DDR4 SDRAM SODIMM Core

Product Description

This specification defines the electrical and mechanical requirements for 260-pin, 1.2V (V_{DD}) double data rate, synchronous DRAM, small-outline dual in-line memory modules (DDR4 SDRAM SODIMMs). These DDR4 SODIMMs are intended for use as main memory when installed in systems such as PCs and laptops. Some specifications are part number specific; refer to the module data sheet addendum of the specific Micron part number-(MPN) for the complete specification.

Features

- DDR4 functionality and operations supported as defined in the component data sheet
- 260-pin SODIMM
- Nominal and dynamic on-die termination (ODT) for data, strobe, and mask signals
- Low-power auto self refresh (LPASR)
- Data bus inversion (DBI) for data bus
- On-die V_{REFDQ} generation and calibration
- Fixed burst chop (BC) of 4 and burst length (BL) of 8 via the mode register set (MRS)
- Selectable BC4 or BL8 on-the-fly (OTF)
- Gold edge contacts
- Halogen-free
- Fly-by topology
- Terminated control, command, and address bus

Table 1: Product Family Attributes

Parameter	Options	Notes
DIMM organization	x64, x72 ECC	
DIMM dimensions (nominal)	69.6mm x 30mm	Refer to Module Dimensions provided in the Micron part number-specific SODIMM Addendum
Pin count	260	
Supported DDR4 SDRAM densities	4Gb, 8Gb, 16Gb	
Capacity	2GB–32GB	
DDR4 SDRAM width	x8, x16	
Data transfer rate	PC4-2133 to PC4-3200	Refer to Key Timing Parameters
Serial presence detect, thermal sensor (SPD/TS)	512-byte	
Voltage options (nominal)	1.2V V_{DD}	
	2.5V V_{PP}	
	2.5V V_{DDSPD}	This supply is separate from the V_{DD} power plane

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Table 1: Product Family Attributes (Continued)

Parameter	Options	Notes
Interface	1.2V signaling	
Operating temperature	T_{OPER} = 0 to 95°C	Refer to Thermal Characteristics

Table 2: Key Timing Parameters – Non 3DS-Based DIMMs

Speed Grade	PC4-	DBI Disabled - Data Rate (MT/s) CL									^{t}RCD (ns)	^{t}RP (ns)	^{t}RC (ns)
		24	22	21	20, 19	18, 17	16, 15	14, 13	12, 11	10			
		DBI Enabled - Data Rate (MT/s) CL											
		28	26	25	23, 22	21, 20	19, 18	16, 15	14, 13	12			
-3G2	3200	3200, 2933	3200, 2933	2933	2666	2400	2133	1866	1600	1333	13.75	13.75	45.75
-2G9	2933	–	2933	2933	2666	2400	2133	1866	1600	1333	14.32 (13.75)[1]	14.32 (13.75)[1]	46.32 (45.75)[1]
-2G6	2666	–	–	–	2666	2400	2133	1866	1600	1333	14.25 (13.75)[1]	14.25 (13.75)[1]	46.25 (45.75)[1]

Note: 1. Down-bin timing; refer to component data sheet Speed Bin Tables for details.

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Pin Assignments

The pin assignment table below is a comprehensive list of all possible pin assignments for DDR4 SODIMM modules. See the Functional Block Diagram located in the module MPN data sheet addendum for pins specific to the module.

