

Memory Module Temperature Sensor w/ EEPROM for SPD

Features

- Meets JEDEC Specification
 - MCP9843 - JC42.4-TSE3000B3 Temperature Sensor
 - MCP98243 --> JC42.4-TSE2002B3 Temperature Sensor with 2 Kbit Serial EEPROM for Serial Presence Detect (SPD)
- 2-wire I²C™/SMBus Interface
- Available Packages:
 - DFN-8, TDFN-8, UDFN-8, TSSOP-8

Temperature Sensor Features

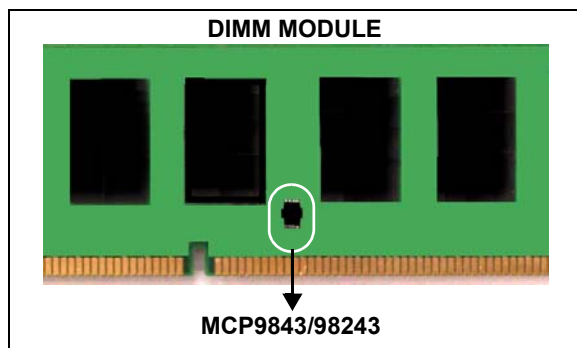
- Temperature-to-Digital Converter
- Sensor Accuracy (Grade B):
 - $\pm 0.2^{\circ}\text{C}/\pm 1^{\circ}\text{C}$ (typ./max.) $\rightarrow +75^{\circ}\text{C}$ to $+95^{\circ}\text{C}$
 - $\pm 0.5^{\circ}\text{C}/\pm 2^{\circ}\text{C}$ (typ./max.) $\rightarrow +40^{\circ}\text{C}$ to $+125^{\circ}\text{C}$
 - $\pm 1^{\circ}\text{C}/\pm 3^{\circ}\text{C}$ (typ./max.) $\rightarrow -20^{\circ}\text{C}$ to $+125^{\circ}\text{C}$
- Specified V_{DD} Range: 3.0V to 3.6V
- Operating Current: 200 μA (typical)
- Operating V_{DD} Range: 2.7V to 5.5V

Serial EEPROM Features (MCP98243)

- Specified V_{DD} Range: 1.8V to 5.5V
- Operating Current:
 - Write \rightarrow 1.1 mA (typical) for 3.5 ms (typical)
 - Read \rightarrow 100 μA (typical)
- Permanent and Reversible Software Write Protect
- Software Write Protection for the lower 1 Kbit
- Organized as 1 block of 256 x 8-bit (2 Kbit)

Typical Applications

- DIMM Modules for Servers, PCs, and Laptops
- General Purpose Temperature Datalog



Description

Microchip Technology Inc.'s MCP9843/98243 digital temperature sensors convert temperature from -40°C and $+125^{\circ}\text{C}$ to a digital word. These sensors meet JEDEC Specification JC42.4-TSE3000B3 and JC42.4-TSE2002B3 Memory Module Thermal Sensor Component. It provides an accuracy of $\pm 0.2^{\circ}\text{C}/\pm 1^{\circ}\text{C}$ (typical/maximum) from $+75^{\circ}\text{C}$ to $+95^{\circ}\text{C}$. In addition, MCP98243 has an internal 256 Byte EEPROM which can be used to store memory module and vendor information.

The MCP9843/98243 digital temperature sensor comes with user-programmable registers that provide flexibility for DIMM temperature-sensing applications. The registers allow user-selectable settings such as Shutdown or Low-Power modes and the specification of temperature Event boundaries. When the temperature changes beyond the specified Event boundary limits, the MCP9843/98243 outputs an Alert signal at the Event pin. The user has the option of setting the temperature Event output signal polarity as either an active-low or active-high comparator output for thermostat operation, or as a temperature Event interrupt output for microprocessor-based systems.

The MCP98243 EEPROM is designed specifically for DRAM DIMMs (Dual In-line Memory Modules) Serial Presence Detect (SPD). The lower 128 Bytes (address 0x00 to 0x7F) can be Permanent Write Protected (PWP) or Software Reversible Write Protected (SWP). This allows DRAM vendor and product information to be stored and write protected. The upper 128 bytes (address 0x80 to 0xFF) can be used for general purpose data storage. These addresses are not write protected.

This sensor has an industry standard 2-wire, I²C compatible serial interface, allowing up to eight devices to be controlled in a single serial bus.

Package Types

| 8-Pin 2x3 DFN/TDFN/UDFN * | | | | 8-Pin TSSOP | | | |
|---------------------------|---|---|-----------------|-------------|---|---|-----------------|
| A0 | 1 | 8 | V _{DD} | A0 | 1 | 8 | V _{DD} |
| A1 | 2 | 7 | Event | A1 | 2 | 7 | Event |
| A2 | 3 | 6 | SCL | A2 | 3 | 6 | SCL |
| GND | 4 | 5 | SDA | GND | 4 | 5 | SDA |

* Includes Exposed Thermal Pad (EP); see Table 3-1.

MCP9843/98243

Sensor Typical Accuracy Performance



Note: This accuracy data from the production system represents the typical accuracy performance of the MCP98242 Memory Module Temperature Sensor. The MCP98242 production methodology is also used for the MCP9843/98243 to achieve the same typical accuracy performance.

MCP98243 VS. MCP98242

| Feature | MCP98243 | MCP98242 |
|--|---|--|
| Event Output in Shutdown Mode | Event Output De-asserts | Event Output Remains in previous state. If the output asserts before shutdown command, it remains asserted during shutdown |
| I ² C communication Timeout Range | t _{OUT} = 25 ms to 35 ms | t _{OUT} = 20 ms to 50 ms |
| I ² C Maximum Bus Frequency | 400 kHz | 100 kHz |
| I ² C SCL & SDA V _{IL} /V _{IH} voltage levels | V _{IL_MAX} =0.3*V _{DD} , V _{IH_MIN} =0.7*V _{DD} | V _{IL_MAX} = 0.8V, V _{IH_MIN} = 2.1V |
| V _{HV A0} range | 7V to 12V | 8V to 12V |
| I ² C Spike Supression | 50 ns | — |
| I ² C input hysteresis | 0.05V _{DD} | 0.5V |
| Device/Revision ID Register | 0x2101 (hex) | 0x2001 |

1.0 ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings †

| | |
|--|---------------------|
| V _{DD} | 6.0V |
| Voltage at all Input/Output pins | GND – 0.3V to 6.0V |
| Pin A0 | GND – 0.3V to 12.5V |
| Storage temperature | -65°C to +150°C |
| Ambient temp. with power applied | -40°C to +125°C |
| Junction Temperature (T _J) | +150°C |
| ESD protection on all pins (HBM:MM) | (4 kV:300V) |
| Latch-Up Current at each pin (25°C) | ±200 mA |

†**Notice:** Stresses above those listed under “Maximum ratings” may cause permanent damage to the device. This is a stress rating only and functional operation of the device at those or any other conditions above those indicated in the operational listings of this specification is not implied. Exposure to maximum rating conditions for extended periods may affect device reliability.

TEMPERATURE SENSOR DC CHARACTERISTICS

| Electrical Specifications: Unless otherwise indicated, V _{DD} = 3.0V to 3.6V, GND = Ground, and T _A = -20°C to +125°C. | | | | | | |
|---|----------------------|------|-------|----------------------|------|---|
| Parameters | Sym | Min | Typ | Max | Unit | Conditions |
| Temperature Sensor Accuracy | | | | | | |
| +75°C < T _A ≤ +95°C | T _{ACY} | -1.0 | ±0.2 | +1.0 | °C | JC42.4 - TSE2002B3 Grade B Accuracy Specification |
| +40°C < T _A ≤ +125°C | | -2.0 | ±0.5 | +2.0 | °C | |
| -20°C < T _A ≤ +125°C | | -3.0 | ±1 | +3.0 | °C | |
| T _A = -40°C | | — | -1 | — | °C | |
| Temperature Conversion Time | | | | | | |
| 0.25°C/bit | t _{CONV} | — | 65 | 125 | ms | 15 s/sec (typical) (See Section 5.2.4) |
| Power Supply | | | | | | |
| Specified Voltage Range | V _{DD} | 3.0 | — | 3.6 | V | JC42.4 Specified Voltage Range |
| Operating Voltage Range | V _{DD} | 2.7 | — | 5.5 | V | Note 1 |
| Operating Current | I _{DD_TS} | — | 200 | 500 | µA | EEPROM Inactive |
| Shutdown Current - MCP9843 MCP98243 | I _{SHDN} | — | 1 | 2 | µA | EEPROM Inactive, I ² C Bus Inactive |
| | | — | 1 | 3 | µA | |
| Power On Reset (POR) | V _{POR_TS} | — | 2.2 | — | V | Threshold for falling V _{DD} voltage |
| Power Supply Rejection, T _A = +25°C | Δ°C/ΔV _{DD} | — | ±0.3 | — | °C/V | V _{DD} = 2.7V to 5.5V |
| | | — | ±0.15 | — | °C | V _{DD} = 3.3V+150 mV _{PP AC} (0 to 1 MHz) |
| Event Output (Open-Drain output, external pull-up or pull-down resistor required), see Section 5.2.3 | | | | | | |
| High-level Current (leakage) | I _{OH} | — | — | 1 | µA | V _{OH} = V _{DD} (Active-Low, Pull-up Resistor) |
| Low-level Voltage | V _{OL} | — | — | 0.4 | V | I _{OL} = 3 mA (Active-Low, Pull-up Resistor) |
| Low-level Current (leakage) | I _{OL} | — | — | 1 | µA | V _{OL} = V _{SS} (Active-High, Pull-down Resistor) |
| High-level Voltage | V _{OH} | — | — | V _{DD} -0.5 | V | I _{OH} = 3 mA (Active-High, Pull-down Resistor) |
| Thermal Response, from +25°C (Air) to +125°C (oil bath) | | | | | | |
| DFN/UDFN/TDFN-8 | t _{RES} | — | 0.7 | — | s | Time to 63% (89°C) |
| TSSOP-8 | | — | 1.4 | — | s | |

Note 1: Characterized but not production tested. Also, see **Section 2.0 “Typical Performance Curves”**.

MCP9843/98243

MCP98243 EEPROM DC CHARACTERISTICS

Electrical Specifications: Unless otherwise indicated, $V_{DD} = 1.8V$ to $5.5V$, GND = Ground, and $T_A = -20^{\circ}C$ to $+125^{\circ}C$.

| Parameters | Sym | Min | Typ | Max | Unit | Conditions |
|--------------------------------|---------------|-----|----------|------|-------------|--|
| Power Supply | | | | | | |
| Operating Voltage Range | V_{DD} | 1.8 | — | 5.5 | V | |
| Current, EEPROM write | I_{DD_EE} | — | 1100 | 2000 | μA | Sensor in Shutdown Mode (for t_{WC}), (Note 1) |
| Current, EEPROM read | I_{DD_EE} | — | 100 | 500 | μA | Sensor in Shutdown Mode (Note 1) |
| Power On Reset (POR) | V_{POR_EE} | — | 1.6 | — | V | EEPROM |
| Write Cycle time (byte/page) | t_{WC} | — | 3 | 5 | ms | |
| Endurance $T_A = +25^{\circ}C$ | — | — | 1M | — | cycles | Number of Write Cycles, $V_{DD} = 5V$ (Note 2) |
| EEPROM Write Temperature | EE_{WRITE} | 0 | — | 85 | $^{\circ}C$ | |
| EEPROM Read Temperature | EE_{READ} | -40 | — | 125 | $^{\circ}C$ | For minimum read temperature, see Note 2 |
| Write Protect Voltage | | | | | | |
| SWP and CWP Voltage | V_{HV} | 7 | — | 12 | V | Applied at A0 pin (Note 3) |
| PWP Voltage | | — | V_{DD} | — | V | |

- Note 1:** For V_{DD} ranges of 1.8V to the temperature sensor V_{POR_TS} , the temperature sensor becomes partially biased and consumes 80 μA (typical) until the sensor POR resets and acknowledges a shutdown command. See [Figure 2-15](#).
- Note 2:** Characterized but not production tested. For endurance estimates in a specific application, please consult the Total Endurance™ Model which can be obtained from Microchip's web site at www.microchip.com.
- Note 3:** The range of voltage applied at A0 pin for Permanent Write Protect is GND to $V_{DD} + 1V$. See [Figure 2-13](#) and [Section 5.3.3 "Write Protection"](#).

INPUT/OUTPUT PIN DC CHARACTERISTICS (NOTE 1)

Electrical Specifications: Unless otherwise indicated, $V_{DD} = 1.8V$ to $5.5V$, GND = Ground and $T_A = -20^{\circ}C$ to $+125^{\circ}C$.

| Parameters | Sym | Min | Typ | Max | Units | Conditions |
|--|------------|-------------|--------------|-------------|-----------|------------------------|
| Serial Input/Output (SCL, SDA, A0, A1, A2) (Note 2) | | | | | | |
| Input | | | | | | |
| High-level Voltage | V_{IH} | $0.7V_{DD}$ | — | — | V | |
| Low-level Voltage | V_{IL} | — | — | $0.3V_{DD}$ | V | |
| Input Current | I_{IN} | — | — | ± 5 | μA | SDA and SCL only |
| Input Impedance (A0, A1, A2) | Z_{IN} | — | 1 | — | $M\Omega$ | $V_{IN} > V_{IH}$ |
| Input Impedance (A0, A1, A2) | Z_{IN} | — | 200 | — | $k\Omega$ | $V_{IN} < V_{IL}$ |
| Output (SDA only) | | | | | | |
| Low-level Voltage | V_{OL} | — | — | 0.4 | V | $I_{OL} = 3\text{ mA}$ |
| High-level Current (leakage) | I_{OH} | — | — | 1 | μA | $V_{OH} = V_{DD}$ |
| Low-level Current | I_{OL} | 6 | — | — | mA | $V_{OL} = 0.6V$ |
| Capacitance | C_{IN} | — | 5 | — | pF | |
| SDA and SCL Inputs | | | | | | |
| Hysteresis | V_{HYST} | — | $0.05V_{DD}$ | — | V | $V_{DD} > 2V$ |
| | | — | $0.1V_{DD}$ | — | V | $V_{DD} < 2V$ |
| Spike Suppression | T_{SP} | — | — | 50 | ns | |

- Note 1:** These specifications apply for the Temperature Sensor and EEPROM.
- Note 2:** For V_{DD} ranges of 1.8V to the temperature sensor V_{POR_TS} , the temperature sensor becomes partially biased and consumes 80 μA (typical) until the sensor POR resets and acknowledges a shutdown command. See [Figure 2-15](#).

