

# THE THERMISTOR

Like the RTD, the thermistor is also a temperature sensitive resistor. While the thermocouple is the most versatile temperature transducer and the PRTD is the most stable, the word that best describes the thermistor is *sensitive*. Of the three major categories of sensors, the thermistor exhibits by far the largest parameter change with temperature.

Thermistors are generally composed of semiconductor materials. Although positive temperature coefficient units are available, most thermistors have a negative temperature coefficient (TC); that is, their resistance decreases with increasing temperature. The negative T.C. can be as large as several percent per degree Celsius, allowing the thermistor circuit to detect minute changes in temperature which could not be observed with an RTD or thermocouple circuit.

The price we pay for this increased sensitivity is loss of linearity. The thermistor is an extremely non-linear device which is highly dependent upon process parameters. Consequently, manufacturers have not standardized thermistor curves to the extent that RTD and thermocouple curves have been standardized.

An individual thermistor curve can be very closely approximated through use of the Steinhart-Hart equation:<sup>18</sup>

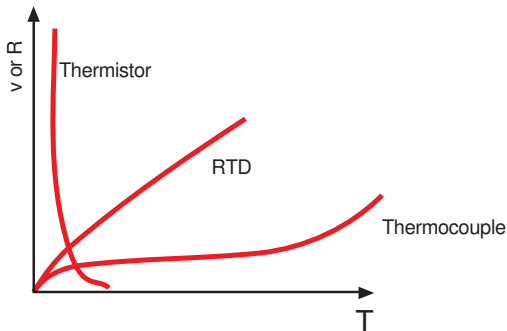


Figure 47

$$\frac{1}{T} = A + B \ln R + C (\ln R)^3$$

where:

T = Degrees Kelvin

R = Resistance of the thermistor

A, B, C = Curve-fitting constants

A, B, and C are found by selecting three data points on the published data curve and solving the three simultaneous equations. When the data points are chosen to span no more than 100°C within the nominal center of the thermistor's temperature range, this equation approaches a rather remarkable  $\pm 0.02^\circ\text{C}$  curve fit.

Somewhat faster computer execution time is achieved through a simpler equation:

$$T = \frac{B}{\ln R - A} - C$$

where A, B, and C are again found by selecting three (R, T) data points and solving the three resultant simultaneous equations. This equation must be applied over a narrower temperature range in order to approach the accuracy of the Steinhart-Hart equation.

## Linear Thermistors

A great deal of effort has gone into the development of thermistors which approach a linear characteristic. These are typically 2- or 4-leaded devices requiring external matching resistors to linearize the characteristic curve. The modern data acquisition system with its computing controller has made this kind of hardware linearization unnecessary.

## Measurement

The high resistivity of the thermistor affords it a distinct measurement advantage. The four-wire resistance measurement is not required as it is with RTD's. For example, a common thermistor value is 5000 ohms at 25°C. With a typical T.C. of 4%/°C, a measurement lead resistance of 100 produces only a .05°C error. This error is a factor of 500 times less than the equivalent RTD error.

**Disadvantages** - Because they are semiconductors, thermistors are more susceptible to permanent decalibration at high temperatures than are RTD's or thermocouples. The use of thermistors is generally limited to a few hundred degrees Celsius and manufacturers warn that extended exposures even well below maximum operating limits will cause the thermistor to drift out of its specified tolerance.

Thermistors can be made very small which means they will respond quickly to temperature changes. It also means that their small thermal mass makes them especially susceptible to self-heating errors.

Thermistors are a good deal more fragile than RTD's or thermocouples and they must be carefully mounted to avoid crushing or bond separation.