



# 1GB – 2x64Mx72 DDR2 SDRAM REGISTERED, w/PLL, VLP Mini-DIMM

## FEATURES

- 244-pin, very low profile dual in-line memory module (VLP Mini-DIMM)
- Fast data transfer rates: PC2-3200, PC2-4200, PC2-5300\*, and PC2-6400\*
- Supports ECC error detection and correction
- $V_{CC} = V_{CCQ} = 1.8V \pm 0.1V$
- $V_{CCSPD} = 1.7V$  to 3.6V
- Differential data strobe (DQS, DQS#) option
- Four-bit prefetch architecture
- Programmable CAS# latency (CL)
- Posted CAS# additive latency (AL)
- On-die termination (ODT)
- Programmable burst lengths: 4 or 8
- Serial Presence Detect (SPD) with EEPROM
- Auto and Self Refresh Capability (64ms: 8,192 cycle refresh)
- Gold (Au) edge contacts
- RoHS compliant
- Dual Rank
- Package option
  - 244 Pin Mini-DIMM
  - PCB – 18.29mm (0.72")

## DESCRIPTION

The W3HG264M72EER is a 2x64Mx72 Double Data Rate DDR2 SDRAM high density module. This memory module consists of eighteen 64Mx8 bit with 4 banks DDR2 Synchronous DRAMs in FBGA packages, mounted on a 244-pin DIMM FR4 substrate.

\* This product is under development, is not qualified or characterized and is subject to change or cancellation without notice.

NOTE: Consult factory for availability of:

- Vendor source control options
- Industrial temperature option
- Parity option

## OPERATING FREQUENCIES

	PC2-3200	PC2-4200	PC2-5300*	PC2-6400*
Clock Speed	200MHz	266MHz	333MHz	400MHz
CL-tRCD-tRP	3-3-3	4-4-4	5-5-5	6-6-6

\* Contact factory for availability



## PIN CONFIGURATION

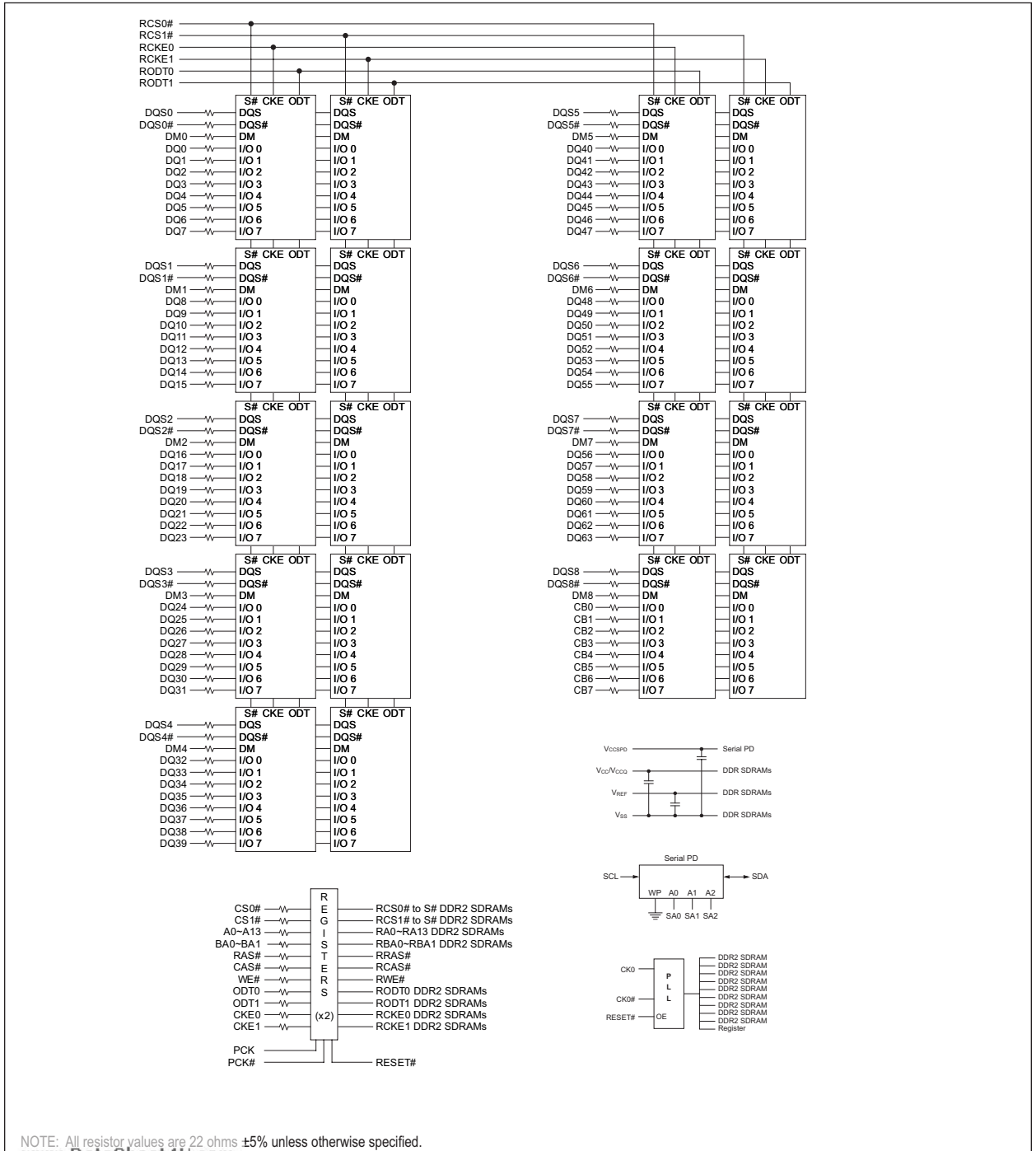
Pin No.	Symbol	Pin No.	Symbol	Pin No.	Symbol	Pin No.	Symbol
1	VREF	62	A4	123	Vss	184	Vcca
2	Vss	63	Vcca	124	DQ4	185	A3
3	DQ0	64	A2	125	DQ5	186	A1
4	DQ1	65	Vcc	126	Vss	187	Vcc
5	Vss	66	Vss	127	DM0	188	CK0
6	DQS0#	67	Vss	128	NC	189	CK0#
7	DQS0	68	NC/PAR_IN	129	Vss	190	Vcc
8	Vss	69	Vcc	130	DQ6	191	A0
9	DQ2	70	A10/AP	131	DQ7	192	BA1
10	DQ3	71	BA0	132	Vss	193	Vcc
11	Vss	72	Vcc	133	DQ12	194	RAS#
12	DQ8	73	WE#	134	DQ13	195	Vcca
13	DQ9	74	Vcca	135	Vss	196	CS0#
14	Vss	75	CAS#	136	DM1	197	Vcca
15	DQS1#	76	Vcca	137	NC	198	ODT0
16	DQS1	77	CS1#	138	Vss	199	A13
17	Vss	78	ODT1	139	NC	200	Vcc
18	RESET#	79	Vcca	140	NC	201	NC
19	NC	80	NC	141	Vss	202	Vss
20	Vss	81	Vss	142	DQ14	203	DQ36
21	DQ10	82	DQ32	143	DQ15	204	DQ37
22	DQ11	83	DQ33	144	Vss	205	Vss
23	Vss	84	Vss	145	DQ20	206	DM4
24	DQ16	85	DQS4#	146	DQ21	207	NC
25	DQ17	86	DQS4	147	Vss	208	Vss
26	Vss	87	Vss	148	DM2	209	DQ38
27	DQS2#	88	DQ34	149	NC	210	DQ39
28	DQS2	89	DQ35	150	Vss	211	Vss
29	Vss	90	Vss	151	DQ22	212	DQ44
30	DQ18	91	DQ40	152	DQ23	213	DQ45
31	DQ19	92	DQ41	153	Vss	214	Vss
32	Vss	93	Vss	154	DQ28	215	DM5
33	DQ24	94	DQS5#	155	DQ29	216	NC
34	DQ25	95	DQS5	156	Vss	217	Vss
35	Vss	96	Vss	157	DM3	218	DQ46
36	DQS3#	97	DQ42	158	NC	219	DQ47
37	DQS3	98	DQ43	159	Vss	220	Vss
38	Vss	99	Vss	160	DQ30	221	DQ52
39	DQ26	100	DQ48	161	DQ31	222	DQ53
40	DQ27	101	DQ49	162	Vss	223	Vss
41	Vss	102	Vss	163	CB4	224	NC
42	CB0	103	SA2	164	CB5	225	NC
43	CB1	104	NC	165	Vss	226	Vss
44	Vss	105	Vss	166	DM8	227	DM6
45	DQS8#	106	DQS6#	167	NC	228	NC
46	DQS8	107	DQS6	168	Vss	229	Vss
47	Vss	108	Vss	169	CB6	230	DQ54
48	CB2	109	DQ50	170	CB7	231	DQ55
49	CB3	110	DQ51	171	Vss	232	Vss
50	Vss	111	Vss	172	NC	233	DQ60
51	NC	112	DQ56	173	Vcca	234	DQ61
52	Vcca	113	DQ57	174	CKE1	235	Vss
53	CKE0	114	Vss	175	Vcc	236	DM7
54	Vcc	115	DQS7#	176	NC	237	NC
55	NC	116	DQS7	177	NC	238	Vss
56	NC/ERR_OUT	117	Vss	178	Vcca	239	DQ62
57	Vcca	118	DQ58	179	A12	240	DQ63
58	A11	119	DQ59	180	A9	241	Vss
59	A7	120	Vss	181	Vcc	242	SDA
60	Vcc	121	SA0	182	A8	243	SCL
61	A5	122	SA1	183	A6	244	VccSPD

