

# MH16S72PHB -7,-8,-10

1207959552-BIT (16777216 - WORD BY 72-BIT)SynchronousDRAM

## DESCRIPTION

The MH16S72PHB is 16777216 - word by 72-bit Synchronous DRAM module. This consists of nine industry standard 16Mx8 Synchronous DRAMs in TSOP and one industry standard EEPROM in TSSOP.

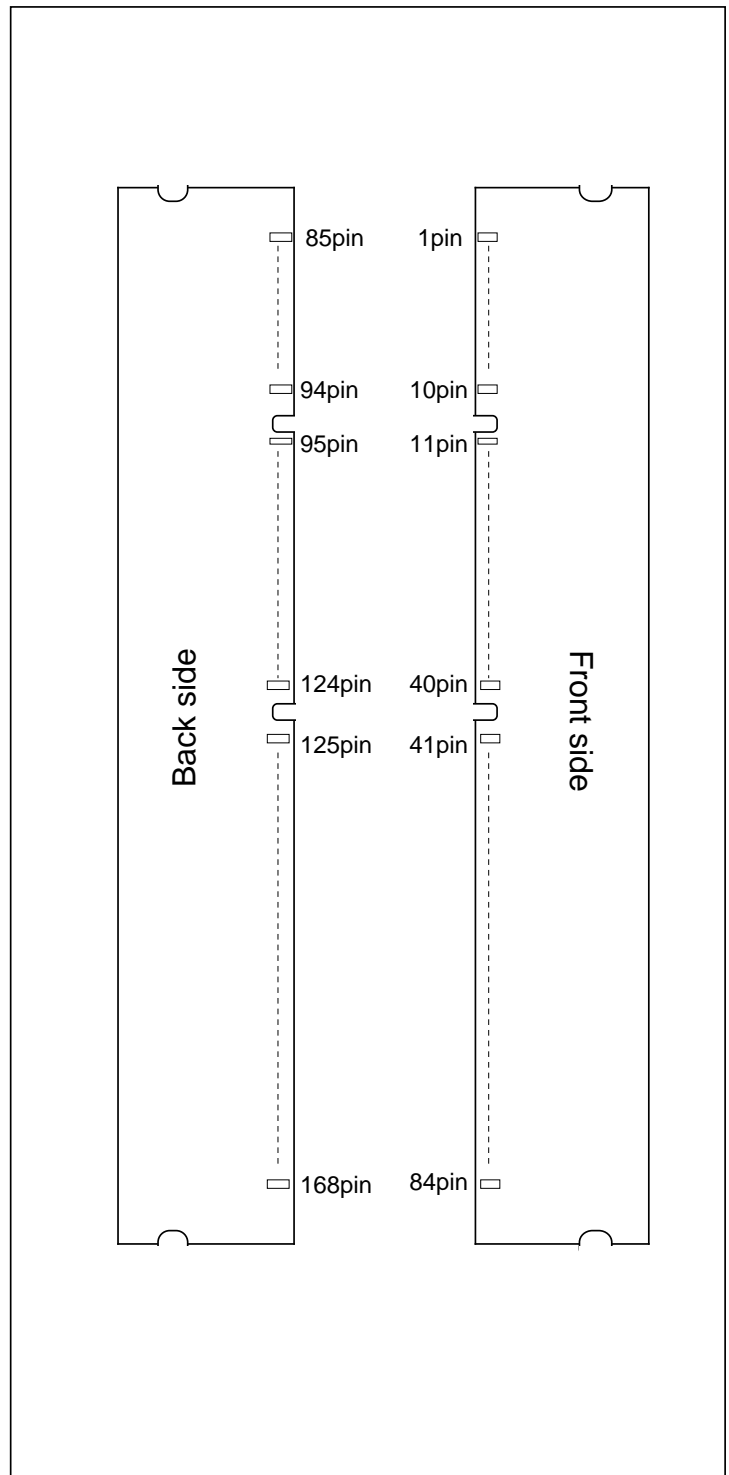
The mounting of TSOP on a card edge Dual Inline package provides any application where high densities and large quantities of memory are required.

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

## FEATURES

|     | Frequency | CLK Access Time<br>(Component SDRAM) |
|-----|-----------|--------------------------------------|
| -7  | 100MHz    | 6.0ns(CL=3)                          |
| -8  | 100MHz    | 6.0ns(CL=3)                          |
| -10 | 100MHz    | 8.0ns(CL=3)                          |

- Utilizes industry standard 16M x 8 Synchronous DRAMs TSOP and industry standard EEPROM in TSSOP
- 168-pin (84-pin dual in-line package)
- single 3.3V±0.3V power supply
- Clock frequency 100MHz
- 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
- Discrete IC and module design conform to PC100 specification.  
(module Spec. Rev. 1.0 and SPD 1.2A)



## APPLICATION

PC main memory

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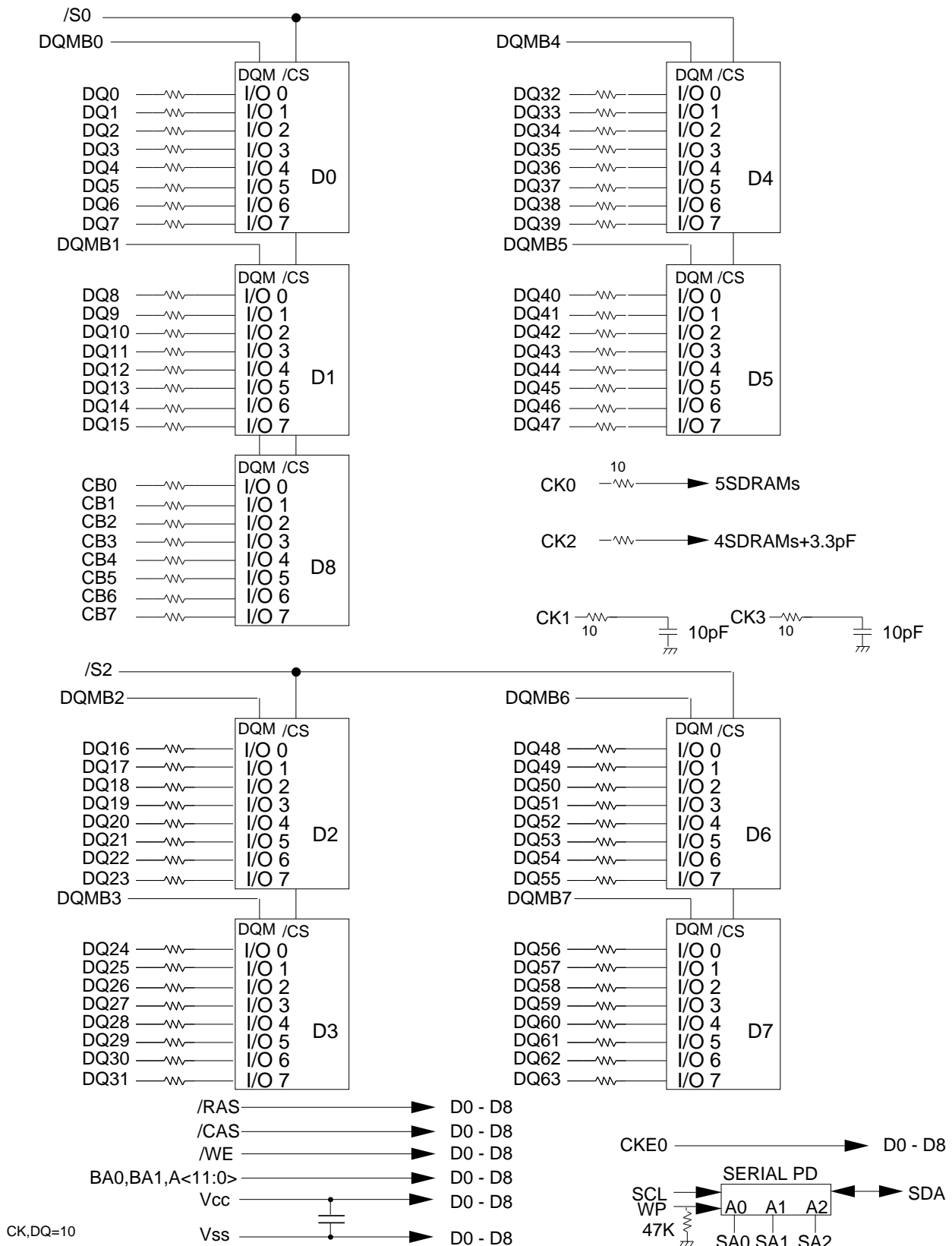
| PIN NO. | PIN NAME | PIN NO. | PIN NAME | PIN NO. | PIN NAME | PIN NO. | PIN NAME |
|---------|----------|---------|----------|---------|----------|---------|----------|
| 1       | VSS      | 43      | VSS      | 85      | VSS      | 127     | VSS      |
| 2       | DQ0      | 44      | NC       | 86      | DQ32     | 128     | CKE0     |
| 3       | DQ1      | 45      | /S2      | 87      | DQ33     | 129     | NC       |
| 4       | DQ2      | 46      | DQMB2    | 88      | DQ34     | 130     | DQMB6    |
| 5       | DQ3      | 47      | DQMB3    | 89      | DQ35     | 131     | DQMB7    |
| 6       | VDD      | 48      | NC       | 90      | VDD      | 132     | NC       |
| 7       | DQ4      | 49      | VDD      | 91      | DQ36     | 133     | VDD      |
| 8       | DQ5      | 50      | NC       | 92      | DQ37     | 134     | NC       |
| 9       | DQ6      | 51      | NC       | 93      | DQ38     | 135     | NC       |
| 10      | DQ7      | 52      | CB2      | 94      | DQ39     | 136     | CB6      |
| 11      | DQ8      | 53      | CB3      | 95      | DQ40     | 137     | CB7      |
| 12      | VSS      | 54      | VSS      | 96      | VSS      | 138     | VSS      |
| 13      | DQ9      | 55      | DQ16     | 97      | DQ41     | 139     | DQ48     |
| 14      | DQ10     | 56      | DQ17     | 98      | DQ42     | 140     | DQ49     |
| 15      | DQ11     | 57      | DQ18     | 99      | DQ43     | 141     | DQ50     |
| 16      | DQ12     | 58      | DQ19     | 100     | DQ44     | 142     | DQ51     |
| 17      | DQ13     | 59      | VDD      | 101     | DQ45     | 143     | VDD      |
| 18      | VDD      | 60      | DQ20     | 102     | VDD      | 144     | DQ52     |
| 19      | DQ14     | 61      | NC       | 103     | DQ46     | 145     | NC       |
| 20      | DQ15     | 62      | NC       | 104     | DQ47     | 146     | NC       |
| 21      | CB0      | 63      | NC       | 105     | CB4      | 147     | NC       |
| 22      | CB1      | 64      | VSS      | 106     | CB5      | 148     | VSS      |
| 23      | VSS      | 65      | DQ21     | 107     | VSS      | 149     | DQ53     |
| 24      | NC       | 66      | DQ22     | 108     | NC       | 150     | DQ54     |
| 25      | NC       | 67      | DQ23     | 109     | NC       | 151     | DQ55     |
| 26      | VDD      | 68      | VSS      | 110     | VDD      | 152     | VSS      |
| 27      | /WE0     | 69      | DQ24     | 111     | /CAS     | 153     | DQ56     |
| 28      | DQMB0    | 70      | DQ25     | 112     | DQMB4    | 154     | DQ57     |
| 29      | DQMB1    | 71      | DQ26     | 113     | DQMB5    | 155     | DQ58     |
| 30      | /S0      | 72      | DQ27     | 114     | NC       | 156     | DQ59     |
| 31      | NC       | 73      | VDD      | 115     | /RAS     | 157     | VDD      |
| 32      | VSS      | 74      | DQ28     | 116     | VSS      | 158     | DQ60     |
| 33      | A0       | 75      | DQ29     | 117     | A1       | 159     | DQ61     |
| 34      | A2       | 76      | DQ30     | 118     | A3       | 160     | DQ62     |
| 35      | A4       | 77      | DQ31     | 119     | A5       | 161     | DQ63     |
| 36      | A6       | 78      | VSS      | 120     | A7       | 162     | VSS      |
| 37      | A8       | 79      | CK2      | 121     | A9       | 163     | CK3      |
| 38      | A10      | 80      | NC       | 122     | BA0      | 164     | NC       |
| 39      | BA1      | 81      | WP       | 123     | A11      | 165     | SA0      |
| 40      | VDD      | 82      | SDA      | 124     | VDD      | 166     | SA1      |
| 41      | VDD      | 83      | SCL      | 125     | CK1      | 167     | SA2      |
| 42      | CK0      | 84      | VDD      | 126     | NC       | 168     | VDD      |

NC = No Connection

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1207959552-BIT (16777216 - WORD BY 72-BIT)SynchronousDRAM

## 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...  | x72                          | 48            |
| 7    | ... Data Width continuation   | 0                            | 00            |
| 8    | Voltage interface standard of this assembly                               | LVTTTL                       | 01            |
| 9    | SDRAM Cyletime at Max. Supported CAS Latency (CL).<br>Cycle time for CL=3 | -7,-8,-10<br>10ns            | A0            |
| 10   | SDRAM Access from Clock<br>tAC for CL=3                                   | -7,-8<br>6ns                 | 60            |
|      |   | -10<br>8ns                   | 80            |
| 11   | DIMM Configuration type (Non-parity,Parity,ECC)                           | ECC                          | 02            |
| 12   | Refresh Rate/Type   | self refresh(15.625uS)       | 80            |
| 13   | SDRAM width,Primary DRAM  | x8                           | 08            |
| 14   | Error Checking SDRAM data width   | x8                           | 08            |
| 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)<br>Cycle time for CL=2          | -7<br>10ns                   | A0            |
|      |   | -8<br>13ns                   | D0            |
|      |   | -10<br>15ns                  | F0            |
| 24   | SDRAM Access form Clock(2nd highest CAS latency)<br>tAC for CL=2          | -7<br>6ns                    | 60            |
|      |   | -8<br>7ns                    | 70            |
|      |   | -10<br>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   | -7,-8<br>20ns                | 14            |
|      |   | -10<br>30ns                  | 1E            |
| 28   | Row Active to Row Active Min.   | -7,-8,-10<br>20ns            | 14            |
| 29   | RAS to CAS Delay Min  | -7,-8<br>20ns                | 14            |
|      |   | -10<br>30ns                  | 1E            |
| 30   | Active to Precharge Min   | -7,-8<br>50ns                | 32            |
|      |   | -10<br>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  | -7,-8 | 2ns               | 20                                 |
|        |  | -10   | N/A               | 00                                 |
| 33     | Command and Address signal input hold time   | -7,-8 | 1ns               | 10                                 |
|        |  | -10   | N/A               | 00                                 |
| 34     | Data signal input setup time                 | -7,-8 | 2ns               | 20                                 |
|        |  | -10   | N/A               | 00                                 |
| 35     | Data signal input hold time                  | -7,-8 | 1ns               | 10                                 |
|        |  | -10   | N/A               | 00                                 |
| 36-61  | Superset Information (may be used in future) |       | option            | 00                                 |
| 62     | SPD Revision                                 | -7,-8 | rev 1.2A          | 12                                 |
|        |  | -10   | rev 1             | 01                                 |
| 63     | Checksum for bytes 0-62                      |       | Check sum for -7  | 28                                 |
|        |  |       | Check sum for -8  | 68                                 |
|        |  |       | Check sum for -10 | 65                                 |
| 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                     |       | MH16S72PHB-7      | 4D4831365337325048422D372020202020 |
|        |  |       | MH16S72PHB-8      | 4D4831365337325048422D382020202020 |
|        |  |       | MH16S72PHB-10     | 4D4831365337325048422D313020202020 |
| 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    | Intetl specification frequency               | -7,-8 | 100MHz            | 64                                 |
|        |  | -10   | 66MHz             | 66                                 |
| 127    | Intel specification CAS# Latency support     | -7    | CL=2/3,AP,CK0,2   | AF                                 |
|        |  | -8    | CL=3,AP,CK0,2     | AD                                 |
|        |  | -10   | CL=2/3            | 06                                 |
| 128+   | Unused storage locations                     |       | open              | 00                                 |

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**PIN FUNCTION**

|                  |              |   |
|------------------|--------------|---|
| CK<br>(CK0,2)    | 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.   |
| /S<br>(/S0,2)    | Input        | Chip Select: When /S 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,<br>CB0-7 | 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   |

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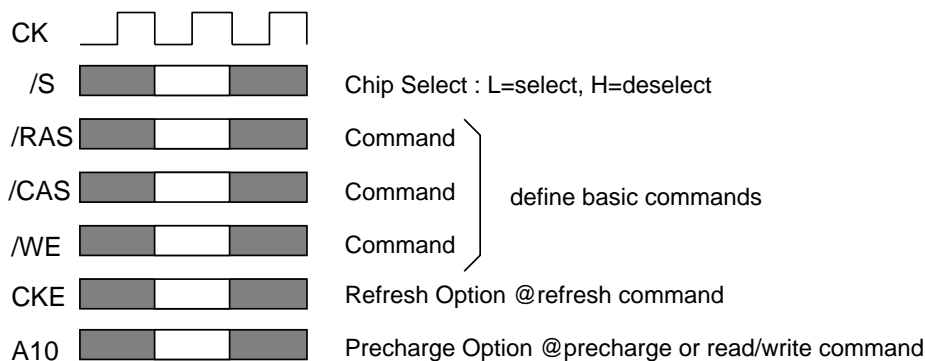
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## BASIC FUNCTIONS

The MH16S72PHB 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, /S, 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.

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## COMMAND TRUTH TABLE

| COMMAND  | MNEMONIC | CKE <sub>n-1</sub> | CKE <sub>n</sub> | /S | /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 | /S | /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,<br>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,<br>Determine Auto-Precharge                          |
|               | L  | H    | L    | L   | BA,CA,A10            | WRITE/<br>WRITEA | Begin Write,Latch CA,<br>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,<br>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,<br>Begin New Read,Determine<br>Auto-Precharge*3 |
|               | L  | H    | L    | L   | BA,CA,A10            | WRITE/WRITEA     | Terminate Burst,Latch CA,<br>Begin Write,Determine Auto-<br>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,<br>Mode-Add | MRS              | ILLEGAL   |

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## FUNCTION TRUTH TABLE(continued)

| Current State                   | /S | /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,<br>Begin Read,Determine Auto-Precharge*3  |
|                                 | L  | H    | L    | L   | BA,CA,A10            | WRITE/<br>WRITEA | Terminate Burst,Latch CA,<br>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,<br>Mode-Add | MRS              | ILLEGAL   |
| READ with<br>AUTO<br>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/<br>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,<br>Mode-Add | MRS              | ILLEGAL   |
| WRITE with<br>AUTO<br>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/<br>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,<br>Mode-Add | MRS              | ILLEGAL   |

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## FUNCTION TRUTH TABLE(continued)

| Current State         | /S | /RAS | /CAS | /WE | Address              | Command    | Action                     |
|-----------------------|----|------|------|-----|----------------------|------------|----------------------------|
| PRE -<br>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                    |
| ROW<br>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                    |
| WRITE RE-<br>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,<br>Mode-Add | MRS        | ILLEGAL                    |

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**FUNCTION TRUTH TABLE(continued)**

| Current State         | /S | /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,<br>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,<br>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.

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**FUNCTION TRUTH TABLE FOR CKE**

| Current State                           | CKE<br>n-1 | CKE<br>n | /S | /RAS | /CAS | /WE | Add | Action                              |
|---|------------|----------|----|------|------|-----|-----|-------------------------------------|
| SELF -<br>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<br>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<br>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<br>other than<br>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

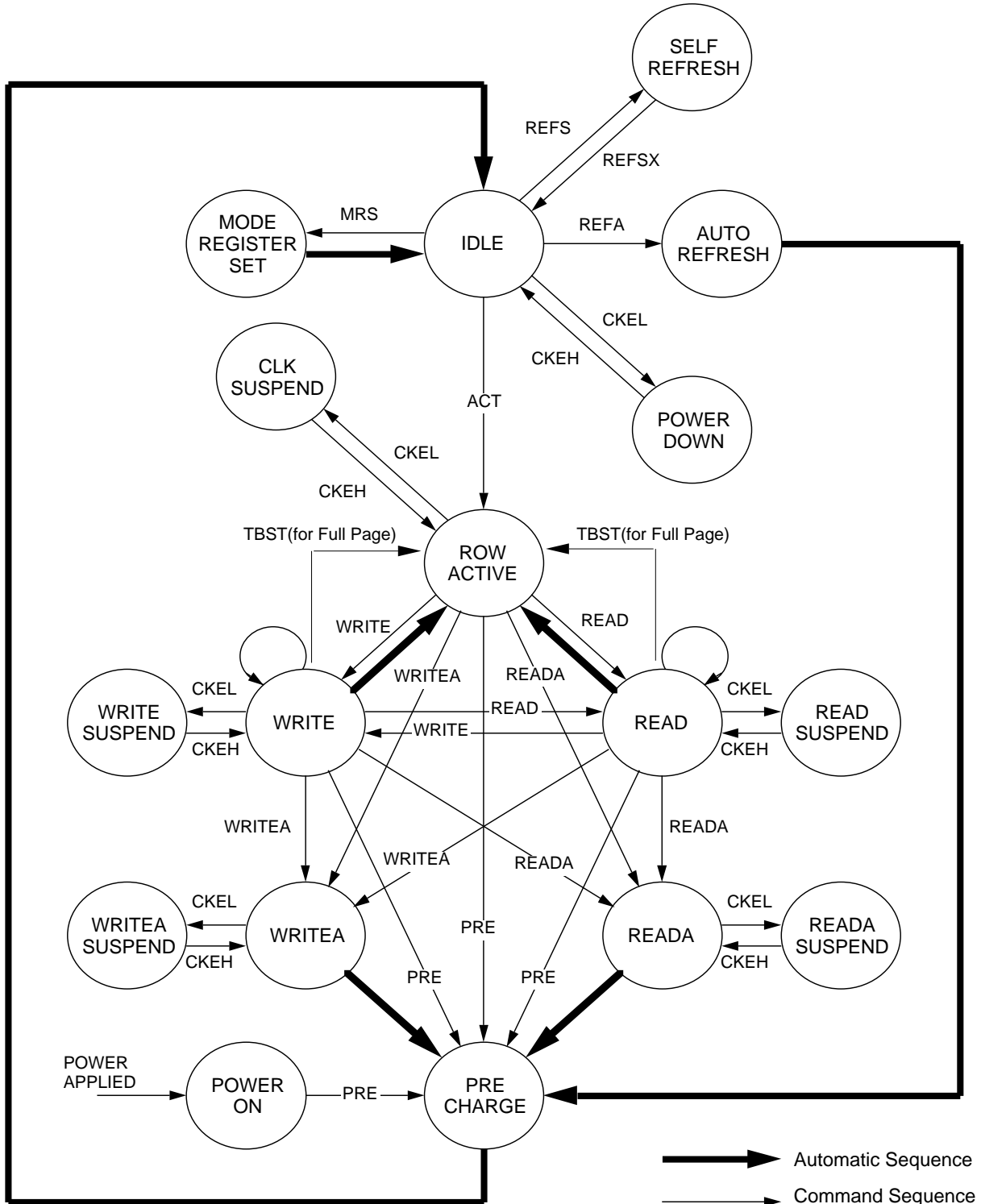
## NOTES:

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.

