4Mb NtRAM™ Specification

100 TQFP with Pb & Pb-Free

(RoHS compliant)

Document Title

128Kx36 & 256Kx18-Bit Pipelined NtRAM™

Revision History

Rev.No.	History	Draft Date	Remark
0.0	1. Initial document.	May. 15. 2001	Preliminary
0.1	1. Changed DC parameters Icc ; from 470mA to 400mA at -25, from 440mA to 360mA at -22, from 400mA to 330mA at -20, from 370mA to 310mA at -18, I_{SB} ; from 180mA to 160mA at -25, from 170mA to 155mA at -22, from 160mA to 150mA at -20, from 150mA to 140mA at -18, I_{SB1} ; from 100mA to 80mA	June. 12. 2001	Preliminary
0.2	1. Add x32 org. and industrial temperature	Aug. 11. 2001	Preliminary
1.0	1. Final spec release 2. Changed Pin Capacitance - Cin ; from 5pF to 4pF - Cout ; from 7pF to 6pF	Nov. 15. 2001	Final
2.0	1. Remove x32 organization. 2. Remove -25/-22 speed bin	Nov. 17. 2003	Final
3.0	1. Add the lead-free package type	Jul. 03. 2006	Final

4Mb NtRAM (Pipelined) Ordering Information

Org.	VDD (V)	Speed (ns)	Access Time (ns)	Part Number	RoHS Avail.
256Kx18	3.3	5.0	2.8	K7N401809B-P(Q)[1]C(I)[2]20	√
128Kx36				K7N403609B-P(Q)[1]C(I)[2]20	√

Note 1. P(Q) [Package type] : P-Pb Free, Q-Pb
2. C(I) [Operating Temperature] : C-Commercial, I-Industrial

128Kx36 & 256Kx18-Bit Pipelined NtRAM™

FEATURES

- V_{DD}=3.3V+0.165V/-0.165V Power Supply.
- V_{DDQ} Supply Voltage 3.3V+0.165V/-0.165V for 3.3V I/O or 2.5V+0.4V/-0.125V for 2.5V I/O.
- 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 datacontention.
- A interleaved burst or a linear burst mode.
- Asynchronous output enable control.
- Power Down mode.
- TTL-Level Three-State Outputs.
- 100-TQFP-1420A Package.
- Operating in commeical and industrial temperature range.

FAST ACCESS TIMES

PARAMETER	Symbol	-20	Unit
Cycle Time	tCYC	5.0	ns
Clock Access Time	tCD	2.8	ns
Output Enable Access Time	tOE	2.8	ns

GENERAL DESCRIPTION

The K7N403609B and K7N401809B are 4,718,592 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).

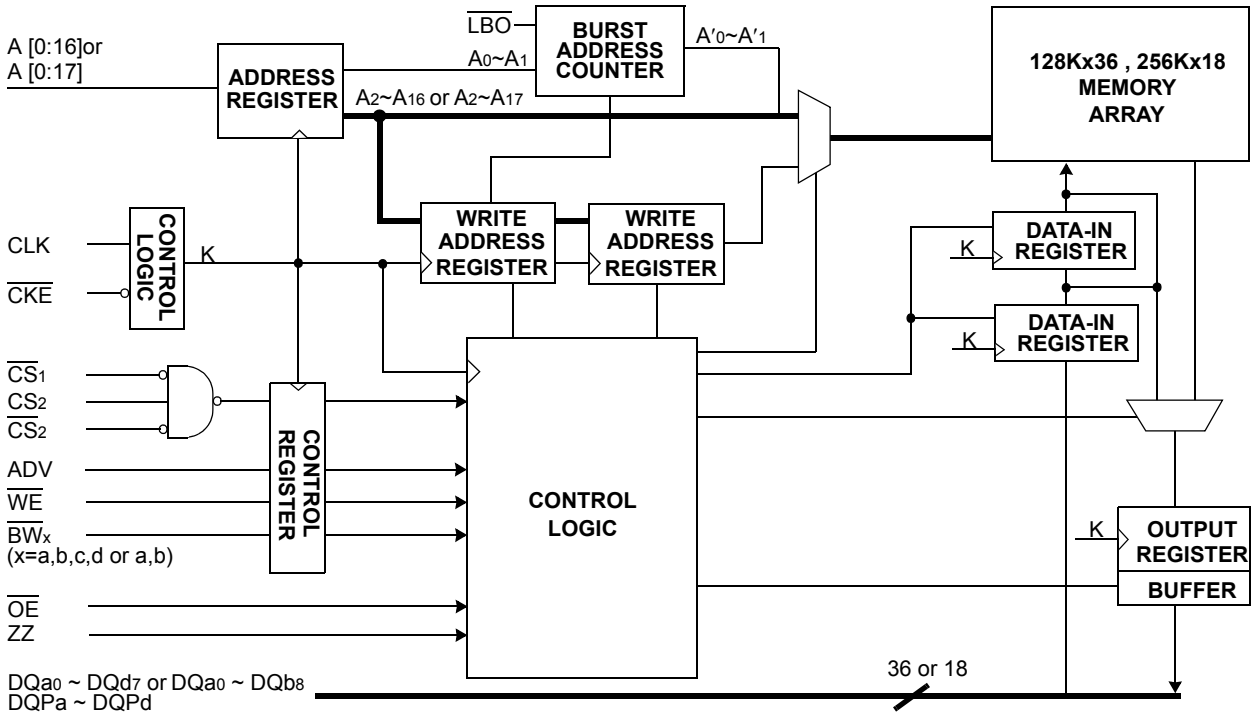
Output Enable controls the outputs at any given time.

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 incomming signals.

