

128Mbit DDR SDRAM

*1M x 32Bit x 4 Banks
Double Data Rate Synchronous RAM
with Bi-directional Data Strobe and DLL
(144-Ball FBGA)*

Revision 2.0
January 2003

Samsung Electronics reserves the right to change products or specification without notice.

Revision History

Revision 2.0 (January 16, 2003)

- Changed package ball height from 0.25mm to 0.35mm

Revision 1.9 (August 12, 2002)

- Changed tRC of K4D26323RA-GC2A from 20tCK to 15tCK
- Changed tRFC of K4D26323RA-GC2A from 22tCK to 17tCK
- Changed tRAS of K4D26323RA-GC2A from 14tCK to 10tCK
- Changed tRCDRD of K4D26323RA-GC2A from 7tCK to 5tCK
- Changed tRCDWR of K4D26323RA-GC2A from 5tCK to 3tCK
- Changed tRP of K4D26323RA-GC2A from 6tCK to 5tCK
- Changed tDAL of K4D26323RA-GC2A from 9tCK to 8tCK
- Changed tRC of K4D26323RA-GC33 from 17tCK to 13tCK
- Changed tRFC of K4D26323RA-GC33 from 19tCK to 15tCK
- Changed tRAS of K4D26323RA-GC33 from 12tCK to 9tCK
- Changed tRCDRD of K4D26323RA-GC33 from 6tCK to 4tCK
- Changed tRCDWR of K4D26323RA-GC33 from 4tCK to 2tCK
- Changed tRP of K4D26323RA-GC33 from 5tCK to 4tCK
- Changed tWR of K4D26323RA-GC33 from 3tCK to 2tCK
- Changed tDAL of K4D26323RA-GC33 from 8tCK to 7tCK

Revision 1.8 (July 18, 2002)

- Changed power dissipation from 2.0W to 3.3W

Revision 1.7 (May 7, 2002)

- Typo corrected

Revision 1.6 (January 29, 2002)

- Changed CL of K4D26323RA-GC33/36 from 5tCK to 4tCK
- Changed tCK(max) of K4D26323RA-GC2A from 5ns to 4ns. **For all the CL5 operation, guaranteed tCK(max) is 4ns.**

Revision 1.5 (December 10, 2001)

- Removed K4D263238A-GC33/40/45/50/55/60(VDD/VDDQ=2.5V) from the spec

Revision 1.4 (November 14, 2001)

- Added K4D26323RA-GC36(VDD/VDDQ=2.8V)

Revision 1.3 (October 22, 2001)

- Corrected part number of K4D263238A-GC2A to K4D26323RA-GC2A
- Changed tCDLR of -GC2A and GC33 from 3tCK to 2tCK and applied since Sept 15, 2001.
- Defined x32 DDR for mobile PC graphics separately - K4D26323AA-GL** featured with VDDQ=1.8V, ICC6=1mA with reduced operating current. Refer to the K4D26323AA-GL** spec for more detail information.

Revision 1.2 (September 13, 2001)

- Define DC spec value of K4D26323RA-GC33 and K4D263238A-GC2A
- Changed tCK(max) of -2A and -33 from 7ns to 5ns

Revision 1.1 (September 3, 2001)

- Added K4D26323RA-GC33(VDD/VDDQ=2.8V)
- Added K4D263238A-GC2A(350MHz)

Revision 1.0 (August 16, 2001)

- Changed tCDLR of K4D263238A-GC33 from 2tCK to 3tCK
- Removed VDDQ=1.8V from the spec.
- Added K4D263238A-GL as a low power part
- Defined DC spec.

Revision 0.1 (August 2, 2001) - Target Spec

- Changed tCK(max) of K4D263238A-GC45/-50/-55/-60 from 7ns to 10ns.

Revision 0.0 (June, 2001) - Target Spec

- Defined Target Specification

* **VDD / VDDQ=2.8V** *

K4D26323RA-GC

128M DDR SDRAM

**1M x 32Bit x 4 Banks Double Data Rate Synchronous RAM
with Bi-directional Data Strobe and DLL**

FEATURES

- 2.8V \pm 5% power supply for device operation
- 2.8V \pm 5% power supply for I/O interface
- SSTL_2 compatible inputs/outputs
- 4 banks operation
- MRS cycle with address key programs
 - Read latency 3,4 (clock)
 - Burst length (2, 4, 8 and Full page)
 - Burst type (sequential & interleave)
- Full page burst length for sequential burst type only
- Start address of the full page burst should be even
- All inputs except data & DM are sampled at the positive going edge of the system clock
- Differential clock input
- No Write-Interrupted by Read Function
- 4 DQS's (1DQS / Byte)
- Data I/O transactions on both edges of Data strobe
- DLL aligns DQ and DQS transitions with Clock transition
- Edge aligned data & data strobe output
- Center aligned data & data strobe input
- DM for write masking only
- Auto & Self refresh
- 32ms refresh period (4K cycle)
- 144-Ball FBGA
- Maximum clock frequency up to 350MHz
- Maximum data rate up to 700Mbps/pin

ORDERING INFORMATION

| Part NO. | Max Freq. | Max Data Rate | Interface | Package |
|-----------------|-----------|---------------|---------------------------|---------------|
| K4D26323RA-GC2A | 350MHz | 700Mbps/pin | SSTL_2 (VDD/VDDQ=2.8V) | 144-Ball FBGA |
| K4D26323RA-GC33 | 300MHz | 600Mbps/pin | | |
| K4D26323RA-GC36 | 275MHz | 550Mbps/pin | | |

GENERAL DESCRIPTION

FOR 1M x 32Bit x 4 Bank DDR SDRAM

The K4D26323RA is 134,217,728 bits of hyper synchronous data rate Dynamic RAM organized as 4 x1,048,576 words by 32 bits, fabricated with SAMSUNG's high performance CMOS technology. Synchronous features with Data Strobe allow extremely high performance up to 2.8GB/s/chip. I/O transactions are possible on both edges of the clock cycle. Range of operating frequencies, programmable burst length and programmable latencies allow the device to be useful for a variety of high performance memory system applications.

