256Mbit GDDR SDRAM

2M x 32Bit x 4 Banks
Graphic Double Data Rate
Synchronous DRAM
with Bi-directional Data Strobe and DLL
(144-Ball FBGA)

Revision 1.3

August 2003

Revision History

Revision 1.3 (August 12, 2003)
• Changed tRC of K4D553238E-JC33/36 from 15tCK to 14tCK
• Changed tRAS of K4D553238E-JC33/36 from 10tCK ro 9tCK

Revision 1.2 (June 9, 2003)
• Added Lead Free package part number in the datasheet.

Revision 1.1 (May 16, 2003)
• K4D553238E-JC33 support wide voltage range from 2.2V to 2.625V

Revision 1.0 (May 9, 2003)
• Defined DC spec

Revision 0.5 (January 16, 2003) - *Target Spec*
• Changed package ball height from 0.25mm to 0.35mm
• Typo corrected

Revision 0.4 (December 24, 2002) - *Target Spec*
• Changed Input capacitance of CIN1, CIN2, CIN3, COUT and CIN4
• About Changed input capacitance of CIN1, CIN2, CIN3, COUT and CIN4, refer to the page 12
• Changed tRC of K4D553238E-JC33/36 from 13tCK to 15tCK
• Changed tRFC of K4D553238E-JC33/36 from 15tCK to 17tCK
• Changed tRAS of K4D553238E-JC33/36 from 9tCK to 10tCK
• Changed tRP of K4D553238E-JC33/36 from 4tCK to 5tCK
• Changed tDAL of K4D553238E-JC33/36 from 7tCK to 8tCK

Revision 0.3 (November 19, 2002) - *Target Spec*
• Changed CL of K4D553238E-JC40 from 3 to 4

Revision 0.2 (November 12, 2002) - *Target Spec*
• Changed tPDEX of K4D553238E-JC33/36/40/50 from 1tCK+tIS to 3tCK+tIS

Revision 0.1 (November 7, 2002) - *Target Spec*
• Changed tCK(max) of K4D553238E-JC33 from 4ns to 10ns
• Changed tCK(max) of K4D553238E-JC36 from 6ns to 10ns

Revision 0.0 (October 28, 2002) - *Target Spec*
• Defined Target Specification

2M x 32Bit x 4 Banks Graphic Double Data Rate Synchronous DRAM with Bi-directional Data Strobe and DLL

FEATURES

- 2.5V ± 5% power supply for device operation
- 2.5V ± 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 and 8)
  - -. Burst type (sequential & interleave)
- All inputs except data & DM are sampled at the positive going edge of the system clock
- Differential clock input
- No Wrtie-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 300MHz
- Maximum data rate up to 600Mbps/pin

ORDERING INFORMATION

Part NO.	Max Freq.	Max Data Rate	Interface	Package
K4D553238E-JC33	300MHz	600Mbps/pin	SSTL_2	144-Ball FBGA
K4D553238E-JC36	275MHz	550Mbps/pin		
K4D553238E-JC40	250MHz	500Mbps/pin		
K4D553238E-JC50	200MHz	400Mbps/pin		

K4D553238E-EC is the Lead Free package part number

GENERAL DESCRIPTION

FOR 2M x 32Bit x 4 Bank GDDR SDRAM

The K4D553238E is 268,435,456 bits of hyper synchronous data rate Dynamic RAM organized as 4 x 2,097,152 words by 32 bits, fabricated with SAMSUNG's high performance CMOS technology. Synchronous features with Data Strobe allow extremely high performance up to 2.4GB/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.

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	RFU1	VSS	VDD	NC	NC
M	$\overline{RAS}$	NC	NC	BA1	A2	A11	A9	A5	RFU2	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

