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Automotive DDR4 SDRAM

MT40A512M8
MT40A256M16

Features

- $V_{DD} = V_{DDQ} = 1.2V \pm 60mV$
- $V_{PP} = 2.5V - 125mV / +250mV$
- On-die, internal, adjustable V_{REFDQ} generation
- 1.2V pseudo open-drain I/O
- Refresh maximum interval time at T_C temperature range:
 - 64ms at $-40^{\circ}C$ to $85^{\circ}C$
 - 32ms at $85^{\circ}C$ to $95^{\circ}C$
 - 16ms at $96^{\circ}C$ to $105^{\circ}C$
 - 8ms at $106^{\circ}C$ to $125^{\circ}C$
- 16 internal banks (x8): 4 groups of 4 banks each
- 8 internal banks (x16): 2 groups of 4 banks each
- 8n-bit prefetch architecture
- Programmable data strobe preambles
- Data strobe preamble training
- Command/Address latency (CAL)
- Multipurpose register read and write capability
- Write leveling
- Self refresh mode
- Low-power auto self refresh (LPASR)
- Temperature controlled refresh (TCR)
- Fine granularity refresh
- Self refresh abort
- Maximum power saving
- Output driver calibration
- Nominal, park, and dynamic on-die termination (ODT)
- Data bus inversion (DBI) for data bus
- Command/Address (CA) parity
- Databus write cyclic redundancy check (CRC)
- Per-DRAM addressability
- Connectivity test
- Hard post package repair (hPPR) and soft post package repair (sPPR) modes
- JEDEC JESD-79-4 compliant
- ACE-Q100
- PPAP submission
- 8D response time

Options¹

- Configuration
 - 512 Meg x 8
 - 256 Meg x 16
- BGA package (Pb-free) – x8
 - 78-ball (9mm x 10.5mm) – Rev. B
- FBGA package (Pb-free) – x16
 - 96-ball (9mm x 14mm) – Rev. B
- Timing – cycle time
 - 0.750ns @ CL = 18 (DDR4-2666)
 - 0.833ns @ CL = 16 (DDR4-2400)
- Product certification
 - Automotive
- Operating temperature
 - Industrial ($-40^{\circ} \leq T_C \leq +95^{\circ}C$)
 - Automotive ($-40^{\circ} \leq T_C \leq +105^{\circ}C$)
 - Ultra-high ($-40^{\circ} \leq T_C \leq +125^{\circ}C$)³
 - Revision

Marking

512M8	
256M16	
RH	
GE	
-075E	
-083E	
A	
IT	
AT	
UT	
:B	

- Notes:
1. Not all options listed can be combined to define an offered product. Use the part catalog search on <http://www.micron.com> for available offerings.
 2. The data sheet does not support x4 mode even though x4 mode description exists in the following sections.
 3. The UT option use based on automotive usage model. Please contact Micron sales representative if you have questions.

Table 1: Key Timing Parameters

Speed Grade	Data Rate (MT/s)	Target t_{RCD} - t_{RP} -CL	t_{RCD} (ns)	t_{RP} (ns)	CL (ns)
-075E ¹	2666	18-18-18	13.5	13.5	13.5
-083E	2400	16-16-16	13.32	13.32	13.32

Note: 1. Backward compatible to 2400, CL = 16

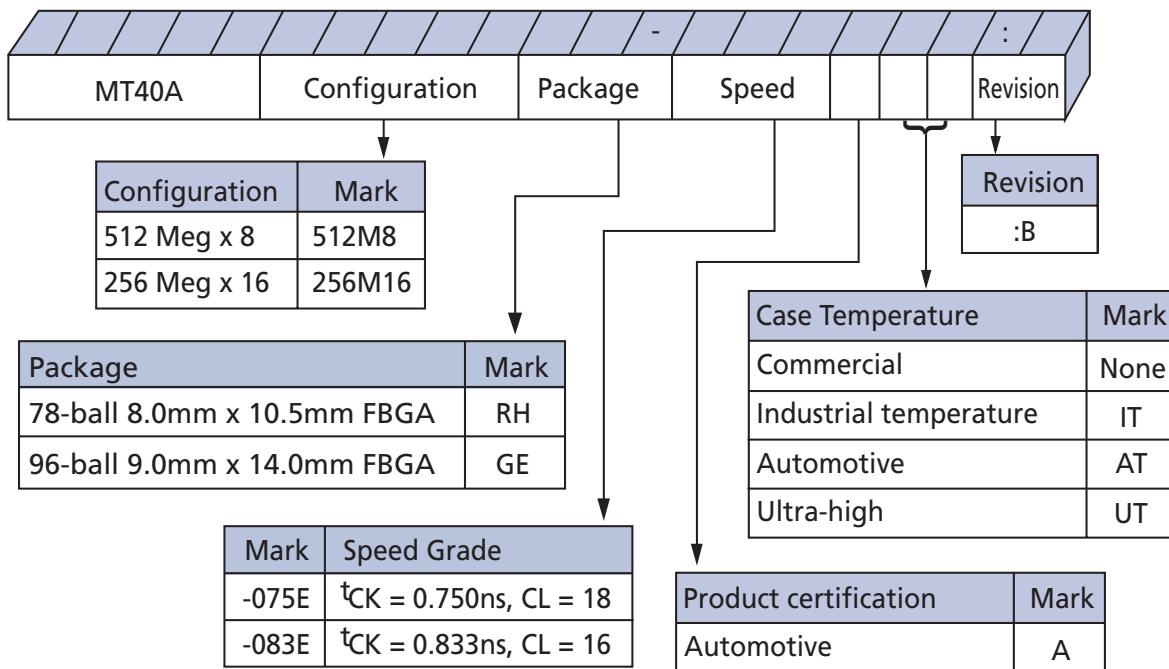
Table 2: Addressing

Parameter	512 Meg x 8	256 Meg x 16
Number of bank groups	4	2
Bank group address	BG[1:0]	BG0
Bank count per group	4	4
Bank address in bank group	BA[1:0]	BA[1:0]
Row addressing	32K (A[14:0])	32K (A[14:0])
Column addressing	1K (A[9:0])	1K (A[9:0])
Page size ¹	1KB	2KB

Note: 1. Page size is per bank, calculated as follows:
 Page size = $2^{COLBITS} \times ORG/8$, where COLBIT = the number of column address bits and ORG = the number of DQ bits.

Figure 1: Order Part Number Example

Example Part Number: MT40A512M8RH-075EAAT:B



Contents

Important Notes and Warnings	18
General Notes and Description	18
Description	18
Industrial Temperature	19
Automotive Temperature	19
Ultra-high Temperature	19
General Notes	19
Definitions of the Device-Pin Signal Level	20
Definitions of the Bus Signal Level	20
Functional Block Diagrams	21
Ball Assignments	22
Ball Descriptions	24
Package Dimensions	27
State Diagram	29
Functional Description	31
RESET and Initialization Procedure	32
Power-Up and Initialization Sequence	32
RESET Initialization with Stable Power Sequence	35
Uncontrolled Power-Down Sequence	36
Programming Mode Registers	37
Mode Register 0	40
Burst Length, Type, and Order	42
CAS Latency	43
Test Mode	43
Write Recovery (WR)/READ-to-PRECHARGE	43
DLL RESET	43
Mode Register 1	44
DLL Enable/DLL Disable	45
Output Driver Impedance Control	46
ODT $R_{TT(NOM)}$ Values	46
Additive Latency	46
DQ RX EQ	46
Write Leveling	47
Output Disable	47
Termination Data Strobe	47
Mode Register 2	48
CAS WRITE Latency	50
Low-Power Auto Self Refresh	50
Dynamic ODT	50
Write Cyclic Redundancy Check Data Bus	50
Mode Register 3	51
Multipurpose Register	52
WRITE Command Latency When CRC/DM is Enabled	53
Fine Granularity Refresh Mode	53
Temperature Sensor Status	53
Per-DRAM Addressability	53
Gear-Down Mode	53
Mode Register 4	54
Hard Post Package Repair Mode	55
Soft Post Package Repair Mode	56



WRITE Preamble	56
READ Preamble	56
READ Preamble Training	56
Temperature-Controlled Refresh	56
Command Address Latency	56
Internal V _{REF} Monitor	56
Maximum Power Savings Mode	57
Mode Register 5	58
Data Bus Inversion	59
Data Mask	60
CA Parity Persistent Error Mode	60
ODT Input Buffer for Power-Down	60
CA Parity Error Status	60
CRC Error Status	60
CA Parity Latency Mode	60
Mode Register 6	61
^t CCD_L Programming	62
V _{REFDQ} Calibration Enable	62
V _{REFDQ} Calibration Range	62
V _{REFDQ} Calibration Value	63
DQ RX EQ	63
Truth Tables	64
NOP Command	67
DESELECT Command	67
DLL-Off Mode	67
DLL-On/Off Switching Procedures	69
DLL Switch Sequence from DLL-On to DLL-Off	69
DLL-Off to DLL-On Procedure	70
Input Clock Frequency Change	71
Write Leveling	72
DRAM Setting for Write Leveling and DRAM TERMINATION Function in that Mode	74
Procedure Description	75
Write Leveling Mode Exit	76
Command Address Latency	77
Low-Power Auto Self Refresh Mode	82
Manual Self Refresh Mode	82
Multipurpose Register	84
MPR Reads	85
MPR Readout Format	87
MPR Readout Serial Format	87
MPR Readout Parallel Format	88
MPR Readout Staggered Format	89
MPR READ Waveforms	90
MPR Writes	92
MPR WRITE Waveforms	93
MPR REFRESH Waveforms	94
Gear-Down Mode	97
Maximum Power-Saving Mode	100
Maximum Power-Saving Mode Entry	100
Maximum Power-Saving Mode Entry in PDA	101
CKE Transition During Maximum Power-Saving Mode	101
Maximum Power-Saving Mode Exit	101