## PIN NAMES

Pin Name	Function
A0-13	Address Inputs
BA0,BA1	SDRAM Bank Address
DQ0-DQ63	Data Input/Output
CB0-CB7	Check Bits
DQS0-DQS8	Data strobes
DQS0#-DQS8#	Data strobes complement
ODT0, ODT1	On-die termination control
CK0,CK0#	Clock Inputs
CKE0, CKE1	Clock Enables
CS0#, CS1#	Chip Selects
RAS#	Row Address Strobe
CAS#	Column Address Strobe
WE#	Write Enable
RESET#	Register Reset Input
DM (0-8)	Data Masks
VccSPD	SPD Power
Vcc	
Vcca	I/O Power (1.8V)
A10/AP	Address Input/Auto Precharge
Vss	Ground
PAR_IN	Parity bit for the address and control bus
ERR_OUT	Parity error found on the address and control bus
SA0-SA2	SPD address
SDA	SPD Data Input/Output
SCL	Clock Input
NC	No connect
VREF	Input/Output Reference



FUNCTIONAL BLOCK DIAGRAM



NOTE: All resistor values are 22 ohms ±5% unless otherwise specified.



**DC OPERATING CONDITIONS**

All voltages referenced to V<sub>SS</sub>

Parameter	Symbol	Min	Typical	Max	Unit	Notes
Supply voltage	V <sub>CC</sub>	1.7	1.8	1.9	V	1
I/O Supply voltage	V <sub>CCQ</sub>	1.7	1.8	1.9	V	4
V <sub>CC</sub> L Supply voltage	V <sub>CCCL</sub>	1.7	1.8	1.9	V	4
I/O Reference voltage	V <sub>REF</sub>	0.49 x V <sub>CCQ</sub>	0.50 x V <sub>CCQ</sub>	0.51 x V <sub>CCQ</sub>	V	2
I/O Termination voltage	V <sub>TT</sub>	V <sub>REF</sub> -0.04	V <sub>REF</sub>	V <sub>REF</sub> + 0.04	V	3

Notes:

- V<sub>CC</sub> and V<sub>CCQ</sub> must track each other. V<sub>CCQ</sub> must be less than or equal to V<sub>CC</sub>.
- V<sub>REF</sub> is expected to equal V<sub>CCQ</sub>/2 of the transmitting device and to track variations in the DC level of the same. Peak-to-peak noise on V<sub>REF</sub> may not exceed ±1 percent of the DC value. Peak-to-peak AC noise on V<sub>REF</sub> may not exceed ±2 percent of V<sub>REF</sub> (DC). This measurement is to be taken at the nearest V<sub>REF</sub> bypass capacitor.
- V<sub>TT</sub> is not applied directly to the device. V<sub>TT</sub> is a system supply for signal termination resistors, is expected to be set equal to V<sub>REF</sub> and must track variations in the DC level of V<sub>REF</sub>.
- V<sub>CCQ</sub> tracks with V<sub>CC</sub>; V<sub>CCCL</sub> track with V<sub>CC</sub>.

