Table of Content-

1. GENERAL DESCRIPTION

PT460816HG is a CMOS Double Data Rate synchronous dynamic random access memory (DDR SDRAM), organized as 2M words x 4 banks x 16 bits. Using pipelined architecture, PT460816HG delivers a data bandwidth of up to 800M bytes per second (-5). To fully comply with the personal computer industrial standard, PT460816HG is sorted into three speed grades: -5, -6, -75.The -5 is compliant to the 400 MHz/CL3 specification, The -6 is compliant to the 333MHz/CL3 specification, the -75 is compliant to the 266 MHz/CL2 specification.

All Inputs reference to the positive edge of CLK (except for DQ, DM, and CKE). The timing reference point for the differential clock is when the CLK and CLK signals cross during a transition. And Write and Read data are synchronized with the both edges of DQS (Data Strobe).

By having a programmable Mode Register, the system can change burst length, latency cycle, interleave or sequential burst to maximize its performance. PT460816HG is ideal for main memory in high performance applications.

2. FEATURES

2.5V ±0.2V Power Supply for DDR266/333

2.6V ±0.1V Power Supply for DDR400

Double Data Rate architecture; two data transfers per clock cycle

DQS is edge-aligned with data for Read; center-aligned with data for Write · CAS Latency: 2, 2.5, 3

Burst Length: 2, 4 and 8

Auto Refresh and Self Refresh

Precharged Power Down and Active Power Down

Write Data Mask

Write Recover time (tWR) = 3 tCK

4K Refresh Cycles / 64 mS

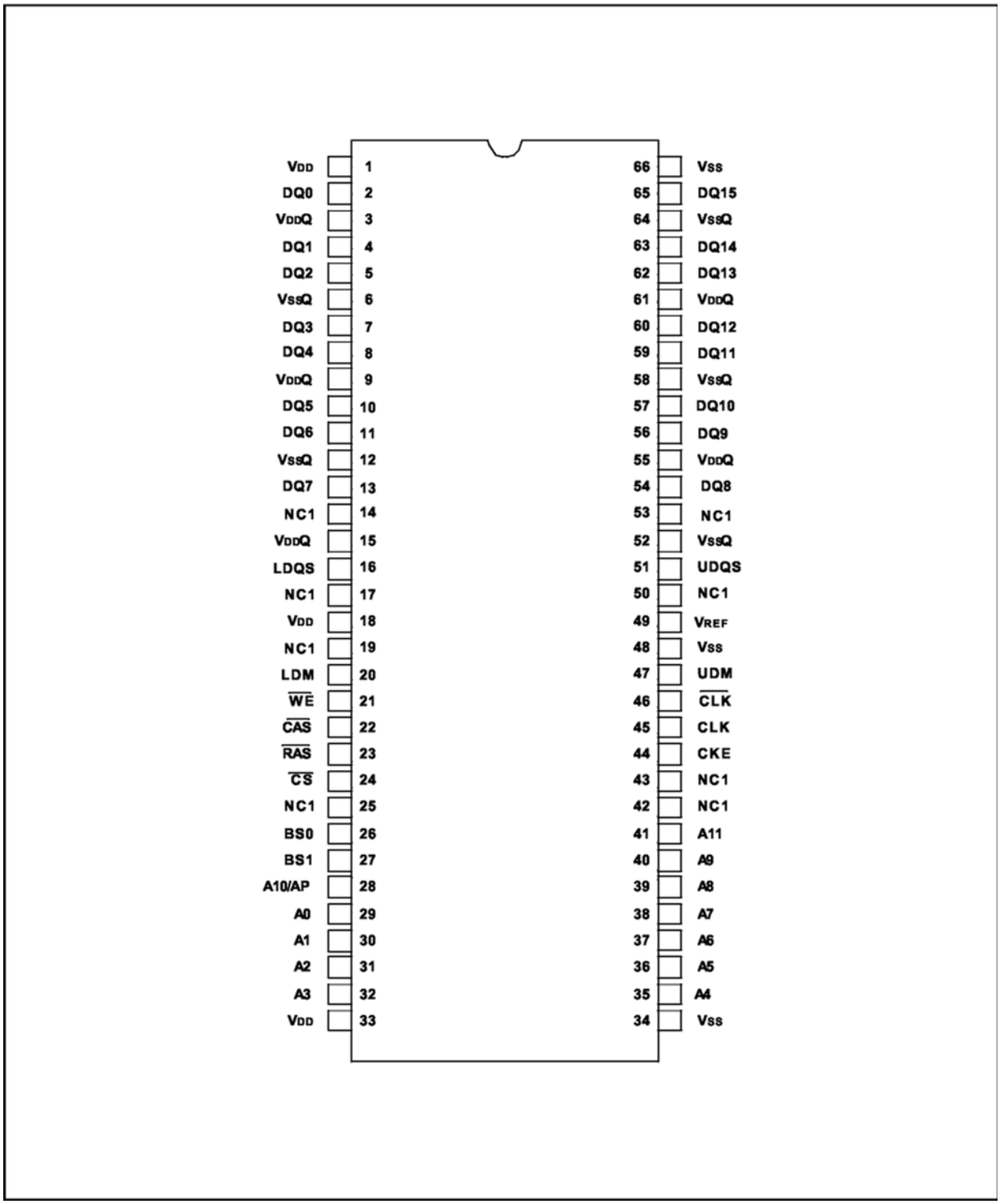
Interface: SSTL-2

Packaged in 66-pin, 400 mil TSOP II, using PB free with RoHS compliant.

3. KEY PARAMETERS

SYMBOL	DESCRIPTION		MIN./MAX.	-5	-6	-75
t_{CK}	Clock Cycle Time	CL = 2	Min.	7.5nS	7.5nS	7.5nS
		CL = 3	Min.	5nS	6nS	7.5nS
t_{RAS}	Active to Precharge Command Period		Min.	40nS	42nS	45nS
t_{RC}	Active to Ref/Active Command Period		Min.	$10t_{CK}$	9 t_{CK}	8 t_{CK}
I_{DD1}	Operation Current (Single bank)		Max.	140mA	130 mA	120 mA
I_{DD4}	Burst Operation Current		Max.	180 mA	170 mA	160 mA
I_{DD6}	Self-refresh Current		Max.	3.2 mA	3mA	3mA

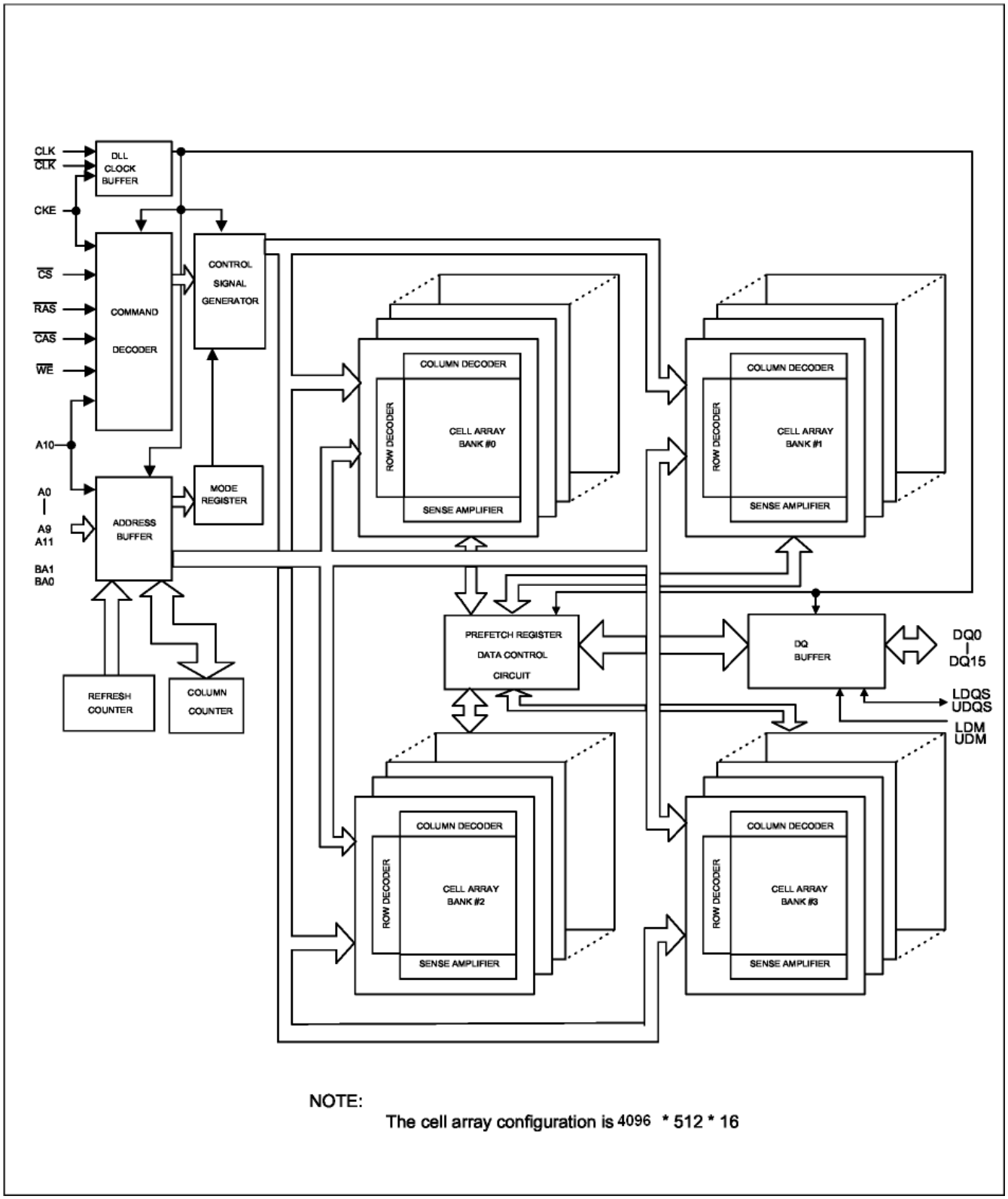
4. PIN CONFIGURATION



5. PIN DESCRIPTION

PIN NUMBER	PIN NAME	FUNCTION	DESCRIPTION
28 - 32, 35 - 41	A0 - A11	Address	Multiplexed pins for row and column address. Row address: A0 - A11. Column address: A0 - A8. (A10 is used for Auto Precharge)
26, 27	BS0, BS1	Bank Select	Select bank to activate during row address latch time, or bank to read/write during column address latch time.
2, 4, 5, 7, 8, 10, 11, 13, 54,56,57, 59, 60, 62, 63, 65	DQ0 - DQ15	Data Input/ Output	The DQ0 – DQ15 input and output data are synchronized with both edges of DQS.
16, 51	LDQS, UDQS	Data Strobe	DQS is Bi-directional signal. DQS is input signal during write operation and output signal during read operation. It is Edge-aligned with read data, Center-aligned with write data.
24	CS	Chip Select	Disable or enable the command decoder. When command decoder is disabled, new command is ignored and previous operation continues.
23, 22, 21	RAS, CAS, WE	Command Inputs	Command inputs (along with CS) define the command being entered.
20, 47	LDM, UDM	Write Mask	When DM is asserted “high” in burst write, the input data is masked. DM is synchronized with both edges of DQS.
45, 46	CLK, !CLK	Differential Clock Inputs	All address and control input signals are sampled on the crossing of the positive edge of CLK and negative edge of CLK.
44	CKE	Clock Enable	CKE controls the clock activation and deactivation. When CKE is low, Power Down mode, Suspend mode, or Self Refresh mode is entered.
49	VREF	Reference Voltage	VREF is reference voltage for inputs.
1, 18, 33	VDD	Power (+2.5V)	Power for logic circuit inside DDR SDRAM.
34, 48, 66	VSS	Ground	Ground for logic circuit inside DDR SDRAM.
3, 9, 15, 55, 61	VDDQ	Power (+2.5V) for I/O Buffer	Separated power from V_{DD}, used for output buffer, to improve noise.
6, 12, 52, 58, 64	VSSQ	Ground for /O Buffer	Separated ground from V_{SS}, used for output buffer, to improve noise.
14, 17, 19, 25, 42,43, 50, 53	NC1	No Connection	No connection

6. BLOCK DIAGRAM



NOTE:

The cell array configuration is 4096 * 512 * 16

7. FUNCTIONAL DESCRIPTION

7.1. Power Up Sequence.

(1) Apply power and attempt to CKE at a low state (≦ 0.2V), all other inputs may be undefined
  (1) Apply V_{DD} before or at the same time as $V_{DD}Q$.
  (2) Apply $V_{DD}Q$ before or at the same time as V_{TT} and V_{REF}.
(2) Start Clock and maintain stable condition for 200 mS(min).
(3) After stable power and clock, apply NOP and take CKE high.
(4) Issue EMRS (Extended Mode Register Set) to enable DLL and establish Output Driver Type.
(5) Issue MRS (Mode Register Set) to reset DLL and set device to idle with bit A8.
  (an additional 200 cycles(min) of clock are required for DLL Lock)
(6) Issue precharge command for all banks of the device.
(7) Issue two or more Auto Refresh commands.
(8) Issue MRS -Initialize device operation.
  (If device operation mode is set at sequence 5, sequence 8 can be skipped.)

7.2. Bank Activate Command

(RAS = "L", CAS = "H", WE = "H", BS0, BS1 = Bank, A0 to A11 = Row Address)
The Bank Activate command activates the bank designated by the BS (Bank address) signal. Row addresses are latched on A0 to A11 when this command is issued and the cell data is read out of the sense amplifiers. The maximum time that each bank can be held in the active state is specified as t_{RAS} (max). After this command is issued, Read or Write operation can be executed.

7.3. Bank Precharge Command

(RAS = "L", CAS = "H", WE = "L", BS0, BS1 = Bank, A10 = "L", A0 to A9, A11 = Don't care)
The Bank Precharge command percharges the bank designated by BS. The precharged bank is switched from the active state to the idle state.

7.4. Precharge All Command

(RAS = "L", CAS = "H", WE = "L", BS0, BS1 = Don't care, A10 = "H", A0 to A9, A11 = Don't care)
The Precharge All command precharges all banks simultaneously. Then all banks are switched to the idle state.

7.5. Write Command

(RAS = "H", CAS = "L", WE = "L", BS0, BS1 = Bank, A10 = "L", A0 to A9, A11 = Column Address)
The write command performs a Write operation to the bank designated by BS. The write data are latched at both edges of DQS. The length of the write data (Burst Length) and column access sequence (Addressing Mode) must be in the Mode Register at power-up prior to the Write operation.

7.6. Write with Auto Precharge Command

(RAS - = "H", CAS = "L", WE = "L", BS0, BS1 = Bank, A10 = "H", A0 to A9, A11 = Column Address)
The Write with Auto Precharge command performs the Precharge operation automatically after the Write operation. This command must not be interrupted by any other commands.

7.7. Read Command

(RAS = "H", CAS = "L", WE = "H", BS0, BS1 = Bank, A10 = "L", A0 to A9, A11 = Column Address)

The Read command performs a Read operation to the bank designated by BS. The read data are synchronized with both edges of DQS. The length of read data (Burst Length), Addressing Mode and CAS Latency (access time from CAS command in a clock cycle) must be programmed in the Mode Register at power-up prior to the Read operation.

7.8. Read with Auto Precharge Command

(RAS= "H", CAS= "L", WE - = "H", BS0, BS1 = Bank, A10 = "H", A0 to A9, A11 = Column Address)

The Read with Auto precharge command automatically performs the Precharge operation after the Read operation.

(1) READA $\geqq t_{RAS}$ (min) - (BL/2) x t_{CK}

(2) Internal precharge operation begins after BL/2 cycle from Read with Auto Precharge command

(3) t_{RCD}(min) $\leqq$ READA < t_{RAS}(min) - (BL/2) x t_{CK}

(4) Data can be read with shortest latency, but the internal Precharge operation does not begin until after t_{RAS} (min) has completed.

This command must not be interrupted by any other command.

7.9. Mode Register Set Command

(RAS = "L", CAS = "L", WE = "L", BS0 = "L", BS1 = "L", A0 to A11 = Register Data)

The Mode Register Set command programs the values of CAS latency, Addressing Mode, Burst Length and DLL reset in the Mode Register. The default values in the Mode Register after power-up are undefined, therefore this command must be issued during the power-up sequence. Also, this command can be issued while all banks are in the idle state. Refer to the table for specific codes.

7.10. Extended Mode Register Set Command

(RAS - = "L", CAS = "L", WE = "L", BS0 = "H", BS1 = "L", A0 to A11 = Register data)

The Extended Mode Register Set command can be implemented as needed for function extensions to the standard (SDR-SDRAM). Currently the only available mode in EMRS is DLL enable/disable, decoded by A0. The default value of the extended mode register is not defined; therefore this command must be issued during the power-up sequence for enabling DLL. Refer to the table for specific codes.

7.11. No-Operation Command

(RAS = "H", CAS = "H", WE = "H")

The No-Operation command simply performs no operation (same command as Device Deselect).

7.12. Burst Read Stop Command

(RAS = "H", CAS = "H", WE = "L")

The Burst stop command is used to stop the burst operation. This command is only valid during a Burst Read operation.

7.13. Device Deselect Command

(CS = "H")

The Device Deselect command disables the command decoder so that the RAS, CAS , WE and Address inputs are ignored. This command is similar to the No-Operation command.

7.14. Auto Refresh Command

(RAS = "L", CAS = "L", WE = "H", CKE = "L", BS0, BS1, A0 to A11 = Don't care)

The Auto Refresh command is used to refresh the row address provided by the internal refresh counter. The Refresh operation must be performed 8192 times within 64ms. The next command can be issued after t_{REF} from the end of the Auto Refresh command. When the Auto Refresh command is used, all banks must be in the idle state.

