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TECH 1010 } TNR 14

Lab #1

Ohm's Law > TNR 20

Conducted 4/18/18 > TNR14

By *yourname* > TNR14 (italics not needed)

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INTRODUCTION

During the nineteenth century so many advances were made in understanding the electrical nature of matter that it has been called the "age of electricity." One such advance was made by an investigator named Georg Simon Ohm. Ohm was interested in examining the relative conductivity of metals and in investigating the relationship between the electromotive force (potential difference) and the current in a conductor.

By taking wires made from different materials but having the same thickness, passing a current through these wires and measuring the electromotive force (i.e., the potential difference between the ends of the conducting wire), he was able to experimentally determine the relative conductivity of certain metals such as silver, copper, and gold.

In another experiment using a piece of apparatus that he built himself, Ohm investigated the effect of current in a conductor on the voltage drop across the conductor. He found that for a given conductor the voltage drop was directly proportional to the current in the wire. When voltage is plotted against the current in a given conductor, the data can be fitted to a straight line, the slope of which is the ***resistance*** of the conductor. This result was published in 1826. In recognition of Ohm's work, this empirical relationship bears his name.

DISCUSSION OF PRINCIPLES

Ohm's Law can be written algebraically as:

$$V = IR \qquad (1)$$

$$I = \frac{V}{R} \qquad (2)$$

$$R = \frac{V}{I} \qquad (3)$$

where V represents the potential drop across the conductor (measured in **volts**), I the current in the conductor (measured in **amperes**), and R the resistance of the conductor measured in units called **"ohms"** (symbolized by Ω, upper-case Greek omega).

Resistance and Resistors

Resistance is a property of materials. Resistors are conducting devices made from materials which satisfy Ohm's Law.

If the potential difference across a resistor is set at 1 volt, and if a current of 1 amp is measured in the conductor, then its resistance is determined to be 1Ω, or 1W. Instead of using thin wires as Ohm did in his original experiment, you will replicate his results using small cylindrical ceramic resistors. You will notice colored bands on the resistors. These bands form a code that indicates the resistance of the resistor. Later in this experiment you will learn how to read this color code.

Combinations of Resistors

Resistors can be combined in simple circuit arrangements that increase or decrease the overall resistance in the circuit. These arrangements are called parallel and series circuits. Figure 1 shows the resistors in a parallel arrangement and Figure 2 illustrates two resistors connected in series.

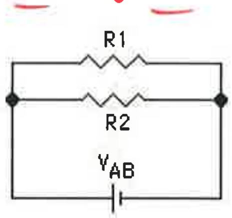


Figure 1 - Parallel Circuit

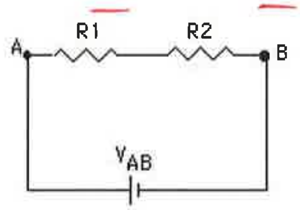


Figure 2 - Series Circuit

In order for charges to move in a conductor, there must be a potential difference across the conductor. In order for charges to move through a circuit, there must be a complete path leading away from and back to the source of emf (V_{AB} in Figure 1).

As you can see, in the parallel arrangement shown in Figure 1, the current can divide at the junction A and recombine at junction B. Therefore, the current through R_1 and R_2 may be different. Notice that in this case

$$V_{AB} = V_1 = V_2 \tag{4}$$

That is, the potential drop across each resistor is the same.

In the series arrangement shown in Figure 2 the current in the circuit goes through each resistor. If we compute the potential drop V_1 across R_1 using Ohm's Law, it is merely:

$$V_1 = IR_1 \tag{5}$$

Likewise, the drop across R_2 is:

$$V_2 = IR_2 \tag{6}$$

The potential drop across both resistors is:

$$V_{AB} = V_1 + V_2 \tag{7}$$

One can think of the applied voltage V_{AB} being divided between the two series resistors R_1 and R_2.

