



Industrial Temperature DDR3 72 bit ECC UNB SODIMM Low Voltage VP7PUxx7298xxxzT

Module Configuration

Viking Part Number	Capacity	Module Configuration	Device Configuration	Device Package	Module Ranks	Performance	CAS Latency
VP7PU287298FBZyzT	1GB	128Mx72	128Mx8 (9)	TFBGA	1	PC3-6400	CL6 (6-6-6)
VP7PU287298FBAyzT	1GB	128Mx72	128Mx8 (9)	TFBGA	1	PC3-8500	CL7 (7-7-7)
VP7PU287298FBDyzT	1GB	128Mx72	128Mx8 (9)	TFBGA	1	PC3-10600	CL9 (9-9-9)
VP7PU287298FBFyzT	1GB	128Mx72	128Mx8 (9)	TFBGA	1	PC3-12800	CL11 (11-11-11)
VP7PU567298GBZyzT	2GB	256Mx72	256Mx8 (9)	TFBGA	1	PC3-6400	CL6 (6-6-6)
VP7PU567298GBAyzT	2GB	256Mx72	256Mx8 (9)	TFBGA	1	PC3-8500	CL7 (7-7-7)
VP7PU567298GBDyzT	2GB	256Mx72	256Mx8 (9)	TFBGA	1	PC3-10600	CL9 (9-9-9)
VP7PU567298GBFyzT	2GB	256Mx72	256Mx8 (9)	TFBGA	1	PC3-12800	CL11 (11-11-11)
VP7PU567298FBZyzT	2GB	256Mx72	128Mx8 (18)	TFBGA	2	PC3-6400	CL6 (6-6-6)
VP7PU567298FBAyzT	2GB	256Mx72	128Mx8 (18)	TFBGA	2	PC3-8500	CL7 (7-7-7)
VP7PU567298FBDyzT	2GB	256Mx72	128Mx8 (18)	TFBGA	2	PC3-10600	CL9 (9-9-9)
VP7PU567298FBFyzT	2GB	256Mx72	128Mx8 (18)	TFBGA	2	PC3-12800	CL11 (11-11-11)
VP7PU127298HBZyzT	4GB	512Mx72	512Mx8 (9)	TFBGA	1	PC3-6400	CL6 (6-6-6)
VP7PU127298HBAyzT	4GB	512Mx72	512Mx8 (9)	TFBGA	1	PC3-8500	CL7 (7-7-7)
VP7PU127298HBDyzT	4GB	512Mx72	512Mx8 (9)	TFBGA	1	PC3-10600	CL9 (9-9-9)
VP7PU127298HBFyzT	4GB	512Mx72	512Mx8 (9)	TFBGA	1	PC3-12800	CL11 (11-11-11)
VP7PU127298GBZyzT	4GB	512Mx72	256Mx8 (18)	TFBGA	2	PC3-6400	CL6 (6-6-6)
VP7PU127298GBAyzT	4GB	512Mx72	256Mx8 (18)	TFBGA	2	PC3-8500	CL7 (7-7-7)
VP7PU127298GBDyzT	4GB	512Mx72	256Mx8 (18)	TFBGA	2	PC3-10600	CL9 (9-9-9)
VP7PU127298GBFyzT	4GB	512Mx72	256Mx8 (18)	TFBGA	2	PC3-12800	CL11 (11-11-11)
VP7PU1G7298HBZyzT	8GB	1Gx72	512Mx8 (18)	TFBGA	2	PC3-6400	CL6 (6-6-6)
VP7PU1G7298HBAyzT	8GB	1Gx72	512Mx8 (18)	TFBGA	2	PC3-8500	CL7 (7-7-7)
VP7PU1G7298HBDyzT	8GB	1Gx72	512Mx8 (18)	TFBGA	2	PC3-10600	CL9 (9-9-9)
VP7PU1G7298HBFyzT	8GB	1Gx72	512Mx8 (18)	TFBGA	2	PC3-12800	CL11 (11-11-11)

Notes: For part numbers containing lowercase characters (x,y,z) contact Viking for the complete PN (yz will typically specify DRAM mfr. and die rev)

Features

- JEDEC standard Power Supply
 - VDD = 1.35V (1.283V to 1.45V)
 - VDDSPD = +3.0V to +3.6V
 - Backward Compatible with 1.5V DDR3 DIMMs
 - VDD = 1.5V (1.425V to 1.575V)
- 204-pin Small Outline Dual-In-Line Memory Module.
- 8 Internal Banks.
- Programmable CAS Latency: 6, 7, 9, 11
- Programmable CAS Write Latency (CWL).
- Programmable Additive Latency (Posted CAS).
- Fixed burst chop (BC) of 4 and burst length (BL) of 8 via the mode register set (MRS)
- Selectable BC4 or BL8 on-the-fly (OTF)
- On-Die-Termination (ODT) and Dynamic ODT for improved signal integrity.
- Refresh. Self Refresh and Power Down Modes.
- Serial Presence Detect with EEPROM.
- On-DIMM Thermal Sensor.
- RoHS Compliant* (see last page)
- Industrial Temperature Range: -40 to +85°C
- Temperature compensated refresh for different operating temperatures

Nomenclature

Module Standard	SDRAM Standard	Clock
PC3-6400	DDR3-800	400MHz
PC3-8500	DDR3-1066	533MHz
PC3-10600	DDR3-1333	667MHz
PC3-12800	DDR3-1600	800MHz

Viking Technology ♦ 2950 Red Hill Ave ♦ Costa Mesa, CA 92626

Office: 714.913.2200 Fax: 714.913.2202 ♦ Website: <http://www.vikingtechnology.com>

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PIN CONFIGURATIONS (UNB-72)

Pin	Front Side	Pin	Back Side	Pin	Front Side	Pin	Back Side	Pin	Front Side	Pin	Back Side	Pin	Front Side	Pin	Back Side
1	VREFDQ	2	Vss	53	Vss	54	DQ28	105	A1	106	A2	157	DM5	158	Vss
3	Vss	4	DQ4	55	DQ24	56	DQ29	107	A0	108	BA1	159	DQ42	160	DQ46
5	DQ0	6	DQ5	57	DQ25	58	Vss	109	VDD	110	VDD	161	DQ43	162	DQ47
7	DQ1	8	Vss	59	DM3	60	DQS3#	111	CK0	112	*CK1	163	Vss	164	Vss
9	Vss	10	DQS0#	61	Vss	62	DQS3	113	CK0#	114	*CK1#	165	DQ48	166	DQ52
11	DM0	12	DQS0	63	DQ26	64	Vss	115	VDD	116	VDD	167	DQ49	168	DQ53
13	DQ2	14	Vss	65	DQ27	66	DQ30	117	A10/AP	118	NC	169	Vss	170	Vss
15	DQ3	16	DQ6	67	Vss	68	DQ31	119	BA0	120	NC	171	DQS6#	172	DM6
17	Vss	18	DQ7	69	CB0	70	Vss	121	WE#	122	RAS#	173	DQS6	174	DQ54
19	DQ8	20	Vss	71	CB1	72	CB4	123	VDD	124	VDD	175	Vss	176	DQ55
21	DQ9	22	DQ12	73	Vss	74	CB5	125	CAS#	126	ODT0	177	DQ50	178	Vss
23	Vss	24	DQ13	75	DQS8#	76	DM8	127	S0#	128	*ODT1	179	DQ51	180	DQ60
25	DQS1#	26	Vss	77	DQS8	78	Vss	129	*S1#	130	A13	181	Vss	182	DQ61
27	DQS1	28	DM1	79	Vss	80	CB6	131	VDD	132	VDD	183	DQ56	184	Vss
29	Vss	30	RESET#	81	CB2	82	CB7	133	DQ32	134	DQ36	185	DQ57	186	DQS7#
31	DQ10	32	Vss	83	CB3	84	VREFCA	135	DQ33	136	DQ37	187	Vss	188	DQS7
33	DQ11	34	DQ14	85	VDD	86	VDD	137	Vss	138	Vss	189	DM7	190	Vss
35	Vss	36	DQ15	87	CKE0	88	A15	139	DQS4#	140	Dm4	191	DQ58	192	DQ62
37	DQ16	38	Vss	89	CKE1	90	A14	141	DQS4	142	DQ38	193	DQ59	194	DQ63
39	DQ17	40	DQ20	91	BA2	92	A9	143	Vss	144	DQ39	195	Vss	196	Vss
41	Vss	42	DQ21	93	VDD	94	VDD	145	DQ34	146	Vss	197	SA0	198	EVENT#
43	DQS2#	44	DM2	95	A12/BC#	96	A11	147	DQ35	148	DQ44	199	VDDSPD	200	SDA
45	DQS2	46	Vss	97	A8	98	A7	149	Vss	150	DQ45	201	SA1	202	SCL
47	Vss	48	DQ22	99	A5	100	A6	151	DQ40	152	Vss	203	Vtt	204	Vtt
49	DQ18	50	DQ23	101	VDD	102	VDD	153	DQ41	154	DQS5#				
51	DQ19	52	Vss	103	A3	104	A4	155	Vss	156	DQS5				

