Enabling an Intelligent Planet

Advantech

AQD-SD4U16GE32-SE
Datasheet

Rev. 0.0

2020-07-23

Description

AQD-SD4U16GE32-SE is a DDR4 3200Mbps ECC SO-DIMM high-speed, memory module that use 18pcs of 1024M x 8 bits DDR4 SDRAM in FBGA package and a 4K bits serial EEPROM on a 260-pin printed circuit board. AQD-SD4U16GE32-SE is a Dual In-Line Memory Module and is intended for mounting into 260-pin edge connector sockets.

Synchronous design allows precise cycle control with the use of system clock. Data I/O transactions are possible on both edges of DQS. Range of operation frequencies, programmable latencies allow the same device to be useful for a variety of high bandwidth, high performance memory system applications.

Features

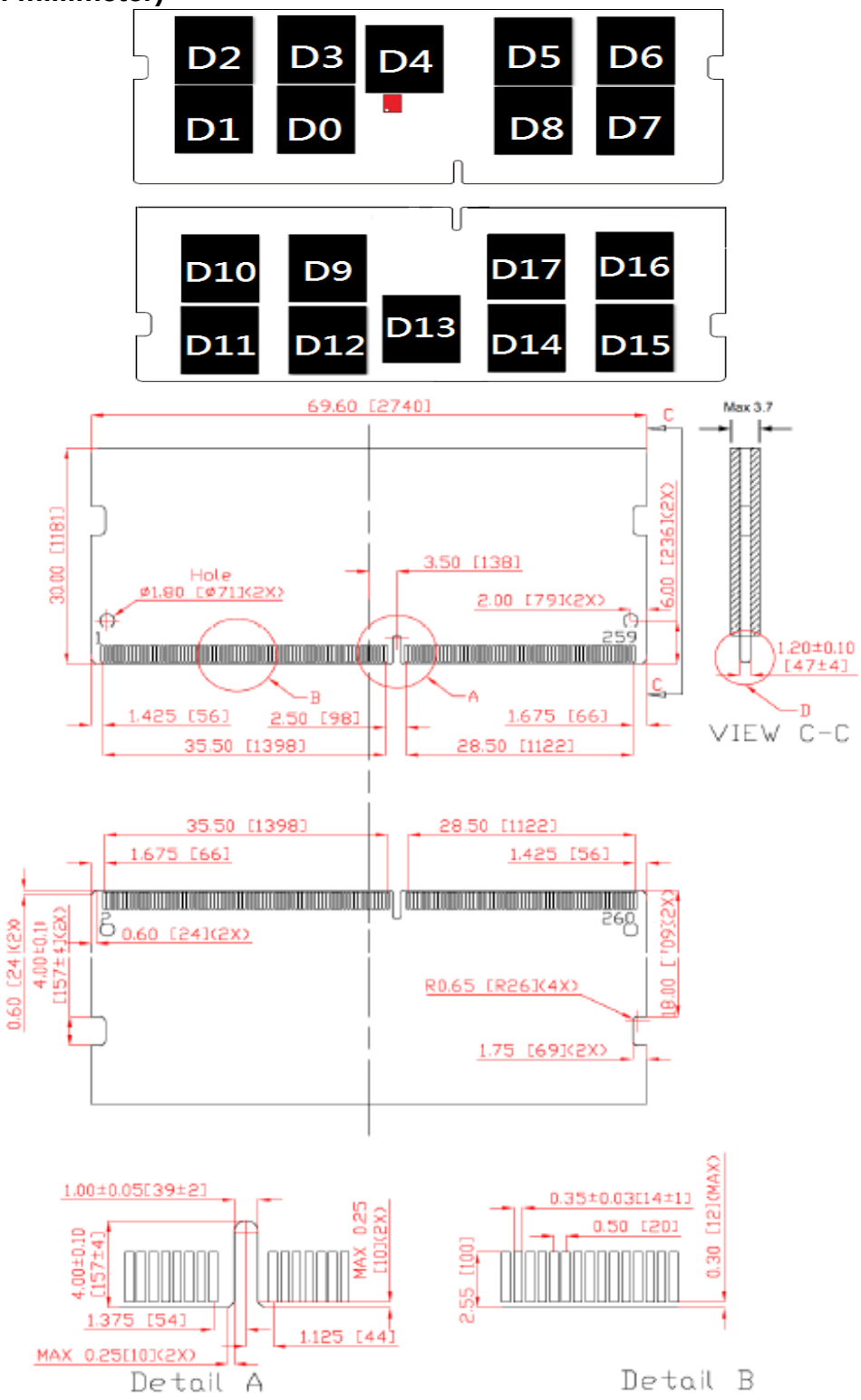
- RoHS compliant products.
- JEDEC standard 1.2V(1.14V~1.26V) Power supply
  VDDQ= 1.2V(1.14V~1.26V)
- VPP = 2.5V +0.25V / -0.125V
- Data transfer rates: PC4-3200
  Programmable CAS Latency:10~22
- 8 bit pre-fetch
- Burst Length (BL) switch on-the-fly BL8 or BC4
- Bi-directional Differential Data-Strobe
- On Die Termination, Nominal, Park, and Dynamic ODT
- Serial presence detect with EEPROM
  Asynchronous reset
  PCB edge connector treated with 30u" Gold-Plating
- Anti - sulfur resistor used

Pin Identification

Symbol	Function
A0–A17[1], BA0~BA1	Address/Bank input
DQ0~DQ63	Bi-direction data bus.
DQS0_t–DQS17_t	Data Buffer data strobes
DQS0_c–DQS17_c	Data Buffer data strobes
CK0_t, CK1_t	Register clock input
CK0_c, CK1_c	Registert clocks input
ODT0 &ODT1	On-die termination control line
CS0_n–CS3_n	DIMM Rank Select Lines input.
RAS_n[2]	Row address strobe
CAS_n[3]	Column address strobe
WE_n[4]	Write Enable
DM0~DM7	Data masks/high data strobes
VDD	Core power supply
VDDQ	I/O driver power supply
V_{REF}CA	Command/address reference supply
V_{DD}SPD	SPD EEPROM power supply
SA0~SA2	I2C serial bus address select for EEPROM
SCL	I2C serial bus clock for EEPROM
SDA	I2C serial bus data for EEPROM
VSS	Ground
RESET_n	Set DRAMs Known State
VTT	DRAM I/O termination supply
VPP	SDRAM Supply
ALERT_n	Register ALERT_n output
EVENT_n	SPD signals a thermal event has occurred
RFU	Reserved for future use

1. Address A17 is only valid for 16 Gb x4 based SDRAMs.
2. RAS_n is a multiplexed function with A16.
3. CAS_n is a multiplexed function with A15.
4. WE_n is a multiplexed function with A14.

