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DDR2 SDRAM

MT47H512M4 – 64 Meg x 4 x 8 banks
MT47H256M8 – 32 Meg x 8 x 8 banks
MT47H128M16 – 16 Meg x 16 x 8 banks

Features

- V_{DD} = 1.8V ±0.1V, V_{DDQ} = 1.8V ±0.1V
- JEDEC-standard 1.8V I/O (SSTL_18-compatible)
- Differential data strobe (DQS, DQS#) option
- 4*n*-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
- Programmable burst lengths: 4 or 8
- Adjustable data-output drive strength
- 64ms, 8192-cycle refresh
- On-die termination (ODT)
- Industrial temperature (IT) option
- RoHS-compliant
- Supports JEDEC clock jitter specification

Options[1]	Marking
• Configuration	
– 512 Meg x 4 (64 Meg x 4 x 8 banks)	512M4
– 256 Meg x 8 (32 Meg x 8 x 8 banks)	256M8
– 128 Meg x 16 (16 Meg x 16 x 8 banks)	128M16
• FBGA package (Pb-free) – x16	
– 84-ball FBGA (11.5mm x 14mm) Rev. A	HG
• FBGA package (Pb-free) – x4, x8	
– 60-ball FBGA (11.5mm x 14mm) Rev. A	HG
• FBGA package (Pb-free) – x16	
– 84-ball FBGA (9mm x 12.5mm) Rev. C	RT
• FBGA package (Pb-free) – x4, x8	
– 60-ball FBGA (9mm x 11.5mm) Rev. C	EB
• FBGA package (Lead solder) – x16	
– 84-ball FBGA (9mm x 12.5mm) Rev. C	PK
• Timing – cycle time	
– 1.875ns @ CL = 7 (DDR2-1066)	-187E
– 2.5ns @ CL = 5 (DDR2-800)	-25E
– 2.5ns @ CL = 6 (DDR2-800)	-25
– 3.0ns @ CL = 5 (DDR2-667)	-3
• Self refresh	
– Standard	None
• Operating temperature	
– Commercial (0°C ≤ T_C ≤ +85°C)	None
– Industrial (–40°C ≤ T_C ≤ +95°C; –40°C ≤ T_A ≤ +85°C)	IT
• Revision	:A/:C

Note: 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.

Table 1: Key Timing Parameters

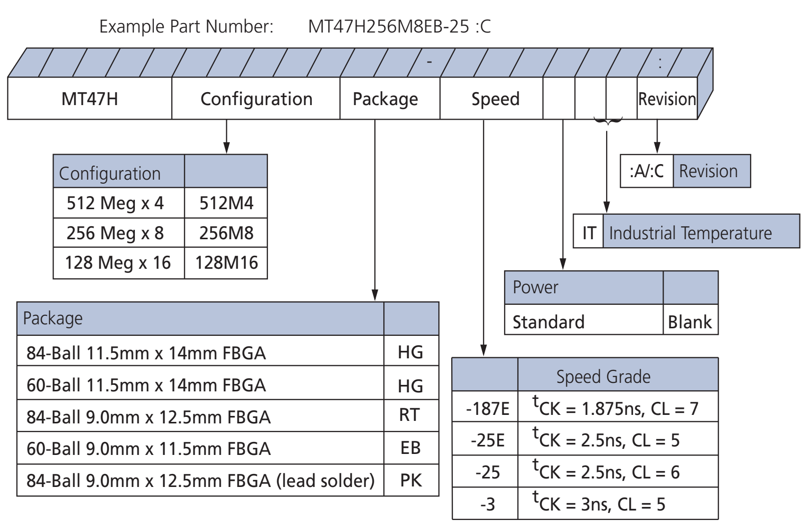
Speed Grade	Data Rate (MHz)					^tRC (ns)
	CL = 3	CL = 4	CL = 5	CL = 6	CL = 7	
-187E	400	533	800	800	1066	54
-25E	400	533	800	800	n/a	55
-25	400	533	667	800	n/a	55
-3	400	533	667	n/a	n/a	55

Table 2: Addressing

Parameter	512 Meg x 4	256 Meg x 8	128 Meg x 16
Configuration	64 Meg x 4 x 8 banks	32 Meg x 8 x 8 banks	16 Meg x 16 x 8 banks
Refresh count	8K	8K	8K
Row address	A[14:0] (32K)	A[14:0] (32K)	A[13:0] (16K)
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)

Part Numbers

Figure 1: 2Gb DDR2 Part Numbers



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

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.

