

## 16Mx32 SDRAM

### FEATURES

- 40% Space Savings vs. Monolithic Solution
- Reduced System Inductance and Capacitance
- 3.3V Operating Supply Voltage
- Fully Synchronous to Positive Clock Edge
- Clock Frequencies of 100MHz - 133MHz
- Burst Operation
  - Sequential or Interleave
  - Burst Length = Programmable 1, 2, 4, 8 or Full Page
  - Burst Read and Write
  - Multiple Burst Read and Single Write
- Data Mask Control Per Byte
- Auto and Self Refresh
- Automatic and Controlled Precharge Commands
- Suspend Mode and Power Down Mode
- 119 Pin BGA, 17mm x 23mm

### DESCRIPTION

The WED3DL3216V is an 16Mx32 Synchronous DRAM configured as 4x4Mx32. The SDRAM BGA is constructed with two 16Mx16 SDRAM die mounted on a multi-layer laminate substrate and packaged in a 119 lead, 17mm by 23mm, BGA.

The WED3DL3216V is available in clock speeds of 133MHz, 125MHz, and 100MHz. The range of operating frequencies, programmable burst lengths and programmable latencies allow the same device to be useful for a variety of high bandwidth, high performance memory system applications.

The package and design provides performance enhancements via a 50% reduction in capacitance vs. two monolithic devices. The design includes internal ground and power planes which reduces inductance on the ground and power pins allowing for improved decoupling and a reduction in system noise.

### PIN CONFIGURATION (Top view)

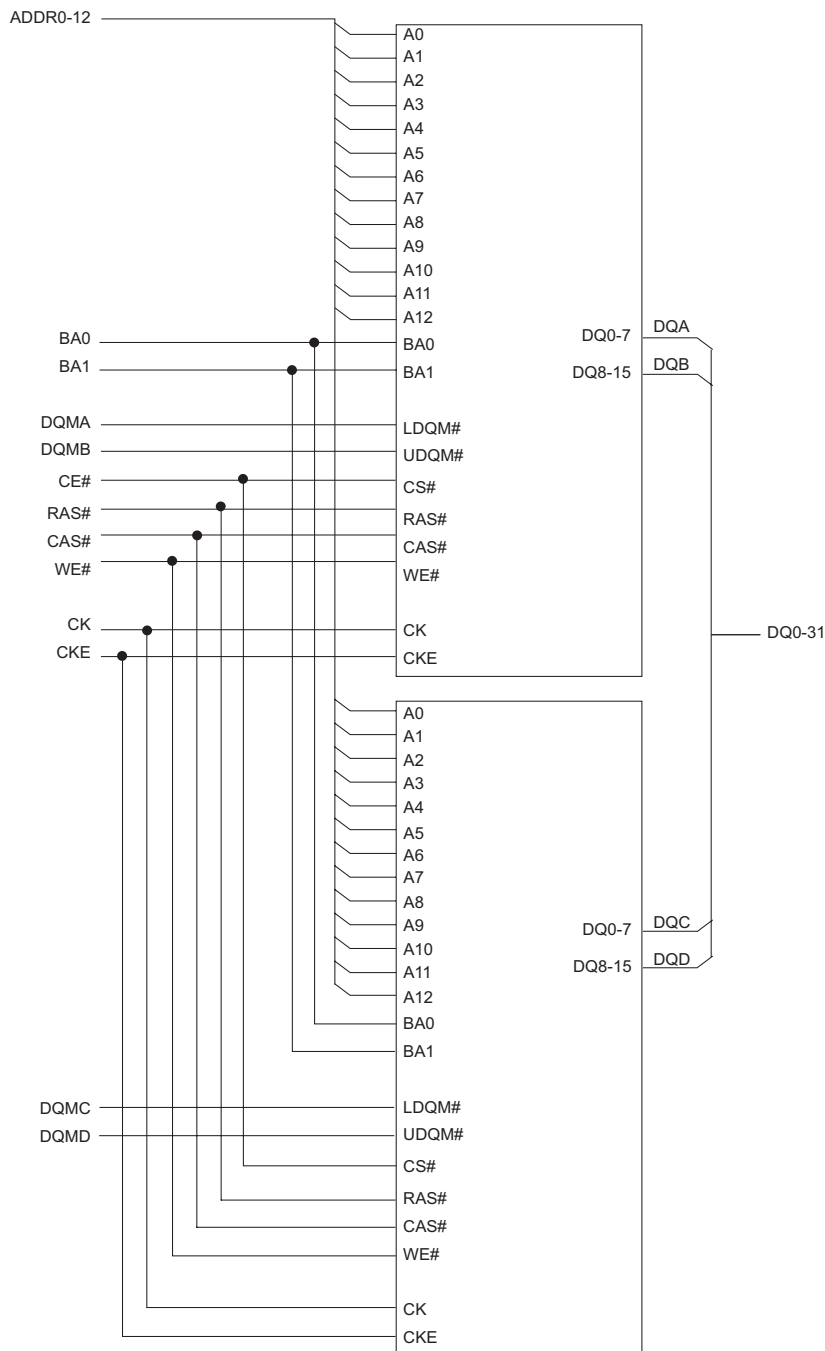
	1	2	3	4	5	6	7	
A	V <sub>CCQ</sub>	NC	BA0	NC	A10	A7	V <sub>CCQ</sub>	A
B	NC	NC	A12	CAS#	A11	NC	NC	B
C	NC	NC	BA1	V <sub>CC</sub>	A9	A8	NC	C
D	DQC	NC	V <sub>SS</sub>	NC	V <sub>SS</sub>	NC	DQB	D
E	DQC	DQC	V <sub>SS</sub>	CE#	V <sub>SS</sub>	DQB	DQB	E
F	V <sub>CCQ</sub>	DQC	V <sub>SS</sub>	RAS#	V <sub>SS</sub>	DQB	V <sub>CCQ</sub>	F
G	DQC	DQC	DQMC	NC	DQMB	DQB	DQB	G
H	DQC	DQC	V <sub>SS</sub>	CKE	V <sub>SS</sub>	DQB	DQB	H
J	V <sub>CCQ</sub>	V <sub>CC</sub>	NC	V <sub>CC</sub>	NC	V <sub>CC</sub>	V <sub>CCQ</sub>	J
K	DQD	DQD	V <sub>SS</sub>	CK	V <sub>SS</sub>	DQA	DQA	K
L	DQD	DQD	DQMD	NC	DQMA	DQA	DQA	L
M	V <sub>CCQ</sub>	DQD	V <sub>SS</sub>	WE#	V <sub>SS</sub>	DQA	V <sub>CCQ</sub>	M
N	DQD	DQD	V <sub>SS</sub>	A1	V <sub>SS</sub>	DQA	DQA	N
P	DQD	NC	V <sub>SS</sub>	A0	V <sub>SS</sub>	NC	DQA	P
R	NC	A6	NC	V <sub>CC</sub>	NC	A2	NC	R
T	NC	NC	A5	A4	A3	NC	NC	T
U	V <sub>CCQ</sub>	NC	NC	NC	NC	NC	V <sub>CCQ</sub>	U
	1	2	3	4	5	6	7	

### PIN DESCRIPTION

A0 – A12	Address Bus
BA0-1	Bank Select Addresses
DQ	Data Bus
CK	Clock
CKE	Clock Enable
DQM	Data Input/Output Mask
RAS#	Row Address Strobe
CAS#	Column Address Strobe
CE#	Chip Enable
V <sub>CC</sub>	Power Supply pins, 3.3V
V <sub>CCQ</sub>	Data Bus Power Supply pins, 3.3V
V <sub>SS</sub>	Ground pins



16MX32 SDRAM BLOCK DIAGRAM





**INPUT/OUTPUT FUNCTIONAL DESCRIPTION**

Symbol	Type	Signal	Polarity	Function
CK	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 CK signal when high and deactivates the CK signal when low. By deactivating the clock, CKE low initiates the Power Down mode, Suspend mode, or the Self Refresh mode
CE#	Input	Pulse	Active Low	CE# disable or enable device operation by masking or enabling all inputs except CK, CKE and DQM.
RAS#, CAS#, WE#	Input	Pulse	Active Low	When sampled at the positive rising edge of the clock, CAS#, RAS# and WE# define the operation to be executed by the SDRAM
BA0, BA1	Input	Level	-	Selects which SDRAM bank is to be active.
A0-12	Input	Level	-	During a Bank Activate command cycle, A0-12 defines the row address (RA0-12) when sampled at the rising clock edge.
				During a Read or Write command cycle, A0-9 defines the column address (CA0-9) when sampled at the rising edge of the clock. In addition to the row address, A10/AP is used to invoke Autoprecharge operation at the end of the Burst Read or Write cycle. If A10/AP is high, autoprecharge is selected and BA0, BA1 defines the bank to be precharged. If A10/AP is low, autoprecharge is disabled.
				During a Precharge command cycle, A10/AP is used in conjunction with BA0, BA1 to control which bank(s) to precharge. If A10/AP is high, all banks will be precharged regardless of the state of BA0, BA1. If A10/AP is low, than BA0, BA1 is used to define which bank to precharge.
DQ	Input/Output	Level	-	Data Input/Output are multiplexed on the same pins

**ABSOLUTE MAXIMUM RATINGS\***

Parameter	Symbol	Min	Max	Units
Power Supply Voltage	V <sub>CC</sub> /V <sub>CCQ</sub>	-1.0	+4.6	V
Input Voltage	V <sub>IN</sub>	-1.0	+4.6	V
Output Voltage	V <sub>OUT</sub>	-1.0	+4.6	V
Operating Temperature	T <sub>OPR</sub>	-0	+70	°C
Storage Temperature	T <sub>TSG</sub>	-55	+125	°C
Power Dissipation	P <sub>D</sub>	—	1.5	W
Short Circuit Output Current	I <sub>OS</sub>	—	50	mA

\* Stress 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 greater than those indicated in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect reliability.



**RECOMMENDED DC OPERATING CONDITIONS**

(VOLTAGE REFERENCED TO:  $V_{SS} = 0V$ ,  $0^{\circ}C \leq T_A \leq 70^{\circ}C$ ; COMMERCIAL OR  $T_A = -40^{\circ}C$  TO  $+85^{\circ}C$ ; INDUSTRIAL)

Parameter	Symbol	Min	Typ	Max	Unit
Supply Voltage	$V_{CC}/V_{CCQ}$	3.0	3.3	3.6	V
Input High Voltage	$V_{IH}$	2.0	3.0	$V_{CC} + 0.3$	V
Input Low Voltage	$V_{IL}$	-0.3	—	0.8	V
Output High Voltage ( $I_{OH} = -2mA$ )	$V_{OH}$	2.4	—	—	V
Output Low Voltage ( $I_{OL} = 2mA$ )	$V_{OL}$	—	—	0.4	V
Input Leakage Voltage	$I_{IL}$	-5	—	5	$\mu A$
Output Leakage Voltage	$I_{OL}$	-5	—	5	$\mu A$

**CAPACITANCE**

( $T_A = 25^{\circ}C$ ,  $f = 1MHz$ ,  $V_{CC} = 3.3V$ )

Parameter	Symbol	Max	Unit
Input Capacitance	$C_{I1}$	4	pF
Input/Output Capacitance (DQ)	$C_{OUT}$	5	pF

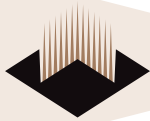
**OPERATING CURRENT CHARACTERISTICS**

( $V_{CC} = 3.3V$ ,  $T_A = 0^{\circ}C$  TO  $70^{\circ}C$ ; COMMERCIAL OR  $T_A = -40^{\circ}C$  TO  $+85^{\circ}C$ ; INDUSTRIAL)

Parameter	Symbol	Conditions	-7	-8	-10	Units
Operating Current (One Bank Active) <sup>1</sup>	$I_{CC1}$	Burst Length = 1, $t_{RC} \geq t_{RC}(min)$ , $I_{OL} = 0mA$	300	280	260	mA
Operating Current (Burst Mode) <sup>1</sup>	$I_{CC4}$	Page Burst, 4 banks active, $t_{CCD} = 2$ clocks	300	280	260	mA
Precharge Standby Current in Power Down Mode	$I_{CC2P}$	$CKE \leq V_{IL}(max)$ , $t_{CC} = 15ns$	2	2	2	mA
	$I_{CC2PS}$	$CKE, CK \leq V_{IL}(max)$ , $t_{CC} = \infty$ , Inputs Stable	2	2	2	mA
Precharge Standby Current in Non-Power Down Mode	$I_{CC1N}$	$CKE = V_{IH}$ , $t_{CC} = 15ns$ Input Change one time every 30ns	140	140	140	mA
	$I_{CC1NS}$	$CKE \geq V_{IH}(min)$ , $t_{CC} = \infty$ No Input Change	70	70	70	mA
Precharge Standby Current in Power Down Mode	$I_{CC3P}$	$CKE \leq V_{IL}(max)$ , $t_{CC} = 15ns$	12	12	12	mA
	$I_{CC3PS}$	$CKE \leq V_{IL}(max)$ , $t_{CC} = \infty$	12	12	12	mA
Active Standby Current in Non-Power Down Mode (One Bank Active)	$I_{CC3N}$	$CKE = V_{IH}$ , $t_{CC} = 15ns$ Input Change one time every 30ns	60	60	60	mA
	$I_{CC3NS}$	$CKE \geq V_{IH}(min)$ , $t_{CC} = \infty$ , No Input Change	50	50	50	mA
Refresh Current <sup>2</sup>	$I_{CC5}$	$t_{RC} \geq t_{RC}(min)$	600	570	550	mA
Self Refresh Current	$I_{CC6}$	$CKE \leq 0.2V$	6.5	6.5	6.5	mA

