

# MH16S64FFB -10,-10L

1073741824-BIT (16777216 - WORD BY 64-BIT)SynchronousDRAM

## DESCRIPTION

The MH16S64FFB is 16777216 - word by 64-bit Synchronous DRAM module. This consists of eight industry standard 16Mx8 Synchronous DRAMs in TSOP and one industry standard EEPROM in TSSOP.

The mounting of TSOP on a card edge Dual Inline package provides any application where high densities and large quantities of memory are required.

This is a socket type - memory modules, suitable for easy interchange or addition of modules.

- Utilizes industry standard 16M x 8 Synchronous DRAMs TSOP and industry standard EEPROM in TSSOP
- 144-pin (72-pin dual in-line package)
- single 3.3V±0.3V power supply
- Clock frequency 100MHz(max.)
- Fully synchronous operation referenced to clock rising edge
- 4 bank operation controlled by BA0,1(Bank Address)
- /CAS latency- 2/3(programmable)
- Burst length- 1/2/4/8/Full Page(programmable)
- Burst type- sequential / interleave(programmable)
- Column access - random
- Auto precharge / All bank precharge controlled by A10
- Auto refresh and Self refresh
- 4096 refresh cycle /64ms
- LVTTTL Interface

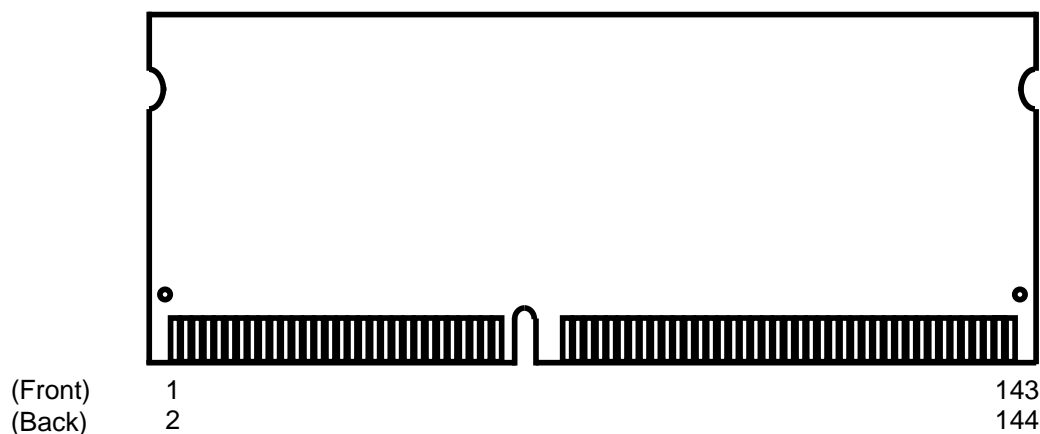
## FEATURES

	Frequency	CLK Access Time (Component SDRAM)
-10,10L	100MHz	8.0ns(CL=3)

## APPLICATION

main memory or graphic memory in computer systems

## PCB Outline



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## PIN CONFIGURATION

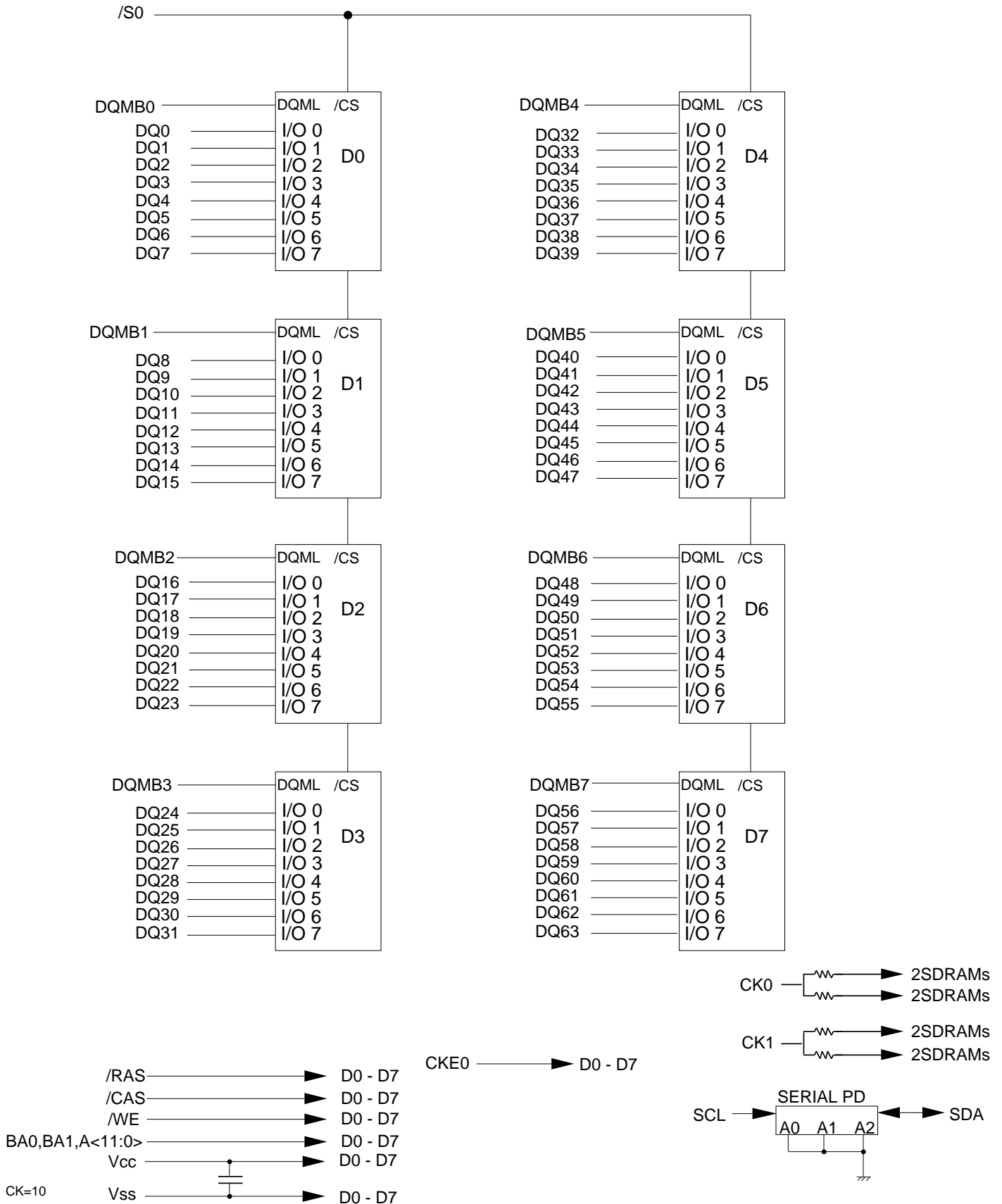
PIN Number	Front side Pin Name	PIN Number	Back side Pin Name	PIN Number	Front side Pin Name	PIN Number	Back side Pin Name
1	Vss	2	Vss	73	NC	74	CK1
3	DQ0	4	DQ32	75	Vss	76	Vss
5	DQ1	6	DQ33	77	NC	78	NC
7	DQ2	8	DQ34	79	NC	80	NC
9	DQ3	10	DQ35	81	Vcc	82	Vcc
11	Vcc	12	Vcc	83	DQ16	84	DQ48
13	DQ4	14	DQ36	85	DQ17	86	DQ49
15	DQ5	16	DQ37	87	DQ18	88	DQ50
17	DQ6	18	DQ38	89	DQ19	90	DQ51
19	DQ7	20	DQ39	91	Vss	92	Vss
21	Vss	22	Vss	93	DQ20	94	DQ52
23	DQMB0	24	DQMB4	95	DQ21	96	DQ53
25	DQMB1	26	DQMB5	97	DQ22	98	DQ54
27	Vcc	28	Vcc	99	DQ23	100	DQ55
29	A0	30	A3	101	Vcc	102	Vcc
31	A1	32	A4	103	A6	104	A7
33	A2	34	A5	105	A8	106	BA0
35	Vss	36	Vss	107	Vss	108	Vss
37	DQ8	38	DQ40	109	A9	110	BA1
39	DQ9	40	DQ41	111	A10	112	A11
41	DQ10	42	DQ42	113	Vcc	114	Vcc
43	DQ11	44	DQ43	115	DQMB2	116	DQMB6
45	Vcc	46	Vcc	117	DQMB3	118	DQMB7
47	DQ12	48	DQ44	119	Vss	120	Vss
49	DQ13	50	DQ45	121	DQ24	122	DQ56
51	DQ14	52	DQ46	123	DQ25	124	DQ57
53	DQ15	54	DQ47	125	DQ26	126	DQ58
55	Vss	56	Vss	127	DQ27	128	DQ59
57	NC	58	NC	129	Vcc	130	Vcc
59	NC	60	NC	131	DQ28	132	DQ60
61	CK0	62	CKE	133	DQ29	134	DQ61
63	Vcc	64	Vcc	135	DQ30	136	DQ62
65	/RAS	66	/CAS	137	DQ31	138	DQ63
67	/WE	68	NC	139	Vss	140	Vss
69	/S0	70	NC	141	SDA	142	SCL
71	NC	72	NC	143	Vcc	144	Vcc

NC = No Connection

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## Block Diagram



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## Serial Presence Detect Table I

Byte	Function described	SPD entry data	SPD DATA(hex)
0	Defines # bytes written into serial memory at module mfg	128	80
1	Total # bytes of SPD memory device	256 Bytes	08
2	Fundamental memory type	SDRAM	04
3	# Row Addresses on this assembly	A0-A11	0C
4	# Column Addresses on this assembly	A0-A9	0A
5	# Module Banks on this assembly	1BANK	01
6	Data Width of this assembly...	x64	40
7	... Data Width continuation	0	00
8	Voltage interface standard of this assembly	LVTTTL	01
9	SDRAM Cycletime at Max. Supported CAS Latency (CL). Cycle time for CL=3	10ns	A0
10	SDRAM Access from Clock tAC for CL=3	8ns	80
11	DIMM Configuration type (Non-parity,Parity,ECC)	Non-PARITY	00
12	Refresh Rate/Type	self refresh(15.625uS)	80
13	SDRAM width,Primary DRAM	x8	08
14	Error Checking SDRAM data width	N/A	00
15	Minimum Clock Delay,Back to Back Random Column Addresses	1	01
16	Burst Lengths Supported	1/2/4/8/Full page	8F
17	# Banks on Each SDRAM device	4bank	04
18	CAS# Latency	2/3	06
19	CS# Latency	0	01
20	Write Latency	0	01
21	SDRAM Module Attributes	non-buffered,non-registered	00
22	SDRAM Device Attributes:General	Precharge All,Auto precharge	0E
23	SDRAM Cycle time(2nd highest CAS latency) Cycle time for CL=2	15ns	F0
24	SDRAM Access form Clock(2nd highest CAS latency) tAC for CL=2	8ns	80
25	SDRAM Cycle time(3rd highest CAS latency)	N/A	00
26	SDRAM Access form Clock(3rd highest CAS latency)	N/A	00
27	Precharge to Active Minimum	30ns	1E
28	Row Active to Row Active Min.	20ns	14
29	RAS to CAS Delay Min	30ns	1E
30	Active to Precharge Min	60ns	3C

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## Serial Presence Detect Table II

31	Density of each bank on module	128MByte	20
32	Command and Address signal input setup time	N/A	00
33	Command and Address signal input hold time	N/A	00
34	Data signal input setup time	N/A	00
35	Data signal input hold time	N/A	00
36-61	Superset Information (may be used in future)	option	00
62	SPD Revision	rev 1	01
63	Checksum for bytes 0-62	Check sum	53
64-71	Manufactures Jedec ID code per JEP-108E	MITSUBISHI	1CFFFFFFFFFFFFFF
72	Manufacturing location	Miyoshi,Japan	01
		Tajima,Japan	02
		NC,USA	03
		Germany	04
73-90	Manufactures Part Number	MH16S64FFB-10	4D4831365336344646422D31302020202020
		MH16S64FFB-10L	4D4831365336344646422D31304C20202020
91-92	Revision Code	PCB revision	rrrr
93-94	Manufacturing date	year/week code	yyww
95-98	Assembly Serial Number	serial number	ssssssss
99-125	Manufacture Specific Data	option	00
126	Intel specification frequency	66MHz	66
127	Intel specification CAS# Latency support	CL=2/3	06
128+	Unused storage locations	open	00

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**PIN FUNCTION**

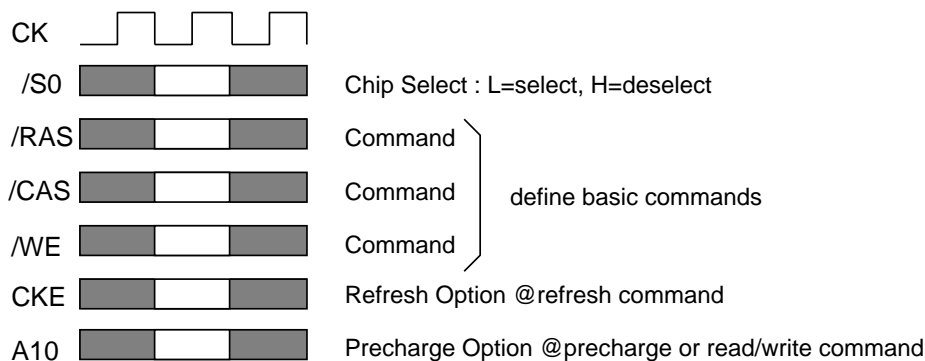
CK (CK0 ~ CK1)	Input	Master Clock:All other inputs are referenced to the rising edge of CK
CKE0	Input	Clock Enable:CKE controls internal clock.When CKE is low,internal clock for the following cycle is ceased. CKE is also used to select auto / self refresh. After self refresh mode is started, CKE becomes asynchronous input.Self refresh is maintained as long as CKE is low.
/S0	Input	Chip Select: When /S0 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 BA.The Row Address is specified by A0-11.The Column Address is specified by A0-9.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, both banks are precharged.
BA0,1	Input	Bank Address:BA0,1 is not simply BA.BA specifies the bank to which a command is applied.BA0,1 must be set with ACT,PRE,READ,WRITE commands
DQ0-63	Input/Output	Data In and Data out are referenced to the rising edge of CK
DQMB0-7	Input	Din Mask/Output Disable:When DQMB is high in burst write.Din for the current cycle is masked.When DQMB is high in burst read,Dout is disabled at the next but one cycle.
Vdd,Vss	Power Supply	Power Supply for the memory mounted module.
SCL	Input	Serial clock for serial PD
SDA	Output	Serial data for serial PD
SA0-3	Input	Address input for serial PD

## BASIC FUNCTIONS

The MH16S64FFB 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 CK rising edge. In addition to 3 signals, /S0, 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 internally. After this command, the banks are precharged automatically.

## COMMAND TRUTH TABLE

COMMAND	MNEMONIC	CKE <sub>n-1</sub>	CKE <sub>n</sub>	/S0	/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 Bank	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	TERM	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 = CK cycle number

**NOTE:**

1.A7-9 = 0, A0-6 = Mode Address



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**FUNCTION TRUTH TABLE**

Current State	/S0	/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

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**FUNCTION TRUTH TABLE(continued)**

Current State	/S0	/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	/S0	/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	/S0	/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	/S0	/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 CK0 Suspend at Next Cycle*3
	L	H	X	X	X	X	X	Exit CK0 Suspend at Next Cycle*3
	L	L	X	X	X	X	X	Maintain CK0 Suspend

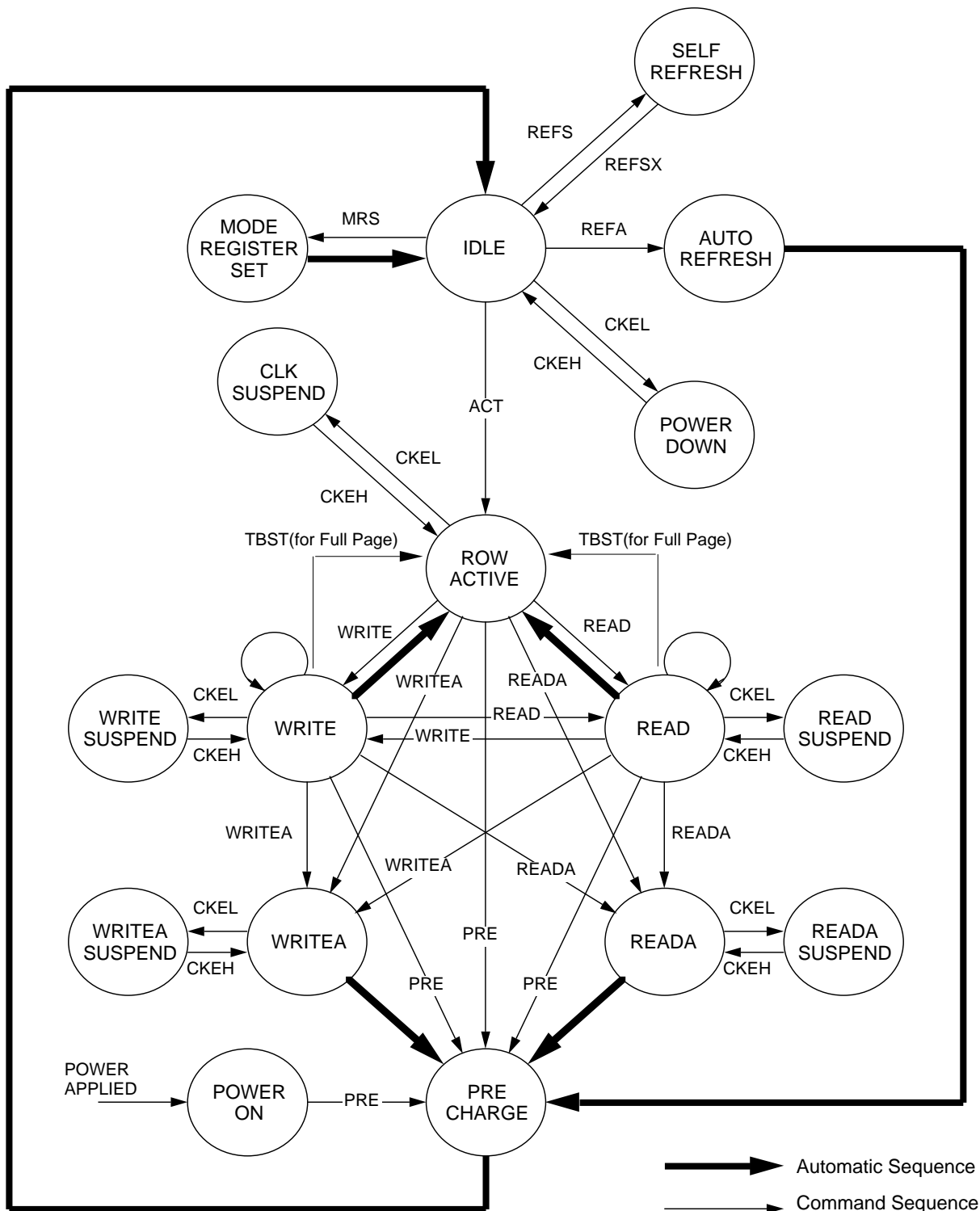
### ABBREVIATIONS:

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

### NOTES:

1. CKE Low to High transition will re-enable CK 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

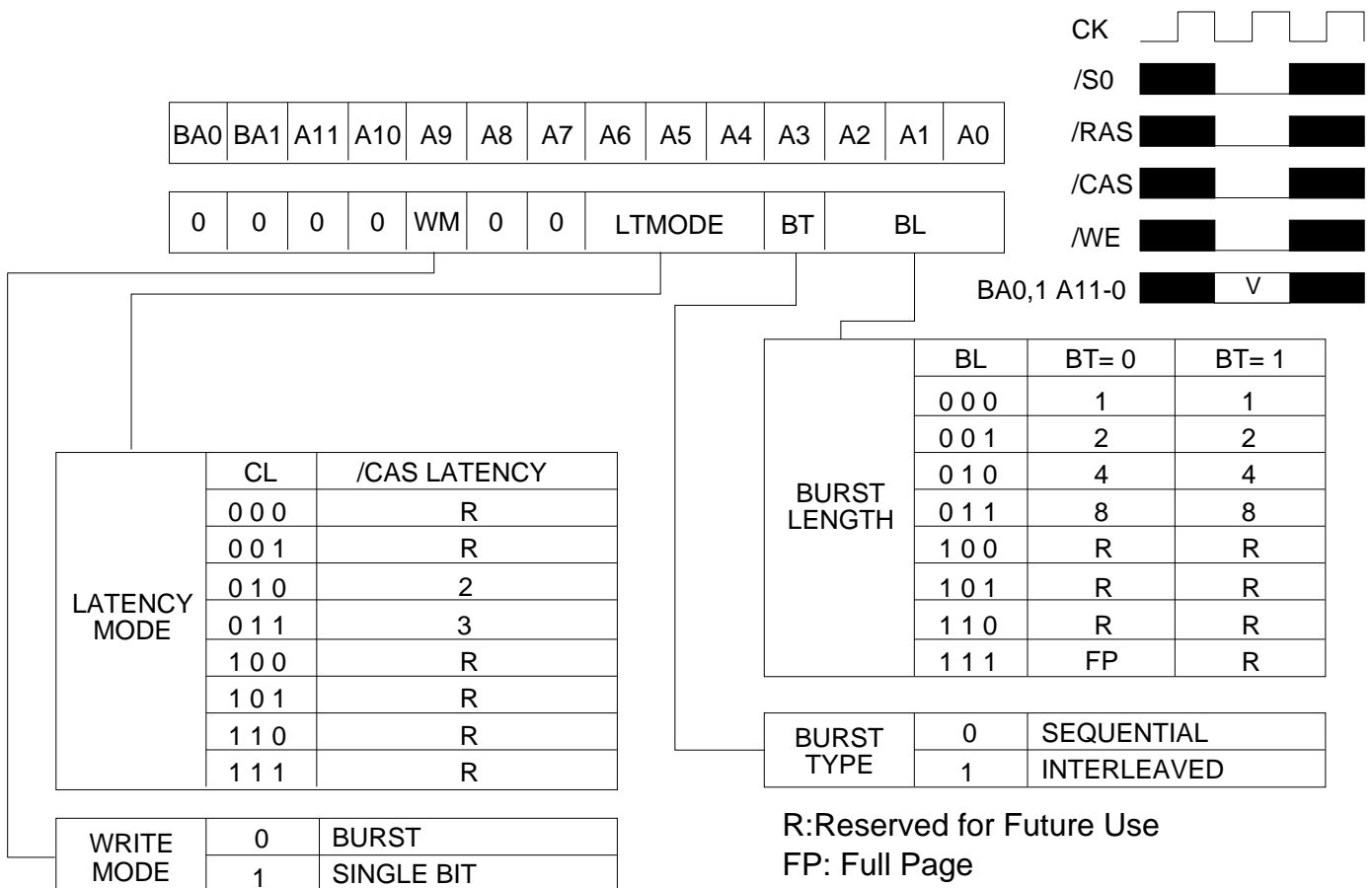
Before starting normal operation, the following power on sequence is necessary to prevent a SDRAM from damaged or malfunctioning.

