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TC72

Digital Temperature Sensor with SPI Interface

Features

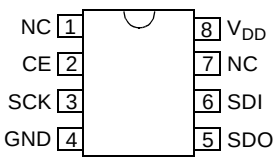
- Temperature-to-Digital Converter
- SPI Compatible Interface
- 10-Bit Resolution (0.25°C/Bit)
- ±2°C (maximum) Accuracy from -40°C to +85°C
- ±3°C (maximum) Accuracy from -55°C to +125°C
- 2.65V to 5.5V Operating Range
- Low Power Consumption:
  - 250 µA (typical) Continuous Temperature Conversion Mode
  - 1 µA (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

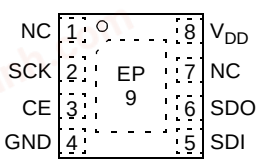
- Personal Computers and Servers
- Hard Disk Drives and Other PC Peripherals
- Entertainment Systems
- Office Equipment
- Datacom Equipment
- Mobile Phones
- General Purpose Temperature Monitoring

Package Types

TC72
MSOP



TC72
3x3 DFN*



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

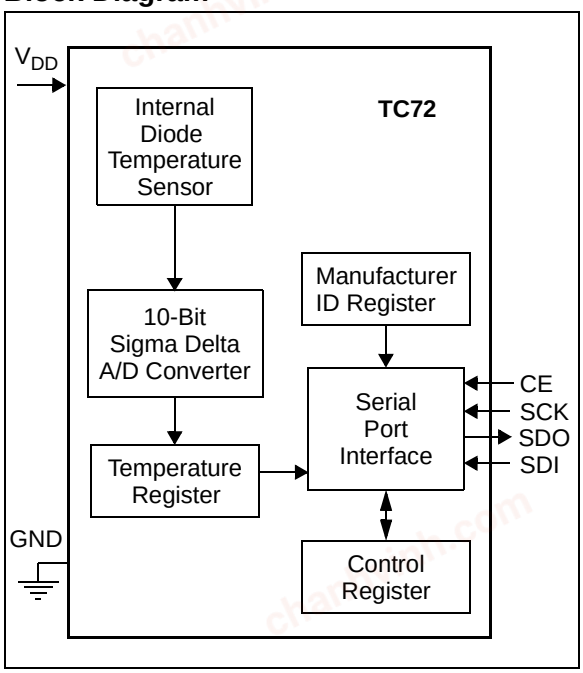
General Description

TC72 is a digital temperature sensor capable of reading temperatures from -55°C to +125°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 µF to 0.1 µF be provided between the V_{DD} 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



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NOTES:

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1.0 ELECTRICAL CHARACTERISTICS

1.1 Maximum Ratings†

V_{DD} 6.0V
All inputs and outputs w.r.t. GND ... -0.3V to V_{DD} +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_{DD} = 2.65V to 5.5V, T_A = -55°C to +125°C.

Parameters	Sym	Min	Typ	Max	Units	Conditions
Power Supply						
Operating Voltage Range	V_{DD}	2.65	—	5.5	V	**Note 1**
Operating Current: Normal Mode, ADC Active	I_{DD-CON}	—	250	400	µA	Continuous Temperature Conversion mode (Shutdown Bit = '0')
Shut-Down Supply Current	I_{SHD}	—	0.1	1.0	µA	Shutdown mode (Shutdown Bit = '1')
Temperature Sensor and Analog-to-Digital Converter						
Temperature Accuracy (**Note 1**)	T_{ACY}	-2.0	—	+2.0	°C	-40°C < T_A < +85°C
		-3.0	—	+3.0		-55°C < T_A < +125°C
Resolution		—	10	—	Bits	**Note 4**
ADC Conversion Time	t_{CONV}	—	150	200	ms	
Digital Input / Output						
High Level Input Voltage	V_{IH}	0.7 V_{DD}	—	—	V	
Low Level Input Voltage	V_{IL}	—	—	0.2 V_{DD}	V	
High Level Output Voltage	V_{OH}	0.7 V_{DD}	—	—	V	I_{OH} = 1 mA
Low Level Output Voltage	V_{OL}	—	—	0.2 V_{DD}	V	I_{OL} = 4 mA
Input Resistance	R_{IN}	1.0	—	—	MΩ	
Pin Capacitance	C_{IN}	—	15	—	pF	
	C_{OUT}	—	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_{DD} 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_L = 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^{10}) = 256/1024 = 0.25°C/Bit

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DC CHARACTERISTICS (CONTINUED)

Electrical Specifications: Unless otherwise noted, all parameters apply at V_{DD} = 2.65V to 5.5V, T_A = -55°C to +125°C.						
Parameters	**Sym**	**Min**	**Typ**	**Max**	**Units**	**Conditions**
Serial Port AC Timing (Note 2, 3)						
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	

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_{DD} 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_L = 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^{10}) = 256/1024 = 0.25°C/Bit

