



TwinDie™ 1.2V DDR4 SDRAM

MT40A1G16 – 64 Meg x 16 x 16 Banks x 1 Ranks

Description

The 16Gb (TwinDie™) DDR4 SDRAM uses Micron’s 8Gb DDR4 SDRAM die; two x8s combined to make one x16. Similar signals as mono x16, there is one extra ZQ connection for faster ZQ Calibration and a BG1 control required for x8 addressing. Refer to Micron’s 8Gb DDR4 SDRAM data sheet (x8 option) for the specifications not included in this document. Specifications for base part number MT40A1G8 correlate to TwinDie manufacturing part number MT40A1G16.

Features

- Uses two x8 8Gb Micron die to make one x16
- Single rank TwinDie
- $V_{DD} = V_{DDQ} = 1.2V$ (1.14–1.26V)
- 1.2V V_{DDQ} -terminated I/O
- JEDEC-standard ball-out
- Low-profile package
- T_C of 0°C to 95°C
 - 0°C to 85°C: 8192 refresh cycles in 64ms
 - 85°C to 95°C: 8192 refresh cycles in 32ms

Options

- Configuration
 - 64 Meg x 16 x 16 banks x 1 rank 1G16
- 96-ball FBGA package (Pb-free)
 - 9.5mm x 14mm x 1.2mm Die Rev :A HBA
 - 8.0mm x 14mm x 1.2mm Die Rev :B, D WBU
 - 7.5mm x 13.5mm x 1.2mm Die Rev :E KNR
- Timing – cycle time¹
 - 0.625ns @ CL = 22 (DDR4-3200) -062E
 - 0.682ns @ CL = 21 (DDR4-2933) -068
 - 0.750ns @ CL = 19 (DDR4-2666) -075
 - 0.750ns @ CL = 18 (DDR4-2666) -075E
 - 0.833ns @ CL = 17(DDR4-2400) -083
 - 0.833ns @ CL = 16 (DDR4-2400) -083E
 - 0.937ns @ CL = 15 (DDR4-2133) -093E
 - 1.071ns @ CL = 13 (DDR4-1866) -107E
- Self refresh
 - Standard None
- Operating temperature
 - Commercial (0°C ≤ T_C ≤ 95°C) None
- Revision
 - :A
 - :B, D
 - :E

Note: 1. CL = CAS (READ) latency.

Table 1: Key Timing Parameters

| Speed Grade ¹ | Data Rate (MT/s) | Target ^t RCD- ^t RP-CL | ^t RCD (ns) | ^t RP (ns) | CL (ns) |
|--------------------------|------------------|---|-----------------------|----------------------|---------------|
| -062Y | 3200 | 22-22-22 | 13.75 (13.32) | 13.75 (13.32) | 13.75 (13.32) |
| -062E | 3200 | 22-22-22 | 13.75 | 13.75 | 13.75 |
| -068 | 2933 | 21-21-21 | 14.32 (13.75) | 14.32 (13.75) | 14.32 (13.75) |
| -075E | 2666 | 18-18-18 | 13.50 | 13.50 | 13.50 |
| -075 | 2666 | 19-19-19 | 14.25 | 14.25 | 14.25 |
| -083E | 2400 | 16-16-16 | 13.32 | 13.32 | 13.32 |
| -083 | 2400 | 17-17-17 | 14.16 (13.75) | 14.16 (13.75) | 14.16 (13.75) |
| -093E | 2133 | 15-15-15 | 14.06 (13.50) | 14.06 (13.50) | 14.06 (13.50) |
| -093 | 2133 | 16-16-16 | 15.00 | 15.00 | 15.00 |
| -107E | 1866 | 13-13-13 | 13.92 (13.50) | 13.92 (13.50) | 13.92 (13.50) |

Note: 1. Refer to Speed Bin Tables for additional details.



Table 2: Addressing

| Parameter | 1024 Meg x 16 |
|----------------------------|---------------------------------|
| Configuration | 64 Meg x 16 x 16 banks x 1 rank |
| Bank group address | BG[1:0] |
| Bank count per group | 4 |
| Bank address in bank group | BA[1:0] |
| Row addressing | 64K (A[15:0]) |
| Column addressing | 1K (A[9:0]) |
| Page size | 1KB |

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

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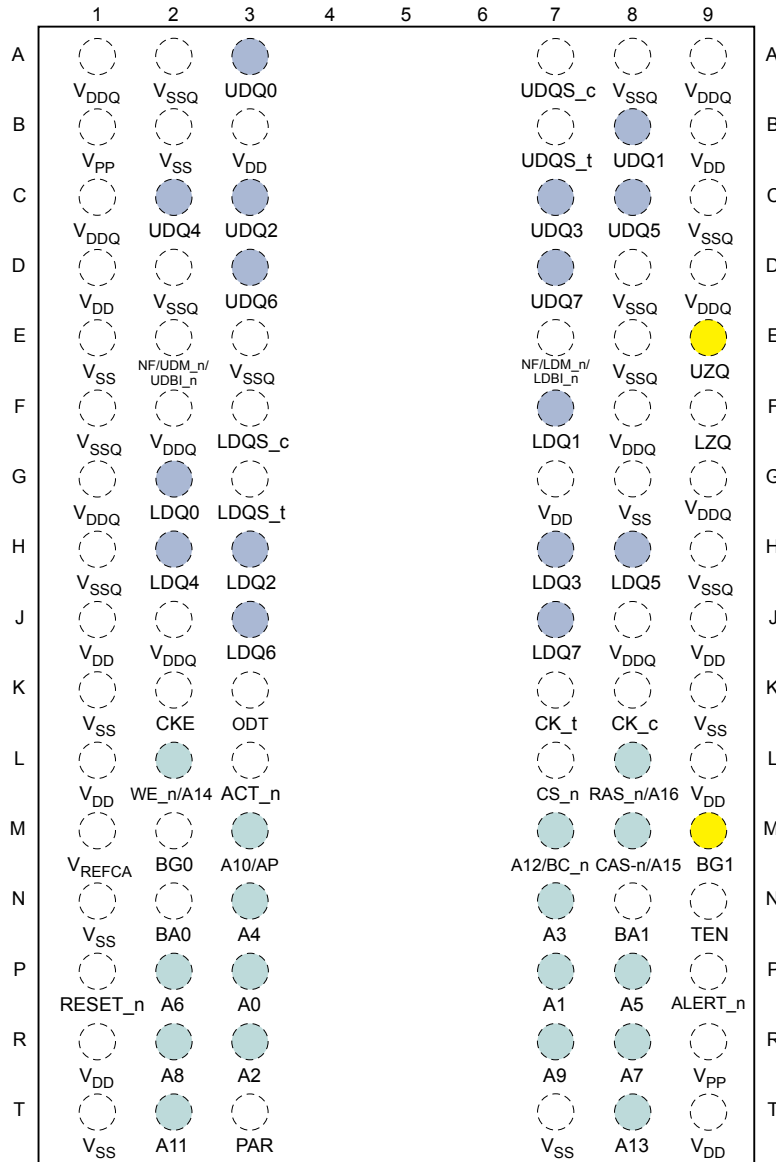
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Ball Assignments

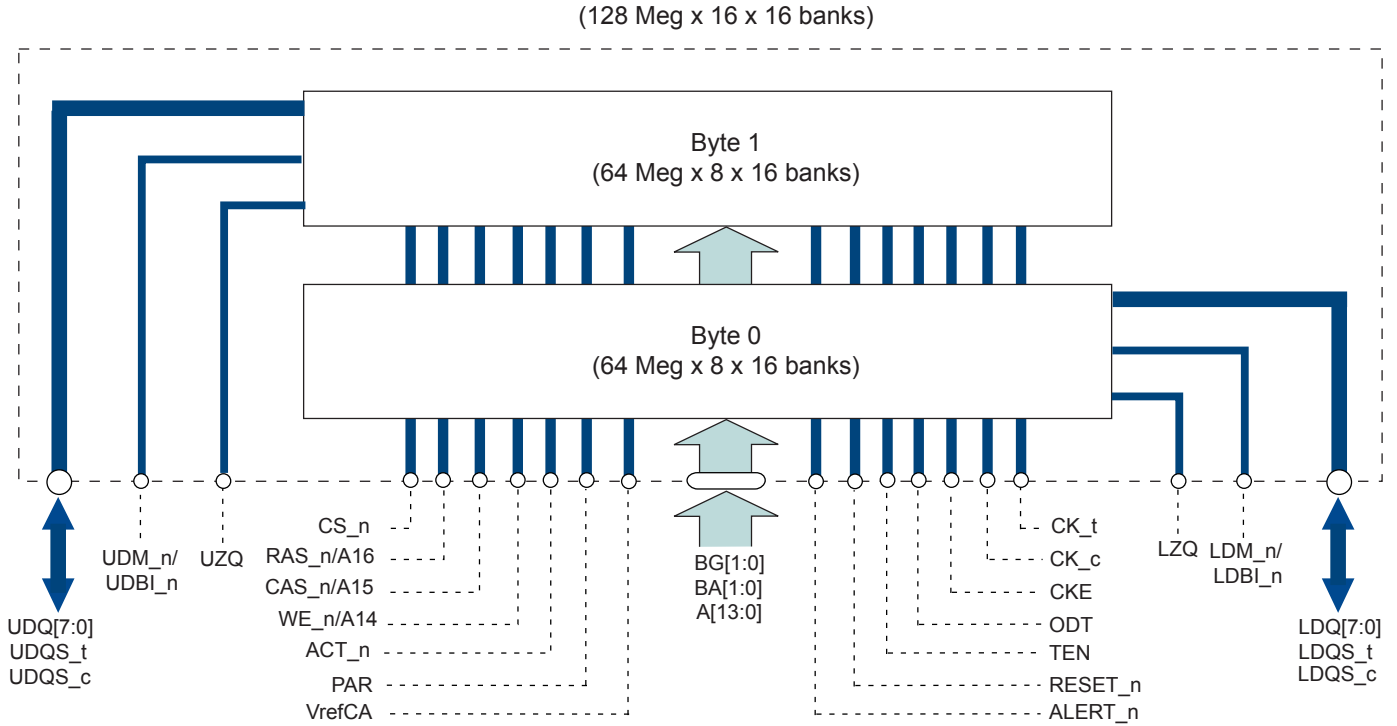
Figure 1: 96-Ball x16 SR DDP Ball Assignments



