

PRELIMINARY

Some of contents are described for general products and are subject to change without notice.

DESCRIPTION

M2V64S20BTP is organized as 4-bank x4,194,304-word x 4-bit, and M2V64S30BTP is organized as 4-bank x 2097152-word x 8-bit, and M2V64S40BTP is organized as 4-bank x 1048576-word x 16-bit Synchronous DRAM with LVTTTL interface. All inputs and outputs are referenced to the rising edge of CLK. M2V64S20BTP, M2V64S30BTP, M2V64S40BTP achieves very high speed data rates up to 133MHz, and is suitable for main memory or graphic memory in computer systems.

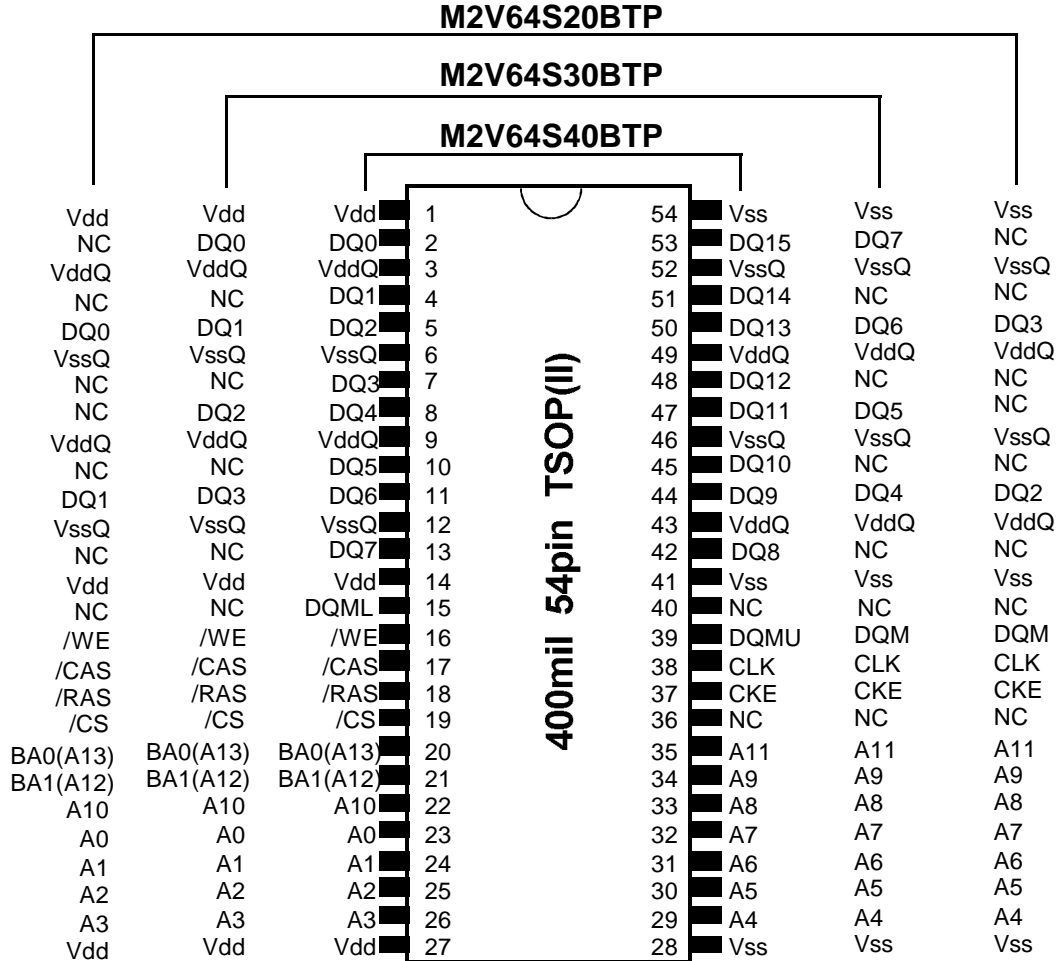
FEATURES

ITEM		M2V64S20TP M2V64S30TP M2V64S40TP
		-6
tCLK	Clock Cycle Time (Min.)	7.5ns
tRAS	Active to Precharge Command Period (Min.)	45ns
tRCD	Row to Column Delay (Min.)	20.0ns
tAC	Access Time from CLK (Max.) (CL=3)	5.4ns
tRC	Ref/Active Command Period (Min.)	67.5ns
Icc1	Operation Current (Max.) [Single Bank]	120mA
Icc6	Self Refresh Current (Max.)	1mA

- Single 3.3V ±0.3V power supply
- Max. Clock frequency -6 : 133MHz [PC133<3-3-3>]
- Fully synchronous operation referenced to clock rising edge
- 4-bank operation controlled by BA0,BA1(Bank Address)
- /CAS latency- 2/3 (programmable)
- Burst length- 1/2/4/8/FP (programmable)
- Burst type- Sequential and interleave burst (programmable)
- Random column access
- Auto precharge / All bank precharge controlled by A10
- Auto and self refresh
- 4096 refresh cycles /64ms
- LVTTTL Interface
- Package 400-mil, 54-pin Thin Small Outline (TSOP II) with 0.8mm lead pitch

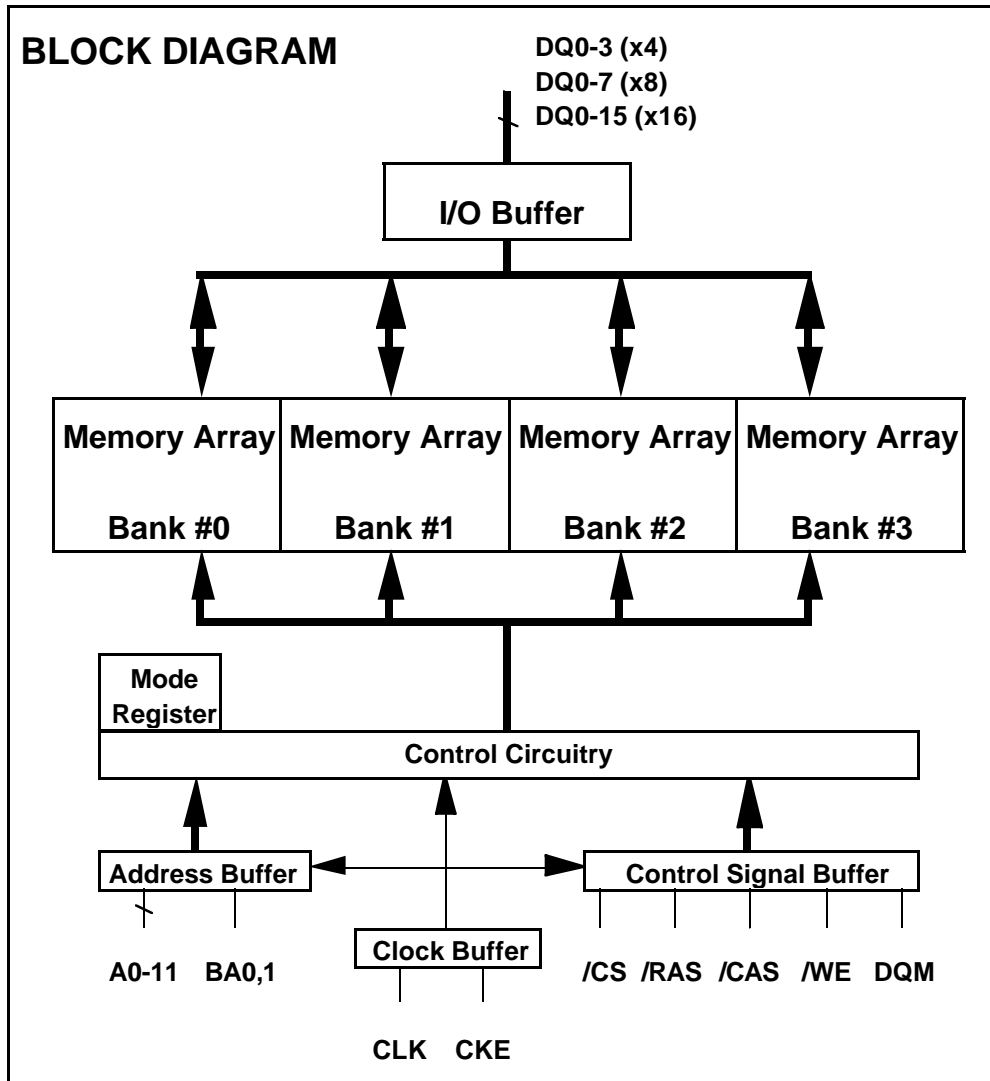


PIN CONFIGURATION (TOP VIEW)



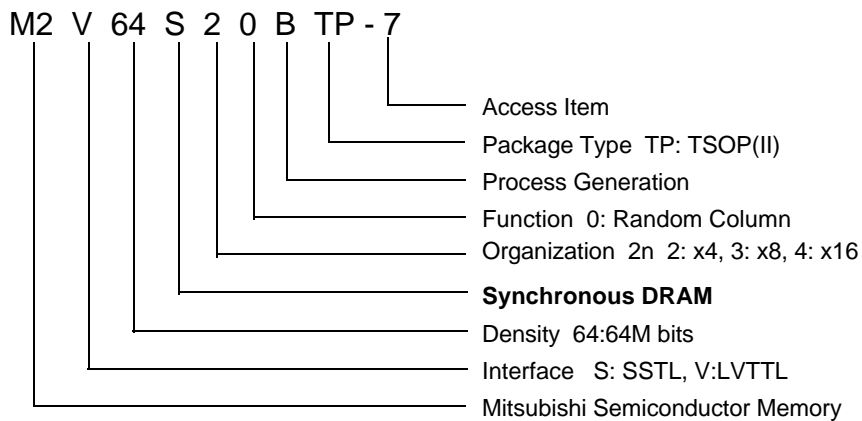
- CLK** : Master Clock
- CKE** : Clock Enable
- /CS** : Chip Select
- /RAS** : Row Address Strobe
- /CAS** : Column Address Strobe
- /WE** : Write Enable
- DQ0-3(x4), DQ0-7(x8), DQ0-15(x16)** : Data I/O
- DQM (x4, x8) ,DQML/U (x16)** : Output Disable/ Write Mask
- A0-11** : Address Input
- BA0,1** : Bank Address
- Vdd** : Power Supply
- VddQ** : Power Supply for Output
- Vss** : Ground
- VssQ** : Ground for Output





Type Designation Code

This rule is applied only to Synchronous DRAM families beyond 64M B-version.



PIN FUNCTION

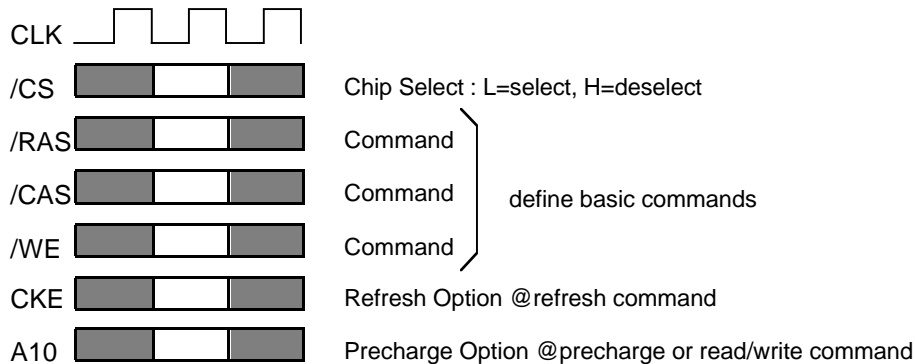
CLK	Input	Master Clock: All other inputs are referenced to the rising edge of CLK.
CKE	Input	Clock Enable: CKE controls internal clock. When CKE is low, internal clock for the following cycle is ceased. CKE is also used to select auto / self refresh. After self refresh mode is started, CKE becomes asynchronous input. Self refresh is maintained as long as CKE is low.
/CS	Input	Chip Select: When /CS is high, any command means No Operation.
/RAS, /CAS, /WE	Input	Combination of /RAS, /CAS, /WE defines basic commands.
A0-11	Input	A0-11 specify the Row / Column Address in conjunction with BA0,1. The Row Address is specified by A0-11. The Column Address is specified by A0-A9(x4), A0-A8(x8), A0-7(x16) . A10 is also used to indicate precharge option. When A10 is high at a read / write command, an auto precharge is performed. When A10 is high at a precharge command, all banks are precharged.
BA0,1	Input	Bank Address: BA0,1 specifies one of four banks to which a command is applied. BA0,1 must be set with ACT, PRE, READ, WRITE commands.
DQ0-3(x4), DQ0-7(x8), DQ0-15(x16)	Input / Output	Data In and Data out are referenced to the rising edge of CLK.
DQM(x4,x8), DQMU/L(x16)	Input	Din Mask / Output Disable: When DQMU/L is high in burst write, Din for the current cycle is masked. When DQMU/L is high in burst read, Dout is disabled at the next but one cycle.
Vdd, Vss	Power Supply	Power Supply for the memory array and peripheral circuitry.
VddQ, VssQ	Power Supply	VddQ and VssQ are supplied to the Output Buffers only.



BASIC FUNCTIONS

The M2V64S20(30,40)BTP provides basic functions, bank (row) activate, burst read / write, bank (row) precharge, and auto / self refresh.

Each command is defined by control signals of /RAS, /CAS and /WE at CLK rising edge. In addition to 3 signals, /CS, CKE and A10 are used as chip select, refresh option, and precharge option, respectively. To know the detailed definition of commands, please see the command truth table.



Activate (ACT) [/RAS =L, /CAS =/WE =H]

ACT command activates a row in an idle bank indicated by BA.

Read (READ) [/RAS =H, /CAS =L, /WE =H]

READ command starts burst read from the active bank indicated by BA. First output data appears after /CAS latency. When A10 =H at this command, the bank is deactivated after the burst read (auto-precharge, **READA**).

Write (WRITE) [/RAS =H, /CAS =/WE =L]

WRITE command starts burst write to the active bank indicated by BA. Total data length to be written is set by burst length. When A10 =H at this command, the bank is deactivated after the burst write (auto-precharge, **WRITEA**).

Precharge (PRE) [/RAS =L, /CAS =H, /WE =L]

PRE command deactivates the active bank indicated by BA. This command also terminates burst read /write operation. When A10 =H at this command, both banks are deactivated (precharge all, **PREA**).

Auto-Refresh (REFA) [/RAS =/CAS =L, /WE =CKE =H]

REFA command starts auto-refresh cycle. Refresh address including bank address are generated inter-nally. After this command, the banks are precharged automatically.



COMMAND TRUTH TABLE

COMMAND	MNEMONIC	CKE n-1	CKE n	/CS	/RAS	/CAS	/WE	BA0,1	A11	A10	A0-9
Deselect	DESEL	H	X	H	X	X	X	X	X	X	X
No Operation	NOP	H	X	L	H	H	H	X	X	X	X
Row Address Entry & Bank Activate	ACT	H	X	L	L	H	H	V	V	V	V
Single Bank Precharge	PRE	H	X	L	L	H	L	V	X	L	X
Precharge All Banks	PREA	H	X	L	L	H	L	X	X	H	X
Column Address Entry & Write	WRITE	H	X	L	H	L	L	V	X	L	V
Column Address Entry & Write with Auto- Precharge	WRITEA	H	X	L	H	L	L	V	X	H	V
Column Address Entry & Read	READ	H	X	L	H	L	H	V	X	L	V
Column Address Entry & Read with Auto- Precharge	READA	H	X	L	H	L	H	V	X	H	V
Auto-Refresh	REFA	H	H	L	L	L	H	X	X	X	X
Self-Refresh Entry	REFS	H	L	L	L	L	H	X	X	X	X
Self-Refresh Exit	REFSX	L	H	H	X	X	X	X	X	X	X
		L	H	L	H	H	H	X	X	X	X
Burst Terminate	TBST	H	X	L	H	H	L	X	X	X	X
Mode Register Set	MRS	H	X	L	L	L	L	L	L	L	V*1

H=High Level, L=Low Level, V=Valid, X=Don't Care, n=CLK cycle number

NOTE:

1. A7-A9 =0, A0-A6 =Mode Address



FUNCTION TRUTH TABLE

Current State	/CS	/RAS	/CAS	/WE	Address	Command	Action
IDLE	H	X	X	X	X	DESEL	NOP
	L	H	H	H	X	NOP	NOP
	L	H	H	L	BA	TBST	ILLEGAL*2
	L	H	L	X	BA, CA, A10	READ / WRITE	ILLEGAL*2
	L	L	H	H	BA, RA	ACT	Bank Active, Latch RA
	L	L	H	L	BA, A10	PRE / PREA	NOP*4
	L	L	L	H	X	REFA	Auto-Refresh*5
	L	L	L	L	Op-Code, Mode-Add	MRS	Mode Register Set*5
ROW ACTIVE	H	X	X	X	X	DESEL	NOP
	L	H	H	H	X	NOP	NOP
	L	H	H	L	BA	TBST	NOP
	L	H	L	H	BA, CA, A10	READ / READA	Begin Read, Latch CA, Determine Auto-Precharge
	L	H	L	L	BA, CA, A10	WRITE / WRITEA	Begin Write, Latch CA, Determine Auto-Precharge
	L	L	H	H	BA, RA	ACT	Bank Active / ILLEGAL*2
	L	L	H	L	BA, A10	PRE / PREA	Precharge / Precharge All
	L	L	L	H	X	REFA	ILLEGAL
	L	L	L	L	Op-Code, Mode-Add	MRS	ILLEGAL
READ	H	X	X	X	X	DESEL	NOP (Continue Burst to END)
	L	H	H	H	X	NOP	NOP (Continue Burst to END)
	L	H	H	L	BA	TBST	Terminate Burst
	L	H	L	H	BA, CA, A10	READ / READA	Terminate Burst, Latch CA, Begin New Read, Determine Auto-Precharge*3
	L	H	L	L	BA, CA, A10	WRITE / WRITEA	Terminate Burst, Latch CA, Begin Write, Determine Auto- Precharge*3
	L	L	H	H	BA, RA	ACT	Bank Active / ILLEGAL*2
	L	L	H	L	BA, A10	PRE / PREA	Terminate Burst, Precharge
	L	L	L	H	X	REFA	ILLEGAL
	L	L	L	L	Op-Code, Mode-Add	MRS	ILLEGAL



FUNCTION TRUTH TABLE (continued)

Current State	/CS	/RAS	/CAS	/WE	Address	Command	Action
WRITE	H	X	X	X	X	DESEL	NOP (Continue Burst to END)
	L	H	H	H	X	NOP	NOP (Continue Burst to END)
	L	H	H	L	BA	TBST	Terminate Burst
	L	H	L	H	BA, CA, A10	READ / READA	Terminate Burst, Latch CA, Begin Read, Determine Auto-Precharge*3
	L	H	L	L	BA, CA, A10	WRITE / WRITEA	Terminate Burst, Latch CA, Begin Write, Determine Auto-Precharge*3
	L	L	H	H	BA, RA	ACT	Bank Active / ILLEGAL*2
	L	L	H	L	BA, A10	PRE / PREA	Terminate Burst, Precharge
	L	L	L	H	X	REFA	ILLEGAL
	L	L	L	L	Op-Code, Mode-Add	MRS	ILLEGAL
READ with AUTO PRECHARGE	H	X	X	X	X	DESEL	NOP (Continue Burst to END)
	L	H	H	H	X	NOP	NOP (Continue Burst to END)
	L	H	H	L	BA	TBST	ILLEGAL
	L	H	L	H	BA, CA, A10	READ / READA	ILLEGAL
	L	H	L	L	BA, CA, A10	WRITE / WRITEA	ILLEGAL
	L	L	H	H	BA, RA	ACT	Bank Active / ILLEGAL*2
	L	L	H	L	BA, A10	PRE / PREA	ILLEGAL*2
	L	L	L	H	X	REFA	ILLEGAL
	L	L	L	L	Op-Code, Mode-Add	MRS	ILLEGAL
WRITE with AUTO PRECHARGE	H	X	X	X	X	DESEL	NOP (Continue Burst to END)
	L	H	H	H	X	NOP	NOP (Continue Burst to END)
	L	H	H	L	BA	TBST	ILLEGAL
	L	H	L	H	BA, CA, A10	READ / READA	ILLEGAL
	L	H	L	L	BA, CA, A10	WRITE / WRITEA	ILLEGAL
	L	L	H	H	BA, RA	ACT	Bank Active / ILLEGAL*2
	L	L	H	L	BA, A10	PRE / PREA	ILLEGAL*2
	L	L	L	H	X	REFA	ILLEGAL
	L	L	L	L	Op-Code, Mode-Add	MRS	ILLEGAL



FUNCTION TRUTH TABLE (continued)

Current State	/CS	/RAS	/CAS	/WE	Address	Command	Action
PRE - CHARGING	H	X	X	X	X	DESEL	NOP (Idle after tRP)
	L	H	H	H	X	NOP	NOP (Idle after tRP)
	L	H	H	L	BA	TBST	ILLEGAL*2
	L	H	L	X	BA, CA, A10	READ / WRITE	ILLEGAL*2
	L	L	H	H	BA, RA	ACT	ILLEGAL*2
	L	L	H	L	BA, A10	PRE / PREA	NOP*4 (Idle after tRP)
	L	L	L	H	X	REFA	ILLEGAL
	L	L	L	L	Op-Code, Mode-Add	MRS	ILLEGAL
ROW ACTIVATING	H	X	X	X	X	DESEL	NOP (Row Active after tRCD)
	L	H	H	H	X	NOP	NOP (Row Active after tRCD)
	L	H	H	L	BA	TBST	ILLEGAL*2
	L	H	L	X	BA, CA, A10	READ / WRITE	ILLEGAL*2
	L	L	H	H	BA, RA	ACT	ILLEGAL*2
	L	L	H	L	BA, A10	PRE / PREA	ILLEGAL*2
	L	L	L	H	X	REFA	ILLEGAL
	L	L	L	L	Op-Code, Mode-Add	MRS	ILLEGAL
WRITE RE- COVERING	H	X	X	X	X	DESEL	NOP
	L	H	H	H	X	NOP	NOP
	L	H	H	L	BA	TBST	ILLEGAL*2
	L	H	L	X	BA, CA, A10	READ / WRITE	ILLEGAL*2
	L	L	H	H	BA, RA	ACT	ILLEGAL*2
	L	L	H	L	BA, A10	PRE / PREA	ILLEGAL*2
	L	L	L	H	X	REFA	ILLEGAL
	L	L	L	L	Op-Code, Mode-Add	MRS	ILLEGAL



FUNCTION TRUTH TABLE (continued)

Current State	/CS	/RAS	/CAS	/WE	Address	Command	Action
RE-FRESHING	H	X	X	X	X	DESEL	NOP (Idle after tRC)
	L	H	H	H	X	NOP	NOP (Idle after tRC)
	L	H	H	L	BA	TBST	ILLEGAL
	L	H	L	X	BA, CA, A10	READ / WRITE	ILLEGAL
	L	L	H	H	BA, RA	ACT	ILLEGAL
	L	L	H	L	BA, A10	PRE / PREA	ILLEGAL
	L	L	L	H	X	REFA	ILLEGAL
	L	L	L	L	Op-Code, Mode-Add	MRS	ILLEGAL
MODE REGISTER SETTING	H	X	X	X	X	DESEL	NOP (Idle after tRSC)
	L	H	H	H	X	NOP	NOP (Idle after tRSC)
	L	H	H	L	BA	TBST	ILLEGAL
	L	H	L	X	BA, CA, A10	READ / WRITE	ILLEGAL
	L	L	H	H	BA, RA	ACT	ILLEGAL
	L	L	H	L	BA, A10	PRE / PREA	ILLEGAL
	L	L	L	H	X	REFA	ILLEGAL
	L	L	L	L	Op-Code, Mode-Add	MRS	ILLEGAL

ABBREVIATIONS:

H=High Level, L=Low Level, X=Don't Care

BA=Bank Address, RA=Row Address, CA=Column Address, NOP=No Operation

NOTES:

1. All entries assume that CKE was High during the preceding clock cycle and the current clock cycle.
2. ILLEGAL to bank in specified state; function may be legal in the bank indicated by BA, depending on the state of that bank.
3. Must satisfy bus contention, bus turn around, write recovery requirements.
4. NOP to bank precharging or in idle state. May precharge bank indicated by BA.
5. ILLEGAL if any bank is not idle.

