DDR2 SDRAM SORDIMM

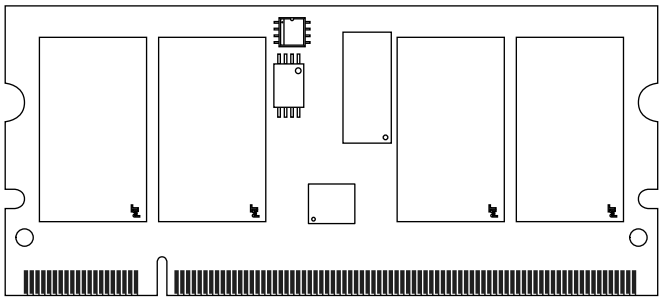
MT9HTF6472RH – 512MB
MT9HTF12872RH – 1GB

Features

- 200-pin, small-outline registered dual in-line memory module
- Fast data transfer rates: PC2-4200, PC2-5300, or PC2-6400
- 512MB (64 Meg x 72) or 1GB (128 Meg x 72)
- Supports ECC error detection and correction
- $V_{DD} = V_{DDQ} = 1.8V$
- $V_{DDSPD} = 3.0–3.6V$
- JEDEC-standard 1.8V I/O (SSTL_18-compatible)
- Differential data strobe (DQS, DQS#) option
- 4*n*-bit prefetch architecture
- Multiple internal device banks for concurrent operation
- Programmable CAS latency (CL)
- Posted CAS additive latency (AL)
- WRITE latency = READ latency - 1 ^{t}CK
- Programmable burst lengths (BL): 4 or 8
- Adjustable data-output drive strength
- 64ms, 8192-cycle refresh
- On-die termination (ODT)
- Serial presence detect (SPD) with EEPROM
- Phase-lock loop (PLL) to reduce system clock line loading
- Gold edge contacts
- Single rank
- I^2C temperature sensor

Figure 1: 200-Pin SORDIMM (MO-274 R/C A)

Module height: 30mm (1.18in)



Options — Marking

- Operating temperature
  - Commercial (0°C ≤ T_A ≤ +70°C) — None
  - Industrial (–40°C ≤ T_A ≤ +85°C)[1] — I
- Package
  - 200-pin DIMM (lead-free) — Y
- Frequency/CL[2]
  - 2.5 @ CL = 5 (DDR2-800) — -80E
  - 2.5 @ CL = 6 (DDR2-800) — -800
  - 3.0ns @ CL = 5 (DDR2-667) — -667
  - 3.75ns @ CL = 4 (DDR2-533)[3] — -53E

Notes:
1. Contact Micron for industrial temperature module offerings
2. CL = CAS (READ) latency; registered mode will add one clock cycle to CL.
3. Not recommended for new designs.

Table 1: Key Timing Parameters

Speed Grade	Industry Nomenclature	Data Rate (MT/s)				^{t}RCD (ns)	^{t}RP (ns)	^{t}RC (ns)
		CL = 6	CL = 5	CL = 4	CL = 3			
-80E	PC2-6400	800	800	533	400	12.5	12.5	55
-800	PC2-6400	800	667	533	400	15	15	55
-667	PC2-5300	–	667	553	400	15	15	55
-53E	PC2-4200	–	–	553	400	15	15	55
-40E	PC2-3200	–	–	400	400	15	15	55

Table 2: Addressing

Parameter	512MB	1GB
Refresh count	8K	8K
Row address	16K A[13:0]	16K A[13:0]
Device bank address	4 BA[1:0]	8 BA[2:0]
Device configuration	512Mb (64 Meg x 8)	1Gb (128 Meg x 8)
Column address	1K A[9:0]	1K A[9:0]
Module rank address	1 S0#	1 S0#

Table 3: Part Numbers and Timing Parameters – 512MB Modules

Base device: MT47H64M8,[1] 512Mb DDR2 SDRAM

Part Number[2]	Module Density	Configuration	Module Bandwidth	Memory Clock/ Data Rate	Clock Cycles (CL-^{t}RCD-^{t}RP)
MT9HTF6472RH(I)Y-80E__	512MB	64 Meg x 72	6.4 GB/s	2.5ns/800 MT/s	5-5-5
MT9HTF6472RH(I)Y-800__	512MB	64 Meg x 72	6.4 GB/s	2.5ns/800 MT/s	6-6-6
MT9HTF6472RH(I)Y-667__	512MB	64 Meg x 72	5.3 GB/s	3.0ns/667 MT/s	5-5-5
MT9HTF6472RH(I)Y-53E__	512MB	64 Meg x 72	4.3 GB/s	3.75ns/533 MT/s	4-4-4

Table 4: Part Numbers and Timing Parameters – 1GB Modules

Base device: MT47H128M8,[1] 1Gb DDR2 SDRAM

Part Number[2]	Module Density	Configuration	Module Bandwidth	Memory Clock/ Data Rate	Clock Cycles (CL-^{t}RCD-^{t}RP)
MT9HTF12872RH(I)Y-80E__	1GB	128 Meg x 72	6.4 GB/s	2.5ns/800 MT/s	5-5-5
MT9HTF12872RH(I)Y-800__	1GB	128 Meg x 72	6.4 GB/s	2.5ns/800 MT/s	6-6-6
MT9HTF12872RH(I)Y-667__	1GB	128 Meg x 72	5.3 GB/s	3.0ns/667 MT/s	5-5-5
MT9HTF12872RH(I)Y-53E__	1GB	128 Meg x 72	4.3 GB/s	3.75ns/533 MT/s	4-4-4

Notes:
1. The data sheet for the base device can be found on Micron's Web site.
2. All part numbers end with a two-place code (not shown) that designates component and PCB revisions. Consult factory for current revision codes. Example: MT9HTF12872RHY-667E1.

