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MCP98242

Memory Module Temperature Sensor w/EEPROM for SPD

Features:

- Temperature Sensor + 256 Byte Serial EEPROM
- EEPROM for Serial Presence Detect (SPD)
- Optimized for Voltage Range: 3.0V to 3.6V
- Shutdown/Standby Current: 3 µA (maximum)
- 2-wire Interface: I^{2}C™/SMBus Compatible
- Available Packages: DFN-8, TDFN-8, UDFN-8, TSSOP-8

Temperature Sensor Features:

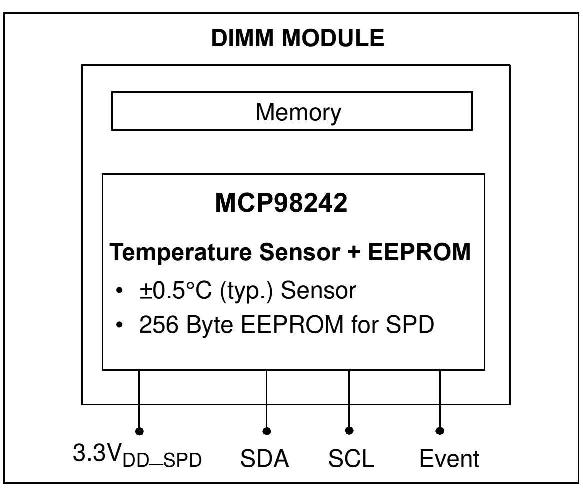
- Temperature-to-Digital Converter
- Operating Current: 200 µA (typical)
- Accuracy:
  - ±0.5°C/±1°C (typ./max.) → +75°C to +95°C
  - ±1°C/±2°C (typ./max.) → +40°C to +125°C
  - ±2°C/±3°C (typ./max.) → -20°C to +125°C

Serial EEPROM Features:

- Operating Current:
  - Write → 1.1 mA (typical) for 3.5 ms (typical)
  - Read → 100 µA (typical)
- Permanent and Reversible Software Write-Protect
- Software Write Protection for the Lower 128 Bytes
- Organized as 1 Block of 256 Bytes (256x8)

Typical Applications:

- DIMM Modules
- Laptops, Personal Computers and Servers
- Hard Disk Drives and Other PC Peripherals



Description:

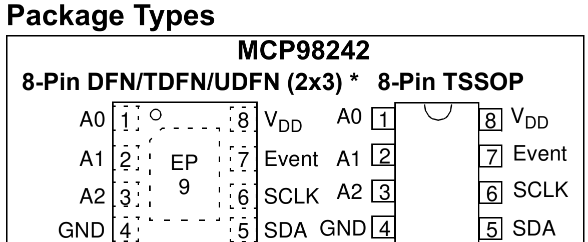
Microchip Technology Inc.'s MCP98242 digital temperature sensor converts temperature from -40°C and +125°C to a digital word. This sensor meets JEDEC Specification JC42.4 Mobile Platform Memory Module Thermal Sensor Component. It provides an accuracy of ±0.5°C/±1°C (typical/maximum) from +75°C to +95°C. In addition, this device has an internal 256 Byte EEPROM which can be used to store memory module and vendor information.

The MCP98242 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 and critical output boundaries. When the temperature changes beyond the specified boundary limits, the MCP98242 outputs an Event signal. The user has the option of setting the 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 Event output can also be configured as a critical temperature output.

The EEPROM is designed specifically for DRAM DIMMs (Dual In-line Memory Modules) Serial Presence Detect (SPD). The lower 128 bytes (address 00h to 7Fh) 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 80h to FFh) can be used for general purpose data storage. These addresses are not write-protected.

This sensor has an industry standard 2-wire, I^{2}C/SMBus compatible serial interface, allowing up to eight devices to be controlled in a single serial bus. To maintain interchangeability with the I^{2}C/SMBus interface the electrical specifications are specified with the operating voltage of 3.0V to 3.6V. In addition, a 40 ms (typical) time out is implemented.

Package Types



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

Notes:

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.

DC CHARACTERISTICS

Electrical Specifications: Unless otherwise indicated, V_{DD} = 3.0V to 3.6V, GND = Ground, SDA/SCL pulled-up to V_{DD}, and T_A = -20°C to +125°C.

Parameters	Sym	Min	Typ	Max	Unit	Conditions
Power Supply						
Operating Voltage	V_{DD}	3.0	—	3.6	V	
Operating Current						
Temperature Sensor	I_{DD}	—	200	500	µA	EEPROM Inactive
EEPROM write	I_{DD}	—	1100	2000	µA	Sensor in Shutdown mode (for t_{WC})
EEPROM read	I_{DD}	—	100	500	µA	Sensor in Shutdown mode
Shutdown Current	I_{SHDN}	—	1	3	µA	EEPROM Inactive, Sensor in Shutdown mode
Power-on-Reset (POR) Threshold	V_{POR}	—	2.3	—	V	Temperature Sensor (V_{DD} falling)
	V_{POR}	—	1.6	—	V	EEPROM (V_{DD} falling) (see **Section 5.4 "Summary of Temperature Sensor Power-on Default"**)
Power Supply Rejection,	$\Delta°C/\Delta V_{DD}$	—	±0.4	—	°C/V	V_{DD} = 3.0V to 3.6V
T_A = +25°C	$\Delta°C/\Delta V_{DD}$	—	±0.15	—	°C	V_{DD} = 3.3V+150 $mV_{PP\ AC}$ (0 to 1 MHz)
Temperature Sensor Accuracy						
+75°C < T_A ≤ +95°C	T_{ACY}	-1.0	±0.5	+1.0	°C	
+40°C < T_A ≤ +125°C	T_{ACY}	-2.0	±1	+2.0	°C	
-20°C < T_A ≤ +125°C	T_{ACY}	-3.0	±2	+3.0	°C	
T_A = -40°C	T_{ACY}	—	-2	—	°C	
Conversion Time						
0.25°C/bit	t_{CONV}	—	65	125	ms	15 s/sec (typical) (See **Section 5.2.3.3 "Temperature Resolution"**)
Event Output (Open-drain)						
High-level Current (leakage)	I_{OH}	—	—	1	µA	$V_{OH} = V_{DD}$
Low-level Voltage	V_{OL}	—	—	0.4	V	I_{OL}= 3 mA
EEPROM						
Write Cycle (byte/page)	t_{WC}	—	3	5	ms	—
Endurance T_A = +25°C	—	1M	—	—	cycles	V_{DD} = 5V, **Note 1**
Write-Protect High Voltage	V_{HI_WP}	8	—	12	V	Applied at A0 pin, **Note 1**
Thermal Response						

Note 1: Characterized but not production tested.

