Sub Module 2.4

Thermistors

Resistance thermometry may be performed using thermistors. Thermistors are many times more sensitive than RTD's and hence are useful over limited ranges of temperature. They are small pieces of ceramic material made by sintering mixtures of metallic oxides of Manganese, Nickel, Cobalt, Copper, Iron etc. They come in different shapes as shown in Figure 29. Resistance of a thermistor decreases non-linearly with temperature. Thermistors are extremely sensitive but over a narrow range of temperatures. The resistance temperature relation is known to follow the law

$$R_T = R_0 e^{\beta\left(\frac{1}{T}-\frac{1}{T_0}\right)} \quad (15)$$

Here is a constant and all the temperatures are in Kelvin, T_o is the ice point temperature and R_0 the corresponding resistance of the thermistor.

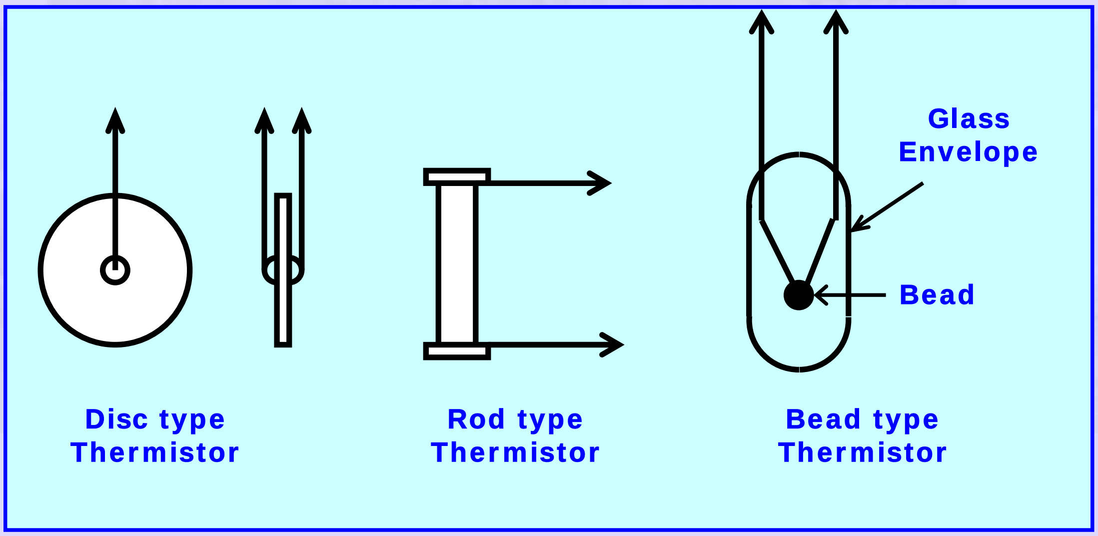

Figure 29 Typical thermistor types

A typical thermistor has the following specifications:

$$R_{25} = 2000\ \Omega,\ \frac{R_0}{R_{70}} = 18.64 \qquad \textbf{(16)}$$

This thermistor has a value of 3917 K and a resistance of 6656 at 0^oC. We may compare the corresponding numbers for a standard Platinum resistance element.

$$R_0 = 100\ \Omega,\ R_{70} = R_0(1 + 0.00385 \times 70) = 1.2695 R_0$$

Hence, we have

$$\frac{R_0}{R_{70}} = \frac{1}{1.2695} = 0.788 \qquad \textbf{(17)}$$

The resistance change is thus very mild in the case of a PRT as compared to a thermistor. The variation of the resistance of the thermistor described above is shown plotted in Figure 30.

