Selecting The Right NTC Thermistor for Your Application
By TDK Electronics

The accuracy of temperature measurement in electronics design is essential to prevent damage and extend the life of the application. Nearly all applications – including consumer, mobile devices, medical, industrial, automotive and home appliances - rely on temperature-based variables to extend the functionality or efficiency of the system.

Negative temperature coefficient (NTC) thermistors provide design engineers with a highly-accurate temperature sensor solution. Selecting the best NTC thermistor for any given application can be a challenge as manufacturers have developed a plethora of different NTC thermistors that differ in design, size, type, material, mounts, performance, accuracy and optimization for various applications.

Design engineers and those involved in the procurement of electronic components - as well as all involved in the development process, should understand how these temperature sensors work, and which ones will best help them prevent system overheating and extend the overall life of their design.

Thermal Sensor Technology

Engineers often want to get the best performance, features and life from their electronic designs. Consequently, the operating thermal limits and packing densities are often strained and pushed so that capabilities may be extended. This places thermal stress on the system creating a new challenge in designs where thermal temperature needs to be considered. This is especially true where size or environmental harshness causes design constraints.

When thermal stress occurs, temperature measurement within the design is required. This is so that steps may be taken to remediate and mitigate any impending overheating. This is most often done through two distinct technologies: Resistance temperature detector (RTD) sensors, and thermal resistors, known as thermistors.

Typically, RTD sensors are employed to measure wide-ranging temperatures. This is because they are manufactured from costly pure metals which expand and contract with temperatures. However, they often need a transmitter which also adds to the cost of the sensor.

There are two types of thermistors: positive temperature coefficient (PTC) thermistors, and negative temperature coefficient (NTC) thermistors. Because thermistors are designed to measure temperature based on thermal resistance, then can offer more precise thermal measurement than RTDs at a much lower cost.

With PTC thermistors, resistance of the sensor increases as temperature increases. When the pre-defined temperature limit of the thermistor is met, the resistance spikes and cuts power to the circuit. As a result, they PTC thermistors are often employed as temperature limiting sensors and are ideal as safety circuits, immediately shutting off current - like a circuit breaker - as switching temperature is reached and maximum resistance is achieved, hence the name of positive temperature coefficient.

Inversely, the resistance in NTC thermistors is reduced as temperature rises. Rather than shutting off with a spike of temperature, the relationship of resistance and temperature (R-T) becomes a controlled flattened curve, ensuring a steady, highly-accurate temperature measurement.

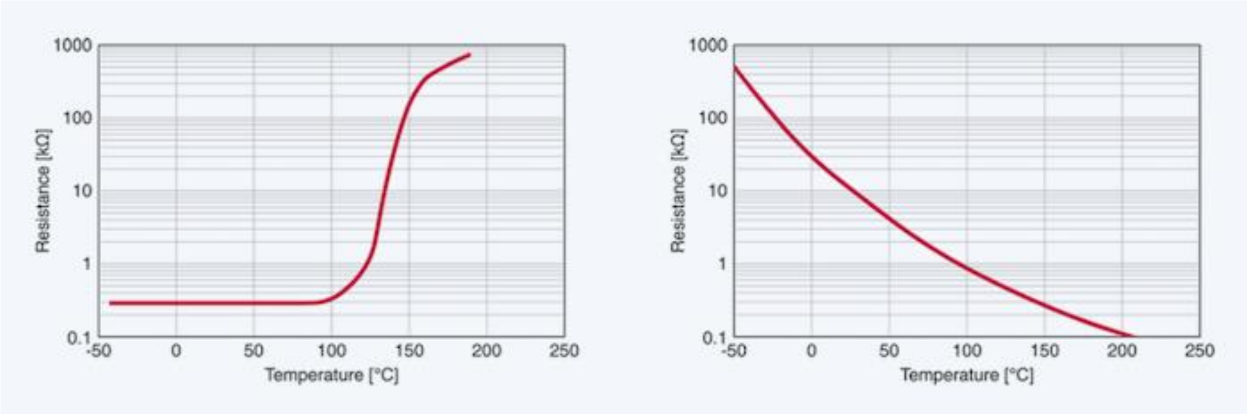


Figure: The Resistance – Temperature (R-T) relationship in PTC (left) and NTC (right) sensors.

When combined with control circuits, surface-mounted (SMD) NTC thermistors offer an efficient, highly-accurate way to measure precise temperatures and respond to thermal changes than both PTC thermistors and RTC sensors.

Selecting NTC Thermistors
The decision of which type of NTC thermistor to specify depends on a few conditions – size, environment, accuracy, response time, and temperature and resistance range. NTC thermistors measure temperature with high degree (pun intended) of accuracy (±0.1°C) and are highly sensitive to thermal changes, making them ideal in most applications.

The epoxy resin-coated (ideal for applications where air temperature and air flow measurements are required) and glass-encapsulated elements (ideal for harsh environmental conditions including moisture penetration) of NTC thermistors measure temperatures typically between -55°C and +155°C.