Table 3: Pin Assignments

260-Pin DDR4 SODIMM Front							
Pin	Symbol	Pin	Symbol	Pin	Symbol	Pin	Symbol
1	V_{SS}	67	DQ29	133	A1	199	DM5_n/ DBI5_n
3	DQ5	69	V_{SS}	135	V_{DD}	201	V_{SS}
5	V_{SS}	71	DQ25	137	CK0_t	203	DQ46
7	DQ1	73	V_{SS}	139	CK0_c	205	V_{SS}
9	V_{SS}	75	DM3_n/ DBI3_n	141	V_{DD}	207	DQ42
11	DQS0_c	77	V_{SS}	143	PARITY	209	V_{SS}
13	DQS0_t	79	DQ30	145	BA1	211	DQ52
15	V_{SS}	81	V_{SS}	147	V_{DD}	213	V_{SS}
17	DQ7	83	DQ26	149	CS0_n	215	DQ49
19	V_{SS}	85	V_{SS}	151	WE_n/ A14	217	V_{SS}
21	DQ3	87	CB5/NC	153	V_{DD}	219	DQS6_c
23	V_{SS}	89	V_{SS}	155	ODT0	221	DQS6_t
25	DQ13	91	CB1/NC	157	CS1_n/ NC	223	V_{SS}
27	V_{SS}	93	V_{SS}	159	V_{DD}	225	DQ55
29	DQ9	95	DQS8_c/ NC	161	ODT1/ NC	227	V_{SS}
31	V_{SS}	97	DQS8_t/ NC	163	V_{DD}	229	DQ51
33	DM1_n/ DBI_n	99	V_{SS}	165	C1, CS3_n, NC	231	V_{SS}
35	V_{SS}	101	CB2/NC	167	V_{SS}	233	DQ61
37	DQ15	103	V_{SS}	169	DQ37	235	V_{SS}
39	V_{SS}	105	CB3/NC	171	V_{SS}	237	DQ56
41	DQ10	107	V_{SS}	173	DQ33	239	V_{SS}
43	V_{SS}	109	CKE0	175	V_{SS}	241	DM7_n/ DBI7_n
45	DQ21	111	V_{DD}	177	DQS4_c	243	V_{SS}
47	V_{SS}	113	BG1	179	DQS4_t	245	DQ62
49	DQ17	115	BG0	181	V_{SS}	247	V_{SS}
51	V_{SS}	117	V_{DD}	183	DQ38	249	DQ58
53	DQS2_c	119	A12	185	V_{SS}	251	V_{SS}
55	DQS2_t	121	A9	187	DQ34	253	SCL
57	V_{SS}	123	V_{DD}	189	V_{SS}	255	V_{DDSPD}

260-Pin DDR4 SODIMM Back							
Pin	Symbol	Pin	Symbol	Pin	Symbol	Pin	Symbol
2	V_{SS}	68	V_{SS}	134	EVENT_n, NF	200	DQS5_t
4	DQ4	70	DQ24	136	V_{DD}	202	V_{SS}
6	V_{SS}	72	V_{SS}	138	CK1_t/NF	204	DQ47
8	DQ0	74	DQS3_c	140	CK1_c/NF	206	V_{SS}
10	V_{SS}	76	DQS3_t	142	V_{DD}	208	DQ43
12	DM0_n/ DBI0_n	78	V_{SS}	144	A0	210	V_{SS}
14	V_{SS}	80	DQ31	146	A10/AP	212	DQ53
16	DQ6	82	V_{SS}	148	V_{DD}	214	V_{SS}
18	V_{SS}	84	DQ27	150	BA0	216	DQ48
20	DQ2	86	V_{SS}	152	RAS_n/ A16	218	V_{SS}
22	V_{SS}	88	CB4/NC	154	V_{DD}	220	DM6_n/ DBI6_n
24	DQ12	90	V_{SS}	156	CAS_n/ A15	222	V_{SS}
26	V_{SS}	92	CB0/NC	158	A13	224	DQ54
28	DQ8	94	V_{SS}	160	V_{DD}	226	V_{SS}
30	V_{SS}	96	DM8_n/ DBI_n/NC	162	C0/ CS2_n/NC	228	DQ50
32	DQS1_c	98	V_{SS}	164	V_{REFCA}	230	V_{SS}
34	DQS1_t	100	CB6/NC	166	SA2	232	DQ60
36	V_{SS}	102	V_{SS}	168	V_{SS}	234	V_{SS}
38	DQ14	104	CB7/NC	170	DQ36	236	DQ57
40	V_{SS}	106	V_{SS}	172	V_{SS}	238	V_{SS}
42	DQ11	108	RESET_n	174	DQ32	240	DQS7_c
44	V_{SS}	110	CKE1/ NC	176	V_{SS}	242	DQS7_t
46	DQ20	112	V_{DD}	178	DM4_n/ DBI4_n	244	V_{SS}
48	V_{SS}	114	ACT_n	180	V_{SS}	246	DQ63
50	DQ16	116	ALERT_n	182	DQ39	248	V_{SS}
52	V_{SS}	118	V_{DD}	184	V_{SS}	250	DQ59
54	DM2_n/ DBI2_n	120	A11	186	DQ35	252	V_{SS}
56	V_{SS}	122	A7	188	V_{SS}	254	SDA
58	DQ22	124	V_{DD}	190	DQ45	256	SA0