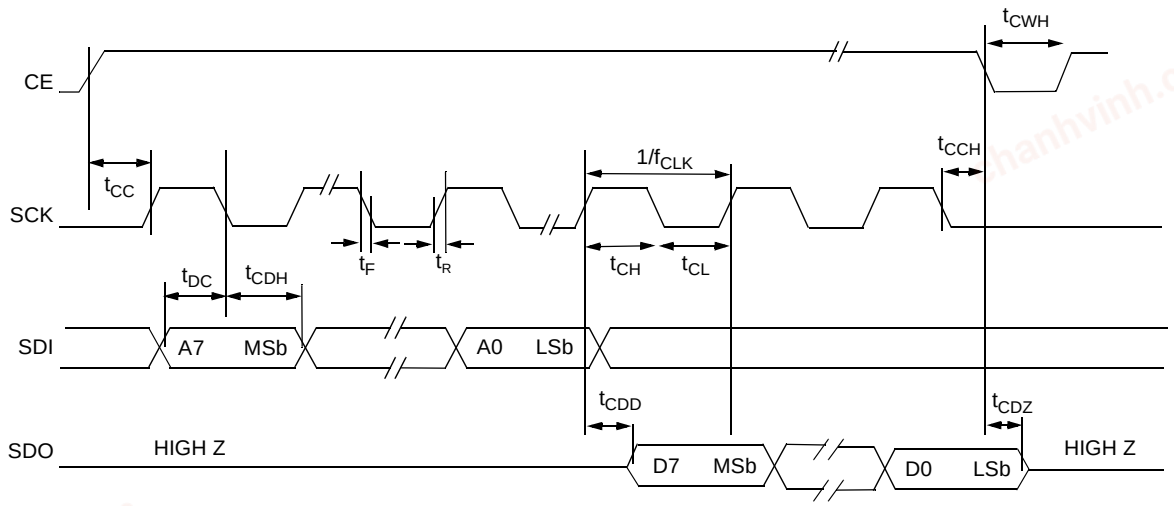
TEMPERATURE SPECIFICATION

Electrical Specifications: Unless otherwise noted, all parameters apply at V_{DD} = 2.65V to 5.5V, T_A = -55°C to +125°C.						
Parameters	**Sym**	**Min**	**Typ**	**Max**	**Units**	**Conditions**
Temperature Ranges						
Specified Temperature Range	T_A	-55	—	+125	°C	
Operating Temperature Range	T_A	-55	—	+125	°C	
Storage Temperature Range	T_A	-65	—	+150	°C	
Thermal Package Resistances						
Thermal Resistance 8-L 3x3 DFN	θ_{JA}	—	56.7	—	°C/W	
Thermal Resistance 8-L MSOP	θ_{JA}	—	211	—	°C/W	

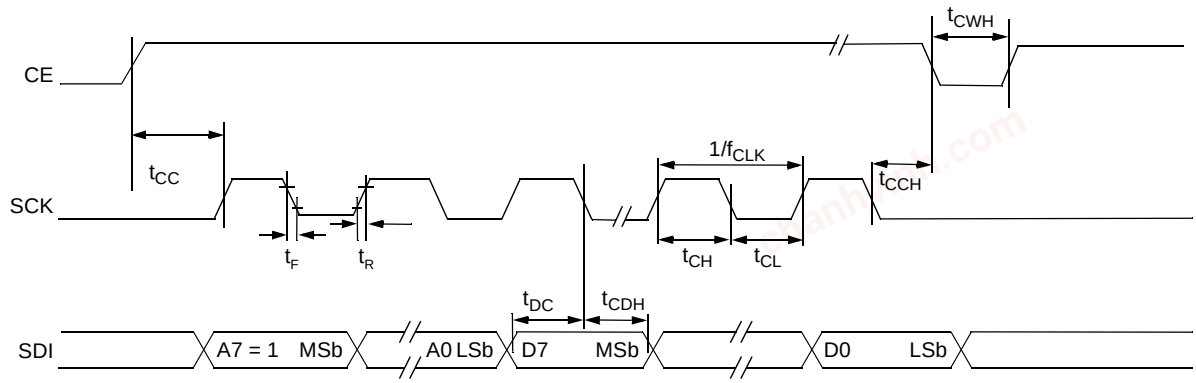
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SPI READ DATA TRANSFER
(CP = 0, data shifted on rising edge of SCK, data clocked on falling edge of SCK, A7 = 0)



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.*

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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°C to +125°C.