7.15. Self Refresh Entry Command

(RAS = "L", CAS = "L", WE = "H", CKE = "L", BS0, BS1, A0 to A11 = don't care)

The Self Refresh Entry command is used to enter Self Refresh mode. While the device is in Self Refresh mode, all input and output buffer (except the CKE buffer) are disabled and the Refresh operation is automatically performed. Self Refresh mode is exited by taking CKE "high" (the Self Refresh Exit command). During self refresh, DLLl is disable.

7.16. Self Refresh Exit Command

(CKE = "H", CS = "H" or CKE = "H", RAS = "H", CAS = "H")

This command is used to exit from Self Refresh mode. Any subsequent commands can be issued after t_{XSNR} (t_{XSRD} for Read Command) from the end of this command.

7.17. Data Write Enable /Disable Command

(DM = "L/H" or LDM, UDM = "L/H")

During a Write cycle, the DM or LDM, UDM signal functions as Data Mask and can control every word of the input data. The LDM signal controls DQ0 to DQ7 and UDM signal controls DQ8 to DQ15.

7.18. Read Operation

Issuing the Bank Activate command to the idle bank puts it into the active state. When the Read command is issued after t_{RCD} from the Bank Activate command, the data is read out sequentially, synchronized with both edges of DQS (Burst Read operation). The initial read data becomes available after CAS latency from the issuing of the Read command. The CAS latency must be set in the Mode Register at power-up.

When the Precharge Operation is performed on a bank during a Burst Read and operation, the Burst operation is terminated.

When the Read with Auto Precharge command is issued, the Precharge operation is performed automatically after the Read cycle, then the bank is switched to the idle state. This command cannot be interrupted by any other commands.

7.19. Write Operation

Issuing the Write command after t_{RCD} from the bank activate command. The input data is latched sequentially, synchronizing with both edges(rising &falling) of DQS after the Write command (Burst write operation). The burst length of the Write data (Burst Length) and Addressing Mode must be set in the Mode Register at power-up.

When the Precharge operation is performed in a bank during a Burst Write operation, the Burst operation is terminated.

When the Write with Auto Precharge command is issued, the Precharge operation is performed automatically after the Write cycle, then the bank is switched to the idle state, The Write with Auto Precharge command cannot be interrupted by any other command for the entire burst data duration.

7.20. Precharge

There are two Commands, which perform the precharge operation (Bank Precharge and Precharge All). When the Bank Precharge command is issued to the active bank, the bank is precharged and then switched to the idle state. The Bank Precharge command can precharge one bank independently of the other bank and hold the unprecharged bank in the active state. The maximum time each bank can be held in the active state is specified as t_{RAS} (max). Therefore, each bank must be precharged within t_{RAS}(max) from the bank activate command.
The Precharge All command can be used to precharge all banks simultaneously. Even if banks are not in the active state, the Precharge All command can still be issued. In this case, the Precharge operation is performed only for the active bank and the precharge bank is then switched to the idle state.

7.21. Burst Termination

When the Precharge command is used for a bank in a Burst cycle, the Burst operation is terminated. When Burst Read cycle is interrupted by the Precharge command, read operation is disabled after clock cycle of (CAS latency) from the Precharge command. When the Burst Write cycle is interrupted by the Precharge command . the input circuit is reset at the same clock cycle at which the precharge command is issued. In this case, the DM signal must be asserted "high": during t_{WR} to prevent writing the invalided data to the cell array.
When the Burst Read Stop command is issued for the bank in a Burst Read cycle, the Burst Read operation is terminated. The Burst read Stop command is not supported during a write burst operation.

7.22. Refresh Operation

Two types of Refresh operation can be performed on the device: Auto Refresh and Self Refresh. By repeating the Auto Refresh cycle, each bank in turn refreshed automatically. The Refresh operation must be performed 4096 times(rows)within 64ms. The period between the Auto Refresh command and the next command is specified by t_{RFC}.
Self Refresh mode enter issuing the Self Refresh command (CKE asserted "low"). while all banks are in the idle state. The device is in Self Refresh mode for as long as CKE held "low". In the case of 4096 burst Auto Refresh commands, 8192 burst Auto Refresh commands must be performed within 15.6 mS before entering and after exiting the Self Refresh mode. In the case of distributed Auto Refresh commands, distributed auto refresh commands must be issued every 15.6 μS and the last distributed Auto Refresh commands must be performed within 15.6 μS before entering the self refresh mode. After exiting from the Self Refresh mode, the refresh operation must be performed within 15.6 μS. In Self Refresh mode, all input/output buffers are disable, resulting in lower power dissipation (except CKE buffer).

7.23. Power Down Mode

Two types of Power Down Mode can be performed on the device: Active Standby Power Down Mode and Precharge Standby Power Down Mode.
When the device enters the Power Down Mode, all input/output buffers and DLL are disabled resulting in low power dissipation (except CKE buffer).
Power Down Mode enter asserting CKE "low" while the device is not running a burst cycle. Taking CKE: "high" can exit this mode. When CKE goes high, a No operation command must be input at next CLK rising edge.

7.24. Mode Register Operation

The mode register is programmed by the Mode Register Set command (MRS/EMRS) when all banks are in the idle state. The data to be set in the Mode Register is transferred using the A0 to A11 and BS0, BS1 address inputs. The Mode Register designates the operation mode for the read or write cycle. The register is divided into five filed:

(1) Burst Length field to set the length of burst data
(2) Addressing Mode selected bit to designate the column access sequence in a Burst cycle
(3) CAS Latency field to set the assess time in clock cycle
(4) DLL reset field to reset the dll
(5) Regular/Extended Mode Register filed to select a type of MRS (Regular/Extended MRS).
EMRS cycle can be implemented the extended function (DLL enable/Disable mode)

The initial value of the Mode Register (including EMRS) after power up is undefined; therefore the Mode Register Set command must be issued before power operation.

1. Burst Length field (A2 to A0)

This field specifies the data length for column access using the A2 to A0 pins and sets the Burst Length to be 2, 4, and 8 words.

A2	A1	A0	Burst Length
0	0	0	Reserved
0	0	1	2 words
0	1	0	4 words
0	1	1	8 words
1	X	X	Reserved

2. Addressing Mode Select (A3)

The Addressing Mode can be one of two modes; Interleave mode or Sequential Mode, When the A3 bit is "0", Sequential mode is selected. When the A3 bit is "1", Interleave mode is selected. Both addressing Mode support burst length 2, 4, and 8 words.

A3	Addressing Mode
0	Sequential
1	Interleave

The disturb address is varied by the Burst Length as shown in Table.

Burst Length	Starting Column Address			Order of Accesses Within a Burst	
				Type = Sequential	Type = Interleaved
2			A0		
			0	0-1	0-1
			1	1-0	1-0
4		A1	A0		
		0	0	0-1-2-3	0-1-2-3
		0	1	1-2-3-0	1-0-3-2
		1	0	2-3-0-1	2-3-0-1
		1	1	3-0-1-2	3-2-1-0
8	A2	A1	A0		
	0	0	0	0-1-2-3-4-5-6-7	0-1-2-3-4-5-6-7
	0	0	1	1-2-3-4-5-6-7-0	1-0-3-2-5-4-7-6
	0	1	0	2-3-4-5-6-7-0-1	2-3-0-1-6-7-4-5
	0	1	1	3-4-5-6-7-0-1-2	3-2-1-0-7-6-5-4
	1	0	0	4-5-6-7-0-1 -2-3	4-5-6-7-0-1 -2-3
	1	0	1	5-6-7-0-1-2-3-4	5-4-7-6-1-0-3-2
	1	1	0	6-7-0-1-2-3-4-5	6-7-4-5-2-3-0-1
	1	1	1	7-0-1-2-3-4-5-6	7-6-5-4-3-2-1-0

3. CAS Latency field (A6 to A4)

This field specifies the number of clock cycles from the assertion of the Read command to the first data read. The minimum values of CAS Latency depends on the frequency of CLK.

A6	A5	A4	CAS Latency
0	0	0	Reserved
0	0	1	Reserved
0	1	0	2
0	1	1	3
1	0	0	Reserved
1	0	1	Reserved
1	1	0	2.5
1	1	1	Reserved

4. DLL Reset bit (A8)

This bit is used to reset DLL. When the A8 bit is "1", DLL is reset.

5. Mode Register /Extended Mode register change bits (BS0, BS1)

These bits are used to select MRS/EMRS.

BS1	BS0	A11-A0
0	0	Regular MRS Cycle
0	1	Extended MRS Cycle
1	x	Reserved

6. Extended Mode Register field

DLL Switch field (A0) This bit is used to select DLL enable or disable

A0	DLL
0	Enable
1	Disable

Output Driver Size Control field (A1)

This bit is used to select Output Driver Size,
both Full strength and Half strength are based on JEDEC standard.

A6	A1	Output Driver
0	0	Full Strength
0	1	Half Strength

7. Reserved field

Test mode entry bit (A7)

This bit is used to enter Test mode and must be set to "0" for normal operation.

Reserved bits (A9, A10, A11)

These bits are reserved for future operations. They must be set to "0" for normal operation

8. OPERATING MODES

8.1. Simplified Truth Table

SYM.	COMMAND	DEVICE STATE	CKEN-1	CKEN	DM(4)	BS0, BS1	A10	A11, A9-A0	CS	RAS	CAS	WE
ACT	Bank Active	Idle(3)	H	X	X	V	V	V	L	L	H	H
PRE	Bank Precharge	Any(3)	H	X	X	V	L	X	L	L	H	L
PREA	Precharge All	Any	H	X	X	X	H	X	L	L	H	L
WRIT	Write	Active(3)	H	X	X	V	L	V	L	H	L	L
WRITA	Write with Auto Precharge	Active(3)	H	X	X	V	H	V	L	H	L	L
READ	Read	Active(3)	H	X	X	V	L	V	L	H	L	H
READA	Read with Auto Precharge	Active(3)	H	X	X	V	H	V	L	H	L	H
MRS	Mode Register	Idle	H	X	X	L, L	C	C	L	L	L	L
EMRS	Extended Mode Register Set	Idle	H	X	X	H, L	V	V	L	L	L	L
NOP	No Operation	Any	H	X	X	X	X	X	L	H	H	H
BST	Burst Read Stop	Active	H	X	X	X	X	X	L	H	H	L
DSL	Device Deselect	Any	H	X	X	X	X	X	H	X	X	X
AREF	Auto Refresh	Idle	H	H	X	X	X	X	L	L	L	H
SELF	Self Refresh	Idle	H	L	X	X	X	X	L	L	L	H
SELEX	Self Refresh Exit	Idle (Self Refresh)	L	H	X	X	X	X	H	X	X	X
									L	H	H	X
PD	Power Down Mode Entry	Idle/ Active(5)	H	L	X	X	X	X	H	X	X	X
									L	H	H	X
PDEX	Power Down Mode Exit	Any (Power Down)	L	H	X	X	X	X	H	X	X	X
									L	H	H	X
WDE	Data Write Enable	Active	H	X	L	X	X	X	X	X	X	X
WDD	Data Write Disable	Active	H	X	H	X	X	X	X	X	X	X

Notes:

(1) V = Valid X = Don't Care L = Low level H = High level

(2) CKEn signal is input level when commands are issued.

CKEn-1 signal is input level one clock cycle before the commands are issued.

(3) These are state designated by the BS0, BS1 signals.

(4) LDM, UDM

(5) Power Down Mode can not entry in the burst cycle

Function Truth Table

(Note 1)

STATE	CS	RAS	CAS	WE	ADDRESS	COMMAND	ACTION	NOTES
Idle	H	X	X	X	X	DSL	Nop	
	L	H	H	X	X	NOP/BST	Nop	
	L	H	L	H	BS, CA, A10	READ/READA	ILLEGAL	3
	L	H	L	L	BS, CA, A10	WRIT/WRITA	ILLEGAL	3
	L	L	H	H	BS, RA	ACT	Row activating	
	L	L	H	L	BS, A10	PRE/PREA	Nop	
	L	L	L	H	X	AREF/SELF	Refresh or Self refresh	2
	L	L	L	L	Op-Code	MRS/EMRS	Mode register accessing	2
Row Active	H	X	X	X	X	DSL	Nop	
	L	H	H	X	X	NOP/BST	Nop	
	L	H	L	H	BS, CA, A10	READ/READA	Begin read: Determine AP	4
	L	H	L	L	BS, CA, A10	WRIT/WRITA	Begin write: Determine AP	4
	L	L	H	H	BS, RA	ACT	ILLEGAL	3
	L	L	H	L	BS, A10	PRE/PREA	Precharge	5
	L	L	L	H	X	AREF/SELF	ILLEGAL	
	L	L	L	L	Op-Code	MRS/EMRS	ILLEGAL	
Read	H	X	X	X	X	DSL	Continue burst to end	
	L	H	H	H	X	NOP	Continue burst to end	
	L	H	H	L	X	BST	Burst stop	
	L	H	L	H	BS, CA, A10	READ/READA	Term burst, new read: Determine AP	6
	L	H	L	L	BS, CA, A10	WRIT/WRITA	ILLEGAL	
	L	L	H	H	BS, RA	ACT	ILLEGAL	3
	L	L	H	L	BS, A10	PRE/PREA	Term burst, precharging	
	L	L	L	H	X	AREF/SELF	ILLEGAL	
	L	L	L	L	Op-Code	MRS/EMRS	ILLEGAL	
Write	H	X	X	X	X	DSL	Continue burst to end	
	L	H	H	H	X	NOP	Continue burst to end	
	L	H	H	L	X	BST	ILLEGAL	
	L	H	L	H	BS, CA, A10	READ/READA	Term burst, start read: Determine AP	6, 7
	L	H	L	L	BS, CA, A10	WRIT/WRITA	Term burst, start read: Determine AP	6
	L	L	H	H	BS, RA	ACT	ILLEGAL	3
	L	L	H	L	BS, A10	PRE/PREA	Term burst. precharging	8
	L	L	L	H	X	AREF/SELF	ILLEGAL	
	L	L	L	L	Op-Code	MRS/EMRS	ILLEGAL	

STATE	CS	RAS	CAS	WE	ADDRESS	COMMAND	ACTION	NOTES
Read with Auto Prechange	H	X	X	X	X	DSL	Continue burst to end	
	L	H	H	H	X	NOP	Continue burst to end	
	L	H	H	L	X	BST	ILLEGAL	
	L	H	L	H	BS, CA, A10	READ/READA	ILLEGAL	
	L	H	L	L	BS, CA, A10	WRIT/WRITA	ILLEGAL	3
	L	L	H	H	BS, RA	ACT	ILLEGAL	3
	L	L	H	L	BS, A10	PRE/PREA	ILLEGAL	
	L	L	L	H	X	AREF/SELF	ILLEGAL	
	L	L	L	L	Op-Code	MRS/EMRS	ILLEGAL	
Write with Auto Precharge	H	X	X	X	X	DSL	Continue burst to end	
	L	H	H	H	X	NOP	Continue burst to end	
	L	H	H	L	X	BST	ILLEGAL	
	L	H	L	H	BS, CA, A10	READ/READA	ILLEGAL	
	L	H	L	L	BS, CA, A10	WRIT/WRITA	ILLEGAL	
	L	L	H	H	BS, RA	ACT	ILLEGAL	3
	L	L	H	L	BS, A10	PRE/PREA	ILLEGAL	3
	L	L	L	H	X	AREF/SELF	ILLEGAL	
	L	L	L	L	Op-Code	MRS/EMRS	ILLEGAL	
Precharge	H	X	X	X	X	DSL	Nop-> Idle after t_{RP}	
	L	H	H	H	X	NOP	Nop-> Idle after t_{RP}	
	L	H	H	L	X	BST	ILLEGAL	
	L	H	L	H	BS, CA, A10	READ/READA	ILLEGAL	3
	L	H	L	L	BS, CA, A10	WRIT/WRITA	ILLEGAL	3
	L	L	H	H	BS, RA	ACT	ILLEGAL	3
	L	L	H	L	BS, A10	PRE/PREA	Idle after t_{RP}	
	L	L	L	H	X	AREF/SELF	ILLEGAL	
	L	L	L	L	Op-Code	MRS/EMRS	ILLEGAL	
Row Activating	H	X	X	X	X	DSL	Nop-> Row active after t_{RCD}	
	L	H	H	H	X	NOP	Nop-> Row active after t_{RCD}	
	L	H	H	L	X	BST	ILLEGAL	
	L	H	L	H	BS, CA, A10	READ/READA	ILLEGAL	3
	L	H	L	L	BS, CA, A10	WRIT/WRITA	ILLEGAL	3
	L	L	H	H	BS, RA	ACT	ILLEGAL	3
	L	L	H	L	BS, A10	PRE/PREA	ILLEGAL	3
	L	L	L	H	X	AREF/SELF	ILLEGAL	
	L	L	L	L	Op-Code	MRS/EMRS	ILLEGAL	

STATE	CS	RAS	CAS	WE	ADDRESS	COMMAND	ACTION	NOTES
Write Recovering	H	X	X	X	X	DSL	Nop- >Row active after t_{WR}	
	L	H	H	H	X	NOP	Nop- >Row active after t_{WR}	
	L	H	H	L	X	BST	ILLEGAL	
	L	H	L	H	BS, CA, A10	READ/READA	ILLEGAL	3
	L	H	L	L	BS, CA, A10	WRIT/WRITA	ILLEGAL	3
	L	L	H	H	BS, RA	ACT	ILLEGAL	3
	L	L	H	L	BS, A10	PRE/PREA	ILLEGAL	3
	L	L	L	H	X	AREF/SELF	ILLEGAL	
	L	L	L	L	Op-Code	MRS/EMRS	ILLEGAL	
Write Recovering with Auto Precharge	H	X	X	X	X	DSL	Nop- >Enter precharge after t_{WR}	
	L	H	H	H	X	NOP	Nop- >Enter precharge after t_{WR}	
	L	H	H	L	X	BST	ILLEGAL	
	L	H	L	H	BS, CA, A10	READ/READA	ILLEGAL	3
	L	H	L	L	BS, CA, A10	WRIT/WRITA	ILLEGAL	3
	L	L	H	H	BS, RA	ACT	ILLEGAL	3
	L	L	H	L	BS, A10	PRE/PREA	ILLEGAL	3
	L	L	L	H	X	AREF/SELF	ILLEGAL	
	L	L	L	L	Op-Code	MRS/EMRS	ILLEGAL	
Refreshing	H	X	X	X	X	DSL	Nop->Idle after t_{RC}	
	L	H	H	H	X	NOP	Nop->Idle after t_{RC}	
	L	H	H	L	X	BST	ILLEGAL	
	L	H	L	H	X	READ/WRIT	ILLEGAL	
	L	L	H	X	X	ACT/PRE/PREA	ILLEGAL	
	L	L	L	X	X	AREF/SELF/MRS/ EMRS	ILLEGAL	
Mode Register Accessing	H	X	X	X	X	DSL	Nop- >Row after t_{MRD}	
	L	H	H	H	X	NOP	Nop->Row after t_{MRD}	
	L	H	H	L	X	BST	ILLEGAL	
	L	H	L	X	X	READ/WRIT	ILLEGAL	
	L	L	X	X	X	ACT/PRE/PREA/ AREF/SELF/MRS/ EMRS	ILLEGAL	