ILLEGAL = Device operation and/or data-integrity are not guaranteed.



FUNCTION TRUTH TABLE for CKE

Current State	CKE _{n-1}	CKE _n	/CS	/RAS	/CAS	/WE	Add	Action
SELF-REFRESH*1	H	X	X	X	X	X	X	INVALID
	L	H	H	X	X	X	X	Exit Self-Refresh (Idle after tRC)
	L	H	L	H	H	H	X	Exit Self-Refresh (Idle after tRC)
	L	H	L	H	H	L	X	ILLEGAL
	L	H	L	H	L	X	X	ILLEGAL
	L	H	L	L	X	X	X	ILLEGAL
	L	L	X	X	X	X	X	NOP (Maintain Self-Refresh)
POWER DOWN	H	X	X	X	X	X	X	INVALID
	L	H	X	X	X	X	X	Exit Power Down to Idle
	L	L	X	X	X	X	X	NOP (Maintain Self-Refresh)
ALL BANKS IDLE*2	H	H	X	X	X	X	X	Refer to Function Truth Table
	H	L	L	L	L	H	X	Enter Self-Refresh
	H	L	H	X	X	X	X	Enter Power Down
	H	L	L	H	H	H	X	Enter Power Down
	H	L	L	H	H	L	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	Refer to Current State =Power Down
ANY STATE other than listed above	H	H	X	X	X	X	X	Refer to Function Truth Table
	H	L	X	X	X	X	X	Begin CLK Suspend at Next Cycle*3
	L	H	X	X	X	X	X	Exit CLK Suspend at Next Cycle*3
	L	L	X	X	X	X	X	Maintain CLK Suspend

ABBREVIATIONS:

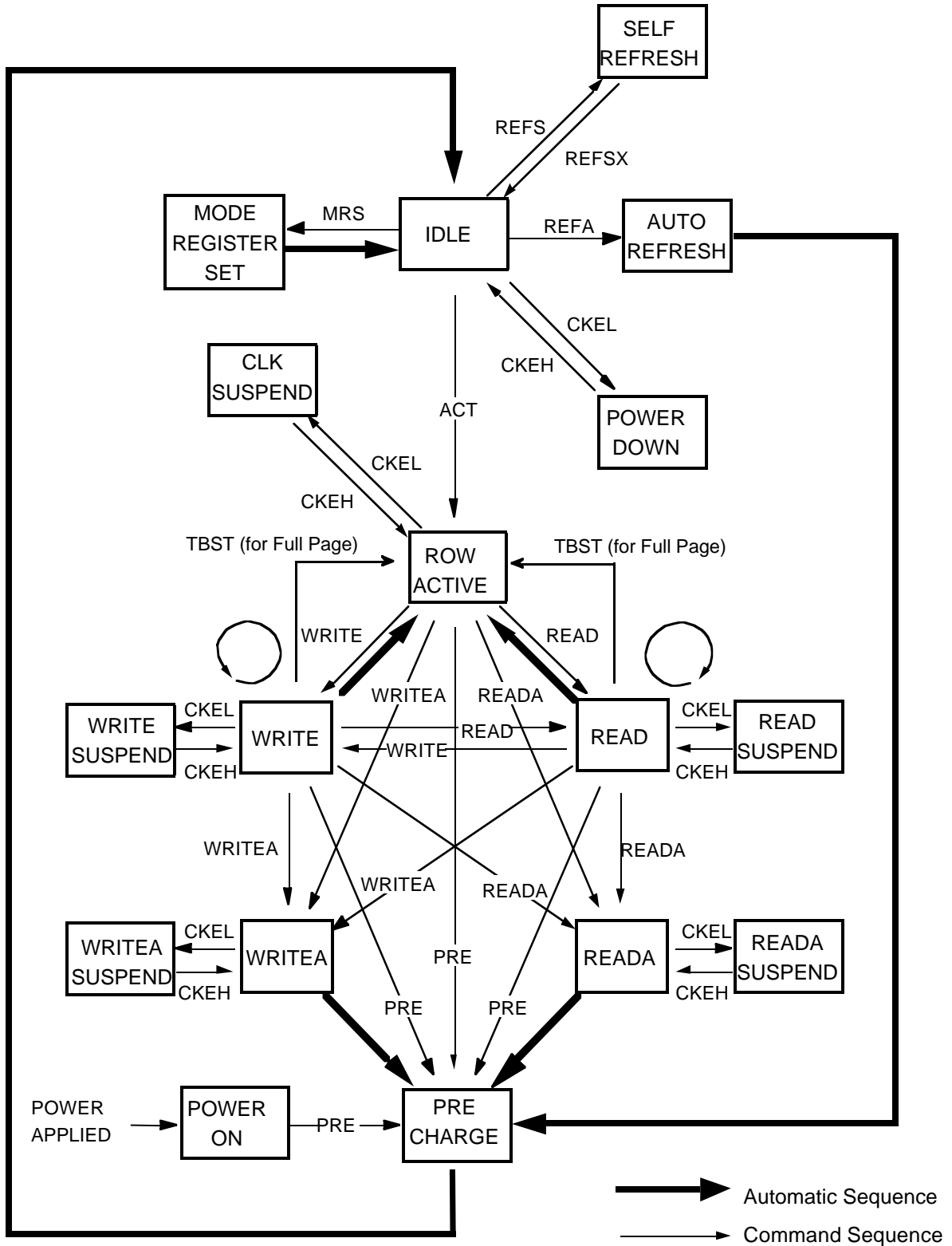
H=High Level, L=Low Level, X=Don't Care

NOTES:

1. 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.
2. Power-Down and Self-Refresh can be entered only from the All Banks Idle State.
3. Must be legal command.



SIMPLIFIED STATE DIAGRAM



POWER ON SEQUENCE

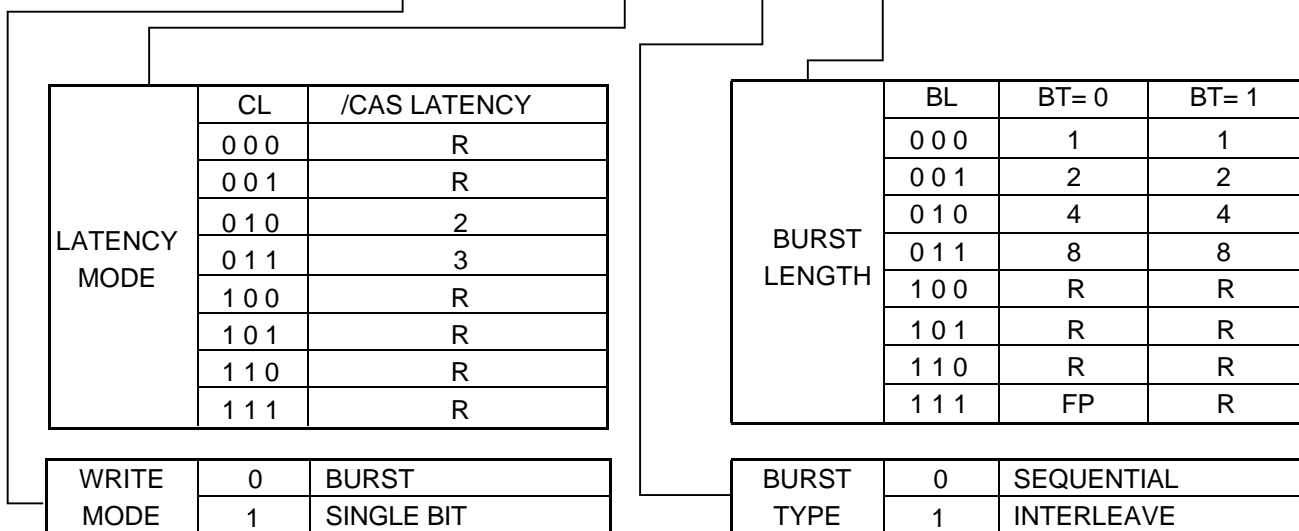
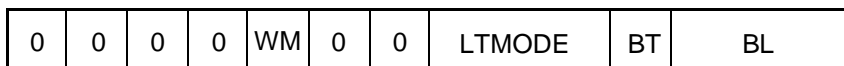
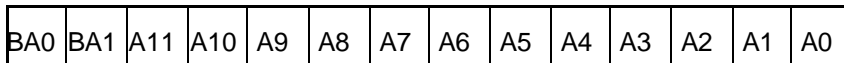
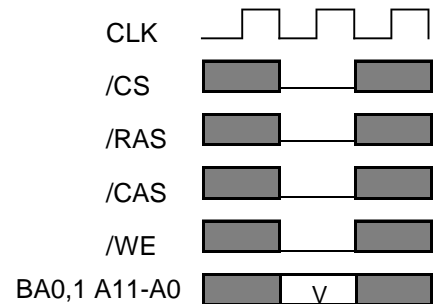
Before starting normal operation, the following power on sequence is necessary to prevent a SDRAM from damaged or malfunctioning.

1. Clock will be applied at power up along with power. Attempt to maintain CKE high, DQM (x4,x8), DQMU/L (x16) high and NOP condition at the inputs along with power.
2. Maintain stable power, stable clock, and NOP input conditions for a minimum of 200us.
3. Issue precharge commands for all banks. (PRE or PREA)
4. After all banks become idle state (after tRP), issue 8 or more auto-refresh commands.
5. Issue a mode register set command to initialize the mode register.

After these sequence, the SDRAM is idle state and ready for normal operation.

MODE REGISTER

Burst Length, Burst Type and /CAS Latency can be programmed by setting the mode register (MRS). The mode register stores these data until the next MRS command, which may be issued when both banks are in idle state. After tRSC from a MRS command, the SDRAM is ready for new command.



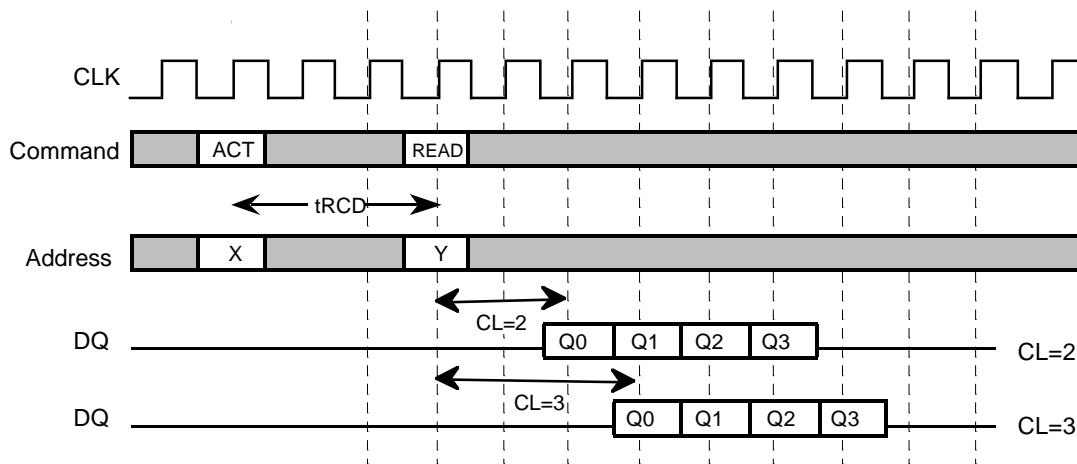
R: Reserved for Future Use
FP: Full Page



[/CAS LATENCY]

/CAS latency, CL, is used to synchronize the first output data with the CLK frequency, i.e., the speed of CLK determines which CL should be used. First output data is available after CL cycles from READ command.

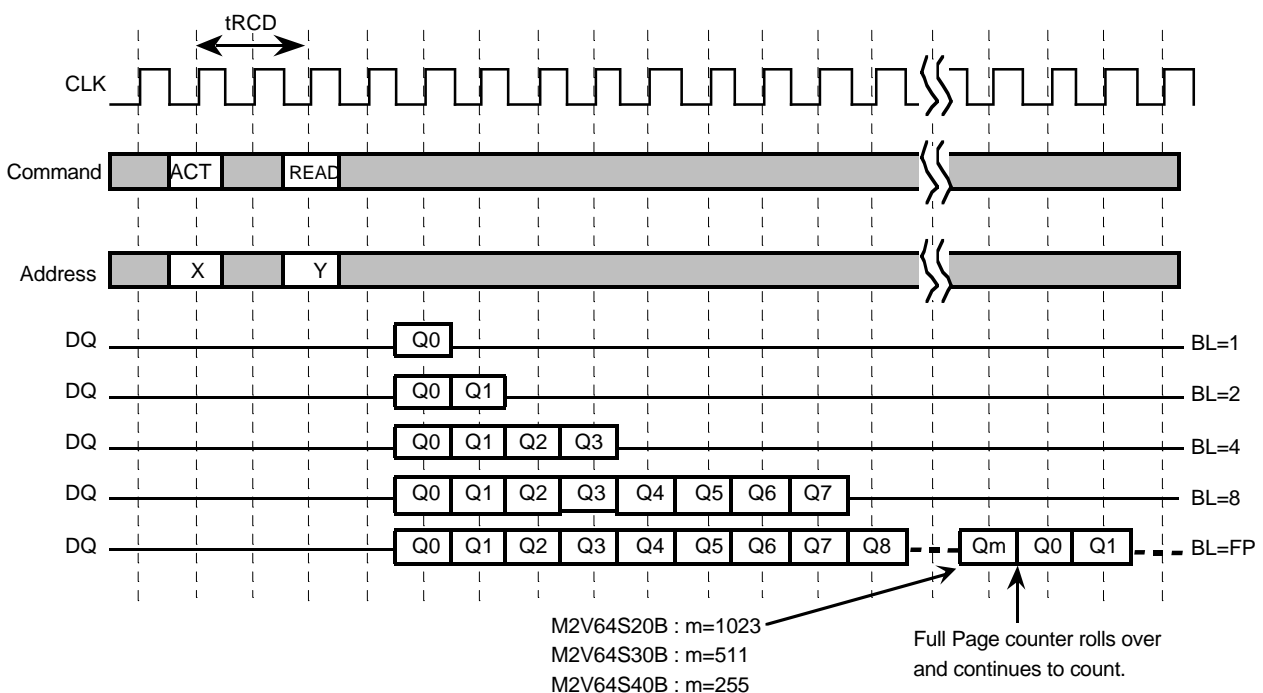
/CAS Latency Timing(BL=4)

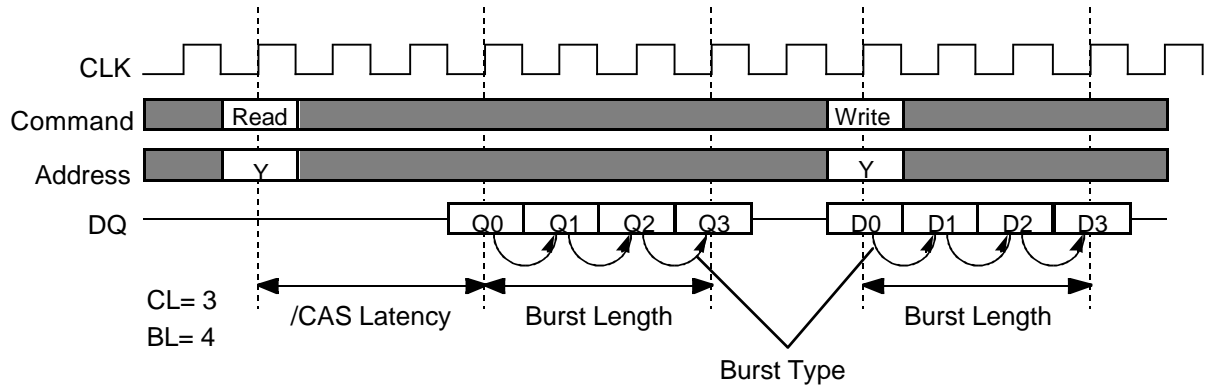


[BURST LENGTH]

The burst length, BL, determines the number of consecutive writes or reads that will be automatically performed after the initial write or read command. For BL=1,2,4,8, full page the output data is tristated (Hi-Z) after the last read. For BL=FP (Full Page), the TBST (Burst Terminate) command should be issued to stop the output of data.

Burst Length Timing(CL=2)





Initial Address			BL	Column Addressing															
A2	A1	A0		Sequential								Interleaved							
0	0	0	8	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
-	0	0	4	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				
-	-	0	2	0	1							0	1						
-	-	1		1	0							1	0						



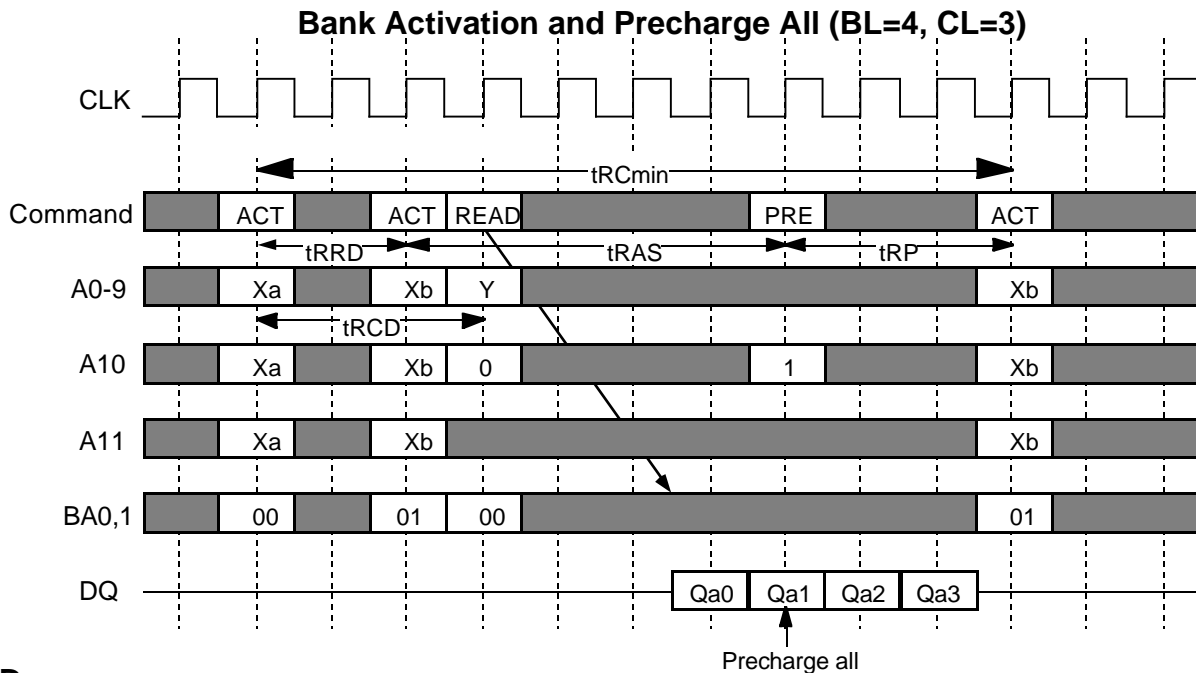
OPERATIONAL DESCRIPTION

BANK ACTIVATE

The SDRAM has four independent banks. Each bank is activated by the ACT command with the bank addresses (BA0,1). A row is indicated by the row addresses A11-0. The minimum activation interval between one bank and the other bank is t_{RRD} . The number of banks which are active concurrently is not limited.

PRECHARGE

The PRE command deactivates the bank indicated by BA0,1. When multiple banks are active, the precharge all command (PREA, PRE + A10=H) is available to deactivate them at the same time. After t_{RP} from the precharge, an ACT command to the same bank can be issued.

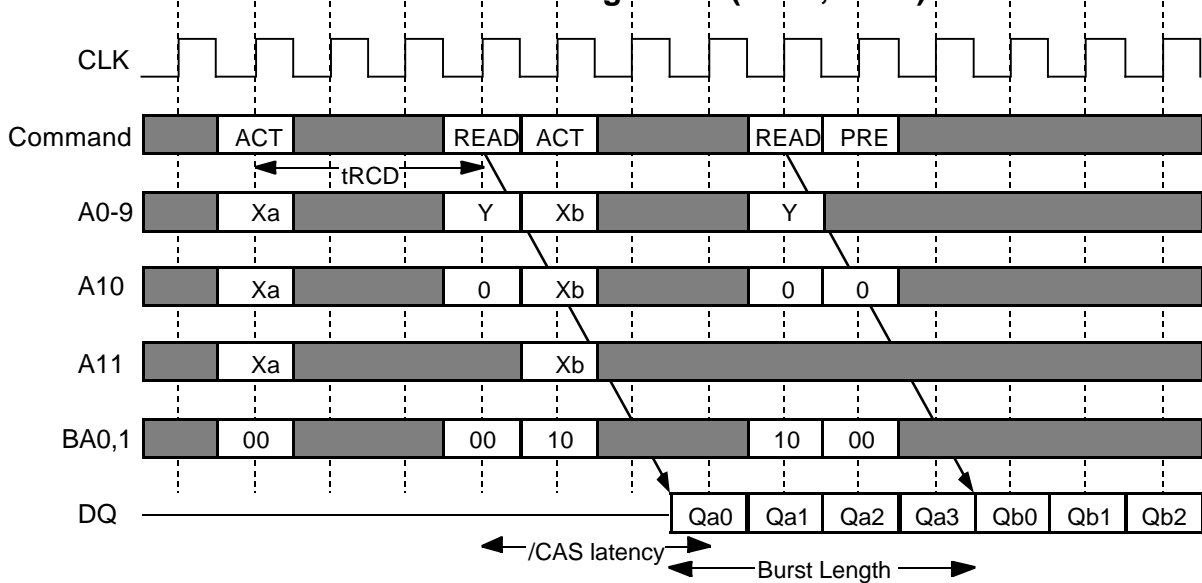


READ

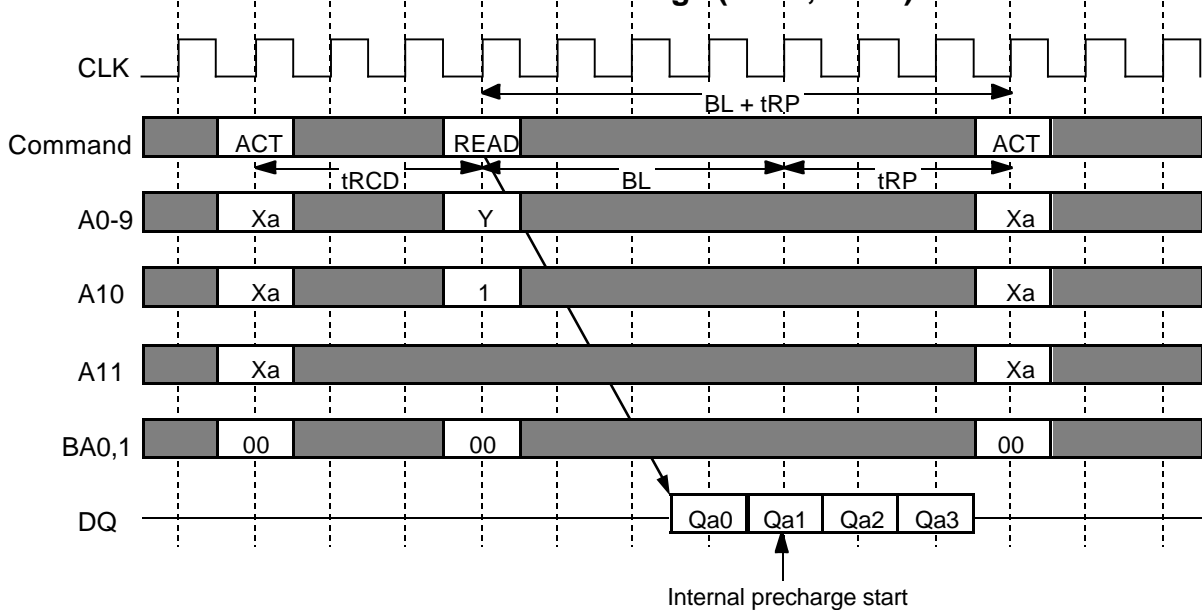
After t_{RCD} from the bank activation, a READ command can be issued. 1st output data is available after the /CAS Latency from the READ, followed by (BL - 1) consecutive data when the Burst Length is BL. The start address is specified by A9-0(x4), A8-0(x8), A7-0(X16), and the address sequence of burst data is defined by the Burst Type. A READ command may be applied to any active bank, so the row precharge time (t_{RP}) can be hidden behind continuous output data by interleaving the multiple banks. When A10 is high at a READ command, the auto-precharge (READA) is performed. Any command (READ, WRITE, PRE, ACT) to the same bank is inhibited till the internal precharge is complete. The internal precharge starts at BL after READA. The next ACT command can be issued after (BL + t_{RP}) from the previous READA.