**ABSOLUTE MAXIMUM DC RATINGS**

Symbol	Parameter	MIN	MAX	U nit	
V <sub>CC</sub>	Voltage on V <sub>CC</sub> pin relative to V <sub>SS</sub>	-1.0	2.3	V	
V <sub>CCQ</sub>	Voltage on V <sub>CCQ</sub> pin relative to V <sub>SS</sub>	-0.5	2.3	V	
V <sub>CCCL</sub>	Voltage on V <sub>CCCL</sub> pin relative to V <sub>SS</sub>	-0.5	2.3	V	
V <sub>IN</sub> , V <sub>OUT</sub>	Voltage on any pin relative to V <sub>SS</sub>	-0.5	2.3	V	
T <sub>STG</sub>	Storage temperature	-55	100	°C	
T <sub>CASE</sub>	Device operating temperature	0	85	°C	
T <sub>OPR</sub>	Operating temperature (ambient)	0	55	°C	
I <sub>L</sub>	Input leakage current; Any input 0V<V <sub>IN</sub> <V <sub>CC</sub> ; V <sub>REF</sub> input 0V<V <sub>IN</sub> <0.95V; Other pins not under test = 0V	Command/Address, RAS#, CAS#, WE#, CS#, CKE	-5	5	µA
		CK, CK#	-5	5	µA
		DM	-5	5	µA
I <sub>oz</sub>	Output leakage current; 0V<V <sub>OUT</sub> <V <sub>CCQ</sub> ; DQs and ODT are disable	DQ, DQS, DQS#	-10	10	µA
I <sub>VREF</sub>	V <sub>REF</sub> leakage current; V <sub>REF</sub> = Valid V <sub>REF</sub> level		-18	18	µA

**INPUT/OUTPUT CAPACITANCE**

T<sub>A</sub>=25 0 C, f=1 00MHz

Parameter	Symbol	Min	Max	Unit
Input capacitance (A0 - A13, BA0 - BA1 ,RAS#,CAS#,WE#)	C <sub>IN1</sub>			pF
Input capacitance (CKE0), (ODT0)	C <sub>IN2</sub>			pF
Input capacitance (CS0#)	C <sub>IN3</sub>			pF
Input capacitance (CK0, CK0#)	C <sub>IN4</sub>			pF
Input capacitance (DM0 - DM8), (DQS0 - DQS8)	C <sub>IN5</sub>			pF
Input capacitance (DQ0 - DQ63), (CB0 - CB7)	C <sub>OUT1</sub>			pF



**OPERATING TEMPERATURE CONDITION**

Parameter	Symbol	Rating	Units	Notes
Operating temperature	T <sub>OPER</sub>	0°C to 85°C	°C	V

- Notes:
1. Operating temperature is the case surface temperature on the center/top side of the DRAM. For the measurement conditions, please refer to JEDEC JESD51.2
  2. At 0 - 85°C, operation temperature range, all DRAM specification will be supported.

**INPUT DC LOGIC LEVEL**

All voltages referenced to V<sub>SS</sub>

Parameter	Symbol	Min	Max	Unit
Input High (Logic 1) Voltage	V <sub>IH</sub> (DC)	V <sub>REF</sub> + 125	V <sub>REF</sub> + 300	mV
Input Low (Logic 0) Voltage	V <sub>IL</sub> (DC)	-300	V <sub>REF</sub> - 125	mV

**INPUT AC LOGIC LEVEL**

All voltages referenced to V<sub>SS</sub>

Parameter	Symbol	Min	Max	Unit
AC Input High (Logic 1) Voltage (DDR2-400/533)	V <sub>IH</sub> (AC)	V <sub>REF</sub> + 250	—	mV
AC Input High (Logic 1) Voltage (DDR2-667)	V <sub>IH</sub> (AC)	V <sub>REF</sub> + 200		mV
AC Input Low (Logic 0) Voltage	V <sub>IL</sub> (AC)	—	V <sub>REF</sub> - 250	mV



**DDR2 I<sub>CC</sub> SPECIFICATIONS AND CONDITIONS**

Includes DDR2 SDRAM components only; T<sub>A</sub> = 0°C, V<sub>CC</sub> = 1.9V

Symbol	Parameter	Condition	806	667	534	403	Unit	
I <sub>CC0*</sub>	Operating one bank active-precharge;	t <sub>CK</sub> = t <sub>CK(I<sub>CC</sub>)</sub> ; t <sub>RC</sub> = t <sub>RC(I<sub>CC</sub>)</sub> ; t <sub>RAS</sub> = t <sub>RAS MIN(I<sub>CC</sub>)</sub> ; CE is HIGH, CS# is HIGH between valid commands; Address bus inputs are SWITCHING; Data bus inputs are SWITCHING	TBD	1,525	1,615	1,795	mA	
I <sub>CC1*</sub>	Operating one bank active-read-precharge;	I <sub>OUT</sub> = 0mA; BL = 4; CL = CL(I <sub>CC</sub> ); t <sub>CK</sub> = t <sub>CK(I<sub>CC</sub>)</sub> ; t <sub>RC</sub> = t <sub>RC(I<sub>CC</sub>)</sub> ; t <sub>RAS</sub> = t <sub>RAS MIN(I<sub>CC</sub>)</sub> ; CE is HIGH, CS# is HIGH between valid commands; Address bus inputs are SWITCHING; Data bus inputs are SWITCHING; Data pattern is same as I <sub>CC4W</sub> .	TBD	1,615	1,750	1,930	mA	
I <sub>CC2P**</sub>	Precharge power-down current;	All banks idle; t <sub>CK</sub> = t <sub>CK(I<sub>CC</sub>)</sub> ; CE is LOW; Other control and address bus inputs are STABLE; Data bus inputs are FLOATING	TBD	490	490	490	mA	
I <sub>CC2Q**</sub>	Precharge quite standby current;	All banks idle; t <sub>CK</sub> = t <sub>CK(I<sub>CC</sub>)</sub> ; CE is HIGH; CS# is HIGH; Other control and address bus inputs are STABLE; Data bus inputs are FLOATING	TBD	1,030	1,120	1,300	mA	
I <sub>CC2N**</sub>	Precharge standby current;	All banks idle; t <sub>CK</sub> = t <sub>CK(I<sub>CC</sub>)</sub> ; CE is HIGH; CS# is HIGH; Other control and address bus inputs are STABLE; Data bus inputs are SWITCHING	TBD	1,120	1,210	1,390	mA	
I <sub>CC3P**</sub>	Active power-down current;	All banks open; t <sub>CK</sub> = t <sub>CK(I<sub>CC</sub>)</sub> , CE is LOW; Other control and address bus inputs are STABLE; Data bus inputs are FLOATING	Fast PDN Exit MRS(12) = 0	TBD	1,030	1,165	1,300	mA
			Slow PDN Exit MRS(12) = 1	TBD	895	985	1,075	mA
I <sub>CC3N**</sub>	Active standby current;	All banks open; t <sub>CK</sub> = t <sub>CK(I<sub>CC</sub>)</sub> ; t <sub>RC</sub> = t <sub>RC(I<sub>CC</sub>)</sub> ; t <sub>RAS</sub> = t <sub>RAS MIN(I<sub>CC</sub>)</sub> ; CE is HIGH, CS# is HIGH between valid commands; Other control and address bus inputs are SWITCHING; Data bus inputs are SWITCHING	TBD	1,210	1,390	1,570	mA	
I <sub>CC4W*</sub>	Operating burst write current;	All banks open; Continuous burst writes; BL = 4; CL = CL(I <sub>CC</sub> ); AL = 0; t <sub>CK</sub> = t <sub>CK(I<sub>CC</sub>)</sub> ; t <sub>RC</sub> = t <sub>RC(I<sub>CC</sub>)</sub> ; t <sub>RAS</sub> = t <sub>RAS MIN(I<sub>CC</sub>)</sub> ; CE is HIGH, CS# is HIGH between valid commands; Address bus inputs are SWITCHING; Data bus inputs are SWITCHING	TBD	1,840	2,155	2,470	mA	
I <sub>CC4R*</sub>	Operating burst read current;	All banks open; Continuous burst reads; T <sub>OUT</sub> = 0mA; BL = 4; CL = CL(I <sub>CC</sub> ); AL = 0; t <sub>CK</sub> = t <sub>CK(I<sub>CC</sub>)</sub> ; t <sub>RC</sub> = t <sub>RC(I<sub>CC</sub>)</sub> ; t <sub>RAS</sub> = t <sub>RAS MIN(I<sub>CC</sub>)</sub> ; CE is HIGH, CS# is HIGH between valid commands; Address bus inputs are SWITCHING; Data pattern is same as I <sub>CC4W</sub> .	TBD	1,840	2,200	2,560	mA	
I <sub>CC5**</sub>	Burst auto refresh current;	t <sub>CK</sub> = t <sub>CK(I<sub>CC</sub>)</sub> ; Refresh command at every t <sub>RC(I<sub>CC</sub>)</sub> interval; CE is HIGH; CS# is HIGH between valid commands; Other control and address bus inputs are SWITCHING; Data bus inputs are SWITCHING	TBD	2,515	2,695	2,875	mA	
I <sub>CC6**</sub>	Self refresh current;	CK and CK# at 0V; CE < 0.2V; Other control and address bus inputs are FLOATING; Data bus inputs are FLOATING	TBD	90	90	90	mA	
I <sub>CC7*</sub>	Operating bank interleave read current;	All bank interleaving reads; I <sub>OUT</sub> = 0mA; BL = 4; CL = CL(I <sub>CC</sub> ); AL = t <sub>RCD(I<sub>CC</sub>)</sub> - 1*t <sub>CK(I<sub>CC</sub>)</sub> ; t <sub>CK</sub> = t <sub>CK(I<sub>CC</sub>)</sub> ; t <sub>RC</sub> = t <sub>RC(I<sub>CC</sub>)</sub> ; t <sub>RRD</sub> = t <sub>RRD MIN(I<sub>CC</sub>)</sub> ; CE is HIGH; CS# is HIGH between valid commands; Address bus inputs are STABLE during DESELECTs; Data bus inputs are SWITCHING	TBD	2,875	3,235	3,415	mA	

