PT 100

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Aim: To measure and analyse the voltage output of PT-100 at varying temperature.

Components required:

1. Breadboard
2. Arduino
3. PT-100 Sensor
4. Resistor
5. Jumper cables
6. Electric kettle
7. Thermometer
8. Mobile with PlatformIO

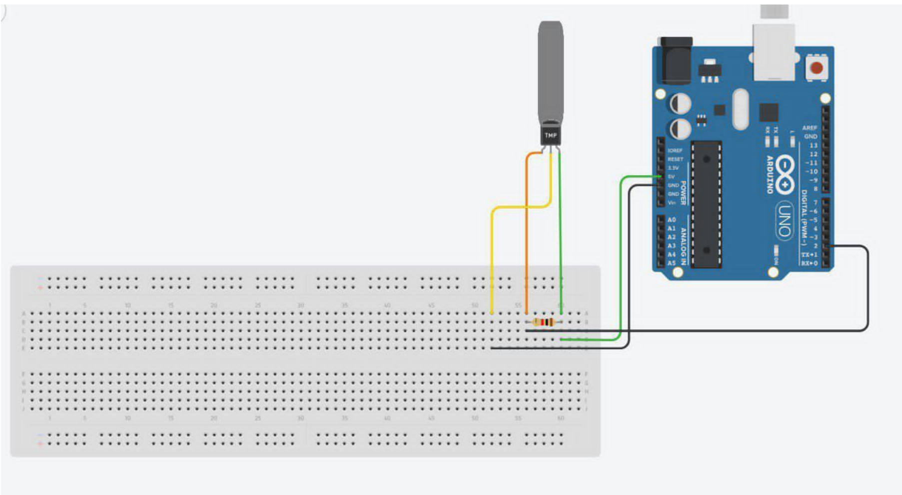
Theory:
PT-100 is a platinum resistance temperature detector (RTD). The resistance of platinum changes with temperature. "PT" stands for platinum and "100" for it having a resistance of $100\,\Omega$ at $0°C$.

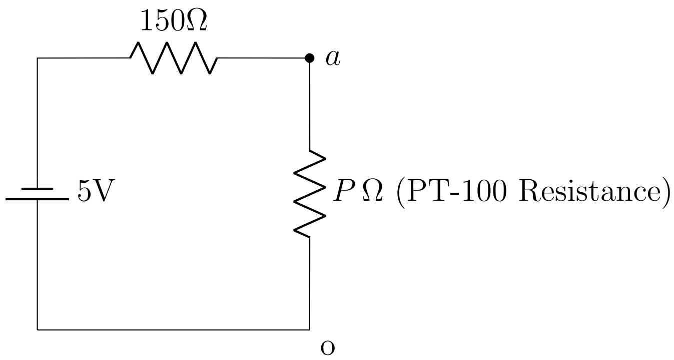
Procedure:

Connections:

1. Arrange all circuit components as shown in the figure behind the page.
2. Electric kettle is used to increase the temperature of PT-100, and values are measured using the next step.

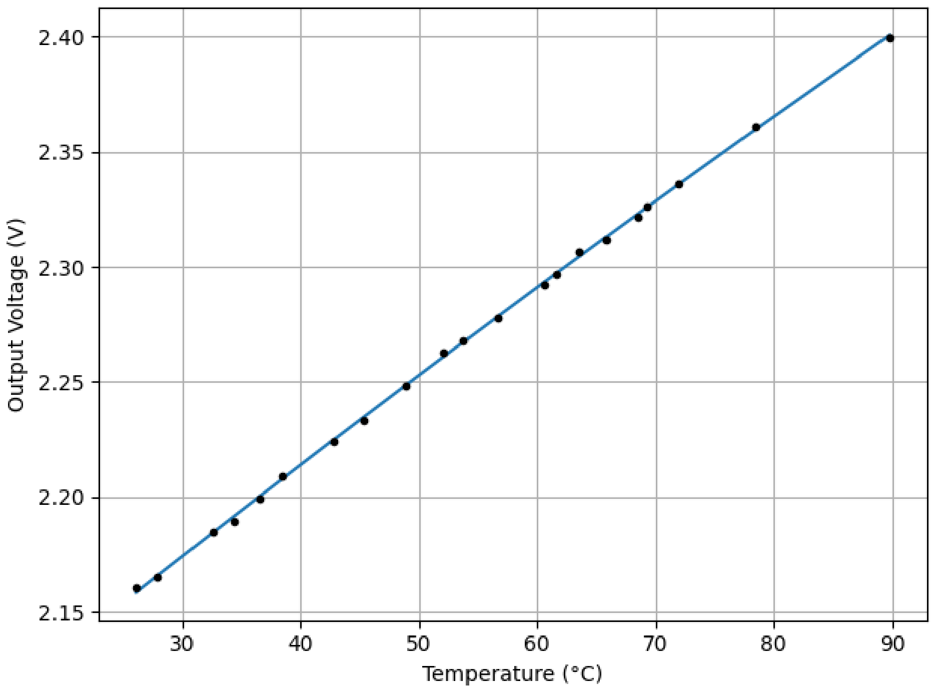
Circuit Diagram(without LCD)