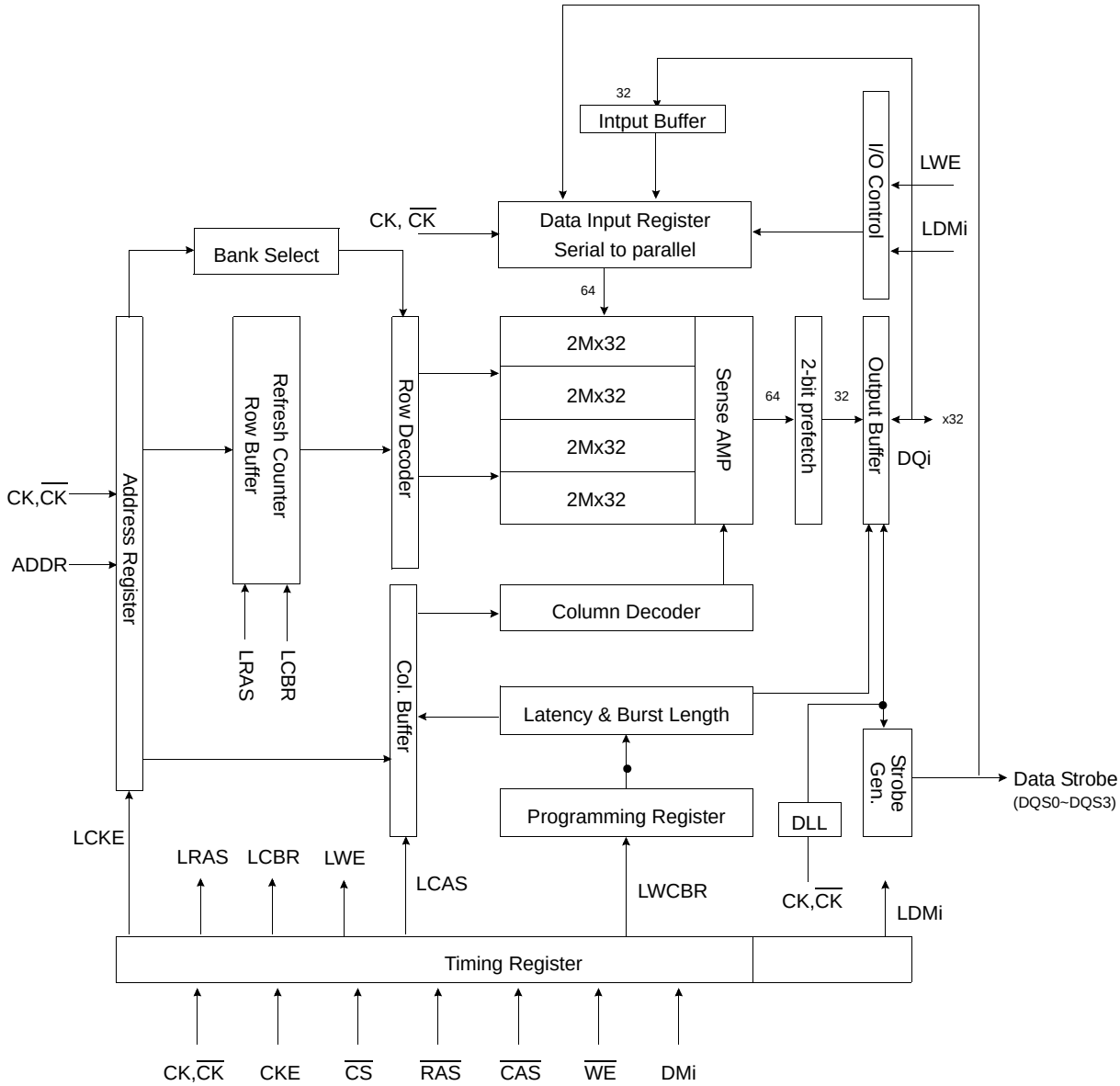
CK,$\overline{CK}$	Differential Clock Input	BA_0, BA_1	Bank Select Address
CKE	Clock Enable	A_0 ~A_{11}	Address Input
$\overline{CS}$	Chip Select	DQ_0 ~ DQ_{31}	Data Input/Output
$\overline{RAS}$	Row Address Strobe	V_{DD}	Power
$\overline{CAS}$	Column Address Strobe	V_{SS}	Ground
WE	Write Enable	V_{DDQ}	Power for DQ's
DQS	Data Strobe	V_{SSQ}	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.
DQS_0 ~ DQS_3	Input/Output	Data input and output are synchronized with both edge of DQS. DQS_0 for DQ_0 ~ DQ_7, DQS_1 for DQ_8 ~ DQ_{15}, DQS_2 for DQ_{16} ~ DQ_{23}, DQS_3 for DQ_{24} ~ DQ_{31}.
DM_0 ~ DM_3	Input	Data In mask. Data In is masked by DM Latency=0 when DM is high in burst write. DM_0 for DQ_0 ~ DQ_7, DM_1 for DQ_8 ~ DQ_{15}, DM_2 for DQ_{16} ~ DQ_{23}, DM_3 for DQ_{24} ~ DQ_{31}.
DQ_0 ~ DQ_{31}	Input/Output	Data inputs/Outputs are multiplexed on the same pins.
BA_0, BA_1	Input	Selects which bank is to be active.
A_0 ~ A_{11}	Input	Row/Column addresses are multiplexed on the same pins. Row addresses : RA_0 ~ RA_{11}, Column addresses : CA_0 ~ CA_7,CA_9 Column address CA_8 is used for auto precharge.
V_{DD}/V_{SS}	Power Supply	Power and ground for the input buffers and core logic.
V_{DDQ}/V_{SSQ}	Power Supply	Isolated power supply and ground for the output buffers to provide improved noise immunity.
V_{REF}	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 V_{REF} to $\overline{CK}$ pin.

BLOCK DIAGRAM (2Mbit x 32I/O x 4 Bank)



FUNCTIONAL DESCRIPTION

• Power-Up Sequence

GDDR 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,$\overline{CK}$), 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.

