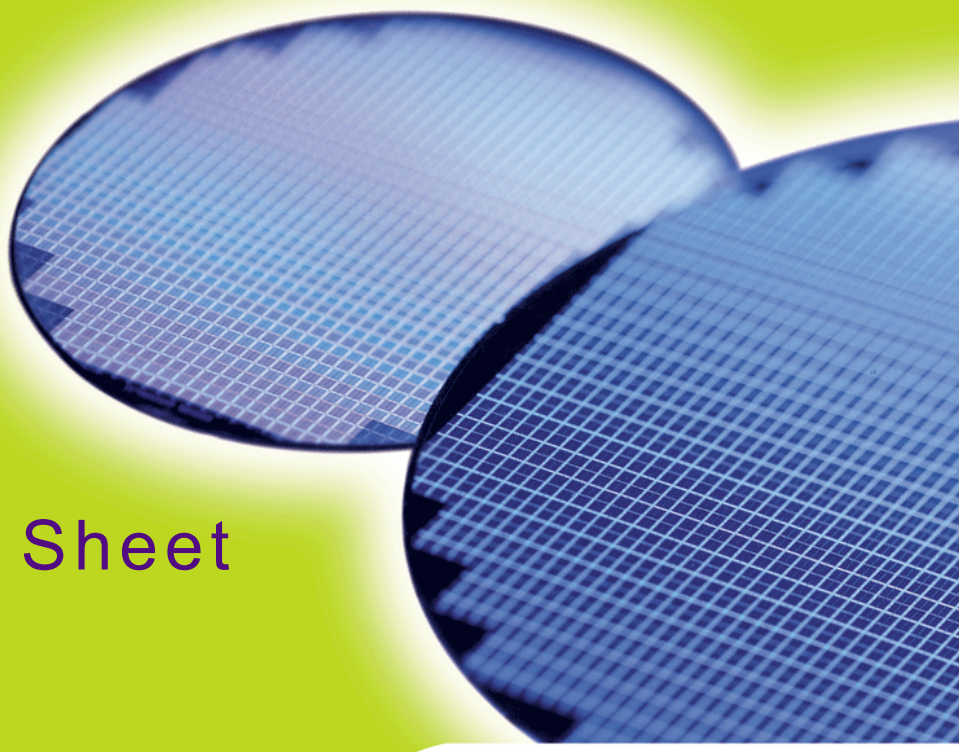
September 2006

HYI25DC256160CE
HYI25DC256800CE

256 Mbit Double-Data-Rate SDRAM
DDR SDRAM
RoHS Compliant



Internet Data Sheet

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All	Adapted internet edition
All	First data sheet

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1 Overview

This chapter lists all main features of the product family HYI25DC256[16/80]0CE and the ordering information.

1.1 Features

- Double data rate architecture: two data transfers per clock cycle
- Industrial operating temperature range: -40°C to +85°C
- Bidirectional data strobe (DQS) is transmitted and received with data, to be used in capturing data at the receiver
- DQS is edge-aligned with data for reads and is center-aligned with data for writes
- Differential clock inputs (CK and $\overline{CK}$)
- Four internal banks for concurrent operation
- Data mask (DM) for write data
- DLL aligns DQ and DQS transitions with CK transitions
- Commands entered on each positive CK edge; data and data mask referenced to both edges of DQS
- Burst Lengths: 2, 4, or 8
- CAS Latency: 2, 2.5, 3
- Auto Precharge option for each burst access
- Auto Refresh and Self Refresh Modes
- RAS-lockout supported t_{RAP}=t_{RCD}
- 7.8 µs Maximum Average Periodic Refresh Interval
- 2.5 V (SSTL_2 compatible) I/O
- V_{DDQ} = 2.6 V ± 0.1 V
- V_{DD} = 2.6 V ± 0.1 V
- PG-TSOPII-66 package
- Lead- and halogene-free = green product

TABLE 1
Performance

Part Number Speed Code			–5	–6	Unit
Speed Grade	Component		DDR400B	DDR333B	—
Max. Clock Frequency	@CL3	f_{CK3}	200	166	MHz
	@CL2.5	$f_{CK2.5}$	166	166	MHz
	@CL2	f_{CK2}	133	133	MHz

1.2 Description

The 256 Mbit Double-Data-Rate SDRAM is a high-speed CMOS, dynamic random-access memory containing 268,435,456 bits. It is internally configured as a quad-bank DRAM.

The 256 Mbit Double-Data-Rate SDRAM uses a double-data-rate architecture to achieve high-speed operation. The double data rate architecture is essentially a 2n prefetch architecture with an interface designed to transfer two data words per clock cycle at the I/O pins. A single read or write access for the 256 Mbit Double-Data-Rate SDRAM effectively consists of a single 2n-bit wide, one clock cycle data transfer at the internal DRAM core and two corresponding n-bit wide, one-half-clock-cycle data transfers at the I/O pins.

A bidirectional data strobe (DQS) is transmitted externally, along with data, for use in data capture at the receiver. DQS is a strobe transmitted by the DDR SDRAM during Reads and by the memory controller during Writes. DQS is edge-aligned with data for Reads and center-aligned with data for Writes.

The 256 Mbit Double-Data-Rate SDRAM operates from a differential clock (CK and $\overline{CK}$; the crossing of CK going HIGH and $\overline{CK}$ going LOW is referred to as the positive edge of CK). Commands (address and control signals) are registered at every positive edge of CK. Input data is registered on both edges of DQS, and output data is referenced to both edges of DQS, as well as to both edges of CK.Read and write accesses to the DDR SDRAM are burst oriented; accesses start at a selected location and continue for a programmed number of locations in a programmed sequence. Accesses begin with the registration of an Active command, which is then followed by a Read or Write command. The address bits registered coincident with the Active command are used to select the bank and row to be accessed. The address bits registered coincident with the Read or Write command are used to select the bank and the starting column location for the burst access.

The DDR SDRAM provides for programmable Read or Write burst lengths of 2, 4 or 8 locations. An Auto Precharge function may be enabled to provide a self-timed row precharge that is initiated at the end of the burst access. As with standard SDRAMs, the pipelined, multibank architecture of DDR SDRAMs allows for concurrent operation, thereby providing high effective bandwidth by hiding row precharge and activation time.

An auto refresh mode is provided along with a power-saving power-down mode. All inputs are compatible with the Industry Standard for SSTL_2. All outputs are SSTL_2, Class II compatible.

Note: The functionality described and the timing specifications included in this data sheet are for the DLL Enabled mode of operation.

TABLE 2
Ordering Information for RoHS Compliant Products

Product Type	Org.	CAS-RCD-RP Latencies	Clock (MHz)	CAS-RCD-RP Latencies	Clock (MHz)	Speed	Package	Note[1)2)]
HYI25DC256800CE–5	×8	3-3-3	200	2.5-3-3	166	DDR400B	PG-TSOPII-66	
HYI25DC256160CE–5	×16							
HYI25DC256800CE–6	×8	2.5-3-3	166	2-3-3	133	DDR333B	green Product	
HYI25DC256160CE–6	×16							

1) HYI: designator for memory components
25D: DDR SDRAMs at V_{DDQ} = 2.5 V
256: 256-Mbit density
160/800: Product variations ×16 and ×8
C: Die revision CE: Package type TSOP (Lead & Halogene free)

2) RoHS Compliant Product: Restriction of the use of certain hazardous substances (RoHS) in electrical and electronic equipment as defined in the directive 2002/95/EC issued by the European Parliament and of the Council of 27 January 2003. These substances include mercury, lead, cadmium, hexavalent chromium, polybrominated biphenyls and polybrominated biphenyl ethers..

