

## Key Features

- Double-data-rate architecture; two data transfers per clock cycle
- Bidirectional data strobe(DQS)
- Four banks operation
- Differential clock inputs(CK and  $\overline{CK}$ )
- DLL aligns DQ and DQS transition with CK transition
- MRS cycle with address key programs
  - . Read latency 2, 2.5 (clock)
  - . Burst length (2, 4, 8)
  - . Burst type (sequential & interleave)
- All inputs except data & DM are sampled at the positive going edge of the system clock(CK)
- Data I/O transactions on both edges of data strobe
- Edge aligned data output, center aligned data input
- LDM,UDM/DM for write masking only
- Auto & Self refresh
- 7.8us refresh interval(8K/64ms refresh)
- Maximum burst refresh cycle : 8
- 60 Ball FBGA package

## ORDERING INFORMATION

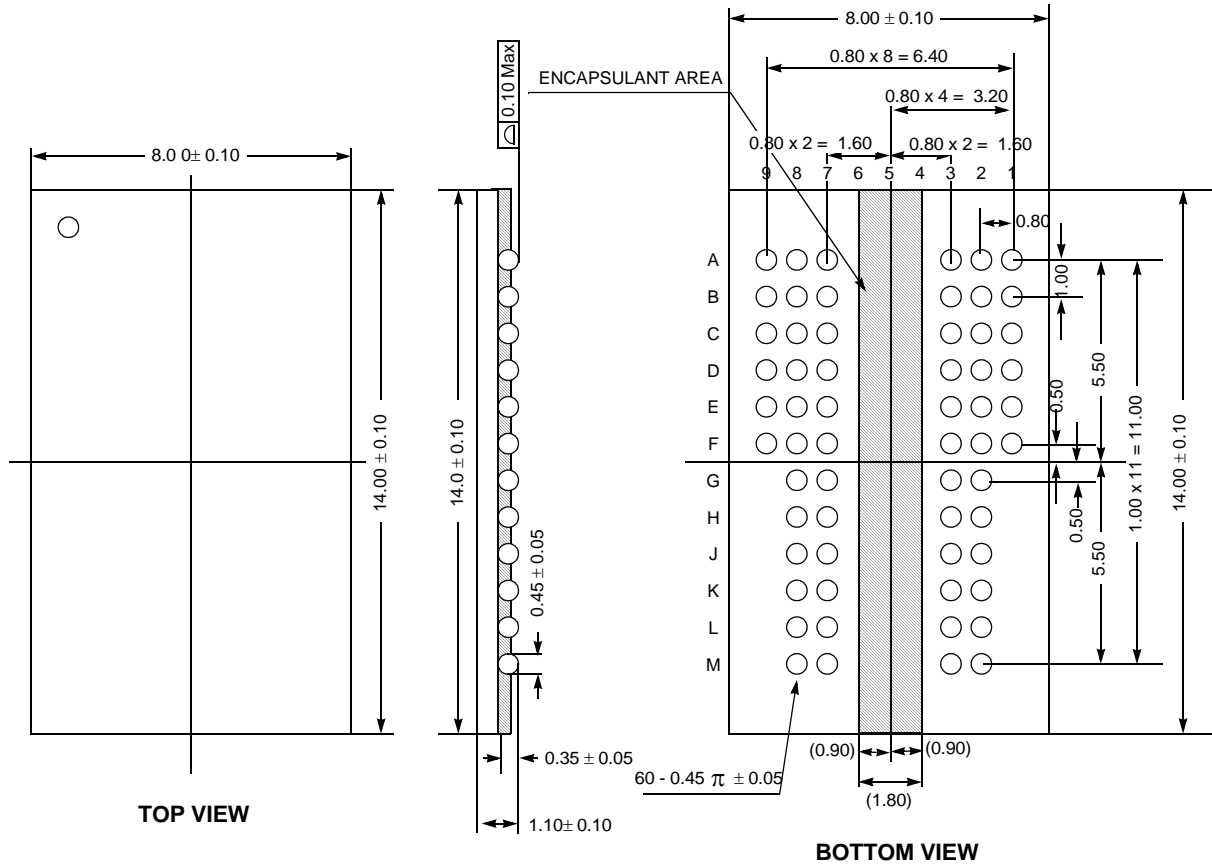
Part No.	Org.	Max Freq.	Interface	Package
K4H560438D-GC(L)B3	64M x 4	B3(DDR333@CL=2.5)	SSTL2	60 ball FBGA
K4H560438D-GC(L)A2		A2(DDR266@CL=2)		
K4H560438D-GC(L)B0		B0(DDR266@CL=2.5)		
K4H560838D-GC(L)B3	32M x 8	B3(DDR333@CL=2.5)	SSTL2	60 ball FBGA
K4H560838D-GC(L)A2		A2(DDR266@CL=2)		
K4H560838D-GC(L)B0		B0(DDR266@CL=2.5)		
K4H561638D-GC(L)B3	16M x 16	B3(DDR333@CL=2.5)	SSTL2	60 ball FBGA
K4H561638D-GC(L)A2		A2(DDR266@CL=2)		
K4H561638D-GC(L)B0		B0(DDR266@CL=2.5)		

## Operating Frequencies

	- B3(DDR333)	- A2(DDR266A)	- B0(DDR266B)
Speed @CL2	133MHz	133MHz	100MHz
Speed @CL2.5	166MHz	133MHz	133MHz

\*CL : Cas Latency

Package Dimension



Organization	Column Address
64Mx4	A0-A9, A11
32Mx8	A0-A9
16Mx16	A0-A8

DM is internally loaded to match DQ and DQS identically.

Column address configuration

Pin configuration

64M x 4

60Ball CSP												
	A	B	C	D	E	F	G	H	J	K	L	M
1	VSSQ	NC	NC	NC	NC	VREF						
2	NC	VDDQ	VSSQ	VDDQ	VSSQ	VSS	CK	A12	A11	A8	A6	A4
3	VSS	DQ3	NC	DQ2	DQS	DM	$\overline{CK}$	CKE	A9	A7	A5	VSS
7	VDD	DQ0	NC	DQ1	NC	NC	$\overline{WE}$	$\overline{RAS}$	BA1	A0	A2	VDD
8	NC	VSSQ	VDDQ	VSSQ	VDDQ	VDD	$\overline{CAS}$	$\overline{CS}$	BA0	A10	A1	A3
9	VDDQ	NC	NC	NC	NC	NC						

32M x 8

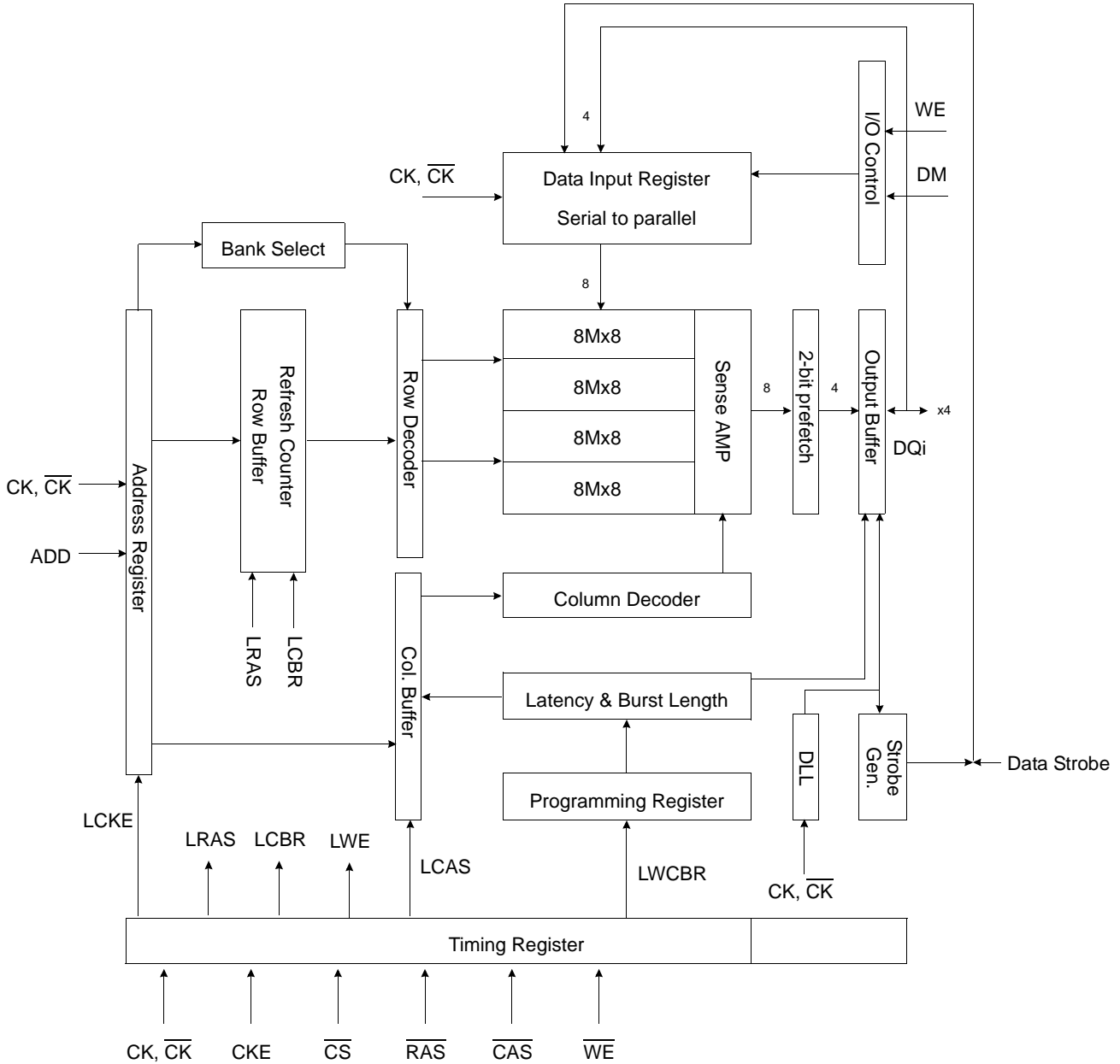
60Ball CSP												
	A	B	C	D	E	F	G	H	J	K	L	M
1	VSSQ	NC	NC	NC	NC	VREF						
2	DQ7	VDDQ	VSSQ	VDDQ	VSSQ	VSS	CK	A12	A11	A8	A6	A4
3	VSS	DQ6	DQ5	DQ4	DQS	DM	$\overline{CK}$	CKE	A9	A7	A5	VSS
7	VDD	DQ1	DQ2	DQ3	NC	NC	$\overline{WE}$	$\overline{RAS}$	BA1	A0	A2	VDD
8	DQ0	VSSQ	VDDQ	VSSQ	VDDQ	VDD	$\overline{CAS}$	$\overline{CS}$	BA0	A10	A1	A3
9	VDDQ	NC	NC	NC	NC	NC						

