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DDR2 SDRAM

MT47H256M4 – 32 Meg x 4 x 8 banks

MT47H128M8 – 16 Meg x 8 x 8 banks

MT47H64M16 – 8 Meg x 16 x 8 banks

Features

- $V_{DD} = 1.8V \pm 0.1V, V_{DDQ} = 1.8V \pm 0.1V$
- JEDEC-standard 1.8V I/O (SSTL_18-compatible)
- Differential data strobe (DQS, DQS#) option
- 4n-bit prefetch architecture
- Duplicate output strobe (RDQS) option for x8
- DLL to align DQ and DQS transitions with CK
- 8 internal banks for concurrent operation
- Programmable CAS latency (CL)
- Posted CAS additive latency (AL)
- WRITE latency = READ latency - 1 t_{CK}
- Selectable burst lengths (BL): 4 or 8
- Adjustable data-output drive strength
- 64ms, 8192-cycle refresh
- On-die termination (ODT)
- Industrial temperature (IT) option
- Automotive temperature (AT) option
- RoHS-compliant
- Supports JEDEC clock jitter specification

Options¹

- | | Marking |
|--|----------------|
| • Configuration | |
| – 256 Meg x 4 (32 Meg x 4 x 8 banks) | 256M4 |
| – 128 Meg x 8 (16 Meg x 8 x 8 banks) | 128M8 |
| – 64 Meg x 16 (8 Meg x 16 x 8 banks) | 64M16 |
| • FBGA package (Pb-free) – x16 | |
| – 84-ball FBGA (8mm x 12.5mm) Die
Rev :H | HR |
| – 84-ball FBGA (8mm x 12.5mm) Die
Rev :M | NF |
| • FBGA package (Pb-free) – x4, x8 | |
| – 60-ball FBGA (8mm x 10mm) Die
Rev :H | CF |
| – 60-ball FBGA (8mm x 10mm) Die
Rev :M | SH |
| • FBGA package (lead solder) – x16 | |
| – 84-ball FBGA (8mm x 12.5mm) Die
Rev :H | HW |
| • FBGA package (lead solder) – x4, x8 | |
| – 60-ball FBGA (8mm x 10mm) Die
Rev :H | JN |
| • Timing – cycle time | |
| – 1.875ns @ CL = 7 (DDR2-1066) | -187E |
| – 2.5ns @ CL = 5 (DDR2-800) | -25E |
| – 3.0ns @ CL = 5 (DDR2-667) | -3 |
| • Self refresh | |
| – Standard | None |
| – Low-power | L |
| • Operating temperature | |
| – Commercial (0°C ≤ T _C ≤ +85°C) ² | None |
| – Industrial (–40°C ≤ T _C ≤ +95°C;
–40°C ≤ T _A ≤ +85°C) | IT |
| • Revision | :H / :M |

- Notes: 1. Not all options listed can be combined to define an offered product. Use the Part Catalog Search on www.micron.com for product offerings and availability.
2. For extended CT operating temperature see IDD Table 11 (page 30) Note 7.

Table 1: Key Timing Parameters

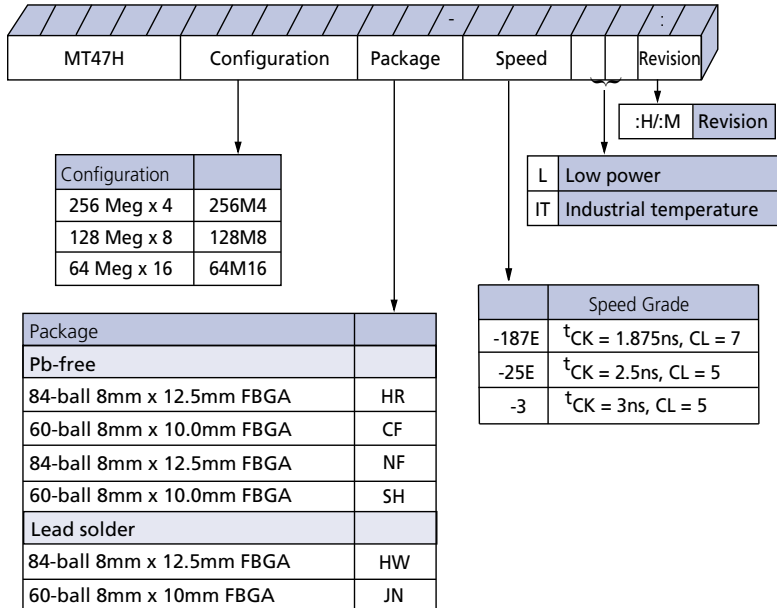
Speed Grade	Data Rate (MT/s)					t _{RC} (ns)
	CL = 3	CL = 4	CL = 5	CL = 6	CL = 7	
-187E	400	533	800	800	1066	54
-25E	400	533	800	800	n/a	55
-3	400	533	667	n/a	n/a	55

Table 2: Addressing

Parameter	256 Meg x 4	128 Meg x 8	64 Meg x 16
Configuration	32 Meg x 4 x 8 banks	16 Meg x 8 x 8 banks	8 Meg x 16 x 8 banks
Refresh count	8K	8K	8K
Row address	A[13:0] (16K)	A[13:0] (16K)	A[12:0] (8K)
Bank address	BA[2:0] (8)	BA[2:0] (8)	BA[2:0] (8)
Column address	A[11, 9:0] (2K)	A[9:0] (1K)	A[9:0] (1K)

Figure 1: 1Gb DDR2 Part Numbers

Example Part Number: MT47H128M8SH-25E:M



Note: 1. Not all speeds and configurations are available in all packages.

FBGA Part Number System

Due to space limitations, FBGA-packaged components have an abbreviated part marking that is different from the part number. For a quick conversion of an FBGA code, see the FBGA Part Marking Decoder on Micron's Web site: <http://www.micron.com>.

Contents

State Diagram	8
Functional Description	9
Industrial Temperature	9
General Notes	10
Functional Block Diagrams	11
Ball Assignments and Descriptions	14
Packaging	18
Package Dimensions	18
FBGA Package Capacitance	22
Electrical Specifications – Absolute Ratings	23
Temperature and Thermal Impedance	23
Electrical Specifications – I _{DD} Parameters	26
I _{DD} Specifications and Conditions	26
I _{DD7} Conditions	27
AC Timing Operating Specifications	32
AC and DC Operating Conditions	44
ODT DC Electrical Characteristics	44
Input Electrical Characteristics and Operating Conditions	45
Output Electrical Characteristics and Operating Conditions	48
Output Driver Characteristics	50
Power and Ground Clamp Characteristics	54
AC Overshoot/Undershoot Specification	55
Input Slew Rate Derating	57
Commands	70
Truth Tables	70
DESELECT	74
NO OPERATION (NOP)	75
LOAD MODE (LM)	75
ACTIVATE	75
READ	75
WRITE	75
PRECHARGE	76
REFRESH	76
SELF REFRESH	76
Mode Register (MR)	76
Burst Length	77
Burst Type	78
Operating Mode	78
DLL RESET	78
Write Recovery	79
Power-Down Mode	79
CAS Latency (CL)	80
Extended Mode Register (EMR)	81
DLL Enable/Disable	82
Output Drive Strength	82
DQS# Enable/Disable	82
RDQS Enable/Disable	82
Output Enable/Disable	82
On-Die Termination (ODT)	83
Off-Chip Driver (OCD) Impedance Calibration	83



Posted CAS Additive Latency (AL)	83
Extended Mode Register 2 (EMR2)	85
Extended Mode Register 3 (EMR3)	86
Initialization	87
ACTIVATE	90
READ	92
READ with Precharge	96
READ with Auto Precharge	98
WRITE	103
PRECHARGE	113
REFRESH	114
SELF REFRESH	115
Power-Down Mode	117
Precharge Power-Down Clock Frequency Change	124
Reset	125
CKE Low Anytime	125
ODT Timing	127
MRS Command to ODT Update Delay	129

