TC72

Digital Temperature Sensor with SPI™ Interface

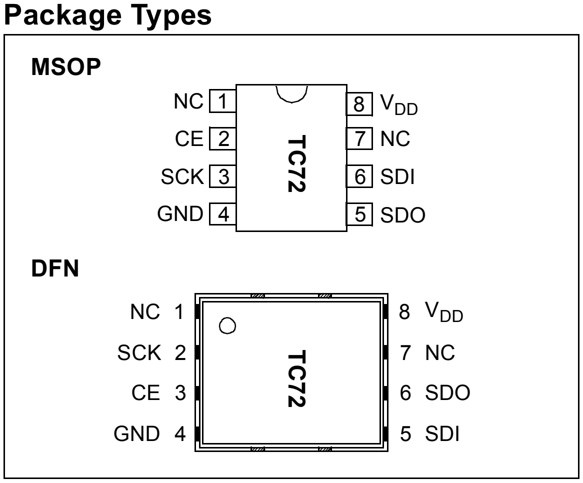
Features

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



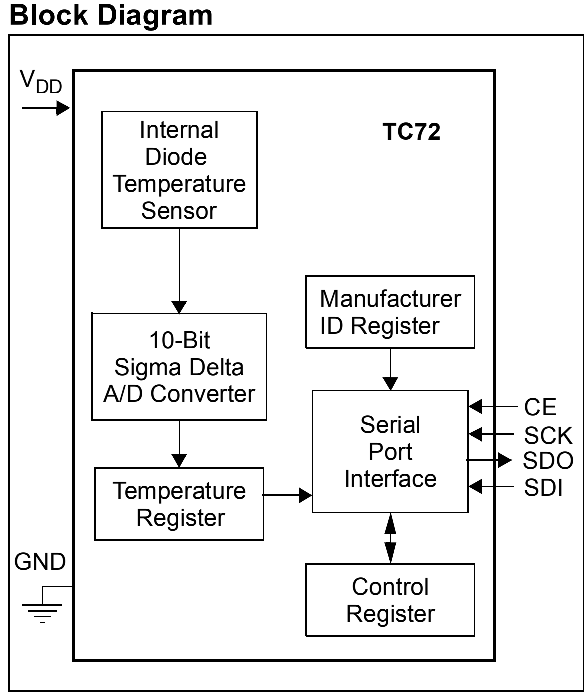
General Description

The 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. The TC72 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.

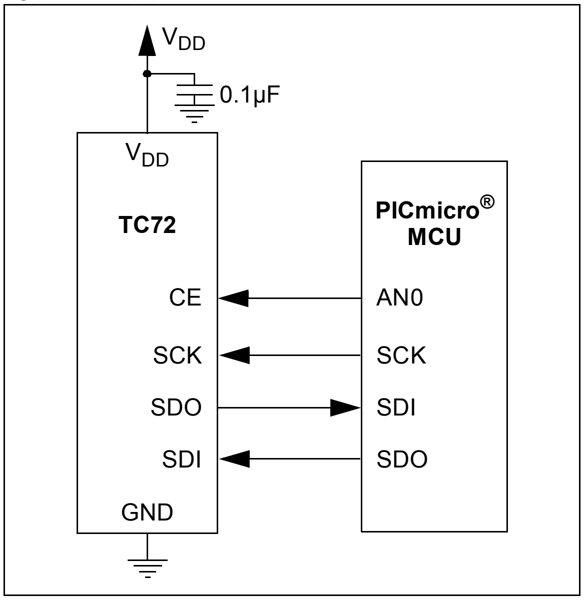
The TC72 can be used either in a Continuous Temperature Conversion mode or a One-Shot Conversion mode. The Continuous Conversion mode measures the temperature approximately every 150 ms and stores the data in the temperature registers. In contrast, the One-Shot mode performs a single temperature measurement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

The 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. The TC72 also features a shutdown mode for low power operation.

Block Diagram



Typical Application



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.

PIN FUNCTION TABLE

Name	Function
NC	No Internal Connection
CE	Chip Enable Input, the device is selected when this input is high
SCK	Serial Clock Input
GND	Ground
SDO	Serial Data Output
SDI	Serial Data Input
NC	No Internal Connection
V_{DD}	Power Supply

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 temp. 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

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	
Thermal Package Resistance						
Thermal Resistance, MSOP-8	θ_{JA}	—	206	—	°C/W	
Thermal Resistance, DFN-8	θ_{JA}	—	60.5	—	°C/W	

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.

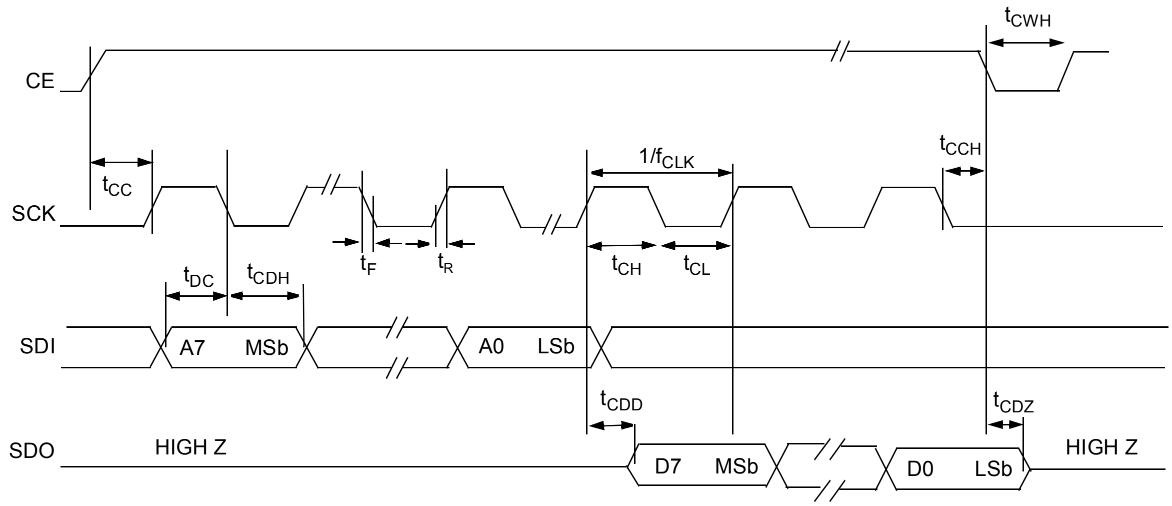
2: Measured with a load of C_L = 50 pF on the SDO output pin of the TC72.

