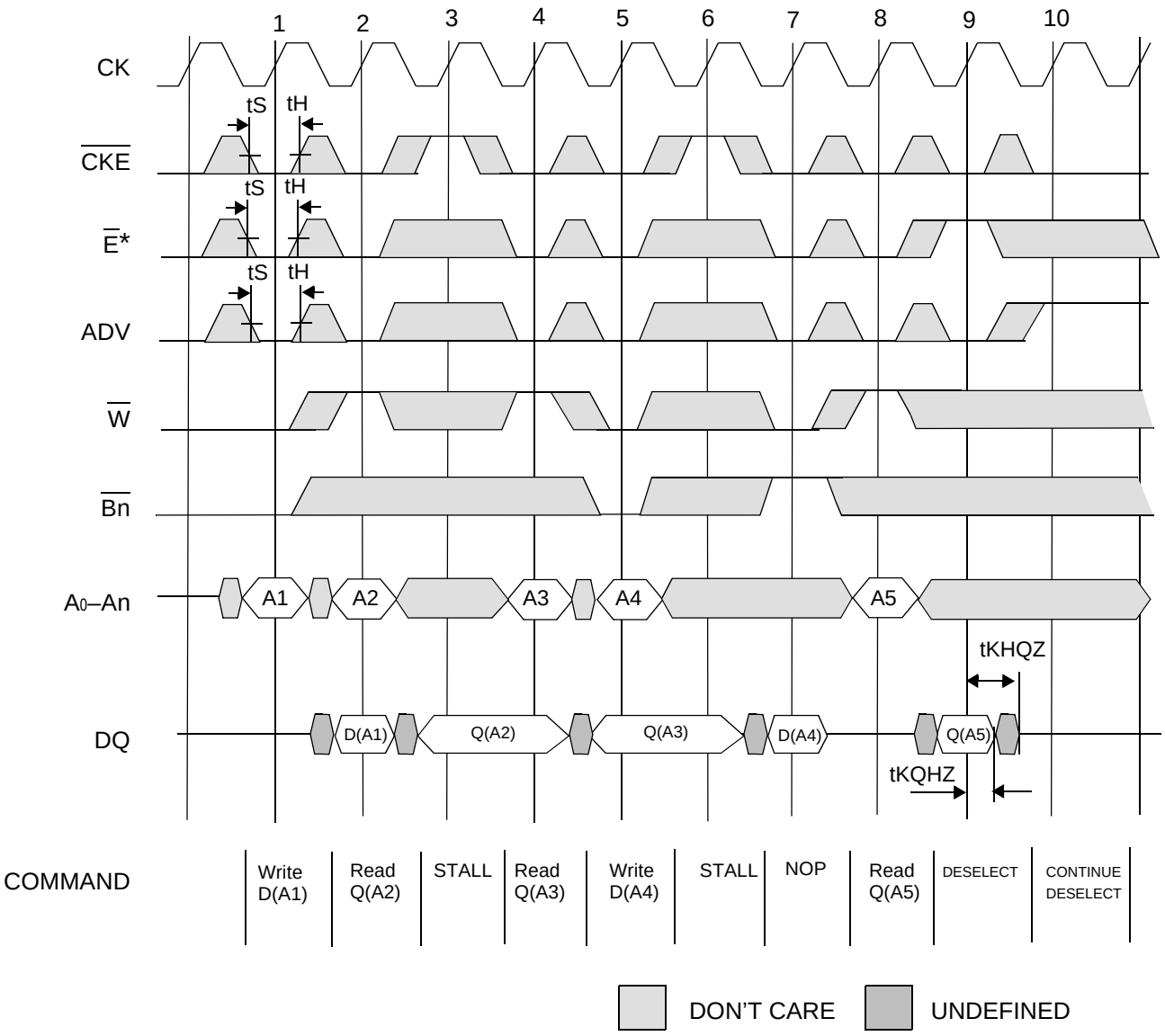

| COMMAND | Write D(A1) | Write D(A2) | BURST Write D(A2+1) | Read Q(A3) | Read Q(A4) | BURST Read Q(A4+1) | Write D(A5) | Read Q(A6) | Write D(A7) | DESELECT |
|---|---|---|---|---|---|---|---|---|---|---|

DON'T CARE  UNDEFINED

*Note: $\overline{E}$ = High (False) if $\overline{E}_1$ = 1 or $E_2$ = 0 or $\overline{E}_3$ = 1

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## Flow Through Mode No-Op, Stall and Deselect Timing




*Note: $\overline{E}$ = High (False) if $\overline{E}_1$ = 1 or $E_2$ = 0 or $\overline{E}_3$ = 1

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## JTAG Port Operation

Due to the fact that this device is built from two die, the two JTAG parts are chained together internally. The following describes the behavior of each die.

### Overview

The JTAG Port on this RAM operates in a manner that is compliant with IEEE Standard 1149.1-1990, a serial boundary scan interface standard (commonly referred to as JTAG). The JTAG Port input interface levels scale with $V_{DD}$. The JTAG output drivers are powered by $V_{DDQ}$.

