

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{CAS}	\overline{WE}	VDD	VSS	A10	VDD	VDD	RFU ₁	VSS	VDD	NC	NC
M	\overline{RAS}	NC	NC	BA1	A2	A11	A9	A5	RFU ₂	CK	\overline{CK}	MCL
N	\overline{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{CK}	Differential Clock Input	BA0, BA1	Bank Select Address
CKE	Clock Enable	A0 ~A11	Address Input
\overline{CS}	Chip Select	DQ0 ~ DQ31	Data Input/Output
\overline{RAS}	Row Address Strobe	VDD	Power
\overline{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, $\overline{\text{CK}}^{*1}$	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 $\overline{\text{CK}}$ signal when low. By deactivating the clock, CKE low indicates the Power down mode or Self refresh mode.
$\overline{\text{CS}}$	Input	$\overline{\text{CS}}$ 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.
$\overline{\text{RAS}}$	Input	Latches row addresses on the positive going edge of the CK with $\overline{\text{RAS}}$ low. Enables row access & precharge.
$\overline{\text{CAS}}$	Input	Latches column addresses on the positive going edge of the CK with $\overline{\text{CAS}}$ low. Enables column access.
$\overline{\text{WE}}$	Input	Enables write operation and row precharge. Latches data in starting from $\overline{\text{CAS}}$, $\overline{\text{WE}}$ 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

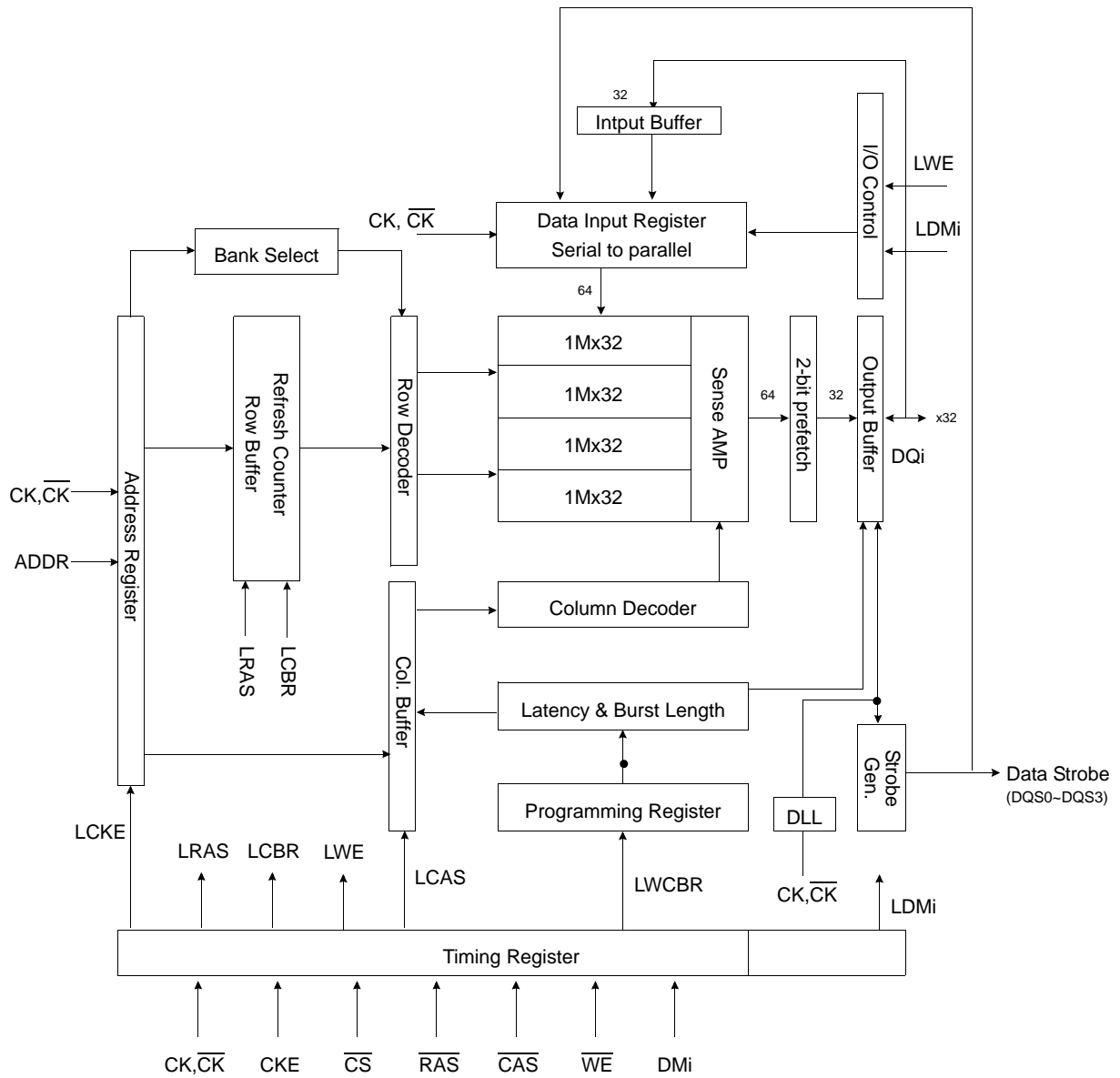
*1 : The timing reference point for the differential clocking is the cross point of CK and $\overline{\text{CK}}$.
For any applications using the single ended clocking, apply VREF to $\overline{\text{CK}}$ pin.

