Teacher's Preparatory Guide

Thermistor Circuit

Purpose
The purpose of this activity is to show a thermistor's usefulness within a circuit. This activity will introduce thermistors in a circuit so that future activities may build upon this idea to conclude with micro/nano-circuits.

Time required: 45 – 55 minutes

Level: High School

Teacher Background
Ohm's Law

Georg Simon Ohm discovered that materials have an ohmic, or linear, region. His equation (Eqn 1) explains that as the potential difference (ΔV) increases, so does the current (I), and the relationship is linear to a point. The slope of a voltage vs. current plot yields the resistance (R). Temperature affects the resistance. If a resistor heats up, the value of its resistance increases, and the resistor is now considered non-ohmmic. Non-ohmmic materials have a non-linear relationship between voltage and current.

$$\Delta V = IR \qquad \text{Eqn 1}$$

Thermistors

Thermistors are sometimes used as temperature devices in the electronics industry. They have unique properties. In this lab it will be shown that thermistors have a negative coefficient of temperature (NTC), which is counter intuitive. Positive coefficient of temperature (PTC) thermistors also exist.

Materials (For each lab set-up)

- Breadboard
- Power Supply
- 10 K NTC Thermistor
- Jumper wires
- Christmas Light bulbs
- Multimeter

Advance Preparation
Holiday light bulbs can be purchased at Home Depot, K-mart, or Walmart store during the holidays. If holiday lights are chosen, the lights will need to be cut. A wire cutter

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can cut and strip the ends to create leads. Twist the exposed copper so that it is easier to place in the breadboard. Thermistors are sold by Radio Shack, Digi-Key, and Mouser.

Safety Information

Make sure students connect the power supply correctly. Also, students should not increase the voltage to a level that will melt the wires.

Directions for the Activity

1. Discuss how to assemble a series circuit with three components (a battery, thermistor, and light bulb). (You may want to include a schematic diagram.)
2. Discuss the role of a thermistor (You may want to include the following activity first. *The Effect of Temperature on the Electrical Resistance Properties of a Thermistor* Activity)
3. Pass out the activity for the students to complete.

Procedure (from Student Activity Guide)

Student Worksheet

Thermistor Circuit

Objective

The purpose of this experiment is to determine the function of an NTC thermistor in a circuit.

Materials

- Breadboard
- Power Supply
- 10 K NTC Thermistor
- Jumper wires
- Holiday Light bulb or LED
- Multimeter

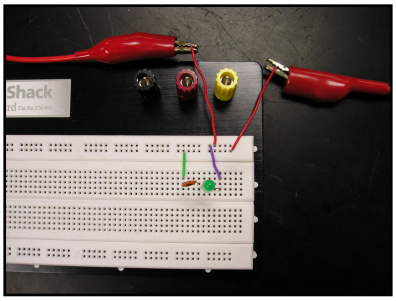

Figure 1. Breadboard setup.

Procedure

Part A: Thermistors and Changing Potential Difference

1. Create a series circuit on the breadboard without attaching the power supply. Place the thermistor before the Holiday light bulb or LED. Figure 1 is the breadboard setup. Figure 2, below is the schematic.

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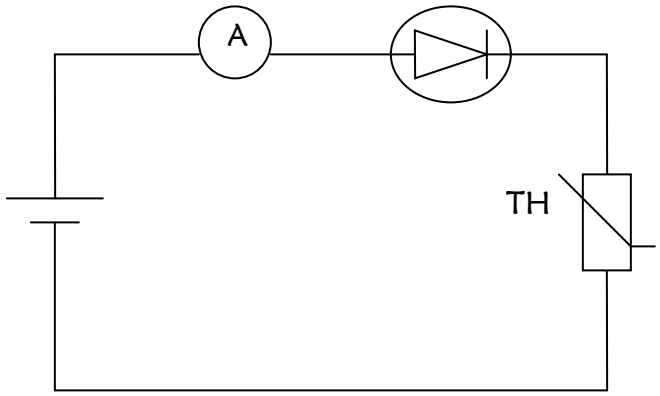

Figure 2. Series circuit of a thermistor and LED or light bulb.