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

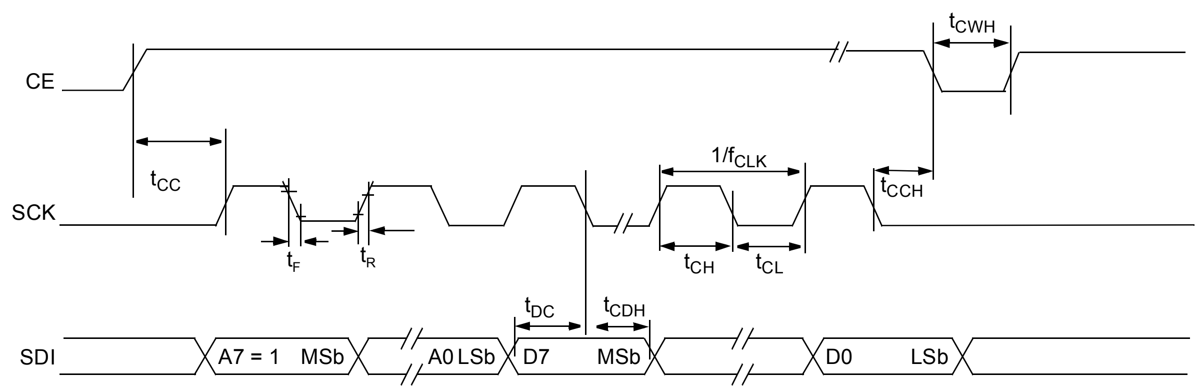
SPI READ DATA TRANSFER

(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 3-3 and Figure 3-2.

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

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, TA = -55°C to +125°C.

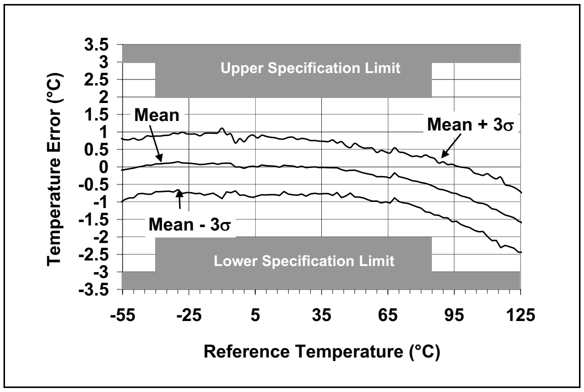


FIGURE 2-1: Accuracy vs. Temperature (TC72-X.XMXX).

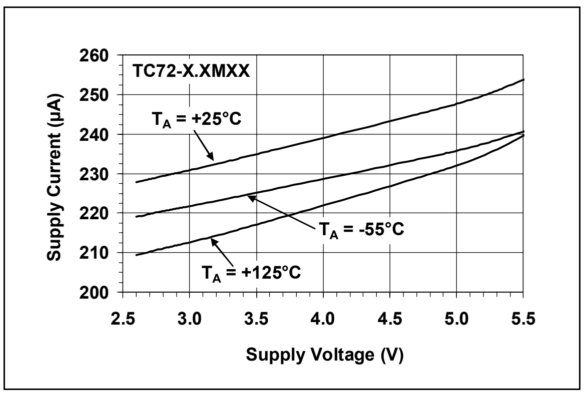


FIGURE 2-2: Supply Current vs. Supply Voltage.

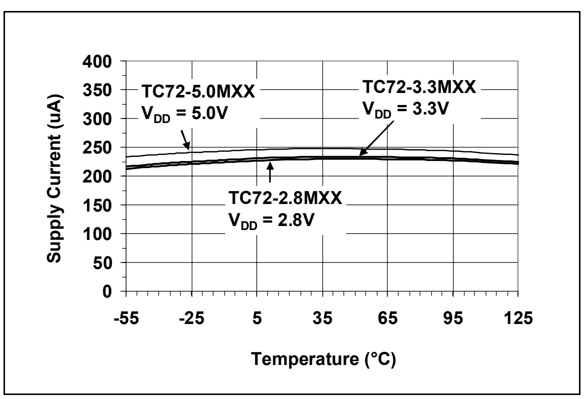


FIGURE 2-3: Supply Current vs. Temperature.

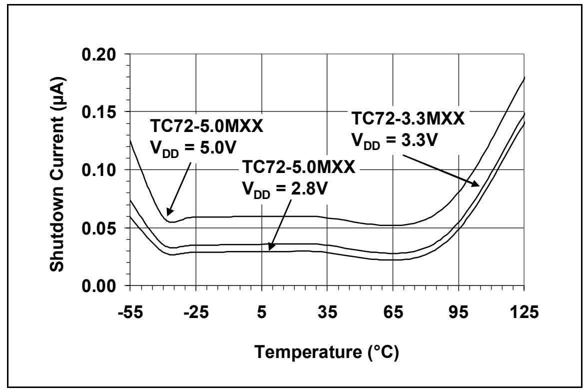


FIGURE 2-4: Shutdown Current vs. Temperature.

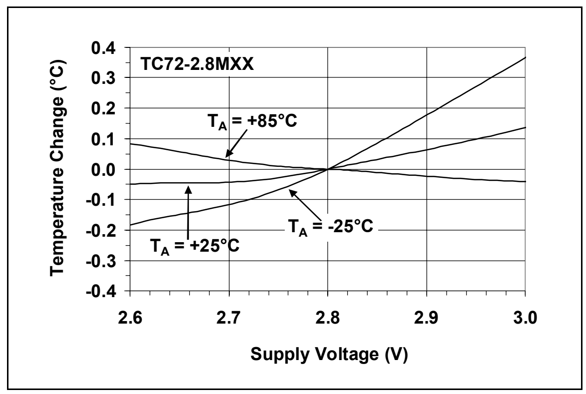


FIGURE 2-5: Temperature Accuracy vs. Supply Voltage (TC72-2.8MXX).

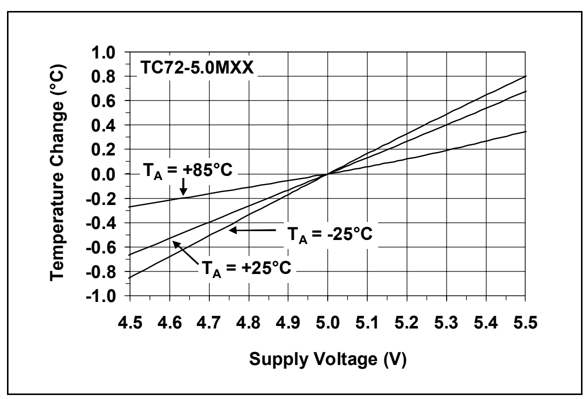


FIGURE 2-6: Temperature Accuracy vs. Supply Voltage (TC72-5.0MXX).