### Disabling the JTAG Port

It is possible to use this device without utilizing the JTAG port. The port is reset at power-up and will remain inactive unless clocked. TCK, TDI, and TMS are designed with internal pull-up circuits.To assure normal operation of the RAM with the JTAG Port unused, TCK, TDI, and TMS may be left floating or tied to either $V_{DD}$ or $V_{SS}$. TDO should be left unconnected.

### JTAG Pin Descriptions

| Pin | Pin Name | I/O | Description |
|---|---|---|---|
| TCK | Test Clock | In | Clocks all TAP events. All inputs are captured on the rising edge of TCK and all outputs propagate from the falling edge of TCK. |
| TMS | Test Mode Select | In | The TMS input is sampled on the rising edge of TCK. This is the command input for the TAP controller state machine. An undriven TMS input will produce the same result as a logic one input level. |
| TDI | Test Data In | In | The TDI input is sampled on the rising edge of TCK. 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 Register (refer to the TAP Controller State Diagram). An undriven TDI pin will produce the same result as a logic one input level. |
| TDO | Test Data Out | Out | Output that is active depending on the state of the TAP state machine. Output changes in response to the falling edge of TCK. This is the output side of the serial registers placed between TDI and TDO. |

Note:
This device does not have a TRST (TAP Reset) pin. TRST is optional in IEEE 1149.1. The Test-Logic-Reset state is entered while TMS is held high for five rising edges of TCK. The TAP Controller is also reset automaticly at power-up.

### JTAG Port Registers

#### Overview

The various JTAG registers, refered to as Test Access Port orTAP Registers, are selected (one at a time) via the sequences of 1s and 0s applied to TMS as TCK is strobed. Each of the TAP Registers is a serial shift register that captures serial input data on the rising edge of TCK and pushes serial data out on the next falling edge of TCK. When a register is selected, it is placed between the TDI and TDO pins.

#### 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 states. Instructions are 3 bits long. The Instruction 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 or whenever the controller is placed in Test-Logic-Reset state.

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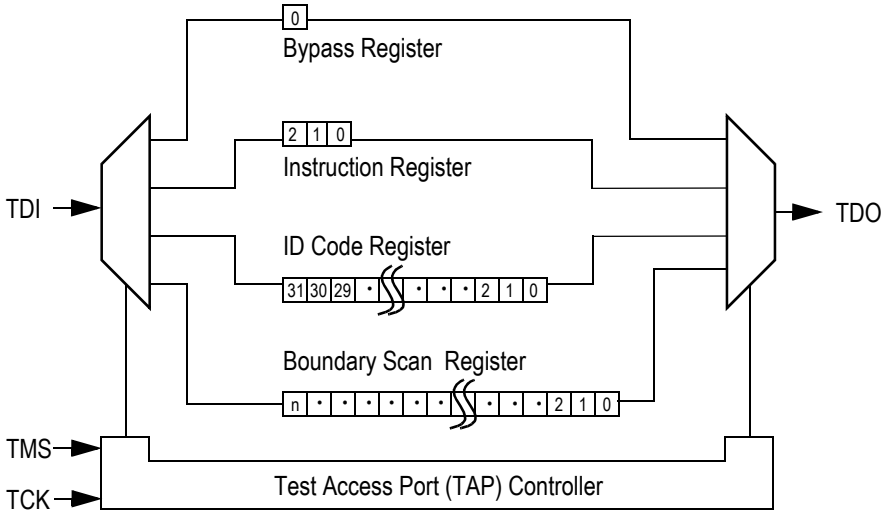
### Bypass Register

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 RAM's JTAG Port to another device in the scan chain with as little delay as possible.

### Boundary Scan Register

The Boundary Scan Register is a collection of flip flops that can be preset by the logic level found on the RAM's input or I/O pins. The flip flops are then daisy chained together so the levels found can be shifted serially out of the JTAG Port's TDO pin. The Boundary Scan Register also includes a number of place holder flip flops (always set to a logic 1). The relationship between the device pins and the bits in the Boundary Scan Register is described in the Scan Order Table following. The Boundary Scan 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. SAMPLE-Z, SAMPLE/PRELOAD and EXTEST instructions can be used to activate the Boundary Scan Register.

## JTAG TAP Block Diagram




### Identification (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 code is loaded from a 32-bit on-chip ROM. It describes various attributes of the RAM as indicated below. The register is then placed between the TDI and TDO pins when the controller is moved into Shift-DR state. Bit 0 in the register is the LSB and the first to reach TDO when shifting begins.