16M x 16

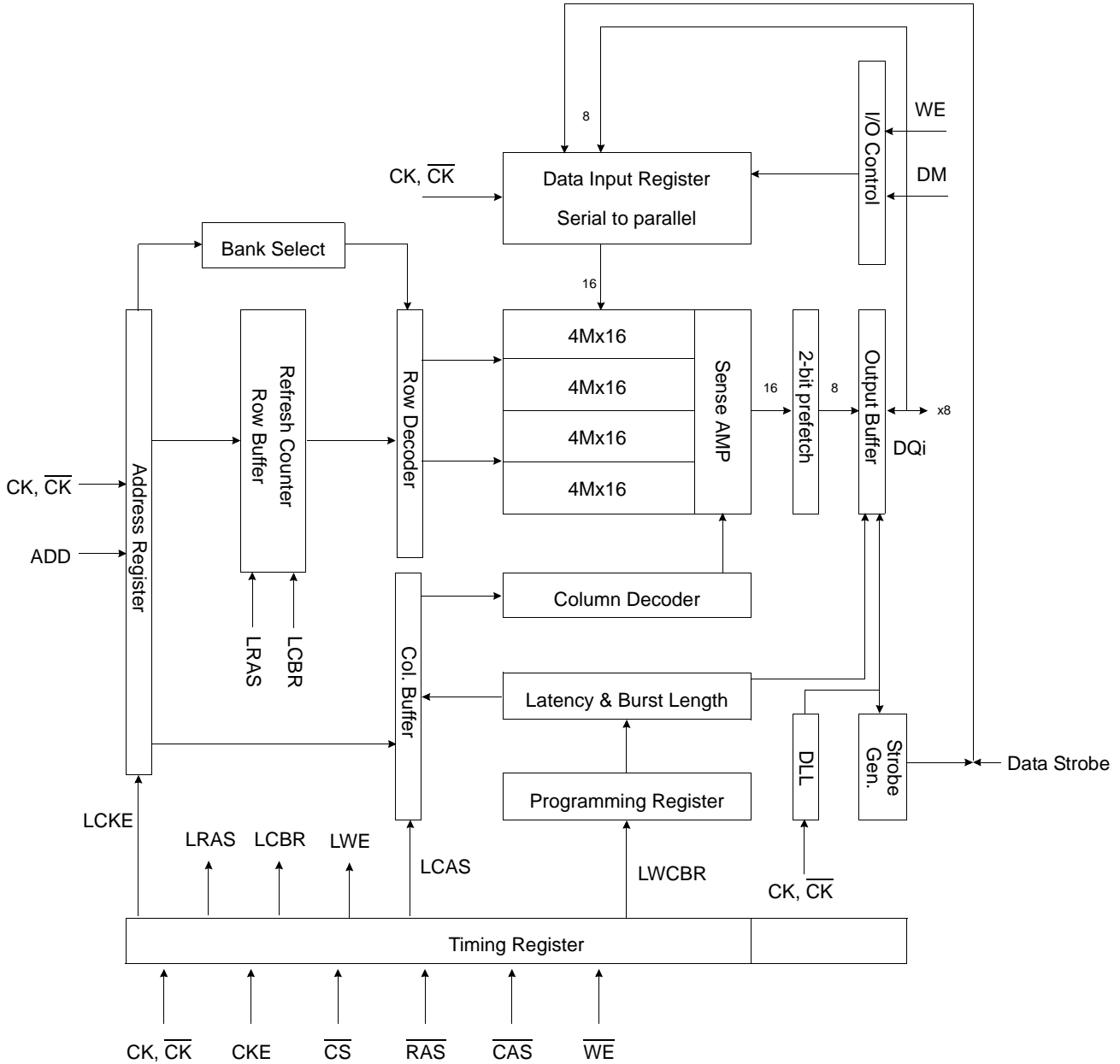
60Ball CSP												
	A	B	C	D	E	F	G	H	J	K	L	M
1	VSSQ	DQ14	DQ12	DQ10	DQ8	VREF						
2	DQ15	VDDQ	VSSQ	VDDQ	VSSQ	VSS	CK	A12	A11	A8	A6	A4
3	VSS	DQ13	DQ11	DQ9	UDQS	UDM	$\overline{CK}$	CKE	A9	A7	A5	VSS
7	VDD	DQ2	DQ4	DQ6	LDQS	LDM	$\overline{WE}$	$\overline{RAS}$	BA1	A0	A2	VDD
8	DQ0	VSSQ	VDDQ	VSSQ	VDDQ	VDD	$\overline{CAS}$	$\overline{CS}$	BA0	A10	A1	A3
9	VDDQ	DQ1	DQ3	DQ5	DQ7	NC						

Pin Name	Pin Function
CLK	System Clock
$\overline{CS}$	Chip Select
CKE	Clock Enable
A0 ~ A12	Address
BA0 ~ BA1	Bank Select Address
$\overline{RAS}$	Row Address Strobe
$\overline{CAS}$	Column Address Strobe
$\overline{WE}$	Write Enable
L(U)DQM	Data Input/Output Mask
DQ0 ~ 15	Data Input/Output
V <sub>DD</sub> /V <sub>SS</sub>	Power Supply/Ground
V <sub>DDQ</sub> /V <sub>SSQ</sub>	Data Output Power/Ground

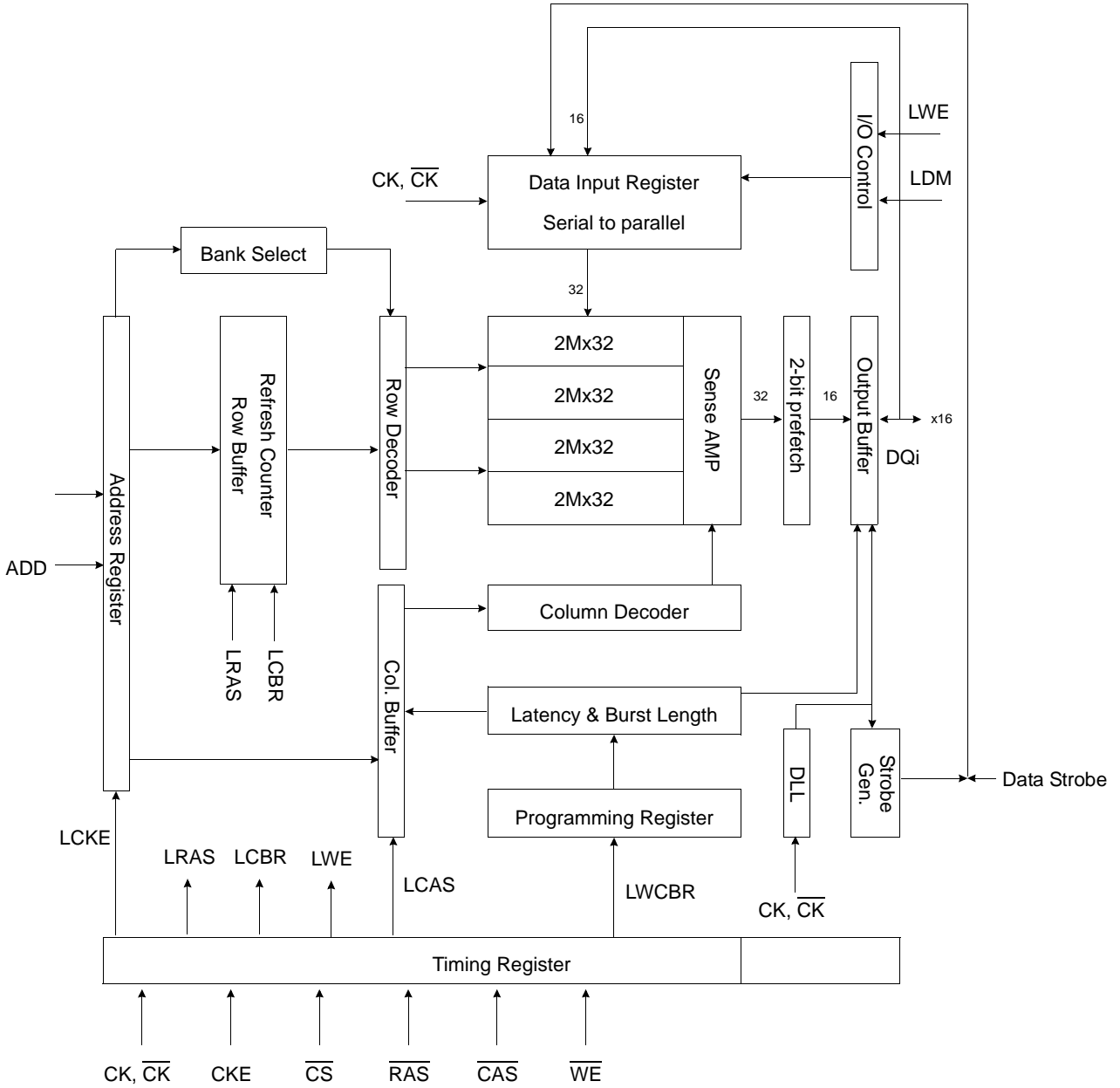
Block Diagram (16Mbit x 4 I/O x 4 Banks)



