256M(16Mx16) gDDR SDRAM

HY5DU561622CTP

Revision History

Revision No.	History	Draft Date	Remark
0.1	Defined target spec.	Aug. 2003	
0.2	Supports Pb free parts for each speed grade	Sep. 2003	
0.3	Insert AC Overshoot comment	Aug. 2004	
0.4	tRAS_max change	Sep. 2004	
0.5	tRAS_min & tQHS change	Oct. 2004	

DESCRIPTION

The Hynix HY5DU561622CTP is a 268,435,456-bit CMOS Double Data Rate(DDR) Synchronous DRAM, ideally suited for the point-to-point applications which requires high bandwidth.

The Hynix 16Mx16 DDR SDRAMs offer fully synchronous operations referenced to both rising and falling edges of the clock. While all addresses and control inputs are latched on the rising edges of the CK (falling edges of the /CK), Data, Data strobes and Write data masks inputs are sampled on both rising and falling edges of it. The data paths are internally pipelined and 2-bit prefetched to achieve very high bandwidth. All input and output voltage levels are compatible with SSTL_2.

FEATURES

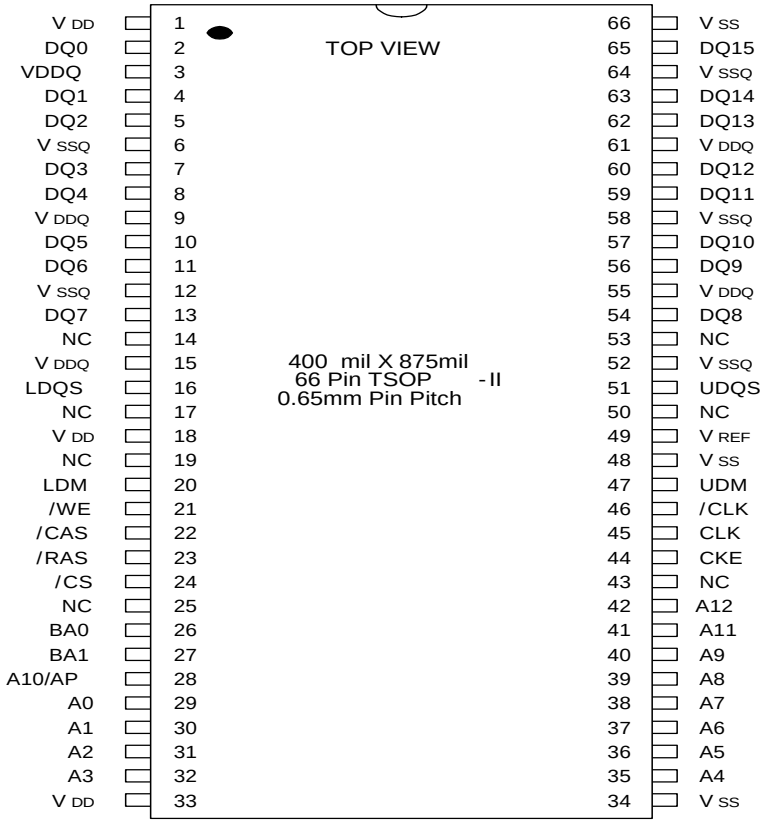
- 2.5V +/-5% VDD and VDDQ power supply supports 250 / 200 / 166MHz
- 2.6V VDD/VDDQ wide range min/max power supply supports 300/275Mhz
- 2.8V +/-0.1V VDD and VDDQ power supply supports 350MHz
- All inputs and outputs are compatible with SSTL_2 interface
- JEDEC standard 400mil 66pin TSOP-II with 0.65mm pin pitch
- Fully differential clock inputs (CK, /CK) operation
- Double data rate interface
- Source synchronous - data transaction aligned to bidirectional data strobe (DQS)
- x16 device has 2 bytewide data strobes (LDQS, UDQS) per each x8 I/O
- Data outputs on DQS edges when read (edged DQ) Data inputs on DQS centers when write (centered DQ)
- Data(DQ) and Write masks(DM) latched on the both rising and falling edges of the data strobe
- All addresses and control inputs except Data, Data strobes and Data masks latched on the rising edges of the clock
- Write mask byte controls by LDM and UDM
- Programmable /CAS latency 3 / 4 supported
- Programmable Burst Length 2 / 4 / 8 with both sequential and interleave mode
- Internal 4 bank operations with single pulsed /RAS
- tRAS Lock-Out function supported
- Auto refresh and self refresh supported
- 4096 refresh cycles / 32ms
- Full, Half and Matched Impedance(Weak) strength driver option controlled by EMRS

ORDERING INFORMATION

Part No.	Power Supply	Clock Frequency	Max Data Rate	interface	Package
HY5DU561622CTP-28	VDD=2.8V VDDQ=2.8V	350MHz	700Mbps/pin	SSTL-2	400mil 66pin TSOP-II
HY5DU561622CTP-33	VDD=2.6V VDDQ=2.6V	300MHz	600Mbps/pin		
HY5DU561622CTP-36		275MHz	550Mbps/pin		
HY5DU561622CTP-4	VDD=2.5V VDDQ=2.5V	250MHz	500Mbps/pin		
HY5DU561622CTP-5		200MHz	400Mbps/pin		
HY5DU561622CTP-6		166MHz	333Mbps/pin		

Note) Hynix supports Pb free parts for each speed grade with same specification, except Pb free material.
We'll add "P" character after "T" for Pb free product. For example, the part number of 300MHz Pb free product is HY5DU561622CTP-33.

PIN CONFIGURATION



ROW and COLUMN ADDRESS TABLE

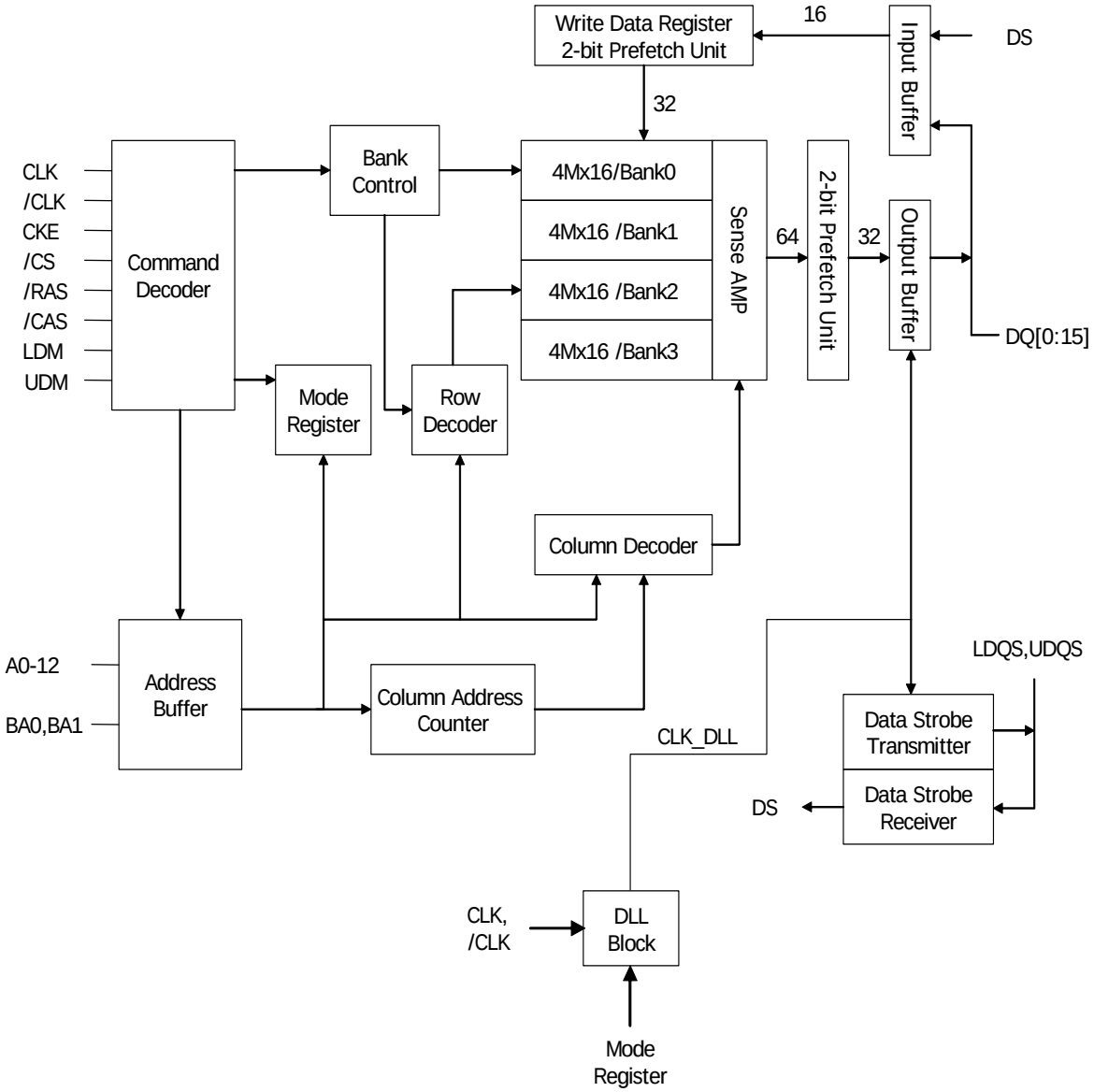
Items	16Mx16
Organization	4M x 16 x 4banks
Row Address	A0 ~ A12
Column Address	A0 ~ A8
Bank Address	BA0, BA1
Auto Precharge Flag	A10
Refresh	4K

