

## Digital Temperature Sensor with SPI Interface

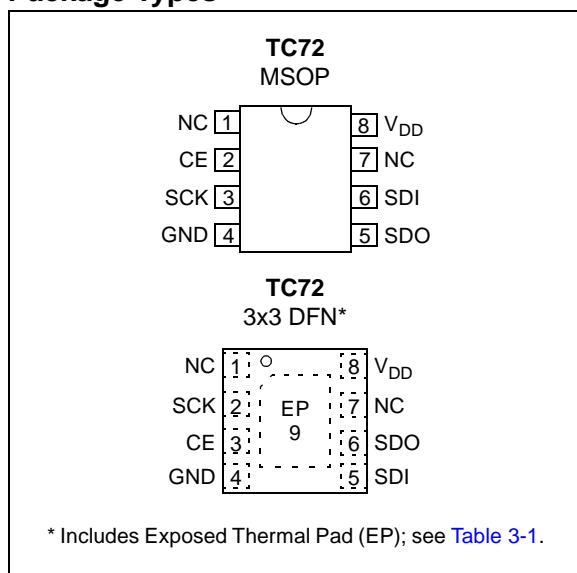
### Features

- Temperature-to-Digital Converter
- SPI Compatible Interface
- 10-Bit Resolution (0.25°C/Bit)
- $\pm 2^{\circ}\text{C}$  (maximum) Accuracy from  $-40^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$
- $\pm 3^{\circ}\text{C}$  (maximum) Accuracy from  $-55^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$
- 2.65V to 5.5V Operating Range
- Low Power Consumption:
  - 250  $\mu\text{A}$  (typical) Continuous Temperature Conversion Mode
  - 1  $\mu\text{A}$  (maximum) Shutdown Mode
- Power Saving One-Shot Temperature Measurement
- Industry Standard 8-Pin MSOP Package
- Space Saving 8-Pin DFN (3x3 mm) Package

### Typical Applications

- Personal Computers and Servers
- Hard Disk Drives and Other PC Peripherals
- Entertainment Systems
- Office Equipment
- Datacom Equipment
- Mobile Phones
- General Purpose Temperature Monitoring

### Package Types



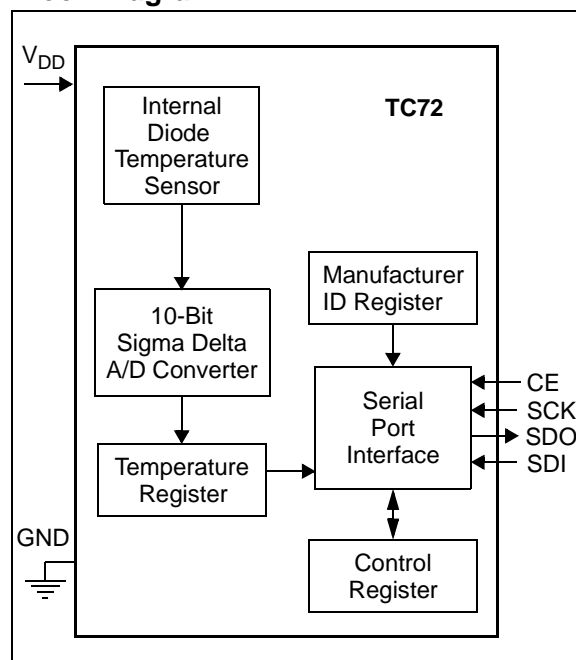
### General Description

TC72 is a digital temperature sensor capable of reading temperatures from  $-55^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$ . This sensor features a serial interface that allows communication with a host controller or other peripherals. The TC72 interface is compatible with the SPI protocol, and does not require any additional external components. However, it is recommended that a decoupling capacitor of 0.01  $\mu\text{F}$  to 0.1  $\mu\text{F}$  be provided between the V<sub>DD</sub> and GND pins.

TC72 can be used either in a Continuous Temperature Conversion mode or a One-Shot Conversion mode. The Continuous Conversion mode measures the temperature approximately every 150 ms and stores the data in the temperature registers. In contrast, the One-Shot mode performs a single temperature measurement and returns to the power saving shutdown mode.

TC72 features high temperature accuracy, ease-of-use and is the ideal solution for implementing thermal management in a variety of systems. The device is available in both 8-pin MSOP and 8-pin DFN space-saving packages. TC72 also features a Shutdown mode for low power operation.

### Block Diagram



# TC72

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NOTES:

## 1.0 ELECTRICAL CHARACTERISTICS

### 1.1 Maximum Ratings†

|  |                                |
|--|--------------------------------|
| V <sub>DD</sub> .....                  | 6.0V                           |
| All inputs and outputs w.r.t. GND ...  | -0.3V to V <sub>DD</sub> +0.3V |
| Storage temperature .....              | -65°C to +150°C                |
| Ambient temp. with power applied ..... | -55°C to +125°C                |
| Junction Temperature .....             | 150°C                          |
| ESD protection on all pins:            |                                |
| Human Body Model (HBM).....            | > 4 kV                         |
| Man Machine Model (MM).....            | > 400V                         |
| Latch-Up Current at each pin .....     | ±200 mA                        |
| Maximum Power Dissipation.....         | 250 mW                         |

† **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 operation 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 noted, all parameters apply at V <sub>DD</sub> = 2.65V to 5.5V, T <sub>A</sub> = -55°C to +125°C. |                     |                     |     |                     |       |   |
|---|---------------------|---------------------|-----|---------------------|-------|---|
| Parameters  | Sym                 | Min                 | Typ | Max                 | Units | Conditions  |
| <b>Power Supply</b>   |                     |                     |     |                     |       |   |
| Operating Voltage Range   | V <sub>DD</sub>     | 2.65                | —   | 5.5                 | V     | <a href="#">Note 1</a>                                      |
| Operating Current:<br>Normal Mode, ADC Active   | I <sub>DD-CON</sub> | —                   | 250 | 400                 | µA    | Continuous Temperature Conversion mode (Shutdown Bit = '0') |
| Shut-Down Supply Current  | I <sub>SHD</sub>    | —                   | 0.1 | 1.0                 | µA    | Shutdown mode (Shutdown Bit = '1')                          |
| <b>Temperature Sensor and Analog-to-Digital Converter</b>   |                     |                     |     |                     |       |   |
| Temperature Accuracy<br><a href="#">(Note 1)</a>  | T <sub>ACY</sub>    | -2.0                | —   | +2.0                | °C    | -40°C < T <sub>A</sub> < +85°C                              |
|   |                     | -3.0                | —   | +3.0                |       | -55°C < T <sub>A</sub> < +125°C                             |
| Resolution  |                     | —                   | 10  | —                   | Bits  | <a href="#">Note 4</a>                                      |
| ADC Conversion Time   | t <sub>CONV</sub>   | —                   | 150 | 200                 | ms    |   |
| <b>Digital Input / Output</b>   |                     |                     |     |                     |       |   |
| High Level Input Voltage  | V <sub>IH</sub>     | 0.7 V <sub>DD</sub> | —   | —                   | V     |   |
| Low Level Input Voltage   | V <sub>IL</sub>     | —                   | —   | 0.2 V <sub>DD</sub> | V     |   |
| High Level Output Voltage   | V <sub>OH</sub>     | 0.7 V <sub>DD</sub> | —   | —                   | V     | I <sub>OH</sub> = 1 mA                                      |
| Low Level Output Voltage  | V <sub>OL</sub>     | —                   | —   | 0.2 V <sub>DD</sub> | V     | I <sub>OL</sub> = 4 mA                                      |
| Input Resistance  | R <sub>IN</sub>     | 1.0                 | —   | —                   | MΩ    |   |
| Pin Capacitance   | C <sub>IN</sub>     | —                   | 15  | —                   | pF    |   |
|   | C <sub>OUT</sub>    | —                   | 50  | —                   |       |   |

**Note 1:** The TC72-2.8MXX, TC72-3.3MXX and TC72-5.0MXX will operate from a supply voltage of 2.65V to 5.5V. However, the TC72-2.8MXX, TC72-3.3MXX and TC72-5.0MXX are tested and specified at the nominal operating voltages of 2.8V, 3.3V and 5.0V respectively. As V<sub>DD</sub> varies from the nominal operating value, the accuracy may be degraded. Refer to [Figure 2-5](#) and [Figure 2-6](#).

**2:** Measured with a load of C<sub>L</sub> = 50 pF on the SDO output pin of the TC72.

**3:** All time measurements are measured with respect to the 50% point of the signal, except for the SCK rise and fall times. The rise and fall times are defined as the 10% to 90% transition time.

