

**1G bits DDR Mobile RAM™****WTR (Wide Temperature Range)  
EDD10321BBH-TS (32M words × 32 bits)****Specifications**

- Density: 1G bits
- Organization: 8M words × 32 bits × 4 banks
- Package: 90-ball FBGA
  - Lead-free (RoHS compliant) and Halogen-free
- Power supply: VDD, VDDQ = 1.7V to 1.95V
- Data rate: 400Mbps/333Mbps (max.)
- 4KB page size
  - Row address: A0 to A12
  - Column address: A0 to A9
- Four internal banks for concurrent operation
- Interface: LVCMOS
- Burst lengths (BL): 2, 4, 8
- Burst type (BT):
  - Sequential (2, 4, 8)
  - Interleave (2, 4, 8)
- /CAS Latency (CL): 3
- Precharge: auto precharge option for each burst access
- Driver strength: normal, 1/2, 1/4
- Refresh: auto-refresh, self-refresh
- Refresh cycles: 8192 cycles/64ms
  - Average refresh period: 7.8μs
- Operating ambient temperature range
  - TA = -25°C to +85°C

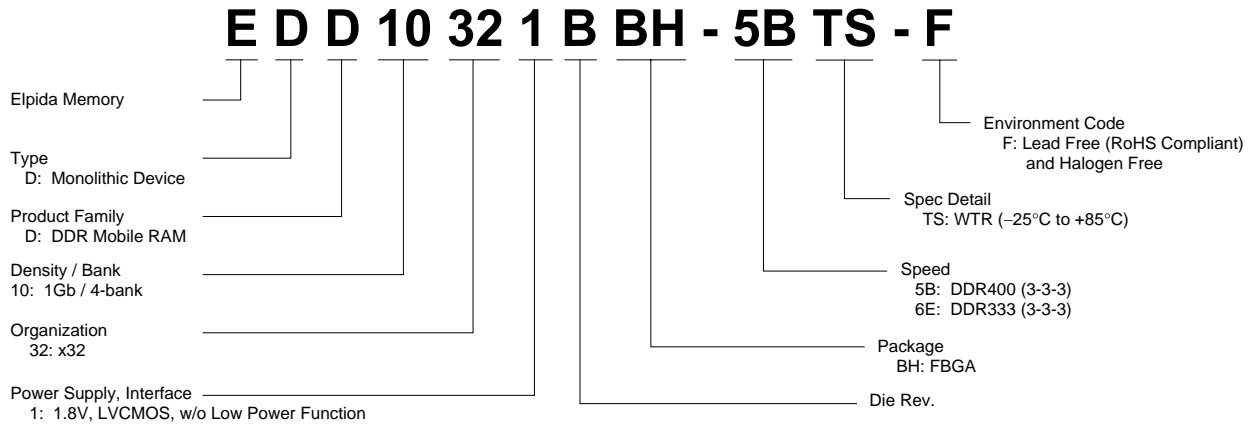
**Features**

- DLL is not implemented
- Low power consumption
- Double-data-rate architecture; two data transfers per one clock cycle
- The high-speed data transfer is realized by the 2 bits prefetch pipelined architecture
- Bi-directional data strobe (DQS) is transmitted /received with data for capturing data at the receiver.
- Data inputs, outputs, and DM are synchronized with DQS
- DQS is edge-aligned with data for READs; center-aligned with data for WRITEs
- Differential clock inputs (CK and /CK)
- Commands entered on each positive CK edge: data and data mask referenced to both edges of DQS
- Data mask (DM) for write data
- Burst termination by burst stop command and Precharge command
- Wide temperature range
  - TA = -25°C to +85°C
- Low Power Function below is not supported
  - Partial Array Self-Refresh (PASR)
  - Auto Temperature Compensated Self-Refresh
  - Deep power-down mode

**Ordering Information**

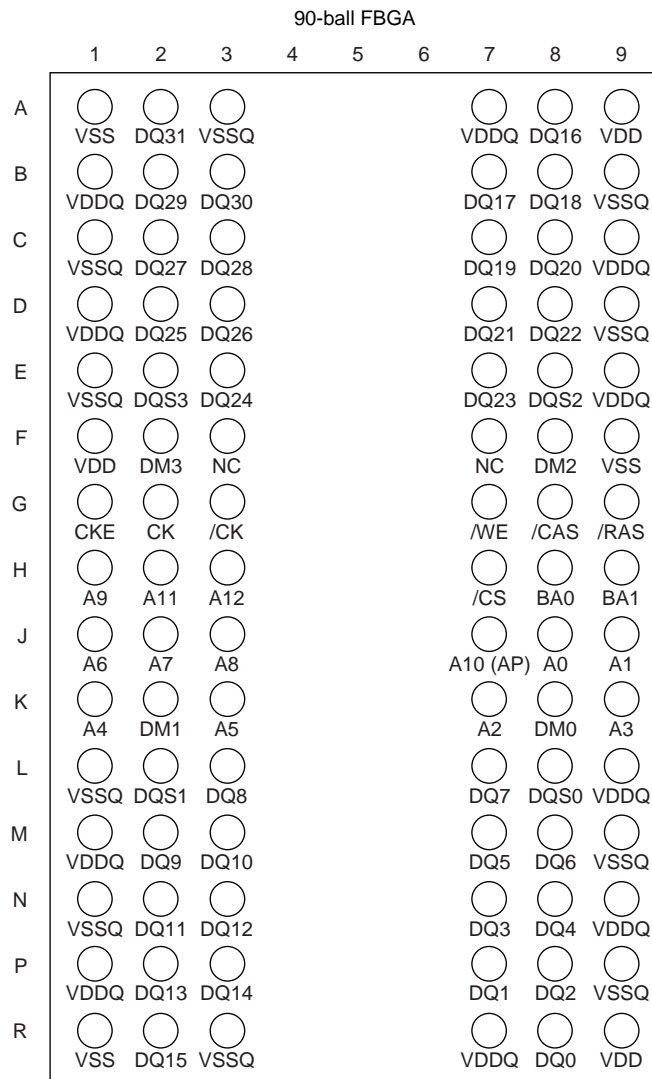
| Part number        | Die revision | Organization (words × bits) | Internal banks | Data rate Mbps (max.) | /CAS latency | Package      |
|--------------------|--------------|-----------------------------|----------------|-----------------------|--------------|--------------|
| EDD10321BBH-5BTS-F | B            | 32M × 32                    | 4              | 400                   | 3            | 90-ball FBGA |
| EDD10321BBH-6ETS-F |              |                             |                | 333                   | 3            |              |

**Part Number**



**Pin Configurations**

/xxx indicate active low signal.



(Top view)

| Pin name     | Function                     | Pin name | Function                    |
|--------------|------------------------------|----------|-----------------------------|
| A0 to A12    | Address inputs               | CK       | Clock input                 |
| BA0, BA1     | Bank select address          | /CK      | Differential clock input    |
| DQ0 to DQ31  | Data-input/output            | CKE      | Clock enable                |
| DQS0 to DQS3 | Input and output data strobe | VDD      | Power for internal circuit  |
| /CS          | Chip select                  | VSS      | Ground for internal circuit |
| /RAS         | Row address strobe           | VDDQ     | Power for DQ circuit        |
| /CAS         | Column address strobe        | VSSQ     | Ground for DQ circuit       |
| /WE          | Write enable                 | NC       | No connection               |
| DM0 to DM3   | Input mask                   |          |                             |

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**Electrical Specifications**

- All voltages are referenced to VSS (GND).
- After power up, wait more than 200 μs and then, execute power on sequence and CBR (Auto) refresh before proper device operation is achieved.

**Absolute Maximum Ratings**

| Parameter                          | Symbol | Rating       | Unit | Note |
|------------------------------------|--------|--------------|------|------|
| Voltage on any pin relative to VSS | VT     | -0.5 to +2.3 | V    |      |
| Supply voltage relative to VSS     | VDD    | -0.5 to +2.3 | V    |      |
| Short circuit output current       | IOS    | 50           | mA   |      |
| Power dissipation                  | PD     | 1.0          | W    |      |
| Operating ambient temperature      | TA     | -25 to +85   | °C   |      |
| Storage temperature                | Tstg   | -55 to +125  | °C   |      |

**Caution**

Exposing the device to stress above those listed in Absolute Maximum Ratings could cause permanent damage. The device is not meant to be operated under conditions outside the limits described in the operational section of this specification. Exposure to Absolute Maximum Rating conditions for extended periods may affect device reliability.

**Recommended DC Operating Conditions (TA = -25°C to +85°C)**

| Parameter                                 | Pins            | Symbol    | min.       | typ.       | max.       | Unit | Notes |
|---|-----------------|-----------|------------|------------|------------|------|-------|
| Supply voltage                            |                 | VDD, VDDQ | 1.7        | 1.8        | 1.95       | V    | 1     |
|   |                 | VSS, VSSQ | 0          | 0          | 0          | V    |       |
| Input high voltage                        | All other input | VIH       | 0.8 × VDDQ | —          | VDDQ + 0.3 | V    |       |
| Input low voltage                         | pins            | VIL       | -0.3       | —          | 0.2 × VDDQ | V    |       |
| DC input voltage level                    | CK, /CK         | VIN (DC)  | -0.3       | —          | VDDQ + 0.3 | V    |       |
| AC Input differential cross point voltage |                 | VIX       | 0.4 × VDDQ | 0.5 × VDDQ | 0.6 × VDDQ | V    | 6     |
| DC input differential voltage             |                 | VID (DC)  | 0.4 × VDDQ | —          | VDDQ + 0.6 | V    | 5     |
| AC input differential voltage             |                 | VID (AC)  | 0.6 × VDDQ | —          | VDDQ + 0.6 | V    | 5     |
| DC input high voltage                     | DQ, DM, DQS     | VIHD (DC) | 0.7 × VDDQ | —          | VDDQ + 0.3 | V    |       |
| DC input low voltage                      |                 | VILD (DC) | -0.3       | —          | 0.3 × VDDQ | V    |       |
| AC input high voltage                     |                 | VIHD (AC) | 0.8 × VDDQ | —          | VDDQ + 0.3 | V    |       |
| AC input low voltage                      |                 | VILD (AC) | -0.3       | —          | 0.2 × VDDQ | V    |       |

Notes: 1. VDDQ must be equal to VDD.

2. VIH (max.) = 2.3V (pulse width ≤ 5ns).
3. VIL (min.) = -0.5V (pulse width ≤ 5ns).
4. All voltage referred to VSS and VSSQ must be same potential.
5. VID (DC) and VID (AC) are the magnitude of the difference between the input level on CK and the input level on /CK.
6. The value of VIX is expected to be 0.5 × VDDQ and must track variations in the DC level of the same.

DC Characteristics 1 (TA = -25°C to +85°C, VDD and VDDQ = 1.7V to 1.95V, VSS and VSSQ = 0V)

| Parameter  | Symbol | Grade      | max.       | Unit | Test condition   | Notes |
|--|--------|------------|------------|------|--|-------|
| Operating current (ACT-PRE)                              | IDD0   | -5B<br>-6E | 95<br>70   | mA   | One bank active-precharge,<br>CKE = H, /CS = H between valid commands,<br>tCK = tCK (min.), tRC = tRC (min.),<br>Address bus inputs are SWITCHING;<br>Data bus inputs are STABLE |       |
| Standby current in power-down                            | IDD2P  |            | 3.2        | mA   | All banks idle,<br>CKE = L, /CS = H, tCK = tCK (min.),<br>Address and control inputs are SWITCHING;<br>Data bus inputs are STABLE  |       |
| Standby current in power-down with clock stop            | IDD2PS |            | 3.0        | mA   | All banks idle,<br>CKE = L, /CS = H, CK = L, /CK = H,<br>Address and control inputs are SWITCHING;<br>Data bus inputs are STABLE   |       |
| Standby current in non power-down                        | IDD2N  |            | 6.0        | mA   | All banks idle,<br>CKE = H, /CS = H, tCK = tCK (min.),<br>Address and control inputs are SWITCHING;<br>Data bus inputs are STABLE  |       |
| Standby current in non power-down with clock stop        | IDD2NS |            | 4.0        | mA   | All banks idle,<br>CKE = H, /CS = H, CK = L, /CK = H,<br>Address and control inputs are SWITCHING;<br>Data bus inputs are STABLE   |       |
| Active standby current in power-down                     | IDD3P  |            | 5.0        | mA   | One bank active,<br>CKE = L, /CS = H, tCK = tCK (min.),<br>Address and control inputs are SWITCHING;<br>Data bus inputs are STABLE   |       |
| Active standby current in power-down with clock stop     | IDD3PS |            | 4.0        | mA   | One bank active,<br>CKE = L, /CS = H, CK = L, /CK = H;<br>Address and control inputs are SWITCHING;<br>Data bus inputs are STABLE  |       |
| Active standby current in non power-down                 | IDD3N  |            | 10         | mA   | One bank active,<br>CKE = H, /CS = H, tCK = tCK (min.),<br>Address and control inputs are SWITCHING;<br>Data bus inputs are STABLE   |       |
| Active standby current in non power-down with clock stop | IDD3NS |            | 7.0        | mA   | One bank active,<br>CKE = H, /CS = H, CK = L, /CK = H,<br>Address and control inputs are SWITCHING;<br>Data bus inputs are STABLE  |       |
| Burst operating current                                  | IDD4   | -5B<br>-6E | 155<br>130 | mA   | One bank active,<br>Continuous burst reads or writes;<br>tCK = tCK (min.), CL = 3, BL = 4, IOUT = 0mA,<br>Address inputs are SWITCHING,<br>50% data change each burst transfer   |       |
| Auto-refresh current                                     | IDD5   |            | 120        | mA   | CKE = H, tCK = tCK (min.), tRFC = tRFC (min.),<br>Address and control inputs are SWITCHING;<br>Data bus inputs are STABLE  |       |
| Self-refresh current                                     | IDD6   |            | 4.0        | mA   | CKE = L  |       |

- Notes: 1. IDD specifications are tested after the device is properly initialized.  
 2. Input slew rate is specified by Test Conditions.  
 3. Definitions for IDD:  
 L is defined as  $V_{IN} \leq 0.1 \times V_{DDQ}$ ;  
 H is defined as  $V_{IN} \geq 0.9 \times V_{DDQ}$ ;  
 STABLE is defined as inputs stable at an H or L level;  
 SWITCHING is defined as:  
 Address and command: inputs changing between H and L once per two clock cycles;  
 Data bus inputs: DQ changing between H and L once per clock cycle; DM and DQS are STABLE.

**DC Characteristics 2 (TA = -25°C to +85°C, VDD and VDDQ = 1.7V to 1.95V, VSS and VSSQ = 0V)**

| Parameter              | Symbol | min.                 | max.                 | Unit | Test condition                                  | Notes |
|------------------------|--------|----------------------|----------------------|------|---|-------|
| Input leakage current  | ILI    | -2.0                 | 2.0                  | μA   | $0 \leq V_{IN} \leq V_{DDQ}$                    |       |
| Output leakage current | ILO    | -1.5                 | 1.5                  | μA   | $0 \leq V_{OUT} \leq V_{DDQ}$ ,<br>DQ = disable |       |
| Output high voltage    | VOH    | $0.9 \times V_{DDQ}$ | —                    | V    | IOH = -0.1mA                                    |       |
| Output low voltage     | VOL    | —                    | $0.1 \times V_{DDQ}$ | V    | IOL = 0.1 mA                                    |       |

**Pin Capacitance (TA = +25°C, VDD and VDDQ = 1.7V to 1.95V)**

| Parameter                      | Symbol | Pins                      | min. | typ. | max. | Unit | Notes |
|--------------------------------|--------|---------------------------|------|------|------|------|-------|
| Input capacitance              | CI1    | CK, /CK                   | 1.5  | —    | 4.0  | pF   | 1     |
|                                | CI2    | All other input-only pins | 1.5  | —    | 4.0  | pF   | 1     |
| Delta input capacitance        | Cdi1   | CK, /CK                   | —    | —    | 0.25 | pF   | 1     |
|                                | Cdi2   | All other input-only pins | —    | —    | 1.0  | pF   | 1     |
| Data input/output capacitance  | CI/O   | DQ, DM, DQS               | 2.0  | —    | 5.0  | pF   | 1, 2  |
| Delta input/output capacitance | Cdio   | DQ, DM, DQS               | —    | —    | 1.0  | pF   | 1     |

- Notes: 1. These parameters are measured on conditions:  $f = 100\text{MHz}$ ,  $V_{OUT} = V_{DDQ}/2$ ,  $\Delta V_{OUT} = 0.2\text{V}$ ,  $T_A = +25^\circ\text{C}$ .  
 2. DOUT circuits are disabled.

**AC Characteristics**

(TA = -25°C to +85°C, VDD and VDDQ = 1.7V to 1.95V, VSS and VSSQ = 0V)

| Parameter  | Symbol | -5B                |        | -6E                |        | Unit | Notes |
|--|--------|--------------------|--------|--------------------|--------|------|-------|
|  |        | min.               | max.   | min.               | max.   |      |       |
| Clock cycle time                                   | tCK    | 5.0                | —      | 6.0                | —      | ns   |       |
| CK high-level width                                | tCH    | 0.45               | 0.55   | 0.45               | 0.55   | tCK  |       |
| CK low-level width                                 | tCL    | 0.45               | 0.55   | 0.45               | 0.55   | tCK  |       |
| CK half period                                     | tHP    | min.<br>(tCH, tCL) | —      | min.<br>(tCH, tCL) | —      | tCK  |       |
| DQ output access time from CK, /CK                 | tAC    | 2.0                | 5.0    | 2.0                | 5.0    | ns   | 2, 8  |
| DQS-in cycle time                                  | tDSC   | 0.9                | 1.1    | 0.9                | 1.1    | tCK  |       |
| DQS output access time from CK, /CK                | tDQSK  | 2.0                | 5.0    | 2.0                | 5.0    | ns   | 2, 8  |
| DQ-out high-impedance time from CK, /CK            | tHZ    | —                  | 5.0    | —                  | 5.0    | ns   | 5, 8  |
| DQ-out low-impedance time from CK, /CK             | tLZ    | 1.0                | —      | 1.0                | —      | ns   | 6, 8  |
| DQS to DQ skew                                     | tDQSQ  | —                  | 0.4    | —                  | 0.5    | ns   | 3     |
| DQ/DQS output hold time from DQS                   | tQH    | tHP – tQHS         | —      | tHP – tQHS         | —      | ns   | 4     |
| Data hold skew factor                              | tQHS   | —                  | 0.5    | —                  | 0.65   | ns   |       |
| DQ and DM input setup time                         | tDS    | 0.48               | —      | 0.6                | —      | ns   | 3     |
| DQ and DM input hold time                          | tDH    | 0.48               | —      | 0.6                | —      | ns   | 3     |
| DQ and DM input pulse width                        | tDIPW  | 1.6                | —      | 1.6                | —      | ns   |       |
| Read preamble                                      | tRPRE  | 0.9                | 1.1    | 0.9                | 1.1    | tCK  |       |
| Read postamble                                     | tRPST  | 0.4                | 0.6    | 0.4                | 0.6    | tCK  |       |
| Write preamble setup time                          | tWPRES | 0                  | —      | 0                  | —      | ns   |       |
| Write preamble                                     | tWPRE  | 0.25               | —      | 0.25               | —      | tCK  |       |
| Write postamble                                    | tWPST  | 0.4                | 0.6    | 0.4                | 0.6    | tCK  | 7     |
| Write command to first DQS latching transition     | tDQSS  | 0.75               | 1.25   | 0.75               | 1.25   | tCK  |       |
| DQS falling edge to CK setup time                  | tDSS   | 0.2                | —      | 0.2                | —      | tCK  |       |
| DQS falling edge hold time from CK                 | tDSH   | 0.2                | —      | 0.2                | —      | tCK  |       |
| DQS input high pulse width                         | tDQSH  | 0.40               | —      | 0.40               | —      | tCK  |       |
| DQS input low pulse width                          | tDQSL  | 0.40               | —      | 0.40               | —      | tCK  |       |
| Address and control input setup time               | tIS    | 0.9                | —      | 1.1                | —      | ns   | 3     |
| Address and control input hold time                | tIH    | 0.9                | —      | 1.1                | —      | ns   | 3     |
| Address and control input pulse width              | tIPW   | 2.3                | —      | 2.7                | —      | ns   | 3     |
| Mode register set command cycle time               | tMRD   | 2                  | —      | 2                  | —      | tCK  |       |
| Active to Precharge command period                 | tRAS   | 40                 | 120000 | 42                 | 120000 | ns   |       |
| Active to Active/Auto-refresh command period       | tRC    | 55                 | —      | 60                 | —      | ns   |       |
| Auto-refresh to Active/Auto-refresh command period | tRFC   | 78                 | —      | 78                 | —      | ns   |       |
| Active to Read/Write delay                         | tRCD   | 15                 | —      | 18                 | —      | ns   |       |
| Precharge to active command period                 | tRP    | 15                 | —      | 18                 | —      | ns   |       |
| Column address to column address delay             | tCCD   | 1                  | —      | 1                  | —      | tCK  |       |
| Active to active command period                    | tRRD   | 10                 | —      | 12                 | —      | ns   |       |
| Write recovery time                                | tWR    | 15                 | —      | 15                 | —      | ns   |       |



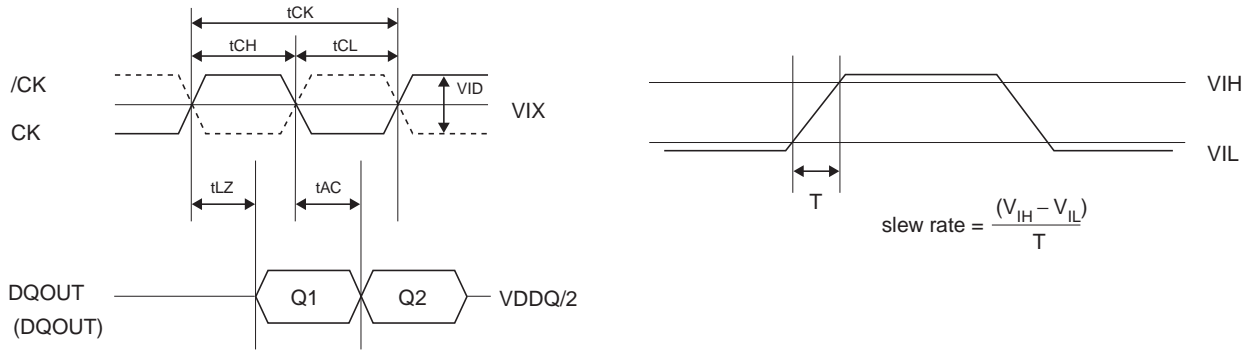
| Parameter                                       | Symbol | -5B  |      | -6E  |      | Unit | Notes |
|---|--------|------|------|------|------|------|-------|
|   |        | min. | max. | min. | max. |      |       |
| Autoprecharge write recovery and precharge time | tDAL   | —    | —    | —    | —    |      | 9     |
| Self-refresh exit period                        | tSREX  | 120  | —    | 120  | —    | ns   |       |
| Internal Write to Read command delay            | tWTR   | 2    | —    | 1    | —    | tCK  |       |
| Average periodic refresh interval               | tREF   | —    | 7.8  | —    | 7.8  | μs   |       |

- Notes:
1. On all AC measurements, we assume the test conditions shown in “Test conditions” and full driver strength is assumed for the output load, that is both A6 and A5 of EMRS is set to be “L”.
  2. This parameter defines the signal transition delay from the cross point of CK and /CK. The signal transition is defined to occur when the signal level crossing VDDQ/2.
  3. The timing reference level is VDDQ/2.
  4. Output valid window is defined to be the period between two successive transition of data out signals. The signal transition is defined to occur when the signal level crossing VDDQ/2.
  5. tHZ is defined as DOUT transition delay from low-Z to high-Z at the end of read burst operation. The timing reference is cross point of CK and /CK. This parameter is not referred to a specific DOUT voltage level, but specify when the device output stops driving.
  6. tLZ is defined as DOUT transition delay from high-Z to low-Z at the beginning of read operation. This parameter is not referred to a specific DOUT voltage level, but specify when the device output begins driving.
  7. The transition from low-Z to high-Z is defined to occur when the device output stops driving. A specific reference voltage to judge this transition is not given.
  8. tAC, tDQSCK, tHZ and tLZ are specified with 15pF bus loading condition.
  9. Minimum 3 clocks of tDAL (= tWR + tRP) is required because it need minimum 2 clocks for tWR and minimum 1 clock for tRP.  
 $tDAL = (tWR/tCK) + (tRP/tCK)$ : for each of the terms above, if not already an integer, round to the next higher integer.

