Temperature Management Overview

In many systems, temperature control is fundamental. There are a number of passive and active temperature sensors that can be used to measure system temperature, including thermocouples, Resistance Temperature Detectors (RTDs) and silicon-based temperature sensors. These sensors provide temperature feedback to the system controller to make decisions such as over-temp shutdown, fan speed control, temperature compensation or temperature monitoring. Alternatively, some systems rely on stand-alone thermal management solutions that include both fan control and temperature sensing.

Microchip offers a broad portfolio of thermal sensing and management products including temperature switches, digital temperature sensors, fan controllers and voltage-out temperature sensors. This array of products allow you to implement the device that best meets your application requirements. Key features include high temperature accuracy, integrated fan control, integrated EEPROM, low power and multi-channel temperature monitoring. Additionally, Microchip's products can be used to support thermocouple, RTD and thermistor based applications.

Temperature Management Applications
- Communications
- Medical devices
- Computing, SSD and data centers
- IoT
- Industrial
- Appliances
- Instrumentation
- Consumer Electronics

Single Channel Temperature Sensors

Temperature Switches
Temperature switches offer excellent temperature accuracy (±1°C, typical), with a very low operating current of less than 25 µA. These devices can replace mechanical switches in a variety of sensing and control applications.

Voltage Output Temperature Sensors
Voltage output temperature sensors develop an output voltage proportional to temperature with a typical temperature coefficient of 6.25 mV/°C, 10 mV/°C and 19.5 mV/°C respectively. These temperature-to-voltage converters can sense temperatures ranging from −40°C to 150°C and feature an offset voltage that allows reading negative temperatures without requiring a negative supply voltage.

Resistance Temperature Detectors (RTDs)
RTDs are able to sense temperature with extreme accuracy, have consistent and repeatable performance and low drift error (−200°C to 1200°C). For precision, these sensors also require a linearization look-up table in the microcontroller due to sensor non-linearities.

Thermistors
Thermistors (−100°C to 150°C) are normally used for over temperature shutdown purposes. Although not as accurate as some of the other temperature sensor solutions, thermistors are inexpensive and come in small packages. They are also non-linear and require a temperature compensation look-up table.

Digital Output
Single channel digital output temperature sensors offer excellent temperature accuracy (±0.25°C, typical) with a very low operating current (250 µA, typical). Communication with these devices is accomplished via an industry standard SMBus-, I²C- or SPI-compatible interface protocol. These devices feature fast conversion rate, with temperature resolution ranging from 0.0625°C to 0.5°C and some contain integrated EEPROM for customer preference storage and for datalogging.

Multichannel Digital Temperature Sensors with Multi-channel Temperature Monitoring
In addition to local temperature sensing, Microchip offers digital temperature sensors with multi-channel TS Temperature monitoring channels. These devices offer excellent temperature accuracy (±0.25°C, typical) as well. The remote channels are inexpensively implemented by using PNP or NPN transistors connected to act as a diode. Analog filtering and resistance error correction allows for remote monitors to be placed several meters away from the IC.

Thermocouples
Thermocouples are usually selected because of their wide temperature range (−270°C to 1750°C), ruggedness and price. However, they are highly non-linear and often require significant linearization algorithms. Additionally, the voltage output of this temperature sensing element is relatively low compared to devices that can convert voltage signals to a digital representation, resulting in required analog gain stages in the circuit.
Thermal Management Overview

**Fan Controller**
Fans are used in cases where heat needs to be dissipated faster than the natural surroundings would accomplish on their own. Microchip has several levels of fan control. For simple fan speed control, there are stand-alone RPM closed-loop controllers. For a full thermal management solution, many devices integrate temperature monitoring in addition to the PWM control. Controllers also incorporate both spin-up and ramp-rate control algorithms to minimize acoustics.

**Single-Channel Digital Output Temperature Solutions for Medical Applications**
Single-Channel Digital Output Temperature Sensors such as the AT30TS74 available in ultra-small Wafer Level Chip Scale Package (WLCSP) is a perfect fit for various products like Medical applications where board space is extremely limited and or constrained. The AT30TS74 WLCSP form factor takes up less than 1mm² of required board space allowing it to be placed closer to the heat source being monitored allowing for a faster thermal response to any temperature changes that occur. This is critically important for medical applications where temperature sensitivity is paramount for proper operation and enables the ability to adjust for and or take fast accurate temperature measurements. The AT30TS74 WLCSP provides a factory calibrated accuracy of ±1.0°C with programmable temperature window with Alert pin output to notify the host MCU of any temperature window violations. For hand-held battery powered medical applications, the AT30TS74 features two power saving features; a shutdown mode that turns off all of its internal circuitry saving power and a one-shot mode that allows the AT30TS74 to make a temperature measurement and update its internal temperature registers and then return to shutdown mode.

**Single-Channel Digital Output Temperature Solutions for HVAC**
Digital Temperature sensors such as the MCP9808 provide greater design flexibility and simplicity for HVAC thermostat applications. Unlike resistance temperature detectors, these sensors do not require instrumentation circuit and circuit-calibration routines, while they do provide low power and superior accuracy. The MCP9808 provides a factory calibrated maximum accuracy of ±0.5°C, and programmable features such as a temperature window monitor output. If temperature exceeds the upper and lower temperature window plus hysteresis, the alert output asserts as an interrupt for microcontrollers or as comparator for thermostat applications.

---

**Figure 2: System diagram**
Thermistor Solutions

Microchip provides various single-chip solutions for thermistors, which are used to assert alert signals to the microcontroller or switch on/off a fan or an LED indicator when temperature exceeds preset limits. For example, chilled water reservoir may use a thermistor to detect the change in temperature of the reservoir to detect water level.

Figure 3 shows how to configure the TC621 dual trip point temperature switch. The thermistor and the alert limit setting resistors directly connect to the device and the alert outputs trigger with ±0.3°C accuracy. The advantage of this device is that it provides a closed-loop temperature switch solution for thermistor applications.

Increasing the Sensor Sensitivity

Although thermistors provide a low-cost solution and are easy to implement, they are highly non-linear, particularly if the application temperature range exceeds approximately 50°C. Look up tables and correction factors are typically provided by the vendors. However, in the non-linear region, as temperature increases the change in resistance per degree Celsius or the sensitivity is reduced exponentially.

For example, a hand-held instrument with an integrated thermistor sensor to detect ambient temperature would need consistent measurement sensitivity in the Winter of Alaska as it would in the Summer of Arizona. Microchip provides various programmable gain amplifier solutions to increase the sensor sensitivity within the non-linear region. Figure 5 shows how to configure a digital potentiometer and a low-power amplifier as a programmable gain amplifier.

Figure 3: Configuration of the TC621 dual trip point temperature switch

Figure 4: Hand-held thermometer

Figure 5: Configuration of a digital potentiometer and a low-power amplifier as a programmable gain amplifier

* A general purpose op amp, such as the MCP6001.
Refrigeration Solutions for Foodstuffs

Multichannel Temperature Sensors

The FDA Food Code 2001 for temperature measuring devices requires accurate temperature sensing to ensure quality of foodstuffs during transport and storage. Applications such as commercial refrigerators, freezers and transport vehicles require temperature accuracy at low temperatures.

The MCP9902/3/4 offers the required accuracy (±1°C) to maintain cooler temperatures for quality foodstuffs.

The key features of the MCP9902/3/4 are:
- Maximum error of ±1°C from –40°C to 105°C
- Automatic beta detection
- Resistance Error Correction (REC) up to 100Ω
- Programmable temperature limits

Commercial White Good Solutions

Multichannel Temperature Sensors

Dishwashers for residential or commercial implement a hot-temperature cleaning cycle. The reduction of water consumption, shorter cycle times, increased rack loads and sanitation of cookware are driving factors for increased efficiency in dishwashers. The National Sanitization Foundation (NSF) requires a final rinse temperature of 150°F for residential dishwashers (NSF/ANSI 184) and 180°F for commercial dishwashers (NSF/ANSI 3), pulling in water from the hot-water line.

A temperature sensor monitors the temperature of the dishwasher and if it is not maintained at a necessary temperature, the heating element turns on.

The EMC1812 provides ±1°C maximum error over the temperature range of interest. Features programmable temperature limits provides a level of notification that may be used to trigger the heating element during pre-wash and main wash cycles of the dishwasher to maintain a level temperature.

Other features of the EMC1812 are:
- Maximum error of ±1°C from –20°C to 105°C
- Automatic beta detection
- Anti-Parallel Diode (APD) functionality
- Resistance Error Correction (REC) up to 100Ω
- Rate of change measurement
Thermocouple
Residential induction heating technology may be found in stand-alone cooktops, rice cookers and hot water pots. Induction-based cooking gives the fine temperature control of gas burners at much higher efficiencies than either gas or radiant heating elements. Insulated-Gate Bipolar Transistors (IGBTs) used in induction cooking applications dissipate a considerable amount of power, so to prevent the IGBT’s junction temperature from rising above its recommended specification value, large heat sinks are usually employed.

For smart Induction Cooktops, monitoring the induction heating surface temperature and the pot temperature provides better control over cooking the recipe. For this application, Thermocouples can be imbedded in both the pan and the induction cooktop surface and the main controller maintains optimum cooking temperature for the food compared to the surface temperature via connected wireless communication. Microchip’s MCP9600 Plug & Play Thermocouple conditioning IC solution is ideal for such embedded applications.

Temperature Switches
Home and small office equipment like document shredders have sheet capacities often up to 18 sheets. The desire for continuous shredding with high capacities increases the heat in the shredder’s which may cause it to seize. A cool-down period is necessary before the shredder is operational. A temperature switch like the MCP9502 may be used to monitor the motor’s temperature and alerting the user to thermal overload via an LED on the front panel.

The MCP9502 is available with factory preset temperature thresholds. This eliminates the need to program a thermal limit through software or using external components. A temperature above the limit will set a visual alert using an LED which identifies an increasing thermal condition.

