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## ±1°C Accurate, 1.8V Digital Temperature Sensor

### Features:

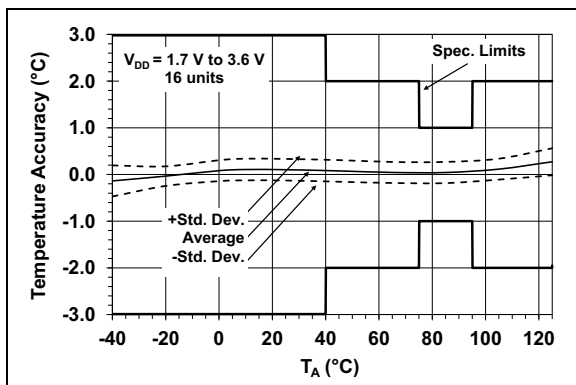
- 1MHz, 2-Wire I<sup>2</sup>C™ Interface
- User-Selectable Measurement Resolution:
  - +0.5°C, +0.25°C, +0.125°C, +0.0625°C
- User-Programmable Temperature Limits:
  - Temperature Window Limit
  - Critical Temperature Limit
- User-Programmable Temperature Alert Output
- Specified V<sub>DD</sub> Range: 1.7V to 3.6V
- Operating Current: 100 µA (typical)
- Available Package: 8-Pin TDFN

### Temperature Sensor Features:

- Temperature-to-Digital Converter (°C)
- Sensor Accuracy:
  - ±0.2°C/±1°C (typ./max.) → +75°C to +95°C
  - ±0.5°C/±2°C (typ./max.) → +40°C to +125°C
  - ±1°C/±3°C (typ./max.) → -40°C to +125°C

### Typical Applications:

- Temperature Sensing for Solid State Drive (SSD)
- General Purpose Temperature Datalog
- General Purpose
- Industrial Applications
- Industrial Freezers and Refrigerators
- Food Processing
- Personal Computers and Servers
- PC Peripherals
- Consumer Electronics
- Handheld/Portable Devices



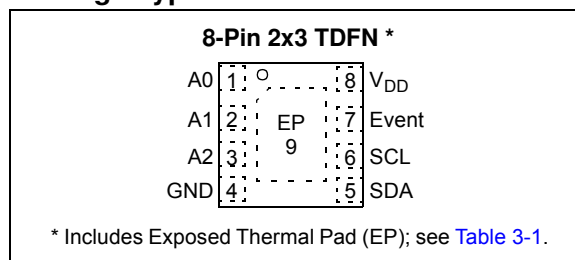
### Description:

Microchip Technology Inc.'s MCP9844 digital temperature sensor converts temperature from -40°C to +125°C to a digital word. It provides an accuracy of ±0.2°C/±1°C (typical/maximum) from +75°C to +95°C with an operating voltage of 1.7V to 3.6V.

The MCP9844 digital temperature sensor comes with user-programmable registers that provide flexibility for 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 MCP9844 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 the thermostat operation, or as a temperature event interrupt output for microprocessor-based systems.

This sensor has an industry standard I<sup>2</sup>C Fast Mode Plus compatible 1 MHz serial interface.

### Package Types



# MCP9844

## 1.0 ELECTRICAL CHARACTERISTICS

### Absolute Maximum Ratings †

V <sub>DD</sub> .....	4.0V
Voltage at all Input/Output pins .....	GND – 0.3V to 4.0V
Pin A0.....	GND – 0.3V to 11V
Storage temperature .....	-65°C to +150°C
Ambient temp. with power applied .....	-40°C to +125°C
Junction Temperature (T <sub>J</sub> ).....	+150°C
ESD protection on all pins (HBM:MM) .....	(4 kV:200V)
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<sub>DD</sub> = 1.7V to 3.6V, GND = Ground, and T<sub>A</sub> = -40°C to +125°C.

Parameters	Sym.	Min.	Typ.	Max.	Unit	Conditions
<b>Temperature Sensor Accuracy</b>						
+75°C < T <sub>A</sub> ≤ +95°C	T <sub>ACY</sub>	-1.0	±0.2	+1.0	°C	V <sub>DD</sub> = 1.8V
+40°C < T <sub>A</sub> ≤ +125°C		-2.0	±0.5	+2.0	°C	
-40°C < T <sub>A</sub> ≤ +125°C		-3.0	±1	+3.0	°C	
<b>Temperature Conversion Time</b>						
0.5°C/bit	t <sub>CONV</sub>	—	30	—	ms	15 s/sec (typical) (See <a href="#">Section 5.2.4</a> )
0.25°C/bit (POR default)		—	65	125	ms	
0.125°C/bit		—	130	—	ms	
0.0625°C/bit		—	260	—	ms	
<b>Power Supply</b>						
Specified Voltage Range	V <sub>DD</sub>	1.7	—	3.6	V	
Operating Current	I <sub>DD</sub>	—	100	500	µA	
Shutdown Current	I <sub>SHDN</sub>	—	0.2	1	µA	T <sub>A</sub> = 85°C
Power On Reset (POR)	V <sub>POR</sub>	—	1.4	1.6	V	Threshold for falling V <sub>DD</sub> voltage
Settling time after POR	t <sub>POR</sub>	—	—	1	ms	For warm and cold power cycles
Line Regulation	Δ°C	—	0.2	—	°C	V <sub>DD</sub> = 1.7V to 3.6V
<b>Event Output (Open-Drain output, external pull-up resistor required), see <a href="#">Section 5.2.3</a></b>						
High-level Current (leakage)	I <sub>OH</sub>	—	—	1	µA	V <sub>OH</sub> = V <sub>DD</sub>
Low-level Voltage	V <sub>OL</sub>	—	—	0.4	V	I <sub>OL</sub> = 3 mA (Active-Low, Pull-up Resistor)
<b>Thermal Response, from +25°C (Air) to +125°C (oil bath)</b>						
TDFN-8	t <sub>RES</sub>	—	0.7	—	s	Time to 63% (89°C)

## INPUT/OUTPUT PIN DC CHARACTERISTICS

<b>Electrical Specifications:</b> Unless otherwise indicated, $V_{DD} = 1.7V$ to $3.6V$ , GND = Ground and $T_A = -40^{\circ}C$ to $+125^{\circ}C$ .						
Parameters	Sym.	Min.	Typ.	Max.	Units	Conditions
Serial Input/Output (SCL, SDA, A0, A1, A2)						
<b>Input</b>						
High-level Voltage	$V_{IH}$	$0.7V_{DD}$	—	—	V	
Low-level Voltage	$V_{IL}$	—	—	$0.3V_{DD}$	V	
Input Current	$I_{IN}$	—	—	$\pm 5$	$\mu A$	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	—	$k\Omega$	$V_{IN} < V_{IL}$
<b>Output (SDA only)</b>						
Low-level Voltage	$V_{OL}$	—	—	0.4	V	$I_{OL} = 3\text{ mA}$
High-level Current (leakage)	$I_{OH}$	—	—	1	$\mu A$	$V_{OH} = V_{DD}$
Low-level Current	$I_{OL}$	20	—	—	$\text{mA}$	$V_{OL} = 0.4V, V_{DD} \geq 2.2V$
		6	—	—	$\text{mA}$	$V_{OL} = 0.6V$
Capacitance	$C_{IN}$	—	5	—	$\text{pF}$	
SDA and SCL Inputs						
Hysteresis	$V_{HYST}$	—	$0.05V_{DD}$	—	V	
Spike Suppression	$T_{SP}$	—	—	50	ns	

## TEMPERATURE CHARACTERISTICS

<b>Electrical Specifications:</b> Unless otherwise indicated, $V_{DD} = 1.7V$ to $3.6V$ , GND = Ground, and $T_A = -40^{\circ}C$ to $+125^{\circ}C$ .						
Parameters	Sym.	Min.	Typ.	Max.	Units	Conditions
<b>Temperature Ranges</b>						
Specified Temperature Range	$T_A$	-40	—	+125	$^{\circ}C$	Note 1
Operating Temperature Range	$T_A$	-40	—	+125	$^{\circ}C$	
Storage Temperature Range	$T_A$	-65	—	+150	$^{\circ}C$	
<b>Thermal Package Resistances</b>						
Thermal Resistance, 8L-TDFN	$\theta_{JA}$	—	52.5	—	$^{\circ}C/W$	