Notes:

1. All entries assume that CKE was active (High level) during the preceding clock cycle and the current clock cycle.
2. Illegal if any bank is not idle.
3. Illegal to bank in specified states; Function may be legal in the bank indicated by Bank Address (BS), depending on the state of that bank.
4. Illegal if tRCD is not satisfied.
5. Illegal if tRAS is not satisfied.
6. Must satisfy burst interrupt condition.
7. Must avoid bus contention, bus turn around, and/or satisfy write recovery requirements.
8. Must mask preceding data which don't satisfy tWR

Remark: H = High level, L = Low level, X = High or Low level (Don't care), V = Valid data

Function Truth Table for CKE

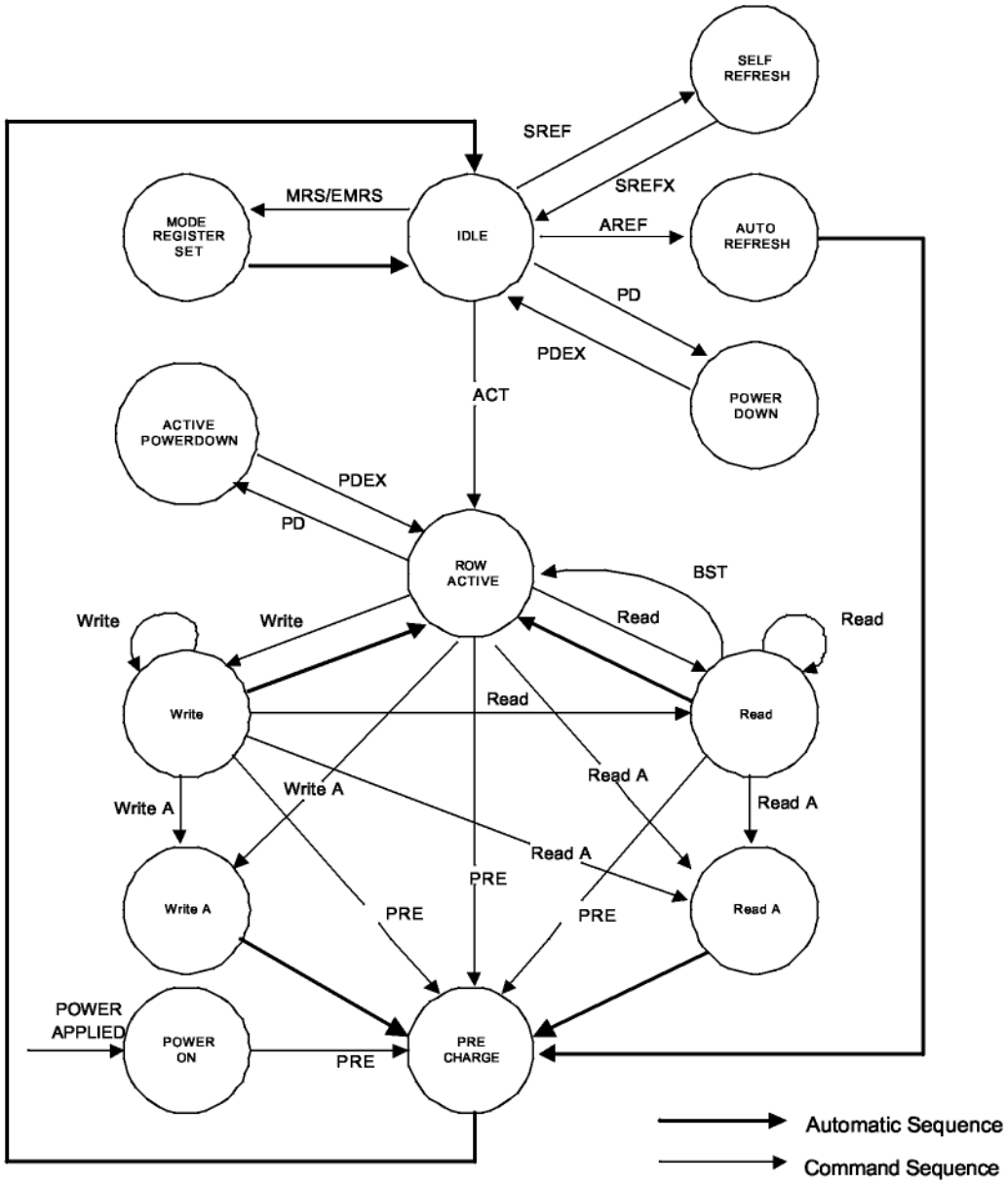
STATE	CKE		CS	RAS	CAS	WE	ADDRESS	ACTION	NOTES
	n-1	n							
Self Refresh	H	X	X	X	X	X	X	INVALID	
	L	H	H	X	X	X	X	Exit Self Refresh- >Idle after t_{XSNR}	
	L	H	L	H	H	X	X	Exit Self Refresh- >Idle after t_{XSNR}	
	L	H	L	H	L	X	X	ILLEGAL	
	L	H	L	L	X	X	X	ILLEGAL	
	L	L	X	X	X	X	X	Maintain Self Refresh	
Power Down	H	X	X	X	X	X	X	INVALID	
	L	H	X	X	X	X	X	Exit Power down->Idle after t_{IS}	
	L	L	X	X	X	X	X	Maintain power down mode	
All banks Idle	H	H	X	X	X	X	X	Refer to Function Truth Table	
	H	L	H	X	X	X	X	Enter Power down	2
	H	L	L	H	H	X	X	Enter Power down	2
	H	L	L	L	L	H	X	Self Refresh	1
	H	L	L	H	L	X	X	ILLEGAL	
	H	L	L	L	X	X	X	ILLEGAL	
	L	X	X	X	X	X	X	Power down	2
Row Active	H	H	X	X	X	X	X	Refer to Function Truth Table	
	H	L	H	X	X	X	X	Enter Power down	2
	H	L	L	H	H	X	X	Enter Power down	2
	H	L	L	L	L	H	X	ILLEGAL	
	H	L	L	H	L	X	X	ILLEGAL	
	H	L	L	L	X	X	X	ILLEGAL	
	L	X	X	X	X	X	X	Power down	
Any State Other Than Listed Above	H	H	X	X	X	X	X	Refer to Function Truth Table	

Notes:

1. Self refresh can enter only from the all banks idle state.
2. Power down can enter only from bank idle or row active state.

Remark: H = High level, L = Low level, X = High or Low level (Don't care), V = Valid data

8.2. SIMPLIFIED STATE DIAGRAM



9. ABSOLUTE MAXIMUM RATINGS

PARAMETER	SYMBOL	RATING	UNIT	NOTES
Input, Output Voltage	V_{IN}, V_{OUT}	-0.3—V_{DD}Q+0.3	V	1
Power Supply Voltage	V_{DD}, V_{DD}Q	-0.3—3.6	V	PowerUP time>180 μs
Operating Temperature	T_{OPR}	0—70	°C	1
Storage Temperature	T_{STG}	-55—150	°C	1
Soldering Temperature (10s)	T_{SOLDER}	260	°C	1
Power Dissipation	P_D	1	W	1
Short Circuit Output Current	I_{OUT}	50	mA	1

Note: Exposure to conditions beyond those listed under Absolute Maximum Ratings may adversely affect the life and reliability of the device.

10. RECOMMENDED DC OPERATING CONDITIONS

(T_A = 0 to 70℃)

SYMBOL	PARAMETER	MIN.	TYP.	MAX.	UNIT	NOTES
V_{DD}	Power Supply Voltage	2.3	2.5	2.7	V	2
V_{DD}Q	Power Supply Voltage (for I/O Buffer)	2.3	2.5	2.7	V	2
V_{REF}	Input reference Voltage	0.49 x V_{DD}Q	0.50 x V_{DD}Q	0.51 x V_{DD}Q	V	2, 3
V_{TT}	Termination Voltage (System)	V_{REF} -0.04	V_{REF}	V_{REF} +0.04	V	2, 8
V_{IH} (DC)	Input High Voltage (DC)	V_{REF} +0.15	-	V_{DD}Q +0.3	V	2
V_{IL} (DC)	Input Low Voltage (DC)	-0.3	-	V_{REF} -0.15	V	2
V_{ICK} (DC)	Differential Clock DC Input Voltage	-0.3	-	V_{DD}Q +0.3	V	15
V_{ID} (DC)	Input Differential Voltage. CLK and !CLK inputs (DC)	0.36	-	V_{DD}Q +0.6	V	13, 15
V_{IH} (AC)	Input High Voltage (AC)	V_{REF} +0.31	-	-	V	2
V_{IL} (AC)	Input Low Voltage (AC)	-	-	V_{REF} -0.31	V	2
V_{ID} (AC)	Input Differential Voltage. CLK and !CLK inputs (AC)	0.7	-	V_{DD}Q +0.6	V	13, 15
V_X (AC)	Differential AC input Cross Point Voltage	V_{DD}Q/2 -0.2	-	V_{DD}Q/2 +0.2	V	12, 15
V_{ISO} (AC)	Differential Clock AC Middle Point	V_{DD}Q/2 -0.2	-	V_{DD}Q/2 +0.2	V	14, 15

Note:

Undershoot Limit: VIL (min) = -0.9V with a pulse width < 5 nS

Overshoot Limit: VIH (max) = VDDQ +0.9V with a pulse width < 5 nS

VIH (DC) and V IL (DC) are levels to maintain the current logic state.

VIH (AC) and V IL (AC) are levels to change to the new logic state.

11. CAPACITANCE

(V_{DD} = V_{DD}Q = 2.5V ±0.2V, f = 1 MHz, TA = 25° C, V_{OUT} (DC) = V_{DD}Q/2, V_{OUT} (Peak to Peak) = 0.2V)

SYMBOL	PARAMETER	MIN.	MAX.	UNIT
CIN	Input Capacitance (except for CLK pins)	2.0	4.0	pF
CCLK	Input Capacitance (CLK pins)	3.0	5.0	pF
CI/O	DQ, DQS, DM Capacitance	1.5	5.5	pF
CNC1	NC1 Pin Capacitance	-	1.5	pF

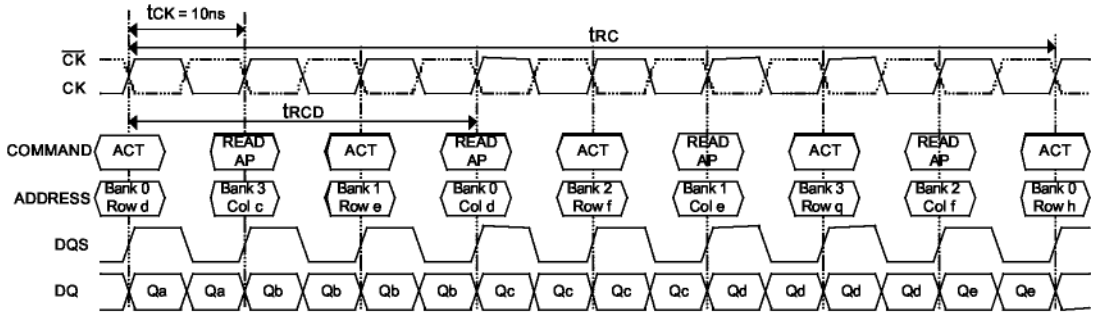
Note: These parameters are periodically sampled and not 100% tested

12. LEAKAGE AND OUPPUT BUFFER CHARACTERISTICS

SYMBOL	PARAMETER		MIN.	MAX.	UNITS	NOTES
I_I (L)	In put Leakage Current ($0V < V_{IN} < V_{DD}Q$, All other pins not under test = 0V)		-2	2	μA	
I_O (L)	Output Leakage Current (Output disabled, $0V < V_{OUT} < V_{DD}Q$)		-5	5	μA	
V_{OH}	Output High Voltage (under AC test load condition)	Full Strength	V_{TT}+0.76	-	V	
V_{OL}	Output Low Voltage (under AC test load condition)		-	V_{TT} -0.76	V	
I_{OH} (DC)	Output Minimum Source DC Current		-15.2	-	mA	4, 6
I_{OL} (DC)	Output Minimum Sink DC Current		15.2	-	mA	4, 6
I_{OH} (DC)	Output Minimum Source DC Current	Half Strength	-10.4	-	mA	5
I_{OL} (DC)	Output Minimum Sink DC Current		10.4	-	mA	5
I_{OH} (DC)	Output Minimum Source DC Current	Matched Impedance	-5.2	-	mA	5
I_{OL} (DC)	Output Minimum Sink DC Current		5.2	-	mA	5

13. DC CHARACTERISTICS

SYM.	PARAMETER	MAX.			UNIT	NOTES
		-5	-6	-75		
I_{DD1}	OPERATING CURRENT: One Bank Active-Read-Precharge	140	130	120	mA	7, 9
I_{DD2P}	PRECHARGE-POWER-DOWN STANDBY CURRENT	20	20	20		
I_{DD2N}	IDLE STANDBY CURRENT	45	45	45		7
I_{DD3P}	ACTIVE POWER-DOWN STANDBY CURRENT	20	20	20		
I_{DD3N}	ACTIVE STANDBY CURRENT	60	60	60		7
I_{DD4}	OPERATING CURRENT	180	170	160		7, 9
I_{DD5}	AUTO REFRESH CURRENT	200	190	180	mA	7
I_{DD6}	SELF REFRESH CURRENT	3.2	3	3		
I_{DD7}	RANDOM READ CURRENT	320	300	280		



RANDOM READ CURRENT Timing (I_{DD7})

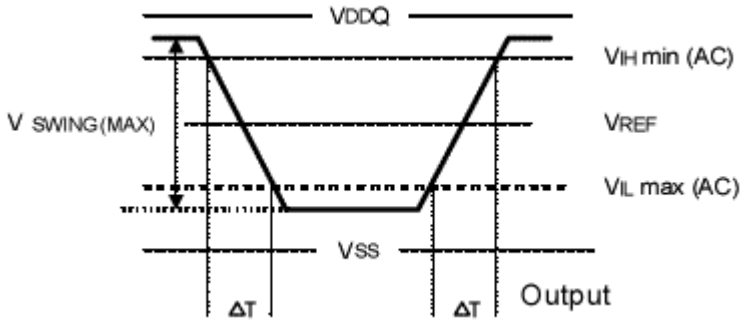
14. AC CHARACTERISTICS

(V_{DD}/V_{DD}Q =2.5 ± 0.2V)

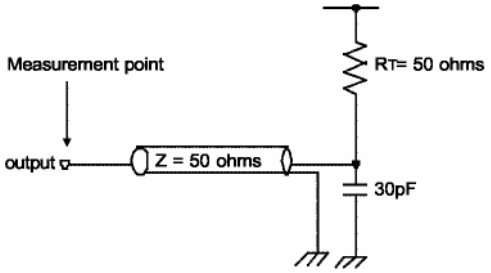
SYMBOL	PARAMETER	-5		-6		-7		UNITS	NOTES
		MIN.	MAX.	MIN.	MAX.	MIN.	MAX.		
tRC	Active to Ref/Active Command Period	60		60		63		ns	
tRFC	Ref to Ref/Active Command Period	63		65		65			
tRAS	Active to Precharge Command Period	40	100000	40	100000	40	100000		
tRCDR	Active to Read Command Delay Time	20		24		28			
tRCDW	Active to Write Command Delay Time	10		12		14			
tRAP	Active to Read with Auto Precharge enable	20		24		28			
tCCD	Read/Write(a) to Read/Write(b) Command Period	1		1		1		tCK	
tRP	Precharge to Active Command Period	20		24		28		ns	
tRRD	Active(a) to Active(b) Command Period	10		12		14			
tWR	Write Recovery time	15		18		21			
tDAL	Auto Precharge Write Recovery + Precharge time	35		42		49			
tCK	CLK Cycle Time CL=3	5	10	6	10	7	10		
tDQSCK	DQS output access time from CLK, CLK	-0.6	0.6	-0.6	0.6	-0.7	0.7		16
tDQSQ	Data Strobe Edge to Output Data Edge Skew		0.4		0.4		0.45		
tCH	CLk High level width	0.45	0.55	0.45	0.55	0.45	0.55		
tCL	CLK Low level width	0.45	0.55	0.45	0.55	0.45	0.55	ns	11
tHP	CLK half period (minimum of actual tCH, tCL)	min (tCL,tCH)		min (tCL,tCH)		min (tCL,tCH)			
tQH	DQ output data hold time from DQS	tHP-0.4		tHP-0.4		tHP-0.45		tCK	
tRPRE	DQS Read Preamble Time	0.7	1.1	0.9	1.1	0.9	1.1		
tRPST	DQS Read Postamble Time	0.4	0.6	0.4	0.6	0.4	0.6	ns	11
tDS	DQ and DM Setup Time	0.4		0.4		0.45			
tDH	DQ and DM Hold Time	0.4		0.4		0.45		tCK	
tDIPW	DQ and DM input pulse width (for each input)	1.75		1.75		1.75			
tDQSH	DQS input high pulse width	0.4	0.6	0.4	0.6	0.4	0.6		
tDQSL	DQS input low pulse width	0.4	0.6	0.4	0.6	0.4	0.6	ns	11
tWPRES	Clock to DQS Write Preamble Set-up Time	0		0		0			
tWPRE	DQS Write Preamble Time	0.3		0.25		0.25		tCK	
tWPST	DQS Write Postamble Time	0.4	0.6	0.4	0.6	0.4	0.6	ns	11
tDQSS	Write command to first DQS latching transition	0.75	1.25	0.8	1.2	0.8	1.2		
tIS	Input Setup Time	0.75		0.9		1			
tIH	Input Hold Time	0.75		0.9		1		tCK	
tIPW	Control & Address input pulse width (for each input)	2.2		2.2		2.5			
tHZ	Data-out High-impedance Time from CLK,CLK	-0.75	0.75	-0.75	0.75	-0.75	0.75		
tLZ	Data-out Low-impedance Time from CLK,CLK	-0.75	0.75	-0.75	0.75	-0.75	0.75		
tT(SS)	SSTL Input Transition	0.5	1.5	0.5	1.5	0.5	1.5		
tWTR	Internal Write to Read command delay	1		1		1			
tXSRD	Exit Self Refresh to Read command	200		200		200		tCK	
tREF	Refresh Time (4k)		64		64		64	ms	
tMRD	Mode Register Set cycle time	10		10		10		ns	

15. AC TEST CONDITIONS

PARAMETER	SYMBOL	VALUE	UNIT
Input High Voltage (AC)	V_{IH}	V_{REF} +0.31	V
Input Low Voltage (AC)	V_{IL}	V_{REF} -0.31	V
Input Reference Voltage	V_{REF}	0.5 x $V_{DD}Q$	V
Termination Voltage	V_{TT}	0.5 x $V_{DD}Q$	V
Input Signal Peak to Peak Swing	V_{SWING}	1.0	V
Differential Clock Input Reference Voltage	V_R	Vx (AC)	V
Input Difference Voltage.CLK and !CLK Inputs (AC)	V_{ID} (AC)	1.5	V
Input Signal Minimum Slew Rate	SLEW	1.0	V/nS
Output Timing Measurement Reference Voltage	V_{OTR}	0.5 x $V_{DD}Q$	V



SLEW = (V IHmin (AC) - VILmax (AC)) / T



A.C. TEST LOAD (A)

Notes:

(1) Conditions outside the limits listed under “ABSOLUTE MAXIMUM RATINGS” may cause permanent damage to the device.

