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## Contact us

Tel: +86-755-8981 8866 Fax: +86-755-8427 6832

Email & Skype: info@chipsmall.com Web: www.chipsmall.com

Address: A1208, Overseas Decoration Building, #122 Zhenhua RD., Futian, Shenzhen, China



# 1.35V DDR3L SDRAM LRDIMM

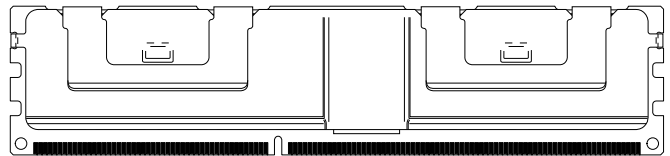
## MT36KSZF2G72LDZ –16GB

### Features

- 240-pin, load-reduced dual in-line memory module (LRDIMM)
- Memory buffer (MB)
- Fast data transfer rate: PC3-12800
- 16GB (2 Gig x 72)
- $V_{DD} = 1.35V$  (1.283–1.45V)
- Backward compatible to  $V_{DD} = 1.5V \pm 0.075V$
- $V_{DDSPD} = 3.0\text{--}3.6V$
- Supports ECC error detection and correction
- Nominal and dynamic on-die termination (ODT) for data and strobe signals
- 8 internal device banks
- Fixed burst chop (BC) of 4 and burst length (BL) of 8 via the mode register set (MRS)
- Two on-board temperature sensors
- Gold edge contacts
- Full module heat spreader
- Halogen-free
- Single load on DQ and DQS
- Terminated control, command, and address bus

Figure 1: 240-Pin LRDIMM (RC/B) MO-269

Module Height: 30.35mm (1.195 in.)



### Options

- Operating temperature
  - Commercial ( $0^{\circ}C \leq T_C \leq +95^{\circ}C$ )
- Package
  - 240-pin DIMM (halogen-free)
- Frequency/CAS latency
  - 1.25ns @ CL = 11 (DDR3-1600)

### Marking

None  
Z  
-1G6

Table 1: Key Timing Parameters

Speed Grade	Industry Nomenclature	Data Rate (MT/s)							$t_{RCD}$ (ns)	$t_{RP}$ (ns)	$t_{RC}$ (ns)
		CL = 11	CL = 10	CL = 9	CL = 8	CL = 7	CL = 6	CL = 5			
-1G6	PC3-12800	1600	1333	1333	1066	1066	800	667	13.125	13.125	48.125
-1G4	PC3-10600	–	1333	1333	1066	1066	800	667	13.125	13.125	49.125
-1G1	PC3-8500	–	–	–	1066	1066	800	667	13.125	13.125	50.625
-1G0	PC3-8500	–	–	–	1066	–	800	667	15	15	52.5
-80B	PC3-6400	–	–	–	–	–	800	667	15	15	52.5



**Table 2: Addressing**

Parameter	16GB
Refresh count	8K
Row address	64K A[15:0]
Device bank address	8 BA[2:0]
Device configuration	4Gb (512 Meg x 8)
Column address	1K A[9:0]
Module rank address	4 S#[3:0]

**Table 3: Part Numbers and Timing Parameters – 16GB Modules**

Base device: MT41K512M8<sup>1</sup>, 4Gb DDR3L SDRAM

Part Number <sup>2</sup>	Module Density	Configuration	Module Bandwidth	Memory Clock/ Data Rate	Clock Cycles (CL- <sup>t</sup> RCD- <sup>t</sup> RP)
MT36KSZF2G72LDZ-1G6__	16GB	2 Gig x 72	12.8 GB/s	1.25ns/1600 MT/s	11-11-11

- Notes:
1. The data sheet for the base device can be found on Micron's web site.
  2. All LRDIMM part numbers end with a two-place code (not shown) that designates component and PCB revisions, and a two-place code (also not shown) that indicates buffer vendor and revision. Consult factory for current revision codes. Example: MT36KSZF2G72LDZ-1G6P1B3.