**Note 1:** Operation in this range must not cause  $T_J$  to exceed Maximum Junction Temperature ( $+150^{\circ}C$ ).

# MCP9844

## SERIAL INTERFACE TIMING SPECIFICATIONS

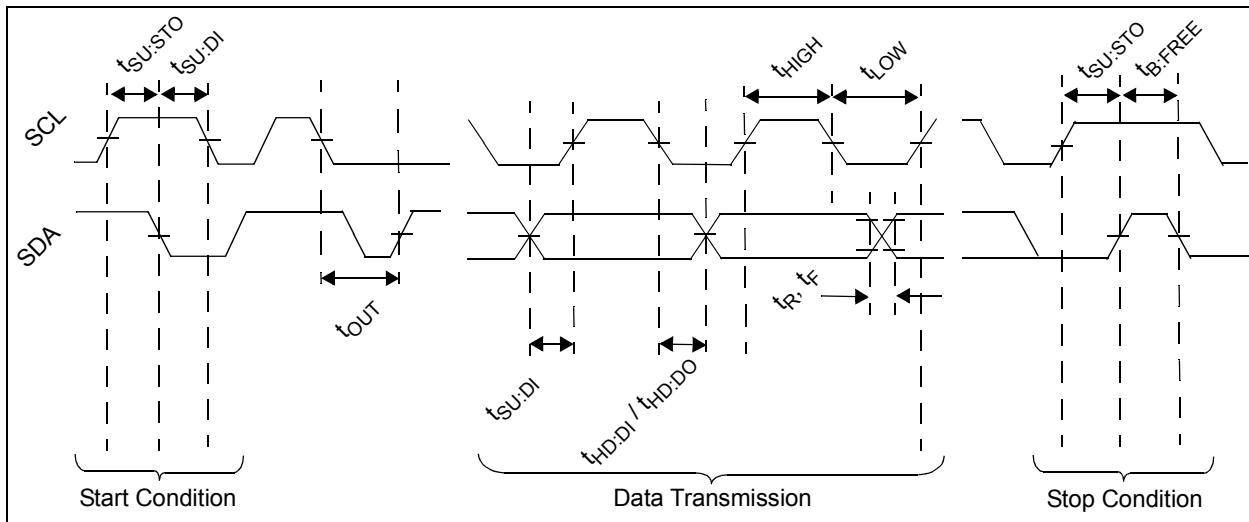
**Electrical Specifications:** Unless otherwise indicated, GND = Ground,  $T_A = -40^\circ\text{C}$  to  $+125^\circ\text{C}$ , and  $C_L = 80\text{ pF}$   
**Note 1.**

Parameters	Sym.	$V_{DD} = 1.7\text{V to }3.6\text{V}$				$V_{DD} = 2.2\text{V to }3.6\text{V}$		Units
		100 kHz		400 kHz		1000 kHz		
		Min.	Max.	Min.	Max.	Min.	Max.	
<b>2-Wire I<sup>2</sup>C™ Interface</b>								
Serial port frequency (Note 2, 4)	$f_{SCL}$	10	100	10	400	10	1000	kHz
Low Clock (Note 2)	$t_{LOW}$	4700	—	1300	—	500	—	ns
High Clock	$t_{HIGH}$	4000	—	600	—	260	—	ns
Rise time (Note 5)	$t_R$	—	1000	20	300	—	120	ns
Fall time (Note 5)	$t_F$	20	300	20	300	—	120	ns
Data in Setup time (Note 3)	$t_{SU:DAT}$	250	—	100	—	50	—	ns
Data in Hold time (Note 6)	$t_{HD:DI}$	0	—	0	—	0	—	ns
Data out Hold time (Note 4)	$t_{HD:DO}$	200	900	200	900	0	350	ns
Start Condition Setup time	$t_{SU:STA}$	4700	—	600	—	260	—	ns
Start Condition Hold time	$t_{HD:STA}$	4000	—	600	—	260	—	ns
Stop Condition Setup time	$t_{SU:STO}$	4000	—	600	—	260	—	ns
Bus Idle/Free	$t_{B-FREE}$	4700	—	1300	—	500	—	ns
Time out	$t_{OUT}$	25	35	25	35	25	35	ms
Bus Capacitive load	$C_b$	—	—	—	400	—	100	pf

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

- If  $t_{LOW} > t_{OUT}$ , the temperature sensor I<sup>2</sup>C interface will time out. A Repeat Start command is required for communication.
- This device can be used in a Standard mode I<sup>2</sup>C bus system, but the requirement  $t_{SU:DAT} \geq 250\text{ ns}$  must be met. This device does not stretch SCL Low period. It outputs the next data bit to the SDA line within  $t_R\text{ MAX} + t_{SU:DAT\text{ MIN}} = 1000\text{ ns} + 250\text{ ns} = 1250\text{ ns}$  (according to the Standard mode I<sup>2</sup>C bus specification) before the SCL line is released.
- As a transmitter, the device provides internal minimum delay time  $t_{HD:DAT\text{ MIN}}$  to bridge the undefined region (min. 200 ns) of the falling edge of SCL  $t_F\text{ MAX}$  to avoid unintended generation of Start or Stop conditions.
- Characterized but not production tested.
- 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.

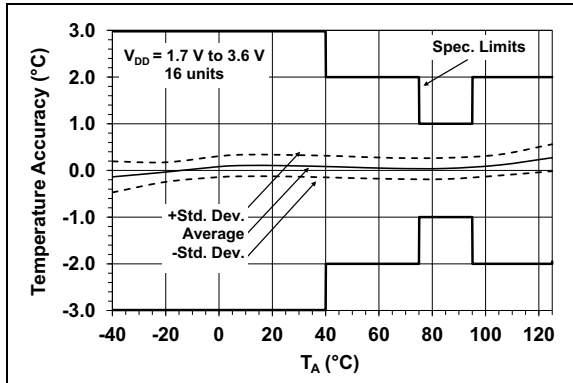
## TIMING DIAGRAM



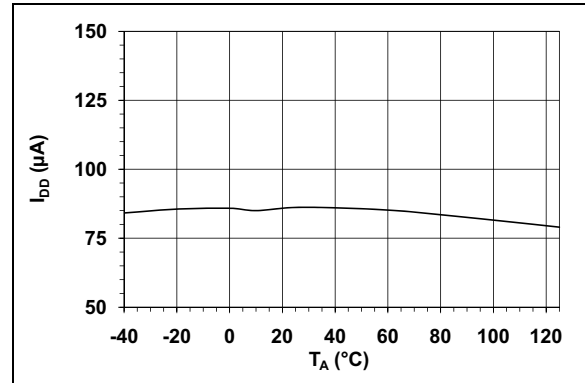
## 2.0 TYPICAL PERFORMANCE CURVES

**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.

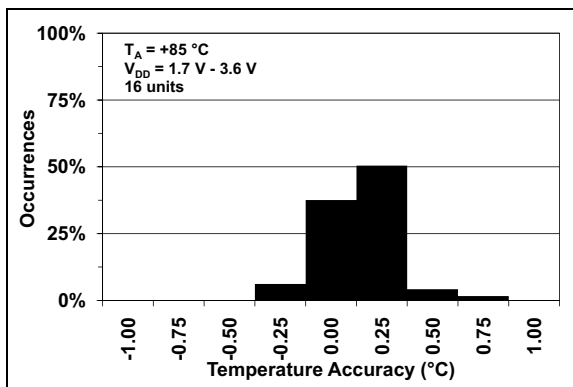
**Note:** Unless otherwise indicated,  $V_{DD} = 1.7V$  to  $3.6V$ , GND = Ground, SDA/SCL pulled-up to  $V_{DD}$ , and  $T_A = -40^{\circ}C$  to  $+125^{\circ}C$ .