List of Figures

Figure 1: 1Gb DDR2 Part Numbers	2
Figure 2: Simplified State Diagram	8
Figure 3: 256 Meg x 4 Functional Block Diagram	11
Figure 4: 128 Meg x 8 Functional Block Diagram	12
Figure 5: 64 Meg x 16 Functional Block Diagram	13
Figure 6: 60-Ball FBGA – x4, x8 Ball Assignments (Top View)	14
Figure 7: 84-Ball FBGA – x16 Ball Assignments (Top View)	15
Figure 8: 84-Ball FBGA Package (8mm x 12.5mm) – x16 Die Rev :H	18
Figure 9: 60-Ball FBGA (8mm x 10mm) – x4, x8 Die Rev :H	19
Figure 10: 84-Ball FBGA Package (8mm x 12.5mm) – x16; "NF" Die Rev :M	20
Figure 11: 60-Ball FBGA (8mm x 10mm) – x4, x8; "SH" Die Rev :M	21
Figure 12: Example Temperature Test Point Location	24
Figure 13: Single-Ended Input Signal Levels	45
Figure 14: Differential Input Signal Levels	46
Figure 15: Differential Output Signal Levels	48
Figure 16: Output Slew Rate Load	49
Figure 17: Full Strength Pull-Down Characteristics	50
Figure 18: Full Strength Pull-Up Characteristics	51
Figure 19: Reduced Strength Pull-Down Characteristics	52
Figure 20: Reduced Strength Pull-Up Characteristics	53
Figure 21: Input Clamp Characteristics	54
Figure 22: Overshoot	55
Figure 23: Undershoot	55
Figure 24: Nominal Slew Rate for ^t IS	60
Figure 25: Tangent Line for ^t IS	60
Figure 26: Nominal Slew Rate for ^t IH	61
Figure 27: Tangent Line for ^t IH	61
Figure 28: Nominal Slew Rate for ^t DS	66
Figure 29: Tangent Line for ^t DS	66
Figure 30: Nominal Slew Rate for ^t DH	67
Figure 31: Tangent Line for ^t DH	67
Figure 32: AC Input Test Signal Waveform Command/Address Balls	68
Figure 33: AC Input Test Signal Waveform for Data with DQS, DQS# (Differential)	68
Figure 34: AC Input Test Signal Waveform for Data with DQS (Single-Ended)	69
Figure 35: AC Input Test Signal Waveform (Differential)	69
Figure 36: MR Definition	77
Figure 37: CL	80
Figure 38: EMR Definition	81
Figure 39: READ Latency	84
Figure 40: WRITE Latency	84
Figure 41: EMR2 Definition	85
Figure 42: EMR3 Definition	86
Figure 43: DDR2 Power-Up and Initialization	87
Figure 44: Example: Meeting ^t RRD (MIN) and ^t RCD (MIN)	90
Figure 45: Multibank Activate Restriction	91
Figure 46: READ Latency	93
Figure 47: Consecutive READ Bursts	94
Figure 48: Nonconsecutive READ Bursts	95
Figure 49: READ Interrupted by READ	96
Figure 50: READ-to-WRITE	96

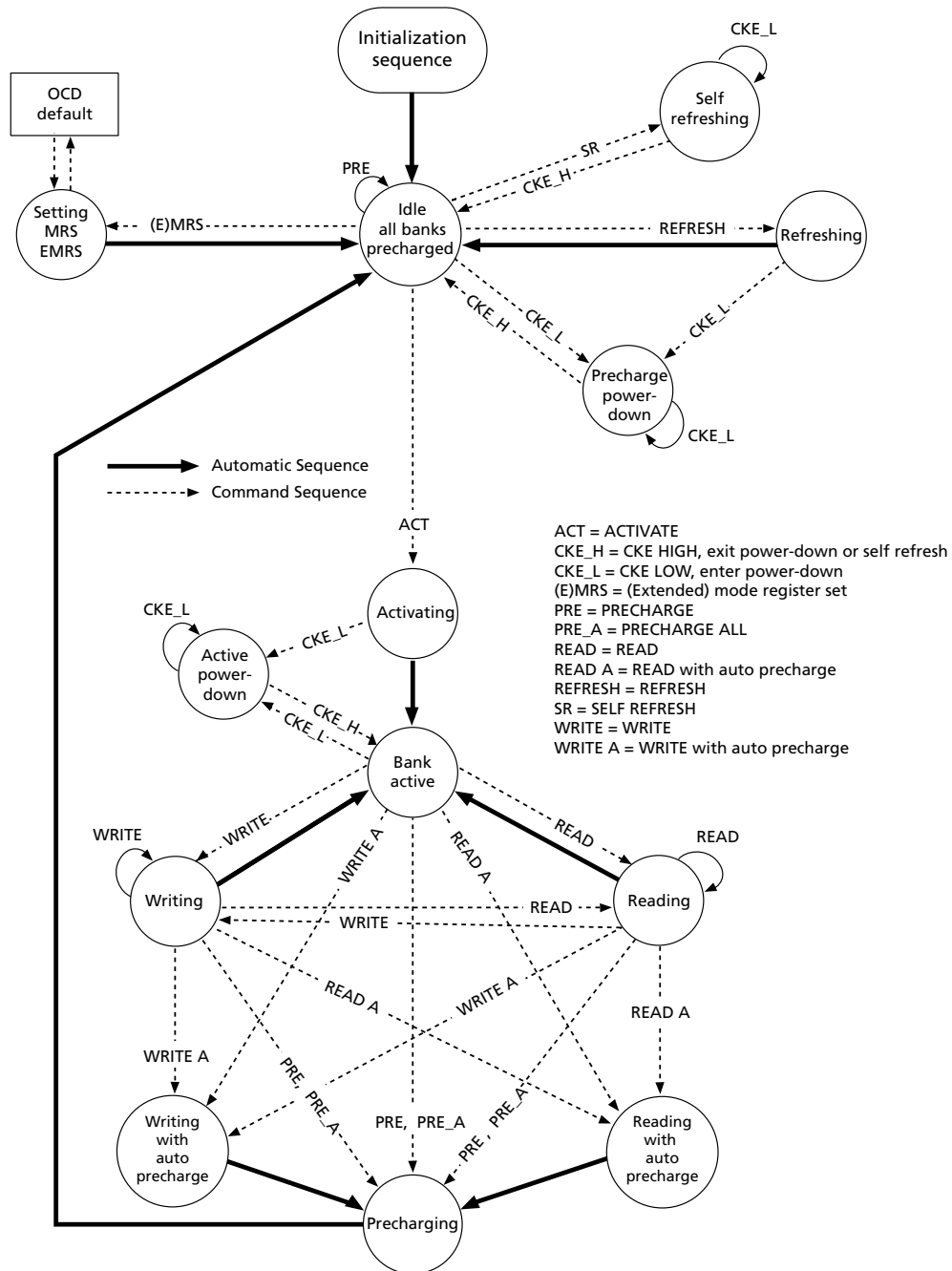
Figure 51: READ-to-PRECHARGE – BL = 4	97
Figure 52: READ-to-PRECHARGE – BL = 8	97
Figure 53: Bank Read – Without Auto Precharge	99
Figure 54: Bank Read – with Auto Precharge	100
Figure 55: x4, x8 Data Output Timing – ^t DQSQ, ^t QH, and Data Valid Window	101
Figure 56: x16 Data Output Timing – ^t DQSQ, ^t QH, and Data Valid Window	102
Figure 57: Data Output Timing – ^t AC and ^t DQSCK	103
Figure 58: Write Burst	105
Figure 59: Consecutive WRITE-to-WRITE	106
Figure 60: Nonconsecutive WRITE-to-WRITE	106
Figure 61: WRITE Interrupted by WRITE	107
Figure 62: WRITE-to-READ	108
Figure 63: WRITE-to-PRECHARGE	109
Figure 64: Bank Write – Without Auto Precharge	110
Figure 65: Bank Write – with Auto Precharge	111
Figure 66: WRITE – DM Operation	112
Figure 67: Data Input Timing	113
Figure 68: Refresh Mode	114
Figure 69: Self Refresh	116
Figure 70: Power-Down	118
Figure 71: READ-to-Power-Down or Self Refresh Entry	120
Figure 72: READ with Auto Precharge-to-Power-Down or Self Refresh Entry	120
Figure 73: WRITE-to-Power-Down or Self Refresh Entry	121
Figure 74: WRITE with Auto Precharge-to-Power-Down or Self Refresh Entry	121
Figure 75: REFRESH Command-to-Power-Down Entry	122
Figure 76: ACTIVATE Command-to-Power-Down Entry	122
Figure 77: PRECHARGE Command-to-Power-Down Entry	123
Figure 78: LOAD MODE Command-to-Power-Down Entry	123
Figure 79: Input Clock Frequency Change During Precharge Power-Down Mode	124
Figure 80: RESET Function	126
Figure 81: ODT Timing for Entering and Exiting Power-Down Mode	128
Figure 82: Timing for MRS Command to ODT Update Delay	129
Figure 83: ODT Timing for Active or Fast-Exit Power-Down Mode	129
Figure 84: ODT Timing for Slow-Exit or Precharge Power-Down Modes	130
Figure 85: ODT Turn-Off Timings When Entering Power-Down Mode	130
Figure 86: ODT Turn-On Timing When Entering Power-Down Mode	131
Figure 87: ODT Turn-Off Timing When Exiting Power-Down Mode	132
Figure 88: ODT Turn-On Timing When Exiting Power-Down Mode	133

