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DDR SDRAM Small-Outline DIMM

MT9VDDT1672PH(I) – 128MB, MT9VDDT3272PH(I) – 256MB, MT9VDDT6472PH(I) – 512MB, MT9VDDT12872PH(I) – 1GB (Advance‡)

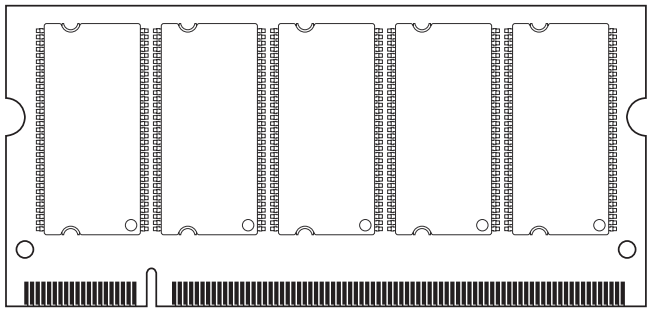
For the lastest data sheet, please refer to the Micron® Web site: www.micron.com/products/modules

Features

- 200-pin, small-outline, dual in-line memory module (SODIMM)
- Supports ECC error detection and correction
- Fast data transfer rates: PC2100 and PC2700
- Utilizes 266 MT/s and 333 MT/s DDR SDRAM components
- 128MB (16 Meg x 72); 256MB (32 Meg x 72); 512MB (64 Meg x 72); 1GB (128 Meg x 72)
- V_{DD} = $V_{DD}Q$ = +2.5V
- V_{DDSPD} = +2.3V to +3.6V
- 2.5V I/O (SSTL_2 compatible)
- Commands entered on each positive CK edge
- DQS edge-aligned with data for READs; center-aligned with data for WRITEs
- Internal, pipelined double data rate (DDR) architecture; two data accesses per clock cycle
- Four internal device banks for concurrent operation
- Programmable burst lengths: 2, 4, or 8
- Auto precharge option
- Auto Refresh and Self Refresh Modes
- 15.625µs (128MB), 7.8125µs (256MB, 512MB, 1GB) maximum average periodic refresh interval
- Serial Presence Detect (SPD) with EEPROM
- Programmable READ CAS latency
- Bidirectional data strobe (DQS) transmitted/received with data—i.e., source-synchronous data capture
- Differential clock inputs CK and CK#
- Gold edge contacts

Figure 1: 200-Pin SODIMM (MO-224)

Low Profile: 1.25in. (31.75mm)



Options — Marking

- Operating Temperature Range
  - Commercial (0°C ≤ T_A ≤ +70°C) — None
  - Industrial (-40°C ≤ T_A ≤ +85°C) — I[1]
- Package
  - 200-pin SODIMM (standard) — G
  - 200-pin SODIMM (lead-free) — Y[1]
- Memory Clock, Speed, CAS Latency[2]
  - 6ns (267 MHz), 333 MT/s, CL = 2.5 — -335
  - 7.5ns (133 MHz), 266 MT/s, CL = 2 — -262[1]
  - 7.5ns (133 MHz), 266 MT/s, CL = 2 — -26A[1]
  - 7.5ns (133 MHz), 266 MT/s, CL = 2.5 — -265
- PCB Height
  - 1.25in. (31.75mm)

Notes: 1. Consult Micron for product availability; industrial temperature option available in -265 speed only.
2. CL = Device CAS (READ) Latency.

Table 1: Address Table

	128MB	256MB	512MB	1GB
Refresh Count	4K	8K	8K	8K
Row Addressing	4K (A0–A11)	8K (A0–A12)	8K (A0–A12)	16K (A0–A13)
DeviceBankAddressing	4 (BA0, BA1)	4 (BA0, BA1)	4 (BA0, BA1)	4 (BA0, BA1)
Base Device Configuration	128Mb (16 Meg x 8)	256Mb (32 Meg x 8)	512Mb (64 Meg x 8)	1Gb (128 Meg x 8)
Column Addressing	1K (A0–A9)	1K (A0–A9)	1K (A0–A9, A11)	2K (A0–A9, A11)
Module Rank Addressing	1 (S0#)	1 (S0#)	1 (S0#	1 (S0#)

Table 2: Part Numbers and Timing Parameters

Part Number	Module Density	Configuration	Module Bandwidth	Memory Clock/ Data Rate	Clock Latency (CL - ^{t}RCD - ^{t}RP)
MT9VDDT1672PHG-335_	128MB	16 Meg x 72	2.7 GB/s	6ns, 333 MT/s	2.5-3-3
MT9VDDT1672PHY-335_	128MB	16 Meg x 72	2.7 GB/s	6ns, 333 MT/s	2.5-3-3
MT9VDDT1672PHG-262_	128MB	16 Meg x 72	2.1 GB/s	7.5ns, 266 MT/s	2-2-2
MT9VDDT1672PHY-262_	128MB	16 Meg x 72	2.1 GB/s	7.5ns, 266 MT/s	2-2-2
MT9VDDT1672PHG-26A_	128MB	16 Meg x 72	2.1 GB/s	7.5ns, 266 MT/s	2-3-3
MT9VDDT1672PHY-26A_	128MB	16 Meg x 72	2.1 GB/s	7.5ns, 266 MT/s	2-3-3
MT9VDDT1672PH(I)G-265_	128MB	16 Meg x 72	2.1 GB/s	7.5ns, 266 MT/s	2.5-3-3
MT9VDDT1672PH(I)Y-265_	128MB	16 Meg x 72	2.1 GB/s	7.5ns, 266 MT/s	2.5-3-3
MT9VDDT3272PHG-335_	256MB	32 Meg x 72	2.7 GB/s	6ns, 333 MT/s	2.5-3-3
MT9VDDT3272PHY-335_	256MB	32 Meg x 72	2.7 GB/s	6ns, 333 MT/s	2.5-3-3
MT9VDDT3272PHG-262_	256MB	32 Meg x 72	2.1 GB/s	7.5ns, 266 MT/s	2-2-2
MT9VDDT3272PHY-262_	256MB	32 Meg x 72	2.1 GB/s	7.5ns, 266 MT/s	2-2-2
MT9VDDT3272PHG-26A_	256MB	32 Meg x 72	2.1 GB/s	7.5ns, 266 MT/s	2-3-3
MT9VDDT3272PHY-26A_	256MB	32 Meg x 72	2.1 GB/s	7.5ns, 266 MT/s	2-3-3
MT9VDDT3272PH(I)G-265_	256MB	32 Meg x 72	2.1 GB/s	7.5ns, 266 MT/s	2.5-3-3
MT9VDDT3272PH(I)Y-265_	256MB	32 Meg x 72	2.1 GB/s	7.5ns, 266 MT/s	2.5-3-3
MT9VDDT6472PHG-335_	512MB	64 Meg x 72	2.7 GB/s	6ns, 333 MT/s	2.5-3-3
MT9VDDT6472PHY-335_	512MB	64 Meg x 72	2.7 GB/s	6ns, 333 MT/s	2.5-3-3
MT9VDDT6472PHG-262_	512MB	64 Meg x 72	2.1 GB/s	7.5ns, 266 MT/s	2-2-2
MT9VDDT6472PHY-262_	512MB	64 Meg x 72	2.1 GB/s	7.5ns, 266 MT/s	2-2-2
MT9VDDT6472PHG-26A_	512MB	64 Meg x 72	2.1 GB/s	7.5ns, 266 MT/s	2-3-3
MT9VDDT6472PHY-26A_	512MB	64 Meg x 72	2.1 GB/s	7.5ns, 266 MT/s	2-3-3
MT9VDDT6472PH(I)G-265_	512MB	64 Meg x 72	2.1 GB/s	7.5ns, 266 MT/s	2.5-3-3
MT9VDDT6472PH(I)Y-265_	512MB	64 Meg x 72	2.1 GB/s	7.5ns, 266 MT/s	2.5-3-3
MT9VDDT12872PHG-335_	1GB	128 Meg x 72	2.7 GB/s	6ns, 333 MT/s	2.5-3-3
MT9VDDT12872PHY-335_	1GB	128 Meg x 72	2.7 GB/s	6ns, 333 MT/s	2.5-3-3
MT9VDDT12872PHG-262_	1GB	128 Meg x 72	2.1 GB/s	7.5ns, 266 MT/s	2-2-2
MT9VDDT12872PHY-262_	1GB	128 Meg x 72	2.1 GB/s	7.5ns, 266 MT/s	2-2-2
MT9VDDT12872PHG-26A_	1GB	128 Meg x 72	2.1 GB/s	7.5ns, 266 MT/s	2-3-3
MT9VDDT12872PHY-26A_	1GB	128 Meg x 72	2.1 GB/s	7.5ns, 266 MT/s	2-3-3
MT9VDDT12872PH(I)G-265_	1GB	128 Meg x 72	2.1 GB/s	7.5ns, 266 MT/s	2.5-3-3
MT9VDDT12872PH(I)Y-265_	1GB	128 Meg x 72	2.1 GB/s	7.5ns, 266 MT/s	2.5-3-3

Note: All part numbers end with a two-place code (not shown), designating component and PCB revisions. Consult factory for current revision codes. Example: MT9VDDT3272PHG-265A1.

