

**Revision History****AS4C32M16D1 - 60-Ball, 8x13x1.2 mm (max) TFBGA PACKAGE**

| Revision | Details               | Date        |
|----------|-----------------------|-------------|
| Rev 1.0  | Preliminary datasheet | August 2014 |

## 32M x 16 bit DDR Synchronous DRAM (SDRAM)

TFBGA option - Advanced (Rev. 1.0, Aug. /2014)

### Features

- Fast clock rate: 200MHz
- Differential Clock CK &  $\overline{CK}$
- Bi-directional DQS
- DLL enable/disable by EMRS
- Fully synchronous operation
- Internal pipeline architecture
- Four internal banks, 8M x 16-bit for each bank
- Programmable Mode and Extended Mode registers
  - CAS Latency: 2, 2.5, 3
  - Burst length: 2, 4, 8
  - Burst Type: Sequential & Interleaved
- Individual bytes write mask control
- DM Write Latency = 0
- Auto Refresh and Self Refresh
- 8192 refresh cycles / 64ms
- Precharge & active power down
- Power supplies:  $V_{DD}$  &  $V_{DDQ} = 2.5V \pm 0.2V$
- Operating temperature range
  - Commercial ( $0^{\circ} \sim 70^{\circ}C$ )
  - Industrial ( $-40^{\circ} \sim 85^{\circ}C$ )
- Interface: SSTL\_2 I/O Interface
- Package: 60-Ball, 8x13x1.2 mm (max) TFBGA
  - Pb free and Halogen Free

**All parts are ROHS compliant**

### Overview

The AS4C32M16D1 is a high-speed CMOS double data rate synchronous DRAM containing 512 Mbits. It is internally configured as a quad 8M x 16 DRAM with a synchronous interface (all signals are registered on the positive edge of the clock signal, CK). Data outputs occur at both rising edges of CK and  $\overline{CK}$ . Read and write accesses to the SDRAM are burst oriented; accesses start at a selected location and continue for a programmed number of locations in a programmed sequence. Accesses begin with the registration of a BankActivate command which is then followed by a Read or Write command. The device provides programmable Read or Write burst lengths of 2, 4, or 8. An auto precharge function may be enabled to provide a self-timed row precharge that is initiated at the end of the burst sequence. The refresh functions, either Auto or Self Refresh are easy to use. In addition, 512Mb DDR features programmable DLL option. By having a programmable mode register and extended mode register, the system can choose the most suitable modes to maximize its performance. These devices are well suited for applications requiring high memory band width; result in a device particularly well suited to high performance main memory and graphics applications.

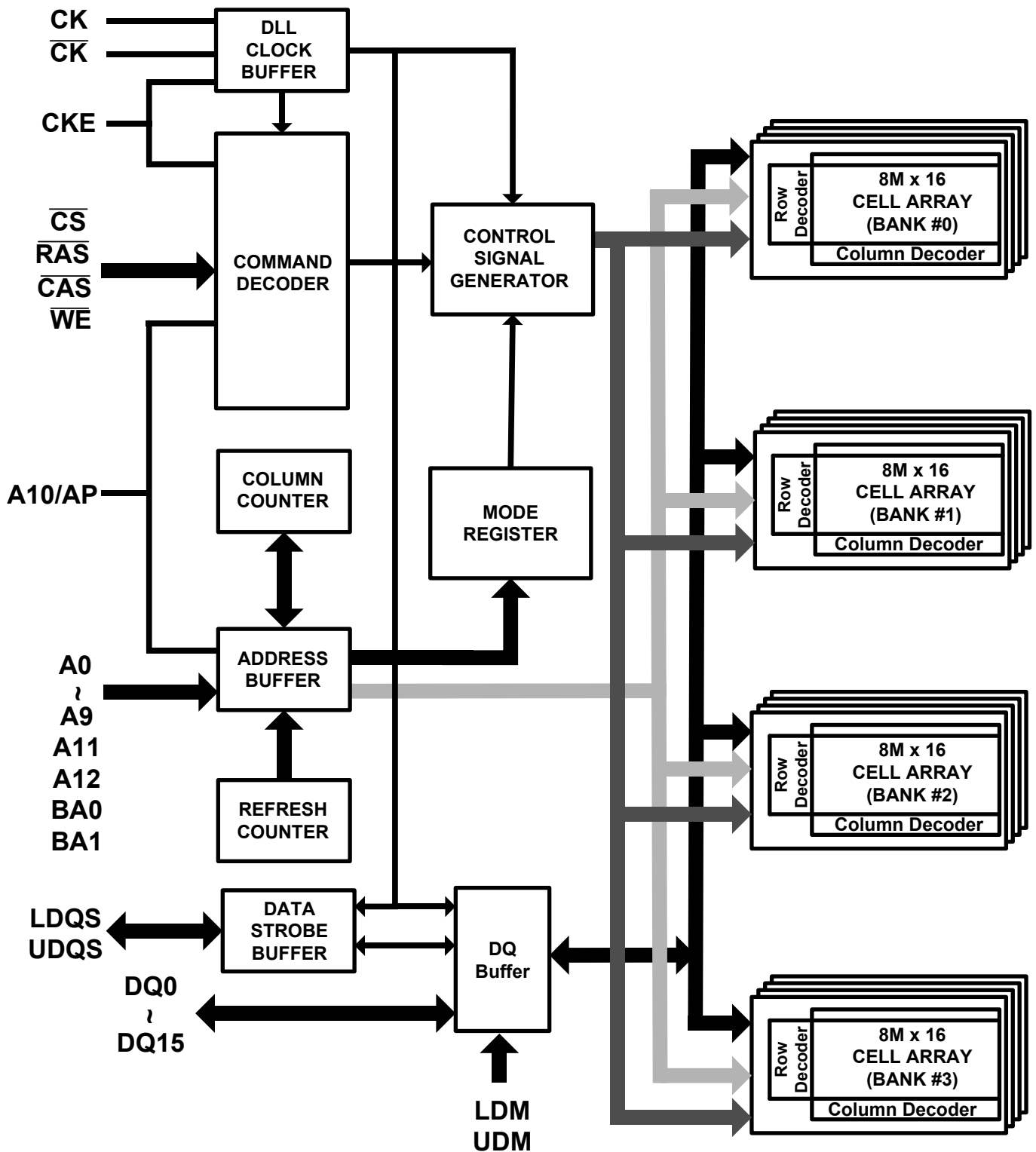
**Table 1.Ordering Information**

| Part Number      | Clock  | Data Rate   | Package       | Temperature | Temp Range |
|------------------|--------|-------------|---------------|-------------|------------|
| AS4C32M16D1-5BCN | 200MHz | 400Mbps/pin | 60 ball TFBGA | Commercial  | 0 ~ 70°C   |
| AS4C32M16D1-5BIN | 200MHz | 400Mbps/pin | 60 ball TFBGA | Industrial  | -40 ~ 85°C |

B: indicates TSOP II package  
 C: indicates Commercial temp.  
 I: indicates Industrial temp.  
 N: indicates lead free ROHS

**Figure 1. Ball Assignment (Top View)**

|   | 1    | 2    | 3    | ... | 7    | 8    | 9    |
|---|------|------|------|-----|------|------|------|
| A | VSSQ | DQ15 | VSS  |     | VDD  | DQ0  | VDDQ |
| B | DQ14 | VDDQ | DQ13 |     | DQ2  | VSSQ | DQ1  |
| C | DQ12 | VSSQ | DQ11 |     | DQ4  | VDDQ | DQ3  |
| D | DQ10 | VDDQ | DQ9  |     | DQ6  | VSSQ | DQ5  |
| E | DQ8  | VSSQ | UDQS |     | LDQS | VDDQ | DQ7  |
| F | VREF | VSS  | UDM  |     | LDM  | VDD  | NC   |
| G |      | CK   | CK   |     | WE   | CAS  |      |
| H |      | A12  | CKE  |     | RAS  | CS   |      |
| J |      | A11  | A9   |     | BA1  | BA0  |      |
| K |      | A8   | A7   |     | A0   | A10  |      |
| L |      | A6   | A5   |     | A2   | A1   |      |
| M |      | A4   | VSS  |     | VDD  | A3   |      |

**Figure 2. Block Diagram**


## Pin Descriptions

**Table 2. Pin Details**

| Symbol              | Type           | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|---------------------|----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| CK, $\overline{CK}$ | Input          | <b>Differential Clock:</b> CK and $\overline{CK}$ are differential clock inputs. All address and control input signals are sampled on the crossing of the positive edge of CK and negative edge of $\overline{CK}$ . Input and output data is referenced to the crossing of CK and $\overline{CK}$ (both directions of the crossing)                                                                                                                                                                                                                                                                                                                                                                                                        |
| CKE                 | Input          | <b>Clock Enable:</b> CKE activates (HIGH) and deactivates (LOW) the CK signal. If CKE goes low synchronously with clock, the internal clock is suspended from the next clock cycle and the state of output and burst address is frozen as long as the CKE remains low. When all banks are in the idle state, deactivating the clock controls the entry to the Power Down and Self Refresh modes.                                                                                                                                                                                                                                                                                                                                            |
| BA0, BA1            | Input          | <b>Bank Activate:</b> BA0 and BA1 define to which bank the BankActivate, Read, Write, or BankPrecharge command is being applied.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| A0-A12              | Input          | <b>Address Inputs:</b> A0-A12 are sampled during the BankActivate command (row address A0-A12) and Read/Write command (column address A0-A9 with A10 defining Auto Precharge).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| $\overline{CS}$     | Input          | <b>Chip Select:</b> $\overline{CS}$ enables (sampled LOW) and disables (sampled HIGH) the command decoder. All commands are masked when $\overline{CS}$ is sampled HIGH. $\overline{CS}$ provides for external bank selection on systems with multiple banks. It is considered part of the command code.                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| $\overline{RAS}$    | Input          | <b>Row Address Strobe:</b> The $\overline{RAS}$ signal defines the operation commands in conjunction with the $\overline{CAS}$ and $\overline{WE}$ signals and is latched at the positive edges of CK. When $\overline{RAS}$ and $\overline{CS}$ are asserted "LOW" and $\overline{CAS}$ is asserted "HIGH," either the BankActivate command or the Precharge command is selected by the $\overline{WE}$ signal. When the $\overline{WE}$ is asserted "HIGH," the BankActivate command is selected and the bank designated by BA is turned on to the active state. When the $\overline{WE}$ is asserted "LOW," the Precharge command is selected and the bank designated by BA is switched to the idle state after the precharge operation. |
| $\overline{CAS}$    | Input          | <b>Column Address Strobe:</b> The $\overline{CAS}$ signal defines the operation commands in conjunction with the $\overline{RAS}$ and $\overline{WE}$ signals and is latched at the positive edges of CK. When $\overline{RAS}$ is held "HIGH" and $\overline{CS}$ is asserted "LOW," the column access is started by asserting $\overline{CAS}$ "LOW." Then, the Read or Write command is selected by asserting $\overline{WE}$ "HIGH" or "LOW".                                                                                                                                                                                                                                                                                           |
| $\overline{WE}$     | Input          | <b>Write Enable:</b> The $\overline{WE}$ signal defines the operation commands in conjunction with the $\overline{RAS}$ and $\overline{CAS}$ signals and is latched at the positive edges of CK. The $\overline{WE}$ input is used to select the BankActivate or Precharge command and Read or Write command.                                                                                                                                                                                                                                                                                                                                                                                                                               |
| LDQS, UDQS          | Input / Output | <b>Bidirectional Data Strobe:</b> Specifies timing for Input and Output data. Read Data Strobe is edge triggered. Write Data Strobe provides a setup and hold time for data and DQM. LDQS is for DQ0~7, UDQS is for DQ8~15.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| LDM, UDM            | Input          | <b>Data Input Mask:</b> Input data is masked when DM is sampled HIGH during a write cycle. LDM masks DQ0-DQ7, UDM masks DQ8-DQ15.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| DQ0 - DQ15          | Input / Output | <b>Data I/O:</b> The DQ0-DQ15 input and output data are synchronized with positive and negative edges of LDQS and UDQS. The I/Os are byte-maskable during Writes.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| V <sub>DD</sub>     | Supply         | <b>Power Supply:</b> 2.5V $\pm$ 0.2V.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |

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|                  |        |                                                                                          |
|------------------|--------|------------------------------------------------------------------------------------------|
| V <sub>SS</sub>  | Supply | <b>Ground</b>                                                                            |
| V <sub>DDQ</sub> | Supply | <b>DQ Power:</b> 2.5V ± 0.2V. Provide isolated power to DQs for improved noise immunity. |
| V <sub>SSQ</sub> | Supply | <b>DQ Ground:</b> Provide isolated ground to DQs for improved noise immunity.            |
| V <sub>REF</sub> | Supply | <b>Reference Voltage for Inputs:</b> +0.5*V <sub>DDQ</sub>                               |
| NC               | -      | <b>No Connect:</b> These pins should be left unconnected.                                |

## Operation Mode

Table 3 shows the truth table for the operation commands.

**Table 3. Truth Table (Note (1), (2))**

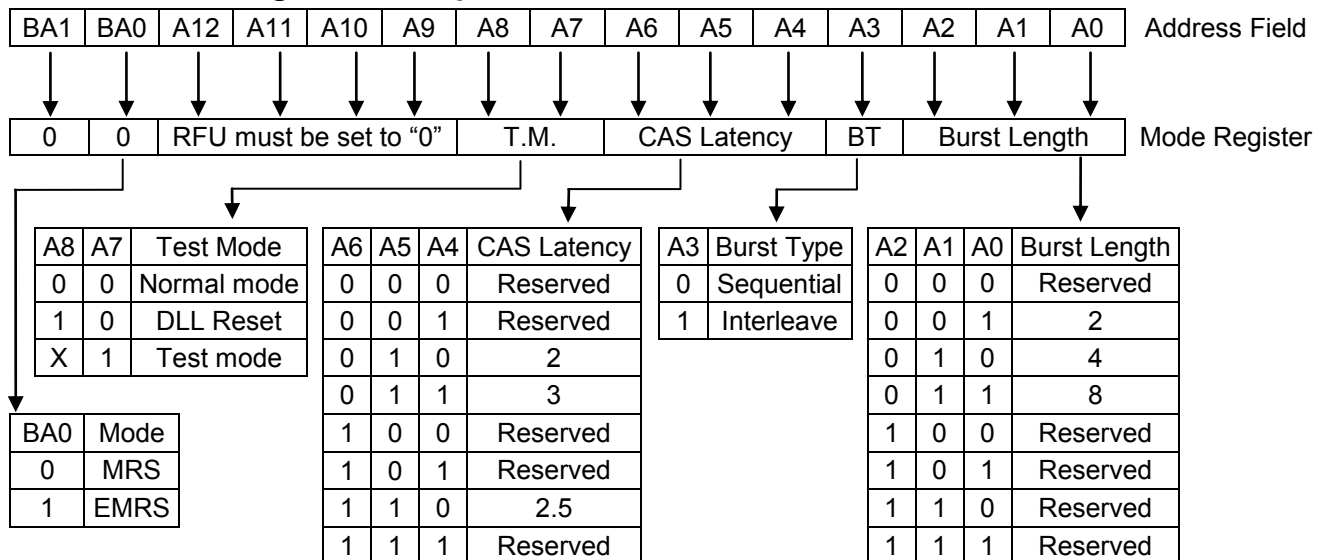
| Command                         | State                 | CKE <sub>n-1</sub> | CKE <sub>n</sub> | DM | BA0,1   | A10         | A0-9, 11-12              | CS | RAS | CAS | WE |
|---------------------------------|-----------------------|--------------------|------------------|----|---------|-------------|--------------------------|----|-----|-----|----|
| BankActivate                    | Idle <sup>(3)</sup>   | H                  | X                | X  | V       | Row address |                          | L  | L   | H   | H  |
| BankPrecharge                   | Any                   | H                  | X                | X  | V       | L           | X                        | L  | L   | H   | L  |
| Precharge All                   | Any                   | H                  | X                | X  | X       | H           | X                        | L  | L   | H   | L  |
| Write                           | Active <sup>(3)</sup> | H                  | X                | X  | V       | L           | Column address (A0 ~ A9) | L  | H   | L   | L  |
| Write and AutoPrecharge         | Active <sup>(3)</sup> | H                  | X                | X  | V       | H           |                          | L  | H   | L   | L  |
| Read                            | Active <sup>(3)</sup> | H                  | X                | X  | V       | L           | Column address (A0 ~ A9) | L  | H   | L   | H  |
| Read and Autoprecharge          | Active <sup>(3)</sup> | H                  | X                | X  | V       | H           |                          | L  | H   | L   | H  |
| Mode Register Set               | Idle                  | H                  | X                | X  | OP code |             |                          | L  | L   | L   | L  |
| Extended MRS                    | Idle                  | H                  | X                | X  | OP code |             |                          | L  | L   | L   | L  |
| No-Operation                    | Any                   | H                  | X                | X  | X       | X           | X                        | L  | H   | H   | H  |
| Burst Stop                      | Active <sup>(4)</sup> | H                  | X                | X  | X       | X           | X                        | L  | H   | H   | L  |
| Device Deselect                 | Any                   | H                  | X                | X  | X       | X           | X                        | H  | X   | X   | X  |
| AutoRefresh                     | Idle                  | H                  | H                | X  | X       | X           | X                        | L  | L   | L   | H  |
| SelfRefresh Entry               | Idle                  | H                  | L                | X  | X       | X           | X                        | L  | L   | L   | H  |
| SelfRefresh Exit                | Idle<br>(SelfRefresh) | L                  | H                | X  | X       | X           | X                        | H  | X   | X   | X  |
|                                 |                       |                    |                  |    |         |             |                          | L  | H   | H   | H  |
| Precharge Power Down Mode Entry | Idle                  | H                  | L                | X  | X       | X           | X                        | H  | X   | X   | X  |
|                                 |                       |                    |                  |    |         |             |                          | L  | H   | H   | H  |
| Precharge Power Down Mode Exit  | Any<br>(PowerDown)    | L                  | H                | X  | X       | X           | X                        | H  | X   | X   | X  |
|                                 |                       |                    |                  |    |         |             |                          | L  | H   | H   | H  |
| Active Power Down Mode Entry    | Active                | H                  | L                | X  | X       | X           | X                        | H  | X   | X   | X  |
|                                 |                       |                    |                  |    |         |             |                          | L  | V   | V   | V  |
| Active Power Down Mode Exit     | Any<br>(PowerDown)    | L                  | H                | X  | X       | X           | X                        | H  | X   | X   | X  |
|                                 |                       |                    |                  |    |         |             |                          | L  | H   | H   | H  |
| Data Input Mask Disable         | Active                | H                  | X                | L  | X       | X           | X                        | X  | X   | X   | X  |
| Data Input Mask Enable(5)       | Active                | H                  | X                | H  | X       | X           | X                        | X  | X   | X   | X  |

- Note:**
1. V=Valid data, X=Don't Care, L=Low level, H=High level
  2. CKE<sub>n</sub> signal is input level when commands are provided.  
CKE<sub>n-1</sub> signal is input level one clock cycle before the commands are provided.
  3. These are states of bank designated by BA signal.
  4. Device state is 2, 4, and 8 burst operation.
  5. LDM and UDM can be enabled respectively.

## Mode Register Set (MRS)

The Mode Register stores the data for controlling various operating modes of a DDR SDRAM. It programs CAS Latency, Burst Type, and Burst Length to make the DDR SDRAM useful for a variety of applications. The default value of the Mode Register is not defined; therefore the Mode Register must be written by the user. Values stored in the register will be retained until the register is reprogrammed. The Mode Register is written by asserting Low on  $\overline{CS}$ ,  $\overline{RAS}$ ,  $\overline{CAS}$ ,  $\overline{WE}$ , BA1 and BA0 (the device should have all banks idle with no bursts in progress prior to writing into the mode register, and CKE should be High). The state of address pins A0~A12 and BA0, BA1 in the same cycle in which  $\overline{CS}$ ,  $\overline{RAS}$ ,  $\overline{CAS}$  and  $\overline{WE}$  are asserted Low is written into the Mode Register. A minimum of two clock cycles, tMRD, are required to complete the write operation in the Mode Register. The Mode Register is divided into various fields depending on functionality. The Burst Length uses A0~A2, Burst Type uses A3, and CAS Latency (read latency from column address) uses A4~A6. A logic 0 should be programmed to all the undefined addresses to ensure future compatibility. Reserved states should not be used to avoid unknown device operation or incompatibility with future versions. Refer to the table for specific codes for various burst lengths, burst types and CAS latencies.

**Table 4. Mode Register Bitmap**



- Burst Length Field (A2~A0)**

This field specifies the data length of column access using the A2~A0 pins and selects the Burst Length to be 2, 4, 8.

**Table 5. Burst Length**

| A2 | A1 | A0 | Burst Length |
|----|----|----|--------------|
| 0  | 0  | 0  | Reserved     |
| 0  | 0  | 1  | 2            |
| 0  | 1  | 0  | 4            |
| 0  | 1  | 1  | 8            |
| 1  | 0  | 0  | Reserved     |
| 1  | 0  | 1  | Reserved     |
| 1  | 1  | 0  | Reserved     |
| 1  | 1  | 1  | Reserved     |

- Addressing Mode Select Field (A3)

The Addressing Mode can be one of two modes, either Interleave Mode or Sequential Mode. Both Sequential Mode and Interleave Mode support burst length of 2, 4 and 8.

**Table 6. Addressing Mode**

| A3 | Addressing Mode |
|----|-----------------|
| 0  | Sequential      |
| 1  | Interleave      |

- Burst Definition, Addressing Sequence of Sequential and Interleave Mode

**Table 7. Burst Address ordering**

| Burst Length | Start Address |    |    | Sequential             | Interleave             |
|--------------|---------------|----|----|------------------------|------------------------|
|              | A2            | A1 | A0 |                        |                        |
| 2            | X             | X  | 0  | 0, 1                   | 0, 1                   |
|              | X             | X  | 1  | 1, 0                   | 1, 0                   |
| 4            | X             | 0  | 0  | 0, 1, 2, 3             | 0, 1, 2, 3             |
|              | X             | 0  | 1  | 1, 2, 3, 0             | 1, 0, 3, 2             |
|              | X             | 1  | 0  | 2, 3, 0, 1             | 2, 3, 0, 1             |
|              | X             | 1  | 1  | 3, 0, 1, 2             | 3, 2, 1, 0             |
| 8            | 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 |

- CAS Latency Field (A6~A4)

This field specifies the number of clock cycles from the assertion of the Read command to the first read data. The minimum whole value of CAS Latency depends on the frequency of CK. The minimum whole value satisfying the following formula must be programmed into this field.  $t_{CAC}(\min) \leq \text{CAS Latency} \times t_{CK}$

**Table 8. CAS Latency**

| A6 | A5 | A4 | CAS Latency |
|----|----|----|-------------|
| 0  | 0  | 0  | Reserved    |
| 0  | 0  | 1  | Reserved    |
| 0  | 1  | 0  | 2 clocks    |
| 0  | 1  | 1  | 3 clocks    |
| 1  | 0  | 0  | Reserved    |
| 1  | 0  | 1  | Reserved    |
| 1  | 1  | 0  | 2.5 clocks  |
| 1  | 1  | 1  | Reserved    |

- Test Mode field (A8~A7)

These two bits are used to enter the test mode and must be programmed to "00" in normal operation.

