3rd sem. Electrical

Sub: CIRCUIT & NETWORK Theory

Prepared by: DEEPAK KUMAR ROUL
Lecturer (Electrical)

Institution Name: G.P. Gajapati

1. CIRCUIT ELEMENTS AND ANALYSIS :

Types of Networks :

(1) Linear Circuit : It is the circuit in which the parameters remains constants with change in applied voltage or current.
Examples are the circuits containing resistors, inductors and or capacitors.
Ohm's Law is applicable in this type of circuits.

(2) NON-LINEAR CIRCUIT : It is a circuit whose parameters change with voltage and current. Examples are the circuits containing semiconductor devices like diode.
Ohm's Law is not applicable here.

(3) UNILATERAL CIRCUIT : It is a circuit, in which the properties or characteristics change with change in the direction of current flow.
Examples are the circuits containing diodes, transistors etc

(4) BILATERAL CIRCUIT : It is a circuit whose properties remains same with the change in the direction of current flow. Examples are the circuits made of high conductive material elements.

(5) ACTIVE CIRCUIT : It is a circuit which contains one or more voltage or current sources.
Examples are the circuits containing batteries and transistors ;

(6) PASSIVE CIRCUIT : It is a circuit which does not contain any source of energy. Examples are the circuits only containing passive elements like Resistor, inductor, or capacitor.

(7) LUMPED CIRCUIT: The circuit containing physically separable elements like R, L, C is called Lumped Circuit.

(8) DISTRIBUTED CIRCUIT; The circuit in which, the circuit elements like R, L, & C are not physically separated and exist in a distributed state is known as distributed circuit. Examples are the transmission line or Cable Circuits.

(9) Recurrent Circuit: When a large circuit consists of similar networks connected one after another the circuit is called as recurrent or cascaded circuit or Ladder Network.

(10) Non Recurrent circuit: A single network or circuit is called as a non-recurrent circuit.

* KIRCHOFF'S LAWS:

Kirchoff's first Law is based on the Law of conservation of charge. Charge can't be created but must be conserved.

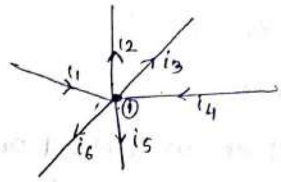
(i) Kirchoff's Current Law (KCL):

→ It states that 'The sum of the currents at a node must equal zero':

$$\sum_{n=1}^{N} i_n = 0$$

where, N = no of branches connected to the node

i_n = nth current entering (leaving) the node.



By taking entering currents as positive & leaving currents as negative, apply KCL at node-1

$$i_1 - i_2 - i_3 + i_4 - i_5 - i_6 = 0$$

$$\Rightarrow i_1 + i_4 = i_2 + i_3 + i_5 + i_6$$

→ The sum of the currents entering a node is equal to the sum of the currents leaving the node.

(2) Kirchhoff's Voltage Law (KVL):

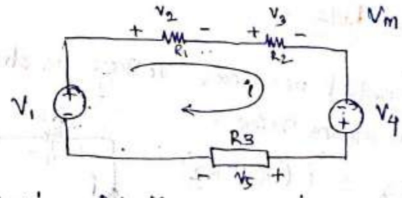
→ It is based on the principle of conservation of energy.

→ It states that 'the algebric sum of all voltages around a closed path (or Loop) is zero.

$$\sum_{m=1}^{M} V_m = 0$$

where, M = no of voltages in the Loop.

V_m = mth voltage.



By taking polarity convention & travelling in the clockwise direction, Applying KVL to the closed path..

$$V_1 - iR_1 - iR_2 + V_4 - iR_3 = 0$$

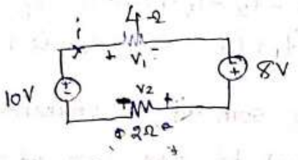
or $V_1 - V_2 - V_3 + V_4 - V_5 = 0$

$\Rightarrow V_1 + V_4 = V_2 + V_3 + V_5$

It can be also stated as, in a closed path the sum of voltage ~~rises~~ rises is equal to the sum of voltage drops.

Problems:

① Find V_1 & V_2 in circuit shown in the Figure ①



Sol^n By applying KVL.

$10 - 4i + 8 - 2i = 0$

$\Rightarrow 18 = 6i$

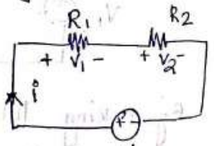
$\boxed{i = 3A}$

$V_1 = 4i = 4 \times 3 = \underline{12\ V}$

$V_2 = -2i = \underline{-6V}$ (Ans)

* **Voltage Division Rule :-**

In series connected resistors voltage is divided & current remains same.



$V = V_1 + V_2 = i(R_1 + R_2)$

$\Rightarrow i = \dfrac{V}{R_1 + R_2}$

Now, $V_1 = iR_1 = \left(\dfrac{V}{R_1+R_2}\right) R_1$

$$\boxed{V_1 = \left(\frac{R_1}{R_1+R_2}\right) V}$$

and $V_2 = iR_2 = \left(\dfrac{V}{R_1+R_2}\right) R_2$

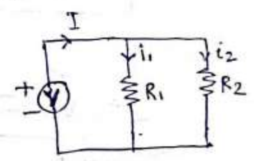
$$\boxed{V_2 = \left(\frac{R_2}{R_1+R_2}\right) V}$$

→ In general, if there are 'N' resistors $(R_1 R_2 \cdots R_n)$ are in series with a voltage source (V), the voltage across nth resistor (R_n) will have the value :-

$$\boxed{V_n = \frac{R_n}{R_1 + R_2 + R_3 \cdots + R_n} \times V}$$

* **Current Division Rule :-**

In parallel connected resistors, current is divided & voltage remains same.



