

# Automotive LPDDR5X SDRAM

## MT62F1G64D4, MT62F2G64D8

### Features

- **Architecture**
  - 17.1 GB/s maximum bandwidth per channel
  - Frequency range: 1067–5 MHz (data rate range per pin: 8533–40 Mb/s with WCK:CK = 4:1)
  - Selectable CKR (WCK:CK = 2:1 or 4:1)
- **LPDDR5X/LPDDR5 data interface**
  - Single x16 channel/die
  - Double-data-rate command/address entry
  - Differential command clocks (CK<sub>t</sub>/CK<sub>c</sub>) for high-speed operation
  - Differential data clocks (WCK<sub>t</sub>/WCK<sub>c</sub>)
  - Differential read strobe (RDQS<sub>t</sub>/RDQS<sub>c</sub>)
  - 16*n*-bit or 32*n*-bit prefetch architecture
  - Command-selectable burst lengths (BL = 16 or 32) in bank group or 16-bank modes
  - Background ZQ calibration/command-based ZQ calibration
  - Link protection (link ECC) support
  - Partial-array self refresh (PASR) and partial-array auto refresh (PAAR) with segment mask
- **Ultra-low-voltage core and I/O power supplies**
  - V<sub>DD1</sub> = 1.70–1.95V; 1.80V TYP
  - V<sub>DD2H</sub> = 1.01–1.12V; 1.05V TYP
  - V<sub>DD2L</sub> = V<sub>DD2H</sub> or 0.87–0.97V; 0.90V TYP
  - V<sub>DDQ</sub> = 0.50V or 0.45V<sup>1</sup> TYP; 0.30V TYP (ODT off only)
- **I/O characteristics**
  - Interface-LVSTL 0.5/0.3
  - I/O type: Low-swing single-ended, V<sub>SS</sub> terminated
  - V<sub>OH</sub>-compensated output drive
  - Programmable V<sub>SS</sub> on-die termination (ODT)
  - Non target ODT support
  - DVFSQ support
- **Low-power features**
  - DVFSC: Dynamic voltage frequency scaling core
  - Single-ended CK, single-ended WCK, and single-ended RDQS
  - Data copy
  - Write X

### Options

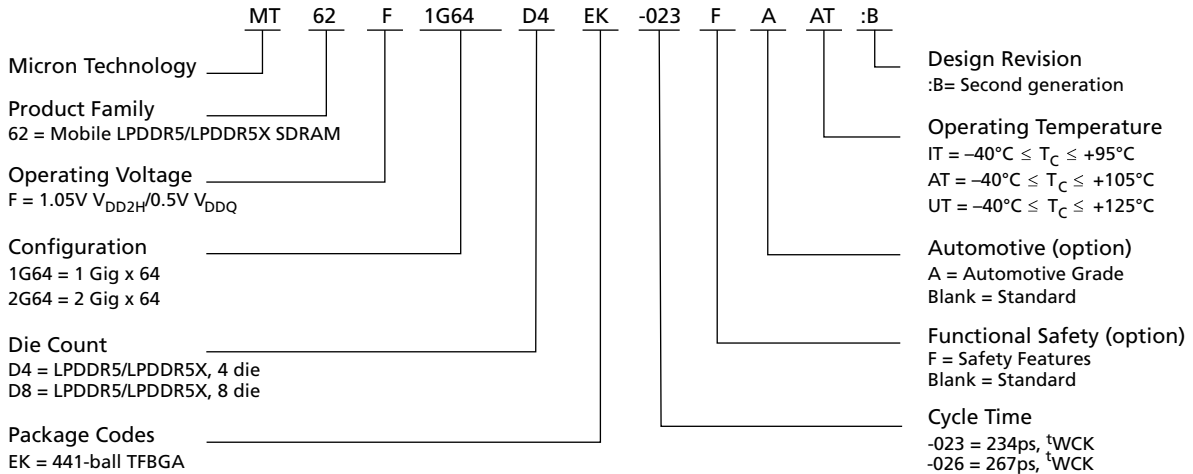
- **Operating Voltage**
  - V<sub>DD1</sub>/V<sub>DD2H</sub>/V<sub>DD2L</sub>/V<sub>DDQ</sub>/V<sub>DDQ</sub> (ODT off only): 1.80V/1.05V/V<sub>DD2H</sub> or 0.90V/0.50V or 0.45V<sup>1</sup>/0.30V
- **Array Configuration:**
  - 1Gig x 64 (1Gx16 x 4 Ch x 1R) 1G64
  - 2Gig x 64 (1Gx16 x 4 Ch x 2R) 2G64
- **Device Configuration:**
  - 4 die in package (1G16 x 4 die) D4
  - 8 die in package (1G16 x 8 die) D8
- **FBGA RoHS-compliant “green” package**
  - 441-ball TFBGA EK  
14.0mm x 14.0mm (TYP),  
seated height 1.1mm (MAX)
- **Speed grade, cycle time (<sup>t</sup>WCK)**
  - 8533 Mb/s -023
  - 7500 Mb/s -026
- **Functional safety features:**
  - Micron safety features enabled
  - Suitable for meeting random HW metrics up to ASIL D F
- **Automotive and functional safety:** A<sup>2</sup>
  - AEC-Q100
  - PPAP
  - ISO 26262 ASIL D compliant development
  - FMEDA (ISO 26262-5:2018, cl. 8, 9)
  - Safety manual
- **Operating temperature:**
  - -40°C ≤ T<sub>C</sub> ≤ +95°C IT
  - -40°C ≤ T<sub>C</sub> ≤ +105°C AT
  - -40°C ≤ T<sub>C</sub> ≤ +125°C UT<sup>3</sup>
- **Revision** :B

- Notes: 1. V<sub>DDQ</sub> = 0.45V (TYP) only supported in 441-ball package up to 6400 Mb/s.  
 2. For functional safety documentation, contact Micron sales representative.  
 3. Based on automotive usage model. Contact Micron sales representative with questions.



## Part Number Ordering Information

**Figure 1: Part Number Chart**



**Table 1: Part Number List**

Part Number	Total Density	Data Rate per Pin
MT62F1G64D4EK-023 AIT:B	8GB (64Gb)	8533 Mb/s
MT62F1G64D4EK-023 AAT:B		
MT62F1G64D4EK-023 AUT:B		
MT62F1G64D4EK-023 FAAT:B		
MT62F2G64D8EK-023 AIT:B	16GB (128Gb)	
MT62F2G64D8EK-023 AAT:B		
MT62F2G64D8EK-023 AUT:B		
MT62F2G64D8EK-023 FAAT:B		
MT62F2G64D8EK-026 AIT:B	16GB (128Gb)	7500 Mb/s
MT62F2G64D8EK-026 AAT:B		

### FBGA Part Marking Decoder

Due to space limitations, FBGA-packaged components have an abbreviated part marking that is different from the part number. Micron’s FBGA part marking decoder is available at [www.micron.com/decoder](http://www.micron.com/decoder).

### LPDDR5/LPDDR5X Data Sheet List

For general LPDDR5/LPDDR5X specifications, please refer to the data sheets below.

- General LPDDR5/LPDDR5X Specifications 1: Mode Registers
- General LPDDR5/LPDDR5X Specifications 2: AC/DC and Interface Specifications
- General LPDDR5/LPDDR5X Specifications 3: Features and Functionalities



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## Important Notes and Warnings

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## General Notes

Throughout the data sheet, figures and text refer to DQs as DQ. DQ should be interpreted as any or all DQs collectively, unless specifically stated otherwise.

RDQS, CK, and WCK should be interpreted as RDQS\_t, RDQS\_c, CK\_t, CK\_c, and WCK\_t, WCK\_c respectively unless specifically stated otherwise. CA includes all CA pins used for a given density.

In timing diagrams, CMD is used as an indicator only. Actual signals occur on CA[6:0].

