Ch1: DC Circuits

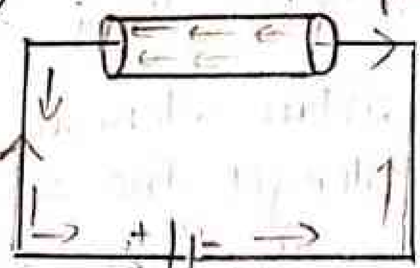
1. **Electricity** The flow of electrons in a closed circuits to do work.

2. **Electric Current** The continous movement of free electron in an electric circuit from -ve terminal of the cell to +ve terminal through external circuit.

$$\text{current} = \frac{q\ (\text{coulomb})}{t\ (\text{sec})} = \text{Ampere}.$$

or

It is the rate of flow of electrons or charge flowing per sec.



3. **Electric potential** The capacity of a charged body to do work

$$V = \frac{\text{Work done}}{\text{Charge}} = \frac{W\ (\text{Joule})}{Q\ (\text{coulomb})} = \text{Volts}$$

4. **OHM's Law** Keeping the physical condition & temp. of conductor etc as constant, current flowing between any two points of a conductor is directly prop. to potential difference across them. R is in ohm.

$$I \propto V$$

$$\frac{V}{I} = \text{Constant} \qquad V = IR \qquad I = \frac{V}{R}$$

5. **Limitation of OHM's law**

This law is not applicable to.

1. Non linear element such as electric arc, powdered carbon, thyrite etc.
2. Unilateral Networks such as electronic tubes & diode (transistor as these elements are not bilateral)

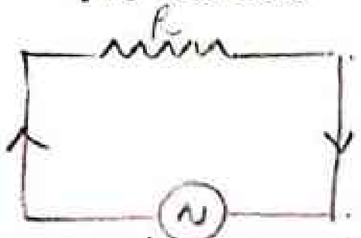
6. **Electric Power** The rate at which work is done in an electrical circuit

$$P = \frac{\text{Work done}}{\text{time}} = \frac{VIt}{t} = VI \qquad W = VQ = VIt$$

1. Circuit It is a closed path through which current flow.

2 types

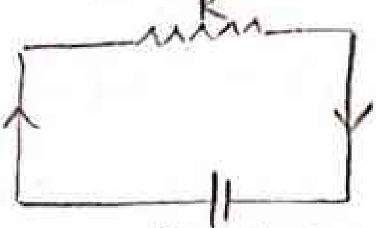
AC Circuit



AC source (generator)

Current and voltage changes w.r.t to time $f = 50Hz$

DC Circuit



DC source (battery)

$f = 0$

Voltages and current remain constant.

8. Linear and Non linear element

The resistive elements for which the Volt Ampere characteristics is straight line are called linear and the circuit containing only linear resistance are called linear circuits.

The ~~resistive~~ elements for which the Volt Ampere characteristi is not straight line are called non linear elements and the circuit containing non linear element are called non linear circuit eg. tungsten lamps, vacuum tubes & transistor etc

9. Unilateral and bilateral circuit.

An electric circuit whose characteristic properties change with the direction of its operation (eg diode, rectifier) are called unilateral circuit.

An electric circuit whose characteristic properties remain same in either ~~of~~ direction (eg. distribution or transmission lines) are called bilateral circuits.

10. Active and passive element

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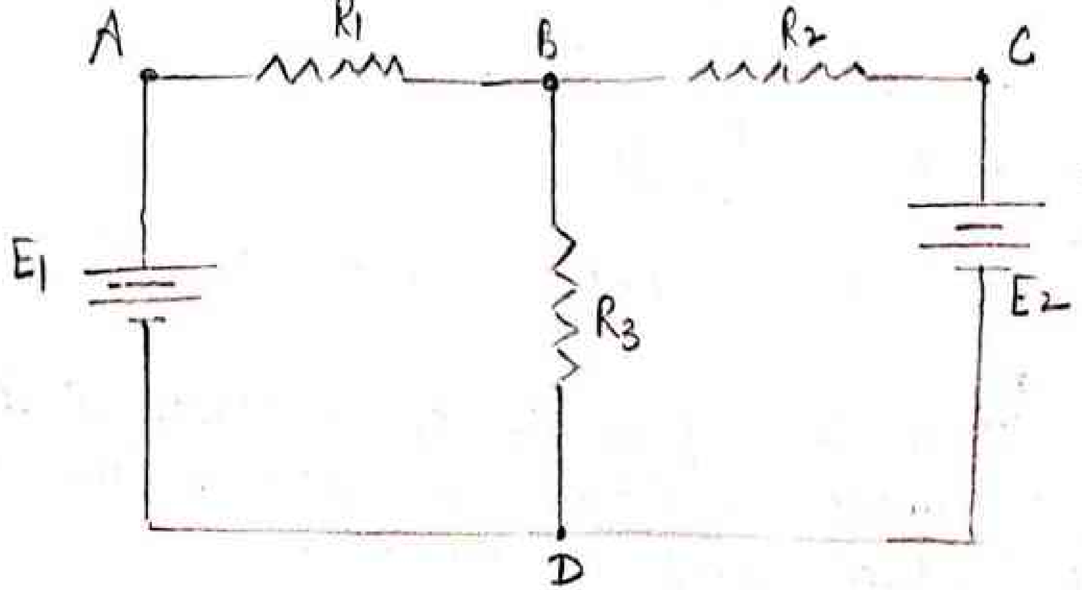
Those element which receiver energy are called ~~active~~ passive element eg Resistor, inductor and Capacitor eg (R_1, R_2, R_3) ②

Those element which supplies energy to circuit is called active element and network having active element is called active network eg. any source (ac or dc) eg (E_1, E_2)



11. Node A node is a point in network where two or more circuit element are joined eg A, B, C & D

12. Junction A point in the network where 3 or more element joined eg B.

13. Branch Part of network which lies b/w the 2 circuit joint DAB . BCD

14. Loop The closed path of network is called loop. (ABDA, BCDA) → (ABCDA)

15. Mesh The loop which can't be further divided is called mesh ABDA and BCDB are 2 mesh but (ABCDA is loop

* Series and parallel circuit.
(Numericals)

1. Electrical Circuit element (R, L and C)

1. **Resistance**: The opposition offered to the flow of current

$$R = \frac{V}{I} \quad \text{or} \quad R = \rho \frac{l}{a} \quad \text{unit: ohm}$$

R (Resistor)

$$P(\text{Power absorbed by resistor}) = VI = IR \times I = I^2 R$$

Or

$$= V \times \frac{V}{R} = \frac{V^2}{R}$$

$$W(\text{energy lost in the form of heat}) = \int_0^t P\,dt$$

$$= \int_0^t I^2 R\,dt = I^2 R t \quad \text{or} \quad \frac{V^2}{R} t$$

2. **Inductance**: It is the property of a material by the virtue of which a change in electric current through it induces emf in conductor.

$$V = L\frac{di}{dt} \quad \text{or} \quad i = \frac{1}{L}\int V\,dt + i_0$$

i_0 initial current.

L (Inductor)

$$\text{Power absorbed} = V \times I = L\frac{di}{dt} \times i = Li\frac{di}{dt}$$

$$\text{Energy absorbed by inductor} = \int_0^t P\,dt = \int_0^{t=i} Li\frac{di}{dt} \times dt = \frac{1}{2}Li^2$$

3. **Capacitance** The capability of an element to store electric charges with in it.

