

PRELIMINARY

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

DESCRIPTION

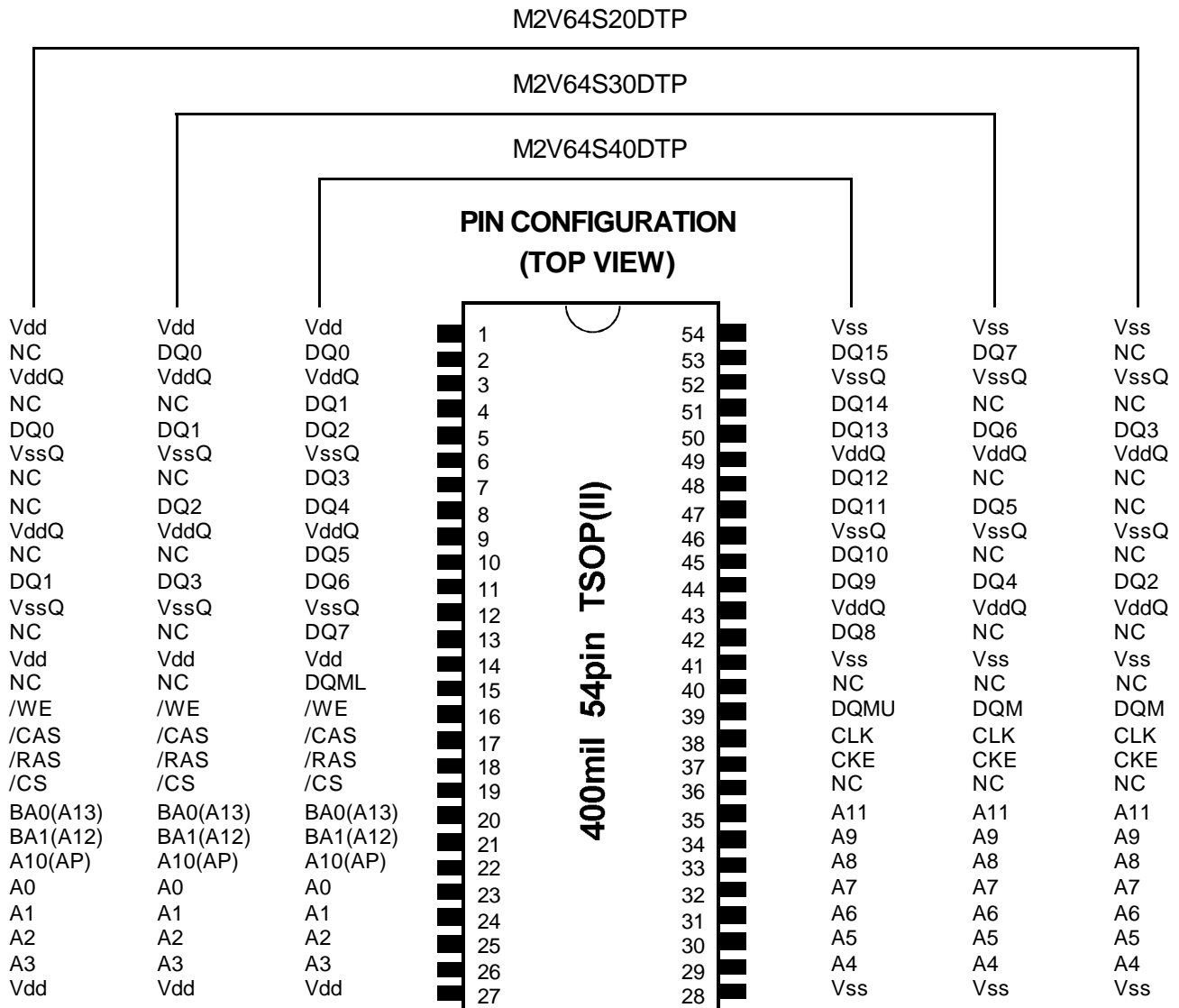
M2V64S20DTP is a 4-bank x 4,194,304-word x 4-bit,
M2V64S30DTP is a 4-bank x 2,097,152-word x 8-bit,
M2V64S40DTP is a 4-bank x 1,048,576-word x 16-bit,
synchronous DRAM, with LVTTL interface. All inputs and outputs are referenced to the rising edge of CLK. M2V64S20DTP, M2V64S30DTP and M2V64S40DTP achieve very high speed data rate up to 133MHz for -6, and are suitable for main memory or graphic memory in computer systems.

FEATURES

| ITEM | | M2V64S20/30/40DTP | | | |
|------|---|-------------------|------|------|------|
| | | -6 | -7 | -8 | |
| tCLK | Clock Cycle Time (Min.) | 7.5ns | 10ns | 10ns | |
| tRAS | Active to Precharge Command Period (Min.) | 45ns | 50ns | 50ns | |
| tRCD | Row to Column Delay (Min.) | 20ns | 20ns | 20ns | |
| tAC | Access Time from CLK (Max.) (CL=3) | 5.4ns | 6ns | 6ns | |
| tRC | Ref/Active Command Period (Min.) | 67.5ns | 70ns | 70ns | |
| Icc1 | Operation Current (Max.) (Single Bank) | V64S20D | 75mA | 70mA | 70mA |
| | | V64S30D | 75mA | 70mA | 70mA |
| | | V64S40D | 85mA | 80mA | 80mA |
| Icc6 | Self Refresh Current (Max.) | 1mA | 1mA | 1mA | |

- Single 3.3v±0.3V power supply
- Max. Clock frequency -6:133MHz<3-3-3>, -7:100MHz<2-2-2>, -8:100MHz<3-2-2>
- Fully Synchronous operation referenced to clock rising edge
- 4 bank operation controlled by BA0 & BA1 (Bank Address)
- /CAS latency- 2 and 3 (programmable)
- Burst length- 1, 2, 4, 8 and full page (programmable)
- Burst type- sequential and interleave (programmable)
- Byte Control- DQML and DQMU for M2V64S40DTP
- Random column access
- Auto precharge and All bank precharge controlled by A10
- Auto refresh and Self refresh
- 4096 refresh cycles every 64ms
- LVTTL Interface
- 400-mil, 54-pin Thin Small Outline Package (TSOP II) with 0.8mm lead pitch

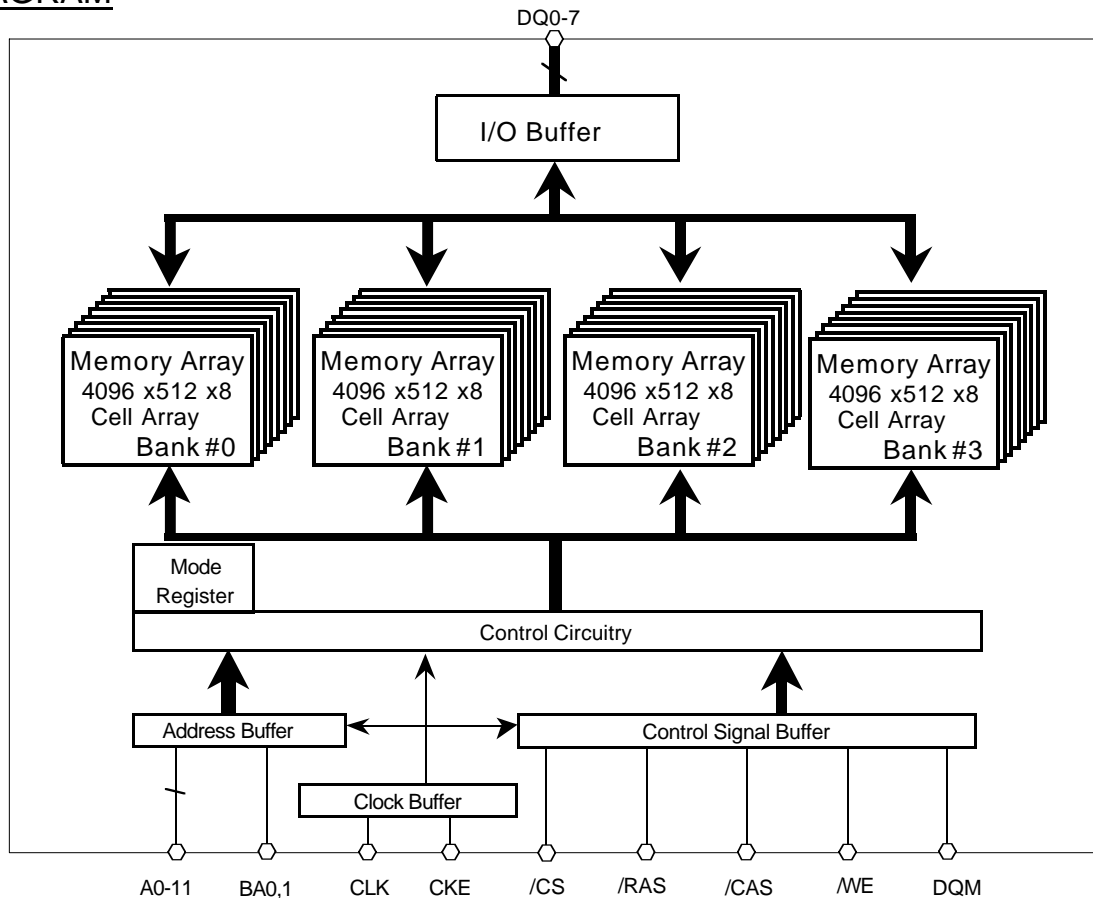
PIN CONFIGURATION (TOP VIEW)



- | | | | |
|---------------|--------------------------------|--------------|-------------------------------------|
| CLK | : Master Clock | DQM | : Output Disable/ Write Mask |
| CKE | : Clock Enable | A0-11 | : Address Input |
| /CS | : Chip Select | BA0,1 | : Bank Address |
| /RAS | : Row Address Strobe | Vdd | : Power Supply |
| /CAS | : Column Address Strobe | VddQ | : Power Supply for Output |
| /WE | : Write Enable | Vss | : Ground |
| DQ0-15 | : Data I/O | VssQ | : Ground for Output |

64M Synchronous DRAM

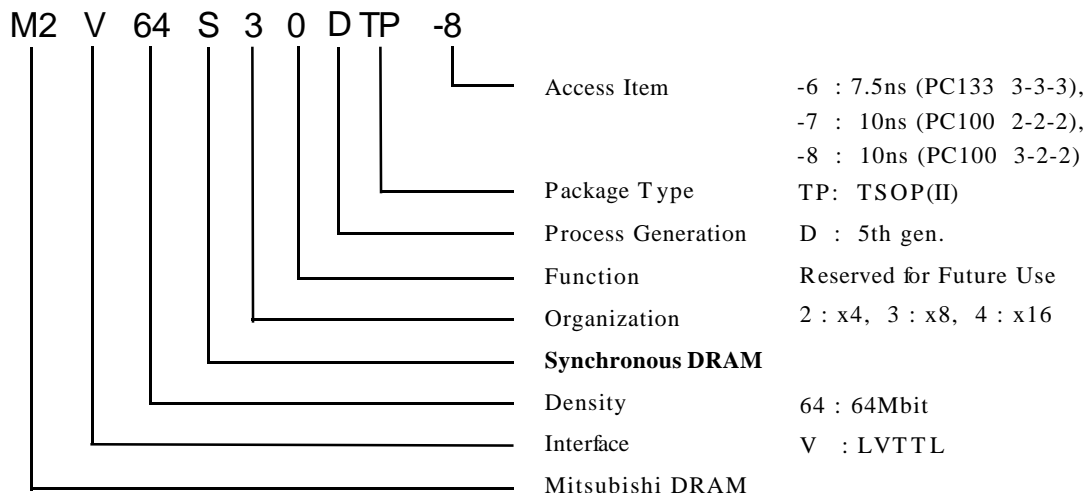
BLOCK DIAGRAM



Note : This figure shows the M2V64S30DTP.
 The M2V64S20DTP configuration is 4096x1024x4 of cell array and DQ 0-3.
 The M2V64S40DTP configuration is 4096x256x16 of cell array and DQ 0-15.

Type Designation Code

These rules are only applied to the Synchronous DRAM family.

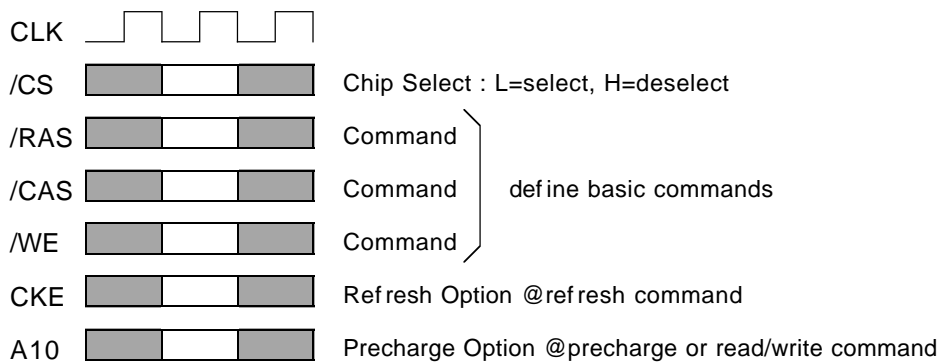


PIN FUNCTION

| | | |
|---|----------------|--|
| 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 / selfrefresh. 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 A0-9 (x4) / A0-8 (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), DQM(U, L)(x16) | Input | Din Mask and Output Disable: When DQM(U, L) is high in burst write, Din for the current cycle is masked. When DQM(U, 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 and 40DTP provides basic functions, bank (row) activate, burst read and write, bank (row) precharge, and auto and 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, all banks are deactivated (precharge all, **PREA**).

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

REFA command starts auto-refresh cycle. Refresh address are generated internally. 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 | V | L | V |
| Column Address Entry & Write with Auto-Precharge | WRITEA | H | X | L | H | L | L | V | V | H | V |
| Column Address Entry & Read | READ | H | X | L | H | L | H | V | V | L | V |
| Column Address Entry & Read with Auto-Precharge | READA | H | X | L | H | L | H | V | V | 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 | X | 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 | X | 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 |

FUNCTION TRUTH TABLE (continued)

| Current State | /CS | /RAS | /CAS | /WE | Address | Command | Action |
|---------------|-----|------|------|-----|-------------------|----------------|---|
| 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 | X | 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 |
| 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 | X | 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 |

FUNCTION TRUTH TABLE (continued)

| Current State | /CS | /RAS | /CAS | /WE | Address | Command | Action |
|---------------------------------|-----|------|------|-----|----------------------|-------------------|-----------------------------|
| 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 | X | 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 | X | 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 | X | 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 | X | 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 |
|---------------------|-----|------|------|-----|----------------------|-----------------|----------------------|
| WRITE RECOVERING | H | X | X | X | X | DESEL | NOP |
| | L | H | H | H | X | NOP | NOP |
| | L | H | H | L | X | 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 |
| REFRESHING | H | X | X | X | X | DESEL | NOP (Idle after tRC) |
| | L | H | H | H | X | NOP | NOP (Idle after tRC) |
| | L | H | H | L | X | 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 |

FUNCTION TRUTH TABLE (continued)

| Current State | /CS | /RAS | /CAS | /WE | Address | Command | Action |
|-----------------------|-----|------|------|-----|-------------------|--------------|-----------------------|
| 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 | X | 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 Power Down) |
| 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 |

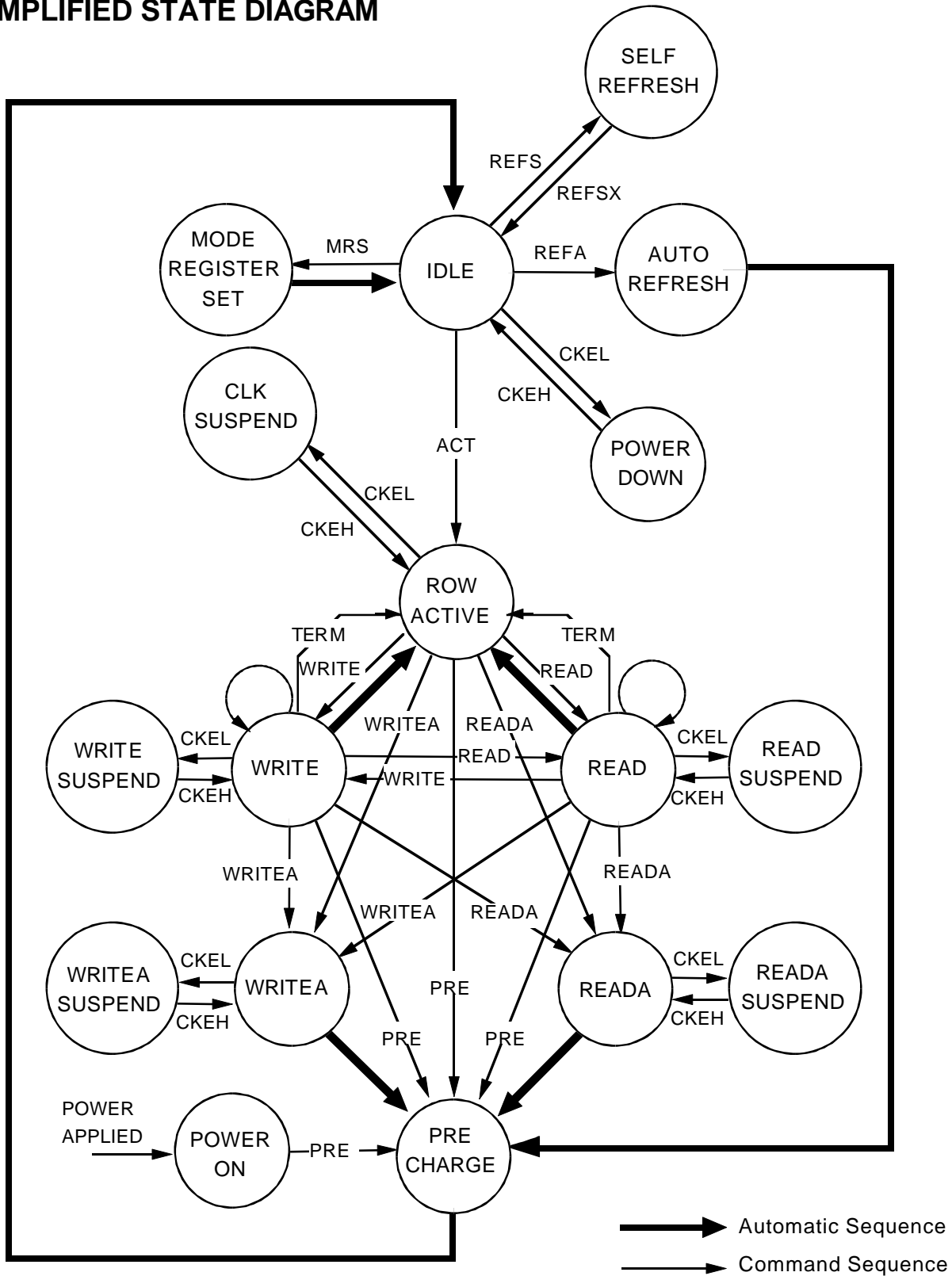
ABBREVIATIONS:

