AMERICAN INTERNATIONAL UNIVERSITY-BANGLADESH

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Assignment Title:	Study of Superposition Theorem for DC circuit.		
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Course Title:	Introduction to Electrical Circuits Laboratory		
Course Code:	COE2102	Section:	T
Semester:	FALL 2022-23	Course Teacher:	BISHWAJIT BANIK PATHIK

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	Marks Obtained	9.5
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Abstract:
The experiment used to be performed to look at the study of superposition theorem for DC circuit. In this experiment we, investigate the application of the superposition theorem to multiple DC circuits in terms of both voltage and current measurements also examine the power meas-urement. To complete this experiment some basic instruments like trainer board, digital multimeter, DC source, resistor, connecting wires etc. are used. By observing this experiment, we verify superposition theorem in DC circuit and also learn power measurement.

Theory and Methodology:
The principal of superposition is applicable only for Linear systems. The concept of superposition can be explained mathematically by the following response and excitation principle:

$i1 \rightarrow v1$

$i2 \rightarrow v2$

$i1 + i2 \rightarrow v1 + v2$

Then, the quantity to the left of the arrow indicates the excitation and to the right, the system response Thus, we can state that a device, if excited by a current i1 will produce a response v1. Similarly, an excitation i2 will cause a response v2. Then if we use an excitation i1+i2; we will find a response v1+v2.

Superposition theorem states that in any linear circuit containing multiple independent sources, the current or voltage at any point in the network may be calculated as algebraic sum of the individual contributions of each source acting alone.

When determining the contribution due to a particular independent source, we disable all the remaining independent sources. That is, all the remaining voltage sources are made zero by replacing them with short circuits, and all remaining current sources are made zero by replacing them with open circuits. Also, it is important to note that if a dependent source is present, it must remain active (unaltered) during the process of superposition.

Action Plan:

(i) In a circuit of many independent sources, only one source is allowed to be active in the circuit, the rest are deactivated (turned off).

(ii) To deactivate a voltage source: Replace it with a short circuit.

To deactivate a current source: Replace it with an open circuit.

(iii) The response obtained by applying each source, one at a time, are then added algebraically to obtain a solution.

Limitations:

Superposition principle applies only to the current and voltage in a linear circuit but it cannot be used to determine power because power is a non-linear function.

Apparatus:

1. Trainer board
2. Digital multimeter
3. DC source
4. Resistors
5. Connecting wires

Experimental Procedure:

Circuit Diagram:

1. The circuit was implemented like figure 6.1.
2. The supply voltage E_2 was removed by short circuit.
3. We have measured the node voltage V_A and noted the polarity.
4. The power supply voltage E_2 was reconnected.
5. By using short circuit supply voltage E_1 was also removed.

6. Lastly we have calculated the deviation between experimental and theoretical values.

Source	V_A Theory	V_A Experimental	Deviation
E_1 only	1.09V	1.522	0.43
E_2 only	2.564V	2.529	0.035
E_1 & E_2	3.65V	4.05	0.4

Table 6.1

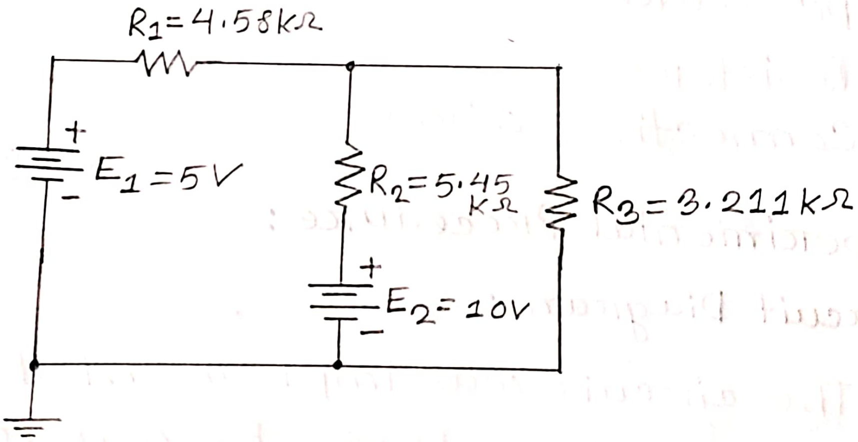


Figure 6.1

7. The circuit was implemented like figure 6.2.
8. Procedure 2 to 6 was repeated and measured I_{R4} current and P_{R4} power across R_4 resistor and noted the direction of I_{R4} current flow.

