What is a Thermistor?

A **thermistor** is a type of resistor whose resistance changes significantly with temperature. It is widely used for temperature sensing, measurement, and control. The term "thermistor" is derived from the words **thermal** and **resistor**.

Types of Thermistors

1. **NTC Thermistor (Negative Temperature Coefficient)**:
    - The resistance of the thermistor decreases as the temperature increases.
    - Commonly used for temperature measurement and control applications.
    - For example:
        - At low temperatures, resistance is high.
        - At high temperatures, resistance is low.
2. **PTC Thermistor (Positive Temperature Coefficient)**:
    - The resistance of the thermistor increases as the temperature increases.
    - Commonly used in overcurrent protection and self-regulating heating elements.
    - For example:
        - At low temperatures, resistance is low.
        - At high temperatures, resistance is high.

Why Use a 10k Pull-Up Resistor?

The **pull-up resistor** (commonly 10kΩ) forms a voltage divider with the thermistor. The purpose of the pull-up resistor is to allow the thermistor's varying resistance to produce a measurable voltage change that corresponds to temperature.

Here's why a 10kΩ resistor is commonly used:

1. **Matching Thermistor's Resistance**:
    - Many NTC thermistors have a nominal resistance of **10kΩ at 25°C**. Using a 10kΩ pull-up ensures a balanced voltage divider.
    - This setup provides a good range of voltage changes across typical temperature ranges, maximizing the resolution of the ADC (analog-to-digital converter).
2. **Optimized ADC Performance**:
    - When the pull-up resistor matches the thermistor's nominal resistance, the output voltage spans a wide range, optimizing the ADC's ability to read temperature changes accurately.
3. **Power Consumption**:
    - A higher resistance (e.g., 10kΩ) reduces current flow, minimizing power consumption while maintaining signal integrity.

Thermistor Resistance-Temperature Relationship

The resistance of an NTC thermistor is calculated using the following formula:

$$R_T = R_N * e^{\beta\left(\frac{1}{T_K} - \frac{1}{T_N}\right)}$$

Where:

- R_T: Resistance of the thermistor at temperature T_K.
- R_N: Resistance of the thermistor at nominal temperature T_N.
- T_K: Absolute temperature in Kelvin (K = 273.15 + °C)
- T_N: Nominal temperature in Kelvin (usually 25°C or 298.15K).
- β: Beta coefficient of the thermistor (typically provided in the datasheet).

Explanation of the Variables

1. R_T:
    - The resistance of the thermistor at a given temperature T_K.
2. R_N:
    - The thermistor's resistance at its nominal temperature (T_N), usually **10kΩ** at 25°C.
3. T_K:
    - The current temperature in Kelvin (273.15 + °C).
4. T_N:
    - The nominal temperature (e.g., 25°C = 298.15K).
5. **Beta Coefficient (β)**:
    - A material-specific constant that describes how the resistance of the thermistor changes with temperature.

Example Calculation

If an NTC thermistor has:

- R_N = 10kΩ
- β = 3950
- T_K= 298.15K (25°C),

You can use the above formula to calculate RTR_TRT at different temperatures.

This setup ensures the thermistor provides precise temperature readings over a wide range of temperatures and is suitable for use in various applications like weather stations, heating systems, or temperature-sensitive circuits.

What is a Thermistor

The effect of temperature on a thermistor

How to Measure Temperature with an NTC Thermistor

How Thermistors Work - The Learning Circuit

Thermistors - NTC & PTC - Thermal Resistors - Temperature Sensors & Resettable Fuses