- Notes:
1. See Ball Descriptions in the monolithic data sheet.
 2. A slash "/" defines a selectable function. For example: Ball E2 = NF/UDM_n/UDBI_n where either NF, UDM_n, or UDBI_n is defined via MRS.

Functional Block Diagrams

Figure 2: Functional Block Diagram (128 Meg x 16 x 16 Banks x 1 Rank)



Connectivity Test Mode

Connectivity test (CT) mode for the x16 TwinDie single rank (SR) device is the same as two mono x8 devices connected in parallel. The mapping is restated for clarity.

Minimum Terms Definition for Logic Equations

The test input and output pins are related by the following equations, where INV denotes a logical inversion operation and XOR a logical exclusive OR operation:

$MT0 = \text{XOR}(A1, A6, PAR)$
 $MT1 = \text{XOR}(A8, ALERT_n, A9)$
 $MT2 = \text{XOR}(A2, A5, A13)$
 $MT3 = \text{XOR}(A0, A7, A11)$
 $MT4 = \text{XOR}(CK_c, ODT, CAS_n/A15)$
 $MT5 = \text{XOR}(CKE, RAS_n/A16, A10/AP)$
 $MT6 = \text{XOR}(ACT_n, A4, BA1)$
 $MT7L = \text{XOR}(BG1, LDM_n/LDBI_n, CK_t)$
 $MT7U = \text{XOR}(BG1, UDM_n/UDBI_n, CK_t)$
 $MT8 = \text{XOR}(WE_n/A14, A12 / BC, BA0)$
 $MT9 = \text{XOR}(BG0, A3, RESET_n \text{ and } TEN)$

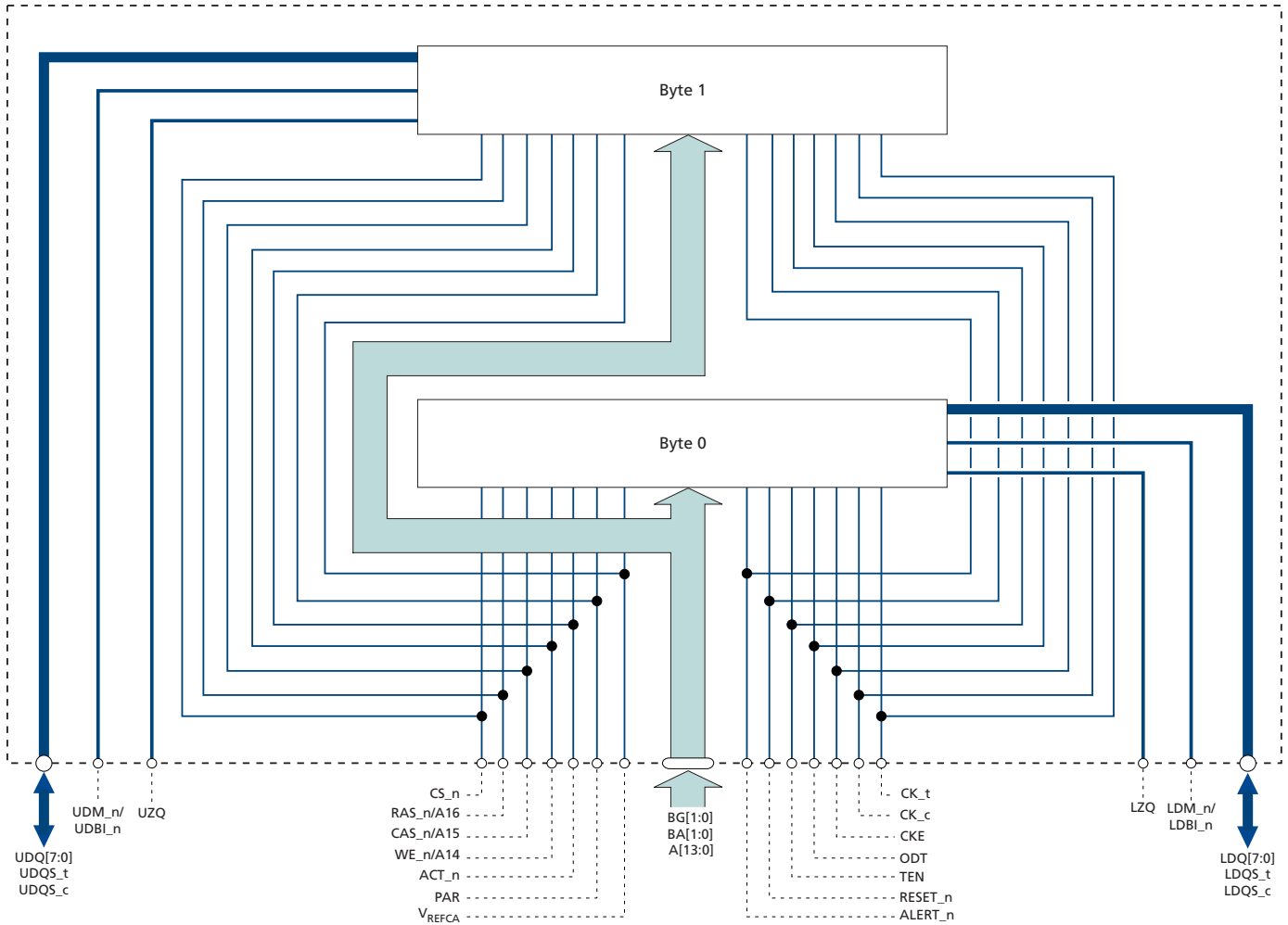
Logic Equations for a x16 TwinDie, SR Device

| Byte 0 | Byte 1 |
|--------------|--------------|
| LDQ0 = MT0 | UDQ0 = MT0 |
| LDQ1 = MT1 | UDQ1 = MT1 |
| LDQ2 = MT2 | UDQ2 = MT2 |
| LDQ3 = MT3 | UDQ3 = MT3 |
| LDQ4 = MT4 | UDQ4 = MT4 |
| LDQ5 = MT5 | UDQ5 = MT5 |
| LDQ6 = MT6 | UDQ6 = MT6 |
| LDQ7 = MT7L | UDQ7 = MT7U |
| LDQS_t = MT8 | UDQS_t = MT8 |
| LDQS_c = MT9 | UDQS_c = MT9 |

x16 TwinDie, SR Internal Connections

The figure below shows the internal connections of the x16 TwinDie, SR. The diagram shows why byte 0 and byte 1 outputs have the same logic equations except LDQ7 and UDQ7; they are different because the DM_n/DBI_n pins are not common for each byte.

Figure 3: x16 TwinDie, SR



Electrical Specifications – Leakages

Table 3: Input and Output Leakages

| Symbol | Parameter | Min | Max | Units | Notes |
|------------|---|-----|-----|---------|-------|
| I_I | Input leakage current Any input $0V \leq V_{IN} \leq V_{DD}$, V_{REF} pin $0V \leq V_{IN} \leq 1.1V$ (All other pins not under test = 0V) | -4 | 4 | μA | 1 |
| I_{VREF} | V_{REF} supply leakage current $V_{REFDQ} = V_{DD}/2$ or $V_{REFCA} = V_{DD}/2$ (All other pins not under test = 0V) | -4 | 4 | μA | 2 |
| I_{ZQ} | Input leakage on ZQ pin | -50 | 10 | μA | |
| I_{TEN} | Input leakage on TEN pin | -12 | 20 | μA | |
| I_{OZPD} | Output leakage: $V_{OUT} = V_{DDQ}$ | - | 10 | μA | 3 |
| I_{OZPU} | Output leakage: $V_{OUT} = V_{SSQ}$ | -50 | - | μA | 3, 4 |

- Notes:
1. Any input $0V < V_{in} < 1.1V$
 2. $V_{REFCA} = V_{DD}/2$, V_{DD} at valid level.
 3. DQs are disabled.
 4. ODT is disabled with the ODT input HIGH.