*Used on dual rank modules

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PIN FUNCTION DESCRIPTION

SYMBOL	TYPE	POLARITY	DESCRIPTION
CK0, CK1	IN	Positive Edge	Positive line of the differential pair of system clock inputs.
#CK0, #CK1	IN	Negative Edge	Negative line of the differential pair of system clock inputs.
CKE[1:0]	IN	Active High	CKE HIGH activates, and CKE LOW deactivates internal clock signals, and device input buffers and output drivers of the SDRAMs. Taking CKE LOW provides PRECHARGE POWER-DOWN and SELF REFRESH operation (all banks idle), or ACTIVE POWER DOWN (row ACTIVE in any bank)
S[3:0]#	IN	Active Low	Enables the associated SDRAM command decoder when low and disables decoder when high. When decoder is disabled, new commands are ignored and previous operations continue. These input signals also disable all outputs (except CKE and ODT) of the register(s) on the DIMM when both inputs are high. When both S[1:0] are high, all register outputs (except CKE, ODT and Chip select) remain in the previous state. For modules supporting 4 ranks, S[3:2] operate similarly to S[1:0] for a second set of register outputs.
ODT[1:0]	IN	Active High	On-Die Termination control signals
RAS#, CAS#, WE#	IN	Active Low	When sampled at the positive rising edge of the clock, CAS#, RAS#, and WE# define the operation to be executed by the SDRAM.
VREFDQ	Supply		Reference voltage for DQ0-DQ63 and CB0-CB7.
VREFCA	Supply		Reference voltage for A0-A15, BA0-BA2, RAS#, CAS#, WE#, S0#, S1#, CKE0, CKE1, Par_In, ODT0 and ODT1.
BA[2:0]	IN	-	Selects which SDRAM bank of eight is activated. BA0 - BA2 define to which bank an Active, Read, Write or Precharge command is being applied. Bank address also determines mode register is to be accessed during an MRS cycle.
A[15:13, 12/BC, 11, 10/AP, 9:0]	IN	-	Provided the row address for Active commands and the column address and Auto Precharge bit for Read/Write commands to select one location out of the memory array in the respective bank. 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 BA. A12 is also utilized for BL 4/8 identification for "BL on the fly" during CAS# command. The address inputs also provide the op-code during Mode Register Set commands.
DQ [63:0], CB [7:0]	I/O	-	Data and Check Bit Input/Output pins
VDD, VSS	Supply	-	Power and ground for the DDR SDRAM input buffers and core logic.
DM [8:0]	IN	Active High	Masks write data when high, issued concurrently with input data.
VDD, VSS	Supply		Power and ground for the DDR SDRAM input buffers and core logic.
VTT	Supply		Termination Voltage for Address/Command/Control/Clock nets.
DQS[17:0]	I/O	Positive Edge	Positive line of the differential data strobe for input and output data.
DQS [17:0]#	I/O	Negative Edge	Negative line of the differential data strobe for input and output data.
TDQS[17:9], TDQS[17:9]#	OUT		TDQS, TDQS# is applicable for X8 DRAMs only. When enabled via Mode Register A11=1 in MR1, 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
SA [2:0]	IN	-	These signals are tied at the system planar to either VSS or VDDSPD to configure the serial SPD EEPROM address range.
SDA	I/O	-	This bidirectional pin is used to transfer data into or out of the SPD EEPROM. A resistor must be connected from the SDA bus line to VDDSPD on the system planar to act as a pull-up.
SCL	IN	-	This signal is used to clock data into and out of the SPD EEPROM. A resistor may be connected from the SCL bus time to VDDSPD on the system planar to act as a pull-up.

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PIN FUNCTION DESCRIPTION

SYMBOL	TYPE	POLARITY	DESCRIPTION
EVENT#	OUT (open drain)	Active Low	This signal indicates that a thermal event has been detected in the thermal sensing device. The system should guarantee the electrical level requirement is met for the EVENT pin on TS/SPD part.
VDDSPD	Supply	-	Serial EEPROM positive power supply wired to a separate power pin at the connector which supports from 3.0 Volt to 3.6 Volt (nominal 3.3V) operation.
RESET#	IN		The RESET# pin is connected to the RESET# pin on each DRAM. When low, all DRAMs are set to a known state.
TEST			Used by memory bus analysis tools (unused (NC) on memory DIMMs)

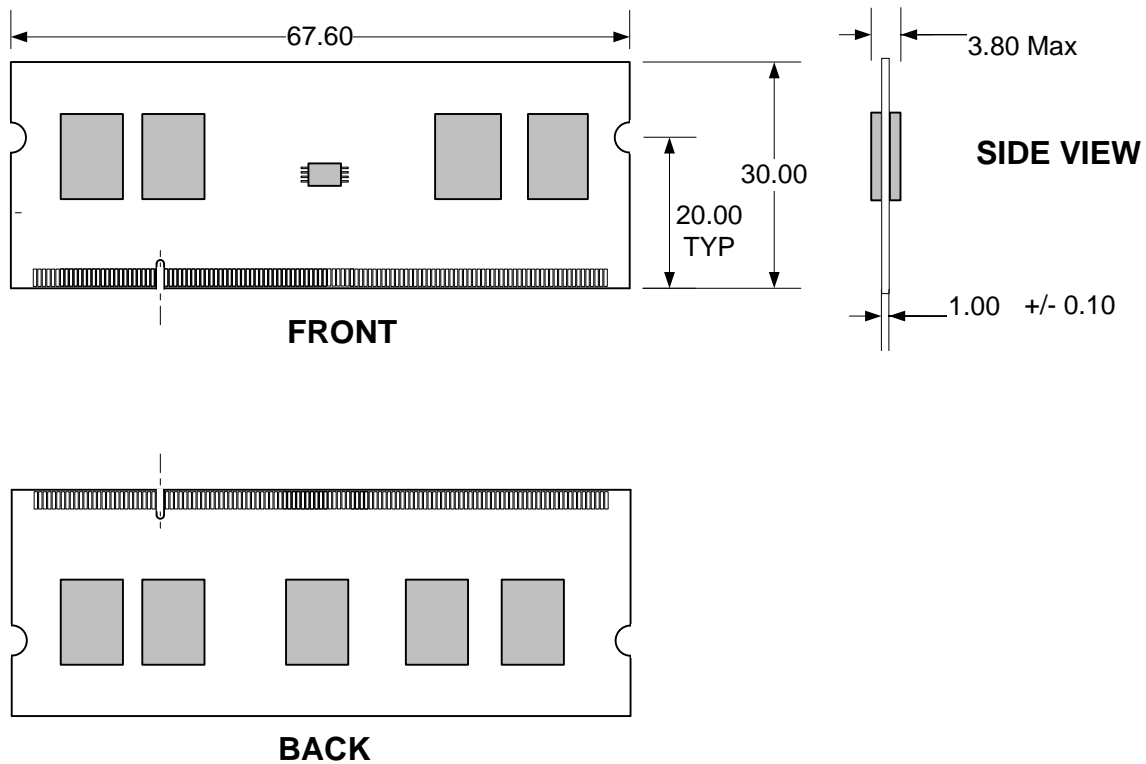
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MECHANICAL OUTLINE SINGLE RANK

Dimensions are in mm. Tolerance is +/- 0.127, unless otherwise stated.



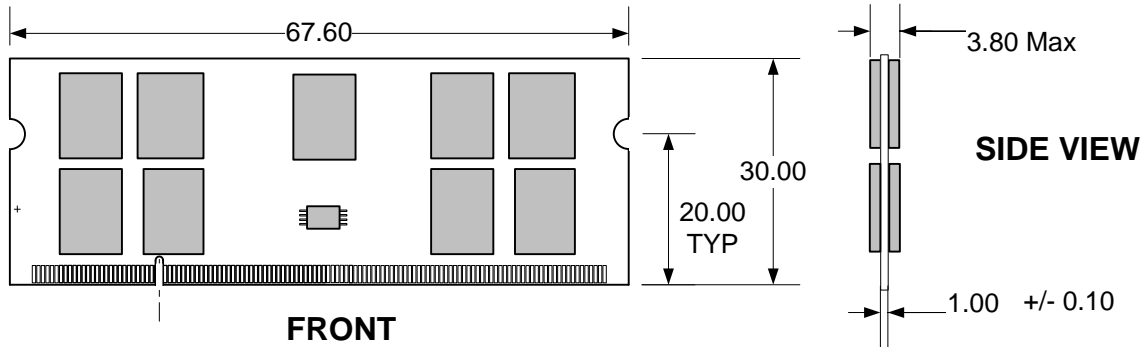
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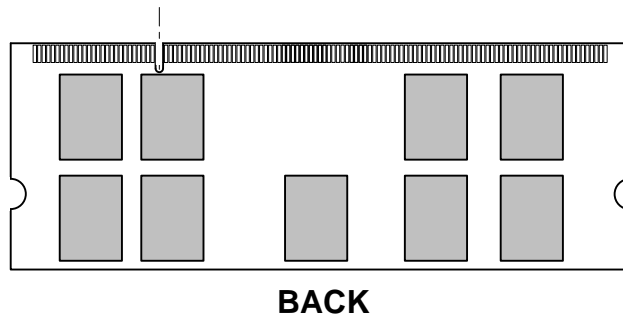


MECHANICAL OUTLINE DUAL RANK

Dimensions are in mm. Tolerance is +/- 0.127, unless otherwise stated.