**4:** Resolution = Temperature Range/No. of Bits = (+127°C – -128°C) / (2<sup>10</sup>) = 256/1024 = 0.25°C/Bit

# TC72

## DC CHARACTERISTICS (CONTINUED)

**Electrical Specifications:** Unless otherwise noted, all parameters apply at  $V_{DD} = 2.65V$  to  $5.5V$ ,  $T_A = -55^{\circ}C$  to  $+125^{\circ}C$ .

| Parameters                               | Sym       | Min | Typ | Max | Units | Conditions |
|--|-----------|-----|-----|-----|-------|------------|
| <b>Serial Port AC Timing (Note 2, 3)</b> |           |     |     |     |       |            |
| Clock Frequency                          | $f_{CLK}$ | DC  | —   | 7.5 | MHz   |            |
| SCK Low Time                             | $t_{CL}$  | 65  | —   | —   | ns    |            |
| SCK High Time                            | $t_{CH}$  | 65  | —   | —   | ns    |            |
| CE to SCK Setup                          | $t_{CC}$  | 400 | —   | —   | ns    |            |
| SCK to Data Out Valid                    | $t_{CDD}$ | —   | —   | 55  | ns    |            |
| CE to Output Tri-state                   | $t_{CDZ}$ | —   | —   | 40  | ns    |            |
| SCK to Data Hold Time                    | $t_{CDH}$ | 35  | —   | —   | ns    |            |
| Data to SCK Set-up Time                  | $t_{DC}$  | 35  | —   | —   | ns    |            |
| SCK to CE Hold Time                      | $t_{CCH}$ | 100 | —   | —   | ns    |            |
| SCK Rise Time                            | $t_R$     | —   | —   | 200 | ns    |            |
| SCK Fall Time                            | $t_F$     | —   | —   | 200 | ns    |            |
| CE Inactive Time                         | $t_{CWH}$ | 400 | —   | —   | ns    |            |

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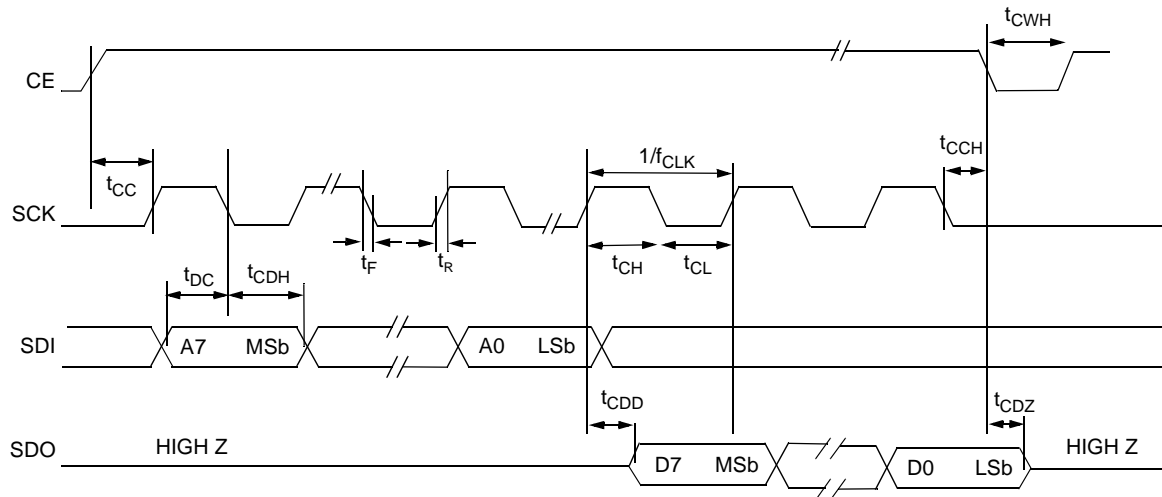
## TEMPERATURE SPECIFICATION

**Electrical Specifications:** Unless otherwise noted, all parameters apply at  $V_{DD} = 2.65V$  to  $5.5V$ ,  $T_A = -55^{\circ}C$  to  $+125^{\circ}C$ .

| Parameters                         | Sym           | Min | Typ  | Max  | Units         | Conditions |
|------------------------------------|---------------|-----|------|------|---------------|------------|
| <b>Temperature Ranges</b>          |               |     |      |      |               |            |
| Specified Temperature Range        | $T_A$         | -55 | —    | +125 | $^{\circ}C$   |            |
| Operating Temperature Range        | $T_A$         | -55 | —    | +125 | $^{\circ}C$   |            |
| Storage Temperature Range          | $T_A$         | -65 | —    | +150 | $^{\circ}C$   |            |
| <b>Thermal Package Resistances</b> |               |     |      |      |               |            |
| Thermal Resistance 8-L 3x3 DFN     | $\theta_{JA}$ | —   | 56.7 | —    | $^{\circ}C/W$ |            |
| Thermal Resistance 8-L MSOP        | $\theta_{JA}$ | —   | 211  | —    | $^{\circ}C/W$ |            |

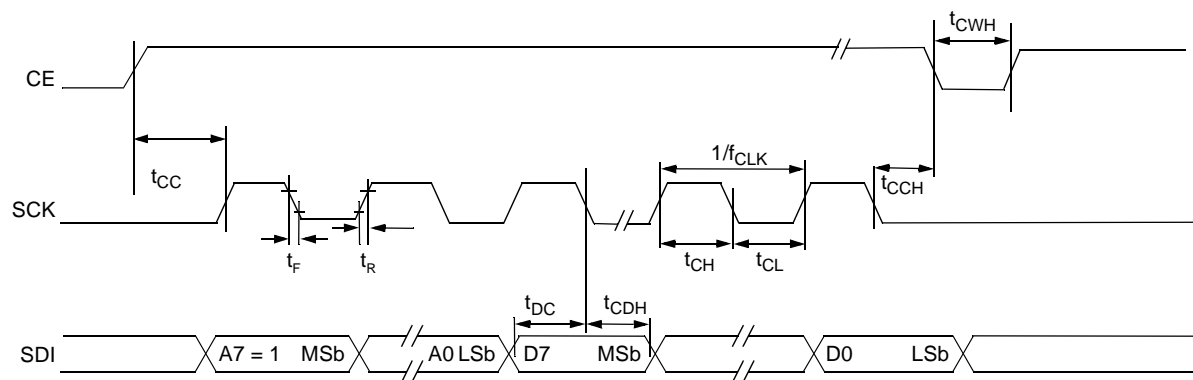
## SPI READ DATA TRANSFER

(CP = 0, data shifted on rising edge of SCK, data clocked on falling edge of SCK, A7 = 0)



## SPI WRITE DATA TRANSFER

(CP = 0, data shifted on rising edge of SCK, data clocked on falling edge of SCK, A7 = 1)



**Note:** The timing diagram is drawn with CP = 0. The TC72 also functions with CP = 1; however, the edges of SCK are reversed as defined in [Table 4-3](#) and [Figure 4-2](#).

**FIGURE 1-1:** Serial Port Timing Diagrams.

# TC72

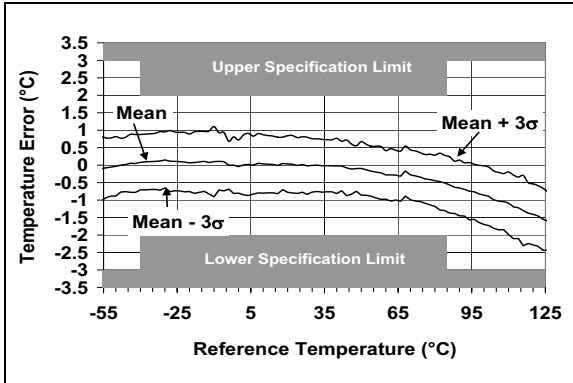
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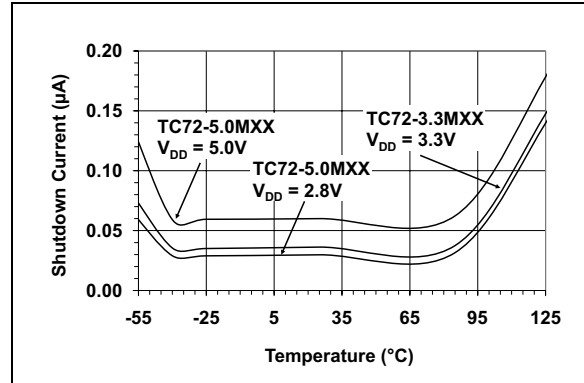
## 2.0 TYPICAL PERFORMANCE CURVES

**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.

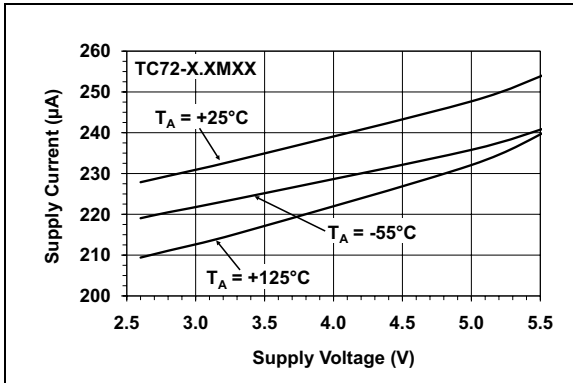
**Note:** Unless otherwise indicated, all parameters apply at  $V_{DD} = 2.65V$  to  $5.5V$ ,  $T_A = -55^{\circ}C$  to  $+125^{\circ}C$ .