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

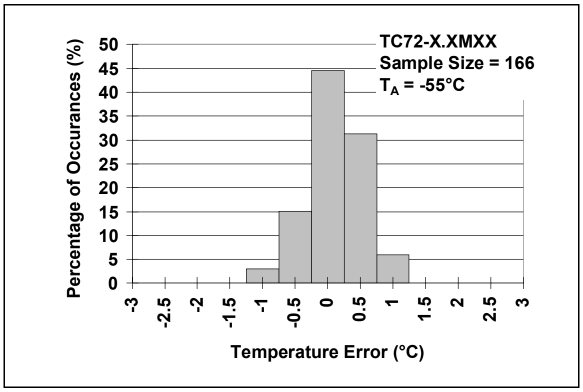


FIGURE 2-7: *Histogram of Temperature Accuracy at -55 Degrees C.*

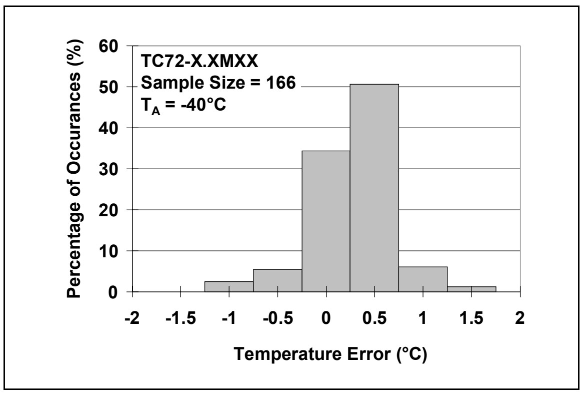


FIGURE 2-8: *Histogram of Temperature Accuracy at -40 Degrees C.*

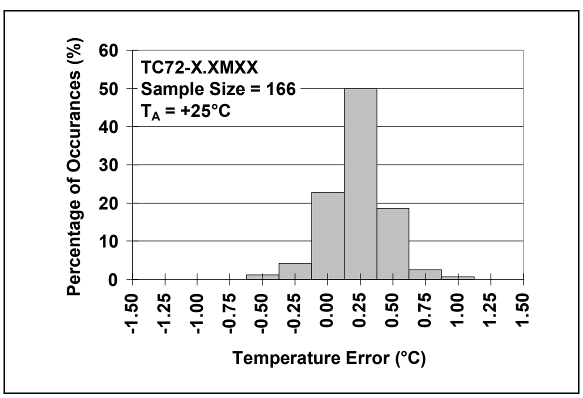


FIGURE 2-9: *Histogram of Temperature Accuracy at +25 Degrees C.*

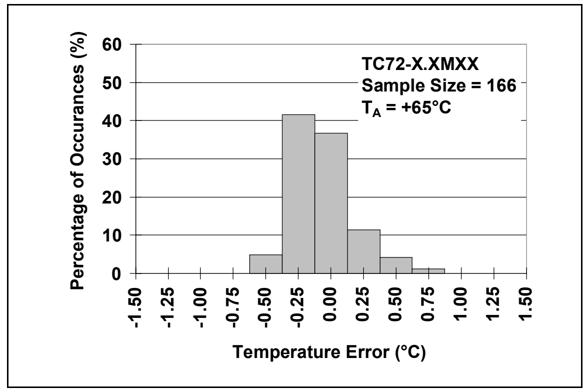


FIGURE 2-10: *Histogram of Temperature Accuracy at +65 Degrees C.*

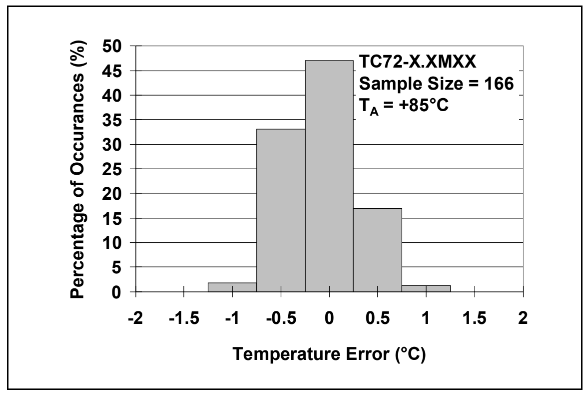


FIGURE 2-11: *Histogram of Temperature Accuracy at +85 Degrees C.*

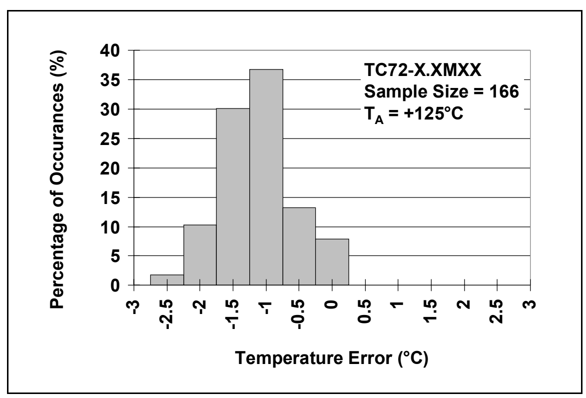


FIGURE 2-12: *Histogram of Temperature Accuracy at +125 Degrees C.*

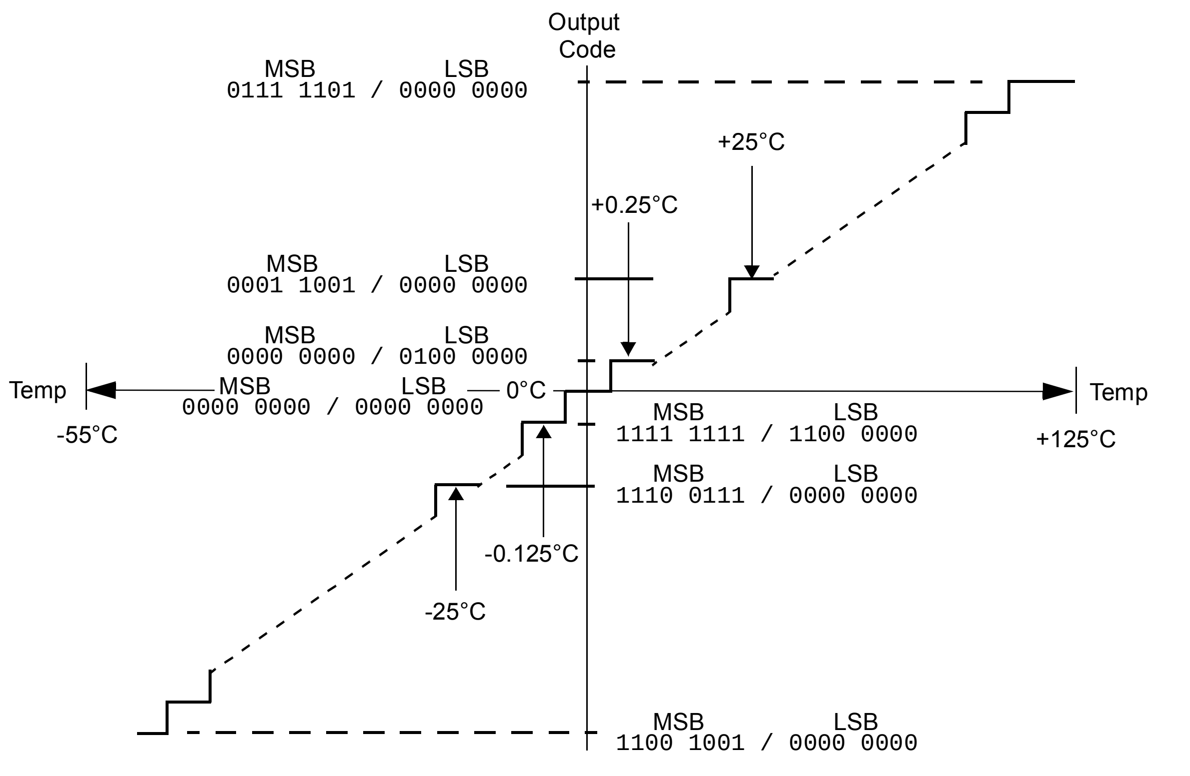
3.0 FUNCTIONAL DESCRIPTION

The 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. The TC72 can be used either in a Continuous Temperature Conversion mode or a One-Shot Conversion mode. The 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. The TC72 has an internal clock generator that controls the automatic temperature conversion sequence. The automatic temperature sampling operation is repeated indefinitely until the TC72 is placed in a shutdown mode by a write operation to the Control register. The TC72 will remain in the 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 3-1: *Temperature-To-Digital Transfer Function (Non-linear Scale).*

3.1 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 the TC72 is specified from -55°C to +125°C.

Example:

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 3-1: 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 3-2: 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

