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# RLDRAM 3

**MT44K32M18 – 2 Meg x 18 x 16 Banks**

**MT44K16M36 – 1 Meg x 36 x 16 Banks**

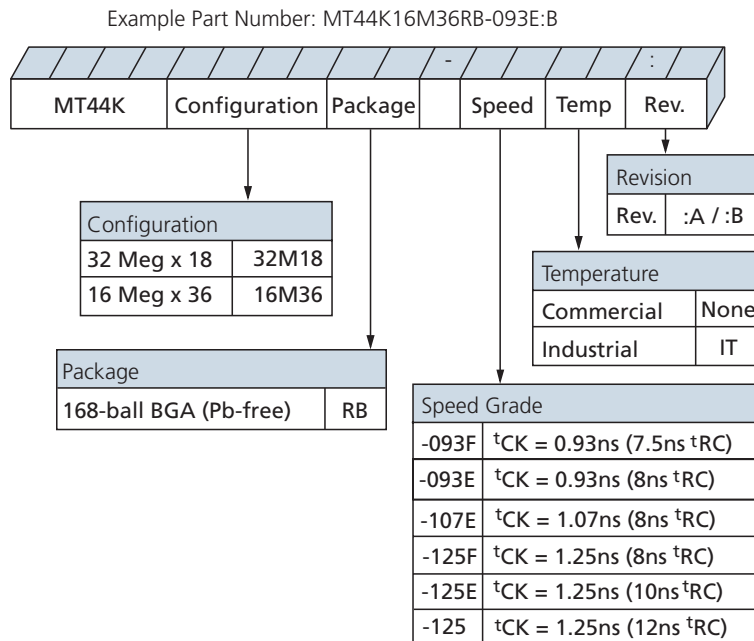
## Features

- 1066 MHz DDR operation (2133 Mb/s/ball data rate)
- 76.8 Gb/s peak bandwidth (x36 at 1066 MHz clock frequency)
- Organization
  - 32 Meg x 18, and 16 Meg x 36 common I/O (CIO)
  - 16 banks
- 1.2V center-terminated push/pull I/O
- 2.5V<sub>V<sub>EXT</sub></sub>, 1.35V<sub>V<sub>DD</sub></sub>, 1.2V<sub>V<sub>DDQ</sub></sub> I/O
- Reduced cycle time (<sup>t</sup>RC (MIN) = 7.5 - 12ns)
- SDR addressing
- Programmable READ/WRITE latency (RL/WL) and burst length
- Data mask for WRITE commands
- Differential input clocks (CK, CK#)
- Free-running differential input data clocks (DKx, DKx#) and output data clocks (QKx, QKx#)
- On-die DLL generates CK edge-aligned data and differential output data clock signals
- 64ms refresh (128K refresh per 64ms)
- 168-ball BGA package
- 40Ω or 60Ω matched impedance outputs
- Integrated on-die termination (ODT)
- Single or multibank writes
- Extended operating range (200–1066 MHz)
- READ training register
- Multiplexed and non-multiplexed addressing capabilities
- Mirror function
- Output driver and ODT calibration
- JTAG interface (IEEE 1149.1-2001)

## Options<sup>1</sup>

- Clock cycle and <sup>t</sup>RC timing
  - 0.93ns and <sup>t</sup>RC (MIN) = 7.5ns (RL3-2133) -093F
  - 0.93ns and <sup>t</sup>RC (MIN) = 8ns (RL3-2133) -093E
  - 1.07ns and <sup>t</sup>RC (MIN) = 8ns (RL3-1866) -107E
  - 1.25ns and <sup>t</sup>RC (MIN) = 8ns (RL3-1600) -125F
  - 1.25ns and <sup>t</sup>RC (MIN) = 10ns (RL3-1600) -125E
  - 1.25ns and <sup>t</sup>RC (MIN) = 12ns (RL3-1600) -125
- Configuration
  - 32 Meg x 18 32M18
  - 16 Meg x 36 16M36
- Operating temperature
  - Commercial (T<sub>C</sub> = 0° to +95°C) None
  - Industrial (T<sub>C</sub> = -40°C to +95°C) IT
- Package
  - 168-ball BGA (Pb-free) RB
- Revision :A / :B

Note: 1. Not all options listed can be combined to define an offered product. Use the part catalog search on [www.micron.com](http://www.micron.com) for available offerings.

**Figure 1: 576Mb RLD RAM® 3 Part Numbers**


### BGA Part Marking Decoder

Due to space limitations, BGA-packaged components have an abbreviated part marking that is different from the part number. Micron's BGA Part Marking Decoder is available on Micron's Web site at [www.micron.com](http://www.micron.com).

## Contents

General Description .....	9
General Notes .....	9
State Diagram .....	10
Functional Block Diagrams .....	11
Ball Assignments and Descriptions .....	13
Package Dimensions .....	17
Electrical Characteristics – I <sub>DD</sub> Specifications .....	18
Electrical Specifications – Absolute Ratings and I/O Capacitance .....	25
Absolute Maximum Ratings .....	25
Input/Output Capacitance .....	25
AC and DC Operating Conditions .....	26
AC Overshoot/Undershoot Specifications .....	27
Slew Rate Definitions for Single-Ended Input Signals .....	31
Slew Rate Definitions for Differential Input Signals .....	32
ODT Characteristics .....	34
ODT Resistors .....	35
ODT Sensitivity .....	36
Output Driver Impedance .....	36
Output Driver Sensitivity .....	37
Output Characteristics and Operating Conditions .....	39
Reference Output Load .....	42
Slew Rate Definitions for Single-Ended Output Signals .....	43
Slew Rate Definitions for Differential Output Signals .....	44
Speed Bin Tables .....	45
AC Electrical Characteristics .....	47
Temperature and Thermal Impedance Characteristics .....	53
Command and Address Setup, Hold, and Derating .....	55
Data Setup, Hold, and Derating .....	62
Commands .....	69
MODE REGISTER SET (MRS) Command .....	70
Mode Register 0 (MR0) .....	71
t <sub>RC</sub> .....	71
Data Latency .....	72
DLL Enable/Disable .....	72
Address Multiplexing .....	72
Mode Register 1 (MR1) .....	73
Output Drive Impedance .....	73
DQ On-Die Termination (ODT) .....	73
DLL Reset .....	73
ZQ Calibration .....	74
ZQ Calibration Long .....	75
ZQ Calibration Short .....	75
AUTO REFRESH Protocol .....	76
Burst Length (BL) .....	76
Mode Register 2 (MR2) .....	78
READ Training Register (RTR) .....	78
WRITE Protocol .....	80
WRITE Command .....	80
Multibank WRITE .....	81
READ Command .....	81



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AUTO REFRESH Command .....	83
INITIALIZATION Operation .....	85
WRITE Operation .....	87
READ Operation .....	91
AUTO REFRESH Operation .....	94
RESET Operation .....	97
Clock Stop .....	97
Mirror Function .....	99
Multiplexed Address Mode .....	100
Data Latency in Multiplexed Address Mode .....	105
REFRESH Command in Multiplexed Address Mode .....	105
IEEE 1149.1 Serial Boundary Scan (JTAG) .....	109
Disabling the JTAG Feature .....	109
Test Access Port (TAP) .....	109
TAP Controller .....	110
Performing a TAP RESET .....	112
TAP Registers .....	112
TAP Instruction Set .....	113

