FORESEE®

LPDDR Datasheet

D-00263

FLXC2002G-C4

Version 1.0

Revision History

Rev.	Date	Changes
1.0	2021/10/09	Document Create.

CONTENTS

1 Key Features

Features

- Ultra-low-voltage core and I/O power supplies
  - VDD1 = 1.70–1.95V; 1.8V nominal
  - VDD2 = 1.06–1.17V; 1.10V nominal
  - VDDQ = 0.57–0.65V; 0.6V nominal
- Frequency range
  - 1600 –10 MHz (data rate range: 3200–20 Mb/s/pin)
- 16n prefetch DDR architecture
- 8 internal banks per channel for concurrent operation
- Single-data-rate CMD/ADR entry
- Bidirectional/differential data strobe per byte lane
- Programmable READ and WRITE latencies (RL/WL)
- Programmable and on-the-fly burst lengths (BL =16,32)
- Directed per-bank refresh for concurrent bank operation and ease of command scheduling
- Up to 12.8 GB/s per chip (2 channels x 6.4 GB/s)
- On-chip temperature sensor to control self refresh rate
- Partial-array self refresh (PASR)
- Selectable output drive strength (DS)
- Clock-stop capability
- RoHS-compliant, “green” packaging
- Programmable VSSQ (ODT) termination
- Single-ended CK and DQS support

Options

- VDD1/VDD2/VDDQ: 1.8V/1.1V/0.6V
- Array configuration
  - 512Meg x 32 (2 channels x16 I/O)
- Device configuration
  - 512M16 x 2 die in package
- FBGA “green” package
  - 200-ball VFBGA (10mm x 14.5mm x1.0mm max)
- Speed grade, cycle time
  - 625ps @ RL = 28/32
- Operating temperature range –25°C to +85°C

