Experiment title – Temperature Measurements

Week no. – 5

Date of experiment – 19/09/2023

Group name – T6

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1. Experiment layout

(Figures, circuit diagrams, basic working principle and equations, photographs of experiment in working condition)

Platinum 100, or Pt100, resistance temperature dectectors (RTDs) are a sensor used to measure temperature accurately and repeatedly. RTDs are sensors whose resistance changes as we increase the temperature of the medium in which they are inserted. This change of resistance is proportional to temperature and varies in a somewhat linear fashion with temperature. So we measure the RTD's resistance and then we determine the value of temperature. In Pt100, 100 means our sensor has resistance of 100Ω at 0°C temperature.

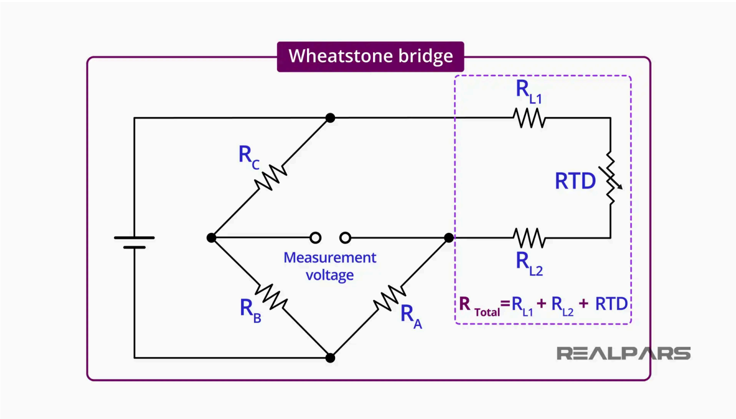
Fig. - Pt100(385) RTD

The alpha coefficient is the rate of change in resistance with temperature. It represents the fractional change in resistance of a Pt100 RTD per degree Celsius change in temperature. It quantifies how the resistance of the Pt100 RTD varies with temperature.

$$\alpha = \frac{R_{R.T} - R_{0C}}{R_{0C} \times 100}$$ where $R_{R.T.}$= Resistance at reference temperature and R_{0C}= Resistance at 0℃

$$R_x = R_{0C} \times (1 + \alpha . T_x)$$ so by measuring R_x we can determine corresponding temperature value T_x.

Further we used a whitestone bridge to determine the exact value of sensor resistance.



For increasing and decreasing the medium temperature, we used the peltier element which works on the basis of the peltier effect. The Peltier effect consists of passing a current through a circuit made up of different materials. In this case, when electric current flows within the closed-circuit, one junction of two dissimilar metals absorbs thermal energy in one junction and discharges the same energy at another junction. So one surface of the peltier element heats and another surface cools down. If we reverse the polarity of current then the surface which was heated cools down and the surface which was cold starts heating.

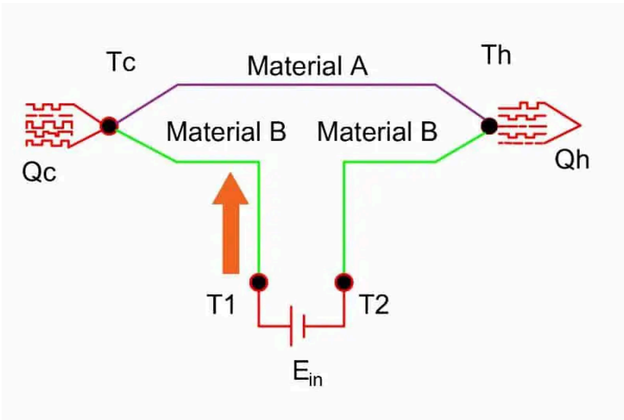


Fig. Peltier Effect

2. Results

Task 1 – Calibrate your Peltier element temperature as a function of current, over the temperature range of 5 to 50 degrees Celsius. Ensure that you don't cross max limits of the device – read the device specifications shared on Moodle. Use the digital thermometer provided for the calibration.