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### ID Register Contents

| | Die Revision Code | | | | Not Used | | | | | | | | | | | | I/O Configuration | | | | GSI Technology JEDEC Vendor ID Code | | | | | | | | | | | Presence Register |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Bit #** | 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| x72 | X | X | X | X | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 1 |
| x36 | X | X | X | X | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 1 |
| x32 | X | X | X | X | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 1 |
| x18 | X | X | X | X | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 1 |
| x16 | X | X | X | X | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 1 |

## Tap Controller Instruction Set

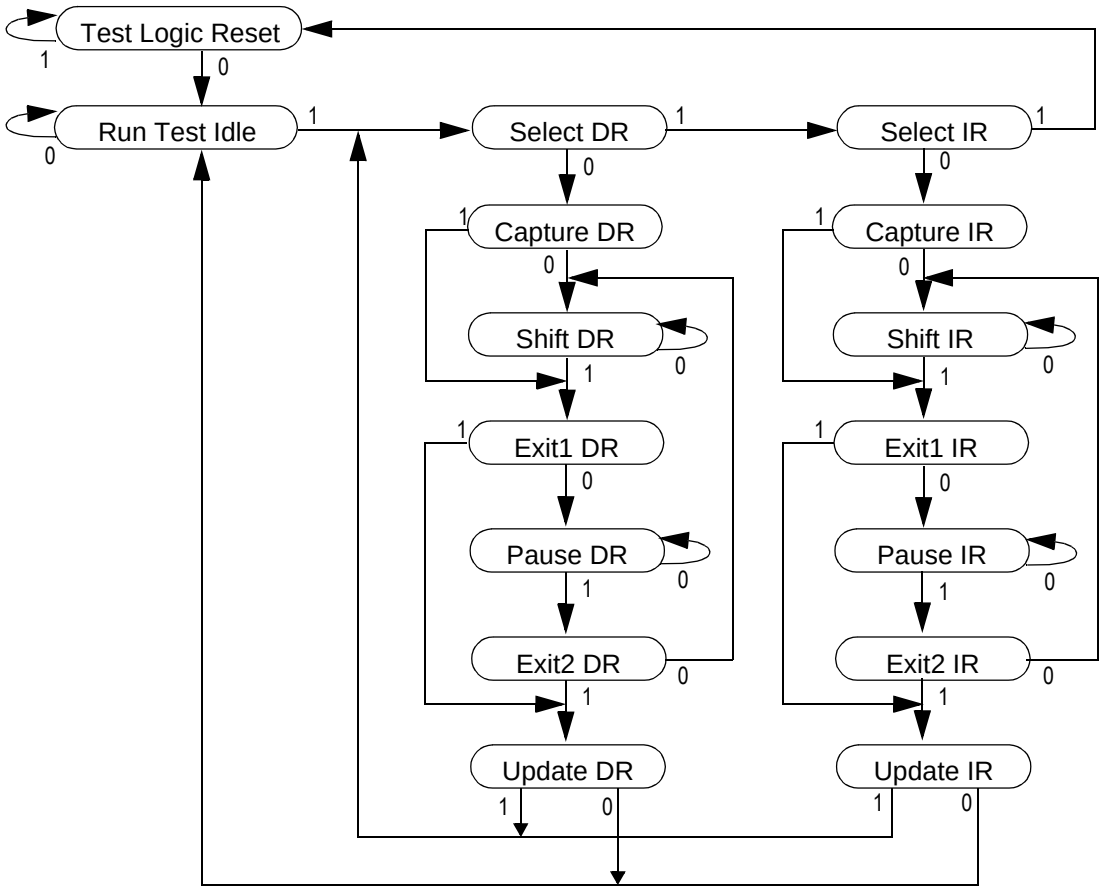
### Overview

There are two classes of instructions defined in the Standard 1149.1-1990; the standard (Public) instructions, and device specific (Private) instructions. Some Public instructions are mandatory for 1149.1 compliance. Optional Public instructions must be implemented in prescribed ways. The TAP on this device may be used to monitor all input and I/O pads, and can be used to load address, data or control signals into the RAM or to preload the I/O buffers.

When the TAP controller is placed in Capture-IR state the two least significant bits of the instruction register are loaded with 01. When the controller is moved to the Shift-IR state the Instruction Register is placed between TDI and TDO. In this state the desired instruction is serially loaded through the TDI input (while the previous contents are shifted out at TDO). For all instructions, the TAP executes newly loaded instructions only when the controller is moved to Update-IR state. The TAP instruction set for this device is listed in the following table.

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## JTAG Tap Controller State Diagram




### Instruction Descriptions

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 I/O buffers into the Boundary Scan Register. Boundary Scan Register locations are not associated with an input or I/O pin, and are loaded with the default state identified in the Boundary Scan Chain table at the end of this section of the datasheet. Because the RAM clock is 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 inputs 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 set-up plus hold time (tTS plus tTH). 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.

EXTEST

EXTEST is an IEEE 1149.1 mandatory public instruction. It is to be executed whenever the instruction register is loaded with all logic 0s.

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The EXTEST command does not block or override the RAM's input pins; therefore, the RAM's internal state is still determined by its input pins.

Typically, the Boundary Scan Register is loaded with the desired pattern of data with the SAMPLE/PRELOAD command. Then the EXTEST command is used to output the Boundary Scan Register's contents, in parallel, on the RAM's data output drivers on the falling edge of TCK when the controller is in the Update-IR state.

Alternately, the Boundary Scan Register may be loaded in parallel using the EXTEST command. When the EXTEST instruction is selected, the sate of all the RAM's input and I/O pins, as well as the default values at Scan Register locations not associated with a pin, are transferred in parallel into the Boundary Scan Register on the rising edge of TCK in the Capture-DR state, the RAM's output pins drive out the value of the Boundary Scan Register location with which each output pin is associated.