## Pin Assignments

Table 4: Pin Assignments

240-Pin DDR3 LRDIMM Front								240-Pin DDR3 LRDIMM Back							
Pin	Symbol	Pin	Symbol	Pin	Symbol	Pin	Symbol	Pin	Symbol	Pin	Symbol	Pin	Symbol	Pin	Symbol
1	V <sub>REFDQ</sub>	31	DQ25	61	A2	91	DQ41	121	V <sub>SS</sub>	151	V <sub>SS</sub>	181	A1	211	V <sub>SS</sub>
2	V <sub>SS</sub>	32	V <sub>SS</sub>	62	V <sub>DD</sub>	92	V <sub>SS</sub>	122	DQ4	152	DQS12	182	V <sub>DD</sub>	212	DQS14
3	DQ0	33	DQS3#	63	NF	93	DQS5#	123	DQ5	153	DQS12#	183	V <sub>DD</sub>	213	DQS14#
4	DQ1	34	DQS3	64	NF	94	DQS5	124	V <sub>SS</sub>	154	V <sub>SS</sub>	184	CK0	214	V <sub>SS</sub>
5	V <sub>SS</sub>	35	V <sub>SS</sub>	65	V <sub>DD</sub>	95	V <sub>SS</sub>	125	DQS9	155	DQ30	185	CK0#	215	DQ46
6	DQS0#	36	DQ26	66	V <sub>DD</sub>	96	DQ42	126	DQS9#	156	DQ31	186	V <sub>DD</sub>	216	DQ47
7	DQS0	37	DQ27	67	V <sub>REFCA</sub>	97	DQ43	127	V <sub>SS</sub>	157	V <sub>SS</sub>	187	EVENT#	217	V <sub>SS</sub>
8	V <sub>SS</sub>	38	V <sub>SS</sub>	68	Par_In	98	V <sub>SS</sub>	128	DQ6	158	CB4	188	A0	218	DQ52
9	DQ2	39	CB0	69	V <sub>DD</sub>	99	DQ48	129	DQ7	159	CB5	189	V <sub>DD</sub>	219	DQ53
10	DQ3	40	CB1	70	A10/AP	100	DQ49	130	V <sub>SS</sub>	160	V <sub>SS</sub>	190	BA1	220	V <sub>SS</sub>
11	V <sub>SS</sub>	41	V <sub>SS</sub>	71	BA0	101	V <sub>SS</sub>	131	DQ12	161	DQS17	191	V <sub>DD</sub>	221	DQS15
12	DQ8	42	DQS8#	72	V <sub>DD</sub>	102	DQS6#	132	DQ13	162	DQS17#	192	RAS#	222	DQS15#
13	DQ9	43	DQS8	73	WE#	103	DQS6	133	V <sub>SS</sub>	163	V <sub>SS</sub>	193	S0#	223	V <sub>SS</sub>
14	V <sub>SS</sub>	44	V <sub>SS</sub>	74	CAS#	104	V <sub>SS</sub>	134	DQS10	164	CB6	194	V <sub>DD</sub>	224	DQ54
15	DQS1#	45	CB2	75	V <sub>DD</sub>	105	DQ50	135	DQS10#	165	CB7	195	ODT0	225	DQ55
16	DQS1	46	CB3	76	S1#	106	DQ51	136	V <sub>SS</sub>	166	V <sub>SS</sub>	196	A13	226	V <sub>SS</sub>
17	V <sub>SS</sub>	47	V <sub>SS</sub>	77	ODT1	107	V <sub>SS</sub>	137	DQ14	167	NF	197	V <sub>DD</sub>	227	DQ60
18	DQ10	48	V <sub>TT</sub>	78	V <sub>DD</sub>	108	DQ56	138	DQ15	168	RESET#	198	S3#	228	DQ61
19	DQ11	49	V <sub>TT</sub>	79	S2#	109	DQ57	139	V <sub>SS</sub>	169	CKE1	199	V <sub>SS</sub>	229	V <sub>SS</sub>
20	V <sub>SS</sub>	50	CKE0	80	V <sub>SS</sub>	110	V <sub>SS</sub>	140	DQ20	170	V <sub>DD</sub>	200	DQ36	230	DQS16
21	DQ16	51	V <sub>DD</sub>	81	DQ32	111	DQS7#	141	DQ21	171	A15	201	DQ37	231	DQS16#
22	DQ17	52	BA2	82	DQ33	112	DQS7	142	V <sub>SS</sub>	172	A14	202	V <sub>SS</sub>	232	V <sub>SS</sub>
23	V <sub>SS</sub>	53	Err_Out#	83	V <sub>SS</sub>	113	V <sub>SS</sub>	143	DQS11	173	V <sub>DD</sub>	203	DQS13	233	DQ62
24	DQS2#	54	V <sub>DD</sub>	84	DQS4#	114	DQ58	144	DQS11#	174	A12	204	DQS13#	234	DQ63
25	DQS2	55	A11	85	DQS4	115	DQ59	145	V <sub>SS</sub>	175	A9	205	V <sub>SS</sub>	235	V <sub>SS</sub>
26	V <sub>SS</sub>	56	A7	86	V <sub>SS</sub>	116	V <sub>SS</sub>	146	DQ22	176	V <sub>DD</sub>	206	DQ38	236	V <sub>DDSPD</sub>
27	DQ18	57	V <sub>DD</sub>	87	DQ34	117	SA0	147	DQ23	177	A8	207	DQ39	237	SA1
28	DQ19	58	A5	88	DQ35	118	SCL	148	V <sub>SS</sub>	178	A6	208	V <sub>SS</sub>	238	SDA
29	V <sub>SS</sub>	59	A4	89	V <sub>SS</sub>	119	SA2	149	DQ28	179	V <sub>DD</sub>	209	DQ44	239	V <sub>SS</sub>
30	DQ24	60	V <sub>DD</sub>	90	DQ40	120	V <sub>TT</sub>	150	DQ29	180	A3	210	DQ45	240	V <sub>TT</sub>

## Pin Descriptions

The pin description table below is a comprehensive list of all possible pins for all DDR3 modules. All pins listed may not be supported on this module. See Pin Assignments for information specific to this module.