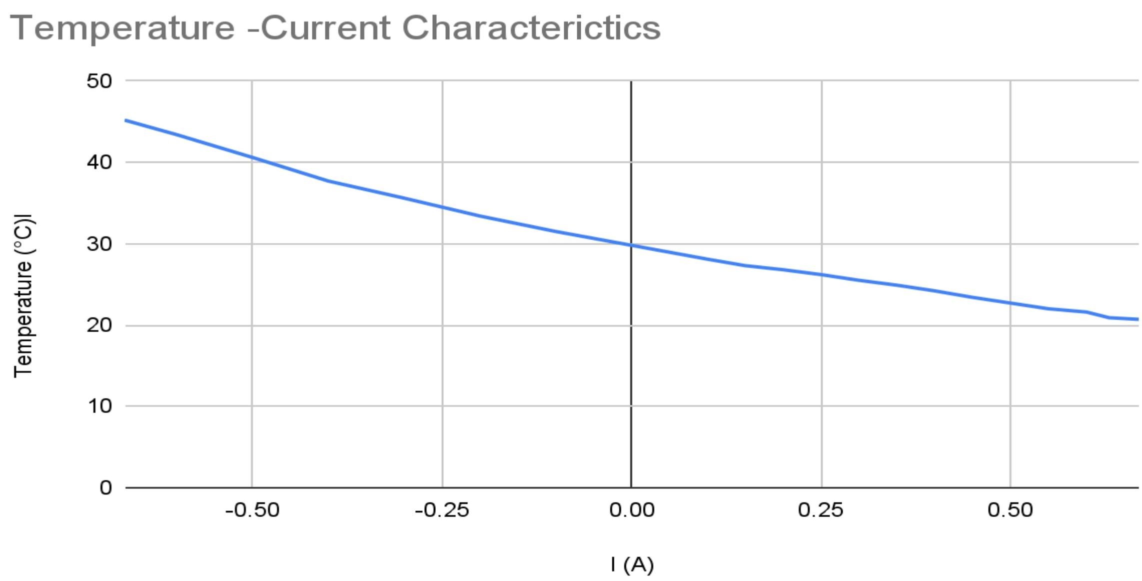
To calibrate the Peltier element, we had started by connecting it to a power supply within safe limits and placing a digital thermometer nearby. Then we begin with the minimum current (0.669 A) and incrementally increase it while measuring and recording the temperature at each step. Ensure the temperature readings correspond to the Peltier element's actual temperature.

Observation Table

Vin (V)	I (A)	Temperature (°C)
2.76	0.669	20.7
2.56	0.6	21.6
2.29	0.5	22.7
1.96	0.4	24.2
1.52	0.3	25.5
1.15	0.2	26.8

0.51	0.1	28.1
0	0	29.8
-0.44	-0.1	31.5
-0.89	-0.2	33.4
-1.35	-0.3	35.6
-1.81	-0.4	37.7
-2.29	-0.5	40.6
-2.81	-0.6	43.4
-3.12	-0.669	45.2

After collecting the data, we analyze it and create a calibration curve representing the relationship between current and temperature as displayed below.



Interpreting the curve gives us the understanding how the element's temperature changes with varying currents in the specified temperature range.

Task 2 – Estimate the change in resistance over the above temperature range, and hence the temperature coefficient of resistance of the PT100 sensor using a multimeter.

