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DDR4 (PC4)
ECC LRDIMM
VP9MLxx72x4xxx

Viking's DDR4 LRDIMM memory module offers lower operating voltages, higher module densities and faster speed categories than prior generation DDR3 memory. JEDEC DDR4 (JESD79-4) specification provides higher performance with improved reliability and reduced power, thereby representing a significant achievement relative to previous DRAM memory technologies.

REVISION HISTORY

Revision	Release Date	Description of Change	Checked By (Full Name)
A	10/07/15	Initial release	
B	3/17/17	Revise logo and color scheme. Change company address	
C	4/17/17	Add 128GB PN's	
D	7/11/17	Add VP9ML4G7224JBJSB	

Legal Information

Legal Information

STATEMENT OF COMPLIANCE

Viking Technology, Sanmina Corporation ("Viking") shall use commercially reasonable efforts to provide components, parts, materials, products and processes to Customer that do not contain: (i) lead, mercury, hexavalent chromium, polybrominated biphenyls (PBB) and polybrominated diphenyl ethers (PBDE) above 0.1% by weight in homogeneous material or (ii) cadmium above 0.01% by weight of homogeneous material, except as provided in any exemption(s) from RoHS requirements (including the most current version of the "Annex" to Directive 2002/95/EC of 27 January, 2003), as codified in the specific laws of the EU member countries. Viking strives to obtain appropriate contractual protections from its suppliers in connection with the RoHS Directives.

All printed circuit boards (PCBs) have a flammability rating of UL94V-0.

Ordering Information and Module Configuration

Viking Part Number	Voltage	Capacity	Module Organization	Device Configuration	Device Package	DIMM Rank	Speed	CAS Latency
VP9ML2G7224HBHSB	1.2V	16GB	2Gx72	1024Mx4 (36)	FBGA	2	PC4-17000	CL15 (15-15-15)
VP9ML2G7224HBJSB	1.2V	16GB	2Gx72	1024Mx4 (36)	FBGA	2	PC4-19200	CL17 (17-17-17)
VP9ML4G7224HEHSB	1.2V	32GB	4Gx72	(1024Mx4)*2 (36)	DDP	4	PC4-17000	CL15 (15-15-15)
VP9ML4G7224HEJSB	1.2V	32GB	4Gx72	(1024Mx4)*2 (36)	DDP	4	PC4-19200	CL17 (17-17-17)
VP9ML4G7224JBJSB	1.2V	32GB	4Gx72	(2048Mx4)x36	FBGA	2	PC4-19200	CL17 (17-17-17)
VP9ML8G7224JEHSB	1.2V	64GB	8Gx72	(2048Mx4)*2 (36)	DDP	4	PC4-17000	CL15 (15-15-15)
VP9ML8G7224JEJSB	1.2V	64GB	8Gx72	(2048Mx4)*2 (36)	DDP	4	PC4-19200	CL17 (17-17-17)
VP9ML6G7224JKHSB	1.2V	128GB	16Gx72	(4096Mx4)*2 (36)	4HTSV	4	PC4-17000	CL15 (15-15-15)
VP9ML6G7224JKJSB	1.2V	128GB	16Gx72	(4096M x4)*2 (36)	4HTSV	4	PC4-19200	CL17 (17-17-17)

Notes:

- The lowercase letters y and z are wildcard characters that indicate DRAM vendor and die revisions and /or for customer specific locked BOMs. Refer to the Viking part number coversheet for details.

Features

- JEDEC Standard Power Supply
  - PC4: VDD = VDDQ = 1.2V± 5% (1.14V-1.26V)
  - External VPP = 2.5 Volt +10%, -5%
  - VDDSPD = 2.5V± 10% (2.25-2.75V)
- 288 pin Dual-In-Line Memory Module
- Edge finger connector ramp zone to reduce insertion force
- Point-to-Point topology to reduce loading
- Pseudo-open drain (POD12) DQ lines
- Write DQ CRC (Cyclic Redundancy Check)
- Internally generated VrefDQ
- ECC recovery from command and parity errors
- On-chip CA Parity detection for the command/address bus
- Programmable CAS Latency: 11,12,13,14,15,17
- Programmable CAS Write Latency (CWL).
- Programmable Additive Latency (Posted CAS)
- Per DRAM addressability is supported
- One load for address/command signals using a Registered Clock Driver (RCD)
- Selectable Fixed burst chop (BC4) of 4 and burst length (BL8) of 8 on-the-fly (OTF) via the mode register set (MRS)
- 8n prefetch with 2 or 4 selectable bank groups: 16 banks (4 bank groups x 4 banks per bank group)
- Separate activation, read, write, refresh operations for each bank group
- 7 mode registers
- Dynamic On-Die-Termination (ODT) and ODT Park for improved signal integrity.
- Self Refresh and several Power Down Modes
- DLL-off mode for power savings
- ZQ pin Self Calibration for output driver and ODT
- System Level Timing Calibration Support via Write Leveling and Multi Purpose Register (MPR) Read Pattern
- Serial Presence Detect with EEPROM
- On-DIMM Thermal Sensor
- Asynchronous Reset
- Bidirectional Differentially Buffered Data Strobes(DQS)
- LRDIMM dimensions within JEDEC MO-309 maximum limits
- RoHS Compliant

DDR4 SPEED BIN Nomenclature

Module Standard	SDRAM Standard	Clock
PC4-12800	DDR4-1600	800 MHz
PC4-14900	DDR4-1866	933 MHz
PC4-17000	DDR4-2133	1066 MHz
PC4-19200	DDR4-2400	1200 MHz

DDR4 Timing Summary

MT/s	tCK (ns)	CAS Latency (tCK)	tRCD (ns)	tRP (ns)	tRAS (ns)	tRC (ns)	CL-tRCD-tRP
DDR4-1600	1.25	11	13.75	13.75	35	48.75	11-11-11
DDR4-1866	1.071	13	13.92	13.92	34	47.92	13-13-13
DDR4-2133	0.93	15	14.06	14.06	33	47.06	15-15-15
DDR4-2400	0.83	17	14.16	14.16	32	46.16	17-17-17

Notes:

- CL = CAS Latency, tRCD = Activate –to-Command Time, tRP = Precharge Time. Refer to Speed Bin tables for details

Addressing

		2048Mbx4 8Gb DDP DRAM
Bank Address	**# of Bank Groups**	4
	BG Address	BG0~BG1
	Bank Address in a BG	BA0~BA1
Row Address		A0~A15
Column Address		A0~ A9
Page size		512B

Note:
Samsung Datasheet specifies 512B for x4 Device.