Dimensions (Unit: millimeter)

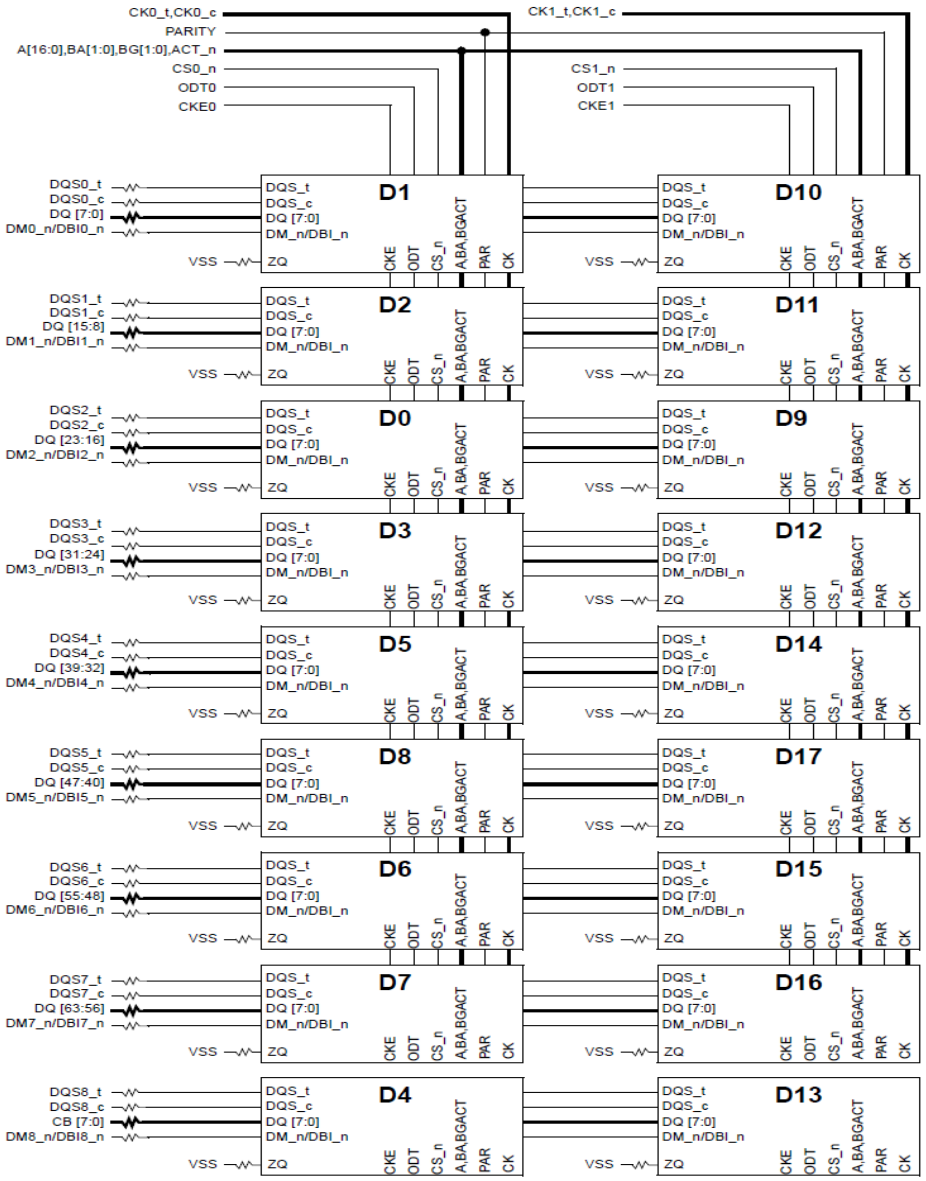


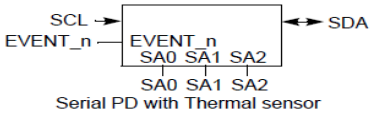
Note:1. Tolerances on all dimensions +/-0.15mm unless otherwise specified.

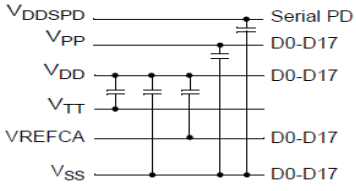
Pin Assignments

Pin	Front	Pin	Front	Pin	Front	Pin	Back	Pin	Back	Pin	Back	Pin	Back
1	12V	41	DQ10	81	VSS	121	A9	161	ODT1	201	VSS	241	D M7_n/D BI7_n
2	VSS	42	DQ11	82	VSS	122	A7	162	C0,CS2_n,NC	202	VSS	242	DQS7_t
3	DQ5	43	VSS	83	DQ26	123	VSS	163	VDD	203	DQ46	243	VSS
4	DQ4	44	VSS	84	DQ27	124	DQ54	164	VREFCA	204	DQ47	244	VSS
5	VSS	45	DQ21	85	VSS	125	VSS	165	C1,CS3_n,NC	205	VSS	245	DQ62
6	VSS	46	DQ20	86	VSS	126	DQ50	166	SA2	206	VSS	246	DQ63
7	DQ1	47	VSS	87	CB5, NC	127	VSS	167	VSS	207	DQ42	247	VSS
8	DQ0	48	VSS	88	CB4, NC	128	DQ60	168	VSS	208	DQ43	248	VSS
9	VSS	49	DQ17	89	VSS	129	VDD	169	DQ37	209	VSS	249	DQ58
10	VSS	50	DQ16	90	VSS	130	VDD	170	DQ36	210	VSS	250	DQ59
11	DQ S0_c	51	VSS	91	CB1, NC	131	A3	171	VSS	211	DQ52	251	VSS
12	D M0_n/D BI0_n, NC	52	VSS	92	CB0, NC	132	A2	172	VSS	212	DQ53	252	VSS
13	DQS0_t	53	DQ S2_c	93	VSS	133	A1	173	DQ33	213	VSS	253	SCL
14	VSS	54	D M2_n/D BI2_n, NC	94	VSS	134	EVENT_n	174	DQ32	214	VSS	254	SDA
15	VSS	55	DQS2_t	95	DQ S8_c	135	VDD	175	VSS	215	DQ49	255	VDDSPD
16	DQ6	56	VSS	96	D M8_n/D BI8_n, NC	136	VDD	176	VSS	216	DQ48	256	SA0
17	DQ7	57	VSS	97	DQ S8_t	137	CK0_t	177	DQS4_c	217	VSS	257	VPP
18	VSS	58	DQ22	98	VSS	138	CK1_t	178	D M4_n/D BI4_n	218	VSS	258	VTT
19	VSS	59	DQ23	99	VSS	139	CK0_c	179	DQS4_t	219	DQS6_c	259	VPP
20	DQ2	60	VSS	100	CB6, NC	140	CK1_c	180	VSS	220	D M6_n/D BI6_n, NC	260	SA1
21	DQ3	61	VSS	101	CB2, NC	141	VDD	181	VSS	221	DQS6_t		
22	VSS	62	DQ18	102	VSS	142	VDD	182	DQ39	222	VSS		
23	VSS	63	DQ19	103	VSS	143	PARITY	183	DQ38	223	VSS		
24	DQ12	64	VSS	104	CB7, NC	144	A0	184	VSS	224	DQ54		
25	DQ13	65	VSS	105	CB3, NC	145	BA1	185	VSS	225	DQ55		
26	VSS	66	DQ28	106	VSS	146	A10/AP	186	DQ35	226	VSS		
27	VSS	67	DQ29	107	VSS	147	VDD	187	DQ34	227	VSS		
28	DQ8	68	VSS	108	RESET_n	148	VDD	188	VSS	228	DQ50		
29	DQ9	69	VSS	109	CKE0	149	CS0_n	189	VSS	229	DQ51		
30	VSS	70	DQ24	110	CKE1	150	BA0	190	DQ45	230	VSS		
31	VSS	71	DQ25	111	VDD	151	A14/WE_n	191	DQ44	231	VSS		
32	DQ S1_c	72	VSS	112	VDD	152	A16/RAS_n	192	VSS	232	DQ60		
33	D M1_n/D BI1_n, NC	73	VSS	113	BG1	153	VDD	193	VSS	233	DQ61		
34	DQS1_t	74	DQ S3_c	114	ACT_n	154	VDD	194	DQ41	234	VSS		
35	VSS	75	D M3_n/D BI3_n, NC	115	BG0	155	ODT0	195	DQ40	235	VSS		
36	VSS	76	DQ S3_t	116	ALERT_n	156	A15/CAS_n	196	VSS	236	DQ57		
37	DQ15	77	VSS	117	VDD	157	CS1_n	197	VSS	237	DQ56		
38	DQ14	78	VSS	118	VDD	158	A13	198	DQS5_c	238	VSS		
39	VSS	79	DQ30	119	A12	159	VDD	199	D M5_n/D BI5_n	239	VSS		
40	VSS	80	DQ31	120	A11	160	VDD	200	VSS	240	DQS7_c		

16GB, 1024Mx18 Module (2 Rank x8)







- This technical information is based on industry standard data and tests believed to be reliable. However, Advantech makes no warranties, either expressed or implied, as to its accuracy and assume no liability in connection with the use of this product. Advantech reserves the right to make changes in specifications at any time without prior notice.