List of Tables

Table 1: Key Timing Parameters	2
Table 2: Addressing	2
Table 3: FBGA 84-Ball – x16 and 60-Ball – x4, x8 Descriptions	16
Table 4: Input Capacitance	22
Table 5: Absolute Maximum DC Ratings	23
Table 6: Temperature Limits	24
Table 7: Thermal Impedance	25
Table 8: General I _{DD} Parameters	26
Table 9: I _{DD7} Timing Patterns (8-Bank Interleave READ Operation)	27
Table 10: DDR2 I _{DD} Specifications and Conditions (Die Revision H)	28
Table 11: DDR2 I _{DD} Specifications and Conditions (Die Revision M)	30
Table 12: AC Operating Specifications and Conditions	32
Table 13: Recommended DC Operating Conditions (SSTL_18)	44
Table 14: ODT DC Electrical Characteristics	44
Table 15: Input DC Logic Levels	45
Table 16: Input AC Logic Levels	45
Table 17: Differential Input Logic Levels	46
Table 18: Differential AC Output Parameters	48
Table 19: Output DC Current Drive	48
Table 20: Output Characteristics	49
Table 21: Full Strength Pull-Down Current (mA)	50
Table 22: Full Strength Pull-Up Current (mA)	51
Table 23: Reduced Strength Pull-Down Current (mA)	52
Table 24: Reduced Strength Pull-Up Current (mA)	53
Table 25: Input Clamp Characteristics	54
Table 26: Address and Control Balls	55
Table 27: Clock, Data, Strobe, and Mask Balls	55
Table 28: AC Input Test Conditions	55
Table 29: DDR2-400/533 Setup and Hold Time Derating Values (t _{IS} and t _{IH})	58
Table 30: DDR2-667/800/1066 Setup and Hold Time Derating Values (t _{IS} and t _{IH})	59
Table 31: DDR2-400/533 t _{DS} , t _{DH} Derating Values with Differential Strobe	62
Table 32: DDR2-667/800/1066 t _{DS} , t _{DH} Derating Values with Differential Strobe	63
Table 33: Single-Ended DQS Slew Rate Derating Values Using t _{DS_b} and t _{DH_b}	64
Table 34: Single-Ended DQS Slew Rate Fully Derated (DQS, DQ at V _{REF}) at DDR2-667	64
Table 35: Single-Ended DQS Slew Rate Fully Derated (DQS, DQ at V _{REF}) at DDR2-533	65
Table 36: Single-Ended DQS Slew Rate Fully Derated (DQS, DQ at V _{REF}) at DDR2-400	65
Table 37: Truth Table – DDR2 Commands	70
Table 38: Truth Table – Current State Bank <i>n</i> – Command to Bank <i>n</i>	71
Table 39: Truth Table – Current State Bank <i>n</i> – Command to Bank <i>m</i>	73
Table 40: Minimum Delay with Auto Precharge Enabled	74
Table 41: Burst Definition	78
Table 42: READ Using Concurrent Auto Precharge	98
Table 43: WRITE Using Concurrent Auto Precharge	104
Table 44: Truth Table – CKE	119

State Diagram

Figure 2: Simplified State Diagram



Note: 1. This diagram provides the basic command flow. It is not comprehensive and does not identify all timing requirements or possible command restrictions such as multibank interaction, power down, entry/exit, etc.

Functional Description

The DDR2 SDRAM uses a double data rate architecture to achieve high-speed operation. The double data rate architecture is essentially a $4n$ -prefetch architecture, with an interface designed to transfer two data words per clock cycle at the I/O balls. A single READ or WRITE operation for the DDR2 SDRAM effectively consists of a single $4n$ -bit-wide, two-clock-cycle data transfer at the internal DRAM core and four corresponding n -bit-wide, one-half-clock-cycle data transfers at the I/O balls.

A bidirectional data strobe (DQS, DQS#) is transmitted externally, along with data, for use in data capture at the receiver. DQS is a strobe transmitted by the DDR2 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 x16 offering has two data strobes, one for the lower byte (LDQS, LDQS#) and one for the upper byte (UDQS, UDQS#).

The DDR2 SDRAM operates from a differential clock (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.

Read and write accesses to the DDR2 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 ACTIVATE command, which is then followed by a READ or WRITE command. The address bits registered coincident with the ACTIVATE 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 DDR2 SDRAM provides for programmable read or write burst lengths of four or eight locations. DDR2 SDRAM supports interrupting a burst read of eight with another read or a burst write of eight with another write. 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 DDR SDRAM, the pipelined, multibank architecture of DDR2 SDRAM enables concurrent operation, thereby providing high, effective bandwidth by hiding row precharge and activation time.

A self refresh mode is provided, along with a power-saving, power-down mode.

All inputs are compatible with the JEDEC standard for SSTL₁₈. All full drive-strength outputs are SSTL₁₈-compatible.

Industrial Temperature

The industrial temperature (IT) option, if offered, has two simultaneous requirements: ambient temperature surrounding the device cannot be less than -40°C or greater than 85°C , and the case temperature cannot be less than -40°C or greater than 95°C . JEDEC specifications require the refresh rate to double when T_C exceeds 85°C ; this also requires use of the high-temperature self refresh option. Additionally, ODT resistance, input/output impedance and I_{DD} values must be derated when T_C is $< 0^{\circ}\text{C}$ or $> 85^{\circ}\text{C}$.

General Notes

- The functionality and the timing specifications discussed in this data sheet are for the DLL-enabled mode of operation.
 - Throughout the data sheet, the various figures and text refer to DQs as “DQ.” The DQ term is to be interpreted as any and all DQ collectively, unless specifically stated otherwise. Additionally, the x16 is divided into 2 bytes: the lower byte and the upper byte. For the lower byte (DQ[7:0]), DM refers to LDM and DQS refers to LDQS. For the upper byte (DQ[15:8]), DM refers to UDM and DQS refers to UDQS.
 - A x16 device's DQ bus is comprised of two bytes. If only one of the bytes needs to be used, use the lower byte for data transfers and terminate the upper byte as noted:
 - Connect UDQS to ground via 1k Ω * resistor
 - Connect UDQS# to V_{DD} via 1k Ω * resistor
 - Connect UDM to V_{DD} via 1k Ω * resistor
 - Connect DQ[15:8] individually to either V_{SS} or V_{DD} via 1k Ω * resistors, or float DQ[15:8].
- *If ODT is used, 1k Ω resistor should be changed to 4x that of the selected ODT.
- Complete functionality is described throughout the document, and any page or diagram may have been simplified to convey a topic and may not be inclusive of all requirements.
 - Any specific requirement takes precedence over a general statement.

Functional Block Diagrams

The DDR2 SDRAM is a high-speed CMOS, dynamic random access memory. It is internally configured as a multibank DRAM.