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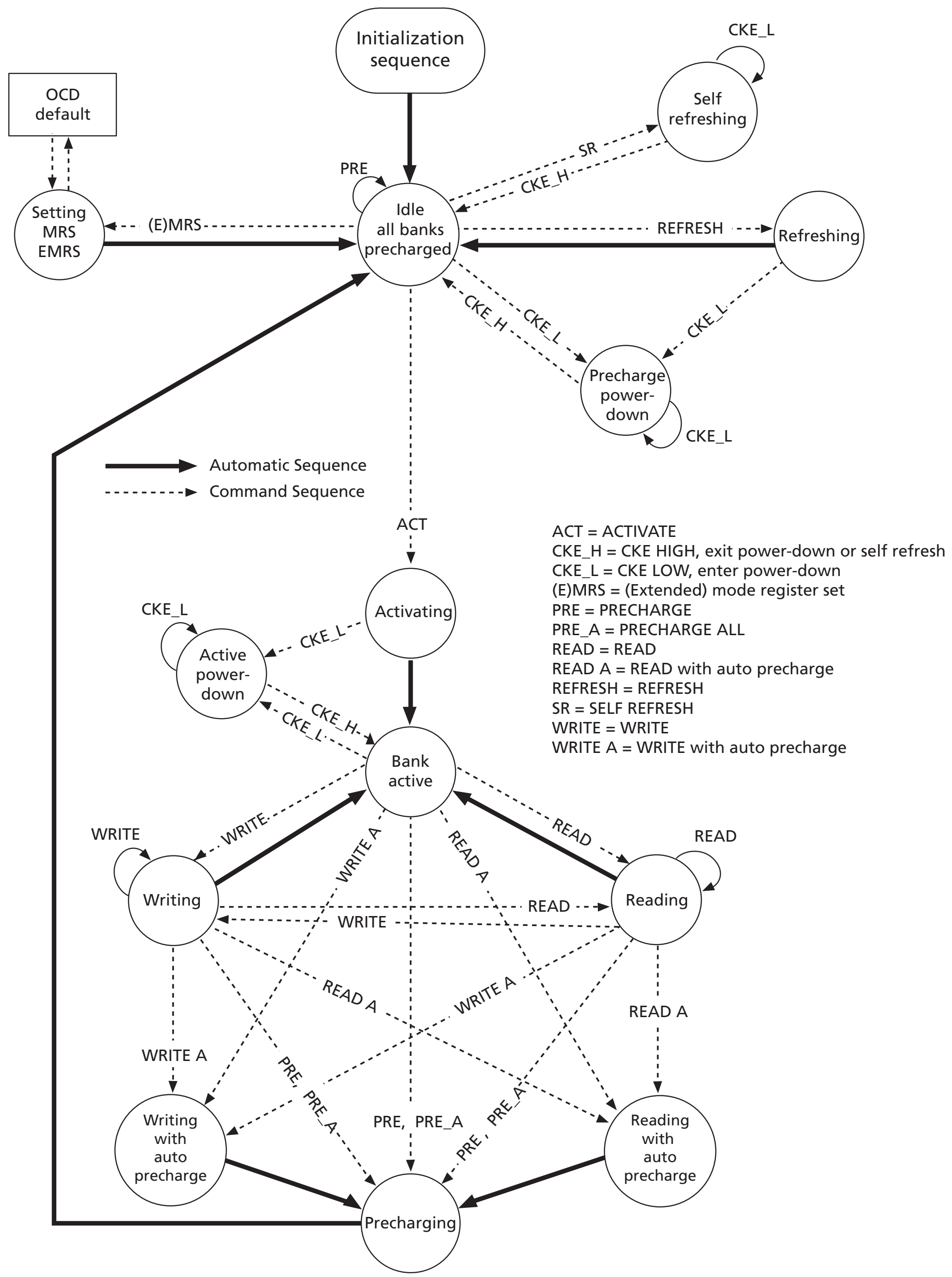
State Diagram

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 SSTL_18. All full drive-strength outputs are SSTL_18-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°C or > 85°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 1kΩ* resistor
  – Connect UDQS# to V_{DD} via 1kΩ* resistor
  – Connect UDM to V_{DD} via 1kΩ* resistor
  – Connect DQ[15:8] individually to either V_{SS} or V_{DD} via 1kΩ* resistors, or float DQ[15:8].

  *If ODT is used, 1kΩ 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: Functional Block Diagram – 512 Meg x 4

