Laboratory Exercise #1

Verification of Ohm's Law

by

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In partial fulfillment of the requirements for Technology 1811
Electronic Circuit Technology
Lecture Section 001
Lab Section 001

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To: Prof. Nick Tesla

OBJECTIVES:

1. To verify Ohm's Law, which defines the relationship between voltage, current and resistance in a series circuit. Ohm's law states that the total current in a circuit (I) is equal to the total impressed voltage (E) divided by the total series resistance (R). The fundamental mathematical form of Ohm's Law is:

$$I = \frac{E}{R}$$

   Where: I is the total circuit current in amperes
   E is the total impressed voltage in volts
   R is the total resistance in ohms

2. To verify the law for resistors in series, which states that in a series circuit, the total resistance of the series circuit is equal to the sum of the individual series resistances.

3. To become familiar with the resistor color code used to identify resistance values. In this color code each color represents a specific digit from 0 through 9. "The color bands are always read from the end that has the band closest to it ... The first and second bands represent the first two digits, respectively. The third band determines the power-of-10 multiplier for the first two digits (actually the number of zeros that follow the first and second digit)."[1] The fourth band (or lack thereof) specifies the manufacturer's tolerance for the resistance value. The colors and the associated digits are:

Bands 1-3 (Nominal Resistance)		Band 4 (Tolerance)	
0	Black	5%	Gold
1	Brown	10%	Silver
2	Red	20%	No Band
3	Orange		
4	Yellow		
5	Green		
6	Blue		
7	Violet		
8	Gray		
9	White		

4. To become familiar with the analog trainer and protoboard, used for the construction and testing of circuits in completing laboratory exercises.

5. To become familiar with the proper usage of measuring instruments, specifically the Digital Multimeter.

MATERIALS and EQUIPMENT:

   1.0 kΩ and 1.2 kΩ resistors
   Analog Trainer: K&H Model IDL-600, Serial No. 4052
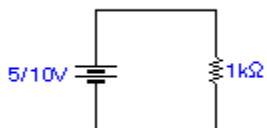   Digital Multimeter: B&K Precision Model 2831A, Serial No. 211-05850

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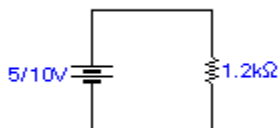
SCHEMATICS:

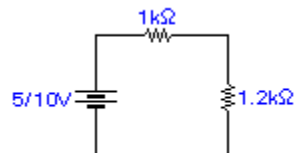Figure 1   Figure 2   Figure 3

PROCEDURE:

1. Using the color codes, determine the value of each resistor and record the results in Table 1.
2. Measure each resistor value using the DMM and record the results in Table 1.
3. Construct the circuit shown in Figure 1.
4. Using a supply voltage of 5V, measure the total circuit current, supplied voltage, and the voltage drop across the resistor. Record results in Table 2.
5. Repeat step 4 using a supply voltage of 10V. Record results in Table 2.
6. Construct the circuit shown in Figure 2.
7. Using a supply voltage of 5V, measure the total circuit current, supplied voltage, and the voltage drop across the resistor. Record results in Table 3.
8. Repeat step 7 using a supply voltage of 10V. Record results in Table 3.
9. Construct the circuit shown in Figure 3. Measure the total series resistance and record the result in Table 4.
10. Using a supply voltage of 5V, measure the total circuit current, supplied voltage, and individual resistor voltage(s). Record results in Table 4.
11. Repeat step 10 using a supply voltage of 10V. Record results in Table 4.
12. Compare the results obtained in steps 3 through 11 to expected values.

