



Chipsmall Limited consists of a professional team with an average of over 10 year of expertise in the distribution of electronic components. Based in Hongkong, we have already established firm and mutual-benefit business relationships with customers from,Europe,America and south Asia,supplying obsolete and hard-to-find components to meet their specific needs.

With the principle of "Quality Parts,Customers Priority,Honest Operation,and Considerate Service",our business mainly focus on the distribution of electronic components. Line cards we deal with include Microchip,ALPS,ROHM,Xilinx,Pulse,ON,Everlight and Freescale. Main products comprise IC,Modules,Potentiometer,IC Socket,Relay,Connector.Our parts cover such applications as commercial,industrial, and automotives areas.

We are looking forward to setting up business relationship with you and hope to provide you with the best service and solution. Let us make a better world for our industry!



Contact us

Tel: +86-755-8981 8866 Fax: +86-755-8427 6832

Email & Skype: info@chipsmall.com Web: www.chipsmall.com

Address: A1208, Overseas Decoration Building, #122 Zhenhua RD., Futian, Shenzhen, China



Automotive SDR SDRAM

MT48LC4M32B2 – 1 Meg x 32 x 4 Banks

Features

- PC100-compliant
- Fully synchronous; all signals registered on positive edge of system clock
- Internal pipelined operation; column address can be changed every clock cycle
- Internal banks for hiding row access/precharge
- Programmable burst lengths: 1, 2, 4, 8, or full page
- Auto precharge, includes concurrent auto precharge and auto refresh modes
- Self refresh mode (not available on AT devices)
- Auto refresh
 - 64ms, 4096-cycle refresh (commercial and industrial)
 - 16ms, 4096-cycle refresh (automotive)
- LVTTTL-compatible inputs and outputs
- Single 3.3V ±0.3V power supply
- Supports CAS latency (CL) of 1, 2, and 3
- AEC-Q100
- PPAP submission
- 8D response time

Options

- Configuration
 - 4 Meg x 32 (1 Meg x 32 x 4 banks)
- Package – OCPL¹
 - 86-pin TSOP II (400 mil)
 - 86-pin TSOP II (400 mil) Pb-free
 - 90-ball VFBGA (8mm x 13mm)
 - 90-ball VFBGA (8mm x 13mm) Pb-free
- Timing (cycle time)
 - 6ns (167 MHz)
 - 6ns (167 MHz)
 - 7ns (143 MHz)
- Revision
- Special options
 - Automotive grade
 - Product longevity program
- Operating temperature range
 - Industrial (–40°C to +85°C)
 - Automotive (–40°C to +105°C)

Marking

4M32B2
TG
P
F5
B5
-6A³
-6²
-7²
:G/:L
A⁴
X
IT
AT⁵

- Notes:
1. Off-center parting line.
 2. Available only on Revision G.
 3. Available only on Revision L.
 4. Some automotive parts are included in the product longevity program (PLP) and some are not, see www.micron.com/plp for a list of PLP parts.
 5. Contact Micron for availability.

Table 1: Key Timing Parameters

CL = CAS (READ) latency

Speed Grade	Clock Frequency (MHz)	Target ^t RCD- ^t RP-CL	^t RCD (ns)	^t RP (ns)	CL (ns)
-6	167	3-3-3	18	18	18
-6A	167	3-3-3	18	18	18
-7	143	3-3-3	15	15	15

Table 2: Address Table

Parameter	4 Meg x 32
Configuration	1 Meg x 32 x 4 banks
Refresh count	4K
Row addressing	4K A[11:0]
Bank addressing	4 BA[1:0]
Column addressing	256 A[7:0]

Table 3: 128Mb (x32) SDR Part Numbering

Part Numbers	Architecture
MT48LC4M32B2TG	4 Meg x 32
MT48LC4M32B2P	4 Meg x 32
MT48LC4M32B2F5 ¹	4 Meg x 32
MT48LC4M32B2B5 ¹	4 Meg x 32

Note: 1. FBGA Device Decoder: www.micron.com/decoder.



Contents

General Description	7
Automotive Temperature	7
Functional Block Diagram	8
Pin and Ball Assignments and Descriptions	9
Package Dimensions	12
Temperature and Thermal Impedance	14
Electrical Specifications	17
Electrical Specifications – I _{DD} Parameters	18
Electrical Specifications – AC Operating Conditions	20
Functional Description	23
Commands	24
COMMAND INHIBIT	24
NO OPERATION (NOP)	25
LOAD MODE REGISTER (LMR)	25
ACTIVE	25
READ	26
WRITE	27
PRECHARGE	28
BURST TERMINATE	28
REFRESH	29
AUTO REFRESH	29
SELF REFRESH	29
Truth Tables	30
Initialization	35
Mode Register	37
Burst Length	39
Burst Type	39
CAS Latency	41
Operating Mode	41
Write Burst Mode	41
Bank/Row Activation	42
READ Operation	43
WRITE Operation	52
Burst Read/Single Write	59
PRECHARGE Operation	60
Auto Precharge	60
AUTO REFRESH Operation	72
SELF REFRESH Operation	74
Power-Down	76
Clock Suspend	77
Revision History	80
Rev. C – 04/16	80
Rev. B – 10/13	80
Rev. A – 10/12	80

List of Figures

Figure 1: 4 Meg x 32 Functional Block Diagram	8
Figure 2: 86-Pin TSOP Pin Assignments (Top View)	9
Figure 3: 90-Ball FBGA Ball Assignments (Top View)	10
Figure 4: 86-Pin Plastic TSOP II (400 mil) – Package Codes TG/P	12
Figure 5: 90-Ball VFBGA (8mm x 13mm)	13
Figure 6: Example: Temperature Test Point Location, 54-Pin TSOP (Top View)	15
Figure 7: Example: Temperature Test Point Location, 90-Ball VFBGA (Top View)	16
Figure 8: ACTIVE Command	25
Figure 9: READ Command	26
Figure 10: WRITE Command	27
Figure 11: PRECHARGE Command	28
Figure 12: Initialize and Load Mode Register	36
Figure 13: Mode Register Definition	38
Figure 14: CAS Latency	41
Figure 15: Example: Meeting $t_{RCD}(\text{MIN})$ When $2 < t_{RCD}(\text{MIN})/t_{CK} \leq 3$	42
Figure 16: Consecutive READ Bursts	44
Figure 17: Random READ Accesses	45
Figure 18: READ-to-WRITE	46
Figure 19: READ-to-WRITE With Extra Clock Cycle	47
Figure 20: READ-to-PRECHARGE	47
Figure 21: Terminating a READ Burst	48
Figure 22: Alternating Bank Read Accesses	49
Figure 23: READ Continuous Page Burst	50
Figure 24: READ – DQM Operation	51
Figure 25: WRITE Burst	52
Figure 26: WRITE-to-WRITE	53
Figure 27: Random WRITE Cycles	54
Figure 28: WRITE-to-READ	54
Figure 29: WRITE-to-PRECHARGE	55
Figure 30: Terminating a WRITE Burst	56
Figure 31: Alternating Bank Write Accesses	57
Figure 32: WRITE – Continuous Page Burst	58
Figure 33: WRITE – DQM Operation	59
Figure 34: READ With Auto Precharge Interrupted by a READ	61
Figure 35: READ With Auto Precharge Interrupted by a WRITE	62
Figure 36: READ With Auto Precharge	63
Figure 37: READ Without Auto Precharge	64
Figure 38: Single READ With Auto Precharge	65
Figure 39: Single READ Without Auto Precharge	66
Figure 40: WRITE With Auto Precharge Interrupted by a READ	67
Figure 41: WRITE With Auto Precharge Interrupted by a WRITE	67
Figure 42: WRITE With Auto Precharge	68
Figure 43: WRITE Without Auto Precharge	69
Figure 44: Single WRITE With Auto Precharge	70
Figure 45: Single WRITE Without Auto Precharge	71
Figure 46: Auto Refresh Mode	73
Figure 47: Self Refresh Mode	75
Figure 48: Power-Down Mode	76
Figure 49: Clock Suspend During WRITE Burst	77
Figure 50: Clock Suspend During READ Burst	78