PCB Thickness Tolerance
+/- 0.004 inches

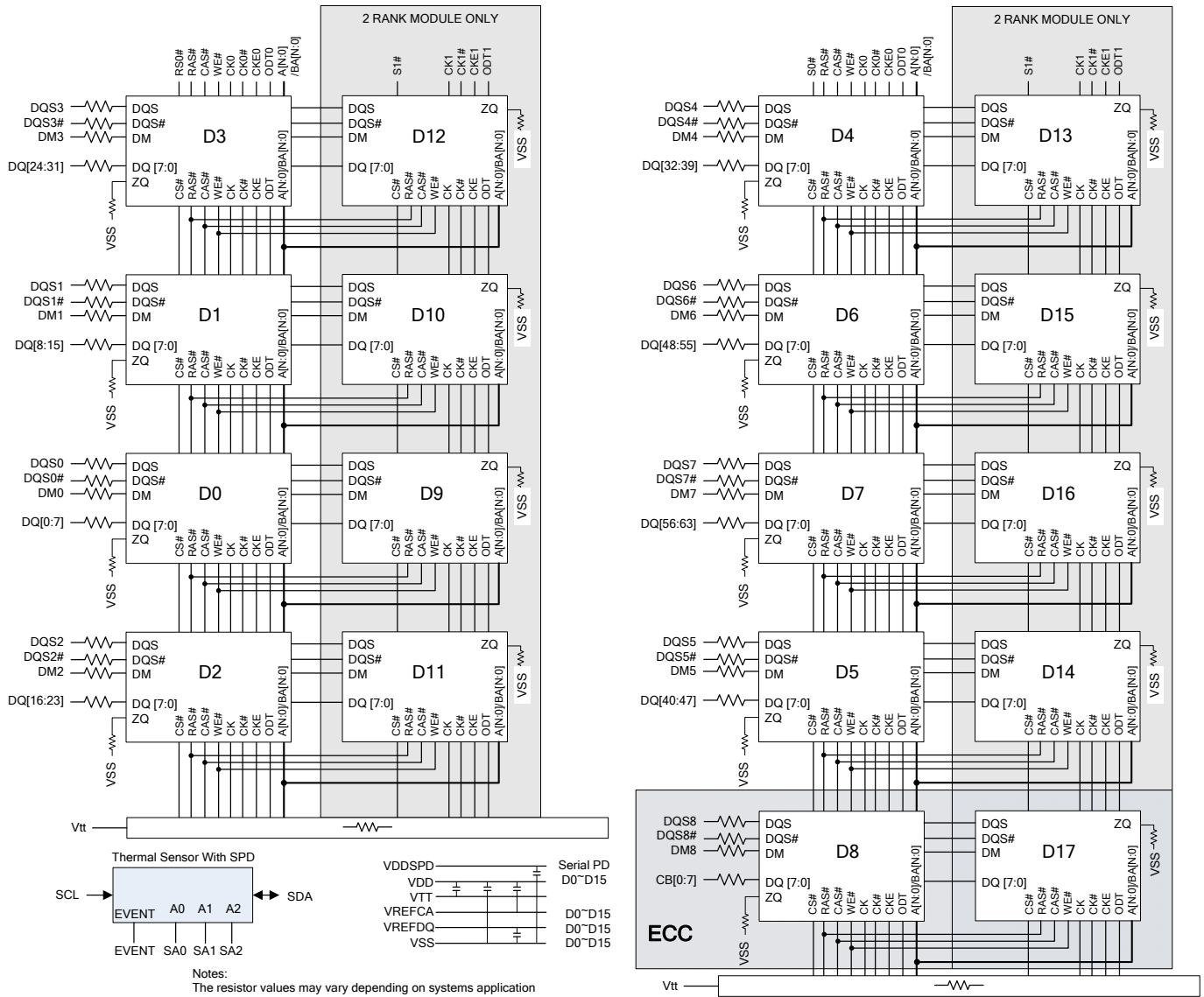


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Office: 714.913.2200 Fax: 714.913.2202 ♦ Website: <http://www.vikingtechnology.com>

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FUNCTIONAL BLOCK DIAGRAM



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ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	Value	Unit
Voltage on any pin relative to GND	Vin, Vout	-0.4 ~ 1.975	V
Voltage on VDD supply relative to GND	VDD	-0.4 ~ 1.975	V
Voltage on VDDQ supply relative to GND	VDDQ	-0.4 ~ 1.975	V
Storage temperature	TSTG	-55 ~ +100	°C

Note: Permanent device damage may occur if 'ABSOLUTE MAXIMUM RATINGS' are exceeded. Functional operation should be restricted to recommended operating condition. Exposure to higher than recommended voltage for extended periods of time could affect device reliability.

DC OPERATING CONDITIONS AND CHARACTERISTICS (SSTL_1.5)

Recommended operating conditions (Voltages referenced to GND, Tcase = 0 to 85°C)

Parameter	Symbol	Min.	Max.	Unit	Notes
Case Temperature for Commercial Temperature: 0 to +95°C	Tcase	0	95	°C	5
Case Temperature for Industrial Temperature: -40 to +95°C	Tcase	-40	95	°C	5
Supply voltage @ 1.35V	VDD	1.283	1.45	V	1, 2
Supply voltage for DQ, DQS @ 1.35V	VDDQ	1.283	1.45	V	1, 2
Supply voltage @ 1.5V	VDD	1.425	1.575	V	1, 2
Supply voltage for DQ, DQS @ 1.5V	VDDQ	1.425	1.575	V	1, 2
Reference Voltage for DQ, DM inputs	VREFDQ(DC)	0.49 x VDD	0.51 x VDD	V	3, 4
Reference Voltage for ADD, CMD inputs	VREFCA(DC)	0.49 x VDD	0.51 x VDD	V	3, 4
Terminal Voltage	VTT	0.49 x VDD	0.51 x VDD	V	3, 4
EEPROM Supply Voltage	VDDSPD	3.0	3.6	V	
Input high voltage	VIH(AC)	VREF + 0.175	-	V	
	VIH(DC)	VREF + 0.100	VDD		
Input low voltage	VIL(AC)	-	VREF - 0.175	V	
	VIL(DC)	VSS	VREF - 0.100		
Input leakage current	Single Rank	IIL	-5	5	µA
Output leakage current	Single Rank	IOL	-5	5	µA
Input leakage current	Dual Rank	IIL	-5	5	µA
Output leakage current	Dual Rank	IOL	-10	10	µA

Notes:

- VDDQ tracks with VDD. AC parameters are measured with VDD and VDDQ tied together
- Under all conditions VDDQ must be less than or equal to VDD.
- The ac peak noise on VREF may not allow VREF to deviate from VREF.DC by more than ±1% VDD (for reference: approx. ± 15 mV).
- For reference: approx. VDD/2 ± 15 mV.
- Refresh rate required to be doubled (tREFI = 3.9µs) when 85°C < TC < 95°C.
A SELF REFRESH mode is provided for all temperature grade offerings along with AUTO SELF REFRESH for Industrial product, as well as, power-saving, POWER-DOWN mode.

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The industrial temperature (I) device requires the ambient temperature not exceed -40°C or $+85^{\circ}\text{C}$. JEDEC specifications require the REFRESH rate to double every 10°C when TA exceeds $+85^{\circ}\text{C}$; this also requires use of the high-temperature SELF REFRESH option. Additionally, ODT resistance and the INPUT/OUTPUT impedance must be derated when the TA is $<0^{\circ}\text{C}$ or $>+85^{\circ}\text{C}$.

The Extended temperature (E) device requires the ambient temperature not exceed -40°C or $+105^{\circ}\text{C}$. JEDEC specifications require the refresh rate to double every 10°C when TA exceeds $+85^{\circ}\text{C}$; this also requires use of the high-temperature SELF REFRESH option. Additionally, ODT resistance and the INPUT/OUTPUT impedance must be derated when the TA is $<0^{\circ}\text{C}$ or $>+85^{\circ}\text{C}$.

The Mil-Temp (M) device requires the ambient temperature not exceed -55°C or $+125^{\circ}\text{C}$. JEDEC requires the REFRESH rate double every 10°C when TA exceeds $+85^{\circ}\text{C}$ and Viking recommends an additional derating as specified in this document as to properly maintain the DRAM core cell charges at temperatures

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DEVICE CAPACITANCE

Parameter	Symbol	DDR3-800		DDR3-1066		DDR3-1333		DDR3-1600		Units	Notes
		Min	Max	Min	Max	Min	Max	Min	Max		
Input/output capacitance (DQ, DM, DQS, DQS#, TDQS, TDQS#)	CIO	1.5	3.0	1.5	2.7	1.5	2.5	1.2	2.3	pF	1,2,3
Input capacitance, CK and CK#	CCK	0.8	1.6	0.8	1.6	0.8	1.4	0.8	1.4	pF	2,3
Input capacitance delta, CK and CK#	CDCK	0	0.15	0	0.15	0	0.15	0	0.15	pF	2,3,4
Input/output capacitance delta DQS and DQS#	CDDQS	0	0.2	0	0.2	0	0.15	0	0.15	pF	2,3,5
Input capacitance, (CTRL, ADD, CMD input-only pins)	CI	0.75	1.4	0.75	1.35	0.75	1.3	0.75	1.3	pF	2,3,6
Input/output capacitance of ZQ pin	CZQ	-	3	-	3	-	3	-	3	pF	2,3,7

- Notes:**
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 VECTOR 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=1.5V, 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 CCK-CCK#
 5. Absolute value of CIO(DQS)-CIO(DQS#)
 6. CI applies to ODT, CS#, CKE, A0-A15, BA0-BA2, RAS#, CAS#, WE#.
 7. Maximum external load capacitance on ZQ pin: 5 pF.