* VDD / VDDQ=2.8V *

K4D26323RA-GC

128M DDR SDRAM

PIN CONFIGURATION (Top View)

| | | | | | | | | | | | | |
|----------|-------------------------|------------------------|----------|----------|-------------|-------------|-------------|------------------|------------------|-----------|------------------------|-----------|
| | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
| B | DQS0 | DM0 | VSSQ | DQ3 | DQ2 | DQ0 | DQ31 | DQ29 | DQ28 | VSSQ | DM3 | DQS3 |
| C | DQ4 | VDDQ | NC | VDDQ | DQ1 | VDDQ | VDDQ | DQ30 | VDDQ | NC | VDDQ | DQ27 |
| D | DQ6 | DQ5 | VSSQ | VSSQ | VSSQ | VDD | VDD | VSSQ | VSSQ | VSSQ | DQ26 | DQ25 |
| E | DQ7 | VDDQ | VDD | VSS | VSSQ | VSS | VSS | VSSQ | VSS | VDD | VDDQ | DQ24 |
| F | DQ17 | DQ16 | VDDQ | VSSQ | VSS Thermal | VSS Thermal | VSS Thermal | VSS Thermal | VSSQ | VDDQ | DQ15 | DQ14 |
| G | DQ19 | DQ18 | VDDQ | VSSQ | VSS Thermal | VSS Thermal | VSS Thermal | VSS Thermal | VSSQ | VDDQ | DQ13 | DQ12 |
| H | DQS2 | DM2 | NC | VSSQ | VSS Thermal | VSS Thermal | VSS Thermal | VSS Thermal | VSSQ | NC | DM1 | DQS1 |
| J | DQ21 | DQ20 | VDDQ | VSSQ | VSS Thermal | VSS Thermal | VSS Thermal | VSS Thermal | VSSQ | VDDQ | DQ11 | DQ10 |
| K | DQ22 | DQ23 | VDDQ | VSSQ | VSS | VSS | VSS | VSS | VSSQ | VDDQ | DQ9 | DQ8 |
| L | $\overline{\text{CAS}}$ | $\overline{\text{WE}}$ | VDD | VSS | A10 | VDD | VDD | RFU ₁ | VSS | VDD | NC | NC |
| M | $\overline{\text{RAS}}$ | NC | NC | BA1 | A2 | A11 | A9 | A5 | RFU ₂ | CK | $\overline{\text{CK}}$ | MCL |
| N | $\overline{\text{CS}}$ | NC | BA0 | A0 | A1 | A3 | A4 | A6 | A7 | A8/AP | CKE | VREF |

NOTE:

1. RFU1 is reserved for A12
2. RFU2 is reserved for BA2
3. VSS Thermal balls are optional

PIN DESCRIPTION

| | | | |
|----------------------------|--------------------------|------------|---------------------|
| CK, $\overline{\text{CK}}$ | Differential Clock Input | BA0, BA1 | Bank Select Address |
| CKE | Clock Enable | A0 ~A11 | Address Input |
| $\overline{\text{CS}}$ | Chip Select | DQ0 ~ DQ31 | Data Input/Output |
| $\overline{\text{RAS}}$ | Row Address Strobe | VDD | Power |
| $\overline{\text{CAS}}$ | Column Address Strobe | VSS | Ground |
| WE | Write Enable | VDDQ | Power for DQ's |
| DQS | Data Strobe | VSSQ | Ground for DQ's |
| DM | Data Mask | NC | No Connection |
| RFU | Reserved for Future Use | MCL | Must Connect Low |

INPUT/OUTPUT FUNCTIONAL DESCRIPTION

| Symbol | Type | Function |
|------------------------|---|---|
| CK, \overline{CK}^*1 | Input | The differential system clock Input. All of the inputs are sampled on the rising edge of the clock except DQ's and DM's that are sampled on both edges of the DQS. |
| CKE | Input | Activates the CK signal when high and deactivates the \overline{CK} signal when low. By deactivating the clock, CKE low indicates the Power down mode or Self refresh mode. |
| \overline{CS} | Input | \overline{CS} enables the command decoder when low and disabled the command decoder when high. When the command decoder is disabled, new commands are ignored but previous operations continue. |
| \overline{RAS} | Input | Latches row addresses on the positive going edge of the CK with \overline{RAS} low. Enables row access & precharge. |
| \overline{CAS} | Input | Latches column addresses on the positive going edge of the CK with \overline{CAS} low. Enables column access. |
| \overline{WE} | Input | Enables write operation and row precharge. Latches data in starting from \overline{CAS} , \overline{WE} active. |
| DQS0 ~ DQS3 | Input/Output | Data input and output are synchronized with both edge of DQS. DQS0 for DQ0 ~ DQ7, DQS1 for DQ8 ~ DQ15, DQS2 for DQ16 ~ DQ23, DQS3 for DQ24 ~ DQ31. |
| DM0 ~ DM3 | Input | Data In mask. Data In is masked by DM Latency=0 when DM is high in burst write. DM0 for DQ0 ~ DQ7, DM1 for DQ8 ~ DQ15, DM2 for DQ16 ~ DQ23, DM3 for DQ24 ~ DQ31. |
| DQ0 ~ DQ31 | Input/Output | Data inputs/Outputs are multiplexed on the same pins. |
| BA0, BA1 | Input | Selects which bank is to be active. |
| A0 ~ A11 | Input | Row/Column addresses are multiplexed on the same pins. Row addresses : RA0 ~ RA11, Column addresses : CA0 ~ CA7. Column address CA8 is used for auto precharge. |
| VDD/VSS | Power Supply | Power and ground for the input buffers and core logic. |
| VDDQ/VSSQ | Power Supply | Isolated power supply and ground for the output buffers to provide improved noise immunity. |
| VREF | Power Supply | Reference voltage for inputs, used for SSTL interface. |
| NC/RFU | No connection/ Reserved for future use | This pin is recommended to be left "No connection" on the device |
| MCL | Must Connect Low | Must connect low |

*1 : The timing reference point for the differential clocking is the cross point of CK and \overline{CK} .