DC CHARACTERISTICS

Electrical Specifications: Unless otherwise indicated, V_{DD} = 3.0V to 3.6V, GND = Ground, SDA/SCL pulled-up to V_{DD}, and T_A = -20°C to +125°C.						
Parameters	**Sym**	**Min**	**Typ**	**Max**	**Unit**	**Conditions**
DFN	t_{RES}	—	0.7	—	s	Time to 63% (89°C) 25°C (Air) to 125°C (oil bath)
TSSOP	t_{RES}	—	1.4	—	s	

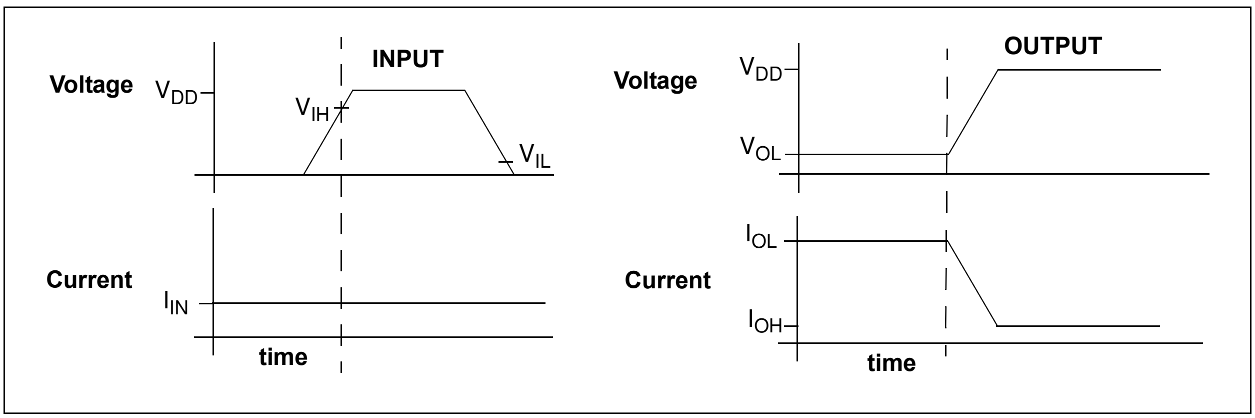
Note 1: Characterized but not production tested.

INPUT/OUTPUT PIN 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**	**Units**	**Conditions**
Serial Input/Output (SCL, SDA, A0, A1, A2)						
Input						
High-level Voltage	V_{IH}	2.1	—	—	V	
Low-level Voltage	V_{IL}	—	—	0.8	V	
Input Current	I_{IN}	—	—	±5	µA	
Output (SDA)						
Low-level Voltage	V_{OL}	—	—	0.4	V	I_{OL} = 3 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}	—	0.5	—	V	

Note: The serial inputs do not load the serial bus for V_{DD} range of 1.8V to 5.5V.

GRAPHICAL SYMBOL DESCRIPTION



TEMPERATURE CHARACTERISTICS

Electrical Specifications: Unless otherwise indicated, V_{DD} = 3.0V to 3.6V, 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						

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

TEMPERATURE CHARACTERISTICS

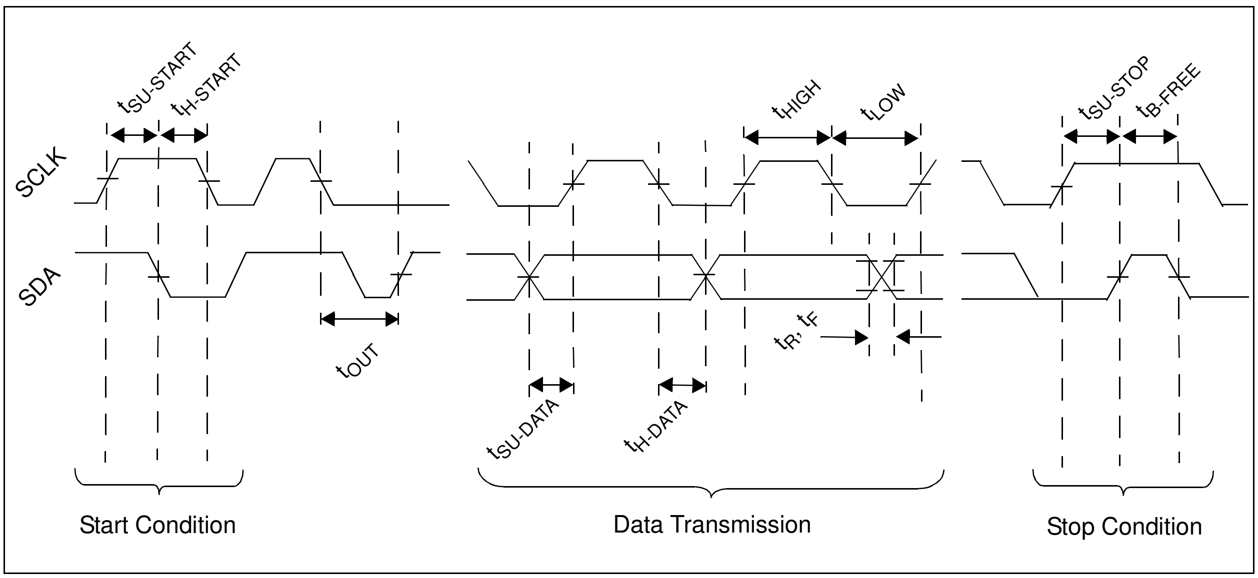
Electrical Specifications: Unless otherwise indicated, V_{DD} = 3.0V to 3.6V, GND = Ground.						
Parameters	**Sym**	**Min**	**Typ**	**Max**	**Units**	**Conditions**
Thermal Resistance, 8L-DFN	θ_{JA}	—	84.5	—	°C/W	
Thermal Resistance, 8L-TDFN	θ_{JA}	—	41	—	°C/W	
Thermal Resistance, 8L-TSSOP	θ_{JA}	—	139	—	°C/W	

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

SENSOR AND EEPROM SERIAL INTERFACE TIMING SPECIFICATIONS

Electrical Specifications: Unless otherwise indicated, V_{DD} = 3.0V to 3.6V, GND = Ground, T_A = -20°C to +125°C, C_L = 80 pF, and all limits measured to 50% point.						
Parameters	**Sym**	**Min**	**Typ**	**Max**	**Units**	**Conditions**
2-Wire I²C™/SMBus-Compatible Interface						
Serial Port Frequency	f_{SC}	10	—	100	kHz	I²C™/SMBus
Low Clock	t_{LOW}	4.7	—	—	µs	
High Clock	t_{HIGH}	4.0	—	—	µs	
Rise Time	t_R	—	—	1000	ns	($V_{IL\ MAX}$ - 0.15V) to ($V_{IH\ MIN}$ + 0.15V)
Fall Time	t_F	—	—	300	ns	($V_{IH\ MIN}$ + 0.15V) to ($V_{IL\ MAX}$ - 0.15V)
Data Setup Before SCLK High	$t_{SU-DATA}$	250	—	—	ns	
Data Hold After SCLK Low	t_{H-DATA}	300	—	—	ns	
Start Condition Setup Time	$t_{SU-START}$	4.7	—	—	µs	
Start Condition Hold Time	$t_{H-START}$	4.0	—	—	µs	
Stop Condition Setup Time	$t_{SU-STOP}$	4.0	—	—	µs	
Bus Idle	t_{B_FREE}	4.7	—	—	µs	
Time Out	t_{OUT}	25	40	50	ms	Temp. Sensor Only (characterized but not production tested)

TIMING DIAGRAM



NOTES:

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} = 3.0V to 3.6V, GND = Ground, SDA/SCL pulled-up to V_{DD}, and T_A = -20°C to +125°C.

