64Mb H-die SDRAM Specification

Revision 1.8

August 2004

Revision History

Revision 0.0 (May, 2003)
- Target spec release

Revision 0.1 (July, 2003)
- Preliminary spec release

Revision 0.2 (August, 2003)
- Modified IBIS characteristic.

Revision 1.0 (September, 2003)
- Finalized.

Revision 1.1 (September, 2003)
- Corrected IBIS Specification.

Revision 1.2 (October, 2003)
- Deleted speed 7C at x4/x8.

Revision 1.3 (October, 2003)
- Deleted AC parameter notes 5.

Revision 1.4 (November, 2003)
- Modified Pin Function description.

Revision 1.5 (February, 2004)
- Corrected typo.

Revision 1.6 (March, 2004)
- Modified Pin Description.

Revision 1.7 (May, 2004)
- Added Note 5. sentense of tRDL parameter.

Revision 1.8 (August, 2004)
- Modified CLK cycle time(tcc) parameter in AC Characteristics.
(If you want use of CL=2 not CL=3, the maximum operating frequency is 100MHz regardless of its speed bin.)

4M x 4Bit x 4 / 2M x 8Bit x 4 / 1M x 16Bit x 4 Banks SDRAM

FEATURES

- JEDEC standard 3.3V power supply
- LVTTL compatible with multiplexed address
- Four banks operation
- MRS cycle with address key programs
  - -. CAS latency (2 & 3)
  - -. Burst length (1, 2, 4, 8 & Full page)
  - -. Burst type (Sequential & Interleave)
- All inputs are sampled at the positive going edge of the system clock
- Burst read single-bit write operation
- DQM (x4,x8) & L(U)DQM (x16) for masking
- Auto & self refresh
- 64ms refresh period (4K cycle)

GENERAL DESCRIPTION

The K4S640432H / K4S640832H / K4S641632H is 67,108,864 bits synchronous high data rate Dynamic RAM organized as 4 x 4,194,304 words by 4 bits, / 4 x 2,097,152 words by 8 bits, / 4 x 1,048,576 words by 16 bits, fabricated with SAMSUNG′s high performance CMOS technology. Synchronous design allows precise cycle control with the use of system clock I/O transactions are possible on every clock cycle. Range of operating frequencies, programmable burst length and programmable latencies allow the same device to be useful for a variety of high bandwidth, high performance memory system applications.