Pin Assignments

Table 5: Pin Assignments

200-Pin SORDIMM Front								200-Pin SORDIMM Back							
Pin	Symbol	Pin	Symbol	Pin	Symbol	Pin	Symbol	Pin	Symbol	Pin	Symbol	Pin	Symbol	Pin	Symbol
1	V_{REF}	51	DQ18	101	V_{DD}	151	V_{SS}	2	V_{SS}	52	V_{SS}	102	A6	152	V_{SS}
3	DQ0	53	DQ19	103	A5	153	DQS5#	4	DQ4	54	DQ28	104	A4	154	DM5
5	V_{SS}	55	V_{SS}	105	A3	155	DQS5	6	DQ5	56	DQ29	106	V_{DD}	156	V_{SS}
7	DQ1	57	DQ24	107	A2	157	V_{SS}	8	V_{SS}	58	V_{SS}	108	A1	158	DQ46
9	DQS0#	59	DQ25	109	V_{DD}	159	DQ42	10	DM0	60	DM3	110	A0	160	DQ47
11	DQS0	61	V_{SS}	111	A10	161	DQ43	12	V_{SS}	62	V_{SS}	112	BA1	162	V_{SS}
13	V_{SS}	63	DQS3#	113	BA0	163	V_{SS}	14	DQ6	64	DQ30	114	V_{DD}	164	DQ52
15	DQ2	65	DQS3	115	RAS#	165	DQ48	16	DQ7	66	DQ31	116	WE#	166	DQ53
17	DQ3	67	V_{SS}	117	V_{DD}	167	DQ49	18	V_{SS}	68	V_{SS}	118	S0#	168	V_{SS}
19	V_{SS}	69	DQ26	119	CAS#	169	V_{SS}	20	DQ12	70	CB4	120	ODT0	170	DM6
21	DQ8	71	DQ27	121	NC	171	DQS6#	22	DQ13	72	CB5	122	A13	172	V_{SS}
23	DQ9	73	V_{SS}	123	V_{DD}	173	DQS6	24	V_{SS}	74	V_{SS}	124	V_{DD}	174	DQ54
25	V_{SS}	75	CB0	125	NC	175	V_{SS}	26	DM1	76	DM8	126	CK0	176	DQ55
27	DQS1#	77	CB1	127	NC	177	DQ50	28	V_{SS}	78	V_{SS}	128	CK0#	178	V_{SS}
29	DQS1	79	V_{SS}	129	DQ32	179	DQ51	30	DQ14	80	CB6	130	V_{SS}	180	DQ60
31	V_{SS}	81	DQS8#	131	V_{SS}	181	V_{SS}	32	DQ15	82	CB7	132	DQ36	182	DQ61
33	DQ10	83	DQS8	133	DQ33	183	DQ56	34	V_{SS}	84	V_{SS}	134	DQ37	184	V_{SS}
35	DQ11	85	V_{SS}	135	DQS4#	185	DQ57	36	DQ20	86	CB2	136	V_{SS}	186	DM7
37	V_{SS}	87	CKE0	137	DQS4	187	V_{SS}	38	DQ21	88	CB3	138	DM4	188	DQ62
39	DQ16	89	NC	139	V_{SS}	189	DQS7#	40	V_{SS}	90	V_{SS}	140	V_{SS}	190	V_{SS}
41	DQ17	91	EVENT#	141	DQ34	191	DQS7	42	RESET#	92[1]	NC/BA2	142	DQ38	192	DQ63
43	V_{SS}	93	V_{DD}	143	DQ35	193	DQ58	44	DM2	94	NC	144	DQ39	194	SDA
45	DQS2#	95	A12	145	V_{SS}	195	V_{SS}	46	V_{SS}	96	A11	146	V_{SS}	196	SCL
47	DQS2	97	A9	147	DQ40	197	DQ59	48	DQ22	98	V_{DD}	148	DQ44	198	SA1
49	V_{SS}	99	A7	149	DQ41	199	V_{DDSPD}	50	DQ23	100	A8	150	DQ45	200	SA0

Note: 1. Pin 92 is NC for 512MB or BA2 for 1GB.

Pin Descriptions

The pin description table below is a comprehensive list of all possible pins for all DDR2 modules. All pins listed may not be supported on this module. See Pin Assignments for information specific to this module.

Table 6: Pin Descriptions

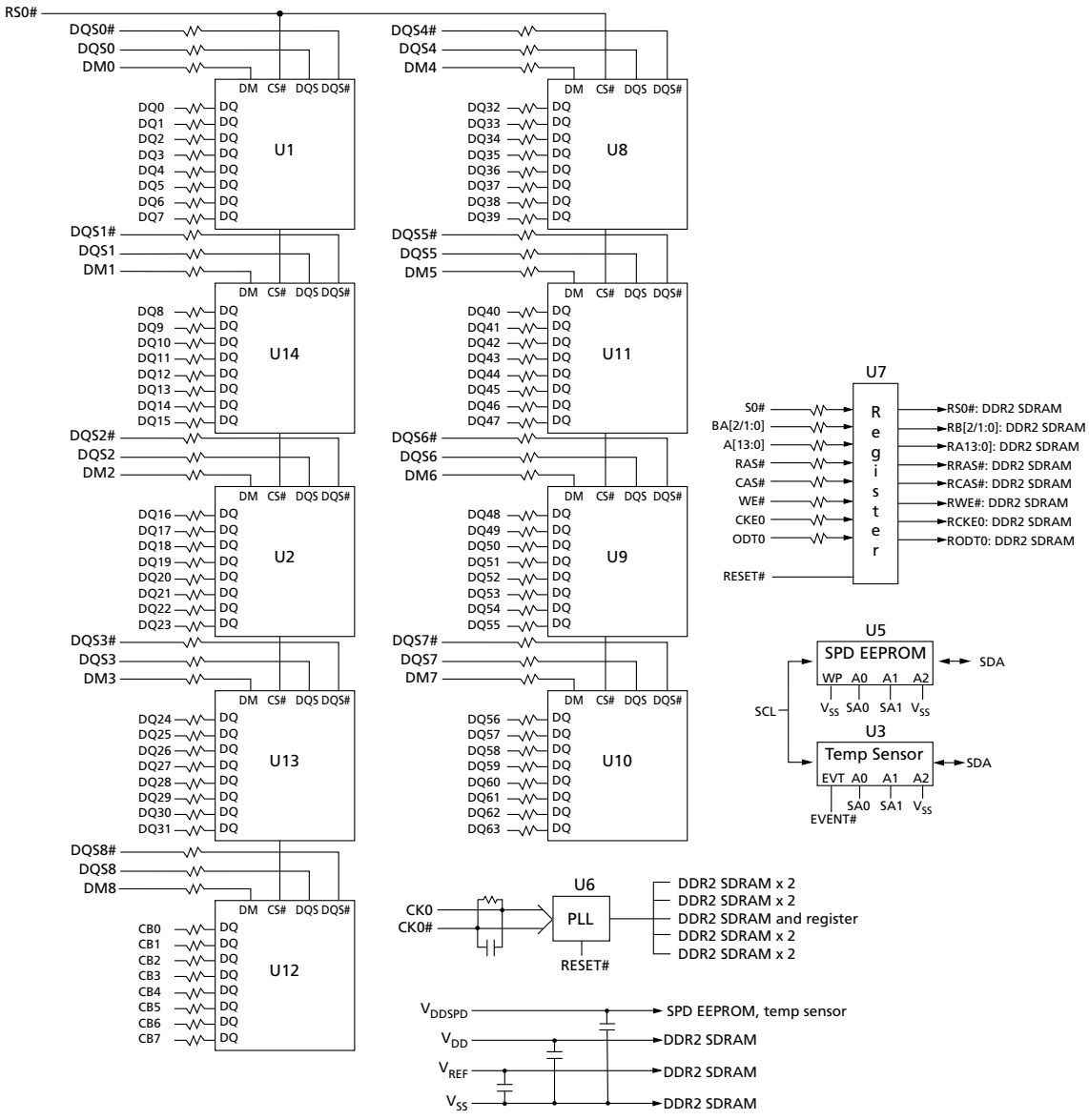
Symbol	Type	Description
Ax	Input	**Address inputs:** Provide the row address for ACTIVE commands, and the column address and auto precharge bit (A10) for READ/WRITE commands, to select one location out of the memory array in the respective bank. A10 sampled during a PRECHARGE command determines whether 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	**Bank address inputs:** Define the device bank to which an ACTIVE, READ, WRITE, or PRECHARGE command is being applied. BA define which mode register (MR0, MR1, MR2, and MR3) is loaded during the LOAD MODE command.
CKx, CK#x	Input	**Clock:** 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	**Clock enable:** Enables (registered HIGH) and disables (registered LOW) internal circuitry and clocks on the DDR2 SDRAM.
DMx,	Input	**Data mask (x8 devices only):** 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	**On-die termination:** Enables (registered HIGH) and disables (registered LOW) termination resistance internal to the DDR2 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	**Parity input:** Parity bit for Ax, RAS#, CAS#, and WE#.
RAS#, CAS#, WE#	Input	**Command inputs:** RAS#, CAS#, and WE# (along with S#) define the command being entered.
RESET#	Input	**Reset:** Asynchronously forces all registered outputs LOW when RESET# is LOW. This signal can be used during power-up to ensure that CKE is LOW and DQ are High-Z.
S#x	Input	**Chip select:** Enables (registered LOW) and disables (registered HIGH) the command decoder.
SAx	Input	**Serial address inputs:** Used to configure the SPD EEPROM address range on the I^2C bus.
SCL	Input	**Serial clock for SPD EEPROM:** Used to synchronize communication to and from the SPD EEPROM on the I^2C bus.
CBx	I/O	**Check bits.** Used for system error detection and correction.
DQx	I/O	**Data input/output:** Bidirectional data bus.
DQSx, DQS#x	I/O	**Data strobe:** Travels with the DQ and is used to capture DQ at the DRAM or the controller. Output with read data; input with write data for source synchronous operation. DQS# is only used when differential data strobe mode is enabled via the LOAD MODE command.

