



GDP2A8LM

DATASHEET



Features

- ◆ Power supply: VDD = VDDQ=1.35V (1.283 - 1.45V)
- ◆ Backward compatible to VDD = VDDQ = 1.5V $\pm$ 0.075V
 - Supports DDR3L devices to be backward compatible in 1.5V application
- ◆ Package: 78 balls FBGA (x8)
- ◆ 400 MHz f_{CK} for 800Mb/sec/pin, 533MHz f_{CK} for 1066Mb/sec/pin, 667MHz f_{CK} for 1333Mb/sec/pin, 800MHz f_{CK} for 1600Mb/sec/pin, 933MHz f_{CK} for 1866Mb/sec/pin and 1067 MHz f_{CK} for 2133Mb/sec/pin
- ◆ Array configuration: 8 Banks
- ◆ 8-bit prefetch architecture
- ◆ Differential clock inputs (CK, CK#)
- ◆ Nominal and dynamic on-die termination (ODT) for data, strobe, and mask signals
- ◆ Programmable CAS (READ) latency (CL)
- ◆ Programmable posted CAS additive latency (AL)
- ◆ Programmable CAS (WRITE) latency (CWL)
- ◆ Fixed burst length (BL) of 8 and burst chop (BC) of 4 (via the mode register set [MRS])
- ◆ Selectable BC4 or BL8 on-the-fly (OTF)
- ◆ Self refresh mode
- ◆ Operating case temperature: 0 °C $\leq$ T_{CASE} $\leq$ 95 °C
- ◆ Average Refresh Period:
 - 7.8 us at 0 °C $\leq$ T_{CASE} $\leq$ 85 °C
 - 3.9 us at 85 °C $\leq$ T_{CASE} $\leq$ 95 °C
- ◆ JEDEC JESD79-3E compliant
- ◆ RoHS compliant

Note:

1. The functionality described and the timing specifications included in this data sheet are for the DLL enabled mode of operation.

**Address Table**

Parameter	512Mbx8
Number of Banks	8
Bank Address	BA0-BA2
Auto precharge	A10/AP
BC switch on the fly	A12/BC#
Row Address	A0-A15
Column Address	A0-A9
Page Size ¹	1KB

Note:

1. Page size is the number of bytes of the data delivered from the array to the internal sense amplifiers when an ACTIVE command is registered. Page size is per bank, calculated as follows:

$$\text{Page size} = 2^{\text{COLBITS}} * \text{ORG} / 8$$

Where

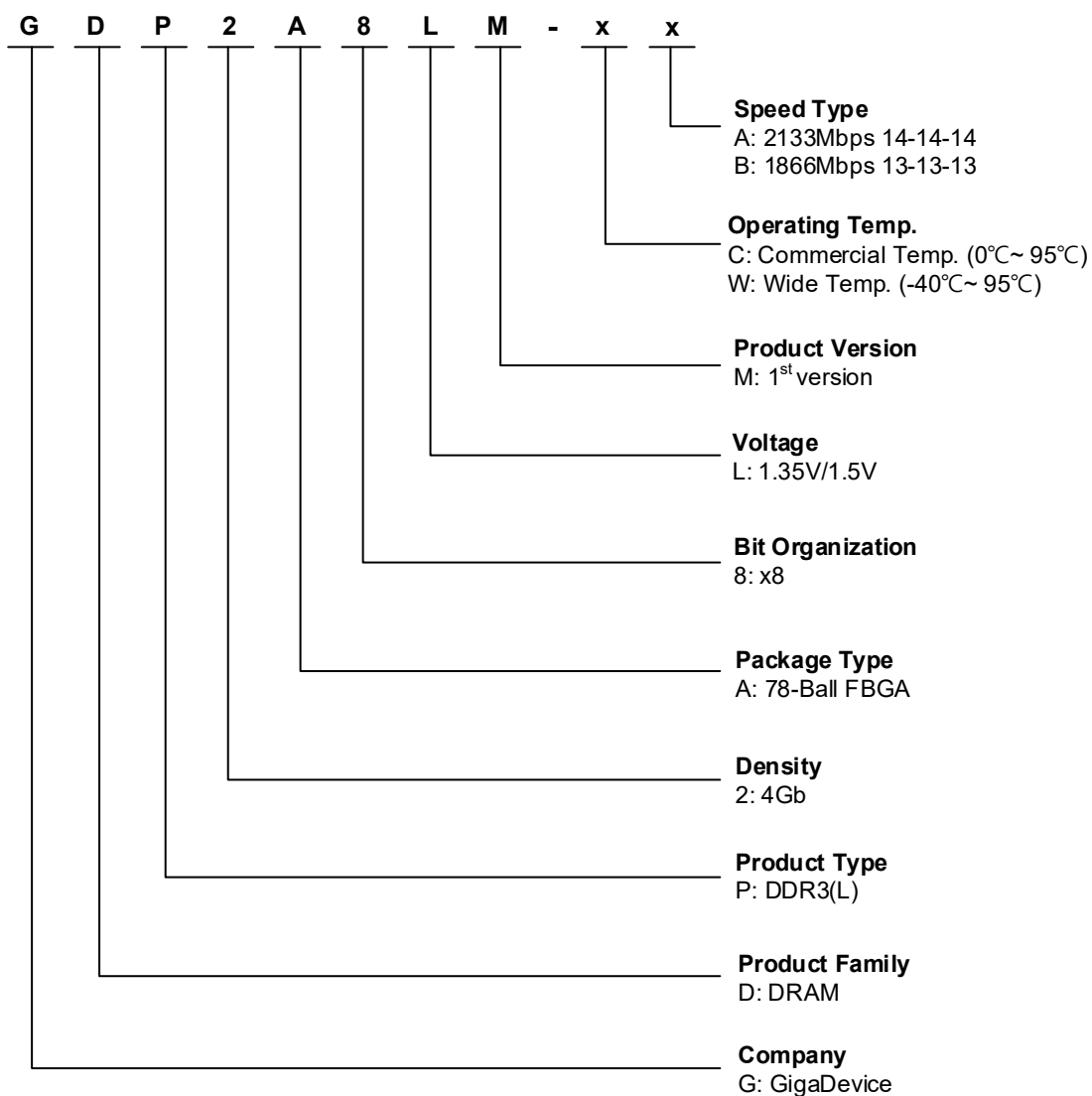
COLBITS = the number of column address bits

ORG = the number of I/O (DQ) bits



Ordering Information

Part Number Decoding



Valid Part Numbers

Part Number	Organization	Data Rate	CL-tRCD-tRP
GDP2A8LM-CB	512Mbx8	1866Mbps	13-13-13
GDP2A8LM-CA	512Mbx8	2133Mbps	14-14-14
GDP2A8LM-WB	512Mbx8	1866Mbps	13-13-13
GDP2A8LM-WA	512Mbx8	2133Mbps	14-14-14

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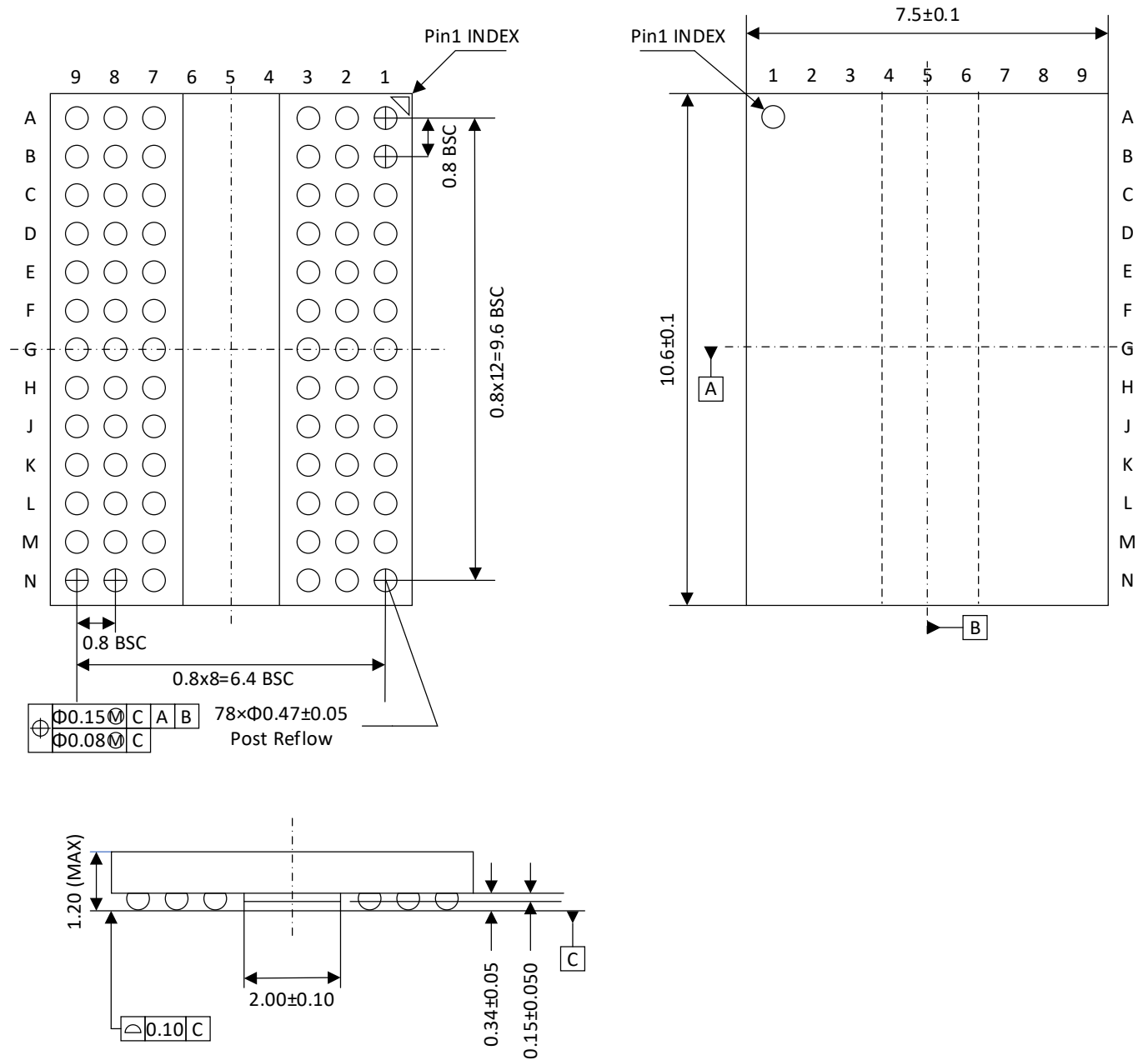


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1 Package Information

1.1 Package 78-Ball FBGA (x8)





2 Ball Assignments

2.1 78-Ball FBGA (x8) ball assignments

	1	2	3	4	5	6	7	8	9	
A	 V _{SS}	 V _{DD}	 NC				 NC	 V _{SS}	 V _{DD}	A
B	 V _{SS}	 V _{SSQ}	 DQ0				 DM	 V _{SSQ}	 V _{DDQ}	B
C	 V _{DDQ}	 DQ2	 DQS				 DQ1	 DQ3	 V _{SSQ}	C
D	 V _{SSQ}	 DQ6	 DQS#				 V _{DD}	 V _{SS}	 V _{SSQ}	D
E	 V _{REFDQ}	 V _{DDQ}	 DQ4				 DQ7	 DQ5	 V _{DDQ}	E
F	 NC	 V _{SS}	 RAS#				 CK	 V _{SS}	 NC	F
G	 ODT	 V _{DD}	 CAS#				 CK#	 V _{DD}	 CKE	G
H	 NC	 CS#	 WE#				 A10/AP	 ZQ	 NC	H
J	 V _{SS}	 BA0	 BA2				 A15	 V _{REFCA}	 V _{SS}	J
K	 V _{DD}	 A3	 A0				 A12/BC#	 BA1	 V _{DD}	K
L	 V _{SS}	 A5	 A2				 A1	 A4	 V _{SS}	L
M	 V _{DD}	 A7	 A9				 A11	 A6	 V _{DD}	M
N	 V _{SS}	 RESET#	 A13				 A14	 A8	 V _{SS}	N
	1	2	3	4	5	6	7	8	9	



2.2 Ball Description

Symbol	Type	Function
CK, CK#	Input	Clock: CK and CK# are differential clock inputs. All address and control input signals are sampled on the crossing of the positive edge of CK and negative edge of CK#. Output (read) data is referenced to the crossings of CK and CK#.
CKE	Input	Clock Enable: CKE HIGH activates, and CKE Low deactivates, internal clock signals and device input buffers and output drivers. Taking CKE Low provides Precharge Power-Down and Self-Refresh operation (all banks idle), or Active Power-Down (row Active in any bank). CKE is asynchronous for Self-Refresh exit. After VREFCA and VREFDQ have become stable during the power on and initialization sequence, they must be maintained during all operations (including Self-Refresh). CKE must be maintained high throughout read and write accesses. Input buffers, excluding CK, CK#, ODT and CKE, are disabled during power-down. Input buffers, excluding CKE, are disabled during Self-Refresh.
CS#	Input	Chip Select: All commands are masked when CS# is registered HIGH. CS# provides for external Rank selection on systems with multiple Ranks. CS# is considered part of the command code.
ODT	Input	On Die Termination: ODT (registered HIGH) enables termination resistance internal to the DDR3 SDRAM. When enabled, ODT is only applied to each DQ, DQS, DQS# and DM/TDQS, NU/TDQS# (When TDQS is enabled via Mode Register A11=1 in MR1) signal for x4/x8 configurations. For x16 configuration, ODT is applied to each DQ, DQSU, DQSU#, DQSL, DQSL#, DMU, and DML signal. The ODT pin will be ignored if MR1 and MR2 are programmed to disable RTT.
RAS#, CAS# WE#	Input	Command Input: RAS#, CAS#, and WE# (along with CS#) defines the command being entered.
DM	Input	Input Data Mask: DM is an input mask signal for write data. Input data is masked when DM is sampled HIGH coincident with that input data during a Write access. DM is sampled on both edges of DQS. For x8 device, the function of DM or TDQS/TDQS# is enabled by Mode Register A11 setting in MR1.
BA0 - BA2	Input	Bank Address Inputs: BA0-BA2 define to which bank an Active, Read, Write or Precharge command is being applied. Bank address also determines which mode register is to be accessed during a MRS cycle.
A0 – A15	Input	Address Inputs: Provide the row address for Activate commands and the column address for Read/Write commands to select one location out of the memory array in the respective bank. (A10 / AP and A12 / BC# have additional functions; see below). The address inputs also provide the op-code during Mode Register Set commands.
A10 / AP	Input	Auto-precharge: A10 is sampled during Read / Write commands to determine whether Autoprecharge should be performed to the accessed bank after the Read/Write operation. (HIGH: Autoprecharge; LOW: No Autoprecharge) A10 is sampled during a Precharge command to determine whether the Precharge applies to one bank (A10 LOW) or all banks (A10 HIGH). If only one bank is to be precharged, the bank is selected by bank addresses..



Symbol	Type	Function
A12 / BC#	Input	Burst Chop: A12 / BC# is sampled during Read and Write commands to determine if burst chop (on-the-fly) will be performed. (HIGH, no burst chop; LOW: burst chopped). See "Command Truth Table" of Operation Guide for details.
RESET#	Input	Active Low Asynchronous Reset: Reset is active when RESET# is LOW, and inactive when RESET# is HIGH. RESET# must be HIGH during normal operation. RESET# is a CMOS rail-to-rail signal with DC high and low at 80% and 20% of VDD, i.e., 1.20V for DC high and 0.30V for DC low.
DQ	I/O	Data Input/Output: Bi-directional data bus.
DQU, DQL DQS, DQS#, DQSU, DQSU#, DQSL, DQSL#	I/O	Data Strobe: Output with Read data, input with Write data. Edge-aligned with Read data, centered in Write data. For the x16, DQSL corresponds to the data on DQL0-DQL7; DQSU corresponds to the data on DQU0-DQU7. The data strobe DQS, DQSL and DQSU are paired with differential signals DQS#, DQSL#, and DQSU#, respectively, to provide differential pair signaling to the system during Reads and Writes. DDR3 SDRAM supports differential data strobe only and does not support single-ended.
TDQS, TDQS#	Output	Termination Data Strobe: TDQS/TDQS# is applicable for x8 DRAMs only. When enabled via Mode Register A11 = 1 in MR1, the DRAM will enable the same termination resistance function on TDQS/TDQS# that is applied to DQS/DQS#. When disabled via mode register A11 = 0 in MR1, DM/TDQS will provide the data mask function and TDQS# is not used. x4/x16 DRAMs must disable the TDQS function via mode register A11 = 0 in MR1.
NC	-	No Connect: No internal electrical connection is present.
V _{DDQ}	Supply	DQ Power Supply: DDR3L operation = 1.283 to 1.45V; DDR3 operation = 1.425 to 1.575V
V _{SSQ}	Supply	DQ Ground
V _{DD}	Supply	Power Supply: DDR3L operation = 1.283 to 1.45V; DDR3 operation = 1.425 to 1.575V
V _{SS}	Supply	Ground
V _{REFDQ}	Supply	Reference voltage for DQ
V _{REFCA}	Supply	Reference voltage for CA
ZQ	Supply	Reference Pin for ZQ calibration

Note:

Input only pins (BA0-BA2, A0-A15, RAS#, CAS#, WE#, CS#, CKE, ODT and RESET#) do not supply termination.



3 Functional Block Diagrams

DDR3 SDRAM is a high-speed, CMOS dynamic random access memory. It is internally configured as an 8-bank DRAM.

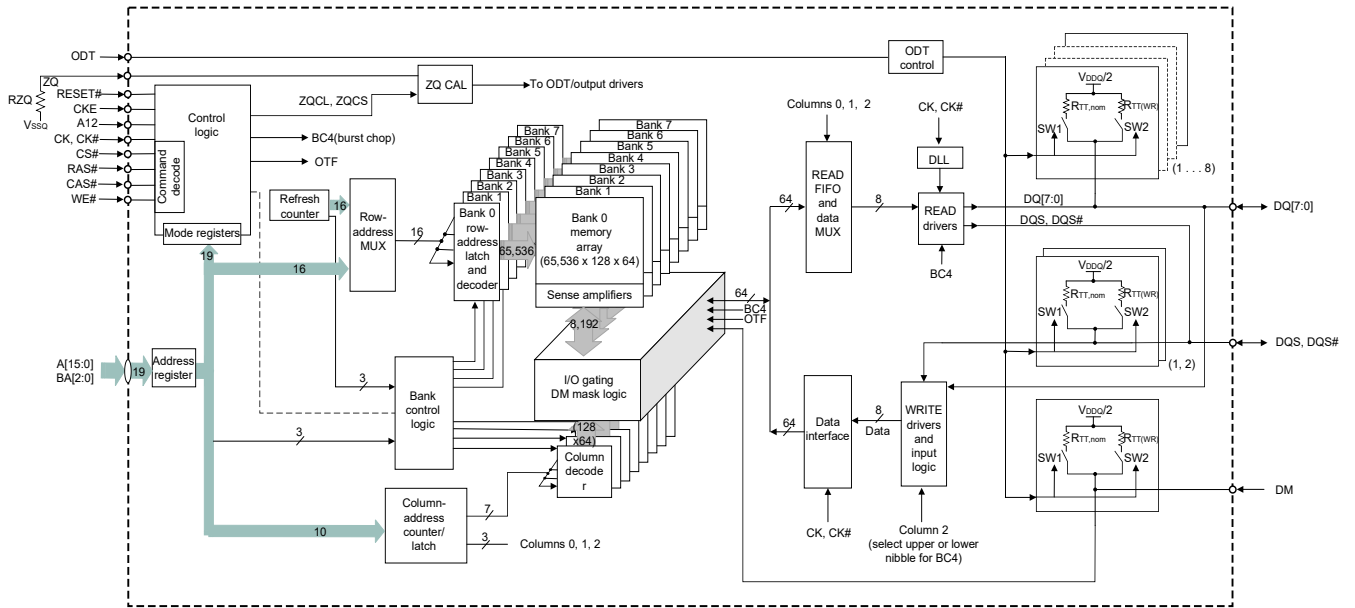


Figure 3-1. 512 Meg x 8 Functional Block Diagram



4 Absolute Maximum Ratings

4.1 Absolute Maximum DC Ratings

Table 4-1. Absolute Maximum DC Ratings

Symbol	Parameter	Rating	Unit	Note
V_{DD}	Voltage on V_{DD} pin relative to V_{SS}	-0.4 V ~ 1.80 V	V	1,3
V_{DDQ}	Voltage on V_{DDQ} pin relative to V_{SS}	-0.4 V ~ 1.80 V	V	1,3
V_{IN}, V_{OUT}	Voltage on any pin relative to V_{SS}	-0.4 V ~ 1.80 V	V	1
T_{STG}	Storage Temperature	-55 ~ 150	°C	1,2

Note:

- 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.
- Storage Temperature is the case surface temperature on the center/top side of the DRAM. For the measurement conditions, please refer to JESD79-3E standard.
- V_{DD} and V_{DDQ} must be within 300 mV of each other at all times; and V_{REF} must be not greater than $0.6 \times V_{DDQ}$. When V_{DD} and V_{DDQ} are less than 500 mV; V_{REF} may be equal to or less than 300 mV.

4.2 Recommended DC Operating Conditions

Table 4-2. Recommended DC Operating Conditions

Symbol	Parameter		Ratings			Unit	Note
			Min	Typ.	Max		
V_{DD}	Supply voltage	DDR3L	1.283	1.35	1.45	V	1,2,3,4,5,6
		DDR3	1.425	1.5	1.575	V	1,2
V_{DDQ}	Supply voltage for output	DDR3L	1.283	1.35	1.45	V	1,2,3,4,5,6
		DDR3	1.425	1.5	1.575	V	1,2

Note:

- Under all conditions V_{DDQ} must be less than or equal to V_{DD} .
- V_{DDQ} tracks with V_{DD} . AC parameters are measured with V_{DD} and V_{DDQ} tied together.
- Maximum DC value may not be greater than 1.425V. The DC value is the linear average of V_{DD}/V_{DD} (t) over a long period of time.
- If the maximum limit is exceeded, the input levels are covered by the DDR3 specification.
- With these supply voltages, the device operates with DDR3L specifications.
- The DDR3L product supports 1.5V operation, and if initialized as such, retains the original speed timings defined for DDR3L speed.



4.3 DRAM Component Operating Temperature Range

Table 4-3. Temperature Range

Symbol	Parameter	Rating	Unit	Note
T _{OPER}	Normal Operating Temperature Range	0 to 85	°C	1,2
	Extended Temperature Range (Optional)	85 to 95	°C	1,3

Note:

1. Operating Temperature T_{OPER} is the case surface temperature on the center / top side of the DRAM. For measurement conditions, please refer to the JEDEC document JESD79-3E.
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 - 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 supported in this range, but the following additional conditions apply:
 - Refresh commands must be doubled in frequency, therefore reducing the Refresh interval tREFI to 3.9 μs. It is also possible to specify a component with 1X refresh (tREFI to 7.8μs) in the Extended Temperature Range. Please refer to the DIMM SPD for option availability.
 - 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 A6 = 0_b and MR2 A7 = 1_b) or enable the optional Auto Self-Refresh mode (MR2 A6 = 1 and MR2 A7 = 1).



5 AC And DC Input Measurement Levels

5.1 AC and DC Logic Input Levels for Single-ended Signals

5.1.1 AC and DC Input Levels for Single-Ended Command and Address Signals

Table 5-1. Single-ended AC and DC Input Levels for Command and Address

Symbol	Parameter	DDR3L-800/1066		DDR3L-1333/1600		DDR3L-1866/2133		Unit	Note
		Min	Max	Min	Max	Min	Max		
$V_{IH.CA}(DC90)$	DC input logic high	$V_{REF} + 0.09$	V_{DD}	$V_{REF} + 0.09$	V_{DD}	$V_{REF} + 0.09$	V_{DD}	V	1
$V_{IL.CA}(DC90)$	DC input logic low	V_{SS}	$V_{REF} - 0.09$	V_{SS}	$V_{REF} - 0.09$	V_{SS}	$V_{REF} - 0.09$	V	1
$V_{IH.CA}(AC160)$	AC input logic high	$V_{REF} + 0.16$	Note 2	$V_{REF} + 0.16$	Note 2	-	-	V	1,2,5
$V_{IL.CA}(AC160)$	AC input logic low	Note 2	$V_{REF} - 0.16$	Note 2	$V_{REF} - 0.16$	-	-	V	1,2,5
$V_{IH.CA}(AC135)$	AC input logic high	$V_{REF} + 0.135$	Note 2	$V_{REF} + 0.135$	Note 2	$V_{REF} + 0.135$	Note 2	V	1,2,5
$V_{IL.CA}(AC135)$	AC input logic low	Note 2	$V_{REF} - 0.135$	Note 2	$V_{REF} - 0.135$	Note 2	$V_{REF} - 0.135$	V	1,2,5
$V_{IH.CA}(AC125)$	AC input logic high	-	-	-	-	$V_{REF} + 0.125$	Note 2	V	1,2,5
$V_{IL.CA}(AC125)$	AC input logic low	-	-	-	-	Note 2	$V_{REF} - 0.125$	V	1,2,5
$V_{REFCA}(DC)$	Reference voltage for ADD, CMD inputs	$0.49 * V_{DD}$	$0.51 * V_{DD}$	$0.49 * V_{DD}$	$0.51 * V_{DD}$	$0.49 * V_{DD}$	$0.51 * V_{DD}$	V	3,4

Symbol	Parameter	DDR3-800/1066		DDR3-1333/1600		DDR3-1866/2133		Unit	Note
		Min	Max	Min	Max	Min	Max		
$V_{IH.CA}(DC100)$	DC input logic high	$V_{REF} + 0.10$	V_{DD}	$V_{REF} + 0.10$	V_{DD}	$V_{REF} + 0.10$	V_{DD}	V	1
$V_{IL.CA}(DC100)$	DC input logic low	V_{SS}	$V_{REF} - 0.10$	V_{SS}	$V_{REF} - 0.10$	V_{SS}	$V_{REF} - 0.10$	V	1
$V_{IH.CA}(AC175)$	AC input logic high	$V_{REF} + 0.175$	Note 2	$V_{REF} + 0.175$	Note 2	-	-	V	1,2,5
$V_{IH.CA}(AC175)$	AC input logic low	Note 2	$V_{REF} - 0.175$	Note 2	$V_{REF} - 0.175$				
$V_{IL.CA}(AC150)$	AC input logic high	$V_{REF} + 0.150$	Note 2	$V_{REF} + 0.150$	Note 2	-	-	V	1,2,5
$V_{IH.CA}(AC150)$	AC input logic low	Note 2	$V_{REF} - 0.150$	Note 2	$V_{REF} - 0.150$	-	-	V	1,2,5
$V_{IL.CA}(AC135)$	AC input logic high	-	-	-	-	$V_{REF} + 0.135$	Note 2	V	1,2,5
$V_{IH.CA}(AC135)$	AC input logic low	-	-	-	-	Note 2	$V_{REF} - 0.135$	V	1,2,5
$V_{IH.CA}(AC125)$	AC input logic high	-	-	-	-	$V_{REF} + 0.125$	Note 2	V	1,2,5



$V_{IL,CA}(AC125)$	AC input logic low	-	-	-	-	Note 2	$V_{REF} - 0.125$	V	1,2,5
$V_{REFCA}(DC)$	Reference voltage for ADD, CMD inputs	$0.49 * V_{DD}$	$0.51 * V_{DD}$	$0.49 * V_{DD}$	$0.51 * V_{DD}$	$0.49 * V_{DD}$	$0.51 * V_{DD}$	V	3,4

Note:

1. For input only pins except RESET#. $V_{REF} = V_{REFCA}(DC)$.
2. See JESD79-3E,9.6 "Overshoot/Undershoot Specification",9.6.1.
3. The AC peak noise on V_{REF} may not allow V_{REF} to deviate from $V_{REF}(DC)$ by more than $\pm 1\% V_{DD}$ (for reference: DDR3 has approx. ± 15 mV, DDR3L has approx. ± 13.5 mV)
4. For reference: DDR3 has approx. $V_{DD}/2 \pm 15$ mV, DDR3L has approx $V_{DD}/2 \pm 13.5$ mV.
5. To allow VREFCA margining, all DRAM Command and Address Input Buffers MUST use external VREF (provided by system) as the input for their VREFCA pins. All VIH/L input level MUST be compared with the external VREF level at the 1st stage of the Command and Address input buffer.
6. $V_{IH}(AC175)$, $V_{IH}(AC150)$, $V_{IH}(AC135)$ and $V_{IH}(AC125)$ correspond to different tDS(base). See table 12-1.



5.1.2 AC and DC Input Levels for Single-Ended Data Signals

Table 5-2. Single-Ended AC and DC Input Levels for DQ and DM

Symbol	Parameter	DDR3L-800/1066		DDR3L-1333/1600		DDR3L-1866/2133		Unit	Note
		Min	Max	Min	Max	Min	Max		
$V_{IH,DQ}(DC90)$	DC input logic high	$V_{REF} + 0.09$	V_{DD}	$V_{REF} + 0.09$	V_{DD}	$V_{REF} + 0.09$	V_{DD}	V	1
$V_{IL,DQ}(DC90)$	DC input logic low	V_{SS}	$V_{REF} - 0.09$	V_{SS}	$V_{REF} - 0.09$	V_{SS}	$V_{REF} - 0.09$	V	1
$V_{IH,DQ}(AC160)$	AC input logic high	$V_{REF} + 0.16$	Note 2	-	-	-	-	V	1,2
$V_{IL,DQ}(AC160)$	AC input logic low	Note 2	$V_{REF} - 0.16$	-	-	-	-	V	1,2
$V_{IH,DQ}(AC135)$	AC input logic high	$V_{REF} + 0.135$	Note 2	$V_{REF} + 0.135$	Note 2	-	-	V	1,2
$V_{IL,DQ}(AC135)$	AC input logic low	Note 2	$V_{REF} - 0.135$	Note 2	$V_{REF} - 0.135$	-	-	V	1,2
$V_{IH,DQ}(AC130)$	AC input logic high	-	-	-	-	$V_{REF} + 0.13$	Note 2	V	1,2
$V_{IL,DQ}(AC130)$	AC input logic low	-	-	-	-	Note 2	$V_{REF} - 0.13$	V	1,2
$V_{REFDQ}(DC)$	Reference voltage for DQ, DM inputs	$0.49 * V_{DD}$	$0.51 * V_{DD}$	$0.49 * V_{DD}$	$0.51 * V_{DD}$	$0.49 * V_{DD}$	$0.51 * V_{DD}$	V	3,4

Symbol	Parameter	DDR3-800/1066		DDR3-1333/1600		DDR3-1866/2133		Unit	Note
		Min	Max	Min	Max	Min	Max		
$V_{IH,DQ}(DC100)$	DC input logic high	$V_{REF} + 0.10$	V_{DD}	$V_{REF} + 0.10$	V_{DD}	$V_{REF} + 0.10$	V_{DD}	V	1
$V_{IL,DQ}(DC100)$	DC input logic low	V_{SS}	$V_{REF} - 0.10$	V_{SS}	$V_{REF} - 0.10$	V_{SS}	$V_{REF} - 0.10$	V	1
$V_{IH,DQ}(AC175)$	AC input logic high	$V_{REF} + 0.175$	Note 2	-	-	-	-	V	1,2
$V_{IL,DQ}(AC175)$	AC input logic low	Note 2	$V_{REF} - 0.175$	-	-	-	-	V	1,2
$V_{IH,DQ}(AC150)$	AC input logic high	$V_{REF} + 0.150$	Note 2	$V_{REF} + 0.150$	Note 2	-	-	V	1,2
$V_{IL,DQ}(AC150)$	AC input logic low	Note 2	$V_{REF} - 0.150$	Note 2	$V_{REF} - 0.150$	-	-	V	1,2
$V_{IH,DQ}(AC135)$	AC input logic high	$V_{REF} + 0.135$	Note 2	$V_{REF} + 0.135$	Note 2	$V_{REF} + 0.135$	Note 2	V	1,2
$V_{IL,DQ}(AC135)$	AC input logic low	Note 2	$V_{REF} - 0.135$	Note 2	$V_{REF} - 0.135$	Note 2	$V_{REF} - 0.135$	V	1,2
$V_{REFDQ}(DC)$	Reference voltage for DQ, DM inputs	$0.49 * V_{DD}$	$0.51 * V_{DD}$	$0.49 * V_{DD}$	$0.51 * V_{DD}$	$0.49 * V_{DD}$	$0.51 * V_{DD}$	V	3,4

Note:

1. $V_{REF} = V_{REFDQ}(DC)$.
2. See JESD79-3E,9.6 "Overshoot/Undershoot Specification",9.6.2.
3. The AC peak noise on V_{REF} may not allow V_{REF} to deviate from $V_{REFDQ}(DC)$ by more than $\pm 1\% V_{DD}$ (for reference: approx. ± 13.5 mV)



-
4. For reference: DDR3 has approx. $VDD/2 \pm 15mV$, and DDR3L has approx. $VDD/2 \pm 13.5mV$.



5.2 V_{Ref} Tolerances

The dc-tolerance limits and ac-noise limits for the reference voltages V_{RefCA} and V_{RefDQ} are illustrated in Figure 5-1. It shows a valid reference voltage $V_{\text{Ref}}(t)$ as a function of time. (V_{Ref} stands for V_{RefCA} and V_{RefDQ} likewise).

$V_{\text{Ref}}(\text{DC})$ is the linear average of $V_{\text{Ref}}(t)$ over a very long period of time (e.g. 1 sec). This average has to meet the min/max requirement in Table 5-1. Furthermore $V_{\text{Ref}}(t)$ may temporarily deviate from $V_{\text{Ref}}(\text{DC})$ by no more than $\pm 1\% V_{\text{DD}}$.

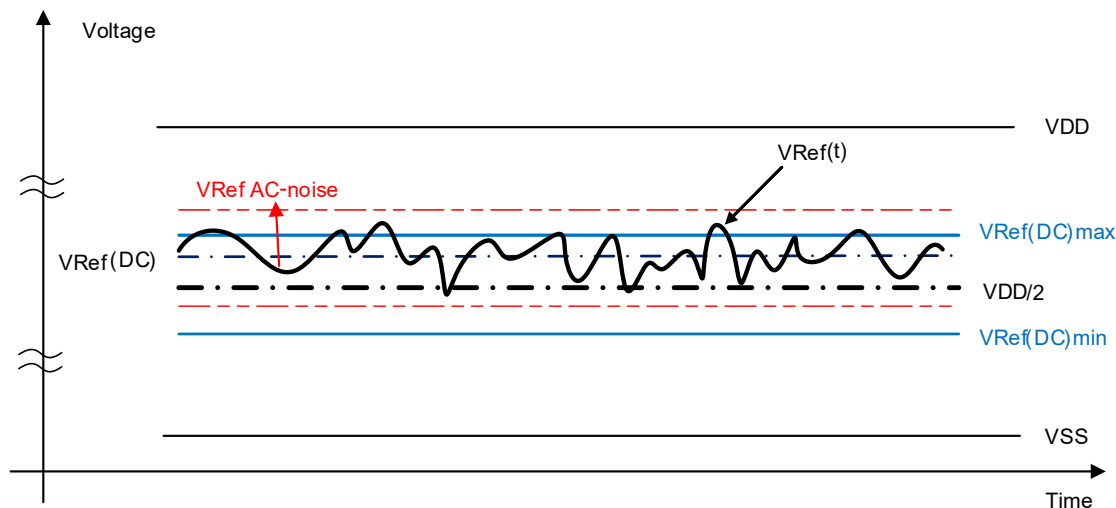


Figure 5-1. Illustration of $V_{\text{Ref}}(\text{DC})$ tolerance and V_{Ref} ac-noise limits

The voltage levels for setup and hold time measurements $V_{\text{IH}}(\text{AC})$, $V_{\text{IH}}(\text{DC})$, $V_{\text{IL}}(\text{AC})$ and $V_{\text{IL}}(\text{DC})$ are dependent on V_{Ref} .

“ V_{Ref} ” should be understood as $V_{\text{Ref}}(\text{DC})$

This clarifies that DC-variations of V_{Ref} affect the absolute voltage a signal has to reach to achieve a valid high or low level, and therefore the time to which setup and hold is measured. System timing and voltage budgets need to account for $V_{\text{Ref}}(\text{DC})$ deviations from the optimum position within the data-eye of the input signals.

This also clarifies that the DRAM setup/hold specification and derating values need to include time and voltage associated with V_{Ref} AC-noise. Timing and voltage effects due to AC-noise on V_{Ref} up to the specified limit ($\pm 1\%$ of V_{DD}) are included in DRAM timings and their associated deratings.