* $VDD / VDDQ=2.8V$ *

K4D26323RA-GC

128M DDR SDRAM

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



FUNCTIONAL DESCRIPTION

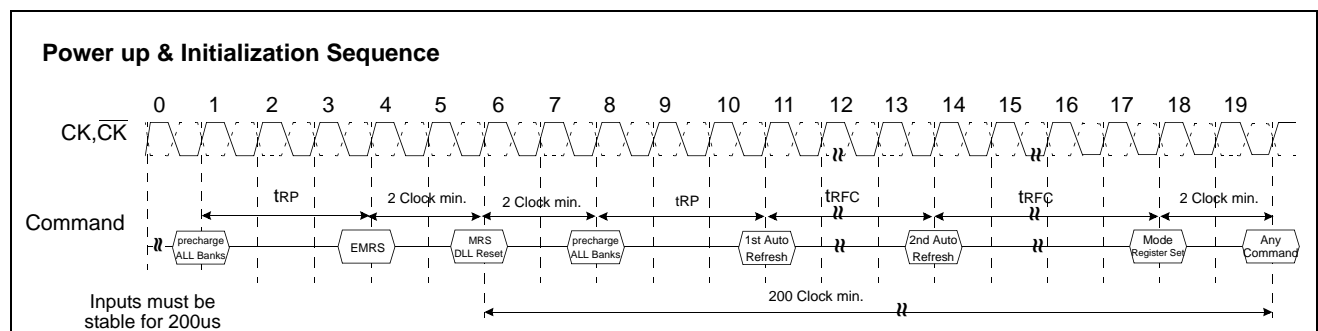
• Power-Up Sequence

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 200 μ s.
3. The minimum of 200 μ s 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.

