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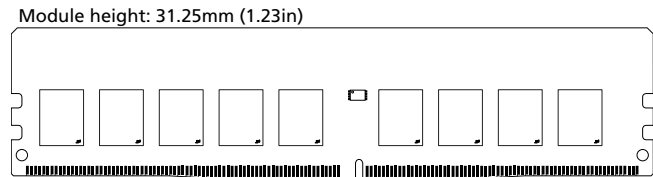
DDR4 SDRAM UDIMM

MTA16ATF1G64AZ – 8GB

Features

- DDR4 functionality and operations supported as defined in the component data sheet
- 288-pin, unbuffered dual in-line memory module (UDIMM)
- Fast data transfer rates: PC4-2666, PC4-2400, and PC4-2133
- 8GB (1 Gig x 64)
- $V_{DD} = 1.20V$ (NOM)
- $V_{PP} = 2.5V$ (NOM)
- $V_{DDSPD} = 2.5V$ (NOM)
- Nominal and dynamic on-die termination (ODT) for data, strobe, and mask signals
- Low-power auto self refresh (LPASR)
- Data bus inversion (DBI) for data bus
- On-die V_{REFDQ} generation and calibration
- Dual-rank
- On-board serial presence-detect (SPD) EEPROM
- 16 internal banks; 4 groups of 4 banks each
- Fixed burst chop (BC) of 4 and burst length (BL) of 8 via the mode register set (MRS)
- Selectable BC4 or BL8 on-the-fly (OTF)
- Gold edge contacts
- Halogen-free
- Fly-by topology
- Terminated control, command, and address bus

Figure 1: 288-Pin UDIMM (MO-309, R/C-B, R/C-B1)



Options

- Operating temperature
 - Commercial ($0^{\circ}C \leq T_{OPER} \leq 95^{\circ}C$)
- Package
 - 288-pin DIMM (halogen-free)
- Frequency/CAS latency
 - 0.75ns @ CL = 19 (DDR4-2666)
 - 0.83ns @ CL = 17 (DDR4-2400)
 - 0.93ns @ CL = 15 (DDR4-2133)

Marking

None
Z
-2G6
-2G3
-2G1

Table 1: Key Timing Parameters

| Speed Grade | Industry Nomenclature | Data Rate (MT/s) | | | | | | | | | | | t_{RCD} (ns) | t_{RP} (ns) | t_{RC} (ns) |
|-------------|-----------------------|------------------|---------|---------|---------|---------|---------|---------|---------|---------|---------|--------|----------------|---------------|---------------|
| | | CL = 20, CL = 19 | CL = 18 | CL = 17 | CL = 16 | CL = 15 | CL = 14 | CL = 13 | CL = 12 | CL = 11 | CL = 10 | CL = 9 | | | |
| -2G6 | PC4-2666 | 2666 | 2666 | 2400 | 2133 | 2133 | 1866 | 1866 | 1600 | – | 1333 | – | 14.16 | 14.16 | 46.16 |
| -2G4 | PC4-2400 | – | 2400 | 2400 | 2400 | 2133 | 1866 | 1866 | 1600 | 1600 | – | 1333 | 13.32 | 13.32 | 45.32 |
| -2G3 | PC4-2400 | – | 2400 | 2400 | 2133 | 2133 | 1866 | 1866 | 1600 | 1600 | 1333 | – | 14.16 | 14.16 | 46.16 |
| -2G1 | PC4-2133 | – | – | – | 2133 | 2133 | 1866 | 1866 | 1600 | 1600 | – | 1333 | 13.5 | 13.5 | 46.5 |

Table 2: Addressing

| Parameter | 8GB |
|-------------------------------|-----------------------------|
| Row address | 32K A[14:0] |
| Column address | 1K A[9:0] |
| Device bank group address | 4 BG[1:0] |
| Device bank address per group | 4 BA[1:0] |
| Device configuration | 4Gb (512 Meg x 8), 16 banks |
| Module rank address | 2 CS_n[1:0] |

Table 3: Part Numbers and Timing Parameters – 8GB Modules

 Base device: MT40A512M8,¹ 4Gb DDR4 SDRAM

| Part Number ² | Module Density | Configuration | Module Bandwidth | Memory Clock/ Data Rate | Clock Cycles (CL- ^t RCD- ^t RP) |
|--------------------------|----------------|---------------|------------------|----------------------------|---|
| MTA16ATF1G64AZ-2G6__ | 8GB | 1 Gig x 64 | 21.3 GB/s | 0.75ns/2666 MT/s | 19-19-19 |
| MTA16ATF1G64AZ-2G3__ | 8GB | 1 Gig x 64 | 19.2 GB/s | 0.83ns/2400 MT/s | 17-17-17 |
| MTA16ATF1G64AZ-2G1__ | 8GB | 1 Gig x 64 | 17.0 GB/s | 0.93ns/2133 MT/s | 15-15-15 |

- Notes:
1. The data sheet for the base device can be found on Micron's web site.
 2. All part numbers end with a two-place code (not shown) that designates component and PCB revisions. Consult factory for current revision codes. Example: MTA16ATF1G64AZ-2G3B1.



Pin Assignments

The pin assignment table below is a comprehensive list of all possible pin assignments for DDR4 UDIMM modules. See Functional Block Diagram for pins specific to this module.

Table 4: Pin Assignments

| 288-Pin DDR4 UDIMM Front | | | | | | | | 288-Pin DDR4 UDIMM Back | | | | | | | |
|--------------------------|-------------------------|-----|-------------------------|-----|-----------------|-----|-------------------------|-------------------------|--------------------|-----|-----------------|-----|-----------------|-----|-----------------|
| Pin | Symbol | Pin | Symbol | Pin | Symbol | Pin | Symbol | Pin | Symbol | Pin | Symbol | Pin | Symbol | Pin | Symbol |
| 1 | NC | 37 | V _{SS} | 73 | V _{DD} | 109 | V _{SS} | 145 | NC | 181 | DQ29 | 217 | V _{DD} | 253 | DQ41 |
| 2 | V _{SS} | 38 | DQ24 | 74 | CK0_t | 110 | DM5_n/ DBI5_n, NC | 146 | V _{REFCA} | 182 | V _{SS} | 218 | CK1_t | 254 | V _{SS} |
| 3 | DQ4 | 39 | V _{SS} | 75 | CK0_c | 111 | NC | 147 | V _{SS} | 183 | DQ25 | 219 | CK1_c | 255 | DQS5_c |
| 4 | V _{SS} | 40 | DM3_n/ DBI3_n, NC | 76 | V _{DD} | 112 | V _{SS} | 148 | DQ5 | 184 | V _{SS} | 220 | V _{DD} | 256 | DQS5_t |
| 5 | DQ0 | 41 | NC | 77 | V _{TT} | 113 | DQ46 | 149 | V _{SS} | 185 | DQS3_c | 221 | V _{TT} | 257 | V _{SS} |
| 6 | V _{SS} | 42 | V _{SS} | 78 | EVENT_n, NF | 114 | V _{SS} | 150 | DQ1 | 186 | DQS3_t | 222 | PARITY | 258 | DQ47 |
| 7 | DM0_n/ DBI0_n, NC | 43 | DQ30 | 79 | A0 | 115 | DQ42 | 151 | V _{SS} | 187 | V _{SS} | 223 | V _{DD} | 259 | V _{SS} |
| 8 | NC | 44 | V _{SS} | 80 | V _{DD} | 116 | V _{SS} | 152 | DQS0_c | 188 | DQ31 | 224 | BA1 | 260 | DQ43 |
| 9 | V _{SS} | 45 | DQ26 | 81 | BA0 | 117 | DQ52 | 153 | DQS0_t | 189 | V _{SS} | 225 | A10_AP | 261 | V _{SS} |
| 10 | DQ6 | 46 | V _{SS} | 82 | RAS_n/ A16 | 118 | V _{SS} | 154 | V _{SS} | 190 | DQ27 | 226 | V _{DD} | 262 | DQ53 |
| 11 | V _{SS} | 47 | CB4/ NC | 83 | V _{DD} | 119 | DQ48 | 155 | DQ7 | 191 | V _{SS} | 227 | NC | 263 | V _{SS} |
| 12 | DQ2 | 48 | V _{SS} | 84 | CS0_n | 120 | V _{SS} | 156 | V _{SS} | 192 | CB5, NC | 228 | WE_n/ A14 | 264 | DQ49 |
| 13 | V _{SS} | 49 | CB0/ NC | 85 | V _{DD} | 121 | DM6_n/ DBI6_n, NC | 157 | DQ3 | 193 | V _{SS} | 229 | V _{DD} | 265 | V _{SS} |
| 14 | DQ12 | 50 | V _{SS} | 86 | CAS_n/ A15 | 122 | NC | 158 | V _{SS} | 194 | CB1, NC | 230 | NC | 266 | DQS6_c |
| 15 | V _{SS} | 51 | DM8_n/ DBI8_n, NC | 87 | ODT0 | 123 | V _{SS} | 159 | DQ13 | 195 | V _{SS} | 231 | V _{DD} | 267 | DQS6_t |
| 16 | DQ8 | 52 | NC | 88 | V _{DD} | 124 | DQ54 | 160 | V _{SS} | 196 | DQS8_c | 232 | A13 | 268 | V _{SS} |
| 17 | V _{SS} | 53 | V _{SS} | 89 | CS1_n, NC | 125 | V _{SS} | 161 | DQ9 | 197 | DQS8_t | 233 | V _{DD} | 269 | DQ55 |
| 18 | DMI_n/ DBI1_n, NC | 54 | CB6/ DBI8_n, NC | 90 | V _{DD} | 126 | DQ50 | 162 | V _{SS} | 198 | V _{SS} | 234 | NC | 270 | V _{SS} |
| 19 | NC | 55 | V _{SS} | 91 | ODT1, NC | 127 | V _{SS} | 163 | DQS1_c | 199 | CB7, NC | 235 | NC | 271 | DQ51 |
| 20 | V _{SS} | 56 | CB2/ NC | 92 | V _{DD} | 128 | DQ60 | 164 | DQS1_t | 200 | V _{SS} | 236 | V _{DD} | 272 | V _{SS} |
| 21 | DQ14 | 57 | V _{SS} | 93 | NC | 129 | V _{SS} | 165 | V _{SS} | 201 | CB3, NC | 237 | NC | 273 | DQ61 |
| 22 | V _{SS} | 58 | RESET_n | 94 | V _{SS} | 130 | DQ56 | 166 | DQ15 | 202 | V _{SS} | 238 | SA2 | 274 | V _{SS} |
| 23 | DQ10 | 59 | V _{DD} | 95 | DQ36 | 131 | V _{SS} | 167 | V _{SS} | 203 | CKE1, NC | 239 | V _{SS} | 275 | DQ57 |