Other features of the MCP9502 are:
- Push-pull output
- Factory presets from 5°C to 125°C
- Programmable hysteresis

Figure 8: Induction Cooktop

The MCP9600 allows for four external sources, standard on a residential cooktop, to be monitored to ±1°C max accuracy up to 125°C. The IGBT modules are mounted on the heat sink to ensure the IGBTs do not exceed their junction temperature. The temperature information is sent back to the system’s microcontroller in real time to mitigate over temperature conditions.

Figure 9: Induction Cooktop Diagram

Figure 10: Home and small office equipment
**RTD Solutions**

A Resistance Temperature Detector (RTD) is a temperature sensor that contain a resistor that changes resistance value as its temperature changes. An RTD is made from a pure material such as platinum. This sensor is typically used in precision applications such as laboratory equipment and medical instrumentation. In order to accurately detect change in temperature using an RTD, precision analog and digital circuits are also needed. For example, medical laboratory ovens require precision closed-loop temperature control systems. An RTD is the preferred sensor for this application for the superior repeatable characteristics as the unit temperature cycles from room temperature to the various preset levels.

Microchip provides various precision solutions for RTDs, such as an Instrumentation Amplifier with an integrated self calibration (MCP6N11), an autozeroed op amp with extremely low input offset voltage (MCP6V01) and a high-resolution precision analog to digital converter (MCP3551).

RTD sensors are available with 2-wire, 3-wire and 4-wire elements. With the 2-wire sensors, both sensor leads are in series with the sensor element. As temperature increases the lead resistance also changes and the voltage drop across the leads reduces the measurement accuracy.

![Wire configurations](image)

**Reference Designs**

**MCP6N11 Wheatstone Birdge Reference Design (ARD00354)**

Microchip provides a reference design which uses a Wheatstone Bridge balanced RTD circuit to analyze and compare the performance of the traditional three op amp instrumentation amplifier with the MCP6V01 family of op amps and the MCP6N11 instrumentation amplifier. This reference design enables users to perform noise analysis and study each circuit characteristics to identify the preferred solution using a software Graphical User Interface (GUI).

**RTD Reference Design (TMPSNSRD-RTD2)**

Microchip also provides a reference design which uses a current source to bias the RTD. This solution uses a high-performance Delta-Sigma Analog-to-Digital Converter (ADC), two external resistors and a reference voltage to measure temperature ratiometrically. A ±0.1°C accuracy and ±0.01°C measurement resolution can be achieved across the RTD temperature range of −200°C to +800°C with a single-point calibration.
**Thermocouple Solutions**

A Thermocouple is a rugged temperature sensor used to measure high temperatures. When the thermocouple Hot-Junction is exposed to high temperatures such as 1000ºC, a small change in voltage can be measured at the open end of the Thermocouple, the Cold-Junction, which is normally at room temperature.

The thermocouple wires are made of two dissimilar materials which are typically categories by either base metal or precious metal compositions. There are several types of Thermocouple standards and the most common types are Type K and Type J Thermocouples. The other type of Thermocouples such as Type T, N, S, B, and R are more of application specific and provide increased sensitivity at various temperature ranges.

Common Applications for thermocouples include petrochemical, industrial ovens, engines, machinery used in the steel and iron industry with operating ambient temperatures ranges of approximately –200ºC to 2000ºC.

Microchip offers a Plug & Play integrated solutions for the common thermocouples, the MCP9600 family. This family of devices integrates the thermocouple error compensation equation and the Cold-Junction compensation sensor with a factory calibrated hot-Junction accuracy of ±1.5ºC, ±4ºC, and ±8ºC maximum accuracy for a high, medium, and low accuracy applications.

In addition, the device provides various user programmable features for embedded applications such as Open-Circuit and Short-Circuit detection, 4-user programmable temperature alert limits, temperature averaging, programmable temperature resolution, and power saving features such as Burst-Mode temperature sampling.

Microchip offers an evaluation board for the MCP9600 which allows users to evaluate the various features.

Microchip also provides a number precision linear products such as op amps and instrumentation amplifiers, MCP6V01 and MCP6N11, respectively. Additionally, Microchip provides high resolution Delta-Sigma Analog-to-Digital Converters for thermocouple solution such as the MCP3461 16-bit, MCP3421 18-bit and MCP3465 24-bit ADCs.

One of the unique advantage of thermocouples is the fast-thermal response characteristics with a typical response time of approximately 5 ms. A typical application for such highspeed response is electrical arcing for industrial or high current breaker switches, and the MCP6V01 family op amps are ideal solutions for such applications (see AN1306 application note from Microchip for details).
Energy Efficient Thermal Solutions

Multichannel Temperature Sensors

The ever increasing power supply requirements and board densities in computing systems require efficient thermal management solutions. Factors such as cost, accuracy and system size help determine the type of temperature sensor applicable to manage the thermal load of the computing system.

Silicon-based temperature sensors use a fundamental property of bipolar transistors to determine temperature. Temperature may be calculated by measuring a change in voltage when two different currents are implemented. Figure 13 and Equation 1 illustrate the concept of a silicon-based temperature measurement.

\[
\Delta V_{BE} = \left( \frac{kT}{q} \right) \ln \left( \frac{I_{C1}}{I_{C2}} \right)
\]

\[
T = \frac{\Delta V_{BE} \times q}{n k \ln \left( \frac{I_{C1}}{I_{C2}} \right)}
\]

Equation 1: Silicon-based temperature measurement

Where \(T\) = temperature in Kelvin
\(\Delta V_{BE}\) = change in diode base emitter voltage
\(k\) = Boltzmann’s constant
\(q\) = electron charge
\(n\) = diode ideality factor
\(I_{C1}\) and \(I_{C2}\) = currents with \(n:1\) ratio

The EMC18xx is ideal for low-cost motherboards to monitor the ambient temperature at several locations. These may include the chassis, add-in card sockets and surrounding components as shown in Figure 14.

As temperatures increase due to high levels of processor load; whether it is the CPU, GPU or memory modules, the system may throttle the clocking frequency to mitigate the temperature rise in the system. The \(\pm 1^\circ C\) maximum accuracy of the EMC18xx eliminates the concern of premature throttling or system shutdown due to increasing system temperature.

- Maximum error of \(\pm 1^\circ C\) from \(-20^\circ C\) to \(+105^\circ C\)
- Programmable temperature limits
- Configurable ALERT function as a comparator mode or as system interrupt mode

For higher-density applications such as high-end system boards for laptops, server racks and tablets, a remote diode temperature sensor, such as the EMC1814, may be used for increased flexibility and reduced component count.

The Anti-Parallel Diode (APD) feature of the EMC1814 allows for a single device to monitor several zones at once, leveraging a stand-alone diode connected transistor or the discrete diode-connected transistor of a CPU, GPU or an ASIC processor.

It is important to understand the processor geometry in today’s computing products. A substrate diode is often used as the temperature sensor. Decreasing geometries degrade the accuracy of the sensor. To ensure accuracy, the EMC1814 employs automatic beta detection before every conversion.

Microchip’s patented frequency hopping technique mitigates noise coupling into the input traces from switching noise sources including backlight inverters, SMPS and other sources of EMI.

The EMC1814’s Resistance Error Correction (REC) mitigates temperature error from long PCB traces, cabling and interconnects resistances. Without REC, every 1Ω of resistance in the measurement path would have added approximately \(+0.7^\circ C\) error to the temperature measurement.

The key features of the EMC1814 are:
- Maximum error of \(\pm 1.5^\circ C\) from \(-20^\circ C\) to \(+105^\circ C\)
- Programmable temperature limits
- Configurable ALERT and THERM functions for system interrupts
Fan Controllers
Temperature sensors may also work in conjunction with fan controllers ensuring a greater depth of thermal management. Microchip offers fan controllers with programmable features allowing for flexible solutions for modify to servers, LCD projectors, workstations, and networking equipment racks.

Audible noise from the fan spinning up or changing RPM too abruptly may dampen the end user experience. The spin-up routine (Figure 15) of Microchip’s fan drivers, such as the EMC2303, mitigate audible noise during the initial start of the fan. During normal operation, programmable ramp-rate control may be implemented to reduce audible fan noise when the speed of the fan is required to change.

In servers and network racks the EMC2303 allows for multiple zones to be cooled. When a system detects a thermal condition from its array of temperature sensors, the CPU will drive the fan to increase air flow volume to lower the temperature.

Typically +12V fans are implemented in the server space requiring an interface circuit to isolate supply voltages as illustrated in Figure 16. The isolation circuit uses only two components, a FET and a Schottky diode.

Cloud computing solutions for modern datacenters further increase the need for thermal management. High-end servers rely on a distributed network of sensors and fans throughout the system. This network allows individual peripherals to be monitored for increased granular control for greater energy efficiency. Implementing APD, REC, automatic beta detection, spin-up and ramp-rate control in one solution while supporting five temperature zones (four external, one internal) to be monitored. Products such as the EMC2106 combine temperature sensing and fan control in a 28-pin QFN package.

Combined with closed-loop fan control, the EMC2106 drives up to two fans to provide additional air flow in the server rack.

Other features of the EMC2106 are:
- Maximum error of ±2°C from 0°C to 125°C
- Stalled fan and aging fan detection

The key features of the EMC2305:
- Closed-loop, PID control
- High-frequency PWM (26 kHz) to reduce acoustical noise
- Stalled fan and aging fan detection
Thermal Management Graphical User Interface

The Microchip Thermal Management Graphical User Interface allows users to evaluate various temperature-sensing evaluation boards. This software tool can be downloaded and installed from the evaluation board product page.

After the installation is successfully completed, the hardware is required to be connected via USB to start the Thermal Management GUI. Once the hardware is connected, the software recognizes the device ID and displays the corresponding GUI for the connected evaluation board. Disconnecting the USB will close the GUI. This tool allows the user to evaluate the sensor features and perform temperature data logging.

The figure above shows an example of the MCP9600 data acquisition interface with a plot of the Thermocouple Hot-Junction and Cold-Junction temperatures.