Pin Assignments and Descriptions

Table 1: Pin Assignment

200-Pin SODIMM Front								200-Pin SODIMM Back							
PIN	SYMBOL	PIN	SYMBOL	PIN	SYMBOL	PIN	SYMBOL	PIN	SYMBOL	PIN	SYMBOL	PIN	SYMBOL	PIN	SYMBOL
1	VREF	51	VSS	101	A9	151	DQ42	2	VREF	52	VSS	102	A8	152	DQ46
3	VSS	53	DQ19	103	VSS	153	DQ43	4	VSS	54	DQ23	104	VSS	154	DQ47
5	DQ0	55	DQ24	105	A7	155	VDD	6	DQ4	56	DQ28	106	A6	156	VDD
7	DQ1	57	VDD	107	A5	157	VDD	8	DQ5	58	VDD	108	A4	158	NC
9	Vdd	59	DQ25	109	A3	159	VSS	10	VDD	60	DQ29	110	A2	160	NC
11	DQS0	61	DQS3	111	A1	161	VSS	12	DM0	62	DM3	112	A0	162	VSS
13	DQ2	63	VSS	113	VDD	163	DQ48	14	DQ6	64	VSS	114	VDD	164	DQ52
15	VSS	65	DQ26	115	A10/AP	165	DQ49	16	VSS	66	DQ30	116	BA1	166	DQ53
17	DQ3	67	DQ27	117	BA0	167	VDD	18	DQ7	68	DQ31	118	RAS#	168	VDD
19	DQ8	69	VDD	119	WE#	169	DQS6	20	DQ12	70	VDD	120	CAS#	170	DM6
21	VDD	71	CB0	121	S0#	171	DQ50	22	VDD	72	CB4	122	NC	172	DQ54
23	DQ9	73	CB1	123	NC/A13	173	VSS	24	DQ13	74	CB5	124	NC	174	VSS
25	DQS1	75	VSS	125	VSS	175	DQ51	26	DM1	76	VSS	126	VSS	176	DQ55
27	VSS	77	DQS8	127	DQ32	177	DQ56	28	VSS	78	DM8	128	DQ36	178	DQ60
29	DQ10	79	CB2	129	DQ33	179	VDD	30	DQ14	80	CB6	130	DQ37	180	VDD
31	DQ11	81	VDD	131	VDD	181	DQ57	32	DQ15	82	VDD	132	VDD	182	DQ61
33	VDD	83	CB3	133	DQS4	183	DQS7	34	VDD	84	CB7	134	DM4	184	DM7
35	CK0	85	NC	135	DQ34	185	VSS	36	VDD	86	NC	136	DQ38	186	VSS
37	CK0#	87	VSS	137	VSS	187	DQ58	38	VSS	88	VSS	138	VSS	188	DQ62
39	VSS	89	NC	139	DQ35	189	DQ59	40	VSS	90	VSS	140	DQ39	190	DQ63
41	DQ16	91	NC	141	DQ40	191	VDD	42	DQ20	92	VDD	142	DQ44	192	VDD
43	DQ17	93	VDD	143	VDD	193	SDA	44	DQ21	94	VDD	144	VDD	194	SA0
45	VDD	95	NC	145	DQ41	195	SCL	46	VDD	96	CKE0	146	DQ45	196	SA1
47	DQS2	97	NC	147	DQS5	197	VDDSPD	48	DM2	98	NC	148	DM5	198	SA2
49	DQ18	99	NC/A12	149	VSS	199	NC	50	DQ22	100	A11	150	VSS	200	NC

Notes: 1. Pin 99 is a No Connect (NC) for 128MB; A12 for 256MB, 512MB, and 1GB.
2. Pin 123 is a No Connect (NC) for 128MB, 256MB, and 512MB; A13 for 1GB

Figure 1: Module Layout

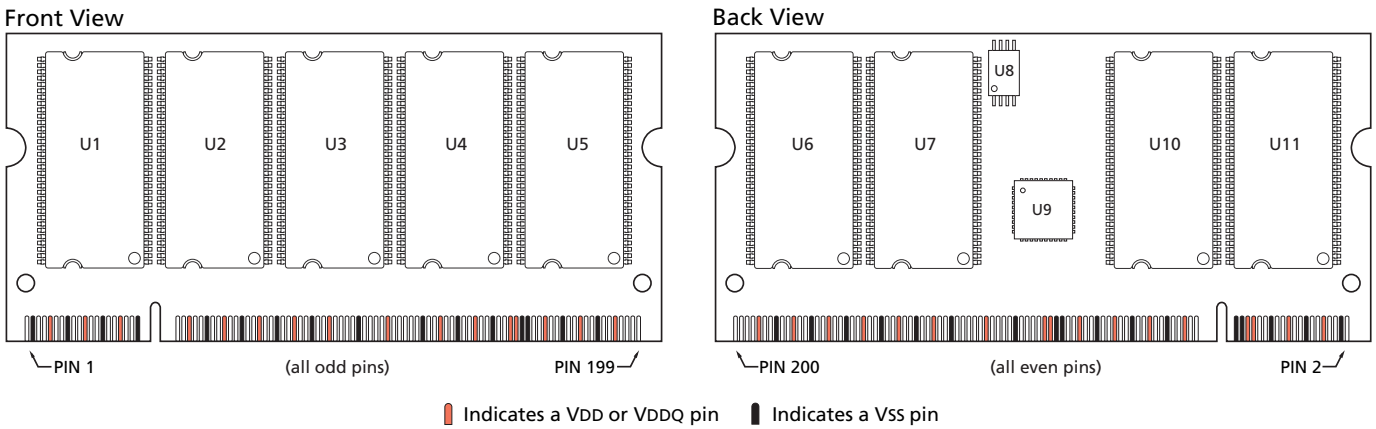


Table 2: Pin Descriptions

Refer to Pin Assignment Tables on page 1 for pin number and symbol correlation.

Pin Numbers	Symbol	Type	Description
118, 119, 120	WE#, CAS#, RAS#	Input	Command Inputs: RAS#, CAS#, and WE# (along with S#) define the command being entered.
35, 37	CK0, CK0#	Input	Clock: CK and CK# are differential clock inputs distributed through an on-board PLL to all devices. All address and control input signals are sampled on the crossing of the positive edge of CK and negative edge of CK#. Output data (DQ and DQS) is referenced to the crossings of CK and CK#.
96	CKE0,	Input	Clock Enable: CKE HIGH activates and CKE LOW deactivates the internal clock, input buffers.and output drivers. Taking CKE LOW provides PRECHARGE POWER- DOWN and SELF REFRESH operations (all device banks idle), or ACTIVE POWER-DOWN (row ACTIVE in any device bank). CKE is synchronous for POWER-DOWN entry and exit, and for SELF REFRESH entry. CKE is asynchronous for SELF REFRESH exit and for disabling the outputs. 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.
121	S0#	Input	Chip Select: S# enables (registered LOW) and disables (registered HIGH) the command decoder. All com- mands are masked when S# is registered HIGH. S# is considered part of the command code.
117, 116	BA0, BA1	Input	Bank Address: BA0, BA1 define to which device bank an ACTIVE, READ, WRITE, or PRECHARGE command is being applied.
99 (A12), 100, 101,102, 105, 106, 107, 108, 109, 110, 111, 112, 115, 123 (A13)	A0–A11 (128MB) A0–A12 (256MB, 512MB) A0–A13 (1GB)	Input	Address Inputs: A0-A11/A12 provide the row address for ACTIVE commands, and the column address, and auto precharge bit (A10) for READ/WRITE commands, to select one location out of the memory array in the respective device bank. A10 sampled during a PRECHARGE command determines whether the PRECHARGE applies to one device bank (A10 LOW, device bank selected by BA0, BA1) or all device banks (A10 HIGH). The address inputs also provide the op-code during a MODE REGISTER SET command. BA0 and BA1 define which mode register (mode register or extended mode register) is loaded during the LOAD MODE REGISTER command.
11, 25, 47, 61, 77, 133, 147,169, 183	DQS0–DQS8	Input/ Output	Data Strobe: Output with READ data, input with WRITE data. DQS is edge-aligned with READ data, centered in WRITE data. Used to capture data.
12, 26, 48, 62, 78, 134, 148, 170, 184	DM0–DM8	Input	Data Mask: DM is an input mask signal for write data. Input data is masked when DM is sampled HIGH along with that input data during a WRITE access. DM is sampled on both edges of DQS. Although DM pins are input-only, the DM loading is designed to match that of DQ and DQS pins.
71, 72, 73, 74, 79, 80, 83, 84	CB0–CB7	Input/ Output	Check Bits.

