Technical Article

How to Choose the Right Thermistor for Your Temperature Sensing Application

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There are thousands of thermistors on the market today, and finding the right one for your temperature-sensing application can be confusing. In this technical article, I'll talk about some of the important parameters that you need to keep in mind when choosing a thermistor, particularly if you're deciding between two popular types of thermistors for temperature sensing: negative temperature coefficient (NTC) thermistors or silicon-based linear thermistors. NTC thermistors are frequently used due to their very low price point, but they deliver low accuracy at temperature extremes. Silicon-based linear thermistors provide higher performance and high accuracy across a wider temperature range, but this typically comes at a higher price point. As we will see in the text below, additional options for linear thermistors are coming on the market to provide more cost-effective, high-performance options to help solve a broad range of temperature sensing needs without increasing total solution cost.

The right thermistor for your application will depend on many parameters, such as:

- Bill-of-materials (BOM) cost.
- Resistance tolerance.
- Calibration points.
- Sensitivity (change in resistance per degree Celsius).
- Self-heating and sensor drift.

BOM cost

Thermistors themselves are inexpensive devices. Because they are discrete, it is possible to alter their voltage drop through the use of additional circuitry. For example, if you are using an NTC thermistor, which is nonlinear, and prefer to have a linear voltage drop across your device, you may choose to add additional resistors to help achieve this characteristic. However, another alternative that would reduce BOM and total solution cost is to use a linear thermistor that already provides the voltage drop you want. The good news is that you can find both thermistor options at a similar cost thanks to our new family of linear thermistors, which help engineers simplify design, lower system cost and reduce printed circuit board (PCB) layout size by at least 33%.

Resistance tolerance

Thermistors are categorized by their resistance tolerance at 25°C, but that doesn't quite tell the whole story of how they vary across temperature. It's important to calculate the tolerance across your specific temperature range of interest by using the minimum, typical and maximum resistance values provided in the device's resistance vs. temperature (R-T) table, which you can find in a design tool or data sheet.

To illustrate how tolerance varies with thermistor technology, let's compare an NTC and our TMP61 silicon-based thermistor, which are both rated at a ±1% resistance tolerance. Figure 1 illustrates that as the temperature moves away from 25°C, both devices increase their resistance tolerance, but there is a very large difference between the two at temperature extremes. It's important to calculate this difference so that you can choose a device that maintains a low tolerance for your temperature range of interest.