Command/Address Parity	103
Per-DRAM Addressability	111
V _{REFDQ} Calibration	114
V _{REFDQ} Range and Levels	115
V _{REFDQ} Step Size	115
V _{REFDQ} Increment and Decrement Timing	116
V _{REFDQ} Target Settings	120
Connectivity Test Mode	122
Pin Mapping	122
Minimum Terms Definition for Logic Equations	123
Logic Equations for a ×4 Device	123
Logic Equations for a ×8 Device	124
Logic Equations for a ×16 Device	124
CT Input Timing Requirements	124
Excessive Row Activation	126
Post Package Repair	127
Post Package Repair	127
Hard Post Package Repair	128
hPPR Row Repair - Entry	128
hPPR Row Repair – WRA Initiated (REF Commands Allowed)	128
hPPR Row Repair – WR Initiated (REF Commands NOT Allowed)	130
sPPR Row Repair	132
hPPR/sPPR Support Identifier	135
ACTIVATE Command	135
PRECHARGE Command	136
REFRESH Command	137
Temperature-Controlled Refresh Mode	139
TCR Mode – Normal Temperature Range	139
TCR Mode – Extended Temperature Range	139
Fine Granularity Refresh Mode	141
Mode Register and Command Truth Table	141
^t REFI and ^t RFC Parameters	141
Changing Refresh Rate	144
Usage with TCR Mode	144
Self Refresh Entry and Exit	144
SELF REFRESH Operation	146
Self Refresh Abort	148
Self Refresh Exit with NOP Command	149
Power-Down Mode	151
Power-Down Clarifications – Case 1	156
Power-Down Entry, Exit Timing with CAL	157
ODT Input Buffer Disable Mode for Power-Down	159
CRC Write Data Feature	161
CRC Write Data	161
WRITE CRC DATA Operation	161
DBI _n and CRC Both Enabled	162
DM _n and CRC Both Enabled	162
DM _n and DBI _n Conflict During Writes with CRC Enabled	162
CRC and Write Preamble Restrictions	162
CRC Simultaneous Operation Restrictions	162
CRC Polynomial	162
CRC Combinatorial Logic Equations	163



Burst Ordering for BL8	164
CRC Data Bit Mapping	164
CRC Enabled With BC4	165
CRC with BC4 Data Bit Mapping	165
CRC Equations for x8 Device in BC4 Mode with A2 = 0 and A2 = 1	168
CRC Error Handling	170
CRC Write Data Flow Diagram	171
Data Bus Inversion	172
DBI During a WRITE Operation	172
DBI During a READ Operation	173
Data Mask	174
Programmable Preamble Modes and DQS Postambles	176
WRITE Preamble Mode	176
READ Preamble Mode	179
READ Preamble Training	179
WRITE Postamble	180
READ Postamble	180
Bank Access Operation	182
READ Operation	186
Read Timing Definitions	186
Read Timing – Clock-to-Data Strobe Relationship	187
Read Timing – Data Strobe-to-Data Relationship	189
^t LZ(DQS), ^t LZ(DQ), ^t HZ(DQS), and ^t HZ(DQ) Calculations	190
^t RPRE Calculation	191
^t RPST Calculation	192
READ Burst Operation	193
READ Operation Followed by Another READ Operation	195
READ Operation Followed by WRITE Operation	200
READ Operation Followed by PRECHARGE Operation	206
READ Operation with Read Data Bus Inversion (DBI)	209
READ Operation with Command/Address Parity (CA Parity)	210
READ Followed by WRITE with CRC Enabled	212
READ Operation with Command/Address Latency (CAL) Enabled	213
WRITE Operation	215
Write Timing Definitions	215
Write Timing – Clock-to-Data Strobe Relationship	215
^t WPRE Calculation	217
^t WPST Calculation	218
Write Timing – Data Strobe-to-Data Relationship	218
WRITE Burst Operation	222
WRITE Operation Followed by Another WRITE Operation	224
WRITE Operation Followed by READ Operation	230
WRITE Operation Followed by PRECHARGE Operation	234
WRITE Operation with WRITE DBI Enabled	237
WRITE Operation with CA Parity Enabled	239
WRITE Operation with Write CRC Enabled	240
Write Timing Violations	245
Motivation	245
Data Setup and Hold Violations	245
Strobe-to-Strobe and Strobe-to-Clock Violations	245
ZQ CALIBRATION Commands	246
On-Die Termination	248



ODT Mode Register and ODT State Table	248
ODT Read Disable State Table	249
Synchronous ODT Mode	250
ODT Latency and Posted ODT	250
Timing Parameters	250
ODT During Reads	252
Dynamic ODT	253
Functional Description	253
Asynchronous ODT Mode	256
Electrical Specifications	257
Absolute Ratings	257
DRAM Component Operating Temperature Range	257
Electrical Characteristics – AC and DC Operating Conditions	258
Supply Operating Conditions	258
Leakages	259
V _{REFCA} Supply	259
V _{REFDQ} Supply and Calibration Ranges	260
V _{REFDQ} Ranges	261
Electrical Characteristics – AC and DC Single-Ended Input Measurement Levels	262
RESET _n Input Levels	262
Command/Address Input Levels	262
Command, Control, and Address Setup, Hold, and Derating	264
Data Receiver Input Requirements	266
Connectivity Test (CT) Mode Input Levels	270
Electrical Characteristics – AC and DC Differential Input Measurement Levels	274
Differential Inputs	274
Single-Ended Requirements for CK Differential Signals	275
Slew Rate Definitions for CK Differential Input Signals	276
CK Differential Input Cross Point Voltage	277
DQS Differential Input Signal Definition and Swing Requirements	279
DQS Differential Input Cross Point Voltage	281
Slew Rate Definitions for DQS Differential Input Signals	282
Electrical Characteristics – Overshoot and Undershoot Specifications	284
Address, Command, and Control Overshoot and Undershoot Specifications	284
Clock Overshoot and Undershoot Specifications	284
Data, Strobe, and Mask Overshoot and Undershoot Specifications	285
Electrical Characteristics – AC and DC Output Measurement Levels	286
Single-Ended Outputs	286
Differential Outputs	287
Reference Load for AC Timing and Output Slew Rate	289
Connectivity Test Mode Output Levels	289
Electrical Characteristics – AC and DC Output Driver Characteristics	291
Connectivity Test Mode Output Driver Electrical Characteristics	291
Output Driver Electrical Characteristics	292
Output Driver Temperature and Voltage Sensitivity	295
Alert Driver	295
Electrical Characteristics – On-Die Termination Characteristics	297
ODT Levels and I-V Characteristics	297
ODT Temperature and Voltage Sensitivity	298
ODT Timing Definitions	299
DRAM Package Electrical Specifications	302
Thermal Characteristics	306



Current Specifications – Measurement Conditions	307
I _{DD} , I _{PP} , and I _{DDQ} Measurement Conditions	307
I _{DD} Definitions	309
Current Specifications – Patterns and Test Conditions	313
Current Test Definitions and Patterns	313
I _{DD} Specifications	322
Current Specifications – Limits	323
Speed Bin Tables	328
Refresh Parameters By Device Density	336
Electrical Characteristics and AC Timing Parameters – DDR4-1600 through DDR4-2400	337
Electrical Characteristics and AC Timing Parameters – DDR4-2666 through DDR4-3200	349
Revision History	361
Rev. F – 11/17	361
Rev. E – 09/17	361
Rev. D – 01/17	361
Rev. C – 10/16	361
Rev. B – 09/16	361
Rev. A – 06/16	361