5.3 AC and DC Logic Input Levels for Differential Signals

5.3.1 Differential Signals Definition

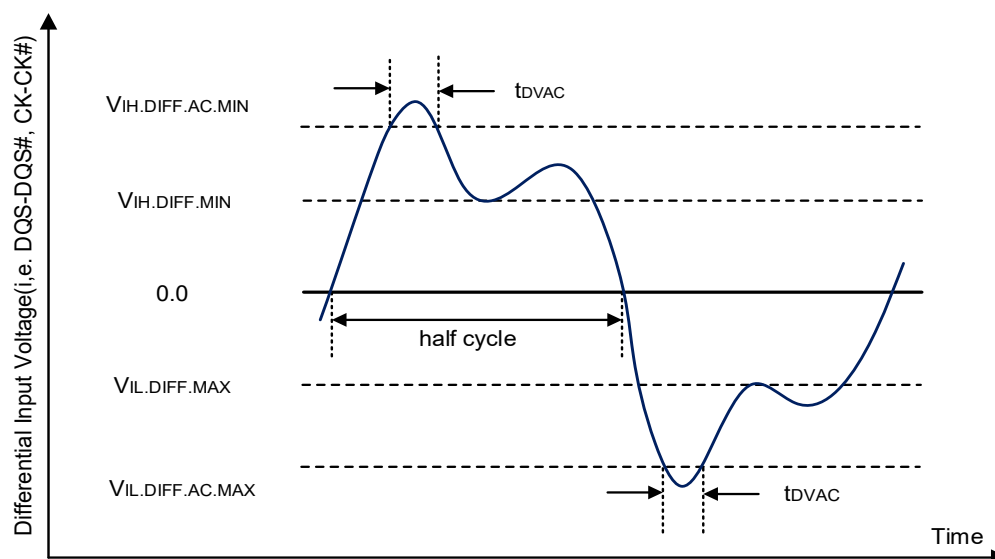


Figure 5-2. Definition of Differential AC-Swing and “Time above AC-Level” t_{DVAC}

5.3.2 Differential Swing Requirements for Clock (CK – CK#) and strobe (DQS – DQS#)

Table 5-3. Differential AC and DC Input Levels

Symbol	Parameter	DDR3L/DDR3-800/1066/1333/1600/1866/2133				Unit	Note
		1.35V		1.5V			
		Min	Max	Min	Max		
V _{IHdiff}	Differential input high	+ 0.18	Note 3	+ 0.20	Note 3	V	1
V _{ILdiff}	Differential input logic low	Note 3	- 0.18	Note 3	- 0.20	V	1
V _{IHdiff(AC)}	Differential input high ac	2 x (V _{IH(AC)} - V _{Ref})	Note 3	2 x (V _{IH(AC)} - V _{Ref})	Note 3	V	2
V _{ILdiff(AC)}	Differential input low ac	Note 3	2 x (V _{IL(AC)} - V _{Ref})	Note 3	2 x (V _{IL(AC)} - V _{Ref})	V	2

Note:

- Used to define a differential signal slew-rate.
- for CK – CK# use $V_{IH}/V_{IL(AC)}$ of ADD/CMD and V_{REFCA} ; for DQS – DQS#, DQSL – DQSL#, DQSU – DQSU# use $V_{IH}/V_{IL(AC)}$ of DQs and V_{REFDQ} ; if a reduced ac-high or ac-low level is used for a signal group, then the reduced level applies also here.
- These values are not defined; however, the single-ended signals CK, CK#, DQS, DQS#, DQSL, DQSL#, DQSU, DQSU# need to be within the respective limits ($V_{IH(DC)}$ max, $V_{IL(DC)}$ min) for single-ended signals as well as the limitations for overshoot and undershoot.



Table 5-4. Allowed Time before Ringback (tDVAC) for CK – CK# and DQS – DQS# (1.35 V)

	DDR3L-800/1066/1333/1600				DDR3L-1866/2133					
Slew Rate [V/ns]	tDVAC [ps] @ VIH/Ldiff(AC) = 320mV		tDVAC [ps] @ VIH/Ldiff(AC) = 270mV		tDVAC [ps] @ VIH/Ldiff(AC) = = 270mV		tDVAC [ps] @ VIH/Ldiff(AC) = 250mV		tDVAC [ps] @ VIH/Ldiff(AC) == 260mV	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
> 4.0	189	-	201	-	163	-	168	-	176	-
4.0	189	-	201	-	163	-	168	-	176	-
3.0	162	-	179	-	140	-	147	-	154	-
2.0	109	-	134	-	95	-	105	-	111	-
1.8	91	-	119	-	80	-	91	-	97	-
1.6	69	-	100	-	62	-	74	-	78	-
1.4	40	-	76	-	37	-	52	-	56	-
1.2	Note	-	44	-	5	-	22	-	24	-
1.0	Note	-	Note	-	Note	-	Note	-	Note	-
<1.0	Note	-	Note	-	Note	-	Note	-	Note	-

Note:

1. Rising input differential signal shall become equal to or greater than VIH(ac) level and Falling input signal shall become equal to or less than VIL(ac) level



Table 5-5. Allowed Time before Ringback (tDVAC) for CK – CK# and DQS – DQS# (1.5 V)

	DDR3-800/1066/1333/1600						DDR3-1866/2133			
Slew Rate [V/ns]	tDVAC [ps] @ VIH/Ldiff(AC) = 350mV		tDVAC [ps] @ VIH/Ldiff(AC) = 300mV		tDVAC [ps] @ VIH/Ldiff(AC) = (DQS – DQS#) only (Optional)		tDVAC [ps] @ VIH/Ldiff(AC) = 300mV		tDVAC [ps] @ VIH/Ldiff(AC) =(CK – CK#) only	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
> 4.0	75	-	175	-	214	-	134	-	139	-
4.0	57	-	170	-	214	-	134	-	139	-
3.0	50	-	167	-	191	-	112	-	118	-
2.0	38	-	119	-	146	-	67	-	77	-
1.8	34	-	102	-	131	-	52	-	63	-
1.6	29	-	81	-	113	-	33	-	45	-
1.4	22	-	54	-	88	-	9	-	23	-
1.2	Note	-	19	-	56	-	Note	-	Note	-
1.0	Note	-	Note	-	11	-	Note	-	Note	-
<1.0	Note	-	Note	-	Note	-	Note	-	Note	-

Note:

1. Rising input differential signal shall become equal to or greater than VIHdiff(ac) level and Falling input differential signal shall become equal to or less than VILdiff(ac) level.



5.3.3 Single-ended Requirements for Differential Signals

Each individual component of a differential signal (CK, DQS, DQSL, DQSU, CK#, DQS#, DQSL#, or DQSU#) has also to comply with certain requirements for single-ended signals.

CK and CK# have to approximately reach V_{SEHmin} / V_{SELmax} (approximately equal to the ac-levels ($V_{IH(ac)}/V_{IL(ac)}$) for ADD/CMD signals) in every half-cycle.

DQS, DQSL, DQSU, DQS#, DQSL# have to reach V_{SEHmin} / V_{SELmax} {approximately the ac-levels [$V_{IH(AC)} / V_{IL(AC)}$] for DQ signal} in every half-cycle proceeding and following a valid transition.

Note that the applicable ac-levels for ADD/CMD and DQ's might be different per speed-bin etc.

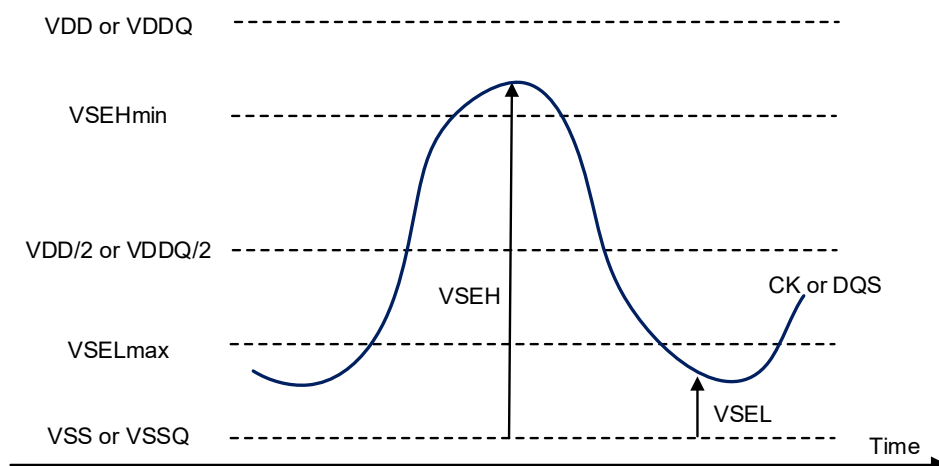


Figure 5-3. Single-ended Requirement for Differential Signals.

Note that, while ADD/CMD and DQ signal requirements are with respect to V_{Ref} , the single-ended components of differential signals have a requirement with respect to $VDD/2$; this is nominally the same. The transition of single-ended signals through the ac-levels is used to measure setup time. For single-ended components of differential signals the requirement to reach V_{SELmax} , V_{SEHmin} has no bearing on timing, but adds a restriction on the common mode characteristics of these signals.

Table 5-6. Single-ended Levels for CK, DQS, DQSL, DQSU, CK#, DQS#, DQSL#, or DQSU#

Symbol	Parameter	DDR3L/DDR3-800/1066/1333/1600/1866/2133		Unit	Note
		Min	Max		
V_{SEH}	Single-ended high-level for strobes	$(VDD/2) + 0.175$	Note 3	V	1,2
	Single-ended high-level for CK, CK#	$(VDD/2) + 0.175$	Note 3	V	1,2
V_{SEL}	Single-ended low-level for strobes	Note 3	$(VDD/2) - 0.175$	V	1,2
	Single-ended low-level for CK, CK#	Note 3	$(VDD/2) - 0.175$	V	1,2

Note:

- For CK, CK# use $V_{IH}/V_{IL(AC)}$ of ADD/CMD; for strobes (DQS, DQS#, DQSL, DQSL#, DQSU, DQSU#) use $V_{IH}/V_{IL(AC)}$ of DQs.
- $V_{IH(AC)}/V_{IL(AC)}$ for DQ is based on V_{REFDQ} ; $V_{IH(AC)}/V_{IL(AC)}$ for ADD/CMD is based on V_{REFCA} ; if a reduced ac-high or ac-low level is used for a signal group, then the reduced level applies also here
- These values are not defined, however the single-ended signals CK, CK#, DQS, DQS#, DQSL, DQSL#, DQSU, DQSU#



need to be within the respective limits ($V_{IH}(DC)$ max, $V_{IL}(DC)$ min) for single-ended signals as well as the limitations for overshoot and undershoot.

5.4 Differential Input Cross Point Voltage

The differential input cross point voltage V_{ix} is measured from the actual cross point of true and complement signals to the midlevel between of VDD and VSS.

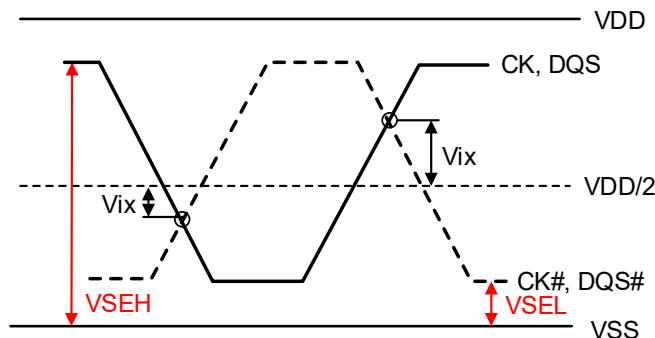


Figure 5-4. V_{ix} Definition

Table 5-7. Cross Point Voltage for Differential Input Signals (CK, DQS):1.35 V

Symbol	Parameter	DDR3L – 800/1066/1333/1600/1866/2133		Unit	Note
		Min	Max		
$V_{ix}(CK)$	Differential Input Cross Point Voltage relative to VDD/2 for CK, CK#	-150	150	mV	1
$V_{ix}(DQS)$	Differential Input Cross Point Voltage relative to VDD/2 for DQS, DQS#	-150	150	mV	

Note:

- The relation between V_{ix} Min/Max and VSEL/VSEH should satisfy following.

$$(VDD/2) + V_{ix}(\text{Min}) - VSEL \geq 25\text{mV}$$

$$VSEH - ((VDD/2) + V_{ix}(\text{Max})) \geq 25\text{mV}$$

Table 5-8. Cross Point Voltage for Differential Input Signals (CK, DQS):1.5 V

Symbol	Parameter	DDR3 – 800/1066/1333/1600/1866/2133		Unit	Note
		Min	Max		
$V_{ix}(CK)$	Differential Input Cross Point Voltage relative to VDD/2 for CK, CK#	-150	150	mV	2
		-175	-175	mV	1
$V_{ix}(DQS)$	Differential Input Cross Point Voltage relative to VDD/2 for DQS, DQS#	-150	150	mV	2

Note:

- Extended range for V_{ix} is only allowed for clock and if single-ended clock input signals CK and CK# are monotonic with a single-ended swing VSEL / VSEH of at least VDD/2 +/-250 mV, and when the differential slew rate of CK - CK# is larger than 3 V/ns.
- The relation between V_{ix} Min/Max and VSEL/VSEH should satisfy following.

$$(VDD/2) + V_{ix}(\text{Min}) - VSEL \geq 25\text{mV}$$



$$V_{SEH} - ((V_{DD}/2) + V_{IX}(\text{Max})) \geq 25\text{mV}$$

5.5 Slew Rate Definitions for Single-Ended Input Signals

See section 10.5 “Address/Command Setup, Hold and Derating” single-ended slew rate definitions for address and command signals.

See section 10.6.1 “Data Setup, Hold and Slew Rate Derating” single-ended slew rate definitions for data signals.

5.6 Slew Rate Definitions for Differential Input Signals

Input slew rate for differential signals (CK, CK#, and DQS, DQS#) are defined and measured as shown in Table 5-9 and Figure 5-5.

Table 5-9. Differential Input Slew Rate Definition

Description	Measured		Defined by
	From	To	
Differential input slew rate for rising edge (CK – CK# and DQS – DQS#).	$V_{ILdiffmax}$	$V_{IHdiffmin}$	$[V_{IHdiffmin} - V_{ILdiffmax}] / \Delta TR_{diff}$
Differential input slew rate for falling edge (CK – CK# and DQS – DQS#).	$V_{IHdiffmin}$	$V_{ILdiffmax}$	$[V_{IHdiffmin} - V_{ILdiffmax}] / \Delta TF_{diff}$

Note:

1. The differential signal (i.e., CK- CK# and DQS – DQS#) must be linear between these thresholds.

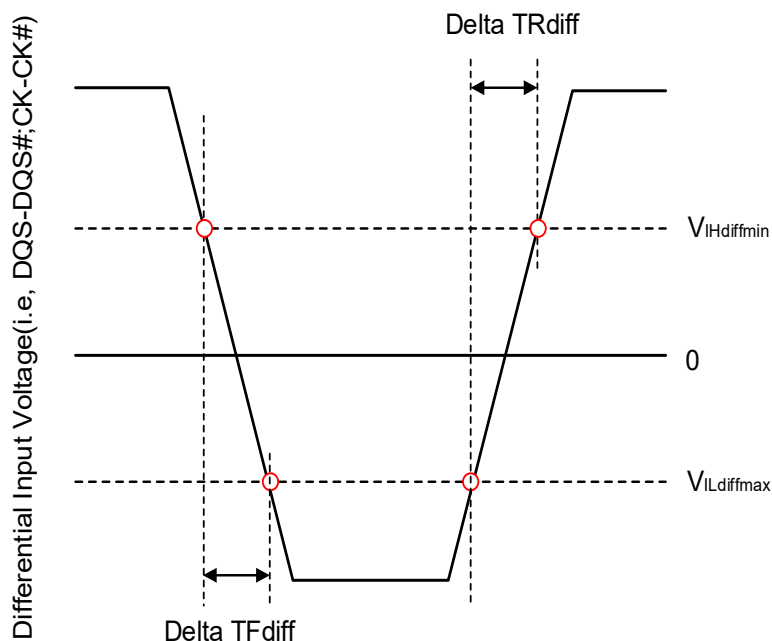


Figure 5-5. Differential Input Slew Rate Definition for DQS, DQS# and CK, CK#



6 AC&DC Output Measurement Levels

6.1 Single Ended AC and DC Output Levels

Table 6-1 shows the output levels used for measurements of single ended signals.

Table 6-1. Single-ended AC&DC Output Levels

Symbol	Parameter	Value	Unit	Note
$V_{OH(DC)}$	DC output high measurement level (for IV curve linearity)	$0.8 \times V_{DDQ}$	V	
$V_{OM(DC)}$	DC output mid measurement level (for IV curve linearity)	$0.5 \times V_{DDQ}$	V	
$V_{OL(DC)}$	DC output low measurement level (for IV curve linearity)	$0.2 \times V_{DDQ}$	V	
$V_{OH(AC)}$	AC output high measurement level (for output SR)	$V_{TT} + 0.1 \times V_{DDQ}$	V	1
$V_{OL(AC)}$	AC output low measurement level (for output SR)	$V_{TT} - 0.1 \times V_{DDQ}$	V	1

Note:

- The swing of $\pm 0.1 \times V_{DDQ}$ is based on approximately 50% of the static single-ended output high or low swing with a driver impedance of 40Ω and an effective test load of 25Ω to $V_{TT} = V_{DDQ}/2$.

6.2 Differential AC and DC Output Levels

Table 6-2 shows the output levels used for measurements of differential signals.

Table 6-2. Differential AC&DC Output Levels

Symbol	Parameter	Value	Unit	Note
$V_{OHdiff(AC)}$	AC differential output high measurement level (for output SR)	$+0.2 \times V_{DDQ}$	V	1
$V_{OLdiff(AC)}$	AC differential output low measurement level (for output SR)	$-0.2 \times V_{DDQ}$	V	1

Note:

- The swing of $\pm 0.2 \times V_{DDQ}$ is based on approximately 50% of the static single-ended output high or low swing with a driver impedance of 40Ω and an effective test load of 25Ω to $V_{TT} = V_{DDQ}/2$ at each of the differential outputs.

6.3 Single Ended Output Slew Rate

With the reference load for timing measurements, output slew rate for falling and rising edges is defined and measured between $V_{OL(AC)}$ and $V_{OH(AC)}$ for single ended signals as shown in Table 6-3 and Figure 6-1.

Table 6-3. Single-ended Output Slew Rate Definition

Description	Measured		Defined by
	From	To	
Single-ended output slew rate for rising edge	$V_{OL(AC)}$	$V_{OH(AC)}$	$[V_{OH(AC)} - V_{OL(AC)}] / \Delta t_{Rse}$
Single-ended output slew rate for falling edge	$V_{OH(AC)}$	$V_{OL(AC)}$	$[V_{OH(AC)} - V_{OL(AC)}] / \Delta t_{Fse}$

Note:

- Output slew rate is verified by design and characterization, and may not be subject to production test.

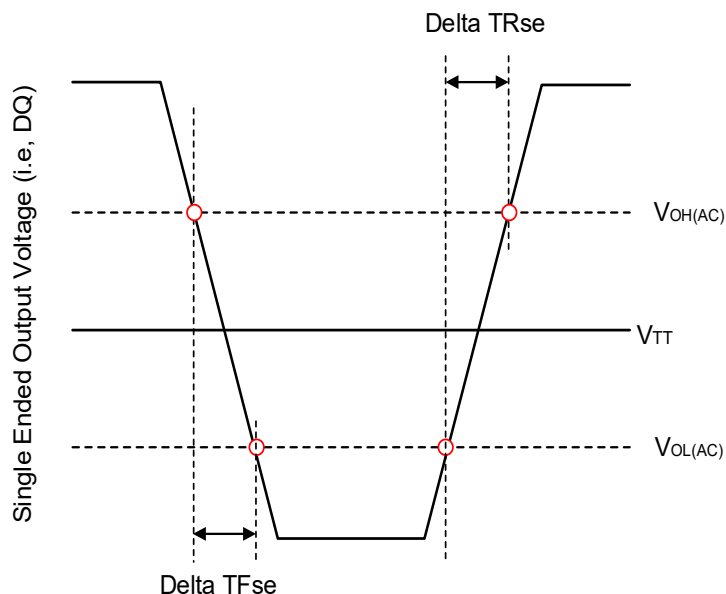


Figure 6-1. Single-ended Output Slew Rate Definition

Table 6-4. Single-ended Output Slew Rate

Parameter	Symbol	Operation Voltage	800		1066		1333		1600		1866		2133		Unit
			Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	
Single ended output slew rate	SRQse	1.35 V	1.75	5 ¹	1.75	5 ¹	1.75	5 ¹	1.75	5 ¹	1.75	5 ¹	1.75	5 ¹	V/ns
		1.5 V	2.5	5	2.5	5	2.5	5	2.5	5	2.5	5 ¹	2.5	5 ¹	V/ns

Description:

SR: Slew Rate;

Q: Query Output (like in DQ, which stands for Data-in, Query-Output)

se: Single-ended Signals;

For RON = RZQ/7 setting

Note:

- In two cases, a maximum slew rate of 6 V/ns applies for a single DQ signal within a byte lane.
 - Case 1 is defined for a single DQ signal within a byte lane which is switching into a certain direction (either from high to low or low to high) while all remaining DQ signals in the same byte lane are static (i.e. they stay at either high or low).
 - Case 2 is defined for a single DQ signal within a byte lane which is switching into a certain direction (either from high to low or low to high) while all remaining DQ signals in the same byte lane are switching into the opposite direction (i.e. from low to high or high to low respectively). For the remaining DQ signal switching into the opposite direction, the regular maximum limit of 5 V/ns applies).



6.4 Differential Output Slew Rate

With the reference load for timing measurements, output slew rate for falling and rising edges is defined and measured between $V_{OLDiff(AC)}$ and $V_{OHDiff(AC)}$ for differential signals as shown in Table 6-5 and Figure 6-2.

Table 6-5. Differential Output Slew Rate Definition

Description	Measured		Defined by
	From	To	
Differential output slew rate for rising edge	$V_{OLDiff(AC)}$	$V_{OHDiff(AC)}$	$[V_{OHDiff(AC)} - V_{OLDiff(AC)}] / \Delta TR_{diff}$
Differential output slew rate for falling edge	$V_{OHDiff(AC)}$	$V_{OLDiff(AC)}$	$[V_{OHDiff(AC)} - V_{OLDiff(AC)}] / \Delta TF_{diff}$

Note:

- Output slew rate is verified by design and characterization, and may not be subject to production test.

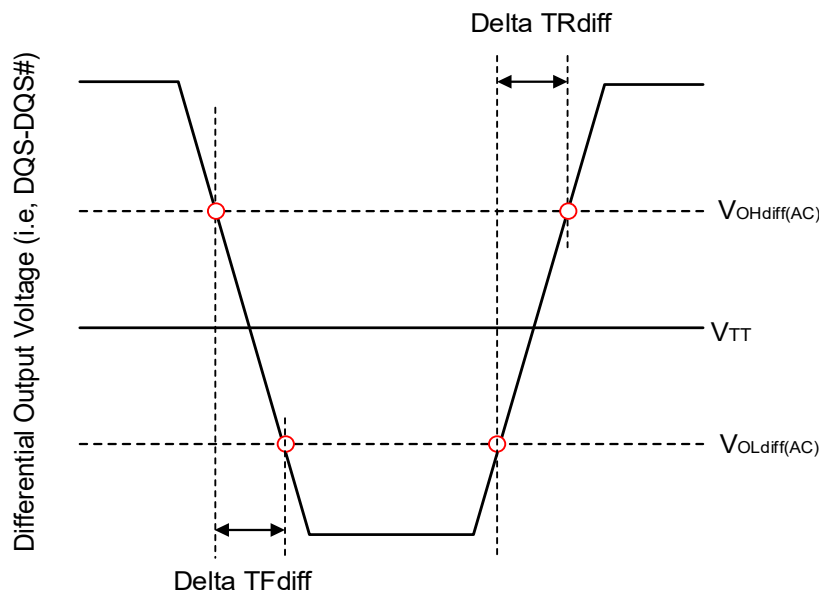


Figure 6-2. Differential Output Slew Rate Definition

Table 6-6. Differential Output Slew Rate

Parameter	Symbol	Operation Voltage	800		1066		1333		1600		1866		2133		Unit
			Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	
Single ended output slew rate	SRQdiff	1.35 V	3.5	12	3.5	12	3.5	12	3.5	12	3.5	12	3.5	12	V/ns
		1.5 V	5	10	5	10	5	10	5	10	5	10	5	10	V/ns

Description:

SR: Slew Rate;

Q: Query Output (like in DQ, which stands for Data-in, Query-Output);

Diff: Differential Signals;

For RON = RZQ/7 setting



6.5 Reference Load for AC Timing and Output Slew Rate

Figure 6-3 represents the effective reference load of 25 ohms used in defining the relevant AC timing parameters of the device as well as output slew rate measurements.

It is not intended as a precise representation of any particular system environment or a depiction of the actual load presented by a production tester. System designers should use IBIS or other simulation tools to correlate the timing reference load to a system environment. Manufacturers correlate to their production test conditions, generally one or more coaxial transmission lines terminated at the tester electronics.

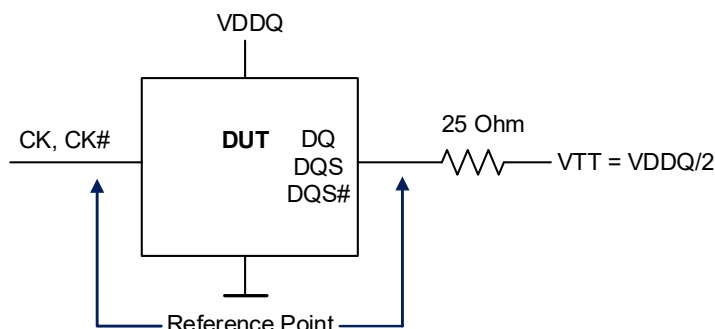


Figure 6-3. Reference Load for AC Timing and Output Slew Rate

6.6 Overshoot and Undershoot Specifications

6.6.1 Address and Control Overshoot and Undershoot Specifications

Table 6-7. AC Overshoot/Undershoot Specification for Address and Control Pins

Parameter	800	1066	1333	1600	1866	2133	Unit
Maximum peak amplitude allowed for overshoot area. ¹	0.4	0.4	0.4	0.4	0.4	0.4	V
Maximum peak amplitude allowed for undershoot area. ²	0.4	0.4	0.4	0.4	0.4	0.4	V
Maximum overshoot area above VDD	0.67	0.5	0.4	0.33	0.28	0.25	V-ns
Maximum undershoot area below VSS	0.67	0.5	0.4	0.33	0.28	0.25	V-ns
(A0-A15, BA0-BA3, CS#, RAS#, CAS#, WE#, CKE, ODT)							

Note:

1. The sum of the applied voltage (VDD) and peak amplitude overshoot voltage is not to exceed absolute maximum DC ratings
2. The sum of applied voltage (VDD) and the peak amplitude undershoot voltage is not to exceed absolute maximum DC ratings

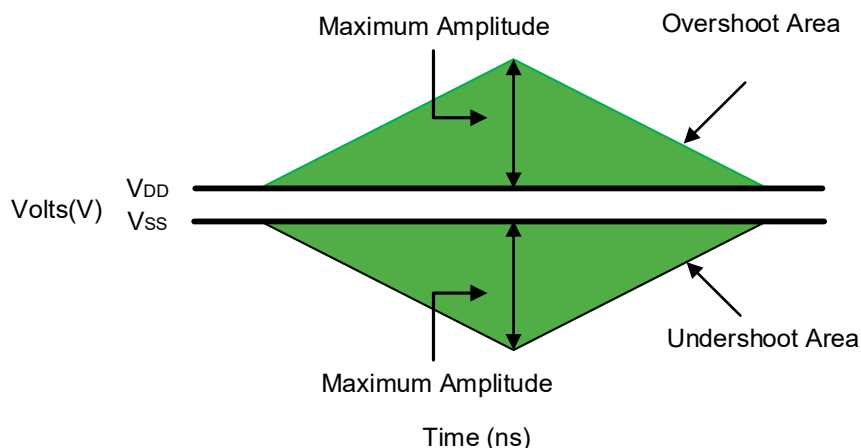


Figure 6-4. Address and Control Overshoot and Undershoot Definition

6.6.2 Clock, Data, Strobe and Mask Overshoot and Undershoot Specifications

Table 6-8. AC Overshoot/Undershoot Specification for Clock, Data, Strobe and Mask

Parameter	800	1066	1333	1600	1866	2133	Unit
Maximum peak amplitude allowed for overshoot area. ¹	0.4	0.4	0.4	0.4	0.4	0.4	V
Maximum peak amplitude allowed for undershoot area. ²	0.4	0.4	0.4	0.4	0.4	0.4	V
Maximum overshoot area above VDDQ	0.25	0.19	0.15	0.13	0.11	0.10	V-ns
Maximum undershoot area below VSSQ	0.25	0.19	0.15	0.13	0.11	0.10	V-ns
(CK., CK#, DQ, DQS, DQS#, DM)							

Note:

1. The sum of the applied voltage (VDD) and peak amplitude overshoot voltage is not to exceed absolute maximum DC ratings.
2. The sum of applied
3. voltage (VDD) and the peak amplitude undershoot voltage is not to exceed absolute maximum DC ratings.

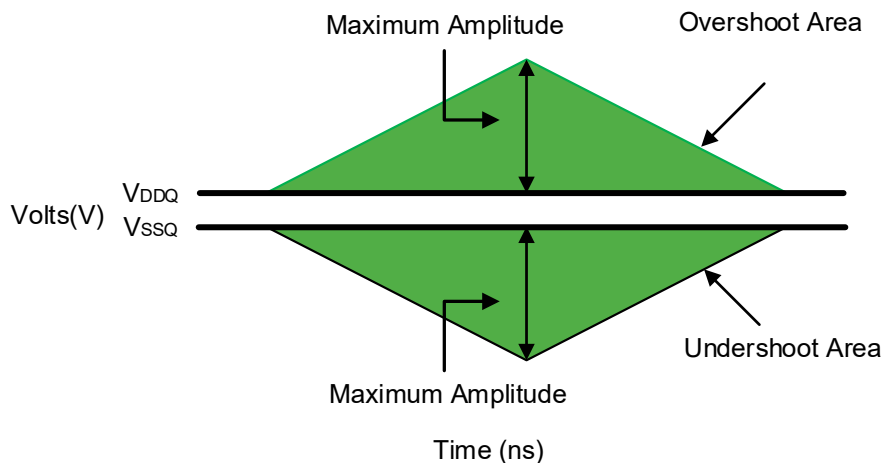


Figure 6-5. Clock, Data, Strobe and Mask Overshoot and Undershoot Definition



6.7 34 Ohm Output Driver DC Electronic Characteristics

A functional representation of the output buffer is shown below. Output driver impedance R_{ON} is defined by the value of external reference resistor R_{ZQ} as follows:

$$R_{ON34} = R_{ZQ}/7 \text{ (Nominal 34.3 ohms } \pm 10\% \text{ with nominal } R_{ZQ}=240 \Omega \text{)}$$

The individual Pull-up and Pull-down resistors ($R_{ON_{Pu}}$ and $R_{ON_{Pd}}$) are defined as follows:

$$R_{ON_{Pu}} = \frac{V_{DDQ} - V_{out}}{|I_{out}|} \text{ under the condition that } R_{ON_{Pd}} \text{ is turned off}$$

$$R_{ON_{Pd}} = \frac{V_{out}}{|I_{out}|} \text{ under the condition that } R_{ON_{Pu}} \text{ is turned off.}$$

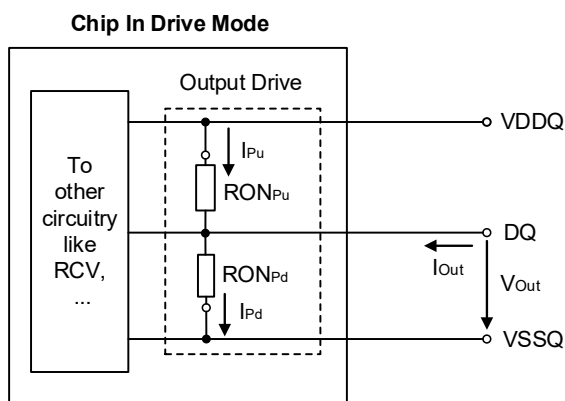


Figure 6-6. Output Driver: Definition of Voltages and Currents

Table 6-9. Output Driver DC Electrical Characteristics, assuming $R_{ZQ} = 240 \Omega$; entire operating temperature range; after proper ZQ calibration (1.35 V)

RONom	Resistor	VOut	min	nom	max	Unit	Note
34 Ω	RON34Pd	VOLdc =0.2 x VDDQ	0.6	1.0	1.15	RZQ/7	1,2,3
		VOMdc =0.5 x VDDQ	0.9	1.0	1.15	RZQ/7	1,2,3
		VOHdc =0.8 x VDDQ	0.9	1.0	1.45	RZQ/7	1,2,3
	RON34Pu	VOLdc =0.2 x VDDQ	0.9	1.0	1.45	RZQ/7	1,2,3
		VOMdc =0.5 x VDDQ	0.9	1.0	1.15	RZQ/7	1,2,3
		VOHdc =0.8 x VDDQ	0.6	1.0	1.15	RZQ/7	1,2,3
40 Ω	RON40Pd	VOLdc =0.2 x VDDQ	0.6	1.0	1.15	RZQ/6	1,2,3
		VOMdc =0.5 x VDDQ	0.9	1.0	1.15	RZQ/6	1,2,3
		VOHdc =0.8 x VDDQ	0.9	1.0	1.45	RZQ/6	1,2,3
	RON40Pu	VOLdc =0.2 x VDDQ	0.9	1.0	1.45	RZQ/6	1,2,3
		VOMdc =0.5 x VDDQ	0.9	1.0	1.15	RZQ/6	1,2,3
		VOHdc =0.8 x VDDQ	0.6	1.0	1.15	RZQ/6	1,2,3
Mismatch between pull-up and pull-down,MMPuPd		VOMdc =0.5 x VDDQ	-10		+10	%	1,2,4

Note:

- The tolerance limits are specified after calibration with stable voltage and temperature. For the behavior of the tolerance limits if temperature or voltage changes after calibration, see following section on voltage and temperature



sensitivity.

- The tolerance limits are specified under the condition that $V_{DDQ} = V_{DD}$ and that $V_{SSQ} = V_{SS}$.
- Pull-down and pull-up output driver impedances are recommended to be calibrated at $0.5 \times V_{DDQ}$. Other calibration schemes may be used to achieve the linearity spec shown above, e.g. calibration at $0.2 \times V_{DDQ}$ and $0.8 \times V_{DDQ}$.
- Measurement definition for mismatch between pull-up and pull-down, MM_{PuPd} :
Measure RON_{Pu} and RON_{Pd} , both at $0.5 \times V_{DDQ}$:

$$MM_{PuPd} = \frac{RON_{Pu} - RON_{Pd}}{RON_{Nom}} \times 100$$

Table 6-10. Output Driver DC Electrical Characteristics, assuming $R_{ZQ} = 240 \Omega$; entire operating temperature range; after proper ZQ calibration (1.5 V)

RONom	Resistor	Vout	min	nom	max	Unit	Note
34 Ω	RON34Pd	VOLdc =0.2 x VDDQ	0.6	1.0	1.1	RZQ/7	1,2,3
		VOMdc =0.5 x VDDQ	0.9	1.0	1.1	RZQ/7	1,2,3
		VOHdc =0.8 x VDDQ	0.9	1.0	1.4	RZQ/7	1,2,3
	RON34Pu	VOLdc =0.2 x VDDQ	0.9	1.0	1.4	RZQ/7	1,2,3
		VOMdc =0.5 x VDDQ	0.9	1.0	1.1	RZQ/7	1,2,3
		VOHdc =0.8 x VDDQ	0.6	1.0	1.1	RZQ/7	1,2,3
40 Ω	RON40Pd	VOLdc =0.2 x VDDQ	0.6	1.0	1.1	RZQ/6	1,2,3
		VOMdc =0.5 x VDDQ	0.9	1.0	1.1	RZQ/6	1,2,3
		VOHdc =0.8 x VDDQ	0.9	1.0	1.4	RZQ/6	1,2,3
	RON40Pu	VOLdc =0.2 x VDDQ	0.9	1.0	1.4	RZQ/6	1,2,3
		VOMdc =0.5 x VDDQ	0.9	1.0	1.1	RZQ/6	1,2,3
		VOHdc =0.8 x VDDQ	0.6	1.0	1.1	RZQ/6	1,2,3
Mismatch between pull-up and pull-down,MMPuPd		VOMdc =0.5 x VDDQ	-10		+10	%	1,2,4

Note:

- The tolerance limits are specified after calibration with stable voltage and temperature. For the behavior of the tolerance limits if temperature or voltage changes after calibration, see following section on voltage and temperature sensitivity.
- The tolerance limits are specified under the condition that $V_{DDQ} = V_{DD}$ and that $V_{SSQ} = V_{SS}$.
- Pull-down and pull-up output driver impedances are recommended to be calibrated at $0.5 \times V_{DDQ}$. Other calibration schemes may be used to achieve the linearity spec shown above, e.g. calibration at $0.2 \times V_{DDQ}$ and $0.8 \times V_{DDQ}$.
- Measurement definition for mismatch between pull-up and pull-down, MM_{PuPd} :
Measure RON_{Pu} and RON_{Pd} , both at $0.5 \times V_{DDQ}$:

$$MM_{PuPd} = \frac{RON_{Pu} - RON_{Pd}}{RON_{Nom}} \times 100$$



6.7.1 Output Driver Temperature and Voltage sensitivity

If temperature and/or voltage change after calibration, the tolerance limits widen according to Table 6-11 and Table 6-12.