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## SIMPLIFIED STATE DIAGRAM



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## POWER ON SEQUENCE

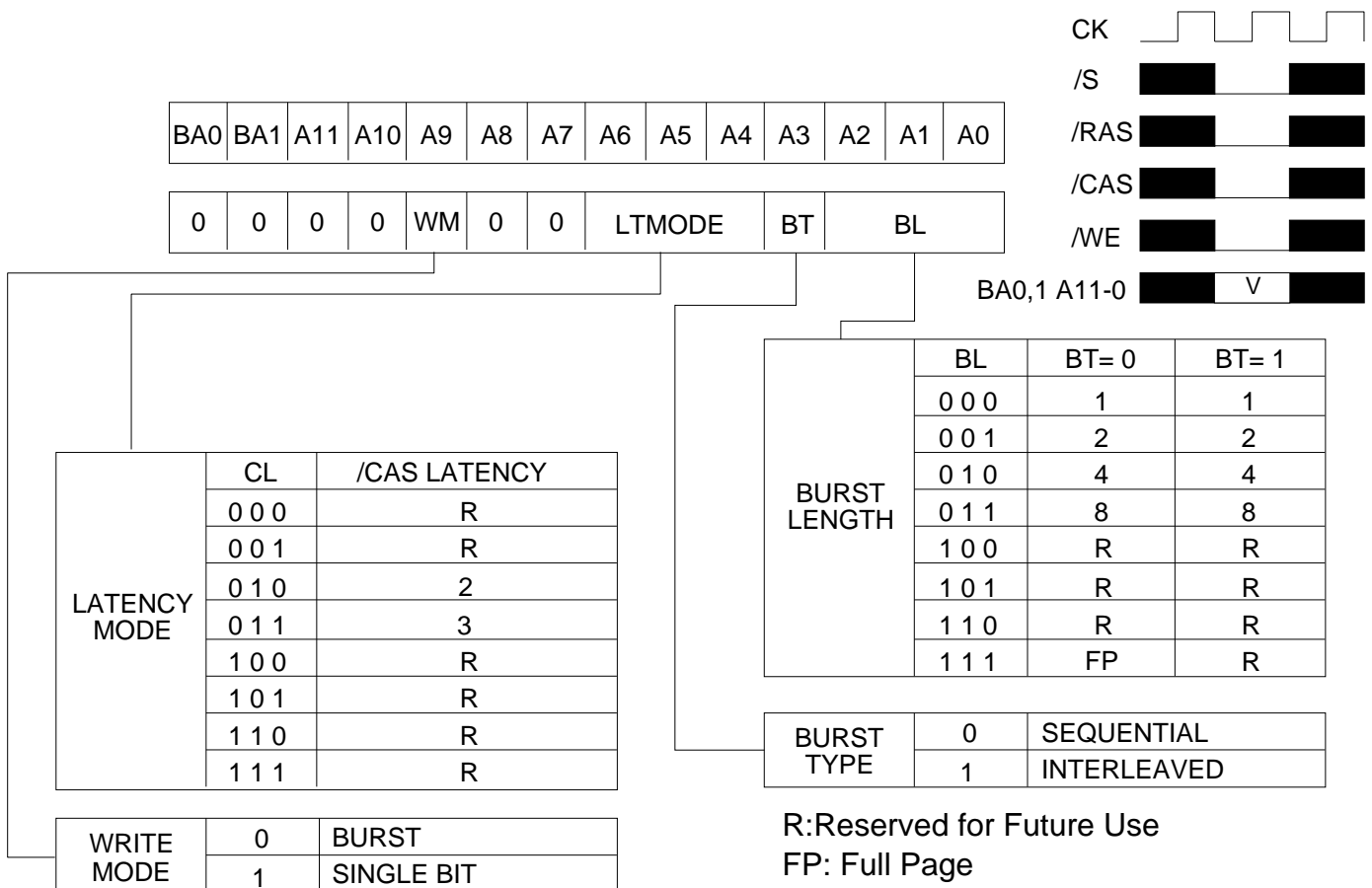
Before starting normal operation, the following power on sequence is necessary to prevent a SDRAM from damaged or malfunctioning.

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 500us.
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.



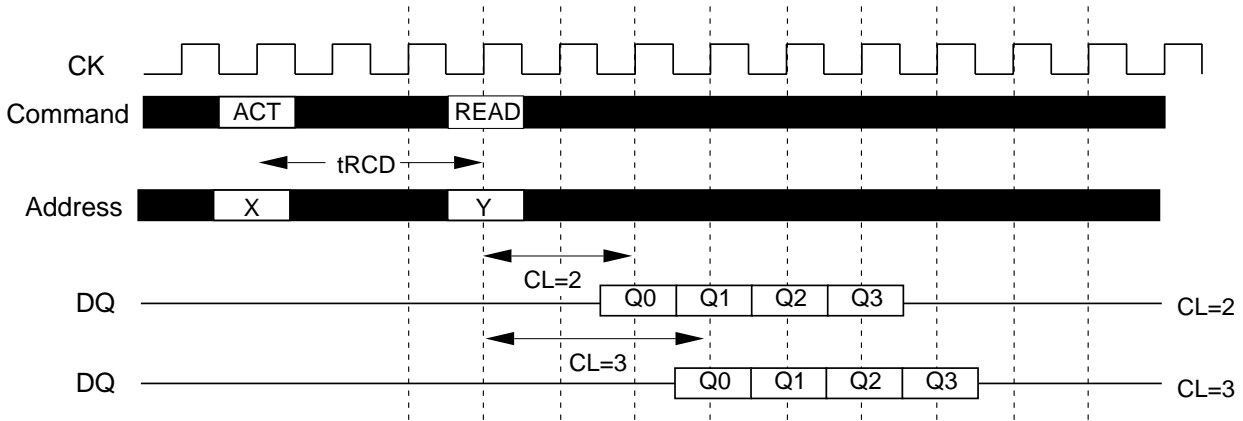
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## [ /CAS LATENCY ]

/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.

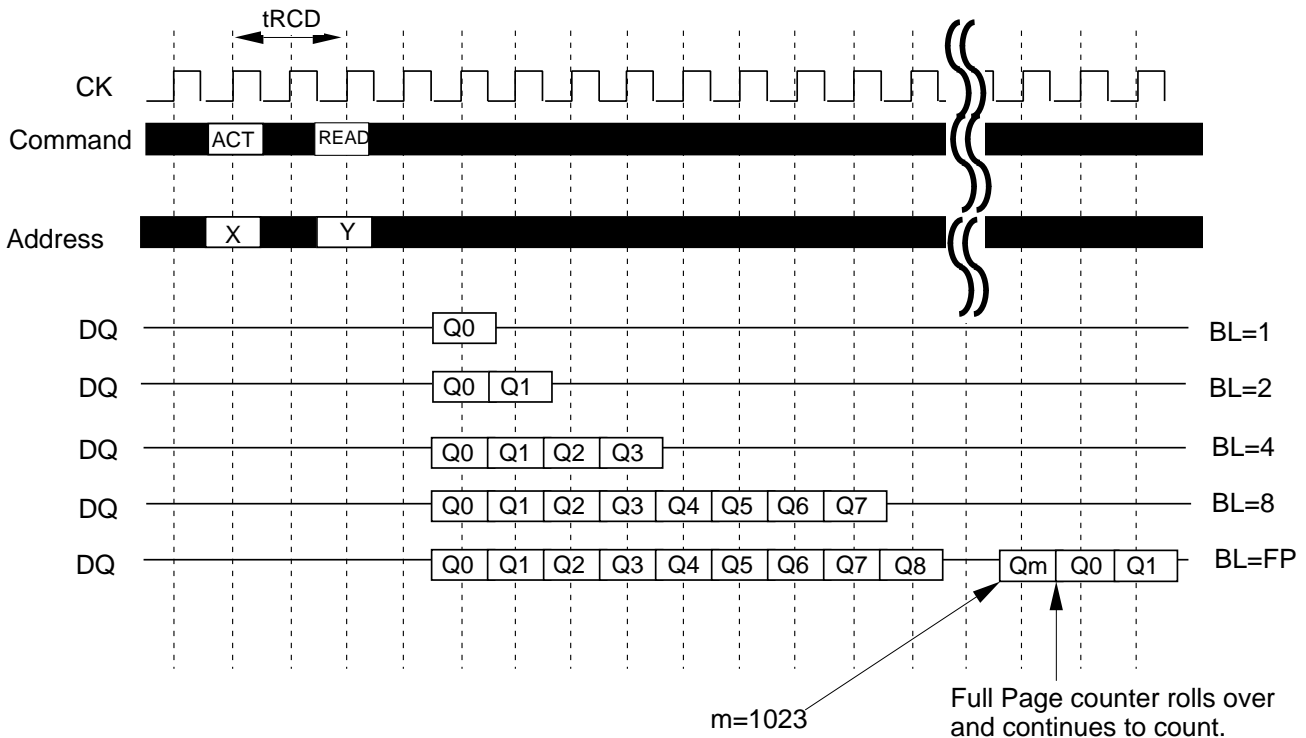
/CAS Latency Timing(BL=4)



## [ 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.

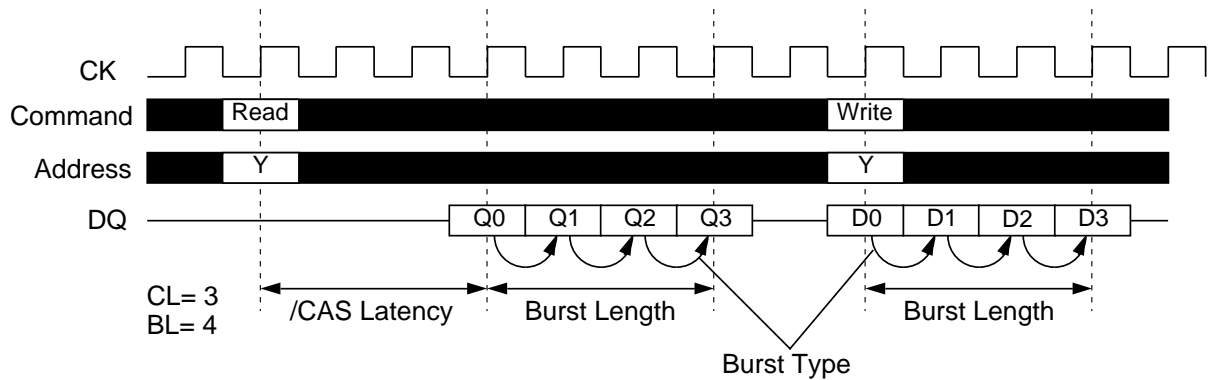
Burst Length Timing(CL=2)





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| 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 |   |   |   |   |   |   |

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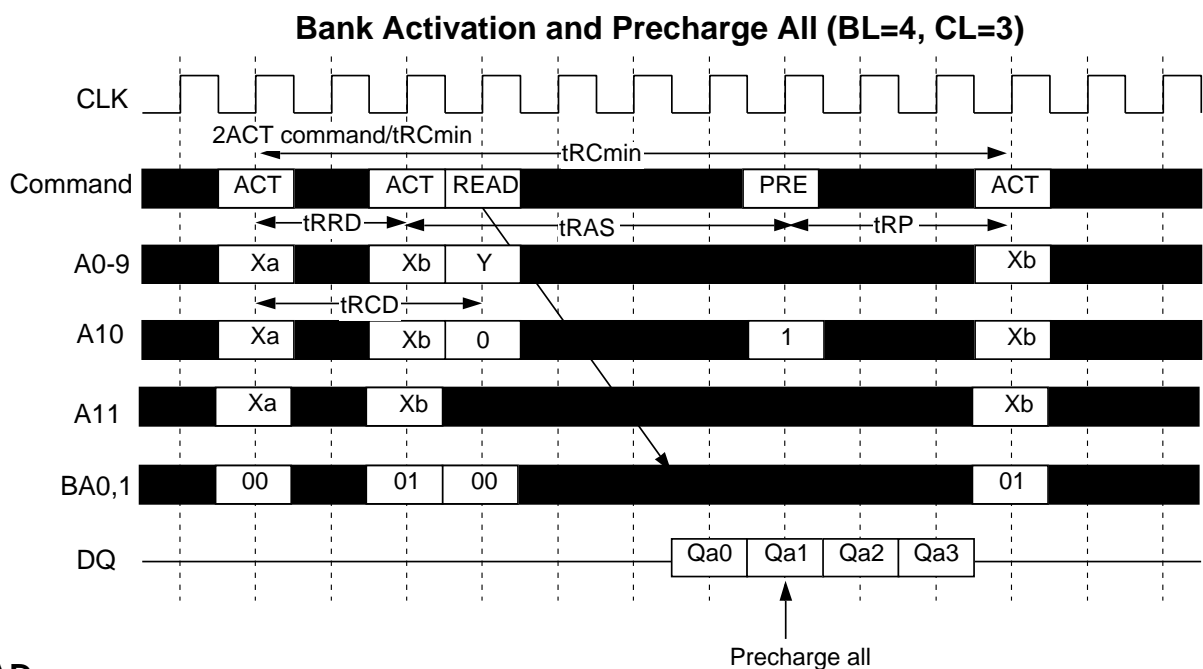
## OPERATION DESCRIPTION

### 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.



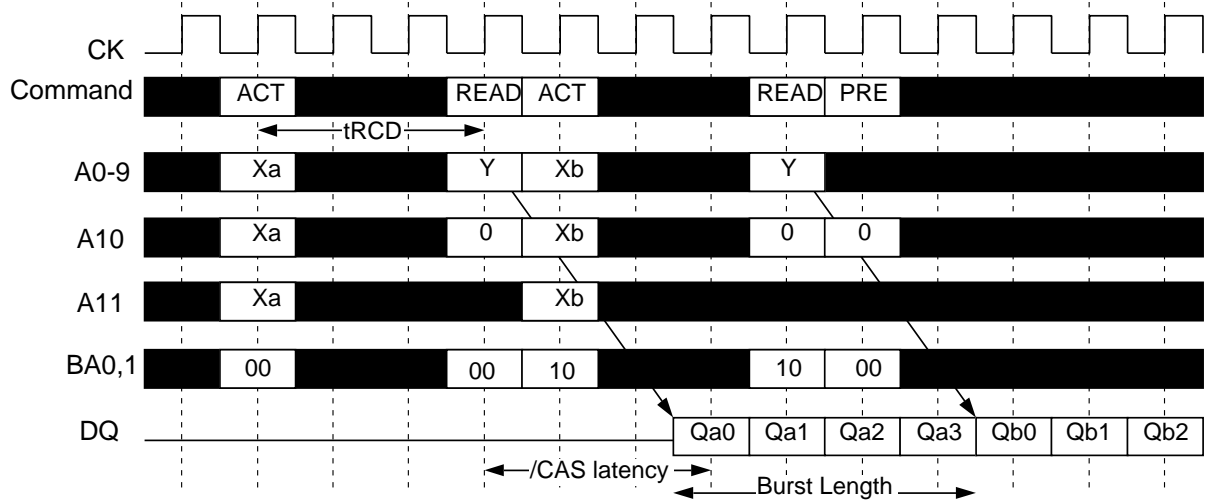
### READ

After tRCD from the bank activation, a READ command can be issued. 1st output 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, 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.

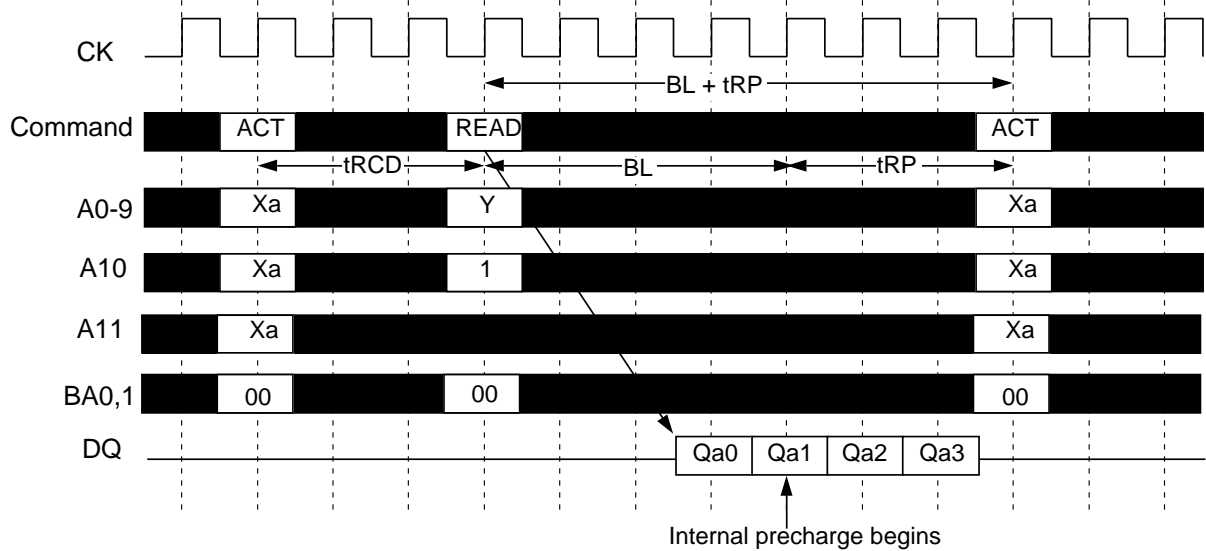
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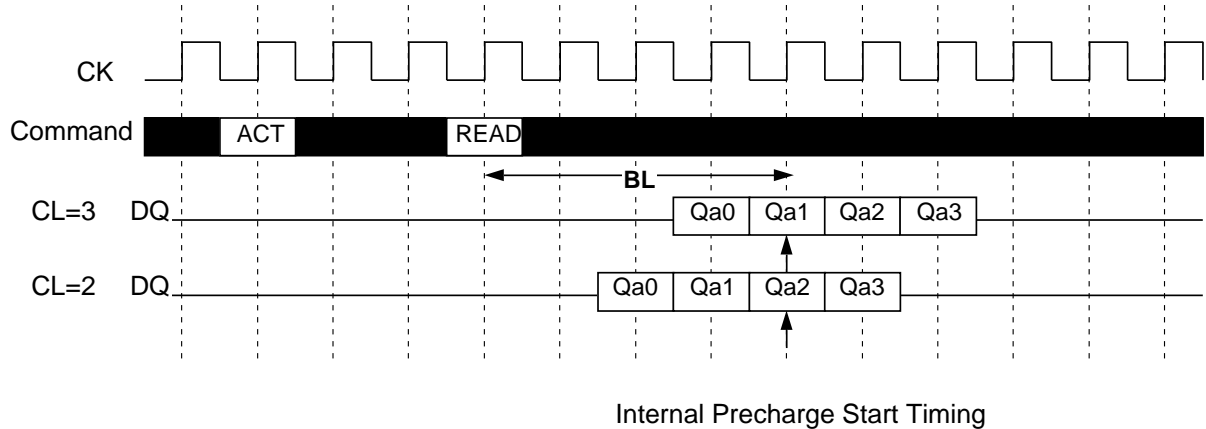
## Multi Bank Interleaving READ (BL=4, CL=3)