Operating Temperature Condition

Parameter	Symbol	Rating	Unit	Note
Operating Temperature	TOPER	0 to 85	°C	1,2

Note: Operating Temperature is the case surface temperature on the center/top side of the DRAM. For the measurement conditions, please refer to JESD51-2 standard.

Absolute Maximum DC Ratings

Parameter	Symbol	Value	Unit	Note
Voltage on V_{DD} relative to Vss	VDD	-0.3 ~ 1.5	V	1
Voltage on V_{DDQ} pin relative to Vss	VDDQ	-0.3 ~ 1.5	V	1
Voltage on any pin relative to Vss	VIN, VOUT	-0.3 ~ 1.5	V	1
Storage temperature	T_{STG}	-55~+100	°C	1,2

Note:
1. Stress greater than those listed under “Absolute Maximum Ratings” may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect reliability.
2. Storage Temperature is the case surface temperature on the center/top side of the DRAM. For the measurement conditions, please refer to JESD51-2 standard.

AC & DC Operating Conditions

Recommended DC operating conditions

Parameter	Symbol	Voltage	Rating			Unit	Notes
			Min	Typ.	Max		
Supply voltage	VDD	1.2V	1.14	1.2	1.26	V	1,2,3
Supply voltage for Output	VDDQ	1.2V	1.14	1.2	1.26	V	1,2,3
I/O Reference Voltage (DQ)	$VREF_{DQ}$(DC)	1.2V	0.49*VDD	0.50*VDD	0.51*VDD	V	4
I/O Reference Voltage (CMD/ADD)	$VREF_{CA}$(DC)	1.2V	0.49*VDD	0.50*VDD	0.51*VDD	V	4
AC Input Logic High	VIH(AC)	1.2V	VREF+90	-	VDD^2	mV	
AC Input Logic Low	VIL(AC)	1.2V	VSS^2	-	VREF–90	mV	
DC Input Logic High	VIH(DC)	1.2V	VREF+65	-	VDD	mV	
DC Input Logic Low	VIL(DC)	1.2V	VSS	-	VREF-65	mV	

Note:
(1) Under all conditions VDDQ must be less than or equal to VDD.
(2) VDDQ tracks with VDD. AC parameters are measured with VDD and VDDQ tied together.
(3) The DC bandwidth is limited to 20MHz.
(4) The AC peak noise on VREF may not allow VREF to deviate from VREF(DC) by more than ±1% VDD (for reference: approx. ±12mV)

IDD Specification parameters Definition - 16GB (2 Rank x8)

Parameter	Symbol	DDR4 3200 CL22	Unit
One bank ACTIVATE-PRECHARGE current	IDD0[1]	459	mA
One bank ACTIVATE-PRECHARGE, wordline boost, IPP current	IPP0[1]	72	mA
One Bank Active-Read-Precharge Current	IDD1[1]	423	mA
Precharge Standby Current	IDD2N[2]	360	mA
Precharge standby ODT current	IDD2NT[1]	315	mA
Precharge Power-Down Current	IDD2P[2]	234	mA
Precharge Quiet Standby Current	IDD2Q[2]	360	mA
Active standby current	IDD3N[2]	540	mA
Active standby IPP current	IPP3N[2]	72	mA
Active Power-Down Current	IDD3P[2]	378	mA
Burst Read Current	IDD4R[1]	1152	mA
Burst write current	IDD4W[1]	1071	mA
Burst refresh current (1x REF)	IDD5B[1]	2187	mA
Burst refresh IPP current (1x REF)	IPP5B[1]	261	mA
Self refresh current: Normal temperature range (0–85°C)	IDD6N[2]	378	mA
Self refresh current: Extended temperature range (0–95°C)	IDD6E[2]	576	mA
Bank interleave read current	IDD7[1]	1539	mA
Bank interleave read IPP current	IPP7[1]	135	mA
Maximum power-down current	IDD8[2]	198	mA

Note: 1. One module rank in the active IDD/PP, the other rank in IDD2P/PP3N.
2. All ranks in this IDD/PP condition.
3.IDD current measure method and detail patterns are described on DDR4 component datasheet. Only for reference.

■ Timing Parameters & Specifications

Parameter		Symbol	DDR4-2400		DDR4-2666		DDR4-2933		DDR4-3200		Unit	Notes
			Min	Max	Min	Max	Min	Max	Min	Max		
Clock Timing												
Clock period average(DLL off mode)		tCK(DLL_OFF)	8	20	8	20	8	20	8	20	ns	
Clock period average		tCK(AVG) (DLL_ON)	0.833	<0.938	0.75	<0.833	0.682	<0.75	0.625	<0.682	ns	14
High pulse width average		tCH (AVG)	0.48	0.52	0.48	0.52	0.48	0.52	0.48	0.52	tCK(AVG)	
Low pulse width average		tCL (AVG)	0.48	0.52	0.48	0.52	0.48	0.52	0.48	0.52	tCK(AVG)	
Clock period jitter	Total	tJITper_tot	–42	42	–38	38	–34	34	–32	32	ps	18 , 19
	Deterministic	tJITper_dj	–21	21	–19	19	–17	17	–16	16	ps	18
	DLL locking	tJITper,lck	–33	33	–30	30	–27	27	–25	25	ps	
Clock absolute period		tCK (ABS)	MIN = tCK (AVG) MIN + tJITper_tot MIN; MAX = tCK (AVG) MAX + tJITper_tot MAX								ps	
Clock absolute high pulse width(includes duty cycle jitter)		tCH (ABS)	0.45	–	0.45	–	0.45	–	0.45	–	tCK(AVG)	
Clock absolute low pulse width(includes duty cycle jitter)		tCL (ABS)	0.45	–	0.45	–	0.45	–	0.45	–	tCK(AVG)	
Cycle-to-cycle jitter	Total	tJITcc _tot	–	83	–	75	–	68	–	62	ps	
	DLL locking	tJITcc,lck	–	67	–	60	–	55	–	50	ps	
Cumulative error across	2 cycles	tERR2per	–61	61	–55	55	–50	50	–46	46	ps	
	3 cycles	tERR3per	–73	73	–66	66	–60	60	–55	55	ps	
	4 cycles	tERR4per	–81	81	–73	73	–66	66	–61	61	ps	
	5 cycles	tERR5per	–87	87	–78	78	–71	71	–65	65	ps	
	6 cycles	tERR6per	–92	92	–83	83	–75	75	–69	69	ps	
	7 cycles	tERR7per	–97	97	–87	87	–79	79	–73	73	ps	
	8 cycles	tERR8per	–101	101	–91	91	–83	83	–76	76	ps	
	9 cycles	tERR9per	–104	104	–94	94	–85	85	–78	78	ps	
	10 cycles	tERR10per	–107	107	–96	96	–88	88	–80	80	ps	
	11 cycles	tERR11per	–110	110	–99	99	–90	90	–83	83	ps	
	12 cycles	tERR12per	–112	112	–101	101	–92	92	–84	84	ps	
	n=13,14…49, 50cycles	tERRnper	tERRnper MIN = (1 + 0.68ln[n]) × tJITper_tot MIN tERRnper MAX = (1 + 0.68ln[n]) × tJITper_tot MAX								ps	

