

# D2516EC4BXGGB

## 4G bits DDR3L SDRAM

### (256M words x 16 bits)

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#### Specifications

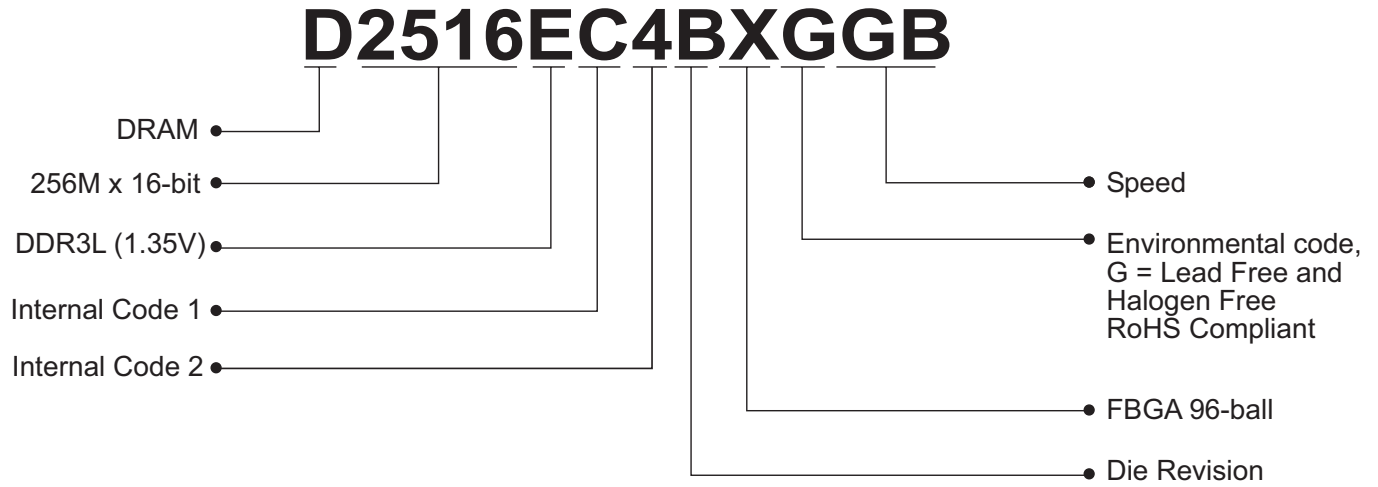
- Density: 4G bits
- Organization
  - 32Mwords x 16bits x 8banks
- Package
  - 96-ball FBGA
  - Lead-free (RoHS compliant) and Halogen-free
- Power supply: 1.35V (Typ)
  - VDD, VDDQ = 1.283V to 1.45V
  - Backward compatible for VDD, VDDQ=1.5V ± 0.075V
- Data rate
  - 1600Mbps/1333Mbps/1066Mbps (max.)
- 2KB page size
  - Row address: A0 to A14
  - Column address: A0 to A9
- Eight internal banks for concurrent operation
- Burst lengths (BL): 8 and 4 with Burst Chop (BC)
- Burst type (BT):
  - Sequential (8, 4 with BC)
  - Interleave (8, 4 with BC)
- Programmable /CAS (Read) Latency (CL)
- Programmable /CAS Write Latency (CWL)
- Precharge: auto precharge option for each burst access
- Driver strength: RZQ/7, RZQ/6 (RZQ = 240Ω)
- Refresh: auto-refresh, self-refresh
- Refresh cycles
  - Average refresh period
  - 7.8μs at 0°C ≤ TC ≤ +85°C
  - 3.9μs at +85°C < TC ≤ +95°C
- Operating case temperature range
  - TC = 0°C to +95°C

#### Features

- Double-data-rate architecture: two data transfers per clock cycle
- The high-speed data transfer is realized by the 8 bits prefetch pipelined architecture
- Bi-directional differential data strobe (DQS and /DQS) is transmitted/received with data for capturing data at the receiver
- DQS is edge-aligned with data for READs; center-aligned with data for WRITEs
- Differential clock inputs (CK and /CK)
- DLL aligns DQ and DQS transitions with CK transitions
- Commands entered on each positive CK edge; data and data mask referenced to both edges of DQS
- Data mask (DM) for write data
- Posted /CAS by programmable additive latency for better command and data bus efficiency
- On-Die Termination (ODT) for better signal quality
  - Synchronous ODT
  - Dynamic ODT
  - Asynchronous ODT
- Multi Purpose Register (MPR) for pre-defined pattern read out
- ZQ calibration for DQ drive and ODT
- Programmable Partial Array Self-Refresh (PASR)
- /RESET pin for Power-up sequence and reset function
- SRT range:
  - Normal/extended
- Programmable Output driver impedance control

## Ordering Information

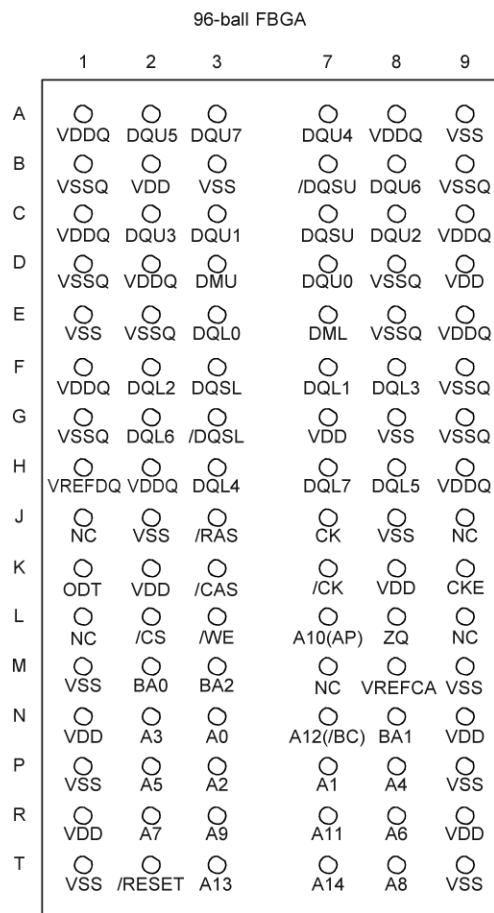
Part Number	Die Revision	Organization (words x bits)	Internal Banks	JEDEC speed bin (CL - tRCD - tRP)	Package
D2516EC4BXGGB	B	256M X 16	8	DDR3L-1600 (11-11-11)	96-ball FBGA



## Pin Configurations

### Pin Configurations (x 16 configuration)

/xxx indicates active low signal.



(Top view)

Pin name	Function	Pin name	Function
A0 to A14*2	Address inputs A10(AP): Auto precharge A12(/BC): Burst chop	/RESET*2	Active low asynchronous reset
BA0 to BA2*2	Bank select	VDD	Supply voltage for internal circuit
DQU0 to DQU7 DQL0 to DQL7	Data input/output	VSS	Ground for internal circuit
DQSU, /DQSU DQSL, /DQSL	Differential data strobe	VDDQ	Supply voltage for DQ circuit
/CS*2	Chip select	VSSQ	Ground for DQ circuit
/RAS, /CAS, /WE*2	Command input	VREFDQ	Reference voltage for DQ
CKE*2	Clock enable	VREFCA	Reference voltage for CA
CK, /CK	Differential clock input	ZQ	Reference pin for ZQ calibration
DMU, DML	Write data mask	NC*1	No connection
ODT*2	ODT control		

Notes: 1. Not internally connected with die.