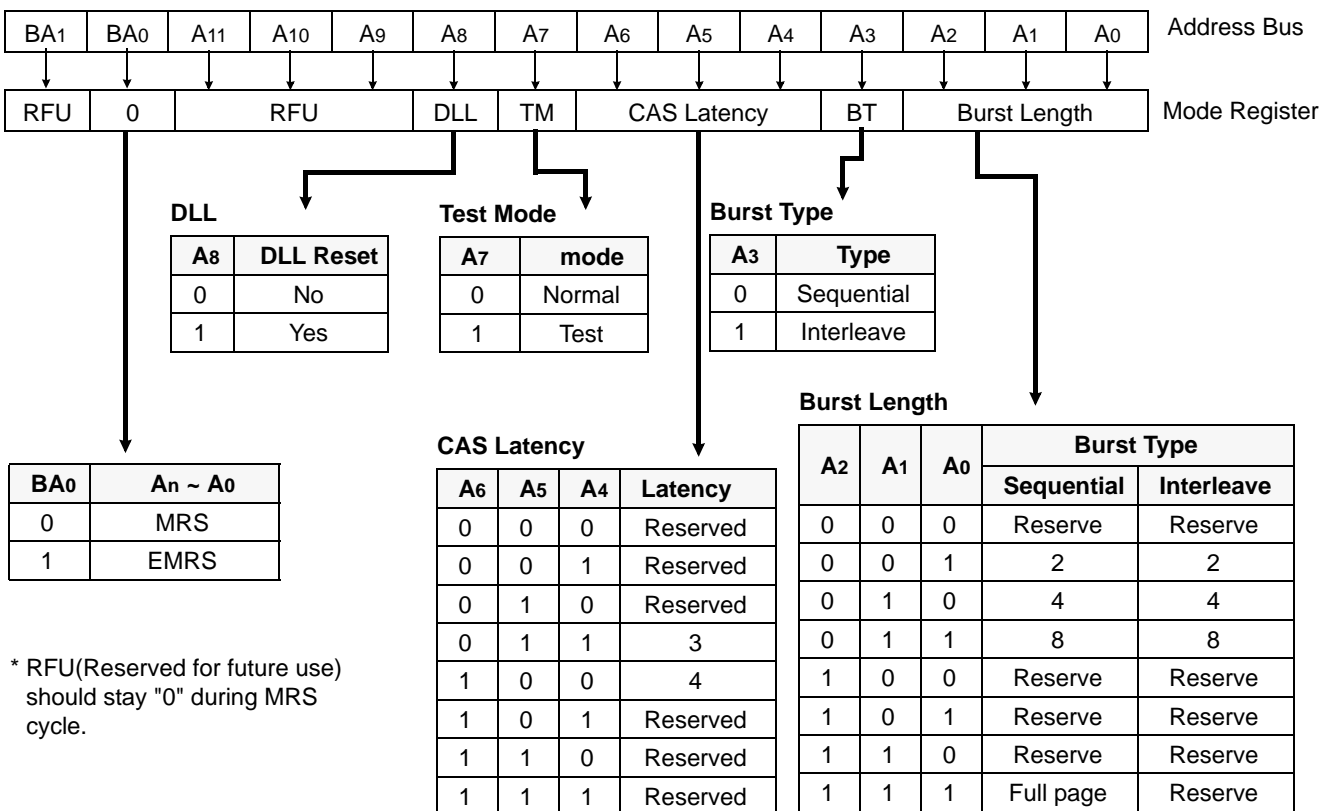
*2 Sequence of 6&7 is regardless of the order.



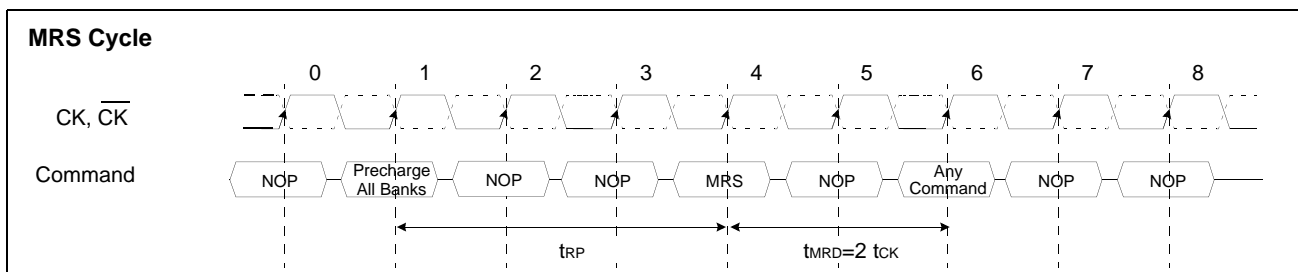
* When the operating frequency is changed, DLL reset should be required again.
After DLL reset again, the minimum 200 cycles of clock input is needed to lock the DLL.

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 \overline{CS} , \overline{RAS} , \overline{CAS} and \overline{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 \overline{CS} , \overline{RAS} , \overline{CAS} and \overline{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.

