SENSOR_LAB_2

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Experiment 2: Temperature Sensor Unit Using NTC Thermistor

Introduction : Purpose and Significance of the Experiment

This experiment involves the design, simulation, and implementation of a temperature sensing unit using an NTC (Negative Temperature Coefficient) thermistor. As the temperature increases, the resistance of the thermistor decreases, enabling its use in temperature-dependent applications.

A signal conditioning circuit is developed to convert the thermistor's nonlinear resistance changes into a usable voltage output, which is then tested and analysed across a temperature range of 30°C to 60°C. The experiment provides practical exposure to sensor interfacing, Analog signal processing, circuit simulation, and real-time data acquisition, reinforcing theoretical concepts through hands-on learning.

Components Used

→ MCP6004 IC - 1

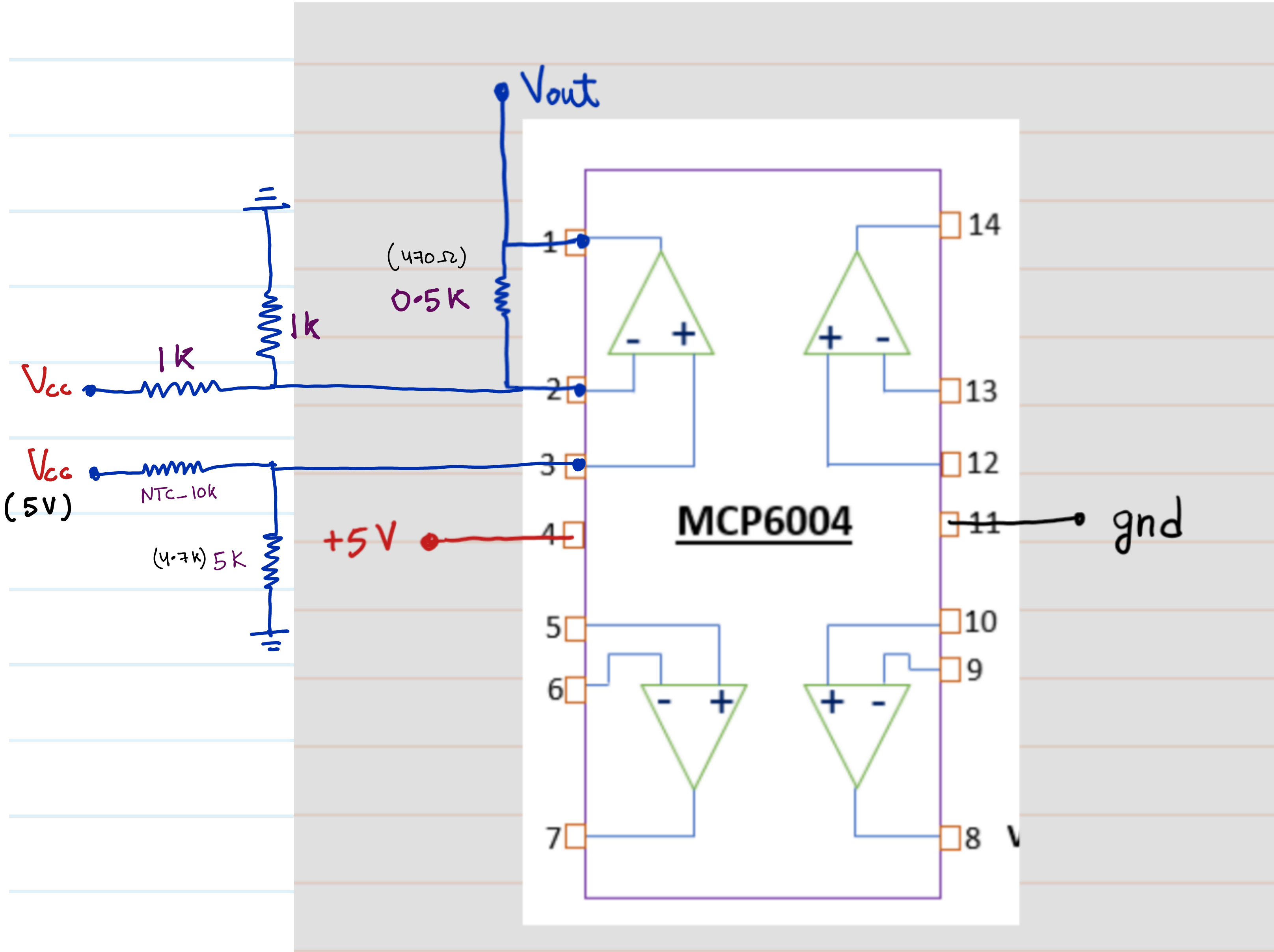
→ 10 kΩ NTC Thermistor

→ Resistor - 1 kΩ (2), 5 kΩ (1), 0.5 kΩ (1)

