

Datasheet | Rev. 1.0 | 2021

# IMM2G64D3(L)DUD8AG (Die Revision F) 16GByte (2G x 64 Bit)

16GB DDR3 Unbuffered DIMM  
RoHS Compliant Product

**Remark:**

Please refer to the last page of the i) Contents ii) List of Table iii) List of Figures.

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## Features

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- 240-Pin Unbuffered Dual-In-Line Memory Module
- Capacity: 16GB
- JEDEC-Standard
- Bi-directional Differential Data-Strobe
- 64 Bit Data Bus Width without ECC
- Programmable CAS Latency (CL):
  - PC3-14900: 6, 7, 8, 9, 10, 11, 13
  - PC3-12800: 5, 6, 7, 8, 9, 10, 11
- Programmable CAS Write Latency (CWL):
  - PC3-14900: 5, 6, 7, 8, 9
  - PC3-12800: 5, 6, 7, 8
- Programmable Additive Latency (Posted /CAS): 0, CL-2 or CL-1(Clock)
- On-Die Termination (ODT)
- ZQ Calibration Supported
- Burst Type (Sequential & Interleave)
- Burst Length: 4, 8
- Refresh Mode: Auto and Self
- 8192 Refresh Cycles / 64ms
- Asynchronous Reset
- Serial Presence Detect (SPD) with EEPROM
- Gold Edge Contacts
- 100% RoHS-Compliant
- Standard Module Height: 30.00mm (1.18inch)

**Table 1 - Ordering Information for RoHS Compliant Product**

Part Number	Module Density	Configuration	# of Ranks	Module Type
IMM2G64D3xDUD8AG-Fzzzy	16GB	2Gx64	2	16GB DDR3 Unbuffered DIMM

Notes:

- x: Operating Voltage
- y: Operating Temperature
- zzz: Speed Grade

**Table 2 - Operating Voltage**

Part Number	Operating Voltage
Blank	$V_{DD}, V_{DDQ} = 1.5V (1.425V-1.575V)$
L	$V_{DD}, V_{DDQ} = 1.35V (1.283V-1.45V)$ Backward compatible to $V_{DD}, V_{DDQ} = 1.5V (1.425V-1.575V)$

**Table 3 – Temperature Grade**

Part Number	Temperature Grade	Tcase
Blank	Commercial temperature	0°C to 95°C
I	Industrial temperature	-40°C to 95°C

Remark: Tcase is the case surface temperature on the center/top side of the DRAM. The refresh rate is required to double when  $85^{\circ}C < T_{case} \leq 95^{\circ}C$ .

**Table 4 – Speed Grade**

Part Number	Speed Grade	Max Clock Frequency (min. Clock Cycle time @ min. CAS Latency)
107	PC3-14900 (DDR3-1866)	933MHz (1.071ns@CL=13)
125	PC3-12800 (DDR3-1600)	800MHz (1.25ns@CL=11)

**Table 5 – Memory Chip Information**

Part Number	Base Device Brand	Base Device	Voltage	Type	Chip Packing
IMM2G64D3(L)DUD8AG-Fzzzy	I'M	IM8G08D3FFBG	1.35V / 1.5V	1Gx8	Lead Free

## Part Number Decoder

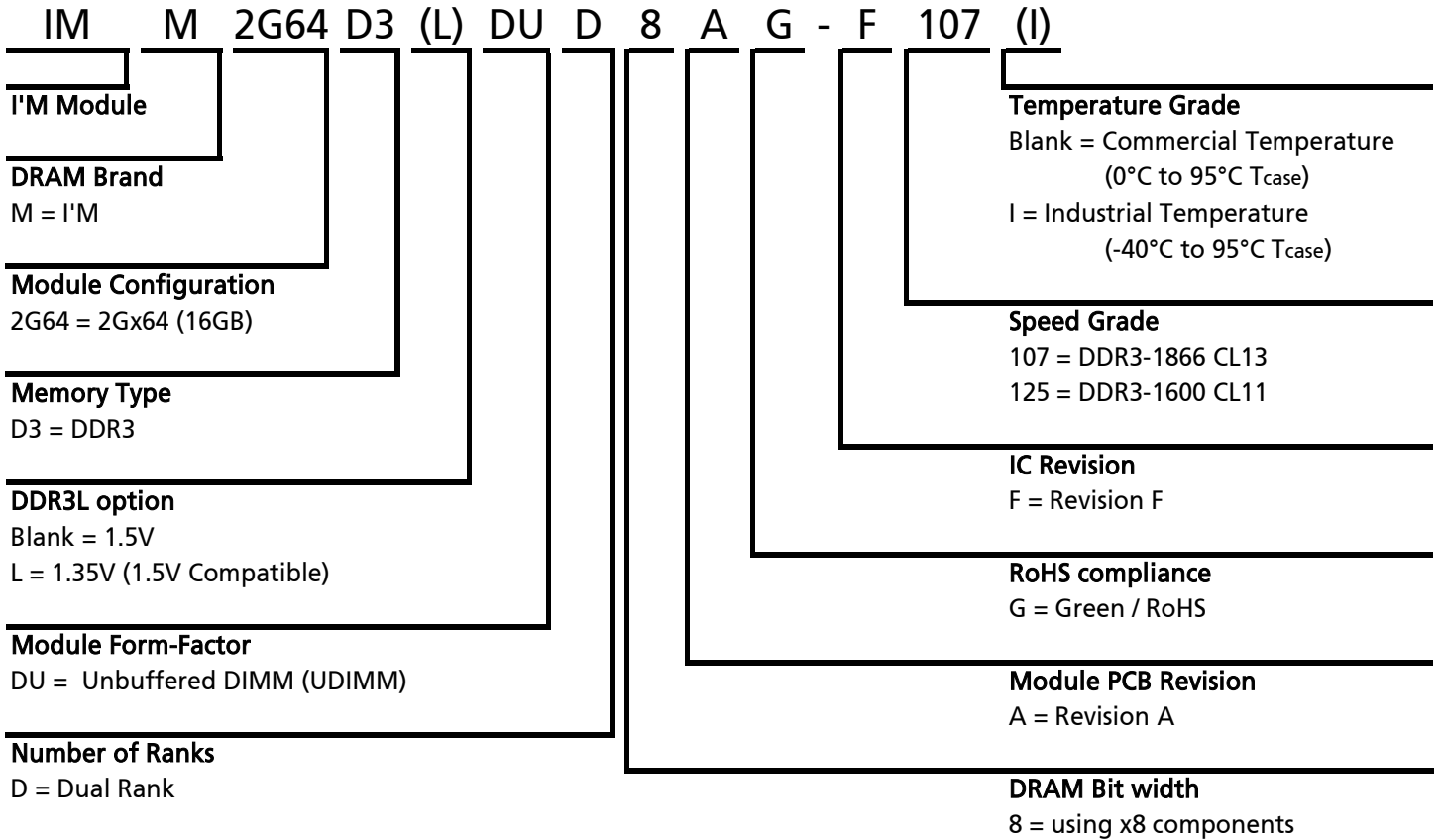


Table 6 - Addressing

Parameter	16GB
Refresh count	8K
Row address	64K A[15:0]
Device bank address	8 BA[2:0]
Device configuration	8Gb (1Gx8)
Column address	2K A[9:0], A11
Module rank address	2 /S[1:0]
Number of devices	16