DDR4 288-pin LRDIMM Pin Wiring Assignments/Configurations

Pin#	Description	Pin#	Description	Pin#	Description	Pin#	Description	Pin#	Description	Pin#	Description
1	12V_NC	145	12V_NC	52	DQS17_c	196	DQS8_c	102	DQ38	246	VSS
2	VSS	146	VREFCA	53	VSS	197	DQS8_t	103	VSS	247	DQ39
3	DQ4	147	VSS	54	CB6	198	VSS	104	DQ34	248	VSS
4	VSS	148	DQ5	55	VSS	199	CB7	105	VSS	249	DQ35
5	DQ0	149	VSS	56	CB2	200	VSS	106	DQ44	250	VSS
6	VSS	150	DQ1	57	VSS	201	CB3	107	VSS	251	DQ45
7	DQS9_t	151	VSS	58	RESET_n	202	VSS	108	DQ40	252	VSS
8	DQS9_c	152	DQS0_c	59	VDD	203	CKE1	109	VSS	253	DQ41
9	VSS	153	DQS0_t	60	CKE0	204	VDD	110	DQS14_t	254	VSS
10	DQ6	154	VSS	61	VDD	205	RFU	111	DQS14_c	255	DQS5_c
11	VSS	155	DQ7	62	ACT_n	206	VDD	112	VSS	256	DQS5_t
12	DQ2	156	VSS	63	BG0	207	BG1	113	DQ46	257	VSS
13	VSS	157	DQ3	64	VDD	208	ALERT_n	114	VSS	258	DQ47
14	DQ12	158	VSS	65	A12/BC_n	209	VDD	115	DQ42	259	VSS
15	VSS	159	DQ13	66	A9	210	A11	116	VSS	260	DQ43
16	DQ8	160	VSS	67	VDD	211	A7	117	DQ52	261	VSS
17	VSS	161	DQ9	68	A8	212	VDD	118	VSS	262	DQ53
18	DQS10_t	162	VSS	69	A6	213	A5	119	DQ48	263	VSS
19	DQS10_c	163	DQS1_c	70	VDD	214	A4	120	VSS	264	DQ49
20	VSS	164	DQS1_t	71	A3	215	VDD	121	DQS15_t	265	VSS
21	DQ14	165	VSS	72	A1	216	A2	122	DQS15_c	266	DQS6_c
22	VSS	166	DQ15	73	VDD	217	VDD	123	VSS	267	DQS6_t
23	DQ10	167	VSS	74	CK0_t	218	CK1_t	124	DQ54	268	VSS
24	VSS	168	DQ11	75	CK0_c	219	CK1_c	125	VSS	269	DQ55
25	DQ20	169	VSS	76	VDD	220	VDD	126	DQ50	270	VSS
26	VSS	170	DQ21	77	VTT	221	VTT	127	VSS	271	DQ51
27	DQ16	171	VSS	78	EVENT_n	222	PARITY	128	DQ60	272	VSS
28	VSS	172	DQ17	79	A0	223	VDD	129	VSS	273	DQ61
29	DQS11_t	173	VSS	80	VDD	224	BA1	130	DQ56	274	VSS
30	DQS11_c	174	DQS2_c	81	BA0	225	A10/AP	131	VSS	275	DQ57
31	VSS	175	DQS2_t	82	RAS_n/A16	226	VDD	132	DQS16_t	276	VSS
32	DQ22	176	VSS	83	VDD	227	RFU	133	DQS16_c	277	DQS7_c
33	VSS	177	DQ23	84	S0_n	228	WE_n/A14	134	VSS	278	DQS7_t
34	DQ18	178	VSS	85	VDD	229	VDD	135	DQ62	279	VSS
35	VSS	179	DQ19	86	CAS_n/A15	230	NC	136	VSS	280	DQ63
36	DQ28	180	VSS	87	ODT0	231	VDD	137	DQ58	281	VSS

Pin#	Description	Pin#	Description	Pin#	Description	Pin#	Description	Pin#	Description	Pin#	Description
37	VSS	181	DQ29	88	VDD	232	A13	138	VSS	282	DQ59
38	DQ24	182	VSS	89	S1_n	233	VDD	139	SA0	283	VSS
39	VSS	183	DQ25	90	VDD	234	A17 NC	140	SA1	284	VDDSPD
40	DQS12_t	184	VSS	91	ODT1	235	C[2] NC	141	SCL	285	SDA
41	DQS12_c	185	DQS3_c	92	VDD	236	VDD	142	VPP	286	VPP
42	VSS	186	DQS3_t	93	S2_n C[0]	237	S3_n C[1]	143	VPP	287	VPP
43	DQ30	187	VSS	94	VSS	238	SA2	144	RFU	288	VPP
44	VSS	188	DQ31	95	DQ36	239	VSS				
45	DQ26	189	VSS	96	VSS	240	DQ37				
46	VSS	190	DQ27	97	DQ32	241	VSS				
47	CB4	191	VSS	98	VSS	242	DQ33				
48	VSS	192	CB5 NC	99	DQS13_t	243	VSS				
49	CB0	193	VSS	100	DQS13_c	244	DQS4_c				
50	VSS	194	CB1	101	VSS	245	DQS4_t				
51	DQS17_t	195	VSS								

Notes:

- Pin 230 is defined as NC for UDIMMs and LRDIMMs. Pin 230 is defined as SAVE_n (ADR) for NVDIMMs.
- A15 needed for 4GBit DRAM, A16 needed for 8GBit DRAM, A17 needed for 16GBit DRAM
- DDR4 pin-out include the following additional pins beyond DDR3: Vpp, ACT_n, A17, BG0, BG1, Alert_n.
- The following DDR3 pins are no longer required for DDR4: BC#, BA2, VREFDQ
- Address A17 is only valid for 16GBit DRAM
- RAS_n is a multiplexed function with A16. (A16 needed for 8GBit DRAM)
- CAS_n is a multiplexed function with A15. (A15 needed for 4GBit DRAM)
- WE_n is a multiplexed function with A14