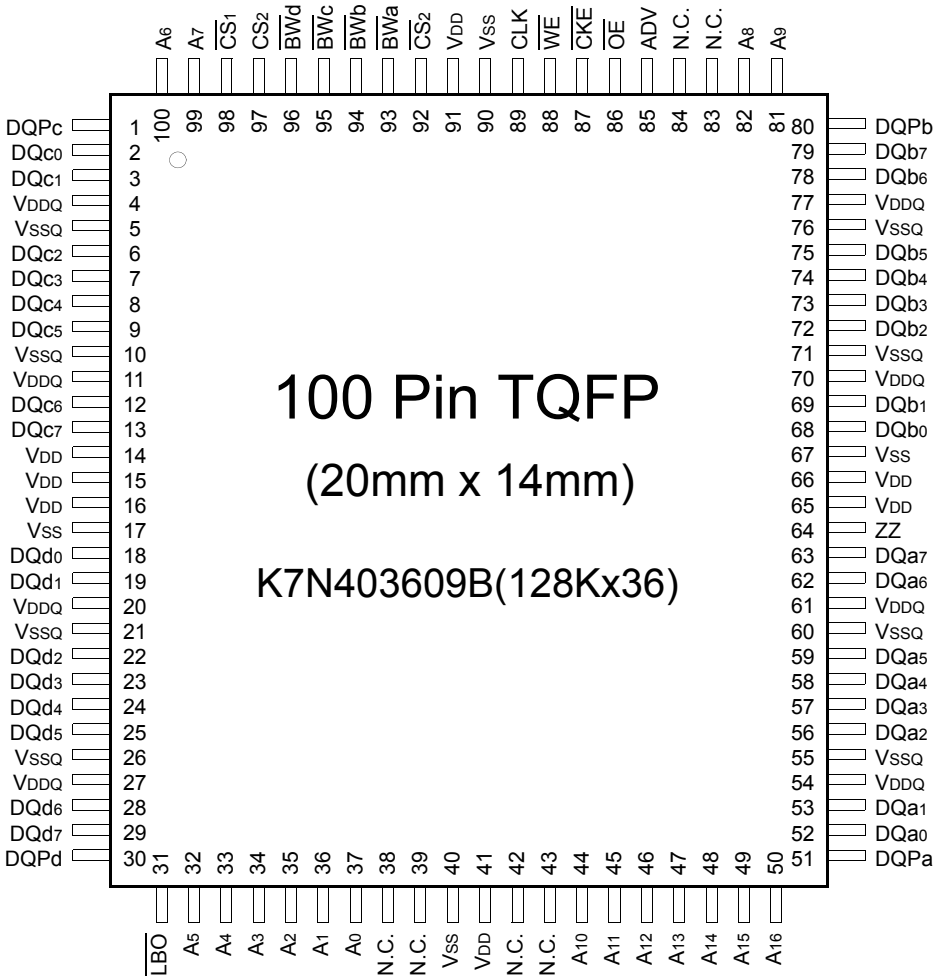
For read cycles, pipelined SRAM output data is temporarily stored by an edge trigered output register and then released to the output bufferes at the next rising edge of clock.

The K7N403609B and K7N401809B are implemented with SAMSUNG′s high performance CMOS technology and is available in 100pin TQFP packages. Multiple power and ground pins minimize ground bounce.

LOGIC BLOCK DIAGRAM



PIN CONFIGURATION(TOP VIEW)

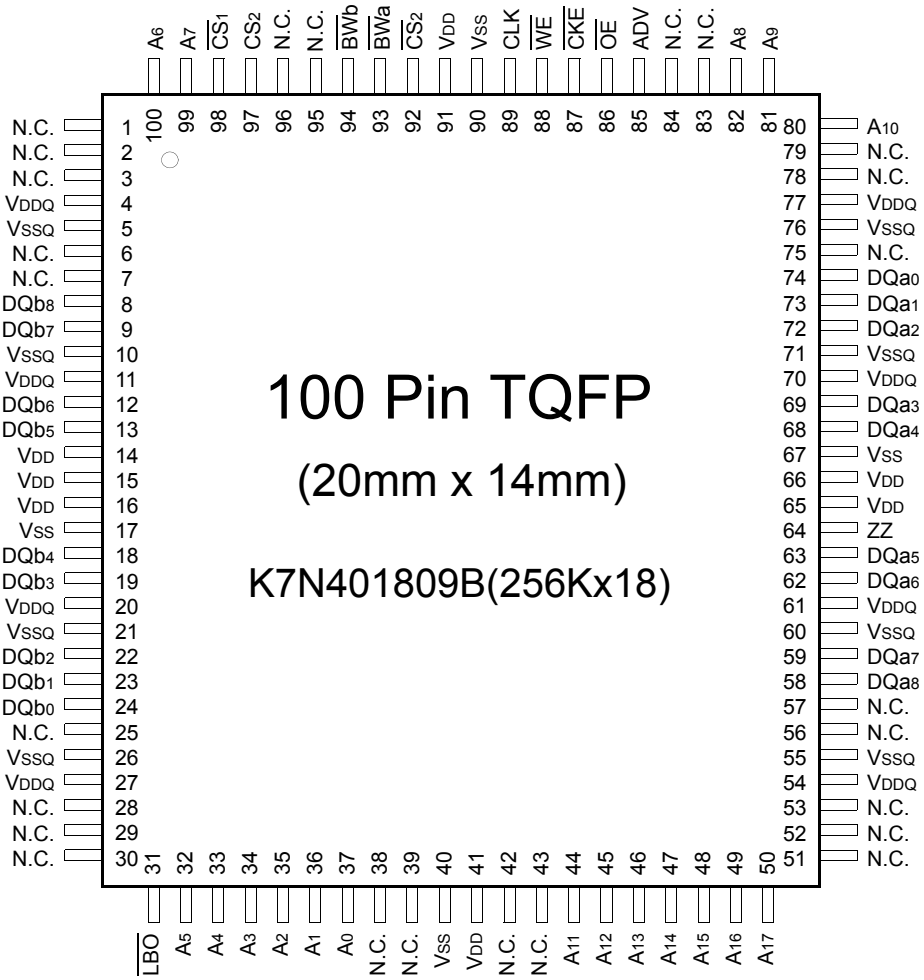


PIN NAME

SYMBOL	PIN NAME	TQFP PIN NO.	SYMBOL	PIN NAME	TQFP PIN NO.
A_0 - A_{16}	Address Inputs	32,33,34,35,36,37 44,45,46,47,48,49 50,81,82,99,100	V_{DD} V_{SS} N.C.	Power Supply(+3.3V) Ground No Connect	14,15,16,41,65,66,91 17,40,67,90 38,39,42,43,83,84
$\overline{ADV}$	Address Advance/Load	85			
$\overline{WE}$	Read/Write Control Input	88	DQa_0~a_7	Data Inputs/Outputs	52,53,56,57,58,59,62,63
$\overline{CLK}$	Clock	89	DQb_0~b_7		68,69,72,73,74,75,78,79
$\overline{CKE}$	Clock Enable	87	DQc_0~c_7		2,3,6,7,8,9,12,13
$\overline{CS_1}$	Chip Select	98	DQd_0~d_7		18,19,22,23,24,25,28,29
$\overline{CS_2}$	Chip Select	97	DQPa~P_d		51,80,1,30
CS_2	Chip Select	92			
$\overline{BW}$x(x=a,b,c,d)	Byte Write Inputs	93,94,95,96	V_{DDQ}	Output Power Supply (2.5V or 3.3V)	4,11,20,27,54,61,70,77
$\overline{OE}$	Output Enable	86			
$\overline{ZZ}$	Power Sleep Mode	64	V_{SSQ}	Output Ground	5,10,21,26,55,60,71,76
$\overline{LBO}$	Burst Mode Control	31			