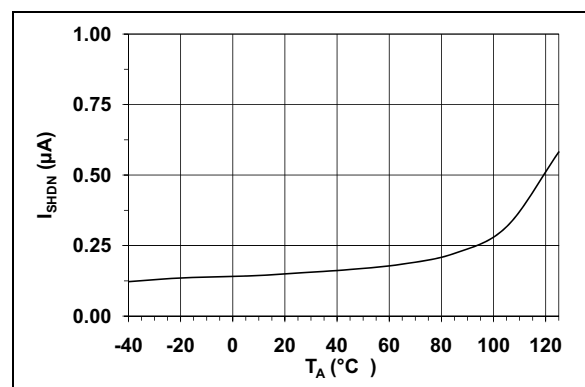
**FIGURE 2-1:** Temperature Accuracy.



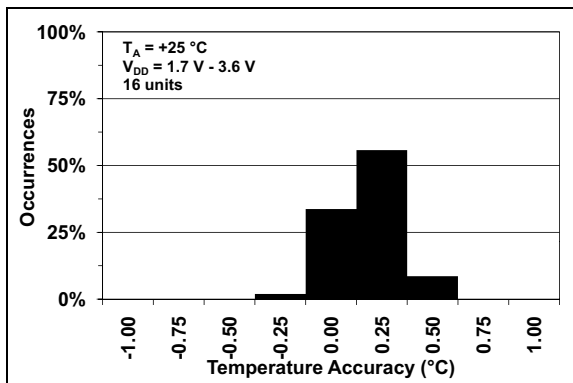
**FIGURE 2-4:** Supply Current Vs. Temperature.



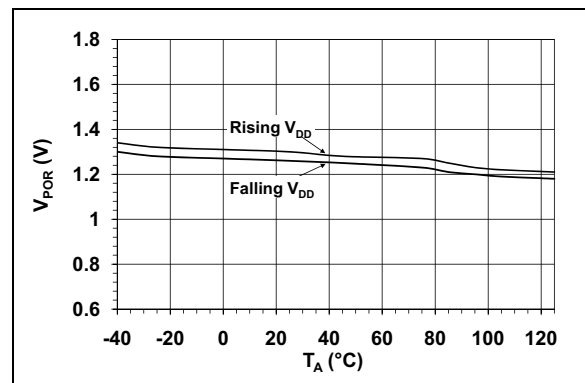
**FIGURE 2-2:** Temperature Accuracy Histogram,  $T_A = +85^{\circ}C$ .



**FIGURE 2-5:** Shutdown Current Vs. Temperature.



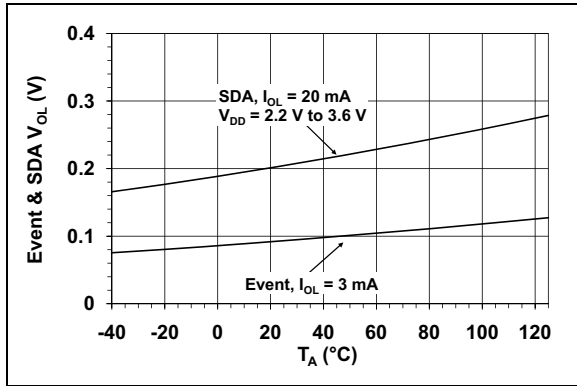
**FIGURE 2-3:** Temperature Accuracy Histogram,  $T_A = +25^{\circ}C$ .



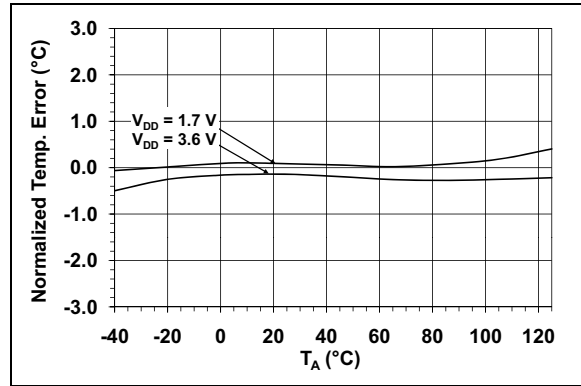
**FIGURE 2-6:** Power-On Reset Threshold Voltage Vs. Temperature.

# MCP9844

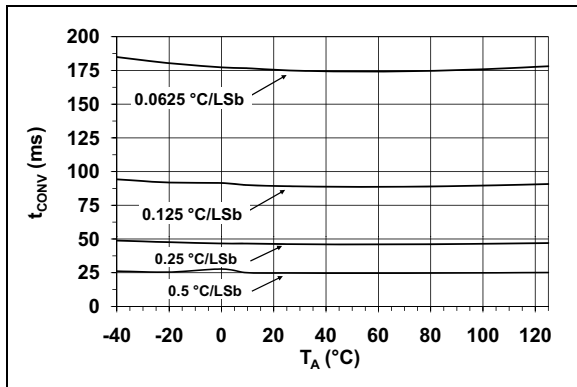
**Note:** Unless otherwise indicated,  $V_{DD} = 1.7\text{V}$  to  $3.6\text{V}$ , GND = Ground, SDA/SCL pulled-up to  $V_{DD}$ , and  $T_A = -40^\circ\text{C}$  to  $+125^\circ\text{C}$ .



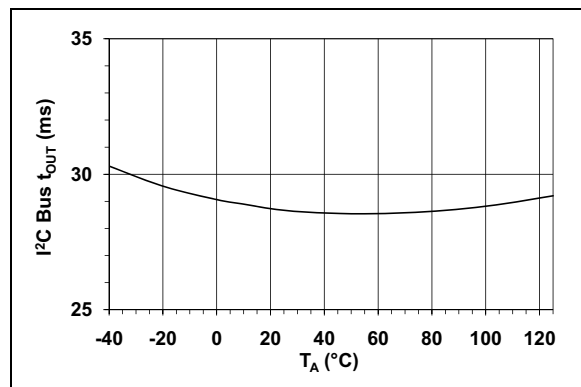
**FIGURE 2-7:** Event Output and SDA  $V_{OL}$  Vs. Temperature.



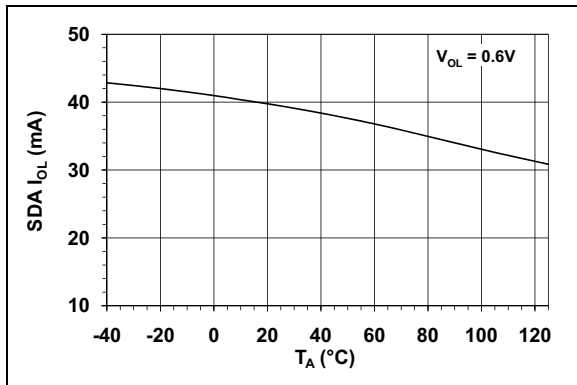
**FIGURE 2-10:** Line Regulation: Change in Temperature Accuracy Vs. Change in  $V_{DD}$ .



**FIGURE 2-8:** Temperature Conversion Rate Vs. Temperature.



**FIGURE 2-11:**  $I^2C^{\text{TM}}$  Protocol Time-out Vs. Temperature.



**FIGURE 2-9:** SDA  $I_{OL}$  Vs. Temperature.

## 3.0 PIN DESCRIPTION

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

**TABLE 3-1: PIN FUNCTION TABLES**

MCP9844	Symbol	Description
TDFN		
1	A0	Slave Address
2	A1	Slave Address
3	A2	Slave Address
4	GND	Ground
5	SDA	Serial Data Line
6	SCL	Serial Clock Line
7	Event	Temperature Alert Output
8	V <sub>DD</sub>	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 the address bits. The Most Significant bits (MSb) are A6, A5, A4, A3. Refer to [Table 3-2](#).

**TABLE 3-2: MCP9844 ADDRESS BYTE**

Device	Address Code				Slave Address		
	A6	A5	A4	A3	A2	A1	A0
Sensor	0	0	1	1	x <sup>1</sup>	x <sup>1</sup>	x <sup>1</sup>

**Note 1:** User-selectable address is shown by X, where X is '1' or '0' for V<sub>DD</sub> and GND, respectively

All address pins have an internal pull-down resistor.

### 3.2 Ground Pin (GND)

The GND pin is the system ground pin.

### 3.3 Serial Data Line (SDA)

The 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 MCP9844 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<sub>DD</sub>)

V<sub>DD</sub> 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.