Input/Output Functional Descriptions

SYMBOL	TYPE	FUNCTION
CK_t, CK_c	Input	Clock: CK_t and CK_c are differential clock inputs. All address and control input signals are sampled on the crossing of the positive edge of CK_t and negative edge of CK_c.
CKE0, (CKE1)	Input	Clock Enable: CKE HIGH activates, and CKE Low deactivates, internal clock signals and device input buffers and output drivers. Taking CKE Low provides Precharge Power-Down and Self-Refresh operation (all banks idle), or Active Power-Down (row Active in any bank). CKE is asynchronous for Self-Refresh exit. After VREFCA and VREFDQ have become stable during the power on and initialization sequence, they must be maintained during all operations (including Self-Refresh). CKE must be maintained high throughout read and write accesses. Input buffers, excluding CK, CK_c, ODT and CKE, are disabled during power-down. Input buffers, excluding CKE, are disabled during Self-Refresh.
CS0_n, (CS1_n)	Input	Chip Select: All commands are masked when CS_n is registered HIGH. CS_n provides for external Rank selection on systems with multiple Ranks. CS_n is considered part of the command code.
C0, C1, C2	Input	Chip ID: Chip ID is only used for 3DS for 2,4,8high stack via TSV to select each slice of stacked component. Chip ID is considered part of the command code.
ODT0, (ODT1)	Input	On Die Termination: ODT (registered HIGH) enables termination resistance internal to the DDR4 SDRAM. When enabled, ODT is only applied to each DQ, DQS_t, The ODT pin will be ignored if MR1 is programmed to disable RTT_NOM.
ACT_n	Input	Activation Command Input: ACT_n defines the Activation command being entered along with CS_n. The input into RAS_n/A16, CAS_n/A15 and WE_n/A14 will be considered as Row Address A16, A15 and A14.
RAS_n/A16, CAS_n/A15, WE_n/A14	Input	Command Inputs RAS_n/A16, CAS_n/A15 and WE_n/A14 (along with CS_n) define the command being entered. Those pins have multi function. For example, for activation with ACT_n Low, those are Addressing like A16,A15 and A14 but for non-activation command with ACT_n High, those are Command pins for Read, Write and other command defined in command truth table.
BG0 - BG1	Input	Bank Group Inputs: BG0 - BG1 define to which bank group an Active, Read, Write or Precharge command is being applied. BG0 also determines which mode register is to be accessed during a MRS cycle. x4 have BG0 and BG1.
BA0 - BA1	Input	Bank Address Inputs: BA0 - BA1 define to which bank an Active, Read, Write or Precharge command is being applied. Bank address also determines if the mode register or extended mode register is to be accessed during a MRS cycle.
A0 - A17	Input	Address Inputs: Provided the row address for ACTIVATE Commands and the column address for Read/Write commands th select one location out of the memory array in the respective bank. (A10/AP, A12/BC_n, RAS_n/A16, CAS_n/A15 and WE_n/A14 have additional functions, see other rows. The address inputs also provide the op-code during Mode Register Set commands. A17 is only defined for the x4 configuration.

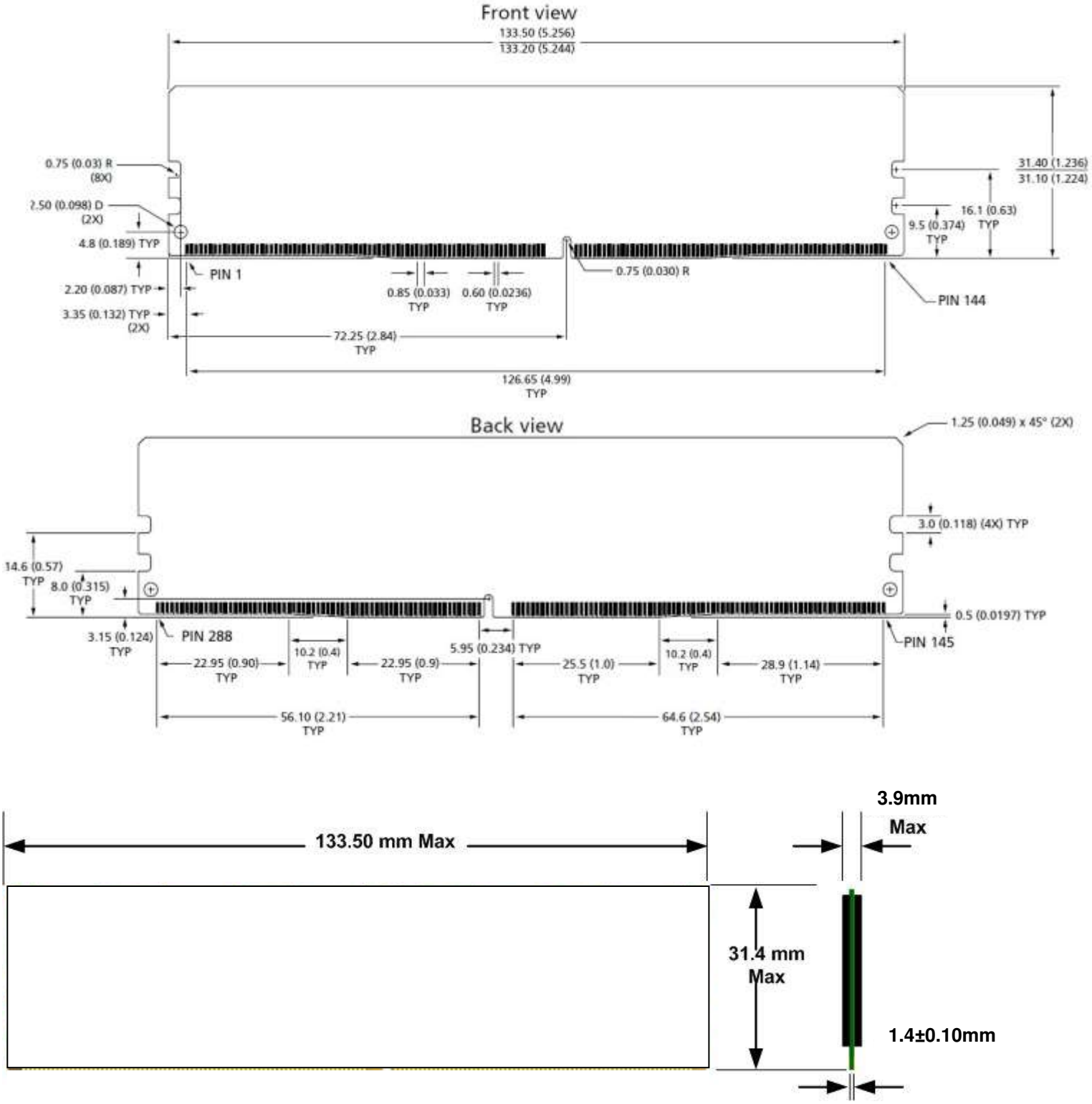
SYMBOL	TYPE	FUNCTION
A10 / AP	Input	Auto-precharge: A10 is sampled during Read/Write commands to determine whether Autoprecharge should be performed to the accessed bank after the Read/Write operation. (HIGH: Autoprecharge; LOW: no Autoprecharge).A10 is sampled during a Precharge command to determine whether the Precharge applies to one bank (A10 LOW) or all banks (A10 HIGH). If only one bank is to be precharged, the bank is selected by bank addresses.
A12 / BC_n	Input	Burst Chop: A12 / BC_n is sampled during Read and Write commands to determine if burst chop (on-the-fly) will be performed. (HIGH, no burst chop; LOW: burst chopped). See command truth table for details.
RESET_n	Input	Active Low Asynchronous Reset: Reset is active when RESET_n is LOW, and inactive when RESET_n is HIGH. RESET_n must be HIGH during normal operation. RESET_n is a CMOS rail to rail signal with DC high and low at 80% and 20% of VDD.
DQ	Input / Output	Data Input/ Output: Bi-directional data bus. If CRC is enabled via Mode register then CRC code is added at the end of Data Burst. Any DQ from DQ0~DQ3 may indicate the internal Vref level during test via Mode Register Setting MR4 A4=High. Refer to vendor specific datasheets to determine which DQ is used.
CB	Input / Output	Check Bit Input/ Output: Bi-directional ECC portion of data bus for x72 configurations
DQS_t, DQS_c, DQSL_t, DQSL_c	Input / Output	Data Strobe: output with read data, input with write data. Edge-aligned with read data, centered in write data. The data strobe DQS_t and DQSL_t, are paired with differential signals DQS_c and DQSL_c respectively, to provide differential pair signaling to the system during reads and writes. DDR4 SDRAM supports differential data strobe only and does not support single-ended.
PAR	Input	Command and Address Parity Input: DDR4 Supports Even Parity check in DRAMs with MR setting. Once it's enabled via Register in MR5, then DRAM calculates Parity with ACT_n, RAS_n/A16, CAS_n/A15, WE_n/A14, BG0-BG1, BA0-BA1, A17-A0. Input parity should maintain at the rising edge of the clock and at the same time with command & address with CS_n LOW.
ALERT_n	Output	Alert: It has multi functions such as CRC error flag, Command and Address Parity error flag. If there is error in CRC, then Alert_n goes LOW for the period time interval and goes back HIGH. IF there is error in Command Address Parity Check, then Alert_n goes LOW for relatively long period until on going DRAM internal recovery transaction to complete.
NC		No Connect: No internal electrical connection is present.
VDDQ	Supply	DQ Power Supply: 1.2 V +/- 0.06 V
VSSQ	Supply	DQ Ground
VDD	Supply	Power Supply: 1.2 V +/- 0.06 V
VSS	Supply	Ground
Vpp	Supply	DRAM Activation Power Supply: 2.5V (2.375V min , 2.75 max)
VREFCA	Supply	Reference voltage for CA