Temperature and Thermal Impedance

It is imperative that the DDR4 SDRAM device's temperature specifications, shown in the following table, be maintained in order to ensure the junction temperature is in the proper operating range to meet data sheet specifications. An important step in maintaining the proper junction temperature is using the device's thermal impedances correctly. The thermal impedances listed in Table 5 (page 9) apply to the current die revision and packages.

Incorrectly using thermal impedances can produce significant errors. Read Micron technical note TN-00-08, "Thermal Applications," prior to using the values listed in the thermal impedance table. For designs that are expected to last several years and require the flexibility to use several DRAM die shrinks, consider using final target theta values (rather than existing values) to account for increased thermal impedances from the die size reduction.

The DDR4 SDRAM device's safe junction temperature range can be maintained when the T_C specification is not exceeded. In applications where the device's ambient temperature is too high, use of forced air and/or heat sinks may be required to satisfy the case temperature specifications.

Table 4: Thermal Characteristics

Notes 1–3 apply to entire table

| Parameter | Symbol | Value | Units | Notes |
|-----------------------|--------|---------|-------|-------|
| Operating temperature | T_C | 0 to 85 | °C | |
| | | 0 to 95 | °C | 4 |

- Notes:
1. MAX operating case temperature T_C is measured in the center of the package, as shown below.
 2. A thermal solution must be designed to ensure that the device does not exceed the maximum T_C during operation.
 3. Device functionality is not guaranteed if the device exceeds 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. The use of self refresh temperature (SRT) or automatic self refresh (ASR), if available, must be enabled.

Figure 4: Temperature Test Point Location

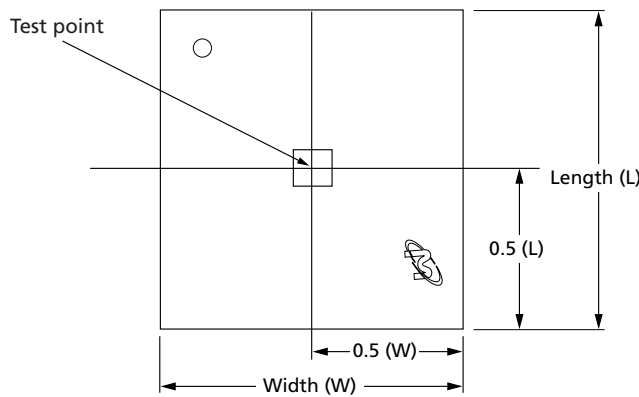


Table 5: Thermal Impedance

| Die Rev. | Substrate conductivity | Θ_{JA} (°C/W) Airflow = 0m/s | Θ_{JA} (°C/W) Airflow = 1m/s | Θ_{JA} (°C/W) Airflow = 2m/s | Θ_{JB} (°C/W) | Θ_{JC} (°C/W) | Notes |
|----------|------------------------|--|--|--|----------------------|----------------------|-------|
| A | Low | TBD | TBD | TBD | N/A | TBD | 1 |
| | High | TBD | TBD | TBD | TBD | N/A | |
| B, D | Low | 43.9 | 33.0 | 29.5 | N/A | 3.3 | 1 |
| | High | 27.1 | 21.7 | 20.1 | 10.5 | N/A | |
| E | Low | TBD | TBD | TBD | N/A | TBD | 1 |
| | High | TBD | TBD | TBD | TBD | N/A | |

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



DRAM Package Electrical Specifications

Table 6: DRAM Package Electrical Specifications for x16 Devices

Notes 1–4 apply to the entire table

| Parameter | | Symbol | DDR4-1600, -1866 | | DDR4-2133, -2400 | | DDR4-2666, -2933 | | Unit | Notes |
|--|-----------------|--------------------|------------------|-----|------------------|-----|------------------|-----|------|-------|
| | | | Min | Max | Min | Max | Min | Max | | |
| Input/ output | Zpkg | Z_{IO} | 30 | 50 | 30 | 50 | 30 | 50 | ohm | 5, 6 |
| | Package delay | Td_{IO} | 60 | 120 | 60 | 120 | 60 | 120 | ps | 6, 7 |
| | Lpkg | L_{IO} | – | 5.0 | – | 5.0 | – | 5.0 | nH | |
| | Cpkg | C_{IO} | – | 3.0 | – | 3.0 | – | 3.0 | pF | |
| DQSL_t/ DQSL_c/ DQSU_t/ DQSU_c | Zpkg | $Z_{IO\ DQS}$ | 30 | 50 | 30 | 50 | 30 | 50 | ohm | 5 |
| | Package delay | $Td_{IO\ DQS}$ | 60 | 120 | 60 | 120 | 60 | 120 | ps | 7 |
| | Lpkg | $L_{IO\ DQS}$ | – | 5.0 | – | 5.0 | – | 5.0 | nH | |
| | Cpkg | $C_{IO\ DQS}$ | – | 3.0 | – | 3.0 | – | 3.0 | pF | |
| DQSL_t/ DQSL_c, DQSU_t/ DQSU_c, | Delta Zpkg | $DZ_{IO\ DQS}$ | – | 20 | – | 20 | – | 20 | ohm | 5, 8 |
| | Delta delay | $DTd_{IO\ DQS}$ | – | 45 | – | 45 | – | 45 | ps | 7, 8 |
| Input CTRL pins | Zpkg | $Z_{I\ CTRL}$ | 35 | 65 | 35 | 65 | 35 | 65 | ohm | 5, 9 |
| | Package delay | $Td_{I\ CTRL}$ | 75 | 120 | 75 | 120 | 75 | 120 | ps | 7, 9 |
| | Lpkg | $L_{I\ CTRL}$ | – | 6.5 | – | 6.5 | – | 6.5 | nH | |
| | Cpkg | $C_{I\ CTRL}$ | – | 2.5 | – | 2.5 | – | 2.5 | pF | |
| Input CMD ADD pins | Zpkg | $Z_{I\ ADD\ CMD}$ | 35 | 65 | 35 | 65 | 35 | 65 | ohm | 5, 10 |
| | Package delay | $Td_{I\ ADD\ CMD}$ | 70 | 125 | 70 | 125 | 70 | 125 | ps | 7, 10 |
| | Lpkg | $L_{I\ ADD\ CMD}$ | – | 6.5 | – | 6.5 | – | 6.5 | nH | |
| | Cpkg | $C_{I\ ADD\ CMD}$ | – | 3.0 | – | 3.0 | – | 3.0 | pF | |
| CK_t, CK_c | Zpkg | Z_{CK} | 30 | 55 | 30 | 55 | 30 | 55 | ohm | 5 |
| | Package delay | Td_{CK} | 80 | 135 | 80 | 135 | 80 | 135 | ps | 7 |
| | Delta Zpkg | DZ_{DCK} | – | 0.5 | – | 0.5 | – | 0.5 | ohm | 5, 11 |
| | Delta delay | DTd_{DCK} | – | 1.2 | – | 1.2 | – | 1.2 | ps | 7, 11 |
| Input CLK | Lpkg | $L_{I\ CLK}$ | – | 6.0 | – | 6.0 | – | 6.0 | nH | |
| | Cpkg | $C_{I\ CLK}$ | – | 3.0 | – | 3.0 | – | 3.0 | pF | |
| ZQ Zpkg | $Z_{O\ ZQ}$ | – | 40 | – | 40 | – | 40 | ohm | 5 | |
| ZQ delay | $Td_{O\ ZQ}$ | 30 | 135 | 30 | 135 | 30 | 135 | ps | 7 | |
| ALERT Zpkg | $Z_{O\ ALERT}$ | 30 | 55 | 30 | 55 | 30 | 55 | ohm | 5 | |
| ALERT delay | $Td_{O\ ALERT}$ | 65 | 110 | 65 | 110 | 65 | 110 | ps | 7 | |

- Notes:
1. The package parasitic (L and C) are not subject to production testing. If the package parasitic (L and C) are measured, the capacitance is measured with V_{DD} , V_{DDQ} , V_{SS} , and V_{SSQ} shorted with all other signal pins floating. The inductance is measured with V_{DD} , V_{DDQ} , V_{SS} , and V_{SSQ} shorted and all other signal pins shorted at the die, not pin, side.
 2. Package implementations should satisfy targets if the Zpkg and package delay fall within the ranges shown, and the maximum Lpkg and Cpkg do not exceed the maximum

values shown. The package design targets are provided for reference, system signal simulations should not use these values but use the Micron package model.