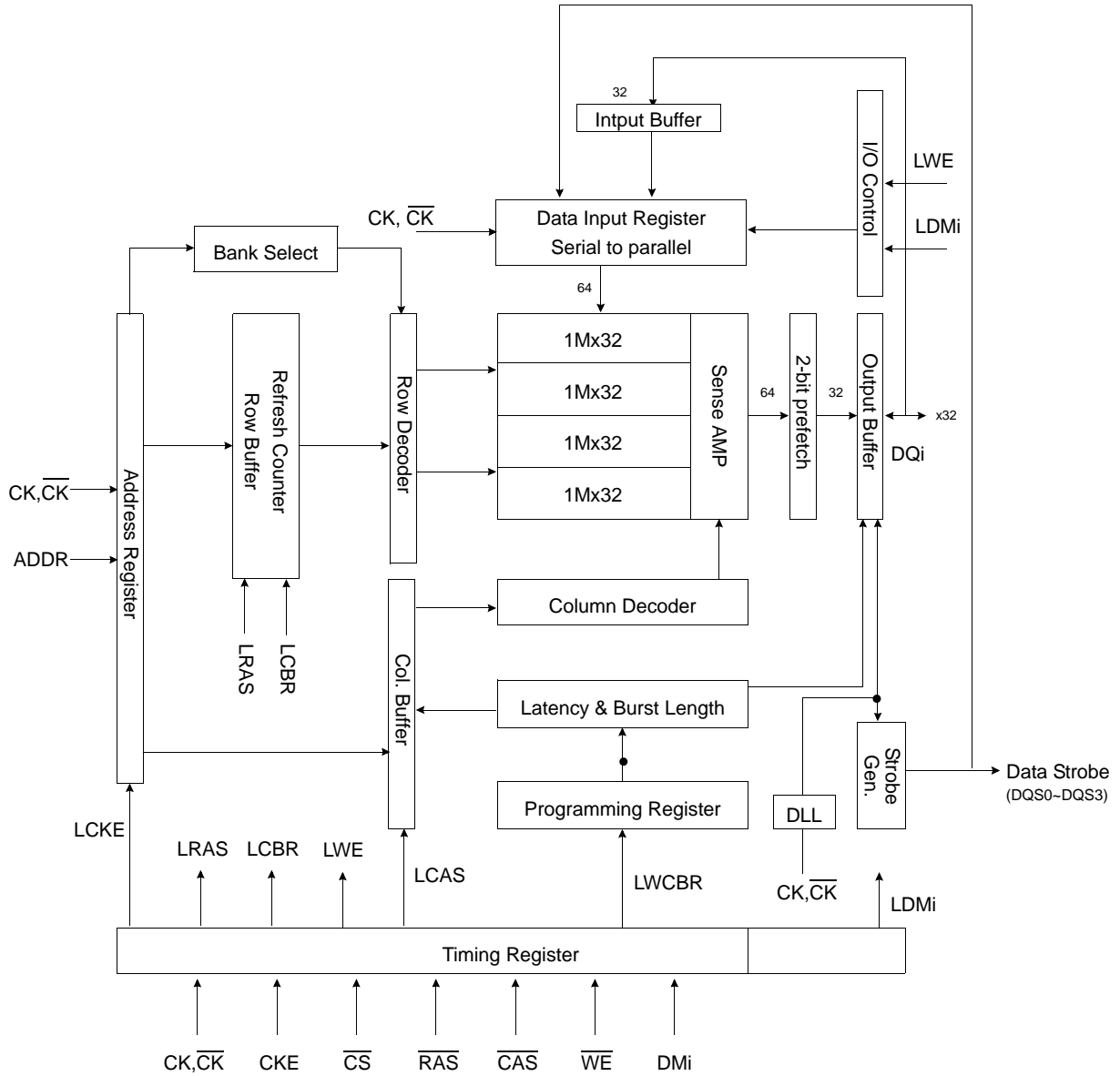
For any applications using the single ended clocking, apply VREF to \overline{CK} pin.

* VDD / VDDQ=2.8V *

K4D26323RA-GC

128M DDR SDRAM

BLOCK DIAGRAM (1Mbit x 32I/O x 4 Bank)



FUNCTIONAL DESCRIPTION

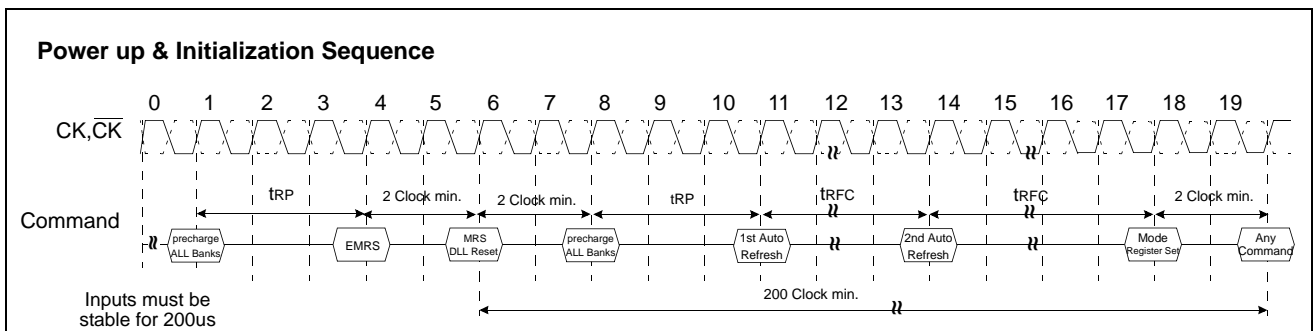
• Power-Up Sequence

DDR SDRAMs must be powered up and initialized in a predefined manner to prevent undefined operations.

1. Apply power and keep CKE at low state (All other inputs may be undefined)
 - Apply VDD before VDDQ .
 - Apply VDDQ before VREF & VTT
2. Start clock and maintain stable condition for minimum 200us.
3. The minimum of 200us after stable power and clock(CK,CK $\bar{}$), apply NOP and take CKE to be high .
4. Issue precharge command for all banks of the device.
5. Issue a EMRS command to enable DLL
- *1 6. Issue a MRS command to reset DLL. The additional 200 clock cycles are required to lock the DLL.
- *1,2 7. Issue precharge command for all banks of the device.
8. Issue at least 2 or more auto-refresh commands.
9. Issue a mode register set command with A8 to low to initialize the mode register.

*1 The additional 200cycles of clock input is required to lock the DLL after enabling DLL.

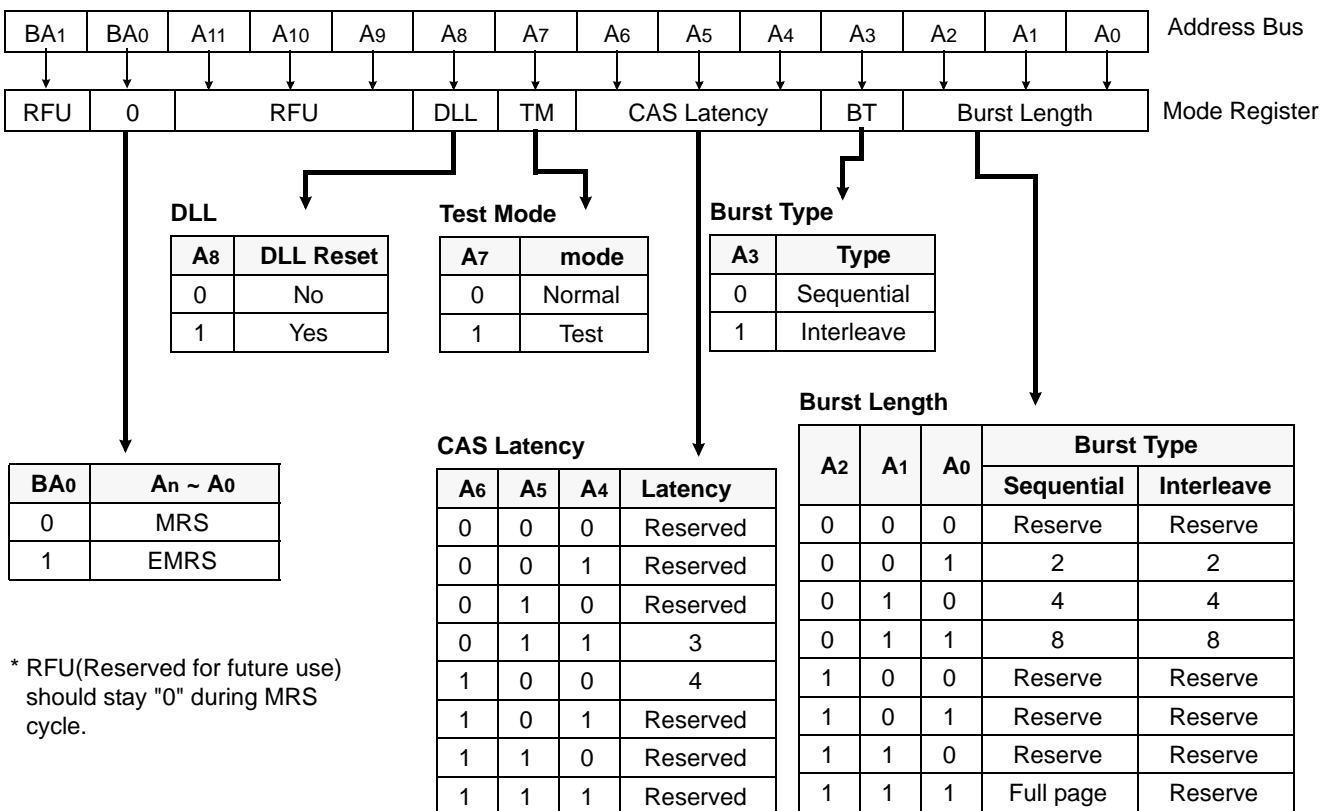
*2 Sequence of 6&7 is regardless of the order.