SYMBOL	TYPE	FUNCTION
ZQ	Supply	Reference Pin for ZQ calibration

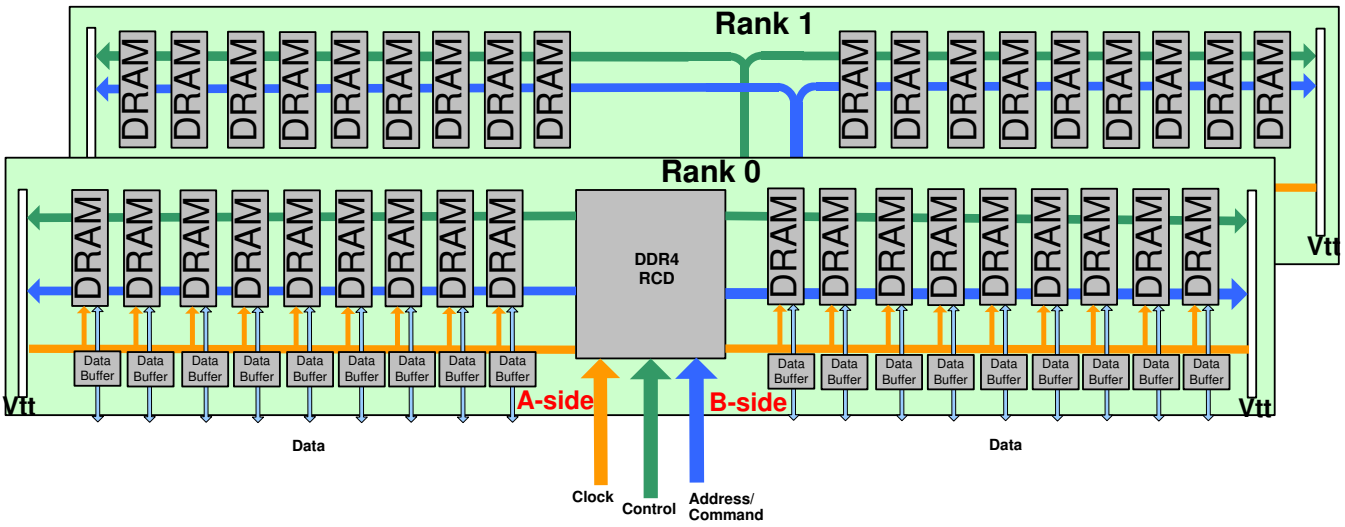
Notes:

1. The input only pins (BG0-BG-1, BA0-BA1, A0-A17, ACT_n, RAS_n,/A16, CAS_n/A15, WE_n/A14, CS_n, CKE, ODT, and RESET_n) do not supply termination.