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



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



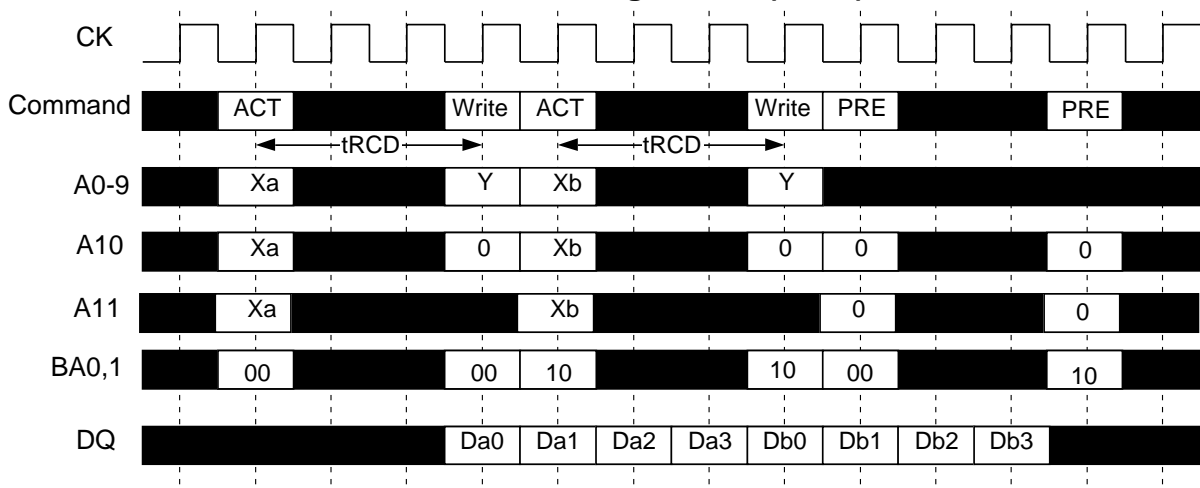
# MH16S72PHB -7,-8,-10

1207959552-BIT (16777216 - WORD BY 72-BIT)SynchronousDRAM

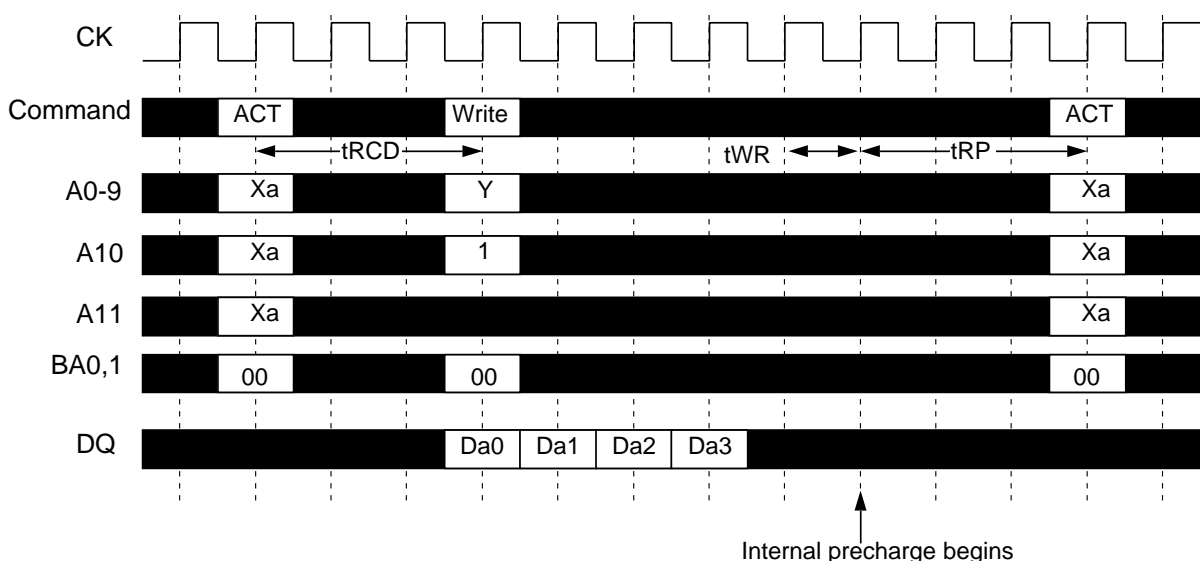
## WRITE

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 A9-0, 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)

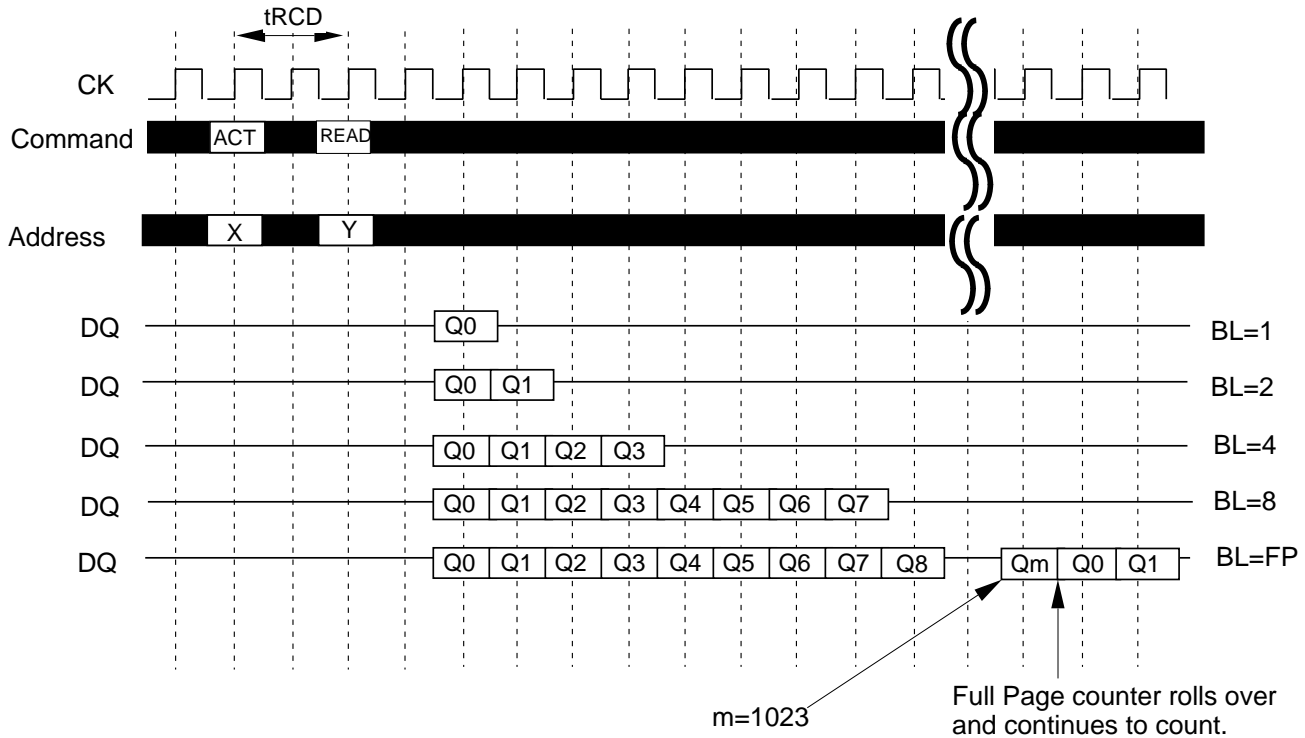


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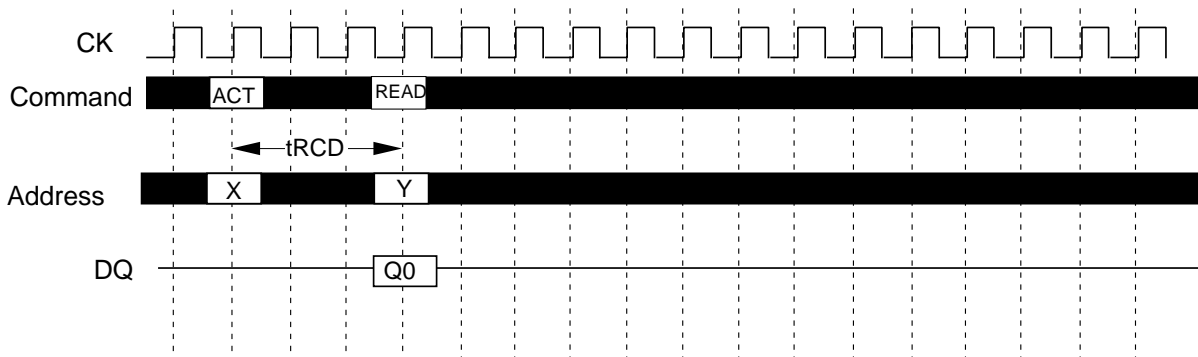
## [ BURST WRITE ]

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.)



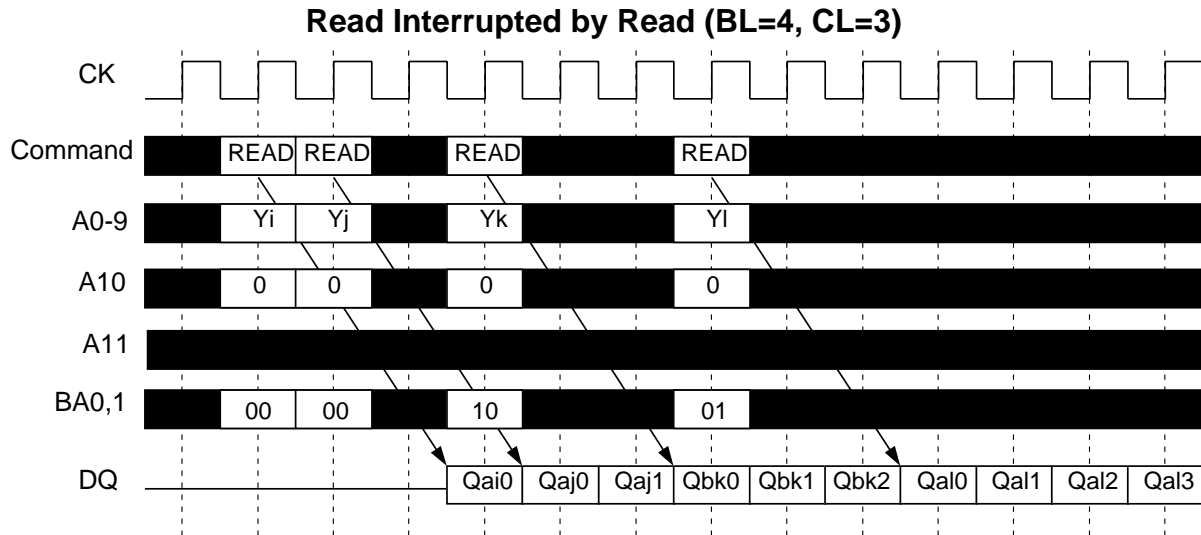
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## BURST INTERRUPTION

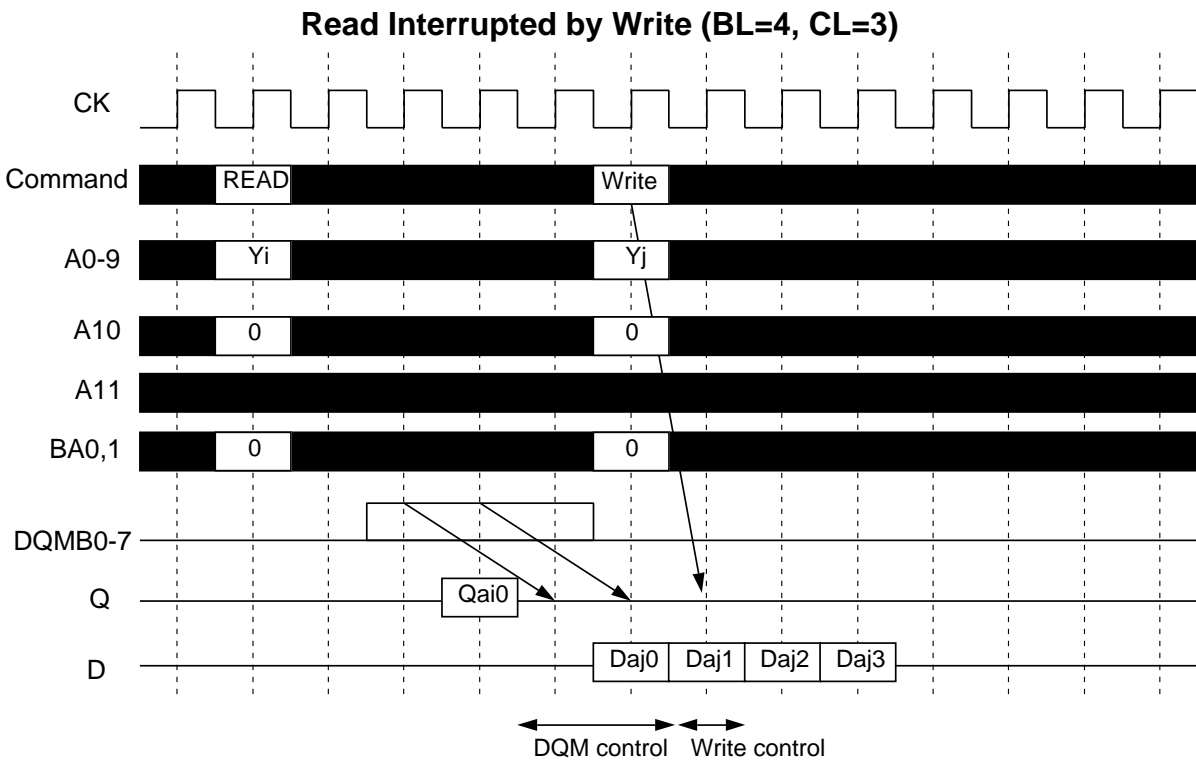
### [ Read Interrupted by Read ]

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.



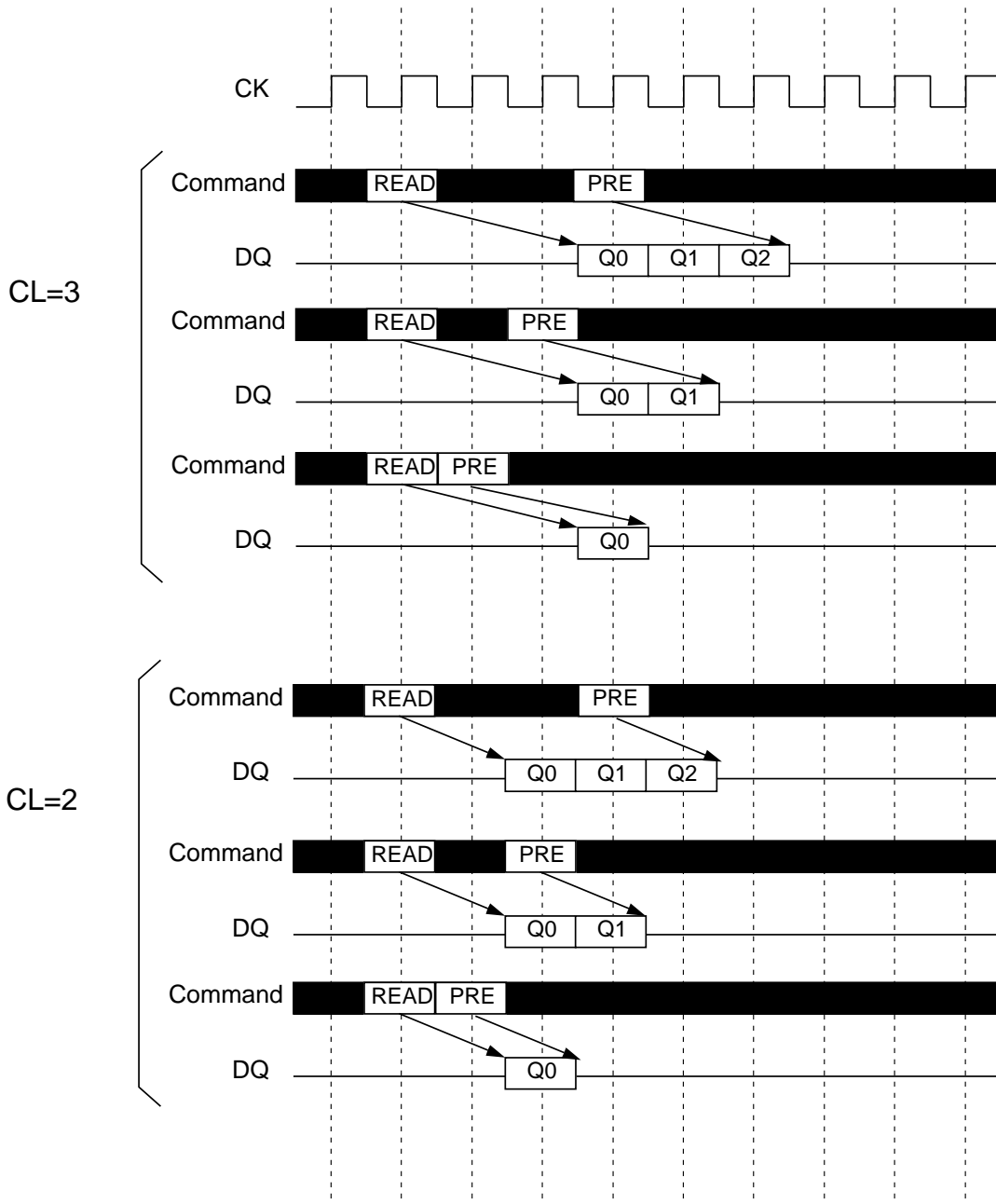
# MH16S72PHB -7,-8,-10

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## [ 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)



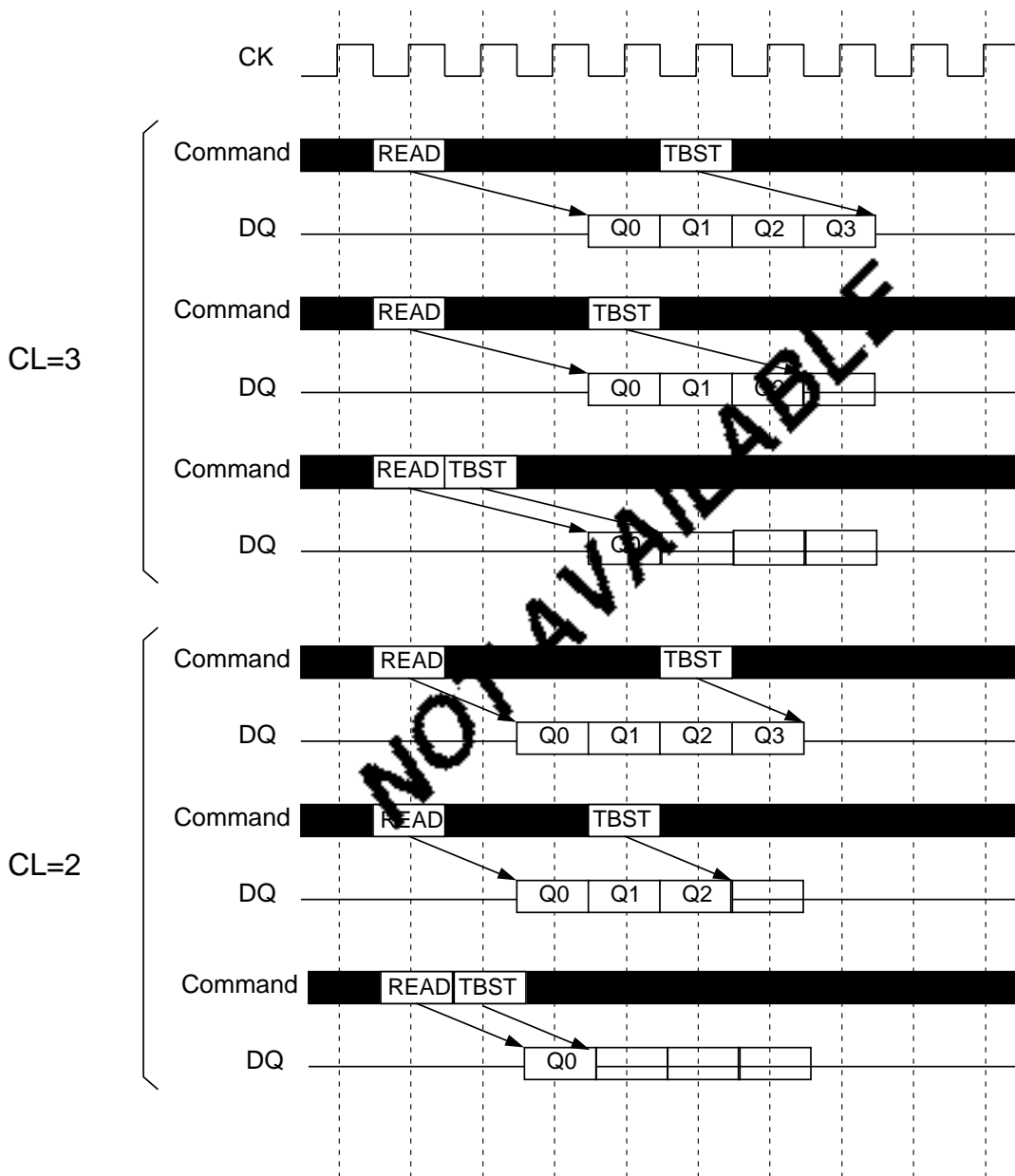
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## [ Read Interrupted by Burst Terminate ]

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)





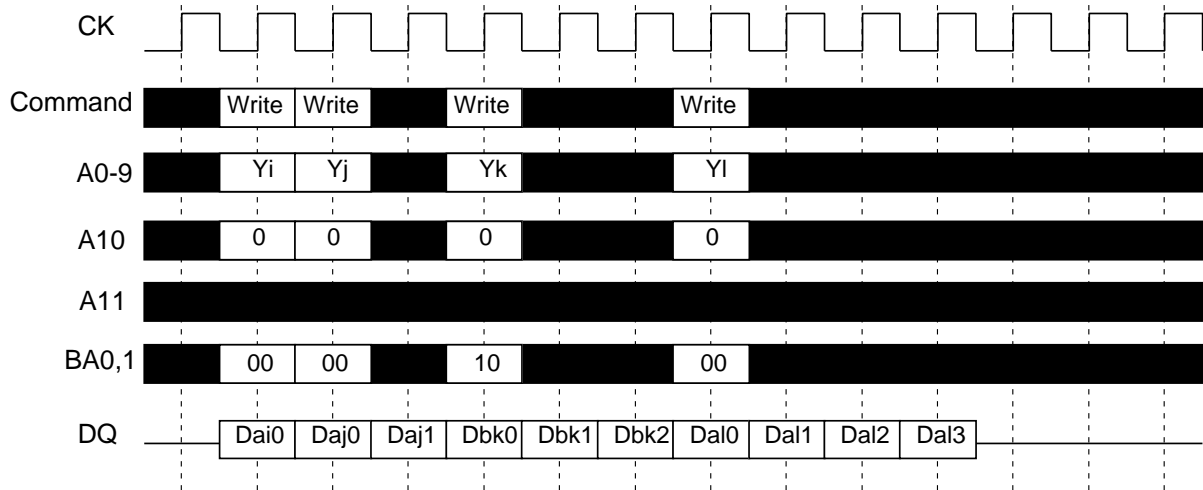
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## [ Write Interrupted by Write ]

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.