2. Input only pins (address, command, CKE, ODT and /RESET) do not supply termination.

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## 1. Electrical Conditions

- All voltages are referenced to VSS (GND)
- Execute power-up and Initialization sequence before proper device operation is achieved.

### 1.1 Absolute Maximum Ratings

**Table 1: Absolute Maximum Ratings**

Parameter	Symbol	Rating	Unit	Notes
Power supply voltage	VDD	-0.4 to +1.975	V	1, 3
Power supply voltage for output	VDDQ	-0.4 to +1.975	V	1, 3
Input voltage	VIN	-0.4 to +1.975	V	1
Output voltage	VOUT	-0.4 to +1.975	V	1
Reference voltage	VREFCA	-0.4 to $0.6 \times VDD$	V	3
Reference voltage for DQ	VREFDQ	-0.4 to $0.6 \times VDDQ$	V	3
Storage temperature	Tstg	-55 to +100	°C	1, 2
Power dissipation	PD	1.0	W	1
Short circuit output current	IOUT	50	mA	1

- Notes: 1. Stresses greater than those listed under Absolute Maximum Ratings may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect reliability.
2. Storage temperature is the case surface temperature on the center/top side of the DRAM.
3. VDD and VDDQ must be within 300mV of each other at all times; and VREF must be no greater than  $0.6 \times VDDQ$ . When VDD and VDDQ are less than 500mV; VREF may be equal to or less than 300mV.

**Caution: Exposing the device to stress above those listed in Absolute Maximum Ratings could cause permanent damage. The device is not meant to be operated under conditions outside the limits described in the operational section of this specification. Exposure to Absolute Maximum Rating conditions for extended periods may affect device reliability.**

### 1.2 Operating Temperature Condition

**Table 2: Operating Temperature Condition**

Parameter	Symbol	Rating	Unit	Notes
Operating case temperature	TC	0 to +95	°C	1, 2, 3

- Notes: 1. Operating temperature is the case surface temperature on the center/top side of the DRAM.
2. The Normal Temperature Range specifies the temperatures where all DRAM specifications will be supported. During operation, the DRAM case temperature must be maintained between 0°C to +85°C under all operating conditions.
3. Some applications require operation of the DRAM in the Extended Temperature Range between +85°C and +95°C case temperature. Full specifications are guaranteed in this range, but the following additional conditions apply:
- Refresh commands must be doubled in frequency, therefore reducing the refresh interval tREFI to 3.9µs. (This double refresh requirement may not apply for some devices.)
  - If Self-refresh operation is required in the Extended Temperature Range, then it is mandatory to either use the Manual Self-Refresh mode with Extended Temperature Range capability (MR2 bit [A6, A7] = [0, 1]) or enable the optional Auto Self-Refresh mode (MR2 bit [A6, A7] = [1, 0]).

### 1.3 Recommended DC Operating Conditions

**Table 3-a: Recommended DC Operating Conditions (TC = 0°C to +85°C), DDR3L Operation.**

Parameter	Symbol	min	typ	max	Unit	Notes
Supply voltage	VDD	1.283	1.35	1.45	V	1, 2
Supply voltage for DQ	VDDQ	1.283	1.35	1.45	V	1, 2

Notes: 1. Under all conditions VDDQ must be less than or equal to VDD.

2. VDDQ tracks with VDD. AC parameters are measured with VDD and VDDQ tied together.

**Table 3-b: Recommended DC Operating Conditions (TC = 0°C to +85°C), DDR3 Operation.**

Parameter	Symbol	min	typ	max	Unit	Notes
Supply voltage	VDD	1.425	1.5	1.575	V	1, 2
Supply voltage for DQ	VDDQ	1.425	1.5	1.575	V	1, 2

Notes: 1. Under all conditions VDDQ must be less than or equal to VDD.

2. VDDQ tracks with VDD. AC parameters are measured with VDD and VDDQ tied together.

## 1.4 IDD and IDDQ Measurement Conditions

In this chapter, IDD and IDDQ measurement conditions such as test load and patterns are defined.

The figure Measurement Setup and Test Load for IDD and IDDQ Measurements shows the setup and test load for IDD and IDDQ measurements.

- IDD currents (such as IDD0, IDD1, IDD2N, IDD2NT, IDD2P0, IDD2P1, IDD2Q, IDD3N, IDD3P, IDD4R, IDD4W, IDD5B, IDD6, IDD6ET, IDD6TC and IDD7) are measured as time-averaged currents with all VDD balls of the DDR3 SDRAM under test tied together. Any IDDQ current is not included in IDD currents.
- IDDQ currents (such as IDDQ2NT and IDDQ4R) are measured as time-averaged currents with all VDDQ balls of the DDR3 SDRAM under test tied together. Any IDD current is not included in IDDQ currents.

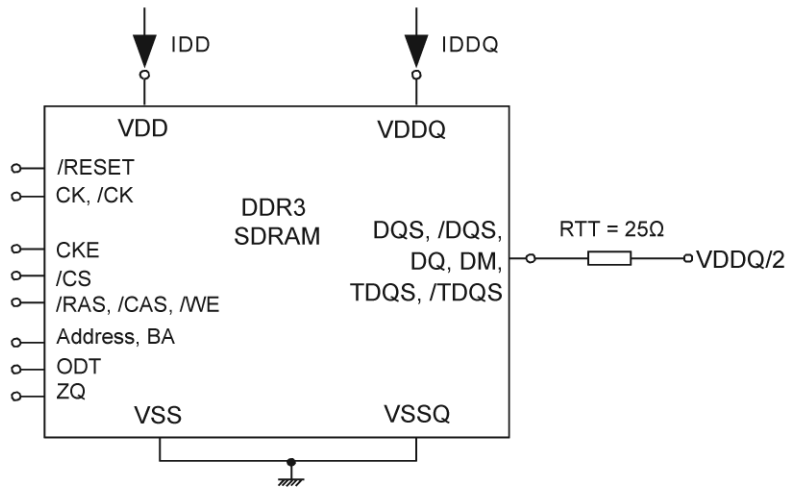
Note:IDDQ values cannot be directly used to calculate I/O power of the DDR3 SDRAM. They can be used to support correlation of simulated I/O power to actual I/O power as outlined in correlation from simulated channel I/O power to actual channel I/O power supported by IDDQ measurement.