**NOTES:**

1. Measured with outputs open.
2. Refresh period is 64ms.



**SDRAM AC CHARACTERISTICS**

Parameter	Symbol	133MHz		125MHz		100MHz		Units	
		Min	Max	Min	Max	Min	Max		
	CL = 3	t <sub>CC</sub>	7	1000	8	1000	10	1000	ns
	CL = 2	t <sub>CC</sub>	7.5	1000	10	1000	12	1000	
Clock to valid Output delay <sup>1,2</sup>		t <sub>SAC</sub>		5.4		6		7	ns
Output Data Hold Time <sup>2</sup>		t <sub>OH</sub>	3		3		3		ns
Clock HIGH Pulse Width <sup>3</sup>		t <sub>CH</sub>	2.5		3		3		ns
Clock LOW Pulse Width <sup>3</sup>		t <sub>CL</sub>	2.5		3		3		ns
Input Setup Time <sup>3</sup>		t <sub>SS</sub>	1.5		2		2		ns
Input Hold Time <sup>3</sup>		t <sub>SH</sub>	0.8		1		1		ns
CK to Output Low-Z <sup>2</sup>		t <sub>SLZ</sub>	2		2		2		ns
CK to Output High-Z		t <sub>SHZ</sub>		5.4		6		7	ns
Row Active to Row Active Delay <sup>4</sup>		t <sub>RRD</sub>	24		20		20		ns
RAS to CAS Delay <sup>4</sup>		t <sub>RCD</sub>	24		20		20		ns
Row Precharge Time <sup>4</sup>		t <sub>RP</sub>	24		20		20		ns
Row Active Time <sup>4</sup>		t <sub>RAS</sub>	60	10,000	50	10,000	50	10,000	ns
Row Cycle Time - Operation <sup>4</sup>		t <sub>RC</sub>	90		70		80		ns
Row Cycle Time - Auto Refresh <sup>4,8</sup>		t <sub>RFC</sub>	90		70		80		ns
Last Data in to New Column Address Delay <sup>5</sup>		t <sub>CDL</sub>	1		1		1		CK
Last Data in to Row Precharge <sup>5</sup>		t <sub>RDL</sub>	1		1		1		CK
Last Data in to Burst Stop <sup>5</sup>		t <sub>BDL</sub>	1		1		1		CK
Column Address to Column Address Delay <sup>6</sup>		t <sub>CCD</sub>	1.5		1.5		1.5		CK
Number of Valid OutputData <sup>7</sup>			2		2		2		ea
			1		1		2		

**NOTES:**

- Parameters depend on programmed CAS latency.
- If clock rise time is longer than 1ns (t<sub>RISE</sub>/2 - 0.5)ns should be added to the parameter.
- Assumed input rise and fall time = 1ns. If t<sub>RISE</sub> or t<sub>FALL</sub> are longer than 1ns, [(t<sub>RISE</sub> + t<sub>FALL</sub>)/2] - 1ns should be added to the parameter.
- The minimum number of clock cycles required is determined by dividing the minimum time required by the clock cycle time and then rounding up to the next higher integer.
- Minimum delay is required to complete write.
- All devices allow every cycle column address changes.
- In case of row precharge interrupt, auto precharge and read burst stop.



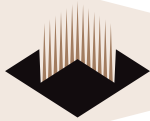
**COMMAND TRUTH TABLE**

Function	CKE		CE#	RAS#	CAS#	WE#	DQM	BA	A0-A10	A12, A11,	Notes
	Previous Cycle	Current Cycle									
Register Mode Register Set	H	X	L	L	L	L	X	OP CODE			
Refresh Auto Refresh (CBR)	H	H	L	L	L	H	X	X	X	X	
Entry Self Refresh	H	L	L	L	L	H	X	X	X	X	
Precharge Single Bank Precharge	H	X	L	L	H	L	X	BA	L	X	2
Precharge all Banks	H	X	L	L	H	L	X	X	H	X	
Bank Activate	H	X	L	L	H	H	X	BA	Row Address		2
Write	H	X	L	H	L	L	X	BA	L	Column	2
Write with Auto Precharge	H	X	L	H	L	L	X	BA	H	Column	2
Read	H	X	L	H	L	L	X	BA	L	Column	2
Read with Auto Precharge	H	X	L	H	L	H	X	BA	H	Column	2
Burst Termination	H	X	L	H	H	L	X	X	X	X	3
No Operation	H	X	L	H	H	H	X	X	X	X	
Device Deselect	H	X	H	X	X	X	X	X	X	X	
Clock Suspend/Standby Mode	L	X	X	X	X	X	X	X	X	X	4
Data Write/Output Disable	H	X	X	X	X	X	L	X	X	X	5
Data Mask/Output Disable	H	X	X	X	X	X	H	X	X	X	5
Power Down Mode	Entry	X	L	H	X	X	X	X	X	X	6
	Exit	X	H	H	X	X	X	X	X	X	6

**NOTES:**

- All of the SDRAM operations are defined by states of CE#, WE#, RAS#, CAS#, and DQM at the positive rising edge of the clock.
- Bank Select (BA), if BA = 0 then bank A is selected, if BA = 1 then bank B is selected.
- During a Burst Write cycle there is a zero clock delay, for a Burst Read cycle the delay is equal to the CAS latency.
- During normal access mode, CKE is held high and CK is enabled. When it is low, it freezes the internal clock and extends data Read and Write operations. One clock delay is required for mode entry and exit.
- The DQM has two functions for the data DQ Read and Write operations. During a Read cycle, when DQM goes high at a clock timing the data outputs are disabled and become high impedance after a two clock delay. DQM also provides a data mask function for Write cycles. When it activates, the Write operation at the clock is prohibited (zero clock latency).

All banks must be precharged before entering the Power Down Mode. The Power Down Mode does not perform any Refresh operations, therefore the device can't remain in this mode longer than the Refresh period ( $t_{REF}$ ) of the device. One clock delay is required for mode entry and exit.

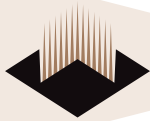


**CLOCK ENABLE (CKE0) TRUTH TABLE**

Current State	CKE		Command						Action	Notes
	Previous Cycle	Current Cycle	CE#	RAS#	CAS#	WE#	BA0-1	A10-11		
Self Refresh	H	X	X	X	X	X	X	X	INVALID	1
	L	H	H	X	X	X	X	X	Exit Self Refresh with Device Deselect	2
	L	H	L	H	H	H	X	X	Exit Self Refresh with No Operation	
	L	H	L	H	H	L	X	X	ILLEGAL	
	L	H	L	L	X	X	X	X	ILLEGAL	
	L	L	X	X	X	X	X	X	Maintain Self Refresh	
Power Down	H	X	X	X	X	X	X	X	INVALID	1
	L	H	H	X	X	X	X	X	Power Down Mode exit, all banks idle	2
	L	H	L	X	X	X	X	X	ILLEGAL	2
	H	X	L	H	L	L	X		Maintain Power Down Mode	2
All Banks Idle	H	H	H	X	X	X			Refer to the Idle State section of the Current State Truth Table	3
	H	H	L	H	X	X				
	H	H	L	L	H	X				
	H	H	L	L	L	H	X	X	CBR Refresh	
	H	H	L	L	L	L	OP Code		Mode Register Set	4
	H	L	H	X	X	X			Refer to the Idle State section of the Current State Truth Table	3
	H	L	L	H	X	X				
	H	L	L	L	H	X			Entry Self Refresh	4
	H	L	L	L	L	H	X	X		
	H	H	L	L	L	L	OP Code		Mode Register Set	
L	X	X	X	X	X	X	X	Power Down	4	
Any State other than listed above	H	H	X	X	X	X	X	X	Refer to the Operations in the Current State Truth Table	
	H	L	X	X	X	X	X	X	Begin Clock Suspend next cycle	5
	L	H	X	X	X	X	X	X	Exit Clock Suspend next cycle	
	L	L	X	X	X	X	X	X	Maintain Clock Suspend	

**NOTES:**

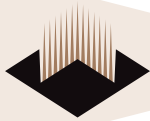
1. For the given Current State CKE must be low in the previous cycle.
2. When CKE has a low to high transition, the clock and other inputs are re-enabled asynchronously. The minimum setup time for CKE ( $t_{CKS}$ ) must be satisfied before any command other than Exit is issued.
3. The address inputs (A12-0) depend on the command that is issued. See the Idle State section of the Current State Truth Table for more information.
4. The Power Down Mode, Self Refresh Mode, and the Mode Register Set can only be entered from the all banks idle state.
5. Must be a legal command as defined in the Current State Truth Table.



**CURRENT STATE TRUTH TABLE**

Current State	Command						Action	Notes	
	CE#	RAS#	CAS#	WE#	BA <sub>0-1</sub>	A <sub>0-A12</sub>	Description		
Idle	L	L	L	L	OP Code		Mode Register Set	Set the Mode Register	2
	L	L	L	H	X	X	Auto or Self Refresh	Start Auto or Self Refresh	2,3
	L	L	H	L	X	X	Precharge	No Operation	
	L	L	H	H	BA	Row Address	Bank Activate	Activate the specified bank and row	
	L	H	L	L	BA	Column	Write w/o Precharge	ILLEGAL	4
	L	H	L	H	BA	Column	Read w/o Precharge	ILLEGAL	2
	L	H	H	L	X	X	Burst Termination	No Operation	
	L	H	H	H	X	X	No Operation	No Operation	
Row Active	H	X	X	X	X	X	Device Deselect	No Operation or Power Down	5
	L	L	L	L	OP Code		Mode Register Set	ILLEGAL	
	L	L	L	H	X	X	Auto or Self Refresh	ILLEGAL	
	L	L	H	L	X	X	Precharge	Precharge	6
	L	L	H	H	BA	Row Address	Bank Activate	ILLEGAL	2
	L	H	L	L	BA	Column	Write	Start Write; Determine if Auto Precharge	7,8
	L	H	L	H	BA	Column	Read	Start Read; Determine if Auto Precharge	
	L	H	H	L	X	X	Burst Termination	No Operation	
L	H	H	H	X	X	No Operation	No Operation		
Read	H	X	X	X	X	X	Device Deselect	No Operation	
	L	L	L	L	OP Code		Mode Register Set	ILLEGAL	
	L	L	L	H	X	X	Auto or Self Refresh	ILLEGAL	
	L	L	H	L	X	X	Precharge	Terminate Burst; Start the Precharge	
	L	L	H	H	BA	Row Address	Bank Activate	ILLEGAL	4
	L	H	L	L	BA	Column	Write	Terminate Burst; Start the Write cycle	8,9
	L	H	L	H	BA	Column	Read	Terminate Burst; Start a new Read cycle	
	L	H	H	L	X	X	Burst Termination	Terminate the Burst	
L	H	H	H	X	X	No Operation	Continue the Burst		
Write	H	X	X	X	X	X	Device Deselect	Continue the Burst	
	L	L	L	L	OP Code		Mode Register Set	ILLEGAL	
	L	L	L	H	X	X	Auto or Self Refresh	ILLEGAL	
	L	L	H	L	X	X	Precharge	Terminate Burst; Start the Precharge	
	L	L	H	H	BA	Row Address	Bank Activate	ILLEGAL	4
	L	H	L	L	BA	Column	Write	Terminate Burst; Start a new Write cycle	8,9
	L	H	L	H	BA	Column	Read	Terminate Burst; Start the Read cycle	
	L	H	H	L	X	X	Burst Termination	Terminate the Burst	
L	H	H	H	X	X	No Operation	Continue the Burst		
Read with Auto Precharge	H	X	X	X	X	X	Device Deselect	Continue the Burst	
	L	L	L	L	OP Code		Mode Register Set	ILLEGAL	
	L	L	L	H	X	X	Auto or Self Refresh	ILLEGAL	
	L	L	H	L	X	X	Precharge	ILLEGAL	4
	L	L	H	H	BA	Row Address	Bank Activate	ILLEGAL	
	L	H	L	L	BA	Column	Write	ILLEGAL	
	L	H	L	H	BA	Column	Read	ILLEGAL	
	L	H	H	L	X	X	Burst Termination	ILLEGAL	
L	H	H	H	X	X	No Operation	Continue the Burst		
H	X	X	X	X	X	Device Deselect	Continue the Burst		