2. Attach a jumper wire to the thermistor to connect to the negative side of the battery. Do NOT turn on the power supply yet.

3. Attach a jumper wire to the light bulb or LED to connect to the positive side of the battery.

4. Now turn the voltage dial on the power supply to zero.

5. Turn on the power supply. Turn the dial to create a voltage of 1 V.

6. Measure the current in the circuit with the multimeter. Record the value for current in Table 1. Remember that the current is measured in series.

7. Measure the voltage across the thermistor. Record the value for voltage in the data table. The voltage is measured in parallel.

8. Increase the voltage by 0.2 V.

9. Repeat steps 6 through 8 until the LED or Holiday light turns on.

10. Do not increase the voltage after the LED or Holiday light turns on because the LED will burn out.

Part B: Thermistor Response to Heating while in a Circuit

1. Turn the voltage to a value between 2.5 V and 3.0 V. A voltage any higher will cause the LED to burn out.

2. Record the current with an ammeter in Table 2.

3. Heat the thermistor with a hair dryer.

4. What happens to the LED or light bulb?

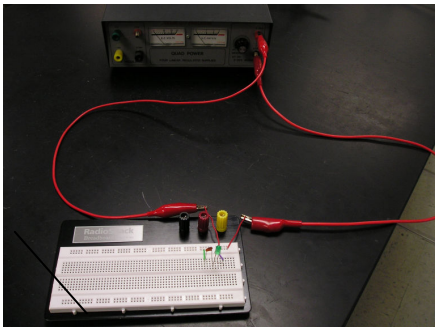
Figure 3. Lab setup.

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5. Record the current as the thermistor becomes warmer in Table 2.

Data

Table 1. Current, voltage, and resistance data for the thermistor circuit.

Power Supply Voltage (V)	Thermistor Voltage (V)	Current	Thermistor Resistance (Ω)	LED (On/Off)
1.0				
1.2				
1.4				
1.6				
1.8				
2.0				
2.2				
2.4				
2.6				
2.8				
3.0				
3.2				
3.4				
3.6				

Table 2. Current data.

	Current (A)
Room Temperature	
Hair Dryer	

Analysis and Conclusion

1. At what temperature did the LED light up? Look at the lab data found from *The Effect of Temperature on the Electrical Resistance Properties of a Thermistor.*
2. Why does the LED eventually turn on?
3. If the light bulb were placed in parallel with the thermistor, what would happen to the lightbulb?

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Cleanup:

Have the students turn off the power supply. Then they should remove all of the components and put them away in their proper place.

Worksheet (with answers)

1. At what temperature did the LED light up? Look at the lab data found from *The Effect of Temperature on the Electrical Resistance Properties of a Thermistor.*
   Look at the resistance value when the LED turns on. Compare it to the data already found in previous experiment.
2. Why does the LED eventually turn on?
   The resistance is low enough that it allows the current to flow through and reach the light bulb to light it.
3. If the light bulb were placed in parallel with the thermistor, what would happen to the lightbulb?
   The lightbulb should decrease in brightness because current takes the path of least resistance (towards the thermistor).

Assessment

Answer the analysis and conclusion section.

Resources:

To learn more about nanotechnology, here are some web sites with educational resources:

http://www.nnin.org
http://mrsec.wisc.edu
http://www.facstaff.bucknell.edu/mastascu/elessonsHTML/Sensors/TempR.html
http://www.gcsescience.com/pe9.htm
http://www.temperatures.com/thermistors.html

Georgia Performance Standards

SP5. Students will evaluate relationships between electrical and magnetic forces.
   b. Determine the relationship among potential difference, current, and resistance in a direct current circuit

National Science Education Standards

Physical Science Standards
- Structures and properties of matter
- Interactions of energy and matter

Science and Technology
- Understandings about science and technology

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