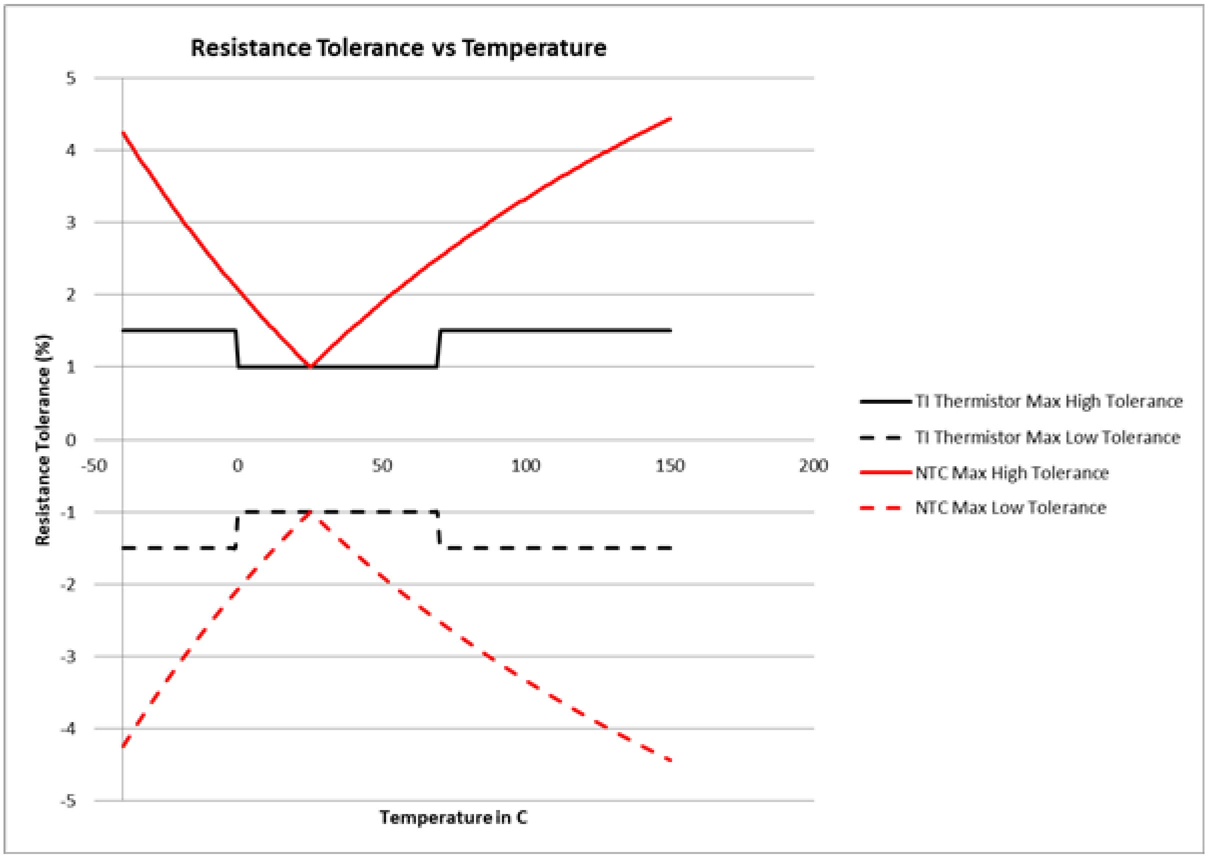

Figure 1. Resistance Tolerance: NTC vs. the TMP61

Calibration points

Not knowing where your thermistor stands within its resistance tolerance span can decrease your system performance, because you need a larger margin of error. Calibrating will tell you what resistance values to expect, which can help you greatly reduce that margin of error. This is, however, an added step in your manufacturing process, so you should try to keep calibration to a minimum.

The number of calibration points you'll need depends on the type of thermistor you're using and the temperature range of your application. For narrow temperature ranges, one point of calibration is fine for most thermistors. For applications requiring a wide temperature range, you have two options: 1) Calibrate three times using an NTC (this is due to their low sensitivity and high resistance tolerance at temperature extremes), or2) calibrate once using a silicon-based linear thermistor, which is significantly more stable than an NTC.

Sensitivity

Having a large change in resistance per degree Celsius (sensitivity) is just one piece of the puzzle when trying to obtain good accuracy from a thermistor. However, a large sensitivity won't be very helpful unless you have the correct resistance values in software by either calibrating or choosing a thermistor with a low resistance tolerance.

NTCs have very large sensitivity at low temperatures given their exponential decrease in resistance values, but the sensitivity drastically decreases as the temperature rises. Silicon-based linear thermistors don't have a large swing in sensitivity like NTCs, which allows for stable measurements across the whole temperature range. As the temperature rises, the sensitivity of silicon-based linear thermistors typically exceeds that of an NTC at about 60°C.

Self-heating and sensor drift

Thermistors dissipate power consumption as heat, which can affect their measurement precision. The amount of heat dissipated depends on many parameters, including the material composition and current passing through the device.

Sensor drift is the amount that a thermistor drifts over time, and is typically specified in data sheets via accelerated life tests given as a percentage change in resistance value. If your application requires a long lifetime of consistent sensitivity and accuracy, look for a thermistor with low self-heating and sensor drift.

So when should you use a silicon-based linear thermistor like the TMP61 over an NTC?

Taking a look at Table 1, you can see that for the same price, nearly any situation that is within the specified operating temperature of silicon-based linear thermistors can benefit from their linearity and stability. Silicon-based linear thermistors are also available in both commercial and automotive variants, and come in the standard 0402 and 0603 footprint packages common to surface-mount-device NTCs.

Table 1. NTCs vs. TI Silicon-based Linear Thermistors

Parameter	NTC thermistors	TI silicon-based linear thermistor
BOM cost	**Low to mid:** • Low cost for the thermistor • May require extra linearization circuitry	**Low:** • Low cost for the thermistor • No need for extra linearization circuitry
Resistance tolerance	**Large:** • Big difference between tolerance at 25°C and temperature extremes	**Small:** • Small ±1.5% maximum tolerance across the whole temperature range
Sensitivity	**Inconsistent:** • Very large at low temperatures • Drastic decrease with rising temperatures	**Consistent:** • Stable sensitivity across the whole temperature range • Greater than NTCs typically above 60°C
Calibration points	**Multiple:** • Multiple points needed for wide-range applications	**One:** • Only one point needed for wide-range applications
Self-heating and sensor drift	**High:** • Increased power consumption with temperature • Large sensor drift	**Minimal:** • Decreased power consumption with temperature • Small sensor drift

For complete R-T tables of TI thermistors and easy temperature conversion methods with example code, download our Thermistor Design Tool.

Additional resources

- Read the white paper, "Temperature Sensing with Thermistors."
- Check out TI's thermistor page.
- Download the TMP61 data sheet.

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