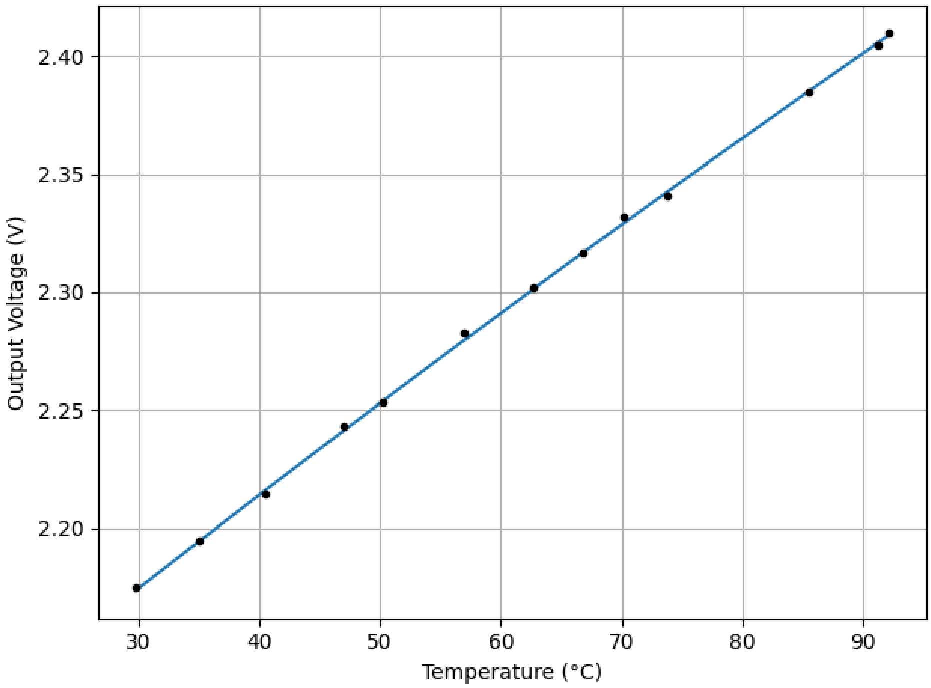
4. Observations : (Training Data)

Temperature (°C)	Voltage (V)
26.1	2.1603
27.9	2.1652
32.6	2.1847
34.4	2.1896
36.5	2.1994
38.4	2.2092
42.8	2.2238
45.3	2.2336
48.9	2.2483
52.1	2.2629
53.8	2.2678
56.7	2.2776
60.6	2.2923
61.7	2.2971
63.6	2.3069
65.8	2.3118
68.5	2.3216
69.3	2.3265
71.9	2.3362
78.5	2.3607
89.8	2.3998



5. Observations : (Validation Data)

Temperature (°C)	Voltage (V)
29.8	2.1749
35.1	2.1945
40.5	2.2141
47.0	2.2434
50.3	2.2532
57.0	2.2825
62.7	2.3020
66.8	2.3167
70.2	2.3318
73.8	2.3411
85.5	2.3851
91.2	2.4046
92.1	2.4095



3. Theory

Using Callendar–Van Dusen equation,

$$V(T) = V(0)\begin{pmatrix}1\\A\\B\end{pmatrix}\begin{pmatrix}1\\T\\T^2\end{pmatrix}$$

$$\Rightarrow\ C = n^T x \quad \text{where } C = V(T),\ x = \begin{pmatrix}1\\T\\T^2\end{pmatrix},\ n = V(0)\begin{pmatrix}1\\A\\B\end{pmatrix}$$

For multiple points,

$$X^T n = C$$

$$X = \begin{pmatrix}1 & 1 & 1 & \cdots & 1\\ T_1 & T_2 & T_3 & \cdots & T_n\\ T_1^2 & T_2^2 & T_3^2 & \cdots & T_n^2\end{pmatrix}, \quad C = \begin{pmatrix}V(T_1)\\V(T_2)\\V(T_3)\\\vdots\\V(T_n)\end{pmatrix}$$

We will use the above equation to find n. Using the least squares method, we estimate:

$$n = (X^T X)^{-1} X^T C$$

Codes:

The codes for this project may be found at the given URL:

`https://github.com/spideyboo/Digital-Thermometer`

Above codes should be typed in **PlatformIO** and the mobile should be connected to **Arduino UNO** so that the codes are compiled and executed. These codes are written in **Embedded C** and the **ML and Error Analysis (Python)**.