For IDD and IDDQ measurements, the following definitions apply:

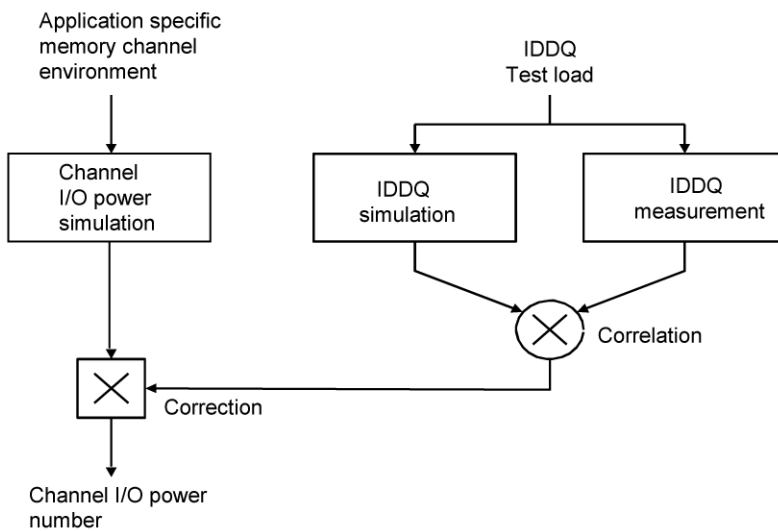
- L and 0:  $V_{IN} \leq V_{IL(AC)max}$
- H and 1:  $V_{IN} \geq V_{IH(AC)min}$
- MID-LEVEL: defined as inputs are  $V_{REF} = V_{DDQ} / 2$
- FLOATING: don't care or floating around  $V_{REF}$ .
- Timings used for IDD and IDDQ measurement-loop patterns are provided in Timings used for IDD and IDDQ Measurement-Loop Patterns table.
- Basic IDD and IDDQ measurement conditions are described in Basic IDD and IDDQ Measurement Conditions table.

Note:The IDD and IDDQ measurement-loop patterns need to be executed at least one time before actual IDD or IDDQ measurement is started.

- Detailed IDD and IDDQ measurement-loop patterns are described in IDD0 Measurement-Loop Pattern table through IDD7 Measurement-Loop Pattern table.
- IDD Measurements are done after properly initializing the DDR3 SDRAM. This includes but is not limited to setting.
  - RON = RZQ/7 (34Ω in MR1);
  - Qoff = 0B (Output Buffer enabled in MR1);
  - RTT\_Nom = RZQ/6 (40Ω in MR1);
  - RTT\_WR = RZQ/2 (120Ω in MR2);
  - TDQS Feature disabled in MR1
- Define D = {/CS, /RAS, /CAS, /WE} := {H, L, L, L}
- Define /D = {/CS, /RAS, /CAS, /WE} := {H, H, H, H}



**Figure 1: Measurement Setup and Test Load for IDD and IDDQ Measurements**



**Figure 2: Correlation from Simulated Channel I/O Power to Actual Channel I/O Power Supported by IDDQ Measurement**



#### 1.4.1 Timings Used for IDD and IDDQ Measurement-Loop Patterns

**Table 4: Timings Used for IDD and IDDQ Measurement-Loop Patterns**

Parameter	DDR3-1066	DDR3-1333	DDR3-1600	Unit
	7-7-7	9-9-9	11-11-11	
CL	7	9	11	nCK
tCK(min)	1.875	1.5	1.25	ns
nRCD(min)	7	9	11	nCK
nRC(min)	27	33	39	nCK
nRAS(min)	20	24	28	nCK
nRP(min)	7	9	11	nCK
nFAW	27	30	32	nCK
nRRD	6	5	6	nCK
nRFC	139	174	208	nCK

## 1.4.2 Basic IDD and IDDQ Measurement Conditions

**Table 5: Basic IDD and IDDQ Measurement Conditions**

Parameter	Symbol	Description
Operating one bank active precharge current	IDD0	CKE: H; External clock: on; tCK, nRC, nRAS, CL: see Table 4; BL: 8*1; AL: 0; /CS: H between ACT and PRE; Command, address, bank address inputs: partially toggling according to Table 6; Data I/O: MID-LEVEL; DM: stable at 0; Bank activity: cycling with one bank active at a time: 0,0,1,1,2,2,... (see Table 6); Output buffer and RTT: enabled in MR*2; ODT signal: stable at 0; Pattern details: see Table 6
Operating one bank active-read-precharge current	IDD1	CKE: H; External clock: On; tCK, nRC, nRAS, nRCD, CL: see Table 4; BL: 8*1..*6; AL: 0; /CS: H between ACT, RD and PRE; Command, address, bank address inputs, data I/O: partially toggling according to Table 7; DM: stable at 0; Bank activity: cycling with one bank active at a time: 0,0,1,1,2,2,... (see Table 7); Output buffer and RTT: enabled in MR*2; ODT Signal: stable at 0; Pattern details: see Table 7
Precharge standby current	IDD2N	CKE: H; External clock: on; tCK, CL: see Table 4 BL: 8*1; AL: 0; /CS: stable at 1; Command, address, bank address Inputs: partially toggling according to Table 8; data I/O: MID-LEVEL; DM: stable at 0; bank activity: all banks closed; output buffer and RTT: enabled in mode registers*2; ODT signal: stable at 0; pattern details: see Table 8
Precharge standby ODT current	IDD2NT	CKE: H; External clock: on; tCK, CL: see Table 4; BL: 8*1; AL: 0; /CS: stable at 1; Command, address, bank address Inputs: partially toggling according to Table 9; data I/O: MID-LEVEL; DM: stable at 0; bank activity: all banks closed; output buffer and RTT: enabled in MR*2; ODT signal: toggling according to Table 9; pattern details: see Table 9
Precharge standby ODT IDDQ current	IDDQ2NT	Same definition like for IDD2NT, however measuring IDDQ current instead of IDD current
Precharge power-down current slow exit	IDD2P0	CKE: L; External clock: on; tCK, CL: see Table 4; BL: 8*1; AL: 0; /CS: stable at 1; Command, address, bank address inputs: stable at 0; data I/O: MID-LEVEL; DM: stable at 0; bank activity: all banks closed; output buffer and RTT: EMR*2; ODT signal: stable at 0; precharge power down mode: slow exit*3
Precharge power-down current fast exit	IDD2P1	CKE: L; External clock: on; tCK, CL: see Table 4; BL: 8*1; AL: 0; /CS: stable at 1; Command, address, bank address Inputs: stable at 0; data I/O: MID-LEVEL; DM: stable at 0; bank activity: all banks closed; output buffer and RTT: enabled in MR*2; ODT signal: stable at 0; precharge power down mode: fast exit*3
Precharge quiet standby current	IDD2Q	CKE: H; External clock: On; tCK, CL: see Table 4; BL: 8*1; AL: 0; /CS: stable at 1; Command, address, bank address Inputs: stable at 0; data I/O: MID-LEVEL; DM: stable at 0; bank activity: all banks closed; output buffer and RTT: enabled in MR*2; ODT signal: stable at 0
Active standby current	IDD3N	CKE: H; External clock: on; tCK, CL: see Table 4; BL: 8*1; AL: 0; /CS: stable at 1; Command, address, bank address Inputs: partially toggling according to Table 8; data I/O: MID-LEVEL; DM: stable at 0; bank activity: all banks open; output buffer and RTT: enabled in MR*2; ODT signal: stable at 0; pattern details: see Table 8
Active power-down current	IDD3P	CKE: L; External clock: on; tCK, CL: see Table 4; BL: 8*1; AL: 0; /CS: stable at 1; Command, address, bank address inputs: stable at 0; data I/O: MID-LEVEL; DM: stable at 0; bank activity: all banks open; output buffer and RTT: enabled in MR*2; ODT signal: stable at 0
Operating burst read current	IDD4R	CKE: H; External clock: on; tCK, CL: see Table 4; BL: 8*1..*6; AL: 0; /CS: H between RD; Command, address, bank address Inputs: partially toggling according to Table 10; data I/O: seamless read data burst with different data between one burst and the next one according to Table 10; DM: stable at 0; bank activity: all banks open, RD commands cycling through banks: 0,0,1,1,2,2,... (see Table 10); Output buffer and RTT: enabled in MR*2; ODT signal: stable at 0; pattern details: see Table 10
Operating burst read IDDQ current	IDDQ4R	Same definition like for IDD4R, however measuring IDDQ current instead of IDD current