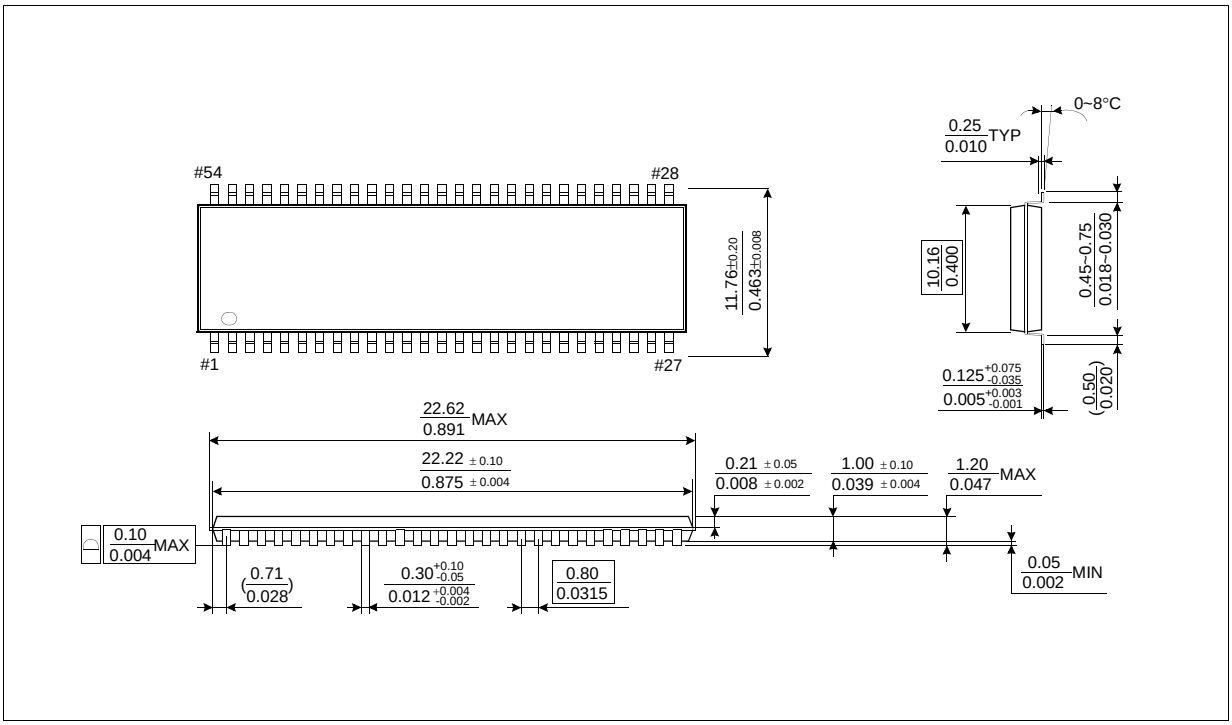
Ordering Information

Part No.	Orgainization	Max Freq.	Interface	Package
K4S640432H-TC(L)75	16Mb x 4	133MHz(CL=3)	LVTTL	54pin TSOP(II)
K4S640832H-TC(L)75	8Mb x 8	133MHz(CL=3)		
K4S641632H-TC(L)60	4Mb x 16	166MHz(CL=3)		
K4S641632H-TC(L)70		143MHz(CL=3)		
K4S641632H-TC(L)75		133MHz(CL=3)		

Organization	Row Address	Column Address
16Mx4	A0~A11	A0-A9
8Mx8	A0~A11	A0-A8
4Mx16	A0~A11	A0-A7

Row & Column address configuration

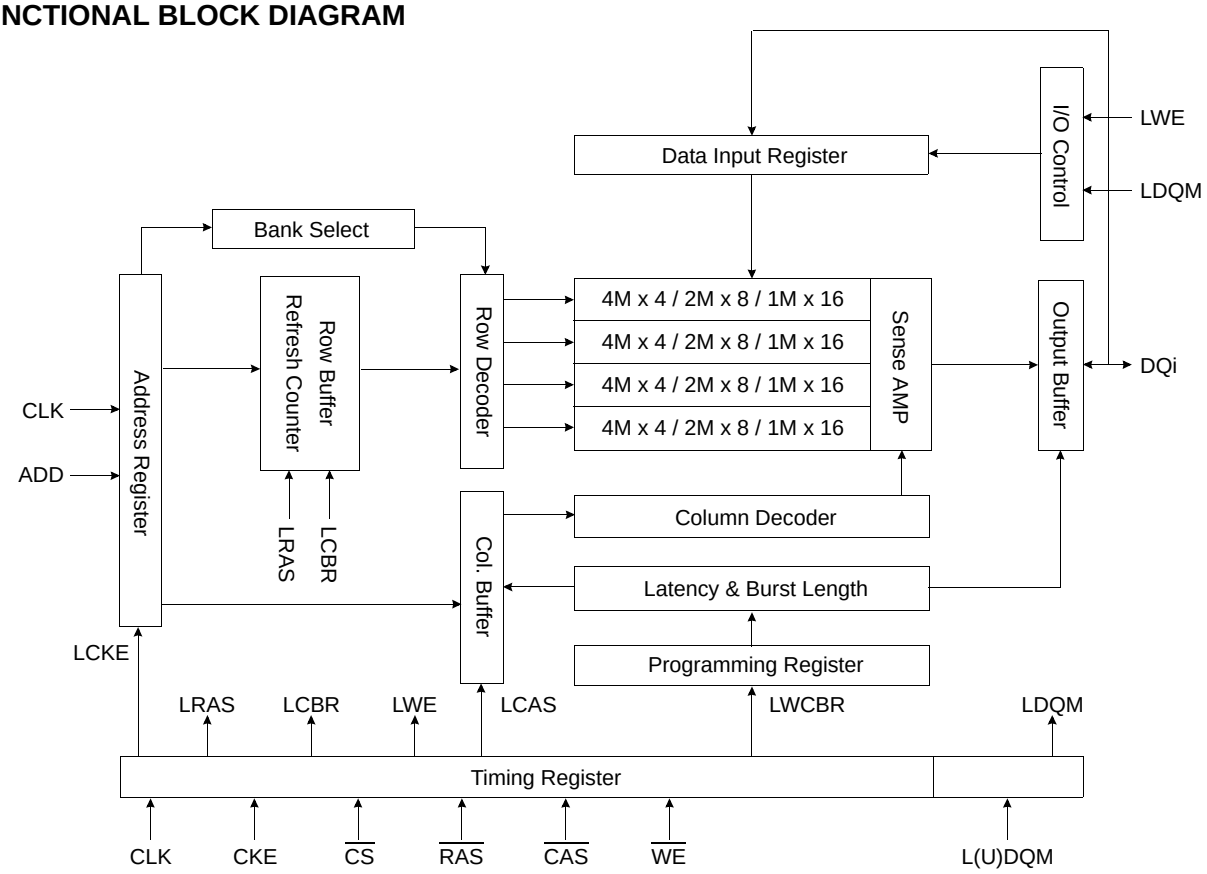
Package Physical Dimension



54Pin TSOP(II) Package Dimension

SAMSUNG ELECTRONICS

FUNCTIONAL BLOCK DIAGRAM



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SAMSUNG ELECTRONICS

PIN CONFIGURATION (Top view)