Parameter		Symbol	DDR4-2400		DDR4-2666		DDR4-2933		DDR4-3200		Unit	Notes
			Min	Max	Min	Max	Min	Max	Min	Max		
DQ Input Timing												
Data setup time to DQS_t, DQS_c	Base(calibrated V_{REF})	tDS	Refer to DQ Input Receiver Specification section (approximately 0.15tCK to 0.28tCK)								–	
	Noncalibrated V_{REF}	tPDA_S	minimum of 0.5UI								UI	23
Data hold time from DQS_t, DQS_c	Base(calibrated V_{REF})	tDS	Refer to DQ Input Receiver Specification section (approximately 0.15tCK to 0.28tCK)								–	
	Noncalibrated V_{REF}	tPDA_S	minimum of 0.5UI								UI	23
DQ and DM minimum data pulse width for each input		tDIPW	0.58	–	0.58	–	0.58	–	0.58	–	UI	
DQ Output Timing (DLL enabled)												
DQS_t, DQS_c to DQ skew, per group, per access		tDQSQ	–	0.17	–	0.18	–	0.19	–	0.22	UI	
DQ output hold time from DQS_t, DQS_c		tQH	0.74	–	0.74	–	0.74	–	0.74	–	UI	
Data Valid Window per device: tQH -tDQSQ each device's output per UI		tDVWd	0.64	–	0.64	–	0.64	–	0.64	–	UI	
Data Valid Window per device, per pin: tQH - tDQSQ each device's output per UI		tDVWp	0.72	–	0.72	–	0.72	–	0.72	–	UI	
DQ Low-Z time from CK_t, CK_c		tLZDQ	–330	175	–310	170	–280	165	–250	160	ps	
DQ High-Z time from CK_t, CK_c		tHZDQ	–	175	–	170	–	165	–	160	ps	
DQ Strobe Input Timing												
DQS_t, DQS_c rising edge to CK_t, CK_c rising edge for 1tCKpreamble		$tDQSS_{1ck}$	–0.27	0.27	–0.27	0.27	–0.27	0.27	–0.27	0.27	CK	
DQS_t, DQS_c rising edge to CK_t, CK_c rising edge for 2tCKpreamble		$tDQSS_{2ck}$	–0.50	0.50	–0.50	0.50	–0.50	0.50	–0.50	0.50	CK	
DQS_t, DQS_c differential input low pulse width		tDQSL	0.46	0.54	0.46	0.54	0.46	0.54	0.46	0.54	CK	

Parameter	Symbol	DDR4-2400		DDR4-2666		DDR4-2933		DDR4-3200		Unit	Notes
		Min	Max	Min	Max	Min	Max	Min	Max		
DQ Strobe Input Timing											
DQS_t, DQS_c differential input high pulse width	tDQSH	0.46	0.54	0.46	0.54	0.46	0.54	0.46	0.54	CK	
DQS_t, DQS_c falling edge setup to CK_t, CK_c rising edge	tDSS	0.18	–	0.18	–	0.18	–	0.18	–	CK	
DQS_t, DQS_c falling edge hold from CK_t, CK_c rising edge	tDSH	0.18	–	0.18	–	0.18	–	0.18	–	CK	
DQS_t, DQS_c differential WRITE preamble for 1tCKpreamble	$tWPRE_{1ck}$	0.9	–	0.9	–	0.9	–	0.9	–	CK	
DQS_t, DQS_c differential WRITE preamble for 2tCKpreamble	$tWPRE_{2ck}$	1.8	–	1.8	–	1.8	–	1.8	–	CK	
DQS_t, DQS_c differential WRITE postamble	tWPST	0.33	–	0.33	–	0.33	–	0.33	–	CK	
DQS Strobe Output Timing (DLL enabled)											
DQS_t, DQS_c rising edge output access time from rising CK_t, CK_c	tDQSCK	–175	175	–170	170	–165	165	–160	160	ps	
DQS_t, DQS_c rising edge output variance window per DRAM	tDQSCKi	–	290	–	270	–	265	–	260	ps	
DQS_t, DQS_c differential output high time	tQSH	0.4	–	0.4	–	0.4	–	0.4	–	CK	
DQS_t, DQS_c differential output low time	tQSL	0.4	–	0.4	–	0.4	–	0.4	–	CK	
DQS_t, DQS_c Low-Z time (RL - 1)	tLZDQS	–330	175	–310	170	–280	165	–250	160	ps	
DQS_t, DQS_c High-Z time (RL + BL/2)	tHZDQS	–	175	–	170	–	165	–	160	ps	
DQS_t, DQS_c differential READ preamble for 1tCKpreamble	$tRPRE_{1ck}$	0.9	–	0.9	–	0.9	–	0.9	–	CK	
DQS_t, DQS_c differential READ preamble for 2tCKpreamble	$tRPRE_{2ck}$	1.8	–	1.8	–	1.8	–	1.8	–	CK	
DQS_t, DQS_c differential READ postamble	tRPST	0.33	–	0.33	–	0.33	–	0.33	–	CK	

Parameter		Symbol	DDR4-2400		DDR4-2666		DDR4-2933		DDR4-3200		Unit	Notes
			Min	Max	Min	Max	Min	Max	Min	Max		
Command and Address Timing												
DLL locking time		tDLLK	768	–	1024	–	1024	–	1024	–	CK	2, 4
CMD, ADDR setup time	Base	tIS	62	–	55	–	48	–	40	–	ps	
to CK_t, CK_c Base referenced to $V_{IH(AC)}$ and $V_{IL(AC)}$ levels	V_{REFCA}	tISVREF	162	–	145	–	138	–	130	–	ps	
CMD, ADDR hold time to	Base	tIH	87	–	80	–	73	–	65	–	ps	
CK_t, CK_c Base referenced to $V_{IH(DC)}$ and $V_{IL(DC)}$ levels	V_{REFCA}	tIHVREF	162	–	145	–	138	–	130	–	ps	
CTRL, ADDR pulse width for each input		tIPW	410	–	385	–	365	–	340	–	ps	
ACTIVATE to internal READ or WRITE delay		tRCD	14.16	–	14.25	–	14.32	–	13.75	–	ns	
PRECHARGE command period		tRP	14.16	–	14.25	–	14.32	–	13.75	–	ns	
ACTIVATE-to-PRECHARGE command period		tRAS	32	9 × tREFI	32	9 × tREFI	32	9 × tREFI	32	9 × tREFI	ns	13
ACTIVATE-to-ACTIVATE or REF command period		tRC	46.16	–	46.25	–	46.32	–	45.75	–	ns	13
ACTIVATE-to-ACTIVATE command period to different bank groups for 1/2KB page size		tRRD_S (1/2KB)	MIN = greater of 4CK or 3.3ns		MIN = greater of 4CK or 3.0ns		MIN = greater of 4CK or 2.7ns		MIN = greater of 4CK or 2.5ns		CK	1
ACTIVATE-to-ACTIVATE command period to different bank groups for 1KB page size		tRRD_S (1KB)	MIN = greater of 4CK or 3.3ns		MIN = greater of 4CK or 3.0ns		MIN = greater of 4CK or 2.7ns		MIN = greater of 4CK or 2.5ns		CK	1
ACTIVATE-to-ACTIVATE command period to different bank groups for 2KB page size		tRRD_S (2KB)	MIN = greater of 4CK or 5.3ns		MIN = greater of 4CK or 5.3ns		MIN = greater of 4CK or 5.3ns		MIN = greater of 4CK or 5.3ns		CK	1
ACTIVATE-to-ACTIVATE command period to same bank groups for 1/2KB page size		tRRD_L (1/2KB)	MIN = greater of 4CK or 4.9ns		MIN = greater of 4CK or 4.9ns		MIN = greater of 4CK or 4.9ns		MIN = greater of 4CK or 4.9ns		CK	1