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.

SAMPLE-Z

If the SAMPLE-Z instruction is loaded in the instruction register, all RAM outputs are forced to an inactive drive state (high-Z) and the Boundary Scan Register is connected between TDI and TDO when the TAP controller is moved to the Shift-DR state.

RFU

These instructions are Reserved for Future Use. In this device they replicate the BYPASS instruction.

### JTAG TAP Instruction Set Summary

| Instruction | Code | Description | Notes |
|---|---|---|---|
| EXTEST | 000 | Places the Boundary Scan Register between TDI and TDO. | 1 |
| IDCODE | 001 | Preloads ID Register and places it between TDI and TDO. | 1, 2 |
| SAMPLE-Z | 010 | Captures I/O ring contents. Places the Boundary Scan Register between TDI and TDO.<br>Forces all RAM output drivers to High-Z. | 1 |
| RFU | 011 | Do not use this instruction; Reserved for Future Use.<br>Replicates BYPASS instruction. Places Bypass Register between TDI and TDO. | 1 |
| SAMPLE/ PRELOAD | 100 | Captures I/O ring contents. Places the Boundary Scan Register between TDI and TDO. | 1 |
| GSI | 101 | GSI private instruction. | 1 |
| RFU | 110 | Do not use this instruction; Reserved for Future Use.<br>Replicates BYPASS instruction. Places Bypass Register between TDI and TDO. | 1 |
| BYPASS | 111 | Places Bypass Register between TDI and TDO. | 1 |

Notes:
1. Instruction codes expressed in binary, MSB on left, LSB on right.
2. Default instruction automatically loaded at power-up and in test-logic-reset state.

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## JTAG Port Recommended Operating Conditions and DC Characteristics

| Parameter | Symbol | Min. | Max. | Unit | Notes |
|---|---|---|---|---|---|
| 3.3 V Test Port Input High Voltage | $V_{IHJ3}$ | 2.0 | $V_{DD3}$ +0.3 | V | 1 |
| 3.3 V Test Port Input Low Voltage | $V_{ILJ3}$ | –0.3 | 0.8 | V | 1 |
| 2.5 V Test Port Input High Voltage | $V_{IHJ2}$ | 0.6 * $V_{DD2}$ | $V_{DD2}$ +0.3 | V | 1 |
| 2.5 V Test Port Input Low Voltage | $V_{ILJ2}$ | –0.3 | 0.3 * $V_{DD2}$ | V | 1 |
| TMS, TCK and TDI Input Leakage Current | $I_{INHJ}$ | –300 | 1 | uA | 2 |
| TMS, TCK and TDI Input Leakage Current | $I_{INLJ}$ | –1 | 100 | uA | 3 |
| TDO Output Leakage Current | $I_{OLJ}$ | –1 | 1 | uA | 4 |
| Test Port Output High Voltage | $V_{OHJ}$ | 1.7 | — | V | 5, 6 |
| Test Port Output Low Voltage | $V_{OLJ}$ | — | 0.4 | V | 5, 7 |
| Test Port Output CMOS High | $V_{OHJC}$ | $V_{DDQ}$ – 100 mV | — | V | 5, 8 |
| Test Port Output CMOS Low | $V_{OLJC}$ | — | 100 mV | V | 5, 9 |

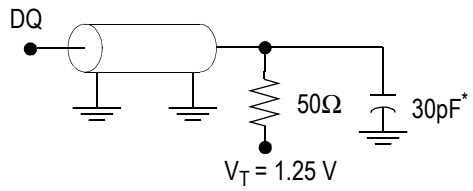
Notes:
1. Input Under/overshoot voltage must be –2 V > Vi < $V_{DDn}$ +2 V not to exceed 4.6 V maximum, with a pulse width not to exceed 20% tTKC.
2. $V_{ILJ} \leq V_{IN} \leq V_{DDn}$
3. $0\ V \leq V_{IN} \leq V_{ILJn}$
4. Output Disable, $V_{OUT}$ = 0 to $V_{DDn}$
5. The TDO output driver is served by the $V_{DDQ}$ supply.
6. $I_{OHJ}$ = –4 mA
7. $I_{OLJ}$ = + 4 mA
8. $I_{OHJC}$ = –100 uA
9. $I_{OHJC}$ = +100 uA

## JTAG Port AC Test Conditions

| Parameter | Conditions |
|---|---|
| Input high level | 2.3 V |
| Input low level | 0.2 V |
| Input slew rate | 1 V/ns |
| Input reference level | 1.25 V |
| Output reference level | 1.25 V |

Notes:
1. Include scope and jig capacitance.
2. Test conditions as as shown unless otherwise noted.

