V54C365164VD(L) HIGH PERFORMANCE 225/200/166/143 MHz 3.3 VOLT 4M X 16 S 4 BANKS X 1Mbit X

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16			
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PRELIMINARY

	45	5	6	7
System Frequency (f _{CK})	225 MHz	200 MHz	166 MHz	143 MHz
Clock Cycle Time (t _{CK3})	4.5 ns	5 ns	6 ns	7 ns
Clock Access Time (t _{AC3}) CAS Latency = 3	4.5 ns	5 ns	5.4 ns	5.4 ns
Clock Access Time (t _{AC2}) CAS Latency = 2	4.5 ns	5 ns	5.5 ns	5.5 ns
Clock Access Time (t _{AC1}) CAS Latency = 1	12 ns	12 ns	12 ns	12 ns

Features

- 4 banks x 1Mbit x 16 organization
- High speed data transfer rates up to 225 MHz
- Full Synchronous Dynamic RAM, with all signals referenced to clock rising edge
- Single Pulsed RAS Interface
- Data Mask for byte Control
- Four Banks controlled by BA0 & BA1
- Programmable CAS Latency: 1, 2, 3
- Programmable Wrap Sequence: Sequential or Interleave
- Programmable Burst Length:
 - 1, 2, 4, 8 and full page for Sequential Type
 - 1, 2, 4, 8 for Interleave Type
- Multiple Burst Read with Single Write Operation
- Automatic and Controlled Precharge Command
- Random Column Address every CLK (1-N Rule)
- Suspend Mode and Power Down Mode
- Auto Refresh and Self Refresh
- Refresh Interval: 4096 cycles/64 ms
- Available in 54 Pin 400 mil TSOP-II
- LVTTL Interface
- Single +3.3 V ±0.3 V Power Supply

Description

The V54C365164VD(L) is a four bank Synchronous DRAM organized as 4 banks x 1Mbit x 16. The V54C365164VD(L) achieves high speed data transfer rates up to 225 MHz by employing a chip architecture that prefetches multiple bits and then synchronizes the output data to a system clock

All of the control, address, data input and output circuits are synchronized with the positive edge of an externally supplied clock.

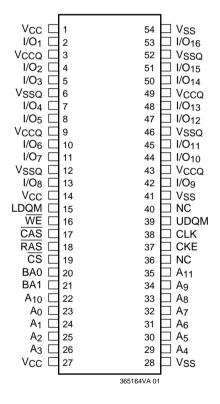
Operating the four memory banks in an interleaved fashion allows random access operation to occur at higher rate than is possible with standard DRAMs. A sequential and gapless data rate of up to 225 MHz is possible depending on burst length, CAS latency and speed grade of the device.

Device Usage Chart

Operating	Package Outline	Α	ccess	Time (r	ns)	Pov	wer	T
Temperature Range	Т	45	5	6	7	Std.	L	Temperature Mark
0°C to 70°C	•	•	•	•	•	•	•	Blank

Description	Pkg.	Pin Count
TSOP-II	Т	54

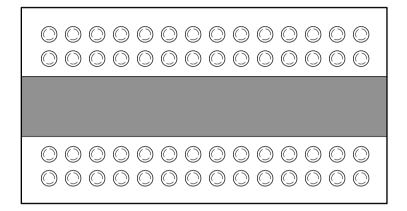
54 Pin Plastic TSOP-II PIN CONFIGURATION Top View



Pin Names

CLK	Clock Input						
CKE	Clock Enable						
CS	Chip Select						
RAS	Row Address Strobe						
CAS	Column Address Strobe						
WE	Write Enable						
A ₀ -A ₁₁	Address Inputs						
BA0, BA1	Bank Select						
I/O ₁ –I/O ₁₆	Data Input/Output						
LDQM, UDQM	Data Mask						
V _{CC}	Power (+3.3V)						
V _{SS}	Ground						
V _{CCQ}	Power for I/O's (+3.3V)						
V _{SSQ}	Ground for I/O's						
NC	Not connected						

56 Ball Grid Array (or BGA)



WBGA SDRAM (X4/X8/X16) 56 PINS ASSIGNMENT (Top View)

							X4						
							X8						
NC	VSS	DQ7	VSS		DQ15	VSS	X16	VDD	NC	VDD	NC	VDD	NC
NC	VSSQ	NC	VSSQ		DQ14	VSSQ		VDDQ	DQ0	VDDQ	DQ0	VDDQ	NC
VDDQ	DQ3	VDDQ	DQ6		VDDQ	DQ13		DQ2	DQ1	DQ1	NC	DQ1	NC
NC	NC	DQ5	NC		DQ11	DQ12		DQ3	VSSQ	NC	VSSQ	NC	VSSQ
NC	VSSQ	NC	VSSQ		DQ10	VSSQ		VDDQ	DQ4	VDDQ	DQ2	VDDQ	NC
VDDQ	DQ2	VDDQ	DQ4		VDDQ	DQ9		DQ6	DQ5	DQ3	NC	DQ1	NC
VSS	NC	VSS	NC		VSS	DQ8		DQ7	VSSQ	NC	VSSQ	NC	VSSQ
DQM	NC	DQM	NC		UDQM	NC		LDQM	VDD	NC	VDD	NC	VDD
CKE	CLK	CKE	CLK		CKE	CLK		CAS	WE	CAS	WE	CAS	WE
A11	-	A11	_		A11	-		CS	RAS	CS	RAS	CS	RAS
A8	A9	A8	A9		A8	A9		BA1	BA0	BA1	BA0	BA1	BA0
A6	A7	A6	A7		A6	A7		A0	A10	A0	A10	A0	A10
A4	A5	A4	A5		A4	A5		A2	A1	A2	A1	A2	A1
NC	VSS	NC	VSS		NC	VSS		VDD	А3	VDD	А3	VDD	А3
				L									

Bottom View (FROM SOLDER BALL SIDE)

							X4							
							X8							
NC	VDD		NC	VDD	NC	VDD	X16	VSS	DQ15		VSS	DQ7	VSS	NC
NC	VDDQ		DQ0	VDDQ	DQ0	VDDQ		VSSQ	DQ14		VSSQ	NC	VSSQ	NC
NC	DQ0		NC	DQ1	DQ1	DQ2		DQ13	VDDQ		DQ6	VDDQ	DQ3	VDDQ
VSSQ	NC		VSSQ	NC	VSSQ	DQ3		DQ12	DQ11		NC	DQS	NC	NC
NC	VDDQ		DQ3	VDDQ	DQ4	VDDO		VSSQ	DQ10		VSSQ	NC	VSSQ	NC
NC	DQ1		NC	DQ3	DQ5	DQ6		DQ9	VDDQ		DQ4	VDDQ	DQ2	VDDQ
VSSQ	NC		VSSQ	NC	VSSQ	DQ7		DQ8	VSS		NC	VSS	NC	VSS
VDD	NC		VDD	NC	VDD	LDQM		NC	UDQM		NC	DQM	NC	DQM
WE	CAS		WE	CAS	WE	CAS		CLK	CKE		CLK	CKS	CLK	CKE
RAS	CS		RAS	CS	RAS	CS		ı	A11		_	A11	_	A11
BA0	BA1		BA0	BA1	BA0	BA1		A9	A8		A9	A8	A9	A8
A10	A0		A10	A0	A10	A0		A7	A6		A7	A6	A7	A6
A1	A2		A1	A2	A1	A2		A5	A4		A5	A4	A5	A4
А3	VDD		АЗ	VDD	А3	VDD		VSS	NC		VSS	NC	VSS	NC
									_	_				
		L												

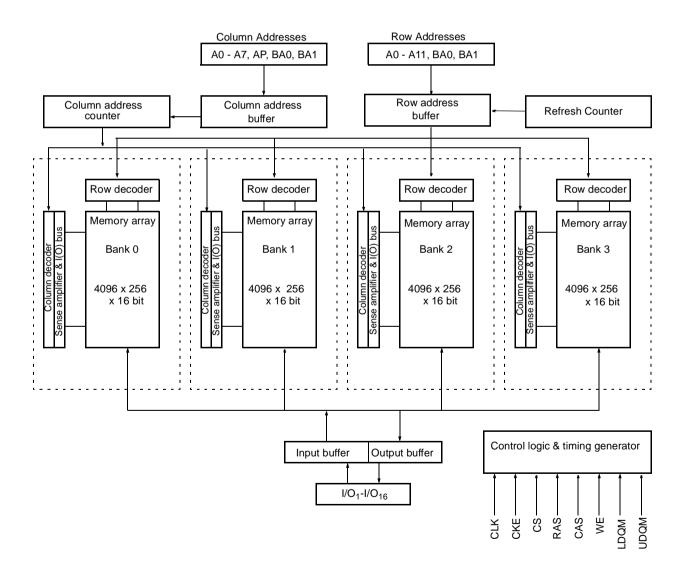
Capacitance*

 T_A = 0 to 70°C, V_{CC} = 3.3 V \pm 0.3 V, f = 1 Mhz

Symbol	Parameter	Max.	Unit
C _{I1}	Input Capacitance (A0 to A11)	5	pF
C _{I2}	Input Capacitance RAS, CAS, WE, CS, CLK, CKE, DQM	5	pF
C _{IO}	Output Capacitance (I/O)	6.5	pF
C _{CLK}	Input Capacitance (CLK)	4	pF

^{*}Note:Capacitance is sampled and not 100% tested.

Block Diagram



Signal Pin Description

Pin	Туре	Signal	Polarity	Function
CLK	Input	Pulse	Positive Edge	The system clock input. All of the SDRAM inputs are sampled on the rising edge of the clock.
CKE	Input	Level	Active High	Activates the CLK signal when high and deactivates the CLK signal when low, thereby initiates either the Power Down mode, Suspend mode, or the Self Refresh mode.
<u>cs</u>	Input	Pulse	Active Low	$\overline{\text{CS}}$ enables the command decoder when low and disables the command decoder when high. When the command decoder is disabled, new commands are ignored but previous operations continue.
RAS, CAS WE	Input	Pulse	Active Low	When sampled at the positive rising edge of the clock, $\overline{\text{CAS}}$, $\overline{\text{RAS}}$, and $\overline{\text{WE}}$ define the command to be executed by the SDRAM.
A0 - A11	Input	Level		During a Bank Activate command cycle, A0-A11 defines the row address (RA0-RA11) when sampled at the rising clock edge. During a Read or Write command cycle, A0-An defines the column address (CA0-CAn) when sampled at the rising clock edge.CAn depends from the SDRAM organization: 4M x 16 SDRAM CA0-CA7 (Page Length = 256 bits) In addition to the column address, A10(=AP) is used to invoke autoprecharge operation at the end of the burst read or write cycle. If A10 is high, autoprecharge is selected and BA0, BA1 defines the bank to be precharged. If A10 is low, autoprecharge is disabled. During a Precharge command cycle, A10(=AP) is used in conjunction with BA0 and BA1 to control which bank(s) to precharge. If A10 is high, all four banks will BA0 and BA1 are used to define which bank to precharge.
BA0, BA1	Input	Level	_	Selects which bank is to be active.
DQx	Input Output	Level	_	Data Input/Output pins operate in the same manner as on conventional DRAMs.
DQM LDQM UDQM	Input	Pulse	Active High	The Data Input/Output mask places the DQ buffers in a high impedance state when sampled high. In Read mode, DQM has a latency of two clock cycles and controls the output buffers like an output enable. In Write mode, DQM has a latency of zero and operates as a word mask by allowing input data to be written if it is low but blocks the write operation if DQM is high. LDQM and UDQM controls the lower and upper bytes in a x16 SDRAMs.
VCC, VSS	Supply			Power and ground for the input buffers and the core logic.
VCCQ VSSQ	Supply	_	_	Isolated power supply and ground for the output buffers to provide improved noise immunity.

Operation Definition

All of SDRAM operations are defined by states of control signals \overline{CS} , \overline{RAS} , \overline{CAS} , \overline{WE} , and DQM at the positive edge of the clock. The following list shows the thruth table for the operation commands.

