

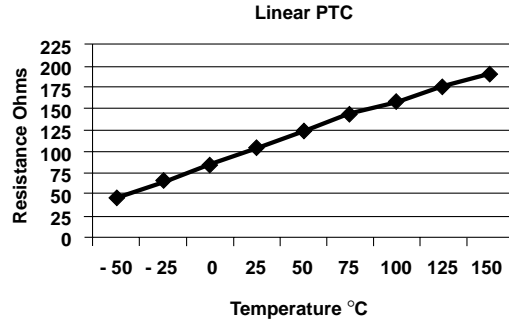
## NTC and PTC Thermistors

### INTRODUCTION

Thermistors are temperature sensitive resistors that have a greater than normal change in resistance value when the temperature changes. The change in resistance is predictable with changes in temperature. The extreme sensitivity to temperature change enables a thermistor to perform many functions and is utilized in an increasing variety of thermal sensing/control applications.

The two basic types of thermistors generally available today are the NTC and the PTC types. The NTC thermistors are ceramic semiconductors that have a high **Negative Temperature Coefficient** of resistance. NTC thermistors decrease in resistance as the temperature increases. PTC thermistors are **Positive Temperature Coefficient** resistors *generally* made of polycrystalline ceramic materials that have a high positive temperature coefficient, which increases in resistance as the temperature increases.

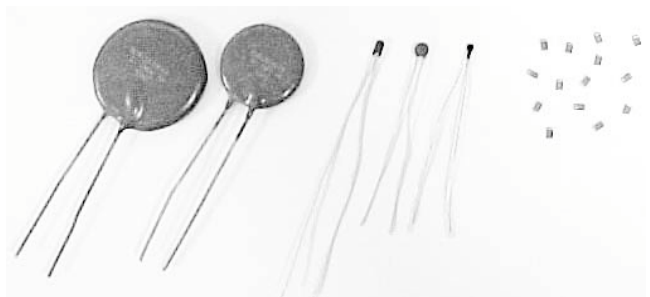
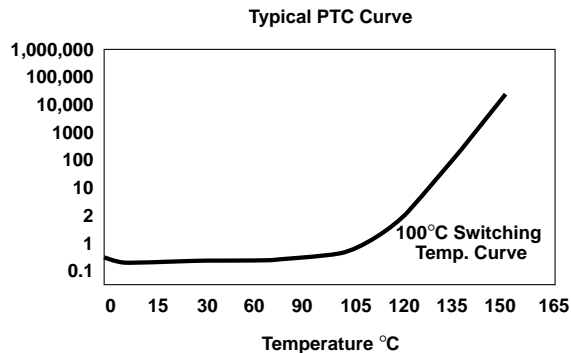
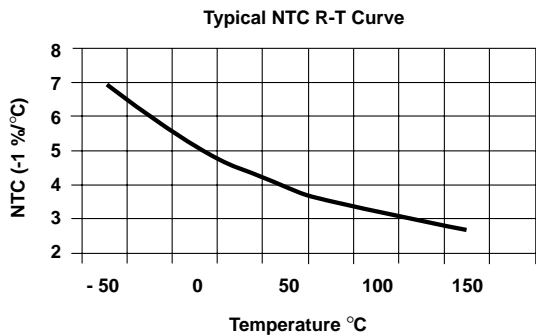
Typically, NTC or PTC thermistors do not increase or decrease in resistance with temperature in a linear fashion. The tables below show several examples of nonlinear resistance-temperature curves. Developed recently was a Vishay Dale linear PTC thermistor that has a linear resistance temperature relationship.



### NTC THERMISTORS

NTC thermistors are composed of sintered metal oxides such as manganese, nickel, cobalt, iron, copper and aluminum. The exact shape of the finished product such as disc or chip is dictated by the specific applications. The most prevalent configurations are discs and chips — both leaded and surface mount varieties.

Generally, the larger disc style thermistor functions in the “self-heating” mode; that is, the change in resistance is a result of the wattage (heat developed by the passage of a relatively large current through the device). The smaller chip style NTC thermistor generally changes body temperature/resistance by absorbing the surrounding or ambient temperature.



### NTC THERMISTOR APPLICATIONS

#### Temperature Measurement

The high sensitivity of a thermistor makes it an ideal candidate for low cost temperature measurement applications.



## Temperature Control

NTC thermistors can be used for temperature control (off/on) using a minimum amount of circuitry.

## Temperature Compensation

In many cases, circuit precision requires that there is some sort of temperature compensation. Oscillators, LCD displays, a battery under charge and some amplifiers are examples of circuits that may require temperature compensation.

## Inrush Current Limiter

An NTC disc thermistor subjected to a change in power will experience a time lag before reaching a lower resistance. This time lag can be utilized to limit the inrush surge current (the larger the part, the greater the lag).

## Fluid Level Applications

The thermistor can be used to sense the presence or absence of a liquid by using the difference in dissipation constants between a liquid and a gas.

## PTC THERMISTORS

The PTC thermistor is generally a polycrystalline ceramic material composed of oxalate or carbonate with added dopant materials. The PTC thermistor exhibits only a slight change of resistance with temperature until the “switching point” is reached at which point an increase of several orders of magnitude in resistance occurs.