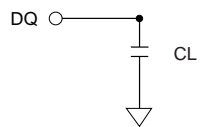
**Test Conditions**

| Parameter   | Symbol        | Value                             | Unit | Note |
|---|---------------|-----------------------------------|------|------|
| Input high voltage  | $V_{IH} (AC)$ | $0.8 \times V_{DDQ}$              | V    | 1    |
| Input low voltage   | $V_{IL} (AC)$ | $0.2 \times V_{DDQ}$              | V    | 1    |
| Input differential voltage, CK and /CK inputs             | $V_{ID} (AC)$ | 1.4                               | V    | 1    |
| Input differential cross point voltage, CK and /CK inputs | $V_{IX} (AC)$ | $V_{DDQ}/2$ with $V_{DD}=V_{DDQ}$ | V    |      |
| Input signal slew rate                                    | SLEW          | 1                                 | V/ns | 1    |
| Output load   | CL            | 15                                | pF   |      |

Note: 1.  $V_{DD} = V_{DDQ}$



**Test Condition (Wave form and Timing Reference)**

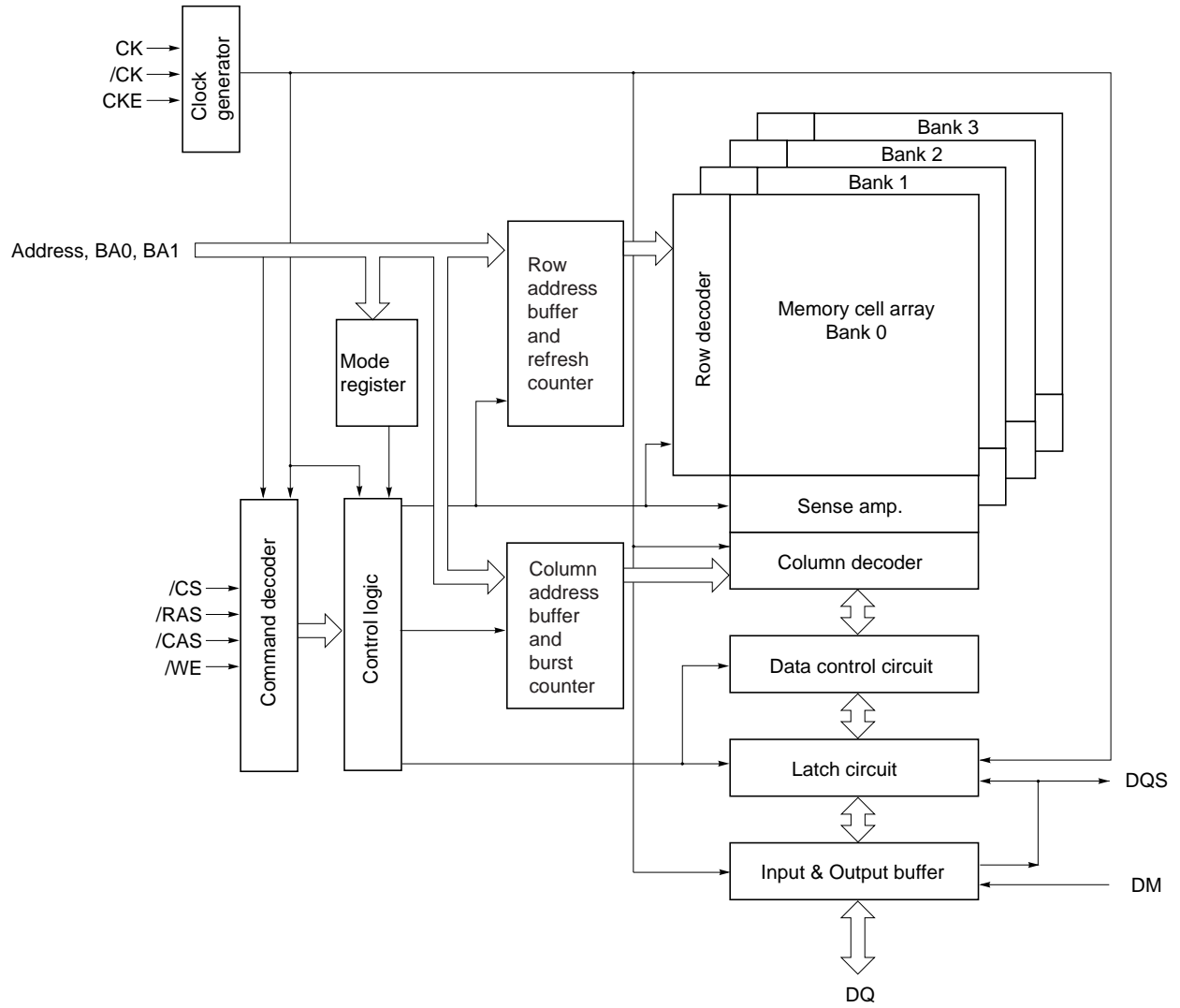


**Output Load**

Timing Parameter Measured in Clock Cycle

| tCK | Parameter   | Symbol | Number of clock cycle |      |          |      |          |      | Unit |
|-----|---|--------|-----------------------|------|----------|------|----------|------|------|
|     |   |        | 5.0ns                 |      | 6.0ns    |      | 7.5ns    |      |      |
|     |   |        | min.                  | max. | min.     | max. | min.     | max. |      |
|     | Write to pre-charge command delay (same bank)                     | tWPD   | 4 + BL/2              | —    | 4 + BL/2 | —    | 3 + BL/2 | —    | tCK  |
|     | Read to pre-charge command delay (same bank)                      | tRPD   | BL/2                  | —    | BL/2     | —    | BL/2     | —    | tCK  |
|     | Write to read command delay (to input all data)                   | tWRD   | 3 + BL/2              | —    | 2 + BL/2 | —    | 2 + BL/2 | —    | tCK  |
|     | Burst stop command to write command delay (CL = 3)                | tBSTW  | 3                     | —    | 3        | —    | 3        | —    | tCK  |
|     | Burst stop command to DQ high-Z (CL = 3)                          | tBSTZ  | 3                     | —    | 3        | —    | 3        | —    | tCK  |
|     | Read command to write command delay (to output all data) (CL = 3) | tRWD   | 3 + BL/2              | —    | 3 + BL/2 | —    | 3 + BL/2 | —    | tCK  |
|     | Pre-charge command to high-Z (CL = 3)                             | tHWP   | 3                     | —    | 3        | —    | 3        | —    | tCK  |
|     | Write command to data in latency                                  | tWCD   | 1                     | —    | 1        | —    | 1        | —    | tCK  |
|     | Write recovery  | tWR    | 3                     | —    | 3        | —    | 2        | —    | tCK  |
|     | DM to data in latency   | tDMD   | 0                     | —    | 0        | —    | 0        | —    | tCK  |
|     | Mode register set command cycle time                              | tMRD   | 2                     | —    | 2        | —    | 2        | —    | tCK  |
|     | Self-refresh exit to non-column command                           | tSREX  | 24                    | —    | 20       | —    | 16       | —    | tCK  |
|     | Auto-refresh period   | tRFC   | 16                    | —    | 13       | —    | 11       | —    | tCK  |
|     | Power-down entry  | tPDEN  | 2                     | —    | 2        | —    | 1        | —    | tCK  |
|     | Power-down exit to command input                                  | tPDEX  | 1                     | —    | 1        | —    | 1        | —    | tCK  |
|     | CKE minimum pulse width   | tCKE   | 2                     | —    | 2        | —    | 2        | —    | tCK  |

Block Diagram



**Pin Function**

**CK, /CK (input pins)**

The CK and the /CK are the master clock inputs. All inputs except DMs, DQSs and DQs are referred to the cross point of the CK rising edge and the /CK falling edge. When a read operation, DQSs and DQs are referred to the cross point of the CK and the /CK. When a write operation, DMs and DQs are referred to the cross point of the DQS and the VDDQ/2 level. DQSs for write operation are referred to the cross point of the CK and the /CK. The other input signals are referred at CK rising edge.

**/CS (input pin)**

When /CS is low, commands and data can be input. When /CS is high, all inputs are ignored. However, internal operations (bank active, burst operations, etc.) are held.

**/RAS, /CAS, and /WE (input pins)**

These pins define operating commands (read, write, etc.) depending on the combinations of their voltage levels. See "Command operation".

**A0 to A12 (input pins)**

Row address (AX0 to AX12) is determined by the A0 to the A12 level at the cross point of the CK rising edge and the /CK falling edge in a bank active command cycle. Column address is loaded at the cross point of the CK rising edge and the /CK falling edge in a read or a write command cycle (See "Address Pins Table"). This column address becomes the starting address of a burst operation.

**[Address Pins Table]**

| Part number | Page size | Organization | Address (A0 to A12) |                |
|-------------|-----------|--------------|---------------------|----------------|
|             |           |              | Row address         | Column address |
| EDD10321BBH | 4KB       | × 32 bits    | AX0 to AX12         | AY0 to AY9     |

**A10 (AP) (input pin)**

A10 defines the precharge mode when a precharge command, a read command or a write command is issued. If A10 = high when a precharge command is issued, all banks are precharged. If A10 = low when a precharge command is issued, only the bank that is selected by BA1/BA0 is precharged. If A10 = high when read or write command, auto precharge function is enabled.

**BA0 and BA1 (input pins)**

BA0 and BA1 are bank select signals (BA). The memory array is divided into bank 0, bank 1, bank 2 and bank 3. (See Bank Select Signal Table)

**[Bank Select Signal Table]**

|        | BA0 | BA1 |
|--------|-----|-----|
| Bank 0 | L   | L   |
| Bank 1 | H   | L   |
| Bank 2 | L   | H   |
| Bank 3 | H   | H   |

Remark: H: VIH. L: VIL.

**CKE (input pin)**

CKE controls power-down mode, self-refresh function with other command inputs.

The CKE level must be kept for 2 clocks at least, that is, if CKE changes at the cross point of the CK rising edge and the /CK falling edge with proper setup time tIS, by the next CK rising edge CKE level must be kept with proper hold time tIH.

**DQ0 to DQ31 (input/output pins)**

Data are input to and output from these pins.

**DQS0 to DQS3 (input and output pin):** DQS provides the read data strobes (as output) and the write data strobes (as input). Each DQS pin corresponds to eight DQ pins, respectively (See DQS and DM Correspondence Table).

**DM0 to DM3 (input pin)**

DM is the reference signals of the data input mask function. DM is sampled at the cross point of DQS and VDDQ/2. When DM = high, the data input at the same timing are masked while the internal burst counter will be counting up. Each DM pin corresponds to eight DQ pins, respectively (See DQS and DM Correspondence Table).

**[DQS and DM Correspondence Table]**

| Part number | Organization | DQS  | Data mask | DQs          |
|-------------|--------------|------|-----------|--------------|
| EDD10321BBH | × 32 bits    | DQS0 | DM0       | DQ0 to DQ7   |
|             |              | DQS1 | DM1       | DQ8 to DQ15  |
|             |              | DQS2 | DM2       | DQ16 to DQ23 |
|             |              | DQS3 | DM3       | DQ24 to DQ31 |

**VDD, VSS, VDDQ, VSSQ (Power supply)**

VDD and VSS are power supply pins for internal circuits. VDDQ and VSSQ are power supply pins for the output buffers. VDD must be equal to VDDQ.

## Command Operation

### Command Truth Table

The DDR Mobile RAM recognizes the following commands specified by the /CS, /RAS, /CAS, /WE and address pins.

| Command                            | Symbol | CKE   |   | /CS | /RAS | /CAS | /WE | BA1 | BA0 | AP | Address |
|------------------------------------|--------|-------|---|-----|------|------|-----|-----|-----|----|---------|
|                                    |        | n - 1 | n |     |      |      |     |     |     |    |         |
| Ignore command                     | DESL   | H     | H | H   | ×    | ×    | ×   | ×   | ×   | ×  | ×       |
| No operation                       | NOP    | H     | H | L   | H    | H    | H   | ×   | ×   | ×  | ×       |
| Burst stop command                 | BST    | H     | H | L   | H    | H    | L   | ×   | ×   | ×  | ×       |
| Column address and read command    | READ   | H     | H | L   | H    | L    | H   | V   | V   | L  | V       |
| Read with auto precharge           | READA  | H     | H | L   | H    | L    | H   | V   | V   | H  | V       |
| Column address and write command   | WRIT   | H     | H | L   | H    | L    | L   | V   | V   | L  | V       |
| Write with auto precharge          | WRITA  | H     | H | L   | H    | L    | L   | V   | V   | H  | V       |
| Row address strobe and bank active | ACT    | H     | H | L   | L    | H    | H   | V   | V   | V  | V       |
| Precharge select bank              | PRE    | H     | H | L   | L    | H    | L   | V   | V   | L  | ×       |
| Precharge all bank                 | PALL   | H     | H | L   | L    | H    | L   | ×   | ×   | H  | ×       |
| Refresh                            | REF    | H     | H | L   | L    | L    | H   | ×   | ×   | ×  | ×       |
|                                    | SELF   | H     | L | L   | L    | L    | H   | ×   | ×   | ×  | ×       |
| Mode register set                  | MRS    | H     | H | L   | L    | L    | L   | L   | L   | L  | V       |
|                                    | EMRS   | H     | H | L   | L    | L    | L   | H   | L   | L  | V       |

Remark: H: VIH. L: VIL. ×: Don't care V: Valid address input

Note: The CKE level must be kept for 1 CK cycle at least.

#### Ignore command [DESL]

When /CS is high at the cross point of the CK rising edge and the VDDQ/2 level, all input signals are neglected and internal state is held.

#### No operation [NOP]

As long as this command is input at the cross point of the CK rising edge and the VDDQ/2 level, address and data input are neglected and internal state is held.

#### Burst stop command [BST]

This command stops a current burst operation.

#### Column address strobe and read command [READ]

This command starts a read operation. The start address of the burst read is determined by the column address (See "Address Pins Table" in Pin Function) and the bank select address. After the completion of the read operation, all output buffers become high-Z.

#### Read with auto precharge [READA]

This command starts a read operation. After completion of the read operation, precharge is automatically executed.

#### Column address strobe and write command [WRIT]

This command starts a write operation. The start address of the burst write is determined by the column address (See "Address Pins Table" in Pin Function) and the bank select address.

#### Write with auto precharge [WRITA]

This command starts a write operation. After completion of the write operation, precharge is automatically executed.

**Row address strobe and bank activate [ACT]**

This command activates the bank that is selected by BA0 and BA1 (See Bank Select Signal Table) and determines the row address (Address Pins Table in "Pin Function").

**Precharge selected bank [PRE]**

This command starts precharge operation for the bank selected by BA0 and BA1. (See Bank Select Signal Table)

**[Bank Select Signal Table]**

|        | BA0 | BA1 |
|--------|-----|-----|
| Bank 0 | L   | L   |
| Bank 1 | H   | L   |
| Bank 2 | L   | H   |
| Bank 3 | H   | H   |

Remark: H: VIH. L: VIL.

**Precharge all banks [PALL]**

This command starts a precharge operation for all banks.

**Refresh [REF/SELF]**

This command starts a refresh operation. There are two types of refresh operation, one is auto-refresh, and another is self-refresh. For details, refer to the CKE truth table section.

**Mode register set/Extended mode register set [MRS/EMRS]**

The DDR Mobile RAM has the two mode registers, the mode register and the extended mode register, to defines how it works. The both mode registers are set through the address pins in the mode register set cycle. For details, refer to "Mode register and extended mode register set".



**Function Truth Table**

The following tables show the operations that are performed when each command is issued in each state of the DDR Mobile RAM.

| Current state                           | /CS                      | /RAS | /CAS | /WE | Address     | Command    | Operation                               |         |
|---|--------------------------|------|------|-----|-------------|------------|---|---------|
| Precharging* <sup>1</sup>               | H                        | ×    | ×    | ×   | ×           | DESL       | NOP                                     |         |
|   | L                        | H    | H    | H   | ×           | NOP        | NOP                                     |         |
|   | L                        | H    | H    | L   | ×           | BST        | ILLEGAL* <sup>11</sup>                  |         |
|   | L                        | H    | L    | H   | BA, CA, A10 | READ/READA | ILLEGAL* <sup>11</sup>                  |         |
|   | L                        | H    | L    | L   | BA, CA, A10 | WRIT/WRITA | ILLEGAL* <sup>11</sup>                  |         |
|   | L                        | L    | H    | H   | BA, RA      | ACT        | ILLEGAL* <sup>11</sup>                  |         |
|   | L                        | L    | H    | L   | BA, A10     | PRE, PALL  | NOP                                     |         |
|   | L                        | L    | L    | ×   | ×           |            | ILLEGAL                                 |         |
| Idle* <sup>2</sup>                      | H                        | ×    | ×    | ×   | ×           | DESL       | NOP                                     |         |
|   | L                        | H    | H    | H   | ×           | NOP        | NOP                                     |         |
|   | L                        | H    | H    | L   | ×           | BST        | NOP                                     |         |
|   | L                        | H    | L    | H   | BA, CA, A10 | READ/READA | ILLEGAL* <sup>11</sup>                  |         |
|   | L                        | H    | L    | L   | BA, CA, A10 | WRIT/WRITA | ILLEGAL* <sup>11</sup>                  |         |
|   | L                        | L    | H    | H   | BA, RA      | ACT        | Activating                              |         |
|   | L                        | L    | H    | L   | BA, A10     | PRE, PALL  | NOP                                     |         |
|   | L                        | L    | L    | H   | ×           | REF, SELF  | Refresh/<br>Self-refresh* <sup>12</sup> |         |
| Refresh<br>(auto-refresh)* <sup>3</sup> | L                        | L    | L    | L   | MODE        | MRS        | Mode register set* <sup>12</sup>        |         |
|   | H                        | ×    | ×    | ×   | ×           | DESL       | NOP                                     |         |
|   | L                        | H    | H    | H   | ×           | NOP        | NOP                                     |         |
|   | H                        | H    | H    | L   | ×           | BST        | ILLEGAL                                 |         |
|   | L                        | H    | L    | ×   | ×           |            | ILLEGAL                                 |         |
|   | L                        | L    | ×    | ×   | ×           |            | ILLEGAL                                 |         |
|   | Activating* <sup>4</sup> | L    | L    | ×   | ×           | ×          |   | ILLEGAL |
|   |                          | H    | ×    | ×   | ×           | ×          | DESL                                    | NOP     |
| L                                       |                          | H    | H    | H   | ×           | NOP        | NOP                                     |         |
| L                                       |                          | H    | H    | L   | ×           | BST        | ILLEGAL* <sup>11</sup>                  |         |
| L                                       |                          | H    | L    | H   | BA, CA, A10 | READ/READA | ILLEGAL* <sup>11</sup>                  |         |
| L                                       |                          | H    | L    | L   | BA, CA, A10 | WRIT/WRITA | ILLEGAL* <sup>11</sup>                  |         |
| L                                       |                          | L    | H    | H   | BA, RA      | ACT        | ILLEGAL* <sup>11</sup>                  |         |
| L                                       |                          | L    | H    | L   | BA, A10     | PRE, PALL  | ILLEGAL* <sup>11</sup>                  |         |
| Active* <sup>5</sup>                    | L                        | L    | L    | ×   | ×           |            | ILLEGAL                                 |         |
|   | H                        | ×    | ×    | ×   | ×           | DESL       | NOP                                     |         |
|   | L                        | H    | H    | H   | ×           | NOP        | NOP                                     |         |
|   | L                        | H    | H    | L   | ×           | BST        | NOP                                     |         |
|   | L                        | H    | L    | H   | BA, CA, A10 | READ/READA | Starting read operation                 |         |
|   | L                        | H    | L    | L   | BA, CA, A10 | WRIT/WRITA | Starting write operation                |         |
|   | L                        | L    | H    | H   | BA, RA      | ACT        | ILLEGAL* <sup>11</sup>                  |         |
|   | L                        | L    | H    | L   | BA, A10     | PRE, PALL  | Pre-charge                              |         |
| L                                       | L                        | L    | ×    | ×   |             | ILLEGAL    |   |         |

