



3-Dimensional Stack (3DS) DDR4 SDRAM

MT40A4G4, MT40A8G4, MT40A2G8, MT40A4G8

Description

The 16Gb, 2-high (2H) and 32Gb, 4-high (4H) 3-dimensional stack (3DS) DDR4 SDRAM use Micron's special 3DS 8Gb DDR4 SDRAM organized as two or four logical ranks. Refer to Micron's 8Gb DDR4 SDRAM data sheet for the specifications not included in this document. Specifications for base part number MT40A2G4 correspond to 2H 3DS manufacturing part number MT40A4G4 and to 4H 3DS manufacturing part number MT40A8G4; specifications for base part number MT40A1G8 correspond to 2H 3DS manufacturing part number MT40A2G8 and to 4H 3DS manufacturing part number MT40A4G8.

Features

- Uses Micron 3DS 8Gb die
- Single electrical signal load for each command, address and data pin
- Two or four logical ranks (includes one or two 2C pins)
- Each rank has 4 groups of 4 internal banks for concurrent operation
- $V_{DD} = V_{DDQ} = 1.2V$ (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

- 2H configurations
 - 128 Meg x 4 x 16 banks x 2 ranks 4G4
 - 64 Meg x 8 x 16 banks x 2 ranks 2G8
- 4H configurations
 - 128 Meg x 4 x 16 banks x 4 ranks 8G4
 - 64 Meg x 8 x 16 banks x 4 ranks 4G8
- FBGA package (Pb-free)
 - 2H 78-ball FBGA (8.0mm x 12mm x 1.2mm) Die Rev :G HPR
 - 2H 78-ball FBGA (7.5mm x 12mm x 1.2mm) Die Rev :E DVN
 - 4H 78-ball FBGA (8.0mm x 12mm x 1.2mm) Die Rev :G KVA
 - 4H 78-ball FBGA (7.5mm x 11mm x 1.2mm) Die Rev :E CLU
- Timing – cycle time¹
 - 0.750ns @ CL = 22 (DDR4-2666) -075H
 - 0.833ns @ CL = 19 (DDR4-2400) -083J
 - 0.833ns @ CL = 20 (DDR4-2400) -083H
 - 0.937ns @ CL = 18 (DDR4-2133) -093H
- Self refresh
 - Standard None
- Operating temperature
 - Commercial (0°C ≤ T_C ≤ 95°C) None
- Revision :G, E

Notes: 1. CL = CAS (READ) latency.
 2. Not all options listed can be combined to define an offered product. Use the part catalog search on <http://www.micron.com> for available offerings.

Table 1: Key Timing Parameters

Speed Grade	Data Rate (MT/s)	Target CL- ^t RCD- ^t RP	CL (ns)	^t RCD (ns)	^t RP (ns)
-075H ^{1, 2}	2666	22-19-19	16.5	14.25	14.25
-083J ¹	2400	19-17-17	15.83	14.16	14.16
-083H	2400	20-18-18	16.67	15.0	15.0
-093H	2133	18-15-15	16.88	14.06	14.06

Notes: 1. Backward compatible to 2133, CL = 18 (-093H).
 2. Backward compatible to 2400, CL = 20 (-083H).



16Gb, 32Gb: x4, x8 3DS DDR4 SDRAM Description

Table 2: 2H Addressing

Parameter	4096 Meg x 4	2048 Meg x 8
Configuration	128 Meg x 4 x 16 banks x 2 ranks	64 Meg x 8 x 16 banks x 2 ranks
Logical rank address	C[0]	C[0]
Bank group address	BG[1:0]	BG[1:0]
Bank count per group	4	4
Bank address in bank group	BA[1:0]	BA[1:0]
Row address	128K A[16:0]	64K A[15:0]
Column address	1K A[9:0]	1K A[9:0]

Table 3: 4H Addressing

Parameter	8192 Meg x 4	4096 Meg x 8
Configuration	128 Meg x 4 x 16 banks x 4 ranks	64 Meg x 8 x 16 banks x 4 ranks
Logical rank address	C[1:0]	C[1:0]
Bank group address	BG[1:0]	BG[1:0]
Bank count per group	4	4
Bank address in bank group	BA[1:0]	BA[1:0]
Row address	128K A[16:0]	64K A[15:0]
Column address	1K A[9:0]	1K A[9:0]



16Gb, 32Gb: x4, x8 3DS DDR4 SDRAM Description

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16Gb, 32Gb: x4, x8 3DS DDR4 SDRAM 3DS (Master/Slave) Overview

3DS (Master/Slave) Overview

The 3DS DDR4 SDRAM provides enhanced functionality and performance when compared to a traditional stacked DDR4 SDRAM device. This data sheet details the product's unique features; providing package dimensions, ball assignments, functional block diagrams, and electrical and timing specifications as applicable. Topics not addressed in this data sheet are covered in the standard Micron DDR4 SDRAM data sheet.

The 3DS device provides a stack of DRAM die with one die configured as the master and the remaining die in the stack configured as slave device(s). Each die functions as a different logical rank. Because the master die provides isolation (or buffering) to the slave die, the electrical signal loading of the external interface is that of a single DDR4 SDRAM, which can improve timing, bus speeds, and signal integrity while lowering power consumption—a significant benefit over a traditional stacked device.

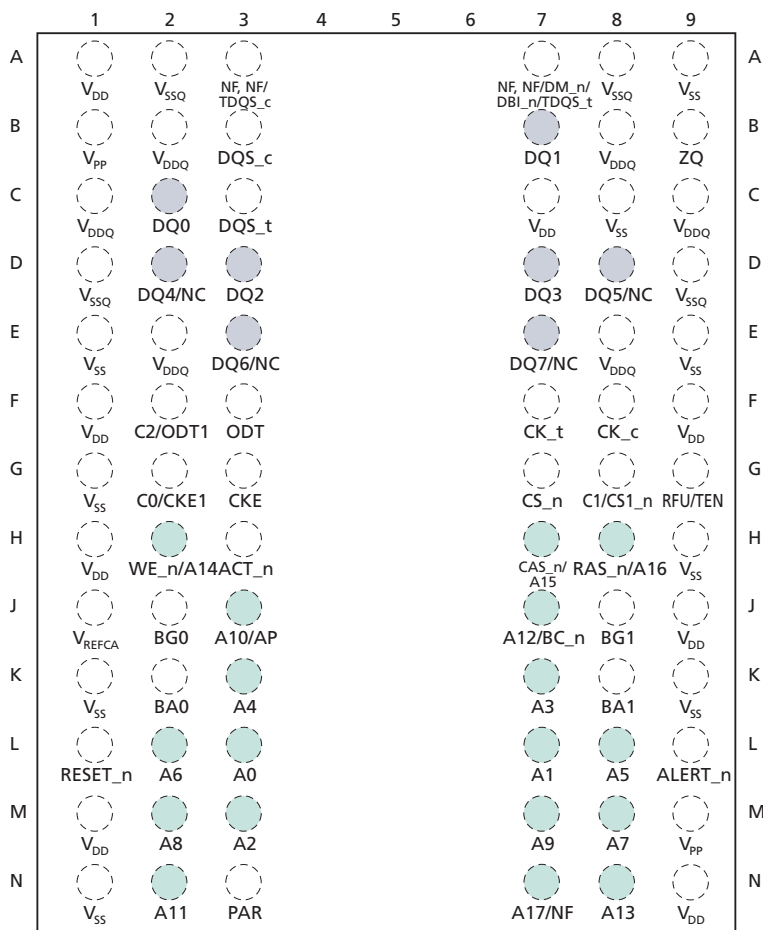


16Gb, 32Gb: x4, x8 3DS DDR4 SDRAM Ball Assignments

Ball Assignments

The 3DS package has a ball grid definition common to a standard DDR4 device. The pins that select a single device within the stack are C0/CKE1, C1/CS1_n, and C2/ODT1, which are also the pins used in controlling a standard TwinDie (DDP) stacked DRAM.

Figure 1: 78-Ball FBGA (Top View)



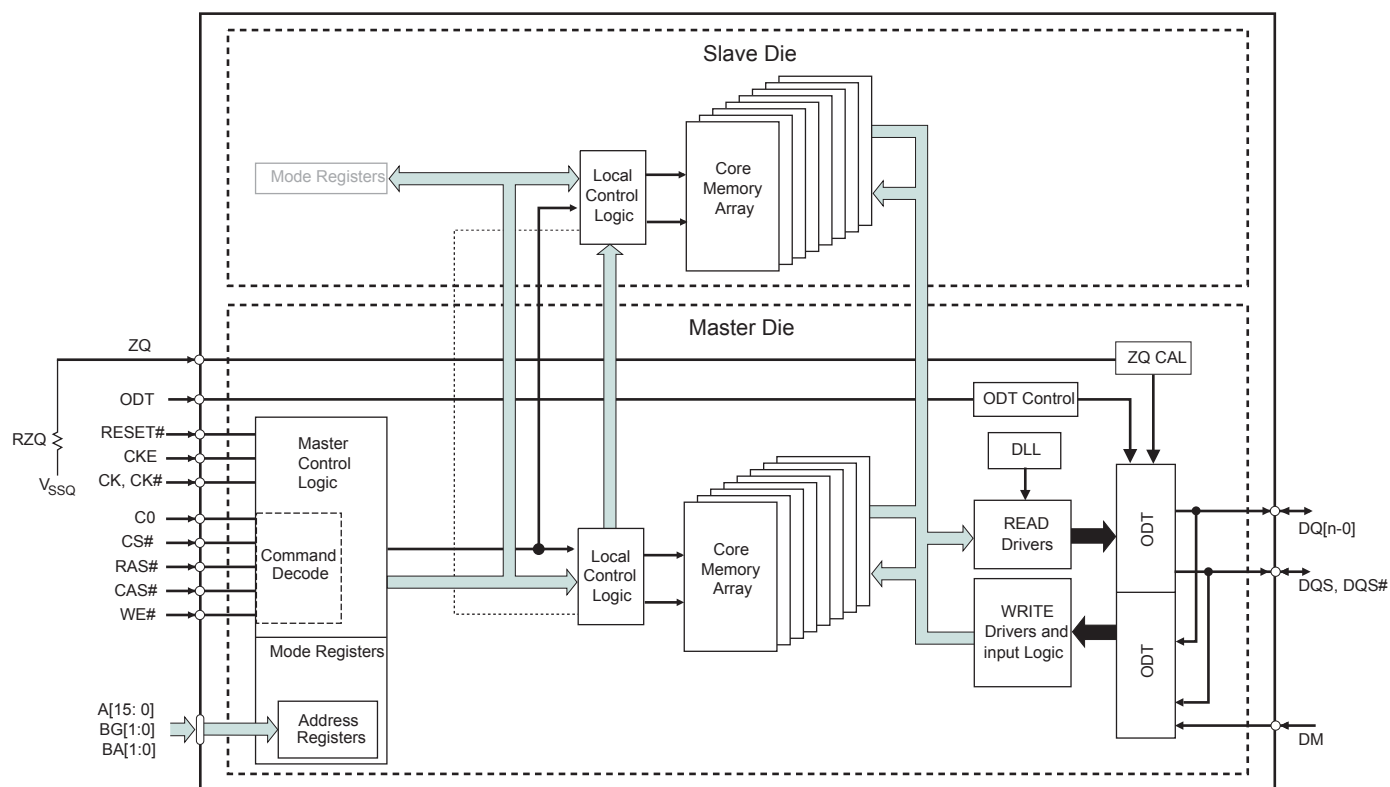
- Notes:
1. See Ball Descriptions.
 2. A comma "," separates the configuration; a slash "/" defines a selectable function. For example: Ball A7 = NF, NF/DM_n/DBI_n/TDQS_t where NF applies to the x4 configuration only. NF/DM_n/DBI_n/TDQS_t applies to the x8 configuration only and is selectable between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

16Gb, 32Gb: x4, x8 3DS DDR4 SDRAM Functionality

Functionality

The 3DS DDR4 SDRAM is a high-speed, CMOS dynamic random access memory built as a 2-high or 4-high 3DS component. The 2-high device consists of one master die and one slave die. The 4-high device consists of one master die and three slave die.

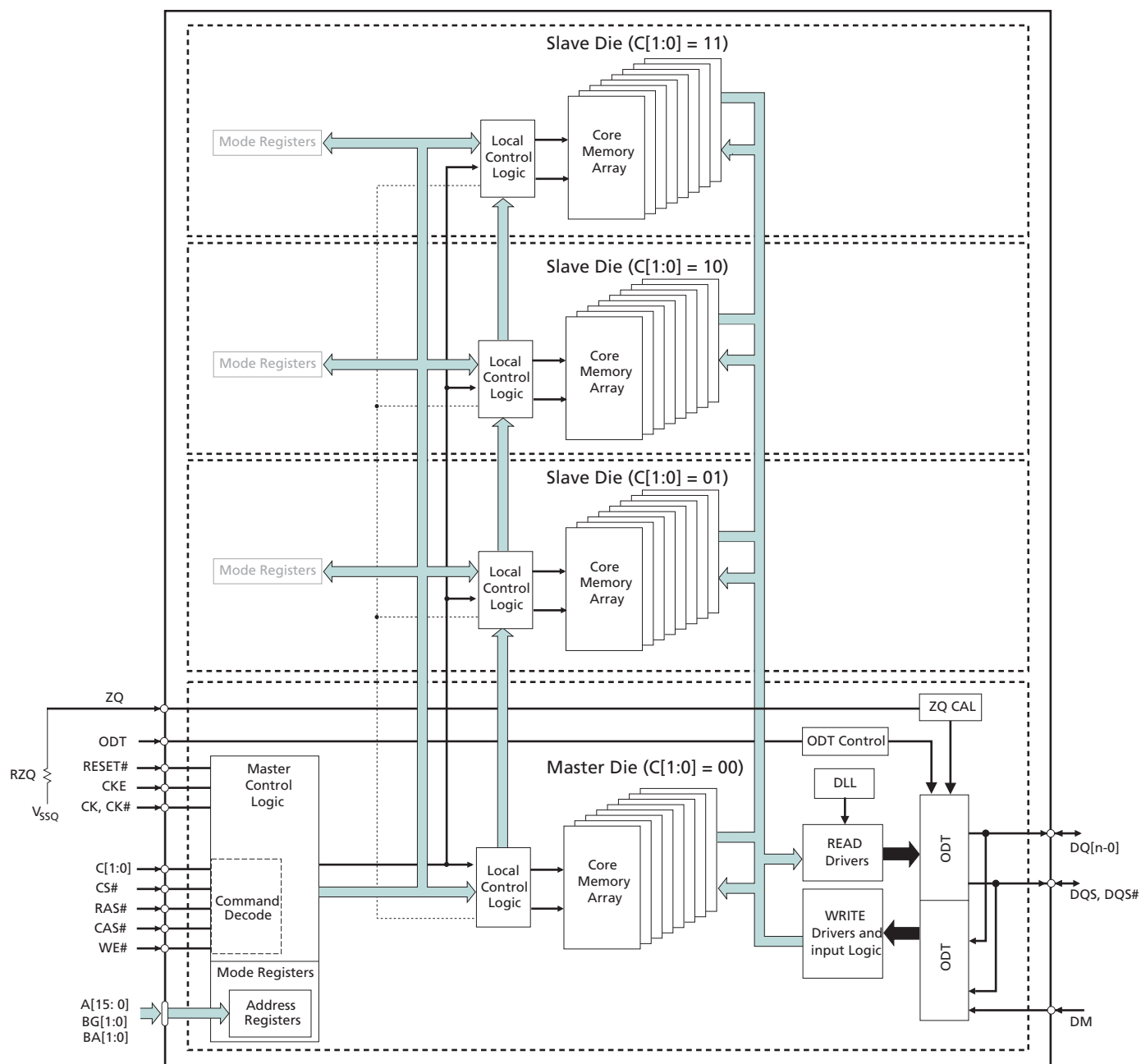
Figure 2: 2-High 3DS Functional Block Diagram





16Gb, 32Gb: x4, x8 3DS DDR4 SDRAM Functionality

Figure 3: 4-High 3DS Functional Block Diagram





Addressing

Each die within the 3DS stack uses the same addressing as its like-density monolithic device. A 2-high stack has two independent selectable logical ranks; a 4-high stack has four independent selectable logical ranks. In contrast to conventionally stacked DDR4 (TwinDie), 3DS stacks only have one CS_n pin regardless of the number of die; die (logical rank) selection is accomplished by the state of the Chip ID (Cx) pin(s), which behave as rank address(es). Because logic is shared between master and slave(s) on the 3DS device, some commands and operations affect all ranks while others only impact a single rank.

Table 4: 3DS Signals

Configuration	Number of Die (Logical Ranks)	Relevant Signals
16Gb (2-high) 3DS addressing – 8Gb die	2	CS _n , C0
32Gb (4-high) 3DS addressing – 8Gb die	4	CS _n , C0, C1

Table 5: 2H Stack Addressing

Logical Rank Selected	CS _n	C0
0	L	L
1	L	H

Table 6: 4H Stack Addressing

Logical Rank Selected	CS _n	C1	C0
0	L	L	L
1	L	L	H
2	L	H	L
3	L	H	H

All-Die Commands vs. Single-Die Commands

Some commands issued to the 3DS stack device only impact the function of a single rank (providing the host controller with the best functionality), while others affect all of the ranks (because of the shared nature of the logic).

Table 7: Commands/Operations vs. Ranks Impacted

Command/Operation	Ranks Impacted	Notes
Mode register	All	One mode register sets condition for all die/ranks
Gear-down mode sync	All	Single electrical interface
Write leveling	All	Single electrical interface
ZQ CAL	All	Single electrical interface
ODT	All	Single electrical interface
Power-down (including SELF REFRESH)	All	Single CKE



16Gb, 32Gb: x4, x8 3DS DDR4 SDRAM Initialization and Reset

Table 7: Commands/Operations vs. Ranks Impacted (Continued)

Command/Operation	Ranks Impacted	Notes
ACTIVE	By rank	New t_{RRD}/t_{FAW} timings
WRITE	By rank	New t_{CCD} timings
READ	By rank	New t_{CCD} timings
PRECHARGE	By rank	Precharge all restrictions
REFRESH	By rank	New t_{RFC} timing to stagger refresh

Initialization and Reset

The 3DS device requires a complete power-up and initialization sequence, which follows the standard DDR4 SDRAM requirement. Mode register commands affect the operation of all die, so there is no need to send mode register commands to each die individually. The 3DS device has special mode register set (MRS) requirements described in the following section; all other power-up and reset timings and conditions follow the normal operations listed in the DDR4 SDRAM specification.

Mode Register Set

Standard mode register locations and definitions apply to the 3DS device as described in the DDR4 SDRAM specification, except as outlined in this section. Any valid MRS command sets the operating mode for all logical ranks. As such, prior to an MRS command, all logical ranks must be precharged and t_{RP} must be met. In addition, t_{MRD} and t_{MOD} apply to MRS commands for the 3DS component.

Table 8: Truth Table for MRS Commands

DRAM Command ¹	CS#	C2	C1	C0	Status
MODE REGISTER SET	L	V	V	V	MRS affects all logical ranks
MODE REGISTER SET	H	V	V	V	All Ranks see DESELECT
Any other command	H	V	V	V	All Ranks see DESELECT

Note: 1. H = High logic level, L = Low logic level, V = H or L (but a defined logic level).

Unique 3DS MRS Values for Mode Register 1

The additional latency settings of the 3DS device requires support for additive latency of 3 ($AL = CL - 3$). This setting is required if $t_{AA} > t_{RCD}$. See Speed Bin tables for more information.


Table 9: MR1 Register Definition

Mode Register	Description
4, 3	Additive latency (AL) – Command additive latency setting 00 = 0 (AL disabled) 01 = CL - 1 ¹ 10 = CL - 2 11 = CL - 3

Note: 1. The additive latency settings for the 3DS device are some different than for monolithic device. The setting AL = CL - 3 may be useful where $nCL > nRCD + 2$.

Multipurpose Register

When CA parity or Write CRC are enabled and an error is detected, the 3DS DDR4 device reports the latched states of C[2:0] for the error cycle in multipurpose register(MPR) Page 1 MPR3[2:0]. This is shown in the MPR Page and MPRx Definitions table in the standard DDR4 data sheet. In the case of 2H and 4H stacks, where not all C[2:0] pins are used, the unused bits report zero.