Parameter	Symbol	DDR4-2400		DDR4-2666		DDR4-2933		DDR4-3200		Unit	Notes
		Min	Max	Min	Max	Min	Max	Min	Max		
Command and Address Timing											
ACTIVATE-to-ACTIVATE command period to same bank groups for 1KB page size	tRRD_L (1KB)	MIN = greater of 4CK or 4.9ns		MIN = greater of 4CK or 4.9ns		MIN = greater of 4CK or 4.9ns		MIN =greater of 4CK or 4.9ns		CK	1
ACTIVATE-to-ACTIVATE command period to same bank groups for 2KB page size	tRRD_L (2KB)	MIN = greater of 4CK or 6.4ns		MIN = greater of 4CK or 6.4ns		MIN = greater of 4CK or 6.4ns		MIN =greater of 4CK or 6.4ns		CK	1
Four ACTIVATE windows for 1/2KB page size	tFAW (1/2KB)	MIN = greater of 16CK or 13ns		MIN = greater of 16CK or 12ns		MIN = greater of 16CK or 10.875ns		MIN =greater of 16CK or 10ns		ns	
Four ACTIVATE windows for 1KB page size	tFAW (1KB)	MIN = greater of 20CK or 21ns		MIN = greater of 20CK or 21ns		MIN = greater of 20CK or 21ns		MIN =greater of 20CK or 21ns		ns	
Four ACTIVATE windows for 2KB page size	tFAW (2KB)	MIN = greater of 28CK or 30ns		MIN = greater of 28CK or 30ns		MIN = greater of 28CK or 30ns		MIN =greater of 28CK or 30ns		ns	
Command and Address Timing											
WRITE recovery time	tWR	MIN = 15ns								ns	5, 10, 1
	tWR2	MIN = 1CK + tWR								CK	5, 11, 1
WRITE recovery time when CRC and DM are both enabled	tWR_CRC_DM	MIN = tWR + greater of (5CK or 3.75ns)								CK	6, 10, 1
	tWR_CRC_DM2	MIN = 1CK + tWR_CRC_DM								CK	6, 11, 1
Delay from start of internal WRITE transaction to internal READ command – Same bank group	tWTR_L	MIN = greater of 4CK or 7.5ns								CK	5, 10, 1
	tWTR_L2	MIN = 1CK + tWTR_L								CK	5, 11, 1
Delay from start of internal WRITE transaction to internal READ command – Same bank group when CRC and DM are both enabled	tWTR_L_CRC_DM	MIN = tWTR_L + greater of (5CK or 3.75ns)								CK	6, 10, 1
	tWTR_L_CRC_DM2	MIN = 1CK + tWTR_L_CRC_DM								CK	6, 11, 1

Parameter	Symbol	DDR4-2400		DDR4-2666		DDR4-2933		DDR4-3200		Unit	Notes
		Min	Max	Min	Max	Min	Max	Min	Max		
Command and Address Timing											
Delay from start of internal WRITE transaction to internal READ command – Different bank group	tWTR_S	MIN = greater of (2CK or 2.5ns)								CK	5, 7, 8, 10, 1
	tWTR_S2	MIN = 1CK + tWTR_S								CK	5, 7, 8, 11, 1
Delay from start of internal WRITE transaction to internal READ command – Different bank group when CRC and DM are both enabled	tWTR_S_CRC_DM	MIN = tWTR_S + greater of (5CK or 3.75ns)								CK	6, 7, 8, 10, 1
	tWTR_S_CRC_DM2	MIN = 1CK + tWTR_S_CRC_DM								CK	6, 7, 8, 11, 1
READ-to-PRECHARGE time	tRTP	MIN = greater of 4CK or 7.5ns								CK	1
CAS_n-to-CAS_n command delay to different bank group	tCCD_S	4	–	4	–	4	–	4	–	CK	
CAS_n-to-CAS_n command delay to samebank group	tCCD_L	MIN = greater of 5CK or 5ns	–	MIN = greater of 5CK or 5ns	–	MIN = greater of 5CK or 5ns	–	MIN = greater of 5CK or 5ns	–	CK	15
Auto precharge write recovery + precharge time	tDAL (MIN)	MIN = WR + ROUNDUPtRP/tCK (AVG); MAX = N/A								CK	
MRS Command Timing											
MRS command cycle time	tMRD	8	–	8	–	8	–	8	–	CK	
MRS command cycle time in PDA mode	tMRD_PDA	MIN = greater of (16nCK, 10ns)									1
MRS command cycle time in CAL mode	tMRD_CAL	MIN = tMOD + tCAL								CK	
MRS command update delay	tMOD	MIN = greater of (24nCK, 15ns)								CK	1
MRS command update delay in PDA mode	tMOD_PDA	MIN = tMOD								CK	
MRS command update delay in CAL mode	tMOD_CAL	MIN = tMOD + tCAL CK								CK	

Parameter	Symbol	DDR4-2400		DDR4-2666		DDR4-2933		DDR4-3200		Unit	Notes
		Min	Max	Min	Max	Min	Max	Min	Max		
MRS Command Timing											
MRS command to DQS drive in preamble training	tSDO	MIN = tMOD + 9ns								CK	
MPR Command Timing											
Multipurpose register recovery time	tMPRR	MIN = 1CK								CK	
Multipurpose register write recovery time	tWR_MPRR	MIN = tMOD + AL + PL									
CRC Error Reporting Timing											
CRC error to ALERT_n latency	tCRC_ALERT	3	13	3	13	3	13	3	13	ns	
CRC ALERT_n pulse width	tCRC_ALERT_PW	6	10	6	10	6	10	6	10	CK	
CA Parity Timing											
Parity latency	PL	5	–	5	–	6	–	6	–	CK	
Commands uncertain to be executed during this time	tPAR_UNKNOWN	–	PL	–	PL	–	PL	–	PL	CK	
Delay from errant command to ALERT_n assertion	tPAR_ALERT_ON	–	PL + 6ns	–	PL + 6ns	–	PL + 6ns	–	PL + 6ns	CK	
Pulse width of ALERT_n signal when asserted	tPAR_ALERT_PW	72	144	80	160	88	176	96	192	CK	
Time from alert asserted until DES command srequired in persistent CA paritymode	tPAR_ALERT_RSP	–	64	–	71	–	78	–	85	CK	
CAL Timing											
CS_n to command address latency	tCAL	5	–	5	–	6	–	6	–	CK	20
CS_n to command address latency in gear-down mode	tCALg	N/A	–	6	–	8	–	8	–	CK	
MPSM Timing											
Command path disable delay upopn MPSM entry	tMPED	MIN = tMOD (MIN) + tCPDED (MIN)								CK	1
Valid clock requirement after MPSM entry	tCKMPE	MIN = tMOD (MIN) + tCPDED (MIN)								CK	1
Valid clock requirement before MPSM	tCKMPX	MIN = tCKSRX (MIN)								CK	1