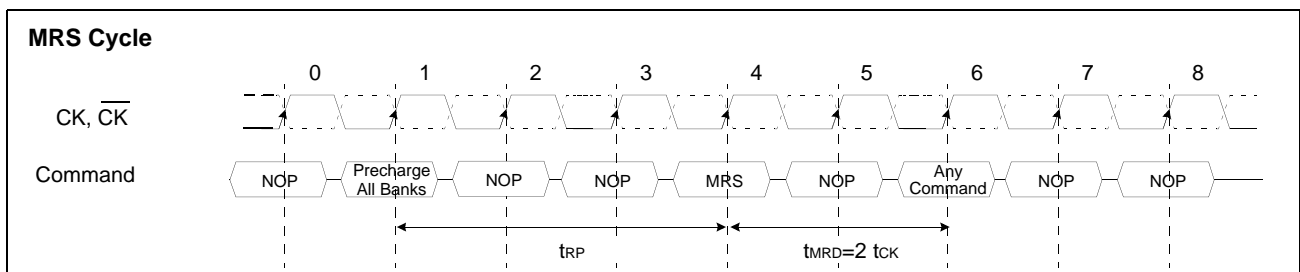
* When the operating frequency is changed, DLL reset should be required again.
 After DLL reset again, the minimum 200 cycles of clock input is needed to lock the DLL.

MODE REGISTER SET(MRS)

The mode register stores the data for controlling the various operating modes of DDR SDRAM. It programs CAS latency, addressing mode, burst length, test mode, DLL reset and various vendor specific options to make DDR SDRAM useful for variety of different applications. The default value of the mode register is not defined, therefore the mode register must be written after EMRS setting for proper operation. The mode register is written by asserting low on CS, RAS, CAS and WE (The DDR SDRAM should be in active mode with CKE already high prior to writing into the mode register). The state of address pins A0 ~ A11 and BA0, BA1 in the same cycle as CS, RAS, CAS and WE going low is written in the mode register. Minimum two clock cycles are requested to complete the write operation in the 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. The mode register is divided into various fields depending on functionality. The burst length uses A0 ~ A2, addressing mode uses A3, CAS latency(read latency from column address) uses A4 ~ A6. A7 is used for test mode. A8 is used for DLL reset. A7,A8, BA0 and BA1 must be set to low for normal MRS operation. Refer to the table for specific codes for various burst length, addressing modes and CAS latencies.



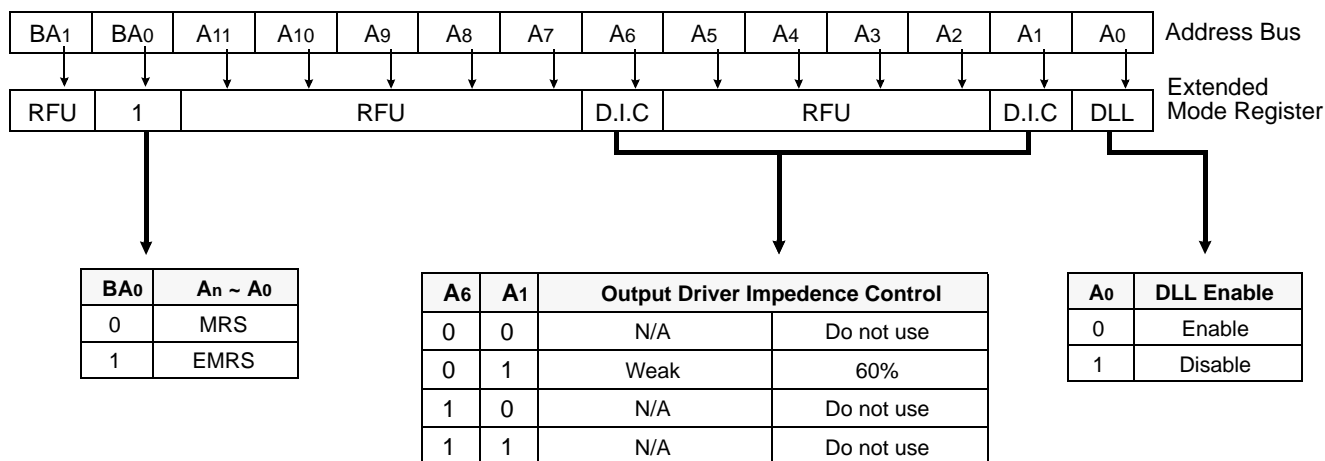
* RFU(Reserved for future use) should stay "0" during MRS cycle.



*1 : MRS can be issued only at all banks precharge state.
 *2 : Minimum trp is required to issue MRS command.

EXTENDED MODE REGISTER SET(EMRS)

The extended mode register 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 the extended mode register must be written after power up for enabling or disabling DLL. The extended mode register is written by asserting low on CS, RAS, CAS, WE and high on BA0(The DDR SDRAM should be in all bank precharge with CKE already high prior to writing into the extended mode register). The state of address pins A0, A2 ~ A5, A7 ~ A11 and BA1 in the same cycle as CS, RAS, CAS and WE going low are written in the extended mode register. A1 and A6 are used for setting driver strength to normal, weak or matched impedance. 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. All the other address pins except A0,A1,A6 and BA0 must be set to low for proper EMRS operation. Refer to the table for specific codes.



*1 : RFU(Reserved for future use) should stay "0" during EMRS cycle.

Figure 7. Extended Mode Register set

* $V_{DD} / V_{DDQ}=2.8V$ *

K4D26323RA-GC

128M DDR SDRAM

ABSOLUTE MAXIMUM RATINGS

| Parameter | Symbol | Value | Unit |
|--|------------------------------------|------------|------|
| Voltage on any pin relative to Vss | V _{IN} , V _{OUT} | -0.5 ~ 3.6 | V |
| Voltage on V _{DD} supply relative to Vss | V _{DD} | -1.0 ~ 3.6 | V |
| Voltage on V _{DDQ} supply relative to Vss | V _{DDQ} | -0.5 ~ 3.6 | V |
| Storage temperature | T _{STG} | -55 ~ +150 | °C |
| Power dissipation | P _D | 3.3 | W |
| Short circuit current | I _{OS} | 50 | mA |

Note : Permanent device damage may occur if ABSOLUTE MAXIMUM RATINGS are exceeded.
Functional operation should be restricted to recommended operating condition.
Exposure to higher than recommended voltage for extended periods of time could affect device reliability.