2 Pin Configuration

The pin configuration of a DDR SDRAM is listed by function in **Table 3** (60 pins). The abbreviations used in the Pin#/Buffer# column are explained in **Table 4** and **Table 5** respectively.

TABLE 3
Pin Configuration of DDR SDRAM

Ball#/Pin#	Name	Pin Type	Buffer Type	Function
Clock Signals				
45	CK	I	SSTL	**Clock Signal**
46	$\overline{CK}$	I	SSTL	**Complementary Clock Signal**
44	CKE	I	SSTL	**Clock Enable**
Control Signals				
23	$\overline{RAS}$	I	SSTL	**Row Address Strobe**
22	$\overline{CAS}$	I	SSTL	**Column Address Strobe**
21	$\overline{WE}$	I	SSTL	**Write Enable**
24	$\overline{CS}$	I	SSTL	**Chip Select**
Address Signals				
26	BA0	I	SSTL	**Bank Address Bus 2:0**
27	BA1	I	SSTL	
29	A0	I	SSTL	**Address Bus 11:0**
30	A1	I	SSTL	
31	A2	I	SSTL	
32	A3	I	SSTL	
35	A4	I	SSTL	
36	A5	I	SSTL	
37	A6	I	SSTL	
38	A7	I	SSTL	
39	A8	I	SSTL	
40	A9	I	SSTL	
28	A10	I	SSTL	
	AP	I	SSTL	
41	A11	I	SSTL	
42	A12	I	SSTL	
17	NC	NC	—	**Address Signal 13** *Note: 512 Mbit or smaller dies*

Ball#/Pin#	Name	Pin Type	Buffer Type	Function
Data Signals				
2	DQ0	I/O	SSTL	**Data Signal 15:0**
4	DQ1	I/O	SSTL	
5	DQ2	I/O	SSTL	
7	DQ3	I/O	SSTL	
8	DQ4	I/O	SSTL	
10	DQ5	I/O	SSTL	
11	DQ6	I/O	SSTL	
13	DQ7	I/O	SSTL	
54	DQ8	I/O	SSTL	
56	DQ9	I/O	SSTL	
57	DQ10	I/O	SSTL	
59	DQ11	I/O	SSTL	
60	DQ12	I/O	SSTL	
62	DQ13	I/O	SSTL	
63	DQ14	I/O	SSTL	
65	DQ15	I/O	SSTL	
Data Strobe				
51	UDQS	I/O	SSTL	**Data Strobe**
16	LDQS	I/O	SSTL	
Data Mask				
47	UDM	I	SSTL	**Data Mask**
20	LDM	I	SSTL	
Power Supplies				
49	V_{REF}	AI	—	**I/O Reference Voltage**
3, 9, 15, 55, 61	V_{DDQ}	PWR	—	**I/O Driver Power Supply**
1, 18, 33	V_{DD}	PWR	—	**Power Supply**
6, 12, 52, 58, 64	V_{SSQ}	PWR	—	**Power Supply Ground for DQs**
34, 48, 66,	V_{SS}	PWR	—	**Power Supply Ground**
Not Connected				
14,17,19, 25, 42, 43, 50, 53	NC	NC	—	**Not connected**

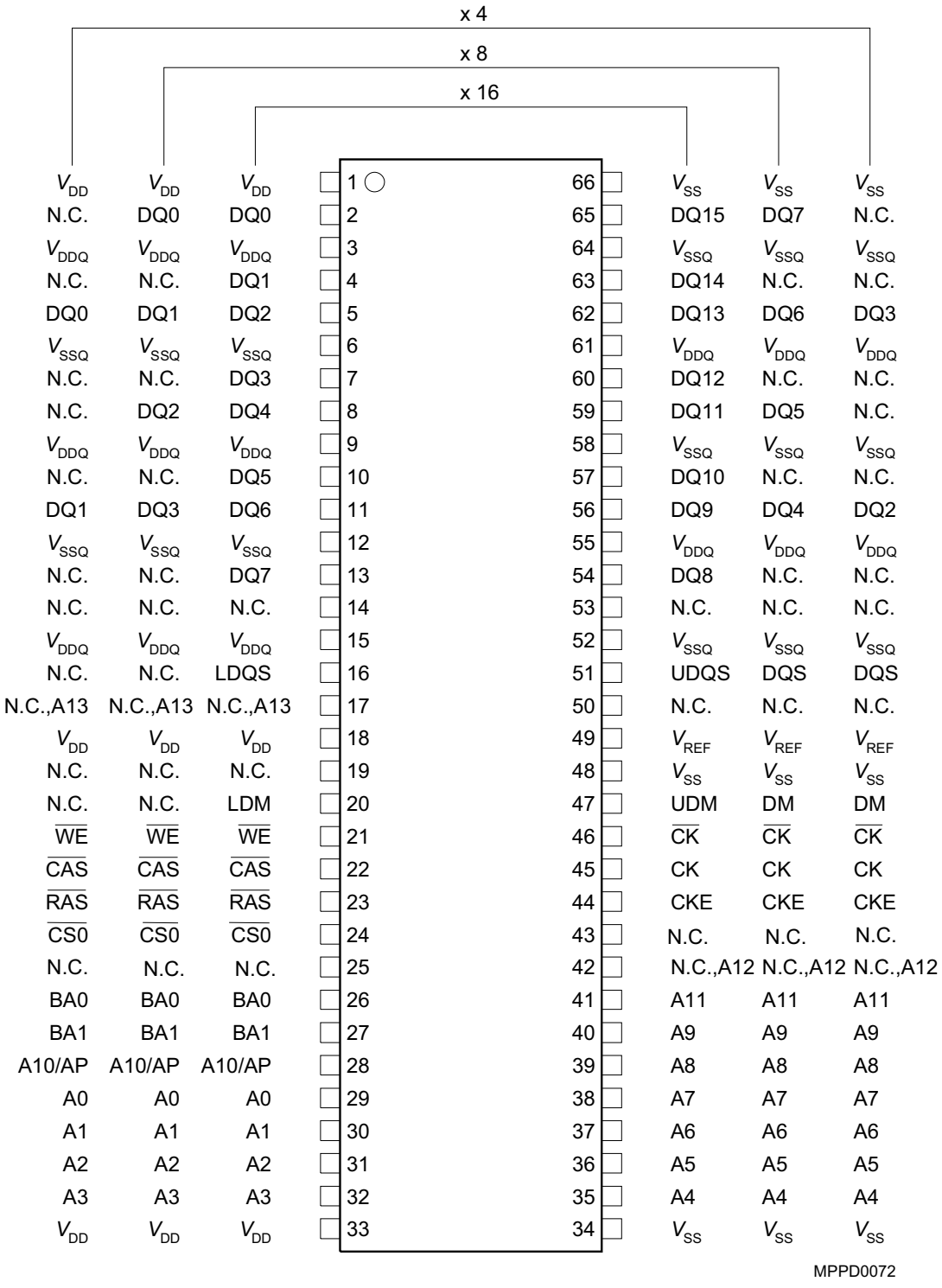
TABLE 4
Abbreviations for Pin Type

Abbreviation	Description
I	Standard input-only pin. Digital levels.
O	Output. Digital levels.
I/O	I/O is a bidirectional input/output signal.
AI	Input. Analog levels.
PWR	Power
GND	Ground
NC	Not Connected