## List of Figures

Figure 1: 576Mb RLD RAM <sup>®</sup> 3 Part Numbers .....	2
Figure 2: Simplified State Diagram .....	10
Figure 3: 32 Meg x 18 Functional Block Diagram .....	11
Figure 4: 16 Meg x 36 Functional Block Diagram .....	12
Figure 5: 168-Ball BGA .....	17
Figure 6: Single-Ended Input Signal .....	27
Figure 7: Overshoot .....	28
Figure 8: Undershoot .....	28
Figure 9: $V_{IX}$ for Differential Signals .....	29
Figure 10: Single-Ended Requirements for Differential Signals .....	30
Figure 11: Definition of Differential AC Swing and $t_{DVAC}$ .....	30
Figure 12: Nominal Slew Rate Definition for Single-Ended Input Signals .....	32
Figure 13: Nominal Differential Input Slew Rate Definition for CK, CK#, DKx, and DKx# .....	33
Figure 14: ODT Levels and I-V Characteristics .....	34
Figure 15: Output Driver .....	37
Figure 16: DQ Output Signal .....	41
Figure 17: Differential Output Signal .....	42
Figure 18: Reference Output Load for AC Timing and Output Slew Rate .....	42
Figure 19: Nominal Slew Rate Definition for Single-Ended Output Signals .....	43
Figure 20: Nominal Differential Output Slew Rate Definition for QKx, QKx# .....	44
Figure 21: Example Temperature Test Point Location .....	54
Figure 22: Nominal Slew Rate and $t_{VAC}$ for $t_{IS}$ (Command and Address - Clock) .....	58
Figure 23: Nominal Slew Rate for $t_{IH}$ (Command and Address - Clock) .....	59
Figure 24: Tangent Line for $t_{IS}$ (Command and Address - Clock) .....	60
Figure 25: Tangent Line for $t_{IH}$ (Command and Address - Clock) .....	61
Figure 26: Nominal Slew Rate and $t_{VAC}$ for $t_{DS}$ (DQ - Strobe) .....	65
Figure 27: Nominal Slew Rate for $t_{DH}$ (DQ - Strobe) .....	66
Figure 28: Tangent Line for $t_{DS}$ (DQ - Strobe) .....	67
Figure 29: Tangent Line for $t_{DH}$ (DQ - Strobe) .....	68
Figure 30: MRS Command Protocol .....	70
Figure 31: MR0 Definition for Non-Multiplexed Address Mode .....	71
Figure 32: MR1 Definition for Non-Multiplexed Address Mode .....	73
Figure 33: ZQ Calibration Timing (ZQCL and ZQCS) .....	75
Figure 34: Read Burst Lengths .....	77
Figure 35: MR2 Definition for Non-Multiplexed Address Mode .....	78
Figure 36: READ Training Function - Back-to-Back Readout .....	79
Figure 37: WRITE Command .....	80
Figure 38: READ Command .....	82
Figure 39: Bank Address-Controlled AUTO REFRESH Command .....	83
Figure 40: Multibank AUTO REFRESH Command .....	84
Figure 41: Power-Up/Initialization Sequence .....	86
Figure 42: WRITE Burst .....	87
Figure 43: Consecutive WRITE Bursts .....	88
Figure 44: WRITE-to-READ .....	88
Figure 45: WRITE - DM Operation .....	89
Figure 46: Consecutive Quad Bank WRITE Bursts .....	89
Figure 47: Interleaved READ and Quad Bank WRITE Bursts .....	90
Figure 48: Basic READ Burst .....	91
Figure 49: Consecutive READ Bursts (BL = 2) .....	92
Figure 50: Consecutive READ Bursts (BL = 4) .....	92

Figure 51: READ-to-WRITE (BL = 2) .....	93
Figure 52: Read Data Valid Window .....	93
Figure 53: Bank Address-Controlled AUTO REFRESH Cycle .....	94
Figure 54: Multibank AUTO REFRESH Cycle .....	94
Figure 55: READ Burst with ODT .....	95
Figure 56: READ-NOP-READ with ODT .....	96
Figure 57: RESET Sequence .....	97
Figure 58: Command Description in Multiplexed Address Mode .....	100
Figure 59: Power-Up/Initialization Sequence in Multiplexed Address Mode .....	101
Figure 60: MR0 Definition for Multiplexed Address Mode .....	102
Figure 61: MR1 Definition for Multiplexed Address Mode .....	103
Figure 62: MR2 Definition for Multiplexed Address Mode .....	104
Figure 63: Bank Address-Controlled AUTO REFRESH Operation with Multiplexed Addressing .....	105
Figure 64: Multibank AUTO REFRESH Operation with Multiplexed Addressing .....	105
Figure 65: Consecutive WRITE Bursts with Multiplexed Addressing .....	106
Figure 66: WRITE-to-READ with Multiplexed Addressing .....	107
Figure 67: Consecutive READ Bursts with Multiplexed Addressing .....	107
Figure 68: READ-to-WRITE with Multiplexed Addressing .....	108
Figure 69: TAP Controller State Diagram .....	111
Figure 70: TAP Controller Functional Block Diagram .....	111
Figure 71: JTAG Operation - Loading Instruction Code and Shifting Out Data .....	114
Figure 72: TAP Timing .....	115

## List of Tables

Table 1: 32 Meg x 18 Ball Assignments – 168-Ball BGA (Top View) .....	13
Table 2: 16 Meg x 36 Ball Assignments – 168-Ball BGA (Top View) .....	14
Table 3: Ball Descriptions .....	15
Table 4: I <sub>DD</sub> Operating Conditions and Maximum Limits (Die Rev :A) .....	18
Table 5: I <sub>DD</sub> Operating Conditions and Maximum Limits (Die Rev :B) .....	22
Table 6: Absolute Maximum Ratings .....	25
Table 7: Input/Output Capacitance .....	25
Table 8: DC Electrical Characteristics and Operating Conditions .....	26
Table 9: Input AC Logic Levels .....	26
Table 10: Control and Address Balls .....	27
Table 11: Clock, Data, Strobe, and Mask Balls .....	28
Table 12: Differential Input Operating Conditions (CK, CK# and DKx, DKx#) .....	29
Table 13: Allowed Time Before Ringback ( <sup>t</sup> DVAC) for CK, CK#, DKx, and DKx# .....	31
Table 14: Single-Ended Input Slew Rate Definition .....	31
Table 15: Differential Input Slew Rate Definition .....	33
Table 16: ODT DC Electrical Characteristics .....	34
Table 17: R <sub>TT</sub> Effective Impedances .....	35
Table 18: ODT Sensitivity Definition .....	36
Table 19: ODT Temperature and Voltage Sensitivity .....	36
Table 20: Driver Pull-Up and Pull-Down Impedance Calculations .....	37
Table 21: Output Driver Sensitivity Definition .....	38
Table 22: Output Driver Voltage and Temperature Sensitivity .....	38
Table 23: Single-Ended Output Driver Characteristics .....	39
Table 24: Differential Output Driver Characteristics .....	40
Table 25: Single-Ended Output Slew Rate Definition .....	43
Table 26: Differential Output Slew Rate Definition .....	44
Table 27: RL3 2133/1866 Speed Bins .....	45
Table 28: RL3 1600 Speed Bins .....	46
Table 29: AC Electrical Characteristics .....	47
Table 30: Temperature Limits .....	53
Table 31: Thermal Impedance .....	53
Table 32: Command and Address Setup and Hold Values Referenced at 1 V/ns – AC/DC-Based .....	55
Table 33: Derating Values for <sup>t</sup> IS/ <sup>t</sup> IH – AC150/DC100-Based .....	56
Table 34: Derating Values for <sup>t</sup> IS/ <sup>t</sup> IH – AC120/DC100-Based .....	57
Table 35: Minimum Required Time <sup>t</sup> VAC Above V <sub>IH(AC)</sub> (or Below V <sub>IL(AC)</sub> ) for Valid Transition .....	57
Table 36: Data Setup and Hold Values at 1 V/ns (DKx, DKx# at 2V/ns) – AC/DC-Based .....	62
Table 37: Derating Values for <sup>t</sup> DS/ <sup>t</sup> DH – AC150/DC100-Based .....	63
Table 38: Derating Values for <sup>t</sup> DS/ <sup>t</sup> DH – AC120/DC100-Based .....	64
Table 39: Minimum Required Time <sup>t</sup> VAC Above V <sub>IH(AC)</sub> (or Below V <sub>IL(AC)</sub> ) for Valid Transition .....	64
Table 40: Command Descriptions .....	69
Table 41: Command Table .....	69
Table 42: <sup>t</sup> RC_MRS Values .....	71
Table 43: Address Widths of Different Burst Lengths .....	76
Table 44: 32 Meg x 18 Ball Assignments with MF Ball Tied HIGH .....	99
Table 45: Address Mapping in Multiplexed Address Mode .....	104
Table 46: TAP Input AC Logic Levels .....	115
Table 47: TAP AC Electrical Characteristics .....	115
Table 48: TAP DC Electrical Characteristics and Operating Conditions .....	116
Table 49: Identification Register Definitions .....	116
Table 50: Scan Register Sizes .....	117





Table 51: Instruction Codes ..... 117  
Table 52: Boundary Scan (Exit), Die Rev. A ..... 117  
Table 53: Boundary Scan (Exit), Die Rev. B ..... 119

## General Description

The Micron® RLD RAM® 3 is a high-speed memory device designed for high-bandwidth data storage—telecommunications, networking, cache applications, and so forth. The chip's 16-bank architecture is optimized for sustainable high-speed operation.

The DDR I/O interface transfers two data bits per clock cycle at the I/O balls. Output data is referenced to the READ strobes.

Commands, addresses, and control signals are also registered at every positive edge of the differential input clock, while input data is registered at both positive and negative edges of the input data strobes.

Read and write accesses to the RL3 device are burst-oriented. The burst length (BL) is programmable to 2, 4, or 8 by a setting in the mode register.

The device is supplied with 1.35V for the core and 1.2V for the output drivers. The 2.5V supply is used for an internal supply.

Bank-scheduled refresh is supported with the row address generated internally.