Table 6: Pin Descriptions (Continued)

Symbol	Type	Description
SDA	I/O	**Serial data:** Used to transfer addresses and data into and out of the SPD EEPROM on the I^2C bus.
RDQSx, RDQS#x	Output	**Redundant data strobe (x8 devices only):** RDQS is enabled/disabled via the LOAD MODE command to the extended mode register (EMR). When RDQS is enabled, RDQS is output with read data only and is ignored during write data. When RDQS is disabled, RDQS becomes data mask (see DMx). RDQS# is only used when RDQS is enabled and differential data strobe mode is enabled.
Err_Out#	Output (open drain)	**Parity error output:** Parity error found on the command and address bus.
V_{DD}/V_{DDQ}	Supply	**Power supply:** 1.8V ±0.1V. The component V_{DD} and V_{DDQ} are connected to the module V_{DD}.
V_{DDSPD}	Supply	**SPD EEPROM power supply:** 1.7–3.6V.
V_{REF}	Supply	**Reference voltage:** $V_{DD}/2$.
V_{SS}	Supply	Ground.
NC	–	**No connect:** These pins are not connected on the module.
NF	–	**No function:** These pins are connected within the module, but provide no functionality.
NU	–	**Not used:** These pins are not used in specific module configurations/operations.
RFU	–	Reserved for future use.

Functional Block Diagram

Figure 2: Functional Block Diagram



General Description

DDR2 SDRAM modules are high-speed, CMOS dynamic random access memory modules that use internally configured 4 or 8-bank DDR2 SDRAM devices. DDR2 SDRAM modules use DDR architecture to achieve high-speed operation. DDR2 architecture is essentially a 4*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 access for the DDR2 SDRAM module effectively consists of a single 4*n*-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.

DDR2 modules use two sets of differential signals: DQS, DQS# to capture data and CK and 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. A bidirectional data strobe (DQS, DQS#) is transmitted externally, along with data, for use in data capture at the receiver. DQS is a strobe transmitted by the DDR2 SDRAM device during READs and by the memory controller during WRITEs. DQS is edge-aligned with data for READs and center-aligned with data for WRITEs.

DDR2 SDRAM modules operate from a differential clock (CK and CK#); the crossing of CK going HIGH and CK# going LOW will be referred to as the positive edge of CK. Commands (address and control signals) are registered at every positive edge of CK. Input data is registered on both edges of DQS, and output data is referenced to both edges of DQS, as well as to both edges of CK.

Serial Presence-Detect EEPROM Operation

DDR2 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 identify the module type and various SDRAM organizations and timing parameters. The remaining 128 bytes of storage are available for use by the customer. System READ/WRITE operations between the master (system logic) and the slave EEPROM device occur via a standard I^2C bus using the DIMM's SCL (clock) SDA (data), and SA (address) pins. Write protect (WP) is connected to V_{SS}, permanently disabling hardware write protection.

Register and PLL Operation

DDR2 SDRAM modules operate in registered mode, where the command/address input signals are latched in the registers on the rising clock edge and sent to the DDR2 SDRAM devices on the following rising clock edge (data access is delayed by one clock cycle). A phase-lock loop (PLL) on the module receives and redrives the differential clock signals (CK, CK#) to the DDR2 SDRAM devices. The registers and PLL minimize system and clock loading. PLL clock timing is defined by JEDEC specifications and ensured by use of the JEDEC clock reference board. Registered mode will add one clock cycle to CL.

Temperature Sensor

An on-board temperature sensor provides the ability to monitor the module temperature along with monitoring alarms. Programmable registers can be used to specify temperature events and critical boundaries. An EVENT# pin is used to signal when different conditions occur based on how the registers are defined.