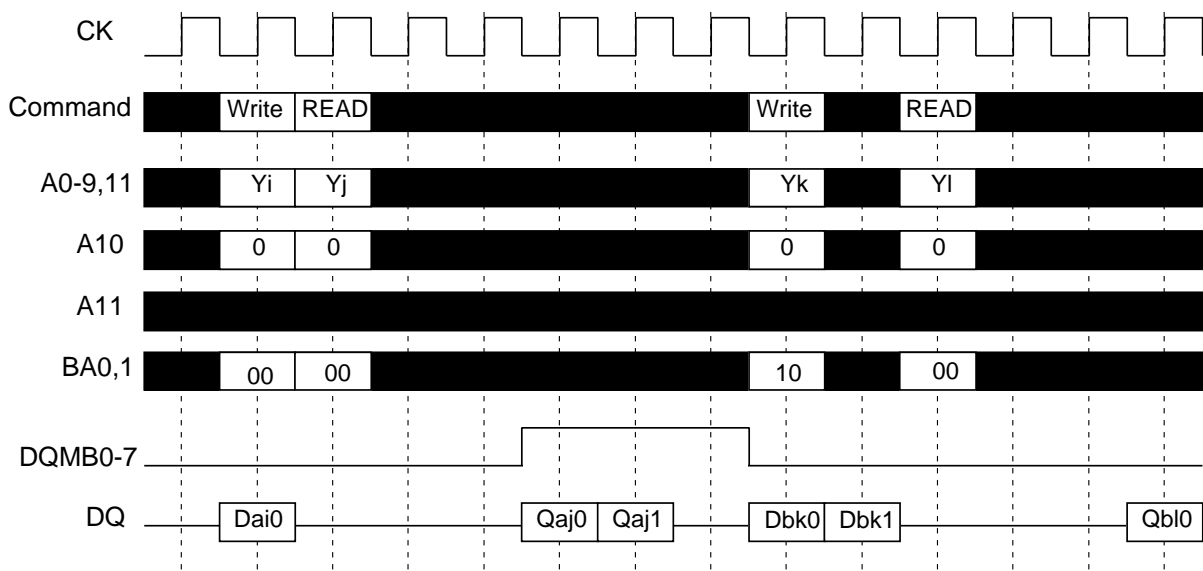
**Write Interrupted by Write (BL=4)**



## [ 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)**



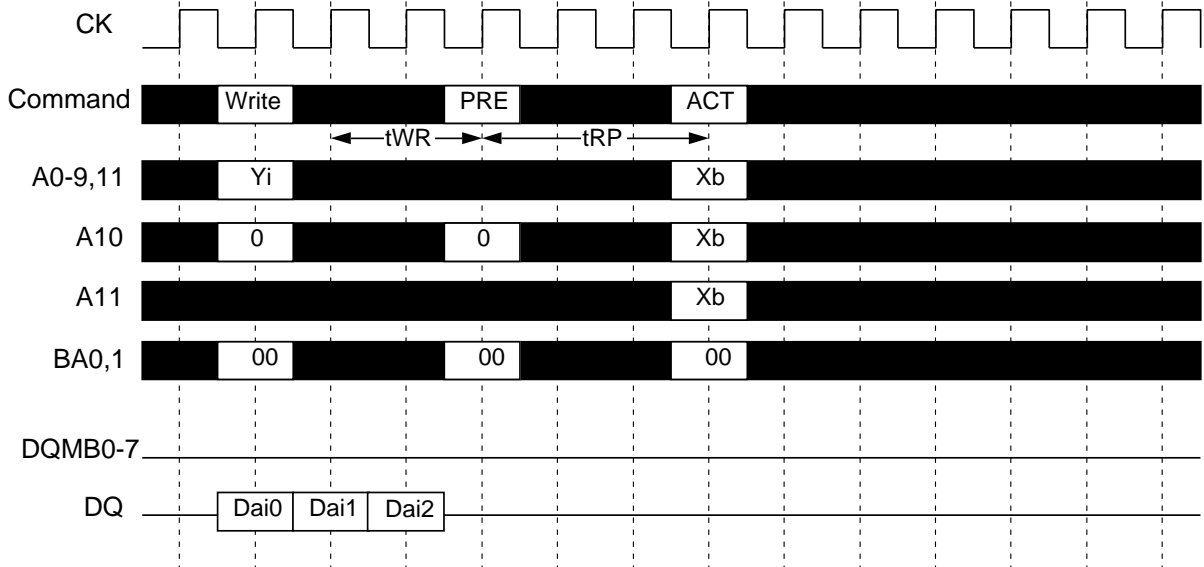
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## [ Write Interrupted by Precharge ]

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.

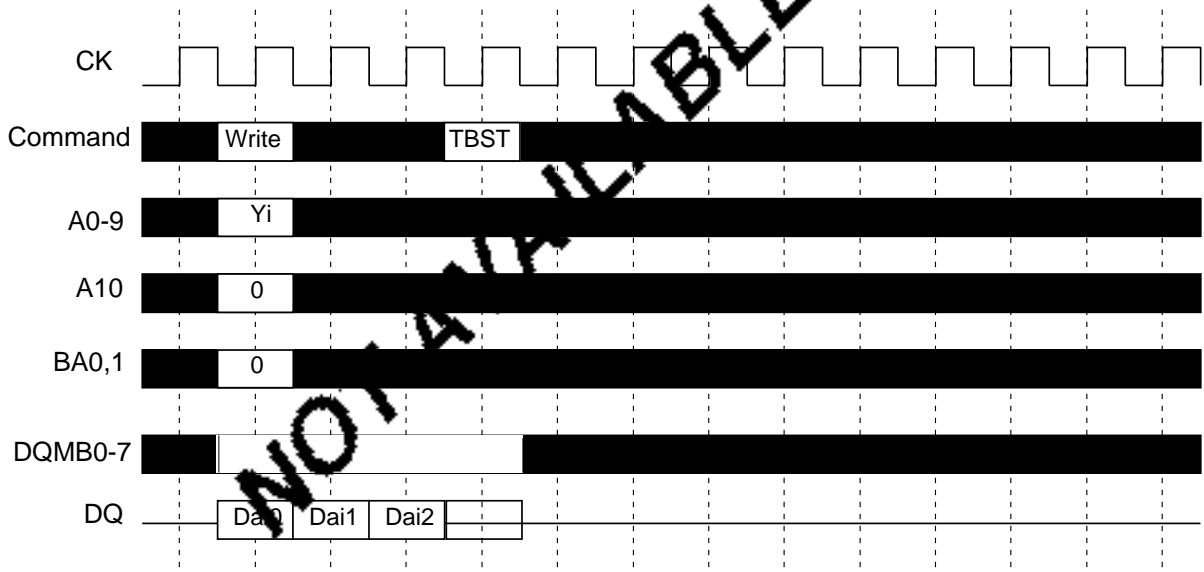
Write Interrupted by Precharge (BL=4)



## [ 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)

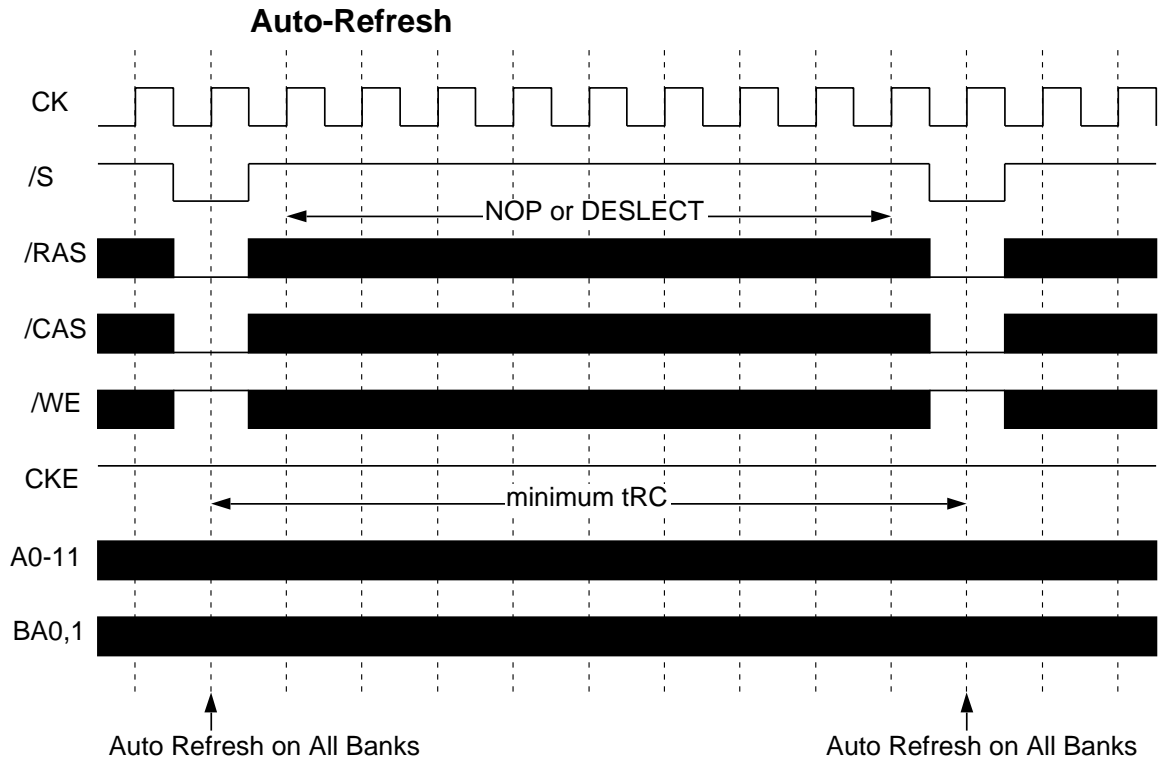


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## AUTO REFRESH

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 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.

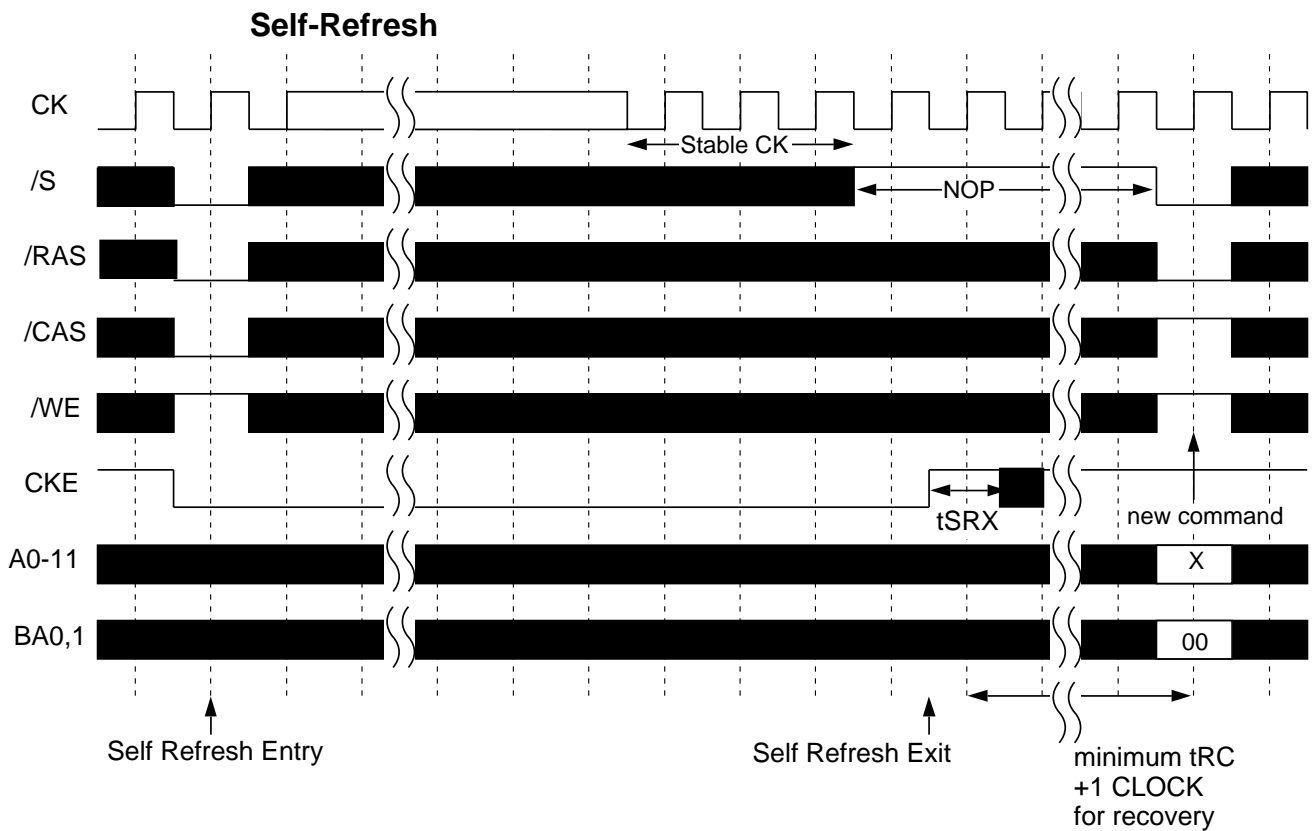


# MH16S72PHB -7,-8,-10

120795952-BIT (16777216 - WORD BY 72-BIT)SynchronousDRAM

## 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  $REFSX$  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.

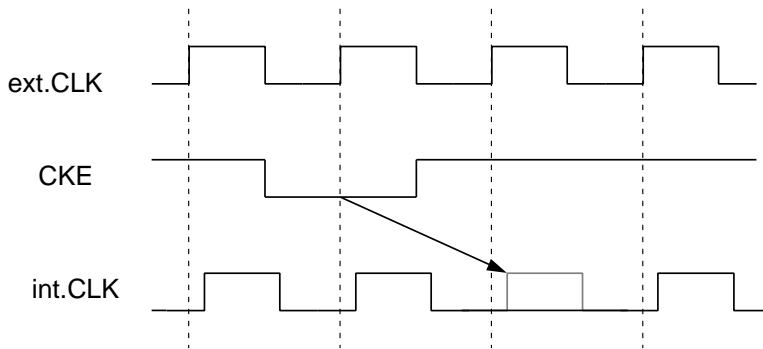


# MH16S72PHB -7,-8,-10

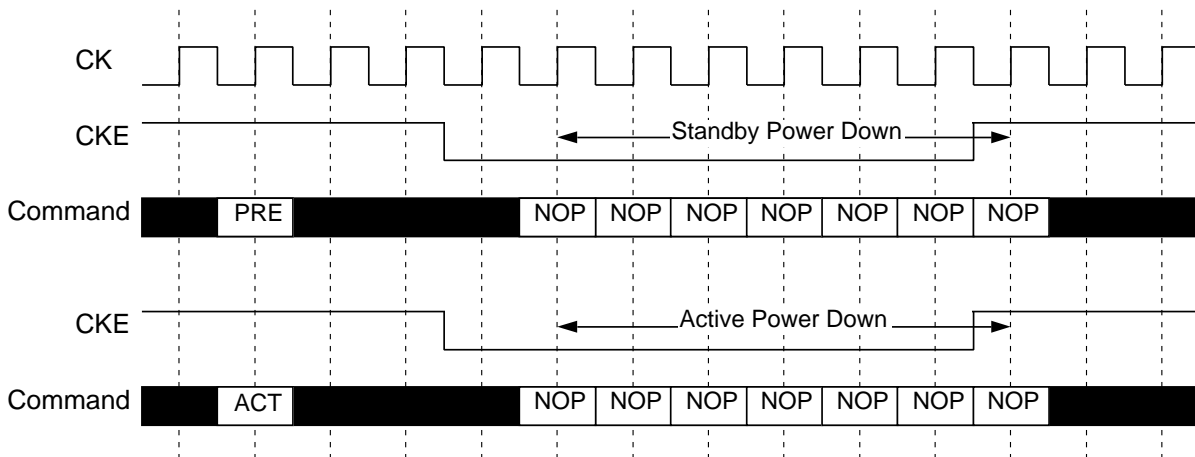
1207959552-BIT (16777216 - WORD BY 72-BIT)SynchronousDRAM

## CLK SUSPEND

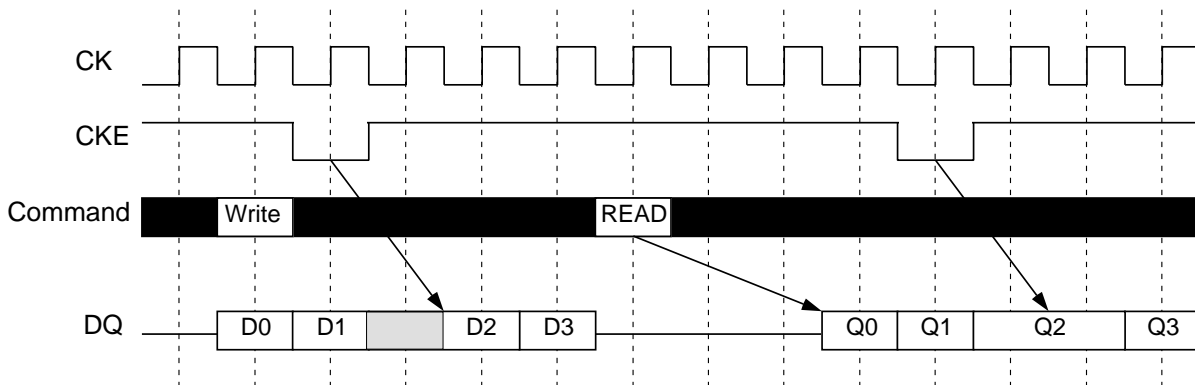
CKE controls the internal CLK at the following cycle. Figure below shows how CKE works. By negating CKE, the next internal CLK is suspended. The purpose of CLK suspend is power down, output suspend or input suspend. CKE is a synchronous input except during the self-refresh mode. CLK suspend can be performed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



### Power Down by CKE



### DQ Suspend by CKE



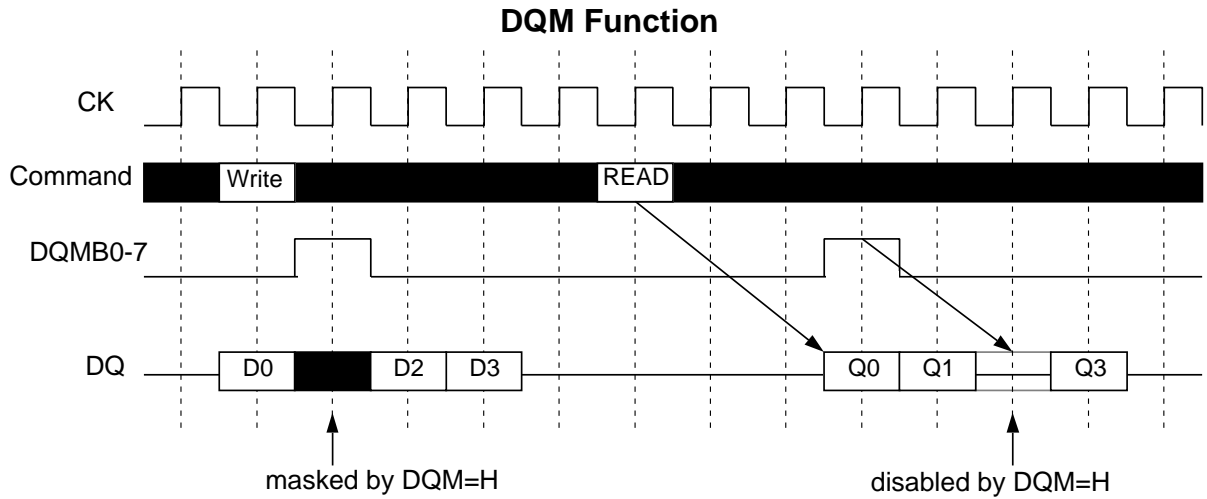
# MH16S72PHB -7,-8,-10

1207959552-BIT (16777216 - WORD BY 72-BIT)SynchronousDRAM

## 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.



**MH16S72PHB -7,-8,-10**

1207959552-BIT (16777216 - WORD BY 72-BIT)SynchronousDRAM

**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<br>f=1MHz<br>Vi=25mVrms | 60           | pF   |
| CI(C)  | Input Capacitance, /RAS,/CAS,/WE |                                  | 60           | pF   |
| CI(K)  | Input Capacitance, CK pin        |                                  | 40           | pF   |
| CI(S)  | Input Capacitance, /CS pin       |                                  | 40           | pF   |
| CI(E)  | Input Capacitance, CKE pin       |                                  | 60           | pF   |
| CI(M)  | Input Capacitance, DQM pin       |                                  | 22           | pF   |
| CI/O   | Input Capacitance, I/O pin       |                                  | 22           | pF   |

# MH16S72PHB -7,-8,-10

1207959552-BIT (16777216 - WORD BY 72-BIT)SynchronousDRAM

## AVERAGE SUPPLY CURRENT from Vdd

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

| Parameter  | Symbol | Test Condition   | Limits (max) |      | Unit | Note |
|--|--------|--|--------------|------|------|------|
|  |        |  | -7, -8       | -10  |      |      |
| operating current one bank active (discrete)                 | Icc1   | tRC=min.tCLK=min, BL=1, CL=3   | 1080         | 855  | mA   | *1   |
| precharge stanby current in non power-down mode /CS>Vcc-0.2V | Icc2N  | tCLK=15ns, CKE = H, VIH > Vcc - 0.2V, VIL < 0.2V                         | 225          | 225  | mA   | *1   |
|  | Icc2NS | CLK=L & CKE=H, VIH > Vcc - 0.2V, VIL < 0.2V all input signals are fixed. | 135          | 135  | mA   | *1   |
| precharge stanby current in power-down mode /CS>Vcc-0.2V     | Icc2P  | tCLK = 15ns, CKE = L   | 18           | 18   | mA   | *1   |
|  | Icc2PS | CLK = L, CKE = L   | 9            | 9    | mA   | *1   |
| active stanby current  | Icc3N  | CKE=H, tCLK=15ns   | 360          | 360  | mA   | *1   |
|  | Icc3NS | CKE=H, CLK=L   | 315          | 315  | mA   | *1   |
| burst current  | Icc4   | tCLK=min, BL=4, CL=3 Aall banks active                                   | 1350         | 1350 | mA   | *1   |
| auto-refresh current   | Icc5   | tRC=min, tCLK=min  | 1800         | 1440 | mA   | *1   |
| self-refresh current   | Icc6   | CKE <0.2V  | 18           | 18   | mA   | *1,2 |
|  |        |  | 7.2          | 7.2  | mA   |      |

Note1:Icc(max) is specified at the output open condition.