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

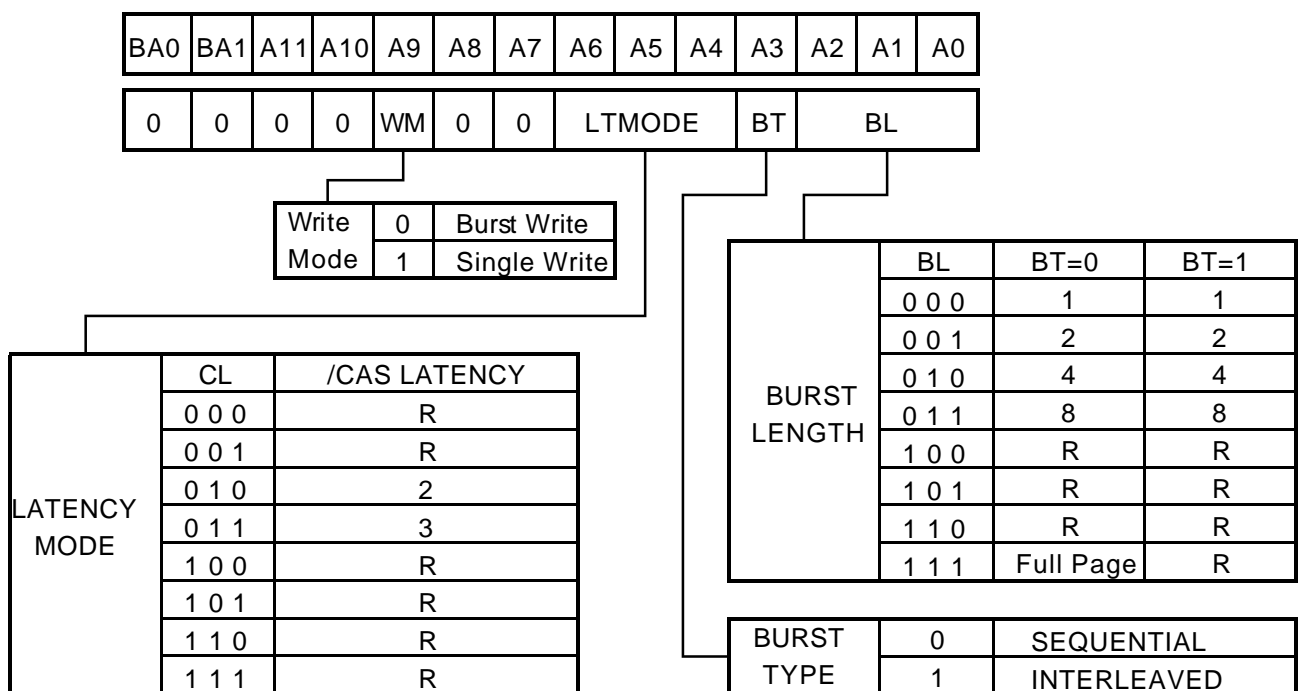
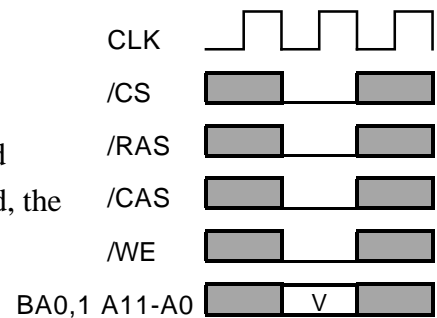
Before starting normal operation, the following power on sequence is necessary to prevent a SDRAM from damaged or malfunctioning.

1. Apply power and start clock. Attempt to maintain CKE high, DQM high and NOP condition at the inputs.
2. Maintain stable power, stable clock, and NOP input conditions for a minimum of 200µs.
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.

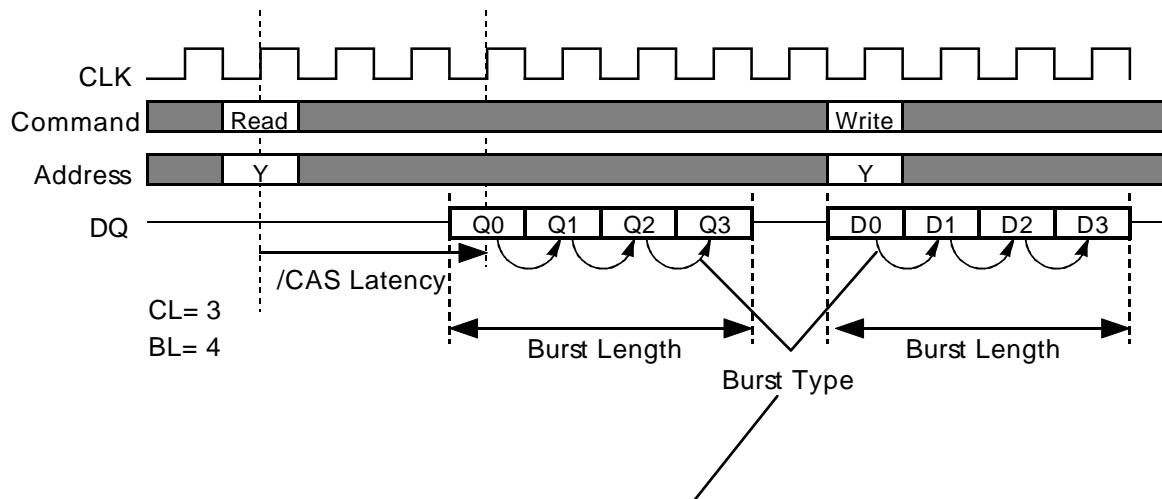
MODE REGISTER

Burst Length, Burst Type, /CAS Latency and Write Mode 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

64M Synchronous DRAM



| 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

One of four banks is activated by an ACT command.

An bank is selected by BA0-1. A row is selected by A0-11.

Multiple banks can be active state concurrently by issuing multiple ACT commands.

Minimum activation interval between one bank and another bank is tRRD.

PRECHARGE

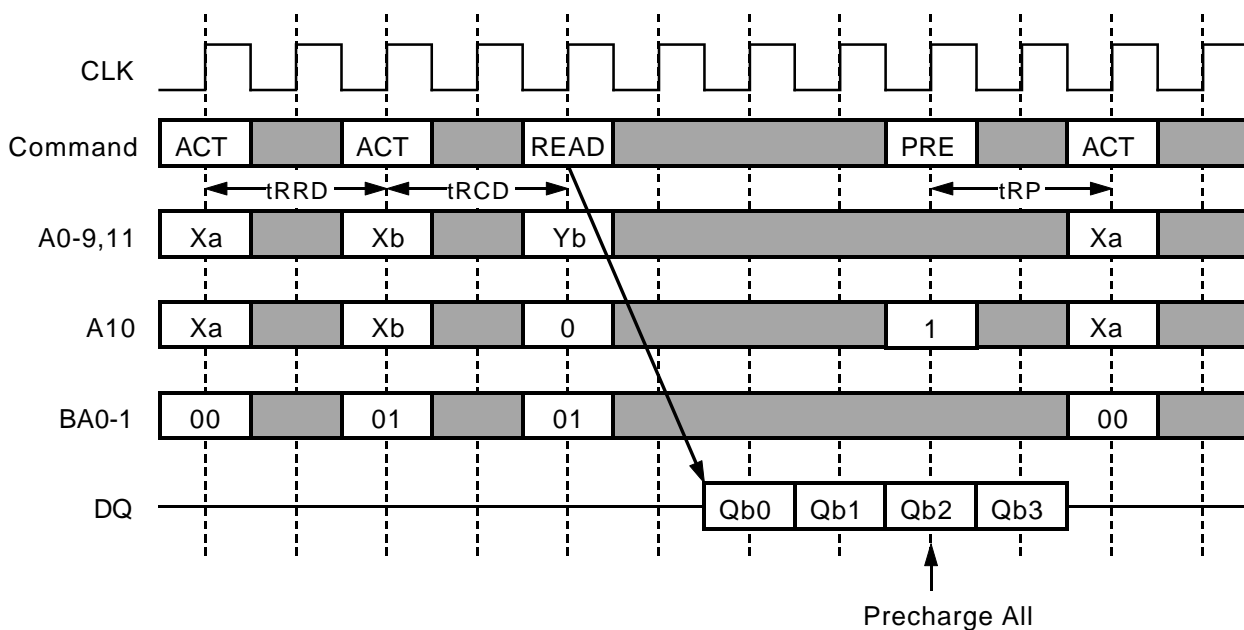
An open bank is deactivated by a PRE command.

A bank to be deactivated is designated by BA0-1.

When multiple banks are active, a precharge all command (PREA, PRE + A10=H) deactivates all of open banks at the same time. BA0-1 are "Don't Care" in this case.

Minimum delay of an ACT command after a PRE command to the same bank is tRP.

Bank Activation and Precharge All (BL=4, CL=2)



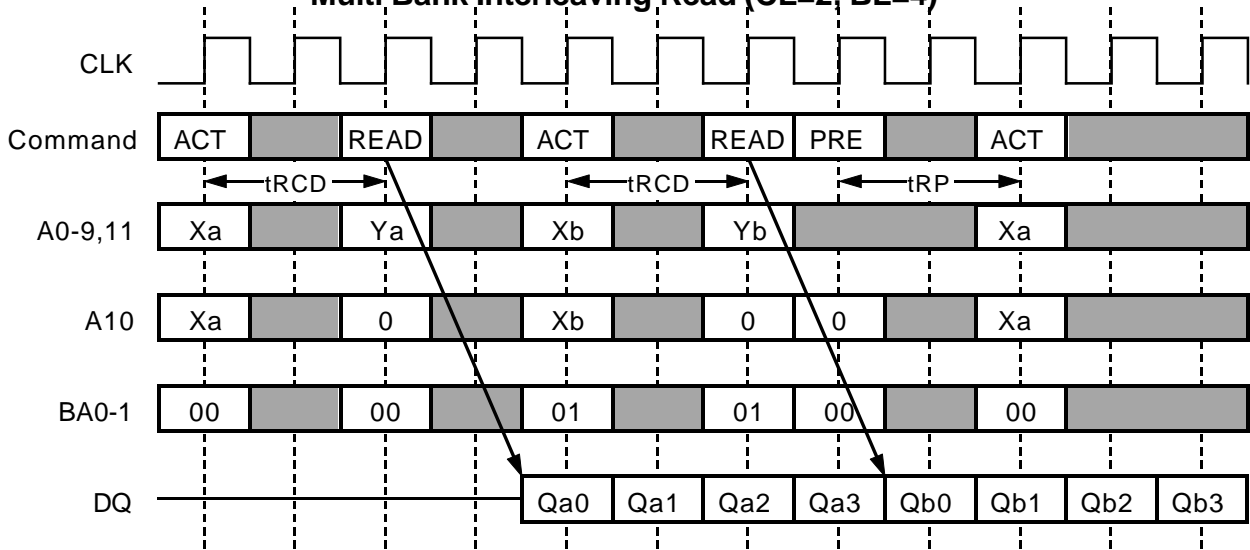
READ

A READ command can be issued to any active bank. The start address is specified by A0-9(x4), A0-8 (x8), A0-7 (x16). 1st output data is available after the /CAS Latency from the READ. The consecutive data length is defined by the Burst Length. The address sequence of the burst data is defined by the Burst Type. Minimum delay of a READ command after an ACT command to the same bank is tRCD.

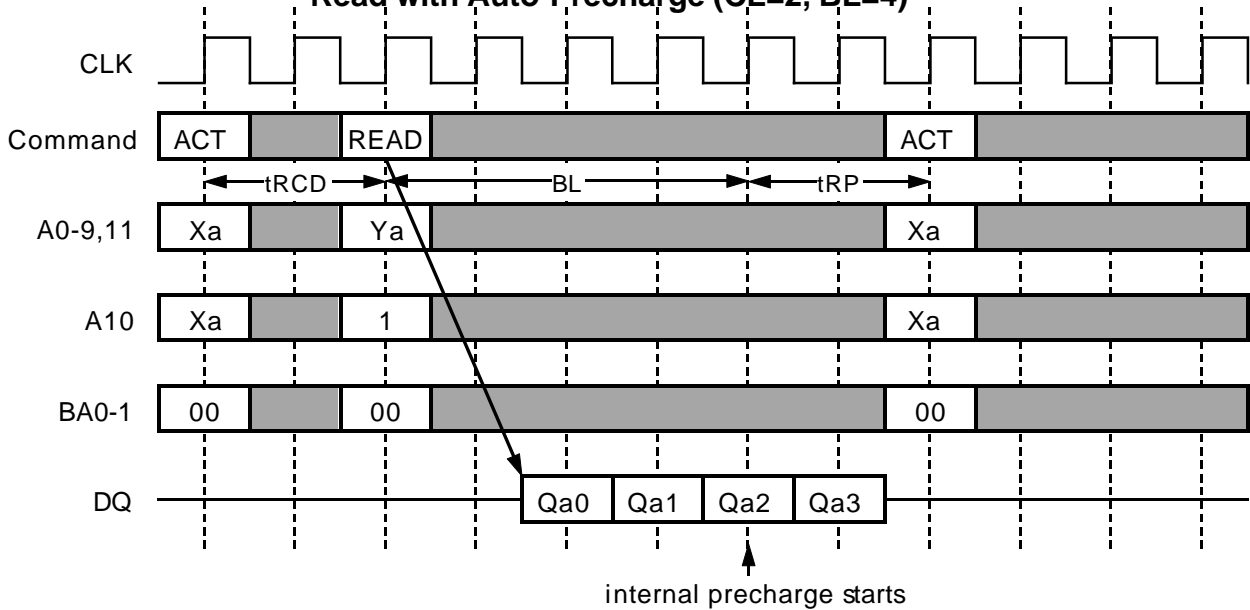
When A10 is high at a READ command, auto-precharge (READA) is performed. Any command (READ, WRITE, PRE, ACT, TBST) to the same bank is inhibited till the internal precharge is complete. The internal precharge starts at the BL after READA. The next ACT command can be issued after (BL + tRP) from the previous READA. In any case, $tRCD + BL \geq tRAS_{min}$ must be met.

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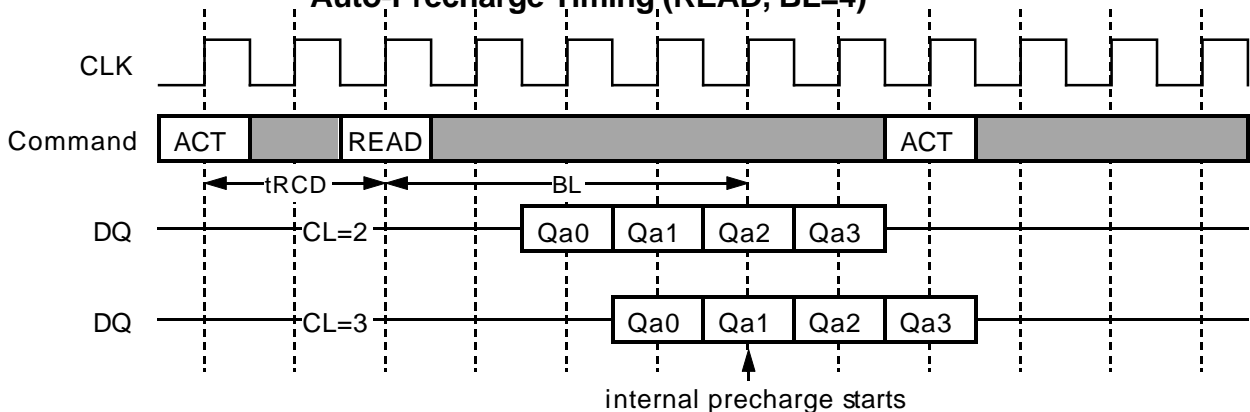
Multi Bank Interleaving Read (CL=2, BL=4)



Read with Auto-Precharge (CL=2, BL=4)



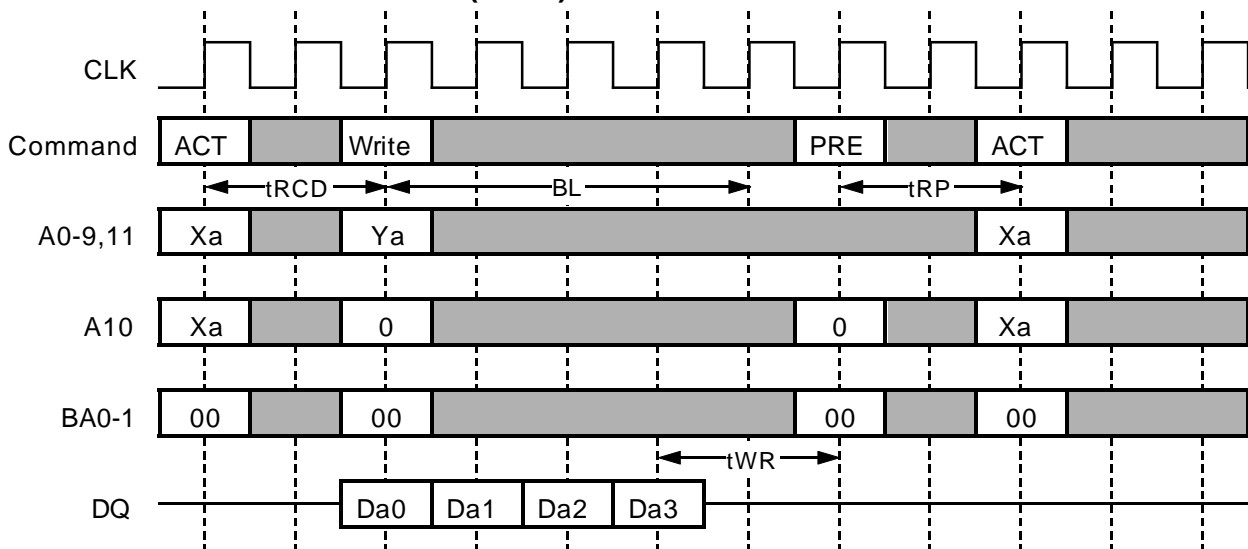
Auto-Precharge Timing (READ, BL=4)



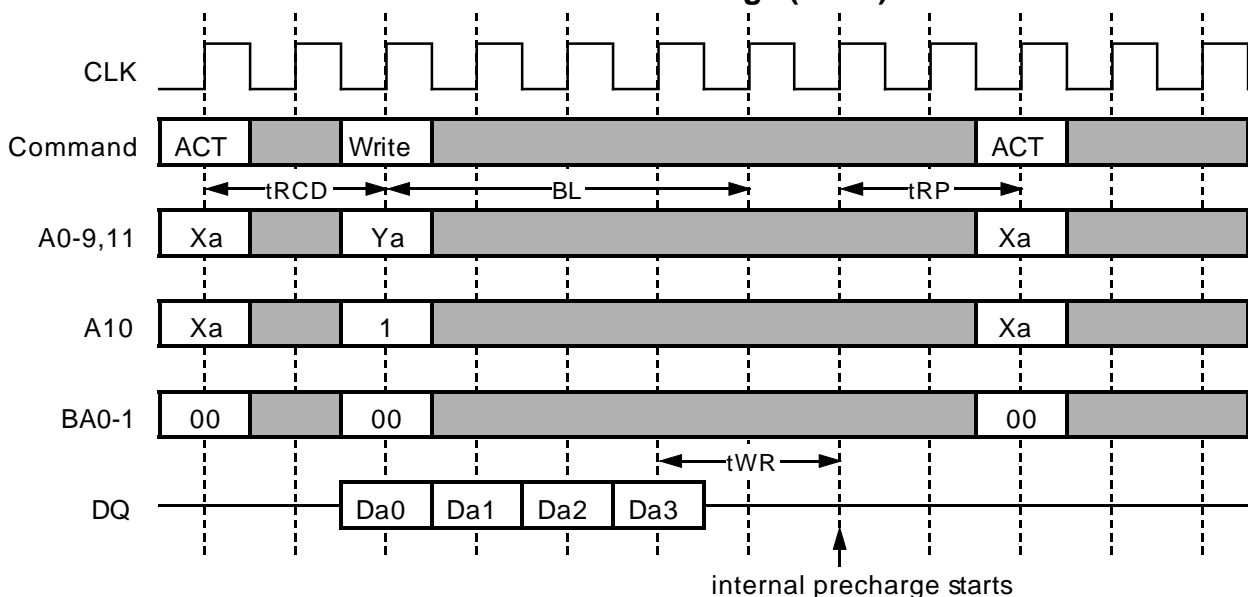
WRITE

A WRITE command can be issued to any active bank. The start address is specified by A0-9(x4), A0-8 (x8), A0-7 (x16). 1st input data is set at the same cycle as the WRITE. The consecutive data length to be written is defined by the Burst Length. The address sequence of burst data is defined by the Burst Type. Minimum delay of a WRITE command after an ACT command to the same bank is tRCD. From the last input data to the PRE command, the write recovery time (tWR) is required. When A10 is high at a WRITE command, auto-precharge (WRITEA) is performed. Any command (READ, WRITE, PRE, ACT, TBST) to the same bank is inhibited till the internal precharge is complete. The internal precharge starts at tWR after the last input data cycle. The next ACT command can be issued after (BL + tWR - 1 + tRP) from the previous WRITEA. In any case, $tRCD + BL + tWR - 1 \geq tRASmin$ must be met.