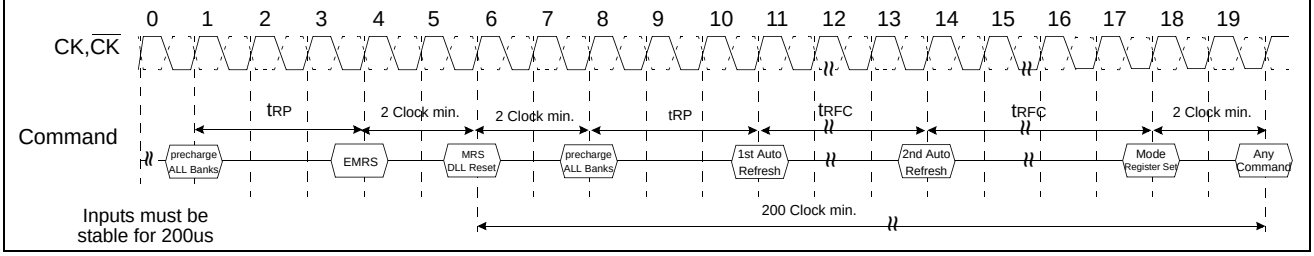
*1,2 7. Issue precharge command for all banks of the device.

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.

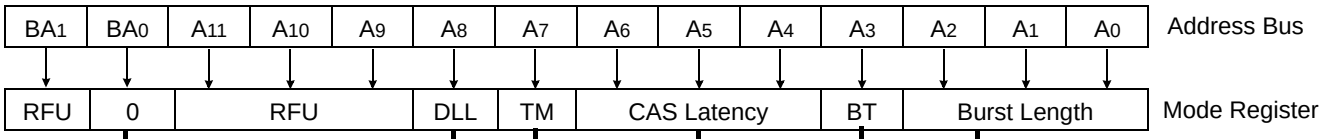
Power up & Initialization Sequence



*** 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 GDDR SDRAM. It programs CAS latency, addressing mode, burst length, test mode, DLL reset and various vendor specific options to make GDDR 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 GDDR SDRAM should be in active mode with CKE already high prior to writing into the mode register). The state of address pins A_0 ~ A_{11} and BA_0, BA_1 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 A_0 ~ A_2, addressing mode uses A_3, CAS latency(read latency from column address) uses A_4 ~ A_6. A_7 is used for test mode. A_8 is used for DLL reset. A_7,A_8, BA_0 and BA_1 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.



DLL

A_8	DLL Reset
0	No
1	Yes

Test Mode

A_7	mode
0	Normal
1	Test

Burst Type

A_3	Type
0	Sequential
1	Interleave

BA_0	A_n ~ A_0
0	MRS
1	EMRS

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

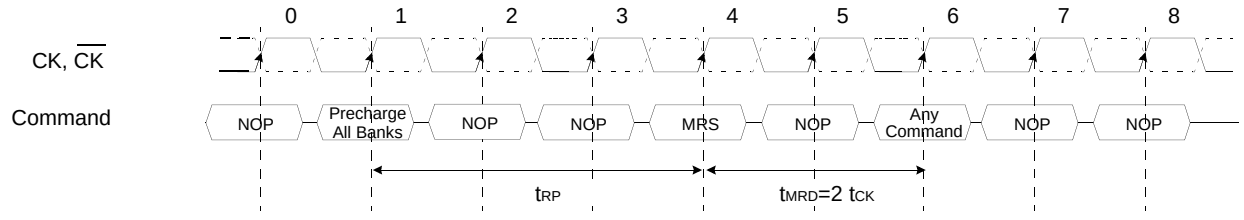
CAS Latency

A_6	A_5	A_4	Latency
0	0	0	Reserved
0	0	1	Reserved
0	1	0	Reserved
0	1	1	3
1	0	0	4
1	0	1	Reserved
1	1	0	Reserved
1	1	1	Reserved

Burst Length

A_2	A_1	A_0	Burst Type	
			Sequential	Interleave
0	0	0	Reserve	Reserve
0	0	1	2	2
0	1	0	4	4
0	1	1	8	8
1	0	0	Reserve	Reserve
1	0	1	Reserve	Reserve
1	1	0	Reserve	Reserve
1	1	1	Reserve	Reserve