8GB (x64, DR) 288-Pin DDR4 UDIMM Pin Assignments

Table 4: Pin Assignments (Continued)

| 288-Pin DDR4 UDIMM Front | | | | | | | | 288-Pin DDR4 UDIMM Back | | | | | | | |
|--------------------------|-------------------------|-----|-----------------|-----|-------------------------|-----|-------------------------|-------------------------|-----------------|-----|-----------------|-----|-----------------|-----|--------------------|
| Pin | Symbol | Pin | Symbol | Pin | Symbol | Pin | Symbol | Pin | Symbol | Pin | Symbol | Pin | Symbol | Pin | Symbol |
| 24 | V _{SS} | 60 | CKE0 | 96 | V _{SS} | 132 | DM7_n/ DBI7_n, NC | 168 | DQ11 | 204 | V _{DD} | 240 | DQ37 | 276 | V _{SS} |
| 25 | DQ20 | 61 | V _{DD} | 97 | DQ32 | 133 | NC | 169 | V _{SS} | 205 | NC | 241 | V _{SS} | 277 | DQS7_c |
| 26 | V _{SS} | 62 | ACT_n | 98 | V _{SS} | 134 | V _{SS} | 170 | DQ21 | 206 | V _{DD} | 242 | DQ33 | 278 | DQS7_t |
| 27 | DQ16 | 63 | BG0 | 99 | DM4_n/ DBI4_n, NC | 135 | DQ62 | 171 | V _{SS} | 207 | BG1 | 243 | V _{SS} | 279 | V _{SS} |
| 28 | V _{SS} | 64 | V _{DD} | 100 | NC | 136 | V _{SS} | 172 | DQ17 | 208 | ALERT_n | 244 | DQS4_c | 280 | DQ63 |
| 29 | DM2_n/ DBI2_n, NC | 65 | A12/BC_n | 101 | V _{SS} | 137 | DQ58 | 173 | V _{SS} | 209 | V _{DD} | 245 | DQS4_t | 281 | V _{SS} |
| 30 | NC | 66 | A9 | 102 | DQ38 | 138 | V _{SS} | 174 | DQS2_c | 210 | A11 | 246 | V _{SS} | 282 | DQ59 |
| 31 | V _{SS} | 67 | V _{DD} | 103 | V _{SS} | 139 | SA0 | 175 | DQS2_t | 211 | A7 | 247 | DQ39 | 283 | V _{SS} |
| 32 | DQ22 | 68 | A8 | 104 | DQ34 | 140 | SA1 | 176 | V _{SS} | 212 | V _{DD} | 248 | V _{SS} | 284 | V _{DDSPD} |
| 33 | V _{SS} | 69 | A6 | 105 | V _{SS} | 141 | SCL | 177 | DQ23 | 213 | A5 | 249 | DQ35 | 285 | SDA |
| 34 | DQ18 | 70 | V _{DD} | 106 | DQ44 | 142 | V _{PP} | 178 | V _{SS} | 214 | A4 | 250 | V _{SS} | 286 | V _{PP} |
| 35 | V _{SS} | 71 | A3 | 107 | V _{SS} | 143 | V _{PP} | 179 | DQ19 | 215 | V _{DD} | 251 | DQ45 | 287 | V _{PP} |
| 36 | DQ28 | 72 | A1 | 108 | DQ40 | 144 | NC | 180 | V _{SS} | 216 | A2 | 252 | V _{SS} | 288 | V _{PP} |

Pin Descriptions

The pin description table below is a comprehensive list of all possible pins for DDR4 modules. All pins listed may not be supported on this module. See Functional Block Diagram for pins specific to this module.

Table 5: Pin Descriptions

| Symbol | Type | Description |
|-----------------------------------|-------|---|
| Ax | Input | Address inputs: Provide the row address for ACTIVATE commands and the column address for READ/WRITE commands in order to select one location out of the memory array in the respective bank (A10/AP, A12/BC_n, WE_n/A14, CAS_n/A15, and 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. A17 is only defined for x4 SDRAM. |
| A10/AP | Input | Auto precharge: A10 is sampled during READ and WRITE commands to determine whether an auto precharge should be performed on 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 Command Truth Table in the DDR4 component data sheet. |
| ACT_n | Input | Command input: ACT_n defines the ACTIVATE command being entered along with CS_n. The input into RAS_n/A16, CAS_n/A15, and WE_n/A14 are considered as row address A16, A15, and A14. See Command Truth Table. |
| BAx | Input | Bank address inputs: Define the bank (with a bank group) to which an ACTIVATE, READ, WRITE, or PRECHARGE command is being applied. Also determine which mode register is to be accessed during a MODE REGISTER SET command. |
| BGx | Input | Bank group address inputs: Define the bank group to which a REFRESH, ACTIVATE, READ, WRITE, or PRECHARGE command is being applied. Also determine which mode register is to be accessed during a MODE REGISTER SET command. BG[1:0] are used in the x4 and x8 configurations. x16-based SDRAM only has BG0. |
| C0, C1, C2 (RDIMM/LRDIMM only) | Input | Chip ID: These inputs are used only when devices are stacked; that is, 2H, 4H, and 8H stacks for x4 and x8 configurations using through-silicon vias (TSVs). These pins are not used in the x16 configuration. Some DDR4 modules support a traditional DDP package, which uses CS1_n, CKE1, and ODT1 to control the second die. All other stack configurations, such as a 4H or 8H, are assumed to be single-load (master/slave) type configurations where C0, C1, and C2 are used as chip ID selects in conjunction with a single CS_n, CKE, and ODT. Chip ID is considered part of the command code. |
| CKx_t CKx_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. |
| CKEx | 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#) are disabled during self refresh. |
| CSx_n | Input | Chip select: All commands are masked when CS_n is registered HIGH. CS_n provides external rank selection on systems with multiple ranks. CS_n is considered part of the command code (CS2_n and CS3_n are not used on UDIMMs). |