Post Package Repair

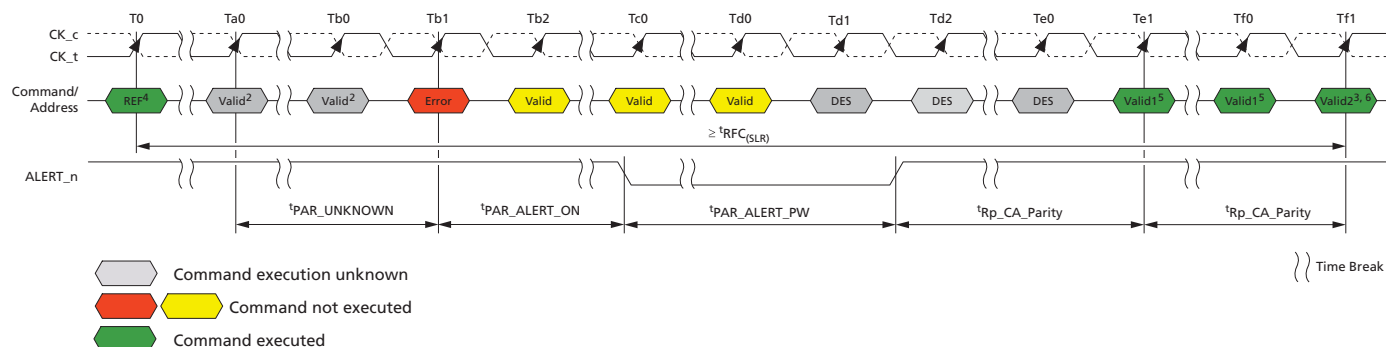
Post package repair (PPR) is supported on 3DS components and functions largely the same as on monolithic components. For 3DS devices, the host also provides the die (logical rank) address on the C[2:0] pins for the ACT command associated with the repair row address, and REFRESH is the only operation allowed by the host on any die while in PPR mode.

Command/Address Parity

Because command/address (CA) parity provides protection against errors on the command/address bus and the 3DS device has only one electrical interface, parity errors may impact operations on all die (logical ranks). Otherwise, with the exception of REFRESH operations discussed below, CA parity on the 3DS device functions largely the same as on the monolithic component.

After a REF command has been issued, a monolithic DDR4 component allows only DESELECT commands until t_{RFC} is satisfied, alleviating the device from having to validate commands for correct parity during this time. A 3DS device allows commands to be latched to one rank while another has a refresh in progress; as a result, the 3DS device has the following behaviors with respect to CA parity:

- A 3DS device continues to calculate CA parity even while refreshes are ongoing
- The CA parity error recovery process shouldn't interrupt refresh(es) that may be in progress
- The CA parity error recovery process returns to a precharge-all state except for any rank(s) already refreshing
- MRS commands must wait until $t_{RFC(SLR)}$ is complete for all refreshes in progress (this is also true for accessing MPR mode)


Figure 4: CA Parity Error During Refresh


- Notes:
1. DRAM is emptying queues. Precharge all and parity checking are off until parity error status bit is cleared.
 2. Command execution is unknown; the corresponding DRAM internal state change may or may not occur. The DRAM controller should consider both cases and make sure that the command sequence meets the specifications.
 3. Normal operation with parity latency (CA parity persistent error mode disabled). Parity checking is off until parity error status bit is cleared.
 4. When a REF command is issued in $t_{PAR_UNKNOWN}$ range, REF may not be executed; the host should wait $t_{RFC(SLR)}$ to issue valid commands to the same logical rank.
 5. Valid commands to the rank with no on-going REF commands are available.
 6. Valid commands to the rank with on-going REF commands, including MRS, are available.

Calibration

All configurations of the 3DS device use only a single ZQ pin, which has the same functionality as that of a standard DDR4 SDRAM device. The 3DS device should be considered a single device from the standpoint of calibration. ZQCL commands are required during the normal initialization and/or reset sequences. ZQCS commands are also required for the 3DS device. When a ZQ command is issued, all ranks must be idle (all banks precharged with only NOP/DES commands) until the calibration sequence is complete. All DDR4 SDRAM core ZQ timing parameters and conditions apply simultaneously to all die within the 3DS stack; after a ZQ command has been issued, the appropriate timing must be met before issuing another ZQ command, regardless of the status of the C[2:0] pins.



ACTIVE Operation

Restrictions for ACT commands to banks of the same logical rank (SLR) follow the standard DDR4 SDRAM specification, that is, t_{RRD} and t_{FAW} apply to 3DS devices as $t_{RRD(SLR)}$ and $t_{FAW(SLR)}$. ACT commands to different logical ranks (DLR) must be separated by $t_{RRD(DLR)}$ as shown in the figure and table below. The rate at which groups of four ACT commands can be issued to different die is given by $t_{FAW(DLR)}$, which is always 16 clocks for every speed, configuration and density.

Figure 5: t_{RRD} and t_{FAW} Timing Example

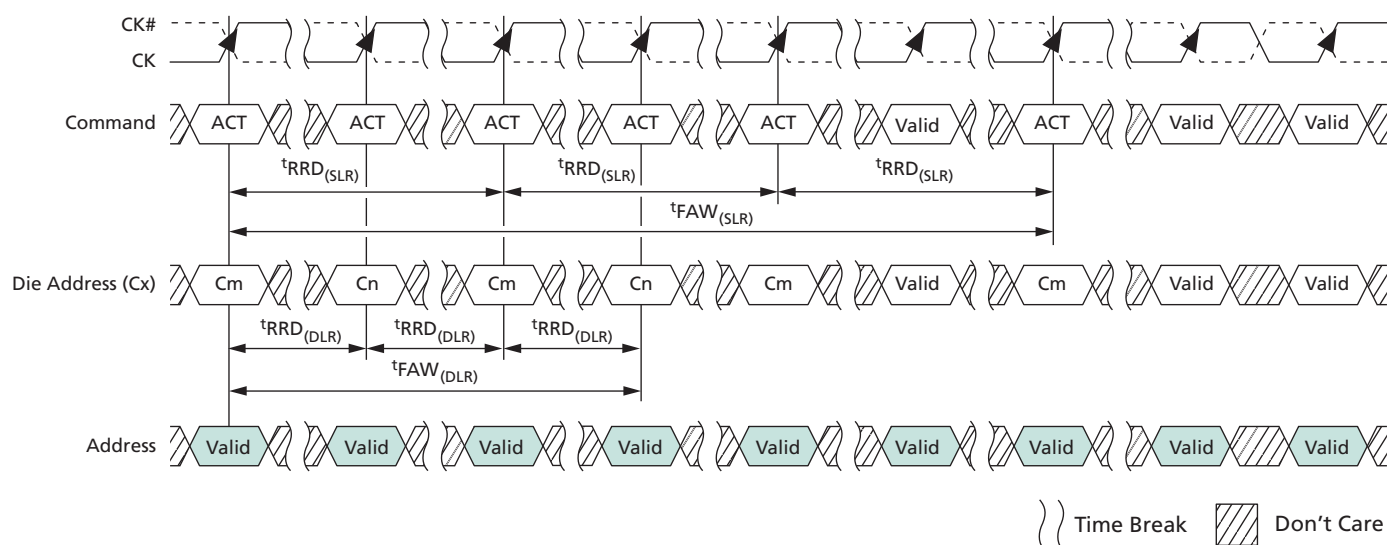


Table 10: 3DS Device t_{RRD} and t_{FAW} Timing at 1600/1866/2133/2400

Symbol	Description		DDR4-1600	DDR4-1866	DDR4-2133	DDR4-2400	Units
$t_{RRD(SLR)}$	Active-to-Active (same logical rank)	Short	MAX (4nCK, 5ns)	MAX (4nCK, 4.2ns)	MAX (4nCK, 3.7ns)	MAX (4nCK, 3.3ns)	CK/ns
		Long	MAX (4nCK, 6ns)	MAX (4nCK, 5.3ns)	MAX (4nCK, 5.3ns)	MAX (4nCK, 4.9ns)	CK/ns
$t_{RRD(DLR)}$	Active-to-Active (different logical ranks)		4	4	4	4	CK
$t_{FAW(SLR)}$	Four active windows (same logical rank)	x4	MAX (16nCK, 20ns)	MAX (16nCK, 17ns)	MAX (16nCK, 15ns)	MAX (16nCK, 13ns)	CK/ns
		x8	MAX (20nCK, 25ns)	MAX (20nCK, 23ns)	MAX (20nCK, 21ns)	MAX (20nCK, 21ns)	CK/ns
$t_{FAW(DLR)}$	Four active windows (different logical ranks)		16	16	16	16	CK
t_{XS}	Exit Self-Refresh to commands not requiring a locked DLL		MAX (5nCK, $t_{RC(SLR)min} + 10ns$)	MAX (5nCK, $t_{RC(SLR)min} + 10ns$)	MAX (5nCK, $t_{RC(SLR)min} + 10ns$)	MAX (5nCK, $t_{RC(SLR)min} + 10ns$)	CK/ns



16Gb, 32Gb: x4, x8 3DS DDR4 SDRAM ACTIVE Operation

Table 11: 3DS Device t_{RRD} and t_{FAW} Timing at 2666/2933/3200

Symbol	Description		DDR4-2666	DDR4-2933	DDR4-3200	Units
$t_{RRD(SLR)}$	Active-to-Active (same logical rank)	Short	MAX (4nCK, 3.0ns)	MAX (4nCK, 2.7ns)	MAX (4nCK, 2.5ns)	CK/ns
		Long	MAX (4nCK, 4.9ns)	MAX (4nCK, 4.9ns)	MAX (4nCK, 4.9ns)	CK/ns
$t_{RRD(DLR)}$	Active-to-Active (different logical ranks)		4	4	4	CK
$t_{FAW(SLR)}$	Four active windows (same logical rank)	x4	MAX (16nCK, 12ns)	MAX (16nCK, 10.875ns)	MAX (16nCK, 10ns)	CK/ns
		x8	MAX (20nCK, 21ns)	MAX (20nCK, 21ns)	MAX (20nCK, 21ns)	CK/ns
$t_{FAW(DLR)}$	Four active windows (different logical ranks)		16	16	16	CK
t_{XS}	Exit Self-Refresh to commands not requiring a locked DLL		MAX (5nCK, $t_{RC(SLR)}min + 10ns$)	MAX (5nCK, $t_{RC(SLR)}min + 10ns$)	MAX (5nCK, $t_{RC(SLR)}min + 10ns$)	CK/ns



16Gb, 32Gb: x4, x8 3DS DDR4 SDRAM Column Access Operation (WRITE and READ) Timings

Column Access Operation (WRITE and READ) Timings

Column accesses, WRITE and READ bursts, on DDR4 3DS components are similar to those for monolithic components. The starting column, bank and die (logical rank) addresses are provided with the WRITE or READ command, and auto precharge is either enabled or disabled for that burst access.

Unlike conventional dual-die package (DDP) and quad-die package (QDP) devices, the 3DS device will allow concatenated column access data from either the same die (C_n) or from different die (C_m), as long as the appropriate t_{CCDx} specification is met. Whenever $t_{CCD} = 4$, the first data element from the new burst follows the last element of a completed burst. The new column access command should be issued t_{CCD} cycles after the first column access command. If BC4 is enabled, t_{CCD} must still be met (which will cause a gap in the data output).

The table below describes the column access timings for 2-high and 4-high 3DS devices.

Table 12: Minimum Column-to-Column Timing for 2-High and 4-High Stacks

Die (Logical Rank)	Bank Group	Symbol	Timing Parameter	DDR4-1600	DDR4-1866	DDR4-2133	DDR4-2400	DDR4-2666	Units
Same	Same	$t_{CCD_L(SLR)}$	READ-to-READ	MAX (4nCK, 6.25ns)	MAX (4nCK, 5.355ns)	MAX (4nCK, 5.355ns)	MAX (4nCK, 5ns)	MAX (4nCK, 5ns)	nCK
			WRITE-to-WRITE						
		$t_{RTW_L(SLR)}$	READ-to-WRITE	CL - CWL - RBL/2 + 1 × t_{CK} + t_{WPRE}					
		$t_{WTR_L(SLR)}$	WRITE-to-READ	CWL + WBL/2 + t_{WTR_L}					
	Different	$t_{CCD_S(SLR)}$	READ-to-READ	4	4	4	4	4	
			WRITE-to-WRITE						
		$t_{RTW_S(SLR)}$	READ-to-WRITE	CL - CWL - RBL/2 + 1 × t_{CK} + t_{WPRE}					
		$t_{WTR_S(SLR)}$	WRITE-to-READ	CWL + WBL/2 + t_{WTR_S}					
Different	Same or Different	$t_{CCD(DLR)}$	READ-to-READ	MAX (4nCK, 3.748ns)					
			WRITE-to-WRITE						
		$t_{RTW(DLR)}$	READ-to-WRITE	CL - CWL - RBL/2 + 1 × t_{CK} + t_{WPRE}					
		$t_{WTR(DLR)}$	WRITE-to-READ	CWL + WBL/2 + t_{WTR_S}					



READ Operation

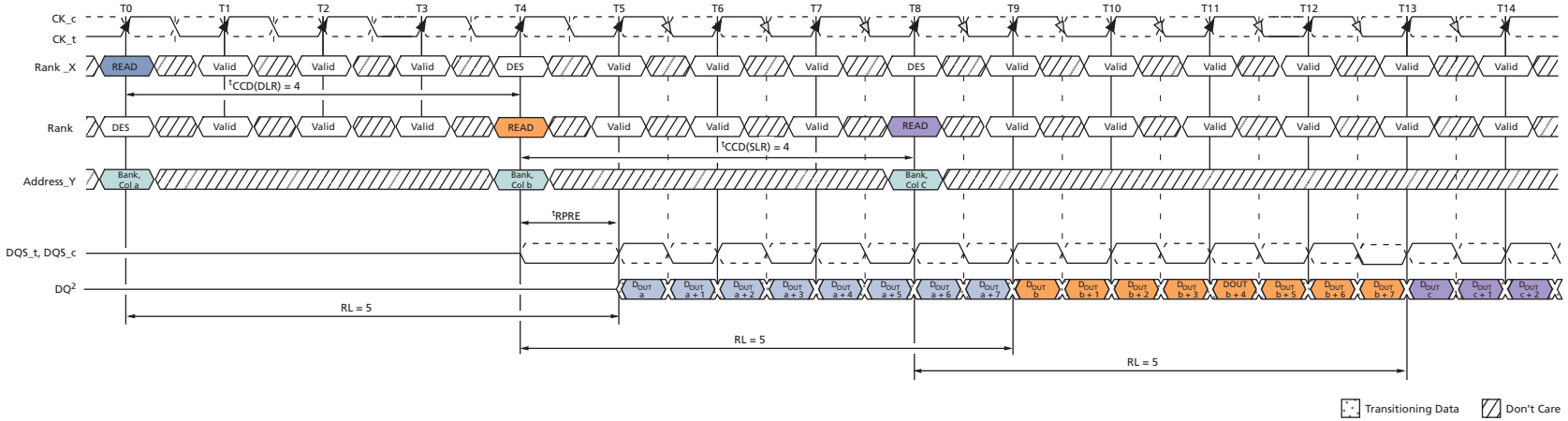
READ bursts are initiated with a READ command. The starting column, bank and die (logical rank) addresses are provided with the READ command, and auto precharge is either enabled or disabled for that burst access.

READ Operation Examples

READ operations on the 3DS device follow the standard DDR4 SDRAM requirements, but include the following specific conditions for back-to-back READ commands:

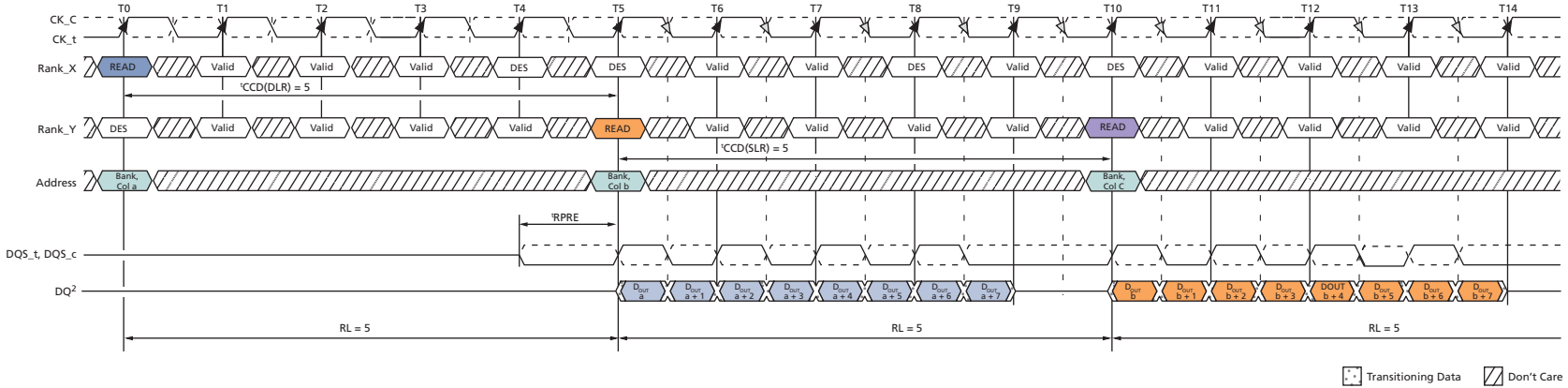
- $t_{CCD} = 4$ to the same logical rank (SLR) or different logical ranks (DLR) single t_{RPRE} , gapless data with continuous DQS_t , DQS_c toggle, see Figure 6 (page 18).
- $t_{CCD} = 5$ to the same logical rank (SLR) or different logical ranks (DLR); DQS_t , DQS_c is maintained between t_{RPST} and t_{RPRE} , see Figure 7 (page 18).
- $t_{CCD} \geq 6$ to the same logical rank (SLR) or different logical ranks (DLR); DQS_t , DQS_c is High-Z between t_{RPST} and t_{RPRE} , see Figure 8 (page 19).

Figure 6: READ BL8 to READ BL8 ($t_{CCD} = 4$) Example

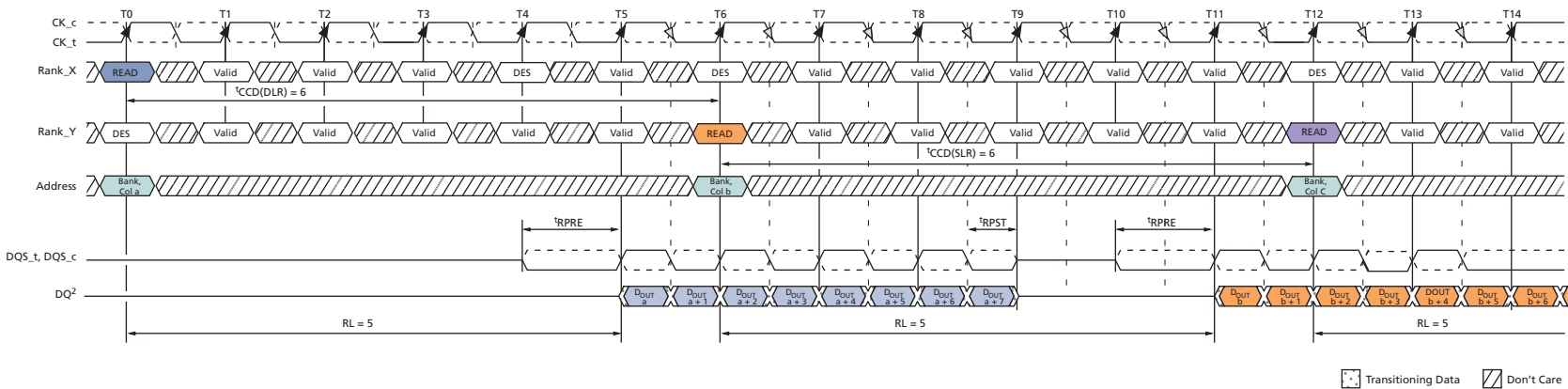


- Notes:
1. BL8, RL = 5 (CL = 5, AL = 0).
 2. D_{OUT} a, b, or c = data-out from column a, b, or c.

Figure 7: READ BL8 to READ BL8 ($t_{CCD} = 5$) Example



- Notes:
1. BL8, RL = 5 (CL = 5, AL = 0).
 2. D_{OUT} a, b, or c = data-out from column a, b, or c.

Figure 8: READ BL8 to READ BL8 ($t_{CCD} = 6$) Example


- Notes:
1. BL8, RL = 5 (CL = 5, AL = 0).
 2. D_{OUT} a, b, or c = data-out from column a, b, or c.



WRITE Operations

WRITE bursts are initiated with a WRITE command. The starting column, bank and die (logical rank) addresses are provided with the WRITE command, and auto precharge is either enabled or disabled for that access. If auto precharge is selected, the row being accessed will be precharged at the end of the WRITE burst. If auto precharge is not selected, the row will remain open for subsequent accesses. After a WRITE command has been issued, the WRITE burst may not be interrupted.