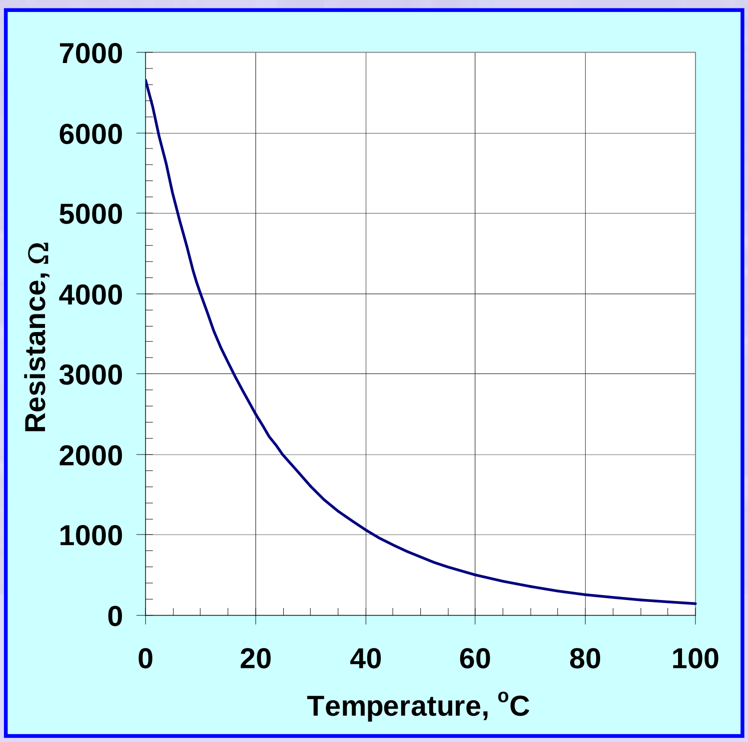

Figure 30 Variation of thermistor resistance with temperature

Typical thermistor circuit for temperature measurement

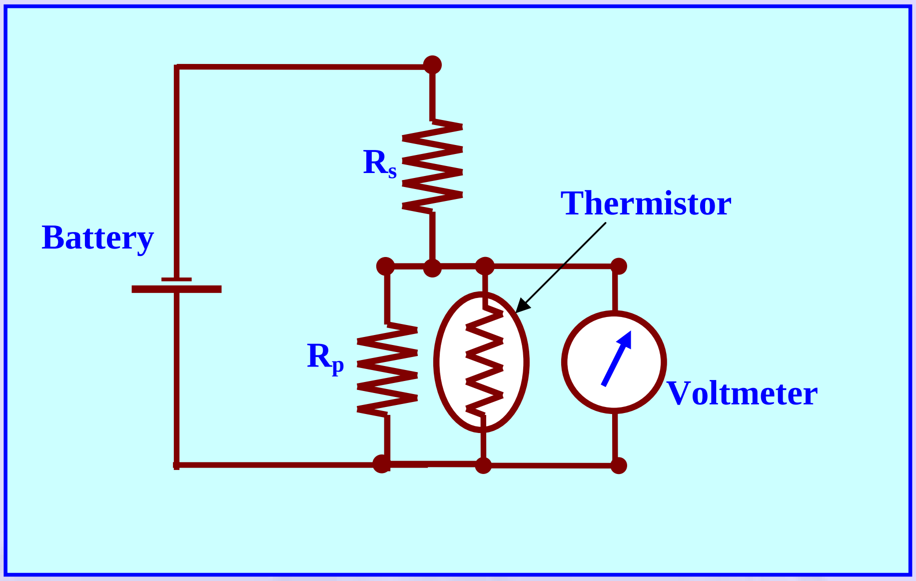

Figure 31 Typical thermistor circuit

Since a thermistor has a highly non-linear temperature response it is necessary to use some arrangement by which the resistance variation with temperature is nearly linear. One way of achieving this is to connect a suitable parallel resistance as shown in Figure 31. As an example we consider the thermistor whose characteristics are given in Figure 30. A parallel resistance of 500 is chosen for the simulation. The equivalent resistance of the thermistor in parallel with R_p varies nearly linearly as shown in Figure 32. The circuit is basically a voltage divider circuit. The potential difference across the series resistance or the thermistor provides an output that is related to the temperature of the thermistor.