Block Diagram (8Mbit x 8 I/O x 4 Banks)



Block Diagram (4Mbit x 16 I/O x 4 Banks)



## Input/Output Function Description

SYMBOL	TYPE	DESCRIPTION
CK, $\overline{CK}$	Input	Clock : CK and $\overline{CK}$ are differential clock inputs. All address and control input signals are sampled on the positive edge of CK and negative edge of $\overline{CK}$ . Output (read) data is referenced to both edges of CK. Internal clock signals are derived from CK/ $\overline{CK}$ .
CKE	Input	Clock Enable : CKE HIGH activates, and CKE LOW deactivates internal clock signals, and device input buffers and output drivers. Deactivating the clock provides PRECHARGE POWER-DOWN and SELF REFRESH operation (all banks idle), or ACTIVE POWER-DOWN (row ACTIVE in any bank). CKE is synchronous for all functions except for disabling outputs, which is achieved asynchronously. Input buffers, excluding CK, $\overline{CK}$ and CKE are disabled during power-down and self refresh modes, providing low standby power. CKE will recognize an LVCMOS LOW level prior to VREF being stable on power-up.
$\overline{CS}$	Input	Chip Select : $\overline{CS}$ enables (registered LOW) and disables (registered HIGH) the command decoder. All commands are masked when CS is registered HIGH. $\overline{CS}$ provides for external bank selection on systems with multiple banks. CS is considered part of the command code.
$\overline{RAS}$ , $\overline{CAS}$ , $\overline{WE}$	Input	Command Inputs : $\overline{RAS}$ , $\overline{CAS}$ and $\overline{WE}$ (along with $\overline{CS}$ ) define the command being entered.
LDM,(U)DM	Input	Input Data Mask : DM is an input mask signal for write data. Input data is masked when DM is sampled HIGH along with that input data during a WRITE access. DM is sampled on both edges of DQS. DM pins include dummy loading internally, to matches the DQ and DQS loading. For the x16, LDM corresponds to the data on DQ0-DQ7 ; UDM corresponds to the data on DQ8-DQ15.
BA0, BA1	Input	Bank Address Inputs : BA0 and BA1 define to which bank an ACTIVE, READ, WRITE or PRECHARGE command is being applied.
A [n : 0]	Input	Address Inputs : Provide the row address for ACTIVE commands, and the column address and AUTO PRECHARGE bit for READ/WRITE commands, to select one location out of the memory array in the respective bank. A10 is sampled during a PRECHARGE command to determine whether the PRECHARGE applies to one bank (A10 LOW) or all banks (A10 HIGH). If only one bank is to be precharged, the bank is selected by BA0, BA1. The address inputs also provide the op-code during a MODE REGISTER SET command. BA0 and BA1 define which mode register is loaded during the MODE REGISTER SET command (MRS or EMRS).
DQ	I/O	Data Input/Output : Data bus
LDQS,(U)DQS	I/O	Data Strobe : Output with read data, input with write data. Edge-aligned with read data, centered in write data. Used to capture write data. For the x16, LDQS corresponds to the data on DQ0-DQ7 ; UDQS corresponds to the data on DQ8-DQ15.
NC	-	No Connect : No internal electrical connection is present.
V <sub>DDQ</sub>	Supply	DQ Power Supply : +2.5V ± 0.2V.
V <sub>SSQ</sub>	Supply	DQ Ground.
V <sub>DD</sub>	Supply	Power Supply : +2.5V ± 0.2V (device specific).
V <sub>SS</sub>	Supply	Ground.
VREF	Input	SSTL_2 reference voltage.

## Command Truth Table

(V=Valid, X=Don't Care, H=Logic High, L=Logic Low)

COMMAND		CKEn-1	CKEn	$\overline{CS}$	$\overline{RAS}$	$\overline{CAS}$	$\overline{WE}$	BA0,1	A10/AP	A11,A12 A9 ~ A0	Note	
Register	Extended MRS	H	X	L	L	L	L	OP CODE			1, 2	
Register	Mode Register Set	H	X	L	L	L	L	OP CODE			1, 2	
Refresh	Auto Refresh	H	H	L	L	L	H	X			3	
			L								3	
	Self Refresh	L	H	L	H	H	H	X			3	
				H	X	X	X				3	
Bank Active & Row Address		H	X	L	L	H	H	V	Row Address			
Read & Column Address	Auto Precharge Disable	H	X	L	H	L	H	V	L	Column Address		4
	Auto Precharge Enable								H			4
Write & Column Address	Auto Precharge Disable	H	X	L	H	L	L	V	L	Column Address		4
	Auto Precharge Enable								H			4, 6
Burst Stop		H	X	L	H	H	L	X			7	
Precharge	Bank Selection	H	X	L	L	H	L	V	L	X		
	All Banks							X	H			5
Active Power Down	Entry	H	L	H	X	X	X	X				
				L	V	V	V					
Precharge Power Down Mode	Entry	H	L	H	X	X	X	X				
				L	H	H	H					
	Exit	L	H	H	X	X	X					
				L	V	V	V					
DM		H		X				X			8	
No operation (NOP) : Not defined		H	X	H	X	X	X	X			9	
				L	H	H	H				9	

1. OP Code : Operand Code. A0 ~ A12 & BA0 ~ BA1 : Program keys. (@EMRS/MRS)

2. EMRS/ MRS can be issued only at all banks precharge state.

A new command can be issued 2 clock cycles after EMRS or MRS.

3. Auto refresh functions are same as the CBR refresh of DRAM.

The automatical precharge without row precharge command is meant by "Auto".

Auto/self refresh can be issued only at all banks precharge state.

4. BA0 ~ BA1 : Bank select addresses.

If both BA0 and BA1 are "Low" at read, write, row active and precharge, bank A is selected.

If BA0 is "High" and BA1 is "Low" at read, write, row active and precharge, bank B is selected.

If BA0 is "Low" and BA1 is "High" at read, write, row active and precharge, bank C is selected.

If both BA0 and BA1 are "High" at read, write, row active and precharge, bank D is selected.

5. If A10/AP is "High" at row precharge, BA0 and BA1 are ignored and all banks are selected.

6. During burst write with auto precharge, new read/write command can not be issued.

Another bank read/write command can be issued after the end of burst.

New row active of the associated bank can be issued at tRP after the end of burst.

7. Burst stop command is valid at every burst length.

8. DM sampled at the rising and falling edges of the DQS and Data-in are masked at the both edges (Write DM latency is 0).

9. This combination is not defined for any function, which means "No Operation(NOP)" in DDR SDRAM.



**16M x 4Bit x 4 Banks Double Data Rate SDRAM****GENERAL DESCRIPTION**

The K4H560438D is 268,435,456 bits of double data rate synchronous DRAM organized as 4 x 16,777,216 words by 4 bits, fabricated with SAMSUNG's high performance CMOS technology. Synchronous features with Data Strobe allow extremely high performance up to 333Mb/s per pin. I/O transactions are possible on both edges of DQS. 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.

**Absolute Maximum Rating**

Parameter	Symbol	Value	Unit
Voltage on any pin relative to VSS	VIN, VOUT	-0.5 ~ 3.6	V
Voltage on VDD & VDDQ supply relative to VSS	VDD, VDDQ	-1.0 ~ 3.6	V
Storage temperature	TSTG	-55 ~ +150	°C
Power dissipation	PD	1.5	W
Short circuit current	IOS	50	mA

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

**DC Operating Conditions**

Recommended operating conditions(Voltage referenced to Vss=0V, TA= 0 to 70°C)

Parameter	Symbol	Min	Max	Unit	Note
Supply voltage(for device with a nominal VDD of 2.5V)	VDD	2.3	2.7		
I/O Supply voltage	VDDQ	2.3	2.7	V	
I/O Reference voltage	VREF	VDDQ/2-50mV	VDDQ/2+50mV	V	1
I/O Termination voltage(system)	VTT	VREF-0.04	VREF+0.04	V	2
Input logic high voltage	V <sub>IH</sub> (DC)	VREF+0.15	VDDQ+0.3	V	4
Input logic low voltage	V <sub>IL</sub> (DC)	-0.3	VREF-0.15	V	4
Input Voltage Level, CK and $\overline{\text{CK}}$ inputs	V <sub>IN</sub> (DC)	-0.3	VDDQ+0.3	V	
Input Differential Voltage, CK and $\overline{\text{CK}}$ inputs	V <sub>ID</sub> (DC)	0.3	VDDQ+0.6	V	3
Input crossing point voltage, CK and $\overline{\text{CK}}$ inputs	V <sub>IX</sub> (DC)	1.15	1.35	V	5
Input leakage current	I <sub>I</sub>	-2	2	uA	
Output leakage current	I <sub>OZ</sub>	-5	5	uA	
Output High Current(Normal strength driver) ;V <sub>OUT</sub> = V <sub>TT</sub> + 0.84V	I <sub>OH</sub>	-16.8		mA	
Output High Current(Normal strength driver) ;V <sub>OUT</sub> = V <sub>TT</sub> - 0.84V	I <sub>OL</sub>	16.8		mA	
Output High Current(Half strength driver) ;V <sub>OUT</sub> = V <sub>TT</sub> + 0.45V	I <sub>OH</sub>	-9		mA	
Output High Current(Half strength driver) ;V <sub>OUT</sub> = V <sub>TT</sub> - 0.45V	I <sub>OL</sub>	9		mA	

- Notes 1. Includes  $\pm 25\text{mV}$  margin for DC offset on VREF, and a combined total of  $\pm 50\text{mV}$  margin for all AC noise and DC offset on VREF, bandwidth limited to 20MHz. The DRAM must accommodate DRAM current spikes on VREF and internal DRAM noise coupled TO VREF, both of which may result in VREF noise. VREF should be de-coupled with an inductance of  $\leq 3\text{nH}$ .
2.  $V_{TT}$  is not applied directly to the device.  $V_{TT}$  is a system supply for signal termination resistors, is expected to be set equal to VREF, and must track variations in the DC level of VREF
3. VID is the magnitude of the difference between the input level on CK and the input level on  $\overline{\text{CK}}$ .
4. These parameters should be tested at the pin on actual components and may be checked at either the pin or the pad in simulation. The AC and DC input specifications are relative to a VREF envelop that has been bandwidth limited to 200MHZ.
5. The value of VIX is expected to equal  $0.5 \cdot V_{DDQ}$  of the transmitting device and must track variations in the dc level of the same.