TABLE 5
Abbreviations for Buffer Type

Abbreviation	Description
SSTL	Serial Stub Terminated Logic (SSTL2)
LV-CMOS	Low Voltage CMOS
CMOS	CMOS Levels
OD	Open Drain. The corresponding pin has 2 operational states, active low and tristate, and allows multiple devices to share as a wire-OR.

FIGURE 1
Pin Configuration P-TSOPII-66-1



3 Functional Description

The 256 Mbit Double-Data-Rate SDRAM is a high-speed CMOS, dynamic random-access memory containing 268,435,456 bits. The 256 Mbit Double-Data-Rate SDRAM is internally configured as a quad-bank DRAM.

The 256 Mbit Double-Data-Rate SDRAM uses a double-data-rate architecture to achieve high-speed operation. The double-data-rate architecture is essentially a 2n prefetch architecture, with an interface designed to transfer two data words per clock cycle at the I/O pins. A single read or write access for the 256 Mbit Double-Data-Rate SDRAM consists of a single 2n-bit wide, one clock cycle data transfer at the internal DRAM core and two corresponding n-bit wide, one-half clock cycle data transfers at the I/O pins.

Read and write accesses to the DDR SDRAM are burst oriented; accesses start at a selected location and continue for a programmed number of locations in a programmed sequence. Accesses begin with the registration of an Active command, which is then followed by a Read or Write command. The address bits registered coincident with the Active command are used to select the bank and row to be accessed. The address bits registered coincident with the Read or Write command are used to select the starting column location for the burst access.

Prior to normal operation, the DDR SDRAM must be initialized. The following sections provide detailed information covering device initialization, register definition, command descriptions and device operation.

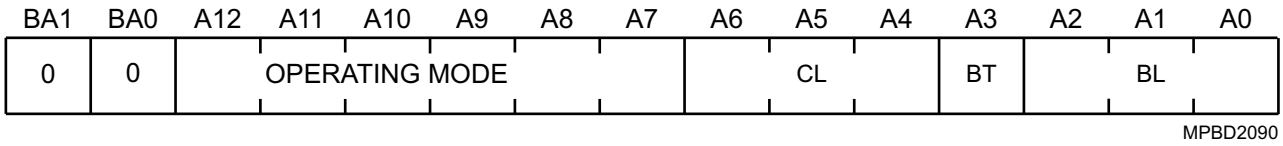


TABLE 6
Mode Register Definition

Field	Bits	Type[1)]	Description
BL	[2:0]	W	**Burst Length** Number of sequential bits per DQ related to one read/write command. *Note: All other bit combinations are RESERVED.* 001_B **2** 010_B **4** 011_B **8**
BT	3		**Burst Type** See **Table 7** for internal address sequence of low order address bits. 0 Sequential 1 Interleaved
CL	[6:4]		**CAS Latency** Number of full clocks from read command to first data valid window. *Note: All other bit combinations are RESERVED.* 010_B **2** 011_B **3** 110_B **2.5** 101_B **1.5** *Note: CL = 1.5 for DDR200 components only*
MODE	[12:7]		**Operating Mode** *Note: All other bit combinations are RESERVED.* 000000 Normal Operation without DLL Reset 000010 Normal Operation with DLL Reset

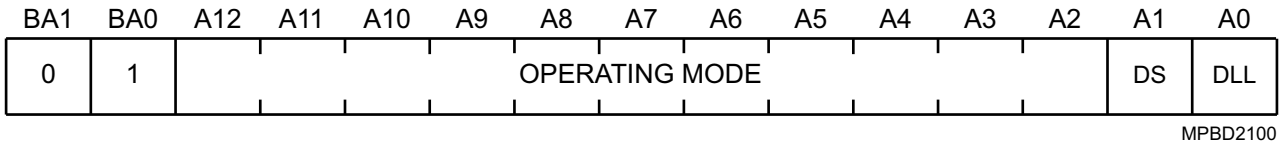
1) W = write only register bit

TABLE 7
Burst Definition

Burst Length	Starting Column Address			Order of Accesses Within a Burst	
	A2	A1	A0	Type = Sequential	Type = Interleaved
2			0	0-1	0-1
			1	1-0	1-0
4		0	0	0-1-2-3	0-1-2-3
		0	1	1-2-3-0	1-0-3-2
		1	0	2-3-0-1	2-3-0-1
		1	1	3-0-1-2	3-2-1-0
8	0	0	0	0-1-2-3-4-5-6-7	0-1-2-3-4-5-6-7
	0	0	1	1-2-3-4-5-6-7-0	1-0-3-2-5-4-7-6
	0	1	0	2-3-4-5-6-7-0-1	2-3-0-1-6-7-4-5
	0	1	1	3-4-5-6-7-0-1-2	3-2-1-0-7-6-5-4
	1	0	0	4-5-6-7-0-1-2-3	4-5-6-7-0-1-2-3
	1	0	1	5-6-7-0-1-2-3-4	5-4-7-6-1-0-3-2
	1	1	0	6-7-0-1-2-3-4-5	6-7-4-5-2-3-0-1
	1	1	1	7-0-1-2-3-4-5-6	7-6-5-4-3-2-1-0

Notes

1. *For a burst length of two, A1-Ai selects the two-data-element block; A0 selects the first access within the block.*
2. *For a burst length of four, A2-Ai selects the four-data-element block; A0-A1 selects the first access within the block.*
3. *For a burst length of eight, A3-Ai selects the eight-data- element block; A0-A2 selects the first access within the block.*
4. *Whenever a boundary of the block is reached within a given sequence above, the following access wraps within the block.*



MPBD2100

TABLE 8
Extended Mode Register

Field	Bits	Type[1)]	Description
DLL	0	W	**DLL Status** 0_B **Enabled** 1_B **Disabled**
DS	1		**Drive Strength** 0_B **Normal** 1_B **Weak**
MODE	[11:2]		**Operating Mode** 0000000000_B**Normal Operation**