**Table 9. Test Mode**

| A8 | A7 | Test Mode   |
|----|----|-------------|
| 0  | 0  | Normal mode |
| 1  | 0  | DLL Reset   |

- (BA0, BA1)

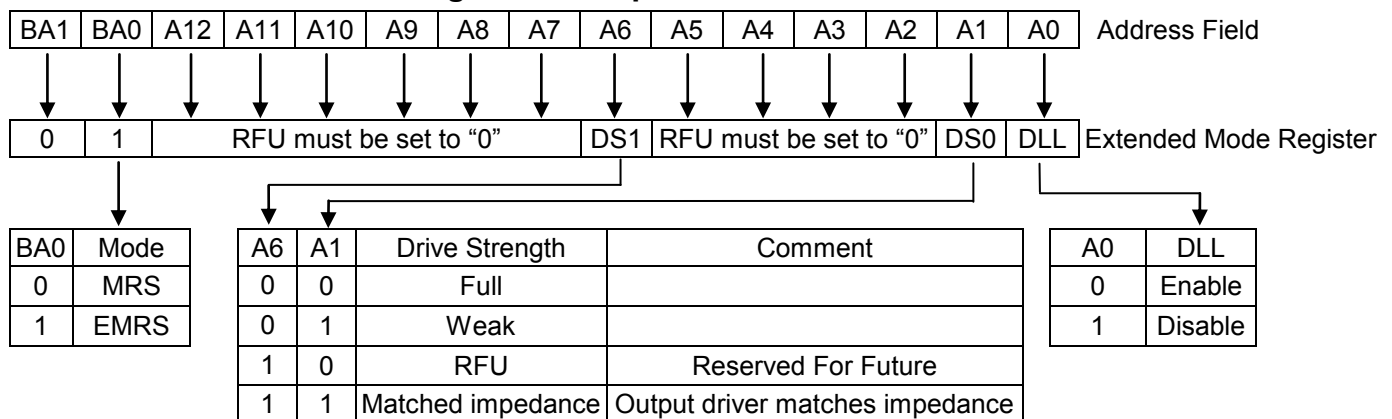
**Table 10. MRS/EMRS**

| BA1 | BA0 | A12 ~ A0                  |
|-----|-----|---------------------------|
| RFU | 0   | MRS Cycle                 |
| RFU | 1   | Extended Functions (EMRS) |

## Extended Mode Register Set (EMRS)

The Extended Mode Register Set stores the data for enabling or disabling DLL and selecting output driver strength. The default value of the extended mode register is not defined, therefore must be written after power up for proper operation. The Extended Mode Register is written by asserting Low on  $\overline{CS}$ ,  $\overline{RAS}$ ,  $\overline{CAS}$ ,  $\overline{WE}$ , BA1 and BA0 (the device should have all banks idle with no bursts in progress prior to writing into the mode register, and CKE should be High). The state of A0 ~ A12, BA0 and BA1 is written in the mode register in the same cycle as  $\overline{CS}$ ,  $\overline{RAS}$ ,  $\overline{CAS}$ , and  $\overline{WE}$  going low. The DDR SDRAM should be in all bank precharge with CKE already high prior to writing into the extended mode register. A1 is used for setting driver strength to normal, or weak. Two clock cycles are required to complete the write operation in the extended mode register. The mode register contents can be changed using the same command and clock cycle requirements during operation as long as all banks are in the idle state. A0 is used for DLL enable or disable. "High" on BA0 is used for EMRS. Refer to the table for specific codes.

**Table 11. Extended Mode Register Bitmap**



**Table 12. Absolute Maximum Rating**

| Symbol                             | Item                         |            | Values                        | Unit |
|------------------------------------|------------------------------|------------|-------------------------------|------|
| V <sub>IN</sub> , V <sub>OUT</sub> | Input, Output Voltage        |            | - 0.5~ V <sub>DDQ</sub> + 0.5 | V    |
| V <sub>DD</sub> , V <sub>DDQ</sub> | Power Supply Voltage         |            | - 1~3.6                       | V    |
| T <sub>A</sub>                     | Ambient Temperature          | Commercial | 0~70                          | °C   |
|                                    |                              | Industrial | -40~85                        | °C   |
| T <sub>STG</sub>                   | Storage Temperature          |            | - 55~150                      | °C   |
| T <sub>SOLDER</sub>                | Soldering Temperature        |            | 260                           | °C   |
| P <sub>D</sub>                     | Power Dissipation            |            | 1                             | W    |
| I <sub>OS</sub>                    | Short Circuit Output Current |            | 50                            | mA   |

Note1: Stress greater than those listed under "Absolute Maximum Ratings" may cause permanent damage to the device.

Note2: These voltages are relative to V<sub>SS</sub>

**Table 13. Recommended D.C. Operating Conditions (T<sub>A</sub> = -40 ~ 85 °C)**

| Symbol               | Parameter                                                     | Min.                    | Max.                    | Unit | Note                    |
|----------------------|---------------------------------------------------------------|-------------------------|-------------------------|------|-------------------------|
| V <sub>DD</sub>      | Power Supply Voltage                                          | 2.3                     | 2.7                     | V    |                         |
| V <sub>DDQ</sub>     | Power Supply Voltage (for I/O Buffer)                         | 2.3                     | 2.7                     | V    |                         |
| V <sub>REF</sub>     | Input Reference Voltage                                       | 0.49*V <sub>DDQ</sub>   | 0.51* V <sub>DDQ</sub>  | V    |                         |
| V <sub>IH</sub> (DC) | Input High Voltage (DC)                                       | V <sub>REF</sub> + 0.15 | V <sub>DDQ</sub> + 0.3  | V    |                         |
| V <sub>IL</sub> (DC) | Input Low Voltage (DC)                                        | -0.3                    | V <sub>REF</sub> - 0.15 | V    |                         |
| V <sub>TT</sub>      | Termination Voltage                                           | V <sub>REF</sub> - 0.04 | V <sub>REF</sub> + 0.04 | V    |                         |
| V <sub>IN</sub> (DC) | Input Voltage Level, CK and $\overline{\text{CK}}$ inputs     | -0.3                    | V <sub>DDQ</sub> + 0.3  | V    |                         |
| V <sub>ID</sub> (DC) | Input Different Voltage, CK and $\overline{\text{CK}}$ inputs | 0.36                    | V <sub>DDQ</sub> + 0.6  | V    |                         |
| I <sub>I</sub>       | Input leakage current                                         | -2                      | 2                       | μA   |                         |
| I <sub>OZ</sub>      | Output leakage current                                        | -5                      | 5                       | μA   |                         |
| I <sub>OH</sub>      | Output High Current                                           | -16.2                   | -                       | mA   | V <sub>OH</sub> = 1.95V |
| I <sub>OL</sub>      | Output Low Current                                            | 16.2                    | -                       | mA   | V <sub>OL</sub> = 0.35V |

**Note** : All voltages are referenced to V<sub>SS</sub>.

**Table 14. Capacitance (V<sub>DD</sub> = 2.5V, f = 1MHz, T<sub>A</sub> = 25 °C)**

| Symbol           | Parameter                                       | Min. | Max. | Unit |
|------------------|-------------------------------------------------|------|------|------|
| C <sub>IN1</sub> | Input Capacitance (CK, $\overline{\text{CK}}$ ) | 2    | 3    | pF   |
| C <sub>IN2</sub> | Input Capacitance (All other input-only pins)   | 2    | 3    | pF   |
| C <sub>I/O</sub> | DQ, DQS, DM Input/Output Capacitance            | 4    | 5    | pF   |

Note: These parameters are guaranteed by design, periodically sampled and are not 100% tested

**Table 15. D.C. Characteristics ( $V_{DD} = 2.5V \pm 0.2V$ ,  $T_A = -40 \sim 85^\circ C$ )**

| Parameter & Test Condition                                                                                                                                                                                                                                        | Symbol | -5   | Unit | Note |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|------|------|------|
|                                                                                                                                                                                                                                                                   |        | Max. |      |      |
| <b>OPERATING CURRENT:</b><br>One bank; Active-Precharge; $t_{RC}=t_{RC}(\min)$ ; $t_{CK}=t_{CK}(\min)$ ; DQ,DM and DQS inputs changing once per clock cycle; Address and control inputs changing once every two clock cycles.                                     | IDD0   | 80   | mA   |      |
| <b>OPERATING CURRENT:</b><br>One bank; BL=4; reads - Refer to the following page for detailed test conditions                                                                                                                                                     | IDD1   | 90   | mA   |      |
| <b>PRECHARGE POWER-DOWN STANDBY CURRENT:</b><br>All banks idle; power-down mode; $t_{CK}=t_{CK}(\min)$ ; CKE = LOW                                                                                                                                                | IDD2P  | 5    | mA   |      |
| <b>PRECHARGE FLOATING STANDBY CURRENT:</b><br>CS = HIGH; all banks idle; CKE = HIGH; $t_{CK} = t_{CK}(\min)$ ; address and other control inputs changing once per clock cycle; $V_{IN} = V_{REF}$ for DQ, DQS and DM                                              | IDD2F  | 35   | mA   |      |
| <b>PRECHARGE QUIET STANDBY CURRENT:</b><br>CS =HIGH; all banks idle; CKE =HIGH; $t_{CK}=t_{CK}(\min)$ address and other control inputs stable at $\geq V_{IH}(\min)$ or $\leq V_{IL}(\max)$ ; $V_{IN} = V_{REF}$ for DQ, DQS and DM                               | IDD2Q  | 35   | mA   |      |
| <b>ACTIVE POWER-DOWN STANDBY CURRENT</b> : one bank active; power-down mode; CKE=LOW; $t_{CK}=t_{CK}(\min)$                                                                                                                                                       | IDD3P  | 20   | mA   |      |
| <b>ACTIVE STANDBY CURRENT</b> : $\overline{CS}$ =HIGH;CKE=HIGH; one bank active ; $t_{RC}=t_{RC}(\max)$ ; $t_{CK}=t_{CK}(\min)$ ;Address and control inputs changing once per clock cycle; DQ,DQS and DM inputs changing twice per clock cycle                    | IDD3N  | 65   | mA   |      |
| <b>OPERATING CURRENT BURST READ</b> : BL=2; READS;<br>Continuous burst; one bank active; Address and control inputs changing once per clock cycle; $t_{CK}=t_{CK}(\min)$ ; $I_{out}=0mA$ ;50% of data changing on every transfer                                  | IDD4R  | 130  | mA   |      |
| <b>OPERATING CURRENT BURST Write</b> : BL=2; WRITES;<br>Continuous Burst ;one bank active; address and control inputs changing once per clock cycle; $t_{CK}=t_{CK}(\min)$ ; DQ,DQS and DM changing twice per clock cycle; 50% of data changing on every transfer | IDD4W  | 130  | mA   |      |
| <b>AUTO REFRESH CURRENT</b> : $t_{RC}=t_{RFC}(\min)$ ; $t_{CK}=t_{CK}(\min)$                                                                                                                                                                                      | IDD5   | 140  | mA   |      |
| <b>SELF REFRESH CURRENT:</b> Self Refresh Mode ; CKE $\leq 0.2V$ ; $t_{CK}=t_{CK}(\min)$                                                                                                                                                                          | IDD6   | 6    | mA   | 1    |
| <b>BURST OPERATING CURRENT 4 bank operation:</b><br>Four bank interleaving READs; BL=4;with Auto Precharge; $t_{RC}=t_{RC}(\min)$ ; $t_{CK}=t_{CK}(\min)$ ; Address and control inputs change only during Active, READ , or WRITE command                         | IDD7   | 210  | mA   |      |

**Table 16. Electrical Characteristics and Recommended A.C. Operating Condition**  
( $V_{DD} = 2.5V \pm 0.2V$ ,  $T_A = -40 \sim 85^\circ C$ )

| Symbol             | Parameter                                             | -5                                       |      | Unit            | Note |
|--------------------|-------------------------------------------------------|------------------------------------------|------|-----------------|------|
|                    |                                                       | Min.                                     | Max. |                 |      |
| t <sub>CK</sub>    | Clock cycle time                                      | CL = 2                                   | 7.5  | 12              | ns   |
|                    |                                                       | CL = 2.5                                 | 6    | 12              | ns   |
|                    |                                                       | CL = 3                                   | 5    | 12              | ns   |
| t <sub>CH</sub>    | Clock high level width                                | 0.45                                     | 0.55 | t <sub>CK</sub> |      |
| t <sub>CL</sub>    | Clock low level width                                 | 0.45                                     | 0.55 | t <sub>CK</sub> |      |
| t <sub>HP</sub>    | Clock half period                                     | t <sub>CLMIN</sub> or t <sub>CHMIN</sub> | -    | ns              | 2    |
| t <sub>HZ</sub>    | Data-out-high impedance time from CK, $\overline{CK}$ | -                                        | 0.7  | ns              | 3    |
| t <sub>LZ</sub>    | Data-out-low impedance time from CK, $\overline{CK}$  | -0.7                                     | 0.7  | ns              | 3    |
| t <sub>DQSK</sub>  | DQS-out access time from CK, $\overline{CK}$          | -0.6                                     | 0.6  | ns              |      |
| t <sub>AC</sub>    | Output access time from CK, $\overline{CK}$           | -0.7                                     | 0.7  | ns              |      |
| t <sub>DQSQ</sub>  | DQS-DQ Skew                                           | -                                        | 0.4  | ns              |      |
| t <sub>RPRE</sub>  | Read preamble                                         | 0.9                                      | 1.1  | t <sub>CK</sub> |      |
| t <sub>RPST</sub>  | Read postamble                                        | 0.4                                      | 0.6  | t <sub>CK</sub> |      |
| t <sub>DQSS</sub>  | CK to valid DQS-in                                    | 0.72                                     | 1.25 | t <sub>CK</sub> |      |
| t <sub>WPRES</sub> | DQS-in setup time                                     | 0                                        | -    | ns              | 4    |
| t <sub>WPRE</sub>  | DQS Write preamble                                    | 0.25                                     | -    | t <sub>CK</sub> |      |
| t <sub>WPST</sub>  | DQS write postamble                                   | 0.4                                      | 0.6  | t <sub>CK</sub> | 5    |
| t <sub>DQSH</sub>  | DQS in high level pulse width                         | 0.35                                     | -    | t <sub>CK</sub> |      |
| t <sub>DQSL</sub>  | DQS in low level pulse width                          | 0.35                                     | -    | t <sub>CK</sub> |      |
| t <sub>IS</sub>    | Address and Control input setup time                  | 0.7                                      | -    | ns              | 6    |
| t <sub>IH</sub>    | Address and Control input hold time                   | 0.7                                      | -    | ns              | 6    |
| t <sub>DS</sub>    | DQ & DM setup time to DQS                             | 0.4                                      | -    | ns              |      |
| t <sub>DH</sub>    | DQ & DM hold time to DQS                              | 0.4                                      | -    | ns              |      |
| t <sub>QH</sub>    | DQ/DQS output hold time from DQS                      | t <sub>HP</sub> - t <sub>QHS</sub>       | -    | ns              |      |
| t <sub>RC</sub>    | Row cycle time                                        | 55                                       | -    | ns              |      |
| t <sub>RFC</sub>   | Refresh row cycle time                                | 70                                       | -    | ns              |      |
| t <sub>RAS</sub>   | Row active time                                       | 40                                       | 70K  | ns              |      |
| t <sub>RCD</sub>   | Active to Read or Write delay                         | 15                                       | -    | ns              |      |
| t <sub>RP</sub>    | Row precharge time                                    | 15                                       | -    | ns              |      |
| t <sub>RRD</sub>   | Row active to Row active delay                        | 10                                       | -    | ns              |      |
| t <sub>WR</sub>    | Write recovery time                                   | 15                                       | -    | ns              |      |
| t <sub>WTR</sub>   | Internal Write to Read Command Delay                  | 2                                        | -    | t <sub>CK</sub> |      |
| t <sub>MRD</sub>   | Mode register set cycle time                          | 10                                       | -    | ns              |      |
| t <sub>REFI</sub>  | Average Periodic Refresh interval                     | -                                        | 7.8  | μs              | 7    |
| t <sub>XSRD</sub>  | Self refresh exit to read command delay               | 200                                      | -    | t <sub>CK</sub> |      |
| t <sub>XSNR</sub>  | Self refresh exit to non-read command delay           | 75                                       | -    | ns              |      |
| t <sub>DAL</sub>   | Auto Precharge write recovery + precharge time        | t <sub>WR</sub> +t <sub>RP</sub>         | -    | ns              |      |
| t <sub>DIPW</sub>  | DQ and DM input pulse width                           | 1.75                                     | -    | ns              |      |
| t <sub>IPW</sub>   | Control and Address input pulse width                 | 2.2                                      | -    | ns              |      |
| t <sub>QHS</sub>   | Data Hold Skew Factor                                 | -                                        | 0.5  | ns              |      |
| t <sub>DSS</sub>   | DQS falling edge to CK setup time                     | 0.2                                      | -    | t <sub>CK</sub> |      |
| t <sub>DSH</sub>   | DQS falling edge hold time from CK                    | 0.2                                      | -    | t <sub>CK</sub> |      |

**Table 17. Recommended A.C. Operating Conditions ( $V_{DD} = 2.5V \pm 0.2V$ ,  $T_A = -40 \sim 85^\circ C$ )**

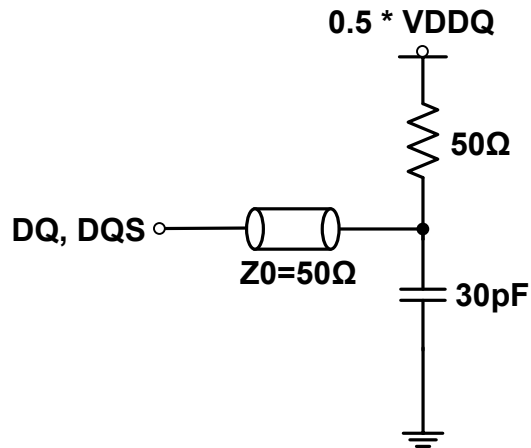
| Symbol        | Parameter                                                   | Min.                      | Max.                      | Unit |
|---------------|-------------------------------------------------------------|---------------------------|---------------------------|------|
| $V_{IH}$ (AC) | Input High Voltage (AC)                                     | $V_{REF} + 0.31$          | -                         | V    |
| $V_{IL}$ (AC) | Input Low Voltage (AC)                                      | -                         | $V_{REF} - 0.31$          | V    |
| $V_{ID}$ (AC) | Input Different Voltage, CK and $\overline{CK}$ inputs      | 0.7                       | $V_{DDQ} + 0.6$           | V    |
| $V_{IX}$ (AC) | Input Crossing Point Voltage, CK and $\overline{CK}$ inputs | $0.5 \cdot V_{DDQ} - 0.2$ | $0.5 \cdot V_{DDQ} + 0.2$ | V    |

**Note:**

- 1) Enables on-chip refresh and address counters.
- 2)  $\text{Min}(t_{CL}, t_{CH})$  refers to the smaller of the actual clock low time and actual clock high time as provided to the device.
- 3)  $t_{HZ}$  and  $t_{LZ}$  transitions occur in the same access time windows as valid data transitions. These parameters are not referenced to a specific voltage level, but specify when the device output is no longer driving(HZ), or begins driving(LZ).
- 4) The specific requirement is that DQS be valid (High, Low, or at some point on a valid transition) on or before this CLK edge. A valid transition is defined as monotonic, and meeting the input slew rate specifications of the device. When no writes were previously in progress on the bus, DQS will be transitioning from High-Z to logic LOW. If a previous write was in progress, DQS could be HIGH, LOW, or transitioning from HIGH to LOW at this time, depending on  $t_{DQSS}$ .
- 5) The maximum limit for this parameter is not a device limit. The device will operate with a greater value for this parameter, but system performance (bus turnaround) will degrade accordingly.
- 6) For command/address and CK &  $\overline{CK}$  slew rate  $\geq 1.0V/ns$ .
- 7) A maximum of eight AUTO REFRESH commands can be posted to any given DDR SDRAM device.
- 8) Power-up sequence is described in Note 10
- 9) A.C. Test Conditions

**Table 18. SSTL \_2 Interface**

|                                                 |                                       |
|-------------------------------------------------|---------------------------------------|
| Reference Level of Output Signals ( $V_{REF}$ ) | $0.5 \cdot V_{DDQ}$                   |
| Output Load                                     | Reference to the Test Load            |
| Input Signal Levels                             | $V_{REF} + 0.31 V / V_{REF} - 0.31 V$ |
| Input Signals Slew Rate                         | 1 V/ns                                |
| Reference Level of Input Signals                | $0.5 \cdot V_{DDQ}$                   |

**Figure 3. SSTL\_2 A.C. Test Load**


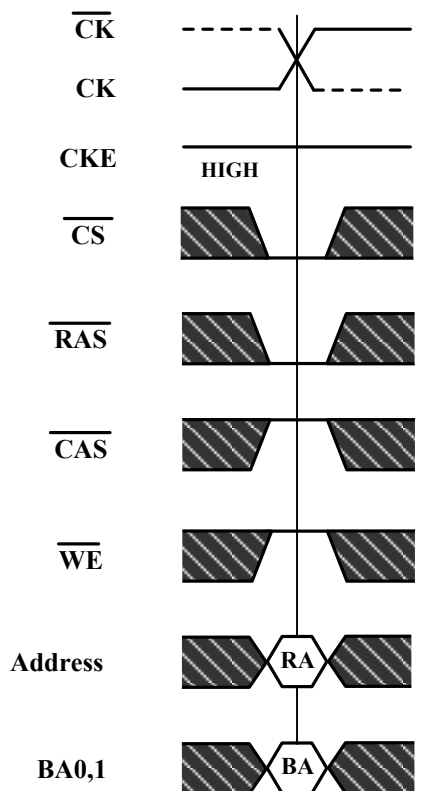
#### 10) Power up Sequence

Power up must be performed in the following sequence.

- 1) Apply power to  $V_{DD}$  before or at the same time as  $V_{DDQ}$ ,  $V_{TT}$  and  $V_{REF}$  when all input signals are held "NOP" state and maintain CKE "LOW".
- 2) Start clock and maintain stable condition for minimum  $200\mu\text{s}$ .
- 3) Issue a "NOP" command and keep CKE "HIGH"
- 4) Issue a "Precharge All" command.
- 5) Issue EMRS – enable DLL.
- 6) Issue MRS – reset DLL. (An additional 200 clock cycles are required to lock the DLL).
- 7) Precharge all banks of the device.
- 8) Issue two or more Auto Refresh commands.
- 9) Issue MRS – with A8 to low to initialize the mode register.