$\Delta T = T - T(@\text{calibration})$; $\Delta V = V_{DDQ} - V_{DDQ}(@\text{calibration})$; $V_{DD} = V_{DDQ}$

Note:

1. dR_{ondT} and dR_{ondV} are not subject to production test but are verified by design and characterization.

Table 6-11. Output Driver Sensitivity Denfinition

Item	Min	Max	Unit
$R_{\text{ONPU}}@V_{\text{OHdc}}$	$0.6 - dR_{\text{ondTH}}* \Delta T - dR_{\text{ondVH}}* \Delta V $	$1.1 + dR_{\text{ondTH}}* \Delta T + dR_{\text{ondVH}}* \Delta V $	RZQ/7
$R_{\text{ON}}@V_{\text{OMdc}}$	$0.9 - dR_{\text{ondTM}}* \Delta T - dR_{\text{ondVM}}* \Delta V $	$1.1 + dR_{\text{ondTM}}* \Delta T + dR_{\text{ondVM}}* \Delta V $	RZQ/7
$R_{\text{ONPD}}@V_{\text{OLdc}}$	$0.6 - dR_{\text{ondTL}}* \Delta T - dR_{\text{ondVL}}* \Delta V $	$1.1 + dR_{\text{ondTL}}* \Delta T + dR_{\text{ondVL}}* \Delta V $	RZQ/7

Table 6-12. Output Driver Voltage and Temperature Sensitivity

Speed Bin	800/1066/1333		1600/1866/2133		Unit
Item	Min	Max	Min	Max	
dR_{ondTM}	0	1.5	0	1.5	%/°C
dR_{ondVM}	0	0.15	0	0.13	%/mV
dR_{ondTL}	0	1.5	0	1.5	%/°C
dR_{ondVL}	0	0.15	0	0.13	%/mV
dR_{ondTH}	0	1.5	0	1.5	%/°C
dR_{ondVH}	0	0.15	0	0.13	%/mV

These parameters may not be subject to production test. They are verified by design and characterization.

6.8 On-die Termination (ODT) Levels and I-V Characteristics

On-Die Termination effective resistance R_{TT} is defined by bits A9, A6 and A2 of MR1 register.

ODT is applied to the DQ, DM, DQS/DQS# and TDQS, TDQS# (x8 devices only) pins.

A functional representation of the on-die termination is shown below. The individual pull-up and pull-down resistors ($R_{\text{TT}_{\text{Pu}}}$ and $R_{\text{TT}_{\text{Pd}}}$) are defined as follows:

$$R_{\text{TT}_{\text{Pu}}} = \frac{V_{\text{DDQ}} - V_{\text{out}}}{|I_{\text{out}}|} \text{ under the condition that } R_{\text{TT}_{\text{Pd}}} \text{ is turned off}$$

$$R_{\text{TT}_{\text{Pd}}} = \frac{V_{\text{out}}}{|I_{\text{out}}|} \text{ under the condition that } R_{\text{TT}_{\text{Pu}}} \text{ is turned off.}$$

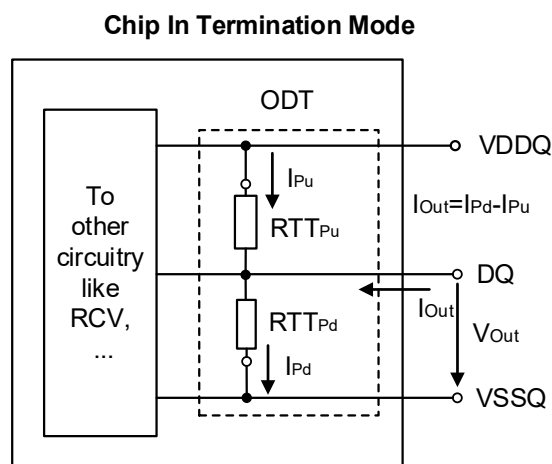


Figure 6-7. On-Die Termination: Definition of Voltages and Currents

6.8.1 ODT DC Temperature and Voltage sensitivity

If temperature and/or voltage change after calibration, the tolerance limits widen according to Table 6-13 and Table 6-14.

$\Delta T = T - T(@calibration)$; $\Delta V = V_{DDQ} - V_{DDQ}(@calibration)$; $V_{DD} = V_{DDQ}$

Table 6-13. ODT Sensitivity Definition

	Min	Max	Unit
RTT	$0.9 - dR_{TTdT} * \Delta T - dR_{TTdV} * \Delta V $	$1.6 + dR_{TTdT} * \Delta T + dR_{TTdV} * \Delta V $	RZQ/2,4,6,8,12

Table 6-14. ODT Voltage and Temperature Sensitivity

	Min	Max	Unit
dR_{TTdT}	0	1.5	%/°C
dR_{TTdV}	0	0.15	%/mV

Note:

- These parameters may not be subject to production test. They are verified by design and characterization.



6.8.2 ODT DC Electrical Characteristic

Table 6-15 provides an overview of the ODT DC electrical characteristics. Their values for $RTT_{60Pd120}$, $RTT_{60Pu120}$, $RTT_{120Pd240}$, $RTT_{120Pu240}$, RTT_{40Pd80} , RTT_{40Pu80} , RTT_{30Pd60} , RTT_{30Pu60} , RTT_{20Pd40} , RTT_{20Pu40} are not specification requirements, but can be used as design guide lines:

Table 6-15. ODT DC Electrics, assuming $R_{ZQ} = 240 \Omega \pm 1\%$ entire operating temperature range; after proper ZQ calibration

MR1 (A9, A6, A2)	RTT	RESISTOR	Vout	Min	Nom	Max (DDR3L)	Max (DDR3)	Unit	Note
(0,1,0)	120 Ω	$RTT_{120Pd240}$	$V_{OL(DC)} 0.2 \times V_{DDQ}$	0.6	1.0	1.15	1.1	R_{ZQ}	1,2,3,4
			$0.5 \times V_{DDQ}$	0.9	1.0	1.15	1.1	R_{ZQ}	1,2,3,4
			$V_{OH(DC)} 0.8 \times V_{DDQ}$	0.9	1.0	1.45	1.4	R_{ZQ}	1,2,3,4
		$RTT_{120Pu240}$	$V_{OL(DC)} 0.2 \times V_{DDQ}$	0.9	1.0	1.45	1.4	R_{ZQ}	1,2,3,4
			$0.5 \times V_{DDQ}$	0.9	1.0	1.15	1.1	R_{ZQ}	1,2,3,4
			$V_{OH(DC)} 0.8 \times V_{DDQ}$	0.6	1.0	1.15	1.1	R_{ZQ}	1,2,3,4
		RTT_{120}	$V_{IL(AC)} \text{ to } V_{IH(AC)}$	0.9	1.0	1.65	1.6	$R_{ZQ}/2$	1,2,5
(0,0,1)	60 Ω	$RTT_{60Pd120}$	$V_{OL(DC)} 0.2 \times V_{DDQ}$	0.6	1.0	1.15	1.1	$R_{ZQ}/2$	1,2,3,4
			$0.5 \times V_{DDQ}$	0.9	1.0	1.15	1.1	$R_{ZQ}/2$	1,2,3,4
			$V_{OH(DC)} 0.8 \times V_{DDQ}$	0.9	1.0	1.45	1.4	$R_{ZQ}/2$	1,2,3,4
		$RTT_{60Pu120}$	$V_{OL(DC)} 0.2 \times V_{DDQ}$	0.9	1.0	1.45	1.4	$R_{ZQ}/2$	1,2,3,4
			$0.5 \times V_{DDQ}$	0.9	1.0	1.15	1.1	$R_{ZQ}/2$	1,2,3,4
			$V_{OH(DC)} 0.8 \times V_{DDQ}$	0.6	1.0	1.15	1.1	$R_{ZQ}/2$	1,2,3,4
		RTT_{60}	$V_{IL(AC)} \text{ to } V_{IH(AC)}$	0.9	1.0	1.65	1.6	$R_{ZQ}/4$	1,2,5
(0,1,1)	40 Ω	RTT_{40Pd80}	$V_{OL(DC)} 0.2 \times V_{DDQ}$	0.6	1.0	1.15	1.1	$R_{ZQ}/3$	1,2,3,4
			$0.5 \times V_{DDQ}$	0.9	1.0	1.15	1.1	$R_{ZQ}/3$	1,2,3,4
			$V_{OH(DC)} 0.8 \times V_{DDQ}$	0.9	1.0	1.45	1.4	$R_{ZQ}/3$	1,2,3,4
		RTT_{40Pu80}	$V_{OL(DC)} 0.2 \times V_{DDQ}$	0.9	1.0	1.45	1.4	$R_{ZQ}/3$	1,2,3,4
			$0.5 \times V_{DDQ}$	0.9	1.0	1.15	1.1	$R_{ZQ}/3$	1,2,3,4
			$V_{OH(DC)} 0.8 \times V_{DDQ}$	0.6	1.0	1.15	1.1	$R_{ZQ}/3$	1,2,3,4
		RTT_{40}	$V_{IL(AC)} \text{ to } V_{IH(AC)}$	0.9	1.0	1.65	1.6	$R_{ZQ}/6$	1,2,5
(1,0,1)	30 Ω	RTT_{30Pd60}	$V_{OL(DC)} 0.2 \times V_{DDQ}$	0.6	1.0	1.15	1.1	$R_{ZQ}/4$	1,2,3,4
			$0.5 \times V_{DDQ}$	0.9	1.0	1.15	1.1	$R_{ZQ}/4$	1,2,3,4
			$V_{OH(DC)} 0.8 \times V_{DDQ}$	0.9	1.0	1.45	1.4	$R_{ZQ}/4$	1,2,3,4
		RTT_{30Pu60}	$V_{OL(DC)} 0.2 \times V_{DDQ}$	0.9	1.0	1.45	1.4	$R_{ZQ}/4$	1,2,3,4



MR1 (A9, A6, A2)	RTT	RESISTOR	Vout	Min	Nom	Max (DDR3L)	Max (DDR3)	Unit	Note
			0.5 x V _{DDQ}	0.9	1.0	1.15	1.1	R _{ZQ} /4	1,2,3,4
			V _{OH} (DC) 0.8 x V _{DDQ}	0.6	1.0	1.15	1.1	R _{ZQ} /4	1,2,3,4
		RTT ₃₀	V _{IL} (AC) to V _{IH} (AC)	0.9	1.0	1.65	1.6	R _{ZQ} /8	1,2,5
(1,0,0)	20 Ω	RTT _{20Pd40}	V _{OL} (DC) 0.2 x V _{DDQ}	0.6	1.0	1.15	1.1	R _{ZQ} /6	1,2,3,4
			0.5 x V _{DDQ}	0.9	1.0	1.15	1.1	R _{ZQ} /6	1,2,3,4
			V _{OH} (DC) 0.8 x V _{DDQ}	0.9	1.0	1.45	1.4	R _{ZQ} /6	1,2,3,4
		RTT _{20Pu40}	V _{OL} (DC) 0.2 x V _{DDQ}	0.9	1.0	1.45	1.4	R _{ZQ} /6	1,2,3,4
			0.5 x V _{DDQ}	0.9	1.0	1.15	1.1	R _{ZQ} /6	1,2,3,4
			V _{OH} (DC) 0.8 x V _{DDQ}	0.6	1.0	1.15	1.1	R _{ZQ} /6	1,2,3,4
		RTT ₂₀	V _{IL} (AC) to V _{IH} (AC)	0.9	1.0	1.65	1.6	R _{ZQ} /12	1,2,5
Deviation of V _{MW} .r.t V _{DDQ} /2, ΔVM				-5	-	+5	+5	%	+5

Note:

1. The tolerance limits are specified after calibration with stable voltage and temperature. For the behavior of the tolerance limits if temperature or voltage changes after calibration, see following section on voltage and temperature sensitivity.
2. The tolerance limits are specified under the condition that $V_{DDQ} = V_{DD}$ and that $V_{SSQ} = V_{SS}$
3. Pull-down and pull-up ODT resistors are recommended to be calibrated at $0.5 \times V_{DDQ}$. Other calibration schemes may be used to achieve the linearity spec shown above, e.g. calibration at $0.2 \times V_{DDQ}$ and $0.8 \times V_{DDQ}$.
4. Not a specification requirement, but a design guide line.
5. Measurement definition for RTT:

Apply $V_{IH(AC)}$ to pin under test and measure current $I(V_{IH(AC)})$, then apply $V_{IL(AC)}$ to pin under test and measure current $I(V_{IL(AC)})$ respectively.

$$RTT = \frac{V_{IH(ac)} - V_{IL(ac)}}{I(V_{IH(ac)}) - I(V_{IL(ac)})}$$

6. Measurement definition for VM and ΔVM : Measure voltage (VM) at test pin (midpoint) with no load:

$$\Delta VM = \left(\frac{2 \times VM}{V_{DDQ}} - 1 \right) \times 100$$

6.9 ODT Timing Definitions

6.9.1 Test Load for ODT Timings

Different than for timing measurements, the reference load for ODT timings is defined in Figure 6-8.

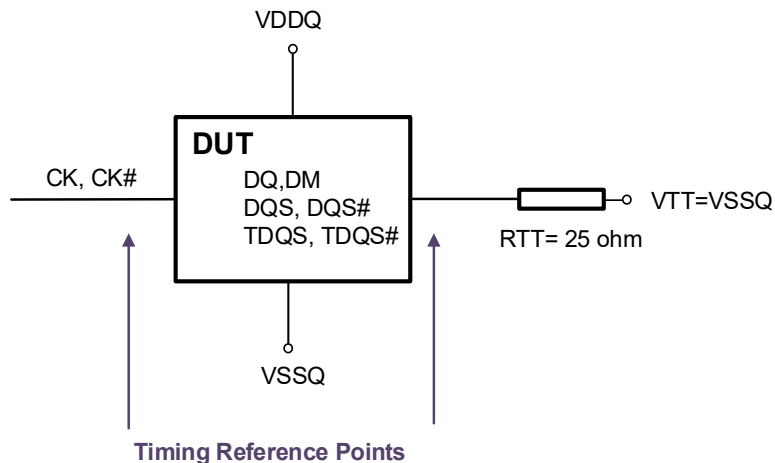


Figure 6-8. ODT Timing Reference Load

6.9.2 ODT Timing Definitions

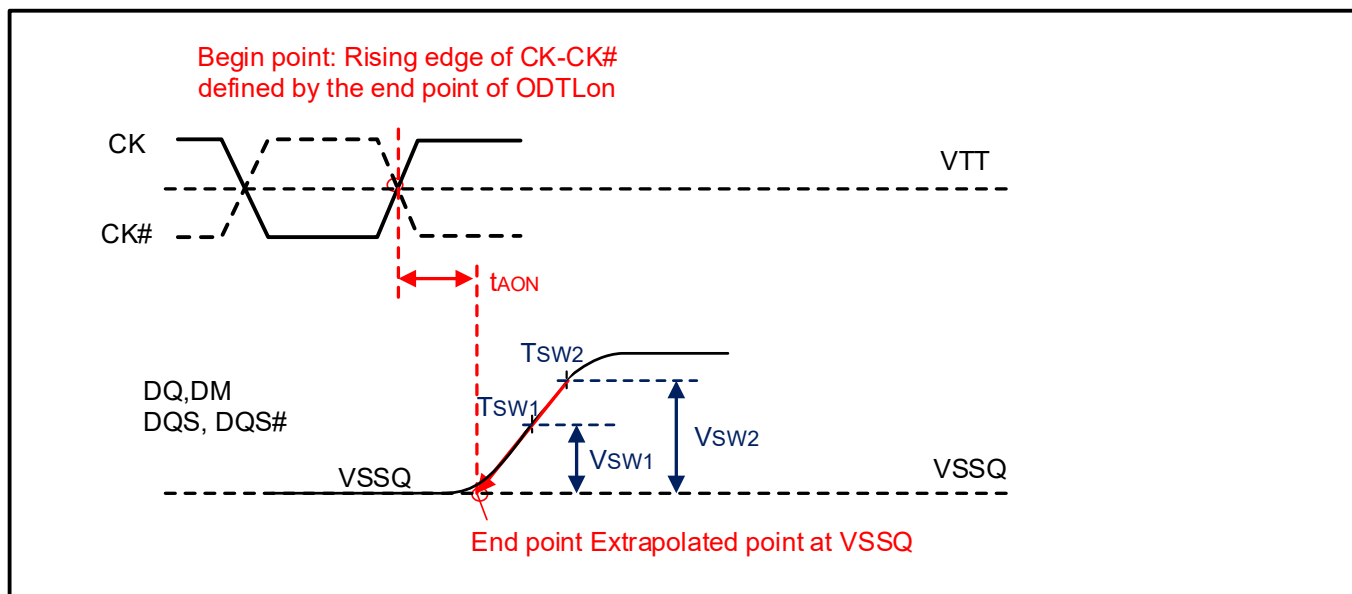
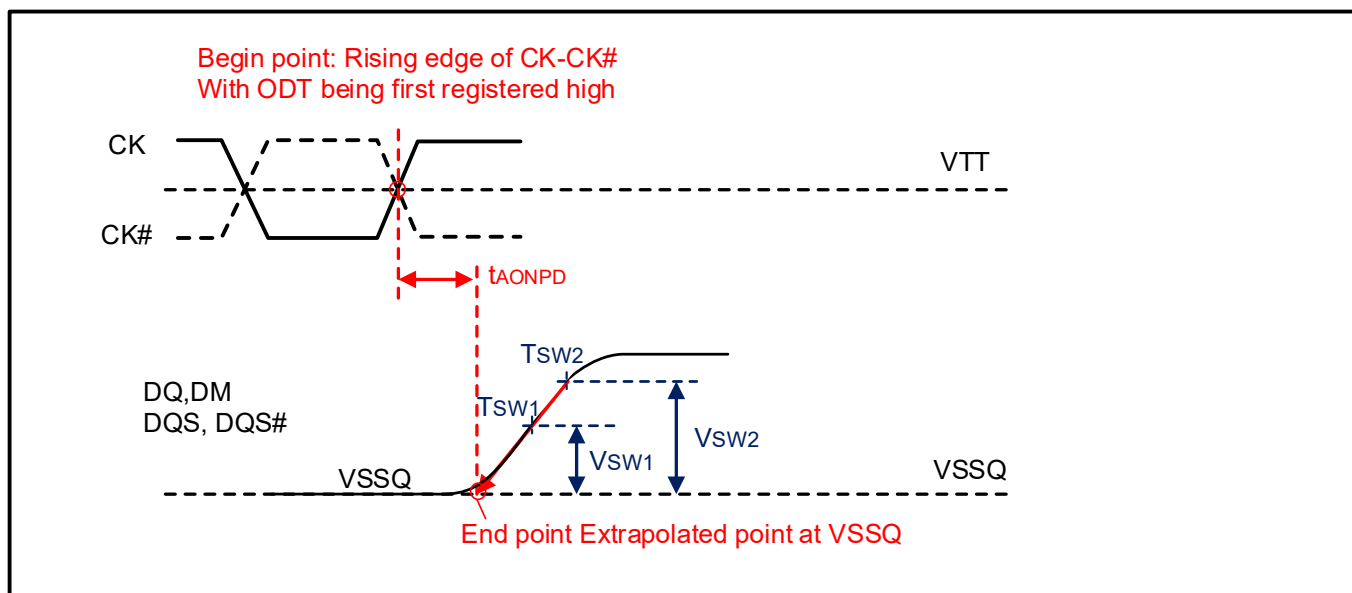
Definitions for t_{AON} , t_{AONPD} , t_{AOF} , t_{AOFPD} and t_{ADC} are provided in Table 6-16 and subsequent figures. Measurement reference settings are provided in Table 6-17.

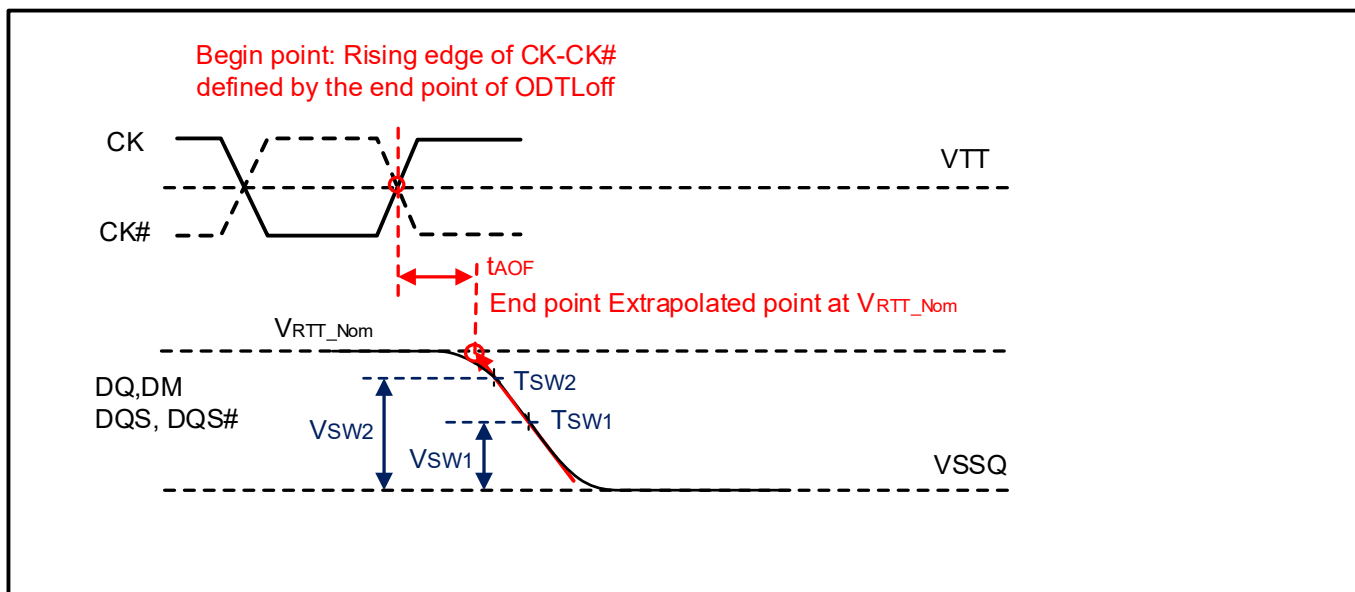
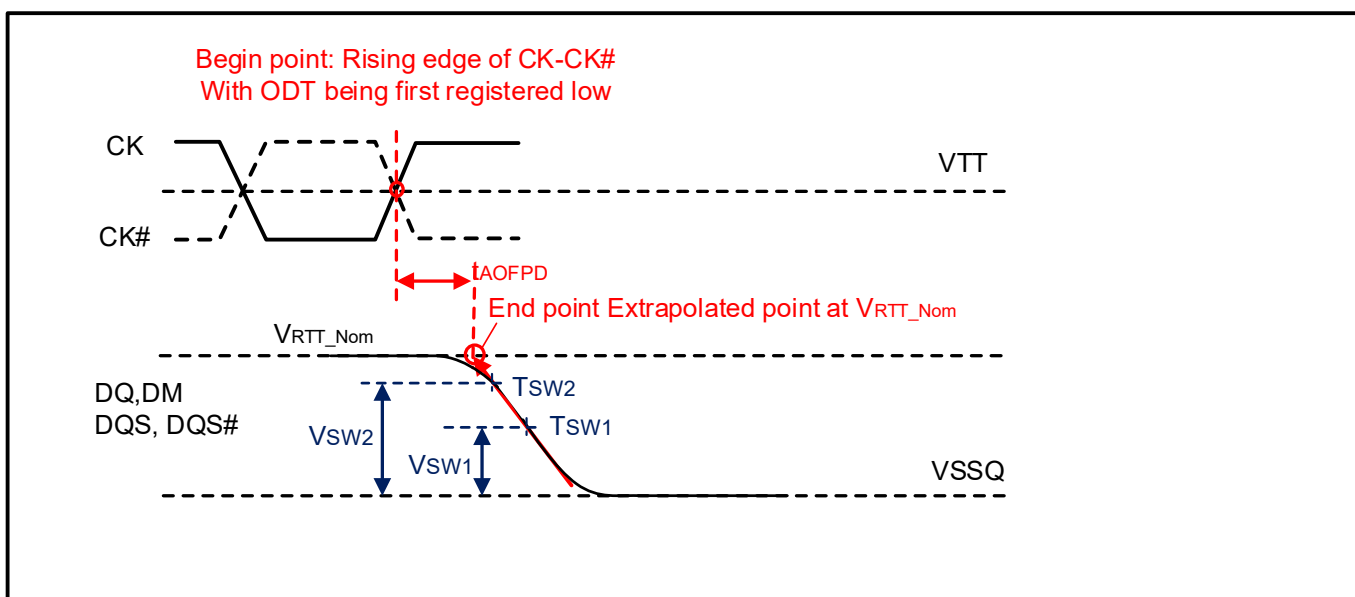
Table 6-16. ODT Timing Definitions

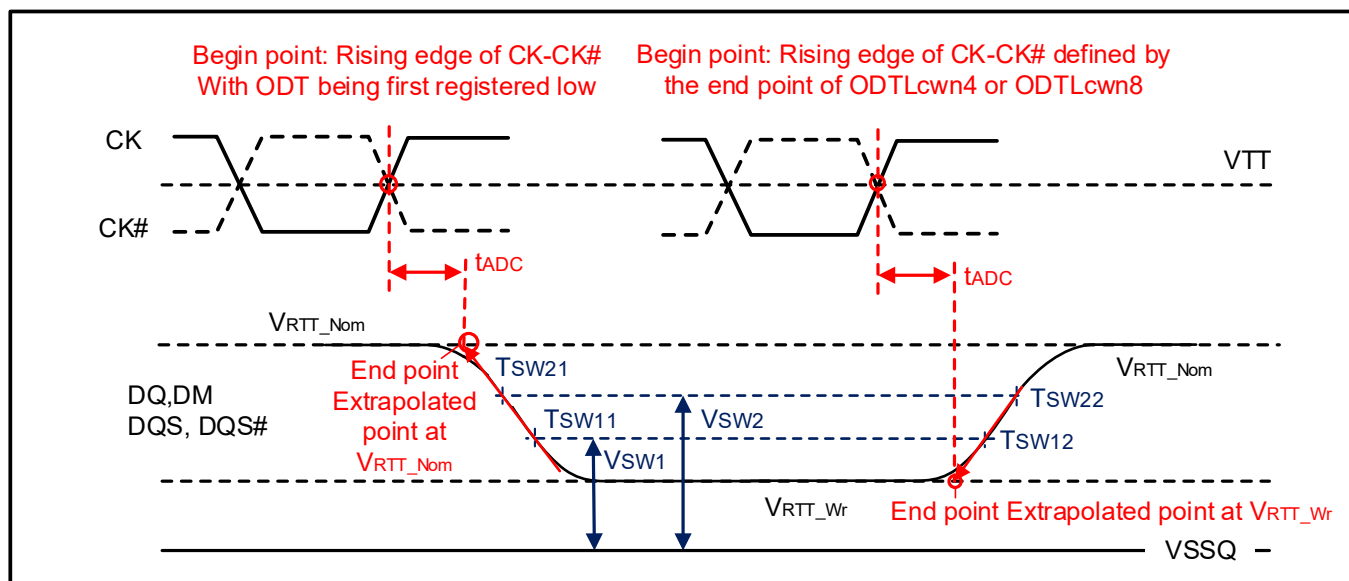
Symbol	Begin Point Definition	End Point Definition	Figure
t_{AON}	Rising edge of CK –CK# defined by the end point of ODTLon	Extrapolated point at V_{SSQ}	Figure 6-9
t_{AONPD}	Rising edge of CK –CK# with ODT being first registered high	Extrapolated point at V_{SSQ}	Figure 6-10
t_{AOF}	Rising edge of CK –CK# defined by the end point of ODTLoff	End point: Extrapolated point at V_{RTT_Nom}	Figure 6-11
t_{AOFPD}	Rising edge of CK –CK# with ODT being first registered low	End point: Extrapolated point at V_{RTT_Nom}	Figure 6-12
t_{ADC}	Rising edge of CK –CK# defined by the end point of ODTLcnw, ODTLcwn4 of ODTLcwn8	End point: Extrapolated point at V_{RTT_Wr} and V_{RTT_Nom} respectively	Figure 6-13

Table 6-17. Reference Settings for ODT Timing Measurements

Measured Parameter		RTT_Nom Setting	RTT_Wr Setting	V _{Sw1} [V]	V _{Sw2} [V]
t_{AON}		$R_{ZQ}/4$	NA	0.05	0.10
		$R_{ZQ}/12$	NA	0.10	0.20
t_{AONPD}		$R_{ZQ}/4$	NA	0.05	0.10
		$R_{ZQ}/12$	NA	0.10	0.20
t_{AOF}		$R_{ZQ}/4$	NA	0.05	0.10
		$R_{ZQ}/12$	NA	0.10	0.20
t_{AOFPD}		$R_{ZQ}/4$	NA	0.05	0.10
		$R_{ZQ}/12$	NA	0.10	0.20
t_{ADC}	DDR3L(1.35 V)	$R_{ZQ}/12$	$R_{ZQ}/2$	0.20	0.25
	DDR3(1.5 V)	$R_{ZQ}/12$	$R_{ZQ}/2$	0.20	0.30

Figure 6-9. Definition of t_{AON} Figure 6-10. Definition of t_{AONPD}

Figure 6-11. Definition of t_{AOF} Figure 6-12. Definition of t_{AOFPD}

Figure 6-13. Definition of t_{ADC}



7 IDD Current Measure Method

7.1 IDD Measurement Conditions

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

Figure 7-1 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.

Attention: IDDQ values cannot be directly used to calculate IO power of the DDR3 SDRAM. They can be used to support correlation of simulated IO power to actual IO power as outlined in Figure 7-2. In DRAM module application, IDDQ cannot be measured separately since VDD and VDDQ are using one merged-power layer in Module PCB.

For IDD and IDDQ measurements, the following definitions apply:

- "0" and "LOW" is defined as $V_{IN} \leq V_{ILAC}(\max)$.
- "1" and "HIGH" is defined as $V_{IN} \geq V_{IHAC}(\min)$.
- "MID-LEVEL" is defined as inputs are $V_{REF} = V_{DD} / 2$.
- "Timing used for IDD and IDDQ Measured - Loop Patterns" are provided in Table 7-1.
- "Basic IDD and IDDQ Measurement Conditions" are described in Table 7-3.
- Detailed IDD and IDDQ Measurement-Loop Patterns are described in Table 7-4 through Table 7-11.
- IDD Measurements are done after properly initializing the DDR3 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);
 TDQS Feature disabled in MR1
- **Attention:** The IDD and IDDQ Measurement-Loop Patterns need to be executed at least one time before actual IDD or IDDQ measurement is started.
- Define $D = \{CS\#, RAS\#, CAS\#, WE\# \} = \{HIGH, LOW, LOW, LOW\}$
- Defined $D = \{CS\#, RAS\#, CAS\#, WE\# \} = \{HIGH, HIGH, HIGH, HIGH\}$

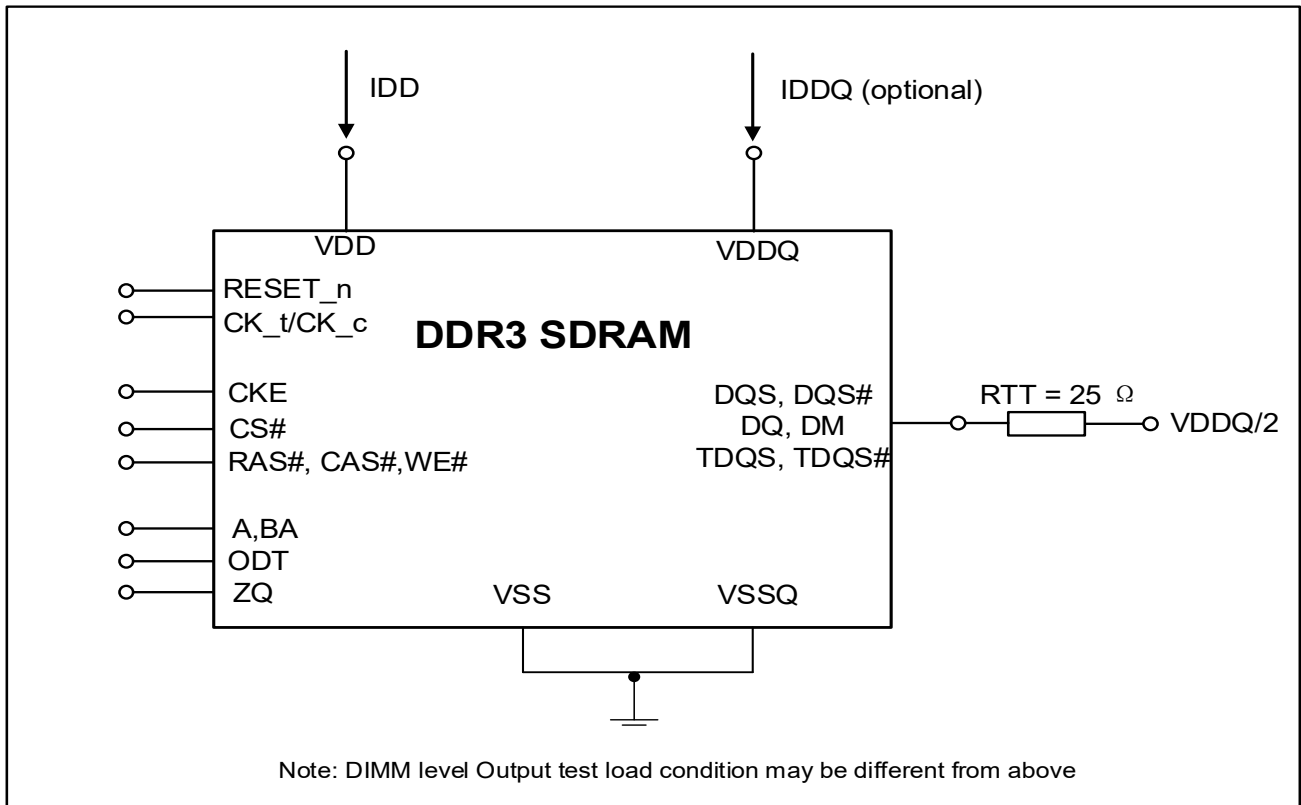


Figure 7-1. Measurement Setup and Test Load for I_{DD} and I_{DDQ} (optional) Measurements

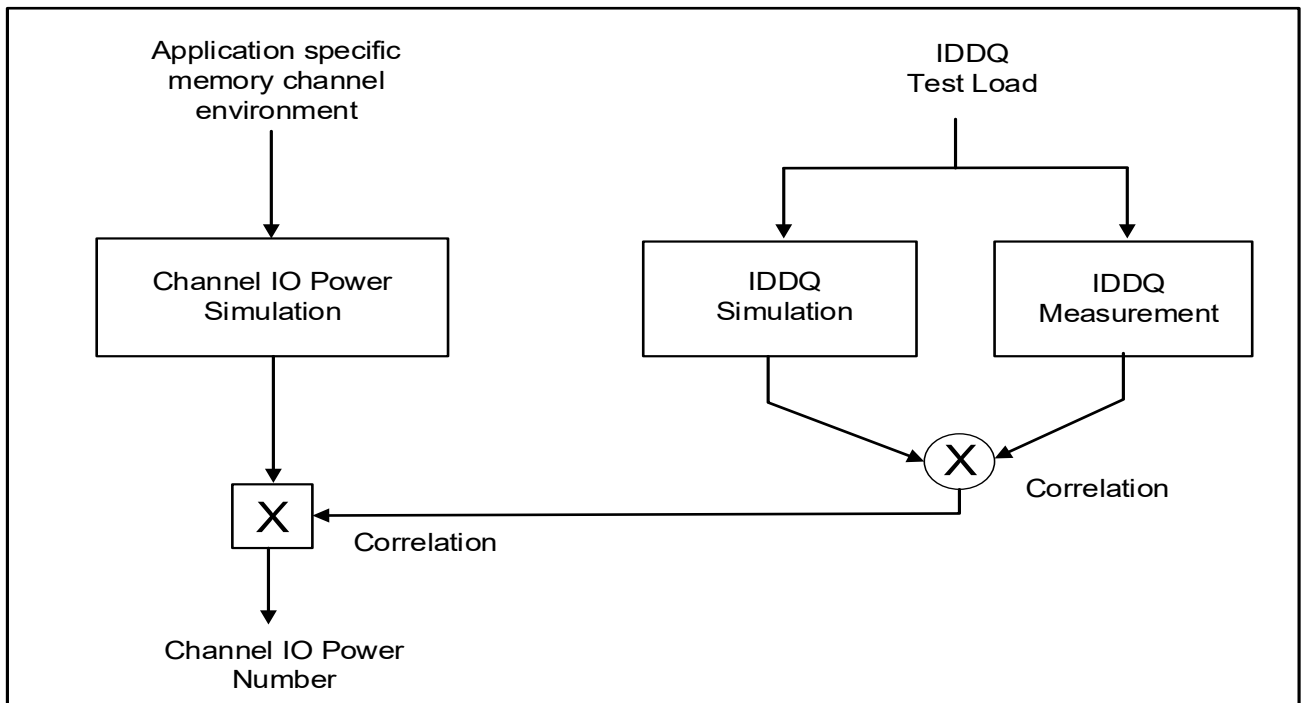


Figure 7-2. Correlation from simulated Channel IO Power to actual Channel IO Power supported by I_{DDQ} Measurement.