SENSOR AND EEPROM SERIAL INTERFACE TIMING SPECIFICATIONS

Electrical Specifications: Unless otherwise indicated, GND = Ground, $T_A = -20^{\circ}\text{C}$ to $+125^{\circ}\text{C}$, and $C_L = 80\text{ pF}$ (**Note 1, 5**).

| | | $V_{DD} = 1.8\text{V to }5.5\text{V}$ | | $V_{DD} = 2.2\text{V to }5.5\text{V}$ | | | |
|--|--------------|---------------------------------------|------|---------------------------------------|-----|-------|---------------------------------------|
| Parameters | Sym | Min | Max | Min | Max | Units | Conditions |
| 2-Wire I²C Interface | | | | | | | |
| Serial port frequency | f_{SCL} | 10 | 100 | 10 | 400 | kHz | Note 2, 4 |
| Low Clock | t_{LOW} | 4700 | — | 1300 | — | ns | Note 2 |
| High Clock | t_{HIGH} | 4000 | — | 600 | — | ns | Note 2 |
| Rise time | t_R | — | 1000 | 20 | 300 | ns | |
| Fall time | t_F | 20 | 300 | 20 | 300 | ns | |
| Data in Setup time | $t_{SU:DI}$ | 250 | — | 100 | — | ns | Note 3 |
| Data in Hold time | $t_{HD:DI}$ | 0 | — | 0 | — | ns | Note 6 |
| Data out Hold time | $t_{HD:DO}$ | 200 | 900 | 200 | 900 | ns | Note 4 |
| Start Condition Setup time | $t_{SU:STA}$ | 4700 | — | 600 | — | ns | |
| Start Condition Hold time | $t_{HD:STA}$ | 4000 | — | 600 | — | ns | |
| Stop Condition Setup time | $t_{SU:STO}$ | 4000 | — | 600 | — | ns | |
| Bus idle | $t_{B:FREE}$ | 4700 | — | 1300 | — | ns | |
| Time out (Sensor Only) | t_{OUT} | — | — | 25 | 35 | ms | $V_{DD} = 3.0\text{V to }3.6\text{V}$ |
| Bus Capacitive load | C_b | — | — | — | 400 | pf | |

Note 1: All values referred to $V_{IL\text{ MAX}}$ and $V_{IH\text{ MIN}}$ levels.

- 2:** If $t_{LOW} > t_{OUT}$ or $t_{HIGH} > t_{OUT}$, the temperature sensor I²C interface will time out. A Repeat Start command is required for communication.
- 3:** This device can be used in a Standard-mode I²C-bus system, but the requirement $t_{SU:DAT} \geq 250\text{ ns}$ must be met. This device does not stretch SCL Low time. It outputs the next data bit to the SDA line within $t_R\text{ MAX} + t_{SU:DI\text{ MIN}} = 1000\text{ ns} + 250\text{ ns} = 1250\text{ ns}$ (according to the Standard-mode I²C-bus specification) before the SCL line is released.
- 4:** As a transmitter, the device provides internal minimum delay time $t_{HD:DAT\text{ MIN}}$ to bridge the undefined region (min. 300 ns) of the falling edge of SCL $t_F\text{ MAX}$ to avoid unintended generation of Start or Stop conditions.
- 5:** For V_{DD} ranges of 1.8V to the temperature sensor $V_{POR\text{ TS}}$, the temperature sensor becomes partially biased and consumes 100 μA (typical) until the sensor POR resets and acknowledges a shutdown command.
- 6:** As a receiver, SDA should not be sampled at the falling edge of SCL. SDA can transition $t_{HD:DI}$ 0 ns after SCL toggles Low.

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TEMPERATURE CHARACTERISTICS

Electrical Specifications: Unless otherwise indicated, $V_{DD} = 1.8V$ to $5.5V$ for the EEPROM, $V_{DD} = 3.0V$ to $3.6V$ for the Temperature Sensor, and GND = Ground.

| Parameters | Sym | Min | Typ | Max | Units | Conditions |
|------------------------------------|---------------|-----|------|------|-------|---------------|
| Temperature Ranges | | | | | | |
| Specified Temperature Range | T_A | -20 | — | +125 | °C | Note 1 |
| Operating Temperature Range | T_A | -40 | — | +125 | °C | |
| Storage Temperature Range | T_A | -65 | — | +150 | °C | |
| Thermal Package Resistances | | | | | | |
| Thermal Resistance, 8L-DFN | θ_{JA} | — | 68 | — | °C/W | |
| Thermal Resistance, 8L-TDFN | θ_{JA} | — | 52.5 | — | °C/W | |
| Thermal Resistance, 8L-TSSOP | θ_{JA} | — | 139 | — | °C/W | |
| Thermal Resistance, 8L-UDFN | θ_{JA} | — | 41 | — | °C/W | |

Note 1: Operation in this range must not cause T_J to exceed Maximum Junction Temperature (+150°C).

TIMING DIAGRAM



GRAPHICAL SYMBOL DESCRIPTION



2.0 TYPICAL PERFORMANCE CURVES

Note: The graphs and tables provided following this note are a statistical summary based on a limited number of samples and are provided for informational purposes only. The performance characteristics listed herein are not tested or guaranteed. In some graphs or tables, the data presented may be outside the specified operating range (e.g., outside specified power supply range) and therefore outside the warranted range.

Note: Unless otherwise indicated, $V_{DD} = 2.7V$ to $5.5V$, GND = Ground, SDA/SCL pulled-up to V_{DD} , and $T_A = -40^{\circ}C$ to $+125^{\circ}C$.

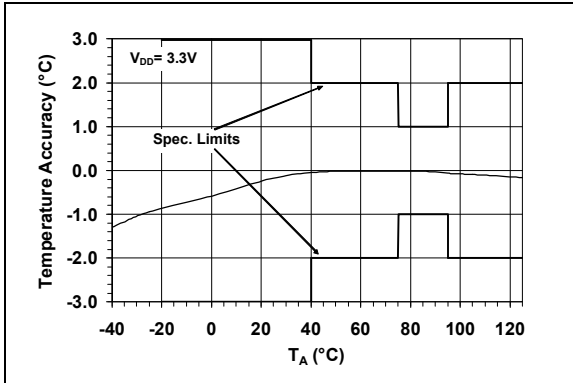


FIGURE 2-1: Average Temperature Accuracy.



FIGURE 2-4: Supply Current vs. Temperature.

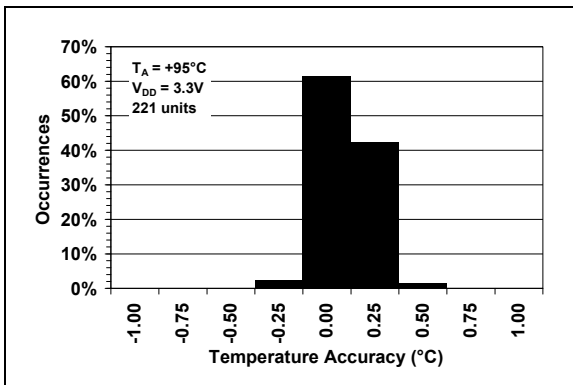


FIGURE 2-2: Temperature Accuracy Histogram, $T_A = +95^{\circ}C$.



FIGURE 2-5: Serial Bus Time-Out vs. Temperature.

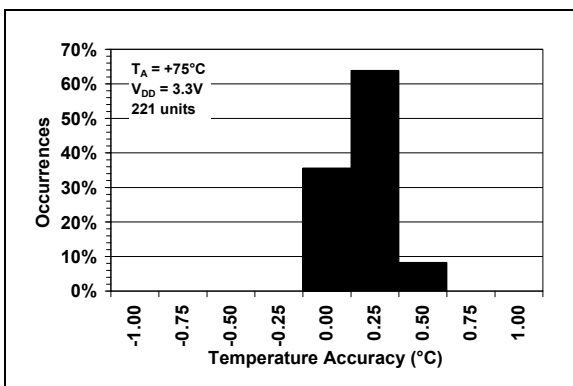


FIGURE 2-3: Temperature Accuracy Histogram, $T_A = +75^{\circ}C$.

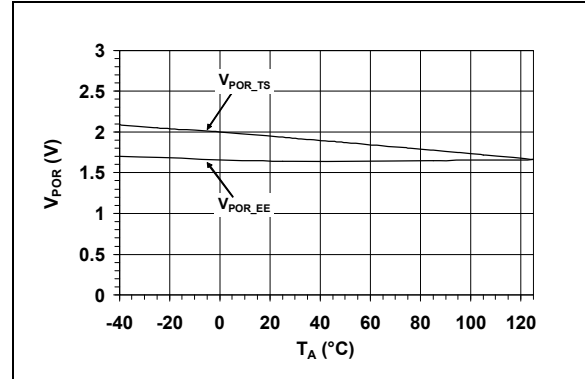


FIGURE 2-6: Power-on Reset Threshold Voltage vs. Temperature.

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Note: Unless otherwise indicated, $V_{DD} = 2.7V$ to $5.5V$, GND = Ground, SDA/SCL pulled-up to V_{DD} , and $T_A = -40^{\circ}C$ to $+125^{\circ}C$.



FIGURE 2-7: Event and SDA V_{OL} vs. Temperature.



FIGURE 2-10: SDA I_{OL} vs. Temperature.



FIGURE 2-8: Conversion Rate vs. Temperature.



FIGURE 2-11: Temperature Accuracy vs. V_{DD} .



FIGURE 2-9: Power Supply Rejection vs. Frequency.



FIGURE 2-12: Package Thermal Response.

Note: Unless otherwise indicated, $V_{DD} = 2.7V$ to $5.5V$, GND = Ground, SDA/SCL pulled-up to V_{DD} , and $T_A = -40^{\circ}C$ to $+125^{\circ}C$.

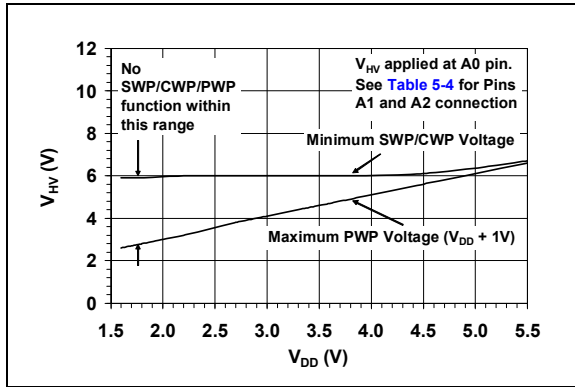


FIGURE 2-13: SWP/CWP/PWP High Voltage Range.

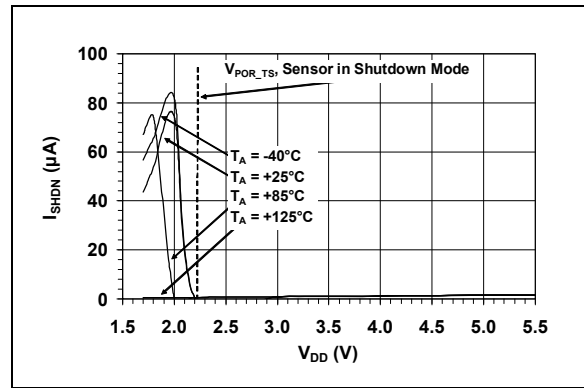


FIGURE 2-15: Shutdown Current vs. V_{DD} .

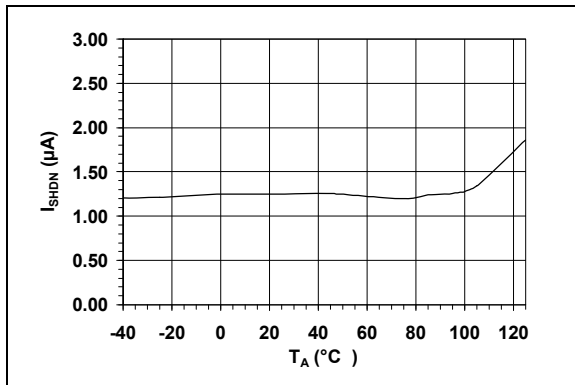


FIGURE 2-14: Shutdown Current vs. Temperature.

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NOTES:

3.0 PIN DESCRIPTION

The descriptions of the pins are listed in [Table 3-1](#).

TABLE 3-1: PIN FUNCTION TABLES

| MCP9843/98243 | | Symbol | Description |
|-----------------|-------|----------|---|
| DFN, TDFN, UDFN | TSSOP | | |
| 1 | 1 | A0 | Slave Address and EEPROM Software Write Protect high voltage input (V_{HV}) |
| 2 | 2 | A1 | Slave Address |
| 3 | 3 | A2 | Slave Address |
| 4 | 4 | GND | Ground |
| 5 | 5 | SDA | Serial Data Line |
| 6 | 6 | SCL | Serial Clock Line |
| 7 | 7 | Event | Temperature Alert Output |
| 8 | 8 | V_{DD} | Power Pin |
| 9 | — | EP | Exposed Thermal Pad (EP); can be connected to GND. |

3.1 Address Pins (A0, A1, A2)

These pins are device address input pins.

The address pins correspond to the Least Significant bits (LSb) of address bits. The Most Significant bits (MSb) (A6, A5, A4, A3). This is shown in [Table 3-2](#).