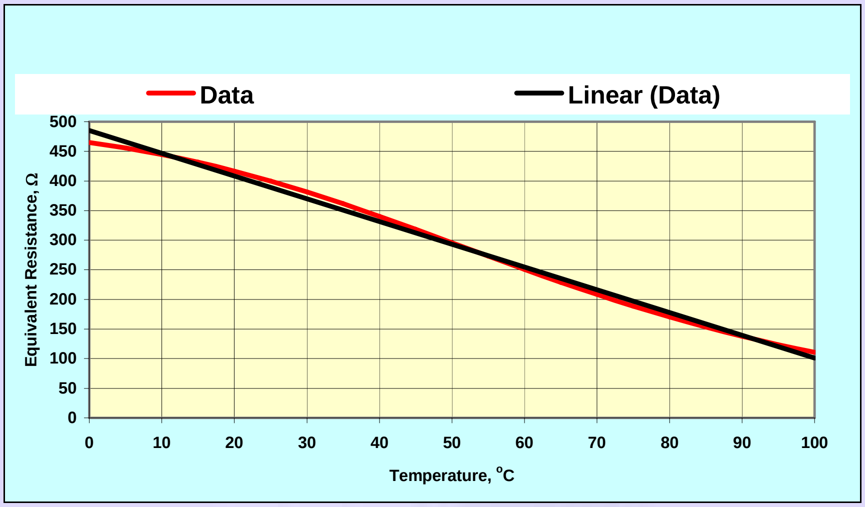

Figure **32 Equivalent resistance variations for the circuit shown in Figure 3**

If the series resistance is chosen as $R_s = 500\ \Omega$ and the battery voltage is 9 V, the voltmeter reading varies as shown in Figure 33. The output decreases monotonically with temperature and the non-linearity is mild.

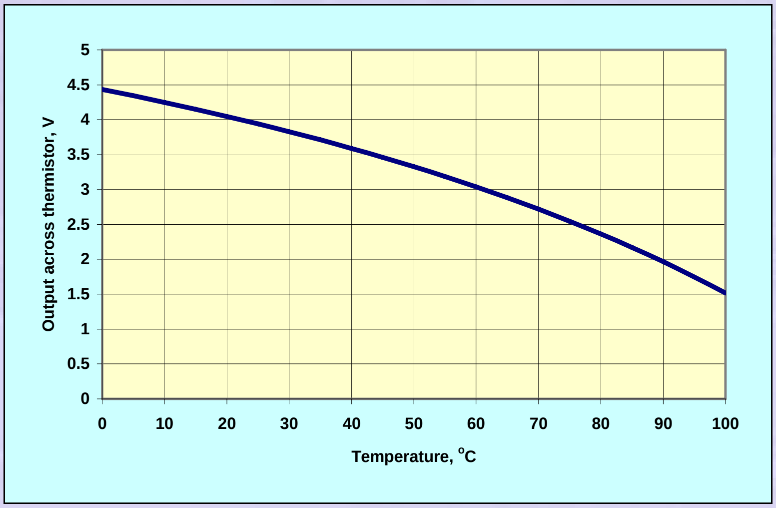

Figure 33 Variation of voltage across thermistor as a function of its temperature

Example 11

- *A thermistor has a resistance temperature relationship given by* $R = R_0 \exp\left[\beta\left(\frac{1}{T} - \frac{1}{T_0}\right)\right]$. *For a certain thermistor* R_0 *=80000* Ω *where* T_0 *= 273.16 K. The resistance of the thermistor has been measured accurately at three other temperatures as given below:*
-

t, ℃	50	100	150
T, K	323.16	373.16	423.16
R, Ω	10980	2575	858

- *Using the above data estimate* β. *Use this* β *to estimate the resistance of the thermistor at 10 and 110* ^oC. *Compare the data with the values calculated using the* β *determined above.*

o *Given Data:* T_0 *= 273.16 K,* R_0 *= 80000* Ω

o *Taking logarithms and rearranging, we have*

$$\beta = \frac{\ln(R/R_0)}{[1/T - 1/T_0]}$$

  - o *The tabulated data in the above expression will thus give three values for* β. *The average of these three values should give the best estimate for* β. *The values of* β *are 3506, 3503 and 3495 K. The mean value is thus equal to 3501 K (whole number retained).*
  - o *Now we calculate the resistances at the three temperatures using the value of* β *obtained above. The data is conveniently tabulated.*

t, °C	*50*	*100*	*150*
R (measured), Ω	*10980*	*2575*	*858*
R (calculated), Ω	*11070*	*2602*	*861*

- *The match is very good!*