Notes : 1. The pin 83 is reserved for address bit for the 8Mb NtRAM.
2. A_0 and A_1 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 - A17	Address Inputs	32,33,34,35,36,37, 44,45,46,47,48,49 50,80,81,82,99,100	VDD	Power Supply(+3.3V)	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, 38,39,42,43,51,52,53, 56,57,75,78,79,83,84 95,96
ADV	Address Advance/Load	85			
WE	Read/Write Control Input	88			
CLK	Clock	89			
CKE	Clock Enable	87			
CS1	Chip Select	98	DQa0~a8	Data Inputs/Outputs	58,59,62,63,68,69,72,73,74
CS2	Chip Select	97	DQb0~b8		8,9,12,13,18,19,22,23,24
CS2	Chip Select	92			
BWx(x=a,b)	Byte Write Inputs	93,94			
OE	Output Enable	86	VDDQ	Output Power Supply (2.5V or 3.3V)	4,11,20,27,54,61,70,77
ZZ	Power Sleep Mode	64			
LBO	Burst Mode Control	31	VSSQ	Output Ground	5,10,21,26,55,60,71,76

Notes : 1. The pin 83 is reserved for address bit for the 8Mb NtRAM.
2. A0 and A1 are the two least significant bits(LSB) of the address field and set the internal burst counter if burst is desired.

FUNCTION DESCRIPTION

The K7N403609B and K7N401809B are N*t*RAM™ 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.

N*t*RAM™ latches external address and initiates a cycle, when $\overline{CKE}$, ADV are driven to low and all three chip enables($\overline{CS}_1$, CS_2, $\overline{CS}_2$) 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($\overline{CS}_1$, CS_2, $\overline{CS}_2$) 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 pipe-lined N*t*RAM™ 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 seguence 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	
		A_1	A_0	A_1	A_0	A_1	A_0	A_1	A_0
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

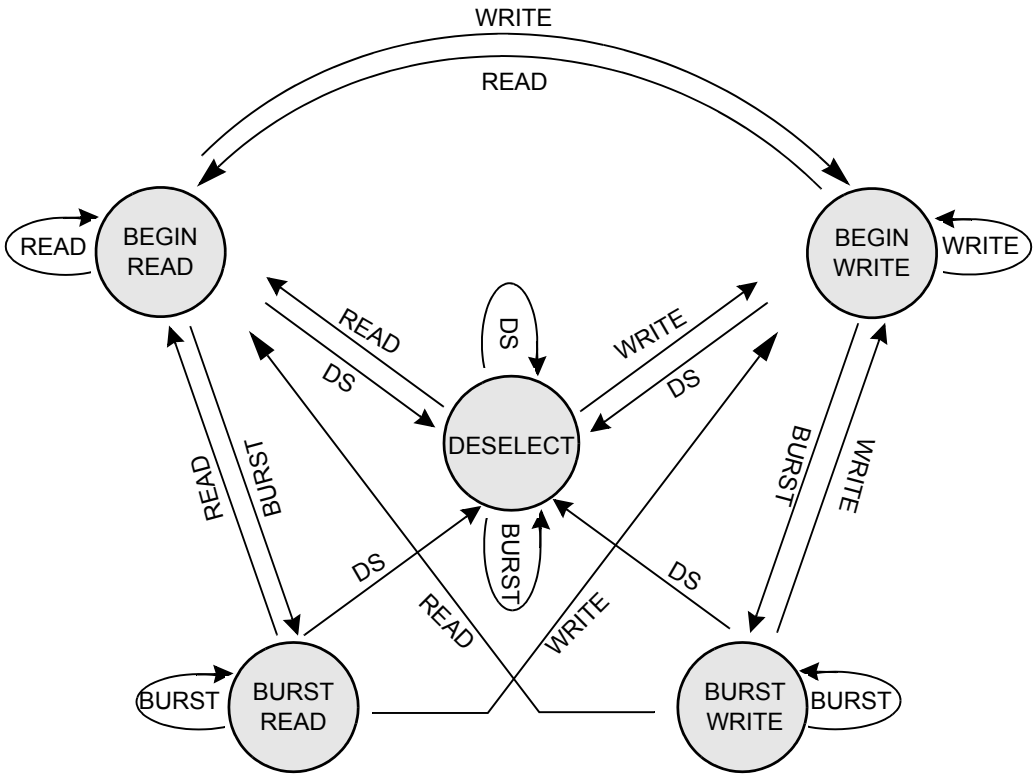
Note : 1. $\overline{LBO}$ pin must be tied to High or Low, and Floating State must not be allowed.

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

$\overline{LBO}$ PIN	LOW	Case 1		Case 2		Case 3		Case 4	
		A_1	A_0	A_1	A_0	A_1	A_0	A_1	A_0
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 is 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

$\overline{CS_1}$	CS_2	$\overline{CS_2}$	ADV	$\overline{WE}$	$\overline{BWx}$	$\overline{OE}$	$\overline{CKE}$	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 enterd if a deselect cycle is executed first.
4. $\overline{WRITE}$ = L means Write operation in WRITE TRUTH TABLE.
$\overline{WRITE}$ = H means Read operation in WRITE TRUTH TABLE.
5. Operation finally depends on status of asynchronous input pins(ZZ and $\overline{OE}$).

WRITE TRUTH TABLE(x36)

$\overline{WE}$	$\overline{BWa}$	$\overline{BWb}$	$\overline{BWc}$	$\overline{BWd}$	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(x18)

$\overline{WE}$	$\overline{BWa}$	$\overline{BWb}$	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 V_{DD} Supply Relative to V_{SS} Voltage on V_{DDQ} Supply Relative to V_{SS}		V_{DD}	-0.3 to 4.6	V
		V_{DDQ}	V_{DD}	V
Voltage on Input Pin Relative to V_{SS}		V_{IN}	-0.3 to V_{DD}+0.3	V
Voltage on I/O Pin Relative to V_{SS}		V_{IO}	-0.3 to V_{DDQ}+0.3	V
Power Dissipation		P_D	1.4	W
Storage Temperature		T_{STG}	-65 to 150	°C
Operating Temperature	Commercial	T_{OPR}	0 to 70	°C
	Industrial	T_{OPR}	-40 to 85	°C
Storage Temperature Range Under Bias		T_{BIAS}	-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 at 3.3V I/O(0°C ≤ T_A ≤ 70°C)

PARAMETER	SYMBOL	MIN	Typ.	MAX	UNIT
Supply Voltage	V_{DD}	3.135	3.3	3.465	V
	V_{DDQ}	3.135	3.3	3.465	V
Ground	V_{SS}	0	0	0	V

* The above parameters are also guaranteed at industrial temperature range.