(2) All voltages are referenced to V SS, VSSQ. (2.6V±0.1V for DDR400)

(3) Peak to peak AC noise on VREF may not exceed ±2% VREF(DC).

(4) VOH = 1.95V, VOL = 0.35V

(5) VOH = 1.9V, VOL = 0.4V

(6) The values of IOH(DC) is based on VDDQ = 2.3V and VTT = 1.3V.
The values of IOL(DC) is based on V DDQ = 2.3V and V TT = 1.2V.

(7) These parameters depend on the cycle rate and these values are measured at a cycle rate with the minimum values of tCK and tRC.

(8) VTT is not applied directly to the device. VTT is a system supply for signal termination resistors, is expected to be set equal to VREF and must track variations in the DC level of V REF.

(9) These parameters depend on the output loading. Specified values are obtained with the output open.

(10) Transition times are measured between VIH min(AC) and VIL max(AC).Transition (rise and fall) of input signals have a fixed slope.

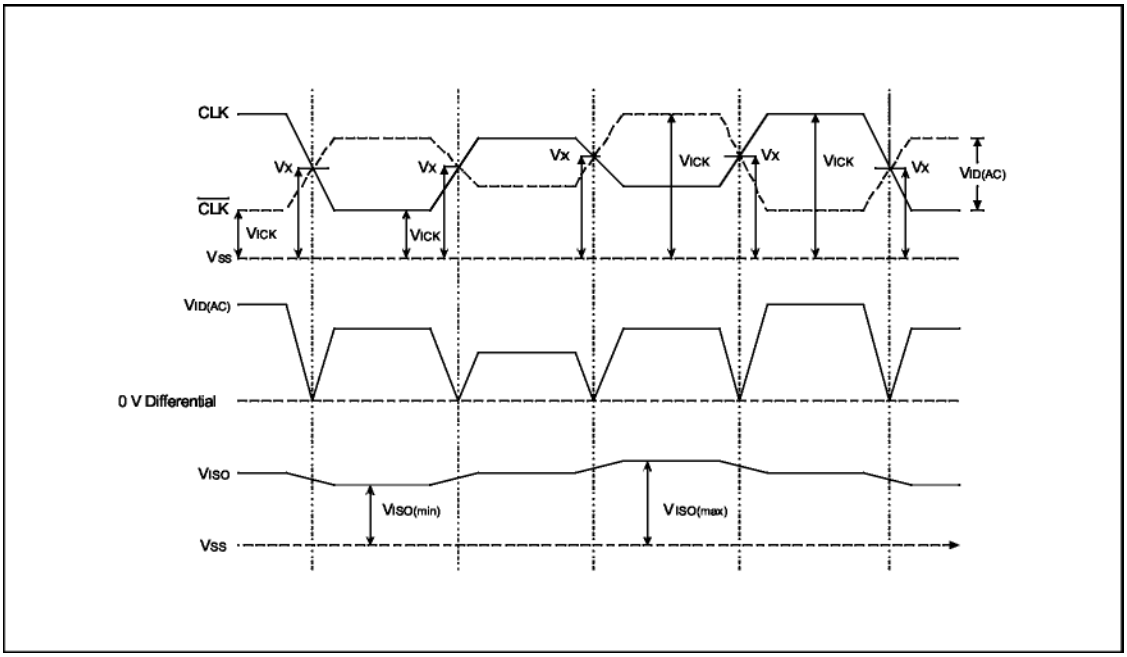
(11) IF the result of nominal calculation with regard to tCK contains more than one decimal place, the result is rounded up to the nearest decimal place.
(i.e., TDQSS = 0.75 ¥ tCK, tCK = 7.5 nS, 0.75 ¥ 7.5 nS = 5.625 nS is rounded up to 5.6 nS.)

(12) VX is the differential clock cross point voltage where input timing measurement is referenced.

(13) VID is magnitude of the difference between CLK input level and CLK input level.

(14) VISO means {VICK(CLK)+VICK(CLK)}/2.

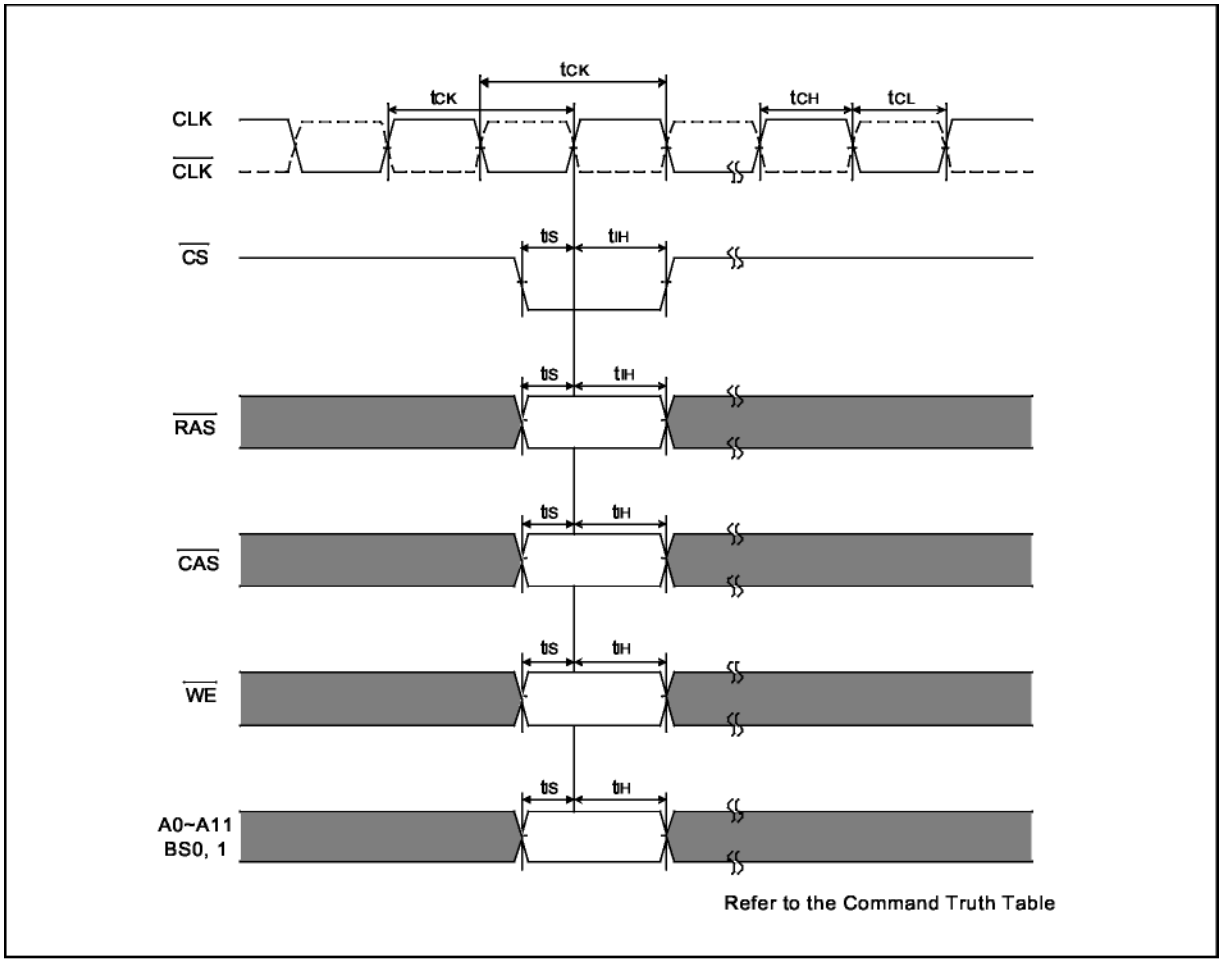
(15) Refer to the figure below.



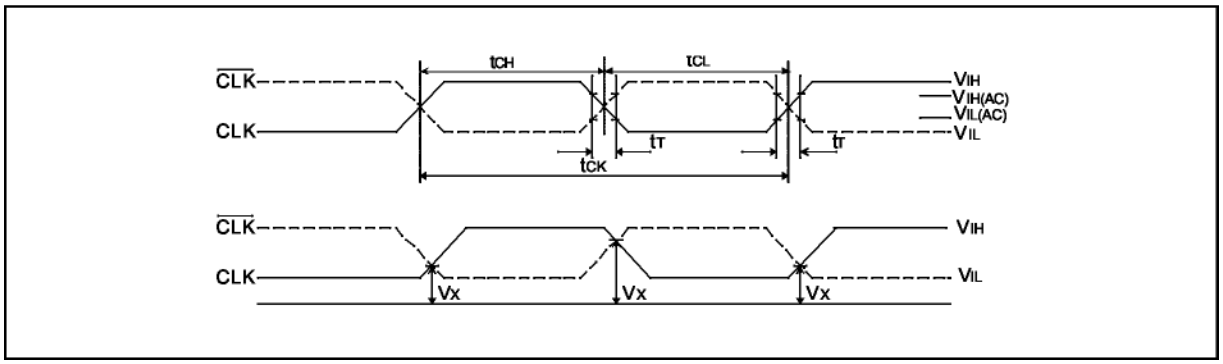
(16) tAC and tDQSCK depend on the clock jitter. These timing are measured at stable clock

16. TIMING WAVEFORMS

16.1. Command Input Timing

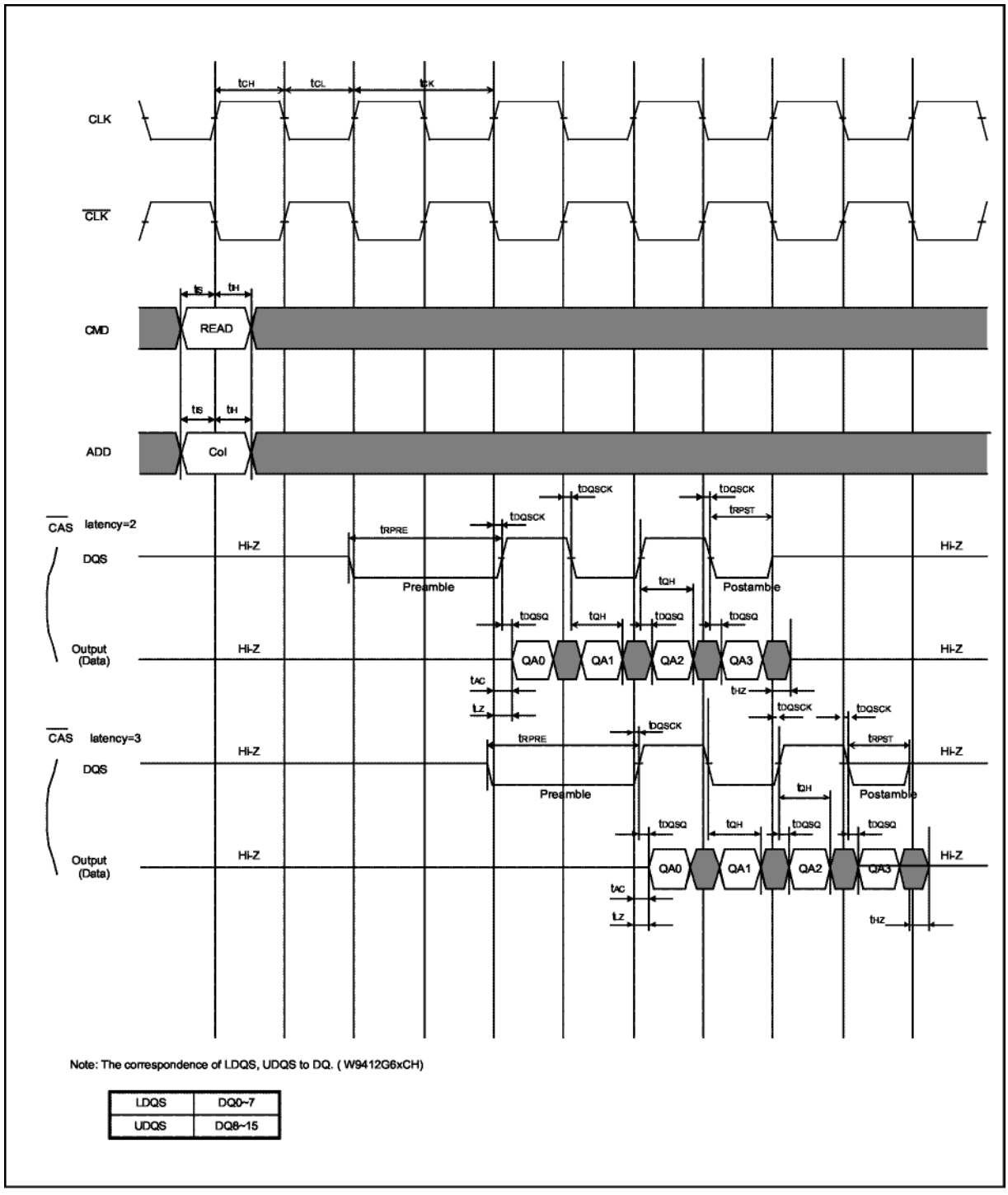


Timing of the CLK Signals



16.2. Read Timing

(Burst Length = 4)

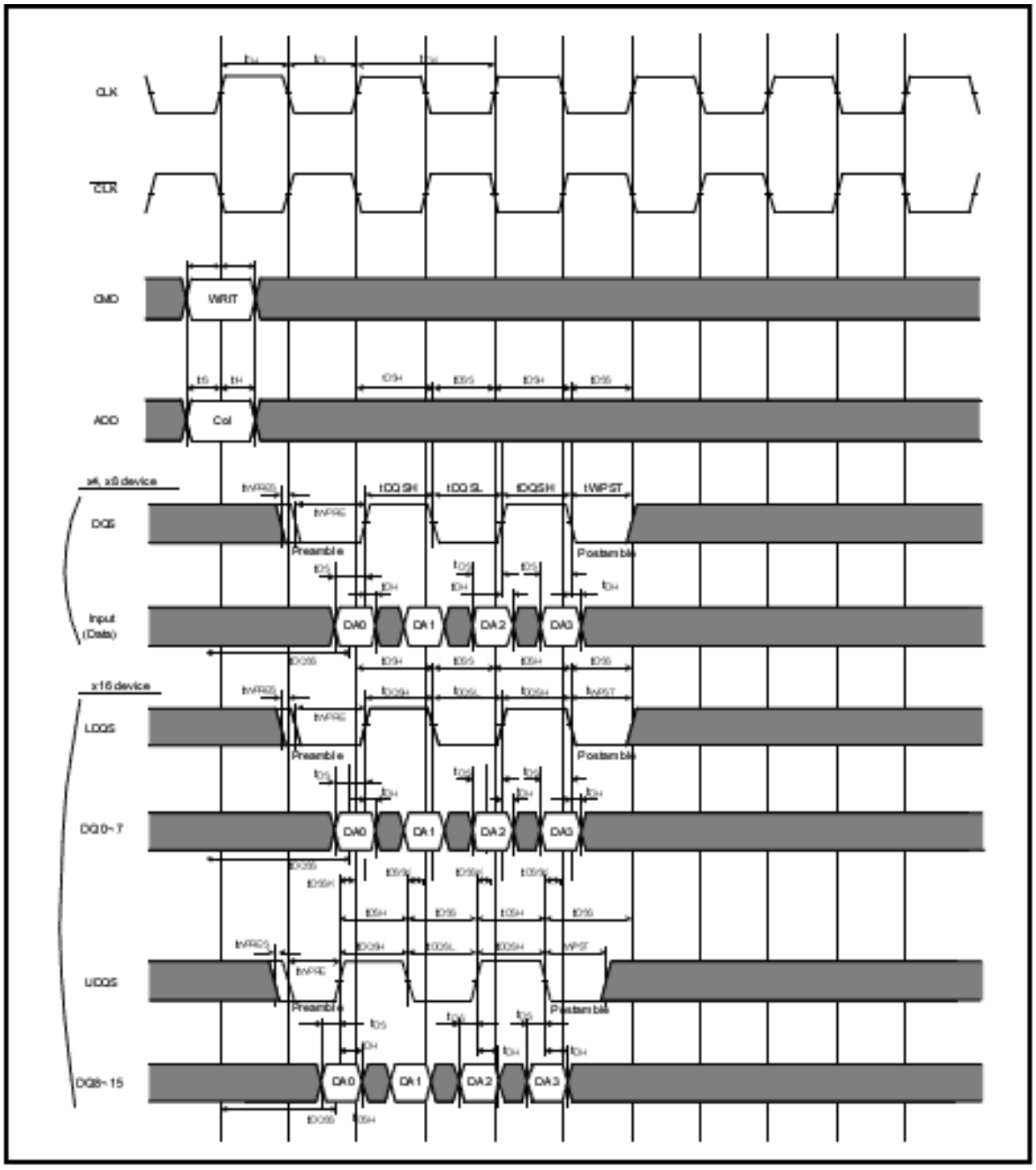


Note: The correspondence of LDQS, UDQS to DQ. (W9412G6xCH)