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Table 3: Pin Assignments (Continued)

260-Pin DDR4 SODIMM Front								260-Pin DDR4 SODIMM Back							
Pin	Symbol	Pin	Symbol	Pin	Symbol	Pin	Symbol	Pin	Symbol	Pin	Symbol	Pin	Symbol	Pin	Symbol
59	DQ23	125	A8	191	DQ44	257	V_{PP}	60	V_{SS}	126	A5	192	V_{SS}	258	V_{TT}
61	V_{SS}	127	A6	193	V_{SS}	259	V_{PP}	62	DQ18	128	A4	194	DQ41	260	SA1
63	DQ19	129	V_{DD}	195	DQ40	–	–	64	V_{SS}	130	V_{DD}	196	V_{SS}	–	–
65	V_{SS}	131	A3	197	V_{SS}	–	–	66	DQ28	132	A2	198	DQS5_c	–	–

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Pin Descriptions

The pin description table below is a comprehensive list of all possible pins for DDR4 modules. All pins listed may not be supported on this module. See the Functional Block Diagram located in the module MPN data sheet addendum for pins specific to the module.

Table 4: Pin Descriptions

Symbol	Type	Description
Ax	Input	**Address inputs:** Provide the row address for ACTIVATE commands and the column address for READ/WRITE commands in order to select one location out of the memory array in the respective bank (A10/AP, A12/BC_n, WE_n/A14, CAS_n/A15, and RAS_n/A16 have additional functions; see individual entries in this table). The address inputs also provide the op-code during the MODE REGISTER SET command. A17 is only defined for x4 SDRAM.
A10/AP	Input	**Auto precharge:** A10 is sampled during READ and WRITE commands to determine whether an auto precharge should be performed on the accessed bank after a READ or WRITE operation (HIGH = auto precharge; LOW = no auto precharge). 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 the bank group and 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 in the DDR4 component data sheet.
ACT_n	Input	**Command input:** ACT_n defines the ACTIVATE command being entered along with CS_n. The input into RAS_n/A16, CAS_n/A15, and WE_n/A14 are considered as row address A16, A15, and A14. See Command Truth Table.
BAx	Input	**Bank address inputs:** Define the bank (with a bank group) to which an ACTIVATE, READ, WRITE, or PRECHARGE command is being applied. Also determine which mode register is to be accessed during a MODE REGISTER SET command.
BGx	Input	**Bank group address inputs:** Define the bank group to which a REFRESH, ACTIVATE, READ, WRITE, or PRECHARGE command is being applied. Also determine which mode register is to be accessed during a MODE REGISTER SET command. BG[1:0] are used in the x4 and x8 configurations. x16-based SDRAM only has BG0.
C0, C1, C2 (RDIMM/LRDIMM only)	Input	**Chip ID:** These inputs are used only when devices are stacked; that is, 2H, 4H, and 8H stacks for x4 and x8 configurations using through-silicon vias (TSVs). These pins are not used in the x16 configuration. Some DDR4 modules support a traditional DDP package, which uses CS1_n, CKE1, and ODT1 to control the second die. All other stack configurations, such as a 4H or 8H, are assumed to be single-load (master/slave) type configurations where C0, C1, and C2 are used as chip ID selects in conjunction with a single CS_n, CKE, and ODT. Chip ID is considered part of the command code.
CKx_t CKx_c	Input	**Clock:** Differential clock inputs. All address, command, and control input signals are sampled on the crossing of the positive edge of CK_t and the negative edge of CK_c.
CKEx	Input	**Clock enable:** CKE HIGH activates and CKE LOW deactivates the internal clock signals, device input buffers, and output drivers. Taking CKE LOW provides PRECHARGE POWER-DOWN and SELF REFRESH operations (all banks idle), or active power-down (row active in any bank). CKE is asynchronous for self refresh exit. After V_{REFCA} has become stable during the power-on and initialization sequence, it must be maintained during all operations (including SELF REFRESH). CKE must be maintained HIGH throughout read and write accesses. Input buffers (excluding CK_t, CK_c, ODT, RESET_n, and CKE) are disabled during power-down. Input buffers (excluding CKE and RESET_n) are disabled during self refresh.
CSx_n	Input	**Chip select:** All commands are masked when CS_n is registered HIGH. CS_n provides external rank selection on systems with multiple ranks. CS_n is considered part of the command code (CS2_n and CS3_n are not used on UDIMMs).