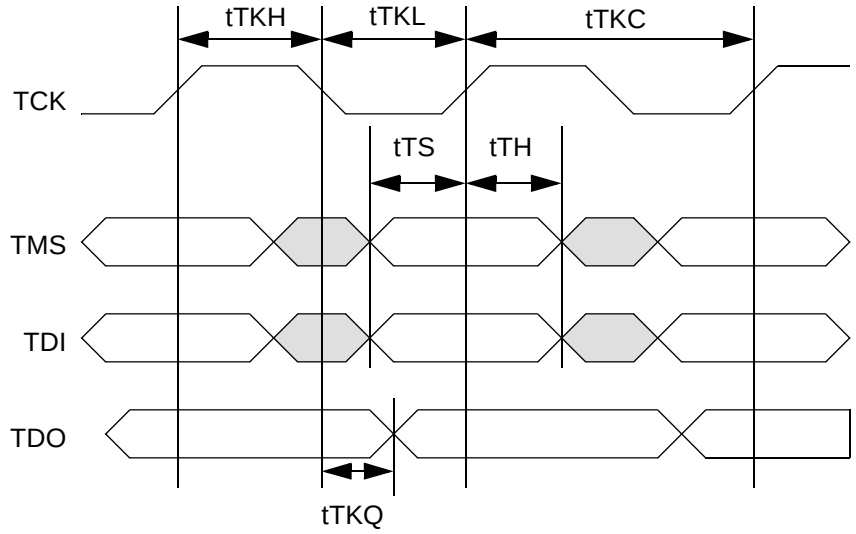
**JTAG Port AC Test Load**




* Distributed Test Jig Capacitance

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## JTAG Port Timing Diagram




## JTAG Port AC Electrical Characteristics

| Parameter | Symbol | Min | Max | Unit |
|---|---|---|---|---|
| TCK Cycle Time | tTKC | 50 | — | ns |
| TCK Low to TDO Valid | tTKQ | — | 20 | ns |
| TCK High Pulse Width | tTKH | 20 | — | ns |
| TCK Low Pulse Width | tTKL | 20 | — | ns |
| TDI & TMS Set Up Time | tTS | 10 | — | ns |
| TDI & TMS Hold Time | tTH | 10 | — | ns |

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### GS8324Z18/36/72 Boundary Scan Chain Order

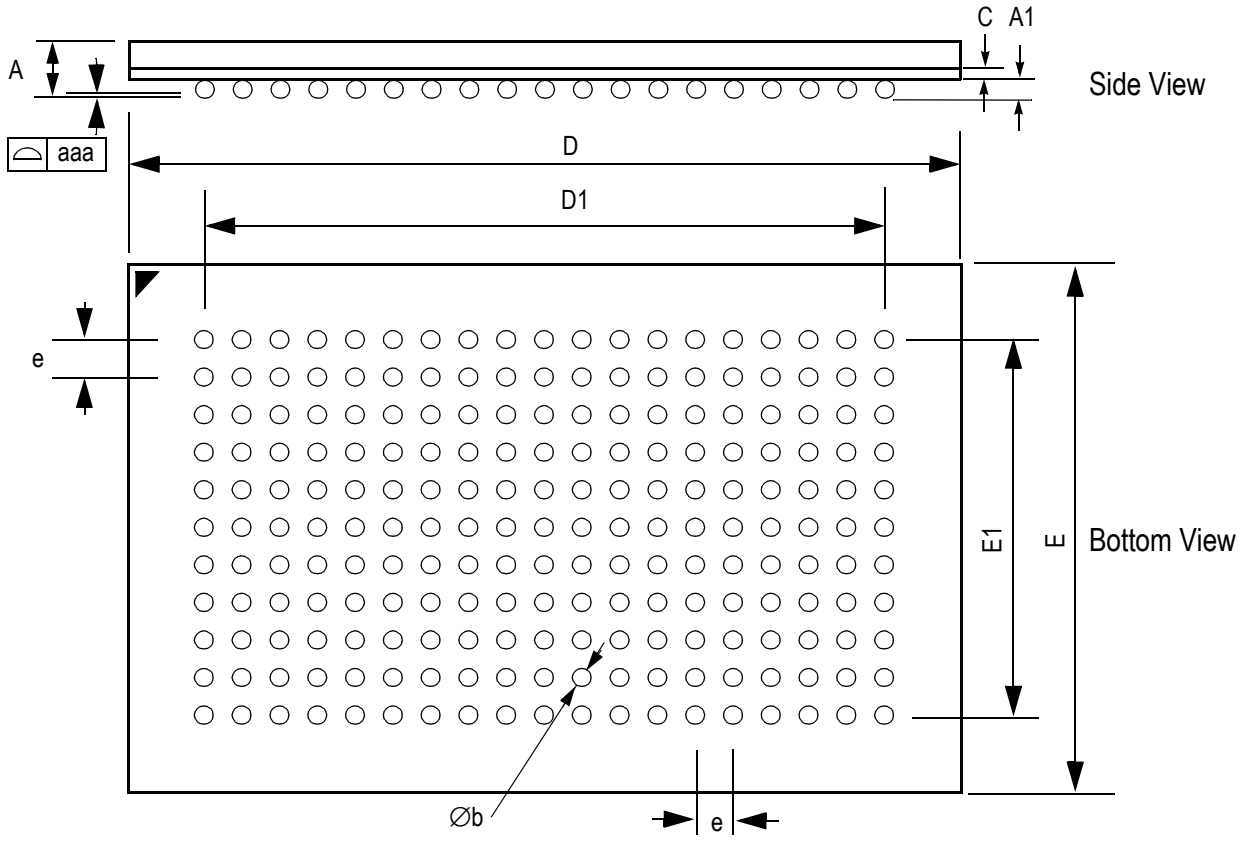
| Order | x72 | x36 | x18 | Bump | | |
|---|---|---|---|---|---|---|
| | | | | x72 | x36 | x18 |
| 1(TBD) | | | | | | |

