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Document Title

2Mx36 & 4Mx18-Bit Pipelined NtRAM™

Revision History

<u>Rev. No.</u>	<u>History</u>	<u>Draft Date</u>	<u>Remark</u>
0.0	1. Initial document.	Sep. 30. 2002	Advance
0.1	1. Delete the speed bins (FT : 7.5ns, 8.5ns / PP : 200MHz)	Oct. 8. 2002	Preliminary
0.2	1. Corrected Part number (K7N643635M -> K7N643631M) 2. Change to the New JTAG scan order.	Feb. 25, 2003	Preliminary
0.3	1. Add the comment about Vdd/Vddq wide by note on page 13.	Mar. 10, 2003	Preliminary

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The attached data sheets are prepared and approved by SAMSUNG Electronics. SAMSUNG Electronics CO., LTD. reserve the right to change the specifications. SAMSUNG Electronics will evaluate and reply to your requests and questions on the parameters of this device. If you have any questions, please contact the SAMSUNG branch office near your office, call or contact Headquarters.

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**64Mb NtRAM (Flow Through / Pipelined) Ordering Information**

Org.	Part Number	Mode	VDD	Speed FT ; Access Time(ns) Pipelined ; Cycle Time(MHz)	PKG	Temp
4Mx18	K7M641835M-Q(H/F)C65	FlowThrough	1.8/2.5/3.3	6.5ns	Q:100TQFP H:119BGA F:165FBGA	C (Commercial Temperature Range)
	K7N641831M-Q(H/F)C25/16	Pipelined	1.8/2.5/3.3	250/167MHz		
2Mx36	K7M643635M-Q(H/F)C65	FlowThrough	1.8/2.5/3.3	6.5ns		
	K7N643631M-Q(H/F)C25/16	Pipelined	1.8/2.5/3.3	250/167MHz		

**2Mx36 & 4Mx18-Bit Pipelined NtRAM™**

**FEATURES**

- 1.8 or 2.5 or 3.3V ±5% Power Supply.
- Byte Writable Function.
- Enable clock and suspend operation.
- Single READ/WRITE control pin.
- Self-Timed Write Cycle.
- Three Chip Enable for simple depth expansion with no data contention .
- A interleaved burst or a linear burst mode.
- Asynchronous output enable control.
- Power Down mode.
- TTL-Level Three-State Outputs.
- 100-TQFP-1420A / 119BGA(7x17 Ball Grid Array Package).
- 165FBGA(11x15 ball array) with body size of 15mmx17mm.

**GENERAL DESCRIPTION**

The K7N643631M and K7N641831M are 75,497,472-bits Synchronous Static SRAMs.

The NtRAM™, or No Turnaround Random Access Memory utilizes all the bandwidth in any combination of operating cycles. Address, data inputs, and all control signals except output enable and linear burst order are synchronized to input clock. Burst order control must be tied "High or Low".

Asynchronous inputs include the sleep mode enable(ZZ). Output Enable controls the outputs at any given time. 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 and provides increased timing flexibility for incoming signals.

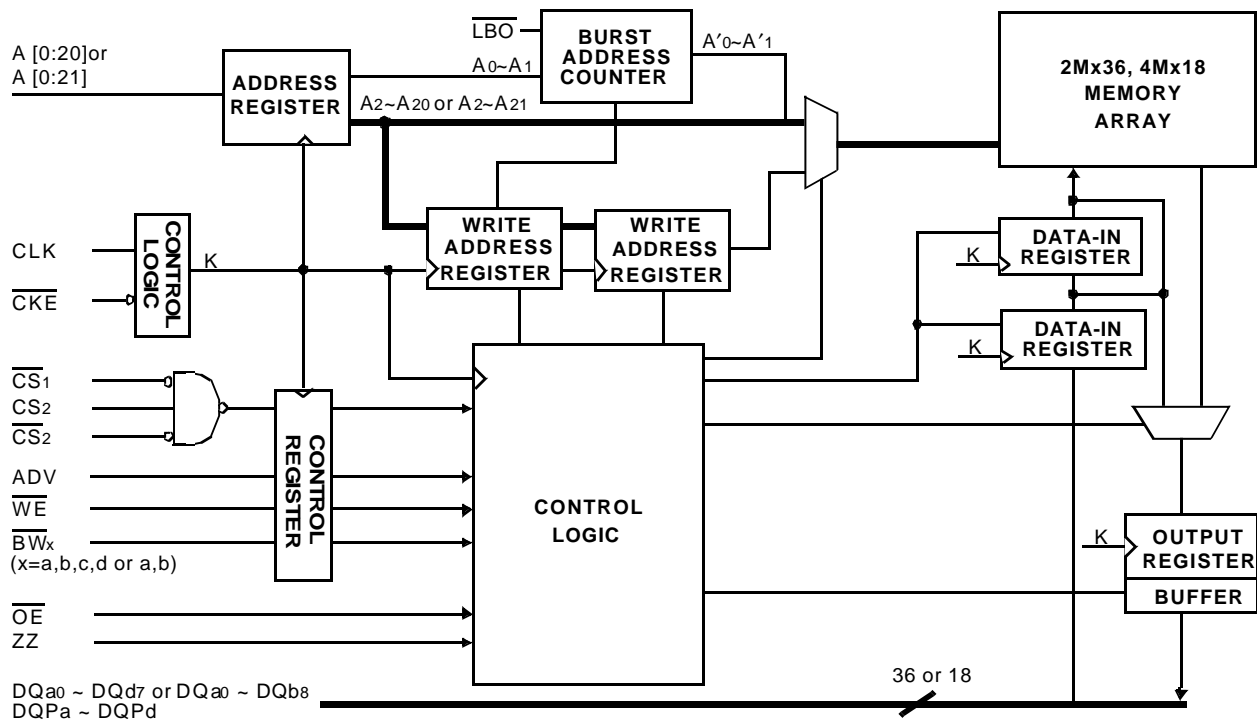
For read cycles, pipelined SRAM output data is temporarily stored by an edge triggered output register and then released to the output buffers at the next rising edge of clock.

The K7N643631M and K7N641831M are implemented with SAMSUNG's high performance CMOS technology and is available in 100pin TQFP, 119BGA and 165FBGA packages. Multiple power and ground pins minimize ground bounce.

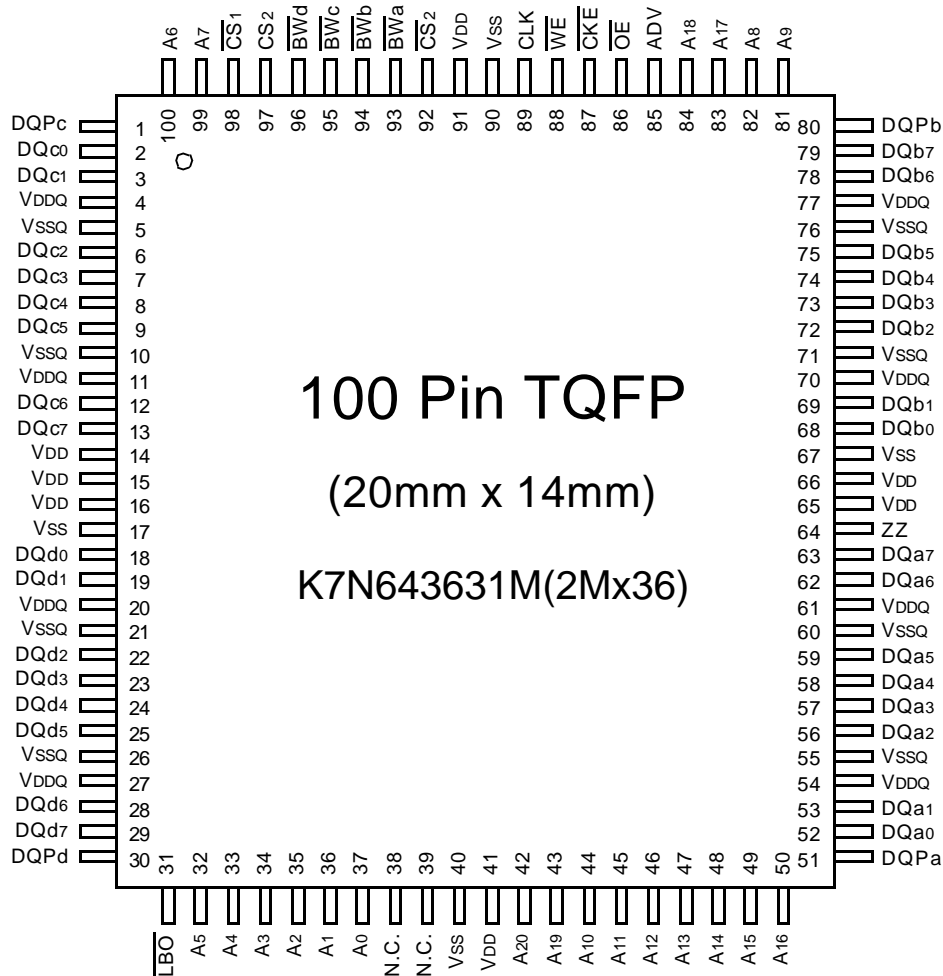
**FAST ACCESS TIMES**

PARAMETER	Symbol	-25	-16	Unit
Cycle Time	tCYC	4.0	6.0	ns
Clock Access Time	tCD	2.6	3.5	ns
Output Enable Access Time	tOE	2.6	3.5	ns

**LOGIC BLOCK DIAGRAM**



**PIN CONFIGURATION(TOP VIEW)**

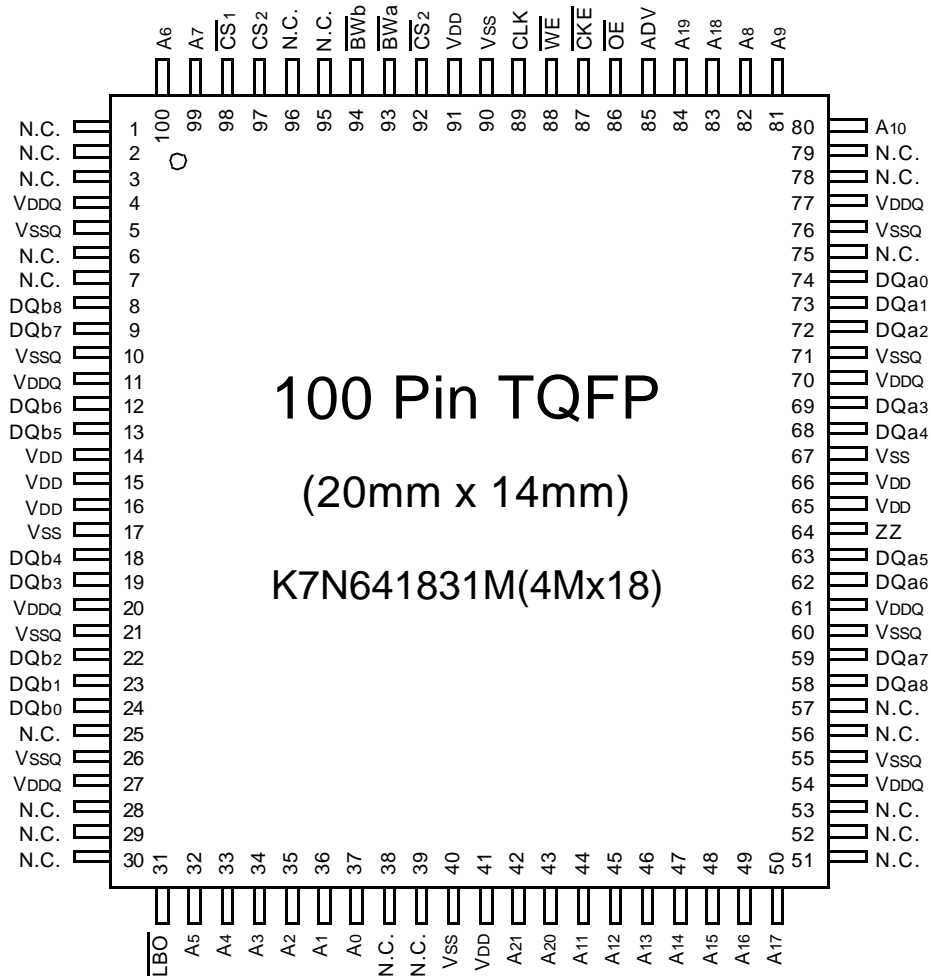


**PIN NAME**

SYMBOL	PIN NAME	TQFP PIN NO.	SYMBOL	PIN NAME	TQFP PIN NO.
A0 - A20	Address Inputs	32,33,34,35,36,37,42,43,44,45,46,47,48,49,50,81,82,83,84,99,100	VDD	Power Supply(2.5V)	14,15,16,41,65,66,91
			VSS	Ground	17,40,67,90
			N.C.	No Connect	38,39
ADV	Address Advance/Load	85	DQa0~a7	Data Inputs/Outputs	52,53,56,57,58,59,62,63
WE	Read/Write Control Input	88	DQb0~b7	Data Inputs/Outputs	68,69,72,73,74,75,78,79
CLK	Clock	89	DQc0~c7	Data Inputs/Outputs	2,3,6,7,8,9,12,13
CKE	Clock Enable	87	DQd0~d7	Data Inputs/Outputs	18,19,22,23,24,25,28,29
CS1	Chip Select	98	DQPa~Pd	Data Inputs/Outputs	51,80,1,30
CS2	Chip Select	97			
CS2	Chip Select	92			
BWx(x=a,b,c,d)	Byte Write Inputs	93,94,95,96	VDDQ	Output Power Supply (2.5V)	4,11,20,27,54,61,70,77
OE	Output Enable	86	VSSQ	Output Ground	5,10,21,26,55,60,71,76
ZZ	Power Sleep Mode	64			
LBO	Burst Mode Control	31			

**Note :** 1. A<sub>0</sub> and A<sub>1</sub> are the two least significant bits(LSB) of the address field and set the internal burst counter if burst is desired.