Write (BL=4)



Write with Auto-Precharge (BL=4)

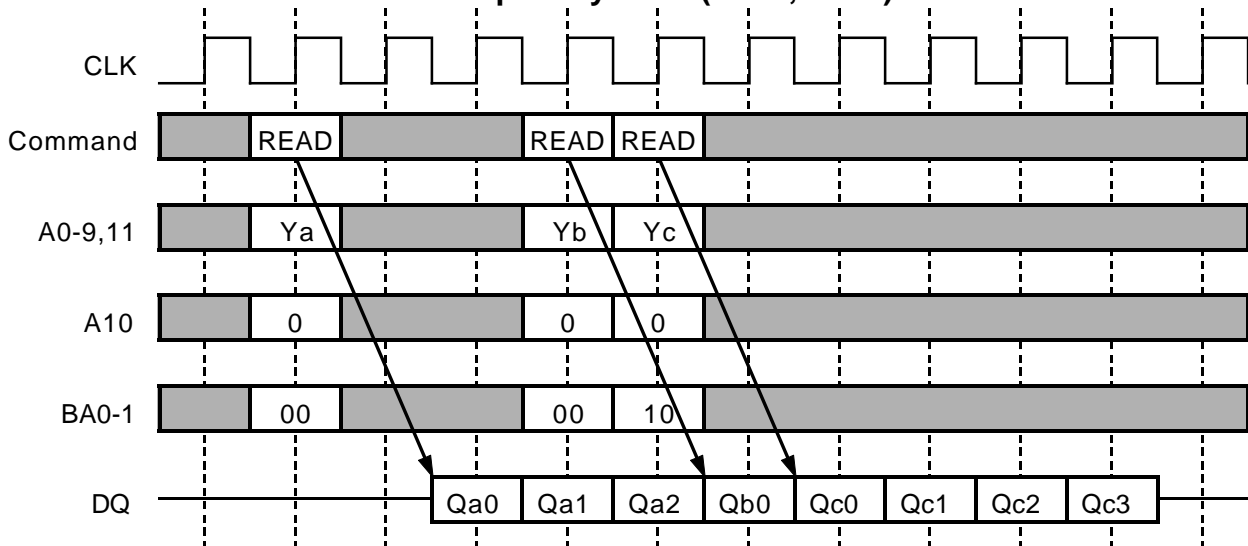


BURST INTERRUPTION

[Read Interrupted by Read]

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

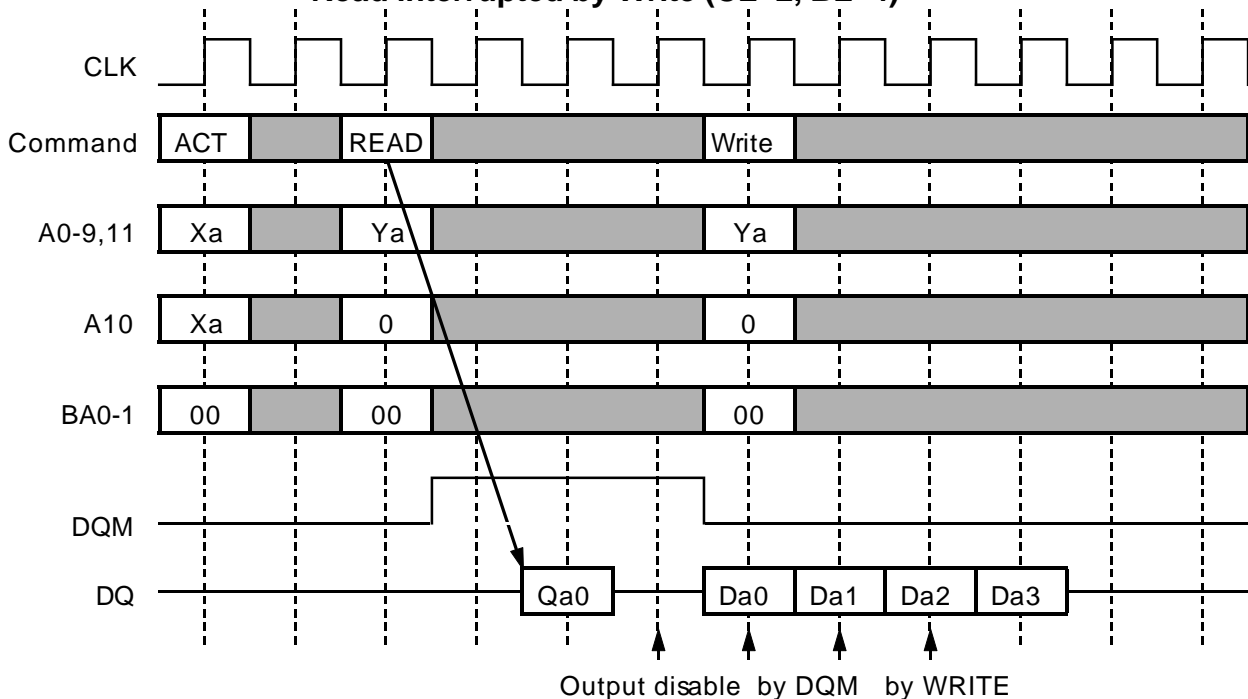
Read interrupted by Read (CL=2, BL=4)



[Read Interrupted by Write]

Burst read operation can be interrupted by write of any active 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 Write (CL=2, BL=4)

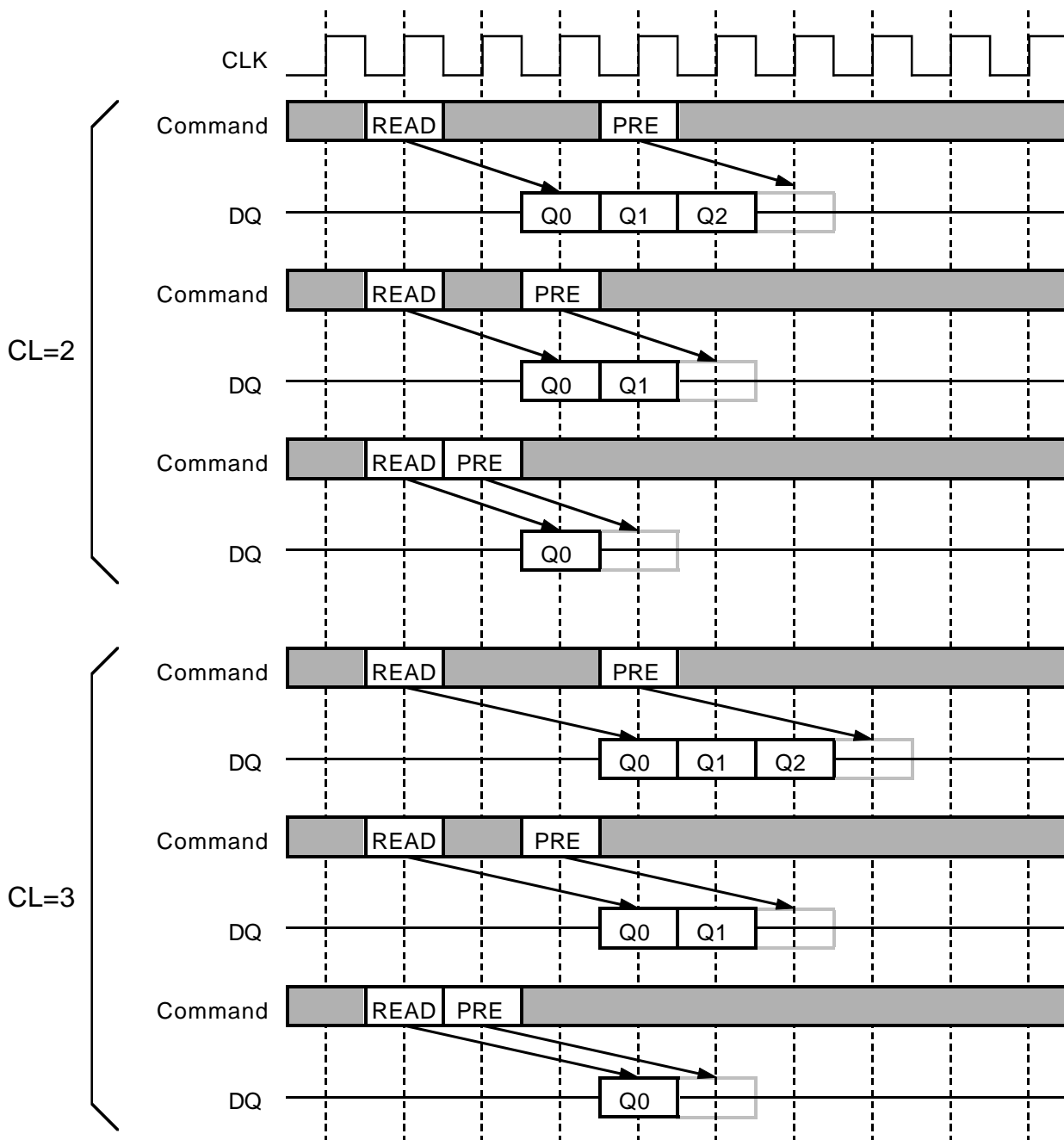


[Read Interrupted by Precharge]

A burst read operation can be interrupted by a precharge of *the same bank*. READ to PRE interval is minimum 1 CLK.

A PRE command to output disable latency is equivalent to the /CAS Latency.

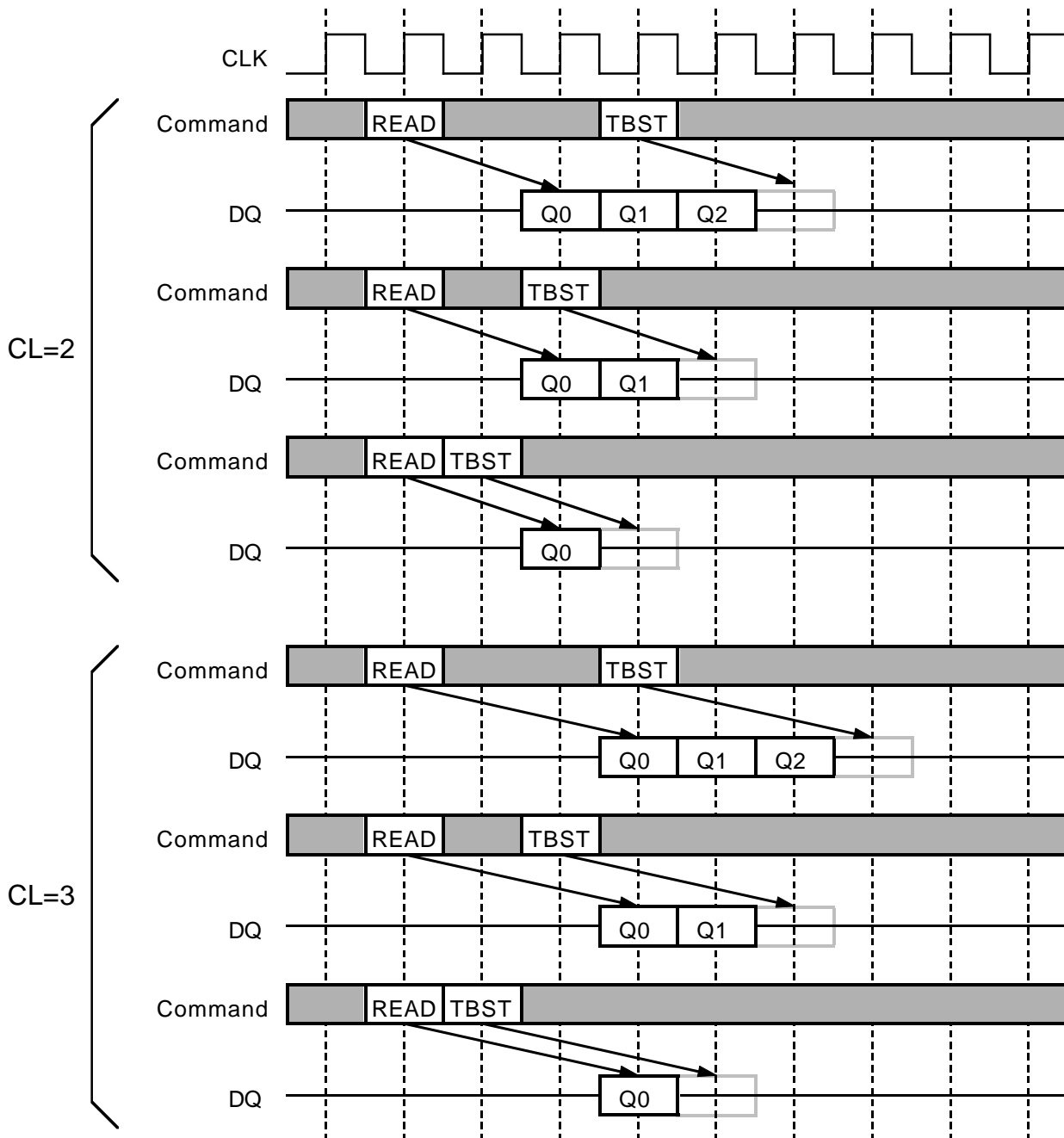
Read interrupted by Precharge (BL=4)



[Read Interrupted by Burst Terminate]

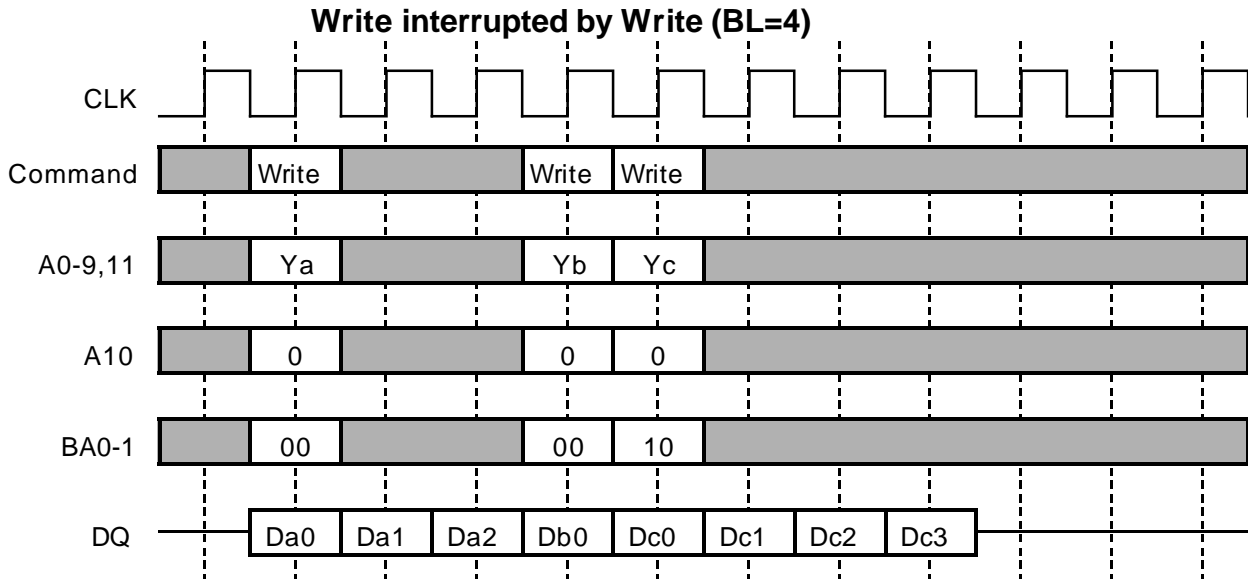
Similarly to the precharge, a burst terminate command can interrupt the burst read operation and disable the data output. The terminated bank remains active. READ to TBST interval is minimum 1 CLK. A TBST command to output disable latency is equivalent to the /CAS Latency.