Operation	Device State	CKE n-1	CKE n	cs	RAS	CAS	WE	DQM	A0-9, A11	A10	BS0 BS1
Row Activate	Idle ³	Н	Х	L	L	Н	Н	Х	V	V	V
Read	Active ³	Н	Х	L	Н	L	Н	Х	V	L	V
Read w/Autoprecharge	Active ³	Н	Х	L	Н	L	Н	Х	V	Н	V
Write	Active ³	Н	Х	L	Н	L	L	Х	V	L	V
Write with Autoprecharge	Active ³	Н	Х	L	Н	L	L	Х	V	Н	V
Row Precharge	Any	Н	Х	L	L	Н	L	Х	Х	L	V
Precharge All	Any	Н	Х	L	L	Н	L	Х	Х	Н	Х
Mode Register Set	Idle	Н	Х	L	L	L	L	Х	V	V	V
No Operation	Any	Н	Х	L	Н	Н	Н	Х	Х	Х	Х
Device Deselect	Any	Н	Х	Н	Х	Х	Х	Х	Х	Х	Х
Auto Refresh	Idle	Н	Н	L	L	L	Н	Х	Х	Х	Х
Self Refresh Entry	ldle	Н	L	L	L	L	Н	Х	Х	Х	Х
Self Refresh Exit	ldle			Н	Х	Х	Х				
	(Self Refr.)	L	Н	L	Н	Н	Х	Х	Х	Х	Х
Power Down Entry	Idle			Н	Х	Х	Х				
	Active ⁵	Н	L	L	Н	Н	Х	Х	Х	Х	Х
Power Down Exit	Any			Н	Х	Х	Х				
	(Power Down)	L	Н	L	Н	Н	L	Х	Х	Х	Х
Data Write/Output Enable	Active	Н	Х	Х	Х	Х	Х	L	Х	Х	Х
Data Write/Output Disable	Active	Н	Х	Х	Х	Х	Х	Н	Х	Х	Х

Notes:

- 1. V = Valid , x = Don't Care, L = Low Level, H = High Level
- 2. CKEn signal is input level when commands are provided, CKEn-1 signal is input level one clock before the commands are provided.
- 3. These are state of bank designated by BS0, BS1 signals.
- 4. Device state is Full Page Burst operation
- 5. Power Down Mode can not entry in the burst cycle. When this command assert in the burst mode cycle device is clock suspend mode.

Power On and Initialization

The default power on state of the mode register is supplier specific and may be undefined. The following power on and initialization sequence guarantees the device is preconditioned to each users specific needs. Like a conventional DRAM, the Synchronous DRAM must be powered up and initialized in a predefined manner. During power on, all VCC and VCCQ pins must be built up simultaneously to the specified voltage when the input signals are held in the "NOP" state. The power on voltage must not exceed VCC+0.3V on any of the input pins or VCC supplies. The CLK signal must be started at the same time. After power on, an initial pause of 200 us is required followed by a precharge of both banks using the precharge command. To prevent data contention on the DQ bus during power on, it is required that the DQM and CKE pins be held high during the initial pause period. Once all banks have been precharged, the Mode Register Set Command must be issued to initialize the Mode Register. A minimum of eight Auto Refresh cycles (CBR) are also required. These may be done before or after programming the Mode Register. Failure to follow these steps may lead to unpredictable start-up modes.

Programming the Mode Register

The Mode register designates the operation mode at the read or write cycle. This register is divided into 4 fields. A Burst Length Field to set the length of the burst, an Addressing Selection bit to program the column access sequence in a burst cycle (interleaved or sequential), a CAS **Latency** Field to set the access time at clock cycle and a Operation mode field to differentiate between normal operation (Burst read and burst Write) and a special Burst Read and Single Write mode. The mode set operation must be done before any activate command after the initial power up. Any content of the mode register can be altered by re-executing the

mode set command. All banks must be in precharged state and CKE must be high at least one clock before the mode set operation. After the mode register is set, a Standby or NOP command is required. Low signals of RAS, CAS, and WE at the positive edge of the clock activate the mode set operation. Address input data at this timing defines parameters to be set as shown in the previous table.

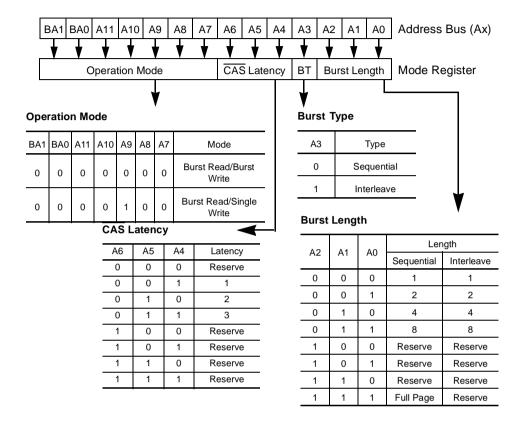
Read and Write Operation

When \overline{RAS} is low and both \overline{CAS} and \overline{WE} are high at the positive edge of the clock, a RAS cycle starts. According to address data, a word line of the selected bank is activated and all of sense amplifiers associated to the wordline are set. A \overline{CAS} cycle is triggered by setting \overline{RAS} high and \overline{CAS} low at a clock timing after a necessary delay, t_{RCD} , from the \overline{RAS} timing. \overline{WE} is used to define either a read $\overline{(WE = H)}$ or a write $\overline{(WE = L)}$ at this stage.

SDRAM provides a wide variety of fast access modes. In a single CAS cycle, serial data read or write operations are allowed at up to a 225 MHz data rate. The numbers of serial data bits are the burst length programmed at the mode set operation, i.e., one of 1, 2, 4, 8 and full page. Column addresses are segmented by the burst length and serial data accesses are done within this boundary. The first column address to be accessed is supplied at the CAS timing and the subsequent addresses are generated automatically by the programmed burst length and its sequence. For example, in a burst length of 8 with interleave sequence, if the first address is '2', then the rest of the burst sequence is 3, 0, 1, 6, 7, 4, and 5.

Full page burst operation is only possible using the sequential burst type and page length is a function of the I/O organisation and column addressing. Full page burst operation do not self terminate once the burst length has been reached. In other words, unlike burst length of 2, 3 or 8, full page burst continues until it is terminated using another command.

Address Input for Mode Set (Mode Register Operation)



Similar to the page mode of conventional DRAM's, burst read or write accesses on any column address are possible once the RAS cycle latches the sense amplifiers. The maximum t_{RAS} or the refresh interval time limits the number of random column accesses. A new burst access can be done even before the previous burst ends. The interrupt operation at every clock cycles is supported. When the previous burst is interrupted, the remaining addresses are overridden by the new address with the full burst length. An interrupt which accompanies

with an operation change from a read to a write is possible by exploiting DQM to avoid bus contention.

When two or more banks are activated sequentially, interleaved bank read or write operations are possible. With the programmed burst length, alternate access and precharge operations on two or more banks can realize fast serial data access modes among many different pages. Once two or more banks are activated, column to column interleave operation can be done between different pages.

Burst Length and Sequence:

Burst Length	Starting Address (A2 A1 A0)	Seque	entia			Add nal)	lres	sing		Inte	Interleave Burst Addressing (decimal)							
2	xx0 xx1				0, 1,						0, 1 1, 0							
4	x00 x01 x10 x11	0, 1, 2, 3 1, 2, 3, 0 2, 3, 0, 1 3, 0, 1, 2									0, 1, 2, 3 1, 0, 3, 2 2, 3, 0, 1 3, 2, 1, 0							
8	000 001 010 011 100 101 110	0 1 2 3 4 5 6 7	1 2 3 4 5 6 7 0	2 3 4 5 6 7 0 1	3 4 5 6 7 0 1 2	4 5 6 7 0 1 2 3	5 6 7 0 1 2 3 4	6 7 0 1 2 3 4 5	7 0 1 2 3 4 5 6		0 1 2 3 4 5 6 7	1 0 3 2 5 4 7 6	2 3 0 1 6 7 4 5	3 2 1 0 7 6 5 4	4 5 6 7 0 1 2 3	5 4 7 6 1 0 3 2	6 7 4 5 2 3 0 1	7 6 5 4 3 2 1 0
Full Page	nnn	Cn, Cn+1, Cn+2,						not supported										

Refresh Mode

SDRAM has two refresh modes, Auto Refresh and Self Refresh. Auto Refresh is similar to the CAS -before-RAS refresh of conventional DRAMs. All of banks must be precharged before applying any refresh mode. An on-chip address counter increments the word and the bank addresses and no bank information is required for both refresh modes.

The chip enters the Auto Refresh mode, when RAS and CAS are held low and CKE and WE are held high at a clock timing. The mode restores word line after the refresh and no external precharge command is necessary. A minimum tRC time is required between two automatic refreshes in a burst refresh mode. The same rule applies to any access command after the automatic refresh operation.

The chip has an on-chip timer and the Self Refresh mode is available. It enters the mode when RAS, CAS, and CKE are low and WE is high at a clock timing. All of external control signals including the clock are disabled. Returning CKE to high enables the clock and initiates the refresh exit operation. After the exit command, at least one t_{RC} delay is required prior to any access command.

DQM Function

DQM has two functions for data I/O read and write operations. During reads, when it turns to "high" at a clock timing, data outputs are disabled and become high impedance after two clock delay (DQM Data Disable Latency t_{DQZ}). It also provides

a data mask function for writes. When DQM is activated, the write operation at the next clock is prohibited (DQM Write Mask Latency t_{DOW} = zero clocks).

Suspend Mode

During normal access mode, CKE is held high enabling the clock. When CKE is low, it freezes the internal clock and extends data read and write operations. One clock delay is required for mode entry and exit (Clock Suspend Latency t_{CSL}).

Power Down

In order to reduce standby power consumption, a power down mode is available. All banks must be precharged and the necessary Precharge delay (trp) must occur before the SDRAM can enter the Power Down mode. Once the Power Down mode is initiated by holding CKE low, all of the receiver circuits except CLK and CKE are gated off. The Power Down mode does not perform any refresh operations, therefore the device can't remain in Power Down mode longer than the Refresh period (tref) of the device. Exit from this mode is performed by taking CKE "high". One clock delay is required for mode entry and exit.

Auto Precharge

Two methods are available to precharge SDRAMs. In an automatic precharge mode, the CAS timing accepts one extra address, CA10, to determine whether the chip restores or not after the

operation. If CA10 is high when a Read Command is issued, the **Read with Auto-Precharge** function is initiated. The SDRAM automatically enters the precharge operation one clock before the last data out for $\overline{\text{CAS}}$ latencies 2, two clocks for $\overline{\text{CAS}}$ latencies 3 and three clocks for CAS latencies 4. If CAS10 is high when a Write Command is issued, the **Write with Auto-Precharge** function is initiated. The SDRAM automatically enters the precharge operation a time delay equal to t_{WR} (Write recovery time) after the last data in.

Precharge Command

There is also a separate precharge command available. When RAS and WE are low and CAS is high at a clock timing, it triggers the precharge operation. Three address bits, BA0, BA1 and A10 are used to define banks as shown in the following list. The precharge command can be imposed one clock before the last data out for CAS latency = 2, two clocks before the last data out for CAS latency = 3 and three clocks before the last data out for CAS latency= 4. Writes require a time delay twr from the last data out to apply the precharge command.

Bank Selection by Address Bits:

A10	BA0	BA1	
0	0	0	Bank 0
0	0	1	Bank 1
0	1	0	Bank 2
0	1	1	Bank 3
1	Х	Х	all Banks

Burst Termination

Once a burst read or write operation has been initiated, there are several methods in which to terminate the burst operation prematurely. These methods include using another Read or Write Command to interrupt an existing burst operation, use a Precharge Command to interrupt a burst cycle and close the active bank, or using the Burst Stop Command to terminate the existing burst operation but leave the bank open for future Read or Write Commands to the same page of the active bank. When interrupting a burst with another Read or Write Command care must be taken to avoid I/O contention. The Burst Stop Command, however, has the fewest restrictions making it the easiest method to use when terminating a burst operation before it has been completed. If a Burst Stop command is issued during a burst write operation, then any residual data from the burst write cycle will be ignored. Data that is presented on the I/O pins before the Burst Stop Command is registered will be written to the memory.

MOSEL VITELIC V54C365164VD(L)

Absolute Maximum Ratings*

Operating temperature range	0 to 70 °C
Storage temperature range	55 to 150 °C
Input/output voltage	-0.3 to (V _{CC} +0.3) V
Power supply voltage	0.3 to 4.6 V
Power dissipation	1 W
Data out current (short circuit)	50 mA
*Note: Stresses above those listed und	
Ratings" may cause permanent	damage of the device.

Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Recommended Operation and Characteristics for LV-TTL

 T_A = 0 to 70 °C; V_{SS} = 0 V; V_{CC} , V_{CCQ} = 3.3 V \pm 0.3 V

		Limit '			
Parameter	Symbol	min.	max.	Unit	Notes
Input high voltage	V _{IH}	2.0	Vcc+0.3	V	1, 2
Input low voltage	V _{IL}	- 0.3	0.8	٧	1, 2
Output high voltage ($I_{OUT} = -2.0 \text{ mA}$)	V _{OH}	2.4	-	V	
Output low voltage (I _{OUT} = 2.0 mA)	V _{OL}	-	0.4	٧	
Input leakage current, any input $(0 \text{ V} < \text{V}_{\text{IN}} < 3.6 \text{ V}, \text{ all other inputs} = 0 \text{ V})$	I _{I(L)}	-5	5	μА	
Output leakage current (DQ is disabled, 0 V < V _{OUT} < V _{CC})	I _{O(L)}	-5	5	μА	

Note:

All voltages are referenced to V_{SS}.
 V_{IH} may overshoot to V_{CC} + 2.0 V for pulse width of < 4ns with 3.3V. V_{IL} may undershoot to -2.0 V for pulse width < 4.0 ns with 3.3V. Pulse width measured at 50% points with amplitude measured peak to DC reference.

Operating Currents (T_A = 0 to 70°C, V_{CC} = 3.3V \pm 0.3V) (Recommended Operating Conditions unless otherwise noted)

Symbol	Parameter & Test Condition	n	-45	-5	-6	-7	Unit	Note
ICC1	Operating Current $t_{RC} = t_{RCMIN}, t_{RC} = t_{CKMIN}.$ Active-precharge command cycling, without Burst Operation	1 bank operation	188	180	165	150	mA	7
ICC2P	Precharge Standby Current in Power Down Mode	t _{CK} = min.	2	2	2	2	mA	7
ICC2PS	$\overline{CS} = V_{IH}, CKE \le V_{IL(max)}$	t _{CK} = Infinity	1	1	1	1	mA	7
ICC2N	Precharge Standby Current in Non-Power Down Mode	t _{CK} = min.	70	65	55	45	mA	
ICC2NS	$\overline{CS} = V_{IH}, CKE \ge V_{IL(max)}$	t _{CK} = Infinity	5	5	5	5	mA	
ICC3	No Operating Current $t_{CK} = min, \overline{CS} = V_{IH(min)}$	$CKE \ge V_{IH(MIN.)}$	80	75	65	55	mA	
ICC3P	bank; active state (4 banks)	$\begin{aligned} & CKE \leq V_{IL(MAX.)} \\ & (Power\;down\;mode) \end{aligned}$	8	8	8	8	mA	
ICC4	Burst Operating Current t _{CK} = min Read/Write command cycling		145	140	130	120	mA	7,8
ICC5	Auto Refresh Current t _{CK} = min Auto Refresh command cycling		180	175	165	150	mA	7
ICC6	Self Refresh Current		1	1	1	1	mA	
	Self Refresh Mode, CKE≤0.2V	L-version	500	500	500	500	μΑ	

Notes:

^{7.} These parameters depend on the cycle rate and these values are measured by the cycle rate under the minimum value of t_{CK} and t_{RC}. Input signals are changed one time during t_{CK}.
 These parameter depend on output loading. Specified values are obtained with output open.

AC Characteristics 1,2,3

 T_A = 0 to 70 °C; V_{SS} = 0 V; V_{DD} = 3.3 V \pm 0.3 V, t_T = 1 ns

#				Limit Values								
#			-4	1 5		-5		-6		7		
11	Symbol	Parameter	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Unit	Note
Clock	and Clock	Enable	I				1		u.	<u>l</u>		<u> </u>
1	t _{CK}	Clock Cycle Time CAS Latency = 3 CAS Latency = 2 CAS Latency = 1	4.5 10 12	- - -	5 10 12	- - -	6 10 12	- - -	7 10 12	- - -	s ns ns ns	
2	^t CK	Clock Frequency CAS Latency = 3 CAS Latency = 2 CAS Latency = 1		225 100 83		200 100 83	1 1 1	166 100 83	- - -	143 100 83	MHz MHz MHz	
3	t _{AC}	Access Time from Clock CAS Latency = 3 CAS Latency = 2 CAS Latency = 1		4.5 4.5 11	- - -	5 5 11	- -	5.4 5.5 11	- - -	5.4 5.5 11	ns ns ns	2, 4
4	t _{CH}	Clock High Pulse Width		_	2.5	_	2.5	_	2.5	-	ns	
5	t _{CL}	Clock Low Pulse Width	2.5	_	2.5	_	2.5	_	2.5	_	ns	
6	t _T	Transition Tim	0.3	1.2	0.3	1.2	0.3	1.2	0.3	1.2	ns	
Setup a	and Hold T	Times										
7	t _{IS}	Input Setup Time	1.5	_	1.5	_	1.5	_	1.5	_	ns	5
8	t _{IH}	Input Hold Time	0.8	_	0.8	_	0.8	_	0.8	_	ns	5
9	t _{CKS}	CKE Setup Time	1.5	_	1.5	_	1.5	_	1.5	_	ns	5
10	t _{CKH}	CKE Hold Time	0.8	_	0.8	_	0.8	_	0.8	_	ns	5
11	t _{RSC}	Mode Register Set-up Time	9	_	10	_	12	_	14	_	ns	
12	t _{SB}	Power Down Mode Entry Time	0	45	0	5	0	6	0	7	ns	
Comm	on Parame	eters										
13	t _{RCD}	Row to Column Delay Time	14	-	15	_	20	_	20	_	ns	6
14	t _{RP}	Row Precharge Time	14	-	15	_	20	_	20	-	ns	6
15	t _{RAS}	Row Active Time	38	100K	40	100K	40	100K	42	100K	ns	6
16	t _{RC}	Row Cycle Time	60	-	60	_	60	_	60	_	ns	6
17	t _{RRD}	Activate(a) to Activate(b) Command Period	9	-	10	-	12	-	14	-	ns	6
18	t _{CCD}	CAS(a) to CAS(b) Command Period	1	_	1	_	1	_	1	_	CLK	
Refres	h Cycle											
19	t _{REF}	Refresh Period (4096 cycles)	_	64	_	64	_	64	_	64	ms	
20	t _{SREX}	Self Refresh Exit Time	10	-	10	_	10	_	10	_	ns	

AC Characteristics (Cont'd)

			Limit Values									
			-45 -5		-6		-7					
#	Symbol	Parameter	Min. Max. Min. Max.		Min.	Max.	Min.	Max.	Unit	Note		
Read	Cycle		•									
21	t _{OH}	Data Out Hold Time	2.5	-1	2.5	-	2.5	-	2.7	_	ns	2
22	t_{LZ}	Data Out to Low Impedance Time	1	_	1	_	1	-	1	-	ns	
23	t _{HZ}	Data Out to High Impedance Time	_	4.5	_	5	_	5.4	_	5.4	ns	7
24	t _{DQZ}	DQM Data Out Disable Latency	_	2	_	2	_	2	_	2	CLK	
Write	Cycle											
25	t _{WR}	Write Recovery Time	2	_	2	_	2	-	2	-	CLK	
26	t _{DQW}	DQM Write Mask Latency	0	1	0	1	0	-	0	_	CLK	

Frequency vs. AC Parameter Relationship Table -45 / -5 / -6 / -7

Frequency	CAS Latency	t _{RC}	t _{RAS}	t _{RP}	t _{RRD}	t _{RCD}	t _{CCD}	t _{CDL}	t _{RDL}	Unit
83 MHz (12 ns)	1	5	4	2	2	2	1	1	1	CLK

Notes for AC Parameters:

- 1. For proper power-up see the operation section of this data sheet.
- 2. AC timing tests have $V_{IL} = 0.8V$ and $V_{IH} = 2.0V$ with the timing referenced to the 1.4 V crossover point. The transition time is measured between V_{IH} and V_{IL} . All AC measurements assume $t_T = 1$ ns with the AC output load circuit shown in Figure 1.

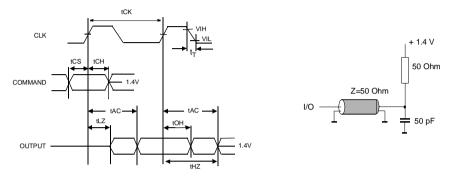


Figure 1.

- 4. If clock rising time is longer than 1 ns, a time $(t_T/2 0.5)$ ns has to be added to this parameter.
- 5. If t_T is longer than 1 ns, a time $(t_T 1)$ ns has to be added to this parameter.
- 6. These parameter account for the number of clock cycle and depend on the operating frequency of the clock, as follows:

the number of clock cycle = specified value of timing period (counted in fractions as a whole number)

Self Refresh Exit is a synchronous operation and begins on the 2nd positive clock edge after CKE returns high. Self Refresh Exit is not complete until a time period equal to tRC is satisfied once the Self Refresh Exit command is registered.

7. Referenced to the time which the output achieves the open circuit condition, not to output voltage levels

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Timing Diagrams

- 1. Bank Activate Command Cycle
- 2. Burst Read Operation
- 3. Read Interrupted by a Read
- 4. Read to Write Interval
 - 4.1 Read to Write Interval
 - 4.2 Minimum Read to Write Interval
 - 4.3 Non-Minimum Read to Write Interval
- 5. Burst Write Operation
- 6. Write and Read Interrupt
 - 6.1 Write Interrupted by a Write
 - 6.2 Write Interrupted by Read
- 7. Burst Write & Read with Auto-Precharge
 - 7.1 Burst Write with Auto-Precharge
 - 7.2 Burst Read with Auto-Precharge
- 8. Burst Termination
 - 8.1 Termination of a Full Page Burst Write Operation
 - 8.2 Termination of a Full Page Burst Write Operation
- 9. AC- Parameters
 - 9.1 AC Parameters for a Write Timing
 - 9.2 AC Parameters for a Read Timing
- 10. Mode Register Set
- 11. Power on Sequence and Auto Refresh (CBR)
- 12. Clock Suspension (using CKE)
 - 12.1 Clock Suspension During Burst Read CAS Latency = 2
 - 12. 2 Clock Suspension During Burst Read CAS Latency = 3
 - 12. 3 Clock Suspension During Burst Write \overline{CAS} Latency = 2
 - 12. 4 Clock Suspension During Burst Write CAS Latency = 3
- 13. Power Down Mode and Clock Suspend
- 14. Self Refresh (Entry and Exit)
- 15. Auto Refresh (CBR)

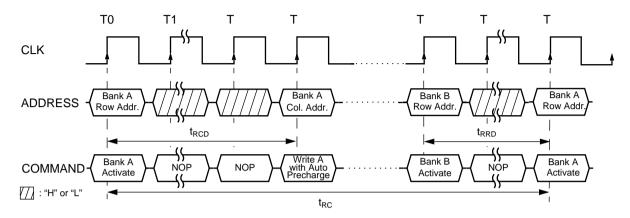
Timing Diagrams (Cont'd)

- 16. Random Column Read (Page within same Bank)
 - 16.1 $\overline{\text{CAS}}$ Latency = 2
 - $16.2 \overline{\text{CAS}} \text{ Latency} = 3$
- 17. Random Column Write (Page within same Bank)
 - 17.1 $\overline{\text{CAS}}$ Latency = 2
 - $17.2 \overline{\text{CAS}} \text{ Latency} = 3$
- 18. Random Row Read (Interleaving Banks) with Precharge
 - 18.1 $\overline{\text{CAS}}$ Latency = 2
 - $18.2 \overline{\text{CAS}} \text{ Latency} = 3$
- 19. Random Row Write (Interleaving Banks) with Precharge
 - 19.1 $\overline{\text{CAS}}$ Latency = 2
 - 19.2 \overline{CAS} Latency = 3
- 20. Full Page Read Cycle
 - 20.1 $\overline{\text{CAS}}$ Latency = 2
 - $20.2 \overline{CAS}$ Latency = 3
- 21. Full Page Write Cycle
 - 21.1 $\overline{\text{CAS}}$ Latency = 2
 - 21.2 $\overline{\text{CAS}}$ Latency = 3
- 22. Precharge Termination of a Burst
 - 22.1 $\overline{\text{CAS}}$ Latency = 2
 - 22.2 $\overline{\mathsf{CAS}}$ Latency = 3

V54C365164VD(L)