POWER & DC OPERATING CONDITIONS(SSTL_2 In/Out)

Recommended operating conditions(Voltage referenced to V_{SS}=0V, T_A=0 to 65°C)

| Parameter | Symbol | Min | Typ | Max | Unit | Note |
|---------------------------|---------------------|------------------------|------------------|------------------------|------|--------------------------|
| Device Supply voltage | V _{DD} | 2.66 | 2.8 | 2.94 | V | 1,7 |
| Output Supply voltage | V _{DDQ} | 2.66 | 2.8 | 2.94 | V | 1,7 |
| Reference voltage | V _{REF} | 0.49*V _{DDQ} | - | 0.51*V _{DDQ} | V | 2 |
| Termination voltage | V _{tt} | V _{REF} -0.04 | V _{REF} | V _{REF} +0.04 | V | 3 |
| Input logic high voltage | V _{IH(DC)} | V _{REF} +0.15 | - | V _{DDQ} +0.30 | V | 4 |
| Input logic low voltage | V _{IL(DC)} | -0.30 | - | V _{REF} -0.15 | V | 5 |
| Output logic high voltage | V _{OH} | V _{tt} +0.76 | - | - | V | I _{OH} =-15.2mA |
| Output logic low voltage | V _{OL} | - | - | V _{tt} -0.76 | V | I _{OL} =+15.2mA |
| Input leakage current | I _{IL} | -5 | - | 5 | uA | 6 |
| Output leakage current | I _{OL} | -5 | - | 5 | uA | 6 |

- Note :**
- Under all conditions V_{DDQ} must be less than or equal to V_{DD}.
 - V_{REF} is expected to equal 0.50*V_{DDQ} of the transmitting device and to track variations in the DC level of the same. Peak to peak noise on the V_{REF} may not exceed + 2% of the DC value.
 - V_{tt} of the transmitting device must track V_{REF} of the receiving device.
 - V_{IH(max.)}= V_{DDQ} +1.5V for a pulse width and it can not be greater than 1/3 of the cycle rate.
 - V_{IL(min.)}= -1.5V for a pulse width and it can not be greater than 1/3 of the cycle rate.
 - For any pin under test input of 0V ≤ V_{IN} ≤ V_{DD} is acceptable. For all other pins that are not under test V_{IN}=0V.
 - For K4D26323RA-GC2A/33/36, V_{DD}/V_{DDQ}=2.8V ± 5%

* **VDD / VDDQ=2.8V** *

K4D26323RA-GC

128M DDR SDRAM

DC CHARACTERISTICS

Recommended operating conditions Unless Otherwise Noted, TA=0 to 65°C)

| Parameter | Symbol | Test Condition | Version | | | Unit | Note |
|---|-------------------|---|---------|------|------|------|------|
| | | | -2A | -33 | -36 | | |
| Operating Current (One Bank Active) | I _{CC1} | Burst Length=2 trc ≥ trc(min) IoL=0mA, tcc= tcc(min) | 500 | 480 | 460 | mA | 1 |
| Precharge Standby Current in Power-down mode | I _{CC2P} | CKE ≤ V _{IL} (max), tcc= tcc(min) | 85 | 80 | 75 | mA | |
| Precharge Standby Current in Non Power-down mode | I _{CC2N} | CKE ≥ V _{IH} (min), CS ≥ V _{IH} (min), tcc= tcc(min) | 145 | 130 | 120 | mA | |
| Active Standby Current power-down mode | I _{CC3P} | CKE ≤ V _{IL} (max), tcc= tcc(min) | 140 | 130 | 120 | mA | |
| Active Standby Current in in Non Power-down mode | I _{CC3N} | CKE ≥ V _{IH} (min), CS ≥ V _{IH} (min), tcc= tcc(min) | 400 | 350 | 320 | mA | |
| Operating Current (Burst Mode) | I _{CC4} | IoL=0mA ,tcc= tcc(min), Page Burst, All Banks activated. | 940 | 840 | 800 | mA | |
| Refresh Current | I _{CC5} | trc ≥ trFC(min) | 330 | 320 | 310 | mA | 2 |
| Self Refresh Current | I _{CC6} | CKE ≤ 0.2V | 4 | | | mA | |
| Operating Current (4Bank interleaving) | I _{CC7} | Burst Length=4 trc ≥ trc(min) IoL=0mA, tcc= tcc(min) | 1200 | 1080 | 1000 | mA | |

- Note :** 1. Measured with outputs open.
2. Refresh period is 32ms.

AC INPUT OPERATING CONDITIONS

Recommended operating conditions(Voltage referenced to V_{SS}=0V, V_{DD}=2.8V± 5%, V_{DDQ}=2.8V± 5%,TA=0 to 65°C)

| Parameter | Symbol | Min | Typ | Max | Unit | Note |
|--|-----------------|---------------------------|-----|---------------------------|------|------|
| Input High (Logic 1) Voltage; DQ | V _{IH} | V _{REF} +0.4 | - | - | V | |
| Input Low (Logic 0) Voltage; DQ | V _{IL} | - | - | V _{REF} -0.4 | V | |
| Clock Input Differential Voltage; CK and \overline{CK} | V _{ID} | 0.8 | - | V _{DDQ} +0.6 | V | 1 |
| Clock Input Crossing Point Voltage; CK and \overline{CK} | V _{IX} | 0.5*V _{DDQ} -0.2 | - | 0.5*V _{DDQ} +0.2 | V | 2 |

- Note :** 1. V_{ID} is the magnitude of the difference between the input level on CK and the input level on \overline{CK}
2. The value of V_{IX} is expected to equal 0.5*V_{DDQ} of the transmitting device and must track variations in the DC level of the same

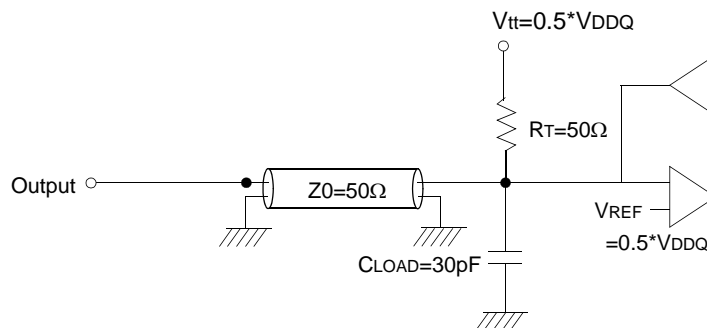
*** VDD / VDDQ=2.8V ***

K4D26323RA-GC

128M DDR SDRAM

AC OPERATING TEST CONDITIONS (VDD=2.8V±5%, TA= 0 to 65°C)

| Parameter | Value | Unit | Note |
|---|-------------------|------|------|
| Input reference voltage for CK(for single ended) | 0.50*VDDQ | V | |
| CK and $\overline{\text{CK}}$ signal maximum peak swing | 1.5 | V | |
| CK signal minimum slew rate | 1.0 | V/ns | |
| Input Levels(VIH/VIL) | VREF+0.4/VREF-0.4 | V | |
| Input timing measurement reference level | VREF | V | |
| Output timing measurement reference level | V _{tt} | V | |
| Output load condition | See Fig.1 | | |



