



# TwinDie™ 1.2V DDR4 SDRAM

## MT40A2G16 – 128 Meg x 16 x 16 Banks x 1 Ranks

### Description

The 32Gb (TwinDie™) DDR4 SDRAM uses Micron’s 16Gb DDR4 SDRAM die; two x8s combined to make one x16. It uses similar signals as the mono x16, and there is one extra ZQ connection for faster ZQ calibration and a BG1 control required for x8 addressing. Refer to Micron’s 16Gb DDR4 SDRAM data sheet (x8 option) for the specifications not included in this document. Specifications for base part number MT40A2G8 correlate to TwinDie manufacturing part number MT40A2G16.

### Features

- Uses two x8 16Gb 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

### Features

- $T_C = 0^\circ C$  to  $95^\circ C$ 
  - $0^\circ C$  to  $85^\circ C$ : 8192 refresh cycles in 64ms
  - $85^\circ C$  to  $95^\circ C$ : 8192 refresh cycles in 32ms

### Options

- Configuration
  - 128 Meg x 16 x 16 banks x 1 rank 2G16
- 96-ball FBGA package (Pb-free) SKL
  - 10.5mm x 13mm x 1.2mm Die Rev :B
- 96-ball FBGA package (Pb-free) TBB
  - 7.5mm x 13mm x 1.2mm Die Rev :F
- Timing – cycle time<sup>1</sup> -062E
  - 0.625ns @ CL = 22 (DDR4-3200)
- Self refresh None
  - Standard
- Operating temperature None
  - Commercial ( $0^\circ C \leq T_C \leq 95^\circ C$ )
- Revision :B, :F

### Marking

**Table 1: Key Timing Parameters**

Speed Grade <sup>1</sup>	Data Rate (MT/s)	Target CL-nRCD-nRP	<sup>t</sup> AA (ns)	<sup>t</sup> RCD (ns)	<sup>t</sup> RP (ns)
-062E	3200	22-22-22	13.75	13.75	13.75

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

**Table 2: Addressing**

Parameter	2048 Meg x 16
Configuration	128 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	128K (A[16:0])
Column addressing	1K (A[9:0])
Page size	1KB

Notes: 1. Page size is per bank, calculated as follows:

$$\text{Page size} = 2^{\text{COLBITS}} \times \text{ORG}/8, \text{ where COLBITS} = \text{the number of column address bits and ORG} = \text{the number of DQ bits.}$$



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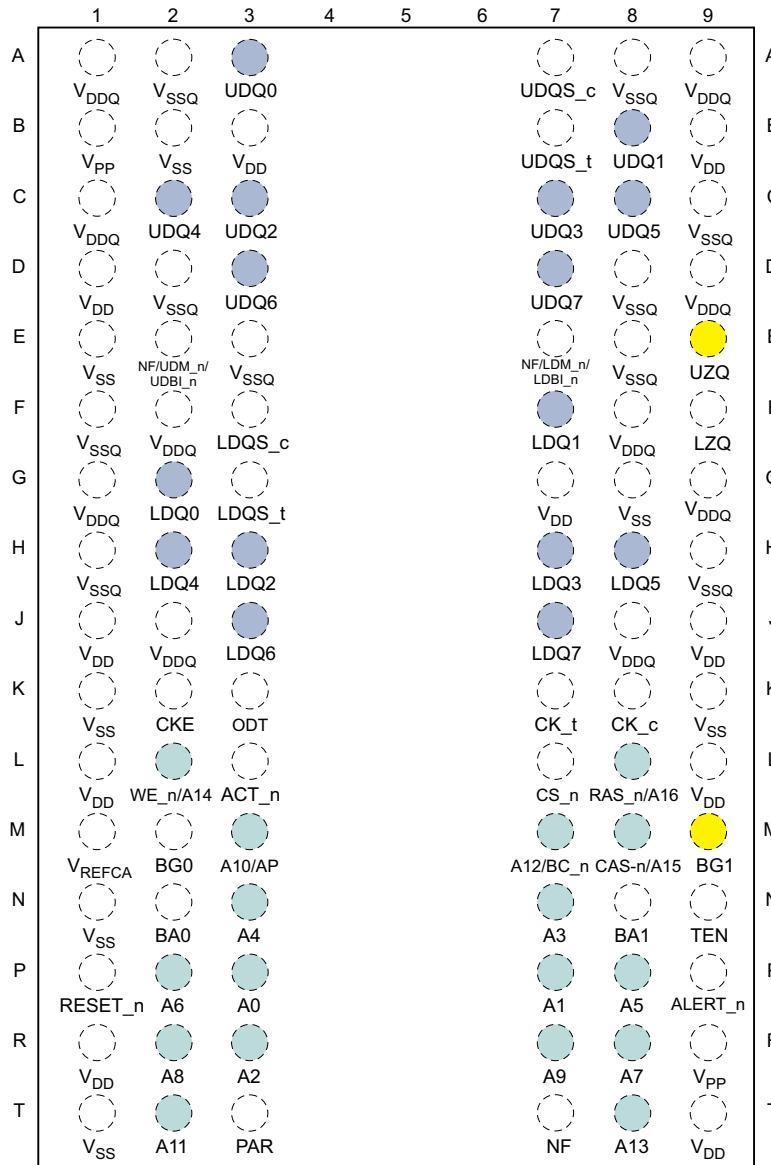
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## Ball Assignments