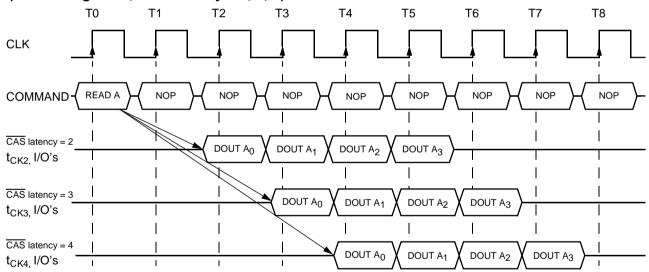
1. Bank Activate Command Cycle

$\overline{(CAS\ latency = 3)}$



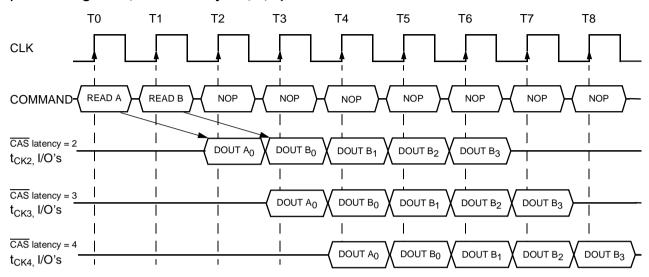
2. Burst Read Operation





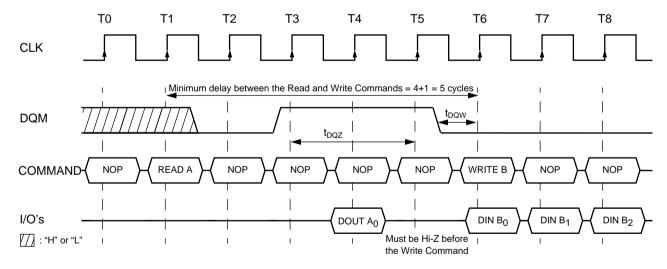
3. Read Interrupted by a Read

(Burst Length = 4, \overline{CAS} latency = 2, 3, 4)



4.1 Read to Write Interval

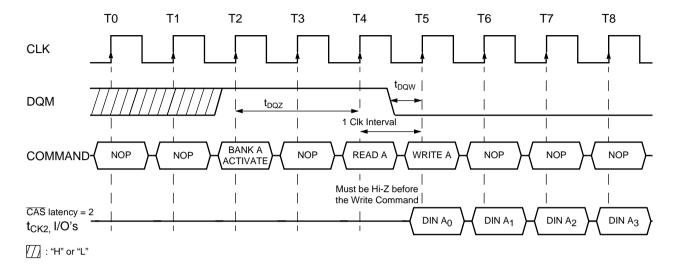
(Burst Length = 4, \overline{CAS} latency = 3)



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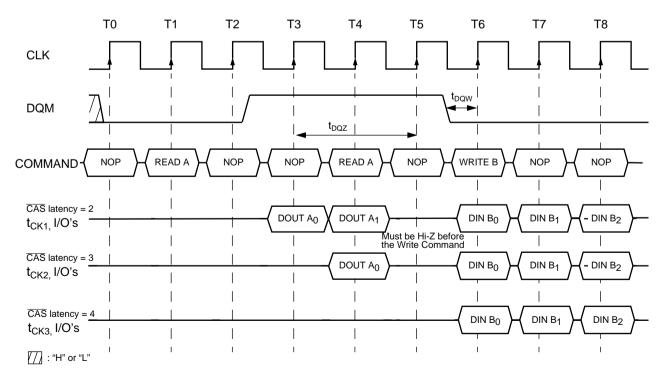
4.2 Minimum Read to Write Interval

(Burst Length = 4, \overline{CAS} latency = 2)



4.3 Non-Minimum Read to Write Interval

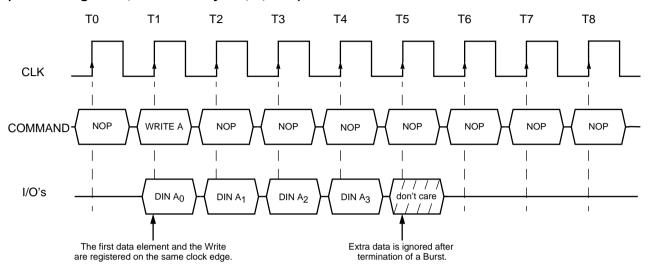
(Burst Length = 4, \overline{CAS} latency = 2, 3, 4



V54C365164VD(L)

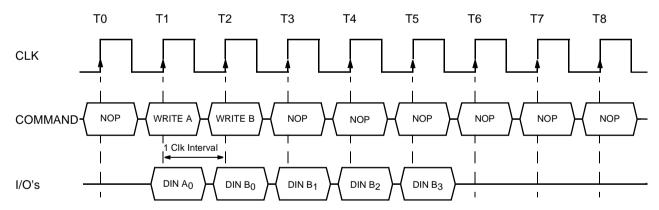
5. Burst Write Operation

(Burst Length = 4, \overline{CAS} latency = 2, 3, or 4)



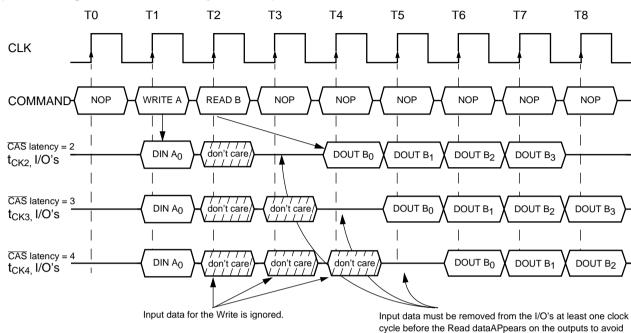
6.1 Write Interrupted by a Write

(Burst Length = 4, \overline{CAS} latency = 2, 3, or 4)



6.2 Write Interrupted by a Read

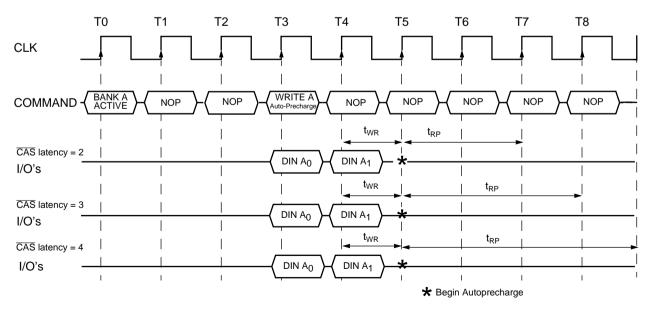




data contention.

7. Burst Write with Auto-Precharge

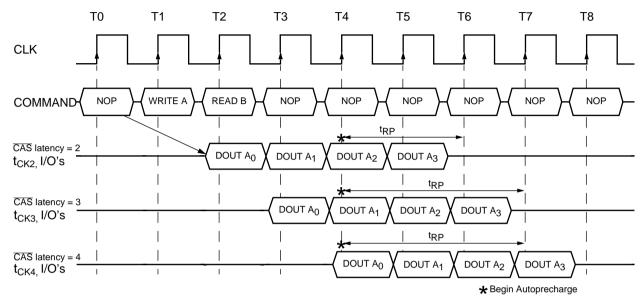
Burst Length = 2, \overline{CAS} latency = 2, 3, 4)



Bank can be reactivated after trp

7.2 Burst Read with Auto-Precharge

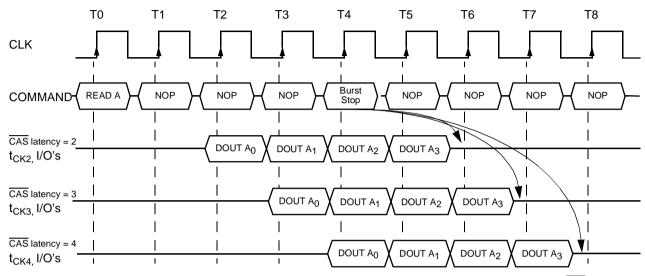
Burst Length = 4, \overline{CAS} latency = 2, 3, 4)



Bank can be reactivated after tRP

8.1 Termination of a Full Page Burst Read Operation

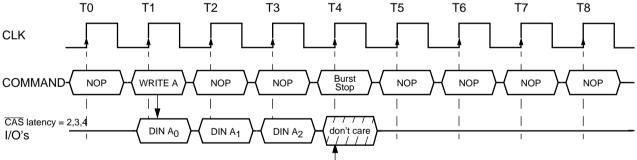
$(\overline{CAS} | latency = 2, 3, 4)$

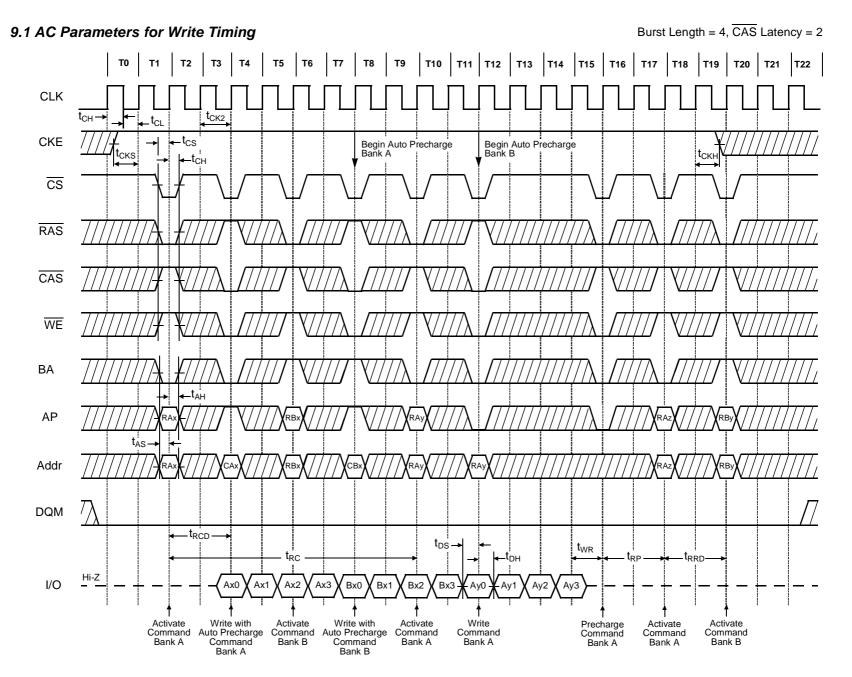


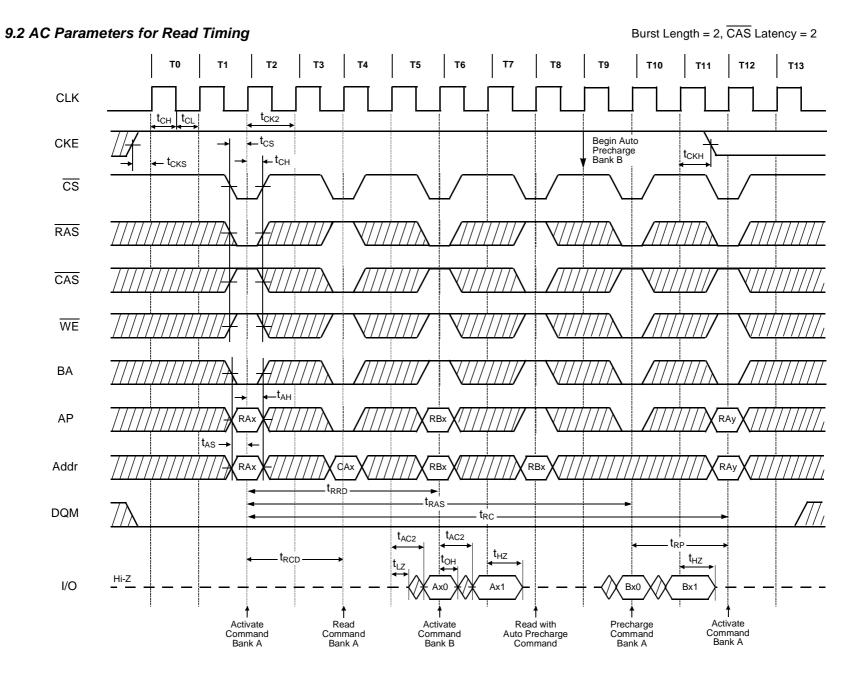
The burst ends after a delay equal to the $\overline{\text{CAS}}$ latency.