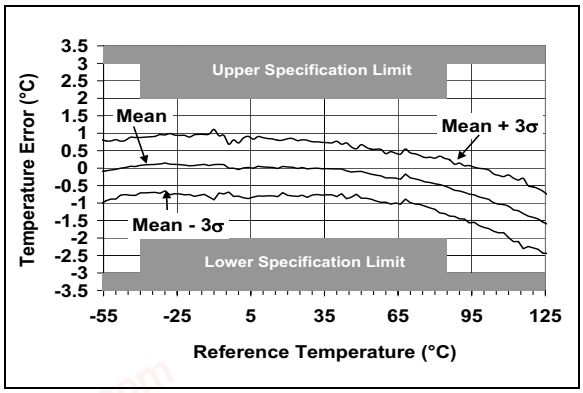


FIGURE 2-1: *Accuracy vs. Temperature (TC72-X.XMXX).*

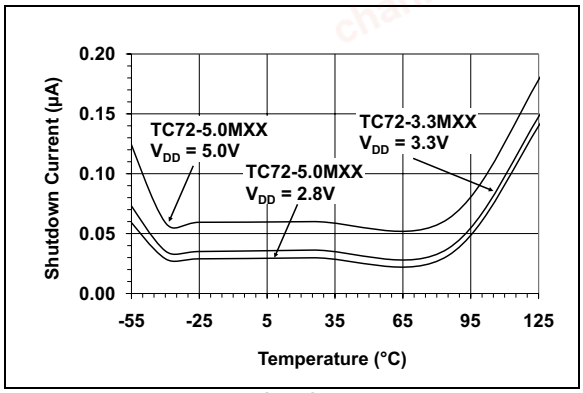


FIGURE 2-4: *Shutdown Current vs. Temperature.*

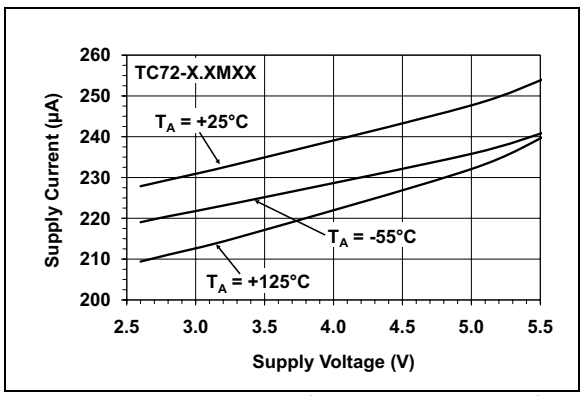


FIGURE 2-2: *Supply Current vs. Supply Voltage.*

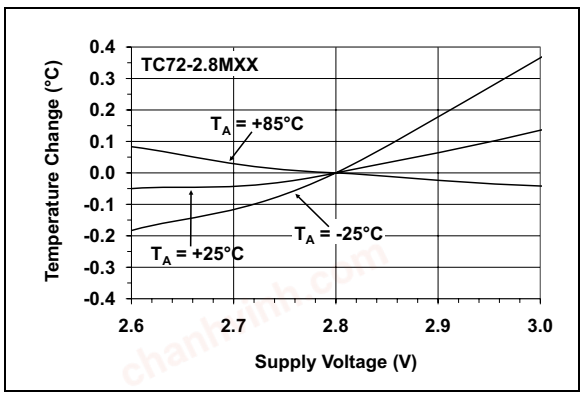


FIGURE 2-5: *Temperature Accuracy vs. Supply Voltage (TC72-2.8MXX).*

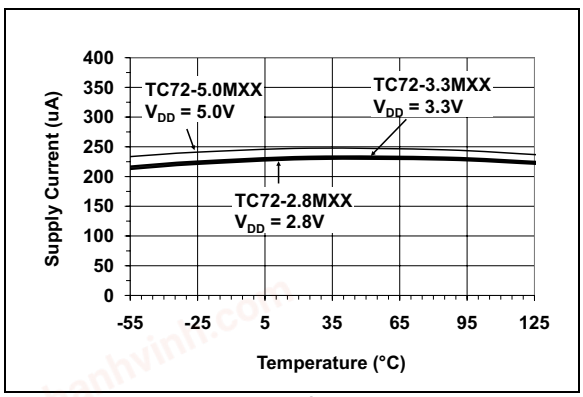


FIGURE 2-3: *Supply Current vs. Temperature.*

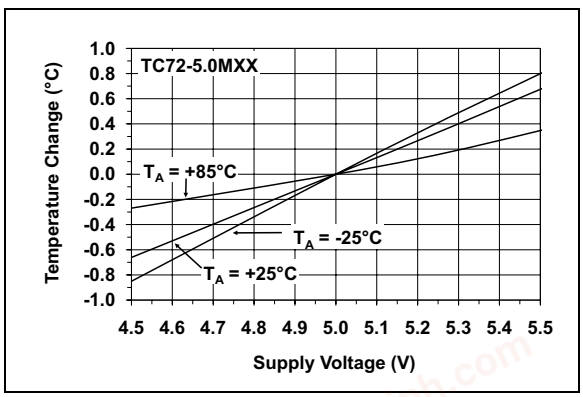


FIGURE 2-6: *Temperature Accuracy vs. Supply Voltage (TC72-5.0MXX).*

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

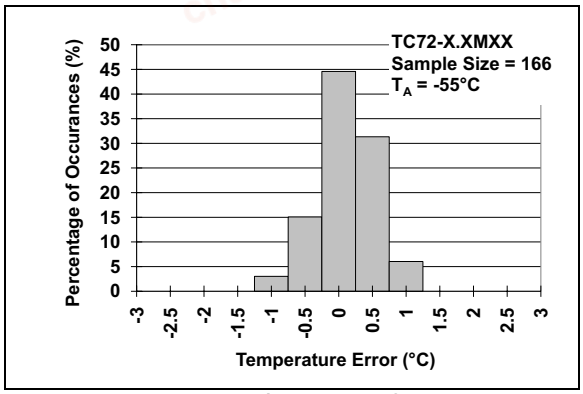


FIGURE 2-7: *Histogram of Temperature Accuracy at -55 Degrees C.*

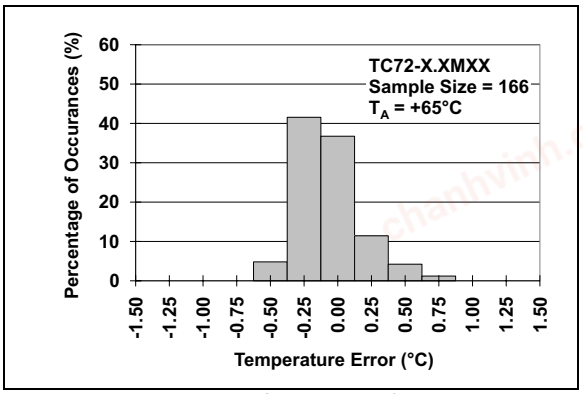