3.2 Power-Up And Power-Down

The TC72 is in the 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 4.0, "Internal Register Structure".

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

3.3 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. The TC72 operates as a slave and is compatible with the SPI bus specifications. The serial interface is designed to be compatible with the Microchip PICmicro® family of microcontrollers.

The CE input is used to select the 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 the 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.

The 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 3-2. Table 3-3 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 3-3.

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 3-3. 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. The 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 3-3: 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.

3.4 Read Operation

The temperature and control register data is outputted from the TC72 using the CE, SCK and SDO lines. Figure 3-3 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 outputted and goes to the tri-state level when the CE line goes to a logic low level.

3.5 Write Operation

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

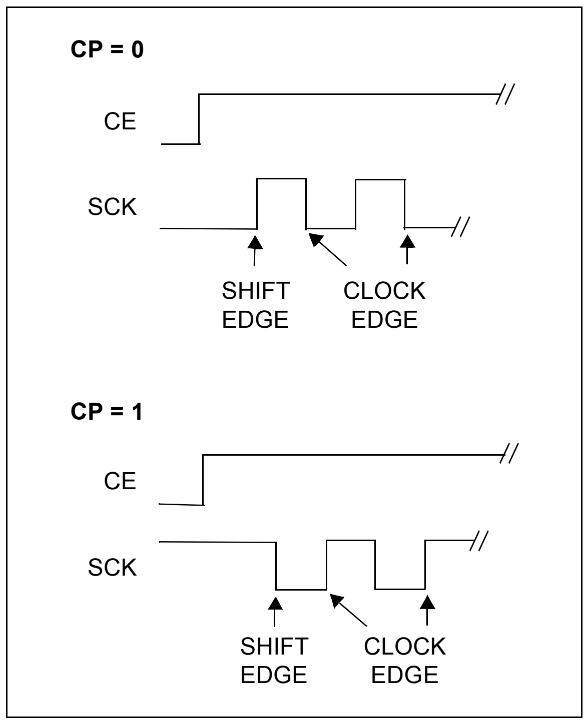


FIGURE 3-2: *Serial Clock Polarity (CP) Operation.*

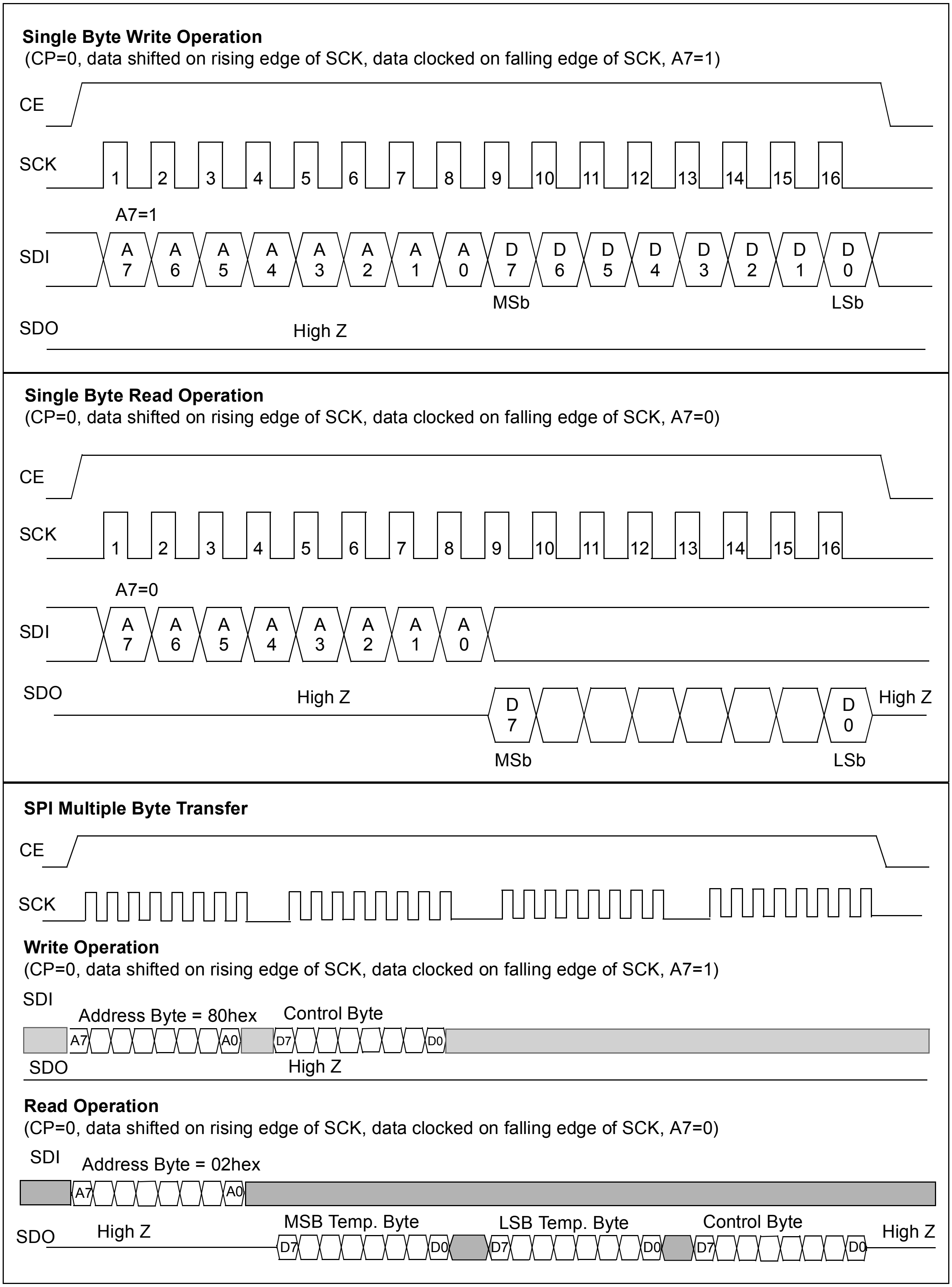


FIGURE 3-3: *Serial Interface Timing Diagrams (CP=0).*

4.0 INTERNAL REGISTER STRUCTURE

The TC72 registers are listed below.

