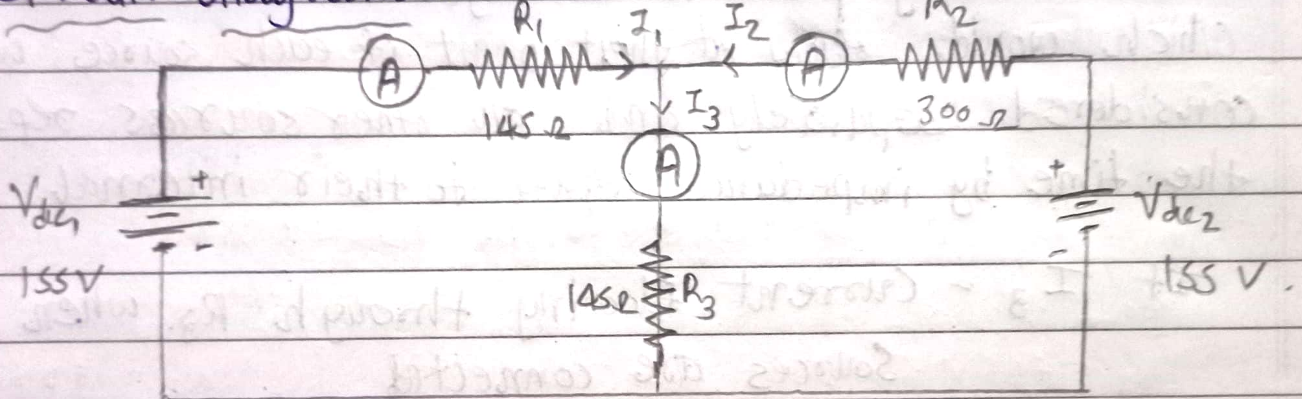
Experiment : 3

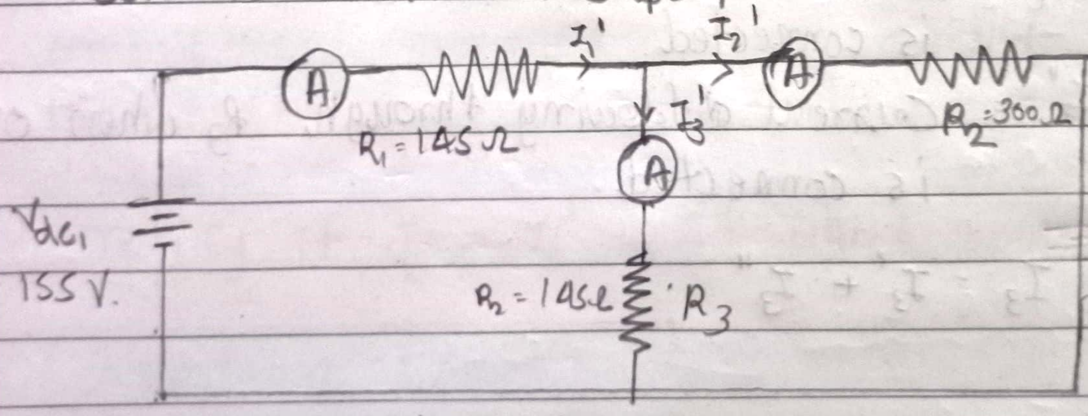
Aim : Verification of superposition theorem for electric circuit.

Apparatus : DC power supply, Ammeter (0-1A) Voltmeter (0-150 V), Rheostat, Multimeter.