1) W = write only register bit

TABLE 9
Truth Table 1a: Commands

Name (Function)	$\overline{CS}$	$\overline{RAS}$	$\overline{CAS}$	$\overline{WE}$	Address	MNE	Note
Deselect (NOP)	H	X	X	X	X	NOP	1)2)
No Operation (NOP)	L	H	H	H	X	NOP	1)2)
Active (Select Bank And Activate Row)	L	L	H	H	Bank/Row	ACT	1)3)
Read (Select Bank And Column, And Start Read Burst)	L	H	L	H	Bank/Col	Read	1)4)
Write (Select Bank And Column, And Start Write Burst)	L	H	L	L	Bank/Col	Write	1)4)
Burst Terminate	L	H	H	L	X	BST	1)5)
Precharge (Deactivate Row In Bank Or Banks)	L	L	H	L	Code	PRE	1)6)
Auto Refresh Or Self Refresh (Enter Self Refresh Mode)	L	L	L	H	X	AR/SR	1)7)8)
Mode Register Set	L	L	L	L	Op-Code	MRS	1)9)

1) CKE is HIGH for all commands shown except Self Refresh. V_{REF} must be maintained during Self Refresh operation
2) Deselect and NOP are functionally interchangeable.
3) BA0-BA1 provide bank address and A0-A12 provide row address.
4) BA0, BA1 provide bank address; A0-Ai provide column address (where i = 8 for x16, i = 9 for x 8); A10 HIGH enables the Auto Precharge feature (nonpersistent), A10 LOW disables the Auto Precharge feature.
5) Applies only to read bursts with Auto Precharge disabled; this command is undefined (and should not be used) for read bursts with Auto Precharge enabled or for write bursts.
6) A10 for x16 LOW: BA0, BA1 determine which bank is precharged. A10 for x16 HIGH: all banks are precharged and BA0, BA1 are “Don’t Care”.
7) This command is Auto Refresh if CKE is HIGH; Self Refresh if CKE is LOW.
8) Internal refresh counter controls row and bank addressing; all inputs and I/Os are “Don’t Care” except for CKE.
9) BA0, BA1 select either the Base or the Extended Mode Register (BA0 = 0, BA1 = 0 selects Mode Register; BA0 = 1, BA1 = 0 selects Extended Mode Register; other combinations of BA0-BA1 are reserved; A0-A12 provide the op-code to be written to the selected Mode Register).

TABLE 10
Truth Table 1b: DM Operation

Name (Function)	DM	DQs	Note
Write Enable	L	Valid	1)
Write Inhibit	H	X	1)

1) Used to mask write data; provided coincident with the corresponding data.

TABLE 11
Truth Table 2: Clock Enable (CKE)

Current State	CKE n-1	CKEn	Command n	Action n	Note
	Previous Cycle	Current Cycle			
Self Refresh	L	L	X	Maintain Self-Refresh	1)
Self Refresh	L	H	Deselect or NOP	Exit Self-Refresh	2)
Power Down	L	L	X	Maintain Power-Down	–
Power Down	L	H	Deselect or NOP	Exit Power-Down	–
All Banks Idle	H	L	Deselect or NOP	Precharge Power-Down Entry	–
All Banks Idle	H	L	AUTO REFRESH	Self Refresh Entry	–
Bank(s) Active	H	L	Deselect or NOP	Active Power-Down Entry	–
	H	H	See **Table 12**	–	–

1) V_{REF} must be maintained during Self Refresh operation

2) Deselect or NOP commands should be issued on any clock edges occurring during the Self Refresh Exit (t_{XSNR}) period. A minimum of 200 clock cycles are needed before applying a read command to allow the DLL to lock to the input clock.

Notes

1. *CKEn is the logic state of CKE at clock edge n: CKE n-1 was the state of CKE at the previous clock edge.*
2. *Current state is the state of the DDR SDRAM immediately prior to clock edge n.*
3. *COMMAND n is the command registered at clock edge n, and ACTION n is a result of COMMAND n.*
4. *All states and sequences not shown are illegal or reserved.*

TABLE 12

Truth Table 3: Current State Bank n - Command to Bank n (same bank)

Current State	$\overline{CS}$	$\overline{RAS}$	$\overline{CAS}$	$\overline{WE}$	Command	Action	Note
Any	H	X	X	X	Deselect	NOP. Continue previous operation.	1)2)3)4)5)6)
	L	H	H	H	No Operation	NOP. Continue previous operation.	1) to 6)
Idle	L	L	H	H	Active	Select and activate row	1) to 6)
	L	L	L	H	AUTO REFRESH	–	1) to7)
	L	L	L	L	MODE REGISTER SET	–	1) to 7)
Row Active	L	H	L	H	Read	Select column and start Read burst	1) to 6),8)
	L	H	L	L	Write	Select column and start Write burst	1) to 6),8)
	L	L	H	L	Precharge	Deactivate row in bank(s)	1) to 6),9)
Read (Auto Precharge Disabled)	L	H	L	H	Read	Select column and start new Read burst	1) to 6),8)
	L	L	H	L	Precharge	Truncate Read burst, start Precharge	1) to 6),9)
	L	H	H	L	BURST TERMINATE	BURST TERMINATE	1) to 6),10)
Write (Auto Precharge Disabled)	L	H	L	H	Read	Select column and start Read burst	1) to 6), 8),11)
	L	H	L	L	Write	Select column and start Write burst	1) to 6),8)
	L	L	H	L	Precharge	Truncate Write burst, start Precharge	1) to 6),9),11)

1) This table applies when CKE n-1 was HIGH and CKE n is HIGH (see **Table 11** and after t_{XSNR}/t_{XSRD} has been met (if the previous state was self refresh).
2) This table is bank-specific, except where noted, i.e., the current state is for a specific bank and the commands shown are those allowed to be issued to that bank when in that state. Exceptions are covered in the notes below.
3) Current state definitions: Idle: The bank has been precharged, and t_{RP} has been met. Row Active: A row in the bank has been activated, and t_{RCD} has been met. No data bursts/accesses and no register accesses are in progress. Read: A Read burst has been initiated, with Auto Precharge disabled, and has not yet terminated or been terminated. Write: A Write burst has been initiated, with Auto Precharge disabled, and has not yet terminated or been terminated.
4) The following states must not be interrupted by a command issued to the same bank. Precharging: Starts with registration of a Precharge command and ends when t_{RP} is met. Once t_{RP} is met, the bank is in the idle state. Row Activating: Starts with registration of an Active command and ends when t_{RCD} is met. Once t_{RCD} is met, the bank is in the “row active” state. Read w/Auto Precharge Enabled: Starts with registration of a Read command with Auto Precharge enabled and ends when t_{RP} has been met. Once t_{RP} is met, the bank is in the idle state. Write w/Auto Precharge Enabled: Starts with registration of a Write command with Auto Precharge enabled and ends when t_{RP} has been met. Once t_{RP} is met, the bank is in the idle state. Deselect or NOP commands, or allowable commands to the other bank should be issued on any clock edge occurring during these states. Allowable commands to the other bank are determined by its current state and according to **Table 13**.
5) The following states must not be interrupted by any executable command; Deselect or NOP commands must be applied on each positive clock edge during these states. Refreshing: Starts with registration of an Auto Refresh command and ends when t_{RFC} is met. Once t_{RFC} is met, the DDR SDRAM is in the “all banks idle” state. Accessing Mode Register: Starts with registration of a Mode Register Set command and ends when t_{MRD} has been met. Once t_{MRD} is met, the DDR SDRAM is in the “all banks idle” state. Precharging All: Starts with registration of a Precharge All command and ends when t_{RP} is met. Once t_{RP} is met, all banks is in the idle state.
6) All states and sequences not shown are illegal or reserved.
7) Not bank-specific; requires that all banks are idle.
8) Reads or Writes listed in the Command/Action column include Reads or Writes with Auto Precharge enabled and Reads or Writes with Auto Precharge disabled.
9) May or may not be bank-specific; if all/any banks are to be precharged, all/any must be in a valid state for precharging.
10) Not bank-specific; BURST TERMINATE affects the most recent Read burst, regardless of bank.
11) Requires appropriate DM masking.