Table 2: Pin Descriptions

Refer to Pin Assignment Tables on page 1 for pin number and symbol correlation.

Pin Numbers	Symbol	Type	Description
5, 6, 7, 8, 13, 14, 17, 18, 19, 20, 23, 24, 29, 30, 31, 32, 41, 42, 43, 44, 49, 50, 53, 54, 55, 56, 59, 60, 61, 65, 66, 67, 68, 127, 128, 129, 130, 135, 136, 139, 140, 141, 142, 145, 146, 151, 152, 153, 154, 163, 164, 165, 166, 171, 172, 175, 176, 177, 181, 182, 187, 188, 189, 190	DQ0–DQ63	Input/ Output	Data I/Os: Data bus.
195	SCL	Input	Serial Clock for Presence-Detect: SCL is used to synchronize the presence-detect data transfer to and from the module.
194, 196, 198	SA0–SA2	Input	Presence-Detect Address Inputs: These pins are used to configure the presence-detect device.
193	SDA	Input/ Output	Serial Presence-Detect Data: SDA is a bidirectional pin used to transfer addresses and data into and out of the presence-detect portion of the module.
1, 2	V_{REF}	Supply	SSTL_2 reference voltage.
9, 10, 21, 22, 33, 34, 36, 45, 46, 57, 58, 69, 70, 81, 82, 92, 93, 94, 113, 114, 131, 132, 143, 144, 155, 156, 157, 167, 168, 179, 180, 191, 192	V_{DD}	Supply	DQ Power Supply: +2.5V ±0.2V.
3, 4, 15, 16, 27, 28, 38, 39, 40, 51, 52, 63, 64, 75, 76, 87, 88, 90, 103, 104, 125, 126, 137, 138, 149, 150, 159, 161, 162, 173, 174, 185, 186	V_{SS}	Supply	Ground.
197	V_{DDSPD}	Supply	Serial EEPROM positive power supply: +2.3V to +3.6V.
85, 86, 89, 91, 95, 97, 98, 99 (128MB), 122, 123 (128MB, 256MB, 512MB), 124, 158, 160, 200	NC	–	No Connect: These pins should be left unconnected.

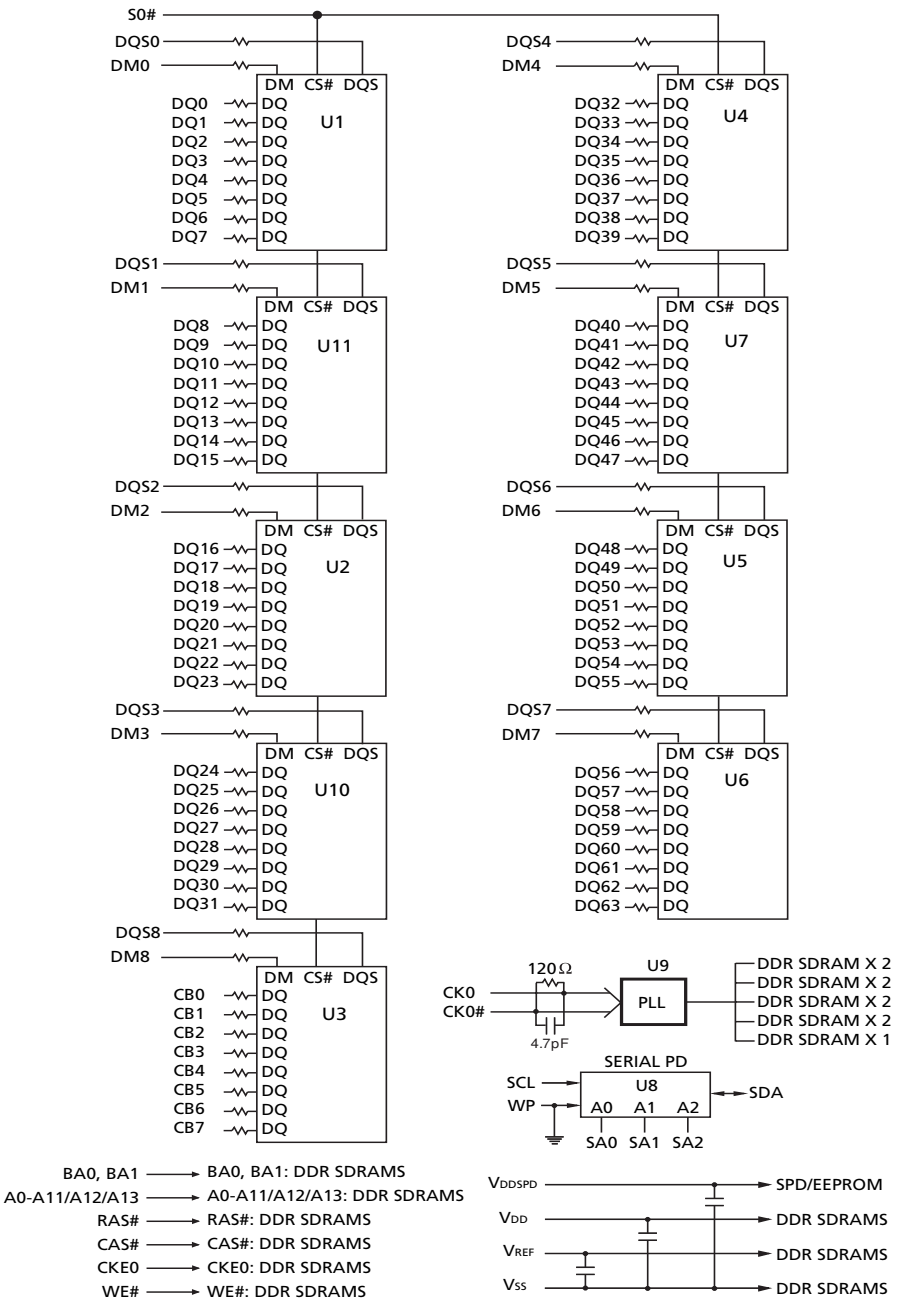
Functional Block Diagram

All resistor values are 22Ω unless otherwise specified. Per industry standard, Micron modules utilize various component speed grades, as referenced in the module part numbering guide at www.micron.com/numberguide.

Standard modules use the following DDR SDRAM devices: MT46V16M8TG (128MB); MT46V32M8TG (256MB); MT46V64M8TG (512MB); and MT46V128M8TG (1GB).

Lead-free modules use the following DDR SDRAM devices: MT46V16M8P (128MB); MT46V32M8P (256MB); MT46V64M8P (512MB); and MT46V128M8P (1GB). Contact Micron for information on IT modules.

Figure 2: Functional Block Diagram



General Description

The Micron MT9VDDT1672PH, MT9VDDT3272PH, MT9VDDT6472PH, and MT9VDDT12872PH, are high-speed CMOS, dynamic random-access, 128MB, 256MB, 512MB, and 1GB memory modules organized in x72 (ECC) configuration. DDR SDRAM modules use internally configured quad-bank DDR SDRAM devices.

DDR SDRAM modules use 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 DDR SDRAM module 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 an intermittent strobe transmitted by the DDR SDRAM device during READs and by the memory controller during WRITEs. DQS is edge-aligned with data for READs and center-aligned with data for WRITEs.

DDR SDRAM modules operate from differential clock inputs (CK and CK#); the crossing of CK going HIGH and CK# going LOW will be 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. A phase-lock loop (PLL) device on the module is used to redrive the differential clock signals to the DDR SDRAM devices to minimize system clock loading.

Read and write accesses to DDR SDRAM modules 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 device bank and row to be accessed (BA0, BA1 select device bank; A0–A11 select device row for 128MB; A0–A12 select device row for 256MB and 512MB; and A0–A13 select device row for 1GB). The address bits registered coincident with the READ or WRITE command are used to select the device bank and the starting device column location for the burst access.

DDR SDRAM modules provide 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.

The pipelined, multibank architecture of DDR SDRAM modules 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 JEDEC Standard for SSTL_2. All outputs are SSTL_2, Class II compatible. For more information regarding DDR SDRAM operation, refer to the 128Mb, 256Mb, 512Mb, or 1Gb DDR SDRAM data sheets.