$V_{REF}$  indicates  $V_{REF(CA)}$  and  $V_{REF(DQ)}$ .

Complete functionality is described throughout the entire document. Any page or diagram may have been simplified to convey a topic and may not be inclusive of all requirements.

Any specific requirement takes precedence over a general statement.

Any functionality not specifically stated herein is considered undefined, illegal, is not supported, and will result in unknown operation.



## Functional Safety Notes

This automotive LPDDR5/LPDDR5X DRAM product family has been developed according to ISO 26262:2018 requirements to provide a level of systematic fault coverage that allows its use in systems targeting up to ASIL D compliance.

This LPDDR5/LPDDR5X DRAM contains several new functional safety features that operate within the JEDEC LPDDR5/LPDDR5X protocols (commands, timings, and so forth) and are made available to the integrator on “F” parts (see Part Number Ordering Information). The specification addendum governing these functional safety features is available under NDA. This LPDDR5/LPDDR5X DRAM may operate as a standard JEDEC LPDDR5/LPDDR5X DRAM only, or as a standard JEDEC LPDDR5/LPDDR5X DRAM specifically designed to include functional safety features to communicate fault detection (only available on “F” parts). Additional support may be available to customers who need to integrate Micron’s products in their functional safety-related applications. This support may include Safety Analysis Report, reporting FMEDA results and metrics, Safety Manual and Pin FMEA Report, providing guidelines and instructions for using Micron products in safety-related applications.

Contact a Micron sales representative to initiate the process required to obtain the functional safety documentation.





## Device Configuration

**Table 2: Die Organization in the Package (x64)**

Die Organization	1G64 (64 Gb/package)	2G64 (128 Gb/package)
Channel A, rank 0	x16 mode × 1 die	x16 mode × 1 die
Channel B, rank 0	x16 mode × 1 die	x16 mode × 1 die
Channel C, rank 0	x16 mode × 1 die	x16 mode × 1 die
Channel D, rank 0	x16 mode × 1 die	x16 mode × 1 die
Channel A, rank 1	–	x16 mode × 1 die
Channel B, rank 1	–	x16 mode × 1 die
Channel C, rank 1	–	x16 mode × 1 die
Channel D, rank 1	–	x16 mode × 1 die

Note: 1. Refer to the Package Block Diagram section in this data sheet.

**Table 3: Die Addressing**

Description	1G64 (64 Gb/package), 2G64 (128 Gb/package)		
	BG mode	16B mode	8B mode
Density per die	16Gb		
Bits	17,179,869,184		
Configuration	64Mb × 16 DQ × 4 Banks × 4BG	64Mb × 16 DQ × 16 Banks	128Mb × 16 DQ × 8 Banks
Number of banks	4	16	8
Number of bank groups	4	1	1
Array prefetch bits	256	256	512
Rows per bank	65,536		
Columns	64		
Page size (bytes)	2048	2048	4096
Native burst length	16	16	32
Number of I/Os	16		
Bank address	BA[1:0]	BA[3:0]	BA[2:0]
Bank group address	BG[1:0]	–	–
Row address	R[15:0]		
Column address	C[5:0]		
Burst address	B[3:0]	B[3:0]	B[4:0]
Burst starting address boundary	128-bit		

Note: 1. Refer to the SDRAM Addressing section in General LPDDR5/LPDDR5X Specifications 3.



## Refresh Requirement Parameters

Table 4: Refresh Requirement Parameters

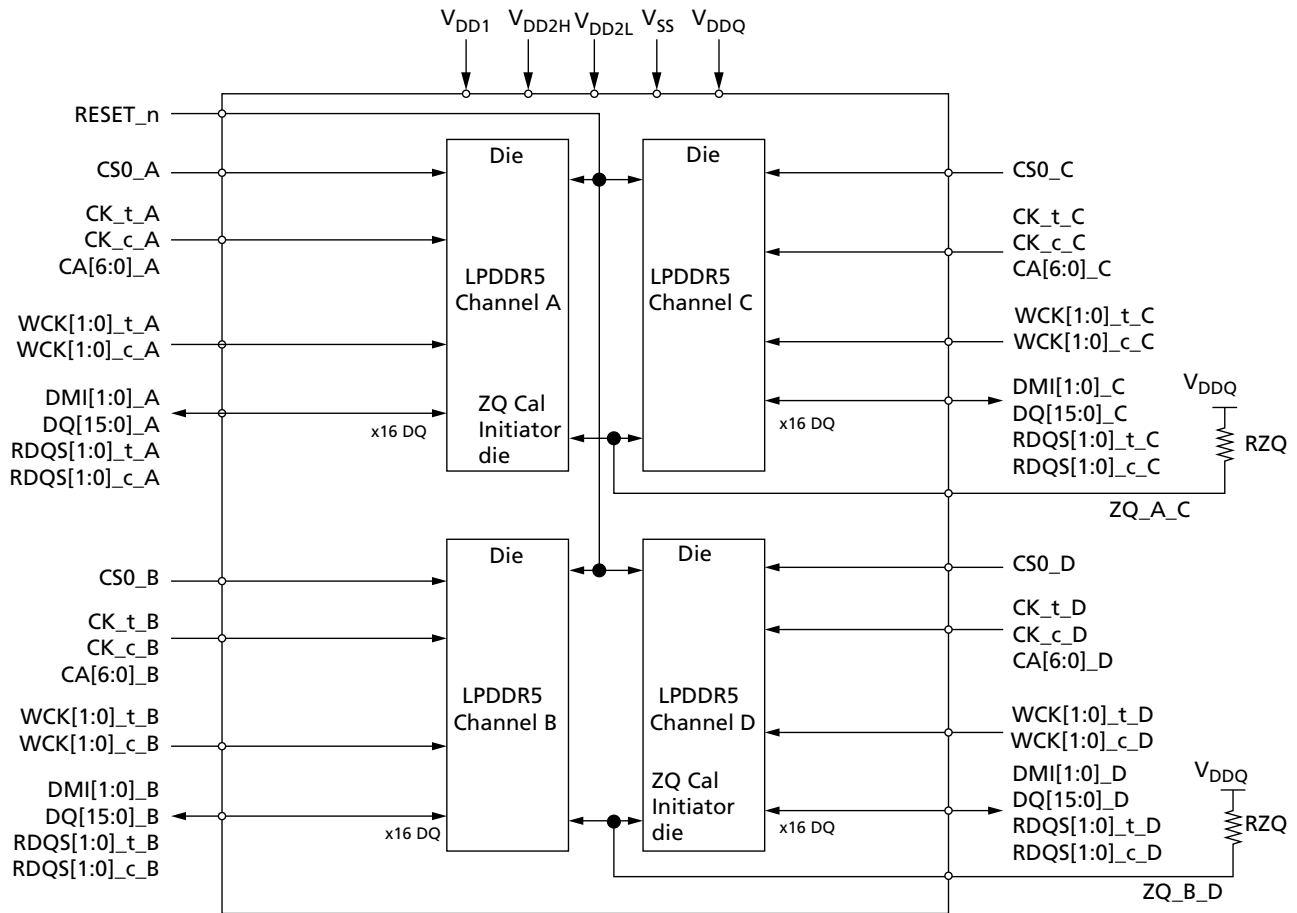
Parameter	Symbol	16Gb Die		Unit
		BG and 16B Mode	8B Mode	
REFRESH cycle time (all banks)	$t_{RFCab}$	280	280	ns
REFRESH cycle time (per bank)	$t_{RFCpb}$	140	140	ns
Per bank refresh to per bank refresh time (different bank)	$t_{PBR2PBR}$	90	90	ns
Per bank refresh to ACTIVATE command time (different bank)	$t_{PBR2ACT}$	7.5	10	ns

Note: 1. This table only describes refresh parameters that are density dependent. Refer to Refresh Requirement section in General LPDDR5/LPDDR5X Specifications 3 for all refresh parameters.