Capacitor

$$C = \frac{Q}{V} \quad -1 \qquad i = \frac{dq}{dt} \quad -3 \qquad dq = i\,dt$$

$$Q = CV \quad -2$$

$$i = \frac{d(CV)}{dt} = C\frac{dv}{dt} \quad \text{and} \quad V = \frac{1}{C}\int i\,dt + V_0$$

V_0 Initial Voltage

$$\text{Power absorbed} = P = VI = C\frac{dV}{dt} \times V = CV\frac{dV}{dt}$$

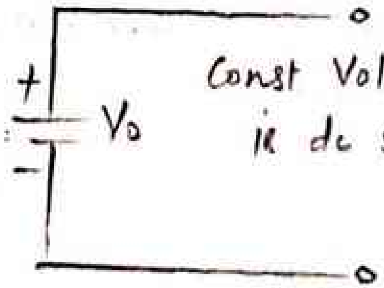
$$\text{Energy stored } W = \int_0^t P\,dt = \int_0^t CV\frac{dV}{dt} \times dt = \int_0^V CV\,dV = \frac{1}{2}CV^2$$

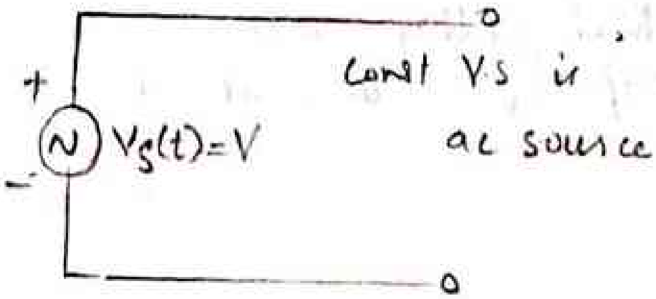
Since at steady state i_0 in inductor and V_0 in capacitor are zero hence energy consumed is zero for both inductor and capacitor in steady state. (3)

Voltage and current sources / (Energy Sources) V.Imp.

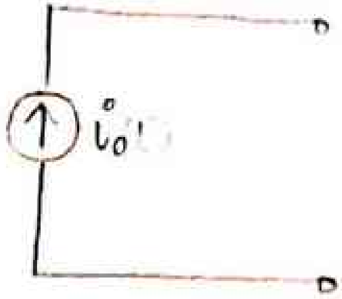
1. Independent Ideal Voltage source
2. Independent Ideal current source
3. Dependent or controlled Voltage sources
4. Dependent or controlled current Sources
5. Real or Non ideal Voltage sources
6. Real or Non ideal current sources.

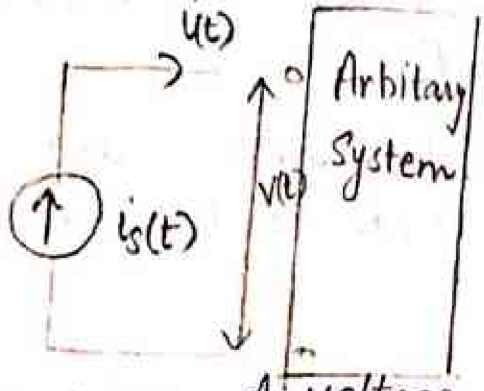
1. IIVS: That maintain as constant terminal Voltage no matter how much current is drawn from it.





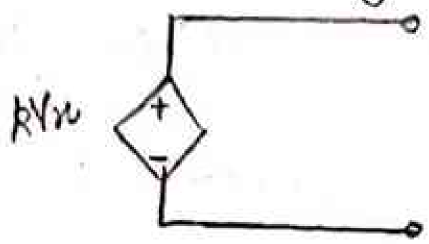
2. IICS: That supply the same current to any resistance connected across it terminal and is independent of Voltage at source terminal.





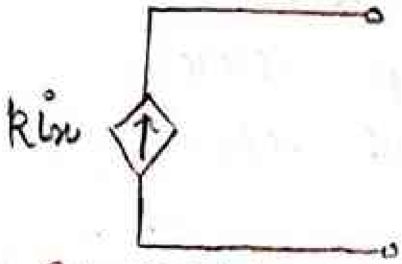
3. Dependent or controlled Voltage source: A voltage source whose $V_s(t)$ depends on the Value of some other Variable

either Voltage or current at some other point in the circuit is dependent Voltage source.



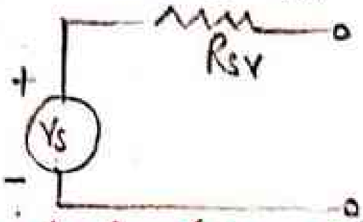
4. Dependent or controlled current source

A current source whose $i_s(t)$ depend on the value of some other Variable (either Voltage or current) at some other point in circuit is dependent current source



5. Real or Non Ideal Voltage Source

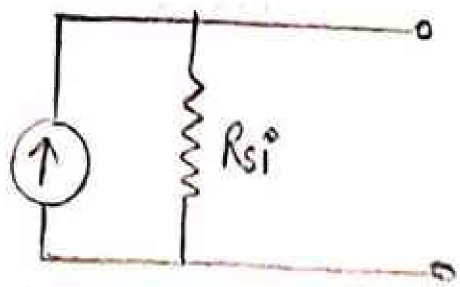
Any ~~non~~ ideal Voltage source cannot be constructed.
& Real voltage source has small but finite resistance R_{sv}.
* if $R_{sv} = 0$ then it become an ideal source.



6. Real or non ideal Current Source

An ideal current source ~~emf~~ cannot be constructed
∴ real current I_s source always has some internal resistance R_{si}

if $R_{si} = \infty$ then such current source become ideal current Source.

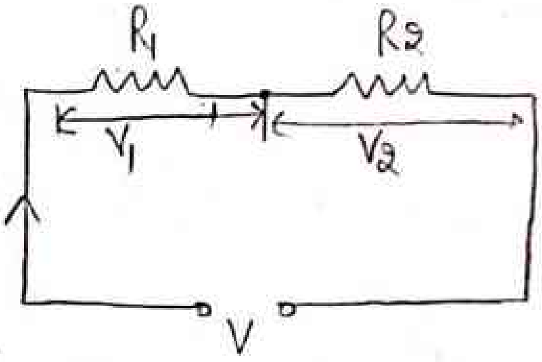


* Can we convert Voltage source into current source and vice versa.