FIGURE 2-10: *Histogram of Temperature Accuracy at +65 Degrees C.*

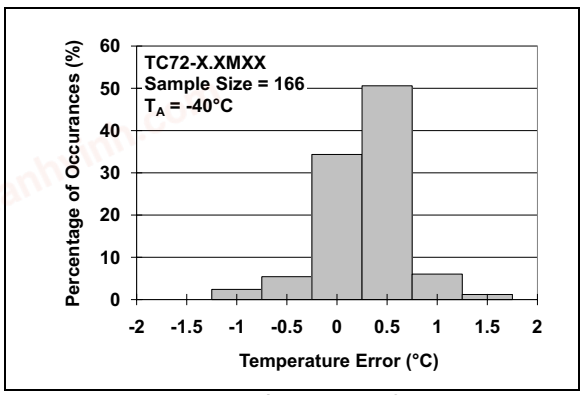


FIGURE 2-8: *Histogram of Temperature Accuracy at -40 Degrees C.*

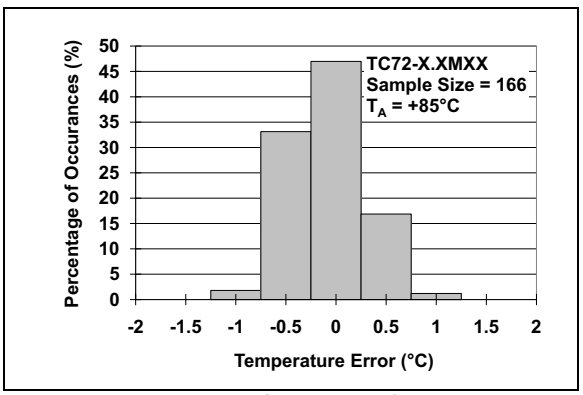


FIGURE 2-11: *Histogram of Temperature Accuracy at +85 Degrees C.*

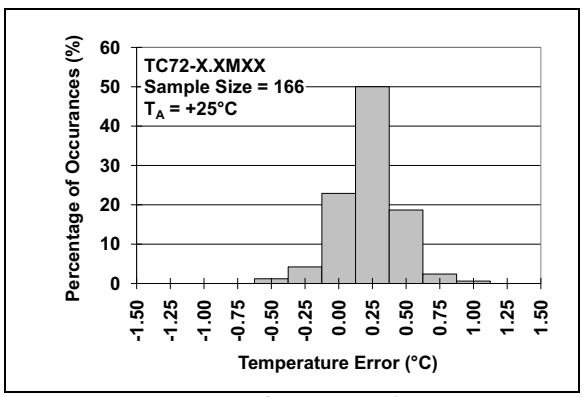


FIGURE 2-9: *Histogram of Temperature Accuracy at +25 Degrees C.*

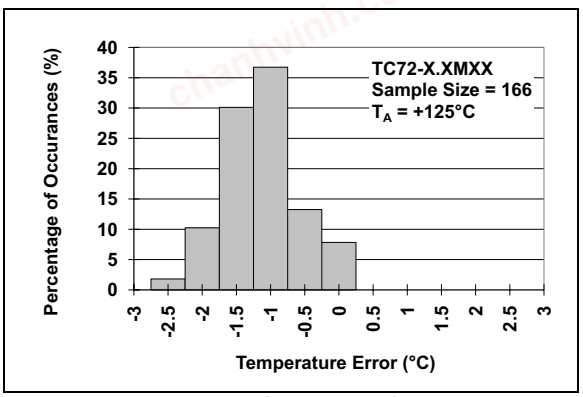


FIGURE 2-12: *Histogram of Temperature Accuracy at +125 Degrees C.*

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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_{DD}	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_{DD}. 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_{DD})

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

3.8 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.