# MCP9844

## 4.0 SERIAL COMMUNICATION

### 4.1 2-Wire Standard Mode I<sup>2</sup>C™ Protocol-Compatible Interface

The MCP9844 serial clock input (SCL) and the bidirectional serial data line (SDA) form a 2-wire bidirectional Standard mode I<sup>2</sup>C compatible communication port (refer to the [Input/Output Pin DC Characteristics](#) table and the [Serial Interface Timing Specifications](#) table).

The following MCP9844 bus protocol is defined in [Table 4-1](#).

**TABLE 4-1: MCP9844 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 MCP9844.
Transmitter	Device sending data to the bus.
Receiver	Device receiving data from the bus.
START	A unique signal from the 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 MCP9844 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 MCP9844 retains 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 MCP9844 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.

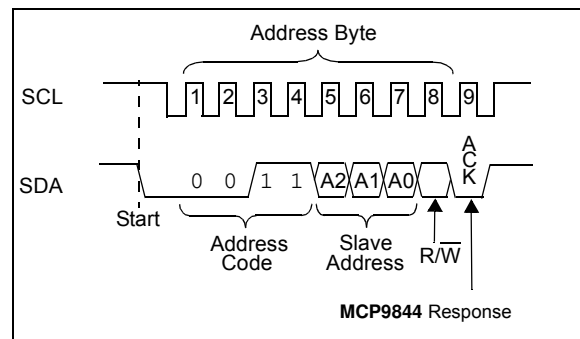
#### 4.1.3 START/STOP CONDITION

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 MCP9844 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 MCP9844. The address for the MCP9844 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<sub>DD</sub> '1' or GND '0'. The 7-bit address transmitted in the serial bit stream must match the selected address for the MCP9844 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.**

## 4.1.5 DATA VALID

After the Start condition, each bit of data in the transmission needs to be settled for a time specified by  $t_{\text{SU-DATA}}$  before SCL toggles from low-to-high (see [Serial Interface Timing Specifications](#) table).

## 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  $t_{\text{SU-DATA}}$  before the low-to-high transition of SCL from the master. SDA also needs to remain pulled down for  $t_{\text{H-DATA}}$  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 ( $T_{\text{OUT}}$ )

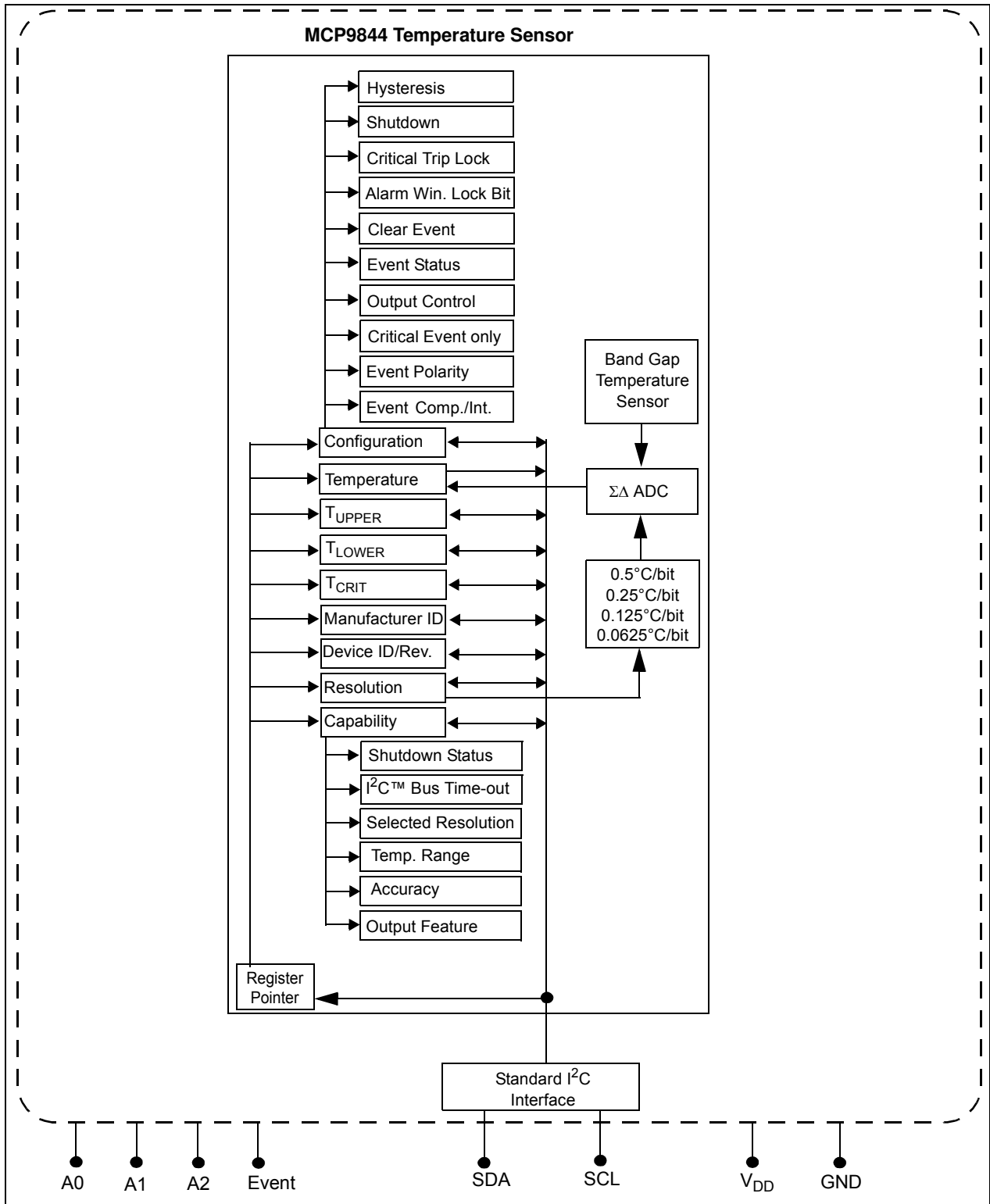
If the SCL stays low or high for time specified by  $t_{\text{OUT}}$ , the MCP9844 resets the serial interface. This dictates the minimum clock speed as specified in the specification.

# MCP9844

## 5.0 FUNCTIONAL DESCRIPTION

The MCP9844 temperature sensors consist of a band gap type temperature sensor, a Delta-Sigma Analog-to-Digital Converter ( $\Sigma\Delta$  ADC), user-programmable

registers and a 2-wire I<sup>2</sup>C protocol compatible serial interface. Figure 5-1 shows a block diagram of the register structure.



**FIGURE 5-1:** Functional Block Diagram.

## 5.1 Registers

The MCP9844 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 and is 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 MCP9844 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 MCP9844’s capability in measurement resolution, measurement range and device accuracy. The device Configuration register provides access to configure the MCP9844’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 MCP9844 using the serial interface. This is an 8-bit write-only pointer. [Register 5-1](#) describes the pointer or the address of each register. This device will not acknowledge commands to register pointers other than those listed in [Register 5-1](#).

### 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 =	Reserved
1001 =	Resolution register
1XXX =	Unused (The device will not acknowledge commands to other pointer locations.)