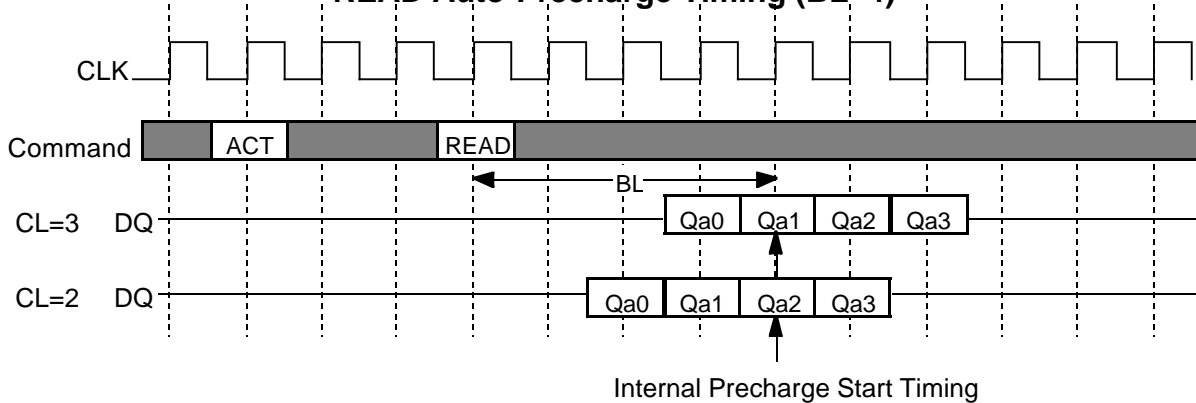
Multi Bank Interleaving READ (BL=4, CL=3)



READ with Auto-Precharge (BL=4, CL=3)

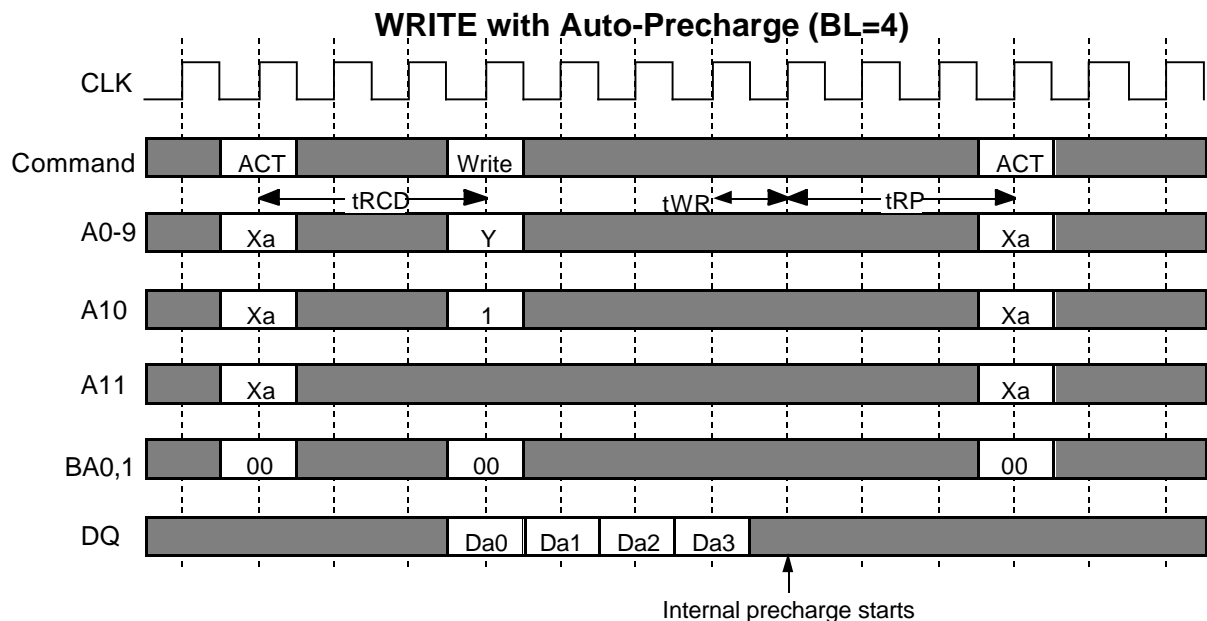
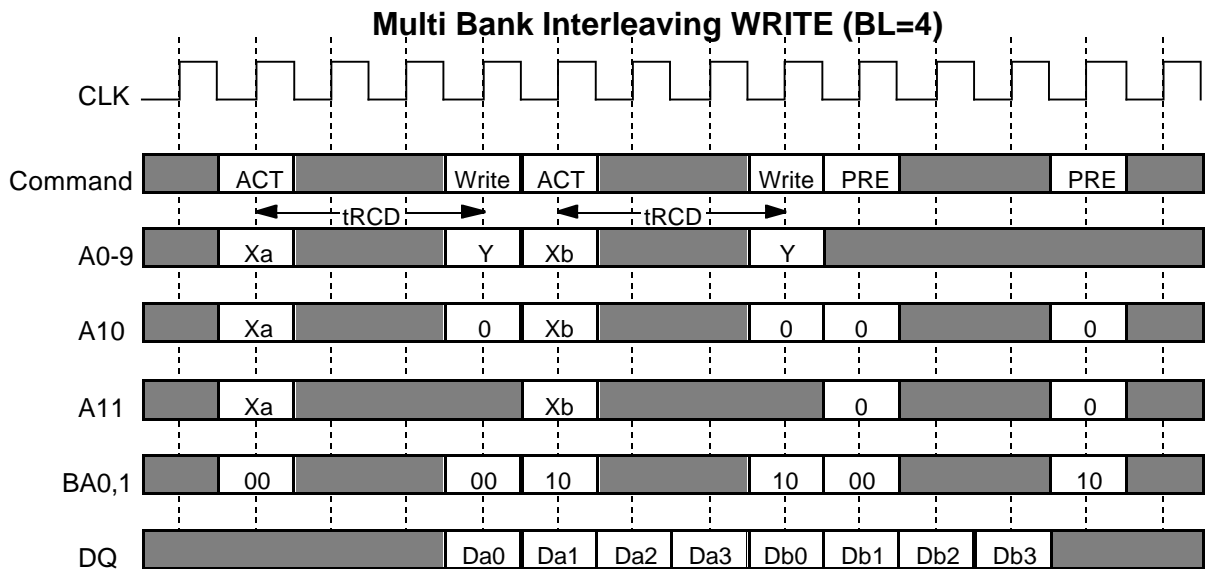


READ Auto-Precharge Timing (BL=4)



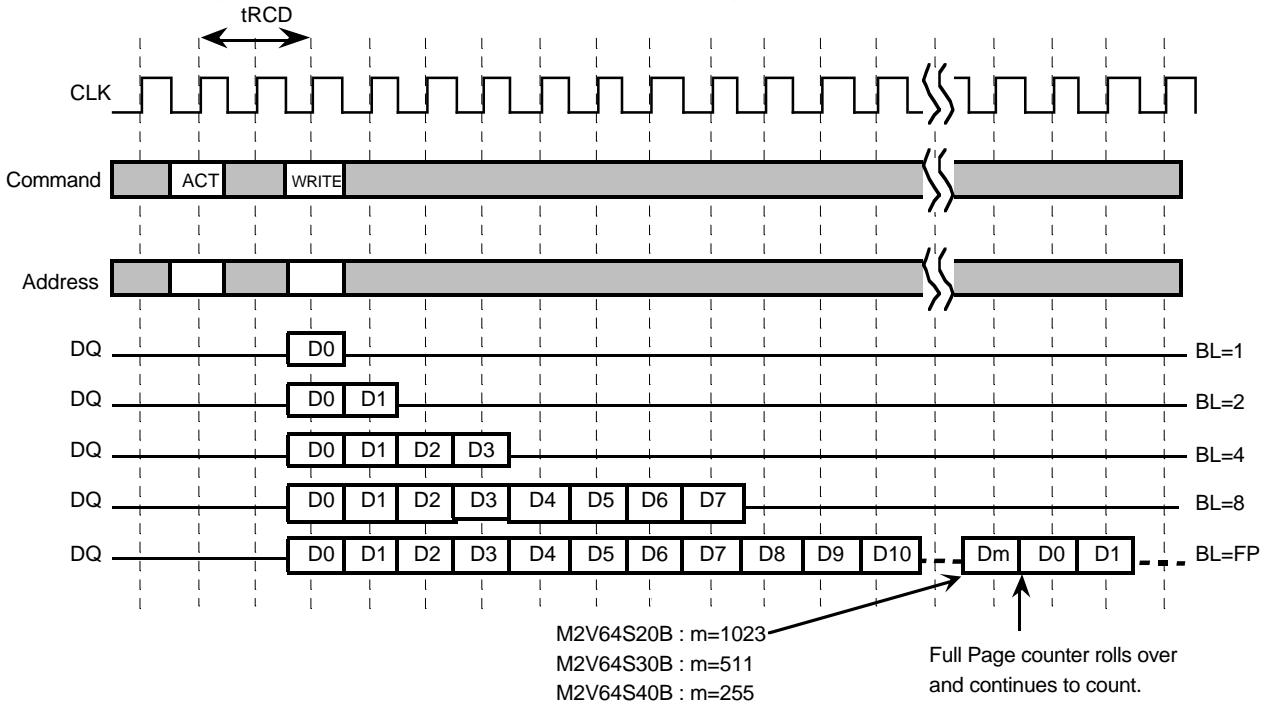
WRITE

After tRCD from the bank activation, a WRITE command can be issued. 1st input data is set at the same cycle as the WRITE. Following (BL - 1) data are written into the RAM, when the Burst Length is BL. The start address is specified by A9-0 (x 4), A8-0 (x 8) and A7-0 (x 16), and the address sequence of burst data is defined by the Burst Type. A WRITE command may be applied to any active bank, so the row precharge time (tRP) can be hidden behind continuous input data by interleaving the multiple banks. From the last input data to the PRE command, the write recovery time (tWR) is required. When A10 is high at a WRITE command, the auto-precharge (WRITEEA) is performed. Any command (READ, WRITE, PRE, ACT) to the same bank is inhibited till the internal precharge is complete. The internal precharge begins at tWR after the last input data cycle. The next ACT command can be issued after tRP from the internal precharge timing. The Mode Register can be programmed for burst read and single write. In this mode the write data is only clocked in when the WRITE command is issued and the remaining burst length is ignored. The read data burst length is unaffected while in this mode



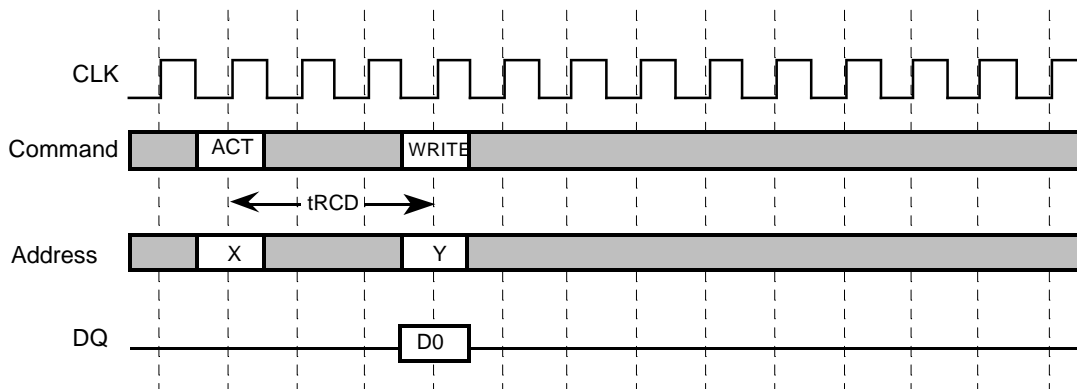
[BURST WRITE]

A burst write operation is enabled by setting A9=0 at MRS. A burst write starts in the same cycle as a write command set. (The latency of data input is 0.) The burst length can be set to 1,2,4,8, and full-page, like burst read operations.



[SINGLE WRITE]

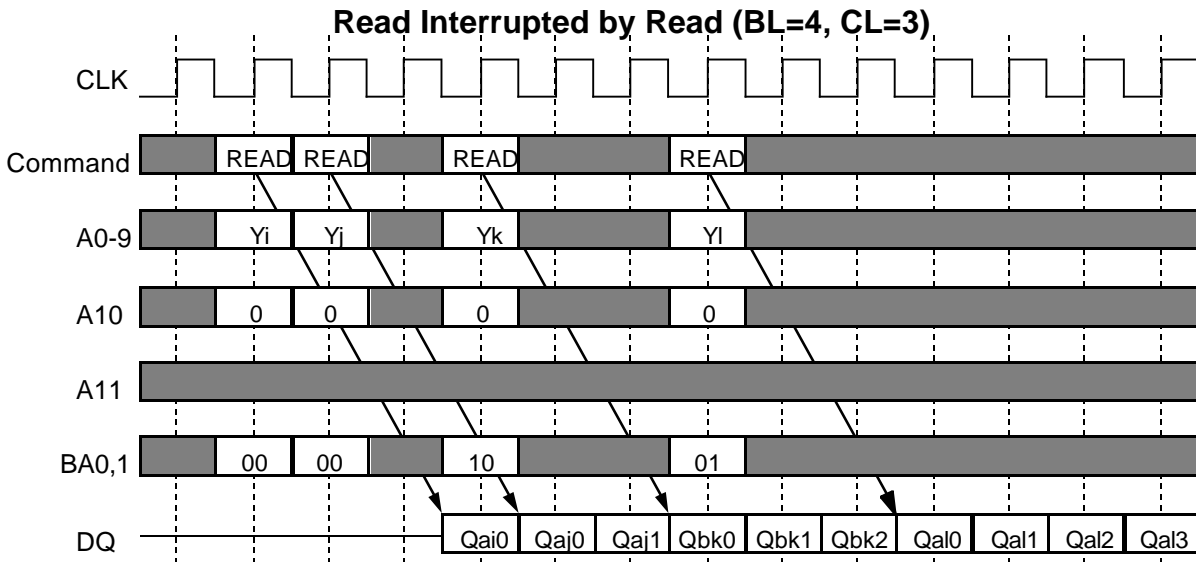
A single write operation is enabled by setting A9=1 at MRS. In a single write operation, data is written only to the column address specified by the write command set cycle without regard to the burst length setting. (The latency of data input is 0.)



BURST INTERRUPTION

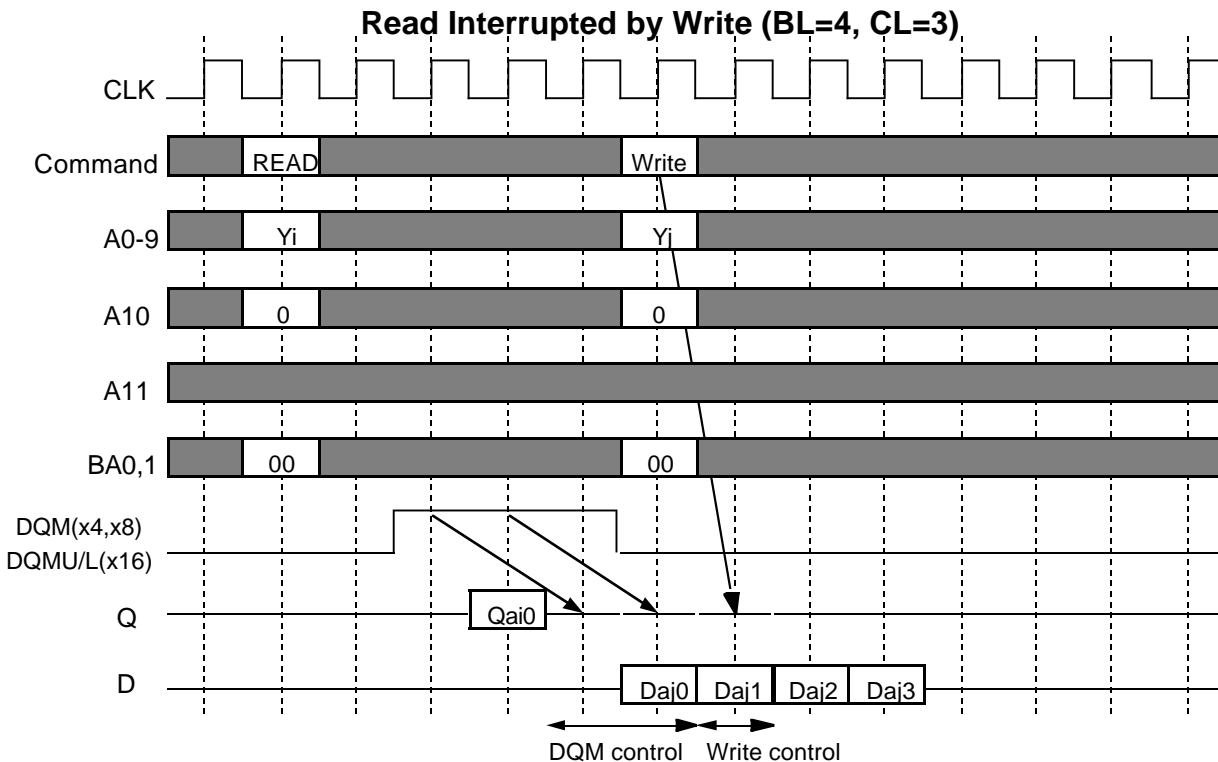
[Read Interrupted by Read]

Burst read operation can be interrupted by new read of any bank. Random column access is allowed. READ to READ interval is minimum 1 CLK.



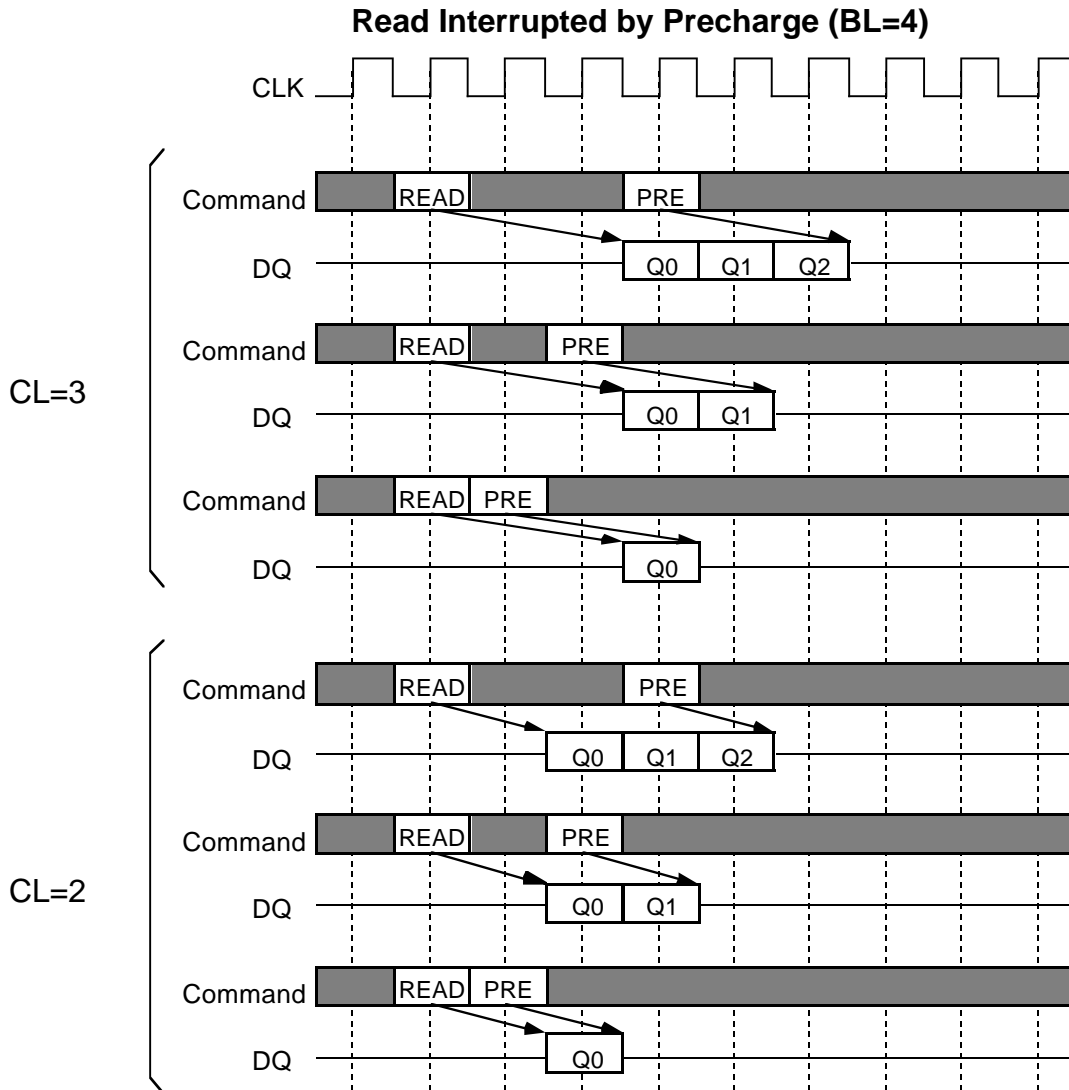
[Read Interrupted by Write]

Burst read operation can be interrupted by write of any bank. Random column access is allowed. In this case, the DQ should be controlled adequately by using the DQM to prevent the bus contention. The output is disabled automatically 1 cycle after WRITE assertion.