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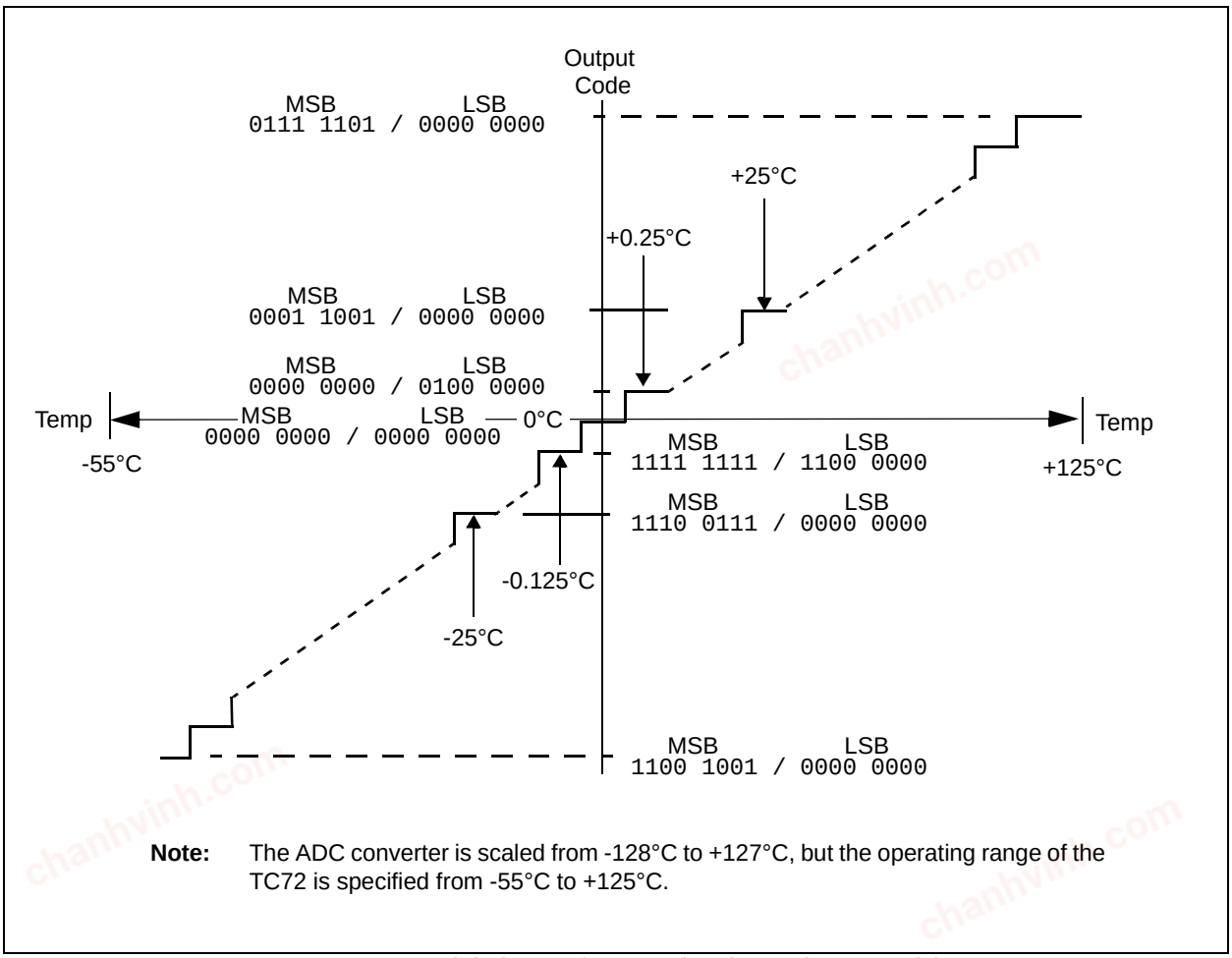
4.0 FUNCTIONAL DESCRIPTION

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°C to +127°C; therefore, the resolution is 0.25°C per bit. The ambient temperature operating range of the TC72 is specified from -55°C to +125°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.



Note: The ADC converter is scaled from -128°C to +127°C, but the operating range of the TC72 is specified from -55°C to +125°C.

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

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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 Temp. MSB
2^{-1}	2^{-2}	0	0	0	0	0	0	01H 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.

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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, Data Clocked on Rising Edge	Data Bit Latch	High Z
		CP=0, Data Shifted on Rising Edge, Data Clocked on Falling Edge		
Read (A7 = 0)	H	CP=1, Data Shifted on Falling Edge, Data Clocked on Rising Edge	X	Next data bit shift, Note 2
		CP=0, Data Shifted on Rising Edge, 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.