(Fig. 1) Output Load Circuit

CAPACITANCE (VDD=2.5V, TA= 25°C, f=1MHz)

| Parameter | Symbol | Min | Max | Unit |
|--|------------------|-----|-----|------|
| Input capacitance(CK, $\overline{\text{CK}}$) | C _{IN1} | 1.0 | 5.0 | pF |
| Input capacitance(A0~A11, BA0~BA1) | C _{IN2} | 1.0 | 4.0 | pF |
| Input capacitance (CKE, CS, RAS, CAS, WE) | C _{IN3} | 1.0 | 4.0 | pF |
| Data & DQS input/output capacitance(DQ0~DQ31) | C _{OUT} | 1.0 | 6.5 | pF |
| Input capacitance(DM0 ~ DM3) | C _{IN4} | 1.0 | 6.5 | pF |

DECOUPLING CAPACITANCE GUIDE LINE

Recommended decoupling capacitance added to power line at board.

| Parameter | Symbol | Value | Unit |
|--|------------------|------------|------|
| Decoupling Capacitance between VDD and VSS | C _{DC1} | 0.1 + 0.01 | uF |
| Decoupling Capacitance between VDDQ and VSSQ | C _{DC2} | 0.1 + 0.01 | uF |

- Note :**
- VDD and VDDQ pins are separated each other.
All VDD pins are connected in chip. All VDDQ pins are connected in chip.
 - VSS and VSSQ pins are separated each other
All VSS pins are connected in chip. All VSSQ pins are connected in chip.

* $VDD / VDDQ=2.8V$ *

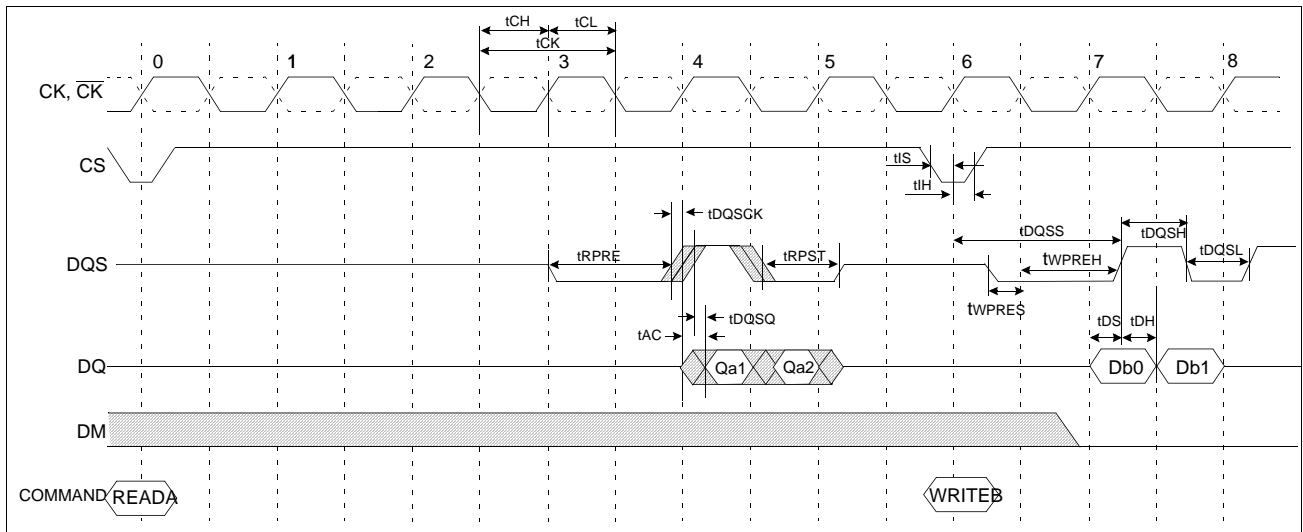
K4D26323RA-GC

128M DDR SDRAM

AC CHARACTERISTICS

| Parameter | Symbol | -2A | | -33 | | -36 | | Unit | Note |
|---------------------------------|--------------------|--|------|--|------|--|------|-----------------|------|
| | | Min | Max | Min | Max | Min | Max | | |
| CK cycle time | t _{CK} | - | 4 | - | 5 | - | 5 | ns | |
| | | 2.86 | | 3.3 | | 3.6 | | ns | |
| CK high level width | t _{CH} | 0.45 | 0.55 | 0.45 | 0.55 | 0.45 | 0.55 | t _{CK} | |
| CK low level width | t _{CL} | 0.45 | 0.55 | 0.45 | 0.55 | 0.45 | 0.55 | t _{CK} | |
| DQS out access time from CK | t _{DQSQ} | -0.6 | 0.6 | -0.6 | 0.6 | -0.6 | 0.6 | ns | |
| Output access time from CK | t _{AC} | -0.6 | 0.6 | -0.6 | 0.6 | -0.6 | 0.6 | ns | |
| Data strobe edge to Dout edge | t _{DQSQ} | - | 0.35 | - | 0.35 | - | 0.40 | ns | 1 |
| Read preamble | t _{RPRE} | 0.9 | 1.1 | 0.9 | 1.1 | 0.9 | 1.1 | t _{CK} | |
| Read postamble | t _{RPST} | 0.4 | 0.6 | 0.4 | 0.6 | 0.4 | 0.6 | t _{CK} | |
| CK to valid DQS-in | t _{DQSS} | 0.85 | 1.15 | 0.85 | 1.15 | 0.85 | 1.15 | t _{CK} | |
| DQS-In setup time | t _{WPRES} | 0 | - | 0 | - | 0 | - | ns | |
| DQS-in hold time | t _{WPREH} | 0.35 | - | 0.35 | - | 0.35 | - | t _{CK} | |
| DQS write postamble | t _{WPST} | 0.4 | 0.6 | 0.4 | 0.6 | 0.4 | 0.6 | t _{CK} | |
| DQS-In high level width | t _{DQSH} | 0.4 | 0.6 | 0.4 | 0.6 | 0.4 | 0.6 | t _{CK} | |
| DQS-In low level width | t _{DQSL} | 0.4 | 0.6 | 0.4 | 0.6 | 0.4 | 0.6 | t _{CK} | |
| Address and Control input setup | t _{IS} | 0.9 | - | 0.9 | - | 0.9 | - | ns | |
| Address and Control input hold | t _{IH} | 0.9 | - | 0.9 | - | 0.9 | - | ns | |
| DQ and DM setup time to DQS | t _{DS} | 0.35 | - | 0.35 | - | 0.40 | - | ns | |
| DQ and DM hold time to DQS | t _{DH} | 0.35 | - | 0.35 | - | 0.40 | - | ns | |
| Clock half period | t _{HP} | t _{CLmin} or t _{CHmin} | - | t _{CLmin} or t _{CHmin} | - | t _{CLmin} or t _{CHmin} | - | ns | 1 |
| Data output hold time from DQS | t _{QH} | t _{HP} -0.35 | - | t _{HP} -0.35 | - | t _{HP} -0.4 | - | ns | 1 |