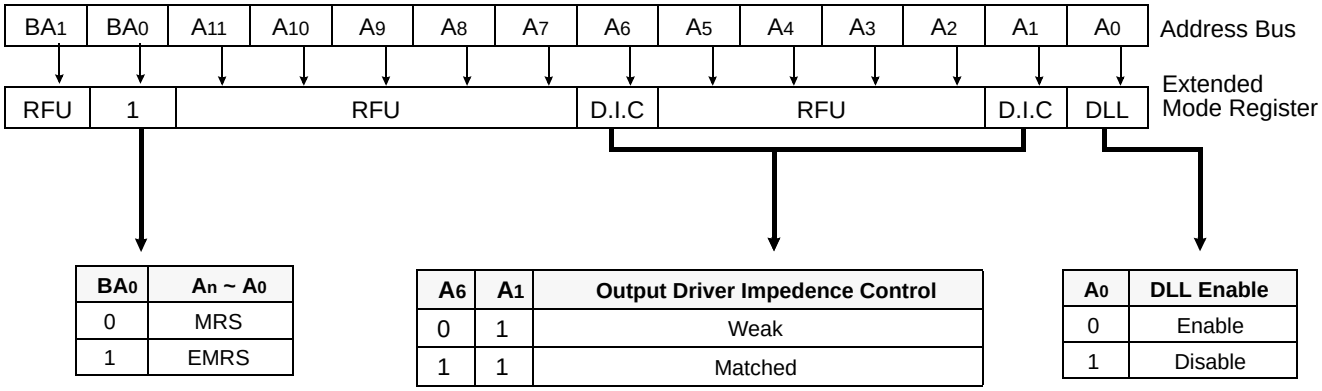
MRS Cycle



*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 extened mode register must be written after power up for enabling or disabling DLL. The extended mode register is written by asserting low on $\overline{CS}$, $\overline{RAS}$, $\overline{CAS}$, $\overline{WE}$ and high on BA0(The GDDR 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 $\overline{CS}$, $\overline{RAS}$, $\overline{CAS}$ and $\overline{WE}$ 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.



BA_0	A_n ~ A_0
0	MRS
1	EMRS

A_6	A_1	Output Driver Impedence Control
0	1	Weak
1	1	Matched

A_0	DLL Enable
0	Enable
1	Disable

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

Figure 7. Extended Mode Register set

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_{DD} supply relative to Vss	V_{DDQ}	-0.5 ~ 3.6	V
Storage temperature	T_{STG}	-55 ~ +150	°C
Power dissipation	P_D	2.0	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}	2.375	2.50	2.625	V	1
		2.2	2.50	2.625	V	7
Output Supply voltage	V_{DDQ}	2.375	2.50	2.625	V	1
		2.2	2.50	2.625	V	7
Reference voltage	V_{REF}	0.49*V_{DDQ}	-	0.51*V_{DDQ}	V	2
Termination voltage	Vtt	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}	Vtt+0.76	-	-	V	I_{OH}=-15.2mA
Output logic low voltage	V_{OL}	-	-	Vtt-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 : 1. Under all conditions V_{DDQ} must be less than or equal to V_{DD}.
2. 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.
3. V_{tt} of the transmitting device must track V_{REF} of the receiving device.
4. V_{IH}(max.)= V_{DDQ} +1.5V for a pulse width and it can not be greater than 1/3 of the cycle rate.
5. V_{IL}(mim.)= -1.5V for a pulse width and it can not be greater than 1/3 of the cycle rate.
6. 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.
7. K4D553238E-JC33 support wide voltage range from 2.2V to 2.625V.

DC CHARACTERISTICS

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

Parameter	Symbol	Test Condition	Version				Unit	Note
			-33	-36	-40	-50		
Operating Current (One Bank Active)	I_{CC1}	Burst Lenth=2 $t_{RC} \geq t_{RC}$(min) I_{OL}=0mA, t_{CC}= t_{CC}(min)	430	400	370	340	mA	1
Precharge Standby Current in Power-down mode	I_{CC2P}	CKE ≤ V_{IL}(max), t_{CC}= t_{CC}(min)	120				mA	
Precharge Standby Current in Non Power-down mode	I_{CC2N}	CKE ≥ V_{IH}(min), CS ≥ V_{IH}(min), t_{CC}= t_{CC}(min)	170	165	155	140	mA	
Active Standby Current power-down mode	I_{CC3P}	CKE ≤ V_{IL}(max), t_{CC}= t_{CC}(min)	150	140	130	120	mA	
Active Standby Current in in Non Power-down mode	I_{CC3N}	CKE ≥ VIH(min), CS ≥ VIH(min), t_{CC}= t_{CC}(min)	250	240	225	215	mA	
Operating Current (Burst Mode)	I_{CC4}	I_{OL}=0mA ,t_{CC}= t_{CC}(min), Page Burst, All Banks activated.	710	670	620	530	mA	
Refresh Current	I_{CC5}	$t_{RC} \geq t_{RFC}$(min)	510	470	440	420	mA	2
Self Refresh Current	I_{CC6}	CKE ≤ 0.2V	6				mA	
Operating Current (4Bank interleaving)	I_{CC7}	Burst Length=4 $t_{RC} \geq t_{RC}$(min) I_{OL}=0mA, t_{CC}= t_{CC}(min)	900	850	780	670	mA	

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

AC INPUT OPERATING CONDITIONS

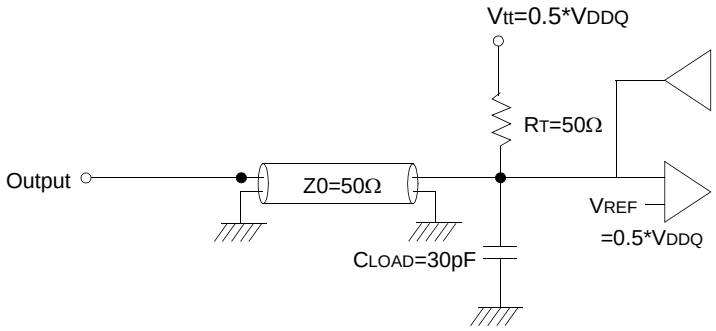
Recommended operating conditions(Voltage referenced to V_{SS}=0V, V_{DD}=2.5V± 5%, V_{DDQ}=2.5V± 5%,T_A=0 to 65°C)