9. Lastly we have calculated the deviation between experimental and theoretical values of table 6.2 and 6.3.

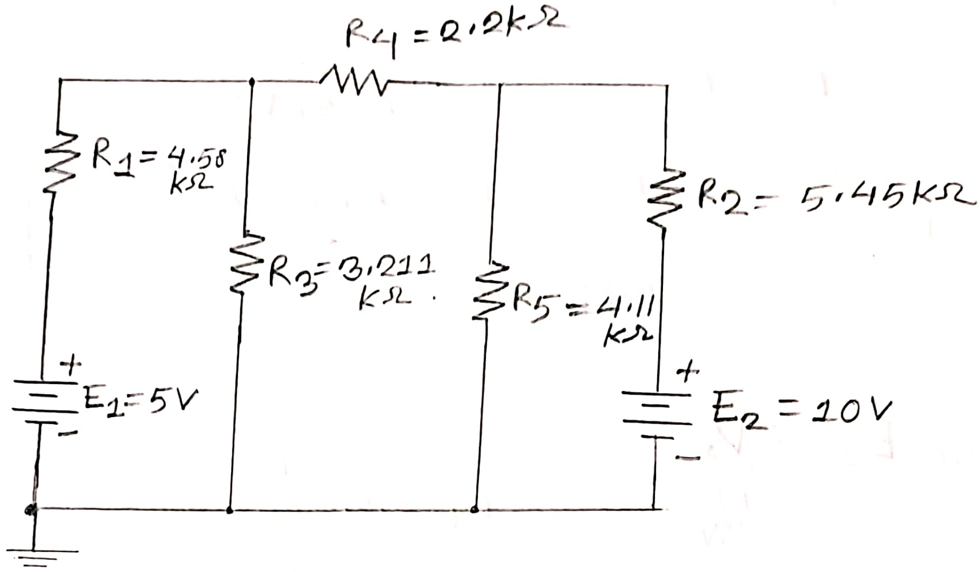


Figure 6.2

Result and Discussion:

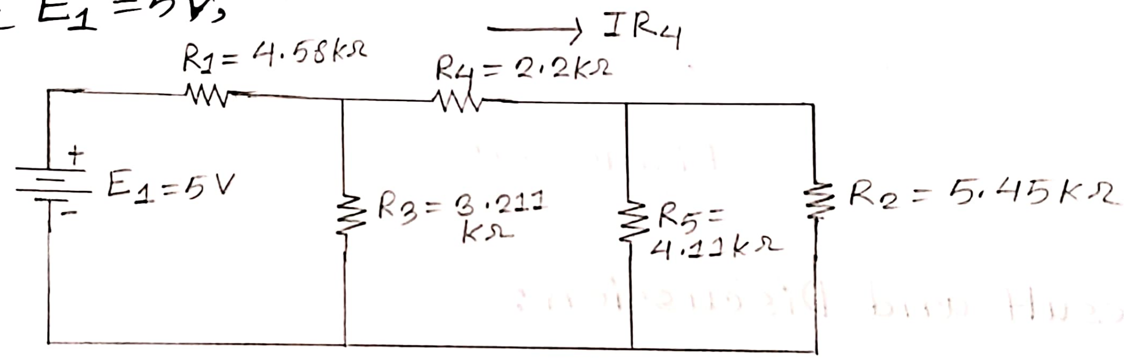
Source	I_{R4} Theory	I_{R4} Experimental	Deviation
E_1 only	0.311mA	0.318mA	2.25%
E_2 only	0.662mA	0.667mA	0.75%
E_1 & E_2	0.975mA	0.979mA	0.41%