TABLE 3-2: MCP9843/98243 ADDRESS BYTE

| Device | Address Code | | | | Slave Address | | |
|----------------------|--------------|----|----|----|---------------|----|----|
| | A6 | A5 | A4 | A3 | A2 | A1 | A0 |
| Sensor | 0 | 0 | 1 | 1 | | | |
| EEPROM | 1 | 0 | 1 | 0 | X | X | X |
| EEPROM Write Protect | 0 | 1 | 1 | 0 | | | |

Note: User-selectable address is shown by X.

The A0 Address pin is a multi-function pin. This input pin is also used for high voltage input V_{HV} to enable the EEPROM Software Write Protect feature, see [Section 5.3.3 “Write Protection”](#).

All address pin have an internal pull-down resistors.

3.2 Ground Pin (GND)

The GND pin is the system ground pin.

3.3 Serial Data Line (SDA)

SDA is a bidirectional input/output pin, used to serially transmit data to/from the host controller. This pin requires a pull-up resistor. (See [Section 4.0 “Serial Communication”](#)).

3.4 Serial Clock Line (SCL)

The SCL is a clock input pin. All communication and timing is relative to the signal on this pin. The clock is generated by the host or master controller on the bus. (See [Section 4.0 “Serial Communication”](#)).

3.5 Temperature Alert, Open-Drain Output (Event)

The MCP9843/98243 temperature Event output pin is an open-drain output. The device outputs a signal when the ambient temperature goes beyond the user-programmed temperature limit. (see [Section 5.2.3 “Event Output Configuration”](#)).

3.6 Power Pin (V_{DD})

V_{DD} is the power pin. The operating voltage range, as specified in the DC electrical specification table, is applied on this pin.

3.7 Exposed Thermal Pad (EP)

There is an internal electrical connection between the Exposed Thermal Pad (EP) and the GND pin; they can be connected to the same potential on the Printed Circuit Board (PCB). This provides better thermal conduction from the PCB to the die.

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NOTES:

4.0 SERIAL COMMUNICATION

4.1 2-Wire Standard Mode I²C™ Protocol-Compatible Interface

The MCP9843/98243 serial clock input (SCL) and the bidirectional serial data line (SDA) form a 2-wire bidirectional Standard mode I²C compatible communication port (refer to the **Input/Output Pin DC Characteristics (Note 1)** Table and **Sensor And EEPROM Serial Interface Timing Specifications** Table).

The following bus protocol has been defined:

TABLE 4-1: MCP9843/98243 SERIAL BUS PROTOCOL DESCRIPTIONS

| Term | Description |
|-------------|---|
| Master | The device that controls the serial bus, typically a microcontroller. |
| Slave | The device addressed by the master, such as the MCP9843/98243. |
| Transmitter | Device sending data to the bus. |
| Receiver | Device receiving data from the bus. |
| START | A unique signal from master to initiate serial interface with a slave. |
| STOP | A unique signal from the master to terminate serial interface from a slave. |
| Read/Write | A read or write to the MCP9843/98243 registers. |
| ACK | A receiver Acknowledges (ACK) the reception of each byte by polling the bus. |
| NAK | A receiver Not-Acknowledges (NAK) or releases the bus to show End-of-Data (EOD). |
| Busy | Communication is not possible because the bus is in use. |
| Not Busy | The bus is in the idle state, both SDA and SCL remain high. |
| Data Valid | SDA must remain stable before SCL becomes high in order for a data bit to be considered valid. During normal data transfers, SDA only changes state while SCL is low. |

4.1.1 DATA TRANSFER

Data transfers are initiated by a Start condition (START), followed by a 7-bit device address and a read/write bit. An Acknowledge (ACK) from the slave confirms the reception of each byte. Each access must be terminated by a Stop condition (STOP).

Repeated communication is initiated after t_{B-FREE} .

This device does not support sequential register read/write. Each register needs to be addressed using the Register Pointer.

This device supports the Receive Protocol. The register can be specified using the pointer for the initial read. Each repeated read or receive begins with a Start condition and address byte. The MCP9843/98243 retain the previously selected register. Therefore, they output data from the previously-specified register (repeated pointer specification is not necessary).

4.1.2 MASTER/SLAVE

The bus is controlled by a master device (typically a microcontroller) that controls the bus access and generates the Start and Stop conditions. The MCP9843/98243 is a slave device and does not control other devices in the bus. Both master and slave devices can operate as either transmitter or receiver. However, the master device determines which mode is activated.

4.1.3 START/STOP CONDITION

A high-to-low transition of the SDA line (while SCL is high) is the Start condition. All data transfers must be preceded by a Start condition from the master. A low-to-high transition of the SDA line (while SCL is high) signifies a Stop condition.

If a Start or Stop condition is introduced during data transmission, the MCP9843/98243 releases the bus. All data transfers are ended by a Stop condition from the master.

4.1.4 ADDRESS BYTE

Following the Start condition, the host must transmit an 8-bit address byte to the MCP9843/98243. The address for the MCP9843/98243 Temperature Sensor is '0011, A2, A1, A0' in binary, where the A2, A1 and A0 bits are set externally by connecting the corresponding pins to V_{DD} '1' or GND '0'. The 7-bit address transmitted in the serial bit stream must match the selected address for the MCP9843/98243 to respond with an ACK. Bit 8 in the address byte is a read/write bit. Setting this bit to '1' commands a read operation, while '0' commands a write operation (see Figure 4-1).

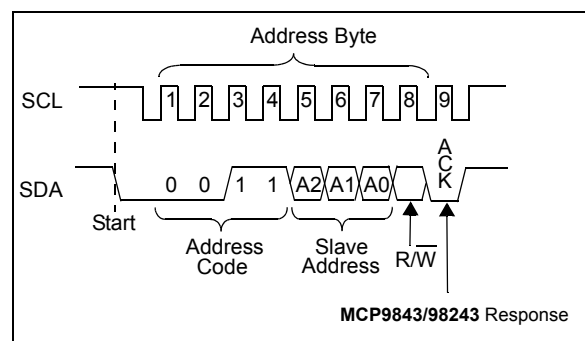


FIGURE 4-1: Device Addressing.

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4.1.5 DATA VALID

After the Start condition, each bit of data in transmission needs to be settled for a time specified by $t_{SU-DATA}$ before SCL toggles from low-to-high (see **“Sensor And EEPROM Serial Interface Timing Specifications” on Page 5**).

4.1.6 ACKNOWLEDGE (ACK/NAK)

Each receiving device, when addressed, is obliged to generate an ACK bit after the reception of each byte. The master device must generate an extra clock pulse for ACK to be recognized.

The acknowledging device pulls down the SDA line for $t_{SU-DATA}$ before the low-to-high transition of SCL from the master. SDA also needs to remain pulled down for t_{H-DATA} after a high-to-low transition of SCL.

During read, the master must signal an End-of-Data (EOD) to the slave by not generating an ACK bit (NAK) once the last bit has been clocked out of the slave. In this case, the slave will leave the data line released to enable the master to generate the Stop condition.

4.1.7 TIME OUT (MCP9843/98243, SENSOR ONLY)

If the SCL stays low or high for time specified by t_{OUT} , the MCP9843/98243 temperature sensor resets the serial interface. This dictates the minimum clock speed as specified in the specification. However, the EEPROM does not reset the serial interface. Therefore, the master can hold the clock indefinitely to process data from the EEPROM.

5.0 FUNCTIONAL DESCRIPTION

The MCP9843/98243 temperature sensors consists of a band-gap type temperature sensor, a Delta-Sigma Analog-to-Digital Converter ($\Sigma\Delta$ ADC), user-program-

mable registers and a 2-wire I²C protocol compatible serial interface. Figure 5-1 shows a block diagram of the register structure.



FIGURE 5-1: Functional Block Diagram.

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5.1 Registers

The MCP9843/98243 device has several registers that are user-accessible. These registers include the Capability register, Configuration register, Event Temperature Upper-Boundary and Lower-Boundary Trip registers, Critical Temperature Trip register, Temperature register, Manufacturer Identification register and Device Identification register.

The Temperature register is read-only, used to access the ambient temperature data. The data is loaded in parallel to this register after t_{CONV} . The Event Temperature Upper-Boundary and Lower-Boundary Trip registers are read/writes. If the ambient temperature drifts beyond the user-specified limits, the MCP9843/98243 device outputs a signal using the Event pin (refer to **Section 5.2.3 “Event Output Configuration”**). In addition, the Critical Temperature Trip register is used to provide an additional critical temperature limit.

The Capability register is used to provide bits describing the MCP9843/98243’s capability in measurement resolution, measurement range and device accuracy. The device Configuration register provides access to configure the MCP9843/98243’s various features. These registers are described in further detail in the following sections.

The registers are accessed by sending a Register Pointer to the MCP9843/98243 using the serial interface. This is an 8-bit write-only pointer. However, the four Least Significant bits are used as pointers and all unused bits (bits 7-4) need to be cleared or set to ‘0’. [Register 5-1](#) describes the pointer or the address of each register.

REGISTER 5-1: REGISTER POINTER (WRITE ONLY)

| | | | | | | | |
|-------|-----|-----|-----|--------------|-----|-----|-------|
| W-0 | W-0 | W-0 | W-0 | W-0 | W-0 | W-0 | W-0 |
| — | — | — | — | Pointer Bits | | | |
| bit 7 | | | | | | | bit 0 |

| | | | |
|-------------------|------------------|------------------------------------|--------------------|
| Legend: | | | |
| R = Readable bit | W = Writable bit | U = Unimplemented bit, read as ‘0’ | |
| -n = Value at POR | ‘1’ = Bit is set | ‘0’ = Bit is cleared | x = Bit is unknown |

- bit 7-4 **Writable Bits:** Write ‘0’
- bit 3-0 **Pointer Bits:**
 - 0000 = Capability register
 - 0001 = Configuration register (CONFIG)
 - 0010 = Event Temperature Upper-Boundary Trip register (T_{UPPER})
 - 0011 = Event Temperature Lower-Boundary Trip register (T_{LOWER})
 - 0100 = Critical Temperature Trip register (T_{CRIT})
 - 0101 = Temperature register (T_A)
 - 0110 = Manufacturer ID register
 - 0111 = Device ID/Revision register
 - 1000 = Resolution register
 - 1XXX = Reserved (This device has additional registers that are reserved for test and calibration. If these registers are accessed, the device may not perform according to the specification.)

**TABLE 5-1: BIT ASSIGNMENT SUMMARY FOR ALL TEMPERATURE SENSOR REGISTERS
(SEE SECTION 5.4)**

| Register Pointer (Hex) | MSB/LSB | Bit Assignment | | | | | | | |
|-------------------------|---------|------------------------------------|-------------------------------------|-------------------------------------|-------------------|--------------------|--------------------|--------------------|--------------------|
| | | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| 0x00 | MSB | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | LSB | SHDN Status | t _{OUT} Range | V _{HV} | Resolution | | Range | Accuracy | Event |
| 0x01 | MSB | 0 | 0 | 0 | 0 | 0 | Hysteresis | | SHDN |
| | LSB | Crt Loc | Win Loc | Int Clr | Evt Stat | Evt Cnt | Evt Sel | Evt Pol | Evt Mod |
| 0x02 | MSB | 0 | 0 | 0 | SIGN | 2 ⁷ °C | 2 ⁶ °C | 2 ⁵ °C | 2 ⁴ °C |
| | LSB | 2 ³ °C | 2 ² °C | 2 ¹ °C | 2 ⁰ °C | 2 ⁻¹ °C | 2 ⁻² °C | 0 | 0 |
| 0x03 | MSB | 0 | 0 | 0 | SIGN | 2 ⁷ °C | 2 ⁶ °C | 2 ⁵ °C | 2 ⁴ °C |
| | LSB | 2 ³ °C | 2 ² °C | 2 ¹ °C | 2 ⁰ °C | 2 ⁻¹ °C | 2 ⁻² °C | 0 | 0 |
| 0x04 | MSB | 0 | 0 | 0 | SIGN | 2 ⁷ °C | 2 ⁶ °C | 2 ⁵ °C | 2 ⁴ °C |
| | LSB | 2 ³ °C | 2 ² °C | 2 ¹ °C | 2 ⁰ °C | 2 ⁻¹ °C | 2 ⁻² °C | 0 | 0 |
| 0x05 | MSB | T _A ≥ T _{CRIT} | T _A > T _{UPPER} | T _A < T _{LOWER} | SIGN | 2 ⁷ °C | 2 ⁶ °C | 2 ⁵ °C | 2 ⁴ °C |
| | LSB | 2 ³ °C | 2 ² °C | 2 ¹ °C | 2 ⁰ °C | 2 ⁻¹ °C | 2 ⁻² °C | 2 ⁻³ °C | 2 ⁻⁴ °C |
| 0x06 | MSB | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | LSB | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 0 |
| 0x07 MCP98243 | MSB | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 |
| | LSB | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 0x07 MCP9843 | MSB | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | LSB | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 0x08 | LSB | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |

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5.1.1 CAPABILITY REGISTER

This is a read-only register used to identify the temperature sensor capability. For example, the MCP9843/98243 device is capable of providing temperature at 0.25°C resolution, measuring temperature below and above 0°C, providing ±1°C and ±2°C accuracy over the active and monitor temperature ranges (respectively) and providing user-programmable temperature event boundary trip limits. [Register 5-2](#) describes the Capability register. These functions are described in further detail in the following sections.