Using some simple algebra and your understanding of the potential drops in a simple series or parallel circuit, the relationships for determining equivalent resistance for resistors in series and/or parallel can be derived. These relationships are:

(Parallel)
$$\frac{1}{R_{equivalent}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_n} \tag{8}$$

(The reciprocal of the equivalent resistance is the sum of the reciprocals of the individual resistances.)

$$R_{equivalent} = R_1 + R_2 + R_n \quad (9)$$

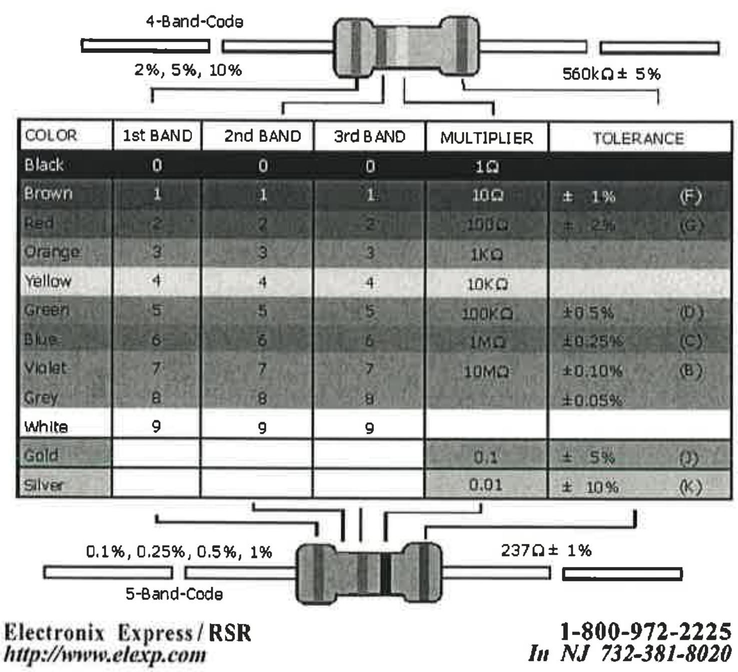
(Series)

(The equivalent resistance is simply the sum of the individual resistances.)

As suggested by the equations above, the sums include a term for each resistor in the circuit.

Resistor Color Code

Resistors are available in many different values, shapes, and physical sizes. Practically all leaded resistors with a power rating up to one watt have a pattern of colored bands that are used to indicate resistance value, tolerance. There are typically four bands on the body of a resistor. The first few bands always represent digits in the value of resistance. Then you will find a multiplier band to signify moving the decimal right or left. The last bands represent tolerance. [1] Below is a chart of the resistor color code:



COLOR	1st BAND	2nd BAND	3rd BAND	MULTIPLIER	TOLERANCE
Black	0	0	0	1Ω	
Brown	1	1	1	10Ω	± 1% (F)
Red	2	2	2	100Ω	± 2% (G)
Orange	3	3	3	1KΩ	
Yellow	4	4	4	10KΩ	
Green	5	5	5	100KΩ	±0.5% (D)
Blue	6	6	6	1MΩ	±0.25% (C)
Violet	7	7	7	10MΩ	±0.10% (B)
Grey	8	8	8		±0.05%
White	9	9	9		
Gold				0.1	± 5% (J)
Silver				0.01	± 10% (K)

Figure 3 - Resistor Color Code

Parts List

- Breadboard
- 2 – 10KΩ Resistors
- Power supply
- DMM

PROCEDURE:

1. Read each the resistor color code and record the nominal resistor value and tolerance in a Table 1.

2. Now place each resistor on a breadboard and connect the DMM to measure the resistor as follows:

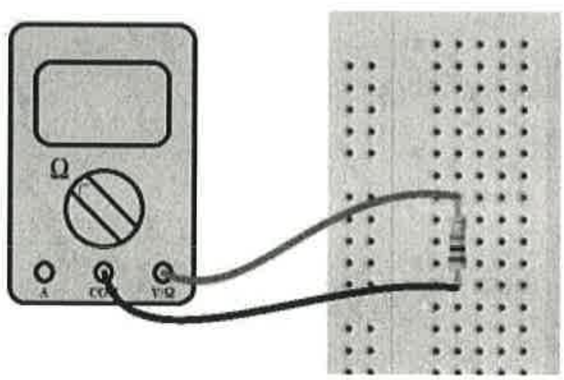


Figure 4 - Measuring Resistance

Record the readings for each resistor and record in Table 1.

3. Calculate the % error using Equation (10)

$$\% \, Error = \frac{Theoredical \, Value - Measure \, Value}{Theoretical \, Value} * 100 \qquad (10)$$

Where: Theoretical Value is the resistor color code value
Measure Value is the DMM Measurement

Record the % Error in Table 1.

4. Using Equation (9), calculate the total resistance of the two resistors in series using both the color code values and the measured value. Place you answers in Table 2.

5. Hook up the circuit as show in Figure 5 . Measure the Total Resistance of the two resistors in series and place you answer in Table 2.