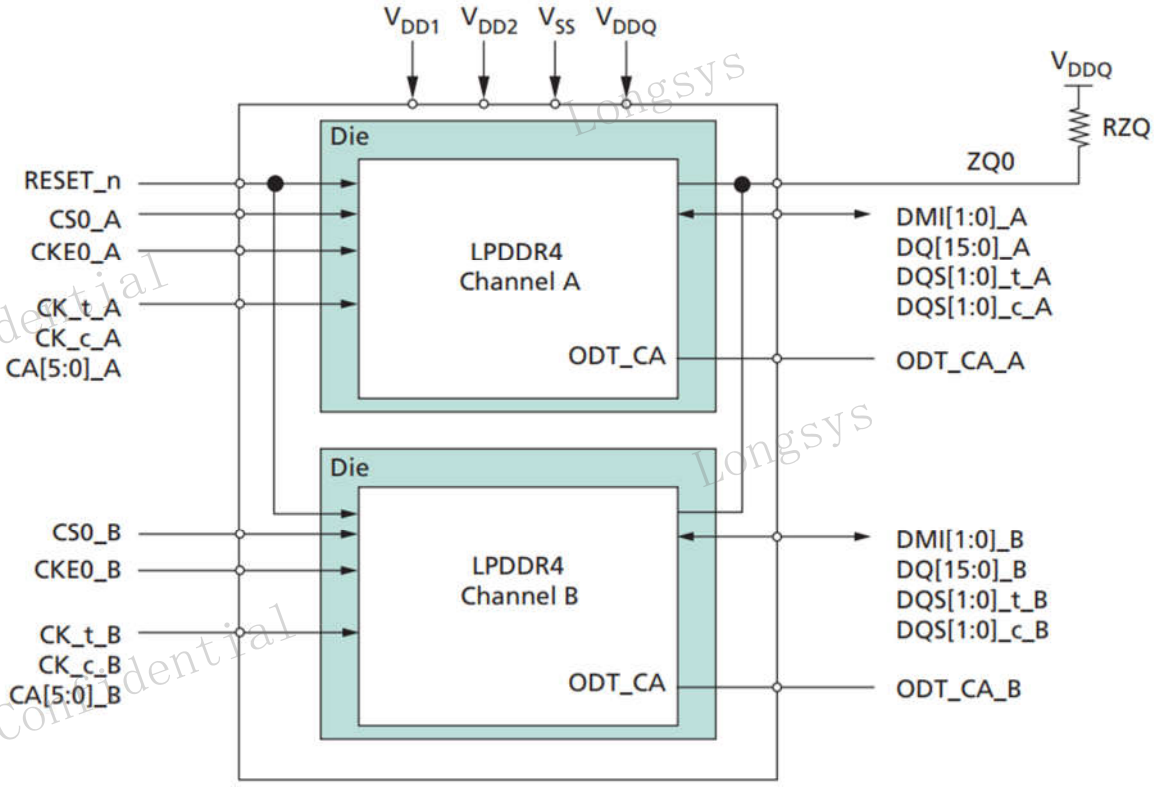
2 SDRAM Addressing

Configuration			512Meg x 32 (16Gb/Package)
Die Configuration	Channel A, Rank 0		x16 mode x 1 die
	Channel B, Rank 0		x16 mode x 1 die
	Channel A, Rank 1		NA
	Channel B, Rank 1		NA
Die Addressing	Device density (per die)		8Gb
	Device density (per channel)		8Gb
	Configuration(per die)		64Mb × 16 DQ × 8 banks
	Number of channels (per die)		1
	Number of banks (per channel)		8
	Array prefetch (bits, per channel)		256
	Number of rows (per channel)		65336
	Number of columns (fetch boundaries)		64
	Page size (bytes)		2048
	Channel density (bits per channel)		8,589,934,592
	Total density (bits per die)		8,589,934,592
	Bank address		BA[2:0]
	x16	Row address	R[15:0]
		Column address	C[9:0]
	Burst starting address boundary		64-bit

3 Functional Block Diagram

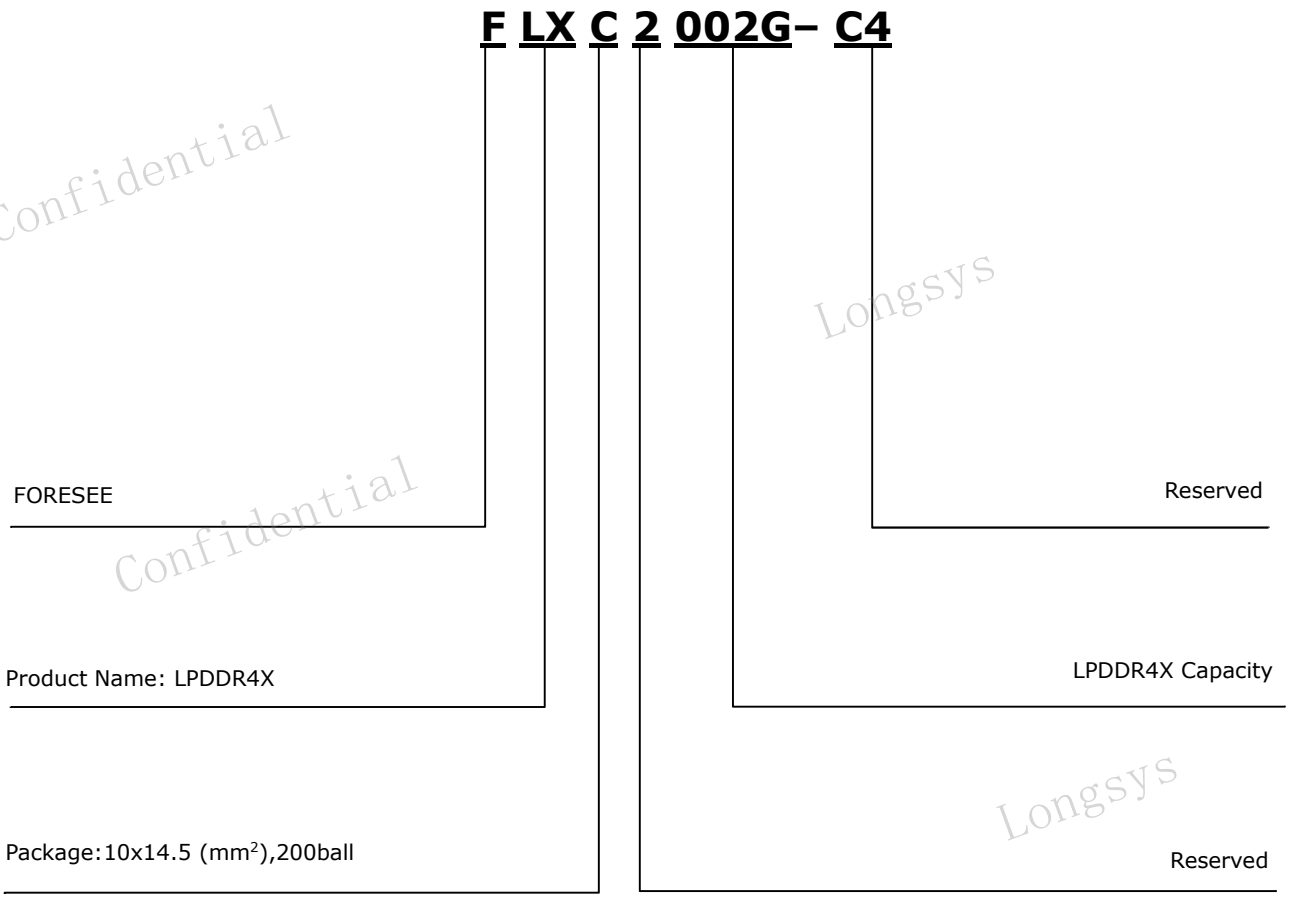
DRAM Block Diagrams

Dual -Die, Dual-Channel, Package Block Diagram



4 Ordering Information

Part Number	Package Size(mm)	Memory Combination	Operation Voltage	Density	Speed	Package
FLXC2002G-C4	10*14.5*1.0 (max)	LPDDR4X	1.8V/1.1V/0.6V	16Gb	3200Mbps	200ball FBGA (Lead & Halogen Free)