**CURRENT STATE TRUTH TABLE (cont.)**

Current State	Command						Action	Notes	
	CE#	RAS#	CAS#	WE#	BA0-1	A0-A12	Description		
Write with Auto Precharge	L	L	L	L		OP Code	Mode Register Set	ILLEGAL	
	L	L	L	H	X	X	Auto orSelf Refresh	ILLEGAL	
	L	L	H	L	X	X	Precharge	ILLEGAL	4
	L	L	H	H	BA	Row Address	Bank Activate	ILLEGAL	
	L	H	L	L	BA	Column	Write	ILLEGAL	
	L	H	L	H	BA	Column	Read	ILLEGAL	
	L	H	H	L	X	X	Burst Termination	ILLEGAL	
	L	H	H	H	X	X	No Operation	Continue the Burst	
Precharging	H	X	X	X	X	X	Device Deselect	Continue the Burst	
	L	L	L	L		OP Code	Mode Register Set	ILLEGAL	
	L	L	L	H	X	X	Auto orSelf Refresh	ILLEGAL	
	L	L	H	L	X	X	Precharge	No Operation; Bank(s) idle after tRP	
	L	L	H	H	BA	Row Address	Bank Activate	ILLEGAL	
	L	H	L	L	BA	Column	Write w/o Precharge	ILLEGAL	4
	L	H	L	H	BA	Column	Read w/o Precharge	ILLEGAL	
	L	H	H	L	X	X	Burst Termination	No Operation; Bank(s) idle after tRP	
Row Activating	L	H	H	H	X	X	No Operation	No Operation; Bank(s) idle after tRP	
	H	X	X	X	X	X	Device Deselect	No Operation; Bank(s) idle after tRP	
	L	L	L	L		OP Code	Mode Register Set	ILLEGAL	
	L	L	L	H	X	X	Auto orSelf Refresh	ILLEGAL	
	L	L	H	L	X	X	Precharge	ILLEGAL	4
	L	L	H	H	BA	Row Address	Bank Activate	ILLEGAL	4,10
	L	H	L	L	BA	Column	Write	ILLEGAL	4
	L	H	L	H	BA	Column	Read	ILLEGAL	
Write Recovering	L	H	H	L	X	X	Burst Termination	No Operation; Row active after tRCD	
	L	H	H	H	X	X	No Operation	No Operation; Row active after tRCD	
	H	X	X	X	X	X	Device Deselect	No Operation; Row active after tRCD	
	L	L	L	L		OP Code	Mode Register Set	ILLEGAL	
	L	L	L	H	X	X	Auto orSelf Refresh	ILLEGAL	
	L	L	H	L	X	X	Precharge	ILLEGAL	4
	L	L	H	H	BA	Row Address	Bank Activate	ILLEGAL	
	L	H	L	L	BA	Column	Write	Start Write; Determine if Auto Precharge	9
Write ecovering with Auto Precharge	L	H	L	H	BA	Column	Read	Start Read; Determine if Auto Precharge	
	L	H	H	L	X	X	Burst Termination	No Operation; Row active after tDPL	
	L	H	H	H	X	X	No Operation	No Operation; Row active after tDPL	
	H	X	X	X	X	X	Device Deselect	No Operation; Row active after tDPL	
	L	L	L	L		OP Code	Mode Register Set	ILLEGAL	
	L	L	L	H	X	X	Auto orSelf Refresh	ILLEGAL	
	L	L	H	L	X	X	Precharge	ILLEGAL	4
	L	L	H	H	BA	Row Address	Bank Activate	ILLEGAL	
Write ecovering with Auto Precharge	L	H	L	L	BA	Column	Write	ILLEGAL	4,9
	L	H	L	H	BA	Column	Read	ILLEGAL	
	L	H	H	L	X	X	Burst Termination	No Operation; Precharge after tDPL	
	L	H	H	H	X	X	No Operation	No Operation; Precharge after tDPL	
	H	X	X	X	X	X	Device Deselect	No Operation; Precharge after tDPL	



CURRENT STATE TRUTH TABLE (cont.)

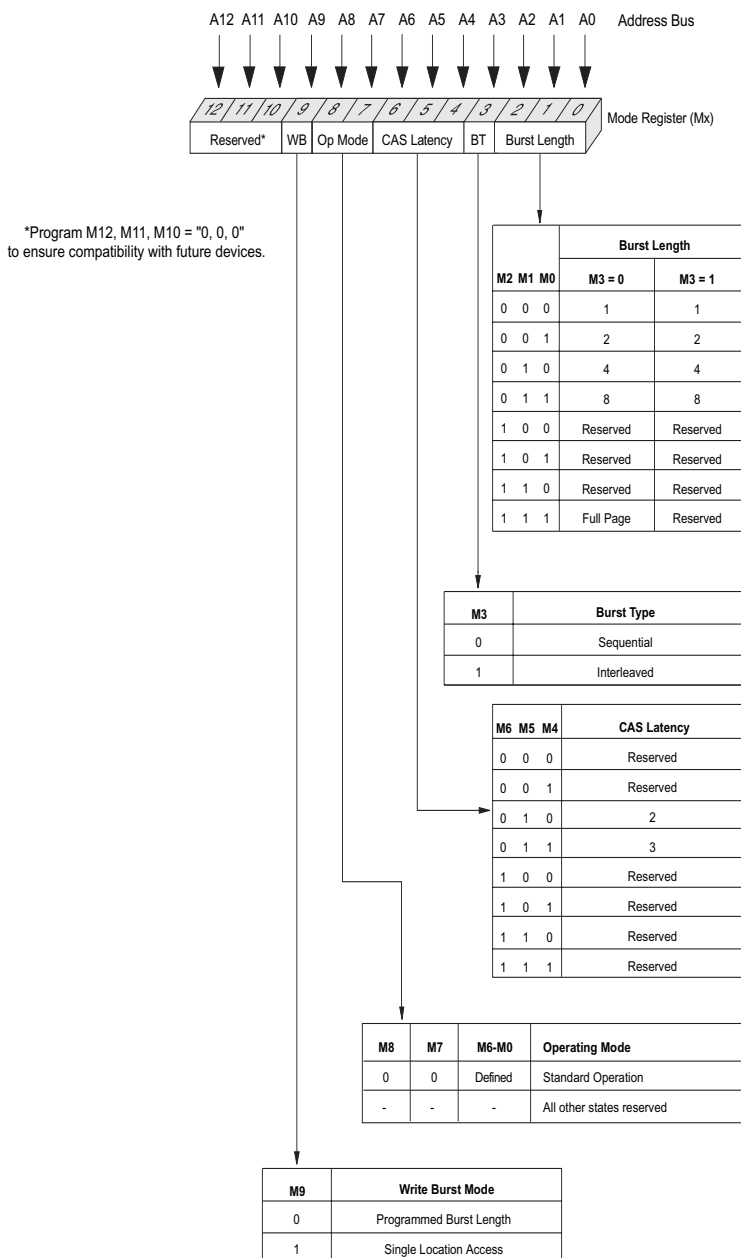
Current State	Command						Action	Notes
	CE#	RAS#	CAS#	WE#	BA0-1	A0-A12	Description	
Refreshing	L	L	L	L	OP Code		Mode Register Set	ILLEGAL
	L	L	L	H	X	X	Auto or Self Refresh	ILLEGAL
	L	L	H	L	X	X	Precharge	ILLEGAL
	L	L	H	H	BA	Row Address	Bank Activate	ILLEGAL
	L	H	L	L	BA	Column	Write	ILLEGAL
	L	H	L	H	BA	Column	Read	ILLEGAL
	L	H	H	L	X	X	Burst Termination	No Operation; Idle after trc
	L	H	H	H	X	X	No Operation	No Operation; Idle after trc
	H	X	X	X	X	X	Device Deselect	No Operation; Idle after trc
Mode Register Accessing	L	L	L	L	OP Code		Mode Register Set	ILLEGAL
	L	L	L	H	X	X	Auto or Self Refresh	ILLEGAL
	L	L	H	L	X	X	Precharge	ILLEGAL
	L	L	H	H	BA	Row Address	Bank Activate	ILLEGAL
	L	H	L	L	BA	Column	Write	ILLEGAL
	L	H	L	H	BA	Column	Read	ILLEGAL
	L	H	H	L	X	X	Burst Termination	ILLEGAL
	L	H	H	H	X	X	No Operation	No Operation; Idle after two clock cycles
	H	X	X	X	X	X	Device Deselect	No Operation; Idle after two clock cycles

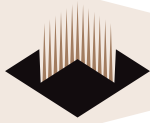
NOTES:

1. CKE is assumed to be active (high) in the previous cycle for all entries. The Current State is the state of the bank that the command is being applied to.
2. Both Banks must be idle otherwise it is an illegal action.
3. If CKE is active (high) the SDRAM starts the Auto (CBR) Refresh operation, if CKE is inactive (low) then the Self Refresh mode is entered.
4. The Current State refers only refers to one of the banks, if BA selects this bank then the action is illegal. If BA selects the bank not being referenced by the Current State then the action may be legal depending on the state of that bank.
5. If CKE is inactive (low) then the Power Down mode is entered, otherwise there is a No Operation.
6. The minimum and maximum Active time ( $t_{RAS}$ ) must be satisfied.
7. The RAS# to CAS# Delay ( $t_{RCD}$ ) must occur before the command is given.
8. Address A10 is used to determine if the Auto Precharge function is activated.
9. The command must satisfy any bus contention, bus turn around, and/or write recovery requirements.
10. The command is illegal if the minimum bank to bank delay time ( $t_{RRD}$ ) is not satisfied.

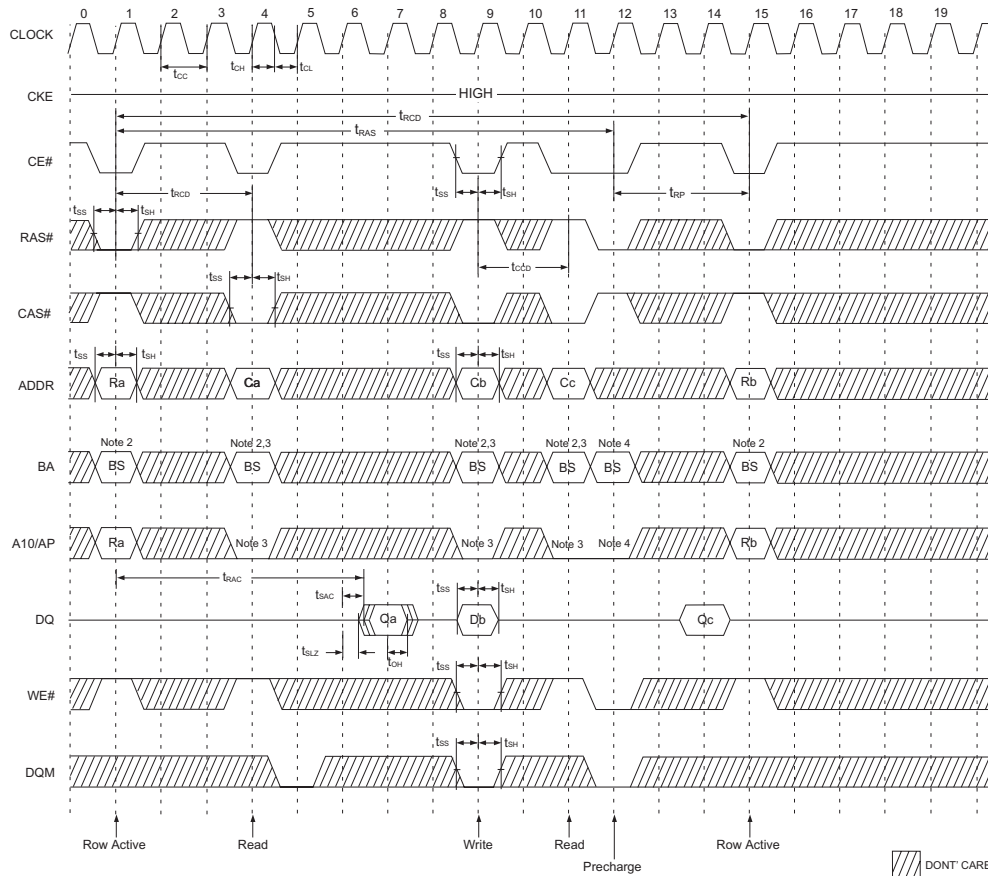


MODE REGISTER DEFINITION





**SINGLE BIT READ-WRITE CYCLE (SAME PAGE) @CAS LATENCY=3, BURST LENGTH=1**



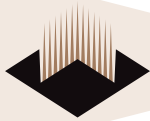
**NOTES:**

- All input except CKE & DQM can be don't care when CE is high at the CK high going edge.
- Bank active & read/write are controlled by BA<sub>0</sub>-BA<sub>1</sub>.
- Enable and disable auto precharge function are controlled by A10/AP in read/write command.
- A10/AP and BA<sub>0</sub>-BA<sub>1</sub> control bank precharge when precharge command is asserted.