| Current state                           | /CS | /RAS | /CAS | /WE | Address     | Command    | Operation  |
|---|-----|------|------|-----|-------------|------------|--|
| Read* <sup>6</sup>                      | H   | ×    | ×    | ×   | ×           | DESL       | NOP  |
|   | L   | H    | H    | H   | ×           | NOP        | NOP  |
|   | L   | H    | H    | L   | ×           | BST        | Burst stop   |
|   | L   | H    | L    | H   | BA, CA, A10 | READ/READA | Interrupting burst read operation to start new read              |
|   | L   | H    | L    | L   | BA, CA, A10 | WRIT/WRITA | ILLEGAL * <sup>13</sup>  |
|   | L   | L    | H    | H   | BA, RA      | ACT        | ILLEGAL * <sup>11</sup>  |
|   | L   | L    | H    | L   | BA, A10     | PRE, PALL  | Interrupting burst read operation to start pre-charge            |
|   | L   | L    | L    | ×   | ×           |            | ILLEGAL  |
| Read with auto pre-charge* <sup>7</sup> | H   | ×    | ×    | ×   | ×           | DESL       | NOP  |
|   | L   | H    | H    | H   | ×           | NOP        | NOP  |
|   | L   | H    | H    | L   | ×           | BST        | ILLEGAL  |
|   | L   | H    | L    | H   | BA, CA, A10 | READ/READA | ILLEGAL * <sup>14</sup>  |
|   | L   | H    | L    | L   | BA, CA, A10 | WRIT/WRITA | ILLEGAL * <sup>14</sup>  |
|   | L   | L    | H    | H   | BA, RA      | ACT        | ILLEGAL * <sup>11, 14</sup>                                      |
|   | L   | L    | H    | L   | BA, A10     | PRE, PALL  | ILLEGAL * <sup>11, 14</sup>                                      |
|   | L   | L    | L    | ×   | ×           |            | ILLEGAL  |
| Write* <sup>8</sup>                     | H   | ×    | ×    | ×   | ×           | DESL       | NOP  |
|   | L   | H    | H    | H   | ×           | NOP        | NOP  |
|   | L   | H    | H    | L   | ×           | BST        | Burst Stop   |
|   | L   | H    | L    | H   | BA, CA, A10 | READ/READA | Interrupting burst write operation to start read operation.      |
|   | L   | H    | L    | L   | BA, CA, A10 | WRIT/WRITA | Interrupting burst write operation to start new write operation. |
|   | L   | L    | H    | H   | BA, RA      | ACT        | ILLEGAL * <sup>11</sup>  |
|   | L   | L    | H    | L   | BA, A10     | PRE, PALL  | Interrupting write operation to start pre-charge.                |
|   | L   | L    | L    | ×   | ×           |            | ILLEGAL  |
| Write recovering* <sup>9</sup>          | H   | ×    | ×    | ×   | ×           | DESL       | NOP  |
|   | L   | H    | H    | H   | ×           | NOP        | NOP  |
|   | L   | H    | H    | L   | ×           | BST        | ILLEGAL  |
|   | L   | H    | L    | H   | BA, CA, A10 | READ/READA | Starting read operation.   |
|   | L   | H    | L    | L   | BA, CA, A10 | WRIT/WRITA | Starting new write operation.                                    |
|   | L   | L    | H    | H   | BA, RA      | ACT        | ILLEGAL * <sup>11</sup>  |
|   | L   | L    | H    | L   | BA, A10     | PRE/PALL   | ILLEGAL * <sup>11</sup>  |
|   | L   | L    | L    | ×   | ×           |            | ILLEGAL  |

| Current state                | /CS | /RAS | /CAS | /WE | Address     | Command     | Operation       |
|------------------------------|-----|------|------|-----|-------------|-------------|-----------------|
| Write with auto pre-charge*1 | H   | ×    | ×    | ×   | ×           | DESL        | NOP             |
|                              | L   | H    | H    | H   | ×           | NOP         | NOP             |
|                              | L   | H    | H    | L   | ×           | BST         | ILLEGAL         |
|                              | L   | H    | L    | H   | BA, CA, A10 | READ/READA  | ILLEGAL *14     |
|                              | L   | H    | L    | L   | BA, CA, A10 | WRIT/WRIT A | ILLEGAL *14     |
|                              | L   | L    | H    | H   | BA, RA      | ACT         | ILLEGAL *11, 14 |
|                              | L   | L    | H    | L   | BA, A10     | PRE, PALL   | ILLEGAL *11, 14 |
|                              | L   | L    | L    | ×   | ×           |             | ILLEGAL         |

Remark: H: VIH. L: VIL. ×: Don't care.

- Notes:
1. The DDR Mobile RAM is in "Precharging" state for tRP after precharge command is issued.
  2. The DDR Mobile RAM reaches "IDLE" state tRP after precharge command is issued.
  3. The DDR Mobile RAM is in "Refresh" state for tRFC after auto-refresh command is issued.
  4. The DDR Mobile RAM is in "Activating" state for tRCD after ACT command is issued.
  5. The DDR Mobile RAM is in "Active" state after "Activating" is completed.
  6. The DDR Mobile RAM is in "READ" state until burst data have been output and DQ output circuits are turned off.
  7. The DDR Mobile RAM is in "READ with auto precharge" from READA command until burst data has been output and DQ output circuits are turned off.
  8. The DDR Mobile RAM is in "WRITE" state from WRIT command to the last burst data are input.
  9. The DDR Mobile RAM is in "Write recovering" for tWR after the last data are input.
  10. The DDR Mobile RAM is in "Write with auto precharge" until tWR after the last data has been input.
  11. This command may be issued for other banks, depending on the state of the banks.
  12. All banks must be in "IDLE".
  13. Before executing a write command to stop the preceding burst read operation, BST command must be issued.
  14. The DDR Mobile RAM supports the concurrent auto precharge feature, a read with auto precharge or a write with auto precharge, can be followed by any command to the other banks, as long as that command does not interrupt the read or write data transfer, and all other related limitations apply (e.g. contention between READ data and WRITE data must be avoided.)

The minimum delay from a read or write command with auto precharge, to a command to a different bank, is summarized below.

| From command | To command (different bank, non-interrupting command) | Minimum delay (Concurrent AP supported) | Units |
|--------------|---|---|-------|
| Read w/AP    | Read or Read w/AP                                     | BL/2                                    | tCK   |
|              | Write or Write w/AP                                   | CL (rounded up)+ (BL/2)                 | tCK   |
|              | Precharge or Activate                                 | 1                                       | tCK   |
| Write w/AP   | Read or Read w/AP                                     | 1 + (BL/2) + tWTR                       | tCK   |
|              | Write or Write w/AP                                   | BL/2                                    | tCK   |
|              | Precharge or Activate                                 | 1                                       | tCK   |

**CKE Truth Table**

| Current state | Command                    | CKE   |   |     |      |      |     | Address | Notes |
|---------------|----------------------------|-------|---|-----|------|------|-----|---------|-------|
|               |                            | n - 1 | n | /CS | /RAS | /CAS | /WE |         |       |
| Idle          | Auto-refresh command (REF) | H     | H | L   | L    | L    | H   | ×       | 2     |
| Idle          | Self-refresh entry (SELF)  | H     | L | L   | L    | L    | H   | ×       | 2     |
| Active/Idle   | Power-down entry (PDEN)    | H     | L | L   | H    | H    | H   | ×       |       |
|               |                            | H     | L | H   | ×    | ×    | ×   | ×       |       |
| Self-refresh  | Self-refresh exit (SELFX)  | L     | H | L   | H    | H    | H   | ×       |       |
|               |                            | L     | H | H   | ×    | ×    | ×   | ×       |       |
| Power-down    | Power-down exit (PDEX)     | L     | H | L   | H    | H    | H   | ×       |       |
|               |                            | L     | H | H   | ×    | ×    | ×   | ×       |       |

Notes: 1. H: VIH . L: VIL × : Don't care.

2. All the banks must be in IDLE before executing this command.
3. The CKE level must be kept for 1 clock cycle at least.

**Auto-refresh command [REF]**

This command executes auto-refresh. The bank and the ROW addresses to be refreshed are internally determined by the internal refresh controller. The output buffer becomes high-Z after auto-refresh start. Precharge has been completed automatically after the auto-refresh. The ACT or MRS command can be issued tRFC after the last auto-refresh command.

The average refresh cycle is 7.8µs. To allow for improved efficiency in scheduling, some flexibility in the absolute refresh interval (64ms) is provided. A maximum of eight auto-refresh commands can be posted to the DDR Mobile RAM or the maximum absolute interval between any auto-refresh command and the next auto-refresh command is 8 × tREF.

**Self-refresh entry [SELF]**

This command starts self-refresh. The self-refresh operation continues as long as CKE is held low. During the self-refresh operation, all ROW addresses are repeated refreshing by the internal refresh controller. A self-refresh is terminated by a self-refresh exit command.

**Power-down mode entry [PDEN]**

tPDEN after the cycle when [PDEN] is issued, the DDR Mobile RAM enters into power-down mode. In power-down mode, power consumption is suppressed by deactivating the input initial circuit. Power-down mode continues while CKE is held low. No internal refresh operation occurs during the power-down mode.

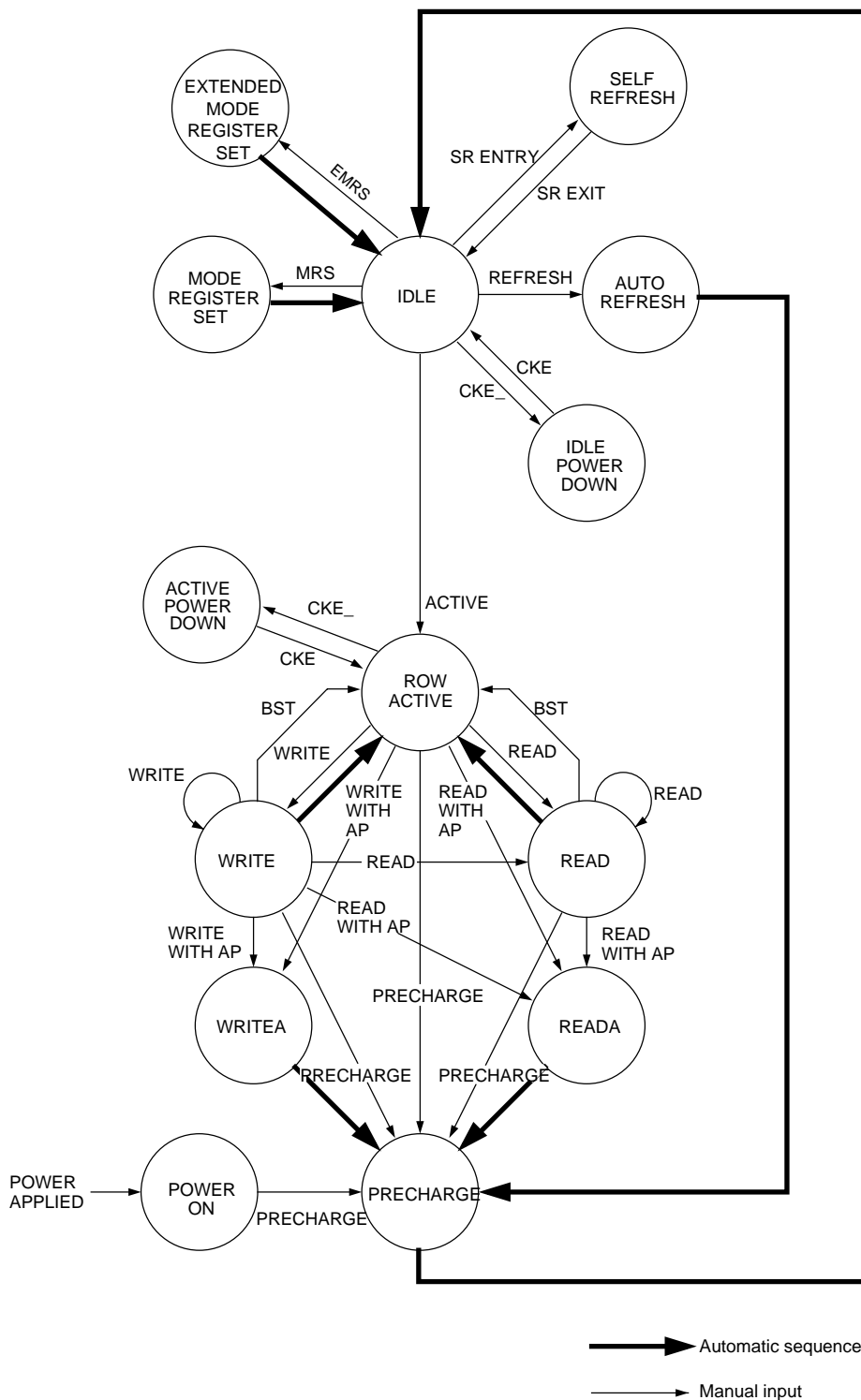
**Self-refresh exit [SELFX]**

This command is executed to exit from self-refresh mode. tSREX after [SELFX], the device will be into idle state.

**Power-down exit [PDEX]**

The DDR Mobile RAM can exit from power-down mode tPDEX (1 cycle min.) after the cycle when [PDEX] is issued.

Simplified State Diagram



## Operation of the DDR Mobile RAM

### Initialization

The DDR Mobile RAM is initialized in the power-on sequence according to the following.

1. Provide power, the device core power (VDD) and the device I/O power (VDDQ) must be brought up simultaneously to prevent device latch-up. Although not required, it is recommended that VDD and VDDQ are from the same power source. Also assert and hold Clock Enable (CKE) to a LV-CMOS logic high level.
2. Once the system has established consistent device power and CKE is driven high, it is safe to apply stable clock.
3. There must be at least 200 $\mu$ s of valid clocks before any command may be given to the DRAM. During this time NOP or deselect (DESL) commands must be issued on the command bus.
4. Issue a precharge all command.
5. Provide NOPs or DESL commands for at least tRP time.
6. Issue an auto-refresh command followed by NOPs or DESL command for at least tRFC time. Issue the second auto-refresh command followed by NOPs or DESL command for at least tRFC time. Note as part of the initialization sequence there must be two auto-refresh commands issued. The typical flow is to issue them at Step 6, but they may also be issued between steps 10 and 11.
7. Using the MRS command, load the base mode register. Set the desired operating modes.
8. Provide NOPs or DESL commands for at least tMRD time.
9. Using the MRS command, program the extended mode register for the desired operating modes.
10. Provide NOP or DESL commands for at least tMRD time.
11. The DRAM has been properly initialized and is ready for any valid command.

**Mode Register and Extended Mode Register Set**

There are two mode registers, the mode register and the extended mode register so as to define the operating mode. Parameters are set to both through the A0 to the A12 and BA0 and BA1 pins by the mode register set command [MRS] or the extended mode register set command [EMRS]. The mode register and the extended mode register are set by inputting signal via the A0 to the A12 and BA0 and BA1 pins during mode register set cycles. BA0 and BA1 determine which one of the mode register or the extended mode register are set. Prior to a read or a write operation, the mode register must be set.

**Mode Register**

The mode register has four fields;

- Reserved : A12 through A7
- /CAS latency : A6 through A4
- Burst type : A3
- Burst length : A2 through A0

Following mode register programming, no command can be issued before at least 2 clocks have elapsed.

**/CAS Latency**

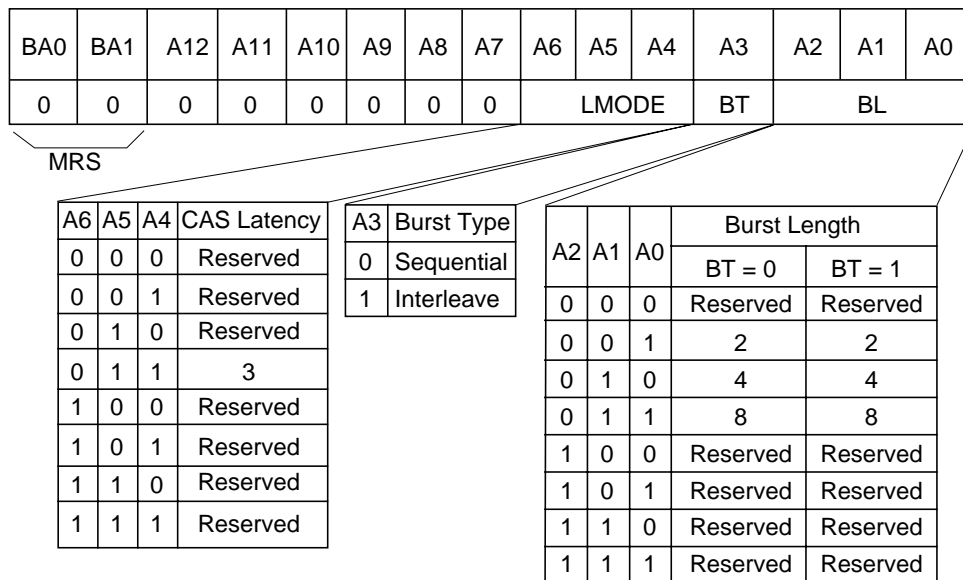
/CAS latency must be set to 3.

**Burst Length**

Burst Length is the number of words that will be output or input in a read or write cycle. After a read burst is completed, the output bus will become high-Z. The burst length is programmable as 2, 4 and 8 .

**Burst Type (Burst Sequence)**

The burst type specifies the order in which the burst data will be addressed. This order is programmable as either "Sequential" or "Interleave". "Burst Operation" shows the addressing sequence for each burst length for each burst type.



**Mode Register Set**

**Extended Mode Register**

The extended mode register is as follows;

- Reserved : A12 through A7, A4 through A0
- Driver Strength : A6 through A5

Following extended mode register programming, no command can be issued before at least 2 clocks have elapsed.

**Driver Strength**

|     |     |     |     |     |    |    |    |    |    |    |    |    |    |    |
|-----|-----|-----|-----|-----|----|----|----|----|----|----|----|----|----|----|
| BA1 | BA0 | A12 | A11 | A10 | A9 | A8 | A7 | A6 | A5 | A4 | A3 | A2 | A1 | A0 |
| 1   | 0   | 0   | 0   | 0   | 0  | 0  | 0  | DS |    | 0  | 0  | 0  | 0  | 0  |

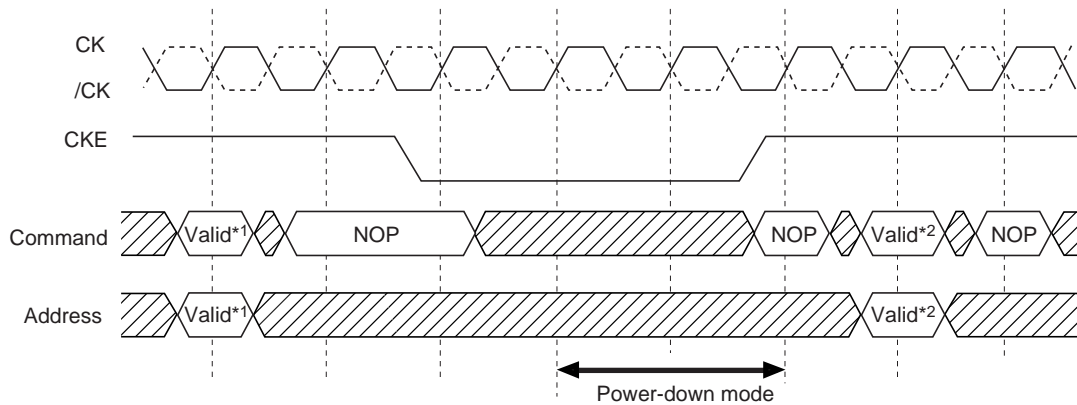
| A6 | A5 | Driver Strength |
|----|----|-----------------|
| 0  | 0  | Normal          |
| 0  | 1  | 1/2 strength    |
| 1  | 0  | 1/4 strength    |
| 1  | 1  | Reserved        |

**Extended Mode Register Set**



**Power-Down Mode and CKE Control**

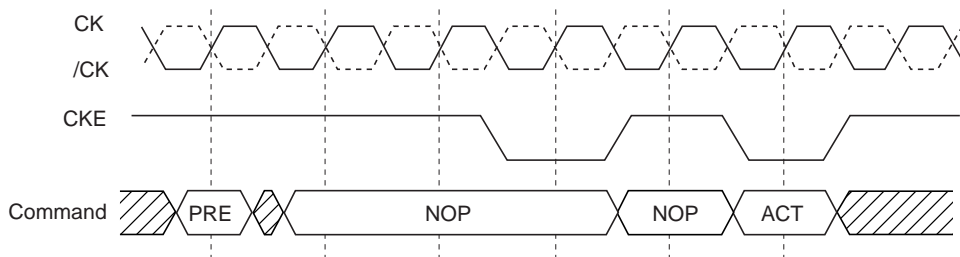
DDR Mobile RAM will be into power-down mode at the second CK rising edge after CKE to be low level with NOP or DESL command at first CK rising edge after CKE signal to be low.



