

209-Bump BGA  
Commercial Temp  
Industrial Temp



**18Mb  $\Sigma$ 1x2Lp CMOS I/O**  
**Double Data Rate SigmaRAM™**

200 MHz–333 MHz  
1.8 V  $V_{DD}$   
1.8 V I/O

## Features

- Double Data Rate Read and Write mode
- Late Write; Pipelined read operation
- JEDEC-standard SigmaRAM™ pinout and package
- 1.8 V +150/–100 mV core power supply
- 1.8 V CMOS Interface
- ZQ controlled user-selectable output drive strength
- Dual Cycle Deselect
- Burst Read and Write option
- Fully coherent read and write pipelines
- Echo Clock outputs track data output drivers
- 2 user-programmable chip enable inputs
- IEEE 1149.1 JTAG-compliant Serial Boundary Scan
- 209-bump, 14 mm x 22 mm, 1 mm bump pitch BGA package
- Pin-compatible with future 36Mb, 72Mb, and 144Mb devices

## SigmaRAM Family Overview

GS8170DD36 SigmaRAMs are built in compliance with the SigmaRAM pinout standard for synchronous SRAMs. They are 18,874,368-bit (18Mb) SRAMs. This family of wide, very low voltage CMOS I/O SRAMs is designed to operate at the speeds needed to implement economical high performance networking systems.

$\Sigma$ RAMs are offered in a number of configurations including Late Write, Double Late Write, and Double Data Rate (DDR). The logical differences between the protocols employed by these RAMs mainly involve various approaches to write

cueing and data transfer rates. The  $\Sigma$ RAM™ family standard allows a user to implement the interface protocol best suited to the task at hand.

## Functional Description

Because SigmaRAMs are synchronous devices, address data inputs and read/write control inputs are captured on the rising edge of the input clock. Write cycles are internally self-timed and initiated by the rising edge of the clock input. This feature eliminates complex off-chip write pulse generation required by asynchronous SRAMs and simplifies input signal timing. In DDR mode the device captures Data In on both rising and falling edges of clock and drives data on both clock edges as well.

Because the DDR  $\Sigma$ RAM always transfers data in two halves, A0 is internally set to 0 for the first half of each read or write transfer, and automatically incremented to 1 for the falling edge transfer. The address field of a DDR  $\Sigma$ RAM is always one address pin less than the advertised index depth (e.g., the 512k x 36 has a 512k addressable index).

$\Sigma$ RAMs support pipelined reads utilizing a rising-edge-triggered output register. DDR  $\Sigma$ RAMs incorporate rising- and falling-edge-triggered output registers. They also utilize a Dual Cycle Deselect (DCD) output deselect protocol.

$\Sigma$ RAMs are implemented with high performance CMOS technology and are packaged in a 209-bump BGA.

## Parameter Synopsis

Key Fast Bin Specs	Symbol	- 333
Cycle Time	tKHKH	3.0 ns
Access Time	tKHQV	1.8 ns

## 512K x 36 Common I/O—Top View (Package C)

	1	2	3	4	5	6	7	8	9	10	11
A	NC	NC	A	E2	A	ADV	A	E3	A	DQb	DQb
B	NC	NC	MCL	NC	A	$\overline{W}$	A	MCL	NC	DQb	DQb
C	NC	NC	NC	MCL	NC (144M)	$\overline{E1}$	NC	NC	MCL	DQb	DQb
D	NC	NC	V <sub>SS</sub>	NC	NC	MCL	NC	NC	V <sub>SS</sub>	DQb	DQb
E	NC	DQc	V <sub>DDQ</sub>	V <sub>DDQ</sub>	V <sub>DD</sub>	V <sub>DD</sub>	V <sub>DD</sub>	V <sub>DDQ</sub>	V <sub>DDQ</sub>	NC	DQb
F	DQc	DQc	V <sub>SS</sub>	V <sub>SS</sub>	V <sub>SS</sub>	ZQ	V <sub>SS</sub>	V <sub>SS</sub>	V <sub>SS</sub>	NC	NC
G	DQc	DQc	V <sub>DDQ</sub>	V <sub>DDQ</sub>	V <sub>DD</sub>	EP2	V <sub>DD</sub>	V <sub>DDQ</sub>	V <sub>DDQ</sub>	NC	NC
H	DQc	DQc	V <sub>SS</sub>	V <sub>SS</sub>	V <sub>SS</sub>	EP3	V <sub>SS</sub>	V <sub>SS</sub>	V <sub>SS</sub>	NC	NC
J	DQc	DQc	V <sub>DDQ</sub>	V <sub>DDQ</sub>	V <sub>DD</sub>	MCH	V <sub>DD</sub>	V <sub>DDQ</sub>	V <sub>DDQ</sub>	NC	NC
K	CQ2	$\overline{CQ2}$	CK	NC	V <sub>SS</sub>	MCL	V <sub>SS</sub>	NC	NC	$\overline{CQ1}$	CQ1
L	NC	NC	V <sub>DDQ</sub>	V <sub>DDQ</sub>	V <sub>DD</sub>	MCL	V <sub>DD</sub>	V <sub>DDQ</sub>	V <sub>DDQ</sub>	DQa	DQa
M	NC	NC	V <sub>SS</sub>	V <sub>SS</sub>	V <sub>SS</sub>	MCH	V <sub>SS</sub>	V <sub>SS</sub>	V <sub>SS</sub>	DQa	DQa
N	NC	NC	V <sub>DDQ</sub>	V <sub>DDQ</sub>	V <sub>DD</sub>	MCH	V <sub>DD</sub>	V <sub>DDQ</sub>	V <sub>DDQ</sub>	DQa	DQa
P	NC	NC	V <sub>SS</sub>	V <sub>SS</sub>	V <sub>SS</sub>	MCL	V <sub>SS</sub>	V <sub>SS</sub>	V <sub>SS</sub>	DQa	DQa
R	DQd	NC	V <sub>DDQ</sub>	V <sub>DDQ</sub>	V <sub>DD</sub>	V <sub>DD</sub>	V <sub>DD</sub>	V <sub>DDQ</sub>	V <sub>DDQ</sub>	DQa	NC
T	DQd	DQd	V <sub>SS</sub>	NC	NC	MCL	NC	NC	V <sub>SS</sub>	NC	NC
U	DQd	DQd	NC	A	NC (72M)	A	NC (36M)	A	NC	NC	NC
V	DQd	DQd	A	A	A	A1	A	A	A	NC	NC
W	DQd	DQd	TMS	TDI	A	MCL	A	TDO	TCK	NC	NC

• 2002.06

 11 x 19 Bump BGA—14 x 22 mm<sup>2</sup> Body—1 mm Bump Pitch

**Note:**

Users of CMOS I/O SigmaRAMs may wish to connect “NC, V<sub>REF</sub>” and the “NC,  $\overline{CK}$ ” pins to V<sub>REF</sub> (i.e., V<sub>DDQ</sub>/2) to allow alternate use of future HSTL I/O SigmaRAMs.

**Pin Description Table**

Symbol	Description	Type	Comments
A	Address	Input	—
ADV	Advance	Input	Active High
$\overline{W}$	Write Enable	Input	Active Low
$\overline{E1}$	Chip Enable	Input	Active Low
E2 & E3	Chip Enable	Input	Programmable Active High or Low
EP2 & EP3	Chip Enable Program Pin	Mode Input	To be tied directly to $V_{DD}$ , $V_{DDQ}$ or $V_{SS}$
CK	Clock	Input	Active High
CQ, $\overline{CQ}$	Echo Clock	Output	Three State - Deselect via E2 or E3 False
DQ	Data I/O	Input/Output	Three State
MCH	Must Connect High	Input	Active High To be tied directly to $V_{DD}$ or $V_{DDQ}$
MCL	Must Connect Low	Input	Active Low To be tied directly to $V_{SS}$
ZQ	Output Impedance Control	Mode Input	Low = Low Impedance [High Drive] High = High Impedance [Low Drive] To be tied directly to $V_{DDQ}$ or $V_{SS}$
TCK	Test Clock	Input	Active High
TDI	Test Data In	Input	—
TDO	Test Data Out	Output	—
TMS	Test Mode Select	Input	—
NC	No Connect	—	Not connected to die or any other pin
$V_{DD}$	Core Power Supply	Input	1.8 V Nominal
$V_{DDQ}$	Output Driver Power Supply	Input	1.8 V Nominal
$V_{SS}$	Ground	Input	—