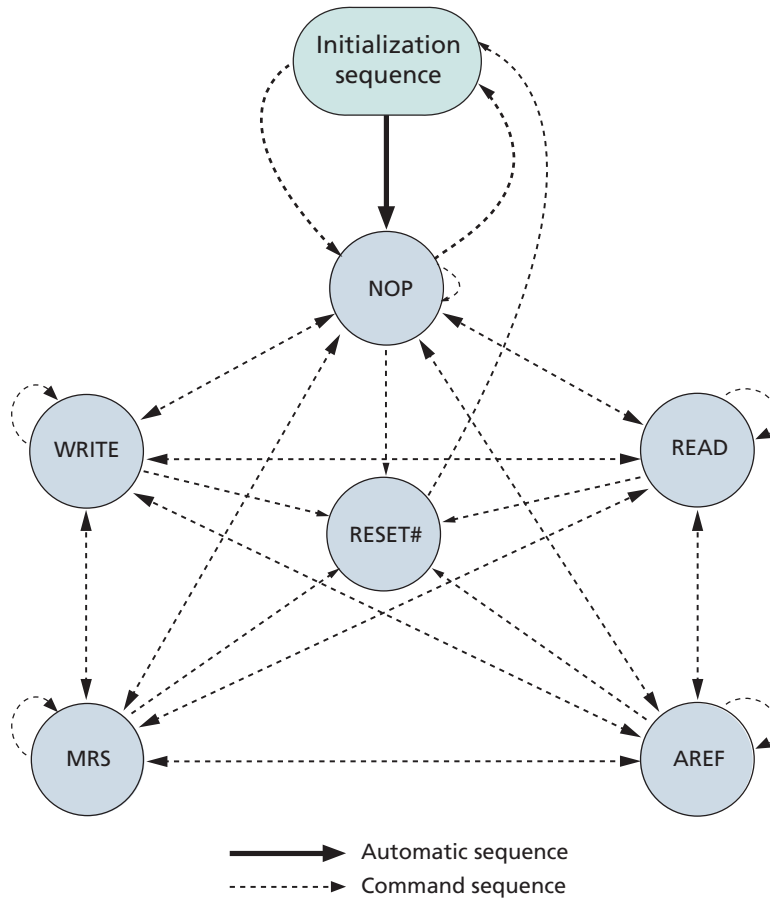
The 168-ball BGA package is used to enable ultra-high-speed data transfer rates.

## General Notes

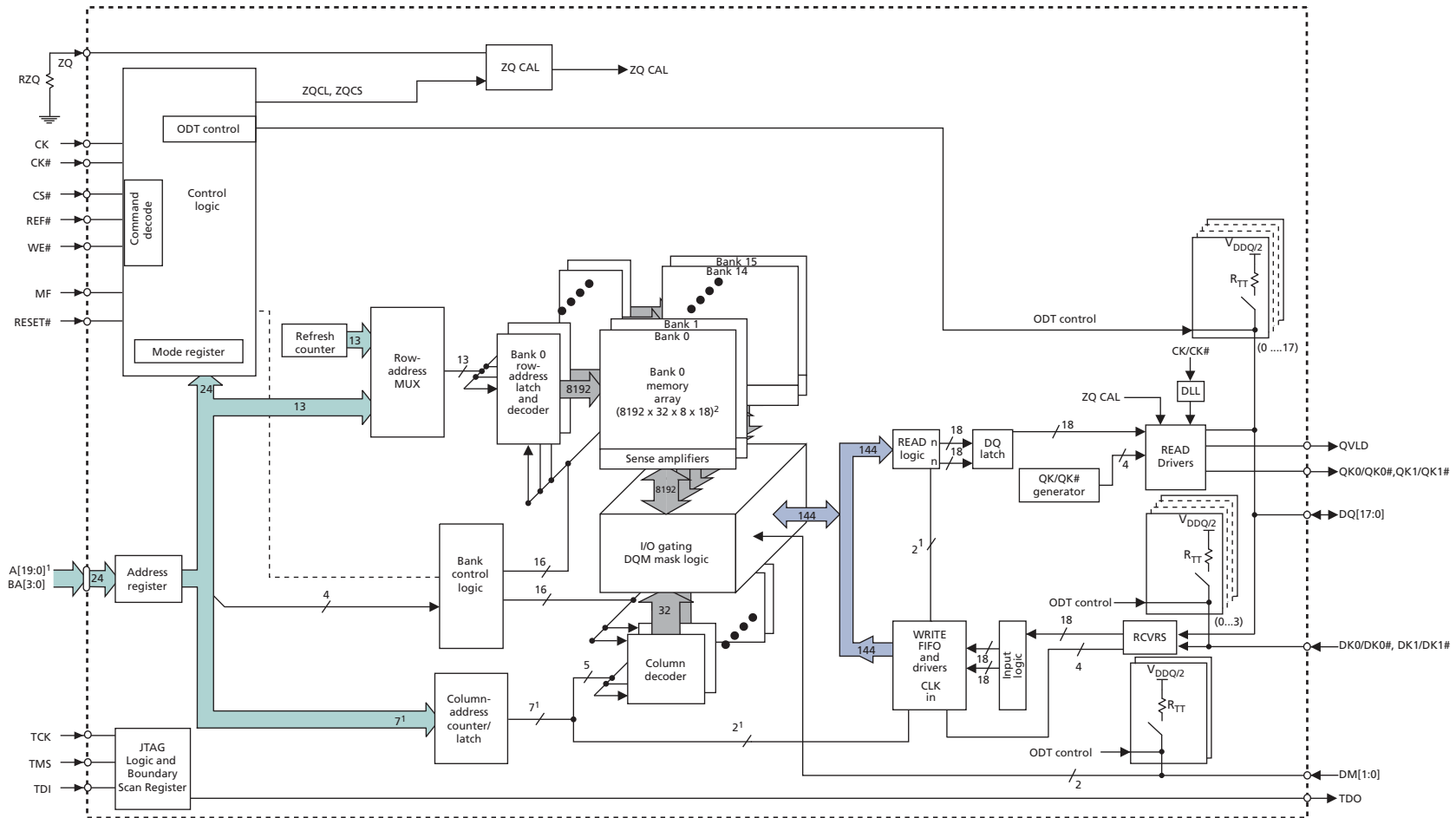
- The functionality and the timing specifications discussed in this data sheet are for the DLL enable mode of operation.
- Any functionality not specifically stated is considered undefined, illegal, and not supported, and can result in unknown operation.
- Nominal conditions are assumed for specifications not defined within the figures shown in this data sheet.
- Throughout this data sheet, the terms "RLDRAM," "DRAM," and "RLDRAM 3" are all used interchangeably and refer to the RLD RAM 3 SDRAM device.
- References to DQ, DK, QK, DM, and QVLD are to be interpreted as each group collectively, unless specifically stated otherwise. This includes true and complement signals of differential signals.
- Non-multiplexed operation is assumed if not specified as multiplexed.
- A x36 device supplies four QK/QK# sets, one per nine DQ. Using only two QK/QK# sets is allowed, but QK0/QK0# and QK1/QK1# must be used. QK0/QK0# control DQ[8:0] and DQ[26:18], and QK1/QK1# control DQ[17:9] and DQ[35:27]. The QK to DQ timing parameter to be used is <sup>t</sup>QKQ02, <sup>t</sup>QKQ13. The unused QK/QK# pins should be left floating.