REGISTER 5-2: CAPABILITY REGISTER (READ-ONLY) → ADDRESS '0000 0000'b

| | | | | | | | |
|--------|-----|-----|-----|-----|-----|-----|-------|
| U-0 | U-0 | U-0 | U-0 | U-0 | U-0 | U-0 | U-0 |
| — | — | — | — | — | — | — | — |
| bit 15 | | | | | | | bit 8 |

| | | | | | | | |
|-------------|------------------------|-----------------|------------|------------|----------|------------|-------|
| R-1 | R-1 | R-1 | R-0 | R-1 | R-1 | R-1 | R-1 |
| SHDN Status | t _{OUT} Range | V _{HV} | Resolution | Meas Range | Accuracy | Temp Alarm | |
| bit 7 | | | | | | | bit 0 |

| | | | |
|-------------------|------------------|------------------------------------|--------------------|
| Legend: | | | |
| R = Readable bit | W = Writable bit | U = Unimplemented bit, read as '0' | |
| -n = Value at POR | '1' = Bit is set | '0' = Bit is cleared | x = Bit is unknown |

bit 15-8 **Unimplemented:** Read as '0'

bit 7 **Event output status during Shutdown (SHDN Status):**
 0 = Event output remains in previous state. If the output asserts before shutdown command, it remains asserted during shutdown.
 1 = Event output de-asserts during shutdown. After shutdown, it takes t_{CONV} to re-assert the Event output (power-up default)

bit 6 **1°C Bus time-out (t_{OUT} Range):**
 0 = Bus time-out range is 10 ms to 60 ms
 1 = Bus time-out range is 25 ms to 35 ms (power-up default)

bit 5 **High Voltage Input**
 0 = Pin A0 does not accept High Voltage
 1 = Pin A0 accepts High Voltage for the EEPROM Write Protect feature (power-up default)

bit 4-3 **Resolution:**
 00 = 0.5°C
 01 = 0.25°C (power up default)
 10 = 0.125°C
 11 = 0.0625°C
 These bits reflect the selected resolution (see **Section 5.2.4 "Temperature Resolution"**)

bit 2 **Temperature Measurement Range (Meas. Range):**
 0 = T_A = 0 (decimal) for temperature below 0°C
 1 = The part can measure temperature below 0°C (power-up default)

REGISTER 5-2: CAPABILITY REGISTER (READ-ONLY) → ADDRESS '0000 0000'b (CONTINUED)

- bit 1 **Accuracy:**
- 0 = Accuracy → ±2°C from +75°C to +95°C (Active Range) and ±3°C from +40°C to +125°C (Monitor Range)
 - 1 = Accuracy → ±1°C from +75°C to +95°C (Active Range) and ±2°C from +40°C to +125°C (Monitor Range)
- bit 0 **Temperature Alarm:**
- 0 = No defined function (This bit will never be cleared or set to '0')
 - 1 = The part has temperature boundary trip limits (T_{UPPER}/T_{LOWER}/T_{CRIT} registers) and a temperature event output (JC 42.4 required feature)



FIGURE 5-2: Timing Diagram for Reading the Capability Register (See **Section 4.0 “Serial Communication”**).

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5.1.2 SENSOR CONFIGURATION REGISTER (CONFIG)

The MCP9843/98243 device has a 16-bit Configuration register (CONFIG) that allows the user to set various functions for a robust temperature monitoring system. Bits 10 thru 0 are used to select Event output boundary hysteresis, device Shutdown or Low-Power mode, temperature boundary and critical temperature lock, temperature Event output enable/disable. In addition, the user can select the Event output condition (output set for T_{UPPER} and T_{LOWER} temperature boundary or T_{CRIT} only), read Event output status and set Event output polarity and mode (Comparator Output or Interrupt Output mode).

The temperature hysteresis bits 10 and 9 can be used to prevent output chatter when the ambient temperature gradually changes beyond the user-specified temperature boundary (see **Section 5.2.2 “Temperature Hysteresis (T_{HYST})”**). The Continuous

Conversion or Shutdown mode is selected using bit 8. In Shutdown mode, the band gap temperature sensor circuit stops converting temperature and the Ambient Temperature register (T_A) holds the previous successfully converted temperature data (see **Section 5.2.1 “Shutdown Mode”**). Bits 7 and 6 are used to lock the user-specified boundaries T_{UPPER}, T_{LOWER} and T_{CRIT} to prevent an accidental rewrite. Bits 5 thru 0 are used to configure the temperature Event output pin. All functions are described in [Register 5-3](#) (see **Section 5.2.3 “Event Output Configuration”**).

REGISTER 5-3: CONFIGURATION REGISTER (CONFIG) → ADDRESS '0000 0001'b

| | | | | | | | |
|--------|-----|-----|-----|-----|-------------------|-------|-------|
| U-0 | U-0 | U-0 | U-0 | U-0 | R/W-0 | R/W-0 | R/W-0 |
| — | — | — | — | — | T _{HYST} | | SHDN |
| bit 15 | | | | | | | bit 8 |

| | | | | | | | |
|------------|-----------|------------|-------------|------------|------------|------------|------------|
| R/W-0 | R/W-0 | R/W-0 | R-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 |
| Crit. Lock | Win. Lock | Int. Clear | Event Stat. | Event Cnt. | Event Sel. | Event Pol. | Event Mod. |
| bit 7 | | | | | | | bit 0 |

| | | | |
|-------------------|------------------|------------------------------------|--------------------|
| Legend: | | | |
| R = Readable bit | W = Writable bit | U = Unimplemented bit, read as '0' | |
| -n = Value at POR | '1' = Bit is set | '0' = Bit is cleared | x = Bit is unknown |

- bit 15-11 **Unimplemented:** Read as '0'
- bit 10-9 **T_{UPPER} and T_{LOWER} Limit Hysteresis (T_{HYST}):**
 - 00 = 0°C (power-up default)
 - 01 = 1.5°C
 - 10 = 3.0°C
 - 11 = 6.0°C

(Refer to **Section 5.2.3 “Event Output Configuration”**)

This bit can not be altered when either of the lock bits are set (bit 6 and bit 7).

This bit can be programmed in shutdown mode.

- bit 8 **Shutdown Mode (SHDN):**
 - 0 = Continuous Conversion (power-up default)
 - 1 = Shutdown (Low-Power mode)

In shutdown, all power-consuming activities are disabled, though all registers can be written to or read. Event output will de-assert.

This bit cannot be set '1' when either of the lock bits is set (bit 6 and bit 7). However, it can be cleared '0' for Continuous Conversion while locked (Refer to **Section 5.2.1 “Shutdown Mode”**).

REGISTER 5-3: CONFIGURATION REGISTER (CONFIG) → ADDRESS '0000 0001'b

| | |
|-------|---|
| bit 7 | <p>T_{CRIT} Lock Bit (Crit. Lock): 0 = Unlocked. T_{CRIT} register can be written. (power-up default) 1 = Locked. T_{CRIT} register can not be written</p> <p>When enabled, this bit remains set '1' or locked until cleared by internal reset (Section 5.4 "Summary of Power-on Default"). This bit does not require a double-write.</p> <p>This bit can be programmed in shutdown mode.</p> |
| bit 6 | <p>T_{UPPER} and T_{LOWER} Window Lock Bit (Win. Lock): 0 = Unlocked. T_{UPPER} and T_{LOWER} registers can be written. (power-up default) 1 = Locked. T_{UPPER} and T_{LOWER} registers can not be written</p> <p>When enabled, this bit remains set '1' or locked until cleared by power-on Respell (Section 5.4 "Summary of Power-on Default"). This bit does not require a double-write.</p> <p>This bit can be programmed in shutdown mode.</p> |
| bit 5 | <p>Interrupt Clear (Int. Clear) Bit: 0 = No effect (power-up default) 1 = Clear interrupt output. When read this bit returns '0'</p> <p>This bit clears the Interrupt flag which de-asserts Event output. In shutdown mode, the Event output is always de-asserted. Therefore, setting this bit in shutdown mode clears the interrupt after the device returns to normal operation.</p> |
| bit 4 | <p>Event Output Status (Event Stat.) Bit: 0 = Event output is not asserted by the device (power-up default) 1 = Event output is asserted as a comparator/Interrupt or critical temperature output</p> <p>In shutdown mode this bit will clear because Event output is always de-asserted in shutdown mode.</p> |
| bit 3 | <p>Event Output Control (Event Cnt.) Bit: 0 = Event output Disabled (power-up default) 1 = Event output Enabled</p> <p>This bit can not be altered when either of the lock bits is set (bit 6 and bit 7).</p> <p>This bit can be programmed in shutdown mode, but Event output will remain de-asserted.</p> |
| bit 2 | <p>Event Output Select (Event Sel.) Bit: 0 = Event output for T_{UPPER}, T_{LOWER} and T_{CRIT} (power-up default) 1 = T_A ≥ T_{CRIT} only. (T_{UPPER} and T_{LOWER} temperature boundaries are disabled.)</p> <p>When the Alarm Window Lock bit is set, this bit cannot be altered until unlocked (bit 6).</p> <p>This bit can be programmed in shutdown mode, but Event output will remain de-asserted.</p> |
| bit 1 | <p>Event Output Polarity (Event Pol.) Bit: 0 = Active low (power-up default. Pull-up resistor required) See Section 5.2.3 "Event Output Configuration" 1 = Active-high (Pull-down resistor required) See Section 5.2.3 "Event Output Configuration"</p> <p>This bit cannot be altered when either of the lock bits is set (bit 6 and bit 7).</p> <p>This bit can be programmed in shutdown mode, but Event output will remain de-asserted.</p> |
| bit 0 | <p>Event Output Mode (Event Mod.) Bit: 0 = Comparator output (power-up default) 1 = Interrupt output</p> <p>This bit cannot be altered when either of the lock bits is set (bit 6 and bit 7).</p> <p>This bit can be programmed in shutdown mode, but Event output will remain de-asserted.</p> |

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FIGURE 5-3: Timing Diagram for Writing to the Configuration Register (See Section 4.0 “Serial Communication”).



FIGURE 5-4: Timing Diagram for Reading from the Configuration Register (See Section 4.0 “Serial Communication”).

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5.1.3 UPPER/LOWER/CRITICAL TEMPERATURE LIMIT REGISTERS ($T_{UPPER}/T_{LOWER}/T_{CRIT}$)

The MCP9843/98243 device has a 16-bit read/write Event output Temperature Upper-Boundary Trip register (T_{UPPER}), a 16-bit Lower-Boundary Trip register (T_{LOWER}) and a 16-bit Critical Boundary Trip register (T_{CRIT}) that contains 11-bit data in two's complement format (0.25°C). This data represents the maximum and minimum temperature boundary or temperature window that can be used to monitor ambient temperature. If this feature is enabled (Section 5.1.2 "Sensor Configuration Register (CONFIG)") and the ambient temperature exceeds the specified boundary or window, the MCP9843/98243 asserts an Event output. (Refer to Section 5.2.3 "Event Output Configuration").

REGISTER 5-4: UPPER/LOWER/CRITICAL TEMPERATURE LIMIT REGISTER ($T_{UPPER}/T_{LOWER}/T_{CRIT}$) → ADDRESS '0000 0010'b/'0000 0011'b/'0000 0100'b (NOTE 1)

| | | | | | | | |
|--------|-----|-----|-------|-----------------------|-----------------------|-----------------------|-----------------------|
| U-0 | U-0 | U-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 |
| — | — | — | Sign | 2^7°C | 2^6°C | 2^5°C | 2^4°C |
| bit 15 | | | bit 8 | | | | |

| | | | | | | | |
|-----------------------|-----------------------|-----------------------|-----------------------|--------------------------|--------------------------|-------|-----|
| R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 | U-0 | U-0 |
| 2^3°C | 2^2°C | 2^1°C | 2^0°C | $2^{-1^{\circ}\text{C}}$ | $2^{-2^{\circ}\text{C}}$ | — | — |
| bit 7 | | | | | | bit 0 | |

| | | | |
|-------------------|------------------|------------------------------------|--------------------|
| Legend: | | | |
| R = Readable bit | W = Writable bit | U = Unimplemented bit, read as '0' | |
| -n = Value at POR | '1' = Bit is set | '0' = Bit is cleared | x = Bit is unknown |

- bit 15-13 **Unimplemented:** Read as '0'
- bit 12 **Sign:**
 - 0 = $T_A \geq 0^{\circ}\text{C}$
 - 1 = $T_A < 0^{\circ}\text{C}$
- bit 11-2 **$T_{UPPER}/T_{LOWER}/T_{CRIT}$:**
Temperature boundary trip data in two's complement format.
- bit 1-0 **Unimplemented:** Read as '0'

Note 1: This table shows two 16-bit registers for T_{UPPER} , T_{LOWER} and T_{CRIT} located at '0000 0010b', '0000 0011b' and '0000 0100b', respectively.



FIGURE 5-5: Timing Diagram for Writing and Reading from the T_{UPPER} Register (See **Section 4.0** “Serial Communication”).

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5.1.4 AMBIENT TEMPERATURE REGISTER (T_A)

The MCP9843/98243 device uses a band gap temperature sensor circuit to output analog voltage proportional to absolute temperature. An internal $\Delta\Sigma$ ADC is used to convert the analog voltage to a digital word. The converter resolution is set to $0.25^\circ\text{C} + \text{sign}$ (11-bit data). The digital word is loaded to a 16-bit read-only Ambient Temperature register (T_A) that contains 11-bit temperature data in two's complement format.

The T_A register bits (bits 12 thru 0) are double-buffered. Therefore, the user can access the register while, in the background, the MCP9843/98243 performs an analog-to-digital conversion. The temperature data from the $\Delta\Sigma$ ADC is loaded in parallel to the T_A register at t_{CONV} refresh rate.

In addition, the T_A register uses three bits (bits 15, 14 and 13) to reflect the Event pin state. This allows the user to identify the cause of the Event output trigger (see **Section 5.2.3 “Event Output Configuration”**); bit 15 is set to '1' if T_A is greater than or equal to T_{CRIT} , bit 14 is set to '1' if T_A is greater than T_{UPPER} and bit 13 is set to '1' if T_A is less than T_{LOWER} .

The T_A register bit assignment and boundary conditions are described in [Register 5-5](#).