PLL Operation

A phase-lock loop (PLL) on the module is used to redrive the differential clock signals CK and CK# to the DDR SDRAM devices to minimize system clock loading.

Serial Presence-Detect Operation

DDR SDRAM modules incorporate serial presence-detect (SPD). The SPD function is implemented using a 2,048-bit EEPROM. This nonvolatile storage device contains 256 bytes. The first 128 bytes can be programmed by Micron to identify the module type and

various SDRAM organizations and timing parameters. The remaining 128 bytes of storage are available for use by the customer. System READ/WRITE operations between the master (system logic) and the slave EEPROM device (DIMM) occur via a standard I^2C bus using the DIMM's SCL (clock) and SDA (data) signals, together with SA(2:0), which provide eight unique DIMM/EEPROM addresses. Write protect (WP) is tied to ground on the module, permanently disabling hardware write protect.

Mode Register Definition

The mode register is used to define the specific mode of operation of DDR SDRAM device. This definition includes the selection of a burst length, a burst type, a CAS latency and an operating mode, as shown in the Mode Register Diagram. The mode register is programmed via the MODE REGISTER SET command (with BA0 = 0 and BA1 = 0) and will retain the stored information until it is programmed again or the device loses power (except for bit A8, which is self-clearing).

Reprogramming the mode register will not alter the contents of the memory, provided it is performed correctly. The mode register must be loaded (reloaded) when all device banks are idle and no bursts are in progress, and the controller must wait the specified time before initiating the subsequent operation. Violating either of these requirements will result in unspecified operation.

Mode register bits A0–A2 specify the burst length, A3 specifies the type of burst (sequential or interleaved), A4–A6 specify the CAS latency, and A7–A11 (128MB), A7–A12 (256MB, 512MB), or A7–A13 (1GB) specify the operating mode.

Burst Length

Read and write accesses to the DDR SDRAM are burst oriented, with the burst length being programmable, as shown in Mode Register Diagram. 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 will wrap within the block if a boundary is reached. The block is uniquely selected by A1–A*i* when the burst length is set to two, by A2–A*i* when the burst length is set to four and by A3–A*i* when the burst length is set to eight (where A*i* is the most significant column address bit for a given configuration; see note 5 of Table 3, Burst Definition Table, on page 8). 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.

Burst Type

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 M3.

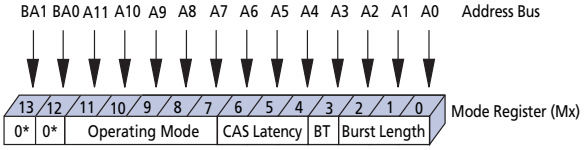
The ordering of accesses within a burst is determined by the burst length, the burst type and the starting column address, as shown in Table 3, Burst Definition Table, on page 8.

Read Latency

The READ latency is the delay, in clock cycles, between the registration of a READ command and the availability of the first bit of output data. The latency can be set to 2 or 2.5 clocks, as shown in Figure 4, CAS Latency Diagram, on page 9.

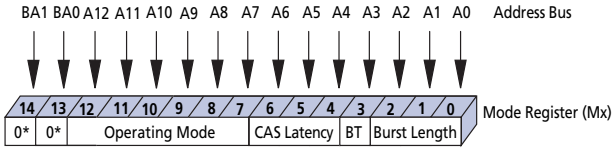
Figure 3: Mode Register Definition Diagram

128MB Module



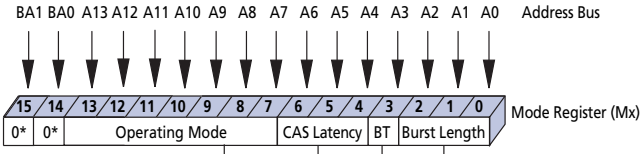
* M13 and M12 (BA0 and BA1) must be "0, 0" to select the base mode register (vs. the extended mode register).

256MB and 512MB Modules



* M14 and M13 (BA0 and BA1) must be "0, 0" to select the base mode register (vs. the extended mode register).

1GB Module



* M15 and M14 (BA1 and BA0) must be "0, 0" to select the base mode register (vs. the extended mode register).

M2	M1	M0	Burst Length M3 = 0
0	0	0	Reserved
0	0	1	2
0	1	0	4
0	1	1	8
1	0	0	Reserved
1	0	1	Reserved
1	1	0	Reserved
1	1	1	Reserved

M3	Burst Type
0	Sequential
1	Interleaved

M6	M5	M4	CAS Latency
0	0	0	Reserved
0	0	1	Reserved
0	1	0	2
0	1	1	Reserved
1	0	0	Reserved
1	0	1	Reserved
1	1	0	2.5
1	1	1	Reserved

M13	M12	M11	M10	M9	M8	M7	M6-M0	Operating Mode
0	0	0	0	0	0	0	Valid	Normal Operation
0	0	0	0	0	1	0	Valid	Normal Operation/Reset DLL
-	-	-	-	-	-	-	-	All other states reserved

Table 3: Burst Definition Table

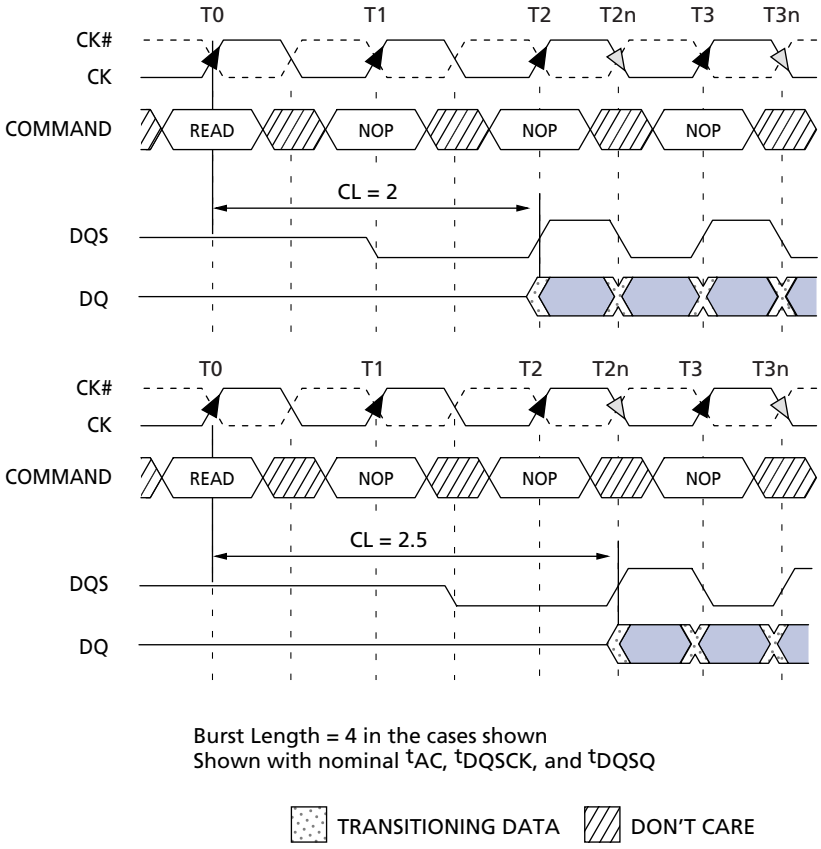
Burst Length	Starting Column Address			Order of Accesses Within a Burst	
				Type = Sequential	Type = Interleaved
2			A0		
			0	0-1	0-1
			1	1-0	1-0
4		A1	A0		
		0	0	0-1-2-3	0-1-2-3
		0	1	1-2-3-0	1-0-3-2
		1	0	2-3-0-1	2-3-0-1
		1	1	3-0-1-2	3-2-1-0
8	A2	A1	A0		
	0	0	0	0-1-2-3-4-5-6-7	0-1-2-3-4-5-6-7
	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-A*i* select the two- data-element block; A0 selects the first access within the block.
2. For a burst length of four, A2-A*i* select the four- data-element block; A0-A1 select the first access within the block.
3. For a burst length of eight, A3-A*i* select the eight- data-element block; A0-A2 select 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.
5. *i* = 9 for 128MB, 256MB
   i = 9, 11 for 512MB, 1GB

Table 4: CAS Latency (CL) Table

Speed	Allowable Operating Clock Frequency (MHz)	
	CL = 2	CL = 2.5
-335	N/A	75 ≤ f ≤ 167
-262	75 ≤ f ≤ 133	75 ≤ f ≤ 133
-26A	75 ≤ f ≤ 133	75 ≤ f ≤ 133
-265	75 ≤ f ≤ 100	75 ≤ f ≤ 133

Figure 4: CAS Latency Diagram



If a READ command is registered at clock edge *n*, and the latency is *m* clocks, the data will be available nominally coincident with clock edge *n* + *m*. Table 4, CAS Latency (CL) Table, on page 8, indicates the operating frequencies at which each CAS latency setting can be used.