Notes:

I<sub>CC</sub> specification is based on **MICRON** components. Other DRAM manufacturers specification may be different.

\* Value calculated as one module rank in this operating condition, and all other module ranks in I<sub>CC2P</sub> ( CE LOW) mode.

\*\* Value calculated reflects all module ranks in this operating condition.



**AC TIMING PARAMETERS**

0°C ≤ T<sub>CASE</sub> < +85°C; V<sub>CCQ</sub> = + 1.8V ± 0.1V, V<sub>CC</sub> = +1.8V ± 0.1V

AC CHARACTERISTICS			806		667		534		403				
PARAMETER		SYMBOL	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	UNIT	Notes	
Clock	Clock cycle time	CL = 6	t <sub>CK (6)</sub>	TBD	TBD						ps	16, 24	
		CL = 5	t <sub>CK (5)</sub>	TBD	TBD	3,000	8,000				ps	16, 24	
		CL = 4	t <sub>CK (4)</sub>	TBD	TBD	3,750	8,000	3,750	8,000	5,000	8,000	ps	16, 24
		CL = 3	t <sub>CK (3)</sub>	TBD	TBD	5,000	8,000	5,000	8,000	5,000	8,000	ps	16, 24
	CK high-level width		t <sub>CH</sub>	TBD	TBD	0.45	0.55	0.45	0.55	0.45	0.55	t <sub>CK</sub>	18
	CK low-level width		t <sub>CL</sub>	TBD	TBD	0.45	0.55	0.45	0.55	0.45	0.55	t <sub>CK</sub>	18
	Half clock period		t <sub>HP</sub>	TBD	TBD	MIN (t <sub>CH</sub> , t <sub>CL</sub> )		MIN (t <sub>CH</sub> , t <sub>CL</sub> )		MIN (t <sub>CH</sub> , t <sub>CL</sub> )		ps	19
Data	DQ output access time from CK/CK#		t <sub>AC</sub>	TBD	TBD	-450	+450	-500	+500	-600	+600	ps	
	Data-out high-impedance window from CK/CK#		t <sub>HZ</sub>	TBD	TBD		t <sub>AC</sub> (MAX)		t <sub>AC</sub> MAX		t <sub>AC</sub> MAX	ps	8, 9
	Data-out low-impedance window from CK/CK#		t <sub>LZ</sub>	TBD	TBD	t <sub>AC</sub> (MIN)	t <sub>AC</sub> (MAX)	t <sub>AC</sub> (MIN)	t <sub>AC</sub> (MAX)	t <sub>AC</sub> (MIN)	t <sub>AC</sub> (MAX)	ps	8, 10
	DQ and DM input setup time relative to DQS		t <sub>DsA</sub>	TBD	TBD	100		100		100		ps	7, 15, 21
	DQ and DM input hold time relative to DQS		t <sub>DhA</sub>	TBD	TBD	175		225		275		ps	7, 15, 21
	DQ and DM input setup time relative to DQS		t <sub>DsB</sub>	TBD	TBD	100		100		150		t <sub>CK</sub>	7, 15, 21
	DQ and DM input hold time relative to DQS		t <sub>DhB</sub>	TBD	TBD	175		225		275		ps	7, 15, 21
	DQ...DQS hold, DQS to first DQ to go nonvalid, per access relative to DQS		t <sub>DIPW</sub>	TBD	TBD	0.35		0.35		0.35		ps	
	Data hold skew factor		t <sub>QHS</sub>	TBD	TBD		340		400		450		
	DQ-DQS hold, DQS to first DQ to go nonvalid, per access		t <sub>QH</sub>	TBD	TBD	t <sub>HP</sub> - t <sub>QHS</sub>		t <sub>HP</sub> - t <sub>QHS</sub>		t <sub>HP</sub> - t <sub>QHS</sub>			15, 17
	Data valid output window (DVW)		t <sub>DVW</sub>	TBD	TBD	t <sub>QH</sub> - t <sub>DQSQ</sub>		t <sub>QH</sub> - t <sub>DQSQ</sub>		t <sub>QH</sub> - t <sub>DQSQ</sub>			15, 17
Data Strobe	DQS input high pulse width		t <sub>DQSH</sub>	TBD	TBD	0.35		0.35		0.35		t <sub>CK</sub>	
	DQS input low pulse width		t <sub>DQSL</sub>	TBD	TBD	0.35		0.35		0.35		t <sub>CK</sub>	
	DQS output access time from CK/CK#		t <sub>DQsCK</sub>	TBD	TBD	-400	+400	-450	+450	-500	+500	ps	
	DQS falling edge to CK rising- setup time		t <sub>DSS</sub>	TBD	TBD	0.2		0.2		0.2		t <sub>CK</sub>	
	DQS falling edge from CK rising - hold time		t <sub>DSH</sub>	TBD	TBD	0.2		0.2		0.2		t <sub>CK</sub>	
	DQS-DQ skew, DQS to last DQ valid, per group, per access		t <sub>DQSQ</sub>	TBD	TBD		240		300		350	ps	15, 17
	DQS read preamble		t <sub>RPRE</sub>	TBD	TBD	0.9	1.1	0.9	1.1	0.9	1.1	t <sub>CK</sub>	35

NOTE:  
AC specification is based on HYNIX components. Other DRAM manufactures specification may be different.