<table>
<thead>
<tr>
<th>Board Name</th>
<th>Order Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermocouple Analog Discrete Component Demo Board</td>
<td>TMPSNSRD-TCPL1</td>
</tr>
<tr>
<td>RTD Demo Board</td>
<td>TMPSNSRD-RTD2</td>
</tr>
<tr>
<td>Thermistor Demo Board</td>
<td>MCP9700DM-TH1</td>
</tr>
<tr>
<td>MCP6N11 and MCP6V2x Wheatstone Bridge Ref Design</td>
<td>ARD00354</td>
</tr>
<tr>
<td>MCP9600 Evaluation Board</td>
<td>ADM00665</td>
</tr>
<tr>
<td>EMC1833 Evaluation Board</td>
<td>ADM00773</td>
</tr>
<tr>
<td>EMC1438/EMC2305 Fan Controller and Temperature Demo</td>
<td>ADM00879</td>
</tr>
<tr>
<td>EMC2103-4 Fan Controller and Temperature Demo</td>
<td>ADM00902</td>
</tr>
</tbody>
</table>
Application Notes

The following application notes are available on the Microchip website: www.microchip.com.

General Temperature Sensing

AN679: Temperature Sensing Technologies
The most popular temperature sensor technologies are discussed at a level of detail that will give you insight into the methods of determining which sensor is most appropriate for a particular application.

AN867: Temperature Sensing with a Programmable Gain Amplifier
The implementation of temperature measurement systems from sensor to PIC® microcontroller using a NTC thermistor, silicon temperature sensor, and anti-aliasing filter, ADC and microcontroller are discussed.

AN929: Temperature Measurement Circuits for Embedded Applications
This application note explores selection techniques for temperature sensor and conditioning circuits to maximize the measurement accuracy, while simplifying the interface to a microcontroller.

AN1001: IC Temperature Sensor Accuracy Compensation with a PIC Microcontroller
The typical accuracy of analog and serial-output IC temperature sensors is within ±1°C, however, at hot or cold extremes, the accuracy decreases non-linearly. This application note is based on the analog output MCP9700/9701 and serial output MCP9800 temperature sensors. It derives an equation describing the sensor’s typical non-linear characteristics, which can be used to compensate for the sensor’s accuracy error over the specified operating temperature range.

Silicon IC Temperature Sensors: Analog Output

AN938: Interfacing a TC1047A Analog Output Temperature Sensors to a PIC Microcontroller
This application note discusses system integration, firmware implementation and PCB layout techniques for using the TC1047A in an embedded system.

TB051: Precision Temperature Measurement Technical Brief
This technical brief provides a description for interfacing a TC1046 temperature sensor to a PIC16F872 microcontroller.

A 2 × 20 dot matrix LCD is included in the design to provide additional functionality.

Silicon IC Temperature Sensors: Logic Output

AN762: Applications of the TC62X Solid-State Temperature Sensor
Sensing temperature and comparing that temperature to preset limits is the basis for a variety of problems that you face is system design and process control. This application note discusses the new generation of small, easy-to-use, temperature-sensing products provided by Microchip, namely the TC62X product family.

AN773: Application Circuits of the TC620/TC621 Solid-State Temperature Sensors
This application note discusses the benefits of the TC620/TC621 solid-state temperature sensors.

Silicon IC Temperature Sensors: Serial Output

AN10.14: Using Temperature-Sensing Diodes with Remote Thermal Sensors
This application note describes how to maintain accuracy when diodes are used as remote sensors with the multi-channel TS devices from Microchip.

AN12.14: Remote Thermal Sensing Diode Selection Guide
This application note is aimed at designers who build systems that use thermal sensors with remote diodes; specifically, remote diodes that are discrete bipolar junction transistors.

AN13.19: Resistance Error Correction
This application note describes the resistance error correction feature available on many Microchip temperature sensor devices.

AN14.0: Microchip Dedicated Slave Devices in I²C Systems
This document describes the key differences that may affect successful application of Microchip’s two-wire serial interface dedicated slaves devices in systems are designed with an I²C master interface.
Related Support Material

AN16.4: Using Anti-Parallel Diodes (APDs) with Microchip’s Remote Temperature Sensing Devices
This application note provides information on maintaining temperature measurement accuracy and noise immunity when using APDs with Microchip’s APD temperature sensing devices.

AN18.15: PCB Design Guidelines for QFN and DQFN Packages
This application note provides information on general Printed Circuit Board (PCB) layout considerations for Microchip products using QFN and DQFN packages. It is written for users who are familiar with PCB design, including signal integrity and thermal management implementation concepts.

AN871: Solving Thermal Measurement Problems Using the TC72 and TC77 Digital Silicon Temperature Sensors
This application note discusses the benefits of the TC72/TC77 temperature sensors by analyzing their internal circuitry, illustrating the principles these sensors employ to accurately measure temperature.

AN913: Interfacing the TC77 Thermal Sensor to a PIC Microcontroller
This application note discusses system integration, firmware implementation and PCB layout techniques for using the TC77 in an embedded system.

AN940: Interfacing the TC72 SPI Digital Temperature Sensor to a PIC Microcontroller
Techniques for integrating the TC72 into an embedded system are demonstrated in this application note using the PICkit™ Flash Starter Kit.

TB050: Monitoring Multiple Temperature Nodes Using TC74 Thermal Sensors and a PIC16C505
The PIC16C505 is a 14-pin MCU that can easily interface to the TC74. This technical brief illustrates the ease of interfacing these two products.

TB052: Multizone Temperature Monitoring with the TCN75 Thermal Sensor
This technical brief presents an example of a simple, multi-zone thermal-monitoring system using the Hardware mode of the Master Synchronous Serial Port (MSSP) module of a PIC microcontroller.

Thermocouples

AN684: Single-Supply Temperature Sensing with Thermocouples
This application note focuses on circuit solutions that use thermocouples in their design. The signal-conditioning path for the thermocouple system is discussed, followed by complete application circuits.

RTDs

AN687: Precision Temperature Sensing with RTD Circuits
This application note focuses on circuit solutions that use platinum RTDs in their design.

AN895: Oscillator Circuits for RTD Temperature Sensors
This application note demonstrates how to design a temperature sensor oscillator circuit using Microchip’s low-cost MCP001 operational amplifier and the MCP6541 comparator.

ADM00768: MCP9904 Multi-Channel Temperature Sensor Evaluation Board
ADM00879: EMC2305/EMC1438 Fan Controller Evaluation Board
ADM00773: EMC1833 Multi-Channel Temperature Sensor Evaluation Board
ADM00902: EMC2103-4 Fan Controller With Multi-Channel Temperature Sensor Evaluation Board
Selected Product Specifications

See Microchip’s Advanced Parts Selector (MAPS) software for complete product selection and specifications.