- Notes: 1. Valid\*1 can be either Activate command or Precharge command, When Valid\*1 is Activate command, power-down mode will be active power-down mode, while it will be precharge power down mode, if Valid\*1 will be Precharge command.
- 2. Valid\*2 can be any command as long as all of specified AC parameters are satisfied.

**Power-Down Entry and Exit**

However, if the CKE has one clock cycle high and on clock cycle low just as below, even DDR Mobile RAM will not enter power-down mode, this command flow does not hurt any data and can be done.



Note: Assume PRE and ACT command is closing and activating same bank.

**CKE Control**

**Burst Operation**

The burst type (BT) and the first three bits of the column address determine the order of a data out.

Burst length = 2

| Starting Ad. | Addressing(decimal) |            |
|--------------|---------------------|------------|
| A0           | Sequence            | Interleave |
| 0            | 0, 1,               | 0, 1,      |
| 1            | 1, 0,               | 1, 0,      |

Burst length = 4

| Starting Ad. |    | Addressing(decimal) |             |
|--------------|----|---------------------|-------------|
| A1           | A0 | Sequence            | Interleave  |
| 0            | 0  | 0, 1, 2, 3,         | 0, 1, 2, 3, |
| 0            | 1  | 1, 2, 3, 0,         | 1, 0, 3, 2, |
| 1            | 0  | 2, 3, 0, 1,         | 2, 3, 0, 1, |
| 1            | 1  | 3, 0, 1, 2,         | 3, 2, 1, 0, |

Burst length = 8

| Starting Ad. |    |    | Addressing(decimal)     |                         |
|--------------|----|----|-------------------------|-------------------------|
| A2           | A1 | A0 | Sequence                | Interleave              |
| 0            | 0  | 0  | 0, 1, 2, 3, 4, 5, 6, 7, | 0, 1, 2, 3, 4, 5, 6, 7, |
| 0            | 0  | 1  | 1, 2, 3, 4, 5, 6, 7, 0, | 1, 0, 3, 2, 5, 4, 7, 6, |
| 0            | 1  | 0  | 2, 3, 4, 5, 6, 7, 0, 1, | 2, 3, 0, 1, 6, 7, 4, 5, |
| 0            | 1  | 1  | 3, 4, 5, 6, 7, 0, 1, 2, | 3, 2, 1, 0, 7, 6, 5, 4, |
| 1            | 0  | 0  | 4, 5, 6, 7, 0, 1, 2, 3, | 4, 5, 6, 7, 0, 1, 2, 3, |
| 1            | 0  | 1  | 5, 6, 7, 0, 1, 2, 3, 4, | 5, 4, 7, 6, 1, 0, 3, 2, |
| 1            | 1  | 0  | 6, 7, 0, 1, 2, 3, 4, 5, | 6, 7, 4, 5, 2, 3, 0, 1, |
| 1            | 1  | 1  | 7, 0, 1, 2, 3, 4, 5, 6, | 7, 6, 5, 4, 3, 2, 1, 0, |

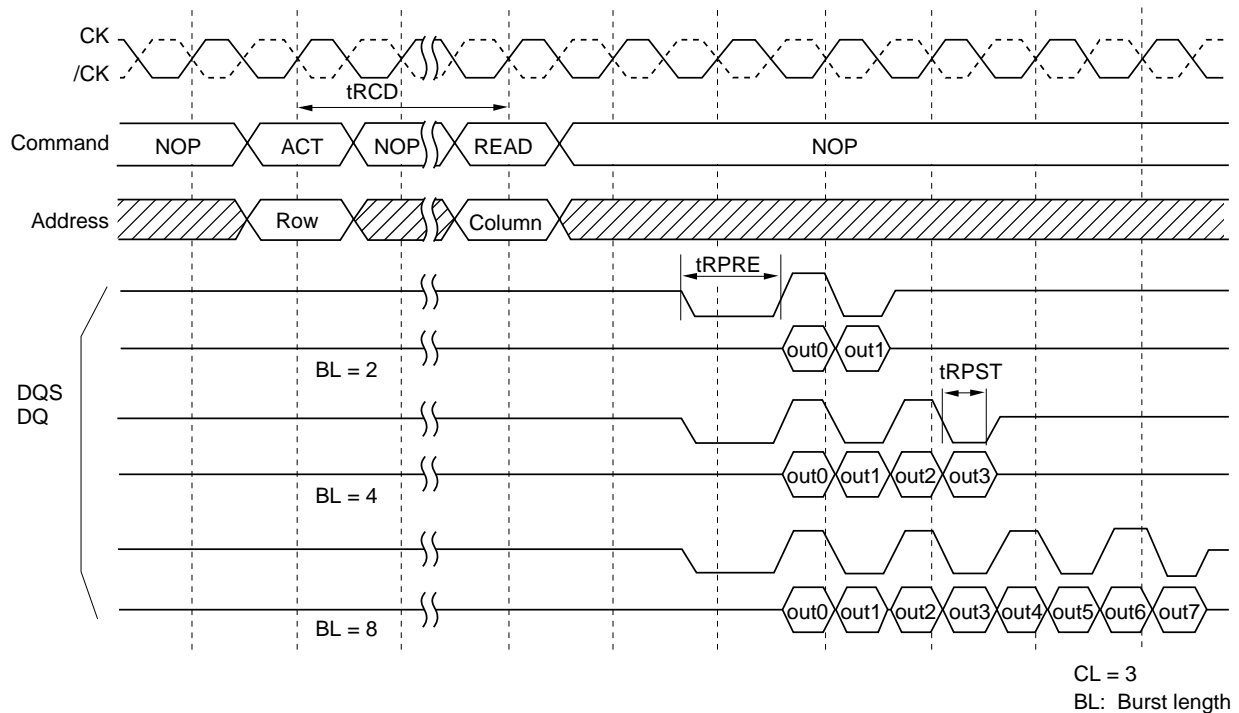
**Read/Write Operations**

**Bank Active**

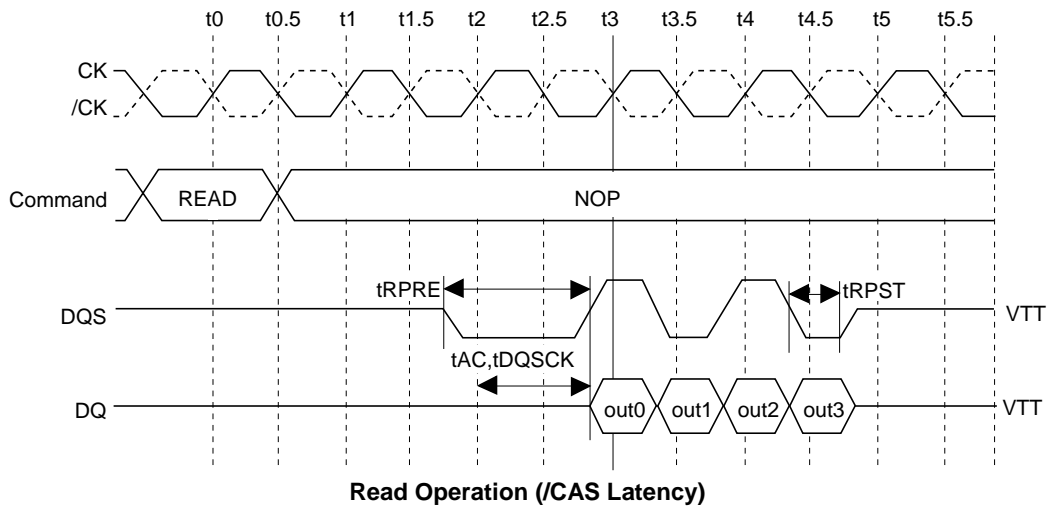
A read or a write operation begins with the bank active command [ACT]. The bank active command determines a bank address and a row address. For the bank and the row, a read or a write command can be issued  $t_{RCD}$  after the ACT is issued.

**Read Operation**

The burst length (BL), the /CAS latency (CL) and the burst type (BT) of the mode register are referred when a read command is issued. The burst length (BL) determines the length of a sequential output data by the read command that can be set to 2, 4 or 8. The starting address of the burst read is defined by the column address, the bank select address (See "Pin Function") in the cycle when the read command is issued. The data output timing is characterized by CL and tAC. The read burst start  $(CL-1) \times t_{CK} + t_{AC}$  (ns) after the clock rising edge where the read command is latched. The DDR Mobile RAM outputs the data strobe through DQS pins simultaneously with data.  $t_{RPRE}$  prior to the first rising edge of the data strobe, the DQS pins are driven low from high-Z state. This low period of DQS is referred as read preamble. The burst data are output coincidentally at both the rising and falling edge of the data strobe. The DQ pins become high-Z in the next cycle after the burst read operation completed.  $t_{RPST}$  from the last falling edge of the data strobe, the DQS pins become high-Z. This low period of DQS is referred as read postamble.

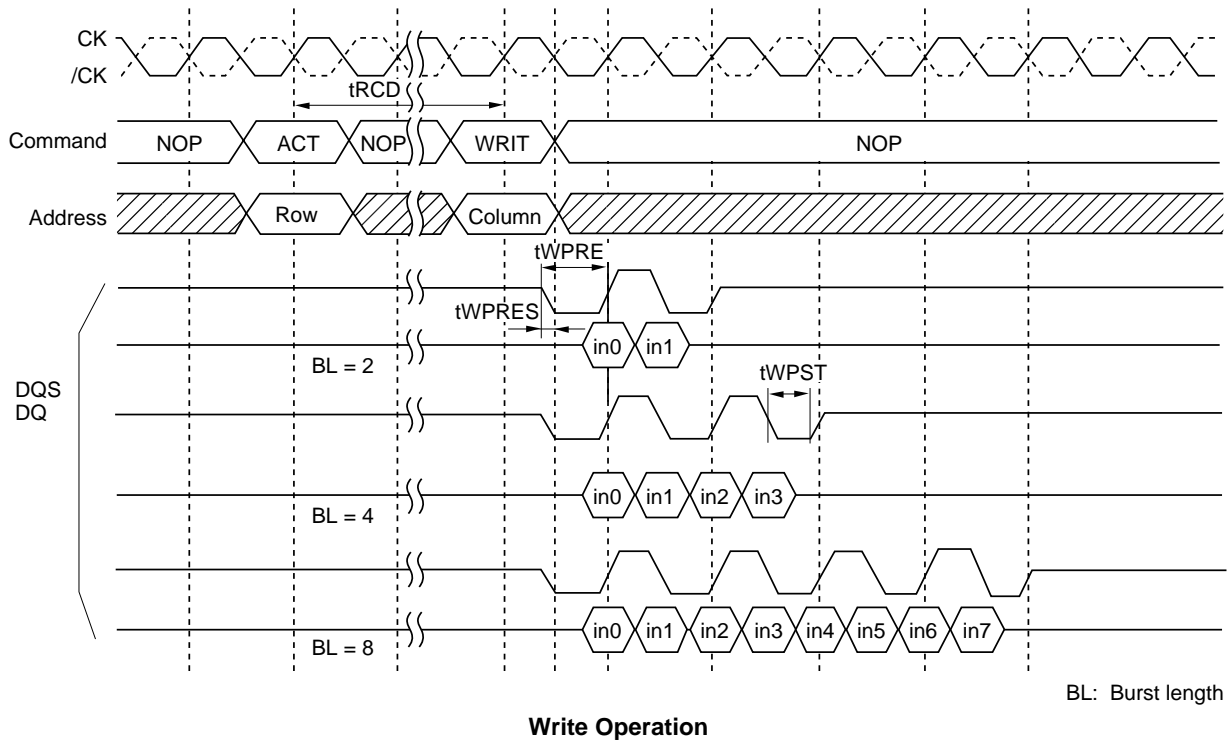


**Read Operation (Burst Length)**



**Write Operation**

The burst length (BL) and the burst type (BT) of the mode register are referred when a write command is issued. The burst length (BL) determines the length of a sequential data input by the write command that can be set to 2, 4 or 8. The latency from write command to data input is fixed to 1. The starting address of the burst write is defined by the column address, the bank select address (See “Pin Function”) in the cycle when the write command is issued. DQS should be input as the strobe for the input-data and DM as well during burst operation. tWPRES prior to the first rising edge of DQS, DQS must be set to low. tWPST after the last falling edge of DQS, the DQS pins can be changed to high-Z. The leading low period of DQS is referred as write preamble. The last low period of DQS is referred as write postamble.



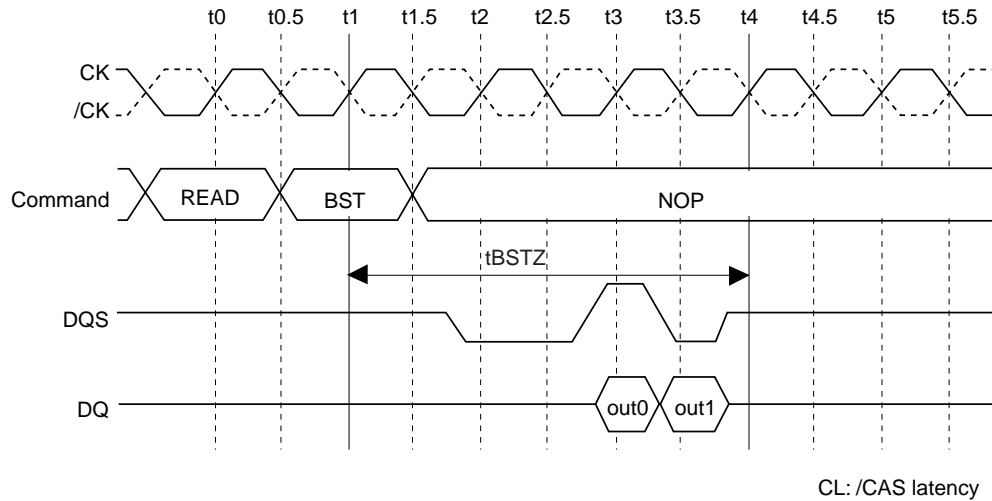
**Burst Stop**

**Burst Stop Command during Burst Operation**

The burst stop (BST) command stops the burst read and sets all output buffers to high-Z.  $t_{BSTZ}$  (= CL) cycles after a BST command issued, all DQ and DQS pins become high-Z.

The BST command is also supported for the burst write operation. No data will be written in subsequent cycles.

Note that bank address is not referred when this command is executed.

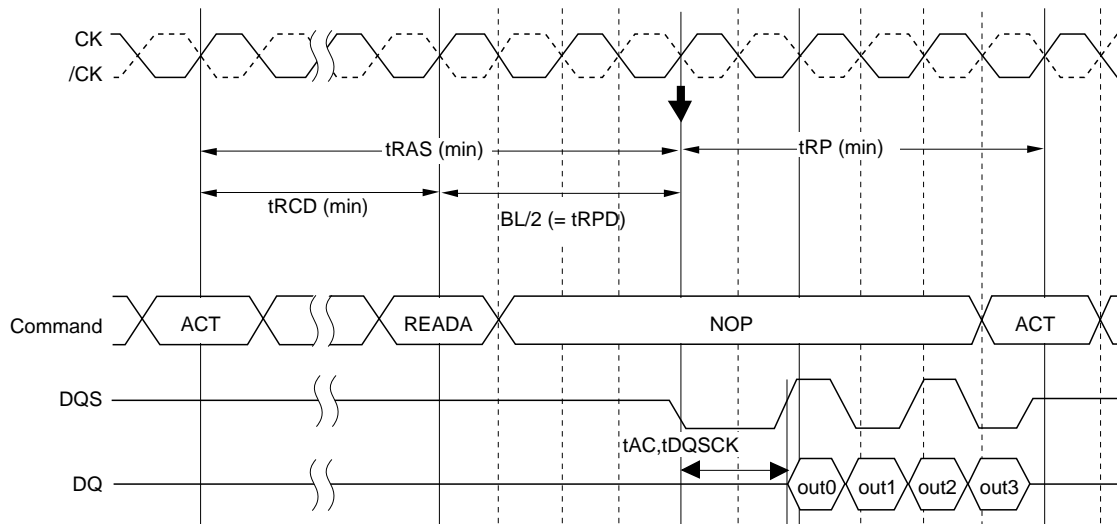


**Burst Stop during a Read Operation**

**Auto Precharge**

**Read with Auto Precharge**

The precharge is automatically performed after completing a read operation. The precharge starts  $BL/2 (= tRPD)$  clocks after READA command input.  $tRAS$  lock out mechanism for READA allows a read command with auto precharge to be issued to a bank that has been activated (opened) but has not yet satisfied the  $tRAS$  (min) specification. A column command to the other active bank can be issued the next cycle after the last data output. Read with auto precharge command does not limit row commands execution for other bank.



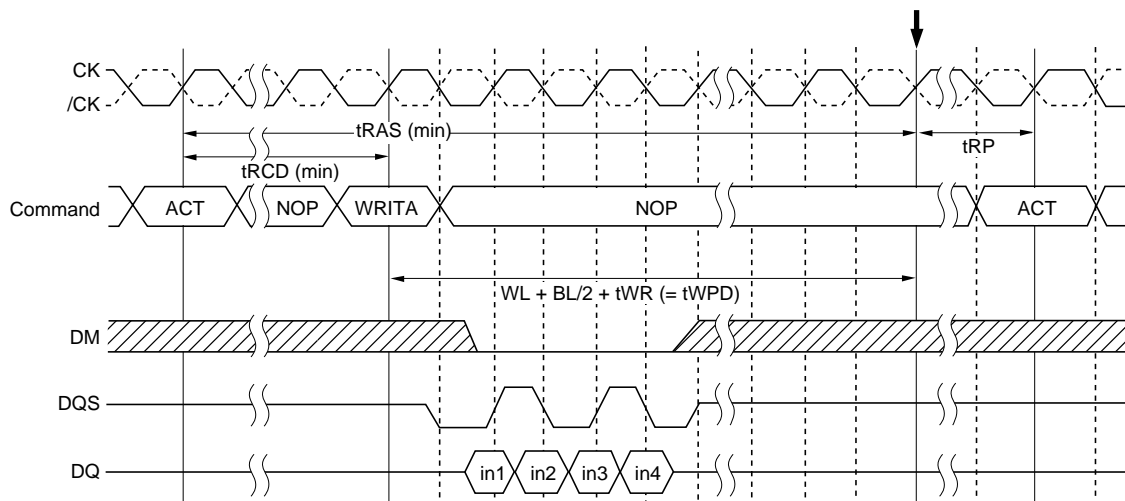
Note: Internal auto-precharge starts at the timing indicated by "↓".

**Read with auto precharge**

**Write with Auto Precharge**

The precharge is automatically performed after completing a burst write operation. The precharge operation is started  $Write\ latency\ (WL) + BL/2 + tWR (= tWPD)$  clocks after WRITA command issued.

A column command to the other banks can be issued the next cycle after the internal precharge command issued. Write with auto precharge command does not limit row commands execution for other bank.



Note: Internal auto-precharge starts at the timing indicated by "↓".