Read interrupted by Terminate (BL=4)



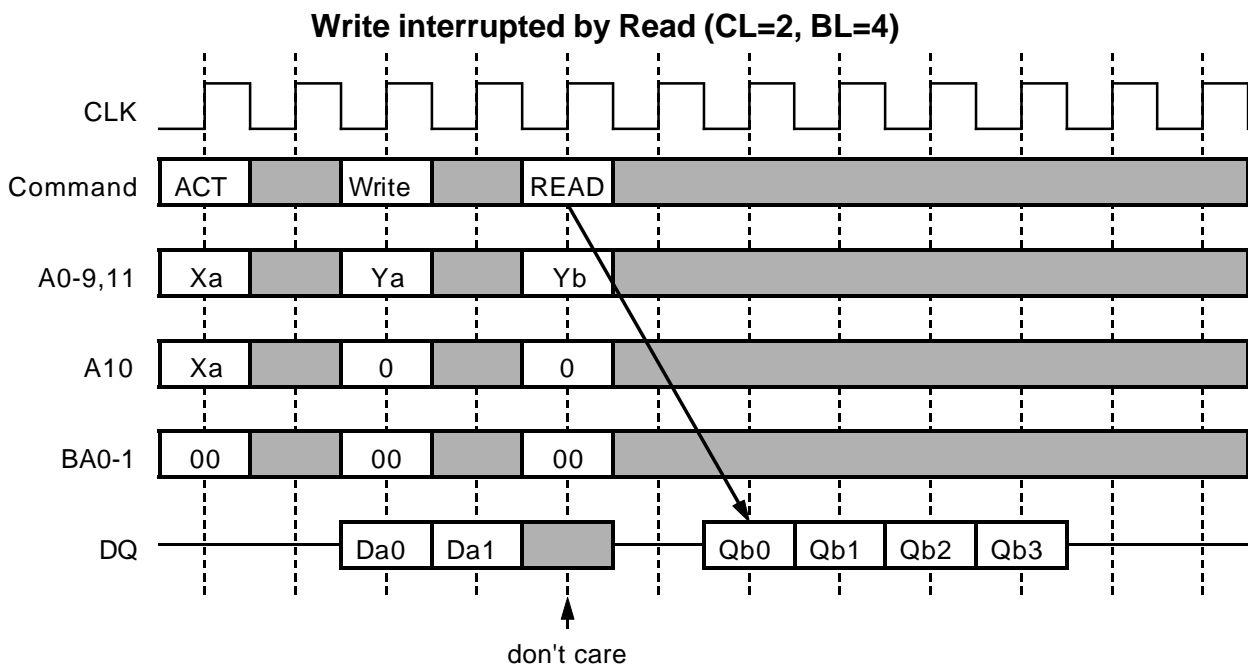
[Write Interrupted by Write]

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



[Write Interrupted by Read]

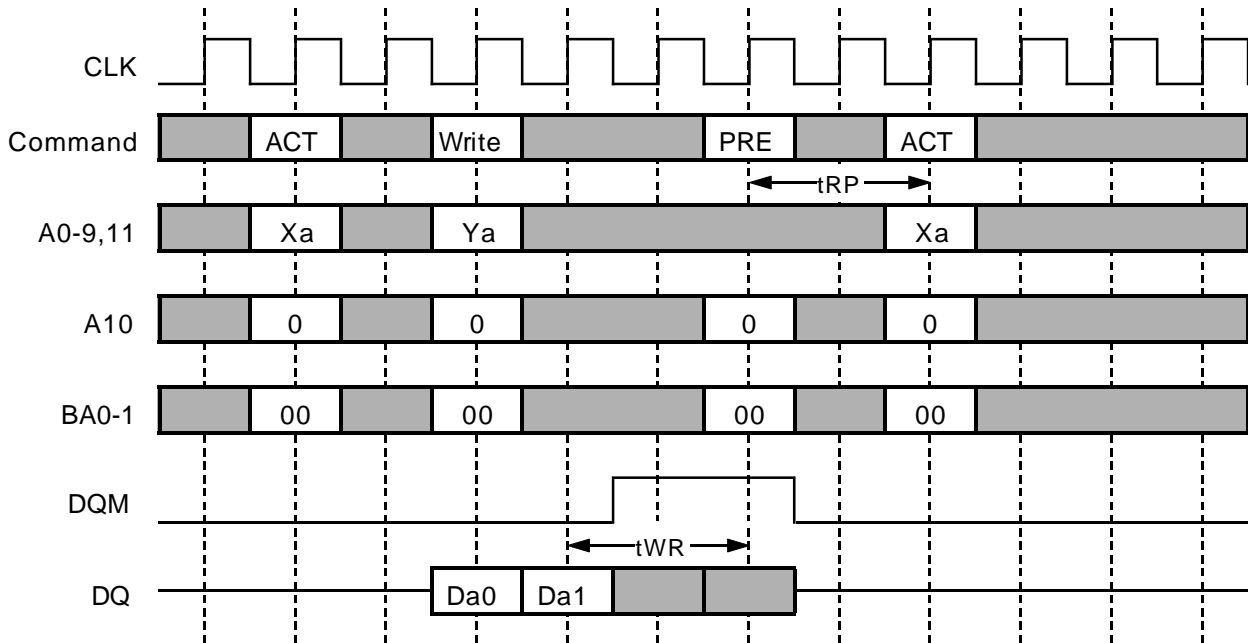
Burst write operation can be interrupted by read of any active bank. Random column access is allowed. WRITE to READ interval is minimum 1 CLK. The input data on DQ at the interrupting READ cycle is "Don't Care".



[Write Interrupted by Precharge]

Burst write operation can be interrupted by precharge of *the same bank*. Write recovery time (t_{WR}) is required from the last data to PRE command. During write recovery, data inputs must be masked by DQM.

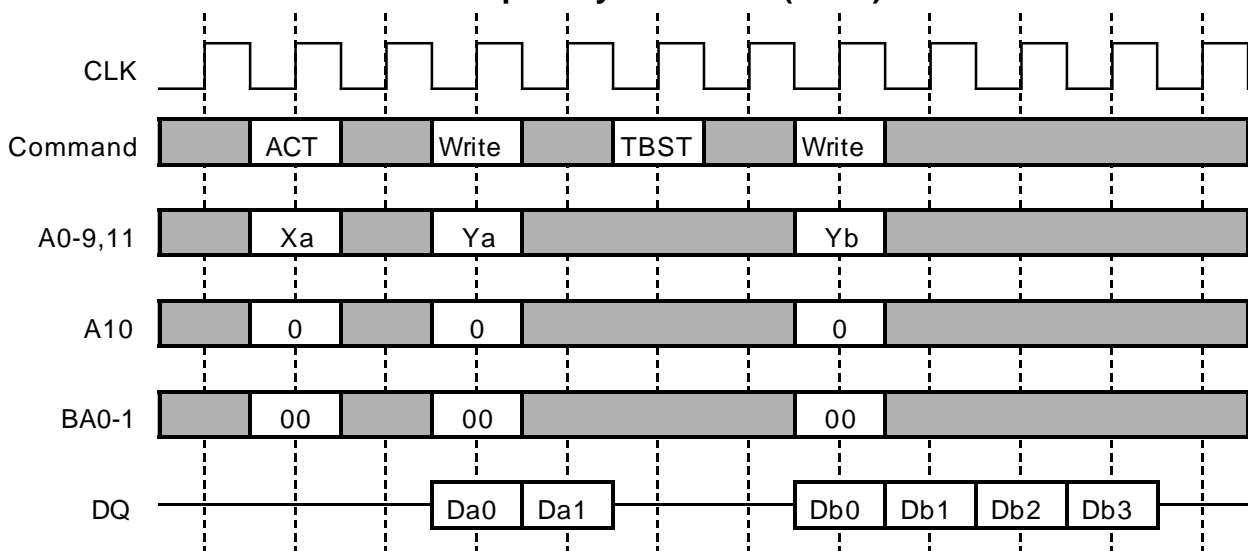
Write interrupted by Precharge (BL=4)



[Write Interrupted by Burst Terminate]

Burst terminate command can terminate burst write operation. In this case, the write recovery time is not required and the bank remains active. WRITE to TBST interval is minimum 1 CLK.

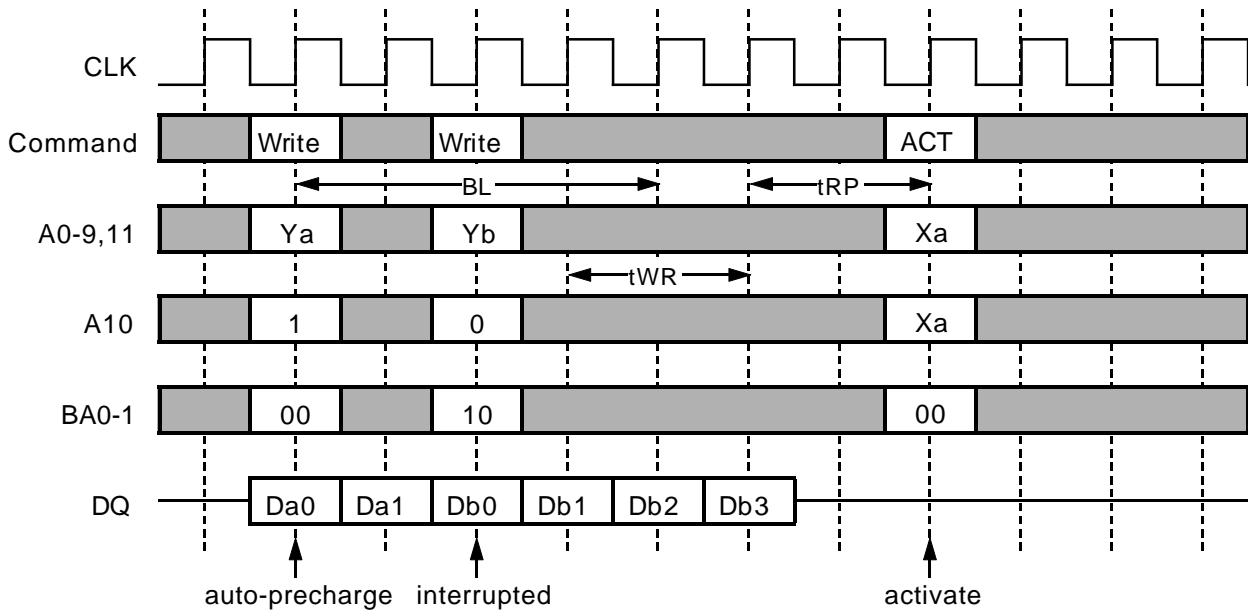
Write interrupted by Terminate (BL=4)



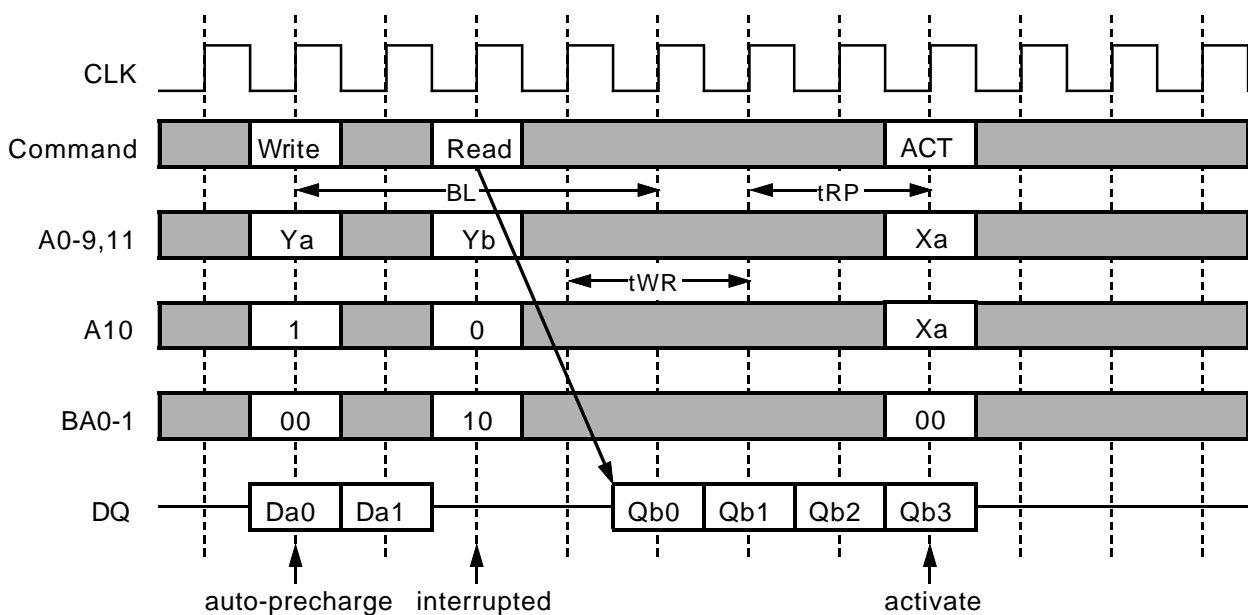
[Write with Auto-Precharge Interrupted by Write or Read to another Bank]

Burst write with auto-precharge can be interrupted by write or read to *another bank*. Next ACT command can be issued after (BL+tWR-1+tRP) from the WRITEEA. Auto-precharge interruption by a command to the same bank is inhibited.

WRITEEA interrupted by WRITE to another bank (BL=4)

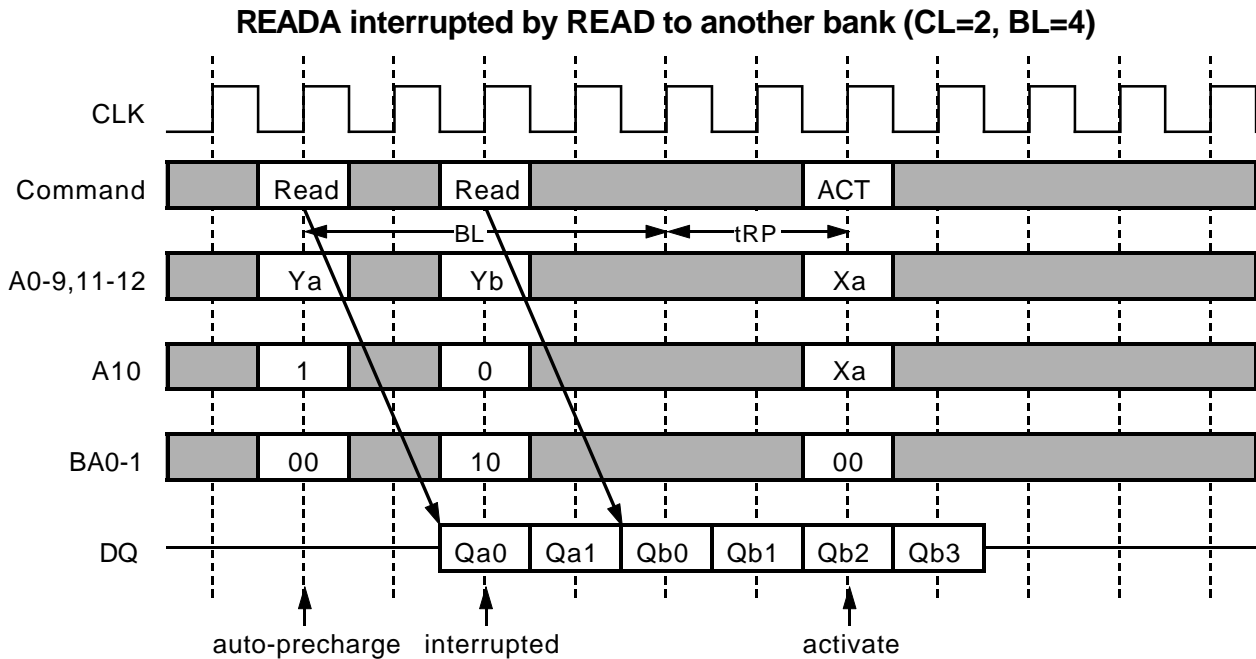


WRITEEA interrupted by READ to another bank (CL=2, BL=4)



[Read with Auto-Precharge Interrupted by Read to another Bank]

Burst read with auto-precharge can be interrupted by read to *another bank*. Next ACT comand can be issued after (BL+tRP) from the READA. Auto-precharge interruption by a command to the same bank is inhibited.



Full Page Burst

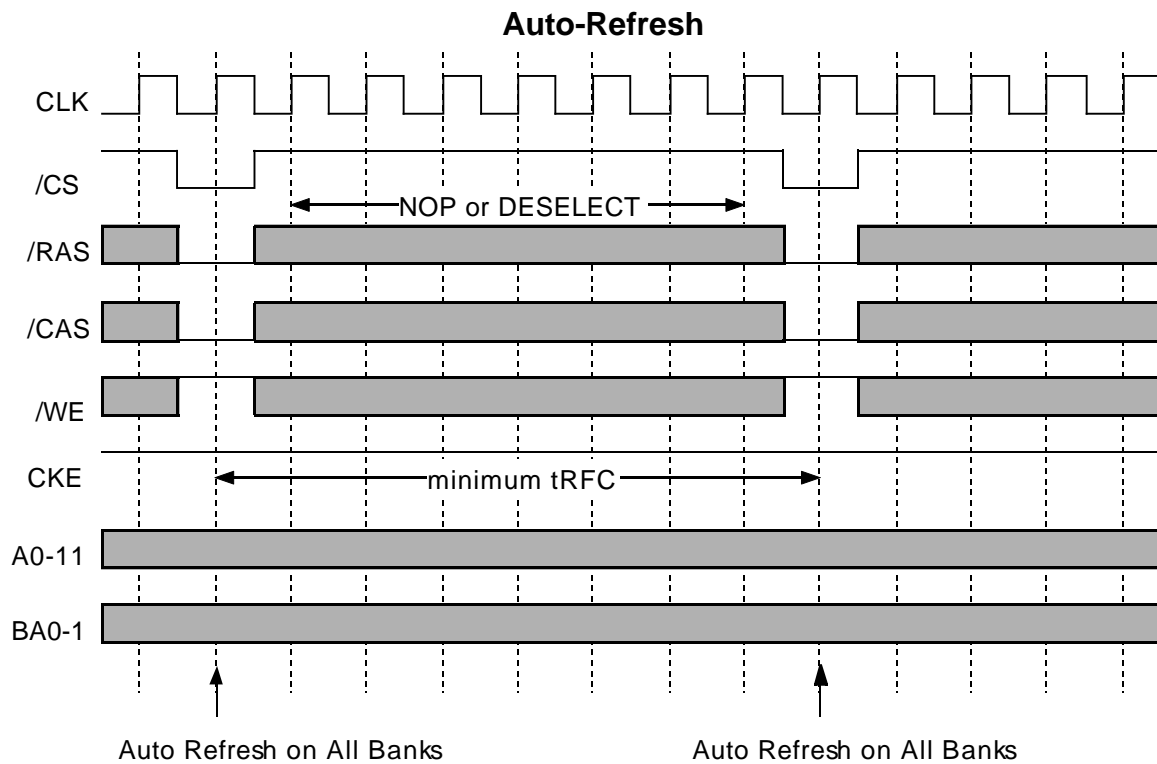
Full page burst length is available for only the sequential burst type. Full page burst read or write is repeated until a Precharge or a Burst Terminate command is issued. In case of the full page burst, a read or write with auto-precharge command is illegal.

Single Write

When single write mode is set, burst length for write is always one, independently of Burst Length defined by (A2-0).