TABLE 13

Truth Table 4: Current State Bank n - Command to Bank m (different bank)

Current State	$\overline{CS}$	$\overline{RAS}$	$\overline{CAS}$	$\overline{WE}$	Command	Action	Note
Any	H	X	X	X	Deselect	NOP. Continue previous operation.	1)2)3)4)5)6)
	L	H	H	H	No Operation	NOP. Continue previous operation.	1) to 6)
Idle	X	X	X	X	Any Command Otherwise Allowed to Bank m	–	1) to 6)
Row Activating, Active, or Precharging	L	L	H	H	Active	Select and activate row	1) to 6)
	L	H	L	H	Read	Select column and start Read burst	1) to7)
	L	H	L	L	Write	Select column and start Write burst	1) to 7)
	L	L	H	L	Precharge	–	1) to 6)
Read (Auto Precharge Disabled)	L	L	H	H	Active	Select and activate row	1) to 6)
	L	H	L	H	Read	Select column and start new Read burst	1) to 7)
	L	L	H	L	Precharge	–	1) to 6)
Write (Auto Precharge Disabled)	L	L	H	H	Active	Select and activate row	1) to 6)
	L	H	L	H	Read	Select column and start Read burst	1) to8)
	L	H	L	L	Write	Select column and start new Write burst	1) to 7)
	L	L	H	L	Precharge	–	1) to 6)
Read (With Auto Precharge)	L	L	H	H	Active	Select and activate row	1) to 6)
	L	H	L	H	Read	Select column and start new Read burst	1) to 7),9)
	L	H	L	L	Write	Select column and start Write burst	1) to 7),9),10)
	L	L	H	L	Precharge	–	1) to 6)
Write (With Auto Precharge)	L	L	H	H	Active	Select and activate row	1) to 6)
	L	H	L	H	Read	Select column and start Read burst	1) to 7),9)
	L	H	L	L	Write	Select column and start new Write burst	1) to 7),9)
	L	L	H	L	Precharge	–	1) to 6)

1) This table applies when CKE n-1 was HIGH and CKE n is HIGH (see **Table 11**: Clock Enable (CKE) and after t_{XSNR}/t_{XSRD} has been met (if the previous state was self refresh).

2) This table describes alternate bank operation, except where noted, i.e., the current state is for bank n and the commands shown are those allowed to be issued to bank m (assuming that bank m is in such a state that the given command is allowable). Exceptions are covered in the notes below.

3) Current state definitions: Idle: The bank has been precharged, and t_{RP} has been met. Row Active: A row in the bank has been activated, and t_{RCD} has been met. No data bursts/accesses and no register accesses are in progress. Read: A Read burst has been initiated, with Auto Precharge disabled, and has not yet terminated or been terminated. Write: A Write burst has been initiated, with Auto Precharge disabled, and has not yet terminated or been terminated. Read with Auto Precharge Enabled: See [10]. Write with Auto Precharge Enabled: See [10].

4) AUTO REFRESH and Mode Register Set commands may only be issued when all banks are idle.

5) A BURST TERMINATE command cannot be issued to another bank; it applies to the bank represented by the current state only.

6) All states and sequences not shown are illegal or reserved.

7) Reads or Writes listed in the Command/Action column include Reads or Writes with Auto Precharge enabled and Reads or Writes with Auto Precharge disabled.

8) Requires appropriate DM masking.

9) **Concurrent Auto Precharge:**This device supports “Concurrent Auto Precharge”. When a read with auto precharge or a write with auto precharge is enabled any command may follow to the other banks as long as that command does not interrupt the read or write data transfer and all other limitations apply (e.g. contention between READ data and WRITE data must be avoided). The minimum delay from a read or write command with auto precharge enable, to a command to a different banks is summarized in **Table 14**.

10) A Write command may be applied after the completion of data output.

TABLE 14
Truth Table 5: Concurrent Auto Precharge

From Command	To Command (different bank)	Minimum Delay with Concurrent Auto Precharge Support	Unit
WRITE w/AP	Read or Read w/AP	1 + (BL/2) + t_{WTR}	t_{CK}
	Write to Write w/AP	BL/2	t_{CK}
	Precharge or Activate	1	t_{CK}
Read w/AP	Read or Read w/AP	BL/2	t_{CK}
	Write or Write w/AP	CL (rounded up) + BL/2	t_{CK}
	Precharge or Activate	1	t_{CK}

4 Electrical Characteristics

4.1 Operating Conditions

TABLE 15
Absolute Maximum Ratings

Parameter	Symbol	Values			Unit	Note/Test Condition
		Min.	Typ.	Max.		
Voltage on I/O pins relative to V_{SS}	V_{IN}, V_{OUT}	–0.5	–	V_{DDQ} + 0.5	V	–
Voltage on inputs relative to V_{SS}	V_{IN}	–1	–	+3.6	V	–
Voltage on V_{DD} supply relative to V_{SS}	V_{DD}	–1	–	+3.6	V	–
Voltage on V_{DDQ} supply relative to V_{SS}	V_{DDQ}	–1	–	+3.6	V	–
Operating temperature (ambient)	T_A	–40	–	+85	°C	–
Storage temperature (plastic)	T_{STG}	-55	–	+150	°C	–
Power dissipation (per SDRAM component)	P_D	–	1	–	W	–
Short circuit output current	I_{OUT}	–	50	–	mA	–

Attention: Stresses above the max. values listed here may cause permanent damage to the device. Exposure to absolute maximum rating conditions for extended periods may affect device reliability. Maximum ratings are absolute ratings; exceeding only one of these values may cause irreversible damage to the integrated circuit.

TABLE 16
Input and Output Capacitances

Parameter	Symbol	Values			Unit	Note/Test Condition
		Min.	Typ.	Max.		
Input Capacitance: CK, $\overline{CK}$	C_{I1}	2.0	—	3.0	pF	1)
Delta Input Capacitance	C_{dI1}	—	—	0.25	pF	1)
Input Capacitance: All other input-only pins	C_{I2}	2.0	—	3.0	pF	1)
Delta Input Capacitance: All other input-only pins	C_{dIO}	—	—	0.5	pF	1)
Input/Output Capacitance: DQ, DQS, DM	C_{IO}	4.0	—	5.0	pF	1)2)
Delta Input/Output Capacitance: DQ, DQS, DM	C_{dIO}	—	—	0.5	pF	1)

1) These values are not subject to production test - verified by design/characterization and are tested on a sample base only. V_{DDQ} = V_{DD} = 2.5 V ± 0.2 V, f = 100 MHz, T_A = 25 ×C, $V_{OUT(DC)}$ = VDDQ/2, V_{OUT} (Peak to Peak) 0.2 V. Unused pins are tied to ground.