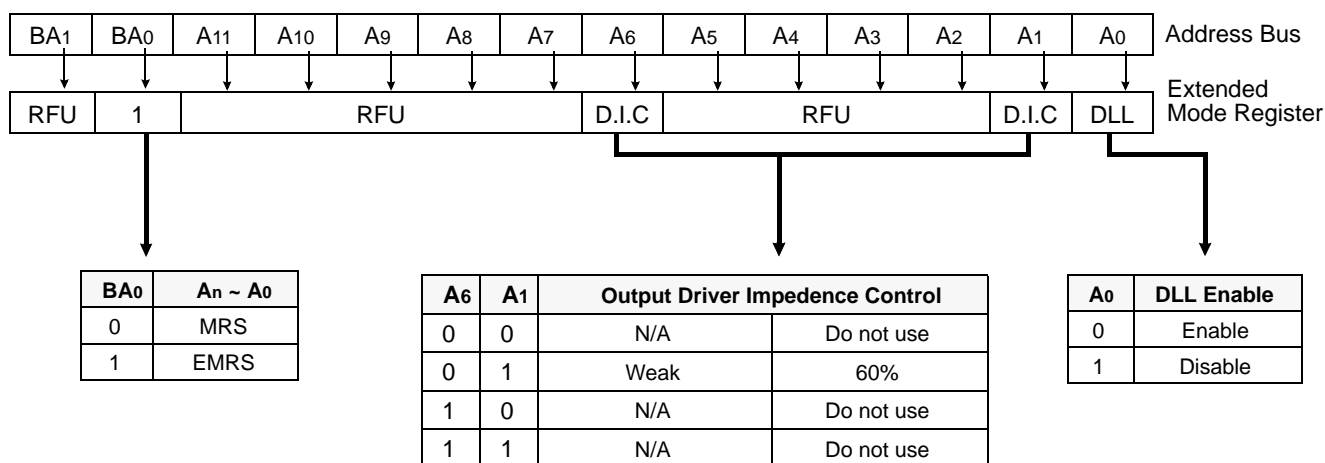


*1 : MRS can be issued only at all banks precharge state.

*2 : Minimum t_{RP} 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

*** VDD / VDDQ=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 VDD supply relative to Vss	VDD	-1.0 ~ 3.6	V
Voltage on VDD supply relative to Vss	VDDQ	-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 Vss=0V, T_A=0 to 65°C)

Parameter	Symbol	Min	Typ	Max	Unit	Note
Device Supply voltage	VDD	2.66	2.8	2.94	V	1,7
Output Supply voltage	VDDQ	2.66	2.8	2.94	V	1,7
Reference voltage	VREF	0.49*VDDQ	-	0.51*VDDQ	V	2
Termination voltage	V _{tt}	VREF-0.04	VREF	VREF+0.04	V	3
Input logic high voltage	V _{IH} (DC)	VREF+0.15	-	VDDQ+0.30	V	4
Input logic low voltage	V _{IL} (DC)	-0.30	-	VREF-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 VDDQ must be less than or equal to VDD.
 - VREF is expected to equal 0.50*VDDQ of the transmitting device and to track variations in the DC level of the same. Peak to peak noise on the VREF may not exceed + 2% of the DC value.
 - V_{tt} of the transmitting device must track VREF of the receiving device.
 - V_{IH}(max.)= VDDQ +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} ≤ VDD is acceptable. For all other pins that are not under test V_{IN}=0V.
 - For K4D26323RA-GC2A/33/36, VDD/VDDQ=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)	ICC1	Burst Length=2 trc ≥ trc(min) IoL=0mA, tcc= tcc(min)	500	480	460	mA	1
Precharge Standby Current in Power-down mode	ICC2P	CKE ≤ VIL(max), tcc= tcc(min)	85	80	75	mA	
Precharge Standby Current in Non Power-down mode	ICC2N	CKE ≥ VIH(min), CS ≥ VIH(min), tcc= tcc(min)	145	130	120	mA	
Active Standby Current power-down mode	ICC3P	CKE ≤ VIL(max), tcc= tcc(min)	140	130	120	mA	
Active Standby Current in in Non Power-down mode	ICC3N	CKE ≥ VIH(min), CS ≥ VIH(min), tcc= tcc(min)	400	350	320	mA	
Operating Current (Burst Mode)	ICC4	IoL=0mA ,tcc= tcc(min), Page Burst, All Banks activated.	940	840	800	mA	
Refresh Current	ICC5	trc ≥ trfc(min)	330	320	310	mA	2
Self Refresh Current	ICC6	CKE ≤ 0.2V	4			mA	
Operating Current (4Bank interleaving)	ICC7	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