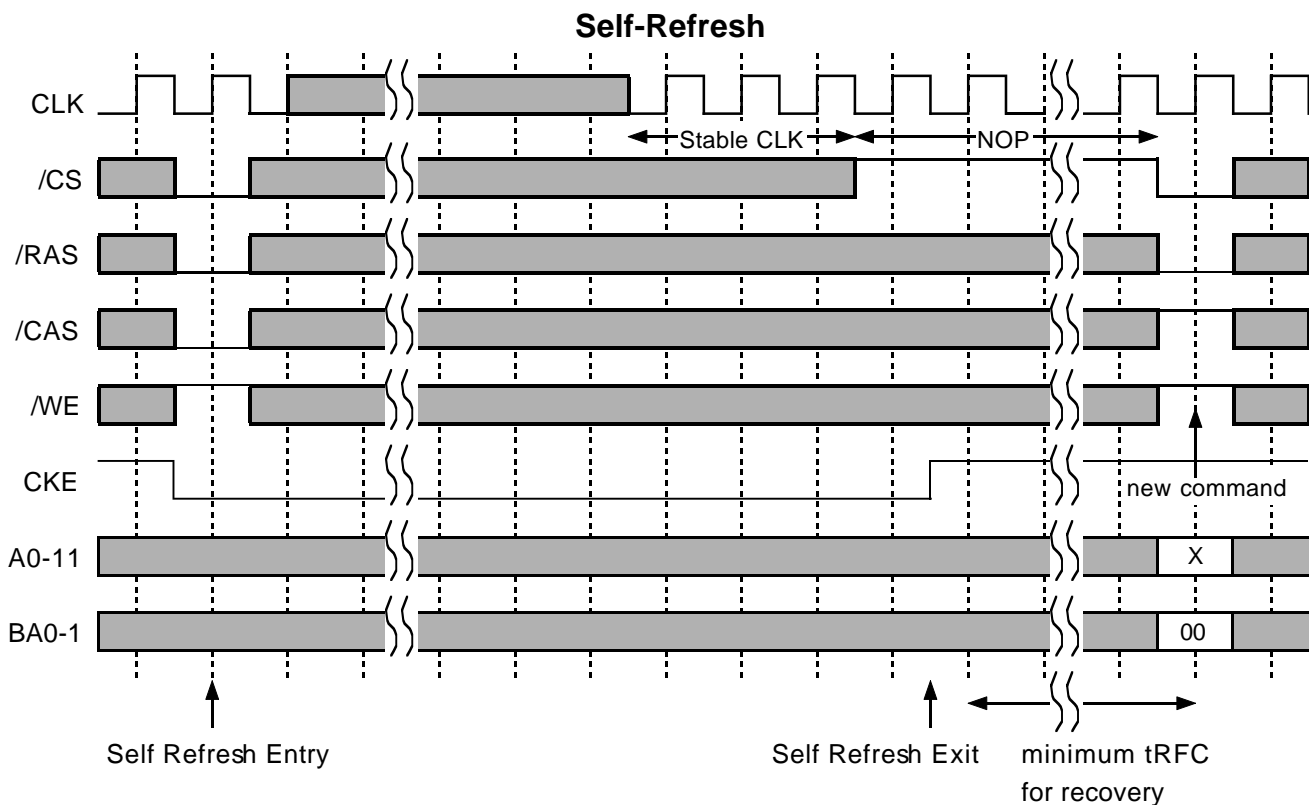
AUTO REFRESH

Single cycle of auto-refresh is initiated with a REFA ($\overline{\text{CS}} = \overline{\text{RAS}} = \overline{\text{CAS}} = \text{L}$, $\overline{\text{WE}} = \overline{\text{CKE}} = \text{H}$) 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 idle state. Auto-refresh to auto-refresh interval is minimum tRFC. Any command must not be issued before tRFC from the REFA command.



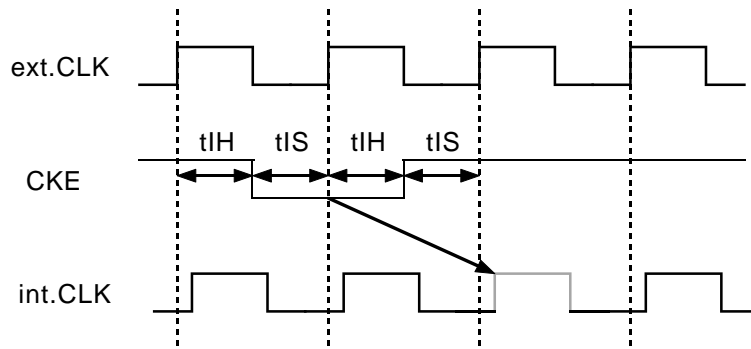
SELF REFRESH

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 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=H. After tRFC from the 1st CLK edge following CKE=H, all banks are in idle state and a new command can be issued, but DESEL or NOP commands must be asserted till then.

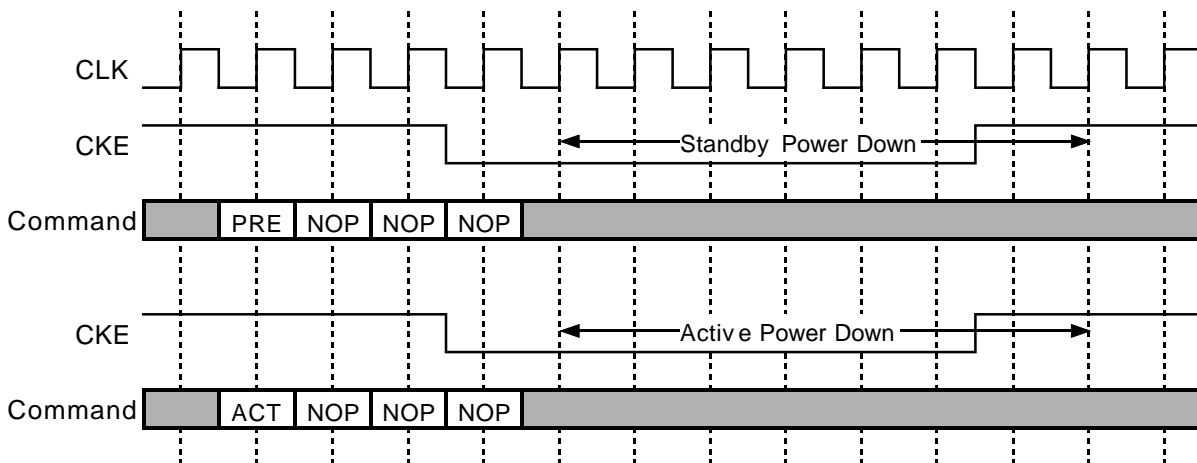


CLK SUSPEND and POWER DOWN

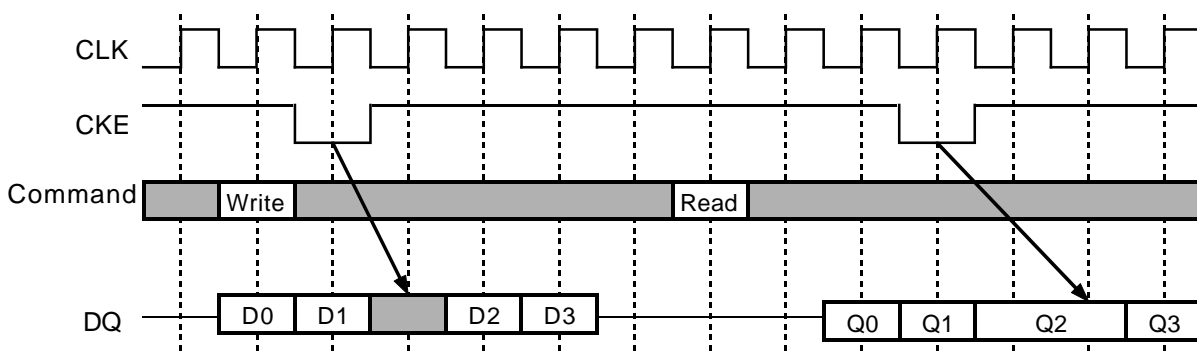
CKE controls the internal CLK at the following cycle. Figure below shows how CKE works. By negating CKE, the next internal CLK is suspended. The purpose of CLK suspend is power down, output suspend or input suspend. CKE is a synchronous input except during the self-refresh mode. CLK suspend can be performed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



Power Down by CKE

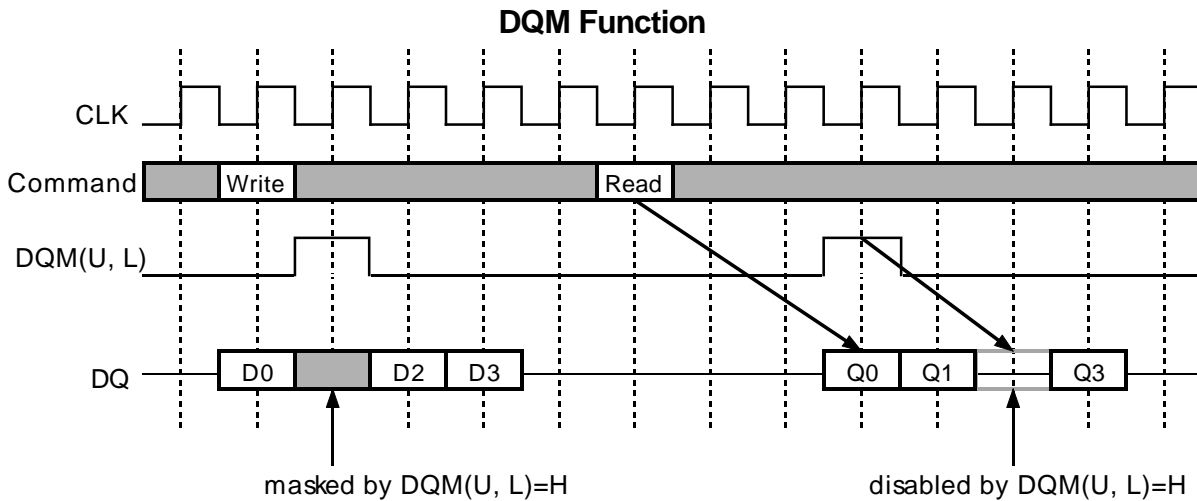


DQ Suspend by CKE



DQM CONTROL

DQM(U, L) is a dual functional signal defined as the data mask for writes and the output disable for reads. During writes, DQM(U, L) masks input data word by word. DQM(U, L) to Data In latency is 0. During reads, DQM(U, L) forces output to Hi-Z word by word. DQM(U, L) to output Hi-Z latency is 2.



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 ~ Vdd+0.5 | V |
| VO | Output Voltage | with respect to VssQ | -0.5 ~ VddQ+0.5 | 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 | | Vdd+0.3 | V |
| VIL *2 | Low-Level Input Voltage all inputs | -0.3 | | 0.8 | V |

NOTES)

1. VIH(max)=5.5V AC for pulse width less than 10ns.
2. VIL(min)=-1.0V AC for pulse width less than 10ns.

CAPACITANCE

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

| Symbol | Parameter | Test Condition | Limits | | Unit |
|--------|--------------------------------|----------------------------------|--------|------|------|
| | | | Min. | Max. | |
| CI(A) | Input Capacitance, address pin | VI=1.4v f=1MHz VI=200mVrms | 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 |

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AVERAGE SUPPLY CURRENT from Vdd

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

| ITEM | | Symbol | Organi- zation | Limits (max.) | | | Unit |
|--|---|--------|-------------------|---------------|-----|-----|------|
| | | | | -6 | -7 | -8 | |
| operating current tRC=min, tCLK=min, BL=1, CL=3 | single bank operation | lcc1 | x4 | 75 | 70 | 70 | mA |
| | | | x8 | 75 | 70 | 70 | |
| | | | x16 | 85 | 80 | 80 | |
| precharge standby current in Non Power down mode /CS > Vcc - 0.2V | tCLK = 15ns CKE = H VIH > Vcc - 0.2V VIL < 0.2V | lcc2N | x4/x8/x16 | 20 | 20 | 20 | mA |
| | CLK = L & CKE = H VIH > Vcc - 0.2V VIL < 0.2V all input signals are fixed. | lcc2NS | x4/x8/x16 | 15 | 15 | 15 | |
| precharge standby current in Power down mode /CS > Vcc - 0.2V | tCLK = 15ns CKE = L | lcc2P | x4/x8/x16 | 2 | 2 | 2 | mA |
| | CLK = L CKE = L | lcc2PS | x4/x8/x16 | 1 | 1 | 1 | |
| active standby current | CKE = H, tCLK=15ns | lcc3N | x4/x8/x16 | 30 | 30 | 30 | mA |
| | CKE = H, CLK=L | lcc3NS | x4/x8/x16 | 25 | 25 | 25 | |
| burst current All Bank Active tCLK = min BL=4, CL=3 | | lcc4 | x4 | 90 | 70 | 70 | mA |
| | | | x8 | 90 | 70 | 70 | |
| | | | x16 | 100 | 80 | 80 | |
| auto-refresh current | tRC=min, tCLK=min | lcc5 | x4/x8/x16 | 130 | 110 | 110 | mA |
| self-refresh current | CKE < 0.2V | lcc6 | x4 /x8 | 6,7,8 | 1 | 1 | |
| | | | x16 | 6L,7L,8L | 0.5 | 0.5 | 0.5 |

NOTE)

1. lcc(max) is specified at the output open condition.
2. Input signals 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 | -5 | 5 | µA |
| Ii | Input Current | VIH=0 ~ VddQ+0.3V | -5 | 5 | µA |

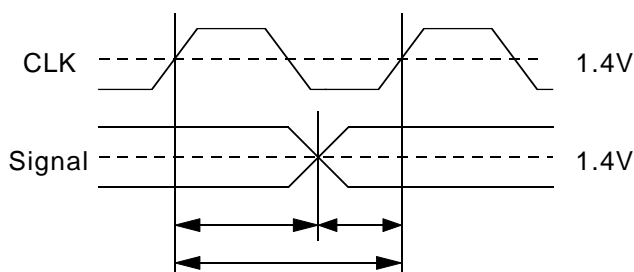
AC TIMING REQUIREMENTS

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

Input Pulse Levels: 0.8V to 2.0V

Input Timing Measurement Level: 1.4V

| Symbol | Parameter | Limits | | | | | | Unit | |
|--------|-------------------------------|--------|------|------|------|------|------|------|----|
| | | -6 | | -7 | | -8 | | | |
| | | Min. | Max. | Min. | Max. | Min. | Max. | | |
| tCLK | CLK cycle time | CL=2 | 10 | | 10 | | 13 | | ns |
| | | CL=3 | 7.5 | | 10 | | 10 | | ns |
| tCH | CLK High pulse width | 2.5 | | 3 | | 3 | | ns | |
| tCL | CLK Low pulse width | 2.5 | | 3 | | 3 | | ns | |
| tT | Transition time of CLK | 1 | 10 | 1 | 10 | 1 | 10 | ns | |
| tIS | Input Setup time (all inputs) | 1.5 | | 2 | | 2 | | ns | |
| tIH | Input Hold time (all inputs) | 0.8 | | 1 | | 1 | | ns | |
| tRC | Row Cycle time | 67.5 | | 70 | | 70 | | ns | |
| tRFC | Refresh Cycle time | 75 | | 80 | | 80 | | ns | |
| tRCD | Row to Column Delay | 20 | | 20 | | 20 | | ns | |
| tRAS | Row Active time | 45 | 100K | 50 | 100K | 50 | 100K | ns | |
| tRP | Row Precharge time | 20 | | 20 | | 20 | | ns | |
| tWR | Write Recovery time | 12 | | 12 | | 12 | | ns | |
| tRRD | Act to Act delay | 15 | | 20 | | 20 | | ns | |
| tRSC | Mode Register Set Cycle time | 10 | | 10 | | 10 | | ns | |
| tREF | Refresh Interval time | | 64 | | 64 | | 64 | ms | |



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

SWITCHING CHARACTERISTICS

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

SWITCHING CHARACTERISTICS

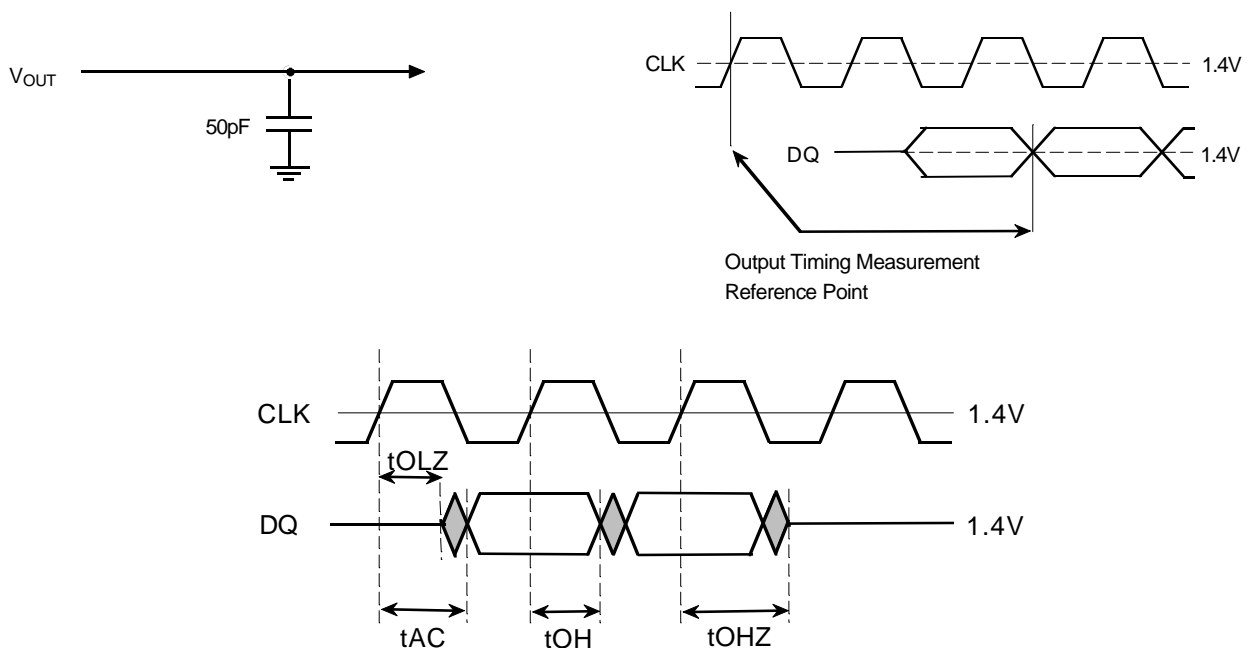
($T_a=0 \sim 70^\circ\text{C}$, $V_{dd} = V_{ddQ} = 3.3 \pm 0.3\text{V}$, $V_{ss} = V_{ssQ} = 0\text{V}$, unless otherwise noted)

| Symbol | Parameter | Limits | | | | | | Unit | Note | | |
|--------|---------------------------------------|--------|------|------|------|------|------|------|------|----|----|
| | | -6 | | -7 | | -8 | | | | | |
| | | Min. | Max. | Min. | Max. | Min. | Max. | | | | |
| tAC | Access time from CLK | CL=2 | | 6 | | 6 | | 7 | ns | *1 | |
| | | CL=3 | | 5.4 | | 6 | | 6 | ns | | |
| tOH | Output Hold time from CLK | CL=2 | 3 | | 3 | | 3 | | ns | | |
| | | CL=3 | 2.7 | | 3 | | 3 | | ns | | |
| tOLZ | Delay, output low-impedance from CLK | | 0 | | 0 | | 0 | | ns | | |
| tOHZ | Delay, output high-impedance from CLK | | 2.7 | 5.4 | | 3 | 6 | | 3 | 6 | ns |