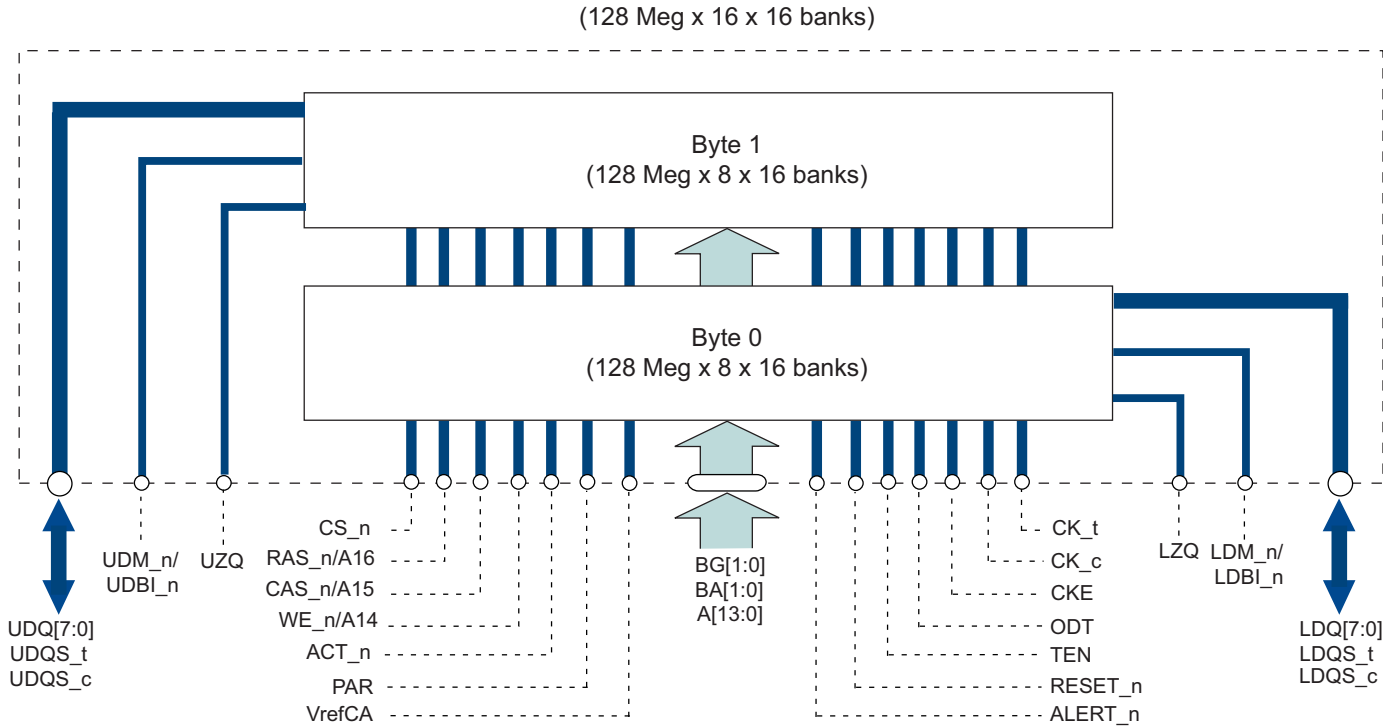
Figure 1: 96-Ball x16 SR DDP Ball Assignments



- Notes:
1. See Ball Descriptions in the monolithic data sheet.
  2. A slash "/" defines a mode register selectable function or command/address function. For example: Ball E2 = NF/UDM<sub>n</sub>/UDBI<sub>n</sub> where either NF, UDM<sub>n</sub>, or UDBI<sub>n</sub> 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:

$MT0 = \text{XOR}(A1, A6, PAR)$   
 $MT1 = \text{XOR}(A8, ALERT\_n, A9)$   
 $MT2 = \text{XOR}(A2, A5, A13)$   
 $MT3 = \text{XOR}(A0, A7, A11)$   
 $MT4 = \text{XOR}(CK\_c, ODT, CAS\_n/A15)$   
 $MT5 = \text{XOR}(CKE, RAS\_n/A16, A10/AP)$   
 $MT6 = \text{XOR}(ACT\_n, A4, BA1)$   
 $MT7L = \text{XOR}(BG1, LDM\_n/LDBI\_n, CK\_t)$   
 $MT7U = \text{XOR}(BG1, UDM\_n/UDBI\_n, CK\_t)$   
 $MT8 = \text{XOR}(WE\_n/A14, A12 / BC, BA0)$   
 $MT9 = \text{XOR}(BG0, A3, RESET\_n \text{ and } TEN)$

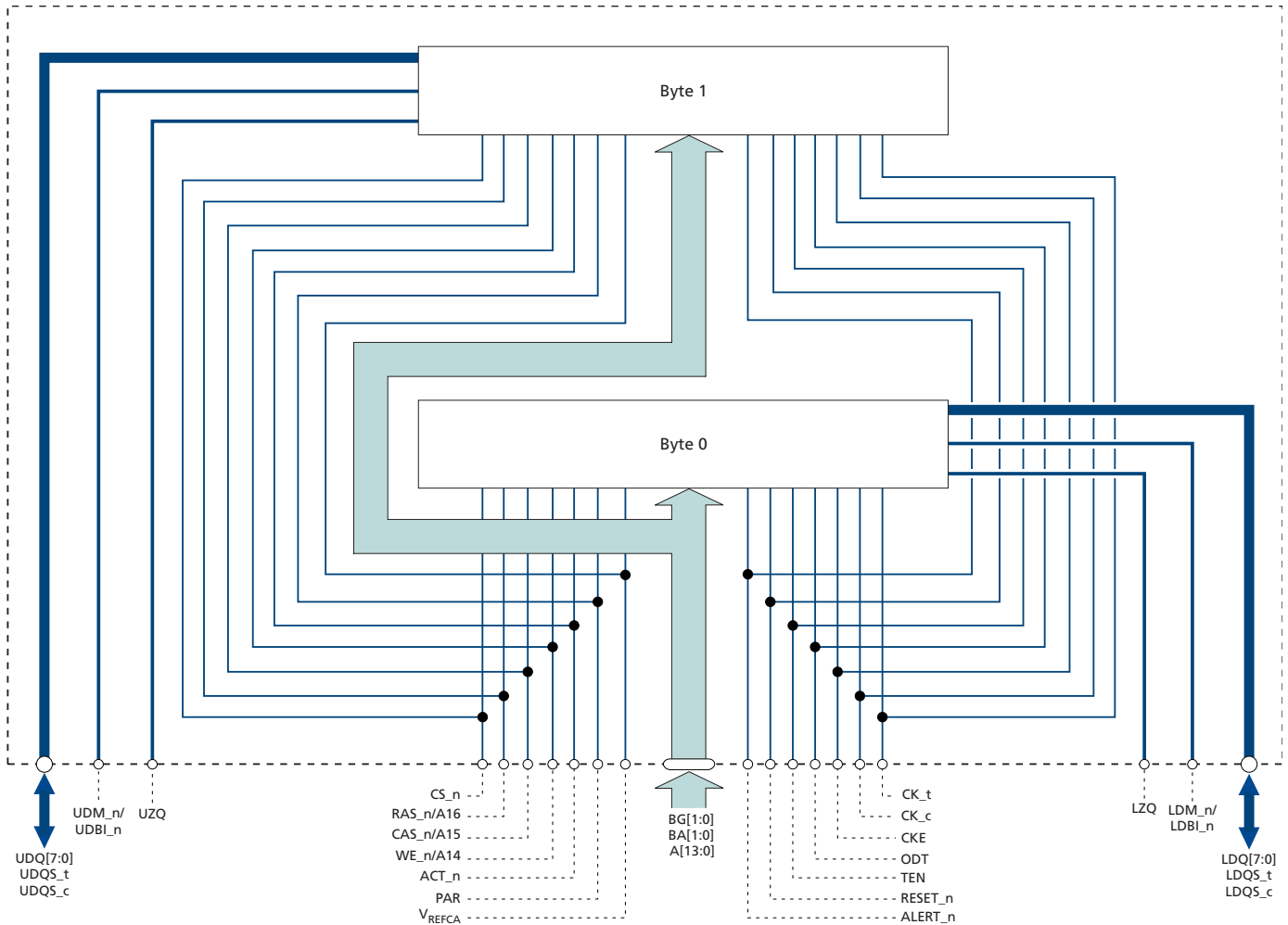
### Logic Equations for a x16 TwinDie, SR Device

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	$\mu A$	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	$\mu A$	2
$I_{ZQ}$	Input leakage on ZQ pin	-50	10	$\mu A$	
$I_{TEN}$	Input leakage on TEN pin	-12	20	$\mu A$	
$I_{OZPD}$	Output leakage: $V_{OUT} = V_{DDQ}$	-	10	$\mu A$	3, 5
$I_{OZPU}$	Output leakage: $V_{OUT} = V_{SSQ}$	-50	-	$\mu A$	3, 4, 5

- 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.  
 5. This value needs to be multiplied by 2 for ALERT\_n since it serves both bytes.