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**TABLE 5-1: BIT ASSIGNMENT SUMMARY FOR ALL TEMPERATURE SENSOR REGISTERS  
(SEE SECTION 5.3)**

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	1	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	$2^7\text{°C}$	$2^6\text{°C}$	$2^5\text{°C}$	$2^4\text{°C}$
	LSB	$2^3\text{°C}$	$2^2\text{°C}$	$2^1\text{°C}$	$2^0\text{°C}$	$2^{-1}\text{°C}$	$2^{-2}\text{°C}$	0	0
0x03	MSB	0	0	0	SIGN	$2^7\text{°C}$	$2^6\text{°C}$	$2^5\text{°C}$	$2^4\text{°C}$
	LSB	$2^3\text{°C}$	$2^2\text{°C}$	$2^1\text{°C}$	$2^0\text{°C}$	$2^{-1}\text{°C}$	$2^{-2}\text{°C}$	0	0
0x04	MSB	0	0	0	SIGN	$2^7\text{°C}$	$2^6\text{°C}$	$2^5\text{°C}$	$2^4\text{°C}$
	LSB	$2^3\text{°C}$	$2^2\text{°C}$	$2^1\text{°C}$	$2^0\text{°C}$	$2^{-1}\text{°C}$	$2^{-2}\text{°C}$	0	0
0x05	MSB	$T_A \geq T_{CRIT}$	$T_A > T_{UPPER}$	$T_A < T_{LOWER}$	SIGN	$2^7\text{°C}$	$2^6\text{°C}$	$2^5\text{°C}$	$2^4\text{°C}$
	LSB	$2^3\text{°C}$	$2^2\text{°C}$	$2^1\text{°C}$	$2^0\text{°C}$	$2^{-1}\text{°C}$	$2^{-2}\text{°C}$	$2^{-3}\text{°C}$	$2^{-4}\text{°C}$
0x06	MSB	0	0	0	0	0	0	0	0
	LSB	0	1	0	1	0	1	0	0
0x07	MSB	0	0	0	0	0	1	1	0
	LSB	0	0	0	0	0	0	0	1
0x08	MSB	0	0	0	0	0	1	1	0
	LSB	0	0	0	0	0	0	0	1
0x09	MSB	0	0	0	0	0	0	0	0
	LSB	0	0	0	0	0	0	Resolution	

## 5.1.1 CAPABILITY REGISTER

This is a read-only register used to identify the temperature sensor capability. For example, the MCP9844 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 <sub>OUT</sub> Range	—	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 deasserts during shutdown. After shutdown, it takes t<sub>CONV</sub> to reassert the event output (power-up default)

bit 6      **I<sup>2</sup>C™ Bus Time-Out (t<sub>OUT</sub> 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      **Unimplemented:** Read as '1'

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):**

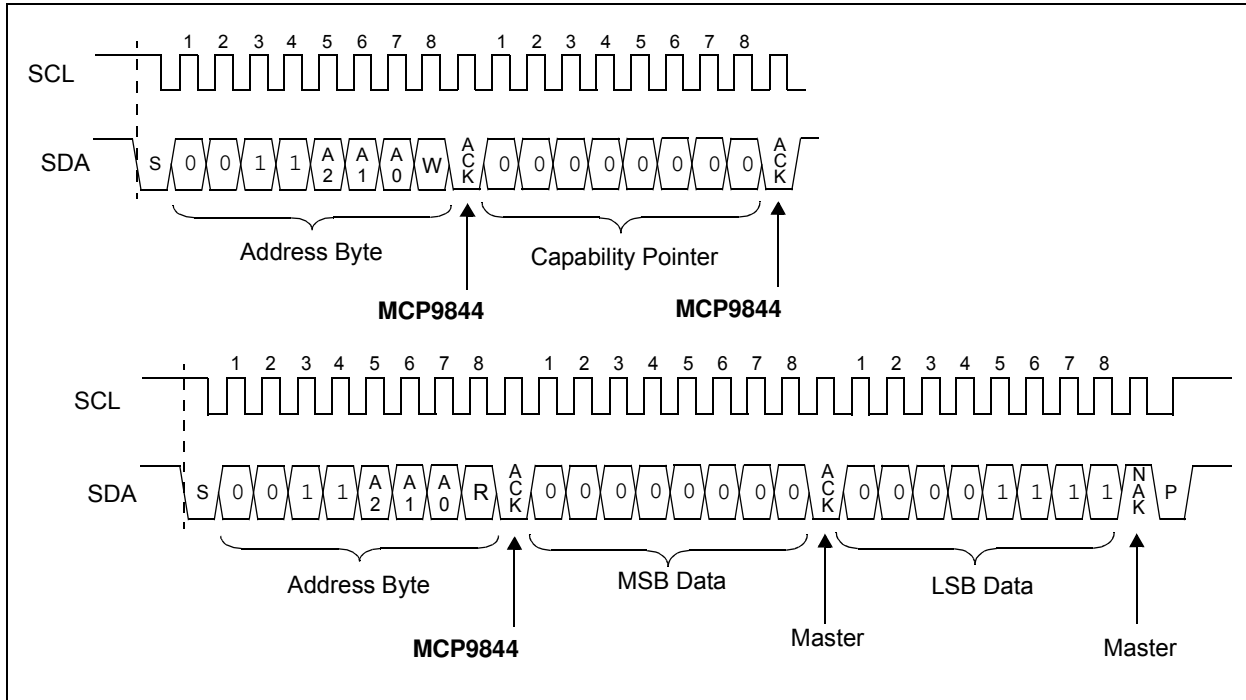
0 = T<sub>A</sub> = 0 (decimal) for temperature below 0°C

1 = The part can measure temperature below 0°C (power-up default)

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## 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<sub>UPPER</sub>/T<sub>LOWER</sub>/T<sub>CRIT</sub> 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”](#)).

## 5.1.2 SENSOR CONFIGURATION REGISTER (CONFIG)

The MCP9844 device has a 16-bit Configuration register (CONFIG) that allows the user to set various functions for a robust temperature monitoring system. Bits 10 through 0 are used to select the event output boundary hysteresis, device Shutdown or Low-Power mode, temperature boundary and critical temperature lock, and 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 through 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 deassert.

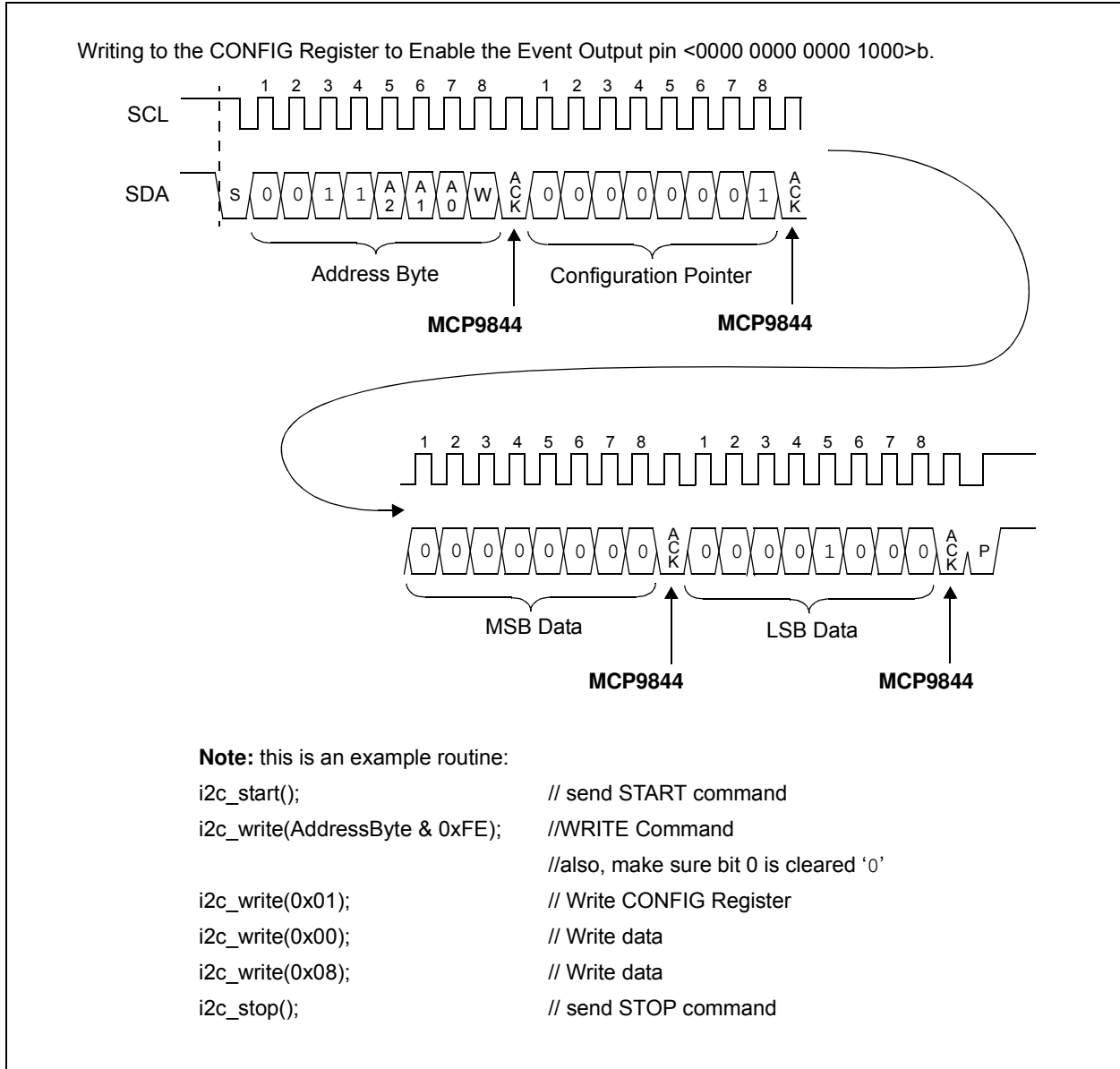
This bit cannot be set '1' when either of the lock bits is set (bit 6 and bit 7). However, it can be cleared '0' for Continuous Conversion while locked (Refer to [Section 5.2.1 “Shutdown Mode”](#)).