## Timing Waveforms

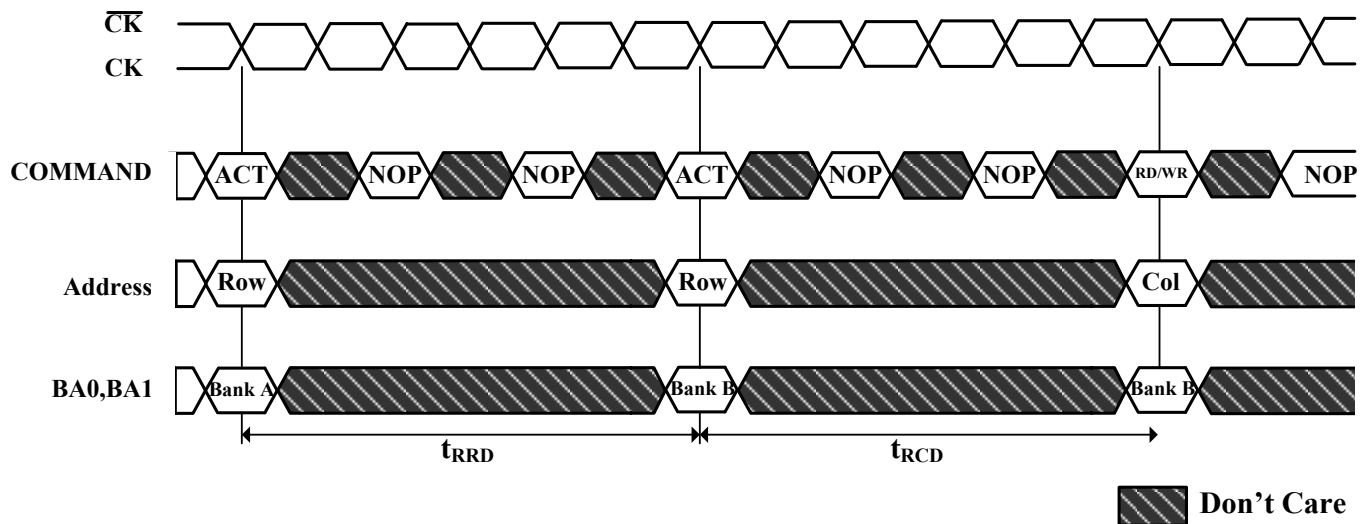
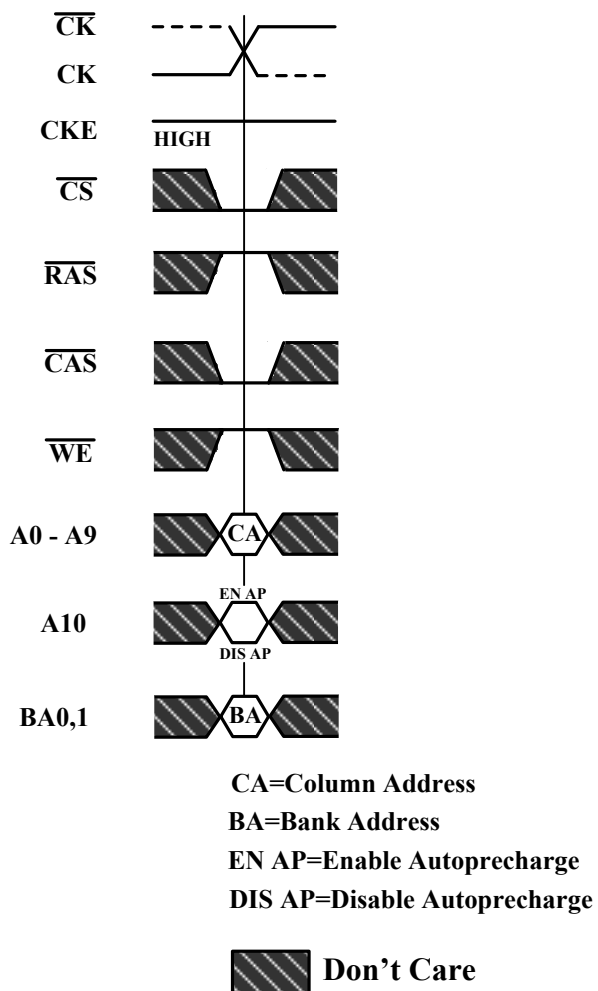
**Figure 4. Activating a Specific Row in a Specific Bank**

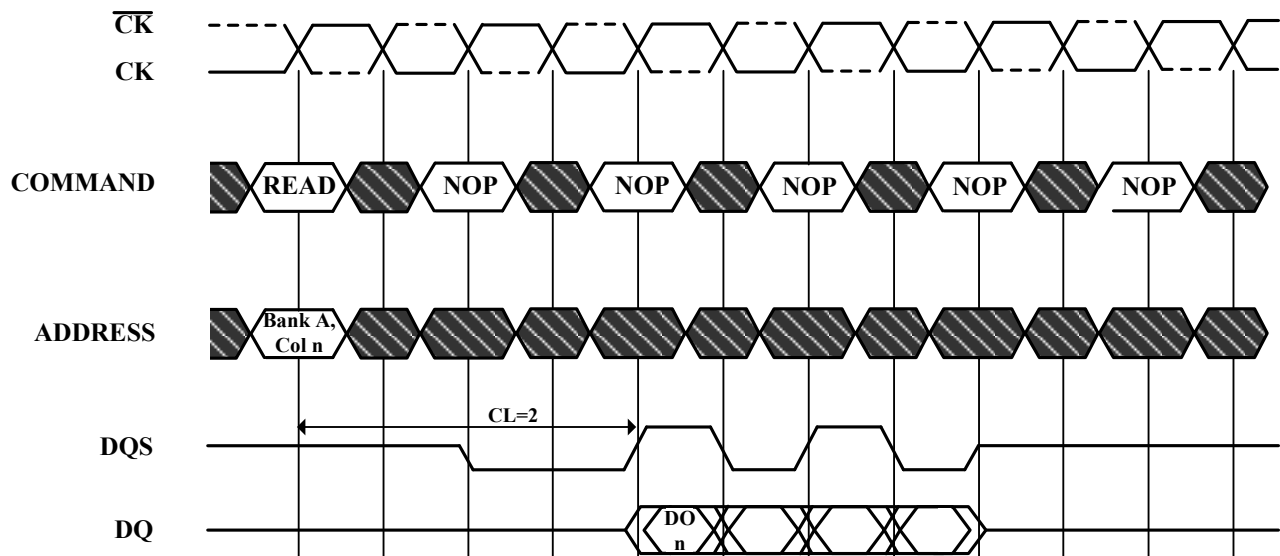


RA=Row Address

BA=Bank Address

 Don't Care

**Figure 5. tRCD and tRRD Definition**

**Figure 6. READ Command**


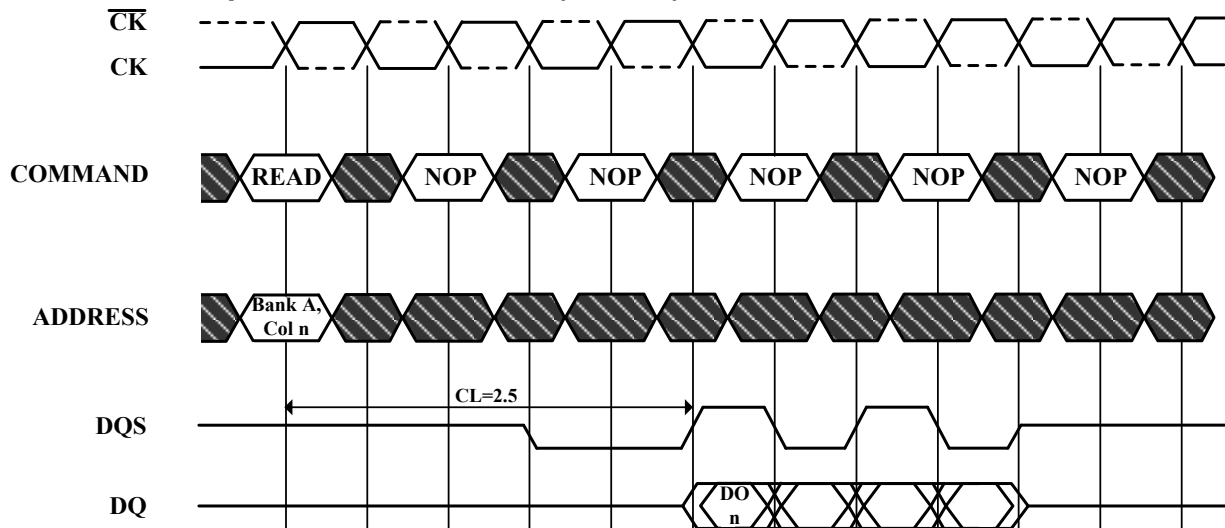
**Figure 7. Read Burst Required CAS Latencies (CL=2)**


DO n=Data Out from column n

Burst Length=4

3 subsequent elements of Data Out appear in the programmed order following DO n

 Don't Care

**Read Burst Required CAS Latencies (CL=2.5)**


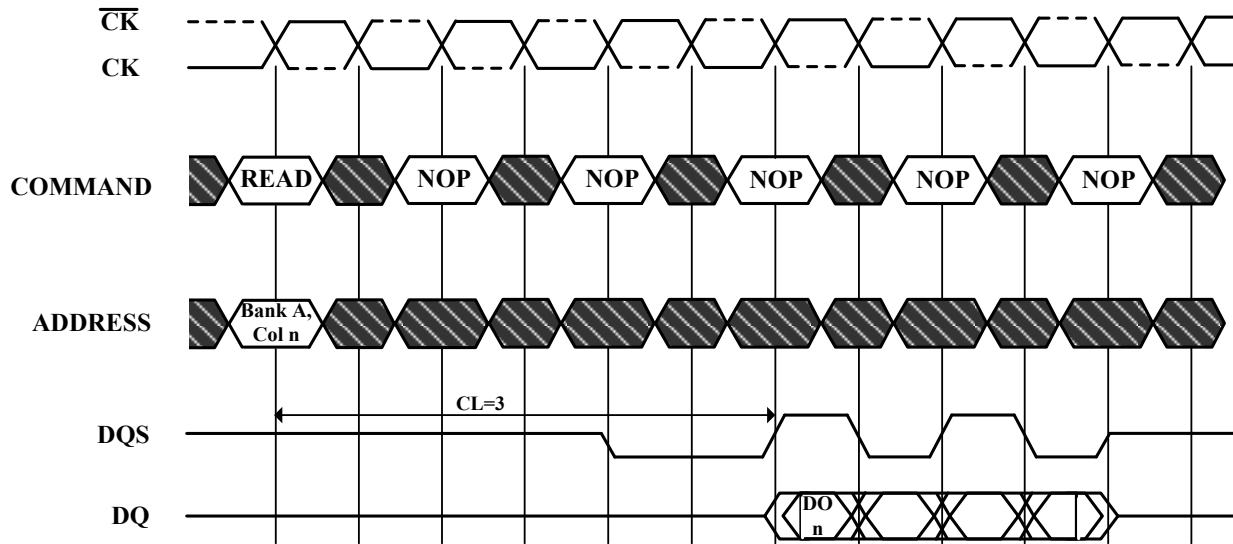
DO n=Data Out from column n

Burst Length=4

3 subsequent elements of Data Out appear in the programmed order following DO n

 Don't Care

## Read Burst Required CAS Latencies (CL=3)

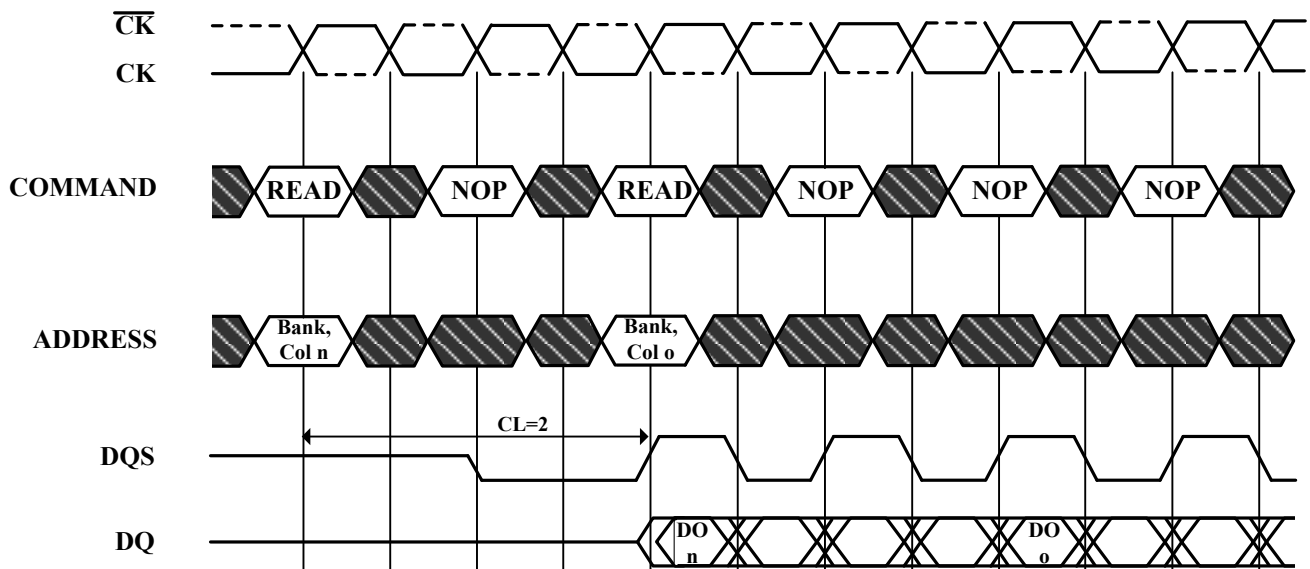


DO n=Data Out from column n

Burst Length=4

3 subsequent elements of Data Out appear in the programmed order following DO n

 Don't Care

**Figure 8. Consecutive Read Bursts Required CAS Latencies (CL=2)**


**DO n (or o)=Data Out from column n (or column o)**

**Burst Length=4 or 8 (if 4, the bursts are concatenated; if 8, the second burst interrupts the first)**

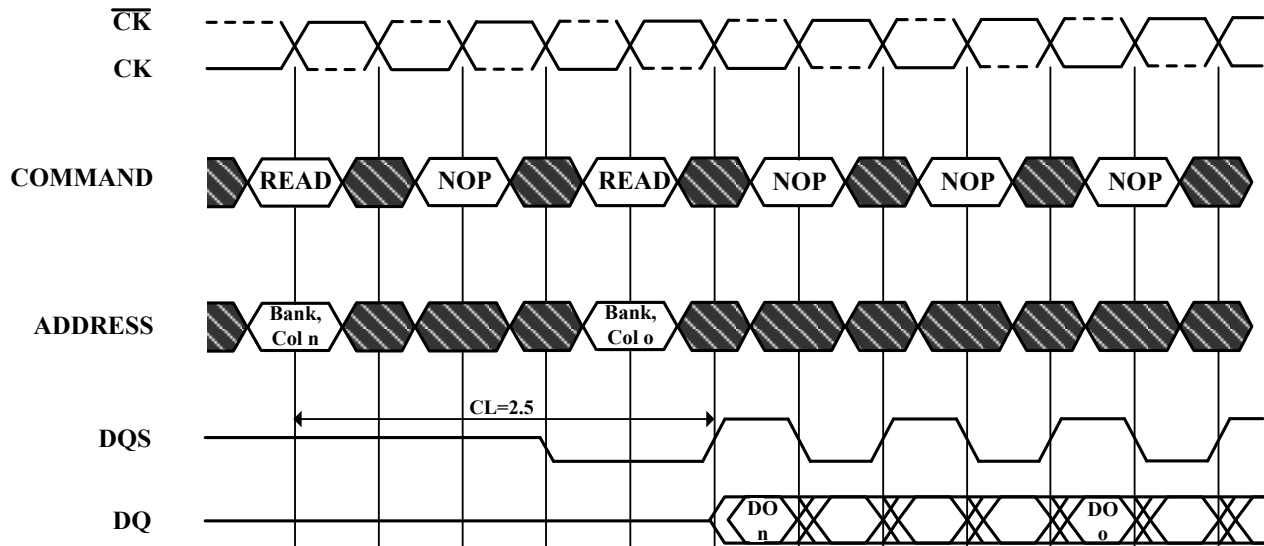
**3 subsequent elements of Data Out appear in the programmed order following DO n**

**3 (or 7) subsequent elements of Data Out appear in the programmed order following DO o**

**Read commands shown must be to the same device**

 **Don't Care**

## Consecutive Read Bursts Required CAS Latencies (CL=2.5)



DO n (or o)=Data Out from column n (or column o)

Burst Length=4 or 8 (if 4, the bursts are concatenated; if 8, the second burst interrupts the first)

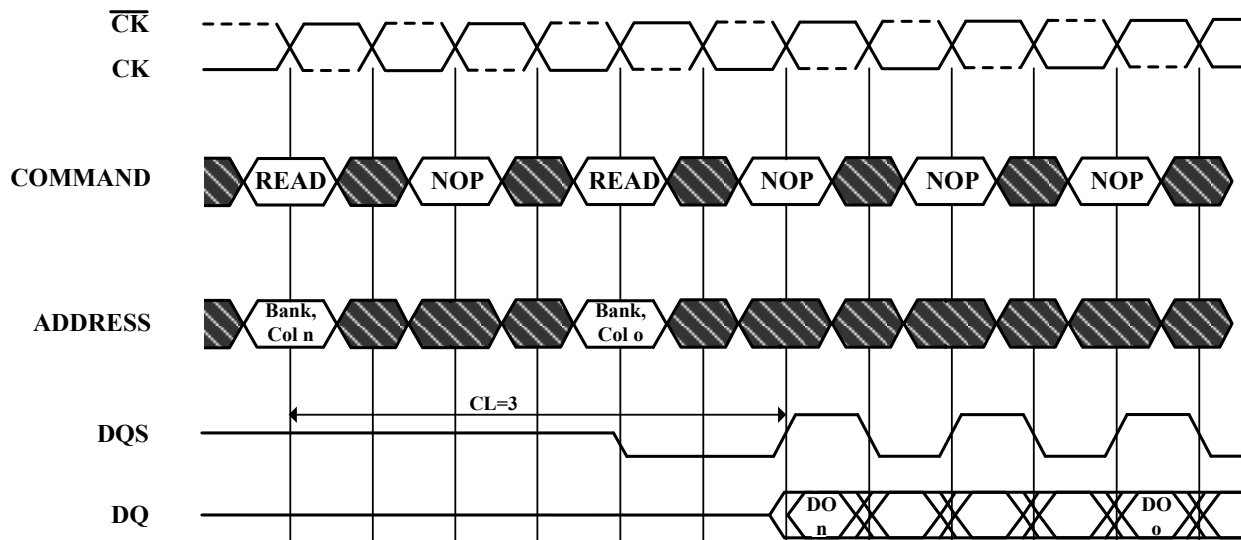
3 subsequent elements of Data Out appear in the programmed order following DO n

3 (or 7) subsequent elements of Data Out appear in the programmed order following DO o

Read commands shown must be to the same device

 Don't Care

## Consecutive Read Bursts Required CAS Latencies (CL=3)



DO n (or o)=Data Out from column n (or column o)

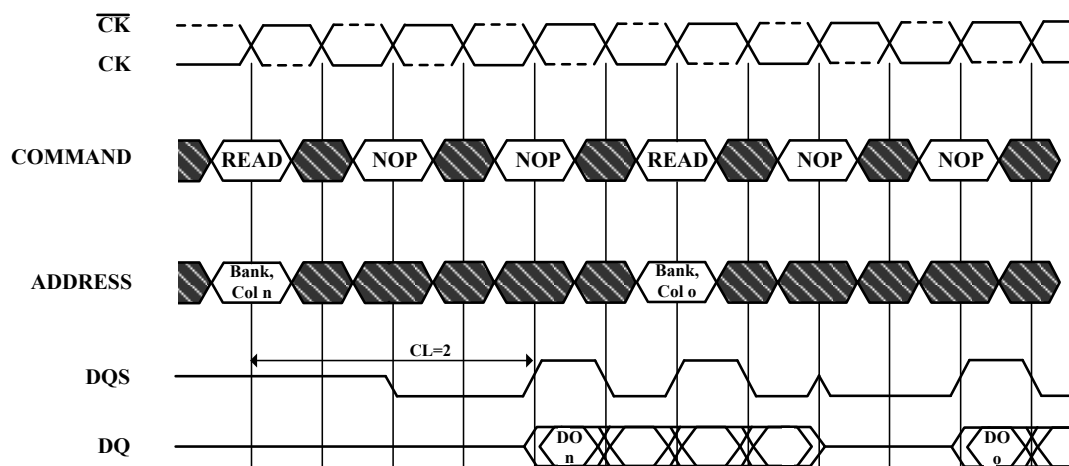
Burst Length=4 or 8 (if 4, the bursts are concatenated; if 8, the second burst interrupts the first)

3 subsequent elements of Data Out appear in the programmed order following DO n

3 (or 7) subsequent elements of Data Out appear in the programmed order following DO o

Read commands shown must be to the same device

 Don't Care

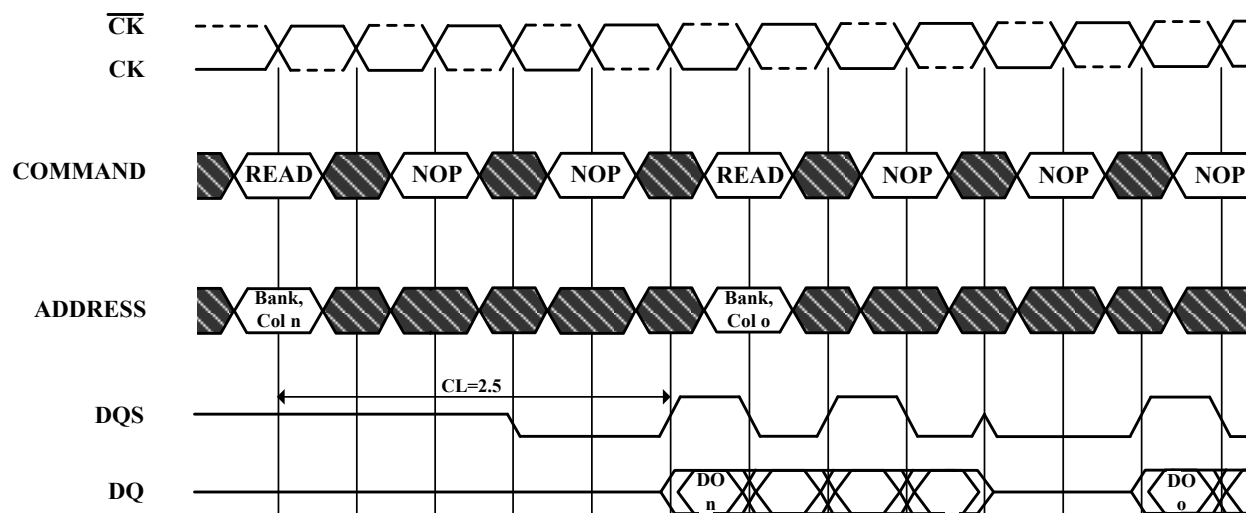
**Figure 9. Non-Consecutive Read Bursts Required CAS Latencies (CL=2)**


DO n (or o)=Data Out from column n (or column o)

Burst Length=4

3 subsequent elements of Data Out appear in the programmed order following DO n  
(and following DO o)

 Don't Care

**Non-Consecutive Read Bursts Required CAS Latencies (CL=2.5)**


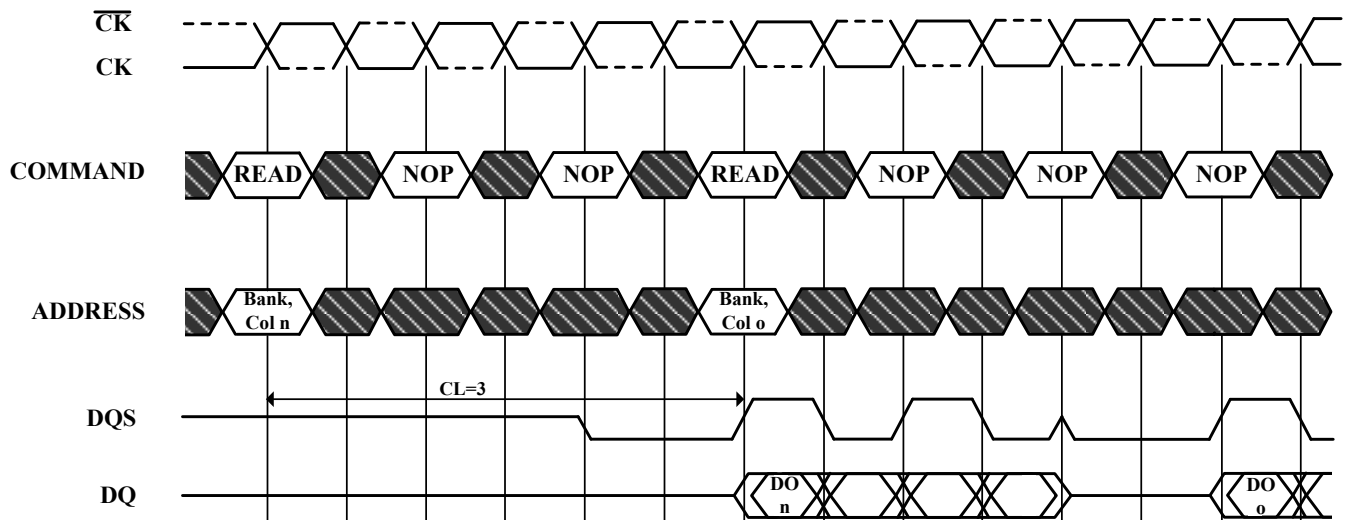
DO n (or o)=Data Out from column n (or column o)

Burst Length=4

3 subsequent elements of Data Out appear in the programmed order following DO n  
(and following DO o)

 Don't Care

## Non-Consecutive Read Bursts Required CAS Latencies (CL=3)

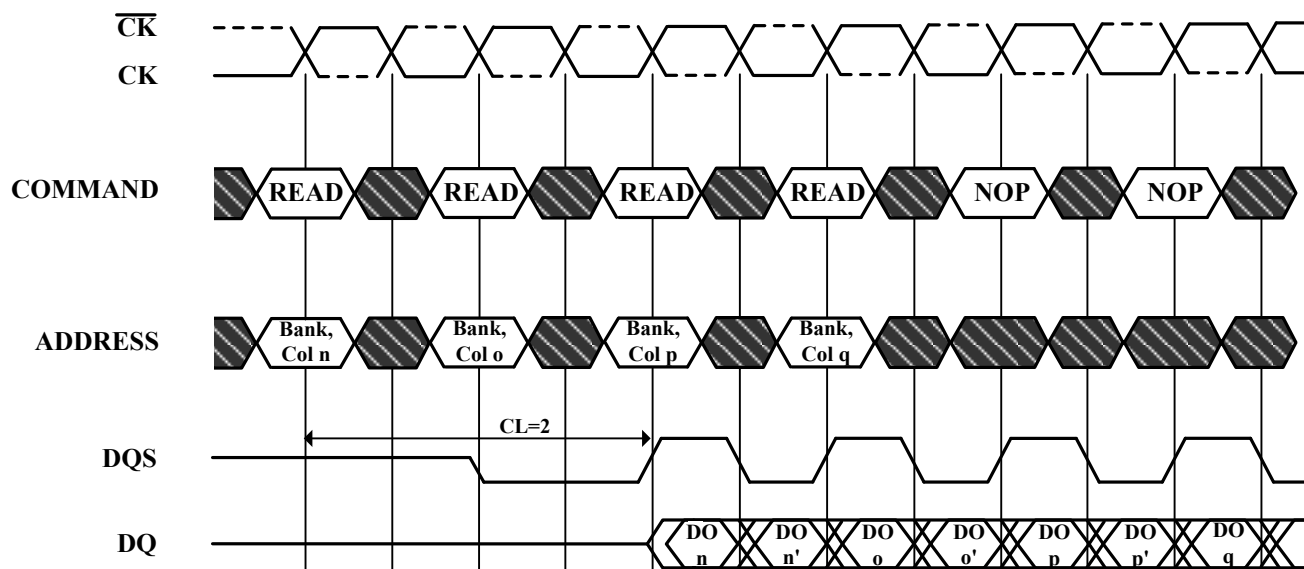


DO n (or o)=Data Out from column n (or column o)

Burst Length=4

3 subsequent elements of Data Out appear in the programmed order following DO n  
(and following DO o)

 Don't Care

**Figure 10. Random Read Accesses Required CAS Latencies (CL=2)**


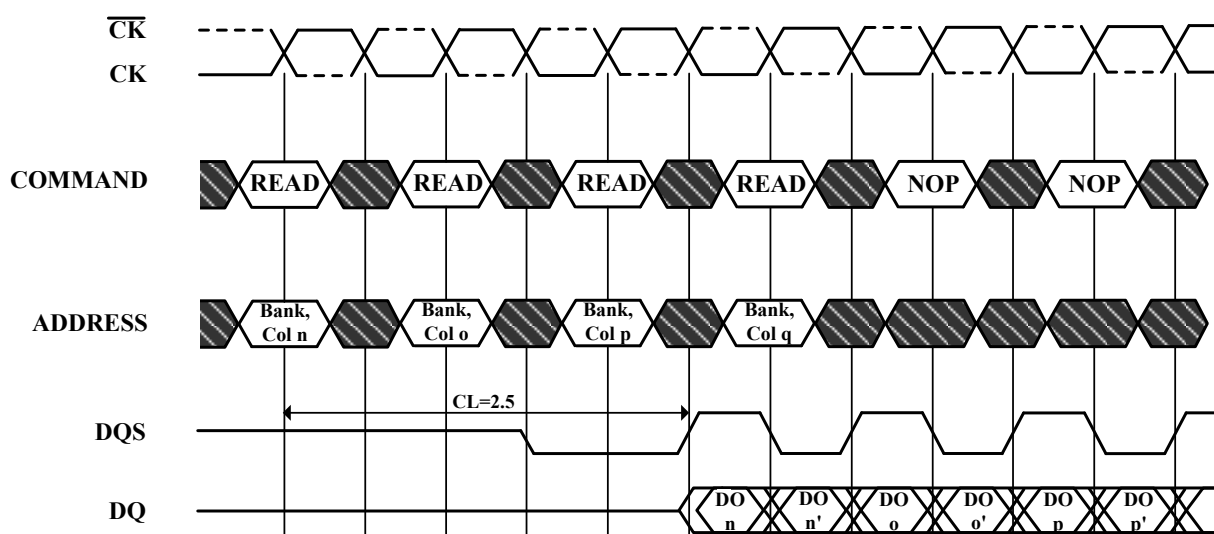
DO n, etc. =Data Out from column n, etc.

n', etc. =the next Data Out following DO n, etc. according to the programmed burst order

Burst Length=2,4 or 8 in cases shown. If burst of 4 or 8, the burst is interrupted

Reads are to active rows in any banks

 Don't Care

**Random Read Accesses Required CAS Latencies (CL=2.5)**


DO n, etc. =Data Out from column n, etc.

