East West University

Lab Report

Semester: Summer-2025

Course Title: Electronic Circuits

Course Code: CSE209

Sec: 01

Expt. No: 2

Expt. Name: Series-Parallel DC Circuit and Verification of Kirchhoff's Laws.

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Experiment NO: 02

Experiment Name: 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:

Σ V rises = Σ 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

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

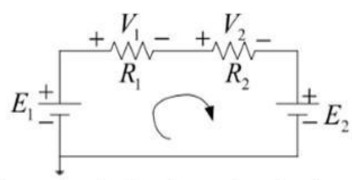

Figure 1. A simple series dc circuit.

Kirchhoff's Current Law (KCL) states that **the sum of the currents entering anode 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 enters the node and I_1 and I_2 are leaving the node. Then, the KCL equation forthe node a is

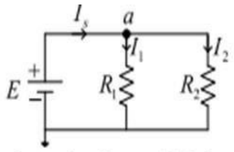

Figure 2. A simple parallel dc circuit.

$$I_S = I_1 + I_2$$

A series-parallel circuit is one that is formed by a combination of series and parallel resistors. For solving series-parallel circuits, parallel combinations of resistors and series combination of resistors are clearly identified. Then the 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_1 and R_2 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, $V2 = V3$. 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

$$I_1 = I_2 + I_3$$

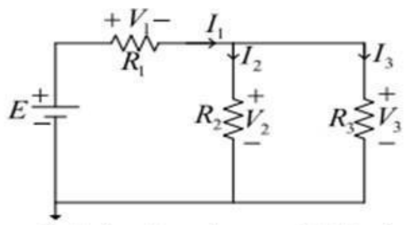

Figure 3. A simple series-parallel dc circuit.

Circuit Diagram:

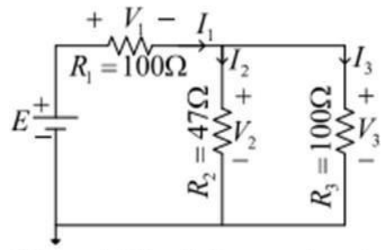

Figure 4. Circuit for experiment.

Pre-Lab Report Questions:

1. Theoretically calculate the values of E, V_1, V_2, V_3, I_1, I_2 and I_3 of the circuit of Figure4 with E =3V.

Ans:

Given that,

R_1 =100Ω

R_2 = 47Ω

$R_3 = 100\Omega$

$E = 3V$

Here, R_2 & R_3 is in parallel connection.

So, $R_p = \left(\frac{1}{R_2} + \frac{1}{R_3}\right)^{-1}\ \Omega$

$= \left(\frac{1}{47} + \frac{1}{100}\right)^{-1}\ \Omega$

= 31.98Ω

Now, R_p and R_1 is in series connection.

So, $R_{eq} = R_p + R_1$

=(31.98+100)Ω

= 131.98 Ω

We know that,

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

$= \frac{3}{131.98}\ A$

$= 0.022A$

So, $I_1 = 0.022A$

Here,

$V_1 = I_1 R_1 = 0.022 \times 100 = 2.27V$

$$V_2 = I_2 R_P = 0.022 \times 31.98 = 0.73\text{V}$$

$$V_3 = I_3 R_P = 0.022 \times 31.98 = 0.73\text{V}$$

$$I_2 = \frac{V_2}{R_2} = \frac{0.73}{47} = 0.015\text{A}$$

$$I_3 = \frac{V_3}{R_3} = \frac{0.73}{100} = 0.0073\text{A}$$

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, $I_1 = I_2 + I_3$.

Ans:

i.

$$V_2 = V_3 = 0.72\text{V}$$

ii.

From the calculated value we get that,

$$V_1 + V_2$$

$$= (2.23 + 0.72)\ \text{V}$$

$$= 3\text{V}$$

iii

$$I_2 + I_3 = (0.015+0.007)\text{A}$$

$$= 0.022\text{A}$$

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)
3	2.3	0.9	0.7	22	7	13	R_1=97.8
							R_2=98.9
							R_3=48.2
5	3.7	1.3	1.1	33	11	20	R_1=97.8
							R_2=98.9
							R_3=48.2

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 and R_2. Compare the calculated values with the measured values and give reason if any discrepancy is found.

Ans:

Given, E = 3V

Here, R_2 & R_3 are in parallel.

So,

$$\frac{1}{R_p} = \frac{1}{R_2} + \frac{1}{R_3}$$

$$= \frac{1}{98.9} + \frac{1}{49.2}\ \Omega$$

$$R_p = 32.85\ \Omega$$

And R_1 & R_p are in series,

$$R_{eq} = R_1 + R_p = 97.8\ \Omega + 32.85\ \Omega = 130.62\ \Omega$$

Now,

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

$$= \frac{3}{130.62}\text{A}$$

= 0.023A

= 23mA

$V_1 = I_1R_1 = 0.023 \times 97.8 = 2.25$ V

$V_2 = V_3 = I_1R_p = 0.023 \times 32.85 = 0.76$V

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

$$= \frac{0.76}{98.9}\text{ A}$$

=0.008A = 8mA

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

$$= \frac{0.76}{48.2} \text{ A}$$

$$=0.016\text{A} = 16\text{mA}$$

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)
3	2.3	0.9	0.7	22	7	13	R_1=97.8 R_2=98.9 R_3=48.2
Calculated Value of E (V)	Calculated Value of V_1 (V)	Calculated Value of V_2 (V)	Calculated Value of V_3 (V)	Calculated Value of I_1 (mA)	Calculated Value of I_2 (mA)	Calculated Value of I_3 (mA)	Calculated Value of Resistances (Ω)
3	2.25	0.76	0.76	23	8	16	R_1= 100 R_2= 47 R_3= 100

Table 2. The discrepancy between theoretical and measured values of V_1, V_2, V_3, I_1, I_2, I_3, R_1,

The calculated and measured values for voltages V_1, V_2, and V_3 show relatively small differences, which could be attributed to measurement inaccuracies. However, the calculated and measured values for currents I_1 , I_2, and I_3 exhibit significant discrepancies, suggesting potential measurement errors or incorrect units. It's essential to double-check the measurement equipment, units, and calibration to ensure accurate readings for current values.

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).

Ans:

From the calculated values,

V_1 = 2.25V
V_2 = 0.76V
V_3 = 0.76V
I_1 = 0.023A
I_2 = 0.008A
I_3 = 0.016A
E = 3V

i

Here, we can see that $V_2 = V_3$; (As R_2 & R_3 are in parallel and in parallel circuit voltages are Same).

ii

Again,

$V_1 + V_2 = 2.25V + 0.76V = 3.1V$

So, we can say that, $E = V_1 + V_2$

iii

Here,

$I_2 + I_3 = 0.008A + 0.016\ A$

$= 0.024A$

$= I_1$

So, we can say that, $I_1 = I_2 + I_3$

Discussion:

In this experiment, we verified kirchhoff's voltage Law (KVL) and Kirchhoff's current Law (KCL) using a series-parallel DC circuit. Theoretical calculations showed ~~that~~ the ~~total~~ voltage and current matched the expected values, satisfying both KVL and KCL. In the experiment setup, measured voltages were close to calculated ones, but some differences in current values were observed, likely due to measurement errors or component tolerances. Overall, the experiment confirmed the validity of kirchhoff's Laws and improved our understanding of series-parallel circuit behavior.