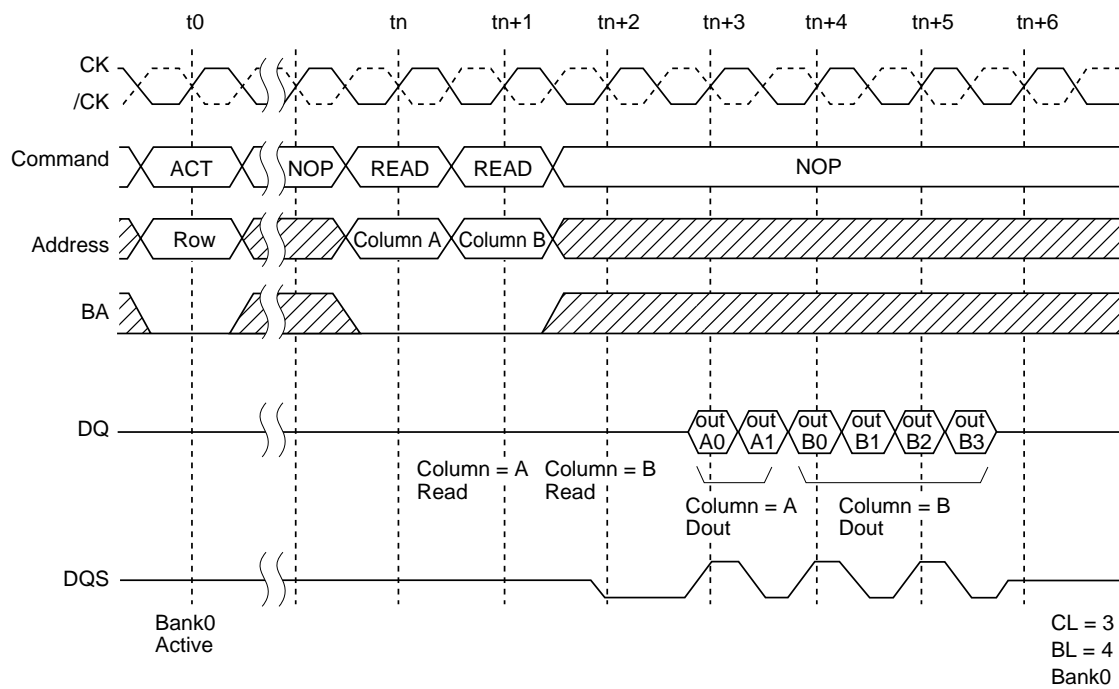
**Burst Write (BL = 4)**

**Command Intervals**

**A Read Command to the Consecutive Read Command Interval**

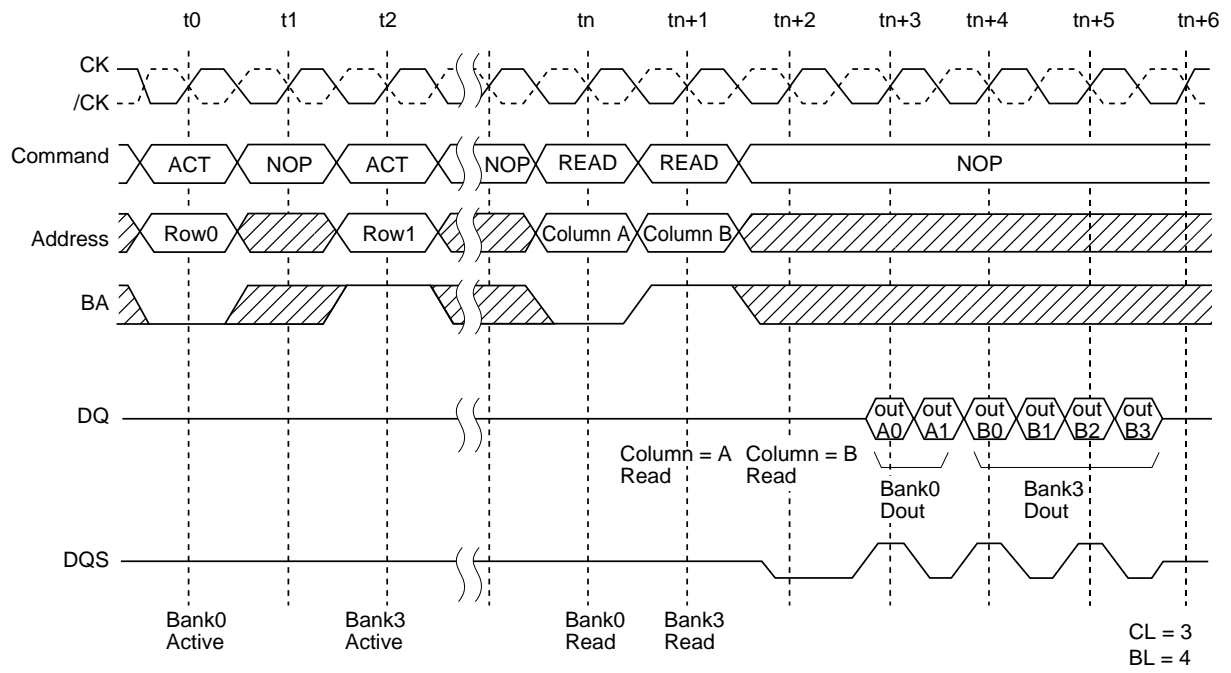
Destination row of the consecutive read command

| Bank address | Row address | State  | Operation   |
|--------------|-------------|--------|---|
| 1. Same      | Same        | ACTIVE | The consecutive read can be performed after an interval of no less than 1 cycle to interrupt the preceding read operation.  |
| 2. Same      | Different   | —      | Precharge the bank to interrupt the preceding read operation. tRP after the precharge command, issue the ACT command. tRCD after the ACT command, the consecutive read command can be issued. See 'A read command to the consecutive precharge interval' section. |
| 3. Different | Any         | ACTIVE | The consecutive read can be performed after an interval of no less than 1 cycle to interrupt the preceding read operation.  |
|              |             | IDLE   | Precharge the bank without interrupting the preceding read operation. tRP after the precharge command, issue the ACT command. tRCD after the ACT command, the consecutive read command can be issued.   |



**READ to READ Command Interval (same ROW address in the same bank)\***

Note:  $n \geq 4$



**READ to READ Command Interval (different bank)\***

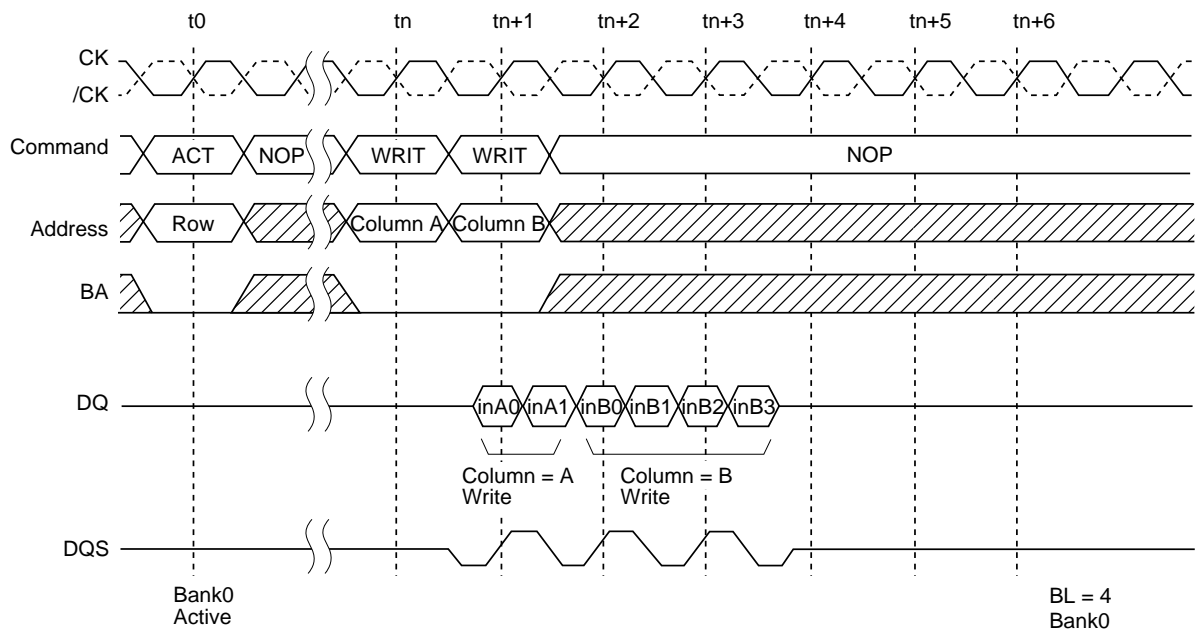
Note:  $n \geq 4$



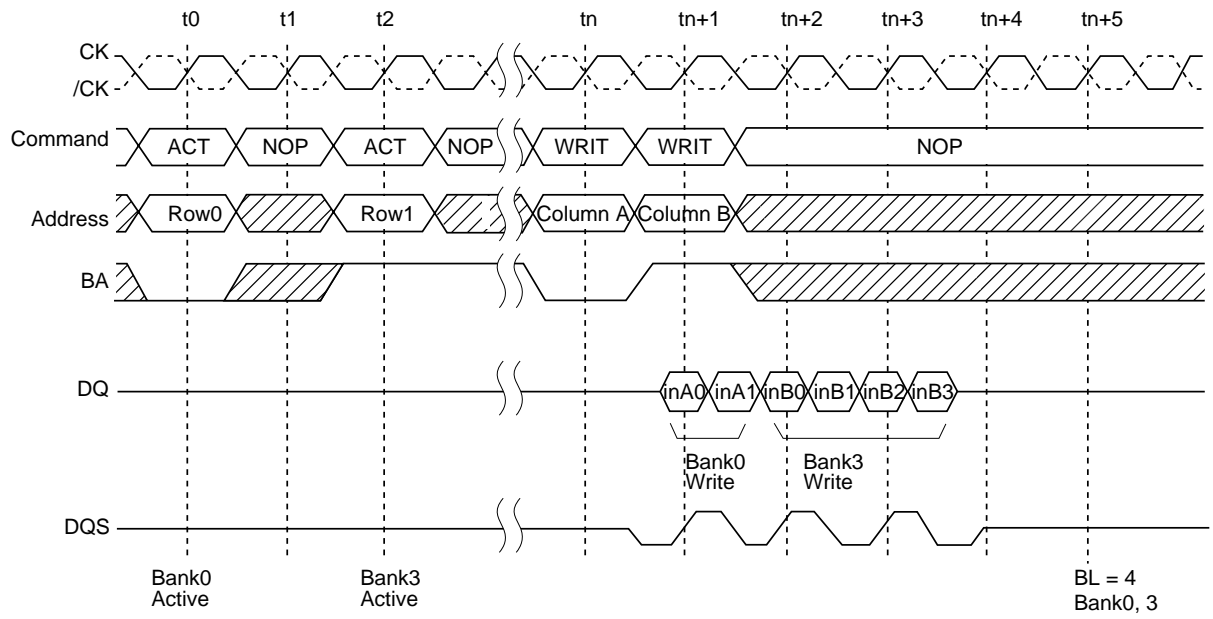
**A Write Command to the Consecutive Write Command Interval**

Destination row of the consecutive write command

| Bank address | Row address | State  | Operation  |
|--------------|-------------|--------|--|
| 1. Same      | Same        | ACTIVE | The consecutive write can be performed after an interval of no less than 1 cycle to interrupt the preceding write operation.   |
| 2. Same      | Different   | —      | Precharge the bank to interrupt the preceding write operation. tRP after the precharge command, issue the ACT command. tRCD after the ACT command, the consecutive write command can be issued. See 'A write command to the consecutive precharge interval' section. |
| 3. Different | Any         | ACTIVE | The consecutive write can be performed after an interval of no less than 1 cycle to interrupt the preceding write operation.   |
|              |             | IDLE   | Precharge the bank without interrupting the preceding write operation. tRP after the precharge command, issue the ACT command. tRCD after the ACT command, the consecutive write command can be issued.  |



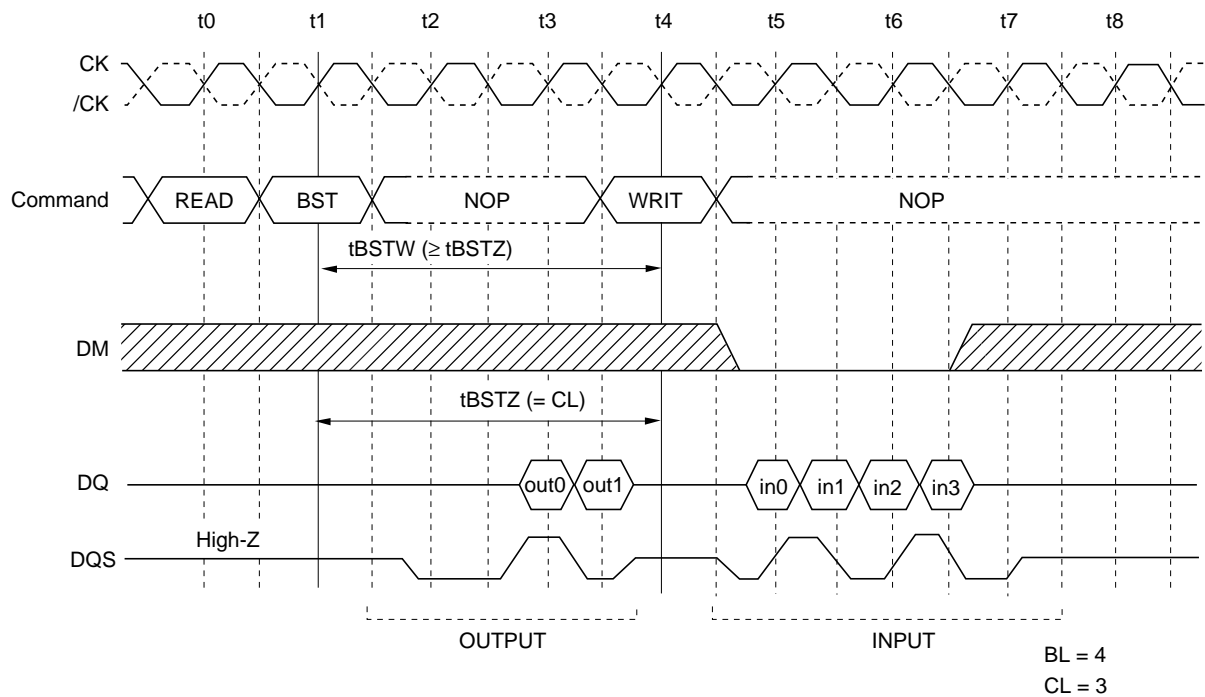
**WRITE to WRITE Command Interval (same ROW address in the same bank)**



**A Read Command to the Consecutive Write Command Interval with the BST Command**

Destination row of the consecutive write command

| Bank address | Row address | State  | Operation  |
|--------------|-------------|--------|--|
| 1. Same      | Same        | ACTIVE | Issue the BST command. $t_{BSTW} (\geq t_{BSTZ})$ after the BST command, the consecutive write command can be issued.  |
| 2. Same      | Different   | —      | Precharge the bank to interrupt the preceding read operation. $t_{RP}$ after the precharge command, issue the ACT command. $t_{RCD}$ after the ACT command, the consecutive write command can be issued. See 'A read command to the consecutive precharge interval' section. |
| 3. Different | Any         | ACTIVE | Issue the BST command. $t_{BSTW} (\geq t_{BSTZ})$ after the BST command, the consecutive write command can be issued.  |
|              |             | IDLE   | Precharge the bank independently of the preceding read operation. $t_{RP}$ after the precharge command, issue the ACT command. $t_{RCD}$ after the ACT command, the consecutive write command can be issued.   |

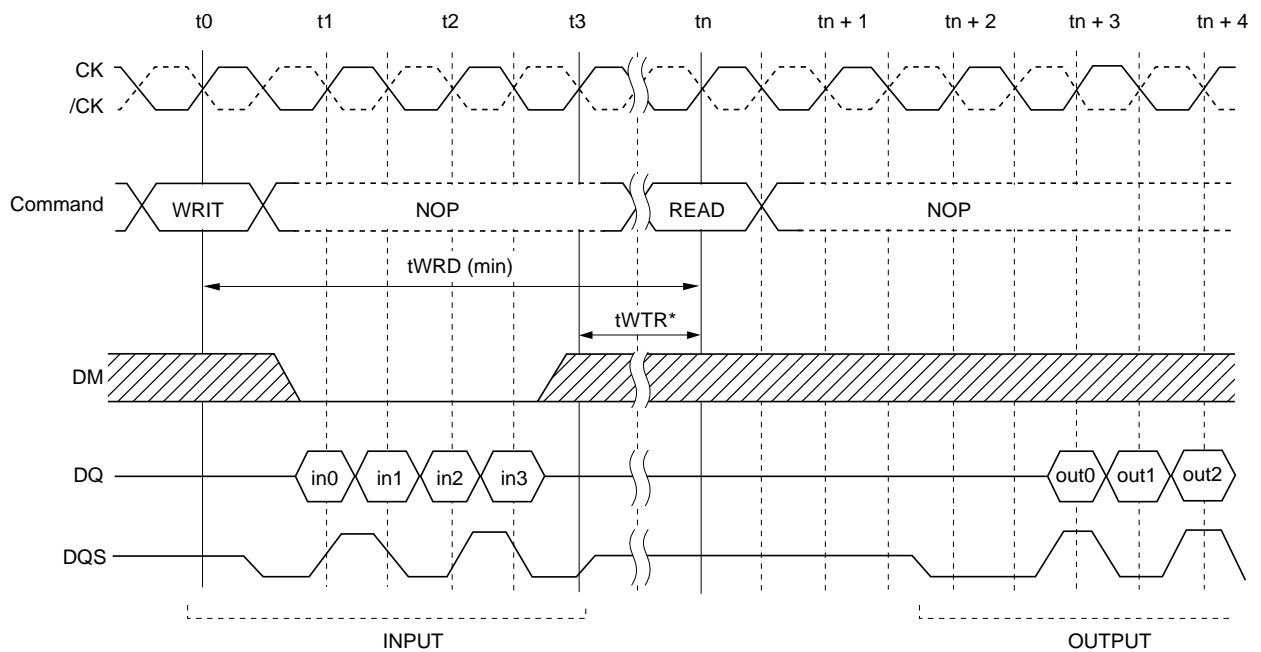


**READ to WRITE Command Interval**

**A Write Command to the Consecutive Read Command Interval: To Complete the Burst Operation**

Destination row of the consecutive read command

| Bank address | Row address | State  | Operation  |
|--------------|-------------|--------|--|
| 1. Same      | Same        | ACTIVE | To complete the burst operation, the consecutive read command should be performed tWRD after the write command.  |
| 2. Same      | Different   | —      | Precharge the bank tWPD after the preceding write command. tRP after the precharge command, issue the ACT command. tRCD after the ACT command, the consecutive read command can be issued. See 'A read command to the consecutive precharge interval' section. |
| 3. Different | Any         | ACTIVE | To complete a burst operation, the consecutive read command should be performed tWRD after the write command.  |
|              |             | IDLE   | Precharge the bank independently of the preceding write operation. tRP after the precharge command, issue the ACT command. tRCD after the ACT command, the consecutive read command can be issued.   |



Note: tWTR is referenced from the first positive CK edge after the last desired data in pair tWTR.

BL = 4  
CL = 3

**WRITE to READ Command Interval**

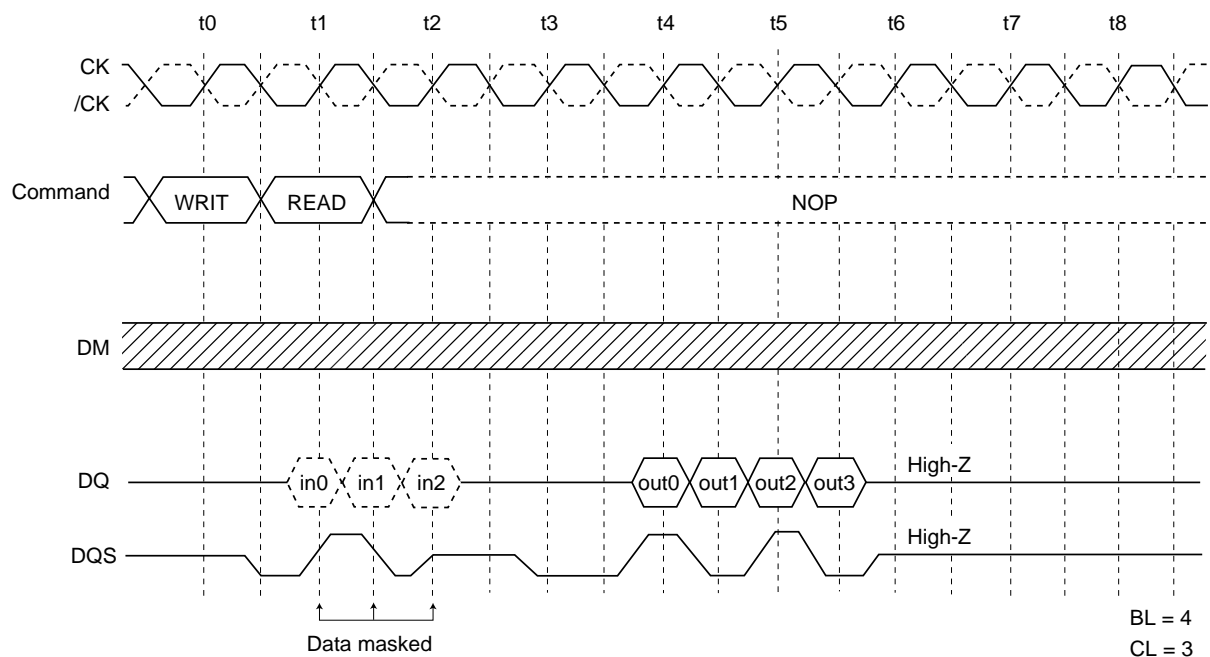
**A Write Command to the Consecutive Read Command Interval: To Interrupt the Write Operation**

Destination row of the consecutive read command

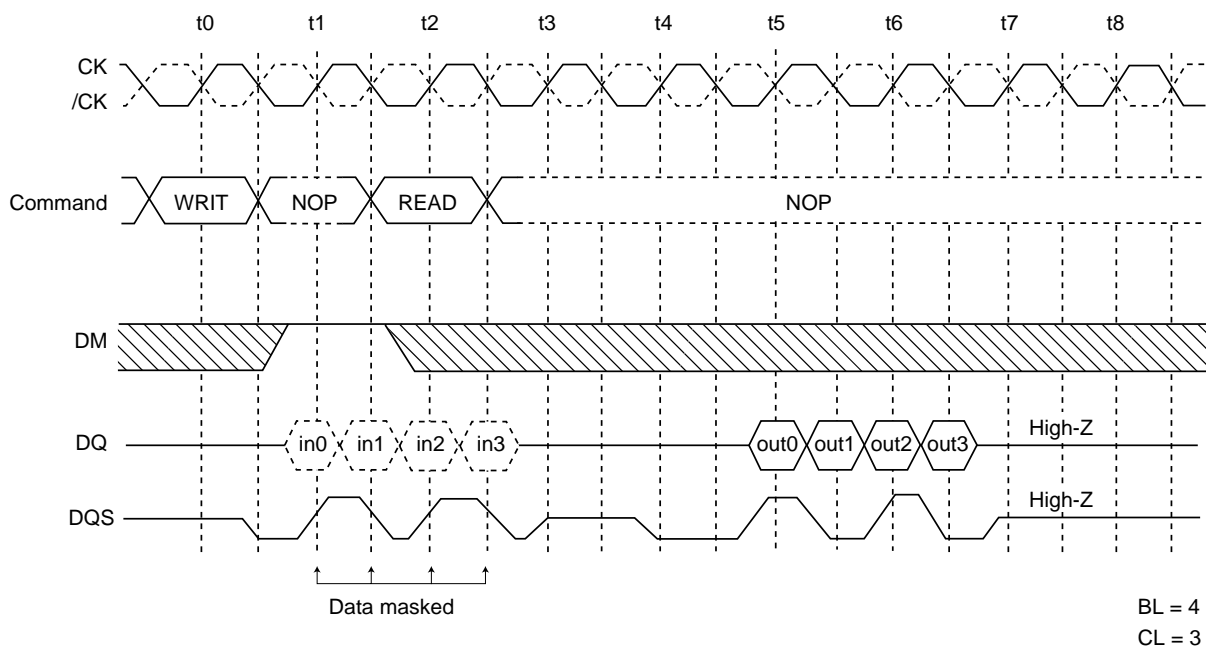
| Bank address | Row address | State  | Operation  |
|--------------|-------------|--------|--|
| 1. Same      | Same        | ACTIVE | DM must be input 1 cycle prior to the read command input to prevent from being written invalid data. In case, the read command is input in the next cycle of the write command, DM is not necessary. |
| 2. Same      | Different   | —      | —*1  |
| 3. Different | Any         | ACTIVE | DM must be input 1 cycle prior to the read command input to prevent from being written invalid data. In case, the read command is input in the next cycle of the write command, DM is not necessary. |
|              |             | IDLE   | —*1  |

Note: 1. Precharge must be preceded to read command. Therefore read command can not interrupt the write operation in this case.