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DC CHARACTERISTICS DEFINITIONS (Recommended operating conditions unless otherwise noted, Tcase = 0 to 85 °C)

Symbol	Conditions	Units	Notes
IDD0	Operating one bank active-precharge current; tCK = tCK(IDD), tRC = tRC(IDD), tRAS = tRASmin(IDD); CKE is HIGH, CS is HIGH between valid commands; Address bus inputs are SWITCHING; Data bus inputs are SWITCHING	mA	1, 2
IDD1	Operating one bank active-read-precharge current; IOUT = 0mA; BL = 8, CL = CL(IDD), AL = 0; tCK = tCK(IDD), tRC = tRC(IDD), tRAS = tRASmin(IDD), tRCD = tRCD(IDD); CKE is HIGH, CS is HIGH between valid commands; Address bus inputs are SWITCHING; Data pattern is same as IDD4W	mA	1, 2
IDD2P-S	Precharge power-down current (slow exit); All banks idle; tCK = tCK(IDD); CKE is LOW; Other control and address bus inputs are STABLE; Data bus inputs are FLOATING	mA	1, 3
IDD2P-F	Precharge power-down current (fast exit); All banks idle; tCK = tCK(IDD); CKE is LOW; Other control and address bus inputs are STABLE; Data bus inputs are FLOATING	mA	1, 3
IDD2Q	Precharge quiet standby current; All banks idle; tCK = tCK(IDD); CKE is HIGH, CS is HIGH; Other control and address bus inputs are STABLE; Data bus inputs are FLOATING	mA	1, 3
IDD2N	Precharge standby current; All banks idle; tCK = tCK(IDD); CKE is HIGH, CS is HIGH; Other control and address bus inputs are SWITCHING; Data bus inputs are SWITCHING	mA	1, 3
IDD3P	Active power-down current; All banks open; tCK = tCK(IDD); CKE is LOW; Other control and address bus inputs are STABLE; Data bus inputs are FLOATING	mA	1, 3
IDD3N	Active standby current; All banks open; tCK = tCK(IDD), tRAS = tRASmax(IDD), tRP = tRP(IDD); CKE is HIGH, CS is HIGH between valid commands; Other control and address bus inputs are SWITCHING; Data bus inputs are SWITCHING	mA	1, 3
IDD4W	Operating burst write current; All banks open, Continuous burst writes; BL = 8, CL = CL(IDD), AL = 0; tCK = tCK(IDD), tRAS = tRASmax(IDD), tRP = tRP(IDD); CKE is HIGH, CS is HIGH between valid commands; Address bus inputs are SWITCHING; Data bus inputs are SWITCHING	mA	1, 2
IDD4R	Operating burst read current; All banks open, Continuous burst reads, IOUT = 0mA; BL = 8, CL = CL(IDD), AL = 0; tCK = tCK(IDD), tRAS = tRAS-max(IDD), tRP = tRP(IDD); CKE is HIGH, CS is HIGH between valid commands; Address bus inputs are SWITCHING; Data pattern is same as IDD4W	mA	1, 2
IDD5B	Burst refresh current; tCK = tCK(IDD); Refresh command at every tRFC(IDD) interval; CKE is HIGH, CS is HIGH between valid commands; Other control and address bus inputs are SWITCHING; Data bus inputs are SWITCHING	mA	1, 3
IDD6	Self refresh current; CK and CK at 0V; CKE ≤ 0.2V; Other control and address bus inputs are FLOATING; Data bus inputs are FLOATING	mA	1, 3
IDD7	Operating bank interleave read current; All bank interleaving reads, IOUT = 0mA; BL = 8, CL = CL(IDD), AL = tRCD(IDD)-1*tCK(IDD); tCK = tCK(IDD), tRC = tRC(IDD), tRRD = tRRD(IDD), tRCD = 1*tCK(IDD); CKE is HIGH, CS is HIGH between valid commands; Address bus inputs are STABLE during DESELECTs; Data pattern is same as IDD4R;	mA	1, 2

Notes:

- 1) Calculated values are from component data.
- 2) One module rank in the active IDD; the other rank in IDD2P-S (slow exit)
- 3) All ranks in this IDD condition.

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DC CHARACTERISTICS CURRENTS for SINGLE RANK with 1Gbit device

Symbol	DDR3-1066	DDR3-1333	Unit
IDD0	360	405	mA
IDD1	450	495	mA
IDD2P-S	90	90	mA
IDD2P-F	135	135	mA
IDD2Q	180	180	mA
IDD2N	180	225	mA
IDD3P	225	225	mA
IDD3N	360	405	mA
IDD4R	720	810	mA
IDD4W	720	855	mA
IDD5B	990	990	mA
IDD6	90	90	mA
IDD7	1215	1485	mA

DC CHARACTERISTICS CURRENTS for SINGLE RANK with 2Gbit devices

Symbol	DDR3-1066	DDR3-1333	DDR3-1600	Unit
IDD0	450	495	540	mA
IDD1	540	585	630	mA
IDD2P-S	108	108	108	mA
IDD2P-F	180	180	180	mA
IDD2Q	225	270	270	mA
IDD2N	225	270	270	mA
IDD3P	225	270	270	mA
IDD3N	405	450	495	mA
IDD4R	810	945	1080	mA
IDD4W	900	1215	1350	mA
IDD5B	1485	1485	1530	mA
IDD6	108	108	108	mA
IDD7	1440	1755	1800	mA

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DC CHARACTERISTICS CURRENTS for SINGLE RANK with 4Gbit devices

Symbol	DDR3-1066	DDR3-1333	DDR3-1600	Unit
IDD0	360	360	405	mA
IDD1	450	450	495	mA
IDD2P-S	135	135	135	mA
IDD2P-F	135	135	135	mA
IDD2Q	180	180	180	mA
IDD2N	180	180	180	mA
IDD3P	135	180	180	mA
IDD3N	225	270	270	mA
IDD4R	630	765	900	mA
IDD4W	675	765	945	mA
IDD5B	1035	1305	1305	mA
IDD6	135	135	135	mA
IDD7	1170	1485	1530	mA

DC CHARACTERISTICS CURRENTS for DUAL RANK with 1Gbit devices

Symbol	DDR3-1066	DDR3-1333	Unit
IDD0	720	810	mA
IDD1	900	990	mA
IDD2P-S	180	180	mA
IDD2P-F	270	270	mA
IDD2Q	360	360	mA
IDD2N	360	450	mA
IDD3P	450	450	mA
IDD3N	720	810	mA
IDD4R	1440	1620	mA
IDD4W	1440	1710	mA
IDD5B	1980	1980	mA
IDD6	180	180	mA

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IDD7	2430	2970	mA
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DC CHARACTERISTICS CURRENTS for DUAL RANK with 2Gbit devices

Symbol	DDR3-1066	DDR3-1333	DDR3-1600	Unit
IDD0	900	990	1080	mA
IDD1	1080	1170	1260	mA
IDD2P-S	216	216	216	mA
IDD2P-F	360	360	360	mA
IDD2Q	450	540	540	mA
IDD2N	450	540	540	mA
IDD3P	450	540	540	mA
IDD3N	810	900	990	mA
IDD4R	1620	1890	2160	mA
IDD4W	1800	2430	2700	mA
IDD5B	2970	2970	3060	mA
IDD6	216	216	216	mA
IDD7	2880	3510	3600	mA

DC CHARACTERISTICS CURRENTS for DUAL RANK with 4Gbit devices

Symbol	DDR3-1066	DDR3-1333	DDR3-1600	Unit
IDD0	720	720	810	mA
IDD1	900	900	990	mA
IDD2P-S	270	270	270	mA
IDD2P-F	270	270	270	mA
IDD2Q	360	360	360	mA
IDD2N	360	360	360	mA
IDD3P	270	360	360	mA
IDD3N	450	540	540	mA
IDD4R	1260	1530	1800	mA
IDD4W	1350	1530	1890	mA
IDD5B	2070	2610	2610	mA
IDD6	270	270	270	mA
IDD7	2340	2970	3060	mA

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AC CHARACTERISTICS

Refresh parameters by device density

Parameter	Symbol	1Gb	2Gb	4Gb	8Gb	Unit	Notes	
REF command to ACT or REF command time	tRFC	110	160	260	350	ns		
Average periodic refresh interval	tREFI	0°C ≤ Tcase ≤ 85°C (self/auto refresh)	7.8	7.8	7.8	7.8	µs	
		85°C ≤ Tcase ≤ 95°C (see note 1)	3.9	3.9	3.9	3.9	µs	4
		95°C ≤ Tcase ≤ 105°C (manual refresh)	1.95	1.95	1.95	1.95	µs	5
		105°C ≤ Tcase ≤ 125°C (manual refresh)	0.4876	0.4876	0.4876	0.4876	µs	5

Notes:

- Operating Temperature TOPER is the case surface temperature on the center / top side of the DRAM. For measurement conditions, please refer to the JEDEC document JESD51-2.
- The Normal Temperature Range specifies the temperatures where all DRAM specifications will be supported. During operation, the DRAM case temperature must be maintained under all operating conditions.
- Some applications require operation of the DRAM in the Extended Temperature Range between 85oC and 95oC case temperature. Full specifications are guaranteed in this range, but the following additional conditions apply:
 - Refresh commands must be doubled in frequency, therefore reducing the Refresh interval tREFI to 3.9 µs. It is also possible to specify a component with 1X refresh (tREFI to 7.8µs) in the Extended Temperature Range.
 - 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 = 0b and MR2 A7 = 1b) or enable the optional Auto Self-Refresh mode (MR2 A6 = 1b and MR2 A7 = 0b). DDR3 SDRAMs support Auto Self-Refresh and in Extended Temperature Range
- 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 requirements referred to in this material.
- This temperature range may not be supported. Contact Viking for more information
- 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 = 0b and MR2 A7 = 1b) or enable the optional Auto Self-Refresh mode (MR2 A6 = 1b and MR2 A7 = 0b).
- 8192 cycle refresh is
 - 64ms between 0 to 85°C
 - 32ms between 85 to 95°C
 - 16ms between 95 to 105°C
 - 8ms between 105 to 125°C

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DDR3-800 Speed Bins and Operating Conditions

Speed Bin		DDR3-800		Unit	Notes	
CL-nRCD-nRP		6-6-6				
Parameter	Symbol	min	max			
Internal read command to first data	<i>tAA</i>	15	20	ns		
ACT to internal read or write delay time	<i>tRCD</i>	15	—	ns		
PRE command period	<i>tRP</i>	15	—	ns		
ACT to ACT or REF command period	<i>tRC</i>	52.5	—	ns		
ACT to PRE command period	<i>tRAS</i>	37.5	9 * tREFI	ns		
CL = 6	CWL = 5	<i>tCK(AVG)</i>	2.5	3.3	ns	1, 2, 3
Supported CL Settings		6		<i>nCK</i>	13	
Supported CWL Settings		5		<i>nCK</i>		