**Operation Control**

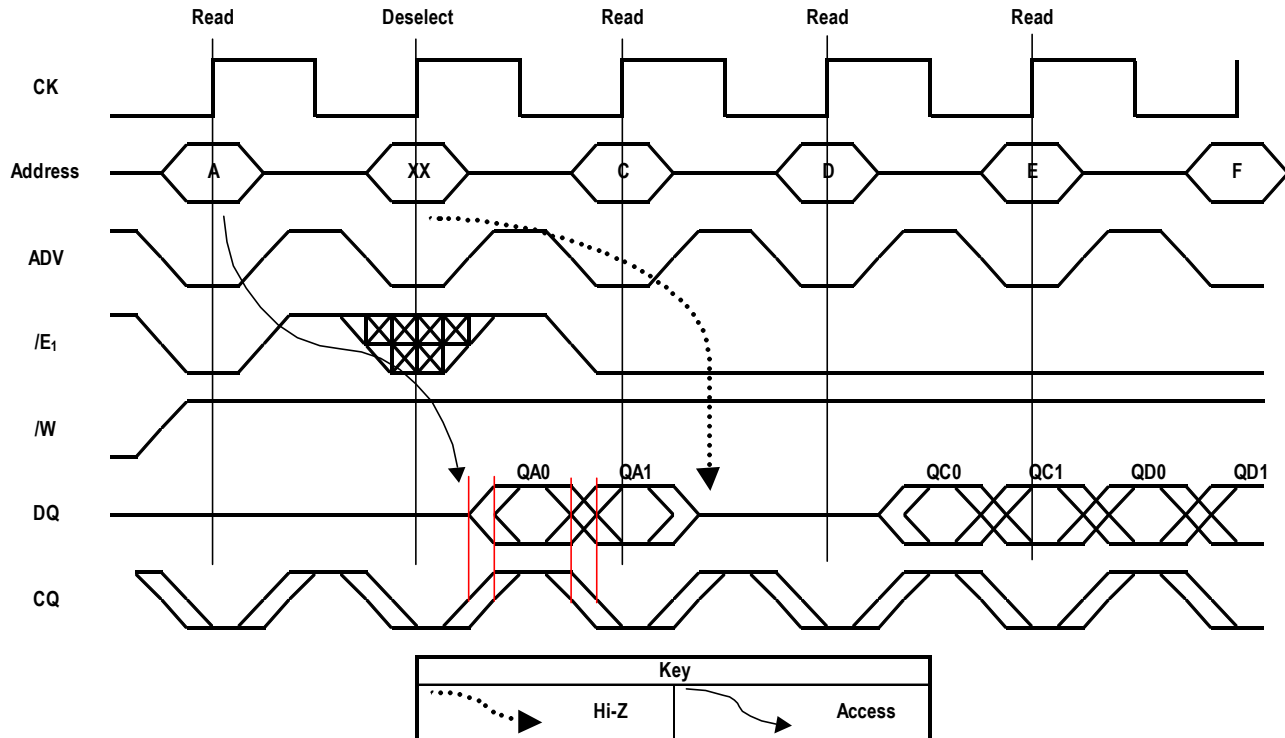
All address, data and control inputs (with the exception of EP2, EP3, ZQ, and the mode pins, L6, M6, and J6) are synchronized to rising clock edges. Data in is captured on both rising and falling edges of CK. Read and write operations must be initiated with the Advance/Load pin (ADV) held low, in order to load the new address. Device activation is accomplished by asserting all three of the Chip Enable inputs ( $\overline{E1}$ , E2, and E3). Deassertion of any one of the Enable inputs will deactivate the device. **It should be noted that ONLY deactivation of the RAM via E2 and/or E3 deactivates the Echo Clocks, CQ1–CQ2.**

## Read Operations

### Double Data Rate Read

In applications where a data rate markedly faster than the RAM's latency is desired, the Double Data Rate protocol doubles the data transfer rate (read or write bandwidth) achieved in Pipeline mode while keeping the RAM's clock frequency constant. In Double Data Rate mode, the RAM multiplexes the results of a read out of the RAM on half the usual number of data pins. The output register/mux behaves just as if it were in Pipeline mode for the first transfer, but then makes a second transfer in response to the next falling edge of clock as well. SigmaRAM DDR RAMs burst in linear order only.

### Double Data Rate Pipelined Read



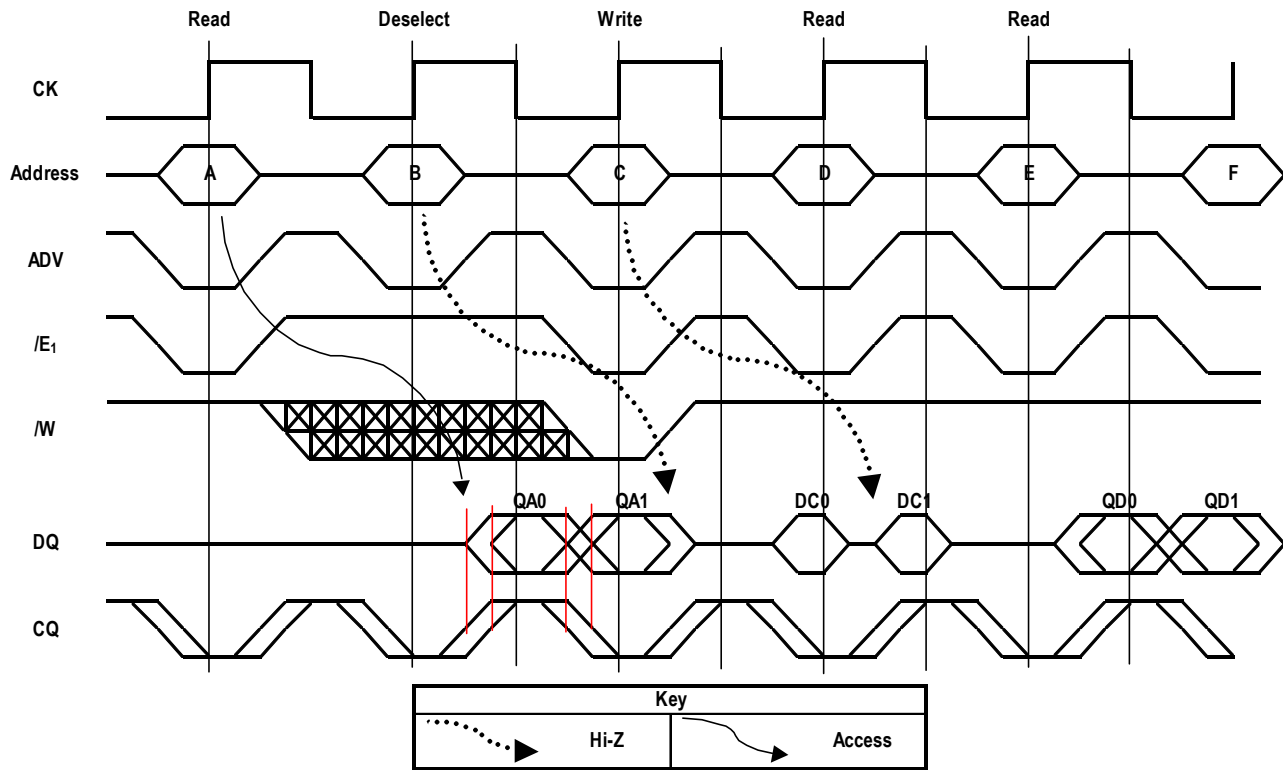
## Write Operations

Write operation occurs when the following conditions are satisfied at the rising edge of clock: All three chip enables ( $\overline{E}_1$ , E2, and E3) are active, the write enable input signal ( $\overline{W}$ ) is asserted low, and ADV is asserted low.

### Double Data Rate Write

A Double Data Rate Write is a specialized form of Late Write. In Double Data Rate mode, the RAM will capture Data In on both rising and falling edges of the RAM clock, CK, beginning with the rising edge of clock that follows the capture of the write address and command.