**AC TIMING PARAMETERS (Continued)**

0°C ≤ T<sub>CASE</sub> < +85°C; V<sub>CCQ</sub> = + 1.8V ± 0.1V, V<sub>CC</sub> = +1.8V ± 0.1V

	AC CHARACTERISTICS		806		665		534		403		UNIT	Notes
	PARAMETER	SYMBOL	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX		
Data Strobe	DQS read preamble	t <sub>RPST</sub>	TBD	TBD	0.4	0.6	0.4	0.6	0.4	0.6	t <sub>CK</sub>	35
	DQS write preamble setup time	t <sub>WPRES</sub>	TBD	TBD	0		0		0		ps	12, 13, 36
	DQS write preamble	t <sub>WPRE</sub>	TBD	TBD	0.35		0.25		0.25		t <sub>CK</sub>	
	DQS write postamble	t <sub>WPST</sub>	TBD	TBD	0.4	0.6	0.4	0.6	0.4	0.6	t <sub>CK</sub>	11
	Write command to first DQS latching transition	t <sub>DQSS</sub>	TBD	TBD	WL-0.25		WL-0.25		WL-0.25		t <sub>CK</sub>	
Command and Address	Address and control input pulse width for each input	t <sub>IPW</sub>	TBD	TBD	0.6		0.6		0.6		t <sub>CK</sub>	
	Address and control input setup time	t <sub>ISa</sub>	TBD	TBD	400		500		600		ps	6, 21
	Address and control input hold time	t <sub>IHa</sub>	TBD	TBD	400		500		600		ps	6, 21
	Address and control input setup time	t <sub>ISb</sub>	TBD	TBD	200		250		350		ps	6, 21
	Address and control input hold time	t <sub>IHb</sub>	TBD	TBD	275		375		475		ps	6, 21
	CAS# to CAS# command delay	t <sub>CCD</sub>	TBD	TBD	2		2		2		t <sub>CK</sub>	
	Active to Active (same bank) command	t <sub>RC</sub>	TBD	TBD	55		55		55		ns	33
	Active bank a to Active b bank command	t <sub>RRD</sub>	TBD	TBD	7.5		7.5		7.5		ns	27
	Active to Read or Write delay	t <sub>RCD</sub>	TBD	TBD	15		15		15		ns	
	Four Bank Activate period	t <sub>FAW</sub>	TBD	TBD	37.5		37.5		37.5		ns	30
	Active to precharge command	t <sub>RAS</sub>	TBD	TBD	40	70,000	40	70,000	40	70,000	ns	20, 33
	Internal Read to precharge command delay	t <sub>RTP</sub>	TBD	TBD	7.5		7.5		7.5		ns	23, 27
	Write recovery time	t <sub>WR</sub>	TBD	TBD	15		15		15		ns	27
	Auto precharge write recovery and precharge time	t <sub>DAL</sub>	TBD	TBD	t <sub>WR</sub> +t <sub>RP</sub>		t <sub>WR</sub> +t <sub>RP</sub>		t <sub>WR</sub> +t <sub>RP</sub>		ns	22
	Interval Write to Read command delay	t <sub>WTR</sub>	TBD	TBD	10		7.5		10		ns	27
	Precharge command period	t <sub>RP</sub>	TBD	TBD	15		15		15		ns	31
Precharge All command period	t <sub>RPA</sub>	TBD	TBD	t <sub>RP</sub> +t <sub>CK</sub>		t <sub>RP</sub> +t <sub>CK</sub>		t <sub>RP</sub> +t <sub>CK</sub>		ns	31	
Load Mode command cycle time	t <sub>MRD</sub>	TBD	TBD	2		2		2		t <sub>CK</sub>		
CKE low to CK,CK# uncertainty	t <sub>DELAY</sub>	TBD	TBD	t <sub>IS</sub> +t <sub>CK</sub> +t <sub>IH</sub>		t <sub>IS</sub> +t <sub>CK</sub> +t <sub>IH</sub>		t <sub>IS</sub> +t <sub>CK</sub> +t <sub>IH</sub>		ns	28	

NOTE:

- AC specification is based on **MICRON** components. Other DRAM manufactures specification may be different.





**AC TIMING PARAMETERS (Continued)**

0°C ≤ T<sub>CASE</sub> < +85°C; V<sub>CCQ</sub> = + 1.8V ± 0.1V, V<sub>CC</sub> = +1.8V ± 0.1V