Serial Output Temperature Sensor Products

<table>
<thead>
<tr>
<th>Device</th>
<th>Serial Communication</th>
<th>Accuracy @25°C (Typ. ±°C / Max. ±°C)</th>
<th>Temperature Range (°C)</th>
<th>Vdd Min. (V)</th>
<th>Vdd Max. (V)</th>
<th>Iq Max. (μA)</th>
<th>Packages</th>
<th>Development Tools</th>
</tr>
</thead>
<tbody>
<tr>
<td>AT30TS00</td>
<td>SMBus</td>
<td>2/3 0.5/1 (+75°C to +95°C)</td>
<td>–20 to +125</td>
<td>2.7</td>
<td>3.6</td>
<td>500</td>
<td>8-pin DFN</td>
<td>-</td>
</tr>
<tr>
<td>AT30TS74</td>
<td>SMBus/PC</td>
<td>2/3 1/2 (-20°C to +100°C)</td>
<td>–40 to +125</td>
<td>1.7</td>
<td>5.5</td>
<td>325</td>
<td>8-pin DFN, 8-pin MSOP, 4/5-ball WLCSP, 8-pin SOIC</td>
<td>-</td>
</tr>
<tr>
<td>AT30TS75A</td>
<td>SMBus/PC</td>
<td>2/3 1/2 (-20°C to +100°C)</td>
<td>–40 to +125</td>
<td>1.7</td>
<td>5.5</td>
<td>325</td>
<td>8-pin DFN, 8-pin MSOP, 8-pin SOIC</td>
<td>-</td>
</tr>
<tr>
<td>AT30TSE002B</td>
<td>SMBus</td>
<td>2/3 0.5/1 (+75°C to +95°C)</td>
<td>–20 to +125</td>
<td>2.7</td>
<td>5.5</td>
<td>500</td>
<td>8-pin DFN</td>
<td>-</td>
</tr>
<tr>
<td>AT30TSE004A</td>
<td>SMBus</td>
<td>2/3 0.5/1 (+75°C to +95°C)</td>
<td>–20 to +125</td>
<td>1.7</td>
<td>5.5</td>
<td>500</td>
<td>8-pin DFN</td>
<td>-</td>
</tr>
<tr>
<td>AT30TSE752A</td>
<td>SMBus/PC</td>
<td>2/3 1/2 (-20°C to +100°C)</td>
<td>–40 to +125</td>
<td>1.7</td>
<td>5.5</td>
<td>325</td>
<td>8-pin DFN, 8-pin MSOP, 8-pin SOIC</td>
<td>-</td>
</tr>
<tr>
<td>AT30TSE754A</td>
<td>SMBus/PC</td>
<td>2/3 1/2 (-20°C to +100°C)</td>
<td>–40 to +125</td>
<td>1.7</td>
<td>5.5</td>
<td>325</td>
<td>8-pin DFN, 8-pin MSOP, 8-pin SOIC</td>
<td>-</td>
</tr>
<tr>
<td>AT30TSE758A</td>
<td>SMBus/PC</td>
<td>2/3 1/2 (-20°C to +100°C)</td>
<td>–40 to +125</td>
<td>1.7</td>
<td>5.5</td>
<td>325</td>
<td>8-pin DFN, 8-pin MSOP, 8-pin SOIC</td>
<td>-</td>
</tr>
<tr>
<td>MCP9800</td>
<td>PC</td>
<td>0.5/1</td>
<td>–40 to +125</td>
<td>2.7</td>
<td>5.5</td>
<td>400</td>
<td>5-pin SOT-23</td>
<td>MCP9800DM-TS1</td>
</tr>
<tr>
<td>MCP9801</td>
<td>PC</td>
<td>0.5/1</td>
<td>–40 to +125</td>
<td>2.7</td>
<td>5.5</td>
<td>400</td>
<td>8-pin MSOP, 8-pin SOIC</td>
<td>-</td>
</tr>
<tr>
<td>MCP9802</td>
<td>SMBus</td>
<td>0.5/1</td>
<td>–40 to +125</td>
<td>2.7</td>
<td>5.5</td>
<td>400</td>
<td>5-pin SOT-23</td>
<td>-</td>
</tr>
<tr>
<td>MCP9803</td>
<td>SMBus</td>
<td>0.5/1</td>
<td>–40 to +125</td>
<td>2.7</td>
<td>5.5</td>
<td>400</td>
<td>8-pin MSOP, 8-pin SOIC</td>
<td>-</td>
</tr>
<tr>
<td>MCP9804</td>
<td>SMBus</td>
<td>0.25/1</td>
<td>–40 to +125</td>
<td>2.7</td>
<td>5.5</td>
<td>400</td>
<td>8-pin DFN, 8-pin MSOP</td>
<td>-</td>
</tr>
<tr>
<td>MCP9805</td>
<td>SMBus</td>
<td>2/3 0.5/1 (+75°C to +95°C)</td>
<td>–20 to +125</td>
<td>3.0</td>
<td>3.6</td>
<td>500</td>
<td>8-pin DFN, 8-pin TSSOP</td>
<td>-</td>
</tr>
<tr>
<td>MCP9808</td>
<td>SMBus</td>
<td>0.25/1 0.25/0.5 (-20°C to +100°C)</td>
<td>–40 to +125</td>
<td>2.7</td>
<td>5.5</td>
<td>400</td>
<td>8-pin DFN, 8-pin MSOP</td>
<td>-</td>
</tr>
<tr>
<td>MCP9814</td>
<td>SMBus</td>
<td>1/3 0.2/1 (+75°C to +95°C)</td>
<td>–20 to +125</td>
<td>2.7</td>
<td>3.6</td>
<td>500</td>
<td>8-pin DFN</td>
<td>-</td>
</tr>
<tr>
<td>MCP9843</td>
<td>SMBus</td>
<td>1/3 0.2/1 (+75°C to +95°C)</td>
<td>–20 to +125</td>
<td>2.7</td>
<td>3.6</td>
<td>500</td>
<td>8-pin DFN</td>
<td>-</td>
</tr>
<tr>
<td>MCP9844</td>
<td>SMBus</td>
<td>1/3 0.2/1 (+75°C to +95°C)</td>
<td>–40 to +125</td>
<td>1.7</td>
<td>3.6</td>
<td>500</td>
<td>8-pin DFN</td>
<td>-</td>
</tr>
<tr>
<td>TC72</td>
<td>4-wire SPI</td>
<td>0.5/1</td>
<td>–40 to +125</td>
<td>2.65</td>
<td>5.5</td>
<td>400</td>
<td>8-pin MSOP, 8-pin DFN</td>
<td>-</td>
</tr>
<tr>
<td>TC74</td>
<td>SMBus/PC</td>
<td>0.5/2</td>
<td>–40 to +125</td>
<td>2.7</td>
<td>5.5</td>
<td>350</td>
<td>5-pin TC-220 5-pin SOT-23</td>
<td>-</td>
</tr>
<tr>
<td>TCN75A</td>
<td>SMBus/PC</td>
<td>0.5/2</td>
<td>–40 to +125</td>
<td>2.7</td>
<td>5.5</td>
<td>500</td>
<td>8-pin MSOP, 8-pin SOIC</td>
<td>-</td>
</tr>
<tr>
<td>TC77</td>
<td>3-wire SPI</td>
<td>0.5/1</td>
<td>–40 to +125</td>
<td>2.7</td>
<td>5.5</td>
<td>400</td>
<td>8-pin SOIC, 5-pin SOT-23</td>
<td>-</td>
</tr>
</tbody>
</table>
# Selected Product Specifications

## Multi-Channel Digital Temperature Sensors

<table>
<thead>
<tr>
<th>Product</th>
<th>Description</th>
<th># Temps Monitored</th>
<th>Typical Accuracy (°C)</th>
<th>±ΔA (°C)</th>
<th>Temp. Range (°C)</th>
<th>Vcc Range (V)</th>
<th>Typical Supply Current (µA)</th>
<th>Resolution (Bits)</th>
<th>Alert/THERM</th>
<th>Hardware Shutdown</th>
<th>Packages</th>
<th>Automotive Recommended</th>
</tr>
</thead>
<tbody>
<tr>
<td>MIC184</td>
<td>SMBus/PC Multi Temperature Sensor</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>–55 to +125</td>
<td>2.7 - 5.5</td>
<td>500</td>
<td>9</td>
<td>1</td>
<td></td>
<td>8/MSOP</td>
<td>No</td>
</tr>
<tr>
<td>MIC280</td>
<td>SMBus/PC Multi Temperature Sensor</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>–55 to +125</td>
<td>3 - 3.6</td>
<td>400</td>
<td>1</td>
<td>1</td>
<td></td>
<td>6/SOT-23</td>
<td>No</td>
</tr>
<tr>
<td>EMC1046</td>
<td>SMBus/PC Multi Temp Sensor with Hottest of Zones</td>
<td>6</td>
<td>0.25</td>
<td>1</td>
<td>–40 to +125</td>
<td>+3.0 - +3.6</td>
<td>395</td>
<td>11</td>
<td></td>
<td></td>
<td>10/MSOP</td>
<td>No</td>
</tr>
<tr>
<td>EMC1047</td>
<td>SMBus/PC Multi Temp Sensor with Hottest of Zones</td>
<td>7</td>
<td>0.25</td>
<td>1</td>
<td>–40 to +125</td>
<td>+3.0 - +3.6</td>
<td>395</td>
<td>11</td>
<td></td>
<td></td>
<td>10/MSOP</td>
<td>No</td>
</tr>
<tr>
<td>EMC1428</td>
<td>SMBus/PC Multi Temp Sensor with Hottest of Zones</td>
<td>8</td>
<td>0.25</td>
<td>1</td>
<td>–40 to +125</td>
<td>+3.0 - +3.6</td>
<td>450</td>
<td>11</td>
<td>1</td>
<td>1</td>
<td>16/QFN</td>
<td>No</td>
</tr>
<tr>
<td>EMC1438</td>
<td>SMBus/PC Multi Temp Sensor with Hottest of Zones</td>
<td>8</td>
<td>0.25</td>
<td>1</td>
<td>–40 to +125</td>
<td>+3.0 - +3.6</td>
<td>450</td>
<td>11</td>
<td>1</td>
<td>1</td>
<td>16/QFN</td>
<td>No</td>
</tr>
<tr>
<td>EMC1422</td>
<td>SMBus/PC Multi Temp Sensor with Shutdown</td>
<td>2</td>
<td>0.25</td>
<td>1</td>
<td>–40 – +125</td>
<td>+3.0 - +3.6</td>
<td>430</td>
<td>11</td>
<td>1</td>
<td>1</td>
<td>8/MSOP</td>
<td>No</td>
</tr>
<tr>
<td>EMC1423</td>
<td>SMBus/PC Multi Temp Sensor with Shutdown</td>
<td>3</td>
<td>0.25</td>
<td>1</td>
<td>–40 – +125</td>
<td>+3.0 - +3.6</td>
<td>430</td>
<td>11</td>
<td>1</td>
<td>1</td>
<td>10/MSOP</td>
<td>No</td>
</tr>
<tr>
<td>EMC1424</td>
<td>SMBus/PC Multi Temp Sensor with Shutdown</td>
<td>4</td>
<td>0.25</td>
<td>1</td>
<td>–40 to +125</td>
<td>+3.0 - +3.6</td>
<td>430</td>
<td>11</td>
<td>1</td>
<td>1</td>
<td>10/MSOP</td>
<td>No</td>
</tr>
<tr>
<td>EMC1412</td>
<td>SMBus/PC Multi Temperature Sensor</td>
<td>2</td>
<td>0.25</td>
<td>1</td>
<td>–40 to +125</td>
<td>+3.0 - +3.6</td>
<td>430</td>
<td>11</td>
<td>2</td>
<td></td>
<td>8/MSOP</td>
<td>No</td>
</tr>
<tr>
<td>EMC1413</td>
<td>SMBus/PC Multi Temperature Sensor</td>
<td>3</td>
<td>0.25</td>
<td>1</td>
<td>–40 to +125</td>
<td>+3.0 - +3.6</td>
<td>430</td>
<td>11</td>
<td>2</td>
<td></td>
<td>10/MSOP/</td>
<td>No</td>
</tr>
<tr>
<td>EMC1414</td>
<td>SMBus/PC Multi Temperature Sensor</td>
<td>4</td>
<td>0.25</td>
<td>1</td>
<td>–40 to +125</td>
<td>+3.0 - +3.6</td>
<td>430</td>
<td>11</td>
<td>2</td>
<td></td>
<td>10/MSOP/</td>
<td>No</td>
</tr>
<tr>
<td>EMC1812</td>
<td>SMBus/PC Multi Temperature Sensor</td>
<td>2</td>
<td>0.25</td>
<td>1</td>
<td>–40 to +125</td>
<td>+3.0 - +3.6</td>
<td>20</td>
<td>11</td>
<td>2</td>
<td></td>
<td>8/WDFN</td>
<td>No</td>
</tr>
<tr>
<td>EMC1813</td>
<td>SMBus/PC Multi Temperature Sensor</td>
<td>3</td>
<td>0.25</td>
<td>1</td>
<td>–40 to +125</td>
<td>+1.62 - +3.60</td>
<td>20</td>
<td>11</td>
<td>2</td>
<td></td>
<td>10/WDFN</td>
<td>No</td>
</tr>
<tr>
<td>EMC1814</td>
<td>SMBus/PC Multi Temperature Sensor</td>
<td>4</td>
<td>0.25</td>
<td>1</td>
<td>–40 to +125</td>
<td>+1.62 - +3.60</td>
<td>20</td>
<td>11</td>
<td>2</td>
<td></td>
<td>10/WDFN</td>
<td>No</td>
</tr>
<tr>
<td>EMC1815</td>
<td>SMBus/PC Multi Temperature Sensor</td>
<td>5</td>
<td>0.25</td>
<td>1</td>
<td>–40 to +125</td>
<td>+1.62 - +3.60</td>
<td>20</td>
<td>11</td>
<td>2</td>
<td></td>
<td>10/WDFN</td>
<td>No</td>
</tr>
<tr>
<td>EMC1822</td>
<td>SMBus/PC Multi Temperature Sensor</td>
<td>2</td>
<td>0.25</td>
<td>1</td>
<td>–40 to +125</td>
<td>+1.62 - +3.60</td>
<td>20</td>
<td>11</td>
<td>1</td>
<td>1</td>
<td>8/WDFN</td>
<td>No</td>
</tr>
<tr>
<td>EMC1823</td>
<td>SMBus/PC Multi Temperature Sensor</td>
<td>3</td>
<td>0.25</td>
<td>1</td>
<td>–40 to +125</td>
<td>+1.62 - +3.60</td>
<td>20</td>
<td>11</td>
<td>1</td>
<td>1</td>
<td>10/WDFN</td>
<td>No</td>
</tr>
<tr>
<td>EMC1824</td>
<td>SMBus/PC Multi Temperature Sensor</td>
<td>4</td>
<td>0.25</td>
<td>1</td>
<td>–40 to +125</td>
<td>+1.62 - +3.60</td>
<td>20</td>
<td>11</td>
<td>1</td>
<td>1</td>
<td>10/WDFN</td>
<td>No</td>
</tr>
<tr>
<td>EMC1825</td>
<td>SMBus/PC Multi Temperature Sensor</td>
<td>5</td>
<td>0.25</td>
<td>1</td>
<td>–40 to +125</td>
<td>+1.62 - +3.60</td>
<td>20</td>
<td>11</td>
<td>1</td>
<td>1</td>
<td>10/WDFN</td>
<td>No</td>
</tr>
<tr>
<td>EMC1833</td>
<td>SMBus/PC Multi Temperature Sensor</td>
<td>3</td>
<td>0.25</td>
<td>1</td>
<td>–40 to +125</td>
<td>+1.62 - +3.60</td>
<td>20</td>
<td>11</td>
<td>2</td>
<td></td>
<td>8/WDFN</td>
<td>No</td>
</tr>
<tr>
<td>EMC1843</td>
<td>SMBus/PC Multi Temperature Sensor</td>
<td>3</td>
<td>0.25</td>
<td>1</td>
<td>–40 to +125</td>
<td>+1.62 - +3.60</td>
<td>20</td>
<td>11</td>
<td>2</td>
<td></td>
<td>8/WDFN</td>
<td>No</td>
</tr>
<tr>
<td>MCP9902</td>
<td>SMBus/PC Multi Temperature Sensor</td>
<td>2</td>
<td>0.25</td>
<td>1</td>
<td>–40 to +125</td>
<td>+3.0 - +3.6</td>
<td>225</td>
<td>11</td>
<td>2</td>
<td></td>
<td>8/WDFN</td>
<td>No</td>
</tr>
<tr>
<td>MCP9903</td>
<td>SMBus/PC Multi Temperature Sensor</td>
<td>3</td>
<td>0.25</td>
<td>1</td>
<td>–40 to +125</td>
<td>+3.0 - +3.6</td>
<td>225</td>
<td>11</td>
<td>2</td>
<td></td>
<td>10/WDFN</td>
<td>No</td>
</tr>
<tr>
<td>MCP9904</td>
<td>SMBus/PC Multi Temperature Sensor</td>
<td>4</td>
<td>0.25</td>
<td>1</td>
<td>–40 to +125</td>
<td>+3.0 - +3.6</td>
<td>225</td>
<td>11</td>
<td>2</td>
<td></td>
<td>10/WDFN</td>
<td>No</td>
</tr>
</tbody>
</table>
# Selected Product Specifications