Ans Yes

18. Voltage division b/w 2 resistors

Total current $I = \frac{V}{(R_1+R_2)}$



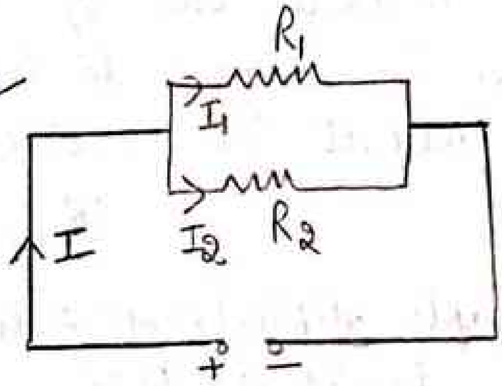
By ohm's law

$$V_1 = R_1 I$$
$$V_1 = R_1 \times \frac{V}{(R_1+R_2)}$$

$$V_2 = R_2 I$$
$$= V \times \frac{R_2}{(R_1+R_2)}$$

19. Current division equation

I = Total current R_p = Total Resistance



$$R_p = \frac{R_1 \times R_2}{R_1+R_2}$$

$$I = \frac{V}{R_p} \qquad I_1 = \frac{V}{R_1} \qquad I_2 = \frac{V}{R_2}$$

So. $\frac{I_1}{I} = \frac{\cancel{V}}{R_1} \times \frac{R_p}{\cancel{V}} = \frac{R_p}{R_1} = \frac{\cancel{R_1} \times R_2}{\cancel{R_1}(R_1+R_2)} = \frac{R_2}{(R_1+R_2)}$

$$I_1 = \frac{R_2}{(R_1+R_2)} \times I$$

Ily $I_2 = \frac{R_1}{(R_1+R_2)} \times I$.

20. Kirchhoff Current law (KCL or Point law) V.Imp

The algebraic sum of all current meeting at a junction or a point is zero or sum of incoming current towards the junction is equal to sum of outgoing current away from the junction

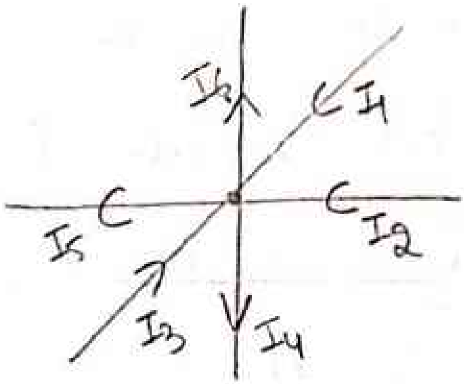
(Kirchoff's first law / KCL / Point law)

$$\Sigma I = 0$$

Here I_1, I_2, I_3 are incoming current

I_4, I_5, I_6 are outgoing current

$$I_1 + I_2 + I_3 - (I_4 + I_5 + I_6) = 0$$



in → +ive

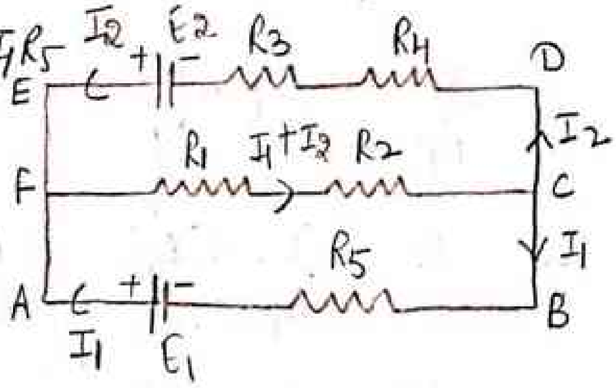
out → -ive

21. Kirchhoff's Voltage law V. Imp

Kirchhoff's second law / KVL / mesh law.

The algebric sum of emf's acting in that circuit or mesh is equal to the algebric sum of the products of current and resistance of each part of circuit.

$$\Sigma IR = \Sigma emf$$



example. AFCBA: $E_1 = (I_1+I_2)R_1 + (I_1+I_2)R_2 + I_1R_5$

$$E_1 = (I_1+I_2)(R_1+R_2) + I_1R_5$$

FEDCF: $-E_2 = -I_2R_3 - I_2R_4 - (I_1+I_2)(R_1+R_2)$

$$E_2 = I_2(R_3+R_4) + (I_1+I_2)(R_1+R_2)$$

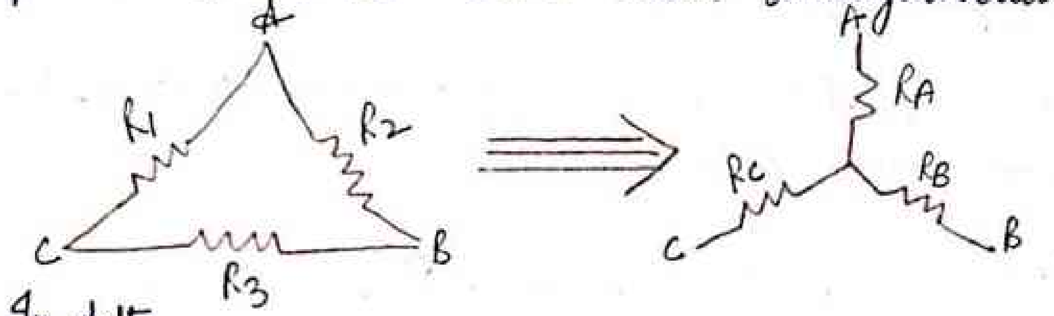
In mesh $E_1 - E_2 = I_1R_5 - I_2(R_3+R_4)$

22. Delta star Transformation V. Imp

The equivalent star resistance connected to given terminal is equal to product of two delta resistance connected to the same terminal divided by sum of delta connected resistance.

$$R_A = \frac{R_1R_2}{R_1+R_2+R_3} \qquad R_B = \frac{R_2 \times R_3}{R_1+R_2+R_3} \qquad R_C = \frac{R_3 \times R_1}{R_1+R_2+R_3}$$

The replacement of delta or mesh by equivalent star s/s is known as delta star transformation.



In delta

<u>Resistance</u> $R_{BC} = R_3 \parallel (R_1 + R_2)$

So $R_{BC} = \dfrac{R_3(R_1+R_2)}{R_3+R_2+R_1}$ In Delta system. — 1

$R_{BC} = R_B + R_C$ In star system — 2

$\underset{R_{BC}}{\text{Delta}} \equiv \underset{R_{BC}}{\text{Star}}$ <u>from 1 and 2</u>

$$\frac{R_3(R_1+R_2)}{R_3+R_2+R_1} = \underline{\underline{R_B+R_C}} \quad -3$$

IIly $\underline{\underline{R_C+R_A}} = \dfrac{R_1(R_2+R_3)}{R_1+R_2+R_3}$ — 4 IIly $\underline{\underline{R_A+R_B}} = \dfrac{R_2(R_1+R_3)}{R_1+R_2+R_3}$ — 5

Now Add 3, 4 and 5

$$\cancel{2}(R_A+R_B+R_C) = \cancel{2}\left(\frac{R_1R_3+R_2R_3+R_1R_2}{R_1+R_2+R_3}\right) \text{ from } \underline{3}\text{eq..}$$

$$R_A+\underline{\underline{R_B+R_C}} = \frac{R_1R_3+R_2R_3+R_1R_2}{R_1+R_2+R_3} \quad -6$$

Put value R_B+R_C from 3 in eq 6

$$R_A + \frac{R_3R_1+R_3R_2}{R_1+R_2+R_3} = \frac{R_1R_3+R_2R_3+R_1R_2}{R_1+R_2+R_3}$$

$$\text{So } R_A = \frac{\cancel{R_1R_3}+\cancel{R_2R_3}+R_1R_2-\cancel{R_3R_1}-\cancel{R_3R_2}}{R_1+R_2+R_3} = \frac{R_1R_2}{R_1+R_2+R_3}$$

IIly $R_B = \dfrac{R_2R_3}{R_1+R_2+R_3}$ $R_C = \dfrac{R_3R_1}{R_1+R_2+R_3}$

if $R_1 = R_2 = R_3 = R$ $\quad R_C = \frac{R^2}{3R} = \frac{R}{3}$

23. Star Delta Transformation

The replacement of star by its equivalent delta system is known as star delta transformation.