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 the device data sheet are 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
V_{DD}	V_{DD} supply voltage relative to V_{SS}		–0.5	2.3	V
V_{IN}, V_{OUT}	Voltage on any pin relative to V_{SS}		–0.5	2.3	V
I_I	Input leakage current; Any input 0V ≤ V_{IN} ≤ V_{DD}; V_{REF} input 0V ≤ V_{IN} ≤ 0.95V; (All other pins not under test = 0V)	Address inputs, RAS#, CAS#, WE#, S#, CKE, ODT, BA	–5	5	µA
		CK0, CK0#	–250	250	
		DM	–5	5	
I_{OZ}	Output leakage current; 0V ≤ V_{OUT} ≤ V_{DDQ}; DQ and ODT are disabled	DQ, DQS, DQS#	–5	5	µA
I_{VREF}	V_{REF} leakage current; V_{REF} = valid V_{REF} level		–18	18	µA
T_A	Module ambient operating temperature	Commercial	0	70	°C
		Industrial	–40	85	°C
T_C[1]	DDR2 SDRAM component operating temperature[2]	Commercial	0	85	°C
		Industrial	–40	95	°C

Notes:
1. The refresh rate is required to double when T_C exceeds 85°C.
2. For further information, refer to technical note TN-00-08: "Thermal Applications," available on Micron's Web site.

DRAM Operating Conditions

Recommended AC operating conditions are given in the DDR2 component data sheets. Component specifications are available on Micron's Web site. Module speed grades correlate with component speed grades.

Table 8: Module and Component Speed Grades

DDR2 components may exceed the listed module speed grades; module may not be available in all listed speed grades

Module Speed Grade	Component Speed Grade
-1GA	-187E
-80E	-25E
-800	-25
-667	-3
-53E	-37E
-40E	-5E

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_{DD} Specifications

Table 9: DDR2 I_{DD} Specifications and Conditions – 512MB

Values shown for MT47H64M8 DDR2 SDRAM only and are computed from values specified in the 512Mb (64 Meg x 8) component data sheet

Parameter		Symbol	-80E/-800	-667	-53E	Units
Operating one bank active-precharge current: $^tCK = ^tCK (I_{DD})$, $^tRC = ^tRC (I_{DD})$, $^tRAS = ^tRAS$ MIN (I_{DD}); CKE is HIGH, S# is HIGH between valid commands; Address bus inputs are switching; Data bus inputs are switching		I_{DD0}	900	810	720	mA
Operating one bank active-read-precharge current: I_{OUT} = 0mA; BL = 4, CL = CL (I_{DD}), AL = 0; $^tCK = ^tCK (I_{DD})$, $^tRC = ^tRC (I_{DD})$, $^tRAS = ^tRAS$ MIN (I_{DD}), $^tRCD = ^tRCD (I_{DD})$; CKE is HIGH, S# is HIGH between valid commands; Address bus inputs are switching; Data pattern is same as I_{DD4W}		I_{DD1}	1035	945	855	mA
Precharge power-down current: All device banks idle; $^tCK = ^tCK (I_{DD})$; CKE is LOW; Other control and address bus inputs are stable; Data bus inputs are floating		I_{DD2P}	63	63	63	mA
Precharge quiet standby current: All device banks idle; $^tCK = ^tCK (I_{DD})$; CKE is HIGH, S# is HIGH; Other control and address bus inputs are stable; Data bus inputs are floating		I_{DD2Q}	450	405	360	mA
Precharge standby current: All device banks idle; $^tCK = ^tCK (I_{DD})$; CKE is HIGH, S# is HIGH; Other control and address bus inputs are switching; Data bus inputs are switching		I_{DD2N}	495	450	405	mA
Active power-down current: All device banks open; $^tCK = ^tCK (I_{DD})$; CKE is LOW; Other control and address bus inputs are stable; Data bus inputs are floating	Fast PDN exit MR[12] = 0	I_{DD3PF}	360	315	270	mA
	Slow PDN exit MR[12] = 1	I_{DD3PS}	108	108	108	
Active standby current: All device banks open; $^tCK = ^tCK (I_{DD})$, $^tRAS = ^tRAS$ MAX (I_{DD}), $^tRP = ^tRP (I_{DD})$; CKE is HIGH, S# is HIGH between valid commands; Other control and address bus inputs are switching; Data bus inputs are switching		I_{DD3N}	630	585	495	mA
Operating burst write current: All device banks open; Continuous burst writes; BL = 4, CL = CL (I_{DD}), AL = 0; $^tCK = ^tCK (I_{DD})$, $^tRAS = ^tRAS$ MAX (I_{DD}), $^tRP = ^tRP (I_{DD})$; CKE is HIGH, S# is HIGH between valid commands; Address bus inputs are switching; Data bus inputs are switching		I_{DD4W}	1755	1530	1260	mA
Operating burst read current: All device banks open; Continuous burst read, I_{OUT} = 0mA; BL = 4, CL = CL (I_{DD}), AL = 0; $^tCK = ^tCK (I_{DD})$, $^tRAS = ^tRAS$ MAX (I_{DD}), $^tRP = ^tRP (I_{DD})$; CKE is HIGH, S# is HIGH between valid commands; Address bus inputs are switching; Data bus inputs are switching		I_{DD4R}	1845	1620	1305	mA
Burst refresh current: $^tCK = ^tCK (I_{DD})$; REFRESH command at every $^tRFC (I_{DD})$ interval; CKE is HIGH, S# is HIGH between valid commands; Other control and address bus inputs are switching; Data bus inputs are switching		I_{DD5}	2070	1620	1305	mA
Self refresh current: CK and CK# at 0V; CKE ≤ 0.2V; Other control and address bus inputs are floating; Data bus inputs are floating		I_{DD6}	63	63	63	mA

Table 9: DDR2 I_{DD} Specifications and Conditions – 512MB (Continued)

Values shown for MT47H64M8 DDR2 SDRAM only and are computed from values specified in the 512Mb (64 Meg x 8) component data sheet

Parameter	Symbol	-80E/-800	-667	-53E	Units
Operating bank interleave read current: All device banks interleaving reads; I_{OUT} = 0mA; BL = 4, CL = CL (I_{DD}), AL = ^{t}RCD (I_{DD}) - 1 × ^{t}CK (I_{DD}); ^{t}CK = ^{t}CK (I_{DD}), ^{t}RC = ^{t}RC (I_{DD}), ^{t}RRD = ^{t}RRD (I_{DD}), ^{t}RCD = ^{t}RCD (I_{DD}); CKE is HIGH, S# is HIGH between valid commands; Address bus inputs are stable during deselects; Data bus inputs are switching	I_{DD7}	2700	2160	2025	mA

