RAQ's

Rarely Asked Questions

Strange stories from the call logs of Analog Devices

How to Avoid Burning Cakes

If only King Alfred had had better oven temperature measurement he need not have allowed the peasant woman's cakes to burn. And even in 880 A.D. it would have been possible to make a thermocouple had he known how.

Q. In an earlier RAQ you said that silicon ICs could be guaranteed between –55°C and +155°C but might work (without guarantees) over a somewhat wider range. How does one measure temperature outside the silicon range?

A. Thermocouples are very simple devices which can measure temperature over a very wide range.

If we have two conductors of different material joined at two points which are at different temperatures, there will be an emf (electromotive force) in the loop so formed—this emf is a function[1] of the temperature difference and can be used to measure temperatures as high as 2300°C and as low as a few Kelvin. One junction is at the temperature to be measured and the other (often known as the "cold" junction, even if it is at a higher temperature than the one being measured) is at a reference temperature (in the past a mixture of ice and water was often used to provide a 0°C reference).

Two pieces of wire of different materials are simple and, usually, inexpensive[2], so thermocouples are widely used. Where the reference will normally be within ±10°C of room temperature and accurate measurement is unnecessary, it is quite usual to use an uncompensated thermocouple for measurements. An example is the flame sensor in a boiler.

If reasonable accuracy is required, the cold junction must be held at a known reference temperature— which is inconvenient, as ice may be unavailable. But the cold junction need not be at a constant temperature as long as it is always known. The cold junction temperature, which is unlikely to be outside –55°C to +155°C, may be measured with a silicon sensor; we then use the emf and the cold junction temperature to calculate the "hot" junction temperature.

This "cold junction compensation" may be done by a digital controller, but it is quite possible to integrate the cold junction sensor, the thermocouple amplifier, and the compensation in a simple analog chip. The AD594/AD595 and AD8494/AD8495/AD8496/AD8497 are examples of such circuits; if King Alfred had had one the cakes would have been perfect.

[1]The function is (approximately) a polynomial of 5th – 13th order, but for some thermocouples simple proportionality is adequate over some ranges.

[2]Platinum (B, R & S) and chromel/gold-iron thermocouples are among the expensive exceptions to this.

To Learn More About Temperature Management
http://designnews.hotims.com/27747-100

Contributing Writer James Bryant, ADI's European Applications Manager from 1982 through 2009, continues to find interesting projects within Analog Devices. He holds a degree in Physics and Philosophy from the University of Leeds. He is also C.Eng., Eur.Eng., MIEE, and an FBIS. In addition to his passion for engineering, James is a radio ham and holds the call sign G4CLF.

Have a question involving a perplexing or unusual analog problem? Submit your question to: http://www.analog.com/askjames

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