The equivalent delta resistance between two terminal is the sum of 2 star resistance connected to those terminal plus the product of same divided by the 3rd star resistance

$$R_1 = R_A + R_C + \frac{R_A R_C}{R_B} \quad R_2 = R_A + R_B + \frac{R_A R_B}{R_C} \quad R_3 = R_B + R_C + \frac{R_B R_C}{R_A}$$

In star $R_A R_B + R_B \times R_C + R_C \times R_A$

$$= \left(\frac{R_1 R_2}{R_1+R_2+R_3} \times \frac{R_2 R_3}{R_1+R_2+R_3}\right) + \left(\frac{R_2 R_3}{R_1+R_2+R_3} \times \frac{R_3 \times R_1}{R_1+R_2+R_3}\right) + \left(\frac{R_3 R_1}{R_1+R_2+R_3} \times \frac{R_1 R_2}{R_1+R_2+R_3}\right) \quad -1$$

$$= \frac{R_1 R_2^2 R_3}{(R_1+R_2+R_3)^2} + \frac{R_1 R_2 R_3^2}{(R_1+R_2+R_3)^2} + \frac{R_1^2 R_2 R_3}{(R_1+R_2+R_3)^2} \quad -2$$

$$= \frac{R_1 R_2^2 R_3 + R_1 R_2 R_3^2 + R_1^2 R_2 R_3}{(R_1+R_2+R_3)^2} \quad -3$$

$$= \frac{R_1 R_2 R_3 \cancel{(R_1+R_2+R_3)}}{\cancel{(R_1+R_2+R_3)^2}} = \frac{R_1 R_2 R_3}{(R_1+R_2+R_3)} \quad -4$$

Divide equation -4 $\quad R_A = \frac{R_1 R_2}{(R_1+R_2+R_3)}$

$$\frac{R_A R_B + R_B \times R_C + R_C \times R_A}{R_A} = \frac{\cancel{R_1 R_2} R_3}{\cancel{(R_1+R_2+R_3)}} \times \frac{\cancel{(R_1+R_2+R_3)}}{\cancel{R_1 R_2}}$$

$$\frac{\cancel{R_A} R_B}{\cancel{R_A}} + \frac{R_B R_C}{R_A} + \frac{R_C \cancel{R_A}}{\cancel{R_A}} = R_3 \quad \text{so } R_3 = R_B + R_C + \frac{R_B R_C}{R_A}$$

Illy $R_1 = \dfrac{R_A R_B + R_B R_C + R_C R_A}{R_B} = R_A + R_C + \dfrac{R_A R_C}{R_B}$

$R_2 = R_A + R_B + \dfrac{R_A R_B}{R_C}$

if $R_A = R_B = R_C = R$

$R = R + R + \dfrac{R \times R}{R} = 3R$

<u>Numerical</u> Three resistance r, 2r and 3r are connected in delta. Determine the resistances for an equivalent star connection.

<u>Solution</u> $R_A = \dfrac{R_1 R_2}{R_1 + R_2 + R_3}$ $R_1 = r$ $R_2 = 2r$ $R_3 = 3r$

$= \dfrac{r \times 2r}{r + 2r + 3r} = \dfrac{2r^2}{6r} = \dfrac{r}{3}$ <u>Ans</u>.

$R_B = \dfrac{R_2 R_3}{R_1 + R_2 + R_3} = \dfrac{2r \times 3r}{r + 2r + 3r} = \dfrac{6r^2}{6r} = r$ <u>Ans</u>

$R_C = \dfrac{R_3 R_1}{R_1 + R_2 + R_3} = \dfrac{3r \times r}{6r} = \dfrac{3r^2}{6r} = \dfrac{1}{2} r$ <u>Ans</u>.

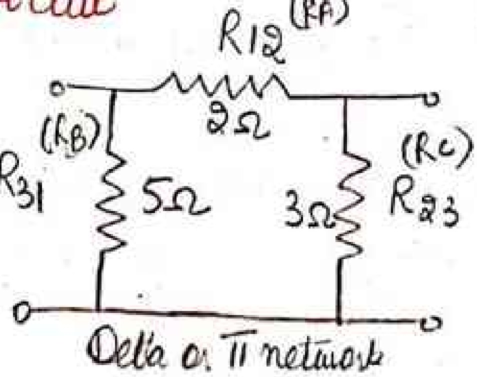
<u>Numerical 2</u> Convert Π network into T equivalent and as a check convert star circuit back to its delta circuit.

<u>Solution</u>

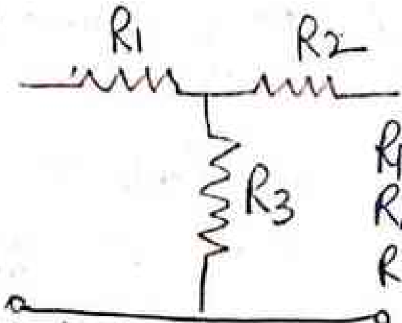
$R_1 = 1\Omega$

$R_2 = 0.6\,\Omega$

$R_3 = 1.5\,\Omega$



Delta or Π network



Star or T network

$R_{12} = 2\Omega$

$R_{23} = 3\Omega$

$R_{31} = 5\Omega$

24. Network Theorems

Network Theorems

Superposition Theorem   Thevenin's Theorem   Norton Theorem.

Network: A network is a collection of Interconnected component (resistor, Inductor, capacitor).

Network analysis is the process of finding the voltage across, and the currents through every component in the network and the network theorem are used to calculate Voltage and current of complex network. These theorem are derived from ohm's law, KCL & KVL.

Superposition Theorem

Theorem: In a linear dc network containing more than one independent source, the overall current response (current or Voltage) in any branch is equal to algebric sum of the response due to each independent source acting one at a time with all other ideal independent sources set equal to zero.

* Ideal current source equal to zero means it is replaced by an open circuit.
* An Ideal Voltage source equal to zero means it is replaced by short circuit.

Note: It is applicable to linear, time varying and time invarient network and also applies only to independent sources.

Procedure 1. Select any one source in circuit.

2. Set all other Independent source is zero.
ie V.S = short circuit, C.S = open circuit

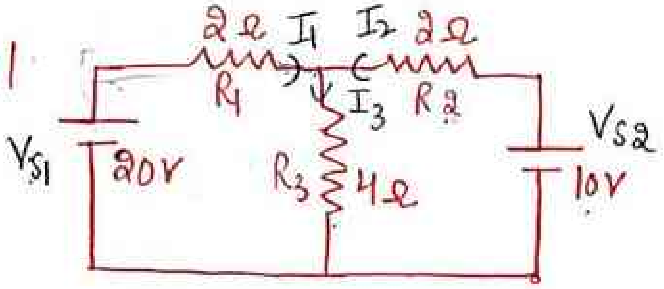
3. Keep the dependent source in circuit undisturbed.