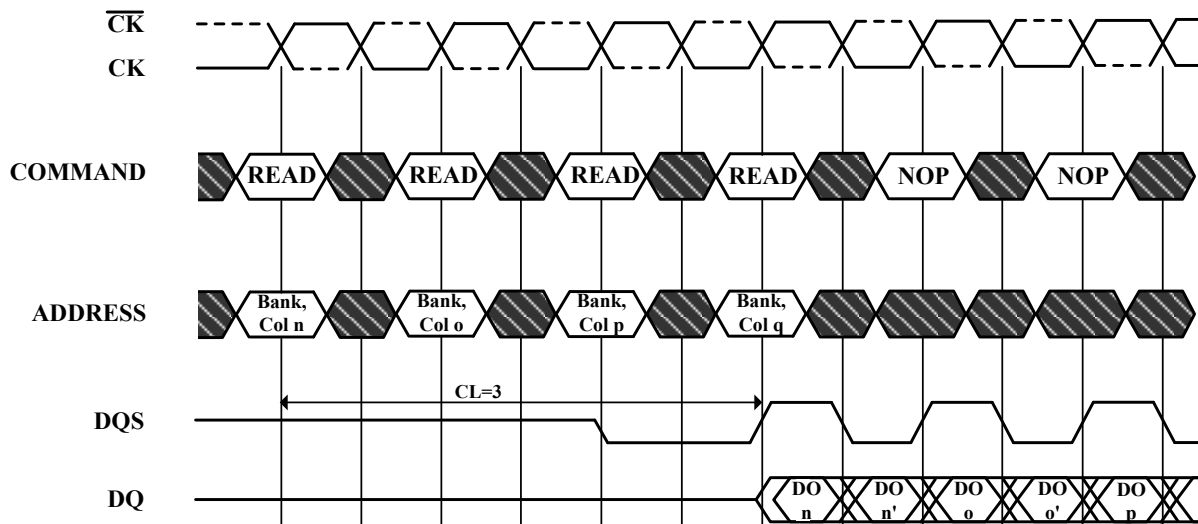
n', etc. =the next Data Out following DO n, etc. according to the programmed burst order

Burst Length=2,4 or 8 in cases shown. If burst of 4 or 8, the burst is interrupted

Reads are to active rows in any banks

 Don't Care

## Random Read Accesses Required CAS Latencies (CL=3)



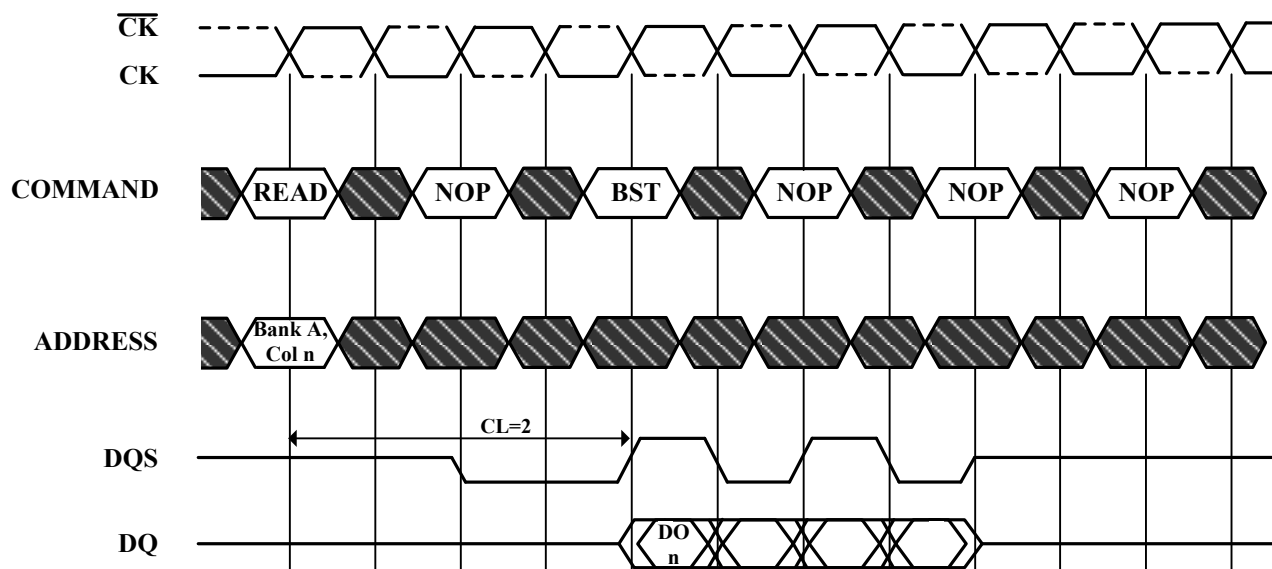
DO n, etc. =Data Out from column n, etc.

n', etc. =the next Data Out following DO n, etc. according to the programmed burst order

Burst Length=2,4 or 8 in cases shown. If burst of 4 or 8, the burst is interrupted

Reads are to active rows in any banks

 Don't Care

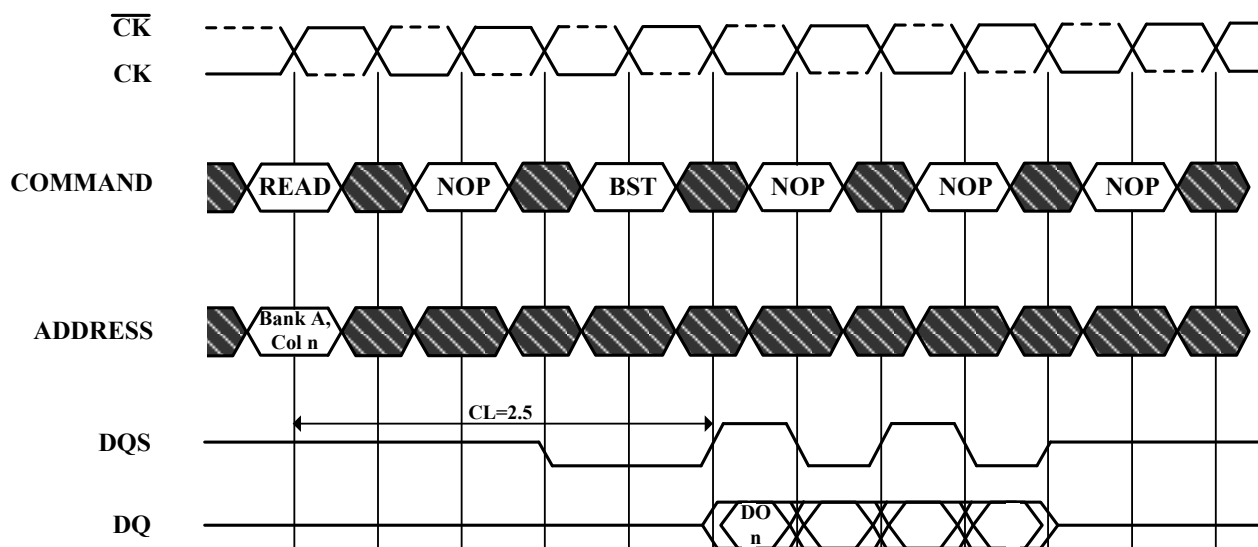
**Figure 11. Terminating a Read Burst Required CAS Latencies (CL=2)**


DO n = Data Out from column n

Cases shown are bursts of 8 terminated after 4 data elements

3 subsequent elements of Data Out appear in the programmed order following DO n

 Don't Care

**Terminating a Read Burst Required CAS Latencies (CL=2.5)**


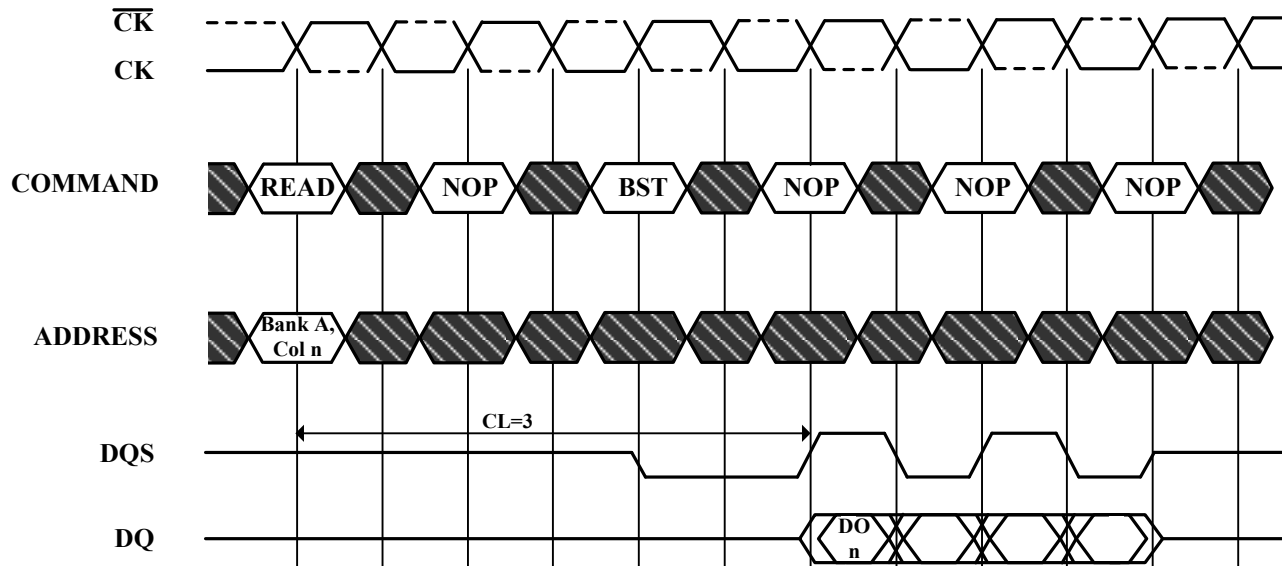
DO n = Data Out from column n

Cases shown are bursts of 8 terminated after 4 data elements

3 subsequent elements of Data Out appear in the programmed order following DO n

 Don't Care

## Terminating a Read Burst Required CAS Latencies (CL=3)

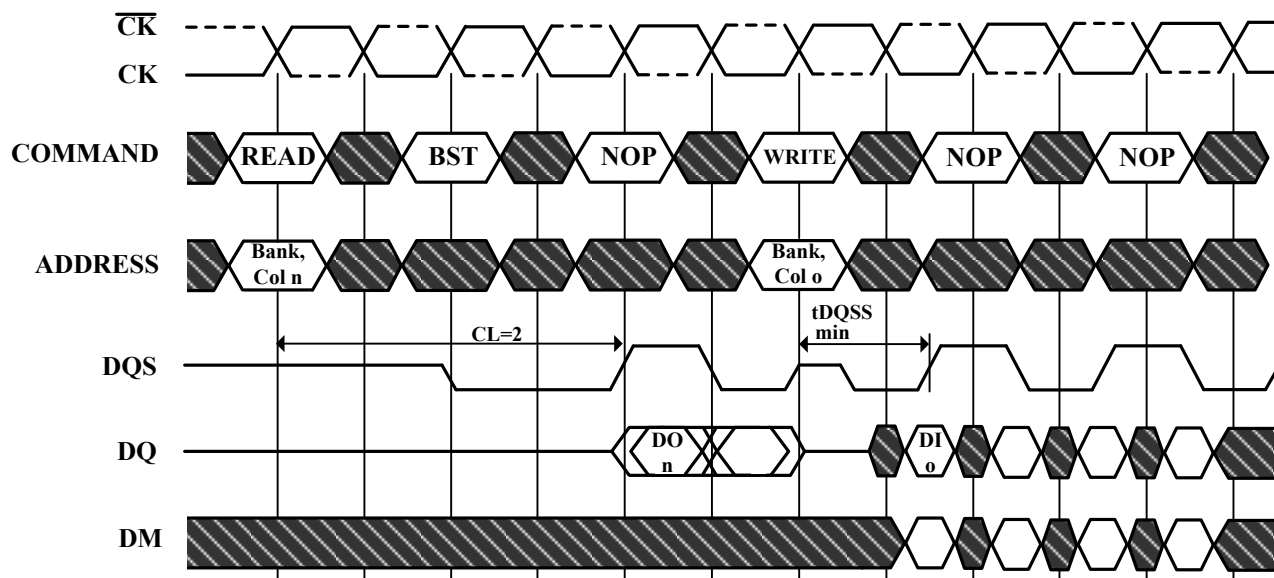


DO n = Data Out from column n

Cases shown are bursts of 8 terminated after 4 data elements

3 subsequent elements of Data Out appear in the programmed order following DO n

 Don't Care

**Figure 12. Read to Write Required CAS Latencies (CL=2)**


DO n (or o)= Data Out from column n (or column o)

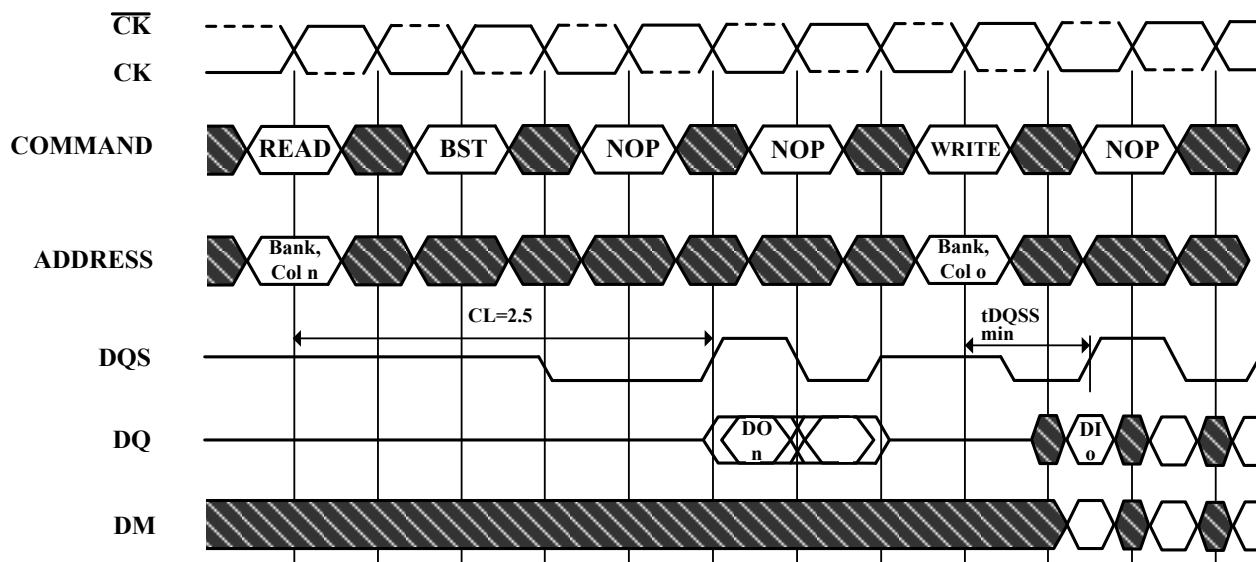
Burst Length= 4 in the cases shown (applies for bursts of 8 as well; if burst length is 2, the BST command shown can be NOP)

1 subsequent element of Data Out appears in the programmed order following DO n

Data in elements are applied following DI o in the programmed order

 Don't Care

## Read to Write Required CAS Latencies (CL=2.5)



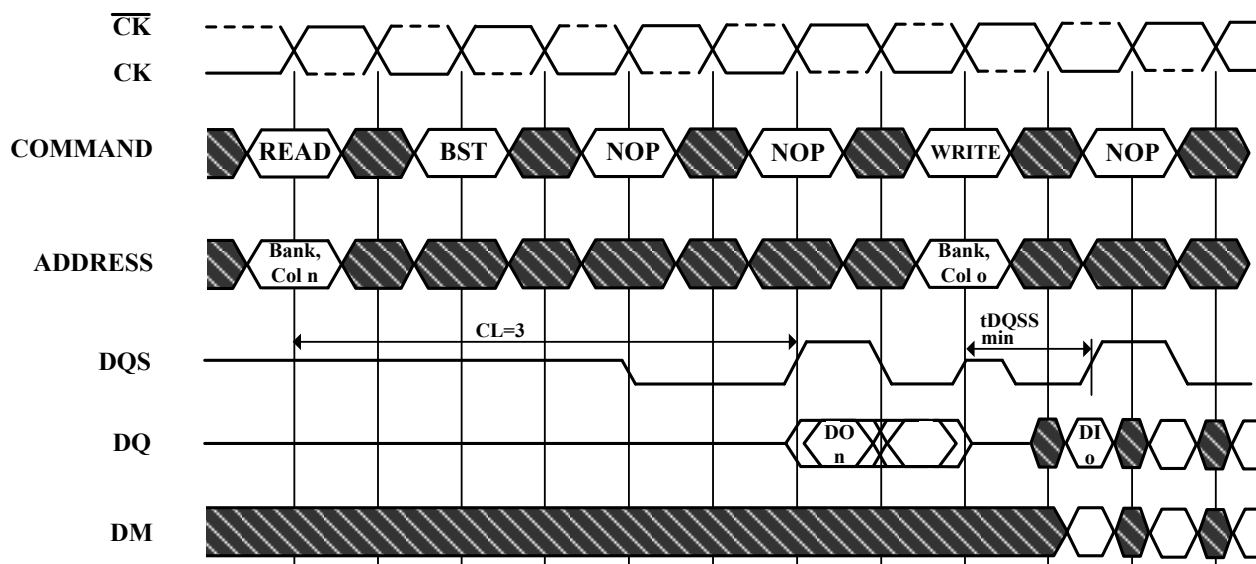
$DO_n$  (or  $o$ ) = Data Out from column  $n$  (or column  $o$ )

Burst Length= 4 in the cases shown (applies for bursts of 8 as well; if burst length is 2, the BST command shown can be NOP)

1 subsequent element of Data Out appears in the programmed order following  $DO_n$

Data in elements are applied following  $DI_o$  in the programmed order

 Don't Care

**Read to Write Required CAS Latencies (CL=3)**


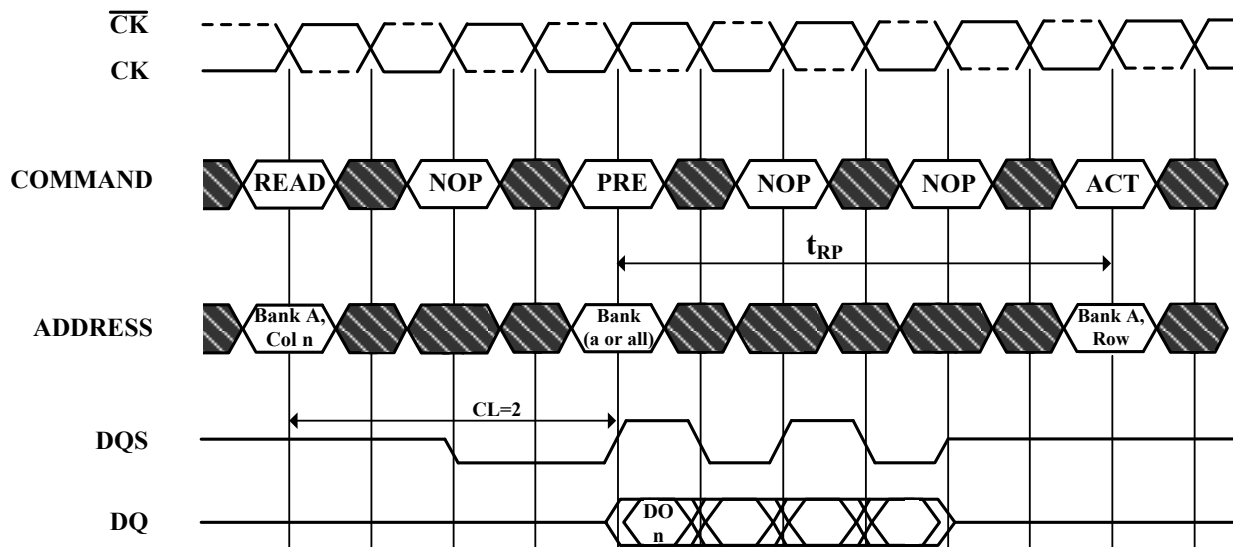
DO n (or o)= Data Out from column n (or column o)

Burst Length= 4 in the cases shown (applies for bursts of 8 as well; if burst length is 2, the BST command shown can be NOP)

1 subsequent element of Data Out appears in the programmed order following DO n

Data in elements are applied following DI o in the programmed order

 Don't Care

**Figure 13. Read to Precharge Required CAS Latencies (CL=2)**


DO n = Data Out from column n

Cases shown are either uninterrupted bursts of 4, or interrupted bursts of 8  
 3 subsequent elements of Data Out appear in the programmed order  
 following DO n