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Table 4: Pin Descriptions (Continued)

Symbol	Type	Description
ODTx	Input	**On-die termination:** ODT (registered HIGH) enables termination resistance internal to the DDR4 SDRAM. When enabled, ODT (R_{TT}) is applied only to each DQ, DQS_t, DQS_c, DM_n/DBI_n/TDQS_t, and TDQS_c signal for x4 and x8 configurations (when the TDQS function is enabled via the mode register). For the x16 configuration, R_{TT} is applied to each DQ, DQSU_t, DQSU_c, DQSL_t, DQSL_c, UDM_n, and LDM_n signal. The ODT pin will be ignored if the mode registers are programmed to disable R_{TT}.
PARITY	Input	**Parity for command and address:** This function can be enabled or disabled via the mode register. When enabled in MR5, the DRAM calculates parity with ACT_n, RAS_n/A16, CAS_n/A15, WE_n/A14, BG[1:0], BA[1:0], A[16:0]. Input parity should be maintained at the rising edge of the clock and at the same time as command and address with CS_n LOW.
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 and/or address being entered and have multiple functions. For example, for activation with ACT_n LOW, these are addresses like A16, A15, and A14, but for a non-activation command with ACT_n HIGH, these are command pins for READ, WRITE, and other commands defined in Command Truth Table.
RESET_n	CMOS 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.
SAx	Input	**Serial address inputs:** Used to configure the temperature sensor/SPD EEPROM address range on the I^2C bus.
SCL	Input	**Serial clock for temperature sensor/SPD EEPROM:** Used to synchronize communication to and from the temperature sensor/SPD EEPROM on the I^2C bus.
DQx, CBx	I/O	**Data input/output and check bit input/output:** Bidirectional data bus. DQ represents DQ[3:0], DQ[7:0], and DQ[15:0] for the x4, x8, and x16 configurations, respectively. If cyclic redundancy checksum (CRC) is enabled via the mode register, the CRC code is added at the end of the data burst. Any one or all of DQ0, DQ1, DQ2, or DQ3 may be used for monitoring of internal V_{REF} level during test via mode register setting MR[4] A[4] = HIGH; training times change when enabled.
DM_n/DBI_n/ TDQS_t (DMU_n, DBIU_n), (DML_n/ DBIl_n)	I/O	**Input data mask and data bus inversion:** DM_n is an input mask signal for write data. Input data is masked when DM_n is sampled LOW coincident with that input data during a write access. DM_n is sampled on both edges of DQS. DM is multiplexed with the DBI function by the mode register A10, A11, and A12 settings in MR5. For a x8 device, the function of DM or TDQS is enabled by the mode register A11 setting in MR1. DBI_n is an input/output identifying whether to store/output the true or inverted data. If DBI_n is LOW, the data will be stored/output after inversion inside the DDR4 device and not inverted if DBI_n is HIGH. TDQS is only supported in x8 SDRAM configurations (TDQS is not valid for UDIMMs).
SDA	I/O	**Serial Data:** Bidirectional signal used to transfer data in or out of the EEPROM or EEPROM/TS combo device.
DQS_t DQS_c DQSU_t DQSU_c DQSL_t DQSL_c	I/O	**Data strobe:** Output with read data, input with write data. Edge-aligned with read data, centered-aligned with write data. For x16 configurations, DQSL corresponds to the data on DQ[7:0], and DQSU corresponds to the data on DQ[15:8]. For the x4 and x8 configurations, DQS corresponds to the data on DQ[3:0] and DQ[7:0], respectively. DDR4 SDRAM supports a differential data strobe only and does not support a single-ended data strobe.
ALERT_n	Output	**Alert output:** Possesses functions such as CRC error flag and command and address parity error flag as output signal. If a CRC error occurs, ALERT_n goes LOW for the period time interval and returns HIGH. If an error occurs during a command address parity check, ALERT_n goes LOW until the on-going DRAM internal recovery transaction is complete. During connectivity test mode, this pin functions as an input. Use of this signal is system-dependent. If not connected as signal, ALERT_n pin must be connected to V_{DD} on DIMMs.
EVENT_n	Output	**Temperature event:** The EVENT_n pin is asserted by the temperature sensor when critical temperature thresholds have been exceeded. This pin has no function (NF) on modules without temperature sensors.