Table 5: Pin Descriptions (Continued)

| Symbol | Type | Description |
|---|------------|--|
| ODTx | 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 x4 and x8 configurations (when the TDQS function is enabled via the mode register). For the x16 configuration, R_{TT} is applied to each DQ, DQSU _t , DQSU _c , DQSL _t , DQSL _c , UDM _n , and LDM _n signal. The ODT pin will be ignored if the mode registers are programmed to disable R_{TT} . |
| PARITY | Input | Parity for command and address: This function can be enabled or disabled via the mode register. When enabled in MR5, the DRAM calculates parity with ACT _n , RAS _n /A16, CAS _n /A15, WE _n /A14, BG[1:0], BA[1:0], A[16:0]. Input parity should be maintained at the rising edge of the clock and at the same time as command and address with CS _n 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) define the command and/or address being entered and have multiple functions. For example, for activation with ACT _n LOW, these are addresses like A16, A15, and A14, but for a non-activation command with ACT _n HIGH, these are command pins for READ, WRITE, and other commands defined in Command Truth Table. |
| RESET _n | CMOS 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. |
| SAX | Input | Serial address inputs: Used to configure the temperature sensor/SPD EEPROM address range on the I ² C bus. |
| SCL | Input | Serial clock for temperature sensor/SPD EEPROM: Used to synchronize communication to and from the temperature sensor/SPD EEPROM on the I ² C bus. |
| DQx, CBx | I/O | Data input/output and check bit input/output: Bidirectional data bus. DQ represents DQ[3:0], DQ[7:0], and DQ[15:0] for the x4, x8, and x16 configurations, respectively. If cyclic redundancy checksum (CRC) is enabled via the mode register, the CRC code is added at the end of the data burst. Any one or all of DQ0, DQ1, DQ2, or DQ3 may be used for monitoring of internal V_{REF} level during test via mode register setting MR[4] A[4] = HIGH; training times change when enabled. |
| DM _n /DBI _n / TDQS _t (DMU _n , DBIU _n), (DML _n / DBIL _n) | I/O | Input data mask and data bus inversion: DM _n is an input mask signal for write data. Input data is masked when DM _n is sampled LOW coincident with that input data during a write access. DM _n is sampled on both edges of DQS. DM is multiplexed with the DBI function by the mode register A10, A11, and A12 settings in MR5. For a x8 device, the function of DM or TDQS is enabled by the mode register A11 setting in MR1. DBI _n is an input/output identifying whether to store/output the true or inverted data. If DBI _n is LOW, the data will be stored/output after inversion inside the DDR4 device and not inverted if DBI _n is HIGH. TDQS is only supported in x8 SDRAM configurations (TDQS is not valid for UDIMMs). |
| SDA | I/O | Serial Data: Bidirectional signal used to transfer data in or out of the EEPROM or EEPROM/TS combo device. |
| DQS _t DQS _c DQSU _t DQSU _c DQSL _t DQSL _c | I/O | Data strobe: Output with read data, input with write data. Edge-aligned with read data, centered-aligned with write data. For x16 configurations, DQSL corresponds to the data on DQ[7:0], and DQSU corresponds to the data on DQ[15:8]. For the x4 and x8 configurations, DQS corresponds to the data on DQ[3:0] and DQ[7:0], respectively. DDR4 SDRAM supports a differential data strobe only and does not support a single-ended data strobe. |
| ALERT _n | Output | Alert output: Possesses functions such as CRC error flag and command and address parity error flag as output signal. If a CRC error occurs, ALERT _n goes LOW for the period time interval and returns HIGH. If an error occurs during a command address parity check, ALERT _n goes LOW until the on-going DRAM internal recovery transaction is complete. During connectivity test mode, this pin functions as an input. Use of this signal is system-dependent. If not connected as signal, ALERT _n pin must be connected to V_{DD} on DIMMs. |
| EVENT _n | Output | Temperature event: The EVENT _n pin is asserted by the temperature sensor when critical temperature thresholds have been exceeded. This pin has no function (NF) on modules without temperature sensors. |

Table 5: Pin Descriptions (Continued)

| Symbol | Type | Description |
|---|--------|--|
| TDQS_t TDQS_c (x8 DRAM-based RDIMM only) | Output | Termination data strobe: When enabled via the mode register, the DRAM device enables the same R_{TT} termination resistance on TDQS_t and TDQS_c that is applied to DQS_t and DQS_c. When the TDQS function is disabled via the mode register, the DM/TDQS_t pin provides the data mask (DM) function, and the TDQS_c pin is not used. The TDQS function must be disabled in the mode register for both the x4 and x16 configurations. The DM function is supported only in x8 and x16 configurations. DM, DBI, and TDQS are a shared pin and are enabled/disabled by mode register settings. For more information about TDQS, see the DDR4 DRAM component data sheet (TDQS_t and TDQS_c are not valid for UDIMMs). |
| V_{DD} | Supply | Module power supply: 1.2V (TYP). |
| V_{PP} | Supply | DRAM activating power supply: 2.5V –0.125V / +0.250V. |
| V_{REFCA} | Supply | Reference voltage for control, command, and address pins. |
| V_{SS} | Supply | Ground. |
| V_{TT} | Supply | Power supply for termination of address, command, and control $V_{DD}/2$. |
| V_{DDSPD} | Supply | Power supply used to power the I ² C bus for SPD. |
| RFU | – | Reserved for future use. |
| NC | – | No connect: No internal electrical connection is present. |
| NF | – | No function: May have internal connection present, but has no function. |

DQ Map

Table 6: Component-to-Module DQ Map (R/C-B PCB 1447)

| Component Reference Number | Component DQ | Module DQ | Module Pin Number | Component Reference Number | Component DQ | Module DQ | Module Pin Number |
|----------------------------|--------------|-----------|-------------------|----------------------------|--------------|-----------|-------------------|
| U1 | 0 | 3 | 157 | U2 | 0 | 11 | 168 |
| | 1 | 1 | 150 | | 1 | 9 | 161 |
| | 2 | 2 | 12 | | 2 | 10 | 23 |
| | 3 | 0 | 5 | | 3 | 8 | 16 |
| | 4 | 7 | 155 | | 4 | 15 | 166 |
| | 5 | 5 | 148 | | 5 | 13 | 159 |
| | 6 | 6 | 10 | | 6 | 14 | 21 |
| | 7 | 4 | 3 | | 7 | 12 | 14 |
| U3 | 0 | 19 | 179 | U4 | 0 | 27 | 190 |
| | 1 | 17 | 172 | | 1 | 25 | 183 |
| | 2 | 18 | 34 | | 2 | 26 | 45 |
| | 3 | 16 | 27 | | 3 | 24 | 38 |
| | 4 | 23 | 177 | | 4 | 31 | 188 |
| | 5 | 21 | 170 | | 5 | 29 | 181 |
| | 6 | 22 | 32 | | 6 | 30 | 43 |
| | 7 | 20 | 25 | | 7 | 28 | 36 |
| U5 | 0 | 39 | 247 | U6 | 0 | 47 | 258 |
| | 1 | 36 | 95 | | 1 | 44 | 106 |
| | 2 | 38 | 102 | | 2 | 46 | 113 |
| | 3 | 37 | 240 | | 3 | 45 | 251 |
| | 4 | 34 | 104 | | 4 | 42 | 115 |
| | 5 | 32 | 97 | | 5 | 40 | 108 |
| | 6 | 35 | 249 | | 6 | 43 | 260 |
| | 7 | 33 | 242 | | 7 | 41 | 253 |
| U7 | 0 | 55 | 269 | U8 | 0 | 63 | 280 |
| | 1 | 52 | 117 | | 1 | 60 | 106 |
| | 2 | 54 | 124 | | 2 | 62 | 113 |
| | 3 | 53 | 262 | | 3 | 61 | 251 |
| | 4 | 50 | 126 | | 4 | 58 | 115 |
| | 5 | 48 | 119 | | 5 | 56 | 108 |
| | 6 | 51 | 271 | | 6 | 59 | 260 |
| | 7 | 49 | 264 | | 7 | 57 | 253 |