**Notes**:
1. Depending on the package, some input pads of the scan chain may not be connected to any external pin. In such case: $\overline{LBO}$ = 1, ZQ = 1, PE = 0, $\overline{SD}$ = 0, ZZ = 0, $\overline{FT}$ = 1, DP = 1, and SCD = 1.
2. Every DQ pad consists of two scan registers—D is for input capture, and Q is for output capture.
3. A single register (#194) for controlling tristate of all the DQ pins is at the end of the scan chain (i.e., the last bit shifted in this tristate control is effective after JTAG EXTEST instruction is executed.
4. 1 = no connect, internally set to logic value 1
5. 0 = no connect, internally set to logic value 0
6. X = no connect, value is undefined

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## 209 BGA Package Drawing

14 mm x 22 mm Body, 1.0 mm Bump Pitch, 11 x 19 Bump Array



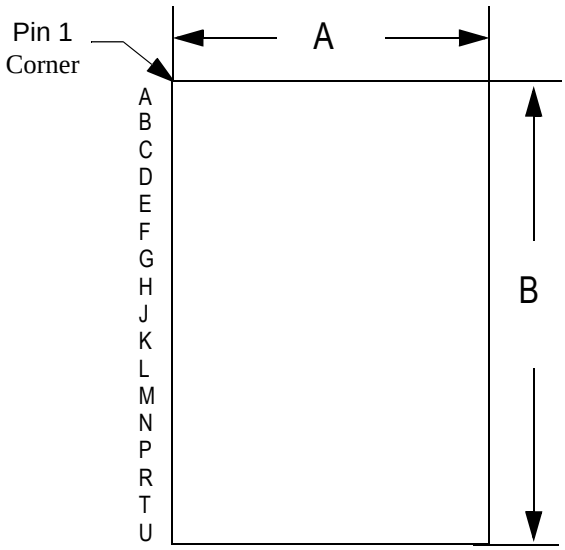

| Symbol | Min | Typ | Max | Units |
|---|---|---|---|---|
| **A** | | | 1.70 | mm |
| **A1** | 0.40 | 0.50 | 0.60 | mm |
| **Øb** | 0.50 | 0.60 | 0.70 | mm |
| **c** | 0.31 | 0.36 | 0.38 | mm |
| **D** | 21.9 | 22.0 | 22.1 | mm |
| **D1** | | 18.0 (BSC) | | mm |
| **E** | 13.9 | 14.0 | 14.1 | mm |
| **E1** | | 10.0 (BSC) | | mm |
| **e** | | 1.00 (BSC) | | mm |
| **aaa** | | 0.15 | | mm |

Rev 1.0

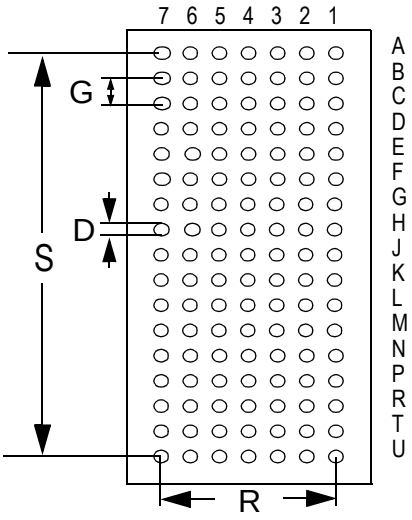
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Package Dimensions—119-Pin PBGA

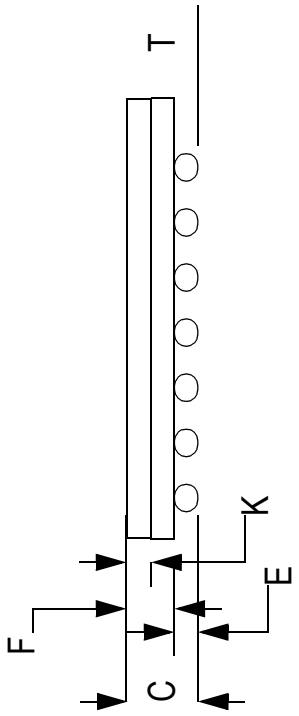
## 119-Bump BGA Package




Top View




Bottom View




Side View

### Package Dimensions—119-Pin PBGA

| Symbol | Description | Min. | Nom. | Max |
|---|---|---|---|---|
| A | Width | 13.9 | 14.0 | 14.1 |
| B | Length | 21.9 | 22.0 | 22.1 |
| C | Package Height (including ball) | 1.73 | 1.86 | 1.99 |
| D | Ball Size | 0.60 | 0.75 | 0.90 |
| E | Ball Height | 0.50 | 0.60 | 0.70 |
| F | Package Height (excluding balls) | 1.16 | 1.26 | 1.36 |
| G | Width between Balls | | 1.27 | |
| K | Package Height above board | 0.65 | 0.70 | 0.75 |
| R | Width of package between balls | | 7.62 | |
| S | Length of package between balls | | 20.32 | |
| T | Variance of Ball Height | | 0.15 | |