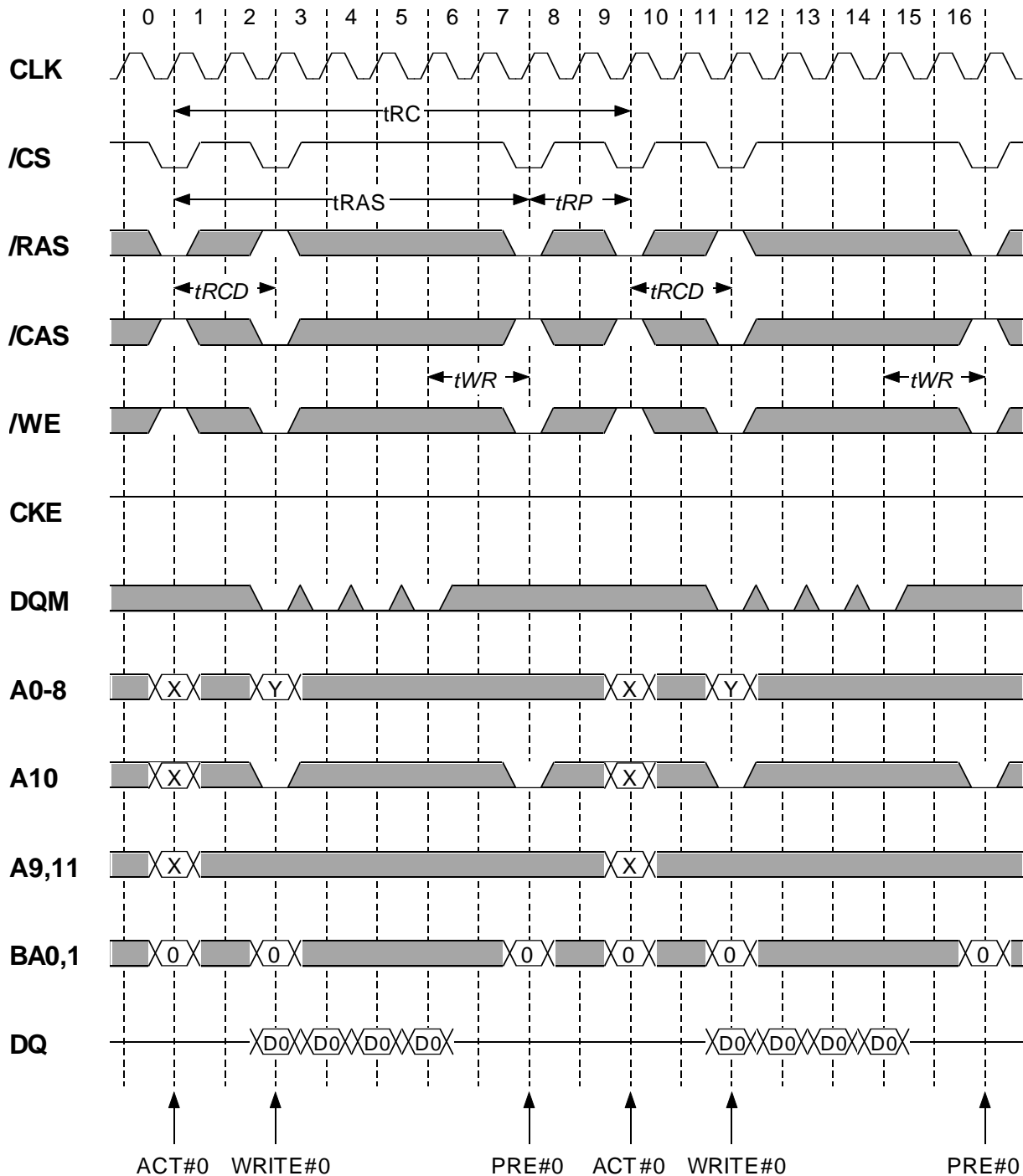
NOTE)

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

Output Load Condition

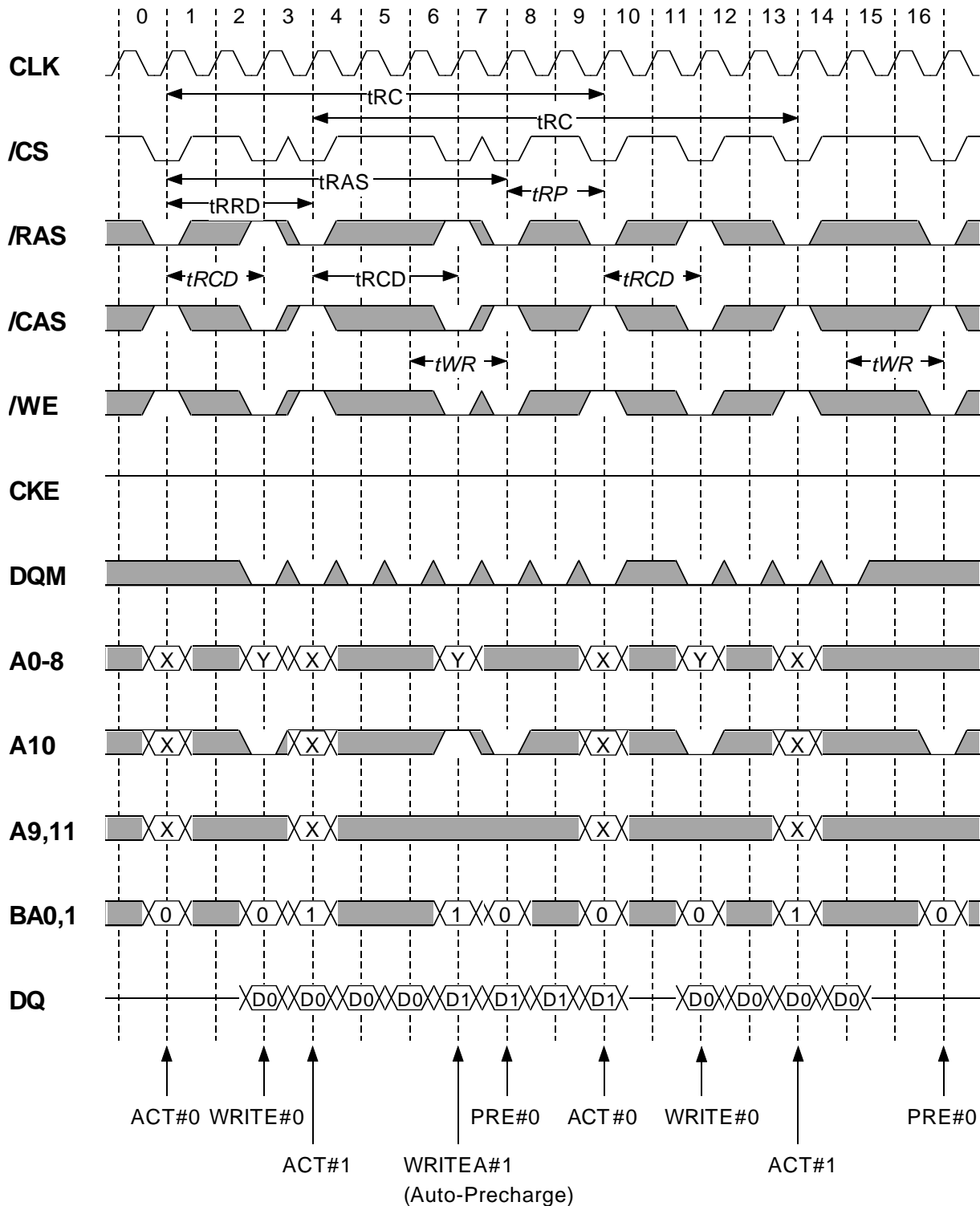


Burst Write (Single Bank) [BL=4]



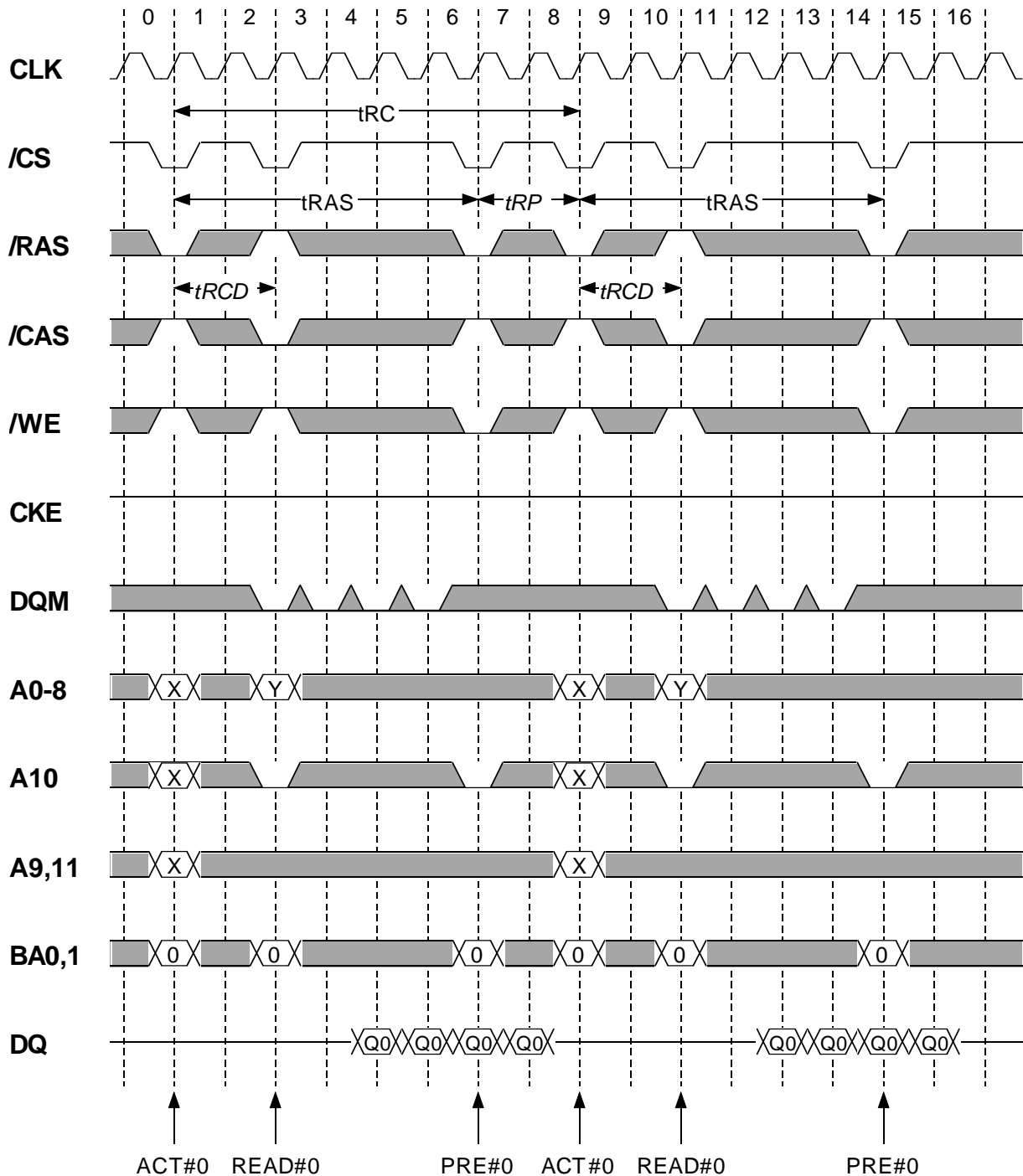
Italic parameter shows minimum case

Burst Write (Multi Bank) [BL=4]



Italic parameter shows minimum case

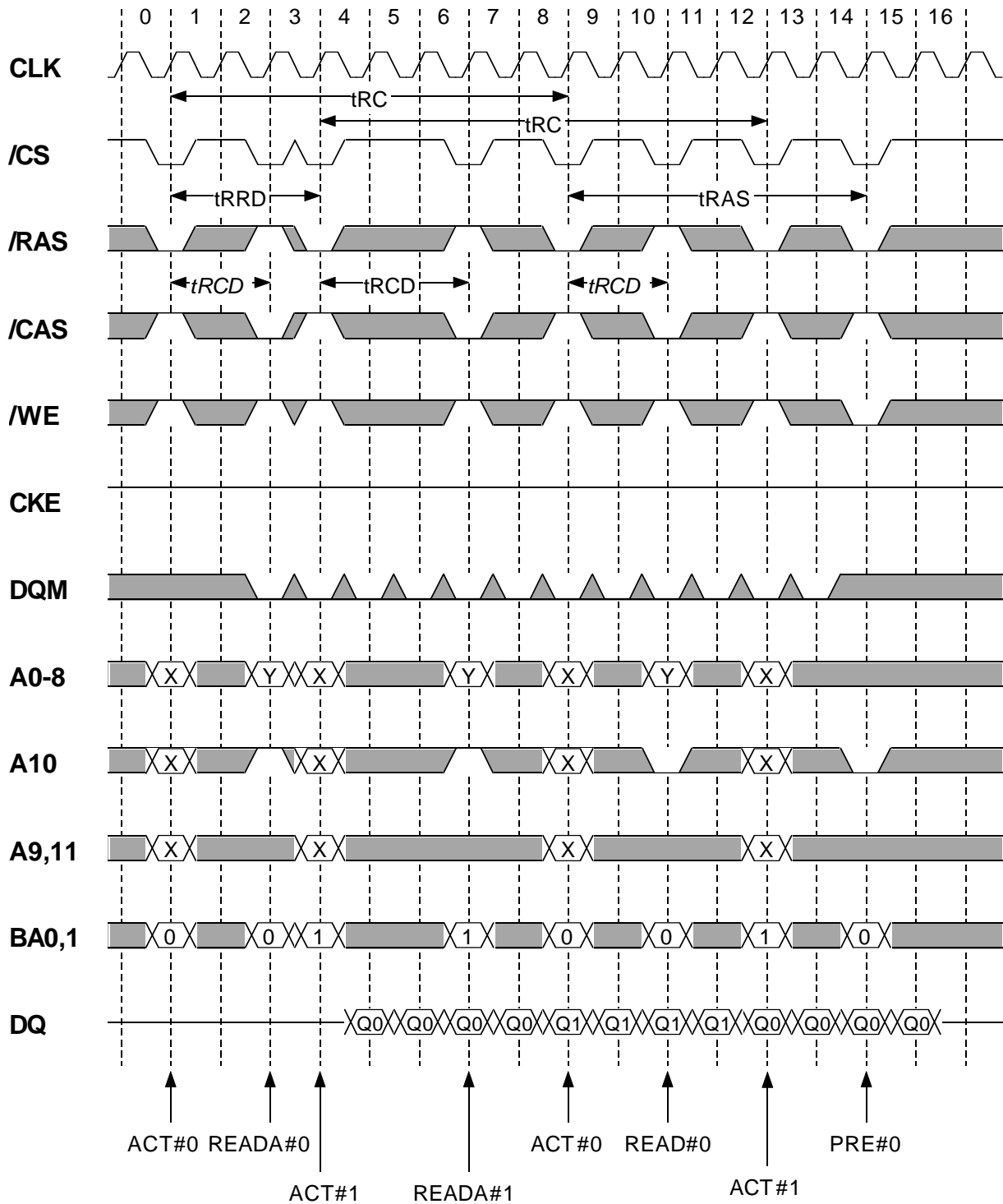
Burst Read (Single Bank) [CL=2, BL=4]



Italic parameter shows minimum case

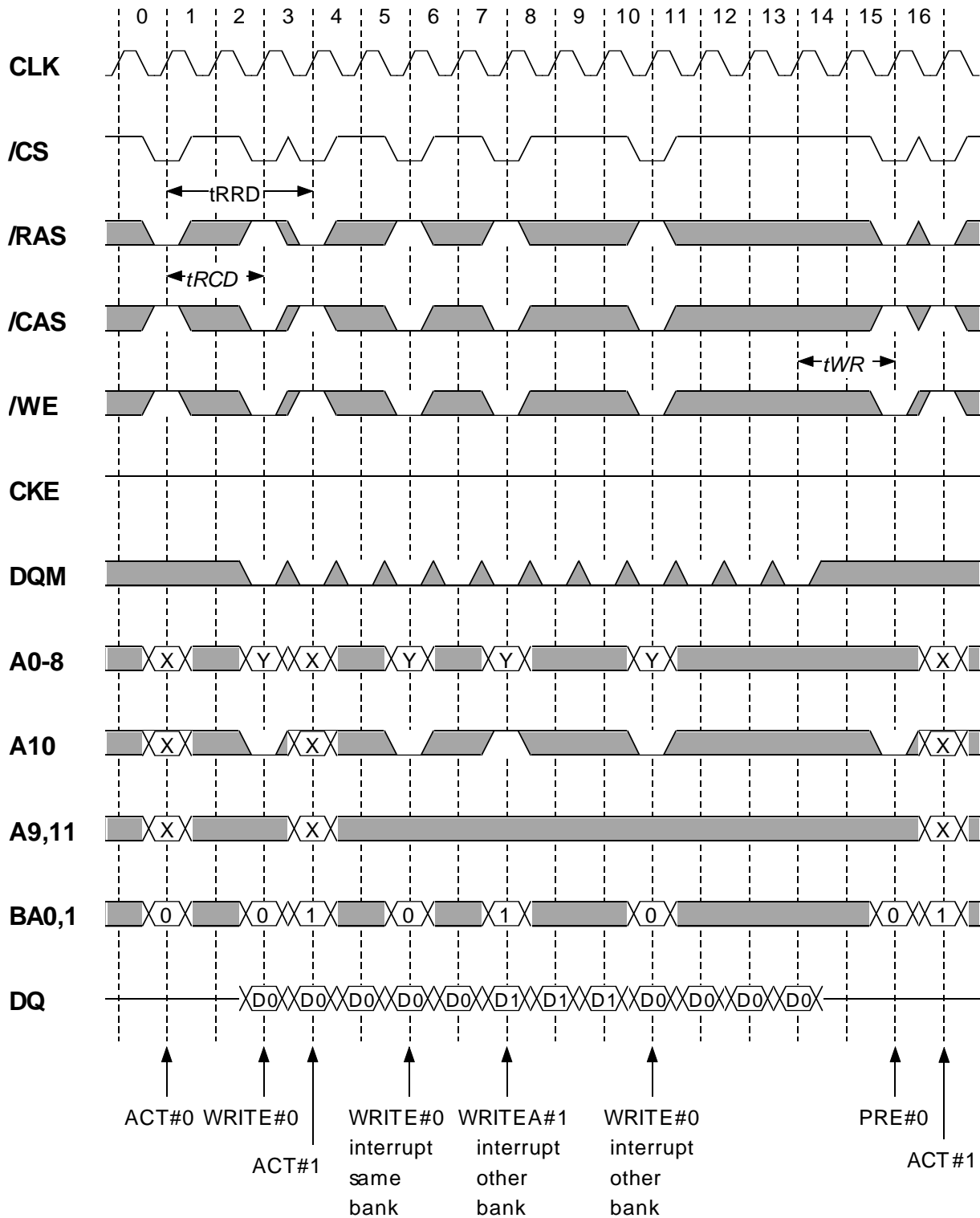
64M Synchronous DRAM

Burst Read (Multi Bank) [CL=2, BL=4]