PIN DESCRIPTION

PIN	TYPE	DESCRIPTION
CK, /CK	Input	Clock: CK and /CK are differential clock inputs. All address and control input signals are sampled on the crossing of the positive edge of CK and negative edge of /CK. Output (read) data is referenced to the crossings of CK and /CK (both directions of crossing).
CKE	Input	Clock Enable: CKE HIGH activates, and CKE LOW deactivates internal clock signals, and device input buffers and output drivers. Taking CKE LOW provides PRECHARGE POWER DOWN and SELF REFRESH operation (all banks idle), or ACTIVE POWER DOWN (row ACTIVE in any bank). CKE is synchronous for POWER DOWN entry and exit, and for SELF REFRESH entry. CKE is asynchronous for SELF REFRESH exit, and for output disable. CKE must be maintained high throughout READ and WRITE accesses. Input buffers, excluding CK, /CK and CKE are disabled during POWER DOWN. Input buffers, excluding CKE are disabled during SELF REFRESH. CKE is an SSTL_2 input, but will detect an LVCMOS LOW level after Vdd is applied.
/CS	Input	Chip Select : Enables or disables all inputs except CK, /CK, CKE, DQS and DM. All commands are masked when CS is registered high. CS provides for external bank selection on systems with multiple banks. CS is considered part of the command code.
BA0, BA1	Input	Bank Address Inputs: BA0 and BA1 define to which bank an ACTIVE, Read, Write or PRECHARGE command is being applied.
A0 ~ A12	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).
/RAS, /CAS, /WE	Input	Command Inputs: /RAS, /CAS and /WE (along with /CS) define the command being entered.
LDM, UDM	Input	Input Data Mask: DM(LDM,UDM) 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. Although DM pins are input only, the DM loading matches the DQ and DQS loading. LDM corresponds to the data on DQ0-Q7; UDM corresponds to the data on DQ8-Q15.
LDQS, UDQS	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. LDQS corresponds to the data on DQ0-Q7; UDQS corresponds to the data on DQ8-Q15.
DQ0 ~ DQ15	I/O	Data input / output pin : Data Bus
V_{DD}/V_{SS}	Supply	Power supply for internal circuits and input buffers.
V_{DDQ}/V_{SSQ}	Supply	Power supply for output buffers for noise immunity.
V_{REF}	Supply	Reference voltage for inputs for SSTL interface.
NC	NC	No connection.

FUNCTIONAL BLOCK DIAGRAM

4Banks x 4Mbit x 16 I/O Double Data Rate Synchronous DRAM



SIMPLIFIED COMMAND TRUTH TABLE

Command		CKEn-1	CKEn	CS	RAS	CAS	WE	ADDR	A10/AP	BA	Note
Extended Mode Register Set		H	X	L	L	L	L	OP code			1,2
Mode Register Set		H	X	L	L	L	L	OP code			1,2
Device Deselect		H	X	H	X	X	X	X			1
No Operation				L	H	H	H				
Bank Active		H	X	L	L	H	H	RA		V	1
Read		H	X	L	H	L	H	CA	L	V	1
Read with Autoprecharge									H		1,3
Write		H	X	L	H	L	L	CA	L	V	1
Write with Autoprecharge									H		1,4
Precharge All Banks		H	X	L	L	H	L	X	H	X	1,5
Precharge selected Bank									L	V	1
Read Burst Stop		H	X	L	H	H	L	X			1
Auto Refresh		H	H	L	L	L	H	X			1
Self Refresh	Entry	H	L	L	L	L	H	X			1
	Exit	L	H	H	X	X	X				1
				L	H	H	H				
Precharge Power Down Mode	Entry	H	L	H	X	X	X	X			1
				L	H	H	H				1
	Exit	L	H	H	X	X	X				1
				L	H	H	H				1
Active Power Down Mode	Entry	H	L	H	X	X	X	X			1
				L	V	V	V				1
	Exit	L	H	X							1

(H=Logic High Level, L=Logic Low Level, X=Don't Care, V=Valid Data Input, OP Code=Operand Code, NOP=No Operation)

Note :

1. LDM/UDM states are Don't Care. Refer to below Write Mask Truth Table.
2. OP Code(Operand Code) consists of A0~A12 and BA0~BA1 used for Mode Register setting during Extended MRS or MRS. Before entering Mode Register Set mode, all banks must be in a precharge state and MRS command can be issued after tRP period from Prechagre command.
3. If a Read with Autoprecharge command is detected by memory component in CK(n), then there will be no command presented to activated bank until CK(n+BL/2+tRP).
4. If a Write with Autoprecharge command is detected by memory component in CK(n), then there will be no command presented to activated bank until CK(n+BL/2+1+tDPL+tRP). Last Data-In to Prechage delay(tDPL) which is also called Write Recovery Time (tWR) is needed to guarantee that the last data has been completely written.
5. If A10/AP is High when Precharge command being issued, BA0/BA1 are ignored and all banks are selected to be precharged.

WRITE MASK TRUTH TABLE

Function	CKEn-1	CKEn	/CS, /RAS, /CAS, /WE	LDM	UDM	ADDR	A10/AP	BA	Note
Data Write	H	X	X	L	L	X			1,2
Data-In Mask	H	X	X	H	H	X			1,2
Lower Byte Write / Upper Byte-In Mask	H	X	X	L	H	X			1,2
Upper Byte Write / Lower Byte-In Mask	H	X	X	H	L	X			1,2

Note :
1. Write Mask command masks burst write data with reference to LDQS/UDQS(Data Strobes) and it is not related with read data.
2. LDM and UDM control lower byte(DQ0~7) and Upper byte(DQ8~15) respectively.

OPERATION COMMAND TRUTH TABLE - I

Current State	/CS	/RAS	/CAS	/WE	Address	Command	Action
IDLE	H	X	X	X	X	DSEL	NOP or power down[3]
	L	H	H	H	X	NOP	NOP or power down[3]
	L	H	H	L	X	BST	ILLEGAL[4]
	L	H	L	H	BA, CA, AP	READ/READAP	ILLEGAL[4]
	L	H	L	L	BA, CA, AP	WRITE/WRITEAP	ILLEGAL[4]
	L	L	H	H	BA, RA	ACT	Row Activation
	L	L	H	L	BA, AP	PRE/PALL	NOP
	L	L	L	H	X	AREF/SREF	Auto Refresh or Self Refresh[5]
	L	L	L	L	OPCODE	MRS	Mode Register Set
ROW ACTIVE	H	X	X	X	X	DSEL	NOP
	L	H	H	H	X	NOP	NOP
	L	H	H	L	X	BST	ILLEGAL[4]
	L	H	L	H	BA, CA, AP	READ/READAP	Begin read : optional AP[6]
	L	H	L	L	BA, CA, AP	WRITE/WRITEAP	Begin write : optional AP[6]
	L	L	H	H	BA, RA	ACT	ILLEGAL[4]
	L	L	H	L	BA, AP	PRE/PALL	Precharge[7]
	L	L	L	H	X	AREF/SREF	ILLEGAL[11]
	L	L	L	L	OPCODE	MRS	ILLEGAL[11]
READ	H	X	X	X	X	DSEL	Continue burst to end
	L	H	H	H	X	NOP	Continue burst to end
	L	H	H	L	X	BST	Terminate burst
	L	H	L	H	BA, CA, AP	READ/READAP	Term burst, new read:optional AP[8]
	L	H	L	L	BA, CA, AP	WRITE/WRITEAP	ILLEGAL
	L	L	H	H	BA, RA	ACT	ILLEGAL[4]
	L	L	H	L	BA, AP	PRE/PALL	Term burst, precharge
	L	L	L	H	X	AREF/SREF	ILLEGAL[11]
	L	L	L	L	OPCODE	MRS	ILLEGAL[11]
WRITE	H	X	X	X	X	DSEL	Continue burst to end
	L	H	H	H	X	NOP	Continue burst to end
	L	H	H	L	X	BST	ILLEGAL[4]
	L	H	L	H	BA, CA, AP	READ/READAP	Term burst, new read:optional AP[8]
	L	H	L	L	BA, CA, AP	WRITE/WRITEAP	Term burst, new write:optional AP

