EXPT NO. 1

SUPERPOSITION THEOREM

DOP : 20.08.19

DOS : 27.08.19

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ROLL NO : 54

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AB

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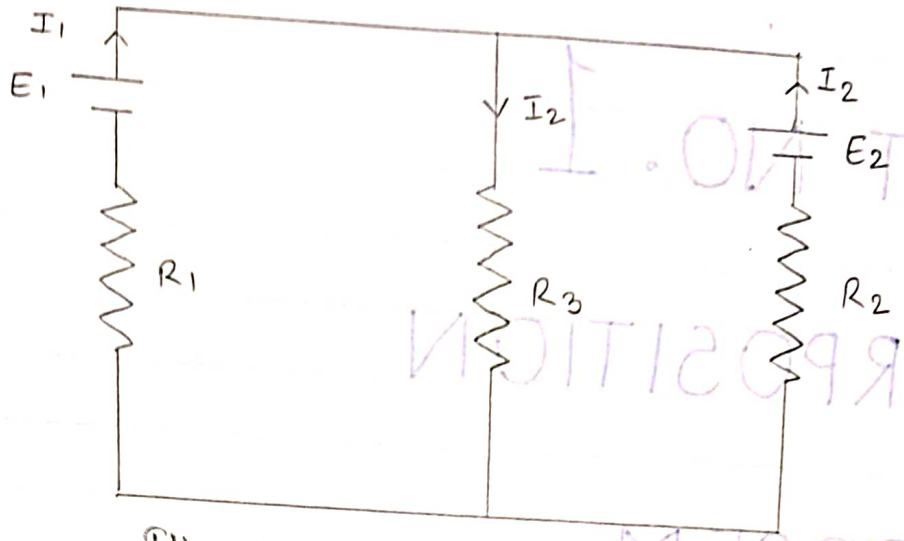
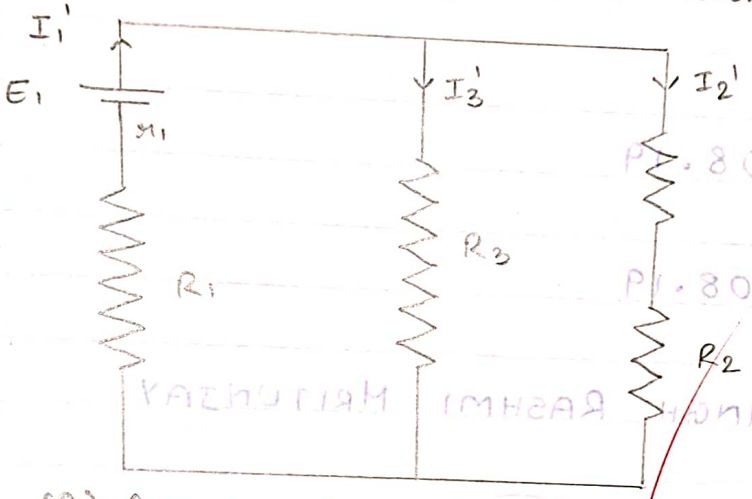
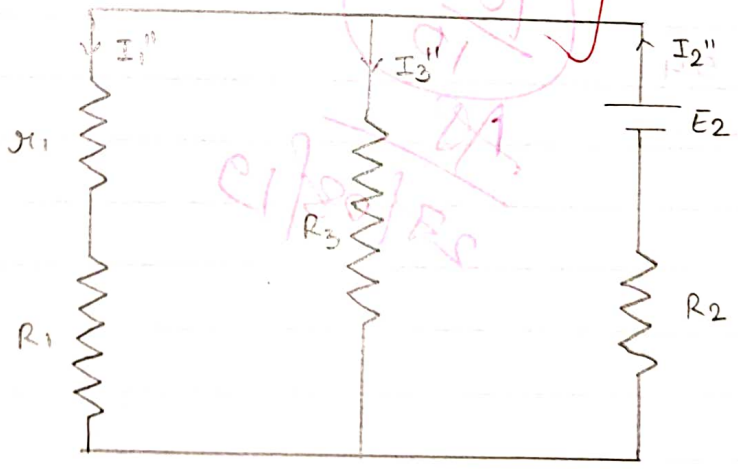


Illustration of superposition theorem.