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Table 4: Pin Descriptions (Continued)

Symbol	Type	Description
TDQS_t TDQS_c (x8 DRAM-based RDIMM only)	Output	**Termination data strobe:** When enabled via the mode register, the DRAM device enables the same R_{TT} termination resistance on TDQS_t and TDQS_c that is applied to DQS_t and DQS_c. When the TDQS function is disabled via the mode register, the DM/TDQS_t pin provides the data mask (DM) function, and the TDQS_c pin is not used. The TDQS function must be disabled in the mode register for both the x4 and x16 configurations. The DM function is supported only in x8 and x16 configurations. DM, DBI, and TDQS are a shared pin and are enabled/disabled by mode register settings. For more information about TDQS, see the DDR4 DRAM component data sheet (TDQS_t and TDQS_c are not valid for UDIMMs).
V_{DD}	Supply	**Module power supply:** 1.2V (TYP).
V_{PP}	Supply	**DRAM activating power supply:** 2.5V –0.125V/+0.250V.
V_{REFCA}	Supply	Reference voltage for control, command, and address pins.
V_{SS}	Supply	Ground.
V_{TT}	Supply	Power supply for termination of address, command, and control $V_{DD}/2$.
V_{DDSPD}	Supply	Power supply used to power the I^2C bus for SPD.
RFU	–	Reserved for future use.
NC	–	**No connect:** No internal electrical connection is present.
NF	–	**No function:** May have internal connection present, but has no function.

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General Description

High-speed DDR4 SDRAM modules use DDR4 SDRAM devices with two or four internal memory bank groups. DDR4 SDRAM modules utilizing 4- and 8-bit-wide DDR4 SDRAM devices have four internal bank groups consisting of four memory banks each, providing a total of 16 banks. 16-bit-wide DDR4 SDRAM devices have two internal bank groups consisting of four memory banks each, providing a total of eight banks. DDR4 SDRAM modules benefit from the DDR4 SDRAM's use of an 8*n*-prefetch architecture with an interface designed to transfer two data words per clock cycle at the I/O pins. A single READ or WRITE operation for the DDR4 SDRAM effectively consists of a single 8*n*-bit-wide, four-clock data transfer at the internal DRAM core and eight corresponding *n*-bit-wide, one-half-clock-cycle data transfers at the I/O pins.

DDR4 modules use two sets of differential signals: DQS_t and DQS_c to capture data and CK_t and CK_c 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.

Fly-By Topology

DDR4 modules use faster clock speeds than earlier DDR technologies, making signal quality more important than ever. 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 accounted for by using the write-leveling feature of DDR4.

Module Manufacturing Location

Micron Technology manufactures modules at sites worldwide. Customers may receive modules from any of the manufacturing locations listed below.