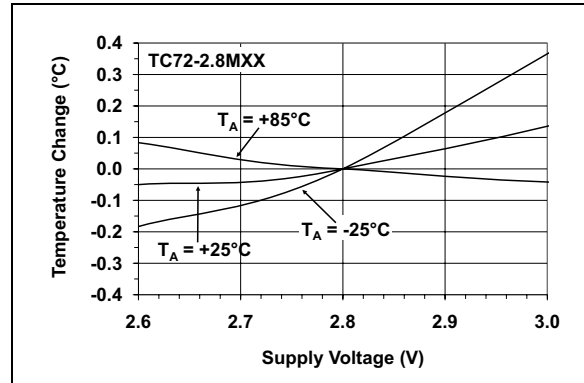
**FIGURE 2-1:** Accuracy vs. Temperature (TC72-X.XMXX).



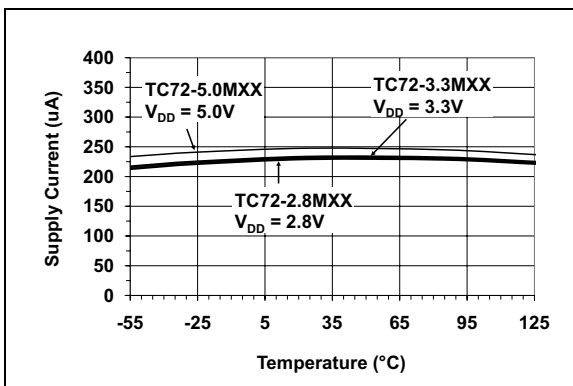
**FIGURE 2-4:** Shutdown Current vs. Temperature.



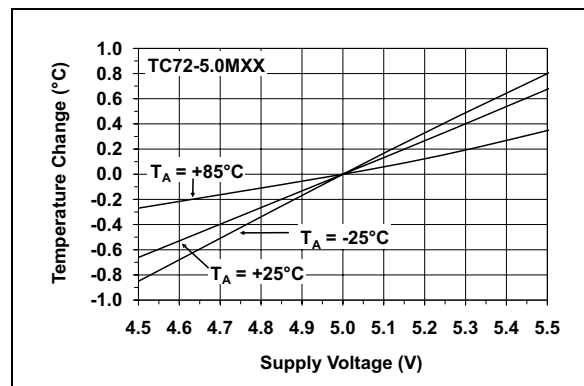
**FIGURE 2-2:** Supply Current vs. Supply Voltage.



**FIGURE 2-5:** Temperature Accuracy vs. Supply Voltage (TC72-2.8MXX).



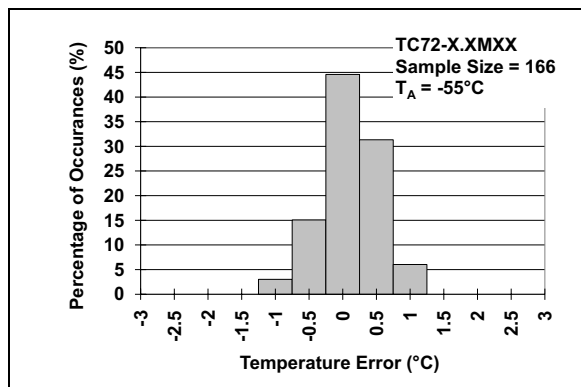
**FIGURE 2-3:** Supply Current vs. Temperature.



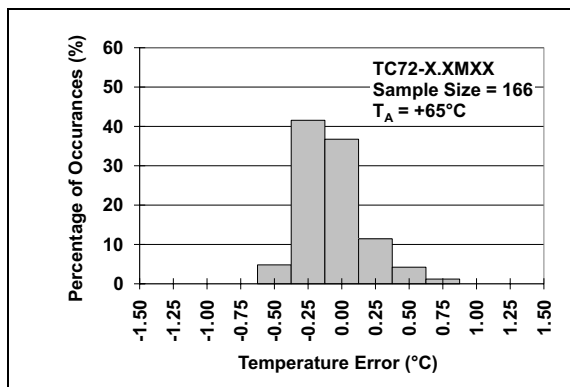
**FIGURE 2-6:** Temperature Accuracy vs. Supply Voltage (TC72-5.0MXX).

# TC72

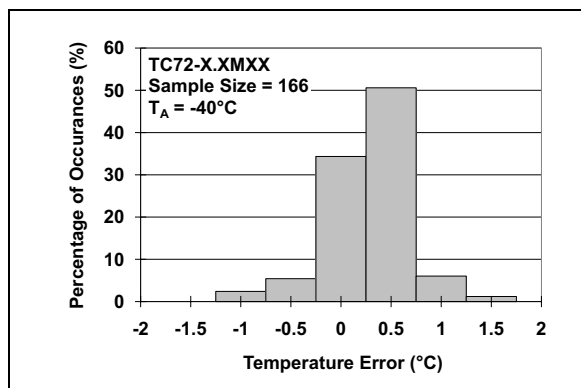
**Note:** Unless otherwise indicated, all parameters apply at  $V_{DD} = 2.65V$  to  $5.5V$ ,  $T_A = -55^{\circ}C$  to  $+125^{\circ}C$ .



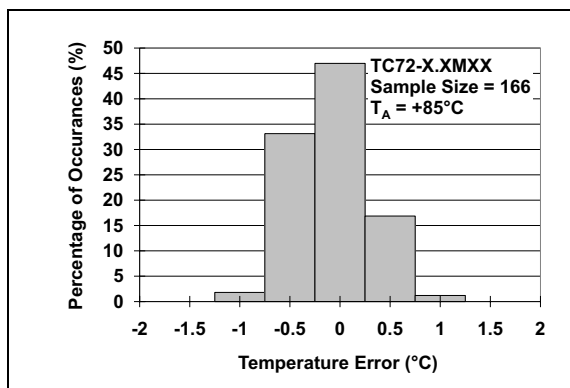
**FIGURE 2-7:** Histogram of Temperature Accuracy at -55 Degrees C.



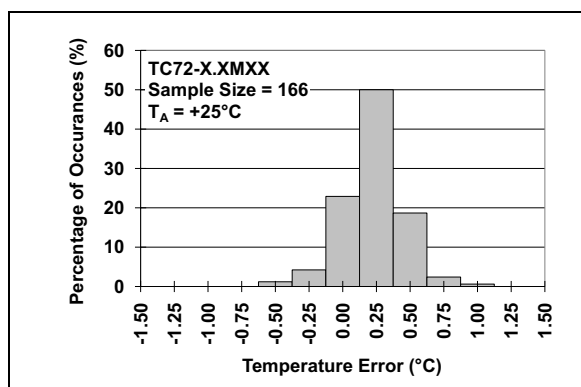
**FIGURE 2-10:** Histogram of Temperature Accuracy at +65 Degrees C.



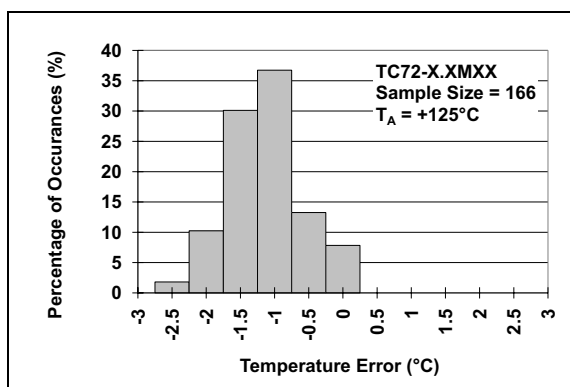
**FIGURE 2-8:** Histogram of Temperature Accuracy at -40 Degrees C.



**FIGURE 2-11:** Histogram of Temperature Accuracy at +85 Degrees C.



**FIGURE 2-9:** Histogram of Temperature Accuracy at +25 Degrees C.



**FIGURE 2-12:** Histogram of Temperature Accuracy at +125 Degrees C.



## 3.0 PIN DESCRIPTION

Pin functionalities are described in [Table 3-1](#).