x16	x8	x4			x4	x8	x16
VDD	VDD	VDD	1	54	VSS	VSS	VSS
DQ0	DQ0	N.C	2	53	N.C	DQ7	DQ15
VDDQ	VDDQ	VDDQ	3	52	VSSQ	VSSQ	VSSQ
DQ1	N.C	N.C	4	51	N.C	N.C	DQ14
DQ2	DQ1	DQ0	5	50	DQ3	DQ6	DQ13
VSSQ	VSSQ	VSSQ	6	49	VDDQ	VDDQ	VDDQ
DQ3	N.C	N.C	7	48	N.C	N.C	DQ12
DQ4	DQ2	N.C	8	47	N.C	DQ5	DQ11
VDDQ	VDDQ	VDDQ	9	46	VSSQ	VSSQ	VSSQ
DQ5	N.C	N.C	10	45	N.C	N.C	DQ10
DQ6	DQ3	DQ1	11	44	DQ2	DQ4	DQ9
VSSQ	VSSQ	VSSQ	12	43	VDDQ	VDDQ	VDDQ
DQ7	N.C	N.C	13	42	N.C	N.C	DQ8
VDD	VDD	VDD	14	41	VSS	VSS	VSS
LDQM	N.C	N.C	15	40	N.C/RFU	N.C/RFU	N.C/RFU
WE	WE	WE	16	39	DQM	DQM	UDQM
CAS	CAS	CAS	17	38	CLK	CLK	CLK
RAS	RAS	RAS	18	37	CKE	CKE	CKE
CS	CS	CS	19	36	N.C	N.C	N.C
BA0	BA0	BA0	20	35	A11	A11	A11
BA1	BA1	BA1	21	34	A9	A9	A9
A10/AP	A10/AP	A10/AP	22	33	A8	A8	A8
A0	A0	A0	23	32	A7	A7	A7
A1	A1	A1	24	31	A6	A6	A6
A2	A2	A2	25	30	A5	A5	A5
A3	A3	A3	26	29	A4	A4	A4
VDD	VDD	VDD	27	28	VSS	VSS	VSS

54Pin TSOP (II)
(400mil x 875mil)
(0.8 mm Pin pitch)

PIN FUNCTION DESCRIPTION

Pin	Name	Input Function
CLK	*System clock*	Active on the positive going edge to sample all inputs.
$\overline{CS}$	*Chip select*	Disables or enables device operation by masking or enabling all inputs except CLK, CKE and DQM
CKE	*Clock enable*	Masks system clock to freeze operation from the next clock cycle. CKE should be enabled at least one cycle prior to new command. Disable input buffers for power down in standby.
A_0 ~ A_{11}	*Address*	Row/column addresses are multiplexed on the same pins. Row address : RA_0 ~ RA_{11}, Column address : (x4 : CA_0 ~ CA_9, x8 : CA_0 ~ CA_8, x16 : CA_0 ~ CA_7)
BA_0 ~ BA_1	*Bank select address*	Selects bank to be activated during row address latch time. Selects bank for read/write during column address latch time.
$\overline{RAS}$	*Row address strobe*	Latches row addresses on the positive going edge of the CLK with $\overline{RAS}$ low. Enables row access & precharge.
$\overline{CAS}$	*Column address strobe*	Latches column addresses on the positive going edge of the CLK with $\overline{CAS}$ low. Enables column access.
$\overline{WE}$	*Write enable*	Enables write operation and row precharge. Latches data in starting from $\overline{CAS}$, $\overline{WE}$ active.
DQM	*Data input/output mask*	Makes data output Hi-Z, t_{SHZ} after the clock and masks the output. Blocks data input when DQM active.
DQ_0 ~ N	*Data input/output*	Data inputs/outputs are multiplexed on the same pins. (x4 : DQ_0 ~ 3), (x8 : DQ_0 ~ 7), (x16 : DQ_0 ~ 15)
VDD/VSS	*Power supply/ground*	Power and ground for the input buffers and the core logic.
VDDQ/VSSQ	*Data output power/ground*	Isolated power supply and ground for the output buffers to provide improved noise immunity.
N.C/RFU	*No connection /reserved for future use*	This pin is recommended to be left No Connection on the device.

ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	Value	Unit
Voltage on any pin relative to V_{SS}	V_{IN}, V_{OUT}	-1.0 ~ 4.6	V
Voltage on V_{DD} supply relative to V_{SS}	V_{DD}, V_{DDQ}	-1.0 ~ 4.6	V
Storage temperature	T_{STG}	-55 ~ +150	°C
Power dissipation	P_D	1	W
Short circuit current	I_{OS}	50	mA

Note : Permanent device damage may occur if "ASOLUTE 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.

DC OPERATING CONDITIONS

Recommended operating conditions (Voltage referenced to V_{SS} = 0V, T_A = 0 to 70°C)

Parameter	Symbol	Min	Typ	Max	Unit	Note
Supply voltage	V_{DD}, V_{DDQ}	3.0	3.3	3.6	V	
Input logic high voltage	V_{IH}	2.0	3.0	V_{DD}+0.3	V	1
Input logic low voltage	V_{IL}	-0.3	0	0.8	V	2
Output logic high voltage	V_{OH}	2.4	-	-	V	I_{OH} = -2mA
Output logic low voltage	V_{OL}	-	-	0.4	V	I_{OL} = 2mA
Input leakage current	I_{LI}	-10	-	10	uA	3

Notes :
1. V_{IH} (max) = 5.6V AC.The overshoot voltage duration is ≤ 3ns.
2. V_{IL} (min) = -2.0V AC. The undershoot voltage duration is ≤ 3ns.
3. Any input 0V ≤ V_{IN} ≤ V_{DDQ}.
   Input leakage currents include Hi-Z output leakage for all bi-directional buffers with Tri-State outputs.

CAPACITANCE (V_{DD} = 3.3V, T_A = 23°C, f = 1MHz, V_{REF} =1.4V ± 200 mV)

Pin	Symbol	Min	Max	Unit	Note
Clock	C_{CLK}	2.5	4.0	pF	1
$\overline{RAS}$, $\overline{CAS}$, $\overline{WE}$, $\overline{CS}$, CKE, DQM	C_{IN}	2.5	5.0	pF	2
Address	C_{ADD}	2.5	5.0	pF	2
(x4 : DQ0 ~ DQ3), (x8 : DQ0 ~ DQ7), (x16 : DQ0 ~DQ15)	C_{OUT}	4.0	6.5	pF	3

DC CHARACTERISTICS (x4, x8)

(Recommended operating condition unless otherwise noted, T_A = 0 to 70°C for x4, x8)

Parameter	Symbol	Test Condition		Version 75	Unit	Note
Operating current (One bank active)	I_{CC1}	Burst length = 1 $t_{RC} \geq t_{RC}$(min) I_O = 0 mA		75	mA	1
Precharge standby current in power-down mode	I_{CC2P}	CKE ≤ V_{IL}(max), t_{CC} = 10ns		1	mA	
	I_{CC2PS}	CKE & CLK ≤ V_{IL}(max), t_{CC} = ∞		1		
Precharge standby current in non power-down mode	I_{CC2N}	CKE ≥ V_{IH}(min), $\overline{CS}$ ≥ V_{IH}(min), t_{CC} = 10ns Input signals are changed one time during 20ns		15	mA	
	I_{CC2NS}	CKE ≥ V_{IH}(min), CLK ≤ V_{IL}(max), t_{CC} = ∞ Input signals are stable		6		
Active standby current in power-down mode	I_{CC3P}	CKE ≤ V_{IL}(max), t_{CC} = 10ns		3	mA	
	I_{CC3PS}	CKE & CLK ≤ V_{IL}(max), t_{CC} = ∞		3		
Active standby current in non power-down mode (One bank active)	I_{CC3N}	CKE ≥ V_{IH}(min), $\overline{CS}$ ≥ V_{IH}(min), t_{CC} = 10ns Input signals are changed one time during 20ns		30	mA	
	I_{CC3NS}	CKE ≥ V_{IH}(min), CLK ≤ V_{IL}(max), t_{CC} = ∞ Input signals are stable		25		
Operating current (Burst mode)	I_{CC4}	I_O = 0 mA Page burst 4Banks Activated t_{CCD} = 2CLKs		115	mA	1
Refresh current	I_{CC5}	$t_{RC} \geq t_{RC}$(min)		135	mA	2
Self refresh current	I_{CC6}	CKE ≤ 0.2V	C	1	mA	3
			L	400	uA	4

Notes : 1. Measured with outputs open.