OPERATING CONDITIONS at 2.5V I/O(0°C ≤ T_A ≤ 70°C)

PARAMETER	SYMBOL	MIN	Typ.	MAX	UNIT
Supply Voltage	V_{DD}	3.135	3.3	3.465	V
	V_{DDQ}	2.375	2.5	2.9	V
Ground	V_{SS}	0	0	0	V

* The above parameters are also guaranteed at industrial temperature range.

CAPACITANCE*(T_A=25°C, f=1MHz)

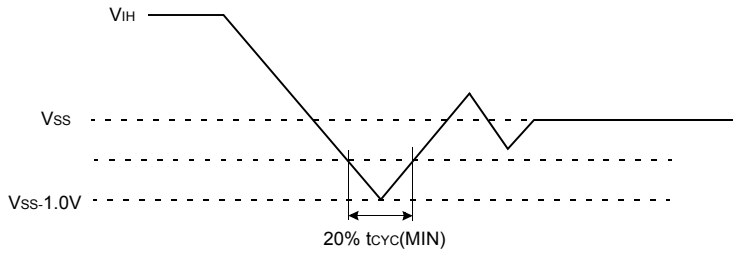
PARAMETER	SYMBOL	TEST CONDITION	TYP	MAX	UNIT
Input Capacitance	C_{IN}	V_{IN}=0V	-	4	pF
Output Capacitance	C_{OUT}	V_{OUT}=0V	-	6	pF

***Note :** Sampled not 100% tested.

DC ELECTRICAL CHARACTERISTICS(V_{DD}=3.3V+0.165V/-0.165V, T_A=0°C to +70°C)

PARAMETER	SYMBOL	TEST CONDITIONS		MIN	MAX	UNIT	NOTES
Input Leakage Current(except ZZ)	I_{IL}	V_{DD}=Max ; V_{IN}=V_{SS} to V_{DD}		-2	+2	μA	
Output Leakage Current	I_{OL}	Output Disabled,		-2	+2	μA	
Operating Current	I_{CC}	V_{DD}=Max , I_{OUT}=0mA ZZ≤V_{IL} , Cycle Time ≥ t_{CYC} Min	-20	-	330	mA	1,2
Standby Current	I_{SB}	Device deselected, I_{OUT}=0mA, ZZ≤V_{IL}, f=Max, All Inputs≤0.2V or ≥ V_{DD}-0.2V	-20	-	150	mA	
	I_{SB1}	Device deselected, I_{OUT}=0mA, ZZ≤0.2V, f=0, All Inputs=fixed (V_{DD}-0.2V or 0.2V)		-	80	mA	
	I_{SB2}	Device deselected, I_{OUT}=0mA, ZZ≥V_{DD}-0.2V, f=Max, All Inputs≤V_{IL} or ≥V_{IH}		-	50	mA	
Output Low Voltage(3.3V I/O)	V_{OL}	I_{OL}=8.0mA		-	0.4	V	
Output High Voltage(3.3V I/O)	V_{OH}	I_{OH}=-4.0mA		2.4	-	V	
Output Low Voltage(2.5V I/O)	V_{OL}	I_{OL}=1.0mA		-	0.4	V	
Output High Voltage(2.5V I/O)	V_{OH}	I_{OH}=-1.0mA		2.0	-	V	
Input Low Voltage(3.3V I/O)	V_{IL}			-0.3*	0.8	V	
Input High Voltage(3.3V I/O)	V_{IH}			2.0	V_{DD}+0.3**	V	3
Input Low Voltage(2.5V I/O)	V_{IL}			-0.3*	0.7	V	
Input High Voltage(2.5V I/O)	V_{IH}			1.7	V_{DD}+0.3**	V	3

Notes : 1.The above parameters are also guaranteed at industrial temperature range.
2. Reference AC Operating Conditions and Characteristics for input and timing.
3. Data states are all zero.
4. In Case of I/O Pins, the Max. V_{IH}=V_{DDQ}+0.3V

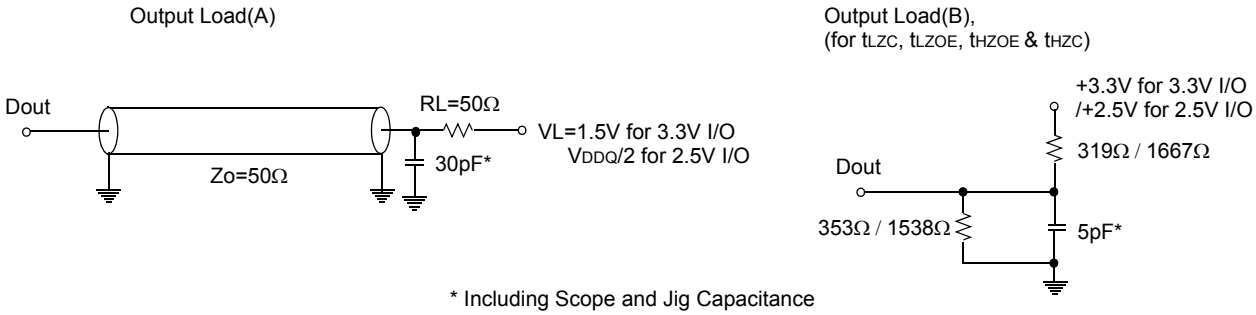


TEST CONDITIONS

(V_{DD}=3.3V+0.165V/-0.165V,V_{DDQ}=3.3V+0.165/-0.165V or V_{DD}=3.3V+0.165V/-0.165V,V_{DDQ}=2.5V+0.4V/-0.125V, T_A=0to70°C)

PARAMETER	VALUE
Input Pulse Level(for 3.3V I/O)	0 to 3.0V
Input Pulse Level(for 2.5V I/O)	0 to 2.5V
Input Rise and Fall Time(Measured at 20% to 80% for 3.3V I/O)	1.0V/ns
Input Rise and Fall Time(Measured at 20% to 80% for 2.5V I/O)	1.0V/ns
Input and Output Timing Reference Levels for 3.3V I/O	1.5V
Input and Output Timing Reference Levels for 2.5V I/O	V_{DDQ}/2
Output Load	See Fig. 1

* The above parameters are also guaranteed at industrial temperature range.