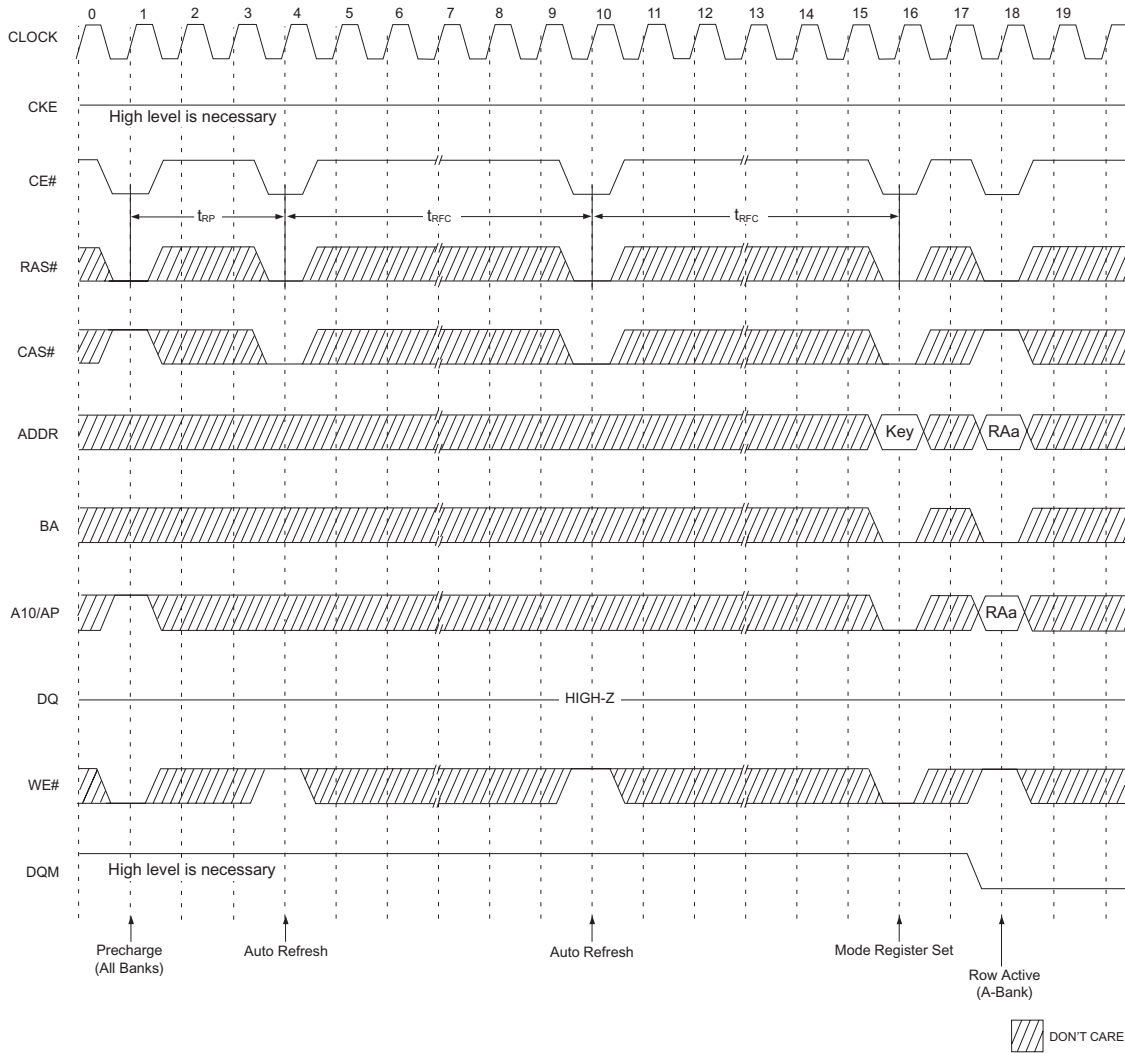
BA0	BA1	Active & Read/Write
0	0	Bank A
0	1	Bank B
1	0	Bank C
1	1	Bank D

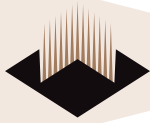
A10/AP	BA0	BA1	Precharge
0	0	0	Bank A
0	0	1	Bank B
0	1	0	Bank C
0	1	1	Bank D
1	x	x	All Banks

A10/AP	BA <sub>0</sub>	BA <sub>1</sub>	Operation
0	0	0	Disable auto precharge, leave bank A active at end of burst.
	0	1	Disable auto precharge, leave bank B active at end of burst.
	1	0	Disable auto precharge, leave bank C active at end of burst.
	1	1	Disable auto precharge, leave bank D active at end of burst.
1	0	0	Enable auto precharge, precharge bank A at end of burst.
	0	1	Enable auto precharge, precharge bank B at end of burst.
	1	0	Enable auto precharge, precharge bank C at end of burst.
	1	1	Enable auto precharge, precharge bank D at end of burst.

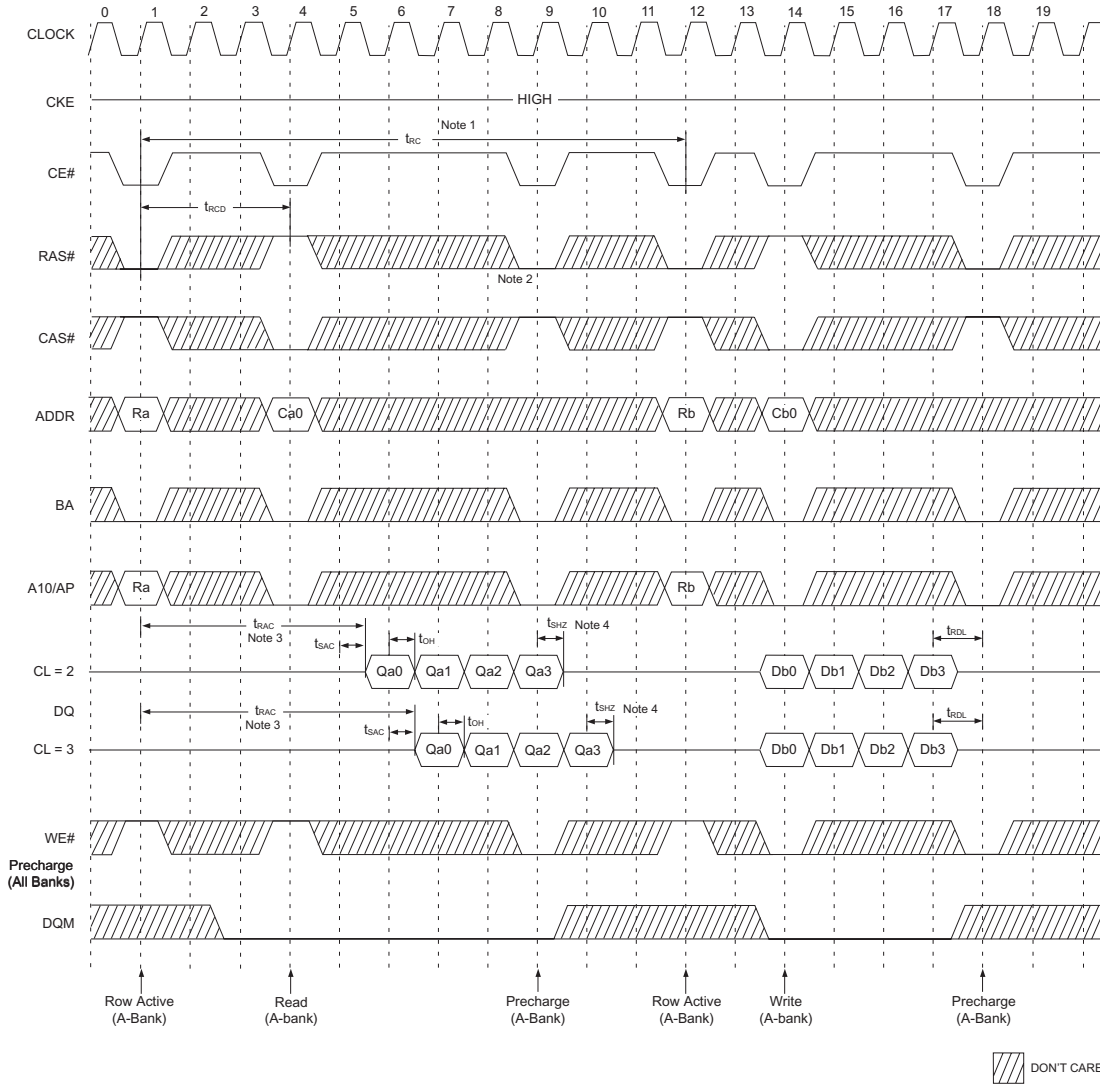


POWER UP SEQUENCE





READ & WRITE CYCLE AT SAME BANK @ BURST LENGTH = 4

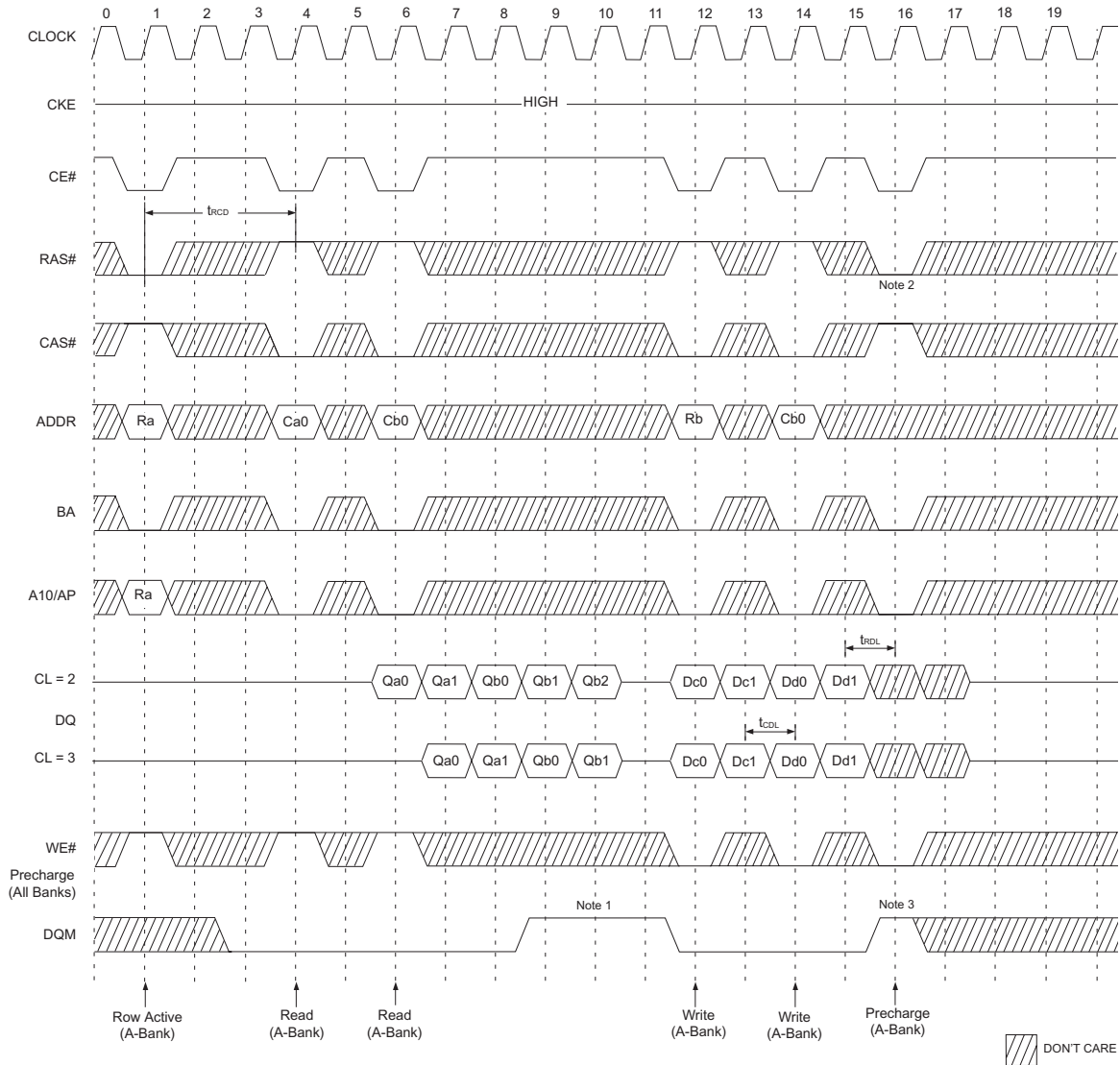


NOTES:

1. Minimum row cycle times are required to complete internal DRAM operation.
2. Row precharge can interrupt burst on any cycle. (CAS# Latency - 1) number of valid output data is available after Row precharge. Last valid output will be Hi-Z( $t_{SHZ}$ ) after the clock.
3. Access time from Row active command.  $t_{CC} = (t_{RCD} + CAS\# \text{ latency} - 1) + t_{SAC}$ .
4. Output will be Hi-Z after the end of burst (1, 2, 4, 8 & full page bit burst).