Note2: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      | -90    | 90   | uA   |



# MH16S72PHB -7,-8,-10

1207959552-BIT (16777216 - WORD BY 72-BIT)SynchronousDRAM

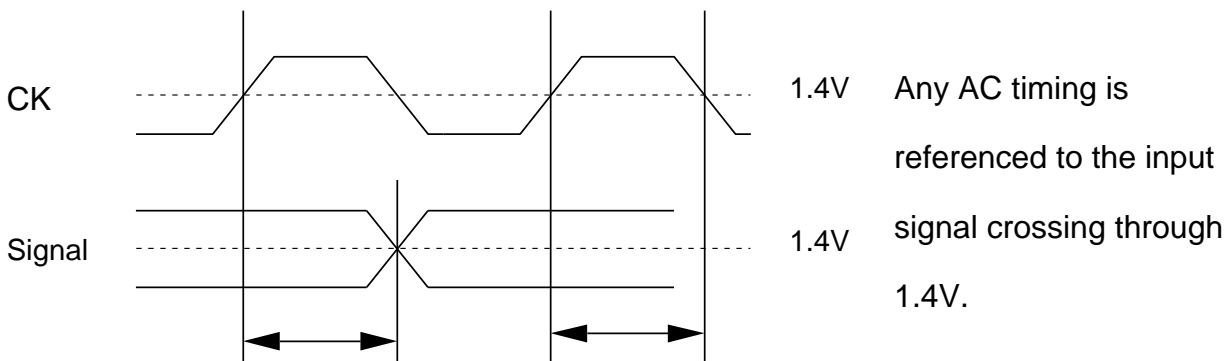
## AC TIMING REQUIREMENTS (SDRAM Component)

(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 |    |
|--------|------------------------------|--------|------|------|------|------|------|------|----|
|        |                              | -7     |      | -8   |      | -10  |      |      |    |
|        |                              | Min.   | Max. | Min. | Max. | Min. | Max. |      |    |
| tCLK   | CK cycle time                | CL=2   | 10   |      | 13   |      | 15   |      | ns |
|        |                              | CL=3   | 10   |      | 10   |      | 10   |      | ns |
| tCH    | CK High pulse width          | 3      |      | 3    |      | 4    |      | ns   |    |
| tCL    | CK Low pulse width           | 3      |      | 3    |      | 4    |      | ns   |    |
| tT     | Transition time of CK        | 1      | 10   | 1    | 10   | 1    | 10   | ns   |    |
| tIS    | Input Setup time(all inputs) | 2      |      | 2    |      | 3    |      | ns   |    |
| tIH    | Input Hold time(all inputs)  | 1      |      | 1    |      | 1    |      | ns   |    |
| tRC    | Row cycle time               | 70     |      | 70   |      | 90   |      | ns   |    |
| tRCD   | Row to Column Delay          | 20     |      | 20   |      | 30   |      | ns   |    |
| tRAS   | Row Active time              | 50     | 100K | 50   | 100K | 60   | 100K | ns   |    |
| tRP    | Row Precharge time           | 20     |      | 20   |      | 30   |      | ns   |    |
| tWR    | Write Recovery time          | 20     |      | 20   |      | 15   |      | ns   |    |
| tRRD   | Act to Act Delay time        | 20     |      | 20   |      | 20   |      | ns   |    |
| tRSC   | Mode Register Set Cycle time | 20     |      | 20   |      | 20   |      | ns   |    |
| tSRX   | Self Refresh Exit time       | 10     |      | 10   |      | 10   |      | ns   |    |
| tPDE   | Power Down Exit time         | 10     |      | 10   |      | 10   |      | ns   |    |
| tREF   | Refresh Interval time        |        | 64   |      | 64   |      | 64   | ms   |    |



# MH16S72PHB -7,-8,-10

1207959552-BIT (16777216 - WORD BY 72-BIT) Synchronous DRAM

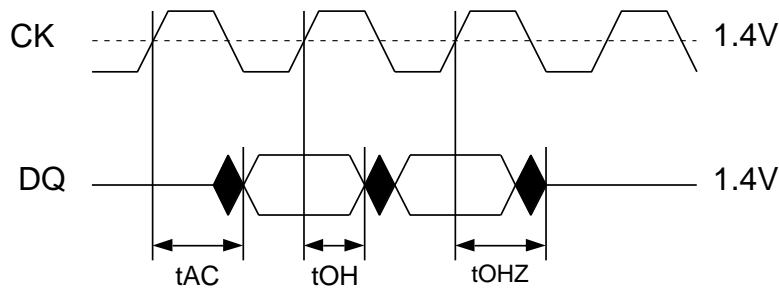
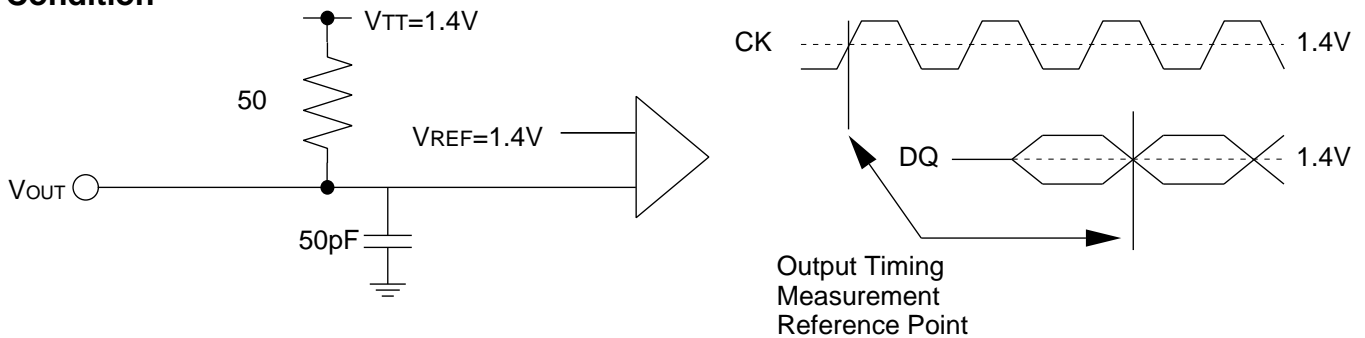
## SWITCHING CHARACTERISTICS (SDRAM Component)

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

| Symbol | Parameter                                 | Limits |      |      |      |      |      | Unit |    |
|--------|---|--------|------|------|------|------|------|------|----|
|        |   | -7     |      | -8   |      | -10  |      |      |    |
|        |   | Min.   | Max. | Min. | Max. | Min. | Max. |      |    |
| tAC    | Access time from CK                       | CL=2   |      | 6    |      | 7    |      | 8    | ns |
|        |   | CL=3   |      | 6    |      | 6    |      | 8    | ns |
| tOH    | Output Hold time from CK                  | 3      |      | 3    |      | 3    |      | 3    | ns |
| tOLZ   | Delay time, output low impedance from CK  | 0      |      | 0    |      | 0    |      | 0    | ns |
| tOHZ   | Delay time, output high impedance from CK | 3      | 6    | 3    | 6    | 3    | 8    | 3    | ns |