TABLE 4-1: 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

4.1 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 4-2. The Shutdown (SHDN) bit is stored in bit 0 of the Control register. If SHDN is equal to '1', the TC72 will go into the power-saving shutdown mode. If SHDN is equal to '0', the TC72 will perform a temperature conversion approximately every 150 ms.

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

The Shutdown mode can be used to minimize the power consumption of the 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.

The 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 the TC72. Bit 2 is set to a logic '1'. Any write operation to these bit locations will have no affect on the operation of the TC72.

4.2 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.

4.3 Manufacturer ID Register

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

TABLE 4-2: 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

5.0 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.

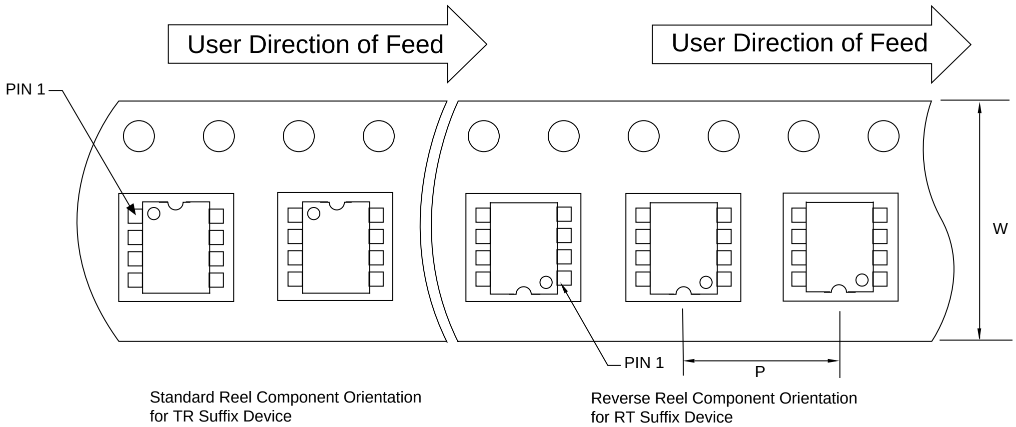
Note that the exposed metal center pad on the bottom of the DFN package is connected to the silicon substrate. The center pad should be connected to either the PCB ground plane or treated as a “No Connect” pin. The mechanical dimensions of the center pad are given in Section 6.0, “Packaging Information”, of this datasheet.

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 the temperature accuracy, the output loading of the SPI signals should be minimized.

6.0 PACKAGING INFORMATION

6.1 Taping Form

Component Taping Orientation for 8-Pin MSOP Devices



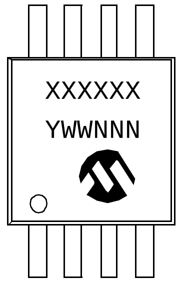
Carrier Tape, Number of Components Per Reel and Reel Size

Package	Carrier Width (W)	Pitch (P)	Part Per Full Reel	Reel Size
8-Pin MSOP	12 mm	8 mm	2500	13 in

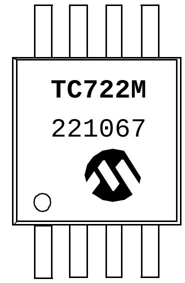
Tape and Reel information for the 8-Lead DFN package will be available TBD.

6.2 Package Marking Information

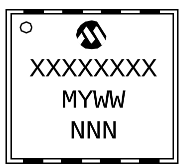
8-Lead MSOP



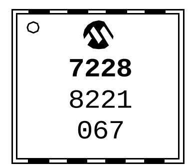
Example:



8-Lead DFN



Example:

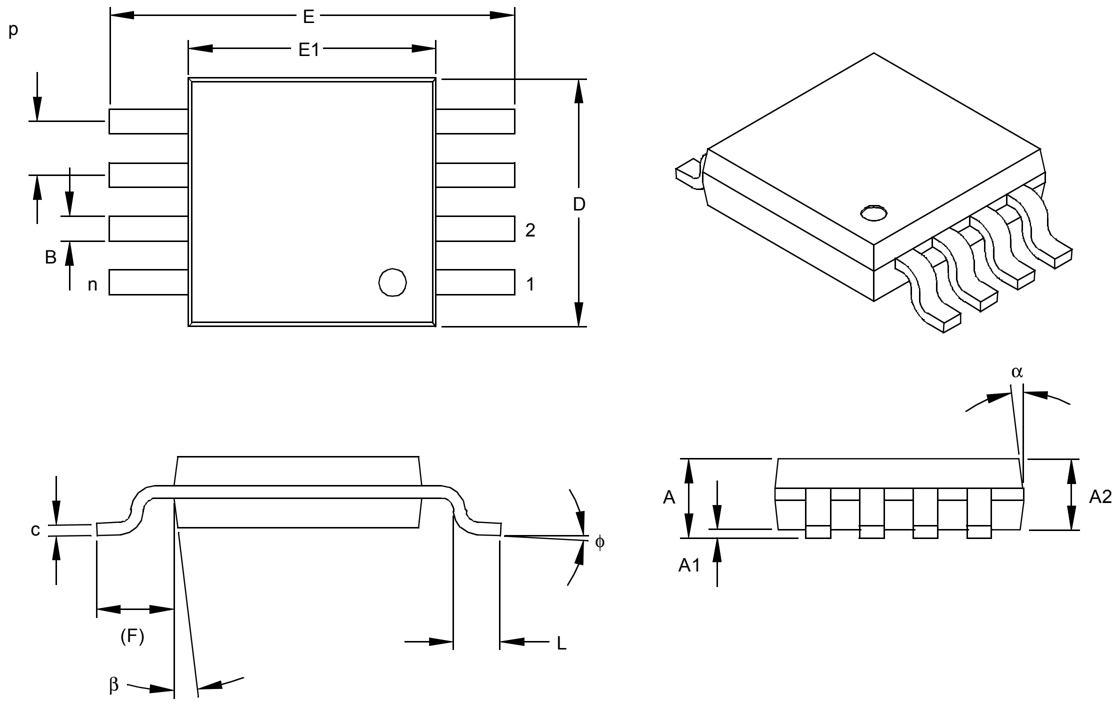


Legend:	XX...X	Customer specific information*
	YY	Year code (last 2 digits of calendar year)
	WW	Week code (week of January 1 is week ‘01’)
	NNN	Alphanumeric traceability code

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.

* Standard OTP marking consists of Microchip part number, year code, week code, and traceability code.

