**A-4-(1).**

**Series Circuits**

**OBJECTIVES:**

After performing this experiment, you will be able to:

1. Use Ohm’s law to find the current and voltages in a series circuit.

2. Apply Kirchhoff’s voltage law to a series circuit.

**READING:**

Electric Circuits, Sections 2 and 3

**MATERIALS NEEDED:**

Resistors:

One 330 Ω, one 1.0 kΩ, one 1.5 kΩ, one 2.2 kΩ

One dc ammeter, 0-10 mA

For Further Investigation: Small light-emitting diode (T-l or equivalent)

**SUMMARY OF THEORY:**

The current in a resistor is directly proportional to the voltage across the resistor as stated by Ohm’s law. Consider the simple circuit illustrated in Figure 1. The source voltage is the total current multiplied by the total resistance. This can be stated in equation form as

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| |  | | --- | | Z:\임시 인터넷 파일\Content.Word\figure6-1.jpg | | **Figure 1** | | |  | | --- | | Z:\임시 인터넷 파일\Content.Word\figure6-2.jpg | | **Figure 2** | |

In a series circuit, the circuit elements are connected together with only one path for current. Figure 2 illustrates a series circuit with two resistors. When we join resistors in series, the total resistance is the sum of the individual resistors. The total resistance for the circuit in Figure 2 is

Substituting this equation into Ohm’s law gives

Multiplying both terms by results in

The identical current, , must flow through each resistor. This causes a voltage drop across each I resistor, which can be expressed as

This result illustrates that the source voltage is equal to the sum of the voltage drops across the resistors. This relationship illustrates *Kirchhoff’s voltage law*, which is more precisely stated as

|  |
| --- |
| The algebraic sum of all voltage rises and drops around  any single closed path in a circuit is equal to zero. |

It is important to pay attention to the polarity of the voltages. Current from the source creates a voltage drop across the load. The voltage drop across the load will have an opposite polarity to the source voltage, as illustrated in Figure 2. We may apply Kirchhoff’s voltage law by using the following rules:

1. Choose an arbitrary starting point. Go either clockwise or counterclockwise from the starting point.

2. For each voltage source or load, write down the first sign you see and the magnitude of the voltage.

3. When you arrive at the starting point, equate the algebraic sum of the voltages to zero.

**PROCEDURE:**

1. Obtain the resistors listed in Table 1. Measure each resistor and record the measured value in Table 1. Compute the total resistance for a series connection by adding the measured values. Enter the computed total resistance in Table 1 in the column for the listed value.

2. Connect the resistors in series, as illustrated in Figure 3. Measure the total resistance of the series connection and verify that it agrees with your computed value. Enter your measured value in Table 1.

|  |
| --- |
|  |
| **Figure 3** |

3. Complete the circuit shown in Figure 4, making certain that the ammeter is connected in series; otherwise damage to the meter may result. Before applying power, have your instructor check your circuit. Compute the current in the circuit by substituting the source voltage and the total resistance into Ohm’s law; that is

Record the computed current in Table 2. Apply power, and confirm that your computed current is within experimental uncertainty of the measured current. Record the measured current in Table 2.

4. In a series circuit, the same current flows through all components. We can use the total current from step 3 and Ohm’s law to compute the voltage drop across each resistor. Compute by multiplying the total current by the resistance between A and B. Record the results as the computed voltage in Table 2.

5. Repeat step 4 for the other voltages listed in Table 2.

6. Measure and record each of the voltages listed in Table 2.

|  |
| --- |
| Z:\임시 인터넷 파일\Content.Word\figure6-4.jpg |
| **Figure 4** |

7. Using the source voltage (+ 15 V) and the measured voltage drops listed in Table 2, prove that the algebraic sum of the voltage rises and drops is zero (within experimental uncertainty). Do this by applying the rules listed in the Summary of Theory. Write the algebraic sum of the voltages on the first line of Table 3. The polarities of voltages are shown on Figure 4.

8. Repeat step 7 by starting at a different point in the circuit and traversing the circuit in the opposite direction. Write the algebraic sum of the voltages on the second line of Table 3.

9. Open the circuit at point B. Measure the voltage across the open circuit. Call this voltage . Prove that Kirchhoff’s voltage law is still valid for the open circuit. Write the algebraic sum of the voltages on the third line of Table 3.

|  |  |
| --- | --- |
| **Report for**  **Experiment A-4** | **Name**  **Date**  **Class** |

**ABSTRACT:**

**DATA:**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| |  |  |  | | --- | --- | --- | | **Table 1** | | | | Component | Listed  Value | Measured  Value | |  | 1.0 kΩ |  | |  | 1.5 kΩ |  | |  | 2.2 kΩ |  | |  | 330 Ω |  | |  |  |  | | |  |  |  | | --- | --- | --- | | **Table 2** | | | |  | Computed  Value | Measured  Value | |  |  |  | |  |  |  | |  |  |  | |  |  |  | |  |  |  | |
| |  |  | | --- | --- | | **Table 3** | | | Step Number | Kirchhoff’s Voltage Law (Measured Values) | | 7 |  | | 8 |  | | 9 |  | | |

**RESULTS AND CONCLUSION:**

**EVALUATION AND REVIEW QUESTIONS:**

1. Why doesn’t the starting point for summing the v1oltages around a closed loop make any difference?

2. Kirchhoff’s voltage law applies to any closed path, even one without current. How did the result of step 9 show that this is true?

3. Based on the result you observed in step 9, what voltage would you expect in a 120 V circuit across an open (blown) fuse?

4. Use Kirchhoff’s voltage law to find in Figure 7.

|  |
| --- |
|  |
| **Figure 7** |

5. A 10 Ω resistor is in series with a bulb and a 12 V source.

(a) If 8 V is across the bulb, what voltage is across the resistor?

(b) What is the current in the circuit?

(c) What is the resistance of the bulb?

6. A student wishes to limit the current to an LED (light-emitting diode) to 10.0 mA. The source voltage is +5 V and the diode drops 1.8 V.

(a) What value resistance is required?

(b) What power is dissipated in the resistor?