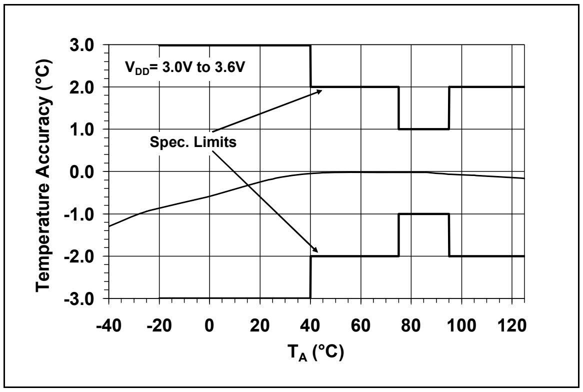


FIGURE 2-1: *Average Temperature Accuracy.*

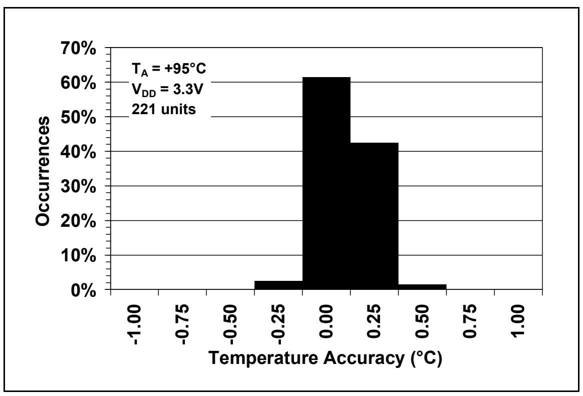


FIGURE 2-2: *Temperature Accuracy Histogram, T_A = +95°C.*

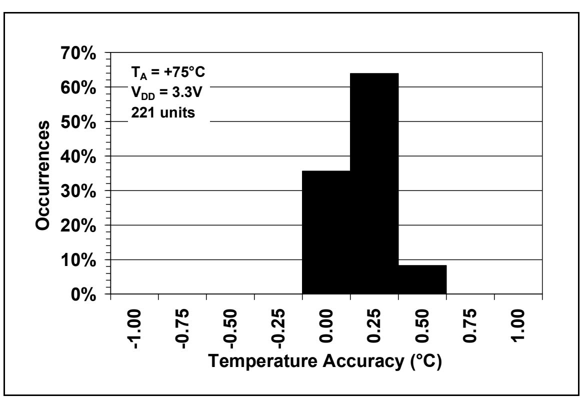


FIGURE 2-3: *Temperature Accuracy Histogram, T_A = +75°C.*

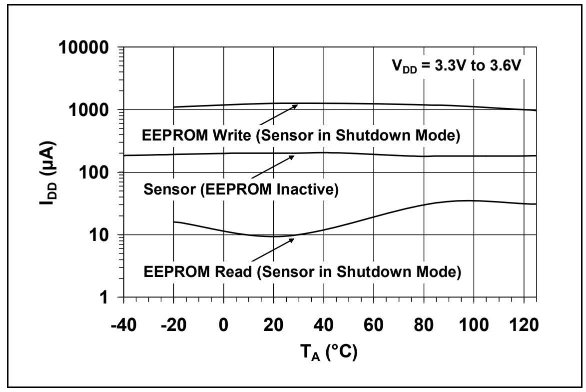


FIGURE 2-4: *Supply Current vs. Temperature.*

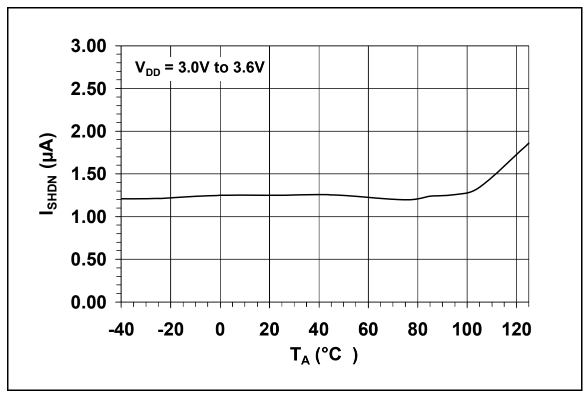


FIGURE 2-5: *Shutdown Current vs. Temperature.*

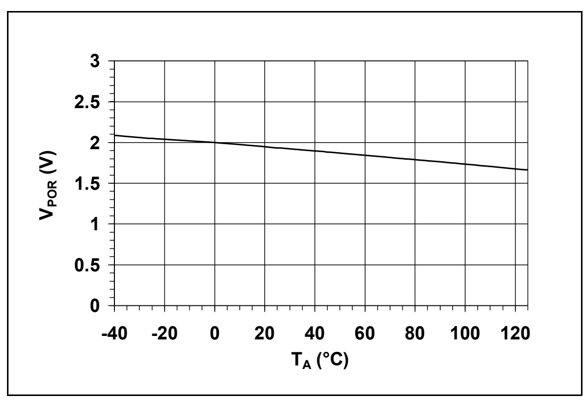


FIGURE 2-6: *Power-on Reset Threshold Voltage vs. Temperature.*

Note: Unless otherwise indicated, V_{DD} = 3.0V to 3.6V, GND = Ground, SDA/SCL pulled-up to V_{DD}, and T_A = -20°C to +125°C.