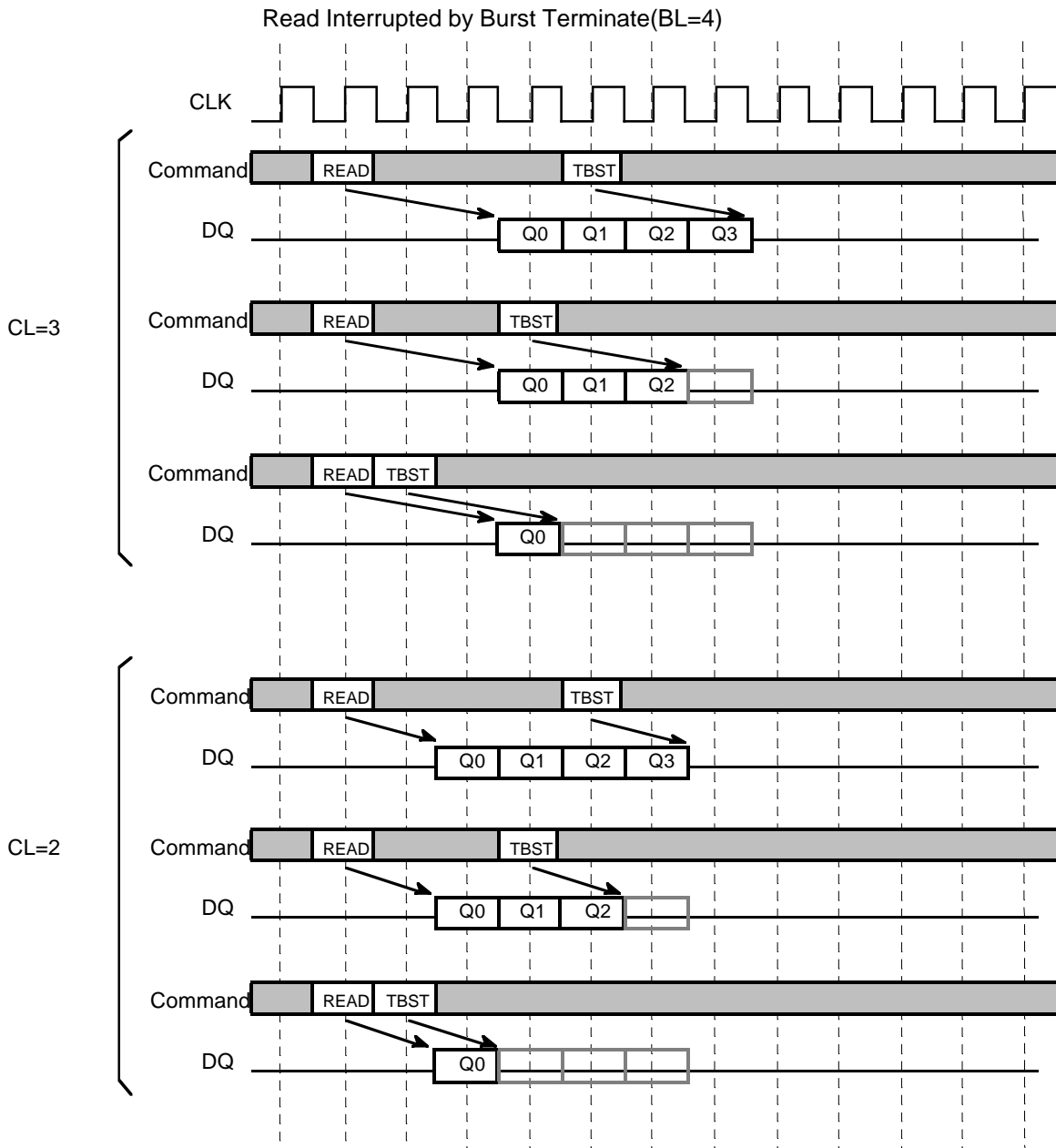
[Read Interrupted by Precharge]

Burst read operation can be interrupted by precharge of *the same bank*. READ to PRE interval is mini-mum 1 CLK. A PRE command to output disable latency is equivalent to the /CAS Latency. As a result, READ to PRE interval determines valid data length to be output. The figure below shows examples of BL=4.



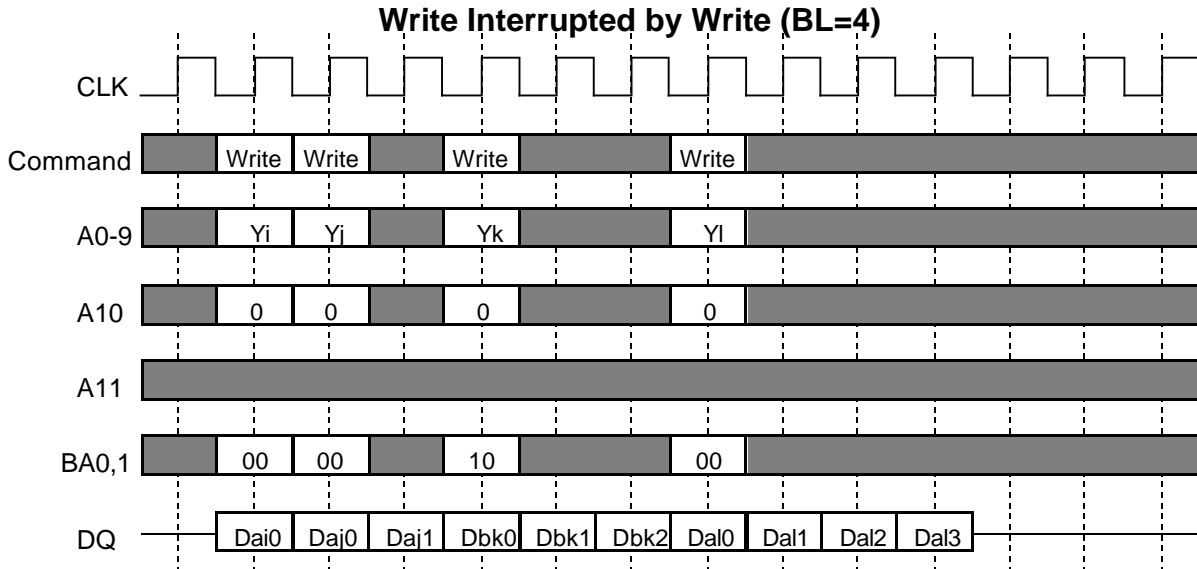
[Read Interrupted by Burst Terminate]

Similar to a precharge, the burst terminate command, TBST, can interrupt the burst read operation and disable the data output. The READ to TBST interval is a minimum of one CLK. TBST is mainly used to interrupt FP bursts. The figures below show examples, of how the output data is terminated with TBST.



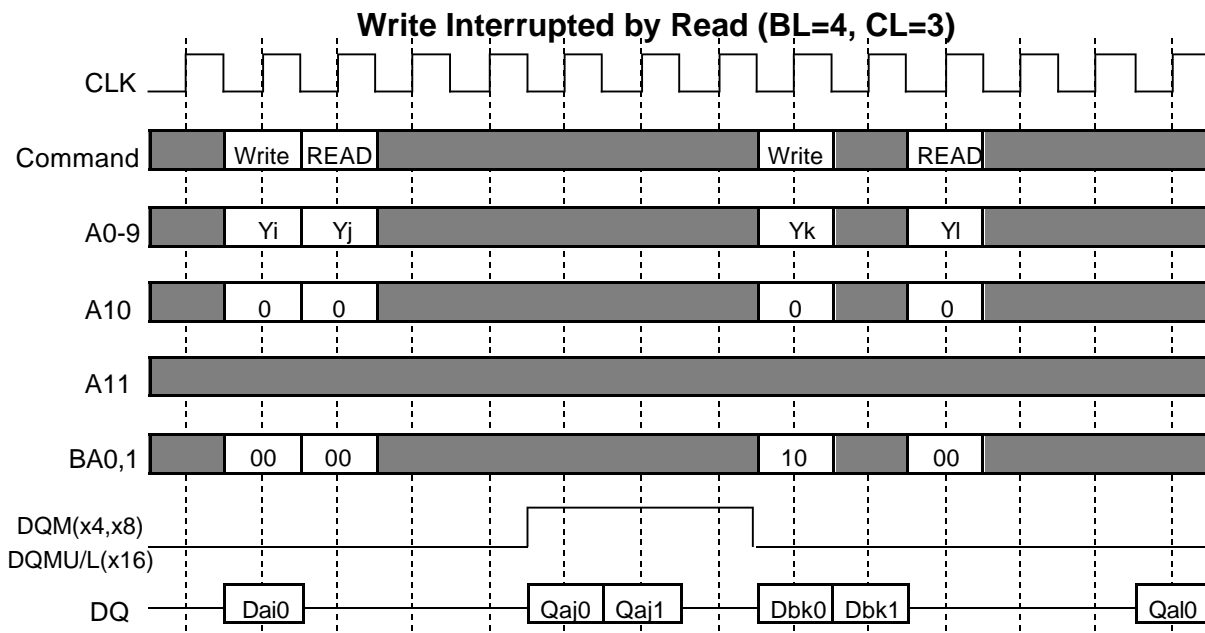
[Write Interrupted by Write]

Burst write operation can be interrupted by new write of any bank. Random column access is allowed. WRITE to WRITE interval is minimum 1 CLK.



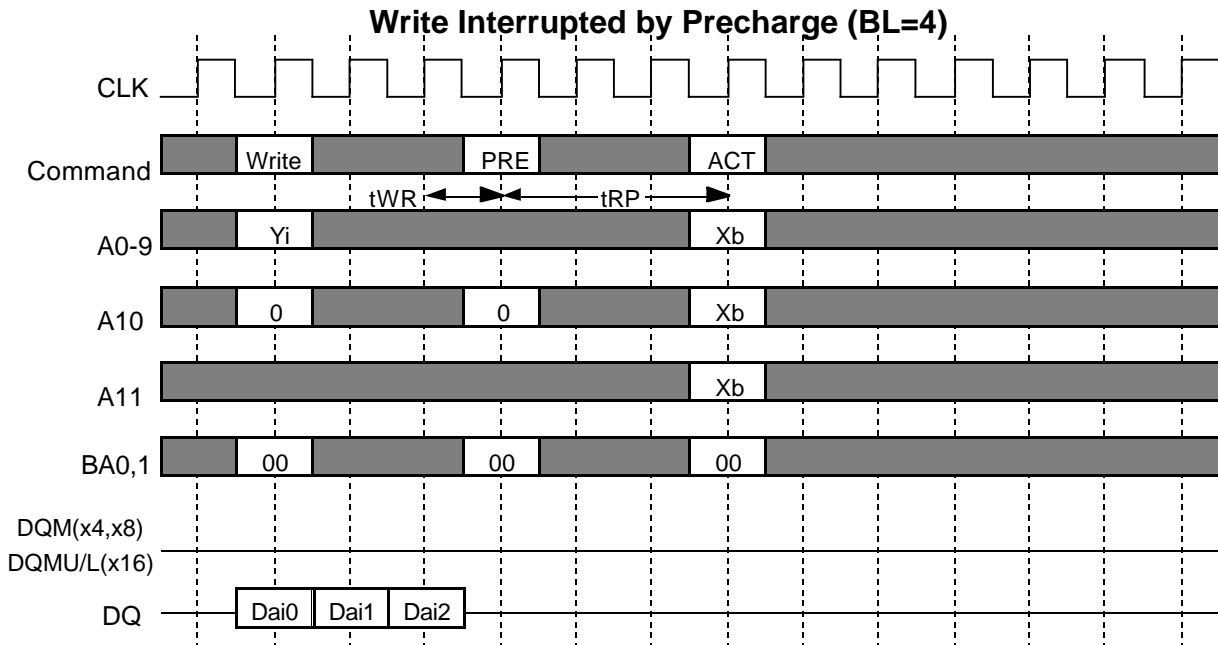
[Write Interrupted by Read]

Burst write operation can be interrupted by read of the same or the other bank. Random column access is allowed. WRITE to READ interval is minimum 1 CLK. The input data on DQ at the interrupting READ cycle is "don't care".



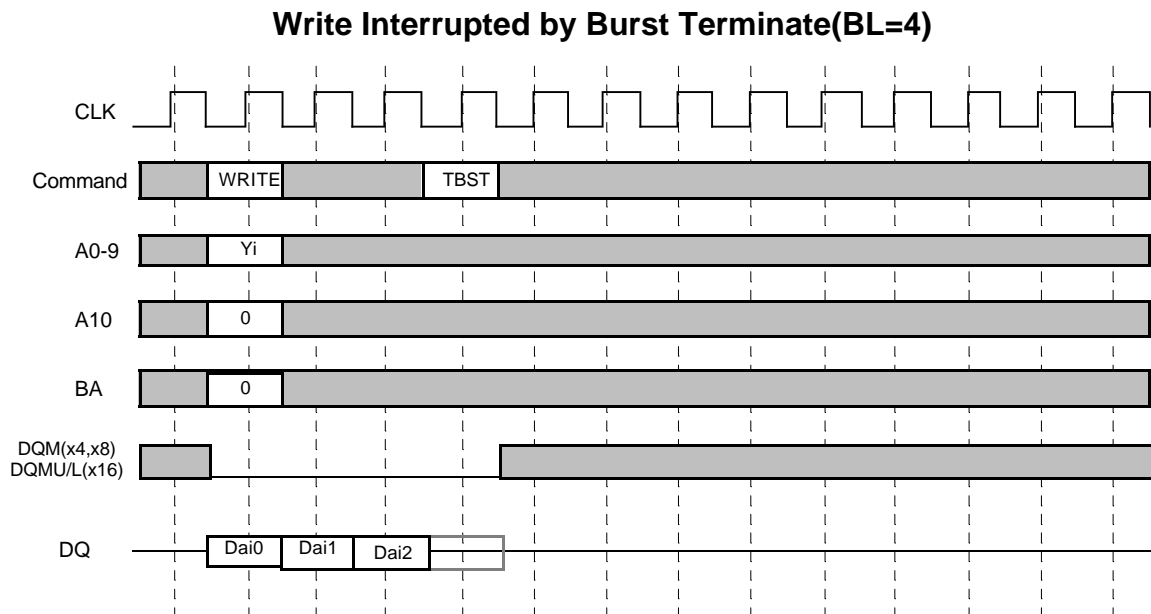
[Write Interrupted by Precharge]

Burst write operation can be interrupted by precharge of *the same bank*. Random column access is allowed. Write recovery time (t_{WR}) is required from the last data to PRE command.



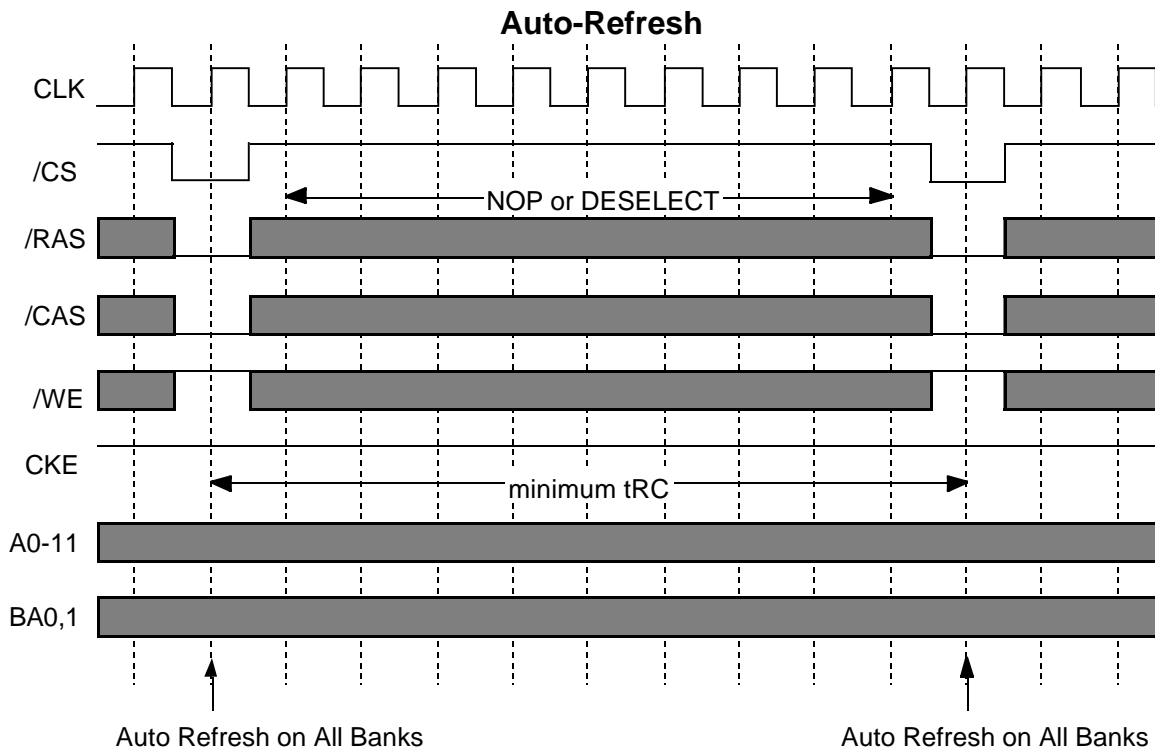
[Write Interrupted by Burst Terminate]

A burst terminate command TBST can be used to terminate a burst write operation. In this case, the write recovery time is not required and the bank remains active (Please see the waveforms below). The WRITE to TBST minimum interval is one CLK.



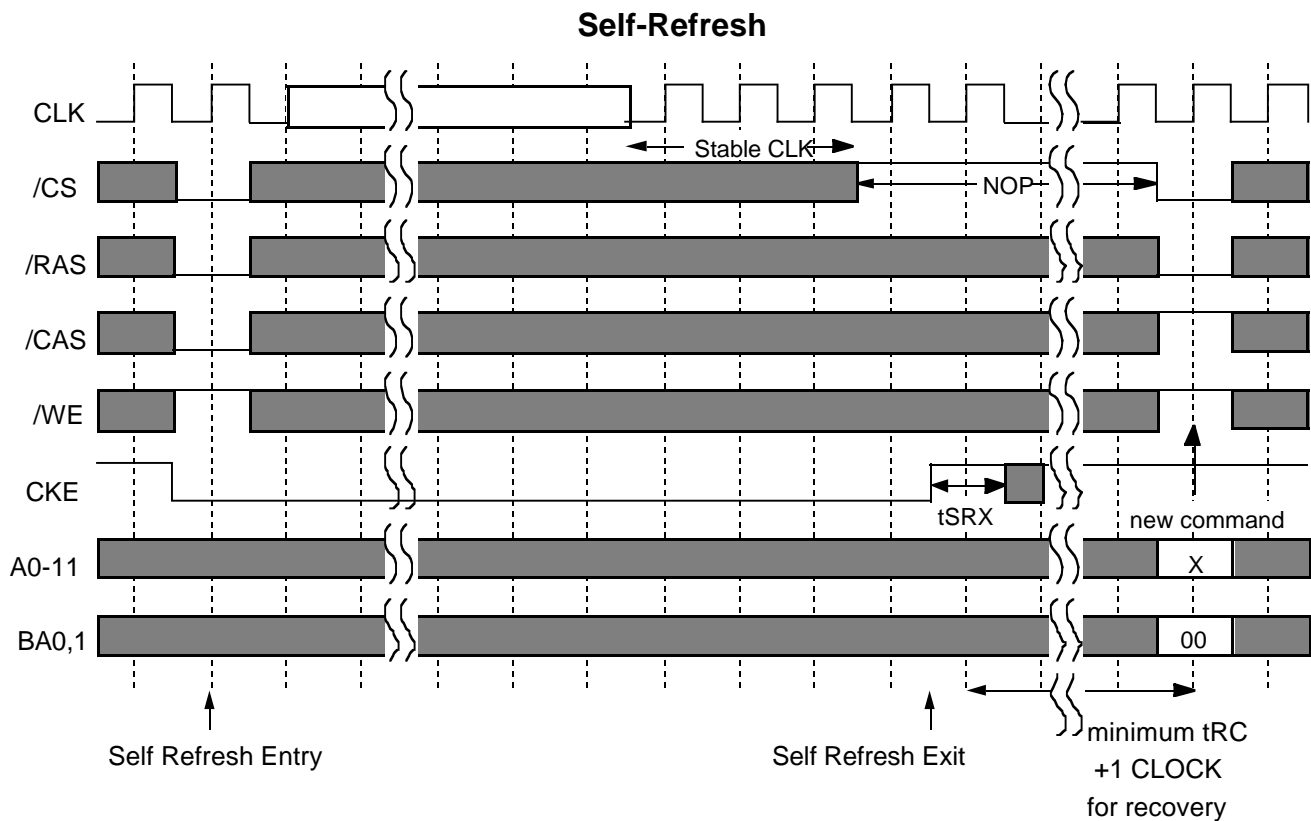
AUTO REFRESH

Single cycle of auto-refresh is initiated with a REFA (/CS= /RAS= /CAS= L, /WE= /CKE= H) command. The refresh address is generated internally. 4096 REFA cycles within 64ms refresh 64Mbit memory cells. The auto-refresh is performed on 4 banks concurrently. Before performing an auto-refresh, all banks must be in the idle state. Auto-refresh to auto-refresh interval is minimum tRC. Any command must not be supplied to the device before tRC from the REFA command.



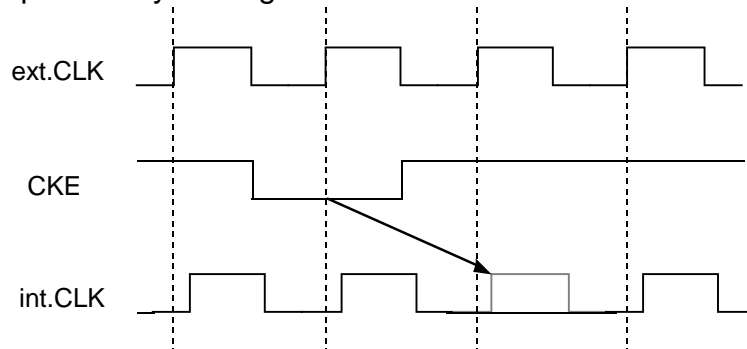
SELF REFRESH

Self-refresh mode is entered by issuing a REFS command ($\overline{CS} = \overline{RAS} = \overline{CAS} = L, \overline{WE} = H, \text{CKE} = L$). Once the self-refresh is initiated, it is maintained as long as CKE is kept low. During the self-refresh mode, CKE is asynchronous and the only enabled input, all other inputs including CLK are disabled and ignored, so that power consumption due to synchronous inputs is saved. To exit the self-refresh, supplying stable CLK inputs, asserting DESEL or NOP command and then asserting CKE (REFSX) for longer than t_{SRX} . After t_{RC} from REFSX all banks are in the idle state and a new command can be issued, but DESEL or NOP commands must be asserted till then.