5 Ball Assignment

200-Ball Dual-Channel Discrete VFBGA

	1	2	3	4	5	6	7	8	9	10	11	12
A	DNU	DNU	V_{SS}	V_{DD2}	ZQ0			NC	V_{DD2}	V_{SS}	DNU	DNU
B	DNU	DQ0_A	V_{DDQ}	DQ7_A	V_{DDQ}			V_{DDQ}	DQ15_A	V_{DDQ}	DQ8_A	DNU
C	V_{SS}	DQ1_A	DMI0_A	DQ6_A	V_{SS}			V_{SS}	DQ14_A	DMI1_A	DQ9_A	V_{SS}
D	V_{DDQ}	V_{SS}	DQS0_t_A	V_{SS}	V_{DDQ}			V_{DDQ}	V_{SS}	DQS1_t_A	V_{SS}	V_{DDQ}
E	V_{SS}	DQ2_A	DQS0_c_A	DQ5_A	V_{SS}			V_{SS}	DQ13_A	DQS1_c_A	DQ10_A	V_{SS}
F	V_{DD1}	DQ3_A	V_{DDQ}	DQ4_A	V_{DD2}			V_{DD2}	DQ12_A	V_{DDQ}	DQ11_A	V_{DD1}
G	V_{SS}	ODT_CA_A	V_{SS}	V_{DD1}	V_{SS}			V_{SS}	V_{DD1}	V_{SS}	NC	V_{SS}
H	V_{DD2}	CA0_A	NC	CS0_A	V_{DD2}			V_{DD2}	CA2_A	CA3_A	CA4_A	V_{DD2}
J	V_{SS}	CA1_A	V_{SS}	CKE0_A	NC			CK_t_A	CK_c_A	V_{SS}	CA5_A	V_{SS}
K	V_{DD2}	V_{SS}	V_{DD2}	V_{SS}	NC			NC	V_{SS}	V_{DD2}	V_{SS}	V_{DD2}
L												
M												
N	V_{DD2}	V_{SS}	V_{DD2}	V_{SS}	NC			NC	V_{SS}	V_{DD2}	V_{SS}	V_{DD2}
P	V_{SS}	CA1_B	V_{SS}	CKE0_B	NC			CK_t_B	CK_c_B	V_{SS}	CA5_B	V_{SS}
R	V_{DD2}	CA0_B	NC	CS0_B	V_{DD2}			V_{DD2}	CA2_B	CA3_B	CA4_B	V_{DD2}
T	V_{SS}	ODT_CA_B	V_{SS}	V_{DD1}	V_{SS}			V_{SS}	V_{DD1}	V_{SS}	RESET_n	V_{SS}
U	V_{DD1}	DQ3_B	V_{DDQ}	DQ4_B	V_{DD2}			V_{DD2}	DQ12_B	V_{DDQ}	DQ11_B	V_{DD1}
V	V_{SS}	DQ2_B	DQS0_c_B	DQ5_B	V_{SS}			V_{SS}	DQ13_B	DQS1_c_B	DQ10_B	V_{SS}
W	V_{DDQ}	V_{SS}	DQS0_t_B	V_{SS}	V_{DDQ}			V_{DDQ}	V_{SS}	DQS1_t_B	V_{SS}	V_{DDQ}
Y	V_{SS}	DQ1_B	DMI0_B	DQ6_B	V_{SS}			V_{SS}	DQ14_B	DMI1_B	DQ9_B	V_{SS}
AA	DNU	DQ0_B	V_{DDQ}	DQ7_B	V_{DDQ}			V_{DDQ}	DQ15_B	V_{DDQ}	DQ8_B	DNU
AB	DNU	DNU	V_{SS}	V_{DD2}	V_{SS}			V_{SS}	V_{DD2}	V_{SS}	DNU	DNU
	1	2	3	4	5	6	7	8	9	10	11	12