**Table 5: Basic IDD and IDDQ Measurement Conditions (cont'd)**

Parameter	Symbol	Description
Operating burst write current	IDD4W	CKE: H; External clock: on; tCK, CL: see Table 4; BL: 8*1; AL: 0; /CS: H between WR; command, address, bank address inputs: partially toggling according to Table 11; data I/O: seamless write data burst with different data between one burst and the next one according to IDD4W Measurement-Loop Pattern table; DM: stable at 0; bank activity: all banks open, WR commands cycling through banks: 0,0,1,1,2,2,... (see Table 11); Output buffer and RTT: enabled in MR*2; ODT signal: stable at H; pattern details: see Table 11
Burst refresh current	IDD5B	CKE: H; External clock: on; tCK, CL, nRFC: see Table 4; BL: 8*1; AL: 0; /CS: H between REF; Command, address, bank address Inputs: partially toggling according to Table 12; data I/O: MID-LEVEL; DM: stable at 0; bank activity: REF command every nRFC (Table 12); output buffer and RTT: enabled in MR*2; ODT signal: stable at 0; pattern details: see Table 12
Self-refresh current: normal temperature range	IDD6	TC: 0 to 85°C; ASR: disabled*4; SRT: Normal*5; CKE: L; External clock: off; CK and /CK: L; CL: see Table 4; BL: 8*1; AL: 0; /CS, command, address, bank address, data I/O: MID-LEVEL; DM: stable at 0; bank activity: Self-refresh operation; output buffer and RTT: enabled in MR*2; ODT signal: MID-LEVEL
Self-refresh current: extended temperature range	IDD6ET	TC: 0 to 95°C; ASR: Disabled*4; SRT: Extended*5; CKE: L; External clock: off; CK and /CK: L; CL: Table 4; BL: 8*1; AL: 0; /CS, command, address, bank address, data I/O: MID-LEVEL; DM: stable at 0; bank activity: Extended temperature self-refresh operation; output buffer and RTT: enabled in MR*2; ODT signal: MID-LEVEL
Auto self-refresh current (Optional)	IDD6TC	TC: 0 to 95°C; ASR: Enabled*4; SRT: Normal*5; CKE: L; External clock: off; CK and /CK: L; CL: Table 4; BL: 8*1; AL: 0; /CS, command, address, bank address, data I/O: MID-LEVEL; DM: stable at 0; bank activity: Auto self-refresh operation; output buffer and RTT: enabled in MR*2; ODT signal: MID-LEVEL
Operating bank interleave read current	IDD7	CKE: H; External clock: on; tCK, nRC, nRAS, nRCD, nRRD, nFAW, CL: see Table 4; BL: 8*1, *6; AL: CL-1; /CS: H between ACT and RDA; Command, address, bank address Inputs: partially toggling according to Table 13; data I/O: read data bursts with different data between one burst and the next one according to Table 13; DM: stable at 0; bank activity: two times interleaved cycling through banks (0, 1, ... 7) with different addressing, see Table 13; output buffer and RTT: enabled in MR*2; ODT signal: stable at 0; pattern details: see Table 13
RESET low current	IDD8	/RESET: low; External clock: off; CK and /CK: low; CKE: FLOATING; /CS, command, address, bank address, Data IO: FLOATING; ODT signal: FLOATING RESET low current reading is valid once power is stable and /RESET has been low for at least 1ms.

- Notes: 1. Burst Length: BL8 fixed by MRS: MR0 bits [1,0] = [0,0].
2. MR: Mode Register  
Output buffer enable: set MR1 bit A12 = 1 and MR1 bits [5, 1] = [0,1];  
RTT\_Nom enable: set MR1 bits [9, 6, 2] = [0, 1, 1]; RTT\_WR enable: set MR2 bits [10, 9] = [1,0].
3. Precharge power down mode: set MR0 bit A12= 0 for Slow Exit or MR0 bit A12 = 1 for fast exit.
4. Auto self-refresh (ASR): set MR2 bit A6 = 0 to disable or 1 to enable feature.
5. Self-refresh temperature range (SRT): set MR0 bit A7= 0 for normal or 1 for extended temperature range.
6. Read burst type: nibble sequential, set MR0 bit A3 = 0

**Table 6: IDD0 Measurement-Loop Pattern**

CK, /CK	CKE	Sub -Loop	Cycle number	Com- mand	/CS	/RAS	/CAS	/WE	ODT	BA* <sup>3</sup>	A11 -Am	A10	A7 -A9	A3 -A6	A0 -A2	Data* <sup>2</sup>				
Toggling	Static	H	0	ACT	0	0	1	1	0	0	0	0	0	0	0	0				
			1, 2	D, D	1	0	0	0	0	0	0	0	0	0	0	0	0			
			3, 4	/D, /D	1	1	1	1	0	0	0	0	0	0	0	0	0			
			...	Repeat pattern 1...4 until nRAS – 1, truncate if necessary																
			nRAS	PRE	0	0	1	0	0	0	0	0	0	0	0	0	0	0		
			...	Repeat pattern 1...4 until nRC – 1, truncate if necessary																
			1 × nRC	ACT	0	0	1	1	0	0	0	0	0	0	0	F	0			
			+ 0																	
			1 × nRC	D, D	1	0	0	0	0	0	0	0	0	0	0	F	0			
			+ 1, 2																	
			1 × nRC	/D, /D	1	1	1	1	0	0	0	0	0	0	0	F	0			
			+ 3, 4																	
			...	Repeat pattern nRC + 1,...,4 until 1 × nRC + nRAS – 1, truncate if necessary																
			1 × nRC	PRE	0	0	1	0	0	0	0	0	0	0	0	F	0			
			+ nRAS																	
			...	Repeat nRC + 1,...,4 until 2 × nRC – 1, truncate if necessary																
			1	2 × nRC	Repeat Sub-Loop 0, use BA= 1 instead															
			2	4 × nRC	Repeat Sub-Loop 0, use BA= 2 instead															
			3	6 × nRC	Repeat Sub-Loop 0, use BA= 3 instead															
			4	8 × nRC	Repeat Sub-Loop 0, use BA= 4 instead															
			5	10 × nRC	Repeat Sub-Loop 0, use BA= 5 instead															
6	12 × nRC	Repeat Sub-Loop 0, use BA= 6 instead																		
7	14 × nRC	Repeat Sub-Loop 0, use BA= 7 instead																		

- Notes: 1. DM must be driven low all the time. DQS, /DQS are FLOATING.  
2. DQ signals are FLOATING.  
3. BA: BA0 to BA2.