Table 5: DRAM Module Manufacturing Locations

Manufacturing Site Location	Country of Origin Specified on Label
Boise, USA	USA
Aguadilla, Puerto Rico	Puerto Rico
Xian, China	China
Singapore	Singapore

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Address Mapping to DRAM

Address Mirroring

To achieve optimum routing of the address bus on DDR4 multirank modules, the address bus will be wired as shown in the table below, or mirrored. For quad-rank modules, ranks 1 and 3 are mirrored, and ranks 0 and 2 are non-mirrored. Highlighted address pins have no secondary functions allowing for normal operation when cross-wired. Data is still read from the same address it was written. However, LOAD MODE operations require a specific address. This requires the controller to accommodate for a rank that is mirrored. Systems may reference DDR4 SPD to determine whether the module has mirroring implemented or not. See the JEDEC DDR4 SPD specification for more details.

Table 6: Address Mirroring

Edge Connector Pin	DRAM Pin, Non-Mirrored	DRAM Pin, Mirrored
A0	A0	A0
A1	A1	A1
A2	A2	A2
A3	A3	A4
A4	A4	A3
A5	A5	A6
A6	A6	A5
A7	A7	A8
A8	A8	A7
A9	A9	A9
A10	A10	A10
A11	A11	A13
A13	A13	A11
A12	A12	A12
A14	A14	A14
A15	A15	A15
A16	A16	A16
A17	A17	A17
BA0	BA0	BA1
BA1	BA1	BA0
BG0	BG0	BG1
BG1	BG1	BG0

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Thermal Sensor with SPD EEPROM Operation

Thermal Sensor Operations

The integrated thermal sensor continuously monitors the temperature of the module PCB directly below the device and updates the temperature data register. Temperature data may be read from the bus host at any time, which provides the host real-time feedback of the module's temperature. Multiple programmable and read-only temperature registers can be used to create a custom temperature-sensing solution based on system requirements and JEDEC JC-42.2.

Note: Thermal sensor is only applicable on x72 ECC DIMMs.

EVENT_n Pin

The thermal sensor also adds the EVENT_n pin (open-drain), which requires a pull-up to V_{DDSPD}. EVENT_n is a thermal sensor output used to flag critical events that can be set up in the sensor's configuration registers. EVENT_n is not used by the serial presence-detect (SPD) EEPROM.

EVENT_n has three defined modes of operation: interrupt, comparator, and TCRIT. In interrupt mode, the EVENT_n pin remains asserted until it is released by writing a 1 to the clear event bit in the status register. In comparator mode, the EVENT_n pin clears itself when the error condition is removed. Comparator mode is always used when the temperature is compared against the TCRIT limit. In TCRIT only mode, the EVENT_n pin is only asserted if the measured temperature exceeds the TCRIT limit; it then remains asserted until the temperature drops below the TCRIT limit minus the TCRIT hysteresis.

Note: EVENT_n is NF on DIMMs without thermal sensor.

SPD EEPROM Operation

DDR4 SDRAM modules incorporate SPD. The SPD data is stored in a 512-byte, JEDEC JC-42.4-compliant EEPROM that is segregated into four 128-byte, write-protectable blocks. The SPD content is aligned with these blocks as shown in the table below.

Block	Range		Description
0	0–127	000h–07Fh	Configuration and DRAM parameters
1	128–255	080h–0FFh	Module parameters
2	256–319	100h–13Fh	Reserved (all bytes coded as 00h)
	320–383	140h–17Fh	Manufacturing information
3	384–511	180h–1FFh	End-user programmable

The first 384 bytes are programmed by Micron to comply with JEDEC standard JC-45, "Appendix X: Serial Presence Detect (SPD) for DDR4 SDRAM Modules." The remaining 128 bytes of storage are available for use by the customer.

The EEPROM resides on a two-wire I^2C serial interface and is not integrated with the memory bus in any manner. It operates as a slave device in the I^2C bus protocol, with all operations synchronized by the serial clock. Transfer rates of up to 1 MHz are achievable at 2.5V (NOM).