Parameter	Symbol	Min	Typ	Max	Unit	Note
Input High (Logic 1) Voltage; DQ	V_{IH}	V_{REF}+0.35	-	-	V	
Input Low (Logic 0) Voltage; DQ	V_{IL}	-	-	V_{REF}-0.35	V	
Clock Input Differential Voltage; CK and $\overline{CK}$	V_{ID}	0.7	-	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

AC OPERATING TEST CONDITIONS (V_{DD}=2.5V±5%, T_A= 0 to 65°C)

Parameter	Value	Unit	Note
Input reference voltage for CK(for single ended)	0.50*V_{DDQ}	V	
CK and $\overline{CK}$ signal maximum peak swing	1.5	V	
CK signal minimum slew rate	1.0	V/ns	
Input Levels(V_{IH}/V_{IL})	V_{REF}+0.35/V_{REF}-0.35	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°C, f=1MHz)

Parameter	Symbol	Min	Max	Unit
Input capacitance(CK, $\overline{CK}$)	C_{IN1}	5.0	10.0	pF
Input capacitance(A_0~A_{11}, BA_0~BA_1)	C_{IN2}	5.0	9.0	pF
Input capacitance (CKE, $\overline{CS}$, $\overline{RAS}$,$\overline{CAS}$, $\overline{WE}$)	C_{IN3}	5.0	9.0	pF
Data & DQS input/output capacitance(DQ_0~DQ_{31})	C_{OUT}	4.0	8.0	pF
Input capacitance(DM0 ~ DM3)	C_{IN4}	4.0	8.0	pF

DECOUPLING CAPACITANCE GUIDE LINE

Recommended decoupling capacitance added to power line at board.

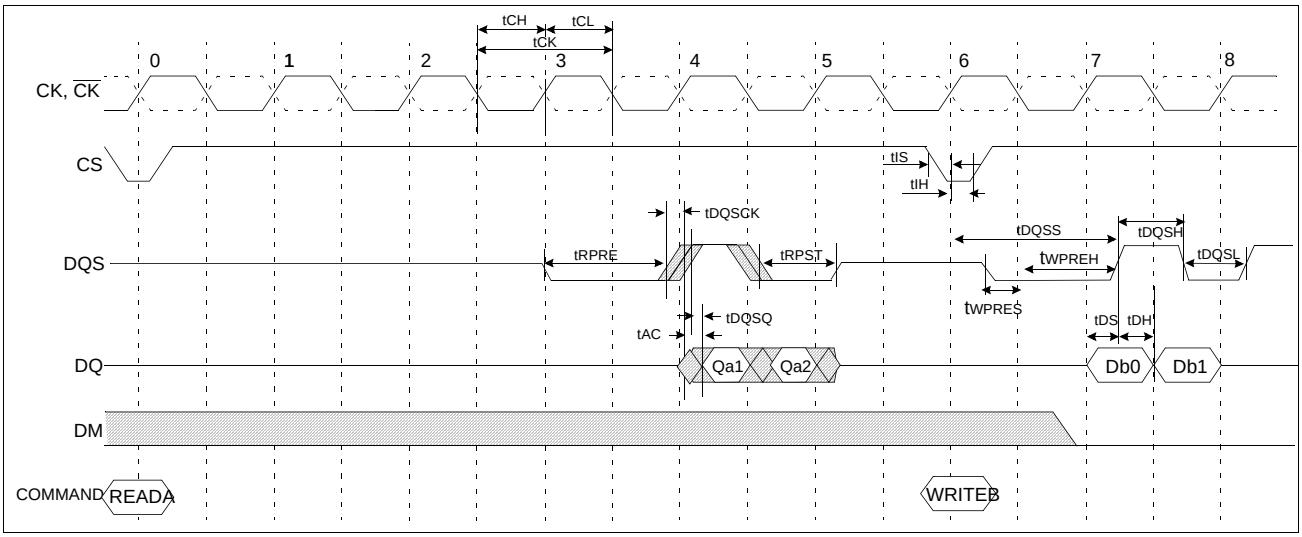
Parameter	Symbol	Value	Unit
Decoupling Capacitance between V_{DD} and V_{SS}	C_{DC1}	0.1 + 0.01	uF
Decoupling Capacitance between V_{DDQ} and V_{SSQ}	C_{DC2}	0.1 + 0.01	uF

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 other
All V_{SS} pins are connected in chip. All V_{SSQ} pins are connected in chip.