Table 7: IDD1 Measurement-Loop Pattern

CK, /CK	CKE	Sub -Loop	Cycle number	Com- mand	/CS	/RAS	/CAS	/WE	ODT	BA* <sup>3</sup>	A11 -Am	A10	A7 -A9	A3 -A6	A0 -A2	Data* <sup>2</sup>
			0	ACT	0	0	1	1	0	0	0	0	0	0	0	—
			1, 2	D, D	1	0	0	0	0	0	0	0	0	0	0	—
			3, 4	/D, /D	1	1	1	1	0	0	0	0	0	0	0	—
			...	Repeat pattern 1...4 until nRCD – 1, truncate if necessary												
			nRCD	RD	0	1	0	1	0	0	0	0	0	0	0	00000000
			...	Repeat pattern 1...4 until nRAS – 1, truncate if necessary												
			nRAS	PRE	0	0	1	0	0	0	0	0	0	0	0	—
			...	Repeat pattern 1...4 until nRC – 1, truncate if necessary												
			1 × nRC + 0	ACT	0	0	1	1	0	0	0	0	0	F	0	—
		0	1 × nRC + 1, 2	D, D	1	0	0	0	0	0	0	0	0	F	0	—
			1 × nRC + 3, 4	/D, /D	1	1	1	1	0	0	0	0	0	F	0	—
			...	Repeat pattern nRC + 1,..., 4 until nRC + nRCD – 1, truncate if necessary												
			1 × nRC + nRCD	RD	0	1	0	1	0	0	0	0	0	F	0	00110011
			...	Repeat pattern nRC + 1,..., 4 until nRC + nRAS – 1, truncate if necessary												
			1 × nRC + nRAS	PRE	0	0	1	0	0	0	0	0	0	F	0	—
			...	Repeat pattern nRC + 1,..., 4 until 2 × nRC – 1, truncate if necessary												
			1	2 × nRC	Repeat Sub-Loop 0, use BA= 1 instead											
			2	4 × nRC	Repeat Sub-Loop 0, use BA= 2 instead											
			3	6 × nRC	Repeat Sub-Loop 0, use BA= 3 instead											
			4	8 × nRC	Repeat Sub-Loop 0, use BA= 4 instead											
			5	10 × nRC	Repeat Sub-Loop 0, use BA= 5 instead											
			6	12 × nRC	Repeat Sub-Loop 0, use BA= 6 instead											
			7	14 × nRC	Repeat Sub-Loop 0, use BA= 7 instead											

- Notes: 1. DM must be driven low all the time. DQS, /DQS are used according to read commands, otherwise FLOATING.  
2. Burst sequence driven on each DQ signal by read command. Outside burst operation, DQ signals are FLOATING.  
3. BA: BA0 to BA2.

**Table 8: IDD2N and IDD3N Measurement-Loop Pattern**

CK, /CK	CKE	Sub -Loop	Cycle number	Com- mand	/CS	/RAS	/CAS	/WE	ODT	BA* <sup>3</sup>	A11 -Am	A10	A7 -A9	A3 -A6	A0 -A2	Data* <sup>2</sup>
			0	D	1	0	0	0	0	0	0	0	0	0	0	0
		0	1	D	1	0	0	0	0	0	0	0	0	0	0	0
			2	/D	1	1	1	1	0	0	0	0	0	F	0	
			3	/D	1	1	1	1	0	0	0	0	0	F	0	
		1	4 to 7	Repeat Sub-Loop 0, use BA= 1 instead												
Toggleing	Static H	2	8 to 11	Repeat Sub-Loop 0, use BA= 2 instead												
		3	12 to 15	Repeat Sub-Loop 0, use BA= 3 instead												
		4	16 to 19	Repeat Sub-Loop 0, use BA= 4 instead												
		5	20 to 23	Repeat Sub-Loop 0, use BA= 5 instead												
		6	24 to 27	Repeat Sub-Loop 0, use BA= 6 instead												
		7	28 to 31	Repeat Sub-Loop 0, use BA= 7 instead												

- Notes: 1. DM must be driven low all the time. DQS, /DQS are FLOATING.  
 2. DQ signals are FLOATING.  
 3. BA: BA0 to BA2.

**Table 9: IDD2NT and IDDQ2NT Measurement-Loop Pattern**

CK, /CK	CKE	Sub -Loop	Cycle number	Com- mand	/CS	/RAS	/CAS	/WE	ODT	BA* <sup>3</sup>	A11 -Am	A10	A7 -A9	A3 -A6	A0 -A2	Data* <sup>2</sup>
			0	D	1	0	0	0	0	0	0	0	0	0	0	0
		0	1	D	1	0	0	0	0	0	0	0	0	0	0	0
			2	/D	1	1	1	1	0	0	0	0	0	F	0	
			3	/D	1	1	1	1	0	0	0	0	0	F	0	
		1	4 to 7	Repeat Sub-Loop 0, but ODT = 0 and BA= 1												
Toggleing	Static H	2	8 to 11	Repeat Sub-Loop 0, but ODT = 1 and BA= 2												
		3	12 to 15	Repeat Sub-Loop 0, but ODT = 1 and BA= 3												
		4	16 to 19	Repeat Sub-Loop 0, but ODT = 0 and BA= 4												
		5	20 to 23	Repeat Sub-Loop 0, but ODT = 0 and BA= 5												
		6	24 to 27	Repeat Sub-Loop 0, but ODT = 1 and BA= 6												
		7	28 to 31	Repeat Sub-Loop 0, but ODT = 1 and BA= 7												

- Notes: 1. DM must be driven low all the time. DQS, /DQS are FLOATING.  
 2. DQ signals are FLOATING.  
 3. BA: BA0 to BA2.

**Table 10: IDD4R and IDDQ4R Measurement-Loop Pattern**

CK, /CK	CKE	Sub -Loop	Cycle number	Com- mand	/CS	/RAS	/CAS	/WE	ODT	BA* <sup>3</sup>	A11 -Am	A10	A7 -A9	A3 -A6	A0 -A2	Data* <sup>2</sup>
			0	RD	0	1	0	1	0	0	0	0	0	0	0	00000000
			1	D	1	0	0	0	0	0	0	0	0	0	0	—
		0	2,3	/D, /D	1	1	1	1	0	0	0	0	0	0	0	—
			4	RD	0	1	0	1	0	0	0	0	0	F	0	00110011
			5	D	1	0	0	0	0	0	0	0	0	F	0	—
			6,7	/D, /D	1	1	1	1	0	0	0	0	0	F	0	—
Toggling	Static H	1	8 to 15	Repeat Sub-Loop 0, but BA= 1												
		2	16 to 23	Repeat Sub-Loop 0, but BA= 2												
		3	24 to 31	Repeat Sub-Loop 0, but BA= 3												
		4	32 to 39	Repeat Sub-Loop 0, but BA= 4												
		5	40 to 47	Repeat Sub-Loop 0, but BA= 5												
		6	48 to 55	Repeat Sub-Loop 0, but BA= 6												
		7	56 to 63	Repeat Sub-Loop 0, but BA= 7												

- Notes: 1. DM must be driven low all the time. DQS, /DQS are used according to read commands, otherwise FLOATING.  
2. Burst sequence driven on each DQ signal by read command. Outside burst operation, DQ signals are FLOATING.  
3. BA: BA0 to BA2.