(a.) Current in various branches due to E1



(b.) Current in various branches due to E2.

AIM:

To study and verify superposition theorem.

APPARATUS:

Digital multimeter, EDKITS superposition theorem kit, patch cords.

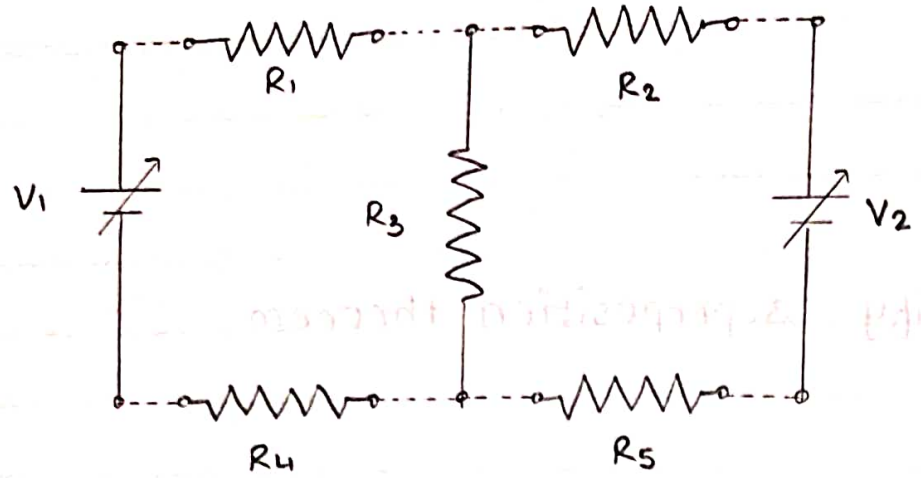
THEORY:

→ Superposition theorem

Many electrical circuits may contain more than one source of emf. In such cases, it more convenient to solve the circuit for the desired current produced by each source of emf acting separately and then combining the results. The theorem is applicable only to linear networks where current is linearly related to voltage as per Ohm's law.

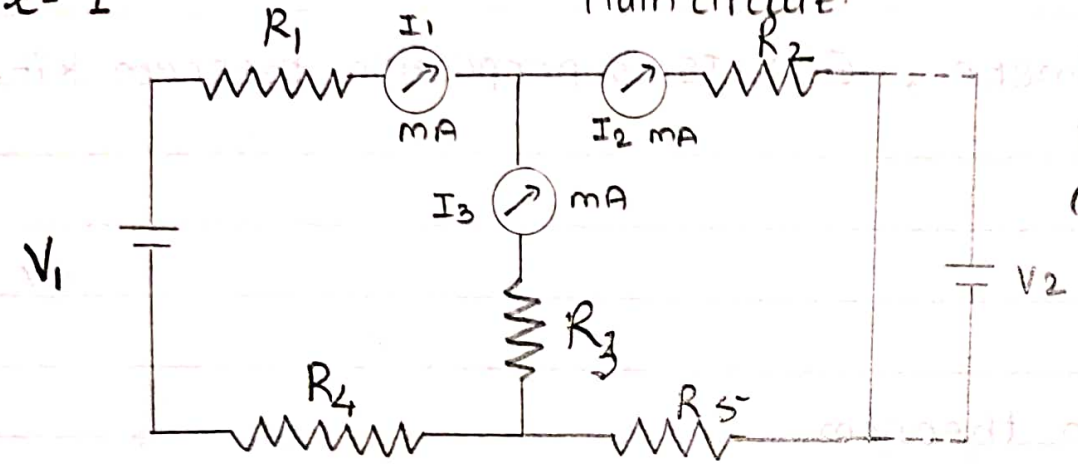
→ Statement

In a network of linear resistances containing more than one source of emf, the current which flows at any point is the sum of all the currents which would flow at that emf point if each source of emf were considered separately and all other sources of emf were considered replaced for the time being by resistances equal to