OPERATION COMMAND TRUTH TABLE - II

Current State	/CS	/RAS	/CAS	/WE	Address	Command	Action
WRITE	L	L	H	H	BA, RA	ACT	ILLEGAL[4]
	L	L	H	L	BA, AP	PRE/PALL	Term burst, precharge
	L	L	L	H	X	AREF/SREF	ILLEGAL[11]
	L	L	L	L	OPCODE	MRS	ILLEGAL[11]
READ WITH AUTOPRE-CHARGE	H	X	X	X	X	DSEL	Continue burst to end
	L	H	H	H	X	NOP	Continue burst to end
	L	H	H	L	X	BST	ILLEGAL
	L	H	L	H	BA, CA, AP	READ/READAP	ILLEGAL[10]
	L	H	L	L	BA, CA, AP	WRITE/WRITEAP	ILLEGAL[10]
	L	L	H	H	BA, RA	ACT	ILLEGAL[4,10]
	L	L	H	L	BA, AP	PRE/PALL	ILLEGAL[4,10]
	L	L	L	H	X	AREF/SREF	ILLEGAL[11]
	L	L	L	L	OPCODE	MRS	ILLEGAL[11]
WRITE AUTOPRE-CHARGE	H	X	X	X	X	DSEL	Continue burst to end
	L	H	H	H	X	NOP	Continue burst to end
	L	H	H	L	X	BST	ILLEGAL
	L	H	L	H	BA, CA, AP	READ/READAP	ILLEGAL[10]
	L	H	L	L	BA, CA, AP	WRITE/WRITEAP	ILLEGAL[10]
	L	L	H	H	BA, RA	ACT	ILLEGAL[4,10]
	L	L	H	L	BA, AP	PRE/PALL	ILLEGAL[4,10]
	L	L	L	H	X	AREF/SREF	ILLEGAL[11]
	L	L	L	L	OPCODE	MRS	ILLEGAL[11]
PRE-CHARGE	H	X	X	X	X	DSEL	NOP-Enter IDLE after tRP
	L	H	H	H	X	NOP	NOP-Enter IDLE after tRP
	L	H	H	L	X	BST	ILLEGAL[4]
	L	H	L	H	BA, CA, AP	READ/READAP	ILLEGAL[4,10]
	L	H	L	L	BA, CA, AP	WRITE/WRITEAP	ILLEGAL[4,10]
	L	L	H	H	BA, RA	ACT	ILLEGAL[4,10]
	L	L	H	L	BA, AP	PRE/PALL	NOP-Enter IDLE after tRP
	L	L	L	H	X	AREF/SREF	ILLEGAL[11]
	L	L	L	L	OPCODE	MRS	ILLEGAL[11]

OPERATION COMMAND TRUTH TABLE - III

Current State	/CS	/RAS	/CAS	/WE	Address	Command	Action
ROW ACTIVATING	H	X	X	X	X	DSEL	NOP - Enter ROW ACT after tRCD
	L	H	H	H	X	NOP	NOP - Enter ROW ACT after tRCD
	L	H	H	L	X	BST	ILLEGAL[4]
	L	H	L	H	BA, CA, AP	READ/READAP	ILLEGAL[4,10]
	L	H	L	L	BA, CA, AP	WRITE/WRITEAP	ILLEGAL[4,10]
	L	L	H	H	BA, RA	ACT	ILLEGAL[4,9,10]
	L	L	H	L	BA, AP	PRE/PALL	ILLEGAL[4,10]
	L	L	L	H	X	AREF/SREF	ILLEGAL[11]
	L	L	L	L	OPCODE	MRS	ILLEGAL[11]
WRITE RECOVERING	H	X	X	X	X	DSEL	NOP - Enter ROW ACT after tWR
	L	H	H	H	X	NOP	NOP - Enter ROW ACT after tWR
	L	H	H	L	X	BST	ILLEGAL[4]
	L	H	L	H	BA, CA, AP	READ/READAP	ILLEGAL
	L	H	L	L	BA, CA, AP	WRITE/WRITEAP	ILLEGAL
	L	L	H	H	BA, RA	ACT	ILLEGAL[4,10]
	L	L	H	L	BA, AP	PRE/PALL	ILLEGAL[4,11]
	L	L	L	H	X	AREF/SREF	ILLEGAL[11]
	L	L	L	L	OPCODE	MRS	ILLEGAL[11]
WRITE RECOVERING WITH AUTOPRE-CHARGE	H	X	X	X	X	DSEL	NOP - Enter precharge after tDPL
	L	H	H	H	X	NOP	NOP - Enter precharge after tDPL
	L	H	H	L	X	BST	ILLEGAL[4]
	L	H	L	H	BA, CA, AP	READ/READAP	ILLEGAL[4,8,10]
	L	H	L	L	BA, CA, AP	WRITE/WRITEAP	ILLEGAL[4,10]
	L	L	H	H	BA, RA	ACT	ILLEGAL[4,10]
	L	L	H	L	BA, AP	PRE/PALL	ILLEGAL[4,11]
	L	L	L	H	X	AREF/SREF	ILLEGAL[11]
	L	L	L	L	OPCODE	MRS	ILLEGAL[11]
REFRESHING	H	X	X	X	X	DSEL	NOP - Enter IDLE after tRC
	L	H	H	H	X	NOP	NOP - Enter IDLE after tRC
	L	H	H	L	X	BST	ILLEGAL[11]
	L	H	L	H	BA, CA, AP	READ/READAP	ILLEGAL[11]

OPERATION COMMAND TRUTH TABLE - IV

Current State	/CS	/RAS	/CAS	/WE	Address	Command	Action
WRITE	L	H	L	L	BA, CA, AP	WRITE/WRITEAP	ILLEGAL[11]
	L	L	H	H	BA, RA	ACT	ILLEGAL[11]
	L	L	H	L	BA, AP	PRE/PALL	ILLEGAL[11]
	L	L	L	H	X	AREF/SREF	ILLEGAL[11]
	L	L	L	L	OPCODE	MRS	ILLEGAL[11]
MODE REGISTER ACCESSING	H	X	X	X	X	DSEL	NOP - Enter IDLE after tMRD
	L	H	H	H	X	NOP	NOP - Enter IDLE after tMRD
	L	H	H	L	X	BST	ILLEGAL[11]
	L	H	L	H	BA, CA, AP	READ/READAP	ILLEGAL[11]
	L	H	L	L	BA, CA, AP	WRITE/WRITEAP	ILLEGAL[11]
	L	L	H	H	BA, RA	ACT	ILLEGAL[11]
	L	L	H	L	BA, AP	PRE/PALL	ILLEGAL[11]
	L	L	L	H	X	AREF/SREF	ILLEGAL[11]
	L	L	L	L	OPCODE	MRS	ILLEGAL[11]

Note :

1. H - Logic High Level, L - Logic Low Level, X - Don't Care, V - Valid Data Input,
   BA - Bank Address, AP - AutoPrecharge Address, CA - Column Address, RA - Row Address, NOP - NO Operation.
2. All entries assume that CKE was active(high level) during the preceding clock cycle.
3. If both banks are idle and CKE is inactive(low level), then in power down mode.
4. Illegal to bank in specified state. Function may be legal in the bank indicated by Bank Address(BA) depending on the state of that bank.
5. If both banks are idle and CKE is inactive(low level), then self refresh mode.
6. Illegal if tRCD is not met.
7. Illegal if tRAS is not met.
8. Must satisfy bus contention, bus turn around, and/or write recovery requirements.
9. Illegal if tRRD is not met.
10. Illegal for single bank, but legal for other banks in multi-bank devices.
11. Illegal for all banks.