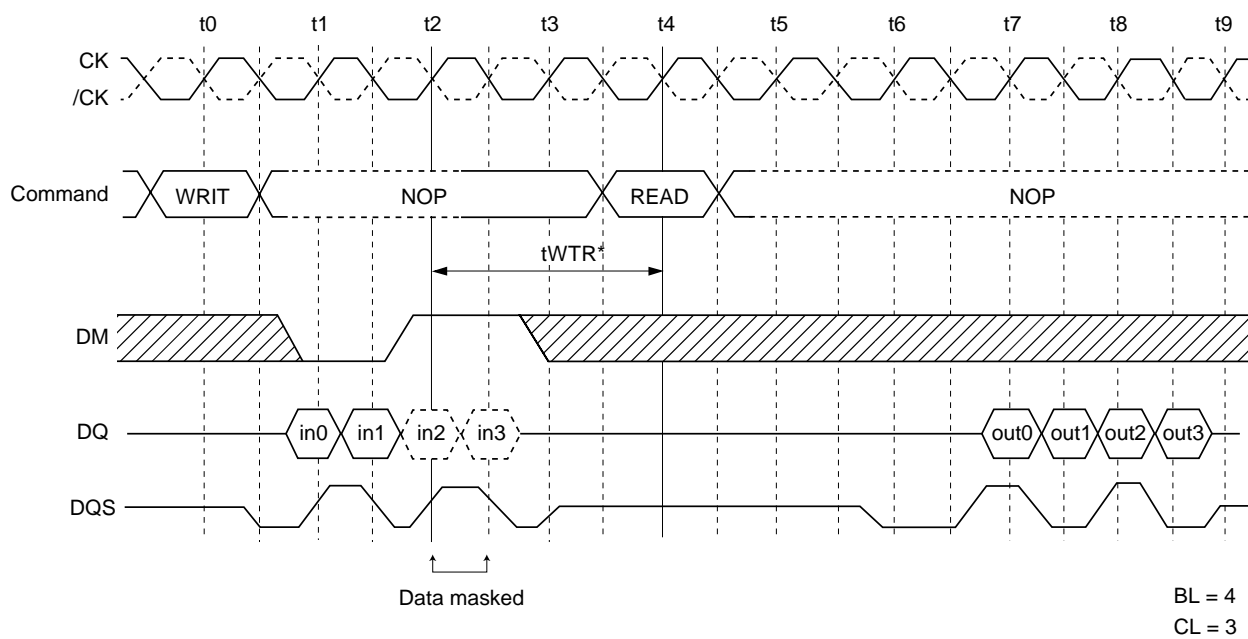
**WRITE to READ Command Interval (Same bank, same ROW address)**



[WRITE to READ delay = 1 clock cycle]



[WRITE to READ delay = 2 clock cycle]

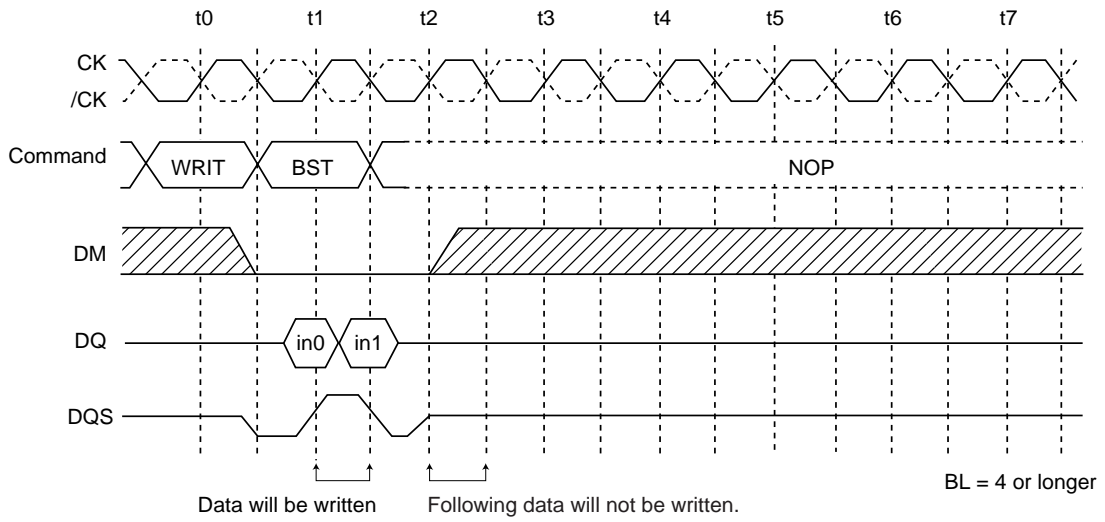


Note:  $t_{WTR}$  is referenced from the first positive CK edge after the last desired data in pair  $t_{WTR}$ .

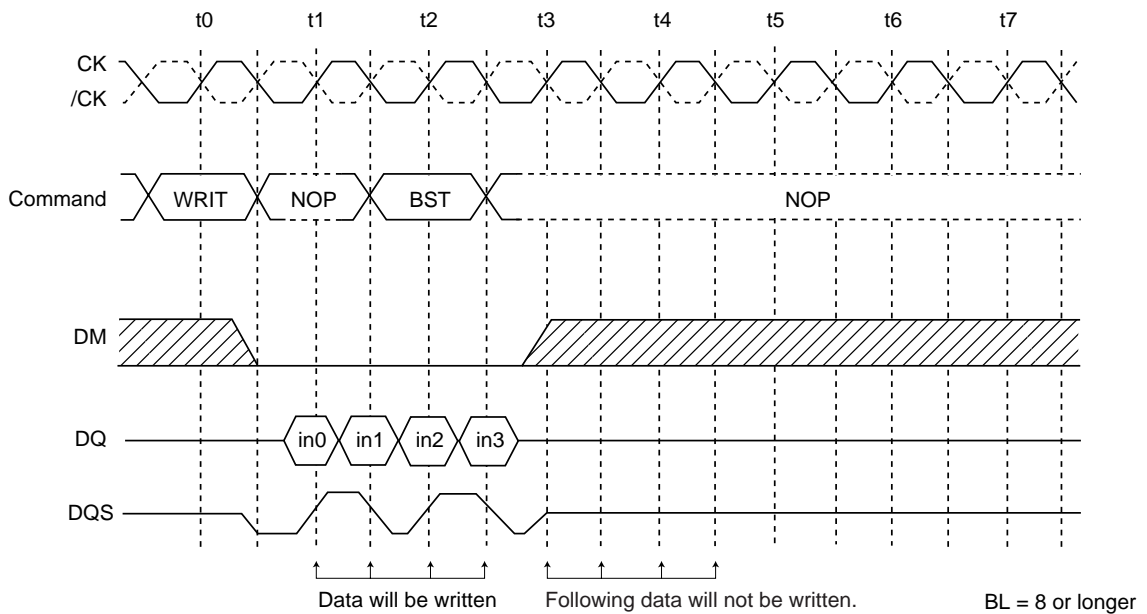
[WRITE to READ delay = 4 clock cycle]

A Write Command to the Bust Stop Command Interval: To Interrupt the Write Operation

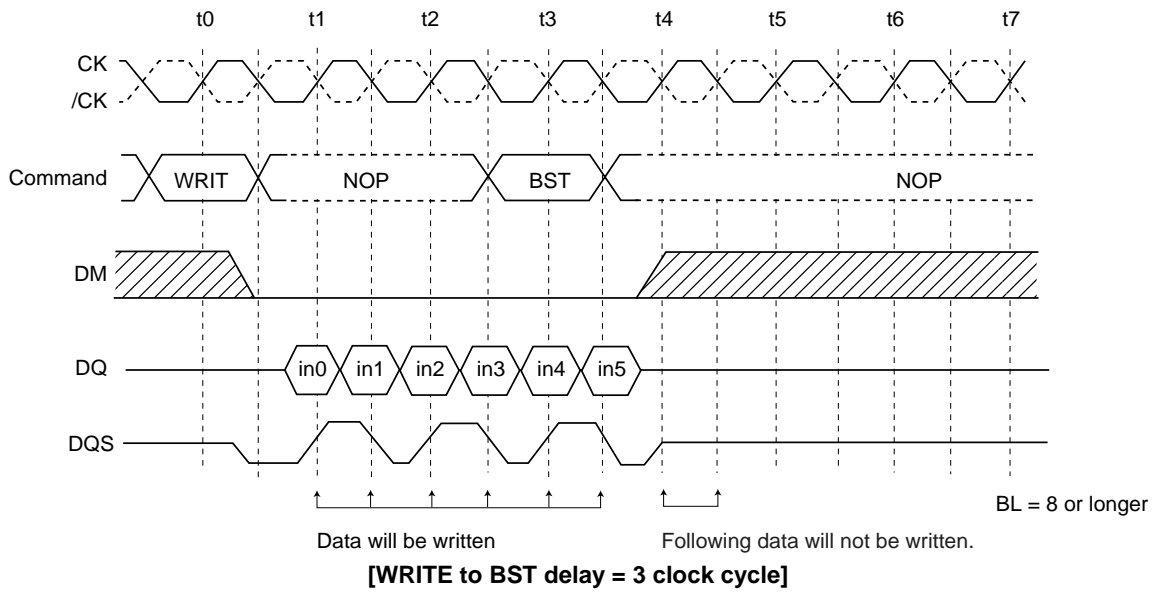
WRITE to BST Command Interval (Same bank, same ROW address)



[WRITE to BST delay = 1 clock cycle]



[WRITE to BST delay = 2 clock cycle]





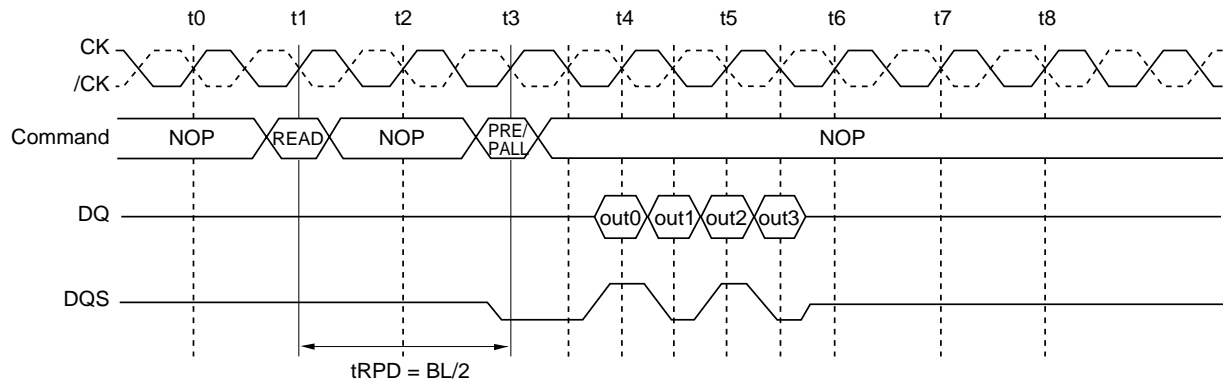
**A READ Command to the Consecutive Precharge Command Interval**

Operation by each case of destination bank of the consecutive Precharge command.

| Bank address | Operation  |
|--------------|--|
| 1. Same      | The PRE and PALL command can interrupt a read operation.<br>To complete a burst read operation, tRPD is required between the read and the precharge command. Please refer to the following timing chart. |
| 2. Different | The PRE command does not interrupt a read command.<br>No interval timing is required between the read and the precharge command.   |

**READ to PRECHARGE Command Interval (same bank) : To output all data**

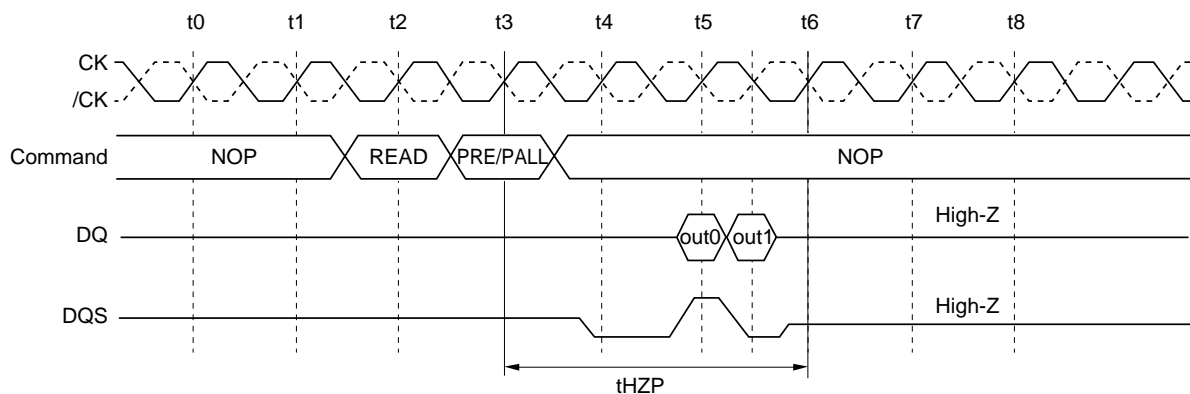
To complete a burst read operation and get a burst length of data, the consecutive precharge command must be issued tRPD (= BL/ 2 cycles) after the read command is issued.



**READ to PRECHARGE Command Interval (same bank): To output all data (CL = 3, BL = 4)**

**READ to PRECHARGE Command Interval (same bank): To stop output data**

A burst data output can be interrupted with a precharge command. All DQ pins and DQS pins become high-Z tHZP (= CL) after the precharge command.



**READ to PRECHARGE Command Interval (same bank): To stop output data (CL = 3, BL = 4, 8)**

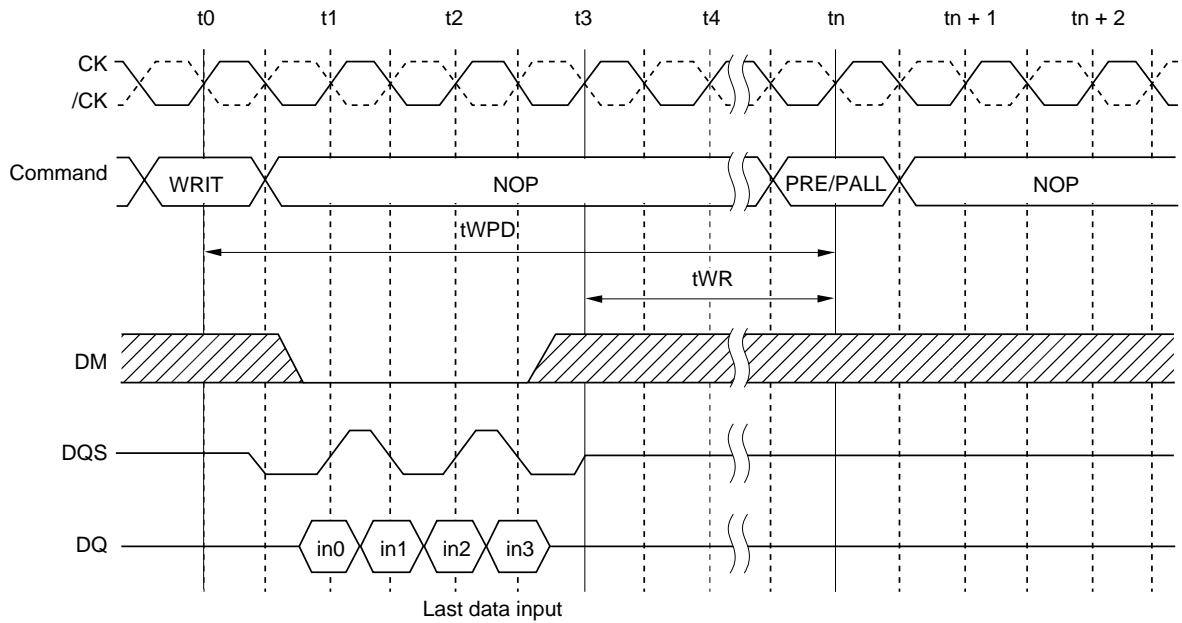
**A Write Command to the Consecutive Precharge Command Interval (same bank)**

Operation by each case of destination bank of the consecutive Precharge command.

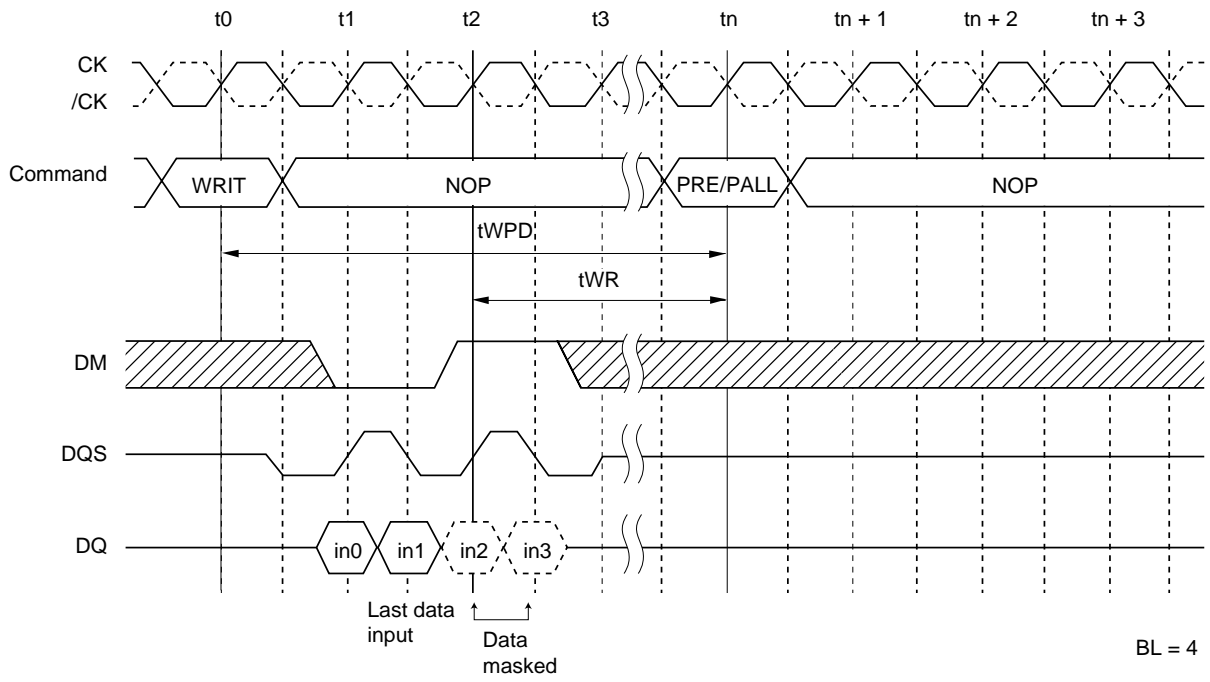
| Bank address | Operation  |
|--------------|--|
| 1. Same      | The PRE and PALL command can interrupt a write operation.<br>To complete a burst write operation, $t_{WPD}$ is required between the write and the precharge command. Please refer to the following timing chart. |
| 2. Different | The PRE command does not interrupt a write command.<br>No interval timing is required between the write and the precharge command.   |

**WRITE to PRECHARGE Command Interval (same bank)**

The minimum interval  $t_{WPD}$  is necessary between the write command and the precharge command.