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

| TC72    |      | Symbol          | Function  |
|---------|------|-----------------|---|
| 3x3 DFN | MSOP |                 |   |
| 1       | 1    | NC              | No internal connection  |
| 2       | 3    | SCK             | Serial Clock input  |
| 3       | 2    | CE              | Chip Enable input, the device is selected when this input is high |
| 4       | 4    | GND             | Ground  |
| 5       | 6    | SDI             | Serial Data input   |
| 6       | 5    | SDO             | Serial Data output  |
| 7       | 7    | NC              | No internal connection  |
| 8       | 8    | V <sub>DD</sub> | Power supply  |
| 9       | —    | EP              | Exposed pad (Ground)  |

### 3.1 No Connection (NC)

This pin is not internally connected to the die.

### 3.2 Serial Clock Input (SCK)

The SCK pin is an Input pin. All communication and timing is relative to the signal on this pin. The clock is generated by the host controller on the SPI bus (see [Section 4.3 “Serial Bus Interface”](#)).

### 3.3 Chip Enable Input (CE)

The CE is a Chip Enable pin. This is an active high input, therefore the device is enabled when CE is toggled to V<sub>DD</sub>. Once the device is enabled, all serial communication begins (see [Section 4.3 “Serial Bus Interface”](#)).

### 3.4 Ground (GND)

The GND is the system Ground pin.

### 3.5 Serial Data Input (SDI)

The SDI is a Data Input pin, used to transmit data from the host to the device (see [Section 4.3 “Serial Bus Interface”](#)).

### 3.6 Serial Data Output (SDO)

The SDO is a Data Output pin, used to transmit data from the device to the host (see [Section 4.3 “Serial Bus Interface”](#)).

### 3.7 Power Supply (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.

### 3.8 Exposed 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.

# TC72

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NOTES:

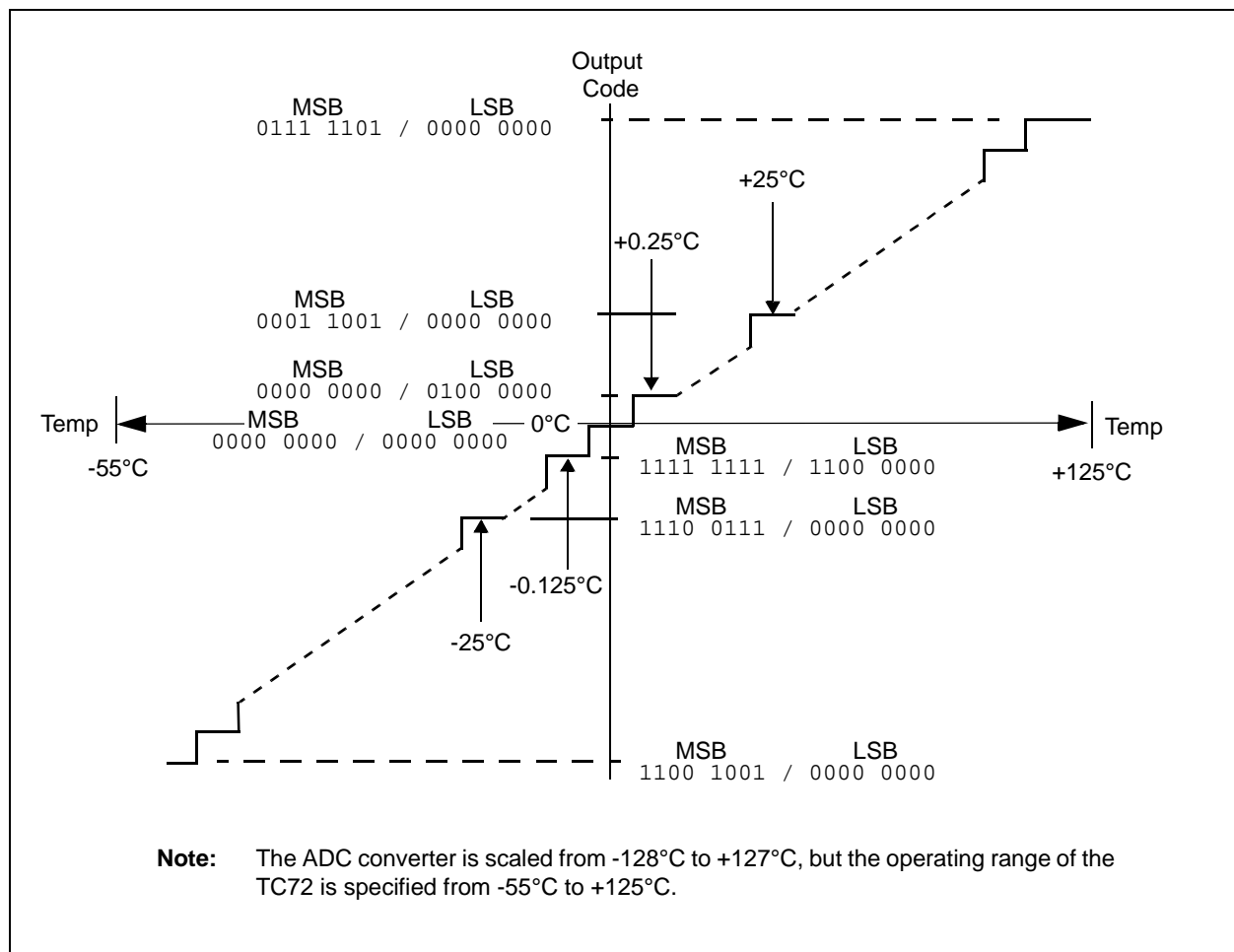
## 4.0 FUNCTIONAL DESCRIPTION

TC72 consists of a band-gap type temperature sensor, a 10-bit Sigma Delta Analog-to-Digital Converter (ADC), an internal conversion oscillator and a double buffer digital output port. The 10-bit ADC is scaled from  $-128^{\circ}\text{C}$  to  $+127^{\circ}\text{C}$ ; therefore, the resolution is  $0.25^{\circ}\text{C}$  per bit. The ambient temperature operating range of the TC72 is specified from  $-55^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$ .

This device features a four-wire serial interface that is fully compatible with the SPI specification and, therefore, allows simple communications with common microcontrollers and processors. TC72 can be used either in a Continuous Temperature Conversion mode or a One-Shot Conversion mode. TC72 temperature measurements are performed in the background and, therefore, reading the temperature via the serial I/O lines does not affect the measurement in progress.

The Continuous Conversion mode measures the temperature approximately every 150 ms and stores the data in the temperature registers. TC72 has an internal clock generator that controls the automatic temperature conversion sequence. The automatic temperature sampling operation is repeated indefinitely until TC72 is placed in Shutdown mode by a write operation to the Control register. TC72 will remain in Shutdown mode until the shutdown bit in the Control register is reset.

In contrast, the One-Shot mode performs a single temperature measurement and returns to the power-saving shut down mode. This mode is especially useful for low power applications.



**FIGURE 4-1:** Temperature-To-Digital Transfer Function (Non-Linear Scale).

## 4.1 Temperature Data Format

Temperature data is represented by a 10-bit two's complement word with a resolution of 0.25°C per bit. The temperature data is stored in the Temperature registers in a two's complement format. The ADC converter is scaled from -128°C to +127°C, but the operating range of TC72 is specified from -55°C to +125°C.

### EXAMPLE 4-1:

|                          |   |                            |
|--------------------------|---|----------------------------|
| Temperature              | = | +41.5°C                    |
| MSB Temperature Register | = | 00101001b                  |
|                          | = | $2^5 + 2^3 + 2^0$          |
|                          | = | 32 + 8 + 1 = 41            |
| LSB Temperature Register | = | 10000000b = $2^{-1} = 0.5$ |

**TABLE 4-1: TC72 TEMPERATURE OUTPUT DATA**

| Temperature | Binary MSB / LSB    | Hex  |
|-------------|---------------------|------|
| +125°C      | 0111 1101/0000 0000 | 7D00 |
| +25°C       | 0001 1001/0000 0000 | 1900 |
| +0.5°C      | 0000 0000/1000 0000 | 0080 |
| +0.25°C     | 0000 0000/0100 0000 | 0040 |
| 0°C         | 0000 0000/0000 0000 | 0000 |
| -0.25°C     | 1111 1111/1100 0000 | FFC0 |
| -25°C       | 1110 0111/0000 0000 | E700 |
| -55°C       | 1100 1001/0000 0000 | C900 |

**TABLE 4-2: TEMPERATURE REGISTER**

| D7       | D6       | D5    | D4    | D3    | D2    | D1    | D0    | Address/ Register |
|----------|----------|-------|-------|-------|-------|-------|-------|-------------------|
| Sign     | $2^6$    | $2^5$ | $2^4$ | $2^3$ | $2^3$ | $2^1$ | $2^0$ | 02H<br>Temp. MSB  |
| $2^{-1}$ | $2^{-2}$ | 0     | 0     | 0     | 0     | 0     | 0     | 01H<br>Temp. LSB  |

## 4.2 Power-Up And Power-Down

TC72 is in low-power consumption Shutdown mode at power-up. The Continuous Temperature Conversion mode is selected by performing a Write operation to the Control register, as described in [Section 5.0 "Internal Register Structure"](#).