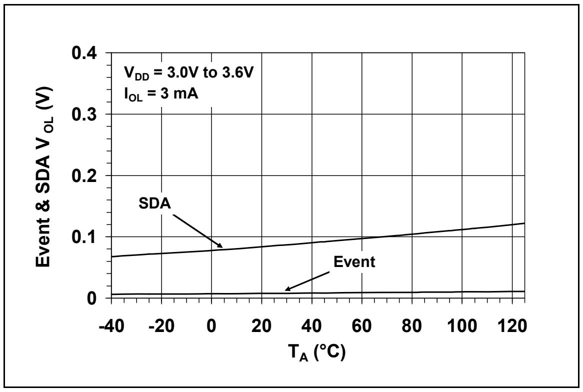


FIGURE 2-7: *Event and SDA V_{OL} vs. Temperature.*

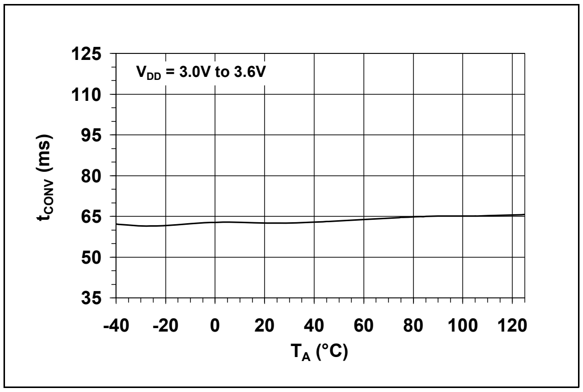


FIGURE 2-8: *Conversion Rate vs. Temperature.*

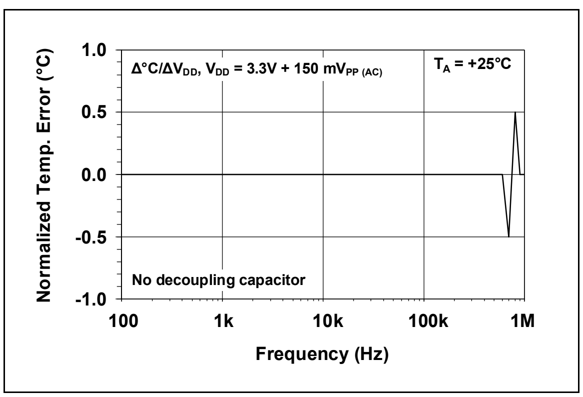


FIGURE 2-9: *Power Supply Rejection vs. Frequency.*

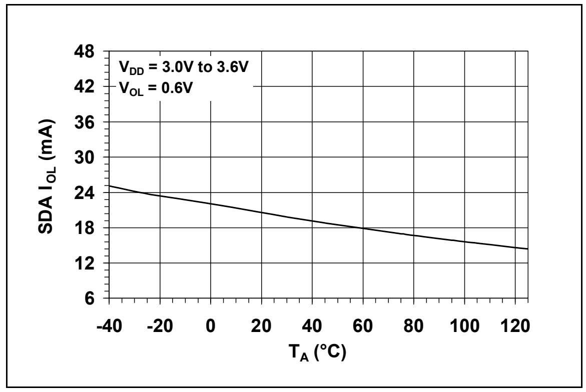


FIGURE 2-10: *SDA IOL vs. Temperature.*

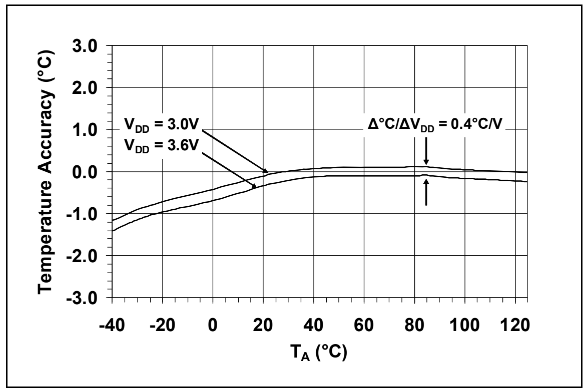


FIGURE 2-11: *Temperature Accuracy vs. V_{DD}.*

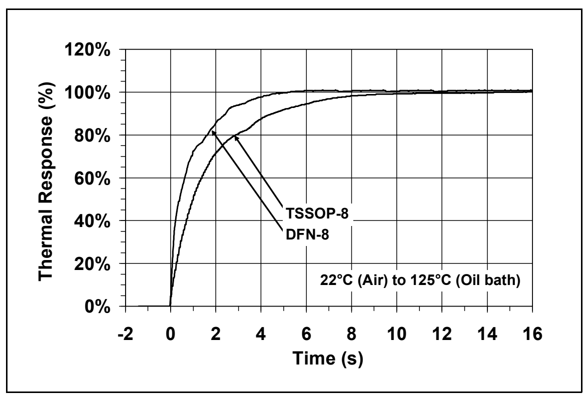


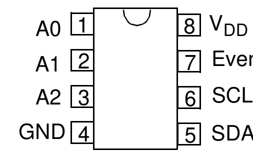
FIGURE 2-12: *Package Thermal Response.*

3.0 PIN DESCRIPTION

The descriptions of the pins are listed in Table 3-1.

TABLE 3-1: PIN FUNCTION TABLES

DFN/TDFN/ UDFN	TSSOP	Symbol	Pin Function	Package Type
1	1	A0	Slave Address	**8-Pin TSSOP**
2	2	A1	Slave Address	
3	3	A2	Slave Address	
4	4	GND	Ground	
5	5	SDA	Serial Data Line	
6	6	SCLK	Serial Clock Line	
7	7	Event	Temperature Alert Output	
8	8	V_{DD}	Power Pin	
9	—	EP	Exposed Thermal Pad (EP); must be connected to V_{SS}.	



3.1 Address Pins (A2, A1, A0)

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: MCP98242 ADDRESS BYTE

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

Note: User-selectable address is shown by X.

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 (SCLK)

The SCLK 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 Open-Drain Temperature Alert Output (Event)

The MCP98242 Event 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 must be connected to the same potential on the Printed Circuit Board (PCB).

NOTES:

4.0 SERIAL COMMUNICATION

4.1 2-Wire SMBus/Standard Mode I^{2}C™ Protocol-Compatible Interface

The MCP98242 serial clock input (SCLK) and the bidirectional serial data line (SDA) form a 2-wire bidirectional SMBus/Standard mode I^{2}C compatible communication port (refer to the Input/Output Pin DC Characteristics Table and Sensor And EEPROM Serial Interface Timing Specifications Table).

The following bus protocol has been defined:

TABLE 4-1: MCP98242 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 MCP98242.
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 MCP98242 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 SCLK remain high.
Data Valid	SDA must remain stable before SCLK becomes high in order for a data bit to be considered valid. During normal data transfers, SDA only changes state while SCLK 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 $t_{B\text{-}FREE}$.

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 MCP98242 retains the previously selected register. Therefore, it outputs 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 MCP98242 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 SCLK is high) is the Start condition. All data transfers must be preceded by a Start condition from the master. If a Start condition is generated during data transfer, the MCP98242 resets and accepts the new Start condition.

A low-to-high transition of the SDA line (while SCLK is high) signifies a Stop condition. If a Stop condition is introduced during data transmission, the MCP98242 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 MCP98242. The address for the MCP98242 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 MCP98242 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).