REGISTER 5-5: AMBIENT TEMPERATURE REGISTER (T_A) → ADDRESS '0000 0101'b (NOTE 1)

| | | | | | | | |
|-----------------------------|------------------------------|------------------------------|------|----------|----------|----------|----------|
| R-0 | R-0 | R-0 | R-0 | R-0 | R-0 | R-0 | R-0 |
| T_A vs. T_{CRIT} | T_A vs. T_{UPPER} | T_A vs. T_{LOWER} | SIGN | 2^7 °C | 2^6 °C | 2^5 °C | 2^4 °C |
| bit 15 | | | | | | | bit 8 |

| | | | | | | | |
|----------|----------|----------|----------|-------------|-------------|-------------|-------------|
| R-0 | R-0 | R-0 | R-0 | R-0 | R-0 | R-0 | R-0 |
| 2^3 °C | 2^2 °C | 2^1 °C | 2^0 °C | 2^{-1} °C | 2^{-2} °C | 2^{-3} °C | 2^{-4} °C |
| bit 7 | | | | | | | bit 0 |

| | | | |
|-------------------|------------------|------------------------------------|--------------------|
| Legend: | | | |
| R = Readable bit | W = Writable bit | U = Unimplemented bit, read as '0' | |
| -n = Value at POR | '1' = Bit is set | '0' = Bit is cleared | x = Bit is unknown |

bit 15 **T_A vs. T_{CRIT} ⁽¹⁾ Bit:**

- 0 = $T_A < T_{\text{CRIT}}$
- 1 = $T_A \geq T_{\text{CRIT}}$

bit 14 **T_A vs. T_{UPPER} ⁽¹⁾ Bit:**

- 0 = $T_A \leq T_{\text{UPPER}}$
- 1 = $T_A > T_{\text{UPPER}}$

bit 13 **T_A vs. T_{LOWER} ⁽¹⁾ Bit:**

- 0 = $T_A \geq T_{\text{LOWER}}$
- 1 = $T_A < T_{\text{LOWER}}$

bit 12 **SIGN Bit:**

- 0 = $T_A \geq 0^\circ\text{C}$
- 1 = $T_A < 0^\circ\text{C}$

bit 11-0 **Ambient Temperature (T_A) Bits: (Note 2)**

12-bit Ambient Temperature data in two's complement format.

Note 1: Bits 15, 14 and 13 are not affected by the status of the Event output configuration (bits 5 to 0 of CONFIG) ([Register 5-3](#)).

2: Bits 2, 1, and 0 may remain clear '0' depending on the status of the resolution register ([Register 5-9](#)). The Power-up default is $0.25^\circ\text{C}/\text{bit}$, bits 1 and 0 remain clear '0'.

5.1.4.1 T_A bits to Temperature Conversion

To convert the T_A bits to decimal temperature, the upper three boundary bits (bits 15, 14 and 13) must be masked out. Then determine the sign bit (bit 12) to check positive or negative temperature, shift the bits accordingly and combine the upper and lower bytes of the 16-bit register. The upper byte contains data for temperatures greater than 32°C while the lower byte contains data for temperature less than 32°C, including fractional data. When combining the upper and lower bytes, the upper byte must be Right-shifted by 4bits (or multiply by 2^4) and the lower byte must be Left-shifted by 4 bits (or multiply by 2^{-4}). Adding the results of the shifted values provides the temperature data in decimal format, see [Equation 5-1](#).

The temperature bits are in two's compliment format, therefore, positive temperature data and negative temperature data are computed differently. [Equation 5-1](#) shows the temperature computation. The example instruction code outlined in [Figure 5-6](#) shows the communication flow, also see [Figure 5-7](#) for timing diagram.

EQUATION 5-1: BYTES TO TEMPERATURE CONVERSION

Temperature $\geq 0^\circ\text{C}$

$$T_A = (\text{UpperByte} \times 2^4 + \text{LowerByte} \times 2^{-4})$$

Temperature $< 0^\circ\text{C}$

$$T_A = 256 - (\text{UpperByte} \times 2^4 + \text{LowerByte} \times 2^{-4})$$

Where:

T_A = Ambient Temperature ($^\circ\text{C}$)

UpperByte = T_A bit 15 to bit 8

LowerByte = T_A bit 7 to bit 0

This example routine assumes the variables and I²C communication subroutines are predefined:

```

i2c_start(); // send START command
i2c_write(AddressByte & 0xFE); //WRITE Command
//also, make sure bit 0 is cleared '0'

i2c_write(0x05); // Write TA Register Address
i2c_start(); //Repeat START
i2c_write(AddressByte | 0x01); // READ Command
//also, make sure bit 0 is Set '1'

UpperByte = i2c_read(ACK); // READ 8 bits
//and Send ACK bit

LowerByte = i2c_read(NAK); // READ 8 bits
//and Send NAK bit

i2c_stop(); // send STOP command

//Convert the temperature data
//First Check flag bits
if ((UpperByte & 0x80) == 0x80){ //TA ≥ TCRIT
}
if ((UpperByte & 0x40) == 0x40){ //TA > TUPPER
}
if ((UpperByte & 0x20) == 0x20){ //TA < TLOWER
}
UpperByte = UpperByte & 0x1F; //Clear flag bits
if ((UpperByte & 0x10) == 0x10){ //TA < 0°C
    UpperByte = UpperByte & 0x0F; //Clear SIGN
    Temperature = 256 - (UpperByte x 16 + LowerByte / 16);
}else //TA ≥ 0°C
    Temperature = (UpperByte x 16 + LowerByte / 16);
//Temperature = Ambient Temperature (°C)
    
```

FIGURE 5-6: Example Instruction Code.

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FIGURE 5-7: Timing Diagram for Reading +25.25°C Temperature from the T_A Register (See Section 4.0 "Serial Communication").

5.1.5 MANUFACTURER ID REGISTER

This register is used to identify the manufacturer of the device in order to perform manufacturer specific operation. The Manufacturer ID for the MCP9843/98243 is 0x0054 (hexadecimal).

REGISTER 5-6: MANUFACTURER ID REGISTER (READ-ONLY) → ADDRESS '0000 0110'b

| | | | | | | | |
|-----------------|-----|-----|-----|-------|-----|-----|-----|
| R-0 | R-0 | R-0 | R-0 | R-0 | R-0 | R-0 | R-0 |
| Manufacturer ID | | | | | | | |
| bit 15 | | | | bit 8 | | | |

| | | | | | | | |
|-----------------|-----|-----|-----|-------|-----|-----|-----|
| R-0 | R-1 | R-0 | R-1 | R-0 | R-1 | R-0 | R-0 |
| Manufacturer ID | | | | | | | |
| bit 7 | | | | bit 0 | | | |

Legend:

R = Readable bit W = Writable bit U = Unimplemented bit, read as '0'
 -n = Value at POR '1' = Bit is set '0' = Bit is cleared x = Bit is unknown

bit 15-0 **Device Manufacturer Identification Number**



FIGURE 5-8: Timing Diagram for Reading the Manufacturer ID Register (See Section 4.0 “Serial Communication”).

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5.1.6 DEVICE ID AND REVISION REGISTER

The upper byte of this register is used to specify the device identification and the lower byte is used to specify device revision. The device ID for the MCP98243 is 0x21 (hex) and the MCP9843 is 0x00 (hex).

The revision (Lower Byte) begins with 0x00 (hex) for the first release, with the number being incremented as revised versions are released. The revision for both MCP9843 and MCP98243 is 0x01.

REGISTER 5-7: MCP98243 DEVICE ID AND DEVICE REVISION (READ-ONLY) → ADDRESS '0000 0111'b

| | | | | | | | | |
|-----------|-----|-----|-----|-----|-----|-----|-----|-------|
| R-0 | R-0 | R-1 | R-0 | R-0 | R-0 | R-0 | R-1 | |
| Device ID | | | | | | | | |
| bit 15 | | | | | | | | bit 8 |

| | | | | | | | | |
|-----------------|-----|-----|-----|-----|-----|-----|-----|-------|
| R-0 | R-0 | R-0 | R-0 | R-0 | R-0 | R-0 | R-1 | |
| Device Revision | | | | | | | | |
| bit 7 | | | | | | | | bit 0 |

| | | | | | | | |
|-------------------|------------------|------------------------------------|--------------------|--|--|--|--|
| Legend: | | | | | | | |
| R = Readable bit | W = Writable bit | U = Unimplemented bit, read as '0' | | | | | |
| -n = Value at POR | '1' = Bit is set | '0' = Bit is cleared | x = Bit is unknown | | | | |

bit 15-8 **Device ID:** Bit 15 to bit 8 are used for device ID
bit 7-0 **Device Revision:** Bit 7 to bit 0 are used for device revision

REGISTER 5-8: MCP9843 DEVICE ID AND DEVICE REVISION (READ-ONLY) → ADDRESS '0000 0111'b

| | | | | | | | | |
|-----------|-----|-----|-----|-----|-----|-----|-----|-------|
| R-0 | R-0 | R-0 | R-0 | R-0 | R-0 | R-0 | R-0 | |
| Device ID | | | | | | | | |
| bit 15 | | | | | | | | bit 8 |

| | | | | | | | | |
|-----------------|-----|-----|-----|-----|-----|-----|-----|-------|
| R-0 | R-0 | R-0 | R-0 | R-0 | R-0 | R-0 | R-1 | |
| Device Revision | | | | | | | | |
| bit 7 | | | | | | | | bit 0 |

| | | | | | | | |
|-------------------|------------------|------------------------------------|--------------------|--|--|--|--|
| Legend: | | | | | | | |
| R = Readable bit | W = Writable bit | U = Unimplemented bit, read as '0' | | | | | |
| -n = Value at POR | '1' = Bit is set | '0' = Bit is cleared | x = Bit is unknown | | | | |

bit 15-8 **Device ID:** Bit 15 to bit 8 are used for device ID
bit 7-0 **Device Revision:** Bit 7 to bit 0 are used for device revision

5.1.7 RESOLUTION REGISTER

This register allows the user to change the sensor resolution (see **Section 5.2.4 “Temperature Resolution”**). The POR default resolution is 0.25°C. The selected resolution is also reflected in the Capability register (see [Register 5-2](#)).

REGISTER 5-9: RESOLUTION → ADDRESS `'0000 1000'b`

| | | | | | | | |
|-------|-----|-----|-----|-----|-----|------------|-------|
| U-0 | U-0 | U-0 | U-0 | U-0 | U-0 | R/W-0 | R/W-0 |
| — | — | — | — | — | — | Resolution | |
| bit 7 | | | | | | bit 0 | |

Legend:

| | | |
|-------------------|------------------|------------------------------------|
| R = Readable bit | W = Writable bit | U = Unimplemented bit, read as '0' |
| -n = Value at POR | '1' = Bit is set | '0' = Bit is cleared |
| | | x = Bit is unknown |

bit 7-2 **Unimplemented:** Read as '0'

bit 1-0 **Resolution:**
 00 = LSB = 0.5°C (t_{CONV} = 30 ms typical)
 01 = LSB = 0.25°C (power up default, t_{CONV} = 65 ms typical)
 10 = LSB = 0.125°C (t_{CONV} = 130 ms typical)
 11 = LSB = 0.0625°C (t_{CONV} = 260 ms typical)



FIGURE 5-9: Timing Diagram for Changing T_A Resolution to 0.0625°C `<0000 0011>b` (See **Section 4.0 “Serial Communication”**).

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5.2 SENSOR FEATURE DESCRIPTION

5.2.1 SHUTDOWN MODE

Shutdown mode disables all power-consuming activities (including temperature sampling operations) while leaving the serial interface active. This mode is selected by setting bit 8 of CONFIG to '1'. In this mode, the device consumes I_{SHDN} . It remains in this mode until bit 8 is cleared '0' to enable Continuous Conversion mode, or until power is recycled.

The Shutdown bit (bit 8) cannot be set to '1' while bits 6 and 7 of CONFIG (Lock bits) are set to '1'. However, it can be cleared '0' or returned to Continuous Conversion while locked.

In Shutdown mode, all registers can be read or written. However, the serial bus activity increases the shutdown current.

If the device is shutdown while the Event pin is asserted, then the Event output will be de-asserted during shutdown. It will remain de-asserted until the device is enabled for normal operation. Once the device is enabled it takes t_{CONV} before the device re-asserts the Event output.

5.2.2 TEMPERATURE HYSTERESIS (T_{HYST})

A hysteresis of 0°C, 1.5°C, 3°C or 6°C can be selected for the T_{UPPER} , T_{LOWER} and T_{CRIT} temperature boundaries using bits 10 and 9 of CONFIG. The hysteresis applies for decreasing temperature only (hot to cold), or as temperature drifts below the specified limit.

The hysteresis bits can not be changed if either of the lock bits, bits 6 and 7 of CONFIG, are set to '1'.

The T_{UPPER} , T_{LOWER} and T_{CRIT} boundary conditions are described graphically in [Figure 5-2](#).

5.2.3 EVENT OUTPUT CONFIGURATION

The Event output can be enabled using bit 3 of CONFIG (Event output control bit) and can be configured as either a comparator output or as Interrupt Output mode using bit 0 of CONFIG (Event mode). The polarity can also be specified as an active-high or active-low using bit 1 of CONFIG (Event polarity). When active-high output is selected, a pull-down resistor is required on the Event pin. When active-low output is selected, a pull-up resistor is required on the Event pin, see [Figure 5-10](#) and [Figure 5-11](#) for graphical circuit description. These configurations are designed to serve processors with Low-to-High or High-to-Low edge triggered inputs. With these configurations, when the Event output De-asserts, power will not be dissipated across the pull-up or pull-down resistors.

When the ambient temperature increases above the critical temperature limit, the Event output is forced to a comparator output (regardless of bit 0 of CONFIG). When the temperature drifts below the critical temperature limit minus hysteresis, the Event output automatically returns to the state specified by bit 0 of CONFIG.



FIGURE 5-10: Active-High Event Output Configuration.



FIGURE 5-11: Active-Low Event Output Configuration.

The status of the Event output can be read using bit 4 of CONFIG (Event status). This bit can not be set to '1' in shutdown mode.

Bit 7 and 6 of the CONFIG register can be used to lock the T_{UPPER} , T_{LOWER} and T_{CRIT} registers. The bits prevent false triggers at the Event output due to an accidental rewrite to these registers.

The Event output can also be used as a critical temperature output using bit 2 of CONFIG (critical output only). When this feature is selected, the Event output becomes a comparator output. In this mode, the interrupt output configuration (bit 0 of CONFIG) is ignored.

