Primer: I/O Solutions for Temperature Monitoring

Sourcing and Selecting Temperature Sensors

Sensors used for temperature monitoring and data acquisition can be quite varied. Applications ranging from simple room temperature monitoring to highly sophisticated batch process control can all be highly dependent on obtaining accurate temperature readings. The primary types of sensors used for this purpose are resistance temperature detectors (RTDs), thermocouples, integrated circuit temperature detectors (ICTDs), thermistors, and infrared sensors.

RTDs determine changes in the electrical resistance of materials in relation to temperature. RTDs deliver very precise readings (typically to 2–3 decimal places) and are manufactured in a variety of form factors. Though they are sometimes composed of nickel, copper, or other metals, historically, RTDs have been made of platinum—largely due to the fact that platinum's resistance-temperature relationship is maintained in a very linear fashion across very broad temperature ranges. RTDs' platinum composition also makes them somewhat expensive and unsuitable for applications involving temperatures above 660 °C, as temperatures above this range compromise the inertness of the platinum and may cause it to become contaminated and deliver inaccurate readings.

RTDs require a small power excitation source to operate and are most useful in applications that require very accurate temperature sensing across wide operating ranges with very little drift.

Thermocouples are bi-metal conductors that, when subjected to heat, generate voltages that correspond with given temperatures. Like RTDs, thermocouples are most often used in industrial settings. They come in a variety of types (B, J, K, R, T, etc.) that offer varied sensitivities and temperature ranges. Thermocouple readings can be less accurate than those of RTDs—sometimes up to a full degree off.

Thermocouples, like RTDs, are very fragile in their raw form. They are normally mounted in a robust probe to suit the application.

Thermocouples are generally inexpensive, though prices can escalate dramatically when pre-built into special housing or equipment. Because they come in so many varieties and measure over large, high-temperature ranges (up to 1800 °C), thermocouples are the sensor of choice for many applications requiring the use of intense heat (though it's important to note, once again, that very high temperature ranges will typically require special housing, packaging, or insulation).

ICTDs are good, general, inexpensive all-purpose temperature sensors. Essentially 2-wire transistor-like devices, ICTDs work by applying a voltage (generally in the 5–30 V range), and the resulting current is linearly proportional to temperature.

Like RTDs, ICTDs are very noise immune, but they are more easily deployed than RTDs because they do not require resistance-measuring circuitry. ICTDs excel at simple, less industrial applications that require fairly accurate temperature sensing in the range of -50 to 100 °C, such as HVAC, refrigeration, and room temperature monitoring.

Thermistors work by offering resistance that varies with the temperature. In this and other ways, thermistors work very much like RTDs, but they differ in that thermistors use 2-wire interconnections that are more sensitive to temperature. This makes thermistor readings somewhat less than precise. Additionally, the material used in thermistors is generally a ceramic or polymer (whereas RTDs use pure metals), making thermistors a cheaper option. Thermistors are a good choice for high-volume temperature sensing applications in the range of -40 to 200 °C where a certain amount of drift is acceptable.

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Infrared sensors represent the newest instrumentation used for temperature sensing. Infrared radiation is used to remotely determine the temperature of objects through sensing the object's electromagnetic radiation (sometimes called *thermography* or *pyrometry*).

Infrared sensing works well for detecting the temperature of fast-moving objects and also in highly volatile environments where the intense heat makes accessibility difficult if not impossible. They are used widely in many manufacturing processes, such as those for metals, glass, cement, ceramic semiconductors, plastics, paper, textiles, and coatings.

Important considerations when determining which type of temperature sensing component will work best for a given application are cost, how accurate the temperatures need to be, the environment in which the equipment will be deployed, and, especially, wiring.

ICTDs, for example, offer the simplest wiring scheme, as any twisted-pair cable will usually work effectively, and lengths can run thousands of feet with no loss of signal. RTDs, by comparison, are 3- or 4-wire. Also with RTDs, the gauge of the wire is much more important. Diameters must match, splices must be seamless, and even under the best conditions, there is greater susceptibility to noise, particularly over longer lengths.

Thermocouple-based applications, meanwhile, usually have the most stringent wiring requirements. Each thermocouple type utilizes its own corresponding wire that has matching thermocouple material incorporated in its composition. This specialized wire can be quite expensive, which is why for thermocouple applications, short wiring runs are usually preferred.

Opto 22 Solutions

SNAP Input Modules. Opto 22 features solutions for all types of temperature sensing equipment—RTDs, thermocouples, ICTDs, thermistors, and infrared sensors. These solutions include a full complement of multi-channel analog input modules that seamlessly connect to these sensing devices for the purposes of remote monitoring and data acquisition.

Opto 22 I/O modules come in multiple configurations and densities, ranging from two to eight channels. Eight-channel modules offer significant cost savings in applications that rely on numerous temperature readings. These applications include those involving water treatment, refrigeration, thermoforming, curing, autoclaving, refining, PID loop control, sterilization, pasteurization, and welding.

Opto 22's SNAP-AICTD-8 module, for example, is designed specifically for energy management-related applications and provides eight channels of analog temperature input from standard ICTDs. It is currently being used by machine builders and systems integrators in HVAC and refrigeration applications.

Similarly, Opto 22's SNAP-AITM-8 offers up to eight channels of temperature input from a variety of standard type B, C, D, G, E, J, K, N, R, S or T thermocouples. This module accepts up to eight isolated thermocouple probes and is ideal for temperature monitoring and data acquisition related to autoclaves, industrial ovens, heat exchangers, and other equipment that requires thermal regulation. This module can also be effectively deployed with significant cost and space savings in machine builder applications, such as the design and development of molding machines and test stands.

Opto 22's RTD solutions include the SNAP-AIRTD module, which provides two channels of analog temperature input spanning the -200 to +850 °C range.

For thermistors, the 8-channel SNAP-AIR400K-8 offers autoranging and a variety of fixed ranges from 0–500 Ohms up to 0–400 kOhms. Temperature is calculated automatically.

Interfaces from Opto 22-based systems to infrared sensors are slightly different in that the connection is made either through serial modules or standard 4–20 mA input modules.

SNAP PAC Brains. SNAP temperature input modules connect directly to temperature sensors and convert their analog field signals to digital signals, which are then sent to the SNAP PAC I/O brain, located on the same mounting rack as the I/O.

It is the brain, an intelligent I/O processor and communications device, that makes the Opto 22 I/O system particularly effective for temperature monitoring. Working at the I/O level, the brain automatically performs many calculations that would otherwise demand processing resources in the controller. Moreover, the essential temperature calculation functions that are built into the brain do not require programming.

For temperature monitoring applications, the SNAP PAC I/O brain:

- Converts measurement units to temperature
- Provides computations for cold junction compensation
- Performs thermocouple linearization

Opto 22's I/O brain and I/O modules work together with sensors of all types to obtain accurate temperature data for multiple applications.

For more information about temperature sensing technologies, see the article "Challenges of Temperature Sensing" from *Control Engineering* online, www.controleng.com/article/CA6620283.html.

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