List of Figures

Figure 1: Order Part Number Example	2
Figure 2: 512 Meg x 8 Functional Block Diagram	21
Figure 3: 256 Meg x 16 Functional Block Diagram	21
Figure 4: 78-Ball x4, x8 Ball Assignments	22
Figure 5: 96-Ball x16 Ball Assignments	23
Figure 6: 78-Ball FBGA – x4, x8 "RH"	27
Figure 7: 96-Ball FBGA – x16 "GE"	28
Figure 8: Simplified State Diagram	29
Figure 9: RESET and Initialization Sequence at Power-On Ramping	35
Figure 10: RESET Procedure at Power Stable Condition	36
Figure 11: ^t MRD Timing	38
Figure 12: ^t MOD Timing	38
Figure 13: DLL-Off Mode Read Timing Operation	68
Figure 14: DLL Switch Sequence from DLL-On to DLL-Off	70
Figure 15: DLL Switch Sequence from DLL-Off to DLL-On	71
Figure 16: Write Leveling Concept, Example 1	73
Figure 17: Write Leveling Concept, Example 2	74
Figure 18: Write Leveling Sequence (DQS Capturing CK LOW at T1 and CK HIGH at T2)	75
Figure 19: Write Leveling Exit	76
Figure 20: CAL Timing Definition	77
Figure 21: CAL Timing Example (Consecutive CS _n = LOW)	77
Figure 22: CAL Enable Timing – ^t MOD _{CAL}	78
Figure 23: ^t MOD _{CAL} , MRS to Valid Command Timing with CAL Enabled	78
Figure 24: CAL Enabling MRS to Next MRS Command, ^t MRD _{CAL}	79
Figure 25: ^t MRD _{CAL} , Mode Register Cycle Time With CAL Enabled	79
Figure 26: Consecutive READ BL8, CAL3, 1 ^t CK Preamble, Different Bank Group	80
Figure 27: Consecutive READ BL8, CAL4, 1 ^t CK Preamble, Different Bank Group	80
Figure 28: Auto Self Refresh Ranges	83
Figure 29: MPR Block Diagram	84
Figure 30: MPR READ Timing	91
Figure 31: MPR Back-to-Back READ Timing	91
Figure 32: MPR READ-to-WRITE Timing	92
Figure 33: MPR WRITE and WRITE-to-READ Timing	93
Figure 34: MPR Back-to-Back WRITE Timing	94
Figure 35: REFRESH Timing	94
Figure 36: READ-to-REFRESH Timing	95
Figure 37: WRITE-to-REFRESH Timing	95
Figure 38: Clock Mode Change from 1/2 Rate to 1/4 Rate (Initialization)	98
Figure 39: Clock Mode Change After Exiting Self Refresh	98
Figure 40: Comparison Between Gear-Down Disable and Gear-Down Enable	99
Figure 41: Maximum Power-Saving Mode Entry	100
Figure 42: Maximum Power-Saving Mode Entry with PDA	101
Figure 43: Maintaining Maximum Power-Saving Mode with CKE Transition	101
Figure 44: Maximum Power-Saving Mode Exit	102
Figure 45: Command/Address Parity Operation	103
Figure 46: Command/Address Parity During Normal Operation	105
Figure 47: Persistent CA Parity Error Checking Operation	106
Figure 48: CA Parity Error Checking – SRE Attempt	106
Figure 49: CA Parity Error Checking – SRX Attempt	107
Figure 50: CA Parity Error Checking – PDE/PDX	107

Figure 51: Parity Entry Timing Example – t_{MRD_PAR}	108
Figure 52: Parity Entry Timing Example – t_{MOD_PAR}	108
Figure 53: Parity Exit Timing Example – t_{MRD_PAR}	109
Figure 54: Parity Exit Timing Example – t_{MOD_PAR}	109
Figure 55: CA Parity Flow Diagram	110
Figure 56: PDA Operation Enabled, BL8	112
Figure 57: PDA Operation Enabled, BC4	112
Figure 58: MRS PDA Exit	113
Figure 59: V_{REFDQ} Voltage Range	114
Figure 60: Example of V_{REF} Set Tolerance and Step Size	116
Figure 61: V_{REFDQ} Timing Diagram for $V_{REFtime}$ Parameter	117
Figure 62: V_{REFDQ} Training Mode Entry and Exit Timing Diagram	118
Figure 63: V_{REF} Step: Single Step Size Increment Case	119
Figure 64: V_{REF} Step: Single Step Size Decrement Case	119
Figure 65: V_{REF} Full Step: From V_{REFmin} to V_{REFmax} Case	120
Figure 66: V_{REF} Full Step: From V_{REFmax} to V_{REFmin} Case	120
Figure 67: V_{REFDQ} Equivalent Circuit	121
Figure 68: Connectivity Test Mode Entry	125
Figure 69: hPPR WRA – Entry	130
Figure 70: hPPR WRA – Repair and Exit	130
Figure 71: hPPR WR – Entry	131
Figure 72: hPPR WR – Repair and Exit	132
Figure 73: sPPR – Entry	134
Figure 74: sPPR – Repair, and Exit	135
Figure 75: t_{RRD} Timing	136
Figure 76: t_{FAW} Timing	136
Figure 77: REFRESH Command Timing	138
Figure 78: Postponing REFRESH Commands (Example)	138
Figure 79: Pulling In REFRESH Commands (Example)	138
Figure 80: TCR Mode Example ¹	140
Figure 81: 4Gb with Fine Granularity Refresh Mode Example	143
Figure 82: OTF REFRESH Command Timing	144
Figure 83: Self Refresh Entry/Exit Timing	147
Figure 84: Self Refresh Entry/Exit Timing with CAL Mode	148
Figure 85: Self Refresh Abort	149
Figure 86: Self Refresh Exit with NOP Command	150
Figure 87: Active Power-Down Entry and Exit	152
Figure 88: Power-Down Entry After Read and Read with Auto Precharge	153
Figure 89: Power-Down Entry After Write and Write with Auto Precharge	153
Figure 90: Power-Down Entry After Write	154
Figure 91: Precharge Power-Down Entry and Exit	154
Figure 92: REFRESH Command to Power-Down Entry	155
Figure 93: Active Command to Power-Down Entry	155
Figure 94: PRECHARGE/PRECHARGE ALL Command to Power-Down Entry	156
Figure 95: MRS Command to Power-Down Entry	156
Figure 96: Power-Down Entry/Exit Clarifications – Case 1	157
Figure 97: Active Power-Down Entry and Exit Timing with CAL	157
Figure 98: REFRESH Command to Power-Down Entry with CAL	158
Figure 99: ODT Power-Down Entry with ODT Buffer Disable Mode	159
Figure 100: ODT Power-Down Exit with ODT Buffer Disable Mode	160
Figure 101: CRC Write Data Operation	161
Figure 102: CRC Error Reporting	170

Figure 103: CA Parity Flow Diagram	171
Figure 104: 1 ^t CK vs. 2 ^t CK WRITE Preamble Mode	176
Figure 105: 1 ^t CK vs. 2 ^t CK WRITE Preamble Mode, ^t CCD = 4	177
Figure 106: 1 ^t CK vs. 2 ^t CK WRITE Preamble Mode, ^t CCD = 5	178
Figure 107: 1 ^t CK vs. 2 ^t CK WRITE Preamble Mode, ^t CCD = 6	178
Figure 108: 1 ^t CK vs. 2 ^t CK READ Preamble Mode	179
Figure 109: READ Preamble Training	180
Figure 110: WRITE Postamble	180
Figure 111: READ Postamble	181
Figure 112: Bank Group x4/x8 Block Diagram	182
Figure 113: READ Burst ^t CCD_S and ^t CCD_L Examples	183
Figure 114: Write Burst ^t CCD_S and ^t CCD_L Examples	183
Figure 115: ^t RRD Timing	184
Figure 116: ^t WTR_S Timing (WRITE-to-READ, Different Bank Group, CRC and DM Disabled)	184
Figure 117: ^t WTR_L Timing (WRITE-to-READ, Same Bank Group, CRC and DM Disabled)	185
Figure 118: Read Timing Definition	187
Figure 119: Clock-to-Data Strobe Relationship	188
Figure 120: Data Strobe-to-Data Relationship	189
Figure 121: ^t LZ and ^t HZ Method for Calculating Transitions and Endpoints	190
Figure 122: ^t RPRE Method for Calculating Transitions and Endpoints	191
Figure 123: ^t RPST Method for Calculating Transitions and Endpoints	192
Figure 124: READ Burst Operation, RL = 11 (AL = 0, CL = 11, BL8)	193
Figure 125: READ Burst Operation, RL = 21 (AL = 10, CL = 11, BL8)	194
Figure 126: Consecutive READ (BL8) with 1 ^t CK Preamble in Different Bank Group	195
Figure 127: Consecutive READ (BL8) with 2 ^t CK Preamble in Different Bank Group	195
Figure 128: Nonconsecutive READ (BL8) with 1 ^t CK Preamble in Same or Different Bank Group	196
Figure 129: Nonconsecutive READ (BL8) with 2 ^t CK Preamble in Same or Different Bank Group	196
Figure 130: READ (BC4) to READ (BC4) with 1 ^t CK Preamble in Different Bank Group	197
Figure 131: READ (BC4) to READ (BC4) with 2 ^t CK Preamble in Different Bank Group	197
Figure 132: READ (BL8) to READ (BC4) OTF with 1 ^t CK Preamble in Different Bank Group	198
Figure 133: READ (BL8) to READ (BC4) OTF with 2 ^t CK Preamble in Different Bank Group	198
Figure 134: READ (BC4) to READ (BL8) OTF with 1 ^t CK Preamble in Different Bank Group	199
Figure 135: READ (BC4) to READ (BL8) OTF with 2 ^t CK Preamble in Different Bank Group	199
Figure 136: READ (BL8) to WRITE (BL8) with 1 ^t CK Preamble in Same or Different Bank Group	200
Figure 137: READ (BL8) to WRITE (BL8) with 2 ^t CK Preamble in Same or Different Bank Group	200
Figure 138: READ (BC4) OTF to WRITE (BC4) OTF with 1 ^t CK Preamble in Same or Different Bank Group	201
Figure 139: READ (BC4) OTF to WRITE (BC4) OTF with 2 ^t CK Preamble in Same or Different Bank Group	202
Figure 140: READ (BC4) Fixed to WRITE (BC4) Fixed with 1 ^t CK Preamble in Same or Different Bank Group	202
Figure 141: READ (BC4) Fixed to WRITE (BC4) Fixed with 2 ^t CK Preamble in Same or Different Bank Group	203
Figure 142: READ (BC4) to WRITE (BL8) OTF with 1 ^t CK Preamble in Same or Different Bank Group	204
Figure 143: READ (BC4) to WRITE (BL8) OTF with 2 ^t CK Preamble in Same or Different Bank Group	204
Figure 144: READ (BL8) to WRITE (BC4) OTF with 1 ^t CK Preamble in Same or Different Bank Group	205
Figure 145: READ (BL8) to WRITE (BC4) OTF with 2 ^t CK Preamble in Same or Different Bank Group	205
Figure 146: READ to PRECHARGE with 1 ^t CK Preamble	206
Figure 147: READ to PRECHARGE with 2 ^t CK Preamble	207
Figure 148: READ to PRECHARGE with Additive Latency and 1 ^t CK Preamble	207
Figure 149: READ with Auto Precharge and 1 ^t CK Preamble	208
Figure 150: READ with Auto Precharge, Additive Latency, and 1 ^t CK Preamble	209
Figure 151: Consecutive READ (BL8) with 1 ^t CK Preamble and DBI in Different Bank Group	209
Figure 152: Consecutive READ (BL8) with 1 ^t CK Preamble and CA Parity in Different Bank Group	210
Figure 153: READ (BL8) to WRITE (BL8) with 1 ^t CK Preamble and CA Parity in Same or Different Bank Group ...	211