LDQS	DQ0~7
UDQS	DQ8~15

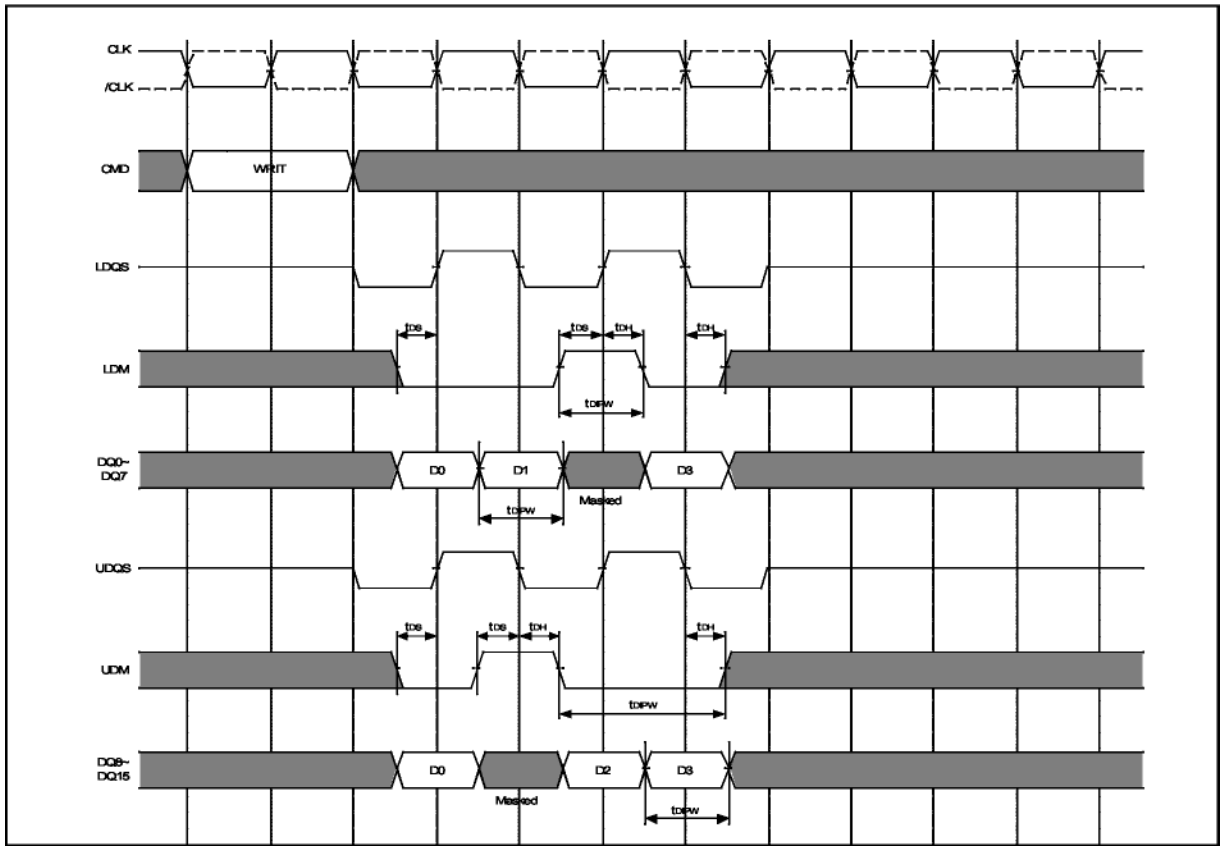
16.3. Write Timing

(Burst Length = 4)

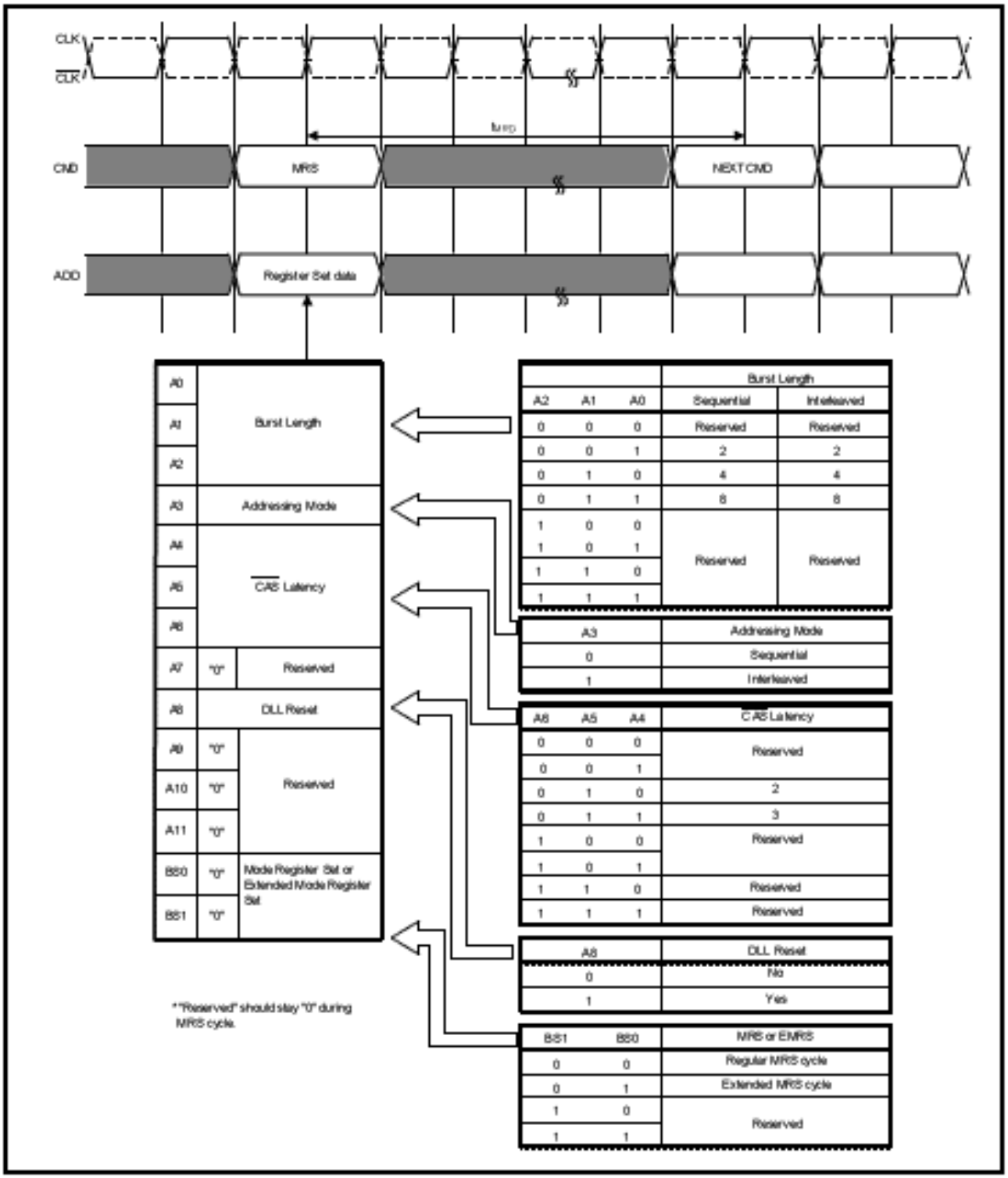


Note: x16 has 2DQS's (UDQS for upper byte and LDQS for lower byte). Even if one of the 2 bytes is not used, both UDQS and LDQS must be toggled.

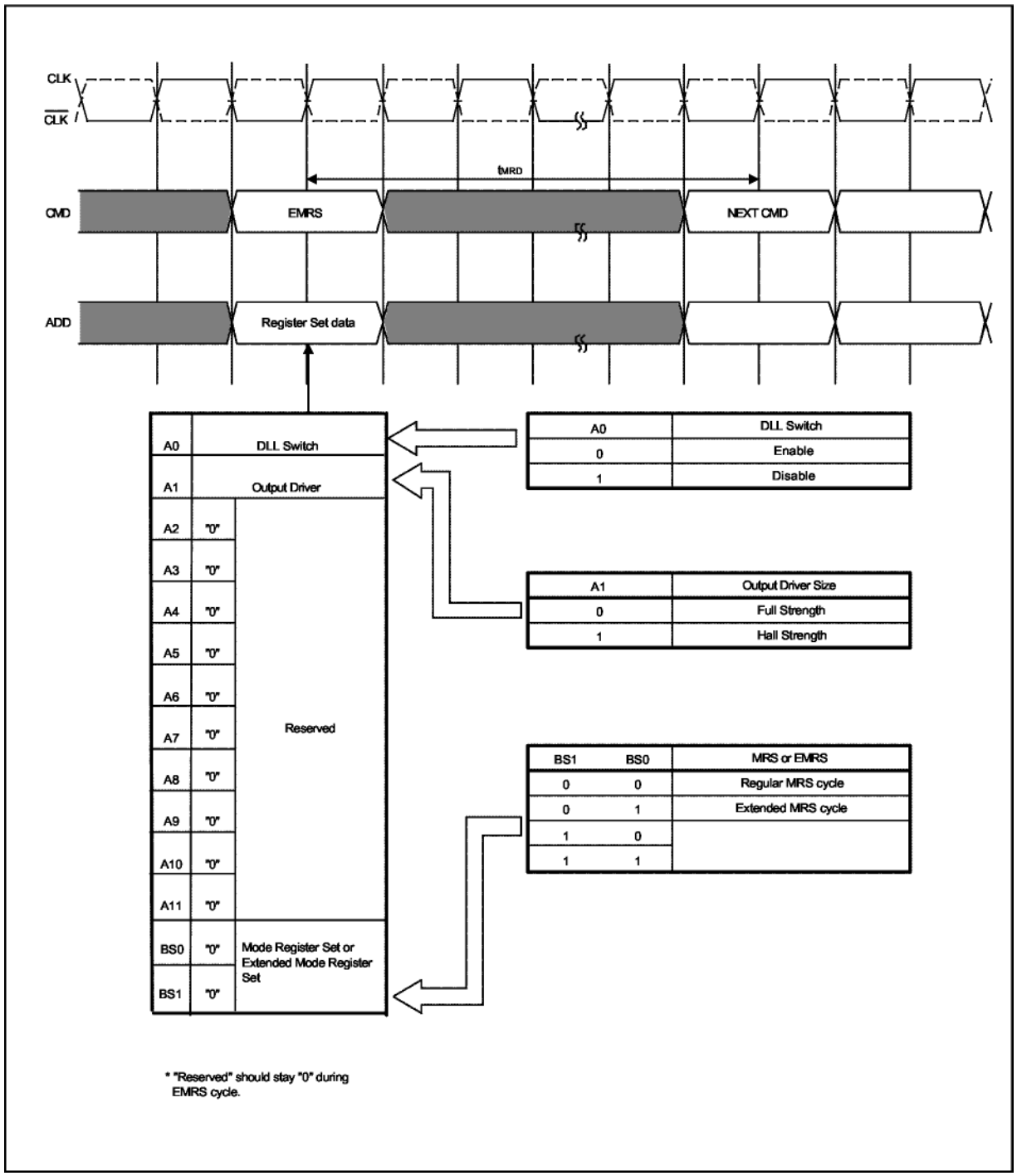
16.4. DM, DATA MASK



16.5. Mode Register Set (MRS) Timing



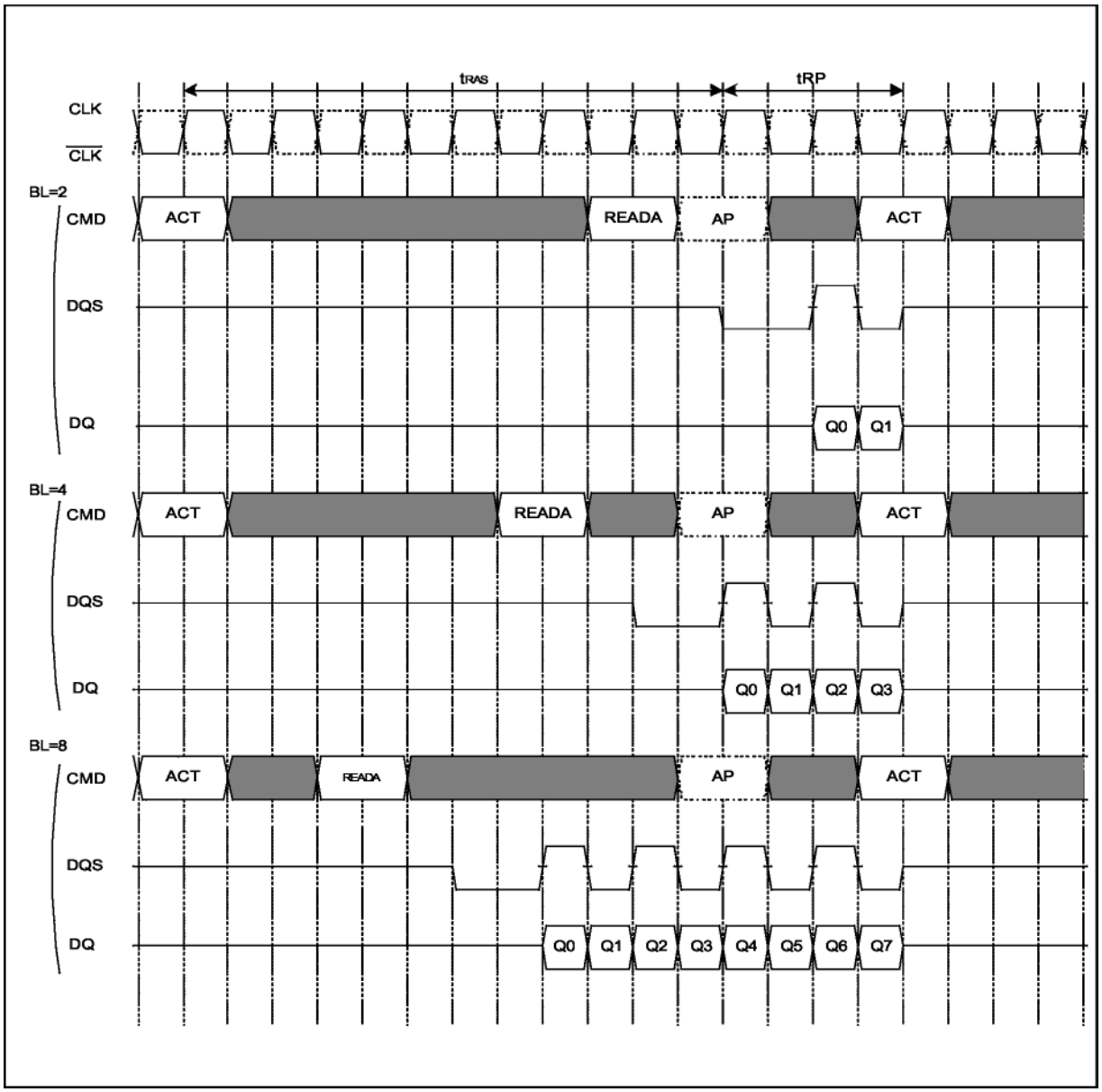
16.6. Extend Mode Register Set (EMRS) Timing



16.7. Auto Precharge Timing

(Read Cycle, CL = 2)