4. Determine the magnitude and direction of current through desired branch due to single source selected.

5. Repeat step 1 to 4 for each source

6. Add all the component of current to obtained desired brach current.

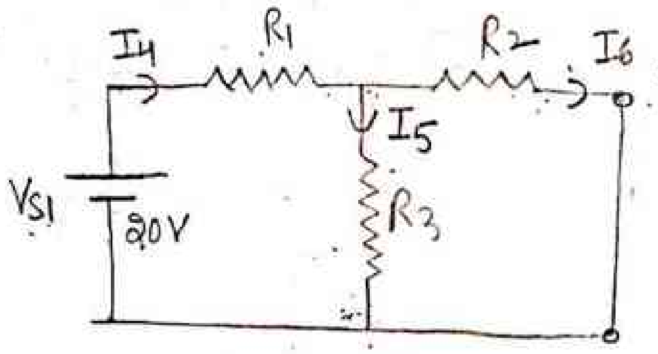
Example 1



$I_1 = +I_4 - I_7$

Solution Step 1 Consider 20V source alone and 10V source is replaced by S.C

So equivalent Resistance



$$R_{23} = \frac{R_2 R_3}{R_2 + R_3} = \frac{2 \times 4}{2+4} = \frac{8}{6} = \frac{4}{3}\,\Omega$$

Total resistance

$$= R_1 + (R_2 \| R_3)$$

$$R_T = 2 + \frac{4}{3} = \frac{6+4}{3} = \frac{10}{3}\,\Omega$$

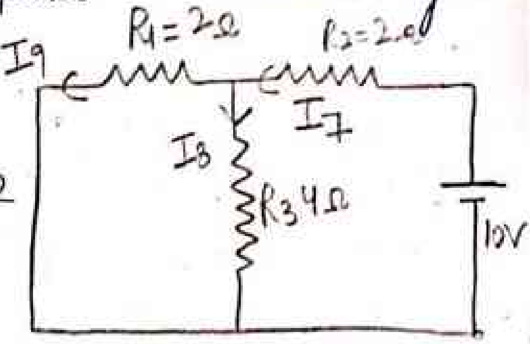
$$\text{So } I_4 = \frac{20}{R_T} = \frac{20}{10} \times 3 = 6A$$

The current I_5 and I_6 found by current divider Theorem.

$$I_5 = I_4 \times \frac{R_2}{R_2 + R_3} = 6 \times \frac{2}{2+4} = \frac{12}{6} = 2A$$

$$I_6 = I_4 \times \frac{R_3}{R_2 + R_3} = 6 \times \frac{4}{4+2} = \cancel{6} \times \frac{4}{\cancel{6}} = 4A$$

Step 2 Now considered 10V source and Replace 20V source by SC



here $(R_1 \| R_3) + R_2 = R_T$

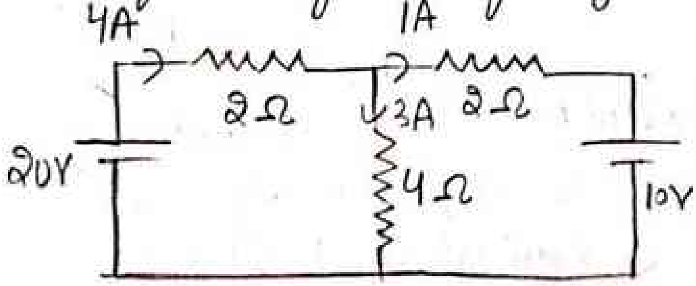
$$R_T = \left(\frac{2\times4}{2+4}\right)+2 = \frac{8}{6}+2 = \frac{12+8}{6} = \frac{20}{6} = \frac{10}{3}$$

So $I_7 = \frac{V_{sr}}{R_T} = \frac{10}{10}\times 3 = 3A$

$I_8 = \frac{R_1}{R_1+R_3}\times I_7 = \frac{2}{2+4}\times 3 = \frac{6}{6} = 1A$

$I_9 = \frac{R_3}{R_1+R_3}\times I_7 = \frac{4}{4+2}\times 3 = \frac{12}{6} = 2A$

Step 3 According to Theorem.
The current through any branch is found by taking algebric sum of current through it.

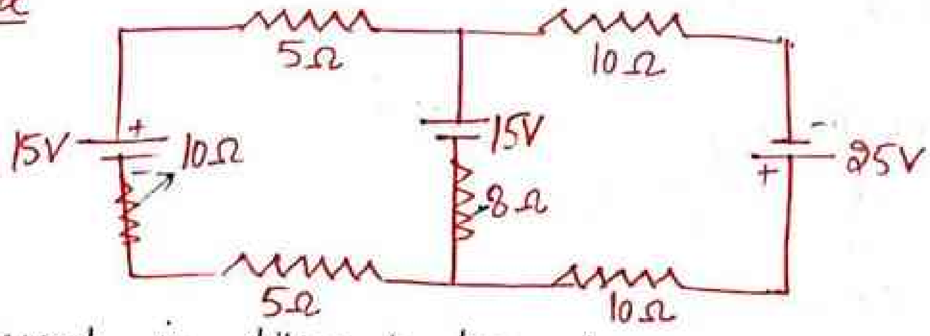


So $I_1 = I_4 - I_9 = 6-2 = 4A$

$I_2 = +I_7 - I_6 = 3-4 = -1A$

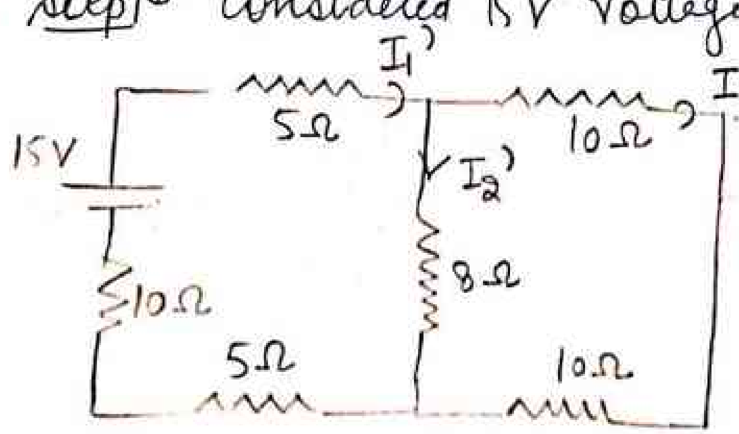
$I_3 = I_5 + I_8 = 2+1 = 3A$

Numerical 2



find current in different branches.

Sol. Step 1st Considered 15V voltage source only.