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

Operating Mode

The normal operating mode is selected by issuing a MODE REGISTER SET command with bits A7–A11 (128MB), A7–A12 (256MB, 512MB), or A7–A13 (1GB) each set to zero, and bits A0–A6 set to the desired values.

A DLL reset is initiated by issuing a MODE REGISTER SET command with bits A7 and A9–A11 (128MB); A7 and A9–A12 (256MB, 512MB); or A7 and A9–A13 (1GB) each set to zero, bit A8 set to one, and bits A0–A6 set to the desired values. Although not required by the Micron device, JEDEC specifications recommend when a LOAD MODE REGISTER command is issued to reset the DLL, it should always be followed by a LOAD MODE REGISTER command to select normal operating mode.

All other combinations of values for A7–A11 (128MB.), A7–A12 (256MB, 512MB), or A7–A13 (1GB) are reserved for future use and/or test modes. Test modes and reserved states should not be used because unknown operation or incompatibility with future versions may result.

Extended Mode Register

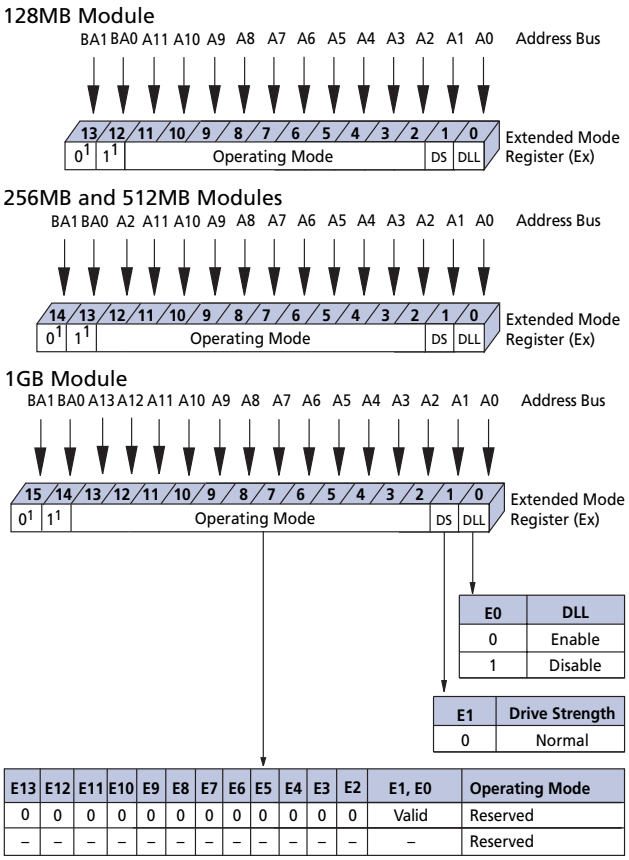
The extended mode register controls functions beyond those controlled by the mode register; these additional functions are DLL enable/disable and output drive strength. These functions are controlled via the bits shown in the Extended Mode Register Definition Diagram. The extended mode register is programmed via the LOAD MODE REGISTER command to the mode register (with BA0 = 1 and BA1 = 0) and will retain the stored information until it is programmed again or the device loses power. The enabling of the DLL should always be followed by a LOAD MODE REGISTER command to the mode register (BA0, /BA1 both low) to reset the DLL.

The extended mode register must be loaded when all device 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 could result in unspecified operation.

DLL Enable/Disable

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. (When the device exits self refresh mode, the DLL is enabled automatically.) Any time the DLL is enabled, 200 clock cycles with CKE HIGH must occur before a READ command can be issued.

Figure 5: Extended Mode Register Definition Diagram



Notes: 1. BA1 and BA0 (E13 and E12 for 128MB; E14 and E13 for 256MB, 512MB; or E15 and E14 for 1GB) must be "0, 1" to select the Extended Mode Register (vs. the base Mode Register).
2.QFC# is not supported.

Commands

Table 5, Commands Truth Table, and Table 6, DM Operation Truth Table, provide a general reference of available commands. For a more detailed description of commands and operations, refer to the Micron 128Mb, 256Mb, 512Mb, or 1Gb DDR SDRAM component data sheets.

Table 5: Commands Truth Table

CKE is HIGH for all commands shown except SELF REFRESH; all states and sequences not shown are illegal or reserved

Name (Function)	CS#	RAS#	CAS#	WE#	Address	Notes
DESELECT (NOP)	H	X	X	X	X	1
NO OPERATION (NOP)	L	H	H	H	X	1
ACTIVE (Select device bank and activate row)	L	L	H	H	Bank/Row	2
READ (Select device bank and column, and start READ burst)	L	H	L	H	Bank/Col	3
WRITE (Select device bank and column, and start WRITE burst)	L	H	L	L	Bank/Col	3
BURST TERMINATE	L	H	H	L	X	4
PRECHARGE (Deactivate row in device bank or banks)	L	L	H	L	Code	5
AUTO REFRESH or SELF REFRESH (Enter self refresh mode)	L	L	L	H	X	6, 7
LOAD MODE REGISTER	L	L	L	L	Op-Code	8

Notes:
1. DESELECT and NOP are functionally interchangeable.
2. BA0–BA1 provide device bank address and A0–A11(128MB), A0–A12 (256MB, 512MB), or A0–A13 (1GB) provide row address.
3. BA0–BA1 provide device bank address; A0–A9 (128MB, 256MB) or A0–A9, A11 (512MB, 1GB) provide column address; A10 HIGH enables the auto precharge feature (nonpersistent), and A10 LOW disables the auto precharge feature.
4. 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 and for WRITE bursts.
5. A10 LOW: BA0–BA1 determine which device bank is precharged. A10 HIGH: all device banks are precharged and BA0–BA1 are "Don't Care."
6. This command is AUTO REFRESH if CKE is HIGH, SELF REFRESH if CKE is LOW.
7. Internal refresh counter controls row addressing; all inputs and I/Os are "Don't Care" except for CKE.
8. BA0–BA1 select either the mode register or the extended mode register (BA0 = 0, BA1 = 0 select the mode register;
   BA0 = 1, BA1 = 0 select extended mode register; other combinations of BA0–BA1 are reserved). A0–A11(128MB), A0–A12 (256MB, 512MB), or A0–A13 (1GB) provide the op-code to be written to the selected mode register.

Table 6: DM Operation Truth Table

Used to mask write data; provided coincident with the corresponding data

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

Absolute Maximum Ratings

Stresses greater than those listed may cause permanent damage to the device. This is a stress rating only, and functional operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect reliability.

VDD Supply Voltage Relative to VSS . . . . . -1V to +3.6V

VDDQ Supply Voltage Relative to VSS . . . . . -1V to +3.6V

VREF and Inputs Voltage Relative to Vss . . . . . -1V to +3.6V

I/O Pins Voltage Relative to VSS . . . . . -0.5V to VddQ +0.5V

Operating Temperature,

T_A (ambient - commercial) . . . . . 0°C to +70°C

T_A (ambient - industrial) . . . . . -40°C to +85°C

Storage Temperature (plastic) . . . . . -55°C to +150°C

Short Circuit Output Current 50mA

Electrical Specifications

Table 7: DC Electrical Characteristics and Operating Conditions

Notes: 1–5, 14; notes appear on pages 19–23; 0°C ≤ T_A ≤ +70°C

Parameter/Condition		Symbol	Min	Max	Units	Notes
Supply Voltage		VDD	2.3	2.7	V	32, 36
I/O Supply Voltage		VDDQ	2.3	2.7	V	32, 36, 39
I/O Reference Voltage		VREF	0.49 x VDDQ	0.51 x VDDQ	V	6, 39
I/O Termination Voltage (system)		VTT	VREF - 0.04	VREF + 0.04	V	7, 39
Input High (Logic 1) Voltage		VIH(DC)	VREF + 0.15	VDD + 0.3	V	25
Input Low (Logic 0) Voltage		VIL(DC)	-0.3	VREF - 0.15	V	25
INPUT LEAKAGE CURRENT Any input 0V ≤ VIN ≤ VDD, VREF pin 0V ≤ VIN ≤ 1.35V (All other pins not under test = 0V)	Command/Address, RAS#, CAS#, WE#, CKE, S#	II	-18	18	µA	46
	CK, CK#	II	-5	5	µA	
	DM	II	-2	2	µA	
OUTPUT LEAKAGE CURRENT (DQs are disabled; 0V ≤ VOUT ≤ VDDQ)	DQ, DQS	IOZ	-5	5	µA	46
OUTPUT LEVELS: High Current (VOUT = VDDQ-0.373V, minimum VREF, minimum VTT) Low Current (VOUT = 0.373V, maximum VREF, maximum VTT)		IOH	-16.8	–	mA	33, 34
		IOL	16.8	–	mA	