RESULTS/DATA:

Table 1 - Resistor Data

Nominal Value	Tolerance Range	Color Code	Actual Value
1.0 kΩ ± 5%	950Ω to 1050Ω	BRN BLK RED GLD	978Ω
1.2 kΩ ± 5%	1140Ω to 1260Ω	BRN RED RED GLD	1196Ω

Table 2 - Data for circuit in Figure 1

	E = 5V		E = 10V	
	Expected	Actual	Expected	Actual
Resistance	1.0 kΩ	978Ω	1.0 kΩ	978Ω
Voltage	5.0 V	5.0 V	10.0 V	10.0 V
Current	5.0 mA	5.11 mA	10.0 mA	10.2 mA
Voltage Drop	5.0 V	5.0 V	10.0 V	10.0 V

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RESULTS/DATA (continued):

Table 3 - Data for circuit in Figure 2

	E = 5V		E = 10V	
	Expected	Actual	Expected	Actual
Resistance	1.2 kΩ	1196Ω	1.2 kΩ	1196Ω
Voltage	5.0 V	5.0 V	10.0 V	10.0 V
Current	4.17 mA	4.19 mA	8.30 mA	8.37 mA
Voltage Drop	5.0 V	5.0 V	10.0 V	5.0 V

Table 4 - Data for circuit in Figure 3

	E = 5V		E = 10V	
	Expected	Actual	Expected	Actual
R_1	1.0 kΩ	978Ω	1.0 kΩ	1.0 kΩ
R_2	1.2 kΩ	1196Ω	1.2 kΩ	1.2 kΩ
$R_{T (series)}$	2.2 kΩ	2174Ω	2.2 kΩ	2.2 kΩ
Voltage	5.0 V	5.0 V	10.0 V	10.0 V
Current	2.27 mA	2.30 mA	4.55 mA	4.60 mA
VR_1	2.27 V	2.25 V	4.55 V	4.50 V
VR_2	2.72 V	2.75 V	5.45 V	5.50 V

DISCUSSION:

As can be seen from the data presented above, Ohm's law can be easily verified using a simple circuit. If the applied voltage and resistance in a series circuit are known, the total circuit current can be predicted using Ohm's law. In fact, if any two of the three terms (voltage, current and resistance) are known, the third can be readily determined.

Consider the data presented in Table 2 above where the nominal resistance is 1kΩ and the applied voltage is 5V. Using Ohm's law, the current flowing in the circuit is expected to be 5mA; the measured current, however is 5.11mA. Although obviously different, these two values become very much in agreement if the current is again calculated using the resistor's actual value of 978Ω. In this case the expected current would be 5.11mA. This phenomenon is seen again in the data of Table 3.

Table 4 represents the data for the series circuit in Figure 4. In this circuit both resistors are placed in series. As before, the total circuit current can be calculated using Ohm's law. In this circuit the total series resistance, which is the sum of the individual resistances, is used as the resistance term. Here the total circuit current with 5V applied was expected to be 2.27mA, but the measured value was 2.3mA. As in earlier discussion, this difference is due to the actual values of the resistances. When calculated based on the measured value for total series resistance, the total circuit current can be expected to be 2.3mA, in direct agreement with the measured value.

The resistor color code was very useful in determining the values of the individual resistors. The data presented in Table 1 indicates that both of the resistors selected were within the tolerance range specified by the color code.

In executing this laboratory exercise, prior planning has proved to be invaluable. For example, determining resistor color codes prior to the laboratory period helped to expedite the location and selection of the proper resistors. Additionally, planning for the types of measurements which must be made and developing a protoboard circuit layout which facilitates these measurements reduced the time required to

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complete the laboratory exercise and decreased the possibility of error. For example, the use of jumpers which can be removed in order to measure circuit current helps to prevent errors which occur when circuit components are repeatedly disconnected and then reconnected. Pre-lab calculations of all expected circuit values is also of great assistance in recognizing when problems do occur.

CONCLUSIONS:

- The data presented and the discussion above have verified the use and accuracy of Ohm's law in solving for basic electronic circuit values. Calculations of circuit current have been shown to be in agreement with the measured values.
- The law for resistors in series has also been verified in that the expected value for total series resistance is in agreement with the measured value.
- Familiarity was easily gained with the resistor color coding scheme as can be evidenced by the fact that the resistors selected using the color code were indeed the required values and were found to be within the specified tolerance range.
- Experience with the lab trainer, protoboard and digital multimeter was gained as a result of performing the lab exercise, however proficiency with this equipment will require additional use.

REFERENCES:

[1]Boylestad, Robert L., Introductory Circuit Analysis, 7th ed., Prentice-Hall, 1997, page 74.

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