2) DM inputs are grouped with I/O pins reflecting the fact that they are matched in loading to DQ and DQS to facilitate trace matching at the board level.

TABLE 17
Electrical Characteristics and DC Operating Conditions

Parameter	Symbol	Values			Unit	Note[1)]/Test Condition
		Min.	Typ.	Max.		
Device Supply Voltage	V_{DD}	2.3	2.5	2.7	V	$f_{CK} \leq$ 166 MHz
Device Supply Voltage	V_{DD}	2.5	2.6	2.7	V	f_{CK} > 166 MHz 2)
Output Supply Voltage	V_{DDQ}	2.3	2.5	2.7	V	$f_{CK} \leq$ 166 MHz 3)
Output Supply Voltage	V_{DDQ}	2.5	2.6	2.7	V	f_{CK} > 166 MHz 2)3)
Supply Voltage, I/O Supply Voltage	V_{SS}, V_{SSQ}	0		0	V	—
Input Reference Voltage	V_{REF}	0.49 × V_{DDQ}	0.5 × V_{DDQ}	0.51 × V_{DDQ}	V	4)
I/O Termination Voltage (System)	V_{TT}	V_{REF} – 0.04		V_{REF} + 0.04	V	5)
Input High (Logic1) Voltage	$V_{IH(DC)}$	V_{REF} + 0.15		V_{DDQ} + 0.3	V	6)
Input Low (Logic0) Voltage	$V_{IL(DC)}$	–0.3		V_{REF} – 0.15	V	6)
Input Voltage Level, CK and $\overline{CK}$ Inputs	$V_{IN(DC)}$	–0.3		V_{DDQ} + 0.3	V	6)
Input Differential Voltage, CK and $\overline{CK}$ Inputs	$V_{ID(DC)}$	0.36		V_{DDQ} + 0.6	V	6)7)
VI-Matching Pull-up Current to Pull-down Current	VI_{Ratio}	0.71		1.4	—	8)
Input Leakage Current	I_I	–2		2	µA	Any input 0 V ≤ $V_{IN} \leq V_{DD}$; All other pins not under test = 0 V 9)
Output Leakage Current	I_{OZ}	–5		5	µA	DQs are disabled; 0 V ≤ $V_{OUT} \leq V_{DDQ}$ 9)
Output High Current, Normal Strength Driver	I_{OH}	—		–16.2	mA	V_{OUT} = 1.95 V
Output Low Current, Normal Strength Driver	I_{OL}	16.2		—	mA	V_{OUT} = 0.35 V

1) 0 °C ≤ T_A ≤ 70 °C; V_{DDQ} = 2.5 V ± 0.2 V, V_{DD} = +2.5 V ± 0.2 V;
2) DDR400 conditions apply for all clock frequencies above 166 MHz
3) Under all conditions, V_{DDQ} must be less than or equal to V_{DD}.
4) Peak to peak AC noise on V_{REF} may not exceed ± 2% $V_{REF.DC}$. V_{REF} is also expected to track noise variations in V_{DDQ}.
5) 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 V_{REF}, and must track variations in the DC level of V_{REF}.
6) Inputs are not recognized as valid until V_{REF} stabilizes.
7) V_{ID} is the magnitude of the difference between the input level on CK and the input level on $\overline{CK}$.
8) The ratio of the pull-up current to the pull-down current is specified for the same temperature and voltage, over the entire temperature and voltage range, for device drain to source voltage from 0.25 to 1.0 V. For a given output, it represents the maximum difference between pull-up and pull-down drivers due to process variation.
9) Values are shown per pin.

4.2 AC Characteristics

(Notes 1-5 apply to the following Tables; Electrical Characteristics and DC Operating Conditions, AC Operating Conditions, I_{DD} Specifications and Conditions, and Electrical Characteristics and AC Timing.)

Notes

1. *All voltages referenced to V_{SS}.*
2. *Tests for AC timing, I_{DD}, and electrical, AC and DC characteristics, may be conducted at nominal reference/supply voltage levels, but the related specifications and device operation are guaranteed for the full voltage range specified.*
3. ***Figure 2** represents the timing reference load used in defining the relevant timing parameters of the part. It is not intended to be either a precise representation of the typical system environment nor a depiction of the actual load presented by a production tester. System designers will use IBIS or other simulation tools to correlate the timing reference load to a system environment. Manufacturers will correlate to their production test conditions (generally a coaxial transmission line terminated at the tester electronics).*
4. *AC timing and I_{DD} tests may use a V_{IL} to V_{IH} swing of up to 1.5 V in the test environment, but input timing is still referenced to V_{REF} (or to the crossing point for CK, $\overline{CK}$), and parameter specifications are guaranteed for the specified AC input levels under normal use conditions. The minimum slew rate for the input signals is 1 V/ns in the range between $V_{IL(AC)}$ and $V_{IH(AC)}$.*
5. *The AC and DC input level specifications are as defined in the SSTL_2 Standard (i.e. the receiver effectively switches as a result of the signal crossing the AC input level, and remains in that state as long as the signal does not ring back above (below) the DC input LOW (HIGH) level).*
6. *For System Characteristics like Setup & Holdtime Derating for Slew Rate, I/O Delta Rise/Fall Derating, DDR SDRAM Slew Rate Standards, Overshoot & Undershoot specification and Clamp V-I characteristics see the latest Industry Standard for DDR components.*

FIGURE 2
AC Output Load Circuit Diagram / Timing Reference Load

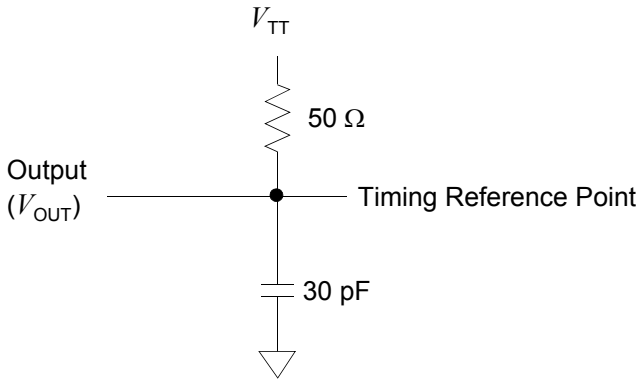


TABLE 18
AC Operating Conditions

Parameter	Symbol	Values		Unit	Note/Test Condition
		Min.	Max.		
Input High (Logic 1) Voltage, DQ, DQS and DM Signals	$V_{IH(AC)}$	V_{REF} + 0.31	—	V	1)2)3)
Input Low (Logic 0) Voltage, DQ, DQS and DM Signals	$V_{IL(AC)}$	—	V_{REF} – 0.31	V	1)2)3)
Input Differential Voltage, CK and $\overline{CK}$ Inputs	$V_{ID(AC)}$	0.7	V_{DDQ} + 0.6	V	1)2)3)4)
Input Closing Point Voltage, CK and $\overline{CK}$ Inputs	$V_{IX(AC)}$	0.5 × V_{DDQ}– 0.2	0.5 × V_{DDQ}+ 0.2	V	1)2)3)5)

1) V_{DDQ} = 2.5 V ± 0.2 V, V_{DD} = +2.5 V ± 0.2 V (DDR200 - DDR333); V_{DDQ} = 2.6 V ± 0.1 V, V_{DD} = +2.6 V ± 0.1 V (DDR400); -40 °C ≤ T_A ≤ 85 °C
2) Input slew rate = 1 V/ns.
3) Inputs are not recognized as valid until V_{REF} stabilizes.
4) V_{ID} is the magnitude of the difference between the input level on CK and the input level on $\overline{CK}$.
5) The value of V_{IX} is expected to equal 0.5 × V_{DDQ} of the transmitting device and must track variations in the DC level of the same.