## 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 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.

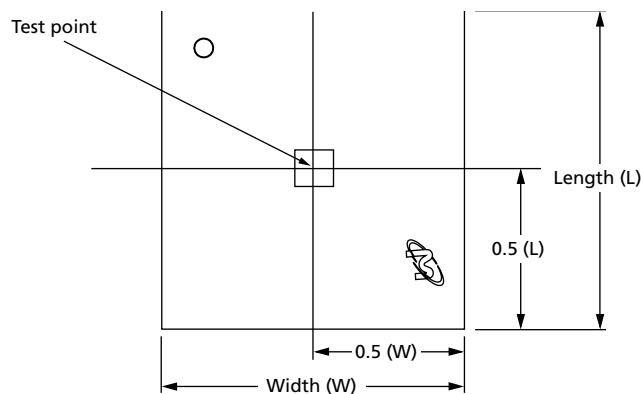
**Table 4: Thermal Characteristics**

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**

Package		Substrate	$\theta_{JA}$ (°C/W) Airflow = 0m/s	$\theta_{JA}$ (°C/W) Airflow = 1m/s	$\theta_{JA}$ (°C/W) Airflow = 2m/s	$\theta_{JB}$ (°C/W)	$\theta_{JC}$ (°C/W)	Notes
98-ball	Rev B "SKL"	Low conductivity	48.8	36.5	32.5	NA	4.6	1
		High conductivity	29.7	23.9	22.2	12.8	NA	
98-ball	Rev F "TBB"	Low conductivity	48.7	36.9	32.4	NA	2.6	1
		High conductivity	28.7	23.7	22.0	9.7	NA	

Notes: 1. Thermal resistance data is based on a typical number.





## DRAM Package Electrical Specifications

**Table 6: DRAM Package Electrical Specifications for x4, x8, and x16 DDP Devices**

Notes 1-2 apply to the entire table

Parameter		Symbol	DDR4-1600, 1866, 2133, 2400, 2666, 2933, 3200		Unit	Notes
			Min	Max		
Input/output	Zpkg	$Z_{IO}$	35	60	ohm	3
	Package delay	$T_{dIO}$	60	120	ps	3
	Lpkg	$L_{IO}$	–	5.5	nH	
	Cpkg	$C_{IO}$	–	4	pF	
DQSL_t/DQSL_c/D QSU_t/DQSU_c	Zpkg	$Z_{IO\ DQS}$	35	60	ohm	
	Package delay	$T_{dIO\ DQS}$	60	120	ps	
	Lpkg	$L_{IO\ DQS}$	–	5.5	nH	
	Cpkg	$C_{IO\ DQS}$	–	4	pF	
DQSL_t/DQSL_c, DQSU_t/DQSU_c,	Delta Zpkg	$DZ_{IO\ DQS}$	–	5	ohm	4
	Delta delay	$DT_{dIO\ DQS}$	–	5	ps	4
Input CTRL pins	Zpkg	$Z_{I\ CTRL}$	30	70	ohm	5
	Package delay	$T_{dI\ CTRL}$	60	120	ps	5
	Lpkg	$L_{I\ CTRL}$	–	7.5	nH	
	Cpkg	$C_{I\ CTRL}$	–	4	pF	
Input CMD ADD pins	Zpkg	$Z_{I\ ADD\ CMD}$	30	60	ohm	6
	Package delay	$T_{dI\ ADD\ CMD}$	60	120	ps	6
	Lpkg	$L_{I\ ADD\ CMD}$	–	7.5	nH	
	Cpkg	$C_{I\ ADD\ CMD}$	–	4	pF	
CK_t, CK_c	Zpkg	$Z_{CK}$	30	60	ohm	
	Package delay	$T_{dCK}$	60	120	ps	
	Delta Zpkg	$DZ_{DCK}$	–	5	ohm	7
	Delta delay	$DT_{dDCK}$	–	5	ps	7
Input CLK	Lpkg	$L_{I\ CLK}$	–	7.5	nH	
	Cpkg	$C_{I\ CLK}$	–	4	pF	
ZQ Zpkg		$Z_{O\ ZQ}$	–	50	ohm	
ZQ delay		$T_{dO\ ZQ}$	30	135	ps	
ALERT Zpkg		$Z_{O\ ALERT}$	30	60	ohm	
ALERT delay		$T_{dO\ ALERT}$	60	110	ps	

Notes: 1. The values in this table are guaranteed by design/simulation only, and are not subject to production testing.