* Including Scope and Jig Capacitance

Fig. 1

AC TIMING CHARACTERISTICS(VDD=3.3V+0.165V/-0.165V, TA=0°C to +70°C)

PARAMETER	Symbol	-20		UNIT
		Min	Max	
Cycle Time	tCYC	5.0	-	ns
Clock Access Time	tCD	-	2.8	ns
Output Enable to Data Valid	tOE	-	2.8	ns
Clock High to Output Low-Z	tLZC	1.0	-	ns
Output Hold from Clock High	tOH	1.0	-	ns
Output Enable Low to Output Low-Z	tLZOE	0	-	ns
Output Enable High to Output High-Z	tHZOE	-	2.8	ns
Clock High to Output High-Z	tHZC	-	2.8	ns
Clock High Pulse Width	tCH	2.0	-	ns
Clock Low Pulse Width	tCL	2.0	-	ns
Address Setup to Clock High	tAS	1.2	-	ns
$\overline{CKE}$ Setup to Clock High	tCES	1.2	-	ns
Data Setup to Clock High	tDS	1.2	-	ns
Write Setup to Clock High ($\overline{WE}$, $\overline{BWX}$)	tWS	1.2	-	ns
Address Advance Setup to Clock High	tADVS	1.2	-	ns
Chip Select Setup to Clock High	tCSS	1.2	-	ns
Address Hold from Clock High	tAH	0.4	-	ns
$\overline{CKE}$ Hold from Clock High	tCEH	0.4	-	ns
Data Hold from Clock High	tDH	0.4	-	ns
Write Hold from Clock High ($\overline{WE}$, $\overline{BWEX}$)	tWH	0.4	-	ns
Address Advance Hold from Clock High	tADVH	0.4	-	ns
Chip Select Hold from Clock High	tCSH	0.4	-	ns
ZZ High to Power Down	tPDS	2	-	cycle
ZZ Low to Power Up	tPUS	2	-	cycle

Notes : 1. The above parameters are also guaranteed at industrial temperature range.
2. 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.
3. Chip selects must be valid at each rising edge of CLK(when ADV is Low) to remain enabled.
4. 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.
5. 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,3.465V) than tHZC, which is a Max. parameter(worst case at 70°C,3.135V)
It is not possible for two SRAMs on the same board to be at such different voltage and temperature.

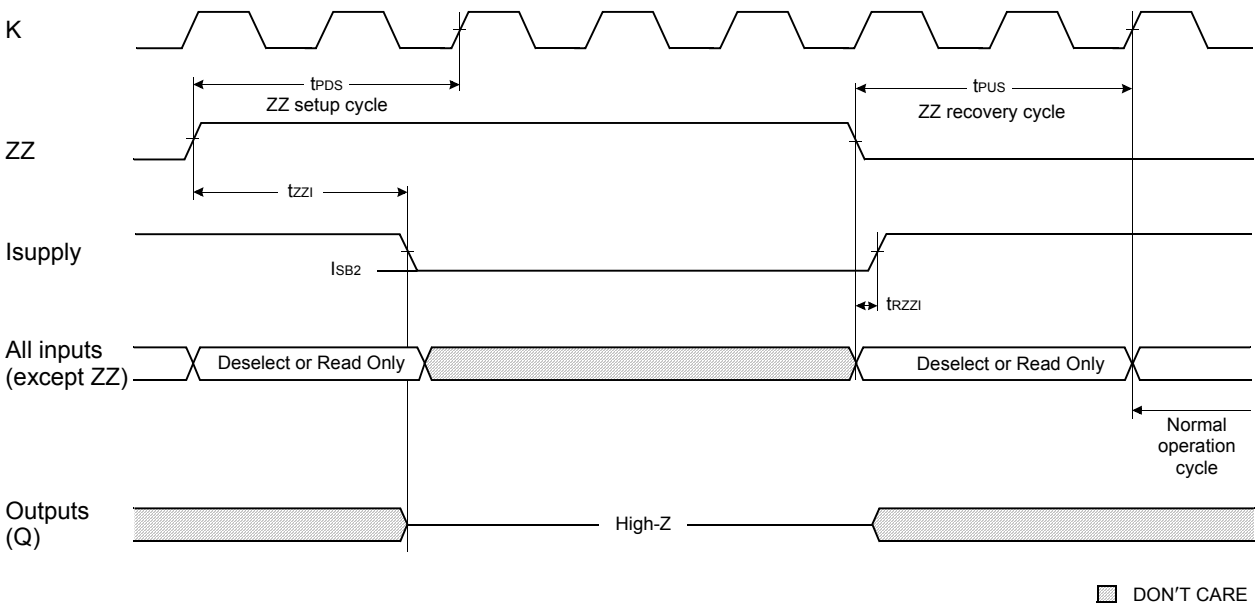
SLEEP MODE

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_{ZZI} 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.