Table 7-1. Timing used for IDD and IDDQ Measured-Loop Patterns for 800/1066/1333/1600

Symbol		DDR3L-800		DDR3L-1066			DDR3L-1333				DDR3L-1600				Unit
		5-5-5	6-6-6	6-6-6	7-7-7	8-8-8	7-7-7	8-8-8	9-9-9	10-10-10	8-8-8	9-9-9	10-10-10	11-11-11	
tCK		2.5		1.875			1.5				1.25				ns
CL		5	6	6	7	8	7	8	9	10	8	9	10	11	nCK
nRCD		5	6	6	7	8	7	8	9	10	8	9	10	11	nCK
nRC		20	21	26	27	28	31	32	33	34	36	37	38	39	nCK
nRAS		15		20			24				28				nCK
nRP		5	6	6	7	8	7	8	9	10	8	9	10	11	nCK
nFAW	1KB page size	16		20			20				24				nCK
	2KB page size	20		27			30				32				nCK
nRRD	1KB page size	4		4			4				5				nCK
	2KB page size	4		6			5				6				nCK
nRFC 512 Mb		36		48			60				72				nCK
nRFC 1 Gb		44		59			74				88				nCK
nRFC 2 Gb		64		86			107				128				nCK
nRFC 4 Gb		104		139			174				208				nCK
nRFC 8 Gb		140		187			234				280				nCK

Table 7-2. Timing used for IDD and IDDQ Measured-Loop Patterns for 1866/2133

Symbol		DDR3L-1866				DDR3L-2133				Unit
		10-10-10	11-11-11	12-12-12	13-13-13	11-11-11	12-12-12	13-13-13	14-14-14	
tCK		1.071				0.938				ns
CL		10	11	12	13	11	12	13	14	nCK
nRCD		10	11	12	13	11	12	13	14	nCK
nRC		42	43	44	45	47	48	49	50	nCK
nRAS		32				36				nCK
nRP		10	11	12	13	11	12	13	14	nCK
nFAW	1KB page size	26				27				nCK
	2KB page size	33				38				nCK
nRRD	1KB page size	5				6				nCK
	2KB page size	6				7				nCK
nRFC 512 Mb		85				97				nCK
nRFC 1 Gb		103				118				nCK
nRFC 2 Gb		150				172				nCK
nRFC 4 Gb		243				279				nCK
nRFC 8 Gb		328				375				nCK

Table 7-3. Basic IDD and IDDQ Measurement Conditions

Symbol	Description
IDD0	Operating One Bank Active-Precharge Current CKE: High; External clock: On; tCK, nRC, nRAS, nRCD, CL: see Table 7-2; BL: 8⁽¹⁾; AL: 0; CS#: High between ACT and PRE; Command, Address, Bank Address Inputs: partially toggling according to Table 7-4; Data IO: MID-LEVEL; DM: stable at 0; Bank Activity: Cycling with one bank active at a time: 0,0,1,1,2,2, ... (see Table 7-4); Output Buffer and RTT: Enabled in Mode Registers⁽²⁾; ODT Signal: stable at 0; Pattern Details: see Table 7-4
IDD1	Operating One Bank Active-Read-Precharge Current CKE: High; External clock: On; tCK, nRC, nRAS, nRCD, CL: see Table 7-1; BL: 8^(1,7); AL: 0; CS#: High between ACT, RD and PRE; Command, Address, Bank Address Inputs, Data IO: partially toggling according to Table 7-5; DM: stable at 0; Bank Activity: Cycling with one bank active at a time: 0,0,1,1,2,2, ... (see Table 7-5); Output Buffer and RTT: Enabled in Mode Registers⁽²⁾; ODT Signal: stable at 0; Pattern Details: see Table 7-5
IDD2N	Precharge Standby Current CKE: High; External clock: On; tCK, CL: see Table 7-1; BL: 8⁽¹⁾; AL: 0; CS#: stable at 1; Command, Address, Bank Address Inputs: partially toggling according to Table 7-6 Data IO: 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 7-6
IDD2NT	Precharge Standby ODT Current CKE: High; External clock: On; tCK, CL: see Table 7-1; BL: 8⁽¹⁾; AL: 0; CS#: stable at 1; Command, Address, Bank Address Inputs: partially toggling according to Table 7-7; Data IO: MID-LEVEL; DM: stable at 0; Bank Activity: all banks closed; Output Buffer and RTT: Enabled in Mode Registers⁽²⁾; ODT Signal: toggling according to Table 7-7; Pattern Details: Table 7-7;
IDDQ2NT (Optional)	Precharge Standby ODT IDDQ Current Same definition like for IDD2NT, however measuring IDDQ current instead of IDD current



Symbol	Description
IDD2P0	Precharge Power-Down Current Slow Exit CKE: Low; External clock: On; tCK, CL; see Table 7-1; BL: 8 ⁽¹⁾ ; AL: 0; CS#: stable at 1; Command, Address, Bank Address Inputs: stable at 0; Data IO: 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 Pecharge Power Down Mode: Slow Exit ⁽³⁾
IPP2P1	Precharge Power-Down Current Fast Exit CKE: Low; External clock: On; tCK, CL; see Table 7-1; BL: 8 ⁽¹⁾ ; AL: 0; CS#: stable at 1; Command, Address, Bank Address Inputs: stable at 0; Data IO: 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 Pecharge Power Down Mode: Fast Exit ⁽³⁾
IDD2Q	Precharge Quiet Standby Current CKE: High; External clock: On; tCK, CL: see Table 7-1; BL: 8 ⁽¹⁾ ; AL: 0; CS#: stable at 1; Command, Address, Bank Address Inputs: stable at 0; Data IO: 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
IDD3N	Active Standby Current CKE: High; External clock: On; tCK, CL: see Table 7-1; BL: 8 ⁽¹⁾ ; AL: 0; CS#: stable at 1; Command, Address, Bank Address Inputs: partially toggling according to Table 7-6; Data IO: MID-LEVEL; DM: stable at 0; Bank Activity: all banks open; Output Buffer and RTT: Enabled in Mode Registers ⁽²⁾ ; ODT Signal: stable at 0; Pattern Details: see Table 7-6



Symbol	Description
IDD3P	Active Power-Down Current CKE: Low; External clock: On; tCK, CL: see Table 7-1; BL: 8 ⁽¹⁾ ; AL: 0; CS#: stable at 1; Command, Address, Bank Address Inputs: stable at 0; Data IO: MID-LEVEL; DM: stable at 0; Bank Activity: all banks open; Output Buffer and RTT: Enabled in Mode Registers ⁽²⁾ ; ODT Signal: stable at 0
IDD4R	Operating Burst Read Current CKE: High; External clock: On; tCK, CL: see Table 7-1; BL: 8 ^(1,7) ; AL: 0; CS#: High between RD; Command, Address, Bank Address Inputs: partially toggling according to Table 7-8; Data IO: seamless read data burst with different data between one burst and the next one according to Table 7-8; DM: stable at 0; Bank Activity: all banks open, RD commands cycling through banks: 0,0,1,1,2,2, ... (see Table 7-8); Output Buffer and RTT: Enabled in Mode Registers ⁽²⁾ ; ODT Signal: stable at 0; Pattern Details: see Table 7-8
IDDQ4R (Optional)	Operating Burst Read IDDQ Current Same definition like for IDD4R, however measuring IDDQ current instead of IDD current
IDD4W	Operating Burst Write Current CKE: High; External clock: On; tCK, CL: see Table 7-1; BL: 8 ⁽¹⁾ ; AL: 0; CS#: High between WR; Command, Address, Bank Address Inputs: partially toggling according to Table 7-9; Data IO: seamless read data burst with different data between one burst and the next one according to Table 7-9; DM: stable at 0; Bank Activity: all banks open, WR commands cycling through banks: 0,0,1,1,2,2, ... (see Table 7-9); Output Buffer and RTT: Enabled in Mode Registers ⁽²⁾ ; ODT Signal: stable at <u>HIGH</u> ; Pattern Details: see Table 7-9
IDD5B	Burst Refresh Current CKE: High; External clock: On; tCK, CL nRFC: see Table 7-1; BL: 8 ⁽¹⁾ ; AL: 0; CS#: High between REF; Command, Address, Bank Address Inputs: partially toggling according to Table 7-10; Data IO: MID-LEVEL; DM: stable at 0; Bank Activity: REF command every nRFC (see Table 7-10); Output Buffer and RTT: Enabled in Mode Registers ⁽²⁾ ; ODT Signal: stable at 0; Pattern Details: see Table 7-10



Symbol	Description
IDD6	Self Refresh Current: Normal Temperature Range T_{CASE}: 0 - 85°C; Auto Self-Refresh (ASR): Disabled⁽⁴⁾; Self-Refresh Temperature Range (SRT): Normal⁽⁵⁾; CKE: Low; External clock: Off; CK and CK#: LOW; CL: see Table 7-1; BL: 8⁽¹⁾; AL: 0; CS#, Command, Address, Bank Address, Data IO: MID-LEVEL; DM: stable at 0; Bank Activity: Self-Refresh operation; Output Buffer and RTT: Enabled in Mode Registers⁽²⁾; ODT Signal: MID-LEVEL
IDD6ET	Self-Refresh Current: Extended Temperature Range T_{CASE}: 0 - 95°C; Auto Self-Refresh (ASR): Disabled⁽⁴⁾; Self-Refresh Temperature Range (SRT): Extended⁽⁵⁾; CKE: Low; External clock: Off; CK and CK#: LOW; CL: see Table 7-1; BL: 8⁽¹⁾; AL: 0; CS#, Command, Address, Bank Address, Data IO: MID-LEVEL; DM: stable at 0; Bank Activity: Extended Temperature Self-Refresh operation; Output Buffer and RTT: Enabled in Mode Registers⁽²⁾; ODT Signal: MID-LEVEL
IDD6TC	Auto Self-Refresh Current (optional)⁽⁶⁾ T_{CASE}: 0 - 95°C; Auto Self-Refresh (ASR): Enabled⁽⁴⁾; Self-Refresh Temperature Range (SRT): Normal⁽⁵⁾; CKE: Low; External clock: Off; CK and CK#: LOW; CL: see Table 7-1; BL: 8⁽¹⁾; AL: 0; CS#, Command, Address, Bank Address, Data IO: MID-LEVEL; DM: stable at 0; Bank Activity: Auto Self-Refresh operation; Output Buffer and RTT: Enabled in Mode Registers⁽²⁾; ODT Signal: MID-LEVEL
IDD7	Operating Bank Interleave Read Current CKE: High; External clock: On; tCK, nRC, nRAS, nRCD, nRRD, nFAW, CL: see Table 7-1; BL: 8⁽¹⁾; AL: CL-1; CS#: High between ACT and RDA; Command, Address, Bank Address Inputs: partially toggling according to Table 7-11; Data IO: Read data bursts with different data between one burst and the next one according to Table 7-11; DM: stable at 0; Bank Activity: two times interleaved cycling through banks (0, 1, ...7) with different addressing, see Table 7-11; Output Buffer and RTT: Enabled in Mode Registers⁽²⁾; ODT Signal: stable at 0; Pattern Details: see Table 7-11.



Symbol	Description
IDD8 (Optional)	RESET Low Current 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.

Note:

1. Burst Length: BL8 fixed by MRS: set MR0 A[1,0] =00B
2. Output Buffer Enable: set MR1 A[12] =0B; set MR1 A[5,1]=01B; RTT_Nom enable: set MR1 A[9,6,2]=011B; RTT_Wr enable: set MR2 A[10,9]=10B
3. Precharge Power Down Mode: set MR0 A12=0B for Slow Exit or MR0 A12=1B for Fast Exit
4. Auto Self-Refresh (ASR): set MR2 A6 =0B to disable or 1B to enable feature
5. Self-Refresh Temperature Range (SRT): set MR2 A7=0B for normal or 1B for extended temperature range
6. Refer to DRAM supplier data sheet and/or DIMM SPD to determine if optional features or requirements are supported by DDR3 SDRAM device
7. Read Burst Type: Nibble Sequential, set MR0 A[3]=0B

Table 7-4. IDD0 Measurement-Loop Pattern¹

CK, CK#	CKE	Sub-Loop	Cycle Number	Command	CS#	RAS#	CAS#	WE#	ODT	BA[2:0]	A[15:11]	A[10]	A[9:7]	A[6:3]	A[2:0]	Data ²
Toggling	Static High	0	0	ACT	0	0	1	1	0	0	00	0	0	0	0	-
			1,2	D, D	1	0	0	0	0	0	00	0	0	0	0	-
			3,4	D_#,D_#	1	1	1	1	0	0	00	0	0	0	0	-
			...	repeat pattern 1...4 unit nRAS -1, truncate if necessary												
			nRAS	PRE	0	0	1	0	0	0	00	0	0	0	0	-
			...	repeat pattern 1...4 unit nRC -1, truncate if necessary												
			1*nRC + 0	ACT	0	0	1	1	0	0	00	0	0	F	0	-
			1*nRC + 1,2	D, D	1	0	0	0	0	0	00	0	0	F	0	-
			1*nRC + 3,4	D_#,D_#	1	1	1	1	0	0	00	0	0	F	0	-
			...	repeat pattern nRC + 1...4 unit 1* nRC + nRAS -1, truncate if necessary												
			1*nRC + nRAS	PRE	0	0	1	0	0	0	00	0	0	F	0	-
			...	repeat nRC + 1...4 unit 2* nRC -1, truncate if necessary												
		1	2*nRC	repeat Sub-Loop 0, use BA[2:0] = 1 instead												
		2	4*nRC	repeat Sub-Loop 0, use BA[2:0] = 2 instead												
		3	6*nRC	repeat Sub-Loop 0, use BA[2:0] = 3 instead												
		4	8*nRC	repeat Sub-Loop 0, use BA[2:0] = 4 instead												
		5	10*nRC	repeat Sub-Loop 0, use BA[2:0] = 5 instead												
		6	12*nRC	repeat Sub-Loop 0, use BA[2:0] = 6 instead												
		7	14*nRC	repeat Sub-Loop 0, use BA[2:0] = 7 instead												

Note:

1. DM must be driven LOW all the time. DQS, DQS# are MID-LEVEL.
2. DQ signals are MID-LEVEL.

Table 7-5. IDD1 Measurement-Loop Pattern¹

CK, CK#	CKE	Sub-Loop	Cycle Number	Command	CS#	RAS#	CAS#	WE#	ODT	BA[2:0]	A[15:11]	A[10]	A[9:7]	A[6:3]	A[2:0]	Data ²
Toggling	Static High	0	0	ACT	0	0	1	1	0	0	00	0	0	0	0	-
			1,2	D, D	1	0	0	0	0	0	00	0	0	0	0	-
			3,4	D_#,D_#	1	1	1	1	0	0	00	0	0	0	0	-
			...	repeat pattern 1...4 unit nRCD -1, truncate if necessary												
			nRCD	RD	0	1	0	1	0	0	00	0	0	0	0	00000000
			...	repeat pattern 1...4 unit nRAS -1, truncate if necessary												
			nRAS	PRE	0	0	1	0	0	0	00	0	0	0	0	-
			...	repeat pattern 1...4 unit nRC -1, truncate if necessary												
			1*nRC + 0	ACT	0	0	1	1	0	0	00	0	0	F	0	-
			1*nRC + 1,2	D, D	1	0	0	0	0	0	00	0	0	F	0	-
			1*nRC + 3,4	D_#,D_#	1	1	1	1	0	0	00	0	0	F	0	-
			...	repeat pattern nRC + 1...4 unit nRC + nRCD -1, truncate if necessary												
			1*nRC + nRCD	RD	0	1	0	1	0	0	00	0	0	F	0	00110011
			...	repeat pattern nRC + 1...4 unit nRC + nRAS -1, truncate if necessary												
			1*nRC + nRAS	PRE	0	0	1	0	0	0	00	0	0	F	0	-
			...	repeat pattern nRC + 1...4 unit 2* nRC -1, truncate if necessary												
		1	2*nRC	repeat Sub-Loop 0, use BA[2:0] = 1 instead												
		2	4*nRC	repeat Sub-Loop 0, use BA[2:0] = 2 instead												
		3	6*nRC	repeat Sub-Loop 0, use BA[2:0] = 3 instead												
		4	8*nRC	repeat Sub-Loop 0, use BA[2:0] = 4 instead												
		5	10*nRC	repeat Sub-Loop 0, use BA[2:0] = 5 instead												
		6	12*nRC	repeat Sub-Loop 0, use BA[2:0] = 6 instead												
		7	14*nRC	repeat Sub-Loop 0, use BA[2:0] = 7 instead												

Note:

1. DM must be driven LOW all thetime. DQS, DQS# are used according to RD Commands, otherwise MID-LEVEL.
2. Burst Sequence driven on each DQ signal by Read Command. Outside burst operation, DQ signals are MID-LEVEL.

Table 7-6. IDD2N and IDD3N Measurement-Loop Pattern¹

CK, CK#	CKE	Sub-Loop	Cycle Number	Command	CS#	RAS#	CAS#	WE#	ODT	BA[2:0]	A[15:11]	A[10]	A[9:7]	A[6:3]	A[2:0]	Data ²
Toggling	Static High	0	0	D	1	0	0	0	0	0	0	0	0	0	0	-
			1	D	1	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	4-7	repeat Sub-Loop 0, use BA[2:0] = 1 instead												
		2	8-11	repeat Sub-Loop 0, use BA[2:0] = 2 instead												
		3	12-15	repeat Sub-Loop 0, use BA[2:0] = 3 instead												
		4	16-19	repeat Sub-Loop 0, use BA[2:0] = 4 instead												
		5	20-23	repeat Sub-Loop 0, use BA[2:0] = 5 instead												
		6	24-27	repeat Sub-Loop 0, use BA[2:0] = 6 instead												
		7	28-31	repeat Sub-Loop 0, use BA[2:0] = 7 instead												

Note:

1. DM must be driven LOW all the time. DQS, DQS# are MID-LEVEL.
2. DQ signals are MID-LEVEL.

Table 7-7. IDD2NT and IDDQ2NT Measurement-Loop Pattern¹

CK, CK#	CKE	Sub-Loop	Cycle Number	Command	CS#	RAS#	CAS#	WE#	ODT	BA[2:0]	A[15:11]	A[10]	A[9:7]	A[6:3]	A[2:0]	Data ²
Toggling	Static High	0	0	D	1	0	0	0	0	0	0	0	0	0	0	-
			1	D	1	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	4-7	repeat Sub-Loop 0, but ODT = 0 and BA[2:0] = 1												
		2	8-11	repeat Sub-Loop 0, but ODT = 1 and BA[2:0] = 2												
		3	12-15	repeat Sub-Loop 0, but ODT = 1 and BA[2:0] = 3												
		4	16-19	repeat Sub-Loop 0, but ODT = 0 and BA[2:0] = 4												
		5	20-23	repeat Sub-Loop 0, but ODT = 0 and BA[2:0] = 5												
		6	24-27	repeat Sub-Loop 0, but ODT = 1 and BA[2:0] = 6												
		7	28-31	repeat Sub-Loop 0, but ODT = 1 and BA[2:0] = 7												

Note:

1. DM must be driven LOW all the time. DQS, DQS# are MID-LEVEL.
2. DQ signals are MID-LEVEL.

Table 7-8. IDD4R and IDDQ4R Measurement-Loop Pattern¹

CK, CK#	CKE	Sub-Loop	Cycle Number	Command	CS#	RAS#	CAS#	WE#	ODT	BA[2:0]	A[15:11]	A[10]	A[9:7]	A[6:3]	A[2:0]	Data ²
Toggling	Static High	0	0	RD	0	1	0	1	0	0	00	0	0	0	0	00000000
			1	D	1	0	0	0	0	0	00	0	0	0	0	-
			2,3	D#, D#	1	1	1	1	0	0	00	0	0	0	0	-
			4	RD	0	1	0	1	0	0	00	0	0	F	0	00110011
			5	D	1	0	0	0	0	0	00	0	0	F	0	
			6,7	D#, D#	1	1	1	1	0	0	00	0	0	F	0	
		1	8-15	repeat Sub-Loop 0, but BA[2:0] = 1												
		2	16-23	repeat Sub-Loop 0, but BA[2:0] = 2												
		3	24-31	repeat Sub-Loop 0, but BA[2:0] = 3												
		4	32-39	repeat Sub-Loop 0, but BA[2:0] = 4												
		5	40-47	repeat Sub-Loop 0, but BA[2:0] = 5												
		6	48-55	repeat Sub-Loop 0, but BA[2:0] = 6												
		7	56-63	repeat Sub-Loop 0, but BA[2:0] = 7												

Note:

1. DM must be driven LOW all the time. DQS, DQS# are used according to RD Commands, otherwise MID-LEVEL.
2. Burst Sequence driven on each DQ signal by Read Command. Outside burst operation, DQ signals are MID-LEVEL.

Table 7-9. IDD4W Measurement-Loop Pattern¹

CK, CK#	CKE	Sub-Loop	Cycle Number	Command	CS#	RAS#	CAS#	WE#	ODT	BA[2:0]	A[15:11]	A[10]	A[9:7]	A[6:3]	A[2:0]	Data ²
Toggling	Static High	0	0	WR	0	1	0	0	1	0	00	0	0	0	0	00000000
			1	D	1	0	0	0	1	0	00	0	0	0	0	-
			2,3	D#, D#	1	1	1	1	1	0	00	0	0	0	0	-
			4	WR	0	1	0	0	1	0	00	0	0	F	0	00110011
			5	D	1	0	0	0	1	0	00	0	0	F	0	
			6,7	D#, D#	1	1	1	1	1	0	00	0	0	F	0	
		1	8-15	repeat Sub-Loop 0, but BA[2:0] = 1												
		2	16-23	repeat Sub-Loop 0, but BA[2:0] = 2												
		3	24-31	repeat Sub-Loop 0, but BA[2:0] = 3												
		4	32-39	repeat Sub-Loop 0, but BA[2:0] = 4												
		5	40-47	repeat Sub-Loop 0, but BA[2:0] = 5												
		6	48-55	repeat Sub-Loop 0, but BA[2:0] = 6												
		7	56-63	repeat Sub-Loop 0, but BA[2:0] = 7												

Note:

1. DM must be driven LOW all the time. DQS, DQS# are used according to WR Commands, otherwise MID-LEVEL.
2. Burst Sequence driven on each DQ signal by WriteCommand. Outside burst operation, DQ signals are MID-LEVEL.

Table 7-10. IDD5B Measurement-Loop Pattern¹

CK, CK#	CKE	Sub-Loop	Cycle Number	Command	CS#	RAS#	CAS#	WE#	ODT	BA[2:0]	A[15:11]	A[10]	A[9:7]	A[6:3]	A[2:0]	Data ²
Toggling	Static High	0	0	REF	0	0	0	1	0	0	00	0	0	0	0	-
		1	1,2	D, D	1	0	0	0	0	0	00	0	0	0	0	-
			3,4	D#, D#	1	1	1	1	0	0	00	0	0	F	0	-
			5...8	repeat cycles 1...4, but BA[2:0] = 1												
			9...12	repeat cycles 1...4, but BA[2:0] = 2												
			13...16	repeat cycles 1...4, but BA[2:0] = 3												
			17...20	repeat cycles 1...4, but BA[2:0] = 4												
			21...24	repeat cycles 1...4, but BA[2:0] = 5												
			25...28	repeat cycles 1...4, but BA[2:0] = 6												
			29...32	repeat cycles 1...4, but BA[2:0] = 7												
		2	33...nRFC-1	repeat Sub-Loop 1, unit nRFC -1. Truncate, if necessary.												

Note:

1. DM must be driven Low all the time. DQS, DQS# are MID-LEVEL.
2. DQ signals are MID-LEVEL.

Table 7-11. IDD7 Measurement-Loop Pattern¹

CK, CK#	CKE	Sub-Loop	Cycle Number	Command	CS#	RAS#	CAS#	WE#	ODT	BA[2:0]	A[15:11]	A[10]	A[9:7]	A[6:3]	A[2:0]	Data ²
Toggling	Static High	0	0	ACT	0	0	1	1	0	0	00	0	0	0	0	-
			1	RDA	0	1	0	1	0	0	00	1	0	0	0	00000000
			2	D	1	0	0	0	0	0	00	0	0	0	0	-
			...	repeat above D Command until nRRD - 1												
		1	nRRD	ACT	0	0	1	1	0	1	00	0	0	F	0	-
			nRRD+1	RDA	0	1	0	1	0	1	00	1	0	F	0	00110011
			nRRD+2	D	1	0	0	0	0	1	00	0	0	F	0	-
			...	repeat above D Command until 2 * nRRD - 1												
		2	2* nRRD	repeat Sub-Loop 0, but BA[2:0] = 2												
		3	3* nRRD	repeat Sub-Loop 1, but BA[2:0] = 3												
		4	4* nRRD	D	1	0	0	0	0	3	00	0	0	F	0	-
				Assert and repeat above D Command until nFAW - 1, if necessary												
		5	nFAW	repeat Sub-Loop 0, but BA[2:0] = 4												
		6	nFAW + nRRD	repeat Sub-Loop 1, but BA[2:0] = 5												
		7	nFAW + 2* nRRD	repeat Sub-Loop 0, but BA[2:0] = 6												
		8	nFAW + 3* nRRD	repeat Sub-Loop 1, but BA[2:0] = 7												
		9	nFAW + 4* nRRD	D	1	0	0	0	0	7	00	0	0	F	0	-
				Assert and repeat above D Command until 2 * nFAW - 1, if necessary												
		10	2* nFAW+0	ACT	0	0	1	1	0	0	00	0	0	F	0	-
			2* nFAW+1	RDA	0	1	0	1	0	0	00	1	0	F	0	00110011
			2* nFAW+2	D	1	0	0	0	0	0	00	0	0	F	0	-
				Repeat above D Command until 2 * nFAW + nRRD - 1												
		11	2*nFAW + nRRD	ACT	0	0	1	1	0	1	00	0	0	0	0	-
			2*nFAW + nRRD +1	RDA	0	1	0	1	0	1	00	1	0	0	0	00000000
			2*nFAW + nRRD+2	D	1	0	0	0	0	1	00	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[2:0] = 2												
		13	2*nFAW + 3*nRRD	repeat Sub-Loop 11, but BA[2:0] = 3												

CK, CK#	CKE	Sub-Loop	Cycle Number	Command	CS#	RAS#	CAS#	WE#	ODT	BA[2:0]	A[15:11]	A[10]	A[9:7]	A[6:3]	A[2:0]	Data ²
		14	2*nFAW + 4*nRRD	D	1	0	0	0	0	3	00	0	0	0	0	-
				Assert and repeat above D Command until 3 * nFAW - 1, if necessary												
		15	3*nFAW	repeat Sub-Loop 10, butBA[2:0] = 4												
		16	3*nFAW + nRRD	repeat Sub-Loop 11, butBA[2:0] = 5												
		17	3*nFAW + 2*nRRD	repeat Sub-Loop 10, butBA[2:0] = 6												
		18	3*nFAW + 3*nRRD	repeat Sub-Loop 11, butBA[2:0] = 7												
		19	3*nFAW + 4*nRRD	D	1	0	0	0	0	7	00	0	0	0	0	-
				Assert and repeat above D Command until 4 * nFAW - 1, if necessary												

Note:

1. DM must be driven LOW all the time. DQS, DQS# are used according to RD Commands, otherwise MID-LEVEL.
2. Burst Sequence driven on each DQ signal by Read Command. Outside burst operation, DQ signals are MID-LEVEL.



7.2 IDD Specifications

IDD values are for full operating range of voltage and temperature unless otherwise noted.

Table 7-12. IDD Specifications (1.35 V)

Speed Grade Bin	DDR3L-1866	DDR3L-2133	Unit	Notes
Symbol	Max.	Max.		
I _{DD0}	63	66	mA	x8
I _{DD1}	80	84	mA	x8
I _{DD2P(0)} slow exit	36	39	mA	x8
I _{DD2P(1)} fast exit	37	40	mA	x8
I _{DD2N}	59	64	mA	x8
I _{DD2NT}	85	89	mA	x8
I _{DD2Q}	49	53	mA	x8
I _{DD3P} fast exit	51	54	mA	x8
I _{DD3N}	73	76	mA	x8
I _{DD4R}	157	171	mA	x8
I _{DD4W}	153	166	mA	x8
I _{DD5B}	292	294	mA	x8
I _{DD6}	31	32	mA	x8
I _{DD6ET} ⁽¹⁾	47	47	mA	x8
I _{DD6TC}	46	47	mA	x8
I _{DD7}	181	183	mA	x8
I _{DD8}	19	19	mA	x8

Note:

1. Users should refer to the DRAM supplier data sheet and/or the DIMM SPD to determine if DDR3L SDRAM devices support the following options or requirements referred to in this material.
2. Some data retains the possibility of future updates.

Table 7-13. I_{DD} Specifications (1.5 V)

SpeedGradeBin	DDR3-1866	DDR3-2133	Unit	Notes
Symbol	Max.	Max.		
I _{DD0}	65	68	mA	x8
I _{DD1}	82	85	mA	x8
I _{DD2P(0)} slowexit	40	43	mA	x8
I _{DD2P(1)} fastexit	40	43	mA	x8
I _{DD2N}	62	65	mA	x8
I _{DD2NT}	90	94	mA	x8
I _{DD2Q}	55	59	mA	x8
I _{DD3P} fastexit	52	55	mA	x8
I _{DD3N}	75	78	mA	x8
I _{DD4R}	160	174	mA	x8
I _{DD4W}	157	170	mA	x8
I _{DD5B}	317	318	mA	x8
I _{DD6}	32	32	mA	x8
I _{DD6ET} ¹	47	47	mA	x8
I _{DD6TC}	47	48	mA	x8
I _{DD7}	183	186	mA	x8
I _{DD8}	22	23	mA	x8

Note:

1. Users should refer to the DRAM supplier data sheet and/or the DIMM SPD to determine if DDR3 SDRAM devices support the following options or requirementsreferred to in this material.
2. Some data retains the possibility of future updates.

8 Input/Output Capacitance

8.1 Input/Output Capacitance

Table 8-1. DDR3L/DDR3-800/1066/1333/1600 Input/Output Capacitance

Symbol	Parameter		800		1066		1333		1600		Unit	Note
			Min	Max	Min	Max	Min	Max	Min	Max		
C _{IO}	Input/output capacitance (DQ, DM,DQS, DQS#, TDQS, TDQS#)	DDR3 (1.5 V)	1.4	3.0	1.4	2.7	1.4	2.5	1.4	2.3	pF	1,2,3
		DDR3L (1.35 V)	1.4	2.5	1.4	2.5	1.4	2.3	1.4	2.1		
C _{CK}	Input capacitance, CK and CK#		0.8	1.6	0.8	1.6	0.8	1.4	0.8	1.4	pF	2,3
C _{DCK}	Input capacitance delta, CK and CK#		0	0.15	0	0.15	0	0.15	0	0.15	pF	2,3,4
C _{DDQS}	Input/output capacitance delta DQS and DQS#		0	0.15	0	0.15	0	0.15	0	0.15	pF	2,3,5
C _I	Input capacitance, (CTRL, ADD,CMD input-only pins)	DDR3 (1.5 V)	0.75	1.4	0.75	1.35	0.75	1.3	0.75	1.3	pF	2,3,6
		DDR3L (1.35 V)	0.75	1.3	0.75	1.3	0.75	1.3	0.75	1.2		
C _{DI_CTRL}	Input capacitance delta, (All CTRLinput-only pins)		-0.5	0.3	-0.5	0.3	-0.4	0.2	-0.4	0.2	pF	2,3,7,8
C _{DI_ADD_CMD}	Input capacitance delta, (All ADD/CMD input-only pins)		-0.5	0.5	-0.5	0.5	-0.4	0.4	-0.4	0.4	pF	2,3,9,10
C _{DIO}	Input/output capacitance delta, DQ,DM, DQS, DQS#, TDQS, TDQS#		-0.5	0.3	-0.5	0.3	-0.5	0.3	-0.5	0.3	pF	2,3,11
C _{ZQ}	Input/output capacitance of ZQ pin		-	3	-	3	-	3	-	3	pF	2,3,12

Note:

1. Although the DM, TDQS and TDQS# pins have different functions, the loading matches DQ and DQS.
2. This parameter is not subject to production test. It is verified by design and characterization. The capacitance is measured according to JEP147("PROCEDURE FOR MEASURING INPUT CAPACITANCE USING A VEC-TOR NETWORK ANALYZER(VNA)") with VDD, VDDQ, VSS, VSSQ applied and all other pins floating (except the pin under test, CKE, RESET# and ODT as necessary). VDD=VDDQ=1.35V, VBIAS=VDD/2 and on-die termination off.
3. This parameter applies to monolithic devices only; stacked/dual-die devices are not covered here
4. Absolute value of C_{CK}-C_{CK#}
5. Absolute value of C_{IO}(DQS)-C_{IO}(DQS#)
6. C_I applies to ODT, CS#, CKE, A0-A15, BA0-BA2, RAS#, CAS#, WE#.

7. C_{DI_CTRL} applies to ODT, CS# and CKE
8. $C_{DI_CTRL} = C_i(CTRL) - 0.5 * (C_i(CLK) + C_i(CLK\#))$
9. $C_{DI_ADD_CMD}$ applies to A0-A15, BA0-BA2, RAS#, CAS# and WE#.
10. $C_{DI_ADD_CMD} = C_i(ADD_CMD) - 0.5 * (C_i(CLK) + C_i(CLK\#))$
11. $C_{DIO} = C_{IO}(DQ, DM) - 0.5 * (C_{IO}(DQS) + C_{IO}(DQS\#))$
12. Maximum external load capacitance on ZQ pin: 5 pF.