## 32Gb: x16 TwinDie Single-Rank DDR4 SDRAM DRAM Package Electrical Specifications

2. Package implementations should satisfy targets if the  $Z_{pkg}$  and package delay fall within the ranges shown, and the maximum  $L_{pkg}$  and  $C_{pkg}$  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.  $Z_{IO}$  and  $Td_{IO}$  apply to DQ, DM, DQS\_c, DQS\_t, TDQS\_t, and TDQS\_c.
4. Absolute value of  $Z_{IO}$  (DQS\_t),  $Z_{IO}$  (DQS\_c) for impedance (Z) or absolute value of  $Td_{IO}$  (DQS\_t),  $Td_{IO}$  (DQS\_c) for delay (Td).
5.  $Z_{CTRL}$  and  $Td_{CTRL}$  apply to ODT, CS\_n, and CKE.
6.  $Z_{I\_ADD\_CMD}$  and  $Td_{I\_ADD\_CMD}$  apply to A[17:0], BA[1:0], BG[1:0], RAS\_n CAS\_n, and WE\_n.
7. Absolute value of  $Z_{CK}_t$ ,  $Z_{CK}_c$  for impedance (Z) or absolute value of  $Td_{CK}_t$ ,  $Td_{CK}_c$  for delay (Td).



## Current Specifications – Limits

**Table 7: DDR4 x16 TwinDie I<sub>CDD</sub> and I<sub>CPP</sub> Specifications and Conditions – Rev. B (0° ≤ T<sub>C</sub> ≤ 85°C)**

Notes 1 and 2 apply to the entire table

Combined Symbol	Individual Die Status	DDR4-2133	DDR4-2400	DDR4-2666	DDR4-2933	DDR4-3200	Units
I <sub>CDD0</sub>	I <sub>CDD0</sub> = I <sub>DD0</sub> * 2	118	120	122	124	126	mA
I <sub>CPP0</sub>	I <sub>CPP0</sub> = I <sub>PP0</sub> * 2	8	8	8	8	8	mA
I <sub>CDD1</sub>	I <sub>CDD1</sub> = I <sub>DD1</sub> * 2	140	142	144	146	148	mA
I <sub>CDD2N</sub>	I <sub>CDD2N</sub> = I <sub>DD2N</sub> * 2	96	98	100	102	104	mA
I <sub>CDD2NT</sub>	I <sub>CDD2NT</sub> = I <sub>DD2NT</sub> * 2	104	106	108	110	112	mA
I <sub>CDD2P</sub>	I <sub>CDD2P</sub> = I <sub>DD2P</sub> * 2	86	86	86	86	86	mA
I <sub>CDD2Q</sub>	I <sub>CDD2Q</sub> = I <sub>DD2Q</sub> * 2	94	94	94	94	94	mA
I <sub>CDD3N</sub>	I <sub>CDD3N</sub> = I <sub>DD3N</sub> * 2	152	154	156	158	160	mA
I <sub>CPP3N</sub>	I <sub>CPP3N</sub> = I <sub>PP3N</sub> * 2	6	6	6	6	6	mA
I <sub>CDD3P</sub>	I <sub>CDD3P</sub> = I <sub>DD3P</sub> * 2	132	134	136	138	138	mA
I <sub>CDD4R</sub>	I <sub>CDD4R</sub> = I <sub>DD4R</sub> * 2	324	344	364	384	404	mA
I <sub>CDD4W</sub>	I <sub>CDD4W</sub> = I <sub>DD4W</sub> * 2	300	316	332	350	366	mA
I <sub>CDD5R</sub>	I <sub>CDD5R</sub> = I <sub>DD5R</sub> * 2	162	162	162	162	162	mA
I <sub>CPP5R</sub>	I <sub>CPP5R</sub> = I <sub>PP5R</sub> * 2	10	10	10	10	10	mA
I <sub>CDD6N</sub>	I <sub>CDD6N</sub> = I <sub>DD6N</sub> * 2	148	148	148	148	148	mA
I <sub>CDD6E</sub> <sup>3</sup>	I <sub>CDD6E</sub> = I <sub>DD6E</sub> * 2	258	258	258	258	258	mA
I <sub>CDD6R</sub> <sup>3</sup>	I <sub>CDD6R</sub> = I <sub>DD6R</sub> * 2	52	52	52	52	52	mA
I <sub>CDD6A</sub> (25°C) <sup>3</sup>	I <sub>CDD6A</sub> = I <sub>DD6A</sub> * 2	30	30	30	30	30	mA
I <sub>CDD6A</sub> (45°C) <sup>3</sup>	I <sub>CDD6A</sub> = I <sub>DD6A</sub> * 2	52	52	52	52	52	mA
I <sub>CDD6A</sub> (75°C) <sup>3</sup>	I <sub>CDD6A</sub> = I <sub>DD6A</sub> * 2	146	146	146	146	146	mA
I <sub>CDD6A</sub> (95°C) <sup>3</sup>	I <sub>CDD6A</sub> = I <sub>DD6A</sub> * 2	258	258	258	258	258	mA
I <sub>CPP6x</sub> <sup>3</sup>	I <sub>CPP6x</sub> = I <sub>PP6x</sub> * 2	18	18	18	18	18	mA
I <sub>CDD7</sub>	I <sub>CDD7</sub> = I <sub>DD7</sub> * 2	366	370	380	386	392	mA
I <sub>CPP7</sub>	I <sub>CPP7</sub> = I <sub>PP7</sub> * 2	20	20	20	20	20	mA
I <sub>CDD8</sub>	I <sub>CDD8</sub> = I <sub>DD8</sub> * 2	80	80	80	80	80	mA

