East West University

Department of CSE

LAB REPORT

Course Code and Name: CSE-209 Electrical Circuits
Experiment no: 02 **Group**-07
Experiment name: Series-Parallel DC Circuit and Verification of Kirchhoff's Laws

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Date of Submission: 18th March, 2025	**Pre-lab marks:** **Post-lab marks:** **Total marks:**

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

Abstract:

This experiment analyzes series-parallel DC circuits and verifies Kirchhoff's Voltage Law (KVL) and Kirchhoff's Current Law (KCL). KVL states that the sum of all voltage rises in a closed loop equals the sum of all voltage drops, while KCL states that the sum of currents entering a node is equal to the sum of currents leaving it. A circuit was constructed with both series and parallel resistor combinations, and voltage and current values were measured to validate these laws. The results were analyzed to compare theoretical and experimental values.

Objectives:

- To analyze series-parallel DC circuits.
- To verify Kirchhoff's Voltage Law (KVL).
- To verify Kirchhoff's Current Law (KCL).
- To measure voltage and current in different circuit configurations.
- To develop practical circuit analysis skills.

Theory:

In an electrical circuit, components are connected in different configurations, such as series, parallel, or a combination of both. This experiment focuses on analyzing series-parallel DC circuits and verifying Kirchhoff's Voltage Law (KVL) and Kirchhoff's Current Law (KCL).

Kirchhoff's Voltage Law (KVL) states that the sum of all voltage rises in a closed loop is equal to the sum of all voltage drops. Mathematically, it is expressed as:

$$\sum V_{rise} = \sum V_{drops}$$

This law is useful in analyzing circuits where multiple voltage sources and resistors are present. In a simple series circuit, voltage sources (E_1 and E_2) and resistors (R_1 and R_2) contribute to the total voltage drop across the components, as given by the equation:

$$E_1 - E_2 = V_1 + V_2$$

where V_1 and V_2 are the voltage drops across resistors R_1 and R_2, respectively.

Kirchhoff's Current Law (KCL) states that the sum of all currents entering a node in a circuit must equal the sum of all currents leaving the node. Mathematically, it is expressed as:

$$\sum I_{in} = \sum I_{out}$$

For example, in a simple parallel circuit with a voltage source E and two resistors R_1 and R_2, the source current I_s is divided into I_1 and I_2, where:

$$I_s = I_1 + I_2$$

A series-parallel circuit consists of both series and parallel resistor combinations. The parallel and series resistances must be determined separately to analyze such a circuit. For example, in a circuit where resistors R_2 and R_3 are in parallel and their combination is in series with R_1, the equivalent resistance R_{eq} is given by:

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

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

Using Ohm's Law (V = IR), the voltage drops and currents can be determined for each component, and the laws of KVL and KCL can be verified through experimental measurements.

Experimental Method:

- Measure the resistance values of the supplied resistors using a multimeter.
- Construct the circuit according to the given diagram.
- Set the voltage source to a specified value (e.g., 3V).
- Measure the voltage drops across each resistor and record the values.
- Measure the currents flowing through different branches of the circuit.
- Verify KVL by summing the voltage drops and comparing them with the total supplied voltage.
- Verify KCL by checking that the sum of entering currents equals the sum of leaving currents at a node.
- Compare the theoretical and experimental results.

Circuit Diagram:

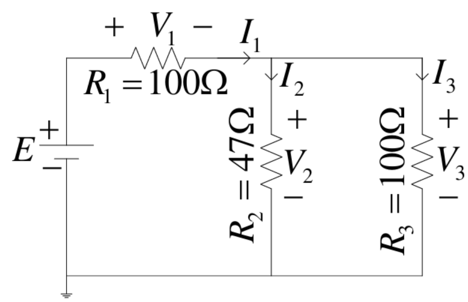

Figure 4. Circuit for experiment.

Experimental Data:

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 Resistance (Ω)**
2.75	**2.15**	**0.712**	**0.725**	**21.9**	**15.0**	**6.4**	**R_1= 97.3** **R_2= 46.4** **R_3= 99.7**

Post Lab Questions

1. Calculate the values of V1, V2, V3, I1, I2, and I3 of the circuit of Figure 4 using measured values of E, R1, R2, and R3. Compare the calculated values with the measured values and give reason if any discrepancy is found.