Table 6.2

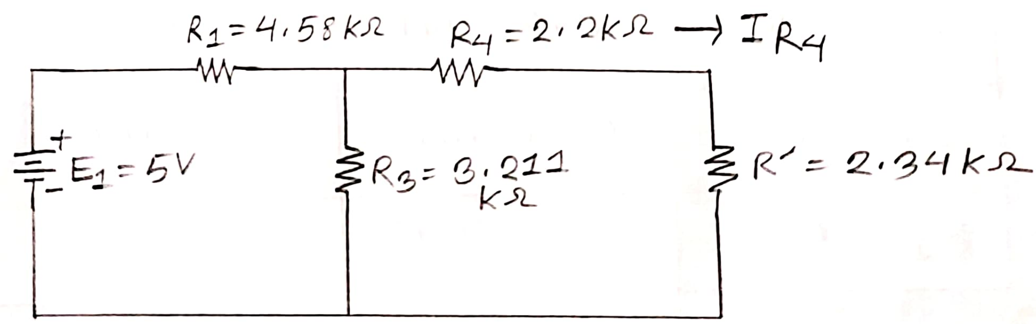
Source	P_{R4}
E_1 only	1.30 W
E_2 only	3.89 W
$E_1 + E_2$	5.19 W
E_1 and E_2	5.19 W

Table 6.3

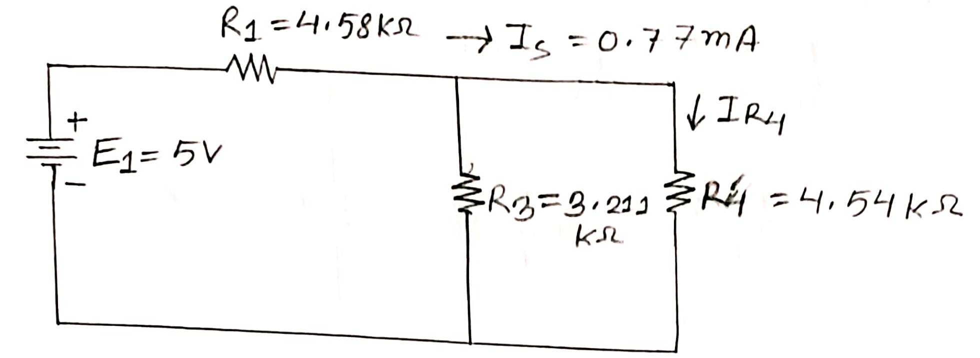
For $E_1 = 5V$,

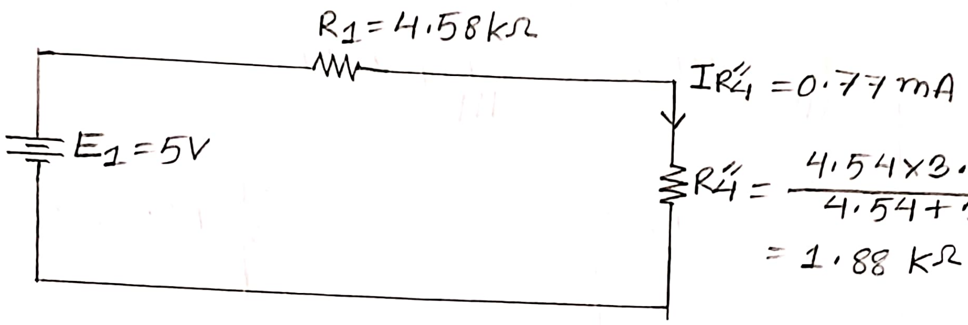


$$R' = R_5 || R_2 = \frac{5.45 \times 4.11}{5.45 + 4.11} = 2.34\,k\Omega$$



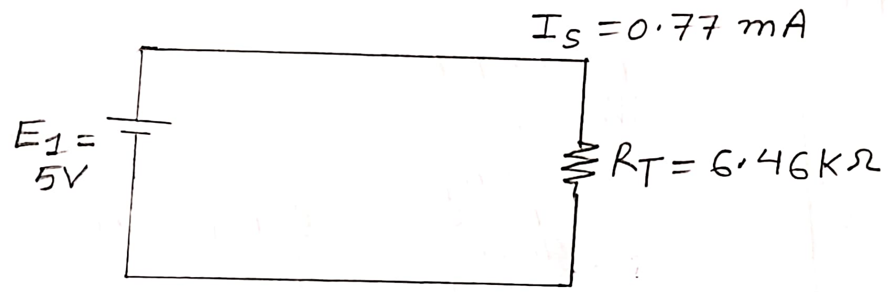
$$R_4' = R_4 + R' = 2.2 + 2.34 = 4.54\,k\Omega$$