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

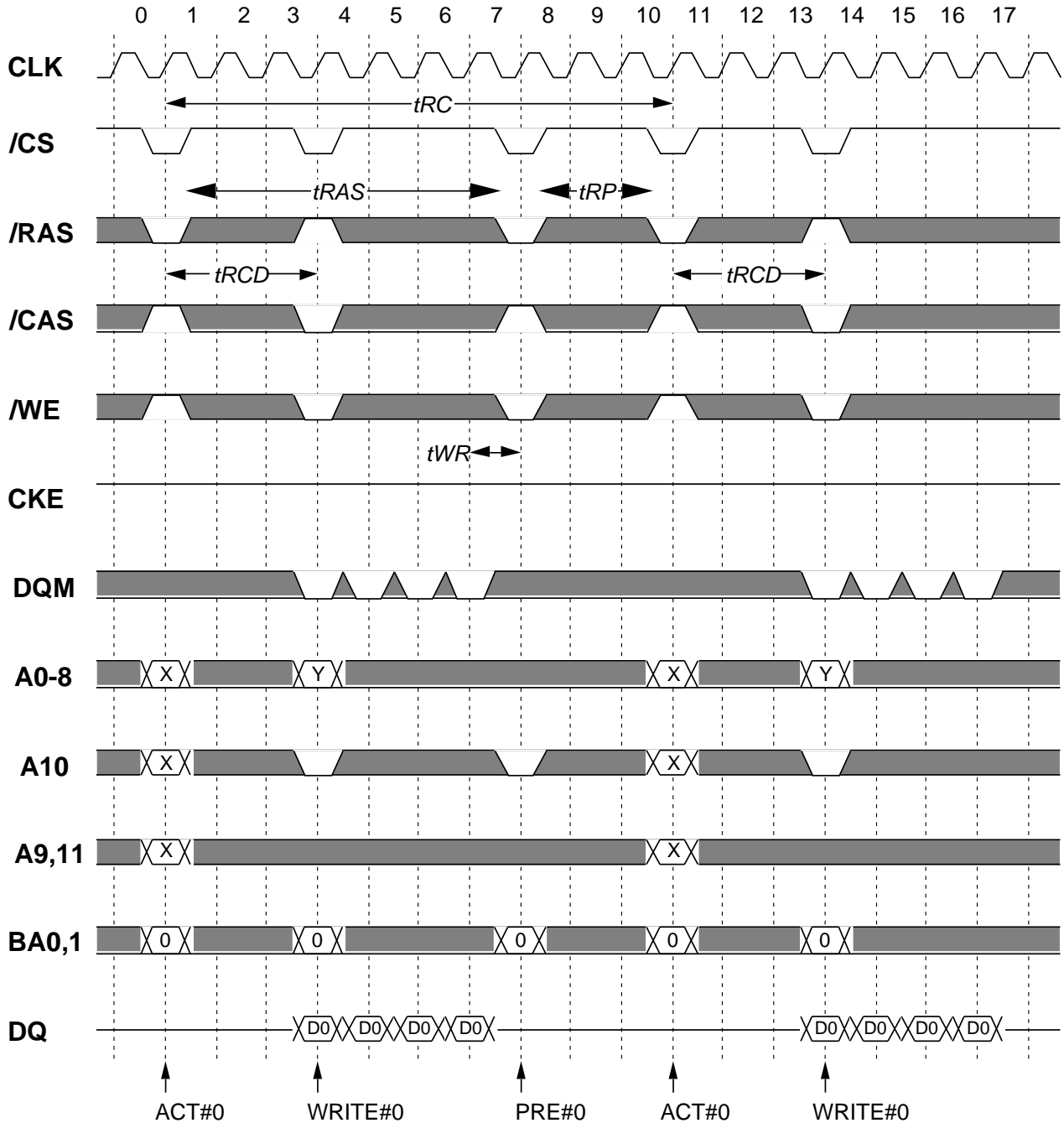
### Output Load Condition



# MH16S72PHB -7,-8,-10

1207959552-BIT (16777216 - WORD BY 72-BIT) Synchronous DRAM

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

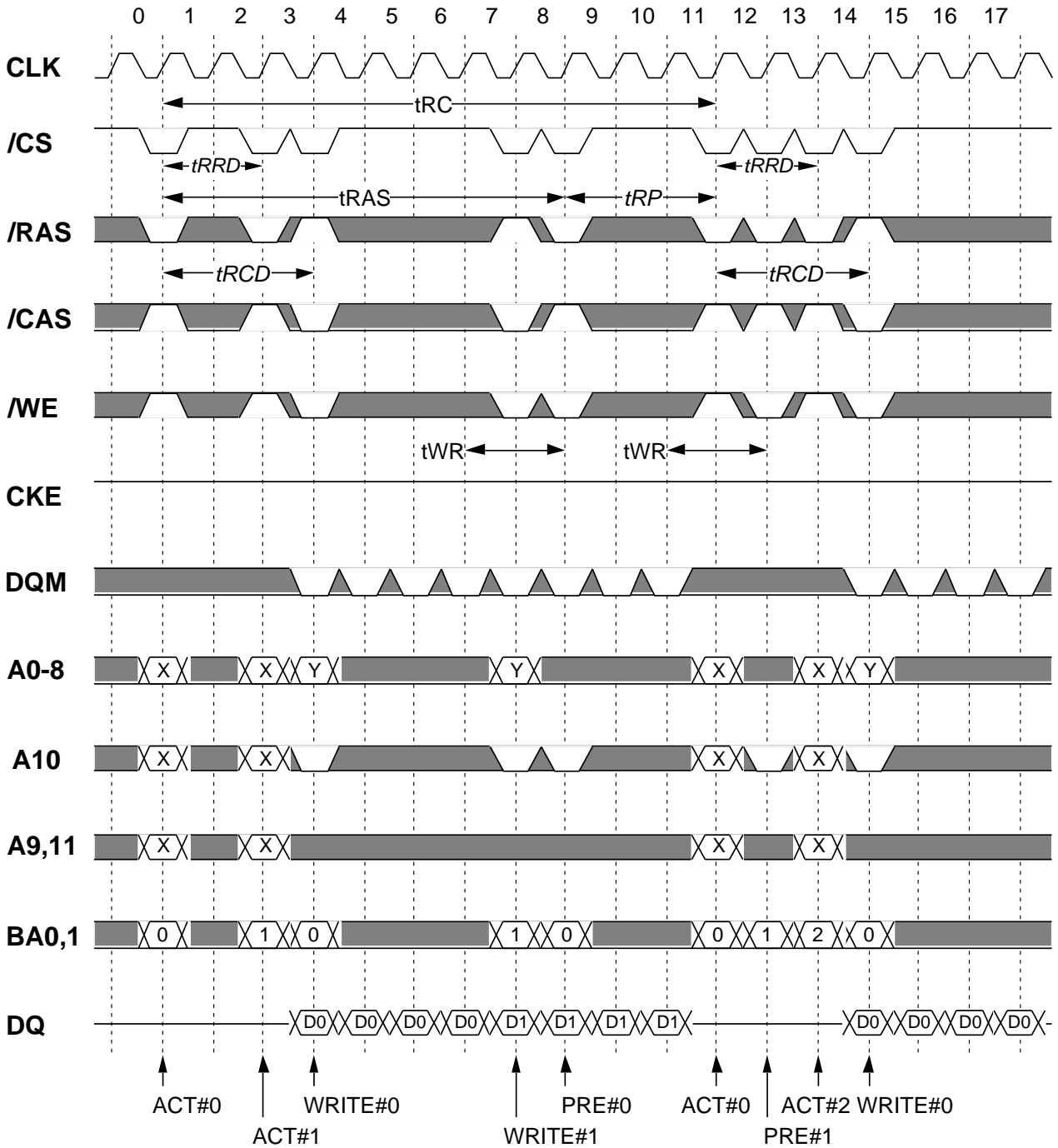


*Italic parameter* indicates minimum case

# MH16S72PHB -7,-8,-10

1207959552-BIT (16777216 - WORD BY 72-BIT) Synchronous DRAM

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

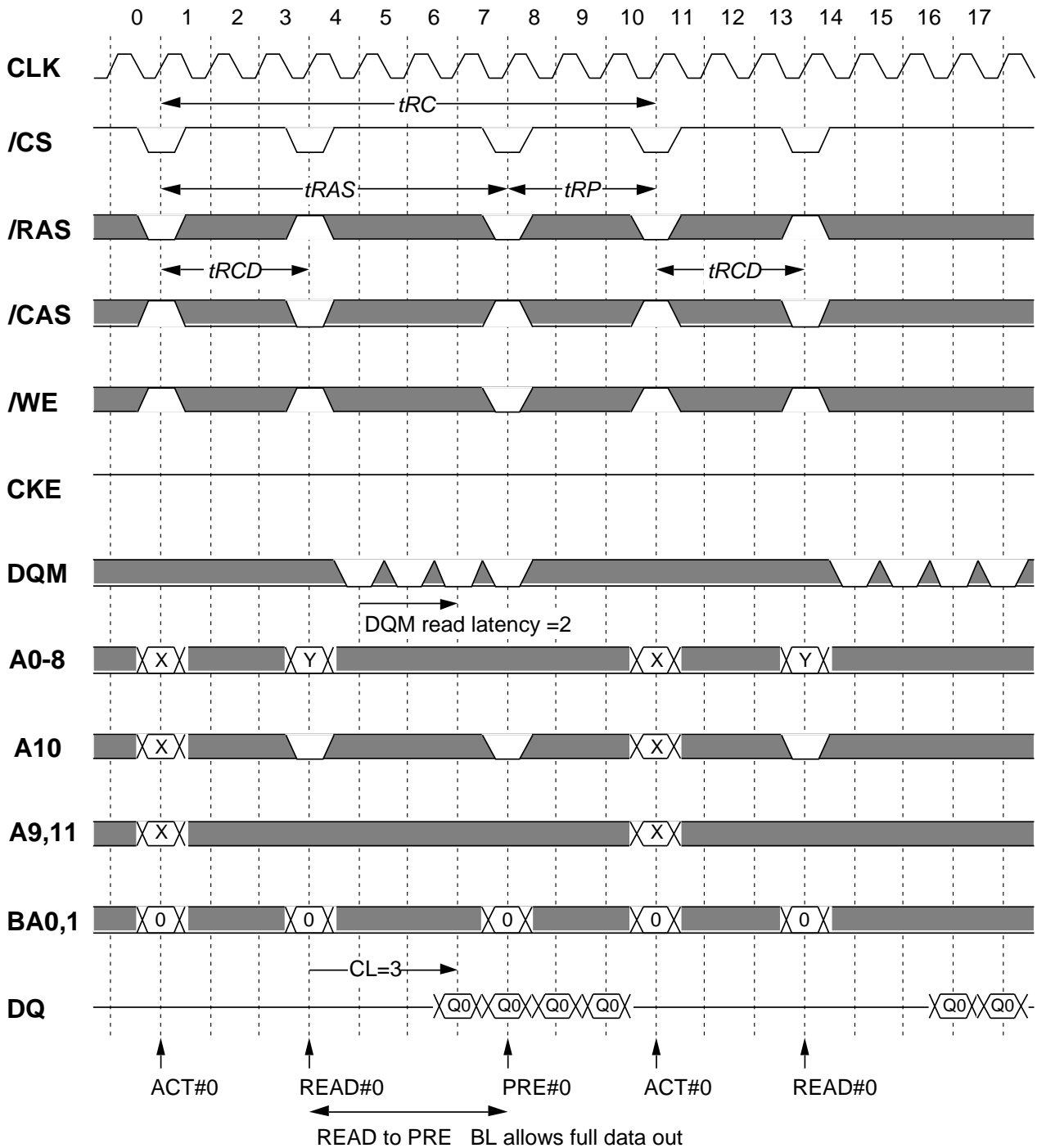


*Italic parameter* indicates minimum case

# MH16S72PHB -7,-8,-10

1207959552-BIT (16777216 - WORD BY 72-BIT) Synchronous DRAM

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

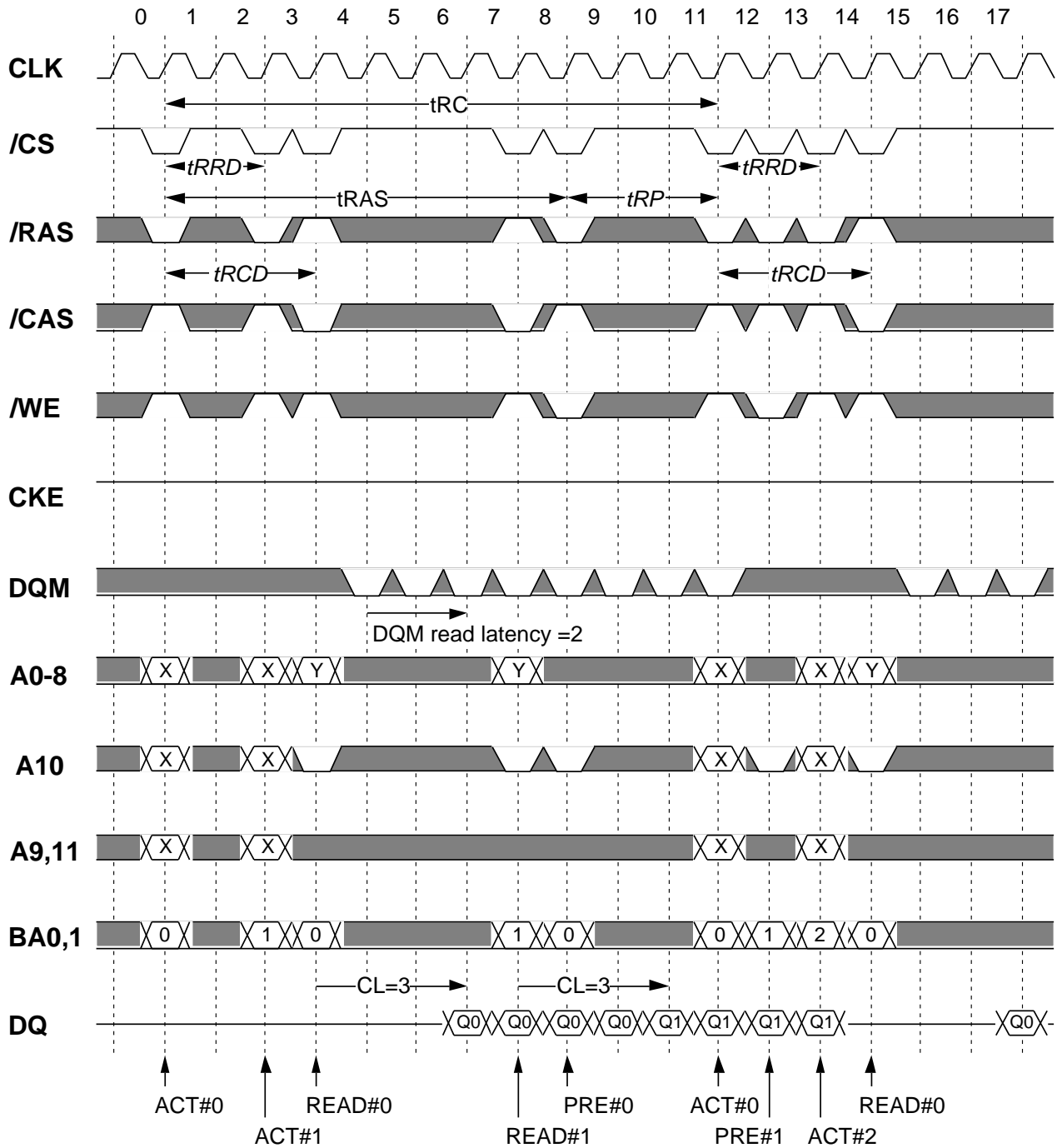


*Italic parameter* indicates minimum case

# MH16S72PHB -7,-8,-10

1207959552-BIT (16777216 - WORD BY 72-BIT) Synchronous DRAM

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

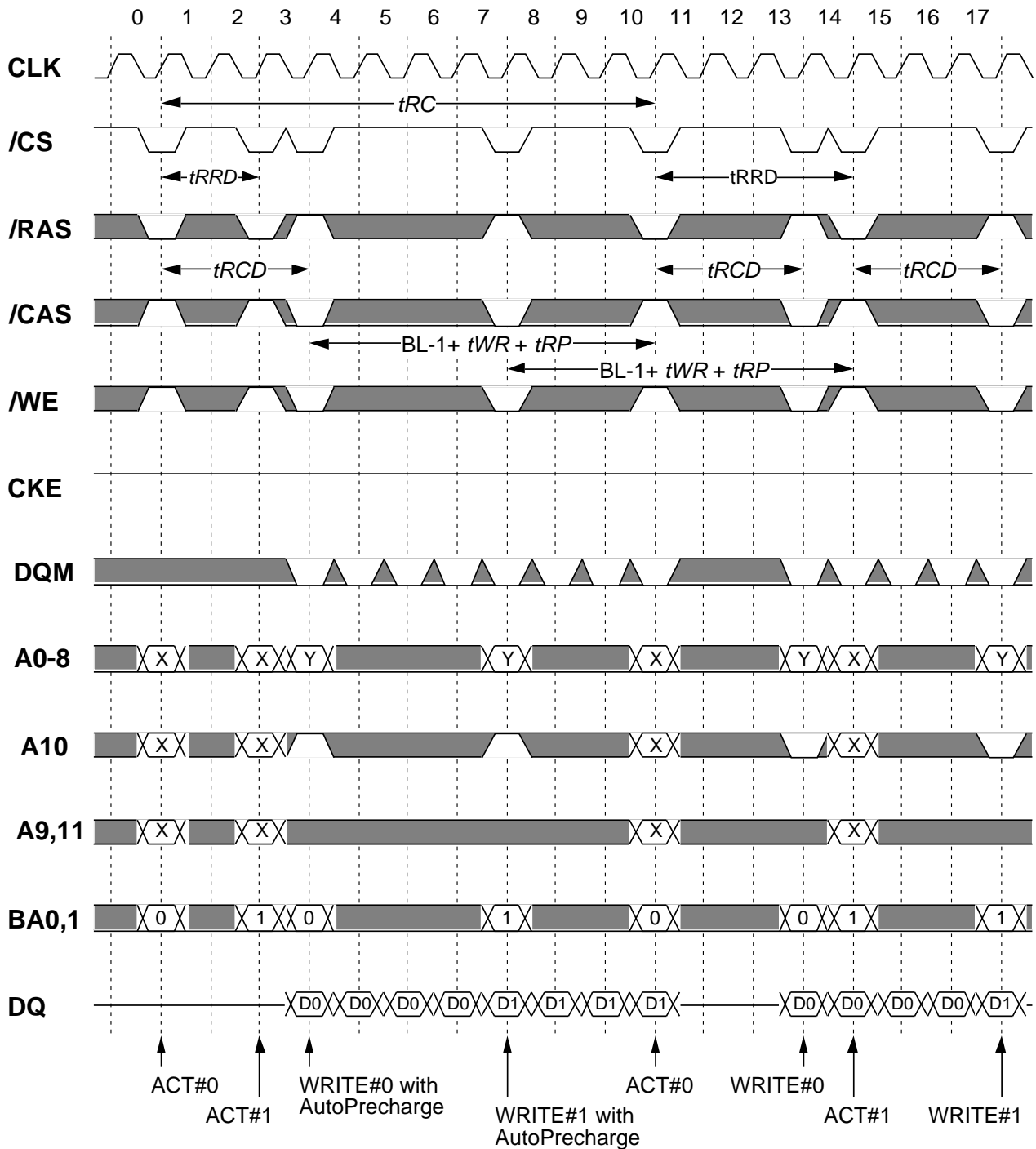


*Italic parameter* indicates minimum case

# MH16S72PHB -7,-8,-10

1207959552-BIT (16777216 - WORD BY 72-BIT)SynchronousDRAM

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

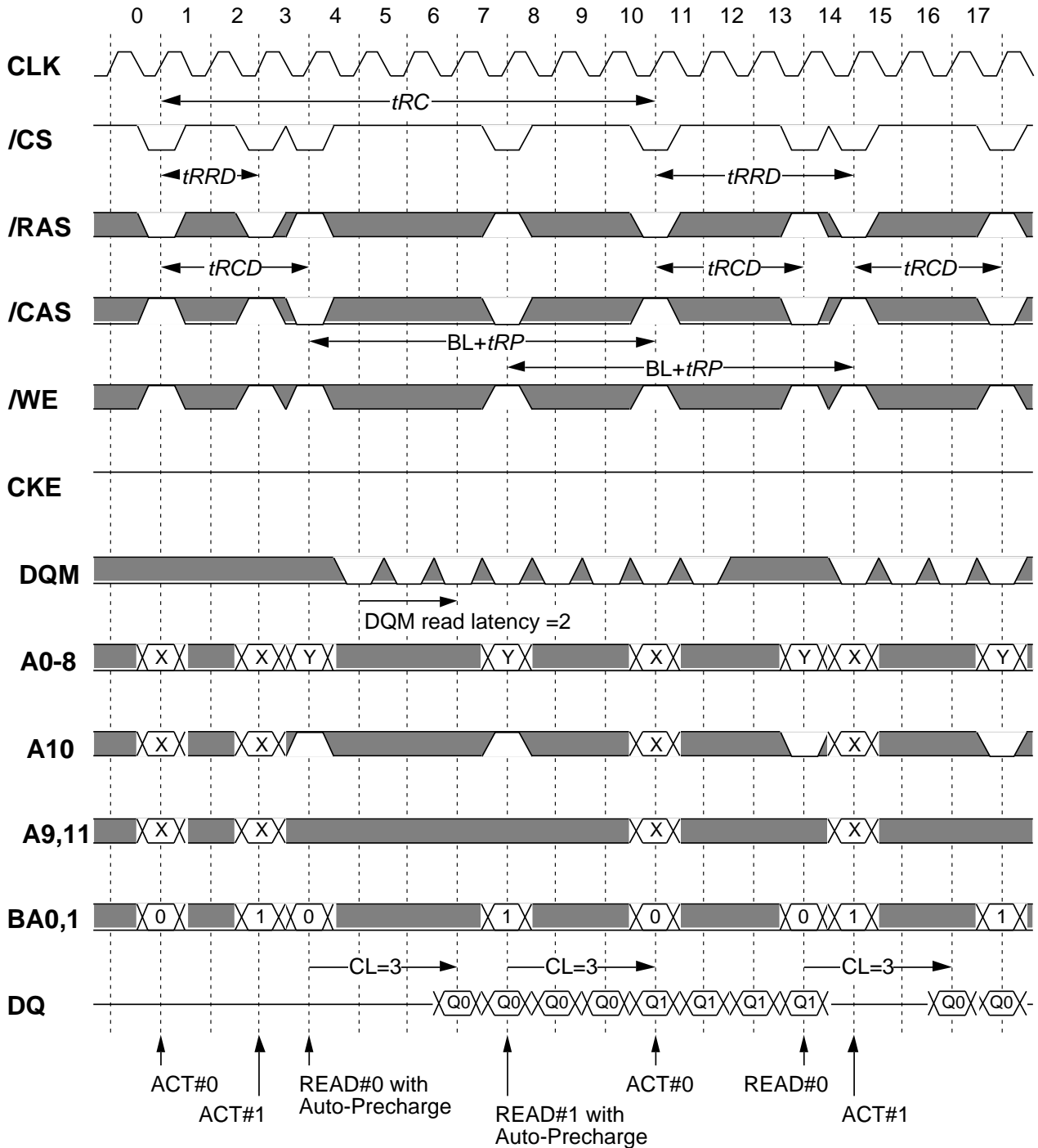


*Italic parameter* indicates minimum case

# MH16S72PHB -7,-8,-10

1207959552-BIT (16777216 - WORD BY 72-BIT)SynchronousDRAM

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



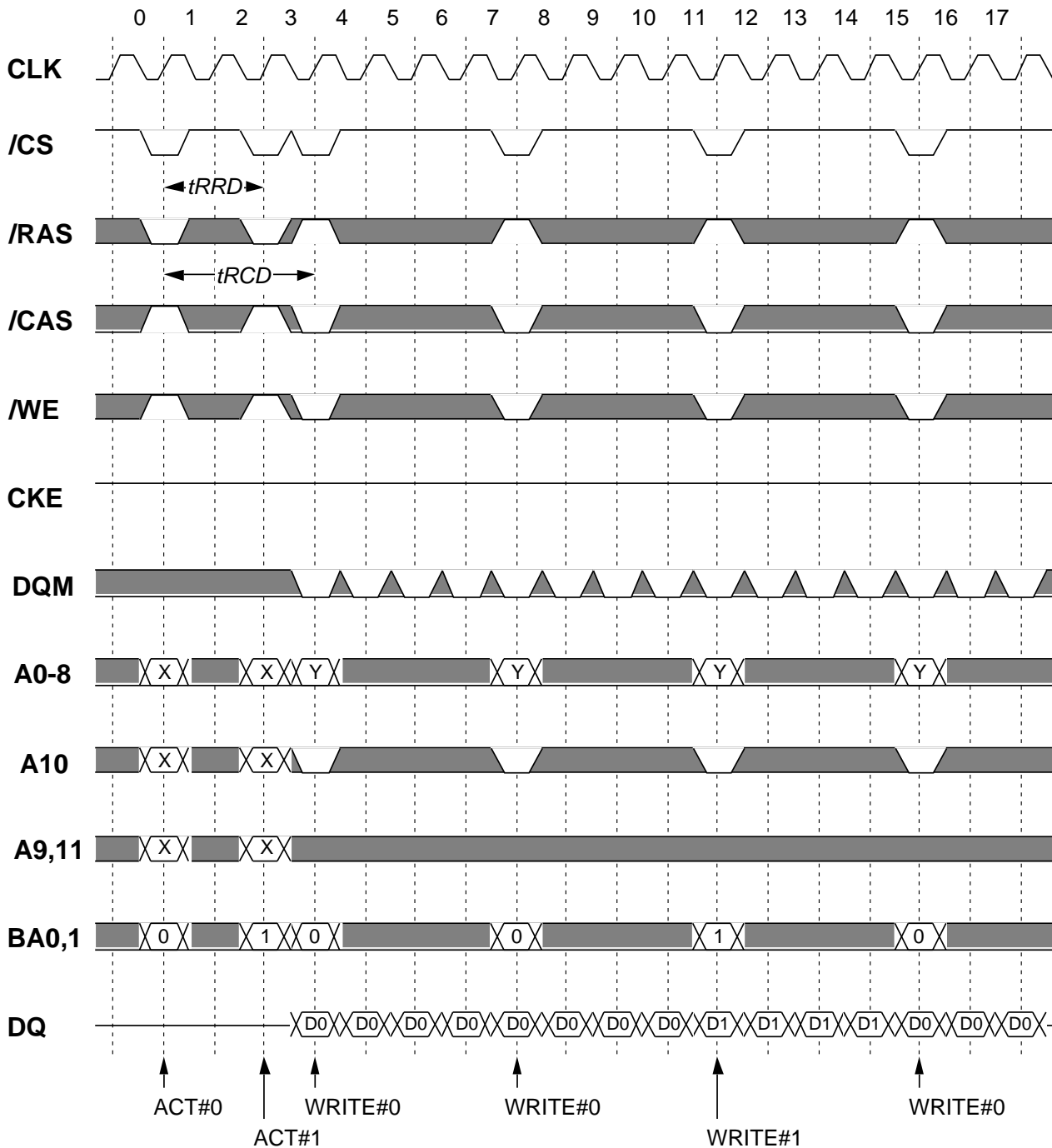
*Italic parameter* indicates minimum case