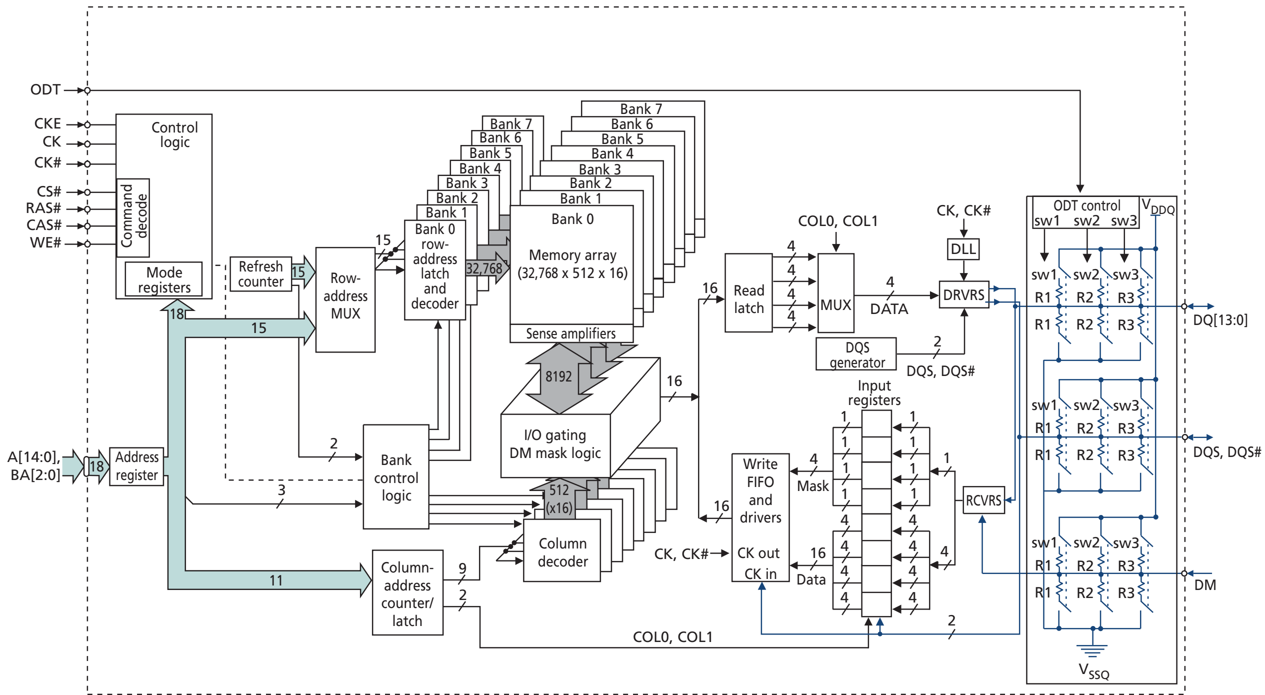


Figure 4: Functional Block Diagram – 256 Meg x 8