Notes: 1. I<sub>CDD</sub> values reflect the combined current of both individual die. I<sub>DDx</sub> represents individual die values.

- I<sub>CDD</sub> values must be derated (increased) when operated outside of the range 0°C ≤ T<sub>C</sub> ≤ 85°C. They must also be derated when using features such as CAL, CA parity, read/write DBI, AL, gear-down, write CRC, 2X/4X REF, and DLL disabled. Refer to the 16Gb monolithic data sheet for all derating values. Derating values apply to each individual I<sub>DDx</sub> that make up the combined I<sub>CDD</sub>.



## 32Gb: x16 TwinDie Single-Rank DDR4 SDRAM Current Specifications – Limits

3.  $I_{CDD6R}$ ,  $I_{CDD6A}$ , and  $I_{CDD6E}$  values are verified by design and characterization, and may not be subject to production test.

**Table 8: DDR4 x16 TwinDie  $I_{CDD}$  and  $I_{CPP}$  Specifications and Conditions – Rev. F ( $0^\circ \leq T_C \leq 85^\circ C$ )**

Notes 1 and 2 apply to the entire table

Combined Symbol	Individual Die Status	DDR4-2133	DDR4-2400	DDR4-2666	DDR4-2933	DDR4-3200	Units
$I_{CDD0}$	$I_{CDD0} = I_{DD0} * 2$	132	134	136	138	140	mA
$I_{CPP0}$	$I_{CPP0} = I_{PP0} * 2$	8	8	8	8	8	mA
$I_{CDD1}$	$I_{CDD1} = I_{DD1} * 2$	160	162	164	166	168	mA
$I_{CDD2N}$	$I_{CDD2N} = I_{DD2N} * 2$	82	84	86	88	90	mA
$I_{CDD2NT}$	$I_{CDD2NT} = I_{DD2NT} * 2$	108	110	112	114	116	mA
$I_{CDD2P}$	$I_{CDD2P} = I_{DD2P} * 2$	76	76	76	76	76	mA
$I_{CDD2Q}$	$I_{CDD2Q} = I_{DD2Q} * 2$	84	84	84	84	84	mA
$I_{CDD3N}$	$I_{CDD3N} = I_{DD3N} * 2$	116	118	120	122	124	mA
$I_{CPP3N}$	$I_{CPP3N} = I_{PP3N} * 2$	4	4	4	4	4	mA
$I_{CDD3P}$	$I_{CDD3P} = I_{DD3P} * 2$	94	96	98	100	102	mA
$I_{CDD4R}$	$I_{CDD4R} = I_{DD4R} * 2$	282	308	334	360	386	mA
$I_{CDD4W}$	$I_{CDD4W} = I_{DD4W} * 2$	202	222	242	262	282	mA
$I_{CDD5R}$	$I_{CDD5R} = I_{DD5R} * 2$	136	136	136	136	136	mA
$I_{CPP5R}$	$I_{CPP5R} = I_{PP5R} * 2$	8	8	8	8	8	mA
$I_{CDD6N}$	$I_{CDD6N} = I_{DD6N} * 2$	106	106	106	106	106	mA
$I_{CDD6E}^3$	$I_{CDD6E} = I_{DD6E} * 2$	180	180	180	180	180	mA
$I_{CDD6R}^3$	$I_{CDD6R} = I_{DD6R} * 2$	40	40	40	40	40	mA
$I_{CDD6A} (25^\circ C)^3$	$I_{CDD6A} = I_{DD6A} * 2$	22	22	22	22	22	mA
$I_{CDD6A} (45^\circ C)^3$	$I_{CDD6A} = I_{DD6A} * 2$	40	40	40	40	40	mA
$I_{CDD6A} (75^\circ C)^3$	$I_{CDD6A} = I_{DD6A} * 2$	102	102	102	102	102	mA
$I_{CDD6A} (95^\circ C)^3$	$I_{CDD6A} = I_{DD6A} * 2$	180	180	180	180	180	mA
$I_{CPP6x}^3$	$I_{CPP6x} = I_{PP6x} * 2$	12	12	12	12	12	mA
$I_{CDD7}$	$I_{CDD7} = I_{DD7} * 2$	400	400	400	400	400	mA
$I_{CPP7}$	$I_{CPP7} = I_{PP7} * 2$	26	26	26	26	26	mA
$I_{CDD8}$	$I_{CDD8} = I_{DD8} * 2$	72	72	72	72	72	mA