Figure 51: Clock Suspend Mode 79

List of Tables

Table 1: Key Timing Parameters	1
Table 2: Address Table	2
Table 3: 128Mb (x32) SDR Part Numbering	2
Table 4: Pin/Ball Descriptions	11
Table 5: Temperature Limits	14
Table 6: Thermal Impedance Simulated Values	15
Table 7: Absolute Maximum Ratings	17
Table 8: DC Electrical Characteristics and Operating Conditions	17
Table 9: Capacitance	17
Table 10: I _{DD} Specifications and Conditions – Revision G	18
Table 11: I _{DD} Specifications and Conditions – Revision L	18
Table 12: Electrical Characteristics and Recommended AC Operating Conditions	20
Table 13: AC Functional Characteristics	21
Table 14: Truth Table – Commands and DQM Operation	24
Table 15: Truth Table – Current State Bank <i>n</i> , Command to Bank <i>n</i>	30
Table 16: Truth Table – Current State Bank <i>n</i> , Command to Bank <i>m</i>	32
Table 17: Truth Table – CKE	34
Table 18: Burst Definition Table	40

General Description

The 128Mb SDRAM is a high-speed CMOS, dynamic random-access memory containing 134,217,728 bits. It is internally configured as a quad-bank DRAM with a synchronous interface (all signals are registered on the positive edge of the clock signal, CLK). Each of the x4's 33,554,432-bit banks is organized as 4096 rows by 2048 columns by 4 bits. Each of the x8's 33,554,432-bit banks is organized as 4096 rows by 1024 columns by 8 bits. Each of the x16's 33,554,432-bit banks is organized as 4096 rows by 512 columns by 16 bits.

Read and write accesses to the 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 (BA[1:0] select the bank; A[11:0] select the row). The address bits registered coincident with the READ or WRITE command are used to select the starting column location for the burst access.

The SDRAM provides for programmable read or write burst lengths (BL) of 1, 2, 4, or 8 locations, or the full page, with a burst terminate option. An auto precharge function may be enabled to provide a self-timed row precharge that is initiated at the end of the burst sequence.

The 128Mb SDRAM uses an internal pipelined architecture to achieve high-speed operation. This architecture is compatible with the $2n$ rule of prefetch architectures, but it also allows the column address to be changed on every clock cycle to achieve a high-speed, fully random access. Precharging one bank while accessing one of the other three banks will hide the PRECHARGE cycles and provide seamless, high-speed, random-access operation.

The 128Mb SDRAM is designed to operate in 3.3V memory systems. An auto refresh mode is provided, along with a power-saving, power-down mode. All inputs and outputs are LVTTTL-compatible.

The devices offer substantial advances in DRAM operating performance, including the ability to synchronously burst data at a high data rate with automatic column-address generation, the ability to interleave between internal banks to hide precharge time, and the capability to randomly change column addresses on each clock cycle during a burst access.

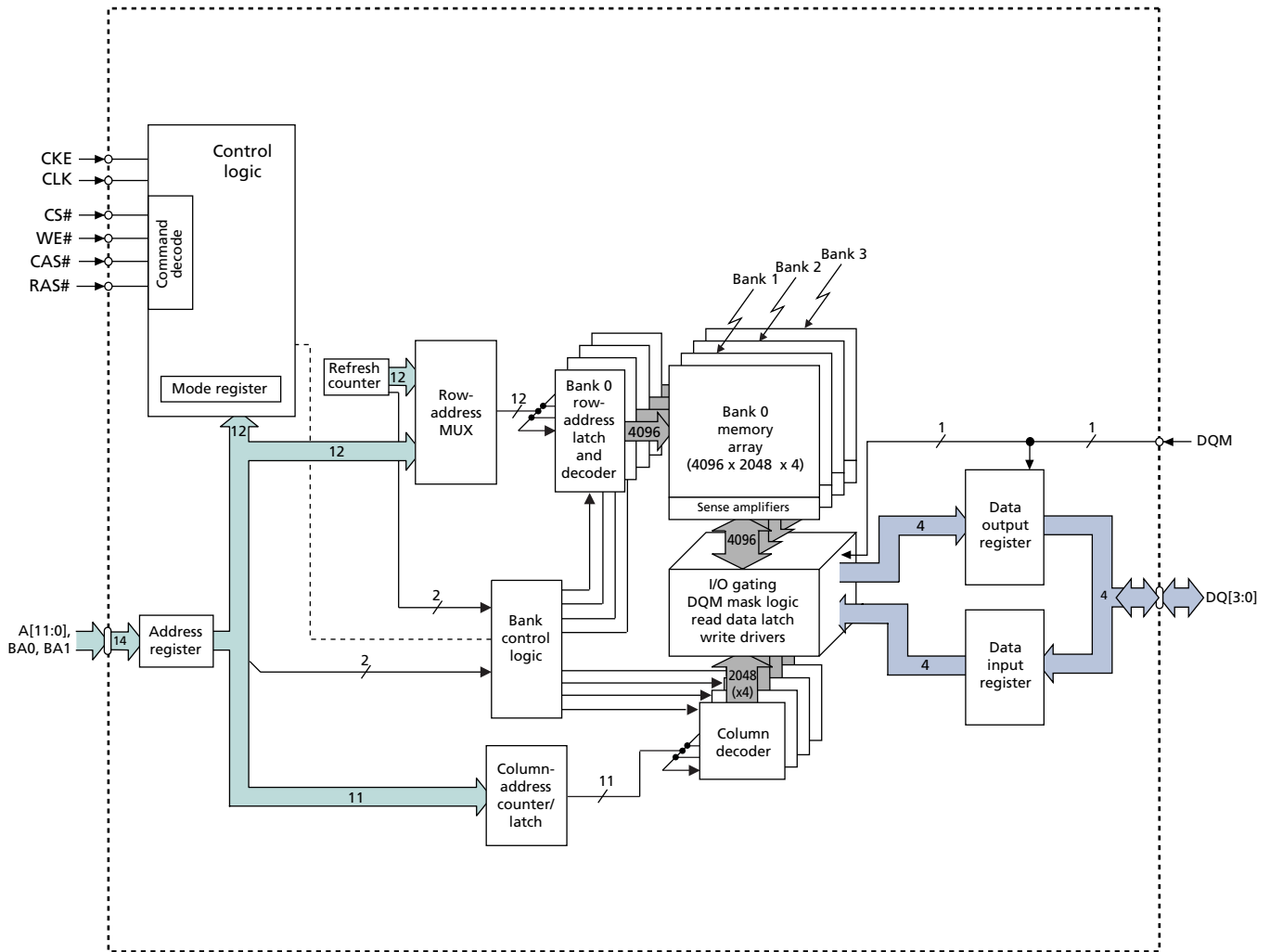
Automotive Temperature

The automotive temperature (AAT) option adheres to the following specifications:

- 16ms auto refresh rate required above 85°C
- Self refresh not supported above 85°C
- Ambient and case temperature cannot be less than -40°C or greater than +105°C

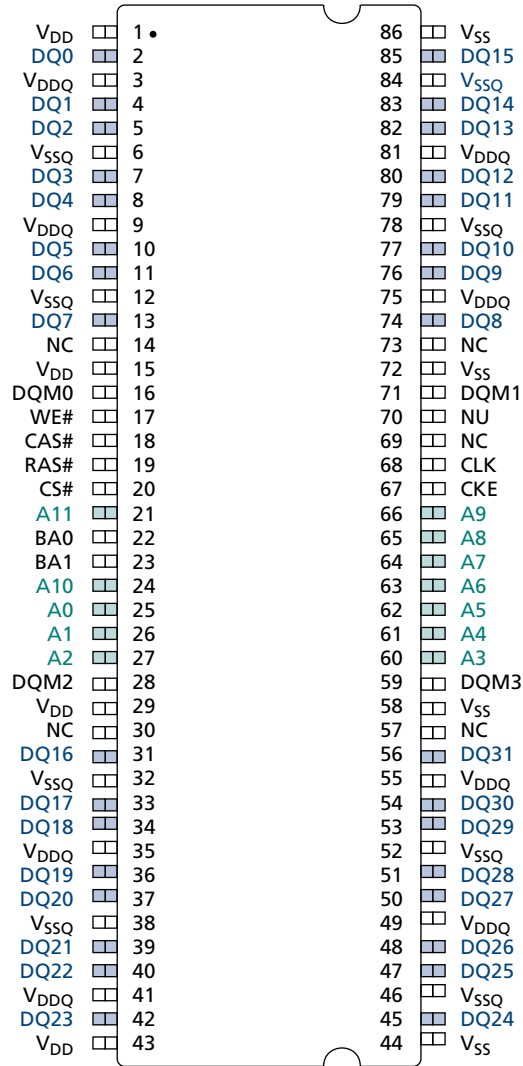
Functional Block Diagram

Figure 1: 4 Meg x 32 Functional Block Diagram



Pin and Ball Assignments and Descriptions

Figure 2: 86-Pin TSOP Pin Assignments (Top View)



Note: 1. Package may or may not be assembled with a location notch.

Figure 3: 90-Ball FBGA Ball Assignments (Top View)

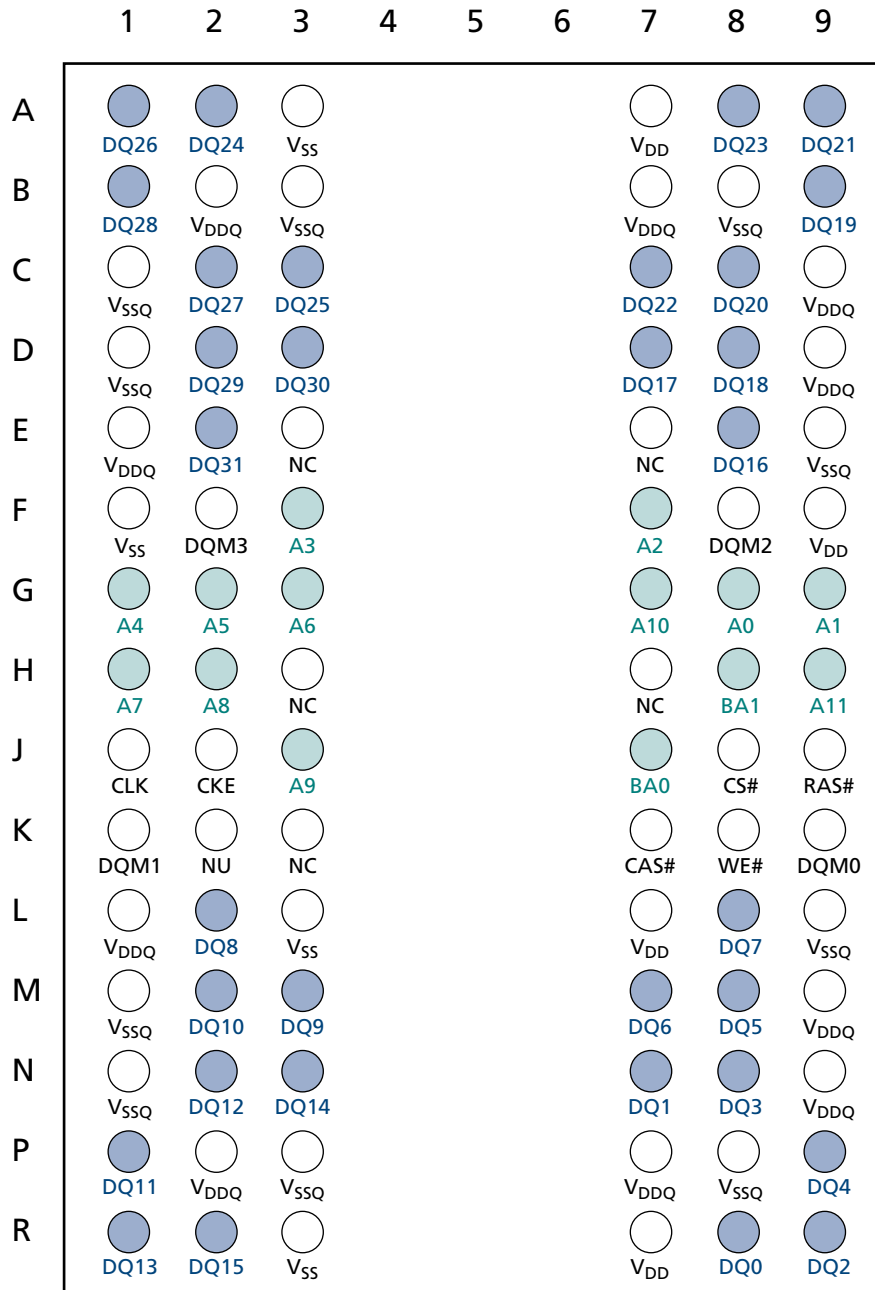
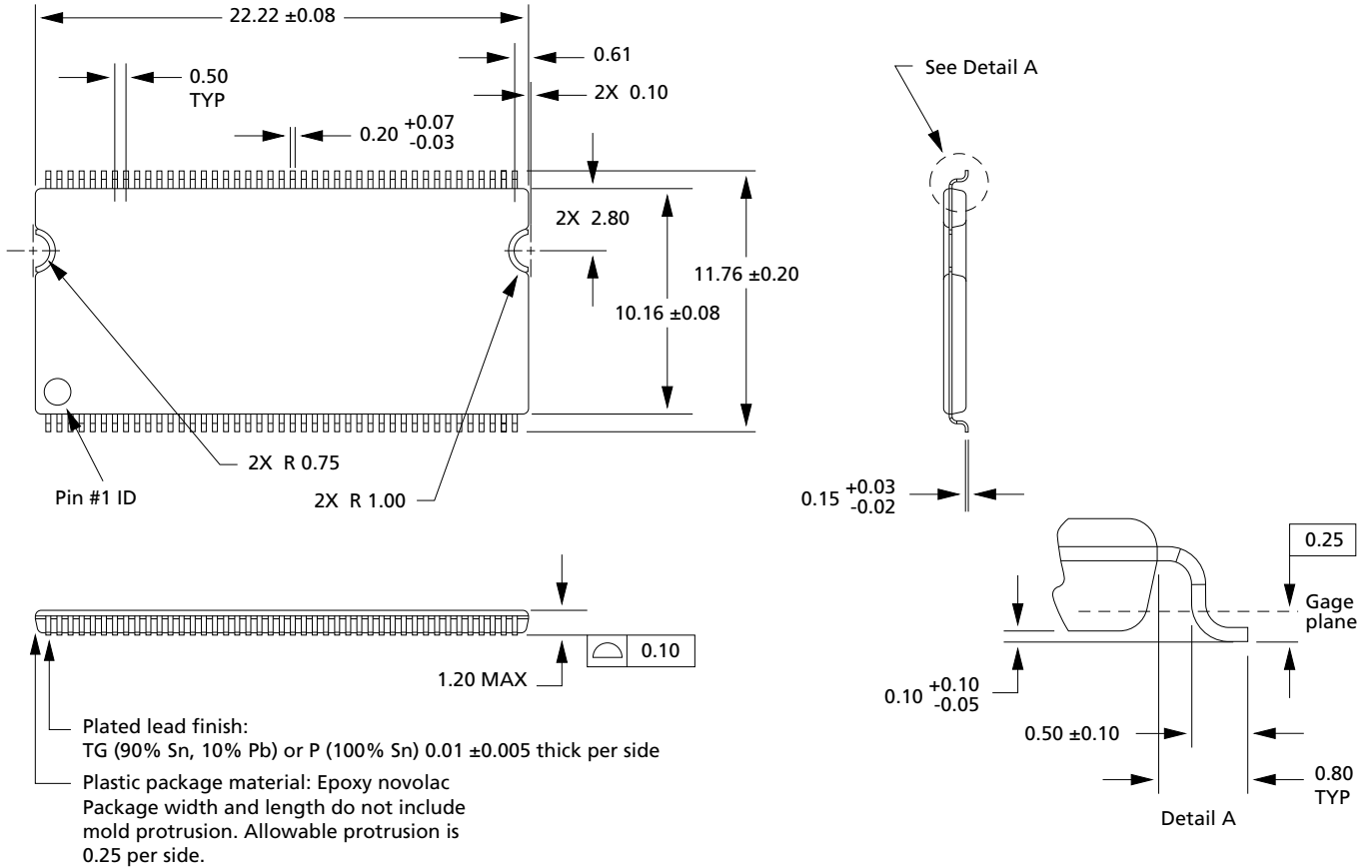