Figure 3: 256 Meg x 4 Functional Block Diagram

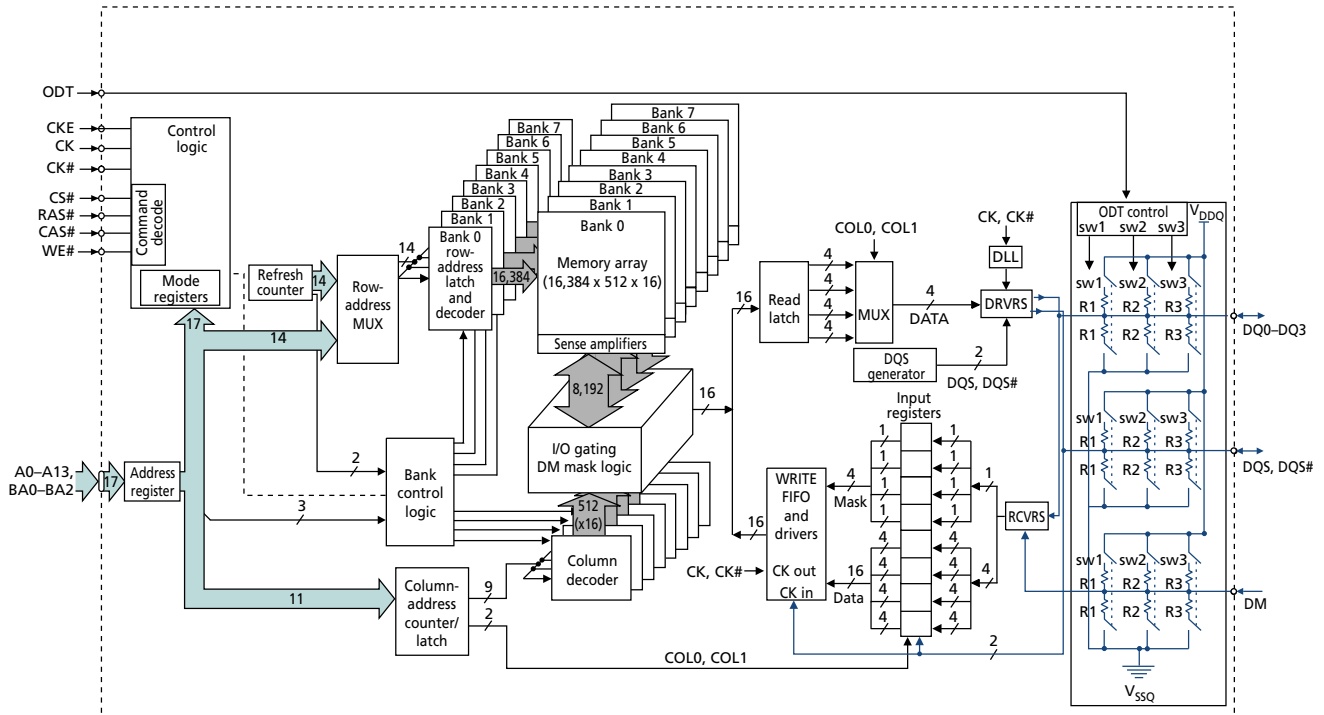


Figure 4: 128 Meg x 8 Functional Block Diagram

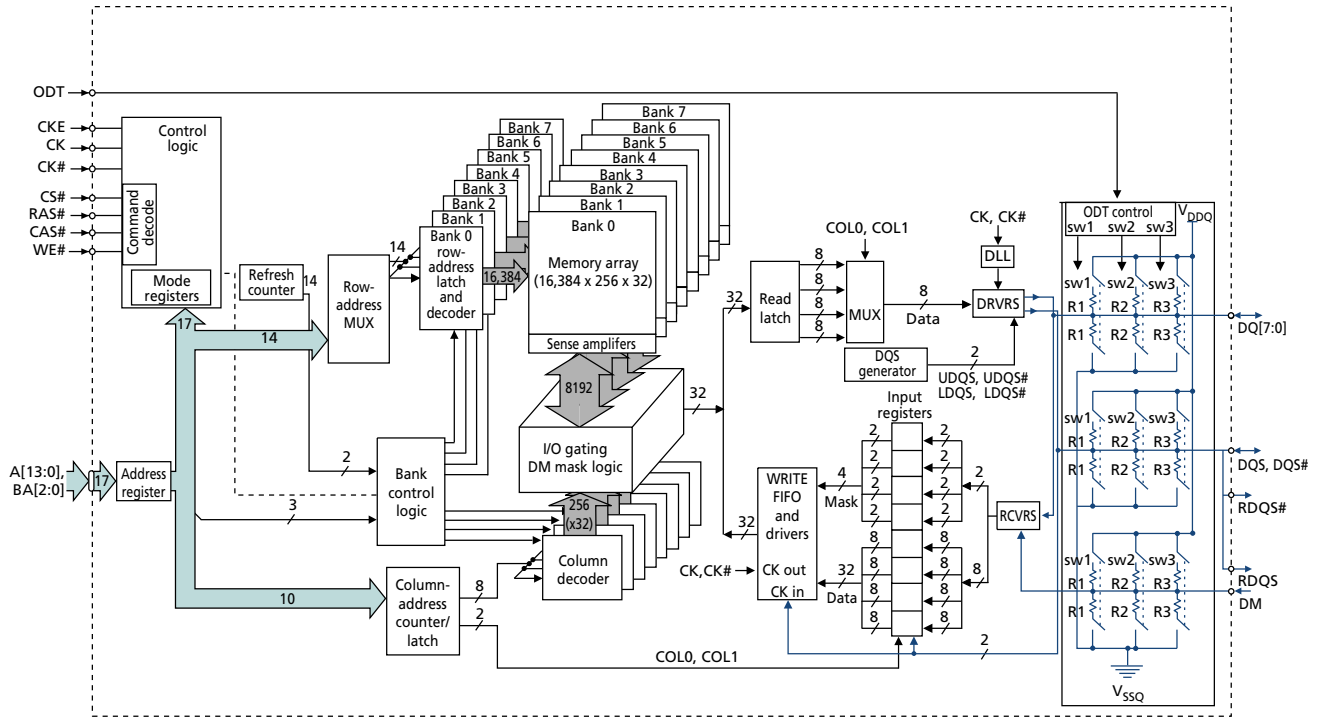
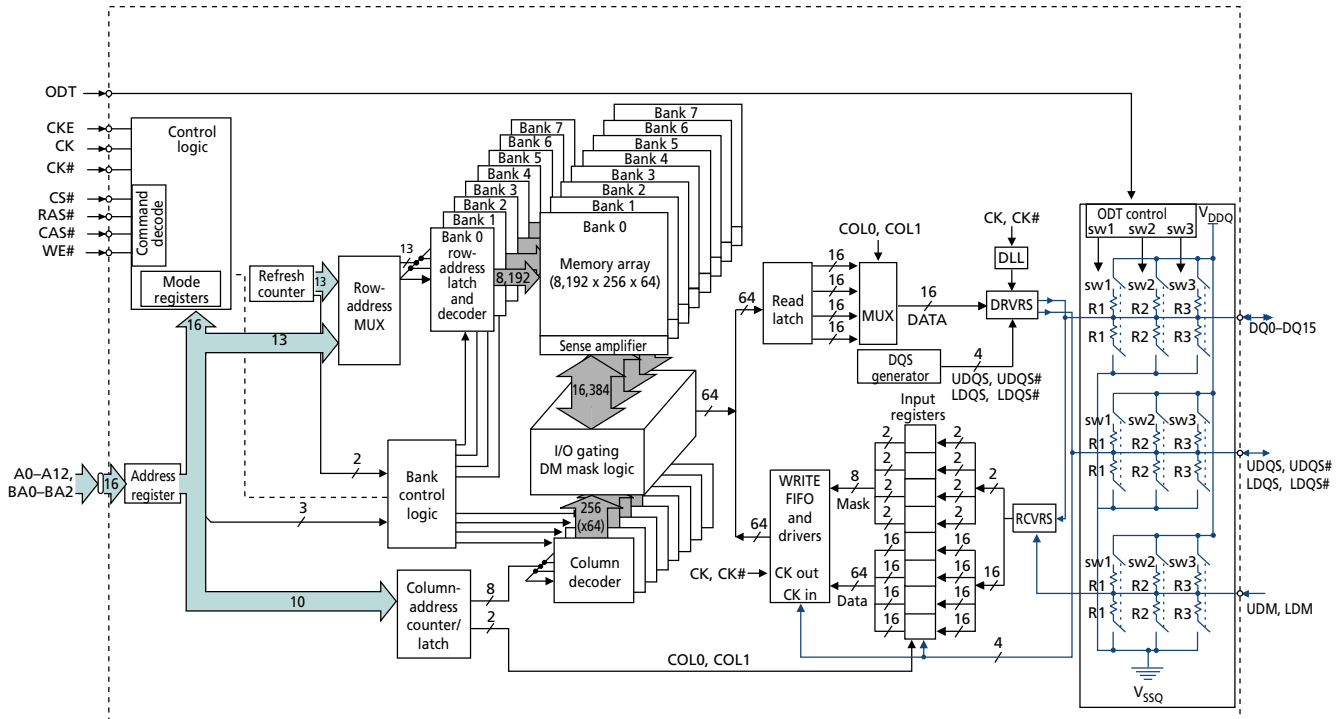


Figure 5: 64 Meg x 16 Functional Block Diagram



Ball Assignments and Descriptions

Figure 6: 60-Ball FBGA – x4, x8 Ball Assignments (Top View)