### SigmaRAM Double Data Rate Read and Write

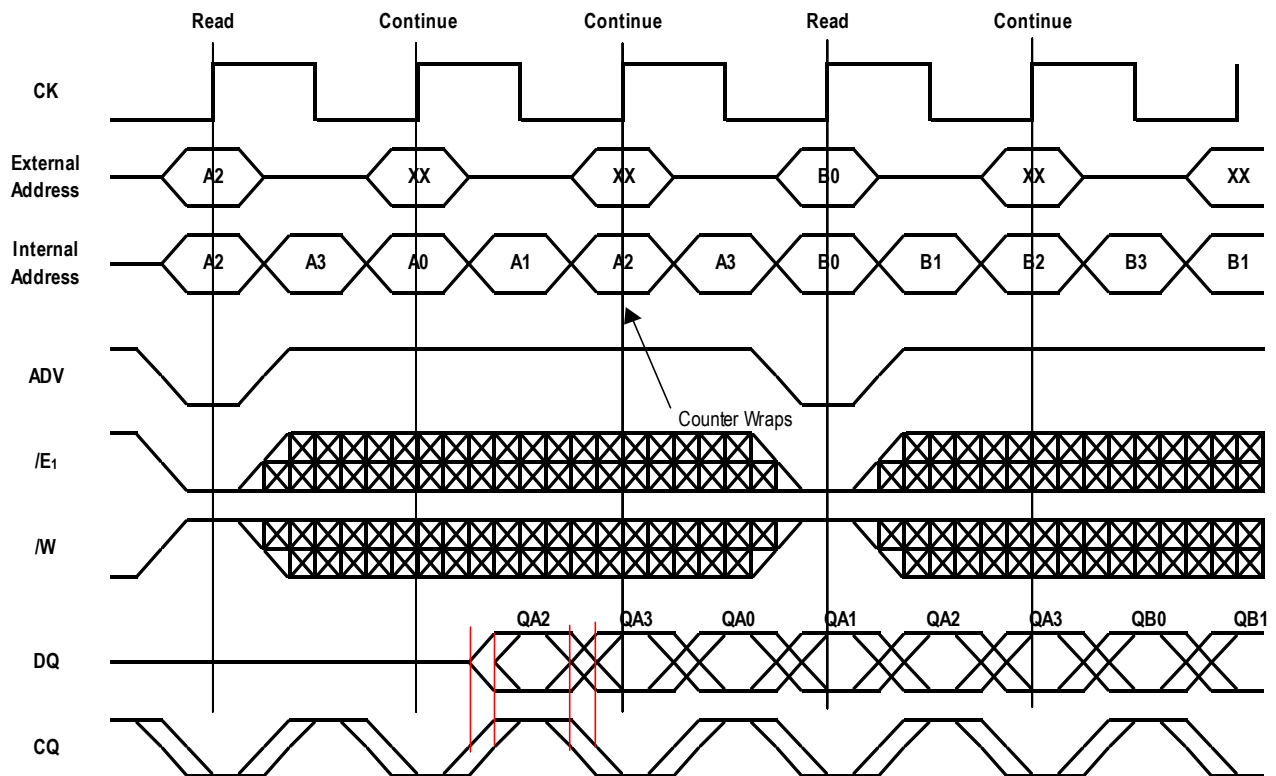


## Special Functions

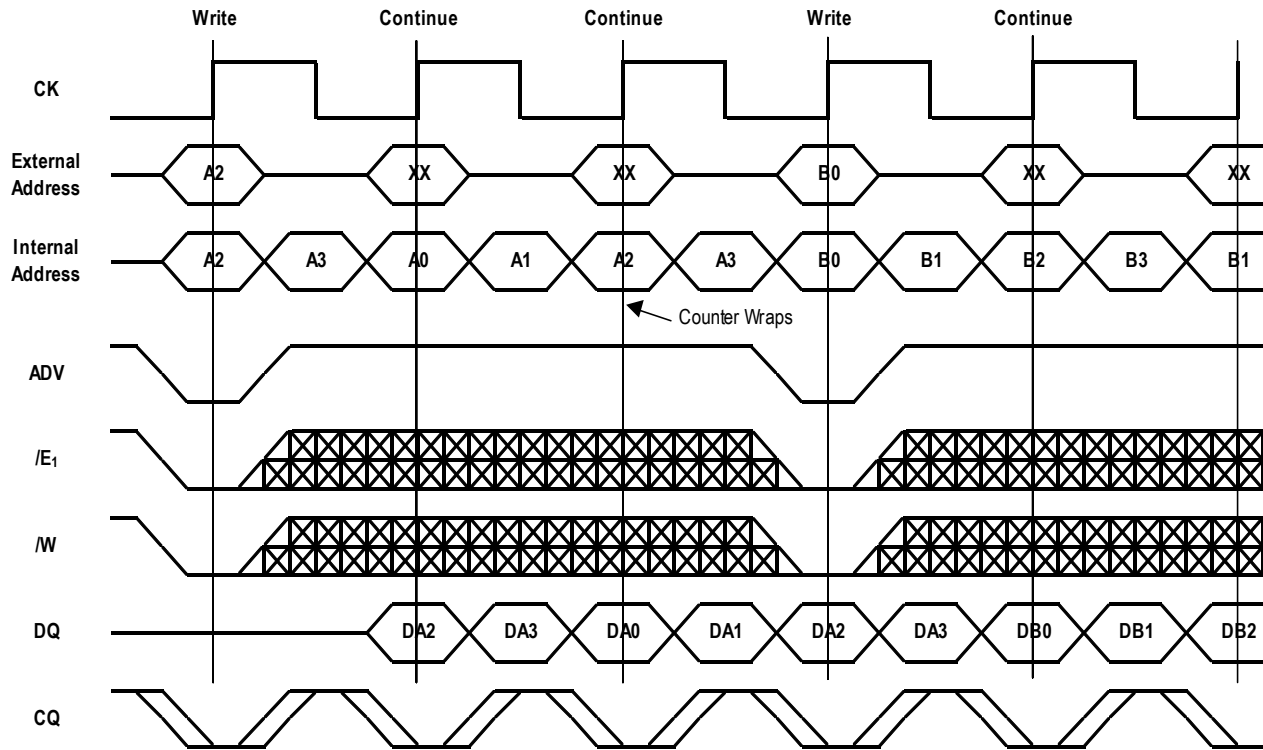
### Burst Cycles

SRAMs provide an on-chip burst address generator that can be utilized, if desired, to 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.

**SigmaRAM DDR Burst Read with Counter Wrap-around**



### SigmaRAM DDR Burst Write with Counter Wrap-around



**Burst Order**

The burst address counter wraps around to its initial state after four internal addresses (the loaded address and three more) have been accessed. SigmaRAMs always count in linear burst order.

**Linear Burst Order**

	A[1:0]	
1st address (Rising Edge CK)	00	10
2nd address (Falling Edge CK)	01	11
3rd address (Rising Edge CK)	10	00
4th address (Falling Edge CK)	11	01

**Notes:**

1. The burst counter wraps to initial state on the 3rd rising edge of clock.
2. The DDR SigmaRAM always begins an read or write at A0 = 0. A0 is internally set to 0 at the rising edge of clock and is not available to the user.

**Echo Clock**

ΣRAMs feature Echo Clocks, CQ1, CQ2,  $\overline{CQ1}$ , and  $\overline{CQ2}$  that track the performance of the output drivers. The Echo Clocks are delayed copies of the main RAM clock, CK. Echo Clocks are designed to track changes in output driver delays due to variance in die temperature and supply voltage. The Echo Clocks are designed to fire with the rest of the data output drivers. SigmaRAMs provide both in-phase, or true, Echo Clock outputs (CQ1 and CQ2) and inverted Echo Clock outputs ( $\overline{CQ1}$  and  $\overline{CQ2}$ ).

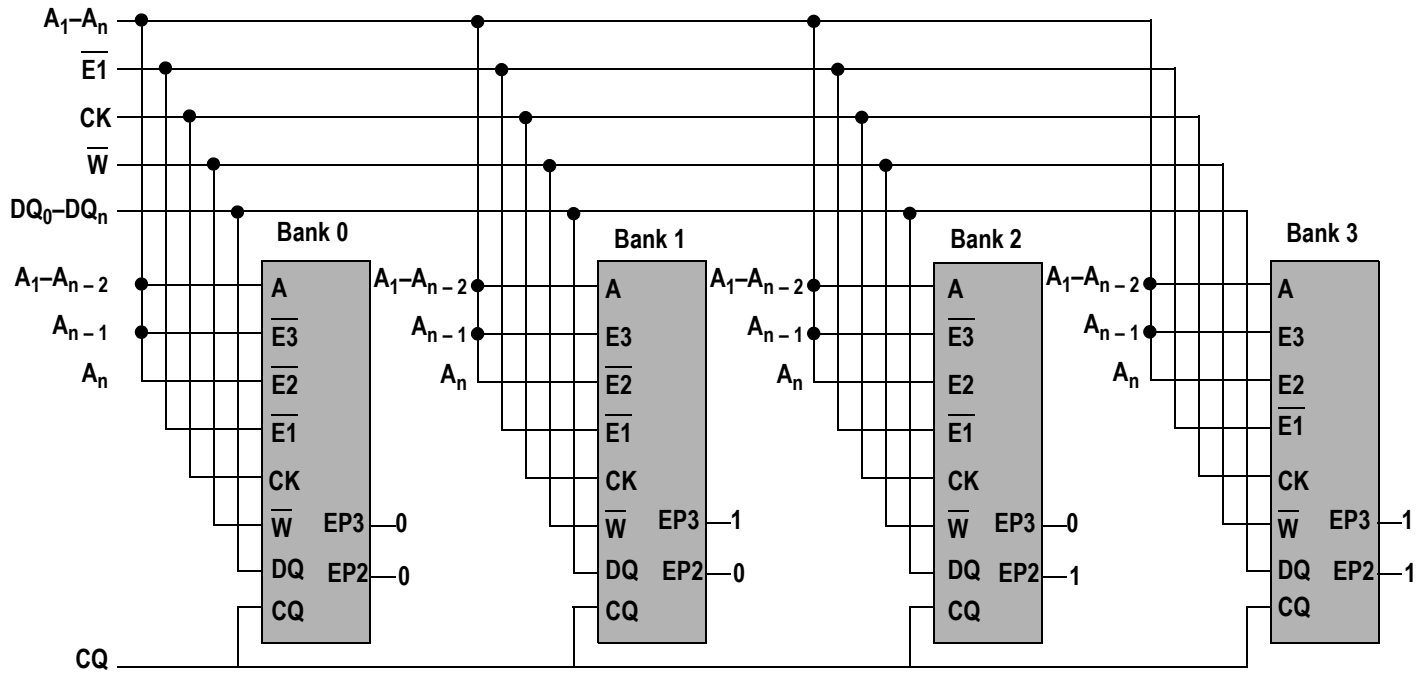
It should be noted that deselection of the RAM via E2 and E3 also deselects the Echo Clock output drivers. The deselection of Echo Clock drivers is always pipelined to the same degree as output data. **Deselection of the RAM via E1 does not deactivate the Echo Clocks.**

**Programmable Enables**

ΣRAMs feature two user-programmable chip enable inputs, E2 and E3. The sense of the inputs, whether they function as active low or active high inputs, is determined by the state of the programming inputs, EP2 and EP3. For example, if EP2 is held at V<sub>DD</sub>, E2 functions as an active high enable. If EP2 is held to V<sub>SS</sub>, E2 functions as an active low chip enable input.

Programmability of E2 and E3 allows four banks of depth expansion to be accomplished with no additional logic. By programming the enable inputs of four SRAMs in binary sequence (00, 01, 10, 11) and driving the enable inputs with two address inputs, four SRAMs can be made to look like one larger RAM to the system.

