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Basics of Temperature Measurement: Thermocouples

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Introduction

Although many sensors are available to measure temperature, the three most common are RTDs, thermocouples, and thermistors. The thermocouple (TC) is the most common of those, and is made up of two dissimilar metals joined together at one end, which produce a voltage for a given temperature.

TCs are the most common temperature sensor for several reasons. Perhaps the biggest reason is their low cost. TCs are also extremely rugged. Most of the time they are simply a spot weld of two alloys at one end. Metal-sheathed TCs are available to help protect them in harsh or corrosive environments.

TCs also come in a wide variety of types. Different alloys allow different ranges and sensitivity of measurement. Some of the different TCs include J, K, T, E, R, S, B, and N. J, K, and T are the most common types.

In general, TCs can cover a wide temperature range. For example, a Type K TC covers from –260°C to +1,370°C. You can find the ranges of all types of thermocouples in the NIST (National Institute of Standards and Technology) reference tables at www.nist.gov.

One important thing to note about thermocouples is their non-linearity; thermocouple voltage is not linear with respect to temperature. Consequently, linearization is required.

Thermocouples consist of two metal alloys joined together at one end and open at the other end. The voltage signal at the open or output end is a function of the temperature at the closed end. As the temperature rises, the voltage signal goes up.

The open-end signal is a function of not only closed end temperature (the point of measurement) but also the temperature at the open end. Only by holding T2 at a standard temperature can the measured signal be considered a direct function of the change in T1.

The industry standard for T2 is 0°C. Most tables and charts make the assumption that T2 is at the 0°C level.

In industrial instrumentation, the difference between the actual temperature at T2 and 0°C is usually corrected electronically within the instrumentation. This adjustment is known as cold junction compensation or ice point reference. See ***Figure 1***.

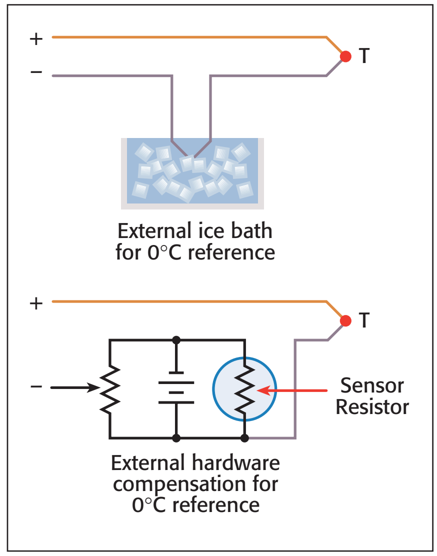

Figure 1.

Advantages

Thermocouples have many advantages over other types of temperature sensors. For one, they are self-powered, requiring no external power supply. They're also extremely rugged, not fragile, and can withstand harsh environments.

Thermocouples are also inexpensive compared to RTDs and thermistors and come in a wide variety of types and have a wide temperature range. For instance, Type C thermocouples have a rating to 2,340°C (4,208°F), while Type N thermocouples have a rating to –270°C (–450°F).

Disadvantages

Thermocouples are non linear and require a cold junction compensation (CJC) for linearization. Also, the voltage signals are low—normally, in the tens to hundreds of microvolts. This requires careful techniques to eliminate noise and drift in a low voltage measurement.

Another drawback is that thermocouples are not as accurate as RTDs or thermistors. They are also the least sensitive temperature sensor. Depending on the thermocouple type, a one degree change could mean a few microvolts change in signal.

Common Mistakes

Avoiding some common mistakes when setting up and using thermocouples will yield better measurements. One common problem is that the CJC is not configured or compensated properly, or at all. This leads to inaccurate or nonlinear temperature measurements.

Another mistake is to use copper wire from the thermocouple connection to the measurement device. Doing so essentially introduces another thermocouple into the measurement, because any junction of dissimilar metals forms a thermocouple.

On the measurement device side, the voltmeter being used may not be sensitive enough for thermocouple measurements. To avoid this problem, make sure the voltmeter is sensitive and accurate enough for the low voltage (micro- to millivolt) measurements.

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