Parameter		Symbol	DDR4-2400		DDR4-2666		DDR4-2933		DDR4-3200		Unit	Notes
			Min	Max	Min	Max	Min	Max	Min	Max		
MPSM Timing												
Exit MPSM to commands not requiring a locked DLL		tXMP	tXS (MIN)								CK	
Exit MPSM to commands requiring a locked DLL		tXMPDLL	MIN = tXMP (MIN) + tXSDLL (MIN)								CK	1
CS setup time to CKE		tMPX_S	MIN = tIS (MIN) + tIH (MIN)								ns	
CS_n HIGH hold time to CKE rising edge		tMPX_HH	MIN = tXP								ns	
CS_n LOW hold time to CKE rising edge		tMPX_LH	12	tXMP -10ns	12	tXMP -10ns	12	tXMP -10ns	12	tXMP -10ns	ns	
Connectivity Test Timing												
TEN pin HIGH to CS_n LOW – Enter CT mode		tCT_Enable	200	–	200	–	200	–	200	–	ns	
CS_n LOW and valid input to valid output		tCT_Valid	–	200	–	200	–	200	–	200	ns	
CK_t, CK_c valid and CKE HIGH after TEN goes HIGH		tCTCKE_Valid	10	–	10	–	10	–	10	–	ns	
Calibration and VREFDQ Train Timing												
ZQCL command: Long calibration time	POWER-UP and RESET operation	tZQinit	1024	–	1024	–	1024	–	1024	–	CK	
	Normal operation	tZQoper	512	–	512	–	512	–	512	–	CK	
ZQCS command: Short calibration time		tZQCS	128	–	128	–	128	–	128	–	CK	
The VREF increment/decrement step time		VREF_time	MIN = 150ns									
Enter VREFDQ training mode to the first write or VREFDQ MRS command delay		tVREFDQE	MIN = 150ns								ns	1
Exit VREFDQ training mode to the first WRITE command delay		tVREFDQX	MIN = 150ns								ns	1

Parameter		Symbol	DDR4-2400		DDR4-2666		DDR4-2933		DDR4-3200		Unit	Notes
			Min	Max	Min	Max	Min	Max	Min	Max		
Initialization and Reset Timing												
Exit reset from CKE HIGH to a valid command		tXPR	MIN = greater of 5CK or tRFC (MIN) + 10ns								CK	1
RESET_L pulse low after power stable		tPW_REST_S	1.0	–	1.0	–	1.0	–	1.0	–	µs	
RESET_L pulse low at power-up		PW_REST_L	200	–	200	–	200	–	200	–	µs	
Begin power supply ramp to power supplies stable		tVDDPR	MIN = N/A; MAX = 200								ms	
RESET_n LOW to power supplies stable		tRPS	MIN = 0; MAX = 0								ns	
RESET_n LOW to I/O and RTT High-Z		tIOZ	MIN = N/A; MAX = undefined								ns	
Refresh Timing												
REFRESH-to-ACTIVATE or REFRESH command period (all bank groups)	4Gb	tRFC1	MIN = 260								ns	1, 12
		tRFC2	MIN = 160								ns	1, 12
		tRFC4	MIN = 110								ns	1, 12
	8Gb	tRFC1	MIN = 350								ns	1, 12
		tRFC2	MIN = 260								ns	1, 12
		tRFC4	MIN = 160								ns	1, 12
	16Gb	tRFC1	MIN = 550								ns	1, 12
		tRFC2	MIN = 350								ns	1, 12
		tRFC4	MIN = 260								ns	1, 12
Average periodic refresh interval	0°C≤TC≤ 85°C	tREFI	MIN = N/A; MAX = 7.8								ns	12
	85°C< TC≤95°C	tREFI	MIN = N/A; MAX = 3.9								µs	12
Self Refresh Timing												
Exit self refresh to commands not requiring a locked DLL SRX to commands not requiring a locked DLL in self refresh abort		tXS	MIN = tRFC + 10ns								ns	1
		tXS_ABORT	MIN = tRFC4 + 10ns								ns	1
Exit self refresh to ZQCL, ZQCS and MRS (CL, CWL, WR, RTP and gear-down)		tXS_FAST	MIN = tRFC4 + 10ns								ns	1

Parameter	Symbol	DDR4-2400		DDR4-2666		DDR4-2933		DDR4-3200		Unit	Notes
		Min	Max	Min	Max	Min	Max	Min	Max		

Self Refresh Timing				
Exit self refresh to commands requiring a locked DLL	tXSDLL	MIN = tDLLK (MIN)	CK	1
Minimum CKE low pulse width for self refresh entry to self refresh exit timing	tCKESR	MIN = tCKE (MIN) + 1nCK	CK	1
Minimum CKE low pulse width for self refresh entry to self refresh exit timing when CA parity is enabled	tCKESR_PAR	MIN = tCKE (MIN) + 1nCK + PL	CK	1
Valid clocks after self refresh entry (SRE) or power-down entry (PDE)	tCKSRE	MIN = greater of (5CK, 10ns)	CK	1
Valid clock requirement after self refresh entry or power-down when CA parity is enabled	tCKSRE_PAR	MIN = greater of (5CK, 10ns) + PL	CK	1
Valid clocks before self refresh exit (SRX) or power-down exit (PDX), or reset exit	tCKSRX	MIN = greater of (5CK, 10ns)	CK	1
Power-Down Timing				
Exit power-down with DLL on to any valid command	tXP	MIN = greater of 4CK or 6ns	CK	1
Exit precharge power-down with DLL frozen to commands not requiring a locked DLL when CA Parity is enabled	tXP _PAR	MIN = (greater of 4CK or 6ns) + PL	CK	1
CKE MIN pulse width	tCKE (MIN)	MIN = greater of 3CK or 5ns	CK	
Command pass disable delay	tCPDED	4 – 4 – 4 – 4 –	CK	
Power-down entry to power-down exit timing	tPD	MIN = tCKE (MIN); MAX = 9 × tREFI	CK	
Begin power-down period prior to CKE registered HIGH	tANPD	WL - 1CK	CK	
Power-down entry period: ODT either synchronous or asynchronous	PDE	Greater of tANPD or tRFC - REFRESH command to CKE LOW time	CK	

Parameter	Symbol	DDR4-2400		DDR4-2666		DDR4-2933		DDR4-3200		Unit	Notes
		Min	Max	Min	Max	Min	Max	Min	Max		

Power-Down Timing											
Power-down exit period: ODT either synchronous or asynchronous	PDX	tANPD + tXSDLL								CK	
Power-Down Entry Minimum Timing											
ACTIVATE command to power-down entry	tACTPDEN	2	–	2	–	2	–	2	–	CK	
PRECHARGE/PRECHARGE ALL command to power-down entry	tPRPDEN	2	–	2	–	2	–	2	–	CK	
REFRESH command to power-down entry	tREFPDEN	2	–	2	–	2	–	2	–	CK	
MRS command to power-down entry	tMRSPDEN	MIN = tMOD (MIN)								CK	1
READ/READ with auto precharge command to power-down entry	tRDPDEN	MIN = RL + 4 + 1								CK	1
WRITE command to power-down entry (BL8OTF, BL8MRS, BC4OTF)	tWRPDEN	MIN = WL + 4 + tWR/tCK (AVG)								CK	1
WRITE command to power-down entry(BC4MRS)	tWRPBC4DEN	MIN = WL + 2 + tWR/tCK (AVG)								CK	1
WRITE with auto precharge command to power-down entry (BL8OTF,BL8MRS,BC4OTF)	tWRAPDEN	MIN = WL + 4 + WR + 1								CK	1
WRITE with auto precharge command to power-down entry (BC4MRS)	tWRAPBC4DEN	MIN = WL + 2 + WR + 1								CK	1
ODT Timing											
Direct ODT turn-on latency	DODTLon	WL - 2 = CWL + AL + PL - 2								CK	
Direct ODT turn-off latency	DODTLoff	WL - 2 = CWL + AL + PL - 2								CK	
R_{TT} dynamic change skew	tADC	0.3	0.7	0.28	0.72	0.26	0.74	0.26	0.74	CK	
Asynchronous RTT(NOM) turn-on delay (DLL off)	tAONAS	1	9	1	9	1	9	1	9	ns	
Asynchronous RTT(NOM) turn-off delay (DLL off)	tAOFAS	1	9	1	9	1	9	1	9	ns	