Table 7 - Pin Assignment

Pin	Name	Pin	Name	Pin	Name	Pin	Name
1	V <sub>REFDQ</sub>	121	V <sub>SS</sub>	61	A2	181	A1
2	V <sub>SS</sub>	122	D4	62	V <sub>DD</sub>	182	V <sub>DD</sub>
3	D0	123	D5	63	CK1	183	V <sub>DD</sub>
4	D1	124	V <sub>SS</sub>	64	/CK1	184	CK0
5	V <sub>SS</sub>	125	DM0	65	V <sub>DD</sub>	185	/CK0
6	/DQS0	126	NC	66	V <sub>DD</sub>	186	V <sub>DD</sub>
7	DQS0	127	V <sub>SS</sub>	67	V <sub>REFCA</sub>	187	NC
8	V <sub>SS</sub>	128	D6	68	NC	188	A0
9	D2	129	D7	69	V <sub>DD</sub>	189	V <sub>DD</sub>
10	D3	130	V <sub>SS</sub>	70	A10, AP	190	BA1
11	V <sub>SS</sub>	131	D12	71	BA0	191	V <sub>DD</sub>
12	D8	132	D13	72	V <sub>DD</sub>	192	/RAS
13	D9	133	V <sub>SS</sub>	73	/WE	193	/S0
14	V <sub>SS</sub>	134	DM1	74	/CAS	194	V <sub>DD</sub>
15	/DQS1	135	NC	75	V <sub>DD</sub>	195	ODT0
16	DQS1	136	V <sub>SS</sub>	76	/S1	196	A13
17	V <sub>SS</sub>	137	D14	77	ODT1	197	V <sub>DD</sub>
18	D10	138	D15	78	V <sub>DD</sub>	198	NC
19	D11	139	V <sub>SS</sub>	79	NC	199	V <sub>SS</sub>
20	V <sub>SS</sub>	140	D20	80	V <sub>SS</sub>	200	D36
21	D16	141	D21	81	D32	201	D37
22	D17	142	V <sub>SS</sub>	82	D33	202	V <sub>SS</sub>
23	V <sub>SS</sub>	143	DM2	83	V <sub>SS</sub>	203	DM4
24	/DQS2	144	NC	84	/DQS4	204	NC
25	DQS2	145	V <sub>SS</sub>	85	DQS4	205	V <sub>SS</sub>
26	V <sub>SS</sub>	146	D22	86	V <sub>SS</sub>	206	D38
27	D18	147	D23	87	D34	207	D39
28	D19	148	V <sub>SS</sub>	88	D35	208	V <sub>SS</sub>
29	V <sub>SS</sub>	149	D28	89	V <sub>SS</sub>	209	D44
30	D24	150	D29	90	D40	210	D45
31	D25	151	V <sub>SS</sub>	91	D41	211	V <sub>SS</sub>
32	V <sub>SS</sub>	152	DM3	92	V <sub>SS</sub>	212	DM5
33	/DQS3	153	NC	93	/DQS5	213	NC
34	DQS3	154	V <sub>SS</sub>	94	DQS5	214	V <sub>SS</sub>
35	V <sub>SS</sub>	155	D30	95	V <sub>SS</sub>	215	D46
36	D26	156	D31	96	D42	216	D47
37	D27	157	V <sub>SS</sub>	97	D43	217	V <sub>SS</sub>
38	V <sub>SS</sub>	158	NC	98	V <sub>SS</sub>	218	D52
39	NC	159	NC	99	D48	219	D53
40	NC	160	V <sub>SS</sub>	100	D49	220	V <sub>SS</sub>
41	V <sub>SS</sub>	161	NC	101	V <sub>SS</sub>	221	DM6
42	NC	162	NC	102	/DQS6	222	NC
43	NC	163	V <sub>SS</sub>	103	DQS6	223	V <sub>SS</sub>
44	V <sub>SS</sub>	164	NC	104	V <sub>SS</sub>	224	D54
45	NC	165	NC	105	D50	225	D55
46	NC	166	V <sub>SS</sub>	106	D51	226	V <sub>SS</sub>
47	V <sub>SS</sub>	167	NC	107	V <sub>SS</sub>	227	D60
48	NC	168	/RESET	108	D56	228	D61
49	NC	169	CKE1	109	D57	229	V <sub>SS</sub>
50	CKE0	170	V <sub>DD</sub>	110	V <sub>SS</sub>	230	DM7
51	V <sub>DD</sub>	171	A15	111	/DQS7	231	NC
52	BA2	172	A14	112	DQS7	232	V <sub>SS</sub>
53	NC	173	V <sub>DD</sub>	113	V <sub>SS</sub>	233	D62
54	V <sub>DD</sub>	174	A12, /BC	114	D58	234	D63
55	A11	175	A9	115	D59	235	V <sub>SS</sub>
56	A7	176	V <sub>DD</sub>	116	V <sub>SS</sub>	236	V <sub>DDSPD</sub>
57	V <sub>DD</sub>	177	A8	117	SA0	237	SA1
58	A5	178	A6	118	SCL	238	SDA
59	A4	179	V <sub>DD</sub>	119	SA2	239	V <sub>SS</sub>
60	V <sub>DD</sub>	180	A3	120	V <sub>TT</sub>	240	V <sub>TT</sub>

Table 8 - Pin Description

Pin Name	Description	Pin Name	Description
V <sub>DD</sub>	SDRAM core power supply	V <sub>REFDQ</sub>	SDRAM I/O reference supply
V <sub>REFCA</sub>	SDRAM command/address reference supply	V <sub>SS</sub>	Power supply return (ground)
A0-A15	SDRAM address bus	BA0-BA2	SDRAM bank addresses
CK0-CK1	SDRAM clocks (positive line of differential pair)	/CK0-/CK1	SDRAM clocks (negative line of differential pair)
/RAS	SDRAM row address strobe	/CAS	SDRAM column address strobe
/WE	SDRAM write enable	CKE0-CKE1	SDRAM clock enable lines
/S0-/S1	DIMM Rank Select Lines	ODT0-ODT1	On-die termination control lines
DQS0-DQS7	SDRAM data strobes (positive line of differential pair)	/DQS0-/DQS7	SDRAM data strobes (negative line of differential pair)
D0-D63	DIMM memory data bus	DM0-DM7	SDRAM data mask/high data strobes
SCL	EEPROM clock	SDA	EEPROM data line
SA0-SA2	EEPROM address input	V <sub>DDSPD</sub>	EEPROM positive power supply
/RESET	Reset Pin	NC	Spare Pins (no connect)
V <sub>TT</sub>	Termination Voltage	-	-

Module Dimension

Figure 1 – 240 Pin DDR3 SDRAM Unbuffered DIMM

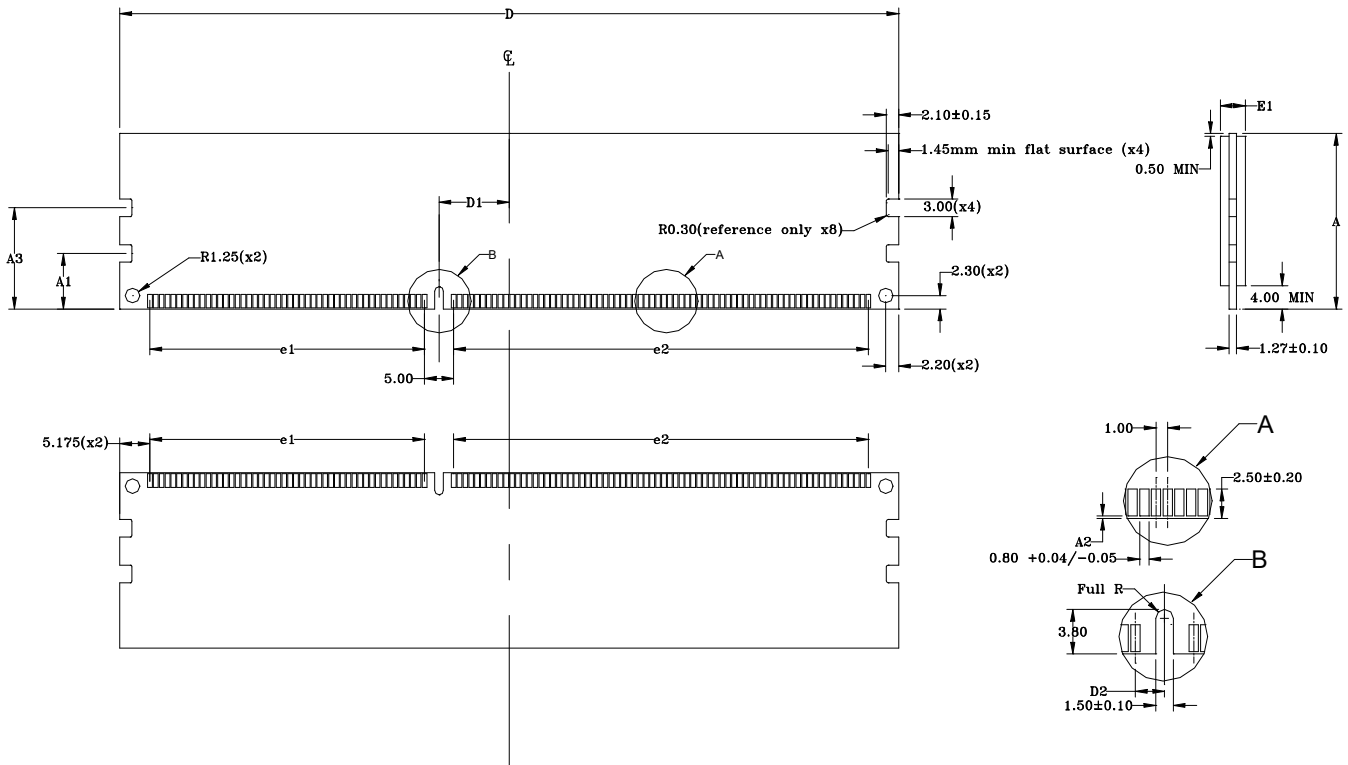


Table 9 - PCB Dimension

Symbol	MIN	NOM	MAX
A	29.85	30.00	30.50
A1		9.35	
A2	0.05	0.20	0.35
A3	17.15	17.30	17.45
D	133.20	133.35	133.50
D1		12.00 Basic	
D2		2.50 Basic	
e1		47.00 Basic	
e2		71.00 Basic	
E1			4.00

Notes:

- All dimensioning and tolerancing conform to ASME Y14.5M-1994.
- Tolerances for all dimensions ±0.15 unless otherwise specified.
- All dimensions are in millimeters.