2. Refresh period is 64ms.
3. K4S6404(08)32H-TC
4. K4S6404(08)32H-TL
5. Unless otherwise noted, input swing level is CMOS(V_{IH}/V_{IL}=V_{DDQ}/V_{SSQ})

DC CHARACTERISTICS (x16)

(Recommended operating condition unless otherwise noted, T_A = 0 to 70°C for x16 only)

Parameter	Symbol	Test Condition		Version			Unit	Note
				60	70	75		
Operating current (One bank active)	I_{CC1}	Burst length = 1 $t_{RC} \geq t_{RC}$(min) I_O = 0 mA		140	115	110	mA	1
Precharge standby current in power-down mode	I_{CC2P}	CKE ≤ V_{IL}(max), t_{CC} = 10ns		1			mA	
	I_{CC2PS}	CKE & CLK ≤ V_{IL}(max), t_{CC} = ∞		1				
Precharge standby current in non power-down mode	I_{CC2N}	CKE ≥ V_{IH}(min), $\overline{CS}$ ≥ V_{IH}(min), t_{CC} = 10ns Input signals are changed one time during 20ns		15			mA	
	I_{CC2NS}	CKE ≥ V_{IH}(min), CLK ≤ V_{IL}(max), t_{CC} = ∞ Input signals are stable		6				
Active standby current in power-down mode	I_{CC3P}	CKE ≤ V_{IL}(max), t_{CC} = 10ns		3			mA	
	I_{CC3PS}	CKE & CLK ≤ V_{IL}(max), t_{CC} = ∞		3				
Active standby current in non power-down mode (One bank active)	I_{CC3N}	CKE ≥ V_{IH}(min), $\overline{CS}$ ≥ V_{IH}(min), t_{CC} = 10ns Input signals are changed one time during 20ns		30			mA	
	I_{CC3NS}	CKE ≥ V_{IH}(min), CLK ≤ V_{IL}(max), t_{CC} = ∞ Input signals are stable		25				
Operating current (Burst mode)	I_{CC4}	I_O = 0 mA Page burst 4Banks Activated t_{CCD} = 2CLKs		160	140	135	mA	1
Refresh current	I_{CC5}	$t_{RC} \geq t_{RC}$(min)		160	140	135	mA	2
Self refresh current	I_{CC6}	CKE ≤ 0.2V	C	1			mA	3
			L	400			uA	4

Notes : 1. Measured with outputs open.

2. Refresh period is 64ms.

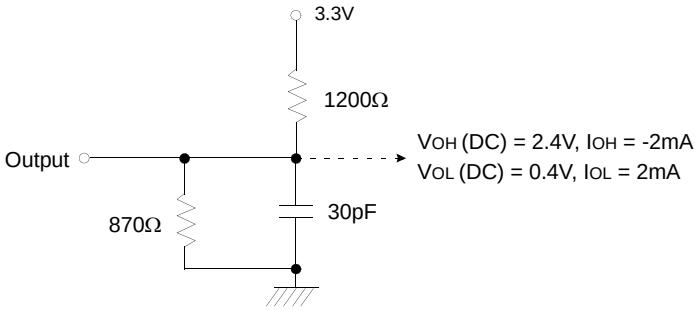
3. K4S641632H-TC

4. K4S641632H-TL

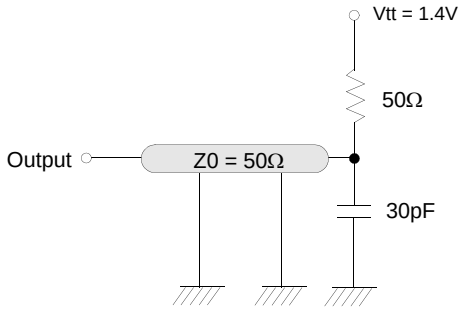
5. Unless otherwise noted, input swing level is CMOS(V_{IH}/V_{IL}=V_{DDQ}/V_{SSQ})

AC OPERATING TEST CONDITIONS (V_{DD} = 3.3V ± 0.3V, T_A = 0 to 70°C)

Parameter	Value	Unit
AC input levels (Vih/Vil)	2.4/0.4	V
Input timing measurement reference level	1.4	V
Input rise and fall time	tr/tf = 1/1	ns
Output timing measurement reference level	1.4	V
Output load condition	See Fig. 2	



(Fig. 1) DC output load circuit



(Fig. 2) AC output load circuit

OPERATING AC PARAMETER

(AC operating conditions unless otherwise noted)

