Log amp linearizes thermistors

Martin Rowe - July 01, 2011

Thermistors make good choices as temperature sensors when you need fine resolution over a relatively small temperature span. Unfortunately, a thermistor’s resistance-temperature curve has a nonlinear negative slope.

Engineers use a variety of techniques to linearize the curve. For example, researchers at the Department of Electrical Engineering at the Indian Institute of Technology Madras have developed a system that uses a logarithmic amplifier in front of an integrating ADC to digitize resistance and convert it to temperature. The researchers tested the circuit at temperatures from 0°C to 120°C. They published a paper describing their work in the May 2011 issue of IEEE Transactions on Instrumentation and Measurement (Ref. 1).

The system, which the researchers first simulated and then tested with real components and test equipment, consists of a voltage reference, a log amp, an integrator, a comparator, and a USB data-acquisition module. The figure shows a simplified schematic.

![Simplified schematic diagram](image)

A log amplifier and integrator form a linearizing ADC for a thermistor. The data-acquisition module includes a timer/counter and digital I/O.

The integrator’s capacitor charges from reference voltages for a fixed time. As the capacitor discharges, the data-acquisition module’s internal counter/timer counts clock pulses. The data-acquisition unit’s digital output represents temperature, which the module sends to a PC over a USB link. The PC need not linearize the digital output, nor does it need to convert from ADC counts to temperature.

The researchers used one of the data-acquisition module’s digital I/O pins to read the comparator’s
output. The comparator output indicates when a conversion takes place. Other I/O pins control the switch, changing it among positive and negative reference voltages ($V_{\text{REF}+}$ and $V_{\text{REF}-}$) and the log amp’s output voltage.

Performing error analysis, the researchers learned that several circuit component values affect the measurement error. For example, the voltage reference plays a key role in the system’s accuracy and stability. Offset voltages in the amplifiers also play a key role in limiting accuracy. The researchers note that “Variation of $V_{\text{LOG}}$ [the log amp’s output] by as little as 5 mV is sufficient to cause the measured temperature to be in error by more than 0.5°C.”

A 6.5-digit multimeter monitored $V_{\text{REF}+}$ and $V_{\text{REF}-}$ during the tests. The oscilloscope provided a view of the log amp’s output voltage and the integrator’s output waveforms, which provided the researchers with confidence in their design. In the future, IC manufacturers could integrate the circuit’s components into a single IC or into a specialized ADC for measuring temperature with a thermistor.

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