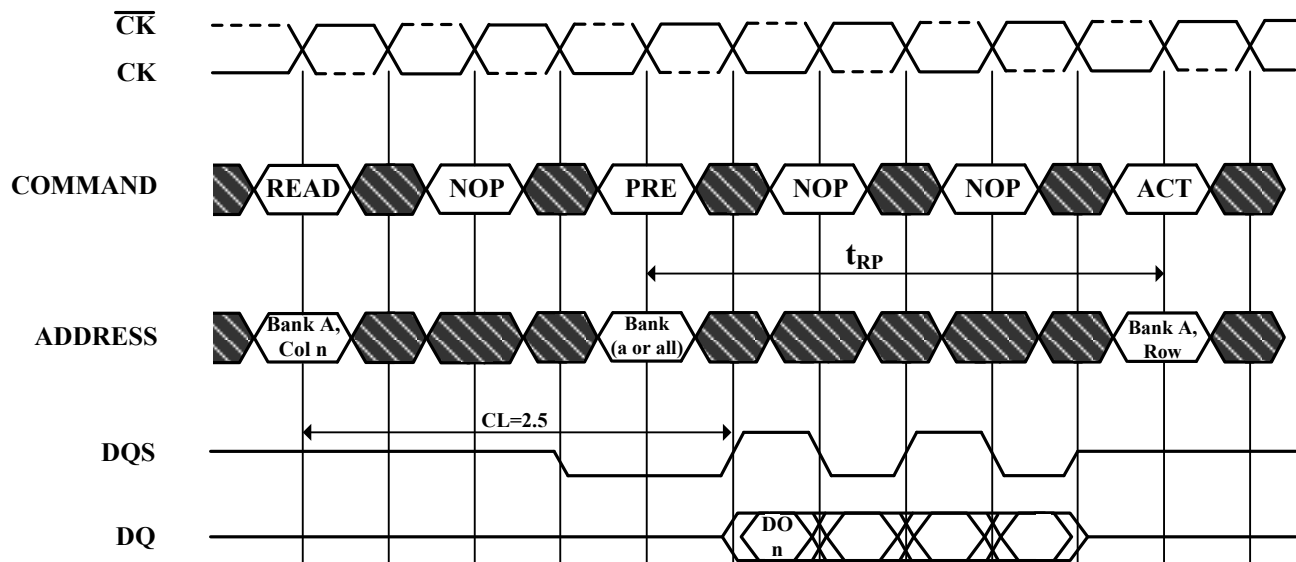
Precharge may be applied at (BL/2) tCK after the READ command

Note that Precharge may not be issued before t<sub>RAS</sub> ns after the ACTIVE  
 command for applicable banks

The Active command may be applied if t<sub>RC</sub> has been met

 Don't Care

## Read to Precharge Required CAS Latencies (CL=2.5)



DO n = Data Out from column n

Cases shown are either uninterrupted bursts of 4, or interrupted bursts of 8  
 3 subsequent elements of Data Out appear in the programmed order  
 following DO n

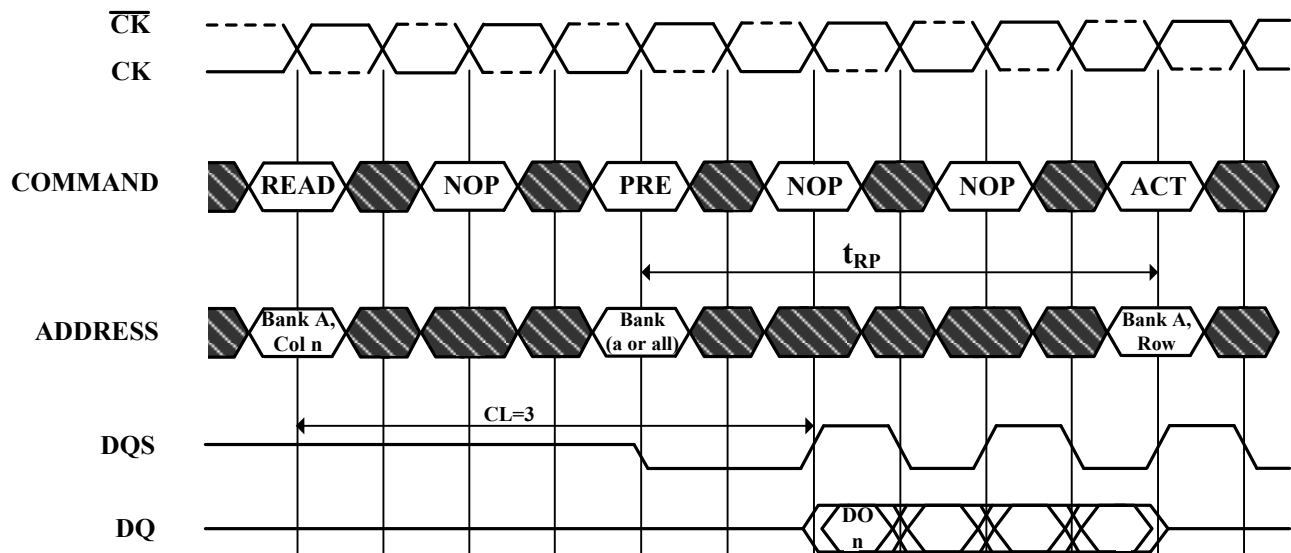
Precharge may be applied at (BL/2) tCK after the READ command

Note that Precharge may not be issued before tRAS ns after the ACTIVE  
 command for applicable banks

The Active command may be applied if tRC has been met

 Don't Care

## Read to Precharge Required CAS Latencies (CL=3)



DO n = Data Out from column n

Cases shown are either uninterrupted bursts of 4, or interrupted bursts of 8

3 subsequent elements of Data Out appear in the programmed order following DO n

Precharge may be applied at (BL/2) tCK after the READ command

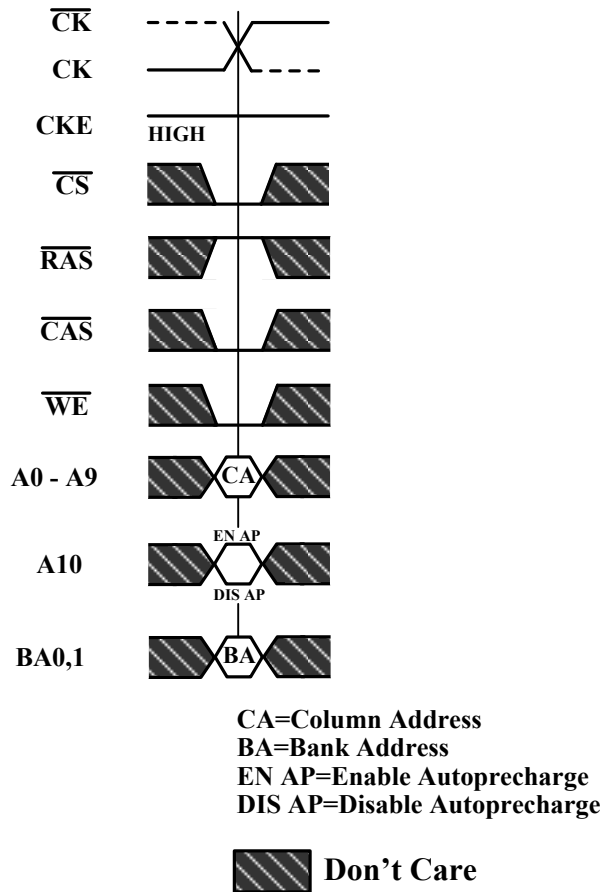
Note that Precharge may not be issued before tRAS ns after the ACTIVE command for applicable banks

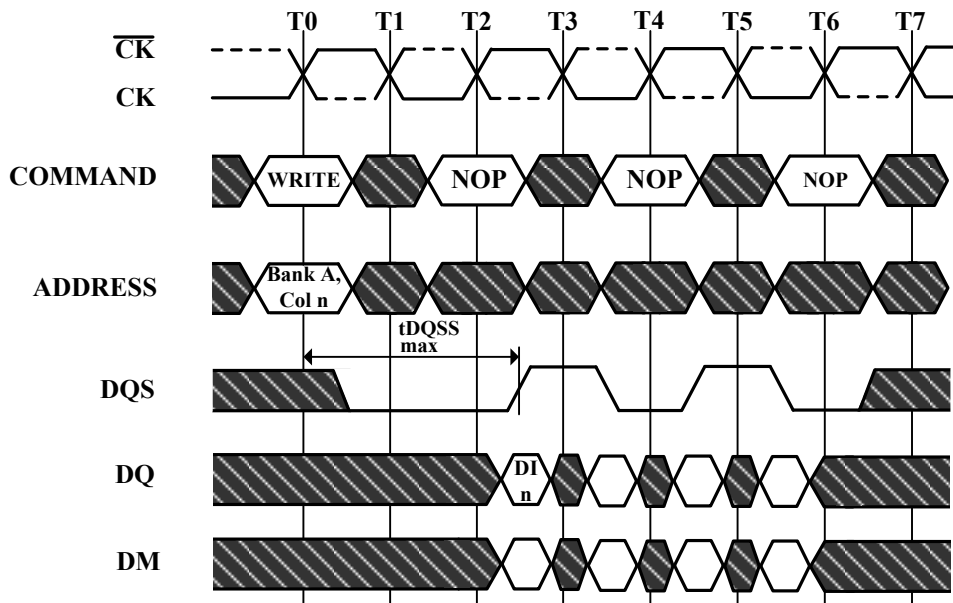
The Active command may be applied if tRC has been met



Don't Care

**Figure 14. Write Command**



**Figure 15. Write Max DQSS**


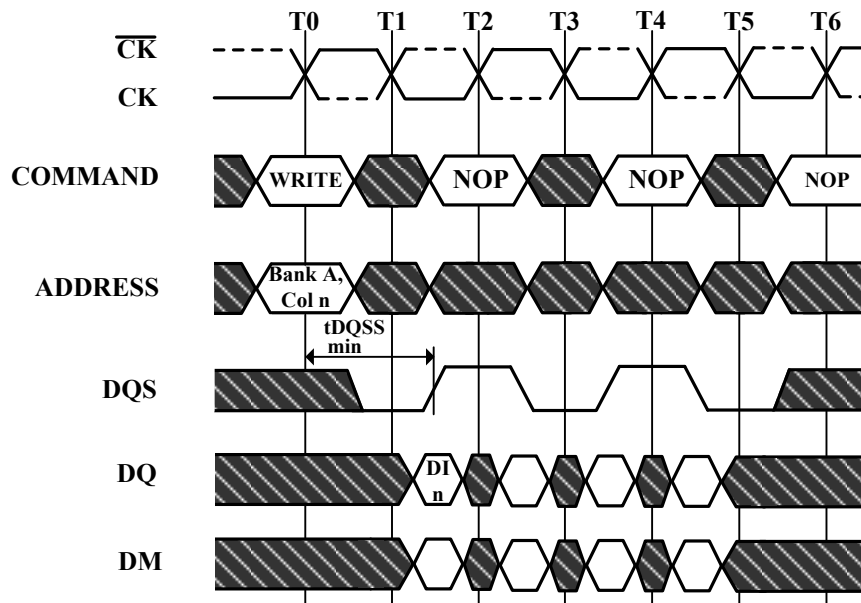
DI n = Data In for column n

3 subsequent elements of Data In are applied in the programmed order following DI n

A non-interrupted burst of 4 is shown

A10 is LOW with the WRITE command (AUTO PRECHARGE disabled)

 Don't Care

**Figure 16. Write Min DQSS**


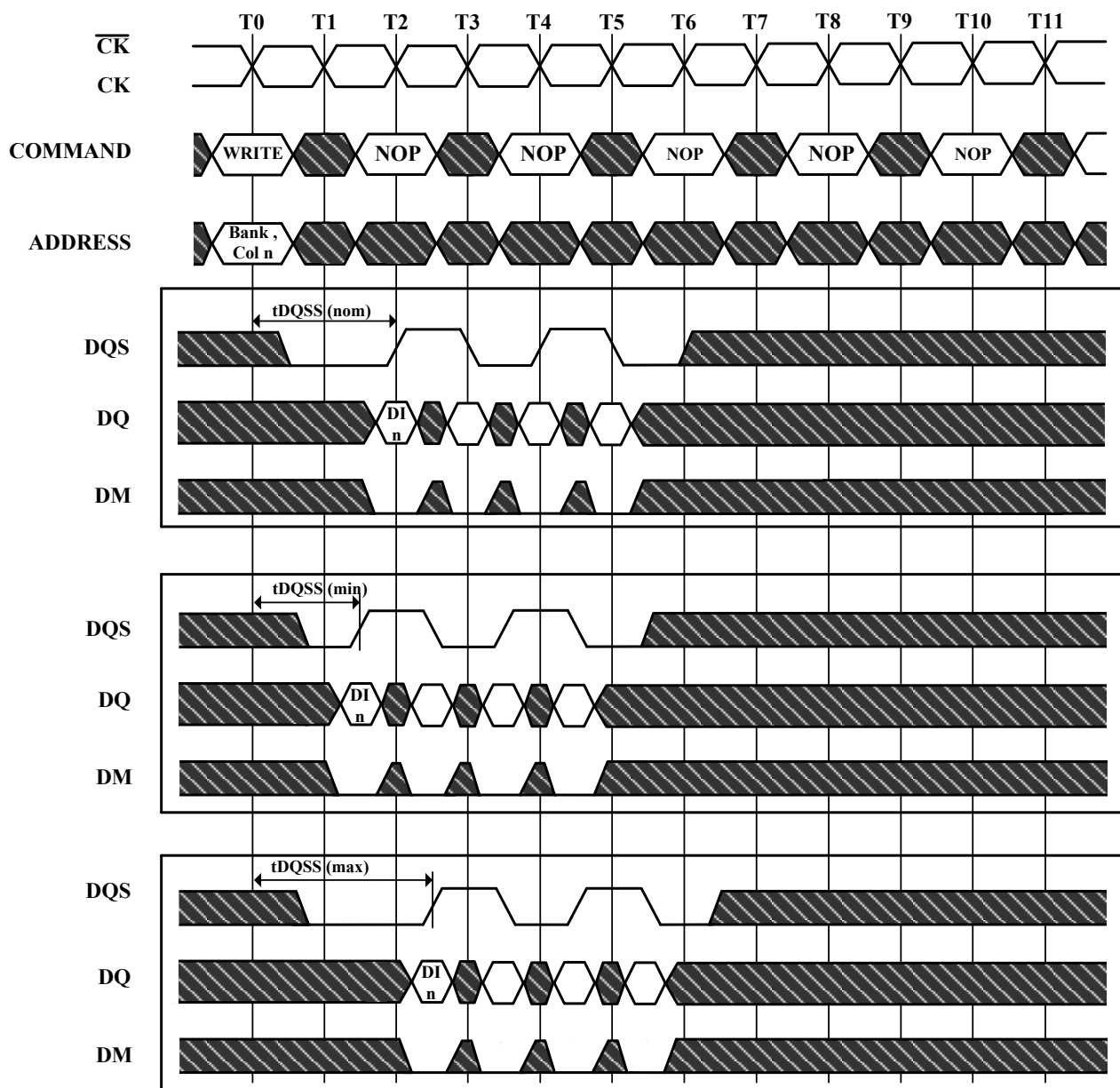
DI<sub>n</sub> = Data In for column n

3 subsequent elements of Data In are applied in the programmed order following DI<sub>n</sub>

A non-interrupted burst of 4 is shown

A10 is LOW with the WRITE command (AUTO PRECHARGE disabled)

 Don't Care

**Figure 17. Write Burst Nom, Min, and Max tDQSS**


DI n = Data In for column n

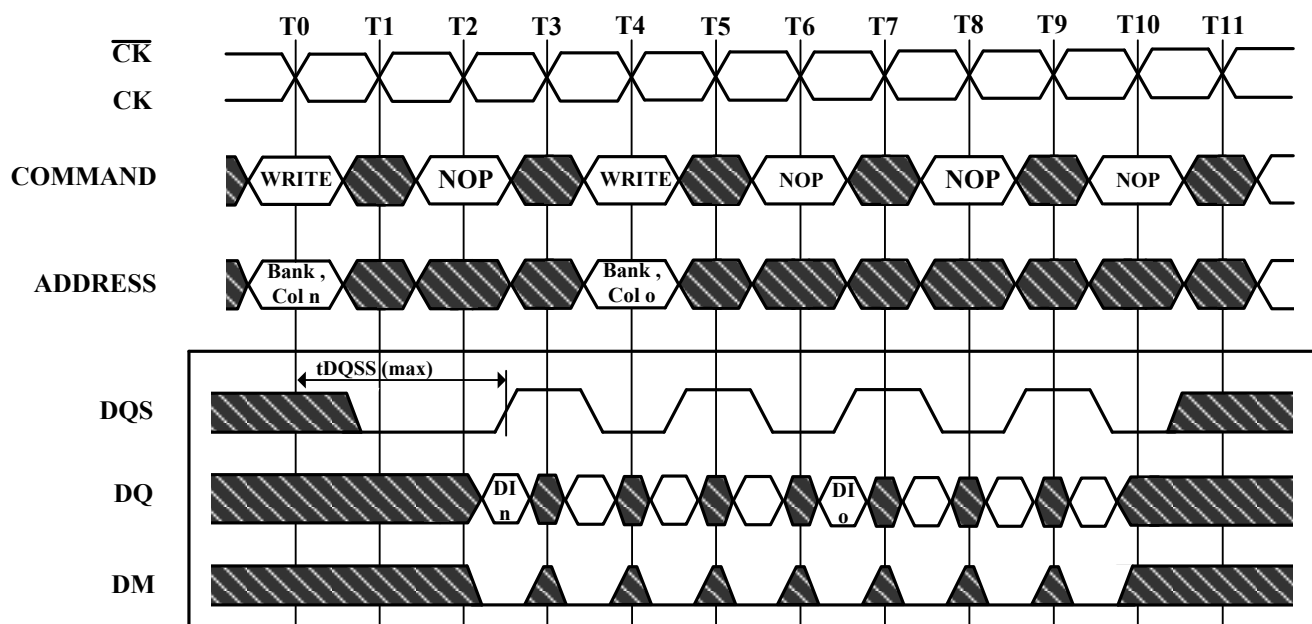
3 subsequent elements of Data are applied in the programmed order following DI n

A non-interrupted burst of 4 is shown

A10 is LOW with the WRITE command (AUTO PRECHARGE disabled)

DM=UDM & LDM

 Don't Care

**Figure 18. Write to Write Max tDQSS**


DI n , etc. = Data In for column n,etc.

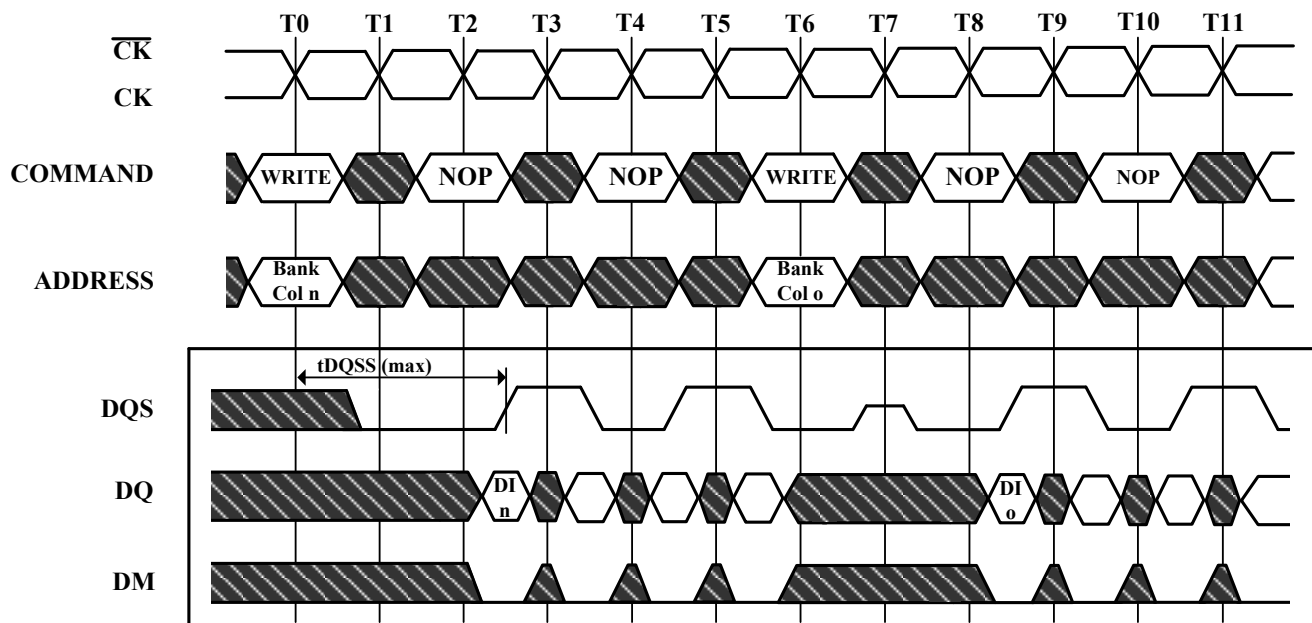
3 subsequent elements of Data In are applied in the programmed order following DI n

3 subsequent elements of Data In are applied in the programmed order following DI o

Non-interrupted bursts of 4 are shown

DM= UDM & LDM

 Don't Care

**Figure 19. Write to Write Max tDQSS, Non Consecutive**


DI n, etc. = Data In for column n, etc.

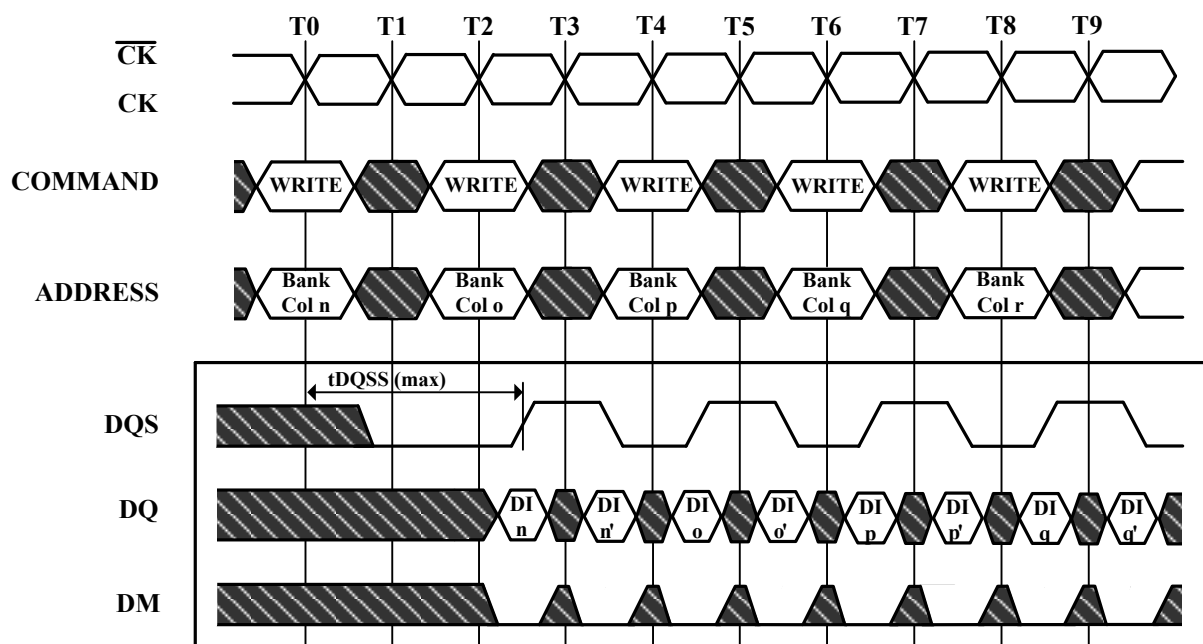
3 subsequent elements of Data In are applied in the programmed order following DI n

3 subsequent elements of Data In are applied in the programmed order following DI o

Non-interrupted bursts of 4 are shown

DM= UDM & LDM

 Don't Care

**Figure 20. Random Write Cycles Max tDQSS**


DI n, etc. = Data In for column n, etc.

n', etc. = the next Data In following DI n, etc. according to the programmed burst order

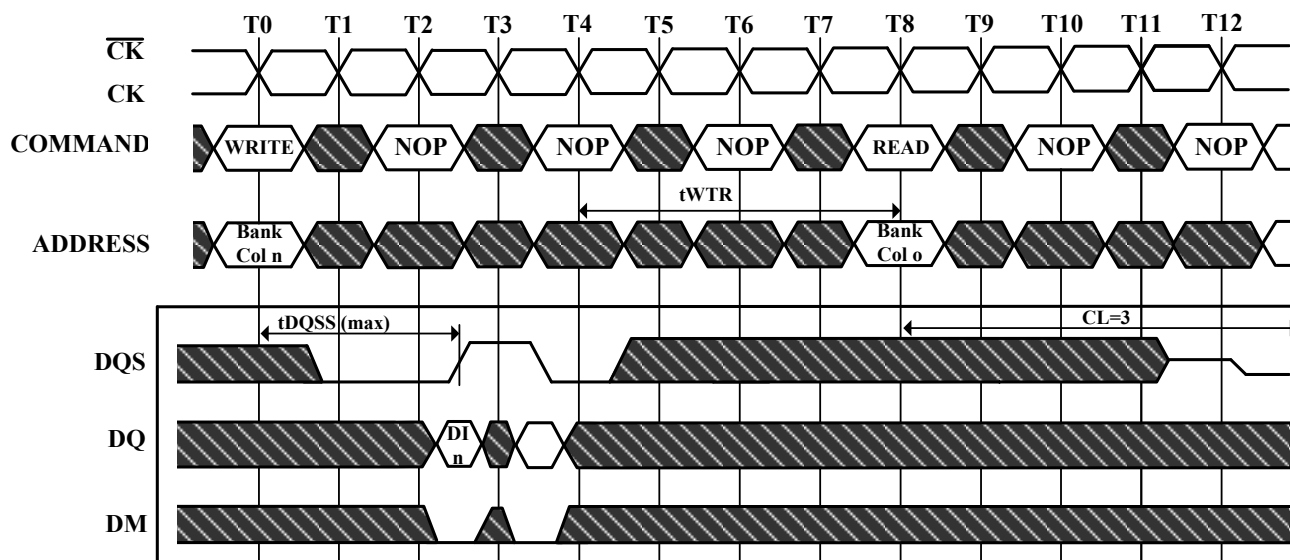
Programmed Burst Length 2, 4, or 8 in cases shown

If burst of 4 or 8, the burst would be truncated

Each WRITE command may be to any bank and may be to the same or different devices

DM= UDM & LDM

 Don't Care

**Figure 21. Write to Read Max tDQSS Non Interrupting**


DI n, etc. = Data In for column n, etc.