**PIN CONFIGURATION(TOP VIEW)**



**PIN NAME**

SYMBOL	PIN NAME	TQFP PIN NO.	SYMBOL	PIN NAME	TQFP PIN NO.
A0 - A21	Address Inputs	32,33,34,35,36,37,42,43,44,45,46,47,48,49,50,80,81,82,83,84,99,100	VDD	Power Supply(2.5V)	14,15,16,41,65,66,91
			Vss	Ground	17,40,67,90
			N.C.	No Connect	1,2,3,6,7,25,28,29,30,38,39,51,52,53,56,57,75,78,79,95,96
ADV	Address Advance/Load	85	DQa0-a8	Data Inputs/Outputs	58,59,62,63,68,69,72,73,74
WE	Read/Write Control Input	88	DQb0-b8	Data Inputs/Outputs	8,9,12,13,18,19,22,23,24
CLK	Clock	89			
CKE	Clock Enable	87	VDDQ	Output Power Supply (2.5V)	4,11,20,27,54,61,70,77
CS1	Chip Select	98	VSSQ	Output Ground	5,10,21,26,55,60,71,76
CS2	Chip Select	97			
CS2	Chip Select	92			
BWx(x=a,b)	Byte Write Inputs	93,94			
OE	Output Enable	86			
ZZ	Power Sleep Mode	64			
LBO	Burst Mode Control	31			

**NOTE :** A<sub>0</sub> and A<sub>1</sub> are the two least significant bits(LSB) of the address field and set the internal burst counter if burst is desired.

**119BGA PACKAGE PIN CONFIGURATIONS (TOP VIEW)**

**K7N643631M(2Mx36)**

	1	2	3	4	5	6	7
<b>A</b>	V <sub>DDQ</sub>	A	A	A	A	A	V <sub>DDQ</sub>
<b>B</b>	NC	CS <sub>2</sub>	A	ADV	A	$\overline{CS}_2$	NC
<b>C</b>	NC	A	A	V <sub>DD</sub>	A	A	NC
<b>D</b>	DQ <sub>c</sub>	DQP <sub>c</sub>	V <sub>SS</sub>	NC	V <sub>SS</sub>	DQP <sub>b</sub>	DQ <sub>b</sub>
<b>E</b>	DQ <sub>c</sub>	DQ <sub>c</sub>	V <sub>SS</sub>	$\overline{CS}_1$	V <sub>SS</sub>	DQ <sub>b</sub>	DQ <sub>b</sub>
<b>F</b>	V <sub>DDQ</sub>	DQ <sub>c</sub>	V <sub>SS</sub>	$\overline{OE}$	V <sub>SS</sub>	DQ <sub>b</sub>	V <sub>DDQ</sub>
<b>G</b>	DQ <sub>c</sub>	DQ <sub>c</sub>	$\overline{BW}_c$	A	$\overline{BW}_b$	DQ <sub>b</sub>	DQ <sub>b</sub>
<b>H</b>	DQ <sub>c</sub>	DQ <sub>c</sub>	V <sub>SS</sub>	$\overline{WE}$	V <sub>SS</sub>	DQ <sub>b</sub>	DQ <sub>b</sub>
<b>J</b>	V <sub>DDQ</sub>	V <sub>DD</sub>	NC	V <sub>DD</sub>	NC	V <sub>DD</sub>	V <sub>DDQ</sub>
<b>K</b>	DQ <sub>d</sub>	DQ <sub>d</sub>	V <sub>SS</sub>	CLK	V <sub>SS</sub>	DQ <sub>a</sub>	DQ <sub>a</sub>
<b>L</b>	DQ <sub>d</sub>	DQ <sub>d</sub>	$\overline{BW}_d$	NC	$\overline{BW}_a$	DQ <sub>a</sub>	DQ <sub>a</sub>
<b>M</b>	V <sub>DDQ</sub>	DQ <sub>d</sub>	V <sub>SS</sub>	$\overline{CKE}$	V <sub>SS</sub>	DQ <sub>a</sub>	V <sub>DDQ</sub>
<b>N</b>	DQ <sub>d</sub>	DQ <sub>d</sub>	V <sub>SS</sub>	A <sub>1</sub> *	V <sub>SS</sub>	DQ <sub>a</sub>	DQ <sub>a</sub>
<b>P</b>	DQ <sub>d</sub>	DQP <sub>d</sub>	V <sub>SS</sub>	A <sub>0</sub> *	V <sub>SS</sub>	DQP <sub>a</sub>	DQ <sub>a</sub>
<b>R</b>	NC	A	$\overline{LBO}$	V <sub>DD</sub>	NC	A	NC
<b>T</b>	NC	A	A	A	A	A	ZZ
<b>U</b>	V <sub>DDQ</sub>	TMS	TDI	TCK	TDO	NC	V <sub>DDQ</sub>

**Note :** \* A<sub>0</sub> and A<sub>1</sub> are the two least significant bits(LSB) of the address field and set the internal burst counter if burst is desired.

**PIN NAME**

SYMBOL	PIN NAME	SYMBOL	PIN NAME
A	Address Inputs	V <sub>DD</sub>	Power Supply
A <sub>0</sub> ,A <sub>1</sub>	Burst Address Inputs	V <sub>SS</sub>	Ground
ADV	Address Advance/Load	N.C.	No Connect
$\overline{WE}$	Read/Write Control Input	DQ <sub>a</sub>	Data Inputs/Outputs
CLK	Clock	DQ <sub>b</sub>	Data Inputs/Outputs
$\overline{CKE}$	Clock Enable	DQ <sub>c</sub>	Data Inputs/Outputs
$\overline{CS}_1$	Chip Select	DQ <sub>d</sub>	Data Inputs/Outputs
$\overline{CS}_2$	Chip Select	DQP <sub>a~Pd</sub>	Data Inputs/Outputs
$\overline{CS}_2$	Chip Select		
$\overline{BW}_x$	Byte Write Inputs	V <sub>DDQ</sub>	Output Power Supply
(x=a,b,c,d)			
$\overline{OE}$	Output Enable		
ZZ	Power Sleep Mode		
$\overline{LBO}$	Burst Mode Control		
TCK	JTAG Test Clock		
TMS	JTAG Test Mode Select		
TDI	JTAG Test Data Input		
TDO	JTAG Test Data Output		

**119BGA PACKAGE PIN CONFIGURATIONS(TOP VIEW)**

**K7N641831M(4Mx18)**

	1	2	3	4	5	6	7
<b>A</b>	VDDQ	A	A	A	A	A	VDDQ
<b>B</b>	NC	CS2	A	ADV	A	$\overline{CS2}$	NC
<b>C</b>	NC	A	A	VDD	A	A	NC
<b>D</b>	DQb	NC	Vss	NC	Vss	DQP <sub>a</sub>	NC
<b>E</b>	NC	DQb	Vss	$\overline{CS1}$	Vss	NC	DQ <sub>a</sub>
<b>F</b>	VDDQ	NC	Vss	$\overline{OE}$	Vss	DQ <sub>a</sub>	VDDQ
<b>G</b>	NC	DQb	$\overline{BWb}$	A	Vss	NC	DQ <sub>a</sub>
<b>H</b>	DQb	NC	Vss	$\overline{WE}$	Vss	DQ <sub>a</sub>	NC
<b>J</b>	VDDQ	VDD	NC	VDD	NC	VDD	VDDQ
<b>K</b>	NC	DQb	Vss	CLK	Vss	NC	DQ <sub>a</sub>
<b>L</b>	DQb	NC	Vss	NC	$\overline{BWa}$	DQ <sub>a</sub>	NC
<b>M</b>	VDDQ	DQb	Vss	$\overline{CKE}$	Vss	NC	VDDQ
<b>N</b>	DQb	NC	Vss	A <sub>1</sub> *	Vss	DQ <sub>a</sub>	NC
<b>P</b>	NC	DQP <sub>b</sub>	Vss	A <sub>0</sub> *	Vss	NC	DQ <sub>a</sub>
<b>R</b>	NC	A	$\overline{LBO}$	VDD	NC	A	NC
<b>T</b>	A	A	A	A	A	A	ZZ
<b>U</b>	VDDQ	TMS	TDI	TCK	TDO	NC	VDDQ

**Note :** \* A<sub>0</sub> and A<sub>1</sub> are the two least significant bits(LSB) of the address field and set the internal burst counter if burst is desired.

**PIN NAME**

SYMBOL	PIN NAME	SYMBOL	PIN NAME
A	Address Inputs	VDD	Power Supply
A <sub>0</sub> ,A <sub>1</sub>	Burst Address Inputs	Vss	Ground
ADV	Address Advance/Load	N.C.	No Connect
$\overline{WE}$	Read/Write Control Input		
CLK	Clock		
$\overline{CKE}$	Clock Enable	DQ <sub>a</sub>	Data Inputs/Outputs
CS <sub>1</sub>	Chip Select	DQ <sub>b</sub>	Data Inputs/Outputs
CS <sub>2</sub>	Chip Select	DQP <sub>a</sub> , P <sub>b</sub>	Data Inputs/Outputs
$\overline{CS2}$	Chip Select		
$\overline{BWx}$ (x=a,b)	Byte Write Inputs	VDDQ	Output Power Supply
$\overline{OE}$	Output Enable		
ZZ	Power Sleep Mode		
$\overline{LBO}$	Burst Mode Control		
TCK	JTAG Test Clock		
TMS	JTAG Test Mode Select		
TDI	JTAG Test Data Input		
TDO	JTAG Test Data Output		

**165-PIN FBGA PACKAGE CONFIGURATIONS(TOP VIEW)**

**K7N643631M(2Mx36)**

	1	2	3	4	5	6	7	8	9	10	11
<b>A</b>	NC**	A	$\overline{CS1}$	$\overline{BWc}$	$\overline{BWb}$	$\overline{CS2}$	$\overline{CKE}$	ADV	A	A	NC
<b>B</b>	NC	A	CS2	$\overline{BWd}$	$\overline{BWa}$	CLK	$\overline{WE}$	$\overline{OE}$	A	A	NC**
<b>C</b>	DQPc	NC	VDDQ	VSS	VSS	VSS	VSS	VSS	VDDQ	NC	DQPb
<b>D</b>	DQc	DQc	VDDQ	VDD	VSS	VSS	VSS	VDD	VDDQ	DQb	DQb
<b>E</b>	DQc	DQc	VDDQ	VDD	VSS	VSS	VSS	VDD	VDDQ	DQb	DQb
<b>F</b>	DQc	DQc	VDDQ	VDD	VSS	VSS	VSS	VDD	VDDQ	DQb	DQb
<b>G</b>	DQc	DQc	VDDQ	VDD	VSS	VSS	VSS	VDD	VDDQ	DQb	DQb
<b>H</b>	NC	VDD	NC	VDD	VSS	VSS	VSS	VDD	NC	NC	ZZ
<b>J</b>	DQd	DQd	VDDQ	VDD	VSS	VSS	VSS	VDD	VDDQ	DQa	DQa
<b>K</b>	DQd	DQd	VDDQ	VDD	VSS	VSS	VSS	VDD	VDDQ	DQa	DQa
<b>L</b>	DQd	DQd	VDDQ	VDD	VSS	VSS	VSS	VDD	VDDQ	DQa	DQa
<b>M</b>	DQd	DQd	VDDQ	VDD	VSS	VSS	VSS	VDD	VDDQ	DQa	DQa
<b>N</b>	DQPd	NC	VDDQ	VSS	NC	NC	NC	VSS	VDDQ	NC	DQPa
<b>P</b>	NC	A	A	A	TDI	A1*	TDO	A	A	A	NC
<b>R</b>	$\overline{LBO}$	A	A	A	TMS	A0*	TCK	A	A	A	A

Note : \* A0 and A1 are the two least significant bits(LSB) of the address field and set the internal burst counter if burst is desired.