Table 4: Pin/Ball Descriptions

Symbol	Type	Description
CLK	Input	Clock: CLK is driven by the system clock. All SDRAM input signals are sampled on the positive edge of CLK. CLK also increments the internal burst counter and controls the output registers.
CKE	Input	Clock enable: CKE activates (HIGH) and deactivates (LOW) the CLK signal. Deactivating the clock provides precharge power-down and SELF REFRESH operation (all banks idle), active power-down (row active in any bank), or CLOCK SUSPEND operation (burst/access in progress). CKE is synchronous except after the device enters power-down and self refresh modes, where CKE becomes asynchronous until after exiting the same mode. The input buffers, including CLK, are disabled during power-down and self refresh modes, providing low standby power. CKE may be tied HIGH.
CS#	Input	Chip select: CS# enables (registered LOW) and disables (registered HIGH) the command decoder. All commands are masked when CS# is registered HIGH, but READ/WRITE bursts already in progress will continue, and DQM operation will retain its DQ mask capability while CS# is HIGH. CS# provides for external bank selection on systems with multiple banks. CS# is considered part of the command code.
CAS#, RAS#, WE#	Input	Command inputs: CAS#, RAS#, and WE# (along with CS#) define the command being entered.
DQM[3:0]	Input	Input/output mask: DQM is sampled HIGH and is an input mask signal for write accesses and an output enable signal for read accesses. Input data is masked during a WRITE cycle. The output buffers are High-Z (two-clock latency) during a READ cycle. DQM0 corresponds to DQ[7:0], DQM1 corresponds to DQ[15:8], DQM2 corresponds to DQ[23:16], and DQM3 corresponds to DQ[31:24]. DQM[3:0] are considered the same state when referenced as DQM.
BA[1:0]	Input	Bank address inputs: BA[1:0] define to which bank the ACTIVE, READ, WRITE, or PRECHARGE command is being applied.
A[11:0]	Input	Address inputs: A[11:0] are sampled during the ACTIVE command (row address A[10:0]) and READ or WRITE command (column address A[7:0] with A10 defining auto precharge) to select one location out of the memory array in the respective bank. A10 is sampled during a PRECHARGE command to determine if all banks are to be precharged (A10 HIGH) or bank selected by BA[1:0] (LOW). The address inputs also provide the op-code during a LOAD MODE REGISTER command.
DQ[31:0]	Input/Output	Data input/output: Data bus.
NC	–	No connect: These pins should be left unconnected. Pin 70 is reserved for SSTL reference voltage supply.
V _{DDQ}	Supply	DQ power supply: Isolated on the die for improved noise immunity.
V _{SSQ}	Supply	DQ ground: Provides isolated ground to DQs for improved noise immunity.
V _{DD}	Supply	Power supply: 3.3V ±0.3V.
V _{SS}	Supply	Ground.