AC CHARACTERISTICS

Parameter		Sym-bol	-33		-36		-40		-50		Unit	Note
			Min	Max	Min	Max	Min	Max	Min	Max		
CK cycle time	CL=3	t_{CK}	-	10	-	10	-	10	5.0	10	ns	
	CL=4		3.3		3.6		4.0		-		ns	
CK high level width		t_{CH}	0.45	0.55	0.45	0.55	0.45	0.55	0.45	0.55	tCK	
CK low level width		t_{CL}	0.45	0.55	0.45	0.55	0.45	0.55	0.45	0.55	tCK	
DQS out access time from CK		t_{DQSCK}	-0.6	0.6	-0.6	0.6	-0.6	0.6	-0.7	0.7	ns	
Output access time from CK		t_{AC}	-0.6	0.6	-0.6	0.6	-0.6	0.6	-0.7	0.7	ns	
Data strobe edge to Dout edge		t_{DQSQ}	-	0.35	-	0.40	-	0.4	-	0.45	ns	1
Read preamble		t_{RPRE}	0.9	1.1	0.9	1.1	0.9	1.1	0.9	1.1	tCK	
Read postamble		t_{RPST}	0.4	0.6	0.4	0.6	0.4	0.6	0.4	0.6	tCK	
CK to valid DQS-in		t_{DQSS}	0.85	1.15	0.85	1.15	0.85	1.15	0.8	1.2	tCK	
DQS-In setup time		t_{WPRES}	0	-	0	-	0	-	0	-	ns	
DQS-in hold time		t_{WPREH}	0.35	-	0.35	-	0.35	-	0.3	-	tCK	
DQS write postamble		t_{WPST}	0.4	0.6	0.4	0.6	0.4	0.6	0.4	0.6	tCK	
DQS-In high level width		t_{DQSH}	0.4	0.6	0.4	0.6	0.4	0.6	0.4	0.6	tCK	
DQS-In low level width		t_{DQSL}	0.4	0.6	0.4	0.6	0.4	0.6	0.4	0.6	tCK	
Address and Control input setup		t_{IS}	0.9	-	0.9	-	0.9	-	1.0	-	ns	
Address and Control input hold		t_{IH}	0.9	-	0.9	-	0.9	-	1.0	-	ns	
DQ and DM setup time to DQS		t_{DS}	0.35	-	0.40	-	0.4	-	0.45	-	ns	
DQ and DM hold time to DQS		t_{DH}	0.35	-	0.40	-	0.4	-	0.45	-	ns	
Clock half period		t_{HP}	tCLmin or tCHmin	-	tCLmin or tCHmin	-	tCLmin or tCHmin	-	tCLmin or tCHmin	-	ns	1
Data output hold time from DQS		t_{QH}	tHP-0.35	-	tHP-0.4	-	tHP-0.4	-	tHP-0.45	-	ns	1

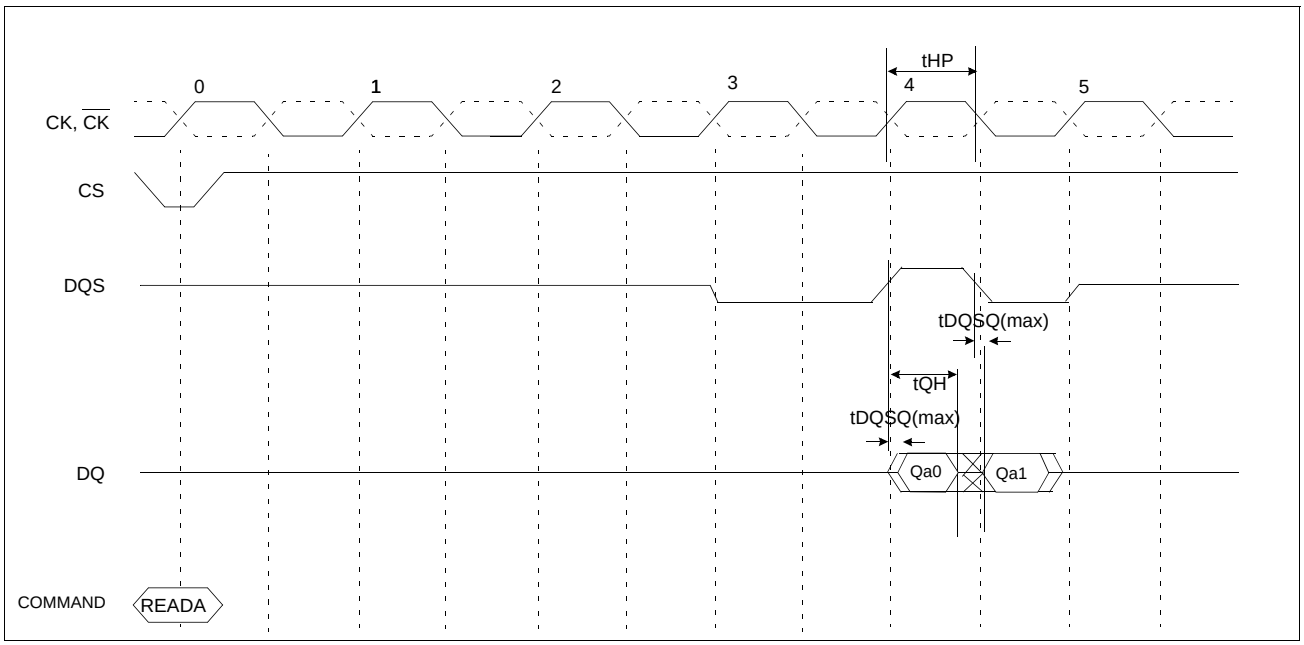
Simplified Timing @ BL=2, CL=4



Note 1 :