1) tRCD (READA)≧ tRAS (min) – (BL/2) X tCK



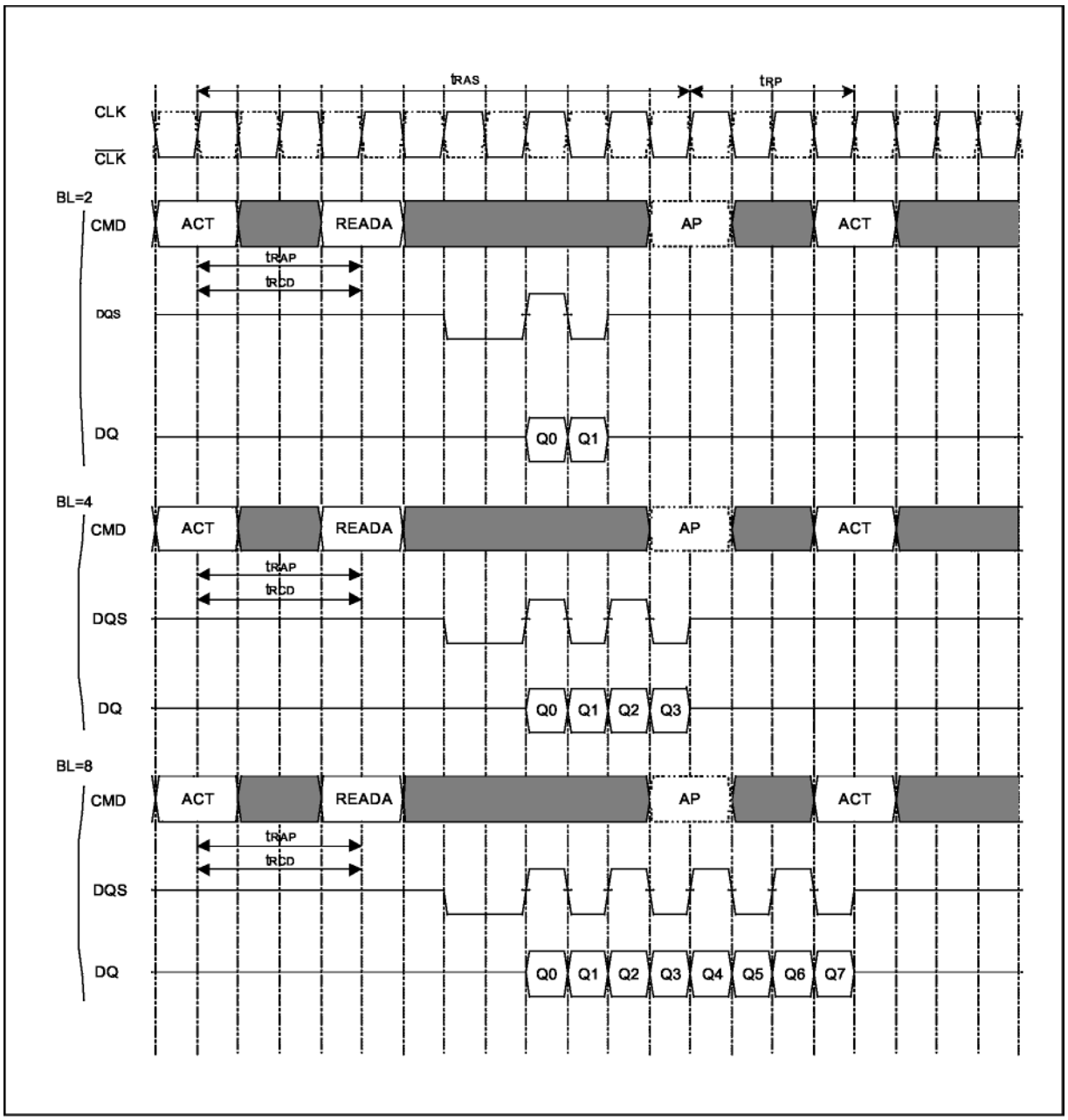
Notes: CL2 shown; same command operation timing with CL = 3

In this case, the internal precharge operation begin after BL/2 cycle from READA command.

AP Represents the start of internal precharging.

The Read with Auto precharge command cannot be interrupted by any other command.

1) tRCD/RAP(min) ≦ tRCD (READA) < tRAS (min) – (BL/2) X tCK



Notes: CL2 shown; same command operation timing with CL = 3

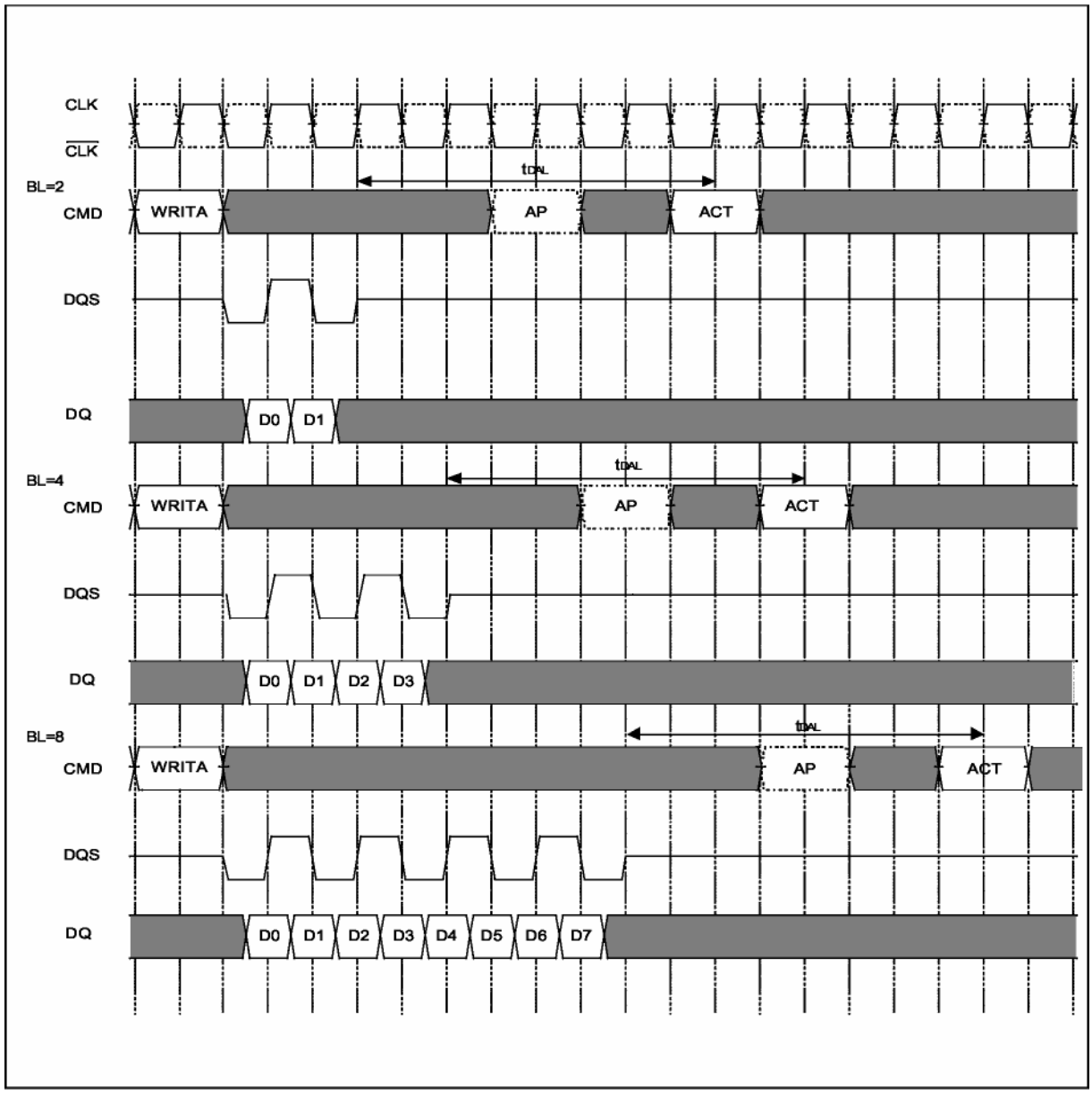
In this case, the internal precharge operation does not begin until after tRAS (min) has command.

AP Represents the start of internal precharging.

The Read with Auto Precharge command cannot be interrupted by any other command.

16.8. Auto Precharge Timing

(Write Cycle)

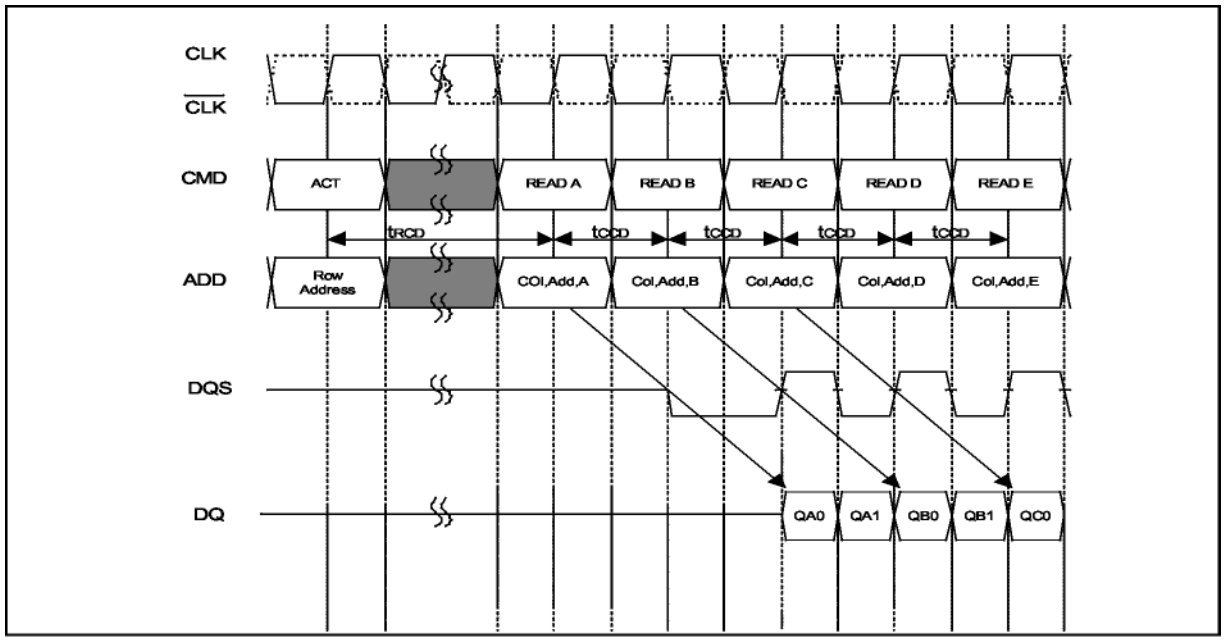


The Write with Auto Precharge command cannot be interrupted by any other command.

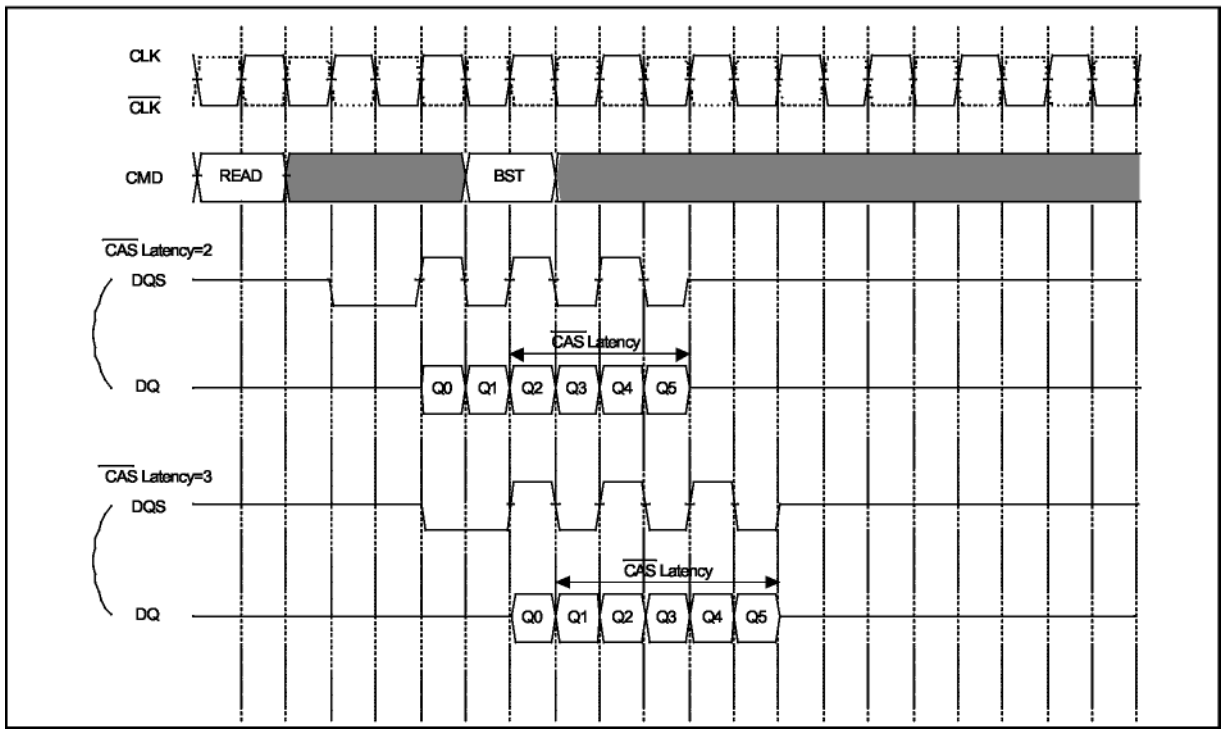
AP Represents the start of internal precharging .

16.9. Read Interrupted by Read

(CL = 2, BL = 2, 4, 8)

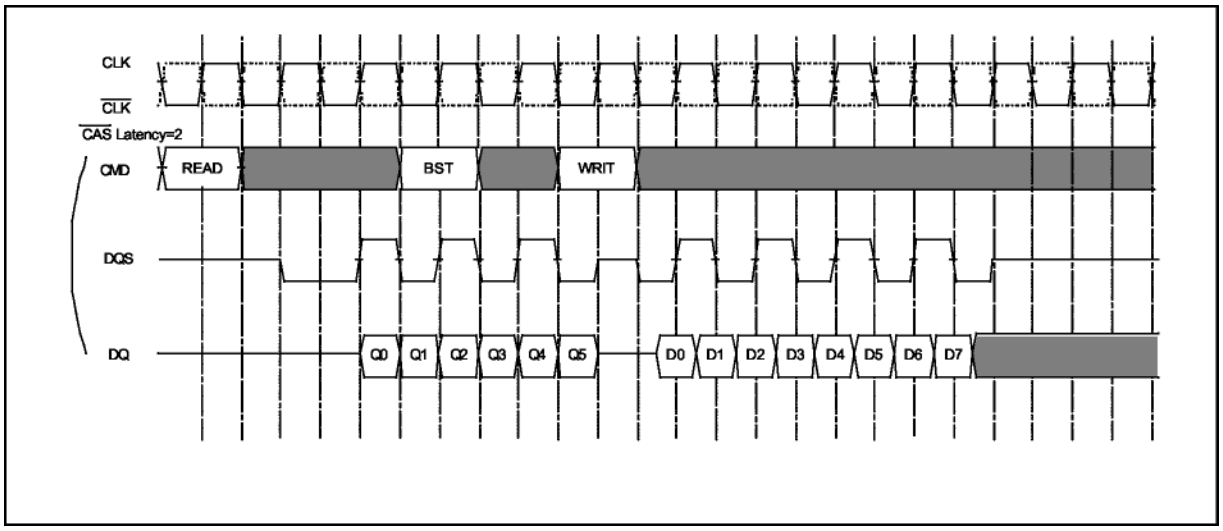


Burst Read Stop (BL = 8)



16.10.Read Interrupted by Write & BST

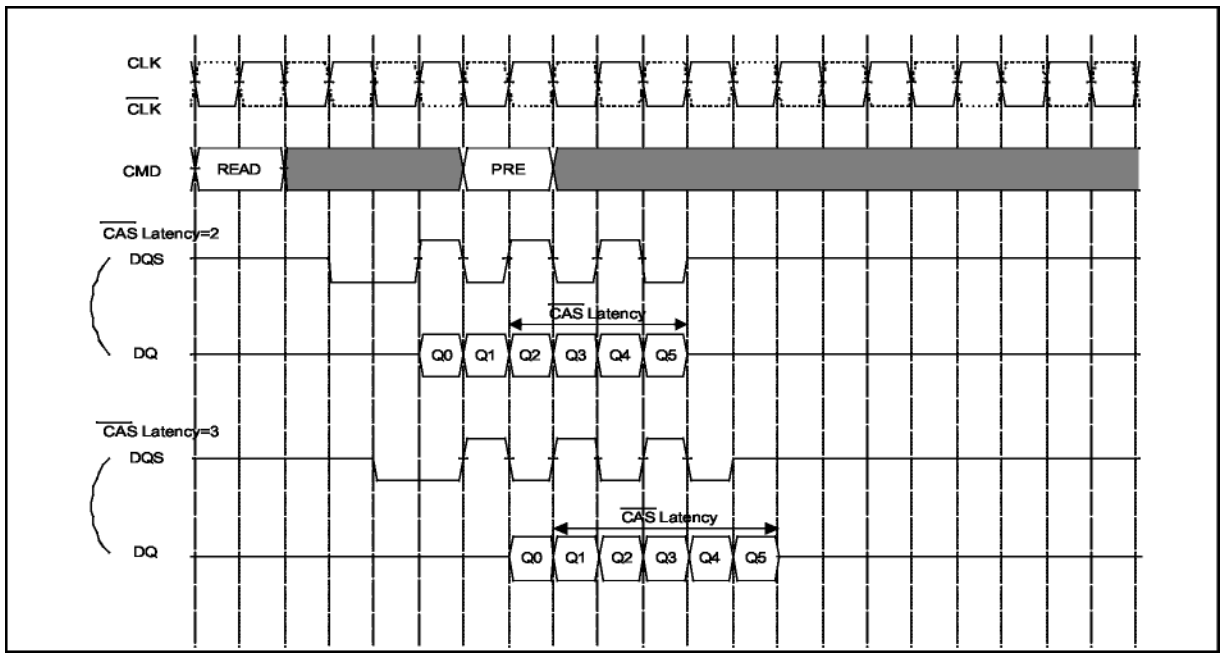
(BL = 8)



Burst Read cycle must be terminated by BST Command to avoid I/O conflict.

