The Effects of Temperature on Resistance

Planning

Aims

To investigate the effects of temperature on resistance.

Background Research

Form background readin g and research I have discovered that for most materials that conduct electricity there is some degree of variation of resistance with temperature. There is a set equation governing this change as follows;

$R_\theta = R_0(1+\alpha\theta) = R_0 + \alpha R_0\theta$

Where

R_θ = Resistance at Temperature θ

R_0 = Resistance at 0°C

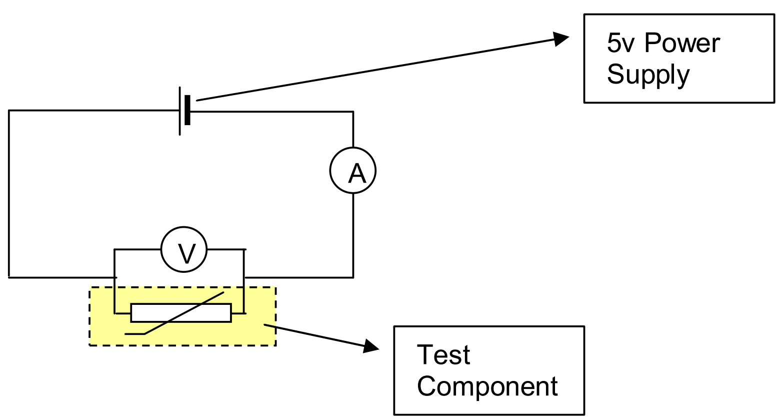
α = The temperature coefficient of resistance.

As we will see after we have done the experiment the temperature coefficient will turn out to be negative as I am sing a N.T.C. Thermistor

Apparatus

- Negative temperature coefficient thermistor.
- Voltage meter (V)
- Ammeter (A)
- Power Pack (Low voltage DC)
- Freezer
- Heater
- Beaker
- Thermometer

Diagram



The Variables

In this section I will look at all the possible variables and decide which o nes should be varied in order to obtain results showing the effect of temperature on resistance. In the circuit above there are several different aspects that can be controlled and hence be variables.

The Voltage: The voltage in this circuit can be change d to an value needed. As only one variable needs to be changed I will keep the voltage constant at 5v.

The Thermistor: Thermistors come in two varieties those that gain resistance when heated and those that drop resistance when heated. For this experimen t I will use negative temperature coefficient thermistor (resistance decreases as temperature increases.) This will be the component that will be varied indirectly with the application of heated or cooled water as in the diagram above.

The Ammeter: This will measure the current in the circuit. Although this has some internal resistance it will be negligible and therefore will not consider it.

The Voltmeter: As with the ammeter this too has an internal resistance, but because of the negligible size I will discount it.

The Wiring: As there is relatively little wiring and the voltage and current will be low I can assume there will be very little/no heating effect and therefore the impedance of the wire will remain constant through the experiment.

The Temperature: This is the most important variable as this is the main aim of the investigation.

The Measured Variables

In order to calculate the resistance in the thermistor I will need the current and voltage. As the voltage is constant the only changing variab le will be the current. As I change the temperature of the thermistor I will observe the change in current.

Accuracy

There are two main forms of inaccuracy, firstly human and secondly equipment inaccuracy. Human inaccuracy is hard to judge but most of the time the scale on the equipment gives us an idea of the inaccuracy that may occur. Equipment inaccuracy can be judged by the degree at which it has been calibrated. In order to eliminate inaccuracy three sets of data will be taken for each temperature and eight temperatures will be tested. All of the inaccuracies will be added as a percentage and be taken into account in the Data processing section.

Data Range

The range of temperatures that will be tested will be from 0 °C – 85°C. This range has been chosen with two factors in mind, first the thermistor operating temperature; reflected in the upper limit of temperature. Secondly the practical application of cooling; it would not be easy to reduce the temperature further than the lower limit and therefore not practical, also it would not be easy to maintain anything equal to or over boiling point.

Proposed Data Processing

Once I have the date we will first take the voltage and current and change it into a resistance. This is done by the formula $R = V/I$. I will then plot the resistance against the temperature. This shows graphically the effect of temperature on resistance.