→ Adalm1000 kit and Wires

#Circuit design

• Pin Diagram

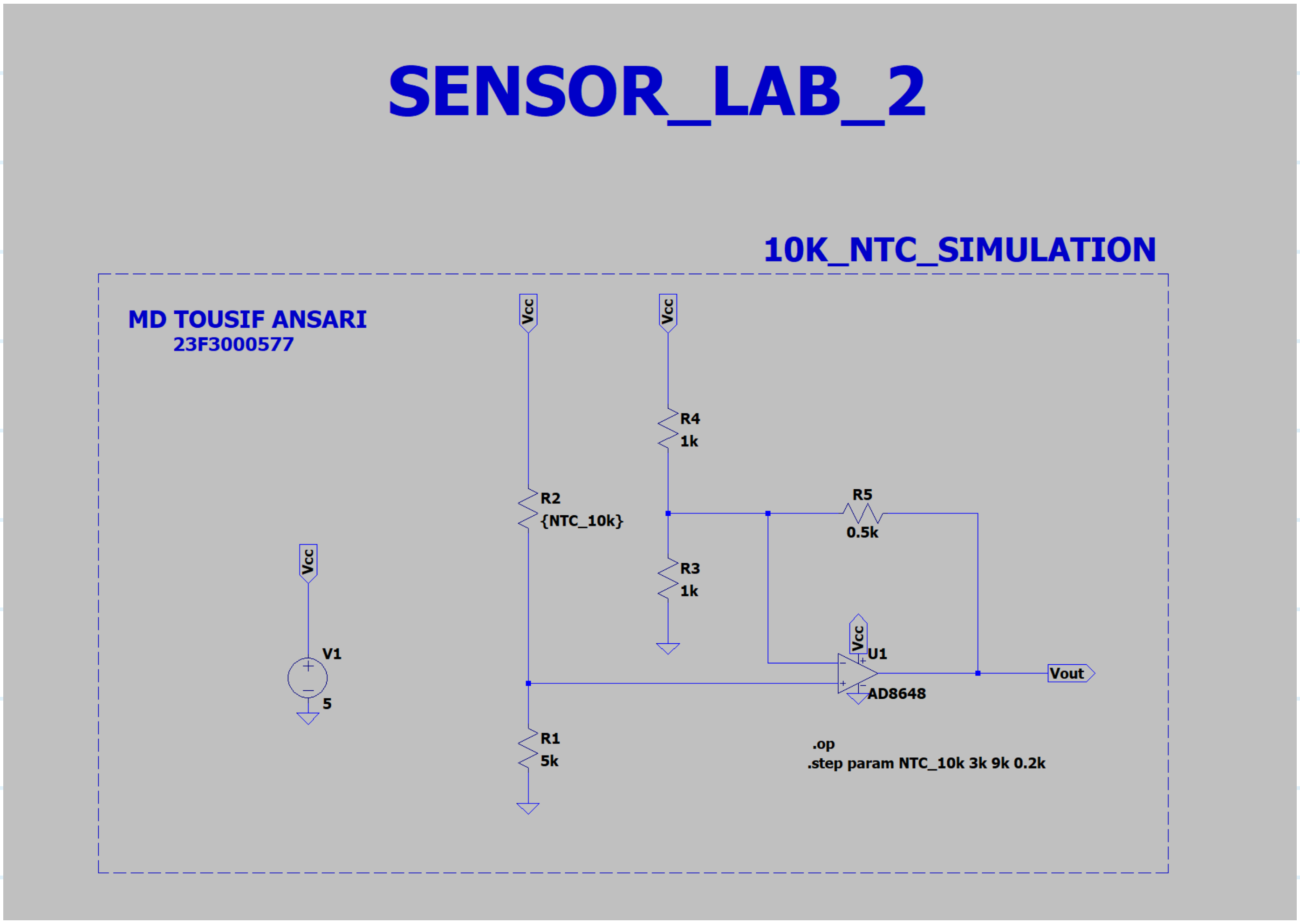


* Thermistor nominal resistance = 10 kΩ

* Output voltage range = 1.71 V at 30°C – 4.37 V at 60°C

• Simulation Circuit Diagram

• Signal Conditioning Circuit



• Simulation Results

Input (Voltage at Resistive divider using 10k NTC)

Output Voltage

vs Thermistor Res.