DDR3-1066 Speed Bins and Operating Conditions

Speed Bin		DDR3-1066		Unit	Note	
CL-nRCD-nRP		7-7-7				
Parameter	Symbol	min	max			
Internal read command to first data	<i>tAA</i>	13.125	20	ns		
ACT to internal read or write delay time	<i>tRCD</i>	13.125	—	ns		
PRE command period	<i>tRP</i>	13.125	—	ns		
ACT to ACT or REF command period	<i>tRC</i>	50.625	—	ns		
ACT to PRE command period	<i>tRAS</i>	37.5	9 * tREFI	ns		
CL = 6	CWL = 5	<i>tCK(AVG)</i>	2.5	3.3	ns	1,2,3,6,
	CWL = 6	<i>tCK(AVG)</i>	Reserved		ns	1,2,3,4,
CL = 7	CWL = 5	<i>tCK(AVG)</i>	Reserved		ns	4,
	CWL = 6	<i>tCK(AVG)</i>	1.875	< 2.5	ns	1,2,3,4,
CL = 8	CWL = 5	<i>tCK(AVG)</i>	Reserved		ns	4,
	CWL = 6	<i>tCK(AVG)</i>	1.875	< 2.5	ns	1,2,3,
Supported CL Settings		6, 7, 8		<i>nCK</i>	13	
Supported CWL Settings		5, 6		<i>nCK</i>		

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DDR3-1333 Speed Bins and Operating Conditions

Speed Bin		DDR3-1333		Unit	Note
CL-nRCD-nRP		9-9-9			
Parameter	Symbol	min	max		
Internal read command to first data	<i>tAA</i>	13.5 (13.125)5,11	20	ns	
ACT to internal read or write delay time	<i>tRCD</i>	13.5 (13.125)5,11	—	ns	
PRE command period	<i>tRP</i>	13.5 (13.125)5,11	—	ns	
ACT to ACT or REF command period	<i>tRC</i>	49.5 (49.125)5,11	—	ns	
ACT to PRE command period	<i>tRAS</i>	36	9 * tREFI	ns	
CL = 6	CWL = 5	<i>tCK(AVG)</i>	2.5 3.3	ns	1,2,3,7
	CWL = 6	<i>tCK(AVG)</i>	Reserved	ns	1,2,3,4,7
	CWL = 7	<i>tCK(AVG)</i>	Reserved	ns	4
CL = 7	CWL = 5	<i>tCK(AVG)</i>	Reserved	ns	4
	CWL = 6	<i>tCK(AVG)</i>	1.875 < 2.5 (Optional)5,11	ns	1,2,3,4,7
	CWL = 7	<i>tCK(AVG)</i>	Reserved	ns	1,2,3,4
CL = 8	CWL = 5	<i>tCK(AVG)</i>	Reserved	ns	4
	CWL = 6	<i>tCK(AVG)</i>	1.875 < 2.5	ns	1,2,3,7
	CWL = 7	<i>tCK(AVG)</i>	Reserved	ns	1,2,3,4
CL = 9	CWL = 5, 6	<i>tCK(AVG)</i>	Reserved	ns	4
	CWL = 7	<i>tCK(AVG)</i>	1.5 <1.875	ns	1,2,3,4
CL = 10	CWL = 5, 6	<i>tCK(AVG)</i>	Reserved	ns	4
	CWL = 7	<i>tCK(AVG)</i>	1.5 <1.875	ns	1,2,3
			(Optional)		
Supported CL Settings		6, 8, (7), 9, (10)		<i>nCK</i>	
Supported CWL Settings		5, 6, 7		<i>nCK</i>	

DDR3-1600 Speed Bins and Operating Conditions

Speed Bin		DDR3-1600		Unit	Note
CL-nRCD-nRP		11-11-11			
Parameter	Symbol	min	max		
Internal read command to first data	<i>tAA</i>	13.75 (13.125)5,11	20	ns	
ACT to internal read or write delay time	<i>tRCD</i>	13.75 (13.125)5,11	—	ns	
PRE command period	<i>tRP</i>	13.75 (13.125)5,11	—	ns	
ACT to ACT or REF command period	<i>tRC</i>	48.75 (49.125)5,11	—	ns	
ACT to PRE command period	<i>tRAS</i>	35	9 * tREFI	ns	
CL = 5	CWL = 5	<i>tCK(AVG)</i>	3.0 3.3	ns	1,2,3,4,7,10,11
	CWL = 6,7,8	<i>tCK(AVG)</i>	Reserved	ns	1,2,3,4
CL = 6	CWL = 5	<i>tCK(AVG)</i>	2.5 3.3	ns	1,2,3,7
	CWL = 6	<i>tCK(AVG)</i>	Reserved	ns	1,2,3,4,7
	CWL = 7,8	<i>tCK(AVG)</i>	Reserved	ns	4
CL = 7	CWL = 5	<i>tCK(AVG)</i>	Reserved	ns	4
	CWL = 6	<i>tCK(AVG)</i>	1.875 < 2.5	ns	1,2,3,4,7

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Speed Bin		DDR3-1600		Unit	Note
CL-nRCD-nRP		11-11-11			
Parameter	Symbol	min	max		
		(Optional)5,11			
	CWL = 7	Reserved		ns	1,2,3,4
	CWL = 8	Reserved		ns	4
CL = 8	CWL = 5	Reserved		ns	4
	CWL = 6	1.875	< 2.5	ns	1,2,3,7
	CWL = 7	Reserved		ns	1,2,3,4,7
	CWL = 8	Reserved		ns	1,2,3,4
CL = 9	CWL = 5, 6	Reserved		ns	4
	CWL = 7	1.5	<1.875	ns	1,2,3,4
	CWL = 8	Reserved		ns	1,2,3,4
CL = 10	CWL = 5, 6	Reserved		ns	4
	CWL = 7	1.5	<1.875	ns	1,2,3
		(Optional)			
	CWL = 8	Reserved		ns	1,2,3,4
CL=11	CWL = 5, 6, 7	Reserved		ns	4
	CWL = 8	1.25	<1.5	ns	1,2,3,9
Supported CL Settings		5, 6, 8, 7, 9, 10,11		nCK	
Supported CWL Settings		5, 6, 7,8		nCK	

DDR3-1866 Speed Bins and Operating Conditions

Speed Bin		DDR3-1866		Unit	Note
CL-nRCD-nRP		13-13-13			
Parameter	Symbol	min	max		
Internal read command to first data	tAA	13.91 (13.125)10	20	ns	
ACT to internal read or write delay time	tRCD	13.91 (13.125)10	—	ns	
PRE command period	tRP	13.91 (13.125)10	—	ns	
ACT to ACT or REF command period	tRC	47.91 (48.125)10	—	ns	
ACT to PRE command period	tRAS	34	9 * tREFI	ns	
CL = 6	CWL = 5	2.5	3.3	ns	1,2,3,8
	CWL = 6	Reserved		ns	1,2,3,4,8
	CWL = 7,8,9	Reserved		ns	4
CL = 7	CWL = 5	Reserved		ns	4
	CWL = 6	1.875	2.5	ns	1,2,3,4,8
		(Optional)5,11			
	CWL = 7,8,9	Reserved		ns	1,2,3,4
CL = 8	CWL = 5	Reserved		ns	4
	CWL = 6	1.875	< 2.5	ns	1,2,3,8
	CWL = 7	Reserved		ns	1,2,3,4,8
	CWL = 8,9	Reserved		ns	4
CL = 9	CWL = 5,6	Reserved		ns	4
	CWL = 7	1.5	1.875	ns	1,2,3,4,8
	CWL = 8	Reserved		ns	4

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Speed Bin			DDR3-1866		Unit	Note
CL-nRCD-nRP			13-13-13			
Parameter	Symbol		min	max		
CL = 10	CWL = 9	tCK(AVG)	Reserved		ns	4
	CWL = 5,6,	tCK(AVG)	Reserved		ns	4
	CWL = 7	tCK(AVG)	1.5	<1.875	ns	1,2,3,8
	CWL = 8	tCK(AVG)	Reserved		ns	1,2,3,4,8
CL = 11	CWL = 5,6,7	tCK(AVG)	Reserved		ns	4
	CWL = 8	tCK(AVG)	1.25	1.5	ns	1,2,3,8
	CWL = 9	tCK(AVG)	Reserved		ns	1,2,3,4
CL = 12	CWL = 5, 6, 7,8	tCK(AVG)	Reserved		ns	4
	CWL = 9	tCK(AVG)	1.25	<1.5	ns	1,2,3,4
CL = 13	CWL = 5,6,7,8	tCK(AVG)	Reserved		ns	4
	CWL = 9	tCK(AVG)	1.071	<1.25	ns	1,2,3,9
Supported CL Settings			6, 8, 7, 9, 10, 11,13		nCK	
Supported CWL Settings			5, 6, 7, 8, 9		nCK	