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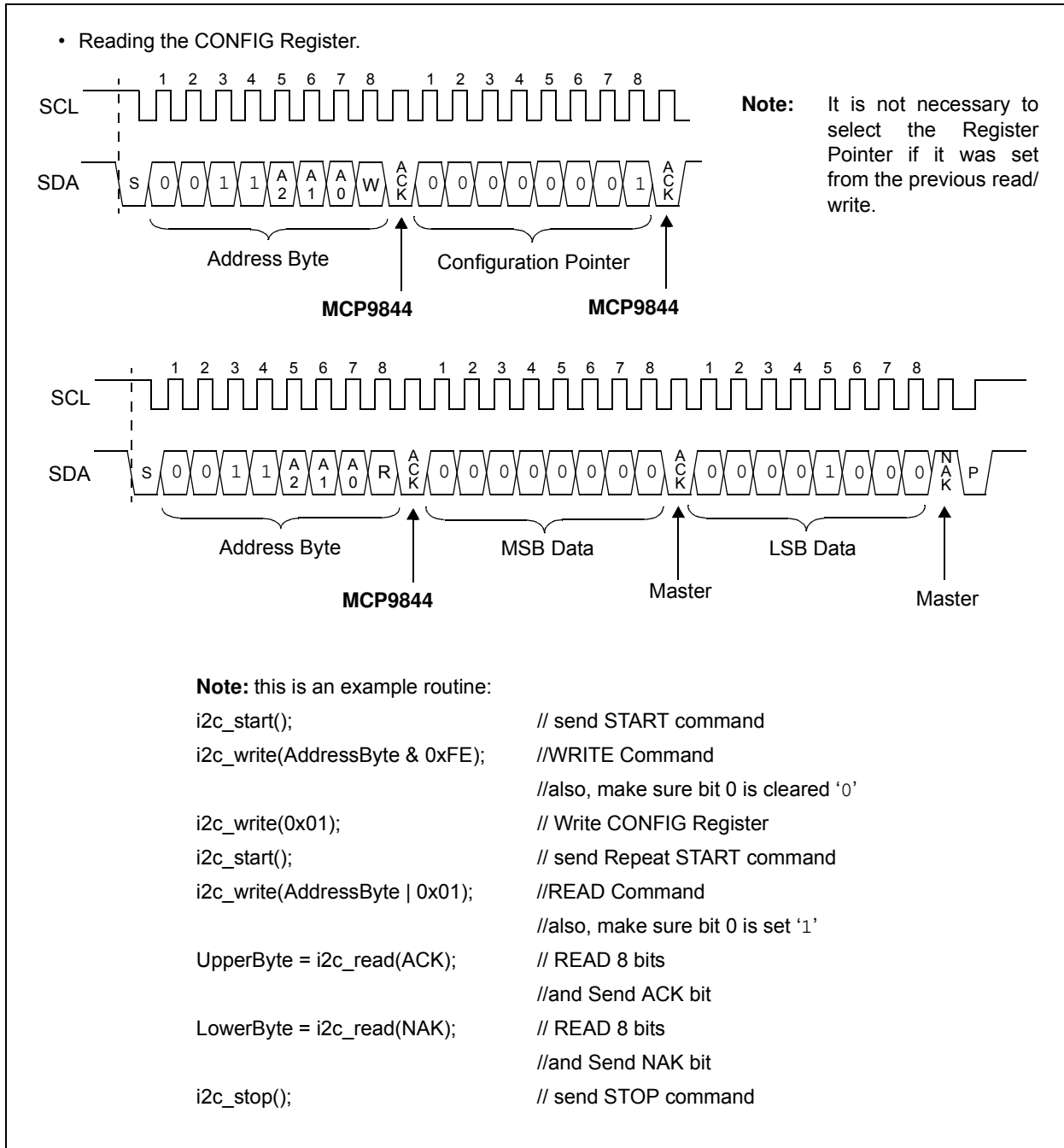
## REGISTER 5-3: CONFIGURATION REGISTER (CONFIG) → ADDRESS '0000 0001'b

bit 7	<b>T<sub>CRIT</sub> Lock Bit (Crit. Lock):</b> 0 = Unlocked. T <sub>CRIT</sub> register can be written. (power-up default) 1 = Locked. T <sub>CRIT</sub> register can not be written  When enabled, this bit remains set '1' or locked until cleared by internal reset ( <a href="#">Section 5.3 “Summary of Power-on Default”</a> ). This bit does not require a double-write.  This bit can be programmed in Shutdown mode.
bit 6	<b>T<sub>UPPER</sub> and T<sub>LOWER</sub> Window Lock Bit (Win. Lock):</b> 0 = Unlocked. T <sub>UPPER</sub> and T <sub>LOWER</sub> registers can be written. (power-up default) 1 = Locked. T <sub>UPPER</sub> and T <sub>LOWER</sub> registers can not be written  When enabled, this bit remains set '1' or locked until cleared by power-on Respell ( <a href="#">Section 5.3 “Summary of Power-on Default”</a> ). This bit does not require a double-write.  This bit can be programmed in Shutdown mode.
bit 5	<b>Interrupt Clear (Int. Clear) Bit:</b> 0 = No effect (power-up default) 1 = Clear interrupt output. When read this bit returns '0'  This bit clears the Interrupt flag which deasserts event output. In Shutdown mode, the event output is always deasserted. Therefore, setting this bit in Shutdown mode clears the interrupt after the device returns to normal operation.
bit 4	<b>Event Output Status (Event Stat.) Bit:</b> 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  In Shutdown mode this bit will clear because event output is always deasserted in Shutdown mode.
bit 3	<b>Event Output Control (Event Cnt.) Bit:</b> 0 = Event output Disabled (power-up default) 1 = Event output Enabled  This bit can not be altered when either of the lock bits is set (bit 6 and bit 7).  This bit can be programmed in Shutdown mode, but event output will remain deasserted.
bit 2	<b>Event Output Select (Event Sel.) Bit:</b> 0 = Event output for T <sub>UPPER</sub> , T <sub>LOWER</sub> and T <sub>CRIT</sub> (power-up default) 1 = T <sub>A</sub> ≥ T <sub>CRIT</sub> only. (T <sub>UPPER</sub> and T <sub>LOWER</sub> temperature boundaries are disabled.)  When the Alarm Window Lock bit is set, this bit cannot be altered until unlocked (bit 6).  This bit can be programmed in Shutdown mode, but event output will remain deasserted.
bit 1	<b>Event Output Polarity (Event Pol.) Bit:</b> 0 = Active-low (power-up default. Pull-up resistor required) 1 = Active-high  This bit cannot be altered when either of the lock bits is set (bit 6 and bit 7).  This bit can be programmed in Shutdown mode, but event output will remain deasserted, see <a href="#">Section 5.2.3 “Event Output Configuration”</a>
bit 0	<b>Event Output Mode (Event Mod.) Bit:</b> 0 = Comparator output (power-up default) 1 = Interrupt output  This bit cannot be altered when either of the lock bits is set (bit 6 and bit 7).  This bit can be programmed in Shutdown mode, but event output will remain deasserted.