TABLE 19
AC Timing - Absolute Specifications

Parameter	Symbol	–5		–6		Unit	Note[1)]/Test Condition
		DDR400B		DDR333B			
		Min.	Max.	Min.	Max.		
DQ output access time from CK/$\overline{CK}$	t_{AC}	–0.5	+0.5	–0.7	+0.7	ns	2)3)4)5)
CK high-level width	t_{CH}	0.45	0.55	0.45	0.55	t_{CK}	2)3)4)5)
Clock cycle time	t_{CK}	5	8	6	12	ns	CL = 3.0 3)4)5)
		6	12	6	12	ns	CL = 2.5 2)3)4)5)
		7.5	12	7.5	12	ns	CL = 2.0 2)3)4)5)
CK low-level width	t_{CL}	0.45	0.55	0.45	0.55	t_{CK}	2)3)4)5)
Auto precharge write recovery + precharge time	t_{DAL}	(t_{WR}/t_{CK})+(t_{RP}/t_{CK})				t_{CK}	2)3)4)5)6)
DQ and DM input hold time	t_{DH}	0.4	—	0.45	—	ns	2)3)4)5)
DQ and DM input pulse width (each input)	t_{DIPW}	1.75	—	1.75	—	ns	2)3)4)5)6)
DQS output access time from CK/$\overline{CK}$	t_{DQSCK}	–0.6	+0.6	–0.6	+0.6	ns	2)3)4)5)
DQS input low (high) pulse width (write cycle)	$t_{DQSL,H}$	0.35	—	0.35	—	t_{CK}	2)3)4)5)
DQS-DQ skew (DQS and associated DQ signals)	t_{DQSQ}	—	+0.40	—	+0.40	ns	TFBGA 2)3)4)5)
Write command to 1st DQS latching transition	t_{DQSS}	0.72	1.25	0.75	1.25	t_{CK}	2)3)4)5)
DQ and DM input setup time	t_{DS}	0.4	—	0.45	—	ns	2)3)4)5)

Parameter	Symbol	–5		–6		Unit	Note[1]/Test Condition
		DDR400B		DDR333B			
		Min.	Max.	Min.	Max.		
DQS falling edge hold time from CK (write cycle)	t_{DSH}	0.2	—	0.2	—	t_{CK}	2)3)4)5)
DQS falling edge to CK setup time (write cycle)	t_{DSS}	0.2	—	0.2	—	t_{CK}	2)3)4)5)
Clock Half Period	t_{HP}	Min. (t_{CL}, t_{CH})		Min. (t_{CL}, t_{CH})		ns	2)3)4)5)
Data-out high-impedance time from CK/$\overline{CK}$	t_{HZ}	—	+0.7	–0.7	+0.7	ns	2)3)4)5)7)
Address and control input hold time	t_{IH}	0.6	—	0.75	—	ns	Fast slew rate 3)4)5)6)8)
		0.7	—	0.8	—	ns	Slow slew rate 3)4)5)6)8)
Control and Addr. input pulse width (each input)	t_{IPW}	2.2	—	2.2	—	ns	2)3)4)5)9)
Address and control input setup time	t_{IS}	0.6	—	0.75	—	ns	Fast slew rate 3)4)5)6)8)
		0.7	—	0.8	—	ns	Slow slew rate 3)4)5)6)8)
Data-out low-impedance time from CK/$\overline{CK}$	t_{LZ}	–0.7	+0.7	–0.7	+0.7	ns	2)3)4)5)7)
Mode register set command cycle time	t_{MRD}	2	—	2	—	t_{CK}	2)3)4)5)
DQ/DQS output hold time	t_{QH}	$t_{HP} - t_{QHS}$		$t_{HP} - t_{QHS}$		ns	2)3)4)5)
Data hold skew factor	t_{QHS}	—	+0.50	—	+0.50	ns	TFBGA 2)3)4)5)
Active to Autoprecharge delay	t_{RAP}	t_{RCD}	—	t_{RCD}	—	ns	2)3)4)5)
Active to Precharge command	t_{RAS}	40	70E+3	42	70E+3	ns	2)3)4)5)
Active to Active/Auto-refresh command period	t_{RC}	55	—	60	—	ns	2)3)4)5)
Active to Read or Write delay	t_{RCD}	15	—	18	—	ns	2)3)4)5)
Average Periodic Refresh Interval	t_{REFI}	—	7.8	—	7.8	µs	2)3)4)5)10)
Auto-refresh to Active/Auto-refresh command period	t_{RFC}	65	—	72	—	ns	2)3)4)5)
Precharge command period	t_{RP}	15	—	18	—	ns	2)3)4)5)
Read preamble	t_{RPRE}	0.9	1.1	0.9	1.1	t_{CK}	2)3)4)5)
Read postamble	t_{RPST}	0.40	0.60	0.40	0.60	t_{CK}	2)3)4)5)
Active bank A to Active bank B command	t_{RRD}	10	—	12	—	ns	2)3)4)5)
Write preamble	t_{WPRE}	0.25	—	0.25	—	t_{CK}	2)3)4)5)
Write preamble setup time	t_{WPRES}	0	—	0	—	ns	2)3)4)5)11)
Write postamble	t_{WPST}	0.40	0.60	0.40	0.60	t_{CK}	2)3)4)5)12)
Write recovery time	t_{WR}	15	—	15	—	ns	2)3)4)5)

Parameter	Symbol	–5		–6		Unit	Note[1]/Test Condition
		DDR400B		DDR333B			
		Min.	Max.	Min.	Max.		
Internal write to read command delay	t_{WTR}	2	—	1	—	t_{CK}	2)3)4)5)
Exit self-refresh to non-read command	t_{XSNR}	75	—	75	—	ns	2)3)4)5)
Exit self-refresh to read command	t_{XSRD}	200	—	200	—	t_{CK}	2)3)4)5)