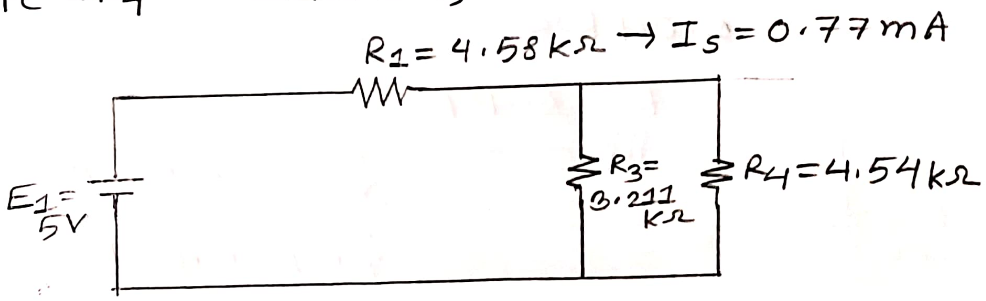
$$R_4'' = \frac{4.54 \times 3.211}{4.54 + 3.211} = 1.88\ k\Omega$$

$$R_T = R_4'' + R_1 = 1.88 + 4.58 = 6.46\ k\Omega$$



$$I_s = \frac{E_1}{R_T} = \frac{5V}{6.46k\Omega} = 0.77mA$$

For I_{R4} calculation,



$$I_{R4} = \frac{R_3}{R_3 + R_4} \times I_s = \frac{3.211}{3.211 + 4.54} \times 0.77$$
$$= 0.31mA$$

For $E_2 = 10\,V$,

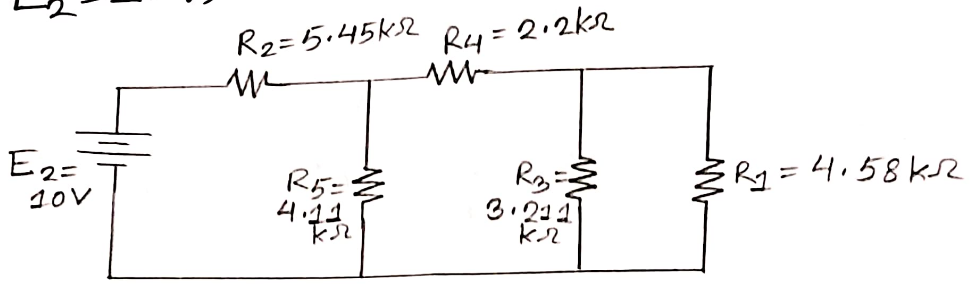


Fig-1

$$R' = R_1 \parallel R_3 = \frac{4.58 \times 3.211}{4.58 + 3.211} = 1.88\,k\Omega$$