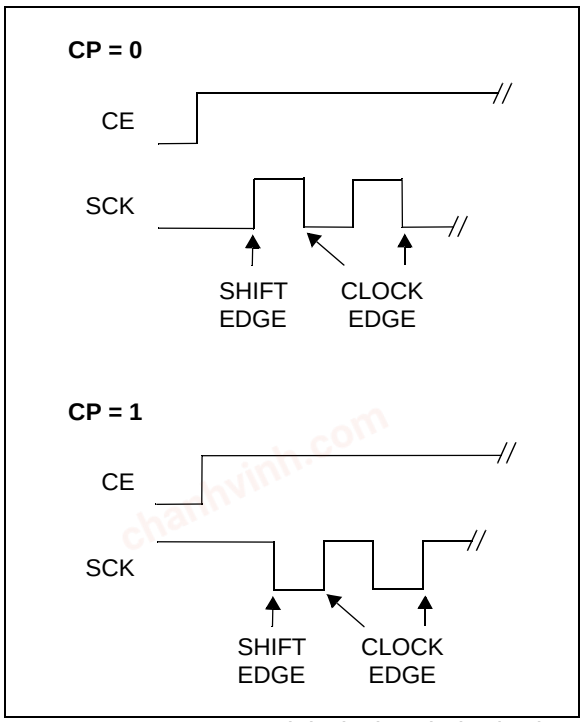


FIGURE 4-2: *Serial Clock Polarity (CP) Operation.*

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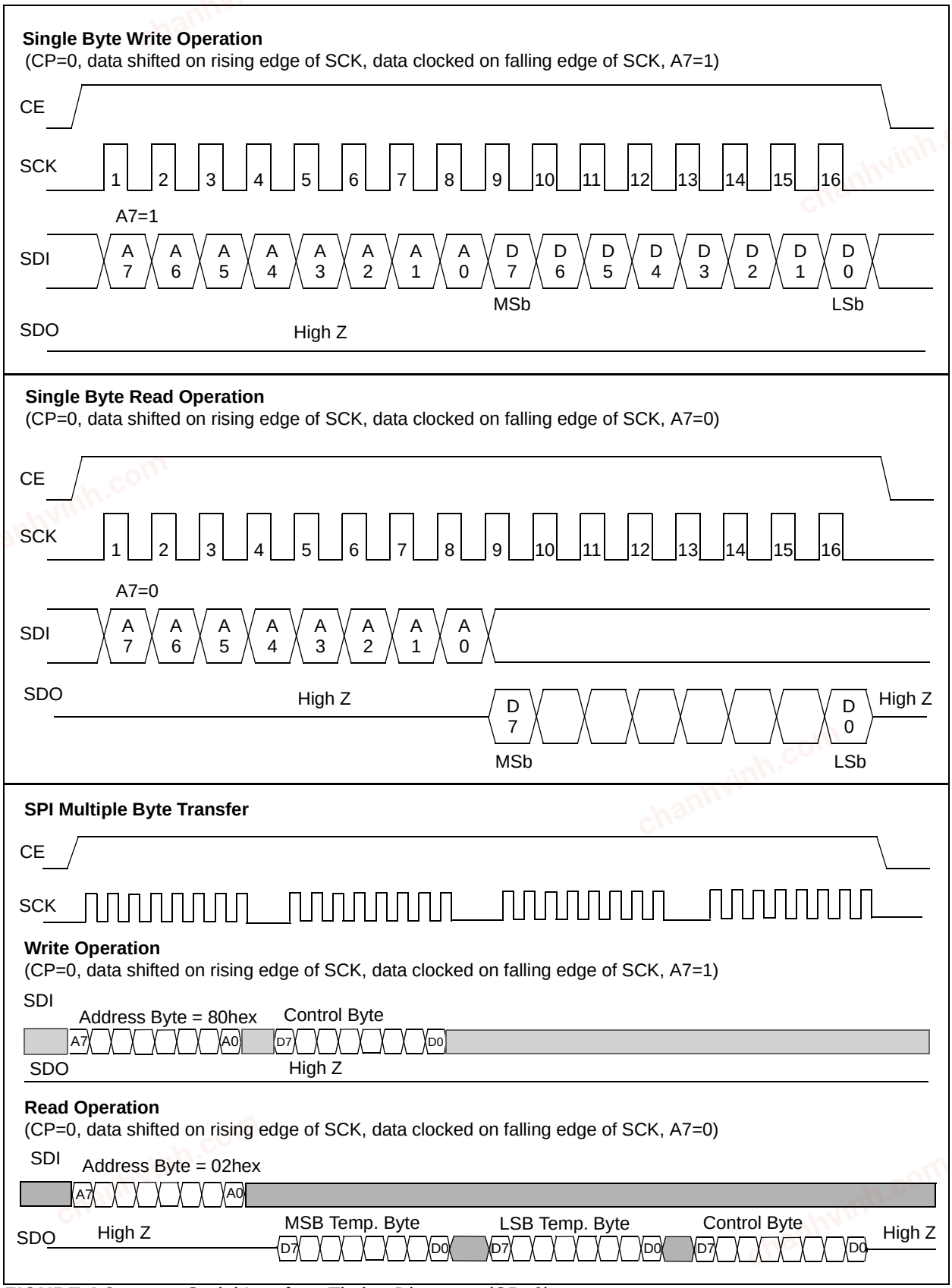


FIGURE 4-3: *Serial Interface Timing Diagrams (CP=0).*

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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 affect 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

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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.

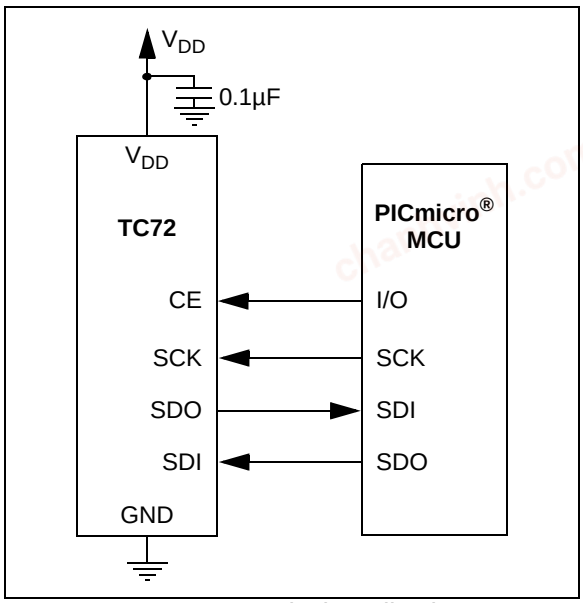


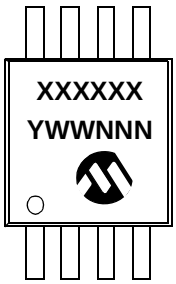
FIGURE 6-1: *Typical Application.*

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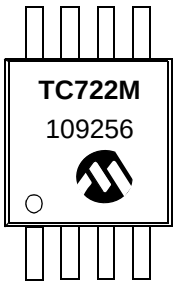
7.0 PACKAGING INFORMATION

7.1 Package Marking Information

8-Lead MSOP



Example:



8-Lead DFN



Example:



Legend:	XX...X	Customer-specific information
	Y	Year code (last digit of calendar year)
	YY	Year code (last 2 digits of calendar year)
	WW	Week code (week of January 1 is week ‘01’)
	NNN	Alphanumeric traceability code
	(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.

