Chapter 05.00E

Physical Problem of Interpolation
Electrical Engineering

Thermistors are temperature-measuring devices based on the principle that the thermistor material exhibits a change in electrical resistance with a change in temperature. By measuring the resistance of the thermistor material, one can then determine the temperature. Thermistors are generally a piece of semiconductor made from metal oxides such as those of manganese, nickel, cobalt, etc. These pieces may be made into a bead, disk, wafer, etc depending on the application.

There are two types of thermistors – negative temperature coefficient (NTC) and positive temperature coefficient (PTC) thermistors. For NTCs, the resistance decreases with temperature, while for PTCs, the resistance increases with temperature. It is the NTCs that are generally used for temperature measurement.

Why would we want to use thermistors for measuring temperature as opposed to other choices such as thermocouples? It is because thermistors have high sensitivity giving more accuracy, a fast response to temperature changes for accuracy and quicker measurements, and relatively high resistance for decreasing the errors caused by the resistance of lead wires themselves.

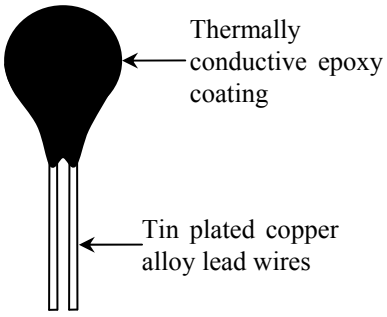

Figure 1. A typical thermistor

But thermistors have a nonlinear output and are valued for a limited range. So, when a thermistor is manufactured, the manufacturer supplies a resistance vs. temperature curve. The curve generally used that gives an accurate representation is given by

$$\frac{1}{T} = a_0 + a_1 \ln(R) + a_2 \{\ln(R)\}^2 + a_3 \{\ln(R)\}^3 \quad (1)$$

where

T is temperature in Kelvin, and
R is resistance in ohms.
a_0, a_1, a_2, a_3 are constants of the calibration curve.

Making change of variables

$y = \frac{1}{T}$, and
$x = \ln R$,

we can change the calibration curve to a polynomial

$y = a_0 + a_1 x + a_2 x^2 + a_3 x^3$.

So if one is able to find the constants of the above formula, one can then use the calibration curve to find the temperature.

Given below is the data of resistance vs. temperature for a thermistor. Can you find the calibration curve?

Table 1 Resistance vs. temperature data for calibration of a thermistor

R	T
Ohm	$°C$
1101.0	25.113
911.3	30.131
636.0	40.120
451.1	50.128

References

1. Betatherm sensors, http://www.betatherm.com
2. Valvanao, J., "Measuring Temeparture Using Thermistors", Curcuit Cellar Online, August 2000, http://www.circuitcellar.com/online
3. Lavenuta, G., "Negative Temperature Coefficient Thermistors: Part 1: Characteristics, Materials, and Configurations", http://www.globalspec.com/cornerstone/ref/negtemp.html
4. Potter, D., "Measuring Temperature with Thermistors – a Tutorial", National Instruments Application Note 065, http://www.seas.upenn.edu/courses/belab/ReferenceFiles/Thermisters/an065.pdf
5. Steinhart, J.S. and Hart, S.R., 1968. "Calibration Curves for Thermistors," Deep Sea Research 15:497.
6. Sapoff, M. et al. 1982. "The Exactness of Fit of Resistance-Temperature Data of Thermistors with Third-Degree Polynomials," Temperature, Its Measurement and Control in Science and Industry, Vol. 5, James F. Schooley, ed., American Institute of Physics, New York, NY:875.

7. Siwek, W.R., et al. 1992. "A Precision Temperature Standard Based on the Exactness of Fit of Thermistor Resistance-Temperature Data Using Third Degree Polynomials," Temperature, Its Measurement and Control in Science and Industry, Vol. 6, James F. Schooley, ed., American Institute of Physics, New York, NY:491-496.

Topic	INTERPOLATION
Sub Topic	Physical Problem
Summary	Thermistors measure temperature based on the principle that resistance of thermistor material changes with temperature. Hence, a manufacturer supplies a resistance vs. temperature calibration curve. This curve is developed using interpolation.
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