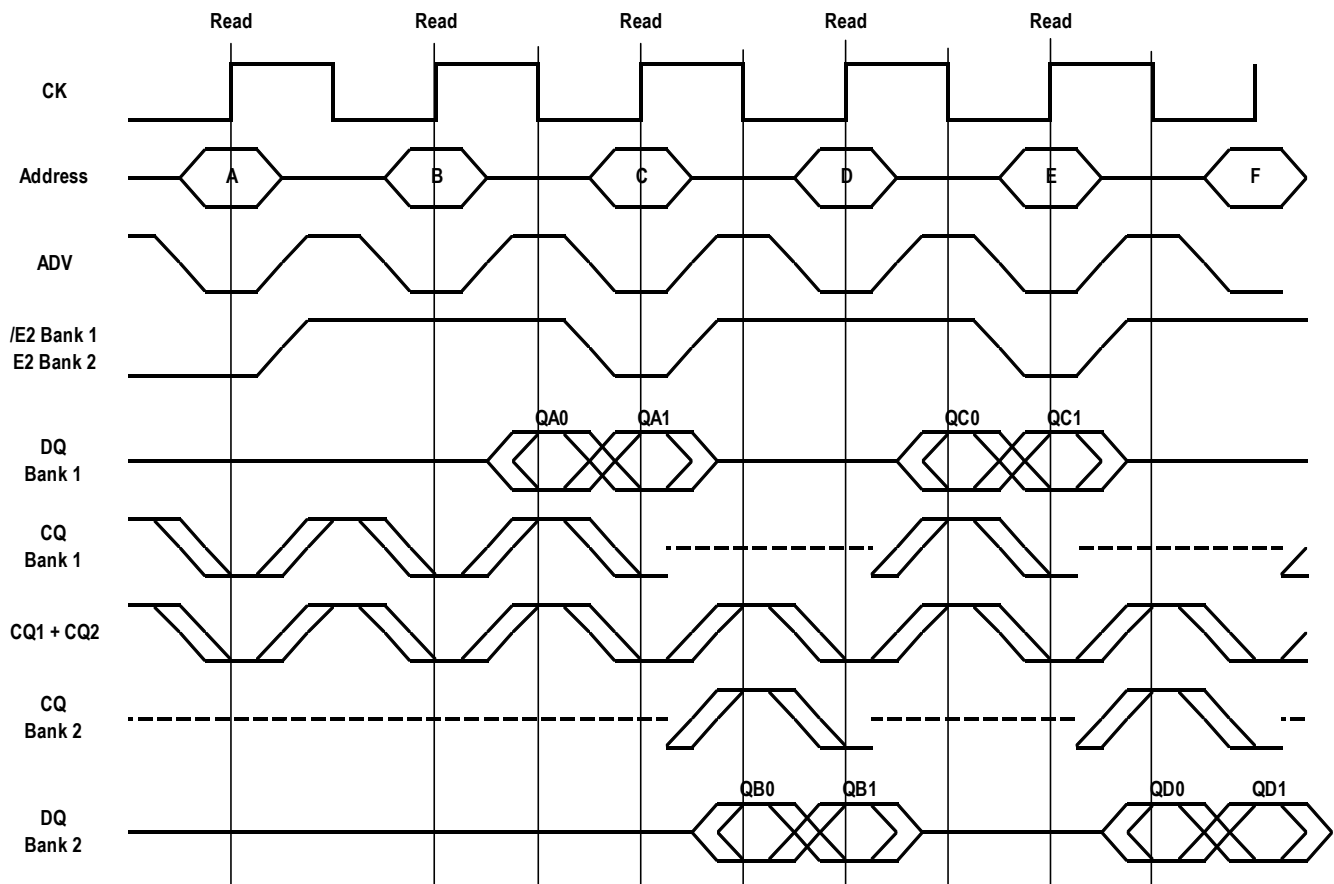


Example Four Bank Depth Expansion Schematic— $\Sigma 1 \times 2 L_p$ 


Bank Enable Truth Table

	EP2	EP3	E2	E3
Bank 0	$V_{SS}$	$V_{SS}$	Active Low	Active Low
Bank 1	$V_{SS}$	$V_{DD}$	Active Low	Active High
Bank 2	$V_{DD}$	$V_{SS}$	Active High	Active Low
Bank 3	$V_{DD}$	$V_{DD}$	Active High	Active High

### Echo Clock Control in Two Banks of Double Data Rate SigmaRAMs

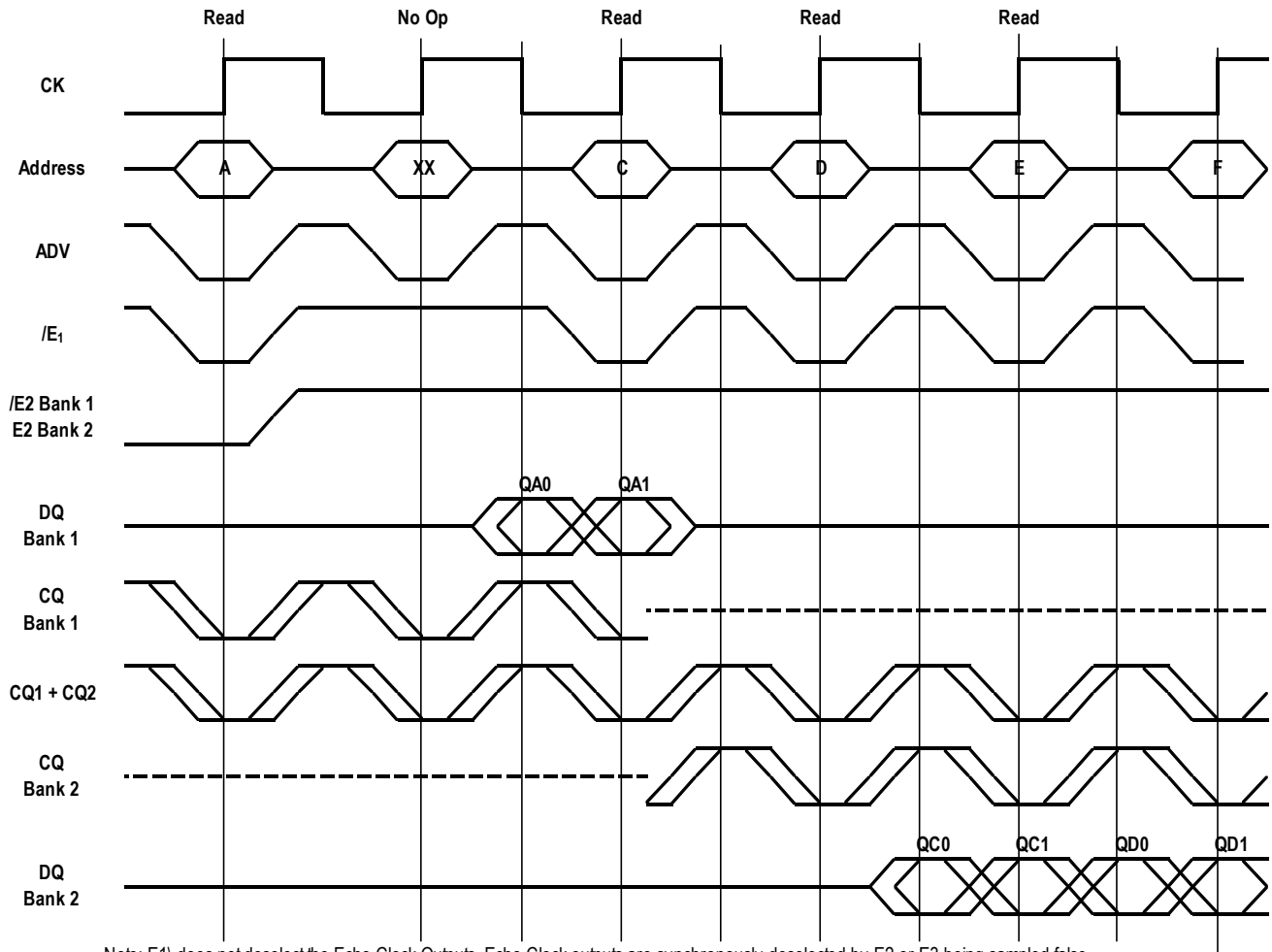


Note:  $\overline{E1}$  does not deselect the Echo Clock Outputs. Echo Clock outputs are synchronously deselected by E2 or E3 being sampled false.

It should be noted that deselection of the RAM via E2 and E3 also deselects the Echo Clock output drivers. The deselection of Echo Clock drivers is always pipelined to the same degree as output data. Deselection of the RAM via  $\overline{E1}$  does not deactivate the Echo Clocks.

In some applications it may be appropriate to pause between banks; to deselect both RAMs with  $\overline{E1}$  before resuming read operations. An  $\overline{E1}$  deselect at a bank switch will allow at least one clock to be issued from the new bank before the first read cycle in the bank. Although the following drawing illustrates a  $\overline{E1}$  read pause upon switching from Bank 1 to Bank 2, a write to Bank 2 would have the same effect, causing the RAM in Bank 2 to issue at least one clock before it is needed.

### SigmaRAM DDR Bank Switch with $\overline{E1}$ Deselect



Note:  $\overline{E1}$  does not deselect the Echo Clock Outputs. Echo Clock outputs are synchronously deselected by E2 or E3 being sampled false.

### CMOS Output Driver Impedance Control

CMOS I/O SigmaRAMs are supplied with selectable (high or low) impedance output drivers. The ZQ pin allows selection between SRAM nominal drive strength (ZQ low) for multi-drop bus applications and low drive strength (ZQ high) point-to-point applications.