	AC CHARACTERISTICS		806		665		534		403		UNIT	Notes
	PARAMETER	SYMBOL	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX		
Self Refresh	Refresh to Active or Refresh to Refresh command interval	t <sub>RFC</sub>	TBD	TBD	127.5	70,000	127.5	70,000	127.5	70,000	ns	14
	Average periodic refresh interval	t <sub>REFI</sub>	TBD	TBD	200	7.8		7.8		7.8	µs	14
	Exit self refresh to non-read command	t <sub>XSNR</sub>	TBD	TBD	t <sub>RFC</sub> (MIN)+10		t <sub>RFC</sub> (MIN)+10		t <sub>RFC</sub> (MIN)+10		ns	
	Exit self refresh to read command	t <sub>XSRD</sub>	TBD	TBD	200		200		200		t <sub>CK</sub>	
	Exit self refresh timing reference	t <sub>ISXR</sub>	TBD	TBD	t <sub>IS</sub>		t <sub>IS</sub>		t <sub>IS</sub>		ps	6, 29
ODT	ODT turn-on delay	t <sub>AO<sub>ND</sub></sub>	TBD	TBD	2	2	2	2	2	2	t <sub>CK</sub>	
	ODT turn-on	t <sub>AO<sub>N</sub></sub>	TBD	TBD	t <sub>AC</sub> (MIN)	t <sub>AC</sub> (MAX)+700	t <sub>AC</sub> (MIN)	t <sub>AC</sub> (MAX)+1,000	t <sub>AC</sub> (MIN)	t <sub>AC</sub> (MAX)+1,000	ps	25
	ODT turn-off delay	t <sub>AO<sub>FD</sub></sub>	TBD	TBD	2.5	2.5	2.5	2.5	2.5	2.5	t <sub>CK</sub>	
	ODT turn-off	t <sub>AO<sub>F</sub></sub>	TBD	TBD	t <sub>AC</sub> (MIN)	t <sub>AC</sub> (MAX)+600	t <sub>AC</sub> (MIN)	t <sub>AC</sub> (MAX)+600	t <sub>AC</sub> (MIN)	t <sub>AC</sub> (MAX)+600	ps	26
	ODT turn-on (power-down mode)	t <sub>AO<sub>N</sub>PD</sub>	TBD	TBD	t <sub>AC</sub> (MIN)+2,000	2x t <sub>CK</sub> + t <sub>AC</sub> (MAX)+1,000	t <sub>AC</sub> (MIN)+2,000	2x t <sub>CK</sub> + t <sub>AC</sub> (MAX)+1,000	t <sub>AC</sub> (MIN)+2,000	2x t <sub>CK</sub> + t <sub>AC</sub> (MAX)+1,000	ps	
	ODT turn-off (power-down mode)	t <sub>AO<sub>F</sub>PD</sub>	TBD	TBD	t <sub>AC</sub> (MIN)+2,000	2x t <sub>CK</sub> + t <sub>AC</sub> (MAX)+1,000	t <sub>AC</sub> (MIN)+2,000	2x t <sub>CK</sub> + t <sub>AC</sub> (MAX)+1,000	t <sub>AC</sub> (MIN)+2,000	2x t <sub>CK</sub> + t <sub>AC</sub> (MAX)+1,000	t <sub>CK</sub>	
	ODT to power-down entry latency	t <sub>AN<sub>PD</sub></sub>	TBD	TBD	3		3		3		t <sub>CK</sub>	
	ODT power-down exit latency	t <sub>AX<sub>PD</sub></sub>	TBD	TBD	8		8		8		t <sub>CK</sub>	
Power-Down	Exit active power-down to READ command, MR[bit12=0]	t <sub>XARD</sub>	TBD	TBD	2		2		2		t <sub>CK</sub>	
	Exit active power-down to READ command, MR[bit12=1]	t <sub>XARDS</sub>	TBD	TBD	7-AL		6-AL		6-AL		t <sub>CK</sub>	
	Exit precharge power-down to any non-READ command.	t <sub>XP</sub>	TBD	TBD	2		2		2		t <sub>CK</sub>	
	CKE minimum high/low time	t <sub>CKE</sub>	TBD	TBD	3		3		3		t <sub>CK</sub>	34

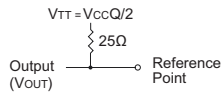
NOTE:

- AC specification is based on **MICRON** components. Other DRAM manufactures specification may be different.



## Notes

- All voltages referenced to  $V_{SS}$
- Tests for AC timing,  $I_{CC}$ , and electrical AC and DC characteristics may be conducted at nominal reference/supply voltage levels, but the related specifications and device operation are guaranteed for the full voltage range specified.
- Outputs measured with equivalent load:



- AC timing and  $I_{CC}$  tests may use a  $V_{IL}$  to  $V_{IH}$  swing of up to 1.0V in the test environment parameter specifications are guaranteed for the specified AC input levels under normal use conditions. The minimum slew rate for the input signals used to test the device is 1.0V/ns for signals in the range between  $V_{IL}$  (AC) and  $V_{IH}$  (AC). Slew rates less than 1.0V/ns require the timing parameters to be derated as specified.
- The AC and DC input level specifications are as defined in the SSTL\_18 standard (i.e., the receiver will effectively switch as a result of the signal crossing the AC input level and will remain in that state as long as the signal does not ring back above [below] the DC input LOW [HIGH] level).
- Command/Address minimum input slew rate is at 1.0V/ns. Command/Address input timing must be derated if the slew rate is not 1.0V/ns. This is easily accommodated using  $t_{SB}$  and the Setup and Hold Time Derating Values table.  $t_{SB}$  timing ( $t_{SB}$ ) is referenced from  $V_{IH}$  (AC) for a rising signal and  $V_{IL}$  (AC) for a falling signal.  $t_{IH}$  timing ( $t_{IH}$ ) is referenced from  $V_{IH}$  (AC) for a rising signal and  $V_{IL}$  (DC) for a falling signal. The timing table also lists the  $t_{SB}$  and  $t_{IH}$  values for a 1.0V/ns slew rate; these are the "base" values.
- Data minimum input slew rate is at 1.0V/ns. Data input timing must be derated if the slew rate is not 1.0V/ns. This is easily accommodated if the timing is referenced from the logic trip points.  $t_{DS}$  timing ( $t_{DS}$ ) is referenced from  $V_{IH}$  (AC) for a rising signal and  $V_{IL}$  (AC) for a falling signal.  $t_{IH}$  timing ( $t_{IH}$ ) is referenced from  $V_{IH}$  (DC) for a rising signal and  $V_{IL}$  (DC) for a falling signal. The timing table lists the  $t_{DS}$  and  $t_{IH}$  values for a 1.0V/ns slew rate. If the DQS/DQS# differential strobe feature is not enabled, timing is no longer referenced to the crosspoint of DQS/DQS#. Data timing is now referenced to  $V_{REF}$ , provided the DQS slew rate is not less than 1.0V/ns. If the DQS slew rate is less than 1.0V/ns, then data timing is now referenced to  $V_{IH}$  (AC) for a rising DQS and  $V_{IL}$  (DC) for a falling DQS.
- $t_{HZ}$  and  $t_{LZ}$  transitions occur in the same access time windows as valid data transitions. These parameters are not referenced to a specific voltage level, but specify when the device output is no longer driving (when the device output is no longer driving ( $t_{HZ}$ ) or begins driving ( $t_{LZ}$ )).
- This maximum value is derived from the referenced test load.  $t_{HZ}$  (MAX) will prevail over  $t_{DQSCK}$  (MAX) +  $t_{RPST}$  (MAX) condition.
- $t_{LZ}$  (MIN)  $t_{LZ}$  will prevail over a  $t_{DQSCK}$  (MIN) +  $t_{RPRE}$  (MAX) condition.
- The intent of the Don't Care state after completion of the postamble is the DQS-driven signal should either be high, low or