Parameter		Symbol	Version			Unit	Note
			60	70	75		
Row active to row active delay		tRRD(min)	12	14	15	ns	1
$\overline{RAS}$ to $\overline{CAS}$ delay		tRCD(min)	18	20	20	ns	1
Row precharge time		tRP(min)	18	20	20	ns	1
Row active time		tRAS(min)	42	49	45	ns	1
		tRAS(max)	100			us	
Row cycle time		tRC(min)	60	68	65	ns	1
Last data in to row precharge		tRDL(min)	2			CLK	2,5
Last data in to Active delay		tDAL(min)	2 CLK + tRP			-	5
Last data in to new col. address delay		tCDL(min)	1			CLK	2
Last data in to burst stop		tBDL(min)	1			CLK	2
Col. address to col. address delay		tCCD(min)	1			CLK	3
Number of valid output data	CAS latency = 3		2			ea	4
	CAS latency = 2		1				

Notes :
1. The minimum number of clock cycles is determined by dividing the minimum time required with clock cycle time and then rounding off to the next higher integer.
2. Minimum delay is required to complete write.
3. All parts allow every cycle column address change.
4. In case of row precharge interrupt, auto precharge and read burst stop.
5. In 100MHz and below 100MHz operating conditions, tRDL=1CLK and tDAL=1CLK + 20ns is also supported. SAMSUNG recommends tRDL=2CLK and tDAL=2CLK + tRP.

AC CHARACTERISTICS (AC operating conditions unless otherwise noted)

Parameter		Symbol	60		70		75		Unit	Note
			Min	Max	Min	Max	Min	Max		
CLK cycle time	CAS latency=3	tCC	6	1000	7	1000	7.5	1000	ns	1
	CAS latency=2		10		10		10			
CLK to valid output delay	CAS latency=3	tSAC	-	5	-	6	-	5.4	ns	1,2
	CAS latency=2		-	6	-	6	-	6		
Output data hold time	CAS latency=3	tOH	2.5	-	3	-	3	-	ns	2
	CAS latency=2		3	-	3	-	3	-		
CLK high pulse width		tCH	2.5	-	3	-	2.5	-	ns	3
CLK low pulse width		tCL	2.5	-	3	-	2.5	-	ns	3
Input setup time		tSS	1.5	-	2	-	1.5	-	ns	3
Input hold time		tSH	1	-	1	-	0.8	-	ns	3
CLK to output in Low-Z		tSLZ	1	-	1	-	1	-	ns	2
CLK to output in Hi-Z	CAS latency=3	tSHZ	-	5	-	6	-	5.4	ns	
	CAS latency=2		-	6	-	6	-	6		

Notes : 1. Parameters depend on programmed CAS latency.
2. If clock rising time is longer than 1ns, (tr/2-0.5)ns should be added to the parameter.
3. Assumed input rise and fall time (tr & tf) = 1ns.
If tr & tf is longer than 1ns, transient time compensation should be considered,
i.e., [(tr + tf)/2-1]ns should be added to the parameter.

DQ BUFFER OUTPUT DRIVE CHARACTERISTICS

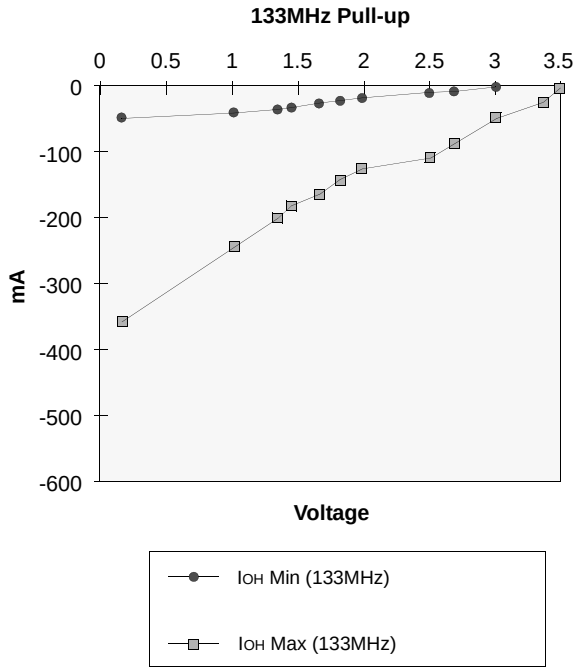
Parameter	Symbol	Condition	Min	Typ	Max	Unit	Notes
Output rise time	trh	Measure in linear region : 1.2V ~ 1.8V	1.37		4.37	Volts/ns	3
Output fall time	tfh	Measure in linear region : 1.2V ~ 1.8V	1.30		3.8	Volts/ns	3
Output rise time	trh	Measure in linear region : 1.2V ~ 1.8V	2.8	3.9	5.6	Volts/ns	1,2
Output fall time	tfh	Measure in linear region : 1.2V ~ 1.8V	2.0	2.9	5.0	Volts/ns	1,2

Notes : 1. Rise time specification based on 0pF + 50 Ω to VSS, use these values to design to.
2. Fall time specification based on 0pF + 50 Ω to VDD, use these values to design to.
3. Measured into 50pF only, use these values to characterize to.
4. All measurements done with respect to VSS.