MECHANICAL OUTLINE

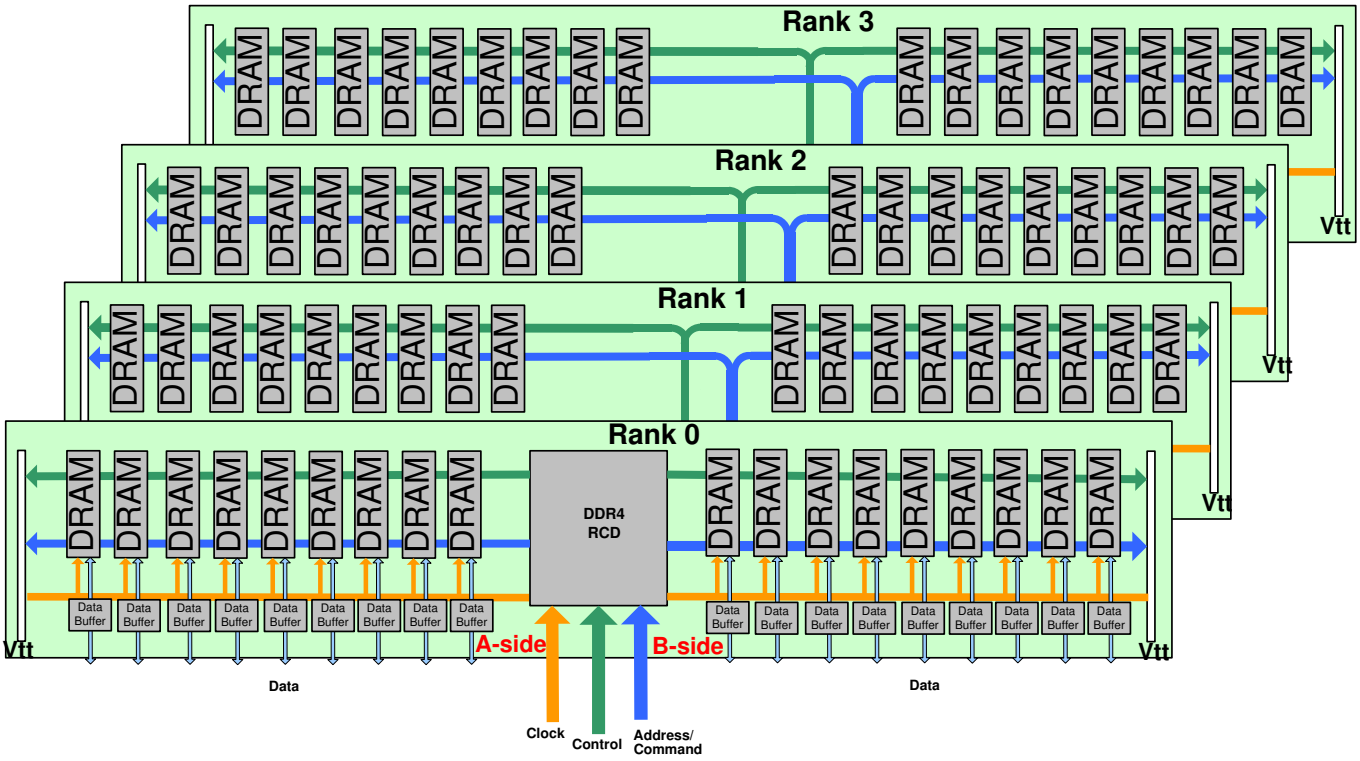


FUNCTIONAL BLOCK DIAGRAM DUAL RANK

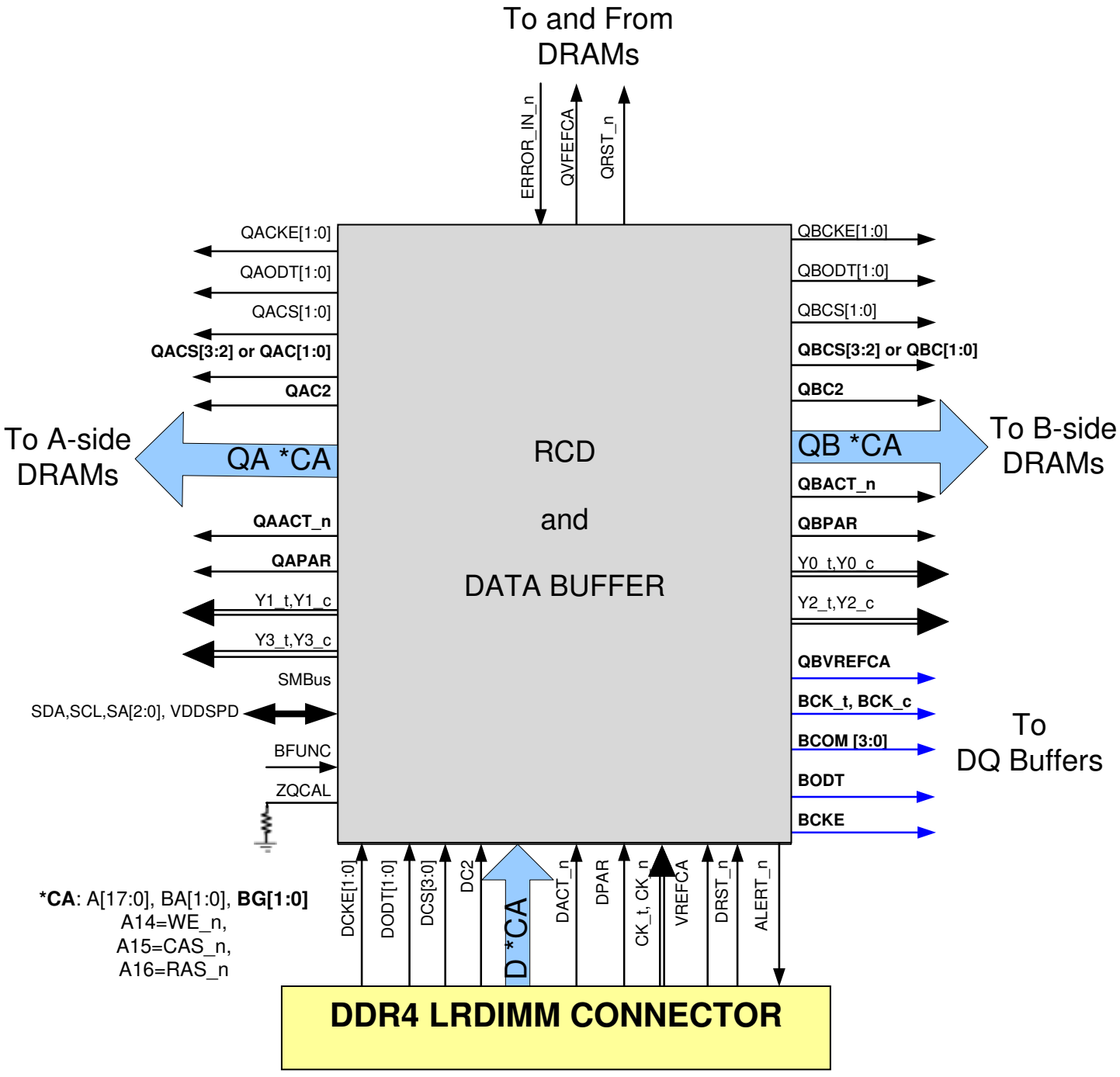


DDR4 HOST MEMORY INTERFACE

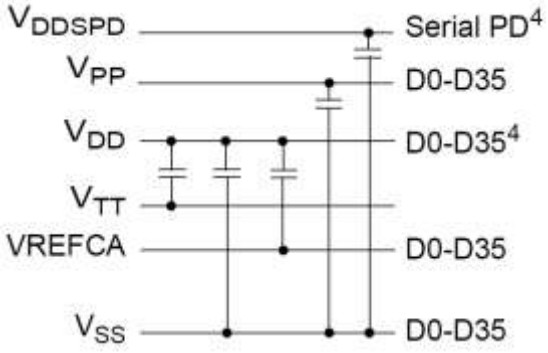
FUNCTIONAL BLOCK DIAGRAM QUAD RANK



DDR4 HOST MEMORY INTERFACE


To and From DRAMs
ERROR_IN_n
QVFEFCA
QRST_n
QACKE[1:0]
QAODT[1:0]
QACS[1:0]
QACS[3:2] or QAC[1:0]
QAC2
To A-side DRAMs
QA *CA
QAACT_n
QAPAR
Y1_t,Y1_c
Y3_t,Y3_c
SMBus
SDA,SCL,SA[2:0], VDDSPD
BFUNC
ZQCAL
RCD
and
DATA BUFFER
QBCKE[1:0]
QBODT[1:0]
QBCS[1:0]
QBCS[3:2] or QBC[1:0]
QBC2
QB *CA
To B-side DRAMs
QBACT_n
QBPAR
Y0_t,Y0_c
Y2_t,Y2_c
QBVREFCA
BCK_t, BCK_c
BCOM [3:0]
BODT
BCKE
To DQ Buffers
*CA: A[17:0], BA[1:0], BG[1:0]
A14=WE_n,
A15=CAS_n,
A16=RAS_n
DCKE[1:0]
DODT[1:0]
DCS[3:0]
DC2
D *CA
DACT_n
DPAR
CK_t, CK_n
VREFCA
DRST_n
ALERT_n
DDR4 LRDIMM CONNECTOR