3. It is assumed that L_{pkg} can be approximated as $L_{pkg} = Z_O \times T_d$.
4. It is assumed that C_{pkg} can be approximated as $C_{pkg} = T_d/Z_O$.
5. Package-only impedance (Z_{pkg}) is calculated based on the L_{pkg} and C_{pkg} total for a given pin where: Z_{pkg} (total per pin) = $\text{SQRT}(L_{pkg}/C_{pkg})$.
6. Z_{IO} and T_{dIO} apply to DQ, DM, DQS_c, DQS_t, TDQS_t, and TDQS_c.
7. Package-only delay (T_{pkg}) is calculated based on L_{pkg} and C_{pkg} total for a given pin where: T_{pkg} (total per pin) = $\text{SQRT}(L_{pkg} \times C_{pkg})$.
8. Absolute value of Z_{IO} (DQS_t), Z_{IO} (DQS_c) for impedance (Z) or absolute value of T_{dIO} (DQS_t), T_{dIO} (DQS_c) for delay (Td).
9. Z_{I_CTRL} and T_{dI_CTRL} apply to ODT, CS_n, and CKE.
10. $Z_{I_ADD_CMD}$ and $T_{dI_ADD_CMD}$ apply to A[17:0], BA[1:0], BG[1:0], RAS_n CAS_n, and WE_n.
11. Absolute value of Z_{CK_t} , Z_{CK_c} for impedance (Z) or absolute value of T_{dCK_t} , T_{dCK_c} for delay (Td).

Table 7: Pad Input/Output Capacitance

| Parameter | Symbol | DDR4-1600, -1866, -2133 | | DDR4-2400, -2666 | | DDR4-2933 | | Unit | Notes |
|--|--------------------|----------------------------|------|---------------------|------|-----------|------|------|--------------|
| | | Min | Max | Min | Max | Min | Max | | |
| Input/output capacitance: DQ, DM, DQS_t, DQS_c, TDQS_t, TDQS_c | C_{IO} | 1.8 | 2.8 | 1.8 | 2.8 | 1.8 | 2.8 | pF | 1, 2, 3 |
| Input capacitance: CK_t and CK_c | C_{CK} | 2.1 | 2.9 | 2.1 | 2.9 | 2.1 | 2.9 | pF | 1, 2, 3, 4 |
| Input capacitance delta: CK_t and CK_c | C_{DCK} | 0 | 0.05 | 0 | 0.05 | 0 | 0.05 | pF | 1, 2, 3, 5 |
| Input/output capacitance delta: DQS_t and DQS_c | C_{DDQS} | 0 | 0.05 | 0 | 0.05 | 0 | 0.05 | pF | 1, 3 |
| Input capacitance: CTRL, ADD, CMD input-only pins | C_I | 1.6 | 2.6 | 1.6 | 2.6 | 1.6 | 2.6 | pF | 1, 3, 6 |
| Input capacitance delta: All CTRL input-only pins | C_{DI_CTRL} | -0.9 | 0.9 | -0.9 | 0.9 | -0.9 | 0.9 | pF | 1, 3, 7 |
| Input capacitance delta: All ADD/CMD input-only pins | $C_{DI_ADD_CMD}$ | -0.9 | 0.9 | -0.9 | 0.9 | -0.9 | 0.9 | pF | 1, 3, 8, 9 |
| Input/output capacitance delta: DQ, DM, DQS_t, DQS_c, TDQS_t, TDQS_c | C_{DIO} | -0.16 | 0.16 | -0.16 | 0.16 | -0.16 | 0.16 | pF | 1, 2, 10, 11 |
| Input/output capacitance: ALERT pin | C_{ALERT} | 1.1 | 2.3 | 1.1 | 2.3 | 1.1 | 2.3 | pF | 1, 3 |
| Input/output capacitance: ZQ pin | C_{ZQ} | - | 3.7 | - | 3.7 | - | 3.7 | pF | 1, 3, 12 |
| Input/output capacitance: TEN pin | C_{TEN} | 0.2 | 2.3 | 0.2 | 2.3 | 0.2 | 2.3 | pF | 1, 3, 13 |

Notes: 1. Although the DM, TDQS_t, and TDQS_c pins have different functions, the loading matches DQ and DQS.

2. This parameter is not subject to a production test; it is verified by design and characterization and are provided for reference; system signal simulations should not use these values but use the Micron package model. The capacitance, if and when, is measured according to the JEP147 specification, "Procedure for Measuring Input Capacitance Using a Vector Network Analyzer (VNA)," with V_{DD} , V_{DDQ} , V_{SS} , and V_{SSQ} applied and all other pins floating (except the pin under test, CKE, RESET_n and ODT, as necessary). $V_{DD} = V_{DDQ} = 1.5V$, $V_{BIAS} = V_{DD}/2$ and on-die termination off.
3. This parameter applies to SR x16 TwinDie, obtained by de-embedding the package L and C parasitics.
4. $C_{DIO} = C_{IO}(DQ, DM) - 0.5 \times (C_{IO}(DQS_t) + C_{IO}(DQS_c))$.
5. Absolute value of $C_{IO}(DQS_t)$, $C_{IO}(DQS_c)$
6. Absolute value of CCK_t , CCK_c
7. C_i applies to ODT, CS_n, CKE, A[15:0], BA[1:0], RAS_n, CAS_n, and WE_n.
8. C_{DL_CTRL} applies to ODT, CS_n, and CKE.
9. $C_{DL_CTRL} = C_i(CTRL) - 0.5 \times (C_i(CLK_t) + C_i(CLK_c))$.
10. $C_{DL_ADD_CMD}$ applies to A[15:0], BA[1:0], RAS_n, CAS_n and WE_n.
11. $C_{DL_ADD_CMD} = C_i(ADD_CMD) - 0.5 \times (C_i(CLK_t) + C_i(CLK_c))$.
12. Maximum external load capacitance on ZQ pin: 5pF.
13. Only applicable if TEN pin does not have an internal pull-up.



Current Specifications – Limits

Table 8: x16 I_{DD}, I_{PP}, and I_{DDQ} Current Limits – Rev. A

| Symbol | DDR4-2133 ¹ | DDR4-2400 | DDR4-2666 | DDR4-2933 | Unit | Notes |
|---|------------------------|-----------|-----------|-----------|------|-----------------------|
| I _{DD0} : One bank ACTIVATE-to-PRECHARGE current | 110 | 120 | 130 | TBD | mA | 2, 3, 4 |
| I _{PP0} : One bank ACTIVATE-to-PRECHARGE I _{PP} current | 6 | 6 | 6 | TBD | mA | |
| I _{DD1} : One bank ACTIVATE-to-READ-to-PRECHARGE current | 140 | 150 | 160 | TBD | mA | 3, 4, 5 |
| I _{DD2N} : Precharge standby current | 90 | 100 | 110 | TBD | mA | 4, 6, 7, 8, 9, 10, 11 |
| I _{DD2NT} : Precharge standby ODT current | 110 | 120 | 130 | TBD | mA | 4, 11 |
| I _{DD2P} : Precharge power-down current | 50 | 60 | 70 | TBD | mA | 4, 11 |
| I _{DD2Q} : Precharge quiet standby current | 90 | 90 | 100 | TBD | mA | 4, 11 |
| I _{DD3N} : Active standby current | 110 | 110 | 120 | TBD | mA | 4, 11 |
| I _{PP3N} : Active standby I _{PP} current | 6 | 6 | 6 | TBD | mA | |
| I _{DD3P} : Active power-down current | 70 | 80 | 80 | TBD | mA | 4, 11 |
| I _{DD4R} : Burst read current | 300 | 300 | 350 | TBD | mA | 4, 14, 13, 11 |
| I _{DD4W} : Burst write current | 300 | 320 | 350 | TBD | mA | 4, 11, 15, 16, 17, 18 |
| I _{DD5R} : Distributed refresh current (1X REF) | 128 | 128 | 136 | TBD | mA | 4, 19, 20 |
| I _{PP5R} : Distributed refresh I _{PP} current (1X REF) | 10 | 10 | 10 | TBD | mA | |
| I _{DD6N} : Self refresh current; 0–85°C | 60 | 60 | 60 | TBD | mA | 11, 21 |
| I _{DD6E} : Self refresh current; 0–95°C | 70 | 70 | 70 | TBD | mA | 11, 22 |
| I _{DD6R} : Self refresh current; 0–45°C | 50 | 50 | 50 | TBD | mA | 11, 23, 24 |
| I _{DD6A} : Auto self refresh current (25°C) | 40 | 40 | 40 | TBD | mA | 11, 24 |
| I _{DD6A} : Auto self refresh current (45°C) | 50 | 50 | 50 | TBD | mA | 11, 24 |
| I _{DD6A} : Auto self refresh current (75°C) | 70 | 70 | 70 | TBD | mA | 11, 24 |
| I _{PP6X} : Auto self refresh current I _{PP} current | 10 | 10 | 10 | TBD | mA | 11, 24 |
| I _{DD7} : Bank interleave read current | 400 | 410 | 430 | TBD | mA | 4 |
| I _{PP7} : Bank interleave read I _{PP} current | 30 | 30 | 30 | TBD | mA | |
| I _{DD8} : Maximum power-down current | 40 | 40 | 40 | TBD | mA | 11 |

- Notes:
1. DDR4-1600 and DDR4-1866 use the same I_{DD} limits as DDR4-2133.
 2. When additive latency is enabled for I_{DD0}, current changes by approximately 0%.
 3. I_{PP0} test and limit is applicable for I_{DD0} and I_{DD1} conditions.
 4. The I_{DD} values must be derated (increased) when operated outside of the range 0°C ≤ T_C ≤ 85°C:



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When $T_C < 0^\circ\text{C}$: I_{DD2P} and I_{DD3P} must be derated by 6%; I_{DD4R} and I_{DD4W} must be derated by +4%; and I_{DD7} must be derated by +11%.