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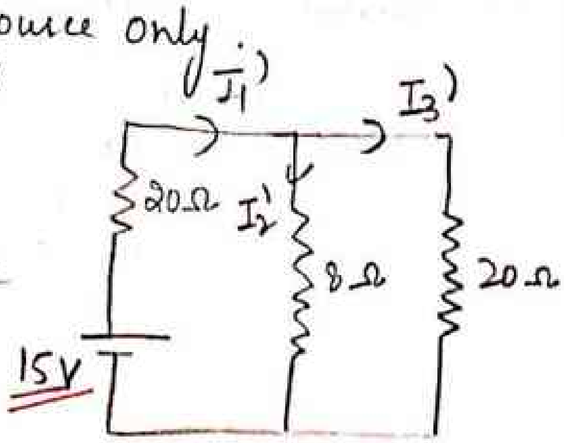


Total Resistance $R_T = 20 + (8 \| 20) = 25.714\ \Omega$

Current $I_1' = \frac{15}{25.714} = 0.5833\ A$

So $I_2' = \frac{20}{28} \times 0.5833 = 0.4167\ A$

$I_3' = \frac{8}{28} \times 0.5833 = 0.1666\ A$

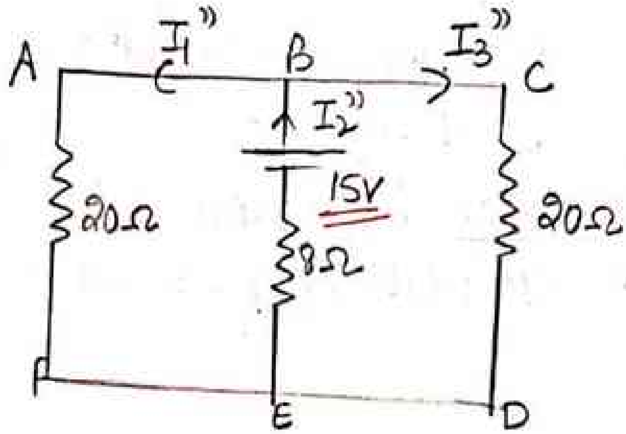
Step 2 Total $R_T = 8 + \frac{20 \times 20}{20+20} = 18\Omega$

2nd source

$I_2'' = \frac{15}{18} = 0.8333A$

So $I_1'' = 0.8333 \times \frac{20}{40} = 0.4167A$

$I_3'' = 0833 \times \frac{20}{40} = 0.4167A$



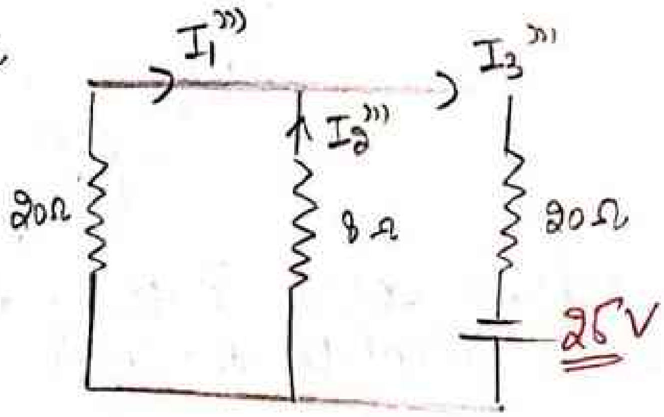
Step 3 $R_T = 20 + \frac{20 \times 8}{28} = 25.714\ \Omega$

3rd source

$I_3''' = \frac{25}{25.714} = 0.9722$

$I_2'' = 0.9722 \times \frac{8}{28} = 0.2778\ A$

$I_2'' = 0.9722 \times \frac{20}{28} = 0.6944\ A$



Step 4 Overall current in each branch.

$I_1 = I_1' - I_1'' + I_1''' = 0.444\ A$

$I_2 = -I_2' + I_2'' + I_2''' = 1.111\ A$

$I_3 = I_3' + I_3'' + I_3''' = 1.555A$

Thevenin's Theorem

It state that the current flowing through a resistor connected across any 2 terminals of a network calculated by an equivalent circuit having V.S (E_{th}) in series with a resistor (R_{th})

E_{th} = O.C Voltage b/w 2 terminal called Thevnin Voltage

R_{th} = The equivalent resistance of the network at 2 terminals.

Procedure 1. Remove the load resistance R_L

2. Calculate open circuit Voltage E_{th}/V_{th}

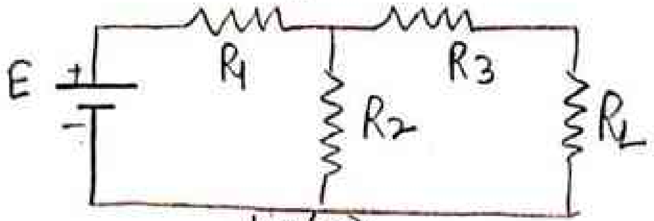
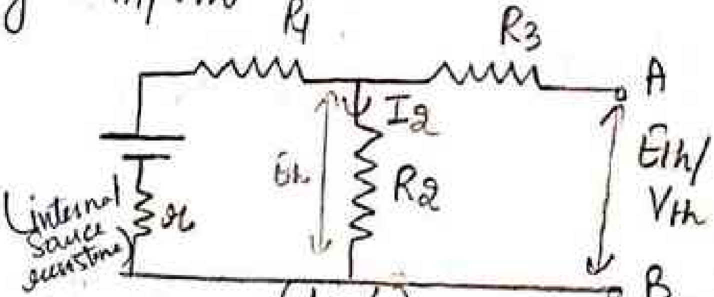


fig (a)



(fig b)

$$E_{th} = I_2 R_2$$

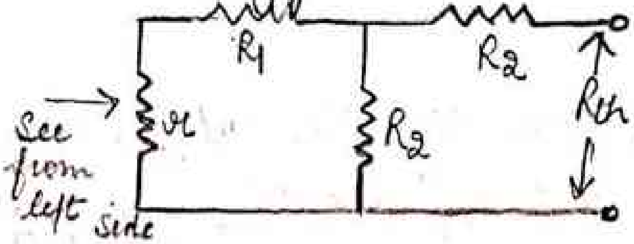
$$= \left(\frac{E}{r+R_1+R_2}\right) \times R_2$$

or voltage division $E_{th} = \left(\frac{R_2}{r+R_1+R_2}\right) \times E$

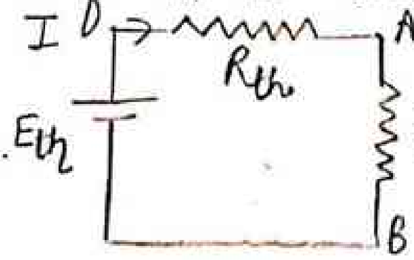
3. Replace source battery by internal source resistance and calculate the total Resistance (fig c).

So $R_{th} = ((r+R_1) \parallel R_2) + R_3$

$$= \frac{(r+R_1)R_2}{r+R_1+R_2} + R_3$$



4. Replace the entire network by single thevenin voltage Source having an emf E_{th} and Internal resistance R_{th} in series &

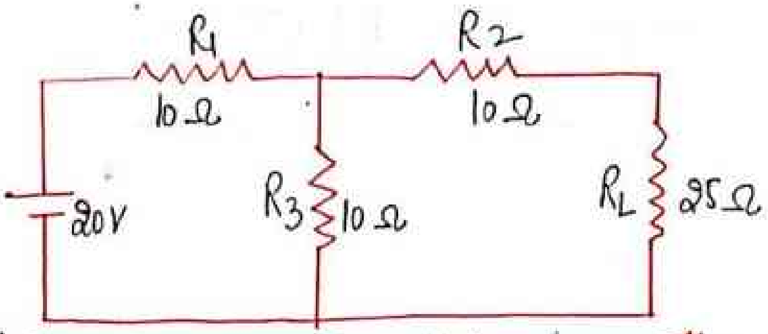


connect the load R_L back to terminal AB.