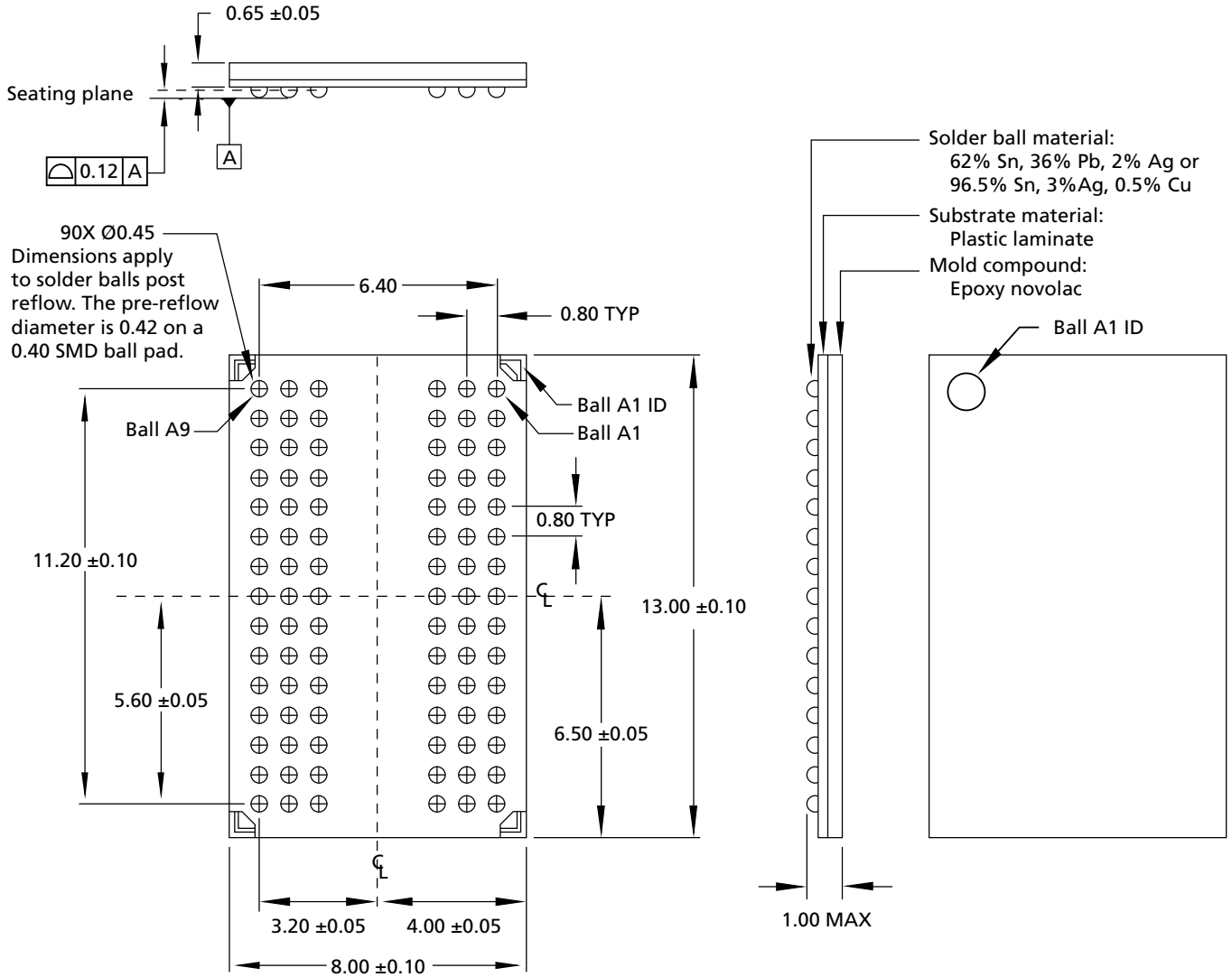
Package Dimensions

Figure 4: 86-Pin Plastic TSOP II (400 mil) – Package Codes TG/P



- Notes:
1. All dimensions are in millimeters.
 2. Package width and length do not include mold protrusion; allowable mold protrusion is 0.25 mm per side.
 3. "2X" means the notch is present in two locations (both ends of the device).
 4. Package may or may not be assembled with a location notch.

Figure 5: 90-Ball VFBGA (8mm x 13mm)



- Notes: 1. All dimensions are in millimeters.
 2. Package width and length do not include mold protrusion; allowable mold protrusion is 0.25mm per side.
 3. Recommended pad size for PCB is 0.33mm ±0.025mm.

Temperature and Thermal Impedance

It is imperative that the SDRAM device's temperature specifications, shown in Temperature Limits below, be maintained to ensure the junction temperature is in the proper operating range to meet data sheet specifications. An important step in maintaining the proper junction temperature is using the device's thermal impedances correctly. The thermal impedances are listed in Table 6 (page 15) for the applicable die revision and packages being made available. These thermal impedance values vary according to the density, package, and particular design used for each device.

Incorrectly using thermal impedances can produce significant errors. Read Micron technical note TN-00-08, "Thermal Applications" prior to using the thermal impedances listed in Table 6 (page 15). To ensure the compatibility of current and future designs, contact Micron Applications Engineering to confirm thermal impedance values.

The SDRAM device's safe junction temperature range can be maintained when the T_C specification is not exceeded. In applications where the device's ambient temperature is too high, use of forced air and/or heat sinks may be required to satisfy the case temperature specifications.

Table 5: Temperature Limits

Parameter		Symbol	Min	Max	Unit	Notes
Operating case temperature	Commercial	T_C	0	80	°C	1, 2, 3, 4
	Industrial		-40	90		
	Automotive		-40	105		
Junction temperature	Commercial	T_J	0	85	°C	3
	Industrial		-40	95		
	Automotive		-40	110		
Ambient temperature	Commercial	T_A	0	70	°C	3, 5
	Industrial		-40	85		
	Automotive		-40	105		
Peak reflow temperature		T_{PEAK}	-	260	°C	

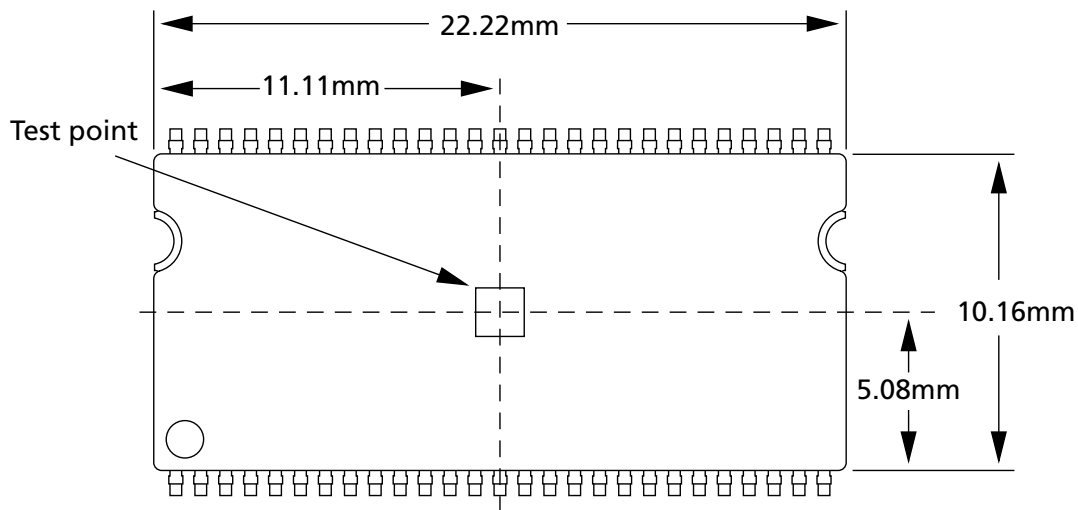
- Notes:
1. MAX operating case temperature T_C is measured in the center of the package on the top side of the device, as shown in Figure 6 (page 15) and Figure 7 (page 16).
 2. Device functionality is not guaranteed if the device exceeds maximum T_C during operation.
 3. All temperature specifications must be satisfied.
 4. The case temperature should be measured by gluing a thermocouple to the top-center of the component. This should be done with a 1mm bead of conductive epoxy, as defined by the JEDEC EIA/JESD51 standards. Take care to ensure that the thermocouple bead is touching the case.
 5. Operating ambient temperature surrounding the package.