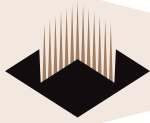


PAGE READ & WRITE CYCLE AT SAME BANK @ BURST LENGTH = 4

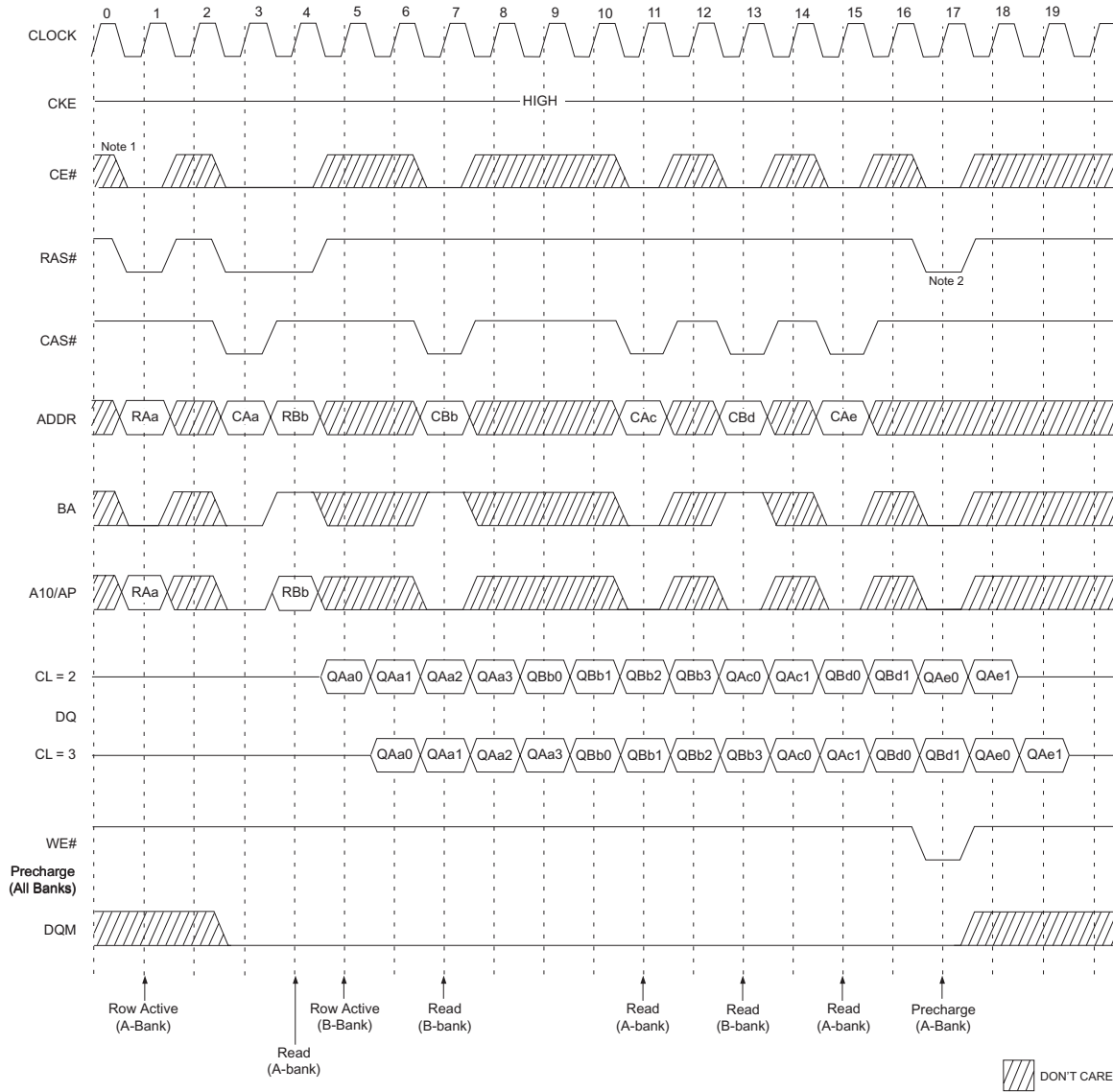


NOTES:

1. To write data before burst read ends, DQM should be asserted three cycles prior to write command to avoid bus contention.
2. Row precharge will interrupt writing. Last data input,  $t_{RDL}$  before Row precharge, will be written.
3. DQM should mask invalid input data on precharge command cycle when asserting precharge before end of burst. Input data after Row precharge cycle will be masked internally.



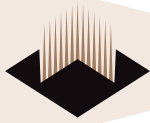
PAGE READ CYCLE AT DIFFERENT BANK @ BURST LENGTH = 4



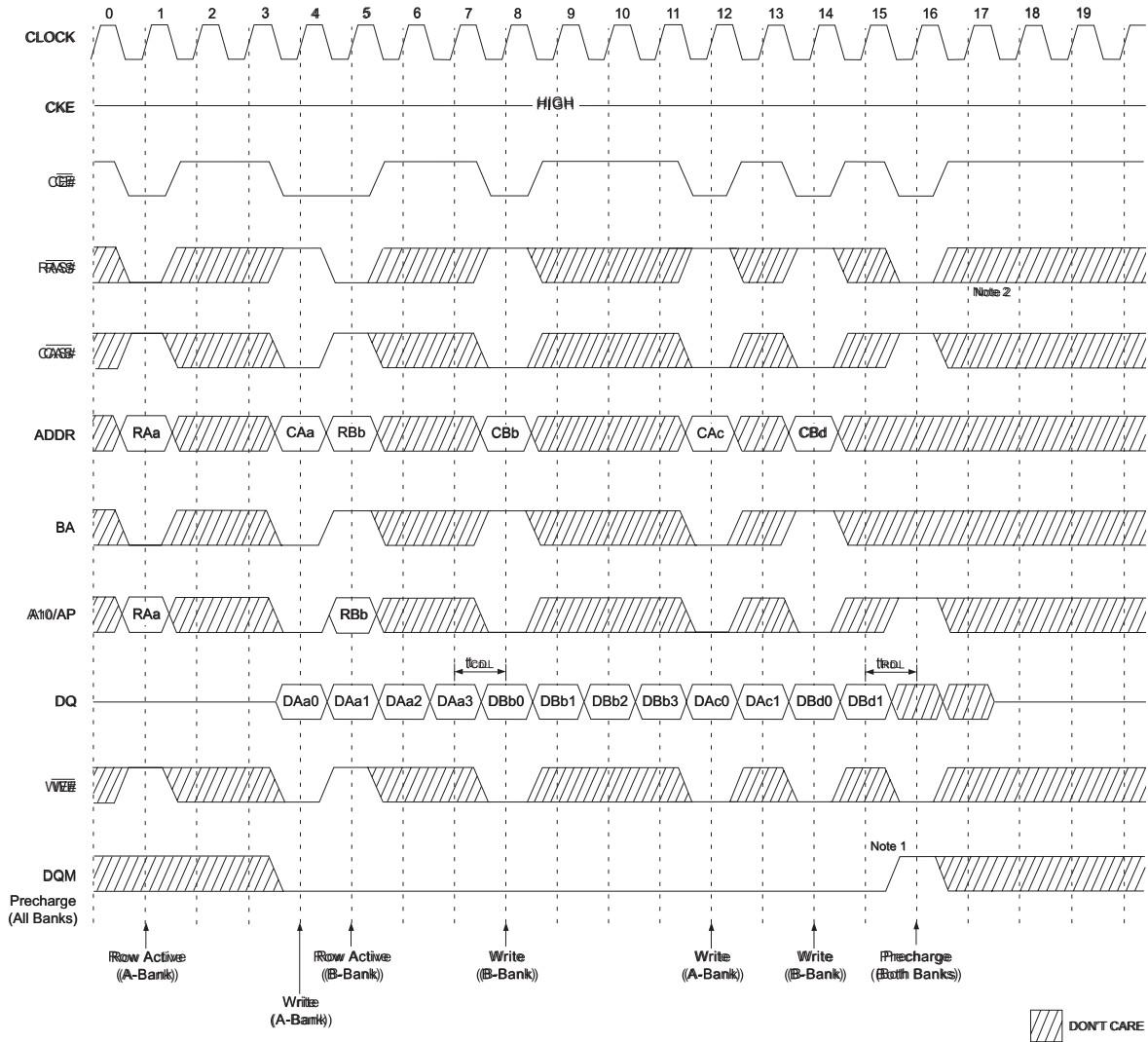
NOTES:

1. CE# can be don't cared when RAS#, CAS# and WE# are high at the clock high going edge.
2. To interrupt a burst read by row precharge, both the read and the precharge banks must be the same.



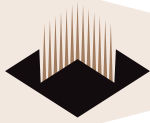


PAGE WRITE CYCLE AT DIFFERENT BANK @ BURST LENGTH = 4

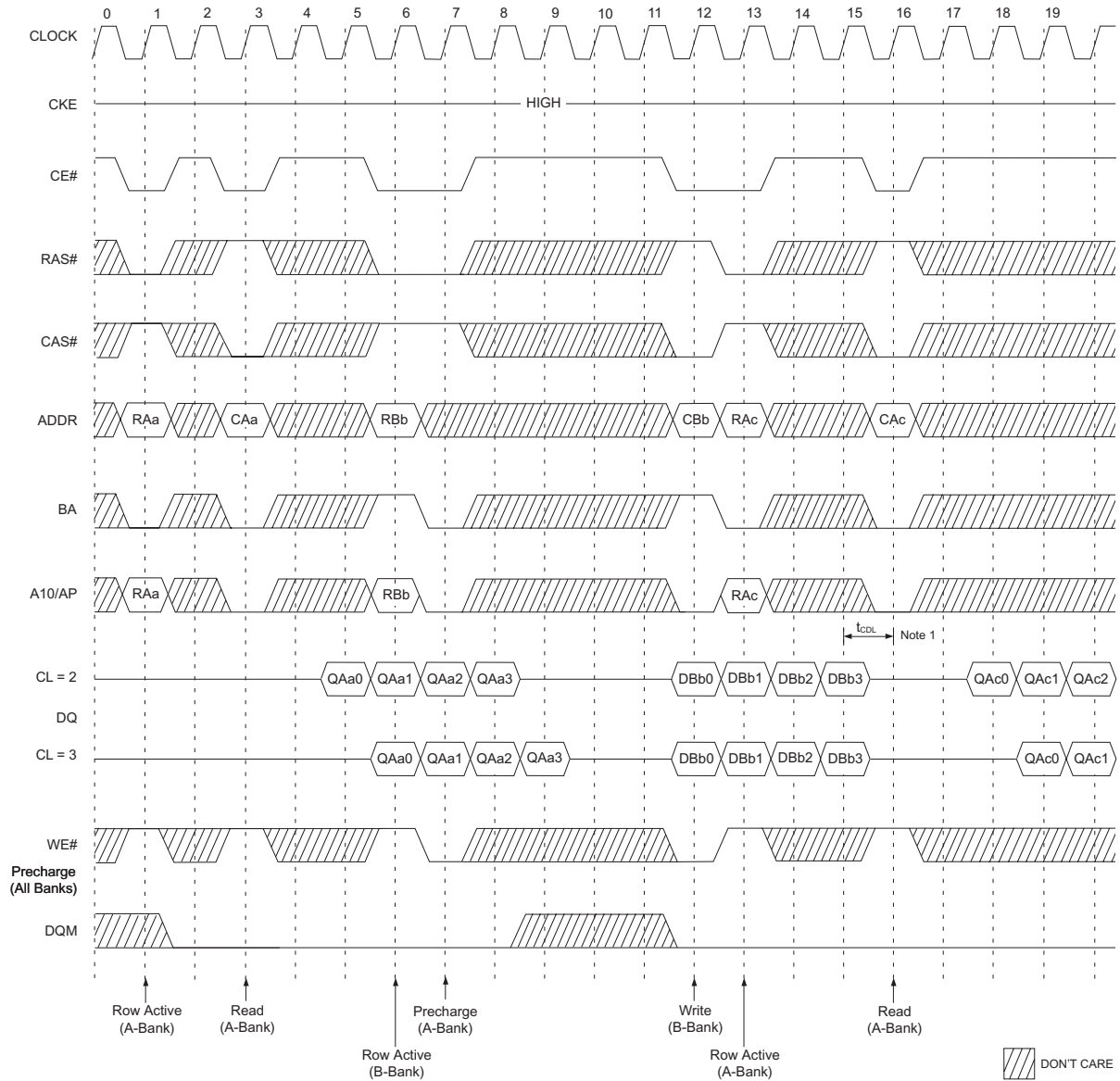


NOTES:

1. To interrupt burst write by Row precharge, DQM should be asserted to mask invalid input data.
2. To interrupt burst write by Row precharge, both the write and the precharge banks must be the same.