Figure 2 – Functional Block Diagram (Page 1 of 3)

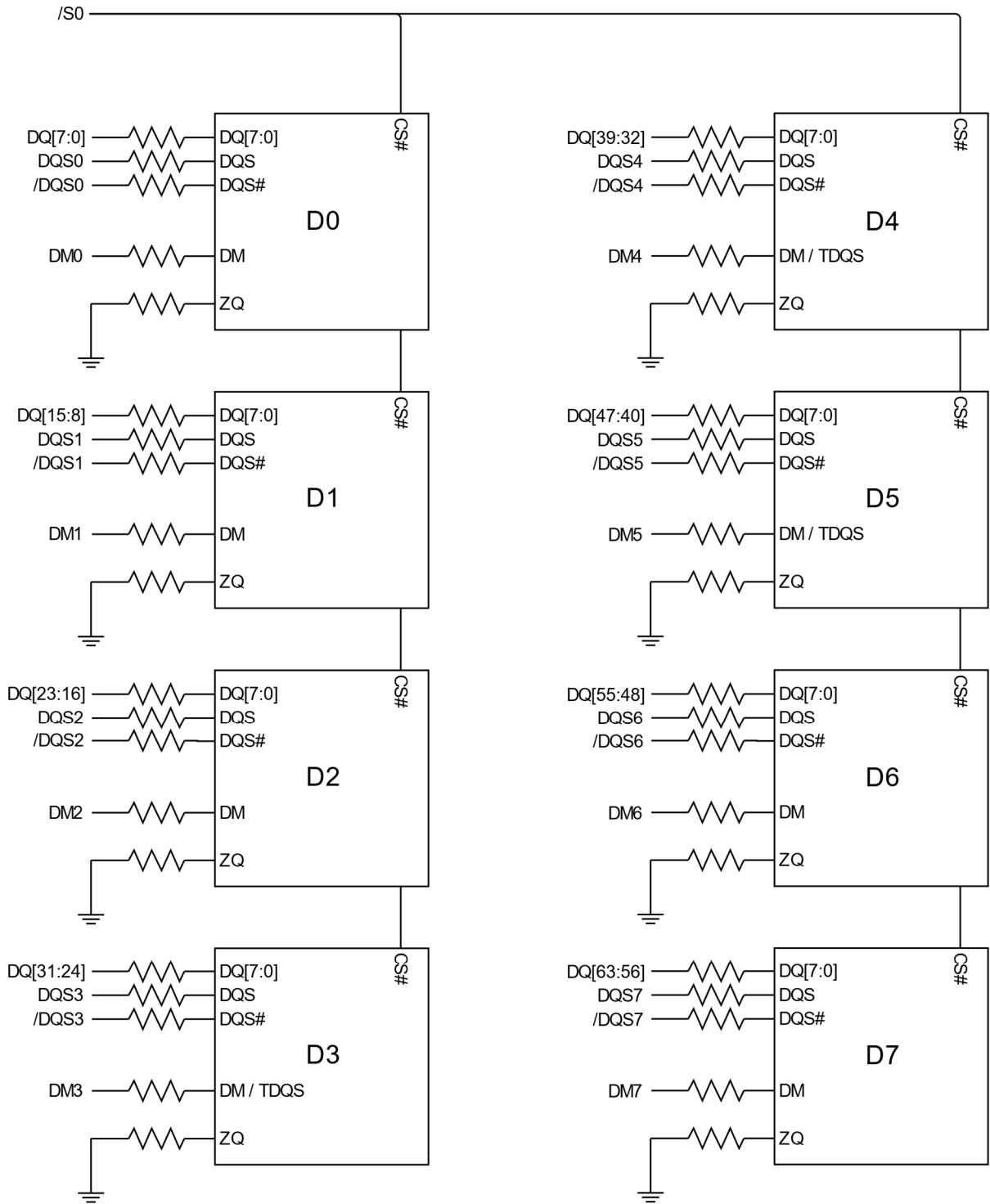




Figure 3 – Functional Block Diagram (Page 2 of 3)