Table 6: Thermal Impedance Simulated Values

Die Revision	Package	Substrate	Θ_{JA} (°C/W) Airflow = 0m/s	Θ_{JA} (°C/W) Airflow = 1m/s	Θ_{JA} (°C/W) Airflow = 2m/s	Θ_{JB} (°C/W)	Θ_{JC} (°C/W)
G	86-pin TSOP	Low Conductivity	82.2	65	59.7	49.4	10.3
		High Conductivity	55	47.2	45.1	40.6	
	90-ball VFBGA	Low Conductivity	64.6	50.8	45.3	37.5	1.8
		High Conductivity	48.2	41.1	38.1	32.1	
L	86-pin TSOP	Low Conductivity	122.3	105.6	98.1	89.5	20.7
		High Conductivity	101.9	93.5	88.8	87.6	
	90-ball VFBGA	Low Conductivity	76.8	63.1	63.1	50.1	10.4
		High Conductivity	56.3	49.6	49.6	43.5	

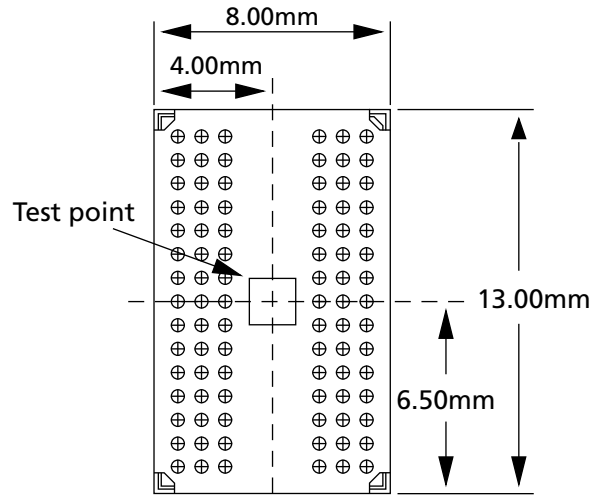
- Notes:
1. For designs expected to last beyond the die revision listed, contact Micron Applications Engineering to confirm thermal impedance values.
 2. Thermal resistance data is sampled from multiple lots, and the values should be viewed as typical.
 3. These are estimates; actual results may vary.

Figure 6: Example: Temperature Test Point Location, 54-Pin TSOP (Top View)



- Note:
1. Package may or may not be assembled with a location notch.

Figure 7: Example: Temperature Test Point Location, 90-Ball VFBGA (Top View)



Electrical Specifications

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.

Table 7: Absolute Maximum Ratings

Voltage/Temperature	Symbol	Min	Max	Unit
Voltage on V_{DD} , V_{DDQ} supply relative to V_{SS}	V_{DD} , V_{DDQ}	-1	4.6	V
Voltage on inputs, NC, or I/O pins relative to V_{SS}	V_{IN}	-1	4.6	V
Storage temperature (plastic)	T_{STG}	-55	150	°C
Power dissipation		-	1	W

Table 8: DC Electrical Characteristics and Operating Conditions

Notes 1, 2 apply to all parameters and conditions; V_{DD} , $V_{DDQ} = 3.3V \pm 0.3V$

Parameter/Condition	Symbol	Min	Max	Unit	Notes
Supply voltage	V_{DD} , V_{DDQ}	3	3.6	V	
Input high voltage: Logic 1; All inputs	V_{IH}	2	$V_{DD} + 0.3$	V	3
Input low voltage: Logic 0; All inputs	V_{IL}	-0.3	0.8	V	3
Output high voltage: $I_{OUT} = -4mA$	V_{OH}	2.4	-	V	
Output low voltage: $I_{OUT} = 4mA$	V_{OL}	-	0.4	V	
Input leakage current: Any input $0V \leq V_{IN} \leq V_{DD}$ (All other pins not under test = $0V$)	I_L	-5	5	μA	
Output leakage current: DQs are disabled; $0V \leq V_{OUT} \leq V_{DDQ}$	I_{OZ}	-5	5	μA	
Operating temperature:	Commercial	T_A	0	70	°C
	Industrial	T_A	-40	85	°C
	Automotive	T_A	-40	105	°C

- Notes:
- All voltages referenced to V_{SS} .
 - The minimum specifications are used only to indicate cycle time at which proper operation over the full temperature range is ensured:
 $0^\circ C \leq T_A \leq +70^\circ C$ (commercial)
 $-40^\circ C \leq T_A \leq +85^\circ C$ (industrial)
 $-40^\circ C \leq T_A \leq +105^\circ C$ (automotive)
 - Based on $t^{CK} = 143$ MHz for -7, 167 MHz for -6/6A.

Table 9: Capacitance

Parameter	Symbol	Min	Max	Unit
Input capacitance: CLK	C_{I1}	2.5	3.5	pF
Input capacitance: All other input-only pins	C_{I2}	2.5	3.8	pF
Input/output capacitance: DQs	C_{IO}	4	6	pF

Electrical Specifications – I_{DD} Parameters

Table 10: I_{DD} Specifications and Conditions – Revision G

Notes 1–5 apply to all parameters and conditions; V_{DD}, V_{DDQ} = 3.3V ±0.3V

Parameter/Condition	Symbol	Max		Unit	Notes
		-6	-7		
Operating current: Active mode; Burst = 2; READ or WRITE; ^t RC = ^t RC (MIN); CL = 3	I _{DD1}	190	165	mA	6, 7, 8, 9
Standby current: Power-down mode; CKE = LOW; All banks idle	I _{DD2}	2	2	mA	
Standby current: Active mode; CS# = HIGH; CKE = HIGH; All banks active after ^t RCD met; No accesses in progress	I _{DD3}	65	55	mA	8, 9
Operating current: Burst mode; Continuous burst; READ or WRITE; All banks active; CL = 3	I _{DD4}	195	175	mA	6, 7, 8, 9
Auto refresh current: CS# = HIGH; CKE = HIGH; CL = 3	I _{DD5}	^t RFC = ^t RFC (MIN)		mA	6, 7, 8, 9, 10
Self refresh current: CKE ≤ 0.2V		I _{DD6}	2		

Table 11: I_{DD} Specifications and Conditions – Revision L

Notes 1–5 apply to all parameters and conditions; V_{DD}, V_{DDQ} = 3.3V ±0.3V

Parameter/Condition	Symbol	Max	Unit	Notes
		-6A		
Operating current: Active mode; Burst = 2; READ or WRITE; ^t RC = ^t RC (MIN); CL = 3	I _{DD1}	120	mA	6, 7, 8, 9
Standby current: Power-down mode; CKE = LOW; All banks idle	I _{DD2}	2.5	mA	
Standby current: Active mode; CS# = HIGH; CKE = HIGH; All banks active after ^t RCD met; No accesses in progress	I _{DD3}	45	mA	8, 9
Operating current: Burst mode; Continuous burst; READ or WRITE; All banks active; CL = 3	I _{DD4}	120	mA	6, 7, 8, 9
Auto refresh current: CS# = HIGH; CKE = HIGH; CL = 3	I _{DD5}	^t RFC = ^t RFC (MIN)		6, 7, 8, 9, 10
Self refresh current: CKE ≤ 0.2V		I _{DD6}	3	