5.2.3.1 Comparator Mode

Comparator mode is selected using bit 0 of CONFIG. In this mode, the Event output is asserted as active-high or active-low using bit 1 of CONFIG. Figure 5-12 shows the conditions that toggle the Event output.

If the device enters Shutdown mode with asserted Event output, the output will de-assert. It will remain de-asserted until the device enters Continuous Conversion mode and after the first temperature conversion is completed, t_{CONV} . After the initial temperature conversion, T_A must satisfy the T_{UPPER} or T_{LOWER} boundary conditions in order for Event output to be asserted.

Comparator mode is useful for thermostat-type applications, such as turning on a cooling fan or triggering a system shutdown when the temperature exceeds a safe operating range.

5.2.3.2 Interrupt Mode

In the Interrupt mode, the Event output is asserted as active-high or active-low (depending on the polarity configuration) when T_A drifts above or below T_{UPPER} and T_{LOWER} limits. The output is deasserted by setting bit 5 (Interrupt Clear) of CONFIG. If the device enters Shutdown mode with asserted Event output, the output will de-assert. It will remain de-asserted until the device enters Continuous Conversion mode and after the first temperature conversion is completed, t_{CONV} . If the interrupt clear bit (Bit 5) is never set, then the Event output will re-assert after the first temperature conversion.

In addition, if $T_A \geq T_{CRIT}$ the Event output is forced as Comparator mode and asserts until $T_A < T_{CRIT} - T_{HYST}$. While the Event output is asserted, user must send Clear Interrupt command (bit 5 of CONFIG) for Event output to de-assert, when temperature drops below the critical limit, $T_A < T_{CRIT} - T_{HYST}$. Otherwise, Event output remains asserted (see Figure 5-12 for graphical description). Switching from Interrupt mode to Comparator mode also de-asserts Event output.

This mode is designed for interrupt driven microcontroller based systems. The microcontroller receiving the interrupt will have to acknowledge the interrupt by setting bit 5 of CONFIG register from the MCP9843/98243.

5.2.4 TEMPERATURE RESOLUTION

The MCP9843/98243 device is capable of providing a temperature data with 0.5°C to 0.0625°C resolution. The Resolution can be selected using the Resolution register (Register 5-9) which is located in address '00001000'b. This address location is not specified in JEDEC Standard JC42.4. However, it provides additional flexibility while being functionally compatible with JC42.4 and provide a 0.25°C resolution at 125 ms (max.). The selected resolution can be read by user using bit 4 and bit 3 of the Capability register (Register 5-2). A 0.25°C resolution is set as POR default by factory.

TABLE 5-2: TEMPERATURE CONVERSION TIME

| Resolution | t_{CONV} (ms) | Samples/sec (typical) |
|------------------------------|-----------------|-----------------------|
| 0.5°C | 30 | 33 |
| 0.25°C (Power-up default) | 65 | 15 |
| 0.125°C | 130 | 8 |
| 0.0625°C | 260 | 4 |

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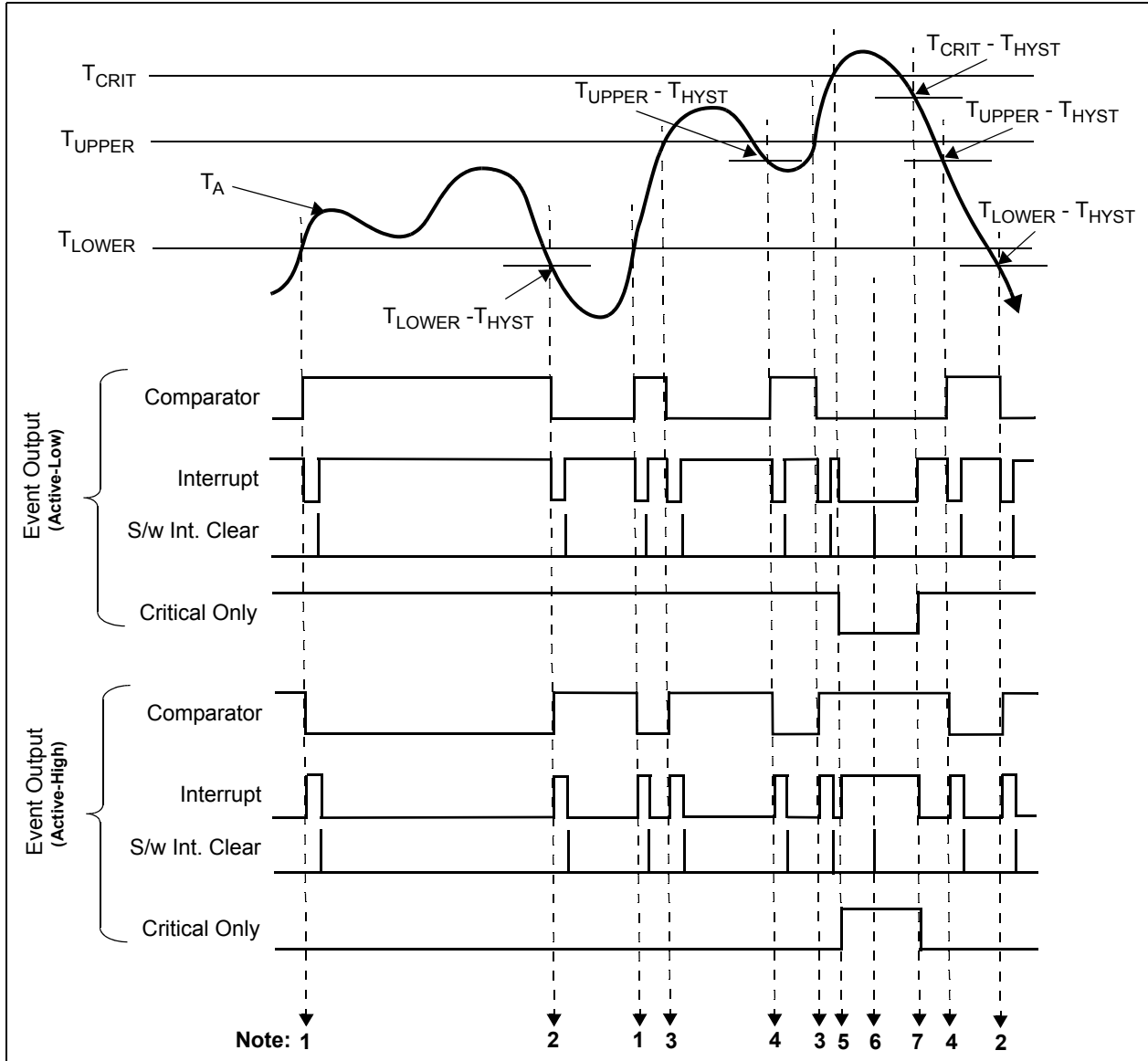


TABLE 5-10: TEMPERATURE EVENT OUTPUT CONDITIONS

| Note | Output Boundary Conditions | Comparator | Interrupt | Critical | T _A Bits | | |
|------|--|------------|-----------|----------|--------------------------------|---|---|
| | | | | | Output State (Active Low/High) | | |
| 1 | T _A ≥ T _{LOWER} | High/Low | Low/High | High/Low | 0 | 0 | 0 |
| 2 | T _A < T _{LOWER} - T _{HYST} | Low/High | Low/High | High/Low | 0 | 0 | 1 |
| 3 | T _A > T _{UPPER} | Low/High | Low/High | High/Low | 0 | 1 | 0 |
| 4 | T _A ≤ T _{UPPER} - T _{HYST} | High/Low | Low/High | High/Low | 0 | 0 | 0 |
| 5 | T _A ≥ T _{CRIT} | Low/High | Low/High | Low/High | 1 | 1 | 0 |
| 6 | When T _A ≥ T _{CRIT} the Event output is forced to Comparator Mode and bits 0 of CONFIG (Event output mode) is ignored until T _A < T _{CRIT} - T _{HYST} . In the Interrupt Mode, if Interrupt is not cleared (bits 5 of CONFIG) as shown in the diagram at Note 6 , then Event will remain asserted at Note 7 until Interrupt is cleared by the controller. | | | | | | |
| 7 | T _A < T _{CRIT} - T _{HYST} | Low/High | High/Low | High/Low | 0 | 1 | 0 |

FIGURE 5-12: Event Output Condition.

5.3 MCP98243 EEPROM FEATURE DESCRIPTION

5.3.1 BYTE WRITE

To write a byte in the MCP98243 EEPROM, the master has to specify the memory location or address. Once the address byte is transmitted correctly followed by a word address, the word address is stored in the EEPROM address pointer. The following byte is data to be stored in the specified memory location. [Figure 5-13](#) shows the timing diagram.



FIGURE 5-13: Timing Diagram for Byte Write (See **Section 4.0 “Serial Communication”**).

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5.3.2 PAGE WRITE

The write Address Byte, word address and the first data byte are transmitted to the MCP98243 in the same way as in a byte write. Instead of generating a Stop condition, the master transmits up to 15 additional data bytes to the MCP98243, which are temporarily stored in the on-chip page buffer and will be written into the memory after the master has transmitted a Stop condition. Upon receipt of each word, the four lower order address pointer bits are internally incremented by one. The higher order four bits of the word address remain constant. If the master should transmit more than 16 bytes prior to generating the Stop condition, the address counter will roll over and the previously received data will be overwritten. As with the byte write operation, once the Stop condition is received, an internal write cycle will begin (Figure 5-14).

Note: Page write operations are limited to writing bytes within a single physical page, regardless of the number of bytes actually being written. Physical page boundaries start at addresses that are integer multiples of the page buffer size (or 'page size') and end at addresses that are integer multiples of [page size - 1]. If a Page Write command attempts to write across a physical page boundary, the result is that the data wraps around to the beginning of the current page (overwriting data previously stored there), instead of being written to the next page, as might be expected. It is therefore necessary for the application software to prevent page write operations that would attempt to cross a page boundary.



FIGURE 5-14: Timing Diagram for Page Write (See Section 4.0 "Serial Communication").

5.3.3 WRITE PROTECTION

The MCP98243 has a Software Write-Protect (SWP) feature that allows the lower half array (addresses 00h - 7Fh) to be write-protected or permanently write-protected (PWP). The write protected area can be cleared by sending Clear Write Protect (CWP) command. However, once the PWP is executed the protected memory can not be cleared. The device will not respond to the CWP command.

To access write protection, the device address code of the Address Byte is set to '0110' instead of '1010'. The '1010' Address code is used to access the memory area and the '0110' address code is used to access the write protection. Once the device is write protected it will not acknowledge certain commands. [Table 5-3](#) shows the corresponding Address Bytes for the write protect feature.

TABLE 5-3: WRITE PROTECT DEVICE ADDRESSING (NOTE 1)

| EEPROM | Operation | Address Pins | | | Address Byte | | | | |
|------------|-----------|--------------|-----------------|-----------------|--------------|---------------|----|----|-------------------------|
| | | A2 | A1 | A0 | Address Code | Slave Address | | | $\overline{\text{R/W}}$ |
| | | | | | | A2 | A1 | A0 | |
| SWP | WRITE | GND | GND | V _{HV} | 0110 | 0 | 0 | 1 | 0 |
| | READ | | | | | | | | 1 |
| CWP | WRITE | GND | V _{DD} | V _{HV} | 0110 | 0 | 1 | 1 | 0 |
| | READ | | | | | | | | 1 |
| PWP (Note) | WRITE | X | X | X | 0110 | X | X | X | 0 |
| | READ | | | | | | | | 1 |

Note 1: The Address Pins are 'X' or don't cares. However, the slave address bits need to match the address pins. For V_{HV} voltage levels, refer to [Figure 2-13](#).

TABLE 5-4: DEVICE RESPONSE WHEN WRITING DATA OR ACCESSING SWP/CWP/PWP (NOTE 1)

| Status | Command | ACK | Address | ACK | Data Byte | ACK | Write Cycle |
|-----------------------|---------------------------------|-------|---------|-------|-----------|-------|-------------|
| Not Protected | SWP/CWP/PWP | ACK | X | ACK | X | ACK | Yes |
| | Page/byte write | ACK | Address | ACK | Data | ACK | Yes |
| Protected with SWP | SWP | NoACK | X | NoACK | X | NoACK | No |
| | CWP | ACK | X | ACK | X | ACK | Yes |
| | PWP | ACK | X | ACK | X | ACK | Yes |
| | Page/byte write lower 128 bytes | ACK | Address | ACK | Data | NoACK | No |
| Permanently Protected | SWP/CWP/PWP | NoACK | X | NoACK | X | NoACK | No |
| | Page/byte write lower 128 bytes | ACK | Address | ACK | Data | NoACK | No |

Note 1: X is defined as 'don't care'.

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5.3.3.1 Software Write Protect (SWP)

The SWP feature is invoked by writing to the write-protect register. This is done by sending an Address Byte similar to a normal Write command. [Figure 5-17](#) shows the timing diagram. SWP can be cleared using the CWP command. See [Section 5.3.3.2 “Clear Write Protect \(CWP\)”](#)

The Slave Address bits need to correspond to the address pin logic configuration. For SWP, a high voltage V_{HV} needs to be applied to the A0 pin and the corresponding slave address needs to be set to ‘1’, as shown in [Table 5-3](#). Both A2 and A1 pins are grounded and the corresponding slave address bits are set to ‘0’.

The device response in this mode is shown in [Table 5-4](#) and [Table 5-5](#).



FIGURE 5-15: Timing Diagram for Setting Software Write Protect (See [Section 4.0 “Serial Communication”](#)).

5.3.3.2 Clear Write Protect (CWP)

The CWP feature is invoked by writing to the clear write-protect register. This is done by sending an Address Byte similar to a normal Write command. [Figure 5-17](#) shows the timing diagram. CWP clears SWP only. PWP can not be cleared using this command.

The Slave Address bits need to correspond to the address pin logic configuration. For CWP, a high voltage V_{HV} needs to be applied to the A0 pin and the corresponding slave address needs to be set to ‘1’. The A1 pin is set to V_{DD} and the corresponding slave address bit is set to ‘1’. And A2 pins is set to ground and the corresponding slave address bits are set to ‘0’.

