Flexible Integrated Temp Sensors Lower System Costs

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ANALOG DESIGN NOTE ADN011

Temperature is one of the most commonly sensed entities in electronic circuits today. This is largely due to the multitude of applications where knowing and using the actual or relative temperature is critical. The most common temperature sensors that are used to perform this task are: Thermocouples, Resistive Temperature Detectors (RTDs), Thermistors and Silicon Temperature Sensors, which are primarily classified according to their output-signaling method. Microchip offers logic output, voltage output and serial or digital output silicon temperature sensors.

Each of these technologies cater to specific temperature ranges and environmental conditions. This ADN focuses on two of Microchip's serial output silicon sensors.

Thermocouples are capable of sensing elevated temperatures (–400°C to +1,260°C). This sensor is non-linear and requires a look-up table in the controller.

The RTD is able to sense temperatures with extreme repeatability and low drift error (–200°C to +850 °C). For precision, this sensor also requires a look-up table in the controller due to non-linearities.

Thermistors (–100°C to +150 °C) are normally used for overtemperature shutdown purposes. Again, this sensor is non-linear and requires a look-up table in the controller.

Although the Thermocouple, RTD and Thermistor are capable of being placed in harsh, high-temperature environments, the silicon temperature sensor becomes the preferred choice in applications where –55°C to +125°C temperatures are sensed. They are easily installed on printed circuit boards, easy to interface with and don't require expensive external circuitry. Applications such as personal computers, mobile phones, automotive, medical equipment and gaming consoles have improved performance when the temperature is monitored and fed back into the system. These types of temperature sensors produce an output that represents the ambient temperature (the air surrounding the device). The style of outputs from these sensors include analog voltage, logic threshold or digital "words" (I^2C™, SMBus or SPI™). Today, the most popular types of thermal sensors are voltage, logic and serial output.

The flexibility of the IC types of sensors provides programmability of thresholds, hysteresis, shutdown and digital code from an A/D conversion. For instance, the 9-bit TCN75 from Microchip is a serially-programmable temperature sensor that notifies the host controller when the ambient temperature exceeds a user-programmed set point. Hysteresis is also programmable. The INT/CMPTR output is programmable as either a simple comparator (for thermostat operation) or as a temperature-event interrupt. Communication with the TCN75 is accomplished via a two-wire bus that is compatible with industry standard protocols. This permits reading the current temperature, programming the set point and hysteresis, as well as configuring the device.

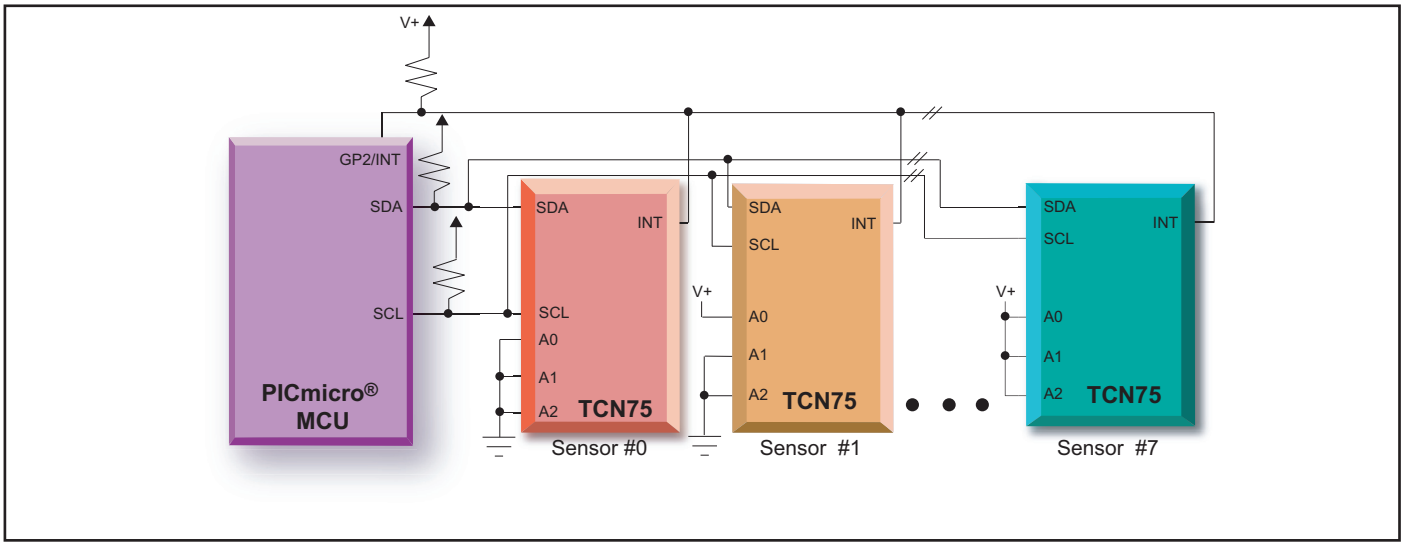

Figure 1. *The TCN75 can be used in a multi-zone application where communication from chip to chip is accomplished through a two-wire, bidirectional interface.*

Figure 1 presents an example of a multi-zone temperature-sensing application. In this example, the TCN75 is being used in an application where temperature is sensed in many locations across a printed circuit board or from board to board. Typically, IC semiconductor sensors are mounted on boards with heat sinks. The IC sensor is used to measure temperature in the vicinity and to indicate, for example, when overtemperature conditions exist. The thermal response time of most silicon temperature sensors is given in minutes. Therefore, they are not an appropriate match for transient sensing requirements.