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



Units		INCHES			MILLIMETERS*		
Dimension Limits		MIN	NOM	MAX	MIN	NOM	MAX
Number of Pins	n		8				8
Pitch	p		.026			0.65	
Overall Height	A			.044			1.18
Molded Package Thickness	A2	.030	.034	.038	0.76	0.86	0.97
Standoff §	A1	.002		.006	0.05		0.15
Overall Width	E	.184	.193	.200	4.67	4.90	.5.08
Molded Package Width	E1	.114	.118	.122	2.90	3.00	3.10
Overall Length	D	.114	.118	.122	2.90	3.00	3.10
Foot Length	L	.016	.022	.028	0.40	0.55	0.70
Footprint (Reference)	F	.035	.037	.039	0.90	0.95	1.00
Foot Angle	φ	0		6	0		6
Lead Thickness	c	.004	.006	.008	0.10	0.15	0.20
Lead Width	B	.010	.012	.016	0.25	0.30	0.40
Mold Draft Angle Top	α		7			7	
Mold Draft Angle Bottom	β		7			7	

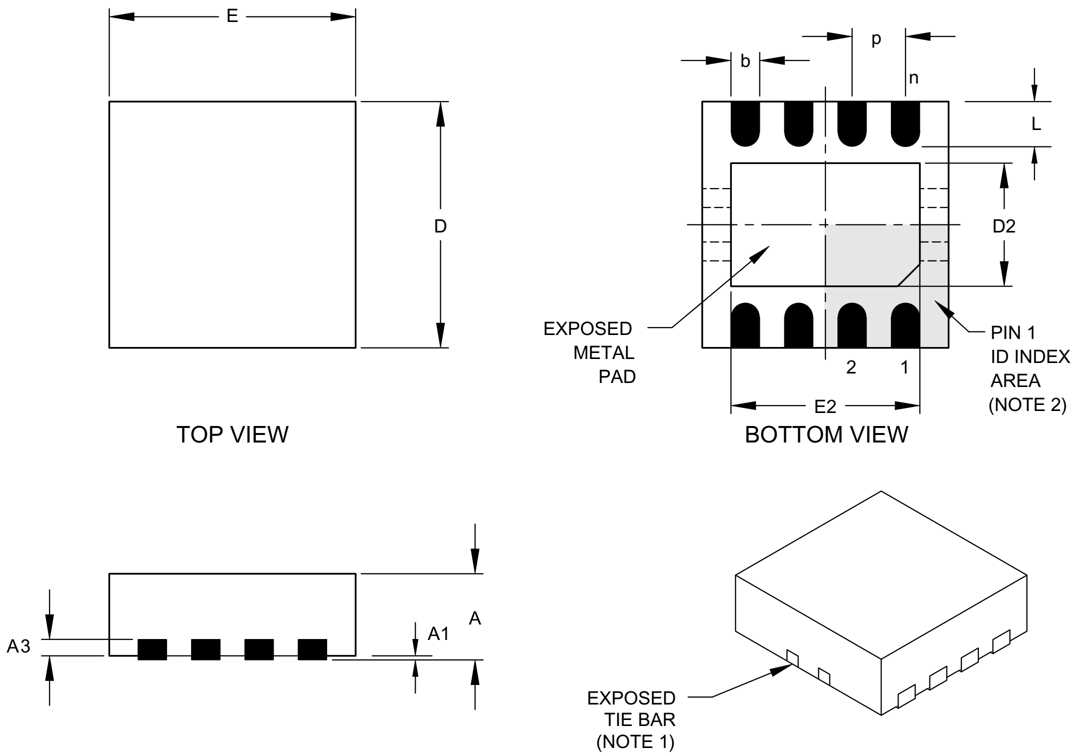
*Controlling Parameter
§ Significant Characteristic

Notes:

Dimensions D and E1 do not include mold flash or protrusions. Mold flash or protrusions shall not exceed .010" (0.254mm) per side.

Drawing No. C04-111

8-Lead Plastic Dual Flat Pack, No Lead (MF) 3x3x1 mm Body (DFN)



Units		INCHES			MILLIMETERS*		
Dimension Limits		MIN	NOM	MAX	MIN	NOM	MAX
Number of Pins	n		8			8	
Pitch	p		.026 BSC			0.65 BSC	
Overall Height	A	.031	.035	.039	0.80	0.90	1.00
Standoff	A1	.000	.001	.002	0.00	0.02	0.05
Lead Thickness	A3		.008 REF.			0.20 REF.	
Overall Length	E		.118 BSC			3.00 BSC	
Exposed Pad Length (Note 4)	E2	.055		.096	1.39		2.45
Overall Width	D		.118 BSC			3.00 BSC	
Exposed Pad Width (Note 4)	D2	.047		.069	1.20		1.75
Lead Width	b	.007	.010	.015	0.23	0.26	0.37
Lead Length	L	.012	.019	.022	0.30	0.48	0.55

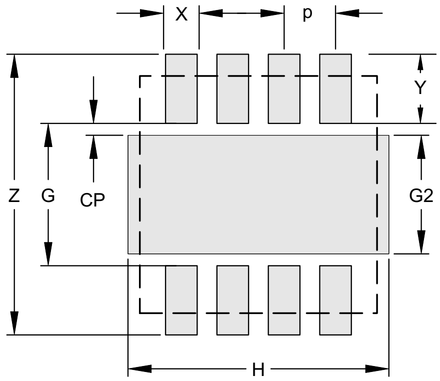
*Controlling Parameter

Notes:

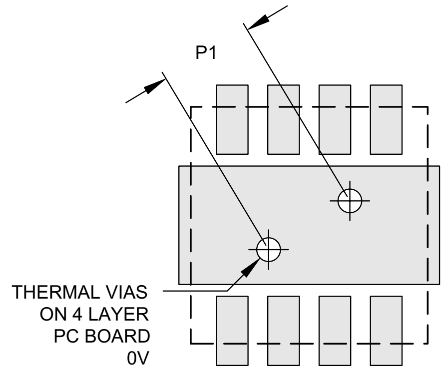
1. Package may have one or more exposed tie bars at ends.
2. Pin 1 visual index feature may vary, but must be located within the hatched area.
3. Dimensions D and E do not include mold flash or protrusions. Mold flash or protrusions shall not exceed .010" (0.254mm) per side.
4. Exposed pad dimensions vary with paddle size.
5. JEDEC equivalent: Pending

Drawing No. C04-062

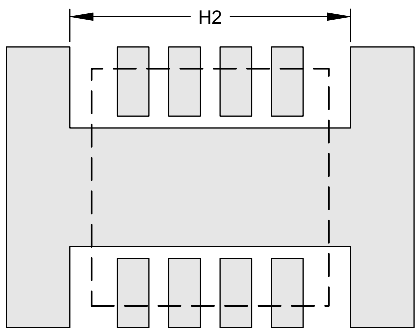
8-Lead Plastic Dual Flat Pack, No Lead (MF) 3x3x1 mm Body (DFN)