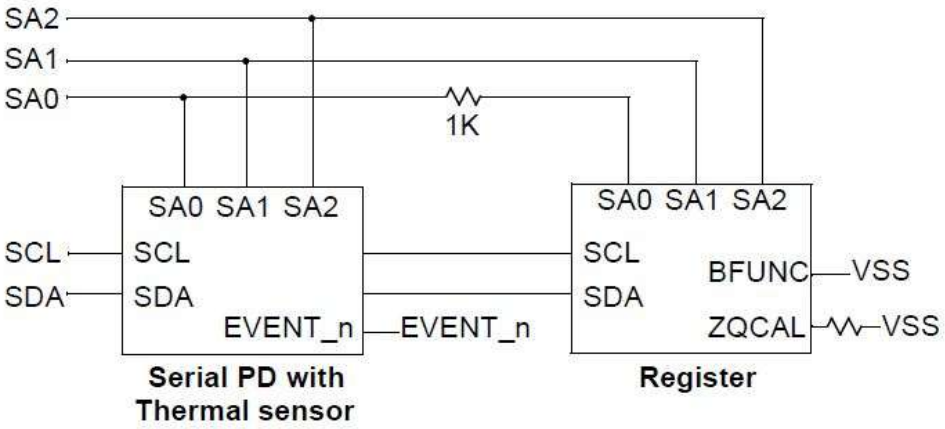
SPD



NOTE:

1. ZQ resistors are 240: ±1%. For all other resistor values refer to the appropriate wiring diagram.
2. See the Net Structure diagrams for all resistors associated with the command, address and control bus.
3. TEN pin of SDRAMs is tied to VSS.
4. VDDSPD is also applied to the register. VDD is also applied to the register and data buffers.

ON DIMM Thermal Sensor



NOTE:

1. All LRDIMMs support Thermal sensor on DIMM

Temperature Sensor Characteristics

Grade Range	range	Temperature Sensor Accuracy			Units	NOTE
		Min.	Typ.	Max.		
B	75 < Ta < 95	-	+/- 0.5	+/- 1.0		-
	40 < Ta < 125	-	+/- 1.0	+/- 2.0		-
	-20 < Ta < 125	-	+/- 2.0	+/- 3.0	°C	-
Resolution		0	0.25		°C /LSB	-

Registering Clock Driver Specification

Timing & Capacitance Values

Symbol	Parameter	Conditions	DDR4-1600/1866/2133		DDR4-2400		Units	Notes
			Min	Max	Min	Max		
fclock	Input Clock Frequency	application frequency	625	1080	625	1350	MHz	
t_{CH}/t_{CL}	Pulse duration, CK_t, CK_c HIGH or LOW		0.4	-	0.4	-	t_{CK}	
t_{ACT}	Inputs active time4 before DRST_n is taken HIGH	DCKE0/1 = LOW and DCS0/1_n = HIGH	8	-	8	-	t_{CK}	
t_{PDM}	Propagation delay, single-bit switching, CK_t/ CK_c to output	1.2V Operation	1	1.3	1	1.3	ns	
t_{DIS}	output disable time	Rising edge of Yn_t to output float	0.5*tCK + tQSK1 (min)	-	0.5*tCK + tQSK1 (min)	-	ps	
t_{EN}	output enable time	Output valid to rising edge of Yn_t	0.5*tCK - tQSK1 (max)	-	0.5*tCK - tQSK1 (max)	-	ps	
C_I	Input capacitance, Data inputs	NOTE1,2	0.8	1.1	0.8	1	pF	
C_{CK}	Input capacitance, CK_t, CK_c	NOTE1,2	0.8	1.1	0.8	1		
C_{IR}	Input capacitance, DRST_n	$V_I=V_{DD}$ or V_{SS} ; V_{DD}=1.2V	0.5	2	0.5	2		

Note:

1. This parameter does not include package capacitance
2. Data inputs are DCKE0/1, DODT0/1, DA0..DA17, DBA0..DBA1, DBG0..DBG1, DACT_n, DC0..DC2, DPAR, DCS0/1_n

Clock Driver Characteristics

Symbol	Parameter	Conditions	DDR4-1600/1866/2133		DDR4-2400		Units	Notes
			Min	Max	Min	Max		
t_{jit} (cc)	Cycle-to-cycle period jitter	CK_t/CK_c stable	0	0.025 x tCK	0	0.025 x tCK	ps	
t_{STAB}	Stabilization time		-	5	-	5	us	
t_{CKsk}	Clock Output skew		-	10	-	10	ps	
t_{jit}(per)	Yn Clock Period jitter		-0.025 * tCK	0.025 * tCK	-0.025 * tCK	0.025 * tCK	ps	
t_{jit}(hper)	Half period jitter		-0.032 * tCK	0.032 * tCK	-0.032 * tCK	0.032 * tCK	ps	
t_{Qsk1}	Qn Output to clock tolerance		-0.125 * tCK	0.125 * tCK	-0.125 * tCK	0.125 * tCK	ps	
t_{dynoff}	Maximum re-driven dynamic clock off-set		-	50	-	45	ps	

OVERVIEW OF DDR4 LRDIMM MODULE OPERATION

The DDR4 architecture is generally a point-to-point topology with a dedicated channel design. The highest system performance levels can be achieved when the system is configured with 1 DIMM Per Channel (1DPC). DDR4 has more features than DDR3 with a pseudo-open drain (POD12) 1.2v I/O for the data channel, trained Vref, bank groups and write CRC (Cyclic Redundancy Check). The POD12 interface only applies to the data channel. The address command channel behave like DDR3 using mid-point termination and mid-point Vref. The new bank group interleaving feature in DDR4 maximizes data transfer bandwidth.