1 subsequent elements of Data In are applied in the programmed order following DI n

A non-interrupted burst of 2 is shown

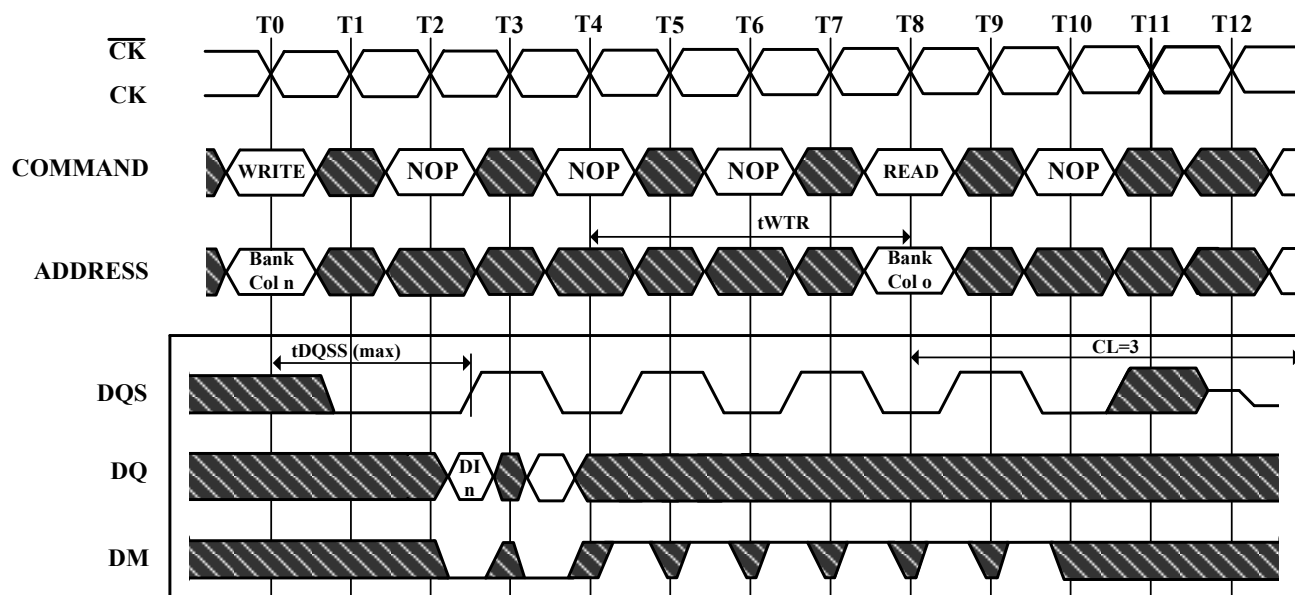
tWTR is referenced from the first positive CK edge after the last Data In Pair

A10 is LOW with the WRITE command (AUTO PRECHARGE is disabled)

The READ and WRITE commands are to the same devices but not necessarily to the same bank

DM= UDM & LDM

 Don't Care

**Figure 22. Write to Read Max tDQSS Interrupting**


DI n, etc. = Data In for column n, etc.

1 subsequent elements of Data In are applied in the programmed order following DI n

An interrupted burst of 8 is shown, 2 data elements are written

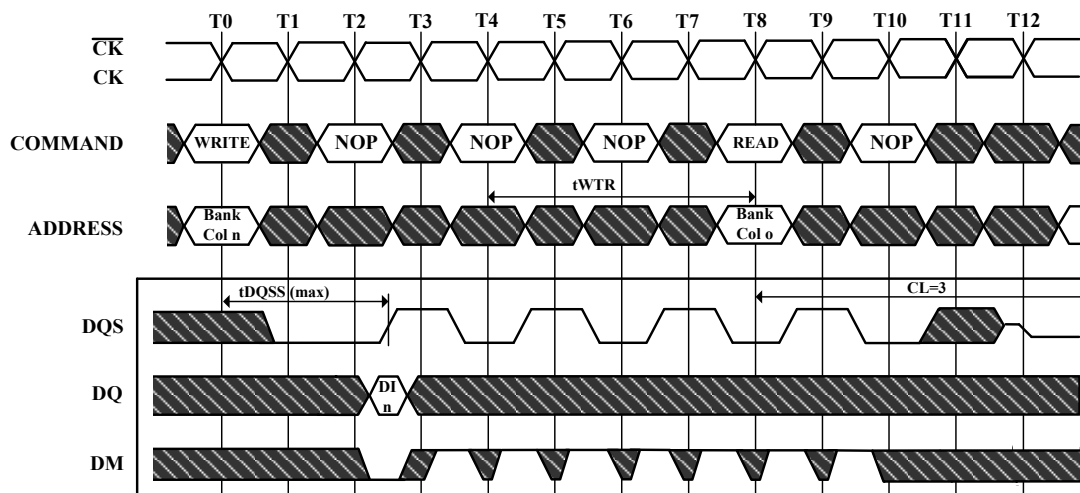
tWTR is referenced from the first positive CK edge after the last Data In Pair

A10 is LOW with the WRITE command (AUTO PRECHARGE is disabled)

The READ and WRITE commands are to the same devices but not necessarily to the same bank

DM= UDM & LDM

 Don't Care

**Figure 23. Write to Read Max tDQSS, ODD Number of Data, Interrupting**


DI n = Data In for column n

An interrupted burst of 8 is shown, 1 data elements are written

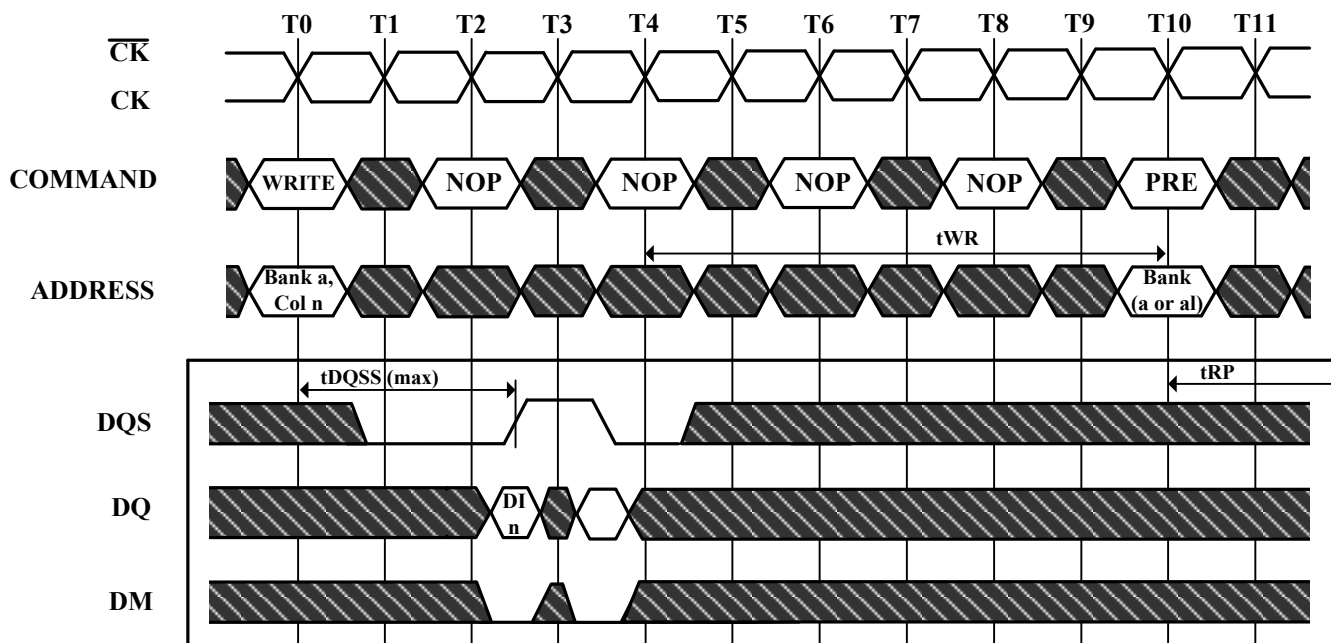
tWTR is referenced from the first positive CK edge after the last Data In Pair (not the last desired Data In element)

A10 is LOW with the WRITE command (AUTO PRECHARGE is disabled)

The READ and WRITE commands are to the same devices but not necessarily to the same bank

DM= LDM & UDM

 Don't Care

**Figure 24. Write to Precharge Max tDQSS, NON- Interrupting**


DI n = Data In for column n

1 subsequent elements of Data In are applied in the programmed order following DI n

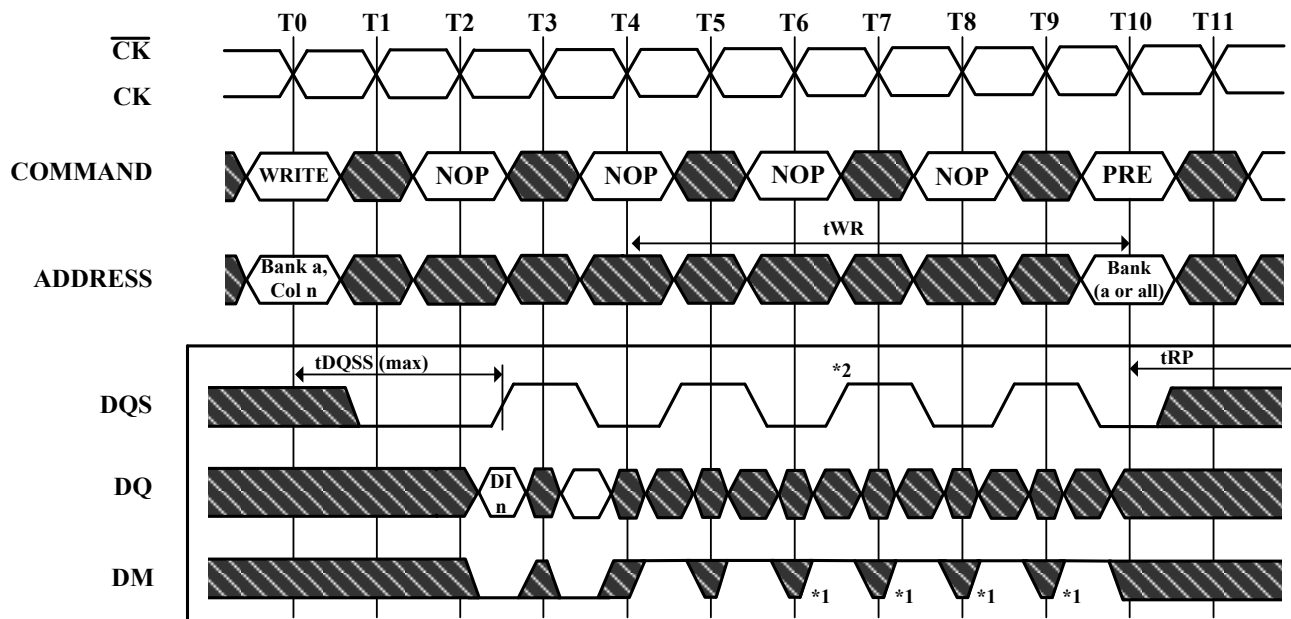
A non-interrupted burst of 2 is shown

tWR is referenced from the first positive CK edge after the last Data In Pair

A10 is LOW with the WRITE command (AUTO PRECHARGE is disabled)

DM= UDM & LDM

 Don't Care

**Figure 25. Write to Precharge Max tDQSS, Interrupting**


DI n = Data In for column n

An interrupted burst of 4 or 8 is shown, 2 data elements are written

tWR is referenced from the first positive CK edge after the last Data In Pair

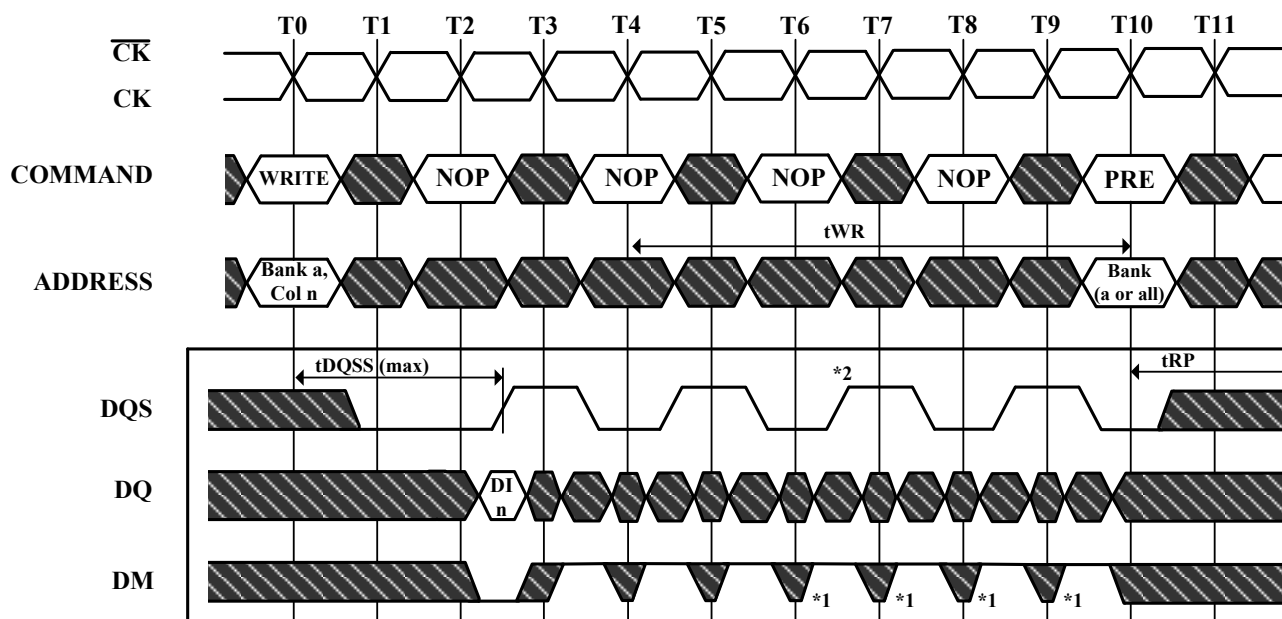
A10 is LOW with the WRITE command (AUTO PRECHARGE is disabled)

\*1 = can be don't care for programmed burst length of 4

\*2 = for programmed burst length of 4, DQS becomes don't care at this point

DM= UDM & LDM

 Don't Care

**Figure 26. Write to Precharge Max tDQSS ODD Number of Data Interrupting**


DI n = Data In for column n

An interrupted burst of 4 or 8 is shown, 1 data element is written

tWR is referenced from the first positive CK edge after the last Data In Pair

A10 is LOW with the WRITE command (AUTO PRECHARGE is disabled)

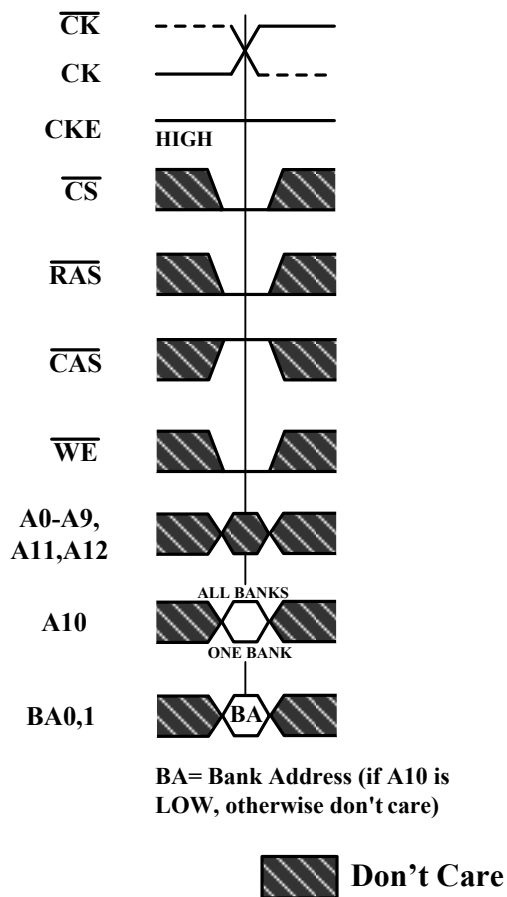
\*1 = can be don't care for programmed burst length of 4

\*2 = for programmed burst length of 4, DQS becomes don't care at this point

DM= UDM & LDM

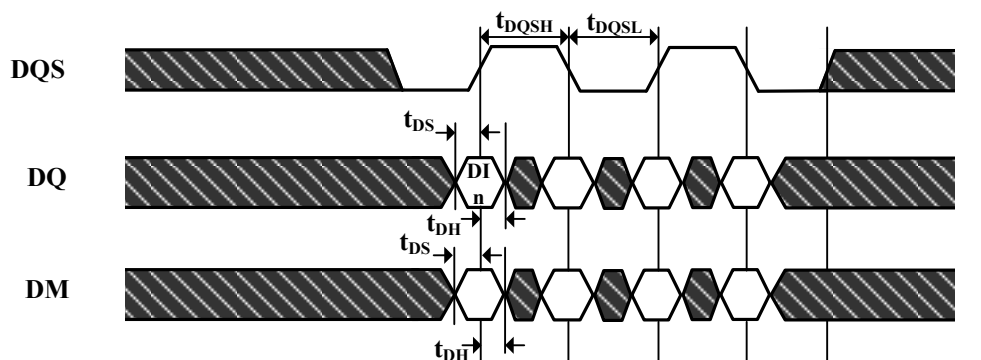
 Don't Care

**Figure 27. Precharge Command**



The diagram illustrates the timing for entering and exiting power-down mode. The clock (CK) is shown as a periodic square wave. The clock enable (CKE) signal transitions from high to low at time T1, entering power-down mode, and returns to high at time Tn+2, exiting power-down mode. The transition time from high to low is labeled  $t_{IS}$ . The command signal is shown as a sequence of hexagonal pulses. The first pulse is labeled 'VALID' and occurs between T0 and T1. The second pulse is labeled 'NOP' and occurs between T1 and T2. The third pulse is labeled 'NOP' and occurs between T2 and T3. The fourth pulse is labeled 'NOP' and occurs between T3 and T4. The fifth pulse is labeled 'NOP' and occurs between T4 and Tn. The sixth pulse is labeled 'NOP' and occurs between Tn and Tn+1. The seventh pulse is labeled 'NOP' and occurs between Tn+1 and Tn+2. The eighth pulse is labeled 'NOP' and occurs between Tn+2 and Tn+3. The ninth pulse is labeled 'NOP' and occurs between Tn+3 and Tn+4. The tenth pulse is labeled 'VALID' and occurs between Tn+4 and Tn+5. The eleventh pulse is labeled 'NOP' and occurs between Tn+5 and Tn+6. Arrows point to the rising edges of the first and eighth 'VALID' pulses, labeled 'No column access in progress' and 'Exit power-down mode' respectively. An arrow points to the falling edge of the first 'NOP' pulse, labeled 'Enter power-down mode'. A legend indicates that a hatched hexagon represents 'Don't Care'.

The diagram illustrates the timing sequence for exiting the PLL. The clock signal (CK) is shown as a series of cycles labeled T0, T1, T2, T4, Tx, Tx+1, Ty, Ty+1, Ty+2, Ty+3, Ty+4, and Tz. The command signal (CMD) shows a sequence of operations: NOP, NOP, a shaded region, a shaded region, a shaded region, a shaded region, a shaded region, NOP, DLL RESET, NOP, NOP, and Valid. The clock enable signal (CKE) shows a high level for tRP, followed by a low level, then a high level for tIS, and finally a low level for 200 clocks. Annotations include 'Frequency Change Occurs here' between Tx and Ty, 'Minimum 2 clocks Required before Changing frequency' between T2 and T4, and 'Stable new clock Before power down exit' between Ty+1 and Ty+2.

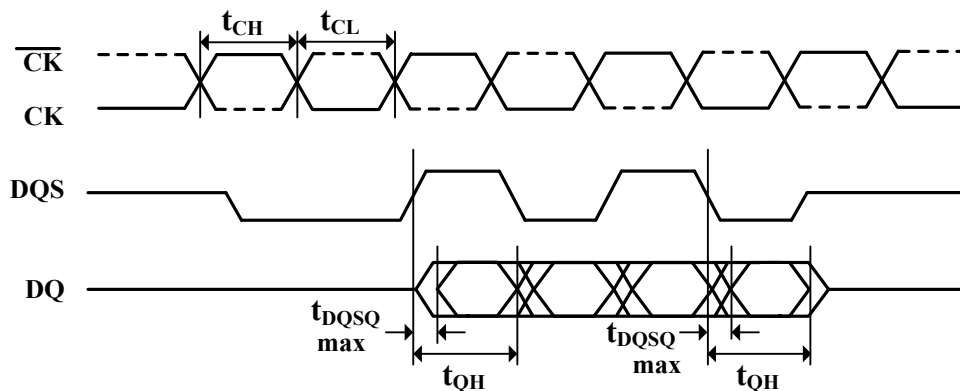
**Figure 30. Data input (Write) Timing**


DI n = Data In for column n

Burst Length = 4 in the case shown

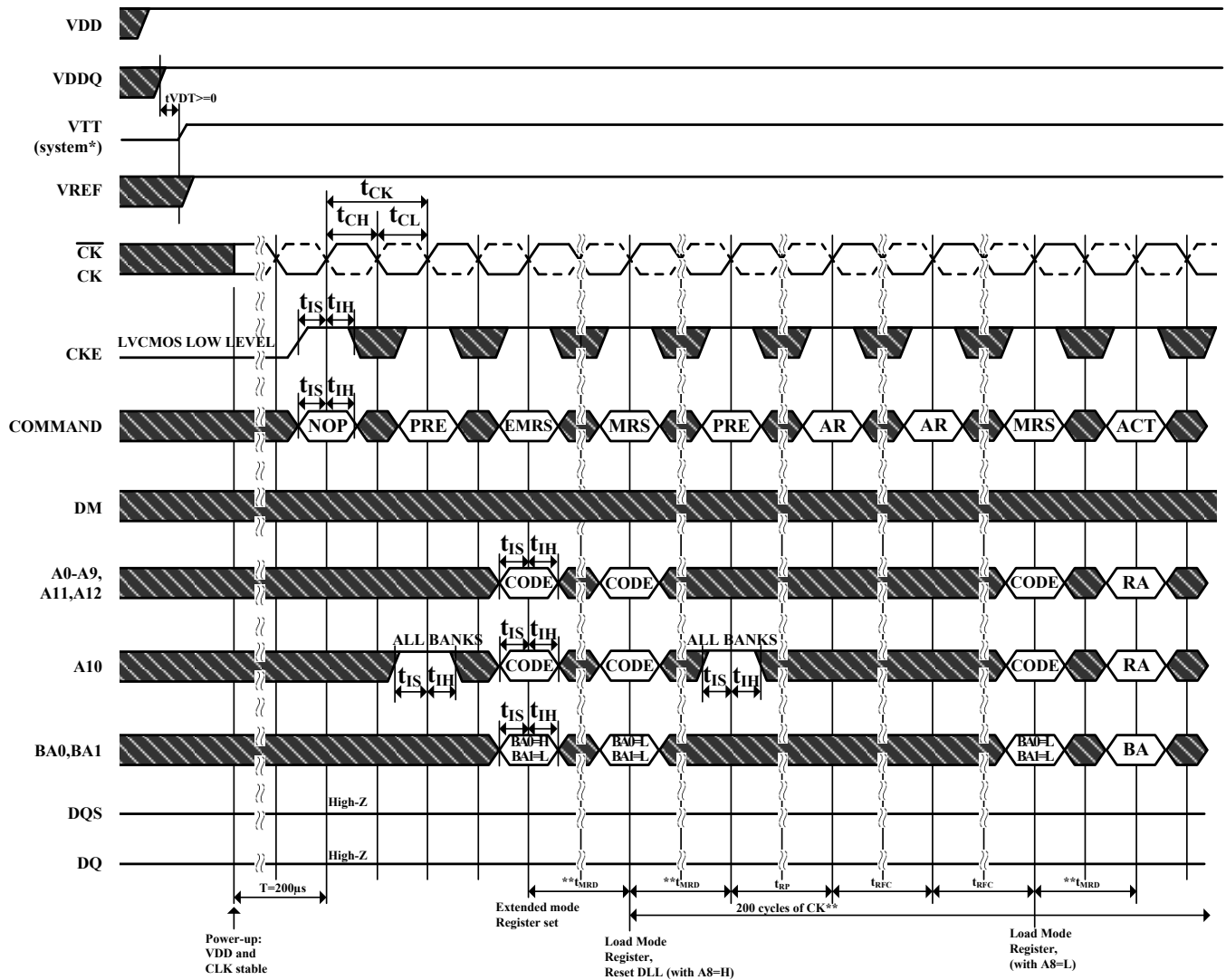
3 subsequent elements of Data In are applied in the programmed order following DI n