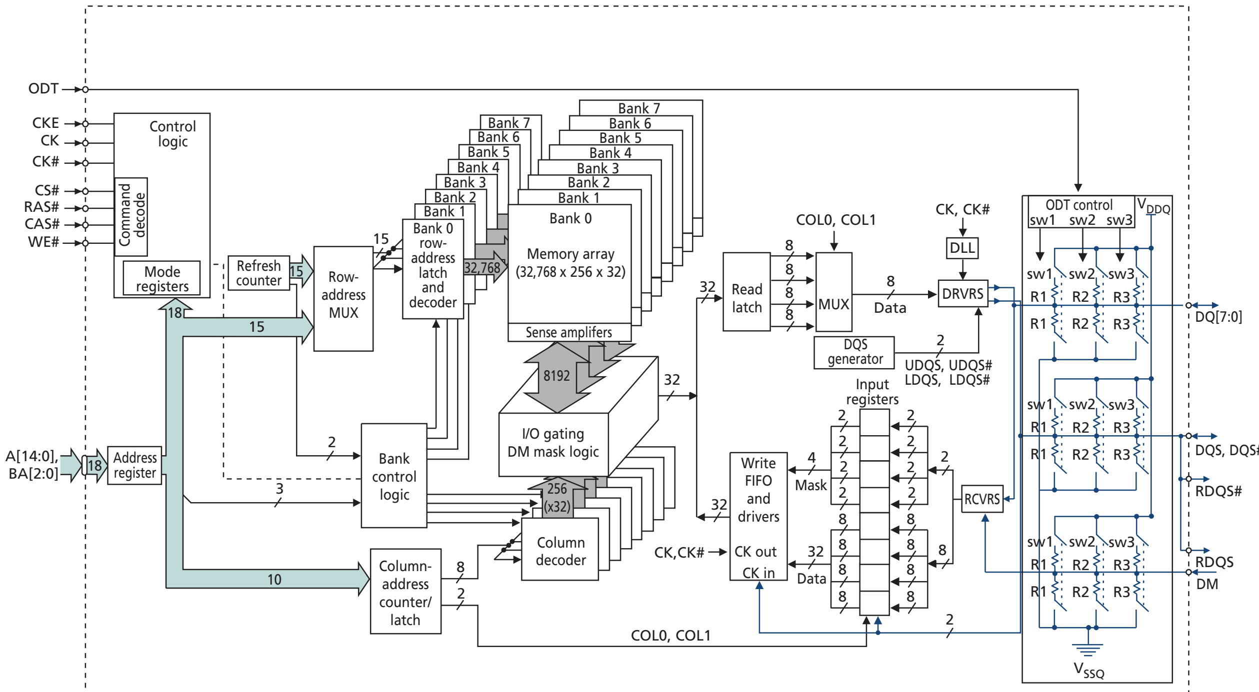
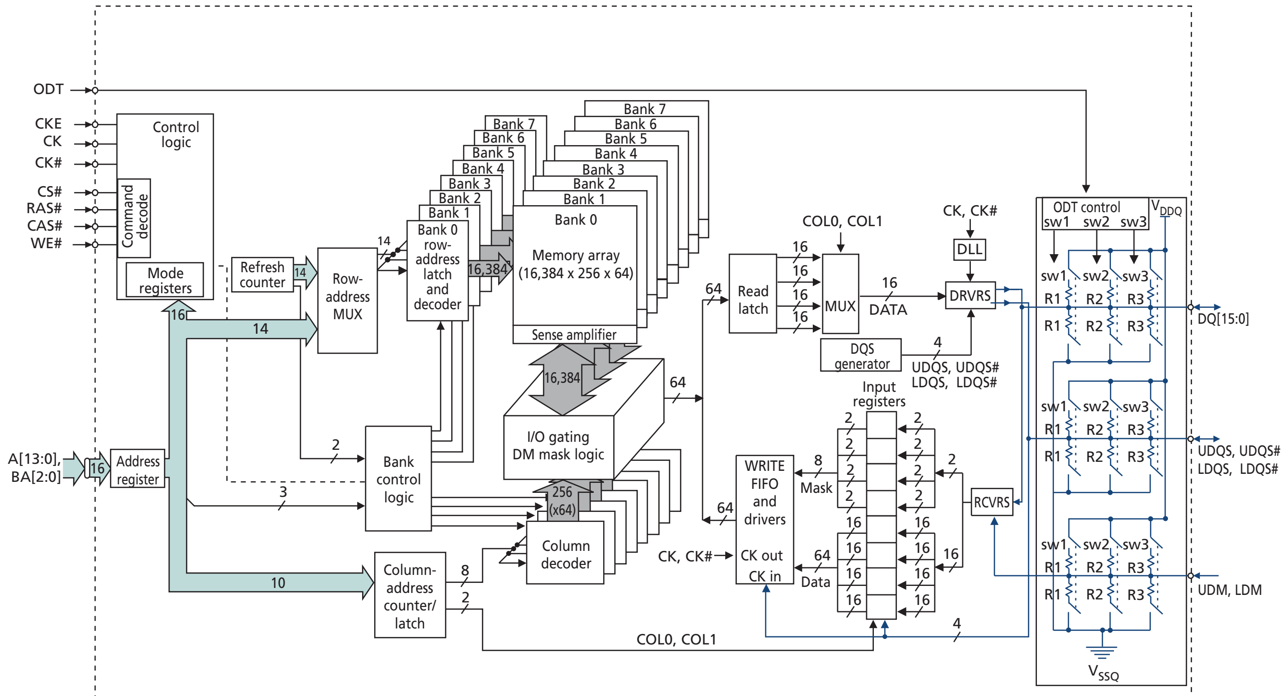