## State Diagram

Figure 2: Simplified State Diagram

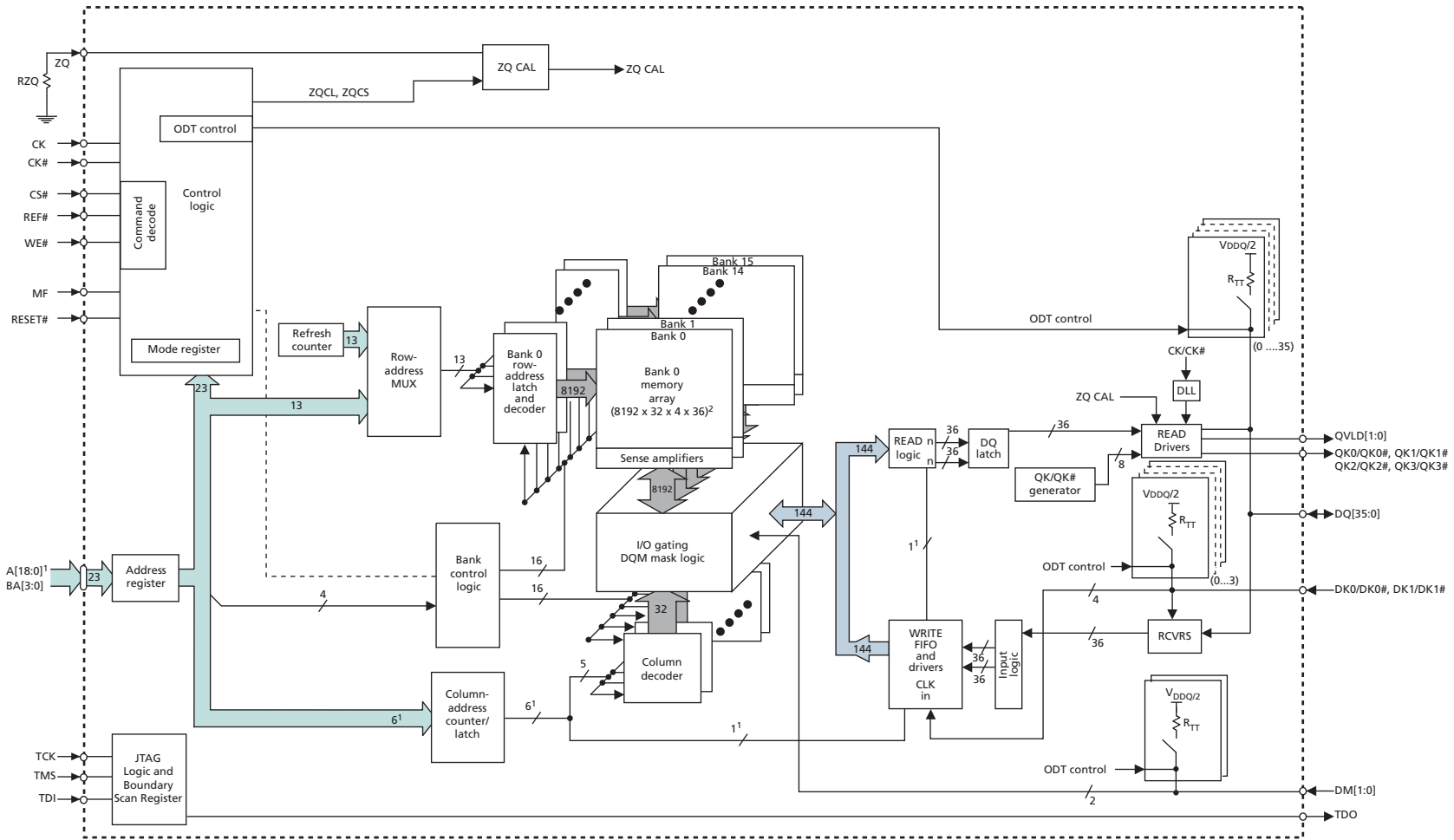


# Functional Block Diagrams

**Figure 3: 32 Meg x 18 Functional Block Diagram**


- Notes:
1. Example for BL = 2; column address will be reduced with an increase in burst length.
  2.  $8 = (\text{length of burst}) \times 2^{\wedge} (\text{number of column addresses to WRITE FIFO and READ logic})$ .

# Functional Block Diagrams

**Figure 4: 16 Meg x 36 Functional Block Diagram**


- Notes:
1. Example for BL = 2; column address will be reduced with an increase in burst length.
  2.  $4 = (\text{length of burst}) \times 2^{\wedge} (\text{number of column addresses to WRITE FIFO and READ logic})$ .

## Ball Assignments and Descriptions

**Table 1: 32 Meg x 18 Ball Assignments – 168-Ball BGA (Top View)**

	1	2	3	4	5	6	7	8	9	10	11	12	13
<b>A</b>		V <sub>SS</sub>	V <sub>DD</sub>	NF	V <sub>DDQ</sub>	NF	V <sub>REF</sub>	DQ7	V <sub>DDQ</sub>	DQ8	V <sub>DD</sub>	V <sub>SS</sub>	RESET#
<b>B</b>	V <sub>EXT</sub>	V <sub>SS</sub>	NF	V <sub>SSQ</sub>	NF	V <sub>DDQ</sub>	DM0	V <sub>DDQ</sub>	DQ5	V <sub>SSQ</sub>	DQ6	V <sub>SS</sub>	V <sub>EXT</sub>
<b>C</b>	V <sub>DD</sub>	NF	V <sub>DDQ</sub>	NF	V <sub>SSQ</sub>	NF	DK0#	DQ2	V <sub>SSQ</sub>	DQ3	V <sub>DDQ</sub>	DQ4	V <sub>DD</sub>
<b>D</b>	A11	V <sub>SSQ</sub>	NF	V <sub>DDQ</sub>	NF	V <sub>SSQ</sub>	DK0	V <sub>SSQ</sub>	QK0	V <sub>DDQ</sub>	DQ0	V <sub>SSQ</sub>	A13
<b>E</b>	V <sub>SS</sub>	A0	V <sub>SSQ</sub>	NF	V <sub>DDQ</sub>	NF	MF	QK0#	V <sub>DDQ</sub>	DQ1	V <sub>SSQ</sub>	CS#	V <sub>SS</sub>
<b>F</b>	A7	NF <sub>(CS1/A20)</sub> <sup>1</sup>	V <sub>DD</sub>	A2	A1	WE#	ZQ	REF#	A3	A4	V <sub>DD</sub>	A5	A9
<b>G</b>	V <sub>SS</sub>	A15	A6	V <sub>SS</sub>	BA1	V <sub>SS</sub>	CK#	V <sub>SS</sub>	BA0	V <sub>SS</sub>	A8	A18	V <sub>SS</sub> (RFU) <sup>2</sup>
<b>H</b>	A19	V <sub>DD</sub>	A14	A16	V <sub>DD</sub>	BA3	CK	BA2	V <sub>DD</sub>	A17	A12	V <sub>DD</sub>	A10
<b>J</b>	V <sub>DDQ</sub>	NF	V <sub>SSQ</sub>	NF	V <sub>DDQ</sub>	NF	V <sub>SS</sub>	QK1#	V <sub>DDQ</sub>	DQ9	V <sub>SSQ</sub>	QVLD	V <sub>DDQ</sub>
<b>K</b>	NF	V <sub>SSQ</sub>	NF	V <sub>DDQ</sub>	NF	V <sub>SSQ</sub>	DK1	V <sub>SSQ</sub>	QK1	V <sub>DDQ</sub>	DQ10	V <sub>SSQ</sub>	DQ11
<b>L</b>	V <sub>DD</sub>	NF	V <sub>DDQ</sub>	NF	V <sub>SSQ</sub>	NF	DK1#	DQ12	V <sub>SSQ</sub>	DQ13	V <sub>DDQ</sub>	DQ14	V <sub>DD</sub>
<b>M</b>	V <sub>EXT</sub>	V <sub>SS</sub>	NF	V <sub>SSQ</sub>	NF	V <sub>DDQ</sub>	DM1	V <sub>DDQ</sub>	DQ15	V <sub>SSQ</sub>	DQ16	V <sub>SS</sub>	V <sub>EXT</sub>
<b>N</b>	V <sub>SS</sub>	TCK	V <sub>DD</sub>	TDO	V <sub>DDQ</sub>	NF	V <sub>REF</sub>	DQ17	V <sub>DDQ</sub>	TDI	V <sub>DD</sub>	TMS	V <sub>SS</sub>

- Notes:
1. F2 is an NF ball for both the X18 & X36 576Mb devices, but is also the Location of CS1 to support the 1Gb x18 DDP device. This same ball has been designated as the location of A20 for the future 1Gb monolithic device. F2 is Internally connected so it can mirror the A5 address signal when MF is asserted HIGH and has parasitic characteristics of an address pin.
  2. G13 is a VSS ball for both X18 & X36 576Mb devices, but has been reserved for future use (RFU) on the 1Gb monolithic devices and will have parasitic characteristics of an address.
  3. NF balls for the x18 configuration are internally connected and have parasitic characteristics of an I/O. Balls may be connected to V<sub>SSQ</sub>.
  4. MF is assumed to be tied LOW for this ball assignment.