**WRITE to PRECHARGE Command Interval (same bank) (BL = 4)**

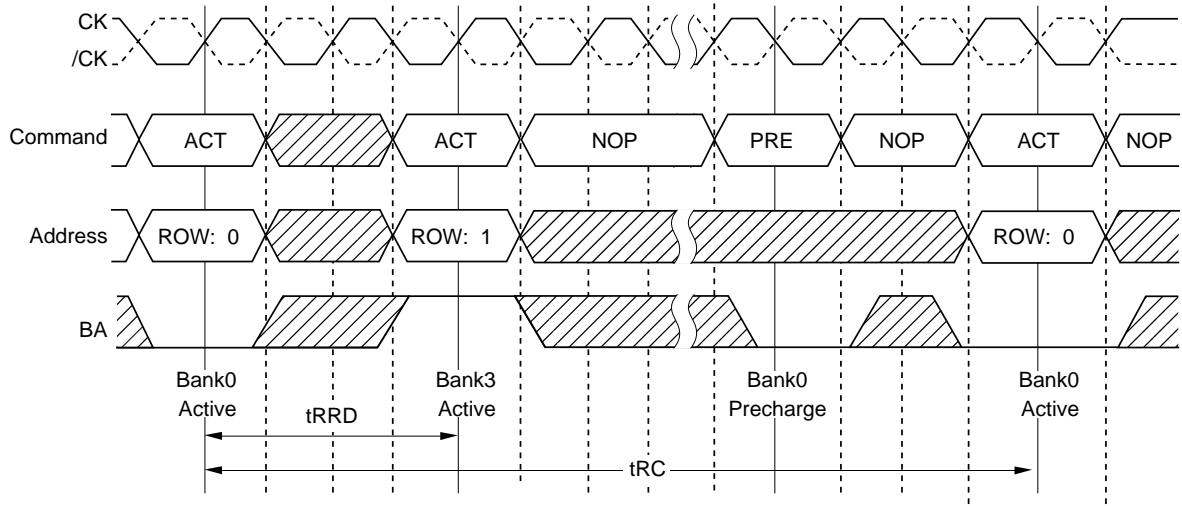


WRITE to PRECHARGE Command Interval (same bank) (BL = 4, DM to mask data)

**Bank Active Command Interval**

Destination row of the consecutive ACT command

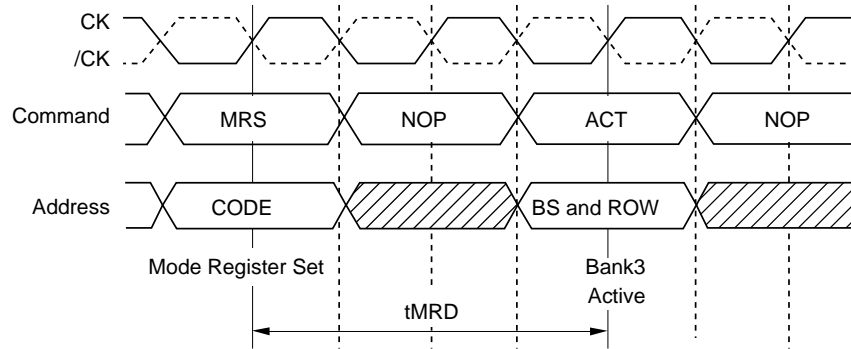
| Bank address | Row address | State  | Operation  |
|--------------|-------------|--------|--|
| 1. Same      | Any         | ACTIVE | Two successive ACT commands can be issued at tRC interval. In between two successive ACT operations, precharge command should be executed. |
| 2. Different | Any         | ACTIVE | Precharge the bank. tRP after the precharge command, the consecutive ACT command can be issued.  |
|              |             | IDLE   | tRRD after an ACT command, the next ACT command can be issued.   |



**Bank Active to Bank Active**

**Mode Register Set to Bank-Active Command Interval**

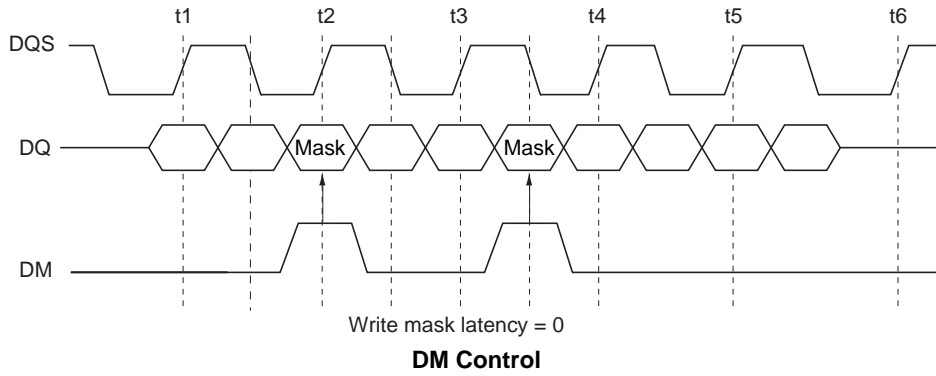
The interval between setting the mode register and executing a bank-active command must be no less than tMRD.



**Mode Register Set to Bank Active**

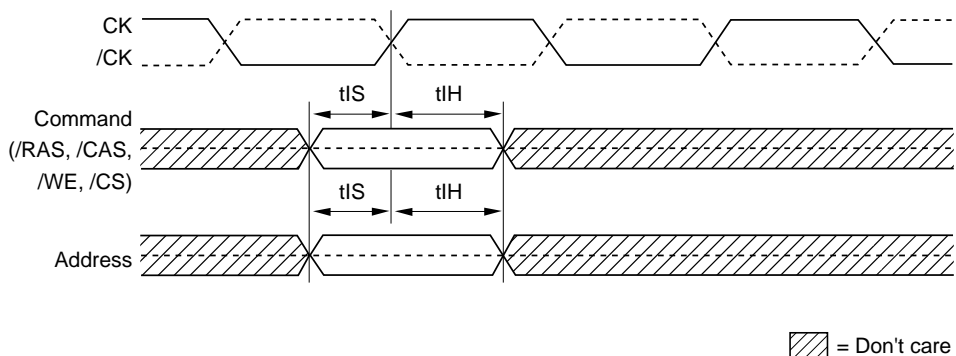
**DM Control**

DM can mask input data. By setting DM to low, data can be written. When DM is set to high, the corresponding data is not written, and the previous data is held. The latency between DM input and enabling/disabling mask function is 0.

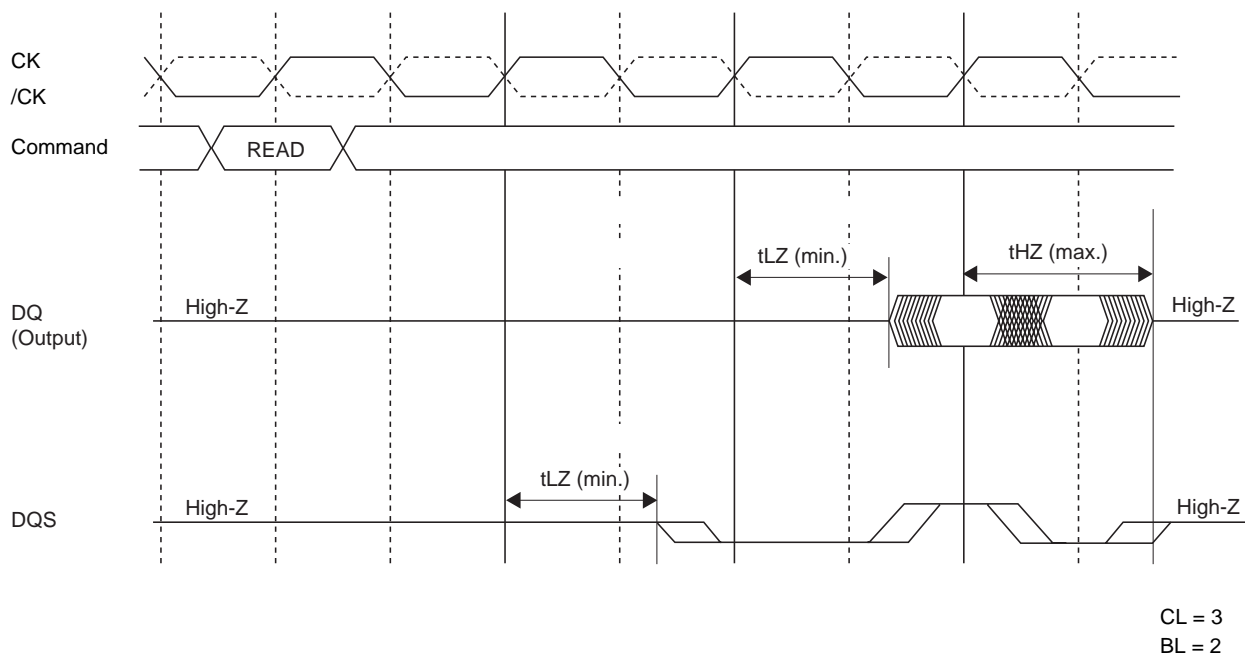


Timing Waveforms

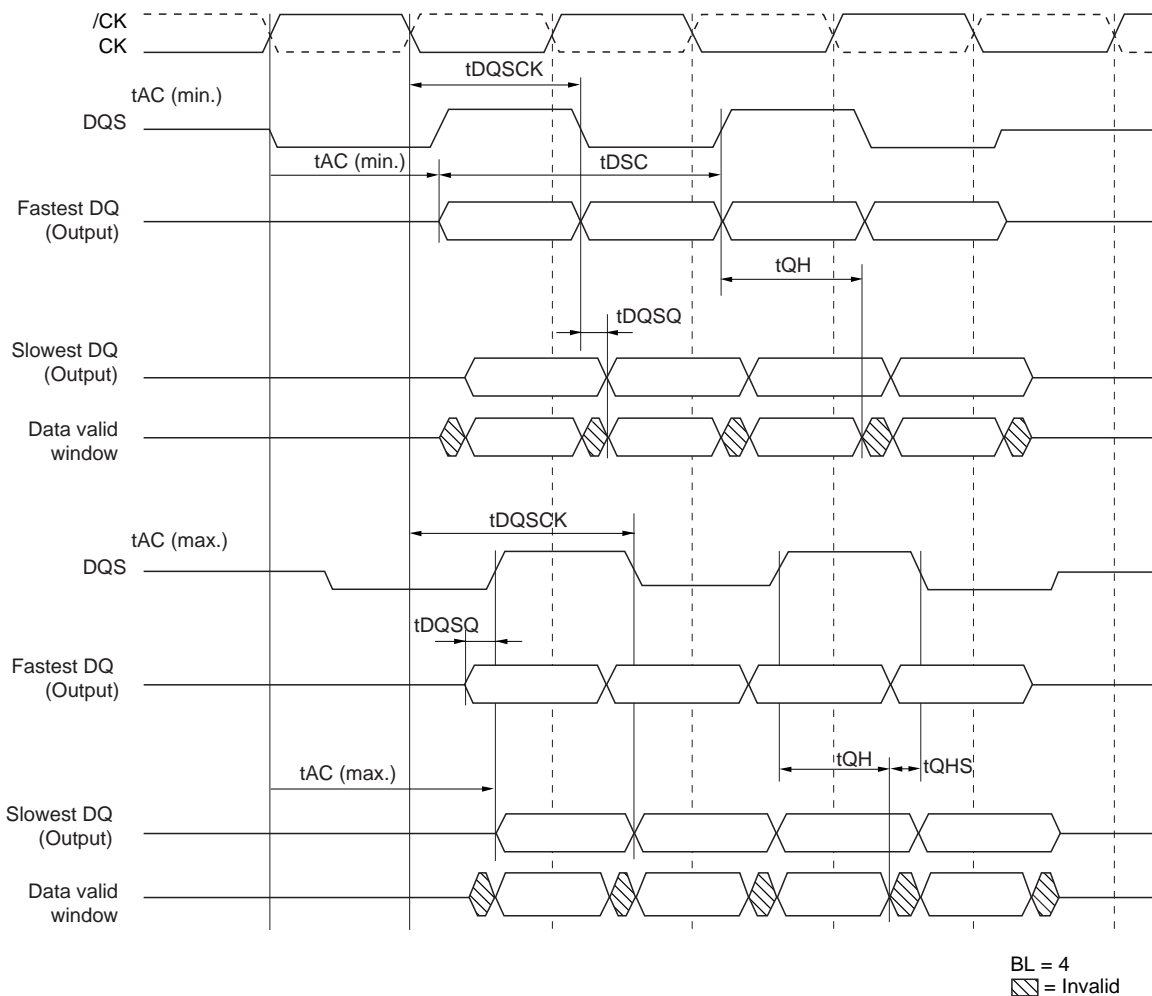
Command and Addresses Input Timing Definition



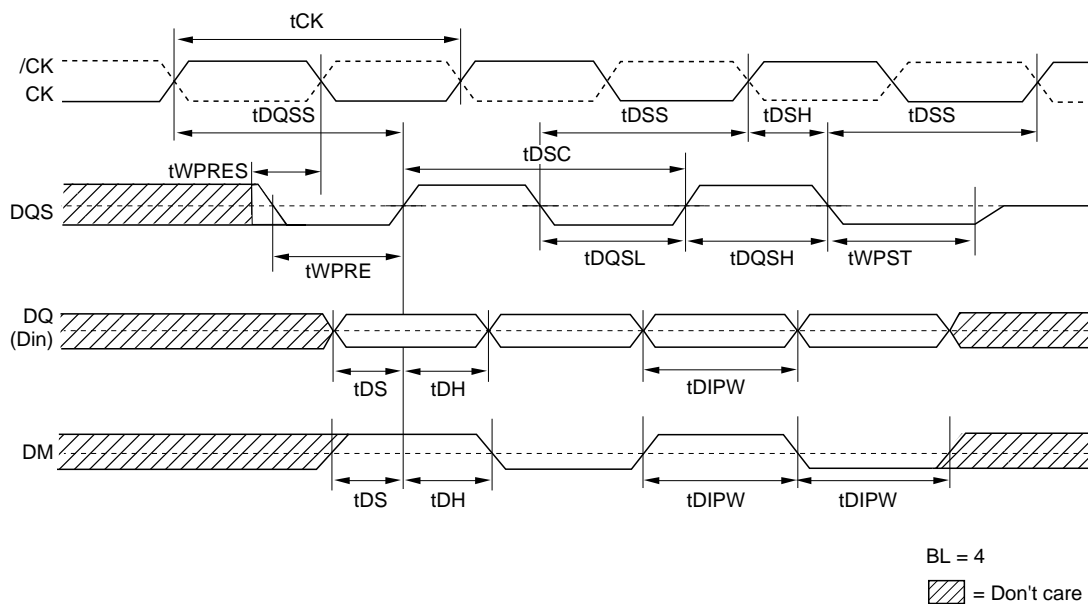
Read Timing Definition (1)



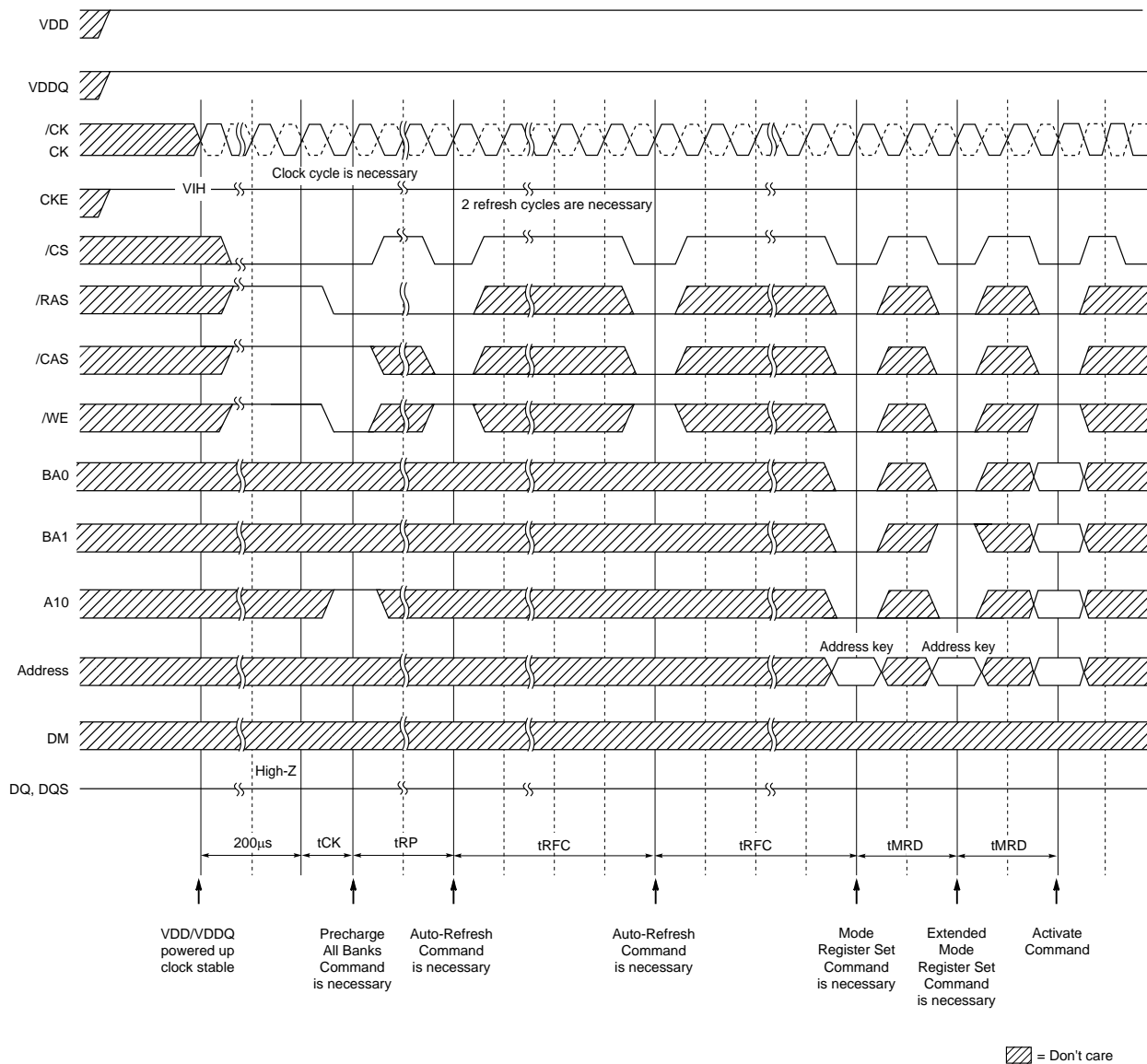
Read Timing Definition (2)



