EE3810 Lab 5: Measuring Temperature and Sensor Characteristics

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1 Concepts

1. sensors
2. data acquisition
3. calibration
4. sensitivity
5. accuracy
6. precision

2 Objectives

In this experiment, you will

1. create a VI which monitors temperature
2. understand how to collect data from a temperature probe in LabView
3. learn how to use the `formula node` function in LabView
4. learn how to determine sensitivity of a sensor and understand what sensitivity tells us
5. measure accuracy and precision of a sensor
6. understand the difference between these different sensor characteristics

3 Pre-lab reading / assignment

- Thibodeau pp. 578 - 580
- Carr & Brown pp. 86-91
- Essick 5.1 - 5.7; review 2.2-2.3 and 4.1-4.3
- Determine the relationship between the voltage output of the temperature probe and the resistance of the sensing element.

4 Background

4.1 Temperature probe

The temperature probe provided by Vernier is a thermistor-based sensor. The resistance is related to temperature by this equation:

$$T = (k_0 + k_1 \cdot \ln R + k_2 \cdot (\ln R)^3)^{-1} - 273.5$$

The sensing element is connected inside the probe to a 15KΩ resistor, as illustrated below.

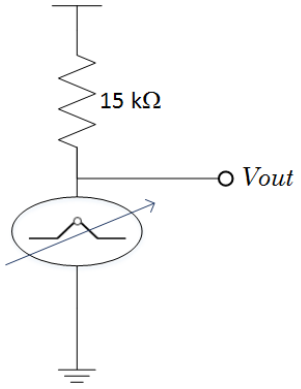

Figure 1: Schematic of the internal circuitry of temperature probe.

Review your notes and reading assignments to learn more about sensitivity, accuracy, precision, and resolution.

5 Procedure

5.1 Creating the temperature monitor VI

1. First show that you can read in the temperature probe signal using DAQ Assistant and a waveform chart.
2. Add a mathscript node to obtain a temperature reading in ^oC.
3. Display the temperature value in both ^oC and ^oF, after adding some arithmetic blocks to do the conversion.

5.2 Adjusting the temperature

You will repeatedly use this procedure to carry out section 5.3

1. Use the electric tea kettle to heat water up.

2. Add cold water to your bowl. Measure the temperature with the conventional thermometer.
3. Get a cup of hot water, and slowly add the hot water while another person gently stirs the water bath until the bath reaches the desired temperature.
4. Keep adding small amounts of cold and hot water to target the different temperature ranges.

5.3 Measuring temperature

The purpose of this procedure is to obtain several measurements at different ranges of temperatures: high end (35 - 45^{o}C); mid-range (20-30^{o}C); and low end (5-15^{o}C)

1. First target the low end; start at the lowest temperature:
2. Measure the temperature of the bath with the thermometer, and the output voltage of your temperature monitor VI.
3. Slightly warm the water water bath using the method described in 5.2.
4. Repeat steps 2 - 3 until you hit the upper limit of the given temerature range. Go back down, taking measurements. Once you reach the lower limit, adjust the temperature of the bath to jump to the lower end of the next range. Then repeat steps 2 - 3 until you have about 10 measurements from each temperature range (5 measurements going up the range, and 5 coming back down the range).

5.4 Conducting sensitivity analysis

1. Enter your data in MS Excel.
2. Look up the help function on `LINEST`. After you understand how it works, apply the `LINEST` function to your data to obtain an estimate of the sensitivity in each range of temperatures.

6 Questions

1. How accurate is your temperature monitor?
2. How sensitive is your temperature monitor?
3. How precise is your temperature monitor?
4. How variable are the results across different temperature ranges?
5. Choose a biomedical application for which this temperature monitor could be used. How would you improve the sensor characteristics to make this temperature monitor better tuned for your selected biomedical application?