QUEENSBOROUGH COMMUNITY COLLEGE
The City University of New York
Department of Engineering Technology

ET 110/H5 – Introduction to Circuit Analysis Laboratory

LAB EXPERIMENT 4
Series Resistance

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ABSTRACT

The physical construction of a series configuration circuit in a protoboard was build according to the rules of series connectivity. The total resistance of a series circuit was measured first using digital multimeter, DMM. The measured values were later compared with the calculated total resistance, which was found by the principal of Ohm's law and Kirchhoff's voltage law. At the end, the percent of difference was determined to be between 0.022% and 0.11% for two and three resistors connected in series configuration.

INTRODUCTION

According to circuit topology, two or more elements are connected in series if they exclusively share a single node and consequently carry the same current. Due to it, an equivalent resistance of resistors connected in series is found by the fundamental circuit laws, Ohm's law and Kirchhoff's law. As it is stated in Ohm's law, where the current through the conductor between points is directly proportional to the potential difference across the two points:

$$I = V/R \qquad (1)$$

and Kirchhoff's voltage law, KVL, where the sum of all voltages is zero volts, then is found that the equivalent resistance of any number of resistors connected in series is the sum of the individual resistance:

$$R_{eq} = R_1 + R_2 + R_3 + \ldots R_N \qquad (2)$$

where N is the total number of resistors connected in series configuration. In this experiment, we determine, by measurements and calculations, the equivalent resistance of different resistors connected in series. The percent of difference between the measured and calculated, using equation 1 and 2, is also states with the following:

$$\%\, Difference = \frac{R_{T(measured)} - R_{T(calculated)}}{R_{T(calculated)}} \times 100\% \qquad (3)$$

II. EXPERIMENT AND PROCEDURE

The components used in lab were:

- Resistors: one of 220 Ω, 330 Ω, 1 kΩ, 100 kΩ (1/4 W), three of 100 Ω (1/4 W)
- Breadboard/protoboard
- Jumper wirers

The Equipment used in lab was:

- DMM
- dc power supply

Post to lab experiment, the total resistance was calculated for part 1, two resistors in series, and part 2, three resistors in series, using equation 2. Calculated results were recorded in Table 4.1.

For the first part of the experiment, two series resistors, we took a 220 Ω and 100 Ω resistor and a protoboard from our lab components kit. The measured value of each resistor, using a digital multimeter, were recorded in the lab manual. Later, both resistors were connected in series configuration in a protoboard: one connected one terminal of the 220 Ω was connected to the positive lead of the digital multimeter and one terminal of the 100 Ω was connected to the negative lead of the digital multimeter. The measured total resistance was recorded in Table 4.1.

After it, the leads for the power supply was obtained from the lab technician and the power supply was set to 8 V: the positive lead of the power was connected to the 220 Ω resistor, and the negative lead to the other terminal of the 100 Ω resistor. After it, the digital multimeter was set to measure current in a milli-amperes scale. Then, the positive lead of the multimeter was connected in series with the circuit by connecting the positive lead of the multimeter with the positive terminal of the power supply, and the negative lead of the multimeter with one terminal of the 220 Ω resistor. The measured the current was 25.1 mA. To confirm the accuracy of the experiment, on a sheet of paper, the total resistance of the circuit was calculated using Ohm's law, equation 1, and the percent of difference, using equation 3, between the measured total resistance, 318.8 Ω, and the calculated total resistance using equation 1, 319 Ω, and equation 2, 318.7 Ω. All calculations were recorded in Table 4.1

For the second part of the experiment, a 330 Ω was included to the experiment and its measured resistance value was 325 Ω. This resistor was connected in series with the previous series circuit. The total resistance of this series circuit was measured using a digital multimeter and measurement was recorded in Table 4.2. Once the total resistance is measured, an 8-volts power supply is applied to power up the series circuit. After it, an ammeter was connected in series with the circuit and the total current was measured and recorded in Table 4.2. Once again, to confirm the accuracy of the experiment, on a sheet of paper, the total resistance was calculated using equation 2, and the percent of difference between the measured total resistance, 644.7 Ω, and the calculated total resistance using equation 1, 644 Ω, and equation 2, 645.2 Ω. All calculations were recorded in Table 4.2.