Glass-encapsulated NTC thermistors are often designed for more compact applications due to their size, with diameters as low as .08mm. They also reduce possible errors in resistance readings and have exceptionally fast response times (milliseconds), and can measure temperatures up to +300°C.

Thermistors are available in screw-in housing, in clip-type housing, conventional leaded styles or new lead-free chip and element styles that can be attached to cable harnesses, heat sinks or as surface mounting devices. This is so that the thermistor's temperature can be appropriately matched to the component that may cause potential thermal changes. Newer lead-free chip and element styles are fully RoHS compliant.

The material, encapsulating material, mounting, assembly and lead length help determine the NTC thermistor's dissipation factor. The dissipation factor is change in the thermistor's body temperature due and resultant power dissipation. This is often expressed in a ratio expressed in mW/K. It represents the load that changes the temperature or the thermistor in its steady-state by 1 k. The higher the dissipation factor, the more heat is dissipated by the thermistor.

Because of this dissipation factor, design engineers should always test the thermistor in both typical and extreme operating environments to ensure that the thermistor will properly measure and control temperatures. These tests determine the maximum allowable input current to ensure a negligible self-heating error inside the thermistor while at maximum measuring/controlling temperature.

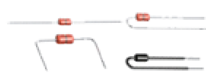
	Glass-encapsulated		Resin coated	
Type	Radial lead	Axial lead	Mini sensor	Under development
Picture				
Type (Part No.)	G15*0/G15*1 (B575*0G1*/B575*1G1*)	NTCDS/NTCDA /NTCDE/NTCDZ	S864 (B57864S*)	L862 (Under Development)
Feature	• Very short response time • Small dimensions	• Hardness lead for easy handling	• Improved resistanceto humidity • Short response time	• Lead-free • Tight temperature tolerances • Extremely high long term stability • High thermal shock resistance
Temperature range	-55 °C to 300 °C	-40 °C to 250 °C	-55 °C to 155 °C	-55 °C to 155 °C
Lead wire	• Dumet wires (copper clad FeNi) • Optional coating of glass body and leads for electrical insulation (G15*1), up to 260°C. • Optional with lead-spacing	• Nickel plated CP wire, available Sn plating. • Optional lead bending (NTCDA, NTCDE) • Optional coating for insulation or reducing stress (NTCDZ), up to 160°C.	• Insulated silver plated nickel wire, AWG30.	• Insulated silver plated nickel wire
Package	Bulk, Stripe	Bulk Ammo packing	Bulk	Bulk, Stripe

Figure: NTC Thermistors: glass-encapsulated and mini resin coated

Applications with NTC Thermistors
NTC thermistors may be employed in a wide variety of applications. For example, they may be used in the following industries:

Computing: NTC Thermistors may be used in the design of server power supply circuit products and data line products. These are often used in high-performance servers that process large volumes of data. When such systems overheat due to their higher clock speeds, performance is negatively impacted. By utilizing NTC Thermistors in the power supply ICs on server boards designers can increase power savings, prevent surges and reduce footprint and minimize cross-talk and noise in data lines.

Automotive: In the automotive industry, applications for NTC thermistors include climate control systems, heated steering wheels and seats and exhaust gas recirculation (EGR) systems. NTC thermistors can act as air intake manifold (AIM) sensors, and temperature and manifold absolute pressure (TMAP) sensors if designed for reliability, stability and harsh environmental conditions including shock and vibrational resistance.

Electric Vehicles: NTC sensors are utilized in electric and hybrid vehicles to ensure the safety of various systems including battery temperature monitoring, electrical impulsion winding and charging.

Home Appliances: There is a significant need for temperature sensing, control and energy efficiency in home appliances due to the range of operating temperatures used in appliances such as clothes dryers, irons, coffee makers, refrigerators, freezers and mixers. NTC sensors measure the cooling compartment's temperature, guard against icing in the evaporator, and detect ambient temperature for cooling and freezing applications.

Medical Device: In the medical electronics industry, NTC thermistors are used to sense and control temperature in medical devices while in operation or during the charging of devices. Thermistors are used to offset temperatures that can affect results from various medical tests including continuous glucose monitoring patches, thermometers and Holter monitors.

Figure: Examples of various NTC Thermistors from TDK

NTC Support from TDK

While the list of applications is endless, the need for NTC thermistors continues to rise. Fortunately, TDK's NTC Thermistor product line is designed to meet the needs of most applications and may be highly customized to meet the need of any application, enabling precise temperature measurements with long-term stability.

TDK not only provides standard and customized NTC thermistors for prototyping and mass production, but provides support files needed to speed design and development time, including 3D drawings, 3D modeling, computer simulations and the 3D printing of systems. TDK further supports manufacturers throughout the design and manufacturing process with concept reviews of designs, prototyping, construction and tooling, and testing and validation.

NTC thermistors from TDK are high quality and feature excellent performance, high accuracy, fast response time and a robust design that meets needs of any application.