**Table 2: 16 Meg x 36 Ball Assignments – 168-Ball BGA (Top View)**

	1	2	3	4	5	6	7	8	9	10	11	12	13
<b>A</b>		V <sub>SS</sub>	V <sub>DD</sub>	DQ26	V <sub>DDQ</sub>	DQ25	V <sub>REF</sub>	DQ7	V <sub>DDQ</sub>	DQ8	V <sub>DD</sub>	V <sub>SS</sub>	RESET#
<b>B</b>	V <sub>EXT</sub>	V <sub>SS</sub>	DQ24	V <sub>SSQ</sub>	DQ23	V <sub>DDQ</sub>	DM0	V <sub>DDQ</sub>	DQ5	V <sub>SSQ</sub>	DQ6	V <sub>SS</sub>	V <sub>EXT</sub>
<b>C</b>	V <sub>DD</sub>	DQ22	V <sub>DDQ</sub>	DQ21	V <sub>SSQ</sub>	DQ20	DK0#	DQ2	V <sub>SSQ</sub>	DQ3	V <sub>DDQ</sub>	DQ4	V <sub>DD</sub>
<b>D</b>	A11	V <sub>SSQ</sub>	DQ18	V <sub>DDQ</sub>	QK2	V <sub>SSQ</sub>	DK0	V <sub>SSQ</sub>	QK0	V <sub>DDQ</sub>	DQ0	V <sub>SSQ</sub>	A13
<b>E</b>	V <sub>SS</sub>	A0	V <sub>SSQ</sub>	DQ19	V <sub>DDQ</sub>	QK2#	MF	QK0#	V <sub>DDQ</sub>	DQ1	V <sub>SSQ</sub>	CS#	V <sub>SS</sub>
<b>F</b>	A7	NF <sub>(CS1/A20)</sub> <sup>1</sup>	V <sub>DD</sub>	A2	A1	WE#	ZQ	REF#	A3	A4	V <sub>DD</sub>	A5	A9
<b>G</b>	V <sub>SS</sub>	A15	A6	V <sub>SS</sub>	BA1	V <sub>SS</sub>	CK#	V <sub>SS</sub>	BA0	V <sub>SS</sub>	A8	A18	V <sub>SS</sub> (RFU) <sup>2</sup>
<b>H</b>	NF <sub>(A19)</sub> <sup>3</sup>	V <sub>DD</sub>	A14	A16	V <sub>DD</sub>	BA3	CK	BA2	V <sub>DD</sub>	A17	A12	V <sub>DD</sub>	A10
<b>J</b>	V <sub>DDQ</sub>	QVLD1	V <sub>SSQ</sub>	DQ27	V <sub>DDQ</sub>	QK3#	V <sub>SS</sub>	QK1#	V <sub>DDQ</sub>	DQ9	V <sub>SSQ</sub>	QVLD0	V <sub>DDQ</sub>
<b>K</b>	DQ29	V <sub>SSQ</sub>	DQ28	V <sub>DDQ</sub>	QK3	V <sub>SSQ</sub>	DK1	V <sub>SSQ</sub>	QK1	V <sub>DDQ</sub>	DQ10	V <sub>SSQ</sub>	DQ11
<b>L</b>	V <sub>DD</sub>	DQ32	V <sub>DDQ</sub>	DQ31	V <sub>SSQ</sub>	DQ30	DK1#	DQ12	V <sub>SSQ</sub>	DQ13	V <sub>DDQ</sub>	DQ14	V <sub>DD</sub>
<b>M</b>	V <sub>EXT</sub>	V <sub>SS</sub>	DQ34	V <sub>SSQ</sub>	DQ33	V <sub>DDQ</sub>	DM1	V <sub>DDQ</sub>	DQ15	V <sub>SSQ</sub>	DQ16	V <sub>SS</sub>	V <sub>EXT</sub>
<b>N</b>	V <sub>SS</sub>	TCK	V <sub>DD</sub>	TDO	V <sub>DDQ</sub>	DQ35	V <sub>REF</sub>	DQ17	V <sub>DDQ</sub>	TDI	V <sub>DD</sub>	TMS	V <sub>SS</sub>

- Notes:
1. F2 is an NF ball for both the X18 & X36 576Mb devices, but is also the Location of CS1 to support the 1Gb x18 DDP device. This same ball has been designated as the location of A20 for the future 1Gb monolithic device. F2 is Internally connected so it can mirror the A5 address signal when MF is asserted HIGH and has parasitic characteristics of an address pin.
  2. G13 is a VSS ball for both X18 & X36 576Mb devices, but has been reserved for future use (RFU) on the 1Gb monolithic devices and will have parasitic characteristics of an address.
  3. NF ball for x36 configuration is internally connected and has parasitic characteristics of an address (A19 for x18 configuration). Ball may be connected to V<sub>SSQ</sub>.
  4. MF is assumed to be tied LOW for this ball assignment.

**Table 3: Ball Descriptions**

Symbol	Type	Description
A[19:0]	Input	<b>Address inputs:</b> A[19:0] define the row and column addresses for READ and WRITE operations. During a MODE REGISTER SET, the address inputs define the register settings along with BA[3:0]. They are sampled at the rising edge of CK.
BA[3:0]	Input	<b>Bank address inputs:</b> Select the internal bank to which a command is being applied.
CK/CK#	Input	<b>Input clock:</b> CK and CK# are differential input clocks. Addresses and commands are latched on the rising edge of CK.
CS#	Input	<b>Chip select:</b> CS# enables the command decoder when LOW and disables it when HIGH. When the command decoder is disabled, new commands are ignored, but internal operations continue.
DQ[35:0]	I/O	<b>Data input:</b> The DQ signals form the 36-bit data bus. During READ commands, the data is referenced to both edges of QK. During WRITE commands, the data is sampled at both edges of DK.
DKx, DKx#	Input	<b>Input data clock:</b> DKx and DKx# are differential input data clocks. All input data is referenced to both edges of DKx. For the x36 device, DQ[8:0] and DQ[26:18] are referenced to DK0 and DK0#, and DQ[17:9] and DQ[35:27] are referenced to DK1 and DK1#. For the x18 device, DQ[8:0] are referenced to DK0 and DK0#, and DQ[17:9] are referenced to DK1 and DK1#. DKx and DKx# are free-running signals and must always be supplied to the device.
DM[1:0]	Input	<b>Input data mask:</b> DM is the input mask signal for WRITE data. Input data is masked when DM is sampled HIGH. DM0 is used to mask the lower byte for the x18 device and DQ[8:0] and DQ[26:18] for the x36 device. DM1 is used to mask the upper byte for the x18 device and DQ[17:9] and DQ[35:27] for the x36 device. Tie DM[1:0] to V <sub>SS</sub> if not used.
TCK	Input	<b>IEEE 1149.1 clock input:</b> This ball must be tied to V <sub>SS</sub> if the JTAG function is not used.
TMS, TDI	Input	<b>IEEE 1149.1 test inputs:</b> These balls may be left as no connects if the JTAG function is not used.
WE#, REF#	Input	<b>Command inputs:</b> Sampled at the positive edge of CK, WE# and REF# (together with CS#) define the command to be executed.
RESET#	Input	<b>Reset:</b> RESET# is an active LOW CMOS input referenced to V <sub>SS</sub> . RESET# assertion and deassertion are asynchronous. RESET# is a CMOS input defined with DC HIGH $\geq 0.8 \times V_{DDQ}$ and DC LOW $\leq 0.2 \times V_{DDQ}$ .
ZQ	Input	<b>External impedance:</b> This signal is used to tune the device's output impedance and ODT. RZQ needs to be 240 $\Omega$ , where RZQ is a resistor from this signal to ground.
QKx, QKx#	Output	<b>Output data clocks:</b> QK and QK# are opposite-polarity output data clocks. They are free-running signals and during READ commands are edge-aligned with the DQs. For the x36 device, QK0, QK0# align with DQ[8:0]; QK1, QK1# align with DQ[17:9]; QK2, QK2# align with DQ[26:18]; QK3, QK3# align with DQ[35:27]. For the x18 device, QK0, QK0# align with DQ[8:0]; QK1, QK1# align with DQ[17:9].
QVLDx	Output	<b>Data valid:</b> The QVLD ball indicates that valid output data will be available on the subsequent rising clock edge. There is a single QVLD ball for the x18 device and two, QVLD0 and QVLD1, for the x36 device. QVLD0 aligns with DQ[17:0]; QVLD1 aligns with DQ[35:18].
MF	Input	<b>Mirror function:</b> The mirror function ball is a DC input used to create mirrored ballouts for simple dual-loaded clamshell mounting. If the ball is tied to V <sub>SS</sub> , the address and command balls are in their true layout. If the ball is tied to V <sub>DDQ</sub> , they are in the complement location. MF must be tied HIGH or LOW and cannot be left floating.
TDO	Output	<b>IEEE 1149.1 test output:</b> JTAG output. This ball may be left as no connect if the JTAG function is not used.