Table 10: DDR2 I_{DD} Specifications and Conditions – 1GB

Values shown for MT47H128M8 DDR2 SDRAM only and are computed from values specified in the 1Gb (128 Meg x 8) component data sheet

Parameter		Symbol	-80E/ 800	-667	-53E	Units
Operating one bank active-precharge current: $^tCK = {}^tCK$ (I_{DD}), $^tRC = {}^tRC$ (I_{DD}), $^tRAS = {}^tRAS$ MIN (I_{DD}); CKE is HIGH, S# is HIGH between valid commands; Address bus inputs are switching; Data bus inputs are switching		I_{DD0}	810	765	630	mA
Operating one bank active-read-precharge current: I_{OUT} = 0mA; BL = 4, CL = CL (I_{DD}), AL = 0; $^tCK = {}^tCK$ (I_{DD}), $^tRC = {}^tRC$ (I_{DD}), $^tRAS = {}^tRAS$ MIN (I_{DD}), $^tRCD = {}^tRCD$ (I_{DD}); CKE is HIGH, S# is HIGH between valid commands; Address bus inputs are switching; Data pattern is same as I_{DD4W}		I_{DD1}	990	900	855	mA
Precharge power-down current: All device banks idle; $^tCK = {}^tCK$ (I_{DD}); CKE is LOW; Other control and address bus inputs are stable; Data bus inputs are floating		I_{DD2P}	63	63	63	mA
Precharge quiet standby current: All device banks idle; $^tCK = {}^tCK$ (I_{DD}); CKE is HIGH, S# is HIGH; Other control and address bus inputs are stable; Data bus inputs are floating		I_{DD2Q}	450	360	360	mA
Precharge standby current: All device banks idle; $^tCK = {}^tCK$ (I_{DD}); CKE is HIGH, S# is HIGH; Other control and address bus inputs are switching; Data bus inputs are switching		I_{DD2N}	450	360	360	mA
Active power-down current: All device banks open; $^tCK = {}^tCK$ (I_{DD}); CKE is LOW; Other control and address bus inputs are stable; Data bus inputs are floating	Fast PDN exit MR[12] = 0	I_{DD3PF}	360	270	270	mA
	Slow PDN exit MR[12] = 1	I_{DD3PS}	90	90	90	
Active standby current: All device banks open; $^tCK = {}^tCK$ (I_{DD}), $^tRAS = {}^tRAS$ MAX (I_{DD}), $^tRP = {}^tRP$ (I_{DD}); CKE is HIGH, S# is HIGH between valid commands; Other control and address bus inputs are switching; Data bus inputs are switching		I_{DD3N}	540	495	405	mA
Operating burst write current: All device banks open; Continuous burst writes; BL = 4, CL = CL (I_{DD}), AL = 0; $^tCK = {}^tCK$ (I_{DD}), $^tRAS = {}^tRAS$ MAX (I_{DD}), $^tRP = {}^tRP$ (I_{DD}); CKE is HIGH, S# is HIGH between valid commands; Address bus inputs are switching; Data bus inputs are switching		I_{DD4W}	1440	1215	1125	mA
Operating burst read current: All device banks open; Continuous burst read, I_{OUT} = 0mA; BL = 4, CL = CL (I_{DD}), AL = 0; $^tCK = {}^tCK$ (I_{DD}), $^tRAS = {}^tRAS$ MAX (I_{DD}), $^tRP = {}^tRP$ (I_{DD}); CKE is HIGH, S# is HIGH between valid commands; Address bus inputs are switching; Data bus inputs are switching		I_{DD4R}	1440	1215	1125	mA
Burst refresh current: $^tCK = {}^tCK$ (I_{DD}); REFRESH command at every ^tRFC (I_{DD}) interval; CKE is HIGH, S# is HIGH between valid commands; Other control and address bus inputs are switching; Data bus inputs are switching		I_{DD5}	2115	1935	1890	mA
Self refresh current: CK and CK# at 0V; CKE ≤ 0.2V; Other control and address bus inputs are floating; Data bus inputs are floating		I_{DD6}	63	63	63	mA
Operating bank interleave read current: All device banks interleaving reads; I_{OUT} = 0mA; BL = 4, CL = CL (I_{DD}), AL = ^tRCD (I_{DD}) - 1 × ^tCK (I_{DD}); $^tCK = {}^tCK$ (I_{DD}), $^tRC = {}^tRC$ (I_{DD}), $^tRRD = {}^tRRD$ (I_{DD}), $^tRCD = {}^tRCD$ (I_{DD}); CKE is HIGH, S# is HIGH between valid commands; Address bus inputs are stable during deselects; Data bus inputs are switching		I_{DD7}	3015	2520	2430	mA

Register and PLL Specifications

Table 11: Register Specifications

SSTU32872 devices or equivalent

Parameter	Symbol	Pins	Condition	Min	Max	Units
DC high-level input voltage	$V_{IH(DC)}$	Control, command, address	SSTL_18	$V_{REF(DC)}$ + 125	V_{DDQ} + 250	mV
DC low-level input voltage	$V_{IL(DC)}$	Control, command, address	SSTL_18	0	$V_{REF(DC)}$ - 125	mV
AC high-level input voltage	$V_{IH(AC)}$	Control, command, address	SSTL_18	$V_{REF(DC)}$ + 250	V_{DD}	mV
AC low-level input voltage	$V_{IL(AC)}$	Control, command, address	SSTL_18	0	$V_{REF(DC)}$ - 250	mV
Output high voltage	V_{OH}	Parity output	SSTL_18	1.2	–	V
Output low voltage	V_{OL}	Parity output	SSTL_18	–	0.5	V
Input current	I_I	All pins	$V_I = V_{DDQ}$ or V_{SSQ}	–5	5	µA
Static standby	I_{DD}	All pins	RESET# = V_{SSQ} (I_O = 0)	–	200	mA or µA??
Static operating	I_{DD}	All pins	RESET# = V_{SSQ}; V_I = $V_{IH(AC)}$ or $V_{IL(DC)}$ I_O = 0	–	80	mA
Dynamic operating (clock tree)	I_{DDD}	N/A	RESET# = V_{DD}; V_I = $V_{IH(AC)}$ or $V_{IL(AC)}$, I_O = 0; CK and CK# switching 50% duty cycle	–	Varies by manufacturer	µA
Dynamic operating (per each input)	I_{DDD}	N/A	RESET# = V_{DD}; V_I = $V_{IH(AC)}$ or $V_{IL(AC)}$, I_O = 0; CK and CK# switching 50% duty cycle; One data input switching at ^tCK/2, 50% duty cycle	–	Varies by manufacturer	µA
Input capacitance (per device, per pin)	C_I	All inputs except RESET#	$V_I = V_{REF}$ ±250mV; V_{DDQ} = 1.8V	2.5	3.5	pF
Input capacitance (per device, per pin)	C_I	RESET#	$V_I = V_{DDQ}$ or V_{SSQ}	–	Varies by manufacturer	pF