The DDR4 LRDIMM has a Registered Clock Driver (RCD) on the address, command and control lines which are center terminated as they were in DDR3. The RCD supports both RDIMM and LRDIMM modes and the default is RDIMM mode. Mode register MR7 (Manufacturing use only to program the RCD) configures the DDR4 RCD using multi-step mode register programming. MR Mode Register Read via MPR Multi-Purpose Register contains the control word bits that select the working mode.

DDR4 DRAM use pseudo-open drain (POD12) 1.2v drivers with Vdd terminations on DQ lines to increase data rates; unlike DDR3 DRAM that uses stub-series terminated logic drivers, The DRAM addressing scheme in DDR4 is organized into bank groups, Side A and Side B. The host DDR4 memory controller interleaves (multiplexes) among the bank groups to achieve high data rates. DDR4 architecture is a 8n prefetch with bank groups, including the use of two or four selectable bank groups. This will permit the DDR4 memory devices to have separate activation, read, write or refresh operations simultaneously underway in each of the unique bank groups to improve overall memory efficiency and bandwidth, especially when small memory granularities are used.

The data written to the DIMM is read back the same way. However when writing to the internal registers with a "load mode" operation, a specific address is required. This requires the controller to know if the rank is mirrored or not. There is a bit assignment in the SPD that indicates whether the module has been designed with a mirrored feature or not.

DDR4 offers ECC recovery from command and parity errors to prevent the host system from crashing. The use of CRC parity is an optional feature on address command and data; (Error command blocking when parity enabled and post CA parity. If the DIMM does not support CRC, the values of 0x00 will fill the CRC table. The new CA parity feature on the command/address bus provides a low-cost method of verifying the integrity of command and address transfers over a link, for all operations.

Some of the main attributes of DDR4 memory are:
1) The ACT_n activate pin replaces RAS#, CAS#, and WE# commands
2) PAR and Alert_n for error checking
3) Bank group Interleaving
4) Improved training modes upon power-up
5) Nominal and dynamic ODT: Improvements to the ODT protocol and a new Park Mode allow for a nominal termination and dynamic write termination without having to drive the ODT pin
6) DQ bus geardown mode for 2667Mhz data rates and beyond
7) External VPP at 2.5V (for wordline boost)
8) 1.2V VDD power with power-saving features that include MPSM Maximum Power Savings Mode, Low Power Auto Self Refresh, Temperature Controlled Refresh, Fine Granularity Refresh, CMD/ADDT latency and DLL off mode
9) Internally generated VrefDQ and Calibration.
   - VrefDQ is supplied by the DRAM internally
   - VrefCA is supplied by the board

Important Note:
Longer boot-up times may be experienced in certain situations for controller initiated functions such as VrefDQ calibration, write leveling and other trainings for the DIMM.

DDR4 MODE REGISTERS

	A12	A11	A10	A9	A8	A7	A6	A5	A4	A3	A2	A1	A0
MR0	RFU	Write Recovery and RTP			DLL Reset	Test Mode	CAS Latency CL			Burst Type	CL	Burst Length BL	
MR1	Qoff	TDQS	Rtt_NOM			Write Leveling	RFU	RFU	Additive Latency		Ron		DLL Enable
MR2	Write CRC	RFU	Rtt_WR		RFU	Auto Self Refresh		CWL			RFU	RFU	RFU
MR3	MPR Read Format		Write CMD Latency with CRC and DM		Fine Granularity Refresh			Temp Sensor	Per-DRAM Addr Mode	Gear down	MPR Enable	MPR Page	
MR4	Write Preamble	Read Preamble	Read Preamble Training Enable	Self Refresh Abort Enable	CS-to-Address Latency CAL			RFU	VrefDQ Monitor Enable	Temp Refresh Mode	Temp. Refresh Range	Max Power Down Enable	RFU
MR5	Read DBI Enable	Write DBI Enable	Data Mask Enable	Parity Persistent Error	Rtt_PARK			ODT input in Power Down	Panty Error Status	CRC Error Clear	CMD Address Parity Latency		
MR6	tCCD_L and tDLLK Timing			RFU	RFU	VrefDQ Training enable	VrefDQ Training Range	VretDQ Training Value					
MR7	**Manufacturing use only to program the RCD**												

Notes:
1. Refer to JEDEC documentation for detail of the control/status bits.

DC OPERATING CONDITIONS AND CHARACTERISTICS

ABSOLUTE MAXIMUM RATINGS

PARAMETER	SYMBOL	VALUE	UNIT	NOTES
Voltage on any pin relative to GND	Vin, Vout	-0.3 ~ 1.5	V	1,
Voltage on VDD supply relative to GND	VDD	-0.3 ~ 1.5	V	1,3
Voltage on VDDQ supply relative to GND	VDDQ	-0.3 ~ 1.5	V	1,3
Voltage on VPP supply relative to GND	VPP	-0.3 ~ 3.0	V	4
Module operating temperature (ambient)	Topr	0 ~ 55	°C	1,5
Storage temperature	Tstg	-55 ~ +100	°C	1,2

Notes:

1. Permanent device damage may occur if 'ABSOLUTE MAXIMUM RATINGS' are exceeded. Functional operation should be restricted to recommended operating condition. Exposure to higher than recommended voltage for extended periods of time could affect device reliability. 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.
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.
   may affect reliability.
3. VDD and VDDQ must be within 300 mV of each other at all times and VREFCA must be not greater than 0.6 x VDDQ, When VDD and VDDQ are less than 500 mV; VREF may be equal to or less than 300 mV.
4. VPP must be equal or greater than VDD/VDDQ at all times.
5. Refer to JEDEC JC451 specification.

DRAM Component Operating Temperature Range

SYMBOL	PARAMETER	RATING	UNITS	NOTES
Toper	Normal Operating Temperature Range	0 to 85	°C	1,2
	Extended Temperature Range	85 to 95	°C	1,3

Notes:

1. Operating Temperature TOPER is the case surface temperature on the center / top side of the DRAM. For measurement conditions, please refer to the JEDEC document JESD51-2.
2. The Normal Temperature Range specifies the temperatures where all DRAM specifications will be supported. During operation, the DRAM case temperature must be maintained between 0 - 85°C under all operating conditions.
3. Some applications require operation of the DRAM in the Extended Temperature Range between 85°C and 95°C case temperature. Full specifications are guaranteed in this range, but the following additional conditions apply:
   a) Refresh commands must be doubled in frequency, therefore reducing the Refresh interval tREFI to 3.9 µs. It is also possible to specify a component with 1X refresh (tREFI to 7.8µs) in the Extended Temperature Range. Please refer to the DIMM SPD for option availability.
   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). DDR4 SDRAM's support Auto Self-Refresh and in Extended Temperature Range and please refer to component datasheet and/or the DIMM SPD for tREFI requirements in the Extended Temperature Range

tREFI by Device Density

PARAMETER	SYMBOL		8Gb	16Gb	UNITS
Average periodic refresh interval	tREFI	0°C ≤ Tcase ≤ 85°C	7.8	7.8	µs
		85°C ≤ Tcase ≤ 95°C	3.9	3.9	µs