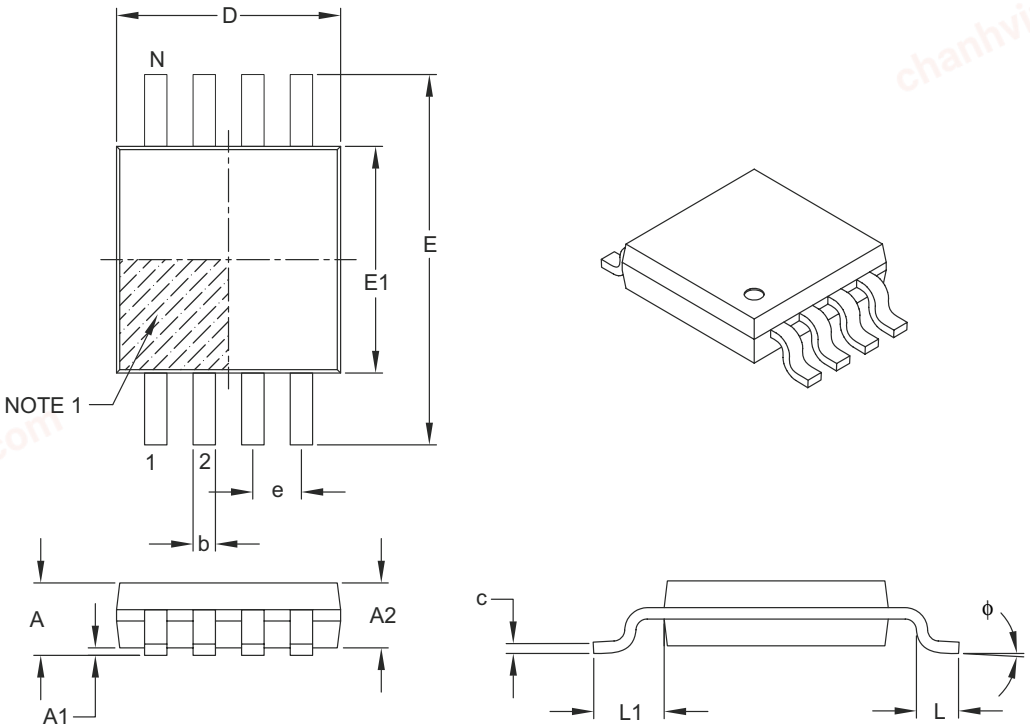
Note: In the event the full Microchip part number cannot be marked on one line, it will be carried over to the next line, thus limiting the number of available characters for customer-specific information.

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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



Units		MILLIMETERS		
Dimension Limits		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	ϕ	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.

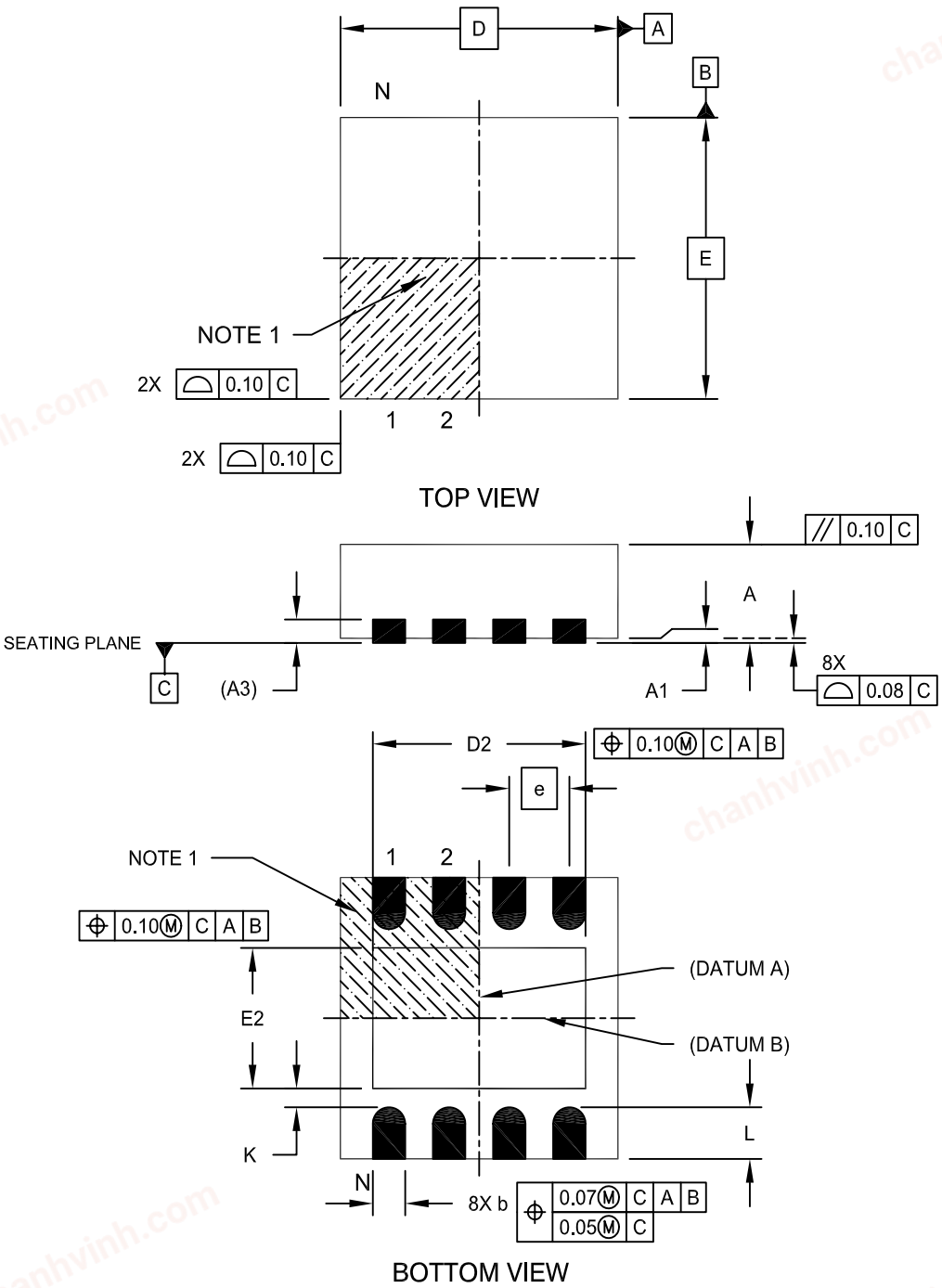
   REF: Reference Dimension, usually without tolerance, for information purposes only.

