East West University
Department of Computer Science and Engineering

Course: CSE209 Electrical Circuits
Expt No.: 2
Title: Series-Parallel DC Circuit and Verification of Kirchhoff's Laws

Objectives:

1. To learn analysis of dc series-parallel circuit.
2. To verify Kirchhoff's Voltage Law (KVL).
3. To verify Kirchhoff's Current Law (KCL).

Theory:

Kirchhoff's Voltage Law (KVL) states that **the sum of the voltage rises around a closed path is equal to the sum of the voltage drops**. The KVL can be written in the following mathematical form:

$$\sum V_{rises} = \sum V_{drops}.$$

The sum of the voltage rises and the sum of the voltage drops are to be calculated in a given direction (normally in the clockwise direction). For example, in the simple series circuit of Figure 1, there are two voltage sources (E_1 and E_2) and two resistors (R_1 and R_2). The voltage drops across the two resistors are V_1 and V_2, respectively. If we write KVL equation for the clockwise direction, then the KVL equation will be

$$E_1 - E_2 = V_1 + V_2.$$

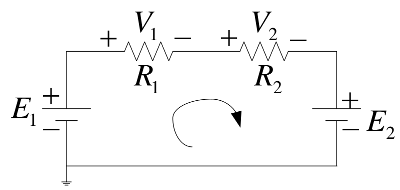

Figure 1. A simple series dc circuit.

Kirchhoff's Current Law (KCL) states that **the sum of the currents entering a node of a circuit is equal to the sum of the currents leaving the node**. The KCL can be written in the following mathematical form:

$$\sum I_i = \sum I_o.$$

For example, in the simple parallel circuit of Figure 2, there is a voltage source (E) and two resistors (R_1 and R_2). The source current drawn from the voltage source is I_s. The currents through resistors R_1 and R_2 are I_1 and I_2, respectively. If we consider the node *a* of the circuit, then I_s is entering the node and I_1 and I_2 are leaving the node. Then, the KCL equation for the node *a* is

$$I_s = I_1 + I_2.$$

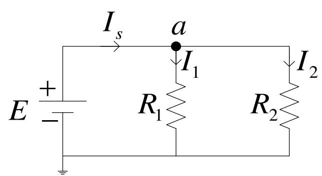

Figure 2. A simple parallel dc circuit.

A series-parallel circuit is one that is formed by a combination of series and parallel resistors. For solving series-parallel circuit, parallel combinations of resistors and series combination of resistors are clearly identified. Then series-parallel reduction method is used to determine the values of the circuit variables. For example, in the simple series-parallel circuit of Figure 3, the resistors R_2 and R_3 are in parallel and this parallel combination is in series with the resistor R_1. As the resistors R_2 and R_3 are in parallel, $V_2 = V_3$. Let $R_p = R_2 \parallel R_3$. Then, the equivalent resistance of the series-parallel combination is $R_{eq} = R_1 + R_p$. Now, the circuit variables can be calculated using the formulas

$$I_1 = \frac{E}{R_{eq}}$$

$$V_1 = I_1 R_1$$

$$V_2 = V_3 = I_1 R_p$$

$$I_2 = \frac{V_2}{R_2}$$

$$I_3 = \frac{V_3}{R_3}$$

The KVL equations for the circuit of Figure 3 can be written as

$$E = V_1 + V_2$$

$$E = V_1 + V_3$$

The KCL equation for the circuit of Figure 3 can be written as

$$I_1 = I_2 + I_3$$

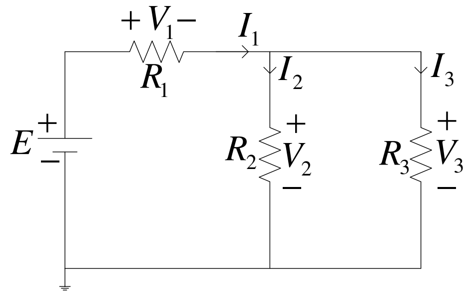

Figure 3. A simple series-parallel dc circuit.

Circuit Diagram:

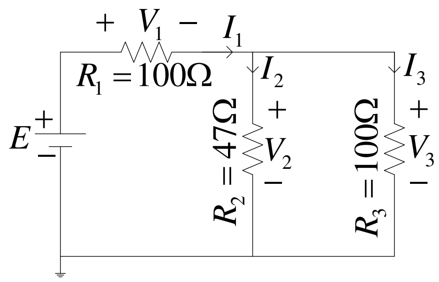

Figure 4. Circuit for experiment.

Pre-Lab Report Questions:

1. Theoretically calculate the values of V_1, V_2, V_3, I_1, I_2, and I_3 of the circuit of Figure 4 with E = 3V.
2. From the calculated values, show that (i) $V_2 = V_3$, (ii) KVL holds, that is, $E = V_1 + V_2$, and (iii) KCL holds, that is, $I_1 = I_2 + I_3$.

Equipments and Components Needed:

1. DC power supply
2. DC voltmeter
3. DC ammeter
4. Multimeter
5. Resistor 100Ω (two) and 47Ω (one)
6. Breadboard
7. Connecting wires

Lab Procedure:

1. Measure the resistance values of the resistors supplied and record them in Table 1.
2. Construct the circuit of Figure 4. Set the value of E at 3 V. Measure the values of E, V_1, V_2, V_3, I_1, I_2, and I_3 and record them in Table 1.
3. From experimental data, (i) show that $V_2 = V_3$, (ii) verify KVL, that is, $E = V_1 + V_2$, and (iii) verify KCL, that is, $I_1 = I_2 + I_3$.

Table 1. Experimental Datasheet

Measured Value of E (V)	Measured Value of V_1 (V)	Measured Value of V_2 (V)	Measured Value of V_3 (V)	Measured Value of I_1 (mA)	Measured Value of I_2 (mA)	Measured Value of I_3 (mA)	Measured Value of Resistances (Ω)
							R_1= R_2= R_3=

4. Have the datasheet signed by your instructor.

Post-Lab Report Questions:

1. Calculate the values of V_1, V_2, V_3, I_1, I_2, and I_3 of the circuit of Figure 4 using measured values of E, R_1, R_2, and R_3. Compare the calculated values with the measured values and give reason if any discrepancy is found.
2. From the calculated values of V_1, V_2, V_3, I_1, I_2, and I_3, show that (i) $V_2 = V_3$, (ii) $E = V_1 + V_2$ (KVL), and (iii) $I_1 = I_2 + I_3$ (KCL).