

Calibrate Steinhart-Hart Coefficients for Thermistors

NTC (Negative Temperature Coefficient) thermistors can be used with LDC500/501 TEC controllers. They have the advantage of 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.

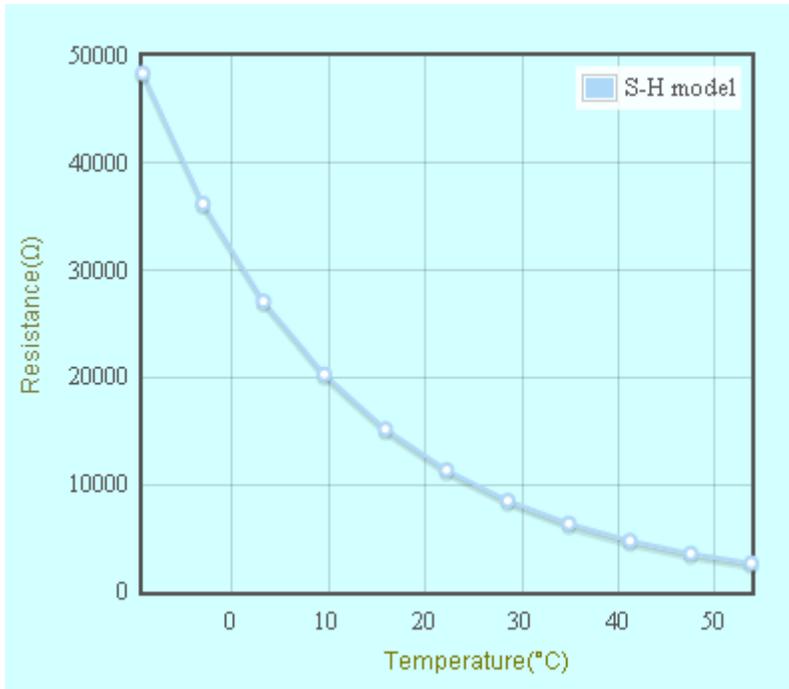


Figure 1: A 10 kΩ, NTC thermistor T- R curve

From the above curve, we can see the resistance value changes from 50 kΩ to 2 kΩ 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.

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

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

Where

Rt is the thermistor resistance (Ω) at temperature T (Kelvin);
A, B, C are 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.

Resistance (Ω)	Temperature ($^{\circ}\text{C}$)
25415	5
10021	25
6545	35

Insert the three pairs of resistance values and temperatures into 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 matrix equation: $A = 1.1384 \times 10^{-3}$, $B = 2.3245 \times 10^{-4}$, $C = 9.489 \times 10^{-8}$. The LDC501 uses these three coefficients to convert resistance into temperature.

There are different ways to get these three 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. The sensor should be wrapped to avoid wetting.

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

Stanford Research Systems provides an NTC coefficient calculator to do the math and draw the T-R curve. The program also provides parameters for β -model coefficients. You can find this calculator at –

<http://www.thinksrs.com/support/Therm%20Calc/NTCCalibrator/NTCCalculator.htm>

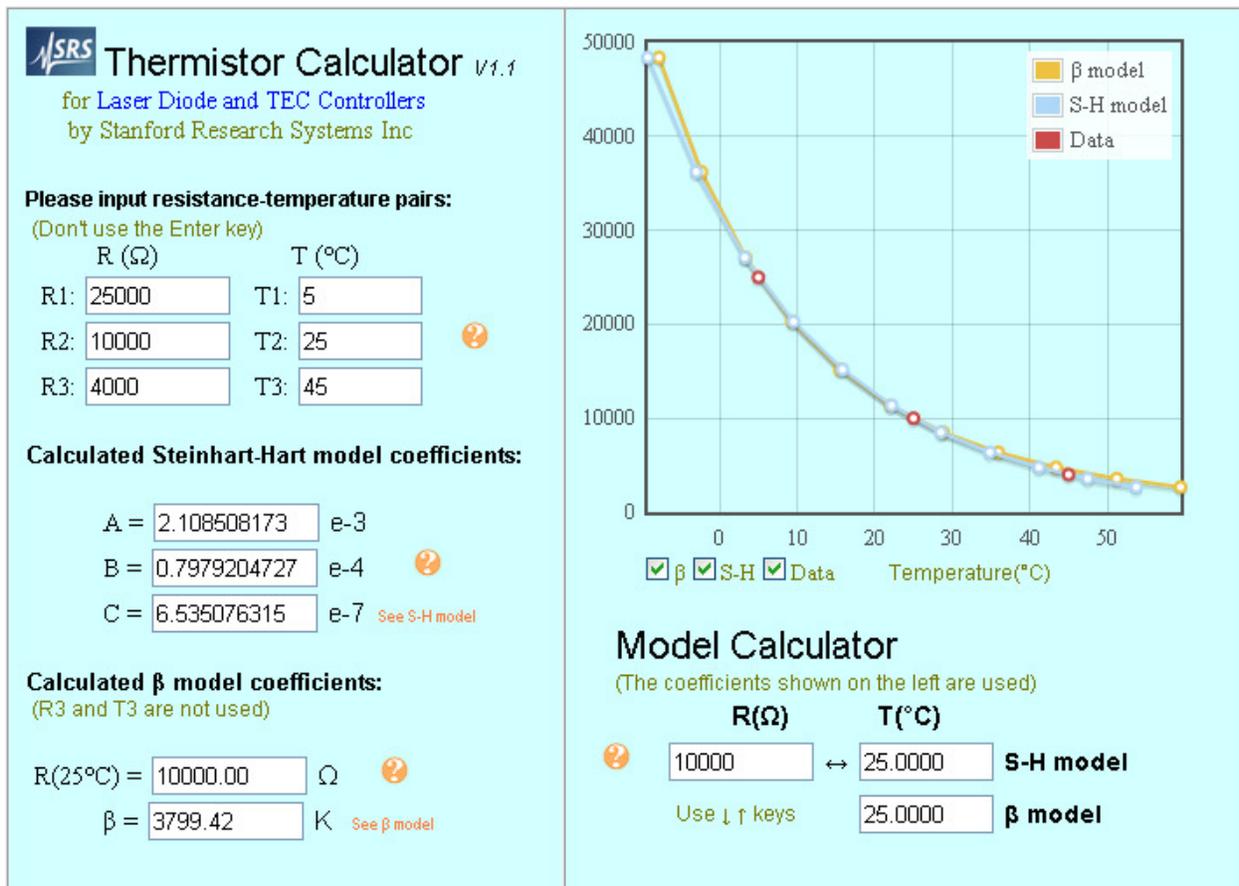


Figure 2: SRS web based Thermistor calculator