Table 8: AC Input Operating Conditions

Notes: 1–5, 12, 48; notes appear on pages 19–23; 0°C ≤ T_A ≤ +70°C; VDD = VDDQ = +2.5V ±0.2V

Parameter/Condition	Symbol	Min	Max	Units	Notes
Input High (Logic 1) Voltage	VIH(AC)	VREF + 0.310	–	V	25, 35
Input Low (Logic 0) Voltage	VIL(AC)	–	VREF - 0.310	V	25, 35
I/O Reference Voltage	VREF(AC)	0.49 x VDDQ	0.51 x VDDQ	V	6

Table 9: IDD Specifications and Conditions – 128MB

DDR SDRAM components only;
Notes: 1–5, 8, 10, 12, 47; notes appear on pages 19–23; 0°C ≤ T_A ≤ +70°C; VDD = VDDQ = +2.5V ±0.2V

			Max				
Parameter/Condition		**Symbol**	**-335**	**-262**	**-26A/ -265**	**Units**	**Notes**
OPERATING CURRENT: One device bank; Active-Precharge; ^tRC = ^tRC (MIN); ^tCK = ^tCK (MIN); DQ, DM and DQS inputs changing once per clock cyle; Address and control inputs changing once every two clock cycles		IDD0	1,125	990	945	mA	20, 41
OPERATING CURRENT: One device bank; Active-Read-Precharge; Burst = 2; ^tRC = ^tRC (MIN); ^tCK = ^tCK (MIN); IOUT = 0mA; Address and control inputs changing once per clock cycle		IDD1	1,215	1,080	1,080	mA	20, 41
PRECHARGE POWER-DOWN STANDBY CURRENT: All device banks idle; Power-down mode; ^tCK = ^tCK (MIN); CKE = (LOW)		IDD2P	27	27	27	mA	21, 28, 43
IDLE STANDBY CURRENT: CS# = HIGH; All device banks idle; ^tCK = ^tCK MIN; CKE = HIGH; Address and other control inputs changing once per clock cycle. VIN = VREF for DQ, DQS, and DM		IDD2F	405	405	360	mA	44
ACTIVE POWER-DOWN STANDBY CURRENT: One device bank active; Power-down mode; ^tCK = ^tCK (MIN); CKE = LOW		IDD3P	225	225	180	mA	21, 28, 43
ACTIVE STANDBY CURRENT: CS# = HIGH; CKE = HIGH; One device bank; Active-Precharge; ^tRC = RAS (MAX); ^tCK = ^tCK (MIN); DQ, DM and DQS inputs changing twice per clock cycle; Address and other control inputs changing once per clock cycle		IDD3N	450	450	405	mA	
OPERATING CURRENT: Burst = 2; Reads; Continuous burst; One device bank active; Address and control inputs changing once per clock cycle; CK = ^tCK (MIN); IOUT = 0mA		IDD4R	1,260	1,170	1,125	mA	20, 41
OPERATING CURRENT: Burst = 2; Writes; Continuous burst; One device bank active; Address and control inputs changing once per clock cycle; ^tCK = ^tCK (MIN); DQ, DM, and DQS inputs changing twice per clock cycle		IDD4W	1,260	1,125	1,080	mA	20
AUTO REFRESH CURRENT	^tREFC = ^tRFC (MIN)	IDD5	2,385	1,980	1,980	mA	20, 43
	^tREFC = 15.625µs	IDD5A	45	45	45	mA	24, 43
SELF REFRESH CURRENT: CKE ≤ 0.2V		IDD6	27	27	18	mA	9
OPERATING CURRENT: Four bank interleaving READs (BL=4) with auto precharge with, ^tRC = ^tRC (MIN); ^tCK = ^tCK (MIN); Address and control inputs change only during Active READ, or WRITE commands		IDD7	3,195	2,970	2,925	mA	20, 42

Table 10: IDD Specifications and Conditions – 256MB

DDR SDRAM components only;
Notes: 1–5, 8, 10, 12, 47; notes appear on pages 19–23; 0°C ≤ T_A ≤ +70°C; VDD = VDDQ = +2.5V ±0.2V

			Max				
Parameter/Condition		**Symbol**	**-335**	**-262**	**-26A/ -265**	**Units**	**Notes**
OPERATING CURRENT: One device bank; Active-Precharge; ^tRC = ^tRC (MIN); ^tCK = ^tCK (MIN); DQ, DM and DQS inputs changing once per clock cyle; Address and control inputs changing once every two clock cycles		IDD0	1,125	1,125	960	mA	20, 41
OPERATING CURRENT: One device bank; Active-Read-Precharge; Burst = 4; ^tRC = ^tRC (MIN); ^tCK = ^tCK (MIN); IOUT = 0mA; Address and control inputs changing once per clock cycle		IDD1	1,530	1,440	1,305	mA	20, 41
PRECHARGE POWER-DOWN STANDBY CURRENT: All device banks idle; Power-down mode; ^tCK = ^tCK (MIN); CKE = (LOW)		IDD2P	35	36	36	mA	21, 28, 43
IDLE STANDBY CURRENT: CS# = HIGH; All device banks idle; ^tCK = ^tCK MIN; CKE = HIGH; Address and other control inputs changing once per clock cycle. VIN = VREF for DQ, DQS, and DM		IDD2F	450	405	405	mA	44
ACTIVE POWER-DOWN STANDBY CURRENT: One device bank active; Power-down mode; ^tCK = ^tCK (MIN); CKE = LOW		IDD3P	270	225	225	mA	21, 28, 43
ACTIVE STANDBY CURRENT: CS# = HIGH; CKE = HIGH; One device bank; Active-Precharge; ^tRC = RAS (MAX); ^tCK = ^tCK (MIN); DQ, DM and DQS inputs changing twice per clock cycle; Address and other control inputs changing once per clock cycle		IDD3N	540	450	450	mA	
OPERATING CURRENT: Burst = 2; Reads; Continuous burst; One device bank active; Address and control inputs changing once per clock cycle; CK = ^tCK (MIN); IOUT = 0mA		IDD4R	1,575	1,350	1,350	mA	20, 41
OPERATING CURRENT: Burst = 2; Writes; Continuous burst; One device bank active; Address and control inputs changing once per clock cycle; ^tCK = ^tCK (MIN); DQ, DM, and DQS inputs changing twice per clock cycle		IDD4W	1,400	1,200	1,200	mA	20
AUTO REFRESH CURRENT	^tREFC = ^tRFC(MIN)	IDD5	2,295	2,115	2,115	mA	20, 43
	^tREFC = 7.8125µs	IDD5A	54	54	54	mA	24, 43
SELF REFRESH CURRENT: CKE ≤ 0.2V		IDD6	36	36	36	mA	9
OPERATING CURRENT: Four bank interleaving READs (BL=4) with auto precharge with, ^tRC = ^tRC (MIN); ^tCK = ^tCK (MIN); Address and control inputs change only during Active READ, or WRITE commands		IDD7	3,645	3,150	3,150	mA	20, 42

Table 11: IDD Specifications and Conditions – 512MB

DDR SDRAM components only;
Notes: 1–5, 8, 10, 12, 47; notes appear on pages 19–23; 0°C ≤ T_A ≤ +70°C; VDD = VDDQ = +2.5V ±0.2V