Table 6: Component-to-Module DQ Map (R/C-B PCB 1447) (Continued)

| Component Reference Number | Component DQ | Module DQ | Module Pin Number | Component Reference Number | Component DQ | Module DQ | Module Pin Number |
|----------------------------|--------------|-----------|-------------------|----------------------------|--------------|-----------|-------------------|
| U10 | 0 | 60 | 128 | U11 | 0 | 52 | 117 |
| | 1 | 63 | 280 | | 1 | 55 | 269 |
| | 2 | 61 | 273 | | 2 | 53 | 252 |
| | 3 | 62 | 135 | | 3 | 54 | 124 |
| | 4 | 56 | 130 | | 4 | 48 | 119 |
| | 5 | 58 | 137 | | 5 | 50 | 126 |
| | 6 | 57 | 275 | | 6 | 49 | 264 |
| | 7 | 59 | 282 | | 7 | 51 | 271 |
| U12 | 0 | 44 | 106 | U13 | 0 | 36 | 95 |
| | 1 | 47 | 258 | | 1 | 39 | 247 |
| | 2 | 45 | 251 | | 2 | 37 | 240 |
| | 3 | 46 | 113 | | 3 | 38 | 102 |
| | 4 | 40 | 108 | | 4 | 32 | 97 |
| | 5 | 42 | 115 | | 5 | 34 | 104 |
| | 6 | 41 | 253 | | 6 | 33 | 242 |
| | 7 | 43 | 260 | | 7 | 35 | 249 |
| U14 | 0 | 25 | 183 | U15 | 0 | 17 | 172 |
| | 1 | 27 | 190 | | 1 | 19 | 179 |
| | 2 | 24 | 38 | | 2 | 16 | 27 |
| | 3 | 26 | 45 | | 3 | 18 | 34 |
| | 4 | 29 | 181 | | 4 | 21 | 170 |
| | 5 | 31 | 188 | | 5 | 23 | 177 |
| | 6 | 28 | 36 | | 6 | 20 | 25 |
| | 7 | 30 | 43 | | 7 | 22 | 32 |
| U16 | 0 | 9 | 161 | U17 | 0 | 1 | 150 |
| | 1 | 11 | 168 | | 1 | 3 | 157 |
| | 2 | 8 | 16 | | 2 | 0 | 5 |
| | 3 | 10 | 23 | | 3 | 2 | 12 |
| | 4 | 13 | 159 | | 4 | 5 | 148 |
| | 5 | 15 | 166 | | 5 | 7 | 155 |
| | 6 | 12 | 14 | | 6 | 4 | 3 |
| | 7 | 14 | 21 | | 7 | 6 | 10 |

Table 7: Component-to-Module DQ Map (R/C-B1 PCB 1866)

| Component Reference Number | Component DQ | Module DQ | Module Pin Number | Component Reference Number | Component DQ | Module DQ | Module Pin Number |
|----------------------------|--------------|-----------|-------------------|----------------------------|--------------|-----------|-------------------|
| U1 | 0 | 2 | 12 | U2 | 0 | 11 | 168 |
| | 1 | 1 | 150 | | 1 | 9 | 161 |
| | 2 | 3 | 157 | | 2 | 10 | 23 |
| | 3 | 0 | 5 | | 3 | 8 | 16 |
| | 4 | 6 | 10 | | 4 | 15 | 166 |
| | 5 | 4 | 3 | | 5 | 13 | 159 |
| | 6 | 7 | 155 | | 6 | 14 | 21 |
| | 7 | 5 | 148 | | 7 | 12 | 14 |
| U3 | 0 | 18 | 34 | U4 | 0 | 27 | 190 |
| | 1 | 16 | 27 | | 1 | 24 | 38 |
| | 2 | 19 | 179 | | 2 | 26 | 45 |
| | 3 | 17 | 172 | | 3 | 25 | 183 |
| | 4 | 22 | 32 | | 4 | 31 | 188 |
| | 5 | 20 | 25 | | 5 | 29 | 181 |
| | 6 | 23 | 177 | | 6 | 30 | 43 |
| | 7 | 21 | 170 | | 7 | 28 | 36 |
| U6 | 0 | 38 | 102 | U7 | 0 | 47 | 258 |
| | 1 | 37 | 240 | | 1 | 44 | 106 |
| | 2 | 39 | 247 | | 2 | 46 | 113 |
| | 3 | 36 | 95 | | 3 | 45 | 251 |
| | 4 | 35 | 249 | | 4 | 42 | 115 |
| | 5 | 33 | 242 | | 5 | 40 | 108 |
| | 6 | 34 | 104 | | 6 | 43 | 260 |
| | 7 | 32 | 97 | | 7 | 41 | 253 |
| U8 | 0 | 55 | 269 | U9 | 0 | 63 | 280 |
| | 1 | 53 | 262 | | 1 | 60 | 128 |
| | 2 | 54 | 124 | | 2 | 62 | 135 |
| | 3 | 52 | 117 | | 3 | 61 | 273 |
| | 4 | 51 | 271 | | 4 | 58 | 137 |
| | 5 | 48 | 119 | | 5 | 56 | 130 |
| | 6 | 50 | 126 | | 6 | 59 | 260 |
| | 7 | 47 | 264 | | 7 | 57 | 275 |

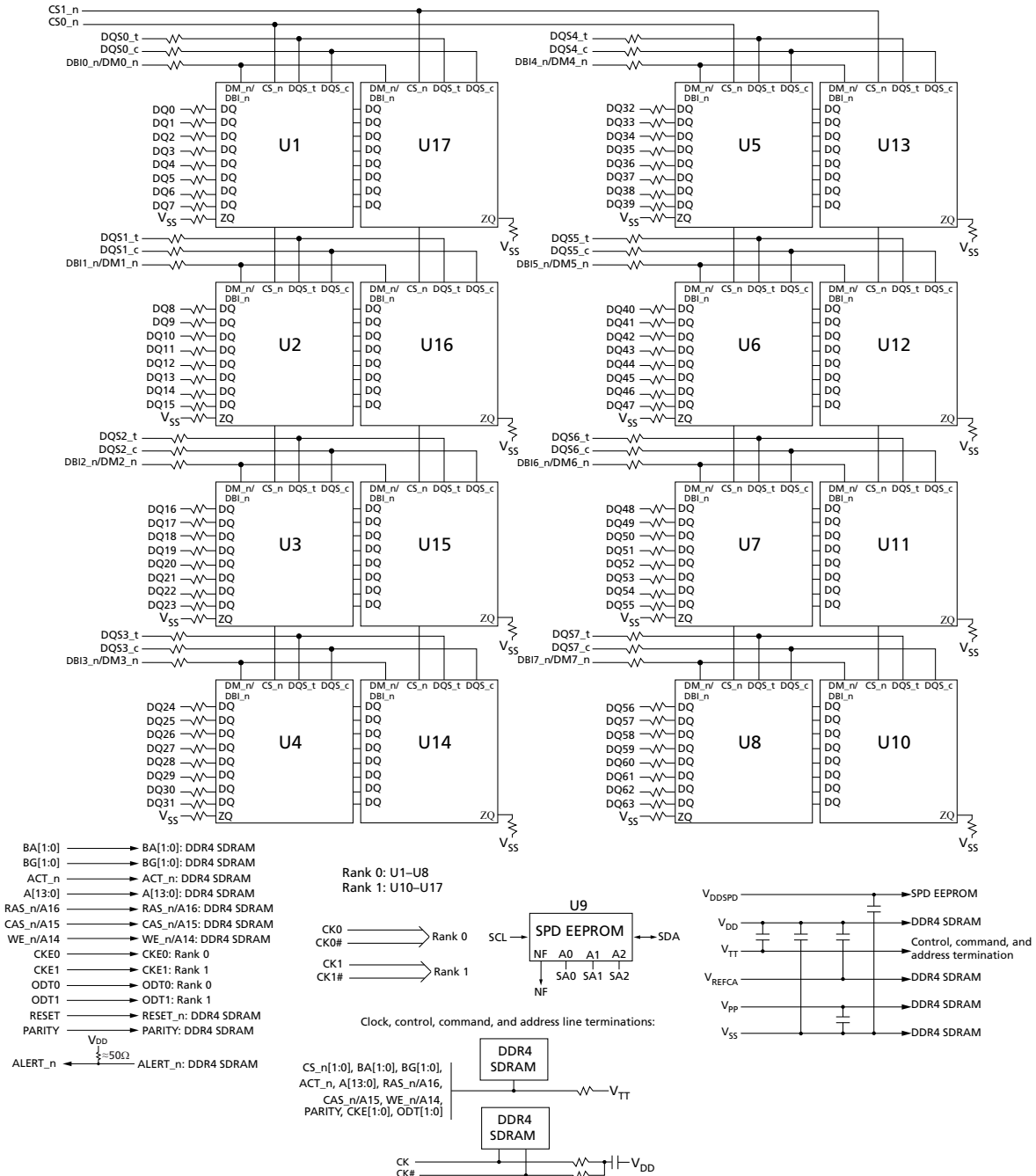


Table 7: Component-to-Module DQ Map (R/C-B1 PCB 1866) (Continued)