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

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

## 5.1.3 UPPER/LOWER/CRITICAL TEMPERATURE LIMIT REGISTERS (T<sub>UPPER</sub>/T<sub>LOWER</sub>/T<sub>CRIT</sub>)

The MCP9844 device has a 16-bit read/write Event Output Temperature Upper-Boundary Trip register (T<sub>UPPER</sub>), a 16-bit Lower-Boundary Trip register (T<sub>LOWER</sub>) and a 16-bit Critical Boundary Trip register (T<sub>CRIT</sub>) 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 MCP9844 asserts an event output. (Refer to Section 5.2.3 “Event Output Configuration”).

### REGISTER 5-4: UPPER/LOWER/CRITICAL TEMPERATURE LIMIT REGISTER (T<sub>UPPER</sub>/T<sub>LOWER</sub>/T<sub>CRIT</sub>) → 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 <sup>7</sup> °C	2 <sup>6</sup> °C	2 <sup>5</sup> °C	2 <sup>4</sup> °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 <sup>3</sup> °C	2 <sup>2</sup> °C	2 <sup>1</sup> °C	2 <sup>0</sup> °C	2 <sup>-1</sup> °C	2 <sup>-2</sup> °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'

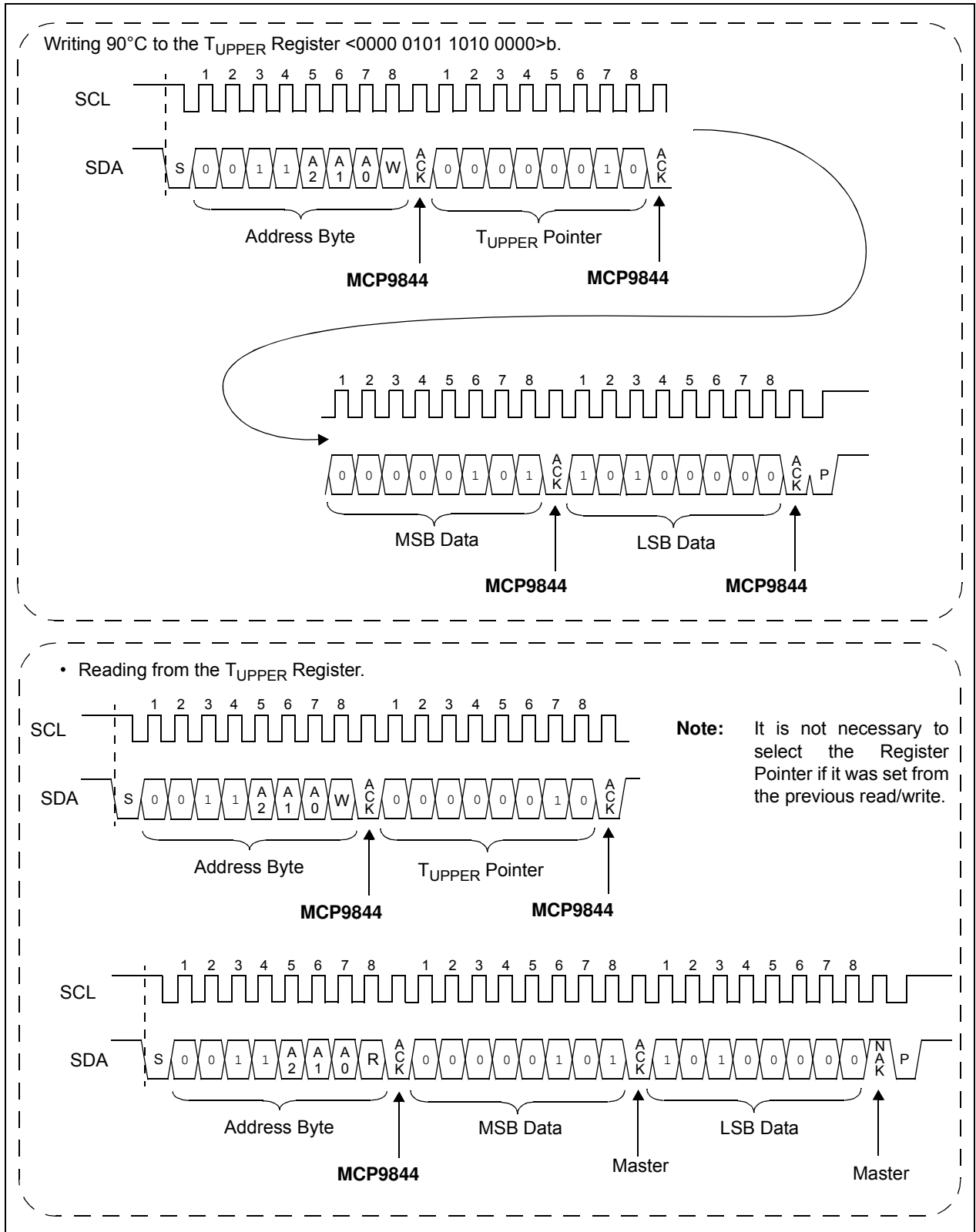
bit 12 **Sign:**  
 0 = T<sub>A</sub> ≥ 0°C  
 1 = T<sub>A</sub> < 0°C

bit 11-2 **T<sub>UPPER</sub>/T<sub>LOWER</sub>/T<sub>CRIT</sub>:**  
 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<sub>UPPER</sub>, T<sub>LOWER</sub> and T<sub>CRIT</sub> located at '0000 0010b', '0000 0011b' and '0000 0100b', respectively.

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**FIGURE 5-5:** Timing Diagram for Writing and Reading from the T<sub>UPPER</sub> Register (See [Section 4.0](#) “Serial Communication”).

## 5.1.4 AMBIENT TEMPERATURE REGISTER (T<sub>A</sub>)

The MCP9844 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°C + sign (11-bit data). The digital word is loaded to a 16-bit read-only Ambient Temperature register (T<sub>A</sub>) that contains 11-bit temperature data in two's complement format.

The T<sub>A</sub> register bits (bits 12 through 0) are double-buffered. Therefore, the user can access the register while, in the background, the MCP9844 performs an Analog-to-Digital conversion. The temperature data from the  $\Delta\Sigma$  ADC is loaded in parallel to the T<sub>A</sub> register at t<sub>CONV</sub> refresh rate.

In addition, the T<sub>A</sub> 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<sub>A</sub> is greater than or equal to T<sub>CRIT</sub>; bit 14 is set to '1' if T<sub>A</sub> is greater than T<sub>UPPER</sub> and bit 13 is set to '1' if T<sub>A</sub> is less than T<sub>LOWER</sub>.

The T<sub>A</sub> register bit assignment and boundary conditions are described in [Register 5-5](#).

### REGISTER 5-5: AMBIENT TEMPERATURE REGISTER (T<sub>A</sub>) → ADDRESS '0000 0101' b (Note 1)

R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0
T <sub>A</sub> vs. T <sub>CRIT</sub>	T <sub>A</sub> vs. T <sub>UPPER</sub>	T <sub>A</sub> vs. T <sub>LOWER</sub>	SIGN	2 <sup>7</sup> °C	2 <sup>6</sup> °C	2 <sup>5</sup> °C	2 <sup>4</sup> °C
bit 15							bit 8

R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0
2 <sup>3</sup> °C	2 <sup>2</sup> °C	2 <sup>1</sup> °C	2 <sup>0</sup> °C	2 <sup>-1</sup> °C	2 <sup>-2</sup> °C	2 <sup>-3</sup> °C	2 <sup>-4</sup> °C
bit 7							bit 0

#### Legend:

R = Readable bit  
-n = Value at POR

W = Writable bit  
'1' = Bit is set

U = Unimplemented bit, read as '0'  
'0' = Bit is cleared

x = Bit is unknown

bit 15 **T<sub>A</sub> vs. T<sub>CRIT</sub> (1) Bit:**

0 = T<sub>A</sub> < T<sub>CRIT</sub>  
1 = T<sub>A</sub> ≥ T<sub>CRIT</sub>

bit 14 **T<sub>A</sub> vs. T<sub>UPPER</sub> (1) Bit:**

0 = T<sub>A</sub> ≤ T<sub>UPPER</sub>  
1 = T<sub>A</sub> > T<sub>UPPER</sub>

bit 13 **T<sub>A</sub> vs. T<sub>LOWER</sub> (1) Bit:**

0 = T<sub>A</sub> ≥ T<sub>LOWER</sub>  
1 = T<sub>A</sub> < T<sub>LOWER</sub>

bit 12 **SIGN Bit:**

0 = T<sub>A</sub> ≥ 0°C  
1 = T<sub>A</sub> < 0°C

bit 11-0 **Ambient Temperature (T<sub>A</sub>) 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. The power-up default is 0.25°C/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 4 bits (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 complement 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. Additionally, refer to [Figure 5-7](#) for the 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  $< 0^\circ\text{C}$