Solution:

From the circuit, Since R_2 and R_3 are in parallel:

calculate the equivalent resistance:

$$R_2 \parallel \mathrm{R}_3 = \frac{R_2 \times R_3}{R_2 + R_3} = 31.66\Omega = R'$$

Resistance, $R_{eq} = R' + R_1 = 128.96\Omega$

We know, $I_1 = \frac{E}{R_e} = \frac{2.75}{128.96} = 21.32mA$

$$V_1 = I_1 \times R_1 = 21.32 \times 100 \times 10^{-3} = 2.07V$$

In parallel circuit, voltages are equal, so $V_2 = V_3$

$$V_2 = V_3 = I_1 \times R' = 21.32 \times 10^{-3} \times 31.66 = 0.675V$$

Now, $I_2 = \frac{V_2}{R_2} = \frac{0.675}{46.4} = 14.54\text{mA}$

$$I_3 = \frac{V_3}{R_3} = \frac{0.725}{99.7} = 7.27mA$$

2. From the calculated values, show that (i) $\boldsymbol{V_2 = V_3}$, (ii) KVL holds, that is, $\boldsymbol{E = V_1 + V_2}$, and (iii) KCL holds, that is, $\boldsymbol{I_1 = I_2 + I_3}$.

Solution:

From the calculated values we get, $V_1 = 2.15\ V$ $\quad I_1 = 21.9\ mA$

$V_2 = 0.712\ V$ $\quad I_2 = 15.0\ mA$

$V_3 = 0.725\ V$ $\quad I_3 = 6.4\ mA$

(i) From the calculated values we get, $V_2 \approx V_3 \approx 0.712\text{V}$

(ii) $E = 2.75V$

Applying Kirchhoff's Voltage Law (KVL):

$E = V_1 + V_2 = 2.15 + 0.712 = 2.862 \approx 3V$

This confirms that KVL holds in the circuit.

(iii) Applying Kirchhoff's Current Law (KCL):

$$I_1 = I_2 + I_3$$

Therefore, $I_2 + I_3 = 15.0 + 6.4 = 21.4 \approx 21.9 = I_1$

Hence, it is confirmed that KCL holds in the circuit.

From the calculated and measured values, we can observe that there are some little differences between these values. This is due to discrepancies in the resistors that were provided for the lab and these happened mainly because of mechanical and human error

Results and Discussion:

The measured voltage of the power source was 2.75V, with voltage drops across resistors R_1, R_2, R_3, and recorded as 2.15V, 0.712V, and 0.725V, respectively. The sum of these voltage drops closely matches the supplied voltage, confirming Kirchhoff's Voltage Law (KVL).

The measured currents through different branches were 21.9mA for I_1, 15.0mA for I_2, and 6.4mA for I_3. The sum of I_2 and I_3 (15.0mA + 6.4mA = 21.4mA) is very close to I_1, validating Kirchhoff's Current Law (KCL) with minor discrepancies attributed to measurement errors.

The experimental resistance values were $R_1 = 97.3\Omega$, $R_2 = 46.4\Omega$, and $R_3 = 99.7\Omega$. The results align well with theoretical predictions, confirming the validity of the laws.

Conclusion:

This experiment provided a hands-on approach to understanding Kirchhoff's laws in series-parallel DC circuits. By measuring voltages and currents and comparing them with theoretical values, the validity of KVL and KCL was confirmed. The small deviations observed highlight the importance of precision in measurements and circuit connections. Overall, the experiment reinforced fundamental circuit analysis concepts and demonstrated their practical applications.

Pre-Lab of Group members:

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Sumya Kawsar (2023-3-60-168)
Md. Hasib Ali (2023-3-60-186)
Experiment no: 02

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)
2.75	2.15	0.712	0.725	21.9	15.0	6.4	$R_1 = 97.3$ $R_2 = 46.4$ $R_3 = 99.7$

(i) $V_2 = V_3 = 0.712$ ✓

~~(ii) $E = V_1 + V_2 = 2.15 + 2.15 =$~~

(ii) $E = 2.75$ ✓

$V_1 + V_2 = 2.15 + 0.712 \approx 2.75$ ✓

$\therefore E = V_1 + V_2$

(iii) $I_1 = 21.9\,mA$

$I_2 + I_3 = 15.0 + 6.4 \approx 21.4\,mA$

14/3/25

Name: Sumya Kawsar

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Experiment no: 2 (Pre lab report)