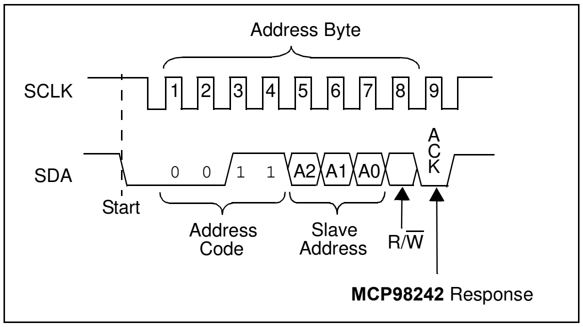


FIGURE 4-1: *Device Addressing.*

4.1.5 DATA VALID

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

4.1.6 ACKNOWLEDGE (ACK)

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 $t_{SU\text{-}DATA}$ before the low-to-high transition of SCLK from the master. SDA also needs to remain pulled down for $t_{H\text{-}DATA}$ after a high-to-low transition of SCLK.

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 (MCP98242)

If the SCLK stays low or high for time specified by t_{OUT}, the MCP98242 temperature sensor resets the serial interface. This dictates the minimum clock speed as specified in the SMBus 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 MCP98242 temperature sensors consists 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^2C/SMBus protocol compatible serial interface. Figure 5-1 shows a block diagram of the register structure.

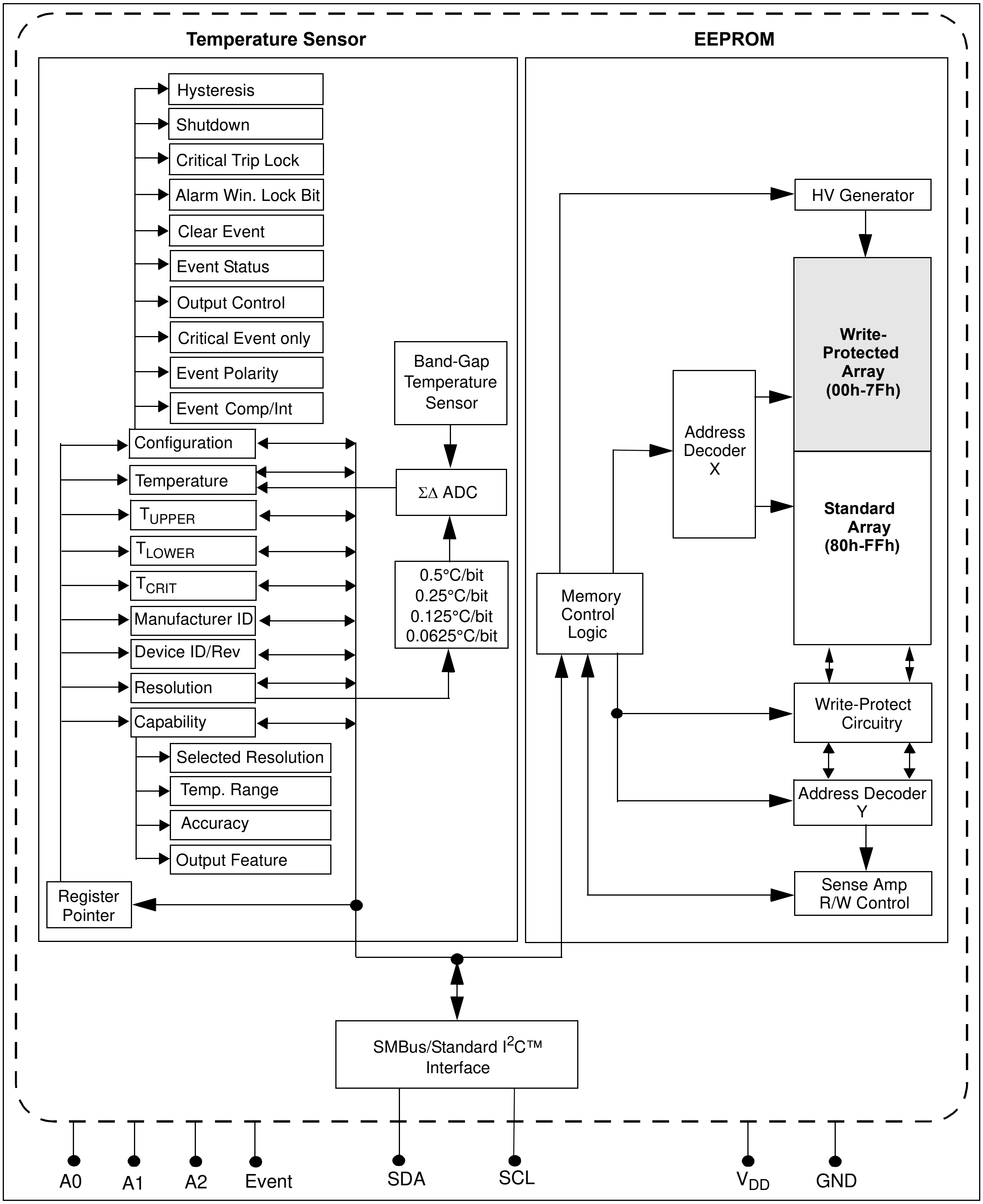


FIGURE 5-1: *Functional Block Diagram.*

5.1 Registers

The MCP98242 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 MCP98242 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 MCP98242's capability in measurement resolution, measurement range and device accuracy. The device Configuration register provides access to configure the MCP98242'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 MCP98242 using the serial interface. This is an 8-bit write-only pointer. However, the three Least Significant bits are used as pointers and all unused bits (bits 7-3) 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''

Bits 7-4 must always be cleared or written to '0'. 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.

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

TABLE 5-1: BIT ASSIGNMENT SUMMARY FOR ALL 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	0	0	0	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 Pol
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	$T_A \geq T_{CRIT}$	$T_A > T_{UPPER}$	$T_A < T_{LOWER}$	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	0	0
0x06	MSB	0	0	0	0	0	0	0	0
	LSB	0	1	0	1	0	1	0	0
0x07	MSB	0	0	1	0	0	0	0	0
	LSB	0	0	0	0	0	0	0	1
0x08	LSB	0	0	0	0	0	0	0	1

5.1.1 CAPABILITY REGISTER

This is a read-only register used to identify the temperature sensor capability. In this case, the MCP98242 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

U-0	U-0	U-0	R-0	R-1	R-1	R-1	R-1
—	—	—	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 15-5 **Unimplemented:** Read as ‘0’

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 5.2.3.3 “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)

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 temperautre event output (JC 42.4 required feature).

