Thermometer Report

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Estimated Time 18 Hours

This assignment is my own unaided work. All sources I have quoted, whether on paper or web-based, have been acknowledged.

Introduction and Theory

The goal of the Thermometer project is to be able to identify the temperature of the area using a thermistor within a range of ±2°C. How this occurs is that as the temperature of the thermistor increases the resistance decreases, as well as voltage decreases. We then display the result in one of three ways, the first way is a galvanometer, the galvanometer will display the current, ,which will change dependant on the resistance of the thermistor, at a certain point in a circuit, the second is a micro controller that can measure the voltage drop across a certain point and calculate the resistance based on the equation of the line when all resistances are graphed against the temperature .The last way is a series of LEDs which will represent a temperature for example a set of 10 LEDs that represent a temperature between 0°C - 100°C, which will light up when the voltage at a certain point is over 1.6V, this can be utilised by having resistors in series before the LED which can reduce the voltage going to the LED. The result of the circuit displayed on one of these three methods will then indicate the temperature of the thermistor

Design and Validation in Multisim

The first step we take to design the circuit is to calibrate the thermistor and record the resistances for every temperature within a range. The range we chose to test within is from 0°C to 100°C. To do this we connect the thermistor to a multimeter to record the resistance, we then put the thermistor in a beaker of water with ice on a hot plate. We check the temperature of the water using a thermometer and make sure the thermometer is close to the thermistor to get an accurate reading for the temperature. Once the water reaches 0°C we turn on the hot plate and start recording the resistance at every temperature. This can be seen in the image below.

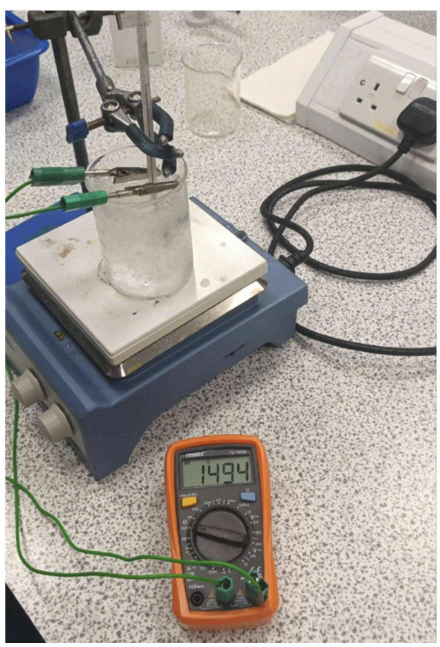


Image 1, Thermistor Calibration

The results of the calibration can be seen in the table below

Temperature *C	resistance	Temperature	resistance	Temperature	resistance
0	1488	20	565	40	242
1	1434	21	547	41	233
2	1360	22	521	42	228
3	1280	23	494	43	217
4	1247	24	476	44	208
5	1170	25	456	45	200
6	1119	26	436	46	192
7	1063	27	417	47	184
8	1013	28	404	48	181
9	950	29	387	49	171
10	900	30	366	50	164
11	850	31	354	51	160
12	812	32	338	52	154
13	784	33	327	53	148
14	760	34	313	54	142
15	709	35	298	55	137
16	683	36	289	56	133
17	649	37	277	57	129
18	615	38	265	58	125
19	588	39	253	59	119

Temperature	resistance	Temperature	resistance
60	115	80	60
61	111	81	58.9
62	107	82	56.6
63	104	83	55.1
64	100	84	53.5
65	97	85	52
66	93	86	50.1
67	90	87	48.8

Temperature	resistance	Temperature	resistance
68	87	88	47.2
69	85	89	45.8
70	82	90	44
71	80.3	91	42.8
72	77.4	92	41.5
73	74	93	40.4
74	72.3	94	39.5
75	69.9	95	38.2
76	68	96	37.2
77	65.8	97	36
78	63.9	98	35.1
79	61.9	99	34
		100	33.4

Table 1, Resistor calibration

After calibrating the thermistor we started designing our first circuit. Our first circuit used a wheatstone bridge with a galvanometer in the middle. When the thermistor's resistance changes the wheatstone bridge would become unbalanced supplying a current to the galvanometer. We would then use the reading from the galvanometer to calculate the resistance of the thermometer and in turn the temperature. The design of the circuit can be seen below.