- The JEDEC GDDR 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 vaild 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 difined 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)



AC CHARACTERISTICS (I)

Parameter	Sym-bol	-33		-36		-40		-50		Unit	Note
		Min	Max	Min	Max	Min	Max	Min	Max		
Row cycle time	tRC	14	-	14	-	13	-	12	-	tCK	
Refresh row cycle time	tRFC	17	-	17	-	15	-	14	-	tCK	
Row active time	tRAS	9	100K	9	100K	9	100K	8	100K	tCK	
RAS to CAS delay for Read	tRCDRD	4	-	4	-	4	-	4	-	tCK	
RAS to CAS delay for Write	tRCDW	2	-	2	-	2	-	2	-	tCK	
Row precharge time	tRP	5	-	5	-	4	-	4	-	tCK	
Row active to Row active	tRRD	3	-	3	-	3	-	3	-	tCK	
Last data in to Row precharge @Normal Precharge	tWR	3	-	3	-	3	-	3	-	tCK	1
Last data in to Row precharge @Auto Precharge	tWR_A	3	-	3	-	3	-	3	-	tCK	1
Last data in to Read command	tCDLR	3	-	2	-	2	-	2	-	tCK	1
Col. address to Col. address	tCCD	1	-	1	-	1	-	1	-	tCK	
Mode register set cycle time	tMRD	2	-	2	-	2	-	2	-	tCK	
Auto precharge write recovery + Precharge	tDAL	8	-	8	-	7	-	7	-	tCK	
Exit self refresh to read command	tXSR	200	-	200	-	200	-	200	-	tCK	
Power down exit time	tPDEX	3tCK+tIS	-	3tCK+tIS	-	3tCK+tIS	-	3tCK+tIS	-	ns	
Refresh interval time	tREF	7.8	-	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)

K4D553238E-JC33

Frequency	Cas Latency	tRC	tRFC	tRAS	tRCDRD	tRCDWR	tRP	tRRD	tDAL	Unit
300MHz (3.3ns)	4	14	17	9	4	2	5	3	8	tCK
275MHz (3.6ns)	4	14	17	9	4	2	5	3	8	tCK
250MHz (4.0ns)	4	13	15	9	4	2	4	3	7	tCK
200MHz (5.0ns)	3	12	14	8	4	2	4	3	7	tCK

K4D553238E-JC36

Frequency	Cas Latency	tRC	tRFC	tRAS	tRCDRD	tRCDWR	tRP	tRRD	tDAL	Unit
275MHz (3.6ns)	4	14	17	9	4	2	5	3	8	tCK
250MHz (4.0ns)	4	13	15	9	4	2	4	3	7	tCK
200MHz (5.0ns)	3	12	14	8	4	2	4	3	7	tCK