Table 12: PLL Specifications

CUA845 device or JEDEC82-21 equivalent

Parameter	Symbol	Pins	Condition	Min	Max	Units
DC high-level input voltage	V_{IH}	OE, OS, CK, CK#	LVCMOS	0.65 × V_{DD}	–	V
DC low-level input voltage	V_{IL}	OE, OS, CK, CK#	LVCMOS	–	0.35 × V_{DD}	V
Input voltage (limits)	V_{IN}			–0.3	V_{DD} + 0.3	V
Input differential-pair cross voltage	V_{IX}		Differential input	(V_{DD}/2) - 0.15	(V_{DD}/2) + 0.15	V
Input differential voltage	$V_{ID(DC)}$		Differential input	0.3	V_{DD} + 0.4	V
Input differential voltage	$V_{ID(AC)}$		Differential input	600	V_{DD} + 0.4	V
Input current	I_I	OE, OS, FBIN, FBIN#	V_I = V_{DD} or V_{SS}	–10	10	µA
		CK, CK#	V_I = V_{DD} or V_{SS}	–250	250	µA
Output disabled current	I_{ODL}		OE = L, V_{ODL} = 100mV	100	–	µA
Static supply current	I_{DDLD}		C_L = 0pf	–	500	µA
Dynamic supply	I_{DD}	N/A	CK and CK# = 410 MHz, all outputs open (not connected to PCB)	–	300	mA
Input capacitance	C_{IN}	Each input	V_I = V_{DD} or V_{SS}	2	3	pF

Table 13: PLL Clock Driver Timing Requirements and Switching Characteristics

Parameter	Symbol	Min	Max	Units
Stabilization time	^{t}L	–	6.0	µs
Input clock slew rate	slr(i)	1.0	4.0	V/ns
SSC modulation frequency	–	30	33.0	kHz
SSC clock input frequency deviation	–	0.0	–0.5	%
PLL loop bandwidth (–3dB from unity gain)	–	2.0	–	MHz

Note: 1. PLL timing and switching specifications are critical for proper operation of the DDR2 DIMM. This is a subset of parameters for the specific PLL used. Detailed PLL information is available in JEDEC Standard JESD82.

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 I^2C bus shared with the SPD EEPROM.

Table 14: Temperature Sensor with Serial Presence-Detect 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}	+1.45	V_{DDSPD} + 1	V
Input low voltage: Logic 0; SCL, SDA	V_{IL}	–	+0.55	V
Output low voltage: I_{OUT} = 2.1mA	V_{OL}	–	+0.4	V
Input current	I_{IN}	–5.0	+5.0	µA
Temperature sensing range	–	–40	+125	°C
Temperature sensor accuracy (class B)	–	–1.0	+1.0	°C

Table 15: Sensor and EEPROM Serial Interface Timing

Parameter/Condition	Symbol	Min	Max	Units
Time bus must be free before a new transition can start	^tBUF	4.7	–	µs
SDA fall time	^tF	20	300	ns
SDA rise time	^tR	–	1000	ns
Data hold time	$^tHD:DAT$	200	900	ns
Start condition hold time	$^tH:STA$	4.0	–	µs
Clock HIGH period	^tHIGH	4.0	50	µs
Clock LOW period	^tLOW	4.7	–	µs
SCL clock frequency	^tSCL	10	100	kHz
Data setup time	$^tSU:DAT$	250	–	ns
Start condition setup time	$^tSU:STA$	4.7	–	µs
Stop condition setup time	$^tSU:STO$	4.0	–	µs

EVENT# Pin

The temperature sensor also adds the EVENT# pin (open drain). 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 register 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 only returns to the logic HIGH state 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.

SM Bus 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 subaddress pins and the RW# bit is the READ/WRITE flag.

If the slave base address is fixed for the temperature sensor/SPD EEPROM, 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.

Figure 3: EVENT# Pin Functionality

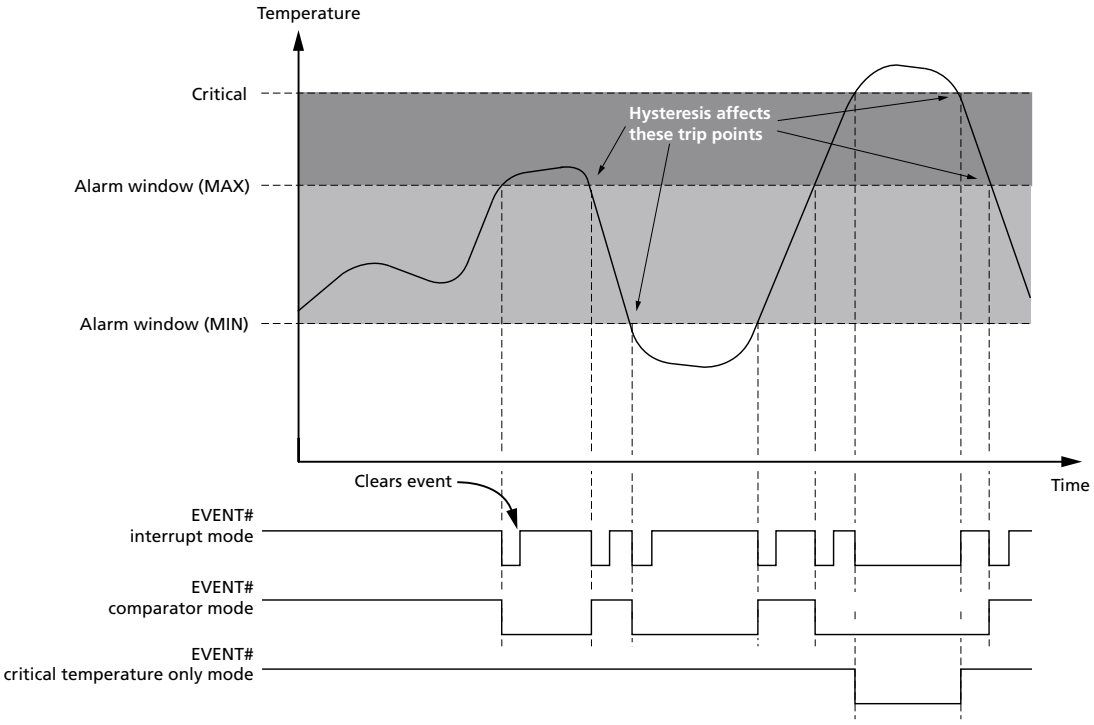


Table 16: Temperature Sensor Registers

Name	Address	Power-on Default
Pointer register	Not applicable	Undefined
Capability register	0x00	0x0001
Configuration register	0x01	0x0000
Alarm temperature upper boundary register	0x02	0x0000
Alarm temperature lower boundary register	0x03	0x0000
Critical temperature register	0x04	0x0000
Temperature register	0x05	Undefined

Pointer Register

The pointer register selects which of the 16-bit registers is being accessed in subsequent READ and WRITE operations. This register is a write-only register.