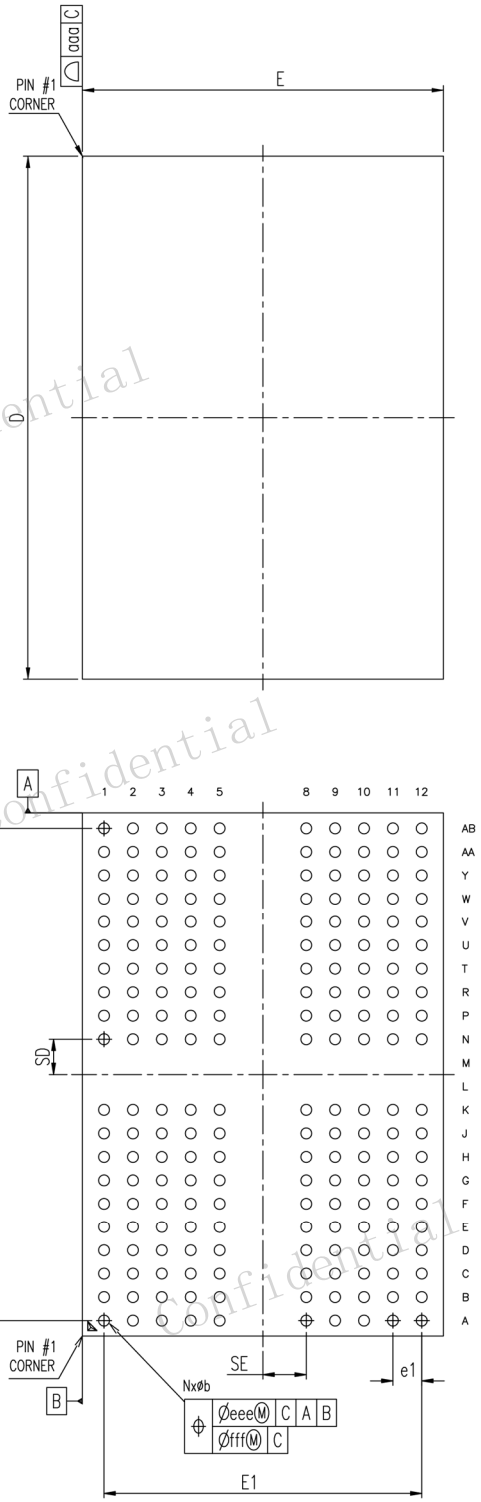
Top View（ball down）

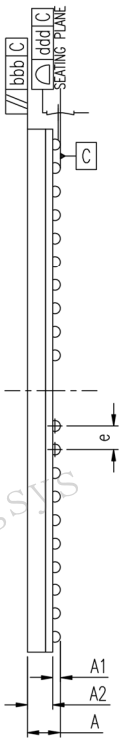
LPDDR4_A(Channel A) LPDDR4_B(Channel B) ZQ, ODT_CA, RESET Supply Ground

6 Pin Description

Symbol	Type	Description
CK_t_A, CK_c_A, CK_t_B, CK_c_B	Input	Clock: CK_t and CK_c are differential clock inputs. All address, command and control input signals are sampled on positive edge of CK_t and the negative edge of CK_c. AC timings for CA parameters are referenced to clock. Each channel (A, B) has its own clock pair.
CKE0_A, CKE0_B	Input	Clock enable: CKE HIGH activates and CKE LOW deactivates the internal clock signals, input buffers, and output drivers. Power-saving modes are entered and exited via CKE transitions. CKE is sampled at the rising edge of CK.
CS0_A, CS0_B	Input	Chip select: Each channel (A, B) has its own CS signals.
CA[5:0]_A, CA[5:0]_B	Input	Command/address inputs: Provide the command and address inputs according to the command truth table. Each channel (A, B) has its own CA signals.
ODT_CA_A, ODT_CA_B	Input	CA ODT control: The ODT_CA pin is used in conjunction with the Mode Register to turn on/off the On-Die-Termination for CA pins.
DQ[15:0]_A, DQ[15:0]_B	I/O	Data input/output: Bidirectional data bus.
DQS[1:0]_t_A, DQS[1:0]_c_A, DQS[1:0]_t_B, DQS[1:0]_c_B	I/O	Data strobe: DQS_t and DQS_c are bi-directional differential output clock signals used to strobe data during a READ or WRITE. The Data Strobe is generated by the DRAM for a READ and is edge-aligned with Data. The Data Strobe is generated by the Memory Controller for a WRITE and must arrive prior to Data. Each byte of data has a Data Strobe signal pair.
DMI[1:0]_A, DMI[1:0]_B	I/O	Data Mask/Data Bus Inversion: DMI is a bi-directional signal which is driven HIGH when the data on the data bus is inverted, or driven LOW when the data is in its normal state. Data Inversion can be disabled via a mode register setting. Each byte of data has a DMI signal. This signal is also used along with the DQ signals to provide write data masking information to the DRAM. The DMI pin function - Data Inversion or Data mask - depends on Mode Register setting.
ZQ0	Reference	ZQ calibration reference: Used to calibrate the output drive strength and the termination resistance. The ZQ pin shall be connected to VDDQ through a 240Ω ±1% resistor.
V_{DDQ}, V_{DD1}, V_{DD2}	Supply	Power supplies: Isolated on the die for improved noise immunity.
V_{SS}	Supply	Ground Reference: Power supply ground reference.
RESET_n	Input	RESET: When asserted LOW, the RESET pin resets both channels of the die.
DNU	-	Do not use: Must be grounded or left floating.
NC	-	No connect: Not internally connected.