8.2 Termination of a Full Page Burst Write Operation

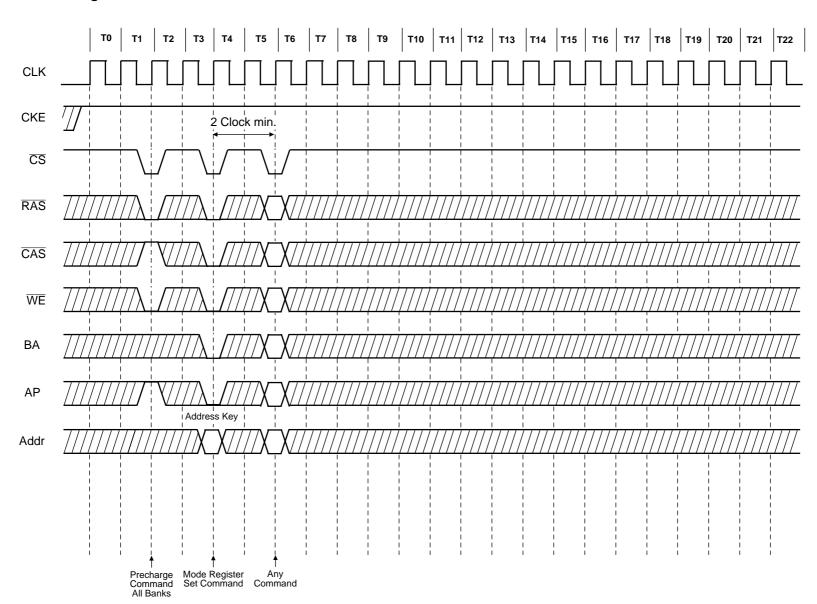
$\overline{(CAS\ latency = 2, 3, 4)}$



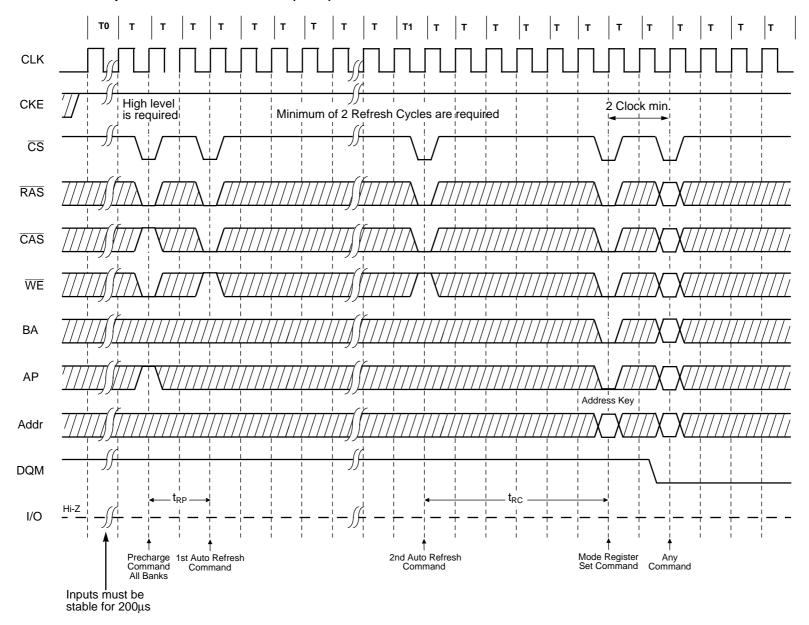


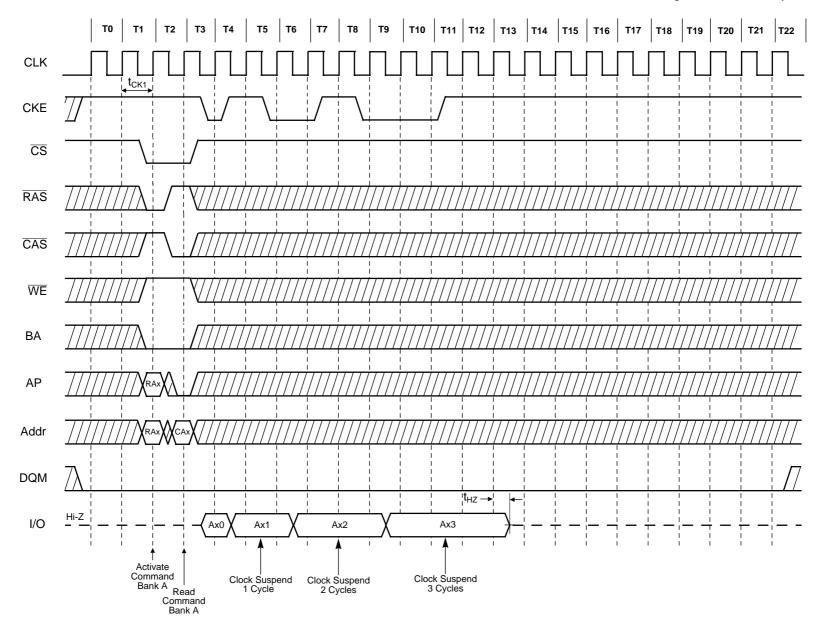


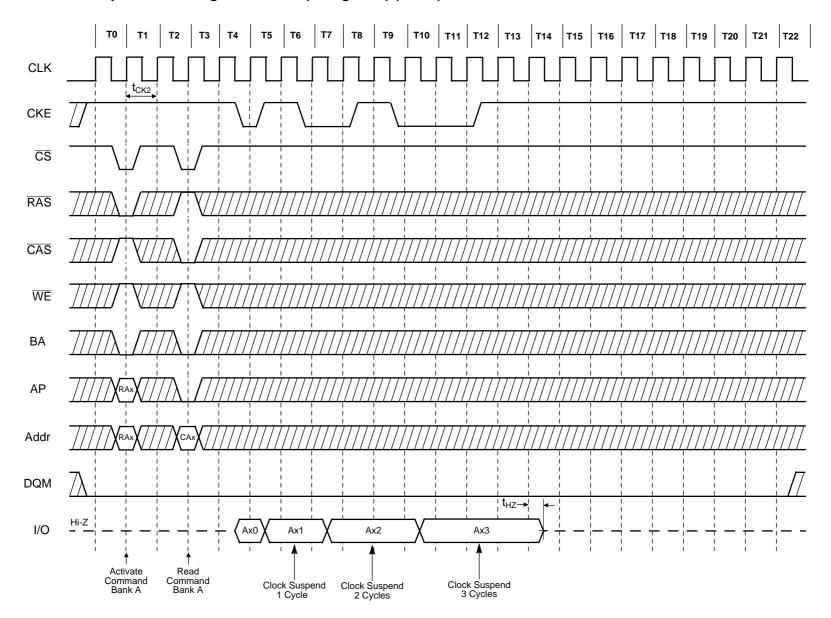
10. Mode Register Set

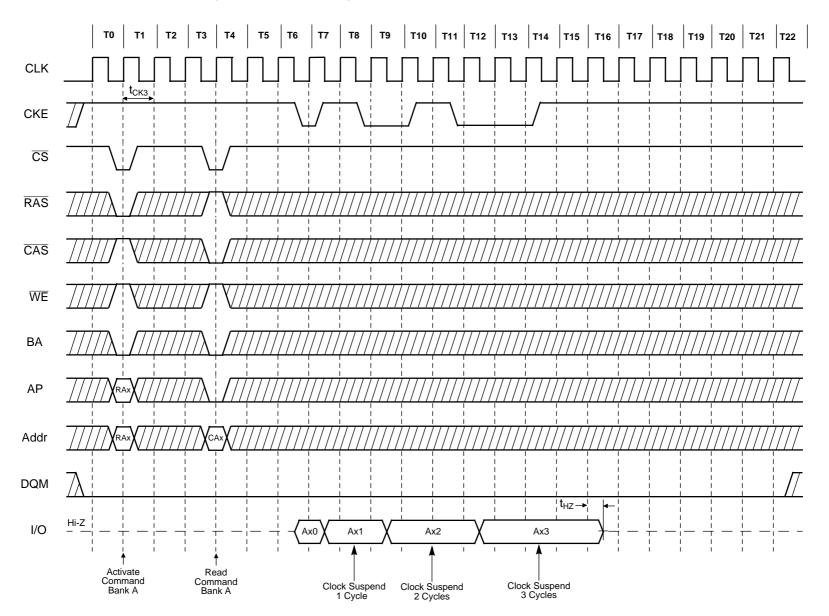


11. Power on Sequence and Auto Refresh (CBR)

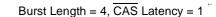


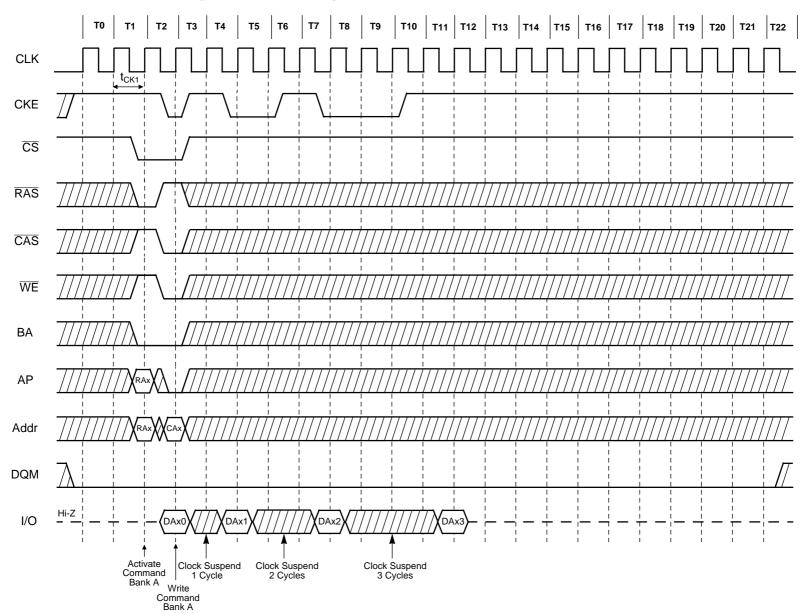


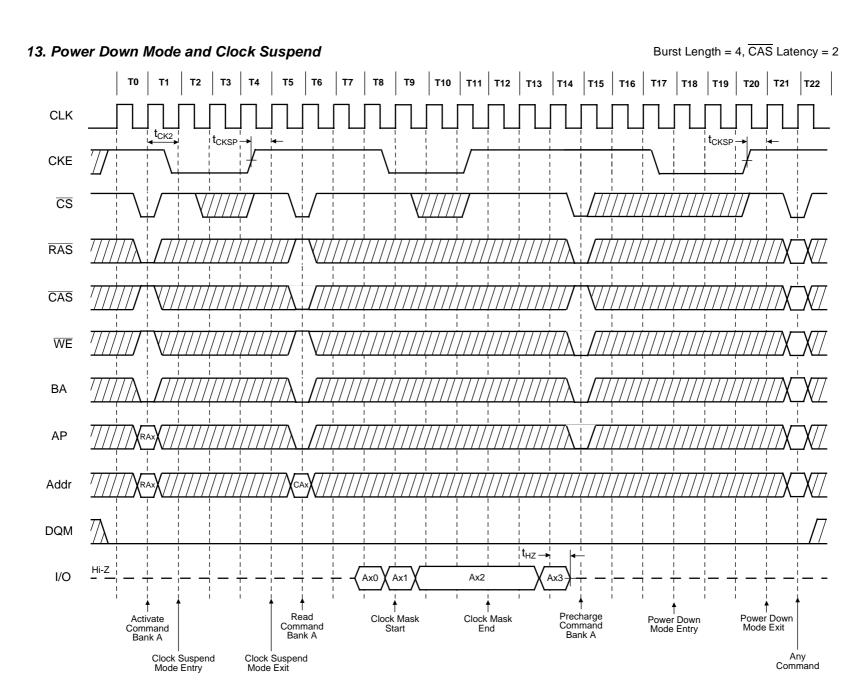




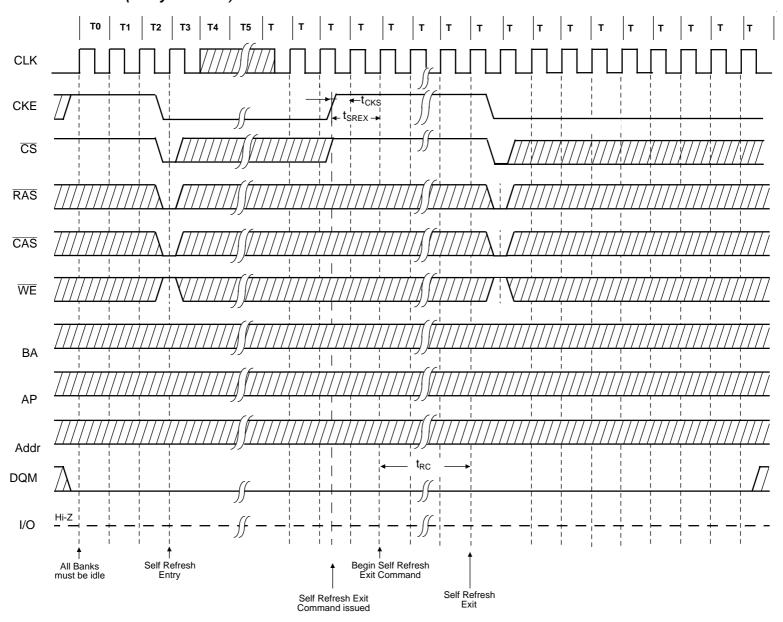


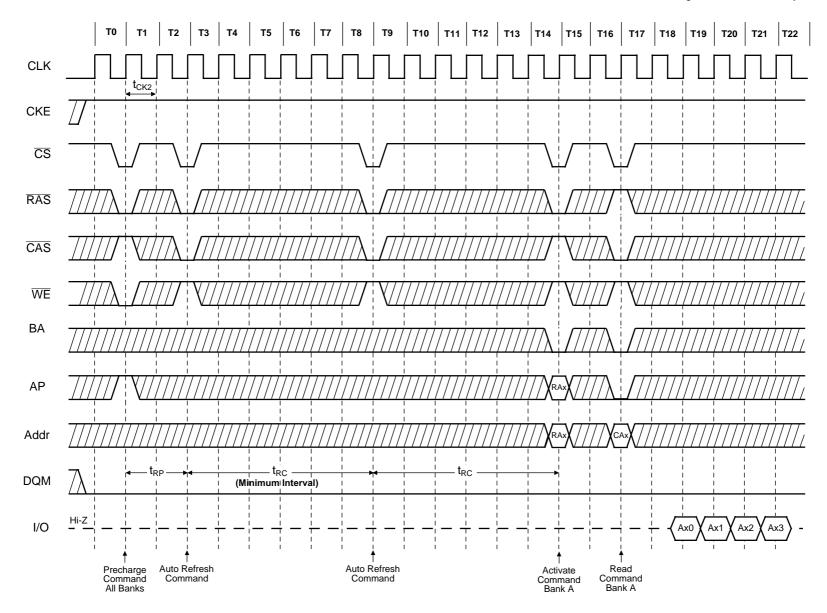


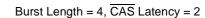


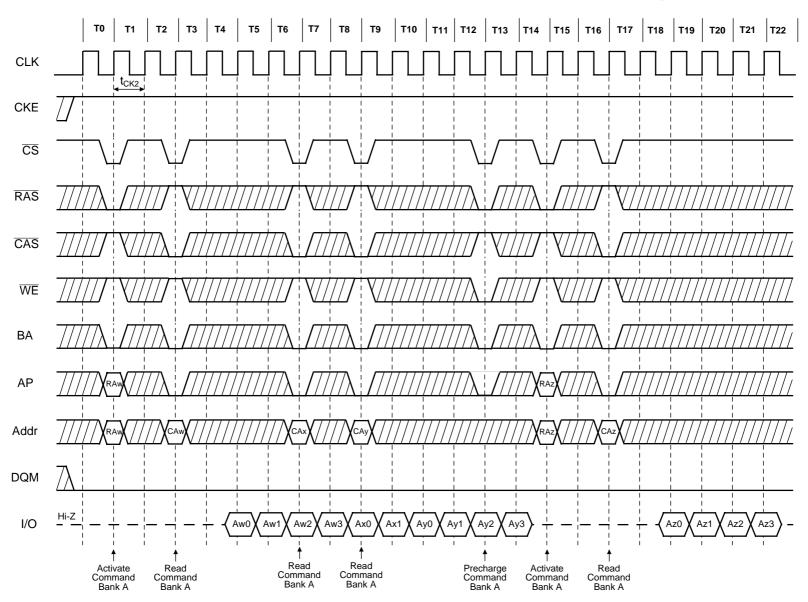


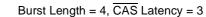
14. Self Refresh (Entry and Exit)