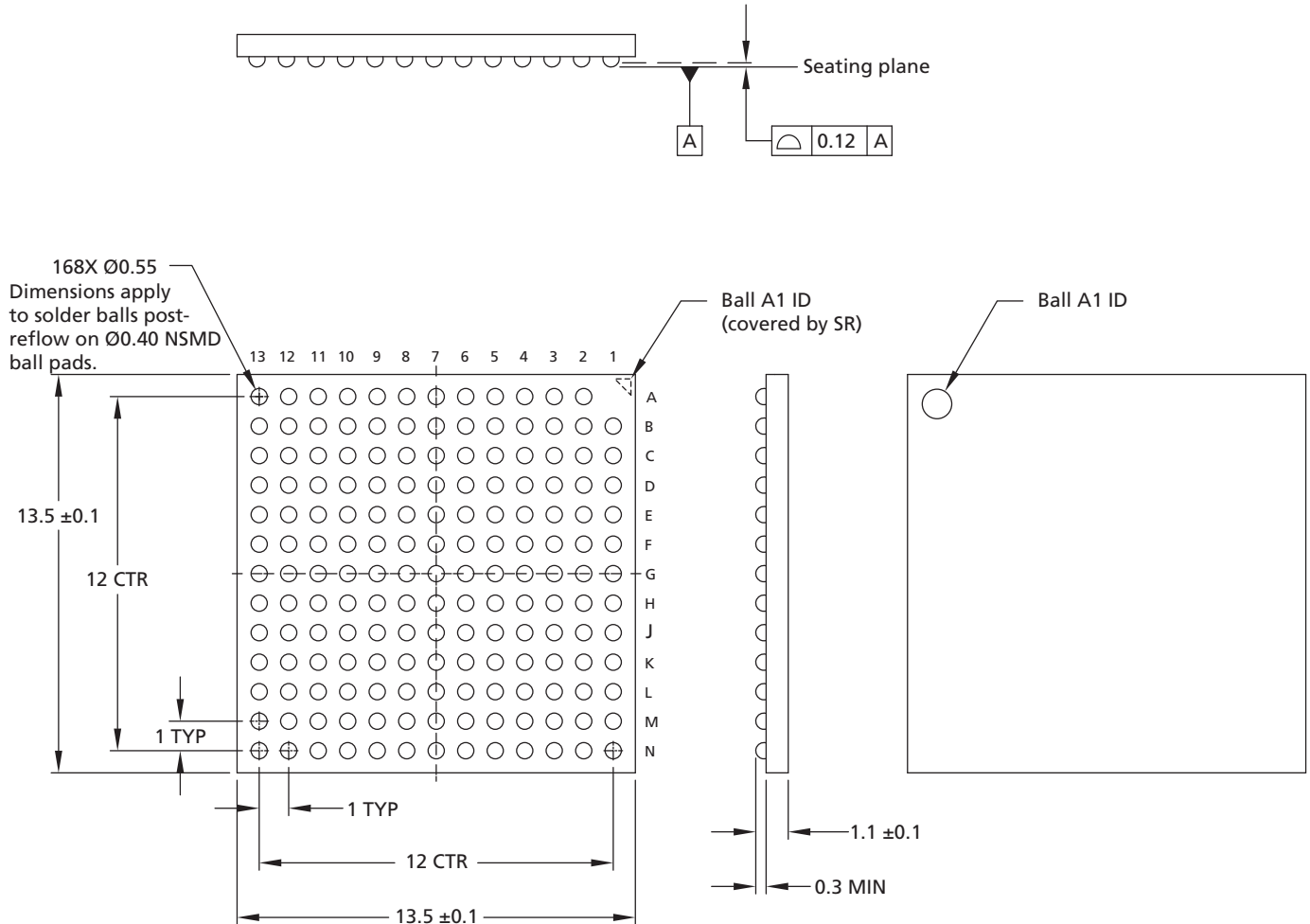


**Table 3: Ball Descriptions (Continued)**

Symbol	Type	Description
V <sub>DD</sub>	Supply	<b>Power supply:</b> 1.35V nominal. See Table 8 (page 26) for range.
V <sub>DDQ</sub>	Supply	<b>DQ power supply:</b> 1.2V nominal. Isolated on the device for improved noise immunity. See Table 8 (page 26) for range.
V <sub>EXT</sub>	Supply	<b>Power supply:</b> 2.5V nominal. See Table 8 (page 26) for range.
V <sub>REF</sub>	Supply	<b>Input reference voltage:</b> V <sub>DDQ</sub> /2 nominal. Provides a reference voltage for the input buffers.
V <sub>SS</sub>	Supply	Ground.
V <sub>SSQ</sub>	Supply	<b>DQ ground:</b> Isolated on the device for improved noise immunity.
NC	–	<b>No connect:</b> These balls are not connected to the DRAM.
NF	–	<b>No function:</b> These balls are connected to the DRAM, but provide no functionality.

## Package Dimensions

**Figure 5: 168-Ball BGA**



- Notes: 1. All dimensions are in millimeters.  
 2. Solder ball material: SAC302 (96.8% Sn, 3% Ag, 0.2% Cu).

## Electrical Characteristics – I<sub>DD</sub> Specifications

**Table 4: I<sub>DD</sub> Operating Conditions and Maximum Limits (Die Rev :A)**

Notes 1–6 apply to the entire table

Description	Condition	Symbol	-093E	-107E	-125F	-125E	-125	Units	Notes
Standby current	<sup>t</sup> CK = idle; All banks idle; No inputs toggling	I <sub>SB1</sub> (V <sub>DD</sub> ) x18	125	125	125	125	125	mA	
		I <sub>SB1</sub> (V <sub>DD</sub> ) x36	125	125	125	125	125		
		I <sub>SB1</sub> (V <sub>EXT</sub> )	30	30	30	30	30		
Clock active standby current	CS# = 1; No commands; Bank address incremented and half address/data change once every four clock cycles	I <sub>SB2</sub> (V <sub>DD</sub> ) x18	870	815	725	725	725	mA	
		I <sub>SB2</sub> (V <sub>DD</sub> ) x36	895	835	740	740	740		
		I <sub>SB2</sub> (V <sub>EXT</sub> )	30	30	30	30	30		
Operational current: BL2	BL = 2; Sequential bank access; Bank transitions once every <sup>t</sup> RC; Half address transitions once every <sup>t</sup> RC; Read followed by write sequence; Continuous data during WRITE commands	I <sub>DD1</sub> (V <sub>DD</sub> ) x18	1175	1100	990	940	915	mA	
		I <sub>DD1</sub> (V <sub>DD</sub> ) x36	1185	1110	1000	950	925		
		I <sub>DD1</sub> (V <sub>EXT</sub> )	35	35	35	35	35		
Operational current: BL4	BL = 4; Sequential bank access; Bank transitions once every <sup>t</sup> RC; Half address transitions once every <sup>t</sup> RC; Read followed by write sequence; Continuous data during WRITE commands	I <sub>DD2</sub> (V <sub>DD</sub> ) x18	1205	1130	1020	970	945	mA	
		I <sub>DD2</sub> (V <sub>DD</sub> ) x36	1215	1140	1030	980	950		
		I <sub>DD2</sub> (V <sub>EXT</sub> )	35	35	35	35	35		
Operational current: BL8	BL = 8; Sequential bank access; Bank transitions once every <sup>t</sup> RC; Half address transitions once every <sup>t</sup> RC; Read followed by write sequence; Continuous data during WRITE commands	I <sub>DD3</sub> (V <sub>DD</sub> ) x18	1300	1200	1085	1030	1000	mA	
		I <sub>DD3</sub> (V <sub>DD</sub> ) x36	NA	NA	N/A	NA	NA		
		I <sub>DD3</sub> (V <sub>EXT</sub> )	35	35	35	35	35		
Burst refresh current	Sixteen bank cyclic refresh using Bank Address Control AREF protocol; Command bus remains in refresh for all sixteen banks; DQs are High-Z and at V <sub>DDQ</sub> /2; Addresses are at V <sub>DDQ</sub> /2	I <sub>REF1</sub> (V <sub>DD</sub> ) x18	1550	1400	1230	1230	1230	mA	
		I <sub>REF1</sub> (V <sub>DD</sub> ) x36	1570	1420	1245	1245	1245		
		I <sub>REF1</sub> (V <sub>EXT</sub> )	80	75	70	70	70		
Distributed refresh current	Single bank refresh using Bank Address Control AREF protocol; Sequential bank access every 0.489μs; DQs are High-Z and at V <sub>DDQ</sub> /2; Addresses are at V <sub>DDQ</sub> /2	I <sub>REF2</sub> (V <sub>DD</sub> ) x18	875	820	730	730	730	mA	
		I <sub>REF2</sub> (V <sub>DD</sub> ) x36	900	840	745	745	745		
		I <sub>REF2</sub> (V <sub>EXT</sub> )	30	30	30	30	30		