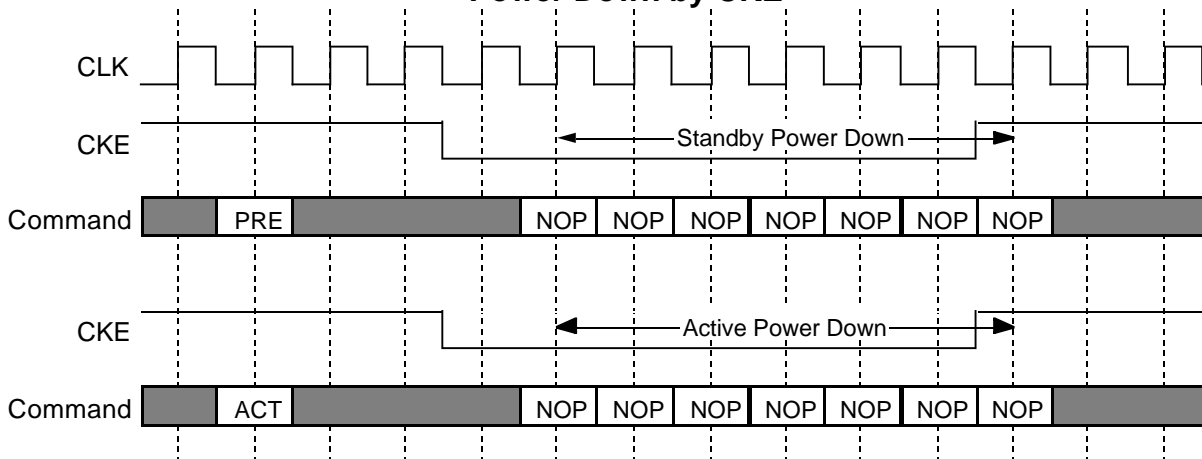


CLK SUSPEND

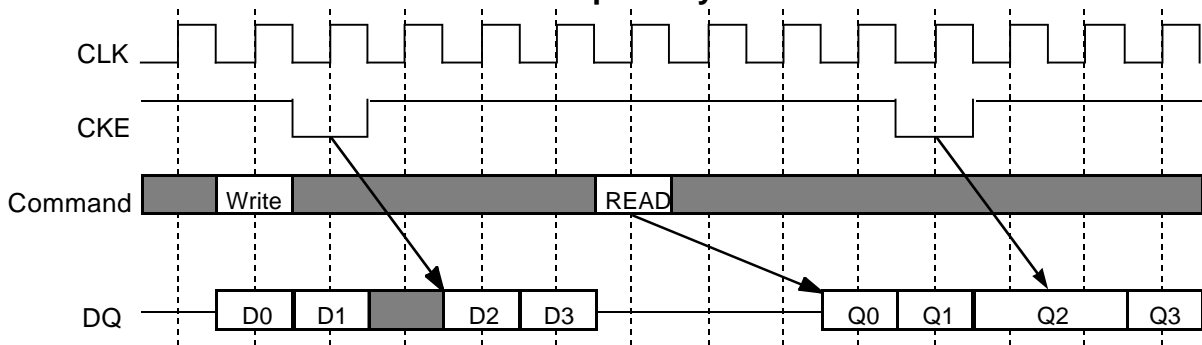
CKE controls the internal CLK at the following cycle. Figure below shows how CKE works. By negating CKE, the next internal CLK is suspended. The purpose of CLK suspend is power down, output suspend or input suspend. CKE is a synchronous input except during the self-refresh mode. CLK suspend can be performed either when the banks are active or idle. A command at the suspended cycle is ignored.



Power Down by CKE

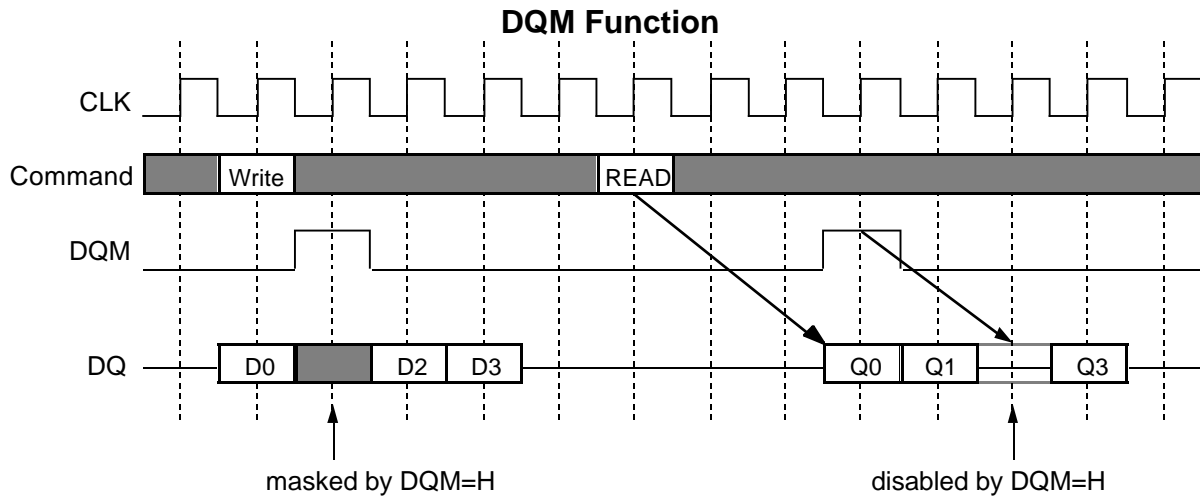


DQ Suspend by CKE

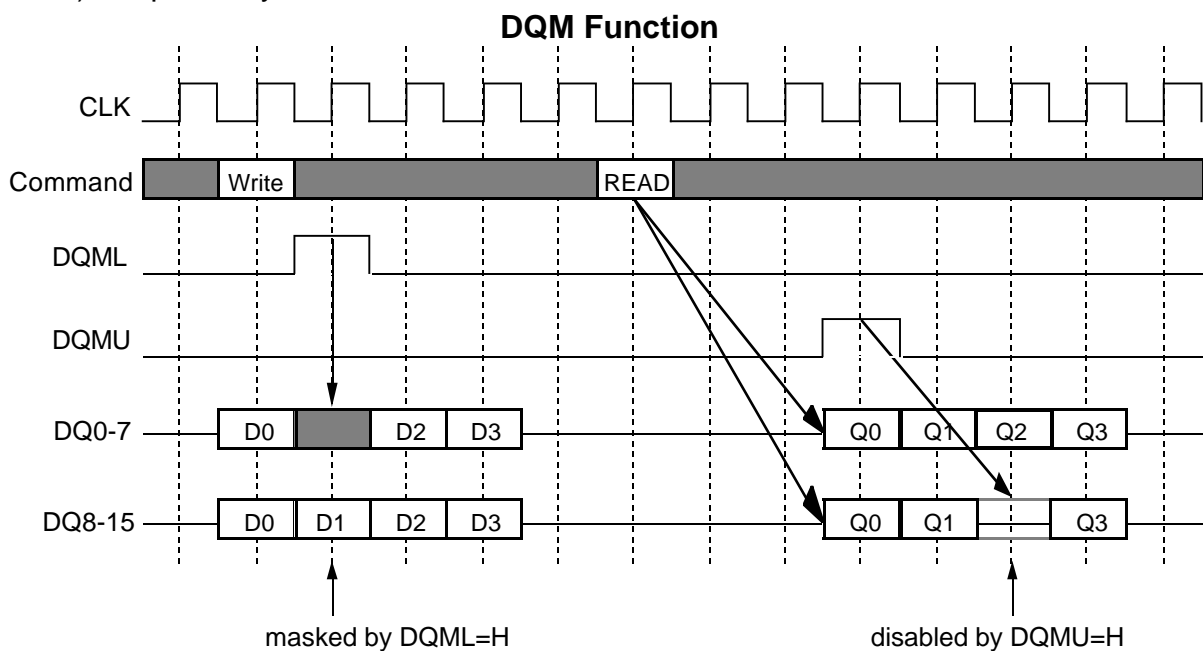


DQM CONTROL

For x4/x8, DQM is a dual function signal defined as the data mask for writes and the output disable for reads. During writes, DQM masks input data word by word. DQM to write mask latency is 0. During reads, DQM forces output to Hi-Z word by word. DQM to output Hi-Z latency is 2.



For x16, DQMU/L are dual function signals defined as the data mask for writes and the output disable for reads. During writes, DQMU/L mask input data word by word. DQMU/L to write mask latency is 0. During reads, DQMU/L force outputs to Hi-Z word by word. DQMU/L to output Hi-Z latency is 2. DQML and DQMU control lower byte (DQ0-7), and upper byte (DQ8-15), respectively.



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Conditions	Ratings	Unit
Vdd	Supply Voltage	with respect to Vss	-0.5 - 4.6	V
VddQ	Supply Voltage for Output	with respect to VssQ	-0.5 - 4.6	V
VI	Input Voltage	with respect to Vss	-0.5 - 4.6	V
VO	Output Voltage	with respect to VssQ	-0.5 - 4.6	V
IO	Output Current		50	mA
Pd	Power Dissipation	Ta = 25°C	1000	mW
Topr	Operating Temperature		0 - 70	°C
Tstg	Storage Temperature		-65 - 150	°C

RECOMMENDED OPERATING CONDITIONS

(Ta=0 – 70°C, unless otherwise noted)

Symbol	Parameter	Limits			Unit
		Min.	Typ.	Max.	
Vdd	Supply Voltage	3.0	3.3	3.6	V
Vss	Supply Voltage	0	0	0	V
VddQ	Supply Voltage for Output	3.0	3.3	3.6	V
VssQ	Supply Voltage for Output	0	0	0	V
VIH*1	High-level Input Voltage all inputs	2.0		VddQ +0.3	V
VIL*2	Low-level Input Voltage all inputs	-0.3		0.8	V

NOTES)

1. VIH(max)= Vdd+2.0V AC for pulse width less than 3ns acceptable.
2. VIL(min) = -2.0V AC for pulse width less than 3ns acceptable.

CAPACITANCE

(Ta=0 – 70°C, Vdd= VddQ= 3.3 ± 0.3V, Vss= VssQ= 0V, unless otherwise noted)

Symbol	Parameter	Test Condition	Limits (min.)	Limits (max.)	Unit
CI(A)	Input Capacitance, address pin	1MHz, 1.4v bias 200mV swing	2.5	3.8	pF
CI(C)	Input Capacitance, control pin		2.5	3.8	pF
CI(K)	Input Capacitance, CLK pin		2.5	3.5	pF
CI/O	Input Capacitance, I/O pin		4.0	6.5	pF



AVERAGE SUPPLY CURRENT from Vdd

(Ta=0 – 70°C, Vdd= VddQ= 3.3 ± 0.3V, Vss= VssQ= 0V, unless otherwise noted)

ITEM	Symbol	Organi- zation	Limits (max.)		Unit	Note
			-6			
operating current tRC=min, tCLK =min, BL=1 , CL=3,IOL=0mA	lcc1	single bank operation	x4/x8	120	mA	*1
			x16	130		
precharge standby current in Non Power down mode	lcc2N	tCLK = 15ns CKE = VIHmin	x4/x8/x16	25	mA	*1,2
	lcc2NS	CLK = VILmax CKE = VIHmin (fixed)	x4/x8/x16	20		
precharge standby current in Power down mode	lcc2P	tCLK = 15ns CKE = VILmax	x4/x8/x16	2	mA	*1,2
	lcc2PS	CLK = CKE =VILmax(fixed)	x4/x8/x16	1		
active standby current in Non Power Down Mode	lcc3N	CKE = /CS=VIHmin, tCLK=15ns	x4/x8/x16	55	mA	*1,2
	lcc3NS	CKE = /CS=VIHmin, CLK=VILmax (fixed)	x4/x8/x16	40		
active standby current in Power Down Mode	lcc3P	tCLK = 15ns CKE = VILmax	x4/x8/x16	2	mA	*1,2
	lcc3PS	CLK = CKE =VILmax(fixed)	x4/x8/x16	1		
burst current	lcc4	All Bank Active,tCLK = min BL=4, CL=3,IOL=0mA	x4/x8	145	mA	*1
			x16	160		
auto-refresh current	lcc5	tRFC=min, tCLK=min	x4/x8/x16	150	mA	*1
self-refresh current	lcc6	CKE < 0.2V	x4/x8/x16	1	mA	*1

NOTE)

1. lcc(max) is specified at the output open condition.
2. Input signal are changed one time during 30ns

AC OPERATING CONDITIONS AND CHARACTERISTICS

(Ta=0 – 70°C, Vdd= VddQ= 3.3 ± 0.3V, Vss= VssQ= 0V, unless otherwise noted)

Symbol	Parameter	Test Conditions	Limits		unit
			Min.	Max.	
VOH (DC)	High-Level Output Voltage (DC)	IOH=-2mA	2.4		V
VOL (DC)	Low-level Output Voltage (DC)	IOL= 2mA		0.4	V
IOZ	Off-state Output Current	Q floating VO=0 -- VddQ	-10	10	µA
Ii	Input Current	VIH = 0 -- VddQ +0.3V	-10	10	µA



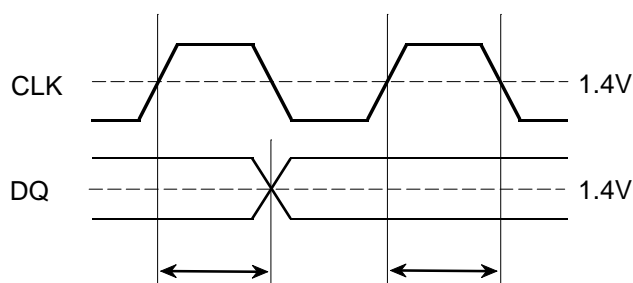
AC TIMING REQUIREMENTS

(Ta=0 – 70°C, Vdd= VddQ= 3.3 ± 0.3V, Vss= VssQ= 0V, unless otherwise noted)

Input Pulse Levels: 0.8V – 2.0V

Input Timing Measurement Level: 1.4V

Symbol	Parameter	Limits		Unit
		-6		
		Min.	Max.	
tCLK	CLK cycle time	CL=3	7.5	ns
		CL=2	10	ns
tCH	CLK High pulse width	2.5		ns
tCL	CLK Low pulse width	2.5		ns
tT	Transition time of CLK	1	10	ns
tIS	Input Setup time (all inputs)	1.5		ns
tIH	Input Hold time (all inputs)	0.8		ns
tRC	Row Cycle time	67.5		ns
tRFC	Row Refresh Cycle time	75		ns
tRCD	Row to Column Delay	20		ns
tRAS	Row Active time	45	100K	ns
tRP	Row Precharge time	20		ns
tWR	Write Recovery time	15		ns
tRRD	Act to Act Delay time	15		ns
tRSC	Mode Register Set Cycle time	15		ns
tSRX	Self-refresh Exit time	7.5		ns
tPDE	Power Down Exit time	7.5		ns
tREF	Refresh Interval time		64	ms



Any AC timing is referenced to the input signal passing through 1.4V.



SWITCHING CHARACTERISTICS

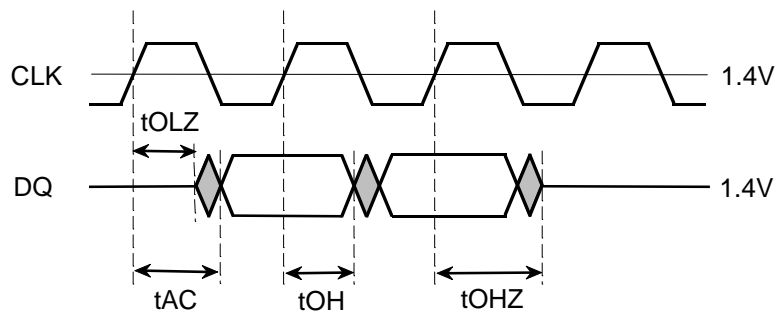
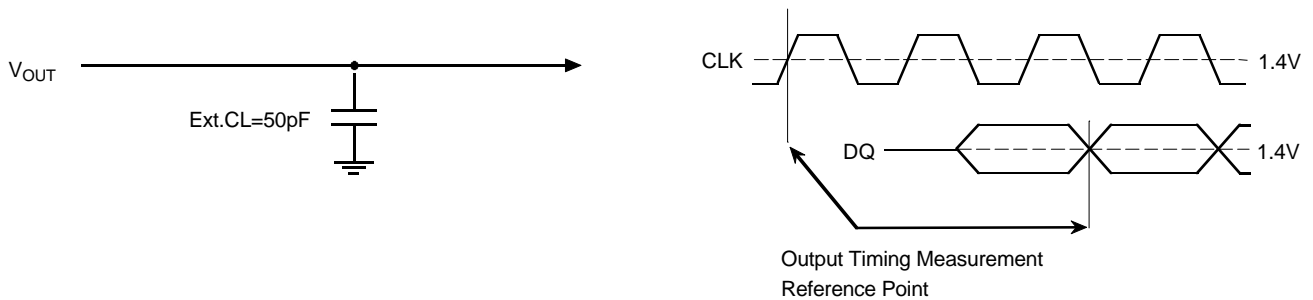
(Ta=0 – 70°C, Vdd= VddQ= 3.3 ± 0.3V, Vss= VssQ= 0V, unless otherwise noted)

Symbol	Parameter	Limits		Unit	Note
		-6			
		Min.	Max.		
tAC	Access time from CLK	CL=3	5.4	ns	*1
		CL=2	6.0	ns	
tOH	Output Hold time from CLK	CL=3	2.7	ns	
		CL=2	3.0	ns	
tOLZ	Delay time, output low-impedance from CLK	0		ns	
tOHZ	Delay time, output high-impedance from CLK	2.7	5.4	ns	

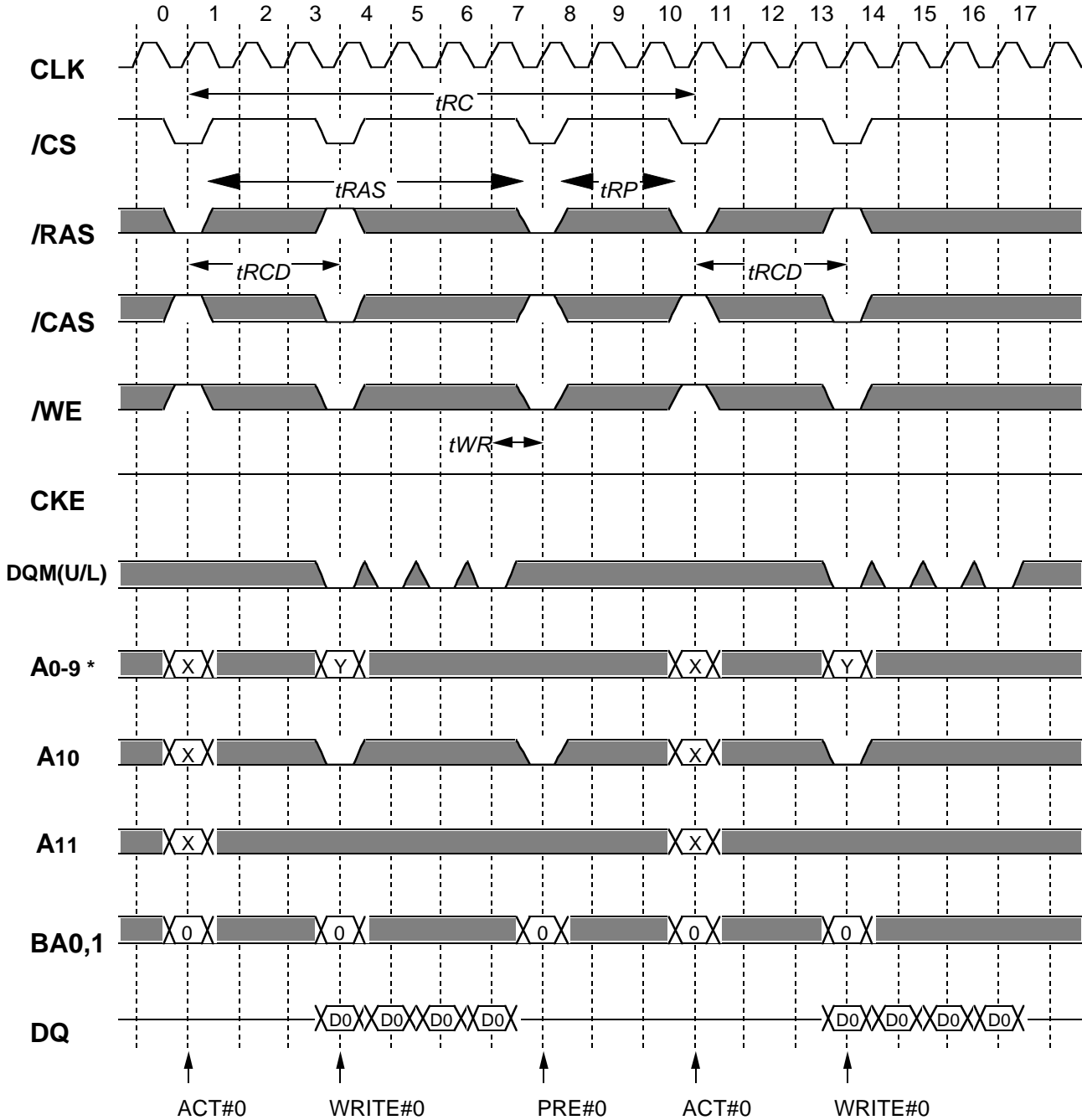
NOTE)