## Package Block Diagrams

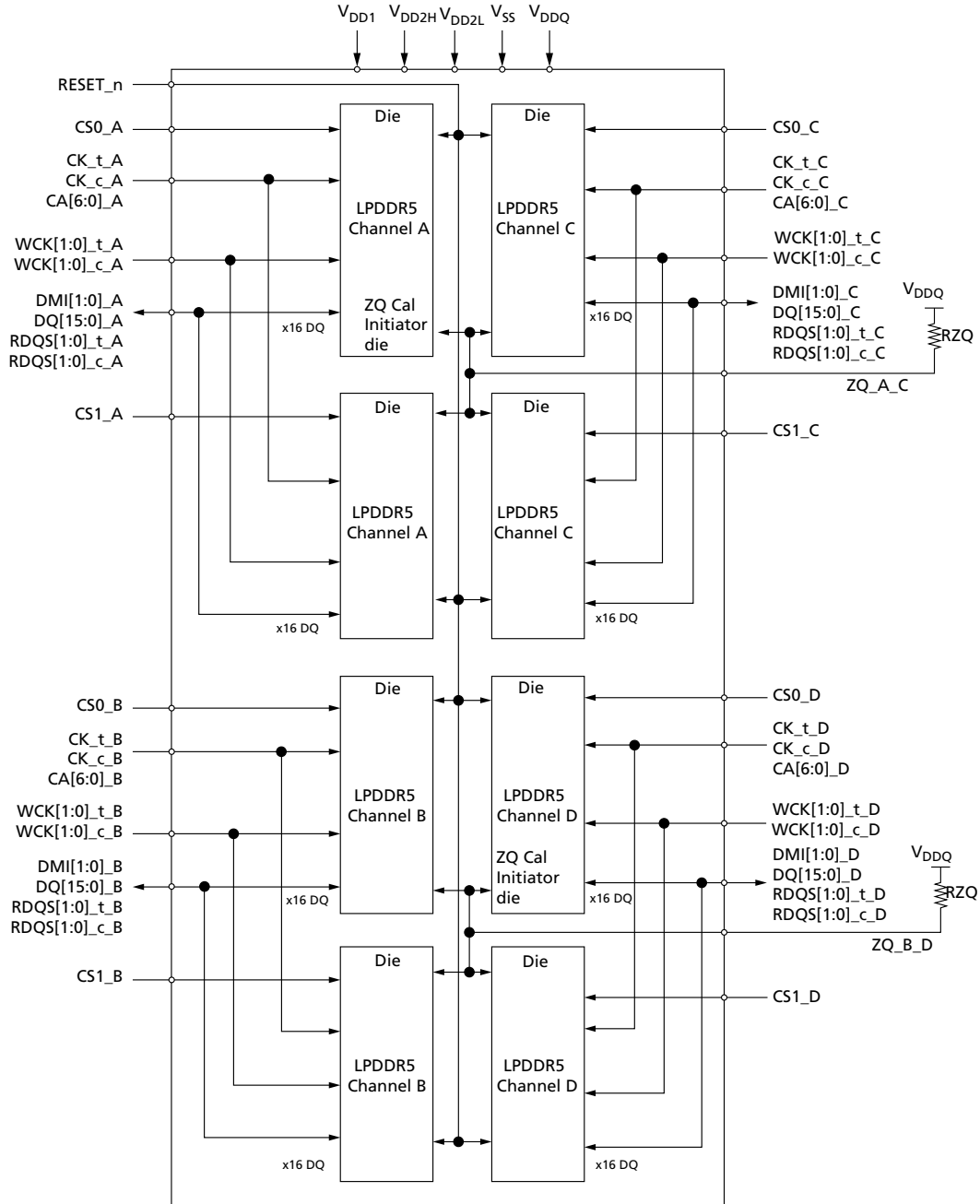
### Quad Die, Quad Channel, Single Rank

Figure 2: Quad-Die, Quad-Channel, Single-Rank Package Block Diagram



**Eight Die, Quad Channel, Dual Rank**

**Figure 3: Eight-Die, Quad-Channel, Dual-Rank Package Block Diagram**





## 441b Quad Channel, 1 Rank, 2 Rank

**Table 5: 441-Ball/Pad Descriptions**

Symbol	Type	Description
CK_t_[A:D], CK_c_[A:D]	Input	<b>Clock:</b> CK_t and CK_c are differential clock inputs. All double data rate (DDR) command/address inputs are sampled on both crossing points of CK_t and CK_c. The first crossing point is the rising (falling) edge of CK_t (CK_c) and second crossing point is falling (rising) edge of CK_t (CK_c). Single data rate (SDR) inputs, CS is sampled on the crossing point that is the rising (falling) edge of CK_t (CK_c).
CS0_[A:D], CS1_[A:D]	Input	<b>Chip select:</b> CS is part of the command code, and is sampled on the rising (falling) edge of CK_t (CK_c) unless the device is in power-down or deep sleep mode where it becomes an asynchronous signal. Each rank (0, 1) has its own CS signals. CS1_[A:D] become NC pins in a single-rank package.
CA[6:0]_[A:D]	Input	<b>Command/address inputs:</b> Provide the command and address inputs according to the command truth table.
WCK[1:0]_t_[A:D], WCK[1:0]_c_[A:D]	Input	<b>Data clock:</b> WCK_t and WCK_c are differential clock inputs used for WRITE data capture and READ data output.
DQ[15:0]_[A:D]	I/O	<b>Data input/output:</b> Bidirectional data bus.
RDQS[1:0]_t_[A:D], RDQS[1:0]_c_[A:D]	I/O Output	<b>Read data strobe:</b> RDQS_t and RDQS_c are differential output clock signals used to strobe data during a READ operation. RDQS_t is also used as a parity pin during write link protection enabled. Each byte of data has RDQS_t and RDQS_c signals.
DMI[1:0]_[A:D]	I/O	<b>Data mask inversion:</b> DMI serves multiple functions such as data mask (DM), data bus inversion (DBI), and parity at READ with ECC operation by setting the mode register. DMI is a bidirectional signal and each byte of data has a DMI signal.
ZQ_A_C, ZQ_B_D	Reference	<b>ZQ calibration reference:</b> Used to calibrate the output drive strength and the termination resistance. The ZQ pin should be connected to V <sub>DDQ</sub> through a 240Ω ±1% resistor.
V <sub>DDQ</sub> , V <sub>DD1</sub> , V <sub>DD2H</sub> , V <sub>DD2L</sub>	Supply	<b>Power supplies:</b> Isolated on the die for improved noise immunity.
V <sub>SS</sub>	Supply	<b>Ground reference:</b> Power supply ground reference.
RESET_n	Input	<b>Reset:</b> When asserted LOW, the RESET pin resets the die. Reset is an asynchronous signal.
NC	–	<b>No connect:</b> Not internally connected.
RFU	–	<b>Reserved Future Use:</b> Not internally connected