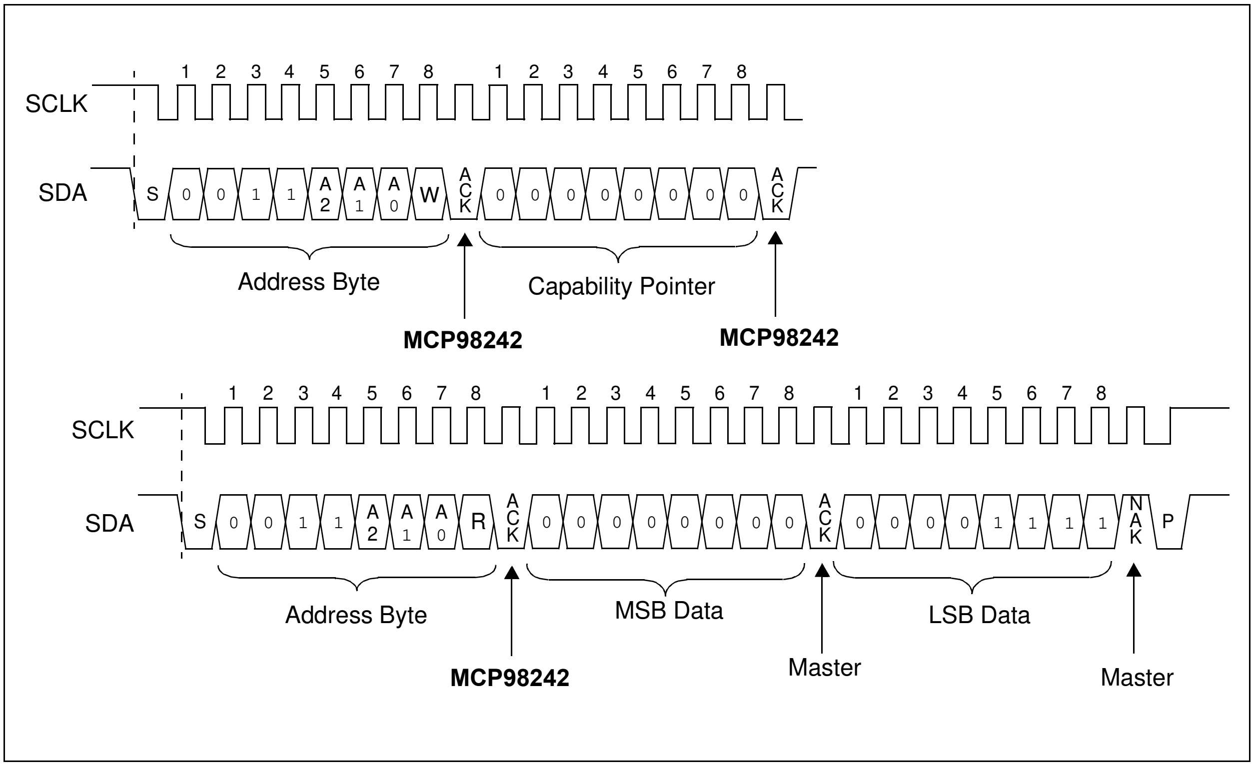


FIGURE 5-2: *Timing Diagram for Reading the Capability Register (See **Section 4.0 "Serial Communication"**).*

5.1.2 SENSOR CONFIGURATION REGISTER (CONFIG)

The MCP98242 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 **Unimplements:** 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

This bit cannot be altered when either of the lock bits are set (bit 6 and bit 7), refer to **Section 5.2.3 "Event Output Configuration"**.

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.

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 **T_{CRIT} Lock Bit (Crit. Lock):**

0 = Unlocked. T_{CRIT} register can be written. (power-up default)
1 = Locked. T_{CRIT} register cannot be written

When enabled, this bit remains set '1' or locked until cleared by internal Reset (**Section 5.4 "Summary of Temperature Sensor Power-on Default"**). This bit does not require a double-write.

bit 6 **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 cannot be written

When enabled, this bit remains set '1' or locked until cleared by internal Reset (**Section 5.4 "Summary of Temperature Sensor Power-on Default"**). This bit does not require a double-write.

bit 5 **Interrupt Clear (Int. Clear) Bit:**

0 = No effect (power-up default)
1 = Clear interrupt output. When read this bit returns '0'

bit 4 **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

bit 3 **Event Output Control (Event Cnt.) Bit:**

0 = Disabled (power-up default)
1 = Enabled

This bit cannot be altered when either of the lock bits is set (bit 6 and bit 7).

bit 2 **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.)

When the Alarm Window Lock bit is set, this bit cannot be altered until unlocked (bit 6).

bit 1 **Event Output Polarity (Event Pol.) Bit:**

0 = Active-low (power-up default)
1 = Active-high

This bit cannot be altered when either of the lock bits is set (bit 6 and bit 7).

bit 0 **Event Output Mode (Event Mod.) Bit:**

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).