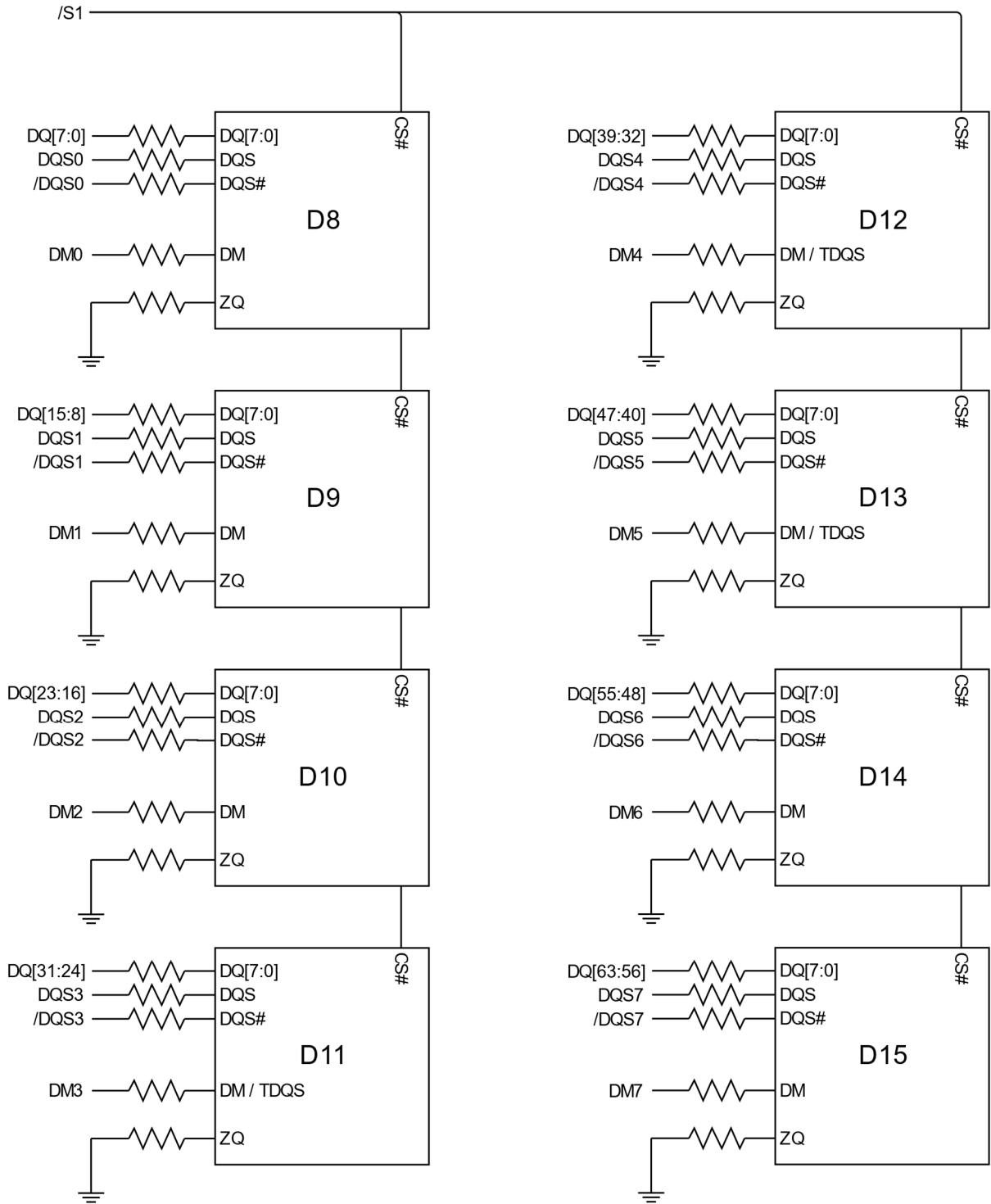
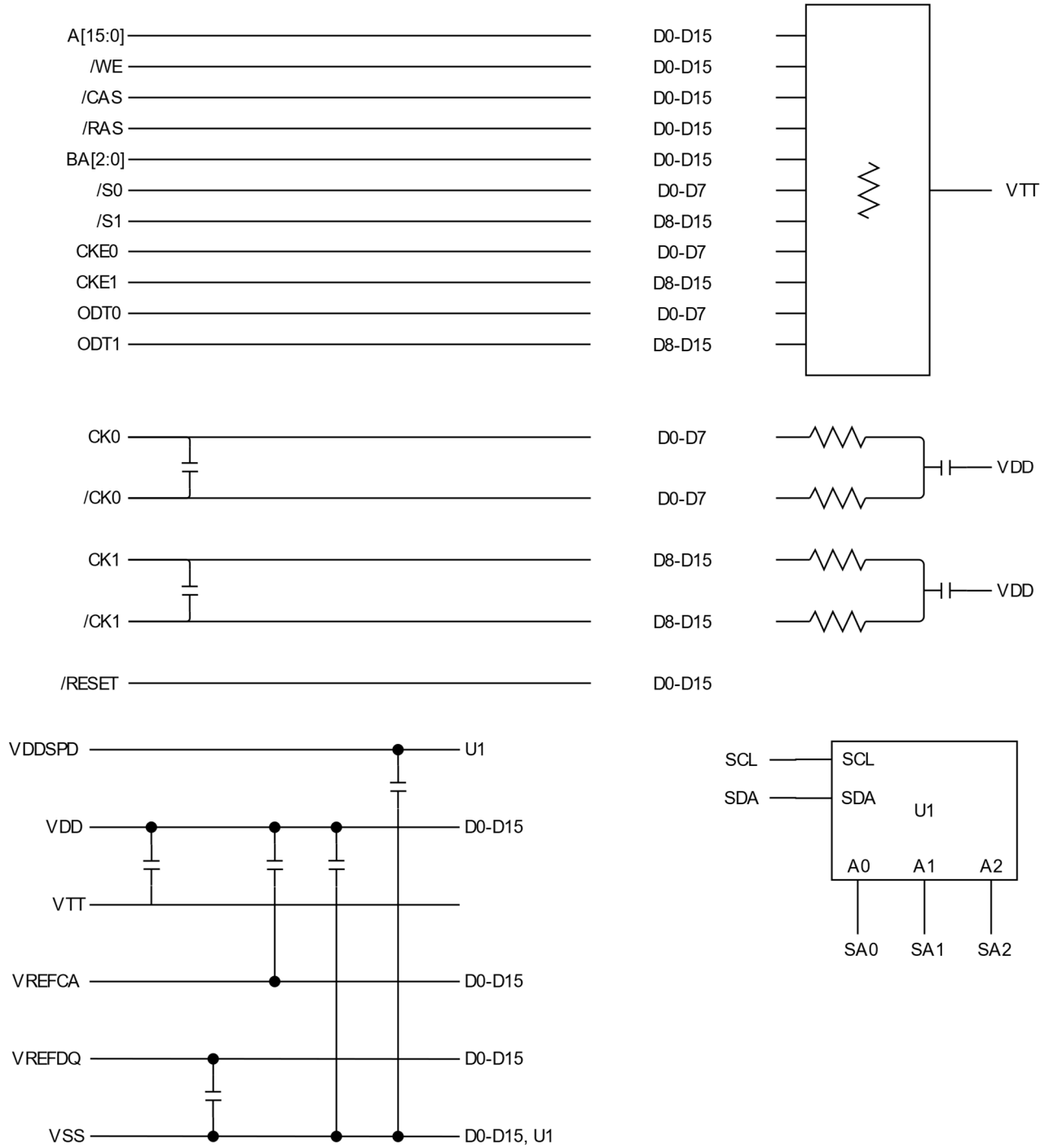


Figure 4 – Functional Block Diagram (Page 3 of 3)



## Electrical Parameter

**Table 10 - Absolute Maximum DC Ratings**

Parameter	Symbol	Rating	Units	Notes
Voltage on V <sub>DD</sub> , pin relative to V <sub>SS</sub>	V <sub>DD</sub>	-0.4V ~ 1.975	V	1,3
Voltage on V <sub>DDQ</sub> , pin relative to V <sub>SS</sub>	V <sub>DDQ</sub>	-0.4V ~ 1.975	V	1,3
Voltage on any pins relative to V <sub>SS</sub>	V <sub>IN</sub> , V <sub>OUT</sub>	-0.4V ~ 1.975	V	1
DRAM Storage temperature	T <sub>STG</sub>	-55 ~ 100	°C	1,2
DRAM Operation temperature for Commercial temperature product	T <sub>case</sub>	0 ~ 95	°C	2,4,6
DRAM Operation temperature for Industrial temperature product	T <sub>case</sub>	-40 ~ 95	°C	2,5,6

Notes:

- Stresses greater than those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect reliability.
- Storage Temperature or DRAM operation temperature is the case surface temperature on the center/top side of the DRAM. For the measurement conditions, please refer to JESD51-2 standard.
- V<sub>DD</sub> and V<sub>DDQ</sub> must be within 300mV of each other at all times; and V<sub>REF</sub> must not be greater than 0.6 x V<sub>DDQ</sub>, when V<sub>DD</sub> and V<sub>DDQ</sub> are less than 500mV; V<sub>REF</sub> may be equal to or less than 300mV.
- The Normal Temperature Range specifies the temperatures when all DRAM specifications will be supported. During operation, the DRAM case temperature must be maintained between 0-85 °C under all operating conditions.
- The Normal Temperature Range specifies the temperatures when all DRAM specifications will be supported. During operation, the DRAM case temperature must be maintained between -40-95 °C under all operating conditions.
- Some applications require operation of the Extended Temperature Range between 85 °C and 95 °C case temperature. Full Specifications are guaranteed in this range but the following additional conditions apply a) Refresh commands must be doubled in frequency, therefore reducing the refresh interval t<sub>REFI</sub> to 3.9us. b) 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).

**Table 11 - DC Electrical Characteristics and Operating Conditions**

Parameter / Condition	Symbol	Rating			Units	Notes
		Min	Typ	Max		
Supply voltage	V <sub>DD</sub>	1.283	1.35	1.45	V	1,2
I/O supply voltage	V <sub>DDQ</sub>				V	1,2
Supply voltage	V <sub>DD</sub>	1.425	1.5	1.575	V	1,2,3
I/O supply voltage	V <sub>DDQ</sub>				V	1,2,3

Notes:

- V<sub>DD</sub> and V<sub>DDQ</sub> must track one another. V<sub>DDQ</sub> must be less than or equal to V<sub>DD</sub>. V<sub>SS</sub> = V<sub>SSQ</sub>.
- V<sub>DD</sub> and V<sub>DDQ</sub> may include AC noise of +/-50mV (250 kHz to 20 MHz) in addition to the DC (0 Hz to 250 kHz) specifications. V<sub>DD</sub> and V<sub>DDQ</sub> must be at same level for valid AC timing parameters.
- Module is backward-compatible with 1.5V operation.