**DDR SDRAM IDD spec table**

(VDD=2.7V, T = 10°C)

Symbol	64Mx4		Unit	Notes
	K4H560438D-GC(L)B3 (DDR333)	K4H560438D-GC(L)A2,B0 (DDR266A/B)		
IDD0	90	80	mA	
IDD1	110	100	mA	
IDD2P	3	3	mA	
IDD2F	25	20	mA	
IDD2Q	20	18	mA	
IDD3P	35	30	mA	
IDD3N	55	45	mA	
IDD4R	150	120	mA	
IDD4W	160	135	mA	
IDD5	180	165	mA	
IDD6	Normal	3	mA	
	Low power	1.5	mA	Optional
IDD7A	290	250	mA	

**AC Operating Conditions**

Parameter/Condition	Symbol	Min	Max	Unit	Note
Input High (Logic 1) Voltage, DQ, DQS and DM signals	VIH(AC)	VREF + 0.31		V	3
Input Low (Logic 0) Voltage, DQ, DQS and DM signals.	VIL(AC)		VREF - 0.31	V	3
Input Differential Voltage, CK and $\overline{\text{CK}}$ inputs	VID(AC)	0.7	VDDQ+0.6	V	1
Input Crossing Point Voltage, CK and $\overline{\text{CK}}$ inputs	VIX(AC)	$0.5 \cdot V_{DDQ} - 0.2$	$0.5 \cdot V_{DDQ} + 0.2$	V	2

- Note 1. VID is the magnitude of the difference between the input level on CK and the input on  $\overline{\text{CK}}$ .
2. The value of VIX is expected to equal  $0.5 \cdot V_{DDQ}$  of the transmitting device and must track variations in the DC level of the same.
3. These parameters should be tested at the pim on actual components and may be checked at either the pin or the pad in simulation. the AC and DC input specifacitims are refation to a Vref envelope that has been bandwidth limited 20MHz.

**Overshoot/Undershoot specification**

Parameter	Specification	
	Address & Control pins	Data pins
Maximum peak amplitude allowed for overshoot	1.6 V	1.2V
Maximum peak amplitude allowed for undershoot	1.6 V	1.2V
The area between the overshoot signal and VDD must be less than or equal to	4.5 V-ns	2.5 V-ns
The area between the undershoot signal and GND must be less than or equal to	4.5 V-ns	2.5 V-ns

## AC Timing Parameters &amp; Specifications

Parameter	Symbol	B3 (DDR333)		A2 (DDR266A)		B0 (DDR266B)		Unit	Note	
		Min	Max	Min	Max	Min	Max			
Row cycle time	tRC	60		65		65		ns		
Refresh row cycle time	tRFC	72		75		75		ns		
Row active time	tRAS	42	70K	45	120K	45	120K	ns		
RAS to CAS delay	tRCD	18		20		20		ns		
Row precharge time	tRP	18		20		20		ns		
Row active to Row active delay	tRRD	12		15		15		ns		
Write recovery time	tWR	15		15		15		ns		
Last data in to Read command	tWTR	1		1		1		tCK		
Col. address to Col. address delay	tCCD	1		1		1		tCK		
Clock cycle time	tCK	CL=2.0	7.5	12	7.5	12	10	12	ns	5
		CL=2.5	6	12	7.5	12	7.5	12	ns	5
Clock high level width	tCH	0.45	0.55	0.45	0.55	0.45	0.55	tCK		
Clock low level width	tCL	0.45	0.55	0.45	0.55	0.45	0.55	tCK		
DQS-out access time from CK/CK	tDQSCK	-0.6	+0.6	-0.75	+0.75	-0.75	+0.75	ns		
Output data access time from CK/CK	tAC	-0.7	+0.7	-0.75	+0.75	-0.75	+0.75	ns		
Data strobe edge to output data edge	tDQSQ	-	0.4	-	0.5	-	0.5	ns	5	
Read Preamble	tRPRE	0.9	1.1	0.9	1.1	0.9	1.1	tCK		
Read Postamble	tRPST	0.4	0.6	0.4	0.6	0.4	0.6	tCK		
CK to valid DQS-in	tDQSS	0.75	1.25	0.75	1.25	0.75	1.25	tCK		
DQS-in setup time	tWPRES	0		0		0		ns	2	
DQS-in hold time	tWPRE	0.25		0.25		0.25		tCK		
DQS falling edge to CK rising-setup time	tDSS	0.2		0.2		0.2		tCK		
DQS falling edge from CK rising-hold time	tDSH	0.2		0.2		0.2		tCK		
DQS-in high level width	tDQSH	0.35		0.35		0.35		tCK		
DQS-in low level width	tDQSL	0.35		0.35		0.35		tCK		
DQS-in cycle time	tDSC	0.9	1.1	0.9	1.1	0.9	1.1	tCK		
Address and Control Input setup time(fast)	tIS	0.75		0.9		0.9		ns	6	
Address and Control Input hold time(fast)	tIH	0.75		0.9		0.9		ns	6	
Address and Control Input setup time(slow)	tIS	0.8		1.0		1.0		ns	6	
Address and Control Input hold time(slow)	tIH	0.8		1.0		1.0		ns	6	
Data-out high impedance time from CK/CK	tHZ	-0.7	+0.7	-0.75	+0.75	-0.75	+0.75	ns		
Data-out low impedance time from CK/CK	tLZ	-0.7	+0.7	-0.75	+0.75	-0.75	+0.75	ns		
Input Slew Rate(for input only pins)	tSL(I)	0.5		0.5		0.5		V/ns	6	
Input Slew Rate(for I/O pins)	tSL(IO)	0.5		0.5		0.5		V/ns	7	
Output Slew Rate(x4,x8)	tSL(O)	1.0	4.5	1.0	4.5	1.0	4.5	V/ns	10	
Output Slew Rate Matching Ratio(rise to fall)	tSLMR	0.67	1.5	0.67	1.5	0.67	1.5			

Parameter	Symbol	-GC(L)B3 (DDR333)		-GC(L)A2 (DDR266A)		-GC(L)B0 (DDR266B)		Unit	Note
		Min	Max	Min	Max	Min	Max		
Mode register set cycle time	tMRD	12		15		15		ns	
DQ & DM setup time to DQS	tDS	0.45		0.5		0.5		ns	7,8,9
DQ & DM hold time to DQS	tDH	0.45		0.5		0.5		ns	7,8,9
Control & Address input pulse width	tIPW	2.2		2.2		2.2		ns	
DQ & DM input pulse width	tDIPW	1.75		1.75		1.75		ns	
Power down exit time	tPDEX	6		7.5		7.5		ns	
Exit self refresh to non-Read command	tXSNR	75		75		75		ns	4
Exit self refresh to read command	tXSRD	200		200		200		tCK	
Refresh interval time	tREFI	7.8		7.8		7.8		us	1
Output DQS valid window	tQH	tHP -tQHS	-	tHP -tQHS	-	tHP -tQHS	-	ns	5
Clock half period	tHP	tCLmin or tCHmin	-	tCLmin or tCHmin	-	tCLmin or tCHmin	-	ns	
Data hold skew factor	tQHS		0.5		0.75		0.75	ns	
DQS write postamble time	tWPST	0.4	0.6	0.4	0.6	0.4	0.6	tCK	3
Active to Read with Auto precharge command	tRAP	18		20		20			
Autoprecharge write recovery + Precharge time	tDAL	(tWR/tCK) + (tRP/tCK)		(tWR/tCK) + (tRP/tCK)		(tWR/tCK) + (tRP/tCK)		tCK	11

1. Maximum burst refresh cycle : 8
2. The specific requirement is that DQS be valid(High or Low) on or before this CK edge. The case shown(DQS going from High\_Z to logic Low) applies when no writes were previously in progress on the bus. If a previous write was in progress, DQS could be High at this time, depending on tDQSS.
3. The maximum limit for this parameter is not a device limit. The device will operate with a great value for this parameter, but system performance (bus turnaround) will degrade accordingly.
4. A write command can be applied with tRCD satisfied after this command.
5. For registered DIMMs, tCL and tCH are ≥ 45% of the period including both the half period jitter (tJIT(HP)) of the PLL and the half period jitter due to crosstalk (tJIT(crosstalk)) on the DIMM.
6. Input Setup/Hold Slew Rate Derating

Input Setup/Hold Slew Rate	ΔtIS	ΔtIH
(V/ns)	(ps)	(ps)
0.5	0	0
0.4	+50	+50
0.3	+100	+100

This derating table is used to increase t<sub>IS</sub>/t<sub>IH</sub> in the case where the input slew rate is below 0.5V/ns. Input setup/hold slew rate based on the lesser of AC-AC slew rate and DC-DC slew rate.