Figure 154: READ (BL8) to WRITE (BL8 or BC4: OTF) with 1 ^t CK Preamble and Write CRC in Same or Different Bank Group	212
Figure 155: READ (BC4: Fixed) to WRITE (BC4: Fixed) with 1 ^t CK Preamble and Write CRC in Same or Different Bank Group	213
Figure 156: Consecutive READ (BL8) with CAL (3 ^t CK) and 1 ^t CK Preamble in Different Bank Group	213
Figure 157: Consecutive READ (BL8) with CAL (4 ^t CK) and 1 ^t CK Preamble in Different Bank Group	214
Figure 158: Write Timing Definition	216
Figure 159: ^t WPRE Method for Calculating Transitions and Endpoints	217
Figure 160: ^t WPST Method for Calculating Transitions and Endpoints	218
Figure 161: Rx Compliance Mask	219
Figure 162: V _{CENT_DQ} V _{REFDQ} Voltage Variation	219
Figure 163: Rx Mask DQ-to-DQS Timings	220
Figure 164: Rx Mask DQ-to-DQS DRAM-Based Timings	221
Figure 165: Example of Data Input Requirements Without Training	222
Figure 166: WRITE Burst Operation, WL = 9 (AL = 0, CWL = 9, BL8)	223
Figure 167: WRITE Burst Operation, WL = 19 (AL = 10, CWL = 9, BL8)	224
Figure 168: Consecutive WRITE (BL8) with 1 ^t CK Preamble in Different Bank Group	224
Figure 169: Consecutive WRITE (BL8) with 2 ^t CK Preamble in Different Bank Group	225
Figure 170: Nonconsecutive WRITE (BL8) with 1 ^t CK Preamble in Same or Different Bank Group	226
Figure 171: Nonconsecutive WRITE (BL8) with 2 ^t CK Preamble in Same or Different Bank Group	226
Figure 172: WRITE (BC4) OTF to WRITE (BC4) OTF with 1 ^t CK Preamble in Different Bank Group	227
Figure 173: WRITE (BC4) OTF to WRITE (BC4) OTF with 2 ^t CK Preamble in Different Bank Group	228
Figure 174: WRITE (BC4) Fixed to WRITE (BC4) Fixed with 1 ^t CK Preamble in Different Bank Group	228
Figure 175: WRITE (BL8) to WRITE (BC4) OTF with 1 ^t CK Preamble in Different Bank Group	229
Figure 176: WRITE (BC4) OTF to WRITE (BL8) with 1 ^t CK Preamble in Different Bank Group	230
Figure 177: WRITE (BL8) to READ (BL8) with 1 ^t CK Preamble in Different Bank Group	230
Figure 178: WRITE (BL8) to READ (BL8) with 1 ^t CK Preamble in Same Bank Group	231
Figure 179: WRITE (BC4) OTF to READ (BC4) OTF with 1 ^t CK Preamble in Different Bank Group	232
Figure 180: WRITE (BC4) OTF to READ (BC4) OTF with 1 ^t CK Preamble in Same Bank Group	232
Figure 181: WRITE (BC4) Fixed to READ (BC4) Fixed with 1 ^t CK Preamble in Different Bank Group	233
Figure 182: WRITE (BC4) Fixed to READ (BC4) Fixed with 1 ^t CK Preamble in Same Bank Group	233
Figure 183: WRITE (BL8/BC4-OTF) to PRECHARGE with 1 ^t CK Preamble	234
Figure 184: WRITE (BC4-Fixed) to PRECHARGE with 1 ^t CK Preamble	235
Figure 185: WRITE (BL8/BC4-OTF) to Auto PRECHARGE with 1 ^t CK Preamble	235
Figure 186: WRITE (BC4-Fixed) to Auto PRECHARGE with 1 ^t CK Preamble	236
Figure 187: WRITE (BL8/BC4-OTF) with 1 ^t CK Preamble and DBI	237
Figure 188: WRITE (BC4-Fixed) with 1 ^t CK Preamble and DBI	238
Figure 189: Consecutive Write (BL8) with 1 ^t CK Preamble and CA Parity in Different Bank Group	239
Figure 190: Consecutive WRITE (BL8/BC4-OTF) with 1 ^t CK Preamble and Write CRC in Same or Different Bank Group	240
Figure 191: Consecutive WRITE (BC4-Fixed) with 1 ^t CK Preamble and Write CRC in Same or Different Bank Group	241
Figure 192: Nonconsecutive WRITE (BL8/BC4-OTF) with 1 ^t CK Preamble and Write CRC in Same or Different Bank Group	242
Figure 193: Nonconsecutive WRITE (BL8/BC4-OTF) with 2 ^t CK Preamble and Write CRC in Same or Different Bank Group	243
Figure 194: WRITE (BL8/BC4-OTF/Fixed) with 1 ^t CK Preamble and Write CRC in Same or Different Bank Group	244
Figure 195: ZQ Calibration Timing	247
Figure 196: Functional Representation of ODT	248
Figure 197: Synchronous ODT Timing with BL8	251
Figure 198: Synchronous ODT with BC4	251
Figure 199: ODT During Reads	252

Figure 200: Dynamic ODT (1 ^t CK Preamble; CL = 14, CWL = 11, BL = 8, AL = 0, CRC Disabled)	254
Figure 201: Dynamic ODT Overlapped with R _{TT(NOM)} (CL = 14, CWL = 11, BL = 8, AL = 0, CRC Disabled)	255
Figure 202: Asynchronous ODT Timings with DLL Off	256
Figure 203: V _{REFDQ} Voltage Range	259
Figure 204: RESET _n Input Slew Rate Definition	262
Figure 205: Single-Ended Input Slew Rate Definition	264
Figure 206: DQ Slew Rate Definitions	267
Figure 207: Rx Mask Relative to ^t DS/ ^t DH	269
Figure 208: Rx Mask Without Write Training	270
Figure 209: TEN Input Slew Rate Definition	271
Figure 210: CT Type-A Input Slew Rate Definition	272
Figure 211: CT Type-B Input Slew Rate Definition	272
Figure 212: CT Type-C Input Slew Rate Definition	273
Figure 213: CT Type-D Input Slew Rate Definition	274
Figure 214: Differential AC Swing and “Time Exceeding AC-Level” ^t DVAC	274
Figure 215: Single-Ended Requirements for CK	276
Figure 216: Differential Input Slew Rate Definition for CK _t , CK _c	277
Figure 217: V _{IX(CK)} Definition	278
Figure 218: Differential Input Signal Definition for DQS _t , DQS _c	279
Figure 219: DQS _t , DQS _c Input Peak Voltage Calculation and Range of Exempt non-Monotonic Signaling	280
Figure 220: V _{IXDQS} Definition	281
Figure 221: Differential Input Slew Rate and Input Level Definition for DQS _t , DQS _c	282
Figure 222: ADDR, CMD, CNTL Overshoot and Undershoot Definition	284
Figure 223: CK Overshoot and Undershoot Definition	285
Figure 224: Data, Strobe, and Mask Overshoot and Undershoot Definition	286
Figure 225: Single-ended Output Slew Rate Definition	287
Figure 226: Differential Output Slew Rate Definition	288
Figure 227: Reference Load For AC Timing and Output Slew Rate	289
Figure 228: Connectivity Test Mode Reference Test Load	290
Figure 229: Connectivity Test Mode Output Slew Rate Definition	290
Figure 230: Output Driver During Connectivity Test Mode	291
Figure 231: Output Driver: Definition of Voltages and Currents	292
Figure 232: Alert Driver	296
Figure 233: ODT Definition of Voltages and Currents	297
Figure 234: ODT Timing Reference Load	299
Figure 235: ^t ADC Definition with Direct ODT Control	300
Figure 236: ^t ADC Definition with Dynamic ODT Control	301
Figure 237: ^t AOFAS and ^t AONAS Definitions	301
Figure 238: Thermal Measurement Point	307
Figure 239: Measurement Setup and Test Load for I _{DDX} , I _{DDPx} , and I _{DDQX}	308
Figure 240: Correlation: Simulated Channel I/O Power to Actual Channel I/O Power	309