IBIS SPECIFICATION

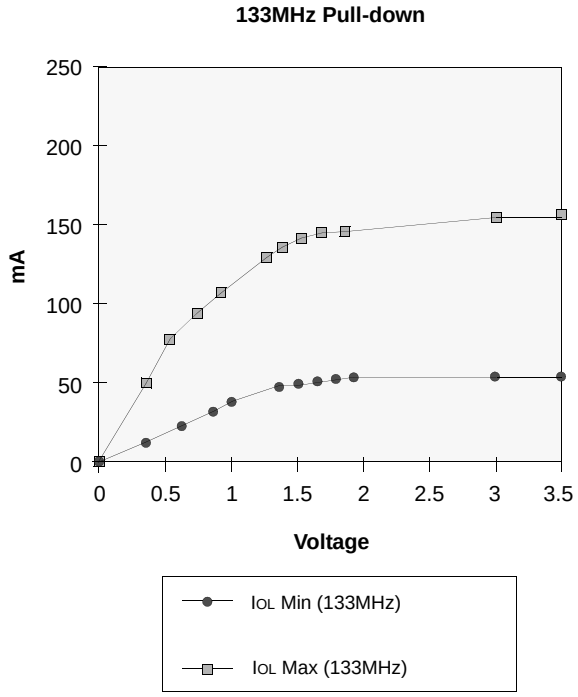
I_{OH} Characteristics (Pull-up)

Voltage	133MHz Min	133MHz Max
(V)	I (mA)	I (mA)
3.45	-	-1.68
3.30	-	-19.11
3.00	-0.35	-51.87
2.70	-3.75	-90.44
2.50	-6.65	-107.31
1.95	-13.75	-137.9
1.80	-17.75	-158.34
1.65	-20.55	-173.6
1.50	-23.55	-188.79
1.40	-26.2	-199.01
1.00	-36.25	-241.15
0.20	-46.5	-351.68



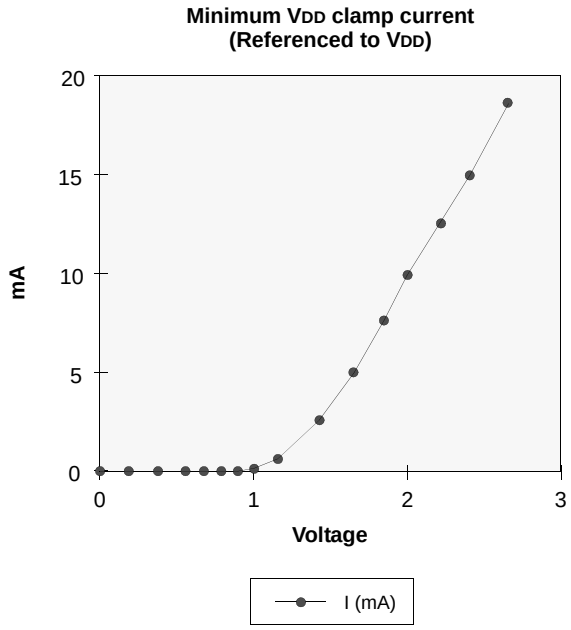
I_{OL} Characteristics (Pull-down)

Voltage	133MHz Min	133MHz Max
(V)	I (mA)	I (mA)
3.45	43.92	155.82
3.30	-	-
3.00	43.36	153.72
1.95	41.20	148.40
1.80	40.56	146.02
1.65	39.60	141.75
1.50	38.40	136.08
1.40	37.28	131.39
1.00	30.08	105.84
0.85	26.64	93.66
0.65	21.52	75.25
0.40	14.16	49.14