Italic parameter shows minimum case

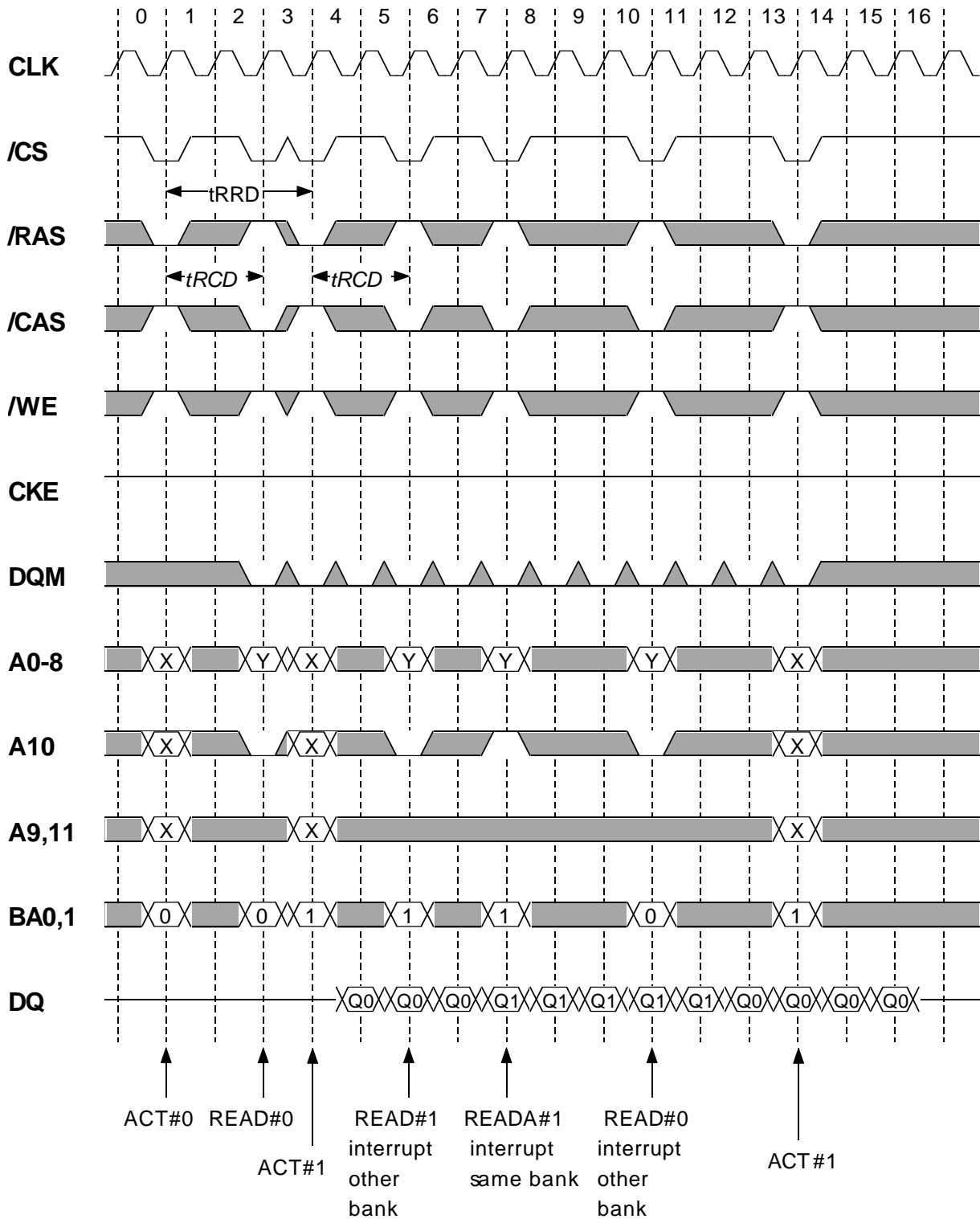
Write Interrupted by Write [BL=4]



Italic parameter shows minimum case

64M Synchronous DRAM

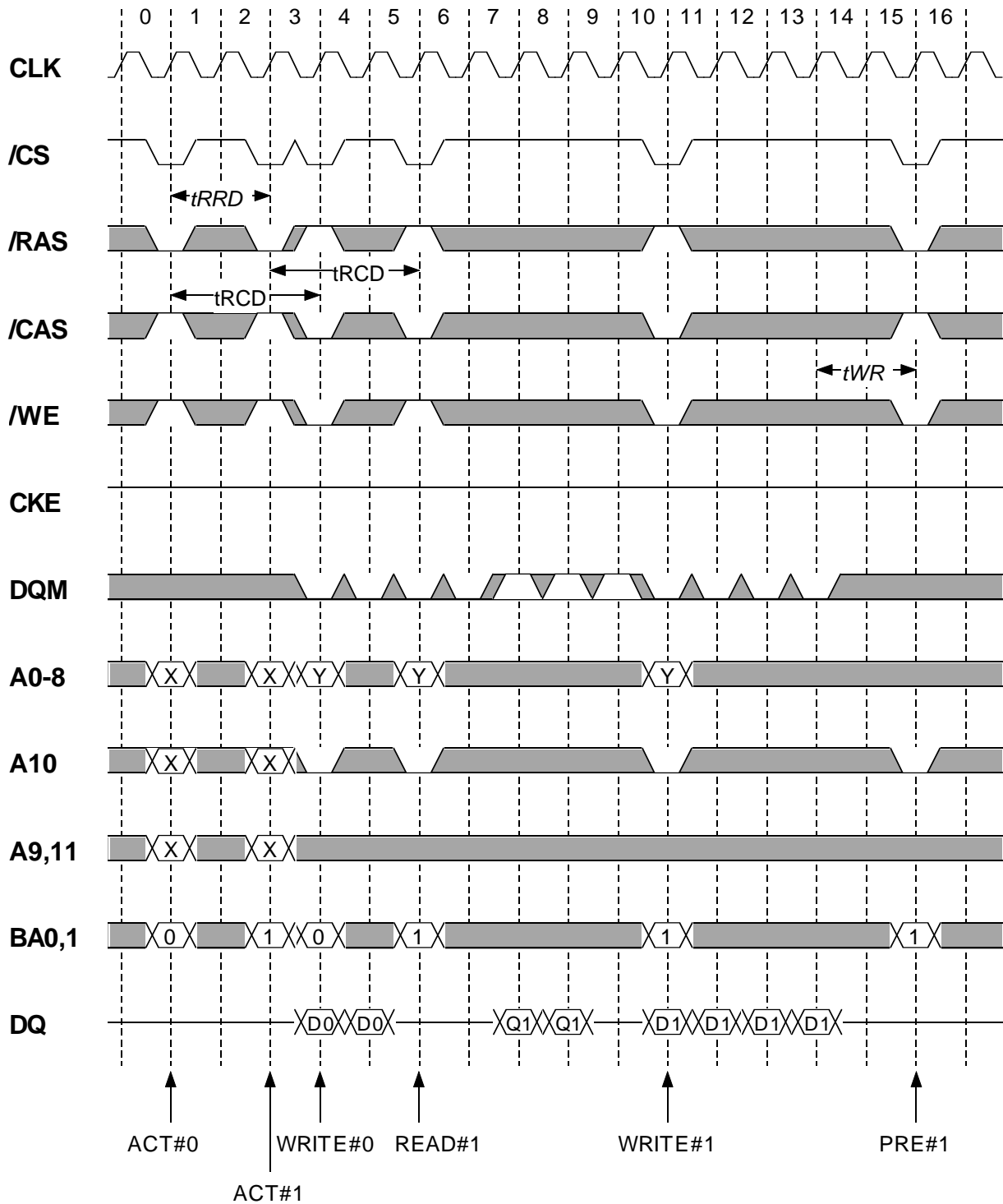
Read Interrupted by Read [CL=2, BL=4]



Italic parameter shows minimum case

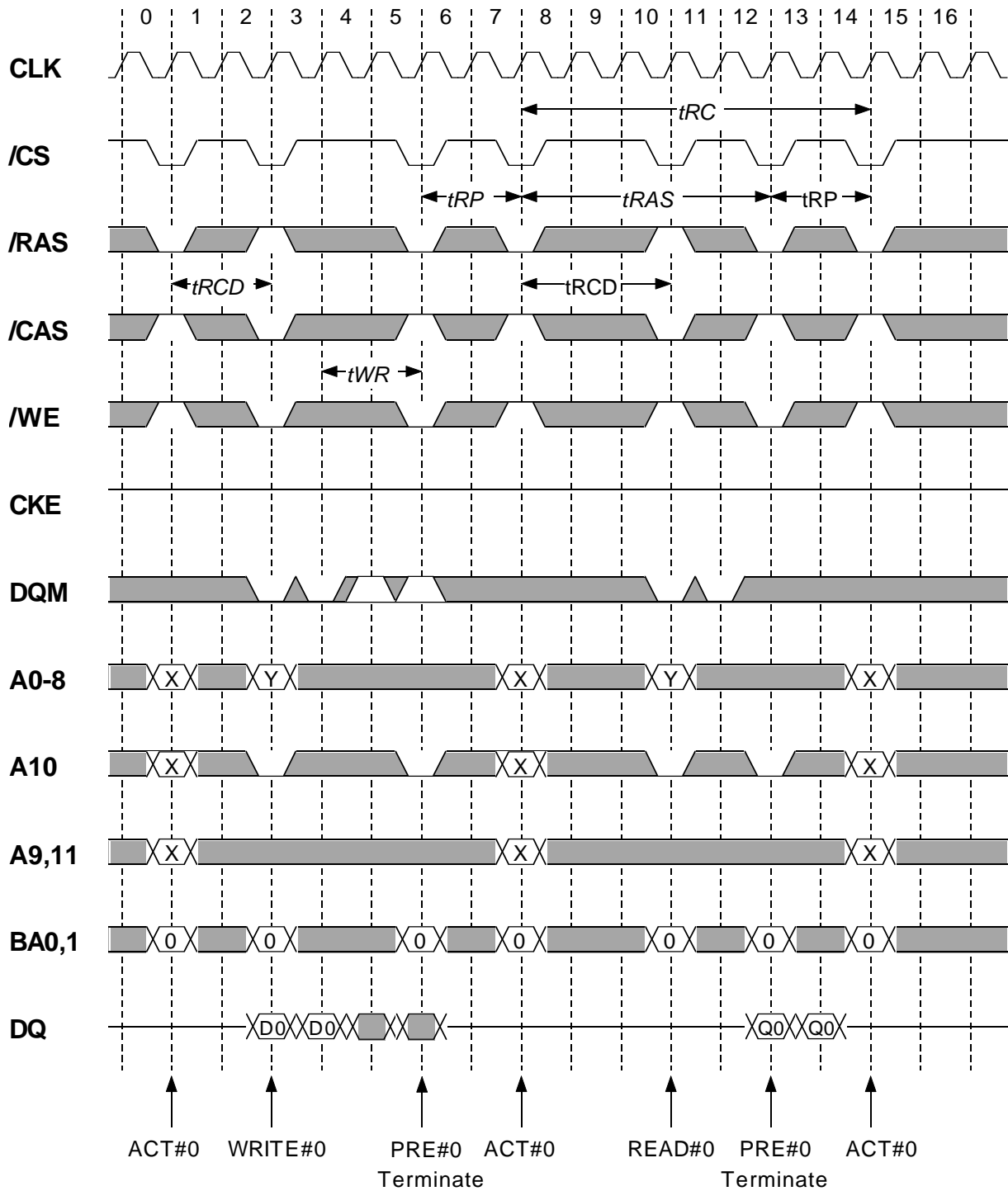
64M Synchronous DRAM

Write Interrupted by Read, Read Interrupted by Write [CL=2, BL=4]



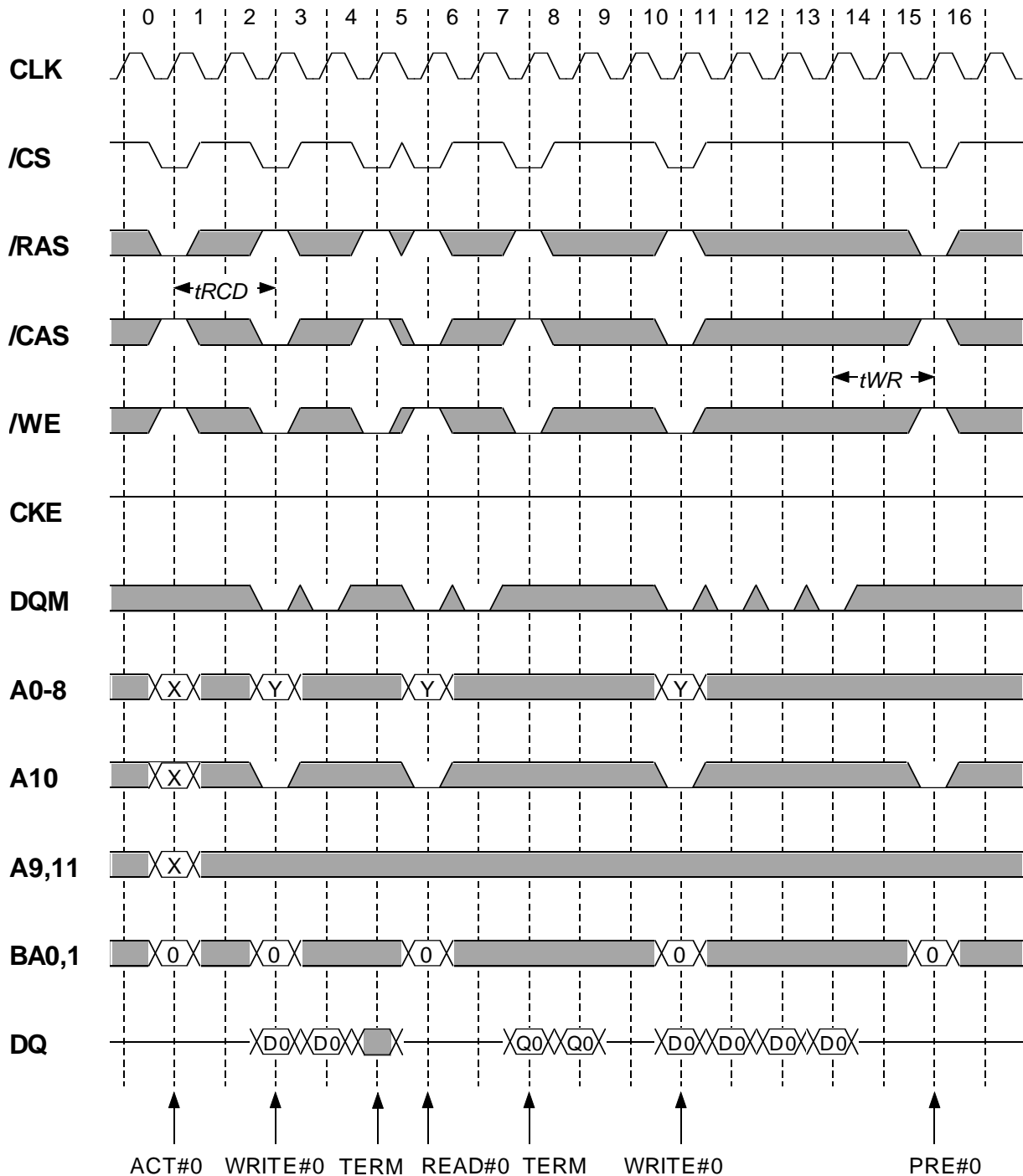
Italic parameter shows minimum case

Write / Read Terminated by Precharge [CL=2, BL=4]



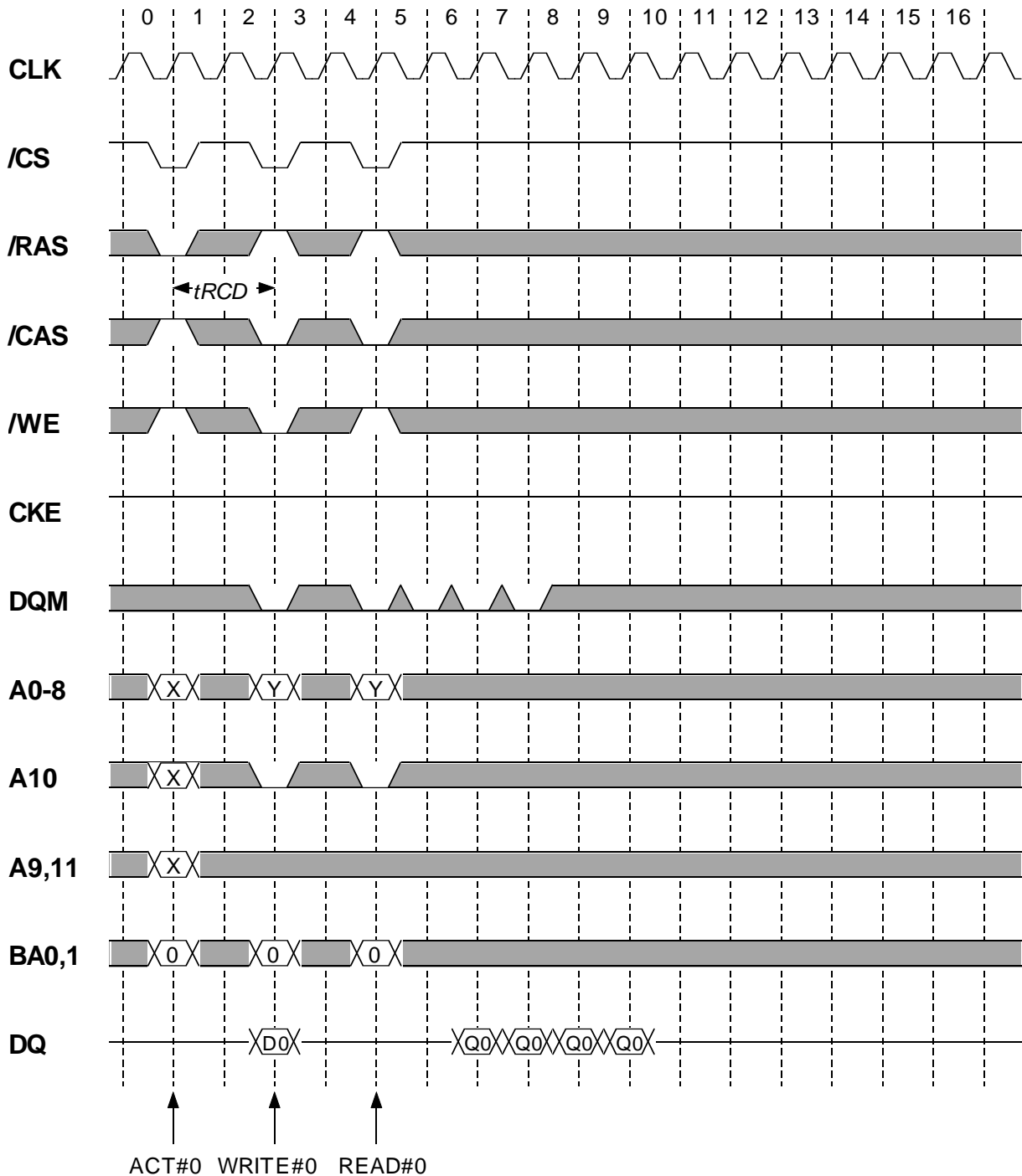
Italic parameter shows minimum case

Write / Read Terminated by Burst Terminate [CL=2, BL=4]



