Spreadsheet Assignment

Thermistor as a temperature sensor

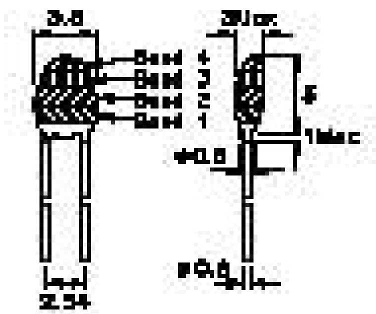
The data sheet below is taken from the Maplin Catalogue.
(http://www.maplin.co.uk/products/details.php?cartid=682189087&moduleno=2218&manufacturer=Philips)

Thermistors can be used as means of measuring temperature. This assignment will involve you in choosing suitable components for a simple electronic thermometer.

The data sheet contains information concerning four thermistors.

Bead Thermistors

Philips



All dimensions in mm

Description:

Bead type thermistors for general applications including temperature measurement and compensation.

Tolerance:	**±5%**
Power (max):	**250mW**
Dissipation factor:	**7mW/°C**
Response time:	**1.2 secs**
Thermal time constant:	**11 secs**
Temperature range:	**-40°C to +125°C reducing to 0° to 55°C at max power**

R at 25°C	B(°K)	R at 100°C (approx)	R at 0°C (approx)
4k7	3977	318.4	15.28k
15k	3740	1.19k	45.13k
47k	4090	2.94k	155.6k
150k	4370	7.73k	534.9k

Colour code

R at 25°C	Band 1	Band 2	Band 3	Band 4
4k7	Yellow	Violet	Red	Gold
15k	Brown	Green	Orange	Gold
47k	Yellow	Violet	Orange	Gold
150k	Brown	Green	Yellow	Gold

There is a rather nasty looking formula that will give you the resistance, R_T, of a thermistor at a given temperature, T, measured in kelvin. And this is it:

$$R_T = R_1 \exp\left(\frac{B}{T} - \frac{B}{T_1}\right) \qquad \{\exp(x) \text{ means } e^x\}$$

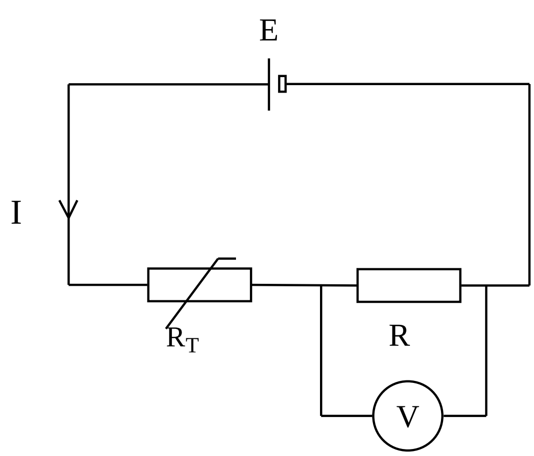
- The letter B is called the characteristic temperature and is found in the data sheet above.
- R_T is the resistance of the thermistor at temperature, T (in kelvin).
- R_1 is the resistance the thermistor has at temperature T_1. The table contains the values of R_1 for the thermistors at 25 ^oC, 0 ^oC and 100 ^oC. It is common to use 25 ^oC as the standard.

Description of Thermistor Temperature Sensor

Electronic circuitry is often used to monitor changes in temperature. The basic principle behind using a thermistor as a temperature sensor is that its electrical resistance changes considerably for small changes in temperature.

Temperature changes could be monitored by direct measurement of the thermistor's resistance. This is not usually done in practice because there's a lot of extra equipment needed to measure the electrical resistance of something. In electronics it is easier to monitor potential difference rather than resistance or current.

Use is made of a potential divider circuit where the thermistor is laced in series with a resistor.



A typical way of measuring the temperature of the thermistor is to measure the p.d. across a resistor, R, connected in series.

The voltmeter reading increases when the temperature rises. Connecting the voltmeter across the thermistor gives a falling value when the temperature rises.