7 Package Information





SYMBOL	DIMENSION IN MM			DIMENSION IN INCH		
	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.
A	---	---	1.00	---	---	0.039
A1	---	0.21	---	---	0.008	---
A2	0.64	0.70	0.76	0.025	0.028	0.030
b	0.25	0.30	0.35	0.010	0.012	0.014
D	14.40	14.50	14.60	0.567	0.571	0.575
E	9.90	10.00	10.10	0.390	0.394	0.398
e	0.65 BSC.			0.026 BSC.		
e1	0.80 BSC.			0.031 BSC.		
JEDEC	MO-311(REF.)/MM					
aaa	0.10					
bbb	0.10					
ddd	0.08					
eee	0.15					
fff	0.08					

N	SE (mm)	SD (mm)	E1 (mm)	D1 (mm)
200	1.20 BSC.	0.975 BSC.	8.80 BSC.	13.65 BSC.

8 Input/Output Capacitance

Part Number	Parameter	Symbol	Min.	Max.	Unit	Notes
FLXC2002G-C4	Input capacitance, CK_t and CK_c	C_{CK}	0.5	0.9	pF	
	Input capacitance delta, CK_t and CK_c	C_{DCK}	0	0.09	pF	3
	Input capacitance, all other input-only pins	C_I	0.5	0.9	pF	4
	Input capacitance delta, all other input-only pins	C_{DI}	-0.10	0.10	pF	5
	Input/output capacitance, DQ, DMI, DQS_t, DQS_c	C_{IO}	0.7	1.3	pF	6
	Input/output capacitance delta, DQS_t, DQS_c	C_{DDQS}	0	0.1	pF	7
	Input/output capacitance delta, DQ, DMI	C_{DIO}	-0.1	0.1	pF	8
	Input/output capacitance ZQ pin	C_{ZQ}	0	5.0	pF	

Notes:

1. This parameter applies to die device only (does not include package capacitance).
2. This parameter is not subject to production test. It is verified. The capacitance is measured according to JEP147 (Procedure for measuring input capacitance using a vector network analyzer (VNA) with VDD1, VDD2, VDDQ, VSS, VSS, VSS applied and all other pins floating.
3. Absolute value of CCK_t – CCK_c.
4. CI applies to CS, CKE, and CA[5:0].
5. CDI = CI – 0.5 × (CCK_t + CCK_c); It does not apply to CKE.
6. DM loading matches DQ and DQS.
7. Absolute value of CDQS_t and CDQS_c.
8. CDIO = CIO – Average (CDQn, CDMI, CDQS_t, CDQS_c) in byte-lane.

8.1 IDD Specification Parameters and Operating Conditions

Parameter/Condition	Symbol	Power Supply	Current	Notes
Operating one bank active-precharge current: tCK=tCK(MIN); tRC=tRC(MIN); CKE is HIGH; CS is LOW between valid commands; CA bus inputs are switching; Data bus inputs are stable; ODT is disabled	IDD01	VDD1	TBD	
	IDD02	VDD2	TBD	
	IDD0Q	VDDQ	TBD	
Idle power-down standby current: tCK = tCK (MIN); CKE is LOW; CS is LOW; All banks are idle; CA bus inputs are switching; Data bus inputs are stable; ODT is disabled	IDD2P1	VDD1	TBD	
	IDD2P2	VDD2	TBD	
	IDD2PQ	VDDQ	TBD	
Idle power-down standby current with clock stop: CK_t =LOW, CK_c = HIGH; CKE is LOW; CS is LOW; All banks	IDD2PS1	VDD1	TBD	

Parameter/Condition	Symbol	Power Supply	Current	Notes
are idle; CA bus inputs are stable; Data bus inputs are stable; ODT is disabled	IDD2PS2	VDD2	TBD	
	IDD2PSQ	VDDQ	TBD	
Idle non-power-down standby current: tCK = tCK (MIN); CKE is HIGH; CS is LOW; All banks are idle; CA bus inputs are switching; Data bus inputs are stable; ODT is disabled	IDD2N1	VDD1	TBD	
	IDD2N2	VDD2	TBD	
	IDD2NQ	VDDQ	TBD	
Idle non-power-down standby current with clock stopped: CK_t = LOW; CK_c = HIGH; CKE is HIGH; CS is LOW; All banks are idle; CA bus inputs are stable; Data bus inputs are stable; ODT is disabled	IDD2NS1	VDD1	TBD	
	IDD2NS2	VDD2	TBD	
	IDD2NSQ	VDDQ	TBD	
Active power-down standby current: tCK = tCK (MIN); CKE is LOW; CS is LOW; One bank is active; CA bus inputs are switching;Data bus inputs are stable; ODT is disabled	IDD3P1	VDD1	TBD	
	IDD3P2	VDD2	TBD	
	IDD3PQ	VDDQ	TBD	
Active power-down standby current with clock stop: CK_t = LOW, CK_c = HIGH; CKE is LOW; CS is LOW; One bank is active; CA bus inputs are stable; Data bus inputs are stable; ODT is disabled	IDD3PS1	VDD1	TBD	
	IDD3PS2	VDD2	TBD	
	IDD3PSQ	VDDQ	TBD	
Active non-power-down standby current: tCK = tCK (MIN);CKE is HIGH; CS is LOW; One bank is active; CA bus inputs are switching; Data bus inputs are stable; ODT is disabled	IDD3N1	VDD1	TBD	
	IDD3N2	VDD2	TBD	
	IDD3NQ	VDDQ	TBD	
Active non-power-down standby current with clock stopped: CK_t = LOW, CK_c = HIGH; CKE is HIGH; CS is LOW; One bank is active; CA bus inputs are stable; Data bus inputs are stable; ODT is disabled	IDD3NS1	VDD1	TBD	
	IDD3NS2	VDD2	TBD	
	IDD3NSQ	VDDQ	TBD	