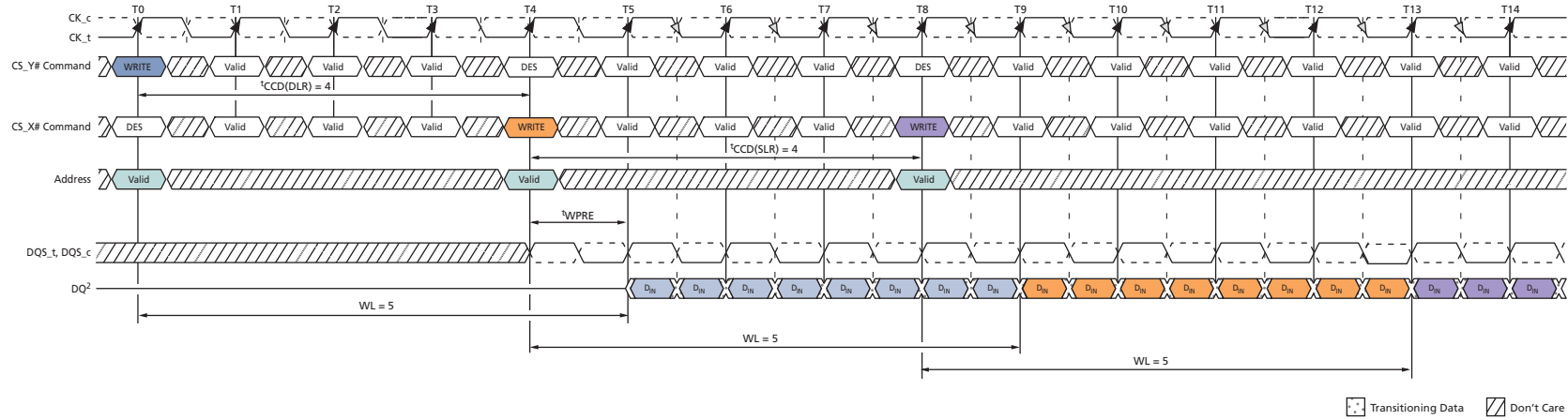
Data for any WRITE burst (if BL = 8) may be concatenated with a subsequent WRITE command to provide a continuous flow of input data. This applies to a sequence of WRITE commands to either $C_{(SLR)}$ or $C_{(DLR)}$. The new WRITE command can be issued t_{CCD} clocks following the previous WRITE command.

WRITE Operation Examples

WRITE operations for the 3DS device follow the standard DDR4 SDRAM requirements, but include the following specific conditions for back-to-back WRITE commands:

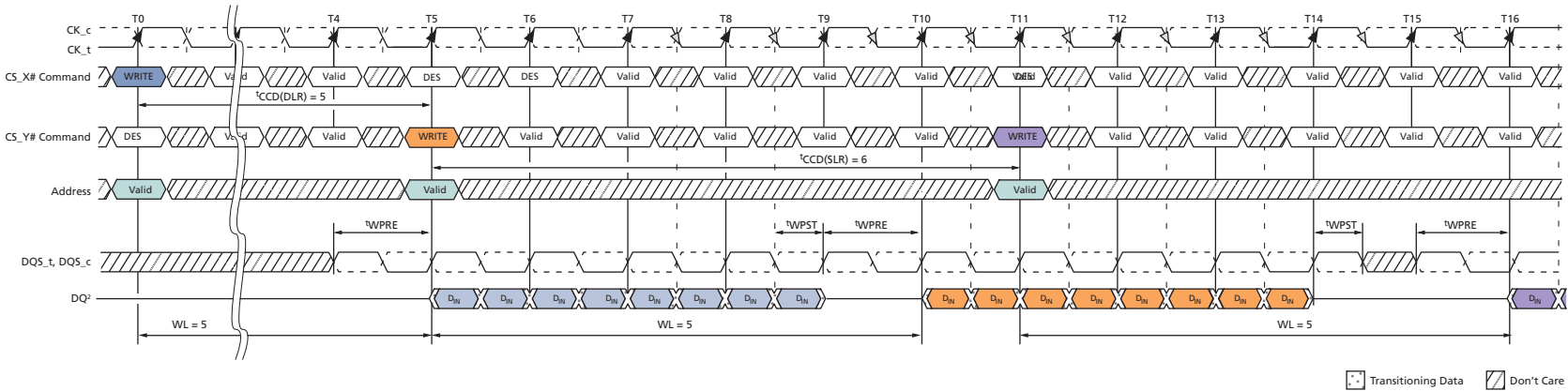
- $t_{CCD} = 4$ to the same logical rank (SLR) or different logical ranks (DLR). An example of a single t_{WPRE} , gapless data with continuous DQS_t, DQS_c toggle is shown in Figure 9 (page 21).
- $t_{CCD} > 4$ to the same logical rank (SLR) or different logical rank (DLR). An example of a standard t_{WPRE} and t_{WPST} with each associated WRITE burst is shown in Figure 10 (page 21).

Figure 9: WRITE BL8 to WRITE BL8 ($t_{CCD} = 4$) Example



- Notes: 1. BL8, WL = 5 (CWL = 5, AL = 0).
2. D_{IN} = data-in.

Figure 10: WRITE BL8 to WRITE BL8 ($t_{CCD} > 4$) Example



- Notes: 1. BL8, WL = 5 (CWL = 5, AL = 0).
2. D_{IN} = data-in.



PRECHARGE Commands

PRECHARGE and PRECHARGE ALL commands affect only the die (logical rank) selected by the state of the C[2:0] pins. All precharge timings for a given logical of the 3DS device are the same as those shown in the standard DDR4 SDRAM data sheet.

REFRESH Operation

REFRESH operation for each die (logical rank) of the 3DS device follows the standard for a DDR4 SDRAM device. Each logical rank, selected by the state of the C[2:0] pins, must receive REFRESH commands that meet the standard t_{REFI} interval and t_{RFC} recovery time. REFRESH operations on one rank may overlap the REFRESH operations on another rank, subject to $t_{RFC(DLR)}$. See Table 13.

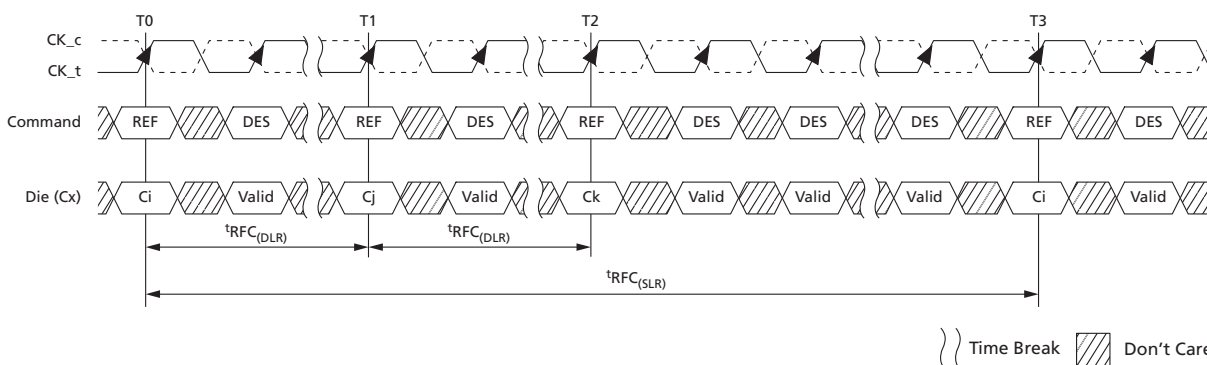
Table 13: Refresh Timing Parameters

Symbol	Description	8Gb per Rank	Units
$t_{RFC(SLR1)}$	Refresh-to-Refresh (same logical rank, 1X mode)	350	ns
$t_{RFC(SLR2)}$	Refresh-to-Refresh (same logical rank, 2X mode)	260	ns
$t_{RFC(SLR4)}$	Refresh-to-Refresh (same logical rank, 4X mode)	160	ns
$t_{RFC(DLR1)}$	Refresh-to-Refresh (different logical rank, 1X mode)	120	ns
$t_{RFC(DLR2)}$	Refresh-to-Refresh (different logical rank, 2X mode)	90	ns
$t_{RFC(DLR4)}$	Refresh-to-Refresh (different logical rank, 4X mode)	55	ns
$t_{REFI(SLR1)}$	Average time between REFRESH commands (same logical rank, 1X mode)	$0^{\circ}\text{C} \leq T_{\text{CASE}} \leq 85^{\circ}\text{C}$	7.8
		$85^{\circ}\text{C} \leq T_{\text{CASE}} \leq 95^{\circ}\text{C}$	3.9
$t_{REFI(SLR2)}$	Average time between REFRESH commands (same logical rank, 2X mode)	$0^{\circ}\text{C} \leq T_{\text{CASE}} \leq 85^{\circ}\text{C}$	3.9
		$85^{\circ}\text{C} \leq T_{\text{CASE}} \leq 95^{\circ}\text{C}$	1.95
$t_{REFI(SLR4)}$	Average time between REFRESH commands (same logical rank, 4X mode)	$0^{\circ}\text{C} \leq T_{\text{CASE}} \leq 85^{\circ}\text{C}$	1.95
		$85^{\circ}\text{C} \leq T_{\text{CASE}} \leq 95^{\circ}\text{C}$	0.975



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Figure 11: REFRESH-to-REFRESH Command Timing Example



SELF REFRESH Operation

Placing the 3DS device into self refresh mode requires that all ranks (C[1:0]=00, 01, 10...) have been provided PRECHARGE commands and t_{RP} has been satisfied. SELF REFRESH entry/exit operation and timing requirements follow the standards shown in the Micron DDR4 SDRAM specification.

Table 14: Allowable SELF REFRESH Commands

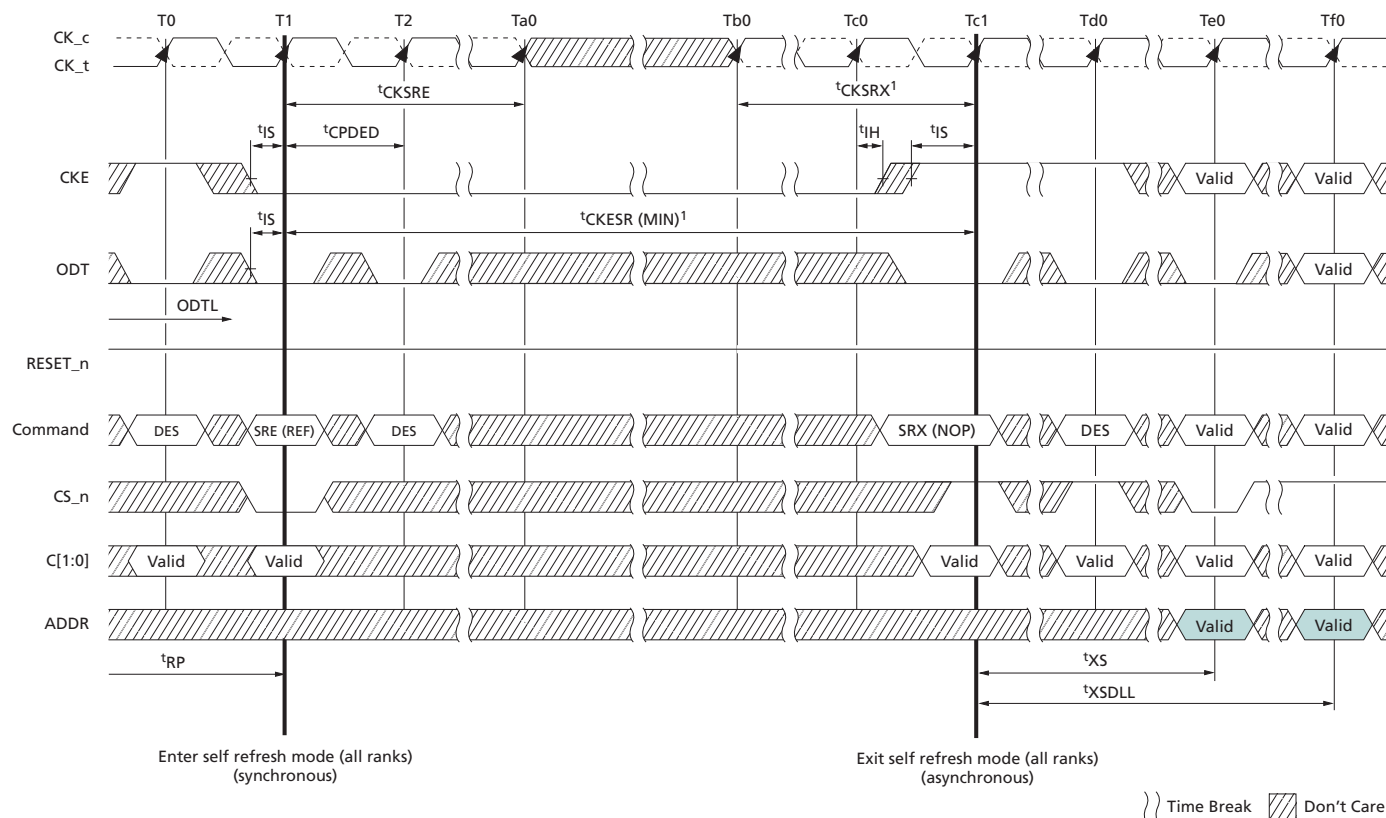
RAS	CAS	WE	CS_n	C[1:0]	Logical Rank 0	Logical Rank 1	Logical Rank 2	Logical Rank 3
L	L	H	L	VV	Performs SRE	Performs SRE	Performs SRE	Performs SRE
L	L	H	H	VV	Performs PDE	Performs PDE	Performs PDE	Performs PDE

- Notes:
1. H = High logic level, L = Low logic level, V = Either H or L (but a defined logic level).
 2. If CS_n is not active, the 3DS device ignores the SELF REFRESH command and instead enters the applicable power-down state.



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Figure 12: SELF REFRESH Command Timing Example



Note: 1. After t_{XS} has completed, a valid command can be issued to any logical rank ($C[1:0]=00,01,10\dots$).

Power-Down Operations

Because the 3DS device has a single CKE input, each rank must be in a valid state prior to toggling CKE LOW. Actual power-down operation follows the standard DDR4 SDRAM specification. Power-down is synchronously entered when CKE is registered LOW coincident with a NOP or DES command. CKE is not allowed to go LOW while an MRS, MPR, ZQCAL, READ, or WRITE operation is in progress to any rank. Each logical rank may be in precharge power-down or active power-down state(s).

On-Die Termination (ODT)

Due to a common external interface, the 3DS device only has a single on-die termination (ODT) ball at location L4. When the ODT feature is enabled via the appropriate MRS setting(s), the ODT input at location L4 is active for any logical rank $C[2:0]$ pin.



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DRAM Package Electrical Specifications

Table 15: DRAM Provisional Package Electrical Specifications for x4 and x8 3DS Devices

Parameter		Symbol	1600/1866/2133/ 2400/2666		2933		3200		Unit	Notes
			Min	Max	Min	Max	Min	Max		
Input/ output	Zpkg	Z_{IO}	45	85	48	85	48	85	ohm	1, 2, 4
	Package delay	Td_{IO}	14	42	14	40	14	40	ps	1, 3, 4
	Lpkg	L_{IO}	–	3.3	–	3.3	–	3.3	nH	
	Cpkg	C_{IO}	–	0.78	–	0.78	–	0.78	pF	
DQS_t, DQS_c	Zpkg	$Z_{IO\ DQS}$	45	85	48	85	48	85	ohm	1, 2
	Package delay	$Td_{IO\ DQS}$	14	42	14	40	14	40	ps	1, 3
	Delta Zpkg	$DZ_{IO\ DQS}$	–	10	–	10	–	10	ohm	1, 2, 5
	Delta delay	$DTd_{IO\ DQS}$	–	5	–	5	–	5	ps	1, 3, 5
	Lpkg	$L_{IO\ DQS}$	–	3.3	–	3.3	–	3.3	nH	
	Cpkg	$C_{IO\ DQS}$	–	0.78	–	0.78	–	0.78	pF	
Input CTRL pins	Zpkg	$Z_{I\ CTRL}$	40	80	40	80	40	80	ohm	1, 2, 6
	Package delay	$Td_{I\ CTRL}$	14	42	14	40	14	40	ps	1, 3, 6
	Lpkg	$L_{I\ CTRL}$	–	3.4	–	3.4	–	3.4	nH	
	Cpkg	$C_{I\ CTRL}$	–	0.7	–	0.7	–	0.7	pF	
Input CMD ADD pins	Zpkg	$Z_{I\ ADD\ CMD}$	40	80	40	80	40	80	ohm	1, 2, 7
	Package delay	$Td_{I\ ADD\ CMD}$	14	45	14	40	14	40	ps	1, 3, 7
	Lpkg	$L_{I\ ADD\ CMD}$	–	3.6	–	3.6	–	3.6	nH	
	Cpkg	$C_{I\ ADD\ CMD}$	–	0.74	–	0.74	–	0.74	pF	
CK_t, CK_c	Zpkg	Z_{CK}	40	80	40	80	40	80	ohm	1, 2
	Package delay	Td_{CK}	14	42	14	42	14	42	ps	1, 3
	Delta Zpkg	DZ_{DCK}	–	10	–	10	–	10	ohm	1, 2, 8
	Delta delay	DTd_{DCK}	–	5	–	5	–	5	ps	1, 3, 8
	Lpkg	$L_{I\ CLK}$	–	3.4	–	3.4	–	3.4	nH	
	Cpkg	$C_{I\ CLK}$	–	0.7	–	0.7	–	0.7	pF	
ZQ Zpkg		$Z_{O\ ZQ}$	–	100	–	100	–	100	ohm	1, 2
ZQ delay		$Td_{O\ ZQ}$	20	55	20	55	20	55	ps	1, 3
ALERT Zpkg		$Z_{O\ ALERT}$	40	100	40	100	40	100	ohm	1, 2
ALERT delay		$Td_{O\ ALERT}$	20	55	20	55	20	55	ps	1, 3

- Notes:
1. The package parasitic (L and C) are validated using package only samples. 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-only impedance (Zpkg) is calculated based on the Lpkg and Cpkg total for a given pin where: Zpkg (total per pin) = $\sqrt{Lpkg/Cpkg}$.
 3. Package-only delay (Tpkg) is calculated based on Lpkg and Cpkg total for a given pin where: Tdpkg (total per pin) = $\sqrt{Lpkg \times Cpkg}$.
 4. Z_{IO} and Td_{IO} apply to DQ, DM, DQS_c, DQS_t, TDQS_t, and TDQS_c.



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5. 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).
6. Z_{I_CTRL} and Td_{I_CTRL} apply to ODT, CS_n , CKE, and C0 if 2H, C0 and C1 if 4H, and C0, C1, and C2 if 8H.
7. $Z_{I_ADD_CMD}$ and $Td_{I_ADD_CMD}$ apply to $A[17:0]$, $BA[1:0]$, $BG[1:0]$, PAR, RAS_n CAS_n , and WE_n .
8. 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).
9. Package implementations will meet specification 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.
10. It is assumed that L_{pkg} can be approximated as $L_{pkg} = Z_O \times Td$.
11. It is assumed that C_{pkg} can be approximated as $C_{pkg} = Td/Z_O$.



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Table 16: Pad Input/Output Provisional Capacitance for x4 and x8 3DS Devices

Parameter	Symbol	DDR4-1600, 1866, 2133		DDR4-2400, 2666		DDR4-2933		DDR4-3200		Unit	Notes
		Min	Max	Min	Max	Min	Max	Min	Max		
Input/output capacitance: DQ, DM, DQS_t, DQS_c, TDQS_t, TDQS_c	C _{IO}	0.55	1.4	0.55	1.15	0.55	1.00	0.55	1.00	pF	1, 2, 3
Input capacitance: CK_t and CK_c	C _{CK}	0.2	0.8	0.2	0.7	0.2	0.7	0.2	0.7	pF	1, 2, 3, 4
Input capacitance delta: CK_t and CK_c	C _{DCK}	0	0.05	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	0	0.05	pF	1, 2, 3
Input capacitance: CTRL, ADD, CMD input-only pins	C _I	0.2	0.8	0.2	0.7	0.2	0.6	0.2	0.55	pF	1, 2, 3, 6
Input capacitance delta: All CTRL input-only pins	C _{DI_CTRL}	-0.1	0.1	-0.1	0.1	-0.1	0.1	-0.1	0.1	pF	1, 2, 3, 7
Input capacitance delta: All ADD/CMD input-only pins	C _{DI_ADD_CMD}	-0.1	0.1	-0.1	0.1	-0.1	0.1	-0.1	0.1	pF	1, 2, 3, 8, 9
Input/output capacitance delta: DQ, DM, DQS_t, DQS_c, TDQS_t, TDQS_c	C _{DIO}	-0.1	0.1	-0.1	0.1	-0.1	0.1	-0.1	0.1	pF	1, 2, 10, 11
Input/output capacitance: ALERT pin	C _{ALERT}	0.5	1.5	0.5	1.5	0.5	1.5	0.5	1.5	pF	1, 2, 2, 3
Input/output capacitance: ZQ pin	C _{ZQ}	–	2.3	–	2.3	–	2.3	–	2.3	pF	1, 2, 3, 12
Input/output capacitance: TEN pin	C _{TEN}	0.2	2.3	0.2	2.3	0.2	2.3	0.2	2.3	pF	1, 2, 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. The capacitance 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. Measured data is rounded using industry standard half-rounded up methodology to the nearest hundredth of the MSB.
 3. This parameter applies to monolithic die, obtained by de-embedding the package L and C parasitics.
 4. C_{DIO} = C_{IO}(DQ, DM) - 0.5 × (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, and C0 if 2H, C0 and C1 if 4H, and C0, C1, and C2 if 8H, A[17:0], BA[1:0], BG[1:0], PAR, RAS_n, CAS_n, and WE_n.
 8. C_{DI_CTRL} apply to ODT, CS_n, CKE, and C0 if 2H, C0 and C1 if 4H, and C0, C1, and C2 if 8H.
 9. C_{DI_CTRL} = C_I(CTRL) - 0.5 × (C_I(CLK_t) + C_I(CLK_c)).



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10. $C_{DL_ADD_CMD}$ applies to A[17:0], BA[1:0], BG[1:0], PAR, 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.