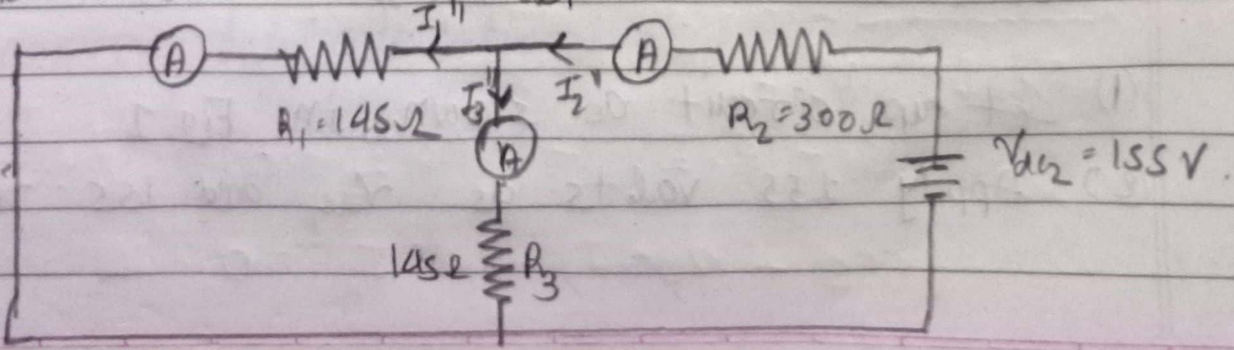
Circuit diagram :



Resistive circuit for superposition theorem



Resistive circuit with Vdc1 = 155 V



Theory :

If network contains two or more than two sources, then principle of superposition theorem is used to simplify network calculations. It may be stated as follow "In a bilateral network if two or more than two energy sources are present, then the current flows at any point is the algebric sum of all currents which would flow at that point if each source was considered separately and all other sources replaced at the time by impedance equal to their internal impedances.

If I_3 = Current flowing through R_3 when both Sources are connected

I_3' = Current flowing through R_3 when only V_{dc_1} is connected.

I_3'' = Current flowing through R_3 when only V_{dc_2} is connected.

Then,

$$I_3 = I_3' + I_3''$$

Procedure :

(1) Set up circuit as shown in Fig. 1

(2) Apply 15 volts as V_{dc_1} and 15 volts as V_{dc_2}

(3) measure the current I_1, I_2, I_3 using ammeters connected in the circuit and note it in table.

(4) Now, short circuit the terminal where V_{dc_2} is connected as shown in Fig 2.

(5) Measure the current I_1', I_2', and I_3' using ammeters connected in the circuit and note it in table.

(6) Now short circuit the terminal where V_{dc_1} is connected and apply 15 V to V_{dc_2} terminal as shown in Fig 3.

(7) Measure the current I_1'', I_2'', and I_3'' using ammeters connected in the circuit and note it in table

(8) verify if $I_3 = I_3' + I_3''$ which woul

Observation :

(1) Experimental calculations :

Current through resistors.

$V_{dc_1} = 155\ V$ $V_{dc_2} = 155\ V$	$V_{dc_1} = 155\ V$ $V_{dc_2} = 0\ V$.	$V_{dc_1} = 0\ V$ $V_{dc_2} = 155\ V$.
$I_1 = 0.5A$ $I_2 = 0.23A$ $I_3 = 0.7A$	$I_1' = 0.7A$ $I_2' = 0.23A$ $I_3' = 0.5A$	$I_1'' = 0.24A$ $I_2'' = 0.45A$ $I_3'' = 0.24A$

(2) mathematical Calculations:

Current through resistors.

$V_{dc_1} = 155\ V$ $V_{dc_2} = 155\ V$	$V_{dc_1} = 155\ V$ $V_{dc_2} = 0\ V$	$V_{dc_1} = 0\ V$ $V_{dc_2} = 155\ V$.
$I_1 = 0.43$ $I_2 = 0.21$ $I_3 = 0.64$	$I_1' = 0.64$ $I_2' = 0.21$ $I_3' = 0.43$	$I_1'' = 0.21$ $I_2'' = 0.42$. $I_3'' = 0.21$

Calculations:

→ For Fig. 1.