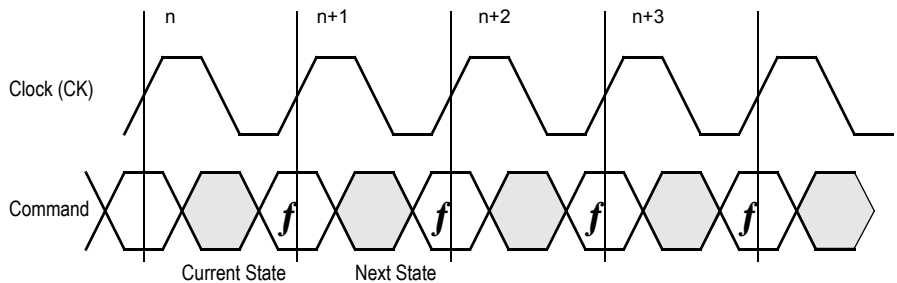
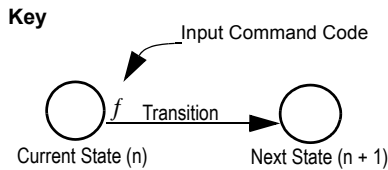
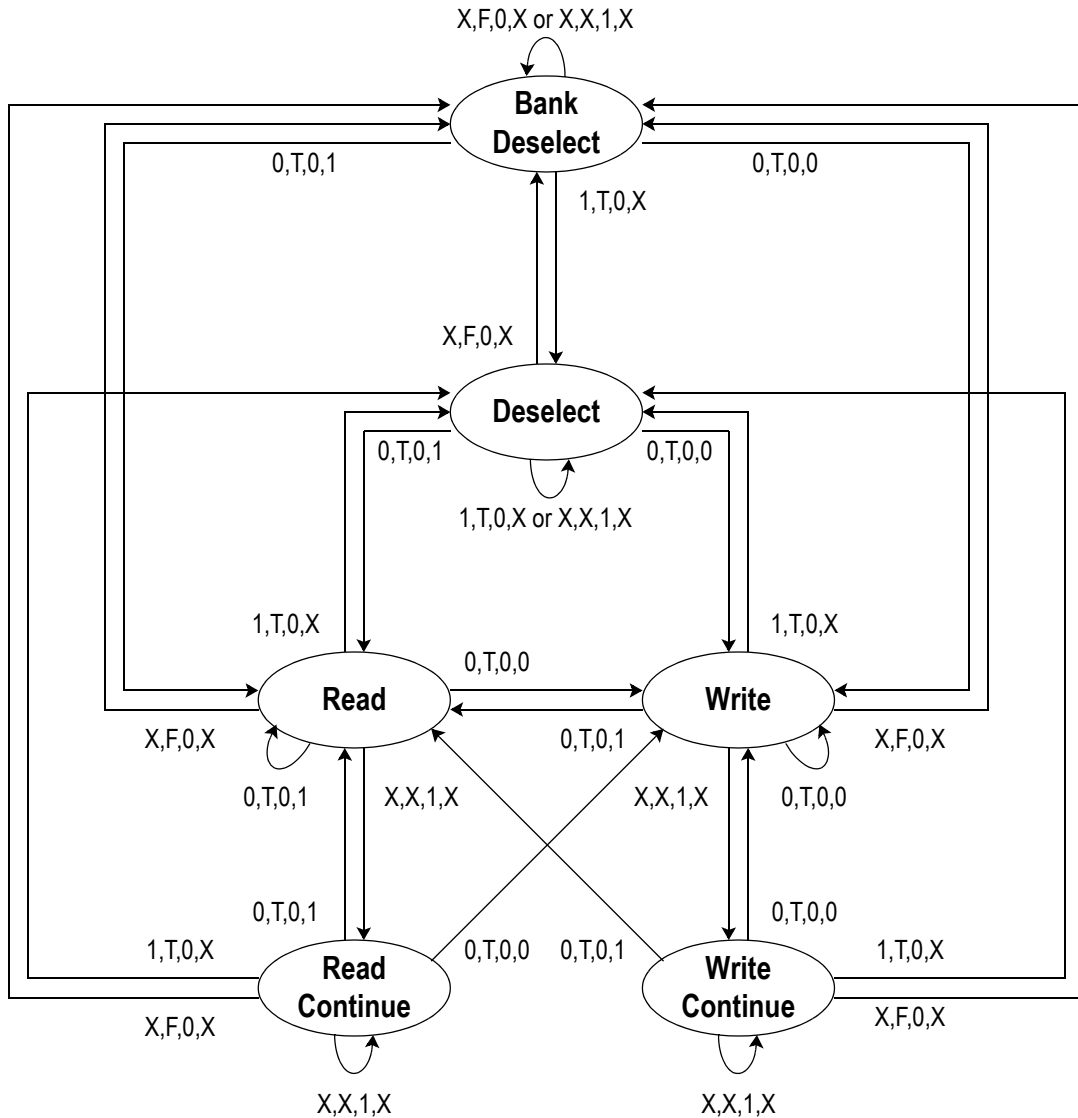
**DDR Late Write, Pipelined Read Truth Table**

CK	$\overline{E1}$ ( $t_n$ )	E ( $t_n$ )	ADV ( $t_n$ )	$\overline{W}$ ( $t_n$ )	Previous Operation	Current Operation	DQ/CQ ( $t_n$ )	DQ/CQ ( $t_{n+1/2}$ )	DQ/CQ ( $t_{n+1}$ )	DQ/CQ ( $t_{n+1/2}$ )
0→1	X	F	0	X	X	Bank Deselect	***/**		Hi-Z/Hi-Z	
0→1	X	X	1	X	Bank Deselect	Bank Deselect (Continue)	Hi-Z/Hi-Z		Hi-Z/Hi-Z	
0→1	1	T	0	X	X	Deselect	***/**		Hi-Z/CQ	
0→1	X	X	1	X	Deselect	Deselect (Continue)	Hi-Z/CQ		Hi-Z/CQ	
0→1	0	T	0	0	X	Write Loads new address	***/**		D1/CQ	D2/CQ
0→1	X	X	1	X	Write	Write Continue Increments address by 2	Dn-2/CQ	Dn-1/CQ	Dn/CQ	Dn+1/CQ
0→1	0	T	0	1	X	Read Loads new address	***/**		Q1/CQ	Q2/CQ
0→1	X	X	1	X	Read	Read Continue Increments address by 2	Qn-2/CQ	Qn-2/CQ	Qn/CQ	Qn+1/CQ

**Notes:**

1. If  $E2 = EP2$  and  $E3 = EP3$  then  $E = "T"$  else  $E = "F"$ .
2. "1" = input "high"; "0" = input "low"; "X" = input "don't care"; "T" = input "true"; "F" = input "false".
3. "\*\*\*" indicates that the DQ input requirement / output state and CQ output state are determined by the previous operation.
4. DQs are tri-stated in response to Bank Deselect, Deselect, and Write commands, one full cycle after the command is sampled.
5. CQs are tri-stated in response to Bank Deselect commands only, one full cycle after the command is sampled.
6. One (1) Continue operation may be initiated after a Read or Write operation is initiated to burst transfer a total of four (4) distinct pieces of data per single external address input. If a second (2nd) Continue operation is initiated, the internal address wraps back to the initial external (base) address.

Common I/O State Diagram



Current State & Next State Definition for Read/Write Control State Diagram

Notes:

1. The notation "X,X,X,X" controlling the state transitions above indicate the states of inputs  $\overline{E1}$ , E, ADV, and  $\overline{W}$  respectively.
2. If (E2 = EP2 and E3 = EP3) then E = "T" else E = "F".
3. "1" = input "high"; "0" = input "low"; "X" = input "don't care"; "T" = input "true"; "F" = input "false".

**Absolute Maximum Ratings**

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

Symbol	Description	Value	Unit
$V_{DD}$	Voltage on $V_{DD}$ Pins	-0.5 to 2.5	V
$V_{DDQ}$	Voltage in $V_{DDQ}$ Pins	-0.5 to $V_{DD}$	V
$V_{I/O}$	Voltage on I/O Pins	-0.5 to $V_{DDQ} + 0.5$ ( $\leq 2.5$ V max.)	V
$V_{IN}$	Voltage on Other Input Pins	-0.5 to $V_{DDQ} + 0.5$ ( $\leq 2.5$ V max.)	V
$I_{IN}$	Input Current on Any Pin	+/-100	mA dc
$I_{OUT}$	Output Current on Any I/O Pin	+/-100	mA dc
$T_J$	Maximum Junction Temperature	125	$^{\circ}$ C
$T_{STG}$	Storage Temperature	-55 to 125	$^{\circ}$ 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 Recommended Operating Conditions, for an extended period of time, may affect reliability of this component.

**Recommended Operating Conditions**
**Power Supplies**

Parameter	Symbol	Min.	Typ.	Max.	Unit	Notes
Supply Voltage	$V_{DD}$	1.7	1.8	1.95	V	
1.8 V I/O Supply Voltage	$V_{DDQ}$	1.7	1.8	$V_{DD}$	V	
Ambient Temperature (Commercial Range Versions)	$T_A$	0	25	70	$^{\circ}$ C	1
Ambient Temperature (Industrial Range Versions)	$T_A$	-40	25	85	$^{\circ}$ C	1

**Note:**

The part number 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.

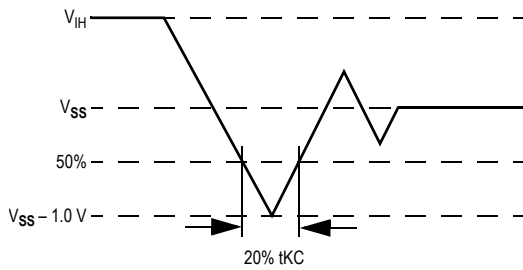
**CMOS I/O DC Input Characteristics**

Parameter	Symbol	Min.	Typ.	Max.	Unit	Notes
CMOS Input High Voltage	$V_{IH}$	$0.65 * V_{DDQ}$	—	$V_{DDQ} + 0.3$	V	1
CMOS Input Low Voltage	$V_{IL}$	-0.3	—	$0.35 * V_{DDQ}$	V	1

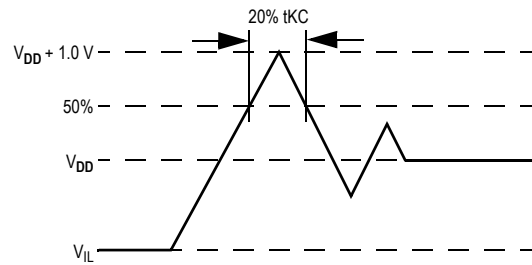
**Note:**

For devices supplied with CMOS input buffers. Compatible with both 1.8 V and 1.5 V I/O drivers.

### Undershoot Measurement and Timing



### Overshoot Measurement and Timing



### Capacitance

( $T_A = 25^\circ\text{C}$ ,  $f = 1 \text{ MHz}$ ,  $V_{DD} = 1.8 \text{ V}$ )

Parameter	Symbol	Test conditions	Typ.	Max.	Unit
Input Capacitance	$C_{IN}$	$V_{IN} = 0 \text{ V}$	4	5	pF
Output Capacitance	$C_{OUT}$	$V_{OUT} = 0 \text{ V}$	6	7	pF

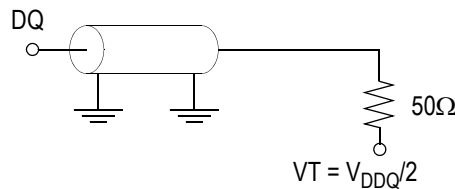
**Note:**

This parameter is sample tested.