16Gb, 32Gb: x4, x8 3DS DDR4 SDRAM 3DS Speed Bin Tables

3DS Speed Bin Tables

Table 17: DDR4-1600 3DS Speed Bins and Operating Conditions

DDR4-1600 3DS Speed Bin				-125J		-125H		-125G		Unit
CL- <i>n</i> RCD- <i>n</i> RP				12-11-10		13-12-11		14-13-12		
Parameter			Symbol	Min	Max	Min	Max	Min	Max	
Internal READ command to first data			^t AA	15.0	21.50	16.25	21.50	17.50	21.50	ns
Internal READ command to first data with read DBI enabled			^t AA_DBI	^t AA (MIN) + 2 <i>n</i> CK	–	^t AA (MIN) + 2 <i>n</i> CK	–	–	^t AA (MAX) + 2 <i>n</i> CK	ns
ACTIVATE to internal READ or WRITE delay time			^t RCD	13.75	–	15.0	–	16.25	–	ns
PRECHARGE command period			^t RP	12.50	–	13.75	–	15.0	–	ns
ACTIVATE-to-PRECHARGE command period			^t RAS	35	9 × ^t REFI	35	9 × ^t REFI	35	9 × ^t REFI	ns
ACTIVATE-to-ACTIVATE or REFRESH command period			^t RC	47.5	–	48.75	–	50.0	–	ns
READ: non-DBI	READ: DBI	WRITE	Symbol	Min	Max	Min	Max	Min	Max	Unit
CL = 12	CL = 14	CWL = 9, 11	^t CK ⁴	1.25	1.9	Reserved		Reserved		ns
CL = 13	CL = 15	CWL = 9, 11	^t CK ⁴	1.25	1.9	1.25	1.9	Reserved		ns
CL = 14	CL = 16	CWL = 9, 11	^t CK ⁴	1.25	1.9	1.25	1.9	1.25	1.9	ns
Supported CL settings				12–14		13, 14		14		<i>n</i> CK
Supported CL settings with Read DBI				14–16		15, 16		16		<i>n</i> CK
Supported CWL settings				9, 11		9, 11		9, 11		<i>n</i> CK

- Notes:
1. Speed Bin table is only valid with DLL enabled and gear-down mode disabled.
 2. When operating in $2t_{CK}$ write preamble mode, CWL must be programmed to a value at least 1 clock greater than the lowest CWL setting supported in the applicable t_{CK} range.
 3. The programmed value of CWL must be less than or equal to programmed value of CL.
 4. $t_{CK}(AVG)$ MIN.



16Gb, 32Gb: x4, x8 3DS DDR4 SDRAM 3DS Speed Bin Tables

Table 18: DDR4-1866 3DS Speed Bins and Operating Conditions

DDR4-1866 3DS Speed Bin				-107J		-107H		-107G		Unit
CL- <i>n</i> RCD- <i>n</i> RP				14-13-12		15-14-13		16-15-14		
Parameter			Symbol	Min	Max	Min	Max	Min	Max	
Internal READ command to first data			^t AA	15.0	21.5	16.07	21.5	17.14	21.5	ns
Internal READ command to first data with read DBI enabled			^t AA_DBI	^t AA (MIN) + 2 <i>n</i> CK	–	^t AA (MIN) + 2 <i>n</i> CK	–	^t AA (MIN) + 2 <i>n</i> CK	–	ns
ACTIVATE to internal READ or WRITE delay time			^t RCD	13.92 ⁵	–	15.0	–	16.07	–	ns
PRECHARGE command period			^t RP	12.85	–	13.92 ⁵	–	15.0	–	ns
ACTIVATE-to-PRECHARGE command period			^t RAS	34	9 × ^t REFI	34	9 × ^t REFI	34	9 × ^t REFI	ns
ACTIVATE-to-ACTIVATE or REFRESH command period			^t RC	^t RAS + ^t RP	–	^t RAS + ^t RP	–	^t RAS + ^t RP	–	ns
READ: nonDBI	READ: DBI	WRITE	Symbol	Min	Max	Min	Max	Min	Max	Unit
CL = 12	CL = 14	CWL = 9, 11	^t CK ⁴	1.25	1.9	Reserved		Reserved		ns
CL = 13	CL = 15	CWL = 9, 11	^t CK ⁴	1.25	1.9	1.25	1.9	Reserved		ns
CL = 14	CL = 16	CWL = 9, 11	^t CK ⁴	1.25	1.9	1.25	1.9	1.25	1.9	ns
CL = 14	CL = 16	CWL = 10, 12	^t CK ⁴	1.071	<1.25	Reserved		Reserved		ns
CL = 15	CL = 17	CWL = 10, 12	^t CK ⁴	1.071	<1.25	1.071	<1.25	Reserved		ns
CL = 16	CL = 18	CWL = 10, 12	^t CK ⁴	1.071	<1.25	1.071	<1.25	1.071	<1.25	ns
Supported CL settings				12–16		13–16		14, 16		<i>n</i> CK
Supported CL settings with read DBI				14–18		15–18		16, 18		<i>n</i> CK
Supported CWL settings				9–12		9–12		9–12		<i>n</i> CK

- Notes:
1. Speed Bin table is only valid with DLL enabled and gear-down mode disabled.
 2. When operating in 2^tCK write preamble mode, CWL must be programmed to a value at least 1 clock greater than the lowest CWL setting supported in the applicable t_{CK} range.
 3. The programmed value of CWL must be less than or equal to programmed value of CL.
 4. $t_{CK}(AVG)$ MIN.
 5. 13.75ns is supported for 3DS-1600 compatibility.



16Gb, 32Gb: x4, x8 3DS DDR4 SDRAM 3DS Speed Bin Tables

Table 19: DDR4-2133 3DS Speed Bins and Operating Conditions

DDR4-2133 3DS Speed Bin				-093J		-093H		-093G		Unit
CL- <i>n</i> RCD- <i>n</i> RP				17-15-15		18-15-15		20-16-16		
Parameter			Symbol	Min	Max	Min	Max	Min	Max	
Internal READ command to first data			^t AA	15.95	21.5	16.88	21.5	18.76 ⁶	21.5	ns
Internal READ command to first data with read DBI enabled			^t AA_DBI	^t AA(MIN) + 3 <i>n</i> CK	–	^t AA(MIN) + 3 <i>n</i> CK	–	^t AA(MIN) + 3 <i>n</i> CK	–	ns
ACTIVATE to internal READ or WRITE delay time			^t RCD	14.06	–	14.06	–	15.0	–	ns
PRECHARGE command period			^t RP	14.06 ⁵	–	14.06	–	15.0	–	ns
ACTIVATE-to-PRECHARGE command period			^t RAS	33	9 × ^t REFI	33	9 × ^t REFI	33	9 × ^t REFI	ns
ACTIVATE-to-ACTIVATE or REFRESH command period			^t RC	47.06	–	47.06	–	48.0	–	ns
READ: nonDBI	READ: DBI	WRITE	Symbol	Min`	Max	Min	Max	Min	Max	Unit
CL = 13	CL = 16	CWL = 9 , 11	^t CK ⁴	1.25	1.9	Reserved		Reserved		ns
CL = 14	CL = 17	CWL = 9, 11	^t CK ⁴	1.25	1.9	1.25	1.9	1.25	1.9	ns
CL = 14	CL = 17	CWL = 10, 12	^t CK ⁴	Reserved		Reserved		Reserved		ns
CL = 15	CL = 18	CWL = 10, 12	^t CK ⁴	1.071	<1.25	Reserved		Reserved		ns
CL = 16	CL = 19	CWL = 10, 12	^t CK ⁴	1.071	<1.25	1.071	<1.25	1.071	<1.25	ns
CL = 16	CL = 19	CWL = 11, 14	^t CK ⁴	Reserved		Reserved		Reserved		ns
CL = 17	CL = 20	CWL = 11, 14	^t CK ⁴	0.937	<1.071	Reserved		Reserved		ns
CL = 18	CL = 21	CWL = 11, 14	^t CK ⁴	0.937	<1.071	0.937	<1.071	Reserved		ns
CL = 20	CL = 23	CWL = 11, 14	^t CK ⁴	0.937	<1.071	0.937	<1.071	0.937	<1.071	ns
Supported CL settings				13–18, 20		14, 16, 18		14, 16, 20		<i>n</i> CK
Supported CL settings with read DBI				16–21, 23		17, 19, 21		17, 19, 23		<i>n</i> CK
Supported CWL settings				9–12, 14		9–12, 14		9–12, 14		<i>n</i> CK

- Notes:
1. Speed Bin table is only valid with DLL enabled and gear-down mode disabled.
 2. When operating in $2t_{CK}$ write preamble mode, CWL must be programmed to a value at least 1 clock greater than the lowest CWL setting supported in the applicable t_{CK} range.
 3. The programmed value of CWL must be less than or equal to programmed value of CL.
 4. $t_{CK(AVG)}$ MIN.
 5. 13.75ns is supported for 3DS-1600 compatibility.
 6. 17.14ns is supported for 3DS-1866 compatibility.



16Gb, 32Gb: x4, x8 3DS DDR4 SDRAM 3DS Speed Bin Tables

Table 20: DDR4-2400 3DS Speed Bins and Operating Conditions

DDR4-2400 3DS Speed Bin				-083K		-083J		-083H		-083G		Unit
CL- <i>n</i> RCD- <i>n</i> RP				18-16-15		19-17-17		20-18-18		22-18-18		
Parameter			Sym	Min	Max	Min	Max	Min	Max	Min	Max	
Internal READ command to first data			^t AA	15.0	21.5	15.83	21.5	16.67	21.5	18.33 ⁵	21.5	ns
Internal READ command to first data with read DBI enabled			^t AA_DBI	^t AA(MI N) + 3 <i>n</i> CK	–	^t AA(MI N) + 3 <i>n</i> CK	–	^t AA(MI N) + 3 <i>n</i> CK	–	^t AA(MI N) + 3 <i>n</i> CK	–	ns
ACTIVATE to internal READ or WRITE delay time			^t RCD	13.33	–	14.16 ⁶	–	15.0	–	15.0	–	ns
PRECHARGE command period			^t RP	12.50	–	14.16 ⁶	–	15.0	–	15.0	–	ns
ACTIVATE-to-PRECHARGE command period			^t RAS	32	9 × ^t RE-FI	32	9 × ^t RE-FI	32	9 × ^t RE-FI	32	9 × ^t RE-FI	ns
ACTIVATE-to-ACTIVATE or REFRESH command period			^t RC	44.50	–	46.16	–	47.0	–	47.0	–	ns
READ: nonDBI	READ: DBI	WRITE	Sym	Min	Max	Min	Max	Min	Max	Min	Max	Unit
CL = 13	CL = 16	CWL = 9, 11	^t CK ⁴	1.25	1.9	1.25	1.9	Reserved		Reserved		ns
CL = 14	CL = 17	CWL = 9,11	^t CK ⁴	1.25	1.9	1.25	1.9	1.25	1.9	1.25	1.9	ns
CL = 14	CL = 17	CWL = 10, 12	^t CK ⁴	1.071	<1.25	Reserved		Reserved		Reserved		ns
CL = 15	CL = 18	CWL = 10, 12	^t CK ⁴	1.071	<1.25	1.071	<1.25	Reserved		Reserved		ns
CL = 16	CL = 19	CWL = 10, 12	^t CK ⁴	1.071	<1.25	1.071	<1.25	1.071	<1.25	1.071	<1.25	ns
CL = 17	CL = 20	CWL = 11, 14	^t CK ⁴	0.937	<1.071	0.937	<1.071	Reserved		Reserved		ns
CL = 18	CL = 21	CWL = 11, 14	^t CK ⁴	0.937	<1.071	0.937	<1.071	0.937	<1.071	Reserved		ns
CL = 20	CL = 23	CWL = 11, 14	^t CK ⁴	Reserved		Reserved		Reserved		0.937	<1.071	ns
CL = 18	CL = 21	CWL = 12, 16	^t CK ⁴	0.833	<0.937	Reserved		Reserved		Reserved		ns
CL = 19	CL = 22	CWL = 12, 16	^t CK ⁴	0.833	<0.937	0.833	<0.937	Reserved		Reserved		ns
CL = 20	CL = 23	CWL = 12, 16	^t CK ⁴	0.833	<0.937	0.833	<0.937	0.833	<0.937	Reserved		ns
CL = 22	CL = 25	CWL = 12, 16	^t CK ⁴	Reserved		Reserved		Reserved		0.833	<0.937	ns
Supported CL settings				13–20		13–20		14, 16, 18, 20		14, 16, 20, 22		<i>n</i> CK
Supported CL settings with Read DBI				16–19, 21, 23		16–23		17, 19, 21, 23		17, 19, 23, 25		<i>n</i> CK
Supported CWL settings				9–12, 14, 16		9–12, 14, 16		9–12, 14, 16		9–12, 14, 16		<i>n</i> CK

- Notes:
1. Speed Bin table is only valid with DLL enabled and gear-down mode disabled.
 2. When operating in 2^tCK WRITE preamble mode, CWL must be programmed to a value at least 1 clock greater than the lowest CWL setting supported in the applicable ^tCK range.
 3. The programmed value of CWL must be less than or equal to programmed value of CL.
 4. ^tCK(AVG) MIN.
 5. 17.14ns is supported for 3DS-1866 compatibility.
 6. 14.06ns is supported for 3DS-2133 18-15-15 compatibility.



16Gb, 32Gb: x4, x8 3DS DDR4 SDRAM 3DS Speed Bin Tables

Table 21: DDR4-2666 3DS Speed Bins and Operating Conditions

DDR4-2666 3DS Speed Bin				-075J		-075H		-075G		Unit
CL- <i>n</i> RCD- <i>n</i> RP				20-17-17		22-19-19		24-20-20		
Parameter			Symbol	Min	Max	Min	Max	Min	Max	
Internal READ command to first data			^t AA	15.0	21.5	16.5	21.5	18.0 ⁵	21.5	ns
Internal READ command to first data with read DBI enabled			^t AA_DBI	^t AA(MIN) + 3 <i>n</i> CK	–	^t AA(MIN) + 3 <i>n</i> CK	–	^t AA(MIN) + 3 <i>n</i> CK	–	ns
ACTIVATE to internal READ or WRITE delay time			^t RCD	12.75	–	14.25 ⁶	–	15.00	–	ns
PRECHARGE command period			^t RP	12.75	–	14.25 ⁶	–	15.00	–	ns
ACTIVATE-to-PRECHARGE command period			^t RAS	32	9 × ^t REFI	32	9 × ^t REFI	32	9 × ^t REFI	ns
ACTIVATE-to-ACTIVATE or REFRESH command period			^t RC	44.75	–	46.25	–	47.0	–	ns
READ: nonDBI	READ: DBI	WRITE	Symbol	Min`	Max	Min	Max	Min	Max	Unit
CL = 13	CL = 16	CWL = 9, 11	^t CK ⁴	1.25	1.9	Reserved		Reserved		ns
CL = 14	CL = 17	CWL = 9,11	^t CK ⁴	1.25	1.9	1.25	1.9	1.25	1.9	ns
CL = 14	CL = 17	CWL = 10, 12	^t CK ⁴	Reserved		Reserved		Reserved		ns
CL = 15	CL = 18	CWL = 10, 12	^t CK ⁴	1.071	<1.25	Reserved		Reserved		ns
CL = 16	CL = 19	CWL = 10, 12	^t CK ⁴	1.071	<1.25	1.071	<1.25	1.071	<1.25	ns
CL = 16	CL = 19	CWL = 11, 14	^t CK ⁴	Reserved		Reserved		Reserved		ns
CL = 18	CL = 21	CWL = 11, 14	^t CK ⁴	0.937	<1.071	0.937	<1.071	Reserved		ns
CL = 20	CL = 23	CWL = 11, 14	^t CK ⁴	0.937	<1.071	0.937	<1.071	0.937	<1.071	ns
CL = 18	CL = 21	CWL = 12, 16	^t CK ⁴	Reserved		Reserved		Reserved		ns
CL = 20	CL = 23	CWL = 12, 16	^t CK ⁴	0.833	<0.937	0.833	<0.937	Reserved		ns
CL = 22	CL = 25	CWL = 12, 16	^t CK ⁴	0.833	<0.937	0.833	<0.937	0.833	<0.937	ns
CL = 20	CL = 23	CWL = 14, 18	^t CK ⁴	0.75	<0.833	Reserved		Reserved		ns
CL = 22	CL = 25	CWL = 14, 18	^t CK ⁴	0.75	<0.833	0.75	<0.833	Reserved		ns
CL = 24	CL = 27	CWL = 14, 18	^t CK ⁴	0.75	<0.833	0.75	<0.833	0.75	<0.833	ns
Supported CL settings				13–16, 18, 20, 22, 24		14, 16, 18, 20, 22, 24		14, 16, 20, 22, 24		<i>n</i> CK
Supported CL settings with Read DBI				16–19, 21, 23, 25, 27		17, 19, 21, 23, 25, 27		17, 19, 23, 25, 27		<i>n</i> CK
Supported CWL settings				9, 10, 11, 12, 14, 16, 18		9, 10, 11, 12, 14, 16, 18		9, 10, 11, 12, 14, 16, 18		<i>n</i> CK

- Notes:
1. Speed Bin table is only valid with DLL enabled and gear-down mode disabled.
 2. When operating in $2t_{CK}$ WRITE preamble mode, CWL must be programmed to a value at least 1 clock greater than the lowest CWL setting supported in the applicable t_{CK} range.
 3. The programmed value of CWL must be less than or equal to programmed value of CL.
 4. $t_{CK(AVG)}$ MIN.
 5. 17.14ns is supported for 3DS-1866 compatibility.



16Gb, 32Gb: x4, x8 3DS DDR4 SDRAM 3DS Speed Bin Tables

6. 14.06ns is supported for 3DS-2133 18-15-15 compatibility and 3DS-2400 19-17-17 compatibility.


**16Gb, 32Gb: x4, x8 3DS DDR4 SDRAM
3DS Speed Bin Tables**
Table 22: DDR4-2933 3DS Speed Bins and Operating Conditions

DDR4-2933 3DS Speed Bin				-068J		-068H		-068G		Unit
CL- <i>n</i> RCD- <i>n</i> RP				23-20-20		24-21-21		25-22-22		
Parameter		Symbol	Min	Max	Min	Max	Min	Max		
Internal READ command to first data		^t AA	15.69	21.5	16.37	21.5	17.05	21.5	ns	
Internal READ command to first data with read DBI enabled		^t AA_DBI	^t AA(MIN) + 3 <i>n</i> CK	–	^t AA(MIN) + 3 <i>n</i> CK	–	^t AA(MIN) + 3 <i>n</i> CK	–	ns	
ACTIVATE to internal READ or WRITE delay time		^t RCD	13.63	–	14.32 ⁵	–	15.0	–	ns	
PRECHARGE command period		^t RP	13.63	–	14.32 ⁵	–	15.0	–	ns	
ACTIVATE-to-PRECHARGE command period		^t RAS	32	9 × ^t REFI	32	9 × ^t REFI	32	9 × ^t REFI	ns	
ACTIVATE-to-ACTIVATE or REFRESH command period		^t RC	45.64	–	46.32	–	47.0	–	ns	
READ: nonDBI	READ: DBI	WRITE	Symbol	Min`	Max	Min	Max	Min	Max	Unit
CL = 13	CL = 16	CWL = 9, 11	^t CK ⁴	1.25	1.9	Reserved		Reserved		ns
CL = 14	CL = 17	CWL = 9,11	^t CK ⁴	1.25	1.9	1.25	1.9	1.25	1.9	ns
CL = 14	CL = 17	CWL = 10, 12	^t CK ⁴	Reserved		Reserved		Reserved		ns
CL = 15	CL = 18	CWL = 10, 12	^t CK ⁴	1.071	<1.25	Reserved		Reserved		ns
CL = 16	CL = 19	CWL = 10, 12	^t CK ⁴	1.071	<1.25	1.071	<1.25	1.071	<1.25	ns
CL = 16	CL = 19	CWL = 11, 14	^t CK ⁴	Reserved		Reserved		Reserved		ns
CL = 18	CL = 21	CWL = 11, 14	^t CK ⁴	0.937	<1.071	0.937	<1.071	Reserved		ns
CL = 20	CL = 23	CWL = 11, 14	^t CK ⁴	0.937	<1.071	0.937	<1.071	0.937	<1.071	ns
CL = 18	CL = 21	CWL = 12, 16	^t CK ⁴	Reserved		Reserved		Reserved		ns
CL = 20	CL = 23	CWL = 12, 16	^t CK ⁴	0.833	<0.937	0.833	<0.937	Reserved		ns
CL = 22	CL = 25	CWL = 12, 16	^t CK ⁴	0.833	<0.937	0.833	<0.937	0.833	<0.937	ns
CL = 20	CL = 23	CWL = 14, 18	^t CK ⁴	Reserved		Reserved		Reserved		ns
CL = 22	CL = 25	CWL = 14, 18	^t CK ⁴	0.75	<0.833	0.75	<0.833	Reserved		ns
CL = 24	CL = 27	CWL = 14, 18	^t CK ⁴	0.75	<0.833	0.75	<0.833	0.75	<0.833	ns
CL = 22	CL = 26	CWL = 16, 20	^t CK ⁴	Reserved		Reserved		Reserved		ns
CL = 23	CL = 27	CWL = 16, 20	^t CK ⁴	0.682	<0.75	Reserved		Reserved		ns
CL = 24	CL = 28	CWL = 16, 20	^t CK ⁴	0.682	<0.75	0.682	<0.75	Reserved		ns
CL = 25	CL = 29	CWL = 16, 20	^t CK ⁴	0.682	<0.75	0.682	<0.75	0.682	<0.75	ns
Supported CL settings				13–16, 18, 20, 22–25		14, 16, 18, 20, 22, 24, 25		14, 16, 20, 22, 24, 25		<i>n</i> CK
Supported CL settings with Read DBI				16–19, 21, 23, 25–28		17, 19, 21, 23, 25, 27, 28		17, 19, 23, 25, 27, 28		<i>n</i> CK



16Gb, 32Gb: x4, x8 3DS DDR4 SDRAM 3DS Speed Bin Tables

Table 22: DDR4-2933 3DS Speed Bins and Operating Conditions (Continued)

DDR4-2933 3DS Speed Bin		-068J		-068H		-068G		Unit
CL- <i>n</i> RCD- <i>n</i> RP		23-20-20		24-21-21		25-22-22		
Parameter	Symbol	Min	Max	Min	Max	Min	Max	
Supported CWL settings		9, 10, 11, 12, 14, 16, 18, 20		9, 10, 11, 12, 14, 16, 18, 20		9, 10, 11, 12, 14, 16, 18, 20		<i>n</i> CK

- Notes:
1. Speed Bin table is only valid with DLL enabled and gear-down mode disabled.
 2. When operating in 2^tCK WRITE preamble mode, CWL must be programmed to a value at least 1 clock greater than the lowest CWL setting supported in the applicable ^tCK range.
 3. The programmed value of CWL must be less than or equal to programmed value of CL.
 4. ^tCK(AVG) MIN.
 5. 14.06ns is supported for 3DS-2133 18-15-15 compatibility, 3DS-2400 19-17-17 compatibility and 3DS-2666 22-19-19 compatibility.