1. If clock rising time is longer than 1ns, (tr /2–0.5ns) should be added to the parameter.

Output Load Condition



Burst Write (single bank) @BL=4

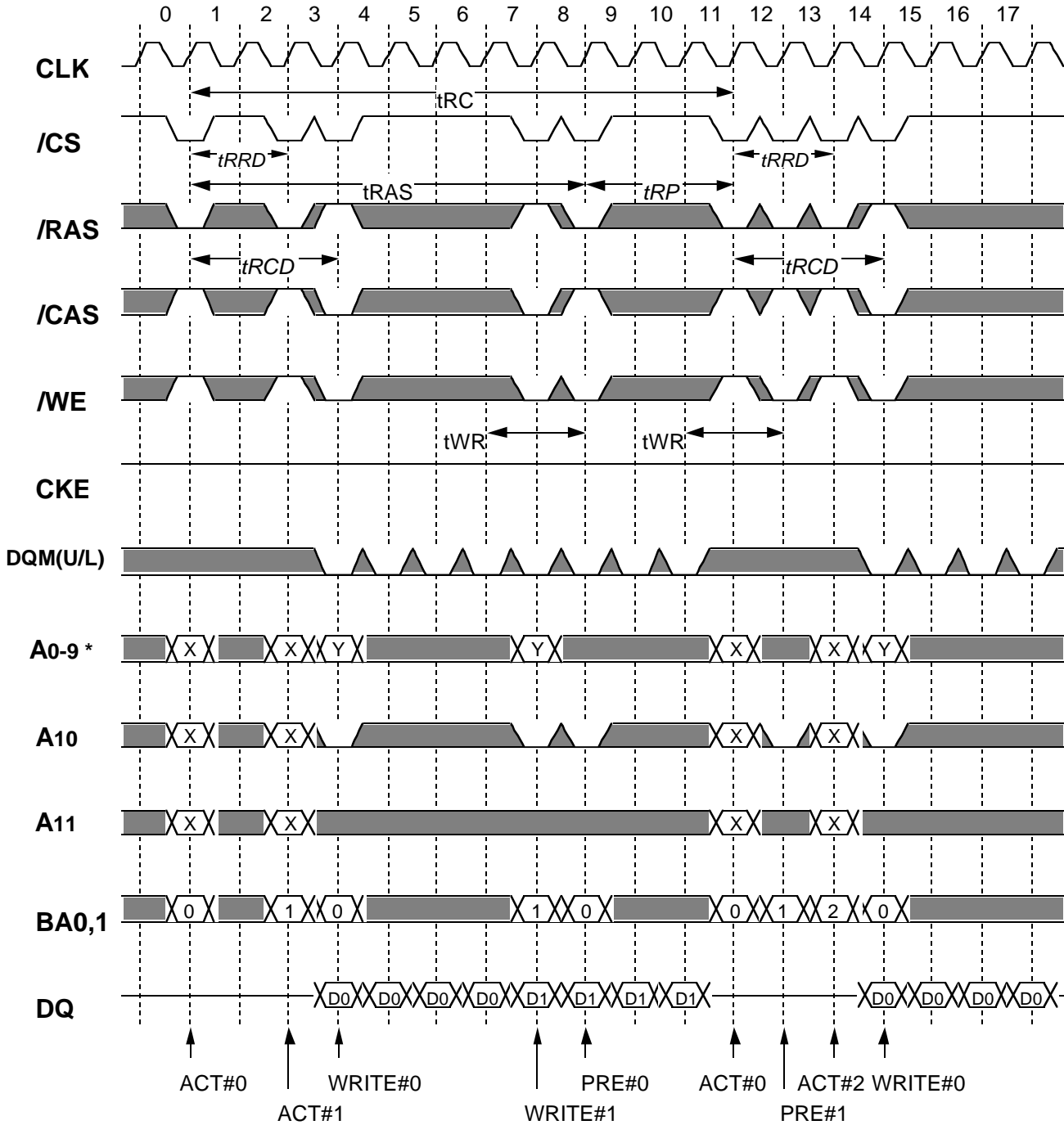


Italic parameter indicates minimum case

* A9 (x8) and A8,A9 (x16) for column address of read/write are don't care



Burst Write (multi bank) @BL=4

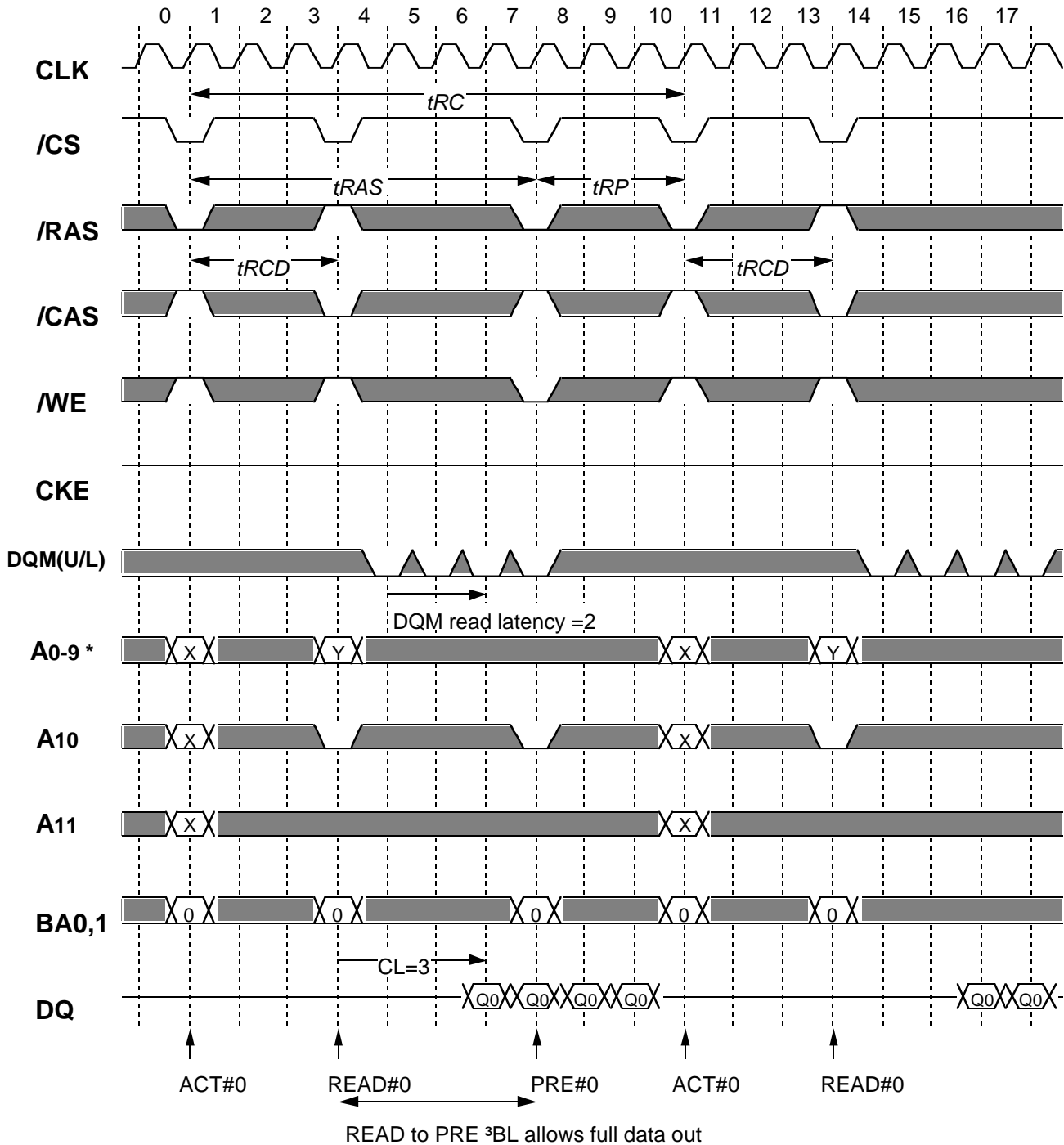


Italic parameter indicates minimum case

* A9 (x8) and A8,A9 (x16) for column address of read/write are don't care



Burst Read (single bank) @BL=4 CL=3

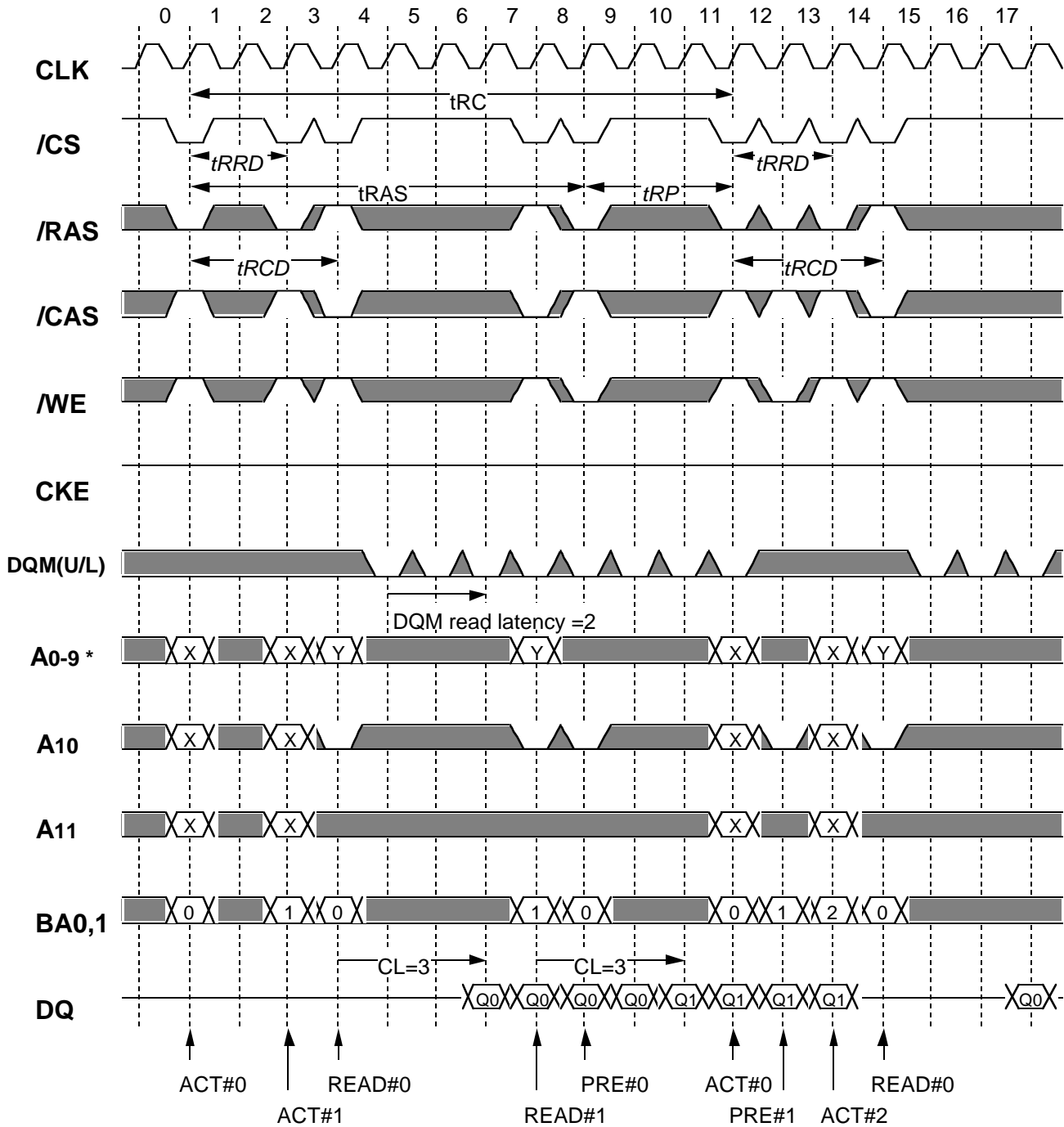


Italic parameter indicates minimum case

* A9 (x8) and A8,A9 (x16) for column address of read/write are don't care



Burst Read (multiple bank) @BL=4 CL=3

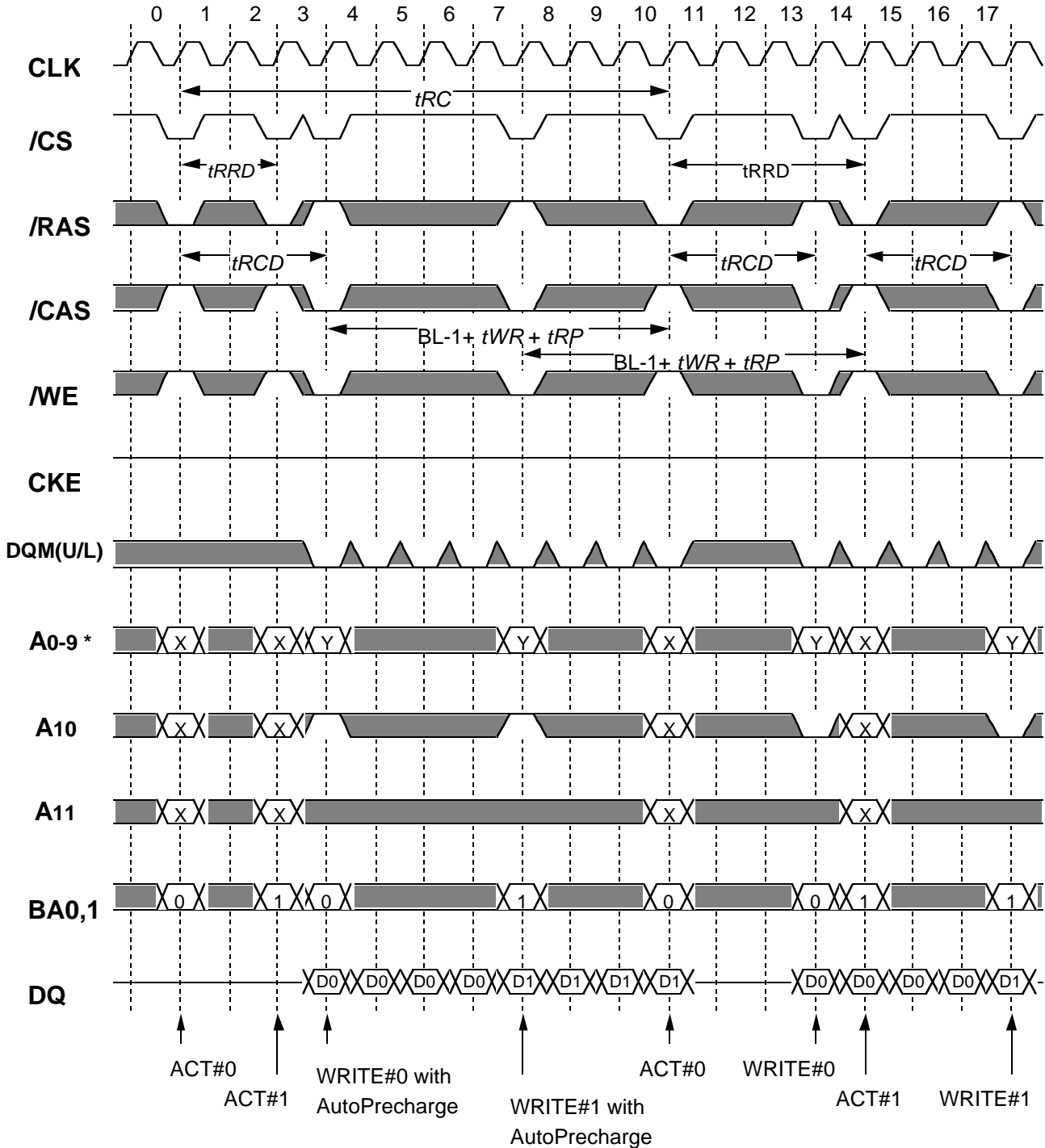


Italic parameter indicates minimum case

* A9 (x8) and A8,A9 (x16) for column address of read/write are don't care



Burst Write (multi bank) with Auto-Precharge @BL=4

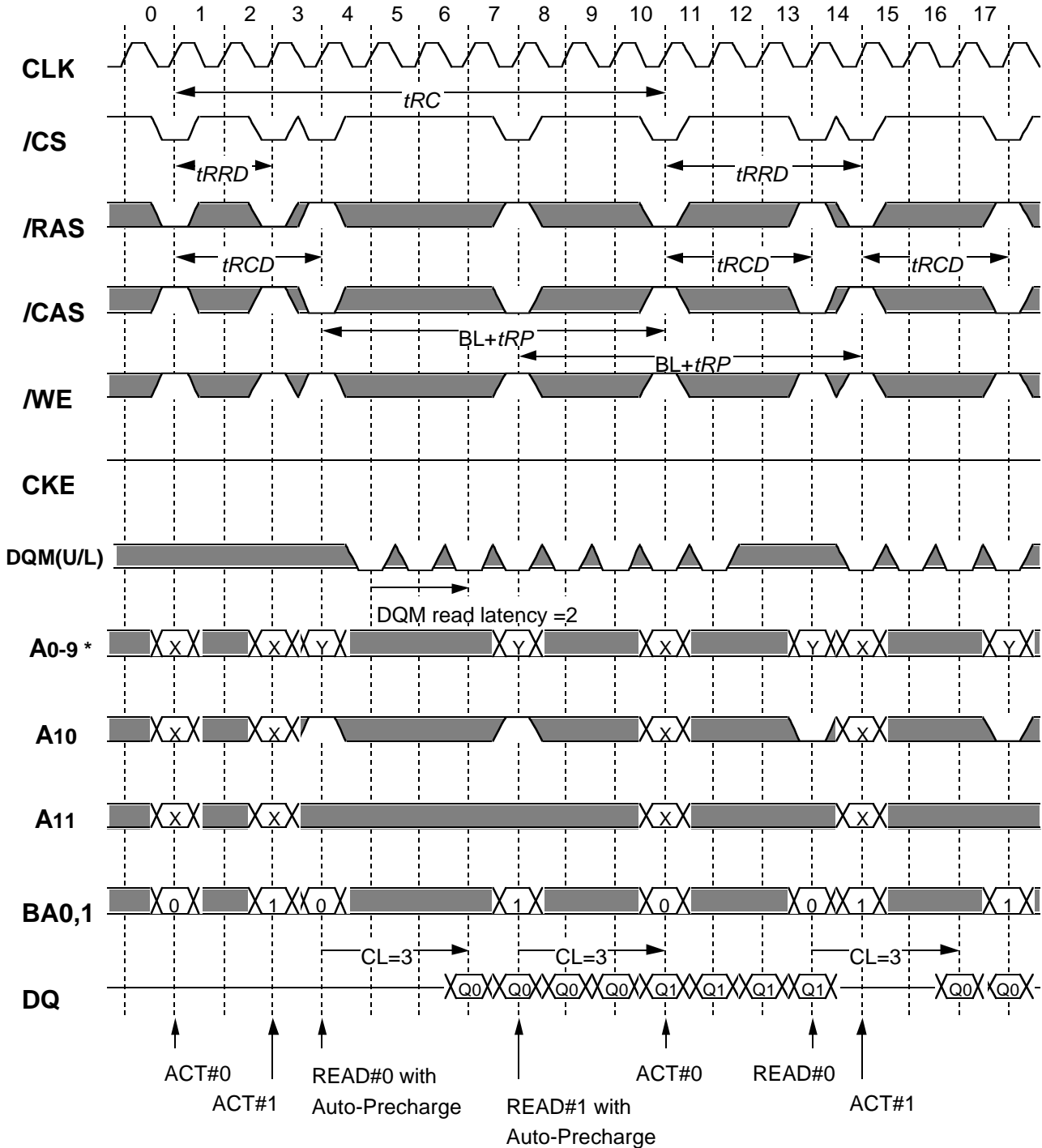


Italic parameter indicates minimum case

* A9 (x8) and A8,A9 (x16) for column address of read/write are don't care



Burst Read (multiple bank) with Auto-Precharge @BL=4 CL=3

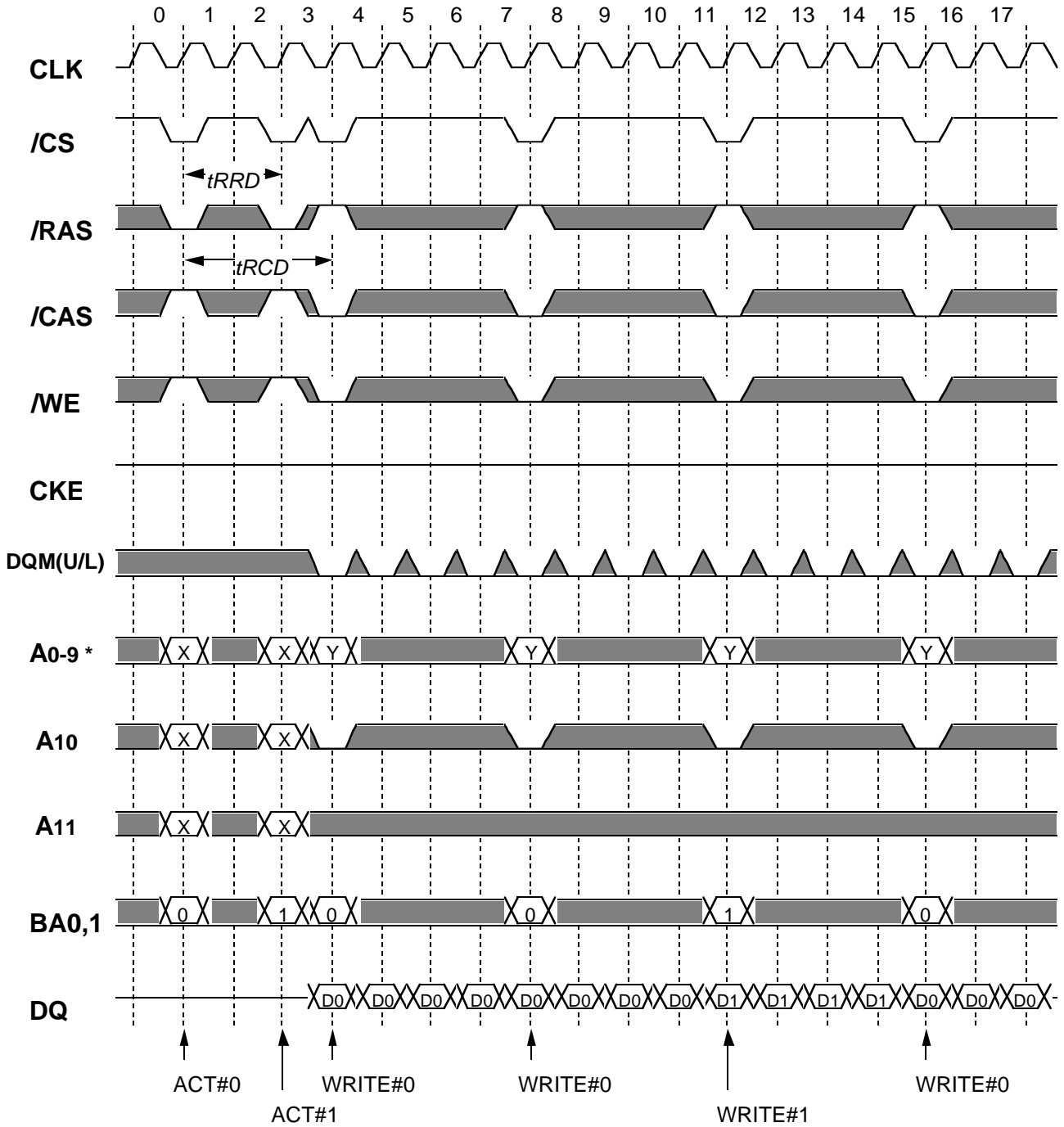


Italic parameter indicates minimum case

* A9 (x8) and A8,A9 (x16) for column address of read/write are don't care



Page Mode Burst Write (multi bank) @BL=4

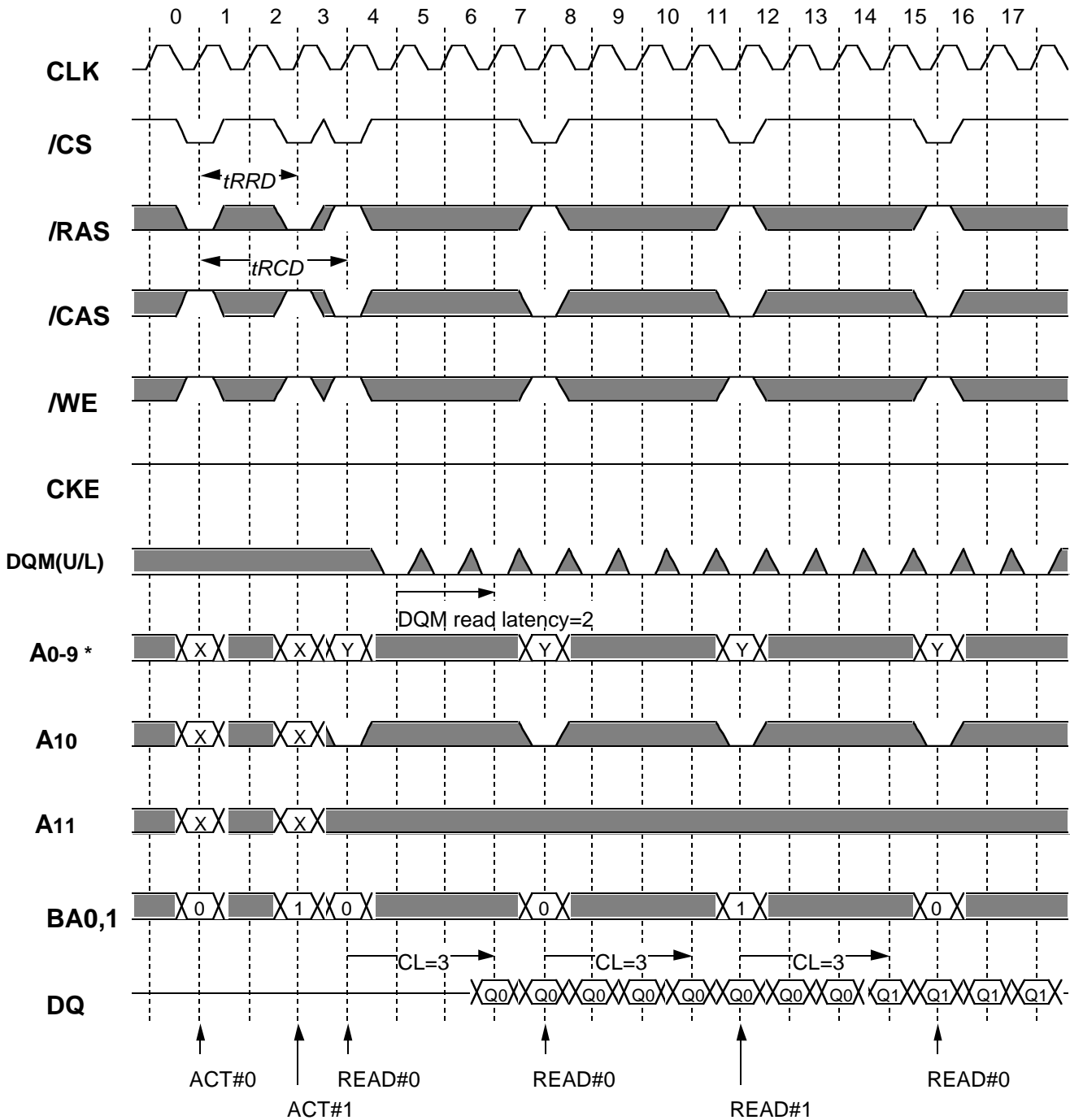


Italic parameter indicates minimum case

* A9 (x8) and A8,A9 (x16) for column address of read/write are don't care



Page Mode Burst Read (multi bank) @BL=4 CL=3

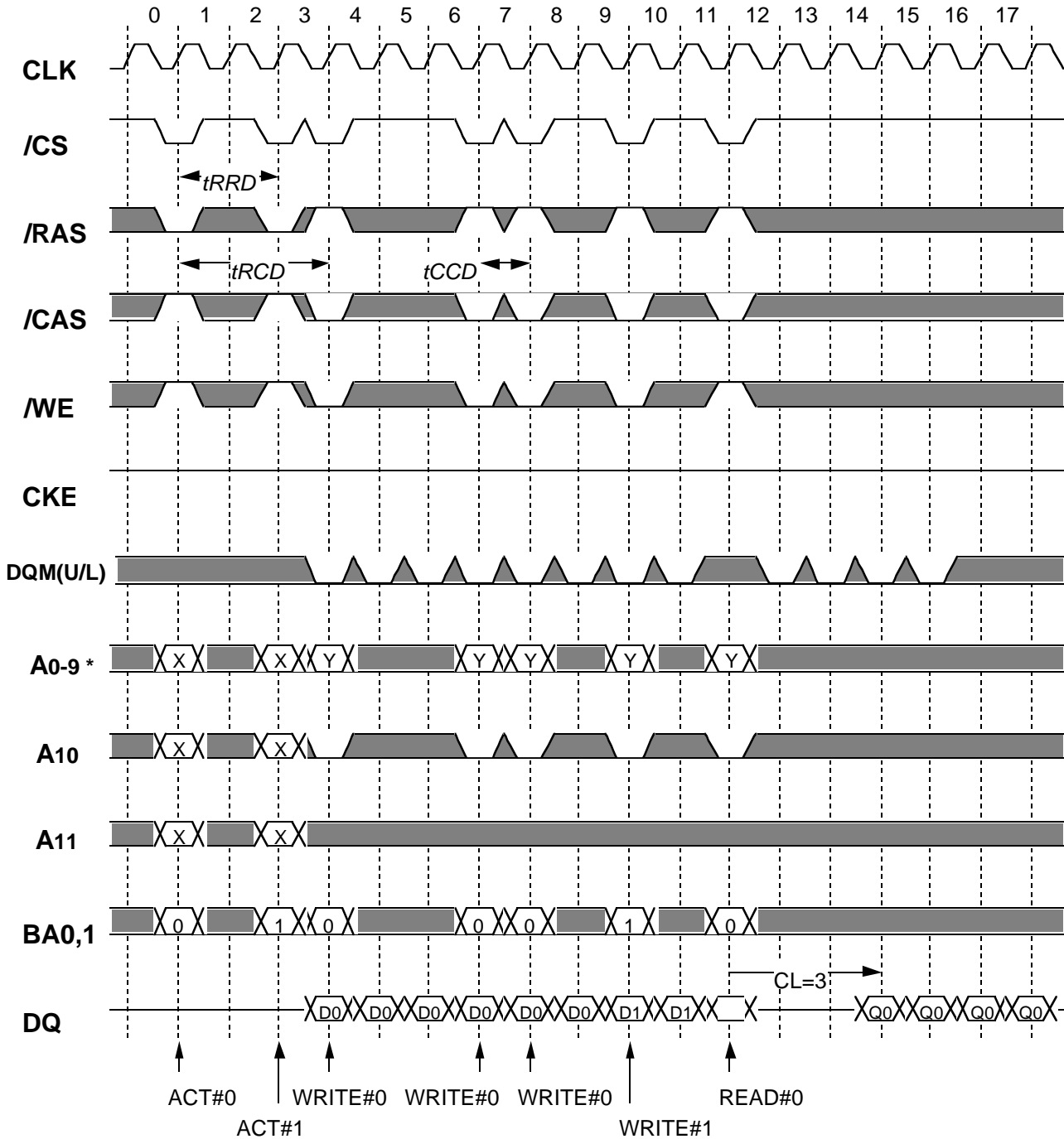


Italic parameter indicates minimum case

* A9 (x8) and A8,A9 (x16) for column address of read/write are don't care



Write Interrupted by Write / Read @BL=4



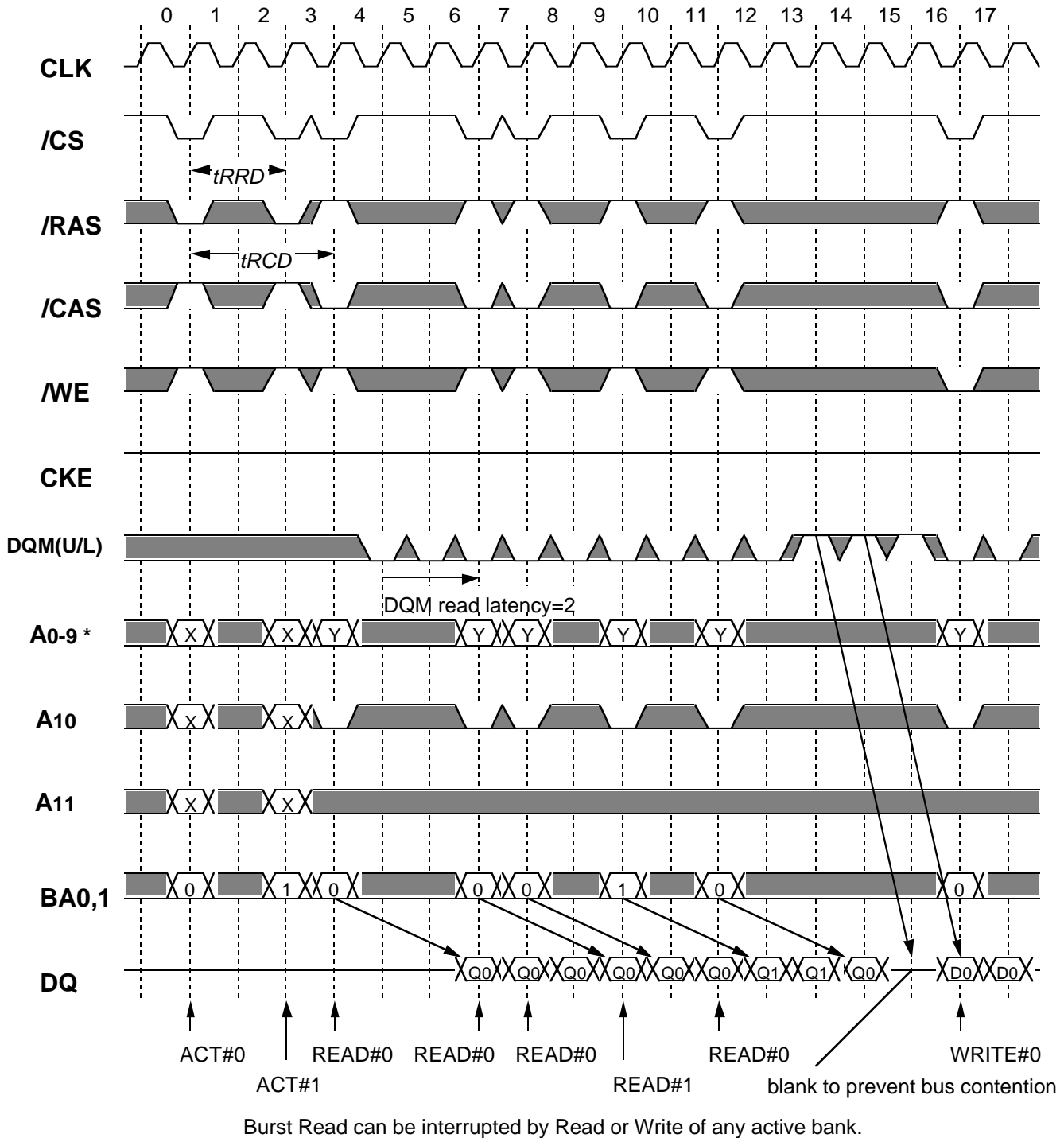
Burst Write can be interrupted by Write or Read of any active bank.