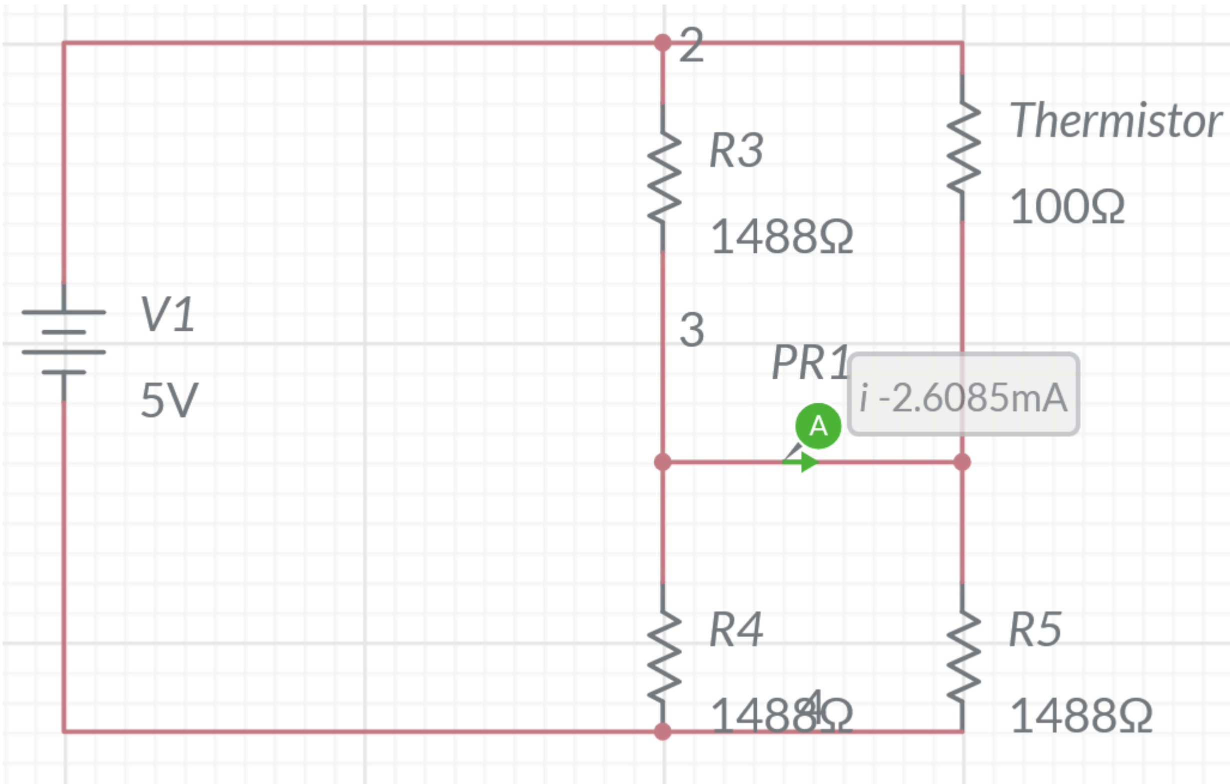
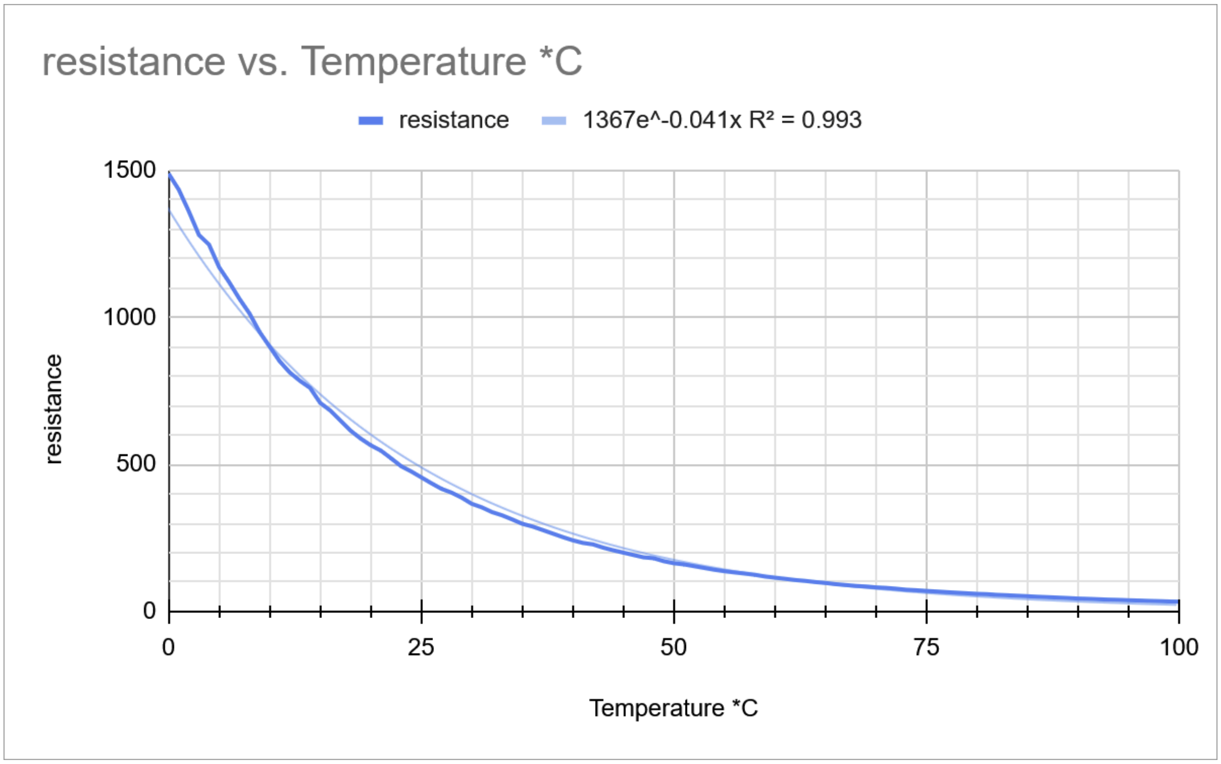