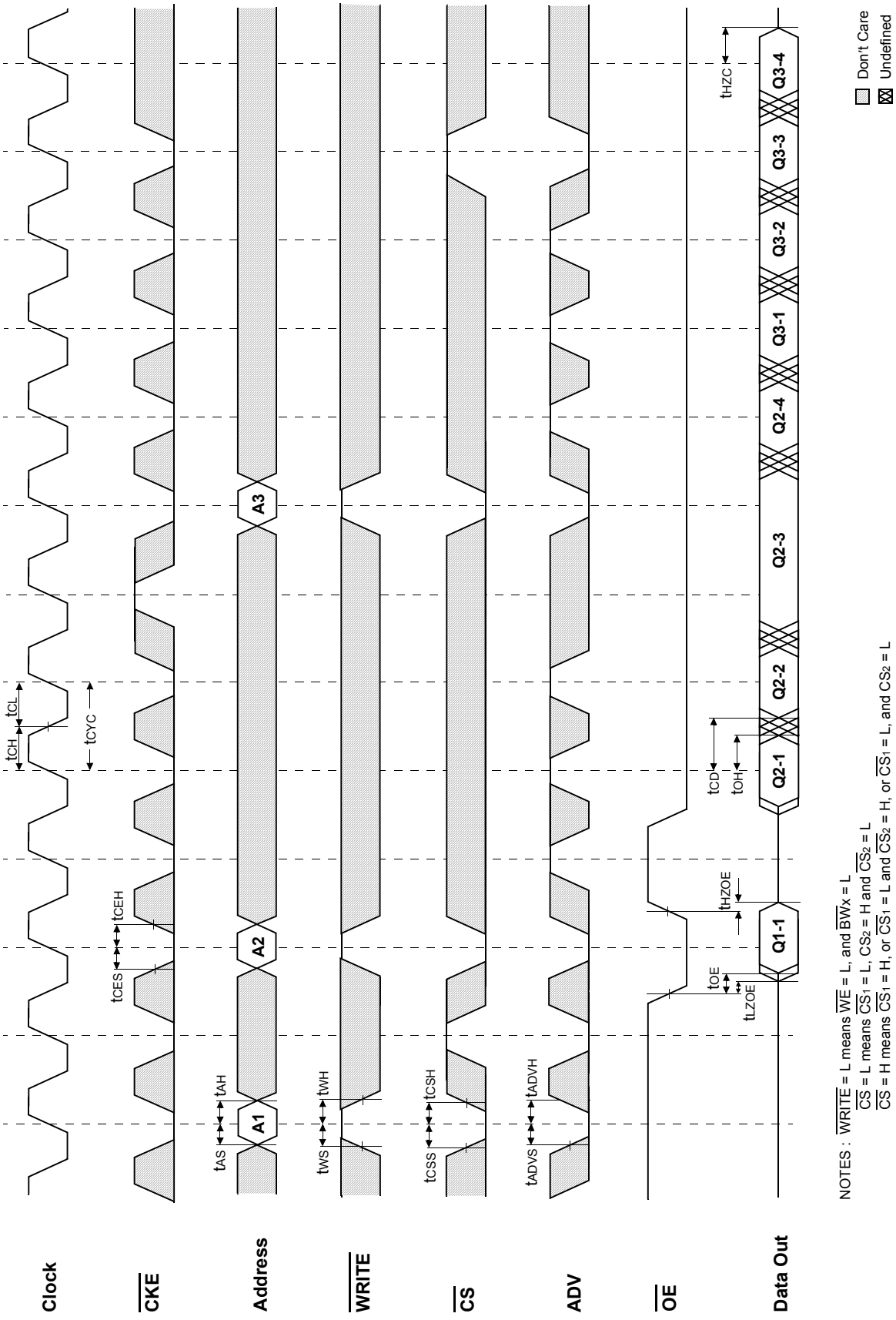
SLEEP MODE ELECTRICAL CHARACTERISTICS

DESCRIPTION	CONDITIONS	SYMBOL	MIN	MAX	UNITS
Current during SLEEP MODE	ZZ ≥ V_{IH}	I_{SB2}		10	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_{ZZI}		2	cycle
ZZ inactive to exit SLEEP current		t_{RZZI}	0		