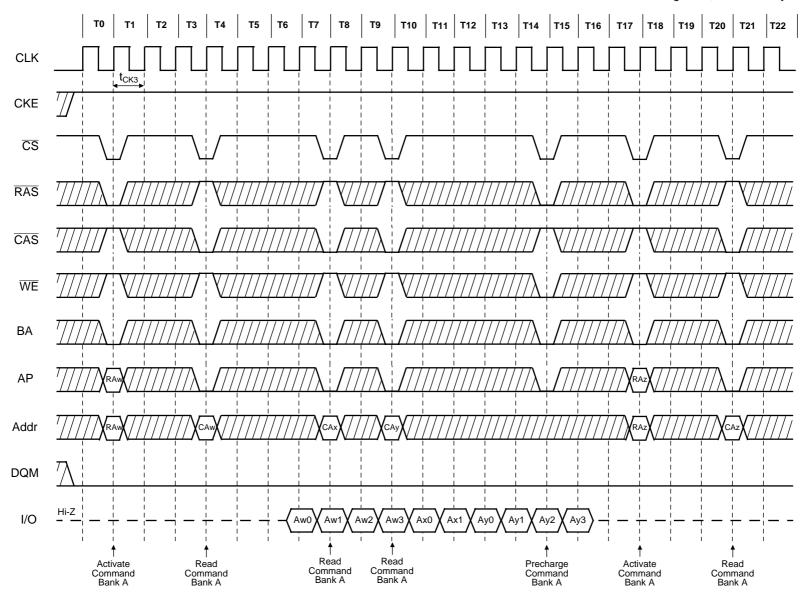


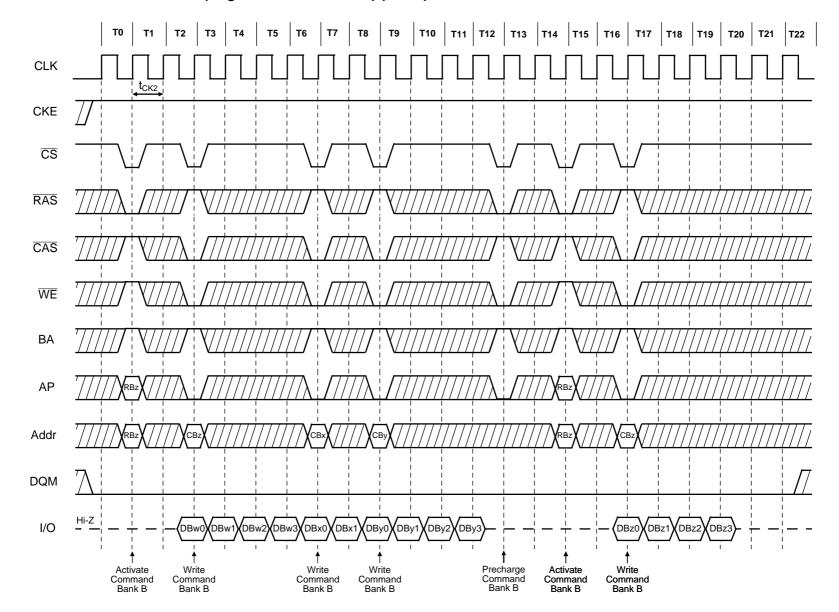


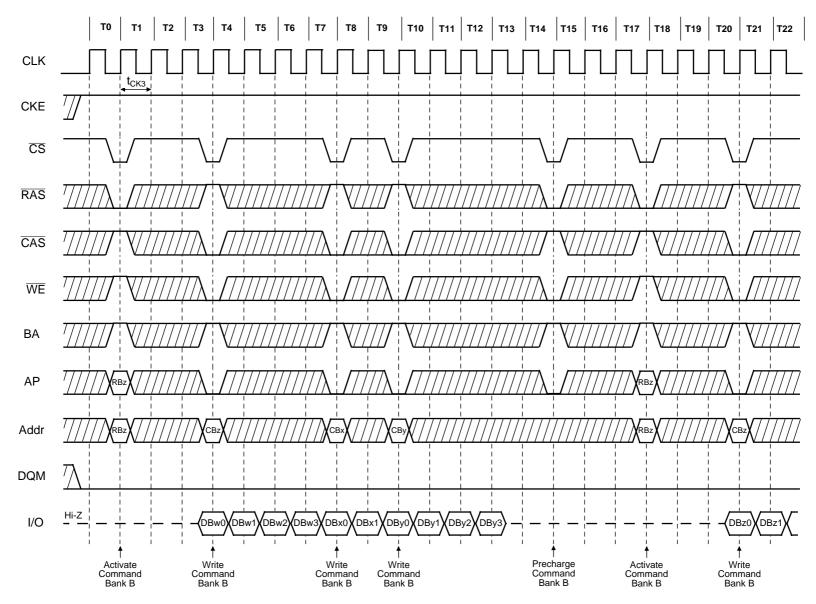


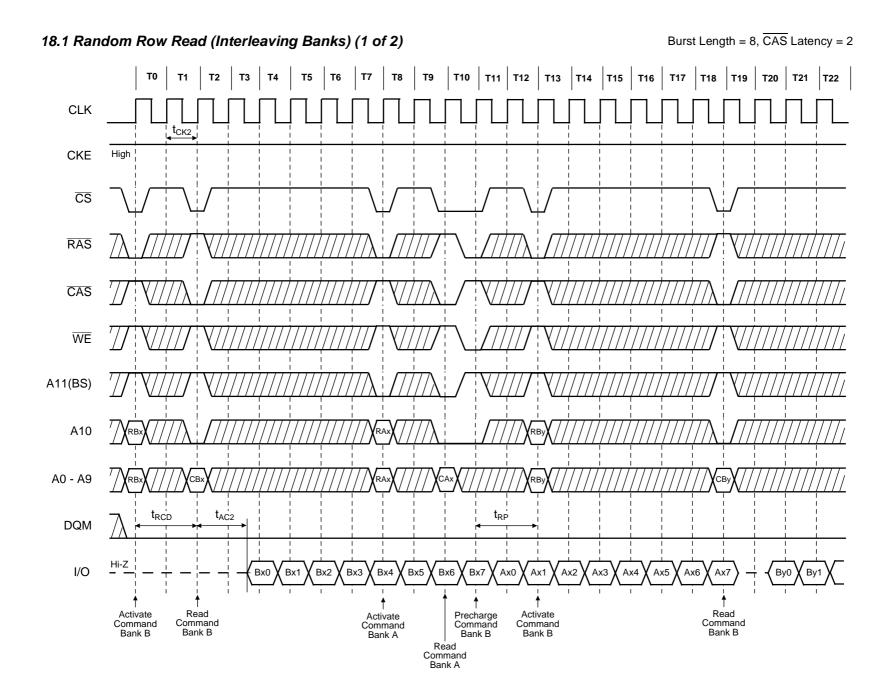


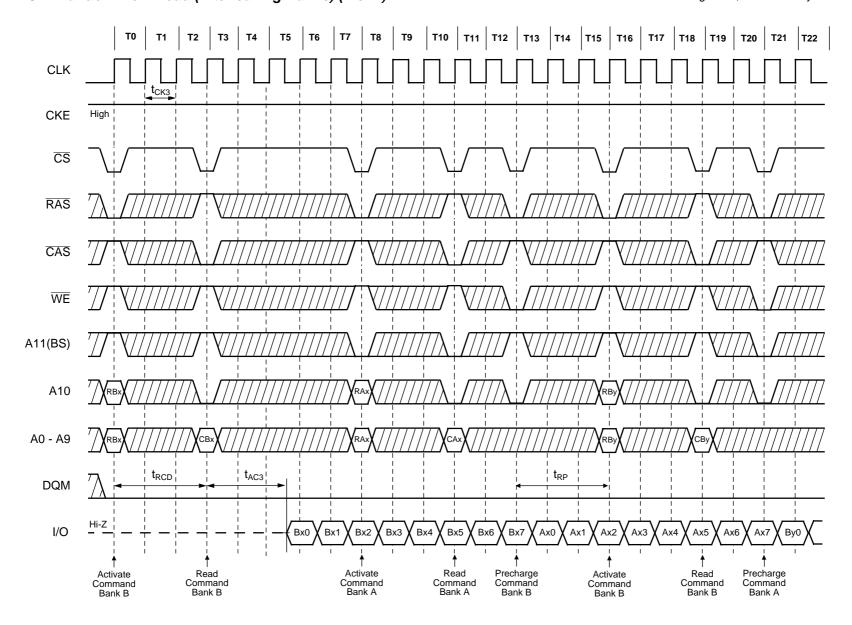


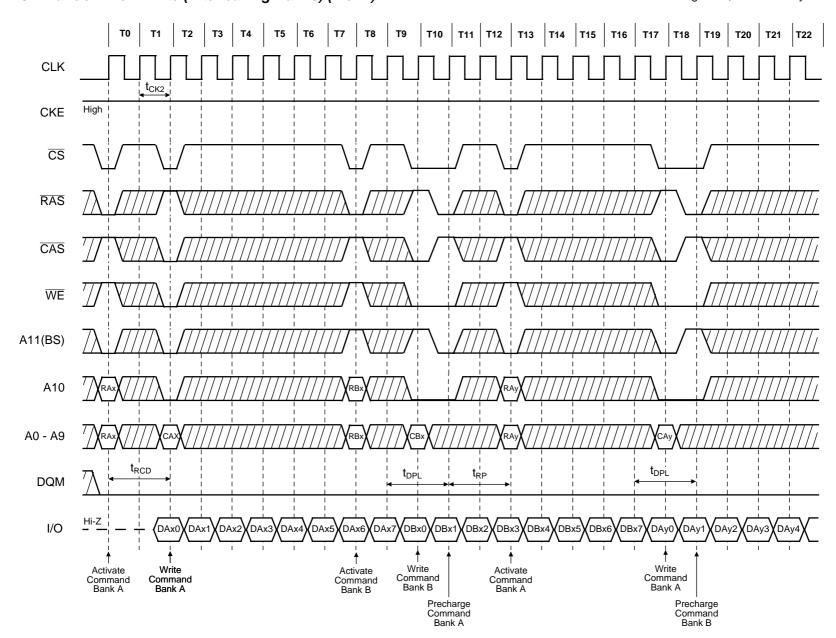


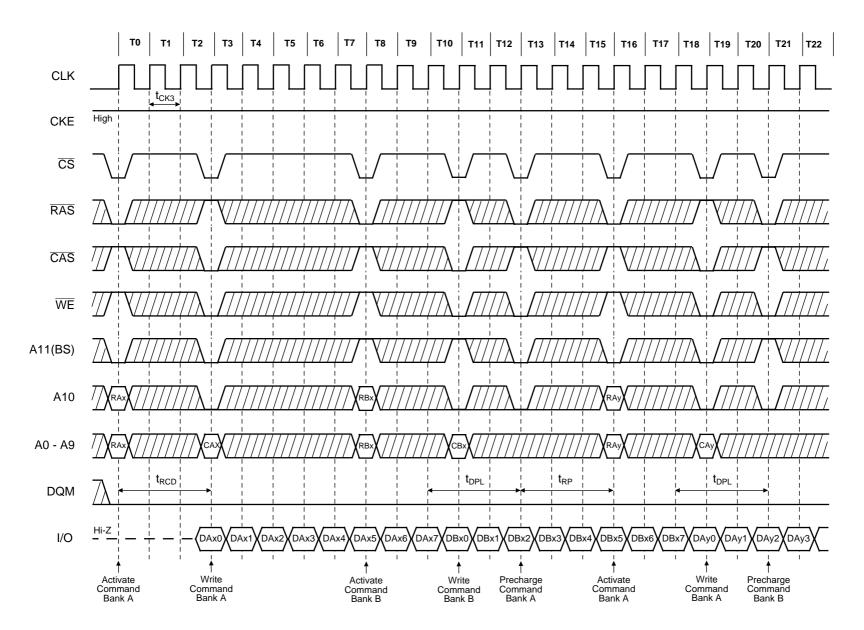


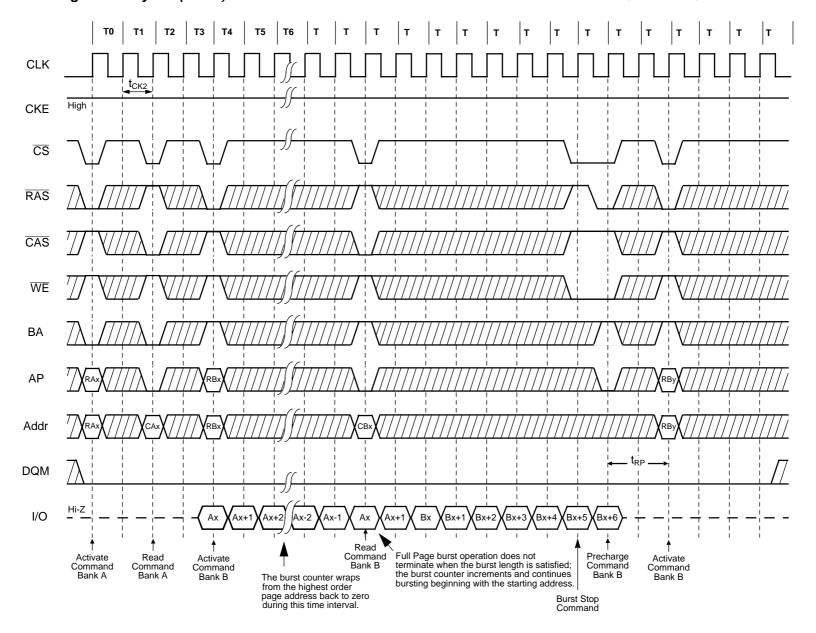


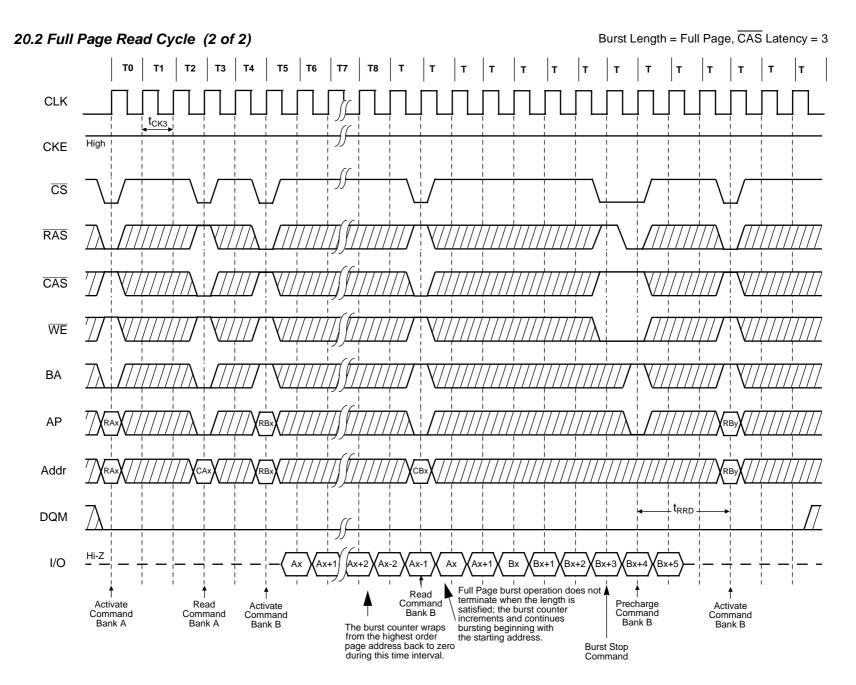


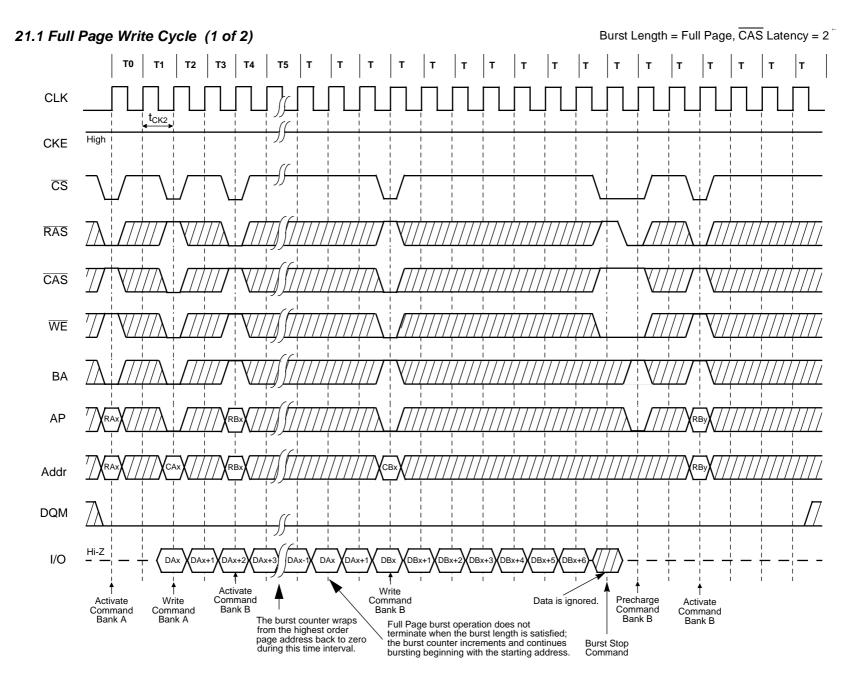


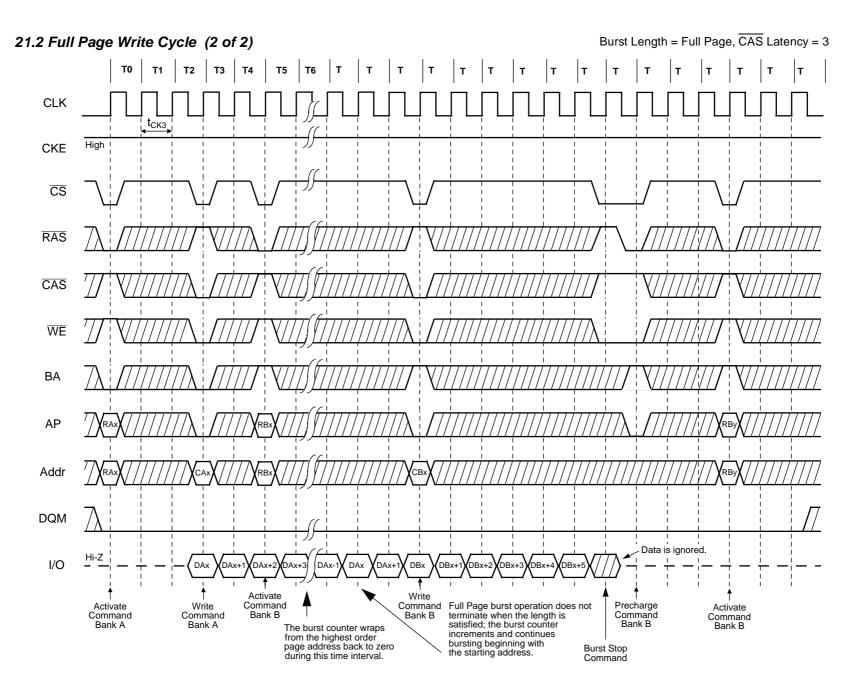






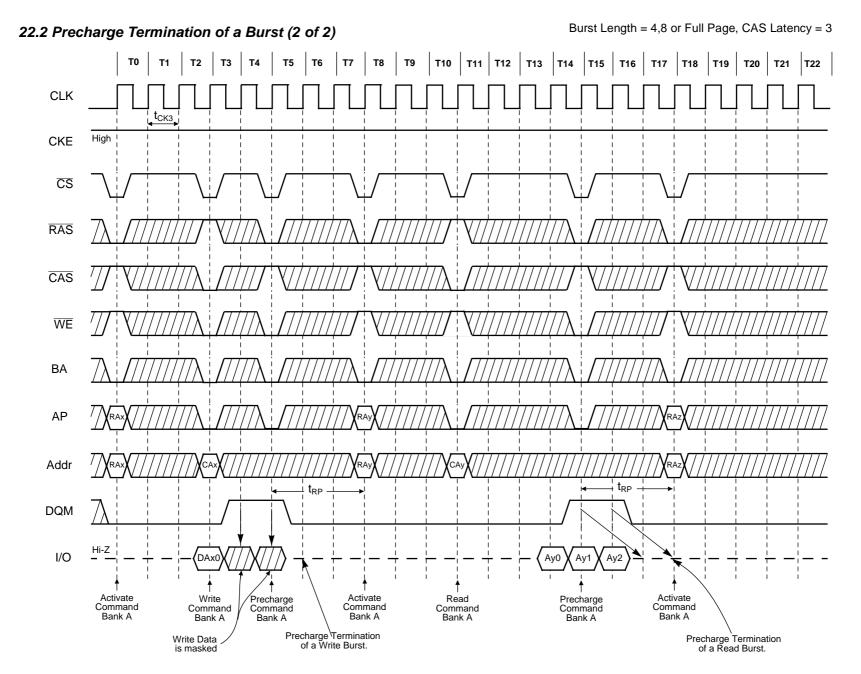






MOSEL

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MOSEL VITELIC

Complete List of Operation Commands

SDRAM Function Truth Table

CURRENT STATE ¹	cs	RAS	CAS	WE	BS	Addr	ACTION
Idle	Н	Х	Х	Х	Х	Х	NOP or Power Down
	L	Н	Н	Н	Х	Х	NOP
	L	Н	Н	L	BS	Х	ILLEGAL ²
	L	Н	L	Х	BS	Χ	ILLEGAL ²
	L	L	Н	Н	BS	RA	Row (&Bank) Active; Latch Row Address
	L	L	Н	L	BS	AP	NOP ⁴
	L	L	L	Н	Х	Х	Auto-Refresh or Self-Refresh ⁵
	L	L	L	L	Ор-	Code	Mode reg. Access ⁵
Row Active	Н	Х	Х	Х	Х	Х	NOP
	L	Н	Н	Х	Х	X	NOP
	L	Н	L	Н	BS	CA,AP	Begin Read; Latch CA; DetermineAP
	L	Н	L	L	BS	CA,AP	Begin Write; Latch CA; DetermineAP
	L	L	Н	Н	BS	X	ILLEGAL ²
	L	L	Н	L	BS	AP	Precharge
	L	L	L	Х	Х	Х	ILLEGAL
Read	Н	Х	Х	X	Х	Х	NOP (Continue Burst to End;>Row Active)
	L	Н	Н	Н	X	X	NOP (Continue Burst to End;>Row Active)
	L	Н	Н	L	BS	X	Burst Stop Command > Row Active
	L	Н	L	Н	BS	CA,AP	Term Burst, New Read, DetermineAP ³
	L	H	L	L	BS	CA,AP	Term Burst, Start Write, DetermineAP ³
	L	L.	H	H	BS	X	ILLEGAL ²
	L	L	H	L	BS	AP	Term Burst, Precharge
	L	L	L	Х	Х	Х	ILLEGAL
Write	Н	Х	Х	Х	Х	Х	NOP (Continue Burst to End;>Row Active)
	L	Н	Н	Н	X	X	NOP (Continue Burst to End;>Row Active)
	L	Н	Н	L	BS	Х	Burst Stop Command > Row Active
	L	H	L	H	BS	CA,AP	Term Burst, Start Read, DetermineAP ³
	L	H	L	L	BS	CA,AP	Term Burst, New Write, DetermineAP ³
	L	L .	H	H	BS	X	ILLEGAL ²
	L	L	H	L	BS	AP	Term Burst, Precharge ³
	L	L	L	Х	Х	Х	ILLEGAL