**Table 4: I<sub>DD</sub> Operating Conditions and Maximum Limits (Die Rev :A) (Continued)**

Notes 1–6 apply to the entire table

Description	Condition	Symbol	-093E	-107E	-125F	-125E	-125	Units	Notes
Multibank refresh current: 4 bank refresh	Quad bank refresh using Multibank AREF protocol; BL = 4; Cyclic bank access; Subject to <sup>t</sup> SAW and <sup>t</sup> MMD specifications; DQs are High-Z and at V <sub>DDQ</sub> /2; Bank addresses are at V <sub>DDQ</sub> /2	I <sub>MBREF4</sub> (V <sub>DD</sub> ) x18	2130	2030	1885	1885	1645	mA	
		I <sub>MBREF4</sub> (V <sub>DD</sub> ) x36	2155	2050	1900	1900	1660		
		I <sub>MBREF4</sub> (V <sub>EXT</sub> )	130	115	105	105	105		
Operating burst write current : BL2	BL = 2; Cyclic bank access; Half of address bits change every clock cycle; Continuous data; Measurement is taken during continuous WRITE	I <sub>DD2W</sub> (V <sub>DD</sub> ) x18	2110	1910	1665	1665	1665	mA	
		I <sub>DD2W</sub> (V <sub>DD</sub> ) x36	2290	2070	1805	1805	1805		
		I <sub>DD2W</sub> (V <sub>EXT</sub> )	80	75	70	70	70		
Operating burst write current : BL4	BL = 4; Cyclic bank access; Half of address bits change every two clock cycles; Continuous data; Measurement is taken during continuous WRITE	I <sub>DD4W</sub> (V <sub>DD</sub> ) x18	1730	1590	1395	1395	1395	mA	
		I <sub>DD4W</sub> (V <sub>DD</sub> ) x36	1815	1665	1460	1460	1460		
		I <sub>DD4W</sub> (V <sub>EXT</sub> )	55	55	50	50	50		
Operating burst write current :BL8	BL = 8; Cyclic bank access; Half of address bits change every four clock cycles; Continuous data; Measurement is taken during continuous WRITE	I <sub>DD8W</sub> (V <sub>DD</sub> ) x18	1475	1335	1190	1190	1190	mA	
		I <sub>DD8W</sub> (V <sub>DD</sub> ) x36	NA	NA	NA	NA	NA		
		I <sub>DD8W</sub> (V <sub>EXT</sub> )	45	40	40	40	40		
Multibank write current: Dual bank write	BL = 4; Cyclic bank access using Dual Bank WRITE; Half of address bits change every two clock cycles; Continuous data; Measurement is taken during continuous WRITE	I <sub>DBWR</sub> (V <sub>DD</sub> ) x18	2305	2170	1885	1885	1885	mA	
		I <sub>DBWR</sub> (V <sub>DD</sub> ) x36	2400	2250	1960	1960	1960		
		I <sub>DBWR</sub> (V <sub>EXT</sub> )	80	75	70	70	70		
Multibank write current: Quad bank write	BL = 4; Cyclic bank access using Quad Bank WRITE; Half of address bits change every two clock cycles; Continuous data; Measurement is taken during continuous WRITE; Subject to <sup>t</sup> SAW specification	I <sub>QBWR</sub> (V <sub>DD</sub> ) x18	2965	2890	2525	2525	2525	mA	
		I <sub>QBWR</sub> (V <sub>DD</sub> ) x36	3195	3000	2615	2615	2615		
		I <sub>QBWR</sub> (V <sub>EXT</sub> )	130	115	100	100	100		
Operating burst read current example	BL = 2; Cyclic bank access; Half of address bits change every clock cycle; Continuous data; Measurement is taken during continuous READ	I <sub>DD2R</sub> (V <sub>DD</sub> ) x18	2250	2045	1785	1785	1785	mA	
		I <sub>DD2R</sub> (V <sub>DD</sub> ) x36	2395	2180	1895	1895	1895		
		I <sub>DD2R</sub> (V <sub>EXT</sub> )	80	75	70	70	70		
Operating burst read current example	BL = 4; Cyclic bank access; Half of address bits change every two clock cycles; Continuous data; Measurement is taken during continuous READ	I <sub>DD4R</sub> (V <sub>DD</sub> ) x18	1740	1595	1400	1400	1400	mA	
		I <sub>DD4R</sub> (V <sub>DD</sub> ) x36	1835	1685	1475	1475	1475		
		I <sub>DD4R</sub> (V <sub>EXT</sub> )	55	55	50	50	50		

**Table 4: I<sub>DD</sub> Operating Conditions and Maximum Limits (Die Rev :A) (Continued)**

Notes 1–6 apply to the entire table

Description	Condition	Symbol	-093E	-107E	-125F	-125E	-125	Units	Notes
Operating burst read current example	BL = 8; Cyclic bank access; Half of address bits change every four clock cycles; Continuous data; Measurement is taken during continuous READ	I <sub>DD8R</sub> (V <sub>DD</sub> ) x18	1450	1315	1175	1175	1175	mA	
		I <sub>DD8R</sub> (V <sub>DD</sub> ) x36	NA	NA	NA	NA	NA		
		I <sub>DD8R</sub> (V <sub>EXT</sub> )	45	40	40	40	40		

- Notes:
1. I<sub>DD</sub> specifications are tested after the device is properly initialized.  $0^{\circ}\text{C} \leq T_C \leq +95^{\circ}\text{C}$ ;  $+1.28\text{V} \leq V_{DD} \leq +1.42\text{V}$ ,  $+1.14\text{V} \leq V_{DDQ} \leq +1.26\text{V}$ ,  $+2.38\text{V} \leq V_{EXT} \leq +2.63\text{V}$ ,  $V_{REF} = V_{DDQ}/2$ .
  2. I<sub>DD</sub> measurements use  $t_{CK}$  (MIN),  $t_{RC}$  (MIN), and minimum data latency (RL and WL).
  3. Input slew rate is 1V/ns for single ended signals and 2V/ns for differential signals.
  4. Definitions for I<sub>DD</sub> conditions:
    - LOW is defined as  $V_{IN} \leq V_{IL(AC)MAX}$ .
    - HIGH is defined as  $V_{IN} \geq V_{IH(AC)MIN}$ .
    - Continuous data is defined as half the DQ signals changing between HIGH and LOW every half clock cycle (twice per clock).
    - Continuous address is defined as half the address signals changing between HIGH and LOW every clock cycle (once per clock).
    - Sequential bank access is defined as the bank address incrementing by one every  $t_{RC}$ .
    - Cyclic bank access is defined as the bank address incrementing by one for each command access. For BL = 2 this is every clock, for BL = 4 this is every other clock, and for BL = 8 this is every fourth clock.
  5. CS# is HIGH unless a READ, WRITE, AREF, or MRS command is registered. CS# never transitions more than once per clock cycle.
  6. I<sub>DD</sub> parameters are specified with ODT disabled.

## Electrical Characteristics – I<sub>DD</sub> Specifications

**Table 5: I<sub>DD</sub> Operating Conditions and Maximum Limits (Die Rev :B )**

Notes 1–6 apply to the entire table

Description	Condition	Symbol	-093F	-093E	-107E	Units
Standby current	<sup>t</sup> CK = idle; All banks idle; No inputs toggling	I <sub>SB1</sub> (V <sub>DD</sub> ) x18	225	225	225	mA
		I <sub>SB1</sub> (V <sub>DD</sub> ) x36	225	225	225	
		I <sub>SB1</sub> (V <sub>EXT</sub> )	55	55	55	
Clock active standby current	CS# = 1; No commands; Bank address incremented and half address/data change once every four clock cycles	I <sub>SB2</sub> (V <sub>DD</sub> ) x18	605	605	570	mA
		I <sub>SB2</sub> (V <sub>DD</sub> ) x36	625	625	585	
		I <sub>SB2</sub> (V <sub>EXT</sub> )	55	55	55	
Operational current: BL2	BL = 2; Sequential bank access; Bank transitions once every <sup>t</sup> RC; Half address transitions once every <sup>t</sup> RC; Read followed by write sequence; Continuous data during WRITE commands	I <sub>DD1</sub> (V <sub>DD</sub> ) x18	1105	1040	975	mA
		I <sub>DD1</sub> (V <sub>DD</sub> ) x36	1115	1050	985	
		I <sub>DD1</sub> (V <sub>EXT</sub> )	60	60	60	
Operational current: BL4	BL = 4; Sequential bank access; Bank transitions once every <sup>t</sup> RC; Half address transitions once every <sup>t</sup> RC; Read followed by write sequence; Continuous data during WRITE commands	I <sub>DD2</sub> (V <sub>DD</sub> ) x18	1200	1130	1060	mA
		I <sub>DD2</sub> (V <sub>DD</sub> ) x36	1210	1140	1070	
		I <sub>DD2</sub> (V <sub>EXT</sub> )	60	60	60	
Operational current: BL8	BL = 8; Sequential bank access; Bank transitions once every <sup>t</sup> RC; Half address transitions once every <sup>t</sup> RC; Read followed by write sequence; Continuous data during WRITE commands	I <sub>DD3</sub> (V <sub>DD</sub> ) x18	1160	1095	1015	mA
		I <sub>DD3</sub> (V <sub>DD</sub> ) x36	NA	NA	NA	
		I <sub>DD3</sub> (V <sub>EXT</sub> )	60	60	60	
Burst refresh current	Sixteen bank cyclic refresh using Bank Address Control AREF protocol; Command bus remains in refresh for all sixteen banks; DQs are High-Z and at V <sub>DDQ</sub> /2; Addresses are at V <sub>DDQ</sub> /2	I <sub>REF1</sub> (V <sub>DD</sub> ) x18	1135	1135	1025	mA
		I <sub>REF1</sub> (V <sub>DD</sub> ) x36	1150	1150	1040	
		I <sub>REF1</sub> (V <sub>EXT</sub> )	115	115	110	
Distributed refresh current	Single bank refresh using Bank Address Control AREF protocol; Sequential bank access every 0.489μs; DQs are High-Z and at V <sub>DDQ</sub> /2; Addresses are at V <sub>DDQ</sub> /2	I <sub>REF2</sub> (V <sub>DD</sub> ) x18	580	580	540	mA
		I <sub>REF2</sub> (V <sub>DD</sub> ) x36	595	595	555	
		I <sub>REF2</sub> (V <sub>EXT</sub> )	55	55	55	
Multibank refresh current: 4 bank refresh	Quad bank refresh using Multibank AREF protocol; BL = 4; Cyclic bank access; Subject to <sup>t</sup> SAW and <sup>t</sup> MMD specifications; DQs are High-Z and at V <sub>DDQ</sub> /2; Bank addresses are at V <sub>DDQ</sub> /2	I <sub>MBREF4</sub> (V <sub>DD</sub> ) x18	1490	1490	1420	mA
		I <sub>MBREF4</sub> (V <sub>DD</sub> ) x36	1510	1510	1435	
		I <sub>MBREF4</sub> (V <sub>EXT</sub> )	185	185	165	
Operating burst write current : BL2	BL = 2; Cyclic bank access; Half of address bits change every clock cycle; Continuous data; Measurement is taken during continuous WRITE	I <sub>DD2W</sub> (V <sub>DD</sub> ) x18	1655	1655	1500	mA
		I <sub>DD2W</sub> (V <sub>DD</sub> ) x36	1810	1810	1635	
		I <sub>DD2W</sub> (V <sub>EXT</sub> )	80	80	75	