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

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 I<sup>2</sup>C™ 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'

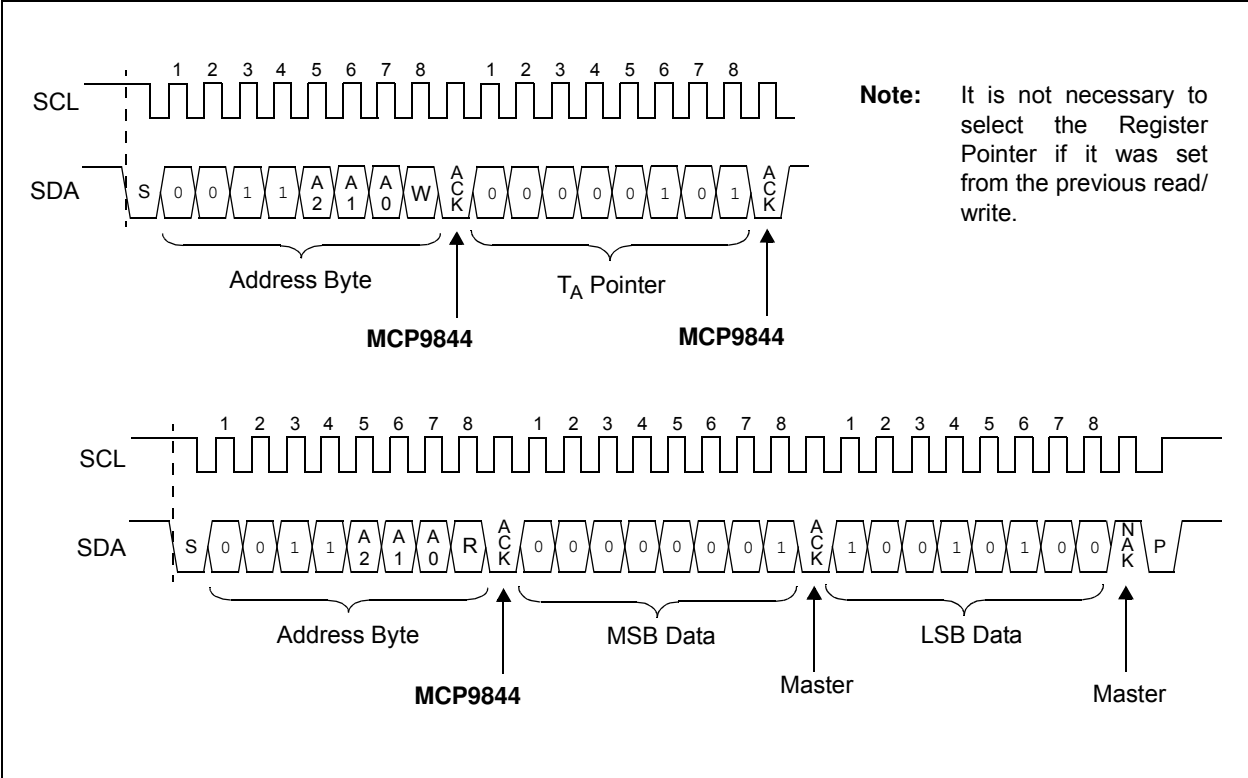
UpperByte = i2c_read(ACK); // READ 8 bits
//and Send ACK bit

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 = (UpperByte x 16 + LowerByte / 16) - 256;
}else //TA ≥ 0°C
    Temperature = (UpperByte x 16 + LowerByte / 16);
//Temperature = Ambient Temperature (°C)
    
```

**FIGURE 5-6:** Example Instruction Code.



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



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## 5.1.5 MANUFACTURER ID REGISTER

This register is used to identify the manufacturer of the device in order to perform manufacturer specific operations. The Manufacturer ID for the MCP9844 is 0x0054 (hexadecimal).

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

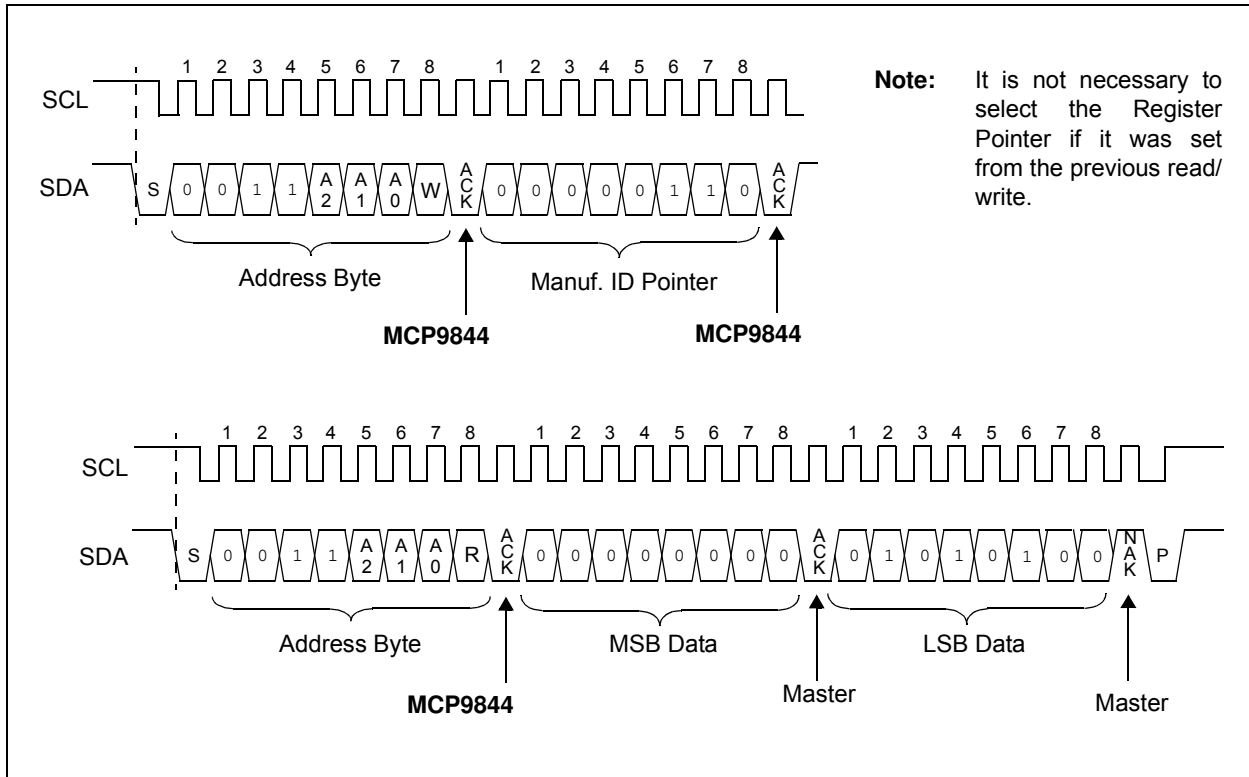
R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0
Manufacturer ID							
bit 15				bit 8			

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”](#)).

## 5.1.6 DEVICE ID AND REVISION REGISTER

The Device ID and Revision register located at Address Pointer 0x08 is used to identify Microchip devices. The upper byte of these registers is used to specify the device identification and the lower byte is used to specify device silicon revision. The device ID for the MCP9844 is 0x06 (hex).

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

### REGISTER 5-7: TSE2004AV DEVICE ID AND DEVICE REVISION (READ-ONLY) → ADDRESS '0000 0111'b AND '0000 1000'b

R-0	R-0	R-0	R-0	R-0	R-1	R-1	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