Italic parameter indicates minimum case

* A9 (x8) and A8,A9 (x16) for column address of read/write are don't care



Read Interrupted by Read / Write @BL=4 CL=3

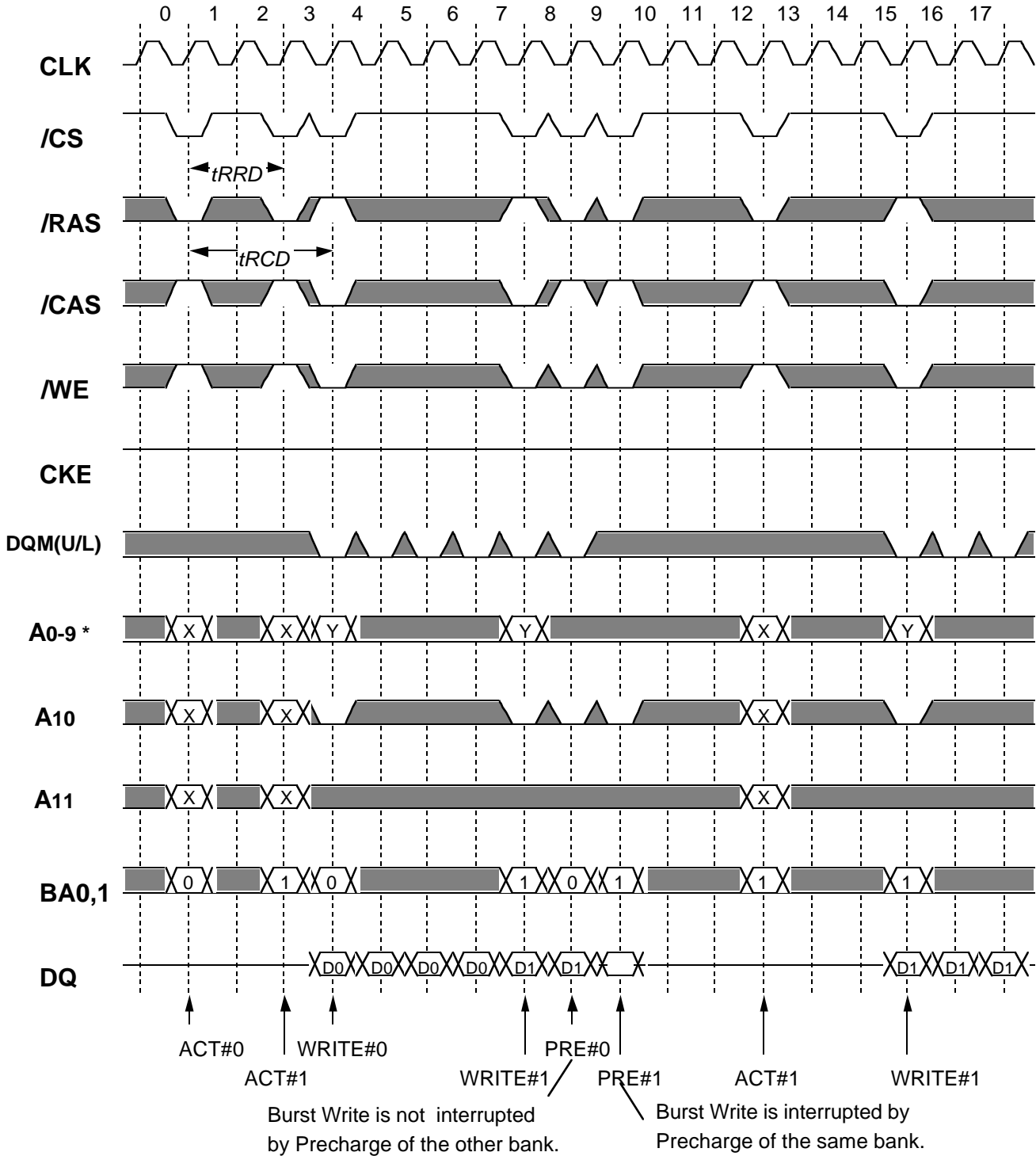


Italic parameter indicates minimum case

* A9 (x8) and A8,A9 (x16) for column address of read/write are don't care



Write Interrupted by Precharge @BL=4

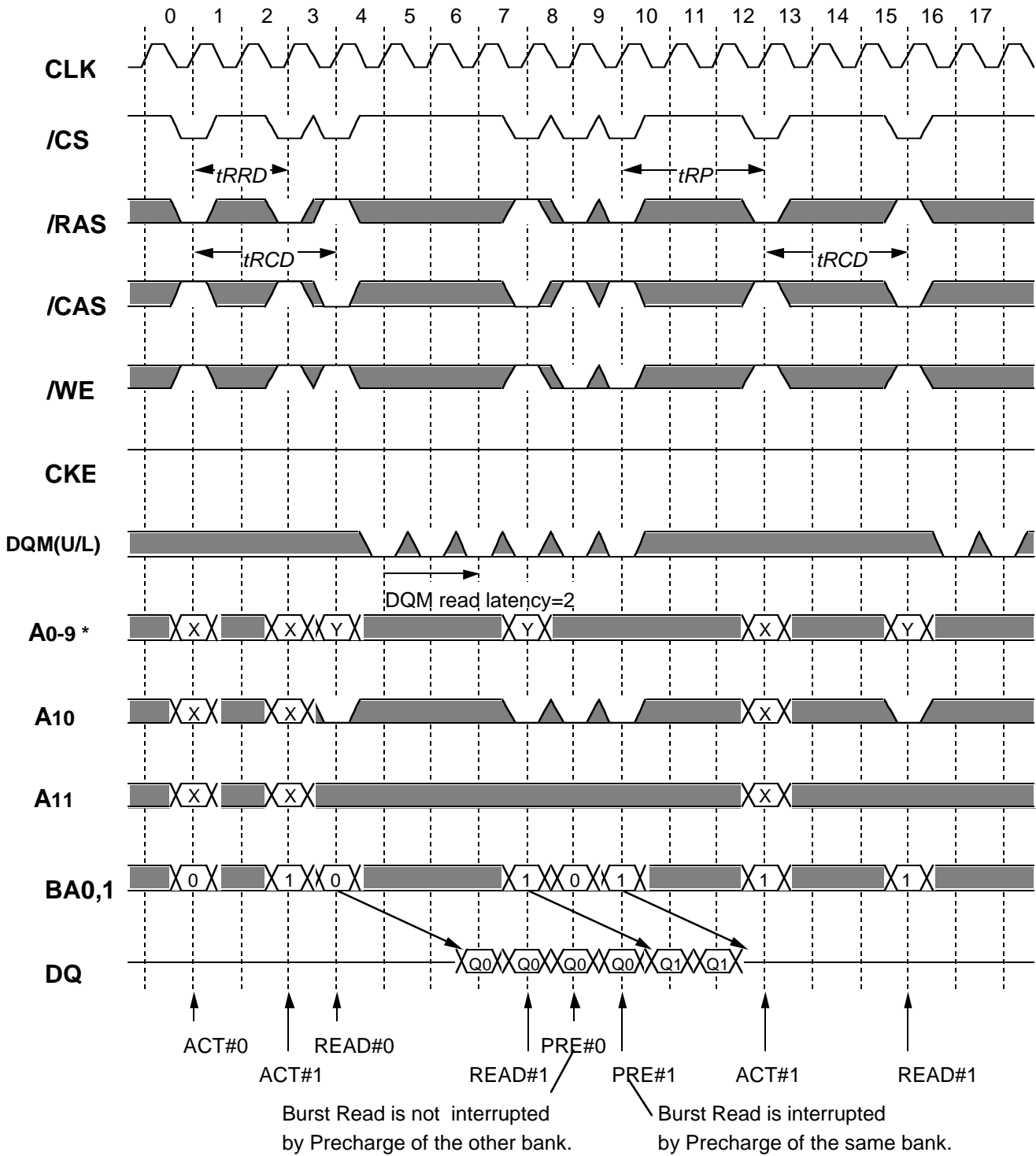


Italic parameter indicates minimum case

* A9 (x8) and A8,A9 (x16) for column address of read/write are don't care



Read Interrupted by Precharge @BL=4 CL=3

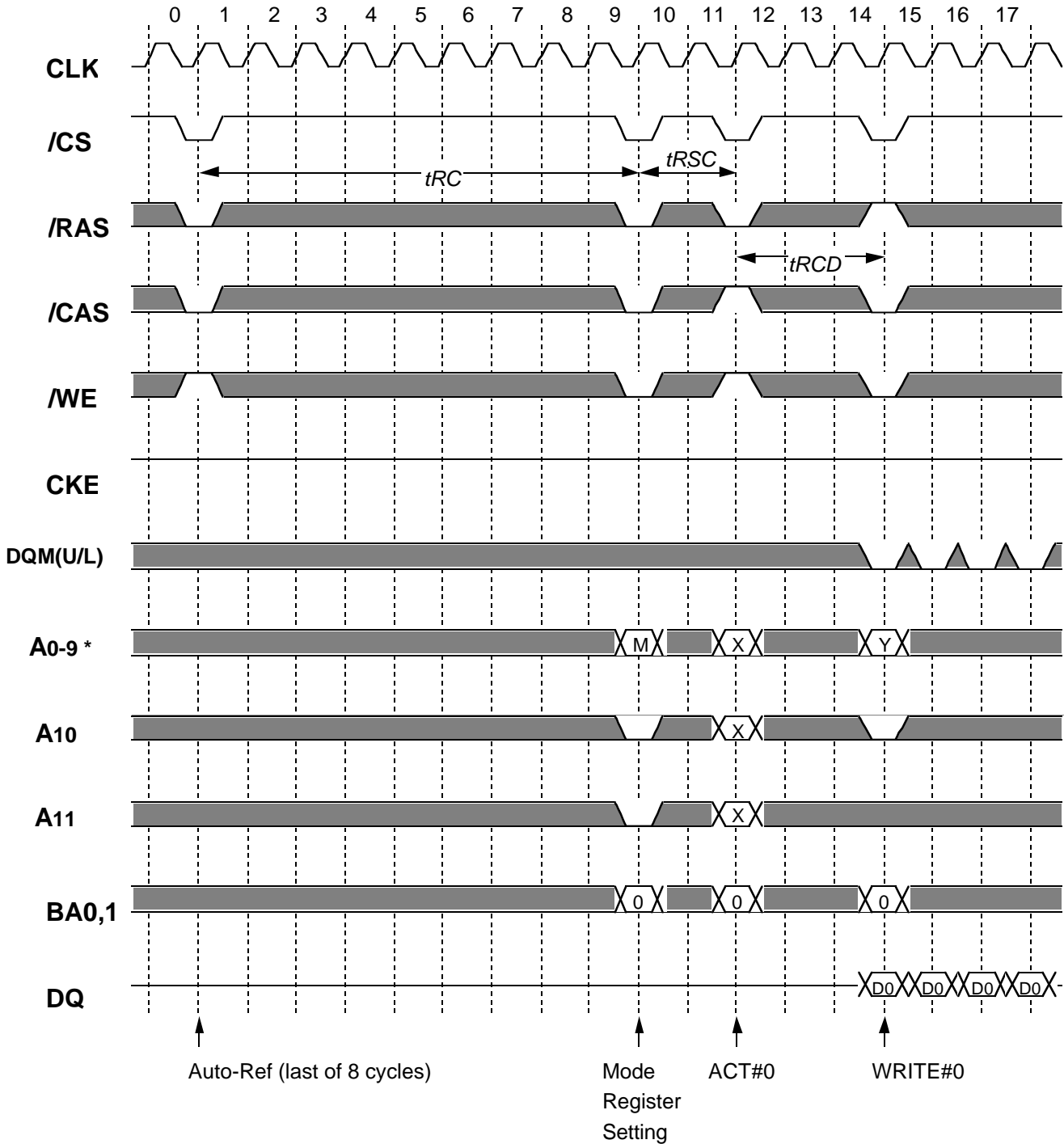


Italic parameter indicates minimum case

* A9 (x8) and A8,A9 (x16) for column address of read/write are don't care



Mode Register Setting

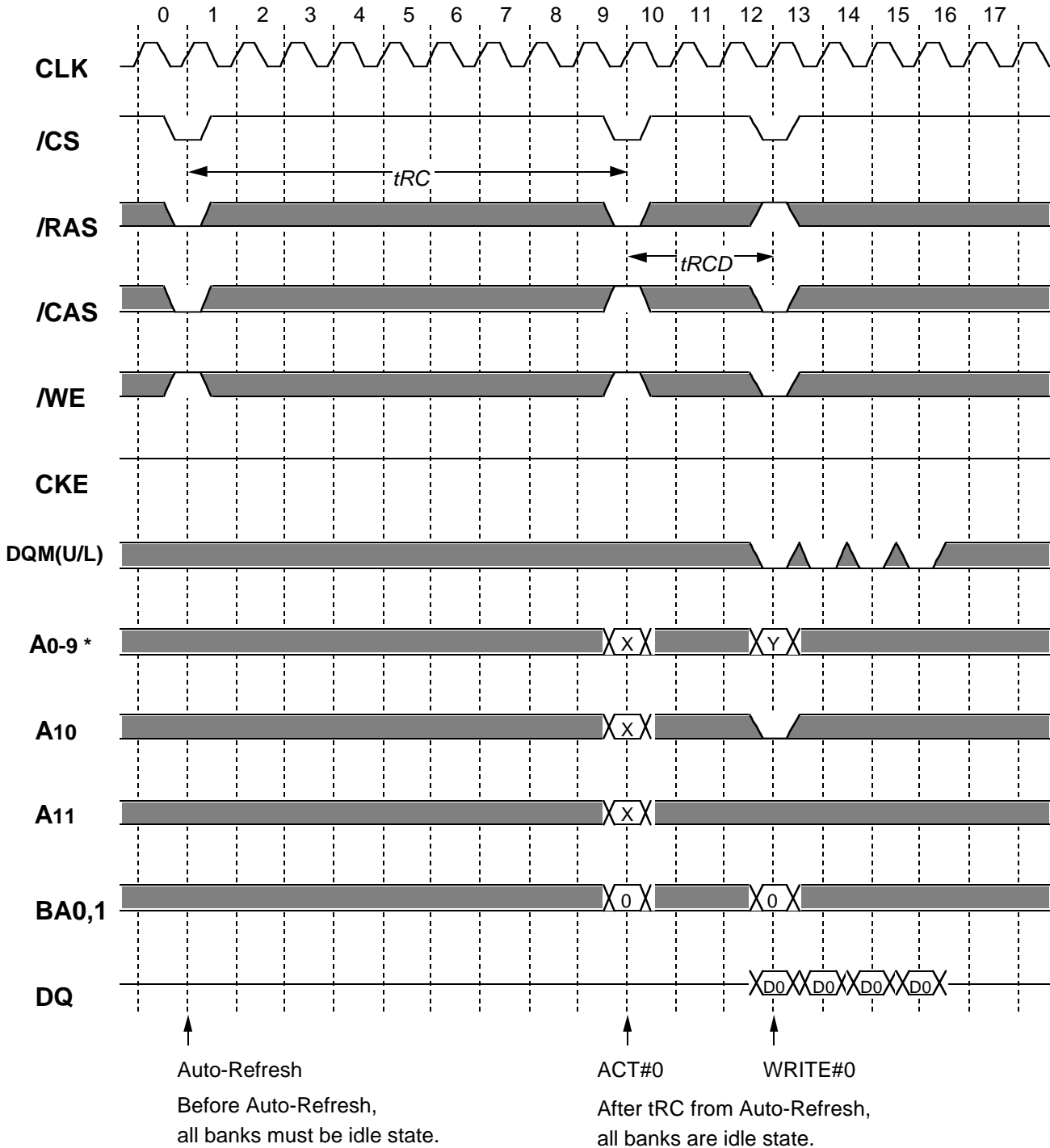


Italic parameter indicates minimum case

* A9 (x8) and A8,A9 (x16) for column address of read/write are don't care



Auto-Refresh @BL=4

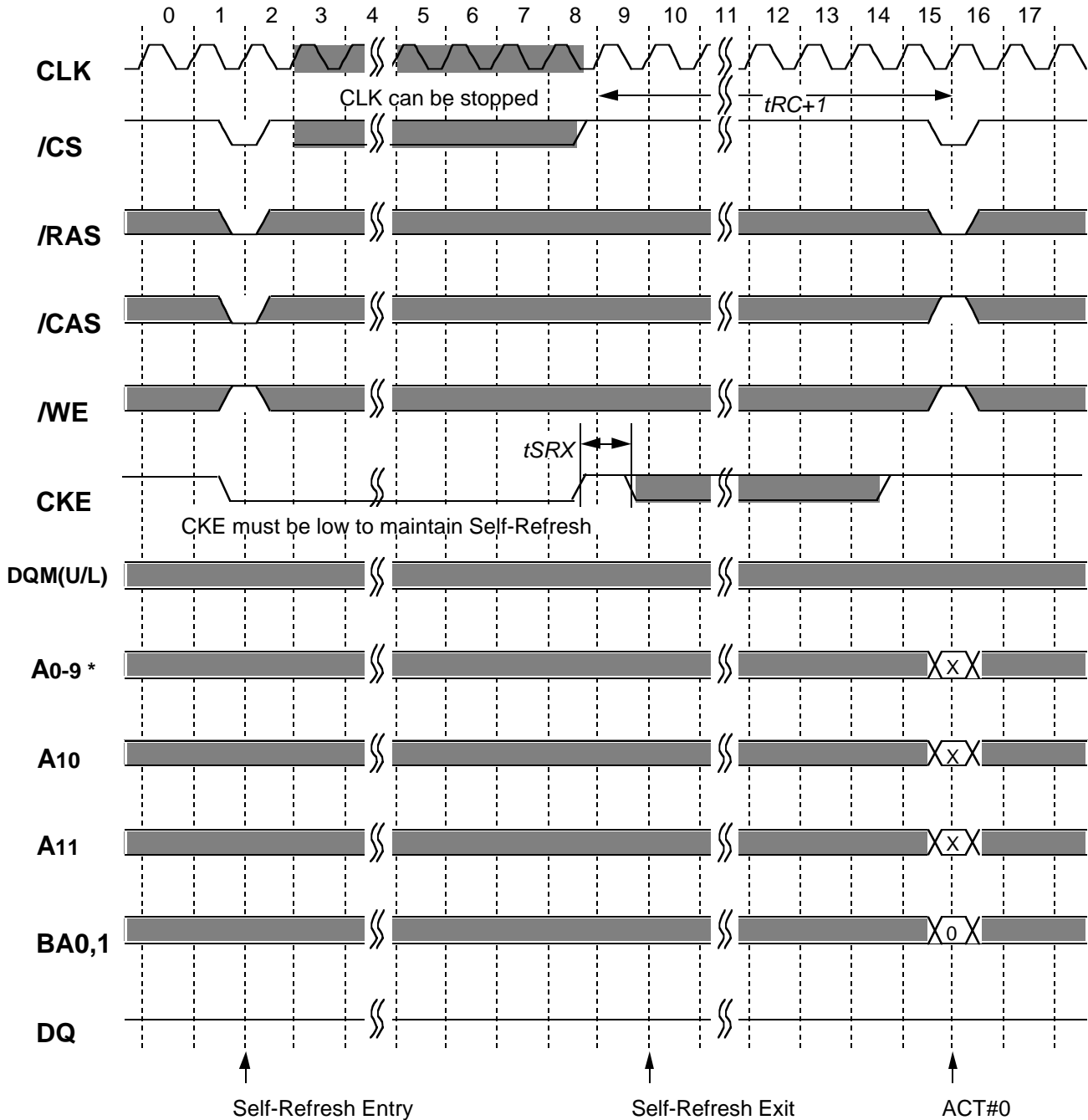


Italic parameter indicates minimum case

* A9 (x8) and A8,A9 (x16) for column address of read/write are don't care