List of Tables

Table 1: Key Timing Parameters	2
Table 2: Addressing	2
Table 3: Ball Descriptions	24
Table 4: State Diagram Command Definitions	30
Table 5: Supply Power-up Slew Rate	32
Table 6: Address Pin Mapping	40
Table 7: MR0 Register Definition	40
Table 8: Burst Type and Burst Order	42
Table 9: Address Pin Mapping	44
Table 10: MR1 Register Definition	44
Table 11: Additive Latency (AL) Settings	46
Table 12: TDQS Function Matrix	47
Table 13: Address Pin Mapping	48
Table 14: MR2 Register Definition	48
Table 15: Address Pin Mapping	51
Table 16: MR3 Register Definition	51
Table 17: Address Pin Mapping	54
Table 18: MR4 Register Definition	54
Table 19: Address Pin Mapping	58
Table 20: MR5 Register Definition	58
Table 21: Address Pin Mapping	61
Table 22: MR6 Register Definition	61
Table 23: Truth Table – Command	64
Table 24: Truth Table – CKE	66
Table 25: MR Settings for Leveling Procedures	74
Table 26: DRAM TERMINATION Function in Leveling Mode	74
Table 27: Auto Self Refresh Mode	82
Table 28: MR3 Setting for the MPR Access Mode	84
Table 29: DRAM Address to MPR UI Translation	84
Table 30: MPR Page and MPRx Definitions	85
Table 31: MPR Readout Serial Format	87
Table 32: MPR Readout – Parallel Format	88
Table 33: MPR Readout Staggered Format, x4	89
Table 34: MPR Readout Staggered Format, x4 – Consecutive READs	90
Table 35: MPR Readout Staggered Format, x8 and x16	90
Table 36: Mode Register Setting for CA Parity	105
Table 37: V _{REFDQ} Range and Levels	115
Table 38: V _{REFDQ} Settings (V _{DDQ} = 1.2V)	121
Table 39: Connectivity Mode Pin Description and Switching Levels	123
Table 40: MAC Encoding of MPR Page 3 MPR3	126
Table 41: PPR MR0 Guard Key Settings	128
Table 42: DDR4 hPPR Timing Parameters DDR4-1600 through DDR4-3200	132
Table 43: sPPR Associated Rows	133
Table 44: PPR MR0 Guard Key Settings	133
Table 45: DDR4 sPPR Timing Parameters DDR4-1600 through DDR4-3200	135
Table 46: DDR4 Repair Mode Support Identifier	135
Table 47: Normal ⁴ REFI Refresh (TCR Disabled)	139
Table 48: Normal ⁴ REFI Refresh (TCR Enabled)	140
Table 49: MRS Definition	141
Table 50: REFRESH Command Truth Table	141



Table 51: t_{REFI} and t_{RFC} Parameters	142
Table 52: Power-Down Entry Definitions	151
Table 53: CRC Error Detection Coverage	162
Table 54: CRC Data Mapping for x4 Devices, BL8	164
Table 55: CRC Data Mapping for x8 Devices, BL8	164
Table 56: CRC Data Mapping for x16 Devices, BL8	165
Table 57: CRC Data Mapping for x4 Devices, BC4	165
Table 58: CRC Data Mapping for x8 Devices, BC4	166
Table 59: CRC Data Mapping for x16 Devices, BC4	167
Table 60: DBI vs. DM vs. TDQS Function Matrix	172
Table 61: DBI Write, DQ Frame Format (x8)	172
Table 62: DBI Write, DQ Frame Format (x16)	172
Table 63: DBI Read, DQ Frame Format (x8)	173
Table 64: DBI Read, DQ Frame Format (x16)	173
Table 65: DM vs. TDQS vs. DBI Function Matrix	174
Table 66: Data Mask, DQ Frame Format (x8)	174
Table 67: Data Mask, DQ Frame Format (x16)	174
Table 68: CWL Selection	177
Table 69: DDR4 Bank Group Timing Examples	182
Table 70: Read-to-Write and Write-to-Read Command Intervals	187
Table 71: Termination State Table	249
Table 72: Read Termination Disable Window	249
Table 73: ODT Latency at DDR4-1600/-1866/-2133/-2400/-2666/-3200	250
Table 74: Dynamic ODT Latencies and Timing (1^t CK Preamble Mode and CRC Disabled)	253
Table 75: Dynamic ODT Latencies and Timing with Preamble Mode and CRC Mode Matrix	254
Table 76: Absolute Maximum Ratings	257
Table 77: Temperature Range	257
Table 78: Recommended Supply Operating Conditions	258
Table 79: V_{DD} Slew Rate	258
Table 80: Leakages	259
Table 81: V_{REFDQ} Specification	260
Table 82: V_{REFDQ} Range and Levels	261
Table 83: RESET_n Input Levels (CMOS)	262
Table 84: Command and Address Input Levels: DDR4-1600 Through DDR4-2400	262
Table 85: Command and Address Input Levels: DDR4-2666	263
Table 86: Command and Address Input Levels: DDR4-2933 and DDR4-3200	263
Table 87: Single-Ended Input Slew Rates	264
Table 88: Command and Address Setup and Hold Values Referenced – AC/DC-Based	265
Table 89: Derating Values for t_{IS}/t_{IH} – AC100DC75-Based	265
Table 90: Derating Values for t_{IS}/t_{IH} – AC90/DC65-Based	266
Table 91: DQ Input Receiver Specifications	267
Table 92: Rx Mask and t_{DS}/t_{DH} without Write Training	270
Table 93: TEN Input Levels (CMOS)	270
Table 94: CT Type-A Input Levels	271
Table 95: CT Type-B Input Levels	272
Table 96: CT Type-C Input Levels (CMOS)	272
Table 97: CT Type-D Input Levels	273
Table 98: Differential Input Swing Requirements for CK_t, CK_c	275
Table 99: Minimum Time AC Time t_{DVAC} for CK	275
Table 100: Single-Ended Requirements for CK	276
Table 101: CK Differential Input Slew Rate Definition	276
Table 102: Cross Point Voltage For CK Differential Input Signals at DDR4-1600 through DDR4-2400	278