### AC Test Conditions

Parameter	Conditions
Input high level	$V_{DDQ}$
Input low level	0 V
Max. input slew rate	2 V/ns
Input reference level	$V_{DDQ}/2$
Output reference level	$V_{DDQ}/2$

### AC Test Load Diagram



$R_Q = 250 \Omega$  (HSTL I/O)

**Input and Output Leakage Characteristics**

Parameter	Symbol	Test Conditions	Min.	Max	Notes
Input Leakage Current (except mode pins)	$I_{IL}$	$V_{IN} = 0$ to $V_{DDQ}$	-2 $\mu$ A	2 $\mu$ A	—
ZQ, MCH, MCL, EP2, EP3 Pin Input Current	$I_{INM}$	$V_{IN} = 0$ to $V_{DDQ}$	-50 $\mu$ A	50 $\mu$ A	—
Output Leakage Current	$I_{OL}$	Output Disable, $V_{OUT} = 0$ to $V_{DDQ}$	-2 $\mu$ A	2 $\mu$ A	—

**Selectable Impedance Output Driver DC Electrical Characteristics**

Parameter	Symbol	Test Conditions	Min.	Max	Notes
Low Drive Output High Voltage	$V_{OHL}$	$I_{OHL} = -4$ mA	$V_{DDQ} - 0.4$ V	—	1
Low Drive Output Low Voltage	$V_{OLL}$	$I_{OLL} = 4$ mA	—	0.4 V	1
High Drive Output High Voltage	$V_{OHH}$	$I_{OHH} = -8$ mA	$V_{DDQ} - 0.4$ V	—	2
High Drive Output Low Voltage	$V_{OLH}$	$I_{OLH} = 8$ mA	—	0.4 V	2

**Notes:**

- ZQ = 1; High Impedance output driver setting
- ZQ = 0; Low Impedance output driver setting

**Operating Currents**

Parameter	Symbol	-333		-300		-250		-200		Test Conditions
		0°C to 70°C	-40°C to +85°C	0°C to 70°C	-40°C to +85°C	0°C to 70°C	-40°C to +85°C	0°C to 70°C	-40°C to +85°C	
Operating Current	x36 $I_{DDP}$ (PL)	345 mA	355 mA	320 mA	330 mA	275 mA	285 mA	225 mA	235 mA	E1 $\leq V_{IL}$ Max. tKHKH $\geq$ tKHKH Min. All other inputs $V_{IL} \geq V_{IN} \geq V_{IH}$
Chip Disable Current	x36 $I_{SB1}$ (PL)	75 mA	85 mA	70 mA	80 mA	65 mA	75 mA	60 mA	70 mA	E1 $\geq V_{IH}$ Min. or tKHKH $\geq$ tKHKH Min. All other inputs $V_{IL} \geq V_{IN} \geq V_{IH}$
Bank Deselect Current	x36 $I_{SB2}$ (PL)	75 mA	85 mA	70 mA	80 mA	65 mA	75 mA	60 mA	70 mA	E2 or E3 False tKHKH $\geq$ tKHKH Min. All other inputs $V_{IL} \geq V_{IN} \geq V_{IH}$
CMOS Deselect Current	$I_{DD3}$	45 mA	55 mA	45 mA	55 mA	45 mA	55 mA	45 mA	55 mA	Device Deselected All inputs $V_{SS} + 0.10$ V $\geq V_{IN} \geq$ $V_{DD} - 0.10$ V



**AC Electrical Characteristics**

Parameter	Symbol	-333		-300		-250		-200		Unit	Notes
		Min	Max	Min	Max	Min	Max	Min	Max		
Clock Cycle Time	tKHKH	3.0	—	3.3	—	4.0	—	5.0	—	ns	—
Clock High Time	tKHKL	1.2	—	1.3	—	1.6	—	1.8	—	ns	—
Clock Low Time	tKCLK	1.2	—	1.3	—	1.6	—	1.8	—	ns	—
Clock High to Echo Clock Low-Z	tKHCX1	0.5	—	0.5	—	0.5	—	0.5	—	ns	2
Clock High to Echo Clock High	tKHCH	—	1.8	—	1.8	—	2.1	—	2.1	ns	—
Clock Low to Echo Clock Low	tKLCL	—	1.8	—	1.8	—	2.1	—	2.1	ns	—
Clock High to Echo Clock High-Z	tKHCZ	—	1.8	—	1.8	—	2.1	—	2.1	ns	1, 2
Clock High to Output Low-Z	tKHQX1	0.5	—	0.5	—	0.5	—	0.5	—	ns	1
Clock High to Output Valid	tKHQV	—	1.8	—	1.8	—	2.1	—	2.1	ns	—
Clock Low to Output Invalid	tKLQX	0.5	—	0.5	—	0.5	—	0.5	—	ns	—
Clock Low to Output Valid	tKLQV	—	1.8	—	1.8	—	2.1	—	2.1	ns	—
Clock High to Output Invalid	tKHQX	0.5	—	0.5	—	0.5	—	0.5	—	ns	—
Clock High to Output High-Z	tKHQZ	—	1.8	—	1.8	—	2.1	—	2.1	ns	1
Echo Clock High to Output Valid	tCHQV	—	0.27	—	0.29	—	0.35	—	0.35	ns	2
Echo Clock Low to Output Invalid	tCLQX	-0.27	—	-0.29	—	-0.35	—	-0.35	—	ns	2
Echo Clock Low to Output Valid	tCLQV	—	0.27	—	0.29	—	0.35	—	0.35	ns	2
Echo Clock High to Output Invalid	tCHQX	-0.27	—	-0.29	—	-0.35	—	-0.35	—	ns	2
Address Valid to Clock High	tAVKH	0.6	—	0.7	—	0.8	—	0.8	—	ns	—
Clock High to Address Don't Care	tKHAX	0.4	—	0.4	—	0.5	—	0.5	—	ns	—
Enable Valid to Clock High	tEVKH	0.6	—	0.7	—	0.8	—	0.8	—	ns	—
Clock High to Enable Don't Care	tKHEX	0.4	—	0.4	—	0.5	—	0.5	—	ns	—
Write Valid to Clock High	tWVKH	0.6	—	0.7	—	0.8	—	0.8	—	ns	—
Clock High to Write Don't Care	tKH WX	0.4	—	0.4	—	0.5	—	0.5	—	ns	—
Data In Valid to Clock High	tDVKH	0.32	—	0.35	—	0.40	—	0.40	—	ns	—

**Notes:**

1. Measured at 100 mV from steady state. Not 100% tested.
2. Guaranteed by design. Not 100% tested.
3. For any specific temperature and voltage tKHCZ < tKHCX1.

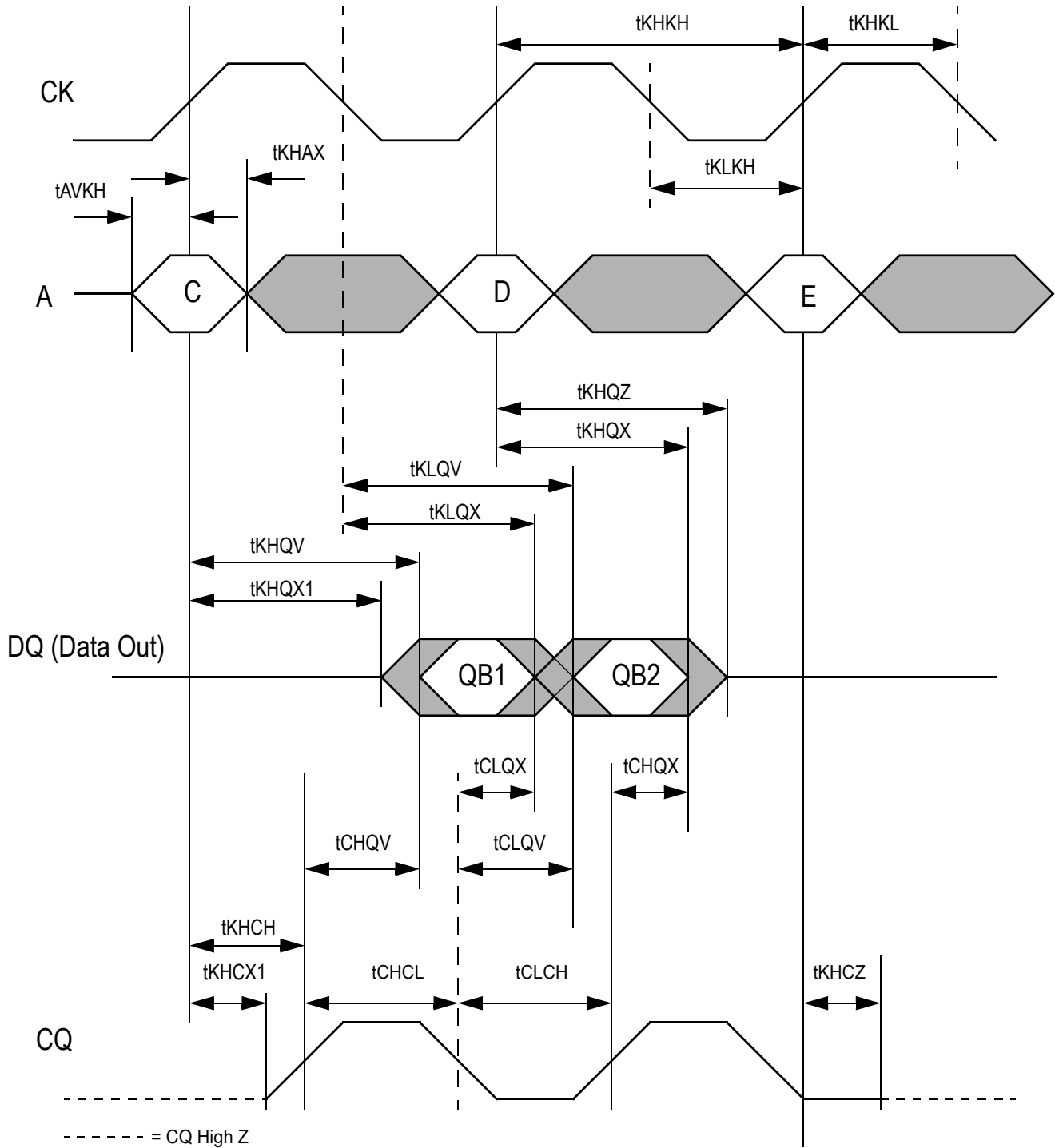
**AC Electrical Characteristics (Continued)**