\*\* Checked NoConnect(NC) pins are reserved for higher density address, i.e. 11B for 128Mb and 1A for 256Mb.

**PIN NAME**

SYMBOL	PIN NAME	SYMBOL	PIN NAME
A	Address Inputs	VDD	Power Supply
A0,A1	Burst Address Inputs	VSS	Ground
ADV	Address Advance/Load	N.C.	No Connect
WE	Read/Write Control Input		
CLK	Clock	DQa	Data Inputs/Outputs
$\overline{CKE}$	Clock Enable	DQb	Data Inputs/Outputs
$\overline{CS1}$	Chip Select	DQc	Data Inputs/Outputs
CS2	Chip Select	DQd	Data Inputs/Outputs
$\overline{CS2}$	Chip Select	DQPa~Pd	Data Inputs/Outputs
$\overline{BWx}$	Byte Write Inputs		
(x=a,b,c,d)		VDDQ	Output Power Supply
$\overline{OE}$	Output Enable		
ZZ	Power Sleep Mode		
$\overline{LBO}$	Burst Mode Control		
TCK	JTAG Test Clock		
TMS	JTAG Test Mode Select		
TDI	JTAG Test Data Input		
TDO	JTAG Test Data Output		



**165-PIN FBGA PACKAGE CONFIGURATIONS(TOP VIEW)**

**K7N641831M(4Mx18)**

	1	2	3	4	5	6	7	8	9	10	11
<b>A</b>	NC**	A	$\overline{CS1}$	$\overline{BWb}$	NC	$\overline{CS2}$	$\overline{CKE}$	ADV	A	A	A
<b>B</b>	NC	A	CS2	NC	$\overline{BWa}$	CLK	$\overline{WE}$	$\overline{OE}$	A	A	NC**
<b>C</b>	NC	NC	VDDQ	VSS	VSS	VSS	VSS	VSS	VDDQ	NC	DQP <sub>a</sub>
<b>D</b>	NC	DQ <sub>b</sub>	VDDQ	VDD	VSS	VSS	VSS	VDD	VDDQ	NC	DQ <sub>a</sub>
<b>E</b>	NC	DQ <sub>b</sub>	VDDQ	VDD	VSS	VSS	VSS	VDD	VDDQ	NC	DQ <sub>a</sub>
<b>F</b>	NC	DQ <sub>b</sub>	VDDQ	VDD	VSS	VSS	VSS	VDD	VDDQ	NC	DQ <sub>a</sub>
<b>G</b>	NC	DQ <sub>b</sub>	VDDQ	VDD	VSS	VSS	VSS	VDD	VDDQ	NC	DQ <sub>a</sub>
<b>H</b>	NC	VDD	NC	VDD	VSS	VSS	VSS	VDD	NC	NC	ZZ
<b>J</b>	DQ <sub>b</sub>	NC	VDDQ	VDD	VSS	VSS	VSS	VDD	VDDQ	DQ <sub>a</sub>	NC
<b>K</b>	DQ <sub>b</sub>	NC	VDDQ	VDD	VSS	VSS	VSS	VDD	VDDQ	DQ <sub>a</sub>	NC
<b>L</b>	DQ <sub>b</sub>	NC	VDDQ	VDD	VSS	VSS	VSS	VDD	VDDQ	DQ <sub>a</sub>	NC
<b>M</b>	DQ <sub>b</sub>	NC	VDDQ	VDD	VSS	VSS	VSS	VDD	VDDQ	DQ <sub>a</sub>	NC
<b>N</b>	DQP <sub>b</sub>	NC	VDDQ	VSS	NC	NC	NC	VSS	VDDQ	NC	NC
<b>P</b>	NC	A	A	A	TDI	A <sub>1</sub> *	TDO	A	A	A	NC
<b>R</b>	$\overline{LBO}$	A	A	A	TMS	A <sub>0</sub> *	TCK	A	A	A	A

**Note :** \* A<sub>0</sub> and A<sub>1</sub> are the two least significant bits(LSB) of the address field and set the internal burst counter if burst is desired.

\*\* Checked NoConnect(NC) pins are reserved for higher density address, i.e. 11B for 128Mb and 1A for 256Mb.

**PIN NAME**

SYMBOL	PIN NAME	SYMBOL	PIN NAME
A	Address Inputs	VDD	Power Supply
A <sub>0</sub> ,A <sub>1</sub>	Burst Address Inputs	VSS	Ground
ADV	Address Advance/Load	N.C.	No Connect
$\overline{WE}$	Read/Write Control Input		
CLK	Clock		
$\overline{CKE}$	Clock Enable	DQ <sub>a</sub>	Data Inputs/Outputs
$\overline{CS1}$	Chip Select	DQ <sub>b</sub>	Data Inputs/Outputs
$\overline{CS2}$	Chip Select	DQP <sub>a</sub> , P <sub>b</sub>	Data Inputs/Outputs
$\overline{CS2}$	Chip Select		
$\overline{BWx}$ (x=a,b)	Byte Write Inputs	VDDQ	Output Power Supply
$\overline{OE}$	Output Enable		
ZZ	Power Sleep Mode		
$\overline{LBO}$	Burst Mode Control		
TCK	JTAG Test Clock		
TMS	JTAG Test Mode Select		
TDI	JTAG Test Data Input		
TDO	JTAG Test Data Output		

**FUNCTION DESCRIPTION**

The K7N643631M and K7N641831M are NtRAM™ designed to sustain 100% bus bandwidth by eliminating turnaround cycle when there is transition from Read to Write, or vice versa.

All inputs (with the exception of  $\overline{OE}$ ,  $\overline{LBO}$  and ZZ) are synchronized to rising clock edges.

All read, write and deselect cycles are initiated by the ADV input. Subsequent burst addresses can be internally generated by the burst advance pin (ADV). ADV should be driven to Low once the device has been deselected in order to load a new address for next operation.

Clock Enable( $\overline{CKE}$ ) pin allows the operation of the chip to be suspended as long as necessary. When  $\overline{CKE}$  is high, all synchronous inputs are ignored and the internal device registers will hold their previous values.

NtRAM™ latches external address and initiates a cycle, when  $\overline{CKE}$ , ADV are driven to low and all three chip enables( $\overline{CS1}$ ,  $CS2$ ,  $\overline{CS2}$ ) are active .

Output Enable( $\overline{OE}$ ) can be used to disable the output at any given time.

Read operation is initiated when at the rising edge of the clock, the address presented to the address inputs are latched in the address register,  $\overline{CKE}$  is driven low, all three chip enables( $\overline{CS1}$ ,  $CS2$ ,  $\overline{CS2}$ ) are active, the write enable input signals  $\overline{WE}$  are driven high, and ADV driven low. The internal array is read between the first rising edge and the second rising edge of the clock and the data is latched in the output register. At the second clock edge the data is driven out of the SRAM. Also during read operation  $\overline{OE}$  must be driven low for the device to drive out the requested data.

Write operation occurs when  $\overline{WE}$  is driven low at the rising edge of the clock.  $\overline{BW}[d:a]$  can be used for byte write operation. The pipelined NtRAM™ uses a late-late write cycle to utilize 100% of the bandwidth.

At the first rising edge of the clock,  $\overline{WE}$  and address are registered, and the data associated with that address is required two cycle later.

Subsequent addresses are generated by ADV High for the burst access as shown below. The starting point of the burst sequence is provided by the external address. The burst address counter wraps around to its initial state upon completion.

The burst sequence is determined by the state of the  $\overline{LBO}$  pin. When this pin is low, linear burst sequence is selected.

And when this pin is high, Interleaved burst sequence is selected.

During normal operation, ZZ must be driven low. When ZZ is driven 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 normally operates after 2 cycles of wake up time.

**BURST SEQUENCE TABLE**

(Interleaved Burst,  $\overline{LBO}$ =High)

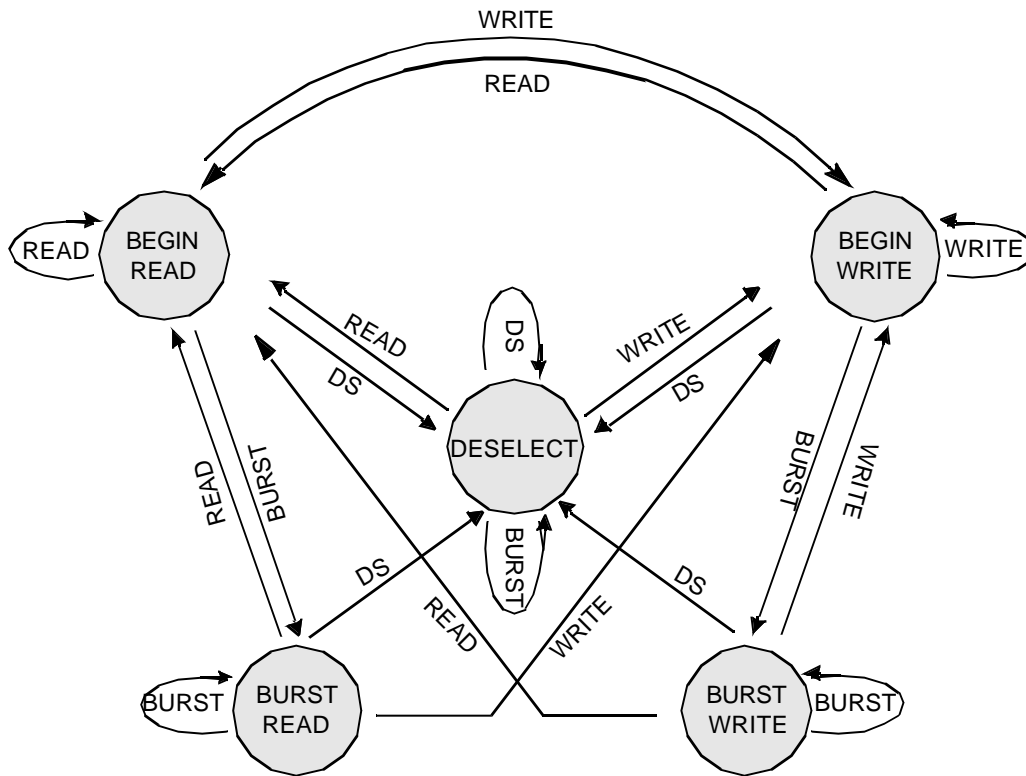
$\overline{LBO}$ PIN	HIGH	Case 1		Case 2		Case 3		Case 4	
		A1	A0	A1	A0	A1	A0	A1	A0
	First Address	0	0	0	1	1	0	1	1
	↓	0	1	0	0	1	1	1	0
	↓	1	0	1	1	0	0	0	1
	Fourth Address	1	1	1	0	0	1	0	0

(Linear Burst,  $\overline{LBO}$ =Low)

$\overline{LBO}$ PIN	LOW	Case 1		Case 2		Case 3		Case 4	
		A1	A0	A1	A0	A1	A0	A1	A0
	First Address	0	0	0	1	1	0	1	1
	↓	0	1	1	0	1	1	0	0
	↓	1	0	1	1	0	0	0	1
	Fourth Address	1	1	0	0	0	1	1	0

