Sensors Laboratory - Experiment 2

Temperature Sensor Unit Using NTC Thermistor

1 Introduction

This experiment focuses on designing and testing a temperature sensor unit using an NTC (Negative Temperature Coefficient) thermistor. The thermistor's resistance decreases with increasing temperature, making it useful for temperature-sensing applications. The sensor unit includes a signal conditioning circuit to convert resistance variations into a measurable voltage output.

In this experiment, we will design, simulate, and implement the circuit, followed by experimental validation using real temperature measurements. This experiment provides hands-on experience with thermistors, signal conditioning circuits, and basic data acquisition techniques, reinforcing theoretical concepts through practical application.

2 Design and Procedure

2.1 Procurement and Initial Design

- Procure one or two NTC thermistors (nominal resistance: 10 k). A reference link for purchase is provided: Link. Equivalent alternatives may also be used.
- The provided TI application note for designing the signal conditioning circuit may be followed: Application Note.
- Design the signal conditioning circuit to convert the resistance variation into an output voltage suitable for measurement. A linearly increasing output is preferred.
- Supply voltage: $V_{DD} = 5V$.
- Output voltage range: 0.1V (for 30°C) to 4.5V (for 60°C).

2.2 Simulation and Circuit Implementation

1. Simulate the designed circuit using LTSPICE or any other circuit simulation software.

2. While waiting for the thermistor, build the signal conditioning circuit on a breadboard.

3. Use the MCP6004 op-amp IC.

4. The application note suggests using a capacitor in parallel to the feedback resistor. Derive an expression for the output with the capacitor present.

5. Select the capacitor value to filter 50 Hz interference and beyond.

2.3 Linearization and Testing with the Thermistor

- The thermistor characteristic is not linear. However, we aim to achieve a nearly linear output in the range of 30°C to 60°C.
- Perform the simulation with and without linearization and compare the results.
- Determine the thermistor resistance at every 5°C interval using its datasheet.
- Use LTSPICE's '.step param' option to vary the thermistor resistance and record the corresponding output.
- Use a variable resistor (potentiometer) to emulate the thermistor's resistance variation over a temperature range of 30°C to 60°C in 5°C steps.
- Manually vary the potentiometer and record the output voltage.
- Once the thermistor arrives, replace the potentiometer with the thermistor in the circuit.
- Test the thermistor by immersing it in water and measuring the output voltage at different temperatures.
- Use a thermometer, if available, to cross-check actual water temperature.
- Plot temperature vs. output voltage and calculate measurement error.

2.4 Room Temperature Monitoring

- Record room temperature over a full day at 30-minute intervals.
- Use the ADALM1000 kit and a computer for data logging.
- Write or use a suitable program for logging and storing data for analysis.

3 Report Preparation

Students should prepare a report containing the following:

1. **Introduction**: Purpose and significance of the experiment.
2. **Circuit Design**:
   - Neat circuit diagram.
   - Explanation of signal conditioning circuit with necessary calculations.
3. **Simulation Results**:
   - Screenshots and voltage response plots from the simulation.
4. **Experimental Setup**:
   - Photographs of the breadboard circuit and measurement setup.
5. **Data and Analysis**:
   - Observed temperature vs. output voltage data.
   - Comparison of results with and without linearization.
   - Error analysis based on cross-checked/reference temperature measurements.
   - Room temperature data log and trend analysis.
6. **Conclusion**:
   - Summary of findings.
   - Performance evaluation.
   - Potential improvements.

Note: In addition to the report, a live online demonstration will be scheduled as part of the evaluation to assess the completion of the experiment.