441b: x64 Automotive LPDDR5X SDRAM  
441b Quad Channel, 1 Rank, 2 Rank

Figure 4: 441-Ball Quad-Channel FBGA

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	
A	V <sub>SS</sub>	V <sub>SS</sub>	V <sub>DD1</sub>	V <sub>DD2L</sub>	V <sub>SS</sub>	V <sub>DD2H</sub>	V <sub>DD1</sub>	V <sub>SS</sub>	V <sub>DD2L</sub>	V <sub>DD2H</sub>	V <sub>DD2H</sub>	V <sub>SS</sub>	V <sub>DD1</sub>	V <sub>DD2L</sub>	V <sub>SS</sub>	V <sub>DD2H</sub>	V <sub>DD1</sub>	V <sub>SS</sub>	V <sub>DD2L</sub>	V <sub>SS</sub>	V <sub>SS</sub>	A
B	V <sub>SS</sub>	DQ0_A	V <sub>SS</sub>	DQ3_A	V <sub>DD2H</sub>	V <sub>SS</sub>	DQ11_A	DQ9_A	DQ8_A	V <sub>SS</sub>	V <sub>DD2H</sub>	DQ0_C	V <sub>SS</sub>	DQ3_C	V <sub>DD2H</sub>	V <sub>SS</sub>	DQ11_C	DQ9_C	DQ8_C	RFU	V <sub>SS</sub>	B
C	V <sub>DD2H</sub>	V <sub>SS</sub>	DQ2_A	V <sub>DDQ</sub>	CA0_A	V <sub>DD2H</sub>	V <sub>SS</sub>	DQ10_A	V <sub>DDQ</sub>	V <sub>DD2H</sub>	V <sub>SS</sub>	DQ2_C	V <sub>DDQ</sub>	CA0_C	V <sub>DD2H</sub>	V <sub>SS</sub>	DQ10_C	V <sub>DDQ</sub>	V <sub>DD2H</sub>	V <sub>DD2H</sub>	V <sub>DD2H</sub>	C
D	V <sub>SS</sub>	DQ1_A	WCK0_c_A	V <sub>SS</sub>	CA1_A	CS0_A	V <sub>DDQ</sub>	V <sub>SS</sub>	WCK1_t_A	V <sub>DD2H</sub>	V <sub>DDQ</sub>	DQ1_C	WCK0_c_C	V <sub>SS</sub>	CA1_C	CS0_C	V <sub>DDQ</sub>	V <sub>SS</sub>	WCK1_t_C	V <sub>DDQ</sub>	V <sub>SS</sub>	D
E	V <sub>DDQ</sub>	RDQ50_c_A	V <sub>SS</sub>	WCK0_t_A	V <sub>SS</sub>	CS1_A	V <sub>SS</sub>	WCK1_c_A	DMI1_A	V <sub>SS</sub>	V <sub>DDQ</sub>	RDQ50_c_C	V <sub>SS</sub>	WCK0_t_C	V <sub>SS</sub>	CS1_C	V <sub>SS</sub>	WCK1_c_C	DMI1_C	V <sub>SS</sub>	V <sub>DD2H</sub>	E
F	V <sub>DDQ</sub>	RDQ50_t_A	V <sub>SS</sub>	V <sub>DDQ</sub>	V <sub>SS</sub>	CA2_A	V <sub>SS</sub>	RDQ51_t_A	V <sub>SS</sub>	V <sub>DDQ</sub>	V <sub>SS</sub>	RDQ50_t_C	V <sub>SS</sub>	V <sub>DDQ</sub>	V <sub>SS</sub>	CA2_C	V <sub>SS</sub>	RDQ51_t_C	V <sub>SS</sub>	V <sub>DDQ</sub>	V <sub>DD2H</sub>	F
G	V <sub>SS</sub>	DQ4_A	V <sub>DDQ</sub>	DMI0_A	RFU	RFU	CA6_A	V <sub>SS</sub>	RDQ51_c_A	V <sub>SS</sub>	V <sub>DDQ</sub>	DMI0_C	V <sub>DDQ</sub>	DQ4_C	RFU	RFU	CA6_C	V <sub>SS</sub>	RDQ51_c_C	V <sub>SS</sub>	V <sub>SS</sub>	G
H	V <sub>DD2L</sub>	V <sub>SS</sub>	DQ5_A	V <sub>SS</sub>	CK_t_A	V <sub>SS</sub>	CA5_A	V <sub>DDQ</sub>	V <sub>SS</sub>	DQ12_A	V <sub>SS</sub>	V <sub>SS</sub>	DQ5_C	V <sub>SS</sub>	CK_t_C	V <sub>SS</sub>	CA5_C	V <sub>DDQ</sub>	V <sub>SS</sub>	DQ12_C	V <sub>DD2L</sub>	H
J	V <sub>DD2H</sub>	DQ6_A	DQ7_A	V <sub>DD2H</sub>	V <sub>SS</sub>	CK_c_A	V <sub>SS</sub>	DQ14_A	DQ13_A	V <sub>SS</sub>	V <sub>DD2L</sub>	DQ6_C	DQ7_C	V <sub>DD2L</sub>	ZQ_A_C	CK_c_C	V <sub>SS</sub>	DQ14_C	DQ13_C	V <sub>SS</sub>	V <sub>DD2H</sub>	J
K	V <sub>SS</sub>	V <sub>DD2H</sub>	V <sub>DD2H</sub>	V <sub>DD2H</sub>	V <sub>SS</sub>	CA3_A	CA4_A	V <sub>DD2L</sub>	V <sub>SS</sub>	DQ15_A	V <sub>DD2H</sub>	V <sub>DD2H</sub>	V <sub>DD2H</sub>	V <sub>DD2H</sub>	V <sub>SS</sub>	CA3_C	CA4_C	V <sub>DD2H</sub>	V <sub>SS</sub>	DQ15_C	V <sub>SS</sub>	K
L	V <sub>DD2H</sub>	V <sub>DD2L</sub>	V <sub>DD2L</sub>	V <sub>DD2H</sub>	V <sub>DD2L</sub>	V <sub>DD2H</sub>	V <sub>SS</sub>	V <sub>DD2H</sub>	V <sub>DD2H</sub>	V <sub>SS</sub>	V <sub>SS</sub>	V <sub>SS</sub>	V <sub>DD2H</sub>	V <sub>DD2H</sub>	V <sub>SS</sub>	V <sub>DD2H</sub>	V <sub>DD2L</sub>	V <sub>DD2H</sub>	V <sub>DD2L</sub>	V <sub>DD2L</sub>	V <sub>DD2H</sub>	L
M	V <sub>SS</sub>	DQ15_B	V <sub>SS</sub>	V <sub>DD2H</sub>	CA4_B	CA3_B	V <sub>SS</sub>	V <sub>DD2H</sub>	V <sub>DD2H</sub>	V <sub>DD2H</sub>	V <sub>DD2H</sub>	DQ15_D	V <sub>SS</sub>	V <sub>DD2L</sub>	CA4_D	CA3_D	V <sub>SS</sub>	V <sub>DD2H</sub>	V <sub>DD2H</sub>	V <sub>DD2H</sub>	V <sub>SS</sub>	M
N	V <sub>DD2H</sub>	V <sub>SS</sub>	DQ13_B	DQ14_B	V <sub>SS</sub>	CK_c_B	ZQ_B_D	V <sub>DD2L</sub>	DQ7_B	DQ6_B	V <sub>DD2L</sub>	V <sub>SS</sub>	DQ13_D	DQ14_D	V <sub>SS</sub>	CK_c_D	V <sub>SS</sub>	V <sub>DD2H</sub>	DQ7_D	DQ6_D	V <sub>DD2H</sub>	N
P	V <sub>DD2L</sub>	DQ12_B	V <sub>SS</sub>	V <sub>DDQ</sub>	CA5_B	V <sub>SS</sub>	CK_t_B	V <sub>SS</sub>	DQ5_B	V <sub>SS</sub>	V <sub>SS</sub>	DQ12_D	V <sub>SS</sub>	V <sub>DDQ</sub>	CA5_D	V <sub>SS</sub>	CK_t_D	V <sub>SS</sub>	DQ5_D	V <sub>SS</sub>	V <sub>DD2L</sub>	P
R	V <sub>SS</sub>	V <sub>SS</sub>	RDQ51_c_B	V <sub>SS</sub>	CA6_B	RFU	RFU	DQ4_B	V <sub>DDQ</sub>	DMI0_B	V <sub>DDQ</sub>	V <sub>SS</sub>	RDQ51_c_D	V <sub>SS</sub>	CA6_D	RFU	RFU	DMI0_D	V <sub>DDQ</sub>	DQ4_D	V <sub>SS</sub>	R
T	V <sub>DD2H</sub>	V <sub>DDQ</sub>	V <sub>SS</sub>	RDQ51_t_B	V <sub>SS</sub>	CA2_B	V <sub>SS</sub>	V <sub>DDQ</sub>	V <sub>SS</sub>	RDQ50_t_B	V <sub>SS</sub>	V <sub>DDQ</sub>	V <sub>SS</sub>	RDQ51_t_D	V <sub>SS</sub>	CA2_D	V <sub>SS</sub>	V <sub>DDQ</sub>	V <sub>SS</sub>	RDQ50_t_D	V <sub>DDQ</sub>	T
U	V <sub>DD2H</sub>	V <sub>SS</sub>	DMI1_B	WCK1_c_B	V <sub>SS</sub>	CS1_B	V <sub>SS</sub>	WCK0_t_B	V <sub>SS</sub>	RDQ50_c_B	V <sub>DDQ</sub>	V <sub>SS</sub>	DMI1_D	WCK1_c_D	V <sub>SS</sub>	CS1_D	V <sub>SS</sub>	WCK0_t_D	V <sub>SS</sub>	RDQ50_c_D	V <sub>DDQ</sub>	U
V	V <sub>SS</sub>	V <sub>DDQ</sub>	WCK1_t_B	V <sub>SS</sub>	V <sub>DDQ</sub>	CS0_B	CA1_B	V <sub>SS</sub>	WCK0_c_B	DQ1_B	V <sub>DDQ</sub>	V <sub>DD2H</sub>	WCK1_t_D	V <sub>SS</sub>	V <sub>DDQ</sub>	CS0_D	CA1_D	V <sub>SS</sub>	WCK0_c_D	DQ1_D	V <sub>SS</sub>	V
W	V <sub>DD2H</sub>	V <sub>DD2H</sub>	V <sub>DDQ</sub>	DQ10_B	V <sub>SS</sub>	V <sub>DD2H</sub>	CA0_B	V <sub>DDQ</sub>	DQ2_B	V <sub>SS</sub>	V <sub>SS</sub>	V <sub>DD2H</sub>	V <sub>DDQ</sub>	DQ10_D	V <sub>SS</sub>	V <sub>DD2H</sub>	CA0_D	V <sub>DDQ</sub>	DQ2_D	V <sub>SS</sub>	V <sub>DD2H</sub>	W
Y	V <sub>SS</sub>	RESET_N	DQ8_B	DQ9_B	DQ11_B	V <sub>SS</sub>	V <sub>DD2H</sub>	DQ3_B	V <sub>SS</sub>	DQ0_B	V <sub>DD2H</sub>	V <sub>SS</sub>	DQ8_D	DQ9_D	DQ11_D	V <sub>SS</sub>	V <sub>DD2H</sub>	DQ3_D	V <sub>SS</sub>	DQ0_D	V <sub>SS</sub>	Y
AA	V <sub>SS</sub>	V <sub>SS</sub>	V <sub>DD2L</sub>	V <sub>SS</sub>	V <sub>DD1</sub>	V <sub>DD2H</sub>	V <sub>SS</sub>	V <sub>DD2L</sub>	V <sub>DD1</sub>	V <sub>SS</sub>	V <sub>DD2H</sub>	V <sub>DD2H</sub>	V <sub>DD2L</sub>	V <sub>SS</sub>	V <sub>DD1</sub>	V <sub>DD2H</sub>	V <sub>SS</sub>	V <sub>DD2L</sub>	V <sub>DD1</sub>	V <sub>SS</sub>	V <sub>SS</sub>	AA