# MH16S72PHB -7,-8,-10

1207959552-BIT (16777216 - WORD BY 72-BIT) Synchronous DRAM

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

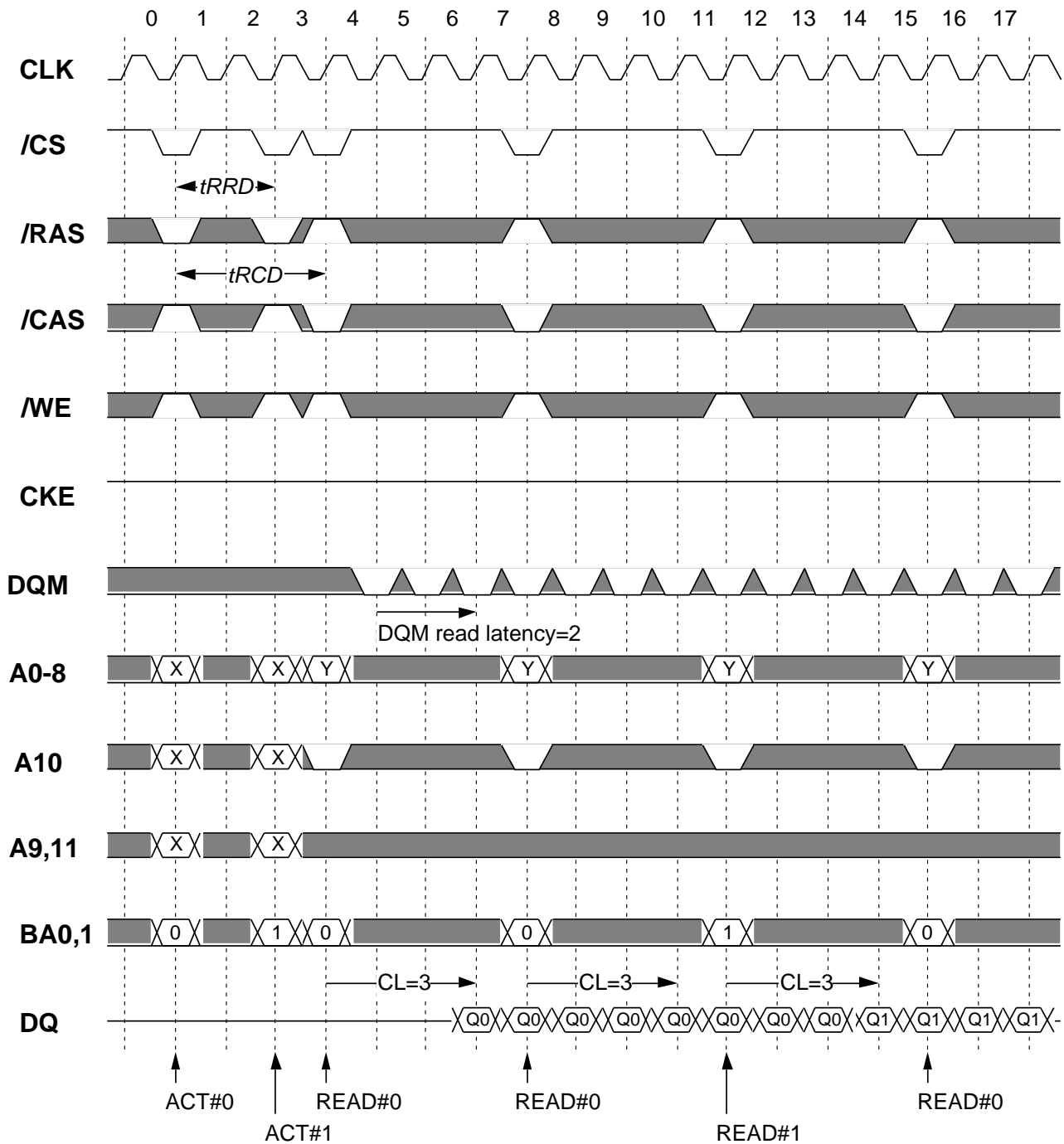


*Italic parameter* indicates minimum case

# MH16S72PHB -7,-8,-10

1207959552-BIT (16777216 - WORD BY 72-BIT) Synchronous DRAM

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

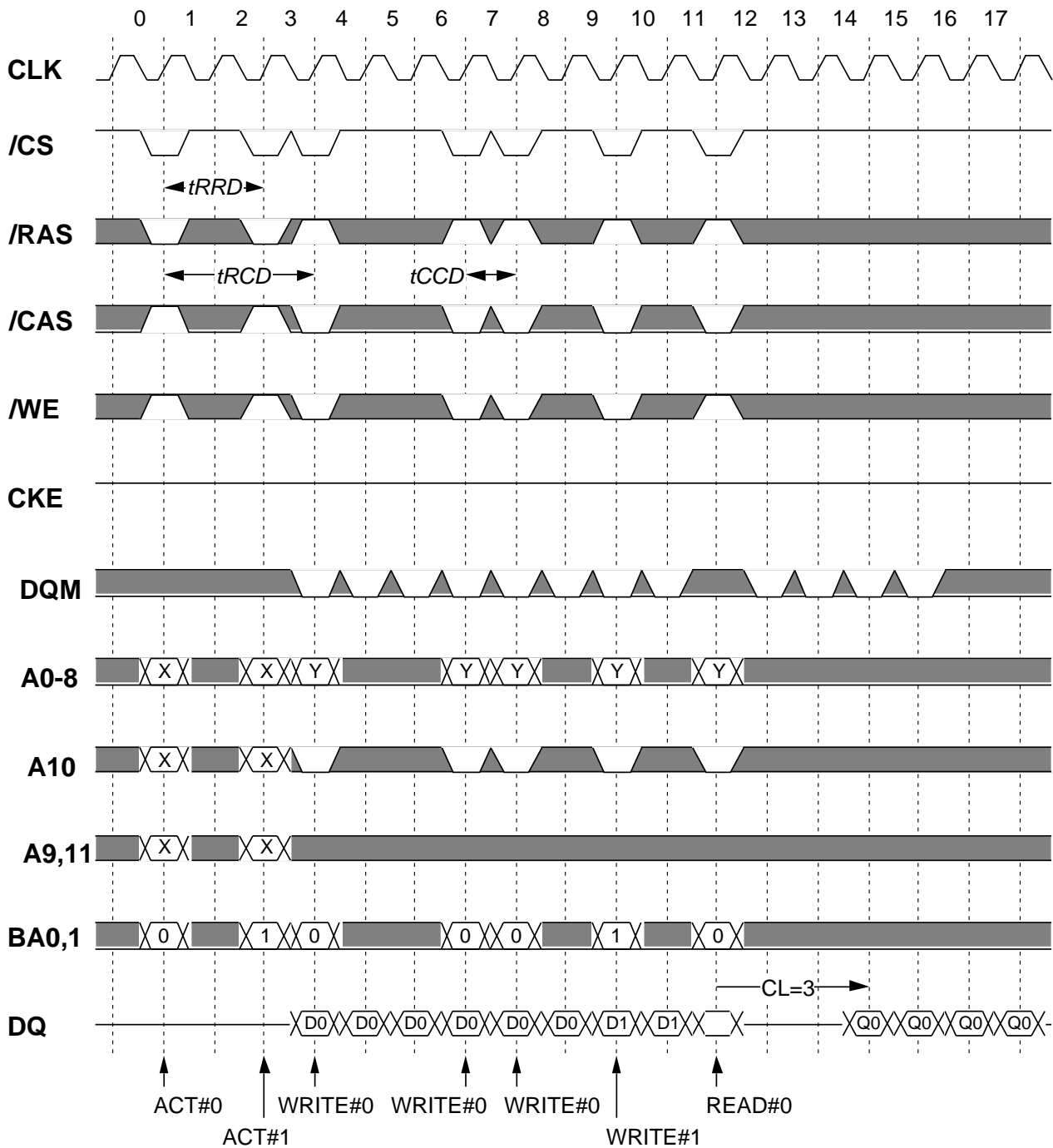


*Italic parameter* indicates minimum case

# MH16S72PHB -7,-8,-10

1207959552-BIT (16777216 - WORD BY 72-BIT) Synchronous DRAM

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



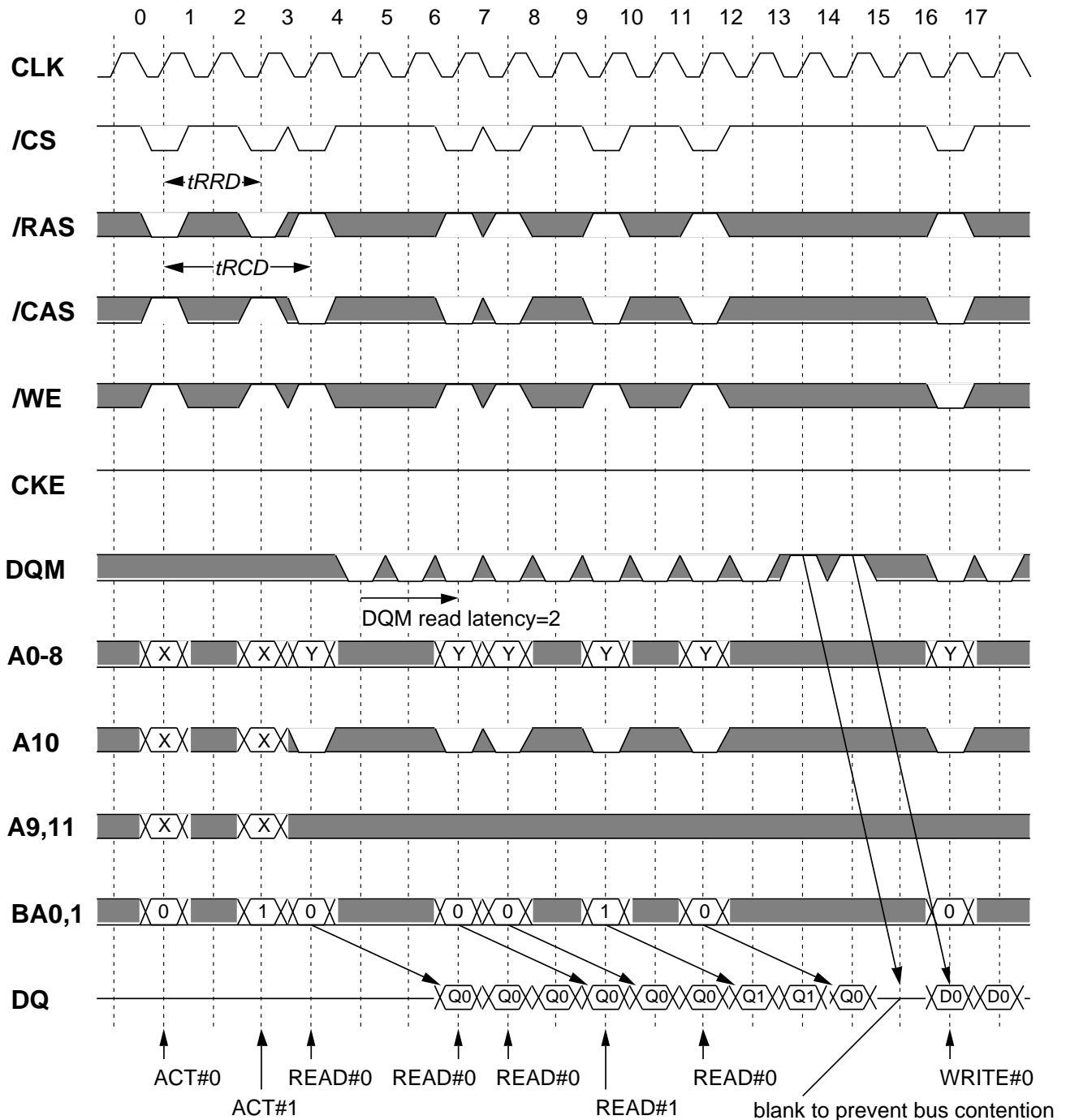
Burst Write can be interrupted by Write or Read of any active bank.

*Italic parameter* indicates minimum case

# MH16S72PHB -7,-8,-10

1207959552-BIT (16777216 - WORD BY 72-BIT) Synchronous DRAM

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



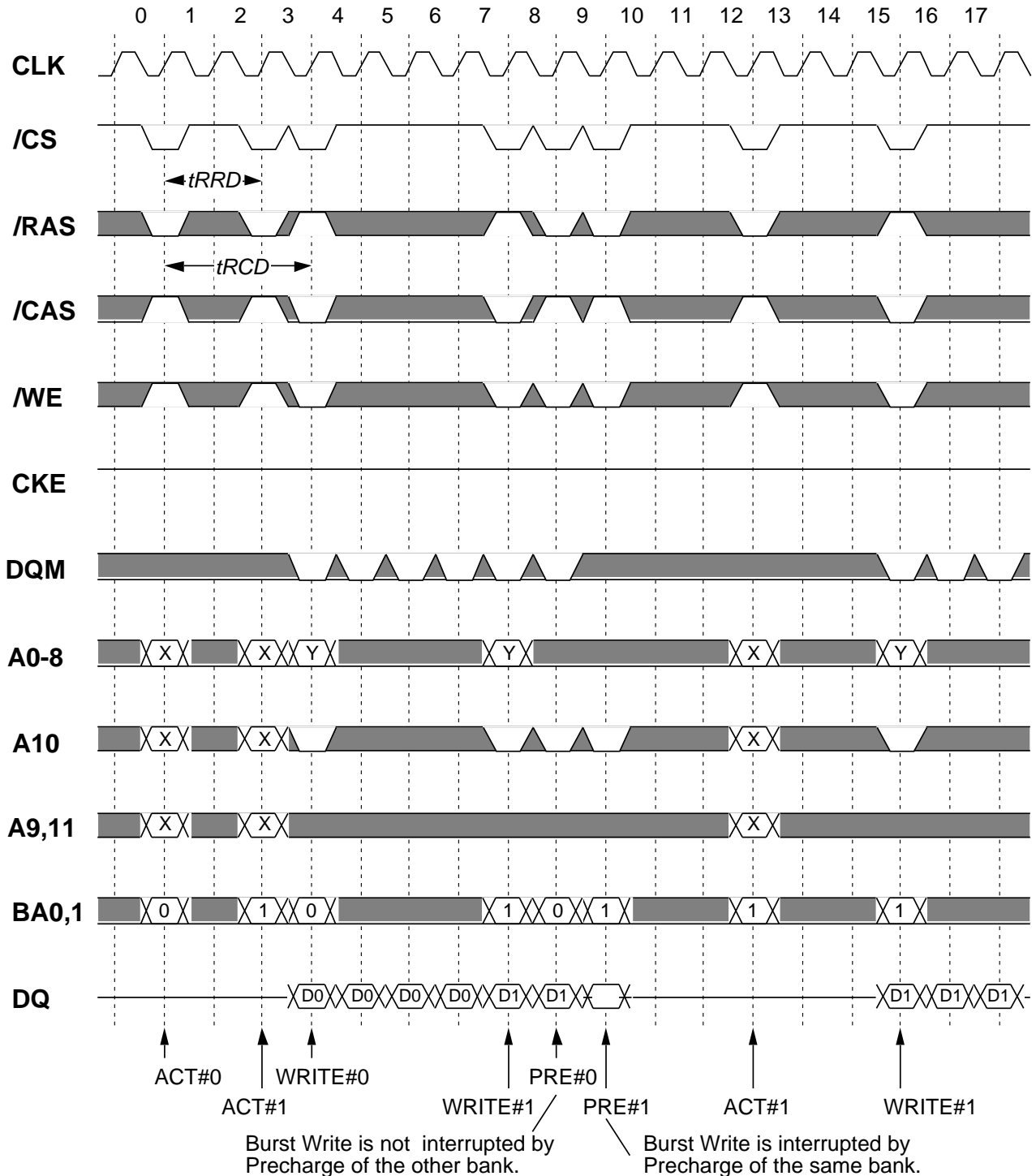
Burst Read can be interrupted by Read or Write of any active bank.

*Italic parameter* indicates minimum case

# MH16S72PHB -7,-8,-10

1207959552-BIT (16777216 - WORD BY 72-BIT) Synchronous DRAM

## Write Interrupted by Precharge @BL=4

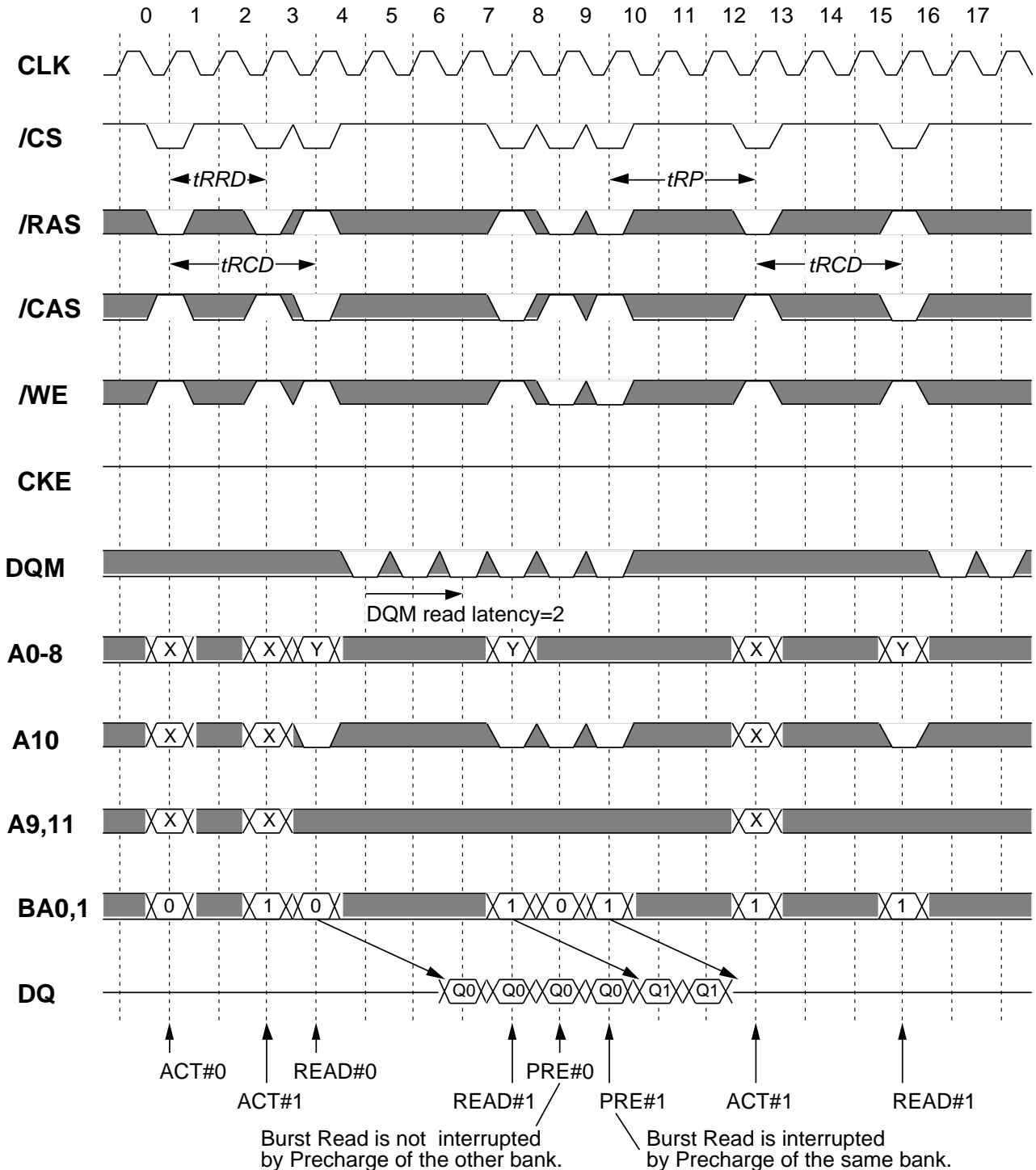


*Italic parameter* indicates minimum case

# MH16S72PHB -7,-8,-10

1207959552-BIT (16777216 - WORD BY 72-BIT) Synchronous DRAM

## Read Interrupted by Precharge @BL=4 CL=3

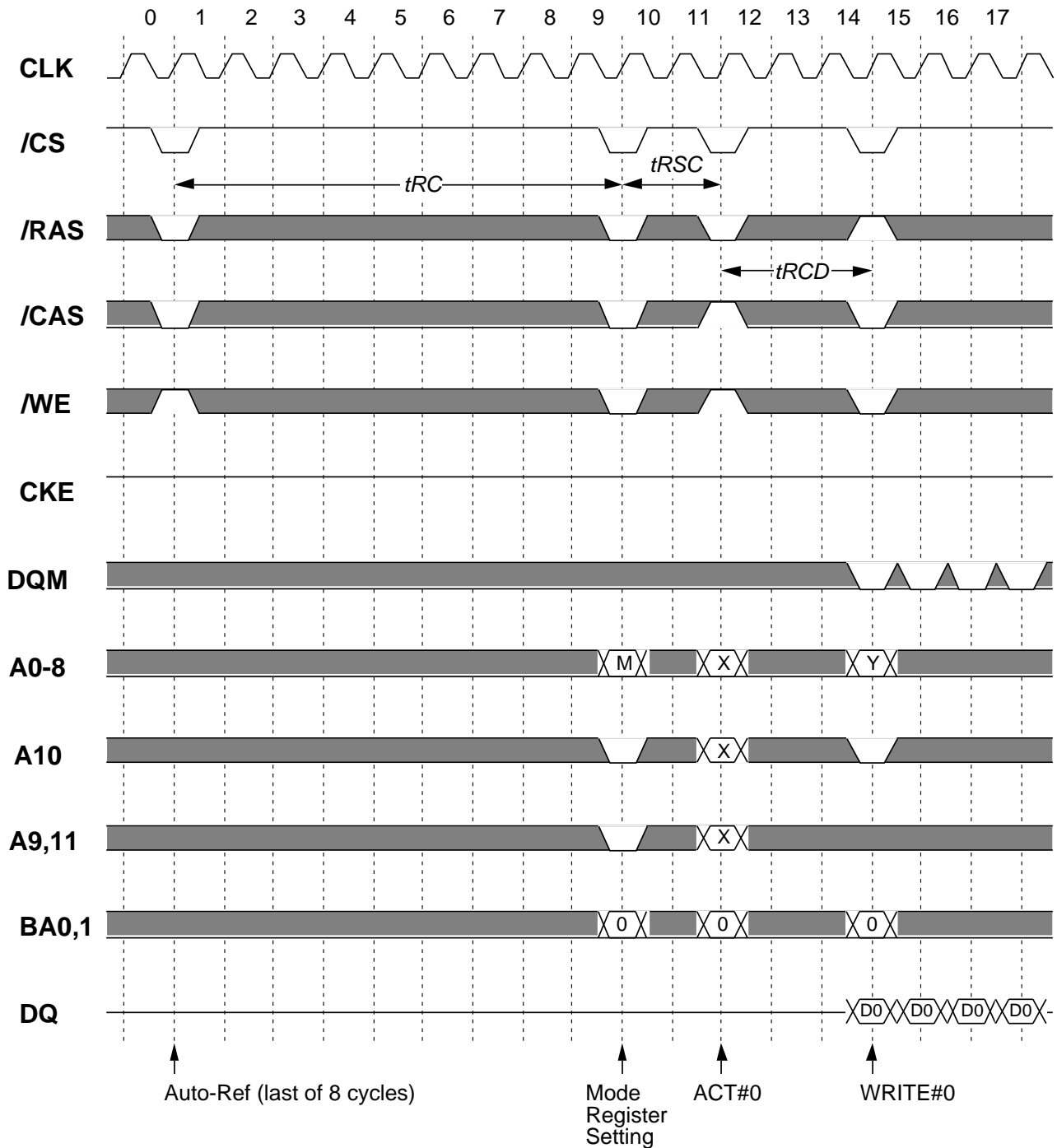


*Italic parameter* indicates minimum case

# MH16S72PHB -7,-8,-10

1207959552-BIT (16777216 - WORD BY 72-BIT) Synchronous DRAM

## Mode Register Setting

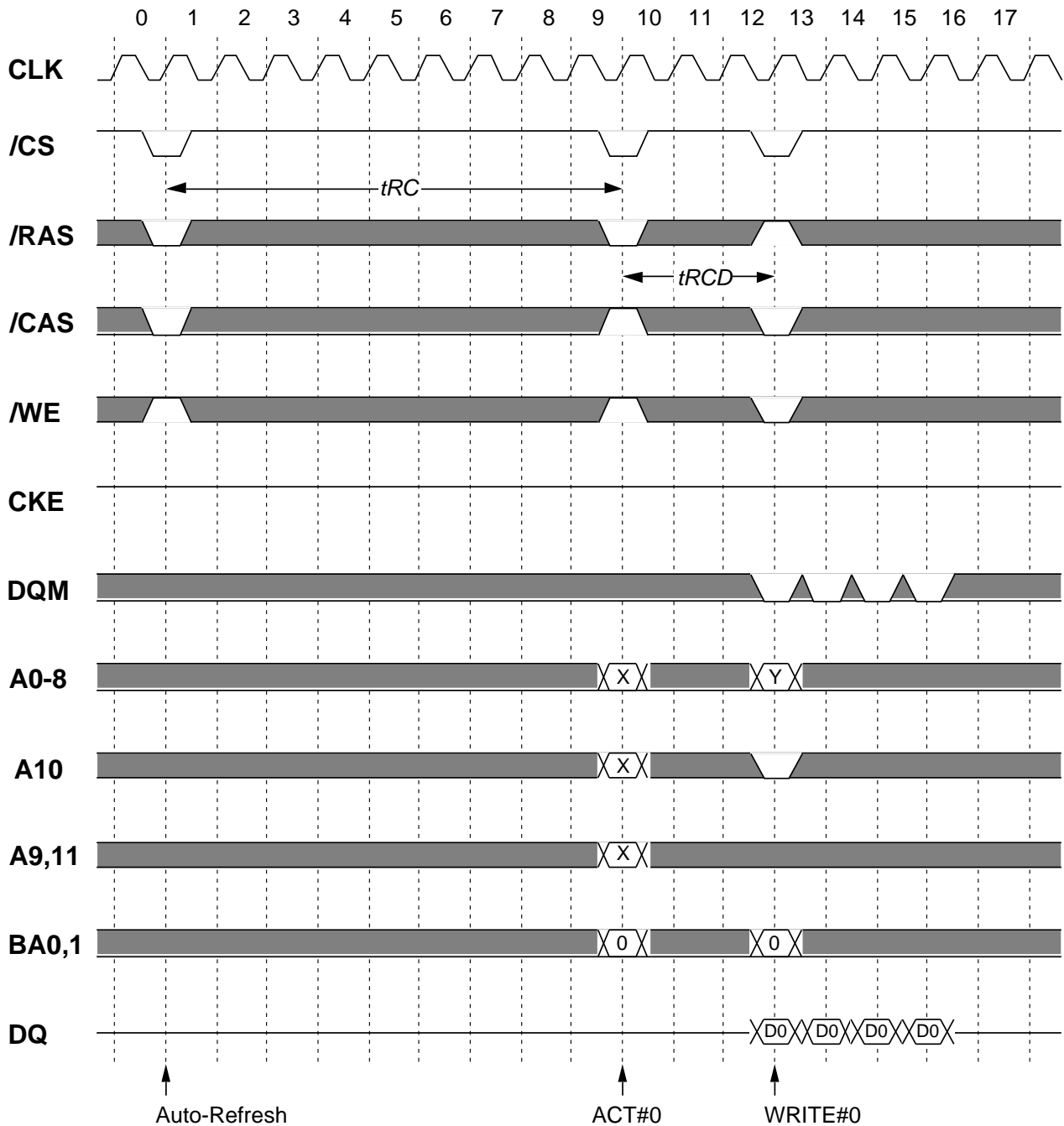


*Italic parameter* indicates minimum case

# MH16S72PHB -7,-8,-10

1207959552-BIT (16777216 - WORD BY 72-BIT)SynchronousDRAM

## Auto-Refresh @BL=4



Before Auto-Refresh,  
all banks must be idle state.

After tRC from Auto-Refresh,  
all banks are idle state.

