

2.1.1: Temperature Measurement System

Overview:

In this lab assignment, students will design another temperature-measuring circuit. Unlike our previous temperature measuring circuit, the output voltage of this circuit is to be relative to the output voltage at room temperature. The output voltage is to be positive if the temperature is above room temperature, and negative if the temperature is below room temperature. As with our previous temperature measuring circuit, this circuit will use a thermistor to sense temperature changes.

Before beginning this lab, you should be able to:

- State Ohm's law
- Determine the equivalent resistance of series and parallel resistive networks
- State the voltage divider and current divider formulae
- Use a digital multimeter to measure resistance, voltage, and current (Labs 1.1 and 1.2.1)
- Use the Analog Discovery's waveform generator to apply constant voltages to a circuit (Lab 1.2.2)
- Use the Analog Discovery voltmeter to measure a constant voltage (Lab 1.2.1)
- Use color codes on resistors to determine the resistor's nominal resistance

After completing this lab, you should be able to:

- Design a thermistor-based circuit to measure temperature
- Use a potentiometer to provide a desired resistance value
- Use multiple power supplies in an electrical circuit.

This lab exercise requires:

- Analog Discovery
- Diligent Analog Parts Kit
- Digital multimeter (optional)

Symbol Key:

- DEMO** Demonstrate circuit operation to teaching assistant; teaching assistant should initial lab notebook and grade sheet, indicating that circuit operation is acceptable.
- ANALYSIS** Analysis; include principle results of analysis in laboratory report.
- SIM** Numerical simulation (using PSPICE or MATLAB as indicated); include results of MATLAB numerical analysis and/or simulation in laboratory report.
- DATA** Record data in your lab notebook.

General Discussion:

In this portion of the lab assignment, we will refine the temperature measurement system we designed in Lab 1.4.4. The system will still use a thermistor to detect temperature changes. (Recall that a thermistor is a device whose electrical resistance changes as a function of the temperature of the thermistor. The thermistor we will use has a temperature-resistance curve approximately as shown in Figure 1. Thermistor operation is discussed in more detail in the companion document to Lab 1.4.4.)

Our design requirements for this assignment are as follows:

1. $\pm 5V$ input voltage to the system
2. Output voltage is $0V \pm 10mV$ at room temperature (approximately $25^{\circ}C$)
3. Output voltage is positive for temperatures above room temperature, negative for temperatures below room temperature
4. Output voltage increases by a minimum of 1V over a temperature range of $25^{\circ}C$ to $37^{\circ}C$. (These temperatures correspond approximately to room temperature and body temperature, respectively.)

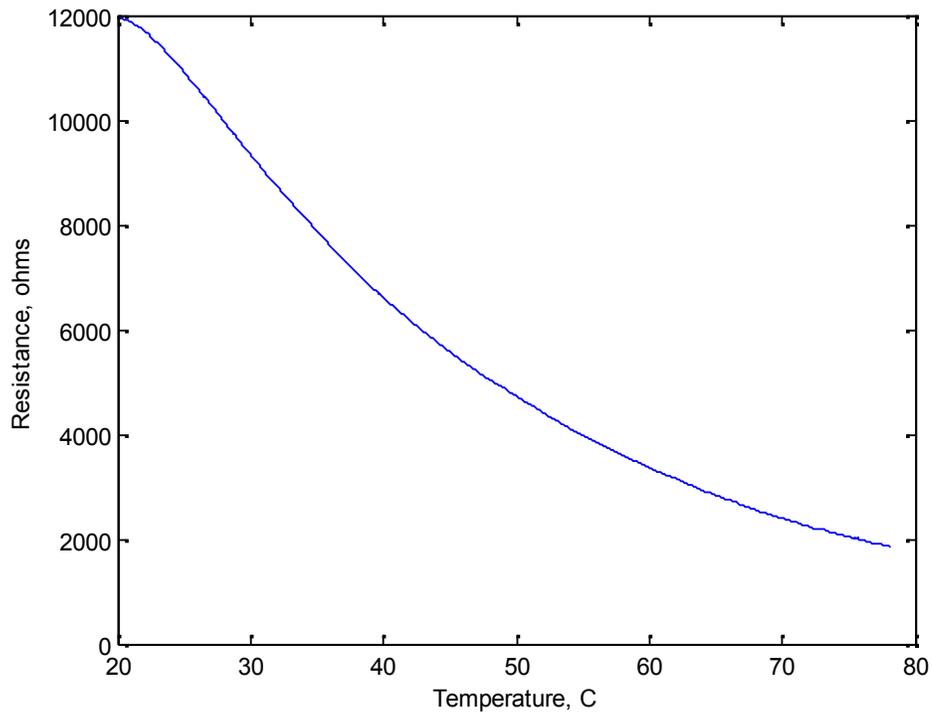


Figure 1. Thermistor temperature-resistance characteristic.

Pre-lab:

ANALYSIS

In the circuit of Figure 2, the resistance R_{TH} is the variable resistance of the thermistor. The voltage v_{out} is the voltage that we will use to indicate temperature. Two 5V voltage supplies are used to apply power to the circuit as shown – note that $V_{ba} = +5V$ and $V_{ca} = -5V$. v_{out} is measured between nodes d and a with the polarity shown. The design problem is to choose a value for R so that v_{out} satisfies the given design requirements. It is recommended that you choose R based on requirement 2, and then check to see that this resistance satisfies the remaining design requirements.

Be sure to document your analyses (preferably in a lab notebook), including the equation(s) governing the system, your desired value for R, your expected output voltage change over the specified temperature range, and your expected output voltage at room temperature.

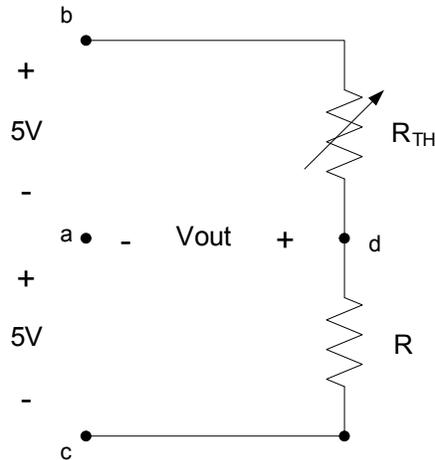


Figure 2. Temperature measurement circuit schematic.

Lab Procedures:

Implement and test the design you created in the pre-lab. It is suggested that you perform at least the following steps when doing this:

DATA

1. Measure the room-temperature resistance of your particular thermistor. Compare this value to the assumed value used in your pre-lab and modify your desired value of R accordingly.

DATA

2. Implement your design. Be sure to record actual resistance values for any fixed resistors used in your design. In order to meet requirement 2, it may be necessary for you to implement a very specific resistance. A potentiometer (variable resistor) can be used to provide an arbitrary resistance value. You can monitor the output voltage while adjusting the potentiometer to ensure that requirement 2 is met. If desired, the potentiometer can be placed in parallel or series with a fixed resistor.

DATA

3. Measure and record the voltage response at room temperature. Measure and record the output voltage at the high temperature condition by firmly holding the thermistor between two fingers. Verify that the output voltage becomes negative when the thermistor is below room temperature by holding a cold can (or bottle) of your favorite beverage against the thermistor. Discuss your circuit's performance relative to the design specifications. (e.g. Were requirements met? If not, why?)

DEMO

4. Demonstrate operation of your circuit to the Teaching Assistant. Have the TA initial the appropriate page(s) of your lab notebook and the lab checklist.