## Open-Loop Fan Controllers and Fan Fault Detectors

<table>
<thead>
<tr>
<th>Part #</th>
<th>Description</th>
<th># of Temp. Monitors</th>
<th>Typical Accuracy</th>
<th>Maximum Accuracy @ 25°C (°C)</th>
<th>Typical Temperature Range (°C)</th>
<th>Vcc Range (V)</th>
<th>Maximum Supply Current (µA)</th>
<th>Features</th>
<th>Packages</th>
</tr>
</thead>
<tbody>
<tr>
<td>EMC2101</td>
<td>Single SMBus TC Fan Manager</td>
<td>2</td>
<td>±0.5</td>
<td>±1</td>
<td>-40 to +125</td>
<td>+3.0 to +3.6</td>
<td>1,000</td>
<td>Fan Controller with high-frequency PWM driver, programmable fan speed table and alert</td>
<td>8-pin MSOP, 8-pin SOIC</td>
</tr>
<tr>
<td>TC642</td>
<td>Fan Manager</td>
<td>1</td>
<td>Note 1</td>
<td>Note 1</td>
<td>-40 to +85</td>
<td>+3.0 to +5.5</td>
<td>1,000</td>
<td>FanSense Fan Monitor, Minimum fan speed control</td>
<td>8-pin PDIP, 8-pin SOIC, 8-pin MSOP</td>
</tr>
<tr>
<td>TC642B</td>
<td>Fan Manager</td>
<td>1</td>
<td>Note 1</td>
<td>Note 1</td>
<td>-40 to +85</td>
<td>+3.0 to +5.5</td>
<td>400</td>
<td>FanSense Fan Monitor, Minimum fan speed control, Fan auto-restart</td>
<td>8-pin PDIP, 8-pin SOIC, 8-pin MSOP</td>
</tr>
<tr>
<td>TC646</td>
<td>Fan Manager</td>
<td>1</td>
<td>Note 1</td>
<td>Note 1</td>
<td>-40 to +85</td>
<td>+3.0 to +5.5</td>
<td>1,000</td>
<td>FanSense Fan Monitor, Auto-shutdown</td>
<td>8-pin PDIP, 8-pin SOIC, 8-pin MSOP</td>
</tr>
<tr>
<td>TC646B</td>
<td>Fan Manager</td>
<td>1</td>
<td>Note 1</td>
<td>Note 1</td>
<td>-40 to +85</td>
<td>+3.0 to +5.5</td>
<td>400</td>
<td>FanSense Fan Monitor, Auto-shutdown, Fan auto-restart</td>
<td>8-pin PDIP, 8-pin SOIC, 8-pin MSOP</td>
</tr>
<tr>
<td>TC647</td>
<td>Fan Manager</td>
<td>1</td>
<td>Note 1</td>
<td>Note 1</td>
<td>-40 to +85</td>
<td>+3.0 to +5.5</td>
<td>1,000</td>
<td>FanSense Fan Monitor, Minimum fan speed control, Fan auto-restart</td>
<td>8-pin PDIP, 8-pin SOIC, 8-pin MSOP</td>
</tr>
<tr>
<td>TC647B</td>
<td>Fan Manager</td>
<td>1</td>
<td>Note 1</td>
<td>Note 1</td>
<td>-40 to +85</td>
<td>+3.0 to +5.5</td>
<td>400</td>
<td>FanSense Fan Monitor, Minimum fan speed control, Fan auto-restart</td>
<td>8-pin PDIP, 8-pin SOIC, 8-pin MSOP</td>
</tr>
<tr>
<td>TC648</td>
<td>Fan Manager</td>
<td>1</td>
<td>Note 1</td>
<td>Note 1</td>
<td>-40 to +85</td>
<td>+3.0 to +5.5</td>
<td>1,000</td>
<td>Overtemperature alert, Auto-shutdown</td>
<td>8-pin PDIP, 8-pin SOIC, 8-pin MSOP</td>
</tr>
<tr>
<td>TC648B</td>
<td>Fan Manager</td>
<td>1</td>
<td>Note 1</td>
<td>Note 1</td>
<td>-40 to +85</td>
<td>+3.0 to +5.5</td>
<td>400</td>
<td>Overtemperature alert, Auto-shutdown, Fan auto-restart</td>
<td>8-pin PDIP, 8-pin SOIC, 8-pin MSOP</td>
</tr>
<tr>
<td>TC649</td>
<td>Fan Manager</td>
<td>1</td>
<td>Note 1</td>
<td>Note 1</td>
<td>-40 to +85</td>
<td>+3.0 to +5.5</td>
<td>1,000</td>
<td>FanSense Fan Monitor, Auto-shutdown</td>
<td>8-pin PDIP, 8-pin SOIC, 8-pin MSOP</td>
</tr>
<tr>
<td>TC649B</td>
<td>Fan Manager</td>
<td>1</td>
<td>Note 1</td>
<td>Note 1</td>
<td>-40 to +85</td>
<td>+3.0 to +5.5</td>
<td>400</td>
<td>FanSense Fan Monitor, Auto-shutdown, Fan auto-restart</td>
<td>8-pin PDIP, 8-pin SOIC, 8-pin MSOP</td>
</tr>
<tr>
<td>TC650</td>
<td>Fan Manager</td>
<td>1</td>
<td>±1</td>
<td>±3</td>
<td>-40 to +125</td>
<td>+2.8 to +5.5</td>
<td>90</td>
<td>Overtemperature alert</td>
<td>8-pin MSOP</td>
</tr>
<tr>
<td>TC651</td>
<td>Fan Manager</td>
<td>1</td>
<td>±1</td>
<td>±3</td>
<td>-40 to +125</td>
<td>+2.8 to +5.5</td>
<td>90</td>
<td>Overtemperature alert, Auto-shutdown</td>
<td>8-pin MSOP</td>
</tr>
<tr>
<td>TC652</td>
<td>Fan Manager</td>
<td>1</td>
<td>±1</td>
<td>±3</td>
<td>-40 to +125</td>
<td>+2.8 to +5.5</td>
<td>90</td>
<td>FanSense Fan Monitor, Overtemperature alert</td>
<td>8-pin MSOP</td>
</tr>
<tr>
<td>TC653</td>
<td>Fan Manager</td>
<td>1</td>
<td>±1</td>
<td>±3</td>
<td>-40 to +125</td>
<td>+2.8 to +5.5</td>
<td>90</td>
<td>FanSense Fan Monitor, Overtemperature alert, Auto-shutdown</td>
<td>8-pin MSOP</td>
</tr>
<tr>
<td>TC654</td>
<td>Dual SMBus Fan Manager</td>
<td>1</td>
<td>Note 1</td>
<td>Note 1</td>
<td>-40 to +85</td>
<td>+3.0 to +5.5</td>
<td>320</td>
<td>FanSense Fan Monitor, RPM data</td>
<td>10-pin MSOP</td>
</tr>
<tr>
<td>TC655</td>
<td>Dual SMBus Fan Manager</td>
<td>1</td>
<td>Note 1</td>
<td>Note 1</td>
<td>-40 to +85</td>
<td>+3.0 to +5.5</td>
<td>320</td>
<td>FanSense Fan Monitor, RPM data, Overtemperature alert</td>
<td>10-pin MSOP</td>
</tr>
<tr>
<td>TC664</td>
<td>Single SMBus Fan Manager</td>
<td>1</td>
<td>Note 1</td>
<td>Note 1</td>
<td>-40 to +85</td>
<td>+3.0 to +5.5</td>
<td>320</td>
<td>FanSense Fan Monitor, RPM data</td>
<td>10-pin MSOP</td>
</tr>
<tr>
<td>TC665</td>
<td>Single SMBus Fan Manager</td>
<td>1</td>
<td>Note 1</td>
<td>Note 1</td>
<td>-40 to +85</td>
<td>+3.0 to +5.5</td>
<td>320</td>
<td>FanSense Fan Monitor, RPM data, Overtemperature alert</td>
<td>10-pin MSOP</td>
</tr>
<tr>
<td>TC670</td>
<td>Predictive Fan Fault Detector</td>
<td>1</td>
<td>N/A</td>
<td>N/A</td>
<td>-40 to +85</td>
<td>+3.0 to +5.5</td>
<td>150</td>
<td>FanSense Fan Monitor, Programmable threshold</td>
<td>6-pin SOT-23</td>
</tr>
</tbody>
</table>
# Selected Product Specifications

