Experiment 3 — Effect of Temperature on Resistance

EL 111 - DC Fundamentals

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Objectives:

1. For the student to verify that some materials increase in resistance with an increase in temperature, while others decrease in resistance with an increase in temperature.
2. For the student to construct a graph from data obtained in a laboratory experiment.

Equipment and Parts:

- Meter: Agilent 34401A Digital Multimeter (DMM)
- Power Supply: Agilent E3631A DC power supply (0 to 20 VDC)
- Resistor R_1: One ≈25 Ω (ceramic body, high power rating) *
- Misc: 1 pilot lamp socket, 1 tungsten pilot lamp (Sylvania #1818)*

  1 globar resistor (#FR291) *

  * The high-wattage resistor, pilot lamp and globar resistor are mounted on a board, and will be given to you by your instructor

Information:

In the Ohm's Law experiment, the student is exposed to the electrical factors that relate to resistance, that is, voltage and current. Resistance is also affected by at least four physical factors, namely specific resistance of the material type, length, cross-sectional-area and temperature. In this experiment, the power dissipated by a tungsten lamp and a globar resistor will be determined. The change in dissipated power will represent a change in temperature. It is this change in dissipated power and temperature which will change the resistance of the components used. In one case a globar resistor will be used to investigate the characteristics of the negative temperature coefficient material. A tungsten lamp will be used to investigate the characteristics of a positive temperature coefficient material.

Since power is directly proportional to temperature, the student will indirectly use the effect of the temperature on resistance. It is a requirement of this experiment that the tabulated results be plotted on ***real*** graph paper.

Procedure:

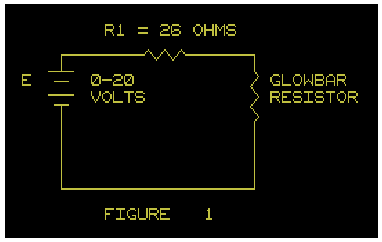
1. Using the multimeter, determine the resistance of the globar resistor at room temperature and the resistance of R_1 (the ≈25 Ω high power resistor). This will be known as the cold resistance (or ambient temperature resistance) of the globar. The multimeter DOES cause a small current to flow through anything it measures, and current DOES cause heating, but the multimeter's current is so small that the temperature change it causes is completely negligible.
   a. Measure and record the resistance of the ≈25 Ω high watt resistor.

R_1 = resistance of the ≈25Ω resistor = ______________

b. Measure and record the resistance of the globar resistor.

cold globar resistance =____________

2. It is necessary to obtain the following measured data and record it in Table 1 (provided below). This will be done for the **globar**, which is the "**device under test**", or D.U.T. These data will be used, in procedure 3, to calculate the globar's resistance and the power dissipated by it.



   a. Connect the circuit in Figure 1.

   b. Adjust the power supply voltage (called E_{app}) to 1.0V. See Column one in Table 1.

   c. Measure E_{R1} (the voltage across R_1) and record in Table 1.

   d. Measure E_{globar} (the voltage across the globar) and record it in Table 1 on the same row with the 1 V value for E_{app}.

   e. Increase the power supply voltage to 2.0V and measure E_{R1} and E_{globar}. Record both measured values in Table 1.

   f. Continue increasing the power supply voltage, in steps of 1.0 volt, and record E_{globar} and E_{R1} in Table 1 for each value of E_{app} until E_{app} reached 14.0 V.

Table 1 - D.U.T. = Globar

(show UNITS for all parameters)

E_{app}	E_{R1}	E_{globar}	$I=E_{R1}/R_1$	$R_{globar} = E_{globar}/I$	$P_{globar} = E_{globar}(I)$
1 V					
2 V					
3 V					
4 V					
5 V					
6 V					
7 V					
8 V					
9 V					
10 V					
11 V					
12 V					
13 V					
14 V					

3. Using the measured data in each row of Table 1, it is now possible and necessary for the student to calculate, using the measured values, circuit current (I), resistance of the globar (R_{globar}), and the power dissipated by the globar (P_{globar}).

    a. For each value of E_{R1} in Table 1 calculate circuit current using E_{R1} and R_1 (measured values). Record these values of current in Table 1.

    b. Using each value of circuit I and E_{globar} from Table 1, calculate R_{globar}. Record these values in Table 1.

    c. Using each value of E_{globar} and I from Table 1, calculate the power dissipated by the globar. Record these values in Table 1.

At this time, jump to procedure step 5. Step 4, constructing ONE graph showing the resistance of both the globar and the tungsten lamp, may be done in lab AFTER step 5 is completed. If time runs out, then the graph of step 4 should be completed at home. *Graphing is neither obvious nor simple; stop in and ask your instructor for assistance in creating this graph.*

4. To meet the second objective of this experiment, it is required that the student plot a curve of the resistance of the globar (**de**pendent variable, on the **vertical** axis) versus the power dissipated by the globar (**in**dependent variable, on the **horizontal** axis). Note: The temperature of the globar increases with the power dissipated by the globar. The globar temperature is not measured directly.

    a. Refer to information on graphing techniques and layout provided by your instructor. This information is very important for the construction of this curve.

    b. For the condition of zero power (I_{globar} = 0) the value of R_{globar} is equal to the cold resistance measured in Procedure 1a. **Be sure to include this plot point on the graph**.

    c. State one major conclusion you can make from an analysis of this curve.

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5. Repeat procedure 1.b through 4.b, this time with the tungsten pilot lamp as the D.U.T., and using the power supply voltages shown in Table 2. Plot your second curve on same piece of graph paper.

    cold lamp resistance:___________

    a. Record all measured data and calculated data in Table 2.

    b. State one major conclusion you can make from an analysis of this curve.

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Table 2 - D.U.T. = Tungsten Lamp

(show UNITS for all parameters)

E_{app}	E_R	E_{lamp}	I	R_{lamp}	P_{lamp}
1 V					
2 V					
3 V					
4 V					
5 V					
6 V					
7 V					
8 V					
9 V					
10 V					
11 V					
12 V					
13 V					
14 V					

HINTS: How to Make a Professional Graph

(Computer Software May NOT Be Used for Graphs in This Experiment)

NOBODY makes a good first graph. Few make a good tenth graph. However, each time you make a graph, your skills at graphing will improve. Do not be discouraged; try to use the sample graph you were given as a model of how to graph. Seek help from your instructor. You WILL become a competent maker of graphs.

1) Use a **full** sheet of commercial graph paper. Make the graph use as much of the area of a full sheet as possible. Do NOT use standard notebook paper.

2) Plan the scaling of each axis. DO use 1, 2, 5, or 10 units per division. NEVER use 3, 6, 7, 8 or 9 units per division; NEVER. IF you must, 4 units per division *may* be used.

3) Plot each data point as a tiny dot. Use a data point indicator (circle, triangle, square, diamond) around each point, and use a different indicator for each curve (globar graph is one curve, tungsten lamp graph is another curve).

4) Use a French curve to make smooth curve, doing a "best fit" to the points. You should **NOT** "connect the dots". Your drawn curve need not hit each point.

5) Put a proper name and unit on each axis. Create **title block** in the body of the graph (but away from the curves), giving **ALL** the information needed. Refer to the sample graph you were given.