SLEEP MODE WAVEFORM

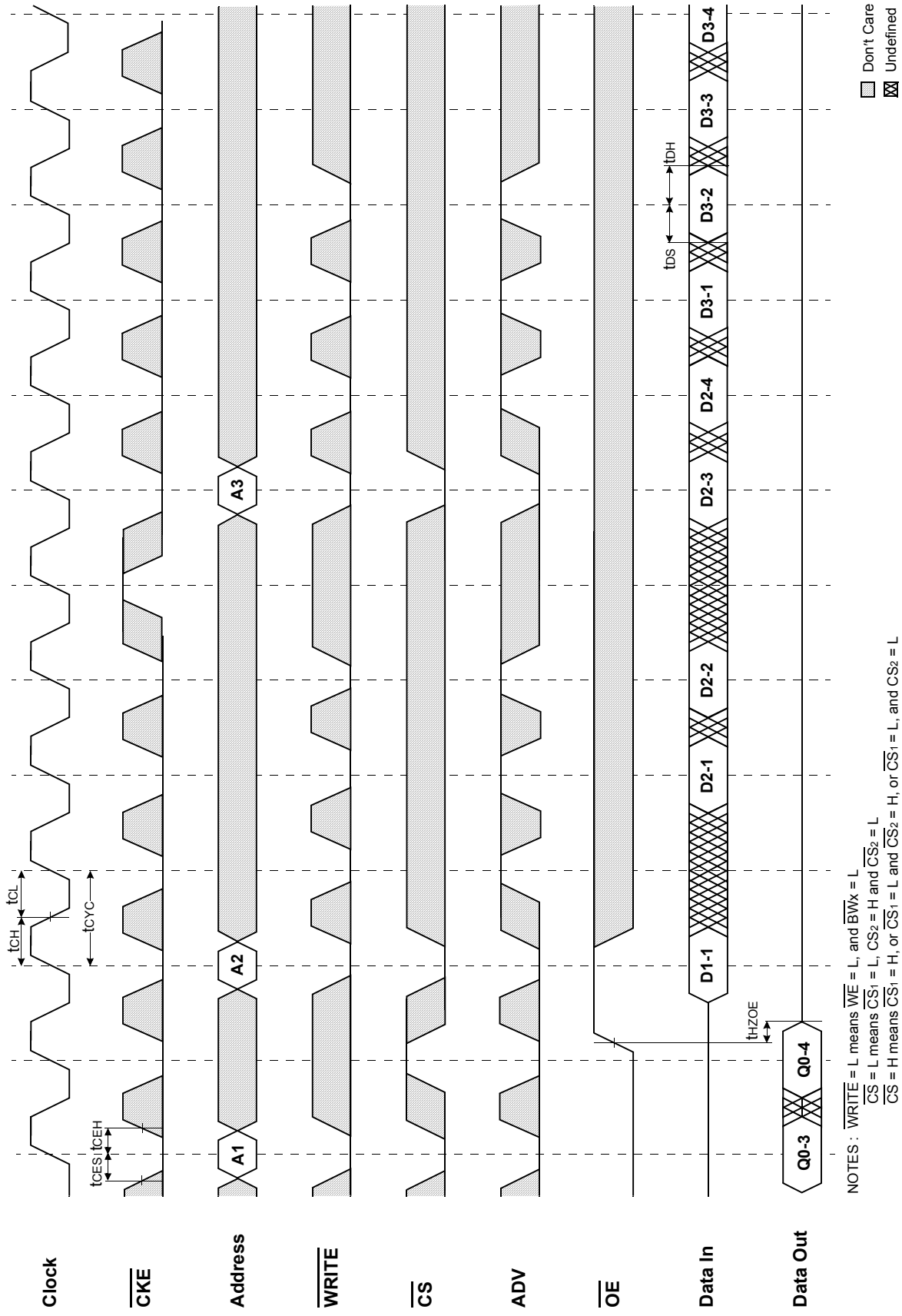


TIMING WAVEFORM OF READ CYCLE

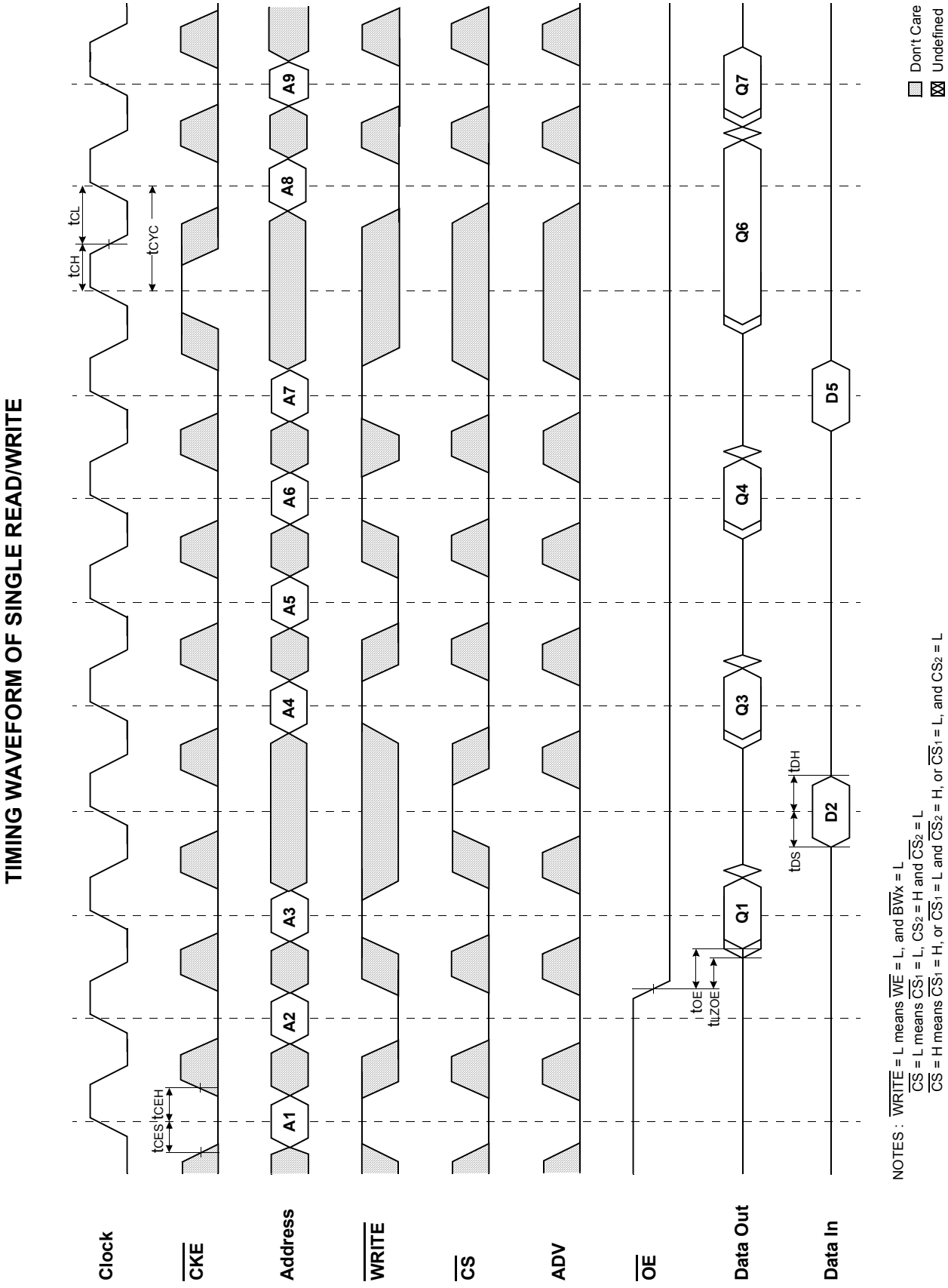


NOTES : $\overline{WRITE}$ = L means $\overline{WE}$ = L, and $\overline{BWx}$ = L
$\overline{CS}$ = L means $\overline{CS_1}$ = L, CS_2 = H and $\overline{CS_2}$ = L
$\overline{CS}$ = H means $\overline{CS_1}$ = H, or $\overline{CS_1}$ = L and $\overline{CS_2}$ = H, or $\overline{CS_1}$ = L, and CS_2 = L