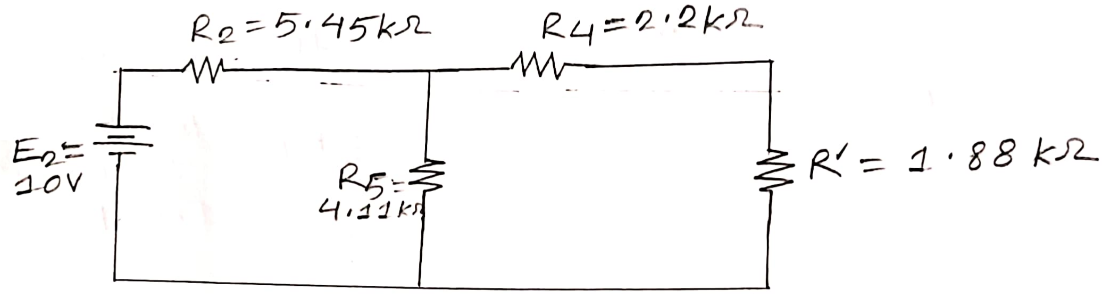


Fig-2

$$R_4' = R_4 + R' = 2.2 + 1.88 = 4.08\,k\Omega$$

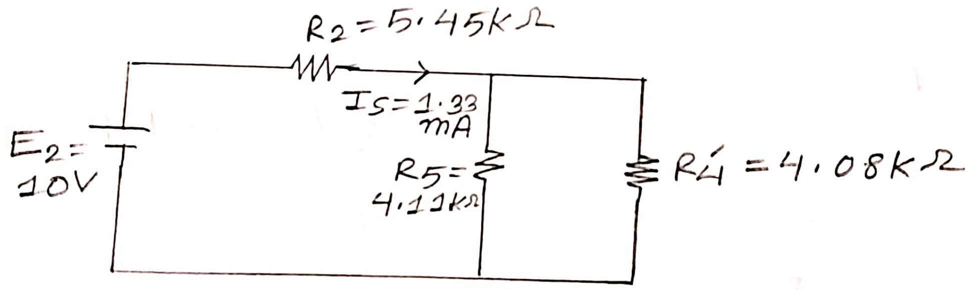


Fig-3

$$R_4'' = R_4 \parallel R_5 = \frac{4.08 \times 4.11}{4.08 + 4.11}$$
$$= 2.04\,k\Omega$$

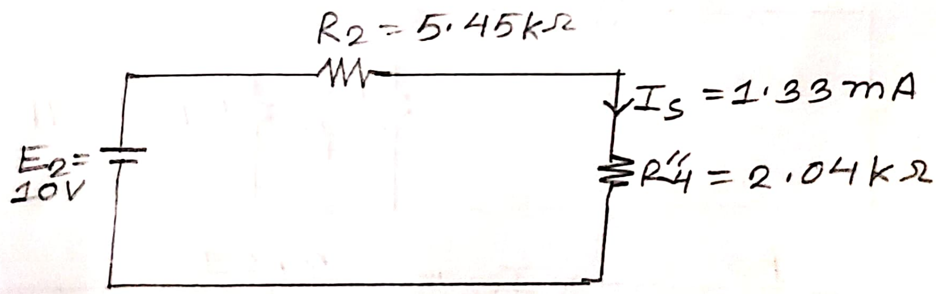


Fig-4

$$R_T = R_{44}' + R_2 = 2.04 + 5.45 = 7.49\,k\Omega$$

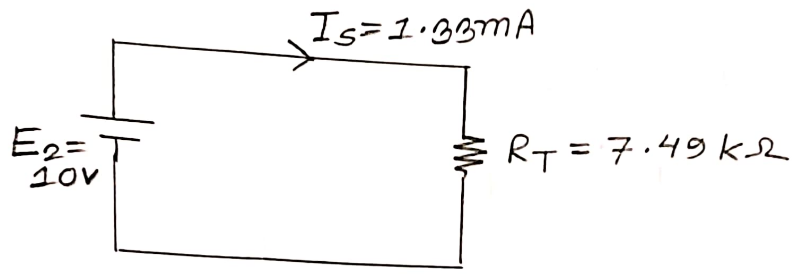
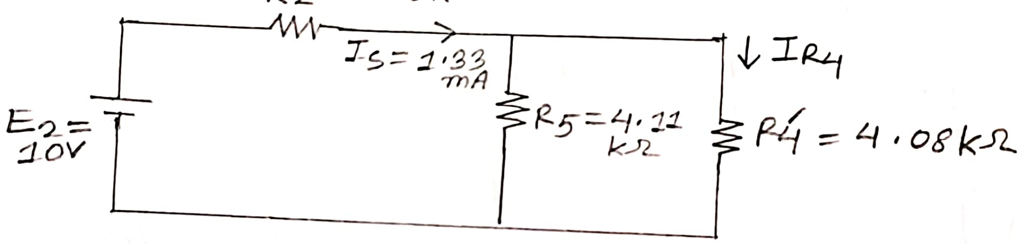