Table 8-2. DDR3L/DDR3-1866/2133 Input/Output Capacitance

Symbol	Parameter		1866		2133		Unit	Note
			Min	Max	Min	Max		
C _{IO}	Input/output capacitance (DQ, DM, DQS, DQS#, TDQS, TDQS#)	DDR3 (1.5 V)	1.4	2.2	1.4	2.1	pF	1,2,3
		DDR3L (1.35 V)	1.4	2.1	-	-		
C _{CK}	Input capacitance, CK and CK#		0.8	1.3	0.8	1.3	pF	2,3
C _{DCK}	Input capacitance delta, CK and CK#		0	0.15	0	0.15	pF	2,3,4
C _{DDQS}	Input/output capacitance delta DQS and DQS#		0	0.15	0	0.15	pF	2,3,5
C _I	Input capacitance, (CTRL, ADD, CMD input-only pins)	DDR3 (1.5 V)	0.75	1.2	0.75	1.2	pF	2,3,6
		DDR3L (1.35 V)	0.75	1.2	-	-		
C _{DI_CTRL}	Input capacitance delta, (All CTRL input-only pins)		-0.4	0.2	-0.4	0.2	pF	2,3,7,8
C _{DI_ADD_CMD}	Input capacitance delta, (All ADD/CMD input-only pins)		-0.4	0.4	-0.4	0.4	pF	2,3,9,10
C _{DIO}	Input/output capacitance delta, DQ, DM, DQS, DQS#, TDQS, TDQS#		-0.5	0.3	-0.5	0.3	pF	2,3,11
C _{ZQ}	Input/output capacitance of ZQ pin		-	3	-	3	pF	2,3,12

Note:

- Although the DM, TDQS and TDQS# pins have different functions, the loading matches DQ and DQS.
- This parameter is not subject to production test. It is verified by design and characterization. The capacitance is measured according to JEP147("PROCEDURE FOR MEASURING INPUT CAPACITANCE USING A VEC-TOR NETWORK ANALYZER(VNA)") with VDD, VDDQ, VSS, VSSQ applied and all other pins floating (except the pin under test, CKE, RESET# and ODT as necessary). VDD=VDDQ=1.35V, VBIAS=VDD/2 and on-die termination off.
- This parameter applies to monolithic devices only; stacked/dual-die devices are not covered here
- Absolute value of C_{CK}-C_{CK#}
- Absolute value of C_{IO}(DQS)-C_{IO}(DQS#)
- C_I applies to ODT, CS#, CKE, A0-A15, BA0-BA2, RAS#, CAS#, WE#.
- C_{DI_CTRL} applies to ODT, CS# and CKE
- C_{DI_CTRL}=C_I(CTRL)-0.5*(C_I(CLK)+C_I(CLK#))
- C_{DI_ADD_CMD} applies to A0-A15, BA0-BA2, RAS#, CAS# and WE#.
- C_{DI_ADD_CMD}=C_I(ADD_CMD) - 0.5*(C_I(CLK)+C_I(CLK#))
- C_{DIO}=C_{IO}(DQ, DM) - 0.5*(C_{IO}(DQS)+C_{IO}(DQS#))
- Maximum external load capacitance on ZQ pin: 5 pF.



9 Electrical Characteristics And Timing For DDR3L-800 To DDR3L-2133

9.1 Clock Specification

The jitter specified is a random jitter meeting a Gaussian distribution. Input clocks violating the min/max values may result in malfunction of the DDR3L SDRAM device.

9.1.1 Definition for tCK(avg)

tCK(avg) is calculated as the average clock period across any consecutive 200 cycle window, where each clock period is calculated from rising edge to rising edge.

$$tCK(avg) = \left(\sum_{j=1}^N tCK_j \right) / N \quad N=200$$

9.1.2 Definition for tCK(abs)

tCK(abs) is defined as the absolute clock period, as measured from one rising edge to the next consecutive rising edge. tCK(abs) is not subject to production test.

9.1.3 Definition for tCH(avg) and tCL(avg)

tCH(avg) is defined as the average high pulse width, as calculated across any consecutive 200 high pulses.

$$tCH(avg) = \left(\sum_{j=1}^N tCH_j \right) / (N \times tCK(avg)) \quad N=200$$

tCL(avg) is defined as the average low pulse width, as calculated across any consecutive 200 low pulses.

$$tCL(avg) = \left(\sum_{j=1}^N tCL_j \right) / (N \times tCK(avg)) \quad N=200$$

9.1.4 Definition for tJIT(per) and tJIT(per, lck)

tJIT(per) is defined as the largest deviation of any signal tCK from tCK(avg).

tJIT(per) = Min/max of {tCK_i - tCK(avg) where i = 1 to 200}.

tJIT(per) defines the single period jitter when the DLL is already locked.

tJIT(per, lck) uses the same definition for single period jitter, during the DLL locking period only.

tJIT(per) and tJIT(per, lck) are not subject to production test.

9.1.5 Definition for tJIT(cc) and tJIT(cc, lck)

tJIT(cc) is defined as the absolute difference in clock period between two consecutive clock cycles.

tJIT(cc) = Max of | {tCK_{i+1} - tCK_i} |.

tJIT(cc) defines the cycle to cycle jitter when the DLL is already locked.

tJIT(cc, lck) uses the same definition for cycle to cycle jitter, during the DLL locking period only.

tJIT(cc) and tJIT(cc, lck) are not subject to production test.

9.1.6 Definition for tERR(nper)

tERR is defined as the cumulative error across n multiple consecutive cycles from tCK(avg). tERR is not subject to production test.



9.2 Refresh parameters by device density

Table 9-1. Refresh parameters by device density

Parameter	Symbol	4Gb	Units	Note
REF command to ACT or REF command time	tRFC	260	ns	
Average periodic refresh interval	tREFI	0 °C ≤ T _{CASE} ≤ 85 °C	7.8	μs
		85 °C < T _{CASE} ≤ 95 °C	3.9	μs 1

Note:

- Users should refer to the DRAM supplier datasheet and/or the DIMM SPD to determine if DDR3L SDRAM devices support the following options or requirements referred to in this material.

9.3 Standard Speed Bins

DDR3 SDRAM Standard Speed Bins include tCK, tRCD, tRP, tRAS and tRC for each corresponding bin.

Table 9-2. DDR3L/DDR3-800 Speed Bins and Operating Conditions

Speed Bin			DDR3L/DDR3-800D		DDR3L/DDR3-800E		Unit	Note
CL-nRCD-nRP			5-5-5		5-5-5			
Parameter	Symbol	Min	Max	Min	Max			
Internal Read command to first data	t _{AA}	12.5	20	15	20	ns		
ACT to internal Read or write delay time	t _{RCD}	12.5	-	15	-	ns		
PRE command period	t _{RP}	12.5	-	15	-	ns		
ACT to ACT or REF command period	t _{RC}	50	-	52.5	-	ns		
ACT to PRE command period	t _{RAS}	37.5	9 * tREFI	37.5	9 * tREFI	ns		
CL =5	CWL = 5	t _{CK(AVG)}	2.5	3.3	3.0	3.3	ns	1,2,3,4,12,13
CL =6	CWL = 5	t _{CK(AVG)}	2.5	3.3	2.5	3.3	ns	1,2,3
Supported CL Settings			5,6		5,6		n _{CK}	13
Supported CWL Settings			5		5		n _{CK}	



Table 9-3. DDR3L/DDR3-1066 Speed Bins and Operating Conditions

Speed Bin			DDR3L/DDR3-1066E		DDR3L/DDR3-1066F		DDR3L/DDR3-1066G		Unit	Note
CL-nRCD-nRP			6-6-6		7-7-7		8-8-8			
Parameter	Symbol	Min	Max	Min	Max	Min	Max			
Internal Read command to first data	t _{AA}	11.25	20	13.125	20	15	20	ns		
ACT to internal Read or write delay time	t _{RCD}	11.25	-	13.125	-	15	-	ns		
PRE command period	t _{RP}	11.25	-	13.125	-	15	-	ns		
ACT to ACT or REF command period	t _{RC}	48.75	-	50.625	-	52.5	-	ns		
ACT to PRE command period	t _{RAS}	37.5	9 * tREFI	37.5	9 * tREFI	37.5	9 * tREFI	ns		
CL = 5	CWL = 5	t _{CK(AVG)}	2.5	3.3	3.0	3.3	3.0	3.3	ns	1,2,3,4,6,12,13
	CWL = 6	t _{CK(AVG)}	Reserved		Reserved		Reserved		ns	4
CL = 6	CWL = 5	t _{CK(AVG)}	2.5	3.3	2.5	3.3	2.5	3.3	ns	1,2,3,6
	CWL = 6	t _{CK(AVG)}	1.875	< 2.5	Reserved		Reserved		ns	1,2,3,4
CL = 7	CWL = 5	t _{CK(AVG)}	Reserved		Reserved		Reserved		ns	4
	CWL = 6	t _{CK(AVG)}	1.875	< 2.5	1.875	< 2.5	Reserved		ns	1,2,3,4
CL = 8	CWL = 5	t _{CK(AVG)}	Reserved		Reserved		Reserved		ns	4
	CWL = 6	t _{CK(AVG)}	1.875	< 2.5	1.875	< 2.5	1.875	< 2.5	ns	1,2,3
Supported CL Settings			5,6,7,8		5,6,7,8		5,6,8		n _{CK}	13
Supported CWL Settings			5,6		5,6		5,6		n _{CK}	



Table 9-4. DDR3L/DDR3-1333 Speed Bins and Operating Conditions

Speed Bin			DDR3L/DDR3-1333F (optional)		DDR3L/DDR3-1333G		DDR3L/DDR3-1333H		DDR3L/DDR3-1333J (optional)		Unit	Note
CL-nRCD-nRP			7-7-7		8-8-8		9-9-9		10-10-10			
Parameter		Symbol	Min	Max	Min	Max	Min	Max	Min	Max		
Internal Read command to first data		t _{AA}	10.5	20	12	20	13.5 (13.125) _{5,11}	20	15	20	ns	
ACT to internal Read or write delay time		t _{RCD}	10.5	-	12	-	13.5 (13.125) _{5,11}	-	15	-	ns	
PRE command period		t _{RP}	10.5	-	12	-	13.5 (13.125) _{5,11}	-	15	-	ns	
ACT to ACT or REF command period		t _{RC}	46.5	-	48	-	49.5 (49.5) ^{5,11}	-	51	-	ns	
ACT to PRE command period		t _{RAS}	36	9 * t _{REFI}	36	9 * t _{REFI}	36	9 * t _{REFI}	36	9 * t _{REFI}	ns	
CL = 5	CWL = 5	t _{CK(AVG)}	2.5	3.3	2.5	3.3	3.0	3.3	3.0	3.3	ns	1,2,3,4,7,12,13
	CWL = 6,7	t _{CK(AVG)}	Reserved		Reserved		Reserved		Reserved		ns	4
CL = 6	CWL = 5	t _{CK(AVG)}	2.5	3.3	2.5	3.3	2.5	3.3	2.5	3.3	ns	1,2,3,7
	CWL = 6	t _{CK(AVG)}	1.875	< 2.5	Reserved		Reserved		Reserved		ns	1,2,3,4,7
	CWL = 7	t _{CK(AVG)}	Reserved		Reserved		Reserved		Reserved		ns	4
CL = 7	CWL = 5	t _{CK(AVG)}	Reserved		Reserved		Reserved		Reserved		ns	4
	CWL = 6	t _{CK(AVG)}	1.875	< 2.5	1.875	< 2.5	1.875	< 2.5	Reserved		ns	1,2,3,4,7
							(Optional) ^{5,11}					
CWL = 7	t _{CK(AVG)}	1.5	< 1.875	Reserved		Reserved		Reserved		ns	1,2,3,4	
CL = 8	CWL = 5	t _{CK(AVG)}	Reserved		Reserved		Reserved		Reserved		ns	4
	CWL = 6	t _{CK(AVG)}	1.875	< 2.5	1.875	< 2.5	1.875	< 2.5	1.875	< 2.5	ns	1,2,3,7
	CWL = 7	t _{CK(AVG)}	1.5	< 1.875	1.5	< 1.875	Reserved		Reserved		ns	1,2,3,4
CL = 9	CWL = 5,6	t _{CK(AVG)}	Reserved		Reserved		Reserved		Reserved		ns	4
	CWL = 7	t _{CK(AVG)}	1.5	< 1.875	1.5	< 1.875	1.5	< 1.875	Reserved		ns	1,2,3,4
CL = 10	CWL = 5,6	t _{CK(AVG)}	Reserved		Reserved		Reserved		Reserved		ns	4
	CWL = 7	t _{CK(AVG)}	1.5	< 1.875	1.5	< 1.875	1.5	< 1.875	1.5 < 1.875		ns	1,2,3
			(Optional)		(Optional)		(Optional)				ns	5
Supported CL Settings			5,6,7,8,9,(10)		5,6,7,8,9,(10)		5,6,8,(7),9,(10)		5,6,8,10		n _{CK}	
Supported CWL Settings			5,6,7		5,6,7		5,6,7		5,6,7		n _{CK}	



Table 9-5. DDR3L/DDR3-1600 Speed Bins and Operating Conditions

Speed Bin			DDR3L/DDR3-1600G (optional)		DDR3L/DDR3-1600H		DDR3L/DDR3-1600J		DDR3L/DDR3-1600K		Unit	Note
CL-nRCD-nRP			8-8-8		9-9-9		10-10-10		11-11-11			
Parameter		Symbol	Min	Max	Min	Max	Min	Max	Min	Max		
Internal Read command to first data		t _{AA}	10	20	11.25	20	12.5	20	13.75 (13.125) 5,11	20	ns	
ACT to internal Read or write delay time		t _{RCD}	10	-	11.25	-	12.5	-	13.75 (13.125) 5,11	-	ns	
PRE command period		t _{RP}	10	-	11.25	-	12.5	-	13.75 (13.125) 5,11	-	ns	
ACT to ACT or REF command period		t _{RC}	45	-	46.25	-	47.5	-	48.75 (48.125) 5,11	-	ns	
ACT to PRE command period		t _{RAS}	35	9 * tREFI	35	9 * tREFI	35	9 * tREFI	35	9 * tREFI	ns	
CL = 5	CWL = 5	t _{CK(AVG)}	2.5	3.3	2.5	3.3	2.5	3.3	3.0	3.3	ns	1,2,3,4,8,12,13
	CWL = 6,7,8	t _{CK(AVG)}	Reserved		Reserved		Reserved		Reserved		ns	4
CL = 6	CWL = 5	t _{CK(AVG)}	2.5	3.3	2.5	3.3	2.5	3.3	2.5	3.3	ns	1,2,3,8
	CWL = 6	t _{CK(AVG)}	1.875	< 2.5	Reserved		Reserved		Reserved		ns	1,2,3,4,8
	CWL = 7,8	t _{CK(AVG)}	Reserved		Reserved		Reserved		Reserved		ns	4
CL = 7	CWL = 5	t _{CK(AVG)}	Reserved		Reserved		Reserved		Reserved		ns	4
	CWL = 6	t _{CK(AVG)}	1.875	< 2.5	1.875	< 2.5	1.875	< 2.5	1.875	< 2.5 (Optional) ^{5,11}	ns	1,2,3,4,8
	CWL = 7	t _{CK(AVG)}	1.5	< 1.875	Reserved		Reserved		Reserved		ns	1,2,3,4,8
	CWL = 8	t _{CK(AVG)}	Reserved		Reserved		Reserved		Reserved		ns	4
CL = 8	CWL = 5	t _{CK(AVG)}	Reserved		Reserved		Reserved		Reserved		ns	4
	CWL = 6	t _{CK(AVG)}	1.875	< 2.5	1.875	< 2.5	1.875	< 2.5	1.875	< 2.5	ns	1,2,3,8
	CWL = 7	t _{CK(AVG)}	1.5	< 1.875	1.5	< 1.875	Reserved		Reserved		ns	1,2,3,4,8
	CWL = 8	t _{CK(AVG)}	1.25	< 1.5	Reserved		Reserved		Reserved		ns	1,2,3,4
CL = 9	CWL = 5,6	t _{CK(AVG)}	Reserved		Reserved		Reserved		Reserved		ns	4
	CWL = 7	t _{CK(AVG)}	1.5	< 1.875	1.5	< 1.875	1.5	< 1.875	1.5	< 1.875 (Optional) ^{5,11}	ns	1,2,3,4,8
	CWL = 8	t _{CK(AVG)}	1.25	< 1.5	1.25	< 1.5	Reserved		Reserved			1,2,3,4
CL = 10	CWL = 5,6	t _{CK(AVG)}	Reserved		Reserved		Reserved		Reserved		ns	4
	CWL = 7	t _{CK(AVG)}	1.5	< 1.875	1.5	< 1.875	1.5	< 1.875	1.5	< 1.875	ns	1,2,3,8
	CWL = 8	t _{CK(AVG)}	1.25	< 1.5	1.25	< 1.5	1.25	< 1.5	Reserved		ns	1,2,3,4
CL = 11	CWL = 5,6,7	t _{CK(AVG)}	Reserved		Reserved		Reserved		Reserved		ns	4
	CWL = 8	t _{CK(AVG)}	1.25	< 1.5	1.25	< 1.5	1.25	< 1.5	1.25	< 1.5	ns	1,2,3
			(Optional)		(Optional)		(Optional)				ns	5
Supported CL Settings			5,6,7,8,9,10,(11)		5,6,7,8,9,10,(11)		5,6,7,8,9,10,(11)		5,6,(7),8,(9),10,11		nck	
Supported CWL Settings			5,6,7,8		5,6,7,8		5,6,7,8		5,6,7,8		nck	



Table 9-6. DDR3L/DDR3-1866 Speed Bins and Operating Conditions

Speed Bin			DDR3L/DDR3-1866J (optional)		DDR3L/DDR3-1866K		DDR3L/DDR3-1866L		DDR3L/DDR3-1866M (optional)		Unit	Note
CL-nRCD-nRP			10-10-10		11-11-11		12-12-12		13-13-13			
Parameter	Symbol		Min	Max	Min	Max	Min	Max	Min	Max		
Internal Read command to first data	t _{AA}		10.7	20	11.77	20	12.84	20	13.91 (13.125) ^{5,14}	20	ns	
ACT to internal Read or write delay time	t _{RCD}		10.7	-	11.77	-	12.84	-	13.91 (13.125) ^{5,14}	-	ns	
PRE command period	t _{RP}		10.7	-	11.77	-	12.84	-	13.91 (13.125) ^{5,14}	-	ns	
ACT to PRE command period	t _{RAS}		34	9 * tREFI	34	9 * tREFI	34	9 * tREFI	34	9 * tREFI	ns	
ACT to ACT or REF command period	t _{RC}		44.7	-	45.77	-	46.84	-	47.91 (47.125) ^{5,14}	-	ns	
CL =5	CWL = 5	t _{CK(AVG)}	2.5	3.3	2.5	3.3	Reserved		Reserved		ns	1,2,3,4,9
	CWL = 6,7,8,9	t _{CK(AVG)}	Reserved		Reserved		Reserved		Reserved		ns	4
CL = 6	CWL = 5	t _{CK(AVG)}	2.5	3.3	2.5	3.3	2.5	3.3	2.5	3.3	ns	1,2,3,9
	CWL = 6	t _{CK(AVG)}	1.875	< 2.5	Reserved		Reserved		Reserved		ns	1,2,3,4,9
	CWL = 7,8,9	t _{CK(AVG)}	Reserved		Reserved		Reserved		Reserved		ns	4
CL =7	CWL = 5	t _{CK(AVG)}	Reserved		Reserved		Reserved		Reserved		ns	4
	CWL = 6	t _{CK(AVG)}	1.875	< 2.5	1.875	< 2.5	1.875	< 2.5	1.875	< 2.5 (Optional) ^{5,14}	ns	1,2,3,4,9
	CWL = 7,8,9	t _{CK(AVG)}	Reserved		Reserved		Reserved		Reserved		ns	4
CL = 8	CWL = 5	t _{CK(AVG)}	Reserved		Reserved		Reserved		Reserved		ns	4
	CWL = 6	t _{CK(AVG)}	1.875	< 2.5	1.875	< 2.5	1.875	< 2.5	1.875	< 2.5	ns	1,2,3,9
	CWL = 7	t _{CK(AVG)}	1.5	< 1.875	1.5	< 1.875	Reserved		Reserved		ns	1,2,3,4,9
	CWL = 8,9	t _{CK(AVG)}	Reserved		Reserved		Reserved		Reserved		ns	4
CL = 9	CWL = 5,6	t _{CK(AVG)}	Reserved		Reserved		Reserved		Reserved		ns	4
	CWL = 7	t _{CK(AVG)}	1.5	< 1.875	1.5	< 1.875	1.5	< 1.875	1.5	< 1.875 (Optional) ^{5,14}	ns	1,2,3,4,9
	CWL = 8	t _{CK(AVG)}	1.25	< 1.5	Reserved		Reserved		Reserved			1,2,3,4,9
	CWL = 9		Reserved		Reserved		Reserved		Reserved			4
CL = 10	CWL = 5,6,9	t _{CK(AVG)}	Reserved		Reserved		Reserved		Reserved		ns	4
	CWL = 7	t _{CK(AVG)}	1.5	< 1.875	1.5	< 1.875	1.5	< 1.875	1.5	< 1.875	ns	1,2,3,9
	CWL = 8	t _{CK(AVG)}	1.25	< 1.5	1.25	< 1.5	Reserved		Reserved		ns	1,2,3,4,9
CL = 11	CWL = 5,6,7	t _{CK(AVG)}	Reserved		Reserved		Reserved		Reserved		ns	4
	CWL = 8	t _{CK(AVG)}	1.25	< 1.5	1.25	< 1.5	1.25	< 1.5	1.25	< 1.5 (Optional) ^{5,14}	ns	1,2,3,4,9
	CWL = 9	t _{CK(AVG)}	1.07	< 1.25	1.07	< 1.25	Reserved		Reserved		ns	1,2,3,4
CL = 12	CWL = 5,6,7,8	t _{CK(AVG)}	Reserved		Reserved		Reserved		Reserved		ns	4
	CWL = 9	t _{CK(AVG)}	1.07	< 1.25	1.07	< 1.25	1.07	< 1.25	Reserved		ns	1,2,3,4
CL = 13	CWL = 5,6,7,8	t _{CK(AVG)}	Reserved		Reserved		Reserved		Reserved		ns	4
	CWL = 9	t _{CK(AVG)}	1.07	< 1.25	1.07	< 1.25	1.07	< 1.25	1.07	< 1.25	ns	1,2,3
			(Optional)		(Optional)		(Optional)				ns	5
Supported CL Settings			5,6,7,8,9,10,11,12,(13)		5,6,7,8,9,10,11,12,(13)		5,6,7,8,9,10,11,12,(13)		6,8,10,13 (7),(9),(11)		n _{CK}	
Supported CWL Settings			5,6,7,8,9		5,6,7,8,9		5,6,7,8,9		5,6,7,8,9		n _{CK}	



Table 9-7. DDR3L/DDR3-2133 Speed Bins and Operating Conditions

Speed Bin		DDR3L/DDR3-1600G (optional)		DDR3L/DDR3-1600H		DDR3L/DDR3-1600J		DDR3L/DDR3-1600K		Unit	Note	
CL-nRCD-nRP		11-11-11		12-12-12		13-13-13		14-14-14				
Parameter	Symbol	Min	Max	Min	Max	Min	Max	Min	Max			
Internal Read command to first data	t _{AA}	10.285	20	11.22	20	12.155	20	13.09	20	ns		
ACT to internal Read or write delay time	t _{RCD}	10.285	-	11.22	-	12.155	-	13.09	-	ns		
PRE command period	t _{RP}	10.285	-	11.22	-	12.155	-	13.09	-	ns		
ACT to PRE command period	t _{RAS}	33	9 * tREFI	33	9 * tREFI	33	9 * tREFI	33	9 * tREFI	ns		
ACT to ACT or REF command period	t _{RC}	43.285	-	44.22	-	45.155	-	46.09	-	ns		
CL = 5	CWL = 5	t _{CK(AVG)}	2.5	3.3	2.5	3.3	2.5	3.3	Reserved	ns	1,2,3,4,10	
	CWL = 6,7,8,9,10	t _{CK(AVG)}	Reserved		Reserved		Reserved		Reserved	ns	4	
CL = 6	CWL = 5	t _{CK(AVG)}	2.5	3.3	2.5	3.3	2.5	3.3	2.5	3.3	ns	1,2,3,10
	CWL = 6	t _{CK(AVG)}	1.875	< 2.5	1.875	< 2.5	Reserved		Reserved		ns	1,2,3,4,10
	CWL = 7,8,9,10	t _{CK(AVG)}	Reserved		Reserved		Reserved		Reserved		ns	4
CL = 7	CWL = 5	t _{CK(AVG)}	Reserved		Reserved		Reserved		Reserved		ns	4
	CWL = 6	t _{CK(AVG)}	1.875	< 2.5	1.875	< 2.5	1.875	< 2.5	1.875	< 2.5	ns	1,2,3,10
	CWL = 7	t _{CK(AVG)}	1.5	< 1.875	Reserved		Reserved		Reserved		ns	1,2,3,4,10
	CWL = 8,9,10	t _{CK(AVG)}	Reserved		Reserved		Reserved		Reserved		ns	4
CL = 8	CWL = 5	t _{CK(AVG)}	Reserved		Reserved		Reserved		Reserved		ns	4
	CWL = 6	t _{CK(AVG)}	1.875	< 2.5	1.875	< 2.5	1.875	< 2.5	1.875	< 2.5	ns	1,2,3,10
	CWL = 7	t _{CK(AVG)}	1.5	< 1.875	1.5	< 1.875	Reserved		Reserved		ns	1,2,3,4,10
	CWL = 8,9,10	t _{CK(AVG)}	Reserved		Reserved		Reserved		Reserved		ns	4
CL = 9	CWL = 5,6	t _{CK(AVG)}	Reserved		Reserved		Reserved		Reserved		ns	4
	CWL = 7	t _{CK(AVG)}	1.5	< 1.875	1.5	< 1.875	1.5	< 1.875	1.5	< 1.875	ns	1,2,3,4,10
	CWL = 8	t _{CK(AVG)}	1.25	< 1.5	1.25	< 1.5	Reserved		Reserved		ns	1,2,3,4,10
	CWL = 9,10	t _{CK(AVG)}	Reserved		Reserved		Reserved		Reserved		ns	4
CL = 10	CWL = 5,6	t _{CK(AVG)}	Reserved		Reserved		Reserved		Reserved		ns	4
	CWL = 7	t _{CK(AVG)}	1.5	< 1.875	1.5	< 1.875	1.5	< 1.875	1.5	< 1.875	ns	1,2,3,10
	CWL = 8	t _{CK(AVG)}	1.25	< 1.5	1.25	< 1.5	1.25	< 1.5	Reserved		ns	1,2,3,4,10
	CWL = 9	t _{CK(AVG)}	1.07	< 1.25	Reserved		Reserved		Reserved		ns	1,2,3,4,10
	CWL = 10	t _{CK(AVG)}	Reserved		Reserved		Reserved		Reserved		ns	4
CL = 11	CWL = 5,6,7	t _{CK(AVG)}	Reserved		Reserved		Reserved		Reserved		ns	4
	CWL = 8	t _{CK(AVG)}	1.25	< 1.5	1.25	< 1.5	1.25	< 1.5	1.25	< 1.5	ns	1,2,3,10
	CWL = 9	t _{CK(AVG)}	1.07	< 1.25	1.07	< 1.25	Reserved		Reserved		ns	1,2,3,4,10
	CWL = 10	t _{CK(AVG)}	0.938	< 1.07	Reserved		Reserved		Reserved		ns	1,2,3,4
CL = 12	CWL = 5,6,7,8	t _{CK(AVG)}	Reserved		Reserved		Reserved		Reserved		ns	4
	CWL = 9	t _{CK(AVG)}	1.07	< 1.25	1.07	< 1.25	1.07	< 1.25	Reserved		ns	1,2,3,4,10
	CWL = 10	t _{CK(AVG)}	0.938	< 1.07	0.938	< 1.07	Reserved		Reserved		ns	1,2,3,4



Speed Bin			DDR3L/DDR3-1600G (optional)		DDR3L/DDR3-1600H		DDR3L/DDR3-1600J		DDR3L/DDR3-1600K		Unit	Note
CL-nRCD-nRP			11-11-11		12-12-12		13-13-13		14-14-14			
Parameter		Symbol	Min	Max	Min	Max	Min	Max	Min	Max		
CL = 13	CWL = 5,6,7,8	t _{CK(AVG)}	Reserved		Reserved		Reserved		Reserved		ns	4
	CWL = 9	t _{CK(AVG)}	1.07	< 1.25	1.07	< 1.25	1.07	< 1.25	1.07	< 1.25	ns	1,2,3,10
	CWL = 10	t _{CK(AVG)}	0.938	< 1.07	0.938	< 1.07	0.938	< 1.07	Reserved		ns	1,2,3,4
CL = 14	CWL = 5,6,7,8,9	t _{CK(AVG)}	Reserved		Reserved		Reserved		Reserved		ns	4
	CWL = 10	t _{CK(AVG)}	0.938	< 1.07	0.938	< 1.07	0.938	< 1.07	0.938	< 1.07	ns	1,2,3
			(Optional)		(Optional)		(Optional)				ns	5
		Supported CL Settings		5,6,7,8,9,10,11,12,13,(14)		5,6,7,8,9,10,11,12,13,(14)		5,6,7,8,9,10,11,12,13,(14)		5,6,7,8,9,10,11,12,13,14		n _{CK}
Supported CWL Settings			5,6,7,8,9,10		5,6,7,8,9,10		5,6,7,8,9,10		5,6,7,8,9,10		n _{CK}	

9.3.1 Speed Bin Table Note

Absolute Specifications {T_{OPER}; V_{DDQ}= V_{DD}= 1.283V to 1.45V & 1.5V(1.425V to 1.575V)};

Note:

1. The CL setting and CWL setting result in t_{CK(AVG)}. MIN and t_{CK(AVG)}. MAX requirements. When making a selection of t_{CK(AVG)}, both need to be fulfilled: Requirements from CL setting as well as requirements from CWL setting.
2. t_{CK(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 t_{CK(AVG)} value (3.0, 2.5, 1.875, 1.5, 1.25, 1.07, or 0.938 ns) when calculating CL [n_{CK}] = tAA[ns] / t_{CK(AVG)} [ns], rounding up to the next 'Supported CL', where t_{CK(AVG)} = 3.0 ns should only be used for CL = 5 calculation
3. t_{CK(AVG)}.MAX limits: Calculate t_{CK(AVG)} = tAA.MAX / CL SELECTED and round the resulting t_{CK(AVG)} down to the next valid speed bin (i.e. 3.3 ns or 2.5 ns or 1.875 ns or 1.5 ns or 1.25 ns or 1.07 ns or 0.938 ns). This result is t_{CK(AVG)}.MAX corresponding to CL SELECTED.
4. 'Reserved' settings are not allowed. User must program a different value.
5. 'Optional' settings allow certain devices in the industry to support this setting, however, it is not a mandatory feature. Refer to supplier's data sheet and/or the DIMM SPD information if and how this setting is supported.
6. Any DDR3L/DDR3-1066 speed bin also supports functional operation at lower frequencies as shown in the corresponding table which are not subject to Production Tests but verified by Design/ Characterization.
7. Any DDR3L/DDR3-1333 speed bin also supports functional operation at lower frequencies as shown in the corresponding table which are not subject to Production Tests but verified by Design/ Characterization.
8. Any DDR3L/DDR3-1600 speed bin also supports functional operation at lower frequencies as shown in the corresponding table which are not subject to Production Tests but verified by Design/ Characterization.
9. Any DDR3L/DDR3-1866 speed bin also supports functional operation at lower frequencies as shown in the corresponding table which are not subject to Production Tests but verified by Design/ Characterization.
10. Any DDR3L/DDR3-2133 speed bin also supports functional operation at lower frequencies as shown in the corresponding table which are not subject to Production Tests but verified by Design/ Characterization.
11. For devices supporting optional down binning to CL=7 and CL=9, tAA/tRCD/tRPmin must be 13.125 ns or lower. SPD settings must be programmed to match. For example, DDR3L-1333H devices supporting down binning to DDR3L-1066F should program 13.125 ns in SPD bytes for tAAmin (Byte 16), tRCDmin (Byte 18), and tRPmin (Byte 20). DDR3L-1600K devices supporting down binning to DDR3L-1333H or DDR3L-1066F should program 13.125 ns



in SPD bytes for tAAmin (Byte16), tRCDmin (Byte 18), and tRPmin (Byte 20). Once tRP (Byte20) is programmed to 13.125ns, tRCmin (Byte 21,23) also should be programmed accordingly. For example, 49.125 ns (tRASmin + tRPmin = 36 ns + 13.125 ns) for DDR3L-1333H and 48.125ns (tRASmin + tRPmin = 35 ns + 13.125 ns) for DDR3L-1600K.

