

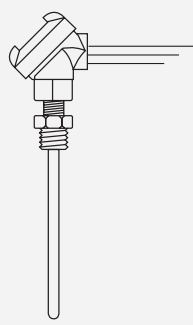
Engineer's Notebook

Many instrument technicians have limited familiarity with RTDs and the calibration of instruments that monitor temperature using RTDs. This article provides a better understanding of these devices.

What is an RTD

A Resistance Temperature Detector (RTD) is a resistor made from a metal that has a predictable change in resistance directly proportional to a change in temperature. RTDs are made from Platinum, Nickel or Copper of calculated purity and trimmed to standard resistances at known temperatures. The most common metal/resistance combinations are: Pt 100Ω, Ni 120Ω and Cu 10Ω.

Platinum RTDs of different purity are used for different purposes. These purities are indicated by the α which is a measure of the resistance change of the sensor vs temperature. In the past α (alpha) was calculated by dividing the resistance at 100°C by the resistance at 0°C. For the equations used to produce the temperature vs resistance tables $\alpha = \text{ohms per ohms per } ^\circ\text{C}$. This is calculated by subtracting the resistance at 0°C from the resistance at 100°C, dividing that value by 100 and dividing that value by the 100Ω nominal value of the RTD. The highest purity platinum (and highest cost) RTDs, used as primary laboratory standards, have an $\alpha = 1.3926$ (also known as 0.003926 or 3926). The DIN/IEC 751 Standard defines an RTD with an $\alpha = 1.3850$ (a.k.a. 0.00385 or simply 385) which is used worldwide for industrial and process applications.



Typical RTD Probe

Two, Three and Four Wire RTDs

The most economical but least accurate method to measure RTDs is to use two wires. This method is most often used when the RTD sensor and the measuring device are close to each other, for example, a controller built into an oven. As shown in Diagram 1, the measuring device sees the resistance of the lead wires in addition to the resistance of the RTD sensor. The effect of the lead wire resistance can be eliminated by using three wires of equal resistance. This is the most popular setup for industrial field applications and works best when all three leads are identical in gauge and length and run in the same path. Some instruments use bridge type circuitry to compensate for lead resistance while other instruments subtract out the resistance of the leads. In Diagram 2 the resistance of two lead

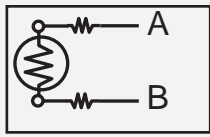


Diagram 1

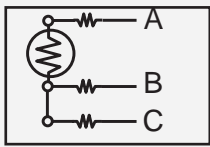


Diagram 2

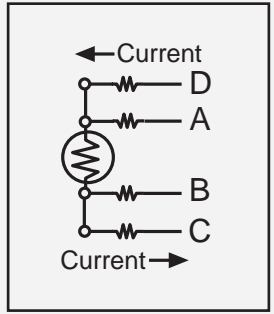


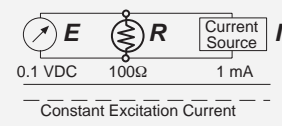
Diagram 3

RTD Instrumentation

wires can be measured between leads B & C. If this resistance is subtracted from the measurement made between leads A & B the result is the resistance of just the RTD sensor. The most accurate method of measuring RTDs is a four wire connection. This is typically used in the lab environment or where the highest accuracy is required in the field. In diagram 3 a precise current is supplied between leads D & C and a high impedance voltage measurement is made between leads A & B. Because there is very little current carried on leads A & B the resistance of the leads becomes insignificant.

How Traditional Instruments Measure Resistance

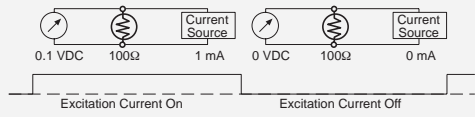
To measure resistance, a constant excitation current (I) of a known value is applied to the resistance. The resistance reading device then measures the voltage (E) developed across the resistance. The resistance (R) is calculated by using Ohms law. $R = E/I$



Constant Excitation Current

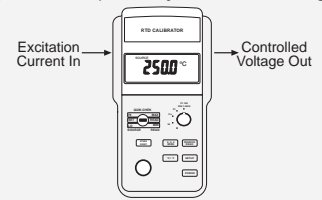
How New Instruments Measure Resistance

While traditional instruments applied a constant excitation current to the unknown resistance, many new instruments use a pulsed excitation current. Some multi-channel devices, such as PLCs and recorders, switch a single excitation current among each of the channels. The RTD connected to a single channel may see this excitation current as a pulse of a few milliseconds duration every few seconds. "Smart" temperature transmitters have different internal energy needs than traditional transmitters. Pulsing the excitation current frees up energy required to run their internal microprocessors and communications.



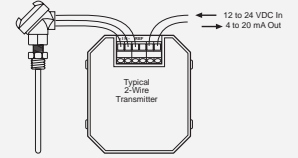
How the New Instruments Simulate Resistance

Modern calibrators such as the Altek Model 311A simulate resistance by conforming to Ohms law. The 311A accurately samples the current and presents a precisely controlled voltage to the reading instrument based on the user selected resistance or RTD temperature. Older RTD calibrators, as well as most multifunction calibrators, are not compatible with pulsed excitation currents. Fast circuitry and precise calibration allow the 311A to simulate RTDs into virtually any instrument, regardless of the pulse speed of the excitation current.



Temperature Transmitters

Temperature transmitters, also known as signal conditioners, are used where there is a long distance between the RTD sensor and the controls for the process loop. The transmitter takes the low level resistance signal of the RTD and converts it into a high level signal, typically 4 to 20 milliamps. This 4 to 20 milliamps can be transmitted over a pair of wires for a long distance without signal loss. Two wire transmitters, the type most commonly used, receive the 12 to 24V DC to power the transmitter on the same pair of wires that the transmitter uses to send the 4 to 20 mA signal back to the controller.



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