

EELE 354 LAB ASSIGNMENT 3:
SERIES AND PARALLEL RESISTORS, OHM'S LAW
AND KIRCHHOFF'S CIRCUIT LAWS

LAB OVERVIEW:

Many electric loads such as electric heaters and light bulbs can be thought of as resistors under normal operating conditions. In power circuitry, resistors themselves can be used to regulate the power delivered to loads. For example, the power delivered to an electric motor can be adjusted using a variable resistor (also sometimes called a rheostat or potentiometer), which in turn regulates the speed and/or torque of the motor. In this lab, students will build and analyze multi-resistive circuits to reinforce the learning of Ohm's Law, and Kirchhoff's Voltage and Current Laws. In doing so, students will view the voltage, current, and power implications of connecting loads (in this lab, the resistors serve as our loads) in series and in parallel. These fundamental concepts are important in understanding the wiring of heating and lighting circuits and power circuits for machinery.

OBJECTIVES:

The objectives of this laboratory assignment are:

- Construct multi-resistive electric circuits and take electrical measurements of the resistors.
- Verify Ohm's Law and Kirchhoff's Current and Voltage Laws by comparing these electrical measurements to calculated values based on theory.
- Extrapolate concepts learned in this lab to comment on the operation of real-world electric circuitry.

PRE-LAB ASSIGNMENT:

Read through the entire lab assignment. In the spaces provided on page 2, draw the schematic diagrams for the circuits that will be assembled for completing items 3 and 9 of this lab assignment. In the schematics, show the complete connection for the power analyzer.

Draw the schematic diagram for item 3 here:

Draw the schematic diagram for item 9 here:

LAB EXPERIMENT:

1. Designate the three resistors (25, 50, 100 Ω) on your workbench as R_1 , R_2 , and R_3 , respectively. Using a multimeter, measure and record below the “true” resistance of each resistor. *Note: Resistors typically have tolerance ratings, e.g. 1% or 5%, meaning that their resistance value will be within the tolerance rating of their nameplate value.*

$$R_1 = \text{_____ } \Omega, \quad R_2 = \text{_____ } \Omega, \quad R_3 = \text{_____ } \Omega$$

2. **Series connect** the resistors in accordance with the table below. Measure the **total combined resistance** of the resistors and record it in the table under column, R_{meas} . Additionally, using the measured resistance values from item 1 above, calculate and record the expected total resistance for each combination in the column, R_{calc} . Finally, calculate and record the percent error in your measurement using the equation,

$$Error = \frac{|R_{calc} - R_{meas}|}{R_{calc}}$$

Resistance	R_{meas} (Ω)	R_{calc} (Ω)	Error (%)
$R_1 + R_2$			
$R_1 + R_2 + R_3$			

3. Connect the single-phase 120 V AC supply to the series combination of all three resistors along with the power analyzer. Ensure that the power analyzer is connected to analyze the supply voltage and the circuit current. **Once your lab instructor checks and approves your circuit, energize your circuit.**
4. Measure the supply voltage, V_{AC} and the circuit current, I_{AC} . Once measured, use the voltmeter portion of the analyzer to measure the voltage, V_R , across each resistor.

$$V_{AC} = \text{_____ } V, \quad I_{AC} = \text{_____ } A,$$

$$V_{R_1} = \text{_____ } V, \quad V_{R_2} = \text{_____ } V, \quad V_{R_3} = \text{_____ } V$$

5. Verify Ohm’s Law (recall: $V = IR$, $I = \frac{V}{R}$, $R = \frac{V}{I}$) by estimating resistance values of the three resistors using the voltage and current measurements of item 4 and ensuring they are similar to the original resistance measurements of item 1.

$$R_{1,est} = \text{_____ } \Omega, \quad R_{2,est} = \text{_____ } \Omega, \quad R_{3,est} = \text{_____ } \Omega$$

6. Verify Kirchhoffs Voltage Law by showing that the individual voltage drops across the three **series connected** resistors sum to the supply voltage.

$$V_{R_1} + V_{R_2} + V_{R_3} = \underline{\hspace{2cm}} \text{ V}$$

7. **De-energize the circuit and disconnect the resistors from the supply.**
8. Connect the resistors in **parallel** according to the table below. Measure the **total combined resistance** of the resistors and record it in the table under column, R_{meas} . Additionally, using the measured resistance values from item 1, calculate and record the expected total resistance for each combination in the column, R_{calc} . Finally, calculate and record the percent error in your measurement.

Resistance	R_{meas} (Ω)	R_{calc} (Ω)	$Error$ (%)
$R_1 R_2$			
$R_1 R_2 R_3$			

9. Connect the supply in series with a power analyzer and the parallel combination of all three resistors. Ensure that the power analyzer is connected so as to measure the total supply current. **Have your lab instructor check and approve your circuit.**
10. Turn on the supply and measure the supply voltage and total circuit current. Then, turn off the supply and connect the ammeter part of the power analyzer to measure the current I_{R_1} (current through R_1). Repeat the above step to measure I_{R_2} and I_{R_3} .

$$V_{AC} = \underline{\hspace{2cm}} \text{ V}, \quad I_{AC} = \underline{\hspace{2cm}} \text{ A},$$

$$I_{R_1} = \underline{\hspace{2cm}} \text{ A}, \quad I_{R_2} = \underline{\hspace{2cm}} \text{ A}, \quad I_{R_3} = \underline{\hspace{2cm}} \text{ A}$$

11. Using the above measured values, verify Kirchhoffs Current Law by showing that the electrical current through the three resistors sums to the total supply current.

$$I_{R_1} + I_{R_2} + I_{R_3} = \underline{\hspace{2cm}} \text{ A}$$

12. De-energize and disassemble your circuit. Return any lab equipment and measurement devices to their appropriate place and ensure your lab bench is clean and organized.

LAB QUESTIONS:

1. In general, residential/commercial circuits, e.g. lighting, have loads wired in parallel. List a couple reasons why this makes sense. Consider that when a lightbulb burns out, it creates an open circuit (similar to removing one of the resistors from the above circuits). Also, consider that standard household lightbulb power ratings assume a 120 V connection.
2. A variable resistor is a resistor who's value can be adjusted by having one of the electrical terminals connected to a sliding contact that can move along a resistive material. These resistors can be placed in series with an electric motor to regulate the electric power delivered to the motor. If the motor is modeled as a resistor (not a great model but sufficient for now), explain how increasing/decreasing the variable resistance affects the current, voltage and overall power (recall $P = IV$) delivered to the motor.

CONCLUSION:

Evaluate the quality and consistency of your work. Note any discrepancies between measured values and expected (calculated) values and explain possible sources of error. Finally, draw conclusions from your work that explains what you learned from this experiment.

Name and initial of lab partners:

Lab Partner 1: _____

Lab Partner 2: _____

Lab Partner 3: _____