			Max				
Parameter/Condition		**Symbol**	**-335**	**-262**	**-26A/ -265**	**Units**	**Notes**
OPERATING CURRENT: One device bank; Active-Precharge; ^tRC = ^tRC (MIN); ^tCK = ^tCK (MIN); DQ, DM and DQS inputs changing once per clock cyle; Address and control inputs changing once every two clock cycles		IDD0	1,040	1,040	920	mA	20, 41
OPERATING CURRENT: One device bank; Active-Read-Precharge; Burst = 4; ^tRC = ^tRC (MIN); ^tCK = ^tCK (MIN); IOUT = 0mA; Address and control inputs changing once per clock cycle		IDD1	1,280	1,280	1,160	mA	20, 41
PRECHARGE POWER-DOWN STANDBY CURRENT: All device banks idle; Power-down mode; ^tCK = ^tCK (MIN); CKE = (LOW)		IDD2P	40	40	40	mA	21, 28, 43
IDLE STANDBY CURRENT: CS# = HIGH; All device banks idle; ^tCK = ^tCK MIN; CKE = HIGH; Address and other control inputs changing once per clock cycle. VIN = VREF for DQ, DQS, and DM		IDD2F	360	360	320	mA	44
ACTIVE POWER-DOWN STANDBY CURRENT: One device bank active; Power-down mode; ^tCK = ^tCK (MIN); CKE = LOW		IDD3P	280	280	240	mA	21, 28, 43
ACTIVE STANDBY CURRENT: CS# = HIGH; CKE = HIGH; One device bank; Active-Precharge; ^tRC = RAS (MAX); ^tCK = ^tCK (MIN); DQ, DM and DQS inputs changing twice per clock cycle; Address and other control inputs changing once per clock cycle		IDD3N	400	400	360	mA	
OPERATING CURRENT: Burst = 2; Reads; Continuous burst; One device bank active; Address and control inputs changing once per clock cycle; CK = ^tCK (MIN); IOUT = 0mA		IDD4R	1,320	1,320	1,160	mA	20, 41
OPERATING CURRENT: Burst = 2; Writes; Continuous burst; One device bank active; Address and control inputs changing once per clock cycle; ^tCK = ^tCK (MIN); DQ, DM, and DQS inputs changing twice per clock cycle		IDD4W	1,400	1,240	1,080	mA	20
AUTO REFRESH CURRENT	^tREFC = ^tRFC (MIN)	IDD5	2,320	2,320	2,240	mA	20, 43
	^tREFC = 7.8125µs	IDD5A	80	80	80	mA	24, 43
SELF REFRESH CURRENT: CKE ≤ 0.2V		IDD6	40	40	40	mA	9
OPERATING CURRENT: Four bank interleaving READs (BL=4) with auto precharge with, ^tRC = ^tRC (MIN); ^tCK = ^tCK (MIN); Address and control inputs change only during Active READ, or WRITE commands		IDD7	3,240	3,200	2,800	mA	20, 42

Table 12: IDD Specifications and Conditions – 1GB

DDR SDRAM components only;
Notes: 1–5, 8, 10, 12, 47; notes appear on pages 19–23; 0°C ≤ T_A ≤ +70°C; VDD = VDDQ = +2.5V ±0.2V

			Max				
Parameter/Condition		**Symbol**	**-335**	**-262**	**-26A/ -265**	**Units**	**Notes**
OPERATING CURRENT: One device bank; Active-Precharge; ^tRC = ^tRC (MIN); ^tCK = ^tCK (MIN); DQ, DM and DQS inputs changing once per clock cyle; Address and control inputs changing once every two clock cycles		IDD0	1,040	1,040	1,160	mA	20, 41
OPERATING CURRENT: One device bank; Active-Read-Precharge; Burst = 4; ^tRC = ^tRC (MIN); ^tCK = ^tCK (MIN); IOUT = 0mA; Address and control inputs changing once per clock cycle		IDD1	1,280	1,280	1,440	mA	20, 41
PRECHARGE POWER-DOWN STANDBY CURRENT: All device banks idle; Power-down mode; ^tCK = ^tCK (MIN); CKE = (LOW)		IDD2P	40	40	80	mA	21, 28, 43
IDLE STANDBY CURRENT: CS# = HIGH; All device banks idle; ^tCK = ^tCK MIN; CKE = HIGH; Address and other control inputs changing once per clock cycle. VIN = VREF for DQ, DQS, and DM		IDD2F	360	360	480	mA	44
ACTIVE POWER-DOWN STANDBY CURRENT: One device bank active; Power-down mode; ^tCK = ^tCK (MIN); CKE = LOW		IDD3P	280	280	240	mA	21, 28, 43
ACTIVE STANDBY CURRENT: CS# = HIGH; CKE = HIGH; One device bank; Active-Precharge; ^tRC = RAS (MAX); ^tCK = ^tCK (MIN); DQ, DM and DQS inputs changing twice per clock cycle; Address and other control inputs changing once per clock cycle		IDD3N	360	360	360	mA	
OPERATING CURRENT: Burst = 2; Reads; Continuous burst; One device bank active; Address and control inputs changing once per clock cycle; CK = ^tCK (MIN); IOUT = 0mA		IDD4R	1,320	1,320	1,600	mA	20, 41
OPERATING CURRENT: Burst = 2; Writes; Continuous burst; One device bank active; Address and control inputs changing once per clock cycle; ^tCK = ^tCK (MIN); DQ, DM, and DQS inputs changing twice per clock cycle		IDD4W	1,240	1,240	1,680	mA	20
AUTO REFRESH CURRENT	^tREFC = ^tRFC (MIN)	IDD5	2,320	2,320	2,640	mA	20, 43
	^tREFC = 7.8125µs	IDD5A	80	80	80	mA	24, 43
SELF REFRESH CURRENT: CKE ≤ 0.2V		IDD6	40	40	72	mA	9
OPERATING CURRENT: Four bank interleaving READs (BL=4) with auto precharge with, ^tRC = ^tRC (MIN); ^tCK = ^tCK (MIN); Address and control inputs change only during Active READ, or WRITE commands		IDD7	3,240	3,200	3,880	mA	20, 42

Table 13: Capacitance)

Note: 11; notes appear on pages 19–23

Parameter	Symbol	Min	Typ	Max	Units
Input/Output Capacitance: DQ, DQS, DM	C_{IO}	4.0	-	5.0	pF
Input Capacitance: Command and Address, S#, CKE	C_{I1}	18.0	-	27.0	pF
Input Capacitance: CK, CK#	C_{I2}	-	7.7	-	pF

Table 14: Electrical Characteristics and Recommended AC Operating Conditions

DDR SDRAM components only; notes appear on pages 19–23

Notes: 1–5, 12–15, 29, 47; 0°C ≤ T_A ≤ +70°C; V_{DD} = $V_{DD}Q$ = +2.5V ±0.2V

AC Characteristics			-335		-262		-26a/-265			
Parameter		Symbol	Min	Max	Min	Max	Min	Max	Units	Notes
Access window of DQs from CK/CK#		^tAC	-0.7	+0.7	-0.75	+0.75	-0.75	+0.75	ns	
CK high-level width		^tCH	0.45	0.55	0.45	0.55	0.45	0.55	^tCK	26
CK low-level width		^tCL	0.45	0.55	0.45	0.55	0.45	0.55	^tCK	26
Clock cycle time	CL = 2.5	^tCK (2.5)	6	13	7.5	13	7.5	13	ns	40, 45
	CL = 2	^tCK (2)	7.5	13	7.5	13	10	13	ns	40, 45
DQ and DM input hold time relative to DQS		^tDH	0.45		0.5		0.5		ns	23, 27
DQ and DM input setup time relative to DQS		^tDS	0.45		0.5		0.5		ns	23, 27
DQ and DM input pulse width (for each input)		^tDIPW	1.75		1.75		1.75		ns	27
Access window of DQS from CK/CK#		^tDQSCK	-0.60	+0.60	-0.75	+0.75	-0.75	+0.75	ns	
DQS input high pulse width		^tDQSH	0.35		0.35		0.35		^tCK	
DQS input low pulse width		^tDQSL	0.35		0.35		0.35		^tCK	
DQS-DQ skew, DQS to last DQ valid, per group, per access		^tDQSQ		0.45		0.5		0.6	ns	22, 23
Write command to first DQS latching transition		^tDQSS	0.75	1.25	0.75	1.25	0.75	1.25	^tCK	
DQS falling edge to CK rising - setup time		^tDSS	0.2		0.2		0.2		^tCK	
DQS falling edge from CK rising - hold time		^tDSH	0.2		0.2		0.2		^tCK	
Half clock period		^tHP	^tCH, ^tCL		^tCH, ^tCL		^tCH, ^tCL		ns	30
Data-out high-impedance window from CK/CK#		^tHZ		+0.70		+0.75		+0.75	ns	16, 37
Data-out low-impedance window from CK/CK#		^tLZ	-0.70		-0.75		-0.75		ns	16, 37
Address and control input hold time (slow slew rate)		^tIH_S	0.75		0.90		1.1		ns	12
Address and control input setup time (slow slew rate)		^tIS_S	0.75		0.90		1.1		ns	12
Address and Control input pulse width (for each input)		^tIPW	2.2		2.2		2.2		ns	
LOAD MODE REGISTER command cycle time		^tMRD	0.80		15		15		ns	
DQ-DQS hold, DQS to first DQ to go non-valid, per access		^tQH	^tHP - ^tQHS		^tHP - ^tQHS		^tHP- ^tQHS		ns	22, 23
Data Hold Skew Factor		^tQHS		0.50		0.75		0.75	ns	

Table 14: Electrical Characteristics and Recommended AC Operating Conditions (Continued)