CKE FUNCTION TRUTH TABLE

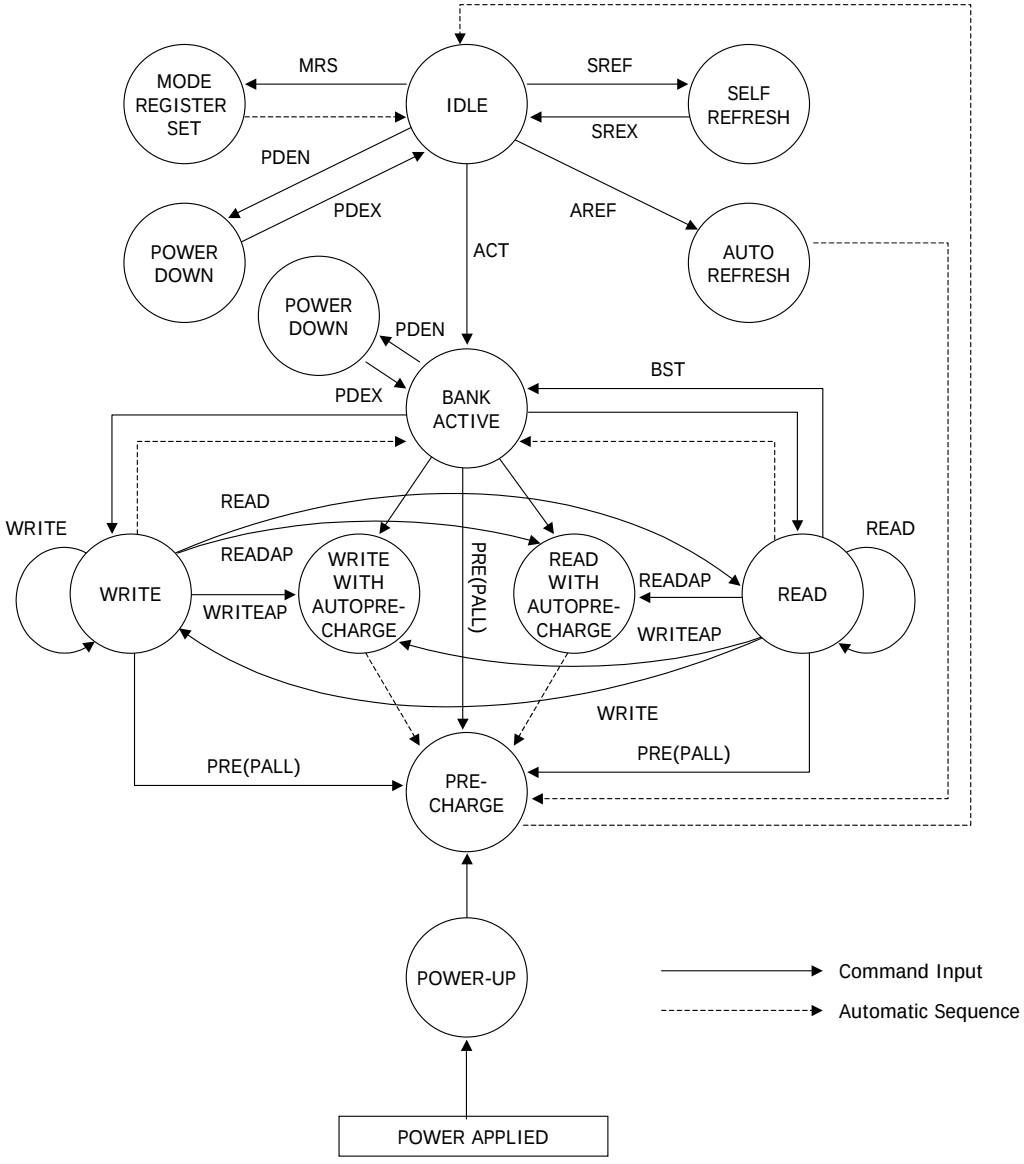
Current State	CKEn-1	CKEn	/CS	/RAS	/CAS	/WE	/ADD	Action
SELF REFRESH[1]	H	X	X	X	X	X	X	INVALID
	L	H	H	X	X	X	X	Exit self refresh, enter idle after tSREX
	L	H	L	H	H	H	X	Exit self refresh, enter idle after tSREX
	L	H	L	H	H	L	X	ILLEGAL
	L	H	L	H	L	X	X	ILLEGAL
	L	H	L	L	X	X	X	ILLEGAL
	L	L	X	X	X	X	X	NOP, continue self refresh
POWER DOWN[2]	H	X	X	X	X	X	X	INVALID
	L	H	H	X	X	X	X	Exit power down, enter idle
	L	H	L	H	H	H	X	Exit power down, enter idle
	L	H	L	H	H	L	X	ILLEGAL
	L	H	L	H	L	X	X	ILLEGAL
	L	H	L	L	X	X	X	ILLEGAL
	L	L	X	X	X	X	X	NOP, continue power down mode
ALL BANKS IDLE[4]	H	H	X	X	X	X	X	See operation command truth table
	H	L	L	L	L	H	X	Enter self refresh
	H	L	H	X	X	X	X	Exit power down
	H	L	L	H	H	H	X	Exit power down
	H	L	L	H	H	L	X	ILLEGAL
	H	L	L	H	L	X	X	ILLEGAL
	H	L	L	L	H	X	X	ILLEGAL
	H	L	L	L	L	L	X	ILLEGAL
	L	L	X	X	X	X	X	NOP
ANY STATE OTHER THAN ABOVE	H	H	X	X	X	X	X	See operation command truth table
	H	L	X	X	X	X	X	ILLEGAL[5]
	L	H	X	X	X	X	X	INVALID
	L	L	X	X	X	X	X	INVALID

Note :

When CKE=L, all DQ and DQS must be in Hi-Z state.

1. CKE and /CS must be kept high for a minimum of 200 stable input clocks before issuing any command.
2. All command can be stored after 2 clocks from low to high transition of CKE.
3. Illegal if CK is suspended or stopped during the power down mode.
4. Self refresh can be entered only from the all banks idle state.
5. Disabling CK may cause malfunction of any bank which is in active state.

SIMPLIFIED STATE DIAGRAM



POWER-UP SEQUENCE AND DEVICE INITIALIZATION

DDR SDRAMs must be powered up and initialized in a predefined manner. Operational procedures other than those specified may result in undefined operation. Except for CKE, inputs are not recognized as valid until after VREF is applied. CKE is an SSTL_2 input, but will detect an LVCMOS LOW level after VDD is applied. Maintaining an LVCMOS LOW level on CKE during power-up is required to guarantee that the DQ and DQS outputs will be in the High-Z state, where they will remain until driven in normal operation (by a read access). After all power supply and reference voltages are stable, and the clock is stable, the DDR SDRAM requires a 200us delay prior to applying an executable command.

Once the 200us delay has been satisfied, a DESELECT or NOP command should be applied, and CKE should be brought HIGH. Following the NOP command, a PRECHARGE ALL command should be applied. Next a EXTENDED MODE REGISTER SET command should be issued for the Extended Mode Register, to enable the DLL, then a MODE REGISTER SET command should be issued for the Mode Register, to reset the DLL, and to program the operating parameters. After the DLL reset, tXSRD(DLL locking time) should be satisfied for read command. After the Mode Register set command, a PRECHARGE ALL command should be applied, placing the device in the all banks idle state.

Once in the idle state, two AUTO REFRESH cycles must be performed. Additionally, a MODE REGISTER SET command for the Mode Register, with the reset DLL bit deactivated low (i.e. to program operating parameters without resetting the DLL) must be performed. Following these cycles, the DDR SDRAM is ready for normal operation.

1. Apply power - VDD, VDDQ, VTT, VREF in the following power up sequencing and attempt to maintain CKE at LVCMOS low state. (All the other input pins may be undefined.

No power sequencing is specified during power up or power down given the following cirteria :

- VDD and VDDQ are driven from a single power converter output.
- VTT is limited to 1.44V (reflecting VDDQ(max)/2 + 50mV VREF variation + 40mV VTT variation).
- VREF tracks VDDQ/2.
- A minimum resistance of 42 ohms (22 ohm series resistor + 22 ohm parallel resistor - 5% tolerance) limits the input current from the VTT supply into any pin.