Parameter	Symbol	-333		-300		-250		-200		Unit	Notes
		Min	Max	Min	Max	Min	Max	Min	Max		
Clock High to Data In Don't Care	tKHDX	0.27	—	0.30	—	0.35	—	0.35	—	ns	—
Data In Valid to Clock Low	tDVKL	0.32	—	0.35	—	0.40	—	0.40	—	ns	
Clock Low to Data In Don't Care	tKLDX	0.27	—	0.30	—	0.35	—	0.35	—	ns	
ADV Valid to Clock High	tadvVKH	0.6	—	0.7	—	0.8	—	0.8	—	ns	—
Clock High to ADV Don't Care	tKHadvX	0.4	—	0.4	—	0.5	—	0.5	—	ns	—

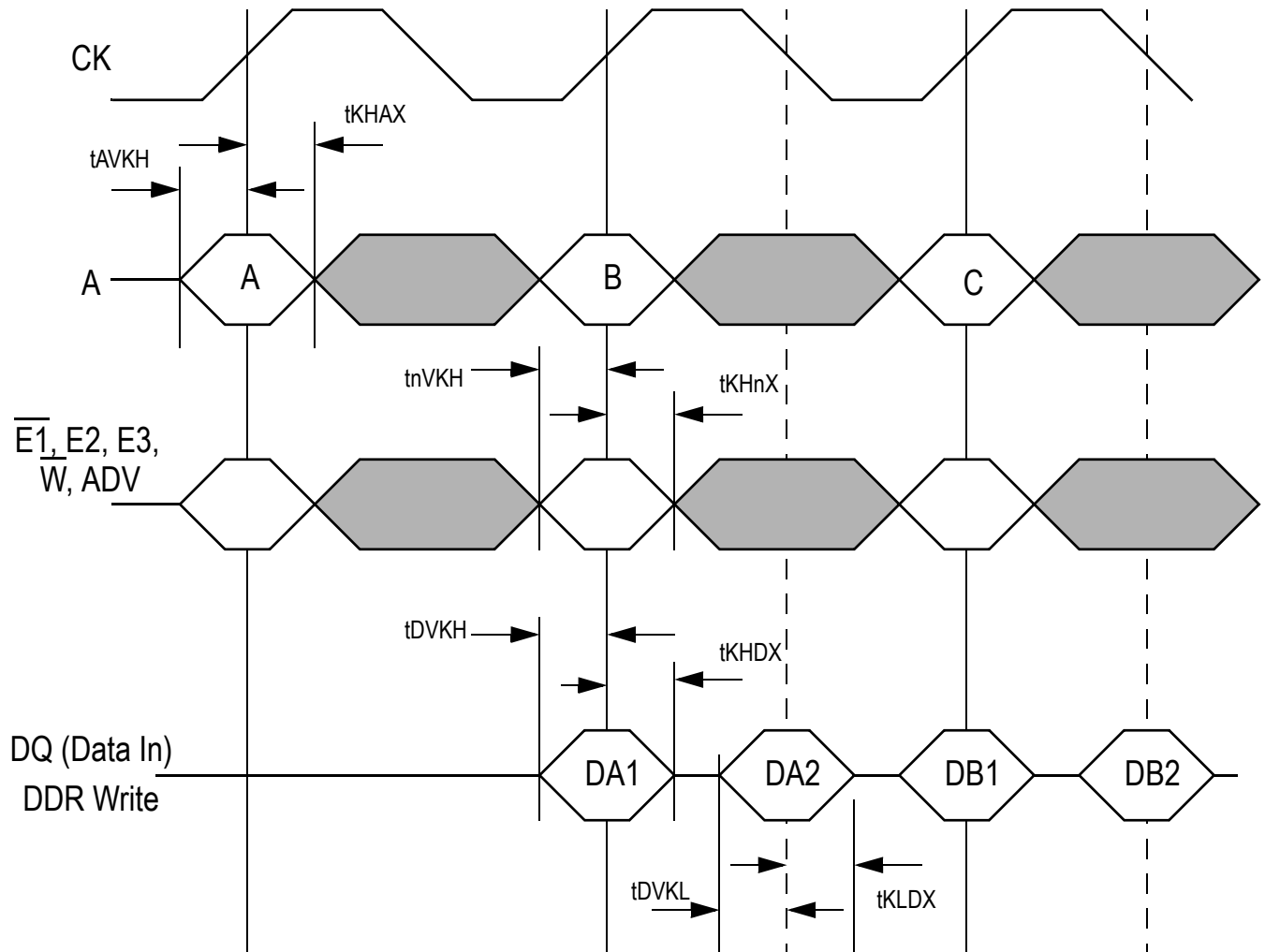
**Notes:**

1. Measured at 100 mV from steady state. Not 100% tested.
2. Guaranteed by design. Not 100% tested.
3. For any specific temperature and voltage tKHCZ < tKHCX1.

Timing Parameter Key—Read Cycle Timing



## Timing Parameter Key—DDR Control and Data In Timing



Note:  $t_{nVKH} = t_{EVKH}, t_{WVKH}, \text{etc.}$  and  $t_{KHnX} = t_{KHEX}, t_{KH WX}, \text{etc.}$

## JTAG Port Operation

### 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 automatically at power-up.

## JTAG Port Registers

### Overview

The various JTAG registers, referred to as Test Access Port or TAP 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.

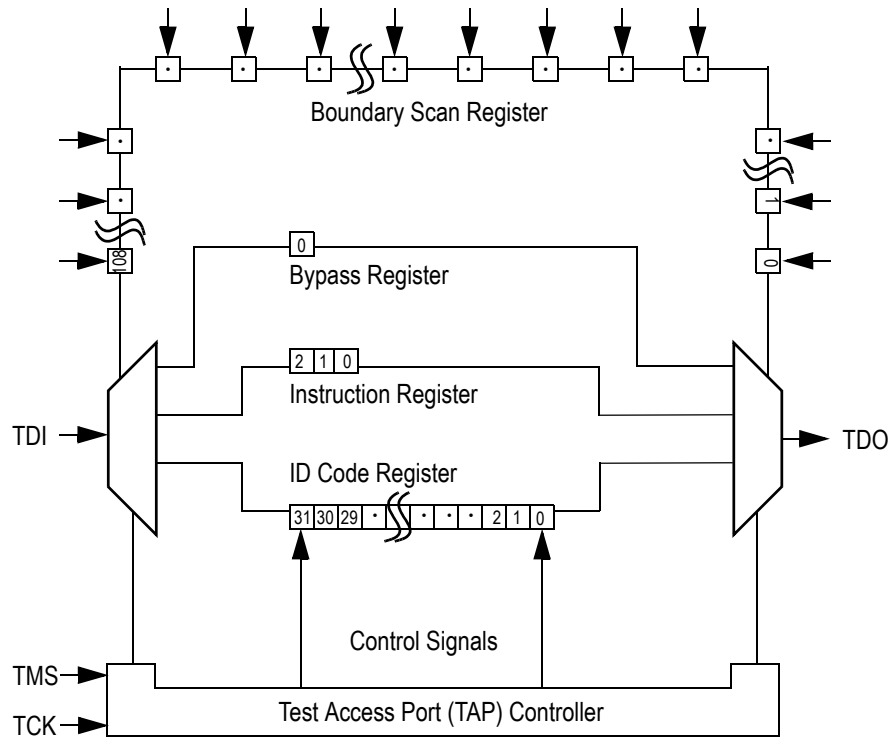
### Bypass Register

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 RAM's 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.