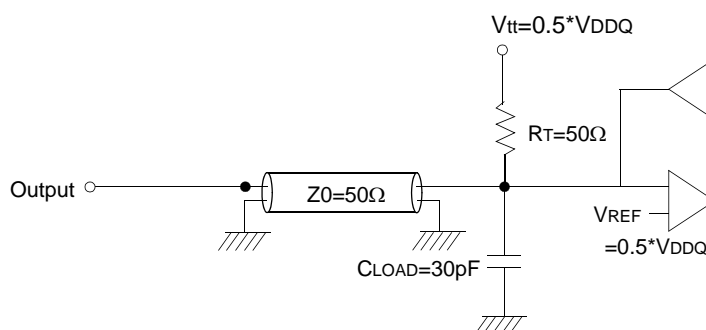
Recommended operating conditions(Voltage referenced to VSS=0V, VDD=2.8V± 5%, VDDQ=2.8V± 5%,TA=0 to 65°C)

Parameter	Symbol	Min	Typ	Max	Unit	Note
Input High (Logic 1) Voltage; DQ	VIH	VREF+0.4	-	-	V	
Input Low (Logic 0) Voltage; DQ	VIL	-	-	VREF-0.4	V	
Clock Input Differential Voltage; CK and \overline{CK}	VID	0.8	-	VDDQ+0.6	V	1
Clock Input Crossing Point Voltage; CK and \overline{CK}	VIX	0.5*VDDQ-0.2	-	0.5*VDDQ+0.2	V	2

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

AC OPERATING TEST CONDITIONS ($V_{DD} = 2.8V \pm 5\%$, $T_A = 0$ to 65°C)

Parameter	Value	Unit	Note
Input reference voltage for CK(for single ended)	$0.50 \cdot V_{DDQ}$	V	
CK and $\overline{\text{CK}}$ signal maximum peak swing	1.5	V	
CK signal minimum slew rate	1.0	V/ns	
Input Levels(V_{IH}/V_{IL})	$V_{REF} + 0.4 / V_{REF} - 0.4$	V	
Input timing measurement reference level	V_{REF}	V	
Output timing measurement reference level	V_{tt}	V	
Output load condition	See Fig.1		



(Fig. 1) Output Load Circuit

CAPACITANCE ($V_{DD} = 2.5V$, $T_A = 25^\circ\text{C}$, $f = 1\text{MHz}$)

Parameter	Symbol	Min	Max	Unit
Input capacitance(CK, $\overline{\text{CK}}$)	C_{IN1}	1.0	5.0	pF
Input capacitance($A_0 \sim A_{11}$, $BA_0 \sim BA_1$)	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($DQ_0 \sim DQ_{31}$)	C_{OUT}	1.0	6.5	pF
Input capacitance($DM_0 \sim DM_3$)	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 V_{DD} and V_{SS}	C_{DC1}	$0.1 + 0.01$	μF
Decoupling Capacitance between V_{DDQ} and V_{SSQ}	C_{DC2}	$0.1 + 0.01$	μF

Note : 1. V_{DD} and V_{DDQ} pins are separated each other.All V_{DD} pins are connected in chip. All V_{DDQ} pins are connected in chip.2. V_{SS} and V_{SSQ} pins are separated each otherAll V_{SS} pins are connected in chip. All V_{SSQ} pins are connected in chip.