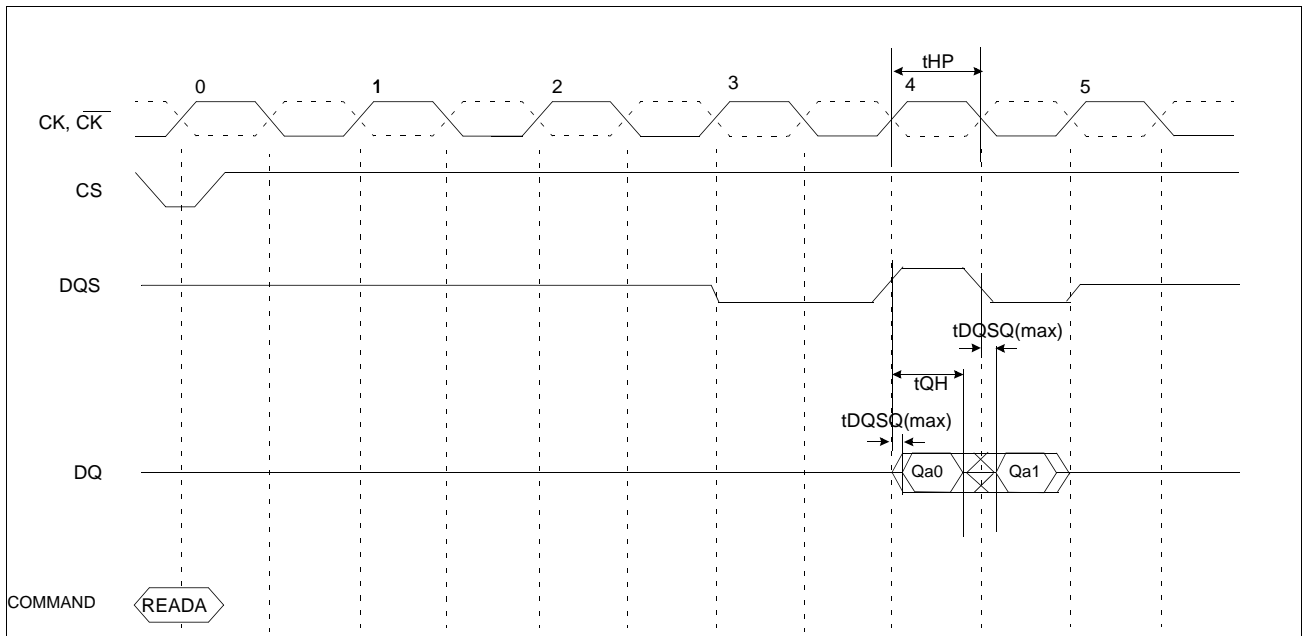
Simplified Timing @ BL=2, CL=4



Note 1 :

- The JEDEC DDR specification currently defines the output data valid window(tDV) as the time period when the data strobe and all data associated with that data strobe are coincidentally valid.
- The previously used definition of tDV(=0.35tCK) artificially penalizes system timing budgets by assuming the worst case output valid window even then the clock duty cycle applied to the device is better than 45/55%
- A new AC timing term, tQH which stands for data output hold time from DQS is defined to account for clock duty cycle variation and replaces tDV
- tQHmin = tHP-X where
 - . tHP=Minimum half clock period for any given cycle and is defined by clock high or clock low time(tCH,tCL)
 - . X=A frequency dependent timing allowance account for tDQSQmax

tQH Timing (CL4, BL2)



* **VDD / VDDQ=2.8V** *

K4D26323RA-GC

128M DDR SDRAM

AC CHARACTERISTICS (I)

| Parameter | Symbol | -2A | | -33 | | -36 | | Unit | Note |
|---|--------|----------|------|----------|------|----------|------|------|------|
| | | Min | Max | Min | Max | Min | Max | | |
| Row cycle time | tRC | 15 | - | 13 | - | 16 | - | tCK | |
| Refresh row cycle time | tRFC | 17 | - | 15 | - | 18 | - | tCK | |
| Row active time | tRAS | 10 | 100K | 9 | 100K | 11 | 100K | tCK | |
| RAS to CAS delay for Read | tRCDRD | 5 | - | 4 | - | 5 | - | tCK | |
| RAS to CAS delay for Write | tRCDWR | 3 | - | 2 | - | 3 | - | tCK | |
| Row precharge time | tRP | 5 | - | 4 | - | 5 | - | tCK | |
| Row active to Row active | tRRD | 4 | - | 3 | - | 3 | - | tCK | |
| Last data in to Row precharge @Normal Precharge | tWR | 3 | - | 2 | - | 3 | - | tCK | 1 |
| Last data in to Row precharge @Auto Precharge | tWR_A | 3 | - | 3 | - | 3 | - | tCK | 1 |
| Last data in to Read command | tCDLR | 2 | - | 2 | - | 2 | - | tCK | 1 |
| Col. address to Col. address | tCCD | 1 | - | 1 | - | 1 | - | tCK | |
| Mode register set cycle time | tMRD | 2 | - | 2 | - | 2 | - | tCK | |
| Auto precharge write recovery + Precharge | tDAL | 8 | - | 7 | - | 8 | - | tCK | |
| Exit self refresh to read com- | tXSR | 200 | - | 200 | - | 200 | - | tCK | |
| Power down exit time | tPDEX | 1tCK+tIS | - | 1tCK+tIS | - | 1tCK+tIS | - | ns | |
| Refresh interval time | tREF | 7.8 | - | 7.8 | - | 7.8 | - | us | |

Note : 1. For normal write operation, even numbers of Din are to be written inside DRAM

(Unit : Number of Clock)

AC CHARACTERISTICS (II)

K4D26323RA-GC2A

| Frequency | Cas Latency | tRC | tRFC | tRAS | tRCDRD | tRCDWR | tRP | tRRD | tDAL | Unit |
|-------------------|-------------|-----|------|------|--------|--------|-----|------|------|------|
| 350MHz (2.86ns) | 4 | 15 | 17 | 10 | 5 | 3 | 5 | 4 | 8 | tCK |
| 300MHz (3.3ns) | 4 | 13 | 15 | 9 | 4 | 2 | 4 | 3 | 7 | tCK |
| 275MHz (3.6ns) | 4 | 16 | 18 | 11 | 5 | 3 | 5 | 3 | 8 | tCK |