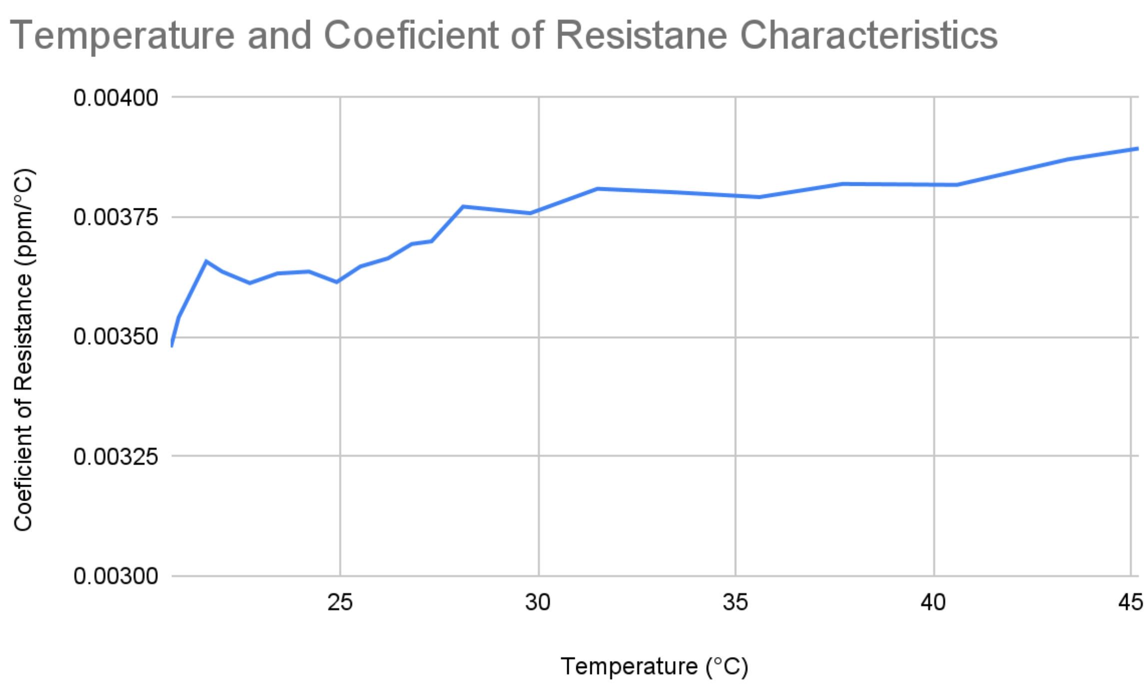
We repeat task 1 but here also estimate the change in resistance of the PT100 sensor over the temperature range of 5 to 50 degrees Celsius regardless of current. We increase the temperature in stable increments, measuring and recording the resistance at each step. Then calculate the change in resistance for each temperature increment. To find the temperature coefficient of resistance, we use the formula given below -

$$TCR = Change\ in\ Resistance/\ (Original\ Resistance\ *\ Change\ in\ Temperature)$$

Temperature (°C)	Resistance measured by multimeter (ohm)	Temperature coefficient calculated (1/°C)

20.7	107.2	0.00348
21.6	107.9	0.00366
22	108	0.00364
23.4	108.5	0.00363
24.2	108.8	0.00364
25.5	109.3	0.00365
26.2	109.6	0.00366
27.3	110.1	0.0037
28.1	110.6	0.00377
29.8	111.2	0.00376
31.5	112	0.00381
33.4	112.7	0.0038
35.6	113.5	0.00379
37.7	114.4	0.00382
40.6	115.5	0.00382
43.4	116.8	0.00387
45.2	117.6	0.00389

Here we used the standard of measure for Resistance of PT100 is 100 ohm at 0°C .



The above visuals help us in determining the sensor's temperature sensitivity.

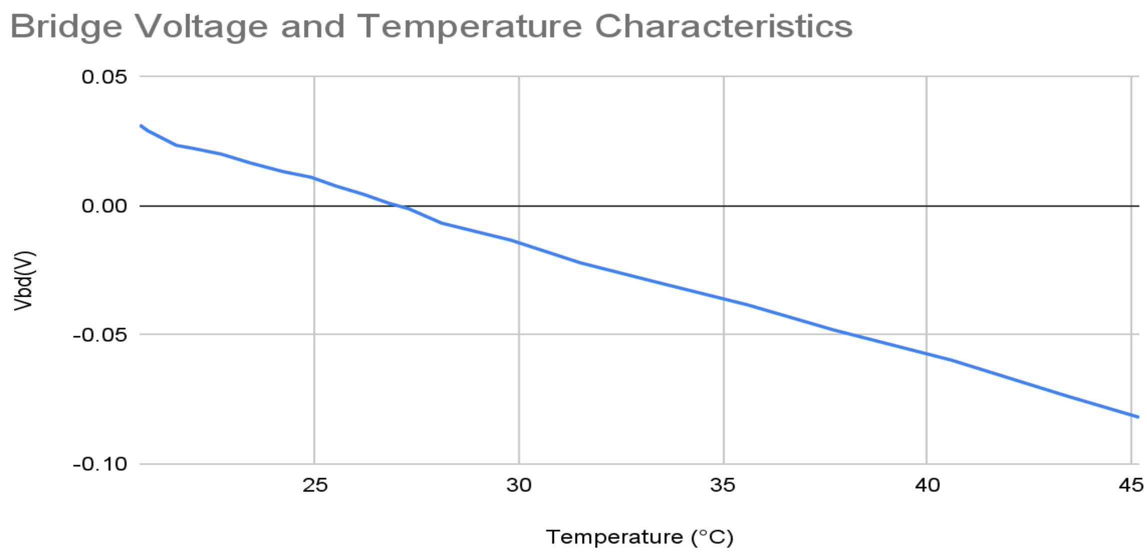
Task 3 – Construct the Wheatstone bridge circuit with the PT100 sensor, and mount the sensor on the Peltier element. Vary the temperature of the Peltier element and obtain a Vbd vs. temperature