Apply KVL

$$155 - 145 I_1 - 145 I_3 = 0 \quad (\because I_3 = I_1 + I_2)$$

$$\therefore 155 - 290 I_1 - 145 I_2 = 0 \quad \text{A}$$

$155 - 145I_1 + 300I_2 - 155 = 0.$

$145I_1 - 300I_2 = 0$ — ②

eq - ① × 2 + eq. 1 so we get

$155 - 290I_1 - 145I_2 + 290I_1 - 600I_2 = 0.$

$I_2 = \frac{155}{745} = 0.208.$

$\boxed{I_2 = 0.21A.}$

From eq. ②. $I_1 = \frac{300(0.21)}{145}$ $\boxed{I_1 = 0.43\ A.}$

and $I_3 = I_1 + I_2 = 0.43 + 0.21$

$\boxed{I_3 = 0.64A.}$

For Fig. 2

$R_{eq} = R_1 + \frac{R_2 R_3}{R_2 + R_3} = 145 + \frac{300 \times 145}{445}$

$\boxed{R_{eq} = 242.75}$

$I_1' = \frac{V_{dc_1}}{R_{eq}} = \frac{155}{242.75} = 0.638 = 0.64.$

$\boxed{I_1' = 0.64A}$

Scanned with CamScanner

$$I_2' = I_1' \times \frac{R_3}{R_2+R_3} = \frac{0.64 \times 145}{445} = 0.21$$

$$\boxed{I_2' = 0.21A.}$$

$$I_3' = I_1' - I_2' = 0.64 - 0.21 = 0.43.$$

$$\boxed{I_3' = 0.43A}$$

For Fig-3

$$R_{eq} = R_2 + \frac{R_1 R_3}{R_1 + R_3} = 300 + \frac{145 \times 145}{290} = 300 + 72.5.$$

$$\boxed{R_{eq} = 372.5\ \Omega.}$$

$$I_2'' = \frac{V_{dc2}}{R_{eq}} = \frac{155}{372.5} = 0.416 \approx 0.42.$$

$$\boxed{I_2'' = 0.42A}$$

As R_1 and R_3 has equal resistance so the current will be divided equally,

$$I_1'' = I_3'' = \frac{0.42}{2} = 0.21$$

$$\boxed{I_1'' = 0.21A} \quad \boxed{I_3'' = 0.21A}$$

Now, let's verify superposition theorem

for I_1

$$I_1 = I_1' - I_1''$$

L.H.S. $I_1 = 0.43$

R.H.S. $I_1' - I_1'' = 0.64 - 0.21 = 0.43$

L.H.S. = R.H.S.

For I_2

$$I_2 = I_2'' - I_2'$$

L.H.S. = $I_2 = 0.21$

R.H.S. $I_2'' - I_2'' = 0.42 - 0.21 = 0.2$

$\therefore$ L.H.S = R.H.S.

For I_3

$$I_3 = I_3' + I_3''$$

L.H.S = $I_3 = 0.64$.

R.H.S = $I_3' + I_3'' = 0.21 + 0.43 = 0.64$.

$\therefore$ L.H.S. = R.H.S.

Hence superposition theorem is valid.

Question:

1) What are the limitations of superposition theorem?

- It cannot be used to measure power.
- It is valid only for linear and bilateral network.
- It can only be used for ~~el~~ circuits having two or more than two energy sources.
- This theorem is not applicable to unbalanced bridge circuits.

Result :

For fig-1

The current through resistor R_1, $I_1 = 0.5\,A$

The current through resistor R_2, $I_2 = 0.23\,A$

The current through resistor R_3, $I_3 = 0.7\,A$.

For Fig-2

The current through resistor R_1, $I_1' = 0.7A$.

The current through resistor R_2, $I_2' = 0.23A$

The current through resistor R_3, $I_3' = 0.5A$

For fig-3

The current through resistor R_1, $I_1'' = 0.24A$

The current through resistor R_2, $I_2'' = 0.45A$.

The current through resistor R_3, $I_3'' = 0.24A$

Scanned with CamScanner

Date
Page

Conclusion:

In this experiment we could see that the superposition theorem which states that. "In a bilateral network with 2 or more than 2 energy sources, the circuit flowing at any point is the algebric sum of all currents which would flow at that point if each source was considered separately and all other sources replaced at the the time by impedence equal to their internal impedence." holds true and verified sucessfully. And we also saw some of the Limitations of superposition theorem.