Parameter/Condition	Symbol	Power Supply	Current	Notes
Operating burst READ current: tCK = tCK (MIN); CS is LOW between valid commands; One bank is active; BL = 16 or 32; RL = RL(MIN);CA bus inputs are switching; 50% data change each burst transfer;ODT is disabled	IDD4R1	VDD1	TBD	
	IDD4R2	VDD2	TBD	
	IDD4RQ	VDDQ	TBD	
Operating burst WRITE current: tCK = tCK (MIN); CS is LOW between valid commands; One bank is active; BL = 16 or 32; WL =WL(MIN); CA bus inputs are switching; 50% data change each burst transfer; ODT is disabled	IDD4W1	VDD1	TBD	
	IDD4W2	VDD2	TBD	
	IDD4WQ	VDDQ	TBD	
All-bank REFRESH burst current: tCK = tCK (MIN); CKE is HIGH between valid commands; tRC = tRFCab (MIN); Burst refresh; CA bus inputs are switching; Data bus inputs are stable; ODT is disabled	IDD51	VDD1	TBD	
	IDD52	VDD2	TBD	
	IDD5Q	VDDQ	TBD	
All-bank REFRESH average current: tCK = tCK (MIN); CKE is High between valid commands tRC = tREFI; CA bus inputs are switching; Data bus inputs are stable; ODT is disabled	IDD5AB1	VDD1	TBD	
	IDD5AB2	VDD2	TBD	
	IDD5ABQ	VDDQ	TBD	
Per-bank REFRESH average current: tCK = tCK (MIN); CKE is High between valid commands tRC = Trefi/8; CA bus inputs are switching; Data bus inputs are stable; ODT is disabled	IDD5PB1	VDD1	TBD	
	IDD5PB2	VDD2	TBD	
	IDD5PBQ	VDDQ	TBD	
Power-down self refresh current: CK_t = LOW, CK_c = HIGH;CKE is LOW; CA bus inputs are stable; Data bus inputs are stable; Maximum 1x self refresh rate; ODT is disabled(25℃)	IDD61	VDD1	TBD	
	IDD62	VDD2	TBD	
	IDD6Q	VDDQ	TBD	

Notes:

1. Published IDD values except IDD4RQ are the maximum of the distribution of the arithmeticmean. Refer to the following note for IDD4RQ;.
2. IDD4RQ value is reference only. Typical value. DBI disabled, VOH = VDDQ/3, TC = 25°C.
3. Measurement conditions of IDD4R and IDD4W values: DBI disabled, BL = 16.

8.2 Absolute Maximum DC Ratings

Parameter	Symbol	Min	Max	Unit	Notes
VDD1 supply voltage relative to VSS	VDD1	-0.4	2.1	V	1
VDD2 supply voltage relative to VSS	VDD2	-0.4	1.5	V	1
VDDQ supply voltage relative to VSS	VDDQ	-0.4	1.5	V	1
Voltage on any ball relative to VSS	VIN, VOUT	-0.4	1.5	V	
Storage temperature	TSTG	-55	125	℃	2

Notes:

1. For information about relationships between power supplies, see the Voltage Ramp and Device Initialization section.
2. Storage temperature is the case surface temperature on the center/top side of the device. For measurement conditions, refer to the JESD51-2 standard.

8.3 Recommended DC Operating Conditions

Symbol	Min	Typ	Max	DRAM	Unit	Notes
VDD1	1.7	1.8	1.95	Core 1 power	V	1,2
VDD2	1.06	1.1	1.17	Core 2 power/Input buffer power	V	1,2,3
VDDQ	0.57	0.6	0.65	I/O buffer power	V	2,3

Notes:

1. VDD1 uses significantly less power than VDD2.
2. The voltage range is for DC voltage only. DC voltage is the voltage supplied at the DRAM and is inclusive of all noise up to 20 MHz at the DRAM package ball.
3. The voltage noise tolerance from DC to 20 MHz exceeding a peak-to-peak tolerance of 45mV at the DRAM ball is not included in the TdIVW.