Results

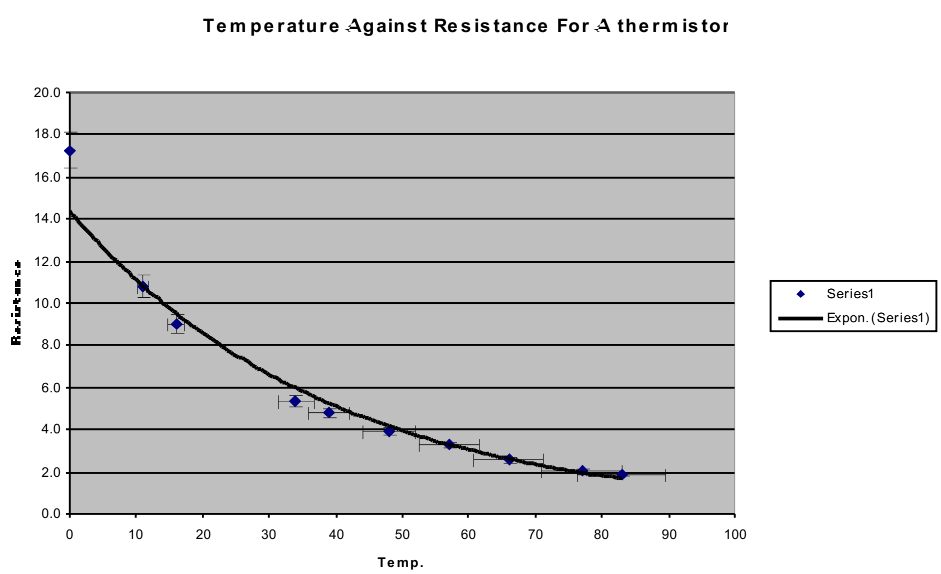
Raw Data

Temp	Set1		Set 2	
	Voltage	Current	Voltage	Current
0	2.31	0.133	2.30	0.134
11	2.01	0.187	2.03	0.186
16	1.94	0.216	1.96	0.216
34	1.66	0.308	1.66	0.309
39	1.48	0.307	1.48	0.310
48	1.35	0.342	1.35	0.346
57	1.21	0.372	1.22	0.371
66	1.15	0.454	1.17	0.447
77	1.01	0.506	1.02	0.489
83	0.90	0.474	0.88	0.465

Processed Data

Temp	Set1		Resistance =	Set 2		Resistance =	Average
+/- 0.5°C	Voltage (V)	Current (A)	V/I (Ω)	Voltage (V)	Current (A)	V/I (Ω)	R (Ω)
0	2.31	0.133	17.368	2.30	0.134	17.164	17.3
11	2.01	0.187	10.749	2.03	0.186	10.914	10.8
16	1.94	0.216	8.981	1.96	0.216	9.074	9.0
34	1.66	0.308	5.390	1.66	0.309	5.372	5.4
39	1.48	0.307	4.821	1.48	0.310	4.774	4.8
48	1.35	0.342	3.947	1.35	0.346	3.902	3.9
57	1.21	0.372	3.253	1.22	0.371	3.288	3.3
66	1.15	0.454	2.533	1.17	0.447	2.617	2.6
77	1.01	0.506	1.996	1.02	0.489	2.086	2.0
83	0.90	0.474	1.899	0.88	0.465	1.892	1.9

Graph of Processed Results



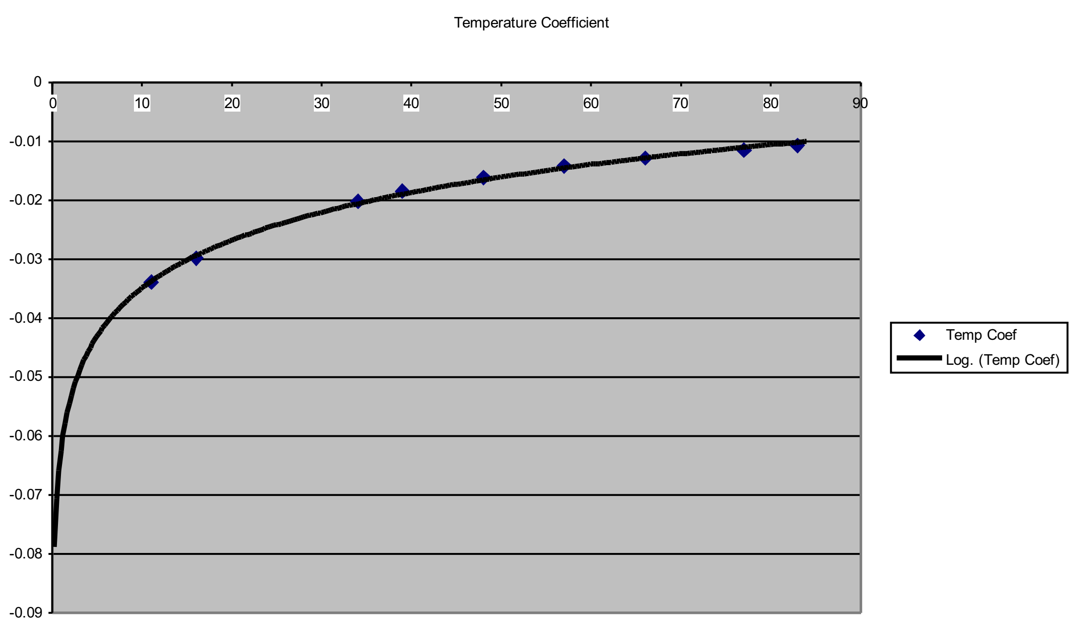
Analysis or Results

Firstly I would like to point out the link with the background research. I can see from the graph that the as the temperature changes the resistance drops. This suggests that the therm istor used has a negative temperature coefficient.

We can work out the temperature coefficient at using the equation and taking an average of all the results.

$R_\theta = R_0(1+\alpha\theta) = R_0 + \alpha R_0\theta$

Temp	Average R (Ω)	Temperature Coefficient
0	17.3	∞
11	10.8	-0.0339
16	9	-0.0298
34	5.4	-0.0202
39	4.8	-0.0185
48	3.9	-0.0161
57	3.3	-0.0142
66	2.6	-0.0129
77	2	-0.0115
83	1.9	-0.0107



As we can see from the graph above the temperature coefficient is indeed negative, but it is not a straight line and therefore not constant. This can be explained by the fact that the thermistor itself dose not have a constant rate of change but instead it has a range depending on the temperature.

One conclusion that can be drawn from the da ta that we have obtained it that there is a distinct change in resistance wit temperature. This can be seen in the first graph, as the temperature rises the resistance falls (NTC).

In further investigation I would like to investigate resistance change and temperature for different components. Also I would like to look at the heating effect on resistors and other components as I think this ma have had some affect on the results.