- Notes:**
1. Absolute Specification (TOPER; VDDQ = VDD = 1.5V +/- 0.075 V);
 2. The CL setting and CWL setting result in tCK(AVG).MIN and tCK(AVG).MAX requirements. When making a selection of tCK(AVG), both need to be fulfilled: Requirements from CL setting as well as requirements from CWL setting.
 3. tCK(AVG).MIN limits: Since CAS Latency is not purely analog - data and strobe output are synchronized by the DLL - all possible intermediate frequencies may not be guaranteed. An application should use the next smaller JEDEC standard tCK(AVG) value (3.0, 2.5, 1.875, 1.5, 1.25, 1.07, or 0.935 ns) when calculating CL [nCK] = tAA [ns] / tCK(AVG) [ns], rounding up to the next 'Supported CL', where tCK(AVG) = 3.0 ns should only be used for CL = 5 calculation.
 4. tCK(AVG).MAX limits: Calculate tCK(AVG) = tAA.MAX / CL SELECTED and round the resulting tCK(AVG) down to the next valid speed bin (i.e. 3.3ns or 2.5ns or 1.875 ns or 1.5 ns or 1.25 ns or 1.07 ns or 0.935 ns). This result is tCK(AVG).MAX corresponding to CL SELECTED.
 5. 'Reserved' settings are not allowed. User must program a different value.
 6. '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.
 7. Any DDR3-1066 speed bin also supports functional operation at lower frequencies as shown in the table which are not subject to Production Tests but verified by Design/Characterization.
 8. Any DDR3-1333 speed bin also supports functional operation at lower frequencies as shown in the table which are not subject to Production Tests but verified by Design/Characterization.
 9. 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, DDR3-1333H devices supporting down binning to DDR3-1066F should program 13.125 ns in SPD bytes for tAAmin (Byte 16), tRCDmin (Byte 18), and tRPmin (Byte 20). DDR3-1600K devices supporting down binning to DDR3-1333H or DDR3-1066F should program 13.125 ns in SPD bytes for tAAmin (Byte16), tRCDmin (Byte 18), and tRPmin (Byte 20). Once tRP (Byte 20) is programmed to 13.125ns, tRCmin (Byte 21, 23) also should be programmed accordingly. For example, 49.125ns (tRASmin + tRPmin = 36 ns + 13.125 ns) for DDR3-1333H and 48.125ns (tRASmin + tRPmin = 35 ns + 13.125 ns) for DDR3-1600K.

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Industrial Temperature DDR3 72 bit ECC UNB SODIMM Low Voltage VP7PUxx7298xxxzT

Timing Parameters

Speed	Parameter	Symbol	DDR3-800		DDR3-1066		DDR3-1333		Units	Note
			MIN	MAX	MIN	MAX	MIN	MAX		
Clock Timing										
	Minimum Clock Cycle Time (DLL off mode)	tCK(DLL_OF F)	8	-	8	-	8	-	ns	6
	Average Clock Period	tCK(avg)	See Speed Bins Table						ps	
	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	ps	
	Average high pulse width	tCH(avg)	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	tCK(avg)	
	Clock Period Jitter	tJIT(per)	-100	100	-90	90	-80	80	ps	
	Clock Period Jitter during DLL locking period	tJIT(per, ick)	-90	90	-80	80	-70	70	ps	
	Cycle to Cycle Period Jitter	tJIT(cc)	200		180		160		ps	
	Cycle to Cycle Period Jitter during DLL locking period	tJIT(cc, ick)	180		160		140		ps	
	Cumulative error across 2 cycles	tERR(2per)	-147	147	-132	132	-118	118	ps	
	Cumulative error across 3 cycles	tERR(3per)	-175	175	-157	157	-140	140	ps	
	Cumulative error across 4 cycles	tERR(4per)	-194	194	-175	175	-155	155	ps	
	Cumulative error across 5 cycles	tERR(5per)	-209	209	-188	188	-168	168	ps	
	Cumulative error across 6 cycles	tERR(6per)	-222	222	-200	200	-177	177	ps	
	Cumulative error across 7 cycles	tERR(7per)	-232	232	-209	209	-186	186	ps	
	Cumulative error across 8 cycles	tERR(8per)	-241	241	-217	217	-193	193	ps	
	Cumulative error across 9 cycles	tERR(9per)	-249	249	-224	224	-200	200	ps	
	Cumulative error across 10 cycles	tERR(10per)	-257	257	-231	231	-205	205	ps	
	Cumulative error across 11 cycles	tERR(11per)	-263	263	-237	237	-210	210	ps	
	Cumulative error across 12 cycles	tERR(12per)	-269	269	-242	242	-215	215	ps	
	Cumulative error across n = 13, 14 ... 49, 50 cycles	tERR(nper)	tERR(nper)min = (1 + 0.68ln(n))*tJIT(per)min tERR(nper)max = (1 + 0.68ln(n))*tJIT(per)max						ps	24
	Absolute clock HIGH pulse width	tCH(abs)	0.43	-	0.43	-	0.43	-	tCK(avg)	25
	Absolute clock Low pulse width	tCL(abs)	0.43	-	0.43	-	0.43	-	tCK(avg)	26
Data Timing										
	DQS, DQS to DQ skew, per group, per access	tDQSQ	-	200	-	150	-	125	ps	13
	DQ output hold time from DQS, DQS	tQH	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	ps	13,14, f
	DQ high-impedance time from CK, CK	tHZ(DQ)	-	400	-	300	-	250	ps	13,14, f
	Data setup time to DQS, DQS referenced to VIH(AC)VIL(AC) levels	tDS(base)	75	-	25	-	30	-	ps	d, 17
	Data hold time to DQS, DQS referenced to VIH(AC)VIL(AC) levels	tDH(base)	150	-	100	-	65	-	ps	d, 17
	DQ and DM Input pulse width for each input	tDIPW	600	-	490	-	400	-	ps	28
Data Strobe Timing										
	DQS, DQS READ Preamble	tRPRE	0.9	Note 19	0.9	Note 19	0.9	Note 19	tCK	13, 19, g
	DQS, DQS differential READ Postamble	tRPST	0.3	Note 11	0.3	Note 11	0.3	Note 11	tCK	11, 13, b
	DQS, DQS output high time	tQSH	0.38	-	0.38	-	0.4	-	tCK(avg)	13, g
	DQS, DQS output low time	tQSL	0.38	-	0.38	-	0.4	-	tCK(avg)	13, g
	DQS, DQS WRITE Preamble	tWPRE	0.9	-	0.9	-	0.9	-	tCK	
	DQS, DQS WRITE Postamble	tWPST	0.3	-	0.3	-	0.3	-	tCK	
	DQS, DQS rising edge output access time from rising CK, CK	tDQSCK	-400	400	-300	300	-255	255	ps	13, f
	DQS, DQS low-impedance time (Referenced from RL-1)	tLZ(DQS)	-800	400	-600	300	-500	250	ps	13,14, f
	DQS, DQS high-impedance time (Referenced from RL+BL/2)	tHZ(DQS)	-	400	-	300	-	250	ps	12,13,14
	DQS, DQS differential input low pulse width	tDQSL	0.45	0.55	0.45	0.55	0.45	0.55	tCK	29, 31
	DQS, DQS differential input high pulse width	tDQSH	0.45	0.55	0.45	0.55	0.45	0.55	tCK	30, 31
	DQS, DQS rising edge to CK, CK rising edge	tDQSS	-0.25	0.25	-0.25	0.25	-0.25	0.25	tCK(avg)	c
	DQS, DQS falling edge setup time to CK, CK rising edge	tDSS	0.2	-	0.2	-	0.2	-	tCK(avg)	c, 32
	DQS, DQS falling edge hold time to CK, CK rising edge	tDSH	0.2	-	0.2	-	0.2	-	tCK(avg)	c, 32

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Industrial Temperature DDR3 72 bit ECC UNB SODIMM Low Voltage VP7PUxx7298xxxzT

Timing Parameters (Cont.)

Speed Parameter	Symbol	DDR3-800		DDR3-1066		DDR3-1333		Units	Note	
		MIN	MAX	MIN	MAX	MIN	MAX			
Command and Address Timing										
DLL locking time	tDLLK	512	-	512	-	512	-	nCK		
internal READ Command to PRECHARGE Command delay	tRTP	max (4nCK,7.5ns)	-	max (4nCK,7.5ns)	-	max (4nCK,7.5ns)	-		e	
Delay from start of internal write transaction to internal read command	tWTR	max (4nCK,7.5ns)	-	max (4nCK,7.5ns)	-	max (4nCK,7.5ns)	-		e,18	
WRITE recovery time	tWR	15	-	15	-	15	-	ns	e	
Mode Register Set command cycle time	tMRD	4	-	4	-	4	-	nCK		
Mode Register Set command update delay	tMOD	max (12nCK,15ns)	-	max (12nCK,15ns)	-	max (12nCK,15ns)	-			
CAS# to CAS# command delay	tCCD	4	-	4	-	4	-	nCK		
Auto precharge write recovery + precharge time	tDAL(min)	WR + roundup (tRP / tCK(AVG))							nCK	
Multi-Purpose Register Recovery Time	tMPRR	1	-	1	-	1	-	nCK	22	
ACTIVE to PRECHARGE command period	tRAS	See 13.3 " Speed Bins and CL, tRCD, tRP, tRC and tRAS for corresponding Bin" on page 37						ns	e	
ACTIVE to ACTIVE command period for 1KB page size	tRRD	max (4nCK,10ns)	-	max (4nCK,7.5ns)	-	max (4nCK,6ns)	-		e	
ACTIVE to ACTIVE command period for 2KB page size	tRRD	max (4nCK,10ns)	-	max (4nCK,10ns)	-	max (4nCK,7.5ns)	-		e	
Four activate window for 1KB page size	tFAW	40	-	37.5	-	30	-	ns	e	
Four activate window for 2KB page size	tFAW	50	-	50	-	45	-	ns	e	
Command and Address setup time to CK, CK referenced to VIH(AC) / VIL(AC) levels	tIS(base)	200	-	125	-	65	-	ps	b,16	
Command and Address hold time from CK, CK referenced to VIH(AC) / VIL(AC) levels	tIH(base)	275	-	200	-	140	-	ps	b,16	
Command and Address setup time to CK, CK referenced to VIH(AC) / VIL(AC) levels	tIS(base) AC150	200 + 150	-	125 + 150	-	65+125	-	ps	b,16,27	
Control & Address Input pulse width for each input	tIPW	900	-	780	-	620	-	ps	28	
Calibration Timing										
Power-up and RESET calibration time	tZQinitl	512	-	512	-	512	-	nCK		
Normal operation Full calibration time	tZQoper	256	-	256	-	256	-	nCK		
Normal operation short calibration time	tZQCS	64	-	64	-	64	-	nCK	23	
Reset Timing										
Exit Reset from CKE HIGH to a valid command	tXPR	max(5nCK, tRFC + 10ns)	-	max(5nCK, tRFC + 10ns)	-	max(5nCK, tRFC + 10ns)	-			
Self Refresh Timing										
Exit Self Refresh to commands not requiring a locked DLL	tXS	max(5nCK, tRFC + 10ns)	-	max(5nCK, tRFC + 10ns)	-	max(5nCK, tRFC + 10ns)	-			
Exit Self Refresh to commands requiring a locked DLL	tXSDLL	tDLLK(min)	-	tDLLK(min)	-	tDLLK(min)	-	nCK		
Minimum CKE low width for Self refresh entry to exit timing	tCKESR	tCKE(min) + 1tCK	-	tCKE(min) + 1tCK	-	tCKE(min) + 1tCK	-			
Valid Clock Requirement after Self Refresh Entry (SRE) or Power-Down Entry (PDE)	tCKSRE	max(5nCK, 10ns)	-	max(5nCK, 10ns)	-	max(5nCK, 10ns)	-			
Valid Clock Requirement before Self Refresh Exit (SRX) or Power-Down Exit (PDX) or Reset Exit	tCKSRX	max(5nCK, 10ns)	-	max(5nCK, 10ns)	-	max(5nCK, 10ns)	-			