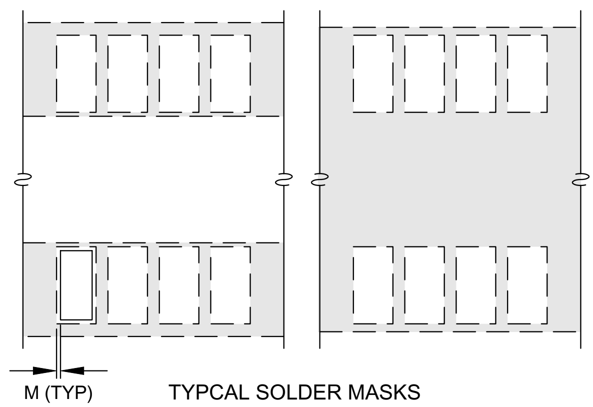
DFN LAND PATTERN



OPTIONAL FOUR LAYER
PCB LAND PATTERN



OPTIONAL TWO LAYER
PCB LAND PATTERN



TYPCAL SOLDER MASKS

Units		INCHES			MILLIMETERS*		
Dimension Limits		MIN	NOM	MAX	MIN	NOM	MAX
Terminal Pitch	p	.026 BSC			0.65 BSC		
Terminal Land Pattern O.D.	Z	.134		.157	3.40		4.00
Terminal Land Pattern I.D.	A1	.057		.060	1.45		1.53
Exposed Pad Clearance	CP	.006			0.15		
Interior Lead Clearance	Z	.071			1.80		
Terminal Land Width	X	.014		.017	0.35		0.42
Terminal Land Length	Y	.033		.035	0.85		0.88
Exposed Pad Length	H	.130			3.30		
Optional Exposed Pad Length	H2	.130			3.30		
Exposed Pad Width (Note 1)	G2	.057		.059	1.45		1.50
Termal Via Pitch	P1		.047			1.20	
Thermal Via Diameter	V		.012			0.30	
Minimum Solder Mask Clearance	M	.002			0.05		

*Controlling Parameter

Notes:

1. Exposed pad dimensions vary with paddle size.

Drawing No. C04-2062

ON-LINE SUPPORT

Microchip provides on-line support on the Microchip World Wide Web site.

The web site is used by Microchip as a means to make files and information easily available to customers. To view the site, the user must have access to the Internet and a web browser, such as Netscape® or Microsoft® Internet Explorer. Files are also available for FTP download from our FTP site.

Connecting to the Microchip Internet Web Site

The Microchip web site is available at the following URL:

www.microchip.com

The file transfer site is available by using an FTP service to connect to:

ftp://ftp.microchip.com

The web site and file transfer site provide a variety of services. Users may download files for the latest Development Tools, Data Sheets, Application Notes, User's Guides, Articles and Sample Programs. A variety of Microchip specific business information is also available, including listings of Microchip sales offices, distributors and factory representatives. Other data available for consideration is:

- Latest Microchip Press Releases
- Technical Support Section with Frequently Asked Questions
- Design Tips
- Device Errata
- Job Postings
- Microchip Consultant Program Member Listing
- Links to other useful web sites related to Microchip Products
- Conferences for products, Development Systems, technical information and more
- Listing of seminars and events

SYSTEMS INFORMATION AND UPGRADE HOT LINE

The Systems Information and Upgrade Line provides system users a listing of the latest versions of all of Microchip's development systems software products. Plus, this line provides information on how customers can receive the most current upgrade kits.The Hot Line Numbers are:

1-800-755-2345 for U.S. and most of Canada, and

1-480-792-7302 for the rest of the world.

092002

READER RESPONSE

It is our intention to provide you with the best documentation possible to ensure successful use of your Microchip product. If you wish to provide your comments on organization, clarity, subject matter, and ways in which our documentation can better serve you, please FAX your comments to the Technical Publications Manager at (480) 792-4150.

Please list the following information, and use this outline to provide us with your comments about this document.

To: Technical Publications Manager Total Pages Sent ________

RE: Reader Response

From: Name ____

Company ____

Address ____

City / State / ZIP / Country ____

Telephone: (_______) _________ - _________ FAX: (______) _________ - _________

Application (optional):

Would you like a reply? ___Y ___N

Device: **TC72** Literature Number: **DS21734A**

Questions:

1. What are the best features of this document?

____

____

2. How does this document meet your hardware and software development needs?

____

____

3. Do you find the organization of this document easy to follow? If not, why?

____

____

4. What additions to the document do you think would enhance the structure and subject?

____

____

5. What deletions from the document could be made without affecting the overall usefulness?

____

____

6. Is there any incorrect or misleading information (what and where)?

____

____

7. How would you improve this document?

____

____

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.	-X.X	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.

Sales and Support

Data Sheets

Products supported by a preliminary Data Sheet may have an errata sheet describing minor operational differences and recommended workarounds. To determine if an errata sheet exists for a particular device, please contact one of the following:

1. Your local Microchip sales office
2. The Microchip Corporate Literature Center U.S. FAX: (480) 792-7277
3. The Microchip Worldwide Site (www.microchip.com)

Please specify which device, revision of silicon and Data Sheet (include Literature #) you are using.

New Customer Notification System

Register on our web site (www.microchip.com/cn) to receive the most current information on our products.

NOTES:

Information contained in this publication regarding device applications and the like is intended through suggestion only and may be superseded by updates. It is your responsibility to ensure that your application meets with your specifications. No representation or warranty is given and no liability is assumed by Microchip Technology Incorporated with respect to the accuracy or use of such information, or infringement of patents or other intellectual property rights arising from such use or otherwise. Use of Microchip's products as critical components in life support systems is not authorized except with express written approval by Microchip. No licenses are conveyed, implicitly or otherwise, under any intellectual property rights.

Trademarks

The Microchip name and logo, the Microchip logo, KEELOQ, MPLAB, PIC, PICmicro, PICSTART and PRO MATE are registered trademarks of Microchip Technology Incorporated in the U.S.A. and other countries.

FilterLab, microID, MXDEV, MXLAB, PICMASTER, SEEVAL and The Embedded Control Solutions Company are registered trademarks of Microchip Technology Incorporated in the U.S.A.

dsPIC, dsPICDEM.net, ECONOMONITOR, FanSense, FlexROM, fuzzyLAB, In-Circuit Serial Programming, ICSP, ICEPIC, microPort, Migratable Memory, MPASM, MPLIB, MPLINK, MPSIM, PICC, PICDEM, PICDEM.net, rfPIC, Select Mode and Total Endurance are trademarks of Microchip Technology Incorporated in the U.S.A. and other countries.

Serialized Quick Turn Programming (SQTP) is a service mark of Microchip Technology Incorporated in the U.S.A.

All other trademarks mentioned herein are property of their respective companies.

Printed on recycled paper.