Table 12 - DC Electrical Characteristics and Input Conditions

Parameter / Condition	Symbol	Rating			Units	Notes
		Min	Typ	Max		
$V_{IN}$ low; DC/commands/address buses (1.35V)	$V_{IL}$	$V_{SS}$	-	-0.090	V	
$V_{IN}$ low; DC/commands/address buses (1.5V)	$V_{IL}$	$V_{SS}$	-	-0.100	V	
$V_{IN}$ high; DC/commands/address buses (1.35V)	$V_{IH}$	0.090	-	$V_{DD}$	V	
$V_{IN}$ high; DC/commands/address buses (1.5V)	$V_{IH}$	0.100	-	$V_{DD}$	V	
Input reference voltage; command/address bus	$V_{REFCA(DC)}$	$0.49 * V_{DD}$	$0.50 * V_{DD}$	$0.51 * V_{DD}$	V	1,2
I/O reference voltage DQ bus	$V_{REFDQ(DC)}$	$0.49 * V_{DD}$	$0.50 * V_{DD}$	$0.51 * V_{DD}$	V	2,3
Command/address termination voltage (system level, not direct DRAM input)	$V_{TT}$	-	$0.50 * V_{DDQ}$	-	V	4

## Notes:

- $V_{REFCA(DC)}$  is expected to be approximately  $0.5 \times V_{DD}$  and to track variations in the DC level. Externally generated peak noise (noncommon mode) on  $V_{REFCA}$  may not exceed  $\pm 1\% \times V_{DD}$  around the  $V_{REFCA(DC)}$  value. Peak-to-peak AC noise on  $V_{REFCA}$  should not exceed  $\pm 2\%$  of  $V_{REFCA(DC)}$ .
- DC values are determined to be less than 20 MHz in frequency. DRAM must meet specifications if the DRAM induces additional AC noise greater than 20 MHz in frequency.
- $V_{REFDQ(DC)}$  is expected to be approximately  $0.5 \times V_{DD}$  and to track variations in the DC level. Externally generated peak noise (noncommon mode) on  $V_{REFDQ}$  may not exceed  $\pm 1\% \times V_{DD}$  around the  $V_{REFDQ(DC)}$  value. Peak-to-peak AC noise on  $V_{REFDQ}$  should not exceed  $\pm 2\%$  of  $V_{REFDQ(DC)}$ .
- $V_{TT}$  is not applied directly to the device.  $V_{TT}$  is a system supply for signal termination resistors. MIN and MAX values are system-dependent.

Table 13 - Input Switching Conditions

Parameter / Condition	Symbol	Value		Units	
		1.35V	1.5V		
<b>Command and Address</b>					
Input high AC voltage: Logic 1 @ 175mV	DDR3-1600	$V_{IH(AC175)min}$	-	175	mV
Input high AC voltage: Logic 1 @ 160mV	DDR3-1600	$V_{IH(AC160)min}$	160	-	mV
Input high AC voltage: Logic 1 @ 150mV	DDR3-1600	$V_{IH(AC150)min}$	-	150	mV
Input high AC voltage: Logic 1 @ 135mV	DDR3-1600	$V_{IH(AC135)min}$	135	-	mV
	DDR3-1866		135	135	
Input high AC voltage: Logic 1 @ 125mV	DDR3-1866	$V_{IH(AC125)min}$	125	125	mV
Input high DC voltage: Logic 1 @ 100mV	DDR3-1866, 1600	$V_{IH(DC100)min}$	-	100	mV
Input high DC voltage: Logic 1 @ 90mV	DDR3-1866, 1600	$V_{IH(DC90)min}$	90	-	mV
Input low DC voltage: Logic 0 @ -90mV	DDR3-1866, 1600	$V_{IL(DC90)max}$	-90	-	mV
Input low DC voltage: Logic 0 @ -100mV	DDR3-1866, 1600	$V_{IL(DC100)max}$	-	-100	mV
Input low AC voltage: Logic 0 @ -125mV	DDR3-1866	$V_{IL(AC125)max}$	-125	125	mV
Input low AC voltage: Logic 0 @ -135mV	DDR3-1600	$V_{IL(AC135)max}$	-135	-	mV
	DDR3-1866		135	135	
Input low AC voltage: Logic 0 @ -150mV	DDR3-1600	$V_{IL(AC150)max}$	-	-150	mV
Input low AC voltage: Logic 0 @ -160mV	DDR3-1600	$V_{IL(AC160)max}$	-160	-	mV
Input low AC voltage: Logic 0 @ -175mV	DDR3-1600	$V_{IL(AC175)max}$	-	-175	mV

Parameter / Condition	Symbol	Value		Units	
		1.35V	1.5V		
<b>DQ and DM</b>					
Input high AC voltage: Logic 1	DDR3-1600	$V_{IH(AC150)min}$	-	150	mV
Input high AC voltage: Logic 1	DDR3-1866, 1600	$V_{IH(AC135)min}$	-	135	mV
	DDR3-1600		135	-	
Input high AC voltage: Logic 1	DDR3-1866	$V_{IH(AC130)min}$	130	-	mV
Input high DC voltage: Logic 1	DDR3-1866, 1600	$V_{IH(DC100)min}$	-	100	mV
Input high DC voltage: Logic 1	DDR3-1866, 1600	$V_{IH(DC90)min}$	90	-	mV
Input low DC voltage: Logic 0	DDR3-1866, 1600	$V_{IL(DC90)max}$	-90	-	mV
Input low DC voltage: Logic 0	DDR3-1866, 1600	$V_{IL(DC100)max}$	-	-100	mV
Input low AC voltage: Logic 0	DDR3-1866	$V_{IL(AC130)max}$	-130	-	mV
Input low AC voltage: Logic 0	DDR3-1600	$V_{IL(AC135)max}$	-135	-	mV
	DDR3-1866, 1600		-	-135	
Input low AC voltage: Logic 0	DDR3-1600	$V_{IL(AC150)max}$	-	-150	mV

Notes:

1. All voltages are referenced to  $V_{REF}$ .  $V_{REF}$  is  $V_{REFCA}$  for control, command, and address. All slew rates and setup/hold times are specified at the DRAM ball.  $V_{REF}$  is  $V_{REFDQ}$  for DQ and DM inputs.
2. Input setup timing parameters ( $t_{IS}$  and  $t_{DS}$ ) are referenced at  $V_{IL(AC)}/V_{IH(AC)}$ , not  $V_{REF(DC)}$ .
3. Input hold timing parameters ( $t_{IH}$  and  $t_{DH}$ ) are referenced at  $V_{IL(DC)}/V_{IH(DC)}$ , not  $V_{REF(DC)}$ .
4. Single-ended input slew rate = 1 V/ns; maximum input voltage swing under test is 900mV (peak-to-peak).

**Table 14 - Differential Input Operating Conditions (CK, /CK and DQS, /DQS)**

Parameter / Condition	Symbol	Rating		Units	Notes
		Min	Max		
Differential input voltage logic high - slew (1.35V)	$V_{IH,diff}$	+180	-	mV	1
Differential input voltage logic high - slew (1.5V)	$V_{IH,diff}$	+200	-	mV	1
Differential input voltage logic low - slew (1.35V)	$V_{IL,diff}$	-	-180	mV	1
Differential input voltage logic low - slew (1.5V)	$V_{IL,diff}$	-	-200	mV	1
Differential input voltage logic high	$V_{IH,diff(AC)}$	$2 * (V_{IH(AC)} - V_{REF})$		mV	2
Differential input voltage logic low	$V_{IL,diff(AC)}$	-	$2 * (V_{IL(AC)} - V_{REF})$	mV	3
Differential Input Cross Point Voltage relative to $V_{DD}/2$ for CK, /CK (1.35V Operation)	$V_{IX}$	-150	150	mV	
Differential Input Cross Point Voltage relative to $V_{DD}/2$ for CK, /CK (1.5V Operation)	$V_{IX}$	-150 -175	150 175	mV	4
Differential Input Cross Point Voltage relative to $V_{DD}/2$ for DQS, /DQS (1.35V Operation)	$V_{IX}$	-150	150	mV	
Differential Input Cross Point Voltage relative to $V_{DD}/2$ for DQS, /DQS (1.5V Operation)	$V_{IX}$	-150	150	mV	

Notes:

1. Defines slew rate reference points, relative to input crossing voltages.
2. Minimum DC limit is relative to single-ended signals; overshoot specifications are applicable.
3. Maximum DC limit is relative to single-ended signals; undershoot specifications are applicable.
4. Extended range for  $V_{IX}$  is only allowed for clock and if single-ended clock input signals CK and /CK are monotonic, have a single-ended swing  $V_{SEL} / V_{SEH}$  of at least  $V_{DD}/2 \pm 250mV$ , and the differential slew rate of CK-/CK is larger than 3V/ns. Refer to the table of Cross point voltage for differential input signals (CK, DQS) for  $V_{SEL}$  and  $V_{SEH}$  standard values.