1. Apply power and start clock. Attempt to maintain CKE high, DQMB0-7 high and NOP condition at the inputs.
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 date until the next MRS command, which may be issue when both banks are in idle state. After tRSC from a MRS command, the SDRAM is ready for new command.



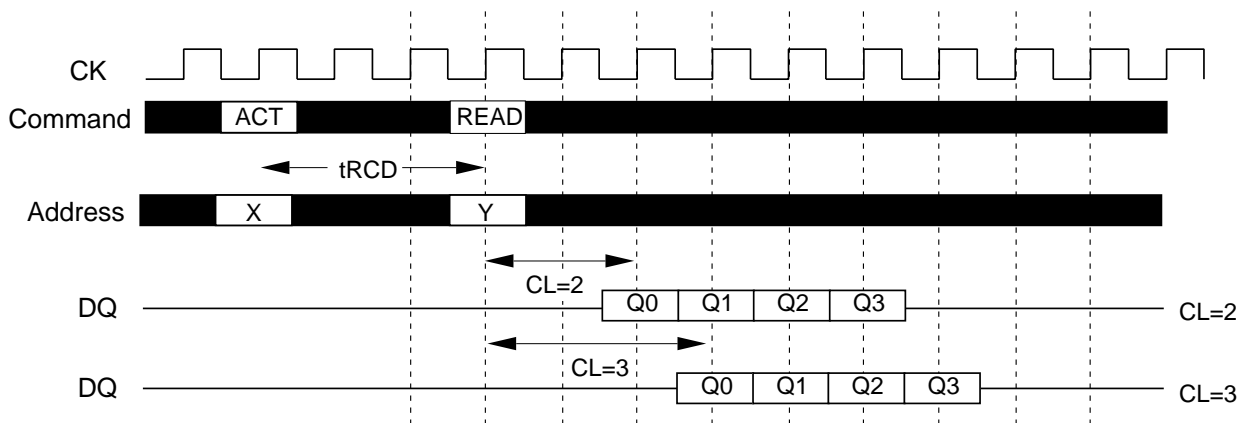
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## [ /CAS LATENCY ]

/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.

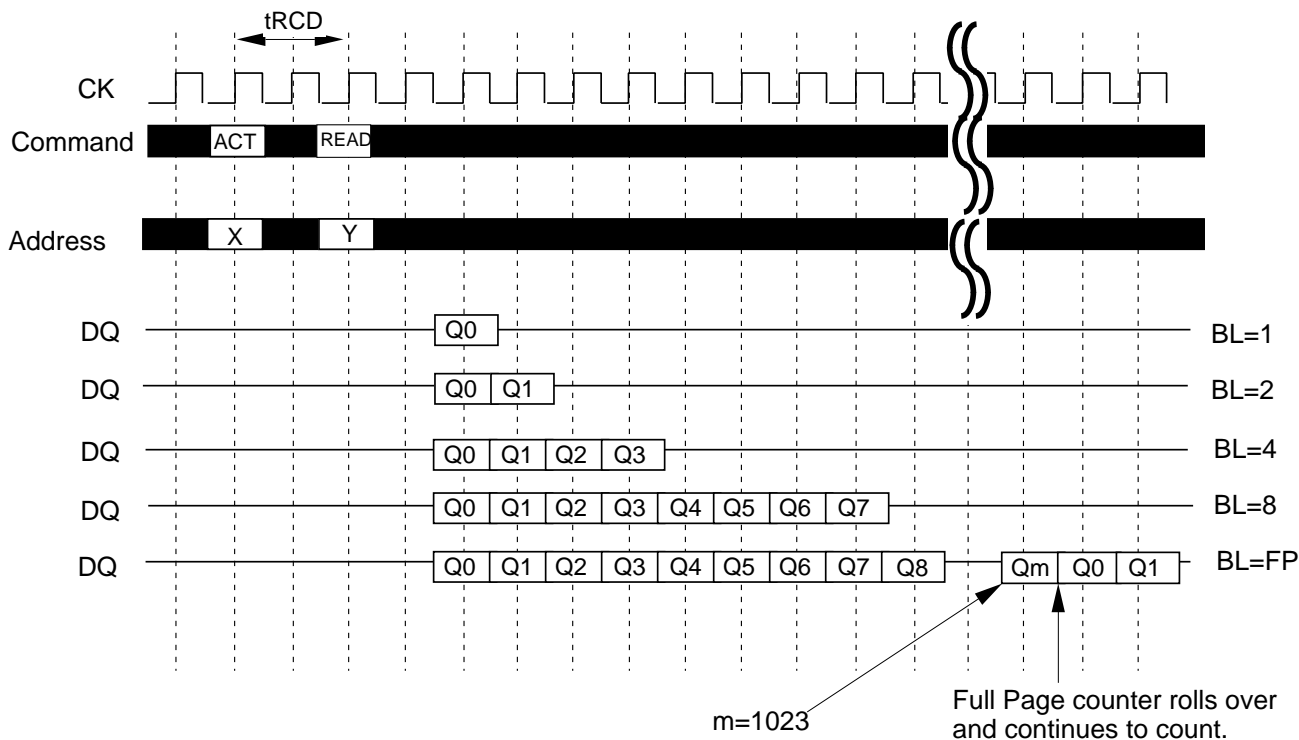
/CAS Latency Timing (BL=4)



## [ 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.

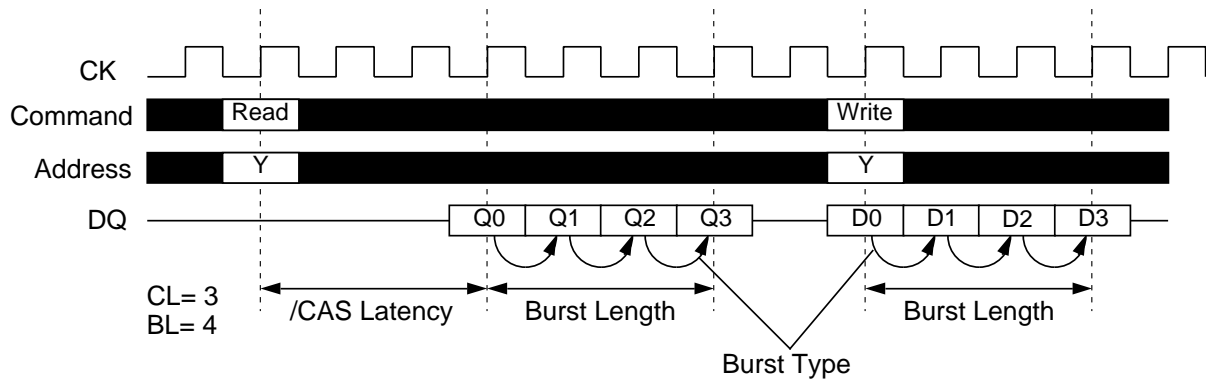
Burst Length Timing (CL=2)





# MH16S64FFB -10,-10L

1073741824-BIT (16777216 - WORD BY 64-BIT)SynchronousDRAM



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						

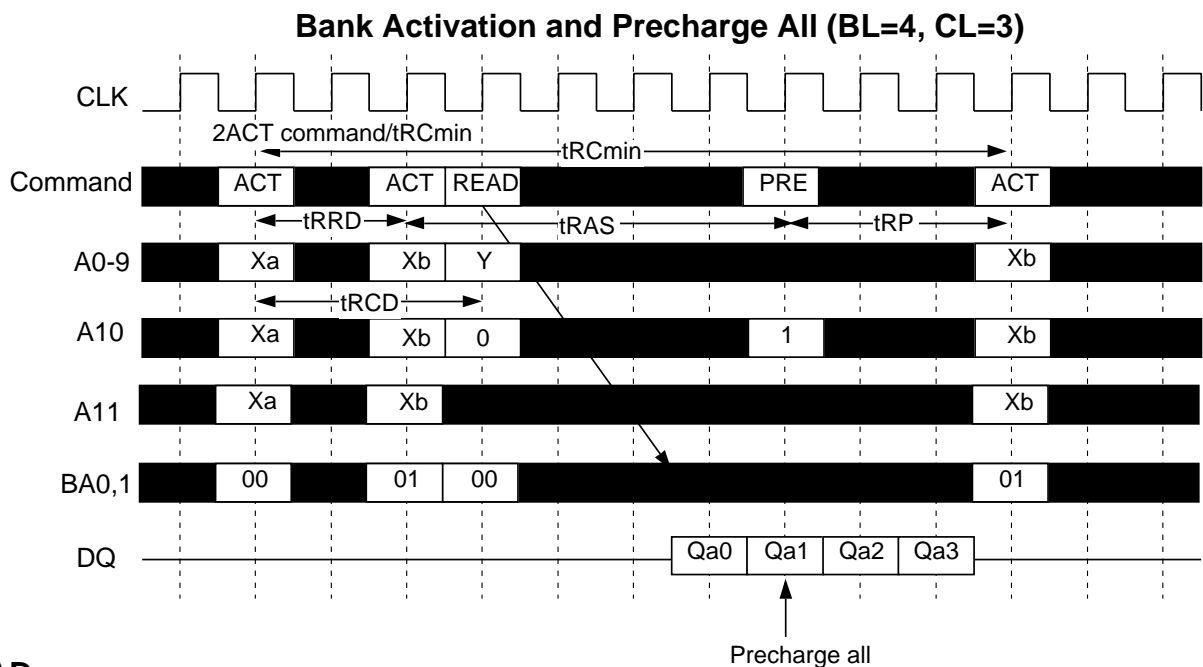
**OPERATION DESCRIPTION**

**BANK ACTIVATE**

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

**PRECHARGE**

The PRE command deactivates indicated by BA. When both banks are active, the precharge all command(PREA,PRE + A10=H) is available to deactivate them at the same time. After tRP from the precharge, an ACT command can be issued.



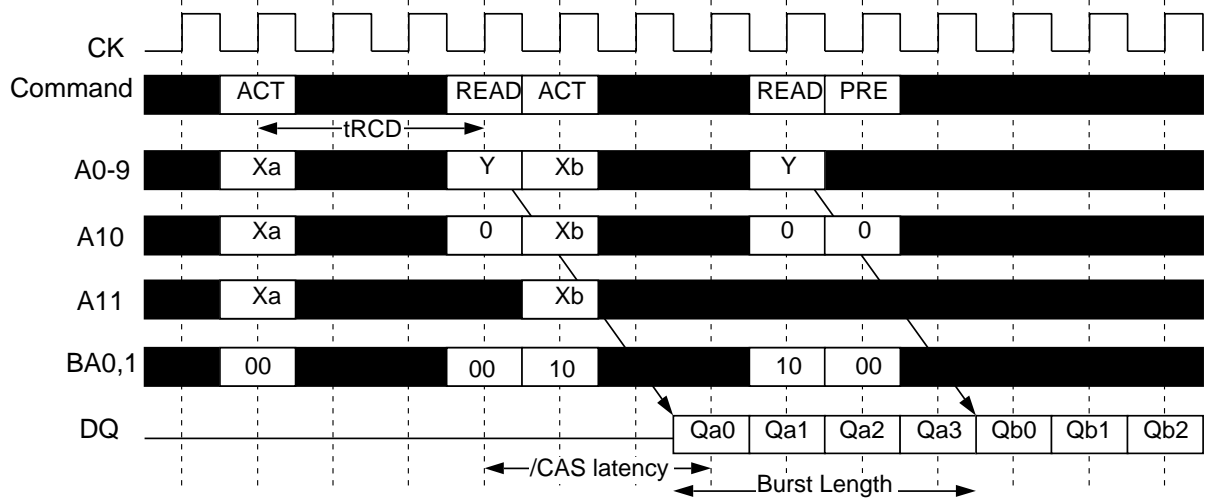
**READ**

After tRCD from the bank activation, a READ command can be issued. 1st output date is available after the /CAS Latency from the READ, followed by (BL-1) consecutive date when the Burst Length is BL. The start address is specified by A8-0, 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(tRP) can be hidden behind continuous output data(in case of BL=8) by interleaving the dual 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 start at BL after READA. The next ACT command can be issued after (BL + tRP) from the previous READA.

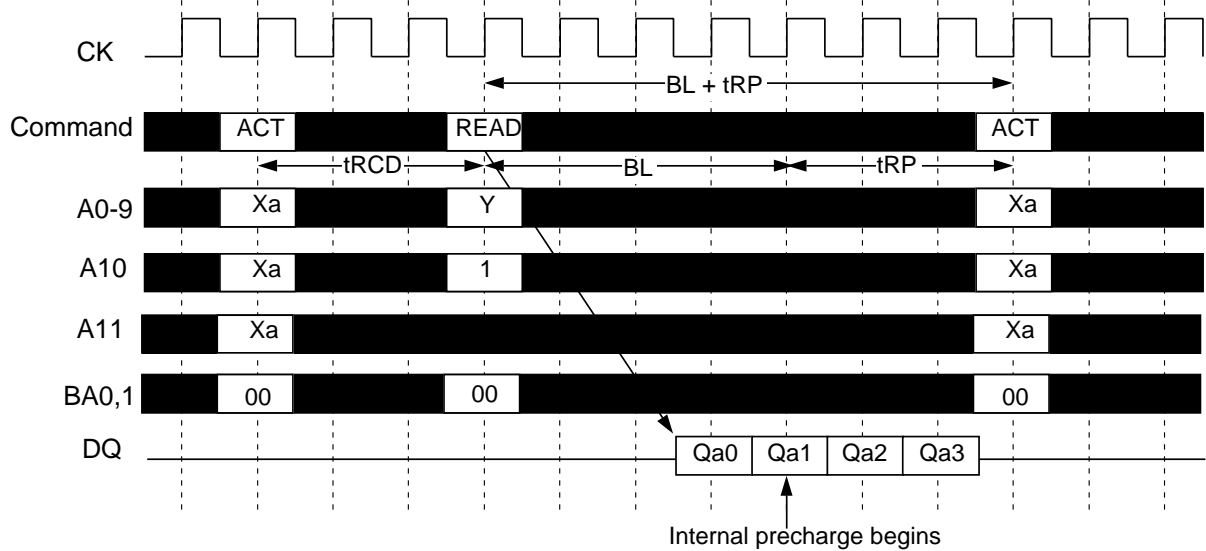
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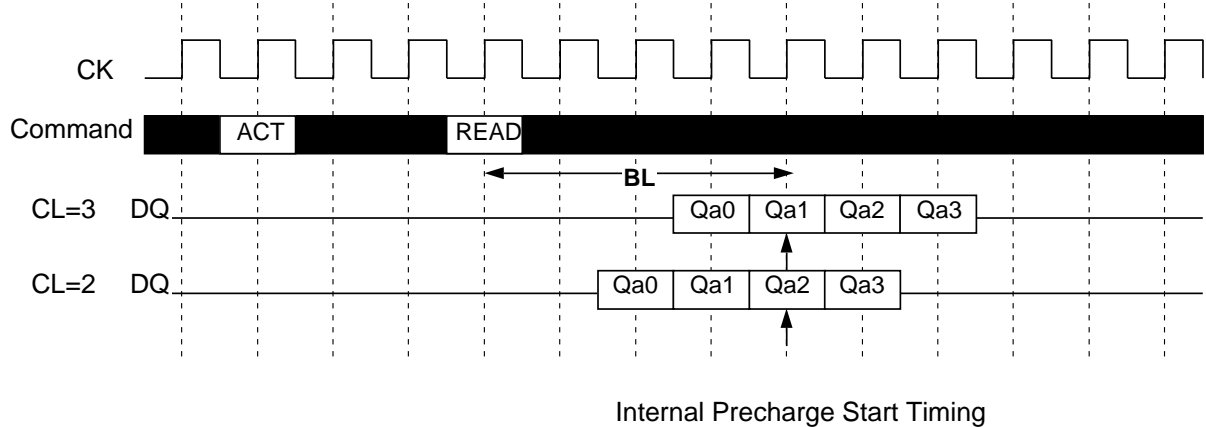
## Multi Bank Interleaving READ (BL=4, CL=3)



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



## READ Auto-Precharge Timing (BL=4)



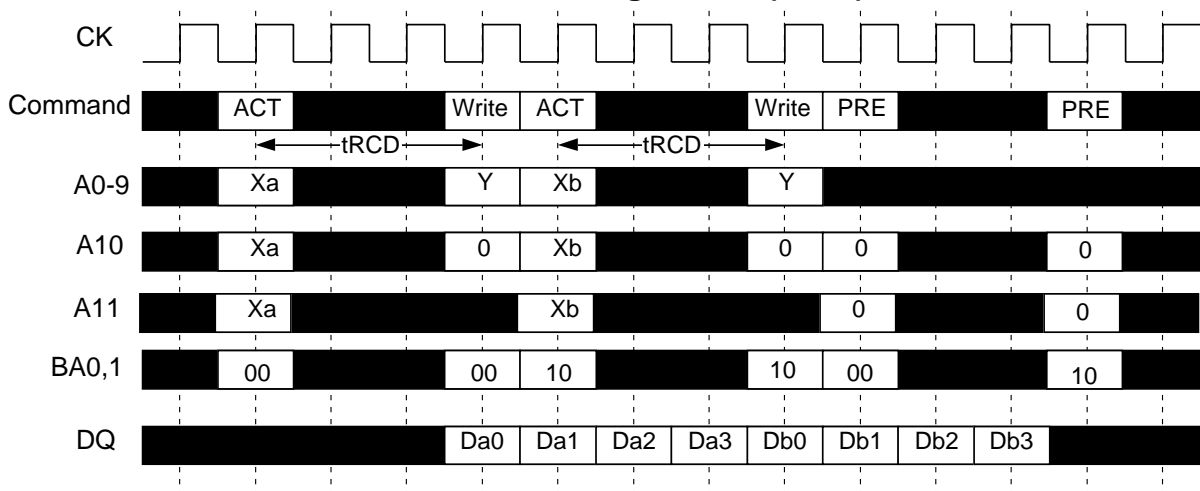
# MH16S64FFB -10,-10L

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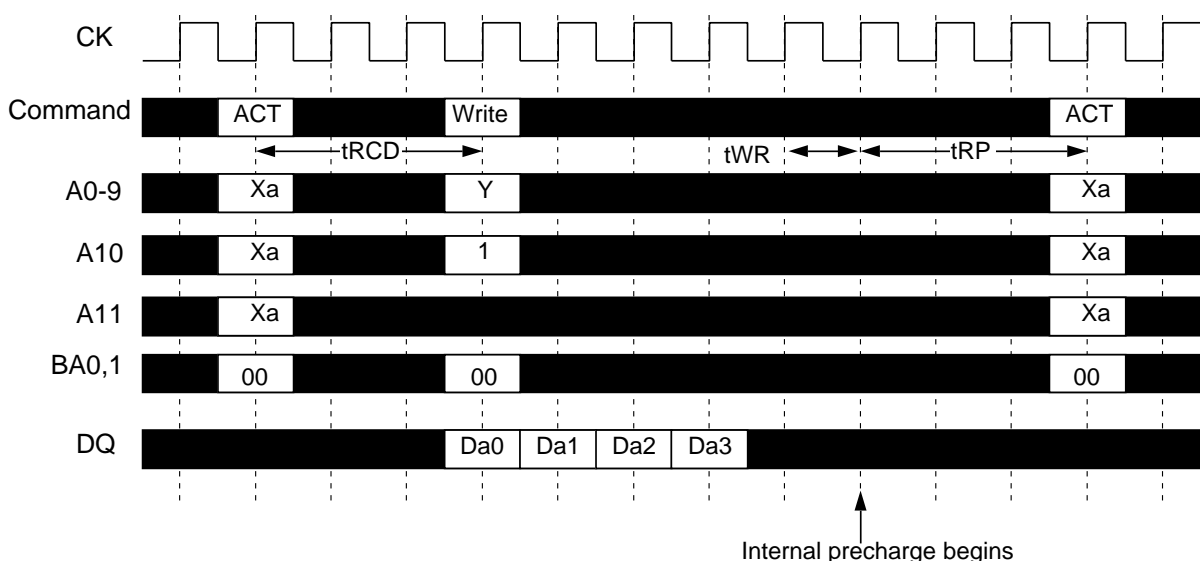
## WRITE

After  $t_{RCD}$  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 A8-0, 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( $t_{RP}$ ) 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 ( $t_{WR}$ ) is required. When A10 is high at a WRITE command, the auto-precharge(WRITEA) 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  $t_{WR}$  after the last input data cycle. The next ACT command can be issued after  $t_{RP}$  from the internal precharge timing. The Mode Register can be WRITE command is issued and the remaining burst length is ignored. The read data burst length os unaffected while in this mode.