| Component Reference Number | Component DQ | Module DQ | Module Pin Number | Component Reference Number | Component DQ | Module DQ | Module Pin Number |
|----------------------------|--------------|-----------|-------------------|----------------------------|--------------|-----------|-------------------|
| U10 | 0 | 60 | 128 | U11 | 0 | 53 | 262 |
| | 1 | 63 | 280 | | 1 | 55 | 269 |
| | 2 | 61 | 273 | | 2 | 52 | 117 |
| | 3 | 62 | 135 | | 3 | 54 | 124 |
| | 4 | 56 | 130 | | 4 | 48 | 119 |
| | 5 | 58 | 137 | | 5 | 51 | 271 |
| | 6 | 57 | 275 | | 6 | 49 | 264 |
| | 7 | 59 | 282 | | 7 | 50 | 126 |
| U12 | 0 | 44 | 106 | U13 | 0 | 37 | 240 |
| | 1 | 47 | 258 | | 1 | 38 | 102 |
| | 2 | 45 | 251 | | 2 | 36 | 95 |
| | 3 | 46 | 113 | | 3 | 39 | 247 |
| | 4 | 40 | 108 | | 4 | 33 | 242 |
| | 5 | 42 | 115 | | 5 | 35 | 249 |
| | 6 | 41 | 253 | | 6 | 32 | 97 |
| | 7 | 43 | 260 | | 7 | 34 | 104 |
| U14 | 0 | 24 | 38 | U15 | 0 | 16 | 27 |
| | 1 | 27 | 190 | | 1 | 18 | 34 |
| | 2 | 25 | 183 | | 2 | 17 | 172 |
| | 3 | 26 | 45 | | 3 | 19 | 179 |
| | 4 | 29 | 181 | | 4 | 20 | 25 |
| | 5 | 31 | 188 | | 5 | 22 | 32 |
| | 6 | 28 | 36 | | 6 | 21 | 170 |
| | 7 | 30 | 43 | | 7 | 23 | 177 |
| U16 | 0 | 9 | 161 | U17 | 0 | 1 | 150 |
| | 1 | 11 | 168 | | 1 | 2 | 12 |
| | 2 | 8 | 16 | | 2 | 0 | 5 |
| | 3 | 10 | 23 | | 3 | 3 | 157 |
| | 4 | 13 | 159 | | 4 | 4 | 3 |
| | 5 | 15 | 166 | | 5 | 6 | 10 |
| | 6 | 12 | 14 | | 6 | 5 | 148 |
| | 7 | 14 | 21 | | 7 | 7 | 155 |

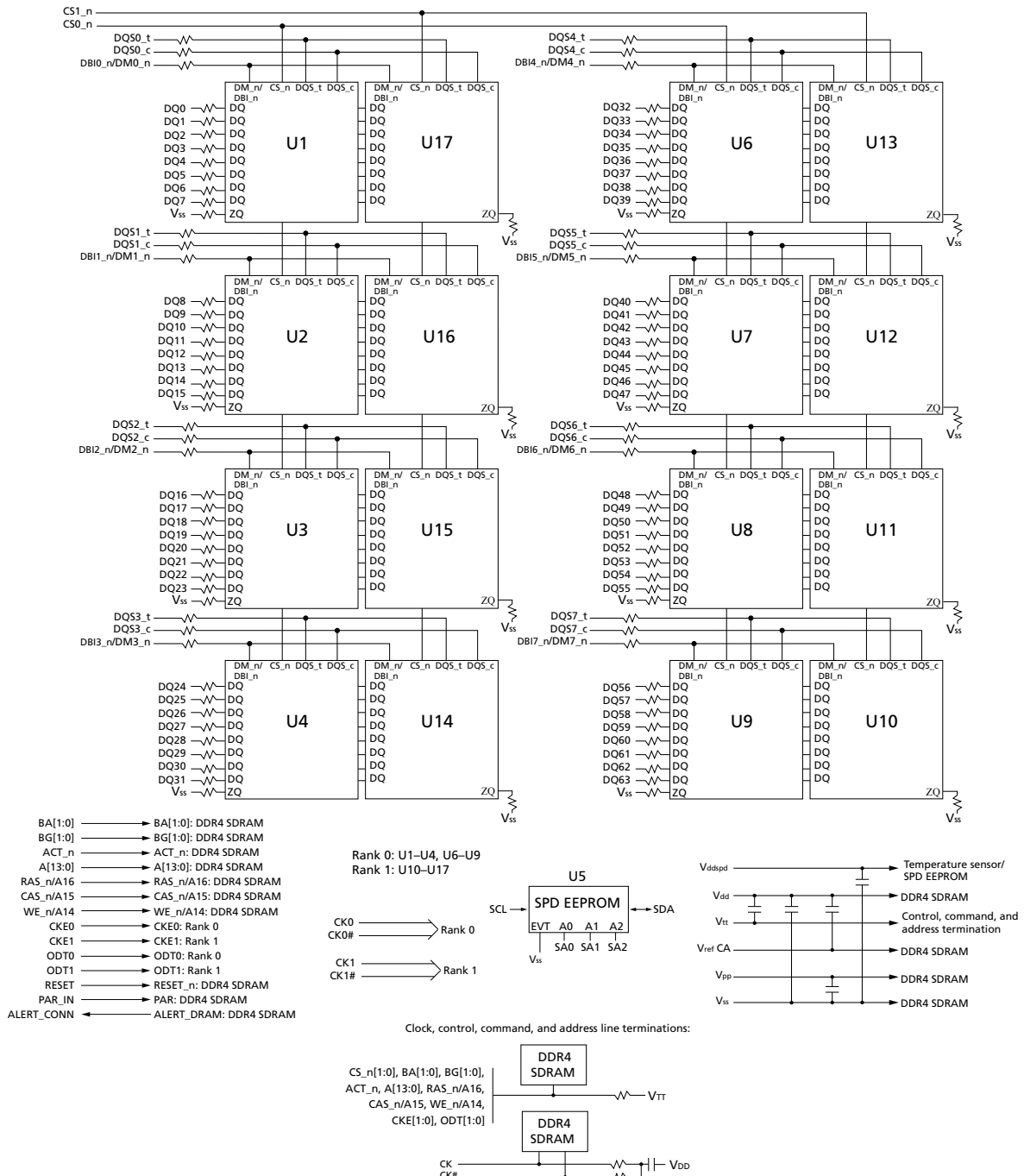
Functional Block Diagrams

Figure 2: Functional Block Diagram (R/C-B PCB 1447)



Note: 1. The ZQ ball on each DDR4 component is connected to an external 240Ω ±1% resistor that is tied to ground. It is used for the calibration of the component's ODT and output driver.

Figure 3: Functional Block Diagram (R/C-B1 PCB 1866)



Note: 1. The ZQ ball on each DDR4 component is connected to an external 240Ω ±1% resistor that is tied to ground. It is used for the calibration of the component's ODT and output driver.

General Description

High-speed DDR4 SDRAM modules use DDR4 SDRAM devices with two or four internal memory bank groups. DDR4 SDRAM modules utilizing 4- and 8-bit-wide DDR4 SDRAM devices have four internal bank groups consisting of four memory banks each, providing a total of 16 banks. 16-bit-wide DDR4 SDRAM devices have two internal bank groups consisting of four memory banks each, providing a total of eight banks. DDR4 SDRAM modules benefit from DDR4 SDRAM's use of an $8n$ -prefetch architecture 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 effectively consists of a single $8n$ -bit-wide, four-clock data transfer at the internal DRAM core and eight corresponding n -bit-wide, one-half-clock-cycle data transfers at the I/O pins.

DDR4 modules use two sets of differential signals: DQS_t and DQS_c to capture data and CK_t and CK_c to capture commands, addresses, and control signals. Differential clocks and data strobes ensure exceptional noise immunity for these signals and provide precise crossing points to capture input signals.

Fly-By Topology

DDR4 modules use faster clock speeds than earlier DDR technologies, making signal quality more important than ever. For improved signal quality, the clock, control, command, and address buses have been routed in a fly-by topology, where each clock, control, command, and address pin on each DRAM is connected to a single trace and terminated (rather than a tree structure, where the termination is off the module near the connector). Inherent to fly-by topology, the timing skew between the clock and DQS signals can be easily accounted for by using the write-leveling feature of DDR4.

Module Manufacturing Location

Micron Technology manufactures modules at sites world-wide. Customers may receive modules from any of the following manufacturing locations:

Table 8: DRAM Module Manufacturing Locations

| Manufacturing Site Location | Country of Origin Specified on Label |
|-----------------------------|--------------------------------------|
| Boise, USA | USA |
| Aguadilla, Puerto Rico | Puerto Rico |
| Xian, China | China |
| Singapore | Singapore |

Address Mapping to DRAM

Address Mirroring

To achieve optimum routing of the address bus on DDR4 multi rank modules, the address bus will be wired as shown in the table below, or mirrored. For quad rank modules, ranks 1 and 3 are mirrored and ranks 0 and 2 are non-mirrored. Highlighted address pins have no secondary functions allowing for normal operation when cross-wired. Data is still read from the same address it was written. However, Load Mode operations require a specific address. This requires the controller to accommodate for a rank that is "mirrored." Systems may reference DDR4 SPD to determine if the module has mirroring implemented or not. See the JEDEC DDR4 SPD specification for more details.