Notes: 1.  $I_{CDD}$  values reflect the combined current of both individual die.  $I_{DDx}$  represents individual die values.

2.  $I_{CDD}$  values must be derated (increased) when operated outside of the range  $0^\circ C \leq T_C \leq 85^\circ C$ . They must also be derated when using features such as CAL, CA parity, read/write DBI, AL, gear-down, write CRC, 2X/4X REF, and DLL disabled. Refer to the 16Gb monolithic data sheet for all derating values. Derating values apply to each individual  $I_{DDx}$  that make up the combined  $I_{CDD}$ .



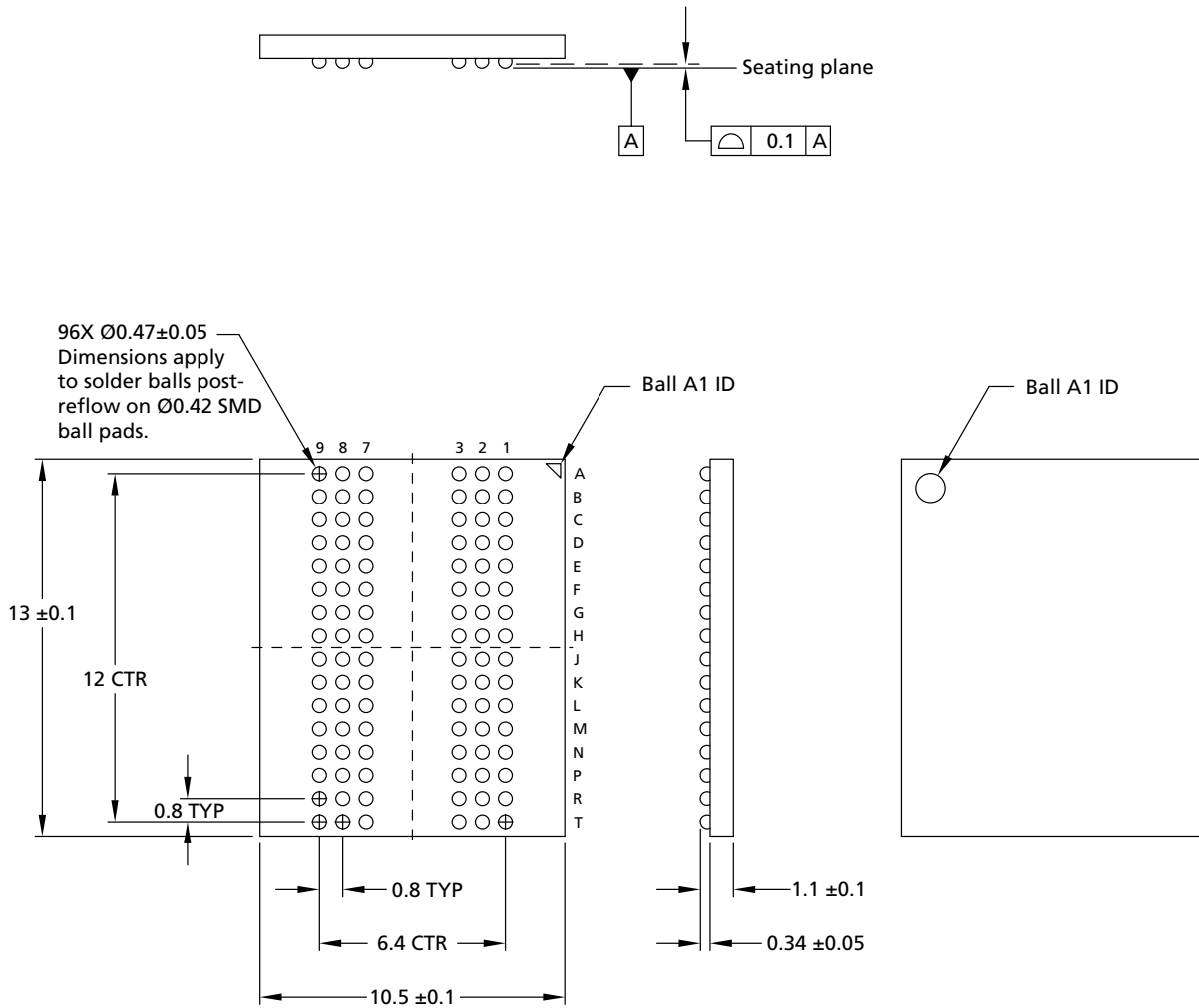
## 32Gb: x16 TwinDie Single-Rank DDR4 SDRAM Current Specifications – Limits

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3.  $I_{CDD6R}$ ,  $I_{CDD6A}$ , and  $I_{CDD6E}$  values are verified by design and characterization, and may not be subject to production test.

