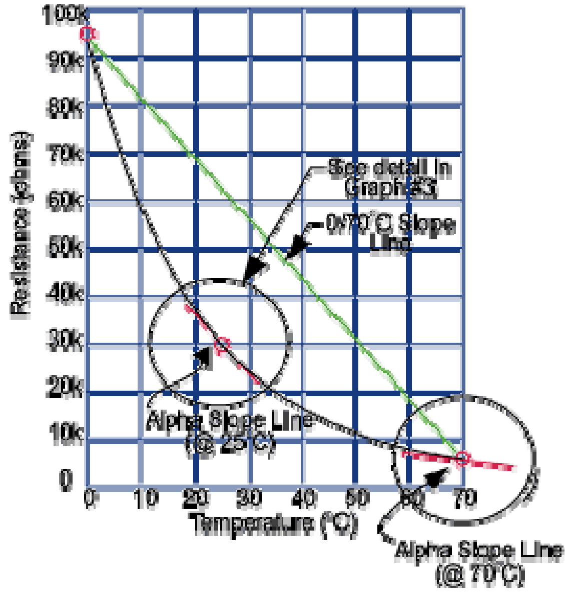
[Alpha (α) (Temperature Coefficient)

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, as illustrated in graph # 2 below.

Curve for 30K5 Thermistor
0°C to 70°C Range with Slope and Alpha details.



Graph # 2

For example, BetaTHERM's Standard Curve 5 thermistor material has an alpha of -4.30%/°C at 25°C, and an alpha of -3.42%/°C at 70°C. The alpha value is a material constant and is independent of the resistance of the component at that temperature.

Calculation of alpha values:
The relevance of alpha values to the Resistance vs Temperature curve of particular material is illustrated in **Graph # 3**. In this graph, a tangent line is drawn along the R-T curve at 25°C. This line represents the gradient or "steepness" of the curve at 25°C. From the definition of Alpha given above, it may be calculated as follows :

$$\alpha = \frac{1}{R_T} \times \frac{dR}{dT} \times 100 \ (\% / {}^{0}C).$$

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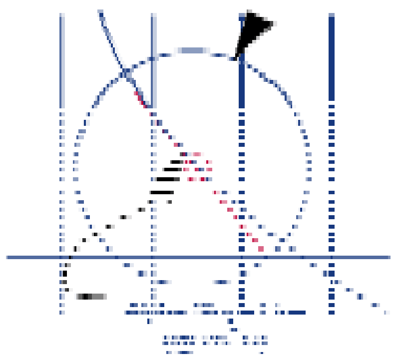
(Equation # 3) Definition of Alpha:
Where RT is the resistance of the component at the relevant temperature T (°C), dR/dt is the gradient of the Resistance vs Temperature curve at that temperature point, and alpha is expressed in units of "percentage change per degree Centigrade". (Note: In some texts the "100" term is omitted from the equation, but it is understood or implied in the units in which alpha values are specified.)

Detail from Graph # 2 showing Alpha Slope Line of the 30K5 Thermistor @ 25°C.



Graph # 3

The purpose of the concepts that have been introduced and discussed so far is to enable some basic calculations to be performed. The most important calculations required in the thermistor industry are those that relate the resistance of thermistor components to their temperature. An example illustrating typical use of alpha value to do this is given next:
Example:
A thermistor made from BetaTHERM material 3 has a resistance of 10000 ohms at 25°C. The alpha value for this material at 25°C is listed in the catalog to be –4.39 %/°C. If the resistance of the device in a stable environment at ideal measurement conditions (discussed later) is measured as 10200 ohms, what temperature is the device at ?
By re-writing Equation 3 in the form:

$$\alpha = \frac{1}{R_T} \times \frac{\Delta R}{\Delta T} \times 100$$

where $\Delta R / \Delta T$ is used as an approximation for the true derivative dR/dt , the reference temperature is 25°C, on re-arranging, the equation becomes:

$$\Delta T = \frac{\Delta R}{R_T} \times \frac{100}{\alpha}$$

Inserting the numerical values given above, the value for ΔT, the temperature difference from 25°C, is given by:

$$\Delta T = \frac{200}{10000} \times \frac{100}{-4.39} = -0.456\,^{\circ}C$$

so that the temperature of the thermistor is:
(25°C - 0.456°C) = 24.554°C
The example is applicable for certain thermistor resistance and temperature calculations. In particular, because of the approximation used for the differential of the R / T curve, it is of relevance for small percentage changes in resistance around the temperature value for which the particular alpha value is quoted.
The alpha value is a very useful parameter provided it is used in a logical way and that it is applied with the constraints in mind.

Limitations in the use of temperature coefficients:
The approach of using temperature coefficient values is adequate provided that accurate alpha values and resistance values are available for a range of temperature points for the thermistor materials. Data is included for Betatherm products in the products section of this website. The use of such look-up

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tables and substitution in equation 3 are useful for initial selection of thermistors for applications. The method is somewhat slow and highlights the need for a mathematical model that can be used to relate the resistance and temperature of thermistors by a single equation. The need for such a model is especially relevant to allow computation of R/T values using modern calculators, computers or microcontrollers.

To discuss the issue further it is instructive to look at a typical NTC thermistor R/T curve, as shown in graph #1. The curve is non-linear, and that presents certain difficulties in developing a useful model. Modelling of the R/T curve is discussed in the notes on mathematical modelling of thermistors