[Table 5-3](#) shows the bit configuration. The device response in this mode is shown in [Table 5-4](#) and [Table 5-5](#).



FIGURE 5-16: Timing Diagram for Setting Clear Write Protect (See [Section 4.0 “Serial Communication”](#)).

5.3.3.3 PWP (Permanent Write Protect)

Once the PWP register is written, the lower half of the memory will be permanent protected and the device will not acknowledge any command. The protected area of the memory can not be cleared, reversed, or re-written. If a write is attempted to the protected area, the device will acknowledge the address byte and word address but not the data byte. (See [Table 5-4](#) and [Table 5-5](#)).

Note: Once the Permanent Write-Protect is executed, it cannot be reversed, even if the device power is cycled. See [Figure 2-13](#) for V_{HV} voltage levels.

Unlike SWP and CWP, a V_{HV} is not applied on the A0 pin to execute PWP. The state of A2, A1, and A0 is user selectable. However, the address pin states need to match the slave address bits, as shown in [Table 5-3](#).



FIGURE 5-17: Timing Diagram for Setting Permanent Write Protect (See [Section 4.0 "Serial Communication"](#)).

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5.3.4 READ OPERATION

Read operations are initiated in the same way as write operations, with the exception that the R/W bit of the slave address is set to '1'. There are three basic types of read operations: current address read, random read and sequential read.

TABLE 5-5: DEVICE RESPONSE WHEN READING SWP/CWP/PWP (NOTE)

| Status | Command | ACK | Address | ACK | Data Byte | ACK |
|-----------------------|-------------|-------|---------|-------|-----------|-------|
| Not Protected | SWP/CWP/PWP | ACK | X | NoACK | X | NoACK |
| Protected with SWP | SWP | NoACK | X | NoACK | X | NoACK |
| | CWP | ACK | X | NoACK | X | NoACK |
| | PWP | ACK | X | NoACK | X | NoACK |
| Permanently Protected | SWP/CWP/PWP | NoACK | X | NoACK | X | NoACK |

Note: X is defined as 'don't care'.

5.3.4.1 Current Address Read

The MCP98243 contains an address counter that maintains the address of the last word accessed, internally incremented by '1'. Therefore, if the previous access (either a read or write operation) was to address n , the next current address read operation would access data from address $n+1$. Upon receipt of the slave address with R/W bit set to '1', the MCP98243 issues an acknowledge and transmits the 8-bit data

word. The master will not acknowledge (NAK) the transfer but does generate a Stop condition and the MCP98243 discontinues transmission (Figure 5-18).

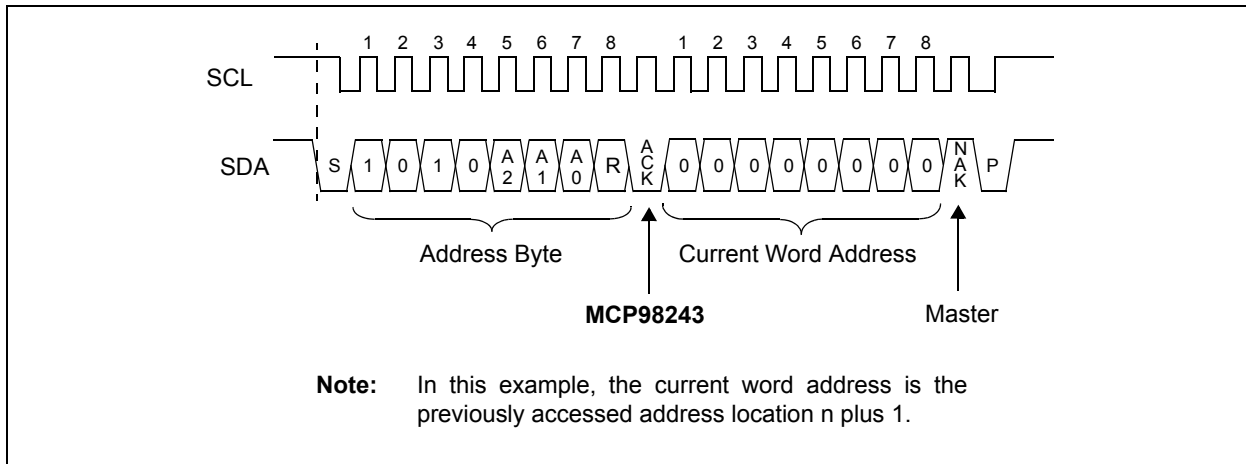


FIGURE 5-18: Reading Current Word Address (See Section 4.0 “Serial Communication”).

5.3.4.2 Random Read

Random read operations allow the master to access any memory location in a random manner. To perform this type of read operation, the word address must first be set. This is done by sending the word address to the MCP98243 as part of a write operation. Once the word address is sent, the master generates a start condition following the acknowledge. This terminates the write operation, but not before the internal address pointer is

set. The master then issues the Address Byte again, but with the R/W bit set to a '1'. The MCP98243 then issues an acknowledge and transmits the 8-bit data word. The master will not acknowledge the transfer but does generate a stop condition and the MCP98243 discontinues transmission (Figure 5-19).



FIGURE 5-19: Timing Diagram for Random Read (See Section 4.0 "Serial Communication").

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5.3.4.3 Sequential Read

Sequential reads are initiated in the same way as a random read, with the exception that after the MCP98243 transmits the first data byte, the master issues an acknowledge, as opposed to a stop condition in a random read. This directs the MCP98243 to transmit the next sequentially addressed 8-bit word (Figure 5-20).

To provide sequential reads, the MCP98243 contains an internal address pointer, which is incremented by one at the completion of each operation. This address pointer allows the entire memory contents to be serially read during one operation.



FIGURE 5-20: Timing Diagram for Sequential Read (See Section 4.0 "Serial Communication").

5.3.5 STANDBY MODE

The design will incorporate a low power standby mode (I_{SHDN}). Standby mode will be entered after a normal termination of any operation and after all internal functions are complete. This would include any error conditions occurring, such as improper number of clock cycles or improper instruction byte as defined previously.

5.4 Summary of Power-on Default

The MCP9843/98243 has an internal Power-on Reset (POR) circuit. If the power supply voltage V_{DD} glitches down to the V_{POR_TS} and V_{POR_EE} thresholds, the device resets the registers to the power-on default settings.

Table 5-6 shows the power-on default summary for the temperature sensor. The EEPROM resets the address pointer to 0x00 hex.

TABLE 5-6: MCP9843/98243 TEMPERATURE SENSOR POWER-ON RESET DEFAULTS

| Registers | | Default Register Data (Hexadecimal) | Power-up Default Register Description |
|-----------------------|---|-------------------------------------|--|
| Address (Hexadecimal) | Register Name | | |
| 0x00 | Capability | 0x00EF | Event output de-asserts in shutdown I ² C time out 25 ms to 35 ms. Accepts V_{HV} at A0 Pin 0.25°C Measurement Resolution Measures temperature below 0°C ±1°C accuracy over active range Temperature event output |
| 0x01 | CONFIG | 0x0000 | Comparator mode Active-Low output Event and critical output Output disabled Event not asserted Interrupt cleared Event limits unlocked Critical limit unlocked Continuous conversion 0°C Hysteresis |
| 0x02 | T _{UPPER} | 0x0000 | 0°C |
| 0x03 | T _{LOWER} | 0x0000 | 0°C |
| 0x04 | T _{CRIT} | 0x0000 | 0°C |
| 0x05 | T _A | 0x0000 | 0°C |
| 0x06 | Manufacturer ID | 0x0054 | 0x0054 (hex) |
| 0x07 | Device ID/ Device Revision for MCP98243 | 0x2101 | 0x2101 (hex) |
| 0x07 | Device ID/ Device Revision for MCP9843 | 0x0001 | 0x0001 (hex) |
| 0x08 | Resolution | 0x01 | 0x01 (hex) |

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NOTES:

6.0 APPLICATIONS INFORMATION

6.1 Layout Considerations

The MCP9843/98243 device does not require any additional components besides the master controller in order to measure temperature. However, it is recommended that a decoupling capacitor of 0.1 μF to 1 μF be used between the V_{DD} and GND pins. A high-frequency ceramic capacitor is recommended. It is necessary for the capacitor to be located as close as possible to the power and ground pins of the device in order to provide effective noise protection.

In addition, good PCB layout is key for better thermal conduction from the PCB temperature to the sensor die. For good temperature sensitivity, add a ground layer under the device pins as shown in [Figure 6-1](#).

6.2 Thermal Considerations

A potential for self-heating errors can exist if the MCP9843/98243 SDA, SCLK and Event lines are heavily loaded with pull-ups (high current). Typically, the self-heating error is negligible because of the relatively small current consumption of the MCP9843/98243. A temperature accuracy error of approximately 0.5°C could result from self-heating if the communication pins sink/source the maximum current specified.

For example, if the Event output is loaded to maximum I_{OL} , [Equation 6-1](#) can be used to determine the effect of self-heating.

EQUATION 6-1: EFFECT OF SELF-HEATING

$$T_{\Delta} = \theta_{\text{JA}}(V_{\text{DD}} \cdot I_{\text{DD}} + V_{\text{OL_Event}} \cdot I_{\text{OL_Event}} + V_{\text{OL_SDA}} \cdot I_{\text{OL_SDA}})$$

Where:

$$T_{\Delta} = T_{\text{J}} - T_{\text{A}}$$

T_{J} = Junction Temperature

T_{A} = Ambient Temperature

θ_{JA} = Package Thermal Resistance

$V_{\text{OL_Event, SDA}}$ = Event and SDA Output V_{OL}
(0.4 V_{max})

$I_{\text{OL_Event, SDA}}$ = Event and SDA Output I_{OL}
(3 mA_{max})

At room temperature ($T_{\text{A}} = +25^{\circ}\text{C}$) with maximum $I_{\text{DD}} = 500 \mu\text{A}$ and $V_{\text{DD}} = 3.6\text{V}$, the self-heating due to power dissipation T_{Δ} is 0.2°C for the DFN-8 package and 0.5°C for the TSSOP-8 package.



FIGURE 6-1: DFN Package Layout.

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NOTES:

7.0 PACKAGING INFORMATION

7.1 Package Marking Information

8-Lead 2x3x0.9 DFN



| Part Number | Code |
|-----------------|------|
| MCP9843-BE/MC | AGK |
| MCP9843T-BE/MC | AGK |
| MCP98243-BE/MC | ABZ |
| MCP98243T-BE/MC | ABZ |

Example:



8-Lead 2x3x0.75 TDFN



| Part Number | Code |
|------------------|------|
| MCP9843T-BE/MNY | AAK |
| MCP98243T-BE/MNY | AAG |

Example:



8-Lead 2x3x0.5 UDFN



| Part Number | Code |
|------------------|------|
| MCP98243T-BE/MUY | AAA |

Example:



8-Lead TSSOP



| Part Number | Code |
|-----------------|------|
| MCP9843-BE/ST | 05AB |
| MCP9843T-BE/ST | 05AB |
| MCP98243-BE/ST | 243B |
| MCP98243T-BE/ST | 243B |

Example:



Legend: XX...X Customer-specific information
 Y Year code (last digit of calendar year)
 YY Year code (last 2 digits of calendar year)
 WW Week code (week of January 1 is week '01')
 NNN Alphanumeric traceability code
 Ⓜ Pb-free JEDEC designator for Matte Tin (Sn)
 * This package is Pb-free. The Pb-free JEDEC designator (Ⓜ) can be found on the outer packaging for this package.

Note: In the event the full Microchip part number cannot be marked on one line, it will be carried over to the next line, thus limiting the number of available characters for customer-specific information.

MCP9843/98243

8-Lead Plastic Dual Flat, No Lead Package (MC) – 2x3x0.9 mm Body [DFN]

Note: For the most current package drawings, please see the Microchip Packaging Specification located at <http://www.microchip.com/packaging>



| Dimension Limits | Units | MILLIMETERS | | |
|------------------------|-------|-------------|------|------|
| | | MIN | NOM | MAX |
| Number of Pins | N | 8 | | |
| Pitch | e | 0.50 BSC | | |
| Overall Height | A | 0.80 | 0.90 | 1.00 |
| Standoff | A1 | 0.00 | 0.02 | 0.05 |
| Contact Thickness | A3 | 0.20 REF | | |
| Overall Length | D | 2.00 BSC | | |
| Overall Width | E | 3.00 BSC | | |
| Exposed Pad Length | D2 | 1.30 | – | 1.55 |
| Exposed Pad Width | E2 | 1.50 | – | 1.75 |
| Contact Width | b | 0.20 | 0.25 | 0.30 |
| Contact Length | L | 0.30 | 0.40 | 0.50 |
| Contact-to-Exposed Pad | K | 0.20 | – | – |

Notes:

- Pin 1 visual index feature may vary, but must be located within the hatched area.
- Package may have one or more exposed tie bars at ends.
- Package is saw singulated.
- Dimensioning and tolerancing per ASME Y14.5M.
 - BSC: Basic Dimension. Theoretically exact value shown without tolerances.
 - REF: Reference Dimension, usually without tolerance, for information purposes only.

Microchip Technology Drawing C04-123C

8-Lead Plastic Dual Flat, No Lead Package (MC) – 2x3x0.9 mm Body [DFN]

Note: For the most current package drawings, please see the Microchip Packaging Specification located at <http://www.microchip.com/packaging>



RECOMMENDED LAND PATTERN

| Dimension Limits | Units | MILLIMETERS | | |
|----------------------------|-------|-------------|-----|------|
| | | MIN | NOM | MAX |
| Contact Pitch | E | 0.50 BSC | | |
| Optional Center Pad Width | W2 | | | 1.45 |
| Optional Center Pad Length | T2 | | | 1.75 |
| Contact Pad Spacing | C1 | 2.90 | | |
| Contact Pad Width (X8) | X1 | | | 0.30 |
| Contact Pad Length (X8) | Y1 | | | 0.75 |
| Distance Between Pads | G | 0.20 | | |

Notes:

1. Dimensioning and tolerancing per ASME Y14.5M

BSC: Basic Dimension. Theoretically exact value shown without tolerances.