Image 2, Wheatstone bridge + Galvanometer design

After building the circuit in multisim we realised the range of current flowing was way too small to measure on the galvanometer only giving us a range of 0mA to 2.6mA. It would be impossible to display a range of temperatures accurately on such a small scale.

Our next plan was to use an XMC1400 microcontroller to measure the voltage drop across the thermistor and calculate the temperature using the equation of the line given by the graph of the temperature vs the resistance in excel which came out to



Graph 1, The resistance of the thermistor graphed against the temperature

$$1367e^{-0.041x}$$

Eg. 1367e^-0.041(x) where x = 50°C = 175.98Ω

This reads 49° C. The equation is not perfect but will be accurate until the lower temperatures of 12°C and lower. Unfortunately we are not allowed to use a microcontroller in our circuit so we had to redesign our circuit once again. Our last method of showing the temperature would be using LEDs. We tried to attempt to make the LEDs display the temperature in binary to reduce the the amount of LEDs needed and to be able to show the full range of temperatures in our testing and demonstration, however we scrapped this idea very quickly as it was too complicated for the time we had remaining to build and test the circuit. In the end we settled for a simple design that would turn on the LED when the voltage is above 1.6V. This was achieved by having resistors of varying resistance in series. When the temperature of the thermistor is above the selected temperature, for example 25°C, the LED will turn off as the voltage has dropped below 1.6V.