Table 9: Address Mirroring

| Edge Connector Pin | DRAM Pin, Non-mirrored | DRAM Pin, Mirrored |
|--------------------|------------------------|--------------------|
| A0 | A0 | A0 |
| A1 | A1 | A1 |
| A2 | A2 | A2 |
| A3 | A3 | A4 |
| A4 | A4 | A3 |
| A5 | A5 | A6 |
| A6 | A6 | A5 |
| A7 | A7 | A8 |
| A8 | A8 | A7 |
| A9 | A9 | A9 |
| A10 | A10 | A10 |
| A11 | A11 | A13 |
| A13 | A13 | A11 |
| A12 | A12 | A12 |
| A14 | A14 | A14 |
| A15 | A15 | A15 |
| A16 | A16 | A16 |
| A17 | A17 | A17 |
| BA0 | BA0 | BA1 |
| BA1 | BA1 | BA0 |
| BG0 | BG0 | BG1 |
| BG1 | BG1 | BG0 |

SPD EEPROM Operation

DDR4 SDRAM modules incorporate serial presence detect (SPD). The SPD data is stored in a 512-byte JEDEC JC-42.4-compliant EEPROM that is segregated into four 128-byte, write-protectable blocks. The SPD content is aligned with these blocks as shown in the table below.

| Block | Range | | Description |
|-------|---------|-----------|-----------------------------------|
| 0 | 0–127 | 000h–07Fh | Configuration and DRAM parameters |
| 1 | 128–255 | 080h–0FFh | Module-specific parameters |
| 2 | 256–319 | 100h–13Fh | Reserved; all bytes coded as 00h |
| | 320–383 | 140h–17Fh | Manufacturing information |
| 3 | 384–511 | 180h–1FFh | End-user programmable |

The first 384 bytes are programmed by Micron to comply with JEDEC standard JC-45, "Appendix X: Serial Presence Detect (SPD) for DDR4 SDRAM Modules." The remaining 128 bytes of storage are available for use by the customer.

The EEPROM resides on a two-wire I²C serial interface and is not integrated with the memory bus in any way. It operates as a slave device in the I²C bus protocol, with all operations synchronized by the serial clock. Transfer rates of up to 1 MHz are achievable at 2.5V (NOM).

Micron implements reversible software write protection on DDR4 SDRAM-based modules. This prevents the lower 384 bytes (bytes 0–383) from being inadvertently programmed or corrupted. The upper 128 bytes remain available for customer use and unprotected.

Electrical Specifications

Stresses greater than those listed may cause permanent damage to the module. This is a stress rating only, and functional operation of the module at these or any other conditions outside those indicated in each device's data sheet is not implied. Exposure to absolute maximum rating conditions for extended periods may adversely affect reliability.

Table 10: Absolute Maximum Ratings

| Symbol | Parameter | Min | Max | Units | Notes |
|-------------------|---|------|-----|-------|-------|
| V_{DD} | V_{DD} supply voltage relative to V_{SS} | -0.4 | 1.5 | V | 1 |
| V_{DDQ} | V_{DDQ} supply voltage relative to V_{SS} | -0.4 | 1.5 | V | 1 |
| V_{PP} | Voltage on V_{PP} pin relative to V_{SS} | -0.4 | 3.0 | V | 2 |
| V_{IN}, V_{OUT} | Voltage on any pin relative to V_{SS} | -0.4 | 1.5 | V | |

Table 11: Operating Conditions

| Symbol | Parameter | Min | Nom | Max | Units | Notes |
|-----------------|---|-----------------------------|---------------------|-----------------------------|---------|-------|
| V_{DD} | V_{DD} supply voltage | 1.14 | 1.2 | 1.26 | V | 1 |
| V_{PP} | DRAM activating power supply | 2.375 | 2.5 | 2.75 | V | 2 |
| $V_{REFCA(DC)}$ | Input reference voltage command/address bus | $0.49 \times V_{DD}$ | $0.5 \times V_{DD}$ | $0.51 \times V_{DD}$ | V | 3 |
| I_{VTT} | Termination reference current from V_{TT} | -750 | - | 750 | mA | |
| V_{TT} | Termination reference voltage (DC) – command/address bus | $0.49 \times V_{DD} - 20mV$ | $0.5 \times V_{DD}$ | $0.51 \times V_{DD} + 20mV$ | V | 4 |
| I_I | Input leakage current; any input excluding ZQ; $0V < V_{IN} < 1.1V$ | -2.0 | - | 2.0 | μA | 5 |
| $I_{I/O}$ | DQ leakage; $0V < V_{in} < V_{DD}$ | -4.0 | - | 4.0 | μA | 5 |
| I_I | Input leakage current; ZQ | -3.0 | - | 3.0 | μA | 5, 6 |
| I_{OZpd} | Output leakage current; $V_{OUT} = V_{DD}$; DQ is disabled | - | - | 5.0 | μA | |
| I_{OZpu} | Output leakage current; $V_{OUT} = V_{SS}$; DQ and ODT are disabled; ODT is disabled with ODT input HIGH | - | - | 5.0 | μA | |
| I_{VREFCA} | V_{REFCA} leakage; $V_{REFCA} = V_{DD}/2$ (after DRAM is initialized) | -2.0 | - | 2.0 | μA | 5 |

- Notes:
- V_{DDQ} tracks with V_{DD} ; V_{DDQ} and V_{DD} are tied together.
 - V_{PP} must be greater than or equal to V_{DD} at all times.
 - V_{REFCA} must not be greater than $0.6 \times V_{DD}$. When V_{DD} is less than 500mV, V_{REF} may be less than or equal to 300mV.
 - V_{TT} termination voltages in excess of the specification limit adversely affect the voltage margins of command and address signals and reduce timing margins.
 - Multiply by the number of DRAM die on the module.
 - Tied to ground. Not connected to edge connector.

Table 12: Thermal Characteristics

| Symbol | Parameter/Condition | Value | Units | Notes |
|-------------------|--|------------|---------|------------|
| T _C | Commercial operating case temperature | 0 to 85 | °C | 1, 2, 3 |
| T _C | | >85 to 95 | °C | 1, 2, 3, 4 |
| T _{OPER} | Normal operating temperature range | 0 to 85 | °C | 5, 7 |
| T _{OPER} | Extended temperature operating range (optional) | >85 to 95 | °C | 5, 7 |
| T _{STG} | Non-operating storage temperature | -55 to 100 | °C | 6 |
| RH _{STG} | Non-operating Storage Relative Humidity (non-condensing) | 5 to 95 | % | |
| NA | Change Rate of Storage Temperature | 20 | °C/hour | |

- Notes:
1. Maximum operating case temperature; T_C is measured in the center of the package.
 2. A thermal solution must be designed to ensure the DRAM device does not exceed the maximum T_C during operation.
 3. Device functionality is not guaranteed if the DRAM device exceeds the maximum T_C during operation.
 4. If T_C exceeds 85°C, the DRAM must be refreshed externally at 2X refresh, which is a 3.9μs interval refresh rate.
 5. The refresh rate must double when 85°C < T_{OPER} ≤ 95°C.
 6. Storage temperature is defined as the temperature of the top/center of the DRAM and does not reflect the storage temperatures of shipping trays.
 7. For additional information, refer to technical note TN-00-08: "Thermal Applications" available at micron.com.

DRAM Operating Conditions

Recommended AC operating conditions are given in the DDR4 component data sheets. Component specifications are available at micron.com. Module speed grades correlate with component speed grades, as shown below.

Table 13: Module and Component Speed Grades

DDR4 components may exceed the listed module speed grades; module may not be available in all listed speed grades

| Module Speed Grade | Component Speed Grade |
|--------------------|-----------------------|
| -2G6 | -075 |
| -2G4 | -083E |
| -2G3 | -083 |
| -2G1 | -093E |
| -1G9 | -107E |

Design Considerations

Simulations

Micron memory modules are designed to optimize signal integrity through carefully designed terminations, controlled board impedances, routing topologies, trace length matching, and decoupling. However, good signal integrity starts at the system level. Micron encourages designers to simulate the signal characteristics of the system's memory bus to ensure adequate signal integrity of the entire memory system.

Power

Operating voltages are specified at the edge connector of the module, not at the DRAM. Designers must account for any system voltage drops at anticipated power levels to ensure the required supply voltage is maintained.