When $T_C > 85^\circ\text{C}$: I_{DD0} , I_{DD1} , I_{DD2N} , I_{DD2NT} , I_{DD2Q} , I_{DD3N} , I_{DD3P} , I_{DD4R} , I_{DD4W} , and I_{DD5R} must be derated by +3%; I_{DD2P} must be derated by +40%.

5. When additive latency is enabled for I_{DD1} , current changes by approximately +4%.
6. When additive latency is enabled for I_{DD2N} , current changes by approximately 0%.
7. When DLL is disabled for I_{DD2N} , current changes by approximately -23%.
8. When CAL is enabled for I_{DD2N} , current changes by approximately -25%.
9. When gear-down is enabled for I_{DD2N} , current changes by approximately 0%.
10. When CA parity is enabled for I_{DD2N} , current changes by approximately +7%.
11. I_{PP3N} test and limit is applicable for all I_{DD2x} , I_{DD3x} , I_{DD4x} , I_{DD6x} , and I_{DD8} conditions; that is, testing I_{PP3N} should satisfy the I_{PPS} for the noted I_{DD} tests.
12. When additive latency is enabled for I_{DD3N} , current changes by approximately +0.6%.
13. When additive latency is enabled for I_{DD4R} , current changes by approximately +5%.
14. When read DBI is enabled for I_{DD4R} , current changes by approximately 0%.
15. When additive latency is enabled for I_{DD4W} , current changes by approximately +4%.
16. When write DBI is enabled for I_{DD4W} , current changes by approximately 0%.
17. When write CRC is enabled for I_{DD4W} , current changes by approximately -3%.
18. When CA parity is enabled for I_{DD4W} , current changes by approximately +12%.
19. When 2X REF is enabled for I_{DD5R} , current changes by approximately -14%.
20. When 4X REF is enabled for I_{DD5R} , current changes by approximately -33%.
21. Applicable for MR2 settings $A7 = 0$ and $A6 = 0$; manual mode with normal temperature range of operation (0–85°C).
22. Applicable for MR2 settings $A7 = 1$ and $A6 = 0$; manual mode with extended temperature range of operation (0–95°C).
23. Applicable for MR2 settings $A7 = 0$ and $A6 = 1$; manual mode with reduced temperature range of operation (0–45°C).
24. I_{DD6R} and I_{DD6A} values are typical.

Table 9: x16 I_{DD} , I_{PP} , and I_{DDQ} Current Limits – Rev. B

| Symbol | DDR4-2133 ¹ | DDR4-2400 | DDR4-2666 | DDR4-2933 | DDR4-3200 | Unit | Notes |
|--|------------------------|-----------|-----------|-----------|-----------|------|-----------------------|
| I_{DD0} : One bank ACTIVATE-to-PRE-CHARGE current | 90 | 96 | 102 | 108 | 114 | mA | 2, 3, 4 |
| I_{PP0} : One bank ACTIVATE-to-PRE-CHARGE I_{PP} current | 6 | 6 | 6 | 6 | 6 | mA | |
| I_{DD1} : One bank ACTIVATE-to-READ-to-PRECHARGE current | 114 | 120 | 126 | 132 | 138 | mA | 3, 4, 5 |
| I_{DD2N} : Precharge standby current | 66 | 68 | 70 | 72 | 74 | mA | 4, 6, 7, 8, 9, 10, 11 |
| I_{DD2NT} : Precharge standby ODT current | 90 | 100 | 100 | 110 | 120 | mA | 4, 11 |
| I_{DD2P} : Precharge power-down current | 50 | 50 | 50 | 50 | 50 | mA | 4, 11 |
| I_{DD2Q} : Precharge quiet standby current | 60 | 60 | 60 | 60 | 60 | mA | 4, 11 |
| I_{DD3N} : Active standby current | 80 | 86 | 92 | 98 | 104 | mA | 4, 11 |



Table 9: x16 I_{DD}, I_{PP}, and I_{DDQ} Current Limits – Rev. B (Continued)

| Symbol | DDR4-2133 ¹ | DDR4-2400 | DDR4-2666 | DDR4-2933 | DDR4-3200 | Unit | Notes |
|--|------------------------|-----------|-----------|-----------|-----------|------|-----------------------------|
| I _{PP3N} : Active standby I _{PP} current | 6 | 6 | 6 | 6 | 6 | mA | |
| I _{DD3P} : Active power-down current | 70 | 74 | 78 | 82 | 86 | mA | 4, 11 |
| I _{DD4R} : Burst read current | 250 | 270 | 292 | 314 | 336 | mA | 4, 14, 13, 11 |
| I _{DD4W} : Burst write current | 230 | 246 | 264 | 282 | 300 | mA | 4, 11, 15, 16, 17, 18 |
| I _{DD5R} : Distributed refresh current (1X REF) | 100 | 106 | 112 | 118 | 124 | mA | 4, 19, 20 |
| I _{PP5R} : Distributed refresh I _{PP} current (1X REF) | 10 | 10 | 10 | 10 | 10 | mA | |
| I _{DD6N} : Self refresh current; 0–85°C | 60 | 60 | 60 | 60 | 60 | mA | 11, 21 |
| I _{DD6E} : Self refresh current; 0–95°C | 70 | 70 | 70 | 70 | 70 | mA | 11, 22 |
| I _{DD6R} : Self refresh current; 0–45°C | 40 | 40 | 40 | 40 | 40 | mA | 11, 23, 24 |
| I _{DD6A} : Auto self refresh current (25°C) | 17.2 | 17.2 | 17.2 | 17.2 | 17.2 | mA | 11, 24 |
| I _{DD6A} : Auto self refresh current (45°C) | 40 | 40 | 40 | 40 | 40 | mA | 11, 24 |
| I _{DD6A} : Auto self refresh current (75°C) | 60 | 60 | 60 | 60 | 60 | mA | 11, 24 |
| I _{PP6X} : Auto self refresh current I _{PP} current | 10 | 10 | 10 | 10 | 10 | mA | 11, 24 |
| I _{DD7} : Bank interleave read current | 340 | 350 | 360 | 370 | 380 | mA | 4 |
| I _{PP7} : Bank interleave read I _{PP} current | 30 | 30 | 30 | 30 | 30 | mA | |
| I _{DD8} : Maximum power-down current | 50 | 50 | 50 | 50 | 50 | mA | 11 |

- Notes:
1. DDR4-1600 and DDR4-1866 use the same I_{DD} limits as DDR4-2133.
 2. When additive latency is enabled for I_{DD0}, current changes by approximately 0%.
 3. I_{PP0} test and limit is applicable for I_{DD0} and I_{DD1} conditions.
 4. The I_{DD} values must be derated (increased) when operated outside of the range 0°C ≤ T_C ≤ 85°C:

When T_C < 0°C: I_{DD2P} and I_{DD3P} must be derated by 6%; I_{DD4R} and I_{DD4W} must be derated by +4%; and I_{DD7} must be derated by +11%.

When T_C > 85°C: I_{DD0}, I_{DD1}, I_{DD2N}, I_{DD2NT}, I_{DD2Q}, I_{DD3N}, I_{DD3P}, I_{DD4R}, I_{DD4W}, and I_{DD5R} must be derated by +3%; I_{DD2P} must be derated by +40%.
 5. When additive latency is enabled for I_{DD1}, current changes by approximately +4%.
 6. When additive latency is enabled for I_{DD2N}, current changes by approximately 0%.
 7. When DLL is disabled for I_{DD2N}, current changes by approximately –23%.
 8. When CAL is enabled for I_{DD2N}, current changes by approximately –25%.
 9. When gear-down is enabled for I_{DD2N}, current changes by approximately 0%.