**Table 15 - Single-Ended Output Driver Characteristics**

Parameter / Condition	Symbol	Rating		Units	Notes
		Min	Max		
Output slew rate: Single-ended; For rising and falling edges, measure between $V_{OL(AC)} = V_{TT} - 0.1 * V_{DDQ}$ and $V_{OH(AC)} = V_{TT} + 0.1 * V_{DDQ}$ (1.35V)	$SRQ_{se}$	1.75	5	V/ns	1,2,3
Output slew rate: Single-ended; For rising and falling edges, measure between $V_{OL(AC)} = V_{TT} - 0.1 * V_{DDQ}$ and $V_{OH(AC)} = V_{TT} + 0.1 * V_{DDQ}$ (1.5V)	$SRQ_{se}$	2.5	5	V/ns	1,2,3
Single-ended high level for strobes	$V_{SEH}$	$V_{DDQ}/2 + 175$	-	mV	2
Single-ended high level for CK, /CK		$V_{DD}/2 + 175$	-	mV	2
Single-ended low level for strobes	$V_{SEL}$	-	$V_{DDQ}/2 - 175$	mV	3
Single-ended low level for CK, /CK		-	$V_{DD}/2 - 175$	mV	3
Single-ended DC high-level output voltage	$V_{OH(DC)}$	$0.8 * V_{DDQ}$		V	1,2
Single-ended DC mid-level output voltage	$V_{OM(DC)}$	$0.5 * V_{DDQ}$		V	1,2
Single-ended DC low-level output voltage	$V_{OL(DC)}$	$0.2 * V_{DDQ}$		V	1,2
Single-ended AC high-level output voltage	$V_{OH(AC)}$	$V_{TT} + 0.1 * V_{DDQ}$		V	1,2
Single-ended AC low-level output voltage	$V_{OL(AC)}$	$V_{TT} - 0.1 * V_{DDQ}$		V	1,2
Test load for AC timing and output slew rates	Output to $V_{TT}$ ( $V_{DDQ}/2$ ) via 25Ω resistor				

Notes:

1. RZQ of 240Ω ( $\pm 1\%$ ) with RZQ/7 enabled (default 34Ω driver) and is applicable after proper ZQ calibration has been performed at a stable temperature and voltage ( $V_{DDQ} = V_{DD}$ ,  $V_{SSQ} = V_{SS}$ ).
2.  $V_{TT} = V_{DDQ}/2$ .
3. The 6 V/ns maximum is applicable for a single DQ signal when it is switching either from HIGH to LOW or LOW to HIGH while the remaining DQ signals in the same byte lane are either all static or all switching the opposite direction. For all other DQ signal switching combinations, the maximum limit of 6 V/ns is reduced to 5 V/ns.

Table 16 - Differential Output Driver Characteristics

Parameter / Condition	Symbol	Rating		Units	Notes
		Min	Max		
Output slew rate: Differential; For rising and falling edges, measure between $V_{OL,diff(AC)} = -0.2 * V_{DDQ}$ and $V_{OH,diff(AC)} = +0.2 * V_{DDQ}$ (1.35V)	$SRQ_{diff}$	3.5	12	V/ns	1
Output slew rate: Differential; For rising and falling edges, measure between $V_{OL,diff(AC)} = -0.2 * V_{DDQ}$ and $V_{OH,diff(AC)} = +0.2 * V_{DDQ}$ (1.5V)	$SRQ_{diff}$ (DDR3-1600)	5	10	V/ns	1
	$SRQ_{diff}$ (DDR3-1866)	5	15	V/ns	1
Differential high-level output voltage	$V_{OH,diff(AC)}$	$+0.2 * V_{DDQ}$		V	1
Differential low-level output voltage	$V_{OL,diff(AC)}$	$-0.2 * V_{DDQ}$		V	1
Test load for AC timing and output slew rates	Output to $V_{TT}$ ( $V_{DDQ}/2$ ) via 25Ω resistor				

Notes:

1. RZQ of 240Ω (±1%) with RZQ/7 enabled (default 34Ω driver) and is applicable after proper ZQ calibration has been performed at a stable temperature and voltage ( $V_{DDQ} = V_{DD}$ ,  $V_{SSQ} = V_{SS}$ ).
2.  $V_{REF} = V_{DDQ}/2$ ; slew rate @ 5V/ns, interpolate for faster slew rate.

For part number IMM2G64D3LDUD8AG-F125

Table 17 - I<sub>DD</sub> Specifications with Conditions and Operation Current

Parameter / Condition	Symbol	Current	Units	Notes
		1.35V		
Operating current 0; One bank ACTIVATE-to-PRECHARGE	I <sub>DD0</sub>	1136	mA	1, 2
Operating current 1; One bank ACTIVATE-to-READ-to-PRECHARGE	I <sub>DD1</sub>	1360	mA	1, 2
Precharge power-down current; Slow exit	I <sub>DD2P0</sub>	256	mA	1, 3
Precharge power-down current; Fast exit	I <sub>DD2P1</sub>	448	mA	1, 3
Precharge quiet standby current	I <sub>DD2Q</sub>	768	mA	1, 3
Precharge standby current	I <sub>DD2N</sub>	768	mA	1, 3
Precharge standby ODT current	I <sub>DD2NT</sub>	832	mA	1, 2
Active power-down current	I <sub>DD3P</sub>	832	mA	1, 3
Active standby current	I <sub>DD3N</sub>	960	mA	1, 3
Burst read operating current	I <sub>DD4R</sub>	1904	mA	1, 2
Burst write operating current	I <sub>DD4W</sub>	3184	mA	1, 2
Refresh current	I <sub>DD5B</sub>	4144	mA	1, 2
Self refresh temperature current: MAX T <sub>case</sub> = 85°C	I <sub>DD6</sub>	384	mA	1, 3
Self refresh temperature current (SRT-enabled): MAX T <sub>case</sub> = 95°C	I <sub>DD6ET</sub>	512	mA	1, 3
All banks interleaved read current	I <sub>DD7</sub>	2464	mA	1, 2
Reset current	I <sub>DD8</sub>	320	mA	1, 3

## Notes:

1. Value shown for DDR3 SDRAM only and are computed from values specified in the 8Gbit component data sheet.
2. One module rank in the active I<sub>DD</sub>, the other rank in I<sub>DD2N</sub>.
3. All ranks in this I<sub>DD</sub> conditions.



For part number IMM2G64D3(L)DUD8AG-F125(I)