## Closed-Loop Fan Controllers with SMBus/i²C Interface

<table>
<thead>
<tr>
<th>Part #</th>
<th># of Fan Drivers</th>
<th>PWM/Linear Control</th>
<th># of Remote Temp. Monitors</th>
<th>Ambient Temp. Sensor</th>
<th>Typical Accuracy (°C)</th>
<th>Maximum Accuracy ±°C (°C)</th>
<th>Maximum Temperature Range (°C)</th>
<th>Vcc Range (V)</th>
<th>SMBus Alert</th>
<th>System Shutdown</th>
<th>Voltage Monitors</th>
<th>Description</th>
<th>Packages</th>
</tr>
</thead>
<tbody>
<tr>
<td>EMC2112</td>
<td>1</td>
<td>Linear</td>
<td>3</td>
<td>1</td>
<td>±0.25</td>
<td>±1.0</td>
<td>0 to +85</td>
<td>+3.3 and +5</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>RPM-Based Fan Controller with Hardware Thermal Shutdown</td>
<td>20-pin QFN</td>
</tr>
<tr>
<td>EMC2103-1</td>
<td>1</td>
<td>PWM</td>
<td>1</td>
<td>1</td>
<td>±0.5</td>
<td>±1.0</td>
<td>−40 to +125</td>
<td>+3.0 to +3.6</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>RPM-Based Fan Controller with Hardware Thermal Shutdown</td>
<td>12-pin QFN</td>
</tr>
<tr>
<td>EMC2103-2</td>
<td>1</td>
<td>PWM</td>
<td>3</td>
<td>1</td>
<td>±0.5</td>
<td>±1.0</td>
<td>−40 to +125</td>
<td>+3.0 to +3.6</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>RPM-Based Fan Controller with Hardware Thermal Shutdown</td>
<td>16-pin QFN</td>
</tr>
<tr>
<td>EMC2103-4</td>
<td>1</td>
<td>PWM</td>
<td>3</td>
<td>1</td>
<td>±0.5</td>
<td>±1.0</td>
<td>−40 to +125</td>
<td>+3.0 to +3.6</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>RPM-Based Fan Controller with Hardware Thermal Shutdown and EEPROM loadable</td>
<td>16-pin QFN</td>
</tr>
<tr>
<td>EMC2104</td>
<td>2</td>
<td>PWM</td>
<td>4</td>
<td>1</td>
<td>±0.25</td>
<td>±1.0</td>
<td>−40 to +85</td>
<td>+3.0 to +3.6</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Dual RPM-Based PWM Fan Controller with Hardware Thermal Shutdown</td>
<td>20-pin QFN</td>
</tr>
<tr>
<td>EMC2105</td>
<td>1</td>
<td>Linear</td>
<td>4</td>
<td>1</td>
<td>±0.25</td>
<td>±1.0</td>
<td>−40 to +85</td>
<td>+3.3 and +5.0</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>RPM-Based High-Side Fan Controller with Hardware Thermal Shutdown</td>
<td>20-pin QFN</td>
</tr>
<tr>
<td>EMC2106</td>
<td>2</td>
<td>PWM &amp; Linear</td>
<td>4</td>
<td>1</td>
<td>±0.25</td>
<td>±1.0</td>
<td>−40 to +85</td>
<td>+3.3 and +5.0</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>RPM-Based High Side Fan Controller with Hardware Thermal Shutdown</td>
<td>28-pin QFN</td>
</tr>
<tr>
<td>EMC2113</td>
<td>1</td>
<td>PWM</td>
<td>3</td>
<td>1</td>
<td>±0.5</td>
<td>±1.0</td>
<td>−40 to +125</td>
<td>+3.0 to +3.6</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Single RPM-Based Fan Controller with Multiple Temperature Zones and Hardware Thermal Shutdown</td>
<td>16-pin QFN</td>
</tr>
<tr>
<td>EMC2301</td>
<td>1</td>
<td>PWM</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>−40 to +125</td>
<td>+3.0 to +3.6</td>
<td>Yes</td>
<td>No</td>
<td>N/A</td>
<td>Single RPM-Based PWM Fan Speed Controller</td>
<td>8-pin MSOP</td>
</tr>
<tr>
<td>EMC2302</td>
<td>2</td>
<td>PWM</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>−40 to +125</td>
<td>+3.0 to +3.6</td>
<td>Yes</td>
<td>No</td>
<td>N/A</td>
<td>Dual RPM-Based PWM Fan Speed Controller</td>
<td>10-pin MSOP</td>
</tr>
<tr>
<td>EMC2303</td>
<td>3</td>
<td>PWM</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>−40 to +125</td>
<td>+3.0 to +3.6</td>
<td>Yes</td>
<td>No</td>
<td>N/A</td>
<td>Triple RPM-Based PWM Fan Speed Controller</td>
<td>12-pin QFN</td>
</tr>
<tr>
<td>EMC2305</td>
<td>5</td>
<td>PWM</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>−40 to +125</td>
<td>+3.0 to +3.6</td>
<td>Yes</td>
<td>No</td>
<td>N/A</td>
<td>Penta RPM-Based PWM Fan Speed Controller</td>
<td>16-pin QFN</td>
</tr>
</tbody>
</table>
## Analog (Voltage Output) Temperature Sensor Products

<table>
<thead>
<tr>
<th>Device</th>
<th>Accuracy @ 25°C (Typ./Max.)</th>
<th>Temperature Range (°C)</th>
<th>Temperature Set Points</th>
<th>Vcc Min. (V)</th>
<th>Vcc Max. (V)</th>
<th>Io Max. (µA)</th>
<th>Slope (mV/°C)</th>
<th>Offset Voltage (Output @ 0°C) (mV)</th>
<th>Packages</th>
<th>Development Tools</th>
</tr>
</thead>
<tbody>
<tr>
<td>MCP9700</td>
<td>1/4</td>
<td>−40 to +125</td>
<td>2.3</td>
<td>5.5</td>
<td>12</td>
<td>10</td>
<td>500</td>
<td></td>
<td>5-pin SOT-23, 5-pin SC-70, 3-pin TO-92</td>
<td>MCP9700DM-PCTL</td>
</tr>
<tr>
<td>MCP9700A</td>
<td>1/2</td>
<td>−40 to +125</td>
<td>2.3</td>
<td>5.5</td>
<td>12</td>
<td>10</td>
<td>500</td>
<td></td>
<td>5-pin SC-70</td>
<td>MCP9700DM-PCTL</td>
</tr>
<tr>
<td>MCP9701</td>
<td>1/4</td>
<td>−40 to +125</td>
<td>3.1</td>
<td>5.5</td>
<td>12</td>
<td>19.5</td>
<td>400</td>
<td></td>
<td>5-pin SC-70, 3-pin TO-92</td>
<td>–</td>
</tr>
<tr>
<td>MCP9701A</td>
<td>1/2</td>
<td>−40 to +125</td>
<td>3.1</td>
<td>5.5</td>
<td>12</td>
<td>19.5</td>
<td>400</td>
<td></td>
<td>5-pin SC-70</td>
<td>–</td>
</tr>
<tr>
<td>TC1046</td>
<td>0.5/2.0</td>
<td>−40 to +125</td>
<td>2.7</td>
<td>4.4</td>
<td>60</td>
<td>6.25</td>
<td>424</td>
<td></td>
<td>3-pin SOT-23</td>
<td>–</td>
</tr>
<tr>
<td>TC1047/A</td>
<td>0.5/2.0</td>
<td>−40 to +125</td>
<td>2.7</td>
<td>4.4</td>
<td>60</td>
<td>10</td>
<td>500</td>
<td></td>
<td>3-pin SOT-23</td>
<td>TC1047ADM-PCTL</td>
</tr>
</tbody>
</table>