**Table 5: I<sub>DD</sub> Operating Conditions and Maximum Limits (Die Rev :B ) (Continued)**

Notes 1–6 apply to the entire table

Description	Condition	Symbol	-093F	-093E	-107E	Units
Operating burst write current : BL4	BL = 4; Cyclic bank access; Half of address bits change every two clock cycles; Continuous data; Measurement is taken during continuous WRITE	I <sub>DD4W</sub> (V <sub>DD</sub> ) x18	1515	1515	1395	mA
		I <sub>DD4W</sub> (V <sub>DD</sub> ) x36	1595	1595	1465	
		I <sub>DD4W</sub> (V <sub>EXT</sub> )	75	75	70	
Operating burst write current :BL8	BL = 8; Cyclic bank access; Half of address bits change every four clock cycles; Continuous data; Measurement is taken during continuous WRITE	I <sub>DD8W</sub> (V <sub>DD</sub> ) x18	1140	1140	1040	mA
		I <sub>DD8W</sub> (V <sub>DD</sub> ) x36	NA	NA	NA	
		I <sub>DD8W</sub> (V <sub>EXT</sub> )	70	70	65	
Multibank write current: Dual bank write	BL = 4; Cyclic bank access using Dual Bank WRITE; Half of address bits change every two clock cycles; Continuous data; Measurement is taken during continuous WRITE	I <sub>DBWR</sub> (V <sub>DD</sub> ) x18	2005	2005	1890	mA
		I <sub>DBWR</sub> (V <sub>DD</sub> ) x36	2090	2090	1960	
		I <sub>DBWR</sub> (V <sub>EXT</sub> )	115	115	110	
Multibank write current: Quad bank write	BL = 4; Cyclic bank access using Quad Bank WRITE; Half of address bits change every two clock cycles; Continuous data; Measurement is taken during continuous WRITE; Subject to t <sub>SAW</sub> specification	I <sub>QBWR</sub> (V <sub>DD</sub> ) x18	2620	2620	2565	mA
		I <sub>QBWR</sub> (V <sub>DD</sub> ) x36	2840	2840	2665	
		I <sub>QBWR</sub> (V <sub>EXT</sub> )	200	200	175	
Operating burst read current example	BL = 2; Cyclic bank access; Half of address bits change every clock cycle; Continuous data; Measurement is taken during continuous READ	I <sub>DD2R</sub> (V <sub>DD</sub> ) x18	1715	1715	1560	mA
		I <sub>DD2R</sub> (V <sub>DD</sub> ) x36	1835	1835	1670	
		I <sub>DD2R</sub> (V <sub>EXT</sub> )	80	80	75	
Operating burst read current example	BL = 4; Cyclic bank access; Half of address bits change every two clock cycles; Continuous data; Measurement is taken during continuous READ	I <sub>DD4R</sub> (V <sub>DD</sub> ) x18	1510	1510	1380	mA
		I <sub>DD4R</sub> (V <sub>DD</sub> ) x36	1595	1595	1465	
		I <sub>DD4R</sub> (V <sub>EXT</sub> )	75	75	70	
Operating burst read current example	BL = 8; Cyclic bank access; Half of address bits change every four clock cycles; Continuous data; Measurement is taken during continuous READ	I <sub>DD8R</sub> (V <sub>DD</sub> ) x18	1135	1135	1040	mA
		I <sub>DD8R</sub> (V <sub>DD</sub> ) x36	NA	NA	NA	
		I <sub>DD8R</sub> (V <sub>EXT</sub> )	70	70	65	



- Notes:
1. I<sub>DD</sub> specifications are tested after the device is properly initialized.  $0^{\circ}\text{C} \leq T_C \leq +95^{\circ}\text{C}$ ;  $+1.28\text{V} \leq V_{DD} \leq +1.42\text{V}$ ,  $+1.14\text{V} \leq V_{DDQ} \leq +1.26\text{V}$ ,  $+2.38\text{V} \leq V_{EXT} \leq +2.63\text{V}$ ,  $V_{REF} = V_{DDQ}/2$ .
  2. I<sub>DD</sub> measurements use  $t_{CK}(\text{MIN})$ ,  $t_{RC}(\text{MIN})$ , and minimum data latency (RL and WL).
  3. Input slew rate is 1 V/ns for single ended signals and 2 V/ns for differential signals.
  4. Definitions for I<sub>DD</sub> conditions:
    - LOW is defined as  $V_{IN} \leq V_{IL(AC)MAX}$ .
    - HIGH is defined as  $V_{IN} \geq V_{IH(AC)MIN}$ .
    - Continuous data is defined as half the DQ signals changing between HIGH and LOW every half clock cycle (twice per clock).
    - Continuous address is defined as half the address signals changing between HIGH and LOW every clock cycle (once per clock).
    - Sequential bank access is defined as the bank address incrementing by one every  $t_{RC}$ .
    - Cyclic bank access is defined as the bank address incrementing by one for each command access. For BL = 2 this is every clock, for BL = 4 this is every other clock, and for BL = 8 this is every fourth clock.
  5. CS# is HIGH unless a READ, WRITE, AREF, or MRS command is registered. CS# never transitions more than once per clock cycle.
  6. I<sub>DD</sub> parameters are specified with ODT disabled.

## Electrical Specifications – Absolute Ratings and I/O Capacitance

### 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 outside those indicated in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may adversely affect reliability.

**Table 6: Absolute Maximum Ratings**

Symbol	Parameter	Min	Max	Units
$V_{DD}$	$V_{DD}$ supply voltage relative to $V_{SS}$	-0.4	1.975	V
$V_{DDQ}$	Voltage on $V_{DDQ}$ supply relative to $V_{SS}$	-0.4	1.66	V
$V_{IN}, V_{OUT}$	Voltage on any ball relative to $V_{SS}$	-0.4	1.66	V
$V_{EXT}$	Voltage on $V_{EXT}$ supply relative to $V_{SS}$	-0.4	2.8	V

### Input/Output Capacitance

**Table 7: Input/Output Capacitance**

Notes 1 and 2 apply to entire table

Capacitance Parameters	Symbol	RL3-2133		RL3-1866		RL3-1600		Units	Notes
		Min	Max	Min	Max	Min	Max		
CK/CK#	$C_{CK}$	1.3	2.1	1.3	2.1	1.3	2.2	pF	
$\Delta C$ : CK to CK#	$C_{DCK}$	0	0.15	0	0.15	0	0.15	pF	
Single-ended I/O: DQ, DM	$C_{IO}$	1.9	2.9	1.9	3.0	2.0	3.1	pF	3
Input strobe: DK/DK#	$C_{IO}$	1.9	2.9	1.9	3.0	2.0	3.1	pF	
Output strobe: QK/QK#, QVLD	$C_{IO}$	1.9	2.9	1.9	3.0	2.0	3.1	pF	
$\Delta C$ : DK to DK#	$C_{DDK}$	0	0.15	0	0.15	0	0.15	pF	
$\Delta C$ : QK to QK#	$C_{DQK}$	0	0.15	0	0.15	0	0.15	pF	
$\Delta C$ : DQ to QK or DQ to DK	$C_{DIO}$	-0.5	0.3	-0.5	0.3	-0.5	0.3	pF	4
Inputs (CMD, ADDR)	$C_I$	1.25	2.25	1.25	2.25	1.25	2.25	pF	5
$\Delta C$ : CMD_ADDR to CK	$C_{DI\_CMD\_ADDR}$	-0.5	0.3	-0.5	0.3	-0.4	0.4	pF	6
JTAG balls	$C_{JTAG}$	1.5	4.5	1.5	4.5	1.5	4.5	pF	7
RESET#, MF balls	$C_I$	-	3.0	-	3.0	-	3.0	pF	

- Notes:
- $+1.28V \leq V_{DD} \leq +1.42V$ ,  $+1.14V \leq V_{DDQ} \leq 1.26V$ ,  $+2.38V \leq V_{EXT} \leq +2.63V$ ,  $V_{REF} = V_{SS}$ ,  $f = 100$  MHz,  $T_C = 25^\circ C$ ,  $V_{OUT(DC)} = 0.5 \times V_{DDQ}$ ,  $V_{OUT}$  (peak-to-peak) = 0.1V.
  - Capacitance is not tested on ZQ ball.
  - DM input is grouped with the I/O balls, because they are matched in loading.
  - $C_{DIO} = C_{IO(DQ)} - 0.5 \times (C_{IO} [QK] + C_{IO} [QK\#])$ .
  - Includes CS#, REF#, WE#, A[19:0], and BA[3:0].
  - $C_{DI\_CMD\_ADDR} = C_I$  (CMD\_ADDR) -  $0.5 \times (C_{CK} [CK] + C_{CK} [CK\#])$ .
  - JTAG balls are tested at 50 MHz.