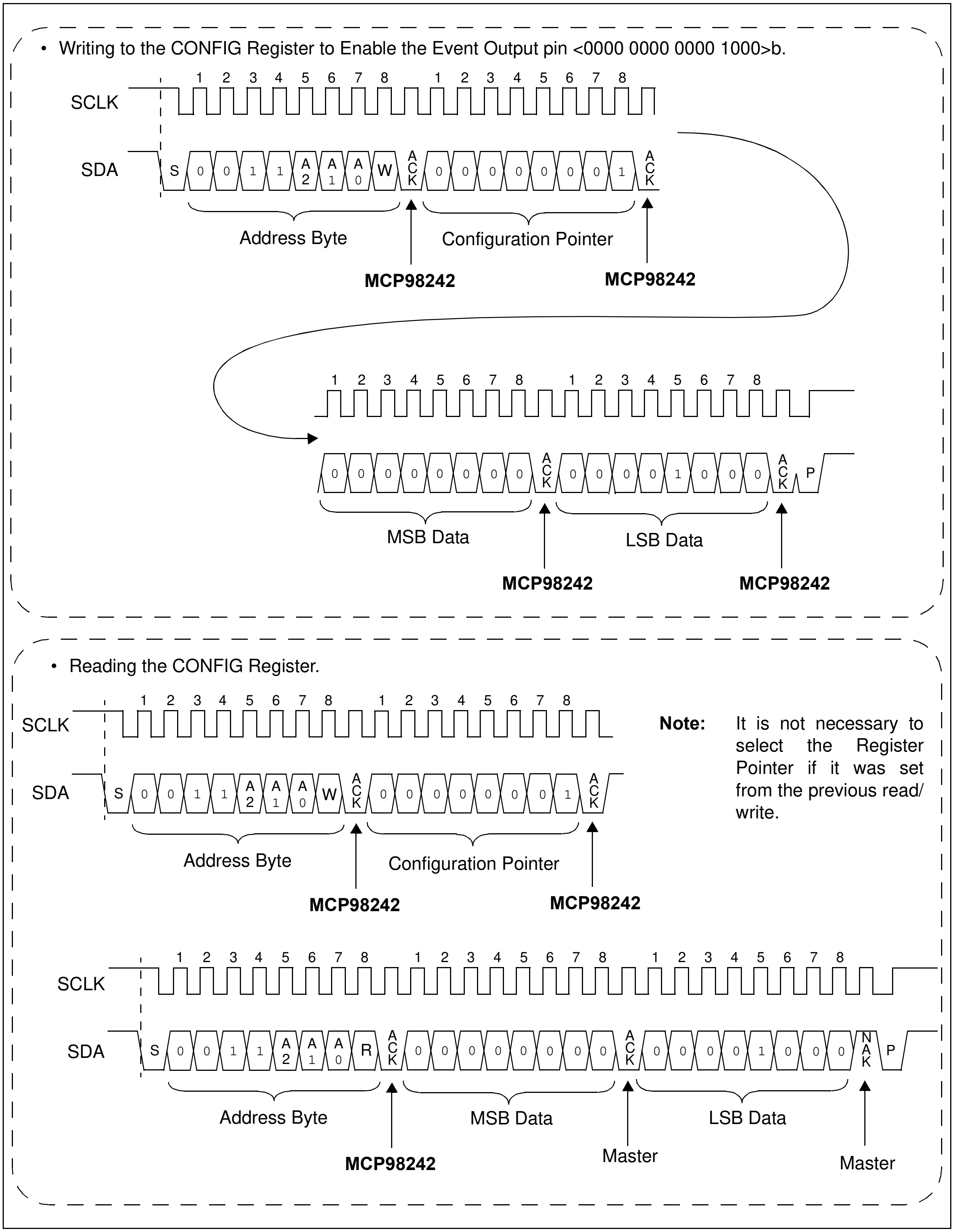


FIGURE 5-3: *Timing Diagram for Writing and Reading from the Configuration Register (See* ***Section 4.0 "Serial Communication"****).*

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

The MCP98242 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 MCP98242 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

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}°C	2^{-2}°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 = $T_A \geq 0$°C
1 = $T_A < 0$°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: 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.

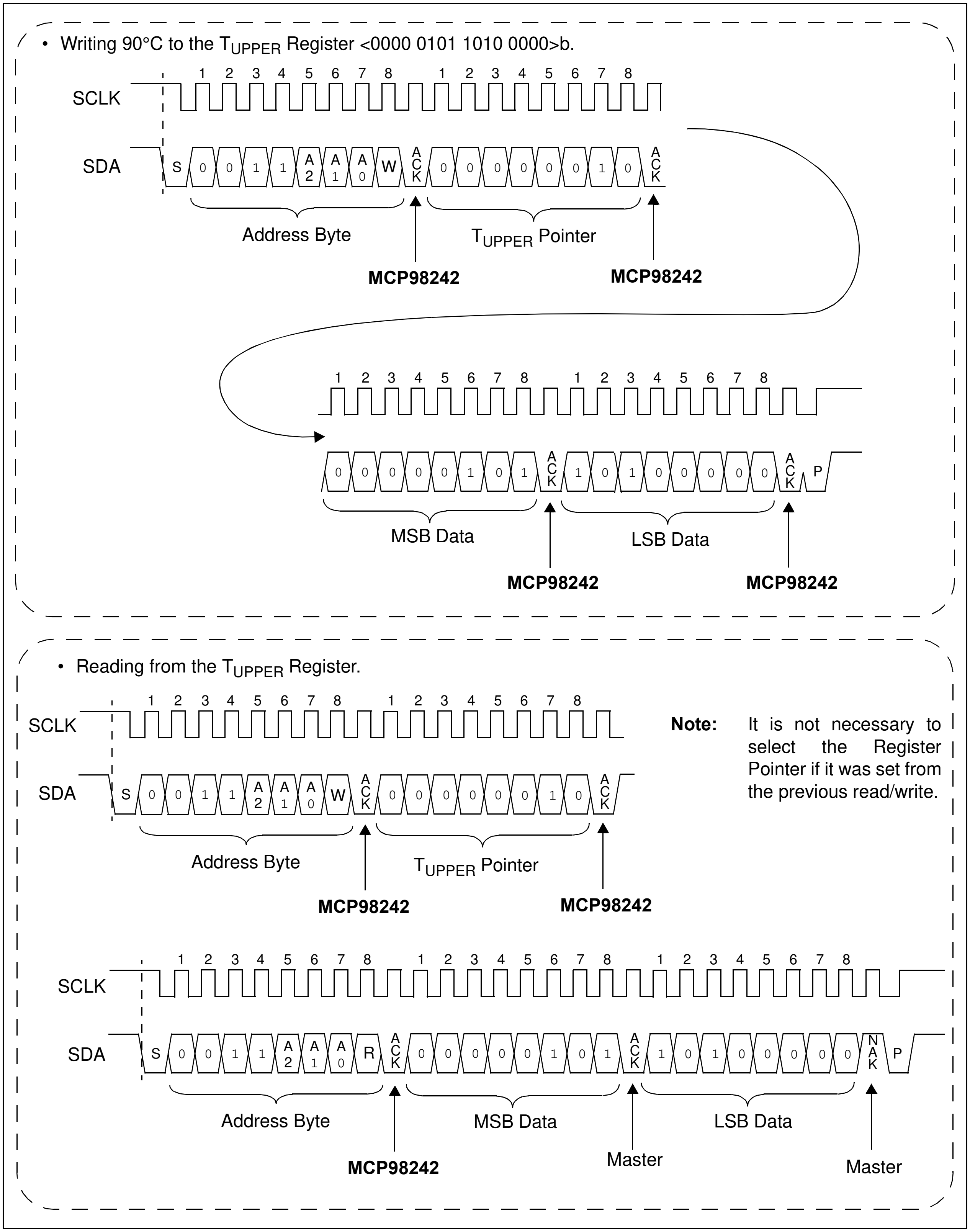


FIGURE 5-4: *Timing Diagram for Writing and Reading from the T_{UPPER} Register (See **Section 4.0 "Serial Communication"**).*

5.1.4 AMBIENT TEMPERATURE REGISTER (T_A)

The MCP98242 uses a band gap temperature sensor circuit to output analog voltage proportional to absolute temperature. An internal ΔΣ 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_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 MCP98242 performs an analog-to-digital conversion. The temperature data from the ΔΣ ADC is loaded in parallel to the T_A register at t_{CONV} refresh rate.

The T_A magnitude in decimal to ambient temperature conversion is shown in Equation 5-1:

EQUATION 5-1: DECIMAL CODE TO TEMPERATURE CONVERSION

$$T_A = \text{Code} \times 2^{-4}$$

Where:

T_A = Ambient Temperature (°C)

Code = MCP98242 temperature output magnitude in decimal (bits 0-11)

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

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

bit 14 **T_A vs. T_{UPPER} (1) Bit:**
- 0 = $T_A \leq T_{UPPER}$
- 1 = $T_A > T_{UPPER}$

bit 13 **T_A vs. T_{LOWER} (1) Bit:**
- 0 = $T_A \geq T_{LOWER}$
- 1 = $T_A < T_{LOWER}$

bit 12 **SIGN Bit:**
- 0 = $T_A \geq 0°C$
- 1 = $T_A < 0°C$

bit 11-2 **Ambient Temperature (T_A) Bits:**
10-bit Ambient Temperature data in two's complement format.

bit 1-0 **T_A:** Data in 2's complement format. Depending on the status of the Resolution Register (Register 5-8), these bits may display 2^{-3}°C (0.125°C) and 2^{-4}°C (0.0625°C), respectively.