Figure 5: Functional Block Diagram – 128 Meg x 16



Ball Assignments and Descriptions

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

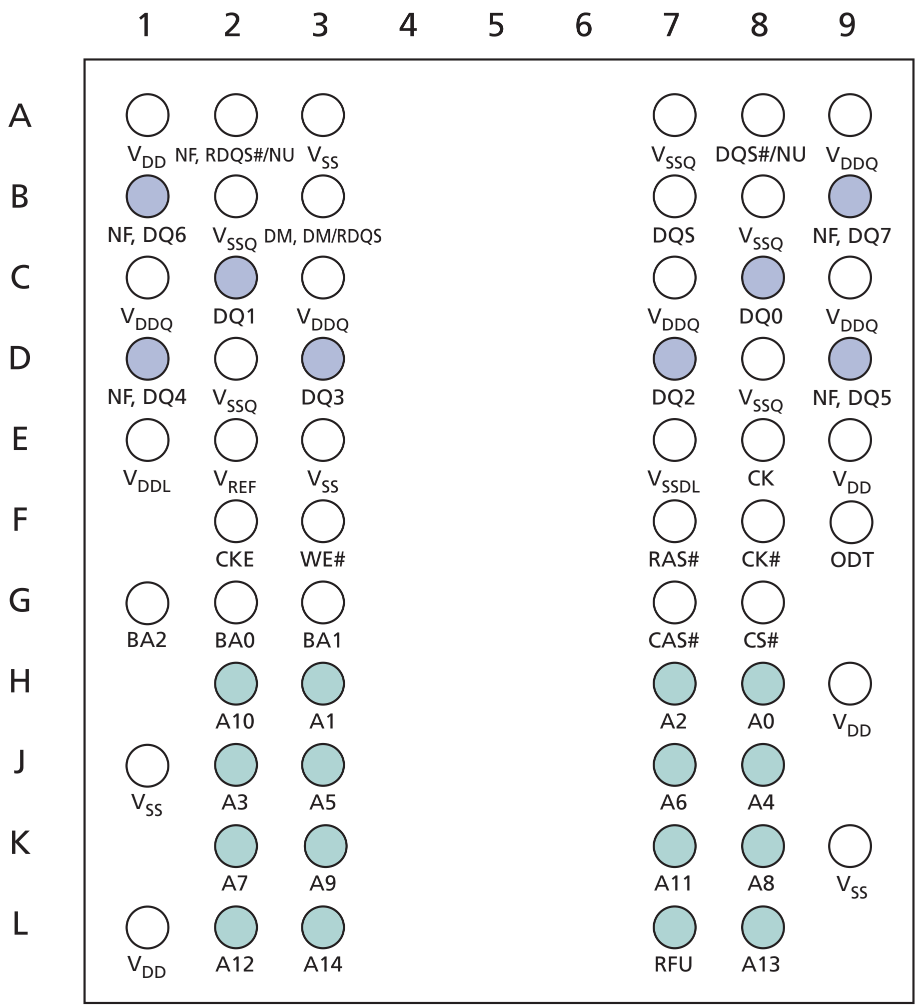


Figure 7: 84-Ball FBGA – x16 Ball Assignments (Top View)