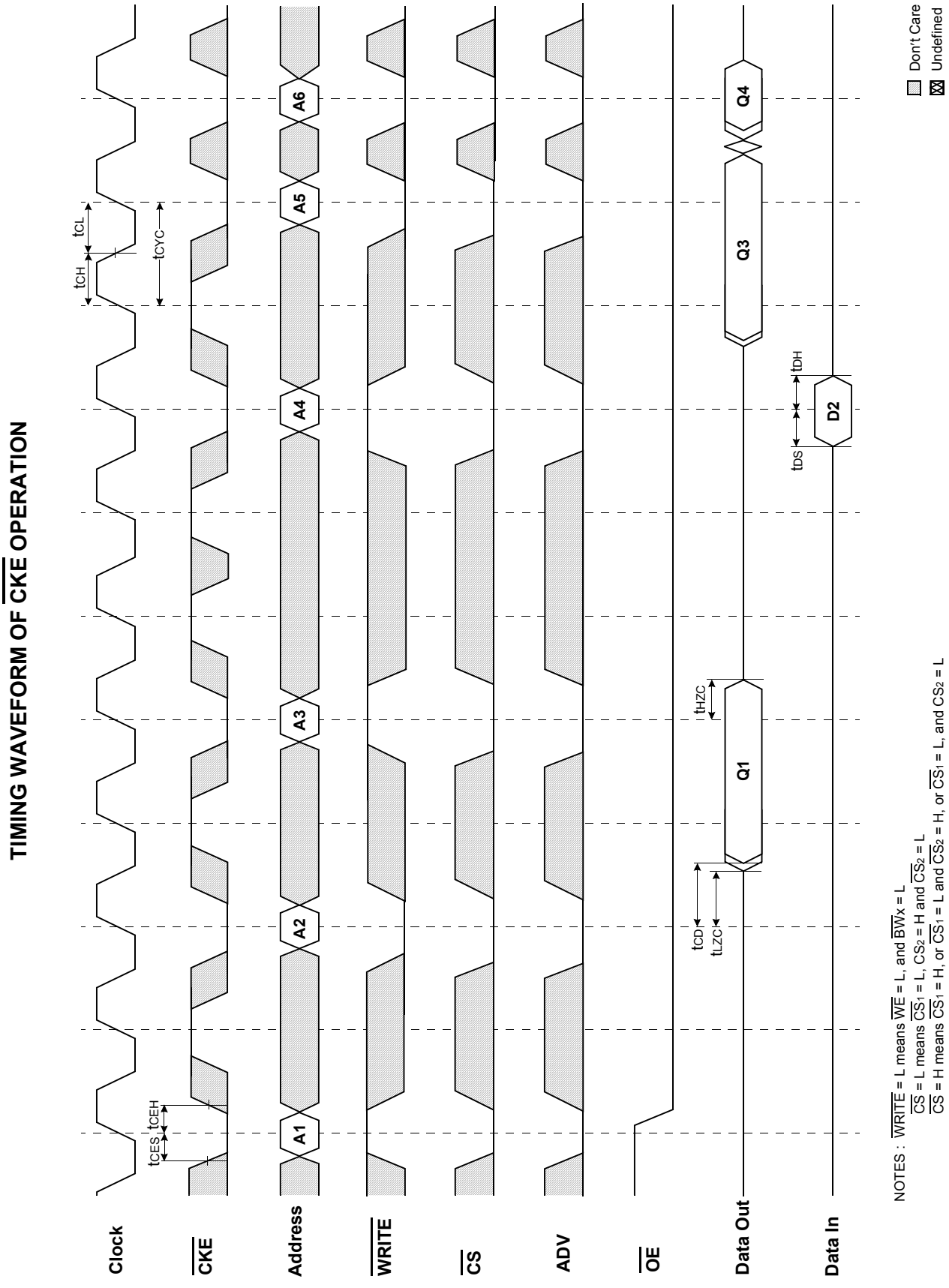
TIMING WAVEFORM OF WRTE CYCLE



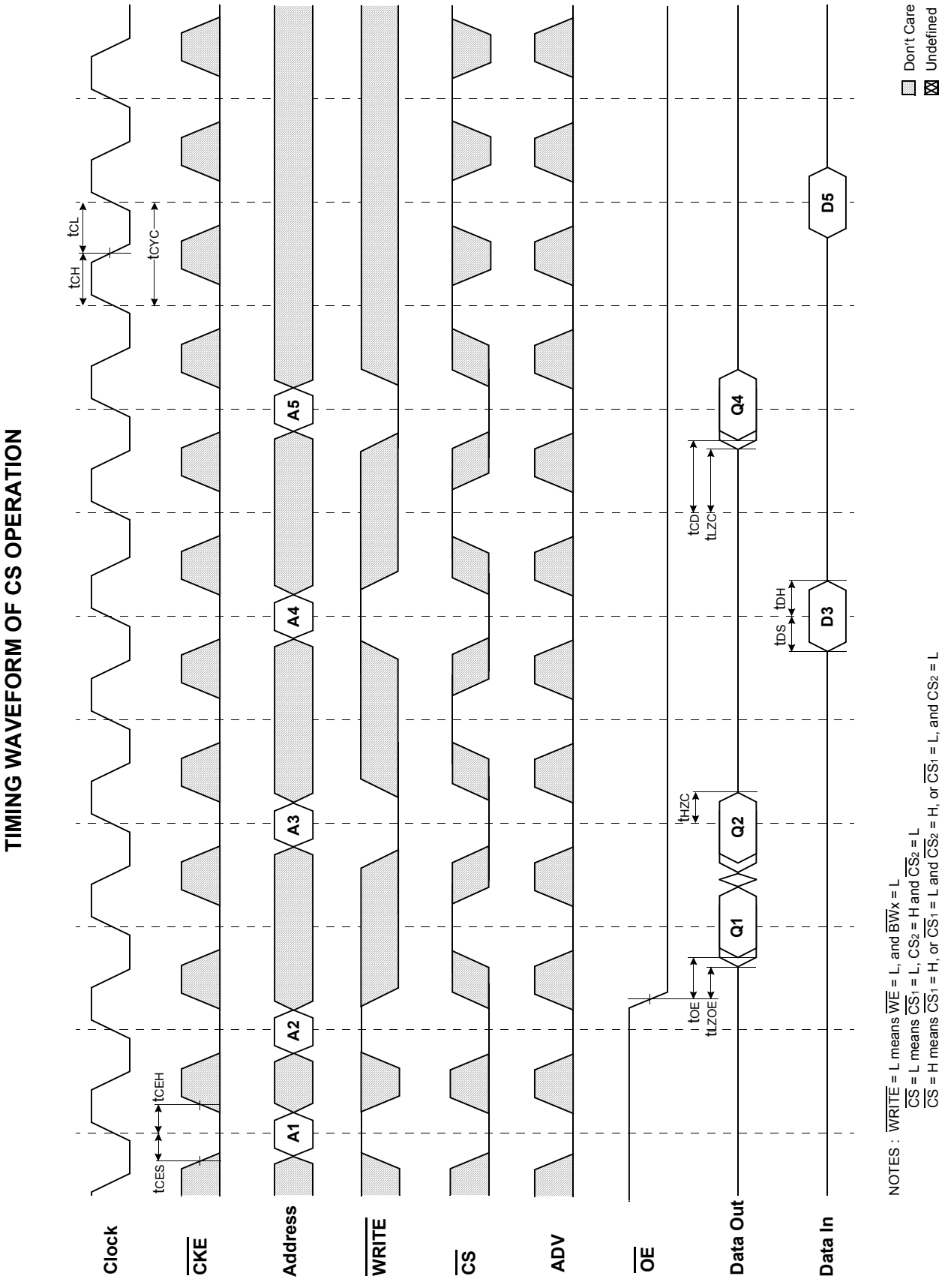
TIMING WAVEFORM OF SINGLE READ/WRITE



TIMING WAVEFORM OF $\overline{CKE}$ OPERATION



TIMING WAVEFORM OF $\overline{CS}$ OPERATION



PACKAGE DIMENSIONS

100-TQFP-1420A

Units ; millimeters/Inches