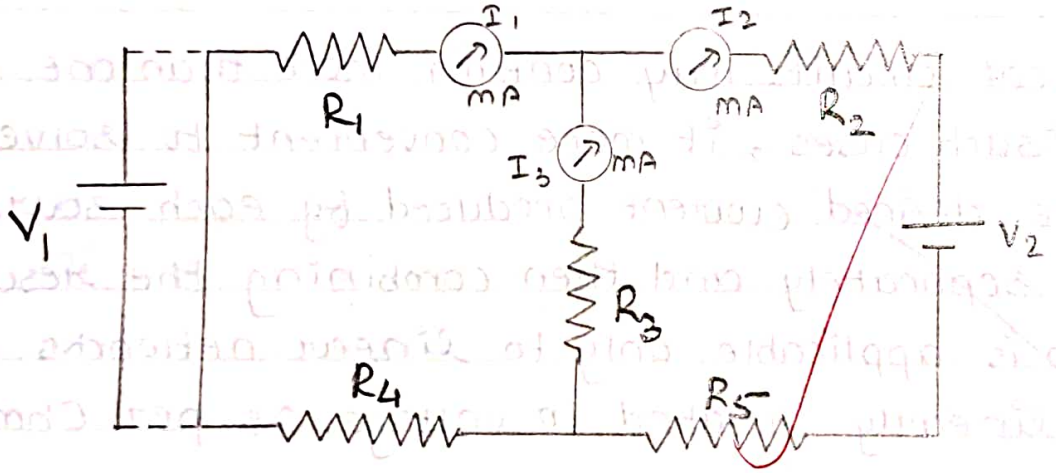


Case- I

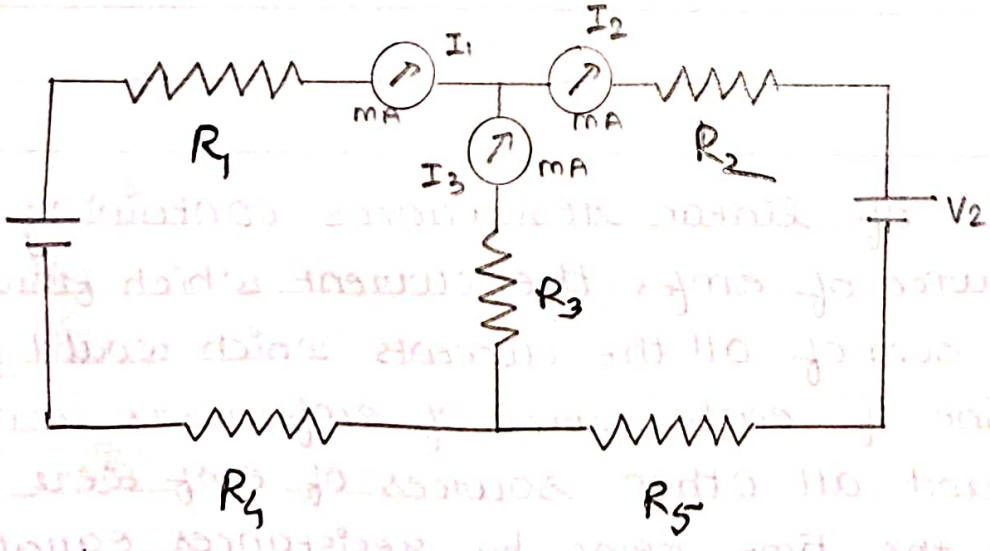
Main circuit



V1 acting alone
(R2 and R5 are short circuited)



V2 acting alone
(R1 and R4 are short circuited)



V1 and V2 are acting together

to natural resistance i.e. internal resistance.

→ Explanation.

To illustrate the theorem consider the circuit shown. Find out the current flowing through resistances R_1, R_2 and R_3.

Let the resultant currents flowing through the resistances R_1, R_2 and R_3 be I_1, I_2 and I_3 respectively.

As per the theorem let us first solve the above circuit with emf E_1 acting along, replacing the other source of emf by its internal resistances as shown. This circuit can easily be solved for I_1', I_2' and I_3'.

Similarly solve with emf E_2 acting along replacing E_1 by its internal resistance r_1 as shown. The circuit is solved for I_1'', I_2'', I_3''. Now by applying superposition theorem to combine resultants in order to find total current in various branches.