Group no: 07 , sec: 02

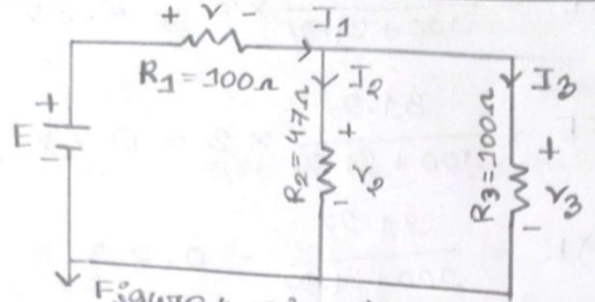


Figure 4. Circuit for experiment

Que: 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 $E = 3v$.

Ans: Given, $R_1 = 100\Omega$, $R_2 = 47\Omega$, $R_3 = 100\Omega$

From the circuit, R_2 and R_3 are in parallel:

The equivalent resistance, $R' = \frac{R_2 . R_3}{R_2 + R_3}$

$= \frac{47 \times 100}{47 + 100} = 31.97\Omega$

Resistance, $R_{eq} = R_1 + R' = 100\Omega + 31.97\Omega$

$= 131.97\Omega$

We know, $I_1 = \frac{E}{R_{eq}} = \frac{3}{131.97} = 22.73\ mA$

Using current divider rule,

$I_2 = \frac{R_3}{R_2 + R_3} \times I_1 = \frac{100}{47 + 100} \times 22.73$

$\therefore I_2 = 15.46\ mA$

and $I_3 = \frac{R_2}{R_2 + R_3} \times I_1 = \frac{47}{47 + 100} \times 22.73$

$\therefore I_3 = 7.27\ mA$

Using voltage divider rule.

$$V_1 = \frac{R_1}{R_1+R'} \times E = \frac{100}{100+31.97} \times 3 = 2.3V$$

$$V_2 = \frac{R'}{R_1+R'} \times E = \frac{31.97}{100+31.97} \times 3 = 0.7V$$

$$V_3 = \frac{R'}{R_1+R'} \times E = \frac{31.97}{100+31.97} = 0.7V$$

<u>Que: 2</u> 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, $I_1 = I_2 + I_3$

<u>Ans:</u> (i) R_2 and R_3 are in parallel and voltage is not divided accross the parallel connection.

From before calculation: $V_2 = V_3 = 0.7V$

$\therefore V_2 = V_3$

(ii) Kirchoff's voltage law (KVL) states that, the sum of the voltage rises around a closed loop is equal to the sum of the voltage drops.

From the loop,

$$-E + V_1 + V_2 = 0$$

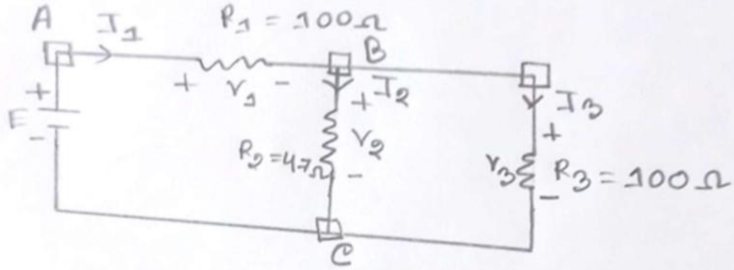
$$\Rightarrow E = V_1 + V_2$$

$$\Rightarrow E = 2.3 + 0.7$$

$$\therefore E = 3V$$

Therefore, KVL holds, $E = V_1 + V_2$

(iii) 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.



At node B,

$$-I_1 + I_2 + I_3 = 0$$

$$\Rightarrow I_1 = I_2 + I_3$$

Here, $I_1 = 22.73$ mA

$$I_2 + I_3 = (15.46 + 7.26) \text{ mA}$$
$$= 22.73 \text{ mA}$$

$$\therefore I_1 = I_2 + I_3$$

Therefore, KCL holds, $I_1 = I_2 + I_3$.