**Note :** 1.  $\overline{LBO}$  pin must be tied to High or Low, and Floating State must not be allowed.

**STATE DIAGRAM FOR NtRAM™**



COMMAND	ACTION
DS	DESELECT
READ	BEGIN READ
WRITE	BEGIN WRITE
BURST	BEGIN READ BEGIN WRITE CONTINUE DESELECT

**Notes :** 1. An IGNORE CLOCK EDGE cycle is not shown in the above diagram. This is because CKE HIGH only blocks the clock(CLK) input and does not change the state of the device.  
2. States change on the rising edge of the clock(CLK)

**TRUTH TABLES**

**SYNCHRONOUS TRUTH TABLE**

CS <sub>1</sub>	CS <sub>2</sub>	CS <sub>2</sub>	ADV	WE	BW <sub>x</sub>	OE	CKE	CLK	ADDRESS ACCESSED	OPERATION
H	X	X	L	X	X	X	L	↑	N/A	Not Selected
X	L	X	L	X	X	X	L	↑	N/A	Not Selected
X	X	H	L	X	X	X	L	↑	N/A	Not Selected
X	X	X	H	X	X	X	L	↑	N/A	Not Selected Continue
L	H	L	L	H	X	L	L	↑	External Address	Begin Burst Read Cycle
X	X	X	H	X	X	L	L	↑	Next Address	Continue Burst Read Cycle
L	H	L	L	H	X	H	L	↑	External Address	NOP/Dummy Read
X	X	X	H	X	X	H	L	↑	Next Address	Dummy Read
L	H	L	L	L	L	X	L	↑	External Address	Begin Burst Write Cycle
X	X	X	H	X	L	X	L	↑	Next Address	Continue Burst Write Cycle
L	H	L	L	L	H	X	L	↑	N/A	NOP/Write Abort
X	X	X	H	X	H	X	L	↑	Next Address	Write Abort
X	X	X	X	X	X	X	H	↑	Current Address	Ignore Clock

- Notes :** 1. X means "Don't Care".      2. The rising edge of clock is symbolized by (↑).  
 3. A continue deselect cycle can only be entered if a deselect cycle is executed first.  
 4.  $\overline{\text{WRITE}} = \text{L}$  means Write operation in WRITE TRUTH TABLE.  
 $\overline{\text{WRITE}} = \text{H}$  means Read operation in WRITE TRUTH TABLE.  
 5. Operation finally depends on status of asynchronous input pins(ZZ and  $\overline{\text{OE}}$ ).

**WRITE TRUTH TABLE<sub>(x36)</sub>**

$\overline{\text{WE}}$	$\overline{\text{BW}}_a$	$\overline{\text{BW}}_b$	$\overline{\text{BW}}_c$	$\overline{\text{BW}}_d$	OPERATION
H	X	X	X	X	READ
L	L	H	H	H	WRITE BYTE a
L	H	L	H	H	WRITE BYTE b
L	H	H	L	H	WRITE BYTE c
L	H	H	H	L	WRITE BYTE d
L	L	L	L	L	WRITE ALL BYTES
L	H	H	H	H	WRITE ABORT/NOP

- Notes :** 1. X means "Don't Care".  
 2. All inputs in this table must meet setup and hold time around the rising edge of CLK(↑).

**WRITE TRUTH TABLE<sub>(x18)</sub>**

$\overline{\text{WE}}$	$\overline{\text{BW}}_a$	$\overline{\text{BW}}_b$	OPERATION
H	X	X	READ
L	L	H	WRITE BYTE a
L	H	L	WRITE BYTE b
L	L	L	WRITE ALL BYTES
L	H	H	WRITE ABORT/NOP

- Notes :** 1. X means "Don't Care".  
 2. All inputs in this table must meet setup and hold time around the rising edge of CLK(↑).

**ASYNCHRONOUS TRUTH TABLE**

OPERATION	ZZ	$\overline{OE}$	I/O STATUS
Sleep Mode	H	X	High-Z
Read	L	L	DQ
	L	H	High-Z
Write	L	X	Din, High-Z
Deselected	L	X	High-Z

**Notes**

1. X means "Don't Care".
2. Sleep Mode means power Sleep Mode of which stand-by current does not depend on cycle time.
3. Deselected means power Sleep Mode of which stand-by current depends on cycle time.

**ABSOLUTE MAXIMUM RATINGS\***

PARAMETER	SYMBOL	RATING	UNIT
Voltage on VDD Supply Relative to VSS	VDD	-0.3 to 3.6	V
Voltage on Any Other Pin Relative to VSS	VIN	-0.3 to VDD+0.3	V
Power Dissipation	PD	1.6	W
Storage Temperature	TSTG	-65 to 150	°C
Operating Temperature	TOPR	0 to 70	°C
Storage Temperature Range Under Bias	TBIAS	-10 to 85	°C

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

**OPERATING CONDITIONS**(0°C ≤ TA ≤ 70°C)

PARAMETER	SYMBOL	MIN	Typ.	MAX	UNIT
Supply Voltage	VDD1	1.7	1.8	1.95	V
	VDDQ1	1.7	1.8	1.95	V
	VDD2	2.375	2.5	2.625	V
	VDDQ2	2.375	2.5	2.625	V
	VDD3	3.135	3.3	3.465	V
	VDDQ3	3.135	3.3	3.465	V
Ground	VSS	0	0	0	V

\*Note: VDD and VDDQ must be supplied with identical voltage levels.  
It should be VDDQ ≤ VDD and It can not be use VDDQ = 1.8V with VDD = 3.3V.

**CAPACITANCE\***(TA=25°C, f=1MHz)

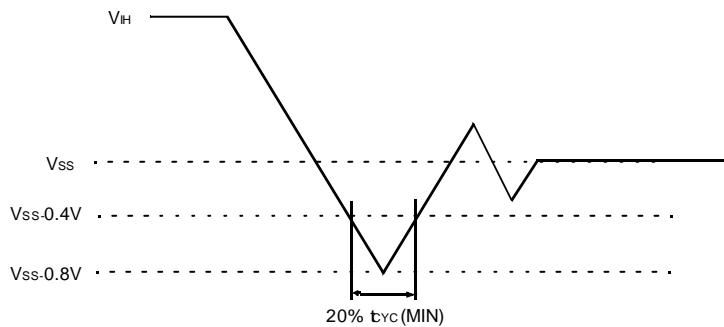
PARAMETER	SYMBOL	TEST CONDITION	TYP	MAX	UNIT
Input Capacitance	CIN	VIN=0V	-	TBD	pF
Output Capacitance	COUT	VOUT=0V	-	TBD	pF

\*Note : Sampled not 100% tested.

**DC ELECTRICAL CHARACTERISTICS**( $V_{DD}=2.5V \pm 5\%$ ,  $T_A=0^\circ C$  to  $+70^\circ C$ )

PARAMETER	SYMBOL	TEST CONDITIONS	MIN	MAX	UNIT	NOTES	
Input Leakage Current(except ZZ)	IIL	$V_{DD}=\text{Max}$ ; $V_{IN}=V_{SS}$ to $V_{DD}$	-2	+2	$\mu A$		
Output Leakage Current	IOL	Output Disabled,	-2	+2	$\mu A$		
Operating Current	ICC	$V_{DD}=\text{Max}$ $I_{OUT}=0mA$ Cycle Time $\geq t_{CYC}$ Min	-25	-	TBD	mA	1,2
			-16	-	TBD		
Standby Current	ISB	Device deselected, $I_{OUT}=0mA$ , $ZZ \leq V_{IL}$ , $f=\text{Max}$ , All Inputs $\leq 0.2V$ or $\geq V_{DD}-0.2V$	-25	-	TBD	mA	
			-16	-	TBD		
	ISB1	Device deselected, $I_{OUT}=0mA$ , $ZZ \leq 0.2V$ , $f=0$ , All Inputs=fixed ( $V_{DD}-0.2V$ or $0.2V$ )	-	-	TBD	mA	
	ISB2	Device deselected, $I_{OUT}=0mA$ , $ZZ \geq V_{DD}-0.2V$ , $f=\text{Max}$ , All Inputs $\leq V_{IL}$ or $\geq V_{IH}$	-	-	TBD	mA	
Output Low Voltage	VOL	$I_{OL}=1.0mA$	-	0.4	V		
Output High Voltage	VOH	$I_{OH}=-1.0mA$	2.0	-	V		
Input Low Voltage	VIL		-0.3*	0.7	V		
Input High Voltage	VIH		1.7	$V_{DD}+0.3^{**}$	V	3	

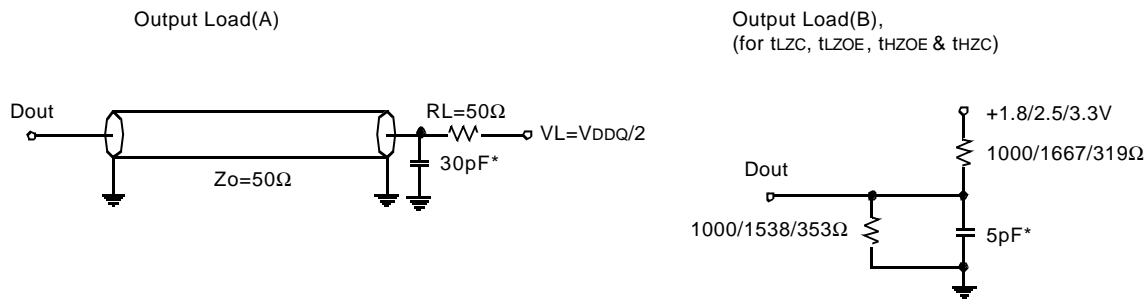
- Notes** : 1. Reference AC Operating Conditions and Characteristics for input and timing.  
2. Data states are all zero.  
3. In Case of I/O Pins, the Max.  $V_{IH}=V_{DDQ}+0.3V$



**TEST CONDITIONS**

( $T_A=0$  to  $70^\circ C$ ,  $V_{DD}=2.5V \pm 5\%$ , unless otherwise specified)

PARAMETER	VALUE
Input Pulse Level	0 to 2.5V
Input Rise and Fall Time(Measured at 20% to 80%)	1.0V/ns
Input and Output Timing Reference Levels	$V_{DDQ}/2$
Output Load	See Fig. 1



\* Including Scope and Jig Capacitance

Fig. 1

**AC TIMING CHARACTERISTICS**  
( $V_{DD}=2.5V \pm 5\%$ ,  $T_A=0$  to  $70^\circ C$ )

PARAMETER	SYMBOL	-25		-16		UNIT
		MIN	MAX	MIN	MAX	
Cycle Time	tCYC	4.0	-	6.0	-	ns
Clock Access Time	tCD	-	2.6	-	3.5	ns
Output Enable to Data Valid	tOE	-	2.6	-	3.5	ns
Clock High to Output Low-Z	tLZC	1.5	-	1.5	-	ns
Output Hold from Clock High	tOH	1.5	-	1.5	-	ns
Output Enable Low to Output Low-Z	tLZOE	0	-	0	-	ns
Output Enable High to Output High-Z	tHZOE	-	2.6	-	3.0	ns
Clock High to Output High-Z	tHZC	-	2.6	-	3.0	ns
Clock High Pulse Width	tCH	1.7	-	2.2	-	ns
Clock Low Pulse Width	tCL	1.7	-	2.2	-	ns
Address Setup to Clock High	tAS	1.2	-	1.5	-	ns
CKE Setup to Clock High	tCES	1.2	-	1.5	-	ns
Data Setup to Clock High	tDS	1.2	-	1.5	-	ns
Write Setup to Clock High ( $\overline{WE}$ , $\overline{BWx}$ )	tWS	1.2	-	1.5	-	ns
Address Advance Setup to Clock High	tADVS	1.2	-	1.5	-	ns
Chip Select Setup to Clock High	tCSS	1.2	-	1.5	-	ns
Address Hold from Clock High	tAH	0.3	-	0.5	-	ns
$\overline{CKE}$ Hold from Clock High	tCEH	0.3	-	0.5	-	ns
Data Hold from Clock High	tDH	0.3	-	0.5	-	ns
Write Hold from Clock High ( $\overline{WE}$ , $\overline{BWx}$ )	tWH	0.3	-	0.5	-	ns
Address Advance Hold from Clock High	tADVH	0.3	-	0.5	-	ns
Chip Select Hold from Clock High	tCSH	0.3	-	0.5	-	ns
ZZ High to Power Down	tPDS	2	-	2	-	cycle
ZZ Low to Power Up	tPUS	2	-	2	-	cycle

- Notes :**
1. All address inputs must meet the specified setup and hold times for all rising clock(CLK) edges when ADV is sampled low and  $\overline{CS}$  is sampled low. All other synchronous inputs must meet the specified setup and hold times whenever this device is chip selected.
  2. Chip selects must be valid at each rising edge of CLK(when ADV is Low) to remain enabled.
  3. A write cycle is defined by  $\overline{WE}$  low having been registered into the device at ADV Low, A Read cycle is defined by  $\overline{WE}$  High with ADV Low, Both cases must meet setup and hold times.
  4. To avoid bus contention, At a given voltage and temperature tLZC is more than tHZC.  
The specs as shown do not imply bus contention because tLZC is a Min. parameter that is worst case at totally different test conditions (0°C,2.625V) than tHZC, which is a Max. parameter(worst case at 70°C,2.375V)  
It is not possible for two SRAMs on the same board to be at such different voltage and temperature.