Unit: mm

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## Ordering Information for GSI Synchronous NBT SRAMs

| Org | Part Number[1] | Type | Package | Speed[2] (MHz/ns) | $T_A$[3] |
|---|---|---|---|---|---|
| 2M x 18 | GS8324Z18B-250 | Pipeline/Flow Through | 119 BGA | 250/6 | C |
| 2M x 18 | GS8324Z18B-225 | Pipeline/Flow Through | 119 BGA | 225/6.5 | C |
| 2M x 18 | GS8324Z18B-200 | Pipeline/Flow Through | 119 BGA | 200/7.5 | C |
| 2M x 18 | GS8324Z18B-166 | Pipeline/Flow Through | 119 BGA | 166/8.5 | C |
| 2M x 18 | GS8324Z18B-150 | Pipeline/Flow Through | 119 BGA | 150/10 | C |
| 2M x 18 | GS8324Z18B-133 | Pipeline/Flow Through | 119 BGA | 133/11 | C |
| 2M x 18 | GS8324Z18C-250 | Pipeline/Flow Through | 209 BGA | 250/6 | C |
| 2M x 18 | GS8324Z18C-225 | Pipeline/Flow Through | 209 BGA | 225/6.5 | C |
| 2M x 18 | GS8324Z18C-200 | Pipeline/Flow Through | 209 BGA | 200/7.5 | C |
| 2M x 18 | GS8324Z18C-166 | Pipeline/Flow Through | 209 BGA | 166/8.5 | C |
| 2M x 18 | GS8324Z18C-150 | Pipeline/Flow Through | 209 BGA | 150/10 | C |
| 2M x 18 | GS8324Z18C-133 | Pipeline/Flow Through | 209 BGA | 133/11 | C |
| 1M x 36 | GS8324Z36B-250 | Pipeline/Flow Through | 119 BGA | 250/6 | C |
| 1M x 36 | GS8324Z36B-225 | Pipeline/Flow Through | 119 BGA | 225/6.5 | C |
| 1M x 36 | GS8324Z36B-200 | Pipeline/Flow Through | 119 BGA | 200/7.5 | C |
| 1M x 36 | GS8324Z36B-166 | Pipeline/Flow Through | 119 BGA | 166/8.5 | C |
| 1M x 36 | GS8324Z36B-150 | Pipeline/Flow Through | 119 BGA | 150/10 | C |
| 1M x 36 | GS8324Z36B-133 | Pipeline/Flow Through | 119 BGA | 133/11 | C |
| 1M x 36 | GS8324Z36C-250 | Pipeline/Flow Through | 209 BGA | 250/6 | C |
| 1M x 36 | GS8324Z36C-225 | Pipeline/Flow Through | 209 BGA | 225/6.5 | C |
| 1M x 36 | GS8324Z36C-200 | Pipeline/Flow Through | 209 BGA | 200/7.5 | C |
| 1M x 36 | GS8324Z36C-166 | Pipeline/Flow Through | 209 BGA | 166/8.5 | C |
| 1M x 36 | GS8324Z36C-150 | Pipeline/Flow Through | 209 BGA | 150/10 | C |
| 1M x 36 | GS8324Z36C-133 | Pipeline/Flow Through | 209 BGA | 133/11 | C |
| 512K x 72 | GS8324Z72C-250 | Pipeline/Flow Through | 209 BGA | 250/6 | C |
| 512K x 72 | GS8324Z72C-225 | Pipeline/Flow Through | 209 BGA | 225/6.5 | C |
| 512K x 72 | GS8324Z72C-200 | Pipeline/Flow Through | 209 BGA | 200/7.5 | C |
| 512K x 72 | GS8324Z72C-166 | Pipeline/Flow Through | 209 BGA | 166/8.5 | C |
| 512K x 72 | GS8324Z72C-150 | Pipeline/Flow Through | 209 BGA | 150/10 | C |

Notes:

1. Customers requiring delivery in Tape and Reel should add the character "T" to the end of the part number. Example: GS8324Z18B-150IB.
2. The speed column indicates the cycle frequency (MHz) of the device in Pipeline mode and the latency (ns) in Flow Through mode. Each device is Pipeline/Flow Through mode-selectable by the user.
3. $T_A$ = C = Commercial Temperature Range. $T_A$ = I = Industrial Temperature Range.
4. GSI offers other versions this type of device in many different configurations and with a variety of different features, only some of which are covered in this data sheet. See the GSI Technology web site (www.gsitechnology.com) for a complete listing of current offerings.