- Notes:
1. All voltages referenced to V_{SS}.
 2. I_{DD} specifications are tested after the device is properly initialized.
 3. The minimum specifications are used only to indicate cycle time at which proper operation over the full temperature range is ensured for IT parts:
0°C ≤ T_A ≤ +70°C
-40°C ≤ T_A ≤ +85°C.
 4. ^tHZ defines the time at which the output achieves the open circuit condition; it is not a reference to V_{OH} or V_{OL}. The last valid data element will meet ^tOH before going High-Z.
 5. Other input signals are allowed to transition no more than once in any two-clock period and are otherwise at valid V_{IH} or V_{IL} levels.
 6. I_{DD} is dependent on output loading and cycle rates. Specified values are obtained with minimum cycle time and the outputs open.

7. Required clocks are specified by JEDEC functionality and are not dependent on any timing parameter.
8. The I_{DD} current will decrease as CL is reduced. This is due to the fact that the maximum cycle rate is slower as CL is reduced.
9. JEDEC and PC100 specify three clocks.
10. AC timing and I_{DD} tests have V_{IL} = 0.25 and V_{IH} = 2.75, with timing referenced to the 1.5V crossover point.
11. Enables on-chip refresh and address counters.
12. CKE is HIGH during refresh command period ^tRFC (MIN), or else CKE is LOW. The I_{DD6} limit is actually a nominal value and does not result in a fail value.



Electrical Specifications – AC Operating Conditions

Table 12: Electrical Characteristics and Recommended AC Operating Conditions

Notes 1–6 apply to all parameters and conditions

Parameter		Symbol	-6A ⁹		-6		-7		Unit	Notes
			Min	Max	Min	Max	Min	Max		
Access time from CLK (positive edge)	CL = 3	t ^{AC} (3)	–	5.4	–	5.5	–	5.5	ns	
	CL = 2	t ^{AC} (2)	–	7.5	–	7.5	–	8	ns	
	CL = 1	t ^{AC} (1)	–	17	–	17	–	17	ns	
Address hold time		t ^{AH}	0.8	–	1.0	–	1.0	–	ns	
Address setup time		t ^{AS}	1.5	–	1.5	–	2	–	ns	
CLK high-level width		t ^{CH}	2.5	–	2.5	–	2.75	–	ns	
CLK low-level width		t ^{CL}	2.5	–	2.5	–	2.75	–	ns	
Clock cycle time	CL = 3	t ^{CK} (3)	6	–	6	–	7	–	ns	10
	CL = 2	t ^{CK} (2)	10	–	10 ⁹	–	10	–	ns	10
	CL = 1	t ^{CK} (1)	20	–	20 ⁹	–	20	–	ns	10
CKE hold time		t ^{CKH}	0.8	–	1.0	–	1.0	–	ns	
CKE setup time		t ^{CKS}	1.5	–	1.5	–	2	–	ns	
CS#, RAS#, CAS#, WE#, DQM hold time		t ^{CMH}	0.8	–	1.0	–	1.0	–	ns	
CS#, RAS#, CAS#, WE#, DQM setup time		t ^{CMS}	1.5	–	1.5	–	2	–	ns	
Data-in hold time		t ^{DH}	0.8	–	1.0	–	1.0	–	ns	
Data-in setup time		t ^{DS}	1.5	–	1.5	–	2	–	ns	
Data-out High-Z time	CL = 3	t ^{HZ} (3)	–	5.4	–	5.5	–	5.5	ns	8
	CL = 2	t ^{HZ} (2)	–	7.5	–	7.5	–	8	ns	8
	CL = 1	t ^{HZ} (1)	–	17	–	17	–	17	ns	8
Data-out Low-Z time		t ^{LZ}	1	–	1	–	1	–	ns	
Data-out hold time (load)		t ^{OH}	3	–	2	–	2.5	–	ns	
Data-out hold time (no load)		t ^{OH_n}	1.8	–	1.8	–	1.8	–	ns	7
ACTIVE-to-PRECHARGE command		t ^{RAS}	42	120,000	42	120,000	42	120,000	ns	
ACTIVE-to-ACTIVE command period		t ^{RC}	60	–	60	–	70	–	ns	11
AUTO REFRESH period		t ^{RFC}	60	–	60	–	70	–	ns	
ACTIVE-to-READ or WRITE delay		t ^{RCD}	18	–	18	–	20	–	ns	
Refresh period (4096 rows)		t ^{REF}	–	64	–	64	–	64	ms	
Refresh period – automotive (4096 rows)		t ^{REF_{AT}}	–	16	–	16	–	16	ms	
PRECHARGE command period		t ^{RP}	18	–	18	–	20	–	ns	
ACTIVE bank a to ACTIVE bank b command		t ^{RRD}	12	–	12	–	15	–	ns	12
Transition time		t ^T	0.3	1.2	0.3	1.2	0.3	1.2	ns	3
WRITE recovery time		t ^{WR}	1 CLK + 7ns	–	1 CLK + 6ns	–	1 CLK + 7ns	–	t ^{CK}	13
			12	–	12	–	14	–	ns	14



Table 12: Electrical Characteristics and Recommended AC Operating Conditions (Continued)

Notes 1–6 apply to all parameters and conditions

Parameter	Symbol	-6A ⁹		-6		-7		Unit	Notes
		Min	Max	Min	Max	Min	Max		
Exit SELF REFRESH-to-ACTIVE command	^t XSR	67	–	70	–	70	–	ns	15

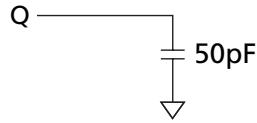
Table 13: AC Functional Characteristics

Notes 1–6 apply to all parameters and conditions

Parameter	Symbol	-6	-6A	-7	Unit	Notes	
READ/WRITE command to READ/WRITE command	^t CCD	1	1	1	^t CK		
CKE to clock disable or power-down entry mode	^t CKED	1	1	1	^t CK	16	
CKE to clock enable or power-down exit setup mode	^t PED	1	1	1	^t CK		
DQM to input data delay	^t DQD	0	0	0	^t CK		
DQM to data mask during WRITES	^t DQM	0	0	0	^t CK		
DQM to data High-Z during READS	^t DQZ	2	2	2	^t CK		
WRITE command to input data delay	^t DWD	0	0	0	^t CK		
Data-in to ACTIVE command	CL = 3	^t DAL(3)	5	4	5	^t CK	17
	CL = 2	^t DAL(2)	4	4	4	^t CK	17
	CL = 1	^t DAL(1)	3	3	3	^t CK	17
Data-in to PRECHARGE command	^t DPL	3	3	3	^t CK	18	
Last data-in to burst STOP command	^t BDL	1	1	1	^t CK		
Last data-in to new READ/WRITE command	^t CDL	1	1	1	^t CK		
Last data-in to burst PRECHARGE command	^t RDL	2	2	2	^t CK	18	
LOAD MODE REGISTER command to ACTIVE or REFRESH command	^t MRD	2	2	2	^t CK		
Data-out to High-Z from PRECHARGE command	CL = 3	^t ROH(3)	3	3	3	^t CK	
	CL = 2	^t ROH(2)	2	2	2	^t CK	
	CL = 1	^t ROH(1)	1	1	1	^t CK	