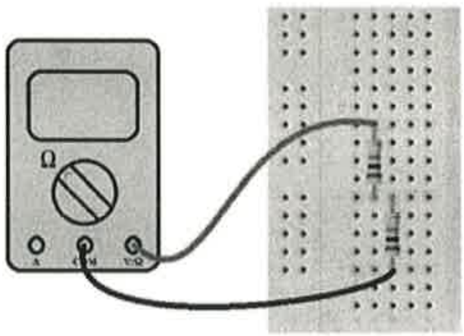


Figure 5 - Series Resistance

6. Now replace the DMM in Figure 5 with a 10V power supply. Measure the current and voltages as shown below:

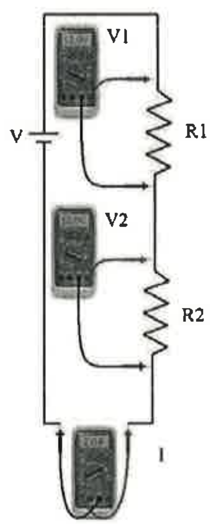


Figure 6 - Measuring a Series Circuit

Record V_1, V_2 and I.

7. Using Ohm's Law, calculate the values of R_1 and R_2.

8. Using Equation (8), calculate the total resistance of the two resistors in parallel using both the color code values and the measured value. Place you answers in Table 2.

9. Hook up the circuit as show in Figure 7. Measure the Total Resistance of the two resistors in series and place you answer in Table 3.

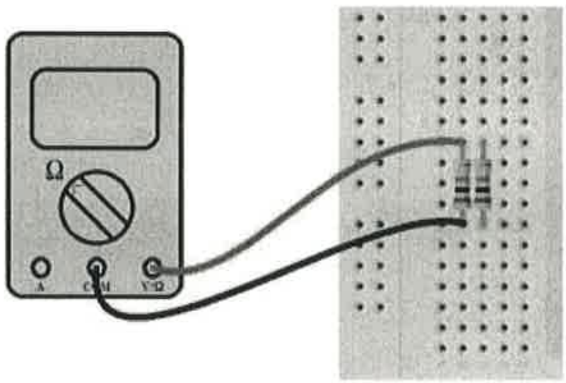


Figure 7 - Parallel Resistors

10. Now replace the DMM in Figure 5 with a 10V power supply. Measure the current and voltages as shown below:

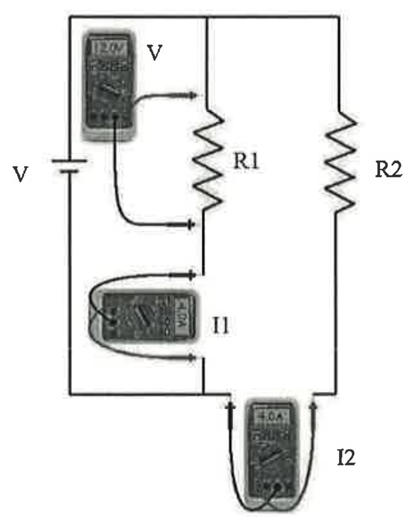


Figure 8 - Measuring a Parallel Circuit

Record V, I_1 and I_2.

11. Using Ohm's Law, calculate the values of R_1 and R_2.

12. Do NOT dismantle the circuit.

13. Calculate expected I_1 and I_2 using Ohm's Law (and measured resistances) and place in Table 4.

14. Leaving the circuit intact, adjust the power supply to 5V. Measure V, I_1 and I_2 and record in Table 4. Increase (in increments of 1V) and record the new values in the table. Repeat up to and including 15V.

15. Graph V vs I for both R_1 and R_2 as an XY Plot. Add a linear trendline on each graph for the measured V vs I along with equation and R^2 value.

Results

Steps 1-3

Table 1 – Theoretical and Measured Values of Resistors

	Color Code Resistor Value (Ω)	Tolerance	Min Resistance (Ω)	Max Resistance (Ω)	Measured Resistance (Ω)	Error (%)
R1	10000	5%	9500	10500	10025	-0.25
R2	10000	5%	9500	10500	9953	0.47

Steps 4-7

Calculation of Resistors in Series

$$R_{series} = R_1 + R_2$$

$$R_{Theoretical} = 10000 + 10000$$
$$= 20000$$

$$R_{Measured} = 10025 + 9953$$
$$= 19978$$

Table 2 – Theoretical and Measured Values of Resistors in Series

From Excel

	Total Resistance (Ω)	Theoretical Total Resistance (Ω)	Theoretical Total Resistance Using Measured (Ω)
Rseries	19972	20000	19978