## PTC THERMISTOR APPLICATIONS

### Overcurrent Protection

When a fault condition occurs, the PTC thermistor will heat up causing it to switch from a low to a very high resistance.

### Electronic Ballast Design

PTC thermistors are used in electronic ballast systems as a time delay element when the circuit is energized.

### Motor Starting

With a PTC thermistor in series with the starting windings in a single phase electronic motor, the PTC acts as a time delay.

### Battery Management

As a rechargeable battery becomes fully charged, its temperature increases and the PTC resistance increases rapidly reducing the charge to a very low level.

### Linear PTC Thermistor

The relatively recent development of the linear PTC thermistor utilizes a thick film technology similar to the thick film resistor.

The linear relationship between temperature and resistance simplifies the designer’s task in that the characteristic non-linear curve needs no normalization.

## THERMISTOR ASSEMBLIES

Thermistor assembly probes are available in a wide variety of configurations. The choice of assembly mounting, housing, etc., is dependent on the application. Primary factors that determine configuration of a thermistor assembly is operating environment, method of mounting and thermal time response. For specialized applications Vishay Dale offers a custom design service which allows the customer to advance from conception to design, manufacture and installation. Typical thermistor assemblies are shown below.



### Thermistor

A thermally sensitive resistor in which its primary function is to exhibit a change in electrical resistance with a change in body temperature.

### Standard Reference Temperature

The thermistor body temperature at which nominal zero-power resistance is specified (25°C).

### Zero-Power Resistance

This is the DC resistance value of a thermistor measured at a specified temperature with a power dissipation by the thermistor low enough that any further decrease in power will result in not more than 1.0 percent (or 1/10 of the specified measurement tolerance, whichever is smaller) change in resistance.

### Resistance Ratio Characteristic

This identifies the ratio of the zero-power resistance of a thermistor measured at 25°C to that resistance measured at 125°C.

### Negative Temperature Coefficient (NTC)

An NTC thermistor is one whose zero-power resistance *decreases* with an increase in temperature.

### Positive Temperature Coefficient (PTC)

A PTC thermistor is one in which the zero-power resistance *increases* with an increase in temperature.



### Maximum Operating Temperature

The maximum body temperature at which the thermistor will operate for an extended period of time with acceptable stability of its characteristics. This temperature is the result of internal heating, external heating, or both, and should not exceed the maximum value specified.

### Maximum Power Rating

The maximum power which a thermistor will dissipate for an extended period of time with acceptable stability of its characteristics.

### Dissipation Constant (D.C.)

The ratio, in milliwatts per degree C, at a specified ambient temperature of a change in power dissipation in a thermistor to the resultant body temperature change.

### Thermal Time Constant (T.C.)

The time required for a thermistor to change 63.2% of the total difference between its initial and final body temperature when subjected to a step function change in temperature under zero-power conditions. This is normally expressed in seconds.

### Resistance-Temperature Characteristic

The relationship between the zero-power resistance of a thermistor and its body temperature.

### Stability

The ability of a thermistor to retain specified characteristics after being subjected to designated environmental or electrical test conditions.

### Base Resistance (R<sub>0</sub>)

The resistance value of a thermistor at a specified temperature with negligible electrical power to avoid self heating. Usually base resistance will be defined at 25°C.

### R @ I<sub>max</sub>

Approximate resistance at maximum steady state current.

### Switch Temperature (T<sub>sw</sub>)

The temperature when the resistance of the PTC thermistor reaches two (2) times the base resistance, sometimes referred to as curie point or transition temperature.

### Temperature Coefficient of Resistance (alpha, α)

The temperature coefficient of resistance is the ratio at a specified temperature, T, of the rate of change of zero-power resistance with temperature to the zero-power resistance of the thermistor. The temperature coefficient is commonly expressed in percent per degree C (%/°C).

$$\alpha T = \frac{(dR/R)}{(dT)}$$

### Ambient Operating Temperature

The temperature of the air surrounding an object, neglecting small localized variations.

### Transition Temperature

The temperature at which the resistance of the PTC thermistor begins to rise sharply.

### Material Constant (Beta β)

The material constant of an NTC thermistor is a measure of its resistance at one temperature compared to its resistance at a different temperature. Its value may be calculated by the formula shown below and is expressed in degrees Kelvin (°K). The reference temperatures used in this formula for determining material constant ratings of RT1 thermistors are 298.15°K and 348.15K.

$$\beta = \ln (R @ T_2 / R @ T_1) / (T_2^{-1} - T_1^{-1})$$

### Maximum steady-state current (I<sub>max</sub>)

The maximum steady-state current is the rating of the maximum current, normally expressed in amperes (A), allowable to be conducted by an inrush limiting NTC thermistor for an extended period of time.

### Maximum Operating Voltage (V<sub>max</sub>)

The maximum rated voltage the thermistor can continuously withstand 60 cycle AC or DC.

### Maximum Continuous Current (I<sub>mcc</sub>)

The maximum amount of current which a PTC thermistor must be able to pass without switching into its high resistance state. Expressed in Amps.

### Minimum Switching Current (I<sub>msc</sub>)

The minimum amount of current necessary to switch the thermistor into its high resistance state. Expressed in Amps.