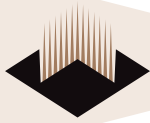


READ & WRITE CYCLE AT DIFFERENT BANK @ BURST LENGTH = 4

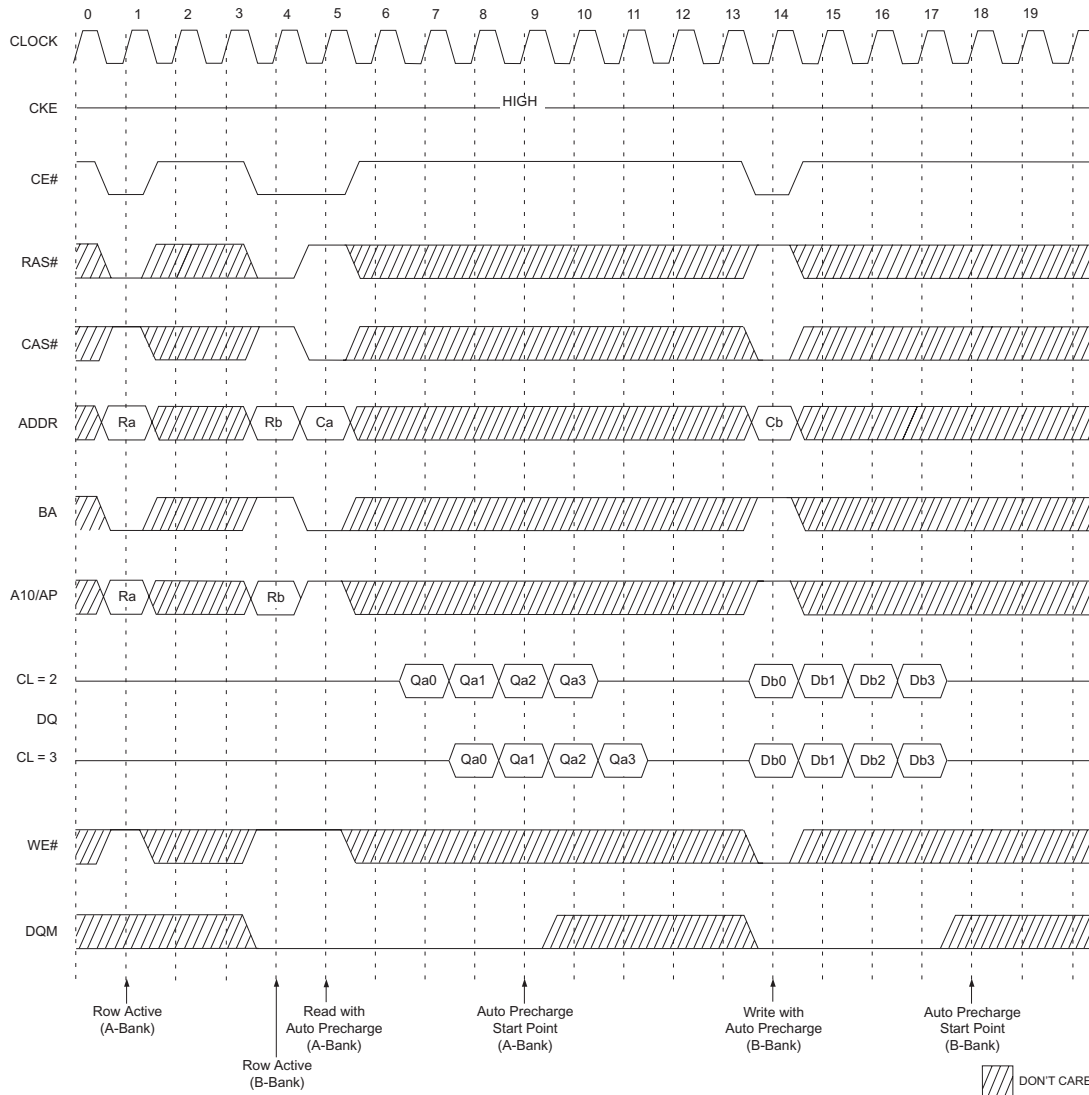


NOTE:

1.  $t_{CDL}$  should be met to complete write.

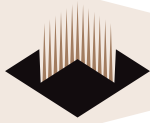


**READ & WRITE CYCLE WITH AUTO PRECHARGE @ BURST LENGTH = 4**

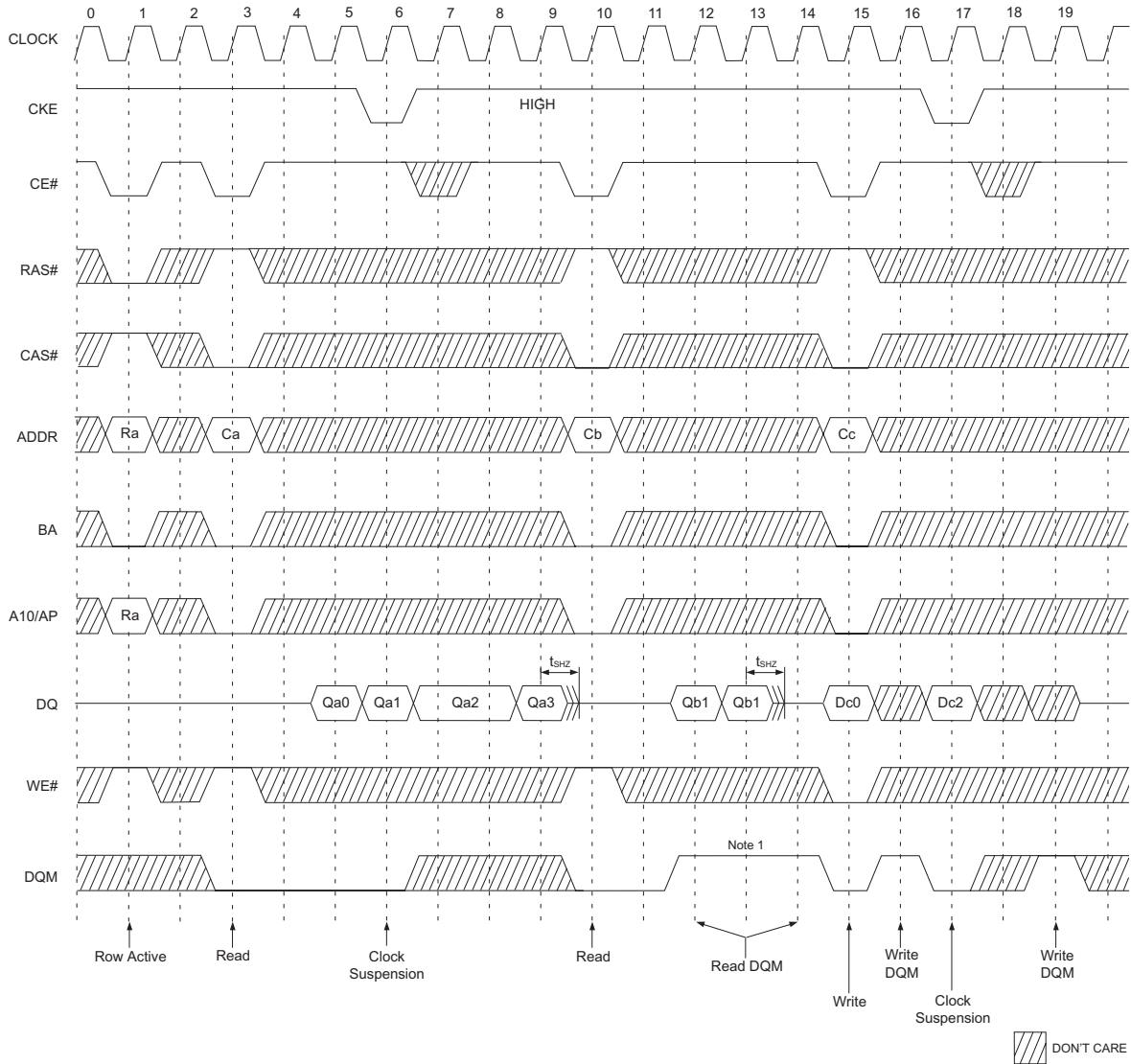


**NOTE:**

1.  $t_{CDL}$  should be controlled to meet minimum  $t_{RAS}$  before internal precharge start. (in the case of Burst Length = 1 & 2 and BRSW mode)

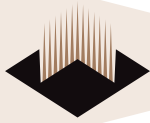


**CLOCK SUSPENSION & DQM OPERATION CYCLE @ CAS LATENCY = 2, BURST LENGTH = 4**

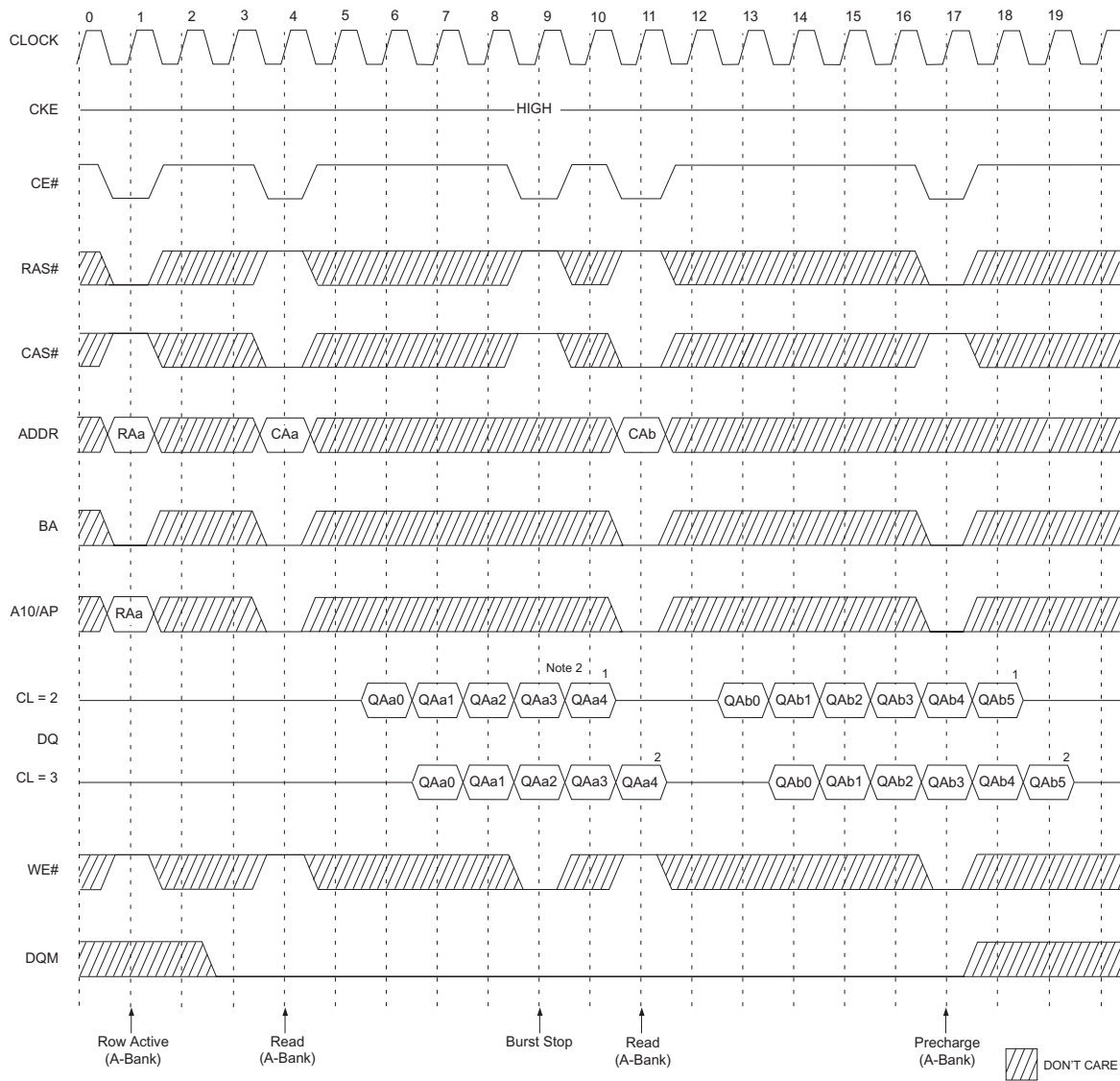


NOTE:

1. DQM is needed to prevent bus contention.

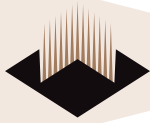


**READ INTERRUPTED BY PRECHARGE COMMAND & READ BURST STOP @ BURST LENGTH = FULL PAGE**

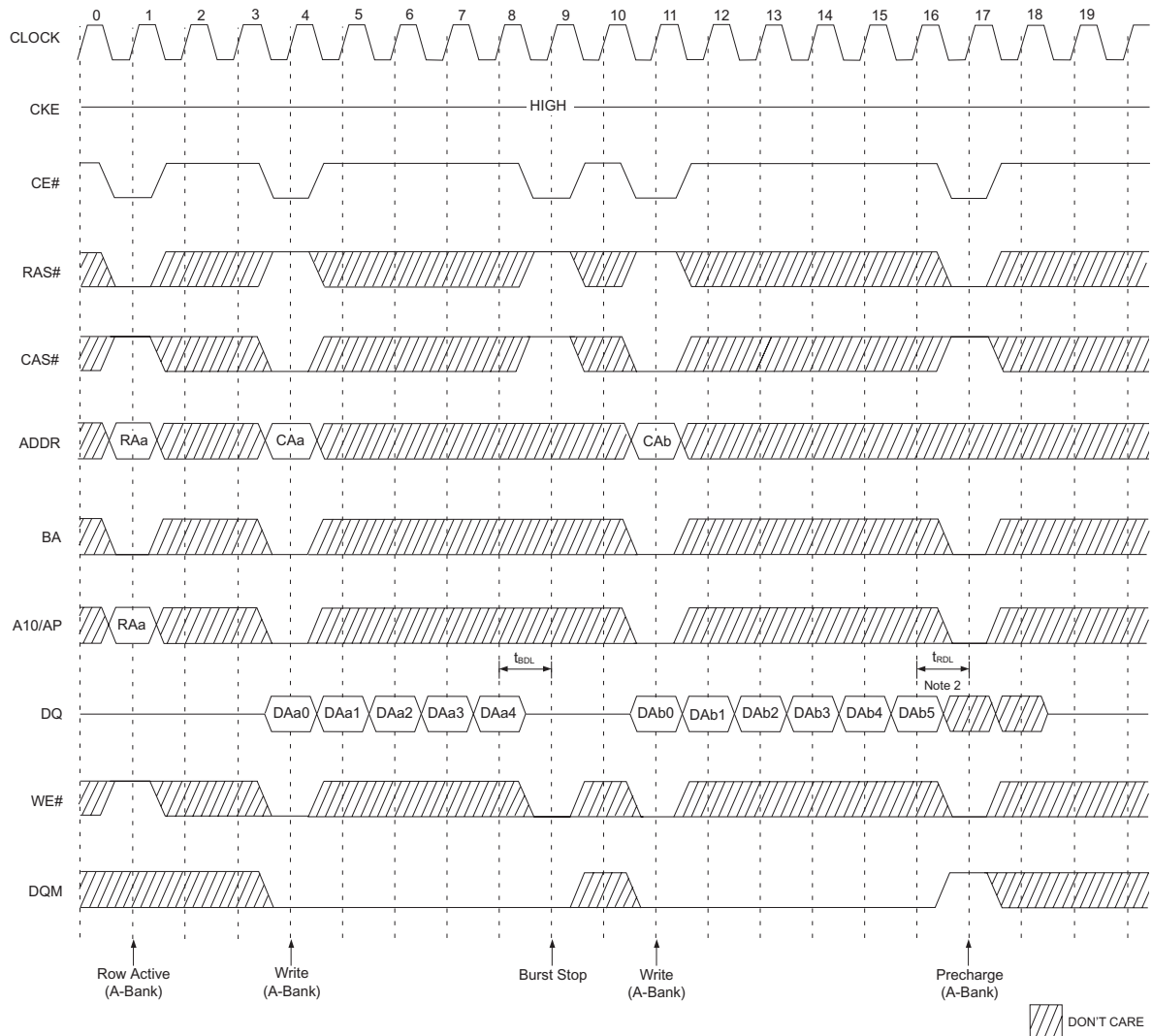


**NOTES:**

1. At full page mode, burst is end at the end of burst. So auto precharge is possible.
2. About the valid DQs after burst stop, it is same as the case of RAS# interrupt. Both cases are illustrated in above timing diagram. See the label 1, 2. But at burst write, Burst stop and RAS# interrupt should be compared carefully. Refer to the timing diagram of "Full page write burst stop cycle."
3. Burst stop is valid at every burst length.



WRITE INTERRUPTED BY PRECHARGE COMMAND & WRITE BURST STOP CYCLE @ BURST LENGTH = FULL PAGE

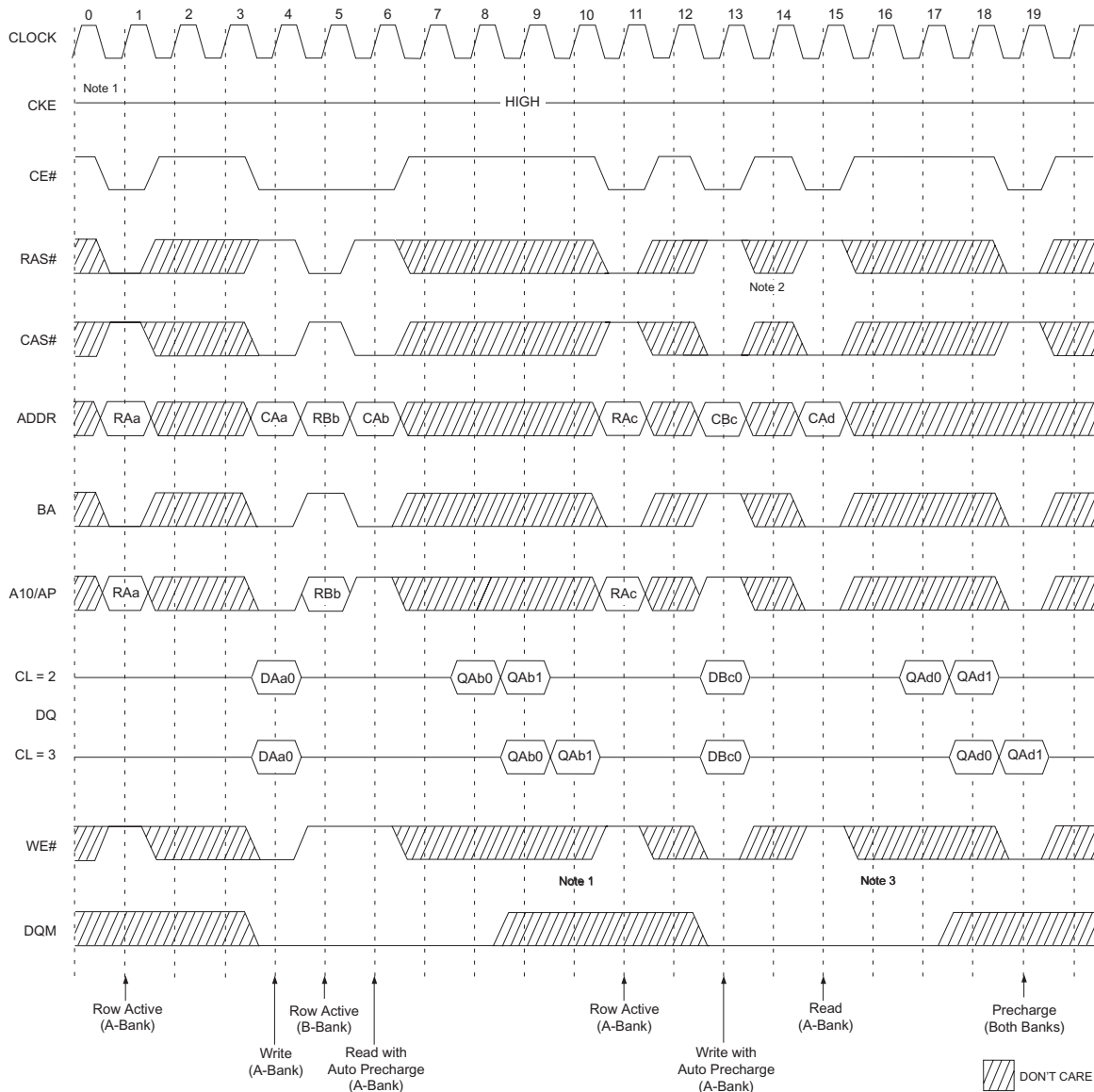


NOTES:

1. At full page mode, burst is end at the end of burst. So auto precharge is possible.
2. Data-in at the cycle of interrupted by precharge cannot be written into the corresponding memory cell. It is defined by AC parameter of  $t_{rdL}$ . DQM at write interrupted by precharge command is needed to prevent invalid write. DQM should mask invalid input data on precharge command cycle when asserting precharge before end of burst. Input data after Row precharge cycle will be masked internally.
3. Burst stop is valid at every burst length.

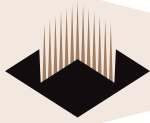


**BURST READ SINGLE BIT WRITE CYCLE @ BURST LENGTH = 2  
@ BURST LENGTH = FULL PAGE**

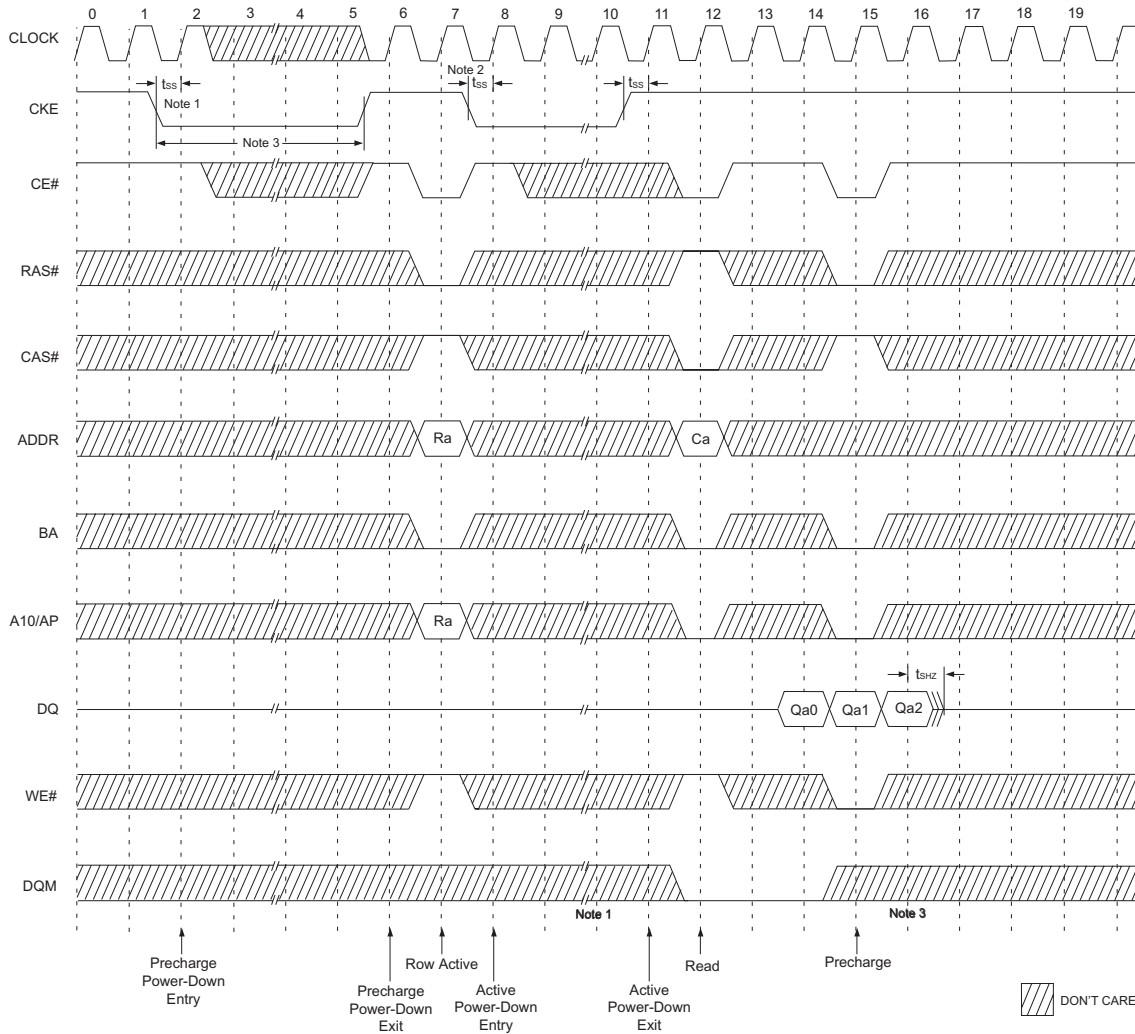


**NOTES:**

1. BRSW mode is enabled by setting As "High" at MRS (Mode Register Set). At the BRSW Mode, the burst length at write is fixed to "1" regardless of programmed burst length.
2. When BRSW write command with auto precharge is executed, keep it in mind that  $t_{RAS}$  should not be violated. Auto precharge is executed at the burst-end cycle, so in the case of BRSW write command, the next cycle starts the precharge.