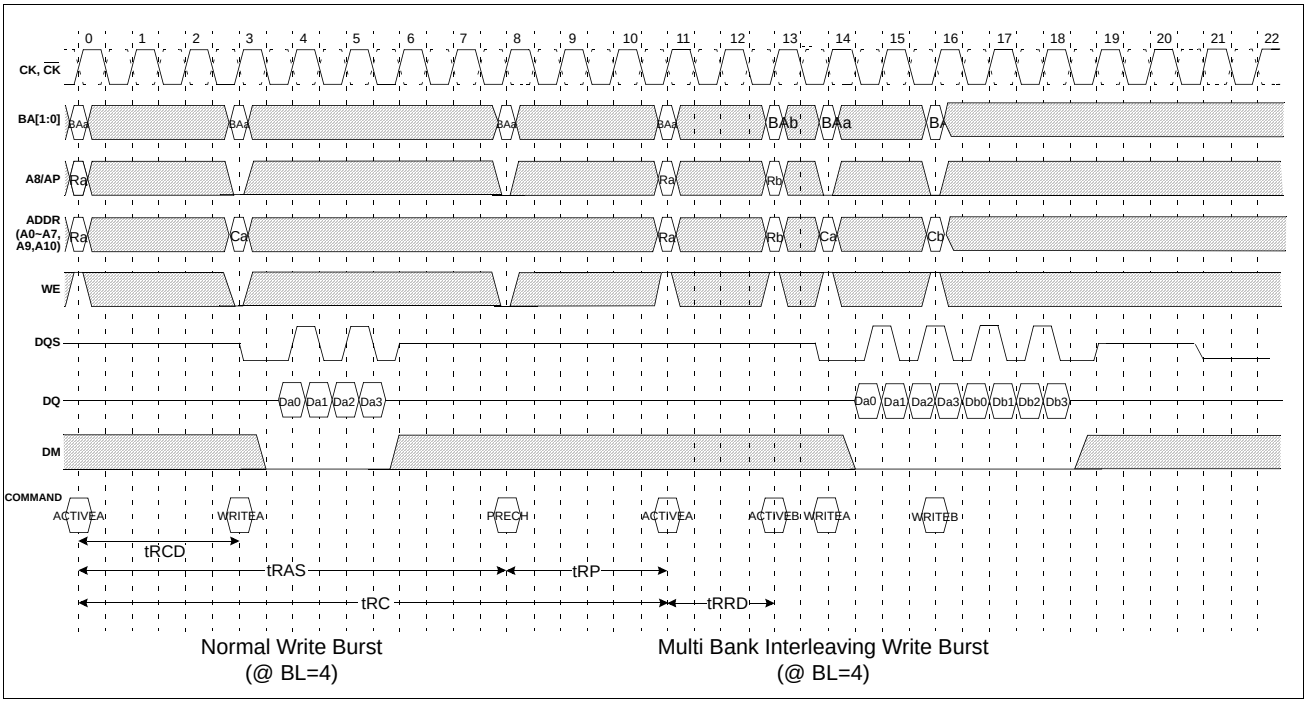
K4D553238E-JC40

Frequency	Cas Latency	tRC	tRFC	tRAS	tRCDRD	tRCDWR	tRP	tRRD	tDAL	Unit
250MHz (4.0ns)	4	13	15	9	4	2	4	3	7	tCK
200MHz (5.0ns)	3	12	14	8	4	2	4	3	7	tCK

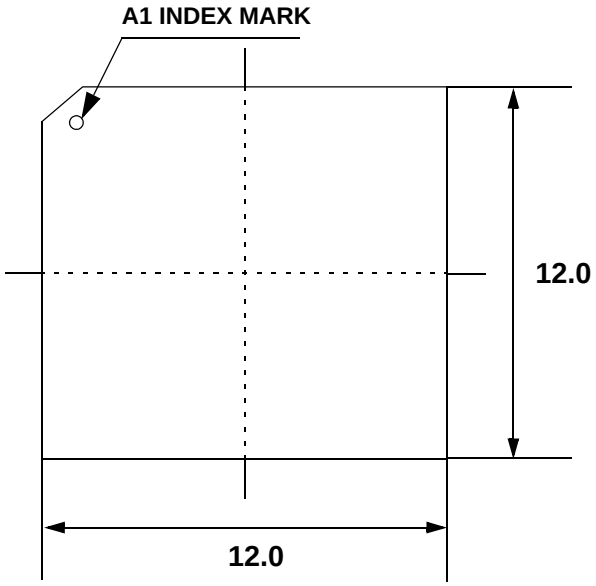
K4D553238E-JC50

Frequency	Cas Latency	tRC	tRFC	tRAS	tRCDRD	tRCDWR	tRP	tRRD	tDAL	Unit
200MHz (5.0ns)	3	12	14	8	4	2	4	3	7	tCK

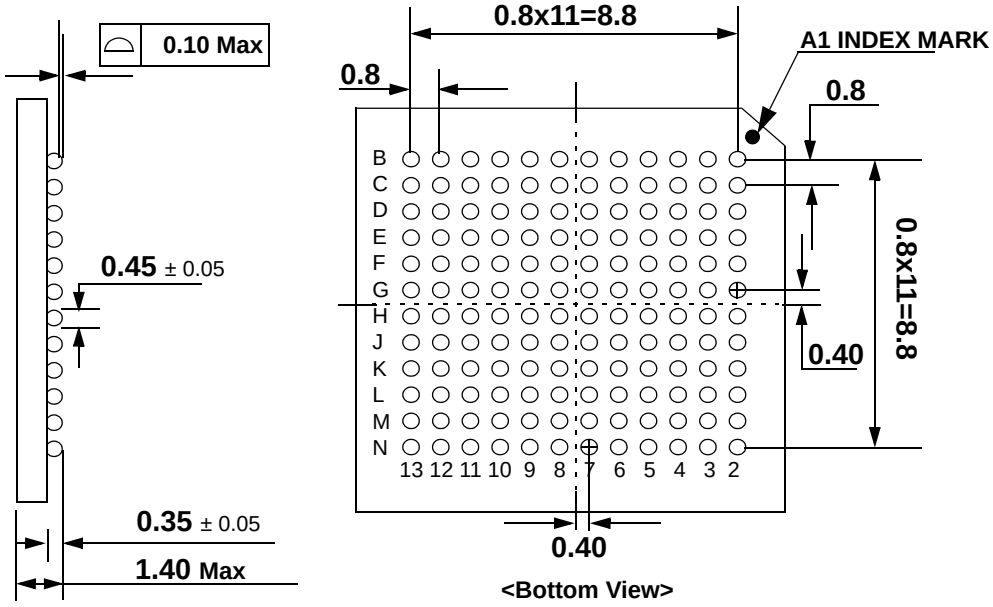
Simplified Timing(2) @ BL=4



PACKAGE DIMENSIONS (144-Ball FBGA)



<Top View>



<Bottom View>

Unit : mm