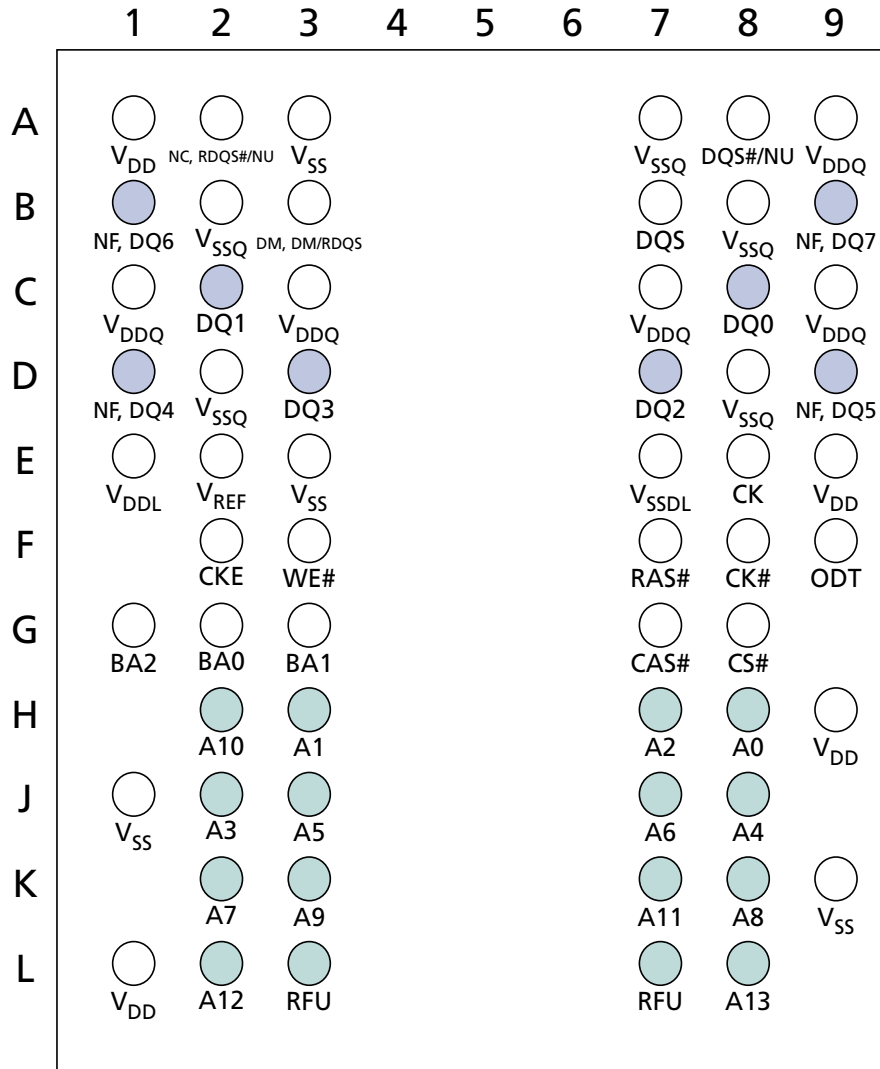


Figure 7: 84-Ball FBGA – x16 Ball Assignments (Top View)

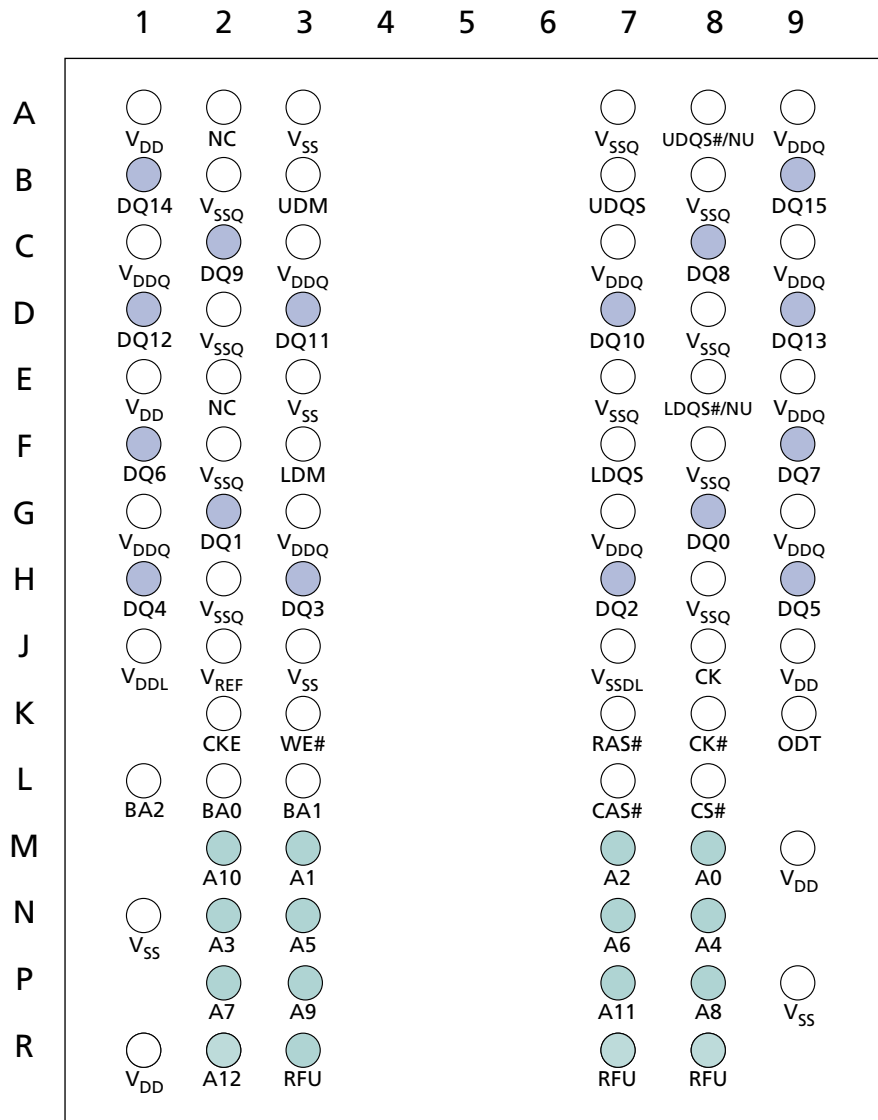


Table 3: FBGA 84-Ball – x16 and 60-Ball – x4, x8 Descriptions

Symbol	Type	Description
A[12:0] (x16), A[13:0] (x4, x8)	Input	Address inputs: Provide the row address for ACTIVATE 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 bank. A10 sampled during a PRECHARGE command determines whether the PRECHARGE applies to one bank (A10 LOW, bank selected by BA[2:0] or all banks (A10 HIGH). The address inputs also provide the op-code during a LOAD MODE command.
BA[2:0]	Input	Bank address inputs: BA[2:0] define to which bank an ACTIVATE, READ, WRITE, or PRECHARGE command is being applied. BA[2:0] define which mode register, including MR, EMR, EMR(2), and EMR(3), is loaded during the LOAD MODE command.
CK, CK#	Input	Clock: CK and CK# are differential clock inputs. All address and control input signals are sampled on the crossing of the positive edge of CK and negative edge of CK#. Output data (DQ and DQS/DQS#) is referenced to the crossings of CK and CK#.
CKE	Input	Clock enable: CKE (registered HIGH) activates and CKE (registered LOW) deactivates clocking circuitry on the DDR2 SDRAM. The specific circuitry that is enabled/disabled is dependent on the DDR2 SDRAM configuration and operating mode. CKE LOW provides precharge power-down and SELF REFRESH operations (all banks idle), or ACTIVATE power-down (row active in any bank). CKE is synchronous for power-down entry, power-down exit, output disable, and for self refresh entry. CKE is asynchronous for self refresh exit. Input buffers (excluding CK, CK#, CKE, and ODT) are disabled during power-down. Input buffers (excluding CKE) are disabled during self refresh. CKE is an SSTL_18 input but will detect a LVCMOS LOW level after V _{DD} is applied during first power-up. After V _{REF} has become stable during the power-on and initialization sequence, it must be maintained for proper operation of the CKE receiver. For proper SELF REFRESH operation, V _{REF} must be maintained.
CS#	Input	Chip select: CS# enables (registered LOW) and disables (registered HIGH) the command decoder. All commands are masked when CS# is registered high. CS# provides for external bank selection on systems with multiple ranks. CS# is considered part of the command code.
LDM, UDM, DM	Input	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 balls are input-only, the DM loading is designed to match that of DQ and DQS balls. LDM is DM for lower byte DQ[7:0] and UDM is DM for upper byte DQ[15:8].
ODT	Input	On-die termination: ODT (registered HIGH) enables termination resistance internal to the DDR2 SDRAM. When enabled, ODT is only applied to each of the following balls: DQ[15:0], LDM, UDM, LDQS, LDQS#, UDQS, and UDQS# for the x16; DQ[7:0], DQS, DQS#, RDQS, RDQS#, and DM for the x8; DQ[3:0], DQS, DQS#, and DM for the x4. The ODT input will be ignored if disabled via the LOAD MODE command.
RAS#, CAS#, WE#	Input	Command inputs: RAS#, CAS#, and WE# (along with CS#) define the command being entered.
DQ[15:0] (x16) DQ[3:0] (x4) DQ[7:0] (x8)	I/O	Data input/output: Bidirectional data bus for 64 Meg x 16. Bidirectional data bus for 256 Meg x 4. Bidirectional data bus for 128 Meg x 8.