Table 17: Pointer Register Bits 0–7

Bit							
7	6	5	4	3	2	1	0
0	0	0	0	Register select	Register select	Register select	Register select

Table 18: Pointer Register Bits 0–2 Descriptions

Bit			Register
2	1	0	
0	0	0	Capability register
0	0	1	Configuration register
0	1	0	Alarm temperature upper boundary register
0	1	1	Alarm temperature lower boundary register
1	0	0	Critical temperature register
1	0	1	Temperature register

Capability Register

The capability register indicates the features and functionality supported by the temperature sensor. This register is a read-only register.

Table 19: Capability Register (Address: 0x00)

Bit							
15	14	13	12	11	10	9	8
RFU	RFU	RFU	RFU	RFU	RFU	RFU	RFU
Bit							
7	6	5	4	3	2	1	0
RFU	RFU	RFU	Temperature resolution		Wider range	Precision	Has alarm and critical temperature

Table 20: Capability Register Bit Description

Bit	Description
0	Basic capability 1: Has alarm and critical trip point capabilities
1	Accuracy 0: ±2°C over the active range and ±3°C over the monitor range 1: ±1°C over the active range and ±2°C over the monitor range
2	Wider range 0: Temperatures lower than 0°C are clamped to a binary value of 0 1: Temperatures below 0°C can be read

Table 20: Capability Register Bit Description (Continued)

Bit	Description
4:3	Temperature resolution 00: 0.5°C LSB 01: 0.25°C LSB 10: 0.125°C LSB 11: 0.0625°C LSB
15:5	0: Must be set to zero

Configuration Register

Table 21: Configuration Register (Address: 0x01)

Bit							
15	**14**	**13**	**12**	**11**	**10**	**9**	**8**
RFU	RFU	RFU	RFU	RFU	Hysteresis		Shutdown mode
Bit							
7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
Critical lock bit	Alarm lock bit	Clear event	Event output status	Event output control	Critical event only	Event polarity	Event mode

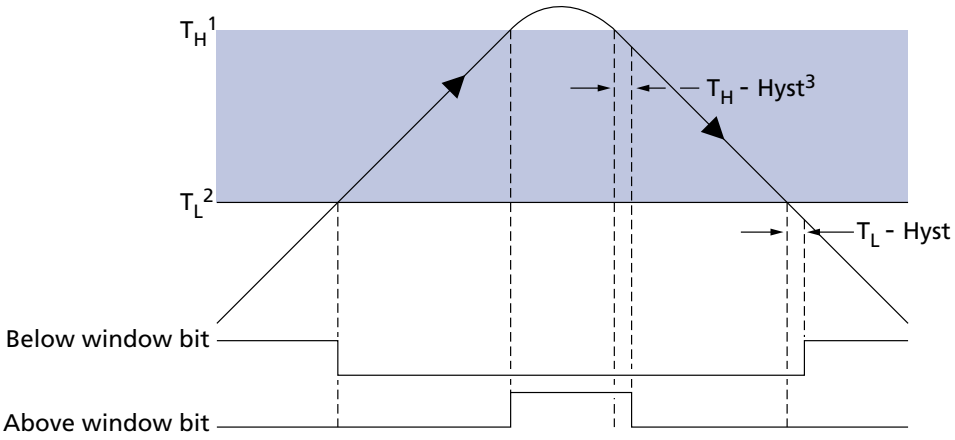
Table 22: Configuration Register Bit Descriptions

Bit	Description	Notes
0	Event mode 0: Comparator mode 1: Interrupt mode	Event mode cannot be changed if either of the lock bits is set.
1	EVENT# polarity 0: Active LOW 1: Active HIGH	EVENT# polarity cannot be changed if either of the lock bits is set.
2	Critical event only 0: EVENT# trips on alarm or critical temperature event 1: EVENT# trips only if critical temperature is reached	
3	Event output control 0: Event output disabled 1: Event output enabled	
4	Event status 0: EVENT# has not been asserted by this device 1: EVENT# is being asserted due to an alarm window or critical temperature condition	This is a read-only field in the register. The event causing the event can be determined from the read temperature register.
5	Clear event 0: No effect 1: Clears the event when the temperature sensor is in the interrupt mode	

Table 22: Configuration Register Bit Descriptions (Continued)

Bit	Description	Notes
6	Alarm window lock bit 0: Alarm trips are not locked and can be changed 1: Alarm trips are locked and cannot be changed	
7	Critical trip lock bit 0: Critical trip is not locked and can be changed 1: Critical trip is locked and cannot be changed	
8	Shutdown mode 0: Enabled 1: Shutdown	The shutdown mode is a power-saving mode that disables the temperature sensor.
10:9	Hysteresis enable 00: Disable 01: Enable at 1.5°C 10: Enable at 3°C 11: Enable at 6°C	When enabled, a hysteresis is applied to temperature movement around the trip points (see Figure 4 (page 21)). As an example, if the hysteresis register is enabled to a delta of 6°C, the preset trip points will toggle when the temperature reaches the programmed value. These values will reset when the temperature drops below the trip points minus the set hysteresis level. In this case, this would be critical temperature minus 6°C. The hysteresis is applied to both the above alarm window and the below alarm window bits found in the read-only temperature register (see Table 23 (page 21)). EVENT# is also affected by this register.

Figure 4: Hysteresis Applied to Temperature Around Trip Points



Notes:
1. T_H is the value set in the alarm temperature upper boundary trip register.
2. T_L is the value set in the alarm temperature lower boundary trip register.
3. Hyst is the value set in the hysteresis bits of the configuration register.