Read	Н	X	X	X	X	X	NOP (Continue Burst to End;> Precharge)
with	L	H	H	H	X	X	NOP (Continue Burst to End;> Precharge)
Auto	L	H	H	L	BS	X	ILLEGAL ²
Precharge	L	H	L	H	BS	X	ILLEGAL ²
	L	H	L	L	X	X	ILLEGAL 2
	L	L	H	H	BS	X	ILLEGAL ² ILLEGAL ²
	L	L	H	L X	BS X	AP X	ILLEGAL
	L	L	L				ILLEGAL

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SDRAM FUNCTION TRUTH TABLE(continued)

Write H with L Auto L Precharge L L L	X H H	X H	Х			
Auto L Precharge L L L	Н	Н		X	Х	NOP (Continue Burst to End;> Precharge)
Precharge L L L			Н	Х	Χ	NOP (Continue Burst to End;> Precharge)
L L L	н	Н	L	BS	Χ	ILLEGAL ²
L L L		L	н	BS	X	ILLEGAL ²
L	Н	L	L	Χ	Х	ILLEGAL
L	L	Н	Н	BS	X	ILLEGAL ²
	L	Н	L	BS	AP	ILLEGAL ²
L	L	L	X	X	X	ILLEGAL
Precharging H	Х	Х	Х	Х	Х	NOP;> Idle after tRP
L	Н	Н	Н	Χ	Χ	NOP;> Idle after tRP
L	Н	Н	L	BS	Χ	ILLEGAL ²
L	Н	L	Х	BS	Х	ILLEGAL ²
L	L	Н	Н	BS	X	ILLEGAL ²
L	L	Н	L	BS	AP	NOP ⁴
L	L	L	X	X	X	ILLEGAL
Row H	Х	Х	Х	Х	Х	NOP;> Row Active after tRCD
Activating L	Н	Н	Н	Χ	X	NOP;> Row Active after tRCD
L	Н	Н	L	BS	Χ	ILLEGAL ²
L	Н	L	Х	BS	X	ILLEGAL ²
L	L	Н	Н	BS	Χ	ILLEGAL ²
L	L	Н	L	BS	AP	ILLEGAL ²
L	L	L	X	Х	Х	ILLEGAL
Write H	Х	Х	Х	Х	Х	NOP
Recovering L	Н	Н	Н	Χ	Χ	NOP
L	Н	Н	L	BS	Χ	ILLEGAL ²
L	Н	L	Х	BS	Χ	ILLEGAL ²
L	L	Н	Н	BS	Χ	ILLEGAL ²
L	L	Н	L	BS	AP	ILLEGAL ²
L	L	L	X	Х	Х	ILLEGAL
Refreshing H	Х	Х	Х	Х	Х	NOP;> Idle after tRC
L	Н	Н	Н	Χ	Χ	NOP;> Idle after tRC
L	Н	Н	L	Х	Χ	ILLEGAL
L	Н	L	X	Χ	Χ	ILLEGAL
L	L	Н	Х	Х	Χ	ILLEGAL
L	L	L	X	X	X	ILLEGAL
Mode H	Х	Х	Х	Х	Х	NOP
Register L	Н	Н	Н	Х	Χ	NOP
L	Н	Н	L	Χ	Χ	ILLEGAL
Accessing L	Н	L	X	Χ	Χ	ILLEGAL
L	L	Χ	Х	Χ	Χ	ILLEGAL

Clock Enable (CKE) Truth Table:

STATE(n)	CKE n-1	CKE n	cs	RAS	CAS	WE	Addr	ACTION
Self-Refresh ⁶	Н	Х	Х	Х	Х	Х	Х	INVALID
	L	Н	Н	Х	Х	Х	Х	EXIT Self-Refresh, Idle after tRC
	L	Н	L	Н	Н	Н	Х	EXIT Self-Refresh, Idle after tRC
	L	Н	L	Н	Н	L	Х	ILLEGAL
	L	Н	L	Н	L	Х	Х	ILLEGAL
	L	Н	L	L	Х	Х	Х	ILLEGAL
	L	L	Х	Х	Х	Х	Х	NOP (Maintain Self-Refresh)
Power-Down	Н	Х	Х	Х	Х	Х	Х	INVALID
	L	Н	Н	X	Х	Х	Х	EXIT Power-Down, > Idle.