Table 18 - AC Timing Parameter and Operating Conditions					
Parameter / Condition		Symbol	Min	Max	Units
Clock Timing					
Clock period average: DLL disable mode	Tcase = 0°C to 85°C	t <sub>CK(DLL_DIS)</sub>	8	-	ns
	Tcase => 85°C to 95°C		8	-	
Clock periods average: DLL enable mode (CL = 11, CWL = 8)		t <sub>CK(avg)</sub>	1.25	1.5	ns
High pulse width average		t <sub>CH(avg)</sub>	0.47	0.53	t <sub>CK(avg)</sub>
Low pulse width average		t <sub>CL(avg)</sub>	0.47	0.53	t <sub>CK(avg)</sub>
Clock period jitter	DLL locked	t <sub>JITper</sub>	-70	70	ps
	DLL locking	t <sub>JIT(per,lock)</sub>	-60	60	ps
Clock absolute period		t <sub>CK(abs)</sub>	t <sub>CK(avg) Min</sub> + t <sub>JITper Min</sub>	t <sub>CK(avg) Max</sub> + t <sub>JITper Max</sub>	ps
Clock absolute high pulse width		t <sub>CH(abs)</sub>	0.43	-	t <sub>CK(avg)</sub>
Clock absolute low pulse width		t <sub>CL(abs)</sub>	0.43	-	t <sub>CK(avg)</sub>
Cycle-to-cycle jitter	DLL locked	t <sub>JITcc</sub>	-	140	ps
	DLL locking	t <sub>JIT(cc,lock)</sub>	-	120	ps
Cumulative error across	2 cycles	t <sub>ERR(2per)</sub>	-103	103	ps
	3 cycles	t <sub>ERR(3per)</sub>	-122	122	ps
	4 cycles	t <sub>ERR(4per)</sub>	-136	136	ps
	5 cycles	t <sub>ERR(5per)</sub>	-147	147	ps
	6 cycles	t <sub>ERR(6per)</sub>	-155	155	ps
	7 cycles	t <sub>ERR(7per)</sub>	-163	163	ps
	8 cycles	t <sub>ERR(8per)</sub>	-169	169	ps
	9 cycles	t <sub>ERR(9per)</sub>	-175	175	ps
	10 cycles	t <sub>ERR(10per)</sub>	-180	180	ps
	11 cycles	t <sub>ERR(11per)</sub>	-174	174	ps
	12 cycles	t <sub>ERR(12per)</sub>	-188	188	ps
	n = 13...49, 50 cycles	t <sub>ERR(nper)</sub>	(1+0.68ln[n]) * t <sub>JITper Min</sub>	(1+0.68ln[n]) * t <sub>JITper Max</sub>	ps
DQ Input Timing					
Data setup time to DQS, /DQS (1.35V)	Base (specification)	t <sub>DS(AC130)</sub>	25	-	ps
Data setup time to DQS, /DQS (1.5V)	Base (specification)	t <sub>DS(AC135)</sub>	10	-	ps
Data hold time from DQS, /DQS (1.35V)	Base (specification)	t <sub>DH(DC90)</sub>	55	-	ps
Data hold time from DQS, /DQS (1.5V)	Base (specification)	t <sub>DH(DC100)</sub>	45	-	ps
Minimum data pulse width		t <sub>DIPW</sub>	360	-	ps
DQ Output Timing					
DQS, /DQS to DQ skew, per access		t <sub>DQSQ</sub>	-	100	ps
DQ output hold time from DQS, /DQS		t <sub>QH</sub>	0.38	-	t <sub>CK(avg)</sub>
DQ Low-Z time from CK, /CK		t <sub>LZ(DQ)</sub>	-450	225	ps
DQ High-Z time from CK, /CK		t <sub>HZ(DQ)</sub>	-	225	ps
DQ Strobe Input Timing					
DQS, /DQS rising to CK, /CK rising		t <sub>DQSS</sub>	-0.27	0.27	t <sub>CK(avg)</sub>
DQS, /DQS differential input low pulse width		t <sub>DQSL</sub>	0.45	0.55	t <sub>CK(avg)</sub>
DQS, /DQS falling setup to CK, /CK rising		t <sub>DSS</sub>	0.18	-	t <sub>CK(avg)</sub>
DQS, /DQS falling hold from CK, /CK rising		t <sub>DSSH</sub>	0.18	-	t <sub>CK(avg)</sub>
DQS, /DQS differential input high pulse width		t <sub>DQSH</sub>	0.45	0.55	t <sub>CK(avg)</sub>
DQS, /DQS differential WRITE preamble		t <sub>WPRE</sub>	0.9	-	t <sub>CK(avg)</sub>
DQS, /DQS differential WRITE postamble		t <sub>WPST</sub>	0.3	-	t <sub>CK(avg)</sub>

For part number IMM2G64D3(L)DUD8AG-F125(I)

Parameter / Condition		Symbol	Min	Max	Units
<b>DQ Strobe Output Timing</b>					
DQS, /DQS rising to/from CK, /CK		t <sub>DQSK</sub>	-225	225	ps
DQS, /DQS differential output high time		t <sub>QSH</sub>	0.40	-	t <sub>CK</sub> (avg)
DQS, /DQS differential output low time		t <sub>QSL</sub>	0.40	-	t <sub>CK</sub> (avg)
DQS, /DQS Low-Z time (RL-1)		t <sub>LZ(DQS)</sub>	-450	225	ps
DQS, /DQS High-Z time (RL+BL/2)		t <sub>HZ(DQS)</sub>	-	225	ps
DQS, /DQS differential READ preamble		t <sub>RPRE</sub>	0.9	-	t <sub>CK</sub> (avg)
DQS, /DQS differential READ postamble		t <sub>RPST</sub>	0.3	-	t <sub>CK</sub> (avg)
<b>Command and Address Timing</b>					
DLL locking time		t <sub>DLLK</sub>	512	-	nCK
CTRL, CMD, ADDR setup to CK, /CK (1.35V)	Base (specification)	t <sub>IS</sub> (AC160)	60	-	ps
	Base (specification)	t <sub>IS</sub> (AC135)	185	-	ps
CTRL, CMD, ADDR setup to CK, /CK (1.5V)	Base (specification)	t <sub>IS</sub> (AC175)	170	-	ps
	Base (specification)	t <sub>IS</sub> (AC150)	120	-	ps
CTRL, CMD, ADDR hold from CK, /CK (1.35V)	Base (specification)	t <sub>IH</sub> (DC90)	130	-	ps
	Base (specification)	t <sub>IH</sub> (DC100)	120	-	ps
Minimum CTRL, CMD, ADDR pulse width		t <sub>IPW</sub>	560	-	ps
ACTIVATE to internal READ or WRITE delay		t <sub>RCD</sub>	13.125	-	ns
PRECHARGE command period		t <sub>RP</sub>	13.125	-	ns
ACTIVATE-to-PRECHARGE command period		t <sub>RAS</sub>	35	9 * t <sub>REFI</sub>	ns
ACTIVATE-to-ACTIVATE command period		t <sub>RC</sub>	48.125	-	ns
ACTIVATE-to-ACTIVATE minimum period (1KB page size)		t <sub>RRD</sub>	greater of 4nCK or 6ns	-	-
ACTIVATE-to-ACTIVATE minimum period (2KB page size)		t <sub>RRD</sub>	greater of 4nCK or 7.5ns	-	-
Four ACTIVATE windows (1KB page size)		t <sub>FAW</sub>	30	-	ns
Four ACTIVATE windows (2KB page size)		t <sub>FAW</sub>	40	-	ns
Write recovery time		t <sub>WR</sub>	15	-	ns
Delay from start of internal WRITE transaction to internal READ command		t <sub>WTR</sub>	greater of 4nCK or 7.5ns	-	-
READ-to-PRECHARGE time		t <sub>RTP</sub>	greater of 4nCK or 7.5ns	-	-
/CAS-to-/CAS command delay		t <sub>CCD</sub>	4	-	nCK
Auto precharge write recovery + precharge time		t <sub>DAL</sub>	WR + t <sub>RP</sub> /t <sub>CK</sub> (avg)	-	t <sub>CK</sub>
MODE REGISTER SET command cycle time		t <sub>MRD</sub>	4	-	nCK
MODE REGISTER SET command update delay		t <sub>MOD</sub>	greater of 12nCK or 15ns	-	-
MULTIPURPOSE REGISTER READ burst end to mode register set for multipurpose register exit		t <sub>MRR</sub>	1	-	nCK
<b>Calibration Timing</b>					
ZQCL command: Long calibration time	POWER-UP and RESET operation	t <sub>ZQinit</sub>	greater of 512nCK or 640ns	-	-
	Normal operation	t <sub>ZQoper</sub>	greater of 256nCK or 320ns	-	-
ZQCS command: Short calibration time		t <sub>ZQCS</sub>	greater of 64nCK or 80ns	-	-
<b>Initialization and Reset Timing</b>					
Exit reset from CKE HIGH to valid command		t <sub>XPR</sub>	greater of 5nCK or t <sub>RFC</sub> Min+10ns	-	-
<b>Refresh Timing</b>					
REFRESH-to-ACTIVATE or REFRESH command period		t <sub>RFC</sub>	300	-	ns

For part number IMM2G64D3(L)DUD8AG-F125(I)