**Table 5: Pin Descriptions**

Symbol	Type	Description
Ax	Input	<b>Address inputs:</b> Provide the row address for ACTIVE commands, and the column address and auto precharge bit (A10) for READ/WRITE commands, to select one location out of the memory array in the respective bank. A10 sampled during a PRECHARGE command determines whether the PRECHARGE applies to one bank (A10 LOW, bank selected by BAx) or all banks (A10 HIGH). The address inputs also provide the op-code during a LOAD MODE command. See the Pin Assignments Table for density-specific addressing information.
BAx	Input	<b>Bank address inputs:</b> Define the device bank to which an ACTIVE, READ, WRITE, or PRECHARGE command is being applied. BA define which mode register (MR0, MR1, MR2, or MR3) is loaded during the LOAD MODE command.
CKx, CKx#	Input	<b>Clock:</b> Differential clock inputs. All control, command, and address input signals are sampled on the crossing of the positive edge of CK and the negative edge of CK#.
CKEx	Input	<b>Clock enable:</b> Enables (registered HIGH) and disables (registered LOW) internal circuitry and clocks on the DRAM.
DMx	Input	<b>Data mask (x8 devices only):</b> DM is an input mask signal for write data. Input data is masked when DM is sampled HIGH, along with that input data, during a write access. Although DM pins are input-only, DM loading is designed to match that of the DQ and DQS pins.
ODTx	Input	<b>On-die termination:</b> Enables (registered HIGH) and disables (registered LOW) termination resistance internal to the DDR3 SDRAM. When enabled in normal operation, ODT is only applied to the following pins: DQ, DQS, DQS#, DM, and CB. The ODT input will be ignored if disabled via the LOAD MODE command.
Par_In	Input	<b>Parity input:</b> Parity bit for Ax, RAS#, CAS#, and WE#.
RAS#, CAS#, WE#	Input	<b>Command inputs:</b> RAS#, CAS#, and WE# (along with S#) define the command being entered.
RESET#	Input (LVCMOS)	<b>Reset:</b> RESET# is an active LOW asynchronous input that is connected to each DRAM and the registering clock driver. After RESET# goes HIGH, the DRAM must be reinitialized as though a normal power-up was executed.
Sx#	Input	<b>Chip select:</b> Enables (registered LOW) and disables (registered HIGH) the command decoder.
SAx	Input	<b>Serial address inputs:</b> Used to configure the temperature sensor/SPD EEPROM address range on the I <sup>2</sup> C bus.
SCL	Input	<b>Serial clock for temperature sensor/SPD EEPROM:</b> Used to synchronize communication to and from the temperature sensor/SPD EEPROM on the I <sup>2</sup> C bus.
CBx	I/O	<b>Check bits:</b> Used for system error detection and correction.
DQx	I/O	<b>Data input/output:</b> Bidirectional data bus.
DQSx, DQSx#	I/O	<b>Data strobe:</b> Differential data strobes. Output with read data; edge-aligned with read data; input with write data; center-aligned with write data.

**Table 5: Pin Descriptions (Continued)**

Symbol	Type	Description
SDA	I/O	<b>Serial data:</b> Used to transfer addresses and data into and out of the temperature sensor/SPD EEPROM on the I <sup>2</sup> C bus.
TDQSx, TDQSx#	Output	<b>Redundant data strobe (x8 devices only):</b> TDQS is enabled/disabled via the LOAD MODE command to the extended mode register (EMR). When TDQS is enabled, DM is disabled and TDQS and TDQS# provide termination resistance; otherwise, TDQS# are no function.
Err_Out#	Output (open drain)	<b>Parity error output:</b> Parity error found on the command and address bus.
EVENT#	Output (open drain)	<b>Temperature event:</b> The EVENT# pin is asserted by the temperature sensor when critical temperature thresholds have been exceeded.
V <sub>DD</sub>	Supply	<b>Power supply:</b> 1.5V ±0.075V. The component V <sub>DD</sub> and V <sub>DDQ</sub> are connected to the module V <sub>DD</sub> .
V <sub>DDSPD</sub>	Supply	<b>Temperature sensor/SPD EEPROM power supply:</b> 3.0–3.6V.
V <sub>REFCA</sub>	Supply	<b>Reference voltage:</b> Control, command, and address V <sub>DD</sub> /2.
V <sub>REFDQ</sub>	Supply	<b>Reference voltage:</b> DQ, DM V <sub>DD</sub> /2.
V <sub>SS</sub>	Supply	Ground.
V <sub>TT</sub>	Supply	<b>Termination voltage:</b> Used for control, command, and address V <sub>DD</sub> /2.
NC	–	<b>No connect:</b> These pins are not connected on the module.
NF	–	<b>No function:</b> These pins are connected within the module, but provide no functionality.



## DQ Map

Table 6: Component-to-Module DQ Map, Front

Component Reference Number	Component DQ	Module DQ	Module Pin Number	Component Reference Number	Component DQ	Module DQ	Module Pin Number
U1	0	35	88	U2	0	25	31
	1	34	87		1	30	155
	2	33	82		2	28	149
	3	36	200		3	31	156
	4	39	207		4	24	30
	5	38	206		5	27	37
	6	32	81		6	29	150
	7	37	201		7	26	36
U3	0	17	22	U4	0	11	19
	1	23	147		1	9	13
	2	16	21		2	12	131
	3	19	28		3	14	137
	4	20	140		4	15	138
	5	18	27		5	10	18
	6	21	141		6	8	12
	7	22	146		7	13	132
U5	0	61	228	U7	0	6	128
	1	62	233		1	4	122
	2	63	234		2	1	4
	3	60	227		3	2	9
	4	58	114		4	7	129
	5	56	108		5	3	10
	6	57	109		6	0	3
	7	59	115		7	5	123
U8	0	47	216	U9	0	50	105
	1	44	209		1	53	219
	2	46	215		2	55	225
	3	42	96		3	48	99
	4	43	97		4	49	100
	5	41	91		5	52	218
	6	45	210		6	51	106
	7	40	90		7	54	224



Table 6: Component-to-Module DQ Map, Front (Continued)

Component Reference Number	Component DQ	Module DQ	Module Pin Number	Component Reference Number	Component DQ	Module DQ	Module Pin Number
U10	0	CB2	45	U11	0	34	87
	1	CB7	165		1	35	88
	2	CB5	159		2	36	200
	3	CB0	39		3	33	82
	4	CB3	46		4	37	201
	5	CB1	40		5	32	81
	6	CB4	158		6	38	206
	7	CB6	164		7	39	207
U12	0	30	155	U13	0	23	147
	1	25	31		1	17	22
	2	31	156		2	19	28
	3	28	149		3	16	21
	4	26	36		4	22	146
	5	29	150		5	21	141
	6	27	37		6	18	27
	7	24	30		7	20	140
U14	0	9	13	U15	0	62	233
	1	11	19		1	61	228
	2	14	137		2	60	227
	3	12	131		3	63	234
	4	13	132		4	59	115
	5	8	12		5	57	109
	6	10	18		6	56	108
	7	15	138		7	58	114
U16	0	4	122	U17	0	44	209
	1	6	128		1	47	216
	2	2	9		2	42	96
	3	1	4		3	46	215
	4	5	123		4	40	90
	5	0	3		5	45	210
	6	3	10		6	41	91
	7	7	129		7	43	97