Parameter	Symbol	DDR4-2400	DDR4-2666	DDR4-2933	DDR4-3200	Unit	Notes

		Min	Max	Min	Max	Min	Max	Min	Max		
ODT Timing											
ODT HIGH time with WRITE command and BL8	ODTH8 1tCK	6	–	6	–	6	–	6	–	CK	
	ODTH8 2tCK	7	–	7	–	7	–	7	–		
ODT HIGH time without WRITE command or with WRITE command and BC4	ODTH4 1tCK	4	–	4	–	4	–	4	–	CK	
	ODTH4 2tCK	5	–	5	–	5	–	5	–		
Write Leveling Timing											
First DQS_t, DQS_c rising edge after write leveling mode is programmed	tWLMRD	40	–	40	–	40	–	40	–	CK	
DQS_t, DQS_c delay after write leveling mode is programmed	tWLDQSEN	25	–	25	–	25	–	25	–	CK	
Write leveling setup from rising CK_t, CK_c crossing to rising DQS_t, DQS_c crossing	tWLS	0.13	–	0.13	–	0.13	–	0.13	–	tCK (AVG)	
Write leveling hold from rising DQS_t, DQS_c crossing to rising CK_t, CK_c crossing	tWLH	0.13	–	0.13	–	0.13	–	0.13	–	tCK (AVG)	
Write leveling output delay	tWLO	0	9.5	0	9.5	0	9.5	0	9.5	ns	
Write leveling output error	tWLOE	0	2	0	2	0	2	0	2	ns	
Gear-Down Timing (Not Supported Below DDR4-2666)											
Exit reset from CKE HIGH to a valid MRS gear-down	tXPR_GEAR	N/A		tXPR		tXPR		tXPR		CK	
CKE HIGH assert to gear-down enable time	tXS_GEAR	N/A		tXS		tXS		tXS		CK	
MRS command to sync pulse time	tSYNC_GEAR	N/A		tMOD + 4CK tMOD		tMOD + 4CK tMOD		tMOD + 4CK tMOD		CK	
Sync pulse to first valid command	tCMD_GEAR	N/A		tMOD		tMOD		tMOD		CK	
Gear-down setup time	tGEAR_setup	N/A	–	2CK	–	2CK	–	2CK	–	CK	
Gear-down hold time	tGEAR_hold	N/A	–	2CK	–	2CK	–	2CK	–	CK	

NOTEs :

1. Maximum limit not applicable.

2. tCCD_L and tDLLK should be programmed according to the value defined per operating frequency.

3. Data rate is greater than or equal to 1066 Mb/s.

4. RFU.

5. WRITE-to-READ when CRC and DM are both not enabled.

6. WRITE-to-READ delay when CRC and DM are both enabled.

7. The start of internal write transactions is defined as follows:

- For BL8 (fixed by MRS and on-the-fly): rising clock edge four clock cycles after WL
- For BC4 (on-the-fly): rising clock edge four clock cycles after WL
- For BC4 (fixed by MRS): rising clock edge two clock cycles after WL

8. For these parameters, the device supports tnPARAM [nCK] = RU{tPARAM [ns]/tCK (AVG) [ns]}, in clock cycles, assuming all input clock jitter specifications are satisfied.

9. Although unlimited row accesses to the same row is allowed within the refresh period, excessive row accesses to the same row over a long term can result in degraded operation.

10. When operating in 1tCK WRITE preamble mode.

11. When operating in 2tCK WRITE preamble mode.

12. When CA parity mode is selected and the DLLoff mode is used, each REF command requires an additional "PL" added to tRFC refresh time.

13. DRAM devices should be evenly addressed when being accessed. Disproportionate accesses to a particular row address may result in reduction of the product lifetime and/or reduction in data retention ability.

14. Applicable from tCK (AVG) MIN to tCK (AVG) MAX as stated in the Speed Bin tables.

15. JEDEC specifies a minimum of five clocks.

16. The maximum read postamble is bound by tDQSCK (MIN) plus tQSH (MIN) on the left side and tHZ(DQS) MAX on the right side.

17. The reference level of DQ output signal is specified with a midpoint as a widest part of output signal eye, which should be approximately 0.7 × VDDQ as a center level of the static single-ended output peak-to-peak swing with a driver impedance of 34 ohms and an effective test load of 50 ohms to VTT = VDDQ.

18. JEDEC hasn't agreed upon the definition of the deterministic jitter; the user should focus on meeting the total limit.

19. Spread spectrum is not included in the jitter specification values. However, the input clock can accommodate spread-spectrum at a sweep rate in the range of 20–60 kHz with an additional 1% of tCK (AVG) as a long-term jitter component; however, the spread spectrum may not use a clock rate below tCK (AVG) MIN.

20. The actual tCAL minimum is the larger of 3 clocks or 3.748ns/tCK; the table lists the applicable clocks required at targeted speed bin.

21. The maximum READ preamble is bounded by tLZ(DQS) MIN on the left side and tDQSCK (MAX) on the right side. See figure in Clock to Data Strobe Relationship. Boundary of DQS Low-Z occur one cycle earlier in 2tCK toggle mode which is illustrated in READ Preamble.

22. DQ falling signal middle-point of transferring from HIGH to LOW to first rising edge of DQS differential signal cross-point.

23. The tPDA_S/tPDA_H parameters may use the tDS/tDH limits, respectively, if the signal is LOW the entire BL8

SERIAL PRESENCE DETECT SPECIFICATION (AQD-SD4U16GE32-SE Serial Presence Detect)