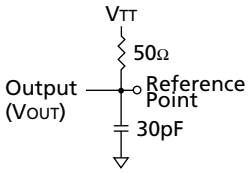
DDR SDRAM components only; notes appear on pages 19–23

Notes: 1–5, 12–15, 29, 47; 0°C ≤ T_A ≤ +70°C; V_{DD} = $V_{DD}Q$ = +2.5V ±0.2V

AC Characteristics			-335		-262		-26a/-265			
Parameter		**Symbol**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Units**	**Notes**
ACTIVE to PRECHARGE command		^tRAS	42	70,000	40	120,000	40	120,000	ns	31, 48
ACTIVE to READ with Auto precharge command		^tRAP	15		15		20		ns	
ACTIVE to ACTIVE/AUTO REFRESH command period		^tRC	60		60		65		ns	
AUTO REFRESH command period	128MB, 256MB, 512MB	^tRFC	72		75		75		ns	43
	1GB		120		120		120		ns	43
ACTIVE to READ or WRITE delay		^tRCD	15		15		20		ns	
PRECHARGE command period		^tRP	15		15		20		ns	
DQS read preamble		^tRPRE	0.9	1.1	0.9	1.1	0.9	1.1	^tCK	38
DQS read postamble		^tRPST	0.4	0.6	0.4	0.6	0.4	0.6	^tCK	38
ACTIVE bank *a* to ACTIVE bank *b* command		^tRRD	12		15		15		ns	
DQS write preamble		^tWPRE	0.25		0.25		0.25		^tCK	
DQS write preamble setup time		^tWPRES	0		0		0		ns	18, 19
DQS write postamble		^tWPST	0.4	0.6	0.4	0.6	0.4	0.6	^tCK	17
Write recovery time		^tWR	15		15		15		ns	
Internal WRITE to READ command delay		^tWTR	1		1		1		^tCK	
Data valid output window (DVW)		na	^tQH - ^tDQSQ		^tQH - ^tDQSQ		^tQH - ^tDQSQ		ns	22
REFRESH to REFRESH command interval	128MB	^tREFC		140.6		140.6		140.6	µs	21
	256MB, 512MB, 1GB			70.3		70.3		70.3	µs	21
Average periodic refresh interval	128MB	^tREFI		15.6		15.6		15.6	µs	21
	256MB, 512MB, 1GB			7.8		7.8	0	7.8	µs	
Terminating voltage delay to V_{DD}		^tVTD	0		0		0		ns	
Exit SELF REFRESH to non-READ command		^tXSNR	75		75		75		ns	
Exit SELF REFRESH to READ command		^tXSRD	200		200		200		^tCK	

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. Outputs measured with equivalent load:



4. AC timing and I_{DD} tests may use a V_{IL}-to-V_{IH} swing of up to 1.5V in the test environment, but input timing is still referenced to V_{REF} (or to the crossing point for CK/CK#), and parameter specifications are guaranteed for the specified AC input levels under normal use conditions. The minimum slew rate for the input signals used to test the device is 1V/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 will effectively switch as a result of the signal crossing the AC input level, and will remain in that state as long as the signal does not ring back above [below] the DC input LOW [HIGH] level).
6. V_{REF} is expected to equal $V_{DD}Q/2$ of the transmitting device and to track variations in the DC level of the same. Peak-to-peak noise (non-common mode) on Vref may not exceed ±2 percent of the DC value. Thus, from $V_{DD}Q/2$, Vref is allowed ±25mV for DC error and an additional ±25mV for AC noise. This measurement is to be taken at the nearest V_{REF} bypass capacitor.
7. 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}.
8. I_{DD} is dependent on output loading and cycle rates. Specified values are obtained with minimum cycle time at CL = 2 for -26A and -202, CL = 2.5 for -335 and -265 with the outputs open.
9. Enables on-chip refresh and address counters.
10. I_{DD} specifications are tested after the device is properly initialized, and is averaged at the defined cycle rate.
11. This parameter is sampled. V_{DD} = +2.5V ±0.2V, $V_{DD}Q$ = +2.5V ±0.2V, V_{REF} = V_{SS}, f = 100 MHz, T_A = 25°C, $V_{OUT}(DC)$ = $V_{DD}Q/2$, V_{OUT} (peak to peak) = 0.2V. DM input is grouped with I/O pins, reflecting the fact that they are matched in loading.
12. For slew rates < 1 V/ns and ≥ to 0.5 Vns. If the slew rate is < 0.5V/ns, timing must be derated: ^{t}IS has an additional 50ps per each 100 mV/ns reduction in slew rate from 500 mV/ns, while ^{t}IH is unaffected. If the slew rate exceeds 4.5 V/ns, functionality is uncertain. For -335, slew rates must be ≥ 0.5 V/ns.
13. The CK/CK# input reference level (for timing referenced to CK/CK#) is the point at which CK and CK# cross; the input reference level for signals other than CK/CK# is V_{REF}.
14. Inputs are not recognized as valid until V_{REF} stabilizes. Exception: during the period before V_{REF} stabilizes, CKE ≤ 0.3 x $V_{DD}Q$ is recognized as LOW.
15. The output timing reference level, as measured at the timing reference point indicated in Note 3, is V_{TT}.

16. ^{t}HZ and ^{t}LZ transitions occur in the same access time windows as data valid transitions. These parameters are not referenced to a specific voltage level, but specify when the device output is no longer driving (HZ) or begins driving (LZ).
17. The intent of the Don't Care state after completion of the postamble is the DQS-driven signal should either be high, low, or high-Z and that any signal transition within the input switching region must follow valid input requirements. That is, if DQS transitions high [above VIHDC (MIN)] then it must not transition low (below VIHDC) prior to ^{t}DQSH (MIN).
18. This is not a device limit. The device will operate with a negative value, but system performance could be degraded due to bus turnaround.
19. It is recommended that DQS be valid (HIGH or LOW) on or before the WRITE command. The case shown (DQS going from High-Z to logic LOW) applies when no WRITEs were previously in progress on the bus. If a previous WRITE was in progress, DQS could be HIGH during this time, depending on ^{t}DQSS.
20. MIN (^{t}RC or ^{t}RFC) for IDD measurements is the smallest multiple of ^{t}CK that meets the minimum absolute value for the respective parameter. ^{t}RAS (MAX) for IDD measurements is the largest multiple of ^{t}CK that meets the maximum absolute value for ^{t}RAS.
21. The refresh period 64ms. This equates to an average refresh rate of 15.625µs (128MB), or 7.8251µs (256MB, 512MB, 1GB). However, an AUTO REFRESH command must be asserted at least once every 140.6µs (128MB) or 70.3µs (256MB, 512MB, 1GB); burst refreshing or posting by the DRAM controller greater than eight refresh cycles is not allowed.
22. The valid data window is derived by achieving other specifications: ^{t}HP (^{t}CK/2), ^{t}DQSQ, and ^{t}QH (^{t}QH = ^{t}HP - ^{t}QHS). The data valid window derates in direct porportion with the clock duty cycle and a practical data valid window can be derived, as shown in Figure 6, Derating Data Valid Window (^{t}QH - ^{t}DQSQ). The clock is allowed a maximum duty cycle variation of 45/55, beyond which functionality is uncertain. The data valid window derating curves are provided below for duty cycles ranging between 50/50 and 45/55.
23. Each byte lane has a corresponding DQS.
24. This limit is actually a nominal value and does not result in a fail value. CKE is HIGH during REFRESH command period (^{t}RFC [MIN]) else CKE is LOW (i.e., during standby).
25. To maintain a valid level, the transitioning edge of the input must:
    a. Sustain a constant slew rate from the current AC level through to the target AC level, VIL(AC) or VIH(AC).
    b. Reach at least the target AC level.
    c. After the AC target level is reached, continue to maintain at least the target DC level, VIL(DC) or VIH(DC).
26. JEDEC specifies CK and CK# input slew rate must be ≤ 1V/ns (2V/ns differentially).
27. DQ and DM input slew rates must not deviate from DQS by more than 10 percent. If the DQ/DM/DQS slew rate is less than 0.5 V/ns, timing must be derated: 50ps must be added to ^{t}DS and ^{t}DH for each 100 mv/ns reduction in slew rate. If slew rate exceeds 4 V/ns, functionality is uncertain. For -335, slew rates must be ≥ 0.5 V/ns.
28. VDD must not vary more than 4 percent if CKE is not active while any bank is active.
29. The clock is allowed up to ±150ps of jitter. Each timing parameter is allowed to vary by the same amount.
30. ^{t}HP min is the lesser of ^{t}CL minimum and t^{t}CH minimum actually applied to the device CK and CK# inputs, collectively during bank active.