Microchip Technology Drawing No. C04-2123A

MCP9843/98243

8-Lead Plastic Dual Flat, No Lead Package (MN) – 2x3x0.75 mm Body [TDFN]

Note: For the most current package drawings, please see the Microchip Packaging Specification located at <http://www.microchip.com/packaging>



| Dimension Limits | Units | MILLIMETERS | | |
|------------------------|-------|-------------|------|------|
| | | MIN | NOM | MAX |
| Number of Pins | N | 8 | | |
| Pitch | e | 0.50 BSC | | |
| Overall Height | A | 0.70 | 0.75 | 0.80 |
| Standoff | A1 | 0.00 | 0.02 | 0.05 |
| Contact Thickness | A3 | 0.20 REF | | |
| Overall Length | D | 2.00 BSC | | |
| Overall Width | E | 3.00 BSC | | |
| Exposed Pad Length | D2 | 1.20 | - | 1.60 |
| Exposed Pad Width | E2 | 1.20 | - | 1.60 |
| Contact Width | b | 0.20 | 0.25 | 0.30 |
| Contact Length | L | 0.25 | 0.30 | 0.45 |
| Contact-to-Exposed Pad | K | 0.20 | - | - |

Notes:

- Pin 1 visual index feature may vary, but must be located within the hatched area.
- Package may have one or more exposed tie bars at ends.
- Package is saw singulated
- Dimensioning and tolerancing per ASME Y14.5M

BSC: Basic Dimension. Theoretically exact value shown without tolerances.

REF: Reference Dimension, usually without tolerance, for information purposes only.

Microchip Technology Drawing No. C04-129B

8-Lead Plastic Dual Flat, No Lead Package (MN) – 2x3x0.75 mm Body [TDFN]

Note: For the most current package drawings, please see the Microchip Packaging Specification located at <http://www.microchip.com/packaging>



RECOMMENDED LAND PATTERN

| Dimension Limits | Units | MILLIMETERS | | |
|----------------------------|-------|-------------|------|------|
| | | MIN | NOM | MAX |
| Contact Pitch | E | 0.50 BSC | | |
| Optional Center Pad Width | W2 | | | 1.46 |
| Optional Center Pad Length | T2 | | | 1.36 |
| Contact Pad Spacing | C1 | | 3.00 | |
| Contact Pad Width (X8) | X1 | | | 0.30 |
| Contact Pad Length (X8) | Y1 | | | 0.75 |
| Distance Between Pads | G | 0.20 | | |

Notes:

1. Dimensioning and tolerancing per ASME Y14.5M

BSC: Basic Dimension. Theoretically exact value shown without tolerances.

Microchip Technology Drawing No. C04-2129A

MCP9843/98243

8-Lead Plastic Dual Flat, No Lead Package (MU) – 2x3x0.5 mm Body [UDFN]

Note: For the most current package drawings, please see the Microchip Packaging Specification located at <http://www.microchip.com/packaging>



| Units | | MILLIMETERS | | |
|------------------------|----|-------------|------|------|
| Dimension Limits | | MIN | NOM | MAX |
| Number of Pins | N | 8 | | |
| Pitch | e | 0.50 BSC | | |
| Overall Height | A | 0.45 | 0.50 | 0.55 |
| Standoff | A1 | | | 0.07 |
| Contact Thickness | A3 | 0.127 REF | | |
| Overall Length | D | 1.95 | 2.00 | 2.05 |
| Overall Width | E | 2.95 | 3.00 | 3.05 |
| Exposed Pad Length | D2 | 1.30 | 1.40 | 1.50 |
| Exposed Pad Width | E2 | 1.20 | 1.30 | 1.40 |
| Contact Width | b | 0.20 | 0.25 | 0.30 |
| Contact Length | L | 0.25 | 0.30 | 0.35 |
| Contact-to-Exposed Pad | K | 0.55 REF | | |

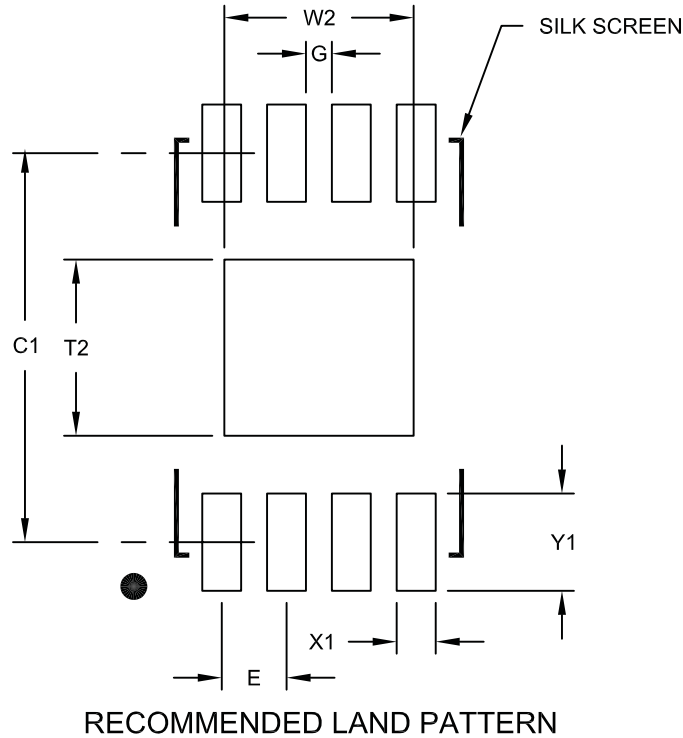
Notes:

1. Pin 1 visual index feature may vary, but must be located within the hatched area.
2. Package may have one or more exposed tie bars at ends.
3. Package is saw singulated
4. Dimensioning and tolerancing per ASME Y14.5M
 - BSC: Basic Dimension. Theoretically exact value shown without tolerances.
 - REF: Reference Dimension, usually without tolerance, for information purposes only.

Microchip Technology Drawing No. C04-136B

8-Lead Plastic Dual Flat, No Lead Package (MU) – 2x3x0.5 mm Body [UDFN]

Note: For the most current package drawings, please see the Microchip Packaging Specification located at <http://www.microchip.com/packaging>



| Dimension Limits | Units | MILLIMETERS | | |
|----------------------------|-------|-------------|------|------|
| | | MIN | NOM | MAX |
| Contact Pitch | E | 0.50 BSC | | |
| Optional Center Pad Width | W2 | | | 1.46 |
| Optional Center Pad Length | T2 | | | 1.36 |
| Contact Pad Spacing | C1 | | 3.00 | |
| Contact Pad Width (X8) | X1 | | | 0.30 |
| Contact Pad Length (X8) | Y1 | | | 0.75 |
| Distance Between Pads | G | 0.20 | | |

Notes:

1. Dimensioning and tolerancing per ASME Y14.5M

BSC: Basic Dimension. Theoretically exact value shown without tolerances.

Microchip Technology Drawing No. C04-2136A

MCP9843/98243

8-Lead Plastic Thin Shrink Small Outline (ST) – 4.4 mm Body [TSSOP]

Note: For the most current package drawings, please see the Microchip Packaging Specification located at <http://www.microchip.com/packaging>



| Dimension Limits | Units | MILLIMETERS | | |
|--------------------------|--------|-------------|------|------|
| | | MIN | NOM | MAX |
| Number of Pins | N | 8 | | |
| Pitch | e | 0.65 BSC | | |
| Overall Height | A | – | – | 1.20 |
| Molded Package Thickness | A2 | 0.80 | 1.00 | 1.05 |
| Standoff | A1 | 0.05 | – | 0.15 |
| Overall Width | E | 6.40 BSC | | |
| Molded Package Width | E1 | 4.30 | 4.40 | 4.50 |
| Molded Package Length | D | 2.90 | 3.00 | 3.10 |
| Foot Length | L | 0.45 | 0.60 | 0.75 |
| Footprint | L1 | 1.00 REF | | |
| Foot Angle | ϕ | 0° | – | 8° |
| Lead Thickness | c | 0.09 | – | 0.20 |
| Lead Width | b | 0.19 | – | 0.30 |

Notes:

- Pin 1 visual index feature may vary, but must be located within the hatched area.
- Dimensions D and $E1$ do not include mold flash or protrusions. Mold flash or protrusions shall not exceed 0.15 mm per side.
- Dimensioning and tolerancing per ASME Y14.5M.
 - BSC: Basic Dimension. Theoretically exact value shown without tolerances.
 - REF: Reference Dimension, usually without tolerance, for information purposes only.

Microchip Technology Drawing C04-086B

8-Lead Plastic Thin Shrink Small Outline (ST) - 4.4 mm Body [TSSOP]

Note: For the most current package drawings, please see the Microchip Packaging Specification located at <http://www.microchip.com/packaging>



RECOMMENDED LAND PATTERN

| | | Units | MILLIMETERS | | |
|--------------------------|----|------------------|-------------|----------|------|
| | | Dimension Limits | MIN | NOM | MAX |
| Contact Pitch | E | | | 0.65 BSC | |
| Contact Pad Spacing | C1 | | | 5.90 | |
| Contact Pad Width (X28) | X1 | | | | 0.45 |
| Contact Pad Length (X28) | Y1 | | | | 1.45 |
| Distance Between Pads | G | 0.20 | | | |

Notes:

1. Dimensioning and tolerancing per ASME Y14.5M

BSC: Basic Dimension. Theoretically exact value shown without tolerances.

Microchip Technology Drawing No. C04-2086A

MCP9843/98243

NOTES:

APPENDIX A: REVISION HISTORY

Revision C (November 2009)

The following is the list of modifications:

1. Added the MCP9843 temperature sensor and updated all specification and description sections to include this device.
2. Updated [Table 5-1](#) and [Table 5-6](#) with information on the MCP9843 device.
3. Added [Register 5-8](#) for MCP9843 device.
4. Updated [Section 7.1 “Package Marking Information”](#).

Revision B (October 2009)

The following is the list of modifications:

1. Added MCP98243 vs MCP98242 comparison table.
2. Added EEPROM Write temperature Range.
3. Changed I²C time out minimum specification to 25 ms.
4. Replaced [Figure 2-5](#).
5. Updated bits 7 and 6 of [Register 5-2: Capability Register](#).
6. Updated Device/Revision ID register.
7. Updated Functional Block Diagram ([Figure 5-1](#)).
8. Updated [Section 5.2.3.1 “Comparator Mode”](#) and [Section 5.2.3.2 “Interrupt Mode”](#).
9. Updated [Figure 5-13](#).
10. Updated package marking drawings.

Revision A (May 2009)

- Original Release of this Document.

MCP9843/98243

NOTES:

PRODUCT IDENTIFICATION SYSTEM

To order or obtain information, e.g., on pricing or delivery, refer to the factory or the listed sales office.

| <u>PART NO.</u> | <u>-X</u> | <u>X</u> | <u>/XXX</u> | Examples: |
|--------------------|-----------|---|---|---|
| Device | Grade | Temperature Range | Package | |
| Device: | | | | |
| | | MCP9843: Digital Temperature Sensor | | a) MCP9843-BE/MC: Extended Temp., 8LD DFN pkg. |
| | | MCP9843T: Digital Temperature Sensor (Tape and Reel) | | b) MCP9843T-BE/MC: Tape and Reel, Extended Temp., 8LD DFN pkg. |
| | | MCP98243: Digital Temp. Sensor + 2k bit EEPROM | | c) MCP9843-BE/ST: Extended Temp., 8LD TSSOP pkg. |
| | | MCP98243T: Digital Temp. Sensor + 2k bit EEPROM (Tape and Reel) | | d) MCP9843T-BE/ST: Tape and Reel, Extended Temp., 8LD TSSOP pkg. |
| Grade: | B | = ±1°C (max.) from +75°C to +95°C, ±2°C (max.) from +40°C to +125°C, and ±3°C (max.) from -20°C to +125°C | | e) MCP9843T-BE/MNY: Tape and Reel, Extended Temp., 8LD TDFN (nickel palladium gold) pkg. |
| Temperature Range: | E | = -40°C to +125°C | | |
| Package: | | | MC = Dual Flat No Lead (2x3x0.9 mm Body), 8-lead, | a) MCP98243-BE/MC: Extended Temp., 8LD DFN pkg. |
| | | | MNY * = Dual Flat No Lead (2x3x0.75 mm Body), 8-lead (Tape and Reel) | b) MCP98243T-BE/MC: Tape and Reel, Extended Temp., 8LD DFN pkg. |
| | | | MUY * = Dual Flat No Lead (2x3x0.5 mm Body), 8-lead (Tape and Reel) | c) MCP98243-BE/ST: Extended Temp., 8LD TSSOP pkg. |
| | | | ST = Plastic Thin Shrink Small Outline (4x4 mm Body), 8-lead | d) MCP98243T-BE/ST: Tape and Reel, Extended Temp., 8LD TSSOP pkg. |
| | | | * Y = nickel palladium gold manufacturing designator. Only available on the TDFN and UDFN packages. | e) MCP98243T-BE/MNY: Tape and Reel, Extended Temp., 8LD TDFN (nickel palladium gold) pkg. |
| | | | | f) MCP98243T-BE/MUY: Tape and Reel, Extended Temp., 8LD UDFN (nickel palladium gold) pkg. |

MCP9843/98243

NOTES:

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Разъемы специального, военного и аэрокосмического назначения:

(Применяются в военной, авиационной, аэрокосмической, морской, железнодорожной, горно- и нефтедобывающей отраслях промышленности)

«FORSTAR» (основан в 1998 г.)

ВЧ соединители, коаксиальные кабели, кабельные сборки и микроволновые компоненты:

(Применяются в телекоммуникациях гражданского и специального назначения, в средствах связи, РЛС, а так же военной, авиационной и аэрокосмической отраслях промышленности).



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