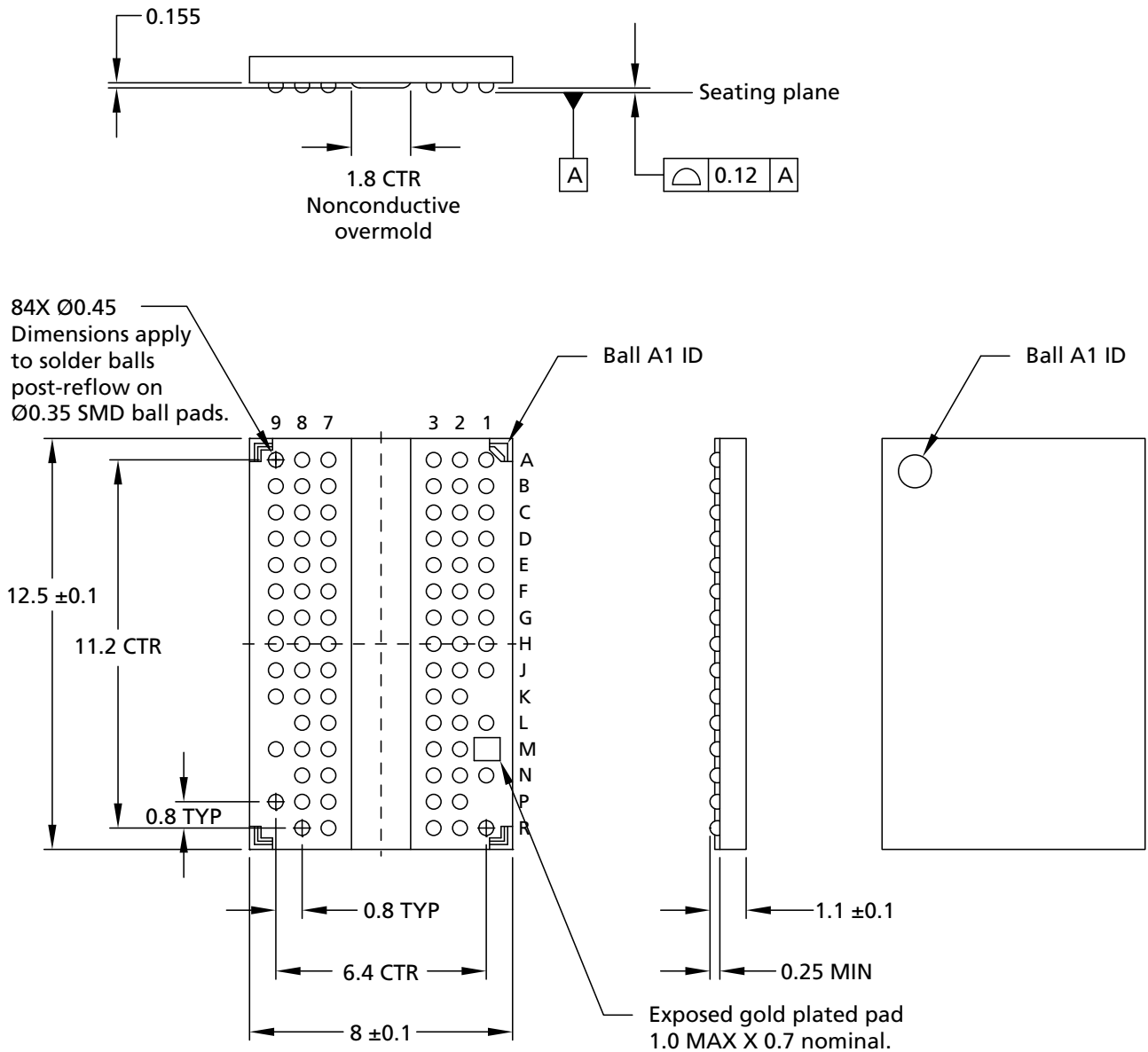
Table 3: FBGA 84-Ball – x16 and 60-Ball – x4, x8 Descriptions (Continued)

Symbol	Type	Description
DQS, DQS#	I/O	Data strobe: Output with read data, input with write data for source synchronous operation. Edge-aligned with read data, center-aligned with write data. DQS# is only used when differential data strobe mode is enabled via the LOAD MODE command.
LDQS, LDQS#	I/O	Data strobe for lower byte: Output with read data, input with write data for source synchronous operation. Edge-aligned with read data, center-aligned with write data. LDQS# is only used when differential data strobe mode is enabled via the LOAD MODE command.
UDQS, UDQS#	I/O	Data strobe for upper byte: Output with read data, input with write data for source synchronous operation. Edge-aligned with read data, center-aligned with write data. UDQS# is only used when differential data strobe mode is enabled via the LOAD MODE command.
RDQS, RDQS#	Output	Redundant data strobe: For x8 only. RDQS is enabled/disabled via the LOAD MODE command to the extended mode register (EMR). When RDQS is enabled, RDQS is output with read data only and is ignored during write data. When RDQS is disabled, ball B3 becomes data mask (see DM ball). RDQS# is only used when RDQS is enabled <i>and</i> differential data strobe mode is enabled.
V _{DD}	Supply	Power supply: 1.8V ±0.1V.
V _{DDQ}	Supply	DQ power supply: 1.8V ±0.1V. Isolated on the device for improved noise immunity.
V _{DDL}	Supply	DLL power supply: 1.8V ±0.1V.
V _{REF}	Supply	SSTL_18 reference voltage (V _{DDQ} /2).
V _{SS}	Supply	Ground.
V _{SSDL}	Supply	DLL ground: Isolated on the device from V _{SS} and V _{SSQ} .
V _{SSQ}	Supply	DQ ground: Isolated on the device for improved noise immunity.
NC	–	No connect: These balls should be left unconnected.
NF	–	No function: x8: these balls are used as DQ[7:4]; x4: they are no function.
NU	–	Not used: For x16 only. If EMR(E10) = 0, A8 and E8 are UDQS# and LDQS#. If EMR(E10) = 1, then A8 and E8 are not used.
NU	–	Not used: For x8 only. If EMR(E10) = 0, A2 and E8 are RDQS# and DQS#. If EMR(E10) = 1, then A2 and E8 are not used.
RFU	–	Reserved for future use: Row address bits A13 (x16 only), A14, and A15.