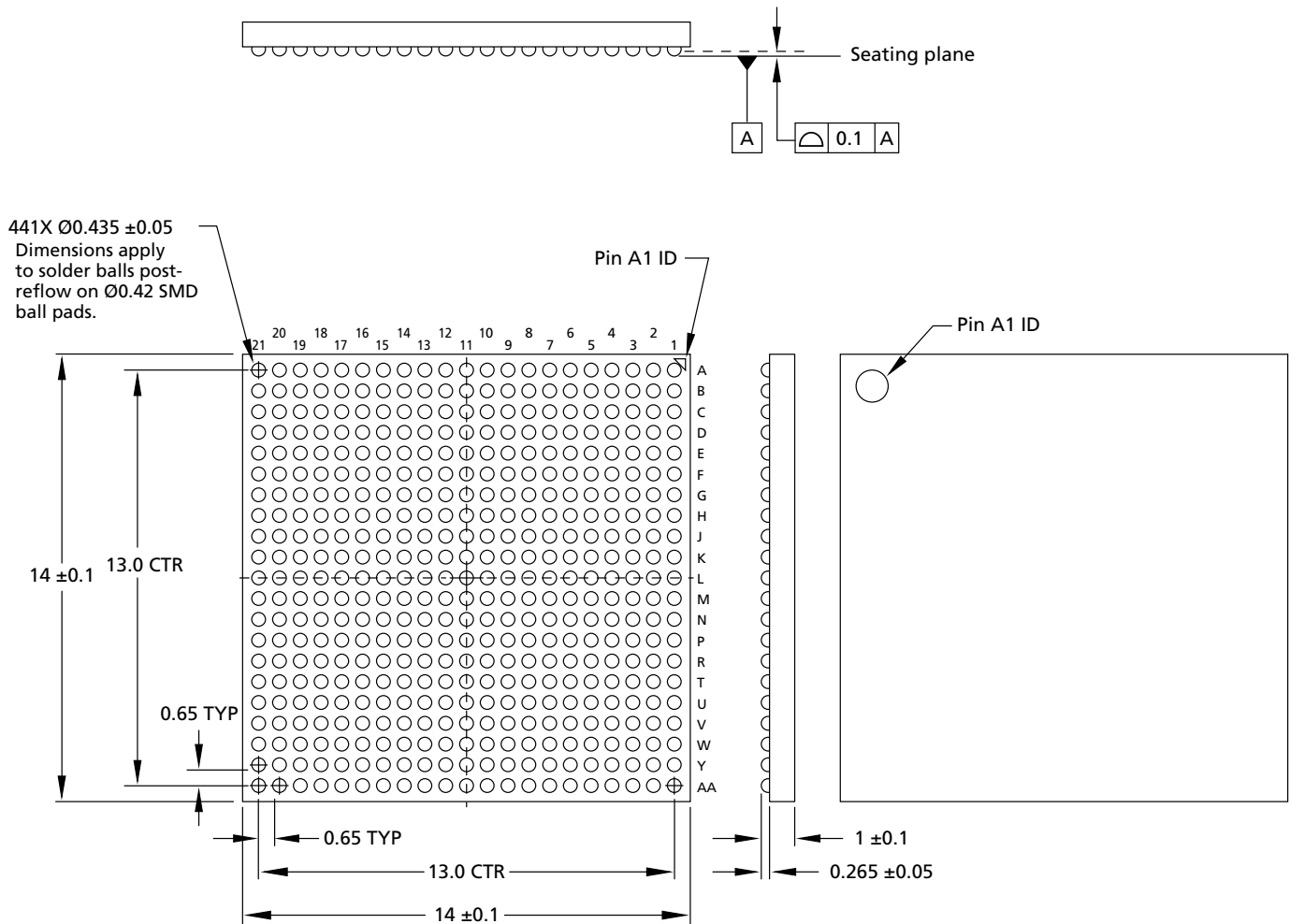
Top View (ball down)



## Package Dimensions

### 441-Ball Package (Package Code: EK)

**Figure 5: 441-Ball TFBGA – 14.0mm (TYP) × 14.0mm (TYP) × 1.1mm (MAX) (Package Code: EK)**



- Notes: 1. All dimensions are in millimeters.  
2. Solder ball composition: SACQ with CuOSP pads (Sn- 4Ag-0.5Cu-3Bi-0.05Ni)