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10. When CA parity is enabled for I_{DD2N} , current changes by approximately +7%.
11. I_{PP3N} test and limit is applicable for all I_{DD2x} , I_{DD3x} , I_{DD4x} , I_{DD6x} , and I_{DD8} conditions; that is, testing I_{PP3N} should satisfy the I_{PPS} for the noted I_{DD} tests.
12. When additive latency is enabled for I_{DD3N} , current changes by approximately +0.6%.
13. When additive latency is enabled for I_{DD4R} , current changes by approximately +5%.
14. When read DBI is enabled for I_{DD4R} , current changes by approximately 0%.
15. When additive latency is enabled for I_{DD4W} , current changes by approximately +4%.
16. When write DBI is enabled for I_{DD4W} , current changes by approximately 0%.
17. When write CRC is enabled for I_{DD4W} , current changes by approximately -3%.
18. When CA parity is enabled for I_{DD4W} , current changes by approximately +12%.
19. When 2X REF is enabled for I_{DD5R} , current changes by approximately -14%.
20. When 4X REF is enabled for I_{DD5R} , current changes by approximately -33%.
21. Applicable for MR2 settings A7 = 0 and A6 = 0; manual mode with normal temperature range of operation (0–85°C).
22. Applicable for MR2 settings A7 = 1 and A6 = 0; manual mode with extended temperature range of operation (0–95°C).
23. Applicable for MR2 settings A7 = 0 and A6 = 1; manual mode with reduced temperature range of operation (0–45°C).
24. I_{DD6R} and I_{DD6A} values are typical.

Table 10: x16 I_{DD} , I_{PP} , and I_{DDQ} Current Limits – Rev. D

| Symbol | DDR4-2133 ¹ | DDR4-2400 | DDR4-2666 | DDR4-2933 | DDR4-3200 | Unit | Notes |
|---|------------------------|-----------|-----------|-----------|-----------|------|-----------------------|
| I_{DD0} : One bank ACTIVATE-to-PRECHARGE current | 90 | 96 | 102 | 108 | 114 | mA | 2, 3, 4 |
| I_{PP0} : One bank ACTIVATE-to-PRECHARGE I_{PP} current | 6 | 6 | 6 | 6 | 6 | mA | |
| I_{DD1} : One bank ACTIVATE-to-READ-to-PRECHARGE current | 114 | 120 | 126 | 132 | 138 | mA | 3, 4, 5 |
| I_{DD2N} : Precharge standby current | 66 | 68 | 70 | 72 | 74 | mA | 4, 6, 7, 8, 9, 10, 11 |
| I_{DD2NT} : Precharge standby ODT current | 90 | 100 | 100 | 110 | 120 | mA | 4, 11 |
| I_{DD2P} : Precharge power-down current | 50 | 50 | 50 | 50 | 50 | mA | 4, 11 |
| I_{DD2Q} : Precharge quiet standby current | 60 | 60 | 60 | 60 | 60 | mA | 4, 11 |
| I_{DD3N} : Active standby current | 90 | 96 | 102 | 108 | 112 | mA | 4, 11 |
| I_{PP3N} : Active standby I_{PP} current | 6 | 6 | 6 | 6 | 6 | mA | |
| I_{DD3P} : Active power-down current | 70 | 74 | 78 | 82 | 86 | mA | 4, 11 |
| I_{DD4R} : Burst read current | 250 | 270 | 292 | 314 | 336 | mA | 4, 14, 13, 11 |
| I_{DD4W} : Burst write current | 250 | 264 | 284 | 300 | 320 | mA | 4, 11, 15, 16, 17, 18 |



Table 10: x16 I_{DD}, I_{PP}, and I_{DDQ} Current Limits – Rev. D (Continued)

| Symbol | DDR4-2133 ¹ | DDR4-2400 | DDR4-2666 | DDR4-2933 | DDR4-3200 | Unit | Notes |
|--|------------------------|-----------|-----------|-----------|-----------|------|------------|
| I _{DD5R} : Distributed refresh current (1X REF) | 112 | 116 | 122 | 128 | 132 | mA | 4, 19, 20 |
| I _{PP5R} : Distributed refresh I _{PP} current (1X REF) | 10 | 10 | 10 | 10 | 10 | mA | |
| I _{DD6N} : Self refresh current; 0–85°C | 62 | 62 | 62 | 62 | 62 | mA | 11, 21 |
| I _{DD6E} : Self refresh current; 0–95°C | 72 | 72 | 72 | 72 | 72 | mA | 11, 22 |
| I _{DD6R} : Self refresh current; 0–45°C | 42 | 42 | 42 | 42 | 42 | mA | 11, 23, 24 |
| I _{DD6A} : Auto self refresh current (25°C) | 17.2 | 17.2 | 17.2 | 17.2 | 17.2 | mA | 11, 24 |
| I _{DD6A} : Auto self refresh current (45°C) | 42 | 42 | 42 | 42 | 42 | mA | 11, 24 |
| I _{DD6A} : Auto self refresh current (75°C) | 62 | 62 | 62 | 62 | 62 | mA | 11, 24 |
| I _{PP6X} : Auto self refresh current I _{PP} current | 10 | 10 | 10 | 10 | 10 | mA | 11, 24 |
| I _{DD7} : Bank interleave read current | 340 | 350 | 360 | 370 | 380 | mA | 4 |
| I _{PP7} : Bank interleave read I _{PP} current | 30 | 30 | 30 | 30 | 30 | mA | |
| I _{DD8} : Maximum power-down current | 50 | 50 | 50 | 50 | 50 | mA | 11 |

- Notes:
1. DDR4-1600 and DDR4-1866 use the same I_{DD} limits as DDR4-2133.
 2. When additive latency is enabled for I_{DD0}, current changes by approximately 0%.
 3. I_{PP0} test and limit is applicable for I_{DD0} and I_{DD1} conditions.
 4. The I_{DD} values must be derated (increased) when operated outside of the range 0°C ≤ T_C ≤ 85°C:

When T_C < 0°C: I_{DD2P} and I_{DD3P} must be derated by 6%; I_{DD4R} and I_{DD4W} must be derated by +4%; and I_{DD7} must be derated by +11%.

When T_C > 85°C: I_{DD0}, I_{DD1}, I_{DD2N}, I_{DD2NT}, I_{DD2Q}, I_{DD3N}, I_{DD3P}, I_{DD4R}, I_{DD4W}, and I_{DD5R} must be derated by +3%; I_{DD2P} must be derated by +40%.

5. When additive latency is enabled for I_{DD1}, current changes by approximately +4%.
6. When additive latency is enabled for I_{DD2N}, current changes by approximately 0%.
7. When DLL is disabled for I_{DD2N}, current changes by approximately –23%.
8. When CAL is enabled for I_{DD2N}, current changes by approximately –25%.
9. When gear-down is enabled for I_{DD2N}, current changes by approximately 0%.
10. When CA parity is enabled for I_{DD2N}, current changes by approximately +7%.
11. I_{PP3N} test and limit is applicable for all I_{DD2x}, I_{DD3x}, I_{DD4x}, I_{DD6x}, and I_{DD8} conditions; that is, testing I_{PP3N} should satisfy the I_{PPs} for the noted I_{DD} tests.
12. When additive latency is enabled for I_{DD3N}, current changes by approximately +0.6%.
13. When additive latency is enabled for I_{DD4R}, current changes by approximately +5%.



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14. When read DBI is enabled for I_{DD4R} , current changes by approximately 0%.
15. When additive latency is enabled for I_{DD4W} , current changes by approximately +4%.
16. When write DBI is enabled for I_{DD4W} , current changes by approximately 0%.
17. When write CRC is enabled for I_{DD4W} , current changes by approximately -3%.
18. When CA parity is enabled for I_{DD4W} , current changes by approximately +12%.
19. When 2X REF is enabled for I_{DD5R} , current changes by approximately -14%.
20. When 4X REF is enabled for I_{DD5R} , current changes by approximately -33%.
21. Applicable for MR2 settings A7 = 0 and A6 = 0; manual mode with normal temperature range of operation (0–85°C).
22. Applicable for MR2 settings A7 = 1 and A6 = 0; manual mode with extended temperature range of operation (0–95°C).
23. Applicable for MR2 settings A7 = 0 and A6 = 1; manual mode with reduced temperature range of operation (0–45°C).
24. I_{DD6R} and I_{DD6A} values are typical.