Write Timing Definition

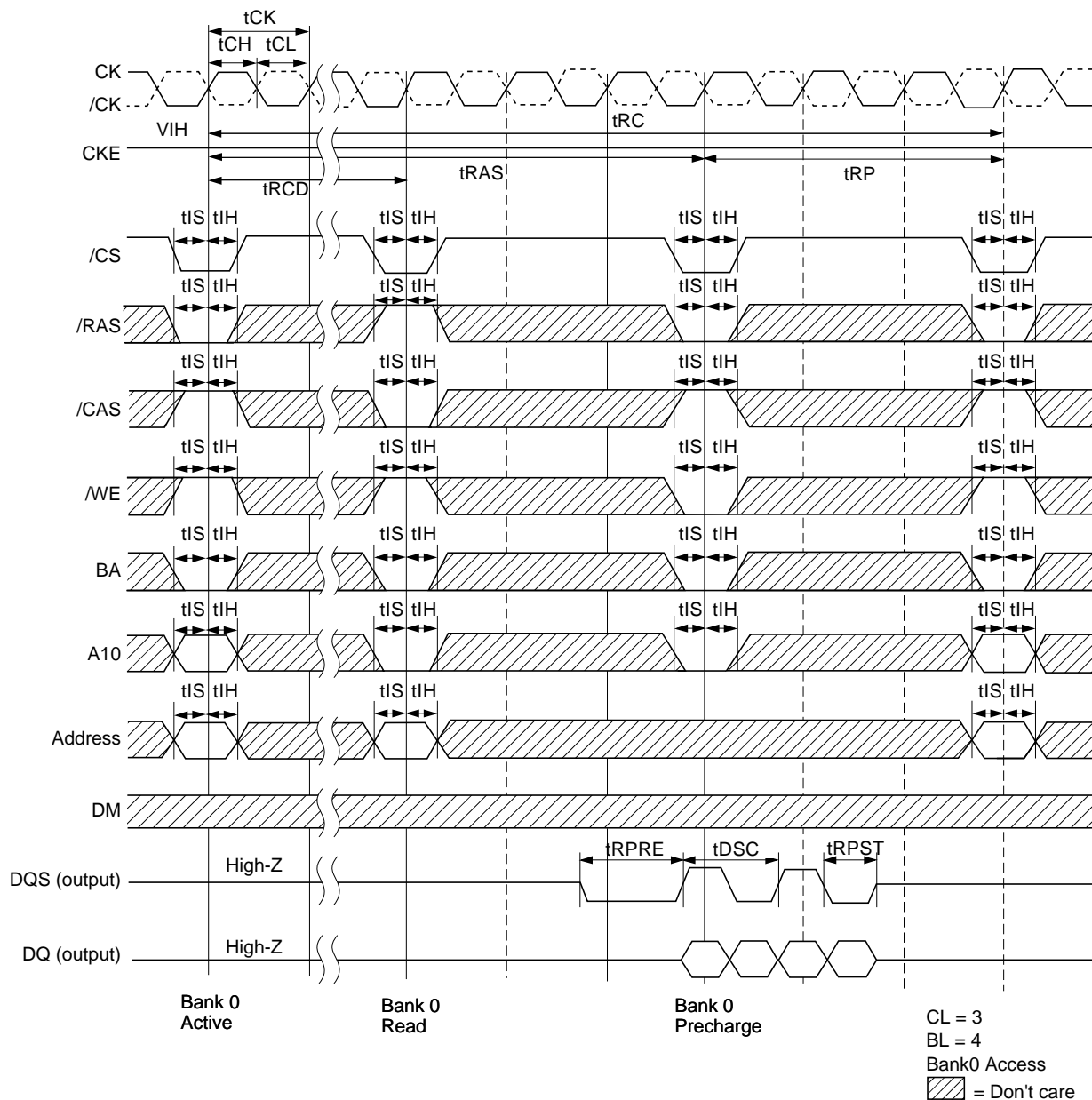


Initialize Sequence



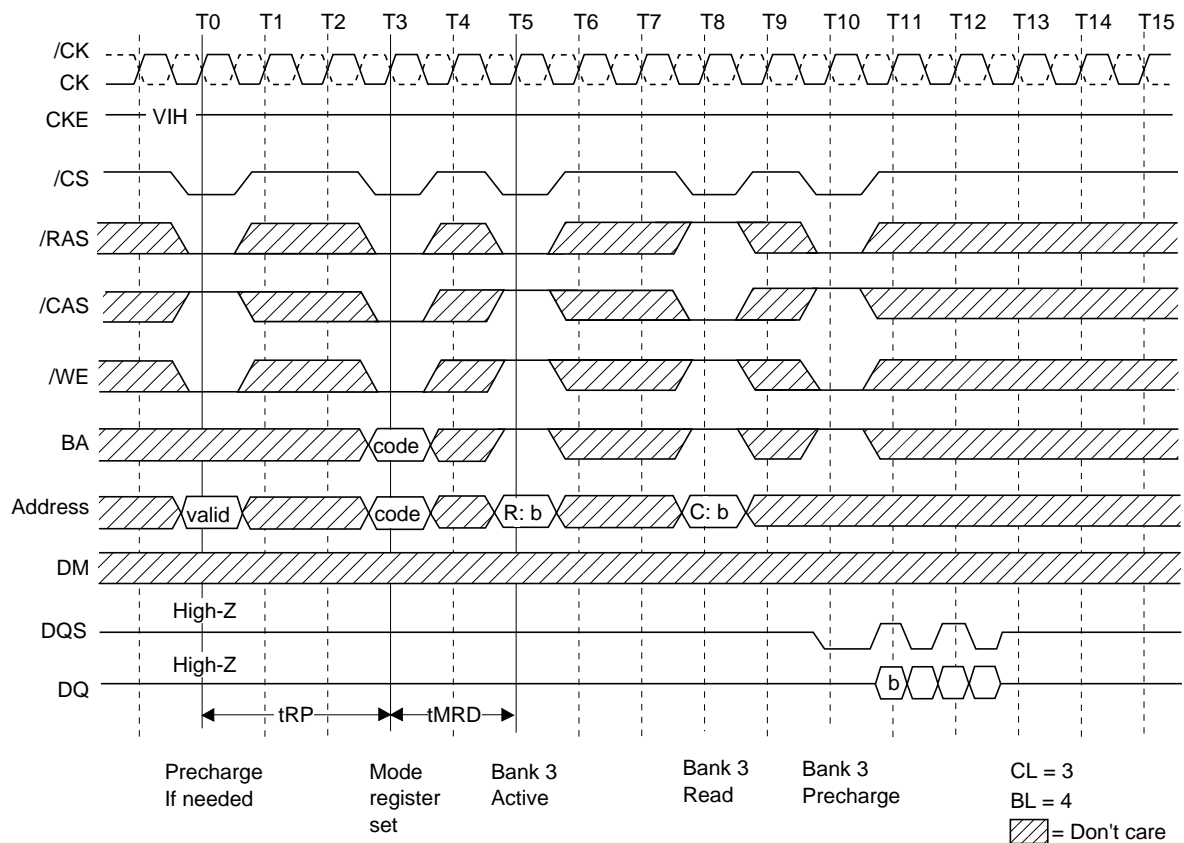


Read Cycle

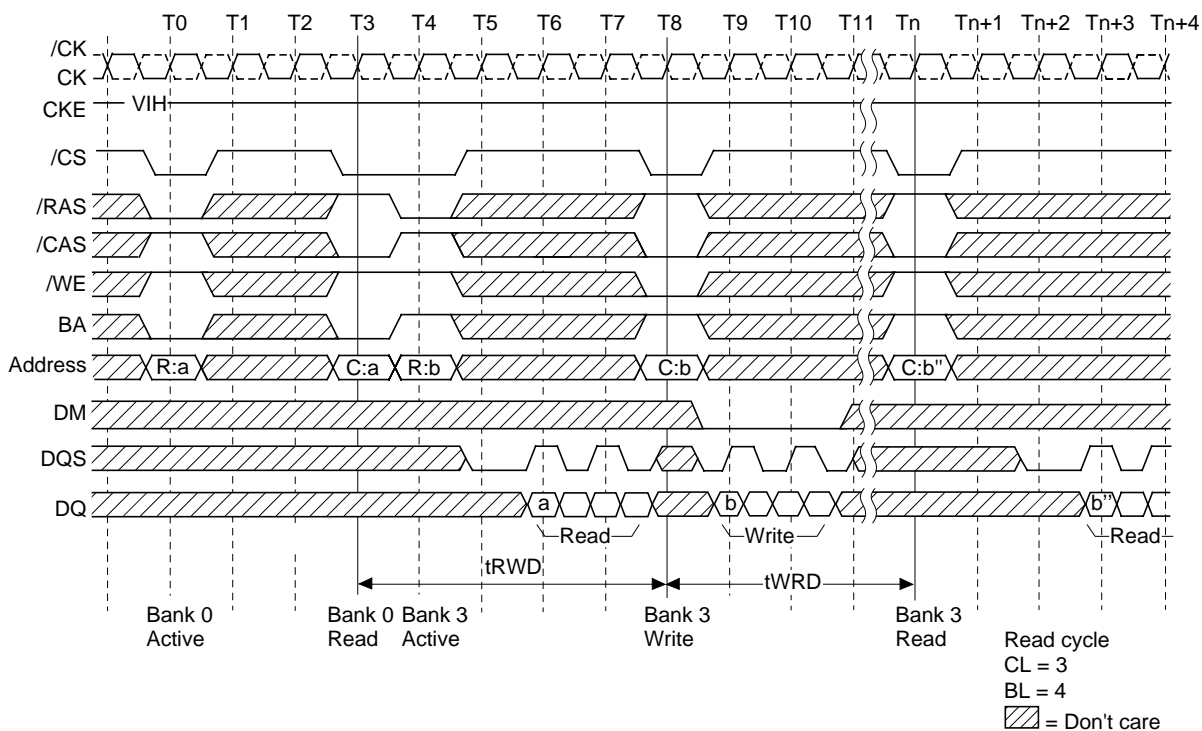




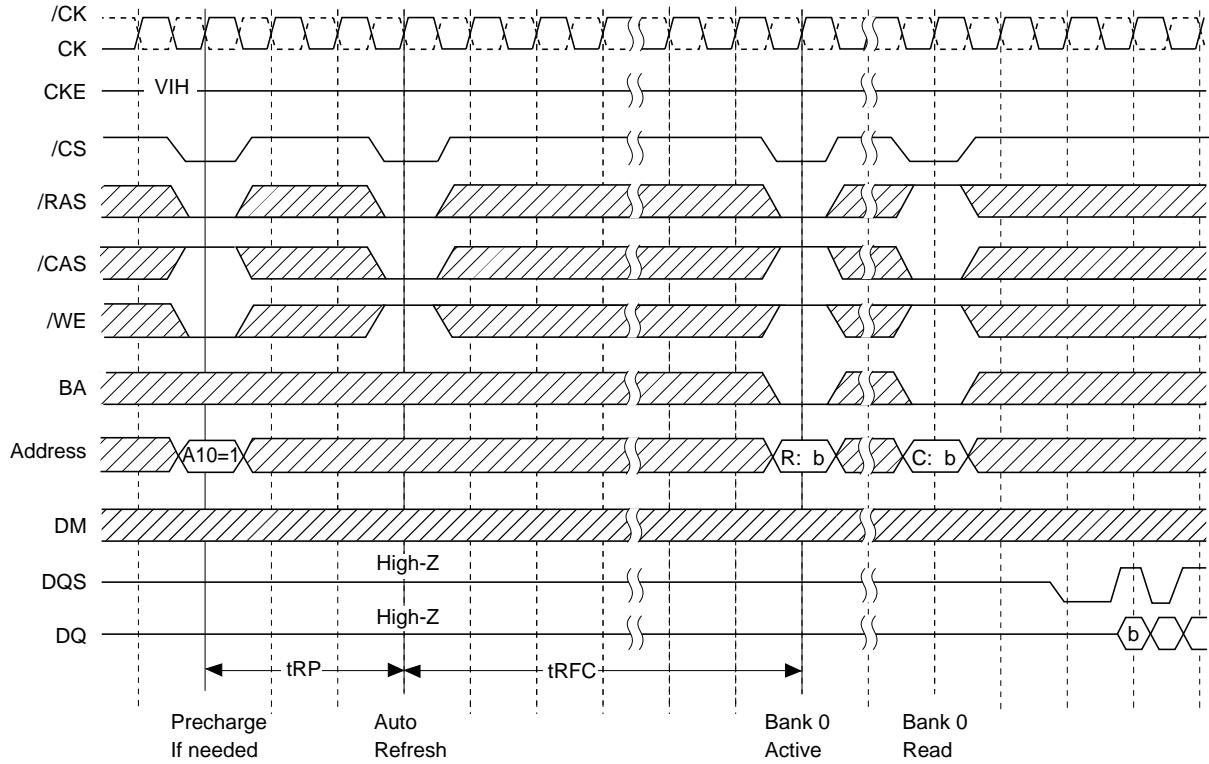
Mode Register Set Cycle



Read/Write Cycle

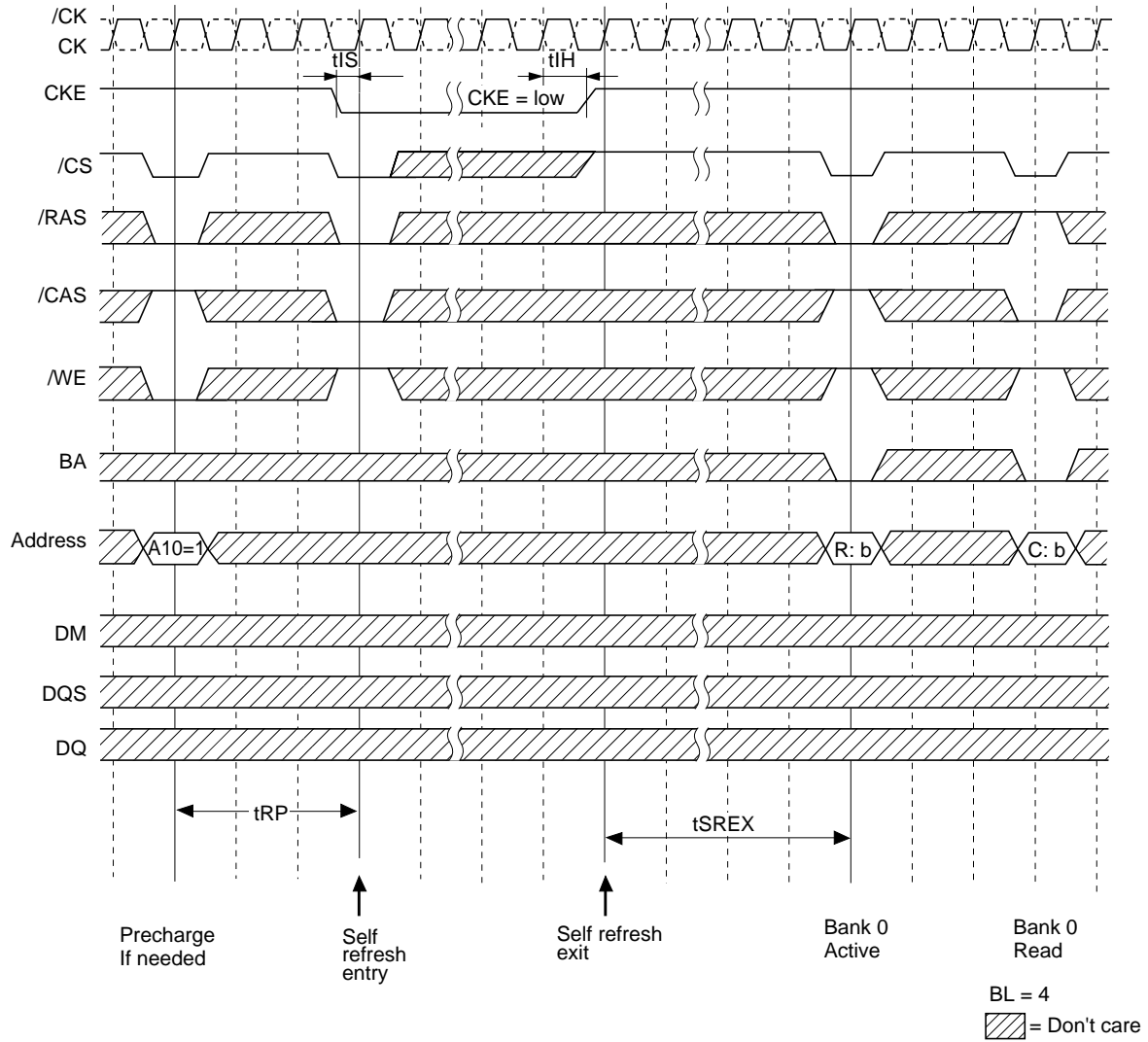


**Auto-Refresh Cycle**

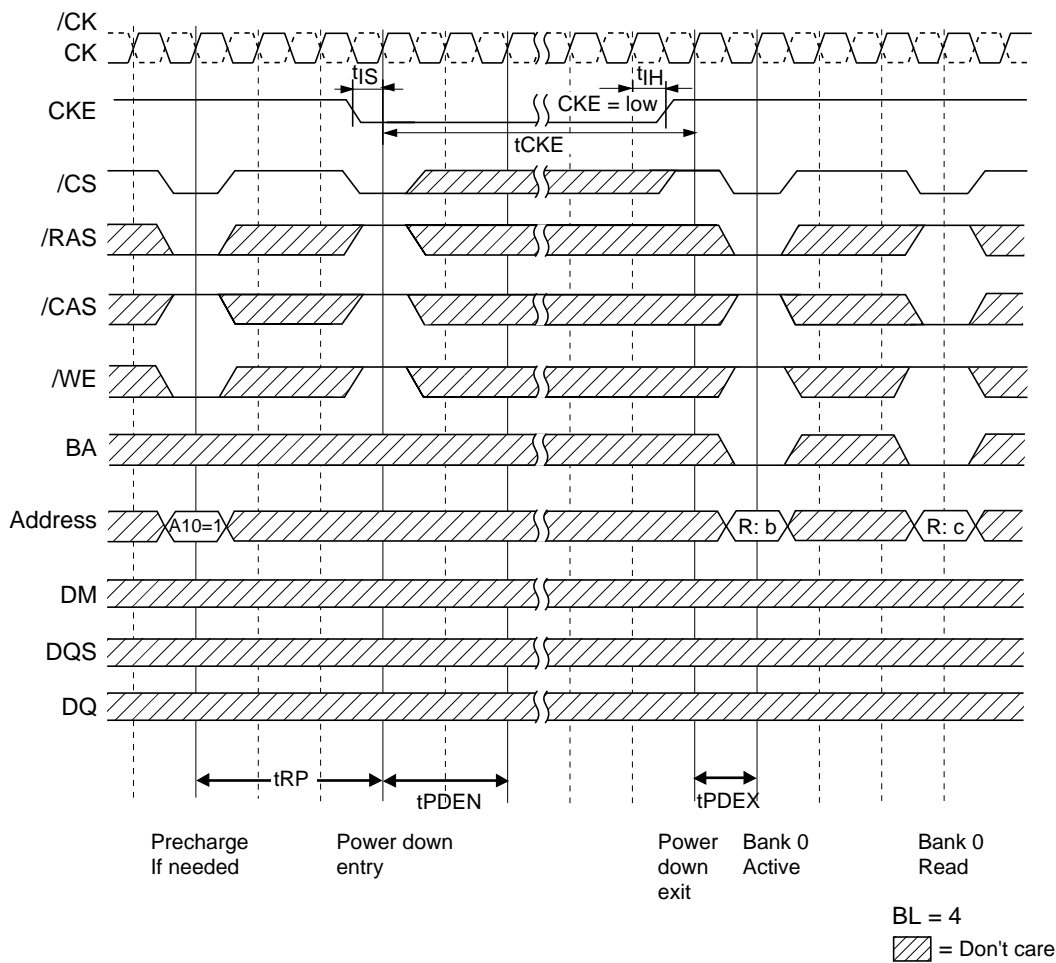


CL = 3  
 BL = 4  
 ▨ = Don't care

Self-Refresh Cycle



Power-Down Entry and Exit

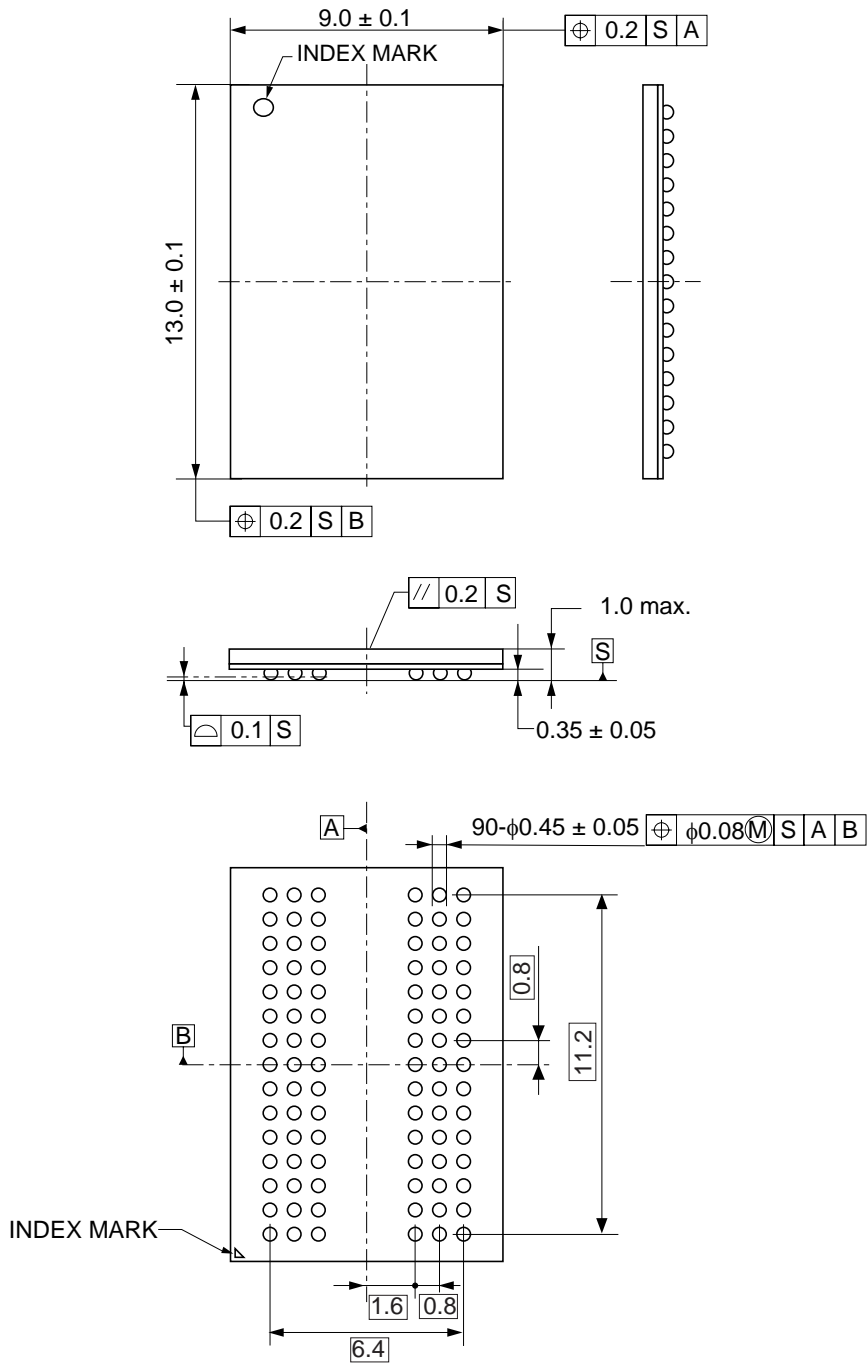


Package Drawing

90-ball FBGA

Solder ball: Lead free (Sn-Ag-Cu)

Unit: mm



ECA-TS2-0293-01

**Recommended Soldering Conditions**

Please consult with our sales offices for soldering conditions of the EDD10321BBH.

**Type of Surface Mount Device**

EDD10321BBH: 90-ball FBGA < Lead free (Sn-Ag-Cu) >



**NOTES FOR CMOS DEVICES****① PRECAUTION AGAINST ESD FOR MOS DEVICES**

Exposing the MOS devices to a strong electric field can cause destruction of the gate oxide and ultimately degrade the MOS devices operation. Steps must be taken to stop generation of static electricity as much as possible, and quickly dissipate it, when once it has occurred. Environmental control must be adequate. When it is dry, humidifier should be used. It is recommended to avoid using insulators that easily build static electricity. MOS devices must be stored and transported in an anti-static container, static shielding bag or conductive material. All test and measurement tools including work bench and floor should be grounded. The operator should be grounded using wrist strap. MOS devices must not be touched with bare hands. Similar precautions need to be taken for PW boards with semiconductor MOS devices on it.

**② HANDLING OF UNUSED INPUT PINS FOR CMOS DEVICES**

No connection for CMOS devices input pins can be a cause of malfunction. If no connection is provided to the input pins, it is possible that an internal input level may be generated due to noise, etc., hence causing malfunction. CMOS devices behave differently than Bipolar or NMOS devices. Input levels of CMOS devices must be fixed high or low by using a pull-up or pull-down circuitry. Each unused pin should be connected to  $V_{DD}$  or GND with a resistor, if it is considered to have a possibility of being an output pin. The unused pins must be handled in accordance with the related specifications.

**③ STATUS BEFORE INITIALIZATION OF MOS DEVICES**

Power-on does not necessarily define initial status of MOS devices. Production process of MOS does not define the initial operation status of the device. Immediately after the power source is turned ON, the MOS devices with reset function have not yet been initialized. Hence, power-on does not guarantee output pin levels, I/O settings or contents of registers. MOS devices are not initialized until the reset signal is received. Reset operation must be executed immediately after power-on for MOS devices having reset function.

CME0107

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**[Usage environment]**

Usage in environments with special characteristics as listed below was not considered in the design. Accordingly, our company assumes no responsibility for loss of a customer or a third party when used in environments with the special characteristics listed below.

Example:

- 1) Usage in liquids, including water, oils, chemicals and organic solvents.
- 2) Usage in exposure to direct sunlight or the outdoors, or in dusty places.
- 3) Usage involving exposure to significant amounts of corrosive gas, including sea air, CL<sub>2</sub>, H<sub>2</sub>S, NH<sub>3</sub>, SO<sub>2</sub>, and NO<sub>x</sub>.
- 4) Usage in environments with static electricity, or strong electromagnetic waves or radiation.
- 5) Usage in places where dew forms.
- 6) Usage in environments with mechanical vibration, impact, or stress.
- 7) Usage near heating elements, igniters, or flammable items.

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