Packaging

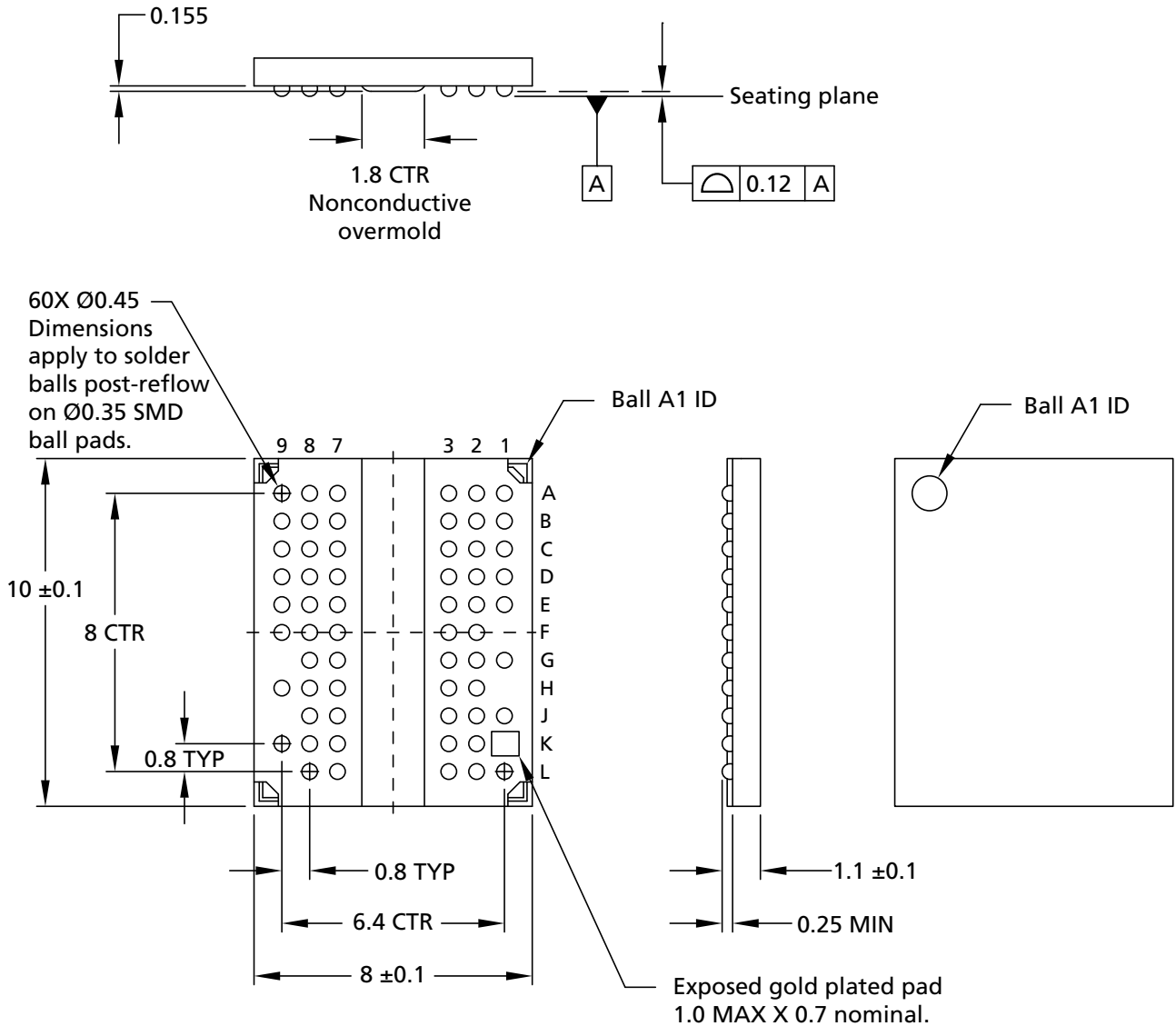
Package Dimensions

Figure 8: 84-Ball FBGA Package (8mm x 12.5mm) – x16 Die Rev :H



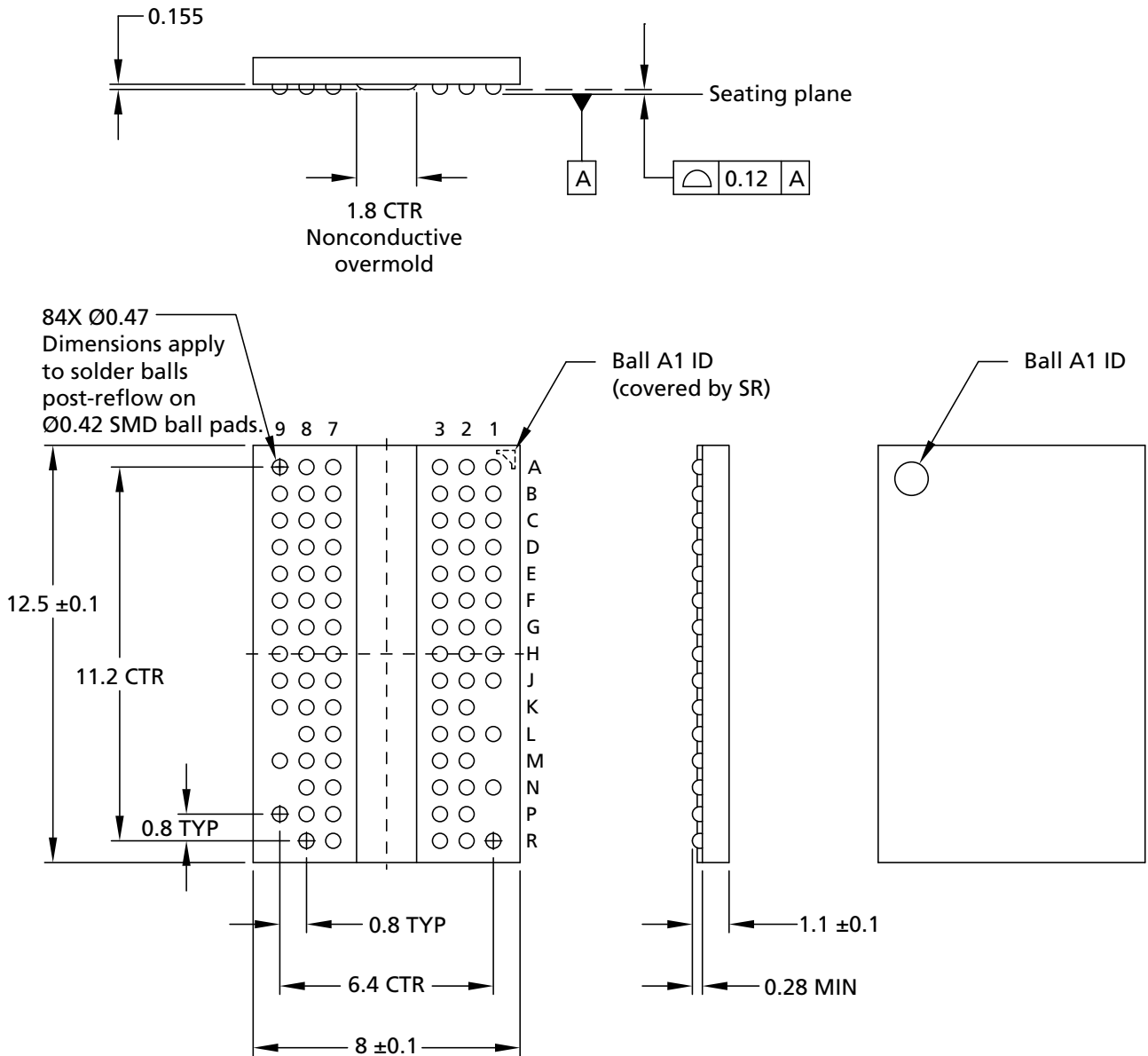
- Notes:
1. All dimensions are in millimeters.
 2. Solder ball material: SAC305 (96.5% Sn, 3% Ag, 0.5% Cu) or leaded Eutectic (62% Sn, 36%Pb, 2% Ag).