 Don't Care

**Figure 31. Data Output (Read) Timing**


Burst Length = 4 in the case shown

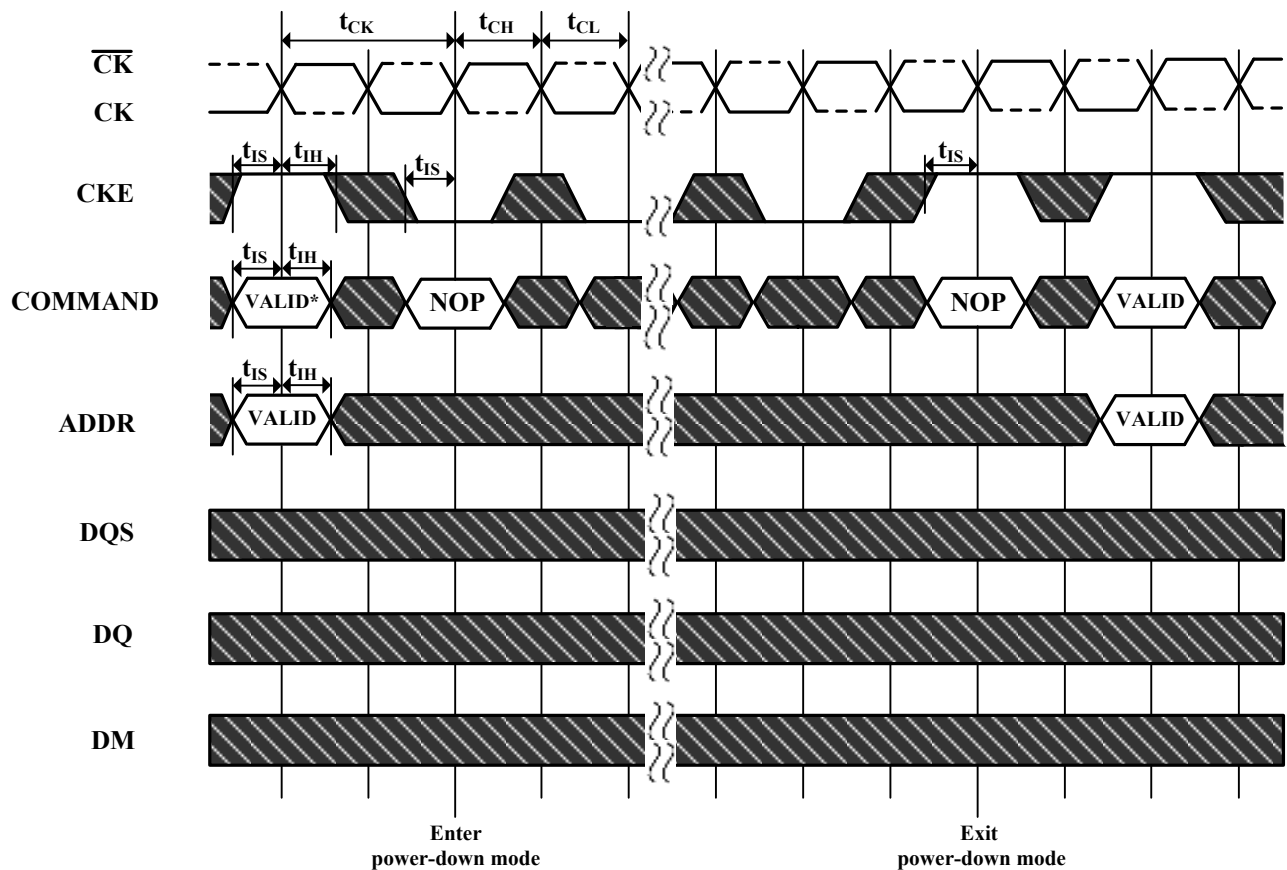
**Figure 32. Initialize and Mode Register Sets**



\*=VTT is not applied directly to the device, however  $t_{VTD}$  must be greater than or equal to zero to avoid device latch-up.

\*\* =  $t_{MRD}$  is required before any command can be applied, and 200 cycles of CK are required before any executable command can be applied the two auto Refresh commands may be moved to follow the first MRS but precede the second PRECHARGE ALL command.

 Don't Care

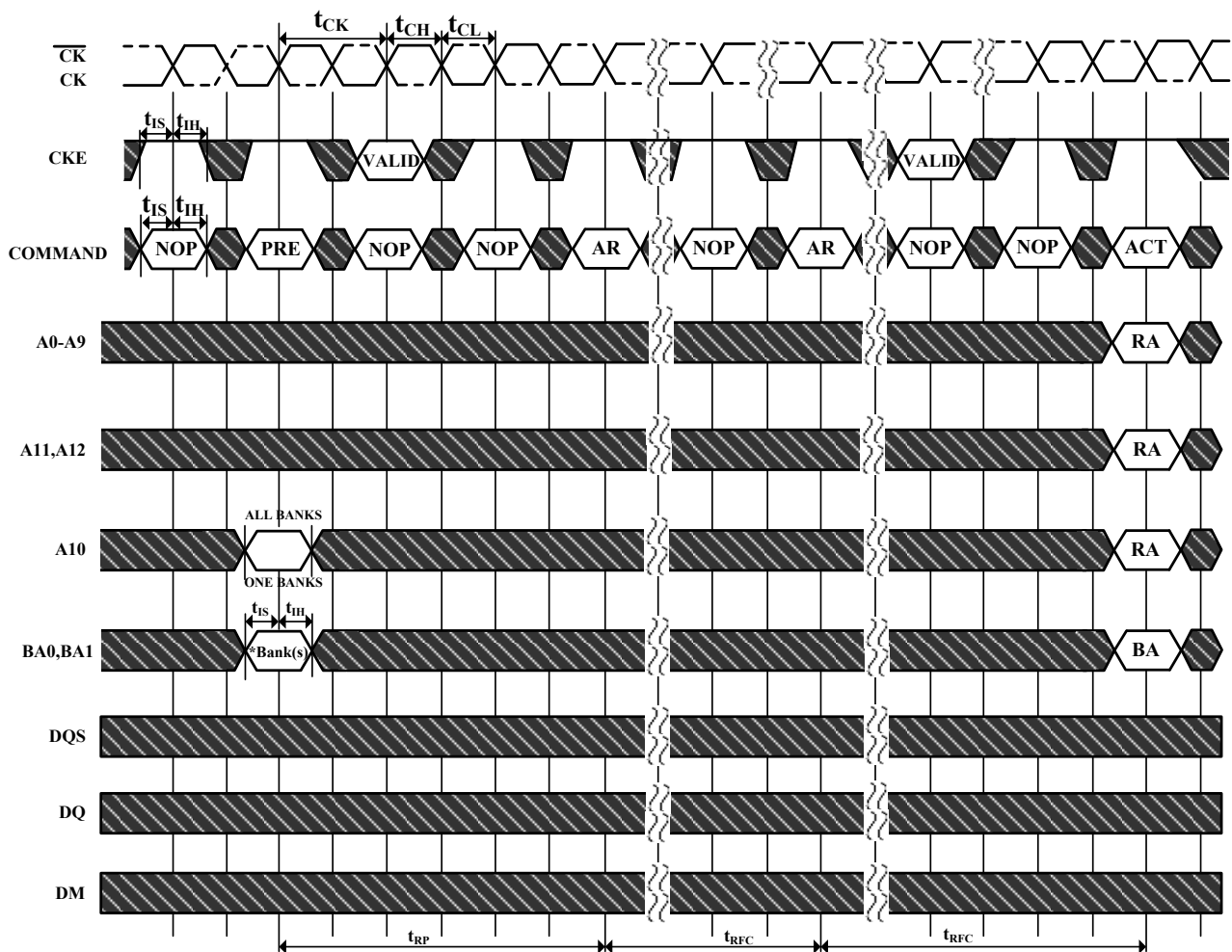
**Figure 33. Power Down Mode**


No column accesses are allowed to be in progress at the time Power-Down is entered

\*=If this command is a PRECHARGE ALL (or if the device is already in the idle state) then the Power-Down mode shown is Precharge Power Down. If this command is an ACTIVE (or if at least one row is already active) then the Power-Down mode shown is active Power Down.

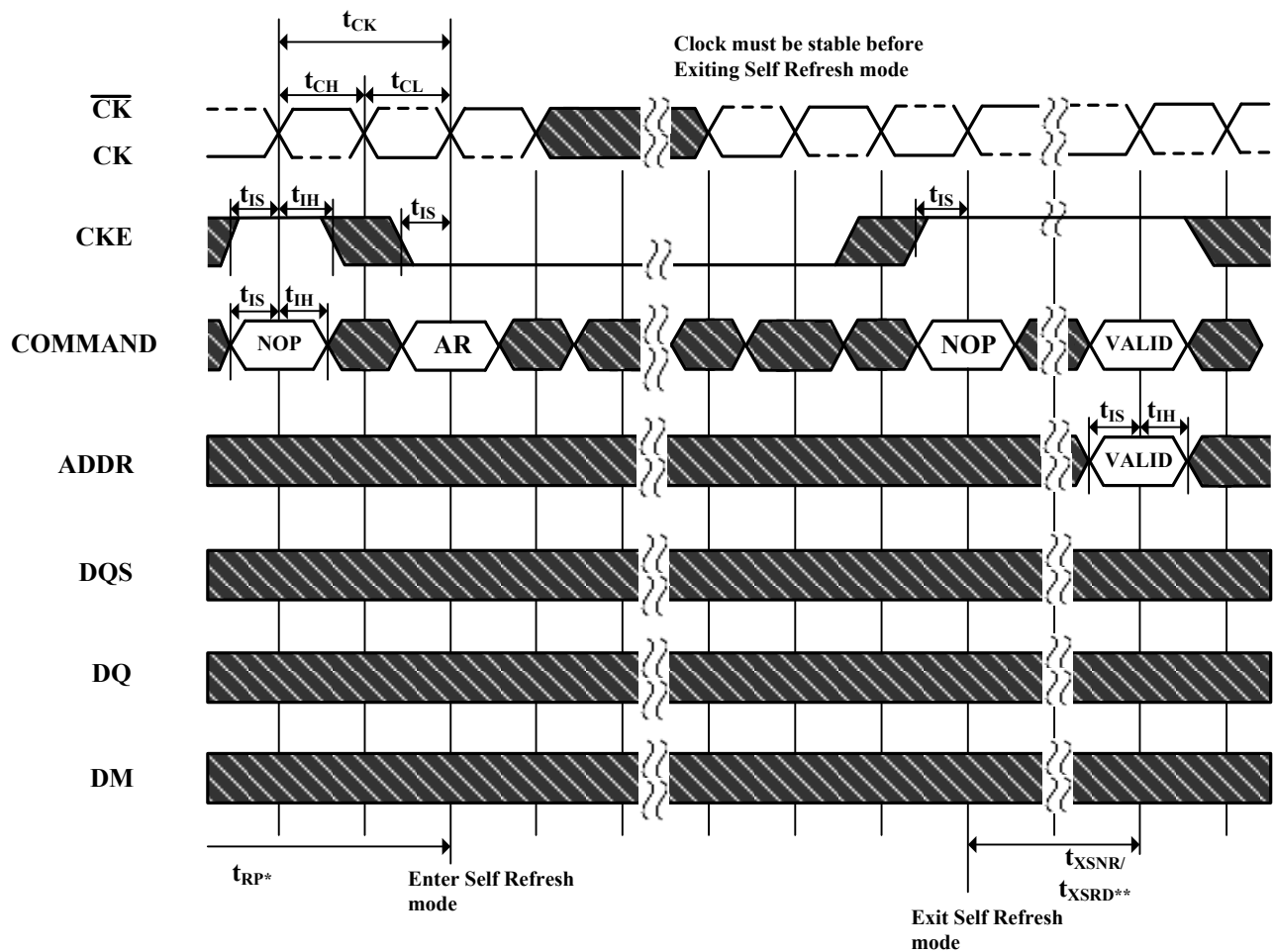
 Don't Care

**Figure 34. Auto Refresh Mode**



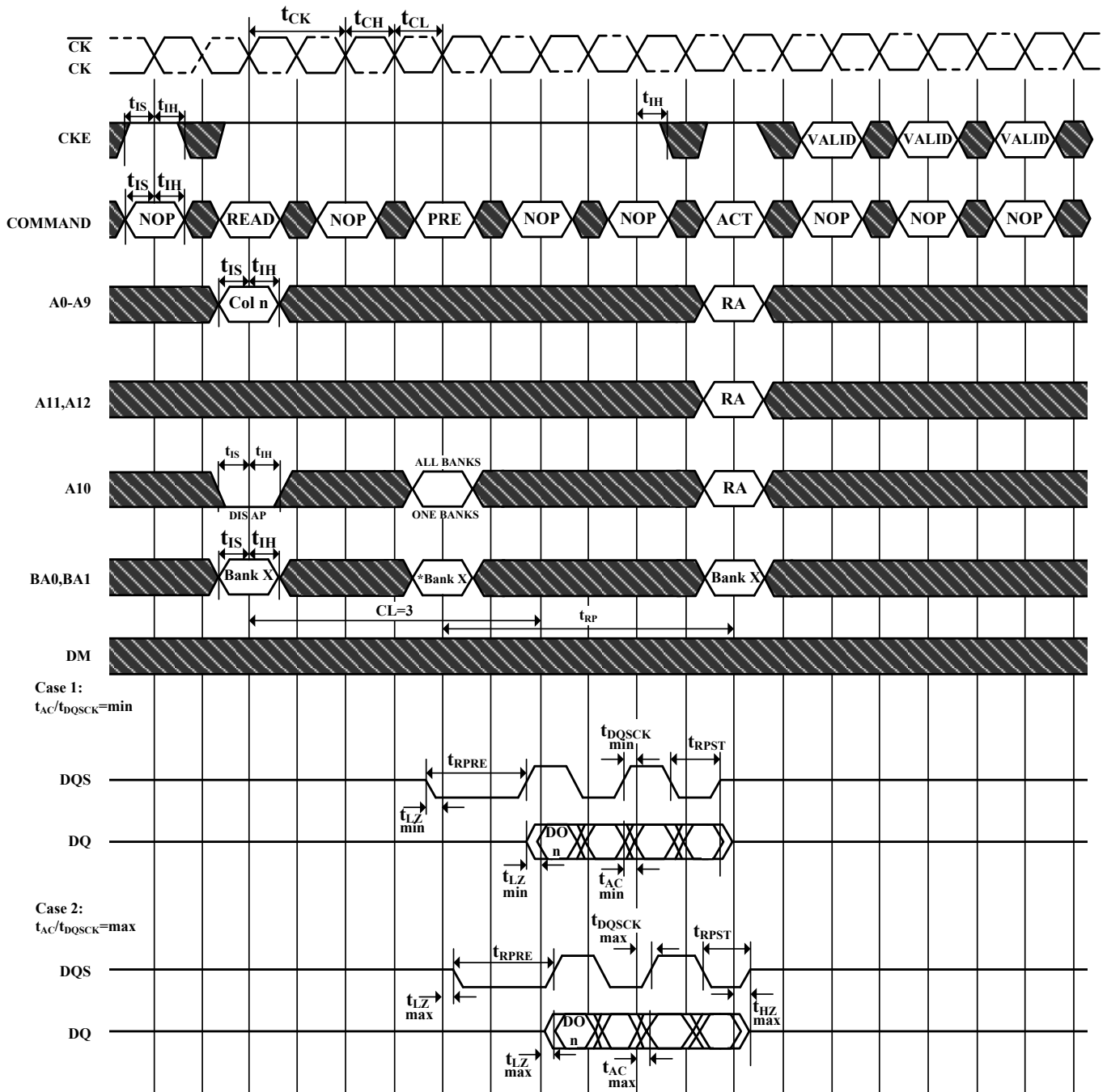
\* = "Don't Care", if A10 is HIGH at this point; A10 must be HIGH if more than one bank is active (i.e., must precharge all active banks)  
 PRE = PRECHARGE, ACT = ACTIVE, RA = Row Address, BA = Bank Address, AR = AUTOREFRESH  
 NOP commands are shown for ease of illustration; other valid commands may be possible after  $t_{RFC}$   
 DM, DQ and DQS signals are all "Don't Care" /High-Z for operations shown

 Don't Care

**Figure 35. Self Refresh Mode**


\* = Device must be in the "All banks idle" state prior to entering Self Refresh mode

\*\* =  $t_{XSNR}$  is required before any non-READ command can be applied, and  $t_{XSRD}$  (200 cycles of CK) is required before a READ command can be applied.

**Figure 36. Read without Auto Precharge**


DO n = Data Out from column n

Burst Length = 4 in the case shown

3 subsequent elements of Data Out are provided in the programmed order following DO n

DIS AP = Disable Autoprecharge

\* = "Don't Care" , if A10 is HIGH at this point

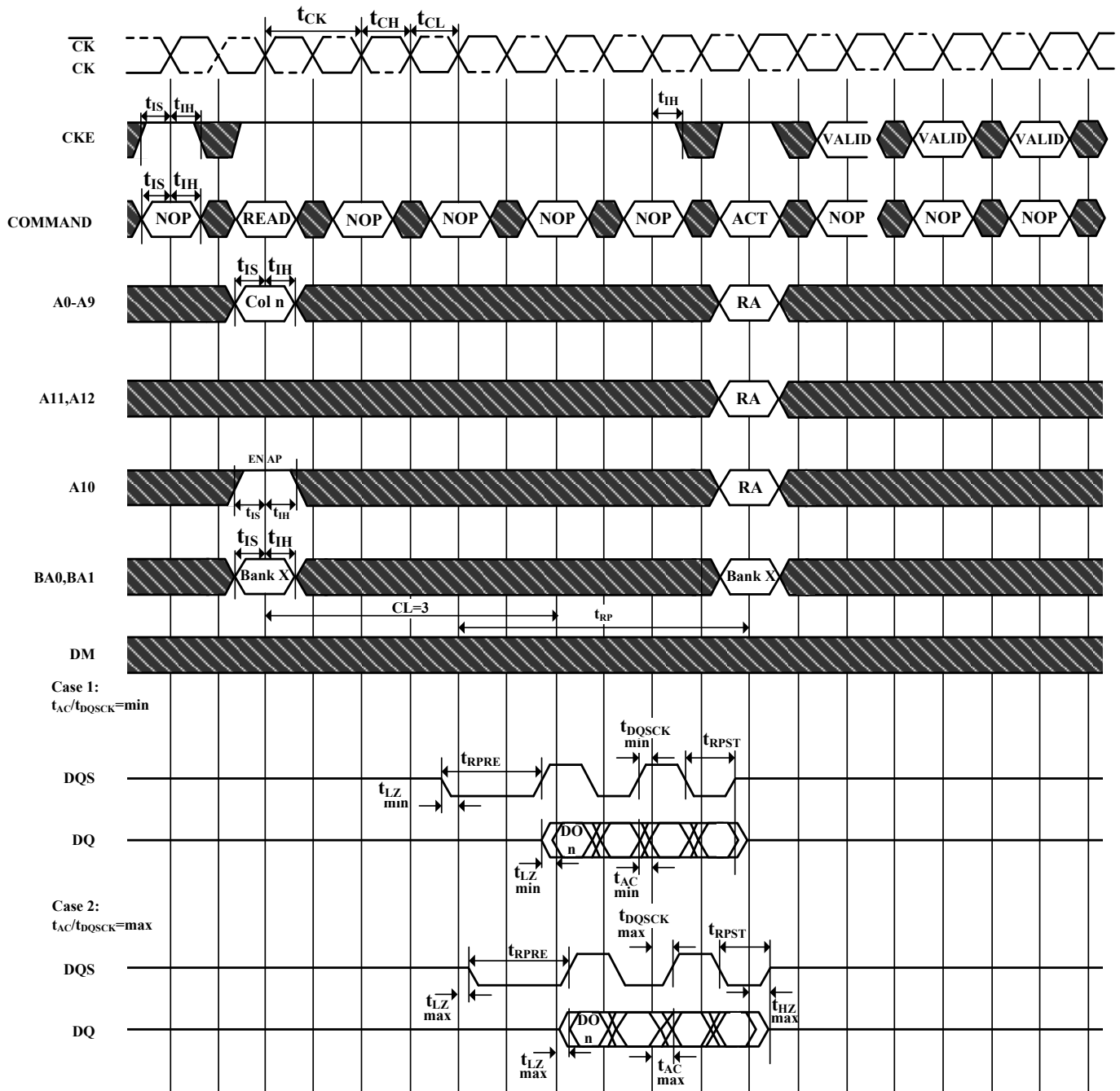
PRE = PRECHARGE, ACT = ACTIVE, RA = Row Address, BA = Bank Address, AR = AUTOREFRESH

NOP commands are shown for ease of illustration; other commands may be valid at these times

Precharge may not be issued before  $t_{RAS}$  ns after the ACTIVE command for applicable banks

 Don't Care

**Figure 37. Read with Auto Precharge**



DO n = Data Out from column n

Burst Length = 4 in the case shown

3 subsequent elements of Data Out are provided in the programmed order following DO n

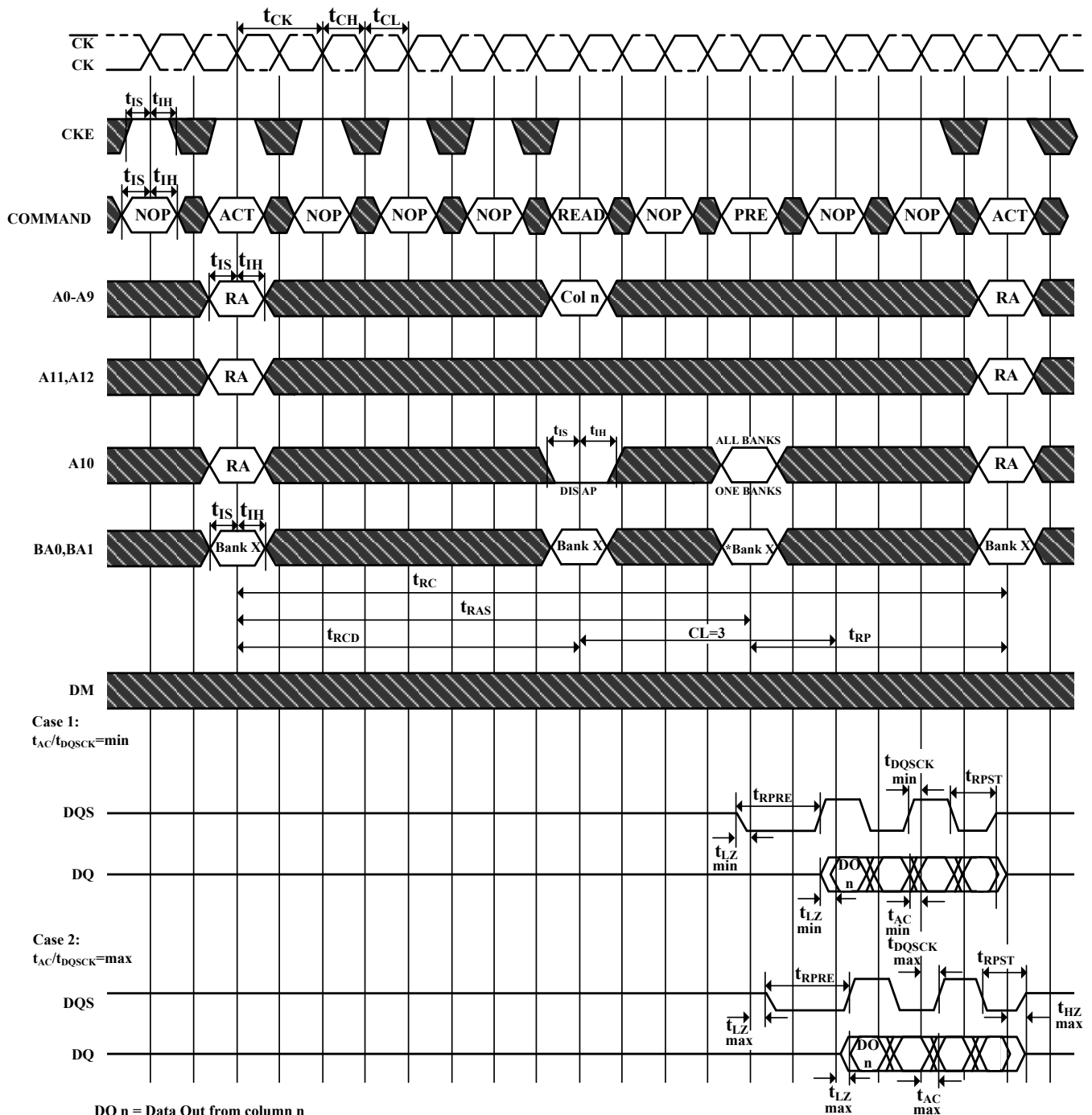
EN AP = Enable Autoprecharge

ACT = ACTIVE, RA = Row Address

NOP commands are shown for ease of illustration; other commands may be valid at these times