Current in resistor $R_1 \Rightarrow I_1 = I_1' - I_1''$

Current in resistor $R_2 \Rightarrow I_2 = I_2' - I_2''$

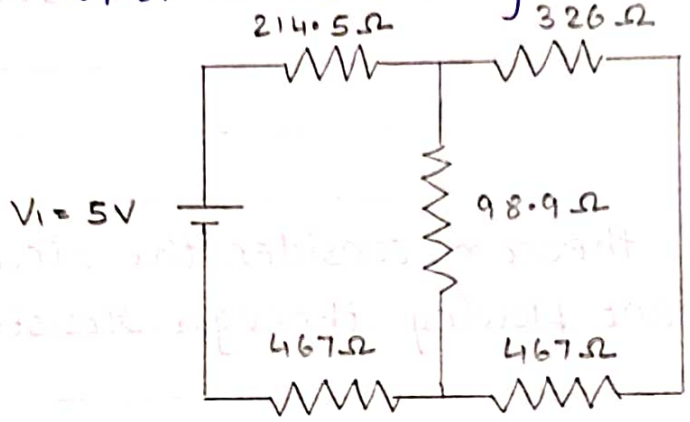
Current in resistor $R_3 \Rightarrow I_3 = I_3' - I_3''$.

→ Advantages.

1. The advantage of superposition theorem over voltage law is that circuit can be analysed with one power source at a time hence circuit is simplified. With Kirchoff Law, sum at junction point is to be found which makes the analysis harder.

CALCULATIONS :

Case : 1 - When V_1 is acting alone ($V_1 = 5V$, $V_2 = 10V$)



$$Req_{(1)} = (326 + 467) \,||\, (98.9)$$
$$= 87.93\ \Omega$$

$$Req_{(2)} = 87.93 + 467 + 214.5$$
$$= 769.43\ \Omega$$

$$I_{11} = \frac{V_1}{Req_{(2)}} = \frac{5}{769.43}$$

$$I_{11} = 6.49 mAmp.$$

$$I_{31} = I_T \times \frac{793}{(793 + 98.9)}$$

$$I_{31} = 5.77 mA.$$

$$I_{21} = I_{11} - I_{31}$$
$$= 6.49 - 5.77$$

$$I_{21} = 0.72\ mA.$$

2. Superposition theorem is applicable to both DC and AC voltage circuits.

3. Voltage or current in entire circuit are added or subtracted arithmetically.
This theorem has the advantage of allowing each source to be taken separately so that only ohm's law equation are required in the circuit.

→ Disadvantages.

1. If a huge number of sources are involved, use of superposition theorem becomes different as final analysis will be more tedious than nodal and mesh analysis.
2. It can only be applied to linear circuit.
3. Superposition theorem can't be applied for finding the power dissipated in the circuit.

→ Applications.

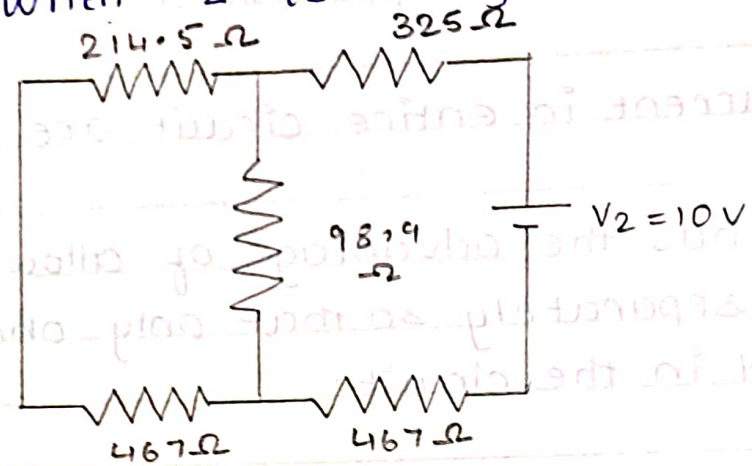
Superposition theorem can be used in electronics when relation between V and I is linear when the current (I) or voltage (V) at same point can be found as the sum of current or voltage for each source taken individually.