- High-Z and that any signal transition within the input switching region must follow valid input requirements. That is if DQS transitions high (above  $V_{IH}$  DC (MIN)) then it must not transition low (below  $V_{IH}$  (DC)) prior to  $t_{DQSH}$  (MIN).
- This is not a device limit. The device will operate with a negative value, but system performance could be degraded due to bus turn around.
- It is recommended that DQS be valid (HIGH or LOW) on or before the WRITE command. The case shown (DQS going from High-Z to logic LOW) applies when no WRITES were previously in progress on the bus. If a previous WRITE was in progress, DQS could be HIGH during this time, depending on  $t_{DQSS}$ .
- The refresh period is 64ms. This equates to an average refresh rate of 7.8125 $\mu$ s. However, a REFRESH command must be asserted at least once every 70.3 $\mu$ s or  $t_{RFC}$  (MAX). To ensure all rows of all banks are properly refreshed, 8192 REFRESH commands must be issued every 64ms.
- Each half-byte lane has a corresponding DQS.
- CK and CK# input slew rate must be  $\geq 1V/ns$  ( $\geq 2V/ns$  if measured differentially).
- The data valid window is derived by achieving other specifications -  $t_{HP}$  ( $t_{CK}/2$ ),  $t_{DQSQ}$ , and  $t_{QH}$  ( $t_{QH} = t_{HP} - t_{QHS}$ ). The data valid window derates in direct proportion to the clock duty cycle and a practical data valid window can be derived.
- MIN ( $t_{CL}$ ,  $t_{CH}$ ) refers to the smaller of the actual clock low time and the actual clock high time as provided to the device (i.e. This value can be greater than the minimum specification limits for  $t_{CL}$  and  $t_{CH}$ . For example,  $t_{CL}$  and  $t_{CH}$  are = 50 percent of the period, less the half period jitter [ $t_{JIT}$ (HP)] of the clock source, and less the half period jitter due to cross talk [ $t_{JIT}$ (cross talk)] into the clock traces.
- $t_{HP}$  (MIN) is the lesser of  $t_{CL}$  minimum and  $t_{CH}$  minimum actually applied to the device CK and CK# inputs.
- READs and WRITEs with auto precharge are allowed to be issued before  $t_{RAS}$  (MIN) is satisfied since  $t_{RAS}$  lockout feature is supported in DDR2 SDRAM devices.
- $V_{IL}/V_{IH}$  DDR2 overshoot/undershoot. REFER to the 512Mb DDR2 SDRAM data sheet for more detail.
- $t_{DAL} = (nWR) + (t_{RP}/t_{CK})$ : For each of the terms above, if not already an integer, round to the next highest integer.  $t_{CK}$  refers to the application clock period; nWR refers to the  $t_{WR}$  parameter stored in the MR[11,10,9]. Example: For 534 at  $t_{CK} = 3.75$  ns with  $t_{WR}$  programmed to four clocks.  $t_{DAL} = 4 + (15 \text{ ns}/3.75\text{ns}) \text{ clock} = 4 + (4) \text{ clocks} = 8 \text{ clocks}$ .
- The minimum READ to internal PRECHARGE time. This parameter is only applicable when  $(t_{RTP}/2*t_{CK}) > 1$ . If  $(t_{RTP}/2*t_{CK}) \leq 1$ , then equation AL + BL/2 applies. Notwithstanding,  $t_{RAS}$  (MIN) has to be satisfied as well. The DDR2 SDRAM device will automatically delay the internal PRECHARGE command until  $t_{RAS}$  (MIN) has been satisfied.
- Operating frequency is only allowed to change during self refresh mode, precharge power-down mode, and system reset condition.
- ODT turn-on time  $t_{AON}$  (MIN) is when the device leaves high impedance and ODT resistance begins to turn on. ODT turn-on time  $t_{AON}$  (MAX) is when the ODT resistance is fully on. Both are measured from  $t_{AOND}$ .



26. ODT turn-off time  $t_{AOF}$  (MIN) is when the device starts to turn off ODT resistance. ODT turn off time  $t_{AOF}$  (MAX) is when the bus is in high impedance. Both are measured from  $t_{AOFD}$ .
27. This parameter has a two clock minimum requirement at any  $t_{CK}$ .
28.  $t_{DELAY}$  is calculated from  $t_{IS} + t_{CK} + t_{IH}$  so that CKE registration LOW is guaranteed prior to CK, CK# being removed in a system RESET condition.
29.  $t_{ISXR}$  is equal to  $t_{IS}$  and is used for CKE setup time during self refresh exit.
30. No more than 4 bank ACTIVE commands may be issued in a given  $t_{FAW}$  (MIN) period.  $t_{RRRD}$  (MIN) restriction still applies. The  $t_{FAW}$  (MIN) parameter applies to all 8 bank DDR2 devices, regardless of the number of banks already open or closed.
31.  $t_{RPA}$  timing applies when the PRECHARGE(ALL) command is issued, regardless of the number of banks already open or closed. If a single-bank PRECHARGE command is issued,  $t_{RP}$  timing applies.  $t_{RPA}$  (MIN) applies to all 8-bank DDR2 devices.
32. Value is minimum pulse width, not the number of clock registrations.
33. Applicable to Read cycles only. Write cycles generally require additional time due to Write recovery time ( $t_{WR}$ ) during arto precharge.
34.  $t_{CKE}$  (MIN) of 3 clocks means CKE must be registered on three consecutive positive clock edges. CKE must remain at the valid input level the entire time it takes to achieve the 3 clocks of registration. Thus, after any CKE transition, CKE may not transition from its valid level during the time period of  $t_{IS} + 2 * t_{CK} + t_{IH}$ .
35. This parameter is not referenced to a specific voltage level, but specified when the device output is no longer driving ( $t_{RPST}$ ) or beginning to drive ( $t_{RPRE}$ ).
36. When DQS is used single-ended, the minimum limit is reduced by 100ps.



