

Calibrate Steinhart-Hart Coefficients for Thermistors

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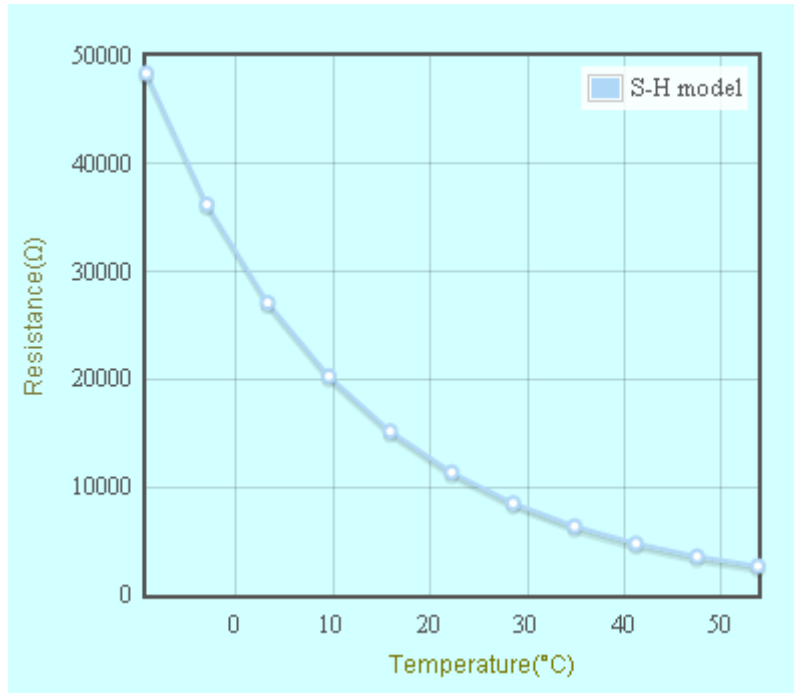


Figure 1 A 10kΩ NTC thermistor T- R curve

NTC (Negative Temperature Coefficient) thermistors can be used in LDC500, LDC501 and LDC502 TEC controllers. They have the advantage of a very high sensitivity to temperature changes, but the disadvantage of an aggressively nonlinear characteristic. The following curve shows the resistance of a typical NTC thermistor device over a temperature range from 0 to 50°C.

From the above curve, resistance value changes from 50kΩ to 2kΩ within 0~50°C. The change is most rapid at low temperatures, giving great resolution for determining the corresponding temperature values there. At higher temperature, resistance changes relatively less with temperature and the measurement resolution will be relatively poor.

Thermistor's T- R curve can be described in equations. The most commonly used form is the **Steinhart-Hart Equation** shown below:

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

Where

R_t --- the thermistor resistance (Ω) at temperature T (Kelvin);

A, B, C --- the thermistor's constants.

Manufacturers may provide typical values of the A, B, and C coefficients, or you can calibrate these values for better accuracy.

It is not hard to calibrate your own response curves, if you have an accurate temperature measurement standard. In the following example, three points are selected, two close to the ends of the operating range and one near the center (shown in the following table).

Resistance (Ω)	Temperature (°C)
25415	5
10021	25
6545	35

Insert the three pair of resistance values and temperatures to the equation to form three equations. Here we write them in matrix form below.

$$\begin{bmatrix} 1 & \ln(25415) & (\ln(25415))^3 \\ 1 & \ln(10021) & (\ln(10021))^3 \\ 1 & \ln(6545) & (\ln(6545))^3 \end{bmatrix} \cdot \begin{pmatrix} A \\ B \\ C \end{pmatrix} = \begin{pmatrix} \frac{1}{5 + 273.15} \\ \frac{1}{25 + 273.15} \\ \frac{1}{35 + 273.15} \end{pmatrix}$$

The Steinhart-Hart coefficients A, B, and C can be obtained by solving the above equations and we get: A=1.1384×10⁻³, B=2.3245×10⁻⁴, C=9.489×10⁻⁸. LDC500 series use these three coefficients to convert resistance into temperature if Steinhart-Hart model is selected.

There are different ways to get these three Resistance – Temperature pairs.

Method 1: Put your thermistor in ice water, boiling water, and room temperature. Use a standard meter to measure your sensor resistances and temperatures. Sensor should be wrapped to avoid wet.