16Gb, 32Gb: x4, x8 3DS DDR4 SDRAM 3DS Speed Bin Tables

Table 23: DDR4-3200 3DS Speed Bins and Operating Conditions

DDR4-3200 3DS Speed Bin				-062J		-062H		-062G		Unit
CL- <i>n</i> RCD- <i>n</i> RP				24-20-20		26-22-22		28-24-24		
Parameter			Symbol	Min	Max	Min	Max	Min	Max	
Internal READ command to first data			^t AA	15.0	21.5	16.25	21.5	17.5 ⁵	21.5	ns
Internal READ command to first data with read DBI enabled			^t AA_DBI	^t AA(MIN) + 3 <i>n</i> CK	–	^t AA(MIN) + 3 <i>n</i> CK	–	^t AA(MIN) + 3 <i>n</i> CK	–	ns
ACTIVATE to internal READ or WRITE delay time			^t RCD	12.5	–	13.75	–	15.0	–	ns
PRECHARGE command period			^t RP	12.5	–	13.75	–	15.0	–	ns
ACTIVATE-to-PRECHARGE command period			^t RAS	32	9 × ^t REFI	32	9 × ^t REFI	32	9 × ^t REFI	ns
ACTIVATE-to-ACTIVATE or REFRESH command period			^t RC	44.5	–	45.75	–	47.0	–	ns
READ: nonDBI	READ: DBI	WRITE	Symbol	Min`	Max	Min	Max	Min	Max	Unit
CL = 13	CL = 16	CWL = 9, 11	^t CK ⁴	1.25	1.9	Reserved		Reserved		ns
CL = 14	CL = 17	CWL = 9,11	^t CK ⁴	1.25	1.9	1.25	1.9	1.25	1.9	ns
CL = 14	CL = 17	CWL = 10, 12	^t CK ⁴	Reserved		Reserved		Reserved		ns
CL = 15	CL = 18	CWL = 10, 12	^t CK ⁴	1.071	<1.25	Reserved		Reserved		ns
CL = 16	CL = 19	CWL = 10, 12	^t CK ⁴	1.071	<1.25	1.071	<1.25	1.071	<1.25	ns
CL = 16	CL = 19	CWL = 11, 14	^t CK ⁴	Reserved		Reserved		Reserved		ns
CL = 18	CL = 21	CWL = 11, 14	^t CK ⁴	0.937	<1.071	0.937	<1.071	Reserved		ns
CL = 20	CL = 23	CWL = 11, 14	^t CK ⁴	0.937	<1.071	0.937	<1.071	0.937	<1.071	ns
CL = 18	CL = 21	CWL = 12, 16	^t CK ⁴	Reserved		Reserved		Reserved		ns
CL = 20	CL = 23	CWL = 12, 16	^t CK ⁴	0.833	<0.937	0.833	<0.937	Reserved		ns
CL = 22	CL = 25	CWL = 12, 16	^t CK ⁴	0.833	<0.937	0.833	<0.937	0.833	<0.937	ns
CL = 20	CL = 23	CWL = 14, 18	^t CK ⁴	Reserved		Reserved		Reserved		ns
CL = 22	CL = 25	CWL = 14, 18	^t CK ⁴	0.75	<0.833	0.75	<0.833	Reserved		ns
CL = 24	CL = 28	CWL = 14, 18	^t CK ⁴	0.75	<0.833	0.75	<0.833	0.75	<0.833	ns
CL = 24	CL = 28	CWL = 16, 20	^t CK ⁴	0.625	<0.75	Reserved		Reserved		ns
CL = 26	CL = 30	CWL = 16, 20	^t CK ⁴	0.625	<0.75	0.625	<0.75	Reserved		ns
CL = 28	CL = 32	CWL = 16, 20	^t CK ⁴	0.625	<0.75	0.625	<0.75	0.625	<0.75	ns
Supported CL settings				13–16, 18, 20, 22, 24, 26, 28		14, 16, 18, 20, 22, 24, 26, 28		14, 16, 20, 22, 24, 28		<i>n</i> CK
Supported CL settings with Read DBI				16–19, 21, 23, 25, 27, 29, 31		17,19, 21, 23, 25, 27, 29, 31		17,19, 23, 25, 27, 31		<i>n</i> CK
Supported CWL settings				9, 10, 11, 12, 14, 16, 18, 20		9, 10, 11, 12, 14, 16, 18, 20		9, 10, 11, 12, 14, 16, 18, 20		<i>n</i> CK

Notes: 1. Speed Bin table is only valid with DLL enabled and gear-down mode disabled.



16Gb, 32Gb: x4, x8 3DS DDR4 SDRAM 3DS Speed Bin Tables

2. When operating in 2^{tCK} WRITE preamble mode, CWL must be programmed to a value at least 1 clock greater than the lowest CWL setting supported in the applicable tCK range.
3. The programmed value of CWL must be less than or equal to programmed value of CL.
4. $tCK(AVG)$ MIN.
5. 17.14ns is supported for 3DS-1866 compatibility.



Current Specifications – Measurement Conditions

I_{DD} , I_{PP} and I_{DDQ} Measurement Conditions

I_{DD} , I_{PP} and I_{DDQ} measurement conditions, such as test load and patterns, are defined in this section.

- I_{DD} currents (I_{DD0} , I_{DD1} , I_{DD2N} , I_{DD2NT} , I_{DD2P} , I_{DD2Q} , I_{DD3N} , I_{DD3P} , I_{DD4R} , I_{DD4W} , I_{DD5B} , I_{DD6N} , I_{DD6E} , I_{DD6R} , I_{DD7} and I_{DD8}) are measured as time-averaged currents with all V_{DD} balls of the DDR4 SDRAM under test grouped together. I_{PP} and I_{DDQ} currents are not included in I_{DD} currents.
- I_{PP} currents are I_{PPSB} for standby cases (I_{DD2N} , I_{DD2NT} , I_{DD2P} , I_{DD2Q} , I_{DD3N} , I_{DD3P} , I_{DD8}); I_{PP0} for active cases (I_{DD0} , I_{DD1} , I_{DD4R} , I_{DD4W}); I_{PP5B} and I_{PP6N} for self refresh cases (I_{DD6N} , I_{DD6E} , I_{DD6R}) and I_{PP7} . These have the same definitions as the I_{DD} currents referenced but are measured on the V_{PP} supply.
- I_{DDQ} currents (I_{DDQ2NT} and I_{DDQ4R}) are measured as time-averaged currents with V_{DDQ} balls of the DDR4 SDRAM under test grouped together. I_{DD} current is not included in I_{DDQ} currents.

Note: I_{DDQ} values cannot be directly used to calculate the I/O power of the DDR4 SDRAM. They can be used to support correlation of simulated I/O power to actual I/O power. In DRAM module application, I_{DDQ} cannot be measured separately because V_{DD} and V_{DDQ} are using a merged-power layer in the module PCB.

The following definitions apply for I_{DD} , I_{DDP} and I_{DDQ} measurements.

- “0” and “LOW” are defined as $V_{IN} \leq V_{IL(AC),max}$
- “1” and “HIGH” are defined as $V_{IN} \geq V_{IH(AC),min}$
- “Midlevel” is defined as inputs $V_{REF} = V_{DD}/2$
- Timings used for I_{DD} , I_{DDP} and I_{DDQ} measurement-loop patterns are provided in the Current Test Definition and Patterns section.
- Basic I_{DD} , I_{PP} and I_{DDQ} measurement conditions are described in the Current Test Definition and Patterns section.
- Detailed I_{DD} , I_{PP} and I_{DDQ} measurement-loop patterns are described in the Current Test Definition and Patterns section.
- Current measurements are done after properly initializing the DDR4 SDRAM. This includes, but is not limited to, setting:
 $R_{ON} = R_{ZQ}/7$ (34 ohm in MR1);
 $Q_{off} = 0B$ (output buffer enabled in MR1);
 $R_{TT(NOM)} = R_{ZQ}/6$ (40 ohm in MR1);
 $R_{TT(WR)} = R_{ZQ}/2$ (120 ohm in MR2);
 $R_{TT(Park)} = \text{disabled}$;
 TDQS Feature disabled in MR1; CRC disabled in MR2; CA parity feature disabled in MR3; Gear-down mode disabled in MR3; Read/Write DBI disabled in MR5; DM disabled in MR5
- Define $D = \{CS_n, RAS_n, CAS_n, WE_n\} = \{HIGH, LOW, LOW, LOW\}$; apply BG/BA changes when directed.
- Define $D_n = \{CS_n, RAS_n, CAS_n, WE_n\} = \{HIGH, HIGH, HIGH, HIGH\}$; apply invert of BG/BA changes when directed above.

Note: The measurement-loop patterns must be executed at least once before actual current measurements can be taken.



16Gb, 32Gb: x4, x8 3DS DDR4 SDRAM Current Specifications – Measurement Conditions

Figure 13: Measurement Setup and Test Load for I_{DDx} , I_{DDPx} and I_{DDQx}

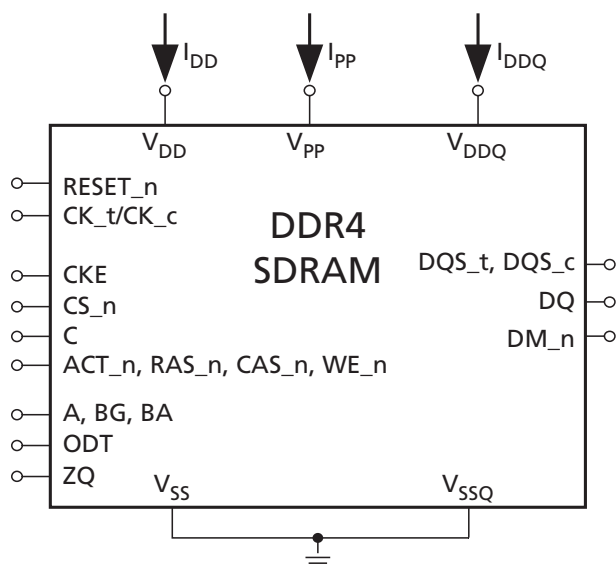
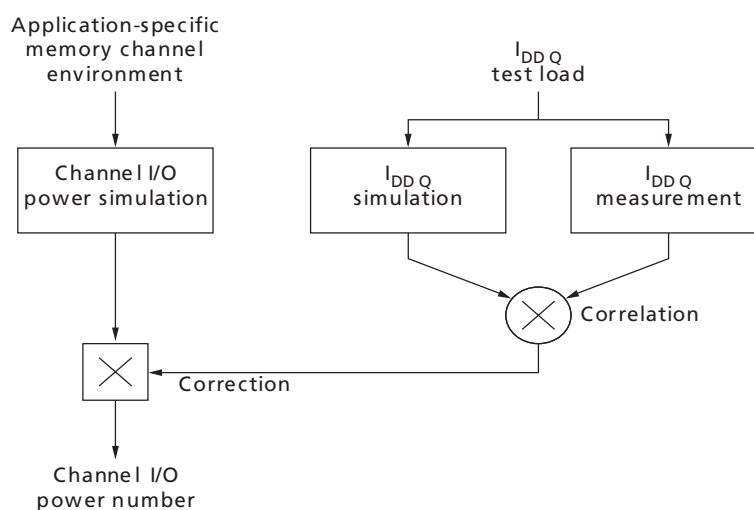


Figure 14: Correlation: Simulated Channel I/O Power to Actual Channel I/O Power



Note: 1. Supported by I_{DDQ} measurement.



16Gb, 32Gb: x4, x8 3DS DDR4 SDRAM Current Specifications – Measurement Conditions

I_{DD} Definitions

Table 24: Basic I_{DD}, I_{PP} and I_{DDQ} Measurement Conditions

Symbol	Description
I _{DD0}	Operating One Bank Active-Precharge Current (AL = 0) CKE: HIGH; External clock: On; ^t CK, nRC, nRAS, CL: see the previous table; BL: 8; ¹ AL: 0; CS_n: HIGH between ACT and PRE; Command, address, bank group address, bank address inputs: partially toggling according to the next table; Data I/O: V _{DDQ} ; DM_n: stable at 0; Bank activity: cycling with one bank active at a time: 0, 0, 1, 1, 2, 2, ... (see the I _{DD0} Measurement-Loop Pattern table); Logical Rank Activity: Cycling with one logical rank active at a time; Output buffer and R _{TT} : enabled in mode registers; ² ODT signal: stable at 0; Pattern details: see the I _{DD0} Measurement-Loop Pattern table
I _{PP0}	Operating One Bank Active-Precharge I_{PP} Current (AL = 0) Same conditions as I _{DD0} above
I _{DD1}	Operating One Bank Active-Read-Precharge Current (AL = 0) CKE: HIGH; External clock: on; ^t CK, nRC, nRAS, nRCD, CL: see the previous table; BL: 8; ¹⁵ AL: 0; CS_n: HIGH between ACT, RD and PRE; Command, address, bank group address, bank address inputs, Data I/O: partially toggling according to the I _{DD1} Measurement-Loop Pattern table; DM_n: stable at 0; Bank activity: cycling with one bank active at a time: 0, 0, 1, 1, 2, 2, ... (see the following table); Logical Rank Activity: Cycling with one logical rank active at a time; Output buffer and R _{TT} : enabled in mode registers; ² ODT Signal: stable at 0; Pattern details: see the I _{DD1} Measurement-Loop Pattern table
I _{DD2N}	Precharge Standby Current (AL = 0) CKE: HIGH; External clock: On; ^t CK, CL: see the previous table; BL: 8; ¹ AL: 0; CS_n: stable at 1; Command, address, bank group address, bank address inputs: partially toggling according to the I _{DD2N} and I _{DD3N} Measurement-Loop Pattern table; Data I/O: V _{DDQ} ; DM_n: stable at 1; Bank activity: all banks closed; Output buffer and R _{TT} : enabled in mode registers; ² ODT signal: stable at 0; Pattern details: see the I _{DD2N} and I _{DD3N} Measurement-Loop Pattern table
I _{DD2NT}	Precharge Standby ODT Current CKE: HIGH; External clock: on; ^t CK, CL: see the previous table; BL: 8; ¹ AL: 0; CS_n: stable at 1; Command, address, bank group address, bank address inputs: partially toggling according to the I _{DD2NT} and I _{DDQ2NT} Measurement-Loop Pattern table; Data I/O: V _{SSQ} ; DM_n: stable at 1; Bank activity: all banks closed; Output buffer and R _{TT} : enabled in mode registers; ² ODT signal: toggling according to the I _{DD2NT} and I _{DDQ2NT} Measurement-Loop Pattern table; Pattern details: see the I _{DD2NT} and I _{DDQ2NT} Measurement-Loop Pattern table
I _{DDQ2NT}	Precharge Standby ODT I_{DDQ} Current Has the same definition as I _{DD2NT} above, with the exception of measuring I _{DDQ} current instead of I _{DD} current
I _{DD2P}	Precharge Power-Down Current CKE: LOW; External clock: on; ^t CK, CL: see the previous table; BL: 8; ¹ AL: 0; CS_n: stable at 1; Command, address, bank group address, bank address inputs: stable at 0; Data I/O: V _{DDQ} ; DM_n: stable at 1; Bank activity: all banks closed; Output buffer and R _{TT} : enabled in mode registers; ² ODT signal: stable at 0
I _{DD2Q}	Precharge Quiet Standby Current CKE: HIGH; External clock: on; ^t CK, CL: see the previous table; BL: 8; ¹ AL: 0; CS_n: stable at 1; Command, address, bank group address, bank address inputs: stable at 0; Data I/O: V _{DDQ} ; DM_n: stable at 1; Bank activity: all banks closed; Output buffer and R _{TT} : enabled in mode registers; ² ODT signal: stable at 0
I _{DD3N}	Active Standby Current (AL = 0) CKE: HIGH; External clock: on; ^t CK, CL: see the previous table; BL: 8; ¹ AL: 0; CS_n: stable at 1; Command, address, bank group address, bank address inputs: partially toggling according to the I _{DD2N} and I _{DD3N} Measurement-Loop Pattern table; Data I/O: V _{DDQ} ; DM_n: stable at 1; Bank activity: all banks open; Output buffer and R _{TT} : enabled in mode registers; ² ODT signal: stable at 0; Pattern details: see the I _{DD2N} and I _{DD3N} Measurement-Loop Pattern table



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Table 24: Basic I_{DD} , I_{PP} and I_{DDQ} Measurement Conditions (Continued)

Symbol	Description
I_{PP5B}	Active Standby I_{PP5B} Current (AL = 0) Same conditions as I_{DD3N} above
I_{DD3P}	Active Power-Down Current (AL = 0) CKE: LOW; External clock: on; t_{CK} , CL: see the previous table; BL: 8; ¹ AL: 0; CS_n: stable at 1; Command, address, bank group address, bank address inputs: stable at 1; Data I/O: V_{DDQ} ; DM_n: stable at 1; Bank activity: all banks open; Output buffer and R_{TT} : enabled in mode registers; ² ODT signal: stable at 0
I_{DD4R}	Operating Burst Read Current (AL = 0) CKE: HIGH; External clock: on; t_{CK} , CL: see the previous table; BL: 8; ¹⁵ AL: 0; CS_n: HIGH between RD; Command, address, bank group address, bank address inputs: partially toggling according to the I_{DD4R} and I_{DDQ4R} Measurement-Loop Pattern table; Data I/O: seamless read data burst with different data between one burst and the next one according to the I_{DD4R} and I_{DDQ4R} Measurement-Loop Pattern table; DM_n: stable at 1; Bank activity: all banks open, RD commands cycling through banks: 0, 0, 1, 1, 2, 2, ... (see the I_{DD4R} and I_{DDQ4R} Measurement-Loop Pattern table); Output buffer and R_{TT} : enabled in mode registers; ² ODT signal: stable at 0; Pattern details: see the I_{DD4R} and I_{DDQ4R} Measurement-Loop Pattern table
I_{DDQ4R}	Operating Burst Read I_{DDQ} Current Has the same definition as I_{DD4R} , with the exception of measuring I_{DDQ} current instead of I_{DD} current
I_{DD4W}	Operating Burst Write Current (AL = 0) CKE: HIGH; External clock: on; t_{CK} , CL: see the previous table; BL: 8; ¹ AL: 0; CS_n: HIGH between WR; Command, address, bank group address, bank address inputs: partially toggling according to the I_{DD4W} Measurement-Loop Pattern table; Data I/O: seamless write data burst with different data between one burst and the next one according to the I_{DD4W} Measurement-Loop Pattern table; DM: stable at 1; Bank activity: all banks open, WR commands cycling through banks: 0, 0, 1, 1, 2, 2, ... (see I_{DD4W} Measurement-Loop Pattern table); Output buffer and R_{TT} : enabled in mode registers (see Note 2); ODT signal: stable at HIGH; Pattern details: see the I_{DD4W} Measurement-Loop Pattern table
I_{DD5B1}	Burst Refresh Current (1X REF) CKE: HIGH; External clock: on; t_{CK} , CL, nR_{FC} : see the previous table; BL: 8; ¹ AL: 0; CS_n: HIGH between REF; Command, address, bank group address, bank address inputs: partially toggling according to the I_{DD5B} Measurement-Loop Pattern table; Data I/O: V_{DDQ} ; DM_n: stable at 1; Bank activity: REF command every nR_{FC} (see the I_{DD5B} Measurement-Loop Pattern table); Logical Rank Activity: REF command staggered $nR_{FC(DLR)}$ between REF command to REF command (2H must meet $nR_{FC(SLR)}$); Output buffer and R_{TT} : enabled in mode registers; ² ODT signal: stable at 0; Pattern details: see the I_{DD5B} Measurement-Loop Pattern table
I_{PP5B1}	Burst Refresh Current (1X REF) Same conditions as I_{DD5B1} above
I_{DD5B2}	Burst Refresh Current (1X REF) CKE: HIGH; External clock: on; t_{CK} , CL, nR_{FC} : see the previous table; BL: 8; ¹ AL: 0; CS_n: HIGH between REF; Command, address, bank group address, bank address inputs: partially toggling according to the I_{DD5B} Measurement-Loop Pattern table; Data I/O: V_{DDQ} ; DM_n: stable at 1; Bank activity: REF command every nR_{FC} (see the I_{DD5B} Measurement-Loop Pattern table); Logical Rank Activity: REF command staggered $nR_{FC(SLR)}$ between REF command to REF command; Output buffer and R_{TT} : enabled in mode registers; ² ODT signal: stable at 0; Pattern details: see the I_{DD5B} Measurement-Loop Pattern table
I_{PP5B2}	Burst Refresh Current (1X REF) Same conditions as I_{DD5B2} above