**SLEEP MODE**

SLEEP MODE is a low current, power-down mode in which the device is deselected and current is reduced to  $I_{SB2}$ . The duration of 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

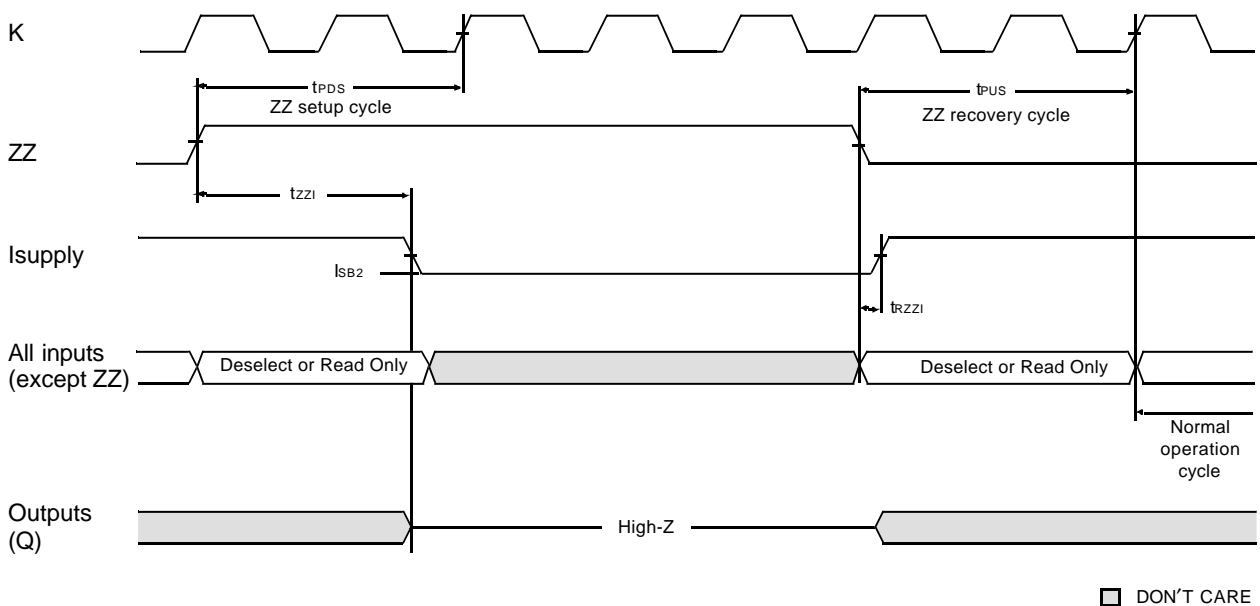
The ZZ pin is an asynchronous, active high input that causes the device to enter SLEEP MODE.

When the ZZ pin becomes a logic High,  $I_{SB2}$  is guaranteed after the time  $t_{ZZ1}$  is met. Any operation pending when entering SLEEP MODE is not guaranteed to successful complete. Therefore, SLEEP MODE (READ or WRITE) must not be initiated until valid pending operations are completed. Similarly, when exiting SLEEP MODE during  $t_{PUS}$ , only a DESELECT or READ cycle should be given while the SRAM is transitioning out of SLEEP MODE.

**SLEEP MODE ELECTRICAL CHARACTERISTICS**

DESCRIPTION	CONDITIONS	SYMBOL	MIN	MAX	UNITS
Current during SLEEP MODE	$ZZ \geq V_{IH}$	$I_{SB2}$		TBD	mA
ZZ active to input ignored		$t_{PDS}$	2		cycle
ZZ inactive to input sampled		$t_{PUS}$	2		cycle
ZZ active to SLEEP current		$t_{ZZ1}$		2	cycle
ZZ inactive to exit SLEEP current		$t_{RZZ1}$	0		

**SLEEP MODE WAVEFORM**

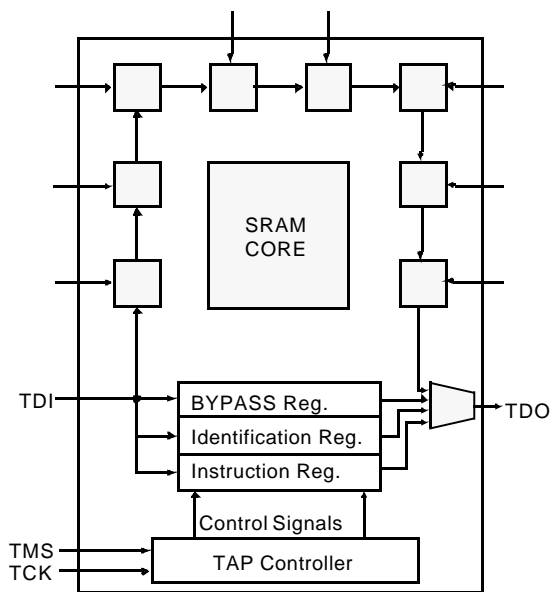




### IEEE 1149.1 TEST ACCESS PORT AND BOUNDARY SCAN-JTAG

This part contains an IEEE standard 1149.1 Compatible Test Access Port(TAP). The package pads are monitored by the Serial Scan circuitry when in test mode. This is to support connectivity testing during manufacturing and system diagnostics. Internal data is not driven out of the SRAM under JTAG control. In conformance with IEEE 1149.1, the SRAM contains a TAP controller, Instruction Register, Bypass Register and ID register. The TAP controller has a standard 16-state machine that resets internally upon power-up, therefore, TRST signal is not required. It is possible to use this device without utilizing the TAP. To disable the TAP controller without interfacing with normal operation of the SRAM, TCK must be tied to V<sub>ss</sub> to preclude mid level input. TMS and TDI are designed so an undriven input will produce a response identical to the application of a logic 1, and may be left unconnected. But they may also be tied to V<sub>DD</sub> through a resistor. TDO should be left unconnected.

### JTAG Block Diagram



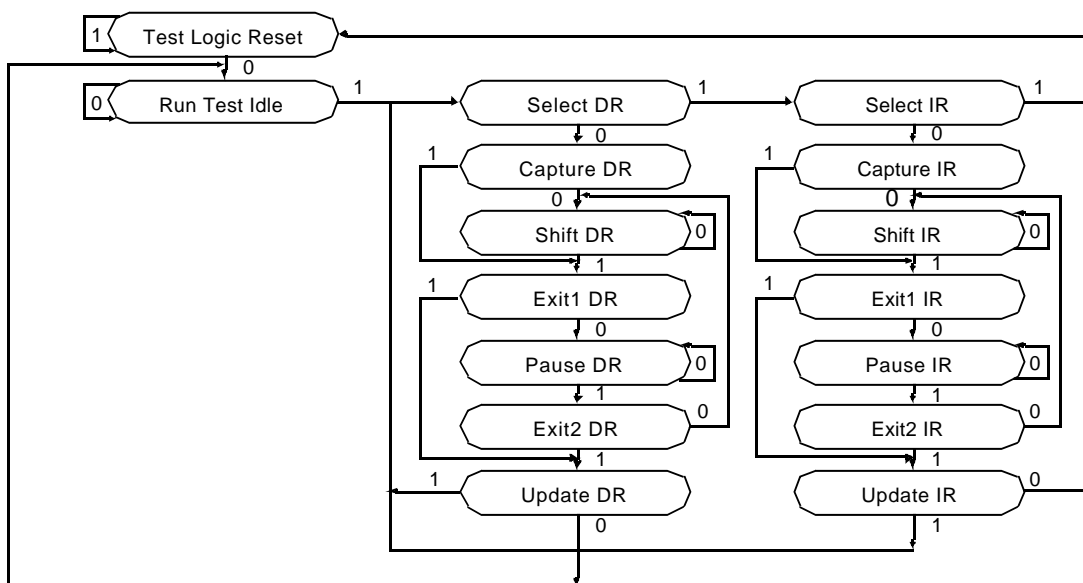
### JTAG Instruction Coding

IR2	IR1	IR0	Instruction	TDO Output	Notes
0	0	0	EXTEST	Boundary Scan Register	1
0	0	1	IDCODE	Identification Register	3
0	1	0	SAMPLE-Z	Boundary Scan Register	2
0	1	1	BYPASS	Bypass Register	4
1	0	0	SAMPLE	Boundary Scan Register	5
1	0	1	RESERVED	Do Not Use	6
1	1	0	BYPASS	Bypass Register	4
1	1	1	BYPASS	Bypass Register	4

**NOTE :**

1. Places DQs in Hi-Z in order to sample all input data regardless of other SRAM inputs. This instruction is not IEEE 1149.1 compliant.
2. Places DQs in Hi-Z in order to sample all input data regardless of other SRAM inputs.
3. TDI is sampled as an input to the first ID register to allow for the serial shift of the external TDI data.
4. Bypass register is initiated to V<sub>ss</sub> when BYPASS instruction is invoked. The Bypass Register also holds serially loaded TDI when exiting the Shift DR states.
5. SAMPLE instruction dose not places DQs in Hi-Z.
6. This instruction is reserved for future use.

### TAP Controller State Diagram





**SCAN INFORMATION (165 FBGA )  
SCAN REGISTER DEFINITION**

Part	Instruction Register	Bypass Register	ID Register	Boundary Scan
2Mx36	3 bits	1 bits	32 bits	89 bits
4Mx18	3 bits	1 bits	32 bits	89 bits

**ID REGISTER DEFINITION**

Part	Revision Number (31:28)	Part Configuration (27:18)	Vendor Definition (17:12)	Samsung JEDEC Code (11: 1)	Start Bit(0)
2Mx36	0000	01001 00100	XXXXXX	00001001110	1
4Mx18	0000	01010 00011	XXXXXX	00001001110	1

**BOUNDARY SCAN EXIT ORDER**

BIT	PIN ID	BIT	PIN ID
1	6N	40	8A
2	7N	41	8B
3	10N	42	7A
4	11P	43	7B
5	8P	44	6B
6	8R	45	6A
7	9R	46	5B
8	9P	47	5A
9	10P	48	4A
10	10R	49	4B
11	11R	50	3B
12	11H	51	3A
13	11N	52	2A
14	11M	53	2B
15	11L	54	2C
16	11K	55	1B
17	11J	56	1A
18	10M	57	1C
19	10L	58	1D
20	10K	59	1E
21	10J	60	1F
22	9H	61	1G
23	10H	62	2D
24	11G	63	2E
25	11F	64	2F
26	11E	65	2G
27	11D	66	1H
28	10G	67	3H
29	10F	68	1J
30	10E	69	1K
31	10D	70	1L
32	11C	71	1M
33	11A	72	2J
34	11B	73	2K
35	10A	74	2L
36	10B	75	2M
37	9A	76	1N
38	9B	77	2N
39	10C	78	1P

BIT	PIN ID	BIT	PIN ID
79	1R		
80	2R		
81	3P		
82	3R		
83	2P		
84	4R		
85	4P		
86	5N		
87	6P		
88	6R		
89	Internal		

Note: 1. NC and Vss pins included in the scan exit order are read as "X" ( i.e. don't care).