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Industrial Temperature DDR3 72 bit ECC UNB SODIMM Low Voltage VP7PUxx7298xxxzT

Timing Parameters(Cont.)

Speed		DDR3-800		DDR3-1066		DDR3-1333		Units	Note
Parameter	Symbol	MIN	MAX	MIN	MAX	MIN	MAX		
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, 7.5ns)	-	max (3nCK, 7.5ns)	-	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)	-		2
CKE minimum pulse width	tCKE	max (3nCK, 7.5ns)	-	max (3nCK, 5.625ns)	-	max (3nCK, 5.625ns)	-		
Command pass disable delay	tCPDED	1	-	1	-	1	-	nCK	
Power Down Entry to Exit Timing	tPD	tCKE(min)	9*tREFI	tCKE(min)	9*tREFI	tCKE(min)	9*tREFI	tCK	15
Timing of ACT command to Power Down entry	tACTPDEN	1	-	1	-	1	-	nCK	20
Timing of PRE command to Power Down entry	tPRPDEN	1	-	1	-	1	-	nCK	20
Timing of RD/RDA command to Power Down entry	tRDPDEN	RL + 4 + 1	-	RL + 4 + 1	-	RL + 4 + 1	-		
Timing of WR command to Power Down entry (BL8OTF, BL8MRS, BL4OTF)	tWRPDEN	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, BL4OTF)	tWRAPDEN	WL + 4 +WR + 1	-	WL + 4 +WR + 1	-	WL + 4 +WR + 1	-	nCK	10
Timing of WR command to Power Down entry (BL4MRS)	tWRPDEN	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 (BL4MRS)	tWRAPDEN	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	-		20,21
Timing of MRS command to Power Down entry	tMRSPDEN	tMOD(min)	-	tMOD(min)	-	tMOD(min)	-		
ODT Timing									
ODT high time without write command or with write command and BC4	ODTH4	4	-	4	-	4	-	nCK	
ODT high time with Write command and BL8	ODTH8	6	-	6	-	6	-	nCK	
Asynchronous RTT turn-on delay (Power-Down with DLL frozen)	tAONPD	2	8.5	2	8.5	2	8.5	ns	
Asynchronous RTT turn-off delay (Power-Down with DLL frozen)	tAOFDP	2	8.5	2	8.5	2	8.5	ns	
ODT turn-on	tAON	-400	400	-300	300	-250	250	ps	7,f
RTT_NOM and RTT_WR turn-off time from ODTLoff reference	tAOF	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	tCK(avg)	f
Write Leveling Timing									
First DQS pulse rising edge after tDQSS margining mode is programmed	tWLMRD	40	-	40	-	40	-	tCK	3
DQS/DQS delay after tDQSS margining mode is programmed	tWLDQSEN	25	-	25	-	25	-	tCK	3
Setup time for tDQSS latch	tWLS	325	-	245	-	195	-	ps	
Write leveling hold time from rising DQS, DQS crossing to rising CK, CK crossing	tWLH	325	-	245	-	195	-	ps	
Write leveling output delay	tWLO	0	9	0	9	0	9	ns	
Write leveling output error	tWLOE	0	2	0	2	0	2	ns	

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Timing Parameters by Speed Bins for DDR3-1600, DDR3-1866 (Cont.)

Speed	Parameter	Symbol	DDR3-1600		DDR3-1866		Units	NOTE
			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 Speed Bins Table				ps	
	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	
	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)	
	Clock Period Jitter	tJIT(per)	-70	70	-60	60	ps	
	Clock Period Jitter during DLL-locking period	tJIT(per, lck)	-50	60	-50	60	ps	
	Cycle to Cycle Period Jitter	tJIT(cc)	140		120		ps	
	Cycle to Cycle Period Jitter during DLL locking period	tJIT(cc, lck)	120		100		ps	
	Cumulative error across 2 cycles	tERR(2per)	-103	103	-88	88	ps	
	Cumulative error across 3 cycles	tERR(3per)	-122	122	-105	105	ps	
	Cumulative error across 4 cycles	tERR(4per)	-136	136	-117	117	ps	
	Cumulative error across 5 cycles	tERR(5per)	-147	147	-126	126	ps	
	Cumulative error across 6 cycles	tERR(6per)	-155	155	-133	133	ps	
	Cumulative error across 7 cycles	tERR(7per)	-163	163	-139	139	ps	
	Cumulative error across 8 cycles	tERR(8per)	-169	169	-145	145	ps	
	Cumulative error across 9 cycles	tERR(9per)	-175	175	-150	150	ps	
	Cumulative error across 10 cycles	tERR(10per)	-180	180	-154	154	ps	
	Cumulative error across 11 cycles	tERR(11per)	-184	184	-158	158	ps	
	Cumulative error across 12 cycles	tERR(12per)	-188	188	-161	161	ps	
	Cumulative error across n = 13, 14 ... 49, 50 cycles	tERR(nper)	tERR(nper)min = (1 + 0.58ln(n))tJIT(per)min tERR(nper)max = (1 + 0.58ln(n))tJIT(per)max				ps	24
	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
Data Timing								
	DQS, DQS to DQ skew, per group, per access	tDQSQ	-	100	-	85	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)	-450	225	-390	195	ps	13, 14, f
	DQ high-impedance time from CK, CK	tHZ(DQ)	-	225	-	195	ps	13, 14, f
	Data setup time to DQS, DQS referenced to V _{DD} (AC)/V _L (AC) levels	tDS(base) AC150	10	-	-	-	ps	d, 17
		tDS(base) AC135	-	-	0	-	ps	d, 17
	Data hold time to DQS, DQS referenced to V _{DD} (DC)/V _L (DC) levels	tDH(base) DC100	45	-	20	-	ps	d, 17
	DQ and DM input pulse width for each input	tDIPW	360	-	320	-	ps	28
Data Strobe Timing								
	DQS, DQS differential READ Preamble	tRPRE	0.9	NOTE 19	0.9	NOTE 19	tCK	13, 15, g
	DQS, DQS differential READ Postamble	tRPST	0.3	NOTE 11	0.3	NOTE 11	tCK	11, 13, b
	DQS, DQS differential output high time	tQSH	0.4	-	0.4	-	tCK(avg)	13, g
	DQS, DQS differential output low time	tQSL	0.4	-	0.4	-	tCK(avg)	13, g
	DQS, DQS differential WRITE Preamble	tWPRE	0.9	-	0.9	-	tCK	
	DQS, DQS differential WRITE Postamble	tWPST	0.3	-	0.3	-	tCK	
	DQS, DQS rising edge output access time from rising CK, CK	tDQSCK	-225	225	-195	195	ps	13, f
	DQS, DQS low-impedance time (Referenced from RL-1)	tLZ(DQS)	-450	225	-390	195	ps	13, 14, f
	DQS, DQS high-impedance time (Referenced from RL+BL/2)	tHZ(DQS)	-	225	-	195	ps	12, 13, 14
	DQS, DQS differential input low pulse width	tDQSL	0.45	0.55	0.45	0.55	tCK	29, 31
	DQS, DQS differential input high pulse width	tDQSH	0.45	0.55	0.45	0.55	tCK	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	0.9	NOTE 19	0.18	-	tCK(avg)	c, 32
	DQS, DQS falling edge hold time to CK, CK rising edge	tDSH	0.3	NOTE 11	0.18	-	tCK(avg)	c, 32

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72 bit ECC UNB SODIMM Low Voltage
VP7PUxx7298xxxzyT**

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Industrial Temperature DDR3 72 bit ECC UNB SODIMM Low Voltage VP7PUxx7298xxxzT