**Table 11: IDD4W Measurement-Loop Pattern**

CK, /CK	CKE	Sub -Loop	Cycle number	Com- mand	/CS	/RAS	/CAS	/WE	ODT	BA* <sup>3</sup>	A11 -Am	A10	A7 -A9	A3 -A6	A0 -A2	Data* <sup>2</sup>
			0	WR	0	1	0	0	1	0	0	0	0	0	0	00000000
			1	D	1	0	0	0	1	0	0	0	0	0	0	—
		0	2,3	/D, /D	1	1	1	1	1	0	0	0	0	0	0	—
			4	WR	0	1	0	0	1	0	0	0	0	F	0	00110011
			5	D	1	0	0	0	1	0	0	0	0	F	0	—
			6,7	/D, /D	1	1	1	1	1	0	0	0	0	F	0	—
Toggling	Static H	1	8 to 15	Repeat Sub-Loop 0, but BA= 1												
		2	16 to 23	Repeat Sub-Loop 0, but BA= 2												
		3	24 to 31	Repeat Sub-Loop 0, but BA= 3												
		4	32 to 39	Repeat Sub-Loop 0, but BA= 4												
		5	40 to 47	Repeat Sub-Loop 0, but BA= 5												
		6	48 to 55	Repeat Sub-Loop 0, but BA= 6												
		7	56 to 63	Repeat Sub-Loop 0, but BA= 7												

- Notes: 1. DM must be driven low all the time. DQS, /DQS are used according to write commands, otherwise FLOATING.  
2. Burst sequence driven on each DQ signal by write command. Outside burst operation, DQ signals are FLOATING.  
3. BA: BA0 to BA2.

**Table 12: IDD5B Measurement-Loop Pattern**

CK, /CK	CKE	Sub -Loop	Cycle number	Com- mand	/CS	/RAS	/CAS	/WE	ODT	BA* <sup>3</sup>	A11 -Am	A10	A7 -A9	A3 -A6	A0 -A2	Data* <sup>2</sup>
			0	REF	0	0	0	1	0	0	0	0	0	0	0	—
		0	1, 2	D	1	0	0	0	0	0	0	0	0	0	0	—
			3,4	/D, /D	1	1	1	1	0	0	0	0	0	F	0	—
			5 to 8	Repeat cycles 1...4, but BA= 1												
			9 to 12	Repeat cycles 1...4, but BA= 2												
			13 to 16	Repeat cycles 1...4, but BA= 3												
Toggling	Static H	1	17 to 20	Repeat cycles 1...4, but BA= 4												
			21 to 24	Repeat cycles 1...4, but BA= 5												
			25 to 28	Repeat cycles 1...4, but BA= 6												
			29 to 32	Repeat cycles 1...4, but BA= 7												
		2	33 to nRFC - 1	Repeat Sub-Loop 1, until nRFC - 1. Truncate, if necessary.												

- Notes: 1. DM must be driven low all the time. DQS, /DQS are FLOATING.  
2. DQ signals are FLOATING.  
3. BA: BA0 to BA2.



Table 13: IDD7 Measurement-Loop Pattern

CK, /CK	CKE	Sub -Loop	Cycle number	Com- mand	/CS	/RAS	/CAS	/WE	ODT	A11 BA*3	A7 -Am	A3 A10	A0 -A9	A0 -A6	A0 -A2	Data*2
			0	ACT	0	0	1	1	0	0	0	0	0	0	0	—
		0	1	RDA	0	1	0	1	0	0	0	1	0	0	0	00000000
			2	D	1	0	0	0	0	0	0	0	0	0	0	—
			...	Repeat above D Command until nRRD – 1												
			nRRD	ACT	0	0	1	1	0	1	0	0	0	F	0	—
		1	nRRD + 1	RDA	0	1	0	1	0	1	0	1	0	F	0	00110011
			nRRD + 2	D	1	0	0	0	0	1	0	0	0	F	0	—
			...	Repeat above D Command until 2 × nRRD – 1												
		2	2 × nRRD	Repeat Sub-Loop 0, but BA= 2												
		3	3 × nRRD	Repeat Sub-Loop 1, but BA= 3												
		4	4 × nRRD	D	1	0	0	0	0	3	0	0	0	F	0	—
				Assert and repeat above D Command until nFAW – 1, if necessary												
		5	nFAW	Repeat Sub-Loop 0, but BA= 4												
		6	nFAW + nRRD	Repeat Sub-Loop 1, but BA= 5												
		7	nFAW + 2 × nRRD	Repeat Sub-Loop 0, but BA= 6												
		8	nFAW + 3 × nRRD	Repeat Sub-Loop 1, but BA= 7												
		9	nFAW + 4 × nRRD	D	1	0	0	0	0	7	0	0	0	F	0	—
				Assert and repeat above D Command until 2 × nFAW – 1, if necessary												
			2 × nFAW + 0	ACT	0	0	1	1	0	0	0	0	0	F	0	—
Toggle	Static	H	10	2 × nFAW + 1	RDA	0	1	0	1	0	0	1	0	F	0	00110011
			2 × nFAW + 2	D	1	0	0	0	0	0	0	0	0	F	0	—
				Repeat above D Command until 2 × nFAW + nRRD – 1												
			2 × nFAW + nRRD	ACT	0	0	1	1	0	1	0	0	0	0	0	—
		11	2 × nFAW + nRRD + 1	RDA	0	1	0	1	0	1	0	1	0	0	0	00000000
			2 × nFAW + nRRD + 2	D	1	0	0	0	0	1	0	0	0	0	0	—
				Repeat above D Command until 2 × nFAW + 2 × nRRD – 1												
		12	2 × nFAW + 2 × nRRD	Repeat Sub-Loop 10, but BA= 2												
		13	2 × nFAW + 3 × nRRD	Repeat Sub-Loop 11, but BA= 3												
		14	2 × nFAW + 4 × nRRD	D	1	0	0	0	0	3	0	0	0	0	0	—
				Assert and repeat above D Command until 3 × nFAW – 1, if necessary												
		15	3 × nFAW	Repeat Sub-Loop 10, but BA= 4												
		16	3 × nFAW + nRRD	Repeat Sub-Loop 11, but BA= 5												
		17	3 × nFAW + 2 × nRRD	Repeat Sub-Loop 10, but BA= 6												
		18	3 × nFAW + 3 × nRRD	Repeat Sub-Loop 11, but BA= 7												
		19	3 × nFAW + 4 × nRRD	D	1	0	0	0	0	7	0	0	0	0	0	—
				Assert and repeat above D Command until 4 × nFAW – 1, if necessary												

- Notes: 1. DM must be driven low all the time. DQS, /DQS are used according to read commands, otherwise FLOATING.  
2. Burst sequence driven on each DQ signal by read command. Outside burst operation, DQ signals are FLOATING.  
3. BA: BA0 to BA2.