If the above criteria cannot be met by the system design, then the following sequencing and voltage relationship must be adhered to during power up :

Voltage description	Sequencing	Voltage relationship to avoid latch-up
VDDQ	After or with VDD	< VDD + 0.3V
VTT	After or with VDDQ	< VDDQ + 0.3V
VREF	After or with VDDQ	< VDDQ + 0.3V

2. Start clock and maintain stable clock for a minimum of 200usec.

3. After stable power and clock, apply NOP condition and take CKE high.

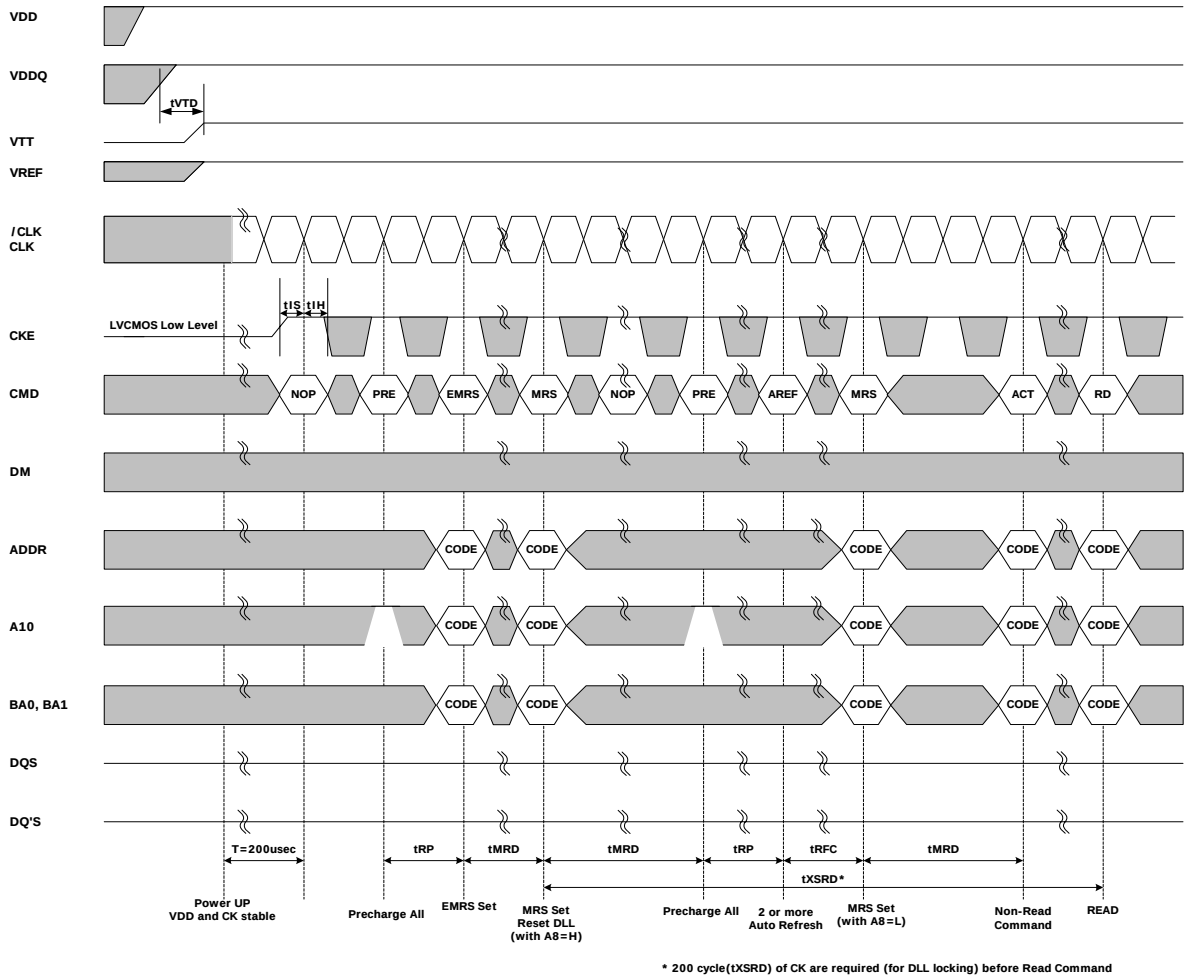
4. Issue Extended Mode Register Set (EMRS) to enable DLL.

5. Issue Mode Register Set (MRS) to reset DLL and set device to idle state with bit A8=high. (An additional 200 cycles(tXSRD) of clock are required for locking DLL)

6. Issue Precharge commands for all banks of the device.

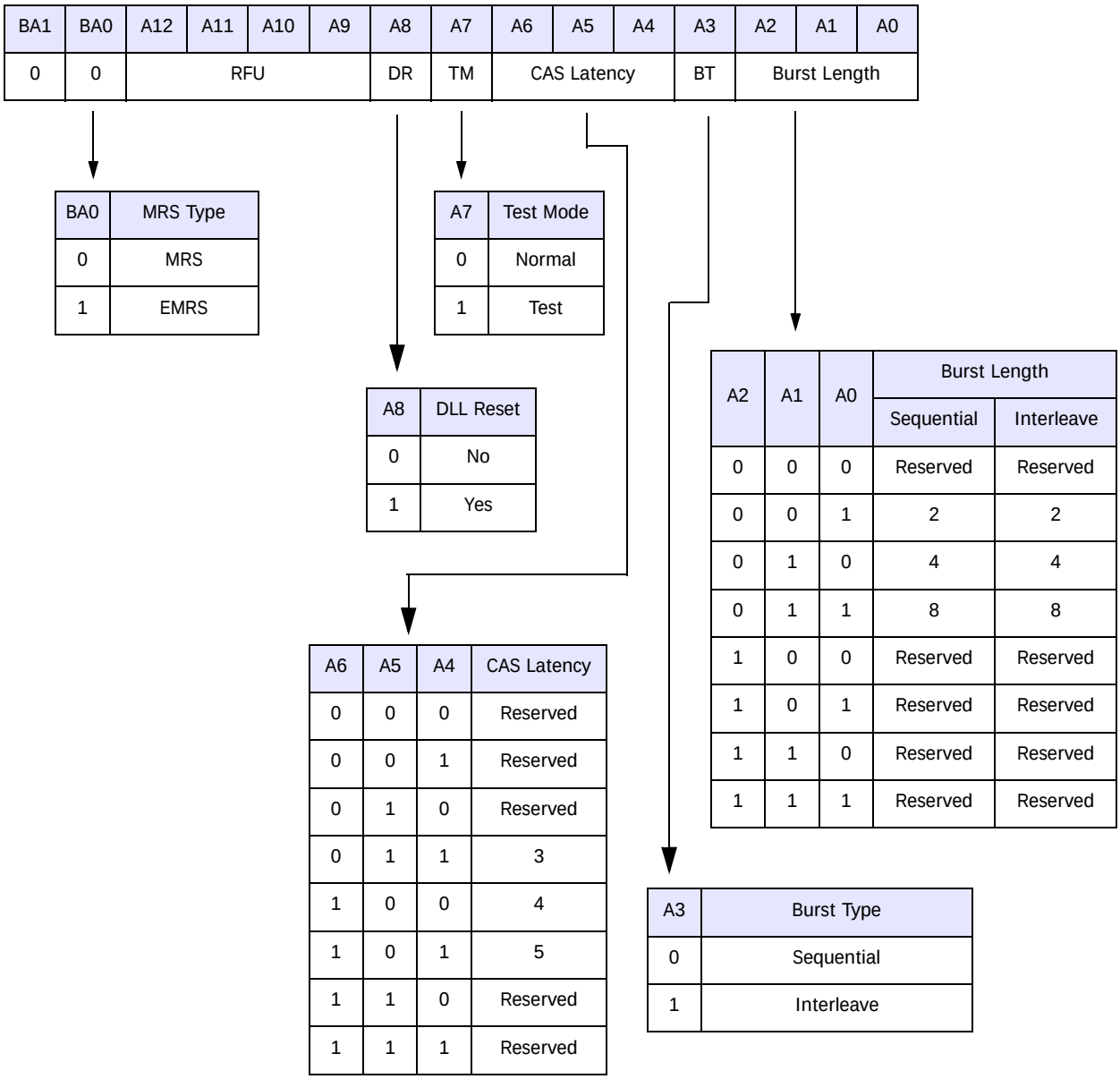
7. Issue 2 or more Auto Refresh commands.
8. Issue a Mode Register Set command to initialize the mode register with bit A8 = Low.

Power-Up Sequence



MODE REGISTER SET (MRS)

The mode register is used to store the various operating modes such as /CAS latency, addressing mode, burst length, burst type, test mode, DLL reset. The mode register is program via MRS command. This command is issued by the low signals of /RAS, /CAS, /CS, /WE and BA0. This command can be issued only when all banks are in idle state and CKE must be high at least one cycle before the Mode Register Set Command can be issued. Two cycles are required to write the data in mode register. During the the MRS cycle, any command cannot be issued. Once mode register field is determined, the information will be held until resetted by another MRS command.