Microchip Technology Drawing C04-111B

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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



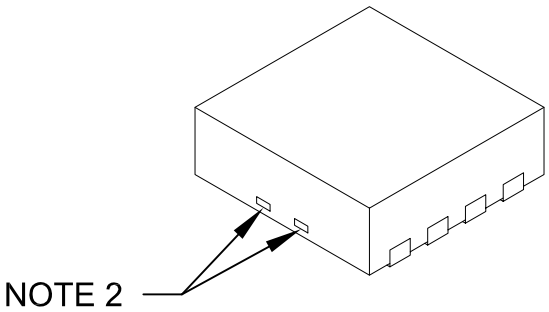
Microchip Technology Drawing No. C04-062C Sheet 1 of 2

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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



Units		MILLIMETERS		
Dimension Limits		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:

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

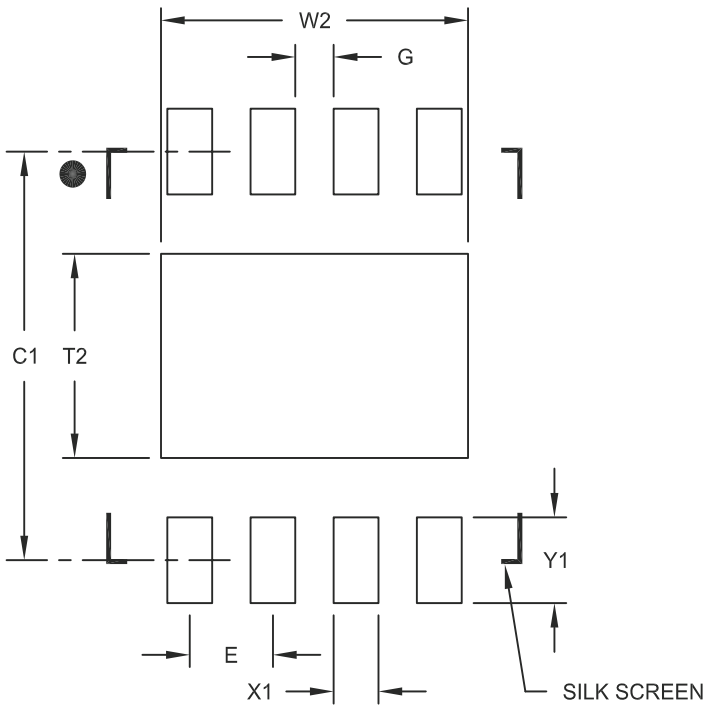
BSC: Basic Dimension. Theoretically exact value shown without tolerances.
REF: Reference Dimension, usually without tolerance, for information purposes only.

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

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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

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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.

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PRODUCT IDENTIFICATION SYSTEM

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

PART NO.	XX	X	/XX
Device	Voltage Range	Temperature Range	Package

Device:	TC72: Digital Temperature Sensor w/SPI Interface	
Voltage Range:	2.8	= Accuracy Optimized for 2.8V
	3.3	= Accuracy Optimized for 3.3V
	5.0	= Accuracy Optimized for 5.0V
Temperature Range:	M	=-55°C to +125°C
Package:	MF	= Dual, Flat, No Lead (DFN) (3x3mm), 8-lead
	MFTR	= Dual, Flat, No Lead (DFN) (3x3mm), 8-lead (Tape and Reel)
	UA	= Plastic Micro Small Outline (MSOP), 8-lead
	UATR	= Plastic Micro Small Outline (MSOP), 8-lead (Tape and Reel)

Examples:

a)	TC72-2.8MUA:	Digital Temperature Sensor, 2.8V, 8LD MSOP package.
b)	TC72-2.8MUATR:	Digital Temperature Sensor, 2.8V, 8LD MSOP (tape and reel) package.
c)	TC72-2.8MMF:	Digital Temperature Sensor, 2.8V, 8LD DFN package.
d)	TC72-3.3MUA:	Digital Temperature Sensor, 3.3V, 8LD MSOP package.
e)	TC72-3.3MMF:	Digital Temperature Sensor, 3.3V, 8LD DFN package.
f)	TC72-5.0MUA:	Digital Temperature Sensor, 5.0V, 8LD MSOP package.
g)	TC72-5.0MMF:	Digital Temperature Sensor, 5.0V, 8LD DFN package.
h)	TC72-5.0MMFTR:	Digital Temperature Sensor, 5.0V, 8LD DFN (tape and reel) package.

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