	1	2	3	4	5	6	7	8	9
A	V_{DD}	NC	V_{SS}				V_{SSQ}	UDQS#/NU	V_{DDQ}
B	DQ14	V_{SSQ}	UDM				UDQS	V_{SSQ}	DQ15
C	V_{DDQ}	DQ9	V_{DDQ}				V_{DDQ}	DQ8	V_{DDQ}
D	DQ12	V_{SSQ}	DQ11				DQ10	V_{SSQ}	DQ13
E	V_{DD}	NC	V_{SS}				V_{SSQ}	LDQS#/NU	V_{DDQ}
F	DQ6	V_{SSQ}	LDM				LDQS	V_{SSQ}	DQ7
G	V_{DDQ}	DQ1	V_{DDQ}				V_{DDQ}	DQ0	V_{DDQ}
H	DQ4	V_{SSQ}	DQ3				DQ2	V_{SSQ}	DQ5
J	V_{DDL}	V_{REF}	V_{SS}				V_{SSDL}	CK	V_{DD}
K		CKE	WE#				RAS#	CK#	ODT
L	BA2	BA0	BA1				CAS#	CS#	
M		A10	A1				A2	A0	V_{DD}
N	V_{SS}	A3	A5				A6	A4	
P		A7	A9				A11	A8	V_{SS}
R	V_{DD}	A12	RFU				RFU	A13	

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

Symbol	Type	Description
A[13:0] (x16) A[14:0] (x4, x8)	Input	**Address inputs:** 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 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 ACTIVE, 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 operation (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 once 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 concurrently sampled HIGH 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 128 Meg x 16. Bidirectional data bus for 512 Meg x 4. Bidirectional data bus for 256 Meg x 8.

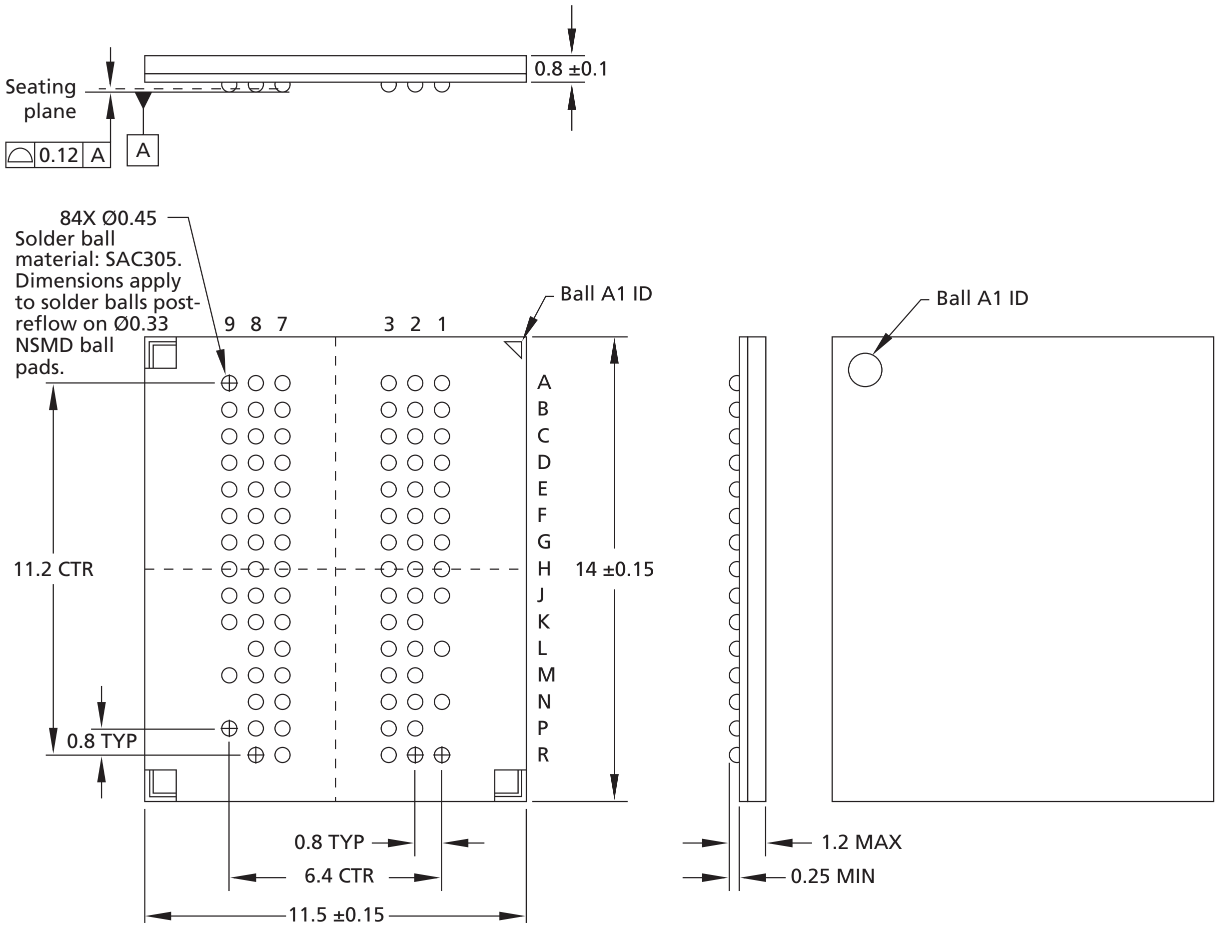
Table 3: FBGA 84-Ball – x16 and 60-Ball – x4, x8 Descriptions (Continued)