The READ command may not be issued until  $t_{RAP}$  has been satisfied. If Fast Autoprecharge is supported,  $t_{RAP} = t_{RCD}$ , else the READ may not be issued prior to  $t_{RASmin} - (BL * t_{CK}/2)$

 Don't Care

**Figure 38. Bank Read Access**


DO n = Data Out from column n

Burst Length = 4 in the case shown

3 subsequent elements of Data Out are provided in the programmed order following DO n

DIS AP = Disable Autoprecharge

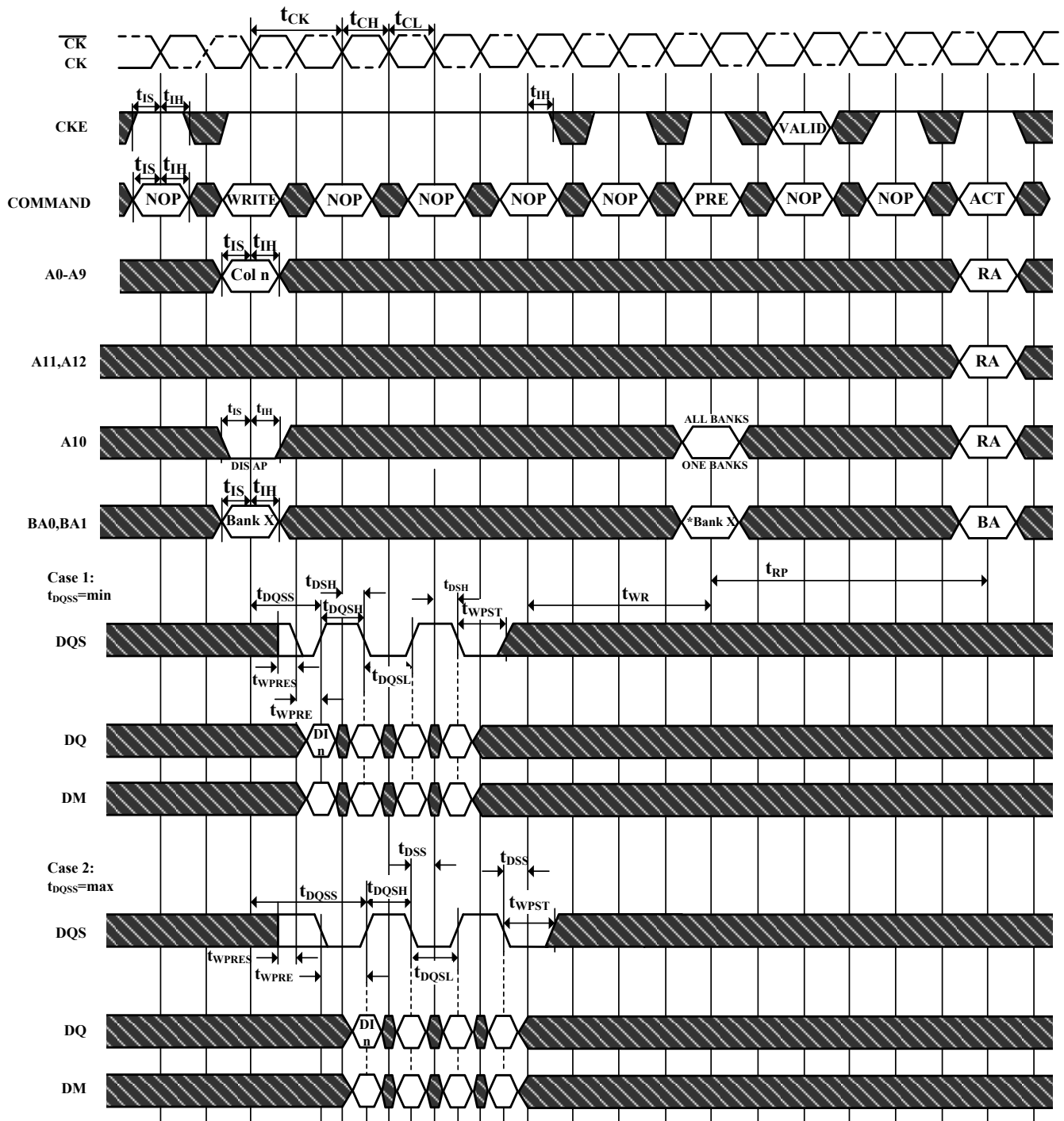
\* = " Don't Care" , if A10 is HIGH at this point

PRE = PRECHARGE, ACT = ACTIVE, RA = Row Address, BA = Bank Address

NOP commands are shown for ease of illustration; other commands may be valid at these times

Note that  $t_{RCD} > t_{RCD\ MIN}$  so that the same timing applies if Autoprecharge is enabled (in which case  $t_{RAS}$  would be limiting)

 Don't Care

**Figure 39. Write without Auto Precharge**


DI n = Data In from column n

Burst Length = 4 in the case shown

3 subsequent elements of Data In are provided in the programmed order following DI n

DIS AP = Disable Autoprecharge

\*=" Don't Care" , if A10 is HIGH at this point

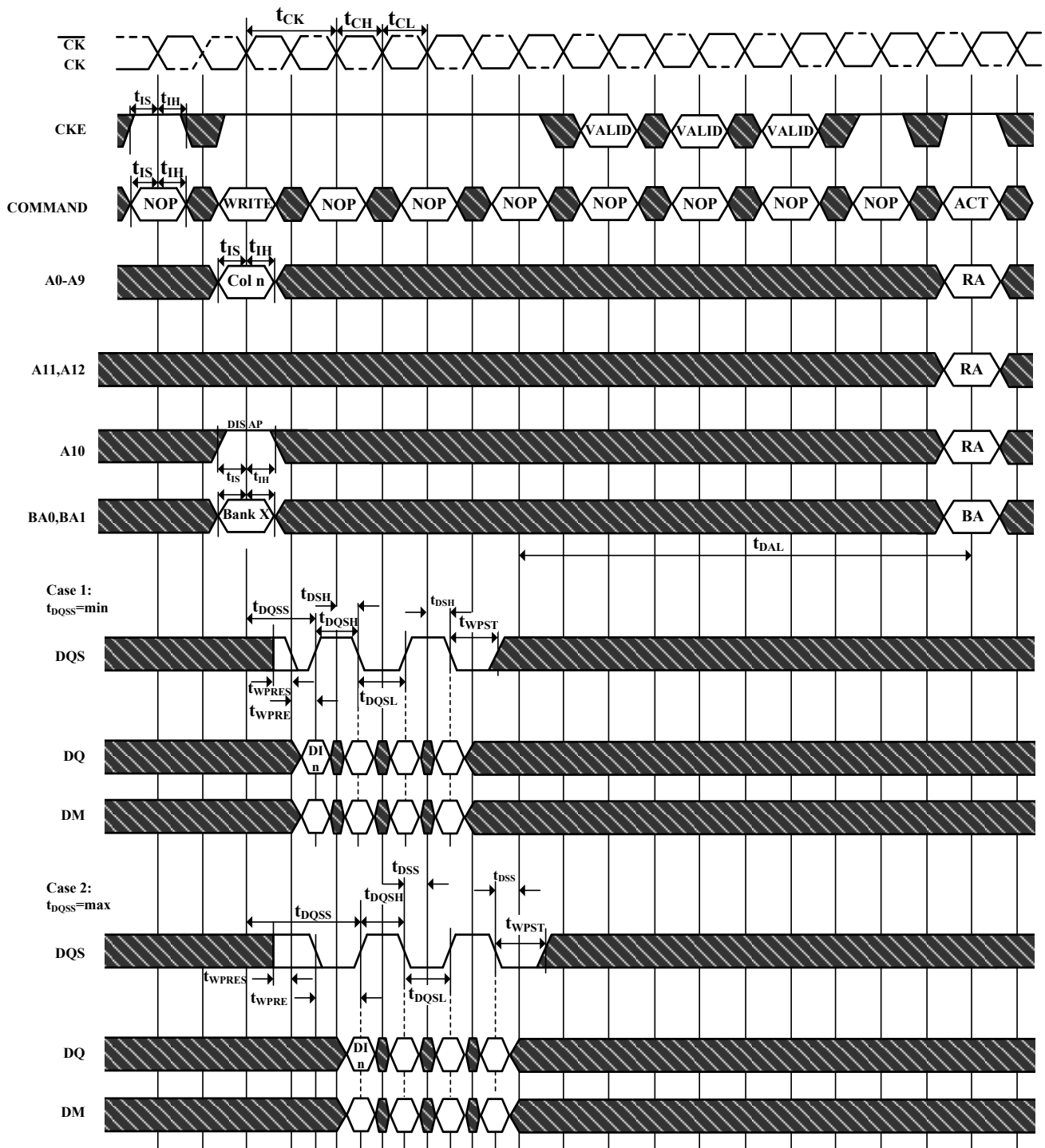
PRE = PRECHARGE, ACT = ACTIVE, RA = Row Address, BA = Bank Address, AR = AUTOREFRESH

NOP commands are shown for ease of illustration; other commands may be valid at these times

Although tDQSS is drawn only for the first DQS rising edge, each rising edge of DQS must fall within the  $\pm 25\%$  window of the corresponding positive clock edge

Precharge may not be issued before tRAS ns after the ACTIVE command for applicable banks

 Don't Care

**Figure 40. Write with Auto Precharge**


DI n = Data In from column n

Burst Length = 4 in the case shown

3 subsequent elements of Data Out are provided in the programmed order following DI n

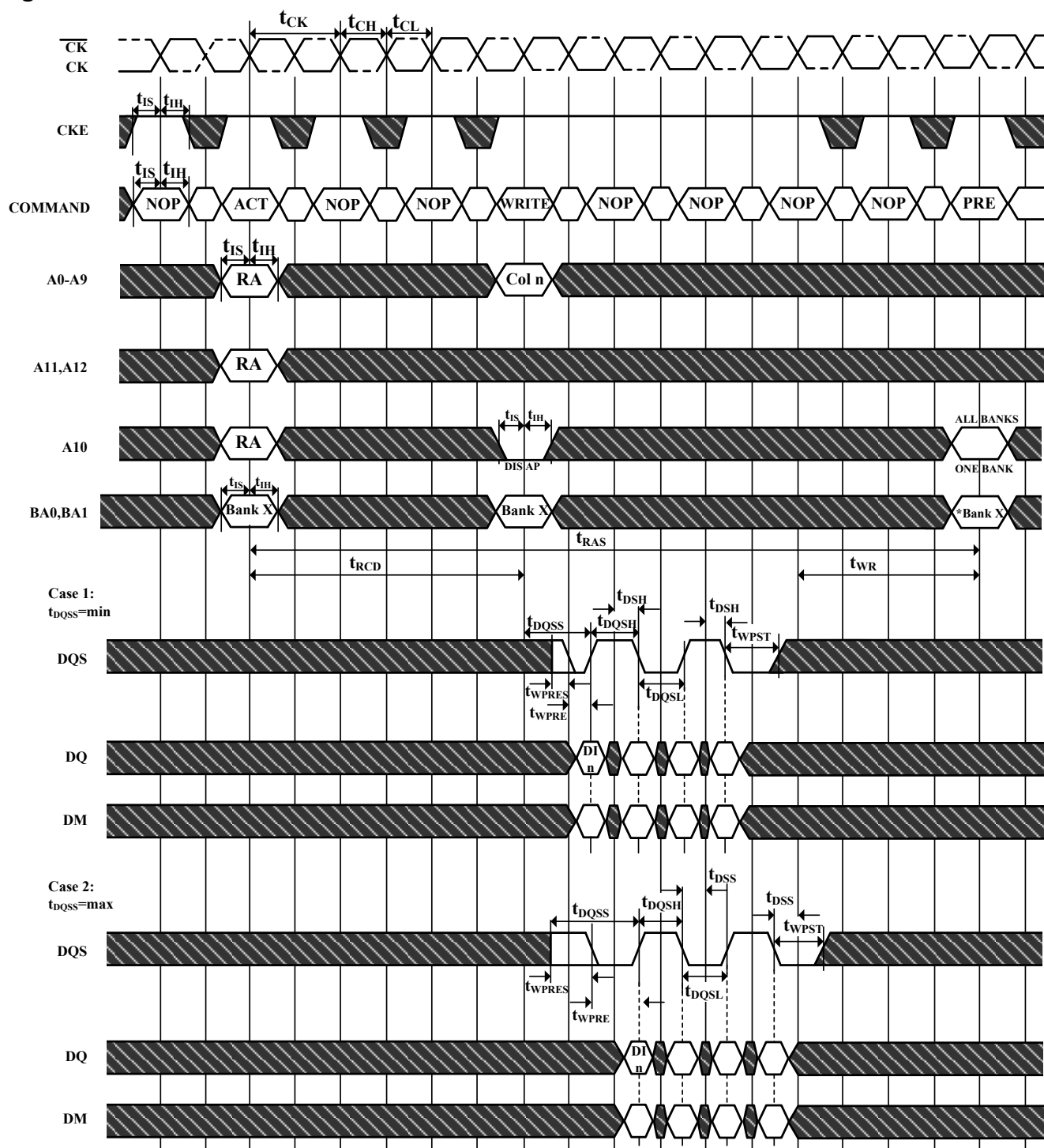
EN AP = Enable Autoprecharge

ACT = ACTIVE, RA = Row Address, BA = Bank Address

NOP commands are shown for ease of illustration; other commands may be valid at these times

Although  $t_{DQSS}$  is drawn only for the first DQS rising edge, each rising edge of DQS must fall within the  $\pm 25\%$  window of the corresponding positive clock edge

 Don't Care

**Figure 41. Bank Write Access**


DI n = Data In from column n

Burst Length = 4 in the case shown

3 subsequent elements of Data Out are provided in the programmed order following DI n

DIS AP = Disable Autoprecharge

\*=" Don't Care" , if A10 is HIGH at this point

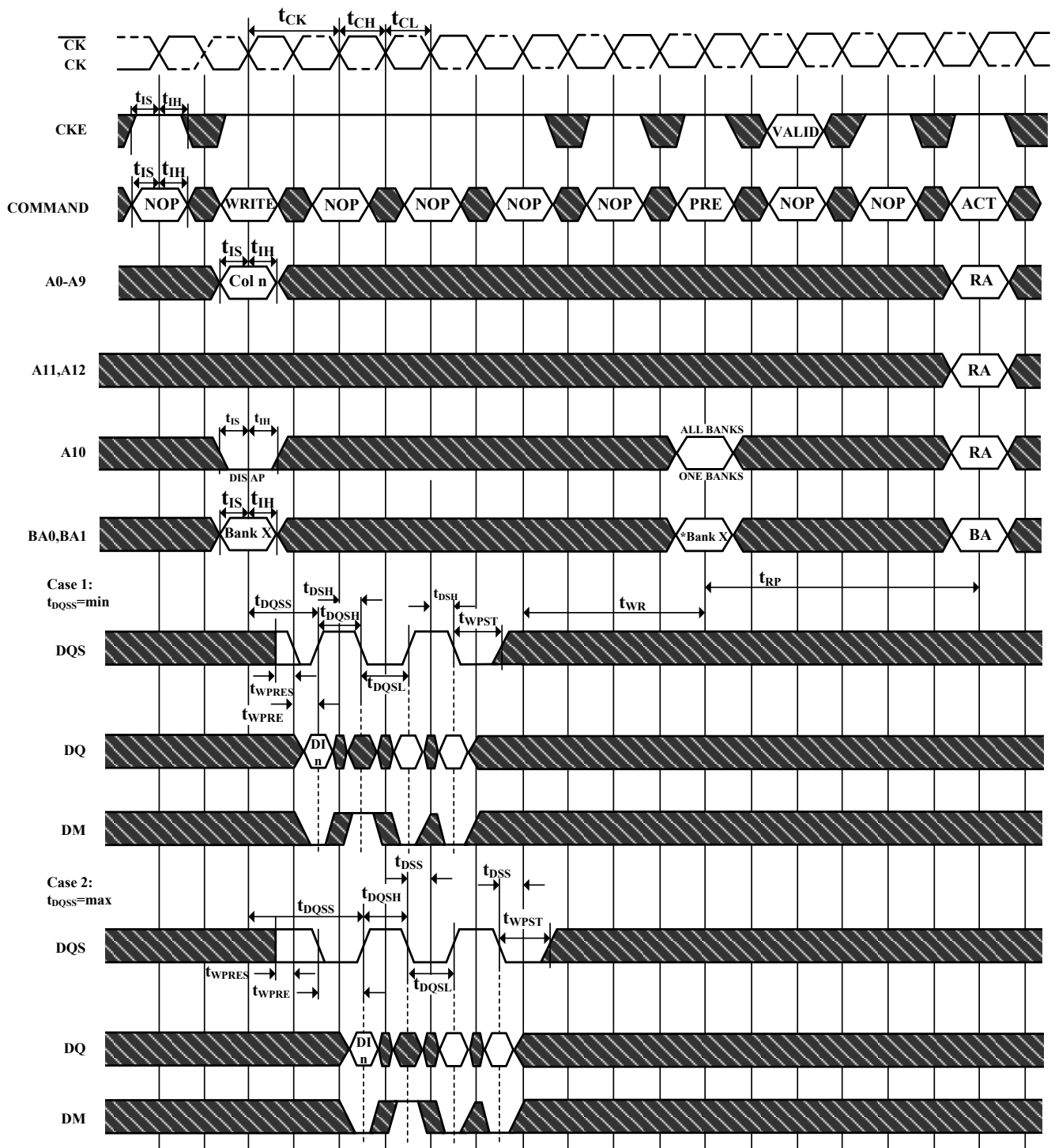
PRE = PRECHARGE, ACT = ACTIVE, RA = Row Address, BA = Bank Address

NOP commands are shown for ease of illustration; other commands may be valid at these times

Although  $t_{DQSS}$  is drawn only for the first DQS rising edge, each rising edge of DQS must fall within the  $\pm 25\%$  window of the corresponding positive clock edge

Precharge may not be issued before  $t_{RAS}$  ns after the ACTIVE command for applicable banks

 Don't Care

**Figure 42. Write DM Operation**


DI n = Data In from column n

Burst Length = 4 in the case shown

3 subsequent elements of Data In are provided in the programmed order following DI n

DIS AP = Disable Autoprecharge

\*=" Don't Care" , if A10 is HIGH at this point

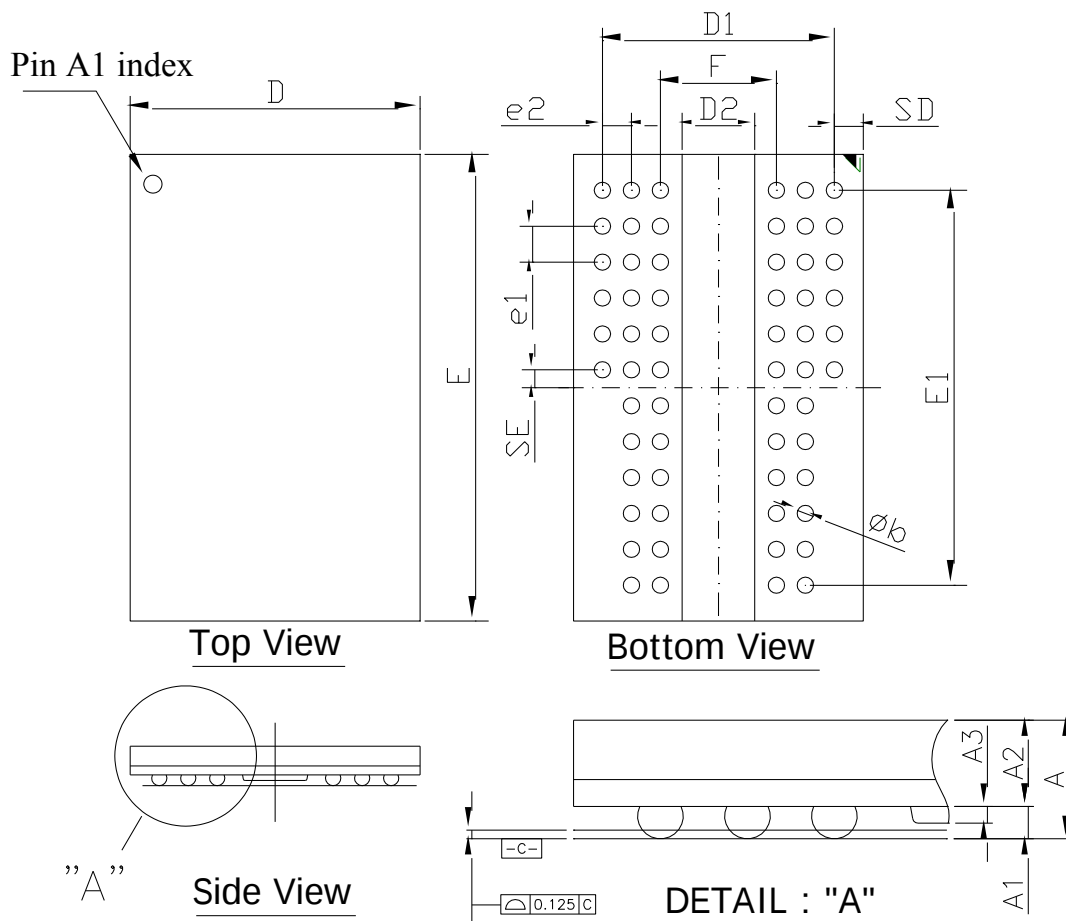
PRE = PRECHARGE, ACT = ACTIVE, RA = Row Address, BA = Bank Address

NOP commands are shown for ease of illustration; other commands may be valid at these times

Although  $t_{DQSS}$  is drawn only for the first DQS rising edge, each rising edge of DQS must fall within the  $\pm 25\%$  window of the corresponding positive clock edge

Precharge may not be issued before  $t_{RAS}$  ns after the ACTIVE command for applicable banks

 Don't Care

**Figure 43. BGA 60ball package Outline Drawing Information**


| Symbol | Dimension (inch) |       |       | Dimension (mm) |       |       |
|--------|------------------|-------|-------|----------------|-------|-------|
|        | Min              | Nom   | Max   | Min            | Nom   | Max   |
| A      | --               | --    | 0.047 | --             | --    | 1.20  |
| A1     | 0.012            | 0.014 | 0.016 | 0.30           | 0.35  | 0.40  |
| A2     | --               | --    | 0.031 | --             | --    | 0.8   |
| A3     | 0.005            | 0.007 | 0.009 | 0.13           | 0.18  | 0.23  |
| D      | 0.311            | 0.315 | 0.319 | 7.90           | 8.00  | 8.10  |
| E      | 0.508            | 0.512 | 0.516 | 12.90          | 13.00 | 13.10 |
| D1     | --               | 0.252 | --    | --             | 6.40  | --    |
| E1     | --               | 0.433 | --    | --             | 11.00 | --    |
| e1     | --               | 0.039 | --    | --             | 1.00  | --    |
| e2     | --               | 0.031 | --    | --             | 0.80  | --    |
| b      | 0.016            | 0.018 | 0.020 | 0.40           | 0.45  | 0.50  |
| F      | --               | 0.126 | --    | --             | 3.20  | --    |
| SD     | --               | 0.031 | --    | --             | 0.80  | --    |
| SE     | --               | 0.02  | --    | --             | 0.50  | --    |
| D2     | --               | --    | 0.081 | --             | --    | 2.05  |

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