Speed		DDR3-1600		DDR3-1866		Units	NOTE	
Parameter	Symbol	MIN	MAX	MIN	MAX			
Command and Address Timing								
DLL locking time	tDLLK	512	-	512	-	nCK		
Internal READ Command to PRECHARGE Command delay	tRTP	max (4nCK, 7.5ns)	-	max (4nCK, 7.5ns)	-		e	
Delay from start of internal write transaction to internal read command	tWTR	max (4nCK, 7.5ns)	-	max (4nCK, 7.5ns)	-		e,18	
WRITE recovery time	tWR	15	-	15	-	ns	e	
Mode Register Set command cycle time	tMRD	4	-	4	-	nCK		
Mode Register Set command update delay	tMOD	max (12nCK, 15ns)	-	max (12nCK, 15ns)	-			
CAS to CAS command delay	tCCD	4	-	4	-	nCK		
Auto precharge write recovery + precharge time	tDAL(min)			WR + roundup (tRP / tCK(AVG))		nCK		
Multi-Purpose Register Recovery Time	tMPRR	1	-	1	-	nCK	22	
ACTIVE to PRECHARGE command period	tRAS	See "Speed Bins and CL, tRCD, tRP, tRC and tRAS for corresponding Bin" on page 42					ns	e
ACTIVE to ACTIVE command period for 1KB page size	tRRD	max (4nCK, 5ns)	-	max (4nCK, 5ns)	-		e	
ACTIVE to ACTIVE command period for 2KB page size	tRRD	max (4nCK, 7.5ns)	-	max (4nCK, 5ns)	-		e	
Four activate window for 1KB page size	tFAW	30	-	27	-	ns	e	
Four activate window for 2KB page size	tFAW	40	-	35	-	ns	e	
Command and Address setup time to CK, \overline{CK} referenced to $V_{IH}(AC) / V_{IL}(AC)$ levels	tIS(base) AC175	45	-	-	-	ps	b,16	
	tIS(base) AC150	170	-	-	-	ps	b,16	
	tIS(base) AC135	-	-	65	-	ps	b,16	
	tIS(base) AC125	-	-	150	-	ps	b,16,27	
Command and Address hold time from CK, \overline{CK} referenced to $V_{IH}(DC) / V_{IL}(DC)$ levels	tIH(base) DC100	120	-	100	-	ps	b,16	
Control & Address Input pulse width for each input	tIPW	560	-	535	-	ps	28	
Calibration Timing								
Power-up and RESET calibration time	tZQInIt	512	-	max(512nCK, 640ns)	-	nCK		
Normal operation Full calibration time	tZQoper	256	-	max(256nCK, 320ns)	-	nCK		
Normal operation short calibration time	tZQCS	64	-	max(64nCK, 80ns)	-	nCK	23	
Reset Timing								
Exit Reset from CKE HIGH to a valid command	tXPR	max(5nCK, tRFC + 10ns)	-	max(5nCK, tRFC + 10ns)	-			
Self Refresh Timing								
Exit Self Refresh to commands not requiring a locked DLL	tXS	max(5nCK, tRFC + 10ns)	-	max(5nCK, tRFC + 10ns)	-			
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) + 1tCK	-	tCKE(min) + 1nCK	-			
Valid Clock Requirement after Self Refresh Entry (SRE) or Power-Down Entry (PDE)	tCKSRE	max(5nCK, 10ns)	-	max(5nCK, 10ns)	-			
Valid Clock Requirement before Self Refresh Exit (SRX) or Power-Down Exit (PDX) or Reset Exit	tCKSRX	max(5nCK, 10ns)	-	max(5nCK, 10ns)	-			

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Speed		DDR3-1600		DDR3-1866		Units	NOTE
Parameter	Symbol	MIN	MAX	MIN	MAX		
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, 6ns)	-	max(3nCK, 6ns)	-		
Exit Precharge Power Down with DLL frozen to commands requiring a locked DLL	IXPDLL	max (10nCK, 24ns)	-	max(10nCK, 24ns)	-		2
CKE minimum pulse width	tCKE	max (3nCK, 5ns)	-	max(3nCK, 5ns)	-		
Command pass disable delay	tCPDED	1	-	2	-	nCK	
Power Down Entry to Exit Timing	tPD	tCKE(min)	9*tREFI	tCKE(min)	9*tREFI	tCK	15
Timing of ACT command to Power Down entry	tACTPDEN	1	-	1	-	nCK	20
Timing of PRE command to Power Down entry	tPRPDEN	1	-	1	-	nCK	20
Timing of RD/RDA command to Power Down entry	tRDPDEN	RL + 4 + 1	-	RL + 4 + 1	-		
Timing of WR command to Power Down entry (BL9OTF, BL8MRS, BC4OTF)	tWRPDEN	WL + 4 + (tWR/ tCK(avg))	-	WL + 4 + (tWR/ tCK(avg))	-	nCK	9
Timing of WRA command to Power Down entry (BL9OTF, 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	-	1	-		20,21
Timing of MRS command to Power Down entry	tMRSPDEN	tMOD(min)	-	tMOD(min)	-		
ODT Timing							
ODT high time without write command or with write command and BC4	ODTH4	4	-	4	-	nCK	
ODT high time with Write command and BLB	ODTHB	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)	tAOPFD	2	8.5	2	8.5	ns	
RTT turn-on	tAON	-225	225	-195	195	ps	7,f
RTT_NOM and RTT_WR turn-off time from ODTLoff 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	-	tCK	3
DQS/DQS delay after write leveling mode is programmed	tWLDQSEN	25	-	25	-	tCK	3
Write leveling setup time from rising CK, CK crossing to rising DQS, DQS crossing	tWLS	165	-	140	-	ps	
Write leveling hold time from rising DQS, DQS crossing to rising CK, CK crossing	tWLH	165	-	140	-	ps	
Write leveling output delay	tWLO	0	7.5	0	7.5	ns	
Write leveling output error	tWLOE	0	2	0	2	ns	

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18.1 Jitter Notes

1. 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.
2. 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.
3. 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.
4. 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. Specific Note 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 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.
5. 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 <= m <= 12. (output deratings are relative to the SDRAM input clock.) For example, if the measured jitter into a 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 + 172 ps = + 572 ps. Similarly, tLZ(DQ) for DDR3-800 derates to tLZ(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 <= n <= 12, and tERR(mper),act,max is the maximum measured value of tERR(nper) where 2 <= n <= 12.
6. 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 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!)= 0.38 x 2500 ps - 72 ps = + 878 ps. (Caution on the min/max usage!)

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18.2 Timing Parameter Notes

1. Actual value dependant upon measurement level definitions which are TBD.
2. Commands requiring a locked DLL are: READ (and RAP) and synchronous ODT commands.
3. The max values are system dependent.
4. WR as programmed in mode register
5. Value must be rounded-up to next higher integer value
6. There is no maximum cycle time limit besides the need to satisfy the refresh interval, tREFI.
7. For definition of RTT turn-on time tAON see "Device Operation"
8. For definition of RTT turn-off time tAOF see "Device Operation".
9. tWR is defined in ns, for calculation of tWRPDEN it is necessary to round up tWR / tCK to the next integer.
10. WR in clock cycles as programmed in MR0
11. The maximum read postamble is bound by tDQSCK(min) plus tQSH(min) on the left side and tHZ(DQS)max on the right side. Device Operation.
12. 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 TBD
13. Value is valid for RON34
14. Single ended signal parameter.
15. tREFI depends on TOPER
16. tIS(base) and tIH(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, VREF(DC) = VREFDQ(DC). FO for input only pins except RESET, VREF(DC)=VREFCA(DC). See "Address/Command Setup, Hold and Derating"
17. tDS(base) and tDH(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, VREF(DC)= VREFDQ(DC). For input only pins except RESET, VREF(DC)=VREFCA(DC). See "Data Setup, Hold and Slew Rate Derating"
18. 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
19. The maximum read preamble is bound by tLZDQS(min) on the left side and tDQSCK(max) on the right side. See "Device Operation"
20. CKE is allowed to be registered low while operations such as row activation, precharge, autoprecharge or refresh are in progress, but power-down IDD spec will not be applied until finishing those operations.
21. Although CKE is allowed to be registered LOW after a REFRESH command once tREFPDEN(min) is satisfied, there are cases where additional time such as tXPDLL(min) is also required. See "Device Operation".
22. Defined between end of MPR read burst and MRS which reloads MPR or disables MPR function.
23. One ZQCS command can effectively correct a minimum of 0.5 % (ZQCorrection) of RON and RTT 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 (Tdristrate) and voltage (Vdristrate) drift rates that the SDRAM is subject to in the application, is illustrated. The interval could be defined by the following formula:

$$\frac{ZQCorrection}{(TSens \times Tdristrate) + (VSens \times Vdristrate)}$$

where TSens = max(dRTTdT, dRONdTM) and VSens = max(dRTTdV, dRONdVM) define the SDRAM temperature and voltage sensitivities.

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

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

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24. n = from 13 cycles to 50 cycles. This row defines 38 parameters.
25. tCH(abs) is the absolute instantaneous clock high pulse width, as measured from one rising edge to the following falling edge.
26. tCL(abs) is the absolute instantaneous clock low pulse width, as measured from one falling edge to the following rising edge.
27. The tIS(base) AC150 specifications are adjusted from the tIS(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 a input signal is defined as the width between the first crossing of VREF(DC) and the consecutive crossing of VREF(DC)
29. tDQSL describes the instantaneous differential input low pulse width on DQS-DQS, as measured from one falling edge to the next consecutive rising edge.
30. tDQSH describes the instantaneous differential input high pulse width on DQS-DQS, as measured from one rising edge to the next consecutive falling edge.
31. tDQSH, act + tDQSL, act = 1 tCK, act ; with tXYZ, act being the actual measured value of the respective timing parameter in the application.
32. tDSH, act + tDSS, act = 1 tCK, act ; with tXYZ, act being the actual measured value of the respective timing parameter in the application.

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