Transistor junction monitors remote temperature

Matt Smith - June 22, 2000

The circuit in Figure 1 uses a regular, general-purpose transistor as the sensing element and a thermal-diode monitor IC to measure temperature. The ADM1021 usually connects to an on-chip thermal diode on a CPU die itself, but in this application the sensor connects to a regulator low-cost discrete npn transistor, the 2N3904. The circuit ties the transistor base and collector together to form a two-wire sensor.

A technique known as $\Delta V_{BE}$ sensing forces two currents through the base-emitter junction. By measuring the differential voltage across the junction, you can accurately determine the junction temperature. This technique avoids the problems associated with thermal measurement using thermistors or thermocouples. The output from the $\Delta V_{BE}$ sensor is approximately 2.2 mV/°C. The ADM1021 amplifies this signal and converts it to digital format.

The circuit features a simple two-wire SMBus or I²C interface, which enables simple communication with a µC or µP. This case achieves communication using three wires on a standard PC Centronics printer port, which makes for a simple and convenient, PC-based temperature-measuring system. A further advantage of the circuit is its inherent power dissipation of 500 µA. This low level enables the circuit to obtain all its power directly from the Centronics port. A graphical-user-interface software application reads the data over the Centronics port and displays the temperature in a strip-chart format or logs readings to an Excel spreadsheet. This application is useful for environmental temperature recording.

Four unused lines on the parallel port power the circuit. Diodes provide isolation to prevent bus contention if any of the lines inadvertently drive low. A 74HC05 buffers the data and clock lines. The clock line is unidirectional, and the data line is bidirectional.

The thermal-diode monitor contains all the necessary circuitry to force differential currents through the sensing transistor. It also contains the amplifiers, scaling circuitry, and a precision ADC to convert the small differential voltages into temperature data. The remote-sensing transistor connects via a shielded twisted pair. The shielded twisted pair is necessary only in electrically noisy environments. The circuit can accommodate temperatures of -128 to +128°C, but in practice the usable range is more limited. The ADM1021 also contains both high- and low-limit registers and has an alert, or alarm, output. If the circuit senses a temperature that exceeds a programmed temperature limit, the IC activates the alarm output, which can drive a buzzer or warning beacon via a buffer.
Analog Devices (www.analog.com) manufactures the ADM1021 and provides PC software for Win95 or Win98 that you can use to monitor and graphically plot the recorded temperature in real time in a moving-strip-chart format. The ADM1021 also monitors its own local temperature as well as the remote-transistor temperature. You can also record temperatures and store them in an Excel format for later analysis. The recording frequency is programmable from a maximum rate of eight recordings per second. (DI #2547)