$I = I_{th}$ Thevenin current

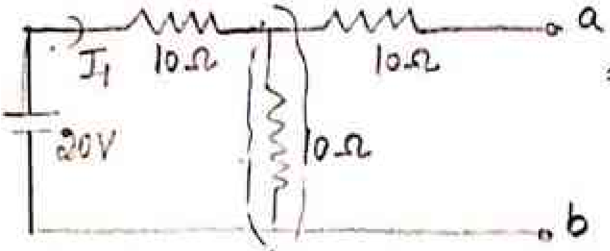
5. Calculate current through the load Resistance R_L $I_{th} = \frac{E_{th}}{R_{th}+R_L}$

Numerical 1.



Use Thevenin's Theorem to determine the current through and voltage across 25 Ω resistor.

Solution Step 1st Remove the R_L (load Resistance) 25 Ω

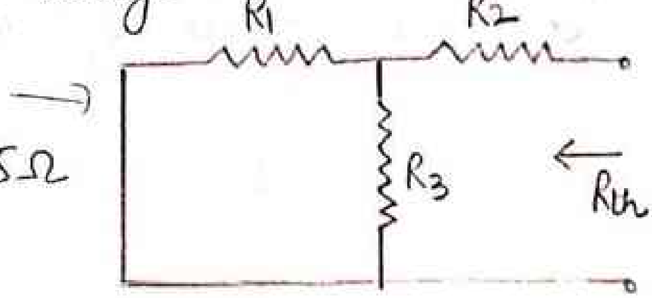


Step 2nd Determine E_{th} / V_{th}.

$$V_{ab} = R_3 \times \frac{V}{R_1+R_3} = 10 \times \frac{20}{10+10} = 10 \times \frac{20}{20} = 10$$

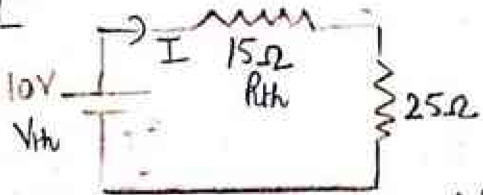
As V_{th} = open circuit voltage at ab = V_{ab} = 10V

Step 3rd Determine R_{th} for this the voltage source is short circuit.



$$R_{th} = (R_1 \parallel R_3) + R_2$$
$$= \frac{10 \times 10}{10+10} + 10 = \frac{100}{20} + 10 = 15\,\Omega$$

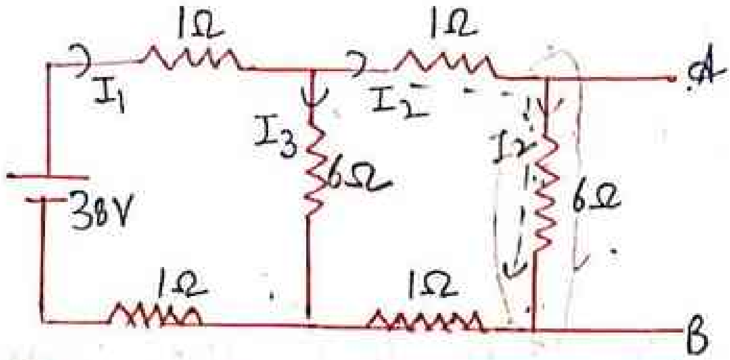
Step 4th



$$I = \frac{V_{th}}{R_{th}+R_L} = \frac{10}{15+25} = \frac{10}{40} = 0.25\,A$$

Voltage across 25 Ω Resistance
$= 25 \times 0.25$
$= 6.25$ Volts.

Numerical 2:



Solve using Thevenin theorem.

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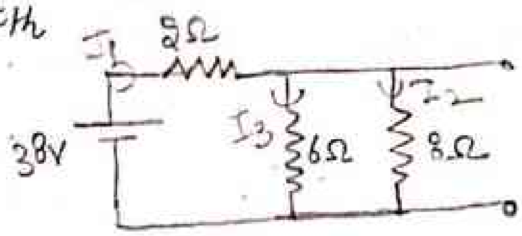
<u>Solution</u> Step 1 Determine value of E_{th}



$$R_T = \{(1+6+1)\|6 + 1+1\}$$
$$= \{(8\|6)+2\}$$
$$= \frac{8\times6}{8+6} + 2 = \frac{38}{7}$$

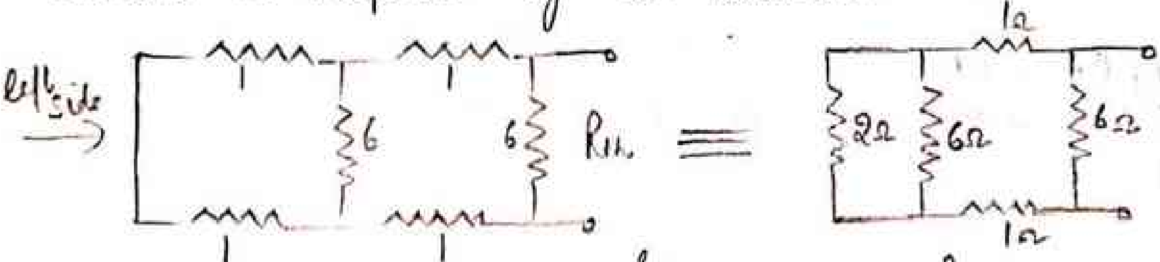
Current supplied by source $= \frac{V}{R_T} = \frac{38}{38}\times 7 = 7A$

Current in 8Ω Resistor $= \frac{6}{6+8}\times 7 = \frac{\cancel{6}^{3}}{\cancel{14}_{2}}\times\cancel{7} = 3A$

So current flow in 6Ω Resistor $= 3A$
connected across AB terminal

So thevenin Voltage $E_{th}/V_{th} = I\times R$ (across AB terminal)
$= 3\times 6 = 18V$

Step 2 Thevenin's Resistance across terminal AB when source is replace by its internal resistance is short circuit.

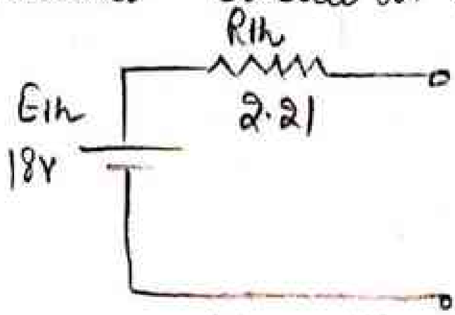


$$R_{th} = \{(2\|6)+(1+1)\|6\} \qquad \{\{(2\|6)+1+1\}\|6\}$$
$$= \left(\frac{2\times6}{2+6}+2\right)\|6 = \left(\frac{12}{8}+2\right)\|6 = 3.5\|6 = \frac{3.5\times6}{3.5+6} = 2.21\,\Omega$$

<u>Step 3</u> The Thevenin's equivalent circuit as shown in fig

$E_{th} = 18V$

$R_{th} = 2.21$

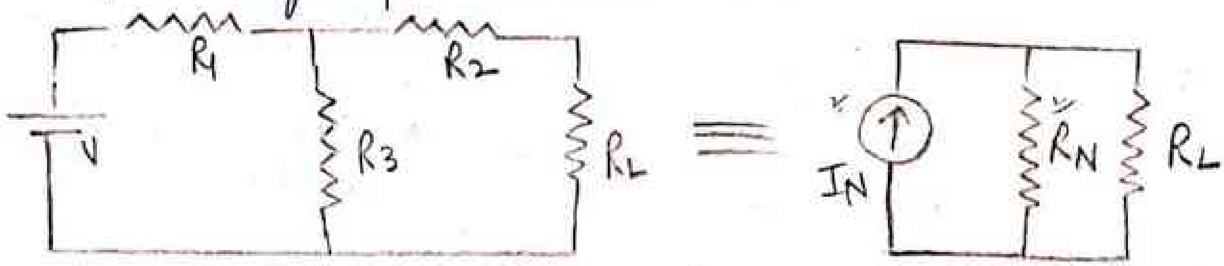


Norton's Theorem: It states that the current flowing through a resistance connected across any two terminal of a network can be determined by replacing the whole a network by an equivalent circuit of a current source having a current output I_N in parallel with resistance R_N.