## Product-Specific Mode Register Definition

Table 6: Mode Register Contents

Mode Register	OP7	OP6	OP5	OP4	OP3	OP2	OP1	OP0	
MR0	Per-pin DFE	Pre Emphasis	Unified NT ODT behavior mode	DMI output behavior mode	Optimized refresh mode	Enhanced WCK always-on mode	Latency mode	NT ODT timing mode	
	OP[0] = 1b: Device supports different NT ODT latency for DQ and RDQS								
	OP[1] = 0b: Device supports x16 mode latency for 1G64, 2G64								
	OP[2] = 1b: Device supports enhanced WCK always-on mode								
	OP[3] = 1b: Device supports optimized refresh mode								
	OP[4] = 1b: Device supports both DMI behavior mode 1 and 2 and mode selection								
	OP[5] = 1b: The NT ODT behavior follows the unified NT ODT behavior								
	OP[6] = 1b: Device supports Pre Emphasis mode								
OP[7] = 0b: Device does not support Per Pin DFE									
MR1							ARFM support <sup>3</sup>	CS ODT OP support	
	OP[0] = 1b: Device supports CS ODT behavior OP								
OP[1] = 1b: Device supports ARFM									
MR3					BK/BG Org				
	OP[4:3] = 00b: BG, 01b: 8B, 10b: 16B Mode Supported								
MR5	Manufacturer ID								
	1111 1111b: Micron								
MR6	Revision ID1								
	0000 0111b								
MR8	I/O width		Density				Type		
	OP[7:6] = 00b: x16 for 1G64, 2G64		OP[5:2] = 0110b: 16Gb				OP[1:0] = 01b: LPDDR5X SDRAM		
MR13						VRO			
	OP[2] = 0b: Normal operation (default) 1b: Output the $V_{REF(CA)}$ value on DQ7 and $V_{REF(DQ)}$ value on DQ6								
MR19			WCK2DQ OSC FM						
	OP[5] = 1b: WCK2DQ OSC FM supported								





## 441b: x64 Automotive LPDDR5X SDRAM Product-Specific Mode Register Definition

**Table 6: Mode Register Contents (Continued)**

Mode Register	OP7	OP6	OP5	OP4	OP3	OP2	OP1	OP0
MR21	<b>WXS</b>				<b>ODTD-CSFS</b>	<b>WXFS</b>	<b>RDCFS</b>	<b>WDCFS</b>
	OP[0] = 1b: WRITE DATA COPY function supported							
	OP[1] = 1b: READ DATA COPY function supported							
	OP[2] = 1b: WRITE X function supported							
	OP[3] = 1b: Device ODTD-CS is supported							
	OP[7] = 1b: Data to be written can be selected with 0 and 1							
MR22	<b>RECC</b>		<b>WECC</b>					
	OP[5:4] = 00b: Write link ECC disabled (default) 01b: Write link ECC enabled (See Note 4)							
	OP[7:6] = 00b: Read link ECC disabled (default) 01b: Read link ECC enabled (See Note 4)							
MR24	<b>DFES</b>				<b>Read DCA</b>			
	OP[3] = 1b: Device supports Read DCA							
	OP[7] = 1b: Device supports DFE (See Note 5)							
MR26		<b>RDQSTFS</b>						
	OP[6] = 1b: Read/write-based RDQS_t TRAINING function supported							
MR27	<b>RAAMULT</b>		<b>RAAIMT</b>				<b>RFM</b>	
	OP[0] = 1b: RFM is required							
	OP[5:1] = 01110b: 112							
	OP[7:6] = 01b: 4X							
MR41						<b>DVFSC/ E-DVFSC Support</b>		
	OP[2:1] = 00b: Only Legacy DVFSC Mode supported							
MR43		<b>SBEC rule</b>						
	OP[6] = 1b: Simultaneous SBE on each DQ byte and DMI are independently counted							
MR57	<b>ARFM<sup>3</sup></b>				<b>RFMSB</b>		<b>RAADEC</b>	
	OP[1:0] = 10b: 2 × RAAIMT							
	OP[3:2] = 00b: 1 = Does not support single-bank mode							
	OP[7:6] = 00b: default (01110b: 112), 01b: Level A = 01101b: 104, Level B = 01100b: 96, Level C = 01011: 88							
MR63 - MR164	Reserved MR bits MR63 through MR164 are RFU by JEDEC standard and should not be accessed by user unless directed by supplier.							

- Notes: 1. The contents of mode registers described here reflect information specific to each die in these packages.  
 2. Refer to General LPDDR5/LPDDR5X Specification 1 for mode registers not described here.  
 3. Refer to General LPDDR5/LPDDR5X Specification 3 for feature description not described here.  
 4. Write link ECC and read link ECC are supported.  
 5. Device supports 3-step DFE.



## I<sub>DD</sub> Parameters

Refer to I<sub>DD</sub> Specification Parameters and Test Conditions section in General LPDDR5/LPDDR5X Specifications 2 for detailed conditions.

**Table 7: I<sub>DD</sub> Parameters at 7500 Mb/s – Single Die**

Symbol	Supply	x16 Mode			Unit	Note
		AUT	AAT	AIT		
I <sub>DD01</sub>	V <sub>DD1</sub>	3.60	3.30	3.30	mA	
I <sub>DD02H</sub>	V <sub>DD2H</sub>	36.00	31.00	31.00		
I <sub>DD02L</sub>	V <sub>DD2L</sub>	0.20	0.20	0.20		
I <sub>DD0Q</sub>	V <sub>DDQ</sub>	0.60	0.60	0.60		
I <sub>DD2P1</sub>	V <sub>DD1</sub>	1.90	1.60	1.60	mA	
I <sub>DD2P2H</sub>	V <sub>DD2H</sub>	3.20	2.70	2.70		
I <sub>DD2P2L</sub>	V <sub>DD2L</sub>	0.20	0.20	0.20		
I <sub>DD2PQ</sub>	V <sub>DDQ</sub>	0.60	0.60	0.60		
I <sub>DD2PS1</sub>	V <sub>DD1</sub>	1.90	1.60	1.60	mA	
I <sub>DD2PS2H</sub>	V <sub>DD2H</sub>	3.20	2.70	2.70		
I <sub>DD2PS2L</sub>	V <sub>DD2L</sub>	0.20	0.20	0.20		
I <sub>DD2PSQ</sub>	V <sub>DDQ</sub>	0.60	0.60	0.60		
I <sub>DD2N1</sub>	V <sub>DD1</sub>	1.90	1.60	1.60	mA	
I <sub>DD2N2H</sub>	V <sub>DD2H</sub>	21.00	18.00	18.00		
I <sub>DD2N2L</sub>	V <sub>DD2L</sub>	0.20	0.20	0.20		
I <sub>DD2NQ</sub>	V <sub>DDQ</sub>	0.60	0.60	0.60		
I <sub>DD2NS1</sub>	V <sub>DD1</sub>	1.90	1.60	1.60	mA	
I <sub>DD2NS2H</sub>	V <sub>DD2H</sub>	21.00	18.00	18.00		
I <sub>DD2NS2L</sub>	V <sub>DD2L</sub>	0.20	0.20	0.20		
I <sub>DD2NSQ</sub>	V <sub>DDQ</sub>	0.60	0.60	0.60		
I <sub>DD3P1</sub>	V <sub>DD1</sub>	1.90	1.60	1.60	mA	
I <sub>DD3P2H</sub>	V <sub>DD2H</sub>	9.00	7.00	7.00		
I <sub>DD3P2L</sub>	V <sub>DD2L</sub>	0.20	0.20	0.20		
I <sub>DD3PQ</sub>	V <sub>DDQ</sub>	0.60	0.60	0.60		
I <sub>DD3PS1</sub>	V <sub>DD1</sub>	1.90	1.60	1.60	mA	
I <sub>DD3PS2H</sub>	V <sub>DD2H</sub>	9.00	7.00	7.00		
I <sub>DD3PS2L</sub>	V <sub>DD2L</sub>	0.20	0.20	0.20		
I <sub>DD3PSQ</sub>	V <sub>DDQ</sub>	0.60	0.60	0.60		