BA1	BA0	A12	A11	A10	A9	A8	A7	A6	A5	A4	A3	A2	A1	A0
0	0	RFU				DR	TM	CAS Latency			BT	Burst Length		

BA0	MRS Type
0	MRS
1	EMRS

A7	Test Mode
0	Normal
1	Test

A8	DLL Reset
0	No
1	Yes

A6	A5	A4	CAS Latency
0	0	0	Reserved
0	0	1	Reserved
0	1	0	Reserved
0	1	1	3
1	0	0	4
1	0	1	5
1	1	0	Reserved
1	1	1	Reserved

A2	A1	A0	Burst Length	
			Sequential	Interleave
0	0	0	Reserved	Reserved
0	0	1	2	2
0	1	0	4	4
0	1	1	8	8
1	0	0	Reserved	Reserved
1	0	1	Reserved	Reserved
1	1	0	Reserved	Reserved
1	1	1	Reserved	Reserved

A3	Burst Type
0	Sequential
1	Interleave

BURST DEFINITION

Burst Length	Starting Address (A2,A1,A0)	Sequential	Interleave
2	XX0	0, 1	0, 1
	XX1	1, 0	1, 0
4	X00	0, 1, 2, 3	0, 1, 2, 3
	X01	1, 2, 3, 0	1, 0, 3, 2
	X10	2, 3, 0, 1	2, 3, 0, 1
	X11	3, 0, 1, 2	3, 2, 1, 0
8	000	0, 1, 2, 3, 4, 5, 6, 7	0, 1, 2, 3, 4, 5, 6, 7
	001	1, 2, 3, 4, 5, 6, 7, 0	1, 0, 3, 2, 5, 4, 7, 6
	010	2, 3, 4, 5, 6, 7, 0, 1	2, 3, 0, 1, 6, 7, 4, 5
	011	3, 4, 5, 6, 7, 0, 1, 2	3, 2, 1, 0, 7, 6, 5, 4
	100	4, 5, 6, 7, 0, 1, 2, 3	4, 5, 6, 7, 0, 1, 2, 3
	101	5, 6, 7, 0, 1, 2, 3, 4	5, 4, 7, 6, 1, 0, 3, 2
	110	6, 7, 0, 1, 2, 3, 4, 5	6, 7, 4, 5, 2, 3, 0, 1
	111	0, 1, 2, 3, 4, 5, 6, 7	7, 6, 5, 4, 3, 2, 1, 0

BURST LENGTH & TYPE

Read and write accesses to the DDR SDRAM are burst oriented, with the burst length being programmable. The burst length determines the maximum number of column locations that can be accessed for a given Read or Write command. Burst lengths of 2, 4 or 8 locations are available for both the sequential and the interleaved burst types. Reserved states should not be used, as unknown operation or incompatibility with future versions may result.

When a Read or Write command is issued, a block of columns equal to the burst length is effectively selected. All accesses for that burst take place within this block, meaning that the burst wraps within the block if a boundary is reached. The block is uniquely selected by A1-Ai when the burst length is set to two, by A2-Ai when the burst length is set to four and by A3-Ai when the burst length is set to eight (where Ai is the most significant column address bit for a given configuration). The remaining (least significant) address bit(s) is (are) used to select the starting location within the block. The programmed burst length applies to both Read and Write bursts.

Accesses within a given burst may be programmed to be either sequential or interleaved; this is referred to as the burst type and is selected via bit A3. The ordering of accesses within a burst is determined by the burst length, the burst type and the starting column address, as shown in Burst Definitionon Table

CAS LATENCY

The Read latency or CAS latency is the delay in clock cycles between the registration of a Read command and the

availability of the first burst of output data. The latency can be programmed 3 or 4 clocks.

If a Read command is registered at clock edge n, and the latency is m clocks, the data is available nominally coincident with clock edge n + m.

Reserved states should not be used as unknown operation or incompatibility with future versions may result.

DLL RESET

The DLL must be enabled for normal operation. DLL enable is required during power up initialization, and upon returning to normal operation after having disabled the DLL for the purpose of debug or evaluation. The DLL is automatically disabled when entering self refresh operation and is automatically re-enabled upon exit of self refresh operation. Any time the DLL is enabled, 200 clock cycles must occur to allow time for the internal clock to lock to the externally applied clock before an any command can be issued.

OUTPUT DRIVER IMPEDANCE CONTROL

The HY5DU561622CT supports Full, Half strength driver and Matched impedance driver, intended for lighter load and/or point-to-point environments. The Full drive strength for all output is specified to be SSTL_2, CLASS II. Half strength driver is to define about 50% of Full drive strength and Matched impedance driver, about 30% of Full drive strength.

EXTENDED MODE REGISTER SET (EMRS)

The Extended Mode Register controls functions beyond those controlled by the Mode Register; these additional functions include DLL enable/disable, output driver strength selection(optional). These functions are controlled via the bits shown below. The Extended Mode Register is programmed via the Mode Register Set command (BA0=1 and BA1=0) and will retain the stored information until it is programmed again or the device loses power.

The Extended Mode Register must be loaded when all banks are idle and no bursts are in progress, and the controller must wait the specified time before initiating any subsequent operation. Violating either of these requirements will result in unspecified operation.

BA1	BA0	A12	A11	A10	A9	A8	A7	A6	A5	A4	A3	A2	A1	A0
0	1	RFU*						DS	RFU*				DS	DLL

BA0	MRS Type
0	MRS
1	EMRS

A0	DLL enable
0	Enable
1	Diable

A6	A1	Output Driver Impedance Control
0	0	Full
0	1	Half
1	0	RFU*
1	1	Matched Impedance (Weak)

* All bits in RFU address fields must be programmed to Zero, all other states are reserved for future usage.

ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	Rating	Unit
Ambient Temperature	T_A	0 ~ 70	^oC
Storage Temperature	T_{STG}	-55 ~ 125	^oC
Voltage on Any Pin relative to V_{SS}	V_{IN}, V_{OUT}	-0.5 ~ 3.6	V
Voltage on V_{DD} relative to V_{SS}	V_{DD}	-0.5 ~ 3.6	V
Voltage on V_{DDQ} relative to V_{SS}	V_{DDQ}	-0.5 ~ 3.6	V
Output Short Circuit Current	I_{OS}	50	mA
Power Dissipation	P_D	1	W
Soldering Temperature · Time	T_{SOLDER}	260 · 10	^oC · sec

Note : Operation at above absolute maximum rating can adversely affect device reliability

DC OPERATING CONDITIONS (T_A=0 to 70^{o}C, Voltage referenced to V_{SS} = 0V)

Parameter	Symbol	Min	Typ.	Max	Unit	Note
Power Supply Voltage	V_{DD}	2.375	2.5	2.625	V	5
Power Supply Voltage	V_{DD}	2.5	2.6	2.9	V	6
Power Supply Voltage	V_{DD}	2.7	2.8	2.9	V	7
Power Supply Voltage	V_{DDQ}	2.375	2.5	2.625	V	5, 1
Power Supply Voltage	V_{DDQ}	2.5	2.6	2.9	V	6, 1
Power Supply Voltage	V_{DDQ}	2.7	2.8	2.9	V	7, 1
Input High Voltage	V_{IH}	V_{REF} + 0.15	-	V_{DDQ} + 0.3	V	
Input Low Voltage	V_{IL}	-0.3	-	V_{REF} - 0.15	V	2
Termination Voltage	V_{TT}	V_{REF} - 0.04	V_{REF}	V_{REF} + 0.04	V	
Reference Voltage	V_{REF}	0.49*V_{DDQ}	0.5*V_{DDQ}	0.51*V_{DDQ}	V	3

Note :
1. V_{DDQ} must not exceed the level of V_{DD}.
2. V_{IL} (min) is acceptable -1.5V AC pulse width with ≤ 5ns of duration.
3. VIH (max) is acceptable VDDQ + 1.5V AC pulse width with < 5ns of duration
4. V_{REF} is expected to be equal to 0.5*V_{DDQ} of the transmitting device, and to track variations in the dc level of the same. Peak to peak noise on V_{REF} may not exceed ± 2% of the dc value.
5. Supports 250/200/166 MHz.
6. Supports 300/275 MHz.
7. Supports 350MHz.

DC CHARACTERISTICS I (T_A=0 to 70oC, Voltage referenced to V_{SS} = 0V)

Parameter	Symbol	Min.	Max	Unit	Note
Input Leakage Current	I_{LI}	-5	5	uA	1
Output Leakage Current	I_{LO}	-5	5	uA	2
Output High Voltage	V_{OH}	V_{TT} + 0.76	-	V	I_{OH} = -15.2mA
Output Low Voltage	V_{OL}	-	V_{TT} - 0.76	V	I_{OL} = +15.2mA

Note : 1. V_{IN} = 0 to 3.6V, All other pins are not tested under V_{IN} = 0V. 2. D_{OUT} is disabled, V_{OUT} = 0 to 2.7V

DC CHARACTERISTICS II (TA=0 to 70°C, Voltage referenced to VSS = 0V)