Note 1: Not affected by the status of the Event output Configuration (bits 5 to 0 of CONFIG), Register 5-3.

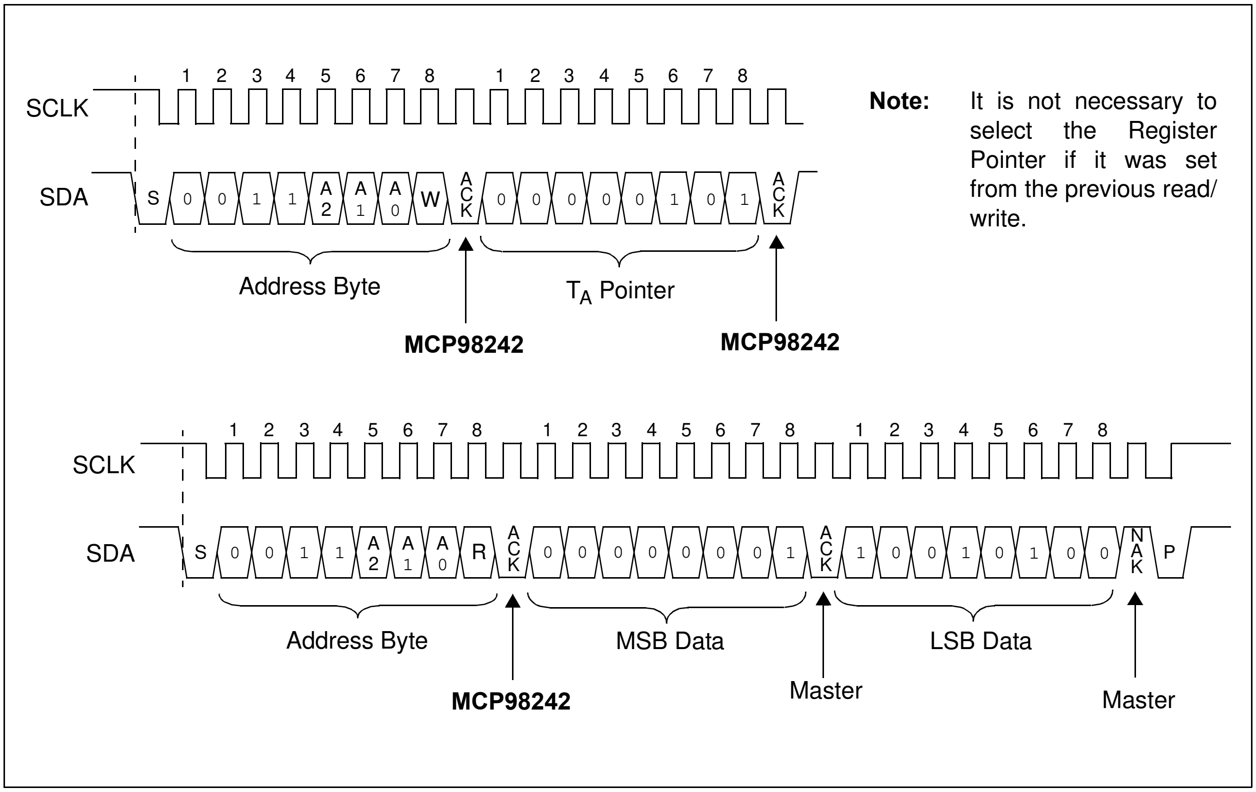


FIGURE 5-5: *Timing Diagram for Reading +25.25°C Temperature from the T_A Register (See* ***Section 4.0 "Serial Communication"****).*

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 MCP98242 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**

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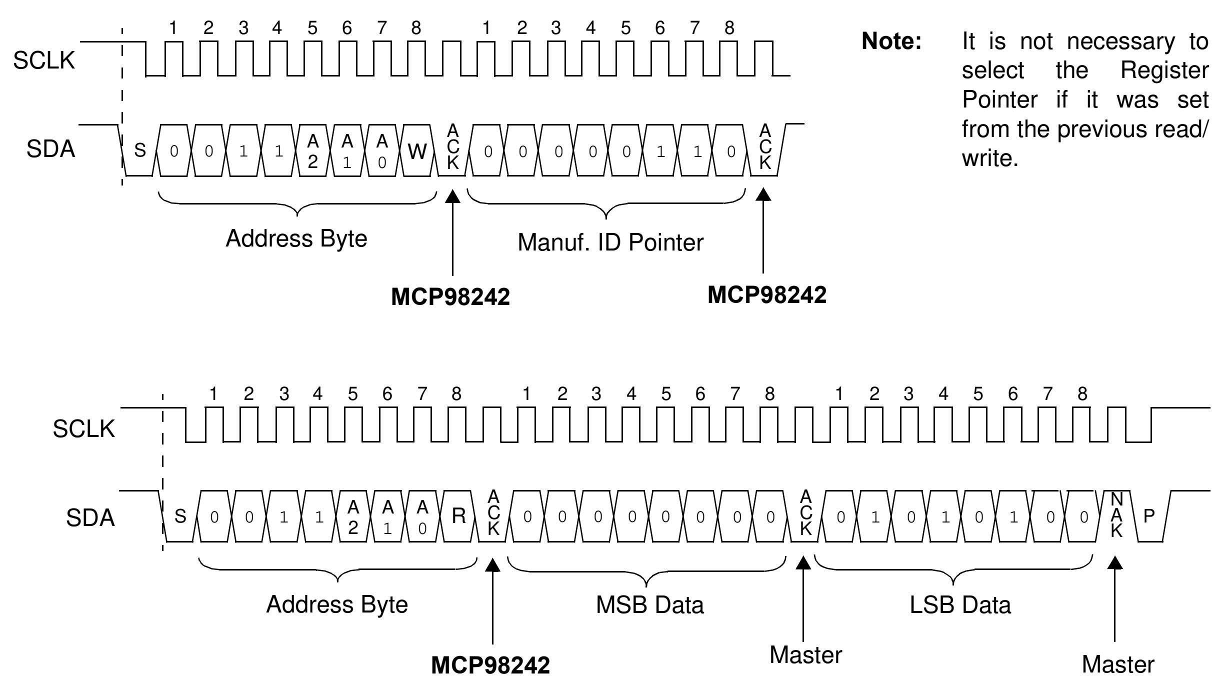

Note: It is not necessary to select the Register Pointer if it was set from the previous read/write.

FIGURE 5-6: *Timing Diagram for Reading the Manufacturer ID Register (See **Section 4.0 "Serial Communication"**).*