## ORDERING INFORMATION FOR AD7

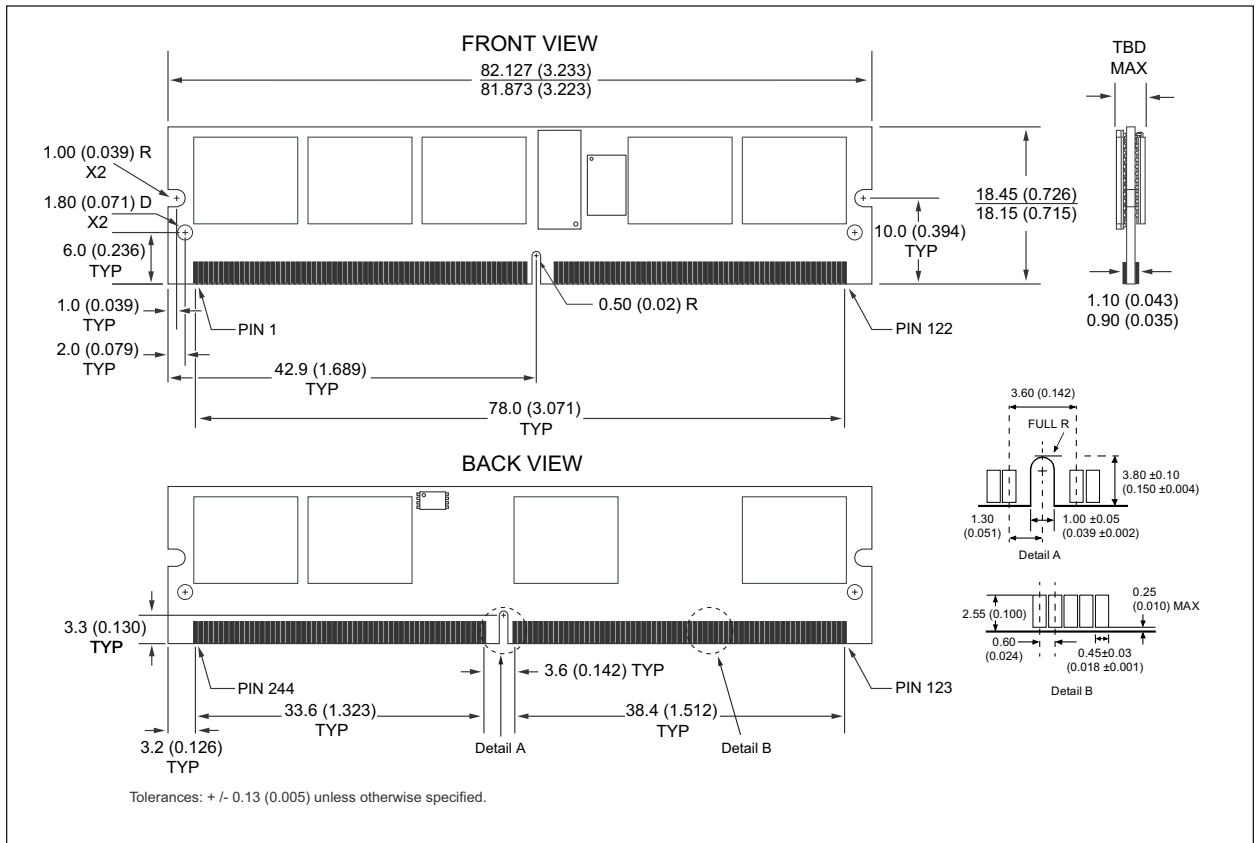
Part Number	Speed/Data Rate	CAS Latency	t <sub>RC</sub> D	t <sub>RP</sub>	Height*
W3HG264M72EER806AD7xG**	400MHz/800Mb/s	6	6	6	18.29mm (0.72")
W3HG264M72EER665AD7xG**	333MHz/667Mb/s	5	5	5	18.29mm (0.72")
W3HG264M72EER534AD7xG	266MHz/533Mb/s	4	4	4	18.29mm (0.72")
W3HG264M72EER403AD7xG	200MHz/400Mb/s	3	3	3	18.29mm (0.72")

\*\*Contact factory for availability.

### NOTES:

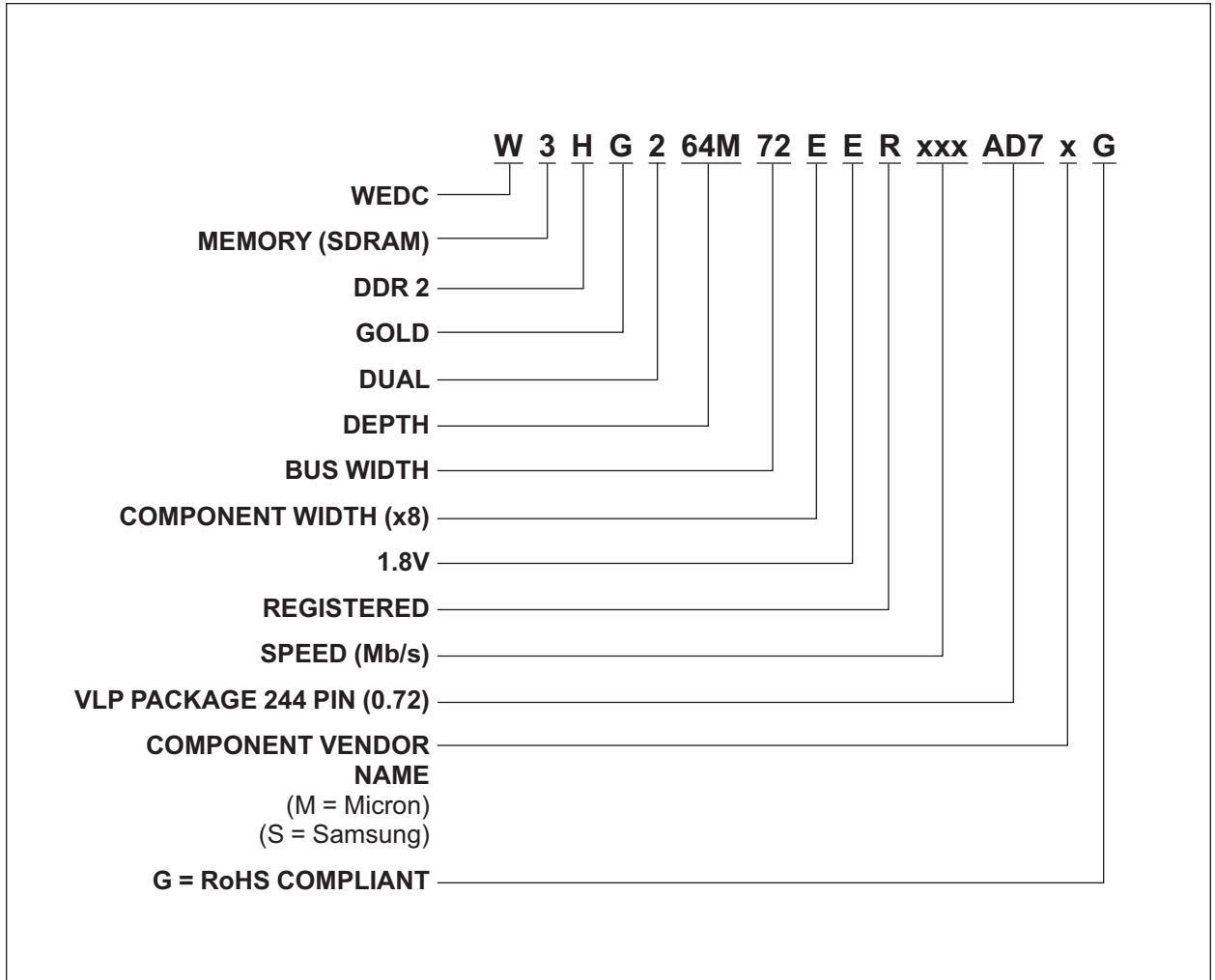
- RoHS product. ("G" = RoHS Compliant)
- Vendor specific part numbers are used to provide memory component source control. The place holder for this is shown as a lower case "x" in the part numbers above and is to be replaced with respective vendors code. Consult factory for qualified sourcing options. (M = Micron, S = Samsung & consult factory for others)
- Consult factory for availability of industrial temperature (-40°C to 85°C) option

## PACKAGE DIMENSIONS FOR VLP AD7





**PART NUMBERING GUIDE**





**Document Title**

1GB – 2x64Mx72 DDR2 SDRAM REGISTERED, w/PLL, VLP Mini-DIMM

**Revision History**

<b>Rev #</b>	<b>History</b>	<b>Release Date</b>	<b>Status</b>
Rev 0	Created	December 2005	Advanced