1) -40 °C ≤ T_A ≤ 85 °C; V_{DDQ} = 2.5 V ± 0.2 V, V_{DD} = +2.5 V ± 0.2 V (DDR333); V_{DDQ} = 2.6 V ± 0.1 V, V_{DD} = +2.6 V ± 0.1 V (DDR400)
2) Input slew rate ≥ 1 V/ns for DDR400, DDR333
3) The CK/$\overline{CK}$ input reference level (for timing reference to CK/$\overline{CK}$) is the point at which CK and $\overline{CK}$ cross: the input reference level for signals other than CK/$\overline{CK}$, is V_{REF}. CK/$\overline{CK}$ slew rate are ≥ 1.0 V/ns.
4) Inputs are not recognized as valid until V_{REF} stabilizes.
5) The Output timing reference level, as measured at the timing reference point indicated in AC Characteristics (note 3) is V_{TT}.
6) For each of the terms, if not already an integer, round to the next highest integer. tCK is equal to the actual systemclock cycle time.
7) t_{HZ} and t_{LZ} transitions occur in the same access time windows as valid data transitions. These parameters are not referred to a specific voltage level, but specify when the device is no longer driving (HZ), or begins driving (LZ).
8) Fast slew rate ≥ 1.0 V/ns , slow slew rate ≥ 0.5 V/ns and < 1 V/ns for command/address and CK & $\overline{CK}$ slew rate > 1.0 V/ns, measured between $V_{IH(ac)}$ and $V_{IL(ac)}$.
9) These parameters guarantee device timing, but they are not necessarily tested on each device.
10) A maximum of eight Autorefresh commands can be posted to any given DDR SDRAM device.
11) The specific requirement is that DQS be valid (HIGH,LOW, or some point on a valid transition) on or before this CK edge. A valid transition is defined as monotonic and meeting the input slew rate specificationsof the device. When no writes were previously in progress on the bus, DQS will be transitioning from Hi-Z to logic LOW. If a previous write was in progress, DQS could be HIGH, LOW at this time, depending on t_{DQSS}.
12) The maximum limit for this parameter is not a device limit. The device operates with a greater value for this parameter, but system performance (bus turnaround) degrades accordingly.

TABLE 20
I_{DD} Conditions

Parameter	Symbol
Operating Current: one bank; active/ precharge; t_{RC} = t_{RCMIN}; t_{CK} = t_{CKMIN}; DQ, DM, and DQS inputs changing once per clock cycle; address and control inputs changing once every two clock cycles.	I_{DD0}
Operating Current: one bank; active/read/precharge; Burst = 4; Refer to the following page for detailed test conditions.	I_{DD1}
Precharge Power-Down Standby Current: all banks idle; power-down mode; CKE ≤V_{ILMAX}; t_{CK} = t_{CKMIN}	I_{DD2P}
Precharge Floating Standby Current: $\overline{CS}$ ≥ V_{IHMIN}, all banks idle; CKE ≥ V_{IHMIN}; t_{CK} = t_{CKMIN}, address and other control inputs changing once per clock cycle, V_{IN} = V_{REF} for DQ, DQS and DM.	I_{DD2F}
Precharge Quiet Standby Current: $\overline{CS}$ ≥ V_{IHMIN}, all banks idle; CKE ≥ V_{IHMIN}; t_{CK} = t_{CKMIN}, address and other control inputs stable at ≥ V_{IHMIN} or ≤ V_{ILMAX}; V_{IN}=V_{REF} for DQ, DQS and DM.	I_{DD2Q}
Active Power-Down Standby Current: one bank active; power-down mode; CKE ≤ V_{ILMAX}; t_{CK}= t_{CKMIN}; V_{IN} = V_{REF} for DQ, DQS and DM.	I_{DD3P}
Active Standby Current: one bank active; $\overline{CS}$ ≥ V_{IHMIN}; CKE ≥ V_{IHMIN}; t_{RC} = t_{RASMAX}; t_{CK} = t_{CKMIN}; DQ, DM and DQS inputs changing twice per clock cycle; address and control inputs changing once per clock cycle	I_{DD3N}
Operating Current: one bank active; Burst = 2; reads; continuous burst; address and control inputs changing once per clock cycle; 50% of data outputs changing on every clock edge; CL = 2 for DDR200 and DDR266A, CL = 3 for DDR333; t_{CK} = t_{CKMIN}; I_{OUT} = 0 mA	I_{DD4R}
Operating Current: one bank active; Burst = 2; writes; continuous burst; address and control inputs changing once per clock cycle; 50% of data outputs changing on every clock edge; CL = 2 for DDR200 and DDR266A, CL = 3 for DDR333; t_{CK} = t_{CKMIN}	I_{DD4W}
Auto-Refresh Current: t_{RC} = t_{RFCMIN}, burst refresh	I_{DD5}
Self-Refresh Current: CKE ≤ 0.2 V; external clock on; t_{CK} = t_{CKMIN}	I_{DD6}
Operating Current: four bank; four bank interleaving with BL = 4; Refer to the following page for detailed test conditions.	I_{DD7}

TABLE 21
I_{DD} Specification

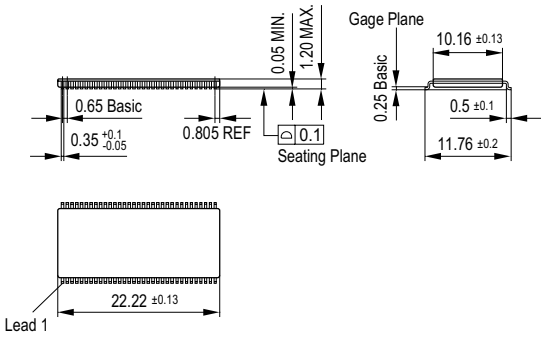
Symbol	–5	–6	Unit	Note[1)]/Test Condition
	DDR400B	DDR333B		
I_{DD0}	90	75	mA	×8[2)3)]
	90	75	mA	×16 [3)]
I_{DD1}	100	85	mA	×8 [3)]
	110	95	mA	×16 [3)]
I_{DD2P}	5	5	mA	[3)]
I_{DD2F}	36	30	mA	[3)]
I_{DD2Q}	28	24	mA	[3)]
I_{DD3P}	18	15	mA	[3)]
I_{DD3N}	45	38	mA	[3)]
	54	45	mA	×16 [3)]
I_{DD4R}	100	85	mA	×8 [3)]
	120	100	mA	×16 [3)]
I_{DD4W}	105	90	mA	×8 [3)]
	130	110	mA	×16 [3)]
I_{DD5}	190	160	mA	[3)]
I_{DD6}	3.0	3.0	mA	[4)]
	—	1.1	mA	Low power[5)]
I_{DD7}	250	215	mA	×8 [3)]
	250	215	mA	×16 [3)]

1) Test conditions: V_{DD} = 2.7 V, T_A = 10 °C
2) I_{DD} specifications are tested after the device is properly initialized and measured at 133 MHz for DDR266, 166 MHz for DDR333, and 200 MHz for DDR400.
3) Input slew rate = 1 V/ns.
4) Enables on-chip refresh and address counters.
5) Low power available on request

5 Package Outlines

There is a package type PG-TFBGA used for this product family in lead-free assembly.

FIGURE 3
Package Outline of PG-TSOPII-66



List of Figures

List of Tables

Table of Contents

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