Introduction

The term "Thermistor" is used to describe a range of electronic components whose principle characteristic is that their electrical resistance changes in response to changes in their temperature. The word "Thermistor" derives from the description "thermally sensitive resistor". Thermistors are further classified as "Positive Temperature Coefficient" devices (PTC devices) or "Negative Temperature Coefficient" devices (NTC devices). PTC devices are devices whose resistance increases as their temperature increases. NTC devices are devices whose resistance decreases as their temperature increases.
NTC thermistors are manufactured from proprietary formulations of ceramic materials based on transition metal oxides.
A discrete thermistor such as a chip, disc or rod is a fundamental electrical component.

Alpha (α) (Temperature Coefficient):

Alpha, a material characteristic, is defined as the percentage resistance change per degree Centigrade. Alpha is also referred to as the temperature coefficient. For Negative Temperature Coefficient (NTC) Thermistors, typical values of alpha are in the range -3%/°C to -6%/°C. The temperature coefficient is a basic concept in thermistor calculations. Because the resistance of NTC thermistors is a nonlinear function of temperature, the alpha value of a particular thermistor material is also nonlinear across the relevant temperature range.

$$\alpha = \frac{1}{R_T} \times \frac{dR}{dT} \times 100 \ (\% / {}^{o}C).$$

Where RT is the resistance of the component at the relevant temperature T (°C), dR/dt is the gradient of the Resistance vs Temperature curve at that temperature point, and alpha is expressed in units of "percentage change per degree Centigrade". (Note: In some texts the "100" term is omitted from the equation, but it is understood or implied in the units in which alpha values are specified.)

Thermal Time Constant (T.C.):

When a thermistor is being used to monitor the temperature of it's environment then the accuracy of measurement of the resistance of the thermistor is critical.
While the power dissipated in the thermistor is an important factor in this measurement as discussed in the previous section, the thermal characteristics of the system and the thermistor are important also. This is especially relevant in systems where the temperature is changing with time. The **dynamic thermal response** of the thermistor must be considered in these situations. To quantify this dynamic response, the concept of a **Thermal Time Constant (T.C.)** is used in the thermistor industry and it is defined as follows:
The Thermal Time Constant for a thermistor is the time required for a thermistor to change its body temperature by 63.2% of a specific temperature span when the measurements are made under zero-power conditions in thermally stable environments.
This concept is illustrated in the example below:
Example: A thermistor is placed in an oil bath at 25°C and allowed to reach equilibrium temperature. The thermistor is then rapidly moved to an oil bath at 75°C.
The T.C. is the time required for the thermistor to reach 56.6°C (63.2% of the temperature span).

The dominant factors that affect the T.C. of a thermistor are:

- The mass and the thermal mass of the thermistor itself
- Custom assemblies and thermal coupling agents that couple the thermistor to the medium being monitored.
- Mounting configurations such as a probe assembly or surface mounting.
- Thermal conductivity of the materials used to assemble the thermistor in probe housings.
- The environment that the thermistor will be exposed to and

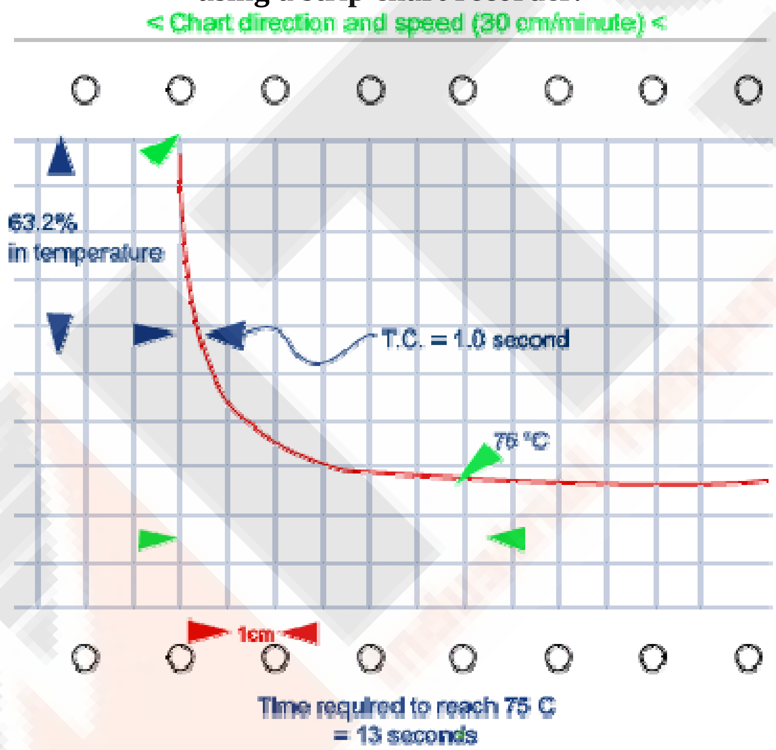
the heat transfer characteristics of that environment. Typically, gases are less dense than liquids so that thermistors have greater time constants wh monitoring temperature in a gaseous medium than in a liquid one.

The definition of Thermal Time Constant arises from the exponential nature of the rate of transfer of heat between the thermistor and the medium that it is monitoring. It is similar in principle to the definition of time constants in describing the responses of systems where physical effects have an exponential response with respect to time.

BetaTHERM offers a wide variety of thermistor devices with T.C.s ranging from 100 milli-seconds to 10 or even 20 seconds depending on test conditions.

Graph # 8 illustrates determination of T.C. for the thermistor of the previous example using a strip chart recorder. When the thermistor is transferred from a 25°C oil bath to a 75°C oil bath it’s resistance will change and the voltage drop across it can be measured using the chart recorder. By measuring the graph and the speed of the chart recorder the T.C. for the device in a stable oil bath environment can be determined.

Time Constant recording of a thermistor element using a strip chart recorder.



The value of resistance of a thermistor that is measured in a physical system depends on the power dissipated in the thermistor due to the measurement method and also on the thermal characteristics of a dynamic temperature system. It is important to consider both effects in implementing thermistor sensing systems.