Self-Refresh



Before Self-Refresh Entry,
all banks must be idle state.

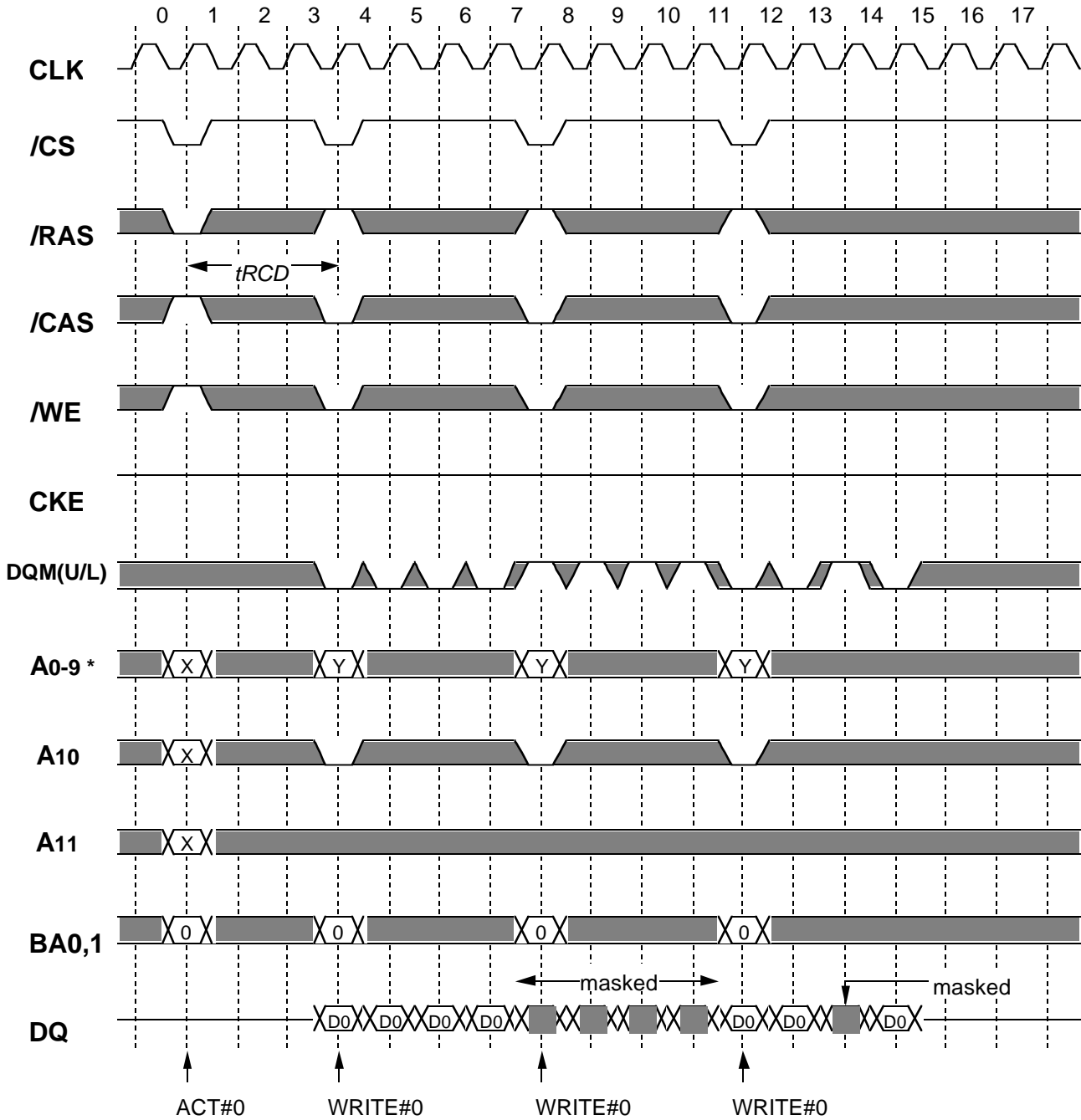
After t_{RC} from Self-Refresh Exit,
all banks are idle state.

Italic parameter indicates minimum case

* A9 (x8) and A8,A9 (x16) for column address of read/write are don't care



DQM Write Mask @BL=4

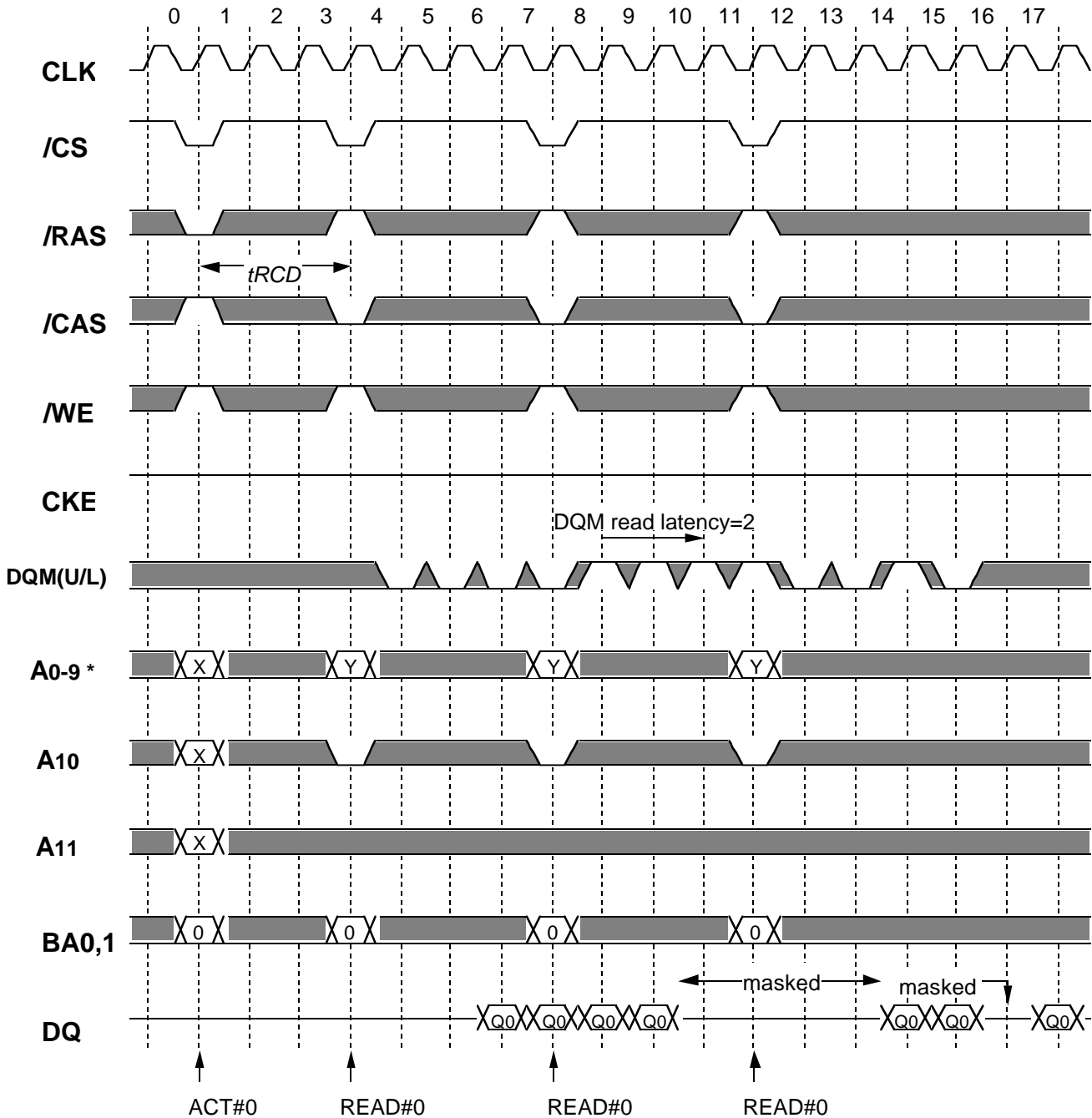


Italic parameter indicates minimum case

* A9 (x8) and A8,A9 (x16) for column address of read/write are don't care



DQM Read Mask @BL=4 CL=3

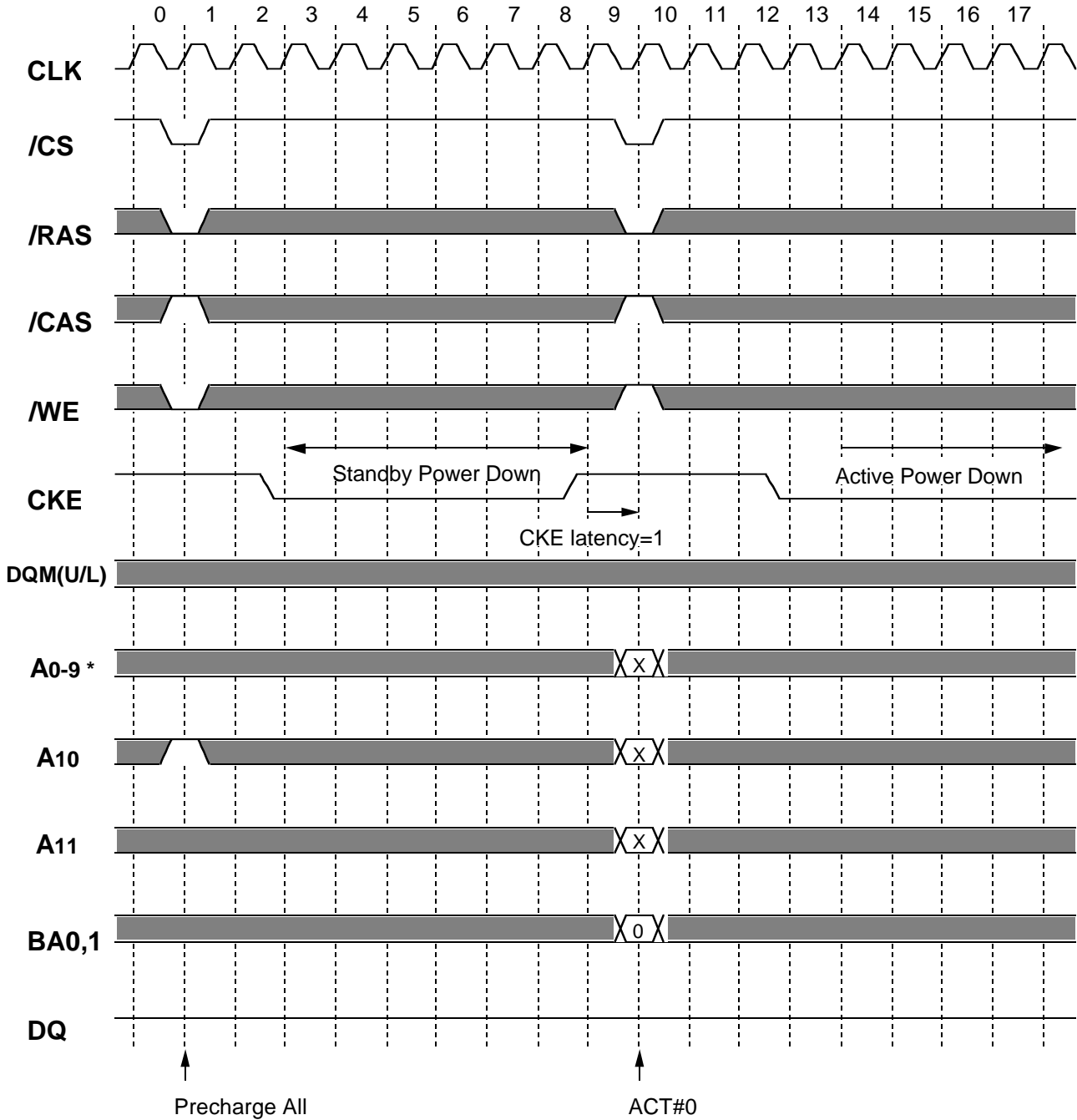


Italic parameter indicates minimum case

* A9 (x8) and A8,A9 (x16) for column address of read/write are don't care



Power Down

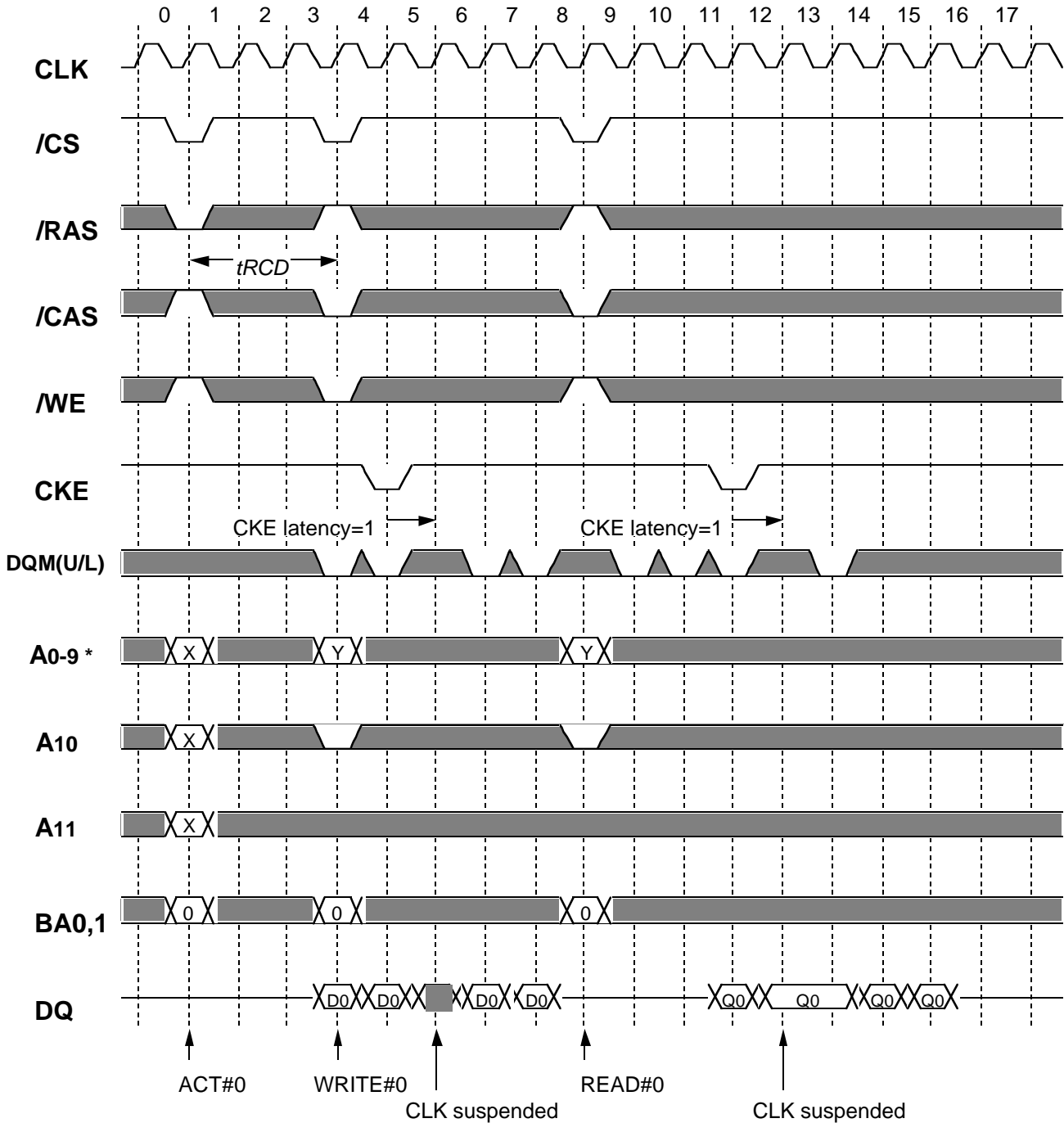


Italic parameter indicates minimum case

* A9 (x8) and A8,A9 (x16) for column address of read/write are don't care



CLK Suspend @BL=4 CL=3



Italic parameter indicates minimum case

* A9 (x8) and A8,A9 (x16) for column address of read/write are don't care



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