Symbol	Parameter	Min	Typ	Max	Unit	Notes
VREF(CA),max_r0	VREF(CA) range-0 MAX operating point	-	-	30%	VDD2	1,11
VREF(CA),min_r0	VREF(CA) range-0 MIN operating point	10%	-	-	VDD2	1,11
VREF(CA),max_r1	VREF(CA) range-1 MAX operating point	-	-	42%	VDD2	1,11
VREF(CA),min_r1	VREF(CA) range-1 MIN operating point	22%	-	-	VDD2	1,11
VREF(CA),step	VREF(CA) step size	0.30%	0.40%	0.50%	VDD2	2
VREF(CA),set_tol	VREF(CA) set tolerance	–1.00%	0.00%	1.00%	VDD2	3,4,6
		–0.10%	0.00%	0.10%	VDD2	3,5,7
tVREF_TIME-SHORT	VREF(CA) step time	-	-	100	ns	8
tVREF_TIME-MIDDLE		-	-	200	ns	12

Symbol	Parameter	Min	Typ	Max	Unit	Notes
tVREF_TIME-LONG		-	-	500	ns	9
tVREF_time_weak		-	-	1	ms	13,14
VREF(CA)_val_tol	VREF(CA) valid tolerance	–0.10%	0.00%	0.10%	VDD2	10

Notes:

1. $V_{REF(CA)}$ DC voltage referenced to $V_{DD2(DC)}$.
2. $V_{REF(CA)}$ step size increment/decrement range. $V_{REF(CA)}$ at DC level.
3. $V_{REF(CA),new} = V_{REF(CA),old} + n \times V_{REF(CA),step}$; n = number of steps; if increment, use "+"; if decrement, use "-".
4. The minimum value of $V_{REF(CA)}$ setting tolerance = $V_{REF(CA),new}$ - 1.0% × V_{DD2}. The maximum value of $V_{REF(CA)}$ setting tolerance = $V_{REF(CA),new}$ + 1.0% × V_{DD2}. For n > 4.
5. The minimum value of $V_{REF(CA)}$ setting tolerance = $V_{REF(CA),new}$ - 0.10% × V_{DD2}. The maximum value of $V_{REF(CA)}$ setting tolerance = $V_{REF(CA),new}$ + 0.10% × V_{DD2}. For n < 4.
6. Measured by recording the minimum and maximum values of the $V_{REF(CA)}$ output over the range, drawing a straight line between those points and comparing all other $V_{REF(CA)}$ output settings to that line.
7. Measured by recording the minimum and maximum values of the $V_{REF(CA)}$ output across four consecutive steps (n = 4), drawing a straight line between those points and comparing all other $V_{REF(CA)}$ output settings to that line.
8. Time from MRW command to increment or decrement one step size for $V_{REF(CA)}$.
9. Time from MRW command to increment or decrement $V_{REF,min}$ to $V_{REF,max}$ or $V_{REF,max}$ to $V_{REF,min}$ change across the $V_{REF(CA)}$ range in V_{REF} voltage.
10. Only applicable for DRAM component level test/characterization purposes. Not applicable for normal mode of operation. V_{REF} valid is to qualify the step times which will be characterized at the component level.
11. DRAM range-0 or range-1 set by MR12 OP[6].
12. Time from MRW command to increment or decrement more than one step size up to a full range of VREF voltage within the same $V_{REF(CA)}$ range.
13. Applies when VRCG high current mode is not enabled, specified by MR13 [OP3] = 0b.
14. ${}^{t}V_{REF}$_time_weak covers all $V_{REF(CA)}$ range and value change conditions are applied to ${}^{t}V_{REF}$_TIME-SHORT/MIDDLE/LONG.

8.4 Initialization Timing Parameters

Parameter	Min	Max	Unit	Comment
tINIT0	-	20	ms	Maximum voltage ramp time
tINIT1	200	-	µs	Minimum RESET_n LOW time after completion of voltage ramp
tINIT2	10	-	ns	Minimum CKE LOW time before RESET_n goes HIGH
tINIT3	2	-	ms	Minimum CKE LOW time after RESET_n goes HIGH
tINIT4	5	-	tCK	Minimum stable clock before first CKE HIGH
tINIT5	2	-	µs	Minimum idle time before first MRW/MRR command
tCKb	Note 1, 2	Note 1, 2	ns	Clock cycle time during boot

Notes:

1. Minimum tCKb guaranteed by DRAM test is 18ns.
2. The system may boot at a higher frequency than dictated by minimum tCKb. The higher boot frequency is system dependent.