### Multi Bank Interleaving WRITE (BL=4)



### WRITE with Auto-Precharge (BL=4)

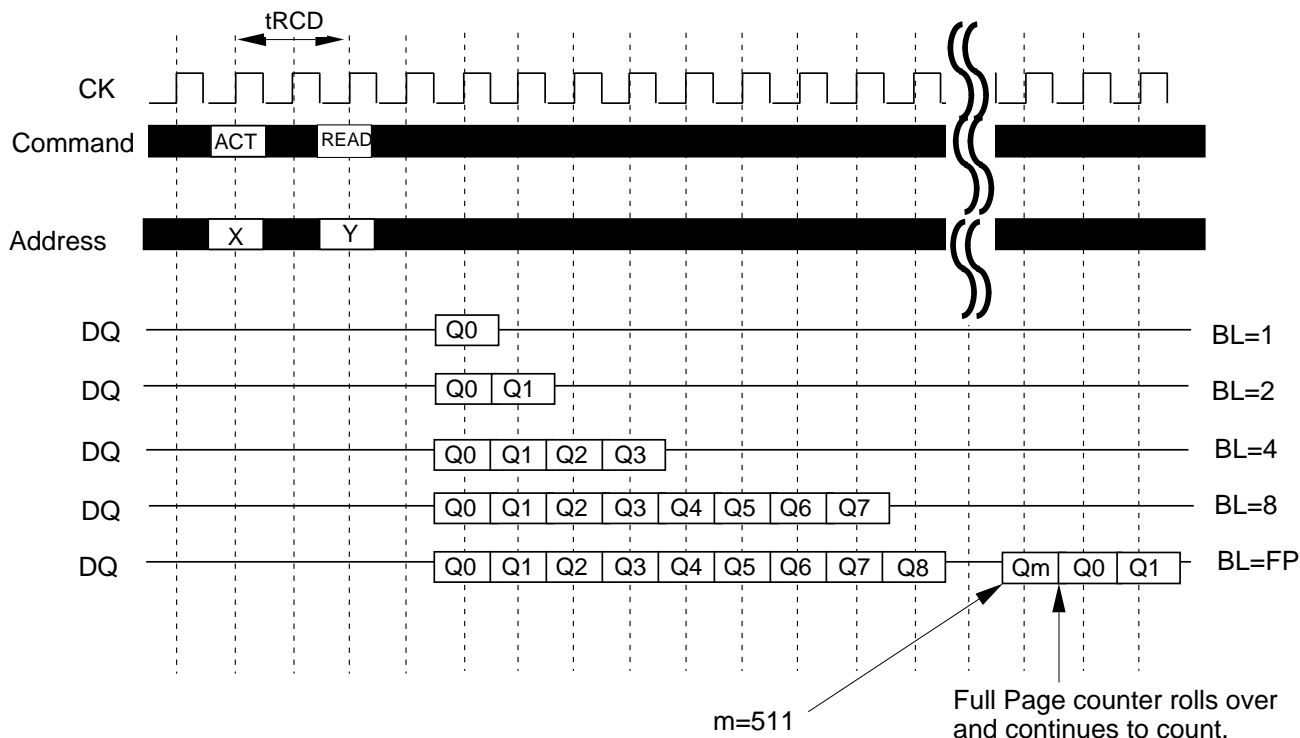


# MH16S64FFB -10,-10L

1073741824-BIT (16777216 - WORD BY 64-BIT)SynchronousDRAM

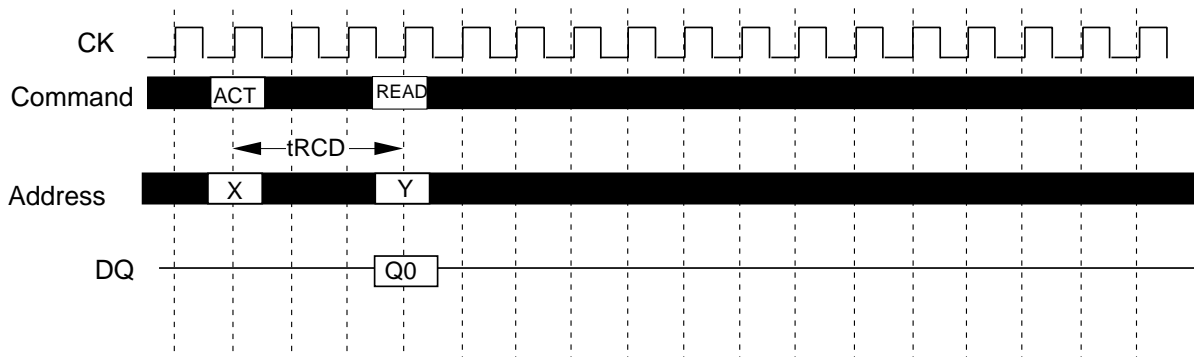
## [ BURST WRITE ]

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.)



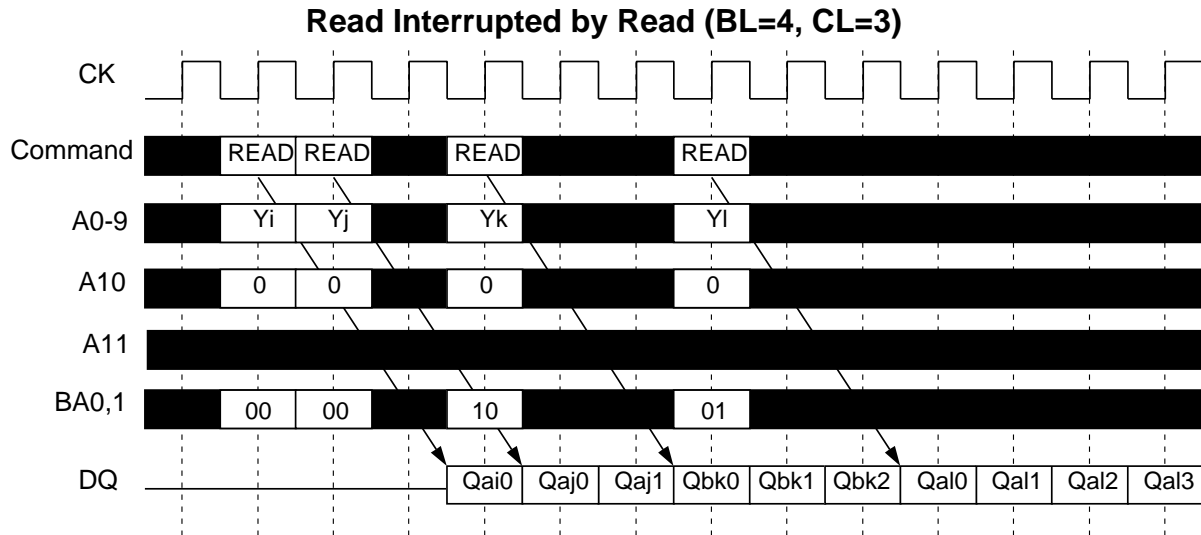
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## BURST INTERRUPTION

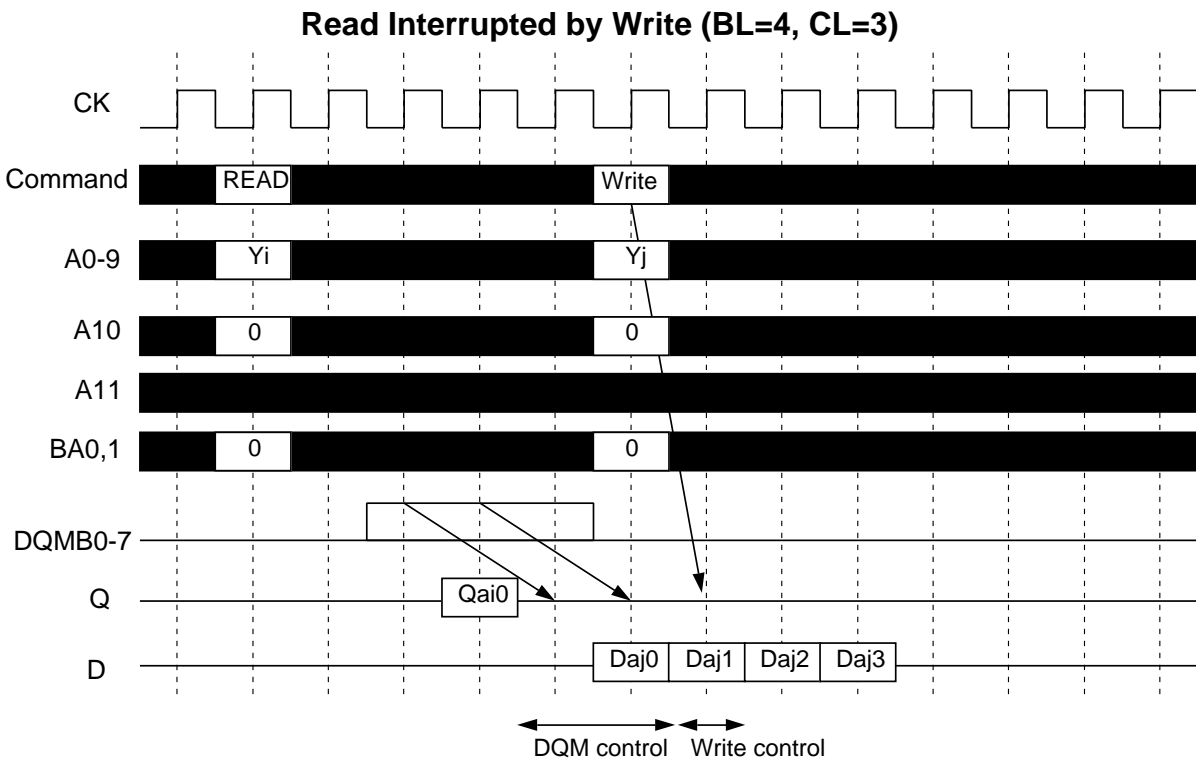
### [ Read Interrupted by Read ]

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



### [ Read Interrupted by Write ]

Burst read operation can be interrupted by write of the same or the other bank. Random column access is allowed. In this case, the DQ should be controlled adequately by using the DQMB0-7 to prevent the bus contention. The output is disabled automatically 1 cycle after WRITE assertion.



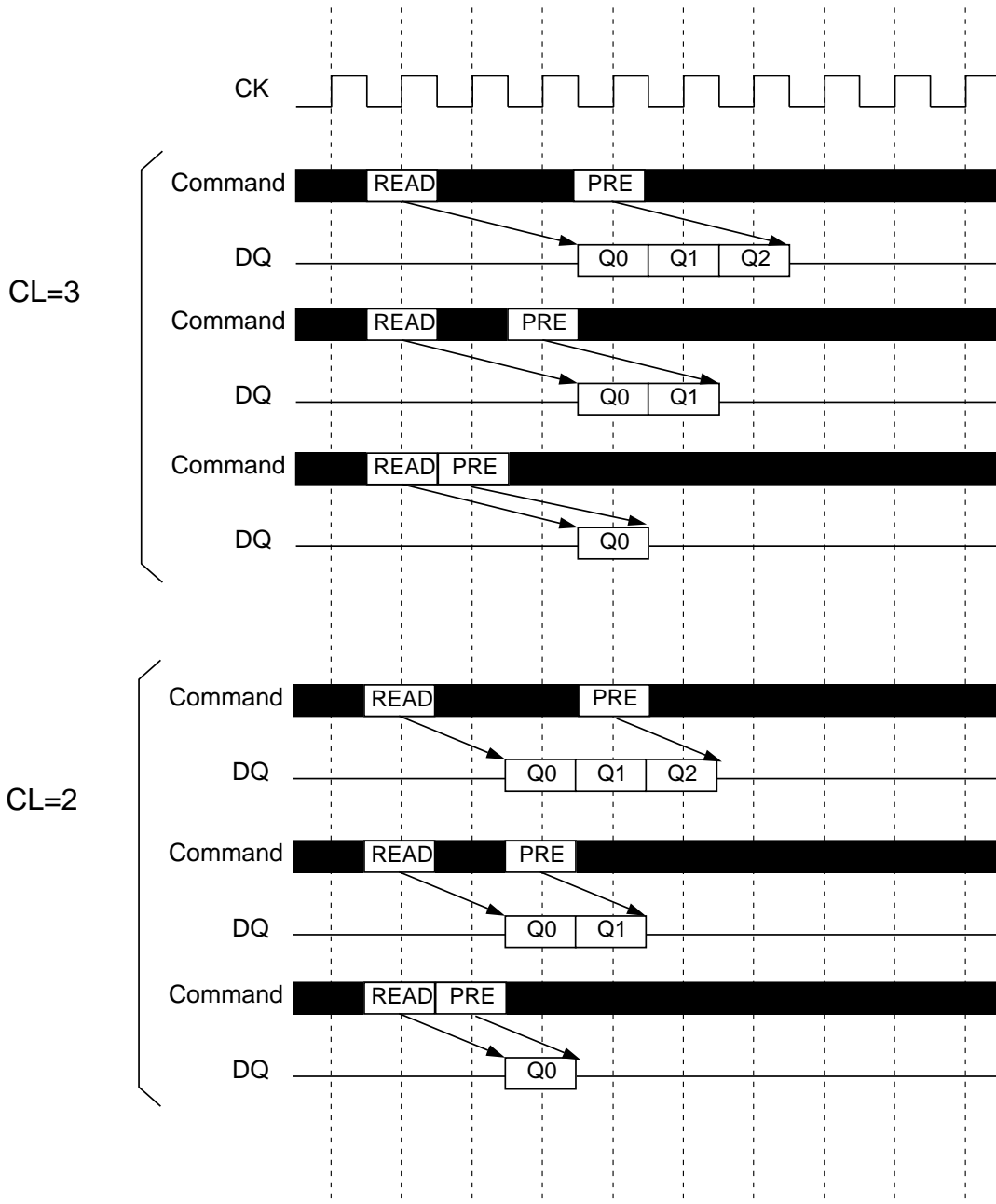
# MH16S64FFB -10,-10L

1073741824-BIT (16777216 - WORD BY 64-BIT)SynchronousDRAM

## [ Read Interrupted by Precharge ]

Burst read operation can be interrupted by precharge of the same or the other bank. Read to PRE interval is minimum 1 CK. A PRE command 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 Precharge (BL=4)



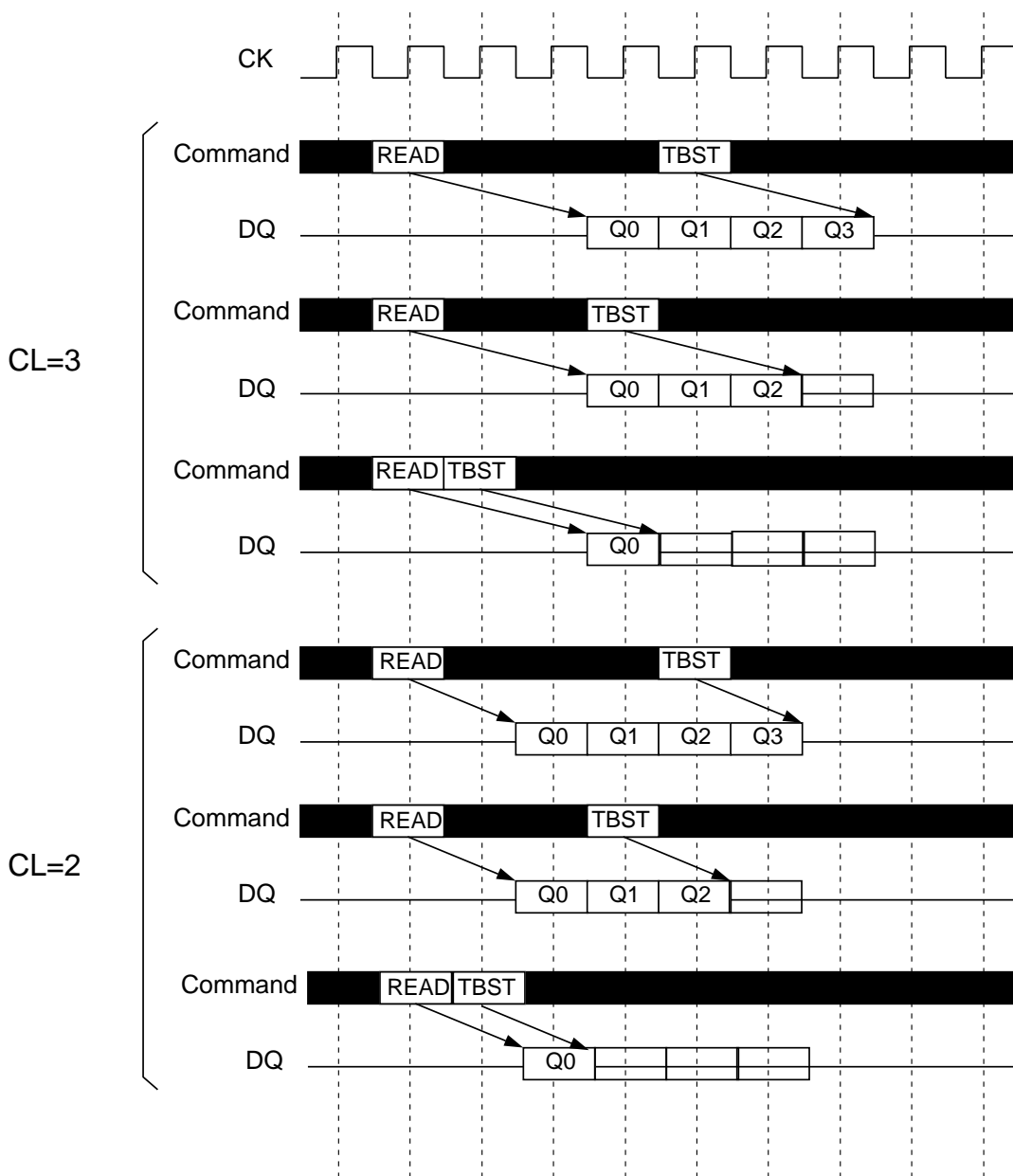
# MH16S64FFB -10,-10L

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## [ Read Interrupted by Burst Terminate ]

Similarly to the precharge, burst terminate command, TBST, can interrupt burst read operation and disable the data output. READ to TBST interval is minimum of 1 CK. TBST is mainly used to interrupt FP bursts. The figure below show examples, of how the output data is terminated with TBST.

### Read Interrupted by Burst Terminate (BL=4)

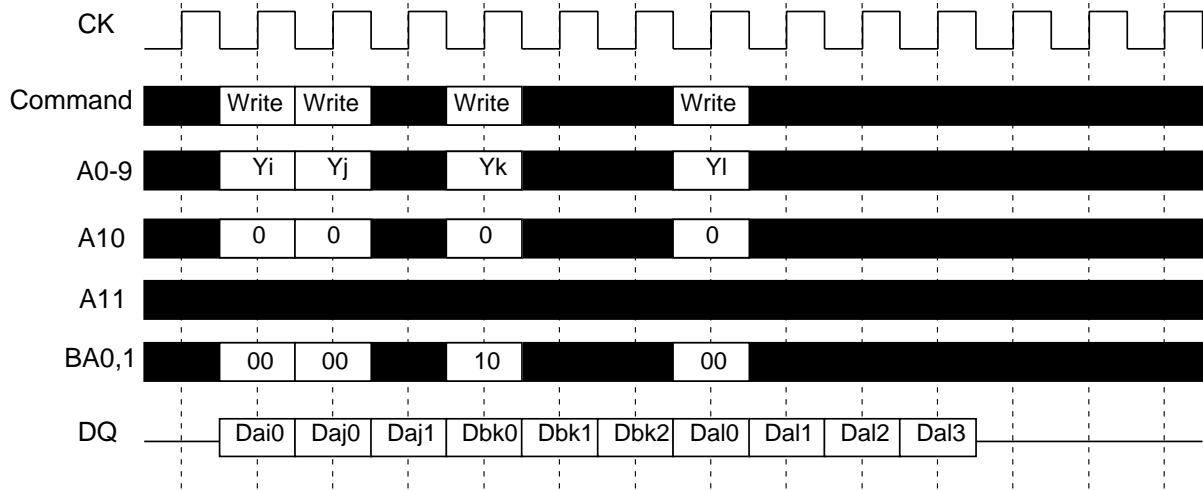




**[ Write Interrupted by Write ]**

Burst write operation can be interrupted by new write of the same or the other bank.  
Random column access is allowed. WRITE to WRITE interval is minimum 1 CK.