DNV Certification, Inc. USA
ANSI • RAB QMS ACCREDITED
DNV MSC The Netherlands Accredited by the RvA
ISO 9001 / QS-9000 REGISTERED FIRM

Microchip received QS-9000 quality system certification for its worldwide headquarters, design and wafer fabrication facilities in Chandler and Tempe, Arizona in July 1999 and Mountain View, California in March 2002. The Company's quality system processes and procedures are QS-9000 compliant for its PICmicro® 8-bit MCUs, KEELOQ® code hopping devices, Serial EEPROMs, microperipherals, non-volatile memory and analog products. In addition, Microchip's quality system for the design and manufacture of development systems is ISO 9001 certified.

WORLDWIDE SALES AND SERVICE

AMERICAS

Corporate Office
2355 West Chandler Blvd.
Chandler, AZ 85224-6199
Tel: 480-792-7200 Fax: 480-792-7277
Technical Support: 480-792-7627
Web Address: http://www.microchip.com

Rocky Mountain
2355 West Chandler Blvd.
Chandler, AZ 85224-6199
Tel: 480-792-7966 Fax: 480-792-4338

Atlanta
500 Sugar Mill Road, Suite 200B
Atlanta, GA 30350
Tel: 770-640-0034 Fax: 770-640-0307

Boston
2 Lan Drive, Suite 120
Westford, MA 01886
Tel: 978-692-3848 Fax: 978-692-3821

Chicago
333 Pierce Road, Suite 180
Itasca, IL 60143
Tel: 630-285-0071 Fax: 630-285-0075

Dallas
4570 Westgrove Drive, Suite 160
Addison, TX 75001
Tel: 972-818-7423 Fax: 972-818-2924

Detroit
Tri-Atria Office Building
32255 Northwestern Highway, Suite 190
Farmington Hills, MI 48334
Tel: 248-538-2250 Fax: 248-538-2260

Kokomo
2767 S. Albright Road
Kokomo, Indiana 46902
Tel: 765-864-8360 Fax: 765-864-8387

Los Angeles
18201 Von Karman, Suite 1090
Irvine, CA 92612
Tel: 949-263-1888 Fax: 949-263-1338

New York
150 Motor Parkway, Suite 202
Hauppauge, NY 11788
Tel: 631-273-5305 Fax: 631-273-5335

San Jose
Microchip Technology Inc.
2107 North First Street, Suite 590
San Jose, CA 95131
Tel: 408-436-7950 Fax: 408-436-7955

Toronto
6285 Northam Drive, Suite 108
Mississauga, Ontario L4V 1X5, Canada
Tel: 905-673-0699 Fax: 905-673-6509

ASIA/PACIFIC

Australia
Microchip Technology Australia Pty Ltd
Suite 22, 41 Rawson Street
Epping 2121, NSW
Australia
Tel: 61-2-9868-6733 Fax: 61-2-9868-6755

China - Beijing
Microchip Technology Consulting (Shanghai) Co., Ltd., Beijing Liaison Office
Unit 915
Bei Hai Wan Tai Bldg.
No. 6 Chaoyangmen Beidajie
Beijing, 100027, No. China
Tel: 86-10-85282100 Fax: 86-10-85282104

China - Chengdu
Microchip Technology Consulting (Shanghai) Co., Ltd., Chengdu Liaison Office
Rm. 2401, 24th Floor,
Ming Xing Financial Tower
No. 88 TIDU Street
Chengdu 610016, China
Tel: 86-28-86766200 Fax: 86-28-86766599

China - Fuzhou
Microchip Technology Consulting (Shanghai) Co., Ltd., Fuzhou Liaison Office
Unit 28F, World Trade Plaza
No. 71 Wusi Road
Fuzhou 350001, China
Tel: 86-591-7503506 Fax: 86-591-7503521

China - Shanghai
Microchip Technology Consulting (Shanghai) Co., Ltd.
Room 701, Bldg. B
Far East International Plaza
No. 317 Xian Xia Road
Shanghai, 200051
Tel: 86-21-6275-5700 Fax: 86-21-6275-5060

China - Shenzhen
Microchip Technology Consulting (Shanghai) Co., Ltd., Shenzhen Liaison Office
Rm. 1315, 13/F, Shenzhen Kerry Centre,
Renminnan Lu
Shenzhen 518001, China
Tel: 86-755-2350361 Fax: 86-755-2366086

China - Hong Kong SAR
Microchip Technology Hongkong Ltd.
Unit 901-6, Tower 2, Metroplaza
223 Hing Fong Road
Kwai Fong, N.T., Hong Kong
Tel: 852-2401-1200 Fax: 852-2401-3431

India
Microchip Technology Inc.
India Liaison Office
Divyasree Chambers
1 Floor, Wing A (A3/A4)
No. 11, O'Shaugnessey Road
Bangalore, 560 025, India
Tel: 91-80-2290061 Fax: 91-80-2290062

Japan
Microchip Technology Japan K.K.
Benex S-1 6F
3-18-20, Shinyokohama
Kohoku-Ku, Yokohama-shi
Kanagawa, 222-0033, Japan
Tel: 81-45-471- 6166 Fax: 81-45-471-6122

Korea
Microchip Technology Korea
168-1, Youngbo Bldg. 3 Floor
Samsung-Dong, Kangnam-Ku
Seoul, Korea 135-882
Tel: 82-2-554-7200 Fax: 82-2-558-5934

Singapore
Microchip Technology Singapore Pte Ltd.
200 Middle Road
#07-02 Prime Centre
Singapore, 188980
Tel: 65-6334-8870 Fax: 65-6334-8850

Taiwan
Microchip Technology (Barbados) Inc.,
Taiwan Branch
11F-3, No. 207
Tung Hua North Road
Taipei, 105, Taiwan
Tel: 886-2-2717-7175 Fax: 886-2-2545-0139

EUROPE

Austria
Microchip Technology Austria GmbH
Durisolstrasse 2
A-4600 Wels
Austria
Tel: 43-7242-2244-399
Fax: 43-7242-2244-393

Denmark
Microchip Technology Nordic ApS
Regus Business Centre
Lautrup hoj 1-3
Ballerup DK-2750 Denmark
Tel: 45 4420 9895 Fax: 45 4420 9910

France
Microchip Technology SARL
Parc d'Activite du Moulin de Massy
43 Rue du Saule Trapu
Batiment A - ler Etage
91300 Massy, France
Tel: 33-1-69-53-63-20 Fax: 33-1-69-30-90-79

Germany
Microchip Technology GmbH
Steinheilstrasse 10
D-85737 Ismaning, Germany
Tel: 49-89-627-144 0 Fax: 49-89-627-144-44

Italy
Microchip Technology SRL
Centro Direzionale Colleoni
Palazzo Taurus 1 V. Le Colleoni 1
20041 Agrate Brianza
Milan, Italy
Tel: 39-039-65791-1 Fax: 39-039-6899883

United Kingdom
Microchip Ltd.
505 Eskdale Road
Winnersh Triangle
Wokingham
Berkshire, England RG41 5TU
Tel: 44 118 921 5869 Fax: 44-118 921-5820

08/01/02