Referring to the block diagram of the TCN75 in Figure 2, this device powers-up in Comparator mode, with a default set point of 80°C and 5°C hysteresis. These defaults allow independent operation as a stand-alone thermostat. A shutdown command may be sent via the 2-wire bus to activate the low-power Standby mode. Address selection inputs allow up to eight TCN75s to share the same 2-wire bus for multi-zone monitoring. All registers can be read by the PICmicro® MCU, with the INT/CMPTR output's polarity being user-programmable. Both polled and interrupt-driven systems are easily accommodated. With temperature accuracy of ±3°C (max) from 25°C to 100°C, this device is available in either an 8-pin SOIC or the smaller MSOP package.

If accuracy is your goal, the TC77 serial output temperature sensor from Microchip has temperature accuracy of ±1.0°C (max.) over the temperature range of +25°C to +65°C. Outside of this temperature range, the TC77 is specified to ±2°C (max.) accuracy from 0°C to +85°C, and ±3°C (max.) accuracy from –55°C to +125°C. The temperature performance of the TC77 is illustrated in Figure 3.

The TC77 is a serially-accessible digital temperature sensor particularly suited for high-accuracy and small form-factor applications. Temperature data is converted from the internal thermal-sensing element and made available at any time as a 13-bit two's compliment digital word. This allows the microcontroller in the circuit to track and monitor a temperature profile. Communication with the TC77 is accomplished via a SPI and Microwire compatible interface. It has a 12-bit plus sign temperature resolution of 0.0625°C per Least Significant bit (LSb). The TC77's configuration register can be used to activate the low-power Shutdown mode (current consumption = 0.1 µA, typ.). Small size, low cost and ease-of-use make the TC77 an ideal choice for implementing thermal management in a variety of systems.

If you are more interested in designing your system than finessing the temperature-monitoring circuit, the "no worries" IC semiconductor temperature sensor is the right product for your application. This type of device produces a direct-digital, linear output versus temperature and does not require external components in your implementation. This integrated solution offers a low-cost solution that is easy to design into your circuit.

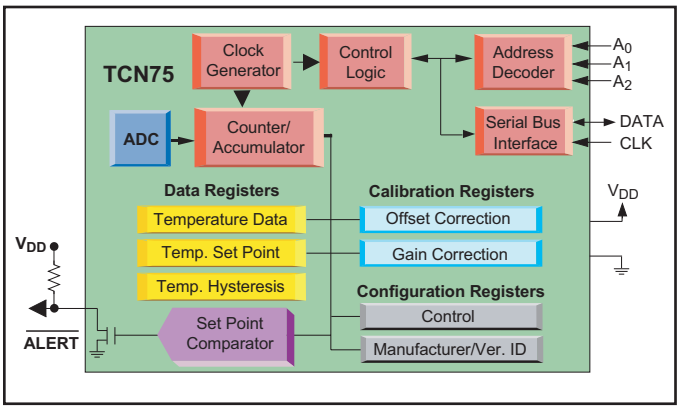

Figure 2. *The TCN75 calibration, data and configuration registers are accessible through a two-wire, serial interface. Additionally, there is an Alert (or interrupt) pin that can be used for thermostat applications.*

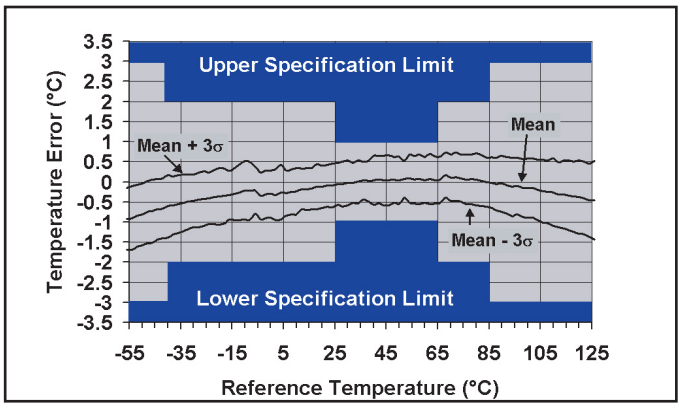

Figure 3. *Typically, the TC77 accuracy is better than 1°C over a 25°C to 65°C temperature range. This device is available in a 5-pin SOT-23 package. If further accuracy is required in the higher or lower temperature ranges (–55°C to 25°C or 65°C to 125°C), calibration, in conjunction with a look-up table, can be used.*