* $VDD / VDDQ=2.8V$ *

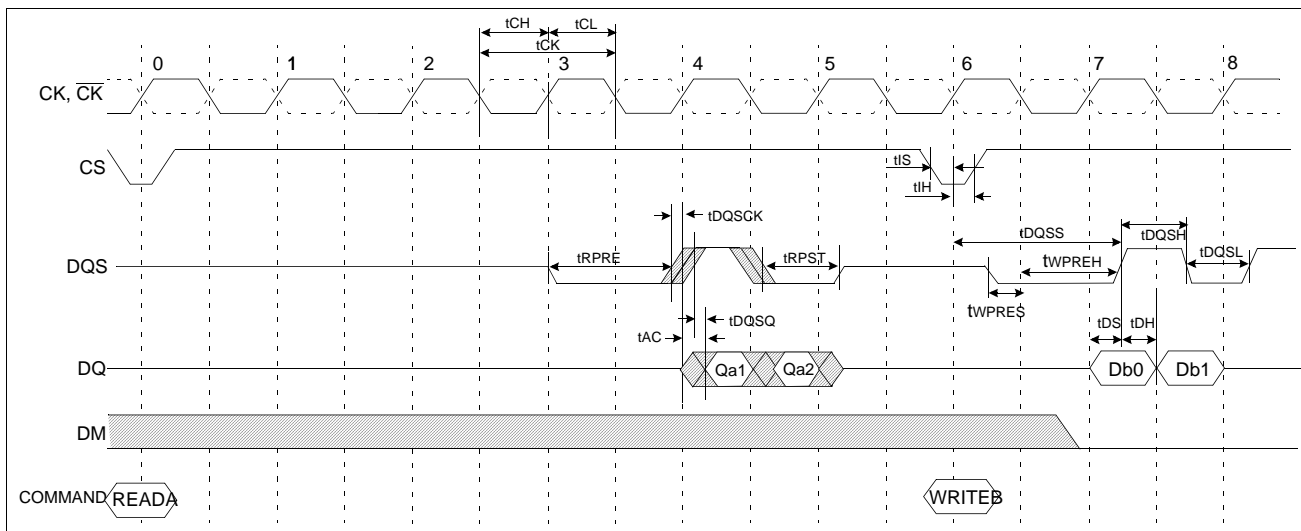
K4D26323RA-GC

128M DDR SDRAM

AC CHARACTERISTICS

Parameter	Sym- bol	-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

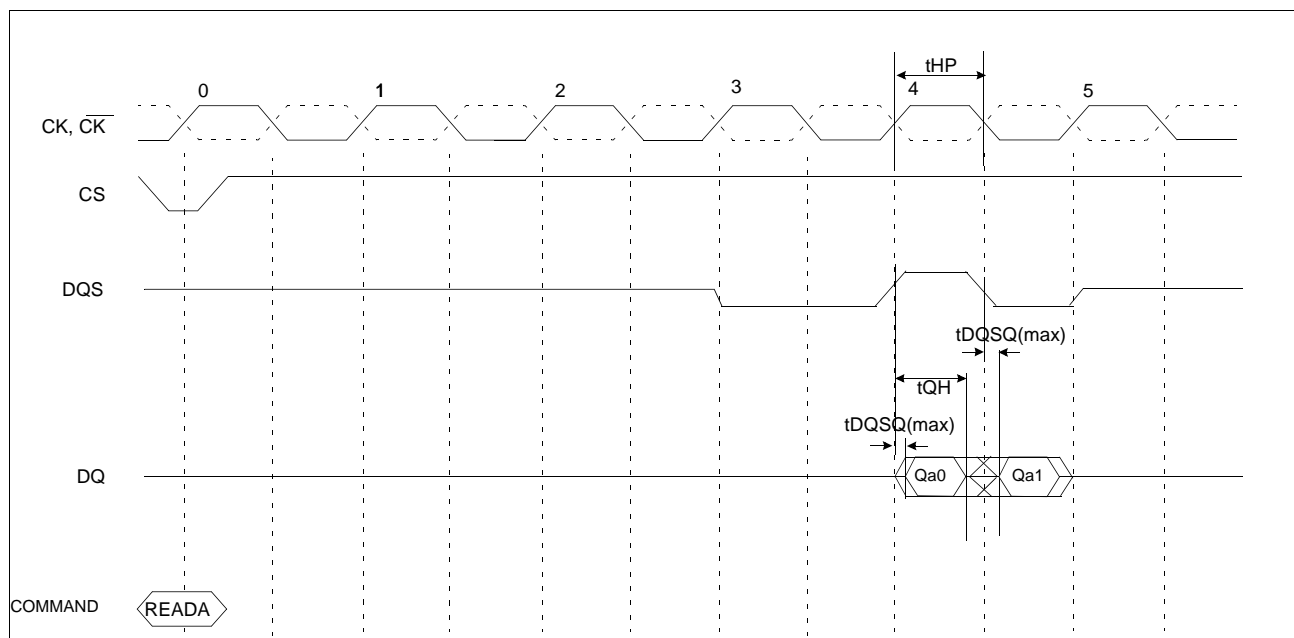
Simplified Timing @ BL=2, CL=4



Note 1 :

- The JEDEC DDR specification currently defines the output data valid window(t_{DV}) as the time period when the data strobe and all data associated with that data strobe are coincidentally valid.
- The previously used definition of $t_{DV}(=0.35t_{CK})$ 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, t_{QH} which