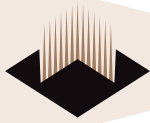
ACTIVE/PRECHARGE POWER DOWN MODE @ CAS LATENCY = 2, BURST LENGTH = 4



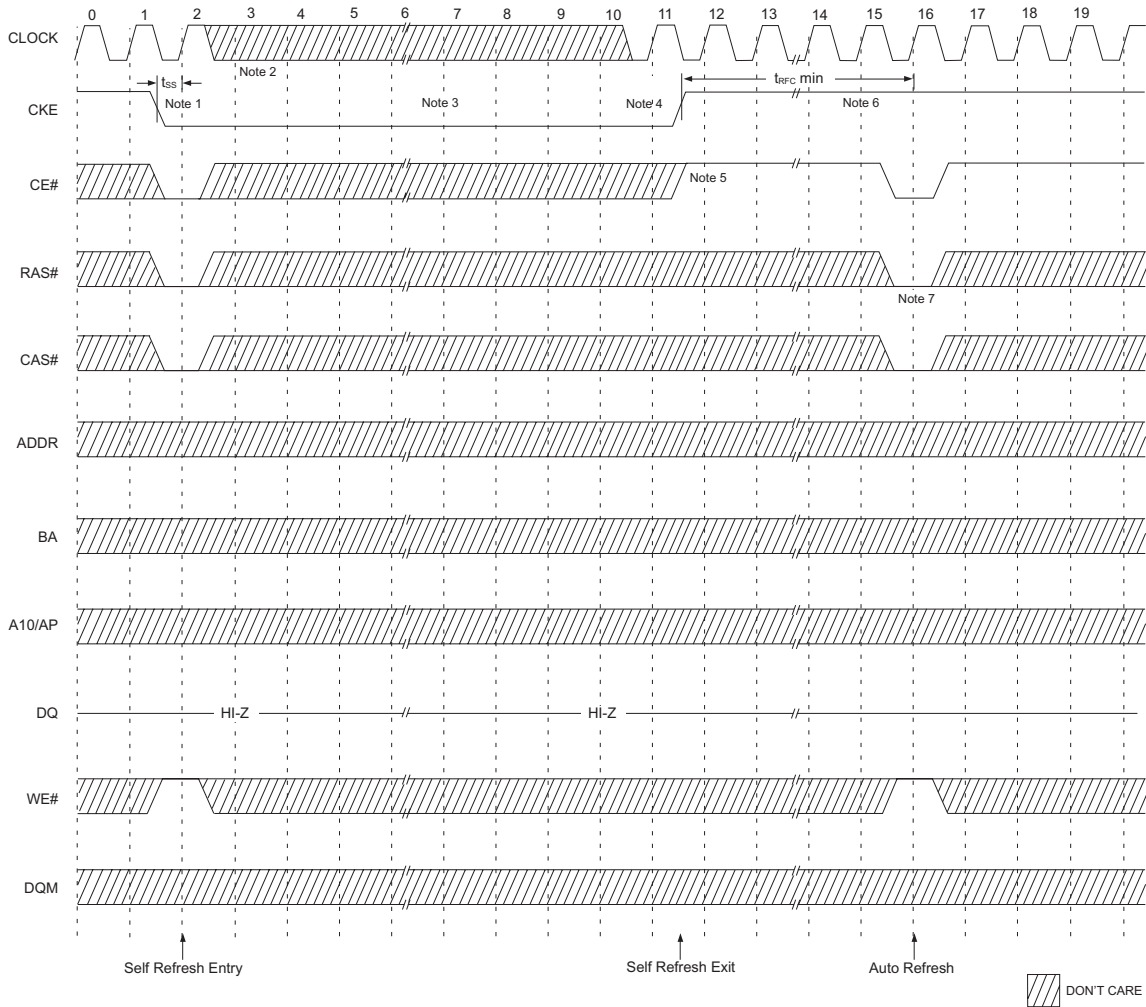
NOTES:

1. Both banks should be in idle state prior to entering precharge power down mode.
2. CKE should be set high at least  $1\text{ CK} + t_{ss}$  prior to Row active command.
3. Cannot violate minimum refresh specification (64ms).





SELF REFRESH ENTRY & EXIT CYCLE



NOTES:

TO ENTER SELF REFRESH MODE

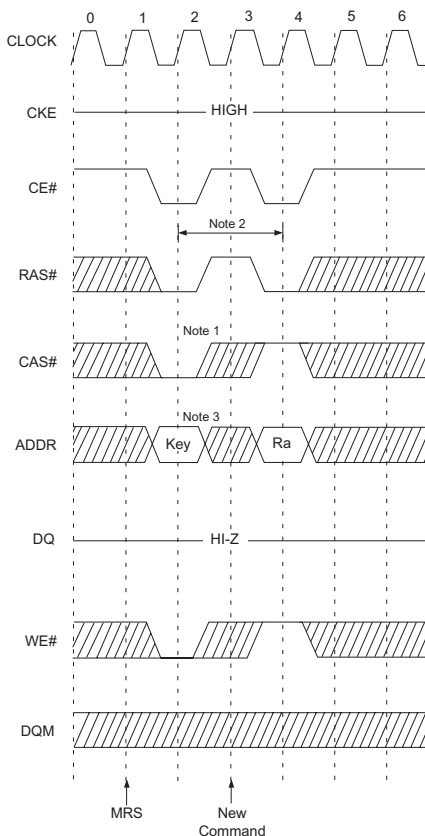
1. CE#, RAS# & CAS# with CKE should be low at the same clock cycle.
2. After 1 clock cycle, all the inputs including the system clock can be don't care except for CKE.
3. The device remains in self refresh mode as long as CKE stays "Low." Once the device enters self refresh mode, minimum  $t_{RAS}$  is required before exit from self refresh.

TO EXIT SELF REFRESH MODE

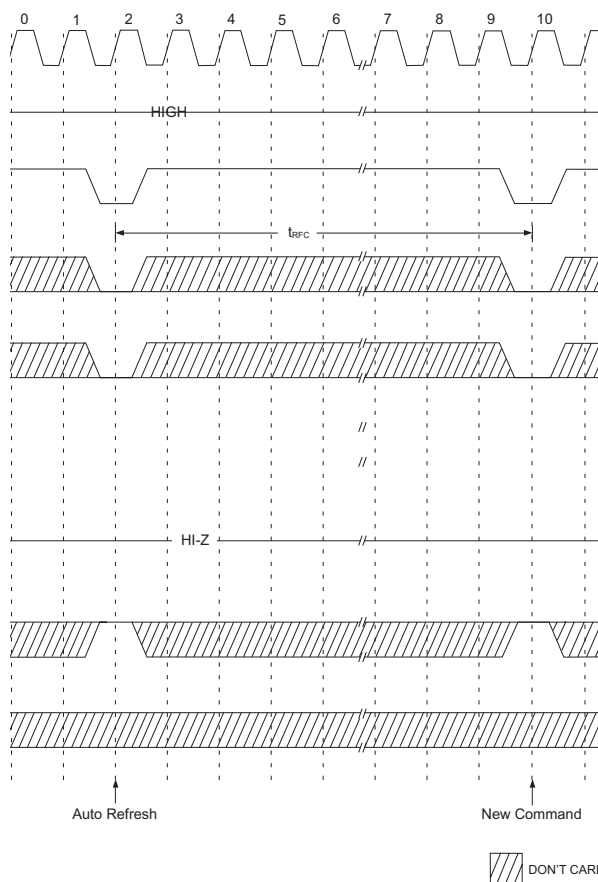
4. System clock restart and be stable before returning CKE high.
5. CE# starts from high.
6. Minimum  $t_{RFC}$  is required after CKE going high to complete self refresh exit.
7. 4K cycle of burst auto refresh is required before self refresh entry and after self refresh exit if the system uses burst refresh.



**MODE REGISTER SET CYCLE**



**AUTO REFRESH CYCLE**



DONT CARE

**NOTES:**

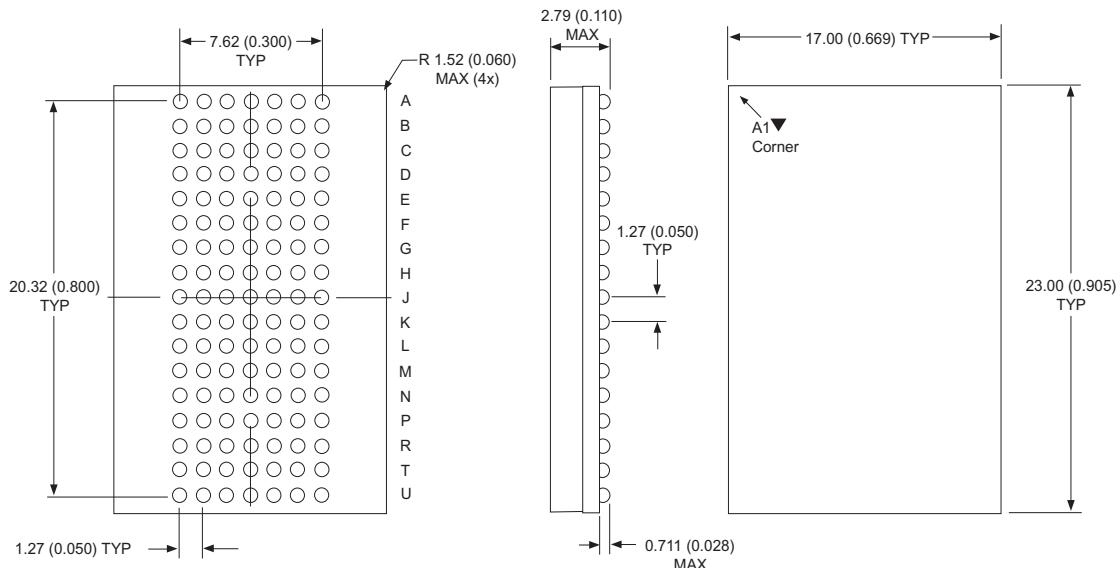
Both banks precharge should be completed before Mode Register Set cycle and auto refresh cycle.

**MODE REGISTER SET CYCLE**

1. CE#, RAS#, CAS#, & WE# activation at the same clock cycle with address key will set internal mode register.
2. Minimum 2 clock cycles should be met before new RAS# activation.
3. Please refer to Mode Register Set table.



**PACKAGE DESCRIPTION 119 PIN BGA  
JEDEC MO-163**



ALL DIMENSIONS ARE IN MILLIMETERS AND PARENTHETICALLY IN INCHES

**ORDERING INFORMATION**

Part Number	Clock Frequency	Package
WED3DL3216V7BC	133MHz	119 BGA
WED3DL3216V8BC	125MHz	119 BGA
WED3DL3216V10BC	100MHz	119 BGA
WED3DL3216V7BI	133MHz, Industrial	119 BGA
WED3DL3216V8BI	125MHz, Industrial	119 BGA
WED3DL3216V10BI	100MHz, Industrial	119 BGA
WED3DL3216V7ES	133MHz, Engineering Samples	119 BGA
WED3DL3216V10ES	100 MHz, Engineering Samples	119 BGA