7. I/O Setup/Hold Slew Rate Derating

I/O Setup/Hold Slew Rate	ΔtDS	ΔtDH
(V/ns)	(ps)	(ps)
0.5	0	0
0.4	+75	+75
0.3	+150	+150

This derating table is used to increase t<sub>DS</sub>/t<sub>DH</sub> in the case where the I/O slew rate is below 0.5V/ns. I/O setup/hold slew rate based on the lesser of AC-AC slew rate and DC-DC slew rate.

8. I/O Setup/Hold Plateau Derating

I/O Input Level	$\Delta t_{DS}$	$\Delta t_{DH}$
(mV)	(ps)	(ps)
$\pm 280$	+50	+50

This derating table is used to increase  $t_{DS}/t_{DH}$  in the case where the input level is flat below  $V_{REF} \pm 310mV$  for a duration of up to 2ns.

9. I/O Delta Rise/Fall Rate(1/slew-rate) Derating

Delta Rise/Fall Rate	$\Delta t_{DS}$	$\Delta t_{DH}$
(ns/V)	(ps)	(ps)
0	0	0
$\pm 0.25$	+50	+50
$\pm 0.5$	+100	+100

This derating table is used to increase  $t_{DS}/t_{DH}$  in the case where the DQ and DQS slew rates differ. The Delta Rise/Fall Rate is calated as  $1/SlewRate1-1/SlewRate2$ . For example, if slew rate 1 = 5V/ns and slew rate 2 = .4V/ns then the Delta Rise/Fall Rate =-0/5ns/V. Input S/H slew rate based on larger of AC-AC delta rise/fall rate and DC-DC delta rise/fall rate.

10. This parameter is fir system simulation purpose. It is guranteed by design.

11. For each of the terms, if not already an integer, round to the next highest integer. tCK is actual to the system clock cycle time.

**<Reference>**

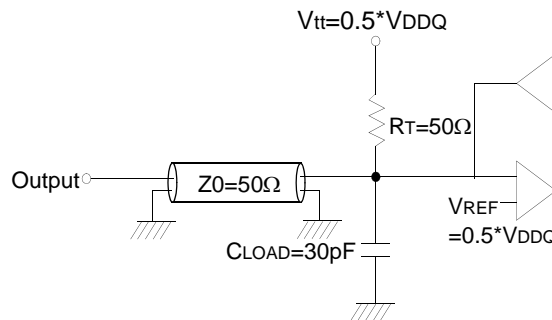
The following table specifies derating values for the specifications listed if the single-ended clock skew rate is less than 1.0V/ns.

CK slew rate (Single ended)	$\Delta t_{IH}/t_{IS}$ (ps)	$\Delta t_{DSS}/t_{DSH}$ (ps)	$\Delta t_{AC}/t_{DQSCK}$ (ps)	$\Delta t_{LZ}(\min)$ (ps)	$\Delta t_{HZ}(\max)$ (ps)
1.0V/ns	0	0	0	0	0
0.75V/ns	+50	+50	+50	-50	+50
0.5V/ns	+100	+100	+100	-100	+100

**AC Operating Test Conditions**

(VDD=2.5V, VDDQ=2.5V, TA= 0 to 70°C)

Parameter	Value	Unit	Note
Input reference voltage for Clock	0.5 * VDDQ	V	
Input signal maximum peak swing	1.5	V	
Input signal minimum slew rate (for input only)	0.5	V/ns	
Input slew rate (I/O pins)	0.5	V/ns	
Input Levels(VIH/VIL)	VREF+0.31/VREF-0.31	V	
Input timing measurement reference level	VREF	V	
Output timing measurement reference level	Vtt	V	
Output load condition	See Load Circuit		



**Output Load Circuit (SSTL\_2)**

**Input/Output Capacitance**

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

Parameter	Symbol	Min	Max	Delta Cap(max)	Unit
Input capacitance (A0 ~ A12, BA0 ~ BA1, CKE, CS, RAS, CAS, WE)	CIN1	1.5	3.5	0.5	pF
Input capacitance( CK, CK̄ )	CIN2	1.5	3.5	0.25	pF
Data & DQS input/output capacitance	COUT	3.5	5.5	0.5	pF
Input capacitance(DM)	CIN3	3.5	5.5		pF

**8M x 8Bit x 4 Banks Double Data Rate SDRAM****GENERAL DESCRIPTION**

The K4H560838D is 268,435,456 bits of double data rate synchronous DRAM organized as 4 x 8,388,608 words by 8 bits, fabricated with SAMSUNG's high performance CMOS technology. Synchronous features with Data Strobe allow extremely high performance up to 333Mb/s per pin. I/O transactions are possible on both edges of DQS. 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.

**Absolute Maximum Rating**

Parameter	Symbol	Value	Unit
Voltage on any pin relative to VSS	VIN, VOUT	-0.5 ~ 3.6	V
Voltage on VDD & VDDQ supply relative to VSS	VDD, VDDQ	-1.0 ~ 3.6	V
Storage temperature	TSTG	-55 ~ +150	°C
Power dissipation	PD	1.5	W
Short circuit current	IOS	50	mA

**Note :** Permanent device damage may occur if ABSOLUTE MAXIMUM RATINGS are exceeded.

Functional operation should be restricted to recommend operation condition.

Exposure to higher than recommended voltage for extended periods of time could affect device reliability

**DC Operating Conditions**

Recommended operating conditions(Voltage referenced to Vss=0V, TA= 0 to 70°C)

Parameter	Symbol	Min	Max	Unit	Note
Supply voltage(for device with a nominal VDD of 2.5V)	VDD	2.3	2.7		
I/O Supply voltage	VDDQ	2.3	2.7	V	
I/O Reference voltage	VREF	VDDQ/2-50mV	VDDQ/2+50mV	V	1
I/O Termination voltage(system)	V <sub>TT</sub>	VREF-0.04	VREF+0.04	V	2
Input logic high voltage	V <sub>IH</sub> (DC)	VREF+0.15	VDDQ+0.3	V	4
Input logic low voltage	V <sub>IL</sub> (DC)	-0.3	VREF-0.15	V	4
Input Voltage Level, CK and $\overline{\text{CK}}$ inputs	V <sub>IN</sub> (DC)	-0.3	VDDQ+0.3	V	
Input Differential Voltage, CK and $\overline{\text{CK}}$ inputs	V <sub>ID</sub> (DC)	0.3	VDDQ+0.6	V	3
Input crossing point voltage, CK and $\overline{\text{CK}}$ inputs	V <sub>IX</sub> (DC)	1.15	1.35	V	5
Input leakage current	I <sub>I</sub>	-2	2	uA	
Output leakage current	I <sub>OZ</sub>	-5	5	uA	
Output High Current(Normal strength driver) ;V <sub>OUT</sub> = V <sub>TT</sub> + 0.84V	I <sub>OH</sub>	-16.8		mA	
Output High Current(Normal strength driver) ;V <sub>OUT</sub> = V <sub>TT</sub> - 0.84V	I <sub>OL</sub>	16.8		mA	
Output High Current(Half strength driver) ;V <sub>OUT</sub> = V <sub>TT</sub> + 0.45V	I <sub>OH</sub>	-9		mA	
Output High Current(Half strength driver) ;V <sub>OUT</sub> = V <sub>TT</sub> - 0.45V	I <sub>OL</sub>	9		mA	

- Notes 1. Includes  $\pm 25\text{mV}$  margin for DC offset on VREF, and a combined total of  $\pm 50\text{mV}$  margin for all AC noise and DC offset on VREF, bandwidth limited to 20MHz. The DRAM must accommodate DRAM current spikes on VREF and internal DRAM noise coupled TO VREF, both of which may result in VREF noise. VREF should be de-coupled with an inductance of  $\leq 3\text{nH}$ .
2.  $V_{TT}$  is not applied directly to the device.  $V_{TT}$  is a system supply for signal termination resistors, is expected to be set equal to VREF, and must track variations in the DC level of VREF
3. VID is the magnitude of the difference between the input level on CK and the input level on  $\overline{\text{CK}}$ .
4. These parameters should be tested at the pin on actual components and may be checked at either the pin or the pad in simulation. The AC and DC input specifications are relative to a VREF envelop that has been bandwidth limited to 200MHZ.
5. The value of VIX is expected to equal  $0.5 \cdot V_{DDQ}$  of the transmitting device and must track variations in the dc level of the same.

**DDR SDRAM IDD spec table**

(VDD=2.7V, T = 10°C)

Symbol	32Mx8		Unit	Notes
	K4H560838D-GC(L)B3 (DDR333)	K4H560838D-GC(L)A2, B0 (DDR266A/B)		
IDD0	90	80	mA	
IDD1	120	110	mA	
IDD2P	3	3	mA	
IDD2F	25	20	mA	
IDD2Q	20	18	mA	
IDD3P	35	30	mA	
IDD3N	55	45	mA	
IDD4R	170	140	mA	
IDD4W	170	140	mA	
IDD5	180	165	mA	
IDD6	Normal	3	mA	
	Low power	1.5	mA	Optional
IDD7A	325	280	mA	

**AC Operating Conditions**

Parameter/Condition	Symbol	Min	Max	Unit	Note
Input High (Logic 1) Voltage, DQ, DQS and DM signals	VIH(AC)	VREF + 0.31		V	3
Input Low (Logic 0) Voltage, DQ, DQS and DM signals.	VIL(AC)		VREF - 0.31	V	3
Input Differential Voltage, CK and $\overline{\text{CK}}$ inputs	VID(AC)	0.7	VDDQ+0.6	V	1
Input Crossing Point Voltage, CK and $\overline{\text{CK}}$ inputs	VIX(AC)	$0.5 \cdot V_{DDQ} - 0.2$	$0.5 \cdot V_{DDQ} + 0.2$	V	2

- Note 1. VID is the magnitude of the difference between the input level on CK and the input on  $\overline{\text{CK}}$ .
2. The value of VIX is expected to equal  $0.5 \cdot V_{DDQ}$  of the transmitting device and must track variations in the DC level of the same.
3. These parameters should be tested at the pim on actual components and may be checked at either the pin or the pad in simulation. the AC and DC input specifcatims are refation to a Vref envelope that has been bandwidth limited 20MHz.