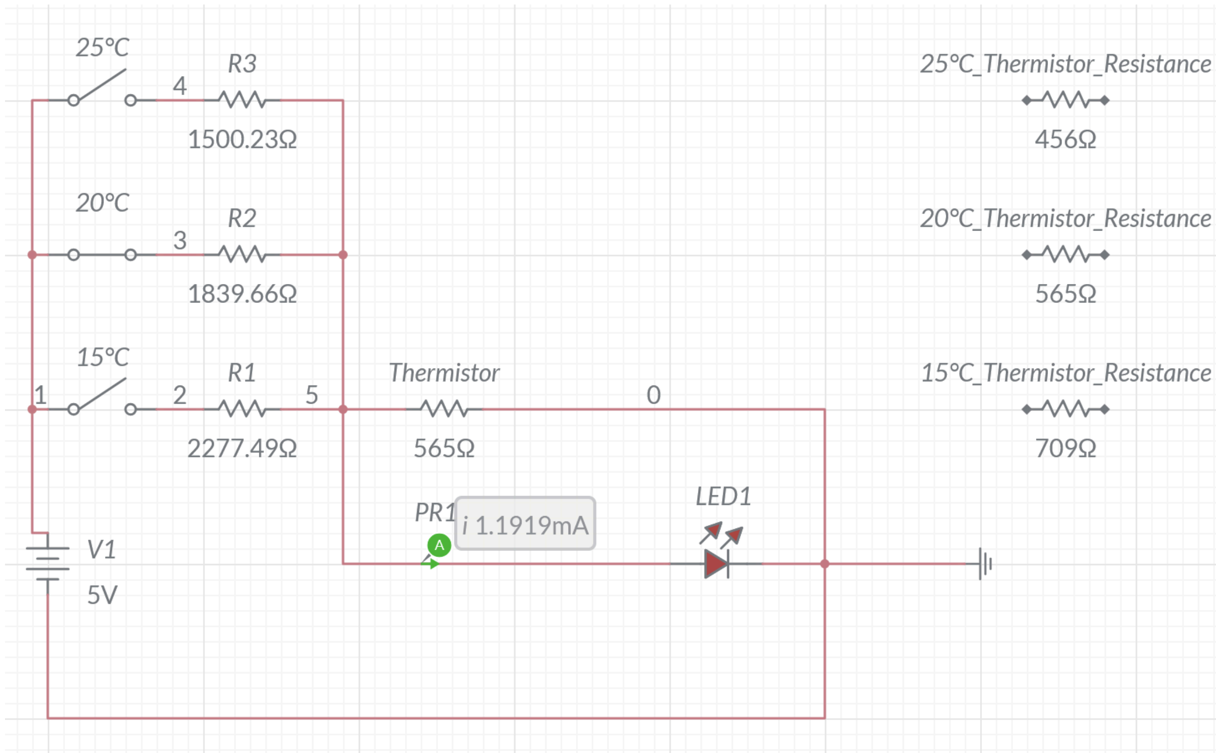


Image 3, Full circuit of final thermometer design at 20°C
(LED is off when checking below temperature, as multisim LEDs work on current rather than voltage so will work opposite to final built version)

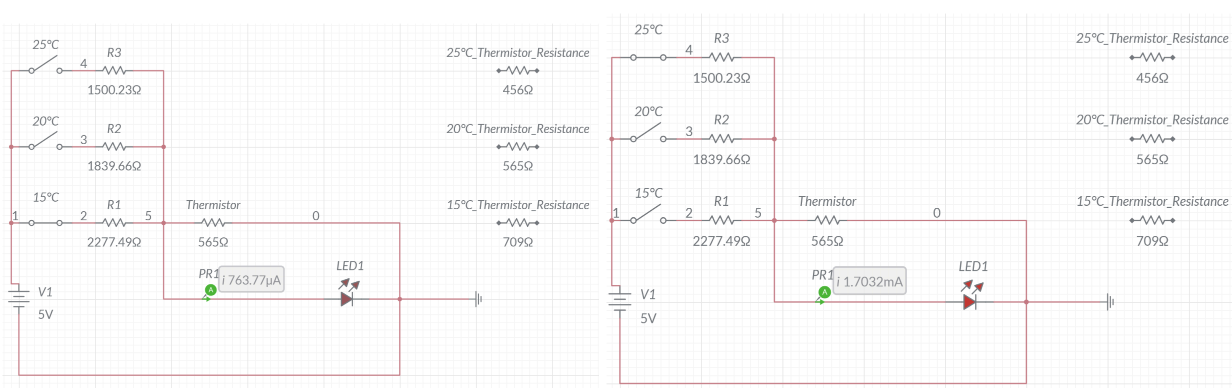


Image 4 + 5, The thermometer checking for 15°C and 25°C in a room at 20°C

This circuit design below is then repeated in parallel for each temperature required and is connected by a switch.