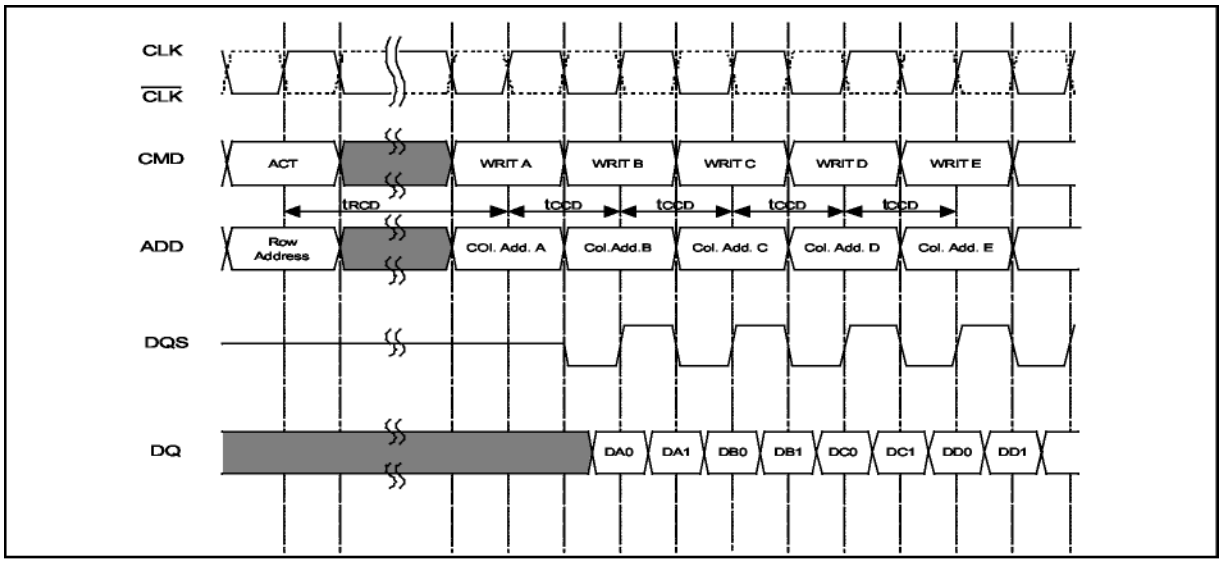
Read Interrupted by Precharge

(BL = 8)

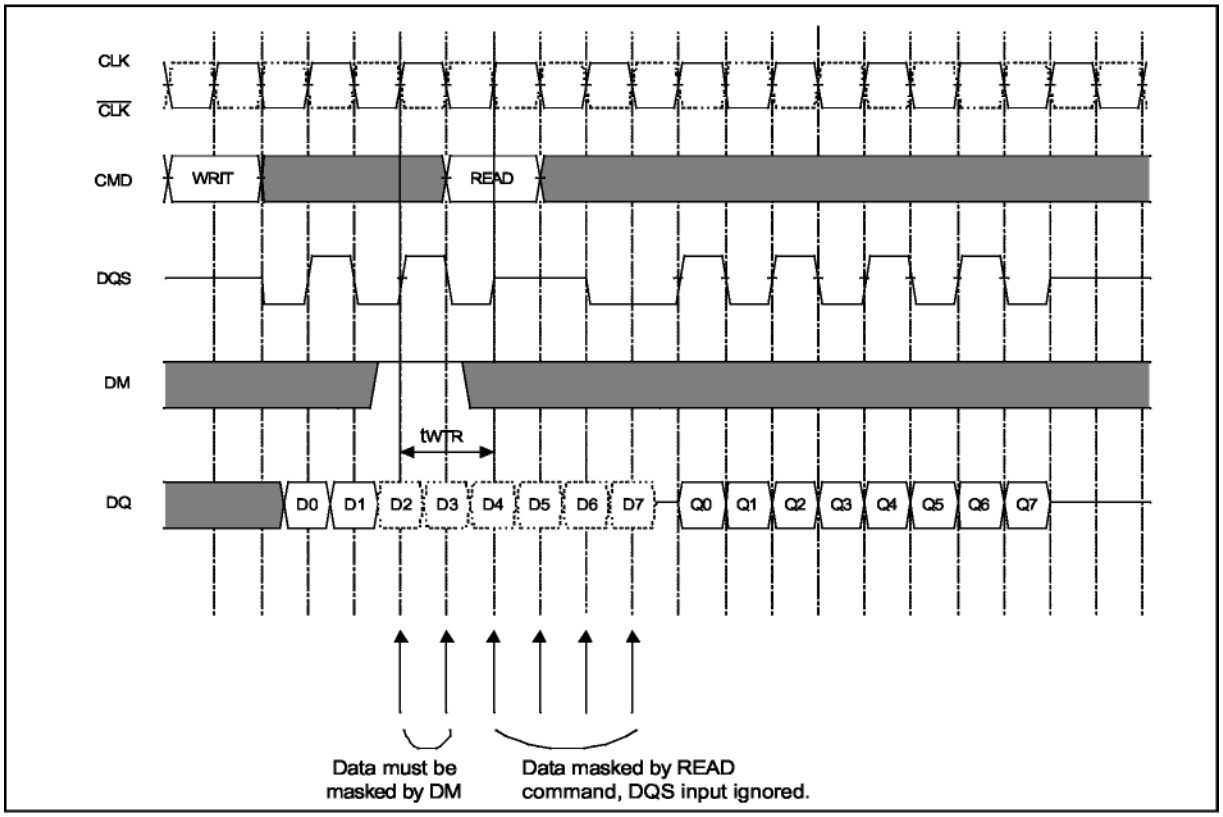


16.11.Write Interrupted by Write

(BL = 2, 4, 8)

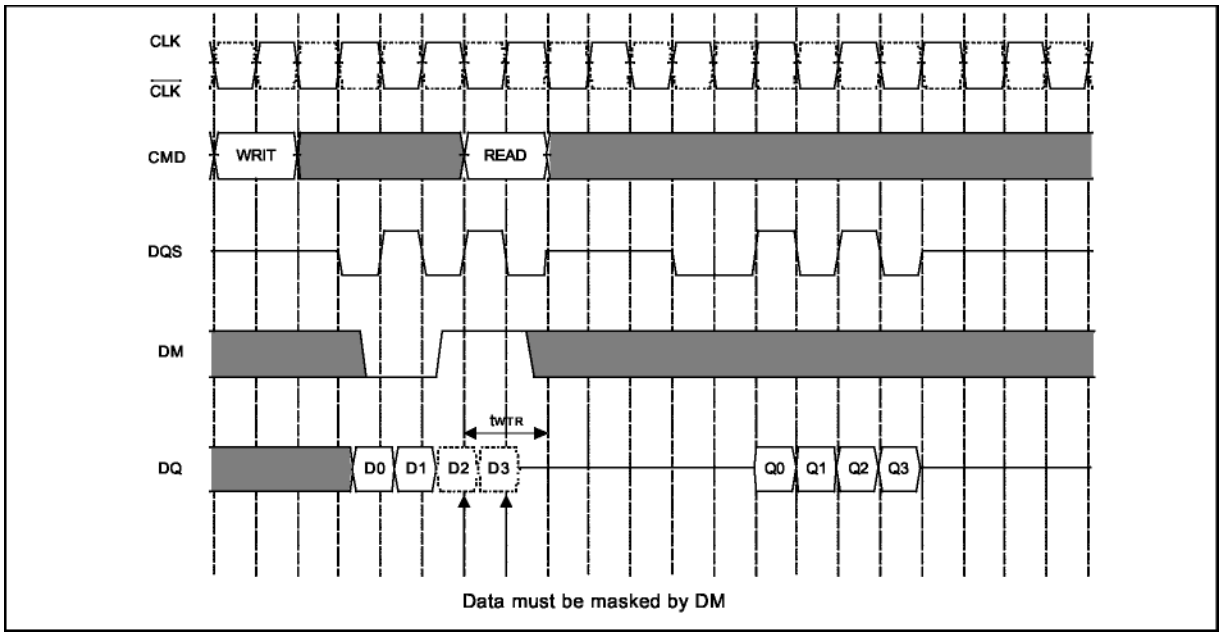


Write Interrupted by Read (CL = 2, BL = 8)



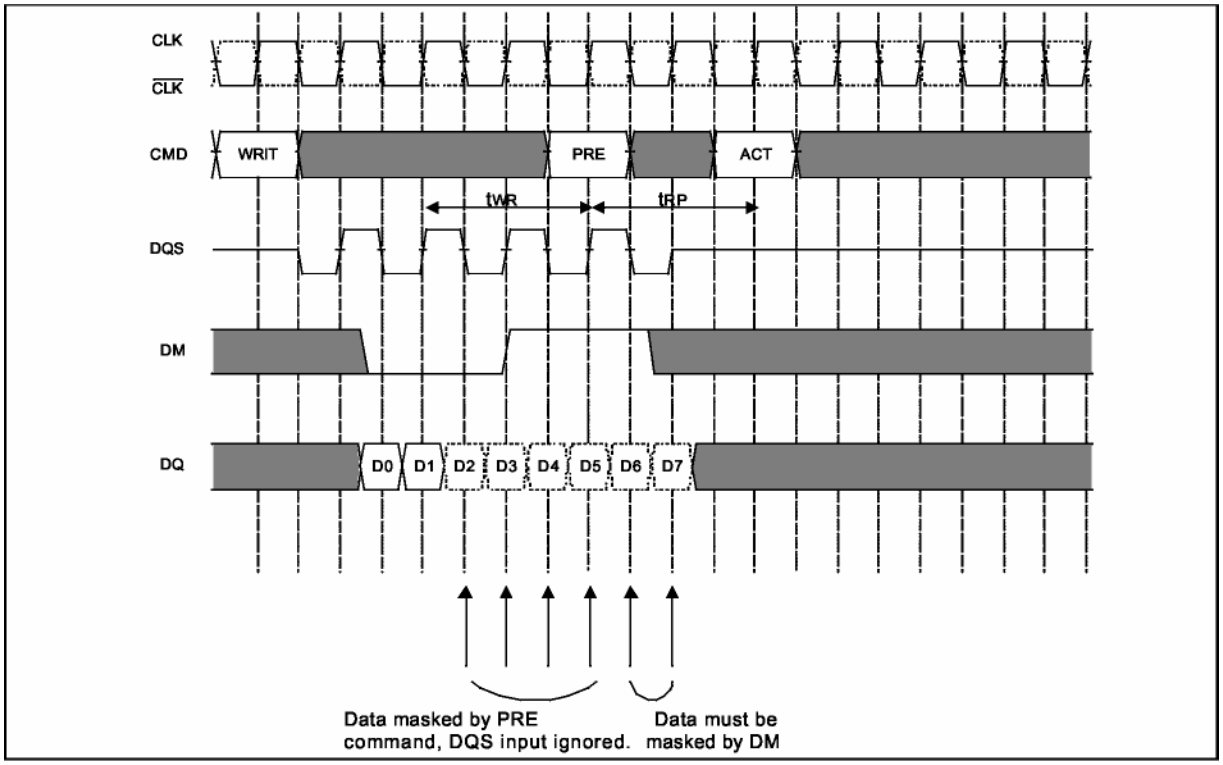
16.12.Write Interrupted by Read

(CL = 3, BL = 4)



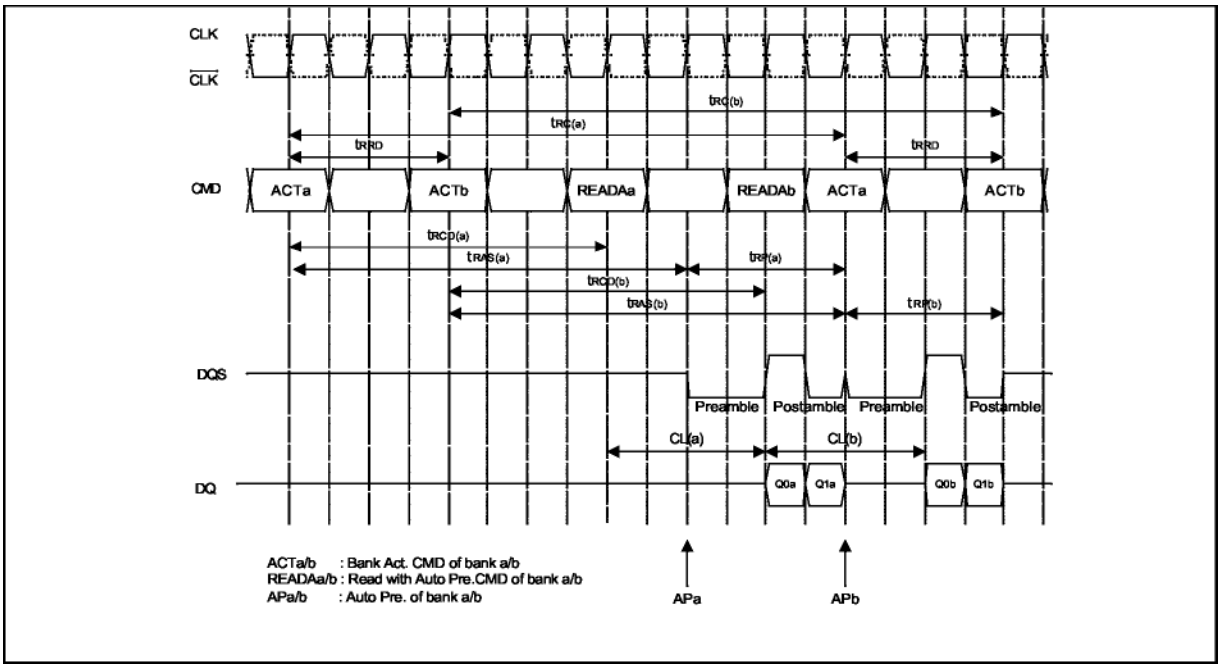
Write Interrupted by Precharge

(BL = 8)



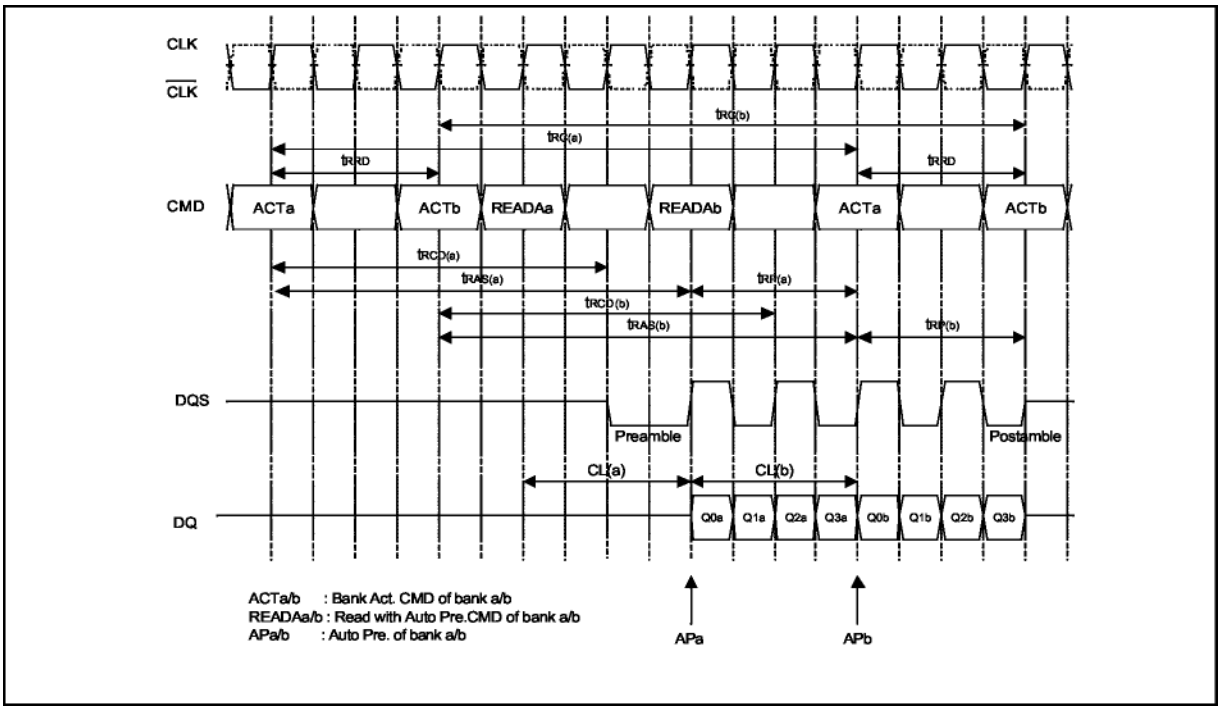
16.13.2 Bank Interleave Read Operation

(CL = 2, BL = 2)



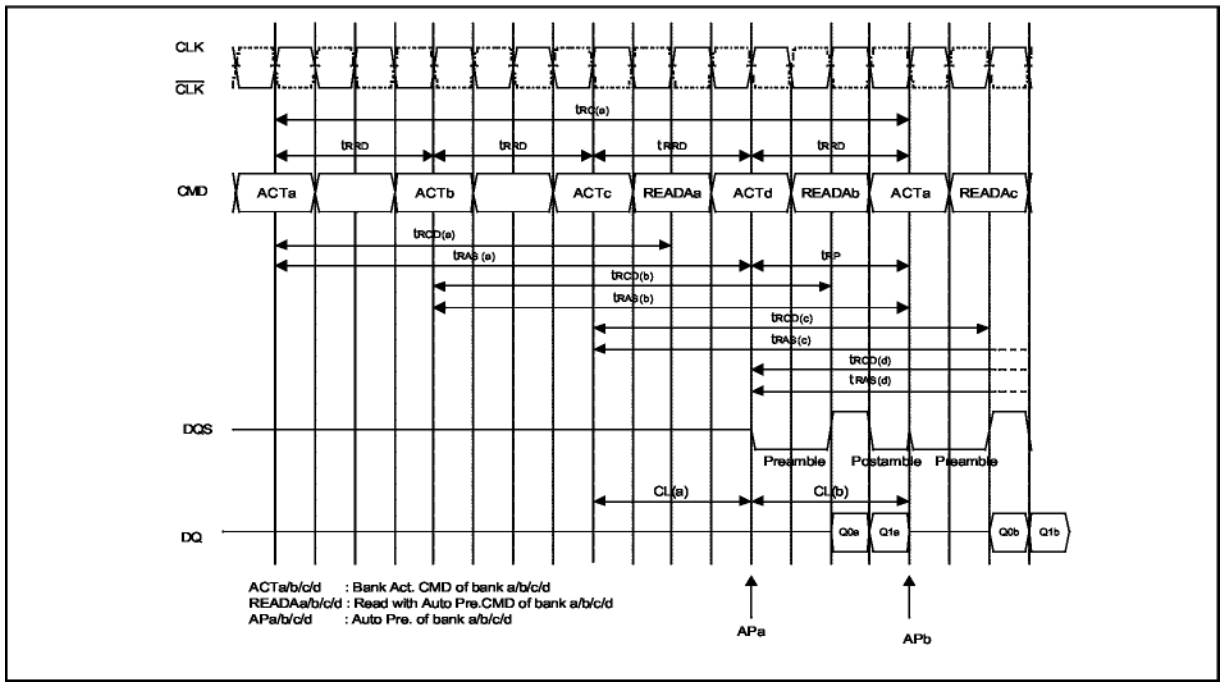
2 Bank Interleave Read Operation

(CL = 2, BL = 4)