**Overshoot/Undershoot specification**

Parameter	Specification	
	Address & Control pins	Data pins
Maximum peak amplitude allowed for overshoot	1.6 V	1.2V
Maximum peak amplitude allowed for undershoot	1.6 V	1.2V
The area between the overshoot signal and VDD must be less than or equal to	4.5 V-ns	2.5 V-ns
The area between the undershoot signal and GND must be less than or equal to	4.5 V-ns	2.5 V-ns



## AC Timing Parameters &amp; Specifications

Parameter	Symbol	B3 (DDR333)		A2 (DDR266A)		B0 (DDR266B)		Unit	Note	
		Min	Max	Min	Max	Min	Max			
Row cycle time	tRC	60		65		65		ns		
Refresh row cycle time	tRFC	72		75		75		ns		
Row active time	tRAS	42	70K	45	120K	45	120K	ns		
$\overline{\text{RAS}}$ to $\overline{\text{CAS}}$ delay	tRCD	18		20		20		ns		
Row precharge time	tRP	18		20		20		ns		
Row active to Row active delay	tRRD	12		15		15		ns		
Write recovery time	tWR	15		15		15		ns		
Last data in to Read command	tWTR	1		1		1		tCK		
Col. address to Col. address delay	tCCD	1		1		1		tCK		
Clock cycle time	tCK	CL=2.0	7.5	12	7.5	12	10	12	ns	5
		CL=2.5	6	12	7.5	12	7.5	12	ns	5
Clock high level width	tCH	0.45	0.55	0.45	0.55	0.45	0.55	tCK		
Clock low level width	tCL	0.45	0.55	0.45	0.55	0.45	0.55	tCK		
DQS-out access time from CK/ $\overline{\text{CK}}$	tDQSK	-0.6	+0.6	-0.75	+0.75	-0.75	+0.75	ns		
Output data access time from CK/ $\overline{\text{CK}}$	tAC	-0.7	+0.7	-0.75	+0.75	-0.75	+0.75	ns		
Data strobe edge to output data edge	tDQSQ	-	0.4	-	0.5	-	0.5	ns	5	
Read Preamble	tRPRE	0.9	1.1	0.9	1.1	0.9	1.1	tCK		
Read Postamble	tRPST	0.4	0.6	0.4	0.6	0.4	0.6	tCK		
CK to valid DQS-in	tDQSS	0.75	1.25	0.75	1.25	0.75	1.25	tCK		
DQS-in setup time	tWPRES	0		0		0		ns	2	
DQS-in hold time	tWPRE	0.25		0.25		0.25		tCK		
DQS falling edge to CK rising-setup time	tDSS	0.2		0.2		0.2		tCK		
DQS falling edge from CK rising-hold time	tDSH	0.2		0.2		0.2		tCK		
DQS-in high level width	tDQSH	0.35		0.35		0.35		tCK		
DQS-in low level width	tDQSL	0.35		0.35		0.35		tCK		
DQS-in cycle time	tDSC	0.9	1.1	0.9	1.1	0.9	1.1	tCK		
Address and Control Input setup time(fast)	tIS	0.75		0.9		0.9		ns	6	
Address and Control Input hold time(fast)	tIH	0.75		0.9		0.9		ns	6	
Address and Control Input setup time(slow)	tIS	0.8		1.0		1.0		ns	6	
Address and Control Input hold time(slow)	tIH	0.8		1.0		1.0		ns	6	
Data-out high impedance time from CK/ $\overline{\text{CK}}$	tHZ	-0.7	+0.7	-0.75	+0.75	-0.75	+0.75	ns		
Data-out low impedance time from CK/ $\overline{\text{CK}}$	tLZ	-0.7	+0.7	-0.75	+0.75	-0.75	+0.75	ns		
Input Slew Rate(for input only pins)	tSL(I)	0.5		0.5		0.5		V/ns	6	
Input Slew Rate(for I/O pins)	tSL(IO)	0.5		0.5		0.5		V/ns	7	
Output Slew Rate(x4,x8)	tSL(O)	1.0	4.5	1.0	4.5	1.0	4.5	V/ns	10	
Output Slew Rate Matching Ratio(rise to fall)	tSLMR	0.67	1.5	0.67	1.5	0.67	1.5			

Parameter	Symbol	B3 (DDR333)		A2 (DDR266A)		B0 (DDR266B)		Unit	Note
		Min	Max	Min	Max	Min	Max		
Mode register set cycle time	tMRD	12		15		15		ns	
DQ & DM setup time to DQS	tDS	0.45		0.5		0.5		ns	7,8,9
DQ & DM hold time to DQS	tDH	0.45		0.5		0.5		ns	7,8,9
Control & Address input pulse width	tIPW	2.2		2.2		2.2		ns	
DQ & DM input pulse width	tDIPW	1.75		1.75		1.75		ns	
Power down exit time	tPDEX	6		7.5		7.5		ns	
Exit self refresh to non-Read command	tXSNR	75		75		75		ns	4
Exit self refresh to read command	tXSRD	200		200		200		tCK	
Refresh interval time	tREFI	7.8		7.8		7.8		us	1
Output DQS valid window	tQH	tHP -tQHS	-	tHP -tQHS	-	tHP -tQHS	-	ns	5
Clock half period	tHP	tCLmin or tCHmin	-	tCLmin or tCHmin	-	tCLmin or tCHmin	-	ns	
Data hold skew factor	tQHS		0.5		0.75		0.75	ns	
DQS write postamble time	tWPST	0.4	0.6	0.4	0.6	0.4	0.6	tCK	3
Active to Read with Auto precharge command	tRAP	18		20		20			
Autoprecharge write recovery + Precharge time	tDAL	(tWR/tCK) + (tRP/tCK)		(tWR/tCK) + (tRP/tCK)		(tWR/tCK) + (tRP/tCK)		tCK	11

1. Maximum burst refresh cycle : 8
2. The specific requirement is that DQS be valid(High or Low) on or before this CK edge. The case shown(DQS going from High\_Z to logic Low) applies when no writes were previously in progress on the bus. If a previous write was in progress, DQS could be High at this time, depending on tDQSS.
3. The maximum limit for this parameter is not a device limit. The device will operate with a great value for this parameter, but system performance (bus turnaround) will degrade accordingly.
4. A write command can be applied with tRCD satisfied after this command.
5. For registered DIMMs, tCL and tCH are ≥ 45% of the period including both the half period jitter (tJIT(HP)) of the PLL and the half period jitter due to crosstalk (tJIT(crosstalk)) on the DIMM.
6. Input Setup/Hold Slew Rate Derating

Input Setup/Hold Slew Rate	ΔtIS	ΔtIH
(V/ns)	(ps)	(ps)
0.5	0	0
0.4	+50	+50
0.3	+100	+100

This derating table is used to increase tIS/tIH in the case where the input slew rate is below 0.5V/ns. Input setup/hold slew rate based on the lesser of AC-AC slew rate and DC-DC slew rate.

7. I/O Setup/Hold Slew Rate Derating

I/O Setup/Hold Slew Rate	ΔtDS	ΔtDH
(V/ns)	(ps)	(ps)
0.5	0	0
0.4	+75	+75
0.3	+150	+150

This derating table is used to increase tDS/tDH in the case where the I/O slew rate is below 0.5V/ns. I/O setup/hold slew rate based on the lesser of AC-AC slew rate and DC-DC slew rate.

8. I/O Setup/Hold Plateau Derating

I/O Input Level	$\Delta t_{DS}$	$\Delta t_{DH}$
(mV)	(ps)	(ps)
$\pm 280$	+50	+50

This derating table is used to increase  $t_{DS}/t_{DH}$  in the case where the input level is flat below  $V_{REF} \pm 310mV$  for a duration of up to 2ns.

9. I/O Delta Rise/Fall Rate(1/slew-rate) Derating

Delta Rise/Fall Rate	$\Delta t_{DS}$	$\Delta t_{DH}$
(ns/V)	(ps)	(ps)
0	0	0
$\pm 0.25$	+50	+50
$\pm 0.5$	+100	+100

This derating table is used to increase  $t_{DS}/t_{DH}$  in the case where the DQ and DQS slew rates differ. The Delta Rise/Fall Rate is calated as  $1/SlewRate1-1/SlewRate2$ . For example, if slew rate 1 = 5V/ns and slew rate 2 = .4V/ns then the Delta Rise/Fall Rate =-0/5ns/V. Input S/H slew rate based on larger of AC-AC delta rise/fall rate and DC-DC delta rise/fall rate.

10. This parameter is fir system simulation purpose. It is guranteed by design.

11. For each of the terms, if not already an integer, round to the next highest integer. tCK is actual to the system clock cycle time.