stands for data output hold time from DQS is defined to account for clock duty cycle variation and replaces t_{DV}
- $t_{QHmin} = t_{HP} - X$ where
 - . t_{HP} = Minimum half clock period for any given cycle and is defined by clock high or clock low time(t_{CH}, t_{CL})
 - . X = A frequency dependent timing allowance account for $t_{DQSQmax}$

t_{QH} 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

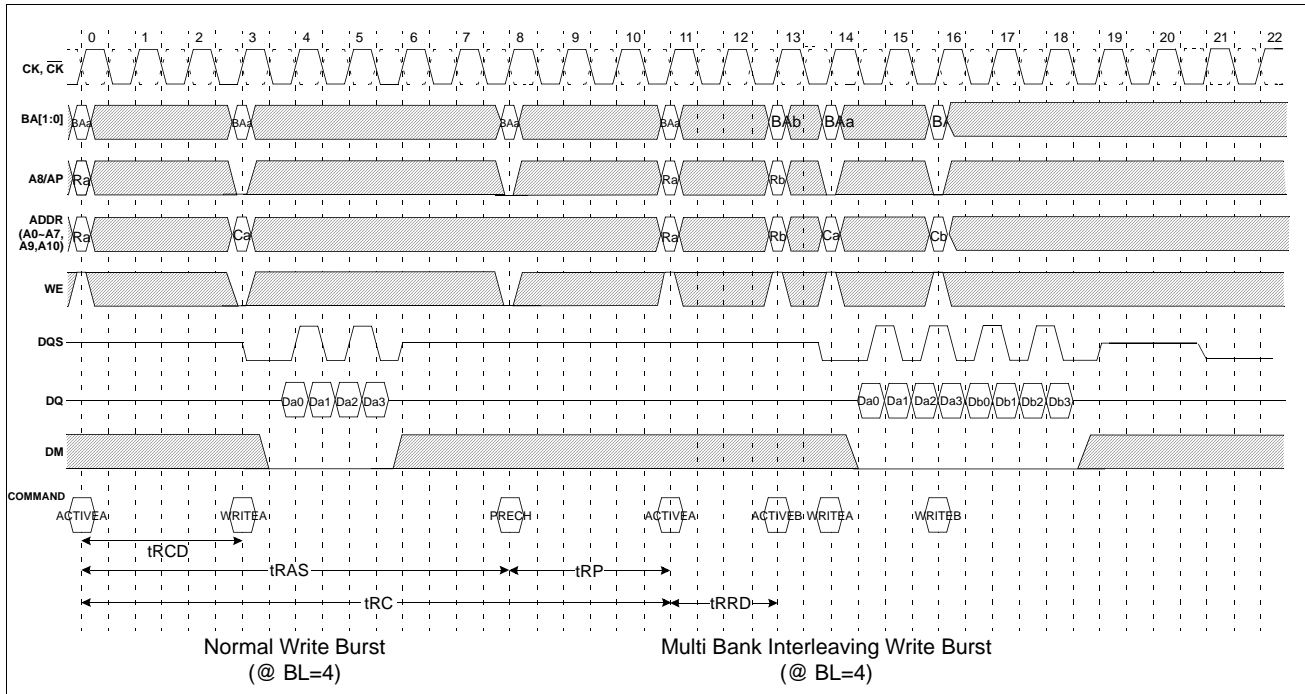
Frequency	Cas Latency	tRC	tRFC	tRAS	tRCDRD	tRCDWR	tRP	tRRD	tDAL	Unit
275MHz (3.6ns)	4	16	18	11	5	3	5	3	8	tCK