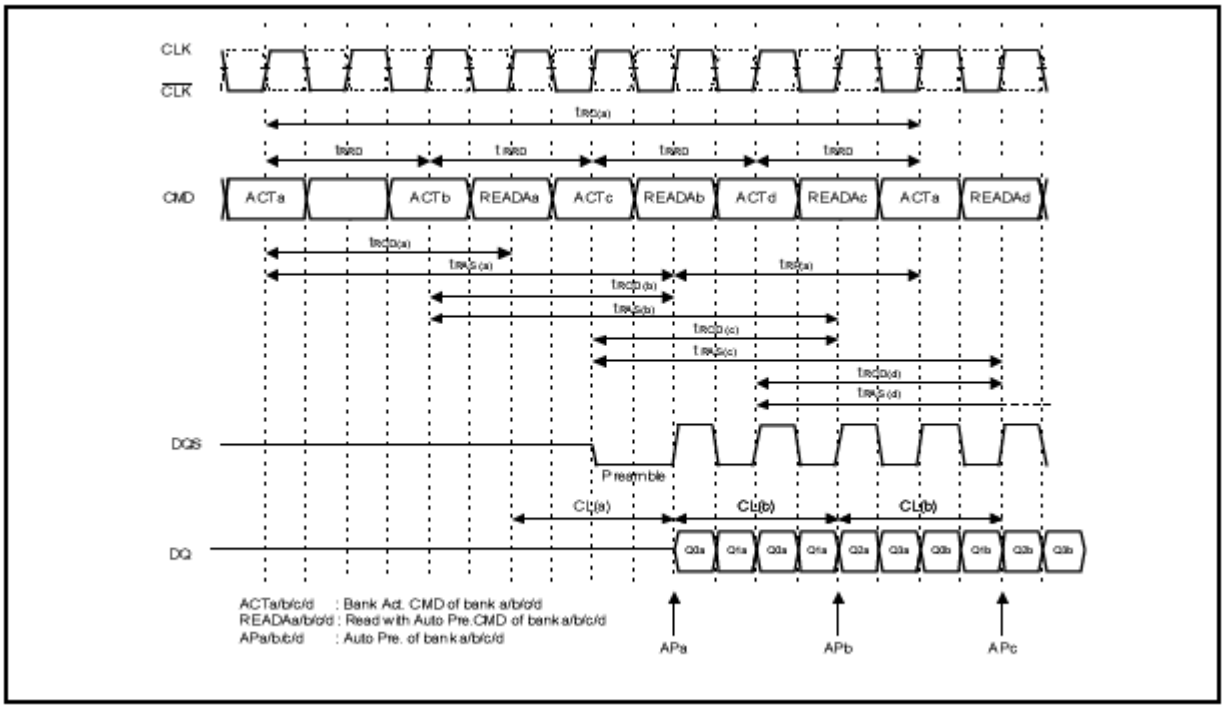
16.14.4 Bank Interleave Read Operation

(CL = 2, BL = 2)

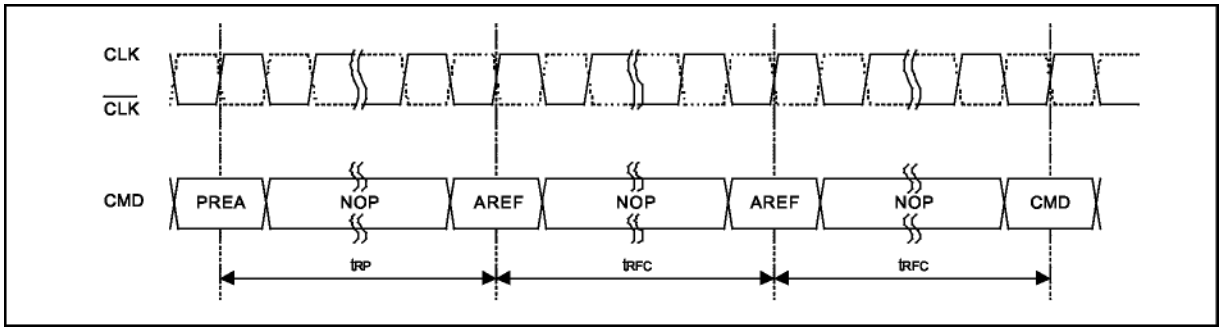


4 Bank Interleave Read Operation

(CL = 2, BL = 4)

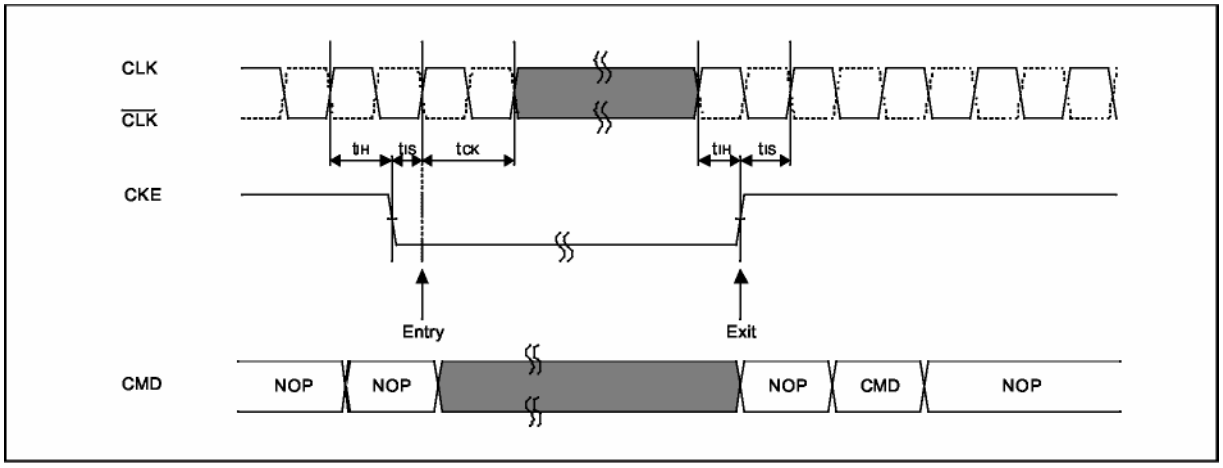


16.15. Auto Refresh Cycle

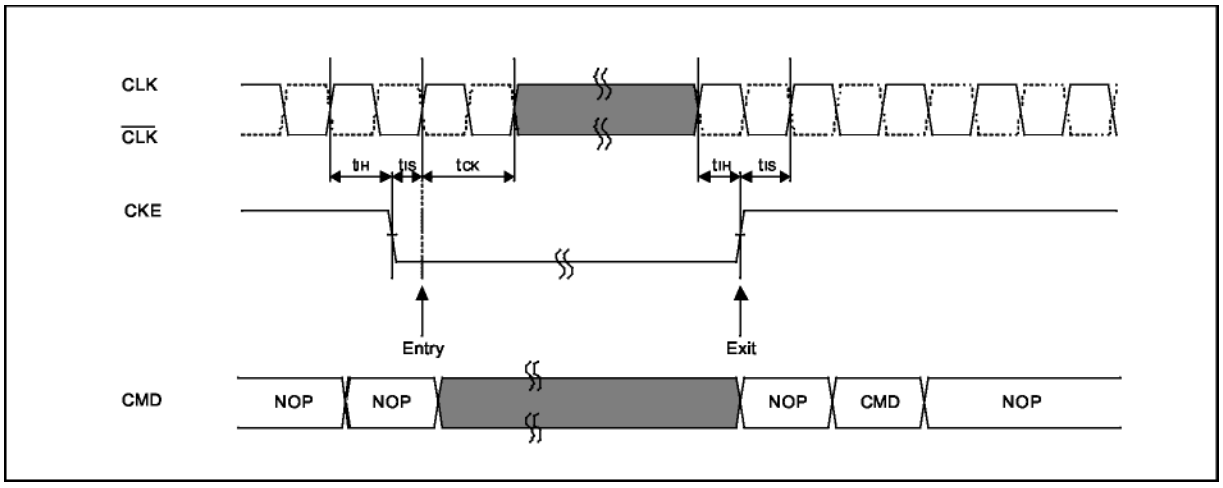


CKE has to be kept "High" level for Auto-Refresh cycle.

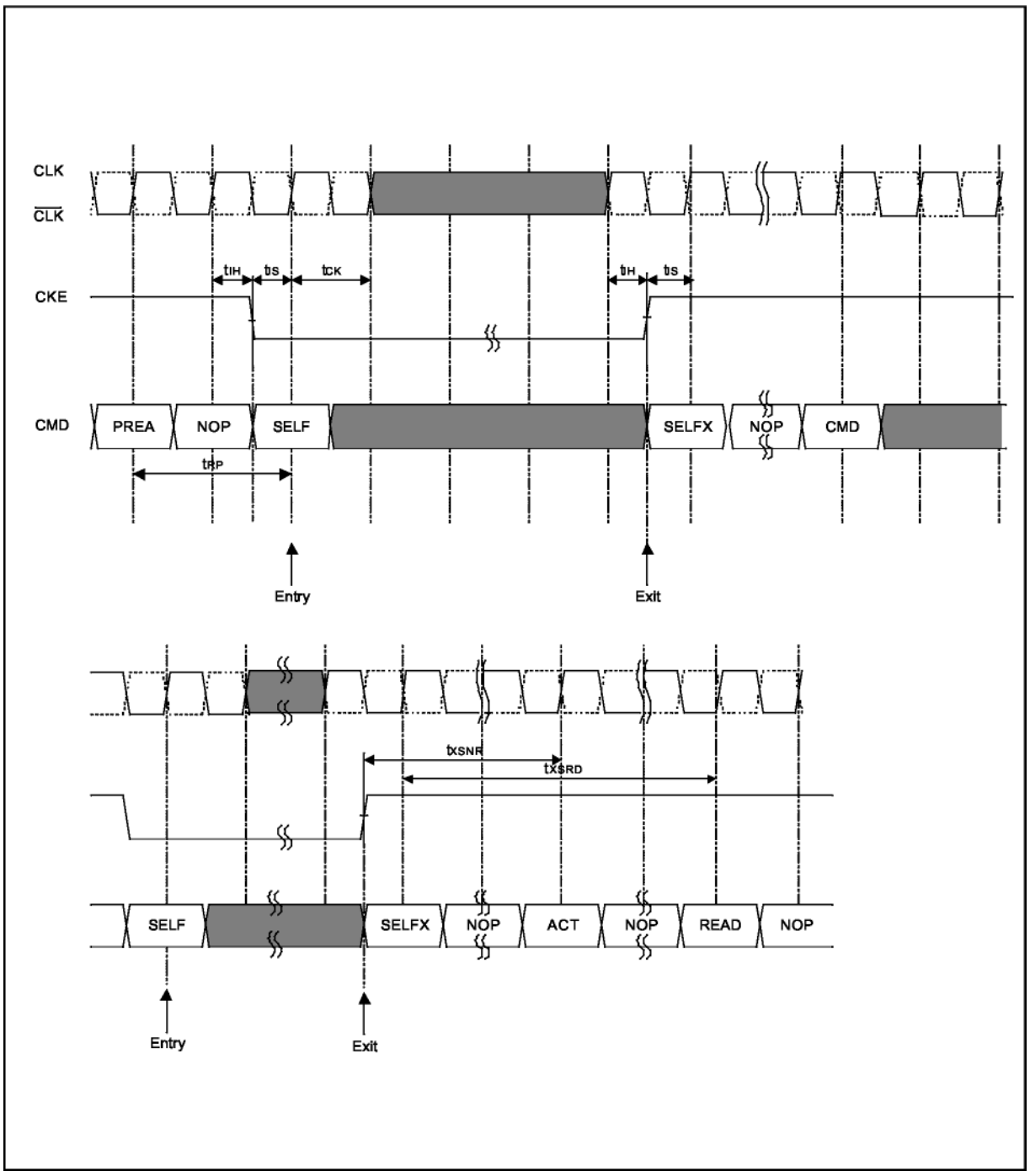
16.16. Active Power Down Mode Entry and Exit Timing



16.17. Precharged Power Down Mode Entry and Exit Timing

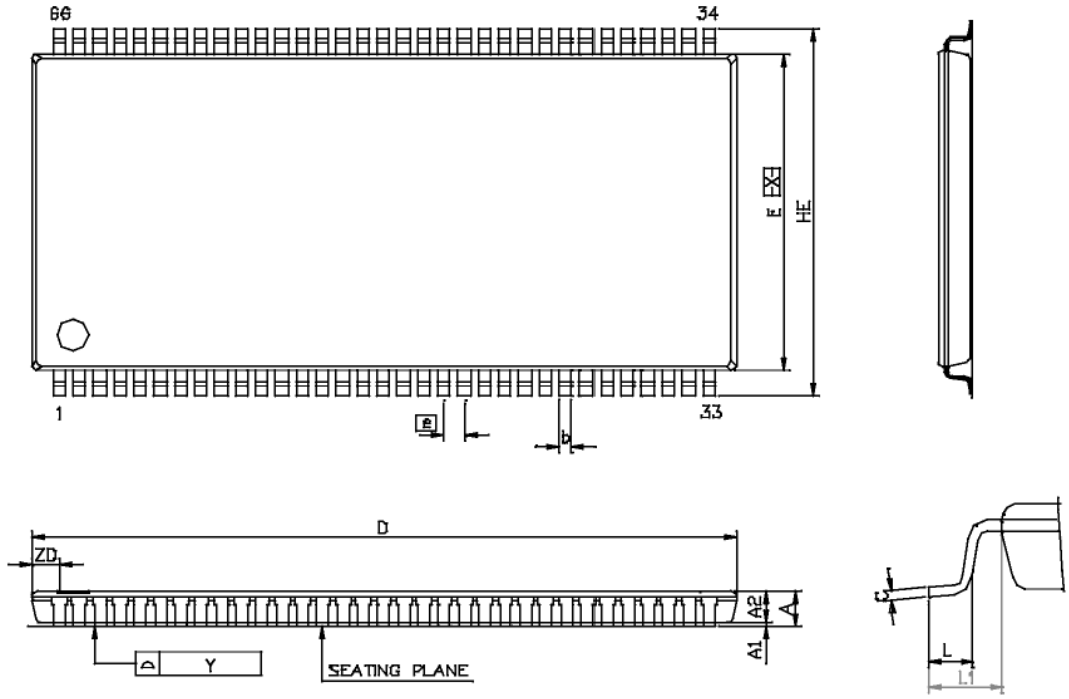


16.18.Self Refresh Entry and Exit Timing



17. PACKAGE DIMENSIONS

17.1. 66L-TSOP (II) 400 mill



SYMBOL	DIMENSION (MM)			DIMENSION (INCH)		
	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.
A	–	–	1.20	–	–	0.047
A1	0.05	–	0.15	0.002	–	0.006
A2	0.95	1.00	1.05	0.037	0.039	0.042
b	0.17	0.24	0.32	0.007	0.009	0.013
c	0.09	0.145	0.2	0.004	0.006	0.008
D	–	–	22.62	–	–	0.891
HE	11.74	11.76	11.78	0.462	0.463	0.464
E	10.15	10.16	10.17	0.3996	0.400	0.4004
L	0.40	0.50	0.60	0.016	0.020	0.024
L1	0.6	0.8	0.10	0.024	0.031	0.0039
e	0.65 BASIC			0.026 BASIC		
Y	0.1 BASIC			0.004 BASIC		
ZD	0.71 REF			0.028 REF		

18. ORDER INFORMATION

Frequency (Data Rate)	Speed (ns)	Order Part NO.	Package
400Mhz	5	PT460816HG-5	66Pin,TSOPII,Lead-Free
333Mhz	6	PT460816HG-6	66Pin,TSOPII,Lead-Free
266Mhz	75	PT460816HG-75	66Pin,TSOPII,Lead-Free

19. REVISION HISTORY

REVISION	DATE	PAGE	DESCRIPTION
A00	08/24/2005	—	Preliminary datasheet
A01	06/26/2006	—	Modified all parameter
A02	11/09/2007	—	Add 18. Order Informatiom
A03	01/26/2008	20	Modified Operation Temperature

Important Notice

Pointec products are not designed, intended, authorized or warranted for use as components in systems or equipment intended for surgical implantation, atomic energy control instruments, airplane or spaceship instruments, transportation instruments, traffic signal instruments, combustion control instruments, or for other applications intended to support or sustain life. Further more, Pointec products are not intended for applications wherein failure of Pointec products could result or lead to a situation wherein personal injury, death or severe property or environmental damage could occur.

Pointec customers using or selling these products for use in such applications do so at their own risk and agree to fully indemnify Pointec for any damages resulting from such improper use or sales.