Parameter	Symbol	Test Condition	Speed						Unit	Note
			28	33	36	4	5	6		
Operating Current	IDD1	One bank; Active - Read - Precharge; Burst Length=4; tRC=tRC(min); tCK=tCK(min); address and control inputs changing once per clock cycle; IOUT=0mA	180	180	170	160	150	150	mA	
Precharge Power Down Standby Current	IDD2P	All banks idle; Power down mode; CKE=Low, tCK=tCK(min)	20						mA	
Idle Standby Current	IDD2F	/CS=High, All banks idle; tCK=tCK(min); CKE=High; address and control inputs changing once per clock cycle. VIN=VREF for DQ, DQS and DM	100	100	90	80	70	70	mA	
Active Power Down Standby Current	IDD3P	One bank active; Power down mode ; CKE=Low, tCK=tCK(min)	45	45	40	35	30	30	mA	
Active Standby Current	IDD3N	/CS=HIGH; CKE=HIGH; One bank; Active-Precharge; tRC=tRAS(max); tCK=tCK(min); DQ, DM and DQS inputs changing twice per clock cycle; Address and other control inputs changing once per clock cycle	110	110	100	90	80	80	mA	
Operating Current	IDD4R	Burst=2;Reads; Continuous burst; One bank active; Address and control inputs changing once per clock cycle; tCK=tCK(min); IOUT=0mA	260	260	240	220	200	200	mA	
	IDD4W	Burst=2; Writes; Continuous burst; One bank active; Address and control inputs changing once per clock cycle; tCK=tCK(min); DQ, DM and DQS inputs changing twice per clock cycle							mA	
Auto Refresh Current	IDD5	tRC=tRFC(min); All banks active	240	240	220	200	180	180	mA	
Self Refresh Current	IDD6	CKE=<0.2V; External clock on; tCK=tCK(min)	4						mA	

AC OPERATING CONDITIONS (TA=0 to 70°C, Voltage referenced to VSS = 0V)

Parameter	Symbol	Min	Max	Unit	Note
Input High (Logic 1) Voltage, DQ, DQS and DM signals	VIH(AC)	VREF + 0.35		V	
Input Low (Logic 0) Voltage, DQ, DQS and DM signals	VIL(AC)		VREF - 0.35	V	
Input Differential Voltage, CK and /CK inputs	VID(AC)	0.7	VDDQ + 0.6	V	1
Input Crossing Point Voltage, CK and /CK inputs	VIX(AC)	0.5*VDDQ-0.2	0.5*VDDQ+0.2	V	2

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

AC OPERATING TEST CONDITIONS (TA=0 to 70°C, Voltage referenced to VSS = 0V)

Parameter	Value	Unit
Reference Voltage	VDDQ x 0.5	V
Termination Voltage	VDDQ x 0.5	V
AC Input High Level Voltage (VIH, min)	VREF + 0.35	V
AC Input Low Level Voltage (VIL, max)	VREF - 0.35	V
Input Timing Measurement Reference Level Voltage	VREF	V
Output Timing Measurement Reference Level Voltage	VTT	V
Input Signal maximum peak swing	1.5	V
Input minimum Signal Slew Rate	1	V/ns
Termination Resistor (RT)	50	Ω
Series Resistor (RS)	25	Ω
Output Load Capacitance for Access Time Measurement (CL)	30	pF

AC CHARACTERISTICS - I (AC operating conditions unless otherwise noted)

Parameter		Symbol	28		33		36		Unit	Note
			Min	Max	Min	Max	Min	Max		
Row Cycle Time (Manual Precharge)		tRC	20	-	18	-	16	-	CK	
Row Cycle Time (Auto Precharge)		tRC_APCG	21	-	19	-	18	-	CK	
Auto Refresh Row Cycle Time		tRFC	24	-	22	-	20	-	CK	
Row Active Time		tRAS	40	70K	40	70K	40	70K	ns	
Row Address to Column Address Delay		tRCDRD	6	-	6	-	5	-	CK	
		tRCDWT	2	-	2	-	2	-	CK	
Row Active to Row Active Delay		tRRD	2	-	2	-	2	-	CK	
Column Address to Column Address Delay		tCCD	1	-	1	-	1	-	CK	
Row Precharge Time		tRP	6	-	6	-	5	-	CK	
Last Data-In to Precharge Delay (Write Recovery Time : tWR)		tDPL	4	-	3	-	3	-	CK	
Last Data-In to Read Command		tDRL	2	-	2	-	2	-	CK	
Auto Precharge Write Recovery + Precharge Time		tDAL	10	-	9	-	8	-	CK	
System Clock Cycle Time	CL = 4.0	tCK	2.8	7.0	3.3	7.0	3.6	7.0	ns	
	CL = 3.0		-	-	-	-	-	-	ns	
Clock High Level Width		tCH	0.45	0.55	0.45	0.55	0.45	0.55	CK	
Clock Low Level Width		tCL	0.45	0.55	0.45	0.55	0.45	0.55	CK	
Data-Out edge to Clock edge Skew		tAC	-0.7	0.7	-0.7	0.7	-0.7	0.7	ns	
DQS-Out edge to Clock edge Skew		tDQSCK	-0.7	0.7	-0.7	0.7	-0.7	0.7	ns	
DQS-Out edge to Data-Out edge Skew		tDQSQ	-	0.4	-	0.4	-	0.4	ns	
Data-Out hold time from DQS		tQH	tHPmin -tQHS	-	tHPmin -tQHS	-	tHPmin -tQHS	-	ns	1, 6
Clock Half Period		tHP	tCH/L min	-	tCH/L min	-	tCH/L min	-	ns	1, 5
Data Hold Skew Factor		tQHS	-	0.4	-	0.4	-	0.4	ns	6
Input Setup Time		tIS	0.75	-	0.75	-	0.75	-	ns	2
Input Hold Time		tIH	0.75	-	0.75	-	0.75	-	ns	2
Write DQS High Level Width		tDQSH	0.4	0.6	0.4	0.6	0.4	0.6	CK	
Write DQS Low Level Width		tDQSL	0.4	0.6	0.4	0.6	0.4	0.6	CK	
Clock to First Rising edge of DQS-In		tDQSS	0.85	1.15	0.85	1.15	0.85	1.15	CK	
Data-In Setup Time to DQS-In (DQ & DM)		tDS	0.4	-	0.4	-	0.4	-	ns	3

Parameter		Symbol	28		33		36		Unit	Note
			Min	Max	Min	Max	Min	Max		
Data-In Hold Time to DQS-In (DQ & DM)		tDH	0.4	-	0.4	-	0.4	-	ns	3
Read DQS Preamble Time		tRPRE	0.9	1.1	0.9	1.1	0.9	1.1	CK	
Read DQS Postamble Time		tRPST	0.4	0.6	0.4	0.6	0.4	0.6	CK	
Write DQS Preamble Setup Time		tWPRES	0	-	0	-	0	-	ns	
Write DQS Preamble Hold Time		tWPREH	1.5	-	1.5	-	1.5	-	ns	
Write DQS Postamble Time		tWPST	0.4	0.6	0.4	0.6	0.4	0.6	CK	
Mode Register Set Delay		tMRD	2	-	2	-	2	-	CK	
Exit Self Refresh to Any Execute Command		tXSC	200	-	200	-	200	-	CK	4
Power Down Exit Time	Except Read Command	tPDEX	1tCK + tIS	-	1tCK + tIS	-	1tCK + tIS	-	CK	
	Read Command	tPDEX_RD	2tCK + tIS	-	2tCK + tIS	-	2tCK + tIS	-	CK	
Average Periodic Refresh Interval		tREFI	-	7.8	-	7.8	-	7.8	us	

AC CHARACTERISTICS - I (AC operating conditions unless otherwise noted)

Parameter		Symbol	4		5		6		Unit	Note
			Min	Max	Min	Max	Min	Max		
Row Cycle Time (Manual Precharge)		tRC	15	-	12	-	11	-	CK	
Row Cycle Time (Auto Precharge)		tRC_APCG	17	-	14	-	11	-	CK	
Auto Refresh Row Cycle Time		tRFC	18	-	14	-	12	-	CK	
Row Active Time		tRAS	40	70K	40	70K	40	70K	ns	
Row Address to Column Address Delay		tRCDRD	5	-	4	-	4	-	CK	
		tRCDWT	2	-	2	-	2	-	CK	
Row Active to Row Active Delay		tRRD	2	-	2	-	2	-	CK	
Column Address to Column Address Delay		tCCD	1	-	1	-	1	-	CK	
Row Precharge Time		tRP	5	-	4	-	4	-	CK	
Last Data-In to Precharge Delay (Write Recovery Time : tWR)		tDPL	3	-	3	-	3	-	CK	
Last Data-In to Read Command		tDRL	2	-	2	-	2	-	CK	
Auto Precharge Write Recovery + Precharge Time		tDAL	8	-	7	-	6	-	CK	
System Clock Cycle Time	CL = 4.0	tCK	4.0	7.0	-	-	-	-	ns	
	CL = 3.0		-	-	5.0	7.0	6.0	7.0	ns	
Clock High Level Width		tCH	0.45	0.55	0.45	0.55	0.45	0.55	CK	
Clock Low Level Width		tCL	0.45	0.55	0.45	0.55	0.45	0.55	CK	
Data-Out edge to Clock edge Skew		tAC	-0.7	0.7	-0.7	0.7	-0.7	0.7	ns	
DQS-Out edge to Clock edge Skew		tDQSCK	-0.7	0.7	-0.7	0.7	-0.7	0.7	ns	
DQS-Out edge to Data-Out edge Skew		tDQSQ	-	0.4	-	0.45	-	0.45	ns	
Data-Out hold time from DQS		tQH	tHPmin -tQHS	-	tHPmin -tQHS	-	tHPmin -tQHS	-	ns	1, 6
Clock Half Period		tHP	tCH/L min	-	tCH/L min	-	tCH/L min	-	ns	1, 5
Data Hold Skew Factor		tQHS	-	0.4	-	0.5	-	0.5	ns	6
Input Setup Time		tIS	0.75	-	0.75	-	0.75	-	ns	2
Input Hold Time		tIH	0.75	-	0.75	-	0.75	-	ns	2
Write DQS High Level Width		tDQSH	0.4	0.6	0.4	0.6	0.4	0.6	CK	
Write DQS Low Level Width		tDQSL	0.4	0.6	0.4	0.6	0.4	0.6	CK	
Clock to First Rising edge of DQS-In		tDQSS	0.85	1.15	0.75	1.25	0.75	1.25	CK	
Data-In Setup Time to DQS-In (DQ & DM)		tDS	0.4	-	0.4	-	0.4	-	ns	3

