ILLINOIS INSTITUTE OF TECHNOLOGY - PHYS 221 L03

Lab Report - Lab 05: Simple Resistor Circuit

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Introduction

In this lab, we observed how Ohm's Law was applied to resistors in circuits and how they behave in different circuit combinations. Using Ohm's Law V = IR (1) and Kirchoff's Laws, we were able to effectively analyze the simple resistor circuits

Equations:

1. $V = IR$
2. $V = V_1 + V_2 + V_3 + \ldots + V_n$ (for series)
3. $IR = I_1R_1 + I_2R_2 + I_3R_3 + \ldots + I_nR_n$ (for series)
4. $R = R_1 + R_2 + R_3 + \ldots + R_n$ (for series)
5. $I = I_1 + I_2 + I_3 + \ldots + I_n$ (for parallel)
6. $V/R = V_1/R_1 + V_2/R_2 + V_3/R_3 + \ldots + V_n/R_n$ (for parallel)
7. $1/R = 1/R_1 + 1/R_2 + 1/R_3 + \ldots + 1/R_n$ (for parallel)

Experimental Methods

First, we set up our circuit by putting the resistors in series. Each resistor has different resistor values. Then we measured the values with an Ohmmeter and compared them with the color codes. Then, configure the circuit as shown in Figure 2 of the lab manual. After the circuit is set up, set the power supply voltage to 10V and measure the current in the circuit, and after that, measure the potential difference across R_1. Then record the voltage of R_1. Repeat for R_2 and R_3, and verify the voltage adds up to the total voltage of 10V.
For Part 2, set up for resistors in parallel shown in Figure 3 of the lab manual. Then, measure the current of R_1 using the Ammeter. Set the power supply voltage to 10V and measure the overall voltage. After, use the ammeter to measure the current of all the resistors. Then, measure the total current of the circuit, and verify that the total current equals the sum of all the resistor's currents.
For the last part, set up the circuit as shown in Figure 4 of the lab manual. Using the ammeter and the voltmeter, find the current and voltage for all resistors in the circuit. Then, verify that the configuration follows Kirchhoff's Laws.

Results and Discussion

The colors of the four resistors used as well as the measured values and the range were recorded in Table 1, which is shown below.

	Color Code	Nominal Value	Lower bound	Upper Bound	Measured Value
R1	Red, Violet, Brown, Gold	270 Ω	256.5 Ω	283.5 Ω	270 Ω
R2	Green, Blue, Brown, Gold	550 Ω	522.5 Ω	577.5 Ω	551 Ω
R3	Brown, Brown, Red, Gold	1.1 kΩ	1.045 kΩ	1.155 kΩ	1.092 kΩ

R4	Orange, Orange, Red, Silver	3.3 kΩ	2.970 kΩ	3.630 kΩ	3.610 kΩ

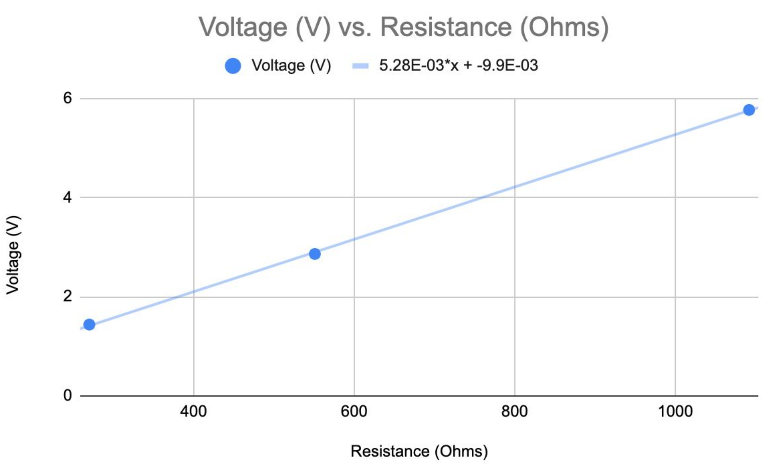
Using the equation for the colors of AB x $10^c \pm D\%$, we get that $R_1 = 70 \pm 13.5\%$, $R_2 = 560 \pm 28\%$, $R_3 = 1100 \pm 55\%$, and $R_4 = 3300 \pm 330\%$. As seen in the calculations and in the data table, the measured resistance values are within the range of the lower and upper bound.

For part 1A, we recorded the data, which is shown in Table 2 below.

Part 1A	Resistors in Series		
	trial 1	trial 2	trial 3
I	0.005 A	0.005 A	0.005 A
V	10.16 V	10.16 V	10.16 V
V1	1.439 V	1.439 V	1.439 V
V2	2.87 V	2.85 V	2.87 V
V3	5.76V	5.77 V	5.77 V

Using the voltage recorded and the resistance calculated, we can plot V/R, which is shown in the graph below.

Graph 1:



Since the equation is linear in the above graph, the slope is constant and represents the current of the circuit, which in the graph is 0.00528A, which is very close to the actual value of 0.005A, proving that Ohm's Law holds constant.

For part 1B, the data recorded is shown below in Table 3.