Table 103: Cross Point Voltage For CK Differential Input Signals at DDR4-2666 through DDR4-3200	278
Table 104: DDR4-1600 through DDR4-2400 Differential Input Swing Requirements for DQS_t, DQS_c	279
Table 105: DDR4-2633 through DDR4-3200 Differential Input Swing Requirements for DQS_t, DQS_c	279
Table 106: Cross Point Voltage For Differential Input Signals DQS	281
Table 107: DQS Differential Input Slew Rate Definition	282
Table 108: DDR4-1600 through DDR4-2400 Differential Input Slew Rate and Input Levels for DQS_t, DQS_c ...	282
Table 109: DDR4-2666 through DDR4-3200 Differential Input Slew Rate and Input Levels for DQS_t, DQS_c ...	283
Table 110: ADDR, CMD, CNTL Overshoot and Undershoot/Specifications	284
Table 111: CK Overshoot and Undershoot/ Specifications	284
Table 112: Data, Strobe, and Mask Overshoot and Undershoot/ Specifications	285
Table 113: Single-Ended Output Levels	286
Table 114: Single-Ended Output Slew Rate Definition	286
Table 115: Single-Ended Output Slew Rate	287
Table 116: Differential Output Levels	287
Table 117: Differential Output Slew Rate Definition	288
Table 118: Differential Output Slew Rate	289
Table 119: Connectivity Test Mode Output Levels	289
Table 120: Connectivity Test Mode Output Slew Rate	291
Table 121: Output Driver Electrical Characteristics During Connectivity Test Mode	292
Table 122: Strong Mode (34Ω) Output Driver Electrical Characteristics	293
Table 123: Weak Mode (48Ω) Output Driver Electrical Characteristics	294
Table 124: Output Driver Sensitivity Definitions	295
Table 125: Output Driver Voltage and Temperature Sensitivity	295
Table 126: Alert Driver Voltage	296
Table 127: ODT DC Characteristics	297
Table 128: ODT Sensitivity Definitions	298
Table 129: ODT Voltage and Temperature Sensitivity	299
Table 130: ODT Timing Definitions	299
Table 131: Reference Settings for ODT Timing Measurements	300
Table 132: DRAM Package Electrical Specifications for x4 and x8 Devices	302
Table 133: DRAM Package Electrical Specifications for x16 Devices	303
Table 134: Pad Input/Output Capacitance	305
Table 135: Thermal Characteristics	306
Table 136: Basic I _{DD} , I _{PP} , and I _{DDQ} Measurement Conditions	309
Table 137: I _{DD0} and I _{PP0} Measurement-Loop Pattern ¹	313
Table 138: I _{DD1} Measurement – Loop Pattern ¹	314
Table 139: I _{DD2N} , I _{DD3N} , and I _{PP3P} Measurement – Loop Pattern ¹	315
Table 140: I _{DD2NT} and I _{DDQ2NT} Measurement – Loop Pattern ¹	316
Table 141: I _{DD4R} Measurement – Loop Pattern ¹	317
Table 142: I _{DD4W} Measurement – Loop Pattern ¹	318
Table 143: I _{DD4WC} Measurement – Loop Pattern ¹	319
Table 144: I _{DD5R} Measurement – Loop Pattern ¹	320
Table 145: I _{DD7} Measurement – Loop Pattern ¹	321
Table 146: Timings used for I _{DD} , I _{PP} , and I _{DDQ} Measurement – Loop Patterns	322
Table 147: I _{DD} , I _{PP} , and I _{DDQ} Current Limits – Rev. B (–40° ≤ T _C ≤ 95°C)	323
Table 148: I _{DD} , I _{PP} , and I _{DDQ} Current Limits – Rev. B (–40° ≤ T _C ≤ 105°C)	324
Table 149: I _{DD} , I _{PP} , and I _{DDQ} Current Limits – Rev. B (–40° ≤ T _C ≤ 125°C)	326
Table 150: DDR4-1600 Speed Bins and Operating Conditions	328
Table 151: DDR4-1866 Speed Bins and Operating Conditions	329
Table 152: DDR4-2133 Speed Bins and Operating Conditions	330
Table 153: DDR4-2400 Speed Bins and Operating Conditions	331
Table 154: DDR4-2666 Speed Bins and Operating Conditions	332



Table 155: DDR4-2933 Speed Bins and Operating Conditions	333
Table 156: DDR4-3200 Speed Bins and Operating Conditions	335
Table 157: Refresh Parameters by Device Density	336
Table 158: Electrical Characteristics and AC Timing Parameters	337
Table 159: Electrical Characteristics and AC Timing Parameters	349

Important Notes and Warnings

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General Notes and Description

Description

The DDR4 SDRAM is a high-speed dynamic random-access memory internally configured as an eight-bank DRAM for the x16 configuration and as a 16-bank DRAM for the

x8 configurations. The DDR4 SDRAM uses an $8n$ -prefetch architecture to achieve high-speed operation. The $8n$ -prefetch architecture is combined with an interface designed to transfer two data words per clock cycle at the I/O pins.

A single READ or WRITE operation for the DDR4 SDRAM consists of a single $8n$ -bit wide, four-clock data transfer at the internal DRAM core and two corresponding n -bit wide, one-half-clock-cycle data transfers at the I/O pins.

Industrial Temperature

An industrial temperature (IT) device option requires that the case temperature not exceed below -40°C or above 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 and the input/output impedance must be derated when operating outside of the commercial temperature range ($0^{\circ}\text{C} \sim +85^{\circ}\text{C}$).

Automotive Temperature

The automotive temperature (AT) device option requires that the case temperature not exceed below -40°C or above 105°C . The specifications require the refresh rate to 2X when T_C exceeds 85°C ; 4X when T_C exceeds 95°C . Additionally, ODT resistance and the input/output impedance must be derated when operating outside of the commercial temperature range ($0^{\circ}\text{C} \sim +85^{\circ}\text{C}$).

Ultra-high Temperature

The ultra-high temperature (UT) device option requires that the case temperature not exceed below -40°C or above 125°C . The specifications require the refresh rate to 2X when T_C exceeds 85°C ; 4X when T_C exceeds 95°C , 8X when T_C exceeds 105°C . Additionally, ODT resistance and the input/output impedance must be derated when operating outside of the commercial temperature range ($0^{\circ}\text{C} \sim +85^{\circ}\text{C}$).

General Notes

- The functionality and the timing specifications discussed in this data sheet are for the DLL enable mode of operation (normal operation), unless specifically stated otherwise.
- 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.
- The terms "_t" and "_c" are used to represent the true and complement of a differential signal pair. These terms replace the previously used notation of "#" and/or overbar characters. For example, differential data strobe pair DQS, DQS# is now referred to as DQS_t, DQS_c.
- The term "_n" is used to represent a signal that is active LOW and replaces the previously used "#" and/or overbar characters. For example: CS# is now referred to as CS_n.
- The terms "DQS" and "CK" found throughout the data sheet are to be interpreted as DQS_t and DQS_c, and CK_t and CK_c respectively, unless specifically stated otherwise.
- Complete functionality may be described throughout the entire document; 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.
- Any functionality not specifically stated here within is considered undefined, illegal, and not supported, and can result in unknown operation.
- Addressing is denoted as BG[n] for bank group, BA[n] for bank address, and A[n] for row/col address.
- The NOP command is not allowed, except when exiting maximum power savings mode or when entering gear-down mode, and only a DES command should be used.
- Not all features described within this document may be available on the rev. A (first) version.
- Not all specifications listed are finalized industry standards; best conservative estimates have been provided when an industry standard has not been finalized.
- Although it is implied throughout the specification, the DRAM must be used after V_{DD} has reached the stable power-on level, which is achieved by toggling CKE at least once every $8192 \times t_{REFI}$. However, in the event CKE is fixed HIGH, toggling CS_n at least once every $8192 \times t_{REFI}$ is an acceptable alternative. Placing the DRAM into self refresh mode also alleviates the need to toggle CKE.
- Not all features designated in the data sheet may be supported by earlier die revisions due to late definition by JEDEC.

Definitions of the Device-Pin Signal Level

- HIGH: A device pin is driving the logic 1 state.
- LOW: A device pin is driving the logic 0 state.
- High-Z: A device pin is tri-state.
- ODT: A device pin terminates with the ODT setting, which could be terminating or tri-state depending on the mode register setting.

Definitions of the Bus Signal Level

- HIGH: One device on the bus is HIGH, and all other devices on the bus are either ODT or High-Z. The voltage level on the bus is nominally V_{DDQ} .
- LOW: One device on the bus is LOW, and all other devices on the bus are either ODT or High-Z. The voltage level on the bus is nominally $V_{OL(DC)}$ if ODT was enabled, or V_{SSQ} if High-Z.
- High-Z: All devices on the bus are High-Z. The voltage level on the bus is undefined as the bus is floating.
- ODT: At least one device on the bus is ODT, and all others are High-Z. The voltage level on the bus is nominally V_{DDQ} .

Functional Block Diagrams

DDR4 SDRAM is a high-speed, CMOS dynamic random access memory. It is internally configured as an 16-bank (4-banks per Bank Group) DRAM.