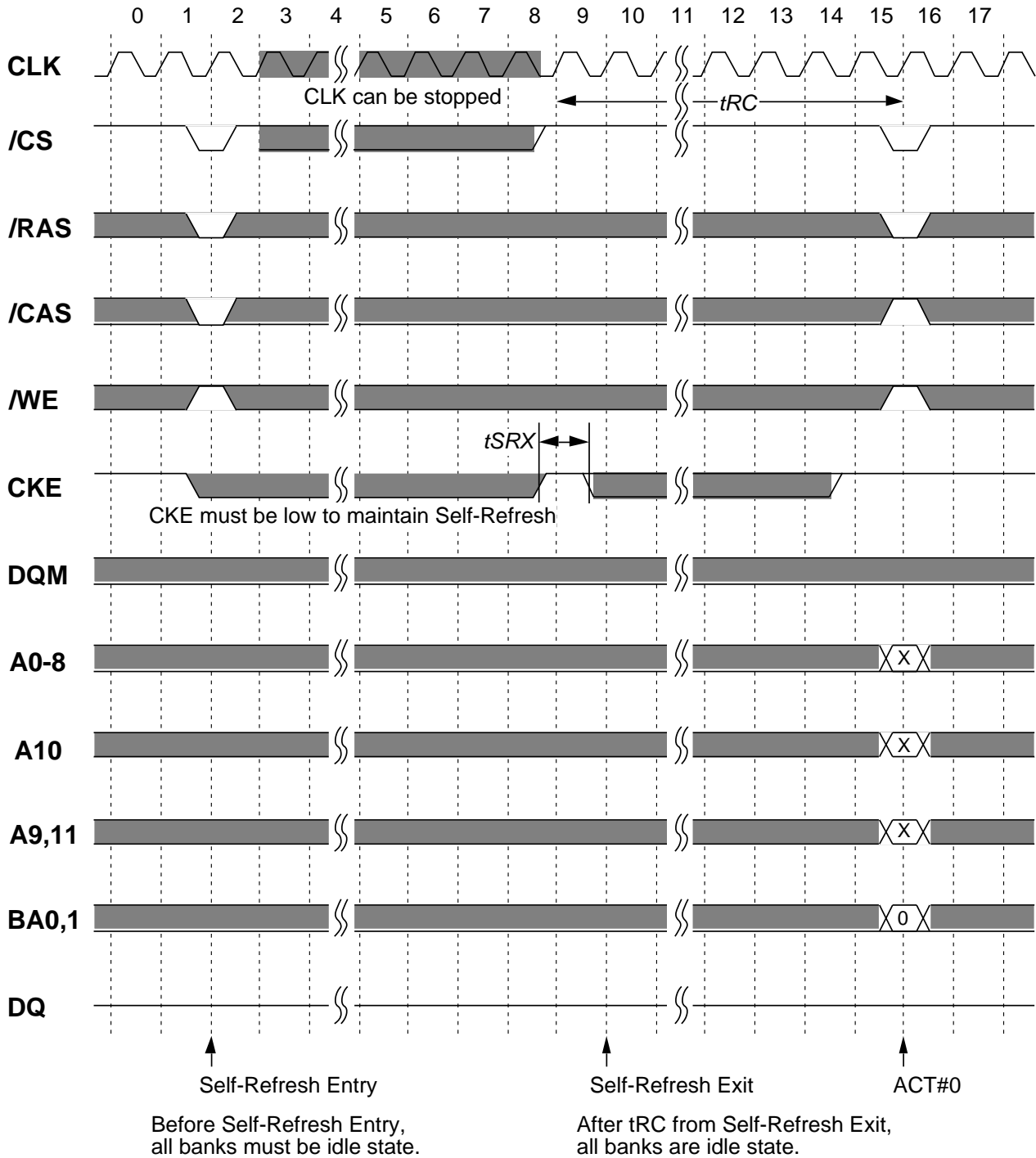
*Italic parameter* indicates minimum case



# MH16S72PHB -7,-8,-10

1207959552-BIT (16777216 - WORD BY 72-BIT)SynchronousDRAM

## Self-Refresh

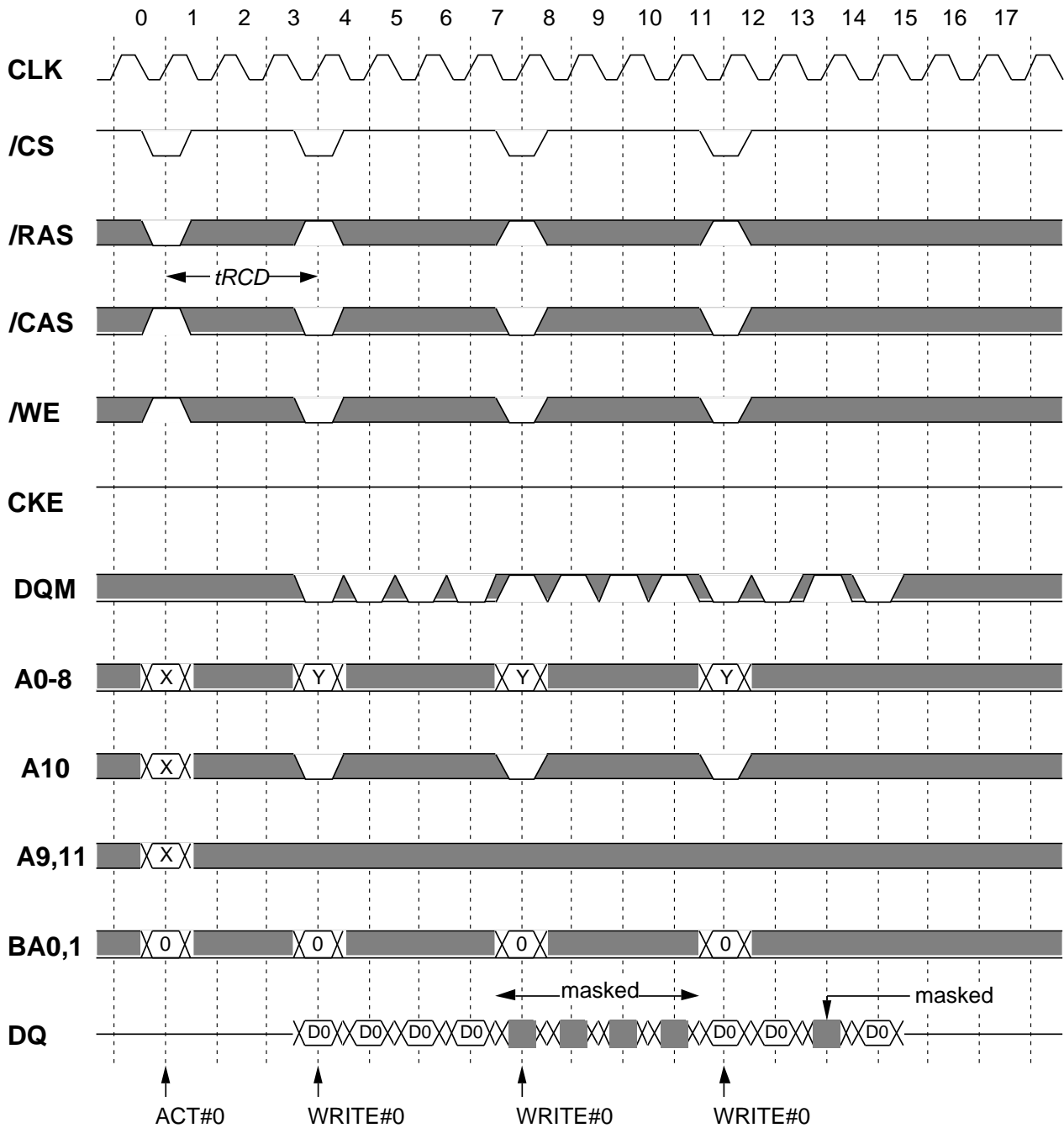


*Italic parameter* indicates minimum case

# MH16S72PHB -7,-8,-10

1207959552-BIT (16777216 - WORD BY 72-BIT)SynchronousDRAM

## DQM Write Mask @BL=4

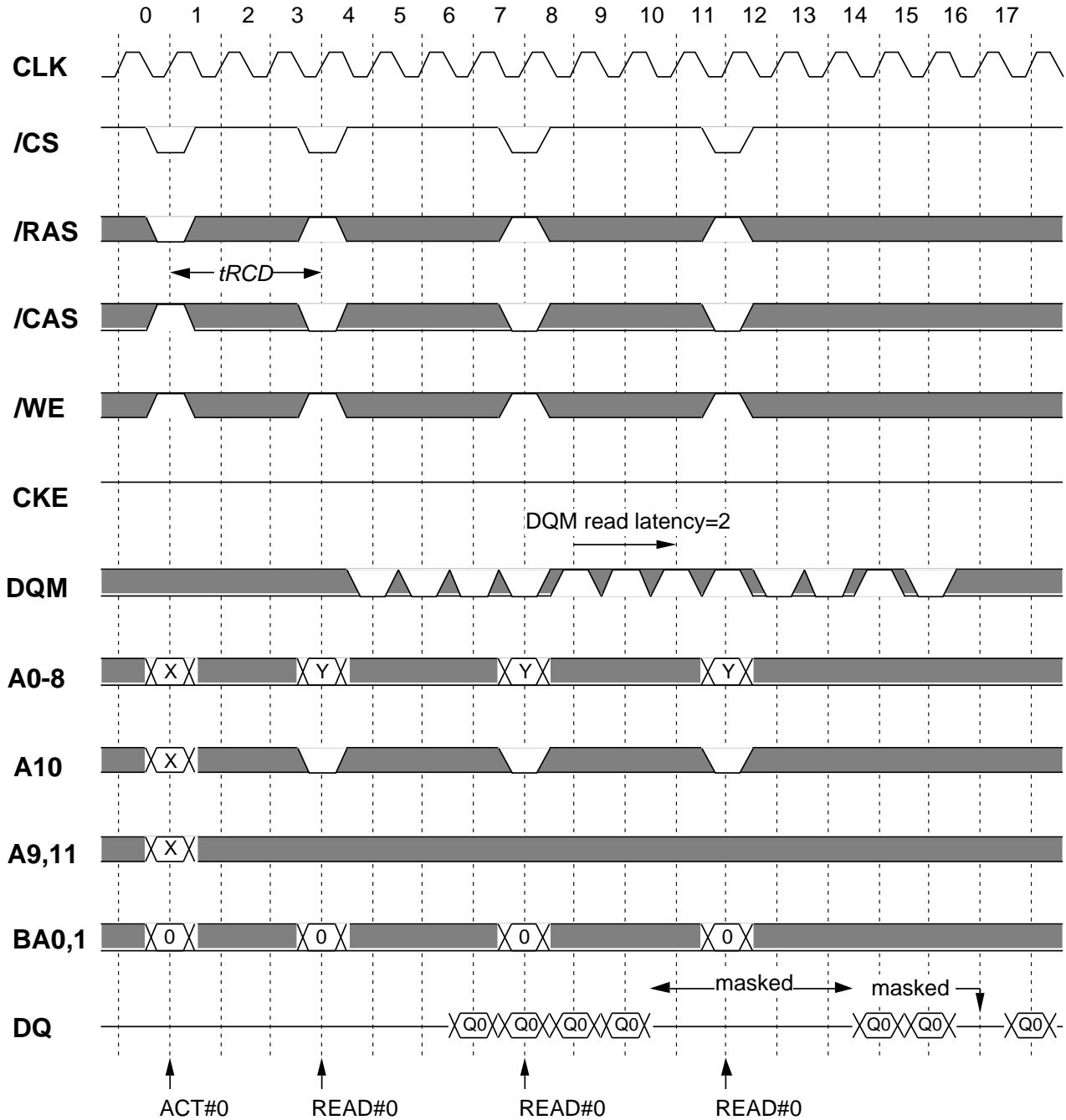


*Italic parameter* indicates minimum case

# MH16S72PHB -7,-8,-10

1207959552-BIT (16777216 - WORD BY 72-BIT) Synchronous DRAM

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

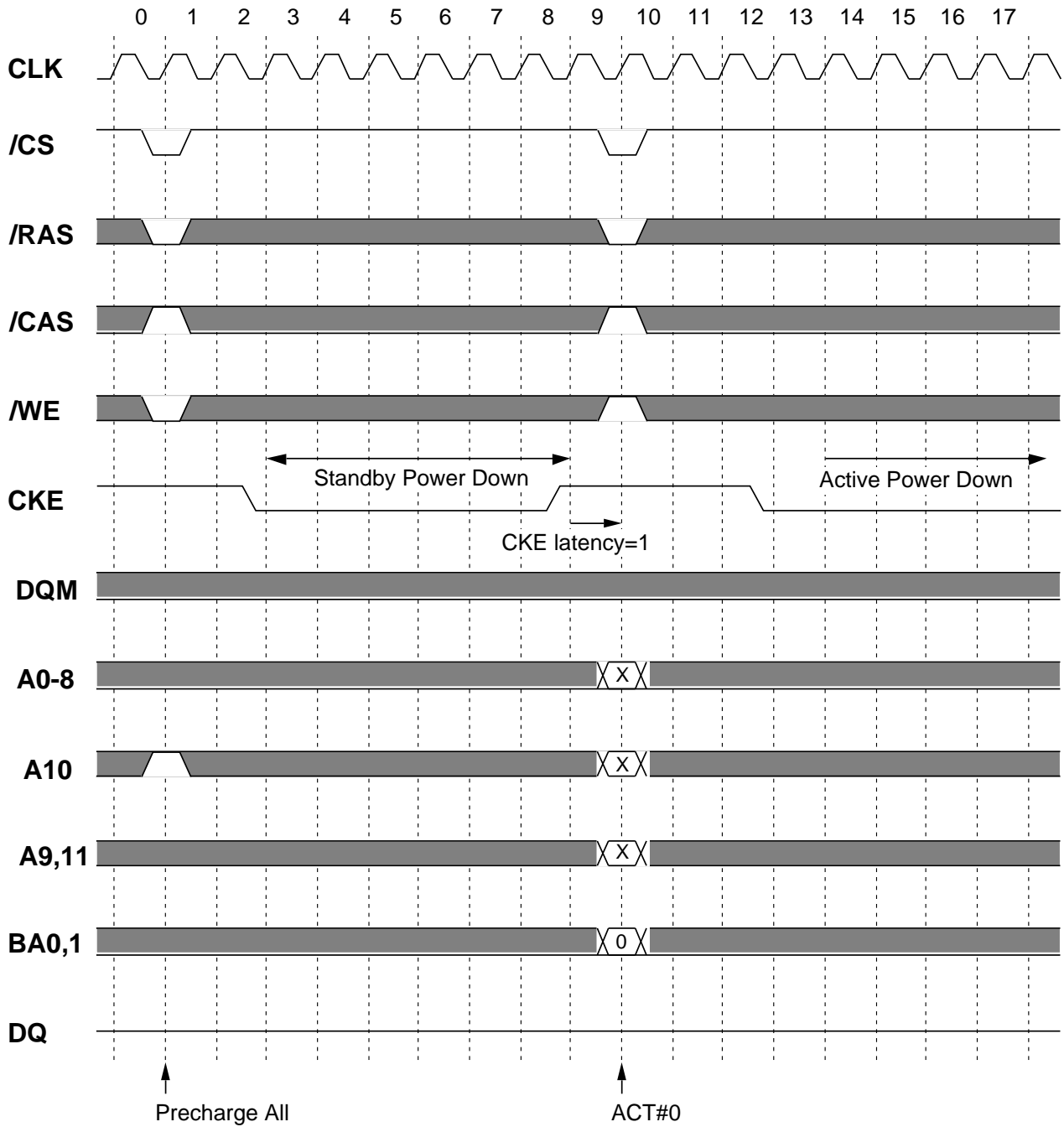


*Italic parameter* indicates minimum case

# MH16S72PHB -7,-8,-10

1207959552-BIT (16777216 - WORD BY 72-BIT)SynchronousDRAM

## Power Down

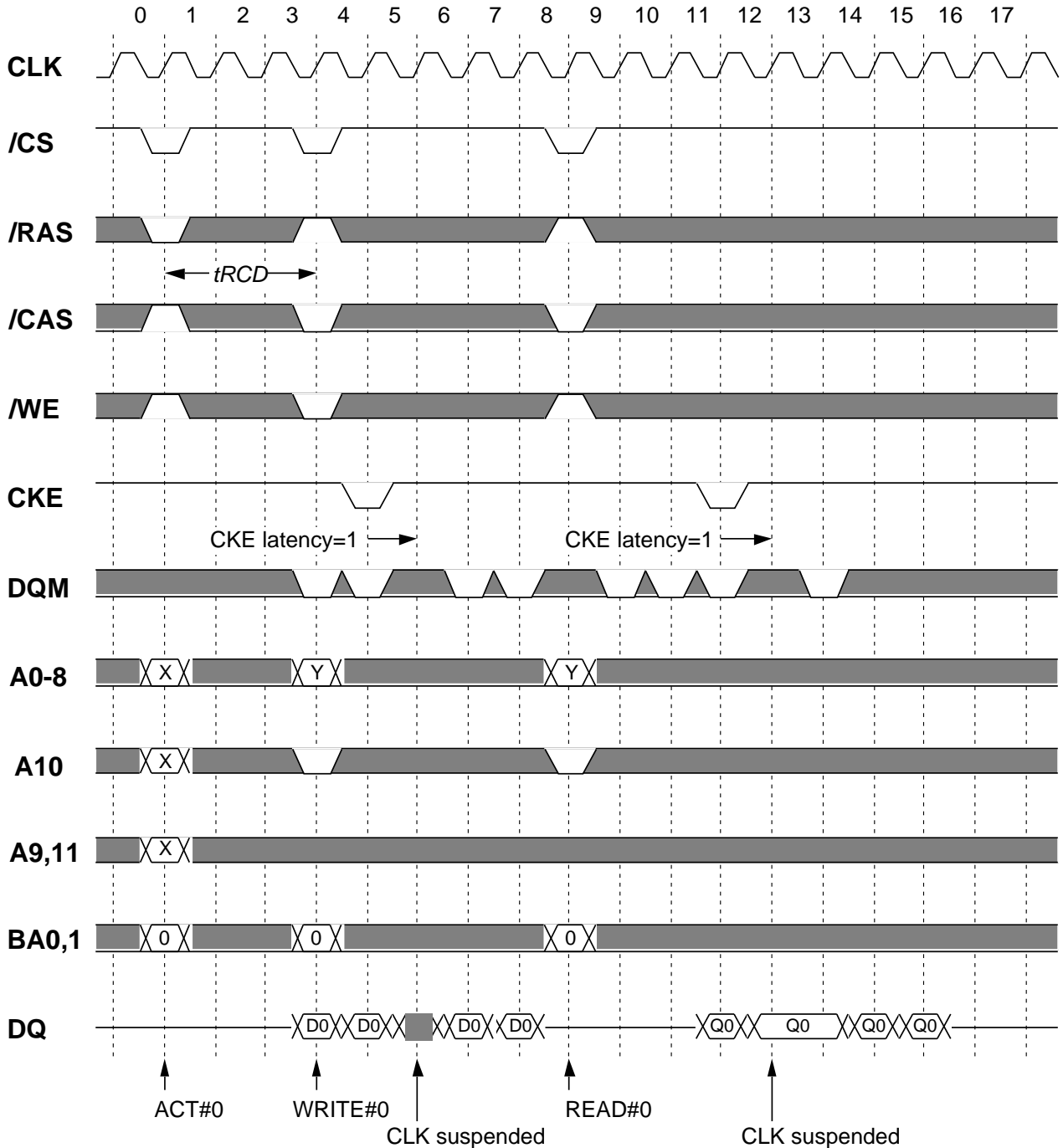


*Italic parameter* indicates minimum case

# MH16S72PHB -7,-8,-10

1207959552-BIT (16777216 - WORD BY 72-BIT) Synchronous DRAM

## CLK Suspend @BL=4 CL=3

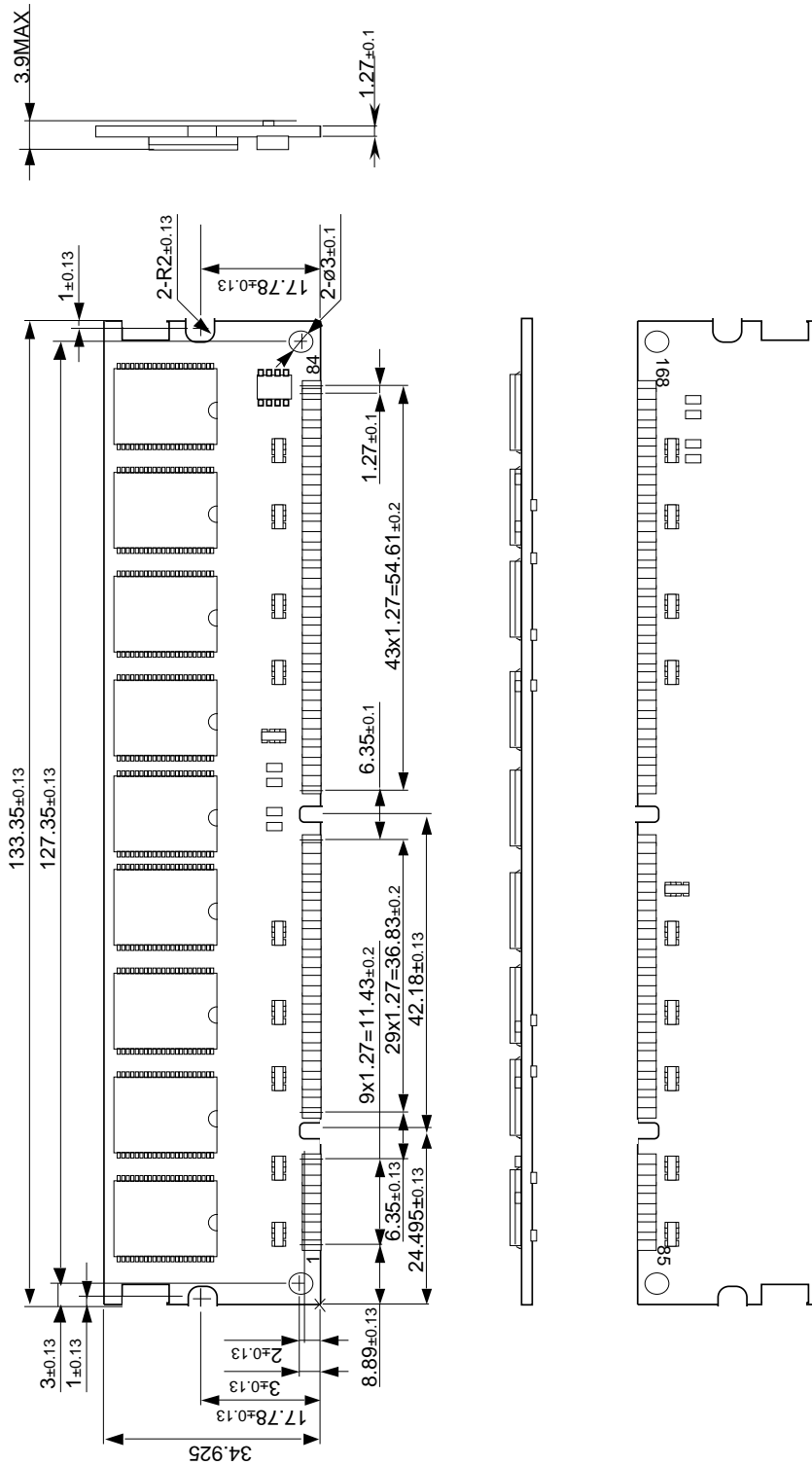


*Italic parameter* indicates minimum case

# MH16S72PHB -7,-8,-10

1207959552-BIT (16777216 - WORD BY 72-BIT)SynchronousDRAM

## OUTLINE



# MH16S72PHB -7,-8,-10

1207959552-BIT (16777216 - WORD BY 72-BIT)SynchronousDRAM

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