8.5 AC Timing

8.5.1 Clock Timing

Parameter	Symbol	Min/ Max	Data Rate 3200Mbps	Unit
Average clock period	tCK(avg)	Min	625	ps
		Max	100	ns
Average HIGH pulse width	tCH(avg)	Min	0.45	tCK(avg)
		Max	0.55	
Average LOW pulse width	tCL(avg)	Min	0.45	tCK(avg)
		Max	0.55	
Absolute clock period	tCK(abs)	Min	tCK(avg)min + tJIT(per)min	ps
Absolute clock HIGH pulse width	tCH(abs)	Min	0.43	tCK(avg)
		Max	0.57	
Absolute clock LOW pulse width	tCL(abs)	Min	0.43	tCK(avg)
		Max	0.57	
Clock period jitter	tJIT(per)allowed	Min	-40	ps
		Max	40	
Maximum clock jitter between two consecutive clock cycles (includes clock period jitter)	tJIT(cc)allowed	Max	80	ps

8.5.2 Read Output Timing

Parameter	Symbol	Min/ Max	Data Rate 3200Mbps	Unit
DQS output access time from CK_t/CK_c	tDQSCK	Min	1500	ps
		Max	3500	
DQS output access time from CK_t/CK_c – voltage variation	tDQSCK_VOLT	Max	7	ps/mV
DQS output access time from CK_t/CK_c– temperature variation	tDQSCK_TEMP	Max	4	ps°/C
CK to DQS rank to rank variation	tDQSCK_rank2rank	Max	1.0	ns

Parameter	Symbol	Min/ Max	Data Rate	Unit
			3200Mbps	
DQS_t, DQS_c to DQ skew total, per group, per access (DBI Disabled)	tDQSQ	Max	0.18	UI
DQ output hold time total from DQS_t, DQS_c (DBI Disabled)	tQH	Min	MIN(tQSH, tQSL)	ps
Data output valid window time total, per pin (DBI-Disabled)	tQW_total	Min	0.75	UI
DQS_t, DQS_c to DQ skew total, per group, per access (DBI-Enabled)	tDQSQ_DBI	Max	0.18	UI
DQ output hold time total from DQS_t, DQS_c (DBI-Enabled)	tQH_DBI	Min	MIN(tQSH_DBI, tQSL_DBI)	ps
Data output valid window time total, per pin (DBI-Enabled)	tQW_total_ DBI	Min	0.75	UI
DQS_t, DQS_c differential output LOW time (DBI-Disabled)	tQSL	Min	tCL(abs) – 0.05	tCK(avg)
DQS_t, DQS_c differential output HIGH time (DBI-Disabled)	tQSH	Min	tCH(abs) – 0.05	tCK(avg)
DQS_t, DQS_c differential output LOW time (DBI-Enabled)	tQSL-DBI	Min	tCL(abs) – 0.045	tCK(avg)
DQS_t, DQS_c differential output HIGH time (DBI-Enabled)	tQSH-DBI	Min	tCH(abs) – 0.045	tCK(avg)
Read preamble	tRPRE	Min	2.0	tCK(avg)

Parameter	Symbol	Min/ Max	Data Rate	Unit
			3200Mbps	
0.5 tCK Read postamble	tRPST	Min	0.5	tCK(avg)
1.5 tCK Read postamble	tRPST	Min	1.5	tCK(avg)
DQS Low-Z from clock	tLZ(DQS)	Min	(RL x tCK)+ tDQSCK(Min) - (tRPRE(Max) x tCK) - 200ps	ps
DQ Low-Z from clock	tLZ(DQ)	Min	(RL x tCK) + tDQSCK(Min) - 200ps	ps
DQS High-Z from clock	tHZ(DQS)	Min	(RL x tCK) + tDQSCK(Max)+(BL/2 x tCK) + (tRPST(Max) xtCK) - 100ps	ps
DQ High-Z from clock	tHZ(DQ)	Min	(RL x tCK) + tDQSCK(Max) + tDQSQ(Max) + (BL/2 x tCK) -100ps	ps

8.5.3 Write Timing

Parameter	Symbol	Min/ Max	Data Rate	Unit
			3200Mbps	
Rx timing window total at VdIVW voltage levels	TdIVW_total	Max	0.3	UI
Rx timing window 1-bit toggle (at VdIVW voltage levels)	TdIVW_1-bit	Max	TBD	UI
DQ and DMI input pulse width (at VCENT_DQ)	TdIPW	Min	0.45	UI
DQ-to-DQS offset	tDQS2DQ	Min	200	ps
		Max	800	
DQ-to-DQ offset	tDQDQ	Max	30	ps
DQ-to-DQS offset temperature variation	tDQS2DQ_temp	Max	0.6	ps/°C
DQ-to-DQS offset voltage variation	tDQS2DQ_volt	Max	33	ps/50mV
DQ-to-DQS offset rank to rank variation	t DQS2DQ_rank2rank	Max	200	ps

Parameter	Symbol	Min/ Max	Data Rate	Unit
			3200Mbps	
WRITE command to first DQS transition	tDQSS	Min	0.75	tCK(avg)
		Max	1.25	
DQS input HIGH-level width	tDQSH	Min	0.4	tCK(avg)
DQS input LOW-level width	tDQSL	Min	0.4	tCK(avg)
DQS falling edge to CK setup time	tDSS	Min	0.2	tCK(avg)
DQS falling edge from CK hold time	tDSH	Min	0.2	tCK(avg)
0.5 Tck Write postamble	tWPST	MIN	0.5	tCK(avg)
1.5 Tck Write postamble	tWPST	Min	1.5	tCK(avg)
Write preamble	tWPRE	Min	2.0	tCK(avg)