Figure 2: 512 Meg x 8 Functional Block Diagram

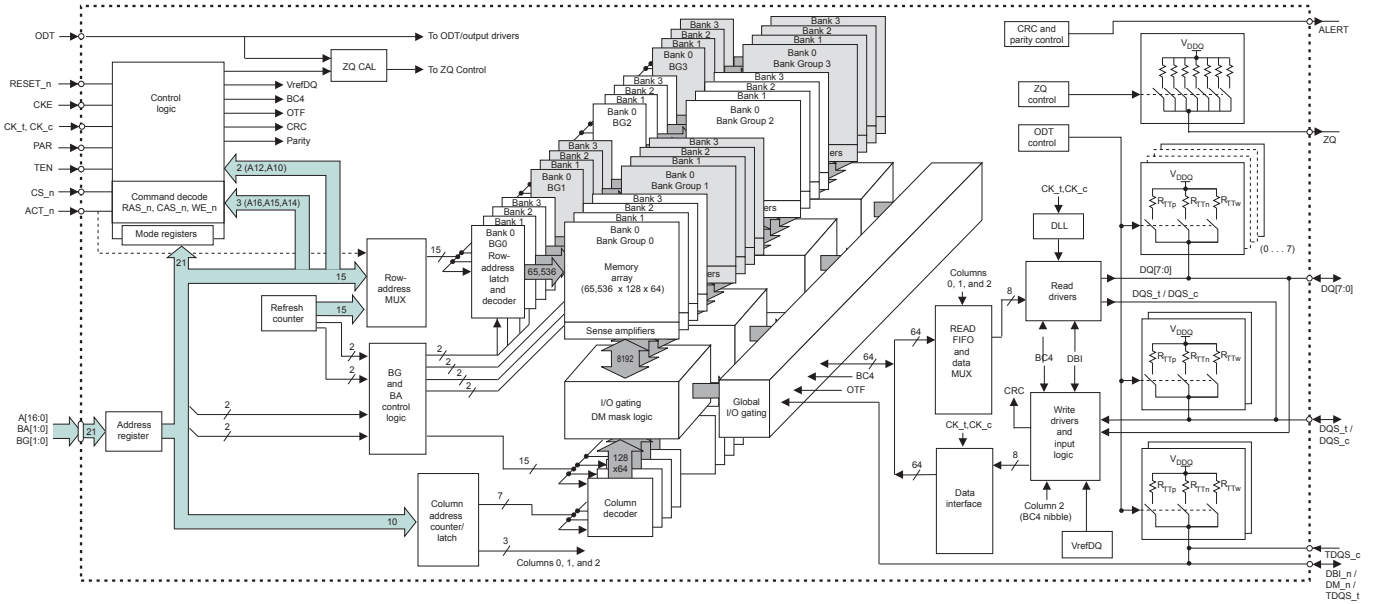
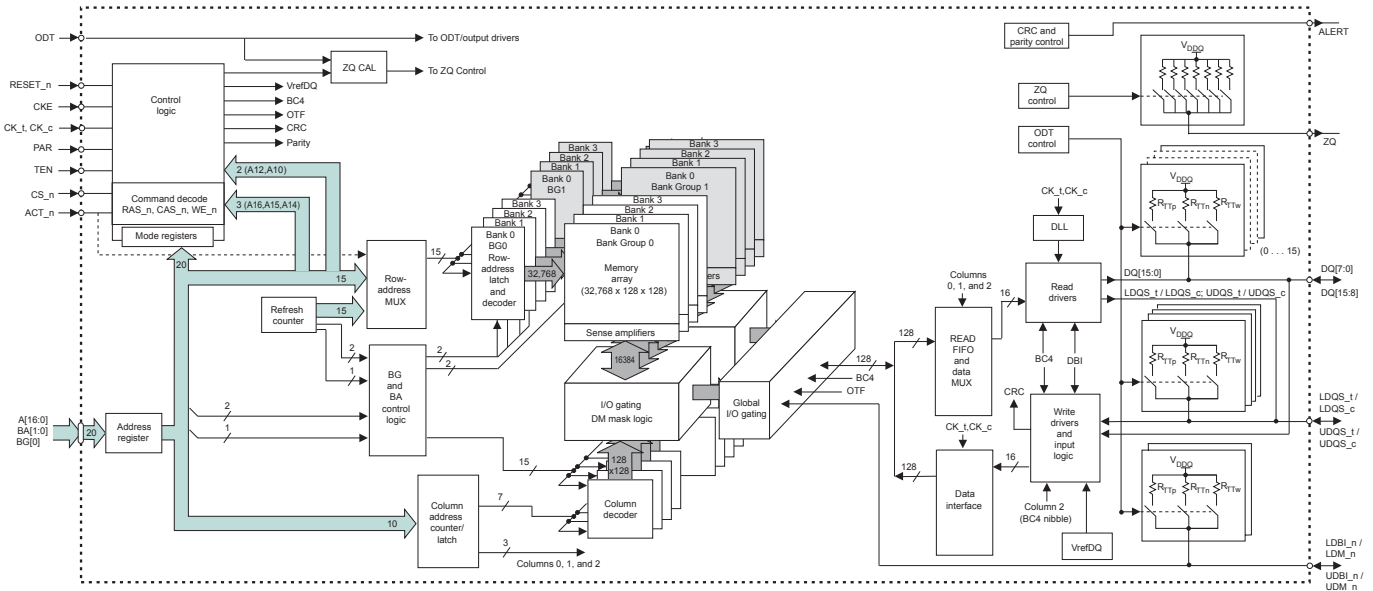
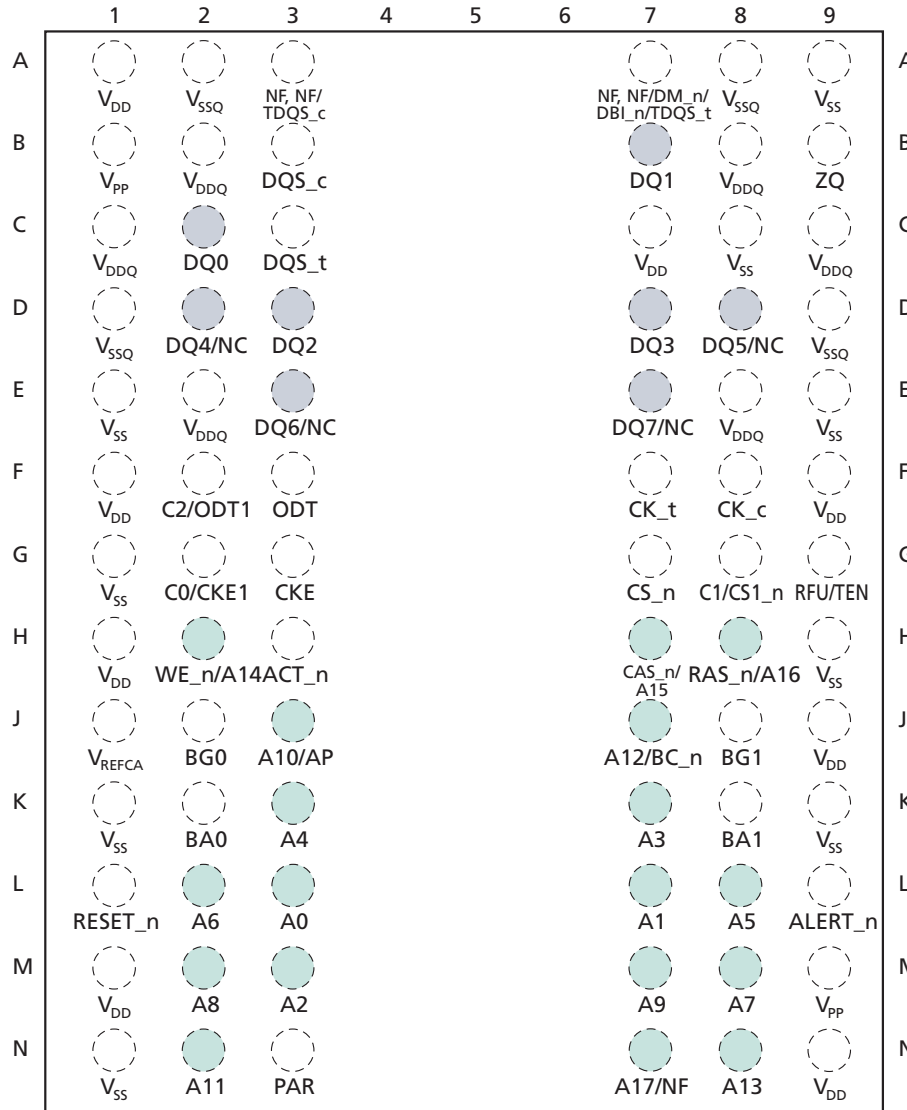