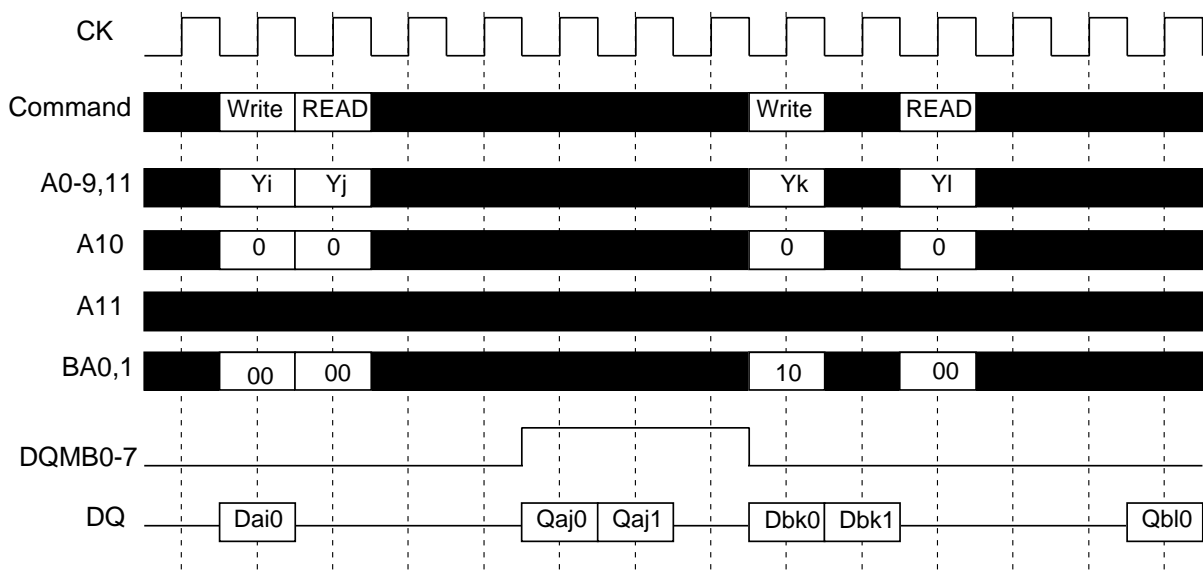
**Write Interrupted by Write (BL=4)**



**[ 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 CK. The input data on DQ at the interrupting READ cycle is "don't care".

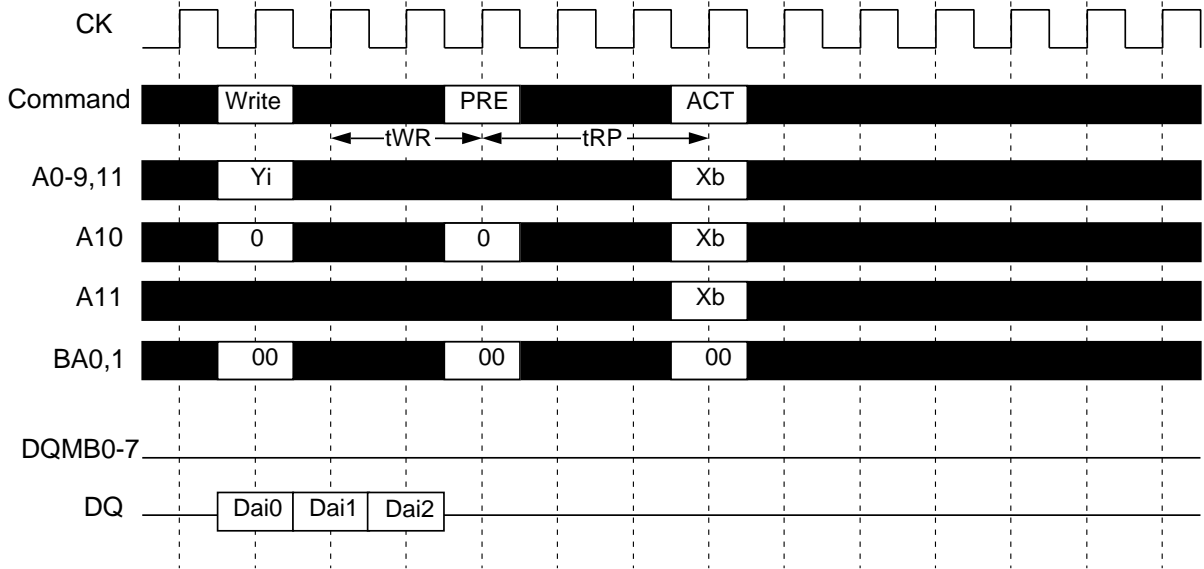
**Write Interrupted by Read (BL=4, CL=3)**



**[ Write Interrupted by Precharge ]**

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

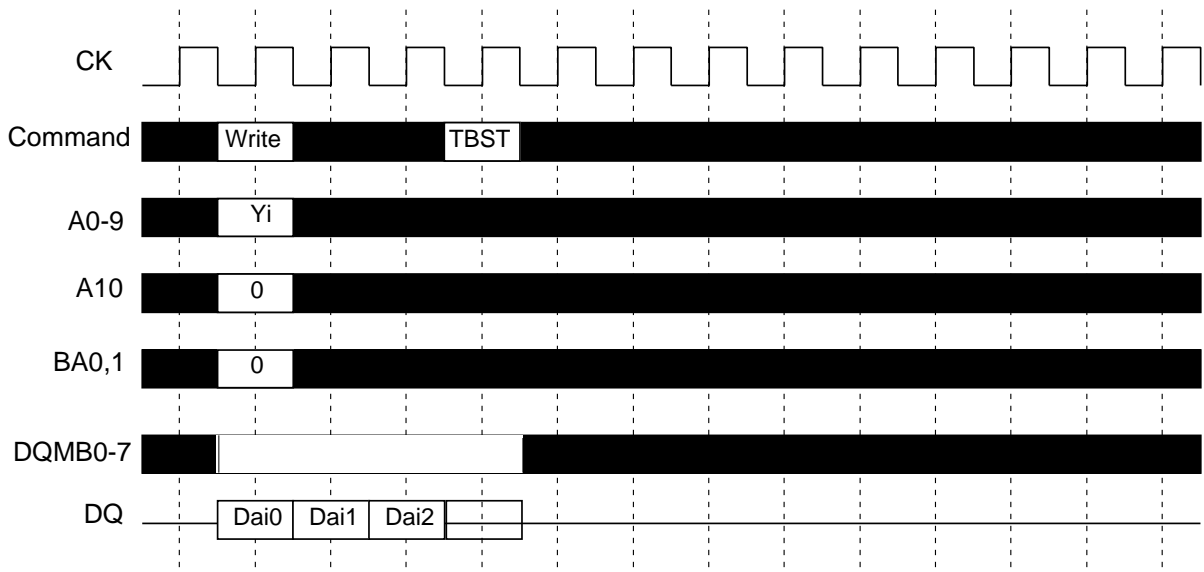
**Write Interrupted by Precharge (BL=4)**



**[ Write Interrupted by Burst Terminate ]**

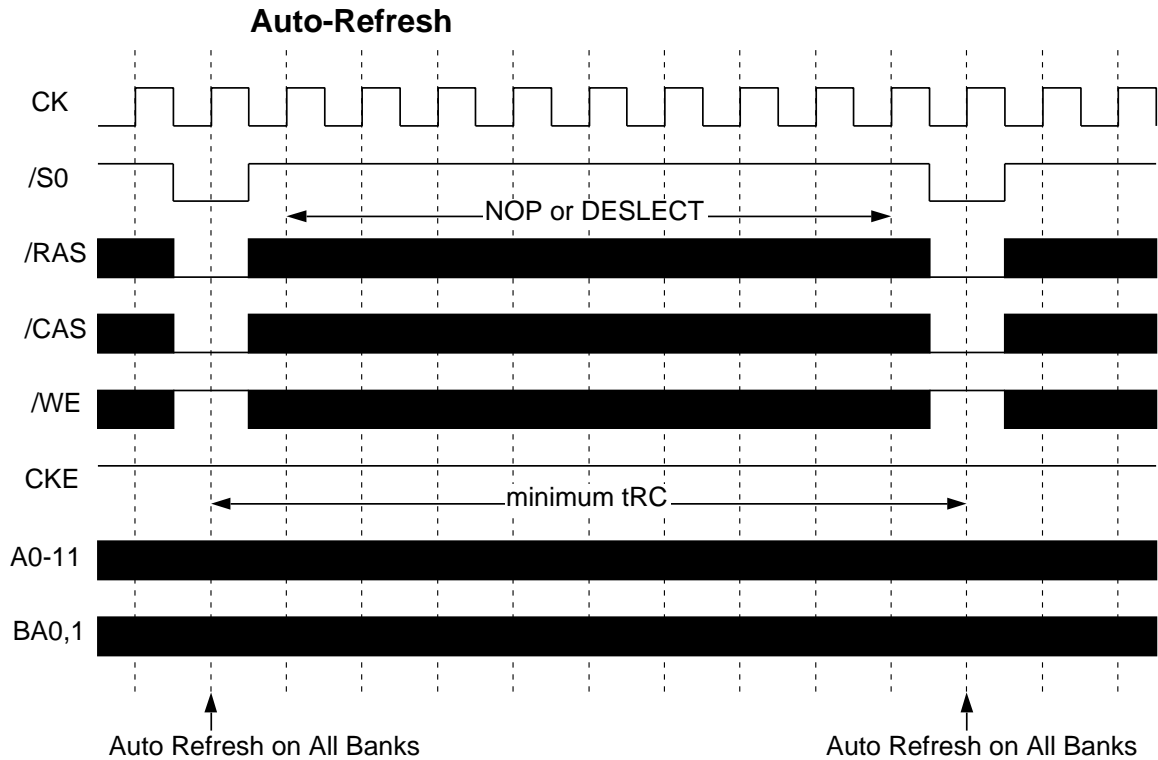
A burst terminate command TBST can terminate burst write operation. In this case, the write recovery time is not required and the bank remains active (Please see the waveforms below). The WRITE to TBST minimum interval is 1CK.

**Write Interrupted by Burst Terminate (BL=4)**



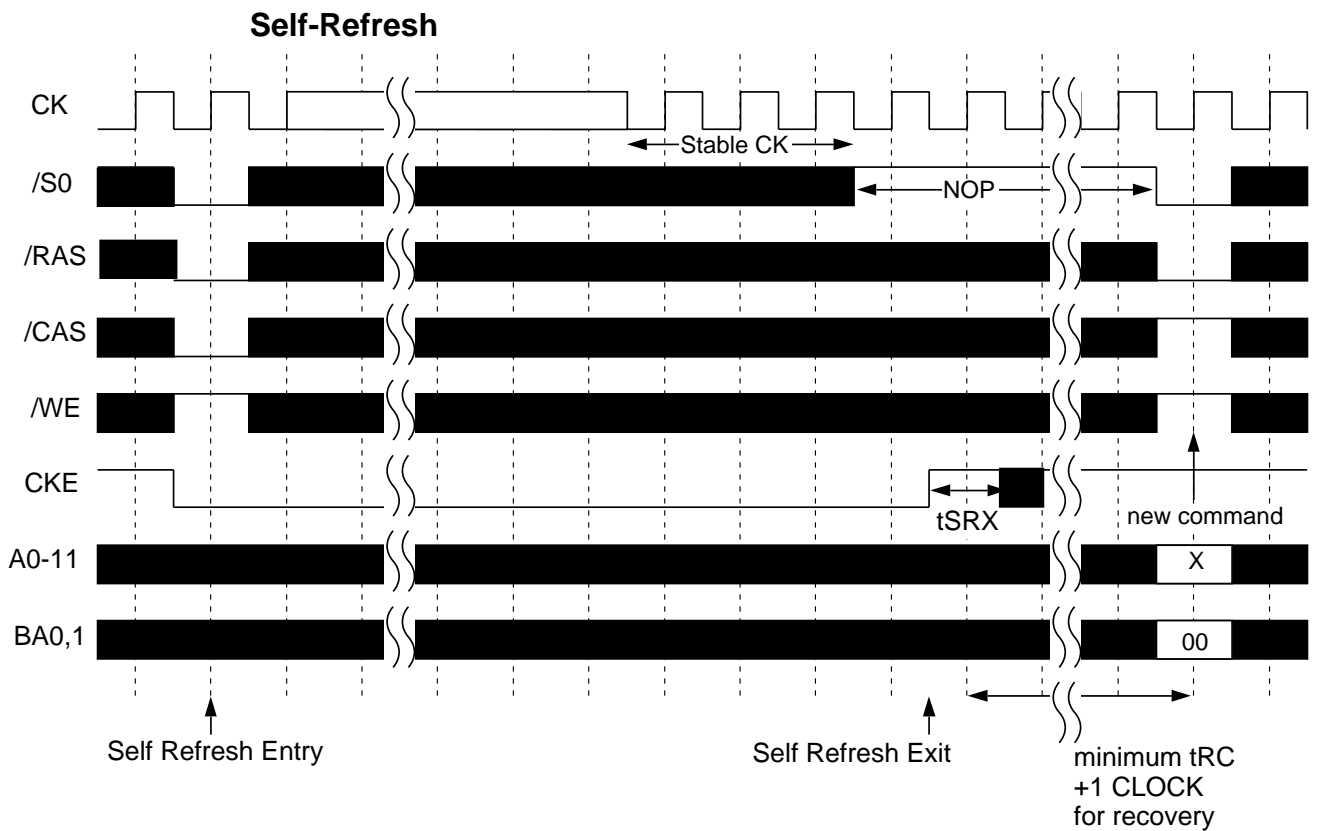
**AUTO REFRESH**

Single cycle of auto-refresh is initiated with a REFA(/S0=/RAS=/CAS=L, /WE=/CKE=H) command. The refresh address is generated internally. 4096 REFA cycles within 64ms refresh 128Mbit memory cells. The auto-refresh is performed on 4bank 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 (/CS=/RAS=/CAS=L, /WE=H, 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 CK are disabled and ignored, so that power consumption due to synchronous inputs is saved. To exit the self-refresh, supplying stable CK inputs, asserting DESEL or NOP command and then asserting CKE(REFSX) for longer than tSRX. After tRC from REF SX all banks are in the idle state and a new command can be issued after tRC, but DESEL or NOP commands must be asserted till then.

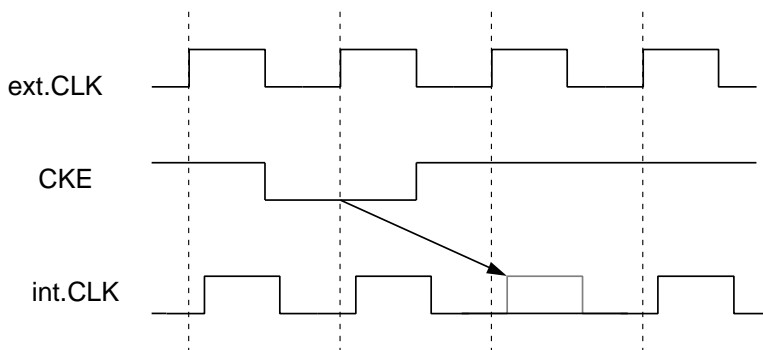


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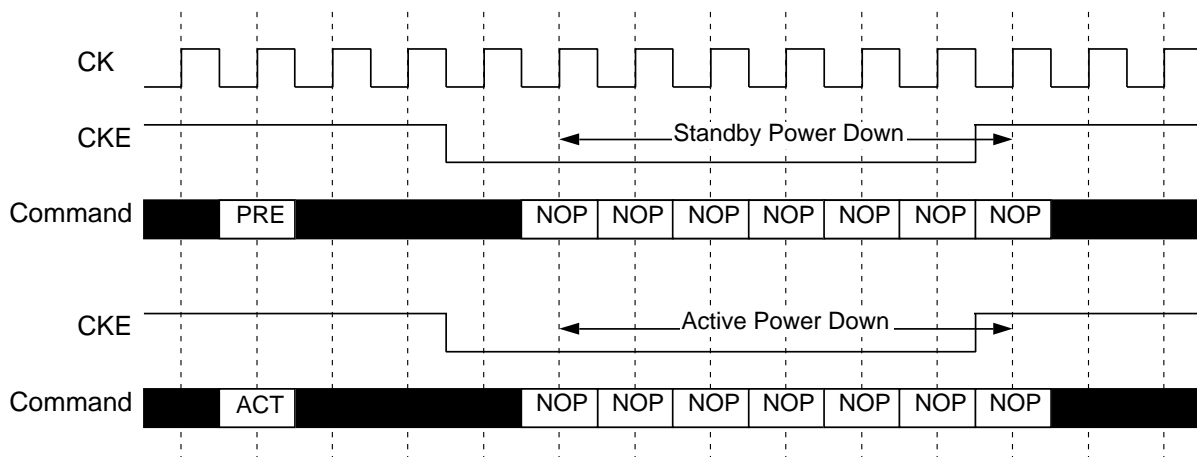
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## CLK SUSPEND

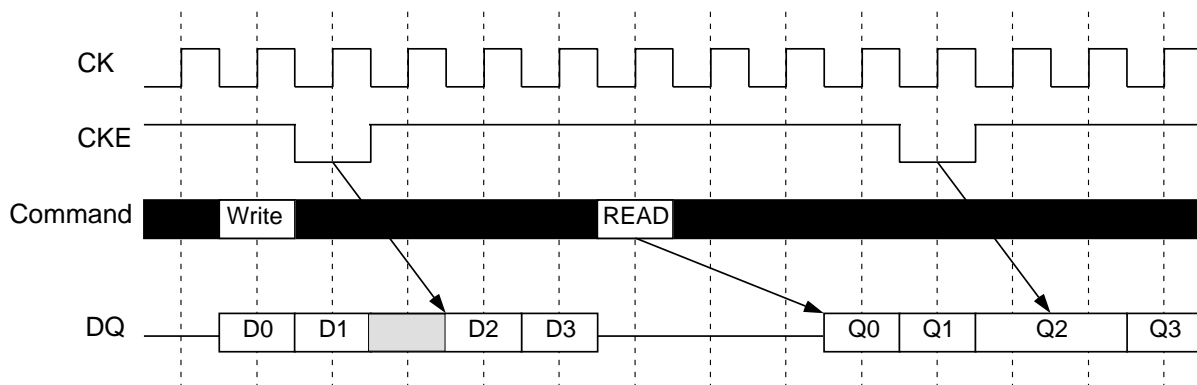
CKE controls the internal CLK at the following cycle. Figure below shows how CKE works. By negating CKE, the next internal CLK is suspended. The purpose of CLK suspend is power down, output suspend or input suspend. CKE is a synchronous input except during the self-refresh mode. CLK suspend can be performed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



### Power Down by CKE



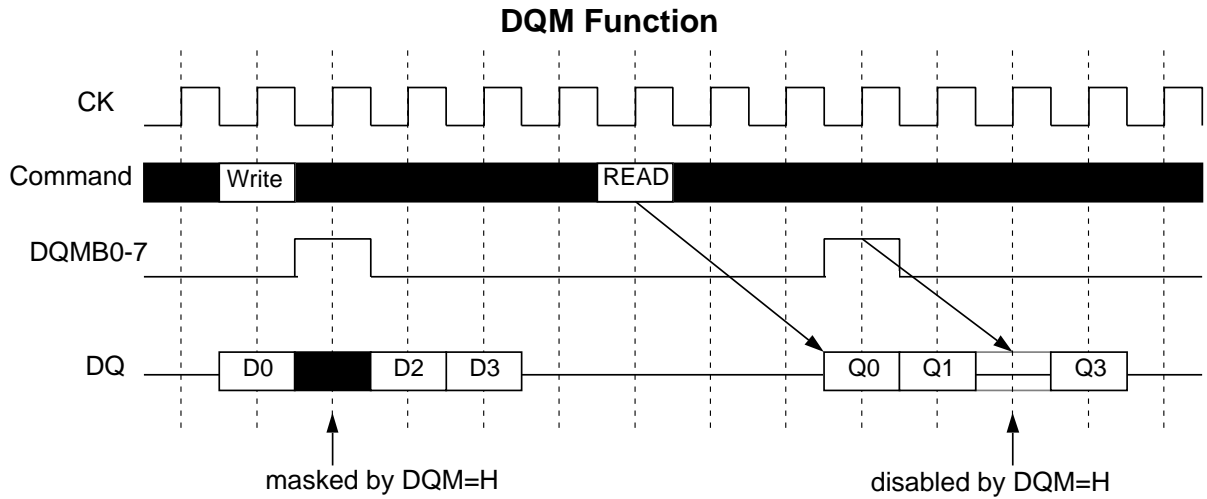
### DQ Suspend by CKE



**DQM CONTROL**

DQMB0-7 is a dual function signal defined as the data mask for writes and the output disable for reads. During writes, DQMB0-7 masks input data word by word. DQMB0-7 to write mask latency is 0.