Parameter / Condition		Symbol	Min	Max	Units
Maximum refresh period	T <sub>case</sub> ≤ 85°C	-	64 (1X)		ms
	T <sub>case</sub> > 85°C		32 (2X)		
Maximum average periodic refresh	T <sub>case</sub> ≤ 85°C	t <sub>REFI</sub>	7.8 (64ms/8192)		us
	T <sub>case</sub> > 85°C		3.9 (32ms/8192)		
<b>Self Refresh Timing</b>					
Exit self refresh to commands not requiring a locked DLL		t <sub>XS</sub>	greater of 5 nCK or t <sub>RFC</sub> Min+10ns	-	-
Exit self refresh to commands requiring a locked DLL		t <sub>XSDLL</sub>	t <sub>DLLK</sub> Min	-	nCK
Minimum CKE low pulse width for self refresh entry to self refresh exit timing		t <sub>CKESR</sub>	t <sub>CKE</sub> Min + 1nCK	-	-
Valid clocks after self refresh entry or power down entry		t <sub>CKSRE</sub>	greater of 5nCK or 10ns	-	-
Valid clocks before self refresh exit, power-down exit, or reset exit		t <sub>CKSRX</sub>	greater of 5nCK or 10ns	-	-
<b>Power-Down Timing</b>					
CKE MIN pulse width		t <sub>CKE</sub>	greater of 3nCK or 5ns	-	-
Command pass disable delay		t <sub>CPDED</sub>	1	-	nCK
Power-down entry to power exit timing		t <sub>PD</sub>	t <sub>CKE</sub> Min	9 * t <sub>REFI</sub>	-
<b>Power-Down Entry Minimum Timing</b>					
ACTIVATE command to power-down entry		t <sub>ACTPDEN</sub>	1	-	nCK
PRECHARGE/PRECHARGE ALL command to power-down entry		t <sub>PRPDEN</sub>	1	-	nCK
REFRESH command to power-down entry		t <sub>REFPDEN</sub>	1	-	nCK
MRS command to power-down entry		t <sub>MRSPDEN</sub>	t <sub>MOD</sub> Min	-	-
READ/READ with auto precharge command to power-down entry		t <sub>RDPDEN</sub>	RL + 4 + 1	-	nCK
WRITE command to power-down entry	BL8 (OTF, MRS) BC4OTF	t <sub>WRPDEN</sub>	WL + 4 + t <sub>WR</sub> /t <sub>CK</sub> (avg)	-	nCK
	BC4MRS	t <sub>WRPDEN</sub>	WL + 2 + t <sub>WR</sub> /t <sub>CK</sub> (avg)	-	nCK
WRITE with auto precharge command to power-down entry	BL8 (OTF, MRS) BC4OTF	t <sub>WRAPDEN</sub>	WL + 4 + t <sub>WR</sub> + 1	-	nCK
	BC4MRS	t <sub>WRAPDEN</sub>	WL + 2 + t <sub>WR</sub> + 1	-	nCK
<b>Power-Down Exit Timing</b>					
DLL on, any valid command, or DLL off to commands not requiring locked DLL		t <sub>XP</sub>	greater of 3nCK or 6ns	-	-
Precharge power-down with DLL off to commands requiring a locked DLL		t <sub>XPDLL</sub>	greater of 10nCK or 24ns	-	-
<b>ODT Timing</b>					
RTT turn-on from ODTL on reference		t <sub>AON</sub>	-225	225	ps
RTT turn-off from ODTL off reference		t <sub>AOFF</sub>	0.3	0.7	t <sub>CK</sub> (avg)
Asynchronous RTT turn-on delay (power-down with DLL off)		t <sub>AOONPD</sub>	2	8.5	ns
Asynchronous RTT turn-off delay (power-down with DLL off)		t <sub>AOFFPD</sub>	2	8.5	ns
ODT HIGH time with WRITE command and BL8		ODTH8	6	-	nCK
ODT HIGH time without WRITE command or WRITE command and BC4		ODTH4	4	-	nCK
<b>Dynamic ODT Timing</b>					
RTT dynamic change skew		t <sub>ADC</sub>	0.3	0.7	t <sub>CK</sub> (avg)
<b>Write Leveling Timing</b>					
First DQS, /DQS rising edge		t <sub>WLMRD</sub>	40	-	nCK
DQS, /DQS delay		t <sub>WLDQSEN</sub>	25	-	nCK
Write leveling setup from rising CK, /CK crossing to rising DQS, /DQS crossing		t <sub>WLS</sub>	165	-	ps
Write leveling hold from rising DQS, /DQS crossing to rising CK, /CK crossing		t <sub>WLH</sub>	165	-	ps
Write leveling output delay		t <sub>WLO</sub>	0	7.5	ns
Write leveling output error		t <sub>WLOE</sub>	0	2	ns

For part number IMM2G64D3(L)DUD8AG-F125

Table 19 - SPD Information

Byte NO.	Description	Note		Hex	
		1.35V	1.5V	1.35V	1.5V
0	Number of SPD Written, SPD Device Size, CRC Coverage	176, 256, 0-116		92	
1	SPD Revision	Revision 1.2		12	
2	Key Byte / DRAM Device Type	DDR3 SDRAM		0B	
3	Key Byte / Module Type	Unbuffered DIMM		02	
4	SDRAM Density and Banks	8Gbits, 8banks		05	
5	SDRAM Addressing	Row 16, Col 11		22	
6	Module Nominal Voltage, V <sub>DD</sub>	1.35V / 1.5V	1.5V	02	00
7	Module Organization	2Ranks, x8		09	
8	Module Memory Bus Width	Non-ECC, 64bits		03	
9	Fine Timebase (FTB) Dividend / Divisor	2.5ps		52	
10	Medium Timebase (MTB) Dividend	1ns		01	
11	Medium Timebase (MTB) Divisor	8		08	
12	SDRAM Minimum Cycle Time (t <sub>CKmin</sub> )	1.25ns		0A	
13	Reserved	-		00	
14	CAS Latencies Supported, LSB	5,6,7,8,9,10,11		FE	
15	CAS Latencies Supported, MSB	-		00	
16	Minimum CAS Latency Time (t <sub>AAmin</sub> )	13.125ns		69	
17	Minimum Write Recovery Time (t <sub>WRmin</sub> )	15ns		78	
18	Minimum RAS# to CAS# Delay Time (t <sub>RCDmin</sub> )	13.125ns		69	
19	Minimum Row Active to Row Active Delay Time (t <sub>RRDmin</sub> )	7.5ns		3C	
20	Minimum Row Precharge Time (t <sub>RPmin</sub> )	13.125ns		69	
21	Upper Nibbles for t <sub>RAS</sub> and t <sub>RC</sub>	-		11	
22	Minimum Active to Precharge Time (t <sub>RASmin</sub> ), LSB	35ns		18	
23	Minimum Active to Active/Refresh Time (t <sub>RCmin</sub> ), LSB	48.125ns		81	
24	Minimum Refresh Recovery Time (t <sub>RFCmin</sub> ), LSB	300ns		60	
25	Minimum Refresh Recovery Time (t <sub>RFCmin</sub> ), MSB	-		09	
26	Minimum Internal Write to Read Command Delay Time (t <sub>WTRmin</sub> )	7.5ns		3C	
27	Minimum Internal Read to Precharge Command Delay Time (t <sub>RTPmin</sub> )	7.5ns		3C	
28	Upper Nibble for t <sub>FAW</sub>	-		01	
29	Minimum Four Activate Window Delay Time (t <sub>FAWmin</sub> )	40ns		40	
30	SDRAM Optional Features	DLL off, RZQ/7, RZQ/6		83	
31	SDRAM Thermal and Refresh Options	ASR, 0°C-95°C, req. 2x Refresh		05	
32	Module Thermal Sensor	No Thermal Sensor incorporated		00	
33	SDRAM Device Type	Dual Die Package		A1	
34	Fine Offset for SDRAM Minimum Cycle Time (t <sub>CKmin</sub> )	-0ps		00	
35	Fine Offset for Minimum CAS Latency Time (t <sub>AAmin</sub> )	-0ps		00	
36	Fine Offset for Minimum RAS# to CAS# Delay Time (t <sub>RCDmin</sub> )	-0ps		00	
37	Fine offset for minimum Row Precharge Delay Time (t <sub>RPmin</sub> )	-0ps		00	

Byte NO.	Description	Note	Hex
38	Fine Offset for Minimum Active to Active/Refresh Delay Time ( $t_{RCmin}$ )	-0ps	00
39-40	Reserved, General Section	-	00
41	SDRAM Maximum Activate Count (MAC) Value	8192* $t_{REFI}$ , Untested MAC	00
42-59	Reserved. General Section	-	00
60	Module Nominal Height	29< Height <=30 mm	0F
61	Module Maximum Thickness	1< tF <=2 mm, 1< tB <=2 mm	11
62	Reference Raw Card	Raw Card B1	21
63	Address Mapping from Edge Connector to DRAM	Mirrored Mapping	01
64-116	Reserved	-	00
117-118	Module Manufacturer's JEDEC ID Code	I'M	04 9E
119	Module Manufacturing Location	-	00
120-121	Module Manufacturing Date	Manufacturer's data	-
122-125	Module Serial Number	Manufacturer's data	-
126-127	Cyclical Redundancy Code (CRC)	-	57 BB   FC 3C
128-145	Module Part Number	Manufacturer's data	-
146-147	Module Revision Code	-	00
148-149	DRAM Manufacturer ID Code	-	00
150-175	Manufacturer's Specific Data	Manufacturer's data	-
176-255	Open For Customer Use	Reserved	00

## Revision History

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Revision	Descriptions	Release Date
1.0	Initial release	Jul, 2021

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