12. DDR3L-800 AC timing apply if DRAM operates at lower than 800 MT/s data rate.
13. For CL5 support, refer to DIMM SPD information. DRAM is required to support CL5. CL5 is not mandatory in SPD coding.
14. For devices supporting optional down binning to CL=11, CL=9 and CL=7, tAA/tRCD/tRPmin must be 13.125ns. SPD setting must be programmed to match. For example, DDR3L/DDR3-1866M devices supporting down binning to DDR3L/DDR3-1600K or DDR3L/DDR3-1333H or 1066F should program 13.125 ns in SPD bytes for tAAmin(byte16), tRCDmin(Byte18) and tRPmin (byte20). Once tRP (Byte 20) is programmed to 13.125ns, tRCmin (Byte 21,23) also should be programmed accordingly. For example, 47.125ns (tRASmin + tRPmin = 34 ns+ 13.125 ns)

10 Electrical Characteristics And AC Timing

10.1 Timing Parameters for DDR3L-800, DDR3L-1066, DDR3L-1333, DDR3L-1600

Table 10-1. Timing Parameters by Speed Bin

Speed		DDR3L/DDR3-800		DDR3L/DDR3-1066		DDR3L/DDR3-1333		DDR3L/DDR3-1600		Unit	Note
Parameter	Symbol	Min	Max	Min	Max	Min	Max	Min	Max		
Clock Timing											
Minimum Clock Cycle Time (DLL off mode)	tCK (DLL_OFF)	8	-	8	-	8	-	8	-	ns	6
Average Clock Period	tCK (avg)	See “Standard Speed Bins”								ps	
Average high pulse width	tCH (avg)	0.47	0.53	0.47	0.53	0.47	0.53	0.47	0.53	tCK (avg)	
Average low pulse width	tCL (avg)	0.47	0.53	0.47	0.53	0.47	0.53	0.47	0.53	tCK (avg)	
Absolute Clock Period	tCK (abs)	tCK(avg)min + tJIT(per)min	tCK(avg)max + tJIT(per)max	tCK(avg)min + tJIT(per)min	tCK(avg)max + tJIT(per)max	tCK(avg)min + tJIT(per)min	tCK(avg)max + tJIT(per)max	tCK(avg)min + tJIT(per)min	tCK(avg)max + tJIT(per)max	ps	
Absolute clock HIGH pulse width	tCH (abs)	0.43	-	0.43	-	0.43	-	0.43	-	tCK (avg)	25
Absolute clock LOW pulse width	tCL (abs)	0.43	-	0.43	-	0.43	-	0.43	-	tCK (avg)	26
Clock Period Jitter	JIT (per)	-100	100	-90	90	-80	80	-70	70	ps	
Clock Period Jitter during DLL locking period	tJIT (per, lck)	-90	90	-80	80	-70	70	-60	60	ps	
Cycle to Cycle Period Jitter	tJIT (cc)	200		180		160		140		ps	
Cycle to Cycle Period Jitter during DLL locking period	tJIT (cc, lck)	180		160		140		120		ps	
Duty Cycle Jittter	tJIT (duty)	-	-	-	-	-	-	-	-		
Cumulative error across 2 cycles	tERR (2per)	-147	147	-132	132	-118	118	-103	103	ps	
Cumulative error across 3 cycles	tERR (3per)	-175	175	-157	157	-140	140	-122	122	ps	
Cumulative error across 4 cycles	tERR (4per)	-194	194	-175	175	-155	155	-136	136	ps	
Cumulative error across 5 cycles	tERR (5per)	-209	209	-188	188	-168	168	-147	147	ps	
Cumulative error across 6 cycles	tERR (6per)	-222	222	-200	200	-177	177	-155	155	ps	
Cumulative error across 7 cycles	tERR (7per)	-232	232	-209	209	-186	186	-163	163	ps	

Speed		DDR3L/DDR3-800		DDR3L/DDR3-1066		DDR3L/DDR3-1333		DDR3L/DDR3-1600		Unit	Note
Parameter	Symbol	Min	Max	Min	Max	Min	Max	Min	Max		
Cumulative error across 8 cycles	tERR (8per)	-241	241	-217	217	-193	193	-169	169	ps	
Cumulative error across 9 cycles	tERR (9per)	-249	249	-224	224	-200	200	-175	175	ps	
Cumulative error across 10 cycles	tERR (10per)	-257	257	-231	231	-205	205	-180	180	ps	
Cumulative error across 11 cycles	tERR (11per)	263	263	-237	237	-210	210	-184	184	ps	
Cumulative error across 12 cycles	tERR (12per)	-269	269	-242	242	-215	215	-188	188	ps	
Cumulative error across n = 13, 14 . . . 49, 50 cycles	tERR (nper)	tERR (nper)min = ((1 + 0.68ln(n)) * tJIT (per)_total min)								ps	24
		tERR (nper)max = ((1 + 0.68ln(n)) * tJIT (per)_total max)									
Data Timing											
DQS,DQS# to DQ skew, per group, per access	tDQSQ	-	200	-	150	-	125	-	100	ps	13
DQ output hold time from DQS, DQS#	tQH	0.38	-	0.38	-	0.38	-	0.38	-	tCK (avg)	13, g
DQ low impedance time from CK, CK#	tLZ (DQ)	-800	400	-600	300	-500	250	-450	225	ps	13,14,f
DQ high impedance time from CK, CK#	tHZ (DQ)	-	400	-	300	-	250	-	225	ps	13,14,f
Data setup time from DQS, DQS# referenced to VIH(ac) / VIL(ac) levels	1.5V										
	tDS(base) AC175	75		25		-		-		ps	d,17
	tDS(base) AC150	125		75		30		10		ps	d,17
	1.35V										
	tDS(base) AC160	90	-	40	-	-	-	-	-	ps	d,17
	tDS(base) AC135	140	-	90	-	45	-	25	-	ps	d,17
Data hold time to DQS, DQS# referenced to VIH(ac) / VIL(ac) levels	1.5V										
	tDH(base) DC100	150		100		65		45		ps	d,17
	1.35V										
	tDH(base) DC90	160	-	110	-	75	-	55	-	ps	d,17

Speed		DDR3L/DDR3-800		DDR3L/DDR3-1066		DDR3L/DDR3-1333		DDR3L/DDR3-1600		Unit	Note
Parameter	Symbol	Min	Max	Min	Max	Min	Max	Min	Max		
DQ and DM Input pulse width for each input	tDIPW	600	-	490	-	400	-	360	-	ps	28
Data Strobe Timing											
DQS, DQS# differential READ Preamble	tRPRE	0.9	Note 19	0.9	Note 19	0.9	Note 19	0.9	Note 19	tCK (avg)	13,19,g
DQS, DQS# differential READ Postamble	tRPST	0.3	Note 11	0.3	Note 11	0.3	Note 11	0.3	Note 11	tCK (avg)	11,13,g
DQS, DQS# differential output high time	tQSH	0.38	-	0.38	-	0.40	-	0.40	-	tCK (avg)	13,g
DQS, DQS# differential output low time	tQSL	0.38	-	0.38	-	0.40	-	0.40	-	tCK (avg)	13,g
DQS, DQS# differential WRITE Preamble	tWPRE	0.9	-	0.9	-	0.9	-	0.9	-	tCK (avg)	1
DQS, DQS# differential WRITE Postamble	tWPST	0.3	-	0.3	-	0.3	-	0.3	-	tCK (avg)	1
DQS, DQS# rising edge output access time from rising CK, CK#	tDQCK	-400	400	-300	300	-255	255	-225	225	ps	13,f
DQS and DQS# low-impedance time (Referenced from RL - 1)	tLZ(DQS)	-800	400	-600	300	-500	250	-450	225	ps	13,14,f
DQS and DQS# high-impedance time (Referenced from RL + BL/2)	tHZ(DQS)	-	400	-	300	-	250	-	225	ps	13,14,f
DQS and DQS# differential input low pulse width	tDQSL	0.45	0.55	0.45	0.55	0.45	0.55	0.45	0.55	tCK (avg)	29,31
DQS and DQS# differential input high pulse width	tDQSH	0.45	0.55	0.45	0.55	0.45	0.55	0.45	0.55	tCK (avg)	30,31
DQS, DQS# rising edge to CK, CK# rising edge	tDQSS	-0.25	0.25	-0.25	0.25	-0.25	0.25	-0.27	0.27	tCK (avg)	c
DQS, DQS# falling edge setup time to CK, CK# rising edge	tDSS	0.2	-	0.2	-	0.2	-	0.18	-	tCK (avg)	c,32
DQS, DQS# falling edge hold time from CK, CK# rising edge	tDSH	0.2	-	0.2	-	0.2	-	0.18	-	tCK (avg)	c,32
Command and Address Timing											
DLL locking time	tDLLK	512	-	512	-	512	-	512	-	nCK	
Internal READ Command to PRECHARGE Command delay	tRTP	Max (4nCK, 7.5 ns)	-	Max (4nCK, 7.5 ns)	-	Max (4nCK, 7.5 ns)	-	Max (4nCK, 7.5 ns)	-		e
Delay from start of internal write transaction to internal read command	tWTR	Max (4nCK, 7.5 ns)	-	Max (4nCK, 7.5 ns)	-	Max (4nCK, 7.5 ns)	-	Max (4nCK, 7.5 ns)	-		e,18
WRITE recovery time	tWR	15	-	15	-	15	-	15	-	ns	e,18

Speed		DDR3L/DDR3-800		DDR3L/DDR3-1066		DDR3L/DDR3-1333		DDR3L/DDR3-1600		Unit	Note
Parameter	Symbol	Min	Max	Min	Max	Min	Max	Min	Max		
Mode Register Set command cycle time	tMRD	4	-	4	-	4	-	4	-	nCK	
Mode Register Set command update delay	tMOD	Max (12nCK, 15 ns)	-	Max (12nCK, 15 ns)	-	Max (12nCK, 15 ns)	-	Max (12nCK, 15 ns)	-		
ACT to internal read or write delay time	tRCD	See Table 9-2		See Table 9-3		see Table 9-4		See Table 9-5			e
PRE command period	tRP	See Table 9-2		See Table 9-3		see Table 9-4		See Table 9-5			e
ACT to ACT or REF command period	tRC	See Table 9-2		See Table 9-3		see Table 9-4		See Table 9-5			e
CAS# to CAS# command delay	tCCD	4	-	4	-	4	-	4	-	nCK	
Auto precharge write recovery + precharge time	tDAL(min)	WR + round up (tRP / tCK(avg))								nCK	
Multi-Purpose Register Recovery Time	tMPRR	1	-	1	-	1	-	1	-	nCK	22
ACTIVE to PRECHARGE command period	tRAS	See Table 9-2		See Table 9-3		see Table 9-4		See Table 9-5			e
ACTIVE to ACTIVE command period for 1KB page size	tRRD	Max (4nCK, 10 ns)	-	Max (4nCK, 7.5 ns)	-	Max (4nCK, 6 ns)	-	Max (4nCK, 6 ns)	-		e
ACTIVE to ACTIVE command period for 2KB page size	tRRD	Max (4nCK, 10 ns)	-	Max (4nCK, 10 ns)	-	Max (4nCK, 7.5 ns)	-	Max (4nCK, 7.5 ns)	-		e
Four activate window for 1KB page size	tFAW	40	-	37.5	-	30	-	30	-	ns	e
Four activate window for 2KB page size	tFAW	50	-	50	-	45	-	40	-	ns	e
Command and Address setup time to CK, CK# referenced to Vih(ac) / Vil(ac) levels	1.5V										
	tIS(base) AC175	200		125		65		45		ps	b,16
	tIS(base) AC150	350		275		190		170		ps	b,16,27
	1.35V										
	tIS(base) AC160	215	-	140	-	80	-	60	-	ps	b,16

Speed		DDR3L/DDR3-800		DDR3L/DDR3-1066		DDR3L/DDR3-1333		DDR3L/DDR3-1600		Unit	Note
Parameter	Symbol	Min	Max	Min	Max	Min	Max	Min	Max		
	tIS(base) AC135	365	-	290	-	205	-	185	-	ps	b,16,27
Command and Address hold time from CK, CK# referenced to Vih(dc) / Vil(dc) levels	1.5V										
	tIH(base) DC100	275	-	200	-	140	-	120	-	ps	b,16
	1.35V										
	tIH(base) DC90	285	-	210	-	150	-	130	-	ps	b,16
Control and Address Input pulse width for each input	tIPW	900	-	780	-	620	-	560	-	ps	28
Calibration Timing											
Power-up and RESET calibration time	tZQinit	Max (512nCK, 640 ns)	-	Max (512nCK, 640 ns)	-	Max (512nCK, 640 ns)	-	Max (512nCK, 640 ns)	-		
Normal operation Full calibration time	tZQoper	Max (256nCK, 320 ns)	-	Max (256nCK, 320 ns)	-	Max (256nCK, 320 ns)	-	Max (256nCK, 320 ns)	-		
Normal operation short calibration time	tZQCS	Max (64nCK, 80 ns)	-	Max (64nCK, 80 ns)	-	Max (64nCK, 80 ns)	-	Max (64nCK, 80 ns)	-		23
Reset Timing											
Exit Reset from CKE HIGH to a valid command	tXPR	Max (5nCK, tRFC(min) + 10 ns)	-	Max (5nCK, tRFC(min) + 10 ns)	-	Max (5nCK, tRFC(min) + 10 ns)	-	Max (5nCK, tRFC(min) + 10 ns)	-		
Self Refresh Timing											
Exit Self Refresh to commands not requiring a locked DLL	tXS	Max (5nCK, tRFC(min) + 10 ns)	-	Max (5nCK, tRFC(min) + 10 ns)	-	Max (5nCK, tRFC(min) + 10 ns)	-	Max (5nCK, tRFC(min) + 10 ns)	-		
Exit Self Refresh to commands requiring a locked DLL	tXSDLL	tDLLK (min)	-	tDLLK (min)	-	tDLLK (min)	-	tDLLK (min)	-	nCK	
Minimum CKE low width for Self refresh entry to exit timing	tCKESR	tCKE (min) + 1nCK	-	tCKE (min) + 1nCK	-	tCKE (min) + 1nCK	-	tCKE (min) + 1nCK	-		
Valid Clock Requirement after Self Refresh Entry (SRE) or Power-Down Entry (PDE)	tCKSRE	Max (5nCK, 10 ns)	-	Max (5nCK, 10 ns)	-	Max (5nCK, 10 ns)	-	Max (5nCK, 10 ns)	-		
Valid Clock Requirement before Self Refresh Exit (SRX) or Power Down Exit (PDX) or Reset Exit	tCKSRX	Max (5nCK, 10 ns)	-	Max (5nCK, 10 ns)	-	Max (5nCK, 10 ns)	-	Max (5nCK, 10 ns)	-		

Speed		DDR3L/DDR3-800		DDR3L/DDR3-1066		DDR3L/DDR3-1333		DDR3L/DDR3-1600		Unit	Note
Parameter	Symbol	Min	Max	Min	Max	Min	Max	Min	Max		
				ns)		ns)		ns)			
Power Down Timing											
Exit Power Down with DLL on to any valid command, Exit Precharge Power Down with DLL frozen to commands not requiring a locked DLL	tXP	Max (3nCK, 7.5 ns)	-	Max (3nCK, 7.5 ns)	-	Max (3nCK, 6ns)	-	Max (3nCK, 6ns)	-		
Exit Precharge Power Down with DLL frozen to commands requiring a locked DLL	tXPDLL	Max (10nCK, 24ns)	-	Max (10nCK, 24ns)	-	Max (10nCK, 24ns)	-	Max (10nCK, 24ns)	-		2
CKE minimum pulse width	tCKE	Max (3nCK, 7.5 ns)	-	Max (3nCK, 5.625 ns)	-	Max (3nCK, 5.625 ns)	-	Max (3nCK, 5ns)	-		
Command pass disable delay	tCPDED	1	-	1	-	1	-	1	-	nCK	
Power Down Entry to Exit Timing	tPD	tCKE (min)	9*tREFI	tCKE (min)	9*tREFI	tCKE (min)	9*tREFI	tCKE (min)	9*tREFI	nCK	15
Timing of ACT command to Power Down entry	tACTPDEN	1	-	1	-	1	-	1	-	nCK	20
Timing of PRE or PREA command to Power Down entry	tPRPDEN	1	-	1	-	1	-	1	-	nCK	20
Timing of RD/RDA command to Power Down entry	tRDPDEN	RL + 4 + 1	-	RL + 4 + 1	-	RL + 4 + 1	-	RL + 4 + 1	-	nCK	
Timing of WR command to Power Down entry (BL8OTF, BL8MRS, BC4OTF)	tWRPDEN	WL + 4 + (tWR/tCK(avg))	-	WL + 4 + (tWR/tCK(avg))	-	WL + 4 + (tWR/tCK(avg))	-	WL + 4 + (tWR/tCK(avg))	-	nCK	9
Timing of WRA command to Power Down entry (BL8OTF, BL8MRS, BC4OTF)	tWRAPDEN	WL + 4 + WR + 1	-	WL + 4 + WR + 1	-	WL + 4 + WR + 1	-	WL + 4 + WR + 1	-	nCK	10
Timing of WR command to Power Down entry (BC4MRS)	tWRPDEN	WL + 2 + (tWR/tCK(avg))	-	WL + 2 + (tWR/tCK(avg))	-	WL + 2 + (tWR/tCK(avg))	-	WL + 2 + (tWR/tCK(avg))	-	nCK	9
Timing of WRA command to Power Down entry (BC4MRS)	tWRAPDEN	WL + 2 + WR + 1	-	WL + 2 + WR + 1	-	WL + 2 + WR + 1	-	WL + 2 + WR + 1	-	nCK	10
Timing of REF command to Power Down entry	tREFPDEN	1	-	1	-	1	-	1	-	nCK	20,21
Timing of MRS command to Power Down entry	tMRSPDEN	tMOD (min)	-	tMOD (min)	-	tMOD (min)	-	tMOD (min)	-	nCK	
ODT Timing											
ODT turn on Latency	ODTLon	WL - 2 = CWL + AL - 2								nCK	
ODT turn off Latency	ODTLoFF	WL - 2 = CWL + AL - 2								nCK	
ODT high time without write command or with write command and BC4	ODTH4	4	-	4	-	4	-	4	-	nCK	

Speed		DDR3L/DDR3-800		DDR3L/DDR3-1066		DDR3L/DDR3-1333		DDR3L/DDR3-1600		Unit	Note
Parameter	Symbol	Min	Max	Min	Max	Min	Max	Min	Max		
ODT high time with Write command and BL8	ODTH8	6	-	6	-	6	-	6	-	nCK	
Asynchronous RTT turn-on delay (Power-Down with DLL frozen)	tAONPD	2	8.5	2	8.5	2	8.5	2	8.5	ns	
Asynchronous RTT turn-off delay (Power-Down with DLL frozen)	tAOFPD	2	8.5	2	8.5	2	8.5	2	8.5	ns	
RTT turn-on	tAON	-400	400	-300	300	-250	250	-225	225	ps	7, f
RTT_Nom and RTT_WR turn-off time from ODTL off reference	tAOF	0.3	0.7	0.3	0.7	0.3	0.7	0.3	0.7	tCK(avg)	8,f
RTT dynamic change skew	tADC	0.3	0.7	0.3	0.7	0.3	0.7	0.3	0.7	tCK(avg)	f
Write Leveling Timing											
First DQS/DQS# rising edge after write leveling mode is programmed	tWLMRD	40	-	40	-	40	-	40	-	nCK	3
DQS/DQS# delay after write leveling mode is programmed	tWLDQSEN	25	-	25	-	25	-	25	-	nCK	3
Write leveling setup time from rising CK, CK# crossing to rising DQS/DQS# crossing	tWLS	325	-	245	-	195	-	165	-	ps	
Write leveling hold time from rising DQS/DQS# crossing to rising CK, CK# crossing	tWLH	325	-	245	-	195	-	165	-	ps	
Write leveling output delay	tWLO	0	9	0	9	0	9	0	7.5	ns	
Write leveling output error	tWLOE	0	2	0	2	0	2	0	2	ns	



10.2 Timing Parameters for DDR3L-1866 and DDR3L-2133 Speed Bins

Table 10-2. Timing Parameters by Speed Bin

Speed		DDR3L/DDR3-1866		DDR3L/DDR3-2133		Unit	Note
Parameter	Symbol	Min	Max	Min	Max		
Clock Timing							
Minimum Clock Cycle Time (DLL off mode)	tCK (DLL_OFF)	8	-	8	-	ns	6
Average Clock Period	tCK (avg)	See “Standard Speed Bins				ns	
Average high pulse width	tCH (avg)	0.47	0.53	0.47	0.53	tCK (avg)	
Average low pulse width	tCL (avg)	0.47	0.53	0.47	0.53	tCK (avg)	
Absolute Clock Period	tCK (abs)	tCK(avg)min + tJIT(per)min	tCK(avg)max + tJIT(per)max	tCK(avg)min + tJIT(per)min	tCK(avg)max + tJIT(per)max	ps	
Absolute clock HIGH pulse width	tCH (abs)	0.43	-	0.43	-	tCK (avg)	25
Absolute clock LOW pulse width	tCL (abs)	0.43	-	0.43	-	tCK (avg)	26
Clock Period Jitter	JIT (per)	-60	60	-50	50	ps	
Clock Period Jitter during DLL locking period	tJIT (per, lck)	-50	50	-40	40	ps	
Cycle to Cycle Period Jitter	tJIT (cc)	120		100		ps	
Cycle to Cycle Period Jitter during DLL locking period	tJIT (cc, lck)	100		80		ps	
Duty Cycle Jittter	tJIT (duty)	-	-	-	-		
Cumulative error across 2 cycles	tERR (2per)	-88	88	-74	74	ps	
Cumulative error across 3 cycles	tERR (3per)	-105	105	-87	87	ps	
Cumulative error across 4 cycles	tERR (4per)	-117	117	-97	97	ps	
Cumulative error across 5 cycles	tERR (5per)	-126	126	-105	105	ps	
Cumulative error across 6 cycles	tERR (6per)	-133	133	-111	111	ps	
Cumulative error across 7 cycles	tERR (7per)	-139	139	-116	116	ps	
Cumulative error across 8 cycles	tERR (8per)	-145	145	-121	121	ps	
Cumulative error across 9 cycles	tERR (9per)	-150	150	-125	125	ps	
Cumulative error across 10 cycles	tERR (10per)	-154	154	-128	128	ps	
Cumulative error across 11 cycles	tERR (11per)	-158	158	-132	132	ps	
Cumulative error across 12 cycles	tERR (12per)	-161	161	-134	134	ps	
Cumulative error across n = 13, 14 . . . 49, 50 cycles	tERR (nper)	tERR (nper)min = ((1 + 0.68ln(n)) * tJIT (per)_total min) tERR (nper)max = ((1 + 0.68ln(n)) * tJIT (per)_total max)				ps	24
Data Timing							
DQS,DQS# to DQ skew, per group, per access	tDQSQ	-	85	-	75	ps	13
DQ output hold time from DQS, DQS#	tQH	0.38	-	0.38	-	tCK (avg)	13, g
DQ low impedance time from CK, CK#	tLZ (DQ)	-390	195	-360	180	ps	13,14,f
DQ high impedance time from CK, CK#	tHZ (DQ)	-	195	-	180	ps	13,14,f
Data setup time from DQS, DQS# referenced to VIH(ac) / VIL(ac) levels	1.5V						
	tDS(base) AC150	-	-	-	-	ps	d,17
	tDS(base) AC135	68	-	53	-	ps	d,17



Speed		DDR3L/DDR3-1866		DDR3L/DDR3-2133		Unit	Note
Parameter	Symbol	Min	Max	Min	Max		
	1.35V						
	tDS(base) AC135	70	-	-	-	ps	d,17
Data hold time to DQS, DQS# referenced to VIH(ac) / VIL(ac) levels	1.5V						
	tDH(base) DC100	-	-	-	-	ps	d,17
	1.35V						
	tDH(base) DC90	75	-	-	-	ps	d,17
DQ and DM Input pulse width for each input	tDIPW	320	-	280	-	ps	28
Data Strobe Timing							
DQS, DQS# differential READ Preamble	tRPRE	0.9	Note 19	0.9	Note 19	tCK (avg)	13,19,g
DQS, DQS# differential READ Postamble	tRPST	0.3	Note 11	0.3	Note 11	tCK (avg)	11,13,g
DQS, DQS# differential output high time	tQSH	0.4	-	0.38	-	tCK (avg)	13,g
DQS, DQS# differential output low time	tQSL	0.4	-	0.38	-	tCK (avg)	13,g
DQS, DQS# differential WRITE Preamble	tWPRE	0.9	-	0.9	-	tCK (avg)	1
DQS, DQS# differential WRITE Postamble	tWPST	0.3	-	0.3	-	tCK (avg)	1
DQS, DQS# rising edge output access time from rising CK, CK#	tDQCK	-195	195	-180	180	ps	13,f
DQS and DQS# low-impedance time (Referenced from RL - 1)	tLZ(DQS)	-390	195	-360	180	ps	13,14,f
DQS and DQS# high-impedance time (Referenced from RL + BL/2)	tHZ(DQS)	-	195	-	180	ps	13,14,f
DQS and DQS# differential input low pulse width	tDQSL	0.45	0.55	0.45	0.55	tCK (avg)	29,31
DQS and DQS# differential input high pulse width	tDQSH	0.45	0.55	0.45	0.55	tCK (avg)	30,31
DQS, DQS# rising edge to CK, CK# rising edge	tDQSS	-0.27	0.27	-0.27	0.27	tCK (avg)	c
DQS, DQS# falling edge setup time to CK, CK# rising edge	tDSS	0.18	-	0.18	-	tCK (avg)	c,32
DQS, DQS# falling edge hold time from CK, CK# rising edge	tDSH	0.18	-	0.18	-	tCK (avg)	c,32
Command and Address Timing							
DLL locking time	tDLLK	512	-	512	-	nCK	
Internal READ Command to PRECHARGE Command delay	tRTP	Max (4nCK, 7.5 ns)	-	Max (4nCK, 7.5 ns)	-		e
Delay from start of internal write transaction to internal read command	tWTR	Max (4nCK, 7.5 ns)	-	Max (4nCK, 7.5 ns)	-		e,18
WRITE recovery time	tWR	15	-	15	-	ns	e,18
Mode Register Set command cycle time	tMRD	4	-	4	-	nCK	
Mode Register Set command update delay	tMOD	Max (12nCK, 15 ns)	-	Max (12nCK, 15 ns)	-		
ACT to internal read or write delay time	tRCD	See Table 9-6		See Table 9-3			e
PRE command period	tRP	See Table 9-6		See Table 9-3			e
ACT to ACT or REF command period	tRC	See Table 9-6		See Table 9-3			e
CAS# to CAS# command delay	tCCD	4	-	4	-	nCK	
Auto precharge write recovery + precharge time	tDAL(min)	WR + roundup (tRP / tCK(avg))				nCK	



Speed		DDR3L/DDR3-1866		DDR3L/DDR3-2133		Unit	Note
Parameter	Symbol	Min	Max	Min	Max		
Multi-Purpose Register Recovery Time	tMPRR	1	-	1	-	nCK	22
ACTIVE to PRECHARGE command period	tRAS	See Table 9-6		See Table 9-3			e
ACTIVE to ACTIVE command period for 1KB page size	tRRD	Max (4nCK, 5.0 ns)	-	Max (4nCK, 5.0 ns)	-		e
ACTIVE to ACTIVE command period for 2KB page size	tRRD	Max (4nCK, 6.0 ns)	-	Max (4nCK, 6.0 ns)	-		e
Four activate window for 1KB page size	tFAW	27	-	25	-	ns	e
Four activate window for 2KB page size	tFAW	35	-	35	-	ns	e
Command and Address setup time to CK, CK# referenced to Vih(ac) / Vil(ac) levels	1.5V						
	tIS(base) AC150	-	-	-	-	ps	b,16
	tIS(base) AC125	150	-	135	-	ps	b,16,27
	1.35V						
	tIS(base) AC135	65	-	-	-	ps	b,16
	tIS(base) AC125	150	-	-	-	ps	b,16,27
Command and Address hold time from CK, CK# referenced to Vih(dc) / Vil(dc) levels	1.5V						
	tIH(base) DC100	100	-	95	-	ps	b,16
	1.35V						
	tIH(base) DC90	110	-	-	-	ps	b,16
Control and Address Input pulse width for each input	tIPW	535	-	470	-	ps	28
Calibration Timing							
Power-up and RESET calibration time	tZQinit	Max (512nCK, 640 ns)	-	Max (512nCK, 640 ns)	-		
Normal operation Full calibration time	tZQoper	Max (256nCK, 320 ns)	-	Max (256nCK, 320 ns)	-		
Normal operation short calibration time	tZQCS	Max (64nCK, 80 ns)	-	Max (64nCK, 80 ns)	-		23
Reset Timing							
Exit Reset from CKE HIGH to a valid command	tXPR	Max (5nCK, tRFC(min) + 10 ns)	-	Max (5nCK, tRFC(min) + 10 ns)	-		
Self Refresh Timing							
Exit Self Refresh to commands not requiring a locked DLL	tXS	Max (5nCK, tRFC(min) + 10 ns)	-	Max (5nCK, tRFC(min) + 10 ns)	-		
Exit Self Refresh to commands requiring a locked DLL	tXSDLL	tDLLK (min)	-	tDLLK (min)	-	nCK	
Minimum CKE low width for Self refresh entry to exit timing	tCKESR	tCKE (min) + 1nCK	-	tCKE (min) + 1nCK	-		
Valid Clock Requirement after Self Refresh Entry (SRE) or Power-Down Entry (PDE)	tCKSRE	Max (5nCK, 10 ns)	-	Max (5nCK, 10 ns)	-		
Valid Clock Requirement before Self Refresh Exit (SRX) or Power-Down Exit (PDX) or Reset Exit	tCKSRX	Max (5nCK, 10 ns)	-	Max (5nCK, 10 ns)	-		
Power Down Timing							



Speed		DDR3L/DDR3-1866		DDR3L/DDR3-2133		Unit	Note
Parameter	Symbol	Min	Max	Min	Max		
Exit Power Down with DLL on to any valid command, Exit Precharge Power Down with DLL frozen to commands not requiring a locked DLL	tXP	Max (3nCK, 6 ns)	-	Max (3nCK, 6 ns)	-		
Exit Precharge Power Down with DLL frozen to commands requiring a locked DLL	tXPDLL	Max (10nCK, 24ns)	-	Max (10nCK, 24ns)	-		2
CKE minimum pulse width	tCKE	Max (3nCK, 5 ns)	-	Max (3nCK, 5 ns)	-		
Command pass disable delay	tCPDED	2	-	2	-	nCK	
Power Down Entry to Exit Timing	tPD	tCKE (min)	9*tREFI	tCKE (min)	9*tREFI		15
Timing of ACT command to Power Down entry	tACTPDEN	1	-	2	-	nCK	20
Timing of PRE or PREA command to Power Down entry	tPRPDEN	1	-	2	-	nCK	20
Timing of RD/RDA command to Power Down entry	tRDPDEN	RL + 4 + 1	-	RL + 4 + 1	-	nCK	
Timing of WR command to Power Down entry (BL8OTF, BL8MRS, BC4OTF)	tWRPDEN	WL + 4 + (tWR / tCK(avg))	-	WL + 4 + (tWR / tCK(avg))	-	nCK	9
Timing of WRA command to Power Down entry (BL8OTF, BL8MRS, BC4OTF)	tWRAPDEN	WL + 4 + WR + 1	-	WL + 4 + WR + 1	-	nCK	10
Timing of WR command to Power Down entry (BC4MRS)	tWRPDEN	WL + 2 + (tWR/tCK(avg))	-	WL + 2 + (tWR/tCK(avg))	-	nCK	9
Timing of WRA command to Power Down entry (BC4MRS)	tWRAPDEN	WL + 2 + WR + 1	-	WL + 2 + WR + 1	-	nCK	10
Timing of REF command to Power Down entry	tREFPDEN	1	-	2	-	nCK	20,21
Timing of MRS command to Power Down entry	tMRSPDEN	tMOD (min)	-	tMOD (min)	-		
ODT Timing							
ODT turn on Latency	ODTLon	WL -2 = CWL + AL - 2				nCK	
ODT turn off Latency	ODTLoff	WL -2 = CWL + AL - 2				nCK	
ODT high time without write command or with write command and BC4	ODTH4	4	-	4	-	nCK	
ODT high time with Write command and BL8	ODTH8	6	-	6	-	nCK	
Asynchronous RTT turn-on delay (Power-Down with DLL frozen)	tAONPD	2	8.5	2	8.5	ns	
Asynchronous RTT turn-off delay (Power-Down with DLL frozen)	tAOFPD	2	8.5	2	8.5	ns	
RTT turn-on	tAON	-195	195	-180	180	ps	7, f
RTT_Nom and RTT_WR turn-off time from ODTL off reference	tAOF	0.3	0.7	0.3	0.7	tCK(avg)	8,f
RTT dynamic change skew	tADC	0.3	0.7	0.3	0.7	tCK(avg)	f
Write Leveling Timing							
First DQS/DQS# rising edge after write leveling mode is programmed	tWLMRD	40	-	40	-	nCK	3
DQS/DQS# delay after write leveling mode is programmed	tWLDQSEN	25	-	25	-	nCK	3
Write leveling setup time from rising CK, CK# crossing to rising DQS/DQS# crossing	tWLS	140	-	125	-	ps	
Write leveling hold time from rising DQS/DQS# crossing to rising CK, CK# crossing	tWLH	140	-	125	-	ps	
Write leveling output delay	tWLO	0	7.5	0	7.5	ns	
Write leveling output error	tWLOE	0	2	0	2	ns	



10.3 Jitter Notes

Note:

- a. Unit 'tCK(avg)' represents the actual tCK(avg) of the input clock under operation. Unit 'nCK' represents one clock cycle of the input clock, counting the actual clock edges.ex) tMRD = 4 [nCK] means; if one Mode Register Set command is registered at Tm, another Mode Register Set command may be registered at Tm+4, even if (Tm+4 - Tm) is 4 x tCK(avg) + tERR(4per).min.
- b. These parameters are measured from a command/address signal (CKE, CS#, RAS#, CAS#, WE#, ODT, BA0, A0, A1, etc.) transition edge to its respective clock signal (CK/CK#) crossing. The spec values are not affected by the amount of clock jitter applied (i.e. tJIT(per), tJIT(cc), etc.), as the setup and hold are relative to the clock signal crossing that latches the command/address. That is, these parameters should be met whether clock jitter is present or not.
- c. These parameters are measured from a data strobe signal (DQS(L/U), DQS (L/U) #) crossing to its respective clock signal (CK, CK#) crossing. The spec values are not affected by the amount of clock jitter applied (i.e. tJIT(per), tJIT(cc), etc.), as these are relative to the clock signal crossing. That is, these parameters should be met whether clock jitter is present or not.
- d. These parameters are measured from a data signal (DM(L/U), DQ(L/U)0, DQ(L/U)1, etc.) transition edge to its respective data strobe signal (DQS(L/U), DQS(L/U) #) crossing.
- e. For these parameters, the DDR3 SDRAM device supports tnPARAM [nCK] = RU {tPARAM [ns] / tCK(avg) [ns]}, which is in clock cycles, assuming all input clock jitter specifications are satisfied. For example, the device will support tnRP = RU {tRP / tCK(avg)}, which is in clock cycles, if all input clock jitter specifications are met. This means: For DDR3L/DDR3-800 6-6-6, of which tRP = 15ns, the device will support tnRP = RU {tRP / tCK(avg)} = 6, as long as the input clock jitter specifications are met, i.e. Precharge command at Tm and Active command at Tm+6 is valid even if (Tm+6 - Tm) is less than 15ns due to input clock jitter.
- f. When the device is operated with input clock jitter, this parameter needs to be derated by the actual tERR(mper), act of the input clock, where $2 \leq m \leq 12$. (output deratings are relative to the SDRAM input clock.)
For example, if the measured jitter into a DDR3L/DDR3-800 SDRAM has tERR(mper), act, min = - 172 ps and tERR(mper), act, max = + 193 ps, then tDQSCK, min(derated) = tDQSCK, min - tERR(mper), act, max = - 400 ps - 193 ps = - 593 ps and tDQSCK, max(derated) = tDQSCK, max - tERR(mper), act, min = 400 ps + 172ps = + 572 ps. Similarly, tLZ(DQ) for DDR3L-800 derates totLZ(DQ), min(derated) = - 800 ps - 193 ps = - 993 ps and tLZ(DQ), max(derated) = 400 ps + 172 ps = + 572 ps. (Caution on the min/max usage!)
Note that tERR(mper), act, min is the minimum measured value of tERR(nper) where $2 \leq n \leq 12$, and tERR(mper), act, max is the maximum measured value of tERR(nper) where $2 \leq n \leq 12$.
- g. When the device is operated with input clock jitter, this parameter needs to be derated by the actual tJIT(per), act of the input clock. (output deratings are relative to the SDRAM input clock.) For example, if the measured jitter into a DDR3L/DDR3-800 SDRAM has tCK(avg), act = 2500 ps, tJIT(per), act, min = - 72 ps and tJIT(per), act, max = + 93 ps, then tRPRE, min(derated) = tRPRE, min + tJIT(per), act, min = 0.9 x tCK(avg), act + tJIT(per), act, min = 0.9 x 2500 ps - 72 ps = + 2178 ps. Similarly, tQH, min(derated) = tQH, min + tJIT(per), act, min = 0.38 x tCK(avg), act + tJIT(per), act, min = 0.38 x 2500 ps - 72 ps = + 878 ps. (Caution on the min/max usage!)



10.4 Timing Parameter Notes

Note:

- Actual value dependant upon measurement level definitions. See “Method for calculating t_{WPRE} transitions and endpoints” and “Method for calculating t_{WPST} transitions and endpoints”.
- Commands requiring a locked DLL are: READ (and RAP) and synchronous ODT commands.
- The max values are system dependent.
- WR as programmed in mode register.
- Value must be rounded-up to next higher integer value.
- There is no maximum cycle time limit besides the need to satisfy the refresh interval, t_{REFI} .
- For definition of R_{TT} turn-on time t_{AON} .
- For definition of R_{TT} turn-off time t_{AOF} .
- t_{WR} is defined in ns, for calculation of t_{WRPDEN} it is necessary to round up t_{WR} / t_{CK} to the next integer.
- WR in clock cycles as programmed in MR0.
- The maximum read postamble is bound by $t_{DQCK(min)}$ plus $t_{QSH(min)}$ on the left side and $t_{HZ(DQS)max}$ on the right side. See “Clock to Data Strobe Relationship”.
- Output timing deratings are relative to the SDRAM input clock. When the device is operated with input clock jitter, this parameter needs to be derated by t.b.d.
- Value is only valid for R_{ON34} .
- Single ended signal parameter, Refer to chapter<t.b.d.> for definition and measurement method.
- t_{REFI} depends on T_{OPER} .
- $t_{IS(base)}$ and $t_{IH(base)}$ values are for 1V/ns CMD/ADD single-ended slew rate and 2V/ns CK, CK# differential slew rate. Note for DQ and DM signals, $V_{REF(DC)} = V_{RefDQ(DC)}$. For input only pins except RESET#, $V_{Ref(DC)} = V_{RefCA(DC)}$. See 11.5 “Address / Command Setup, Hold and Derating”.
- $t_{DS(base)}$ and $t_{DH(base)}$ values are for 1V/ns DQ single-ended slew rate and 2V/ns DQS, DQS# differential slew rate. Note for DQ and DM signals, $V_{REF(DC)} = V_{RefDQ(DC)}$. For input only pins except RESET#, $V_{Ref(DC)} = V_{RefCA(DC)}$. See 12.6 “Data Setup, Hold and Slew Rate Derating”.
- Start of internal write transaction is defined as follows:
For BL8 (fixed by MRS and on- the-fly): Rising clock edge 4 clock cycles after WL.
For BC4 (on- the- fly): Rising clock edge 4 clock cycles after WL.
For BC4 (fixed by MRS): Rising clock edge 2 clock cycles after WL.
- The maximum read preamble is bound by $t_{LZ(DQS)min}$ on the left side and $t_{DQCK(max)}$ on the right side.
- CKE is allowed to be registered low while operations such as row activation, precharge, auto-precharge or refresh are in progress, but power-down I_{DD} spec will not be applied until finishing those operations.
- Although CKE is allowed to be registered LOW after a REFRESH command once $t_{REFPDEN(min)}$ is satisfied, there are cases where additional time such as $t_{XPDLL(min)}$ is also required.
- Defined between end of MPR read burst and MRS which reloads MPR or disables MPR function.
- One ZQCS command can effectively correct a minimum of 0.5 % (ZQ Correction) of R_{ON} and R_{TT} impedance error within 64 nCK for all speed bins assuming the maximum sensitivities specified in the ‘Output Driver Voltage and Temperature Sensitivity’ and ‘ODT Voltage and Temperature Sensitivity’ tables. The appropriate interval between ZQCS commands can be determined from these tables and other application-specific parameters.