During reads, DQMB0-7 forces output to Hi-Z word by word. DQMB0-7 to output Hi-Z latency is 2.



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**ABSOLUTE MAXIMUM RATINGS**

Symbol	Parameter	Condition	Ratings	Unit
Vdd	Supply Voltage	with respect to Vss	-0.5 ~ 4.6	V
VI	Input Voltage	with respect to Vss	-0.5 ~ 4.6	V
VO	Output Voltage	with respect to Vss	-0.5 ~ 4.6	V
IO	Output Current		50	mA
Pd	Power Dissipation	Ta=25°C	8	W
Topr	Operating Temperature		0 ~ 70	°C
Tstg	Storage Temperature		-40 ~ 100	°C

**RECOMMENDED OPERATING CONDITION**

(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
VIH	High-Level Input Voltage all inputs	2.0		Vdd+0.3	V
VIL	Low-Level Input Voltage all inputs	-0.3		0.8	V

Note:\* VIH (max) = 5.5V for pulse width less than 10ns.

VIL (min) = -1.0V for pulse width less than 10ns.

**CAPACITANCE**

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

Symbol	Parameter	Test Condition	Limits(max.)	Unit
CI(A)	Input Capacitance, address pin	VI = Vss f=1MHz Vi=25mVrms	55	pF
CI(C)	Input Capacitance, /RAS,/CAS,/WE		55	pF
CI(K)	Input Capacitance, CK pin		40	pF
CI(S)	Input Capacitance, /CS pin		40	pF
CI(E)	Input Capacitance, CKE pin		55	pF
CI(M)	Input Capacitance, DQM pin		22	pF
CI/O	Input Capacitance, I/O pin		22	pF

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## AVERAGE SUPPLY CURRENT from Vdd

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

ITEM		Symbol	Limits (max)	Unit	Note	
operating current tRC=min,tCLK=min, BL=1, OL=3	single bank operation	Icc1	800	mA	*1	
precharge stanby current in Non Power down mode /S0 > Vcc - 0.2V	tCLK = min CKE = H VIH > Vcc - 0.2V VIL < 0.2V	Icc2N	160	mA	*1	
	CLK = L & CKE = H VIH > Vcc - 0.2V VIL < 0.2V all input signals are fixed	Icc2NS	64	mA	*1	
precharge stanby current in Power down mode /S0 > Vcc - 0.2V	tCLK = min CKE =L	Icc2P	16	mA	*1	
	CLK = L CKE = L	Icc2PS	8	mA	*1	
Active standby current in Non Power down mode	CKE = L, tCLK = min.	Icc3N	200	mA	*1	
	CKE = L, tCLK = L	Icc3NS	160			
Active standby current in Power down mode	CKE = L, tCLK = min.	Icc3P	40			
	CKE = L, tCLK = L	Icc3PS	40			
Burst current	All bank Active tCLK = min. BL=4, CL=3	Icc4	1040	mA	*1	
auto-refresh current	tRC=min, tCLK=min	Icc5	1120	mA	*1	
self-refresh current	CKE < 0.2V	Icc6	-10	8	mA	*1
			-10L	4.8	mA	*1,2

Note)

1. Icc(max) is specified at the output open condition.

2. Low Power version

## AC OPERATING CONDITIONS AND CHARACTERISTICS

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

Symbol	Parameter	Test Condition	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-stare Output Current	Q floating VO=0 ~ Vdd	-10	10	uA
Ii	Input Current	VIH=0 ~ Vdd+0.3V	-80	80	uA



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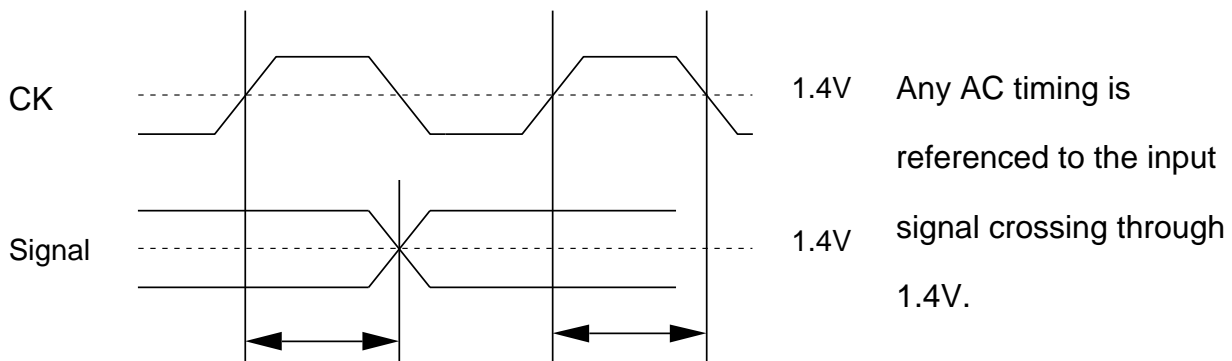
## AC TIMING REQUIREMENTS (SDRAM Component)

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

Input Pulse Levels: 0.8V to 2.0V

Input Timing Measurement Level: 1.4V

Symbol	Parameter	Limits		Unit
		Min.	Max.	
tCLK	CK cycle time	CL=2	15	ns
		CL=3	10	ns
tCH	CK High pulse width	4		ns
tCL	CK Low pulse width	4		ns
tT	Transition time of CK	1	10	ns
tIS	Input Setup time(all inputs)	3		ns
tIH	Input Hold time(all inputs)	1		ns
tRC	Row cycle time	90		ns
tRCD	Row to Column Delay	30		ns
tRAS	Row Active time	60	100K	ns
tRP	Row Precharge time	30		ns
tWR	Write Recovery time	12		ns
tRRD	Act to Act Deley time	20		ns
tRSC	Mode Register Set Cycle time	20		ns
tSRX	Self Refresh Exit time	10		ns
tPDE	Power Down Exit time	10		ns
tREF	Refresh Interval time		64	ms



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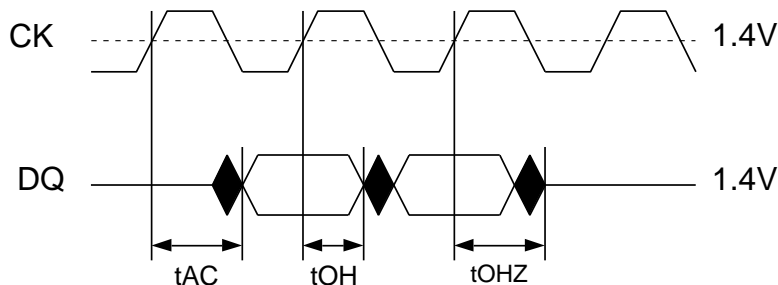
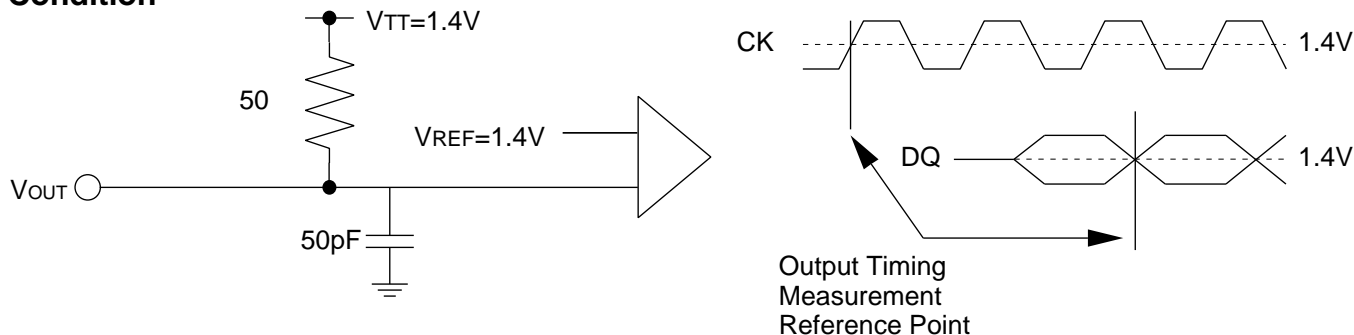
## SWITCHING CHARACTERISTICS (SDRAM Component)

( $T_a=0 \sim 70^\circ\text{C}$ ,  $V_{dd} = 3.3 \pm 0.3\text{V}$ ,  $V_{ss} = 0\text{V}$ , unless otherwise note3)

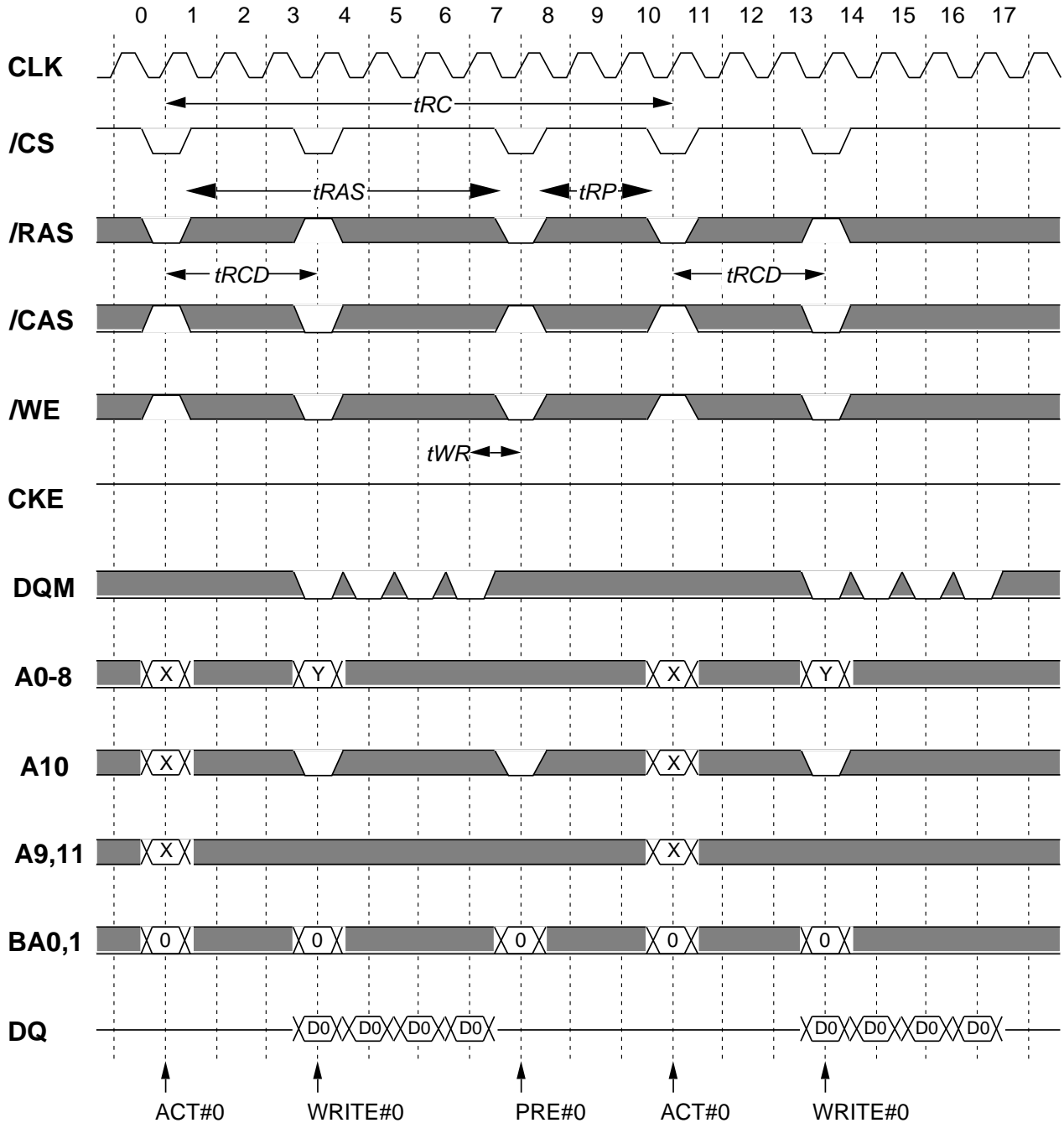
Symbol	Parameter	Limits		Unit
		Min.	Max.	
tAC	Access time from CK	CL=2	8	ns
		CL=3	8	ns
tOH	Output Hold time from CK	3		ns
tOLZ	Delay time, output low impedance from CK	0		ns
tOHZ	Delay time, output high impedance from CK	3	8	ns

Note:3 If clock rising time is longer than 1ns,  $(t_r/2-0.5)\text{ns}$  should be added to parameter.

### Output Load Condition



**Burst Write (single bank) @BL=4**

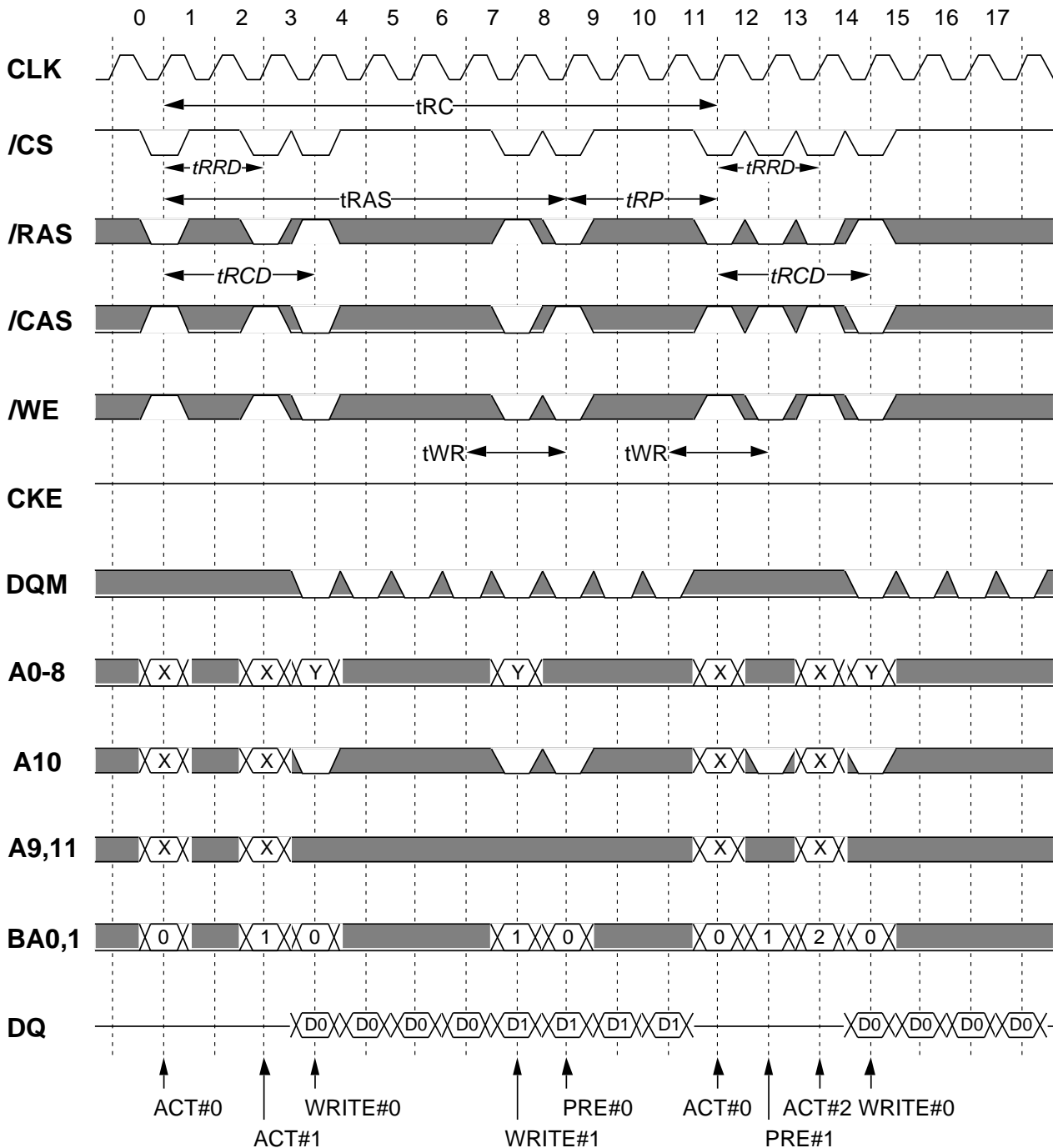


*Italic parameter* indicates minimum case

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## Burst Write (multi bank) @BL=4



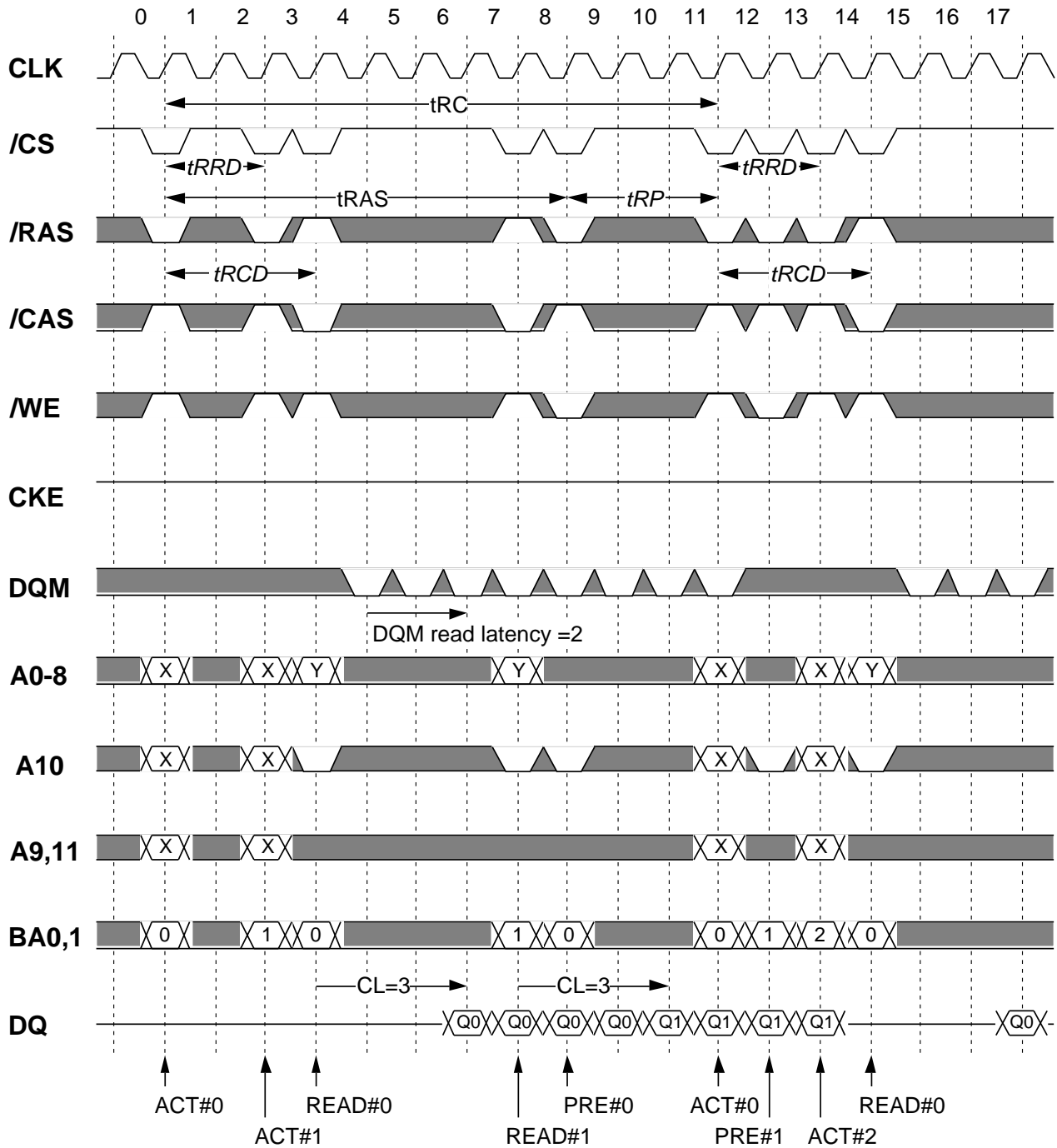
*Italic parameter* indicates minimum case