Measured values from Circuit

$V_1 = 5.068V$

$V_2 = 5.026V$

$I = 0.505mA$

Using Ohm's Law

$$R_1 = \frac{V_1}{I}$$

$$= \frac{5.068V}{0.505mA}$$

$$= 10035.6\Omega$$

align =

$$R_2 = \frac{V_2}{I}$$

$$= \frac{5.026V}{0.505mA}$$

$$= 9952.5\Omega$$

align =

h2 Steps 8-11

Calculations of Resistors in Parallel

$$\frac{1}{R_{equivalent}} = \frac{1}{R_1} + \frac{1}{R_2}$$

$$R_{Theoretical} = 1/(1/10000 + 1/10000)$$
$$= 5000$$

↑ align =

$$R_{Measured} = 1/(1/10025 + 1/9953)$$
$$= 4994$$

↑ align =

Table 3 – Theoretical and Measured Values of Resistors in Parallel

↙ From Excel

	Total Resistance (Ω)	Theoretical Total Resistance (Ω)	Theoretical Total Resistance Using Measured (Ω)
Rparallel	4995	5000	4994

Measured values from Circuit

$$V = 10.1V$$

$$I_1 = 1.007mA$$

$$I_2 = 1.015mA$$

Using Ohm's Law

$$R_1 = \frac{V}{I_1}$$
$$= \frac{10.1V}{1.007mA}$$
$$= 10029.8\Omega$$

↑ align =

$$R_2 = \frac{V}{I_2}$$
$$= \frac{10.1V}{1.015mA}$$
$$= 9950.7\Omega$$

↑ align =

h2 Steps 13-15

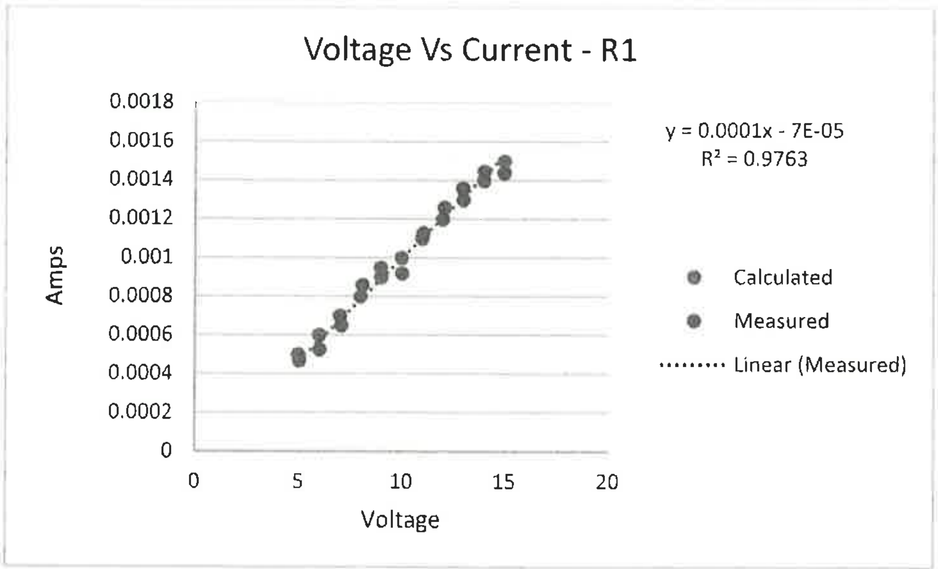
Table 4 – Theoretical and practical currents for various input voltages

From Excel

R1 =	10025
R2 =	9953

Calculated		
Voltage	I1	I2
5	0.000499	0.000502
6	0.000599	0.000603
7	0.000698	0.000703
8	0.000798	0.000804
9	0.000898	0.000904
10	0.000998	0.001005
11	0.001097	0.001105
12	0.001197	0.001206
13	0.001297	0.001306
14	0.001397	0.001407
15	0.001496	0.001507

Measured		
Voltage	I1	I2
5.04	0.000467	0.000545
6.02	0.000524	0.000702
7.06	0.000649	0.000753
8.09	0.000857	0.000821
8.99	0.000947	0.000831
10.02	0.000919	0.001033
11.05	0.001126	0.001037
12.08	0.001257	0.001251
12.98	0.001356	0.001293
14.02	0.001444	0.001412
14.99	0.001435	0.001436