**Table 6: Component-to-Module DQ Map, Front (Continued)**

Component Reference Number	Component DQ	Module DQ	Module Pin Number	Component Reference Number	Component DQ	Module DQ	Module Pin Number
U18	0	53	219	U19	0	CB7	165
	1	50	105		1	CB2	45
	2	48	99		2	CB0	39
	3	55	225		3	CB5	156
	4	54	224		4	CB6	164
	5	51	106		5	CB4	158
	6	52	218		6	CB1	40
	7	49	100		7	CB3	46

**Table 7: Component-to-Module DQ Map, Back**

Component Reference Number	Component DQ	Module DQ	Module Pin Number	Component Reference Number	Component DQ	Module DQ	Module Pin Number
U21	0	CB7	165	U22	0	53	219
	1	CB2	45		1	50	105
	2	CB0	39		2	48	99
	3	CB5	159		3	55	225
	4	CB6	164		4	54	224
	5	CB4	158		5	51	106
	6	CB1	40		6	52	218
	7	CB3	46		7	49	100
U23	0	44	209	U24	0	4	122
	1	47	216		1	6	128
	2	42	96		2	2	9
	3	46	215		3	1	4
	4	40	90		4	5	123
	5	45	210		5	0	2
	6	41	91		6	3	10
	7	43	97		7	7	129



Table 7: Component-to-Module DQ Map, Back (Continued)

Component Reference Number	Component DQ	Module DQ	Module Pin Number	Component Reference Number	Component DQ	Module DQ	Module Pin Number
U25	0	62	223	U26	0	9	13
	1	61	228		1	11	19
	2	60	227		2	14	137
	3	63	234		3	12	131
	4	59	115		4	13	132
	5	57	109		5	8	12
	6	56	108		6	10	18
	7	58	114		7	15	138
U27	0	23	147	U28	0	30	155
	1	17	22		1	25	31
	2	19	28		2	31	156
	3	16	21		3	28	149
	4	22	146		4	26	36
	5	21	141		5	29	150
	6	18	27		6	27	37
	7	20	140		7	24	30
U29	0	34	87	U30	0	CB2	45
	1	35	88		1	CB7	165
	2	36	200		2	CB5	159
	3	33	82		3	CB0	39
	4	37	201		4	CB3	46
	5	32	81		5	CB1	40
	6	38	206		6	CB4	158
	7	39	207		7	CB6	164
U31	0	50	105	U32	0	47	216
	1	53	219		1	44	209
	2	55	225		2	46	215
	3	48	99		3	42	96
	4	49	100		4	43	97
	5	52	218		5	41	91
	6	51	106		6	45	210
	7	54	224		7	40	90