I_{DD} Specifications

Table 14: DDR4 I_{DD} Specifications and Conditions – 8GB (Die Revision A)

Values are for the MT40A512M8 DDR4 SDRAM only and are computed from values specified in the 4Gb (512 Meg x 8) component data sheet

| Parameter | Symbol | 2400 | 2133 | Units |
|--|---------------------------------|------|------|-------|
| One bank ACTIVATE-PRECHARGE current | I _{DD0} ¹ | 768 | 720 | mA |
| One bank ACTIVATE-PRECHARGE, wordline boost, I _{pp} current | I _{PP0} ¹ | 56 | 56 | mA |
| One bank ACTIVATE-READ-PRECHARGE current | I _{DD1} ¹ | 800 | 760 | mA |
| Precharge standby current | I _{DD2N} ² | 800 | 736 | mA |
| Precharge standby ODT current | I _{DD2NT} ¹ | 720 | 672 | mA |
| Precharge power-down current | I _{DD2P} ² | 512 | 480 | mA |
| Precharge quiet standby current | I _{DD2Q} ² | 656 | 624 | mA |
| Active standby current | I _{DD3N} ² | 1072 | 1008 | mA |
| Active standby I _{pp} current | I _{PP3N} ² | 48 | 48 | mA |
| Active power-down current | I _{DD3P} ² | 704 | 704 | mA |
| Burst read current | I _{DD4R} ¹ | 1536 | 1440 | mA |
| Burst read I _{DDQ} current | I _{DDQ4R} ¹ | 576 | 528 | mA |
| Burst write current | I _{DD4W} ¹ | 1696 | 1520 | mA |
| Burst refresh current (1x REF) | I _{DD5B} ¹ | 1792 | 1760 | mA |
| Burst refresh I _{pp} current (1x REF) | I _{PP5B} ¹ | 200 | 200 | mA |
| Self refresh current: Normal temperature range (0–85°C) | I _{DD6N} ² | 320 | 320 | mA |
| Self refresh current: Extended temperature range (0–95°C) | I _{DD6E} ² | 432 | 432 | mA |
| Self refresh current: Reduced temperature range (0–45°C) | I _{DD6R} ² | 160 | 160 | mA |
| Auto self refresh current (25°C) | I _{DD6A} ² | 144 | 144 | mA |
| Auto self refresh current (45°C) | I _{DD6A} ² | 160 | 160 | mA |
| Auto self refresh current (75°C) | I _{DD6A} ² | 256 | 256 | mA |
| Bank interleave read current | I _{DD7} ¹ | 1936 | 1720 | mA |
| Bank interleave read I _{pp} current | I _{PP7} ¹ | 136 | 120 | mA |
| Maximum power-down current | I _{DD8} ² | 288 | 288 | mA |

- Notes: 1. One module rank in the active I_{DD/PP}, the other rank in I_{DD2P/PP3N}.
2. All ranks in this I_{DD/PP} condition.

Table 15: DDR4 I_{DD} Specifications and Conditions – 8GB (Die Revision B)

Values are for the MT40A512M8 DDR4 SDRAM only and are computed from values specified in the 4Gb (512 Meg x 8) component data sheet

| Parameter | Symbol | 2666 | 2400 | 2133 | Units |
|--|---------------------------------|------|------|------|-------|
| One bank ACTIVATE-PRECHARGE current | I _{DD0} ¹ | 792 | 72 | 656 | mA |
| One bank ACTIVATE-PRECHARGE, wordline boost, I _{PP} current | I _{PP0} ¹ | 48 | 48 | 48 | mA |
| One bank ACTIVATE-READ-PRECHARGE current | I _{DD1} ¹ | 832 | 752 | 696 | mA |
| Precharge standby current | I _{DD2N} ² | 800 | 720 | 672 | mA |
| Precharge standby ODT current | I _{DD2NT} ¹ | 712 | 632 | 616 | mA |
| Precharge power-down current | I _{DD2P} ² | 544 | 464 | 423 | mA |
| Precharge quite standby current | I _{DD2Q} ² | 640 | 592 | 560 | mA |
| Active standby current | I _{DD3N} ² | 1040 | 960 | 880 | mA |
| Active standby I _{PP} current | I _{PP3N} ² | 48 | 48 | 48 | mA |
| Active power-down current | I _{DD3P} ² | 640 | 640 | 640 | mA |
| Burst read current | I _{DD4R} ¹ | 1632 | 1392 | 1296 | mA |
| Burst write current | I _{DD4W} ¹ | 1832 | 1632 | 1456 | mA |
| Burst refresh current (1x REF) | I _{DD5B} ¹ | 1672 | 1632 | 1576 | mA |
| Burst refresh I _{PP} current (1x REF) | I _{PP5B} ¹ | 200 | 200 | 200 | mA |
| Self refresh current: Normal temperature range (0–85°C) | I _{DD6N} ² | 288 | 288 | 288 | mA |
| Self refresh current: Extended temperature range (0–95°C) | I _{DD6E} ² | 384 | 384 | 384 | mA |
| Self refresh current: Reduced temperature range (0–45°C) | I _{DD6R} ² | 192 | 192 | 192 | mA |
| Auto self refresh current (25°C) | I _{DD6A} ² | 144 | 144 | 144 | mA |
| Auto self refresh current (45°C) | I _{DD6A} ² | 192 | 192 | 192 | mA |
| Auto self refresh current (75°C) | I _{DD6A} ² | 288 | 288 | 288 | mA |
| Bank interleave read current | I _{DD7} ¹ | 1872 | 1752 | 1536 | mA |
| Bank interleave read I _{PP} current | I _{PP7} ¹ | 152 | 136 | 120 | mA |
| Maximum power-down current | I _{DD8} ² | 256 | 256 | 256 | mA |

- Notes: 1. One module rank in the active I_{DD}/I_{PP}, the other rank in I_{DD2P}/I_{PP3N}.
2. All ranks in this I_{DD}/I_{PP} condition.

SPD EEPROM Operating Conditions

For the latest SPD data, refer to Micron's SPD page: micron.com/spd.

Table 16: SPD EEPROM DC Operating Conditions

| Parameter/Condition | Symbol | Min | Nom | Max | Units |
|--|-------------|------------------------|-----|------------------------|---------|
| Supply voltage | V_{DDSPD} | – | 2.5 | – | V |
| Input low voltage: logic 0; all inputs | V_{IL} | –0.5 | – | $V_{DDSPD} \times 0.3$ | V |
| Input high voltage: logic 1; all inputs | V_{IH} | $V_{DDSPD} \times 0.7$ | – | $V_{DDSPD} + 0.5$ | V |
| Output low voltage: 3mA sink current $V_{DDSPD} > 2V$ | V_{OL} | – | – | 0.4 | V |
| Input leakage current: (SCL, SDA) $V_{IN} = V_{DDSPD}$ or V_{SSSPD} | I_{LI} | – | – | ± 5 | μA |
| Output leakage current: $V_{OUT} = V_{DDSPD}$ or V_{SSSPD} , SDA in High-Z | I_{LO} | – | – | ± 5 | μA |

- Notes:
1. Table is provided as a general reference. Consult JEDEC JC-42.4 EE1004 and TSE2004 device specifications for complete details.
 2. All voltages referenced to V_{DDSPD} .