Calculations

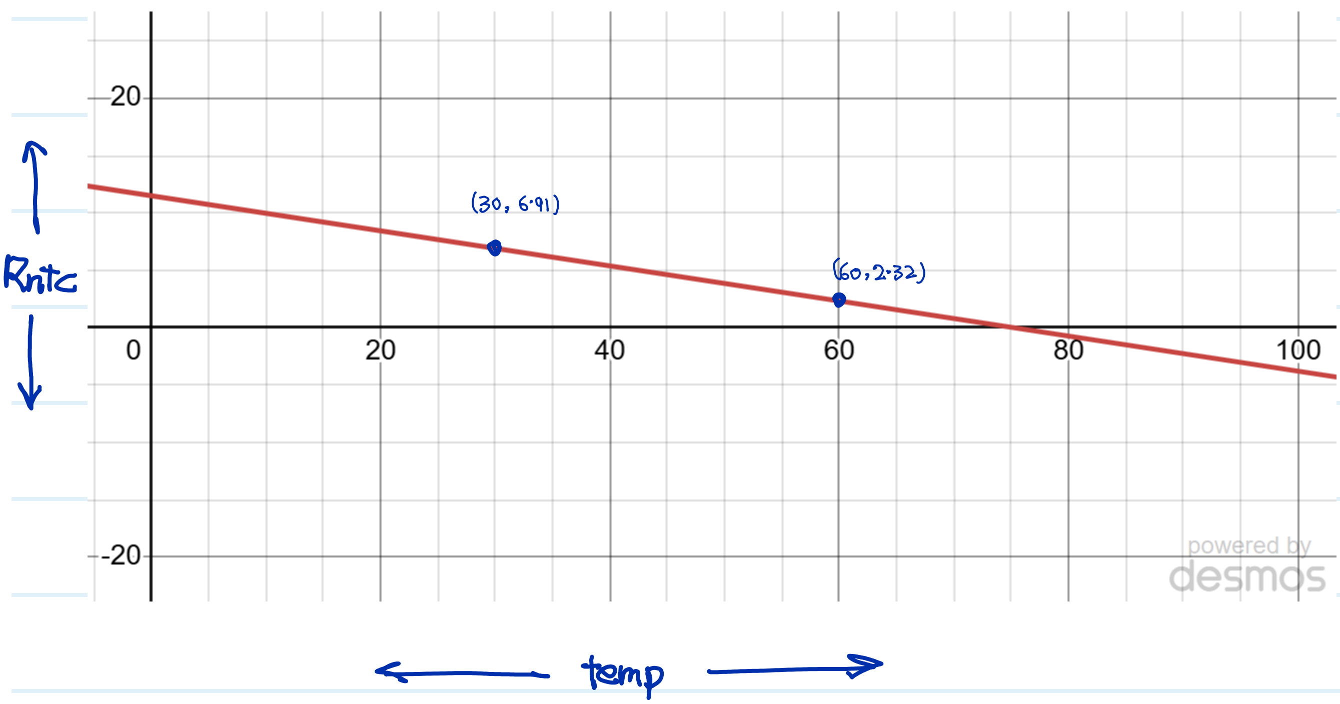
- Values as marked in simulation

⇒ $R_3, R_4 = 1k\Omega$; $R_5 = 0.5\,K$ {By using Application note}

⇒ $R_1 \approx 5\,k\Omega$ {By using Application note}

Relation between temp and Rntc

$$R_{ntc} = -0.153\,Temp + 11.5$$

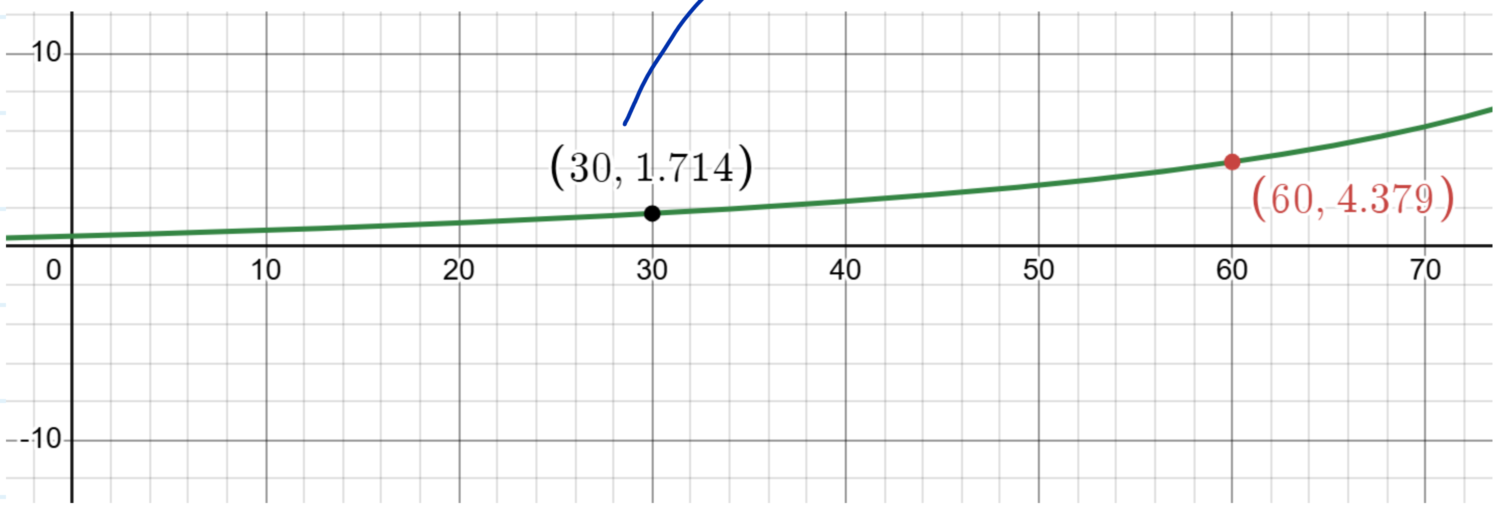


Relation between Vout vs Temp

$$V_{out} = -2.5 + \frac{50}{16.45 - 0.153\,Temp}$$

@ 30°C Voltage = 1.714 V

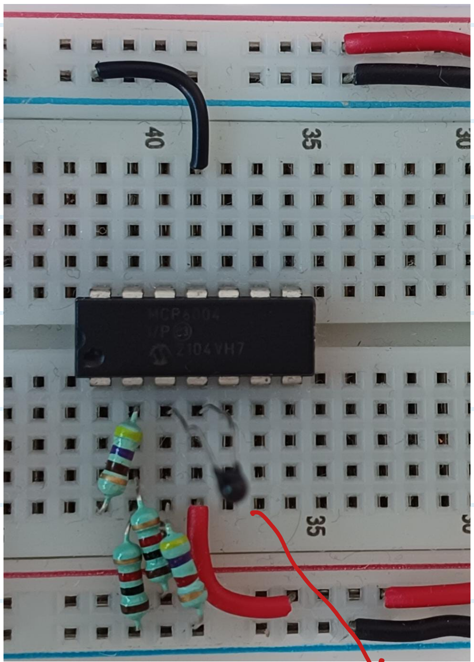
Vout

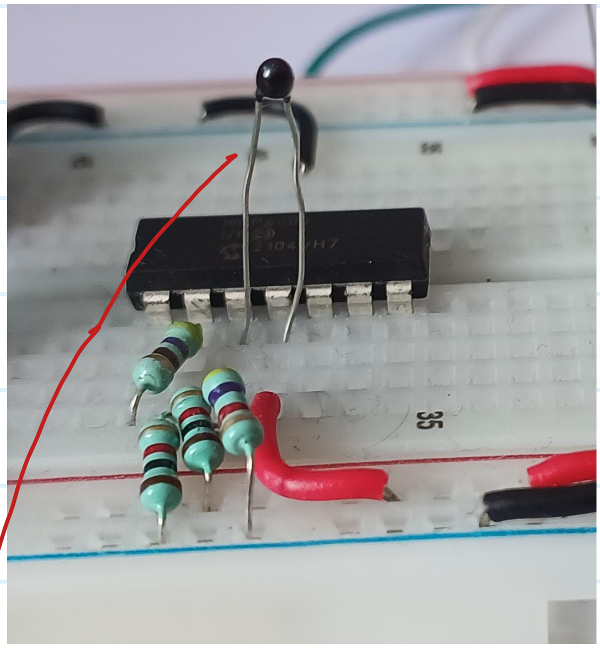


Temp

Experimental Setup

{Photograph of Breadboard circuit}

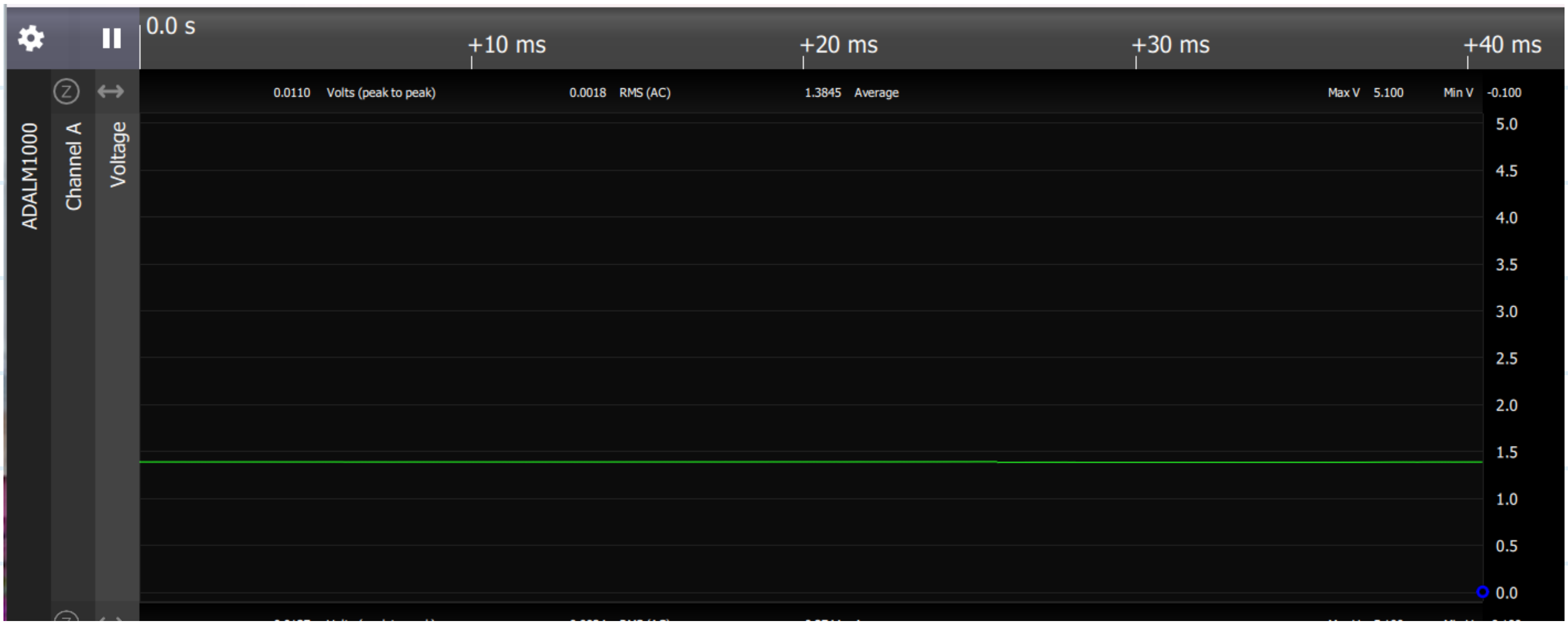




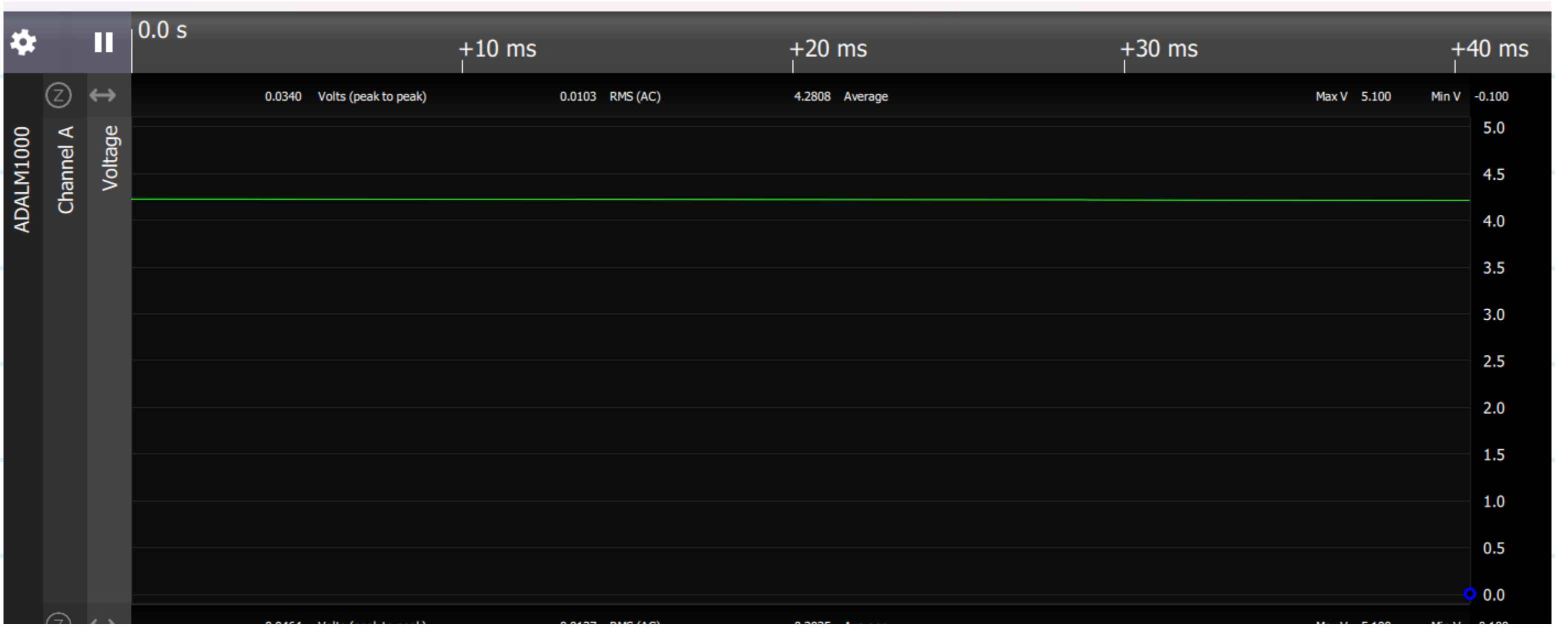
10K - NTC Thermistor