	L	Н	L	Н	Н	Н	Х	EXIT Power-Down, > Idle.
	L	Н	L	Н	Н	L	Х	ILLEGAL
	L	Н	L	Н	L	Х	Х	ILLEGAL
	L	Н	L	L	Х	Х	X	ILLEGAL
	L	L	X	Х	Х	Х	Х	NOP (Maintain Low-Power Mode)
All. Banks	Н	Н	Х	Х	Х	Х	Х	Refer to the function truth table
Idle ⁷	Н	L	Н	Х	Х	Х	Х	Enter Power- Down
	Н	L	L	Н	Н	Н	Х	Enter Power- Down
	Н	L	L	Н	Н	L	X	ILLEGAL
	Н	L	L	Н	L	Х	Х	ILLEGAL
	Н	L	L	L	Н	Х	Х	ILLEGAL
	Н	L	L	L	L	Н	Х	Enter Self-Refresh
	Н	L	L	L	L	L	Х	ILLEGAL
	L	L	Х	Х	Х	Х	Х	NOP
Any State	Н	Н	Х	Х	Х	Х	Х	Refer to the function truth table
other than	Н	L	Х	Х	Х	Х	Х	Begin Clock Suspend next cycle ⁸
listed above	L	Н	X	Х	Х	Х	Х	Exit Clock Suspend next cycle ⁸ .
	L	L	X	Х	Х	Х	Х	Maintain Clock Suspend.

Abbreviations:

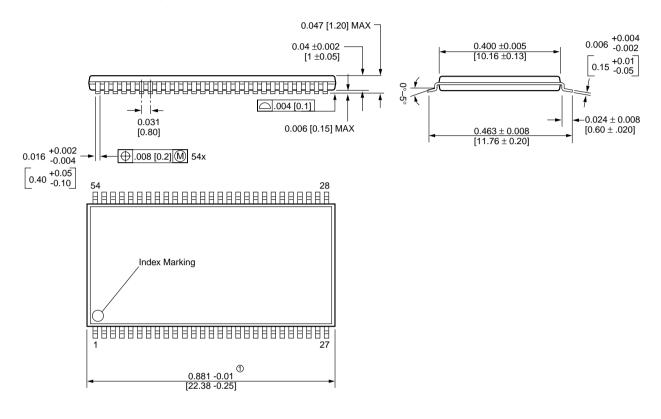
RA = Row Address BS = Bank Address
CA = Column Address AP = Auto Precharge

Notes for SDRAM function truth table:

- 1. Current State is state of the bank determined by BS. All entries assume that CKE was active (HIGH) during the preceding clock cycle.
- 2. Illegal to bank in specified state; Function may be legal in the bank indicated by BS, depending on the state of that bank.
- 3. Must satisfy bus contention, bus turn around, and/or write recovery requirements.
- 4. NOP to bank precharging or in Idle state. May precharge bank(s) indicated by BS (andAP).
- 5. Illegal if any bank is not Idle.
- 6. CKE Low to High transition will re-enable CLK and other inputs asynchronously. A minimum setup time must be satisfied before any command other than EXIT.
- 7. Power-Down and Self-Refresh can be entered only from the All Banks Idle State.
- 8. Must be legal command as defined in the SDRAM function truth table.

Package Diagram

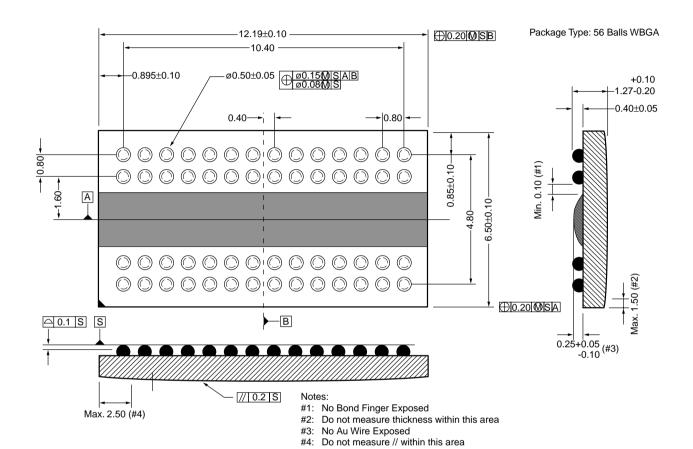
54-Pin Plastic TSOP-II (400 mil)



① Does not include plastic or metal protrusion of 0.15 max. per side

Unit in inches [mm]

56 Ball Grid Array (or BGA)



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