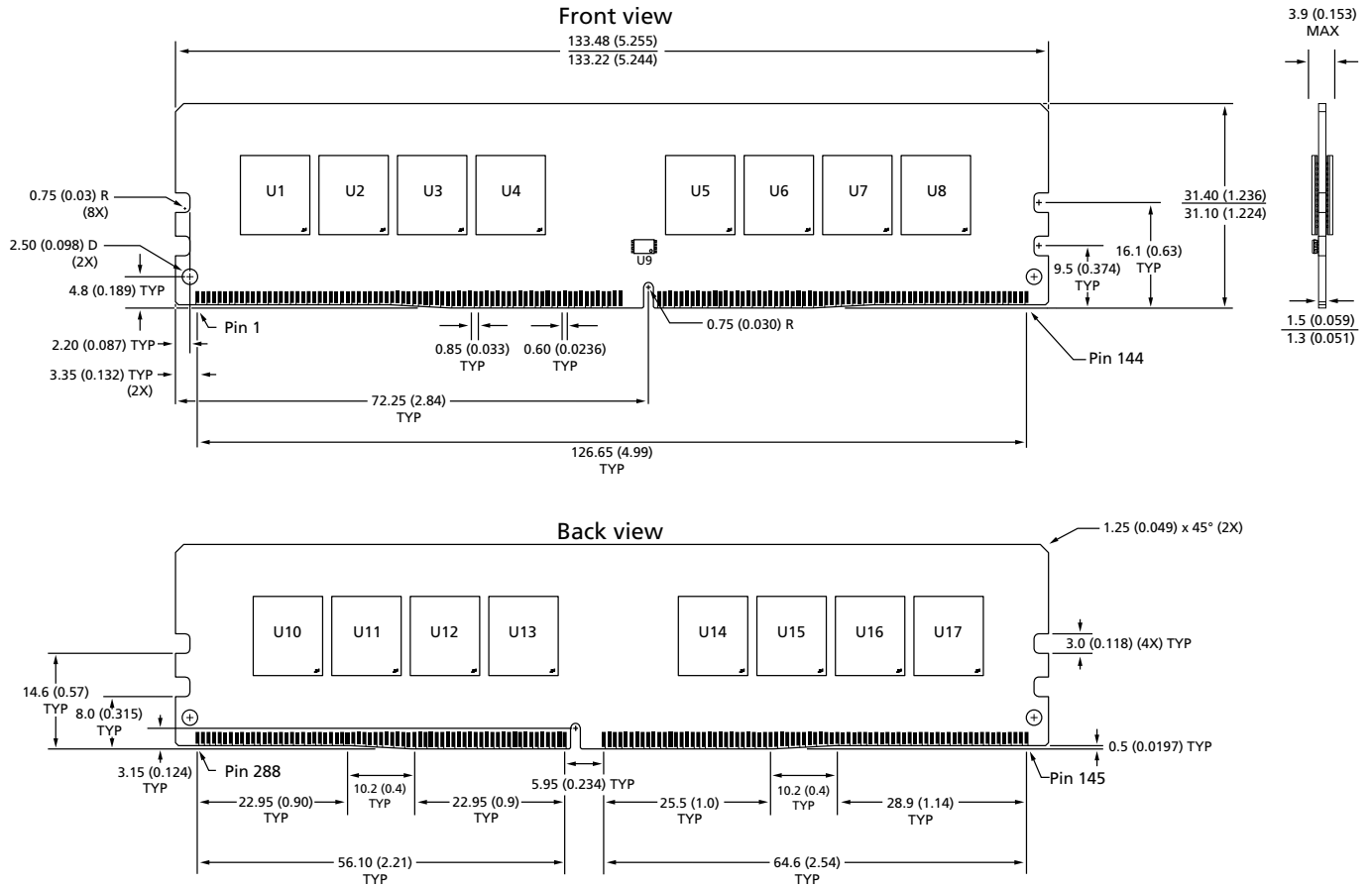
Table 17: SPD EEPROM AC Operating Conditions

| Parameter/Condition | Symbol | Min | Max | Units |
|---|---------------|-----|------|-------|
| Clock frequency | t_{SCL} | 10 | 1000 | kHz |
| Clock pulse width HIGH time | t_{HIGH} | 260 | – | ns |
| Clock pulse width LOW time | t_{LOW} | 500 | – | ns |
| Detect clock LOW timeout | $t_{TIMEOUT}$ | 25 | 35 | ms |
| SDA rise time | t_R | – | 120 | ns |
| SDA fall time | t_F | – | 120 | ns |
| Data-in setup time | $t_{SU:DAT}$ | 50 | – | ns |
| Data-in hold time | $t_{HD:DI}$ | 0 | – | ns |
| Data out hold time | $t_{HD:DAT}$ | 0 | 350 | ns |
| Start condition setup time | $t_{SU:STA}$ | 260 | – | ns |
| Start condition hold time | $t_{HD:STA}$ | 260 | – | ns |
| Stop condition setup time | $t_{SU:STO}$ | 260 | – | ns |
| Time the bus must be free before a new transition can start | t_{BUF} | 500 | – | ns |
| Write time | t_W | – | 5 | ms |
| Warm power cycle time off | t_{POFF} | 1 | – | ms |
| Time from power on to first command | t_{INIT} | 10 | – | ms |

- Note:
1. Table is provided as a general reference. Consult JEDEC JC-42.4 EE1004 and TSE2004 device specifications for complete details.

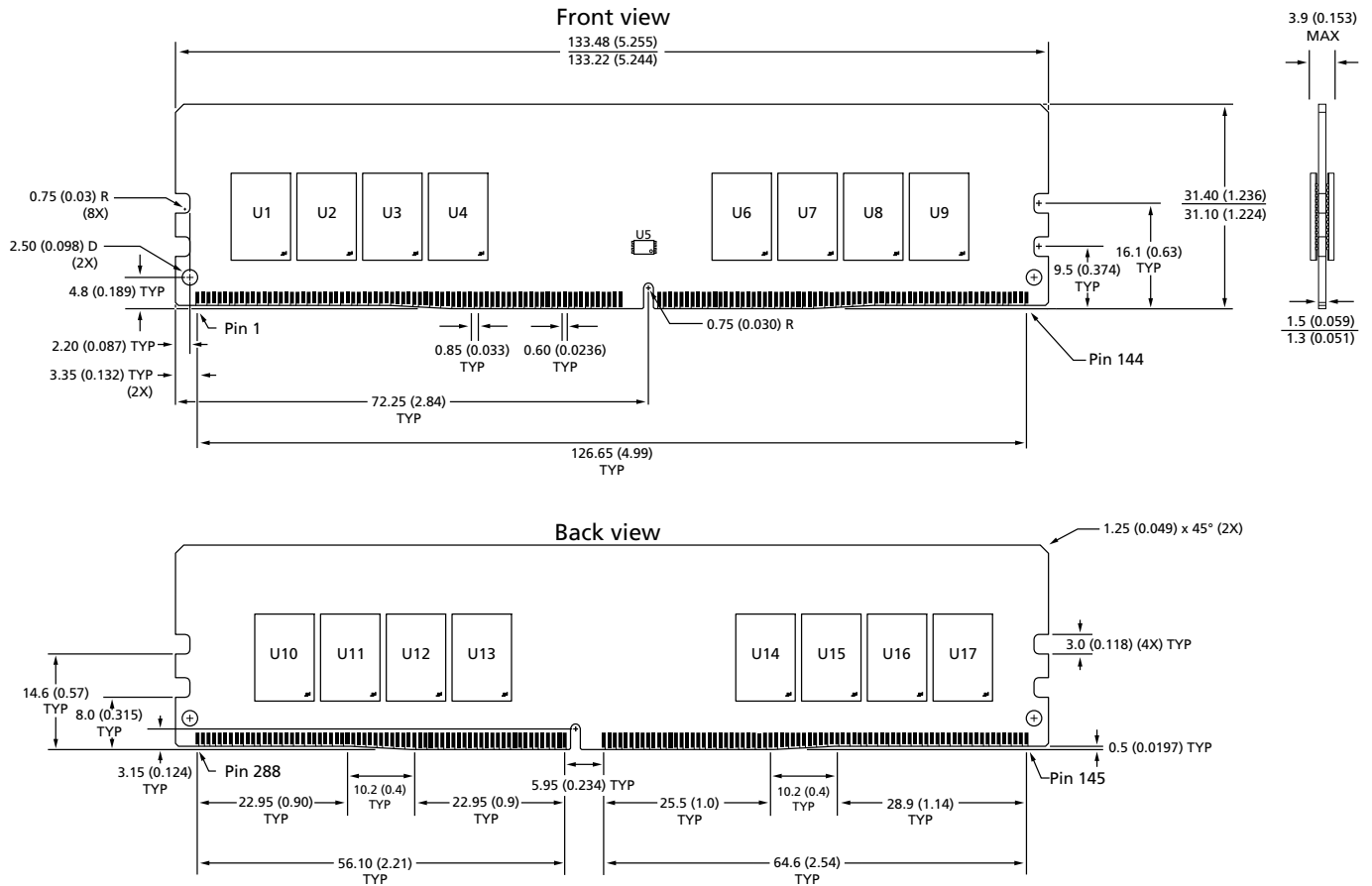
Module Dimensions

Figure 4: 288-Pin DDR4 UDIMM (R/C-B PCB 1447)



- Notes: 1. All dimensions are in millimeters (inches); MAX/MIN or typical (TYP) where noted.
2. The dimensional diagram is for reference only.

Figure 5: 288-Pin DDR4 UDIMM (R/C-B1 PCB 1866)



- Notes: 1. All dimensions are in millimeters (inches); MAX/MIN or typical (TYP) where noted.
 2. The dimensional diagram is for reference only.

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This data sheet contains minimum and maximum limits specified over the power supply and temperature range set forth herein. Although considered final, these specifications are subject to change, as further product development and data characterization sometimes occur.