# MH16S64FFB -10,-10L

1073741824-BIT (16777216 - WORD BY 64-BIT) Synchronous DRAM

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

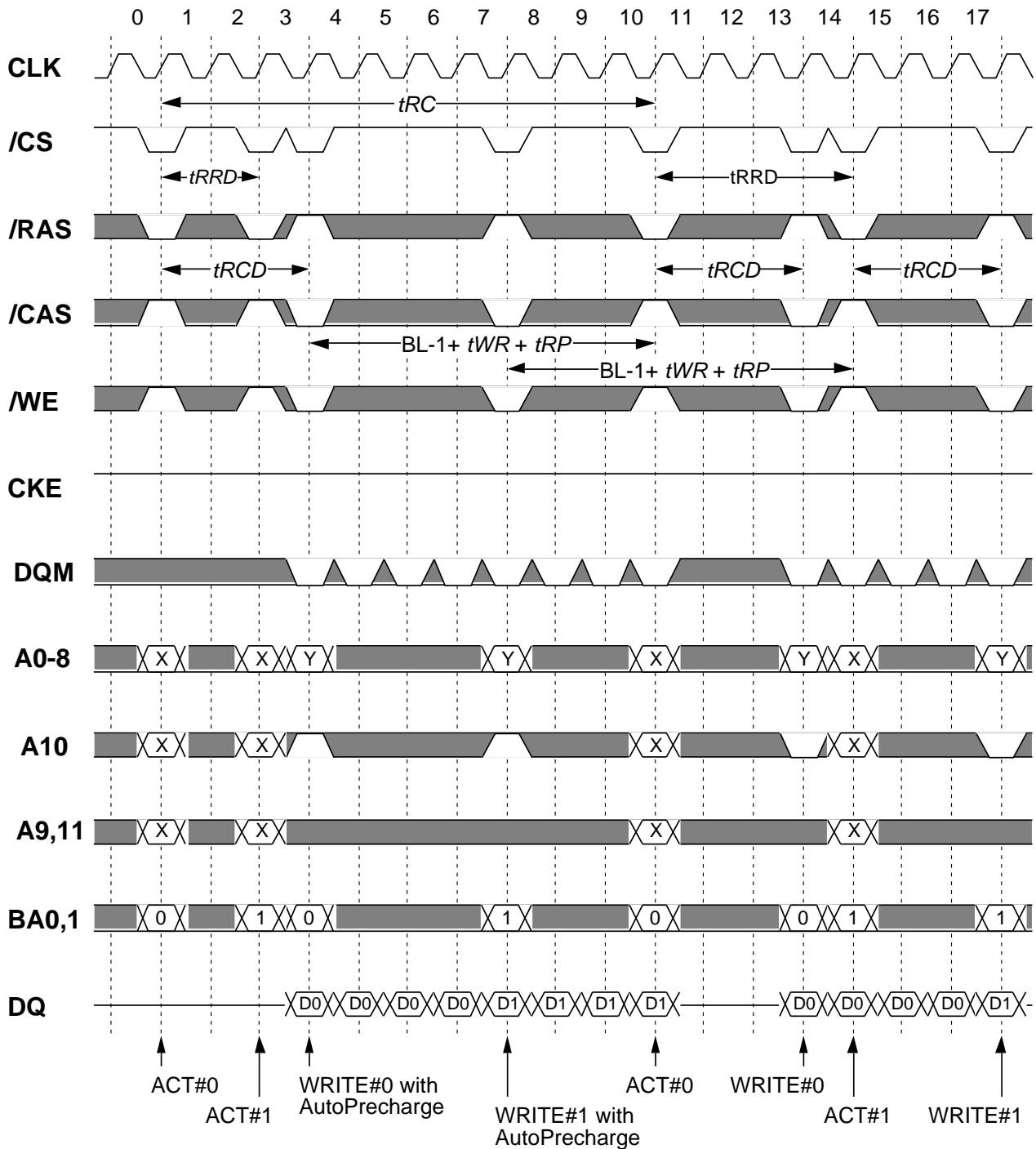


*Italic parameter* indicates minimum case

# MH16S64FFB -10,-10L

1073741824-BIT (16777216 - WORD BY 64-BIT) Synchronous DRAM

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

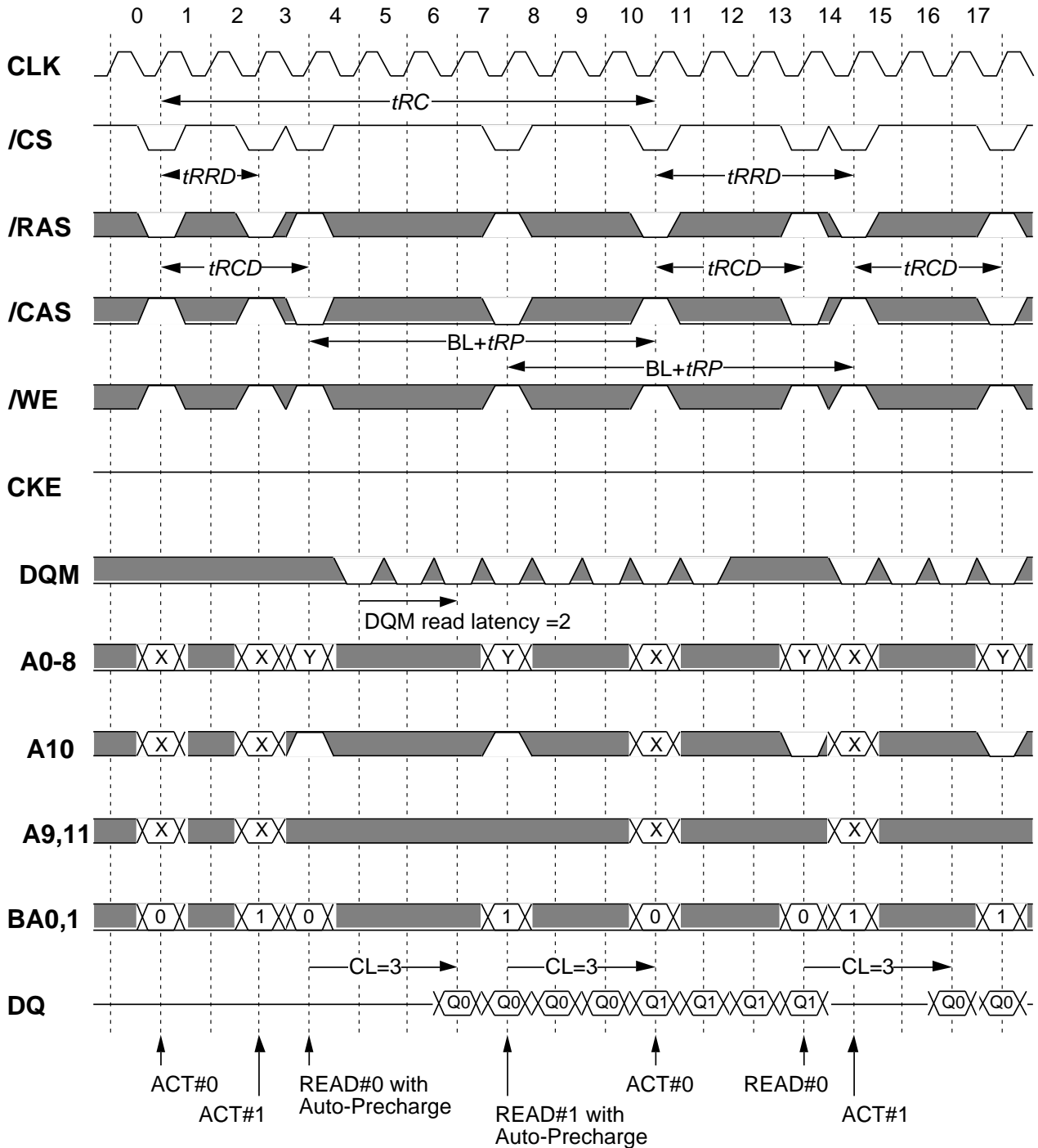


*Italic parameter* indicates minimum case

# MH16S64FFB -10,-10L

1073741824-BIT (16777216 - WORD BY 64-BIT)SynchronousDRAM

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



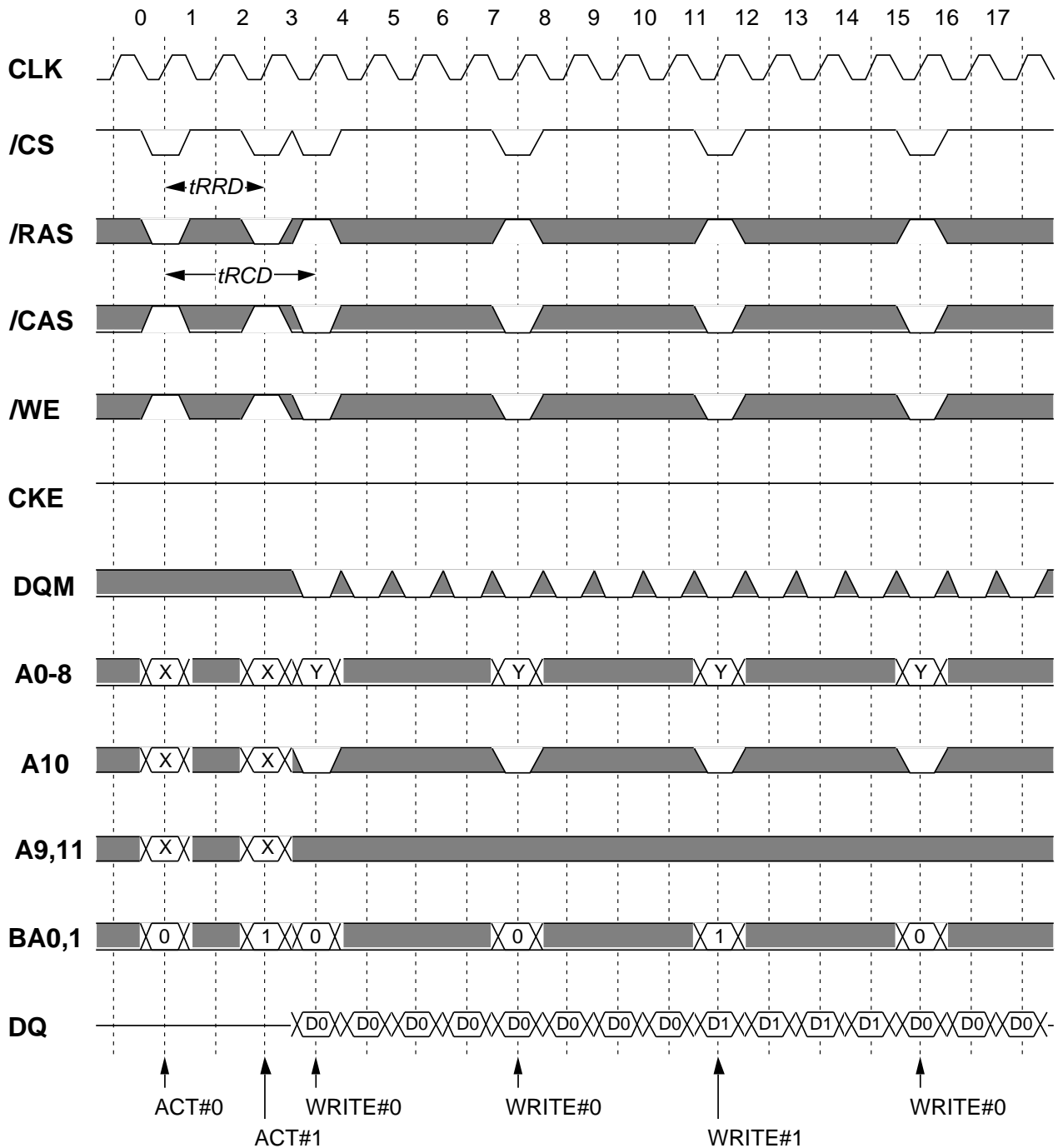
*Italic parameter* indicates minimum case



# MH16S64FFB -10,-10L

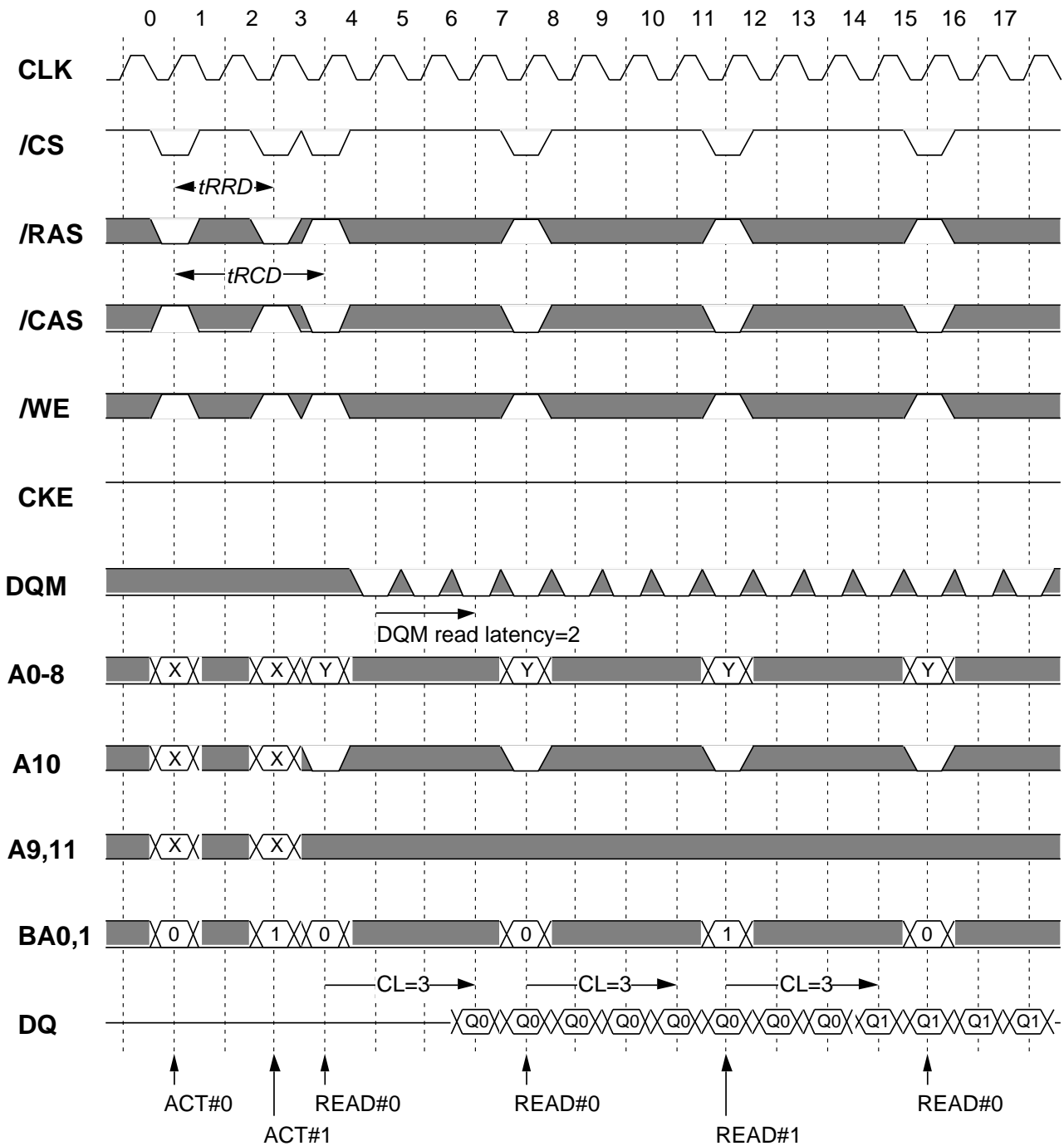
1073741824-BIT (16777216 - WORD BY 64-BIT) Synchronous DRAM

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



*Italic parameter* indicates minimum case

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

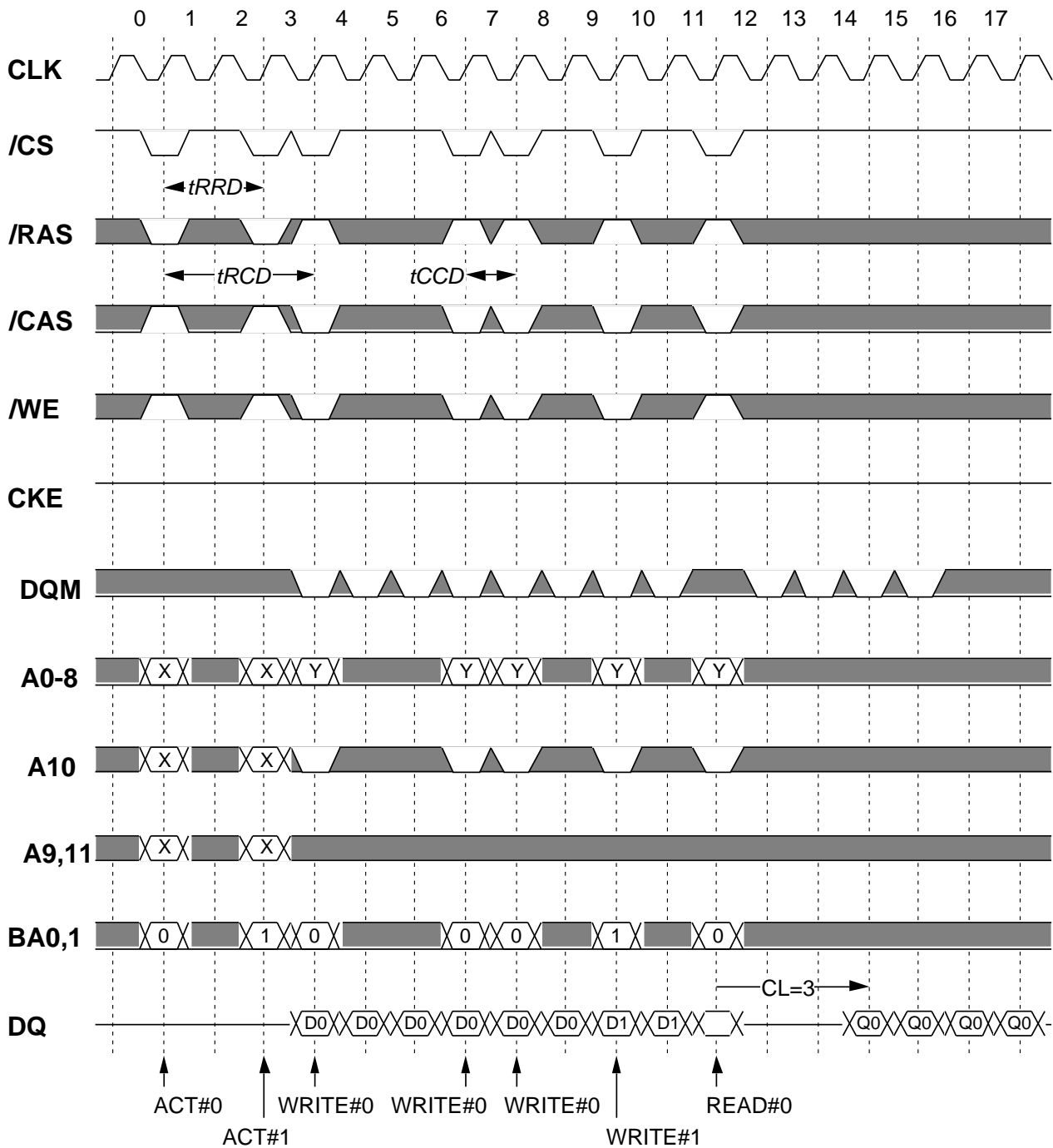


*Italic parameter* indicates minimum case

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1073741824-BIT (16777216 - WORD BY 64-BIT) Synchronous DRAM

Write Interrupted by Write / Read @BL=4



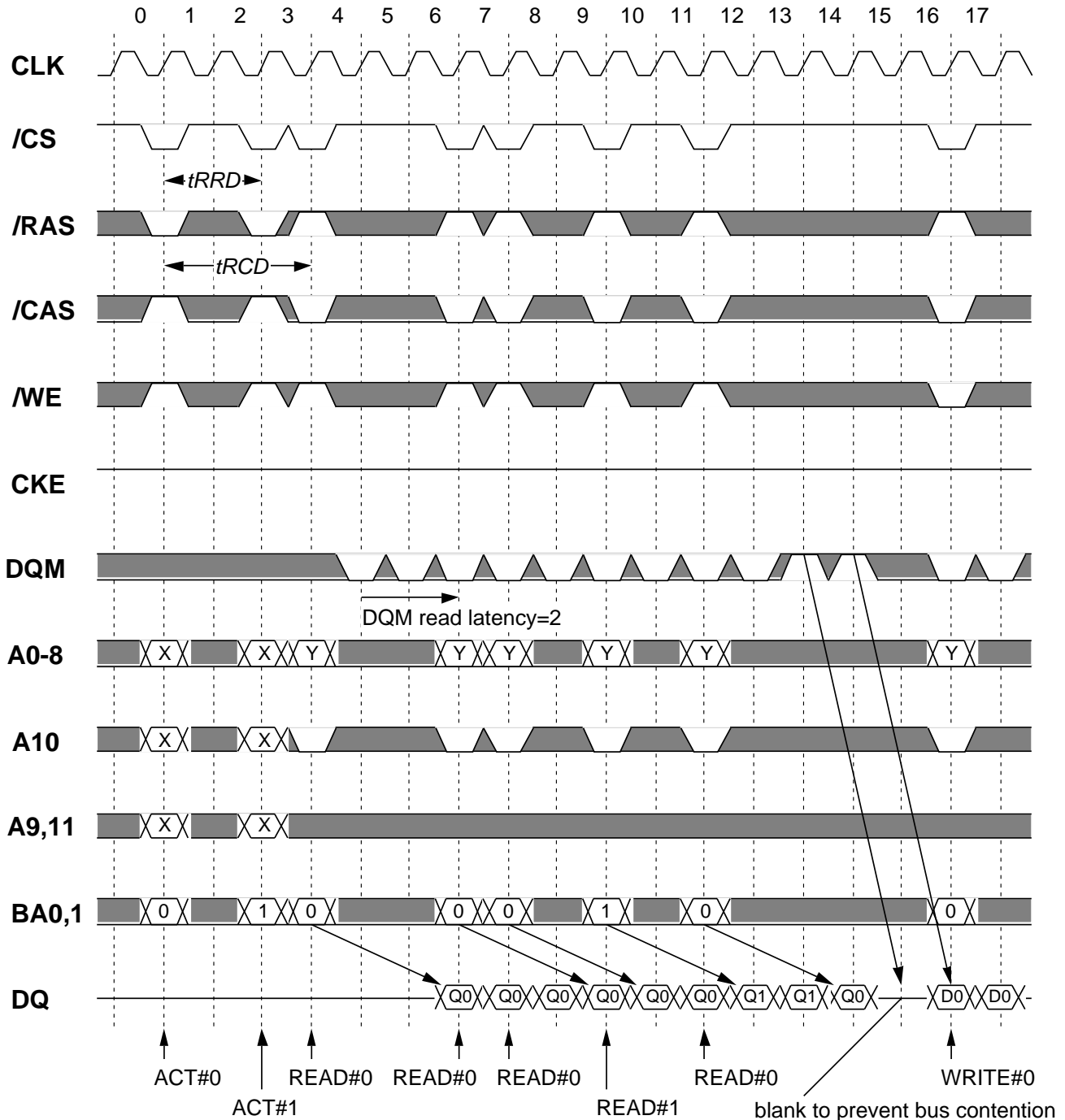
Burst Write can be interrupted by Write or Read of any active bank.