Table 23: Hysteresis Applied to Alarm Window Bits in the Temperature Register

Condition	Below Alarm Window Bit		Above Alarm Window Bit	
	Temperature Gradient	Critical Temperature	Temperature Gradient	Critical Temperature
Sets	Falling	T_L - Hyst	Rising	T_H
Clears	Rising	T_L	Falling	T_H - Hyst

Temperature Format

The temperature trip point registers and temperature readout register use a 2's complement format to enable negative numbers. The least significant bit (LSB) is equal to 0.0625°C or 0.25°C, depending on which register is referenced. For example, assuming an LSB of 0.0625°C:

- A value of 0x018C would equal 24.75°C
- A value of 0x06C0 would equal 108°C
- A value of 0x1E74 would equal –24.75°C

Temperature Trip Point Registers

The upper and lower temperature boundary registers are used to set the maximum and minimum values of the alarm window. LSB for these registers is 0.25°C. All RFU bits in the register will always report zero.

Table 24: Alarm Temperature Lower Boundary Register (Address: 0x02)

Bit														
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	MSB										LSB	RFU	RFU
			Alarm window upper boundary temperature												

Table 25: Alarm Temperature Lower Boundary Register (Address: 0x03)

Bit														
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	MSB										LSB	RFU	RFU
			Alarm window lower boundary temperature												

Critical Temperature Register

The critical temperature register is used to set the maximum temperature above the alarm window. The LSB for this register is 0.25°C. All RFU bits in the register will always report zero.

Table 26: Critical Temperature Register (Address: 0x04)

Bit														
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	MSB										LSB	RFU	RFU
			Critical temperature trip point												

Temperature Register

The temperature register is a read-only register that provides the current temperature detected by the temperature sensor. The LSB for this register is 0.0625°C with a resolution of 0.0625°C. The most significant bit (MSB) is 128°C in the readout section of this register.

The upper three bits of the register are used to monitor the trip points that are set in the previous three registers.

Table 27: Temperature Register (Address: 0x05)

Bit															
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Above critical trip	Above alarm window	Below alarm window	MSB												LSB
			Temperature												

Table 28: Temperature Register Bit Descriptions

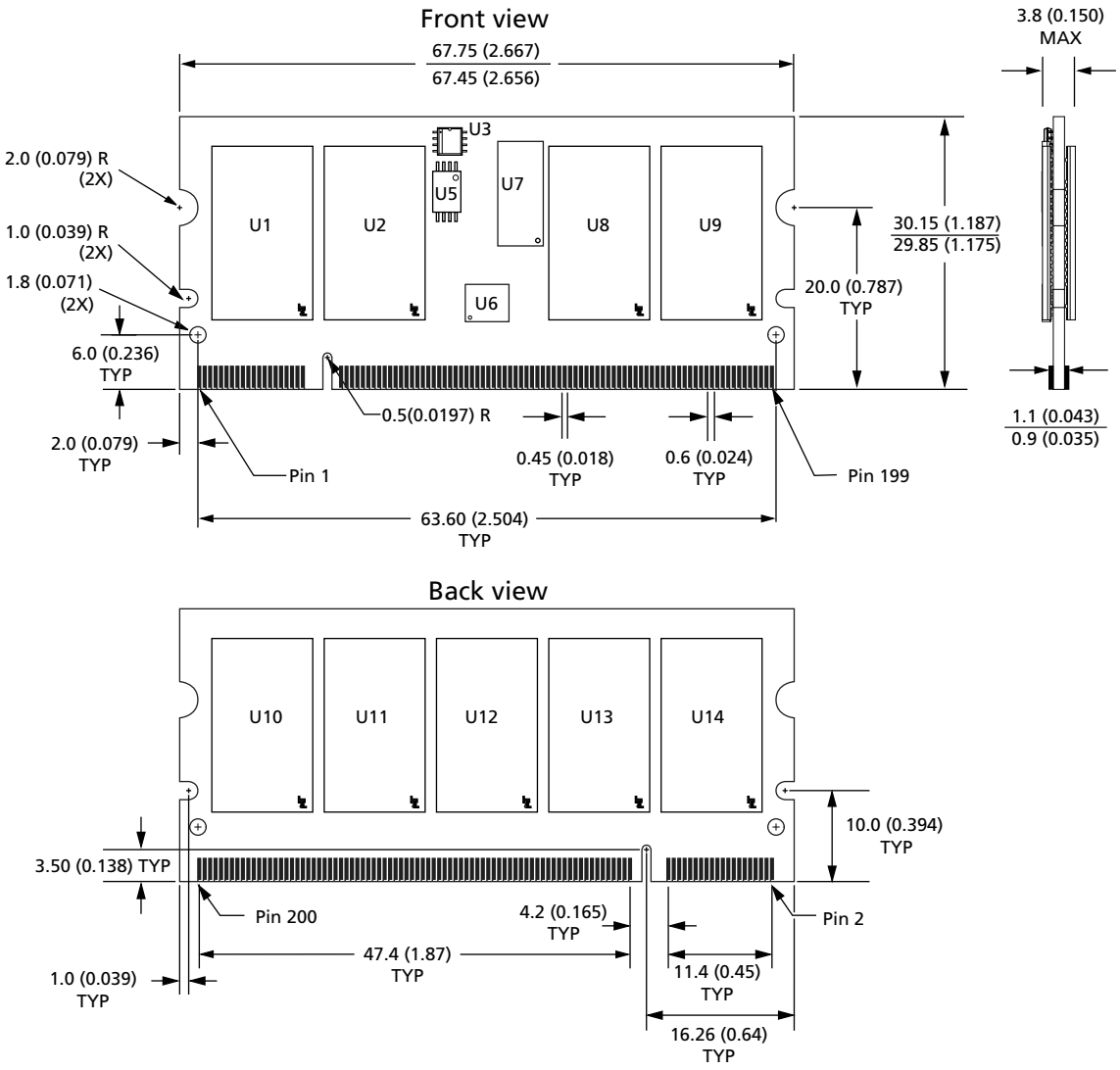
Bit	Description
13	Below alarm window 0: Temperature is equal to or above the lower boundary 1: Temperature is below alarm window
14	Above alarm window 0: Temperature is equal to or below the upper boundary 1: Temperature is above alarm window
15	Above critical trip point 0: Temperature is below critical trip point 1: Temperature is above critical trip point

Serial Presence-Detect Data

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

Module Dimensions

Figure 5: 200-Pin DDR2 SORDIMM



Notes:
1. All dimensions are in millimeters (inches); MAX/MIN or typical (TYP) where noted.
2. The dimensional diagram is for reference only. Refer to the JEDEC MO document for additional design dimensions.