**JTAG DC OPERATING CONDITIONS**

Parameter	Symbol	Min	Typ	Max	Unit	Note
Power Supply Voltage	V <sub>DD</sub>	3.135/2.375/1.7	3.3/2.5/1.8	3.465/2.625/1.9	V	
Input High Level	V <sub>IH</sub>	2.0/1.7/1.3	-	V <sub>DD</sub> +0.3	V	
Input Low Level	V <sub>IL</sub>	-0.3	-	0.8/0.7/0.5	V	
Output High Voltage	V <sub>OH</sub>	2.4/2.0/1.4	-	-	V	
Output Low Voltage	V <sub>OL</sub>	-	-	0.4/0.4/0.4	V	

**NOTE:** The input level of SRAM pin is to follow the SRAM DC specification.

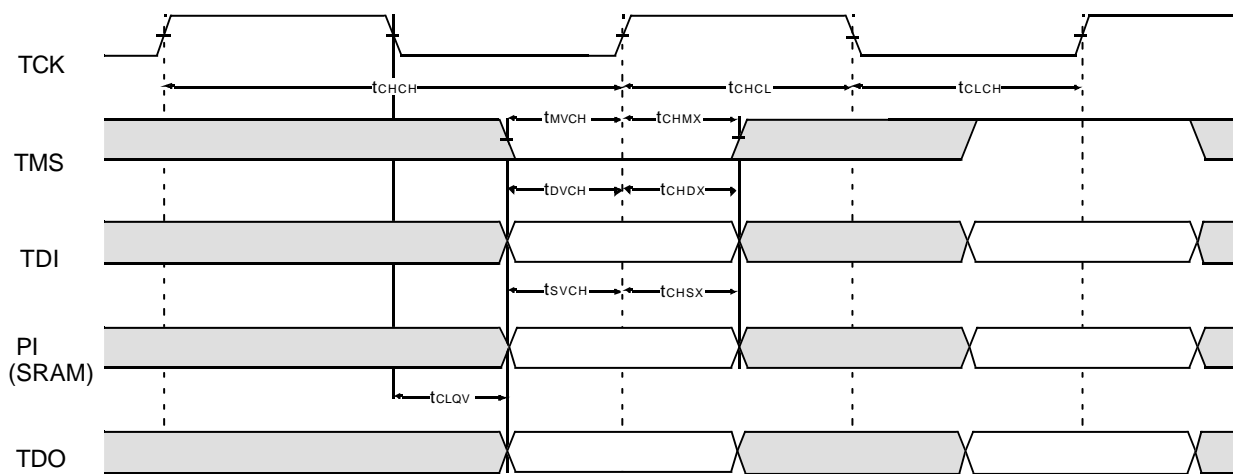
**JTAG AC TEST CONDITIONS**

Parameter	Symbol	Min	Unit	Note
Input High/Low Level	V <sub>IH</sub> /V <sub>IL</sub>	3.0/0, 2.5/0, 1.3/0.5	V	
Input Rise/Fall Time	T <sub>R</sub> /T <sub>F</sub>	1.0/1.0, 1.0/1.0, 1.0/1.0	ns	
Input and Output Timing Reference Level		V <sub>DDQ</sub> /2	V	

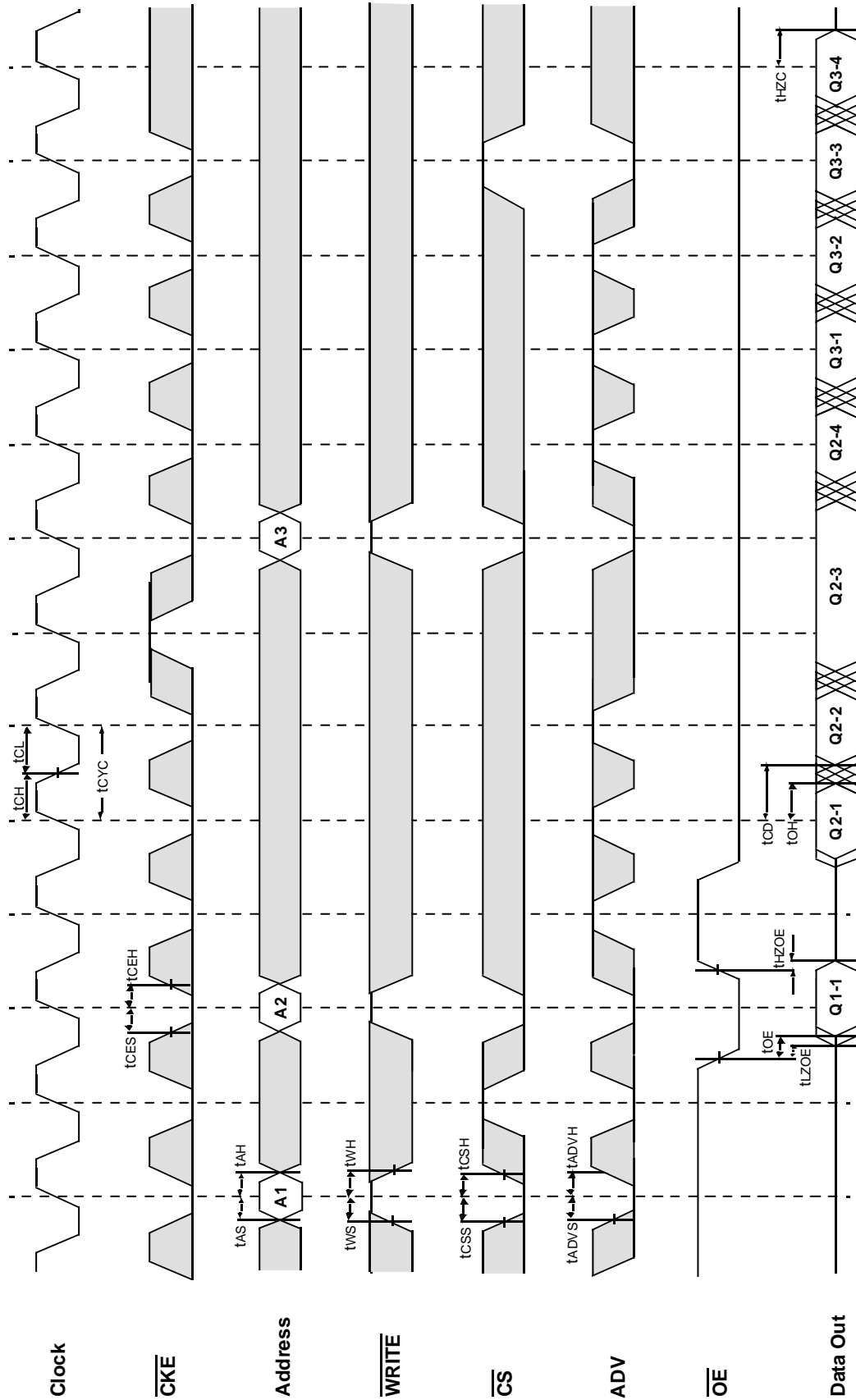
**JTAG AC Characteristics**

Parameter	Symbol	Min	Max	Unit	Note
TCK Cycle Time	t <sub>CHCH</sub>	50	-	ns	
TCK High Pulse Width	t <sub>CHCL</sub>	20	-	ns	
TCK Low Pulse Width	t <sub>CLCH</sub>	20	-	ns	
TMS Input Setup Time	t <sub>MVCH</sub>	5	-	ns	
TMS Input Hold Time	t <sub>CHMX</sub>	5	-	ns	
TDI Input Setup Time	t <sub>DVCH</sub>	5	-	ns	
TDI Input Hold Time	t <sub>CHDX</sub>	5	-	ns	
SRAM Input Setup Time	t <sub>SVCH</sub>	5	-	ns	
SRAM Input Hold Time	t <sub>CHSX</sub>	5	-	ns	
Clock Low to Output Valid	t <sub>CLQV</sub>	0	10	ns	