5. Error Analysis

The quadratic loss function of a linear regression model is defined as

$$\text{MSE} = \frac{\sum (y_{\text{exp}} - y_{\text{act}})^2}{n}$$

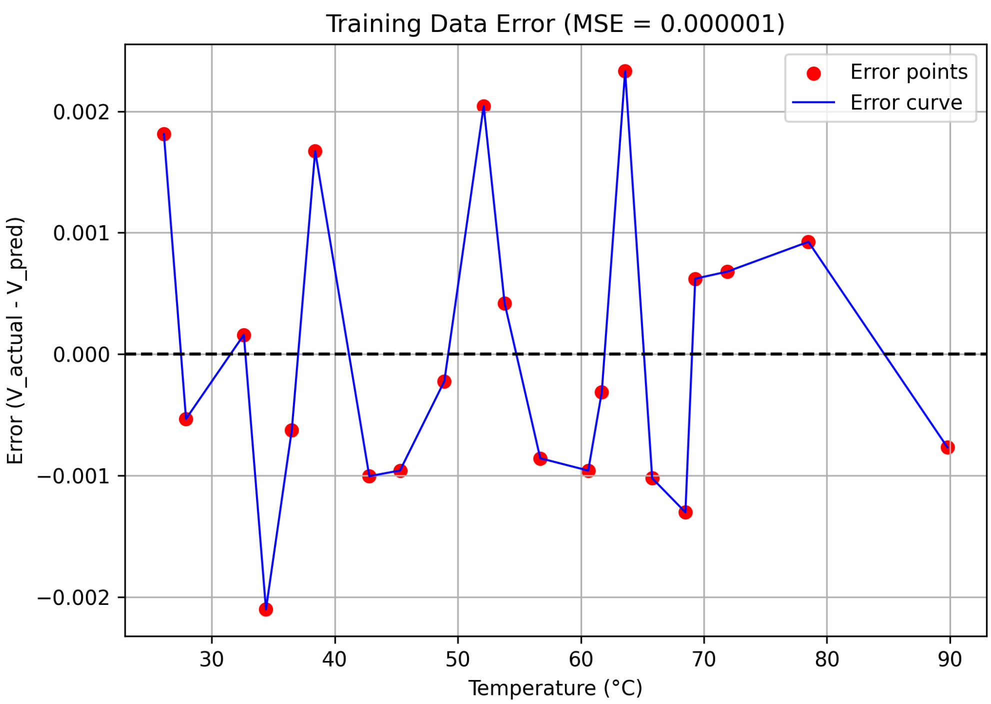
where n = number of readings.

For Training data set:

$$\text{MSE} = 1.41598774 \times 10^{-6}$$

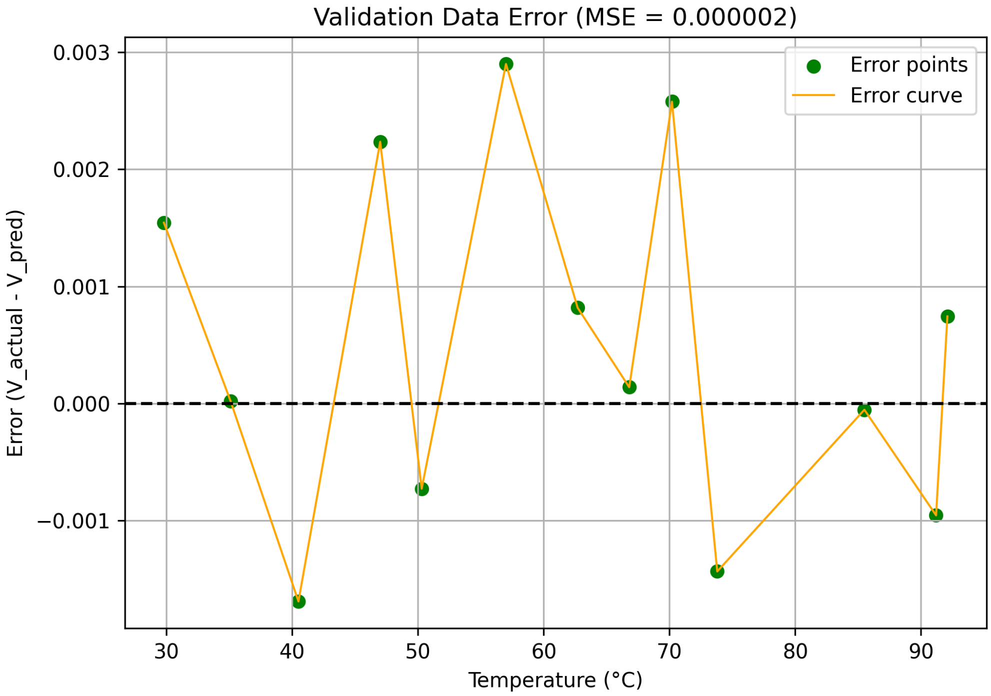
For Validation data set:

$$\text{MSE} = 2.31182403 \times 10^{-6}$$



6. Conclusion

In conclusion, this report successfully demonstrates the use of the PT-100 sensor with Arduino for temperature measurement. The project involved setting up a circuit, coding, and data collection to observe the sensor's response across varying temperature. The experiment verified the PT-100's effectiveness in providing reliable temperature readings,



making it a valuable component for precise temperature monitoring in various applications.