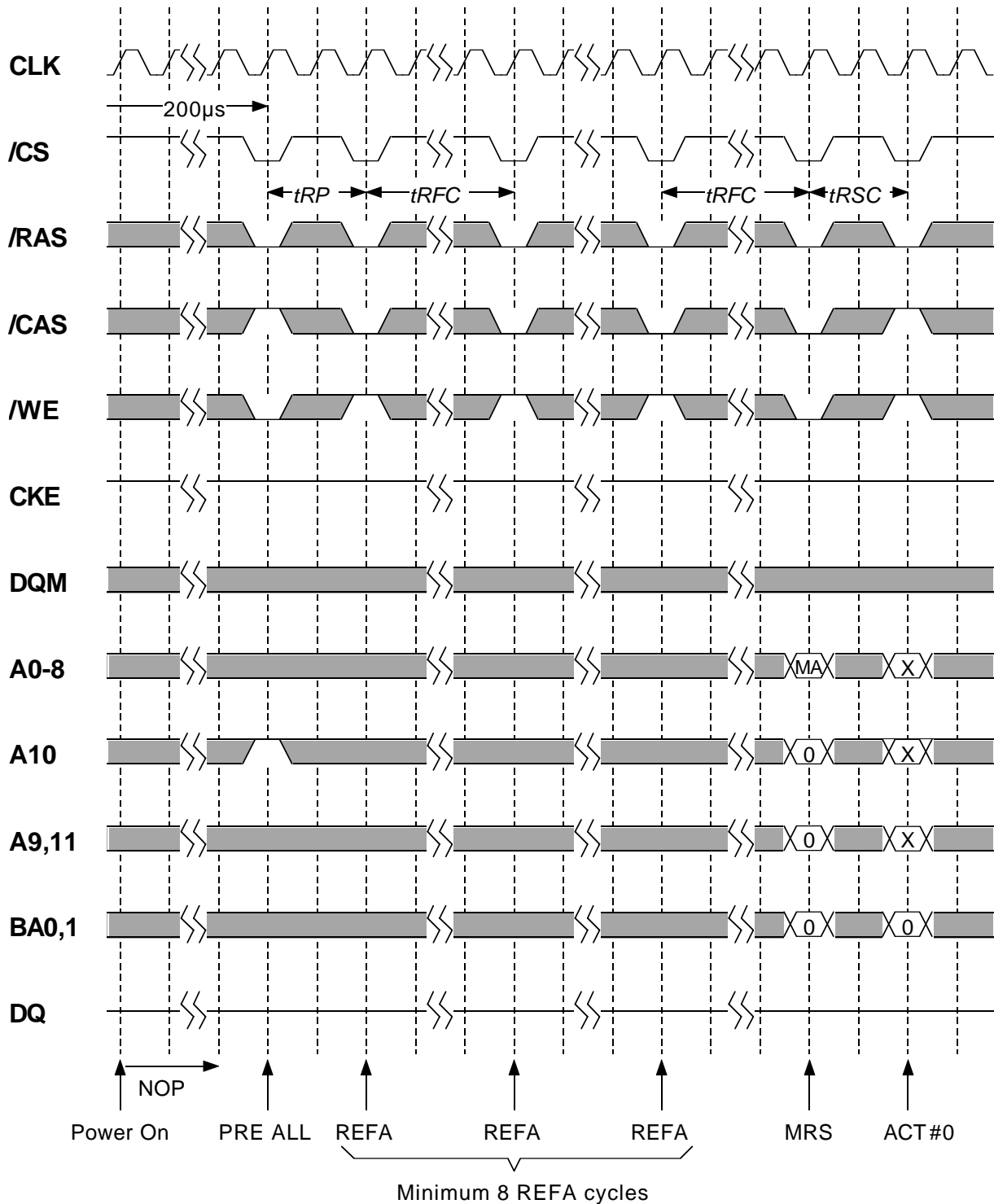
Italic parameter shows minimum case

Single Write Burst Read [CL=2, BL=4]



Italic parameter shows minimum case

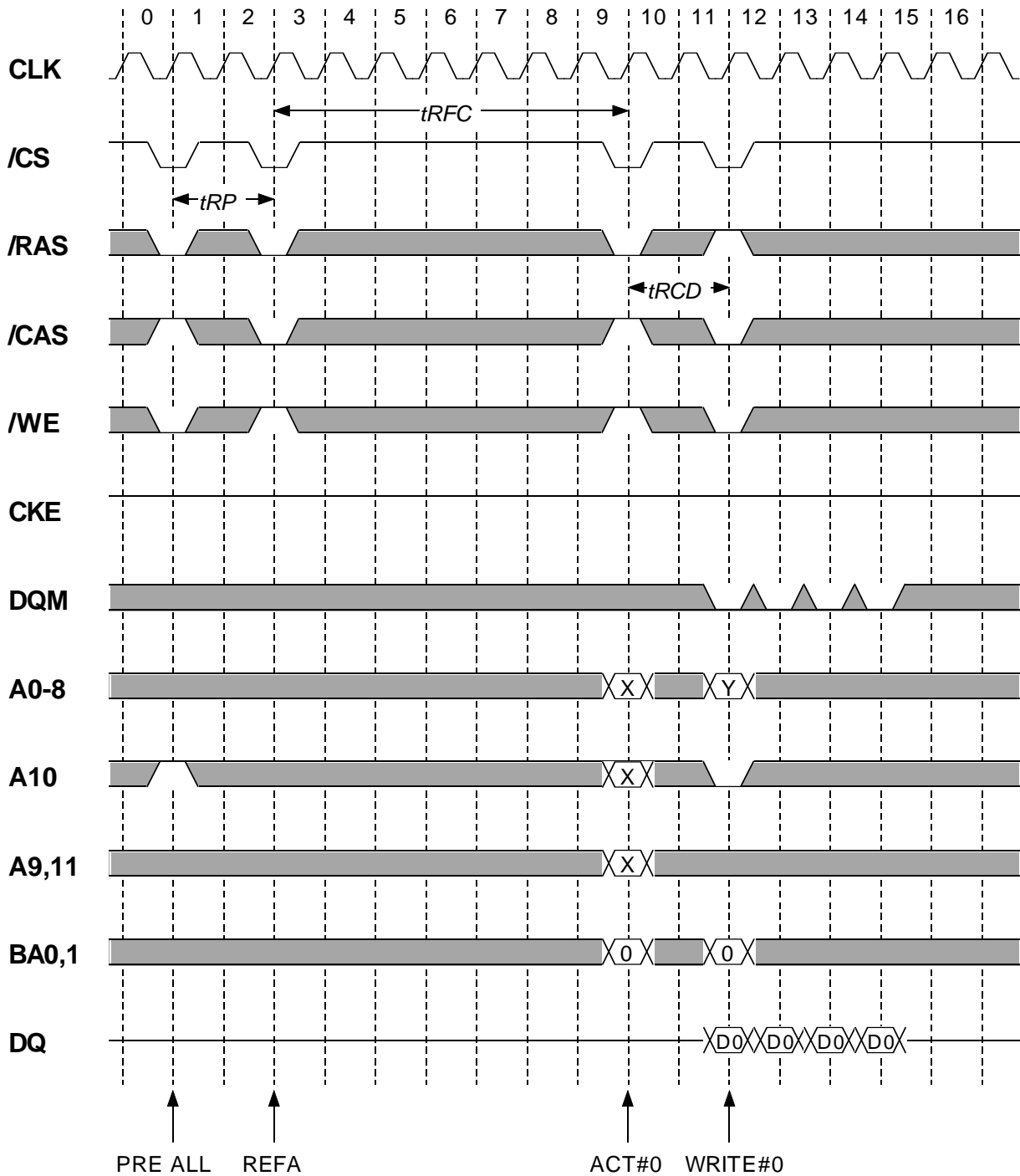
Power-Up Sequence and Intialize



Italic paramater shows minimum case

64M Synchronous DRAM

Auto Refresh

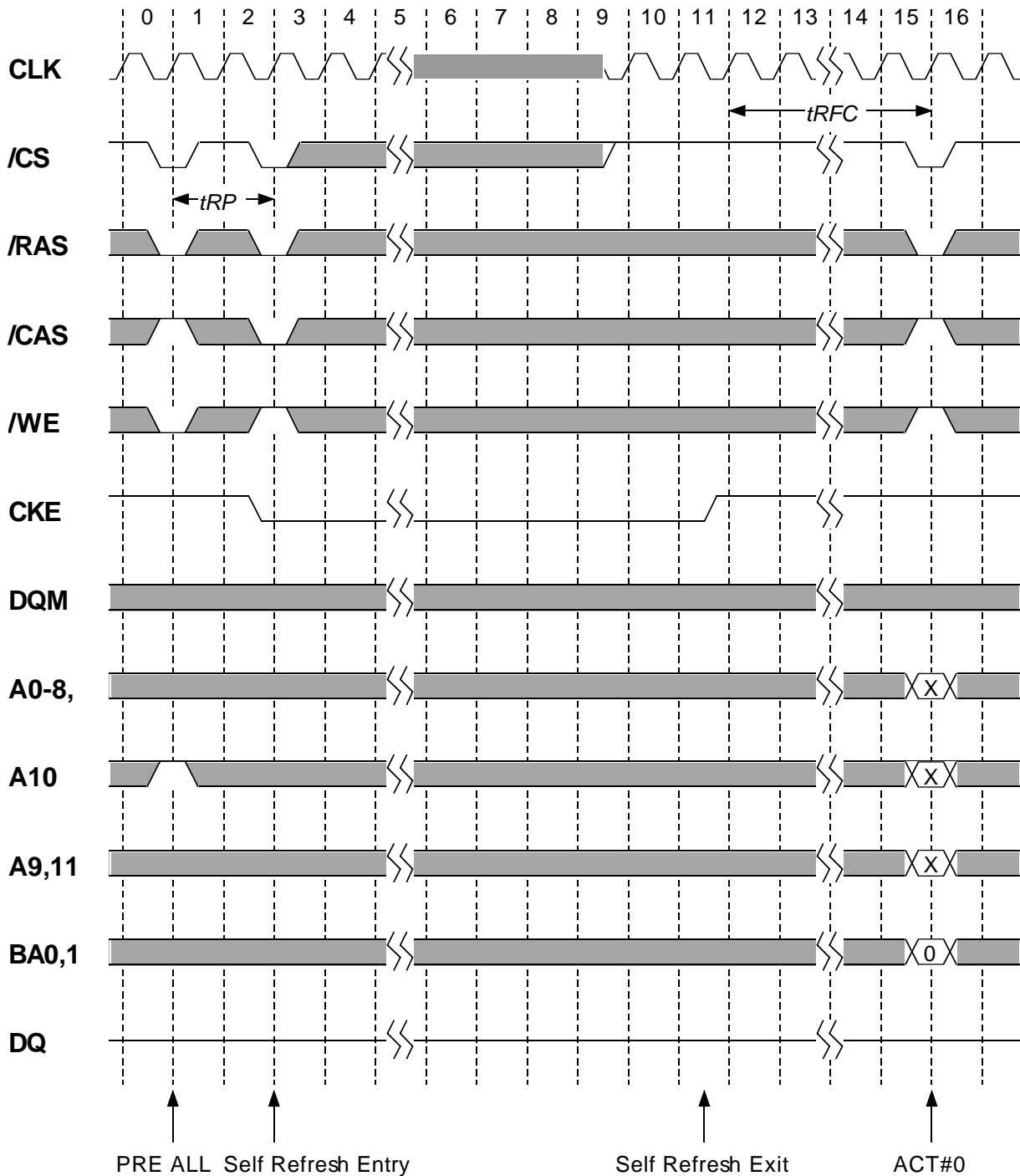


All banks must be idle before REFA is issued.

Italic parameter shows minimum case

64M Synchronous DRAM

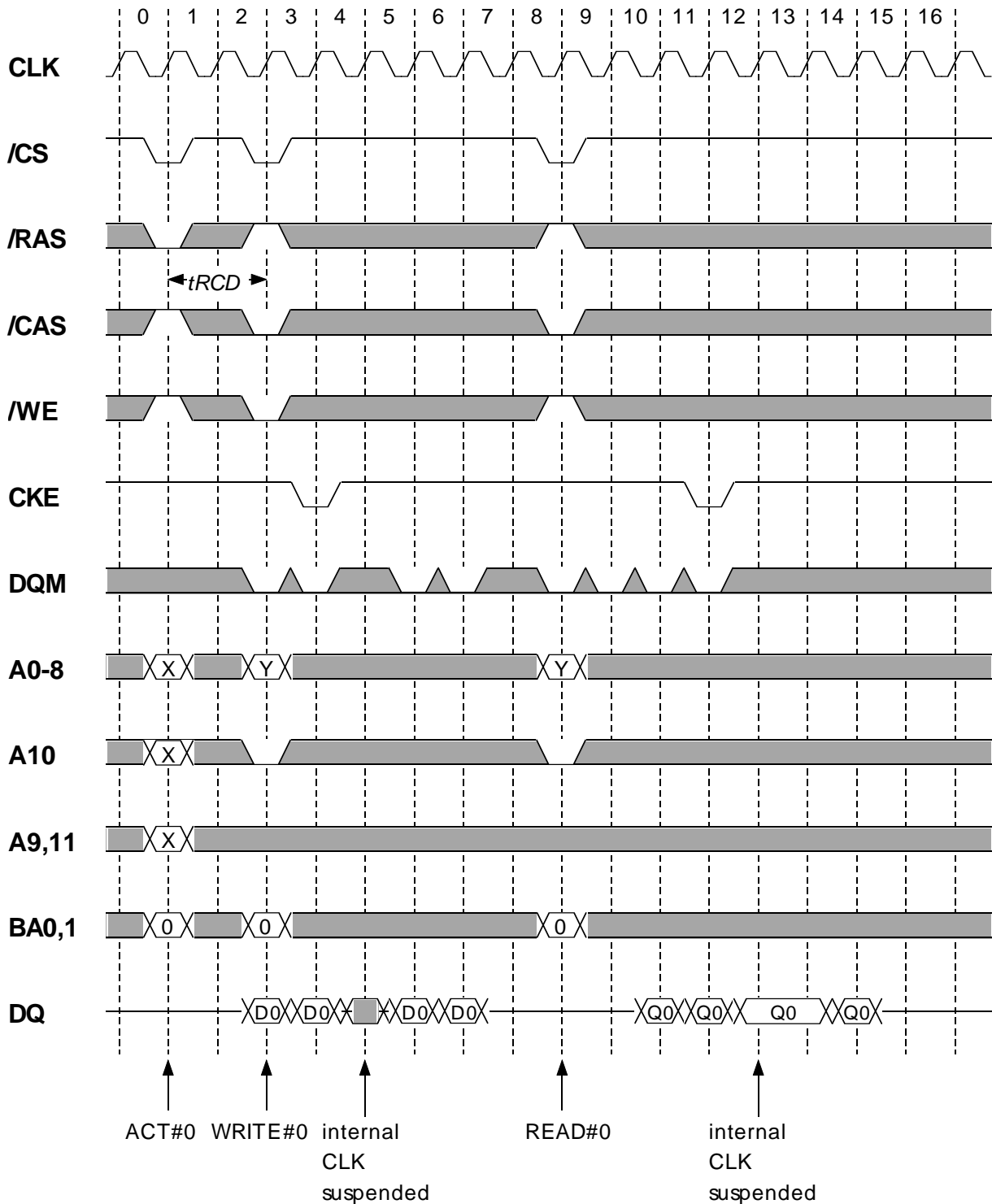
Self Refresh



All banks must be idle before REFS is issued.

Italic parameter shows minimum case

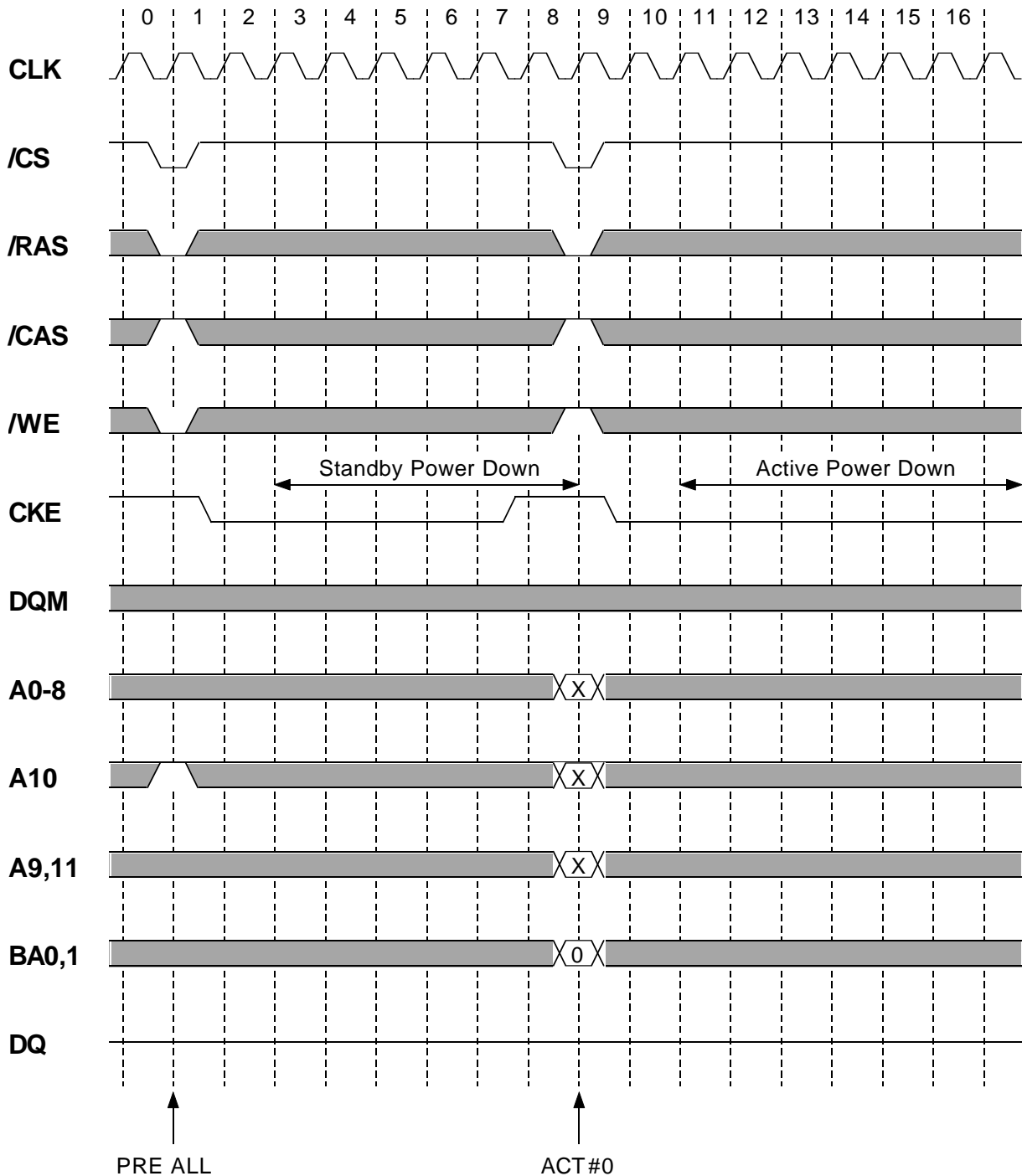
CLK Suspension [CL=2, BL=4]



Italic parameter shows minimum case

64M Synchronous DRAM

Power Down



Italic parameter shows minimum case

Revision History

| Rev. | Date | Description |
|------|----------|--|
| 1.0 | Jun '99 | -1st edition |
| 2.0 | July '99 | -single write mode is added -Icc5 for -6 is changed form 110mA to 130mA -tRFC is added -tRSC is changed |
| 3.0 | Oct. '99 | -tSRX and tPDE are removed |
| 3.1 | Oct. '99 | -tWR is changed to 12ns |

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