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Table 24: Basic I_{DD} , I_{PP} and I_{DDQ} Measurement Conditions (Continued)

Symbol	Description
I_{DD6N}	Self Refresh Current: Normal Temperature Range T _C : 0–85°C; Auto self refresh (ASR): disabled; ³ Self refresh temperature range (SRT): normal; ⁴ CKE: LOW; External clock: off; CK _t and CK _c : LOW; CL: see the table above; BL: 8; ¹ AL: 0; CS _n , command, address, bank group address, bank address, data I/O: V _{DDQ} ; DM _n : stable at 1; Bank activity: SELF REFRESH operation; Output buffer and R _{TT} : enabled in mode registers; ² ODT signal: midlevel
I_{PP6N}	Self Refresh I_{PP} Current: Normal Temperature Range Same conditions as I_{DD6N} above
I_{DD6E}	Self Refresh Current: Extended Temperature Range ⁴ T _C : 0–95°C; Auto self refresh (ASR): disabled; ⁴ Self refresh temperature range (SRT): extended; ⁴ CKE: LOW; External clock: off; CK _t and CK _c : LOW; CL: see the previous table; BL: 8; ¹ AL: 0; CS _n , command, address, group bank address, bank address, data I/O: V _{DDQ} ; DM _n : stable at 1; Bank activity: EXTENDED TEMPERATURE SELF REFRESH operation; Output buffer and R _{TT} : enabled in mode registers; ² ODT signal: midlevel
I_{DD6R}	Self Refresh Current: Reduced Temperature Range T _C : 0–45°C; Auto self refresh (ASR): disabled; Self refresh temperature range (SRT): reduced; ⁴ CKE: LOW; External clock: off; CK _t and CK _c : LOW; CL: see the previous table; BL: 8; ¹ AL: 0; CS _n , command, address, bank group address, bank address, data I/O: V _{DDQ} ; DM _n : stable at 1; Bank activity: EXTENDED TEMPERATURE SELF REFRESH operation; Output buffer and R _{TT} : enabled in mode registers; ² ODT signal: midlevel
I_{DD7}	Operating Bank Interleave Read Current CKE: HIGH; External clock: on; ^t CK, nRC, nRAS, nRCD, nRRD, nFAW, CL: see the previous table; BL: 8; ¹⁵ AL: CL - 1; CS _n : HIGH between ACT and RDA; Command, address, group bank address, bank address inputs: partially toggling according to the I_{DD7} Measurement-Loop Pattern table; Data I/O: read data bursts with different data between one burst and the next one according to the I_{DD7} Measurement-Loop Pattern table; DM: stable at 0; Bank activity: two times interleaved cycling through banks (0, 1, ...7) with different addressing, see the I_{DD7} Measurement-Loop Pattern table; Output buffer and R _{TT} : enabled in mode registers; ² ODT signal: stable at 0; Pattern details: see the I_{DD7} Measurement-Loop Pattern table
I_{PP7}	Operating Bank Interleave Read I_{PP} Current Same conditions as I_{DD7} above
I_{DD8}	Maximum Power Down Current Place DRAM in MPSM then CKE: HIGH; External clock: on; ^t CK, CL: see the previous table; BL: 8; ¹ AL: 0; CS _n : stable at 1; Command, address, bank group address, bank address inputs: stable at 0; Data I/O: V _{DDQ} ; DM _n : stable at 1; Bank activity: all banks closed; Output buffer and R _{TT} : enabled in mode registers; ² ODT signal: stable at 0

- Notes:
1. Burst length: BL8 fixed by MRS: set MR0 [1:0] 00.
 2. Output buffer enable: set MR1 [12] 0 (output buffer enabled); set MR1 [2:1] 00 (R_{ON} = RZQ/7); R_{TT(NOM)} enable: set MR1 [10:8] = 011 (RZQ/6); R_{TT(WR)} enable: set MR2 [11:9] 001 (RZQ/2) and R_{TT(Park)} enable: set MR5 [8:6] 000 (disabled).
 3. Auto self refresh (ASR): set MR2 [6] 0 to disable or MR2 [6] 1 to enable feature.
 4. Self refresh temperature range (SRT): set MR2 [7] 0 for normal or MR2 [7] 1 for extended temperature range.
 5. READ burst type: Nibble sequential, set MR0 [3] 0.



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Current Specifications – Patterns and Test Conditions

Current Test Definitions and Patterns

Table 25: I_{DD0} and I_{pp0} Measurement-Loop Pattern¹

CK_t, CK_c	CKE	Sub-Loop	Logical Rank Loop	Cycle Number	Command	CS_n	ACT_n	RAS_n/A16	CAS_n/A15	WE_n/A14	ODT	C[2:0] ²	BG[1:0]	BA[1:0]	A12/BC_n	A[17,13,11]	A[10]/AP	A[9:7]	A[6:3]	A[2:0]	Data ³
Toggling	Static High	0	0	0	ACT	0	0	0	0	0	0	000	0	0	0	0	0	0	0	0	–
				1, 2	D, D	1	0	0	0	0	0	000	0	0	0	0	0	0	0	0	–
				3, 4	D_n, D_n	1	1	1	1	1	0	000	3	3	0	0	0	7	F	0	–
				...	Repeat pattern 1...4 until nRAS - 1; truncate if necessary																
				nRAS	PRE	0	1	0	1	0	0	000	0	0	0	0	0	0	0	–	
				...	Repeat pattern 1...4 until nRC - 1; truncate if necessary																
			1	1 × nRC	Repeat Logical Rank Loop 0, use C[2:0] = 001 instead ²																
			2	2 × nRC	Repeat Logical Rank Loop 0, use C[2:0] = 010 instead ²																
			3	3 × nRC	Repeat Logical Rank Loop 0, use C[2:0] = 011 instead ²																
			4	4 × nRC	Repeat Logical Rank Loop 0, use C[2:0] = 100 instead ²																
			5	5 × nRC	Repeat Logical Rank Loop 0, use C[2:0] = 101 instead ²																
			6	6 × nRC	Repeat Logical Rank Loop 0, use C[2:0] = 110 instead ²																
			7	7 × nRC	Repeat Logical Rank Loop 0, use C[2:0] = 111 instead ²																
		1		8 × nRC	Repeat sub-loop 0, use BG[1:0] = 1, use BA[1:0] = 1 instead																
		2		16 × nRC	Repeat sub-loop 0, use BG[1:0] = 0, use BA[1:0] = 2 instead																
		3		24 × nRC	Repeat sub-loop 0, use BG[1:0] = 1, use BA[1:0] = 3 instead																
		4		32 × nRC	Repeat sub-loop 0, use BG[1:0] = 0, use BA[1:0] = 1 instead																
		5		40 × nRC	Repeat sub-loop 0, use BG[1:0] = 1, use BA[1:0] = 2 instead																
		6		48 × nRC	Repeat sub-loop 0, use BG[1:0] = 0, use BA[1:0] = 3 instead																
		7		56 × nRC	Repeat sub-loop 0, use BG[1:0] = 1, use BA[1:0] = 0 instead																
		8		64 × nRC	Repeat sub-loop 0, use BG[1:0] = 2, use BA[1:0] = 0 instead																
		9		72 × nRC	Repeat sub-loop 0, use BG[1:0] = 3, use BA[1:0] = 1 instead																
		10		80 × nRC	Repeat sub-loop 0, use BG[1:0] = 2, use BA[1:0] = 2 instead																
		11		88 × nRC	Repeat sub-loop 0, use BG[1:0] = 3, use BA[1:0] = 3 instead																
		12		96 × nRC	Repeat sub-loop 0, use BG[1:0] = 2, use BA[1:0] = 1 instead																
		13		104 × nRC	Repeat sub-loop 0, use BG[1:0] = 3, use BA[1:0] = 2 instead																
		14		112 × nRC	Repeat sub-loop 0, use BG[1:0] = 2, use BA[1:0] = 3 instead																
		15		120 × nRC	Repeat sub-loop 0, use BG[1:0] = 3, use BA[1:0] = 0 instead																

Notes: 1. DQS_t, DQS_c are V_{DDQ}.



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2. C2 is a "Don't Care" for 2-high and 4-high devices; C1 is a "Don't Care" for 2-high devices.
3. DQ signals are V_{DDQ} .

Table 26: I_{DD1} Measurement-Loop Pattern¹

CK_c, CK_t,	CKE	Sub-Loop	Logical Rank Loop	Cycle Number	Command	CS_n	ACT_n	RAS_n/A16	CAS_n/A15	WE_n/A14	ODT	C[2:0] ²	BG[1:0]	BA[1:0]	A12/BC_n	A[17,13,11]	A[10]/AP	A[9:7]	A[6:3]	A[2:0]	Data ³		
Toggling	Static High	0	0	0	ACT	0	0	0	0	0	0	000	0	0	0	0	0	0	0	0	0	–	
				1, 2	D, D	1	0	0	0	0	0	000	0	0	0	0	0	0	0	0	0	0	–
				3, 4	D_n, D_n	1	1	1	1	1	0	000	3	3	0	0	0	7	F	0	0	0	–
				...	Repeat pattern 1...4 until $nRCD - AL - 1$; truncate if necessary																		
				$nRCD - AL$	RD	0	1	1	0	1	0	000	0	0	0	0	0	0	0	0	0	D0 = 00, D1 = FF, D2 = FF, D3 = 00, D4 = FF, D5 = 00, D5 = 00, D7 = FF	
				...	Repeat pattern 1...4 until $nRAS - 1$; truncate if necessary																		
				$nRAS$	PRE	0	1	0	1	0	0	000	0	0	0	0	0	0	0	0	0		
				...	Repeat pattern 1...4 until $nRC - 1$; truncate if necessary																		
			1	$1 \times nRC$	Repeat logical rank loop 0, use C[2:0] = 001 instead ²																		
			2	$2 \times nRC$	Repeat logical rank loop 0, use C[2:0] = 010 instead ²																		
			3	$3 \times nRC$	Repeat logical rank loop 0, use C[2:0] = 011 instead ²																		
			4	$4 \times nRC$	Repeat logical rank loop 0, use C[2:0] = 100 instead ²																		
			5	$5 \times nRC$	Repeat logical rank loop 0, use C[2:0] = 101 instead ²																		
			6	$6 \times nRC$	Repeat logical rank loop 0, use C[2:0] = 110 instead ²																		
			7	$7 \times nRC$	Repeat logical rank loop 0, use C[2:0] = 111 instead ²																		
		1	0	$8 \times nRC + 0$	ACT	0	0	0	1	1	0		1	1	0	0	0	0	0	0	0	0	–
				$8 \times nRC + 1, 2$	D, D	1	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	–
				$8 \times nRC + 3, 4$	D_n, D_n	1	1	1	1	1	0		3	3	0	0	0	7	F	0	0	0	–
				...	Repeat pattern $nRC + 1...4$ until $1 \times nRC + nRAS - 1$; truncate if necessary																		
				$8 \times nRC + nRCD - AL$	RD	0	1	1	0	1	0		1	1	0	0	0	0	0	0	0	D0 = FF, D1 = 00, D2 = 00, D3 = FF, D4 = 00, D5 = FF, D5 = FF, D7 = 00	
				...	Repeat pattern 1...4 until $nRAS - 1$; truncate if necessary																		
				$8 \times nRC + nRAS$	PRE	0	1	0	1	0	0		1	1	0	0	0	0	0	0	0		
				...	Repeat pattern $nRC + 1...4$ until $2 \times nRC - 1$; truncate if necessary																		



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Table 26: I_{DD1} Measurement-Loop Pattern¹ (Continued)

CK_c, CK_t,	CKE	Sub-Loop	Logical Rank Loop	Cycle Number	Command	CS_n	ACT_n	RAS_n/A16	CAS_n/A15	WE_n/A14	ODT	C[2:0] ²	BG[1:0]	BA[1:0]	A12/BC_n	A[17,13,11]	A[10]/AP	A[9:7]	A[6:3]	A[2:0]	Data ³
Toggling	Static High	1	1	9 × nRC	Repeat logical rank loop 0, use C[2:0] = 001 instead ²																
			2	10 × nRC	Repeat logical rank loop 0, use C[2:0] = 010 instead ²																
			3	11 × nRC	Repeat logical rank loop 0, use C[2:0] = 011 instead ²																
			4	12 × nRC	Repeat logical rank loop 0, use C[2:0] = 100 instead ²																
			5	13 × nRC	Repeat logical rank loop 0, use C[2:0] = 101 instead ²																
			6	14 × nRC	Repeat logical rank loop 0, use C[2:0] = 110 instead ²																
			7	15 × nRC	Repeat logical rank loop 0, use C[2:0] = 111 instead ²																
		2		16 × nRC	Repeat sub-loop 0, use BG[1:0] = 0, use BA[1:0] = 2 instead																
				24 × nRC	Repeat sub-loop 0, use BG[1:0] = 1, use BA[1:0] = 3 instead																
				32 × nRC	Repeat sub-loop 0, use BG[1:0] = 0, use BA[1:0] = 1 instead																
				40 × nRC	Repeat sub-loop 0, use BG[1:0] = 1, use BA[1:0] = 2 instead																
				48 × nRC	Repeat sub-loop 0, use BG[1:0] = 0, use BA[1:0] = 3 instead																
				56 × nRC	Repeat sub-loop 0, use BG[1:0] = 1, use BA[1:0] = 0 instead																
				64 × nRC	Repeat sub-loop 0, use BG[1:0] = 2, use BA[1:0] = 0 instead																
				72 × nRC	Repeat sub-loop 0, use BG[1:0] = 3, use BA[1:0] = 1 instead																
				80 × nRC	Repeat sub-loop 0, use BG[1:0] = 2, use BA[1:0] = 2 instead																
				88 × nRC	Repeat sub-loop 0, use BG[1:0] = 3, use BA[1:0] = 3 instead																
				96 × nRC	Repeat sub-loop 0, use BG[1:0] = 2, use BA[1:0] = 1 instead																
				104 × nRC	Repeat sub-loop 0, use BG[1:0] = 3, use BA[1:0] = 2 instead																
				112 × nRC	Repeat sub-loop 0, use BG[1:0] = 2, use BA[1:0] = 3 instead																
				120 × nRC	Repeat sub-loop 0, use BG[1:0] = 3, use BA[1:0] = 0 instead																

- Notes:
1. DQS_t, DQS_c are V_{DDQ} when not toggling.
 2. C2 is a "Don't Care" for 2-high and 4-high devices; C1 is a "Don't Care" for 2-high devices.
 3. DQ signals are V_{DDQ} except when burst sequence drives each DQ signal by a READ command.



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Table 27: I_{DD2N}, I_{DD3N} and I_{pp3p} Measurement-Loop Pattern¹

CK_c, CK_t	CKE	Sub-Loop	Cycle Number	Command	CS_n	ACT_n	RAS_n/A16	CAS_n/A15	WE_n/A14	ODT	C[2:0] ²	BG[1:0]	BA[1:0]	A12/BC_n	A[17,13,11]	A[10]/AP	A[9:7]	A[6:3]	A[2:0]	Data ³
Toggling	Static High	0	0	D	1	0	0	0	0	0	000	0	0	0	0	0	0	0	0	–
			1	D	1	0	0	0	0	0	000	0	0	0	0	0	0	0	0	–
			2	D_n	1	1	1	1	1	0	000	3	3	0	0	0	7	F	0	–
			3	D_n	1	1	1	1	1	0	000	3	3	0	0	0	7	F	0	–
		1	4–7	Repeat sub-loop 0, use BG[1:0] = 1, use BA[1:0] = 1 instead																
		2	8–11	Repeat sub-loop 0, use BG[1:0] = 0, use BA[1:0] = 2 instead																
		3	12–15	Repeat sub-loop 0, use BG[1:0] = 1, use BA[1:0] = 3 instead																
		4	16–19	Repeat sub-loop 0, use BG[1:0] = 0, use BA[1:0] = 1 instead																
		5	20–23	Repeat sub-loop 0, use BG[1:0] = 1, use BA[1:0] = 2 instead																
		6	24–27	Repeat sub-loop 0, use BG[1:0] = 0, use BA[1:0] = 3 instead																
		7	28–31	Repeat sub-loop 0, use BG[1:0] = 1, use BA[1:0] = 0 instead																
		8	32–35	Repeat sub-loop 0, use BG[1:0] = 2, use BA[1:0] = 0 instead																
		9	36–39	Repeat sub-loop 0, use BG[1:0] = 3, use BA[1:0] = 1 instead																
		10	40–43	Repeat sub-loop 0, use BG[1:0] = 2, use BA[1:0] = 2 instead																
		11	44–47	Repeat sub-loop 0, use BG[1:0] = 3, use BA[1:0] = 3 instead																
		12	48–51	Repeat sub-loop 0, use BG[1:0] = 2, use BA[1:0] = 1 instead																
		13	52–55	Repeat sub-loop 0, use BG[1:0] = 3, use BA[1:0] = 2 instead																
		14	56–59	Repeat sub-loop 0, use BG[1:0] = 2, use BA[1:0] = 3 instead																
		15	60–63	Repeat sub-loop 0, use BG[1:0] = 3, use BA[1:0] = 0 instead																

- Notes:
1. DQS_t, DQS_c are V_{DDQ}.
 2. C2 is a "Don't Care" for 2-high and 4-high devices; C1 is a "Don't Care" for 2-high devices.
 3. DQ signals are V_{DDQ}.



16Gb, 32Gb: x4, x8 3DS DDR4 SDRAM Current Specifications – Patterns and Test Conditions

Table 28: I_{DD2NT} and I_{DDQ2NT} Measurement-Loop Pattern¹

CK_c, CK_t	CKE	Sub-Loop	Cycle Number	Command	CS_n	ACT_n	RAS_n/A16	CAS_n/A15	WE_n/A14	ODT	C[2:0] ²	BG[1:0]	BA[1:0]	A12/BC_n	A[17,13,11]	A[10]/AP	A[9:7]	A[6:3]	A[2:0]	Data ³
Toggling	Static High	0	0	D	1	0	0	0	0	0	000	0	0	0	0	0	0	0	0	–
			1	D	1	0	0	0	0	0	000	0	0	0	0	0	0	0	0	–
			2	D_n	1	1	1	1	1	0	000	3	3	0	0	0	7	F	0	–
			3	D_n	1	1	1	1	1	0	000	3	3	0	0	0	7	F	0	–
		1	4–7	Repeat sub-loop 0 with ODT = 1, use BG[1:0] = 1, use BA[1:0] = 1 instead																
		2	8–11	Repeat sub-loop 0 with ODT = 0, use BG[1:0] = 0, use BA[1:0] = 2 instead																
		3	12–15	Repeat sub-loop 0 with ODT = 1, use BG[1:0] = 1, use BA[1:0] = 3 instead																
		4	16–19	Repeat sub-loop 0 with ODT = 0, use BG[1:0] = 0, use BA[1:0] = 1 instead																
		5	20–23	Repeat sub-loop 0 with ODT = 1, use BG[1:0] = 1, use BA[1:0] = 2 instead																
		6	24–27	Repeat sub-loop 0 with ODT = 0, use BG[1:0] = 0, use BA[1:0] = 3 instead																
		7	28–31	Repeat sub-loop 0 with ODT = 1, use BG[1:0] = 1, use BA[1:0] = 0 instead																
		8	32–35	Repeat sub-loop 0 with ODT = 0, use BG[1:0] = 2, use BA[1:0] = 0 instead																
		9	36–39	Repeat sub-loop 0 with ODT = 1, use BG[1:0] = 3, use BA[1:0] = 1 instead																
		10	40–43	Repeat sub-loop 0 with ODT = 0, use BG[1:0] = 2, use BA[1:0] = 2 instead																
		11	44–47	Repeat sub-loop 0 with ODT = 1, use BG[1:0] = 3, use BA[1:0] = 3 instead																
		12	48–51	Repeat sub-loop 0 with ODT = 0, use BG[1:0] = 2, use BA[1:0] = 1 instead																
		13	52–55	Repeat sub-loop 0 with ODT = 1, use BG[1:0] = 3, use BA[1:0] = 2 instead																
		14	56–59	Repeat sub-loop 0 with ODT = 0, use BG[1:0] = 2, use BA[1:0] = 3 instead																
		15	60–63	Repeat sub-loop 0 with ODT = 1, use BG[1:0] = 3, use BA[1:0] = 0 instead																

- Notes:
1. DQS_t, DQS_c are V_{SSQ}.
 2. C2 is a "Don't Care" for 2-high and 4-high devices; C1 is a "Don't Care" for 2-high devices.
 3. DQ signals are V_{SSQ}.