**<Reference>**

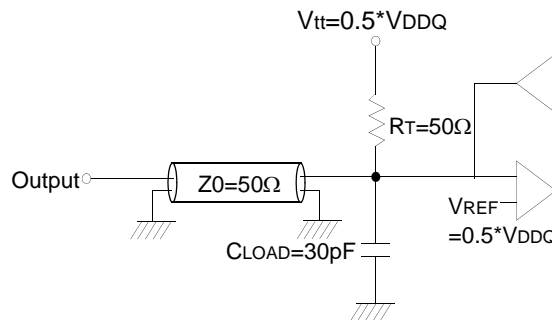
The following table specifies derating values for the specifications listed if the single-ended clock skew rate is less than 1.0V/ns.

CK slew rate (Single ended)	$\Delta t_{IH}/t_{IS}$ (ps)	$\Delta t_{DSS}/t_{DSH}$ (ps)	$\Delta t_{AC}/t_{DQSCK}$ (ps)	$\Delta t_{LZ}(\min)$ (ps)	$\Delta t_{HZ}(\max)$ (ps)
1.0V/ns	0	0	0	0	0
0.75V/ns	+50	+50	+50	-50	+50
0.5V/ns	+100	+100	+100	-100	+100

**AC Operating Test Conditions**

(VDD=2.5V, VDDQ=2.5V, TA= 0 to 70°C)

Parameter	Value	Unit	Note
Input reference voltage for Clock	0.5 * VDDQ	V	
Input signal maximum peak swing	1.5	V	
Input signal minimum slew rate (for input only)	0.5	V/ns	
Input slew rate (I/O pins)	0.5	V/ns	
Input Levels(VIH/VIL)	VREF+0.31/VREF-0.31	V	
Input timing measurement reference level	VREF	V	
Output timing measurement reference level	Vtt	V	
Output load condition	See Load Circuit		



**Output Load Circuit (SSTL\_2)**

**Input/Output Capacitance**

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

Parameter	Symbol	Min	Max	Delta Cap(max)	Unit
Input capacitance (A0 ~ A12, BA0 ~ BA1, CKE, CS, RAS, CAS, WE)	CIN1	1.5	3.5	0.5	pF
Input capacitance( CK, CK )	CIN2	1.5	3.5	0.25	pF
Data & DQS input/output capacitance	COUT	3.5	5.5	0.5	pF
Input capacitance(DM)	CIN3	3.5	5.5		pF

**4M x 16Bit x 4 Banks Double Data Rate SDRAM****GENERAL DESCRIPTION**

The K4H561638D is 268,435,456 bits of double data rate synchronous DRAM organized as 4 x 4,194,304 words by 16 bits, fabricated with SAMSUNG's high performance CMOS technology. Synchronous features with Data Strobe allow extremely high performance up to 333Mb/s per pin. I/O transactions are possible on both edges of DQS. 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.

**Absolute Maximum Rating**

Parameter	Symbol	Value	Unit
Voltage on any pin relative to VSS	VIN, VOUT	-0.5 ~ 3.6	V
Voltage on VDD & VDDQ supply relative to VSS	VDD, VDDQ	-1.0 ~ 3.6	V
Storage temperature	TSTG	-55 ~ +150	°C
Power dissipation	PD	1.5	W
Short circuit current	IOS	50	mA

**Note :** Permanent device damage may occur if ABSOLUTE MAXIMUM RATINGS are exceeded.

Functional operation should be restricted to recommend operation condition.

Exposure to higher than recommended voltage for extended periods of time could affect device reliability

**DC Operating Conditions**

Recommended operating conditions(Voltage referenced to Vss=0V, TA= 0 to 70°C)

Parameter	Symbol	Min	Max	Unit	Note
Supply voltage(for device with a nominal VDD of 2.5V)	VDD	2.3	2.7		
I/O Supply voltage	VDDQ	2.3	2.7	V	
I/O Reference voltage	VREF	VDDQ/2-50mV	VDDQ/2+50mV	V	1
I/O Termination voltage(system)	V <sub>TT</sub>	VREF-0.04	VREF+0.04	V	2
Input logic high voltage	V <sub>IH</sub> (DC)	VREF+0.15	VDDQ+0.3	V	4
Input logic low voltage	V <sub>IL</sub> (DC)	-0.3	VREF-0.15	V	4
Input Voltage Level, CK and $\overline{CK}$ inputs	V <sub>IN</sub> (DC)	-0.3	VDDQ+0.3	V	
Input Differential Voltage, CK and $\overline{CK}$ inputs	V <sub>ID</sub> (DC)	0.3	VDDQ+0.6	V	3
Input crossing point voltage, CK and $\overline{CK}$ inputs	V <sub>IX</sub> (DC)	1.15	1.35	V	5
Input leakage current	I <sub>I</sub>	-2	2	uA	
Output leakage current	I <sub>OZ</sub>	-5	5	uA	
Output High Current(Normal strength driver) ;V <sub>OUT</sub> = V <sub>TT</sub> + 0.84V	I <sub>OH</sub>	-16.8		mA	
Output High Current(Normal strength driver) ;V <sub>OUT</sub> = V <sub>TT</sub> - 0.84V	I <sub>OL</sub>	16.8		mA	
Output High Current(Half strength driver) ;V <sub>OUT</sub> = V <sub>TT</sub> + 0.45V	I <sub>OH</sub>	-9		mA	
Output High Current(Half strength driver) ;V <sub>OUT</sub> = V <sub>TT</sub> - 0.45V	I <sub>OL</sub>	9		mA	

- Notes 1. Includes  $\pm 25\text{mV}$  margin for DC offset on VREF, and a combined total of  $\pm 50\text{mV}$  margin for all AC noise and DC offset on VREF, bandwidth limited to 20MHz. The DRAM must accommodate DRAM current spikes on VREF and internal DRAM noise coupled TO VREF, both of which may result in VREF noise. VREF should be de-coupled with an inductance of  $\leq 3\text{nH}$ .
2.  $V_{TT}$  is not applied directly to the device.  $V_{TT}$  is a system supply for signal termination resistors, is expected to be set equal to VREF, and must track variations in the DC level of VREF
3. VID is the magnitude of the difference between the input level on CK and the input level on  $\overline{\text{CK}}$ .
4. These parameters should be tested at the pin on actual components and may be checked at either the pin or the pad in simulation. The AC and DC input specifications are relative to a VREF envelop that has been bandwidth limited to 200MHZ.
5. The value of VIX is expected to equal  $0.5 \cdot V_{DDQ}$  of the transmitting device and must track variations in the dc level of the same.

**DDR SDRAM IDD spec table**

(VDD=2.7V, T = 10°C)

Symbol	16Mx16		Unit	Notes
	K4H560838D-GC(L)B3 (DDR333)	K4H560838D-GC(L)A2, B0 (DDR266A/B)		
IDD0	90	80	mA	
IDD1	125	115	mA	
IDD2P	3	3	mA	
IDD2F	25	20	mA	
IDD2Q	20	18	mA	
IDD3P	35	30	mA	
IDD3N	55	45	mA	
IDD4R	200	170	mA	
IDD4W	190	155	mA	
IDD5	180	165	mA	
IDD6	Normal	3	mA	
	Low power	1.5	mA	Optional
IDD7A	350	300	mA	

**AC Operating Conditions**

Parameter/Condition	Symbol	Min	Max	Unit	Note
Input High (Logic 1) Voltage, DQ, DQS and DM signals	VIH(AC)	VREF + 0.31		V	3
Input Low (Logic 0) Voltage, DQ, DQS and DM signals.	VIL(AC)		VREF - 0.31	V	3
Input Differential Voltage, CK and $\overline{\text{CK}}$ inputs	VID(AC)	0.7	VDDQ+0.6	V	1
Input Crossing Point Voltage, CK and $\overline{\text{CK}}$ inputs	VIX(AC)	$0.5 \cdot V_{DDQ} - 0.2$	$0.5 \cdot V_{DDQ} + 0.2$	V	2

- Note 1. VID is the magnitude of the difference between the input level on CK and the input on  $\overline{\text{CK}}$ .
2. The value of VIX is expected to equal  $0.5 \cdot V_{DDQ}$  of the transmitting device and must track variations in the DC level of the same.
3. These parameters should be tested at the pim on actual components and may be checked at either the pin or the pad in simulation. the AC and DC input specifcatims are refation to a Vref envelope that has been bandwidth limited 20MHz.

**Overshoot/Undershoot specification**

Parameter	Specification	
	Address & Control pins	Data pins
Maximum peak amplitude allowed for overshoot	1.6 V	1.2V
Maximum peak amplitude allowed for undershoot	1.6 V	1.2V
The area between the overshoot signal and VDD must be less than or equal to	4.5 V-ns	2.5 V-ns
The area between the undershoot signal and GND must be less than or equal to	4.5 V-ns	2.5 V-ns