A supply voltage lower than 1.6V (typical) is considered a power-down state for TC72. If the supply voltage drops below the 1.6V threshold, the internal registers are reset to the power-up default state.

## 4.3 Serial Bus Interface

The serial interface consists of the Chip Enable (CE), Serial Clock (SCK), Serial Data Input (SDI) and Serial Data Output (SDO) signals. TC72 operates as a slave and is compatible with the SPI bus specifications. The serial interface is designed to be compatible with the Microchip PIC® family of microcontrollers.

The CE input is used to select TC72 when multiple devices are connected to the serial clock and data lines. The CE is active-high, and data is written to or read from the device, when CE is equal to a logic high voltage. The SCK input is disabled when CE is low. The rising edge of the CE line initiates a read or write operation, while the falling edge of CE completes a read or write operation.

The SCK input is provided by the external microcontroller and is used to synchronize the data on the SDI and SDO lines. The SDI input writes data into TC72's Control register, while the SDO outputs the temperature data from the Temperature register and the status of Shutdown bit of the Control register.

TC72 has the capability to function with either an active-high or low SCK input. The SCK inactive state is detected when the CE signal goes high, while the polarity of the clock input (CP) determines whether the data is clocked and shifted on either the rising or falling edge of the system clock, as shown in [Figure 4-2](#). [Table 4-3](#) gives the appropriate clock edge used to transfer data into and out of the registers. Each data bit is transferred at each clock pulse, and the data bits are clocked in groups of eight bits, as shown in [Figure 4-3](#).

The address byte is transferred first, followed by the data. A7, the MSb of the address, determines whether a read or write operation will occur. If A7 = '0', one or more read cycles will occur; otherwise, if A7 = '1', one or more write cycles will occur.

Data can be transferred either in a single byte or a multi-byte packet, as shown in [Figure 4-3](#). In the 3-byte packet, the data sequence consists of the MSb temperature data, LSb temperature data, followed by the Control register data. The multi-byte read feature is initiated by writing the highest address of the desired packet to registers. TC72 will automatically send the register addressed and all of the lower address registers, as long as the Chip Enable pin is held active.

**TABLE 4-3: OPERATIONAL MODES**

| Mode           | CE | SCK (Note 1)   | SDI            | SDO                                   |
|----------------|----|--|----------------|---------------------------------------|
| Disable        | L  | Input Disabled   | Input Disabled | High Z                                |
| Write (A7 = 1) | H  | CP=1, Data Shifted on Falling Edge,<br>Data Clocked on Rising Edge | Data Bit Latch | High Z                                |
|                |    | CP=0, Data Shifted on Rising Edge,<br>Data Clocked on Falling Edge |                |                                       |
| Read (A7 = 0)  | H  | CP=1, Data Shifted on Falling Edge,<br>Data Clocked on Rising Edge | X              | Next data bit shift,<br><b>Note 2</b> |
|                |    | CP=0, Data Shifted on Rising Edge,<br>Data Clocked on Falling Edge |                |                                       |

**Note 1:** CP is the Clock Polarity of the microcontroller system clock. If the inactive state of SCK is logic level high, CP is equal to '1'; otherwise, if the inactive state of SCK is low, CP is equal to '0'.

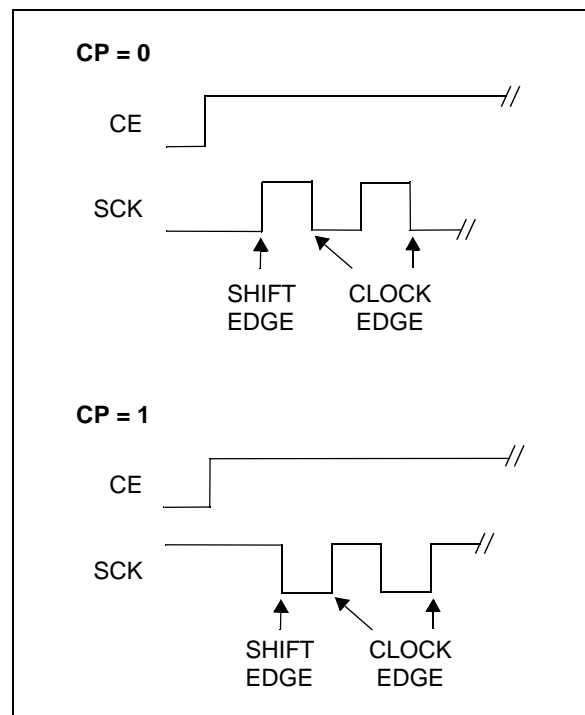
**2:** During a Read operation, SDO remains at a high impedance (High Z) level until the eight bits of data begin to be shifted out of the Temperature register.

## 4.4 Read Operation

The TC72 uses the CE, SCK and SDO lines to output the Temperature and Control register data. [Figure 4-3](#) shows a timing diagram of the read operation. Communication is initiated by the chip enable (CE) going high. The SDO line remains at the voltage level of the LSb bit that is output and goes to the tri-state level when the CE line goes to a logic low level.

## 4.5 Write Operation

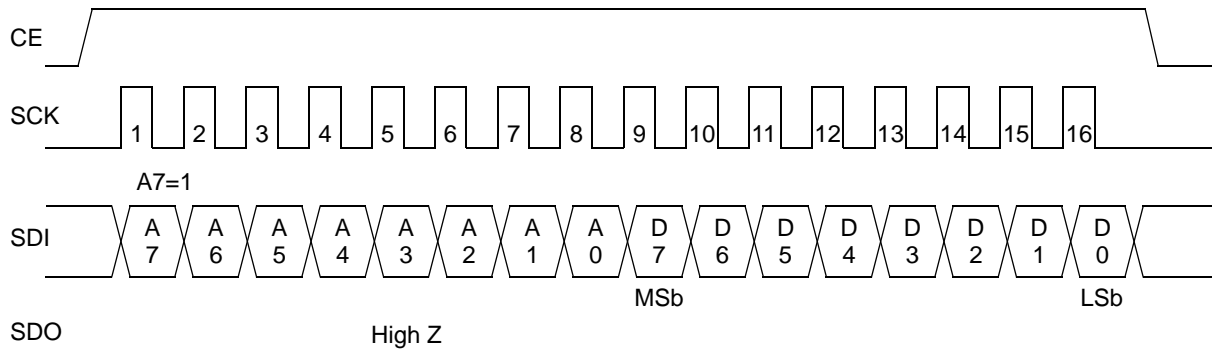
Data is clocked into the Control register in order to enable TC72's power saving shutdown mode. The write operation is shown in [Figure 4-3](#) and is accomplished using the CE, SCK and SDI lines.



**FIGURE 4-2:** Serial Clock Polarity (CP) Operation.

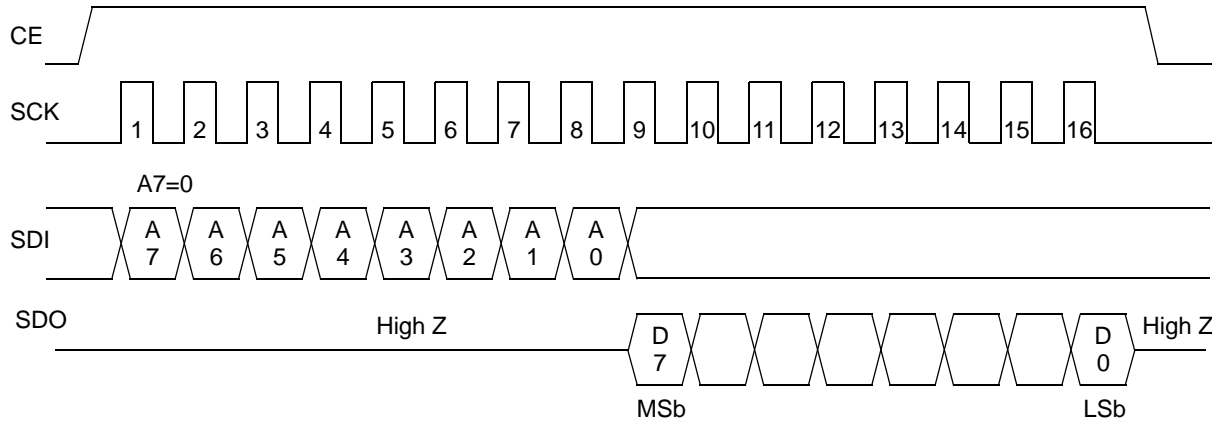
## Single Byte Write Operation

(CP=0, data shifted on rising edge of SCK, data clocked on falling edge of SCK, A7=1)