Parameter		Symbol	4		5		6		Unit	Note
			Min	Max	Min	Max	Min	Max		
Data-In Hold Time to DQS-In (DQ & DM)		tDH	0.4	-	0.4	-	0.4	-	ns	3
Read DQS Preamble Time		tRPRE	0.9	1.1	0.9	1.1	0.9	1.1	CK	
Read DQS Postamble Time		tRPST	0.4	0.6	0.4	0.6	0.4	0.6	CK	
Write DQS Preamble Setup Time		tWPRES	0	-	0	-	0	-	ns	
Write DQS Preamble Hold Time		tWPREH	1.5	-	1.5	-	1.5	-	ns	
Write DQS Postamble Time		tWPST	0.4	0.6	0.4	0.6	0.4	0.6	CK	
Mode Register Set Delay		tMRD	2	-	2	-	2	-	CK	
Exit Self Refresh to Any Execute Command		tXSC	200	-	200	-	200	-	CK	4
Power Down Exit Time	Except Read Command	tPDEX	1tCK + tIS	-	1tCK + tIS	-	1tCK + tIS	-	CK	
	Read Command	tPDEX_RD	2tCK + tIS	-	2tCK + tIS	-	2tCK + tIS	-	CK	
Average Periodic Refresh Interval		tREFI	-	7.8	-	7.8	-	7.8	us	

Note :

1. This calculation accounts for tDQSQ(max), the pulse width distortion of on-chip circuit and jitter.
2. Data sampled at the rising edges of the clock : A0~A12, BA0~BA1, CKE, /CS, /RAS, /CAS, /WE.
3. Data latched at both rising and falling edges of Data Strobes(LDQS/UDQS) : DQ, LDM/UDM.
4. Minimum of 200 cycles of stable input clocks after Self Refresh Exit command, where CKE is held high, is required to complete Self Refresh Exit and lock the internal DLL circuit of DDR SDRAM.
5. Min (tCL, tCH) refers to the smaller of the actual clock low time and the actual clock high time as provided to the device (i.e. this value can be greater than the minimum specification limits for tCL and tCH).
6. tHP = minimum half clock period for any given cycle and is defined by clock high or clock low (tCH, tCL). tQHS consists of tDQSQmax, the pulse width distortion of on-chip clock circuits, data pin to pin skew and output pattern effects, and p-channel to n-channel variation of the output drivers.
7. DQS, DM and DQ input slew rate is specified to prevent double clocking of data and preserve setup and hold times. Signal transitions through the DC region must be monotonic.

AC CHARACTERISTICS - II

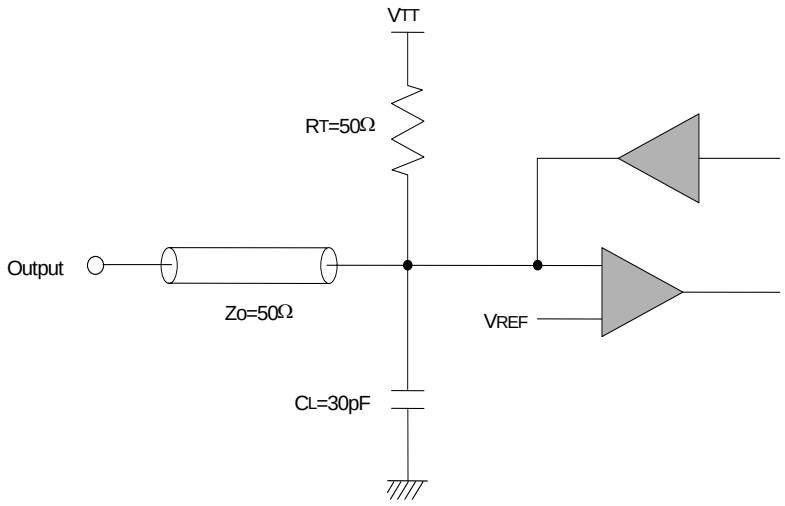
Frequency	CL	tRC (Manual Precharge)	tRC_APCG (AUTO Precharge)	tRFC	tRAS	tRCDRD	tRCDWR	tRP	tDAL	Unit
350MHz (2.8ns)	4	20	21	24	40ns	6	2	6	10	tCK
300MHz (3.3ns)	4	18	16	22	40ns	6	2	6	9	tCK
275MHz (3.6ns)	4	16	18	20	40ns	5	2	5	8	tCK
250MHz (4.0ns)	4	15	17	18	40ns	5	2	5	8	tCK
200MHz (5.0ns)	3	12	14	14	40ns	4	2	4	7	tCK
166MHz (6.0ns)	3	11	11	12	40ns	4	2	4	6	tCK

CAPACITANCE (T_A=25°C, f=1MHz)

Parameter	Pin	Symbol	Min	Max	Unit
Input Clock Capacitance	CK, $\overline{CK}$	C_{CK}	2.0	3.0	pF
Input Capacitance	All other input-only pins	C_{IN}	2.0	3.0	pF
Input / Output Capacitanc	DQ, DQS, DM	C_{IO}	4.0	5.0	pF

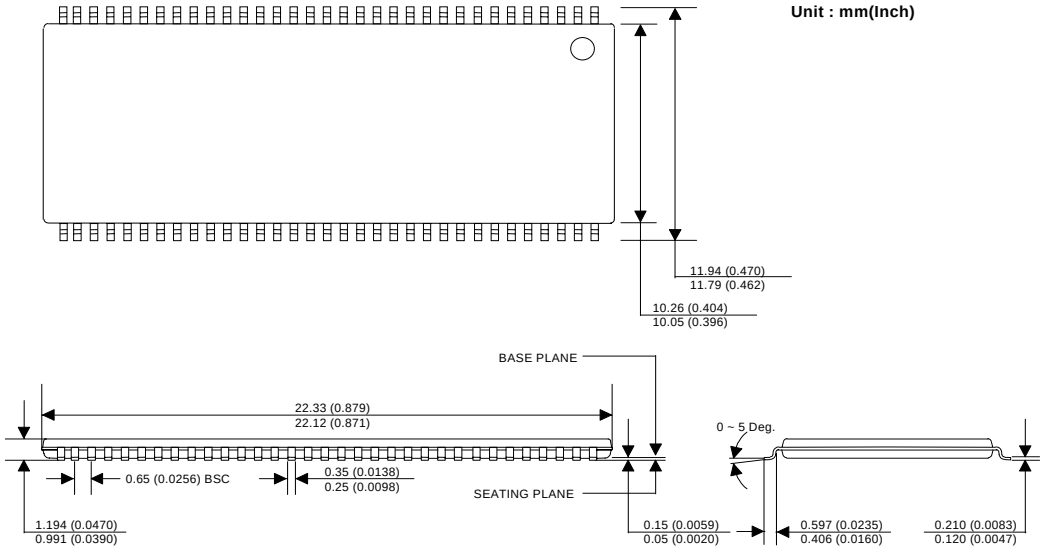
Note :
1. V_{DD} = min. to max., V_{DDQ} = 2.3V to 2.7V, V_{ODC} = V_{DDQ}/2, $V_{Opeak-to-peak}$ = 0.2V
2. Pins not under test are tied to GND.
3. These values are guaranteed by design and are tested on a sample basis only.

OUTPUT LOAD CIRCUIT



PACKAGE INFORMATION

400mil 66pin Thin Small Outline Package



Note : Package do not mold protrusion. Allowable protrusion of both sides is 0.4mm.