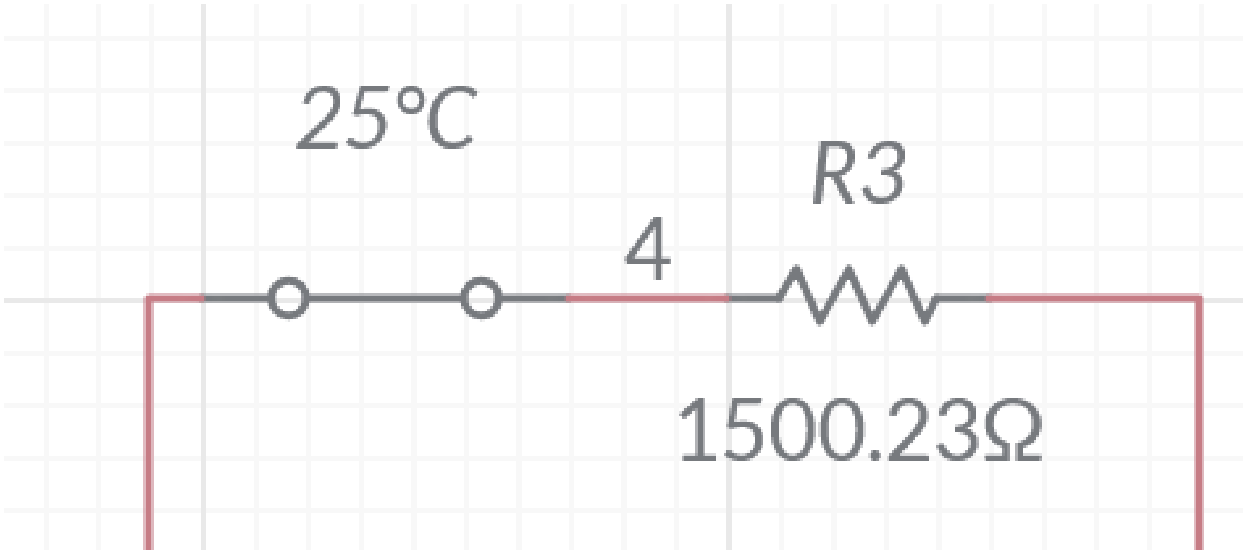


Image 6, The parts added to check at a new temperature

To find the temperature you turn on the circuit going through it until the LED stays off which will be 1 degree above the temperature if you build a circuit for each temperature, or in our test we built it in a scale for every 5°C meaning it would be 5°C above the temperature

Assembly and Testing

After a considerable amount of time designing and planning the circuit we knew we wanted to make the circuit to test temperature between 15°C and 30°C which would be the ideal range to test at room temperature and body temperature. it would be four circuits in parallel with resistances of 2277.49Ω (15°C), 1839.66Ω (20°C), 1500.23Ω (25°C), 1214.59Ω (30°C) connecting in series to the thermistor and a LED in parallel. This can be seen in the image below, as we had no switches we just kept the circuits unplugged except the temperature we are testing at.