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Micron implements reversible software write protection on DDR4 SDRAM-based modules. This prevents the lower 384 bytes (bytes 0 to 383) from being inadvertently programmed or corrupted. The upper 128 bytes remain available for customer use and are unprotected.

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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 7: Absolute Maximum Ratings

Symbol	Parameter	Min	Max	Units	Notes
V_{DD}	V_{DD} supply voltage relative to V_{SS}	–0.4	1.5	V	1
V_{DDQ}	V_{DDQ} supply voltage relative to V_{SS}	–0.4	1.5	V	1
V_{PP}	Voltage on V_{PP} pin relative to V_{SS}	–0.4	3.0	V	2
V_{IN}, V_{OUT}	Voltage on any pin relative to V_{SS}	–0.4	1.5	V	

Table 8: Operating Conditions

Symbol	Parameter	Min	Nom	Max	Units	Notes
V_{DD}	V_{DD} supply voltage	1.14	1.2	1.26	V	1
V_{PP}	DRAM activating power supply	2.375	2.5	2.75	V	2
$V_{REFCA(DC)}$	Input reference voltage command/ address bus	0.49 × V_{DD}	0.5 × V_{DD}	0.51 × V_{DD}	V	3
I_{VTT}	Termination reference current from V_{TT}	–500	–	500	mA	
V_{TT}	Termination reference voltage (DC) – command/address bus	0.49 × V_{DD} - 20mV	0.5 × V_{DD}	0.51 × V_{DD} + 20mV	V	4
I_{IN}	Input leakage current; any input excluding ZQ; 0V < V_{IN} < 1.1V	–2.0	–	2.0	µA	5
I_{ZQ}	Input leakage current; ZQ	–50.0	–	10.0	µA	5, 6
I_{OZpd}	Output leakage current; V_{OUT} = V_{DD}; DQ is High-Z	–	–	10.0	µA	7
I_{OZpu}	Output leakage current; V_{OUT} = V_{SS}; DQ is High-Z; ODT is disabled with ODT input HIGH	–50.0	–	–	µA	7
I_{VREFCA}	V_{REFCA} leakage; V_{REFCA} = V_{DD}/2 (after DRAM is initialized)	–2.0	–	2.0	µA	5

Notes:
1. V_{DDQ} tracks with V_{DD}; V_{DDQ} and V_{DD} are tied together.
2. V_{PP} must be greater than or equal to V_{DD} at all times.
3. V_{REFCA} must not be greater than 0.6 x V_{DD}. When V_{DD} is less than 500mV, V_{REF} may be less than or equal to 300mV.
4. V_{TT} termination voltages in excess of the specification limit adversely affect the voltage margins of command and address signals and reduce timing margins.
5. Multiply by the number of DRAM die on the module.
6. Tied to ground. Not connected to edge connector.
7. Multiply by the number of module ranks and then by the number of die per package.

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Table 9: Thermal Characteristics

Symbol	Parameter/Condition	Value	Units	Notes
T_C	Commercial operating case temperature	0 to 85	°C	1, 2, 3
T_C		>85 to 95	°C	1, 2, 3, 4
T_{OPER}	Normal operating temperature range	0 to 85	°C	5, 7
T_{OPER}	Extended temperature operating range (optional)	>85 to 95	°C	5, 7
T_{STG}	Non-operating storage temperature	–55 to 100	°C	6
RH_{STG}	Non-operating storage relative humidity (non-condensing)	5 to 95	%	
NA	Change rate of storage temperature	20	°C/hour	

Notes:
1. Maximum operating case temperature; T_C is measured in the center of the package.
2. A thermal solution must be designed to ensure the DRAM device does not exceed the maximum T_C during operation.
3. Device functionality is not guaranteed if the DRAM device exceeds the maximum T_C during operation.
4. If T_C exceeds 85°C, the DRAM must be refreshed externally at 2X refresh, which is a 3.9µs interval refresh rate.
5. The refresh rate must double when 85°C < T_{OPER} ≤ 95°C.
6. Storage temperature is defined as the temperature of the top/center of the DRAM and does not reflect the storage temperatures of shipping trays.
7. For additional information, refer to technical note TN-00-08: "Thermal Applications" available at micron.com.