Table 11: x16 I_{DD} , I_{PP} , and I_{DDQ} Current Limits – Rev. E

| Symbol | DDR4-2133 ¹ | DDR4-2400 | DDR4-2666 | DDR4-2933 | DDR4-3200 | Unit | Notes |
|---|------------------------|-----------|-----------|-----------|-----------|------|-----------------------|
| I_{DD0} : One bank ACTIVATE-to-PRECHARGE current | 78 | 82 | 86 | 90 | 94 | mA | 2, 3, 4 |
| I_{PP0} : One bank ACTIVATE-to-PRECHARGE I_{PP} current | 6 | 6 | 6 | 6 | 6 | mA | |
| I_{DD1} : One bank ACTIVATE-to-READ-to-PRECHARGE current | 110 | 114 | 118 | 122 | 126 | mA | 3, 4, 5 |
| I_{DD2N} : Precharge standby current | 58 | 60 | 62 | 64 | 66 | mA | 4, 6, 7, 8, 9, 10, 11 |
| I_{DD2NT} : Precharge standby ODT current | 72 | 76 | 80 | 84 | 88 | mA | 4, 11 |
| I_{DD2P} : Precharge power-down current | 44 | 44 | 44 | 44 | 44 | mA | 4, 11 |
| I_{DD2Q} : Precharge quiet standby current | 52 | 52 | 52 | 52 | 52 | mA | 4, 11 |
| I_{DD3N} : Active standby current | 70 | 74 | 78 | 82 | 86 | mA | 4, 11 |
| I_{PP3N} : Active standby I_{PP} current | 6 | 6 | 6 | 6 | 6 | mA | |
| I_{DD3P} : Active power-down current | 58 | 60 | 62 | 64 | 66 | mA | 4, 11 |
| I_{DD4R} : Burst read current | 270 | 290 | 312 | 334 | 356 | mA | 4, 14, 13, 11 |
| I_{DD4W} : Burst write current | 228 | 246 | 264 | 282 | 300 | mA | 4, 11, 15, 16, 17, 18 |
| I_{DD5R} : Distributed refresh current (1X REF) | 92 | 94 | 96 | 98 | 100 | mA | 4, 19, 20 |
| I_{PP5R} : Distributed refresh I_{PP} current (1X REF) | 10 | 10 | 10 | 10 | 10 | mA | |
| I_{DD6N} : Self refresh current; 0–85°C | 68 | 68 | 68 | 68 | 68 | mA | 11, 21 |



Table 11: x16 I_{DD}, I_{PP}, and I_{DDQ} Current Limits – Rev. E (Continued)

| Symbol | DDR4-2133 ¹ | DDR4-2400 | DDR4-2666 | DDR4-2933 | DDR4-3200 | Unit | Notes |
|---|------------------------|-----------|-----------|-----------|-----------|------|------------|
| I _{DD6E} : Self refresh current; 0–95°C | 116 | 116 | 116 | 116 | 116 | mA | 11, 22 |
| I _{DD6R} : Self refresh current; 0–45°C | 42 | 42 | 42 | 42 | 42 | mA | 11, 23, 24 |
| I _{DD6A} : Auto self refresh current (25°C) | 17.2 | 17.2 | 17.2 | 17.2 | 17.2 | mA | 11, 24 |
| I _{DD6A} : Auto self refresh current (45°C) | 42 | 42 | 42 | 42 | 42 | mA | 11, 24 |
| I _{DD6A} : Auto self refresh current (75°C) | 62 | 62 | 62 | 62 | 62 | mA | 11, 24 |
| I _{PP6X} : Auto self refresh current I _{PP} current | 10 | 10 | 10 | 10 | 10 | mA | 11, 24 |
| I _{DD7} : Bank interleave read current | 340 | 350 | 360 | 370 | 380 | mA | 4 |
| I _{PP7} : Bank interleave read I _{PP} current | 26 | 26 | 26 | 26 | 26 | mA | |
| I _{DD8} : Maximum power-down current | 36 | 36 | 36 | 36 | 36 | mA | 11 |

- Notes:
1. DDR4-1600 and DDR4-1866 use the same I_{DD} limits as DDR4-2133.
 2. When additive latency is enabled for I_{DD0}, current changes by approximately +1%.
 3. I_{PP0} test and limit is applicable for I_{DD0} and I_{DD1} conditions.
 4. The I_{DD} values must be derated (increased) when operated outside of the range 0°C ≤ T_C ≤ 85°C:

When T_C < 0°C: I_{DD2P} and I_{DD3P} must be derated by +6%; I_{DD4R} and I_{DD4W} must be derated by +4%; and I_{DD7} must be derated by +11%.

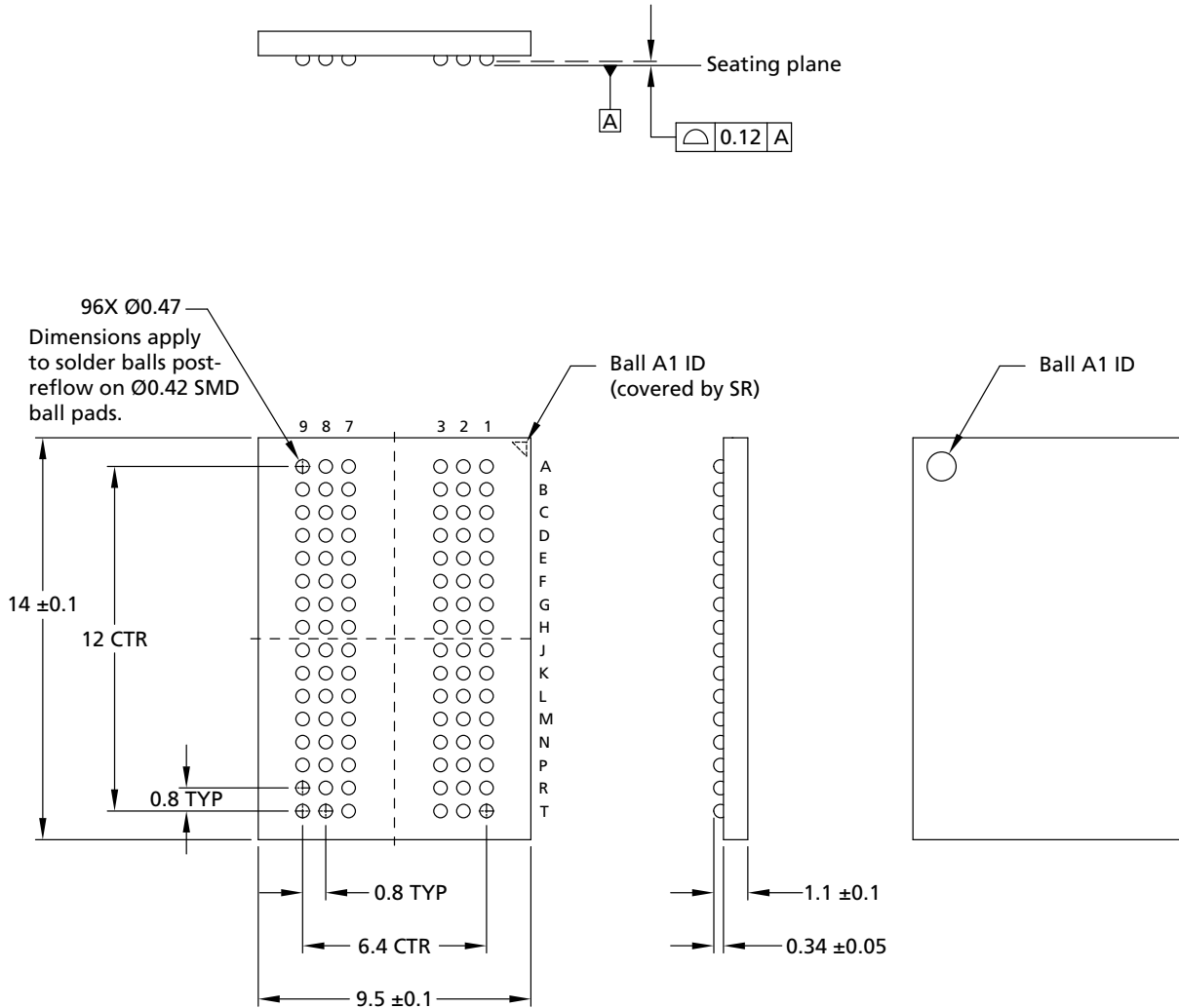
When T_C > 85°C: I_{DD0}, I_{DD1}, I_{DD2N}, I_{DD2NT}, I_{DD2Q}, I_{DD3N}, I_{DD3P}, I_{DD4R}, I_{DD4W}, and I_{DD5R} must be derated by +3%; I_{DD2P} must be derated by +10%.

5. When additive latency is enabled for I_{DD1}, current changes by approximately +8%.
6. When additive latency is enabled for I_{DD2N}, current changes by approximately +1%.
7. When DLL is disabled for I_{DD2N}, current changes by approximately –6%.
8. When CAL is enabled for I_{DD2N}, current changes by approximately –30%.
9. When gear-down is enabled for I_{DD2N}, current changes by approximately 0%.
10. When CA parity is enabled for I_{DD2N}, current changes by approximately +10%.
11. I_{PP3N} test and limit is applicable for all I_{DD2X}, I_{DD3X}, I_{DD4X}, I_{DD6X}, and I_{DD8} conditions; that is, testing I_{PP3N} should satisfy the I_{PPS} for the noted I_{DD} tests.
12. When additive latency is enabled for I_{DD3N}, current changes by approximately +1%.
13. When additive latency is enabled for I_{DD4R}, current changes by approximately +4%.
14. When read DBI is enabled for I_{DD4R}, current changes by approximately -14%.
15. When additive latency is enabled for I_{DD4W}, current changes by approximately +3%.
16. When write DBI is enabled for I_{DD4W}, current changes by approximately 0%.
17. When write CRC is enabled for I_{DD4W}, current changes by approximately +5%.
18. When CA parity is enabled for I_{DD4W}, current changes by approximately +12%.
19. When 2X REF is enabled for I_{DD5R}, current changes by approximately –25%.