## AC Timing Parameters &amp; Specifications

Parameter	Symbol	B3 (DDR333)		A2 (DDR266A)		B0 (DDR266B)		Unit	Note	
		Min	Max	Min	Max	Min	Max			
Row cycle time	tRC	60		65		65		ns		
Refresh row cycle time	tRFC	72		75		75		ns		
Row active time	tRAS	42	70K	45	120K	45	120K	ns		
$\overline{\text{RAS}}$ to $\overline{\text{CAS}}$ delay	tRCD	18		20		20		ns		
Row precharge time	tRP	18		20		20		ns		
Row active to Row active delay	tRRD	12		15		15		ns		
Write recovery time	tWR	15		15		15		ns		
Last data in to Read command	tWTR	1		1		1		tCK		
Col. address to Col. address delay	tCCD	1		1		1		tCK		
Clock cycle time	tCK	CL=2.0	7.5	12	7.5	12	10	12	ns	5
		CL=2.5	6	12	7.5	12	7.5	12	ns	5
Clock high level width	tCH	0.45	0.55	0.45	0.55	0.45	0.55	tCK		
Clock low level width	tCL	0.45	0.55	0.45	0.55	0.45	0.55	tCK		
DQS-out access time from $\overline{\text{CK}}/\overline{\text{CK}}$	tDQSCK	-0.6	+0.6	-0.75	+0.75	-0.75	+0.75	ns		
Output data access time from $\overline{\text{CK}}/\overline{\text{CK}}$	tAC	-0.7	+0.7	-0.75	+0.75	-0.75	+0.75	ns		
Data strobe edge to output data edge	tDQSQ	-	0.4	-	0.5	-	0.5	ns	5	
Read Preamble	tRPRE	0.9	1.1	0.9	1.1	0.9	1.1	tCK		
Read Postamble	tRPST	0.4	0.6	0.4	0.6	0.4	0.6	tCK		
CK to valid DQS-in	tDQSS	0.75	1.25	0.75	1.25	0.75	1.25	tCK		
DQS-in setup time	tWPRES	0		0		0		ns	2	
DQS-in hold time	tWPRE	0.25		0.25		0.25		tCK		
DQS falling edge to CK rising-setup time	tDSS	0.2		0.2		0.2		tCK		
DQS falling edge from CK rising-hold time	tDSH	0.2		0.2		0.2		tCK		
DQS-in high level width	tDQSH	0.35		0.35		0.35		tCK		
DQS-in low level width	tDQSL	0.35		0.35		0.35		tCK		
DQS-in cycle time	tDSC	0.9	1.1	0.9	1.1	0.9	1.1	tCK		
Address and Control Input setup time(fast)	tIS	0.75		0.9		0.9		ns	6	
Address and Control Input hold time(fast)	tIH	0.75		0.9		0.9		ns	6	
Address and Control Input setup time(slow)	tIS	0.8		1.0		1.0		ns	6	
Address and Control Input hold time(slow)	tIH	0.8		1.0		1.0		ns	6	
Data-out high impedance time from $\overline{\text{CK}}/\overline{\text{CK}}$	tHZ	-0.7	+0.7	-0.75	+0.75	-0.75	+0.75	ns		
Data-out low impedance time from $\overline{\text{CK}}/\overline{\text{CK}}$	tLZ	-0.7	+0.7	-0.75	+0.75	-0.75	+0.75	ns		
Input Slew Rate(for input only pins)	tSL(I)	0.5		0.5		0.5		V/ns	6	
Input Slew Rate(for I/O pins)	tSL(IO)	0.5		0.5		0.5		V/ns	7	
Output Slew Rate(x4,x8)	tSL(O)	1.0	4.5	1.0	4.5	1.0	4.5	V/ns	10	
Output Slew Rate Matching Ratio(rise to fall)	tSLMR	0.67	1.5	0.67	1.5	0.67	1.5			

Parameter	Symbol	B3 (DDR333)		A2 (DDR266A)		B0 (DDR266B)		Unit	Note
		Min	Max	Min	Max	Min	Max		
Mode register set cycle time	tMRD	12		15		15		ns	
DQ & DM setup time to DQS	tDS	0.45		0.5		0.5		ns	7,8,9
DQ & DM hold time to DQS	tDH	0.45		0.5		0.5		ns	7,8,9
Control & Address input pulse width	tIPW	2.2		2.2		2.2		ns	
DQ & DM input pulse width	tDIPW	1.75		1.75		1.75		ns	
Power down exit time	tPDEX	6		7.5		7.5		ns	
Exit self refresh to non-Read command	tXSNR	75		75		75		ns	4
Exit self refresh to read command	tXSRD	200		200		200		tCK	
Refresh interval time	tREFI	7.8		7.8		7.8		us	1
Output DQS valid window	tQH	tHP -tQHS	-	tHP -tQHS	-	tHP -tQHS	-	ns	5
Clock half period	tHP	tCLmin or tCHmin	-	tCLmin or tCHmin	-	tCLmin or tCHmin	-	ns	
Data hold skew factor	tQHS		0.5		0.75		0.75	ns	
DQS write postamble time	tWPST	0.4	0.6	0.4	0.6	0.4	0.6	tCK	3
Active to Read with Auto precharge command	tRAP	18		20		20			
Autoprecharge write recovery + Precharge time	tDAL	(tWR/tCK) + (tRP/tCK)		(tWR/tCK) + (tRP/tCK)		(tWR/tCK) + (tRP/tCK)		tCK	11

1. Maximum burst refresh cycle : 8
2. The specific requirement is that DQS be valid(High or Low) on or before this CK edge. The case shown(DQS going from High\_Z to logic Low) applies when no writes were previously in progress on the bus. If a previous write was in progress, DQS could be High at this time, depending on tDQSS.
3. The maximum limit for this parameter is not a device limit. The device will operate with a great value for this parameter, but system performance (bus turnaround) will degrade accordingly.
4. A write command can be applied with tRCD satisfied after this command.
5. For registered DIMMs, tCL and tCH are ≥ 45% of the period including both the half period jitter (tJIT(HP)) of the PLL and the half period jitter due to crosstalk (tJIT(crosstalk)) on the DIMM.
6. Input Setup/Hold Slew Rate Derating

Input Setup/Hold Slew Rate	ΔtIS	ΔtIH
(V/ns)	(ps)	(ps)
0.5	0	0
0.4	+50	+50
0.3	+100	+100

This derating table is used to increase tIS/tIH in the case where the input slew rate is below 0.5V/ns. Input setup/hold slew rate based on the lesser of AC-AC slew rate and DC-DC slew rate.

7. I/O Setup/Hold Slew Rate Derating

I/O Setup/Hold Slew Rate	ΔtDS	ΔtDH
(V/ns)	(ps)	(ps)
0.5	0	0
0.4	+75	+75
0.3	+150	+150

This derating table is used to increase tDS/tDH in the case where the I/O slew rate is below 0.5V/ns. I/O setup/hold slew rate based on the lesser of AC-AC slew rate and DC-DC slew rate.



8. I/O Setup/Hold Plateau Derating

I/O Input Level	$\Delta t_{DS}$	$\Delta t_{DH}$
(mV)	(ps)	(ps)
$\pm 280$	+50	+50

This derating table is used to increase  $t_{DS}/t_{DH}$  in the case where the input level is flat below  $V_{REF} \pm 310mV$  for a duration of up to 2ns.

9. I/O Delta Rise/Fall Rate(1/slew-rate) Derating

Delta Rise/Fall Rate	$\Delta t_{DS}$	$\Delta t_{DH}$
(ns/V)	(ps)	(ps)
0	0	0
$\pm 0.25$	+50	+50
$\pm 0.5$	+100	+100

This derating table is used to increase  $t_{DS}/t_{DH}$  in the case where the DQ and DQS slew rates differ. The Delta Rise/Fall Rate is calated as  $1/SlewRate1-1/SlewRate2$ . For example, if slew rate 1 = 5V/ns and slew rate 2 = .4V/ns then the Delta Rise/Fall Rate =-0/5ns/V. Input S/H slew rate based on larger of AC-AC delta rise/fall rate and DC-DC delta rise/fall rate.

10. This parameter is fir system simulation purpose. It is guranteed by design.

11. For each of the terms, if not already an integer, round to the next highest integer. tCK is actual to the system clock cycle time.

**<Reference>**

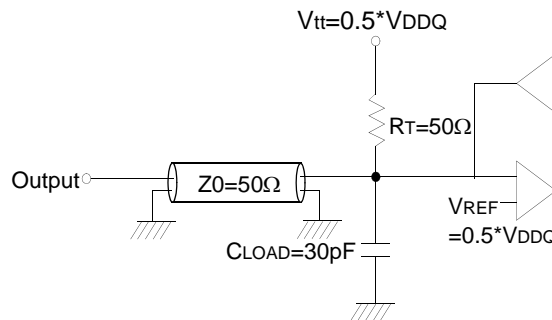
The following table specifies derating values for the specifications listed if the single-ended clock skew rate is less than 1.0V/ns.

CK slew rate (Single ended)	$\Delta t_{IH}/t_{IS}$ (ps)	$\Delta t_{DSS}/t_{DSH}$ (ps)	$\Delta t_{AC}/t_{DQSCK}$ (ps)	$\Delta t_{LZ}(\min)$ (ps)	$\Delta t_{HZ}(\max)$ (ps)
1.0V/ns	0	0	0	0	0
0.75V/ns	+50	+50	+50	-50	+50
0.5V/ns	+100	+100	+100	-100	+100

**AC Operating Test Conditions**

(VDD=2.5V, VDDQ=2.5V, TA= 0 to 70°C)

Parameter	Value	Unit	Note
Input reference voltage for Clock	0.5 * VDDQ	V	
Input signal maximum peak swing	1.5	V	
Input signal minimum slew rate (for input only)	0.5	V/ns	
Input slew rate (I/O pins)	0.5	V/ns	
Input Levels(VIH/VIL)	VREF+0.31/VREF-0.31	V	
Input timing measurement reference level	VREF	V	
Output timing measurement reference level	Vtt	V	
Output load condition	See Load Circuit		



**Output Load Circuit (SSTL\_2)**

**Input/Output Capacitance**

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

Parameter	Symbol	Min	Max	Delta Cap(max)	Unit
Input capacitance (A0 ~ A12, BA0 ~ BA1, $\overline{\text{CKE}}$ , $\overline{\text{CS}}$ , $\overline{\text{RAS}}$ , $\overline{\text{CAS}}$ , $\overline{\text{WE}}$ )	CIN1	1.5	3.5	0.5	pF
Input capacitance( CK, $\overline{\text{CK}}$ )	CIN2	1.5	3.5	0.25	pF
Data & DQS input/output capacitance	COUT	3.5	5.5	0.5	pF
Input capacitance(DM)	CIN3	3.5	5.5		pF