Experimental Output

- V_{out} = 1.41 V at Temp 28°C



- V_{out} = 4.23V at temp 58°C

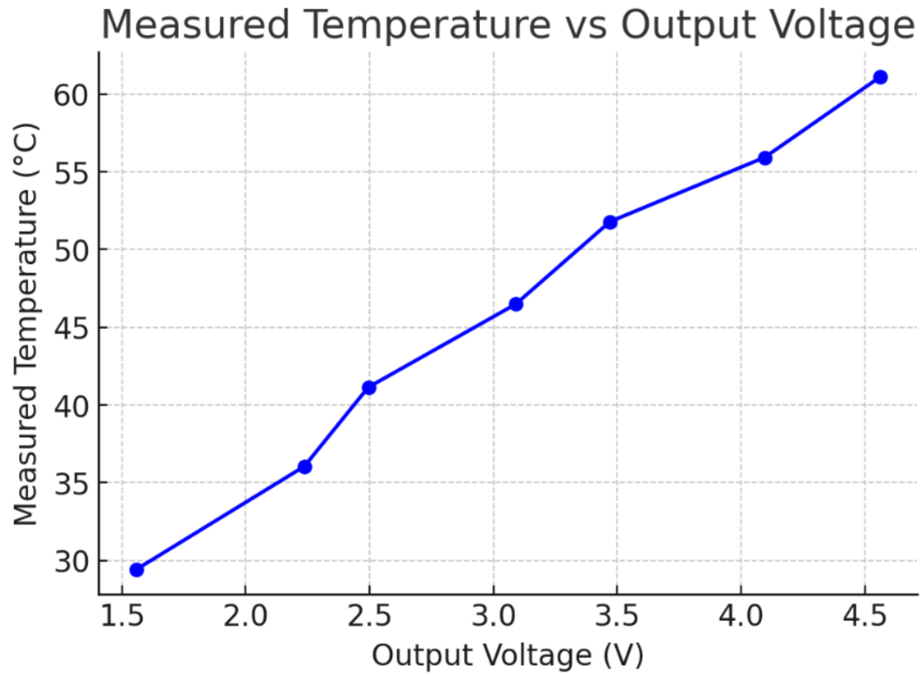


Data and Analysis

- Observed temp vs output voltage

Output Voltage (V)	Reference Temperature (°C)	Measured Temperature (°C)	Percentage Error (%)
1.557	30	29.414	1.95
2.237	35	36.059	3.03
2.495	40	41.145	2.86
3.091	45	46.499	3.33
3.471	50	51.797	3.59
4.096	55	55.938	1.71
4.562	60	61.112	1.85

Graphical Representation



- Room temperature data log

→ Data taken after every 1 hours using adalm1000

Time	Temperature (°F)	Temperature (°C)
4:00 AM	76°	24°
5:00 AM	80°	27°
6:00 AM	81°	27°
7:00 AM	82°	28°
8:00 AM	84°	29°
9:00 AM	85°	29°
10:00 AM	85°	29°