From Excel

Figure 9 - Voltage vs Current R1

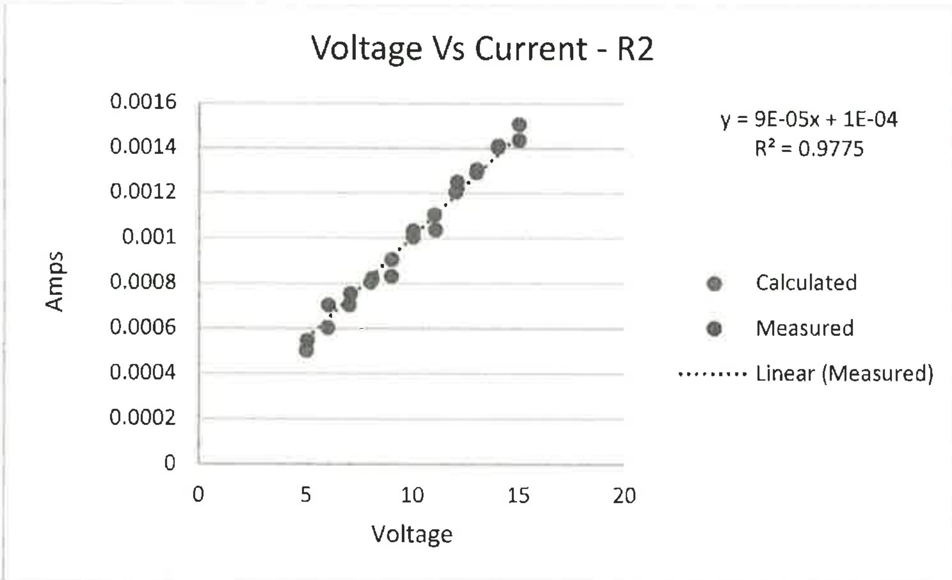


Figure 10 - Voltage vs Current R2

Discussion

Steps 1-3 – Resistance Measurement

As seen in Table 1, the resistor values R_1 and R_2 color code values to not match the measured values exactly, but are within the tolerance of the resistor (as shown in the error column as compare to the tolerance column).

Steps 4-7 – Resistors in Series

As shown in Table 2, the measured total resistance is almost identical to that of the theoretical total resistance calculated and is within the tolerance of the resistor values (5%).

The calculations show that using Ohm's law, the calculated values of the resistances are within acceptable errors of the measured resistor values.

Steps 8-11 – Resistors in Parallel

As shown in Table 3, the measured total resistance is almost identical to that of the theoretical total resistance calculated and is within the tolerance of the resistor values (5%).

The calculations show that using Ohm's law, the calculated values of the resistances are within acceptable errors of the measured resistor values.

Steps 13-15 – Ohm's Law with varying input voltages

As shown in Table 4, the calculated values of the currents flowing though the resistors closely matches the measured values. Also, since the relationship of V vs I for both R_1 and R_2 are close to a straight line and the R^2 values are close to 1 (perfect relationship), this proves the relationship of Ohm's Law, as per equation (3) is correct.

Error Analysis

As seen in the graphs, slight measurement errors do occur and show up as points off the straight light (and R^2 not being equal to one). These are probably due to measurement errors cause.

Conclusion

As seen in the results, calculated resistors in series and parallel matched the measured results. Also, Ohm's law was proven by showing the calculated expected currents and the measured currents were within acceptable limits as compared to the ratio of voltage to resistance.

Bibliography

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[1] "Cracking the Resistor Color Code," Arrow Electronics, [Online]. Available: https://www.arrow.com/en/research-and-events/articles/resistor-color-code. [Accessed 18 April 2018].

[2] T. L. Floyd, "Principles of Electic Circuits: Conventional Current Version 9th Ed," Upper Saddle River, New Jersey, Pearson Education, 2005.

[3] "All About Circuits Chapter 2 - Ohm's Law," EETech Media LLC, [Online]. Available: https://www.allaboutcircuits.com/textbook/direct-current/chpt-2/voltage-current-resistance-relate/. [Accessed 17 4 2018].

[4] "Series and Parallel Circuits," Sparkfun, [Online]. Available: https://learn.sparkfun.com/tutorials/series-and-parallel-circuits. [Accessed 19 April 2018].

[5] "AUSV 1320 Open Automotive Electronics," Weber State, [Online]. Available: https://weber.instructure.com/courses/181471. [Accessed 19 April 2018].

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