## 2. Electrical Specifications

### 2.1 DC Characteristics

**Table 14: DC Characteristics 1 (TC = 0°C to +85°C, VDD, VDDQ = 1.283V to 1.45V)**

Parameter	Symbol	Data rate (Mbps)	X16	Unit	Notes
			max		
Operating current (ACT-PRE)	IDD0	1066	55	mA	
		1333	60		
		1600	65		
Operating current (ACT-RD-PRE)	IDD1	1066	70	mA	
		1333	75		
		1600	80		
Precharge power-down standby current	IDD2P1	1066	30	mA	Fast PD Exit
		1333	35		
		1600	40		
Precharge standby current	IDD2P0	1066	20	mA	Slow PD Exit
		1333	20		
		1600	20		
Precharge standby current	IDD2N	1066	45	mA	
		1333	45		
		1600	45		
Precharge standby ODT current	IDD2NT	1066	45	mA	
		1333	45		
		1600	45		
Precharge quiet standby current	IDD2Q	1066	40	mA	
		1333	45		
		1600	50		
Active power-down current (Always fast exit)	IDD3P	1066	37	mA	
		1333	39		
		1600	41		
Active standby current	IDD3N	1066	50	mA	
		1333	55		
		1600	60		
Operating current (Burst read operating)	IDD4R	1066	125	mA	
		1333	135		
		1600	145		
Operating current (Burst write operating)	IDD4W	1066	135	mA	
		1333	145		
		1600	155		
Burst refresh current	IDD5B	1066	250	mA	
		1333	250		
		1600	250		
All bank interleave read current	IDD7	1066	210	mA	
		1333	220		
		1600	230		
RESET low current	IDD8		17	mA	

**Table 15: Self-Refresh Current (TC = 0°C to +85°C, VDD, VDDQ = 1.283V to 1.45V)**

Parameter	Symbol	Value	Unit	Notes
Self-refresh current normal temperature range	IDD6	12	mA	Max
Self-refresh current extended temperature range	IDD6ET	25	mA	Max

## 2.2 Pin Capacitance

**Table 16: Pin Capacitance [DDR3-1066 to 1600] (TC = 25°C, VDD, VDDQ = 1.283V to 1.45V)**

Parameter	Symbol	DDR3-1066		DDR3-1333		DDR3-1600		Units	Notes
		Min	Max	Min	Max	Min	Max		
Input/output capacitance	CIO	1.4	2.7	1.4	2.5	1.4	2.3	pF	1, 2
Input capacitance, CK and /CK	CCK	0.8	1.6	0.8	1.4	0.8	1.4	pF	2
Input capacitance delta, CK and /CK	CDCK	0	0.15	0	0.15	0	0.15	pF	2, 3
Input/output capacitance delta, DQS and /DQS	CDDQS	0	0.2	0	0.15	0	0.15	pF	2, 4
Input capacitance, (control, address, command, input-only pins)	CI	0.75	1.35	0.75	1.3	0.75	1.3	pF	2, 5
Input capacitance delta, (All control input-only pins)	CDI_CTRL	-0.5	0.3	-0.4	0.2	-0.4	0.2	pF	2, 6, 7
Input capacitance delta, (All address/command input-only pins)	CDI_ADD_CMD	-0.5	0.5	-0.4	0.4	-0.4	0.4	pF	2, 8, 9
Input/output capacitance delta, DQ,DM, DQS, /DQS, TDQS, /TDQS	CDIO	-0.5	0.3	-0.5	0.3	-0.5	0.3	pF	2, 10
Input/output capacitance of ZQ pin	CZQ	—	3	—	3	—	3	pF	2, 11

- Notes: 1. Although the DM, TDQS and /TDQS pins have different functions, the loading matches DQ and DQS.  
 2. VDD, VDDQ, VSS, VSSQ applied and all other pins floating (except the pin under test, CKE, /RESET and ODT as necessary). VDD = VDDQ = 1.5V, VBIAS=VDD/2 and ondie termination off.  
 3. Absolute value of CCK-C/CK.  
 4. Absolute value of CIO(DQS)-CIO(/DQS).  
 5. CI applies to ODT, /CS, CKE, A0-A15, BA0-BA2, /RAS, /CAS and /WE.  
 6. CDI\_CTRL applies to ODT, /CS and CKE.  
 7.  $CDI\_CTRL = CI(CTRL) - 0.5 \times (CI(CK) + CI(/CK))$ .  
 8. CDI\_ADD\_CMD applies to A0-A15, BA0-BA2, /RAS, /CAS and /WE.  
 9.  $CDI\_ADD\_CMD = CI(ADD\_CMD) - 0.5 \times (CI(CK) + CI(/CK))$ .  
 10.  $CDIO = CIO(DQ,DM) - 0.5 \times (CIO(DQS) + CIO(/DQS))$ .  
 11. Maximum external load capacitance on ZQ pin: 5pF.

## 2.3 Standard Speed Bins

**Table 17: DDR3-1066 Speed Bins**

Speed Bin		DDR3-1066		Unit	Notes
CL-tRCD-tRP		7-7-7			
Symbol	/CAS write latency	min	max		
tAA		13.125	20	ns	9
tRCD		13.125	—	ns	9
tRP		13.125	—	ns	9
tRC		50.625	—	ns	9
tRAS		37.5	9 × tREFI	ns	8
tCK(avg) @CL=5	CWL = 5	3.0	3.3	ns	1, 2, 3, 4, 5
	CWL = 6	Reserved	Reserved	ns	4
tCK(avg) @CL=6	CWL = 5	2.5	3.3	ns	1, 2, 3, 5
	CWL = 6	Reserved	Reserved	ns	4
tCK(avg) @CL=7	CWL = 5	Reserved	Reserved	ns	4
	CWL = 6	1.875	< 2.5	ns	1, 2, 3, 4
tCK(avg) @CL=8	CWL = 5	Reserved	Reserved	ns	4
	CWL = 6	1.875	< 2.5	ns	1, 2, 3
Supported CL settings			5, 6, 7, 8	nCK	
Supported CWL settings			5, 6	nCK	