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## Ordering Information for GSI Synchronous NBT SRAMs (Continued)

| Org | Part Number[1] | Type | Package | Speed[2] (MHz/ns) | $T_A$[3] |
|---|---|---|---|---|---|
| 512K x 72 | GS8324Z72C-133 | Pipeline/Flow Through | 209 BGA | 133/11 | C |
| 2M x 18 | GS8324Z18B-250I | Pipeline/Flow Through | 119 BGA | 250/6 | I |
| 2M x 18 | GS8324Z18B-225I | Pipeline/Flow Through | 119 BGA | 225/6.5 | I |
| 2M x 18 | GS8324Z18B-200I | Pipeline/Flow Through | 119 BGA | 200/7.5 | I |
| 2M x 18 | GS8324Z18B-166I | Pipeline/Flow Through | 119 BGA | 166/8.5 | I |
| 2M x 18 | GS8324Z18B-150I | Pipeline/Flow Through | 119 BGA | 150/10 | I |
| 2M x 18 | GS8324Z18B-133I | Pipeline/Flow Through | 119 BGA | 133/11 | I |
| 2M x 18 | GS8324Z18C-250I | Pipeline/Flow Through | 209 BGA | 250/6 | I |
| 2M x 18 | GS8324Z18C-225I | Pipeline/Flow Through | 209 BGA | 225/6.5 | I |
| 2M x 18 | GS8324Z18C-200I | Pipeline/Flow Through | 209 BGA | 200/7.5 | I |
| 2M x 18 | GS8324Z18C-166I | Pipeline/Flow Through | 209 BGA | 166/8.5 | I |
| 2M x 18 | GS8324Z18C-150I | Pipeline/Flow Through | 209 BGA | 150/10 | I |
| 2M x 18 | GS8324Z18C-133I | Pipeline/Flow Through | 209 BGA | 133/11 | I |
| 1M x 36 | GS8324Z36B-250I | Pipeline/Flow Through | 119 BGA | 250/6 | I |
| 1M x 36 | GS8324Z36B-225I | Pipeline/Flow Through | 119 BGA | 225/6.5 | I |
| 1M x 36 | GS8324Z36B-200I | Pipeline/Flow Through | 119 BGA | 200/7.5 | I |
| 1M x 36 | GS8324Z36B-166I | Pipeline/Flow Through | 119 BGA | 166/8.5 | I |
| 1M x 36 | GS8324Z36B-150I | Pipeline/Flow Through | 119 BGA | 150/10 | I |
| 1M x 36 | GS8324Z36B-133I | Pipeline/Flow Through | 119 BGA | 133/11 | I |
| 1M x 36 | GS8324Z36C-250I | Pipeline/Flow Through | 209 BGA | 250/6 | I |
| 1M x 36 | GS8324Z36C-225I | Pipeline/Flow Through | 209 BGA | 225/6.5 | I |
| 1M x 36 | GS8324Z36C-200I | Pipeline/Flow Through | 209 BGA | 200/7.5 | I |
| 1M x 36 | GS8324Z36C-166I | Pipeline/Flow Through | 209 BGA | 166/8.5 | I |
| 1M x 36 | GS8324Z36C-150I | Pipeline/Flow Through | 209 BGA | 150/10 | I |
| 1M x 36 | GS8324Z36C-133I | Pipeline/Flow Through | 209 BGA | 133/11 | I |
| 512K x 72 | GS8324Z72C-250I | Pipeline/Flow Through | 209 BGA | 250/6 | I |

Notes:
1. Customers requiring delivery in Tape and Reel should add the character "T" to the end of the part number. Example: GS8324Z18B-150IB.
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## Ordering Information for GSI Synchronous NBT SRAMs (Continued)

| Org | Part Number[1] | Type | Package | Speed[2] (MHz/ns) | $T_A$[3] |
|---|---|---|---|---|---|
| 512K x 72 | GS8324Z72C-225I | Pipeline/Flow Through | 209 BGA | 225/6.5 | I |
| 512K x 72 | GS8324Z72C-200I | Pipeline/Flow Through | 209 BGA | 200/7.5 | I |
| 512K x 72 | GS8324Z72C-166I | Pipeline/Flow Through | 209 BGA | 166/8.5 | I |
| 512K x 72 | GS8324Z72C-150I | Pipeline/Flow Through | 209 BGA | 150/10 | I |
| 512K x 72 | GS8324Z72C-133I | Pipeline/Flow Through | 209 BGA | 133/11 | I |

Notes:
1. Customers requiring delivery in Tape and Reel should add the character "T" to the end of the part number. Example: GS8324Z18B-150IB.
2. The speed column indicates the cycle frequency (MHz) of the device in Pipeline mode and the latency (ns) in Flow Through mode. Each device is Pipeline/Flow Through mode-selectable by the user.
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## 36Mb Sync SRAM Datasheet Revision History

| DS/DateRev. Code: Old; New | Types of Changes Format or Content | Page;Revisions;Reason |
|---|---|---|
| 8324Z18_r1 | | • Creation of new datasheet |

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