*Italic parameter* indicates minimum case

# MH16S64FFB -10,-10L

1073741824-BIT (16777216 - WORD BY 64-BIT) Synchronous DRAM

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



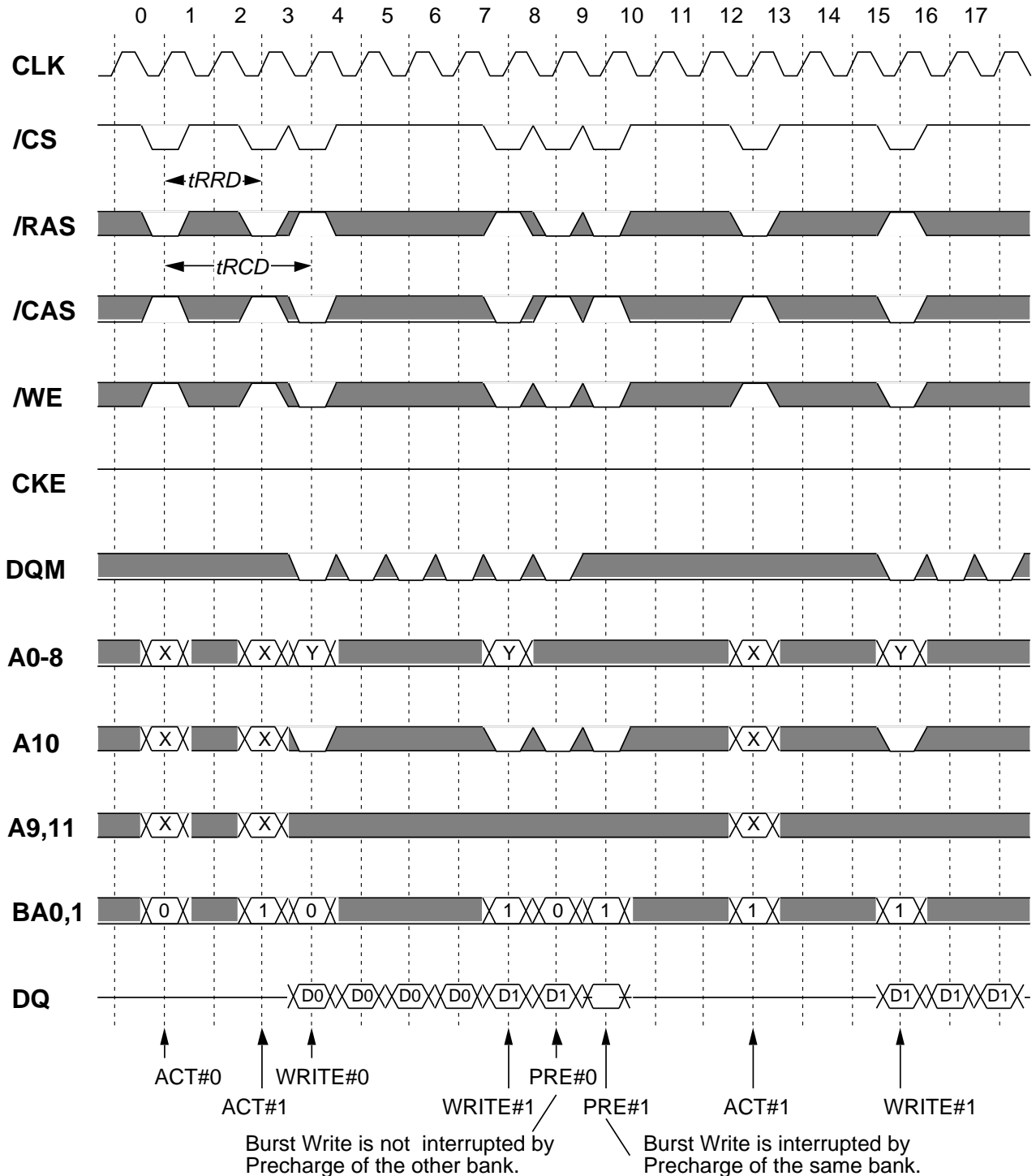
Burst Read can be interrupted by Read or Write of any active bank.

*Italic parameter* indicates minimum case

MH16S64FFB -10,-10L

1073741824-BIT (16777216 - WORD BY 64-BIT) Synchronous DRAM

Write Interrupted by Precharge @BL=4

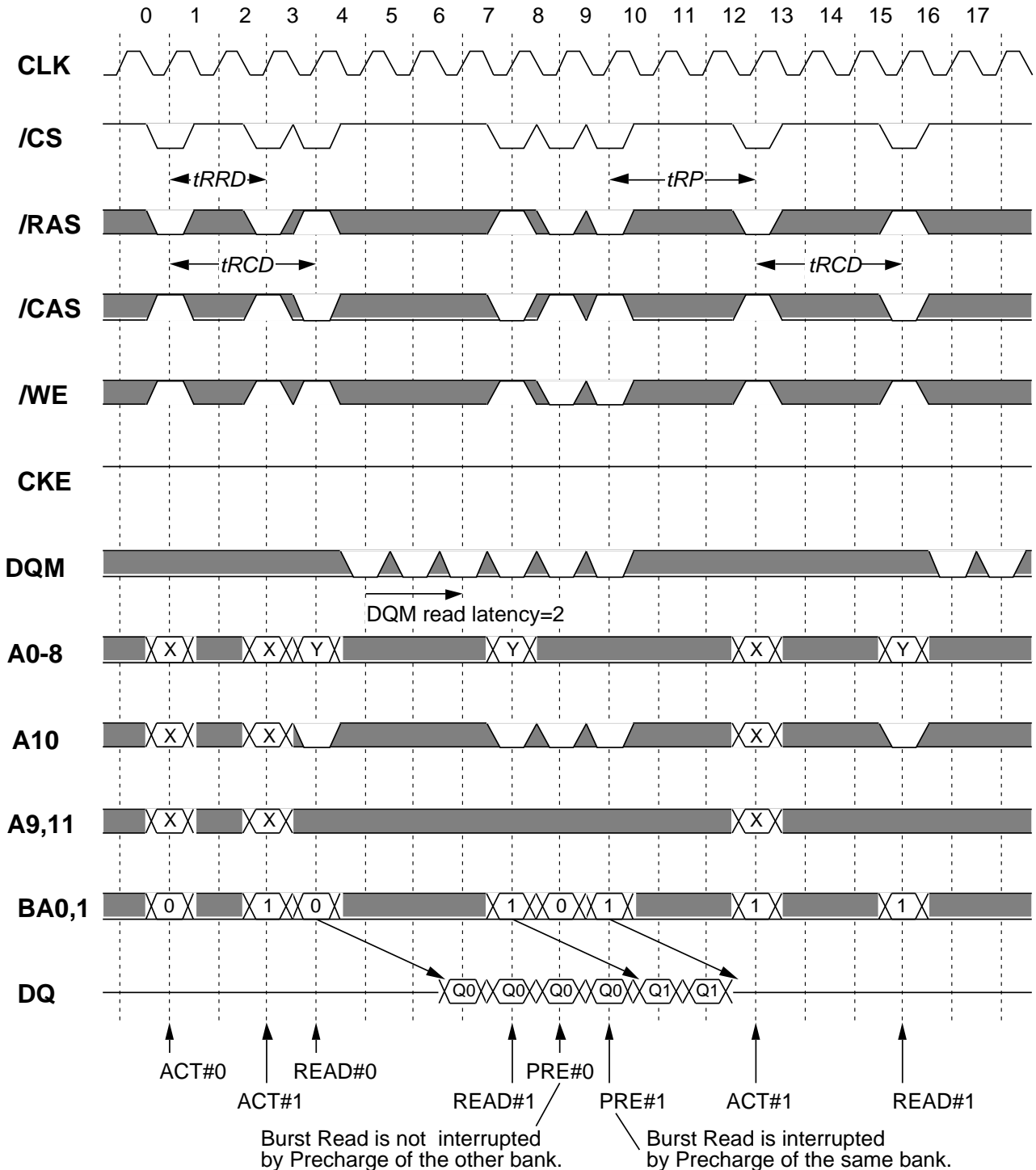


*Italic parameter* indicates minimum case

MH16S64FFB -10,-10L

1073741824-BIT (16777216 - WORD BY 64-BIT)SynchronousDRAM

Read Interrupted by Precharge @BL=4 CL=3

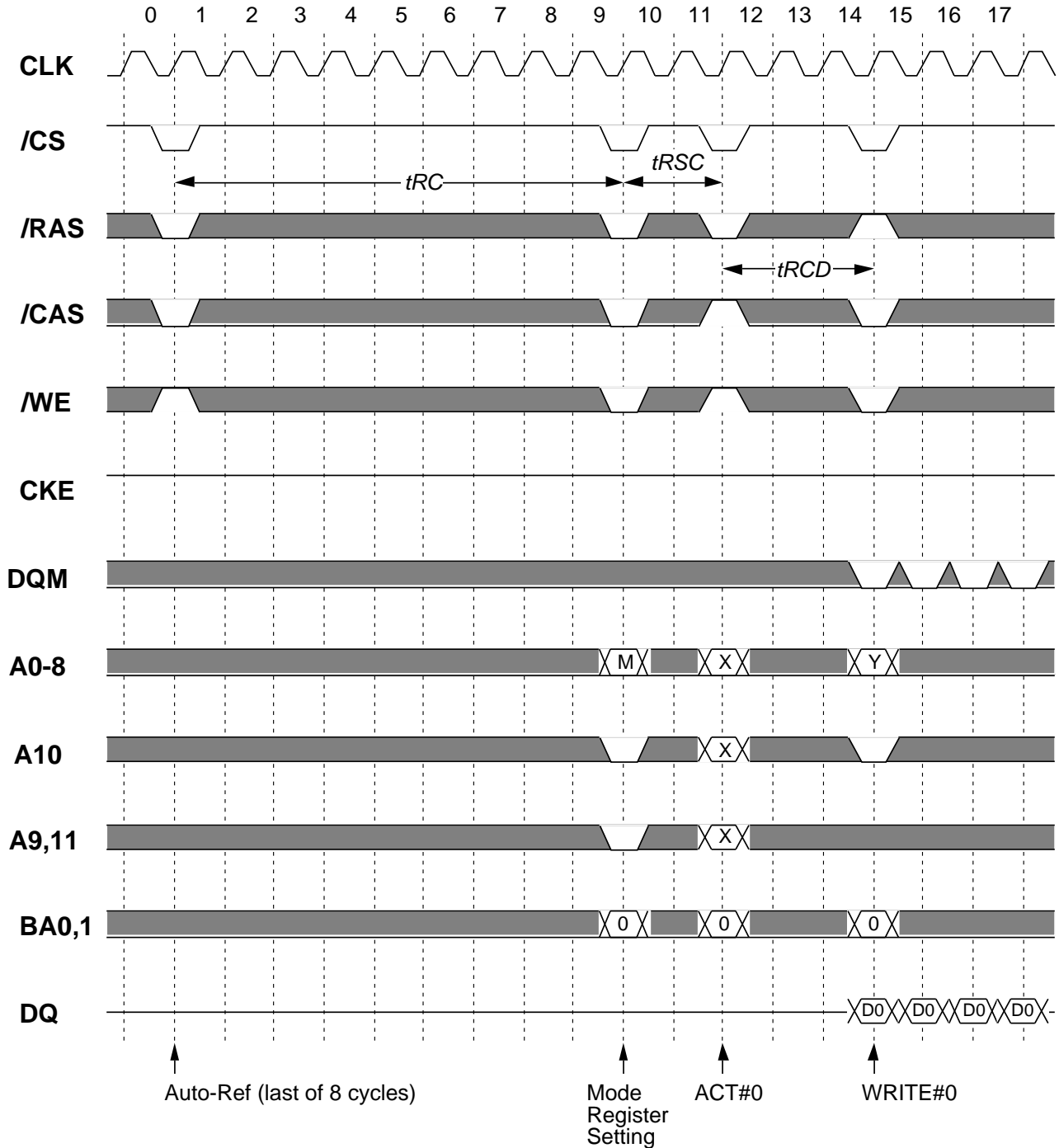


*Italic parameter* indicates minimum case

# MH16S64FFB -10,-10L

1073741824-BIT (16777216 - WORD BY 64-BIT) Synchronous DRAM

## Mode Register Setting

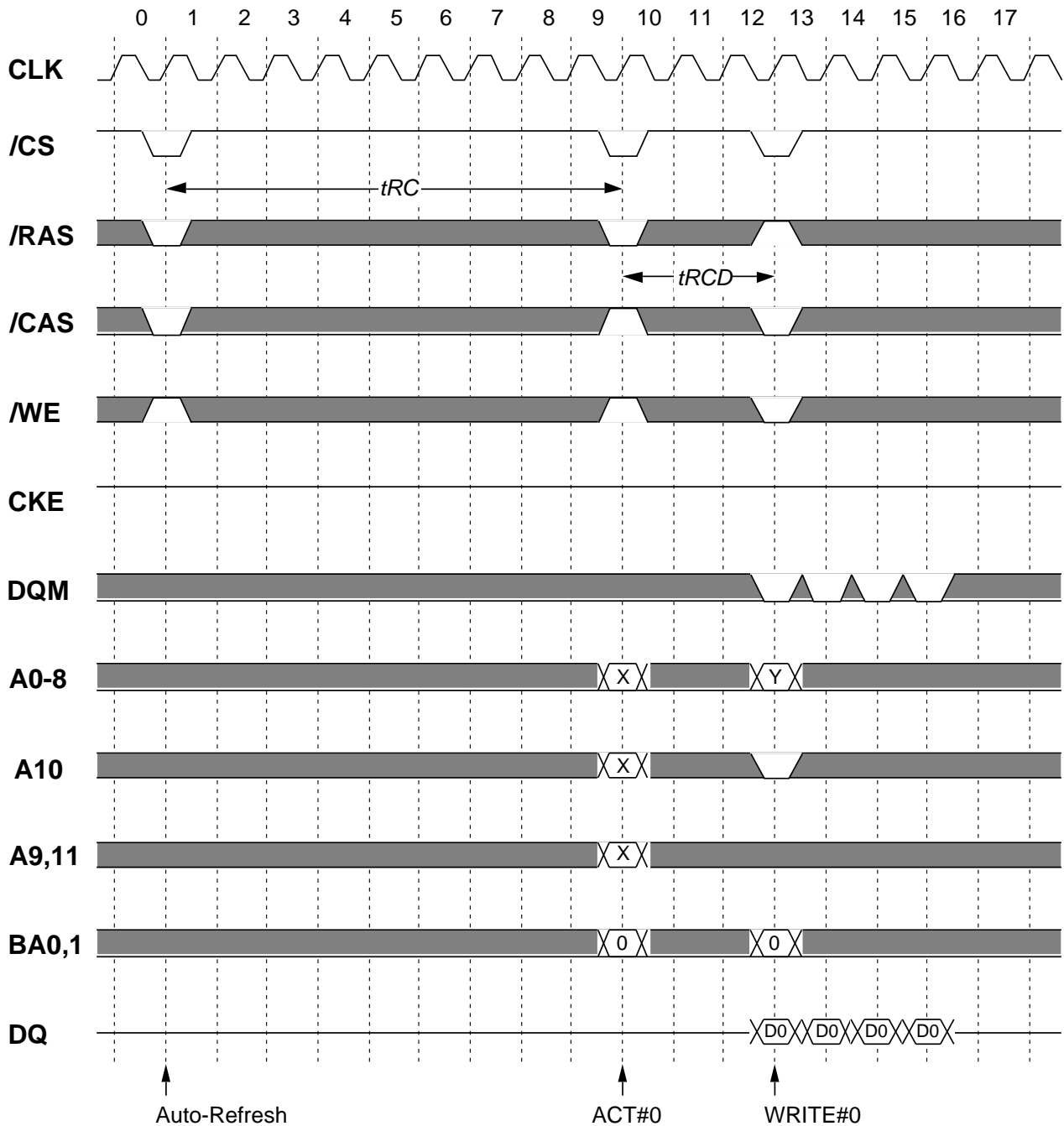


*Italic parameter* indicates minimum case

# MH16S64FFB -10,-10L

1073741824-BIT (16777216 - WORD BY 64-BIT) Synchronous DRAM

## Auto-Refresh @BL=4



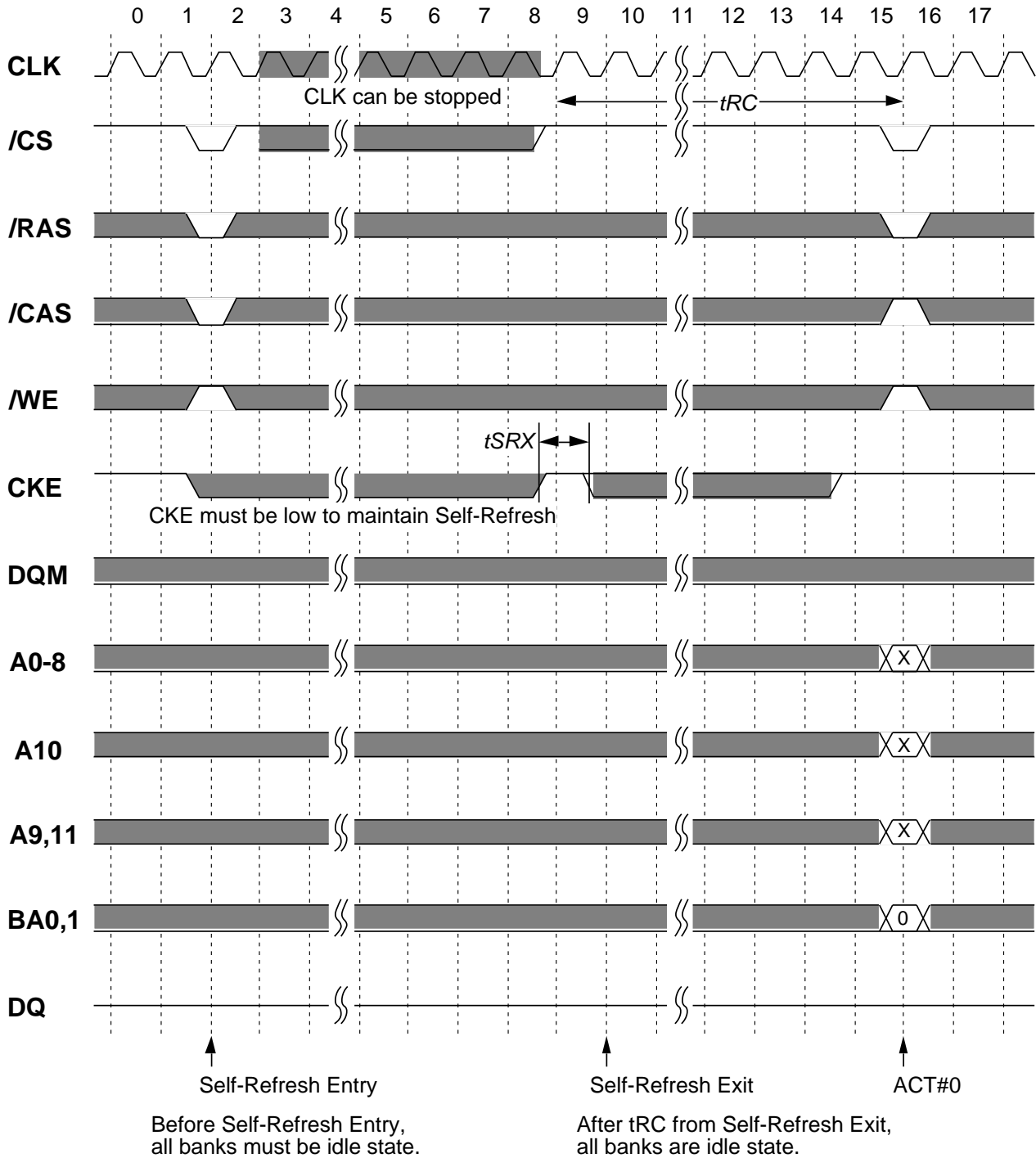
*Italic parameter* indicates minimum case