One method for calculating the interval between ZQCS commands, given the temperature ($T_{driftrate}$) and voltage ($V_{driftrate}$) drift rates that the SDRAM is subject to in the application, is illustrated. The interval could be defined by the following formula:

$$\frac{ZQCorrection}{(TSens \times Tdriftrate) + (VSens \times Vdriftrate)}$$

where TSens = max(dR_{TTdT}, dR_{OND_{TM}}) and VSens = max(dR_{TTdV}, dR_{OND_{VM}}) define the SDRAM temperature and voltage sensitivities.

For example, if TSens = 1.5% / °C, VSens = 0.15% / mV, Tdriftrate = 1 °C / sec and Vdriftrate = 15 mV / sec, then the interval between ZQCS commands is calculated as:

$$\frac{0.5}{(1.5 \times 1) + (0.15 \times 15)} = 0.133 \approx 128 \text{ms}$$

24. n = from 13 cycles to 50 cycles. This row defines 38 parameters.
25. t_{CH(abs)} is the absolute instantaneous clock high pulse width, as measured from one rising edge to the following falling edge.
26. t_{CL(abs)} is the absolute instantaneous clock low pulse width, as measured from one falling edge to the following rising edge.
27. The t_{S(base)} AC150 specifications are adjusted from the t_{S(base)} specification by adding an additional 100 ps of derating to accommodate for the lower alternate threshold of 150 mV and another 25 ps to account for the earlier reference point [(175 mv - 150 mV) / 1 V/ns].
28. Pulse width of an input signal is defined as the width between the first crossing of V_{ref(dc)} and the consecutive crossing of V_{ref(dc)}.
29. t_{DQSL} describes the instantaneous differential input low pulse width on DQS - DQS#, as measured from one falling edge to the next consecutive rising edge.
30. t_{DQSH} describes the instantaneous differential input high pulse width on DQS - DQS#, as measured from one rising edge to the next consecutive falling edge.
31. t_{DQSH, act} + t_{DQSL, act} = 1 t_{CK, act}; with t_{XYZ, act} being the actual measured value of the respective timing parameter in the application.
32. t_{DSH, act} + t_{DSS, act} = 1 t_{CK, act}; with t_{XYZ, act} being the actual measured value of the respective timing parameter in the application.



10.5 Address / Command Setup, Hold and Derating

For all input signals the total tIS (setup time) and tIH (hold time) required is calculated by adding the datasheet tIS(base) and tIH(base) value (see Table 10-3) to the ΔtIS and ΔtIH derating value (see Table 10-5) respectively. Example: tIS (total setup time) = tIS(base) + ΔtIS

Setup (tIS) nominal slew rate for a rising signal is defined as the slew rate between the last crossing of $V_{REF(dc)}$ and the first crossing of $V_{IH(ac)min}$. Setup (tIS) nominal slew rate for a falling signal is defined as the slew rate between the last crossing of $V_{REF(dc)}$ and the first crossing of $V_{IL(ac)max}$. If the actual signal is always earlier than the nominal slew rate line between shaded ' $V_{REF(dc)}$ to ac region', use nominal slew rate for derating value (see Figure 10-1). If the actual signal is later than the nominal slew rate line anywhere between shaded ' $V_{REF(dc)}$ to ac region', the slew rate of a tangent line to the actual signal from the ac level to $V_{REF(dc)}$ level is used for derating value (see Figure 10-2).

Hold (tIH) nominal slew rate for a rising signal is defined as the slew rate between the last crossing of $V_{IL(dc)max}$ and the first crossing of $V_{REF(dc)}$. Hold (tIH) nominal slew rate for a falling signal is defined as the slew rate between the last crossing of $V_{IH(dc)min}$ and the first crossing of $V_{REF(dc)}$. If the actual signal is always later than the nominal slew rate line between shaded 'dc to $V_{REF(dc)}$ region', use nominal slew rate for derating value (see Figure 10-1). If the actual signal is earlier than the nominal slew rate line anywhere between shaded 'dc to $V_{REF(dc)}$ region', the slew rate of a tangent line to the actual signal from the dc level to $V_{REF(dc)}$ level is used for derating value (see Figure 10-3).

For a valid transition the input signal has to remain above/below $V_{IH/IL(ac)}$ for some time t_{VAC} (see Table 10-12).

Although for slow slew rates the total setup time might be negative (i.e. a valid input signal will not have reached $V_{IH/IL(ac)}$ at the time of the rising clock transition, a valid input signal is still required to complete the transition and reach $V_{IH/IL(ac)}$).

For slew rates in between the values listed in Table 10-5, the derating values may obtained by linear interpolation.

These values are typically not subject to production test. They are verified by design and characterization.

**Table 10-3. ADD/CMD Setup and Hold Base-Values for 1V/ns (1.35 V)**

Symbol	Reference	DDR3L-800	DDR3L-1066	DDR3L-1333	DDR3L-1600	DDR3L-1866	DDR3L-2133	Units
tIS(base, AC160)	V _{IH/L} (AC)	215	140	80	60	-	-	ps
tIS(base, AC135)	V _{IH/L} (AC)	365	290	205	185	65	60	ps
tIS(base, AC125)	V _{IH/L} (AC)	-	-	-	-	150	135	ps
tIH(base, DC90)	V _{IH/L} (DC)	285	210	150	130	110	105	ps

Note:

- (ac/dc referenced for 1V/ns Address/Command slew rate and 2 V/ns differential CK-CK# slew rate).
- The tIS(base) AC135 specifications are adjusted from the tIS(base) AC160 specification by adding an additional 125 ps for DDR3L-800/1066 or 100ps for DDR3L-1333/1600 of derating to accommodate for the lower alternate threshold of 135 mV and another 25 ps to account for the earlier reference point [(160 mv - 135 mV) / 1 V/ns].
- The tIS(base) AC125 specifications are adjusted from the tIS(base) AC135 specification by adding an additional 75 ps for DDR3L-1866 and 65ps for DDR3L-2133 to accommodate for the lower alternate threshold of 125 mV and another 10 ps to account for the earlier reference point [(135 mv - 125 mV) / 1 V/ns].

Table 10-4. ADD/CMD Setup and Hold Base-Values for 1V/ns (1.5 V)

Symbol	Reference	DDR3-800	DDR3-1066	DDR3-1333	DDR3-1600	DDR3-1866	DDR3-2133	Units
tIS(base, AC175)	V _{IH/L} (AC)	200	125	65	45	-	-	ps
tIS(base, AC150)	V _{IH/L} (AC)	350	275	190	170	-	-	ps
tIS(base, AC135)	V _{IH/L} (AC)	-	-	-	-	65	60	ps
tIS(base, AC125)	V _{IH/L} (AC)	-	-	-	-	150	135	ps
tIH(base, DC100)	V _{IH/L} (DC)	275	200	140	120	100	95	ps

Note:

- (ac/dc referenced for 1V/ns Address/Command slew rate and 2 V/ns differential CK-CK# slew rate).
- The tIS(base) AC135 specifications are adjusted from the tIS(base) AC160 specification by adding an additional 125 ps for DDR3L-800/1066 or 100ps for DDR3L-1333/1600 of derating to accommodate for the lower alternate threshold of 135 mV and another 25 ps to account for the earlier reference point [(160 mv - 135 mV) / 1 V/ns].
- The tIS(base) AC125 specifications are adjusted from the tIS(base) AC135 specification by adding an additional 75 ps for DDR3L-1866 and 65ps for DDR3L-2133 to accommodate for the lower alternate threshold of 125 mV and another 10 ps to account for the earlier reference point [(135 mv - 125 mV) / 1 V/ns].



Table 10-5. Derating value DDR3L-800/1066/1333/1600 tIS/tIH – AC/DC based AC160 Threshold (1.35 V)

		$\Delta tIS, \Delta tIH$ derating in [ps] AC/DC based AC160 Threshold $\rightarrow V_{IH}(ac)=V_{REF}(dc)+175mV, V_{IL}(ac)=V_{REF}(dc)-160mV$															
		CK, CK# Differential Slew Rate															
		4.0 V/ns		3.0 V/ns		2.0 V/ns		1.8 V/ns		1.6 V/ns		1.4 V/ns		1.2 V/ns		1.0 V/ns	
		ΔtIS	ΔtIH	ΔtIS	ΔtIH	ΔtIS	ΔtIH	ΔtIS	ΔtIH	ΔtIS	ΔtIH	ΔtIS	ΔtIH	ΔtIS	ΔtIH	ΔtIS	ΔtIH
CMD/ADD Slew Rate V/ns	2.0	80	45	80	45	80	45	88	53	96	61	104	69	112	79	120	95
	1.5	53	30	53	30	53	30	61	38	69	46	77	54	85	64	93	80
	1.0	0	0	0	0	0	0	8	8	16	16	24	24	32	34	40	50
	0.9	-1	-3	-1	-3	-1	-3	7	5	15	13	23	21	31	31	39	47
	0.8	-3	-8	-3	-8	-3	-8	5	1	13	9	21	17	29	27	37	43
	0.7	-5	-13	-5	-13	-5	-13	3	-5	11	3	19	11	27	21	35	37
	0.6	-8	-20	-8	-20	-8	-20	0	-12	8	-4	16	4	24	14	32	30
	0.5	-20	-30	-20	-30	-20	-30	-12	-22	-4	-14	4	-6	12	4	20	20
	0.4	-40	-45	-40	-45	-40	-45	-32	-37	-24	-29	-16	-21	-8	-11	0	5

Table 10-6. Derating value DDR3L-800/1066/1333/1600 tIS/tIH – AC/DC based Alternate AC135 Threshold (1.35 V)

		$\Delta tIS, \Delta tIH$ derating in [ps] AC/DC based Alternate AC135 Threshold $\rightarrow V_{IH}(ac)=V_{REF}(dc)+135mV, V_{IL}(ac)=V_{REF}(dc)-135mV$															
		CK, CK# Differential Slew Rate															
		4.0 V/ns		3.0 V/ns		2.0 V/ns		1.8 V/ns		1.6 V/ns		1.4 V/ns		1.2 V/ns		1.0 V/ns	
		ΔtIS	ΔtIH	ΔtIS	ΔtIH	ΔtIS	ΔtIH	ΔtIS	ΔtIH	ΔtIS	ΔtIH	ΔtIS	ΔtIH	ΔtIS	ΔtIH	ΔtIS	ΔtIH
CMD/ADD Slew Rate V/ns	2.0	68	45	68	45	68	45	76	53	84	61	92	69	100	79	108	95
	1.5	45	30	45	30	45	30	53	38	61	46	69	54	77	64	85	80
	1.0	0	0	0	0	0	0	8	8	16	16	24	24	32	34	40	50
	0.9	2	-3	2	-3	2	-3	10	5	18	13	26	21	34	31	42	47
	0.8	3	-8	3	-8	3	-8	11	1	19	9	27	17	35	27	43	43
	0.7	6	-13	6	-13	6	-13	14	-5	22	3	30	11	38	21	46	37
	0.6	9	-20	9	-20	9	-20	17	-12	25	-4	33	4	41	14	49	30
	0.5	5	-30	5	-30	5	-30	13	-22	21	-14	29	-6	37	4	45	20
	0.4	-3	-45	-3	-45	-3	-45	6	-37	14	-29	22	-21	30	-11	38	5



Table 10-7. Derating value DDR3L-1866/2133 tIS/tIH – AC/DC based Alternate AC125 Threshold (1.35 V)

		$\Delta tIS, \Delta tIH$ derating in [ps] AC/DC based Alternate AC125 Threshold $\rightarrow V_{IH}(ac)=V_{REF}(dc)+125mV, V_{IL}(ac)=V_{REF}(dc)-125mV$															
		CK, CK# Differential Slew Rate															
		4.0 V/ns		3.0 V/ns		2.0 V/ns		1.8 V/ns		1.6 V/ns		1.4 V/ns		1.2 V/ns		1.0 V/ns	
		ΔtIS	ΔtIH	ΔtIS	ΔtIH	ΔtIS	ΔtIH	ΔtIS	ΔtIH	ΔtIS	ΔtIH	ΔtIS	ΔtIH	ΔtIS	ΔtIH	ΔtIS	ΔtIH
CMD/ADD Slew Rate V/ns	2.0	63	45	63	45	63	45	71	53	79	61	87	69	95	79	103	95
	1.5	42	30	42	30	42	30	50	38	58	46	66	54	74	64	82	80
	1.0	0	0	0	0	0	0	8	8	16	16	24	24	32	34	40	50
	0.9	3	-3	3	-3	3	-3	11	5	19	13	27	21	35	31	43	47
	0.8	6	-8	6	-8	6	-8	14	1	22	9	30	17	38	27	46	43
	0.7	10	-13	10	-13	10	-13	18	-5	26	3	34	11	42	21	50	37
	0.6	16	-20	16	-20	16	-20	24	-12	32	-4	40	4	48	14	56	30
	0.5	15	-30	15	-30	15	-30	23	-22	31	-14	39	-6	47	4	55	20
	0.4	13	-45	13	-45	13	-45	21	-37	29	-29	37	-21	45	-11	53	5

Table 10-8. Derating value DDR3-800/1066/1333/1600 tIS/tIH – AC/DC based AC175 Threshold (1.5 V)

		$\Delta tIS, \Delta tIH$ derating in [ps] AC/DC based AC175 Threshold $\rightarrow V_{IH}(ac)=V_{REF}(dc)+175mV, V_{IL}(ac)=V_{REF}(dc)-175mV$															
		CK, CK# Differential Slew Rate															
		4.0 V/ns		3.0 V/ns		2.0 V/ns		1.8 V/ns		1.6 V/ns		1.4 V/ns		1.2 V/ns		1.0 V/ns	
		ΔtIS	ΔtIH	ΔtIS	ΔtIH	ΔtIS	ΔtIH	ΔtIS	ΔtIH	ΔtIS	ΔtIH	ΔtIS	ΔtIH	ΔtIS	ΔtIH	ΔtIS	ΔtIH
CMD/ADD Slew Rate V/ns	2.0	88	50	88	50	88	50	96	58	104	66	112	74	120	84	128	100
	1.5	59	34	59	34	59	34	67	42	75	50	83	58	91	68	99	84
	1.0	0	0	0	0	0	0	8	8	16	16	24	24	32	34	40	50
	0.9	-2	-4	-2	-4	-2	-4	6	4	14	12	22	20	30	30	38	46
	0.8	-6	-10	-6	-10	-6	-10	2	-2	10	6	18	14	26	24	34	40
	0.7	-11	-16	-11	-16	-11	-16	-3	-8	5	0	13	8	21	18	29	34
	0.6	-17	-26	-17	-26	-17	-26	-9	-18	-1	-10	7	-2	15	8	23	24
	0.5	-35	-40	-35	-40	-35	-40	-27	-32	-19	-24	-11	-16	-2	-6	5	10
	0.4	-62	-60	-62	-60	-62	-60	-54	-52	-46	-44	-38	-36	-30	-26	-22	-10



Table 10-9. Derating value DDR3-800/1066/1333/1600 tIS/tIH – AC/DC based AC150 Threshold (1.5 V)

		$\Delta tIS, \Delta tIH$ derating in [ps] AC/DC based Alternate AC150 Threshold -> $V_{IH}(ac)=V_{REF}(dc)+150mV$, $V_{IL}(ac)=V_{REF}(dc)-150mV$															
		CK, CK# Differential Slew Rate															
		4.0 V/ns		3.0 V/ns		2.0 V/ns		1.8 V/ns		1.6 V/ns		1.4 V/ns		1.2 V/ns		1.0 V/ns	
		ΔtIS	ΔtIH	ΔtIS	ΔtIH	ΔtIS	ΔtIH	ΔtIS	ΔtIH	ΔtIS	ΔtIH	ΔtIS	ΔtIH	ΔtIS	ΔtIH	ΔtIS	ΔtIH
CMD/ADD Slew Rate V/ns	2.0	75	50	75	50	75	50	83	58	91	66	99	74	107	84	115	100
	1.5	50	34	50	34	50	34	58	42	66	50	74	58	82	68	90	84
	1.0	0	0	0	0	0	0	8	8	16	16	24	24	32	34	40	50
	0.9	0	-4	0	-4	0	-4	8	4	16	12	24	20	32	30	40	46
	0.8	0	-10	0	-10	0	-10	8	-2	16	6	24	14	32	24	40	40
	0.7	0	-16	0	-16	0	-16	8	-8	16	0	24	8	32	18	40	34
	0.6	-1	-26	-1	-26	-1	-26	7	-18	15	-10	23	-2	31	8	39	24
	0.5	-10	-40	-10	-40	-10	-40	-2	-32	6	-24	14	-16	22	-6	30	10
	0.4	-25	-60	-25	-60	-25	-60	-17	-52	-9	-44	-1	-36	7	-26	15	-10

Table 10-10. Derating value DDR3-1866/2133 tIS/tIH – AC/DC based AC135 Threshold (1.5 V)

		$\Delta tIS, \Delta tIH$ derating in [ps] AC/DC based Alternate AC135 Threshold -> $V_{IH}(ac)=V_{REF}(dc)+135mV$, $V_{IL}(ac)=V_{REF}(dc)-135mV$															
		CK, CK# Differential Slew Rate															
		4.0 V/ns		3.0 V/ns		2.0 V/ns		1.8 V/ns		1.6 V/ns		1.4 V/ns		1.2 V/ns		1.0 V/ns	
		ΔtIS	ΔtIH	ΔtIS	ΔtIH	ΔtIS	ΔtIH	ΔtIS	ΔtIH	ΔtIS	ΔtIH	ΔtIS	ΔtIH	ΔtIS	ΔtIH	ΔtIS	ΔtIH
CMD/ADD Slew Rate V/ns	2.0	68	50	68	50	68	50	76	58	84	66	92	74	100	84	108	100
	1.5	45	34	45	34	45	34	53	42	61	50	69	58	77	68	85	84
	1.0	0	0	0	0	0	0	8	8	16	16	24	24	32	34	40	50
	0.9	2	-4	2	-4	2	-4	10	4	18	12	26	20	34	30	42	46
	0.8	3	-10	3	-10	3	-10	11	-2	19	6	27	14	35	24	43	40
	0.7	6	-16	6	-16	6	-16	14	-8	22	0	30	8	38	18	46	34
	0.6	9	-26	9	-26	9	-26	17	-18	25	-10	33	-2	41	8	49	24
	0.5	5	-40	5	-40	5	-40	13	-32	21	-24	29	-16	37	-6	45	10
	0.4	-3	-60	-3	-60	-3	-60	6	-52	14	-44	22	-36	30	-26	38	-10



Table 10-11. Derating value DDR3-1866/2133 tIS/tIH – AC/DC based AC125 Threshold (1.5 V)

		$\Delta tIS, \Delta tIH$ derating in [ps] AC/DC based Alternate AC125 Threshold -> $V_{IH}(ac)=V_{REF}(dc)+125mV$, $V_{IL}(ac)=V_{REF}(dc)-125mV$															
		CK, CK# Differential Slew Rate															
		4.0 V/ns		3.0 V/ns		2.0 V/ns		1.8 V/ns		1.6 V/ns		1.4 V/ns		1.2 V/ns		1.0 V/ns	
		ΔtIS	ΔtIH	ΔtIS	ΔtIH	ΔtIS	ΔtIH	ΔtIS	ΔtIH	ΔtIS	ΔtIH	ΔtIS	ΔtIH	ΔtIS	ΔtIH	ΔtIS	ΔtIH
CMD/ADD Slew Rate V/ns	2.0	63	50	63	50	63	50	71	58	79	66	87	74	95	84	103	100
	1.5	42	34	42	34	42	34	50	42	58	50	66	58	74	68	82	84
	1.0	0	0	0	0	0	0	8	8	16	16	24	24	32	34	40	50
	0.9	4	-4	4	-4	4	-4	12	4	20	12	28	20	36	30	44	46
	0.8	6	-10	6	-10	6	-10	14	-2	22	6	30	14	38	24	46	40
	0.7	11	-16	11	-16	11	-16	19	-8	27	0	35	8	43	18	51	34
	0.6	16	-26	16	-26	16	-26	24	-18	32	-10	40	-2	48	8	56	24
	0.5	15	-40	15	-40	15	-40	23	-32	31	-24	39	-16	47	-6	55	10
	0.4	13	-60	13	-60	13	-60	21	-52	29	-44	37	-36	45	-26	53	-10

Table 10-12. Required minimum time t_{VAC} above $V_{IH}(ac)$ {below $V_{IL}(ac)$ } for valid ADD/CMD transition (1.35 V)

Slew Rate [V/ns]	DDR3				DDR3L			
	t800/1066/1333/1600		1866/2133		800/1066/1333/1600		1866/2133	
	175mV [ps]	150mV [ps]	135mV [ps]	125mV [ps]	160mV [ps]	135mV [ps]	135mV [ps]	125mV [ps]
>2.0	75	175	168	173	200	213	200	205
2.0	57	170	168	173	200	213	200	205
1.5	50	167	145	152	173	190	178	184
1.0	38	130	100	110	120	145	133	143
0.9	34	113	85	96	102	130	118	129
0.8	29	93	66	79	80	111	99	111
0.7	22	66	42	56	51	87	75	89
0.6	Note	30	10	27	13	55	43	59
0.5	Note	Note	Note	Note	Note	10	Note	18
<0.5	Note	Note	Note	Note	Note	10	Note	18

Note:

1. Rising input signal shall become equal to or greater than $V_{IH}(ac)$ level and Falling input signal shall become equal to or less than $V_{IL}(ac)$ level.

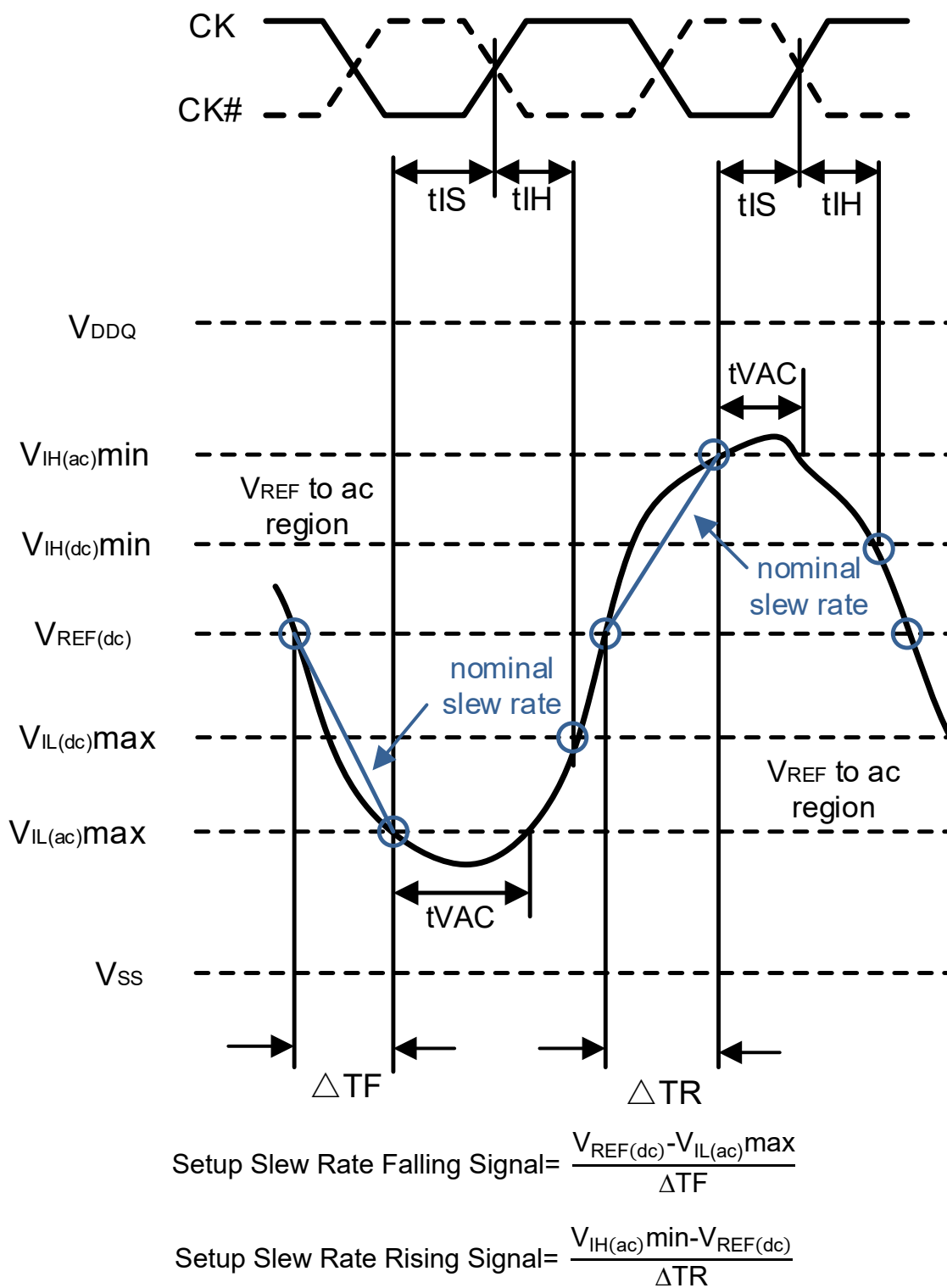


Figure 10-1. Illustration of nominal slew rate and t_{VAC} for setup time t_{IS} (for ADD/CMD with respect to clock).

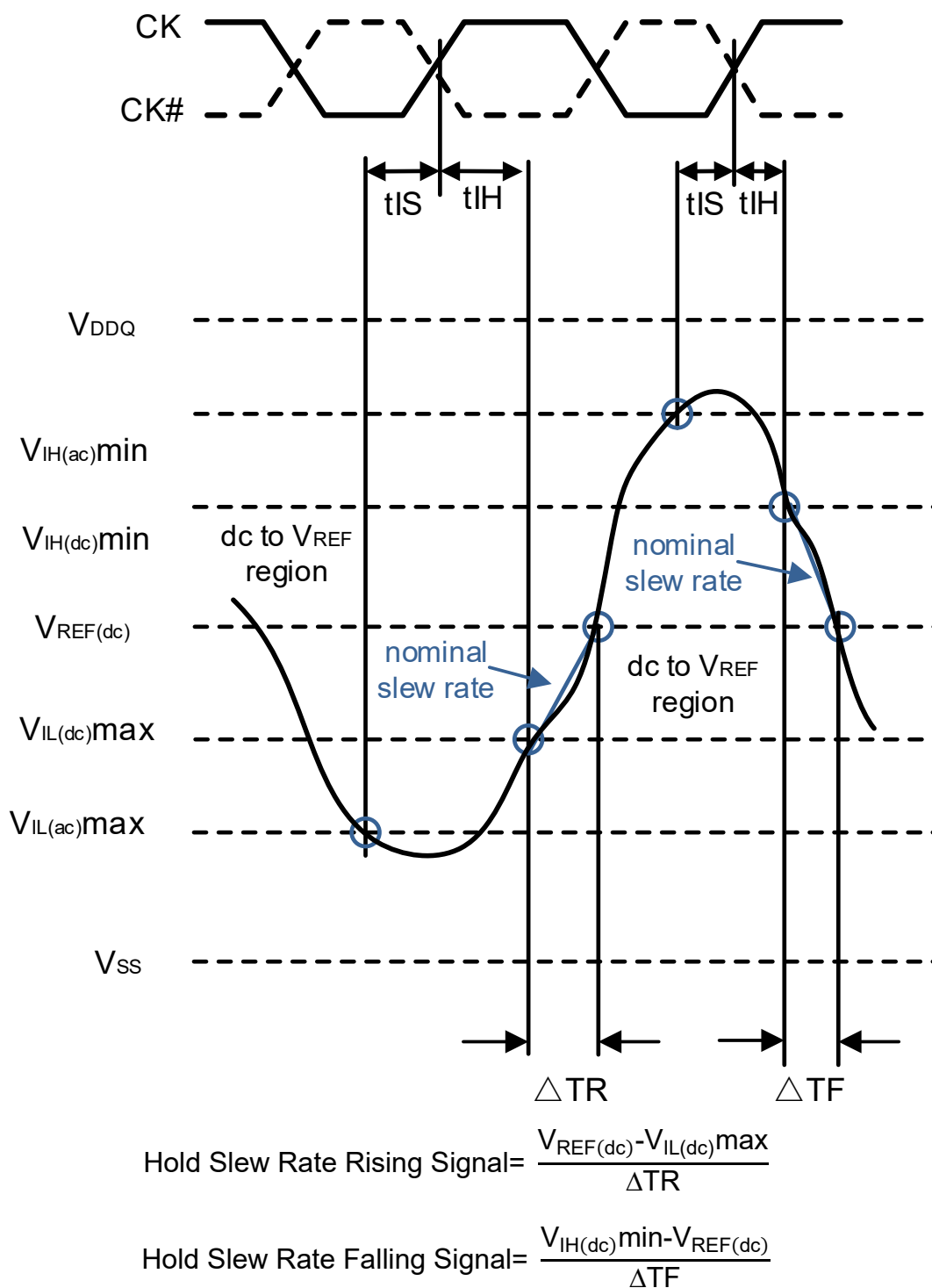
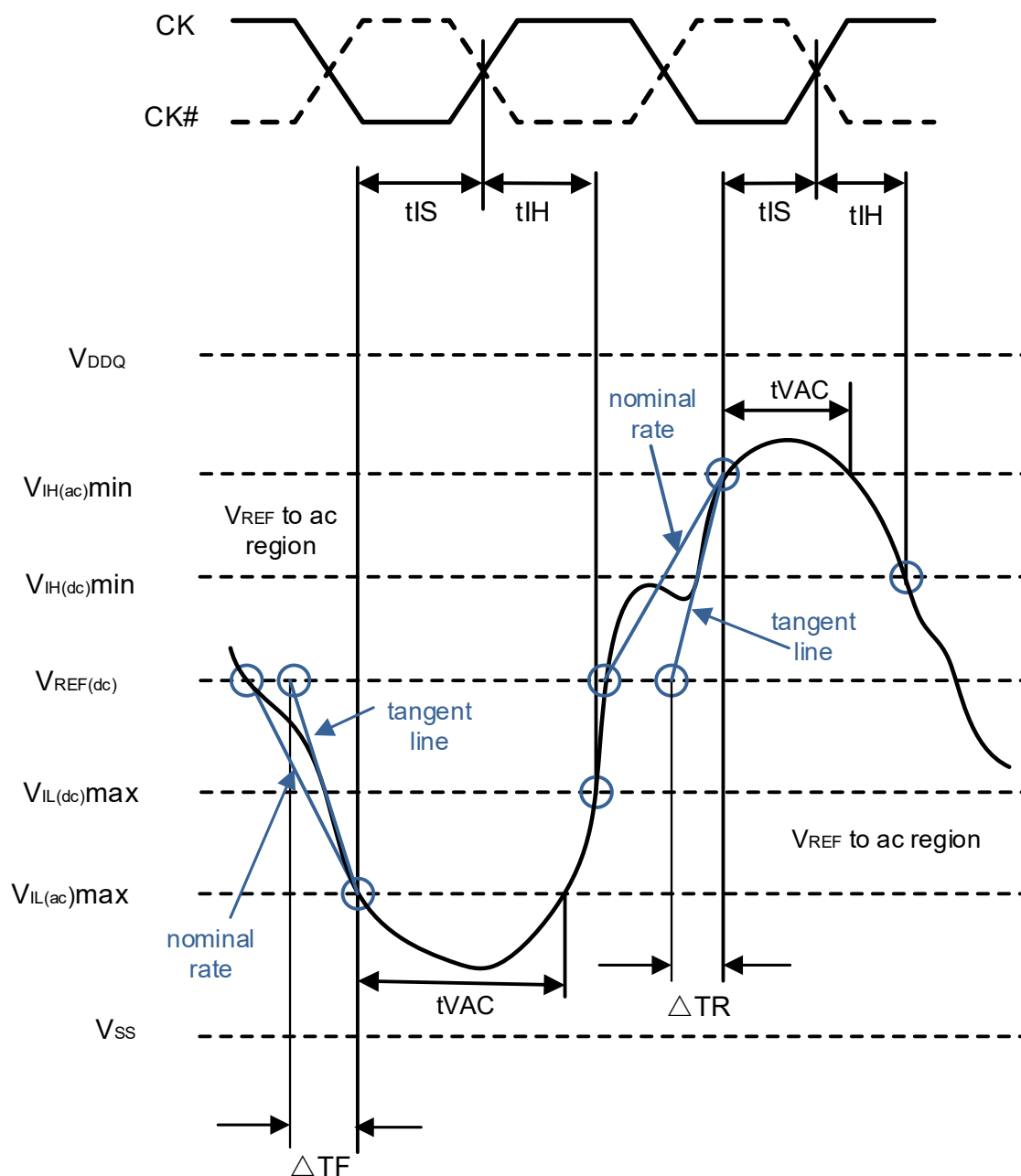


Figure 10-2. Illustration of nominal slew rate for hold time t_{IH} (for ADD/CMD with respect to clock).



$$\text{Setup Slew Rate Rising Signal} = \frac{\text{tangent line}[V_{IH(ac)min} - V_{REF(dc)}]}{\Delta TR}$$

$$\text{Setup Slew Rate Falling Signal} = \frac{\text{tangent line}[V_{REF(dc)} - V_{IL(ac)max}]}{\Delta TF}$$

Figure 10-3. Illustration of tangent line for setup time t_{IS} (for ADD/CMD with respect to clock).

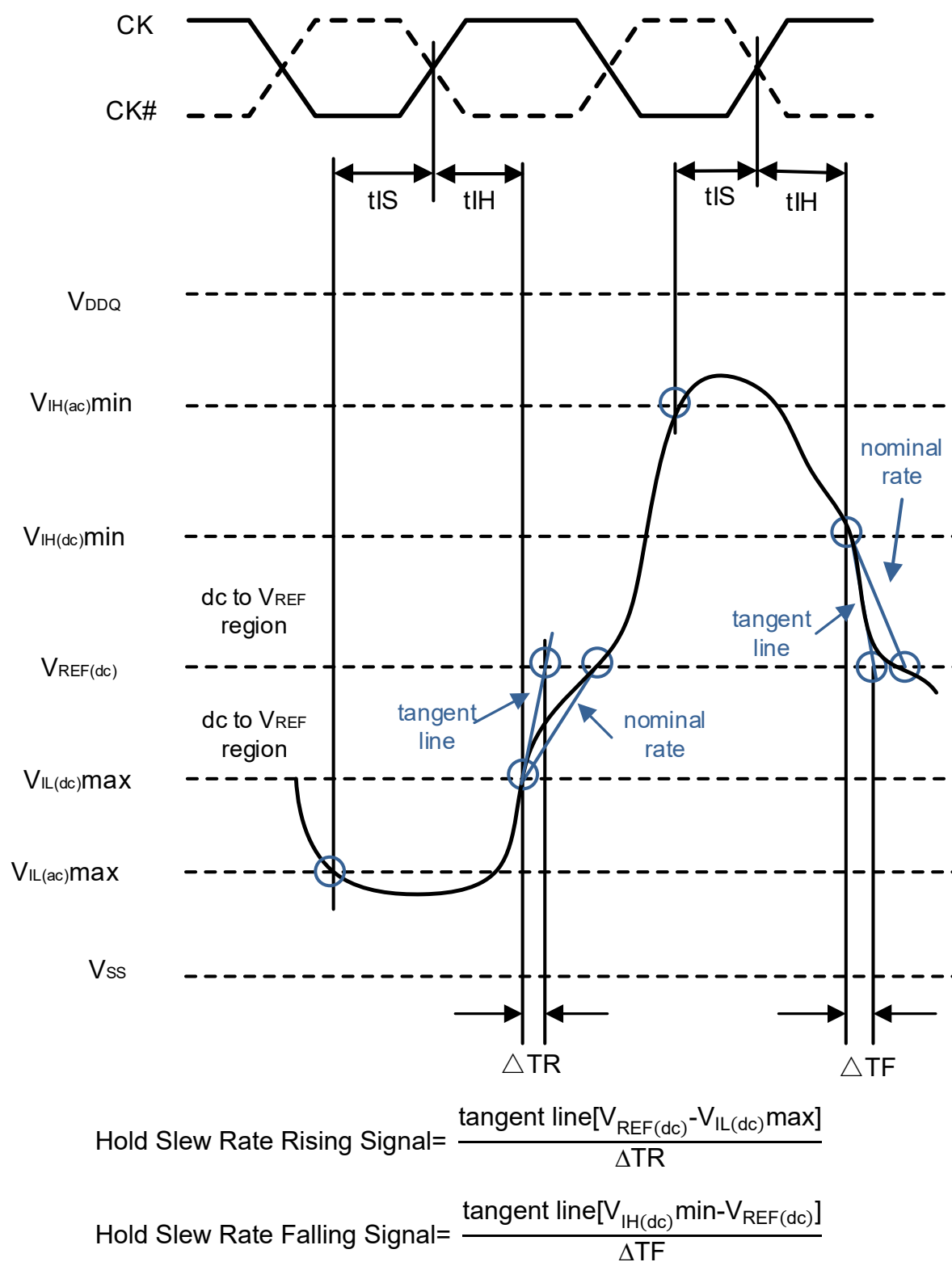


Figure 10-4. Illustration of tangent line for hold time t_{IH} (for ADD/CMD with respect to clock).