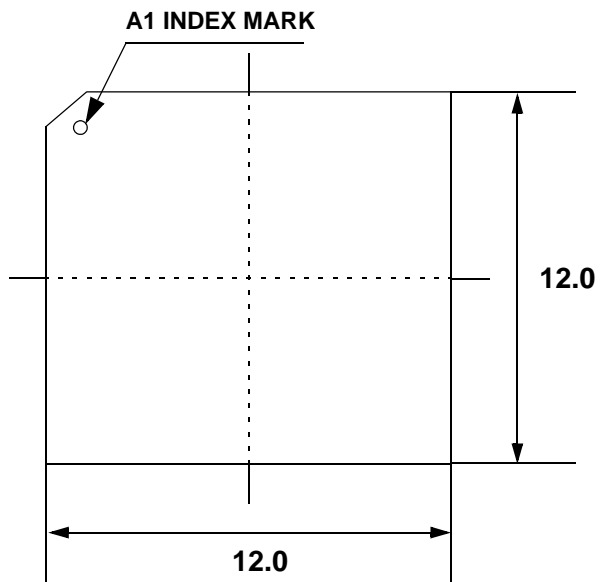
* $V_{DD} / V_{DDQ} = 2.8V$ *

K4D26323RA-GC

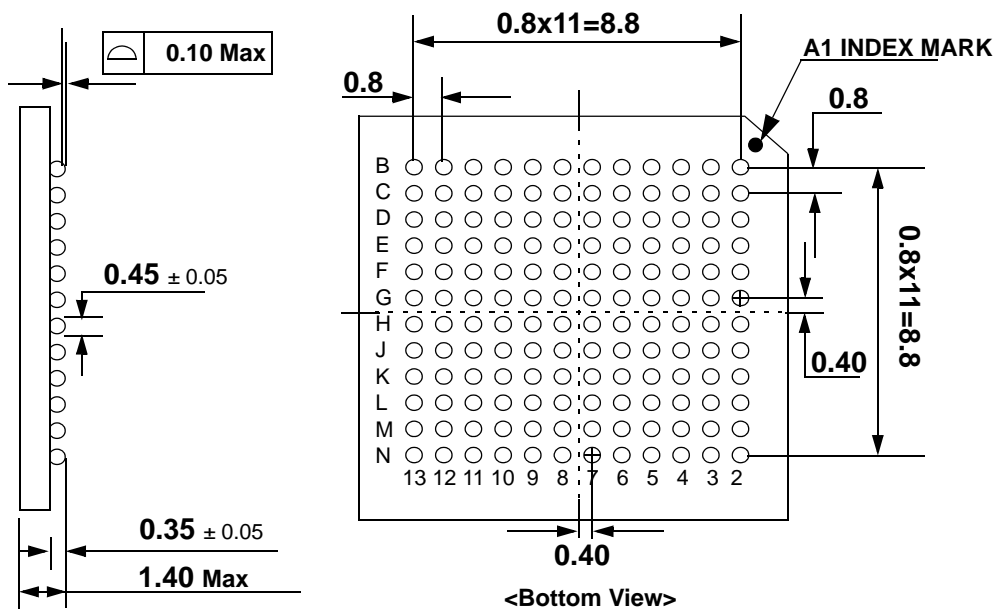
128M DDR SDRAM

Simplified Timing(2) @ BL=4





<Top View>



Unit : mm