16Gb, 32Gb: x4, x8 3DS DDR4 SDRAM Current Specifications – Patterns and Test Conditions

Table 29: I_{DD4R} and I_{DDQ4R} Measurement-Loop Pattern¹

CK_c, CK_t,	CKE	Sub-Loop	Logical Rank Loop	Cycle Number	Command	CS_n	ACT_n	RAS_n/A16	CAS_n/A15	WE_n/A14	ODT	C[2:0] ²	BG[1:0]	BA[1:0]	A12/BC_n	A[17,13,11]	A[10]/AP	A[9:7]	A[6:3]	A[2:0]	Data ³
Toggling	Static High	0	0	0	RD	0	1	1	0	1	0	000	0	0	0	0	0	0	0	0	D0 = 00, D1 = FF, D2 = FF, D3 = 00, D4 = FF, D5 = 00, D5 = 00, D7 = FF
				1	D	1	0	0	0	0	0	000	0	0	0	0	0	0	0	0	
				2, 3	D_n, D_n	1	1	1	1	1	0	000	3	3	0	0	0	7	F	0	
		1		4	RD	0	1	1	0	1	0	000	1	1	0	0	0	7	F	0	D0 = FF, D1 = 00 D2 = 00, D3 = FF D4 = 00, D5 = FF D5 = FF, D7 = 00
				5	D	1	0	0	0	0	0	000	0	0	0	0	0	0	0	0	
				6, 7	D_n, D_n	1	1	1	1	1	0	000	3	3	0	0	0	7	F	0	
		2		8–11	Repeat sub-loop 0, use BG[1:0] = 0, use BA[1:0] = 2 instead																
		3		12–15	Repeat sub-loop 1, use BG[1:0] = 1, use BA[1:0] = 3 instead																
		4		16–19	Repeat sub-loop 0, use BG[1:0] = 0, use BA[1:0] = 1 instead																
		5		20–23	Repeat sub-loop 1, use BG[1:0] = 1, use BA[1:0] = 2 instead																
		6		24–27	Repeat sub-loop 0, use BG[1:0] = 0, use BA[1:0] = 3 instead																
		7		28–31	Repeat sub-loop 1, use BG[1:0] = 1, use BA[1:0] = 0 instead																
		8		32–35	Repeat sub-loop 0, use BG[1:0] = 2, use BA[1:0] = 0 instead																
		9		36–39	Repeat sub-loop 1, use BG[1:0] = 3, use BA[1:0] = 1 instead																
		10		40–43	Repeat sub-loop 0, use BG[1:0] = 2, use BA[1:0] = 2 instead																
		11		44–47	Repeat sub-loop 1, use BG[1:0] = 3, use BA[1:0] = 3 instead																
		12		48–51	Repeat sub-loop 0, use BG[1:0] = 2, use BA[1:0] = 1 instead																
		13		52–55	Repeat sub-loop 1, use BG[1:0] = 3, use BA[1:0] = 2 instead																
		14		56–59	Repeat sub-loop 0, use BG[1:0] = 2, use BA[1:0] = 3 instead																
		15		60–63	Repeat sub-loop 1, use BG[1:0] = 3, use BA[1:0] = 0 instead																
Toggling	Static High	1		64–127	Repeat logical rank loop 0, use C[2:0] = 001 instead ²																
		2		128–191	Repeat logical rank loop 0, use C[2:0] = 010 instead ²																
		3		192–255	Repeat logical rank loop 0, use C[2:0] = 011 instead ²																
		4		256–319	Repeat logical rank loop 0, use C[2:0] = 100 instead ²																
		5		320–383	Repeat logical rank loop 0, use C[2:0] = 101 instead ²																
		6		384–447	Repeat logical rank loop 0, use C[2:0] = 110 instead ²																
		7		448–511	Repeat logical rank loop 0, use C[2:0] = 111 instead ²																

- Notes:
1. DQS_t, DQS_c are V_{DDQ} when not toggling.
 2. C2 is a "Don't Care" for 2-high and 4-high devices; C1 is a "Don't Care" for 2-high devices.
 3. Burst sequence driven on each DQ signal by a READ command. Outside burst operation, DQ signals are V_{DDQ}.



16Gb, 32Gb: x4, x8 3DS DDR4 SDRAM

Current Specifications – Patterns and Test Conditions

Table 30: I_{DD4W} Measurement-Loop Pattern¹

CK_c, CK_t,	CKE	Sub-Loop	Logical Rank Loop	Cycle Number	Command	CS_n	ACT_n	RAS_n/A16	CAS_n/A15	WE_n/A14	ODT	C[2:0] ²	BG[1:0]	BA[1:0]	A12/BC_n	A[17,13,11]	A[10]/AP	A[9:7]	A[6:3]	A[2:0]	Data ³
Toggling	Static High	0	0	0	WR	0	1	1	0	0	1	000	0	0	0	0	0	0	0	0	D0 = 00, D1 = FF, D2 = FF, D3 = 00, D4 = FF, D5 = 00, D5 = 00, D7 = FF
				1	D	1	0	0	0	0	1	000	0	0	0	0	0	0	0	0	
				2, 3	D_n, D_n	1	1	1	1	0	1	000	3	3	0	0	0	7	F	0	
		1		4	WR	0	1	1	0	0	1	000	1	1	0	0	0	7	F	0	D0 = FF, D1 = 00 D2 = 00, D3 = FF D4 = 00, D5 = FF D5 = FF, D7 = 00
				5	D	1	0	0	0	0	1	000	0	0	0	0	0	0	0	0	
				6, 7	D_n, D_n	1	1	1	1	0	1	000	3	3	0	0	0	7	F	0	
		2		8–11	Repeat sub-loop 0, use BG[1:0] = 0, use BA[1:0] = 2 instead																
		3		12–15	Repeat sub-loop 1, use BG[1:0] = 1, use BA[1:0] = 3 instead																
		4		16–19	Repeat sub-loop 0, use BG[1:0] = 0, use BA[1:0] = 1 instead																
		5		20–23	Repeat sub-loop 1, use BG[1:0] = 1, use BA[1:0] = 2 instead																
		6		24–27	Repeat sub-loop 0, use BG[1:0] = 0, use BA[1:0] = 3 instead																
		7		28–31	Repeat sub-loop 1, use BG[1:0] = 1, use BA[1:0] = 0 instead																
		8		32–35	Repeat sub-loop 0, use BG[1:0] = 2, use BA[1:0] = 0 instead																
		9		36–39	Repeat sub-loop 1, use BG[1:0] = 3, use BA[1:0] = 1 instead																
		10		40–43	Repeat sub-loop 0, use BG[1:0] = 2, use BA[1:0] = 2 instead																
		11		44–47	Repeat sub-loop 1, use BG[1:0] = 3, use BA[1:0] = 3 instead																
		12		48–51	Repeat sub-loop 0, use BG[1:0] = 2, use BA[1:0] = 1 instead																
		13		52–55	Repeat sub-loop 1, use BG[1:0] = 3, use BA[1:0] = 2 instead																
		14		56–59	Repeat sub-loop 0, use BG[1:0] = 2, use BA[1:0] = 3 instead																
		15		60–63	Repeat sub-loop 1, use BG[1:0] = 3, use BA[1:0] = 0 instead																
Toggling	Static High		1	64–127	Repeat logical rank loop 0, use C[2:0] = 001 instead																
			2	128–191	Repeat logical rank loop 0, use C[2:0] = 010 instead																
			3	192–255	Repeat logical rank loop 0, use C[2:0] = 011 instead																
			4	256–319	Repeat logical rank loop 0, use C[2:0] = 100 instead																
			5	320–383	Repeat logical rank loop 0, use C[2:0] = 101 instead																
			6	384–447	Repeat logical rank loop 0, use C[2:0] = 110 instead																
			7	448–511	Repeat logical rank loop 0, use C[2:0] = 111 instead																

- Notes:
1. DQS_t, DQS_c are V_{DDQ} when not toggling.
 2. C2 is a "Don't Care" for 2-high and 4-high devices. C1 is a "Don't Care" for 2-high devices.
 3. Burst sequence driven on each DQ signal by WRITE command. Outside burst operation, DQ signals are V_{DDQ}.



16Gb, 32Gb: x4, x8 3DS DDR4 SDRAM

Current Specifications – Patterns and Test Conditions

Table 31: I_{DD4Wc} Measurement-Loop Pattern¹

CK_c, CK_t	CKE	Sub-Loop	Cycle Number	Command	CS_n	ACT_n	RAS_n/A16	CAS_n/A15	WE_n/A14	ODT	C[2:0] ³	BG[1:0]	BA[1:0]	A12/BC_n	A[17,13,11]	A[10]/AP	A[9:7]	A[6:3]	A[2:0]	Data ⁴
Toggling	Static High	0	0	WR	0	1	1	0	0	0	000	0	0	0	0	0	0	0	0	D0 = 00, D1 = FF, D2 = FF, D3 = 00, D4 = FF, D5 = 00, D8 = CRC
			1, 2	D, D	1	0	0	0	0	0	000	0	0	0	0	0	0	0	0	
			3, 4	D_n, D_n	1	1	1	1	0	0	000	3	3	0	0	0	7	F	0	
		1	5	WR	0	1	1	0	0	0	000	1	1	0	0	0	7	F	0	D0 = FF, D1 = 00, D2 = 00, D3 = FF, D4 = 00, D5 = FF, D5 = FF, D7 = 00 D8 = CRC
			6, 7	D, D	1	0	0	0	0	0	000	0	0	0	0	0	0	0	0	
			8, 9	D_n, D_n	1	1	1	1	0	0	000	3	3	0	0	0	7	F	0	
		2	10–14	Repeat sub-loop 0, use BG[1:0] = 0, use BA[1:0] = 2 instead																
		3	15–19	Repeat sub-loop 1, use BG[1:0] = 1, use BA[1:0] = 3 instead																
		4	20–24	Repeat sub-loop 0, use BG[1:0] = 0, use BA[1:0] = 1 instead																
		5	25–29	Repeat sub-loop 1, use BG[1:0] = 1, use BA[1:0] = 2 instead																
		6	30–34	Repeat sub-loop 0, use BG[1:0] = 0, use BA[1:0] = 3 instead																
		7	35–39	Repeat sub-loop 1, use BG[1:0] = 1, use BA[1:0] = 0 instead																
		8	40–44	Repeat sub-loop 0, use BG[1:0] = 2, use BA[1:0] = 0 instead																
		9	45–49	Repeat sub-loop 1, use BG[1:0] = 3, use BA[1:0] = 1 instead																
		10	50–54	Repeat sub-loop 0, use BG[1:0] = 2, use BA[1:0] = 2 instead																
		11	55–59	Repeat sub-loop 1, use BG[1:0] = 3, use BA[1:0] = 3 instead																
		12	60–64	Repeat sub-loop 0, use BG[1:0] = 2, use BA[1:0] = 1 instead																
		13	65–69	Repeat sub-loop 1, use BG[1:0] = 3, use BA[1:0] = 2 instead																
		14	70–74	Repeat sub-loop 0, use BG[1:0] = 2, use BA[1:0] = 3 instead																
		15	75–79	Repeat sub-loop 1, use BG[1:0] = 3, use BA[1:0] = 0 instead																

- Notes:
1. Pattern provided for reference only.
 2. DQS_t, DQS_c are V_{DDQ} when not toggling.
 3. C2 is a "Don't Care" for 2-high and 4-high devices; C1 is a "Don't Care" for 2-high devices.
 4. Burst sequence driven on each DQ signal by WRITE command. Outside burst operation, DQ signals are V_{DDQ}.



16Gb, 32Gb: x4, x8 3DS DDR4 SDRAM

Current Specifications – Patterns and Test Conditions

Table 32: I_{DD5b1} Measurement-Loop Pattern¹

CK_c, CK_t,	CKE	Sub-Loop	Logical Rank Loop	Cycle Number	Command	CS_n	ACT_n	RAS_n/A16	CAS_n/A15	WE_n/A14	ODT	C[2:0] ²	BG[1:0]	BA[1:0]	A12/BC_n	A[17,13,11]	A[10]/AP	A[9:7]	A[6:3]	A[2:0]	Data ³
Toggling	Static High	0	0	0	REF	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	–
		1		1	D	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	–
				2	D	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	–
				3	D_n	0	1	1	1	1	0	0	3	3	0	0	0	7	F	0	–
				4	D_n	0	1	1	1	1	0	0	3	3	0	0	0	7	F	0	–
				5–8	Repeat pattern 1...4, use BG[1:0] = 1, use BA[1:0] = 1 instead																
				9–12	Repeat pattern 1...4, use BG[1:0] = 0, use BA[1:0] = 2 instead																
				13–16	Repeat pattern 1...4, use BG[1:0] = 1, use BA[1:0] = 3 instead																
				17–20	Repeat pattern 1...4, use BG[1:0] = 0, use BA[1:0] = 1 instead																
				21–24	Repeat pattern 1...4, use BG[1:0] = 1, use BA[1:0] = 2 instead																
				25–28	Repeat pattern 1...4, use BG[1:0] = 0, use BA[1:0] = 3 instead																
				29–32	Repeat pattern 1...4, use BG[1:0] = 1, use BA[1:0] = 0 instead																
				33–36	Repeat pattern 1...4, use BG[1:0] = 2, use BA[1:0] = 0 instead																
				37–40	Repeat pattern 1...4, use BG[1:0] = 3, use BA[1:0] = 1 instead																
				41–44	Repeat pattern 1...4, use BG[1:0] = 2, use BA[1:0] = 2 instead																
				45–48	Repeat pattern 1...4, use BG[1:0] = 3, use BA[1:0] = 3 instead																
				49–52	Repeat pattern 1...4, use BG[1:0] = 2, use BA[1:0] = 1 instead																
				53–56	Repeat pattern 1...4, use BG[1:0] = 3, use BA[1:0] = 2 instead																
				57–60	Repeat pattern 1...4, use BG[1:0] = 2, use BA[1:0] = 3 instead																
				61–64	Repeat pattern 1...4, use BG[1:0] = 3, use BA[1:0] = 0 instead																
		2		65...nRFC _(D LR) - 1 ⁴	Repeat sub-loop 1; truncate if necessary																
			1	nRFC _(DLR) ... 2 × nRF _(DLR) - 1 ⁴	Repeat logical rank loop 0, use C[2:0] = 001 instead ²																
			2	2 × nRFC _(DLR) ... 3 × nRF _(DLR) - 1 ⁴	Repeat logical rank loop 0, use C[2:0] = 010 instead ²																
			3	3 × nRFC _(DLR) ... 4 × nRF _(DLR) - 1 ⁴	Repeat logical rank loop 0, use C[2:0] = 011 instead ²																



16Gb, 32Gb: x4, x8 3DS DDR4 SDRAM

Current Specifications – Patterns and Test Conditions

Table 32: I_{DD5b1} Measurement-Loop Pattern¹ (Continued)

CK_c, CK_t,	CKE	Sub-Loop	Logical Rank Loop	Cycle Number	Command	CS_n	ACT_n	RAS_n/A16	CAS_n/A15	WE_n/A14	ODT	C[2:0] ²	BG[1:0]	BA[1:0]	A12/BC_n	A[17,13,11]	A[10]/AP	A[9:7]	A[6:3]	A[2:0]	Data ³
Toggling	Static High		4	4 × $nRFC_{(DLR)}$... 5 × $nRF_{(DLR)} - 1$ 4	Repeat logical rank loop 0, use C[2:0] = 100 instead ²																
			5	5 × $nRFC_{(DLR)}$... 6 × $nRF_{(DLR)} - 1$ 4	Repeat logical rank loop 0, use C[2:0] = 101 instead ²																
			6	6 × $nRFC_{(DLR)}$... 7 × $nRF_{(DLR)} - 1$ 4	Repeat logical rank loop 0, use C[2:0] = 110 instead ²																
			7	7 × $nRFC_{(DLR)}$... 8 × $nRF_{(DLR)} - 1$ 4	Repeat logical rank loop 0, use C[2:0] = 111 instead ²																

- Notes:
1. DQS_t, DQS_c are V_{DDQ}.
 2. C2 is a "Don't Care" for 2-high and 4-high devices; C1 is a "Don't Care" for 2-high devices.
 3. DQ signals are V_{DDQ}.
 4. $nRFC_{(SLR)}$ must be met for 2-high devices.



16Gb, 32Gb: x4, x8 3DS DDR4 SDRAM

Current Specifications – Patterns and Test Conditions

Table 33: I_{DD5b2} Measurement-Loop Pattern¹

CK_c, CK_t,	CKE	Sub-Loop	Logical Rank Loop	Cycle Number	Command	CS_n	ACT_n	RAS_n/A16	CAS_n/A15	WE_n/A14	ODT	C[2:0] ²	BG[1:0]	BA[1:0]	A12/BC_n	A[17,13,11]	A[10]/AP	A[9:7]	A[6:3]	A[2:0]	Data ³
Toggling	Static High	0	0	0	REF	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	–
		1	1	1	D	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	–
				2	D	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	–
				3	D_n	0	1	1	1	1	0	0	3	3	0	0	0	7	F	0	–
				4	D_n	0	1	1	1	1	0	0	3	3	0	0	0	7	F	0	–
				5–8	Repeat pattern 1...4, use BG[1:0] = 1, use BA[1:0] = 1 instead																
				9–12	Repeat pattern 1...4, use BG[1:0] = 0, use BA[1:0] = 2 instead																
				13–16	Repeat pattern 1...4, use BG[1:0] = 1, use BA[1:0] = 3 instead																
				17–20	Repeat pattern 1...4, use BG[1:0] = 0, use BA[1:0] = 1 instead																
				21–24	Repeat pattern 1...4, use BG[1:0] = 1, use BA[1:0] = 2 instead																
				25–28	Repeat pattern 1...4, use BG[1:0] = 0, use BA[1:0] = 3 instead																
				29–32	Repeat pattern 1...4, use BG[1:0] = 1, use BA[1:0] = 0 instead																
				33–36	Repeat pattern 1...4, use BG[1:0] = 2, use BA[1:0] = 0 instead on page																
				37–40	Repeat pattern 1...4, use BG[1:0] = 3, use BA[1:0] = 1 instead on page																
				41–44	Repeat pattern 1...4, use BG[1:0] = 2, use BA[1:0] = 2 instead on page																
				45–48	Repeat pattern 1...4, use BG[1:0] = 3, use BA[1:0] = 3 instead on page																
				49–52	Repeat pattern 1...4, use BG[1:0] = 2, use BA[1:0] = 1 instead on page																
				53–56	Repeat pattern 1...4, use BG[1:0] = 3, use BA[1:0] = 2 instead on page																
				57–60	Repeat pattern 1...4, use BG[1:0] = 2, use BA[1:0] = 3 instead on page																
				61–64	Repeat pattern 1...4, use BG[1:0] = 3, use BA[1:0] = 0 instead on page																
		2	1	65...nRFC _(SLR) - 1	Repeat sub-loop 1; truncate if necessary																
				nRFC _(SLR) ... 2 × nRF _(SLR) - 1	Repeat logical rank loop 0, use C[2:0] = 001 instead ²																
				2 × nRFC _(SLR) ... 3 × nRF _(SLR) - 1	Repeat logical rank loop 0, use C[2:0] = 010 instead ²																
				3 × nRFC _(SLR) ... 4 × nRF _(SLR) - 1	Repeat logical rank loop 0, use C[2:0] = 011 instead ²																



16Gb, 32Gb: x4, x8 3DS DDR4 SDRAM

Current Specifications – Patterns and Test Conditions

Table 33: I_{DD5b2} Measurement-Loop Pattern¹ (Continued)

CK_c, CK_t,	CKE	Sub-Loop	Logical Rank Loop	Cycle Number	Command	CS_n	ACT_n	RAS_n/A16	CAS_n/A15	WE_n/A14	ODT	C[2:0] ²	BG[1:0]	BA[1:0]	A12/BC_n	A[17,13,11]	A[10]/AP	A[9:7]	A[6:3]	A[2:0]	Data ³
Toggling	Static High		4	4 × $nRFC_{(SLR)} \dots$ 5 × $nRF_{(SLR)} - 1$	Repeat logical rank loop 0, use C[2:0] = 100 instead ²																
			5	5 × $nRFC_{(SLR)} \dots$ 6 × $nRF_{(SLR)} - 1$	Repeat logical rank loop 0, use C[2:0] = 101 instead ²																
			6	6 × $nRFC_{(SLR)} \dots$ 7 × $nRF_{(SLR)} - 1$	Repeat logical rank loop 0, use C[2:0] = 110 instead ²																
			7	7 × $nRFC_{(SLR)} \dots$ 8 × $nRF_{(SLR)} - 1$	Repeat logical rank loop 0, use C[2:0] = 111 instead ²																

- Notes:
1. DQS_t, DQS_c are V_{DDQ}.
 2. C2 is a "Don't Care" for 2-high and 4-high devices; C1 is a "Don't Care" for 2-high devices.
 3. DQ signals are V_{DDQ}.