11:00 AM	83°	28°
12:00 PM	84°	29°
1:00 PM	85°	29°
2:00 PM	86°	30°
3:00 PM	85°	29°
4:00 PM	84°	29°
5:00 PM	83°	28°
6:00 PM	82°	28°
7:00 PM	82°	28°
8:00 PM	81°	27°
9:00 PM	80°	27°
10:00 PM	82°	28°
11:00 PM	81°	27°

→ Temperature recorded manually using thermistor circuit and calculated based on Output Voltage.

Temp. of my Room {10 Aug 2025}

Conclusion

The designed temperature sensor unit using an NTC thermistor successfully demonstrated the conversion of temperature variations into a measurable voltage output through an appropriate signal conditioning circuit. Simulation results closely matched the experimental findings, confirming the correctness of the design and the accuracy of the thermistor's resistance–temperature model used during the design phase.

The inclusion of a parallel capacitor in the feedback path effectively reduced 50 Hz interference, improving signal stability and measurement consistency. Comparative testing with and without linearization showed that the linearized configuration provided a more predictable voltage–temperature relationship, reducing calibration complexity. Experimental measurements with the thermistor immersed in water exhibited minor deviations from simulated values, primarily due to tolerances in thermistor specifications, op-amp offset, and measurement conditions.

Room temperature monitoring over a full day using the ADALM1000 kit provided a clear understanding of environmental variations and confirmed the sensor's capability for continuous data logging applications.

Overall, the experiment met its objectives by integrating theoretical understanding with practical implementation, covering thermistor characteristics, op-amp-based signal conditioning, simulation validation, and real-world testing.

Future improvements could include implementing digital calibration using a microcontroller, Use higher-accuracy thermistors or instrumentation amplifiers for better precision, adding temperature compensation for self-heating effects, and exploring higher-order linearization methods for broader temperature ranges.