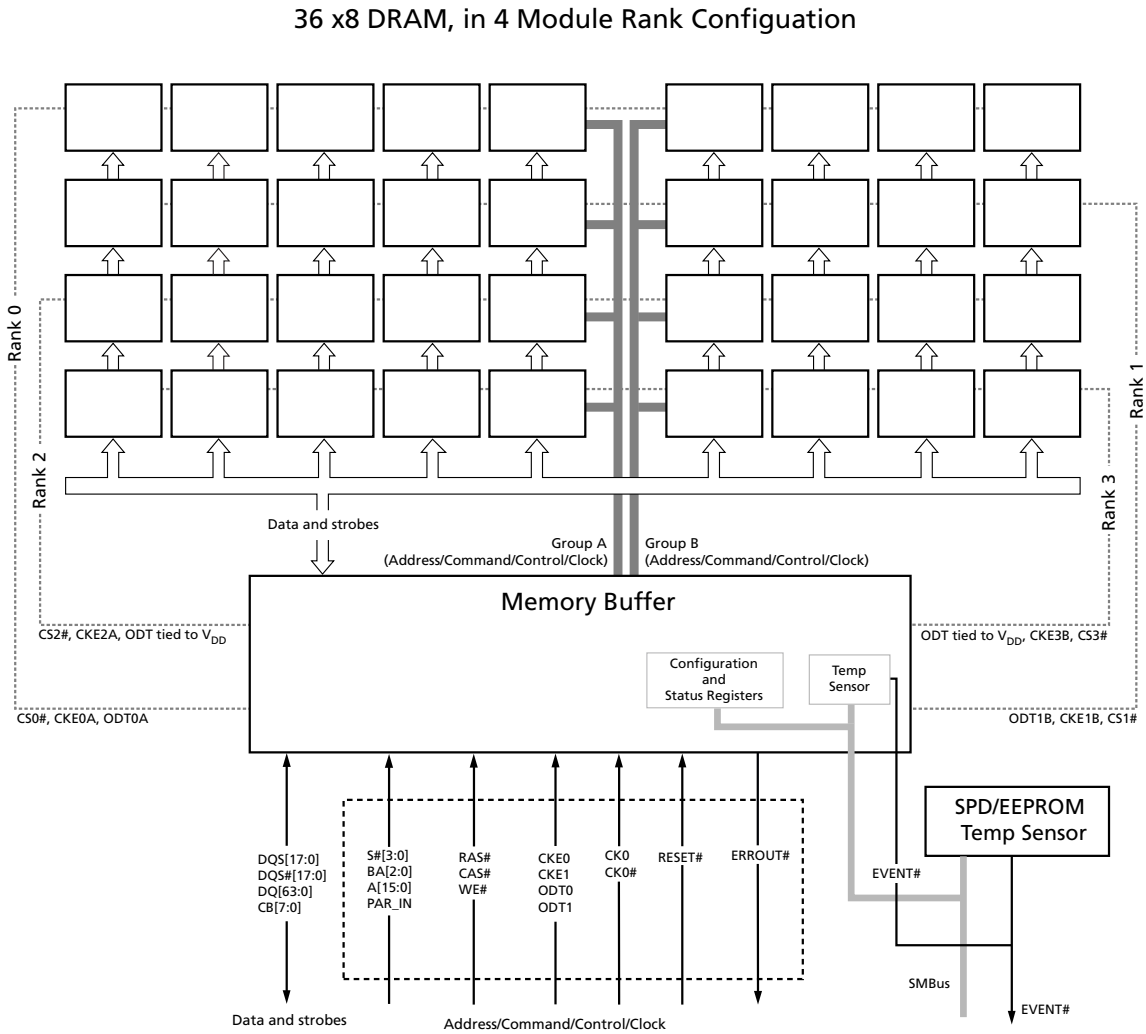


Table 7: Component-to-Module DQ Map, Back (Continued)

Component Reference Number	Component DQ	Module DQ	Module Pin Number	Component Reference Number	Component DQ	Module DQ	Module Pin Number
U33	0	6	128	U34	0	61	228
	1	4	122		1	62	233
	2	1	4		2	63	234
	3	2	9		3	60	227
	4	7	129		4	58	114
	5	3	10		5	56	108
	6	0	3		6	57	109
	7	5	123		7	59	115
U35	0	11	19	U36	0	17	22
	1	9	13		1	23	147
	2	12	131		2	16	21
	3	14	137		3	19	28
	4	15	138		4	20	140
	5	10	18		5	18	27
	6	8	12		6	21	141
	7	13	132		7	22	146
U37	0	25	31	U38	0	35	88
	1	30	155		1	34	87
	2	28	149		2	33	82
	3	31	156		3	36	200
	4	24	30		4	39	207
	5	27	37		5	38	206
	6	29	150		6	32	81
	7	26	36		7	37	201

## Functional Block Diagram

**Figure 2: Functional Block Diagram**



## General Description

The LRDIMM uses the same interface as the standard DDR3 RDIMM, but reduces the channel loading by buffering all signals that go to the DRAM. Like a standard RDIMM, the command, control, address, and clocks are redriven by the memory buffer and have similar characteristics to single-registered RDIMM. Additionally, the LRDIMM buffers all data and strobes through the memory buffer. This reduces the channel loading, as there is only a single load per signal, per module, for all DQ and DQS nodes.

The LRDIMM is a high-speed, CMOS dynamic random access memory module that uses internally configured 8-bank DDR3 SDRAM devices. DDR3 architecture is an  $8n$ -prefetch architecture with an interface designed to transfer two data words per clock cycle at the I/O pins. A single read or write access for the DDR3 SDRAM module consists of a single  $8n$ -bit-wide, one-clock-cycle data transfer at the internal DRAM core and eight corresponding  $n$ -bit-wide, one-half-clock-cycle data transfers at the I/O pins.

For improved signal quality, the clock, control, command, and address buses have been routed in a fly-by topology, where each clock, control, command, and address pin on each DRAM is connected to a single trace and terminated (rather than a tree structure, where the termination is off the module near the connector). Inherent to fly-by topology, the timing skew between the clock and DQS signals can be easily accounted for by using the write-leveling feature of DDR3.

LRDIMMs use two sets of differential signals: DQS/DQS# to capture data and CK/CK# to capture commands, addresses, and control signals. Differential clocks and data strobes ensure exceptional noise immunity for these signals and provide precise crossing points to capture input signals.

The LRDIMM includes two temperature sensors:

- A temperature sensor located within the memory buffer monitors the temperature of that high-current device on the PCB.
- A temperature sensor integrated with the serial presence-detect (SPD) EEPROM monitors the temperature of the module PCB directly through a heat paddle under the EEPROM.

The DRAM temperature is related to these two indicators by a combination of heat spreader performance, ambient temperature, and air flow.

## Memory Buffer Operation

LRDIMMs provide increased performance by presenting a single memory buffer to the system, rather than multiple DRAM. Additionally, increased capacity is achieved due to the well-defined topology and load that is achieved on the module because the memory buffer drives only the SDRAM.

Four chip selects are possible at the edge connector; however, the memory buffer provides an address multiplication feature to increase the number of ranks accessible to the system. The memory buffer uses one or two of the upper chip selects not directly usable by the SDRAM to generate additional chip selects. This feature is configurable within the memory buffer.

## Control and Status Registers

The memory buffer contains control and status registers. All control and status registers are accessible through the SMBus, as well as through in-band channel commands. The



registers can be read by software from the SMBus host any time the memory buffer is powered, except when the memory buffer is in clock-stopped power-down mode, or when the device RESET# pin is asserted.

### **Temperature Sensor**

The memory buffer contains a class-C temperature sensor that can be configured to assert the EVENT# pin when temperature thresholds are exceeded. The temperature sensor is accessible through the SMBus.

### **Parity Operations**

The memory buffer can accept a parity bit from the system's memory controller, providing even parity for the control, command, and address bus. Parity is calculated from all command and address signals (CKE, ODT, and S# are not included in parity). The last bit of the sum is compared to the parity signal provided by the system at the Par\_In pin. Parity errors are flagged on the Err\_Out# pin. Parity is also checked during control-word programming.

## **Serial Presence-Detect EEPROM with Temperature Sensor**

### **Serial Presence-Detect EEPROM Operation**

DDR3 SDRAM modules incorporate serial presence-detect. The SPD data is stored in a 256-byte EEPROM. The first 128 bytes are programmed by Micron to comply with JEDEC standard JC-45, "Appendix X: Serial Presence Detect (SPD) for DDR3 SDRAM Modules." These bytes identify module-specific timing parameters, configuration information, and physical attributes. User-specific information can be written into the remaining 128 bytes of storage. READ/WRITE operations between the system (master) and the EEPROM (slave) device occur via the SMBus. Write-protect (WP) is connected to V<sub>SS</sub>, permanently disabling hardware write-protect. For further information please refer to Micron technical note TN-04-42, "Memory Module Serial Presence-Detect."