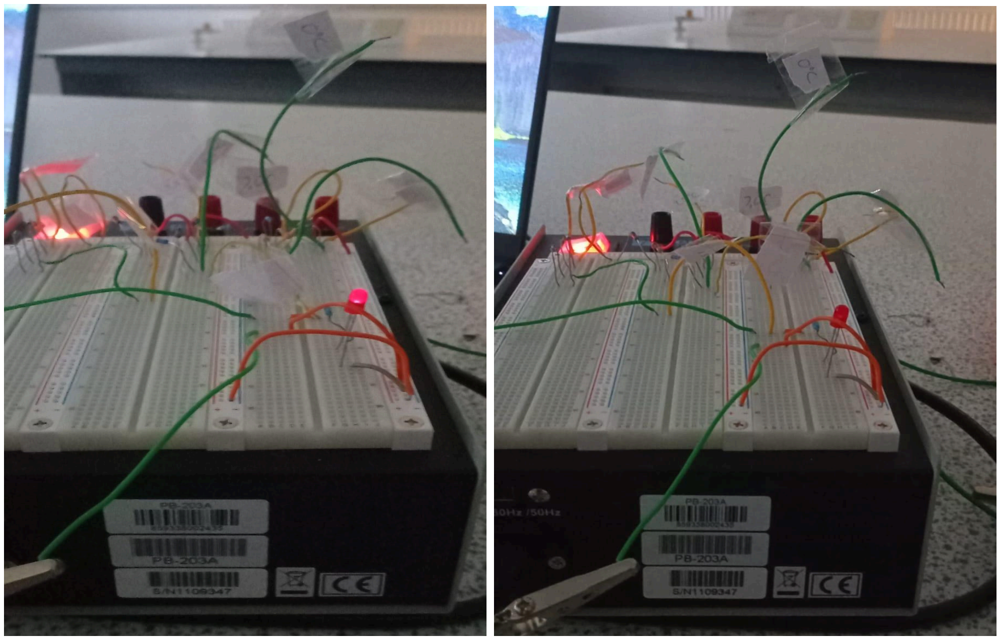


Image 7 + 8, Testing at 25°C (LED on) and 20°C (LED off) in a room at 21°C to 23°C

After assembling the circuit we tested the circuit at room temperature which ranged from 21°C to 23°C and at roughly 35°C by holding the thermometer in our hand. The 25°C circuit initially failed which we found out the cause to be incorrect resistors which most likely got mixed up when assembling the circuit and retested after correcting it and the thermometer worked perfectly after that.

Discussion

Our results show us that as long as we know the resistance of the thermistor at a given temperature, we can configure the circuit to find the temperature of the thermistor as well as configure how big or small the circuit is as well as detecting within or above a certain temperature. However the results will start to get inaccurate after a certain temperature as the difference in resistance will become negligible. A further problem that can occur is that the LED will dimly light up even when the temperature is too low. Possible improvements can be made to the circuit, the most notable being to use a linearly scaling thermistor that decreases or preferably increases, to allow a larger range of temperature values, in resistance uniformly. This will allow for more accurate and consistent readings especially at the higher temperatures as the resistance change between higher temperatures fall as low as 0.9Ω. Another change that could be implemented, though would not be ideal, is using a variable resistor to allow for quick and easy change of resistance to test for certain temperatures. This can allow for a smaller and more practical circuit however it would come at the cost of knowing the temperature immediately as the resistance of the variable resistor would need to be compared to the table to find the temperature. In the end the original design with the fixed resistance would be better suited for our purpose.

Conclusions

It is possible to accurately find the temperature, within a certain range, of a thermistor if the resistance at that temperature is known and it is possible to display it in a circuit using LEDs by using Ohms law and resistors in series.

References

Image 1, Thomas O'Mahony, Adam Noel*, Image 1, Thermistor Calibration, 05/04/2025.*

Table 1, Thomas O'Mahony, Adam Noel, Table 1, Resistor calibration*, 07/05/2025.*

Image 2, Thomas O'Mahony , Image 2, Wheatstone bridge + Galvanometer design*, 07/05/2025.*

Graph 1, Thomas O'Mahony, Adam Noel , Graph 1, The resistance of the thermistor graphed against the temperature*, 07/05/2025.*

Image 3, Thomas O'Mahony , Image 3, Full circuit of final thermometer design at 20°C*, 07/05/2025.*

Image 4 + Image 5, Thomas O'Mahony , Image 4 + 5, The thermometer checking for 15°C and 25°C…*, 07/05/2025.*

Image 6, Thomas O'Mahony , Image 6, The parts added to check at a new temperature*, 07/05/2025.*

Image 7 + Image 8, Thomas O'Mahony, Adam Noel, Image 7 + 8, Testing at 25°C (LED on)…*, 07/05/2025.*