10.6 Data Setup, Hold and Slew Rate Derating

For all input signals the total tDS (setup time) and tDH (hold time) required is calculated by adding the data sheet tDS(base) and tDH(base) value to the ΔtDS and ΔtDH derating value respectively. Example: tDS (total setup time) = tDS(base) + ΔtDS .

Setup (tDS) nominal slew rate for a rising signal is defined as the slew rate between the last crossing of $V_{REF(dc)}$ and the first crossing of $V_{IH(ac)min}$. Setup (tDS) nominal slew rate for a falling signal is defined as the slew rate between the last crossing of $V_{REF(dc)}$ and the first crossing of $V_{IL(ac)max}$ (see Figure 10-5). If the actual signal is always earlier than the nominal slew rate line between shaded ' $V_{REF(dc)}$ to ac region', use nominal slew rate for derating value. If the actual signal is later than the nominal slew rate line anywhere between shaded ' $V_{REF(dc)}$ to ac region', the slew rate of a tangent line to the actual signal from the ac level to $V_{REF(dc)}$ level is used for derating value (see Figure 10-7).

Hold (tDH) nominal slew rate for a rising signal is defined as the slew rate between the last crossing of $V_{IL(dc)max}$ and the first crossing of $V_{REF(dc)}$. Hold (tDH) nominal slew rate for a falling signal is defined as the slew rate between the last crossing of $V_{IH(dc)min}$ and the first crossing of $V_{REF(dc)}$ (see Figure 10-6). If the actual signal is always later than the nominal slew rate line between shaded 'dc level to $V_{REF(dc)}$ region', use nominal slew rate for derating value. If the actual signal is earlier than the nominal slew rate line anywhere between shaded 'dc to $V_{REF(dc)}$ region', the slew rate of a tangent line to the actual signal from the dc level to $V_{REF(dc)}$ level is used for derating value (see Figure 10-8).

For a valid transition the input signal has to remain above/below $V_{IH/IL(ac)}$ for some time t_{VAC} .

Although for slow slew rates the total setup time might be negative (i.e. a valid input signal will not have reached $V_{IH/IL(ac)}$ at the time of the rising clock transition) a valid input signal is still required to complete the transition and reach $V_{IH/IL(ac)}$.

For slew rates in between the values listed in the tables the derating values may obtained by linear interpolation.

These values are typically not subject to production test. They are verified by design and characterization.



10.6.1 Data Setup, Hold and Slew Rate Derating of DDR3-1866/2133

tDS(base) and tDH(base) of DDR3-1866/2133 are referenced for 2V/ns DQ-slew-rate and 4V/ns DQS slew-rate. Derating values ΔtDS and ΔtDH with DQ base slew rate 2V/ns shall be used to calculate total tDS and tDH of DDR3-1866/2133.

This means that for Data input signal above 1600Mbps the reference slew rate for setup/hold specification shall be set to 2V/ns. When DDR3-1866/2133 devices are used at or below 1600Mbps they shall meet an associated data setup/hold specification (including reference slew rate, levels and derating table) of the speed grade associated with that data rate.

For example, a 2133 device operating at 1600Mbps shall require tDS(AC150) = 10ps and tDH(DC100) = 45ps at 1V/ns (and the respective derating table.)

(Note that the AC levels of 135mV also do not apply if the device is not operated at highest data rate.)

Table 10-13. Data Setup and Hold Base-Values (1.35 V)

Symbol	Reference	DDR3L-800	DDR3L-1066	DDR3L-1333	DDR3L-1600	DDR3L-1866	Units	Note
tDS(base, AC160)	$V_{IH/L(ac)}$ SR=1V/ns	90	40	-	-	-	ps	1
tDS(base, AC135)	$V_{IH/L(ac)}$ SR=1V/ns	140	90	45	25	-	ps	1
tDS(base, AC130)	$V_{IH/L(ac)}$ SR=2V/ns	-	-	-	-	70	ps	2
tDH(base, DC90)	$V_{IH/L(dc)}$ SR=1V/ns	160	110	75	55		ps	1
tDH(base, DC90)	$V_{IH/L(dc)}$ SR=2V/ns	-	-	-	-	75	ps	1

Note:

- (ac/dc referenced for 2V/ns DQ-slew rate and 4V/ns DQS slew rate)
- (ac/dc referenced for 1V/ns DQ-slew rate and 2V/ns DQS slew rate)
- Optional in DDR3L SDRAM

Table 10-14. Data Setup and Hold Base-Values (1.5 V)

Symbol	Reference	DDR3-800	DDR3-1066	DDR3-1333	DDR3-1600	DDR3-1866	DDR3-2133	Units	Note
tDS(base, AC175)	$V_{IH/L(ac)}$ SR=1V/ns	75	25	-	-	-	-	ps	2
tDS(base, AC150)	$V_{IH/L(ac)}$ SR=1V/ns	125	75	30	10	-	-	ps	2
tDS(base, AC135)	$V_{IH/L(ac)}$ SR=1V/ns	165	115	60	40	-	-	ps	2,3
tDS(base, AC135)	$V_{IH/L(ac)}$ SR=2V/ns	-	-	-	-	68	53	ps	1
tDH(base, DC100)	$V_{IH/L(dc)}$ SR=1V/ns	150	100	65	45	-	-	ps	2
tDH(base, DC100)	$V_{IH/L(dc)}$ SR=2V/ns	-	-	-	-	70	55	ps	1

Note:

- (ac/dc referenced for 2V/ns DQ-slew rate and 4V/ns DQS slew rate)
- (ac/dc referenced for 1V/ns DQ-slew rate and 2V/ns DQS slew rate)
- Optional in DDR3 SDRAM



Table 10-15. Derating values for DDR3L-800/1066 tDS/tDH – (AC160) (1.35 V)

AC160 Threshold-> VIH(ac)=VREF(dc)+160mV, VIL(ac)=VREF(dc)-160mV																	
DDR3L		DQS, DQS# Differential Slew Rate															
		4.0 V/ns		3.0 V/ns		2.0 V/ns		1.8 V/ns		1.6 V/ns		1.4 V/ns		1.2 V/ns		1.0 V/ns	
		Δt_{DS}	Δt_{DH}	Δt_{DS}	Δt_{DH}	Δt_{DS}	Δt_{DH}	Δt_{DS}	Δt_{DH}	Δt_{DS}	Δt_{DH}	Δt_{DS}	Δt_{DH}	Δt_{DS}	Δt_{DH}	Δt_{DS}	Δt_{DH}
DQ Slew Rate V/ns	2.0	80	45	80	45	80	45	-	-	-	-	-	-	-	-	-	-
	1.5	53	30	53	30	53	30	61	38	-	-	-	-	-	-	-	-
	1.0	0	0	0	0	0	0	8	8	16	16	-	-	-	-	-	-
	0.9	-	-	-1	-3	-1	-3	7	5	15	13	23	21	-	-	-	-
	0.8	-	-	-	-	-3	-8	5	1	13	9	21	17	29	27	-	-
	0.7	-	-	-	-	-	-	3	-5	11	3	19	11	27	21	35	37
	0.6	-	-	-	-	-	-	-	-	8	-4	16	4	24	14	32	30
	0.5	-	-	-	-	-	-	-	-	-	-	4	-6	12	4	20	20
	0.4	-	-	-	-	-	-	-	-	-	-	-	-	-8	-11	0	5

Note:

- Cell contents which is '-' are defined as 'not supported'

Table 10-16. Derating values for DDR3L-800/1066/1333/1600 tDS/tDH – (AC135) (1.35 V)

AC135 Threshold-> VIH(ac)=VREF(dc)+135mV, VIL(ac)=VREF(dc)-135mV																	
DDR3L		DQS, DQS# Differential Slew Rate															
		4.0 V/ns		3.0 V/ns		2.0 V/ns		1.8 V/ns		1.6 V/ns		1.4 V/ns		1.2 V/ns		1.0 V/ns	
		Δt_{DS}	Δt_{DH}	Δt_{DS}	Δt_{DH}	Δt_{DS}	Δt_{DH}	Δt_{DS}	Δt_{DH}	Δt_{DS}	Δt_{DH}	Δt_{DS}	Δt_{DH}	Δt_{DS}	Δt_{DH}	Δt_{DS}	Δt_{DH}
DQ Slew Rate V/ns	2.0	68	45	68	45	68	45	-	-	-	-	-	-	-	-	-	-
	1.5	45	30	45	30	45	30	53	38	-	-	-	-	-	-	-	-
	1.0	0	0	0	0	0	0	8	8	16	16	-	-	-	-	-	-
	0.9	-	-	2	-3	2	-3	10	5	18	13	26	21	-	-	-	-
	0.8	-	-	-	-	3	-8	11	1	19	9	27	17	35	27	-	-
	0.7	-	-	-	-	-	-	14	-5	22	3	30	11	38	21	46	37
	0.6	-	-	-	-	-	-	-	-	25	-4	33	4	41	14	49	30
	0.5	-	-	-	-	-	-	-	-	-	-	29	-6	37	4	45	20
	0.4	-	-	-	-	-	-	-	-	-	-	-	-	30	-11	38	5

Note:

- Cell contents which is '-' are defined as 'not supported'

Table 10-17. Derating values for DDR3L-1866 tDS/tDH – (AC130) (1.35 V)

AC130 Threshold-> VIH(ac)=VREF(dc)+130mV, VIL(ac)=VREF(dc)-130mV																									
DDR3L		DQS, DQS# Differential Slew Rate																							
		8.0 V/ns		7.0 V/ns		6.0 V/ns		5.0 V/ns		4.0 V/ns		3.0 V/ns		2.0 V/ns		1.8 V/ns		1.6 V/ns		1.4 V/ns		1.2 V/ns		1.0 V/ns	
		Δt_{DS}	Δt_{DH}	Δt_{DS}	Δt_{DH}	Δt_{DS}	Δt_{DH}	Δt_{DS}	Δt_{DH}	Δt_{DS}	Δt_{DH}	Δt_{DS}	Δt_{DH}	Δt_{DS}	Δt_{DH}	Δt_{DS}	Δt_{DH}	Δt_{DS}	Δt_{DH}	Δt_{DS}	Δt_{DH}	Δt_{DS}	Δt_{DH}	Δt_{DS}	Δt_{DH}
DQ Slew Rate V/ns	4.0	33	23	33	23	33	23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	3.5	28	19	28	19	28	19	28	19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	3.0	22	15	22	15	22	15	22	15	22	15	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2.5	-	-	13	9	13	9	13	9	13	9	13	9	-	-	-	-	-	-	-	-	-	-	-	-
	2.0	-	-	-	-	0	0	0	0	0	0	0	0	0	0	-	-	-	-	-	-	-	-	-	-
	1.5	-	-	-	-	-	-	-22	-15	-22	-15	-22	-15	-22	-15	-14	-7	-	-	-	-	-	-	-	-
	1.0	-	-	-	-	-	-	-	-	-65	-45	-65	-45	-65	-45	-57	-37	-49	-29	-	-	-	-	-	-
	0.9	-	-	-	-	-	-	-	-	-	-	-62	-48	-62	-48	-54	-40	-46	-32	-38	-24	-	-	-	-
	0.8	-	-	-	-	-	-	-	-	-	-	-	-	-61	-53	-53	-45	-45	-37	-37	-29	-29	-19	-	-
	0.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-49	-50	-41	-42	-33	-34	-25	-24	-17	-8
	0.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-37	-49	-29	-41	-21	-31	-13	-15
	0.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-31	-51	-23	-41	-15	-25
	0.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-28	-56	-20	-40

Note:

1. Cell contents which is '-' are defined as 'not supported'



Table 10-18. Derating values for DDR3-800/1066 tDS/tDH – (AC175) (1.5 V)

AC175 Threshold-> VIH(ac)=VREF(dc)+175mV, VIL(ac)=VREF(dc)-175mV																	
DDR3		DQS, DQS# Differential Slew Rate															
		4.0 V/ns		3.0 V/ns		2.0 V/ns		1.8 V/ns		1.6 V/ns		1.4 V/ns		1.2 V/ns		1.0 V/ns	
		Δt_{DS}	Δt_{DH}	Δt_{DS}	Δt_{DH}	Δt_{DS}	Δt_{DH}	Δt_{DS}	Δt_{DH}	Δt_{DS}	Δt_{DH}	Δt_{DS}	Δt_{DH}	Δt_{DS}	Δt_{DH}	Δt_{DS}	Δt_{DH}
DQ Slew Rate V/ns	2.0	88	50	88	50	88	50	-	-	-	-	-	-	-	-	-	-
	1.5	59	34	59	34	59	34	67	42	-	-	-	-	-	-	-	-
	1.0	0	0	0	0	0	0	8	8	16	16	-	-	-	-	-	-
	0.9	-	-	-2	-4	-2	-4	6	4	14	12	22	20	-	-	-	-
	0.8	-	-	-	-	-6	-10	2	-2	10	6	18	14	26	24	-	-
	0.7	-	-	-	-	-	-	-3	-8	5	0	13	8	21	18	29	34
	0.6	-	-	-	-	-	-	-	-	-1	-10	7	-2	15	8	23	24
	0.5	-	-	-	-	-	-	-	-	-	-	-11	-16	-2	-6	5	10
	0.4	-	-	-	-	-	-	-	-	-	-	-	-	-30	-26	-22	-10

Table 10-19. Derating values for DDR3-800/1066/1333/1600 tDS/tDH – (AC150) (1.5V)

AC150 Threshold-> VIH(ac)=VREF(dc)+150mV, VIL(ac)=VREF(dc)-150mV																	
DDR3		DQS, DQS# Differential Slew Rate															
		4.0 V/ns		3.0 V/ns		2.0 V/ns		1.8 V/ns		1.6 V/ns		1.4 V/ns		1.2 V/ns		1.0 V/ns	
		Δt_{DS}	Δt_{DH}	Δt_{DS}	Δt_{DH}	Δt_{DS}	Δt_{DH}	Δt_{DS}	Δt_{DH}	Δt_{DS}	Δt_{DH}	Δt_{DS}	Δt_{DH}	Δt_{DS}	Δt_{DH}	Δt_{DS}	Δt_{DH}
DQ Slew Rate V/ns	2.0	75	50	75	50	75	50	-	-	-	-	-	-	-	-	-	-
	1.5	50	34	50	34	50	34	58	42	-	-	-	-	-	-	-	-
	1.0	0	0	0	0	0	0	8	8	16	16	-	-	-	-	-	-
	0.9	-	-	0	-4	0	-4	8	4	16	12	24	20	-	-	-	-
	0.8	-	-	-	-	0	-10	8	-2	16	6	24	14	32	24	-	-
	0.7	-	-	-	-	-	-	8	-8	16	0	24	8	32	18	40	34
	0.6	-	-	-	-	-	-	-	-	15	-10	23	-2	31	8	39	24
	0.5	-	-	-	-	-	-	-	-	-	-	14	-16	22	-6	30	10
	0.4	-	-	-	-	-	-	-	-	-	-	-	-	7	-26	15	-10



Table 10-20. Derating values for DDR3-800/1066/1333/1600 tDS/tDH – (AC135) (1.5V)

AC150 Threshold-> VIH(ac)=VREF(dc)+150mV, VIL(ac)=VREF(dc)-150mV																	
DDR3		DQS, DQS# Differential Slew Rate															
		4.0 V/ns		3.0 V/ns		2.0 V/ns		1.8 V/ns		1.6 V/ns		1.4 V/ns		1.2 V/ns		1.0 V/ns	
		Δt_{DS}	Δt_{DH}	Δt_{DS}	Δt_{DH}	Δt_{DS}	Δt_{DH}	Δt_{DS}	Δt_{DH}	Δt_{DS}	Δt_{DH}	Δt_{DS}	Δt_{DH}	Δt_{DS}	Δt_{DH}	Δt_{DS}	Δt_{DH}
DQ Slew Rate V/ns	2.0	68	50	68	50	68	50	-	-	-	-	-	-	-	-	-	-
	1.5	45	34	45	34	45	34	53	42	-	-	-	-	-	-	-	-
	1.0	0	0	0	0	0	0	8	8	16	16	-	-	-	-	-	-
	0.9	-	-	2	-4	2	-4	10	4	18	12	26	20	-	-	-	-
	0.8	-	-	-	-	3	-10	11	-2	19	6	27	14	35	24	-	-
	0.7	-	-	-	-	-	-	14	-8	22	0	30	8	38	18	46	34
	0.6	-	-	-	-	-	-	-	-	25	-10	33	-2	41	8	49	24
	0.5	-	-	-	-	-	-	-	-	-	-	29	-16	37	-6	45	10
	0.4	-	-	-	-	-	-	-	-	-	-	-	-	30	-26	38	-10

Table 10-21. Derating values for DDR3-1866/2133 tDS/tDH – (AC135) (1.5V)

AC135Threshold -> VIH(ac)=VREF(dc)+135mV, VIL(ac)= VREF(dc)-135mV DC100Threshold -> VIH(dc)=VREF(dc)+100mV, VIL(dc)= VREF(dc)-100mV																									
		DQS, DQS# Differential Slew Rate																							
		8.0 V/ns		7.0 V/ns		6.0 V/ns		5.0 V/ns		4.0 V/ns		3.0 V/ns		2.0 V/ns		1.8 V/ns		1.6 V/ns		1.4 V/ns		1.2 V/ns		1.0 V/ns	
		Δt_{DS}	Δt_{DH}	Δt_{DS}	Δt_{DH}	Δt_{DS}	Δt_{DH}	Δt_{DS}	Δt_{DH}	Δt_{DS}	Δt_{DH}	Δt_{DS}	Δt_{DH}	Δt_{DS}	Δt_{DH}	Δt_{DS}	Δt_{DH}	Δt_{DS}	Δt_{DH}	Δt_{DS}	Δt_{DH}	Δt_{DS}	Δt_{DH}	Δt_{DS}	Δt_{DH}
DQ Slew Rate V/ns	4.0	34	25	34	25	34	25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	3.5	29	21	29	21	29	21	29	21	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	3.0	23	17	23	17	23	17	23	17	23	17	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2.5	-	-	14	10	14	10	14	10	14	10	14	10	-	-	-	-	-	-	-	-	-	-	-	-
	2.0	-	-	-	-	0	0	0	0	0	0	0	0	0	0	-	-	-	-	-	-	-	-	-	-
	1.5	-	-	-	-	-	-	-23	-17	-23	-17	-23	-17	-23	-17	-15	-9	-	-	-	-	-	-	-	-
	1.0	-	-	-	-	-	-	-	-	-68	-50	-68	-50	-68	-50	-60	-42	-52	-34	-	-	-	-	-	-
	0.9	-	-	-	-	-	-	-	-	-	-	-66	-54	-66	-54	-58	-46	-50	-38	-42	-30			-	-
	0.8	-	-	-	-	-	-	-	-	-	-			-64	-60	-56	-52	-48	-44	-40	-36	-32	-26	-	-
	0.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-53	-59	-45	-51	-37	-43	-29	-33	-21	-17
	0.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-43	-61	-35	-53	-27	-43	-19	-27
	0.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-39	-66	-31	-56	-23	-40
	0.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-36	-76	-30	-60

Table 10-22. Required minimum time t_{VAC} above $V_{IH}(ac)$ {below $V_{IL}(ac)$ } for valid DQ transition

Slew Rate [V/ns]	DDR3 (1.5 V)						DDR3L (1.35 V)			
	800/1066	800/1066/1333/1600	800/1066/1333/1600	1866	2133	800/1066	800/1066/1333/1600	1866	2133	
	AC175	AC150	AC135			AC160	AC135	AC130	AC130	
>2.0	75	105	113	93	73	165	113	95	73	
2.0	57	105	113	93	73	165	113	95	73	
1.5	50	80	90	70	50	138	90	73	50	
1.0	38	30	45	25	5	85	45	30	5	
0.9	34	13	30	Note	Note	67	30	16	Note	
0.8	29	Note	11	Note	Note	45	11	Note	Note	
0.7	Note	Note	Note	-	-	16	Note	-	-	
0.6	Note	Note	Note	-	-	Note	Note	-	-	
0.5	Note	Note	Note	-	-	Note	Note	-	-	
<0.5	Note	Note	Note	-	-	Note	Note	-	-	

Note:

1. Rising input signal shall become equal to or greater than $V_{IH}(ac)$ level and Falling input signal shall become equal to or less than $V_{IL}(ac)$ level.

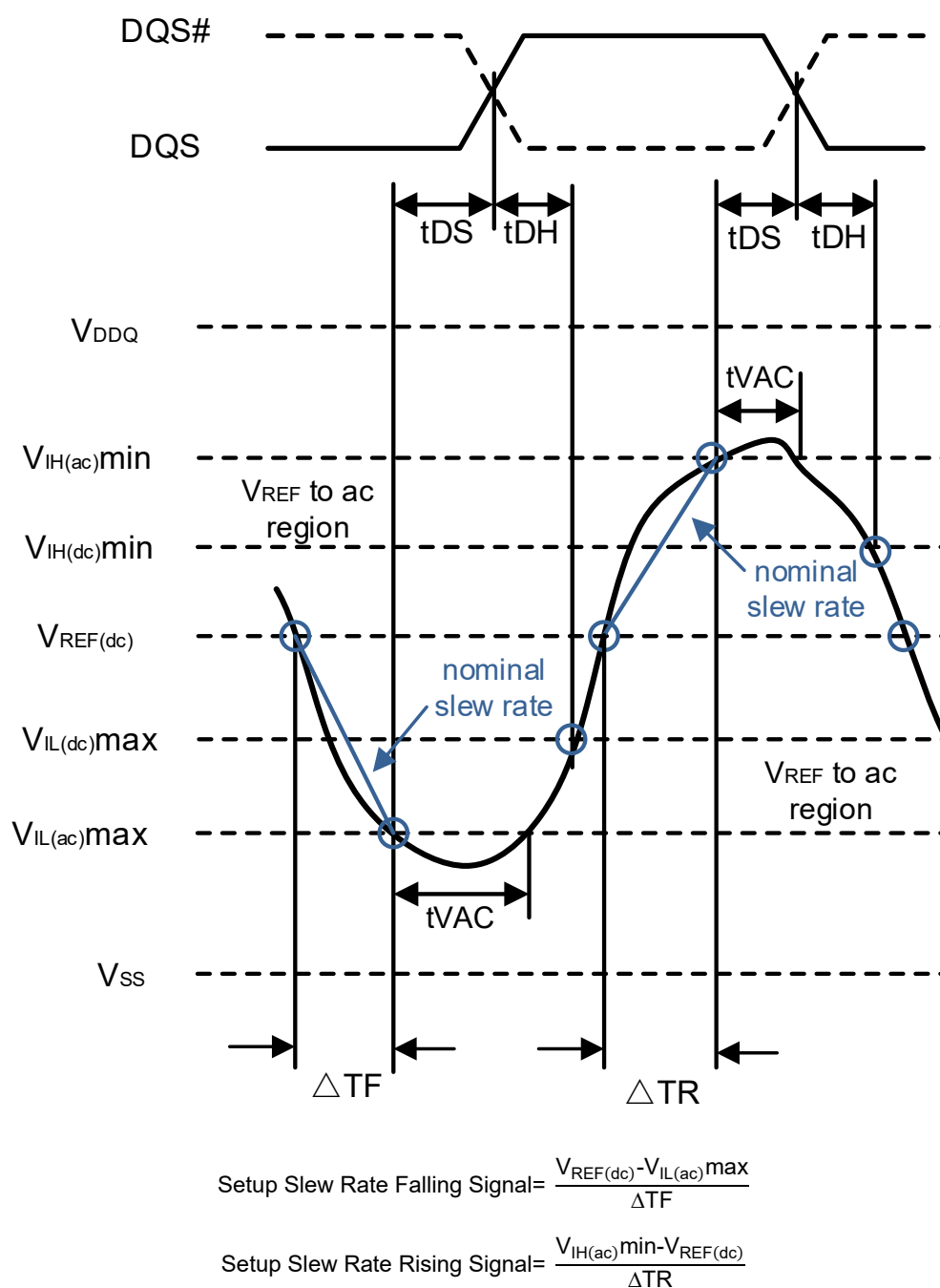


Figure 10-5. Illustration of nominal slew rate and t_{VAC} for setup time t_{DS} (for DQ with respect to strobe)

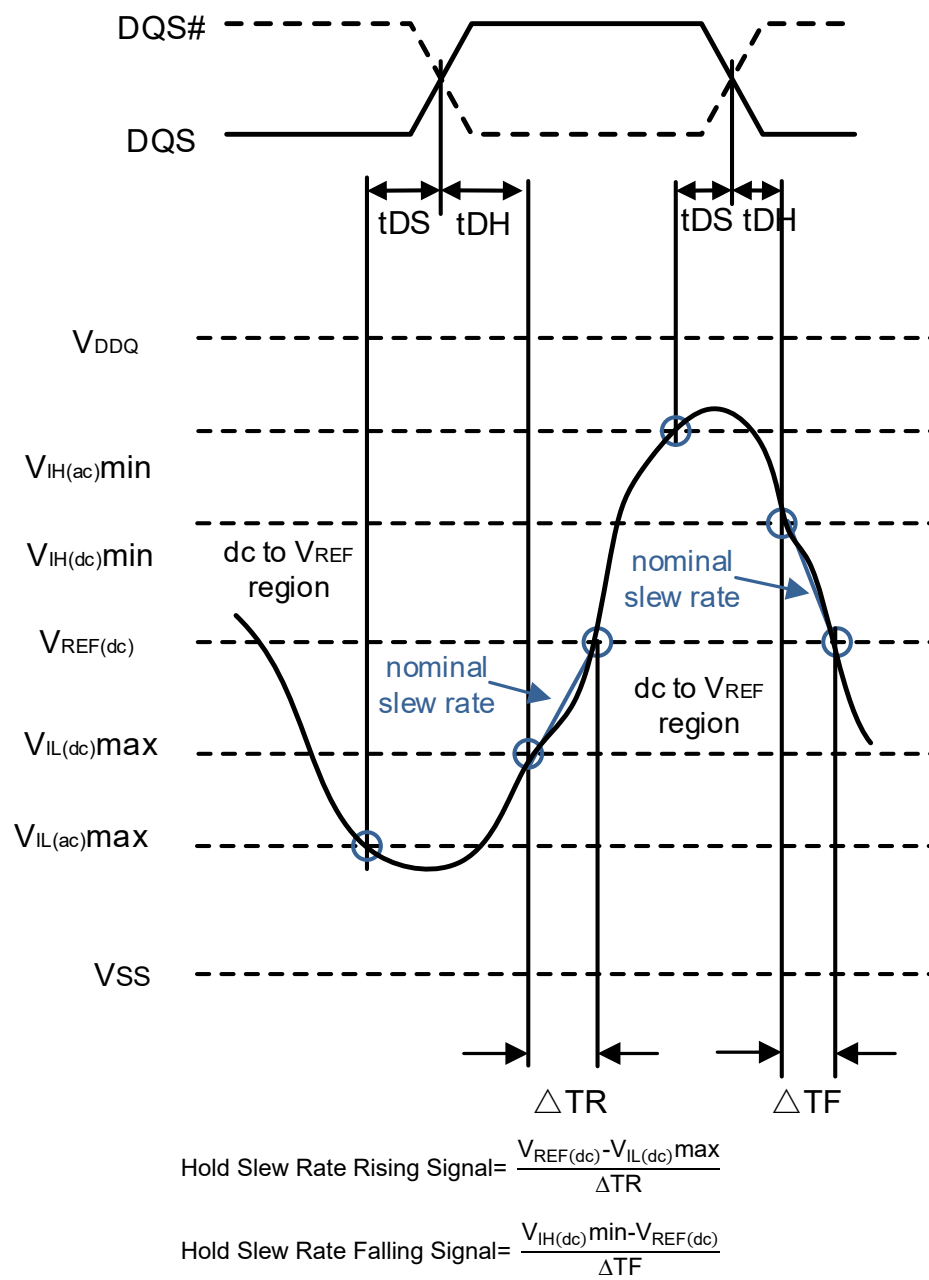


Figure 10-6. Illustration of nominal slew rate for hold time t_{DH} (for DQ with respect to strobe)

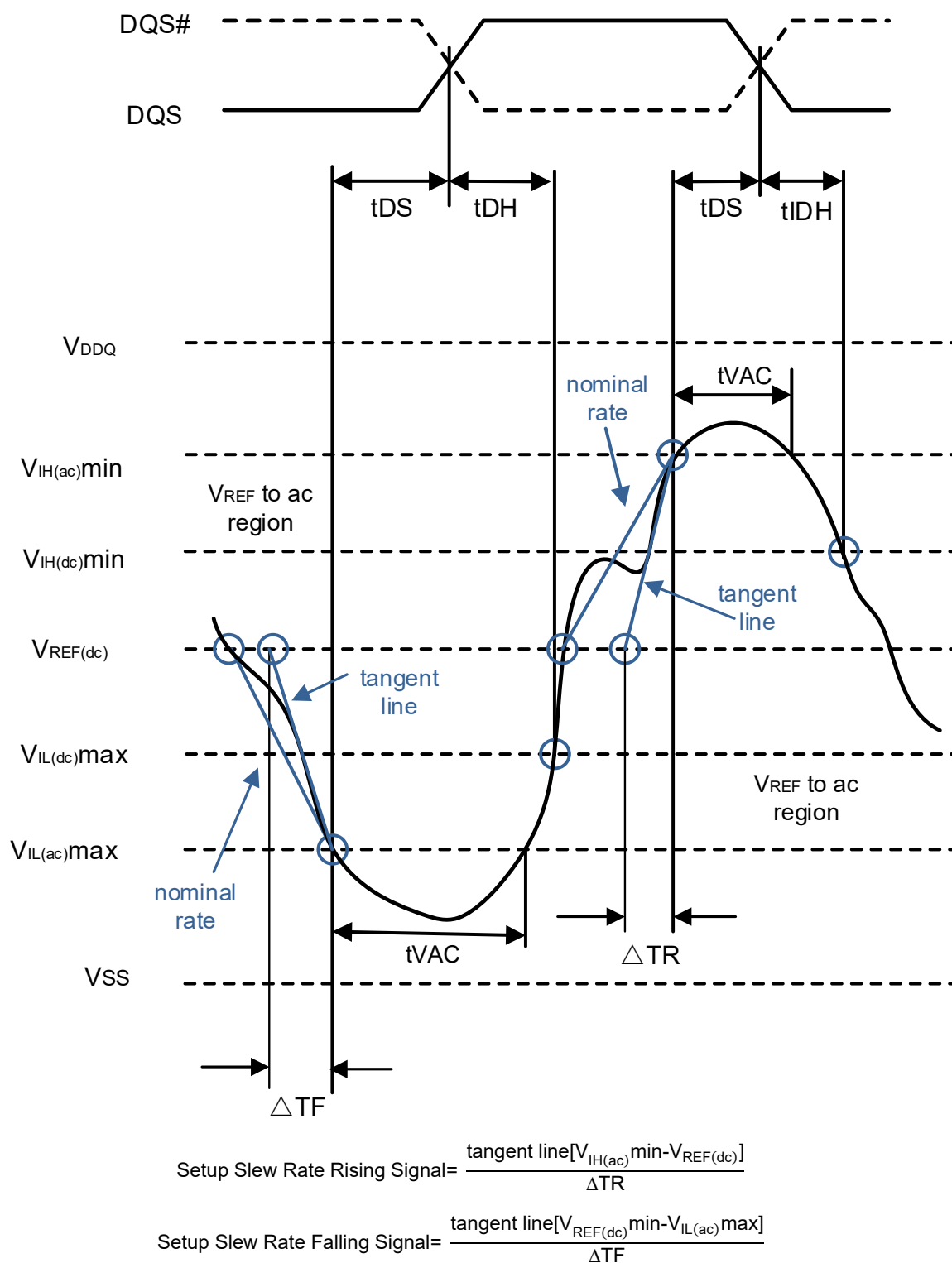


Figure 10-7. Illustration of tangent line for setup time t_{DS} (for DQ with respect to strobe)

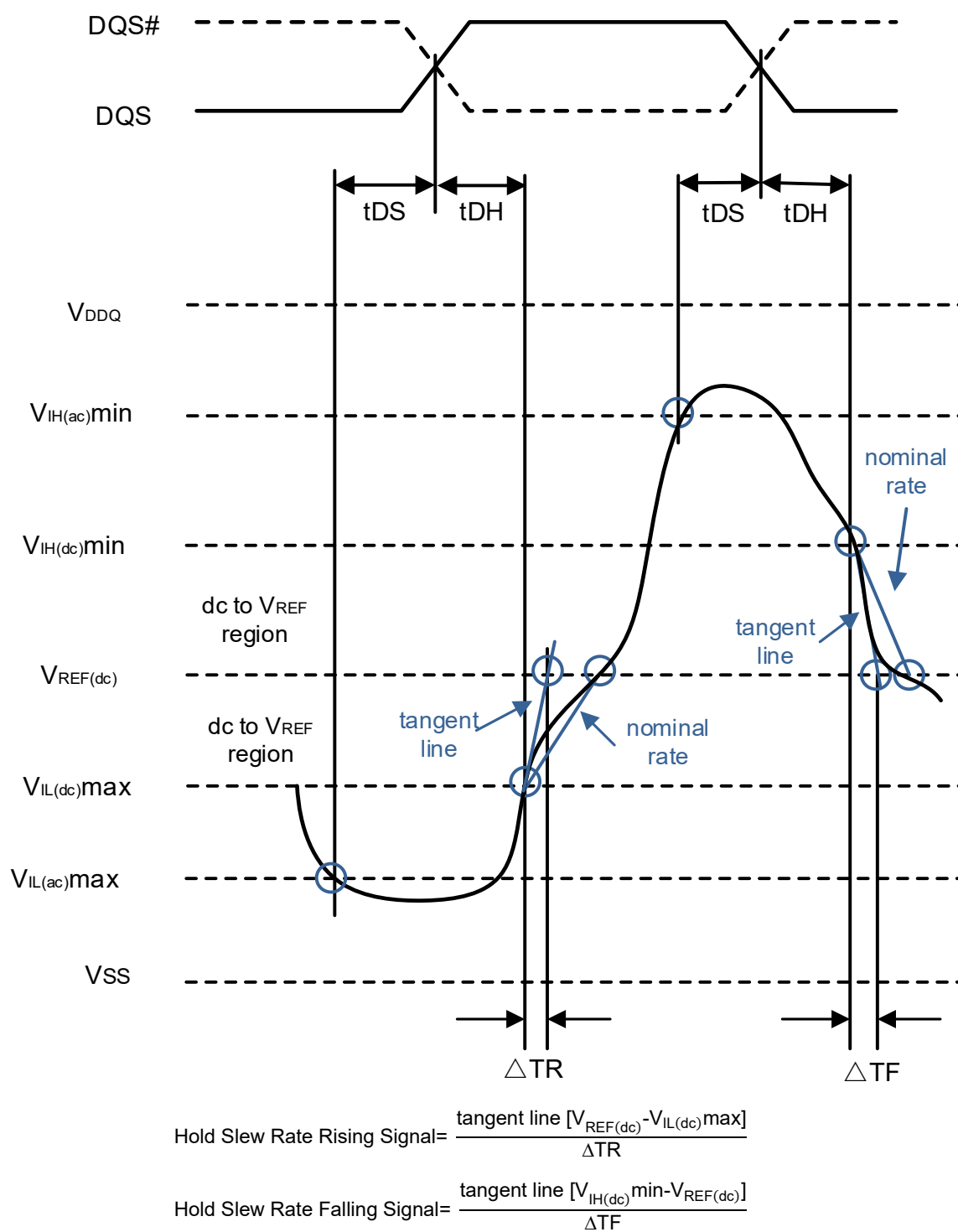


Figure 10-8. Illustration of tangent line for hold time t_{DH} (for DQ with respect to strobe)



11 Revision History

Version No	Description	Page	Date
1.0	Initial release	All	2022/8/24
1.1	Update the package diagram	9-10	2023/6/28
1.2	1. Delete the related contents of "X16". 2. Update the description in some details.	All	2024/4/19
1.3	Update the IDD values	56,57	2025/1/13

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