## Logic Output Temperature Sensor Products

<table>
<thead>
<tr>
<th>Device</th>
<th>Accuracy @ 25°C (Typ./Max.)</th>
<th>Temperature Range (°C)</th>
<th>Temperature Set Points</th>
<th>Vcc Min. (V)</th>
<th>Vcc Max. (V)</th>
<th>Io Max. (µA)</th>
<th>Packages</th>
<th>Development Tools</th>
</tr>
</thead>
<tbody>
<tr>
<td>TC620</td>
<td>1/3</td>
<td>−40 to +125</td>
<td>User-selectable, set by external resistor</td>
<td>4.5</td>
<td>18</td>
<td>400</td>
<td>8-pin PDIP, 8-pin SOIC</td>
<td>–</td>
</tr>
<tr>
<td>TC621</td>
<td>1/3</td>
<td>−40 to +125</td>
<td>User-selectable, set by external resistor</td>
<td>4.5</td>
<td>18</td>
<td>400</td>
<td>8-pin PDIP, 8-pin SOIC</td>
<td>–</td>
</tr>
<tr>
<td>TC622</td>
<td>1/5</td>
<td>−40 to +125</td>
<td>User-selectable, set by external resistor</td>
<td>4.5</td>
<td>18</td>
<td>600</td>
<td>8-pin PDIP, 8-pin SOIC, 5-pin TO-220</td>
<td>–</td>
</tr>
<tr>
<td>TC623</td>
<td>1/3</td>
<td>−40 to +125</td>
<td>User-selectable, set by external resistor</td>
<td>2.7</td>
<td>4.5</td>
<td>250</td>
<td>8-pin PDIP, 8-pin SOIC</td>
<td>–</td>
</tr>
<tr>
<td>TC624</td>
<td>1/5</td>
<td>−40 to +125</td>
<td>User-selectable, set by external resistor</td>
<td>2.7</td>
<td>4.5</td>
<td>300</td>
<td>8-pin PDIP, 8-pin SOIC</td>
<td>–</td>
</tr>
<tr>
<td>TC6501</td>
<td>0.5/4</td>
<td>−40 to +125</td>
<td>Factory programmed thresholds</td>
<td>2.7</td>
<td>5.5</td>
<td>40</td>
<td>5-pin SOT-23</td>
<td>–</td>
</tr>
<tr>
<td>TC6502</td>
<td>0.5/4</td>
<td>−40 to +125</td>
<td>Factory programmed thresholds</td>
<td>2.7</td>
<td>5.5</td>
<td>40</td>
<td>5-pin SOT-23</td>
<td>–</td>
</tr>
<tr>
<td>TC6503</td>
<td>0.5/4</td>
<td>−40 to +125</td>
<td>Factory programmed thresholds</td>
<td>2.7</td>
<td>5.5</td>
<td>40</td>
<td>5-pin SOT-23</td>
<td>–</td>
</tr>
<tr>
<td>TC6504</td>
<td>0.5/4</td>
<td>−40 to +125</td>
<td>Factory programmed thresholds</td>
<td>2.7</td>
<td>5.5</td>
<td>40</td>
<td>5-pin SOT-23</td>
<td>–</td>
</tr>
</tbody>
</table>

## Thermocouple Conditioning IC Products

<table>
<thead>
<tr>
<th>Device</th>
<th>Serial Communication</th>
<th>Cold-Junction Temperature Accuracy (°C)</th>
<th>Hot-Junction Temperature Accuracy (°C)</th>
<th>Thermocouple Open/circuit detection</th>
<th>Temp. Range (°C)</th>
<th>Valid Min. (V)</th>
<th>Valid Max. (V)</th>
<th>Io Max. (µA)</th>
<th>Packages</th>
<th>Development Tools</th>
</tr>
</thead>
<tbody>
<tr>
<td>MCP9600</td>
<td>I²C</td>
<td>0.5</td>
<td>0.5</td>
<td>No</td>
<td>−40 to +125</td>
<td>2.7</td>
<td>5.5</td>
<td>500</td>
<td>20-pin MQFN</td>
<td>ADM00665</td>
</tr>
<tr>
<td>MCP9601</td>
<td>I²C</td>
<td>0.5</td>
<td>0.5</td>
<td>Yes</td>
<td>−40 to +125</td>
<td>2.7</td>
<td>5.5</td>
<td>500</td>
<td>20-pin MQFN</td>
<td>ADM00665</td>
</tr>
<tr>
<td>MCP96L00</td>
<td>I²C</td>
<td>0.5</td>
<td>2</td>
<td>No</td>
<td>−40 to +125</td>
<td>2.7</td>
<td>5.5</td>
<td>500</td>
<td>20-pin MQFN</td>
<td>ADM00665</td>
</tr>
<tr>
<td>MCP96L01</td>
<td>I²C</td>
<td>0.5</td>
<td>2</td>
<td>Yes</td>
<td>−40 to +125</td>
<td>2.7</td>
<td>5.5</td>
<td>500</td>
<td>20-pin MQFN</td>
<td>ADM00665</td>
</tr>
<tr>
<td>MCP96RL00</td>
<td>I²C</td>
<td>0.5</td>
<td>4</td>
<td>No</td>
<td>−40 to +125</td>
<td>2.7</td>
<td>5.5</td>
<td>500</td>
<td>20-pin MQFN</td>
<td>ADM00665</td>
</tr>
<tr>
<td>MCP96RL01</td>
<td>I²C</td>
<td>0.5</td>
<td>4</td>
<td>Yes</td>
<td>−40 to +125</td>
<td>2.7</td>
<td>5.5</td>
<td>500</td>
<td>20-pin MQFN</td>
<td>ADM00665</td>
</tr>
</tbody>
</table>
## Operational Amplifiers

<table>
<thead>
<tr>
<th>Device</th>
<th># per Package</th>
<th>GBWP (kHz)</th>
<th>$I_0$ (Typ./Max.) (µA)</th>
<th>$V_{os}$ Max. (mV)</th>
<th>Temperature Range (°C)</th>
<th>Operating Voltage (V)</th>
<th>Packages</th>
<th>Development Tools</th>
</tr>
</thead>
<tbody>
<tr>
<td>TC913A</td>
<td>2</td>
<td>1500</td>
<td>8500/1100</td>
<td>0.15</td>
<td>0 to +70</td>
<td>6.5 to 16</td>
<td>8-pin PDIP</td>
<td>–</td>
</tr>
<tr>
<td>TC7650</td>
<td>1</td>
<td>2000</td>
<td>2000/3500</td>
<td>0.05</td>
<td>0 to +70</td>
<td>4.5 to 16</td>
<td>8-pin PDIP, 14-pin PDIP</td>
<td>–</td>
</tr>
<tr>
<td>TC7652</td>
<td>1</td>
<td>400</td>
<td>1000/3000</td>
<td>0.05</td>
<td>0 to +70</td>
<td>5 to 16</td>
<td>8-pin PDIP, 14-pin PDIP</td>
<td>–</td>
</tr>
<tr>
<td>MCP601</td>
<td>1, 2, 4</td>
<td>2800</td>
<td>230/325</td>
<td>2</td>
<td>−40 to +125</td>
<td>2.7 to 5.5</td>
<td>14-pin TSSOP, 8-pin PDIP, 8-pin SOIC, 5-pin SOT-23</td>
<td>–</td>
</tr>
<tr>
<td>MCP616</td>
<td>1, 2, 4</td>
<td>190</td>
<td>19/25</td>
<td>0.15</td>
<td>−40 to +85</td>
<td>2.3 to 5.5</td>
<td>PDIP-8, SOIC-8, MSOP-8</td>
<td>–</td>
</tr>
<tr>
<td>MCP6001</td>
<td>1, 2, 4</td>
<td>1000</td>
<td>100/170</td>
<td>7</td>
<td>−40 to +125</td>
<td>1.8 to 5.5</td>
<td>5-pin SOT-23, 5-pin SC-70</td>
<td>–</td>
</tr>
<tr>
<td>MCP6041</td>
<td>1, 2, 4</td>
<td>14</td>
<td>0.6/1</td>
<td>3</td>
<td>−40 to +125</td>
<td>1.4 to 5.5</td>
<td>14-pin TSSOP, 8-pin PDIP, 8-pin SOIC, 8-pin MSOP, 5-pin SOT-23</td>
<td>–</td>
</tr>
<tr>
<td>MCP6141</td>
<td>1, 2, 4</td>
<td>100</td>
<td>0.6/1</td>
<td>3</td>
<td>−40 to +125</td>
<td>1.4 to 5.5</td>
<td>14-pin TSSOP, 8-pin PDIP, 8-pin SOIC, 8-pin MSOP, 5-pin SOT-23</td>
<td>–</td>
</tr>
<tr>
<td>MCP6231</td>
<td>1, 2, 4</td>
<td>300</td>
<td>20/30</td>
<td>7</td>
<td>−40 to +125</td>
<td>1.8 to 5.5</td>
<td>14-pin TSSOP, 8-pin PDIP, 8-pin SOIC, 5-pin SOT-23, 5-pin SC-70</td>
<td>–</td>
</tr>
<tr>
<td>MCP6271</td>
<td>1, 2, 4</td>
<td>2000</td>
<td>120/240</td>
<td>3</td>
<td>−40 to +125</td>
<td>2.0 to 5.5</td>
<td>14-pin TSSOP, 8-pin PDIP, 8-pin SOIC, 8-pin MSOP, 5-pin SOT-23</td>
<td>–</td>
</tr>
<tr>
<td>MCP6281</td>
<td>1, 2, 4</td>
<td>5000</td>
<td>450/570</td>
<td>3</td>
<td>−40 to +125</td>
<td>7.2 to 5.5</td>
<td>14-pin TSSOP, 8-pin PDIP, 8-pin SOIC, 8-pin MSOP, 5-pin SOT-23</td>
<td>–</td>
</tr>
<tr>
<td>MCP6291</td>
<td>1, 2, 4</td>
<td>10,000</td>
<td>1000/1300</td>
<td>3</td>
<td>−40 to +125</td>
<td>2.4 to 5.5</td>
<td>14-pin TSSOP, 8-pin PDIP, 8-pin SOIC, 8-pin MSOP, 5-pin SOT-23</td>
<td>–</td>
</tr>
</tbody>
</table>