Method 2: Use LDC501 TEC controller to control a TEC stage (with its own sensor). Locate your thermistor on the stage. Let TEC work at three different temperatures, and use standard meter to measure your sensor resistances and temperatures

Method 3: If your thermistor is in the LDC501 control loop, let it work in constant resistance mode. Set controller at three different resistances and measure the stage temperatures using a standard thermometer.

Stanford Research Systems provides a NTC coefficient calculator to do the math and draw the T-R curve. The program provides parameters for both Steihart-Hart model and β-model coefficients. Go to our website:

<http://www.thinksrs.com/downloads/programs/Therm%20Calc/NTCCalibrator/NTCcalculator.htm>

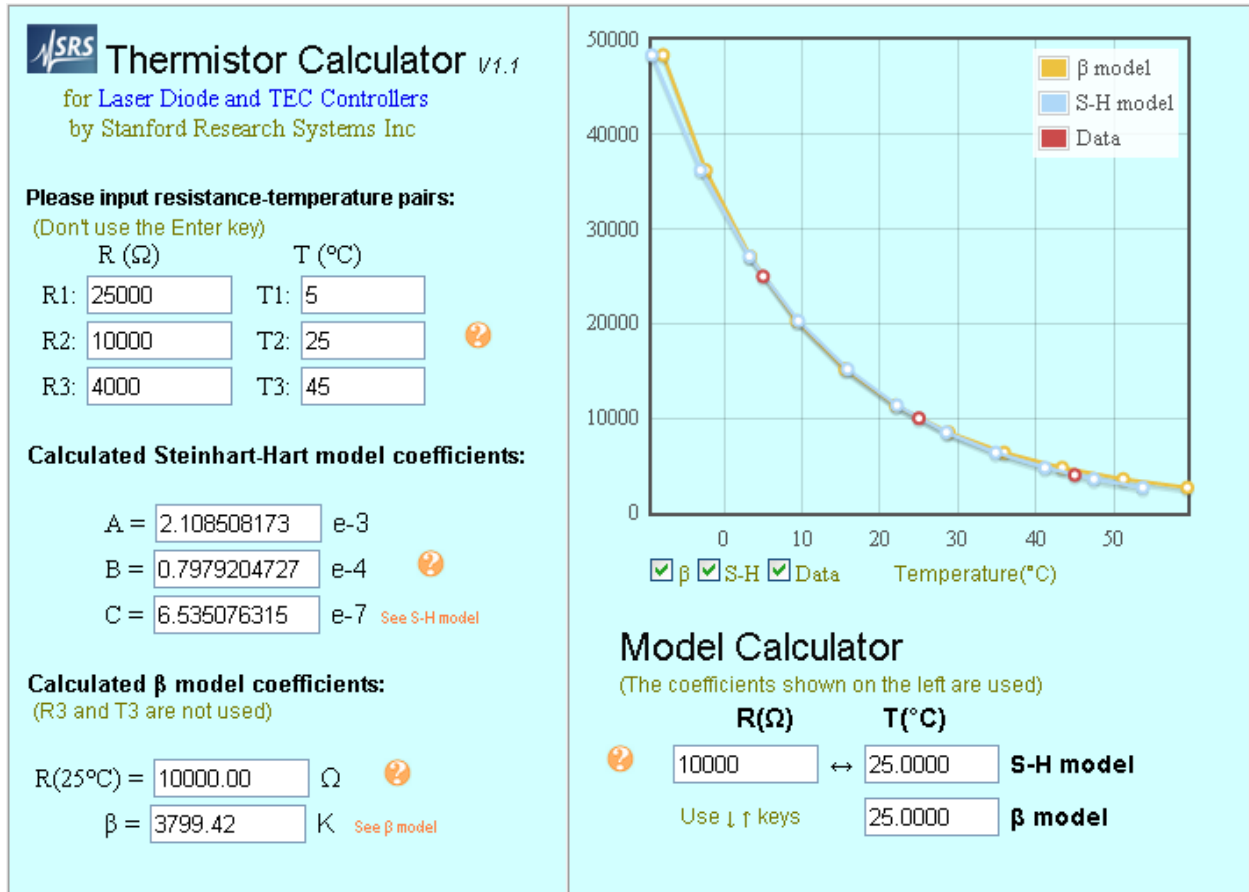


Figure 2 SRS web based Thermistor calculator