I often have to get a reasonably accurate temperature measurement for a laser, transistor, or printed circuit board. I usually use a thermistor for my temperature sensor because they are inexpensive. However, the thermistor’s nonlinear resistance characteristic makes accurate temperature conversion complex. To minimize this difficulty, I often linearize the thermistor’s resistance characteristic by placing the thermistor within a resistor divider. This linearized response is simpler to convert to a temperature value than the thermistor’s raw response. To obtain an optimum level of linearity, I have derived a pair of formulas that are useful in determining component values ($R_s$ and $R_p$) for this common linearization circuit.

**Figure 1** shows the thermistor linearization circuit that I am addressing in this Design Idea. The temperature of the thermistor is linearly related to the output voltage (approximately).
The design process begins by picking a temperature, which I call the inflection temperature $T_I$, at which we want the flattest possible transfer function ($V_{OUT}/V_{IN}$). My design task is to compute values for $R_s$ and $R_p$ given $T_I$ and the resistor ratio $\mu=V_{OUT}/V_{IN}$ at $T_I$.

Three parameters, $R_0$, $\beta$, and $T_{REF}$, are often used with Eq. 1 to model the thermistor’s resistance versus temperature characteristic.

$$R_T(T) = R_0 \cdot e^{\frac{\beta}{T_{REF}} - \frac{\beta}{T}}$$

(Eq. 1)

I determine $R_s$ and $R_p$ by setting the second derivative of $V_{OUT}/V_{IN}$ in Figure 1 to 0 at temperature $T_I$. After much algebra, I obtained the two formulas shown in Eq. 2.

**Figure 1** Two-resistor thermistor linearization circuit
Not all ratios are possible with passive components – ratios less than \( \mu_{\text{Critical}} = \frac{(\beta - 2 \cdot T_i)}{2 \cdot \beta} \) result in negative RP values.

**Figure 2** shows a graph of the linearized thermistor voltage transfer function for a common thermistor.

I have put together an Excel spreadsheet and a Mathcad worksheet that models this data, downloadable below.
ZIP archive of spreadsheet & worksheet (please use "Save as" and remove the dummy .txt extension before saving)

Also see:

- Temperature-to-period circuit provides linearization of thermistor response
- Genetic algorithm solves thermistor-network component values
- Thermistor and DMM Measure Temperature
- Pseudologarithmic thermistor signal conditioning spans wide temperature range
- Wringing out thermistor nonlinearities
- Log amp linearizes thermistors
- Designing with temperature sensors, part two: thermistors
- Important design considerations for digital thermometers