Fig-5

$$I_S = \frac{10V}{7.49k\Omega} = 1.33mA$$

For I_{R4} calculation,

From fig-3,



$$I_{R4} = \frac{R5}{R5 + R'_4} \times I_S$$

$$= \frac{4.11}{4.08 + 4.11} \times 1.33$$

$$= 0.66mA$$

P_{R4} Calculation:

For E_1,

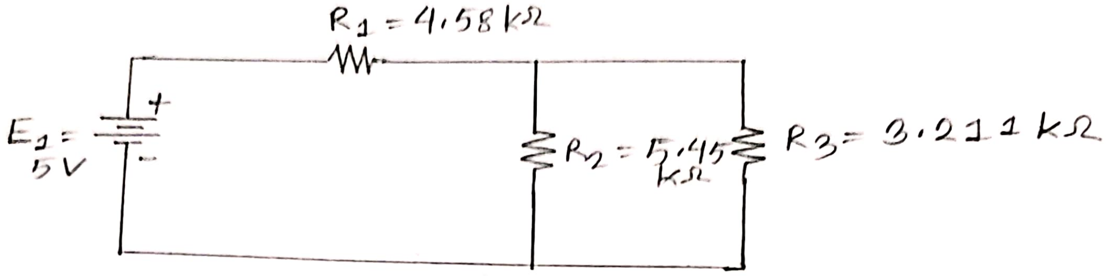
$$P_{R4} = I^2 \times R4 = 0.77^2 \times 2.2 = 1.30W$$

For E_2,

$$P_{R4} = I^2 \times R4 = 1.33^2 \times 2.2 = 3.89W$$

V_A Calculation:

Considering $E_1 = 5V$,

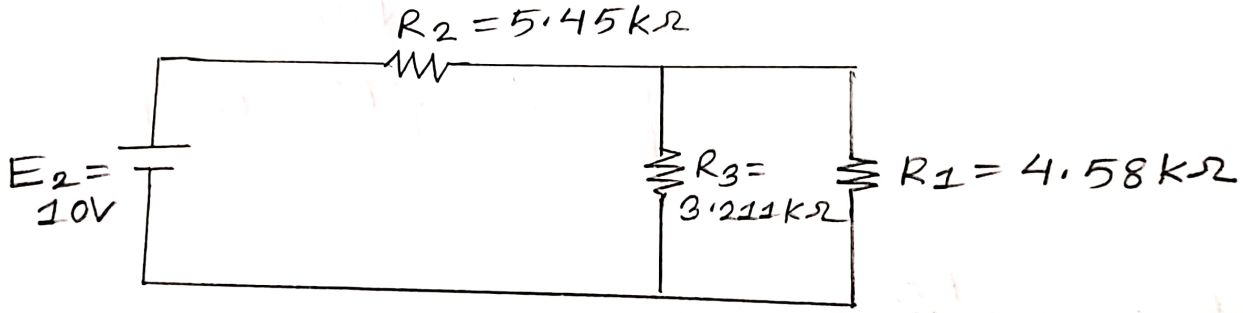


$R' = R_2 \| R_3 = 2.02$

V_A or,

$$V_{2.02} = \frac{2.02}{2.02 \times 4.58} \times 5 = 1.09V$$

Considering $E_2 = 10V$,



$R' = R_3 \| R_1 = 1.88$

$$V_A = \frac{1.88}{1.88 + 5.45} \times 10$$

$$= 2.564V$$

Discussion:

In this experiment, we use DC source circuit to show and verify superposition theorem. We have showed the measurement of voltage and current. By this experiment we have got a clear idea about how superposition theorem works both practically and theoritically. We have faced some difficulty while measuring the current I_{R4} while considering E_2 voltage and there might have some error. Otherwise we have done all things quite perfectly.

Conclusion:

In conclusion we can say that our experiment was successful.

Reference:

1. Robert L. Boylestad, "Introductory Circuit Analysis", Prentice Hall, 12th Edition, New York, 2010, ISBN 9780137146666.