I_N = Norton Current (Short circuit current supplied by the source that would flow b/w the 2 selected terminals when they s.c)

R_N = equivalent Resistance of network b/w 2 terminals.

* emf source replaced by Internal resistance and current source replaced by open circuit.

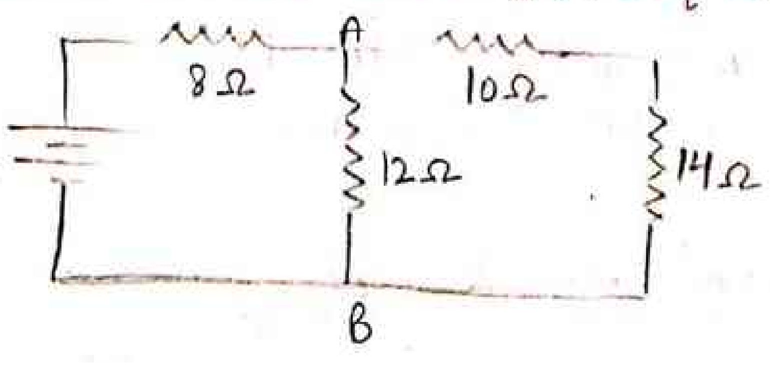


Procedure 1. Short circuit the terminal across which load resistance connected & calculate I_N (Norton current)

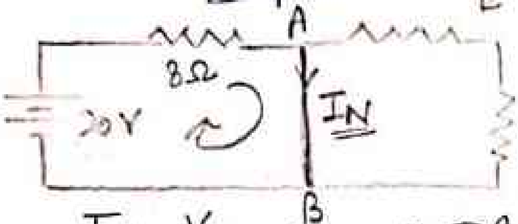
2. Redraw the network replacing each voltage source by short circuit in series with internal resistance if any and current source by open circuit in parallel with its internal resistance.

3. Determine R_N of the network and draw norton equivalent circuit as shown in fig.

Numerical 1 Using Norton theorem determine the current in 12 Ω resistor in the network shown below.

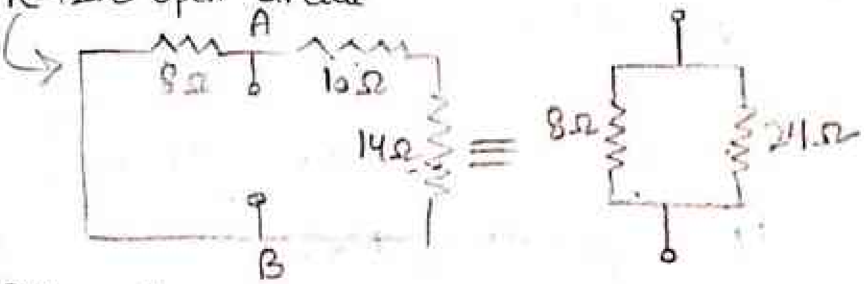


Solution **Step 1st** AB is short circuit.



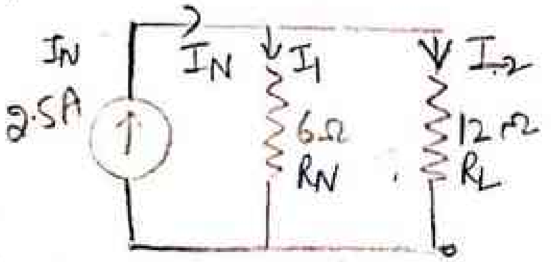
$$I_N = \frac{V}{R} = \frac{20}{8} = 2.5A$$

Step 2 Voltage source replaced by internal resistance and short circuit.
Also R=12Ω open circuit



$$R_N = 8 \| (10+14) = \frac{8 \times 24}{8+24} = 6\,\Omega$$

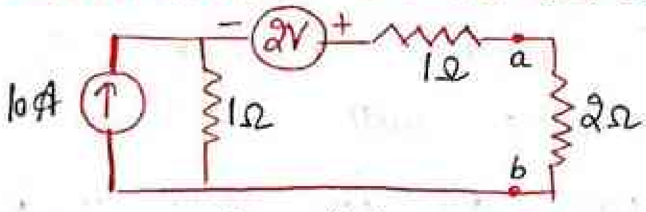
Step 3 Draw equivalent circuit.



Current flow in 12 Ω Resistor

$$I_2 = I_N \frac{R_N}{R_N+R_L} = 2.5 \times \frac{6}{6+12}$$
$$= 0.833\,A$$

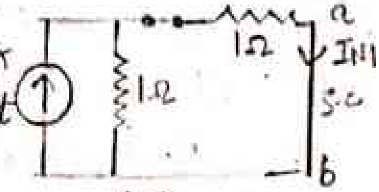
Numerical 2 Determine V across 2Ω resistor using Norton theorem.



Solution 1. Short ckt the load Resistance.

2. Consider only 10A Current Source in ckt V.S is short ckt

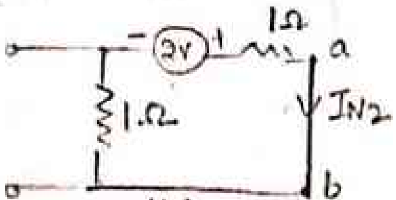
$$I_{1N} = \frac{1}{1+1} \times 10 = \frac{1}{2} \times 10 = 5A \text{ (fig a)}$$



(a)

3. Consider only 2V source. CS is open circuit.

$$I_{2N} \times 1 - 2 + I_{2N} \times 1 = 0 \quad \text{or} \quad I_{2N} = \frac{V}{R} = \frac{2}{2} = 1$$
$$2I_{2N} = 2 \quad I_{2N} = 1 \quad \text{(fig b)}$$

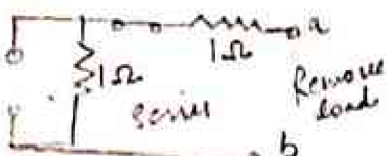


(b)

4. Total current $I_N = I_{1N} + I_{2N} = 5+1 = 6A$

5. Calculate Norton resistance CS is O.C V.S is S.C

$$R_N = 1+1 = 2\Omega \quad \text{(fig c)}$$



(c)

6. Equivalent Circuit

$$I_L = I_N \times \frac{2}{2+2} = \overset{3}{\cancel{6}} \times \frac{\cancel{2}^{1}}{\cancel{4}_{2}} = 3\Omega \qquad V_L = I_L R_L$$
$$= 3 \times 2 = 6V$$