AC & DC Operating Conditions

DC OPERATING CONDITIONS AND CHARACTERISTICS (POD12)

SYMBOL	PARAMETER	RATING			UNITS	NOTES
		Min	Typ	Max		
VDD	Supply Voltage VDD: PG4:1.2V±5%, PG4L: 1.05 (TBD)	1.14	1.2	1.26	v	1,2,3
VDDQ	Supply Voltage for Output. Values in () are at 70% of VDD	1.14 (0.798)	1.2 (0.84)	1.26 (0.882)	v	1
VPP	2.5V +10%, -5%	2.375	2.5	2.75	v	3
VDDSPD	2.5V± 10%	2.25	2.5	2.75	v	

Notes:

- PODI2 1.2 V Pseudo Open Drain Interface has a VDDQ value of 1.2V but the reference voltage allows PODI2 to be used with other VDDQ values. POD12 signals have pull-up-only parallel input termination and have an asymmetric output drive impedance. For example, if the output drivers were using a 60 ohm pull-up drive impedance then the pull-down drivers would be expected to produce a 40 ohm pull-down drive impedance. PODI2 does not explicitly call for series termination resistors, so it is suitable for point-to-point as well as multi-drop stub environments which may require some additional termination.

1. JESD8-24 specifies Vref to be 70% of VDDQ. 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. DC bandwidth is limited to 20MHz.

DC CHARACTERISTICS, IDD CURRENTS

IDD DEFINITIONS

SYMBOL	DDR4 IDD, IDDQ, and IPP Specs
IDD0A	Operating One Bank Active-Precharge Current (AL=CL-1)
IPP0	Operating One Bank Active-Precharge IPP Current
IDD1A	Operating One Bank Active-Read-Precharge Current (AL=CL-1)
IPP1	Operating One Bank Active-Read-Precharge IPP Current
IDD2NA	Precharge Standby Current (AL=CL-1)
IPP2N	Precharge Standby IPP Current
IDD2NL	Precharge Standby Current with CAL enabled
IDD2NG	Precharge Standby Current with Gear Down mode enabled
IDD2ND	Precharge Standby Current with DLL disabled
IDD2N_par	Precharge Standby Current with CA parity enabled
IPP2P	Precharge Power-Down IPP Current
IDD3NA	Active Standby Current (AL=CL-1)
IPP3N	Active Standby IPP Current
IPP3P	Active Power-Down IPP Current
IDD4RA	Operating Burst Read Current (AL=CL-1)
IDD4RB	Operating Burst Read Current with Read DBI
IPP4R	Operating Burst Read IPP Current
IDDQ4RB	(Optional) Operating Burst Read IDDQ Current with Read DBI
IDD4WA	Operating Burst Write Current (AL=CL-1)
IDD4WB	Operating Burst Write Current with Write DBI
IDD4WC	Operating Burst Write Current with Write CRC
IDD4W_par	Operating Burst Write Current with CA Parity
IPP4W	Operating Burst Write IPP Current
IPP5B	Burst Refresh Write IPP Current (1x REF)
IDD5F2	Burst Refresh Current (2x REF)
IPP5F2	Burst Refresh Write IPP Current (2x REF)
IDD5F4	Burst Refresh Current (4x REF)
IPP5F4	Burst Refresh Write IPP Current (4x REF)
IPP6N	Self Refresh IPP Current: Normal Temperature Range
IPP6E	Self Refresh IPP Current: Extended Temperature Range
IDD6R	Self-Refresh Current: Reduced Temperature Range
IPP6R	Self Refresh IPP Current: Reduced Temperature Range
IPP6A	Auto Self-Refresh IPP Current
IPP7	Operating bank Interleave Read IPP Current
IPP8	Maximum Power Down IPP Current

Notes:

1) DDR4 IDD and IDDQ specs include the same DDR3 IDD and IDDQ specs with these exceptions:
   a. IDD2P0 and IDD2P1 are replaced with a single IDD2P. There's no longer any difference in power for the DLL because of better DLL power management inside the DRAM device without any benefit for using slow exit.
   b. IDD6 is renamed IDD6N Self Refresh Current: Normal Temperature Range
   c. IDD6ET is renamed IDD6E Self-Refresh Current: Extended Temperature Range
   d. IDD6TC is renamed IDD6AAut0 Self-Refresh Current
   e. IDD8 is redefined from (optional) RESET Low Current to IDD8 Maximum Power Down Current, TBD
2) IDD values are an average (not peak) current drawn throughout the entire time that it takes to execute the set of conditions specified by JEDEC standards.
3) Consult with Viking for tools to help specify the Total Design Power (TDP)

IDD SPEC Table

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

IDD CURRENTS, DUAL RANK, 8Gbit

Symbol	DDR4-2133 15-15-15 1.2V	DDR4-2400 17-17-17 1.2V	Units
IDD0[1]	874.8	891	mA
IDD0A[1]	918	954	mA
IDD1[1]	1101.6	1144.8	mA
IDD1A[1]	1143	1197	mA
IDD2N[2]	756	792	mA
IDD2NA[1]	702	720	mA
IDD2NT[1]	702	720	mA
IDD2NL[1]	540	558	mA
IDD2NG[1]	648	666	mA
IDD2ND[1]	612	630	mA
IDD2N_par[1]	666	684	mA
IDD2P[2]	540	540	mA
IDD2Q[2]	684	720	mA
IDD3N[2]	1260	1260	mA
IDD3NA[2]	1368	1368	mA
IDD3P[2]	720	756	mA
IDD4R[1]	1881	2034	mA
IDD4RA[1]	1933.2	2095.2	mA
IDD4RB[1]	1890	2043	mA
IDD4W[1]	1782	1879.2	mA
IDD4WA[1]	1854	1963.8	mA
IDD4WB[1]	1782	1879.2	mA
IDD4WC[1]	1594.8	1634.4	mA
IDD4W_par[1]	1924.2	2046.6	mA
IDD5B[1]	4134.6	4132.8	mA
IDD5F2[1]	2973.6	2995.2	mA
IDD5F4[1]	2538	2561.4	mA
IDD6N[2]	792	792	mA
IDD6E[2]	1188	1188	mA
IDD7[1]	4080.6	4516.2	mA
IDD8[2]	360	360	mA

Notes:

1. One module rank in the active IDD/PP, the other rank in IDD2P/PP3N.
2. All ranks in this IDD/PP condition.
3. Users should refer to the DRAM supplier data sheet and/or the DIMM SPD to determine if DDR4 SDRAM devices support the following options or requirements referred to in this material.
4. Values as per Samsung Datasheet.