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DRAM Operating Conditions

Recommended AC operating conditions are given in the DDR4 component data sheets. Component specifications are available at micron.com. Module speed grades correlate with component speed grades, as shown below.

Table 10: Module and Component Speed Grades

DDR4 components may exceed the listed module speed grades; module may not be available in all listed speed grades

Module Speed Grade	Component Speed Grade
-3G2	-062E
-2G9	-068
-2G6	-075

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

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Thermal Sensor with SPD EEPROM Operating Conditions

The thermal sensor continuously monitors the module's temperature and can be read back at any time over the I^2C bus shared with the serial presence-detect (SPD) EEPROM. Refer to JEDEC JC-42.4 EE1004 and TSE2004 device specifications for complete details.

Note: Integrated thermal sensor only applicable to x72 ECC DIMMs. The following AC/DC operating condition specifications apply both to devices that do contain the integrated thermal sensor and devices that do not include the thermal sensor.

SPD Data

For the latest SPD data, refer to Micron's SPD page: micron.com/SPD.

Table 11: Thermal Sensor with SPD EEPROM DC Operating Conditions

Parameter/Condition	Symbol	Min	Nom	Max	Units
Supply voltage	V_{DDSPD}	1.7	2.5	3.3	V
Input low voltage: Logic 0; All inputs	V_{IL}	–0.5	–	V_{DDSPD} × 0.3	V
Input high voltage: Logic 1; All inputs	V_{IH}	V_{DDSPD} × 0.7	–	V_{DDSPD} + 0.5	V
Output low voltage: 3mA sink current V_{DDSPD} > 2V	V_{OL}	–	–	0.4	V
Input leakage current: (SCL, SDA) V_{IN} = V_{DDSPD} or V_{SSSPD}	I_{LI}	–	–	±5	µA
Output leakage current: V_{OUT} = V_{DDSPD} or V_{SSSPD}, SDA in High-Z	I_{LO}	–	–	±5	µA

Notes:
1. Table is provided as a general reference. Consult JEDEC JC-42.4 TSE2004 device specifications for complete details.
2. Operation at ^{t}SCL > 100 kHz may require V_{DDSPD} ≤ 2.2.
3. All voltages referenced to V_{DDSPD}.

Table 12: Thermal Sensor with SPD EEPROM AC Operating Conditions

Parameter/Condition	Symbol	Min	Max	Units
Clock frequency	^{f}SCL	10	1000	kHz
Clock pulse width HIGH time	^{t}HIGH	260	–	ns
Clock pulse width LOW time	^{t}LOW	500	–	ns
Detect clock LOW timeout	^{t}TIMEOUT	25	35	ms
SDA rise time	^{t}R	–	120	ns
SDA fall time	^{t}F	–	120	ns
Data-in setup time	^{t}SU:DAT	50	–	ns
Data-in hold time	^{t}HD:DI	0	–	ns
Data out hold time	^{t}HD:DAT	0	350	ns
Start condition setup time	^{t}SU:STA	260	–	ns
Start condition hold time	^{t}HD:STA	260	–	ns
Stop condition setup time	^{t}SU:STO	260	–	ns
Time the bus must be free before a new transition can start	^{t}BUF	500	–	ns
Write time	^{t}W	–	5	ms

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Table 12: Thermal Sensor with SPD EEPROM AC Operating Conditions (Continued)

Parameter/Condition	Symbol	Min	Max	Units
Warm power cycle time off	^{t}POFF	1	–	ms
Time from power-on to first command	^{t}INIT	10	–	ms

Notes:
1. Table is provided as a general reference. Consult JEDEC JC-42.4 TSE2004 device specifications for complete details.
2. Operation at ^{f}SCL > 100 kHz may require V_{DDSPD} ≤ 2.2.

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