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 and 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_{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:** Not used only on x4. These are data lines on the x8.
NU	–	**Not used:** Not used only on x16. 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 x4: Not used. For x8: If EMR[E10] = 0, E2 and E8 are RDQS# and DQS#; if EMR[E10] = 1, then E2 and E8 are not used.
RFU	–	**Reserved for future use:** Row address bits A14 (R3), A15 (R7) on the x16, and A15 (L7) on the x4/x8.

Packaging

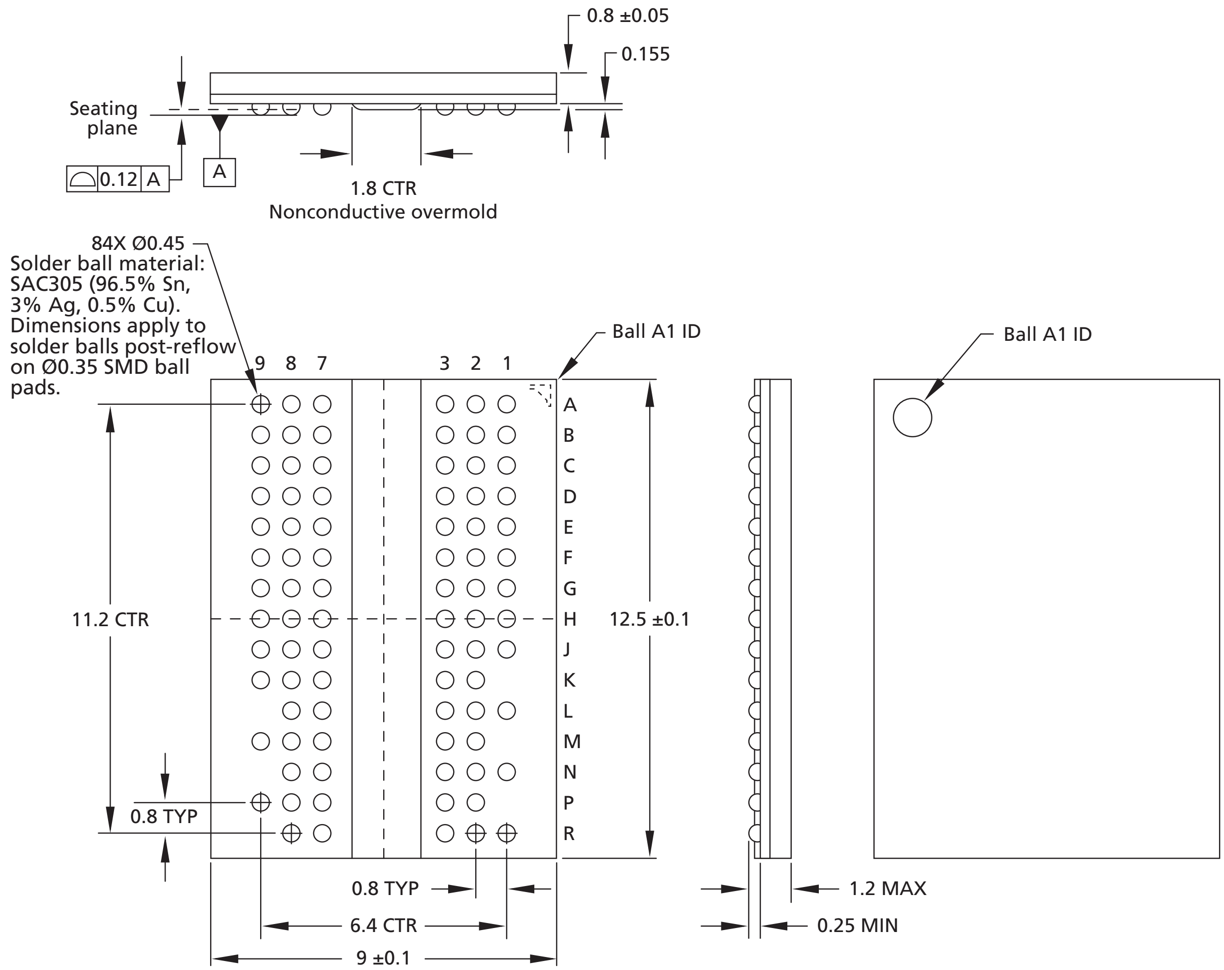
Package Dimensions

Figure 8: 84-Ball FBGA Package (11.5mm x 14mm) – x16



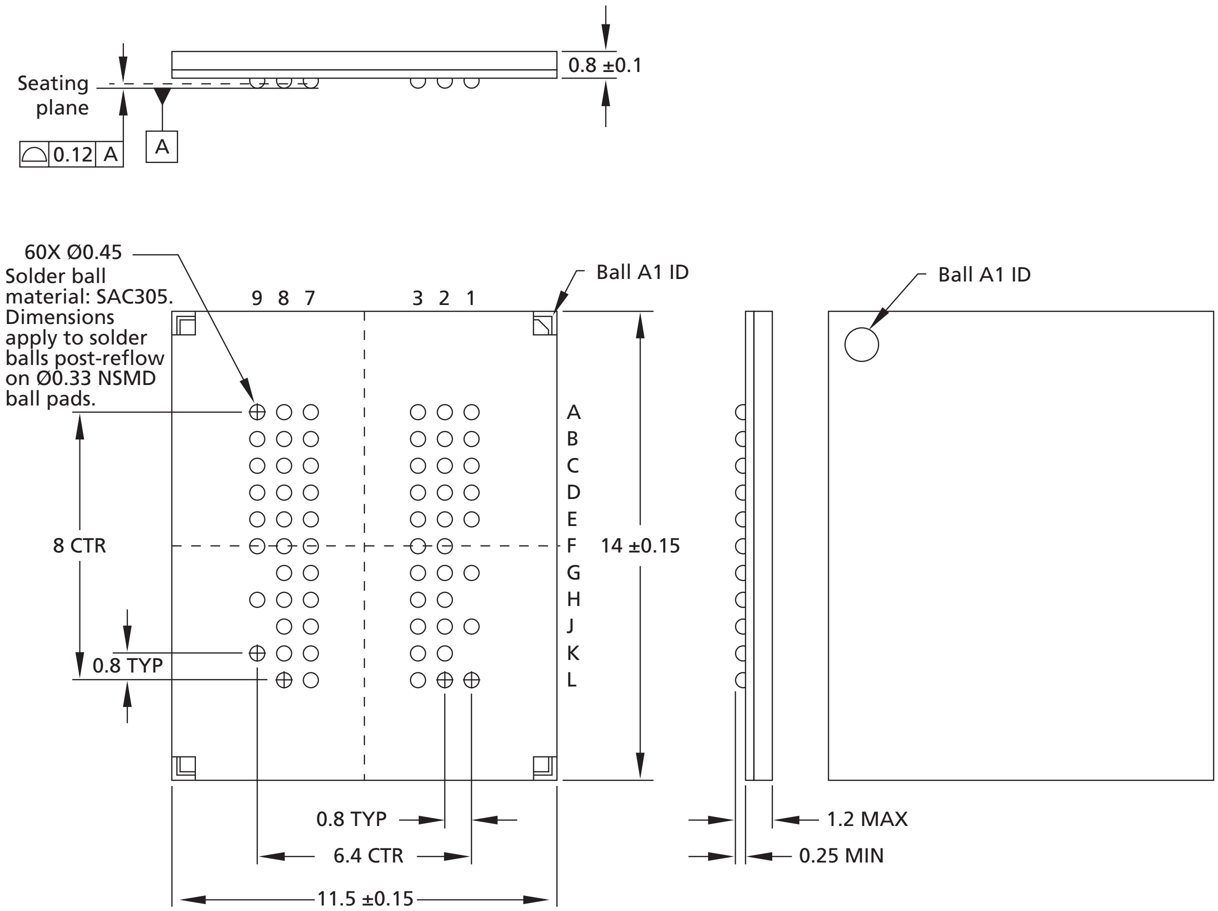
Notes:
1. All dimensions are in millimeters.
2. Solder ball material: SAC305 (96.5% Sn, 3% Ag, 0.5% Cu).