Byte	Function Described	Function		HEX Value
0	Number of Bytes Used / Number of Bytes in SPD Device / CRC Coverage	SPD Total: 512Bytes, SPD Used : 384Bytes		23
1	SPD Revision	Version 1.1		11
2	Key Byte / DRAM Device Type	DDR4 SDRAM		0C
3	Key Byte / Module Type	SO-DIMM		03
4	SDRAM Density and Banks	4 bank group / 4 bank	8Gb	85
5	SDRAM Addressing	Row : 16	Column : 10	21
6	SDRAM Package Type	Mono / Not specified		00
7	SDRAM Optional Features	Unlimited MAC		08
8	SDRAM Thermal and Refresh Options	-		00
9	Other SDRAM Optional Features	hPPR,sPPR supported		60
10	Reserved	-		00
11	Module Nominal Voltage, VDD	1.2v		03
12	Module Organization	2Rank	x8	09
13	Module Memory Bus Width	8bit ECC	64bits	0B
14	Module Thermal Sensor	Thermal Sensor on Module		80
15~16	Reserved	-		00
17	Timebases	MTB: 125ps	FTB: 1ps	00
18	SDRAM Minimum Cycle Time (tCKAVGmin)	0.625 ns		05
19	SDRAM Maximum Cycle Time (tCKAVGmax)	1.6 ns		0D
20	CAS Latencies Supported, First Byte	CL 10,11,12,13,14		F8
21	CAS Latencies Supported, Second Byte	CL 15,16,17,18,19,20,22		BF
22	CAS Latencies Supported, Third Byte	CL24		02
23	CAS Latencies Supported, Fourth Byte	-		00
24	Minimum CAS Latency Time(tAAmin)	13.75 ns		6E
25	Minimum RAS to CAS Delay Time (tRCDmin)	13.75 ns		6E
26	Minimum Row Precharge Delay Time (tRPmin)	13.75 ns		6E
27	Upper Nibbles for tRASmin and tRCmin	-		11
28	Minimum Active to Precharge Delay Time (tRASmin), Least Significant Byte	32 ns		00
29	Minimum Active to Active/Refresh Delay Time (tRCmin), Least Significant Byte	45.75 ns		6E
30	Minimum Refresh Recovery Delay Time (tRFC1min), Least Significant Byte	350 ns		F0
31	Minimum Refresh Recovery Delay Time (tRFC1min), Most Significant Byte			0A
32	Minimum Refresh Recovery Delay Time (tRFC2min), Least Significant Byte	260 ns		20
33	Minimum Refresh Recovery Delay Time (tRFC2min), Most Significant Byte			08
34	Minimum Refresh Recovery Delay Time (tRFC4min), Least Significant Byte	160 ns		00
35	Minimum Refresh Recovery Delay Time (tRFC4min), Most Significant Byte			05
36	Minimum Four Activate Window Time (tFAWmin), Most Significant Nibble	21 ns		00
37	Minimum Four Activate Window Time (tFAWmin), Least Significant Byte			A8
38	Minimum Activate to Activate Delay Time (tRRD_Smin), different bank group	2.5 ns		14
39	Minimum Activate to Activate Delay Time (tRRD_Lmin), same bank group	4.9 ns		28
40	Minimum CAS to CAS Delay Time (tCCD_Lmin), same bank group	5 ns		28
41	Upper Nibble for tWRmin	15 ns		00
42	Minimum Write Recovery Time(tWRmin)	15 ns		78
43	Upper Nibbles for tWTRmin	2.5/7.5 ns		00
44	Minimum Write to Read Time(tWTR_Smin) , different bank group	2.5 ns		14
45	Minimum Write to Read Time(tWTR_Lmin) , same bank group	7.5 ns		3C
46~59	Reserved, Base Configuration Section	-		00
60	Connector to SDRAM Bit Mapping	DQ0, DQ1, DQ2, DQ3		0B
61	Connector to SDRAM Bit Mapping	DQ4, DQ5, DQ6, DQ7		2B
62	Connector to SDRAM Bit Mapping	DQ8, DQ9, DQ10, DQ11		0C
63	Connector to SDRAM Bit Mapping	DQ12, DQ13, DQ14, DQ15		2B
64	Connector to SDRAM Bit Mapping	DQ16, DQ17, DQ18, DQ19		2B
65	Connector to SDRAM Bit Mapping	DQ20, DQ21, DQ22, DQ23		0B
66	Connector to SDRAM Bit Mapping	DQ24, DQ25, DQ26, DQ27		16
67	Connector to SDRAM Bit Mapping	DQ28, DQ29, DQ30, DQ31		36
68	Connector to SDRAM Bit Mapping	CB0-3		0C
69	Connector to SDRAM Bit Mapping	CB4-7		2B
70	Connector to SDRAM Bit Mapping	DQ32, DQ33, DQ34, DQ35		15
71	Connector to SDRAM Bit Mapping	DQ36, DQ37, DQ38, DQ39		2C
72	Connector to SDRAM Bit Mapping	DQ40, DQ41, DQ42, DQ43		0B
73	Connector to SDRAM Bit Mapping	DQ44, DQ45, DQ46, DQ47		35
74	Connector to SDRAM Bit Mapping	DQ48, DQ49, DQ50, DQ51		16
75	Connector to SDRAM Bit Mapping	DQ52, DQ53, DQ54, DQ55		36
76	Connector to SDRAM Bit Mapping	DQ56, DQ57, DQ58, DQ59		16

Byte	Function Described	Function		HEX Value
77	Connector to SDRAM Bit Mapping	DQ60, DQ61, DQ62, DQ63		36
78~116	Reserved, Base Configuration Section	-		00
117	Fine Offset for Minimum CAS to CAS Delay Time(tCCD_Lmin), same bank group	0ns		00
118	Fine Offset for Minimum Activate to Activate Delay Time(tRRD_Lmin), different bank group	-0.1ns		9C
119	Fine Offset for Minimum Activate to Activate Delay Time(tRRD_Smin), same bank group	0ns		00
120	Fine Offset for Minimum Activate to Activate/Refresh Delay Time(tRCmin)	0ns		00
121	Fine Offset for Minimum Row Precharge Delay Time(tRPmin)	0ns		00
122	Fine Offset for Minimum RAS to CAS Delay Time(tRCDmin)	0ns		00
123	Fine Offset for Minimum CAS Latency Time(tAAmin)	0ns		00
124	Fine Offset for SDRAM Maximum Cycle Time(tCKAVGmax)	-0.025ns		E7
125	Fine Offset for SDRAM Minimum Cycle Time(tCKAVGmin)	0ns		00
126	Cyclical Redundancy Code for Base Configuration Section, LSB	CRC-CCITT(LOW)		8D
127	Cyclical Redundancy Code for Base Configuration Section, MSB	CRC-CCITT(HIGH)		93
128	(Unbuffered): Raw Card Extension, Module Nominal Height	Revision 1	30.00 mm	0F
129	(Unbuffered): Module Maximum Thickness	-		11
130	(Unbuffered): Reference Raw Card Used	Raw Card G	Revision 1	26
131	(Unbuffered): Address Mapping from Edge Connector to DRAM	Mirrored		01
132~253	(Unbuffered): Reserved	-		00
254	(Unbuffered): CRC for Module Specific Section, Least Significant Byte	CRC-CCITT(LOW)		CB
255	(Unbuffered): CRC for Module Specific Section, Most Significant Byte	CRC-CCITT(HIGH)		86
256~319	Hybrid Memory Architecture Specific Parameters			00
320	Module Manufacturer ID Code, LSB			04
321	Module Manufacturer ID Code, MSB			CB
322	Module ID: Module Manufacturing Location	*Note: 1		-
323	Module ID: Module Manufacturing Date(Year)	*Note: 2		-
324	Module ID: Module Manufacturing Date(Week)	*Note: 3		-
325~328	Module ID : Module Serial Number	*Note: 4		-
329~348	Module Part Number	*Note: 5		-
349	Module Revision Code	-		00
350	SDRAM Manufacturer's JEDEC ID Code, LSB	Samsung		80
351	SDRAM Manufacturer's JEDEC ID Code, MSB			CE
352	DRAM Stepping	-		FF
353~381	Manufacturer's Specific Data	*Note: 7		-
382	Reserved			00
383	Reserved			00
384~511	End User Programmable	*Note: 8		-

Note : 1. Byte 322 -- Manufacturing location by manufacturing location (00:Taiwan /01:China)
2. Byte 323 -- Module manufacturing date by year (YY).
3. Byte 324 -- Module manufacturing date by week (WW).
4. Bytes 325~328 -- Module Serial Number.
5. Bytes 329~348 -- Manufacturer Part Number by module part number , (Unused digits are coded as ASCII blanks (20h)).
6. Bytes 353~381 -- These bytes are undefined and can be used own purpose. Digits are coded as 00h except the following:
   6-1. Bytes 353~367 -- Manufacturer's Specific Data by working order number.
   6-2. Bytes 368~381 -- Manufacturer's Specific Data by SPD naming number.
7. Bytes 384~511 -- These bytes are undefined and can be used own purpose. Digits are coded as 00h except the following:7-1. Bytes 384 -- The byte is coded as ADh.