curve for the PT100 sensor. Calculate the value of the temperature coefficient of the PT100 sensor from this response curve, and compare it to the multimeter estimated value of the coefficient.

In Task 3, we had started by constructing a Wheatstone bridge circuit with the PT100 sensor and mounting the sensor onto the Peltier element and executed all the steps of variations as in earlier tasks. We systematically varied the temperature of the Peltier element from 20 to 45 degrees Celsius (considering the maximum limit of current to flow through the element) while measuring and recording the corresponding bridge voltage (Vbd).

We took Rp = 220k ohm, Rq = 300k ohm and Rs = 150 ohm, and applied an input voltage V of 5V. These values are taken to ensure that we will get to a point where we get a balanced wheatstone bridge (Vbd = 0). Now knowing the values of V_{BD} , V and the three resistances, we calculated the values of the unknown resistance using equations of wheatstone bridge.

Temperature (°C)	Vbd (V)	Unknown resistance of the Peltier element calculated (in ohm)	Resistance calculated in task 2 (in ohm)	Temperature coefficient calculated(1/°C)	Temperature coefficient from task 2 (1/°C)
20.7	0.0314	107.1387	107.2	0.003449	0.00348
21.6	0.02349	107.8564	107.9	0.003641	0.00366
22	0.02236	107.9689	108	0.003622	0.00364
23.4	0.01674	108.4824	108.5	0.003625	0.00363
24.2	0.01338	108.7884	108.8	0.003632	0.00364
25.5	0.00779	109.296	109.3	0.003645	0.00365
26.2	0.00444	109.5992	109.6	0.003664	0.00366
27.3	-0.00111	110.1	110.1	0.0037	0.0037
28.1	-0.00664	110.5971	110.6	0.003771	0.00377
29.8	-0.01325	111.1888	111.2	0.003755	0.00376
31.5	-0.02202	111.9697	112	0.0038	0.00381
33.4	-0.02965	112.6453	112.7	0.003786	0.0038
35.6	-0.03832	113.4086	113.5	0.003766	0.00379
37.7	-0.048	114.2556	114.4	0.003781	0.00382
40.6	-0.05976	115.277	115.5	0.003763	0.00382
43.4	-0.07352	116.4619	116.8	0.003793	0.00387
45.2	-0.08192	117.1798	117.6	0.003801	0.00389



3. Conclusion

1. **What in your opinion is the most important thing you learnt from the experiment?**
   We have learnt that the values of coefficient of resistance measured by the multimeter and the values we have got from the response curve both are different(i.e theoretical and practical values of PT100).

2. **What was interesting about the experiment?** It was interesting to observe the trend among various quantities we were measuring like Voltage(Vin),Temperature, Resistance , Coefficient of Resistance. It was interesting to check whether the device is at the same temperature as we are measuring.

3. **What was challenging about the experiment?**
   We were getting values different from the ones we got before when we disturbed the setup for once and retake the values for the same input value(like voltage or temperature). The other challenge we faced was with the stability of the readings. The PT100 took some time, around 90-100 seconds to give relatively stable values whenever we changed the current flowing through it.

4. **Were there any drawbacks of the way the experiment was done? How would you do it better?**
   We did the experiment to the best of our knowledge, and there were no possible drawbacks in the way the experiment was conducted. The measured and the calculated values came out to be pretty close to each other, which made us confident about how we did the experiment.

5. **Contribution statement** – Adarsh took on the task of calculating actual values and tabulating observed readings. Saransh and Jasnoor worked on making the circuits for the tasks and observed and relayed the readings to Adarsh. Binduthraya and Rawal did the calculations of values and plotted the graphs. As for the report, everyone contributed towards its making.