Figure 9: 84-Ball FBGA Package (9mm x 12.5mm) – x16



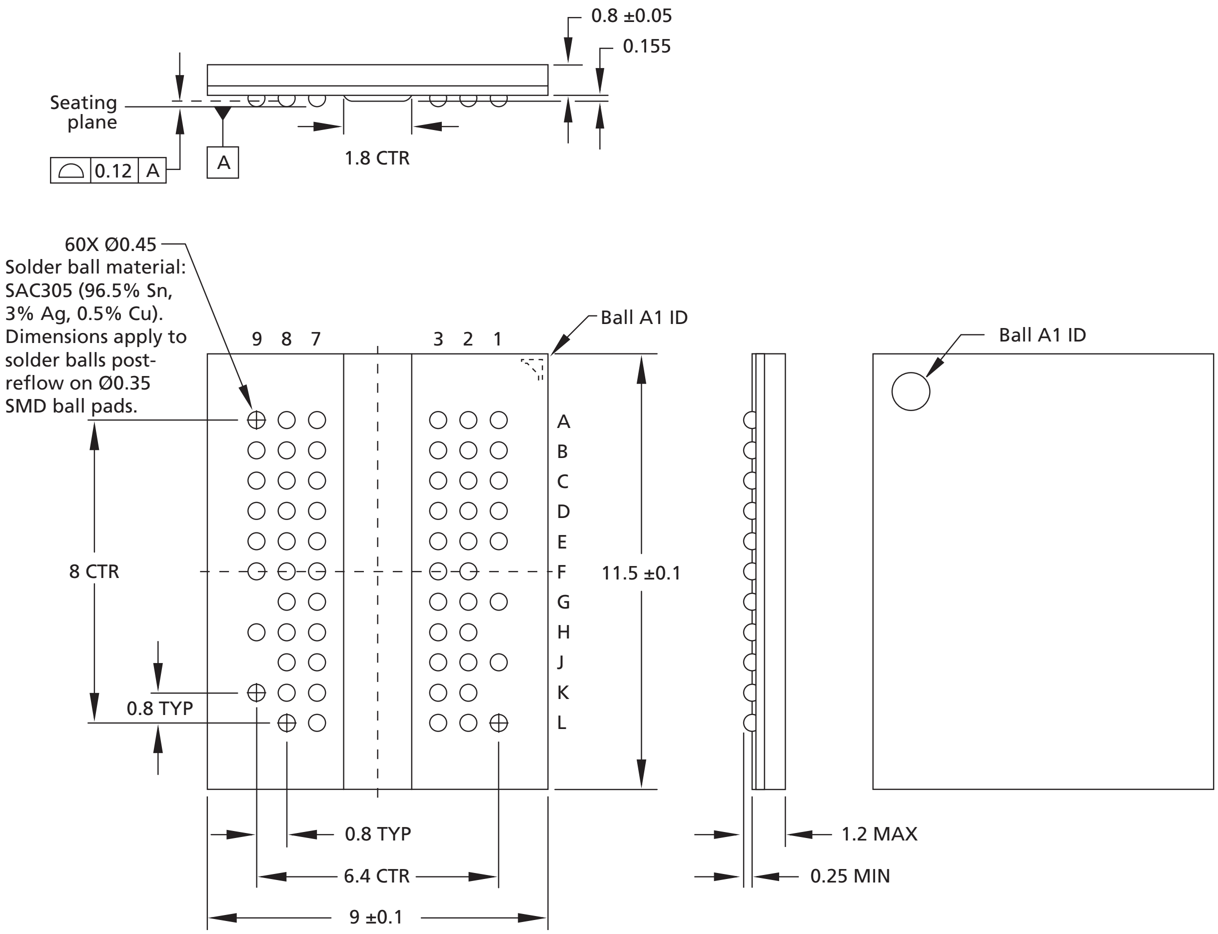
Notes: 1. All dimensions are in millimeters.
2. Solder ball material: SAC305 (96.5% Sn, 3% Ag, 0.5% Cu) or leaded Eutectic (62% Sn, 36%Pb, 2% Ag).

Figure 10: 60-Ball FBGA Package (11.5mm x 14mm) – x4, x8



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 Package (9mm x 11.5mm) – x4, x8



Note: 1. All dimensions are in millimeters.

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: BA[2:0], A[14:0] (A[13:0] on x16), CS#, RAS#, CAS#, WE#, CKE, ODT	C_I	1.0	2.0	pF	1
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, 4
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 ±0.1V, V_{DDQ} = 1.8V ±0.1V, V_{REF} = V_{SS}, f = 100 MHz, T_C = 25°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 -3/-3E 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 x 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 designs, consider using final target theta values, rather than existing values, to account for larger thermal impedances.

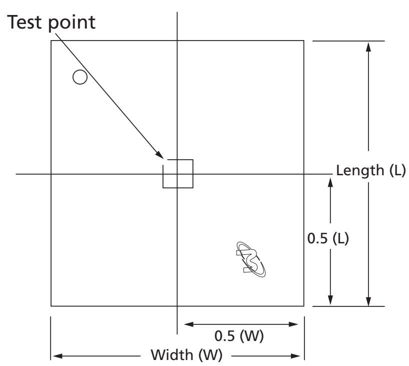
The DDR2 SDRAM device's safe junction temperature range can be maintained when the T_C specification is not exceeded. In applications where the device's ambient temperature is too high, use of forced air and/or heat sinks may be required in order to satisfy the case temperature specifications.

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_{AMB}	–40	85	°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



Lmm x Wmm FBGA

Table 7: Thermal Impedance

Die Rev	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)
A[1]	60-ball	2-layer	48.0	34.4	29.3	21.6	1.6
		4-layer	33.7	26.7	23.8	19.7	
	84-ball	2-layer	48.0	34.4	29.3	21.6	1.6
		4-layer	33.7	26.7	23.8	19.7	
C[1]	60-ball	2-layer	63.8	46.9	40.8	29.9	4.3
		4-layer	46.9	38.1	34.4	29.2	
	84-ball	2-layer	60.0	43.5	37.9	26.0	4.1
		4-layer	43.2	34.7	31.5	25.5	

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