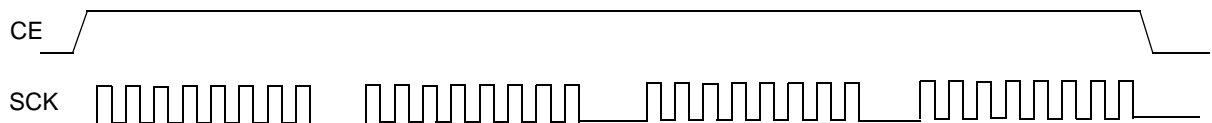


## Single Byte Read Operation

(CP=0, data shifted on rising edge of SCK, data clocked on falling edge of SCK, A7=0)

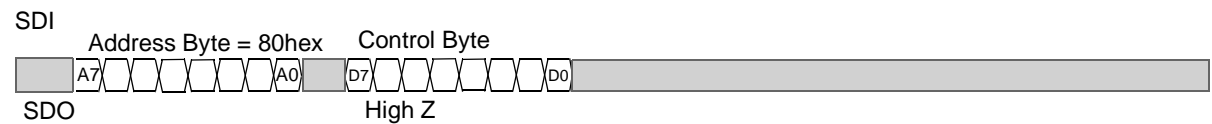


## SPI Multiple Byte Transfer



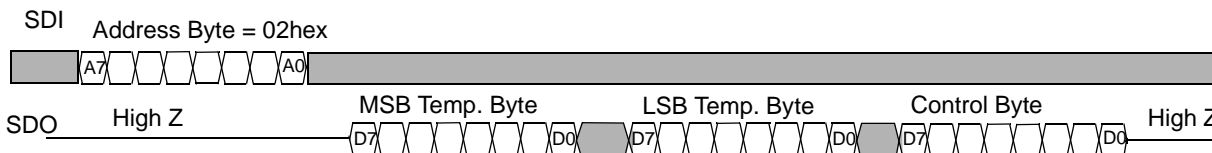
### Write Operation

(CP=0, data shifted on rising edge of SCK, data clocked on falling edge of SCK, A7=1)



### Read Operation

(CP=0, data shifted on rising edge of SCK, data clocked on falling edge of SCK, A7=0)



**FIGURE 4-3:** Serial Interface Timing Diagrams (CP=0).

## 5.0 INTERNAL REGISTER STRUCTURE

TC72 registers are listed below.

**TABLE 5-1: REGISTERS FOR TC72**

| Register        | Read Address | Write Address | Bit 7 | Bit 6 | Bit 5 | Bit 4         | Bit 3 | Bit 2 | Bit 1 | Bit 0           | Value on POR/BOR |
|-----------------|--------------|---------------|-------|-------|-------|---------------|-------|-------|-------|-----------------|------------------|
| Control         | 00hex        | 80hex         | 0     | 0     | 0     | One-Shot (OS) | 0     | 1     | 0     | Shutdown (SHDN) | 05hex            |
| LSB Temperature | 01hex        | N/A           | T1    | T0    | 0     | 0             | 0     | 0     | 0     | 0               | 00hex            |
| MSB Temperature | 02hex        | N/A           | T9    | T8    | T7    | T6            | T5    | T4    | T3    | T2              | 00hex            |
| Manufacturer ID | 03hex        | N/A           | 0     | 1     | 0     | 1             | 0     | 1     | 0     | 0               | 54hex            |

### 5.1 Control Register

The Control register is both a read and a write register that is used to select either the Shutdown, Continuous or One-Shot Conversion operating mode. The Temperature Conversion mode selection logic is shown in [Table 5-2](#). The Shutdown (SHDN) bit is stored in bit 0 of the Control register. If SHDN is equal to '1', TC72 will go into power-saving Shutdown mode. If SHDN is equal to '0', TC72 will perform a temperature conversion approximately every 150 ms.

At power-up, the SHDN bit is set to '1'. Thus, TC72 is in Shutdown operating mode at startup. Continuous Temperature Conversion mode is selected by writing a '0' to the SHDN bit of the Control register.

Shutdown mode can be used to minimize the power consumption of TC72 when active temperature monitoring is not required. The Shutdown mode disables the temperature conversion circuitry; however, the serial I/O communication port remains active. A temperature conversion will be initialized by a Write operation to the Control register to select either the Continuous Temperature Conversion or the One-Shot operating mode. The temperature data will be available in the MSB and LSB Temperature registers approximately 150 ms after the Control register Write operation.

One-Shot mode is selected by writing a '1' into bit 4 of the Control register. The One-Shot mode performs a single temperature measurement and returns to the power-saving Shutdown mode. After completion of the temperature conversion, the One-Shot bit (OS) is reset to '0' (i.e. "OFF"). The user must set the One-Shot bit to '1' to initiate another temperature conversion.

Bits 1, 3, 5, 6 and 7 of the Control register are not used by TC72. Bit 2 is set to a logic '1'. Any write operation to these bit locations will have no effect on the operation of TC72.

### 5.2 Temperature Register

The Temperature register is a read-only register and contains a 10-bit two's complement representation of the temperature measurement. Bit 0 through Bit 5 of the LSB Temperature register are always set to a logic '0'.

At Power-On Reset (POR) or a Brown-Out Reset (BOR) low voltage occurrence, the temperature register is reset to all zeroes, which corresponds to a temperature value of 0°C. A  $V_{DD}$  power supply less than 1.6V is considered a reset event and will reset the Temperature register to the power-up state.

### 5.3 Manufacturer ID Register

The Manufacturer Identification (ID) register is a read-only register used to identify the temperature sensor as a Microchip component.

**TABLE 5-2: CONTROL REGISTER TEMPERATURE CONVERSION MODE SELECTION**

| Operational Mode  | One-Shot (OS) Bit 4 | Shutdown (SHDN) Bit 0 |
|---|---------------------|-----------------------|
| Continuous Temperature Conversion   | 0                   | 0                     |
| Shutdown  | 0                   | 1                     |
| Continuous Temperature Conversion (One-Shot Command is ignored if SHDN = '0') | 1                   | 0                     |
| One-Shot  | 1                   | 1                     |

# TC72

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NOTES:



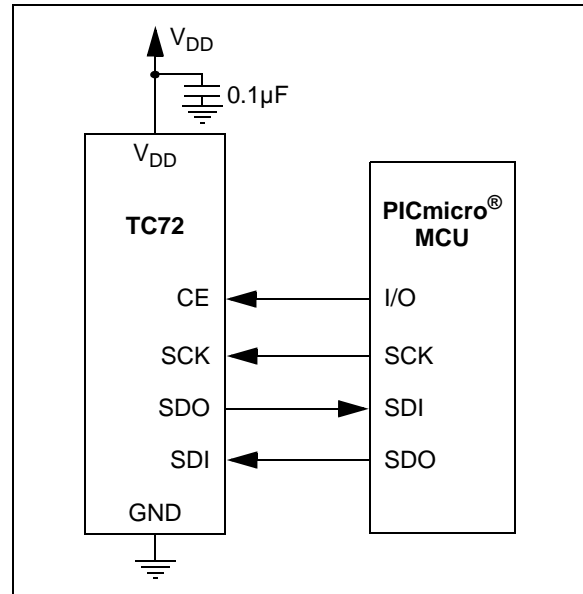
## 6.0 APPLICATIONS INFORMATION

The TC72 does not require any additional components in order to measure temperature; however, it is recommended that a decoupling capacitor of 0.1mF to 1mF be provided between the  $V_{DD}$  and GND pins. Although the current consumption of the TC72 is modest (250 mA, typical), the TC72 contains an on chip data acquisition with internal digital switching circuitry. Thus, it is considered good design practice to use an external decoupling capacitor with the sensor. A high frequency ceramic capacitor should be used and be located as close as possible to the IC power pins in order to provide effective noise protection to the TC72.

The TC72 measures temperature by monitoring the voltage of a diode located on the IC die. The IC pins of the TC72 provide a low impedance thermal path between the die and the PCB, allowing the TC72 to effectively monitor the temperature of the PCB board. The thermal path between the ambient air is not as efficient because the plastic IC housing package functions as a thermal insulator. Thus, the ambient air temperature (assuming that a large temperature gradient exists between the air and PCB) has only a small effect on the temperature measured by the TC72.

Note that the exposed metal center pad on the bottom of the DFN package is connected to the silicon substrate. The center pad should be connected to either the PCB ground plane or treated as a “No Connect” pin. The mechanical dimensions of the center pad are given in [Section 7.0 “Packaging Information”](#) of this data sheet.

A potential for self-heating errors can exist if the TC72 SPI communication lines are heavily loaded. Typically, the self-heating error is negligible because of the relatively small current consumption of the TC72. A temperature accuracy error of approximately +0.5°C will result from self-heating if the SPI communication pins sink/source the maximum current specified for the TC72. Thus, to maximize temperature accuracy, the output loading of the SPI signals should be minimized.