### **Temperature Sensor**

A class-B temperature sensor is integrated with the SPD EEPROM component on the module. The sensor temperature is monitored and converted into a digital word via the SMBus. System designers can use the user-programmable registers to create a custom temperature-sensing solution based on system requirements. Programming and configuration details comply with JEDEC standard No. 21-C page 4.7-1, "Definition of the TSE2002av, Serial Presence Detect with Temperature Sensor."

## Electrical Specifications

Stresses greater than those listed may cause permanent damage to the module. This is a stress rating only, and functional operation of the module at these or any other conditions outside those indicated in each device's data sheet is not implied. Exposure to absolute maximum rating conditions for extended periods may adversely affect reliability.

**Table 8: Absolute Maximum Ratings**

Symbol	Parameter	Min	Max	Units
$V_{DD}$	$V_{DD}$ supply voltage relative to $V_{SS}$	-0.4	1.975	V
$V_{IN}, V_{OUT}$	Voltage on any pin relative to $V_{SS}$	-0.4	1.975	V

**Table 9: Operating Conditions**

Symbol	Parameter	Min	Nom	Max	Units	Notes	
$V_{DD}$	$V_{DD}$ supply voltage	1.283	1.35	1.45	V		
		1.425	1.5	1.575	V	1	
$V_{REFCA(DC)}$	Input reference voltage command/address bus	$0.49 \times V_{DD}$	$0.5 \times V_{DD}$	$0.51 \times V_{DD}$	V		
$V_{REFDQ(DC)}$	I/O reference voltage DQ bus	$0.49 \times V_{DD}$	$0.5 \times V_{DD}$	$0.51 \times V_{DD}$	V		
$I_{VTT}$	Termination reference current from $V_{TT}$	-600	-	600	mA		
$V_{TT}$	Termination reference voltage (DC) – command/address bus	$0.49 \times V_{DD} - 20mV$	$0.5 \times V_{DD}$	$0.51 \times V_{DD} + 20mV$	V	2	
$T_A$	Module ambient operating temperature	Commercial	0	-	70	°C	3, 4
$T_C$	DDR3 SDRAM component case operating temperature	Commercial	0	-	95	°C	3, 4, 5

- Notes:
1. Module is backward compatible with 1.5V operation. Refer to device specification for details and operation guidance.
  2.  $V_{TT}$  termination voltage in excess of the stated limit will adversely affect the command and address signals' voltage margin and will reduce timing margins.
  3.  $T_A$  and  $T_C$  are simultaneous requirements.
  4. For further information, refer to technical note TN-00-08: "Thermal Applications," available on Micron's web site.
  5. The refresh rate is required to double when  $85^\circ\text{C} < T_C \leq 95^\circ\text{C}$ .

## DRAM Operating Conditions

Recommended AC operating conditions are given in the DDR3 component data sheets. Component specifications are available at [micron.com](http://micron.com). Module speed grades correlate with component speed grades, as shown below.

**Table 10: Module and Component Speed Grades**

DDR3 components may exceed the listed module speed grades; module may not be available in all listed speed grades

Module Speed Grade	Component Speed Grade
-2G1	-093
-1G9	-107
-1G6	-125
-1G4	-15E
-1G1	-187E
-1G0	-187
-80C	-25E
-80B	-25

## Design Considerations

### Simulations

Micron memory modules are designed to optimize signal integrity through carefully designed terminations, controlled board impedances, routing topologies, trace length matching, and decoupling. However, good signal integrity starts at the system level. Micron encourages designers to simulate the signal characteristics of the system's memory bus to ensure adequate signal integrity of the entire memory system.

### Power

Operating voltages are specified at the DRAM, not at the edge connector of the module. Designers must account for any system voltage drops at anticipated power levels to ensure the required supply voltage is maintained.

## I<sub>DD</sub> Specifications

**Table 11: DDR3 I<sub>DD</sub> Specifications and Conditions – 16GB (Die Revision E)**

Values are for the MT41K512M8 DDR3L SDRAM only and are computed from values specified in the 1.35V 4Gb (512 Meg x 8) component data sheet

Parameter	Symbol	1600	Units
Operating current 0: One bank ACTIVATE-to-PRECHARGE	I <sub>DD0</sub> <sup>1</sup>	981	mA
Operating current 1: One bank ACTIVATE-to-READ-to-PRECHARGE	I <sub>DD1</sub> <sup>1</sup>	1080	mA
Precharge power-down current: Slow exit	I <sub>DD2P0</sub> <sup>2</sup>	648	mA
Precharge power-down current: Fast exit	I <sub>DD2P1</sub> <sup>2</sup>	1152	mA
Precharge quiet standby current	I <sub>DD2Q</sub> <sup>2</sup>	1152	mA
Precharge standby current	I <sub>DD2N</sub> <sup>2</sup>	1152	mA
Precharge standby ODT current	I <sub>DD2NT</sub> <sup>1</sup>	837	mA
Active power-down current	I <sub>DD3P</sub> <sup>2</sup>	1368	mA
Active standby current	I <sub>DD3N</sub> <sup>2</sup>	1368	mA
Burst read operating current	I <sub>DD4R</sub> <sup>1</sup>	1899	mA
Burst write operating current	I <sub>DD4W</sub> <sup>1</sup>	1611	mA
Refresh current	I <sub>DD5B</sub> <sup>1</sup>	2601	mA
Self refresh temperature current: MAX T <sub>C</sub> = 85°C	I <sub>DD6</sub> <sup>2</sup>	720	mA
Self refresh temperature current (SRT-enabled): MAX T <sub>C</sub> = 95°C	I <sub>DD6ET</sub> <sup>2</sup>	900	mA
All banks interleaved read current	I <sub>DD7</sub> <sup>1</sup>	2466	mA
Reset current	I <sub>DD8</sub> <sup>2</sup>	720	mA

- Notes: 1. One module rank in the active I<sub>DD</sub>, the other ranks in I<sub>DD2P0</sub> (slow exit).  
2. All ranks in this I<sub>DD</sub> condition.