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Table 34: I_{DD7} Measurement-Loop Pattern¹

CK_t, CK_c	CKE	Sub-Loop	Cycle Number	Command	CS_n	ACT_n	RAS_n/A16	CAS_n/A15	WE_n/A14	ODT	C[2:0] ²	BG[1:0]	BA[1:0]	A12/BC_n	A[17,13,11]	A[10]/AP	A[9:7]	A[6:3]	A[2:0]	Data ³
Toggling	Static High	0	0	ACT	0	0	0	0	0	0	000	0	0	0	0	0	0	0	0	–
			1	RDA	0	1	1	0	1	0	000	0	0	0	0	1	0	0	0	
			2	D	1	0	0	0	0	0	000	0	0	0	0	0	0	0	0	–
			3	D_n	1	1	1	1	1	0	000	3	3	0	0	0	7	F	0	–
			...	Repeat pattern 2...3 until nRRD - 1, if nRCD > 4. Truncate if necessary																
		1	nRRD	ACT	0	0	0	0	0	0	000	1	1	0	0	0	0	0	0	–
			nRRD+1	RDA	0	1	1	0	1	0	000	1	1	0	0	1	0	0	0	
			...	Repeat pattern 2...3 until 2 × nRRD - 1, if nRCD > 4. Truncate if necessary																
		2	2 × nRRD	Repeat sub-loop 0, use BG[1:0] = 0, use BA[1:0] = 2 instead																
		3	3 × nRRD	Repeat sub-loop 1, use BG[1:0] = 1, use BA[1:0] = 3 instead																
		4	4 × nRRD	Repeat pattern 2...3 until nFAW - 1, if nFAW > 4 × nRCD. Truncate if necessary																
		5	nFAW	Repeat sub-loop 0, use BG[1:0] = 0, use BA[1:0] = 1 instead																
		6	nFAW + nRRD	Repeat sub-loop 1, use BG[1:0] = 1, use BA[1:0] = 2 instead																
		7	nFAW + 2 × nRRD	Repeat sub-loop 0, use BG[1:0] = 0, use BA[1:0] = 3 instead																
		8	nFAW + 3 × nRRD	Repeat sub-loop 1, use BG[1:0] = 1, use BA[1:0] = 0 instead																
		9	nFAW + 4 × nRRD	Repeat sub-loop 4																
		10	2 × nFAW	Repeat sub-loop 0, use BG[1:0] = 2, use BA[1:0] = 0 instead																
		11	2 × nFAW + nRRD	Repeat sub-loop 1, use BG[1:0] = 3, use BA[1:0] = 1 instead																
		12	2 × nFAW + 2 × nRRD	Repeat sub-loop 0, use BG[1:0] = 2, use BA[1:0] = 2 instead																
		13	2 × nFAW + 3 × nRRD	Repeat sub-loop 1, use BG[1:0] = 3, use BA[1:0] = 3 instead																
		14	2 × nFAW + 4 × nRRD	Repeat sub-loop 4																
		15	3 × nFAW	Repeat sub-loop 0, use BG[1:0] = 2, use BA[1:0] = 1 instead																
		16	3 × nFAW + nRRD	Repeat sub-loop 1, use BG[1:0] = 3, use BA[1:0] = 2 instead																
		17	3 × nFAW + 2 × nRRD	Repeat sub-loop 0, use BG[1:0] = 2, use BA[1:0] = 3 instead																
		18	3 × nFAW + 3 × nRRD	Repeat sub-loop 1, use BG[1:0] = 3, use BA[1:0] = 0 instead																
		19	3 × nFAW + 4 × nRRD	Repeat sub-loop 4																
		20	4 × nFAW	Repeat pattern 2...3 until nRC - 1, if nRC > 4 × nFAW. Truncate if necessary																

Notes: 1. DQS_t, DQS_c are V_{DDQ}.

2. C2 is a "Don't Care" for 2-high and 4-high devices; C1 is a "Don't Care" for 2-high devices.



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3. DQ signals are V_{DDQ} except when burst sequence drives each DQ signal by a READ command.

I_{DD} Specifications

Table 35: Timings used for I_{DD} , I_{PP} and I_{DDQ} Measurement-Loop Patterns

Symbol		DDR4-1600			DDR4-1866			DDR4-2133			DDR4-2400			DDR4-2666			DDR4-2933			Unit
		12-11-10	13-12-11	14-13-12	14-13-12	15-14-13	16-15-14	16-15-14	18-16-16	20-16-16	18-16-15	20-18-18	22-18-18	20-19-17	22-20-19	24-20-20	22-20-19	24-22-21	26-22-22	
t ^{CK}		1.25			1.071			0.938			0.833			0.750			0.682			ns
CL		12	13	14	14	15	16	16	18	20	18	20	22	20	22	24	12	24	26	CK
CWL		9	11	11	10	12	12	11	14	14	12	16	16	14	18	18	16	20	20	CK
nRCD		11	12	13	13	14	15	15	16	16	16	18	18	19	20	20	20	22	22	CK
nRC		38	39	40	44	45	46	50	51	52	54	55	57	60	62	63	66	68	69	CK
nRP		10	11	12	12	13	14	14	16	16	15	18	18	17	19	20	19	21	22	CK
nRAS		28			32			36			39			43			47			CK
nFAW _(SLR)	x4 ¹	16			16			16			16			16			16			CK
	x8	20			22			23			26			28			31			CK
nRRD _{S(SLR)}	x4	4			4			4			4			4			4			CK
	x8	4			4			4			4			4			4			CK
nRRD _{L(SLR)}	x4	5			5			6			6			7			7			CK
	x8	5			5			6			6			7			7			CK
nCCD _S		4			4			4			4			4			4			CK
nCCD _L		5			5			6			6			7			7			CK
nWTR _S		2			3			3			3			4			4			CK
nWTR _L		6			7			8			9			10			11			CK
nRFC _(SLR) 4Gb		208			243			278			313			347			381			CK
nRFC _(SLR) 8Gb		280			327			374			421			467			513			CK
nRFC _(SLR) 16Gb		TBD			TBD			TBD			TBD			TBD			TBD			CK
nRFC _(DLR) 4Gb		72			85			97			108			120			132			CK
nRFC _(DLR) 8Gb		96			113			129			144			160			176			CK
nRFC _(DLR) 16Gb		~TBD/3			~TBD/3			~TBD/3			~TBD/3			~TBD/3			~TBD/3			CK

Note: 1. 1KB-based x4 devices use the same number of clocks for $nFAW$ as the x8 device.



Current Specifications – Limits

Table 36: 2-High I_{DD} , I_{PP} and I_{DDQ} Current Limits; Die Rev. G

Symbol	Width	DDR4-2133	DDR4-2400	DDR4-2666	Unit
I_{DD0} : One bank ACTIVATE-to-PRECHARGE current	x4	TBD	TBD	TBD	mA
	x8	TBD	TBD	TBD	mA
I_{PP0} : One bank ACTIVATE-to-PRECHARGE I_{PP} current	ALL	TBD	TBD	TBD	mA
I_{DD1} : One bank ACTIVATE-to-READ-to- PRECHARGE current	x4	TBD	TBD	TBD	mA
	x8	TBD	TBD	TBD	mA
I_{DD2N} : Precharge standby current	ALL	TBD	TBD	TBD	mA
I_{DD2NT} : Precharge standby ODT current	ALL	TBD	TBD	TBD	mA
I_{DD2P} : Precharge power-down current	ALL	TBD	TBD	TBD	mA
I_{DD2Q} : Precharge quiet standby current	ALL	TBD	TBD	TBD	mA
I_{DD3N} : Active standby current	x4	TBD	TBD	TBD	mA
	x8	TBD	TBD	TBD	mA
I_{PP3N} : Active standby I_{PP} current	ALL	TBD	TBD	TBD	mA
I_{DD3P} : Active power-down current	ALL	TBD	TBD	TBD	mA
I_{DD4R} : Burst read current	x4	TBD	TBD	TBD	mA
	x8	TBD	TBD	TBD	mA
I_{DDQ4R} : Burst read I_{DDQ} current	x4	TBD	TBD	TBD	mA
	x8	TBD	TBD	TBD	mA
I_{DD4W} : Burst write current	x4	TBD	TBD	TBD	mA
	x8	TBD	TBD	TBD	mA
I_{DD5B} : Burst refresh current (1X REF)	ALL	TBD	TBD	TBD	mA
I_{PP5B} : Burst refresh I_{PP} current (1X REF)	ALL	TBD	TBD	TBD	mA
I_{DD6N} : Self refresh current; 0–85°C ¹	ALL	TBD	TBD	TBD	mA
I_{DD6E} : Self refresh current; 0–95°C ²	ALL	TBD	TBD	TBD	mA
I_{DD6R} : Self refresh current; 0–45°C ^{3,4}	ALL	TBD	TBD	TBD	mA
I_{DD6A} : Auto self refresh current (25°C) ⁴	ALL	TBD	TBD	TBD	mA
I_{DD6A} : Auto self refresh current (45°C) ⁴	ALL	TBD	TBD	TBD	mA
I_{DD6A} : Auto self refresh current (75°C) ⁴	ALL	TBD	TBD	TBD	mA
I_{DD7} : Bank interleave read current	x4	TBD	TBD	TBD	mA
	x8	TBD	TBD	TBD	mA
I_{PP7} : Bank interleave read I_{PP} current	ALL	TBD	TBD	TBD	mA
I_{DD8} : Maximum power-down current	ALL	TBD	TBD	TBD	mA

- Notes:
1. Applicable for MR2 settings A7 = 0 and A6 = 0; manual mode with normal temperature range of operation (0–85°C).
 2. Applicable for MR2 settings A7 = 1 and A6 = 0; manual mode with extended temperature range of operation (0–95°C).
 3. Applicable for MR2 settings A7 = 0 and A6 = 1; manual mode with reduced temperature range of operation (0–45°C).
 4. I_{DD6R} and I_{DD6A} values are typical.



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5. When additive latency is enabled for I_{DD0} , current changes by approximately 0%.
6. When additive latency is enabled for I_{DD1} , current changes by approximately +5%.
7. When additive latency is enabled for I_{DD2N} , current changes by approximately +0.6%.
8. When DLL is disabled for I_{DD2N} , current changes by approximately 0%.
9. When CAL is enabled for I_{DD2N} , current changes by approximately -44%.
10. When gear-down is enabled for I_{DD2N} , current changes by approximately 0%.
11. When CA parity is enabled for I_{DD2N} , current changes by approximately +14%.
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 read DBI is enabled for I_{DDQ4R} , current changes by approximately -48%.
16. When additive latency is enabled for I_{DD4W} , current changes by approximately +1.6%.
17. When write DBI is enabled for I_{DD4W} , current changes by approximately 0%.
18. When write CRC is enabled for I_{DD4W} , current changes by approximately -8%(2133/2400), -5%(1600/1866).
19. When CA parity is enabled for I_{DD4W} , current changes by approximately +14% (x8).
20. When 2X REF is enabled for I_{DD5B} , current changes by approximately -14%.
21. When 4X REF is enabled for I_{DD5B} , current changes by approximately -33%.
22. I_{PP0} test and limit is applicable for I_{DD0} and I_{DD1} conditions.
23. I_{PP3N} test and limit is applicable for all I_{DD2x} , I_{DD3x} , I_{DD4x} , I_{DD6} and I_{DD8} conditions; that is, testing I_{PP3N} should satisfy the I_{PPs} for the noted I_{DD} tests.

Table 37: 4-High I_{DD} , I_{PP} and I_{DDQ} Current Limits; Die Rev. G

Symbol	Width	DDR4-2133	DDR4-2400	DDR4-2666	Unit
I_{DD0} : One bank ACTIVATE-to-PRECHARGE current	x4	TBD	TBD	TBD	mA
	x8	TBD	TBD	TBD	mA
I_{PP0} : One bank ACTIVATE-to-PRECHARGE I_{PP} current	ALL	TBD	TBD	TBD	mA
I_{DD1} : One bank ACTIVATE-to-READ-to- PRECHARGE current	x4	TBD	TBD	TBD	mA
	x8	TBD	TBD	TBD	mA
I_{DD2N} : Precharge standby current	ALL	TBD	TBD	TBD	mA
I_{DD2NT} : Precharge standby ODT current	ALL	TBD	TBD	TBD	mA
I_{DD2P} : Precharge power-down current	ALL	TBD	TBD	TBD	mA
I_{DD2Q} : Precharge quiet standby current	ALL	TBD	TBD	TBD	mA
I_{DD3N} : Active standby current	x4	TBD	TBD	TBD	mA
	x8	TBD	TBD	TBD	mA
I_{PP3N} : Active standby I_{PP} current	ALL	TBD	TBD	TBD	mA
I_{DD3P} : Active power-down current	ALL	TBD	TBD	TBD	mA
I_{DD4R} : Burst read current	x4	TBD	TBD	TBD	mA
	x8	TBD	TBD	TBD	mA
I_{DDQ4R} : Burst read I_{DDQ} current	x4	TBD	TBD	TBD	mA
	x8	TBD	TBD	TBD	mA
I_{DD4W} : Burst write current	x4	TBD	TBD	TBD	mA
	x8	TBD	TBD	TBD	mA
I_{DD5B} : Burst refresh current (1X REF)	ALL	TBD	TBD	TBD	mA
I_{PP5B} : Burst refresh I_{PP} current (1X REF)	ALL	TBD	TBD	TBD	mA



16Gb, 32Gb: x4, x8 3DS DDR4 SDRAM Current Specifications – Limits

Table 37: 4-High I_{DD} , I_{PP} and I_{DDQ} Current Limits; Die Rev. G (Continued)

Symbol	Width	DDR4-2133	DDR4-2400	DDR4-2666	Unit
I_{DD6N} : Self refresh current; 0–85°C ¹	ALL	TBD	TBD	TBD	mA
I_{DD6E} : Self refresh current; 0–95°C ²	ALL	TBD	TBD	TBD	mA
I_{DD6R} : Self refresh current; 0–45°C ^{3,4}	ALL	TBD	TBD	TBD	mA
I_{DD6A} : Auto self refresh current (25°C) ⁴	ALL	TBD	TBD	TBD	mA
I_{DD6A} : Auto self refresh current (45°C) ⁴	ALL	TBD	TBD	TBD	mA
I_{DD6A} : Auto self refresh current (75°C) ⁴	ALL	TBD	TBD	TBD	mA
I_{DD7} : Bank interleave read current	x4	TBD	TBD	TBD	mA
	x8	TBD	TBD	TBD	mA
I_{PP7} : Bank interleave read I_{PP} current	ALL	TBD	TBD	TBD	mA
I_{DD8} : Maximum power-down current	ALL	TBD	TBD	TBD	mA

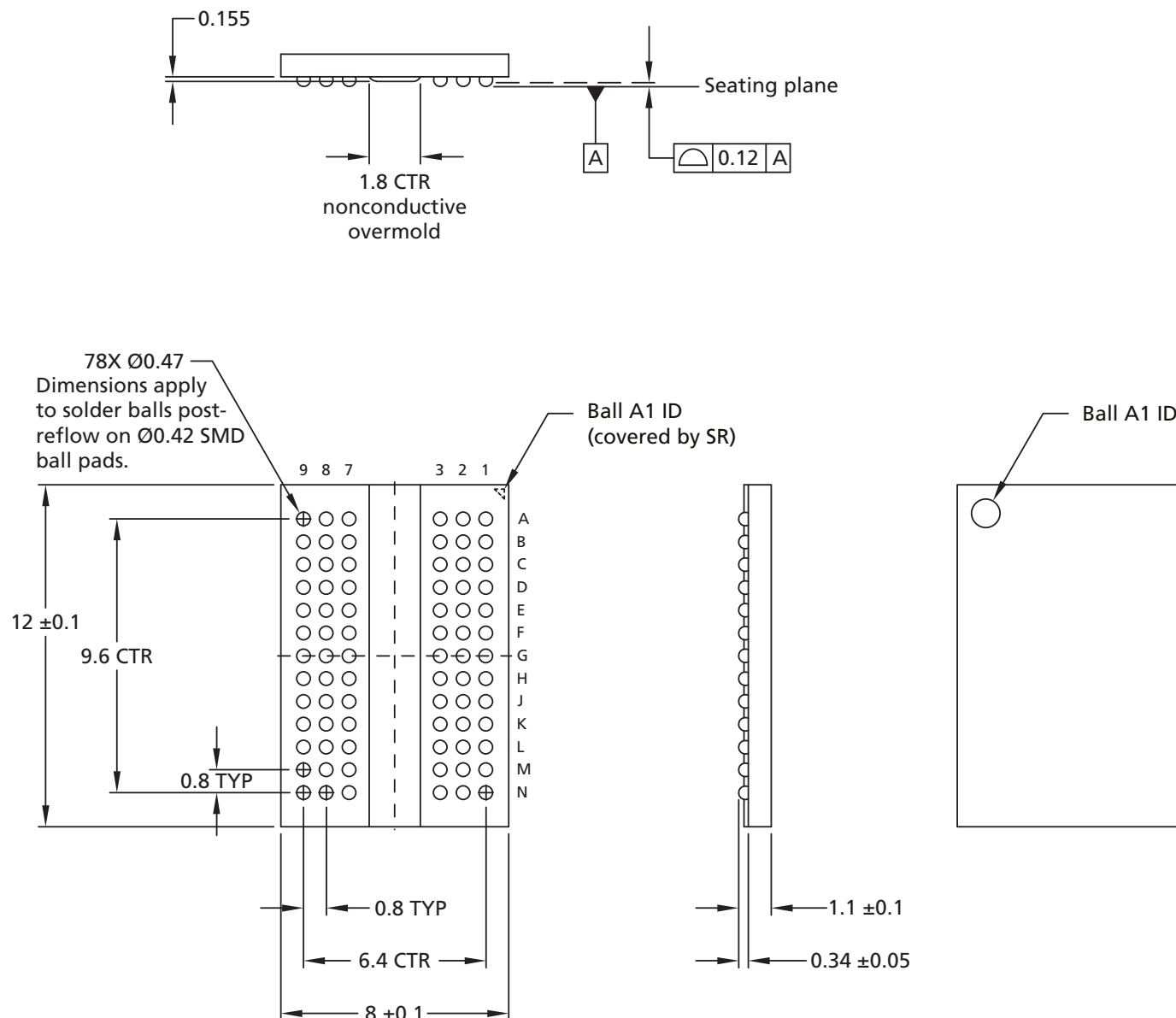
- Notes:
1. Applicable for MR2 settings A7 = 0 and A6 = 0; manual mode with normal temperature range of operation (0–85°C).
 2. Applicable for MR2 settings A7 = 1 and A6 = 0; manual mode with extended temperature range of operation (0–95°C).
 3. Applicable for MR2 settings A7 = 0 and A6 = 1; manual mode with reduced temperature range of operation (0–45°C).
 4. I_{DD6R} and I_{DD6A} values are typical.
 5. When additive latency is enabled for I_{DD0} , current changes by approximately 0%.
 6. When additive latency is enabled for I_{DD1} , current changes by approximately +5%.
 7. When additive latency is enabled for I_{DD2N} , current changes by approximately +0.6%.
 8. When DLL is disabled for I_{DD2N} , current changes by approximately 0%.
 9. When CAL is enabled for I_{DD2N} , current changes by approximately –44%.
 10. When gear-down is enabled for I_{DD2N} , current changes by approximately 0%.
 11. When CA parity is enabled for I_{DD2N} , current changes by approximately +14%.
 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 read DBI is enabled for I_{DDQ4R} , current changes by approximately –48%.
 16. When additive latency is enabled for I_{DD4W} , current changes by approximately +1.6%.
 17. When write DBI is enabled for I_{DD4W} , current changes by approximately 0%.
 18. When write CRC is enabled for I_{DD4W} , current changes by approximately –8%(2133/2400), –5%(1600/1866).
 19. When CA parity is enabled for I_{DD4W} , current changes by approximately +14% (x8).
 20. When 2X REF is enabled for I_{DD5B} , current changes by approximately –14%.
 21. When 4X REF is enabled for I_{DD5B} , current changes by approximately –33%.
 22. I_{PP0} test and limit is applicable for I_{DD0} and I_{DD1} conditions.
 23. I_{PP3N} test and limit is applicable for all I_{DD2x} , I_{DD3x} , I_{DD4x} , I_{DD6} and I_{DD8} conditions; that is, testing I_{PP3N} should satisfy the I_{PPs} for the noted I_{DD} tests.



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Package Dimensions

Figure 15: 78-Ball FBGA Die Rev. G (package codes HPR and KVA)



- Notes: 1. All dimensions are in millimeters.
2. Solder ball material: SAC305 (96.5% Sn, 3% Ag, 0.5% Cu).

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