TABLES

Table 4.1 – Total resistance of two resistors connected in series and % difference between the measured and calculated value: Total resistance value found my measurement using digital multimeter, and by calculation using equation 1 and 2; % difference found using equation (3)

R_T (Calculated)	R_T (Ohmmeter)	% difference	I (Measured)	R_T (Ohm's Law)	% Difference
319 Ω	318.9 Ω	6.3×10^{-2} %	25.1 mA	318.7 Ω	2.2×10^{-2} %

Table 4.2 – Total resistance of three resistors connected in series and % difference: Total resistance value found my measurement using digital multimeter, and by calculation using equation 1 and 2; % difference found using equation (3)

R_T (Calculated)	R_T (Ohmmeter)	% difference	I (Measured)	R_T (Ohm's Law)	% Difference
644Ω	644.7 Ω	1.1×10^{-1} %	12.4 mA	645.2 Ω	7.0×10^{-2} %

CALCULATION

Part 1: two series resistors

R_1(measured) = 218 Ω

R_2(measured) = 101 Ω

$R_T = R_1 + R_2 = 218\ \Omega + 101\ \Omega$

$R_T = 319\ \Omega$

$$\%\,Difference = \frac{318.8\ \Omega - 319\ \Omega}{319\ \Omega} \times 100\% = 0.063\%$$

$$R_T = \frac{E}{I} = \frac{8\ V}{25.1\ mA} = 318.73\ \Omega$$

$$\%\,Difference = \frac{318.8\ \Omega - 318.73\ \Omega}{318.73\ \Omega} \times 100\% = 0.022\%$$

Part 2: Three series resistors

R_1(measured) = 101 Ω

R_2(measured) = 218 Ω

R_3(measured) = 325 Ω

R_T = R1 + R2 + R3 = 101 Ω + 218 Ω + 325 Ω

R_T = 644 Ω

QUESTIONS

1. For a circuit with a constant resistance, what happens to the current as the voltage increases?

If there is a constant resistance in the circuit, the current is directly proportional to the voltage and will increase as the voltage increases.

2. For a circuit with a constant resistance, what kind of relationship (e.g., inverse, linear) does the current have to the voltage?

For a circuit with a constant resistance, current will have a directly proportional and hence linear relationship with voltage. This can be proven by looking at Ohm's law V=I×R and also by looking at the graphs of this experiment.

III. RESULTS AND DISCUSSION

For part 1, two series resistors configuration circuit, 100 Ω and 220 Ω resistors, was built to find the total resistance. The total resistance was found by calculation, using equation 1 and 2, and measurement, using a digital multimeter. Table 4.1 presents the total resistance of two resistors connected in series and the percent of difference between the measured and calculated value. Rearranging from equation 1, indicates that the total resistance of a series configuration circuit is directly proportional to the voltage source and inversely proportional to the current source. According to it, the calculated total resistance was found to be 318.7 Ω. Also, from equation 2, the total resistance of a series configuration circuit is the sum of the individual resistance connected in series, giving a calculated value of 319 Ω. In connection to it, the percent of difference between each calculated value and measured value is found to be 0.022 %, for total resistance calculated using equation 1, and 0.063%, for total resistance calculated using equation 2.

For part 2, Table 4.2 gives the total resistance of three series resistors connected in series configuration, 100 Ω, 220 Ω, and 330 Ω resistors, and the percent of difference between the measured and calculated value. The total resistance is found using equation 1, 645.2 Ω, equation 2, 644 Ω, and by measurement, 644.7 Ω, using a digital multimeter. At the end, the percent of Difference between each calculated value and measured value is found to be 0.07 %, for total resistance calculated using equation 1, and 0.11%, for total resistance calculated using equation 2.

IV. CONCLUSION

We can conclude from our results in part 1 and 2 that the total resistance is directly proportional to the voltage source and inversely proportional to current source, equation 1. Also, in a series resistors circuit, since all resistors share the same current flow, and by applying the principles of Kirchhoff's law, the total resistance of resistors connected in series is the sum of its individual resistance, equation 2. At the end, the percent of difference between the calculated value and measured value is found to be between 0.022% and 0.11%. This indicates that the founding of the total resistance by experiment is almost equal to the calculated value, using different approach theories of resistance in series resistors configuration.