**JTAG TIMING DIAGRAM**



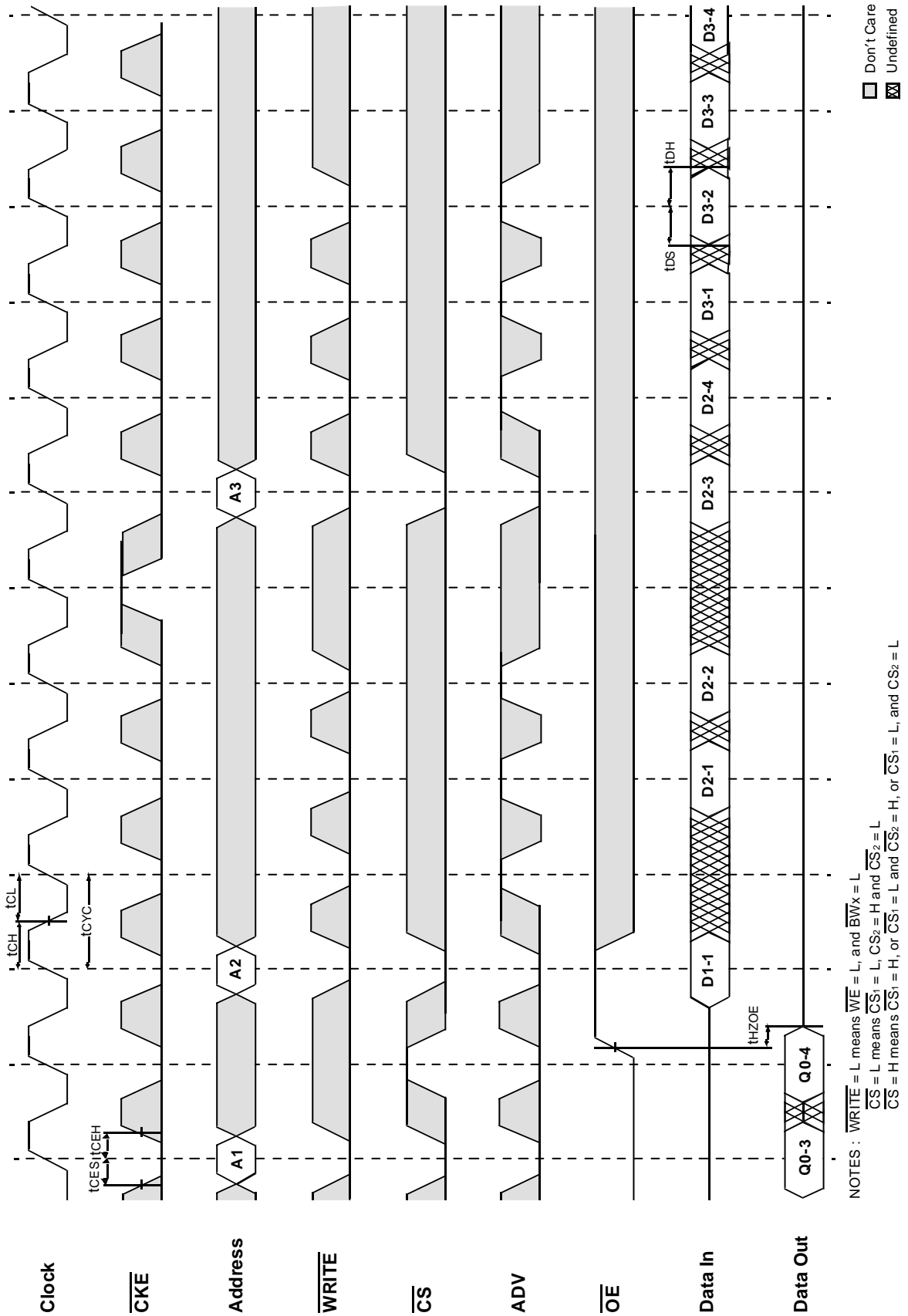
**TIMING WAVEFORM OF READ CYCLE**



□ Don't Care  
⊗ Undefined

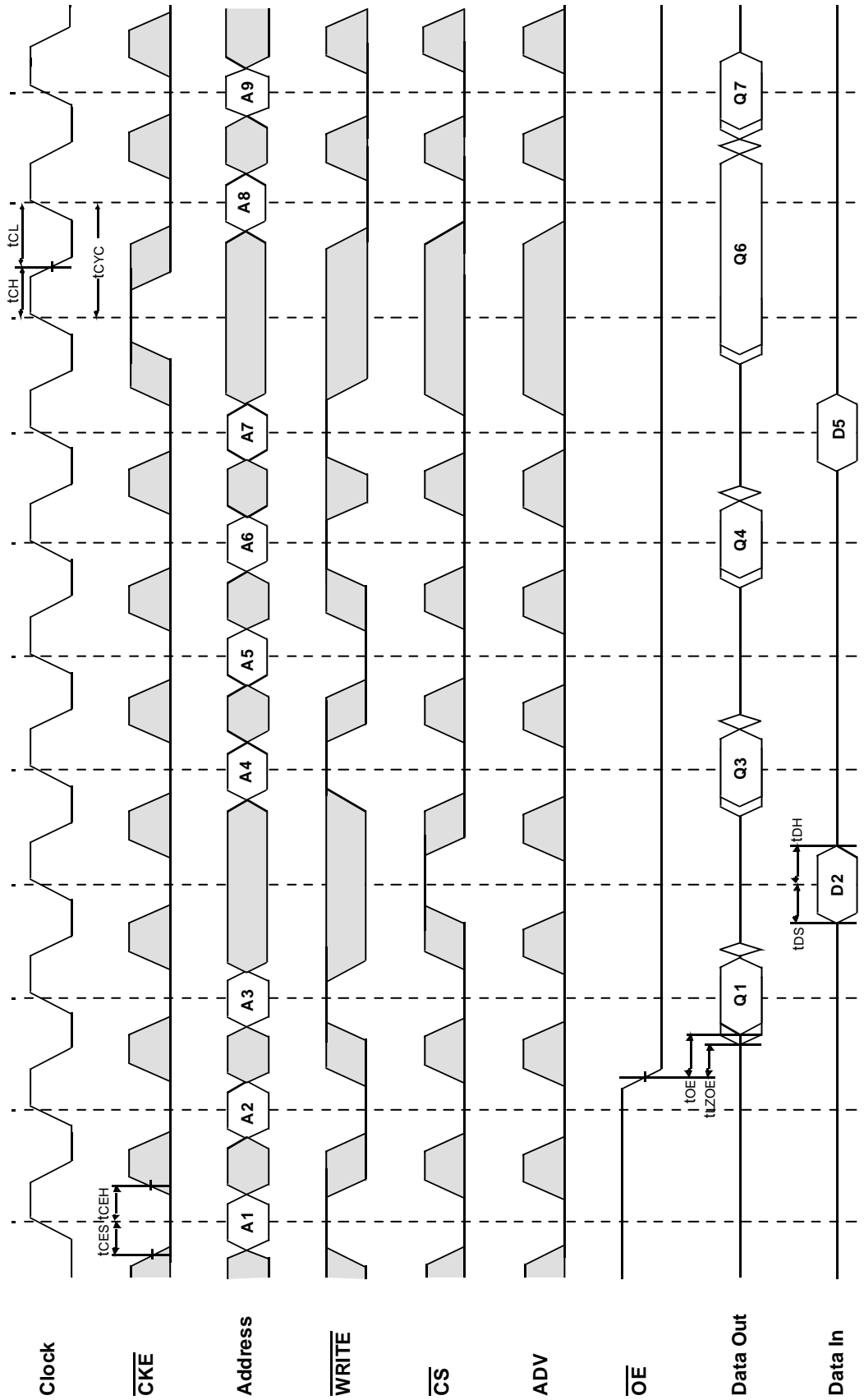
NOTES:  $\overline{WRITE} = L$  means  $\overline{WE} = L$ , and  $\overline{BWx} = L$   
 $\overline{CS} = L$  means  $\overline{CS}_1 = L$ ,  $\overline{CS}_2 = H$  and  $\overline{CS}_2 = L$   
 $\overline{CS} = H$  means  $\overline{CS}_1 = H$ , or  $\overline{CS}_1 = L$  and  $\overline{CS}_2 = H$ , or  $\overline{CS}_1 = L$ , and  $\overline{CS}_2 = L$

TIMING WAVEFORM OF WRTE CYCLE



NOTES :  $\overline{\text{WRITE}} = \text{L}$  means  $\overline{\text{WE}} = \text{L}$ , and  $\overline{\text{BWx}} = \text{L}$   
 $\overline{\text{CS}} = \text{L}$  means  $\overline{\text{CS}}_1 = \text{L}$ ,  $\overline{\text{CS}}_2 = \text{H}$  and  $\overline{\text{CS}}_2 = \text{L}$   
 $\overline{\text{CS}} = \text{H}$  means  $\overline{\text{CS}}_1 = \text{H}$ , or  $\overline{\text{CS}}_1 = \text{L}$  and  $\overline{\text{CS}}_2 = \text{H}$ , or  $\overline{\text{CS}}_1 = \text{L}$ , and  $\overline{\text{CS}}_2 = \text{L}$

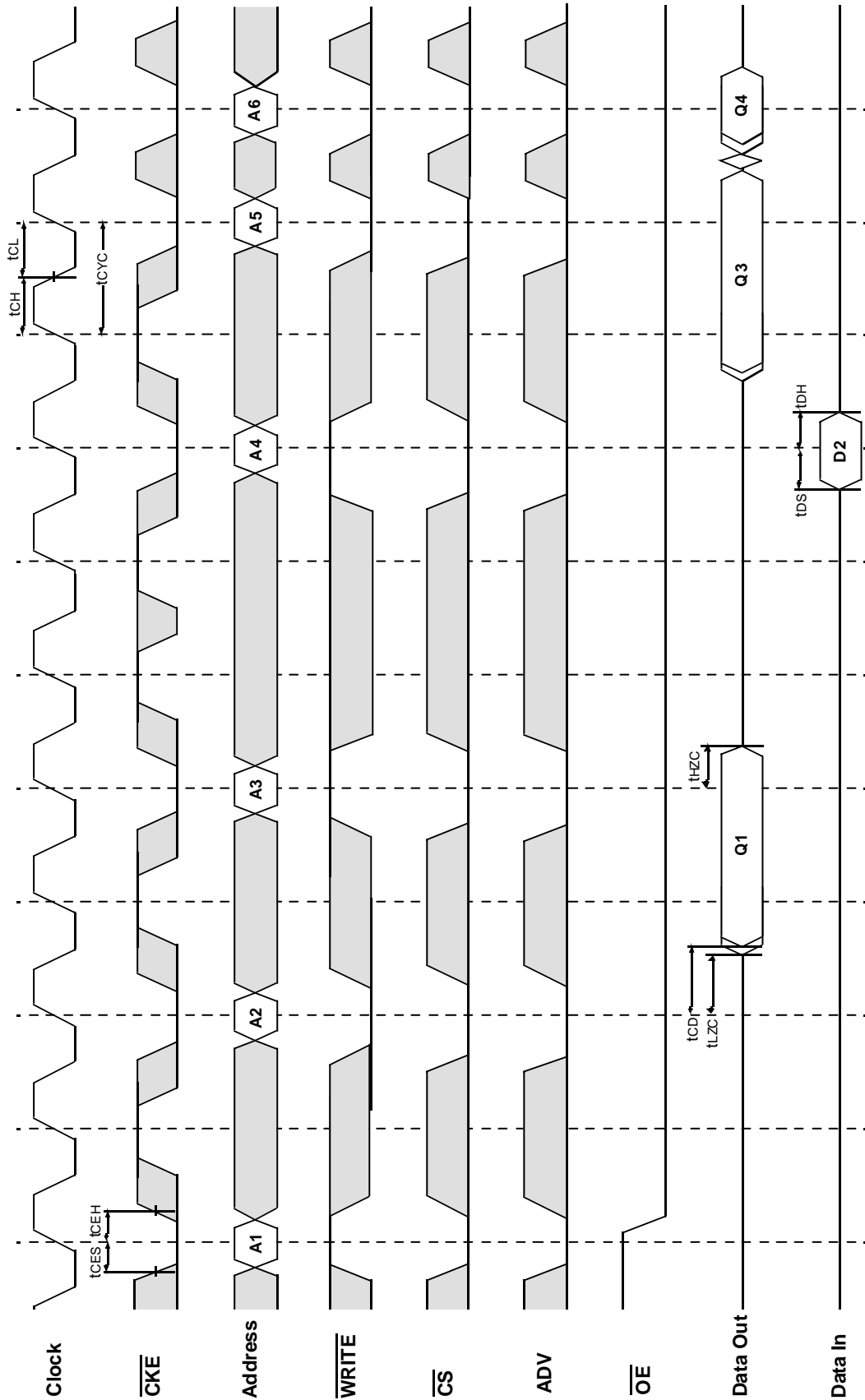
TIMING WAVEFORM OF SINGLE READ/WRITE



Don't Care  
 Undefined

NOTES:  $\overline{\text{WRITE}} = \text{L}$  means  $\overline{\text{WE}} = \text{L}$ , and  $\overline{\text{BW}} = \text{L}$   
 $\overline{\text{CS}} = \text{L}$  means  $\overline{\text{CS}}_1 = \text{L}$ ,  $\overline{\text{CS}}_2 = \text{H}$  and  $\overline{\text{CS}}_2 = \text{L}$   
 $\overline{\text{CS}} = \text{H}$  means  $\overline{\text{CS}}_1 = \text{H}$ , or  $\overline{\text{CS}}_1 = \text{L}$  and  $\overline{\text{CS}}_2 = \text{H}$ , or  $\overline{\text{CS}}_1 = \text{L}$ , and  $\overline{\text{CS}}_2 = \text{L}$

TIMING WAVEFORM OF CKE OPERATION

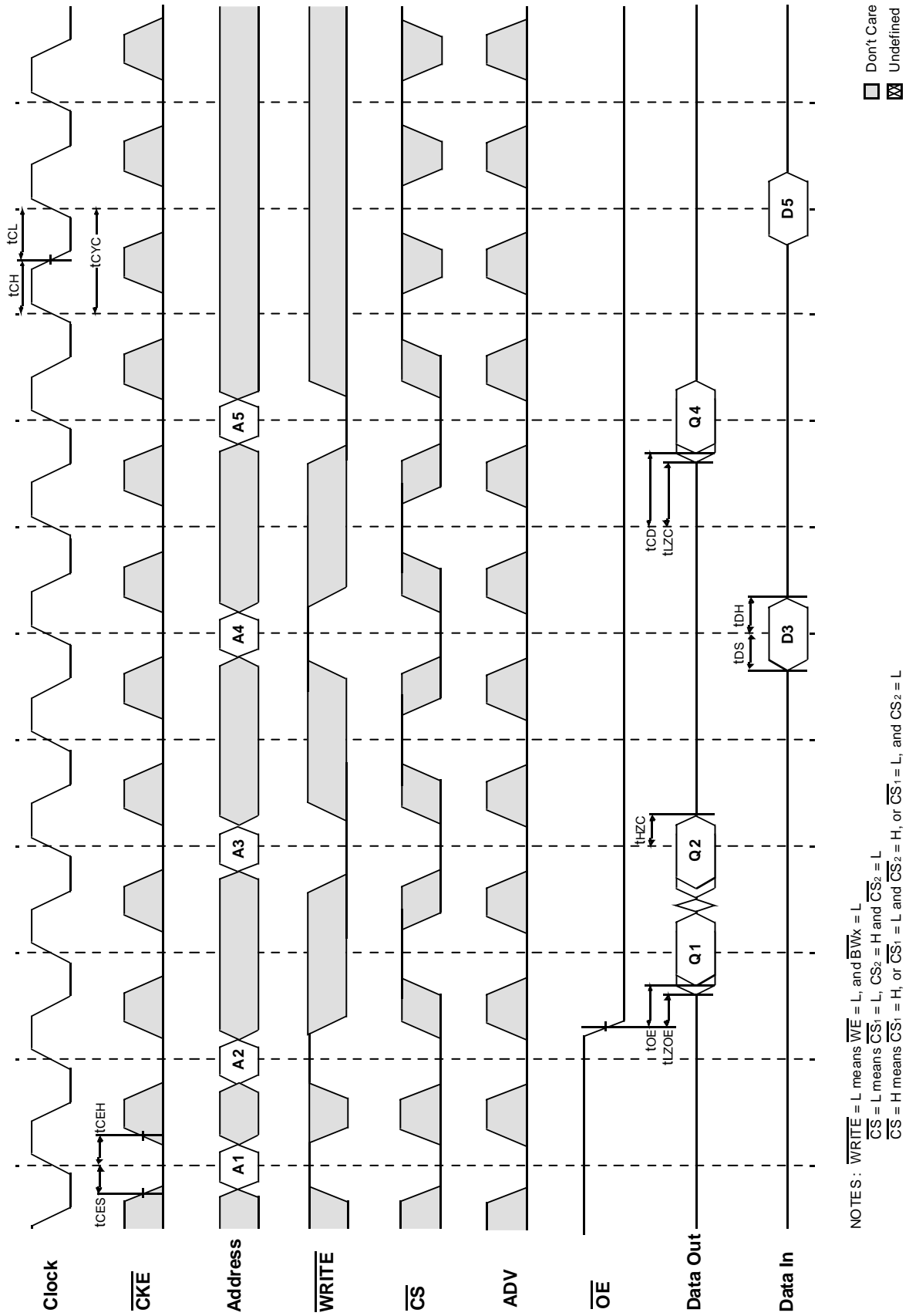


□ Don't Care  
⊠ Undefined

NOTES :  $\overline{WRITE} = L$  means  $\overline{WE} = L$ , and  $\overline{BWx} = L$   
 $\overline{CS} = L$  means  $\overline{CS}_1 = L$ ,  $\overline{CS}_2 = H$  and  $\overline{CS}_2 = L$   
 $\overline{CS} = H$  means  $\overline{CS}_1 = H$ , or  $\overline{CS}_1 = L$  and  $\overline{CS}_2 = H$ , or  $\overline{CS}_1 = L$ , and  $\overline{CS}_2 = L$