K4D26323RA-GC33

| Frequency | Cas Latency | tRC | tRFC | tRAS | tRCDRD | tRCDWR | tRP | tRRD | tDAL | Unit |
|------------------|-------------|-----|------|------|--------|--------|-----|------|------|------|
| 300MHz (3.3ns) | 4 | 13 | 15 | 9 | 4 | 2 | 4 | 3 | 7 | tCK |
| 275MHz (3.6ns) | 4 | 16 | 18 | 11 | 5 | 3 | 5 | 3 | 8 | tCK |

K4D26323RA-GC36

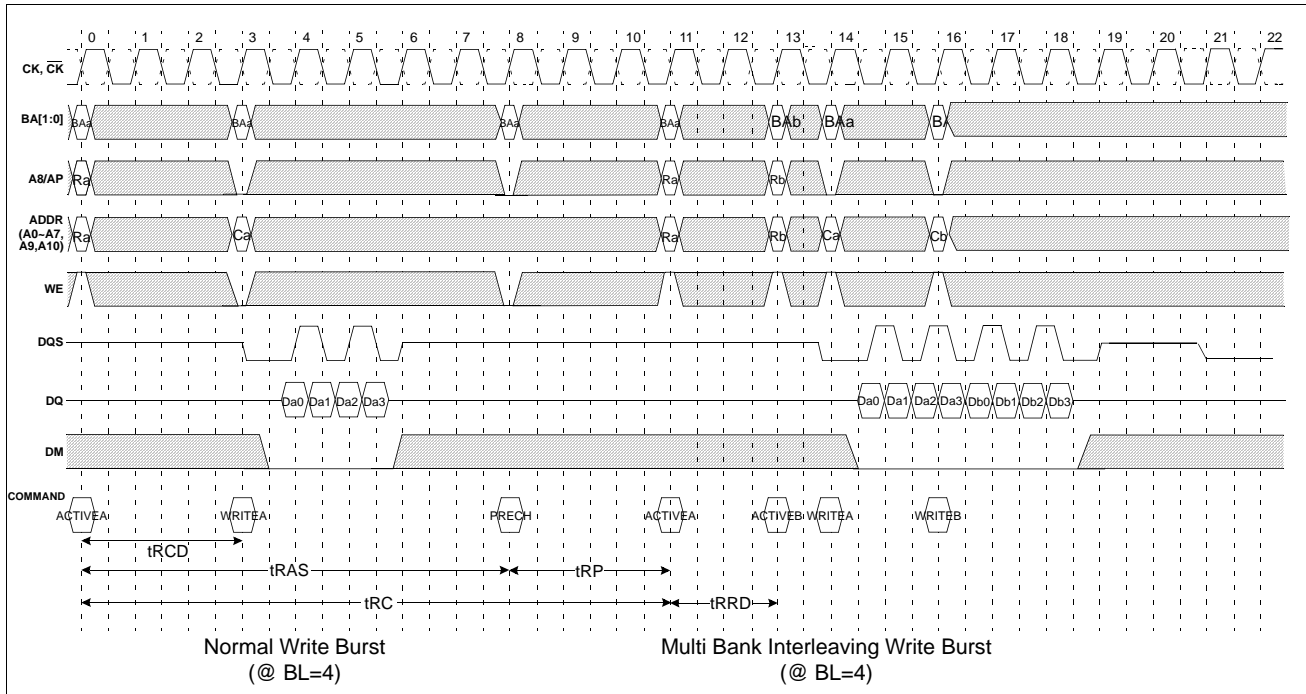
| Frequency | Cas Latency | tRC | tRFC | tRAS | tRCDRD | tRCDWR | tRP | tRRD | tDAL | Unit |
|------------------|-------------|-----|------|------|--------|--------|-----|------|------|------|
| 275MHz (3.6ns) | 4 | 16 | 18 | 11 | 5 | 3 | 5 | 3 | 8 | tCK |

* VDD / VDDQ=2.8V *

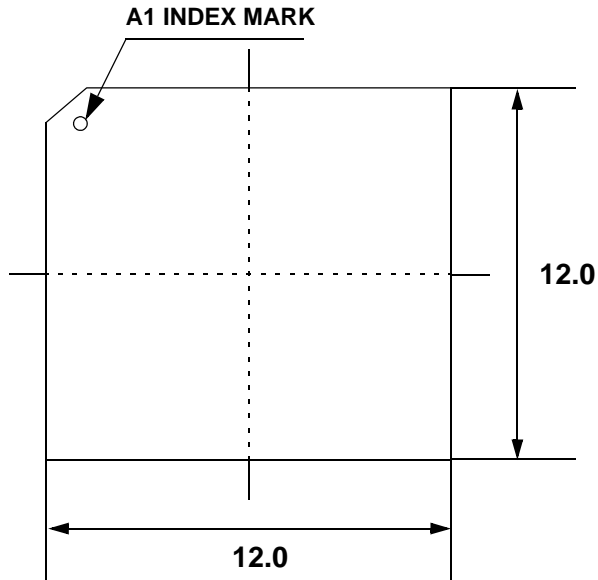
K4D26323RA-GC

128M DDR SDRAM

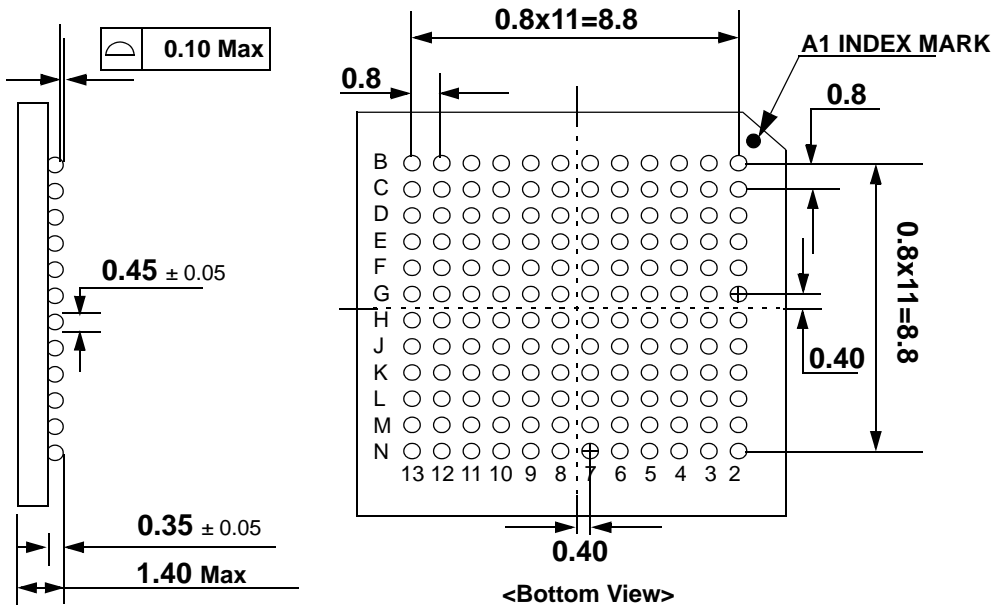
Simplified Timing(2) @ BL=4



PACKAGE DIMENSIONS (144-Ball FBGA)



<Top View>



<Bottom View>

Unit : mm