Table 7: I<sub>DD</sub> Parameters at 7500 Mb/s – Single Die

Symbol	Supply	x16 Mode			Unit	Note
		AUT	AAT	AIT		
I <sub>DD3N1</sub>	V <sub>DD1</sub>	2.10	1.90	1.90	mA	
I <sub>DD3N2H</sub>	V <sub>DD2H</sub>	27.00	23.00	23.00		
I <sub>DD3N2L</sub>	V <sub>DD2L</sub>	0.20	0.20	0.20		
I <sub>DD3NQ</sub>	V <sub>DDQ</sub>	0.60	0.60	0.60		
I <sub>DD3NS1</sub>	V <sub>DD1</sub>	2.10	1.90	1.90	mA	
I <sub>DD3NS2H</sub>	V <sub>DD2H</sub>	27.00	23.00	23.00		
I <sub>DD3NS2L</sub>	V <sub>DD2L</sub>	0.20	0.20	0.20		
I <sub>DD3NSQ</sub>	V <sub>DDQ</sub>	0.60	0.60	0.60		
I <sub>DD4R1</sub>	V <sub>DD1</sub>	12.00	11.00	11.00	mA	3, 4
I <sub>DD4R2H</sub>	V <sub>DD2H</sub>	450.00	440.00	440.00		
I <sub>DD4R2L</sub>	V <sub>DD2L</sub>	0.20	0.20	0.20		
I <sub>DD4RQ</sub>	V <sub>DDQ</sub>	116.0	116.0	116.0		
I <sub>DD4W1</sub>	V <sub>DD1</sub>	11.00	10.00	10.00	mA	3
I <sub>DD4W2H</sub>	V <sub>DD2H</sub>	320.00	310.00	310.00		
I <sub>DD4W2L</sub>	V <sub>DD2L</sub>	0.20	0.20	0.20		
I <sub>DD4WQ</sub>	V <sub>DDQ</sub>	0.60	0.60	0.60		
I <sub>DD51</sub>	V <sub>DD1</sub>	23.50	23.00	23.00	mA	
I <sub>DD52H</sub>	V <sub>DD2H</sub>	170.00	165.00	165.00		
I <sub>DD52L</sub>	V <sub>DD2L</sub>	0.20	0.20	0.20		
I <sub>DD5Q</sub>	V <sub>DDQ</sub>	0.60	0.60	0.60		
I <sub>DD5AB1</sub>	V <sub>DD1</sub>	3.50	3.20	3.20	mA	
I <sub>DD5AB2H</sub>	V <sub>DD2H</sub>	31.00	27.00	27.00		
I <sub>DD5AB2L</sub>	V <sub>DD2L</sub>	0.20	0.20	0.20		
I <sub>DD5ABQ</sub>	V <sub>DDQ</sub>	0.60	0.60	0.60		
I <sub>DD5PB1</sub>	V <sub>DD1</sub>	3.50	3.20	3.20	mA	
I <sub>DD5PB2H</sub>	V <sub>DD2H</sub>	31.00	27.00	27.00		
I <sub>DD5PB2L</sub>	V <sub>DD2L</sub>	0.20	0.20	0.20		
I <sub>DD5PBQ</sub>	V <sub>DDQ</sub>	0.60	0.60	0.60		

- Notes: 1. Published I<sub>DD</sub> values except I<sub>DD4RQ</sub> are the maximum I<sub>DD</sub> values considering the worst-case conditions of process, temperature, and voltage.  
 2. BG mode. DVFS and DVFSQ disabled.  
 3. BL = 16, DBI disabled.  
 4. I<sub>DD4RQ</sub> value is reference only. Typical value. Output load = 5pF; R<sub>ON</sub> = 40 ohms; T<sub>C</sub> = 25°C  
 5. V<sub>DD1</sub> = 1.70–1.95V; V<sub>DD2H</sub> = 1.01–1.12V; V<sub>DD2L</sub> = 0.87–0.97V; V<sub>DDQ</sub> = 0.47–0.57V  
 6. Notes 1, 2, and 5 apply to entire table.



Table 8: I<sub>DD</sub> Parameters at 8533 Mb/s – Single Die

Symbol	Supply	x16 Mode			Unit	Note
		AUT	AAT	AIT		
I <sub>DD01</sub>	V <sub>DD1</sub>	3.60	3.30	3.30	mA	
I <sub>DD02H</sub>	V <sub>DD2H</sub>	36.00	31.00	31.00		
I <sub>DD02L</sub>	V <sub>DD2L</sub>	0.20	0.20	0.20		
I <sub>DD0Q</sub>	V <sub>DDQ</sub>	0.60	0.60	0.60		
I <sub>DD2P1</sub>	V <sub>DD1</sub>	1.90	1.60	1.60	mA	
I <sub>DD2P2H</sub>	V <sub>DD2H</sub>	3.20	2.70	2.70		
I <sub>DD2P2L</sub>	V <sub>DD2L</sub>	0.20	0.20	0.20		
I <sub>DD2PQ</sub>	V <sub>DDQ</sub>	0.60	0.60	0.60		
I <sub>DD2PS1</sub>	V <sub>DD1</sub>	1.90	1.60	1.60	mA	
I <sub>DD2PS2H</sub>	V <sub>DD2H</sub>	3.20	2.70	2.70		
I <sub>DD2PS2L</sub>	V <sub>DD2L</sub>	0.20	0.20	0.20		
I <sub>DD2PSQ</sub>	V <sub>DDQ</sub>	0.60	0.60	0.60		
I <sub>DD2N1</sub>	V <sub>DD1</sub>	1.90	1.60	1.60	mA	
I <sub>DD2N2H</sub>	V <sub>DD2H</sub>	21.00	18.00	18.00		
I <sub>DD2N2L</sub>	V <sub>DD2L</sub>	0.20	0.20	0.20		
I <sub>DD2NQ</sub>	V <sub>DDQ</sub>	0.60	0.60	0.60		
I <sub>DD2NS1</sub>	V <sub>DD1</sub>	1.90	1.60	1.60	mA	
I <sub>DD2NS2H</sub>	V <sub>DD2H</sub>	21.00	18.00	18.00		
I <sub>DD2NS2L</sub>	V <sub>DD2L</sub>	0.20	0.20	0.20		
I <sub>DD2NSQ</sub>	V <sub>DDQ</sub>	0.60	0.60	0.60		
I <sub>DD3P1</sub>	V <sub>DD1</sub>	1.90	1.60	1.60	mA	
I <sub>DD3P2H</sub>	V <sub>DD2H</sub>	9.00	7.00	7.00		
I <sub>DD3P2L</sub>	V <sub>DD2L</sub>	0.20	0.20	0.20		
I <sub>DD3PQ</sub>	V <sub>DDQ</sub>	0.60	0.60	0.60		
I <sub>DD3PS1</sub>	V <sub>DD1</sub>	1.90	1.60	1.60	mA	
I <sub>DD3PS2H</sub>	V <sub>DD2H</sub>	9.00	7.00	7.00		
I <sub>DD3PS2L</sub>	V <sub>DD2L</sub>	0.20	0.20	0.20		
I <sub>DD3PSQ</sub>	V <sub>DDQ</sub>	0.60	0.60	0.60		
I <sub>DD3N1</sub>	V <sub>DD1</sub>	2.10	1.90	1.90	mA	
I <sub>DD3N2H</sub>	V <sub>DD2H</sub>	27.00	23.00	23.00		
I <sub>DD3N2L</sub>	V <sub>DD2L</sub>	0.20	0.20	0.20		
I <sub>DD3NQ</sub>	V <sub>DDQ</sub>	0.60	0.60	0.60		