Figure 3: 256 Meg x 16 Functional Block Diagram



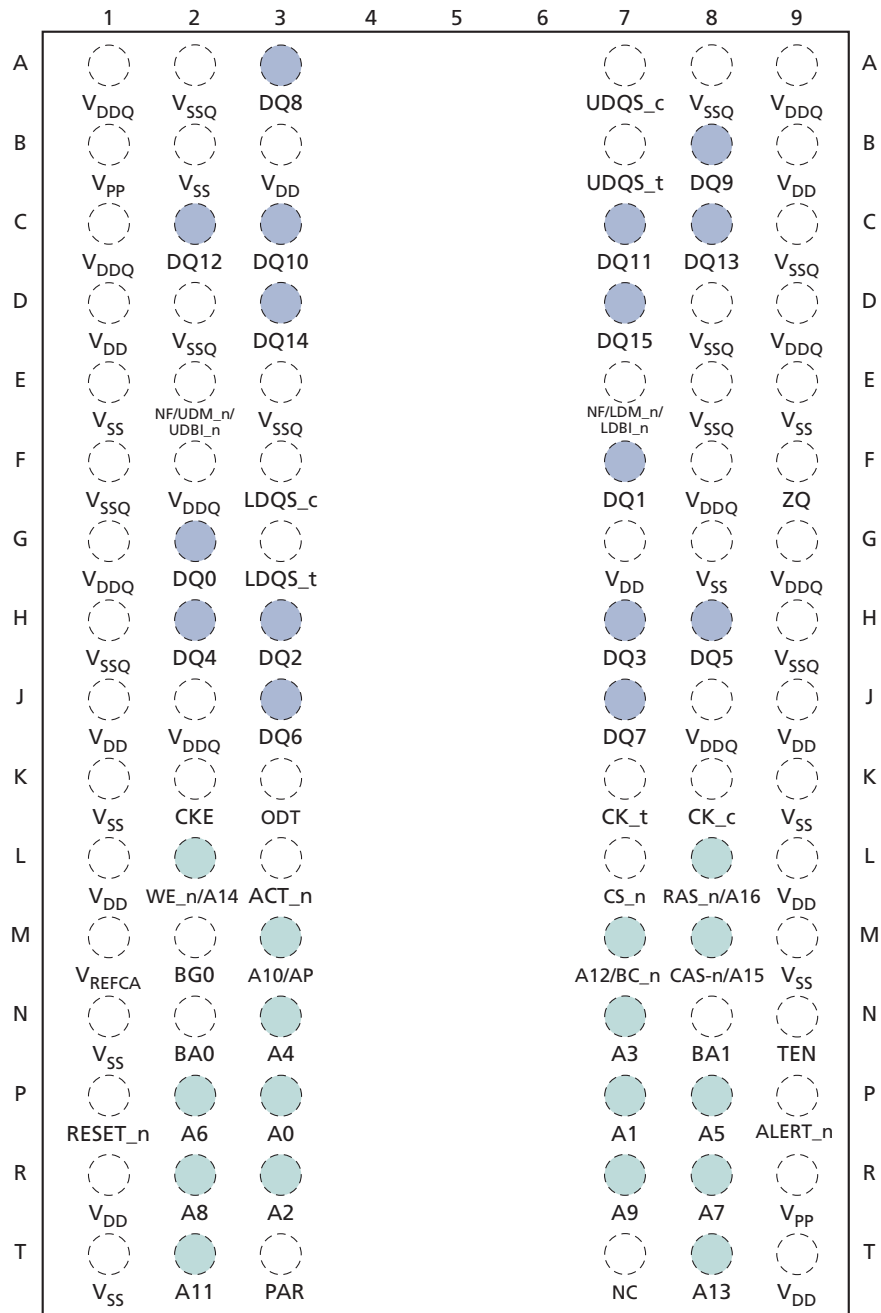
Ball Assignments

Figure 4: 78-Ball x4, x8 Ball Assignments



- Notes:
1. See Ball Descriptions.
 2. A comma "," separates the configuration; a slash "/" defines a selectable function. For example: Ball A7 = NF, NF/DM_n/DBI_n/TDQS_t where NF applies to the x4 configuration only. NF/DM_n/DBI_n/TDQS_t applies to the x8 configuration only and is selectable between NF, DM_n, DBI_n, or TDQS_t via MRS.
 3. Address bits (including bank groups) are density- and configuration-dependent (see Addressing).

Figure 5: 96-Ball x16 Ball Assignments



- Notes:
1. See Ball Descriptions.
 2. A slash "/" defines a selectable function. For example: Ball E7 = NF/LDM_n. If data mask is enabled via the MRS, ball E7 = LDM_n. If data mask is disabled in the MRS, E7 = NF (no function).
 3. Address bits (including bank groups) are density- and configuration-dependent (see Addressing).

Ball Descriptions

The pin description table below is a comprehensive list of all possible pins for DDR4 devices. All pins listed may not be supported on the device defined in this data sheet. See the Ball Assignments section to review all pins used on this device.

Table 3: Ball Descriptions

Symbol	Type	Description
A[17:0]	Input	Address inputs: Provide the row address for ACTIVATE commands and the column address for READ/WRITE commands to select one location out of the memory array in the respective bank. (A10/AP, A12/BC_n, WE_n/A14, CAS_n/A15, RAS_n/A16 have additional functions, see individual entries in this table.) The address inputs also provide the op-code during the MODE REGISTER SET command. A16 is used on some 8Gb and 16Gb parts, and A17 is only used on some 16Gb parts.
A10/AP	Input	Auto precharge: A10 is sampled during READ and WRITE commands to determine whether auto precharge should be performed to the accessed bank after a READ or WRITE operation. (HIGH = auto precharge; LOW = no auto precharge.) A10 is sampled during a PRECHARGE command to determine whether the PRECHARGE applies to one bank (A10 LOW) or all banks (A10 HIGH). If only one bank is to be precharged, the bank is selected by the bank group and bank addresses.
A12/BC_n	Input	Burst chop: A12/BC_n is sampled during READ and WRITE commands to determine if burst chop (on-the-fly) will be performed. (HIGH = no burst chop; LOW = burst chopped). See the Command Truth Table.
ACT_n	Input	Command input: ACT_n indicates an ACTIVATE command. When ACT_n (along with CS_n) is LOW, the input pins RAS_n/A16, CAS_n/A15, and WE_n/A14 are treated as row address inputs for the ACTIVATE command. When ACT_n is HIGH (along with CS_n LOW), the input pins RAS_n/A16, CAS_n/A15, and WE_n/A14 are treated as normal commands that use the RAS_n, CAS_n, and WE_n signals. See the Command Truth Table.
BA[1:0]	Input	Bank address inputs: Define the bank (within a bank group) to which an ACTIVATE, READ, WRITE, or PRECHARGE command is being applied. Also determines which mode register is to be accessed during a MODE REGISTER SET command.
BG[1:0]	Input	Bank group address inputs: Define the bank group to which an ACTIVATE, READ, WRITE, or PRECHARGE command is being applied. Also determines which mode register is to be accessed during a MODE REGISTER SET command. BG[1:0] are used in the x4 and x8 configurations. BG1 is not used in the x16 configuration.
C0/CKE1, C1/CS1_n, C2/ODT1	Input	Stack address inputs: These inputs are used only when devices are stacked; that is, they are used in 2H, 4H, and 8H stacks for x4 and x8 configurations (these pins are not used in the x16 configuration). DDR4 will support a traditional DDP package, which uses these three signals for control of the second die (CS1_n, CKE1, ODT1). DDR4 is not expected to support a traditional QDP package. For all other stack configurations, such as a 4H or 8H, it is assumed to be a single-load (master/slave) type of configuration where C0, C1, and C2 are used as chip ID selects in conjunction with a single CS_n, CKE, and ODT signal.
CK_t, CK_c	Input	Clock: Differential clock inputs. All address, command, and control input signals are sampled on the crossing of the positive edge of CK_t and the negative edge of CK_c.

Table 3: Ball Descriptions (Continued)

Symbol	Type	Description
CKE	Input	Clock enable: CKE HIGH activates and CKE LOW deactivates the internal clock signals, device input buffers, and output drivers. Taking CKE LOW provides PRECHARGE POWER-DOWN and SELF REFRESH operations (all banks idle), or active power-down (row active in any bank). CKE is asynchronous for self refresh exit. After V_{REFCA} has become stable during the power-on and initialization sequence, it must be maintained during all operations (including SELF REFRESH). CKE must be maintained HIGH throughout read and write accesses. Input buffers (excluding CK_t, CK_c, ODT, RESET_n, and CKE) are disabled during power-down. Input buffers (excluding CKE and RESET_n) are disabled during self refresh.
CS_n	Input	Chip select: All commands are masked when CS_n is registered HIGH. CS_n provides for external rank selection on systems with multiple ranks. CS_n is considered part of the command code.
DM_n, UDM_n LDM_n	Input	Input data mask: DM_n is an input mask signal for write data. Input data is masked when DM is sampled LOW coincident with that input data during a write access. DM is sampled on both edges of DQS. DM is not supported on x4 configurations. The UDM_n and LDM_n pins are used in the x16 configuration: UDM_n is associated with DQ[15:8]; LDM_n is associated with DQ[7:0]. The DM, DBI, and TDQS functions are enabled by mode register settings. See the Data Mask section.
ODT	Input	On-die termination: ODT (registered HIGH) enables termination resistance internal to the DDR4 SDRAM. When enabled, ODT (R_{TT}) is applied only to each DQ, DQS_t, DQS_c, DM_n/DBI_n/TDQS_t, and TDQS_c signal for the x4 and x8 configurations (when the TDQS function is enabled via mode register). For the x16 configuration, R_{TT} is applied to each DQ, UDQS_t, UDQS_c, LDQS_t, LDQS_c, UDM_n, and LDM_n signal. The ODT pin will be ignored if the mode registers are programmed to disable R_{TT} .
PAR	Input	Parity for command and address: This function can be enabled or disabled via the mode register. When enabled, the parity signal covers all command and address inputs, including ACT_n, RAS_n/A16, CAS_n/A15, WE_n/A14, A[17:0], A10/AP, A12/BC_n, BA[1:0], and BG[1:0] with C0, C1, and C2 on 3DS only devices. Control pins NOT covered by the parity signal are CS_n, CKE, and ODT. Unused address pins that are density- and configuration-specific should be treated internally as 0s by the DRAM parity logic. Command and address inputs will have parity check performed when commands are latched via the rising edge of CK_t and when CS_n is LOW.
RAS_n/A16, CAS_n/A15, WE_n/A14	Input	Command inputs: RAS_n/A16, CAS_n/A15, and WE_n/A14 (along with CS_n and ACT_n) define the command and/or address being entered. See the ACT_n description in this table.
RESET_n	Input	Active LOW asynchronous reset: Reset is active when RESET_n is LOW, and inactive when RESET_n is HIGH. RESET_n must be HIGH during normal operation. RESET_n is a CMOS rail-to-rail signal with DC HIGH and LOW at 80% and 20% of V_{DD} (960 mV for DC HIGH and 240 mV for DC LOW).
TEN	Input	Connectivity test mode: TEN is active when HIGH and inactive when LOW. TEN must be LOW during normal operation. TEN is a CMOS rail-to-rail signal with DC HIGH and LOW at 80% and 20% of V_{DD} (960mV for DC HIGH and 240mV for DC LOW).