## Voltage Reference

<table>
<thead>
<tr>
<th>Device</th>
<th>$V_{cc}$ Range</th>
<th>Output Voltage (V)</th>
<th>Max. Load Current (mA)</th>
<th>Initial Accuracy (%)</th>
<th>Temperature Coefficient (ppm/°C)</th>
<th>Max. Supply Current (µA @ 25°C)</th>
<th>Packages</th>
<th>Development Tools</th>
</tr>
</thead>
<tbody>
<tr>
<td>MCP1525</td>
<td>2.7 to 5.5</td>
<td>2.5</td>
<td>±2</td>
<td>±1</td>
<td>150</td>
<td>100</td>
<td>3pin TO-92, 3-pin SOT-23B</td>
<td>–</td>
</tr>
</tbody>
</table>

## Comparators

<table>
<thead>
<tr>
<th>Device</th>
<th># per Package</th>
<th>Typical Propagation Delay (µsec)</th>
<th>$I_0$ Max. (µA)</th>
<th>$V_{os}$ Max. (µV)</th>
<th>Operating Voltage (V)</th>
<th>Temperature Range (°C)</th>
<th>Packages</th>
<th>Development Tools</th>
</tr>
</thead>
<tbody>
<tr>
<td>MCP6541</td>
<td>1</td>
<td>4</td>
<td>1</td>
<td>5</td>
<td>1.6 to 5.5</td>
<td>−40 to +85</td>
<td>8-pin PDIP, 8-pin SOIC, 8-pin MSOP, 5-pin SOT-23</td>
<td>–</td>
</tr>
<tr>
<td>MCP6542</td>
<td>2</td>
<td>4</td>
<td>1</td>
<td>5</td>
<td>1.6 to 5.5</td>
<td>−40 to +85</td>
<td>8-pin PDIP, 8-pin SOIC, 8-pin MSOP</td>
<td>–</td>
</tr>
<tr>
<td>MCP6543</td>
<td>1</td>
<td>4</td>
<td>1</td>
<td>5</td>
<td>1.6 to 5.5</td>
<td>−40 to +85</td>
<td>8-pin PDIP, 8-pin SOIC, 8-pin MSOP</td>
<td>–</td>
</tr>
<tr>
<td>MCP6544</td>
<td>4</td>
<td>4</td>
<td>1</td>
<td>5</td>
<td>1.6 to 5.5</td>
<td>−40 to +85</td>
<td>14-pin PDIP, 14-pin SOIC, 14-pin TSSOP</td>
<td>–</td>
</tr>
</tbody>
</table>

## Programmable Gain Amplifiers (PGAs)

<table>
<thead>
<tr>
<th>Device</th>
<th>Channels</th>
<th>~3 dB BW (MHz)</th>
<th>$I_0$ Typical (mA)</th>
<th>$V_{os}$ (µV)</th>
<th>Operating Voltage (V)</th>
<th>Temperature Range (°C)</th>
<th>Packages</th>
<th>Development Tools</th>
</tr>
</thead>
<tbody>
<tr>
<td>MCP6S21</td>
<td>1</td>
<td>2 to 12</td>
<td>1.1</td>
<td>275</td>
<td>2.5 to 5.5</td>
<td>−40 to +85</td>
<td>8-pin PDIP, 8-pin SOIC, 8-pin MSOP</td>
<td>–</td>
</tr>
<tr>
<td>MCP6S22</td>
<td>2</td>
<td>2 to 12</td>
<td>1.1</td>
<td>275</td>
<td>2.5 to 5.5</td>
<td>−40 to +85</td>
<td>8-pin PDIP, 8-pin SOIC, 8-pin MSOP</td>
<td>–</td>
</tr>
<tr>
<td>MCP6S26</td>
<td>6</td>
<td>2 to 12</td>
<td>1.1</td>
<td>275</td>
<td>2.5 to 5.5</td>
<td>−40 to +85</td>
<td>14-pin PDIP, 14-pin SOIC, 14-pin TSSOP</td>
<td>–</td>
</tr>
<tr>
<td>MCP6S28</td>
<td>8</td>
<td>2 to 12</td>
<td>1.1</td>
<td>275</td>
<td>2.5 to 5.5</td>
<td>−40 to +85</td>
<td>16-pin PDIP, 16-pin SOIC</td>
<td>–</td>
</tr>
</tbody>
</table>
Support
Microchip is committed to supporting its customers in developing products faster and more efficiently. We maintain a worldwide network of field applications engineers and technical support ready to provide product and system assistance. For more information, please visit www.microchip.com:

- Technical Support: www.microchip.com/support
- Evaluation samples of any Microchip device: www.microchip.com/sample
- Knowledge base and peer help: www.microchip.com/forums
- Sales and Global Distribution: www.microchip.com/sales

Training
If additional training interests you, Microchip offers several resources including in-depth technical training and reference material, self-paced tutorials and significant online resources.

- Overview of Technical Training Resources: www.microchip.com/training
- MASTERS Conferences: www.microchip.com/masters
- Developer Help Website: www.microchip.com/developerhelp
- Technical Training Centers: www.microchip.com/seminars

Sales Office Listing

**AMERICAS**
- Atlanta, GA
  Tel: 678-957-9614
- Austin, TX
  Tel: 512-257-3370
- Boston, MA
  Tel: 774-760-0087
- Chandler, AZ (HQ)
  Tel: 480-792-7200
- Chicago, IL
  Tel: 630-285-0071
- Dallas, TX
  Tel: 972-818-7423
- Detroit, MI
  Tel: 248-848-4000
- Houston, TX
  Tel: 774-760-0087
- Indianapolis, IN
  Tel: 317-773-8323
- Kansas City, MO
  Tel: 816-751-8540
- Los Angeles, CA
  Tel: 562-868-7177
- Raleigh, NC
  Tel: 919-844-7510
- San Jose, CA
  Tel: 408-735-9110
- Seattle, WA
  Tel: 206-533-2260
- Tustin, CA
  Tel: 714-732-0204
- Westford, MA
  Tel: 978-855-0300

**EUROPE**
- Austria - Wels
  Tel: 43-7242-2244-39
- Belgium - Brussels
  Tel: 32-2-788-2516
- Denmark - Copenhagen
  Tel: 45-4485-5910
- France - Paris
  Tel: 33-1-69-53-63-20
- Germany - Garching
  Tel: 49-8931-9700
- Germany - Haan
  Tel: 49-2129-3766-400
- Germany - Heilbronn
  Tel: 49-711-4763-0
- Germany - Karlsruhe
  Tel: 49-721-62537-0
- Germany - Munich
  Tel: 49-89-627-144-0
- Germany - Rosenheim
  Tel: 49-8031-354-600
- Germany - Schwabach
  Tel: 49-931-933-270
- Germany - Wuerzburg
  Tel: 49-931-933-270
- Italy - Milan
  Tel: 39-0331-742611
- Italy - Padova
  Tel: 39-049-7625286
- Netherlands - Drunen
  Tel: 31-416-690399
- Norway - Trondheim
  Tel: 47-7289-7561
- Poland - Warsaw
  Tel: 48-22-3325737
- Romania - Bucharest
  Tel: 40-21-407-87-50
- Spain - Madrid
  Tel: 34-9-708-08-90
- Sweden - Gothenberg
  Tel: 46-31-704-60-40
- Sweden - Stockholm
  Tel: 46-8-6000-4654
- UK - Wokingham
  Tel: 44-118-921-5800

**ASIA/PACIFIC**
- Australia - Sydney
  Tel: 61-2-9868-6785
- China - Beijing
  Tel: 86-10-8569-7000
- China - Chengdu
  Tel: 86-28-8665-5511
- China - Chongqing
  Tel: 86-23-8980-9588
- China - Dongguan
  Tel: 86-769-8702-9880
- China - Guangzhou
  Tel: 86-20-8755-8029
- China - Hangzhou
  Tel: 86-571-8792-8115
- China - Hong Kong SAR
  Tel: 852-2943-5100
- China - Nanjing
  Tel: 86-25-8473-2460
- China - Qingdao
  Tel: 86-532-8502-7355
- China - Shanghai
  Tel: 86-21-3326-8000
- China - Shenzyang
  Tel: 86-24-2334-2829
- China - Shenzhen
  Tel: 86-755-8864-2200
- China - Suzhou
  Tel: 86-186-6233-1526
- China - Wuhan
  Tel: 86-27-5980-5300
- China - Xiamen
  Tel: 86-592-2388138
- China - Xian
  Tel: 86-29-8833-7252
- Japan - Osaka
  Tel: 81-6-6152-7160
- Japan - Tokyo
  Tel: 81-3-6880-3770
- Korea - Daegu
  Tel: 82-53-744-4301
- Korea - Seoul
  Tel: 82-2-554-7200
- Malaysia - Kuala Lumpur
  Tel: 60-3-7651-7906
- Malaysia - Penang
  Tel: 60-4-227-9870
- Philippines - Manila
  Tel: 63-2-634-9065
- Singapore
  Tel: 65-6334-8870
- Taiwan - Hsin Chu
  Tel: 886-3-577-8366
- Taiwan - Kaohsiung
  Tel: 886-7-213-7830
- Taiwan - Taipei
  Tel: 886-2-2508-8600
- Thailand - Bangkok
  Tel: 66-2-694-1351
- Vietnam - Ho Chi Minh
  Tel: 84-28-5448-2100

© 2020, Microchip Technology Incorporated. All Rights Reserved. 6/20