Table 8: I<sub>DD</sub> Parameters at 8533 Mb/s – Single Die

Symbol	Supply	x16 Mode			Unit	Note
		AUT	AAT	AIT		
I <sub>DD3NS1</sub>	V <sub>DD1</sub>	2.10	1.90	1.90	mA	
I <sub>DD3NS2H</sub>	V <sub>DD2H</sub>	27.00	23.00	23.00		
I <sub>DD3NS2L</sub>	V <sub>DD2L</sub>	0.20	0.20	0.20		
I <sub>DD3NSQ</sub>	V <sub>DDQ</sub>	0.60	0.60	0.60		
I <sub>DD4R1</sub>	V <sub>DD1</sub>	13.00	12.00	12.00	mA	3, 4
I <sub>DD4R2H</sub>	V <sub>DD2H</sub>	500.00	490.00	490.00		
I <sub>DD4R2L</sub>	V <sub>DD2L</sub>	0.20	0.20	0.20		
I <sub>DD4RQ</sub>	V <sub>DDQ</sub>	126.00	126.00	126.00		
I <sub>DD4W1</sub>	V <sub>DD1</sub>	12.00	11.00	11.00	mA	3
I <sub>DD4W2H</sub>	V <sub>DD2H</sub>	350.00	340.00	340.00		
I <sub>DD4W2L</sub>	V <sub>DD2L</sub>	0.20	0.20	0.20		
I <sub>DD4WQ</sub>	V <sub>DDQ</sub>	0.60	0.60	0.60		
I <sub>DD51</sub>	V <sub>DD1</sub>	23.50	23.00	23.00	mA	
I <sub>DD52H</sub>	V <sub>DD2H</sub>	170.00	165.00	165.00		
I <sub>DD52L</sub>	V <sub>DD2L</sub>	0.20	0.20	0.20		
I <sub>DD5Q</sub>	V <sub>DDQ</sub>	0.60	0.60	0.60		
I <sub>DD5AB1</sub>	V <sub>DD1</sub>	3.50	3.20	3.20	mA	
I <sub>DD5AB2H</sub>	V <sub>DD2H</sub>	31.00	27.00	27.00		
I <sub>DD5AB2L</sub>	V <sub>DD2L</sub>	0.20	0.20	0.20		
I <sub>DD5ABQ</sub>	V <sub>DDQ</sub>	0.60	0.60	0.60		
I <sub>DD5PB1</sub>	V <sub>DD1</sub>	3.50	3.20	3.20	mA	
I <sub>DD5PB2H</sub>	V <sub>DD2H</sub>	31.00	27.00	27.00		
I <sub>DD5PB2L</sub>	V <sub>DD2L</sub>	0.20	0.20	0.20		
I <sub>DD5PBQ</sub>	V <sub>DDQ</sub>	0.60	0.60	0.60		

- Notes: 1. Published I<sub>DD</sub> values except I<sub>DD4RQ</sub> are the maximum I<sub>DD</sub> values considering the worst-case conditions of process, temperature, and voltage.  
 2. BG mode. DVFS and DVFSQ disabled.  
 3. BL = 16, DBI disabled.  
 4. I<sub>DD4RQ</sub> value is reference only. Typical value. Output load = 5pF; R<sub>ON</sub> = 40 ohms; T<sub>C</sub> = 25°C  
 5. V<sub>DD1</sub> = 1.70–1.95V; V<sub>DD2H</sub> = 1.01–1.12V; V<sub>DD2L</sub> = 0.87–0.97V; V<sub>DDQ</sub> = 0.47–0.57V  
 6. Notes 1, 2, and 5 apply to entire table.



**Table 9: Full-Array Power-Down Self Refresh Current – Single Die**

Temperature	Symbol	Supply	Value	Unit
25°C	I <sub>DD61</sub>	V <sub>DD1</sub>	0.27	mA
	I <sub>DD62H</sub>	V <sub>DD2H</sub>	0.60	
	I <sub>DD62L</sub>	V <sub>DD2L</sub>	(See Note 4)	
	I <sub>DD6Q</sub>	V <sub>DDQ</sub>	(See Note 4)	
	I <sub>DD6DS1</sub>	V <sub>DD1</sub>	0.27	
	I <sub>DD6DS2H</sub>	V <sub>DD2H</sub>	0.60	
	I <sub>DD6DS2L</sub>	V <sub>DD2L</sub>	(See Note 4)	
	I <sub>DD6DSQ</sub>	V <sub>DDQ</sub>	(See Note 4)	
95°C	I <sub>DD61</sub>	V <sub>DD1</sub>	3.70	mA
	I <sub>DD62H</sub>	V <sub>DD2H</sub>	16.00	
	I <sub>DD62L</sub>	V <sub>DD2L</sub>	0.20	
	I <sub>DD6Q</sub>	V <sub>DDQ</sub>	0.60	
	I <sub>DD6DS1</sub>	V <sub>DD1</sub>	3.70	
	I <sub>DD6DS2H</sub>	V <sub>DD2H</sub>	16.00	
	I <sub>DD6DS2L</sub>	V <sub>DD2L</sub>	0.20	
	I <sub>DD6DSQ</sub>	V <sub>DDQ</sub>	0.60	
105°C	I <sub>DD61</sub>	V <sub>DD1</sub>	4.80	mA
	I <sub>DD62H</sub>	V <sub>DD2H</sub>	23.00	
	I <sub>DD62L</sub>	V <sub>DD2L</sub>	0.20	
	I <sub>DD6Q</sub>	V <sub>DDQ</sub>	0.60	
	I <sub>DD6DS1</sub>	V <sub>DD1</sub>	4.80	
	I <sub>DD6DS2H</sub>	V <sub>DD2H</sub>	23.0	
	I <sub>DD6DS2L</sub>	V <sub>DD2L</sub>	0.20	
	I <sub>DD6DSQ</sub>	V <sub>DDQ</sub>	0.60	
125°C	I <sub>DD61</sub>	V <sub>DD1</sub>	8.00	mA
	I <sub>DD62H</sub>	V <sub>DD2H</sub>	45.00	
	I <sub>DD62L</sub>	V <sub>DD2L</sub>	0.20	
	I <sub>DD6Q</sub>	V <sub>DDQ</sub>	0.60	
	I <sub>DD6DS1</sub>	V <sub>DD1</sub>	8.00	
	I <sub>DD6DS2H</sub>	V <sub>DD2H</sub>	45.00	
	I <sub>DD6DS2L</sub>	V <sub>DD2L</sub>	0.20	
	I <sub>DD6DSQ</sub>	V <sub>DDQ</sub>	0.60	



## 441b: x64 Automotive LPDDR5X SDRAM I<sub>DD</sub> Parameters

- Notes:
1. I<sub>DD6</sub>25°C is the typical value in the distribution with nominal V<sub>DD</sub> and a reference-only value. I<sub>DD6</sub>95/105/125°C is the maximum I<sub>DD</sub> guaranteed value considering the worst-case conditions of process, temperature, and voltage.
  2. DVFS and DVFSQ disabled.
  3. V<sub>DD1</sub> = 1.70–1.95V; V<sub>DD2H</sub> = 1.01–1.12V; V<sub>DD2L</sub> = 0.87–0.97V; V<sub>DDQ</sub> = 0.47–0.57V
  4. V<sub>DD2L</sub> and V<sub>DDQ</sub> power rails are not used during power-down self refresh.



## **Revision History**

### **Rev. B – 11/2022**

- Updated legal status to Production
- Updated general clarifications, namely on page #1
- Updated Mode Register Contents table: Corrected values

### **Rev. A – 05/2022**

- Initial Preliminary release

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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.