Figure 9: 60-Ball FBGA (8mm x 10mm) – x4, x8 Die Rev :H



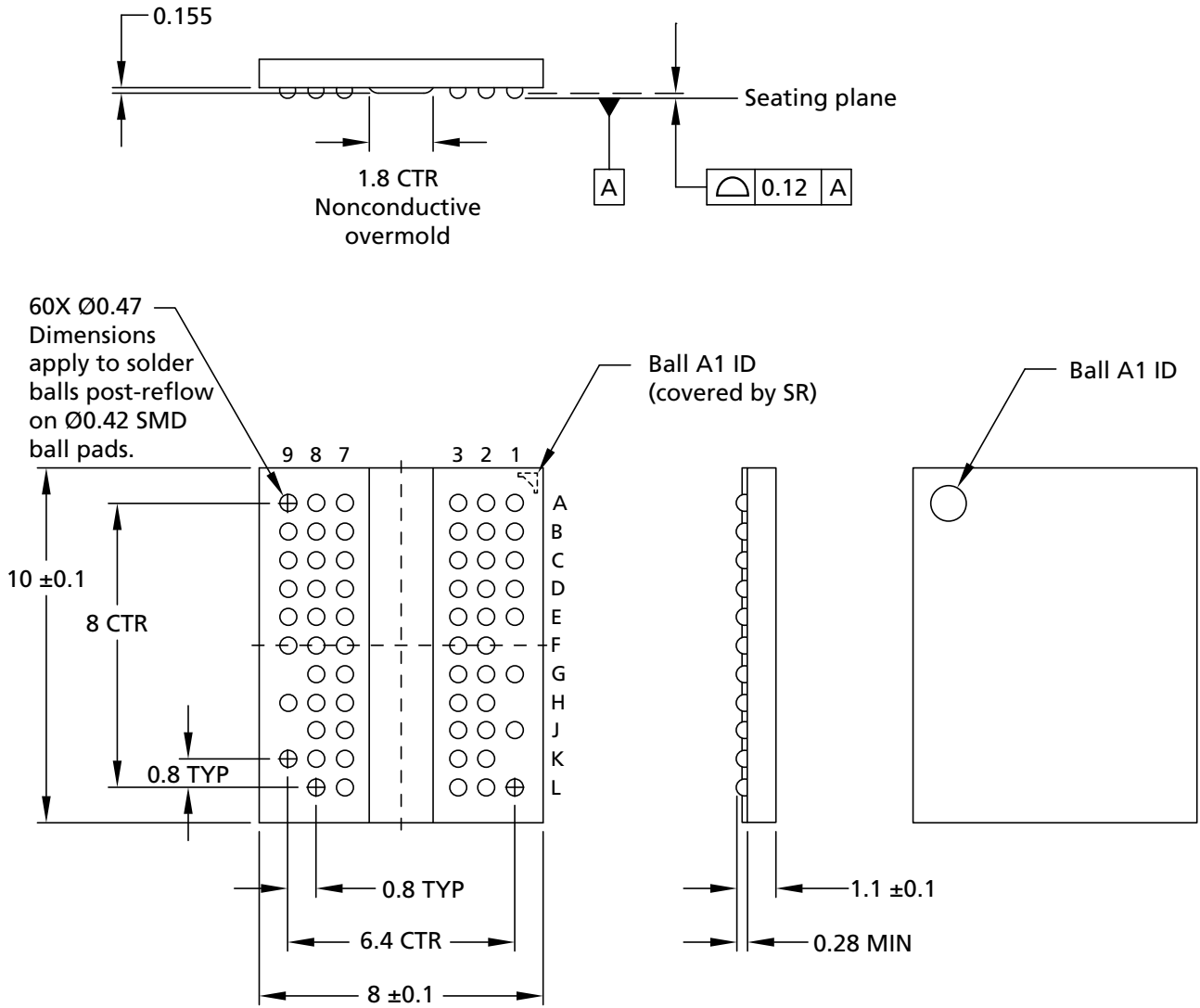
- Notes:
1. All dimensions are in millimeters.
 2. Solder ball material: SAC305 (96.5% Sn, 3% Ag, 0.5% Cu) or leaded Eutectic (62% Sn, 36%Pb, 2% Ag).

Figure 10: 84-Ball FBGA Package (8mm x 12.5mm) – x16; "NF" Die Rev :M



- Notes: 1. All dimensions are in millimeters.
 2. Solder ball material: SAC305 (96.5% Sn, 3% Ag, 0.5% Cu).

Figure 11: 60-Ball FBGA (8mm x 10mm) – x4, x8; "SH" Die Rev :M



- Notes: 1. All dimensions are in millimeters.
 2. Solder ball material: SAC305 (96.5% Sn, 3% Ag, 0.5% Cu).

FBGA Package Capacitance
Table 4: Input Capacitance

Parameter	Symbol	Min	Max	Units	Notes
Input capacitance: CK, CK#	C_{CK}	1.0	2.0	pF	1
Delta input capacitance: CK, CK#	C_{DCK}	–	0.25	pF	2, 3
Input capacitance: Address balls, bank address balls, CS#, RAS#, CAS#, WE#, CKE, ODT	C_I	1.0	2.0	pF	1, 4
Delta input capacitance: Address balls, bank address balls, CS#, RAS#, CAS#, WE#, CKE, ODT	C_{DI}	–	0.25	pF	2, 3
Input/output capacitance: DQ, DQS, DM, NF	C_{IO}	2.5	4.0	pF	1, 5
Delta input/output capacitance: DQ, DQS, DM, NF	C_{DIO}	–	0.5	pF	2, 3

- Notes:
1. This parameter is sampled. $V_{DD} = 1.8V \pm 0.1V$, $V_{DDQ} = 1.8V \pm 0.1V$, $V_{REF} = V_{SS}$, $f = 100$ MHz, $T_C = 25^\circ C$, $V_{OUT(DC)} = V_{DDQ}/2$, V_{OUT} (peak-to-peak) = 0.1V. DM input is grouped with I/O balls, reflecting the fact that they are matched in loading.
 2. The capacitance per ball group will not differ by more than this maximum amount for any given device.
 3. ΔC are not pass/fail parameters; they are targets.
 4. Reduce MAX limit by 0.25pF for -25, -25E, and -187E speed devices.
 5. Reduce MAX limit by 0.5pF for -3, -3E, -25, -25E, and -187E speed devices.

Electrical Specifications – Absolute 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 outside 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 5: Absolute Maximum DC Ratings

Parameter	Symbol	Min	Max	Units	Notes
V _{DD} supply voltage relative to V _{SS}	V _{DD}	-1.0	2.3	V	1
V _{DDQ} supply voltage relative to V _{SSQ}	V _{DDQ}	-0.5	2.3	V	1, 2
V _{DDL} supply voltage relative to V _{SSL}	V _{DDL}	-0.5	2.3	V	1
Voltage on any ball relative to V _{SS}	V _{IN} , V _{OUT}	-0.5	2.3	V	3
Input leakage current; any input 0V ≤ V _{IN} ≤ V _{DD} ; all other balls not under test = 0V	I _I	-5	5	μA	
Output leakage current; 0V ≤ V _{OUT} ≤ V _{DDQ} ; DQ and ODT disabled	I _{OZ}	-5	5	μA	
V _{REF} leakage current; V _{REF} = Valid V _{REF} level	I _{VREF}	-2	2	μA	

- Notes:
1. V_{DD}, V_{DDQ}, and V_{DDL} must be within 300mV of each other at all times; this is not required when power is ramping down.
 2. V_{REF} ≤ 0.6 × V_{DDQ}; however, V_{REF} may be ≥ V_{DDQ} provided that V_{REF} ≤ 300mV.
 3. Voltage on any I/O may not exceed voltage on V_{DDQ}.

Temperature and Thermal Impedance

It is imperative that the DDR2 SDRAM device's temperature specifications, shown in Table 6 (page 24), be maintained in order 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 7 (page 25) for the applicable and available die revision and packages.

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 7. For designs that are expected to last several years and require the flexibility to use several DRAM die shrinks, consider using final target theta values (rather than existing values) to account for increased thermal impedances from the die size reduction.

The DDR2 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 in order to satisfy the case temperature specifications.

Table 6: Temperature Limits

Parameter	Symbol	Min	Max	Units	Notes
Storage temperature	T_{STG}	-55	150	°C	1
Operating temperature: commercial	T_C	0	85	°C	2, 3
Operating temperature: industrial	T_C	-40	95	°C	2, 3, 4
	T_A	-40	85	°C	4, 5
Operating temperature: automotive	T_C	-40	105	°C	2, 3, 4
	T_A	-40	105	°C	4, 5

- Notes:
1. MAX storage case temperature T_{STG} is measured in the center of the package, as shown in Figure 12. This case temperature limit is allowed to be exceeded briefly during package reflow, as noted in Micron technical note TN-00-15, "Recommended Soldering Parameters."
 2. MAX operating case temperature T_C is measured in the center of the package, as shown in Figure 12.
 3. Device functionality is not guaranteed if the device exceeds maximum T_C during operation.
 4. Both temperature specifications must be satisfied.
 5. Operating ambient temperature surrounding the package.

Figure 12: Example Temperature Test Point Location

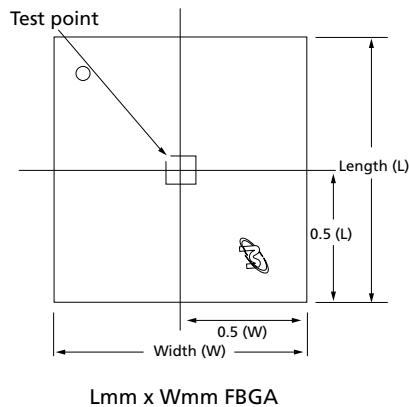




Table 7: Thermal Impedance

Die Revision	Package	Substrate (pcb)	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)
H ¹	60-ball	2-layer	72.5	55.5	49.5	35.6	5.7
		4-layer	54.5	45.7	42.3	35.2	
	84-ball	2-layer	68.8	52.0	46.5	32.5	5.6
		4-layer	51.3	42.7	39.6	32.3	
M ¹	60-ball	Low Conductivity	85.4	70.6	64.5	42.8	11.7
		High Conductivity	63.2	56.1	52.8		
	84-ball	Low Conductivity	80.8	67.0	61.6	44.7	11.7
		High Conductivity	59.7	53.3	50.7		

Note: 1. Thermal resistance data is based on a number of samples from multiple lots and should be viewed as a typical number.