**Table 18: DDR3-1333 Speed Bins**

Speed Bin CL-tRCD-tRP		DDR3-1333		Unit	Notes
		9-9-9			
Symbol	/CAS write latency	min	max		
tAA		13.5 (13.125)	20	ns	9
tRCD		13.5 (13.125)	—	ns	9
tRP		13.5 (13.125)	—	ns	9
tRC		49.5 (49.125)	—	ns	9
tRAS		36	9 × tREFI	ns	8
tCK(avg) @CL=5	CWL = 5	3.0	3.3	ns	1, 2, 3, 4, 6
	CWL = 6, 7	Reserved	Reserved	ns	4
tCK(avg) @CL=6	CWL = 5	2.5	3.3	ns	1, 2, 3, 6
	CWL = 6	Reserved	Reserved	ns	4
	CWL = 7	Reserved	Reserved	ns	4
tCK(avg) @CL=7	CWL = 5	Reserved	Reserved	ns	4
	CWL = 6	1.875	< 2.5	ns	1, 2, 3, 4, 6
	CWL = 7	Reserved	Reserved	ns	4
tCK(avg) @CL=8	CWL = 5	Reserved	Reserved	ns	4
	CWL = 6	1.875	< 2.5	ns	1, 2, 3, 6
	CWL = 7	Reserved	Reserved	ns	4
tCK(avg) @CL=9	CWL = 5, 6	Reserved	Reserved	ns	4
	CWL = 7	1.5	< 1.875	ns	1, 2, 3, 4
tCK(avg) @CL=10	CWL = 5, 6	Reserved	Reserved	ns	4
	CWL = 7	1.5	< 1.875	ns	1, 2, 3
Supported CL settings			5, 6, 7, 8, 9, 10	nCK	
Supported CWL settings			5, 6, 7	nCK	

**Table 19: DDR3-1600 Speed Bins**

Speed Bin		DDR3-1600			
CL-tRCD-tRP		11-11-11		Unit	Notes
Symbol	/CAS write latency	min	max		
tAA		13.75 (13.125)	20	ns	9
tRCD		13.75 (13.125)	—	ns	9
tRP		13.75 (13.125)	—	ns	9
tRC		48.75 (48.125)	—	ns	9
tRAS		35	9 × tREFI	ns	8
tCK(avg) @CL=5	CWL = 5	3.0	3.3	ns	1, 2, 3, 4, 7
	CWL = 6, 7, 8	Reserved	Reserved	ns	4
tCK(avg) @CL=6	CWL = 5	2.5	3.3	ns	1, 2, 3, 7
	CWL = 6	Reserved	Reserved	ns	4
	CWL = 7, 8	Reserved	Reserved	ns	4
tCK(avg) @CL=7	CWL = 5	Reserved	Reserved	ns	4
	CWL = 6	1.875	< 2.5	ns	1, 2, 3, 4, 7
	CWL = 7	Reserved	Reserved	ns	4
tCK(avg) @CL=8	CWL = 8	Reserved	Reserved	ns	4
	CWL = 5	Reserved	Reserved	ns	4
	CWL = 6	1.875	< 2.5	ns	1, 2, 3, 7
tCK(avg) @CL=9	CWL = 7	Reserved	Reserved	ns	4
	CWL = 5, 6	Reserved	Reserved	ns	4
	CWL = 8	1.5	< 1.875	ns	1, 2, 3, 4, 7
tCK(avg) @CL=10	CWL = 8	Reserved	Reserved	ns	4
	CWL = 7	Reserved	Reserved	ns	4
	CWL = 5, 6	Reserved	Reserved	ns	4
tCK(avg) @CL=11	CWL = 7	1.5	< 1.875	ns	1, 2, 3, 7
	CWL = 8	Reserved	Reserved	ns	4
	CWL = 5, 6, 7	Reserved	Reserved	ns	4
	CWL = 8	1.25	< 1.5	ns	1, 2, 3
Supported CL settings		5, 6, 7, 8, 9, 10, 11		nCK	
Supported CWL settings		5, 6, 7, 8		nCK	

- Notes:
1. The CL setting and CWL setting result in tCK(avg)min and tCK(avg)max requirements. When making a selection of tCK(avg), both need to be fulfilled: Requirements from CL setting as well as requirements from CWL setting.
  2. tCK(avg)min limits: Since /CAS latency is not purely analog - data and strobe output are synchronized by the DLL - all possible intermediate frequencies may not be guaranteed. An application should use the next smaller JEDEC standard tCK(avg) value (3.0, 2.5, 1.875, 1.5, or 1.25ns) when calculating CL(nCK) = tAA(ns) / tCK(avg)(ns), rounding up to the next 'Supported CL'.
  3. tCK(avg)max limits: Calculate tCK(avg) + tAA(max)/CL selected and round the resulting tCK(avg) down to the next valid speed bin (i.e. 3.3ns or 2.5ns or 1.875ns or 1.25ns). This result is tCK(avg)max corresponding to CL selected.
  4. 'Reserved' settings are not allowed. User must program a different value.
  5. Any DDR3-1066 speed bin also supports functional operation at lower frequencies as shown in the table DDR3-1066 Speed Bins which are not subject to production tests but verified by design/characterization.
  6. Any DDR3-1333 speed bin also supports functional operation at lower frequencies as shown in the table DDR3-1333 Speed Bins which is not subject to production tests but verified by design/characterization.
  7. Any DDR3-1600 speed bin also supports functional operation at lower frequencies as shown in the table DDR3-1600 Speed Bins which is not subject to production tests but verified by design/characterization.
  8. tREFI depends on operating case temperature (TC).
  9. For devices supporting optional down binning to CL = 7 and CL = 9, tAA/tRCD/tRP(min) must be 13.125 ns or lower. SPD settings must be programmed to match.





**NOTES FOR CMOS DEVICES****① PRECAUTION AGAINST ESD FOR MOS DEVICES**

Exposing the MOS devices to a strong electric field can cause destruction of the gate oxide and ultimately degrade the MOS devices operation. Steps must be taken to stop generation of static electricity as much as possible, and quickly dissipate it, when once it has occurred. Environmental control must be adequate. When it is dry, humidifier should be used. It is recommended to avoid using insulators that easily build static electricity. MOS devices must be stored and transported in an anti-static container, static shielding bag or conductive material. All test and measurement tools including work bench and floor should be grounded. The operator should be grounded using wrist strap. MOS devices must not be touched with bare hands. Similar precautions need to be taken for PW boards with semiconductor MOS devices on it.

**② HANDLING OF UNUSED INPUT PINS FOR CMOS DEVICES**

No connection for CMOS devices input pins can be a cause of malfunction. If no connection is provided to the input pins, it is possible that an internal input level may be generated due to noise, etc., hence causing malfunction. CMOS devices behave differently than Bipolar or NMOS devices. Input levels of CMOS devices must be fixed high or low by using a pull-up or pull-down circuitry. Each unused pin should be connected to  $V_{DD}$  or GND with a resistor, if it is considered to have a possibility of being an output pin. The unused pins must be handled in accordance with the related specifications.

**③ STATUS BEFORE INITIALIZATION OF MOS DEVICES**

Power-on does not necessarily define initial status of MOS devices. Production process of MOS does not define the initial operation status of the device. Immediately after the power source is turned ON, the MOS devices with reset function have not yet been initialized. Hence, power-on does not guarantee output pin levels, I/O settings or contents of registers. MOS devices are not initialized until the reset signal is received. Reset operation must be executed immediately after power-on for MOS devices having reset function.