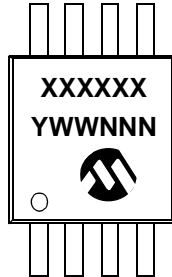


**FIGURE 6-1:** Typical Application.

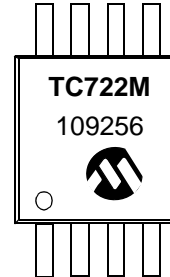
## 7.0 PACKAGING INFORMATION

### 7.1 Package Marking Information

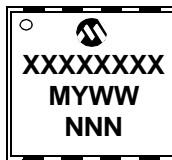
8-Lead MSOP



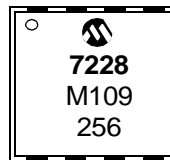
Example:



8-Lead DFN



Example:

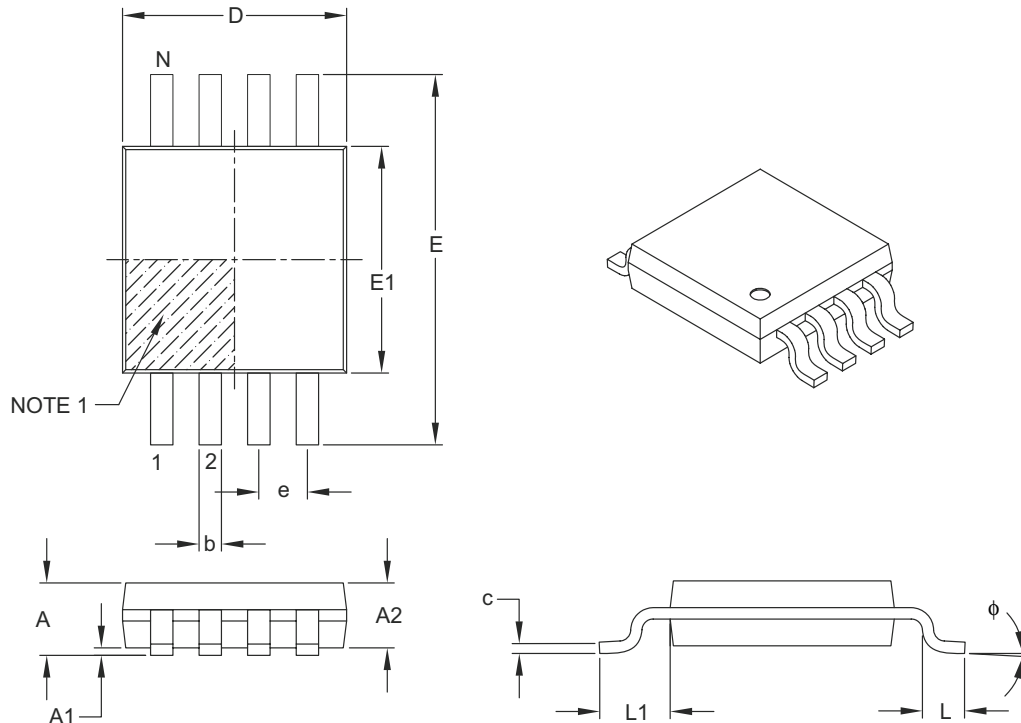


|                |        |  |
|----------------|--------|--|
| <b>Legend:</b> | XX...X | Customer-specific information  |
|                | Y      | Year code (last digit of calendar year)  |
|                | YY     | Year code (last 2 digits of calendar year)   |
|                | WW     | Week code (week of January 1 is week '01')   |
|                | NNN    | Alphanumeric traceability code   |
|                | (e3)   | Pb-free JEDEC designator for Matte Tin (Sn)  |
|                | *      | This package is Pb-free. The Pb-free JEDEC designator (e3) 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.

## 8-Lead Plastic Micro Small Outline Package (MS) [MSOP]

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



| Dimension                | Units  | MILLIMETERS |      |      |
|--------------------------|--------|-------------|------|------|
|                          |        | MIN         | NOM  | MAX  |
| Number of Pins           | N      | 8           |      |      |
| Pitch                    | e      | 0.65 BSC    |      |      |
| Overall Height           | A      | –           | –    | 1.10 |
| Molded Package Thickness | A2     | 0.75        | 0.85 | 0.95 |
| Standoff                 | A1     | 0.00        | –    | 0.15 |
| Overall Width            | E      | 4.90 BSC    |      |      |
| Molded Package Width     | E1     | 3.00 BSC    |      |      |
| Overall Length           | D      | 3.00 BSC    |      |      |
| Foot Length              | L      | 0.40        | 0.60 | 0.80 |
| Footprint                | L1     | 0.95 REF    |      |      |
| Foot Angle               | $\phi$ | 0°          | –    | 8°   |
| Lead Thickness           | c      | 0.08        | –    | 0.23 |
| Lead Width               | b      | 0.22        | –    | 0.40 |

**Notes:**

1. Pin 1 visual index feature may vary, but must be located within the hatched area.
2. Dimensions D and E1 do not include mold flash or protrusions. Mold flash or protrusions shall not exceed 0.15 mm per side.
3. Dimensioning and tolerancing per ASME Y14.5M.

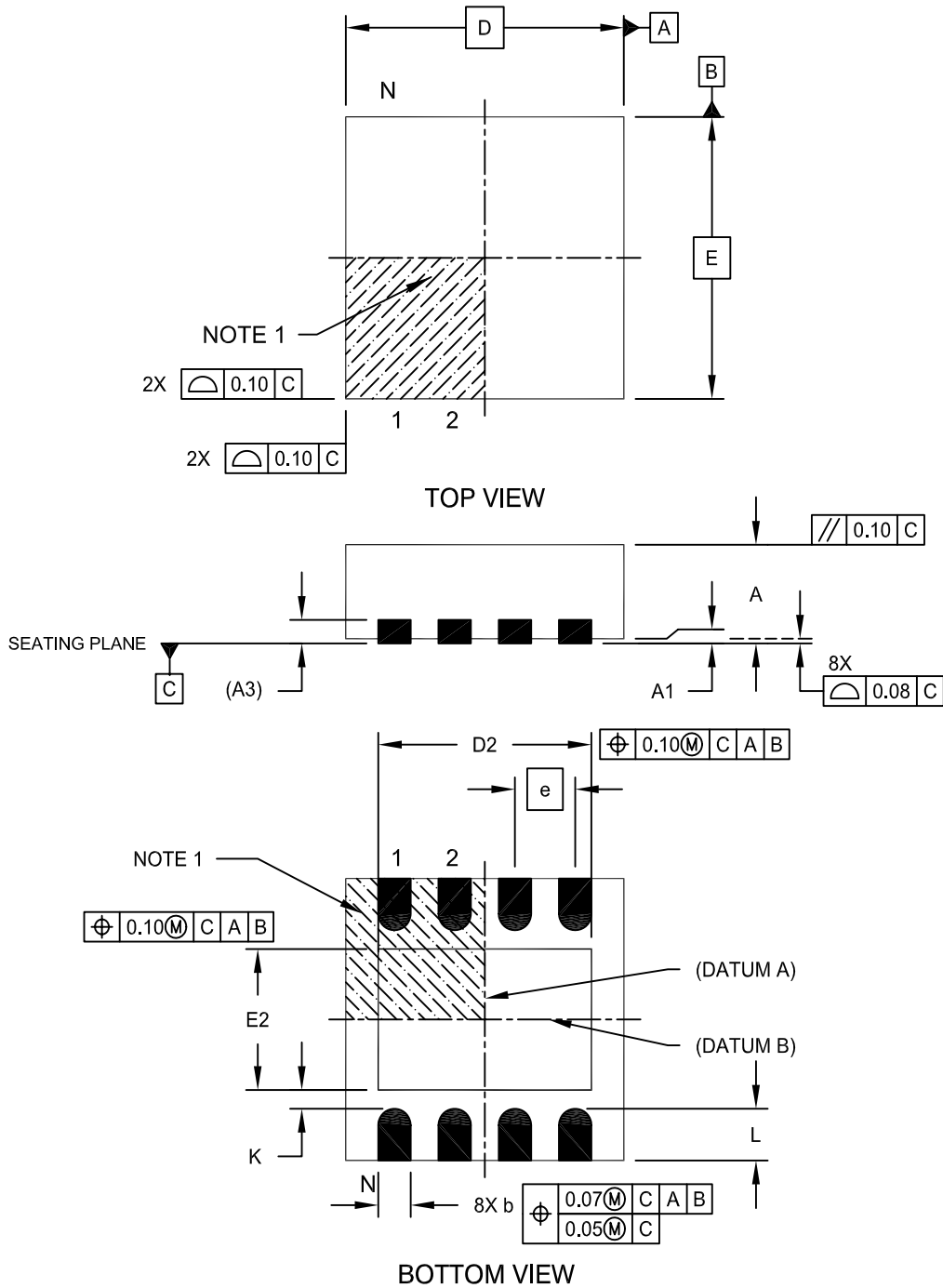
BSC: Basic Dimension. Theoretically exact value shown without tolerances.