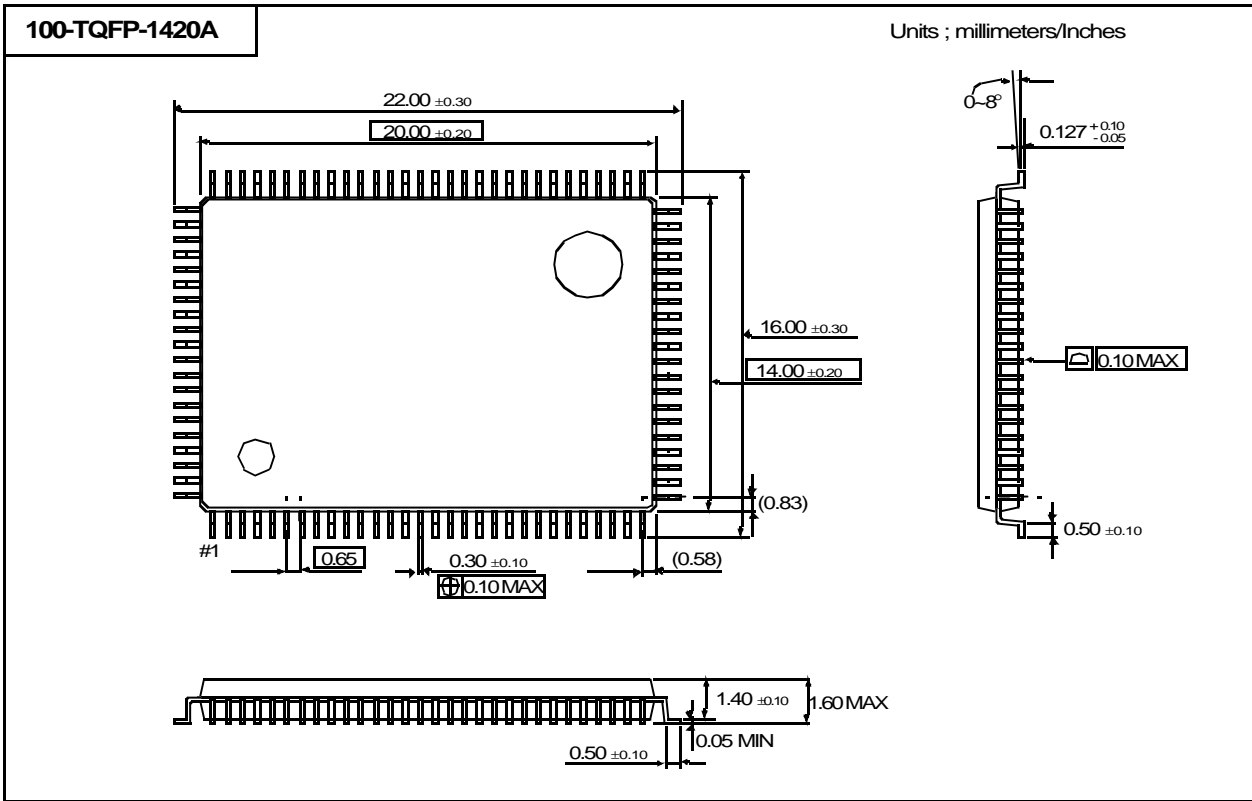


TIMING WAVEFORM OF  $\overline{CS}$  OPERATION

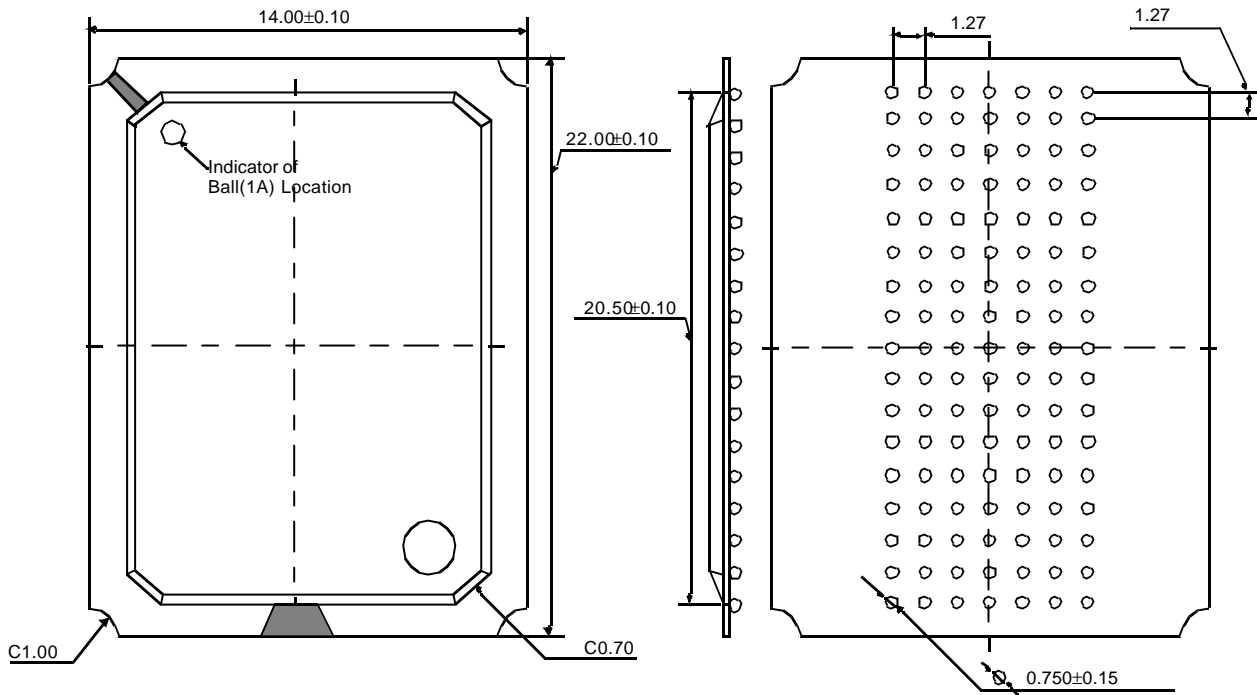


NOTES:  $\overline{WRITE} = L$  means  $\overline{WE} = L$ , and  $\overline{BW} = L$   
 $\overline{CS} = L$  means  $\overline{CS}_1 = L$ ,  $\overline{CS}_2 = H$  and  $\overline{CS}_2 = L$   
 $\overline{CS} = H$  means  $\overline{CS}_1 = H$ , or  $\overline{CS}_1 = L$  and  $\overline{CS}_2 = H$ , or  $\overline{CS}_1 = L$ , and  $\overline{CS}_2 = L$

**PACKAGE DIMENSIONS**



**119BGA PACKAGE DIMENSIONS**

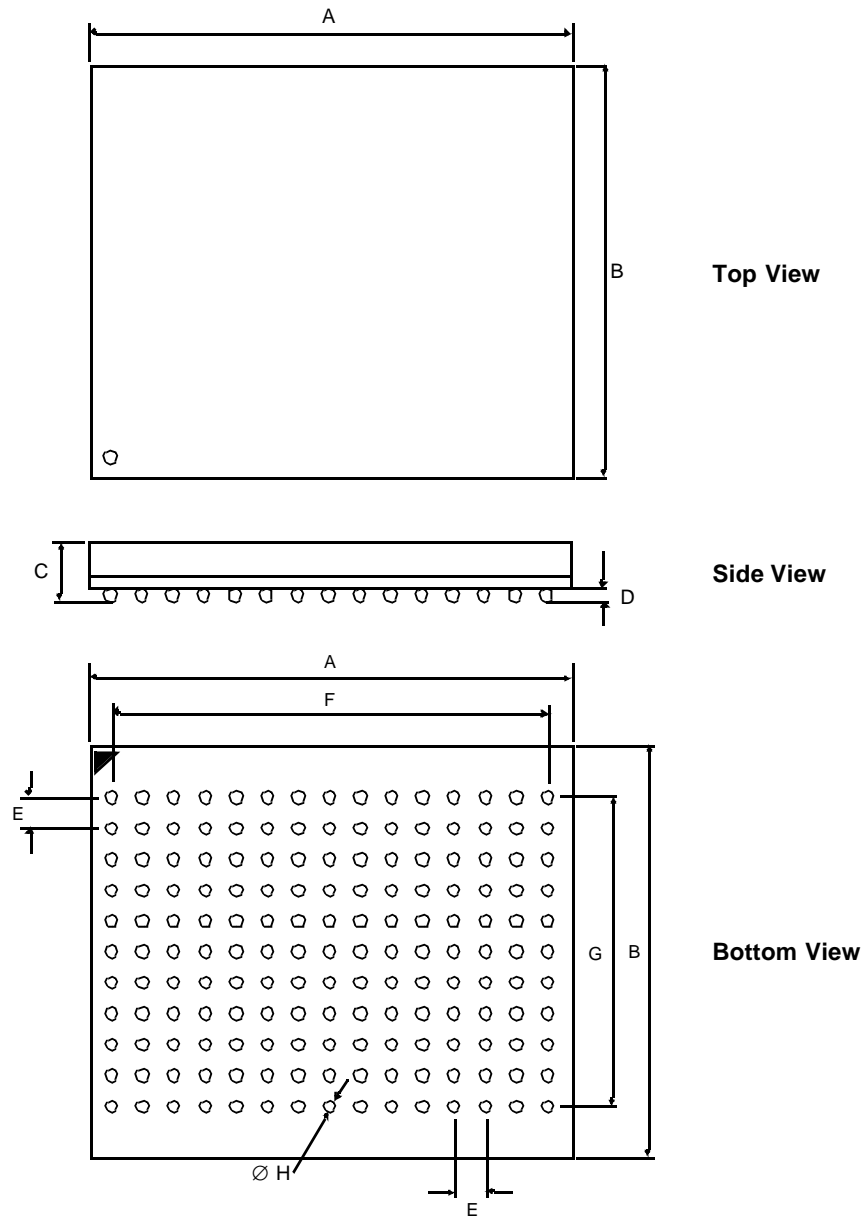


**NOTE :**

1. All Dimensions are in Millimeters.
2. Solder Ball to PCB Offset : 0.10 MAX.
3. PCB to Cavity Offset : 0.10 MAX.

**165 FBGA PACKAGE DIMENSIONS**

15mm x 17mm Body, 1.0mm Bump Pitch, 11x15 Ball Array



Symbol	Value	Units	Note	Symbol	Value	Units	Note
A	17 ± 0.1	mm		E	1.0	mm	
B	15 ± 0.1	mm		F	14.0	mm	
C	1.3 ± 0.1	mm		G	10.0	mm	
D	0.35 ± 0.05	mm		H	0.45 ± 0.05	mm	