PROCEDURE:

1. Adjust V=05 V and measure the resistance in superposition kit in Off condition.

CALCULATIONS :

Case 2 : When V_2 is acting alone ($V_1 = 0V$, $V_2 = 10V$)



$$Req_{(1)} = 681.5\ \Omega$$

$$Req_{(2)} = (681.5) \,||\, (98.9)$$

$$= 86.36\ \Omega$$

$$Req = 86.36 + 325 + 467$$

$$= 878.36\ \Omega$$

$$I_{22} = \frac{10}{878.36}$$

$$I_{22} = 11.38\ mA.$$

$$I_{32} = 11.38 \times \frac{681.5}{(681.5 + 98.9)}$$

$$I_{32} = 9.93\ mA.$$

$$I_{12} = I_{22} - I_{32}$$

$$I_{12} = 11.38 - 9.93$$

$$I_{12} = 1.45\ mA$$

2. Switch on the power supply to the kit.

3. Adjust the $V_1 = 5V$ alone and short circuit V_2 and measure the value of current through R_1, R_2 and R_3.

4. Adjust $V_2 = 10V$ alone and short circuit V_1 to measure the value of current I through R_1, R_2 and R_3

5. Adjust $V_1 = 5V$ and $V_2 = 10V$ and measure the value of current through R_1, R_2 and R_3.

OBSERVATIONS :

$R_1 = 214.5\ \Omega$
$R_2 = 325\ \Omega$
$R_3 = 98.9\ \Omega$
$R_4 = 467\ \Omega$
$R_5 = 467\ \Omega$

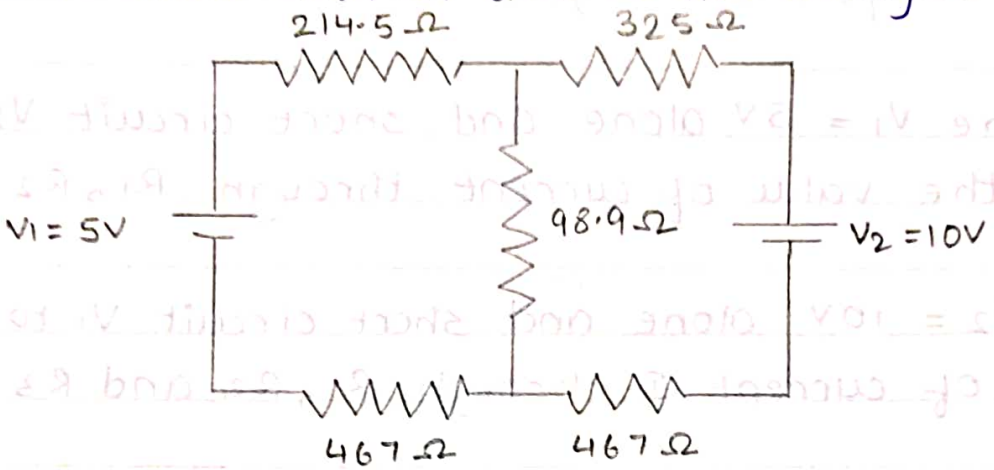
Observation table.

(a.) Practical values.

Sr. No.	V_1 (V)	V_2 (V)	I_1 (mA)	I_2 (mA)	I_3 (mA)
1.	5	0	5.8 (→)	0.87 (→)	5 (↓)
2.	0	10	1.76 (←)	10.7 (←)	8.6 (↓)
3.	5	10	4.2 (→)	10 (←)	13.6 (↓)

CALCULATIONS :

Case 3 : When both V_1 and V_2 are acting ($V_1 = 5V$ $V_2 = 10V$



By theorem of superposition,

$$I_1 = I_{11} - I_{12}$$
$$= 6.49 - 1.45$$
$$= 5.04 \text{ mA}$$

$$I_2 = I_{22} - I_{21}$$
$$= 11.38 - 0.72$$
$$= 10.66 \text{ mA}$$

$$I_3 = I_{31} + I_{32}$$
$$= 5.77 + 9.93$$
$$= 15.7 \text{ mA}$$

b.) Theoretical values.

Sr. No.	V_1(V)	V_2(V)	I_1(mA)	I_2(mA)	I_3(mA)
1.	5	0	6.49(→)	0.72(→)	5.77 (↓)
2.	0	10	1.045(←)	11.38 (←)	9.93 (↓)
3.	5	10	15.04(→)	10.66(←)	15.70 (↓)

RESULT :

1. Observed and theoretical values of current almost the same.

2. Practical value of current = 4.2mA, 10 mA, 13.6mA.
Theoretical value of current = 5.04mA, 10.66mA, 15.7mA.

CONCLUSION :

1. We have studied and verified superposition theorem.

2. It is found that current through a point in a circuit through containing multiple sources is the sum of currents through that point when each source acts independently.