Table 3:

Part 1B	Resistors in Parallel		
	trial 1	trial 2	trial 3
V	10.08 V	10.09 V	10.09 V
I	0.065 A	0.065 A	0.065 A
I1	0.035 A	0.035 A	0.035 A
I2	0.012 A	0.012 A	0.012 A
I3	0.009 A	0.009 A	0.009 A
I4	0.003 A	0.0025 A	0.003 A

Using these values in the table above, the average values for current of all the resistors are 0.035A, 0.012A, 0.009A, and 0.003A for R_1, R_2, R_3, and R_4, all measured using the ammeter.

For part 2, the resistors were placed in a parallel series combination. Below are the values recorded in the table.

Table 4:

Part 2	Resistors in Parallel and Series Combination		
	trial 1	trial 2	trial 3
V	10.03 V	10.06 V	10.03 V
V1	4.23 V	4.24 V	4.24 V
I1	0.015 A	0.015 A	0.015 A
V2	5.76 V	5.77 V	5.76V
I2	0.010 A	0.0120 A	0.0120 A
V3	5.76 V	5.76 V	5.76 V
I3	0.005 A	0.005 A	0.005 A

Using the values from the table above the average values for V_1, V_2, and V_3 are 4.24V, 5.76V, and 5.76V respectively, while the average values for I_1, I_2, and I_3 are 0.015A, 0.011A, and 0.005A respectively.

Part 1 Procedure A Questions

1. Find the experimental value of the resistance of each resistor using Equation 1 (i.e. R1 = V1/I, etc.).
    a. $R_1 = V_1/I = 1.439/0.005 = 287.8\Omega$
    b. $R_2 = V_2/I = 2.863/0.005 = 572.6\Omega$
    c. $R_3 = V_3/I = 5.767/0.005 = 1153.4\Omega$
2. Find the experimental value of the total effective resistance R in series using the value of I, total V, and Equation 3.
    a. $V = V_1 + V_2 + V_3 = 5.76 + 2.87 + 1.439 = 10.16V$
    $10.16 = (0.005)R$
    $R = 2032\Omega$
3. Compare resistance values for R1, R2, and R3 obtained from the ohmmeter with those found using Ohm's Law.
    a. Table 5:

Measured R (Ω)	Calculated R (Ω)	% difference
270	287.8	6.38%
551	572.6	3.84%
1092	1153.4	5.47%

Since the percent difference is a small value, then we know that our values are accurate.

4. (Why didn't we use resistor number 4?!?) Using the measured values of resistance, estimate the value of I with all 4 resistors in series (v = 10V), and compare the result to the resolution of the Ammeter on it's most sensitive scale.

a. We did not use resistor 4 because we could not measure the current using our equipment because the value would be too small for the equipment to read it.
$R = R_1 + R_2 + R_3 + R_4 = 5523\Omega$
$V = IR$
$10 = I(5523)$
$I = 0.0018A$

Part 1 Procedure B Questions

1. Find the experimental value of the resistance of each resistor using Equation 1.
   a. $R_1 = V/I_1 = 10.083/0.065 = 288.094\Omega$
   $R_2 = V/I_2 = 10.083/0.012 = 840.277\Omega$
   $R_3 = V/I_3 = 10.083/0.009 = 1120.37\Omega$
   $R_4 = V/I_4 = 10.083/0.003 = 3361.111\Omega$
2. Find the experimental value of the total effective resistance R using the value of total I, total V, and Equation 1.
   a. $R = V/I_{tot} = 10.083/0.065 = 155.126\Omega$
3. Compare the experimental value of R with the one calculated using Equation 7.
   a. $R_{eq} = (1/R_1 + 1/R_2 + 1/R_3 + 1/R_4)^{-1} = 170.904$
   b. Using the percent difference formula, the difference between the 2 values is 9.682%. Because of the low value for the percent difference, we know that our data is accurate.

Part 2 Calculations

$V_1 = 4.237V$ $V_2 = 5.763V$ $V_3 = 5.76V$ $I_1 = 0.015A$ $I_2 = 0.011A$ $I_3 = 0.005A$
$R_1 = 270\Omega$ $R_2 = 551\Omega$ $R_3 = 1092\Omega$

$I_1 = I_2 + I_3$ $V = V_1 + V_2$ $V_2 = V_3$
Therefore, Kirchoff's rule holds true.
$\frac{V_1}{270} = \frac{V_2}{551} + \frac{V_3}{1092}$
$x = V_2 = V_3$ and $y = V_1$
$\frac{y}{270} = \frac{1092x+551x}{1092}$
$443610x=1092y$
$V_{tot} = 10V$
$10 = y+x$
$x = 10 - y$
$y = 9.975$
$V_1=9.975V$
$V_2=V_3=4.988V$ by dividing V_1 by 2
$V = IR$
$I_1= 0.037A$, $I_2= 0.009A$, $I_3= 0.005A$.

Conclusion

Using resistors inside circuits in series and in parallel, we were able to see the relationship of the voltage, amps, and resistance by proving that the configurations follow Ohm's Law and

Kirchhoff’s Rules by substituting the values in Ohm’s Law, and comparing the measured and experimental values.