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Date : 12th March, 2025

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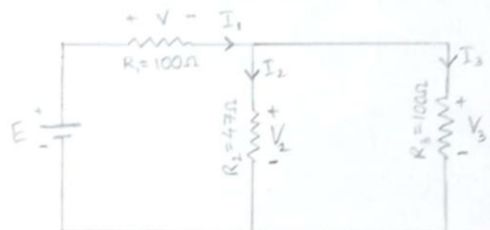

* Theoretically calculate the values of V_1, V_2, V_3, I_1, I_2, I_3 of the above circuit with $E = \cancel{4}3V$.

$\Rightarrow R' = R_2 \| R_3 = \left(\frac{1}{R_2} + \frac{1}{R_3}\right)^{-1} = \left(\frac{1}{47} + \frac{1}{100}\right)^{-1} = 31.97 \; \cancel{mA}\,\Omega$

$\therefore R_{eq} = R' + R_1 = 131.97\ \Omega$

We know, $I_1 = E/R_{eq} = \left(3/131.97\right) mA = 22.731\ mA$

$V_1 = I_1 R_1 = (22.731 \times 100 \times 10^{-3})\ V = 2.27\ V$

In parallel circuit voltages are equal,

so, $V_2 = V_3 = I_1 R' = (22.731 \times 10^{-3} \times 31.97)\ V$
$= 0.73\ V$

Now, $I_2 = V_2/R_2 = 15.53\ mA$

$I_3 = V_3/R_3 = 7.3\ mA$

* From the calculated values, show that

i) $V_2 = V_3$, ii) KVL holds, that is, $E = V_1 + V_2$

iii) KCL holds, that is, $I_1 = I_2 + I_3$

=> From the calculated values we get,

$V_1 = 2.27\,V$, $V_2 = 0.73\,V$, $V_3 = 0.73$

$I_1 = 22.74\,mA$, $I_2 = 15.53\,mA$, $I_3 = 7.21\,mA$

i) From the calculated values we get $V_2 = V_3$
$= 0.73V$

ii) $E = 3V$

Applying ~~KL~~ KVL,

$E = V_1 + V_2 = 2.27 + 0.73 = 3V$

This confims that KVL holds in the circuit.

iii) Applying KCL,

$I_1 = I_2 + I_3$

$= (15.53 + 7.21)\,mA = 22.74\,mA$

Hence, it confirmed that KCL holds in the circuit.

Pre-Lab Report

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Course: CSE 209
Section: 02
Expt No: 02
Group NO: 07

① Theoritically calculate the values of V_1, V_2, V_3, I_1, I_2 and I_3 of the circuit of Figure 4 with $E = 3V$

Ans: The circuit R_2 and R_3 are in parallel

$$R' = R_2 \| R_3 = \frac{R_2 \times R_3}{R_2 + R_3} = \frac{47 \times 100}{47 + 100} = 31.9\,\Omega$$

$$\therefore R_{eq} = R' + R_1 = 131.9\,\Omega$$

We know, $I_1 = \frac{E}{R_{eq}} = \frac{3}{131.9} = 22.74\ mA$

and, $V_1 = I_1 R_1 = (22.74 \times 10^{-3} \times 100)$
$= 2.27V$

In parallel, voltage are equal, so, $V_2 = V_3$

$$V_2 = V_3 = I_1 R' = (22.74 \times 10^{-3} \times 31.9) = 0.73V$$

Now, $I_2 = V_2/R_2 = \frac{0.73}{47} = 15.53\ mA$

and $I_3 = V_3/R_3 = \frac{0.73}{100} = \cancel{7.3\ mA}\ 7.21\ mA$

(2) From the calculated values, show that

(i) $V_2 = V_3$, (ii) KVL holds, that is, $E = V1 + V2$,

and (iii) KCL holds that is, $I_1 = I_2 + I_3$

Ans: (i) From question "1" we get in parallel circuits voltage are same $V_2 = V_3 = 0.73V$

(ii) Given, $E = 3V$

Applying KVL,

$$E = V_1 + V_2 = 2.27 + 0.73 = 3V$$

This confirms that KVL holds in the circuit.

(iii) From question "1" we get, $I_1 = 22.74\ mA$

$I_2 = 15.53\ mA$ and $I_3 = 7.21\ mA$

Applying KCL, $I_1 = I_2 + I_3 = (15.53 + 7.21) = 22.74m$

Hence, it is confirmed that KCL holds in the circuit.