20. When 4X REF is enabled for I_{DD5R} , current changes by approximately –35%.
21. Applicable for MR2 settings $A7 = 0$ and $A6 = 0$; manual mode with normal temperature range of operation (0–85°C).
22. Applicable for MR2 settings $A7 = 1$ and $A6 = 0$; manual mode with extended temperature range of operation (0–95°C).
23. Applicable for MR2 settings $A7 = 0$ and $A6 = 1$; manual mode with reduced temperature range of operation (0–45°C).
24. I_{DD6R} and I_{DD6A} values are typical.

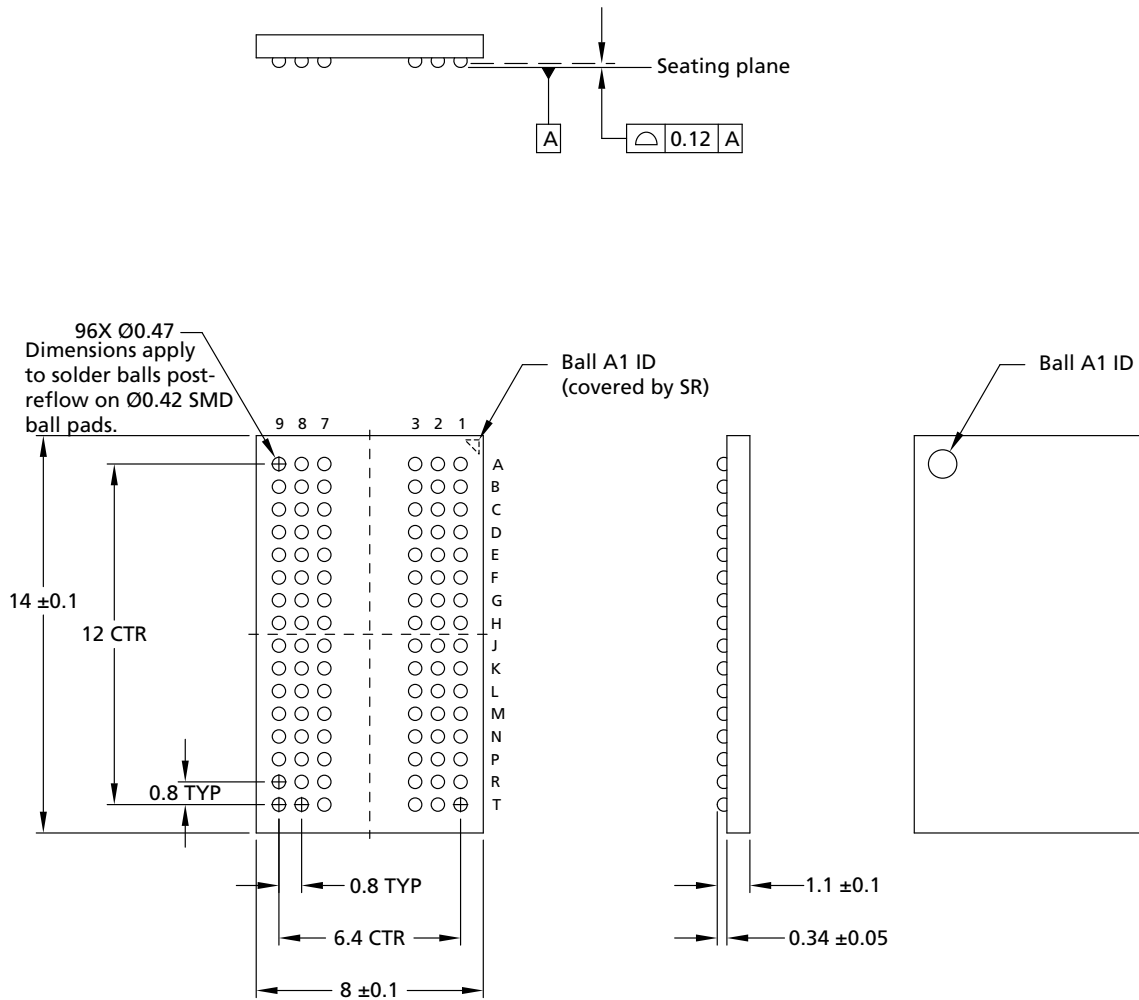
Package Dimensions

Figure 5: 96-Ball FBGA Die Rev. A (package code HBA)



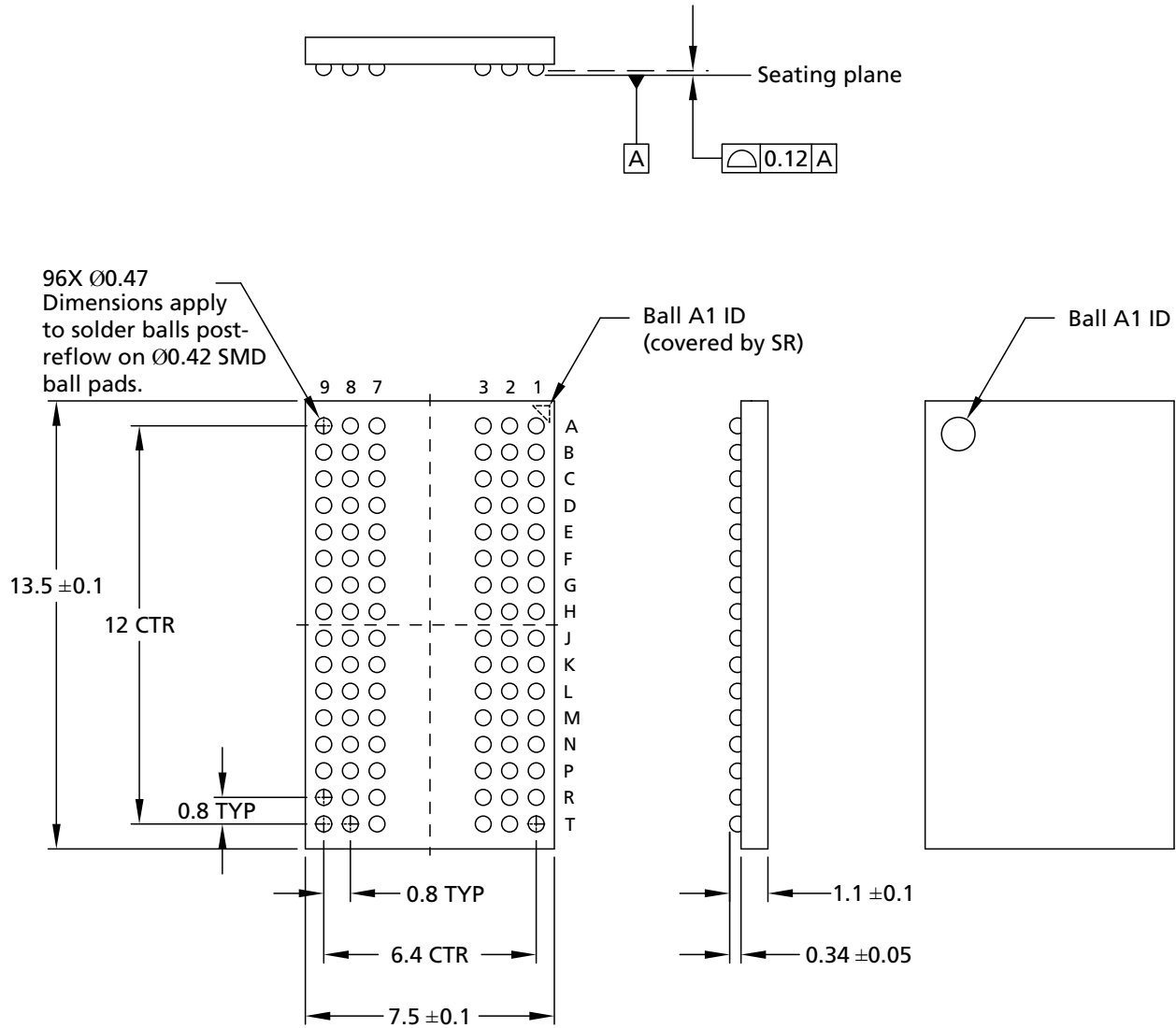
- Notes:
1. All dimensions are in millimeters.
 2. Solder ball material: SAC302 (96.8% Sn, 3% Ag, 0.2% Cu).

Figure 6: 96-Ball FBGA Die Rev. B (package code WBU)



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

Figure 7: 96-Ball FBGA Die Rev. E (package code KNR)



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

8000 S. Federal Way, P.O. Box 6, Boise, ID 83707-0006, Tel: 208-368-4000

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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.