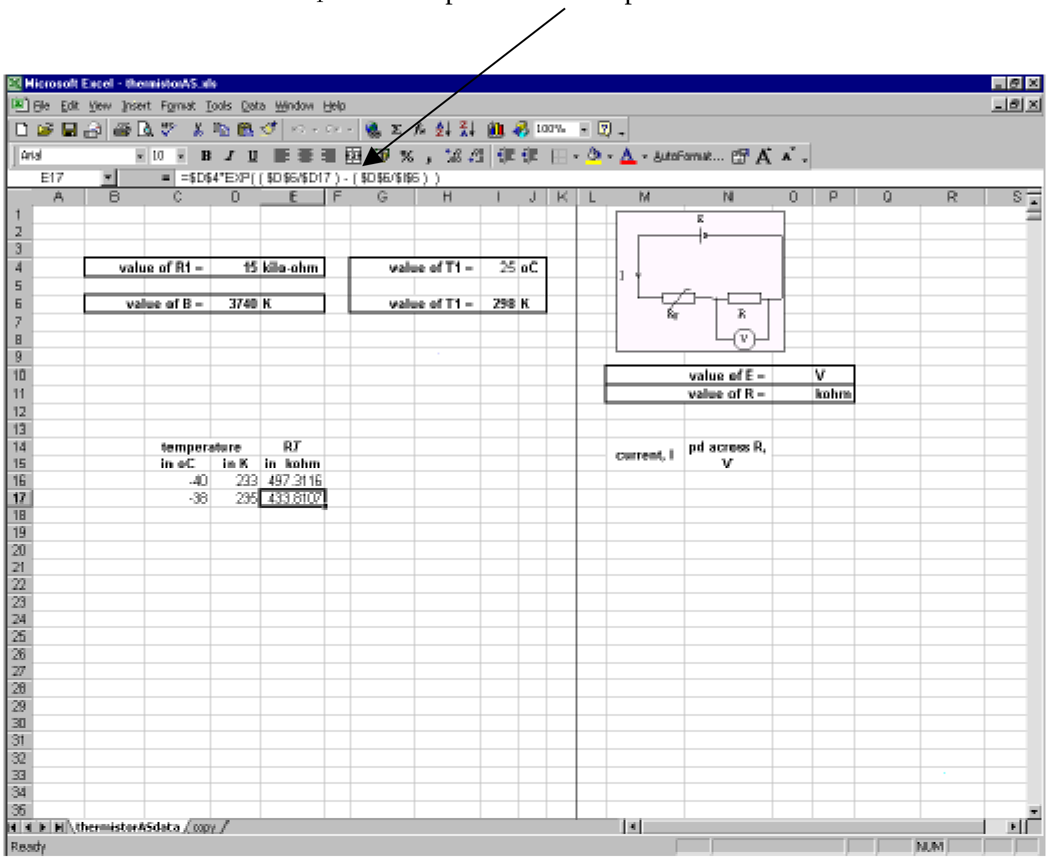
The value of the potential difference across R will depend upon E, R and R_T. In this activity you will investigate how exactly the voltmeter reading will change as the temperature changes.

The calculations are quite involved and become tedious if we have to calculate them for every temperature in a range. The tedium is reduced if we use a spreadsheet and becomes interesting when we tinker with it.

The spreadsheet is found on the CD or website. (thermistorAS.xsl)

Notes on the spreadsheet:

- The formula for R_T has been placed on the spreadsheet in cells E16 and E17.



- The sheet is separated in two parts. On the left we have information used to calculate R_T at different temperatures. On the right details concerning the potential divider circuit.
- Cell D4 contains the resistance (R_1) of the thermistor at temperature T_1.
- The temperature T1 is placed in cell I4, it automatically updates cell I6.
- Cell D6 contains the value of B, the characteristic temperature.
- Cells C16 and C17 contain the lowest and next lowest temperatures. You can select what starting temperature you need. Cells D16 and D17 automatically convert the temperatures into kelvin
- Cells D4, D6 and I4 are the ones that need changing for different thermistors.
- Cell O10 will contain the emf of the power supply.
- Cell O11 will contain the resistance of the resistor, R, in series with the thermistor in the potential divider circuit.

Activity:

The sensor will be used to monitor temperatures in the range –20 ^oC to +10 ^oC.

The sensitivity of the temperature readings should be such that the readings are accurate to 0.1 K (±0.05 K).
The voltmeter has a sensitivity of ± 0.5 mV in the range 0 to 1 V.

1. Extend the values on the left hand side to span the range –20 ^oC to +10 ^oC so that the resistance of the thermistor is known for this range. Make sure that the sensitivity is taken into account.
2. Choose, at present, arbitrary values for E and R.
3. Write down an equation that will give the value of the current, I, that flows in the circuit using E, R and R_T.
4. Use the formula in 3 to produce values of the current in column M.
5. Write down an equation for the p.d. across the resistor R in terms of I and R.
6. Use the formula in 5 to produce values of the current in column N.
7. Produce the following graphs:
    i) R_T (on y-axis) against temperature (on x-axis)
    ii) pd across R (on y-axis) against temperature (on x-axis)
8. Vary the values of R and E to ensure that the p.d. doesn't exceed 1.00 V for any reading. Look at the values of V to ensure that the sensitivity meets the requirements.
9. Produce a screen dump of the graphs and the details of the spreadsheet for a situation where the requirements are met.
10. Do the same procedure as in 8 and 9 for all four thermistors (remember to alter the values for B and R_1 and T_1).
11. Comment upon the most suitable thermistor and resistor combination.