**Table 12: DDR3 I<sub>DD</sub> Specifications and Conditions – 16GB (Die Revision P)**

Values are for the MT41K512M8 DDR3L SDRAM only and are computed from values specified in the 1.35V 4Gb (512 Meg x 8) component data sheet

Parameter	Symbol	1600	Units
Operating current 0: One bank ACTIVATE-to-PRECHARGE	I <sub>DD0</sub> <sup>1</sup>	522	mA
Operating current 1: One bank ACTIVATE-to-READ-to-PRECHARGE	I <sub>DD1</sub> <sup>1</sup>	657	mA
Precharge power-down current: Slow exit	I <sub>DD2P0</sub> <sup>2</sup>	360	mA
Precharge power-down current: Fast exit	I <sub>DD2P1</sub> <sup>2</sup>	396	mA
Precharge quiet standby current	I <sub>DD2Q</sub> <sup>2</sup>	540	mA
Precharge standby current	I <sub>DD2N</sub> <sup>2</sup>	576	mA
Precharge standby ODT current	I <sub>DD2NT</sub> <sup>1</sup>	450	mA
Active power-down current	I <sub>DD3P</sub> <sup>2</sup>	540	mA
Active standby current	I <sub>DD3N</sub> <sup>2</sup>	720	mA
Burst read operating current	I <sub>DD4R</sub> <sup>1</sup>	1080	mA
Burst write operating current	I <sub>DD4W</sub> <sup>1</sup>	1179	mA
Refresh current	I <sub>DD5B</sub> <sup>1</sup>	1638	mA
Self refresh temperature current: MAX T <sub>C</sub> = 85°C	I <sub>DD6</sub> <sup>2</sup>	540	mA
Self refresh temperature current (SRT-enabled): MAX T <sub>C</sub> = 95°C	I <sub>DD6ET</sub> <sup>2</sup>	828	mA
All banks interleaved read current	I <sub>DD7</sub> <sup>1</sup>	1440	mA
Reset current	I <sub>DD8</sub> <sup>2</sup>	468	mA

- Notes: 1. One module rank in the active I<sub>DD</sub>, the other ranks in I<sub>DD2P0</sub> (slow exit).  
2. All ranks in this I<sub>DD</sub> condition.





## Temperature Sensor with Serial Presence-Detect EEPROM

The temperature sensor continuously monitors the module's temperature and can be read back at any time over the SMBus bus shared with the SPD EEPROM and memory buffer.

### Serial Presence-Detect

For the latest SPD data, refer to Micron's SPD page: [www.micron.com/SPD](http://www.micron.com/SPD).

**Table 13: Temperature Sensor with SPD EEPROM Operating Conditions**

Parameter/Condition	Symbol	Min	Max	Units
Supply voltage	$V_{DDSPD}$	3.0	3.6	V
Supply current: $V_{DD} = 3.3V$	$I_{DD}$	–	2.0	mA
Input high voltage: Logic 1; SCL, SDA	$V_{IH}$	$V_{DDSPD} \times 0.7$	$V_{DDSPD} + 1$	V
Input low voltage: Logic 0; SCL, SDA	$V_{IL}$	–0.5	$V_{DDSPD} \times 0.3$	V
Output low voltage: $I_{OUT} = 2.1mA$	$V_{OL}$	–	0.4	V
Input current	$I_{IN}$	–5.0	5.0	$\mu A$
Temperature sensing range	–	–40	125	$^{\circ}C$
Temperature sensor accuracy (class B)	–	–1.0	1.0	$^{\circ}C$

**Table 14: Temperature Sensor and SPD EEPROM Serial Interface Timing**

Parameter/Condition	Symbol	Min	Max	Units
Time bus must be free before a new transition can start	$t_{BUF}$	4.7	–	$\mu s$
SDA fall time	$t_F$	20	300	ns
SDA rise time	$t_R$	–	1000	ns
Data hold time	$t_{HD:DAT}$	200	900	ns
Start condition hold time	$t_{H:STA}$	4.0	–	$\mu s$
Clock HIGH period	$t_{HIGH}$	4.0	50	$\mu s$
Clock LOW period	$t_{LOW}$	4.7	–	$\mu s$
SCL clock frequency	$t_{SCL}$	10	100	kHz
Data setup time	$t_{SU:DAT}$	250	–	ns
Start condition setup time	$t_{SU:STA}$	4.7	–	$\mu s$
Stop condition setup time	$t_{SU:STO}$	4.0	–	$\mu s$

### EVENT# Pin

The temperature sensor also adds the EVENT# pin (open-drain). Although not used by the SPD EEPROM, EVENT# is a temperature sensor output used to flag critical events that can be set up in the sensor's configuration register.

EVENT# has three defined modes of operation: interrupt mode, compare mode, and critical temperature mode. The open-drain output of EVENT# under the three separate operating modes is illustrated below. Event thresholds are programmed in the 0x01 reg-

ister using a hysteresis. The alarm window provides a comparison window, with upper and lower limits set in the alarm upper boundary register and the alarm lower boundary register, respectively. When the alarm window is enabled, EVENT# will trigger whenever the temperature is outside the MIN or MAX values set by the user.