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

Microchip Technology Drawing C04-111B

## 8-Lead Plastic Dual Flat, No Lead Package (MF) - 3x3x0.9mm Body [DFN]

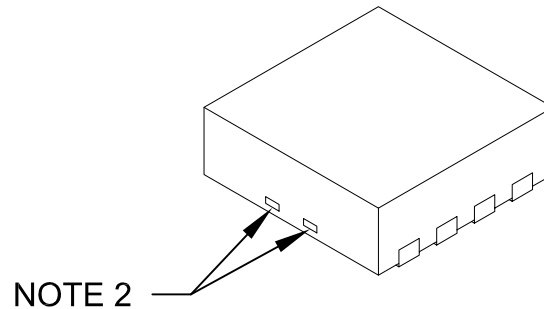
**Note:** For the most current package drawings, please see the Microchip Packaging Specification located at <http://www.microchip.com/packaging>



Microchip Technology Drawing No. C04-062C Sheet 1 of 2

## 8-Lead Plastic Dual Flat, No Lead Package (MF) - 3x3x0.9mm Body [DFN]

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



| Dimension              | Units | MILLIMETERS |      |      |
|------------------------|-------|-------------|------|------|
|                        |       | MIN         | NOM  | MAX  |
| Number of Pins         | N     | 8           |      |      |
| Pitch                  | e     | 0.65 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     | 3.00 BSC    |      |      |
| Exposed Pad Width      | E2    | 1.34        | -    | 1.60 |
| Overall Width          | E     | 3.00 BSC    |      |      |
| Exposed Pad Length     | D2    | 1.60        | -    | 2.40 |
| Contact Width          | b     | 0.25        | 0.30 | 0.35 |
| Contact Length         | L     | 0.20        | 0.30 | 0.55 |
| 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

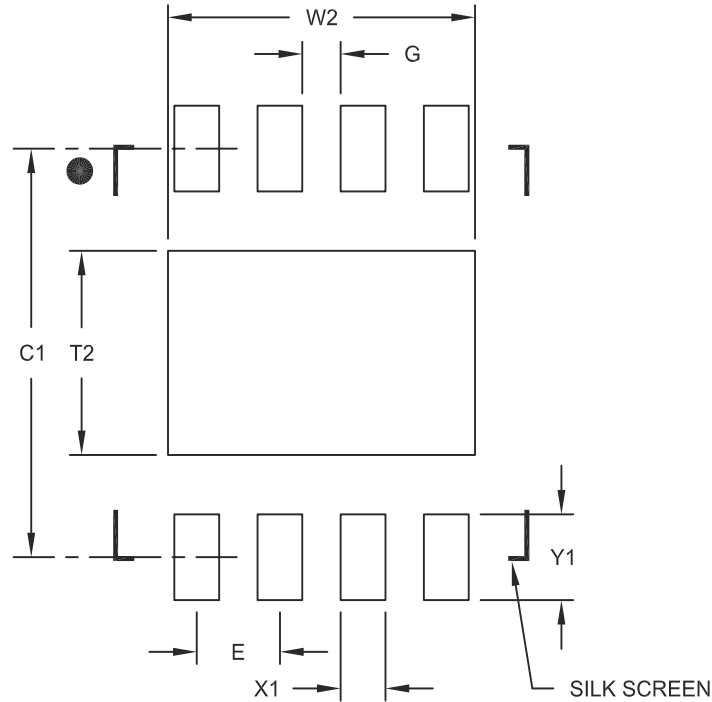
BSC: Basic Dimension. Theoretically exact value shown without tolerances.

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

Microchip Technology Drawing No. C04-062C Sheet 2 of 2

## 8-Lead Plastic Dual Flat, No Lead Package (MF) – 3x3x0.9 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

| Units                      |    | MILLIMETERS |      |      |
|----------------------------|----|-------------|------|------|
| Dimension Limits           |    | MIN         | NOM  | MAX  |
| Contact Pitch              | E  | 0.65 BSC    |      |      |
| Optional Center Pad Width  | W2 |             |      | 2.40 |
| Optional Center Pad Length | T2 |             |      | 1.55 |
| Contact Pad Spacing        | C1 |             | 3.10 |      |
| Contact Pad Width (X8)     | X1 |             |      | 0.35 |
| Contact Pad Length (X8)    | Y1 |             |      | 0.65 |
| Distance Between Pads      | G  | 0.30        |      |      |

Notes:

1. Dimensioning and tolerancing per ASME Y14.5M

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

Microchip Technology Drawing No. C04-2062A

## APPENDIX A: REVISION HISTORY

### Revision B (July 2011)

The following is the list of modifications:

1. Updated DFN pin drawing.
2. Added new chapter **Section 3.0 “PIN Description”**.
3. Moved Typical Application figure in **Section 6.0 “Applications information”** (see **Figure 6-1**).
4. Updated **Section 7.0 “Packaging Information”**

### Revision A (October 2002)

- Original data sheet for the TC72 device.

# TC72

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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>XX</u>  | <u>X</u>          | <u>XX</u> |
|---|--|-------------------|-----------|
| Device  | Voltage Range  | Temperature Range | Package   |
| <b>Device:</b> TC72: Digital Temperature Sensor w/SPI Interface<br><br><b>Voltage Range:</b> 2.8 = Accuracy Optimized for 2.8V<br>3.3 = Accuracy Optimized for 3.3V<br>5.0 = Accuracy Optimized for 5.0V<br><br><b>Temperature Range:</b> M = -55°C to +125°C<br><br><b>Package:</b> MF = Dual, Flat, No Lead (DFN) (3x3mm), 8-lead<br>MFTR = Dual, Flat, No Lead (DFN) (3x3mm), 8-lead (Tape and Reel)<br>UA = Plastic Micro Small Outline (MSOP), 8-lead<br>UATR = Plastic Micro Small Outline (MSOP), 8-lead (Tape and Reel) | <b>Examples:</b><br><br>a) TC72-2.8MUA: Digital Temperature Sensor, 2.8V, 8LD MSOP package.<br>b) TC72-2.8MUATR: Digital Temperature Sensor, 2.8V, 8LD MSOP (tape and reel) package.<br>c) TC72-2.8MMF: Digital Temperature Sensor, 2.8V, 8LD DFN package.<br>d) TC72-3.3MUA: Digital Temperature Sensor, 3.3V, 8LD MSOP package.<br>e) TC72-3.3MMF: Digital Temperature Sensor, 3.3V, 8LD DFN package.<br>f) TC72-5.0MUA: Digital Temperature Sensor, 5.0V, 8LD MSOP package.<br>g) TC72-5.0MMF: Digital Temperature Sensor, 5.0V, 8LD DFN package.<br>h) TC72-5.0MMFTR: Digital Temperature Sensor, 5.0V, 8LD DFN (tape and reel) package. |                   |           |

# TC72

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NOTES:

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**Netherlands - Drunen**  
Tel: 31-416-690399  
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**Spain - Madrid**  
Tel: 34-91-708-08-90  
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**UK - Wokingham**  
Tel: 44-118-921-5869  
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05/02/11



Компания «ЭлектроПласт» предлагает заключение долгосрочных отношений при поставках импортных электронных компонентов на взаимовыгодных условиях!

Наши преимущества:

- Оперативные поставки широкого спектра электронных компонентов отечественного и импортного производства напрямую от производителей и с крупнейших мировых складов;
- Поставка более 17-ти миллионов наименований электронных компонентов;
- Поставка сложных, дефицитных, либо снятых с производства позиций;
- Оперативные сроки поставки под заказ (от 5 рабочих дней);
- Экспресс доставка в любую точку России;
- Техническая поддержка проекта, помощь в подборе аналогов, поставка прототипов;
- Система менеджмента качества сертифицирована по Международному стандарту ISO 9001;
- Лицензия ФСБ на осуществление работ с использованием сведений, составляющих государственную тайну;
- Поставка специализированных компонентов (Xilinx, Altera, Analog Devices, Intersil, Interpoint, Microsemi, Aeroflex, Peregrine, Syfer, Eurofarad, Texas Instrument, Miteq, Cobham, E2V, MA-COM, Hittite, Mini-Circuits, General Dynamics и др.);

Помимо этого, одним из направлений компании «ЭлектроПласт» является направление «Источники питания». Мы предлагаем Вам помощь Конструкторского отдела:

- Подбор оптимального решения, техническое обоснование при выборе компонента;
- Подбор аналогов;
- Консультации по применению компонента;
- Поставка образцов и прототипов;
- Техническая поддержка проекта;
- Защита от снятия компонента с производства.



#### Как с нами связаться

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