MH16S64FFB -10,-10L

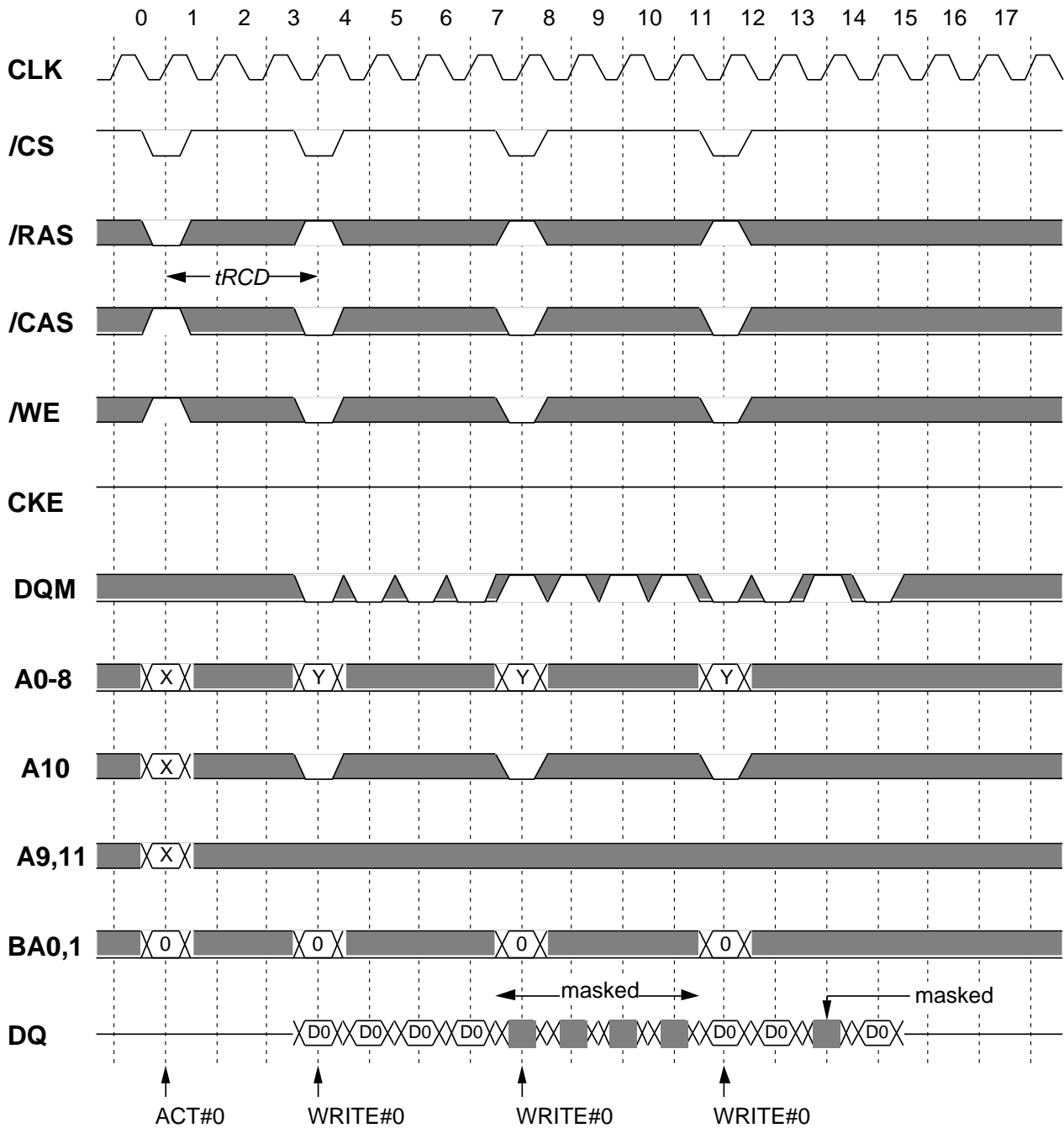
1073741824-BIT (16777216 - WORD BY 64-BIT)SynchronousDRAM

**Self-Refresh**



*Italic parameter* indicates minimum case

**DQM Write Mask @BL=4**

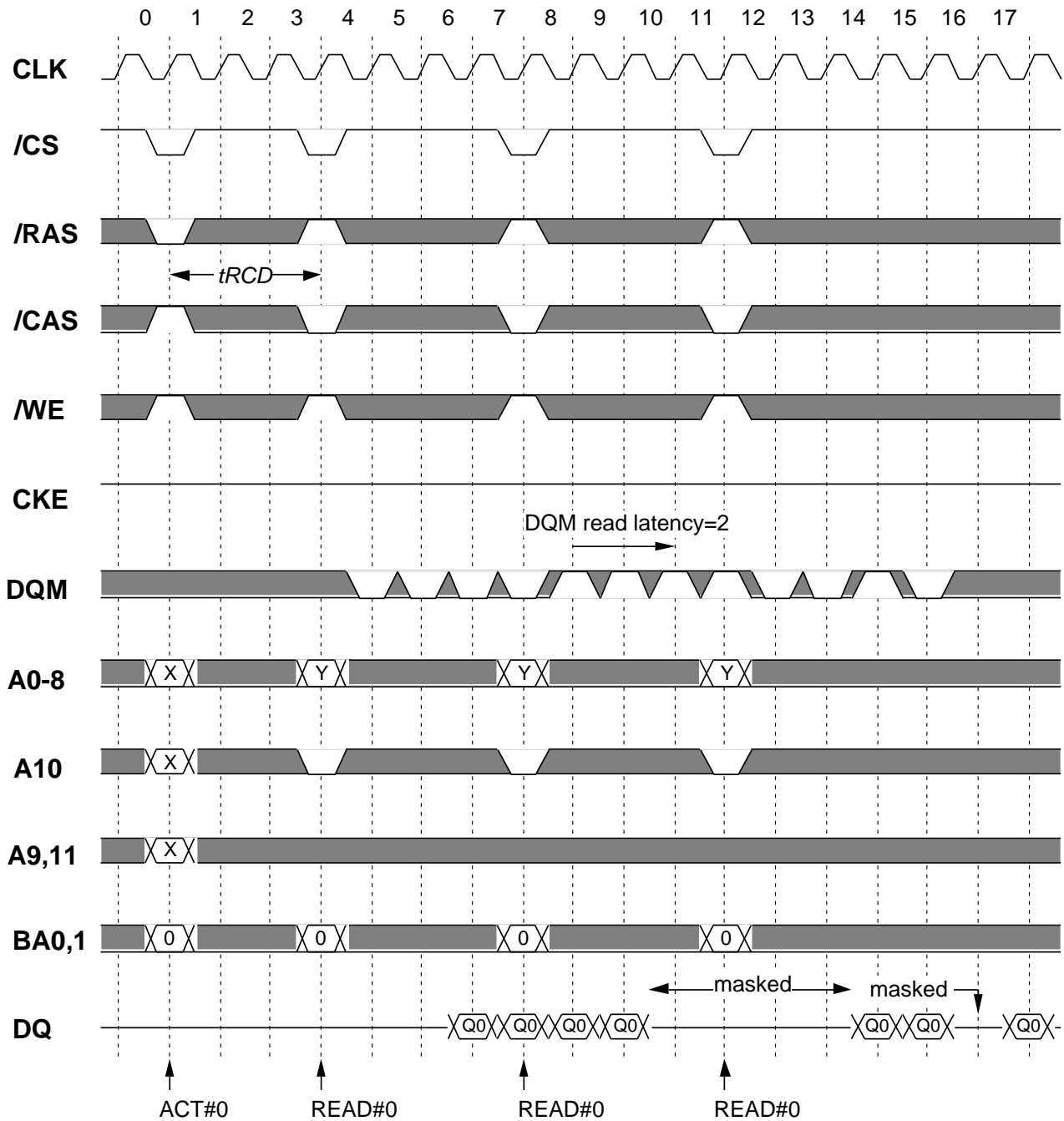


*Italic parameter* indicates minimum case

# MH16S64FFB -10,-10L

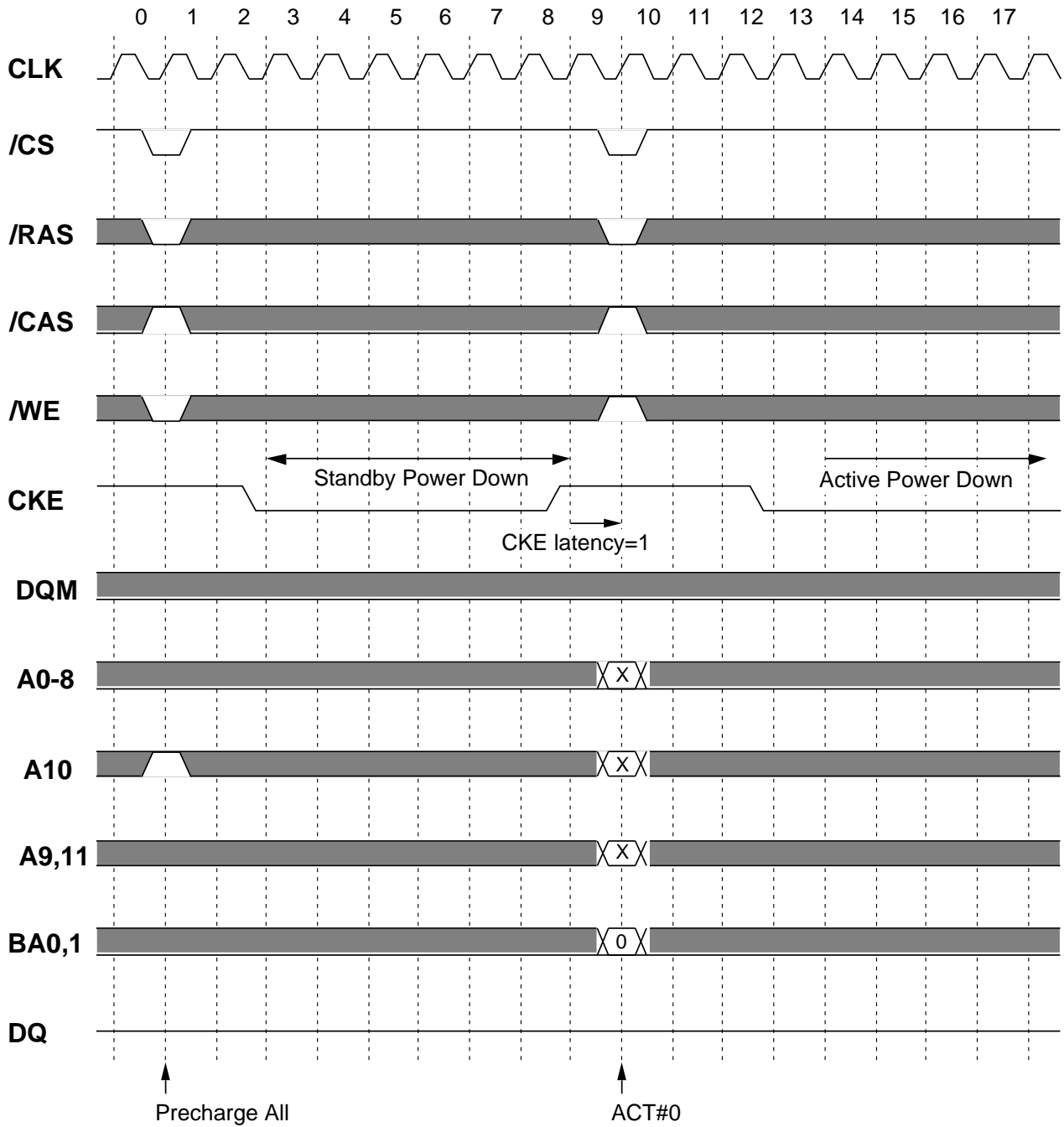
1073741824-BIT (16777216 - WORD BY 64-BIT) Synchronous DRAM

## DQM Read Mask @BL=4 CL=3



*Italic parameter* indicates minimum case

### Power Down

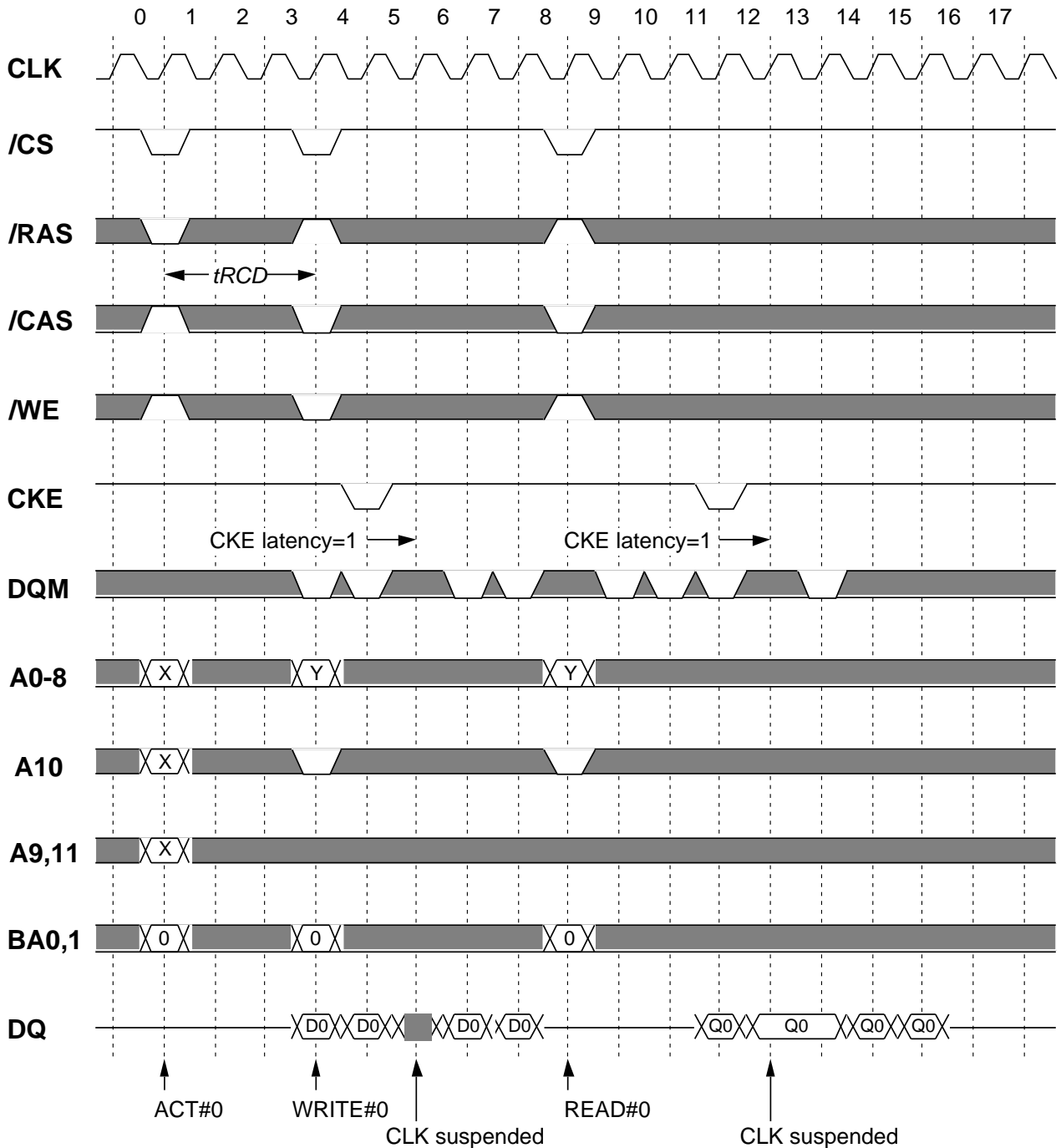


*Italic parameter* indicates minimum case

# MH16S64FFB -10,-10L

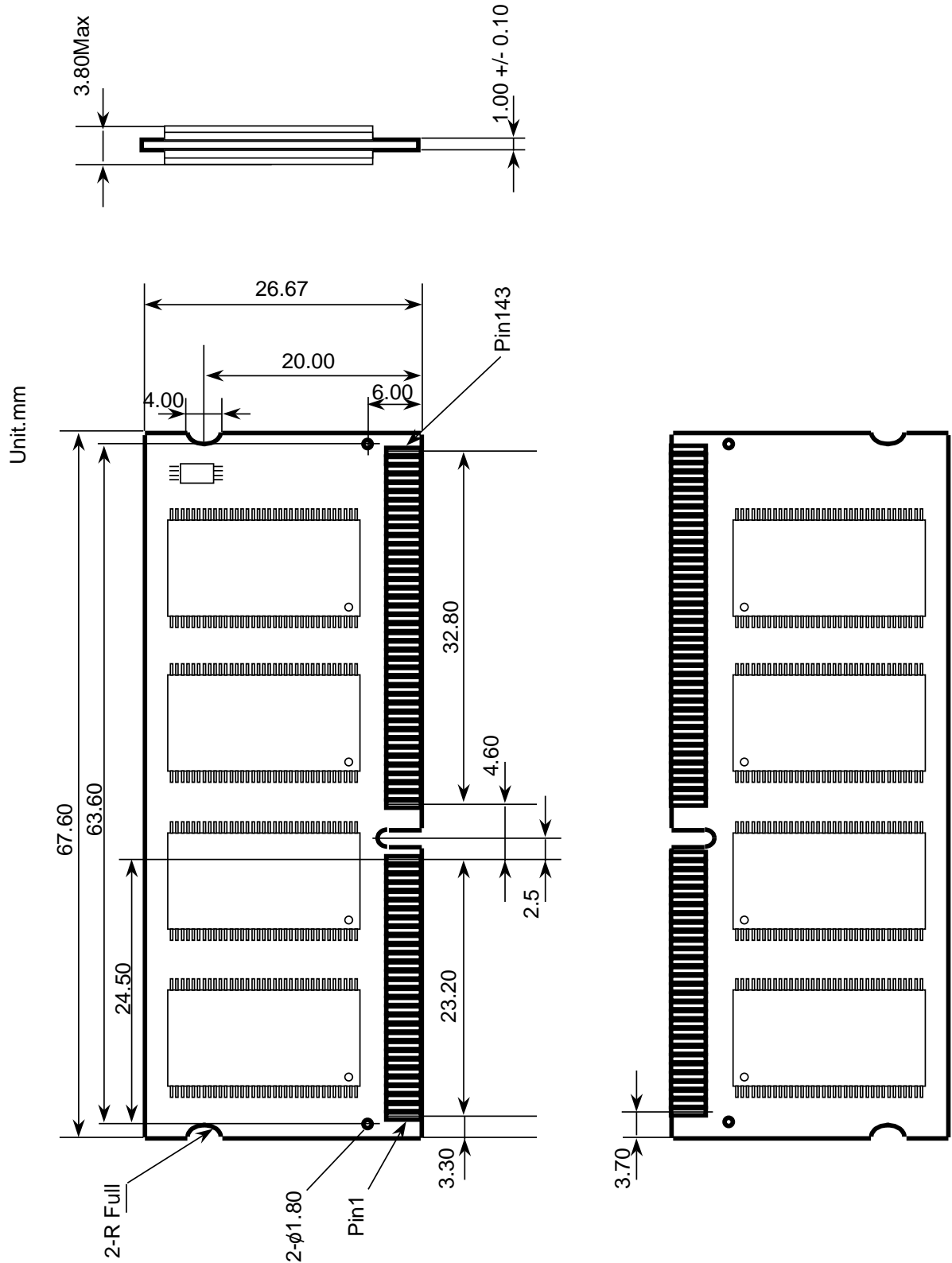
1073741824-BIT (16777216 - WORD BY 64-BIT)SynchronousDRAM

## CLK Suspend @BL=4 CL=3



*Italic parameter* indicates minimum case

OUTLINE



## Keep safety first in your circuit designs!

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