#### 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
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

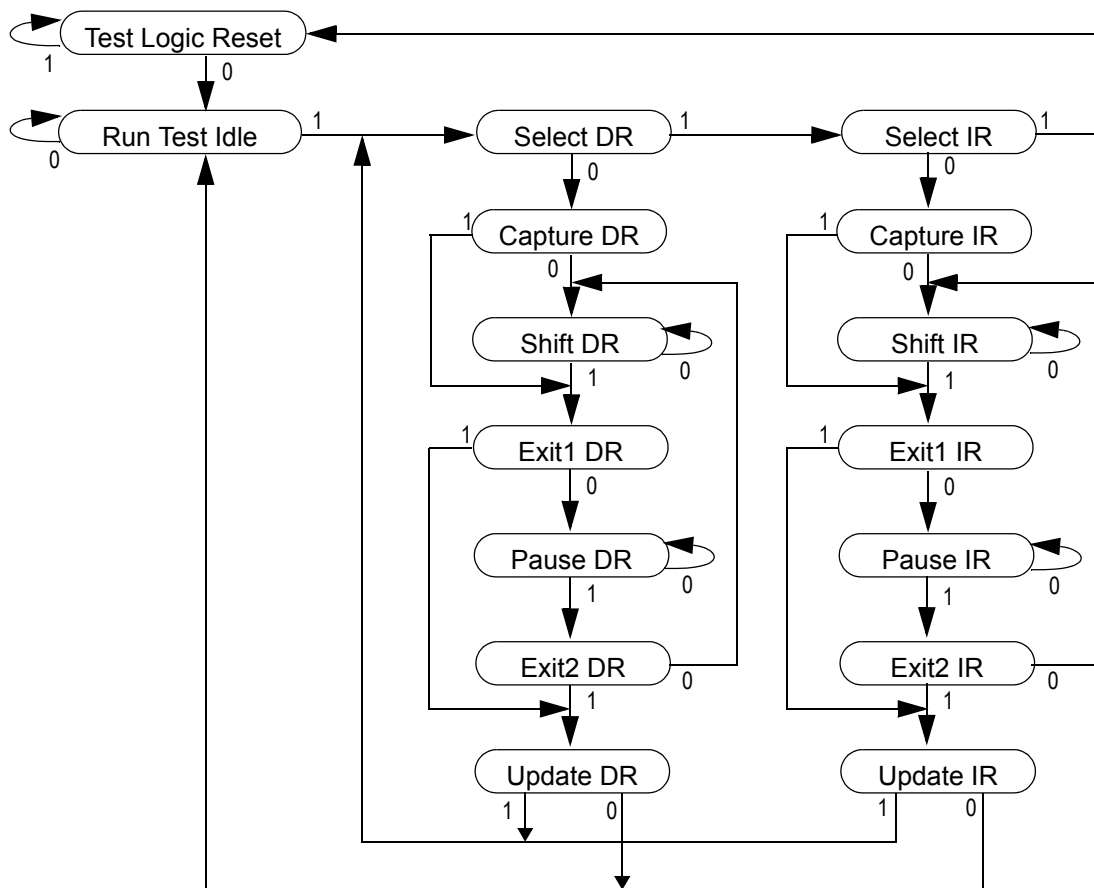
## Tap Controller Instruction Set

### 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.

### 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. 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 state 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.

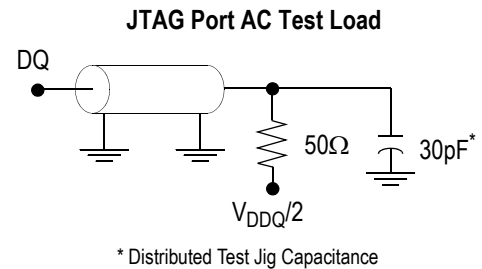
**RFU**

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



**JTAG Port AC Test Conditions**

Parameter	Conditions
Input high level	$V_{DD} - 0.2 V$
Input low level	0.2 V
Input slew rate	1 V/ns
Input reference level	$V_{DDQ}/2$
Output reference level	$V_{DDQ}/2$


**Notes:**

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

**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. Forces all RAM output drivers to High-Z.	1
RFU	011	Do not use this instruction; Reserved for Future Use. 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. 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.

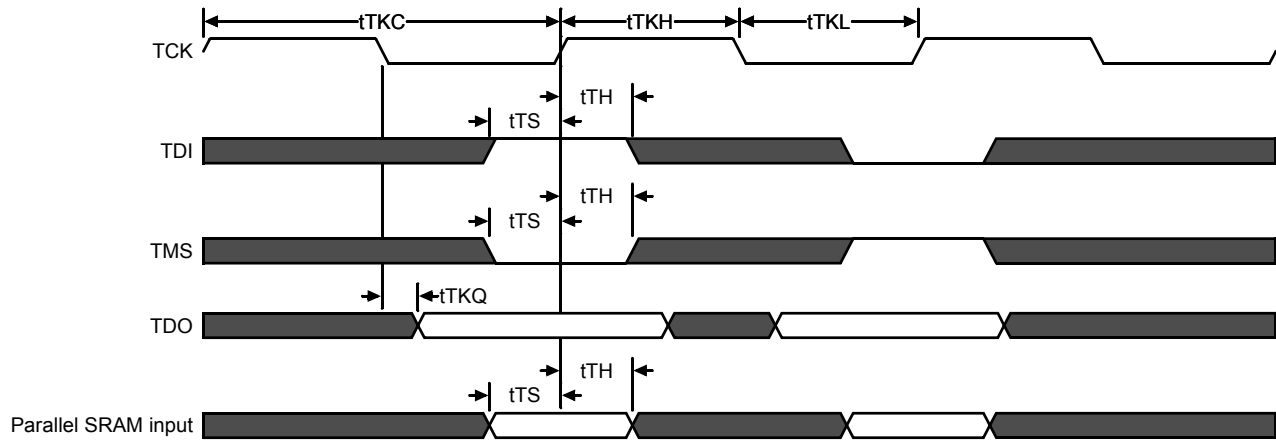
**JTAG Port Recommended Operating Conditions and DC Characteristics**

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	$V_{OHJC}$	$V_{DDQ} - 100 \text{ mV}$	—	V	5, 8
Test Port Output CMOS Low	$V_{OLJC}$	—	100 mV	V	5, 9

**Notes:**

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

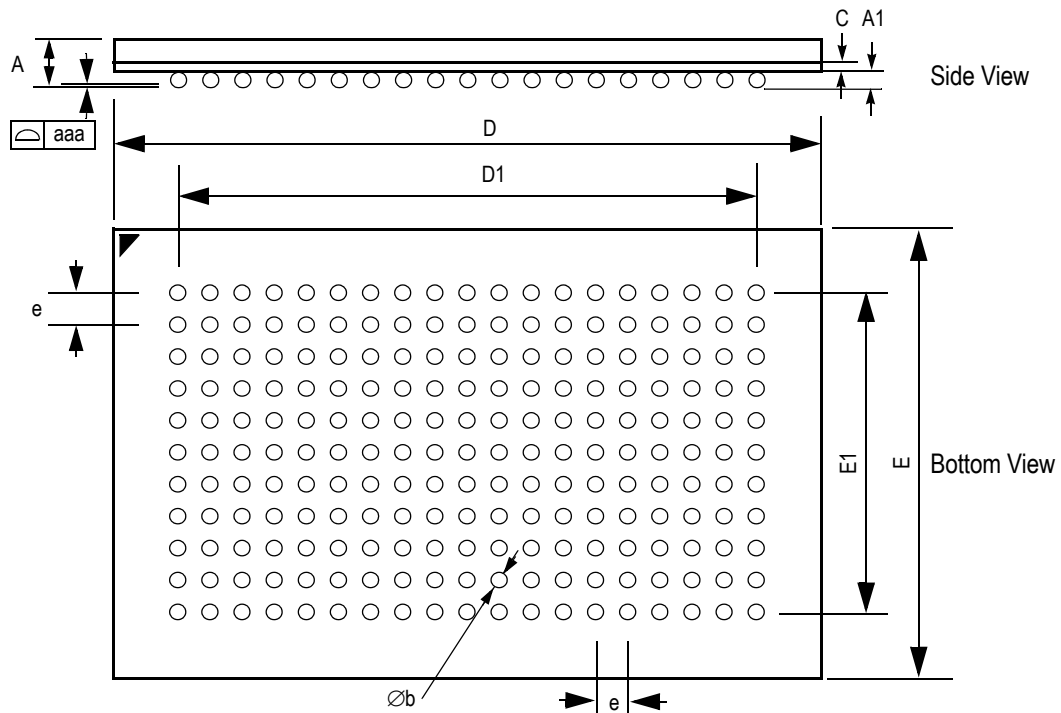
### JTAG Port Timing Diagram



Parameter	Symbol	Min	Max	Unit
TCK Cycle Time	$t_{TKC}$	50	—	ns
TCK Low to TDO Valid	$t_{TKQ}$	—	20	ns
TCK High Pulse Width	$t_{TKH}$	20	—	ns
TCK Low Pulse Width	$t_{TKL}$	20	—	ns
TDI & TMS Set Up Time	$t_{TS}$	10	—	ns
TDI & TMS Hold Time	$t_{TH}$	10	—	ns

**209 BGA Package Drawing (Package C)**

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



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

Rev 1.0

**Ordering Information—GSI SigmaRAM**

Org	Part Number	Type	I/O	Speed (MHz)	T <sub>A</sub>
512K x 36	GS8170DD36C-333	Double Data Rate $\Sigma$ 1x2Lp SRAM	CMOS	333 MHz	C
512K x 36	GS8170DD36C-300	Double Data Rate $\Sigma$ 1x2Lp SRAM	CMOS	300 MHz	C
512K x 36	GS8170DD36C-250	Double Data Rate $\Sigma$ 1x2Lp SRAM	CMOS	250 MHz	C
512K x 36	GS8170DD36C-200	Double Data Rate $\Sigma$ 1x2Lp SRAM	CMOS	200 MHz	C
512K x 36	GS8170DD36C-333I	Double Data Rate $\Sigma$ 1x2Lp SRAM	CMOS	333 MHz	I
512K x 36	GS8170DD36C-300I	Double Data Rate $\Sigma$ 1x2Lp SRAM	CMOS	300 MHz	I
512K x 36	GS8170DD36C-250I	Double Data Rate $\Sigma$ 1x2Lp SRAM	CMOS	250 MHz	I
512K x 36	GS8170DD36C-200I	Double Data Rate $\Sigma$ 1x2Lp SRAM	CMOS	200 MHz	I

**Notes:**

- Customers requiring delivery in Tape and Reel should add the character "T" to the end of the part number. Example: GS817xx36C-300T.
- T<sub>A</sub> = C = Commercial Temperature Range. T<sub>A</sub> = I = Industrial Temperature Range.

DS/DateRev. Code: Old; New	Types of Changes Format or Content	Page;Revisions;Reason
8170DD18_r1		• Creation of new datasheet
8170DD18_r1; 8170DD18_r1_01	Content	• Removed all references to FT mode
8170DD18_r1_01; 8170DD18_r2	Content	• Complete rewrite (DC from 36Mb)
8170DD18_r2; 8170DD18_r2_01	Content/format	• Added 200 MHz speed bin • Updated format
8170DD18_r2_01; 8170DD18_r2_02	Content/format	• Pervasive edit • Added x72 information to ordering information
8170DDxx_r2_02; 8170DDxx_r2_03	Content/format	• Updated format • Removed Preliminary banner due to qualification