The interrupt mode enables software to reset EVENT# after a critical temperature threshold has been detected. Threshold points are set in the configuration register by the user. This mode triggers the critical temperature limit and both the MIN and MAX of the temperature window.

The compare mode is similar to the interrupt mode, except EVENT# cannot be reset by the user and returns to the logic HIGH state only when the temperature falls below the programmed thresholds.

Critical temperature mode triggers EVENT# only when the temperature has exceeded the programmed critical trip point. When the critical trip point has been reached, the temperature sensor goes into comparator mode, and the critical EVENT# cannot be cleared through software.

## SMBus Slave Subaddress Decoding

The temperature sensor's physical address differs from the SPD EEPROM's physical address: binary 0011 for A0, A1, A2, and RW#, where A2, A1, and A0 are the three slave sub-address pins and the RW# bit is the READ/WRITE flag.

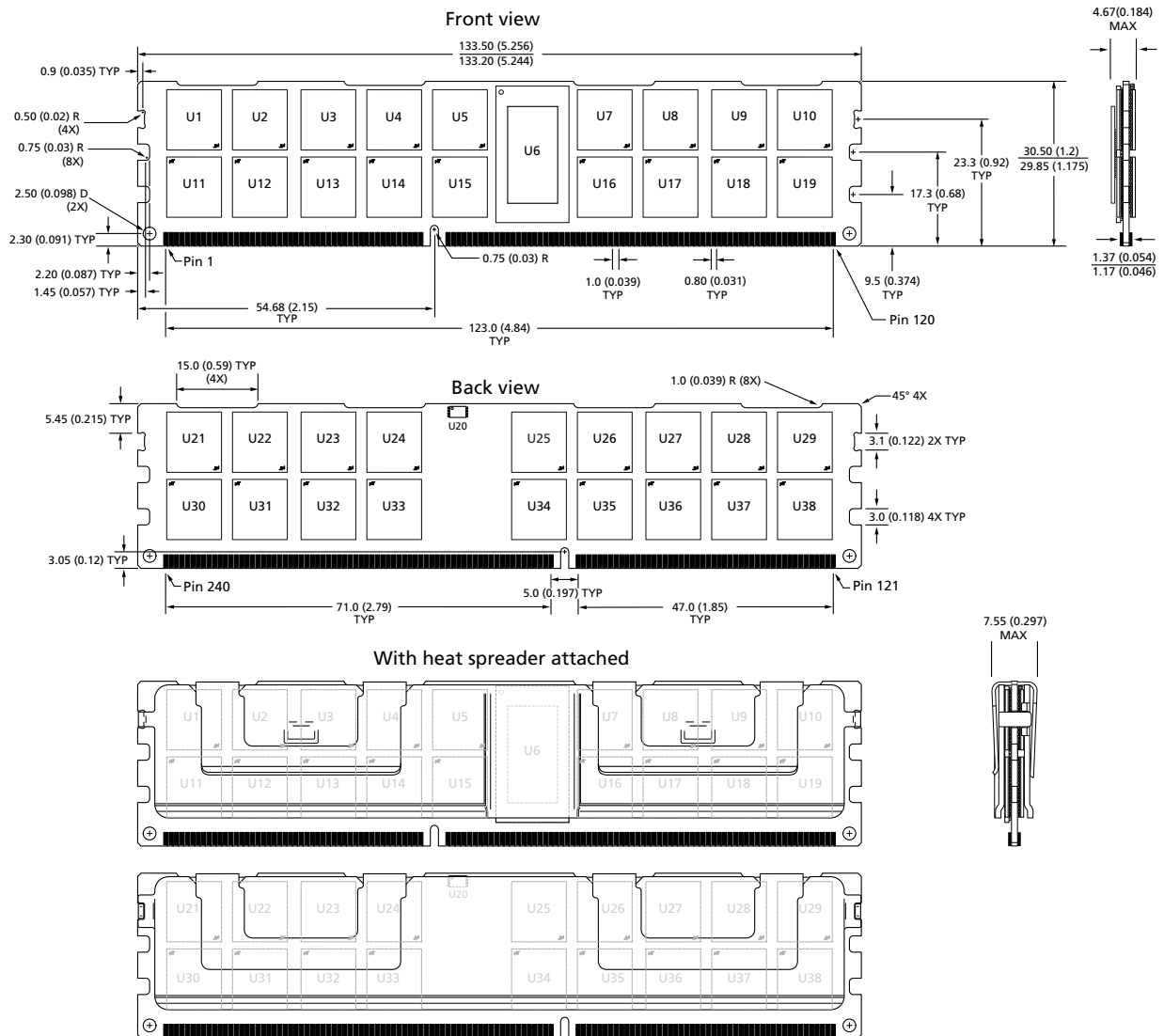
If the slave base address is fixed for the SPD EEPROM/temperature sensor, then the pins set the subaddress bits of the slave address, enabling the devices to be located anywhere within the eight slave address locations. For example, they could be set from 30h to 3Eh.

## Serial Presence-Detect Data

For the latest serial presence-detect data, refer to Micron's SPD page: [www.micron.com/SPD](http://www.micron.com/SPD).

## Module Dimensions

Figure 3: 240-Pin DDR3 LRDIMM



- Notes: 1. All dimensions are in millimeters (inches); MAX/MIN or typical (TYP) where noted.  
 2. The dimensional diagram is for reference only.



## 16GB (x72, ECC, QR x8) 240-Pin DDR3L LRDIMM Module Dimensions

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8000 S. Federal Way, P.O. Box 6, Boise, ID 83707-0006, Tel: 208-368-4000  
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This data sheet contains minimum and maximum limits specified over the power supply and temperature range set forth herein.  
Although considered final, these specifications are subject to change, as further product development and data characterization some-  
times occur.