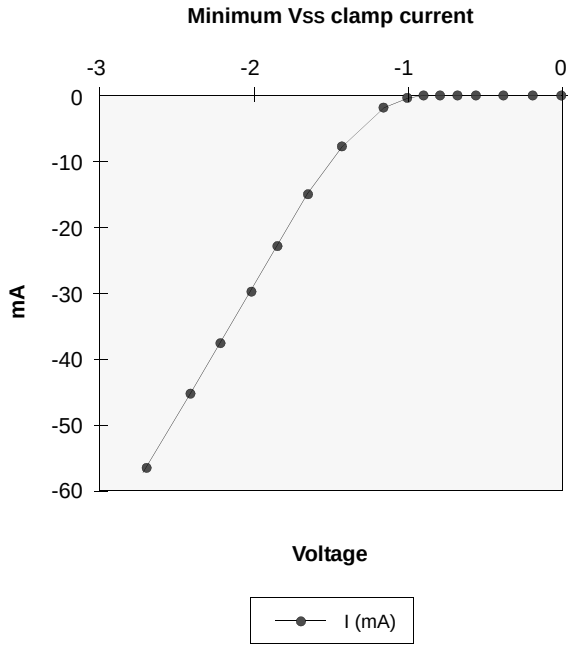
V_{DD} Clamp @ CLK, CKE, $\overline{CS}$, DQM & DQ

V_{DD} (V)	I (mA)
0.0	0.0
0.2	0.0
0.4	0.0
0.6	0.0
0.7	0.0
0.8	0.0
0.9	0.0
1.0	0.23
1.2	1.34
1.4	3.02
1.6	5.06
1.8	7.35
2.0	9.83
2.2	12.48
2.4	15.30
2.6	18.31



V_{SS} Clamp @ CLK, CKE, $\overline{CS}$, DQM & DQ

V_{SS} (V)	I (mA)
-2.6	-57.23
-2.4	-45.77
-2.2	-38.26
-2.0	-31.22
-1.8	-24.58
-1.6	-18.37
-1.4	-12.56
-1.2	-7.57
-1.0	-3.37
-0.9	-1.75
-0.8	-0.58
-0.7	-0.05
-0.6	0.0
-0.4	0.0
-0.2	0.0
0.0	0.0



SIMPLIFIED TRUTH TABLE

(V=Valid, X=Don't care, H=Logic high, L=Logic low)

Command			CKEn-1	CKEn	$\overline{CS}$	$\overline{RAS}$	$\overline{CAS}$	$\overline{WE}$	DQM	$BA_{0,1}$	A_{10}/AP	A_{11}, A_9 ~ A_0	Note
Register	Mode register set		H	X	L	L	L	L	X	OP code			1,2
Refresh	Auto refresh		H	H	L	L	L	H	X	X			3
	Self refresh	Entry		L									3
		Exit	L	H	L	H	H	H	X	X			3
					H	X	X	X					3
Bank active & row addr.			H	X	L	L	H	H	X	V	Row address		
Read & column address	Auto precharge disable		H	X	L	H	L	H	X	V	L	Column address	4
	Auto precharge enable										H		4,5
Write & column address	Auto precharge disable		H	X	L	H	L	L	X	V	L	Column address	4
	Auto precharge enable										H		4,5
Burst stop			H	X	L	H	H	L	X	X			6
Precharge	Bank selection		H	X	L	L	H	L	X	V	L	X	
	All banks									X	H		
Clock suspend or active power down		Entry	H	L	H	X	X	X	X	X			
					L	V	V	V					
		Exit	L	H	X	X	X	X	X				
Precharge power down mode		Entry	H	L	H	X	X	X	X	X			
					L	H	H	H					
		Exit	L	H	H	X	X	X	X				
					L	V	V	V					
DQM			H	X					V	X			7
No operation command			H	X	H	X	X	X	X	X			
					L	H	H	H					

Notes : 1. OP Code : Operand code
A_0 ~ A_{11} & BA_0 ~ BA_1 : Program keys. (@ MRS)

2. MRS can be issued only at all banks precharge state.
A new command can be issued after 2 CLK cycles of MRS.

3. Auto refresh functions are as same as 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. BA_0 ~ BA_1 : Bank select addresses.
If both BA_0 and BA_1 are "Low" at read, write, row active and precharge, bank A is selected.
If both BA_0 is "Low" and BA_1 is "High" at read, write, row active and precharge, bank B is selected.
If both BA_0 is "High" and BA_1 is "Low" at read, write, row active and precharge, bank C is selected.
If both BA_0 and BA_1 are "High" at read, write, row active and precharge, bank D is selected.
If A_{10}/AP is "High" at row precharge, BA_0 and BA_1 is ignored and all banks are selected.

5. During burst read or 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 t_{RP} after the end of burst.

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

7. DQM sampled at positive going edge of a CLK and masks the data-in at the very CLK (Write DQM latency is 0), but makes Hi-Z state the data-out of 2 CLK cycles after. (Read DQM latency is 2)