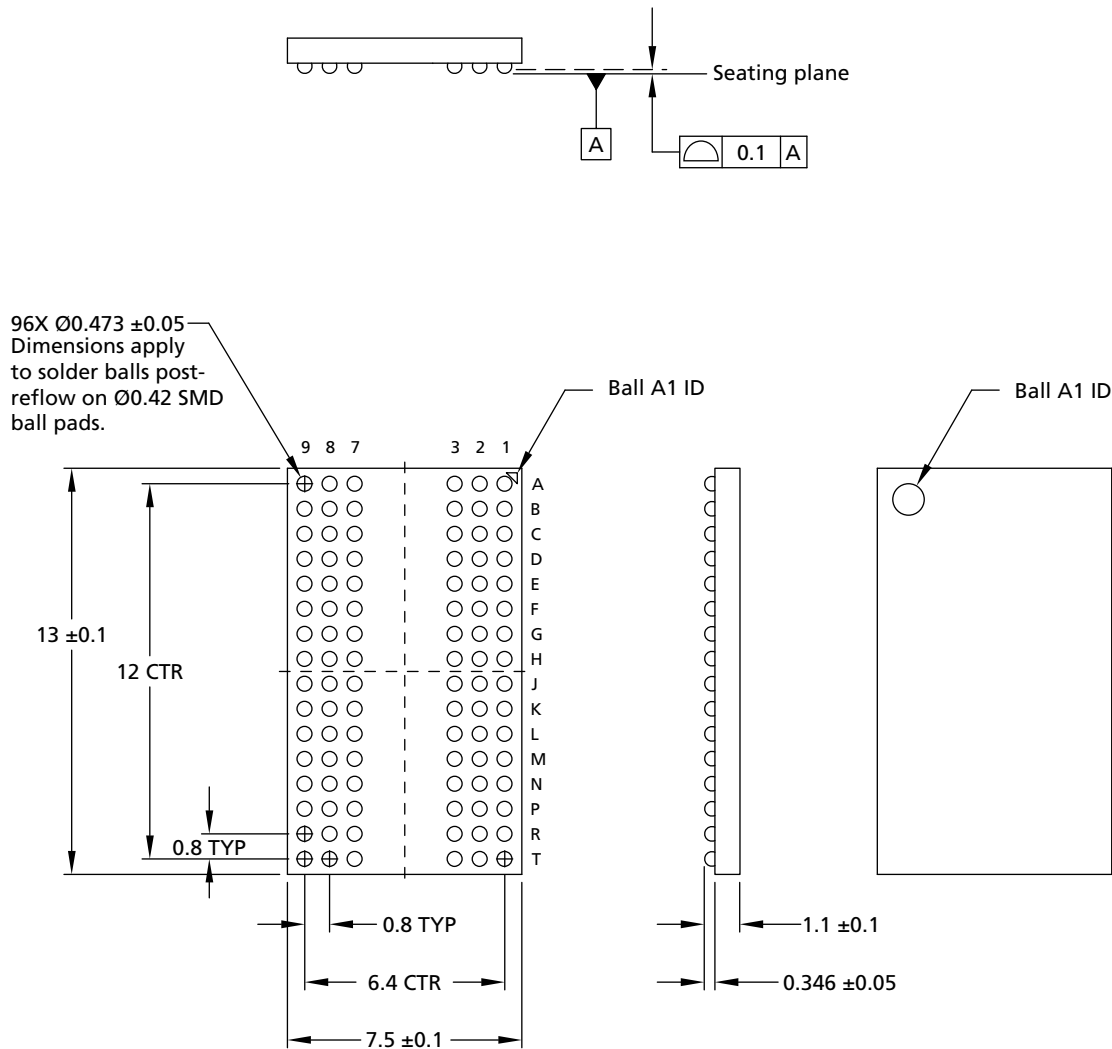
## Package Dimensions

**Figure 5: 96-Ball FBGA Die Rev. B (Package Code SKL)**



- 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. F (Package Code TBB)**



- Notes: 1. All dimensions are in millimeters.  
 2. Solder ball material: SACQ (92.5% Sn, 4% Ag, 3% Bi, 0.5% Cu).

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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.