- Notes:
- Minimum specifications are used only to indicate the cycle time at which proper operation over the full temperature range is ensured:
 $0^{\circ}\text{C} \leq T_A \leq +70^{\circ}\text{C}$ (commercial)
 $-40^{\circ}\text{C} \leq T_A \leq +85^{\circ}\text{C}$ (industrial)
 $-40^{\circ}\text{C} \leq T_A \leq +105^{\circ}\text{C}$ (automotive)
 - Minimum specifications are used only to indicate the cycle time at which proper operation over the full temperature range is ensured for IT parts:
 $0^{\circ}\text{C} \leq T_A \leq +70^{\circ}\text{C}$
 $-40^{\circ}\text{C} \leq T_A \leq +85^{\circ}\text{C}$
 - An initial pause of 100 μs is required after power-up, followed by two AUTO REFRESH commands, before proper device operation is ensured. (V_{DD} and V_{DDQ} must be powered up simultaneously. V_{SS} and V_{SSQ} must be at same potential.) The two AUTO REFRESH command wake-ups should be repeated any time the ^tREF refresh requirement is exceeded.
 - AC characteristics assume ^tT = 1ns.

5. In addition to meeting the transition rate specification, the clock and CKE must transit between V_{IH} and V_{IL} (or between V_{IL} and V_{IH}) in a monotonic manner.
6. Outputs measured at 1.5V with equivalent load:



7. Parameter guaranteed by design. Note 6 does not apply to t_{OHn} .
8. t_{HZ} defines the time at which the output achieves the open circuit condition; it is not a reference to V_{OH} or V_{OL} . The last valid data element will meet t_{OH} before going High-Z.
9. Not applicable for Revision G.
10. V_{IH} overshoot: $V_{IH,max} = V_{DDQ} + 1.2V$ for a pulse width $\leq 3ns$, and the pulse width cannot be greater than one third of the cycle rate. V_{IL} undershoot: $V_{IL,min} = -1.2V$ for a pulse width $\leq 3ns$, and the pulse width cannot be greater than one third of the cycle rate.
11. DRAM devices should be evenly addressed when being accessed. Disproportionate accesses to a particular row address may result in reduction of the product lifetime.
12. Auto precharge mode only.
13. The clock frequency must remain constant (stable clock is defined as a signal cycling within timing constraints specified for the clock pin) during access or precharge states (READ, WRITE, including t_{WR} , and PRECHARGE commands). CKE may be used to reduce the data rate.
14. $t_{CK} = 7ns$ for -7, 6ns for -6/6A.
15. Address transitions average on transition every two clocks.
16. Timing is specified by t_{CKS} . Clock(s) specified as a reference only at minimum cycle rate.
17. Timing is specified by t_{WR} plus t_{RP} . Clock(s) specified as a reference only at minimum cycle rate.
18. Timing is specified by t_{WR} .

Functional Description

In general, 128Mb SDRAM devices (1 Meg x 32 x 4 banks) are quad-bank DRAM that operate at 3.3V and include a synchronous interface (all signals are registered on the positive edge of the clock signal, CLK). Each of the 33,554,432-bit banks is organized as 4096 rows by 256 columns by 32 bits.

Read and write accesses to the 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, 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 (BA[1:0] select the bank; A[11:0] select the row). The address bits (A[7:0]) 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 SDRAM must be initialized. The following sections provide detailed information covering device initialization, register definition, command descriptions, and device operation.

Commands

The following table provides a quick reference of available commands, followed by a written description of each command. Additional Truth Tables (Table 15 (page 30), Table 16 (page 32), and Table 17 (page 34)) provide current state/next state information.

Table 14: Truth Table – Commands and DQM Operation

Note 1 applies to all parameters and conditions

Name (Function)	CS#	RAS#	CAS#	WE#	DQM	ADDR	DQ	Notes
COMMAND INHIBIT (NOP)	H	X	X	X	X	X	X	
NO OPERATION (NOP)	L	H	H	H	X	X	X	
ACTIVE (select bank and activate row)	L	L	H	H	X	Bank/row	X	2
READ (select bank and column, and start READ burst)	L	H	L	H	L/H	Bank/col	X	3
WRITE (select bank and column, and start WRITE burst)	L	H	L	L	L/H	Bank/col	Valid	3
BURST TERMINATE	L	H	H	L	X	X	Active	4
PRECHARGE (Deactivate row in bank or banks)	L	L	H	L	X	Code	X	5
AUTO REFRESH or SELF REFRESH (enter self refresh mode)	L	L	L	H	X	X	X	6, 7
LOAD MODE REGISTER	L	L	L	L	X	Op-code	X	8
Write enable/output enable	X	X	X	X	L	X	Active	9
Write inhibit/output High-Z	X	X	X	X	H	X	High-Z	9

- Notes:
1. CKE is HIGH for all commands shown except SELF REFRESH.
 2. A[0:n] provide row address (where An is the most significant address bit), BA0 and BA1 determine which bank is made active.
 3. A[0:i] provide column address (where i = the most significant column address for a given device configuration). A10 HIGH enables the auto precharge feature (nonpersistent), while A10 LOW disables the auto precharge feature. BA0 and BA1 determine which bank is being read from or written to.
 4. The purpose of the BURST TERMINATE command is to stop a data burst, thus the command could coincide with data on the bus. However, the DQ column reads a "Don't Care" state to illustrate that the BURST TERMINATE command can occur when there is no data present.
 5. A10 LOW: BA0, BA1 determine the bank being precharged. A10 HIGH: all banks 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. A[11:0] define the op-code written to the mode register.
 9. Activates or deactivates the DQ during WRITES (zero-clock delay) and READS (two-clock delay).

COMMAND INHIBIT

The COMMAND INHIBIT function prevents new commands from being executed by the device, regardless of whether the CLK signal is enabled. The device is effectively de-selected. Operations already in progress are not affected.

NO OPERATION (NOP)

The NO OPERATION (NOP) command is used to perform a NOP to the selected device (CS# is LOW). This prevents unwanted commands from being registered during idle or wait states. Operations already in progress are not affected.

LOAD MODE REGISTER (LMR)

The mode registers are loaded via inputs A[n:0] (where An is the most significant address term), BA0, and BA1 (see "Mode Register"). The LOAD MODE REGISTER command can only be issued when all banks are idle and a subsequent executable command cannot be issued until tMRD is met.

ACTIVE

The ACTIVE command is used to activate a row in a particular bank for a subsequent access. The value on the BA0, BA1 inputs selects the bank, and the address provided selects the row. This row remains active for accesses until a PRECHARGE command is issued to that bank. A PRECHARGE command must be issued before opening a different row in the same bank.

Figure 8: ACTIVE Command