$I = i_1 + i_2$

$= \dfrac{V}{R_1} + \dfrac{V}{R_2} = V\left(\dfrac{1}{R_1} + \dfrac{1}{R_2}\right)$

$\Rightarrow V = \dfrac{I}{\left(\frac{1}{R_1}\right) + \left(\frac{1}{R_2}\right)}$

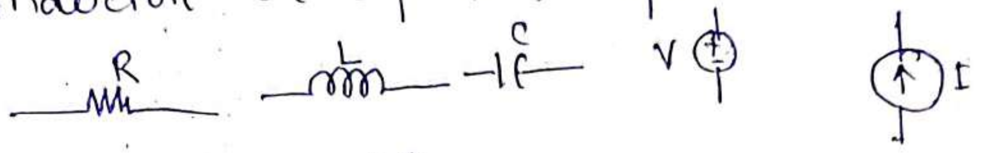
Now $i_1 = \dfrac{V}{R_1} = \dfrac{1}{R_1} \dfrac{I}{(1/R_1 + 1/R_2)} = \dfrac{\frac{1}{R_1}}{\left(1/R_1 + \frac{1}{R_2}\right)} I$

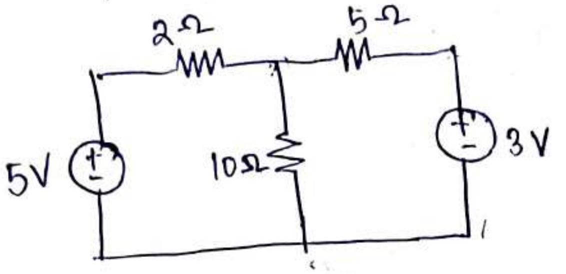
Similarly $i_2 = \dfrac{1/R_2}{(1/R_1 + 1/R_2)} \times I$

In general, if there are 'N' resistors $(R_1, R_2 \cdots R_n)$ are in parallel with source current (I), the current through nth resistor (R_n) is given by :- $\boxed{I_n = \dfrac{1/R_n}{1/R_1 + 1/R_2 + \cdots + 1/R_n} \times I}$

Circuit terminoloy

Branch: It represents single circuit element such as Voltagesource, current source, Resistor, Inductor or ~~Capacitor~~ Capacitor etc.



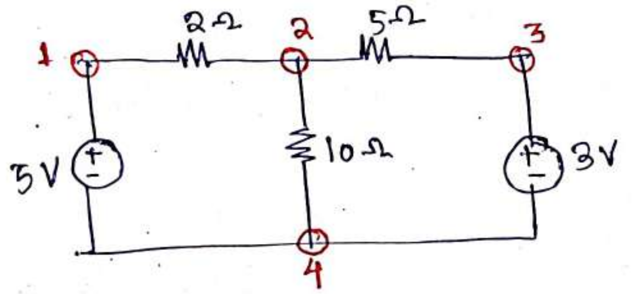


$\boxed{\text{Total branches} = 5}$

Node: A point in a network where two or more elements are connected is called node.

→ Simple node — 2 branch.

→ Principle node/Junction — atleast 3 branch

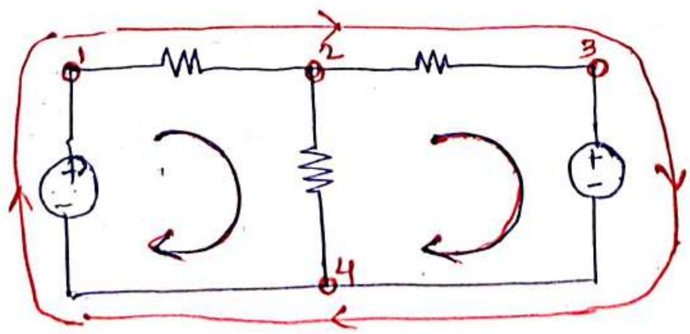


$\boxed{\text{Total Node} = 4}$

Principle node = 2 (i.e. 2, 4)

Simple node = 2 (i.e. 1 & 3)

Loop: Any close path in electrical circuit is called loop.



$\boxed{\text{Loop} = 3}$

1st Loop = node (1 - 2 - 4 - 1)

2nd loop = node (2 - 3 - 4 - 2)

3rd loop = node (1 - 2 - 3 - 4 - 1)

Mesh: A closed path in the circuit which does not enclose any other close path in-side it is called mesh.

$\boxed{\text{Mesh} = 2}$

1st mesh = node (1 - 2 - 4 - 1), 2nd mesh = node (2 - 3 - 4 - 2)

MESH ANALYSIS :

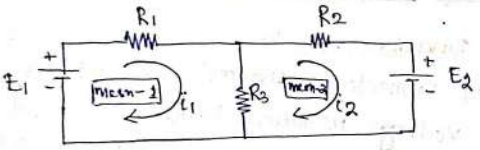
It provides a general procedure for analyzing circuits using 'mesh current' as a circuit variable.

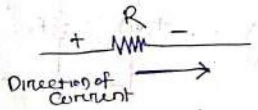
Steps to determine mesh currents :

(i) Select meshes and assign mesh currents $i_1\ i_2 \cdots i_n$ to the n-meshes.

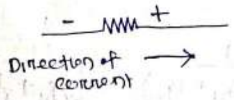
(ii) Apply 'KVL' to each of the 'n' meshes. Use Ohm's Law to express the voltage in terms of the mesh currents.

(iii) Solve the resulting and simultaneous equation to get the mesh currents.

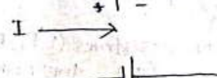




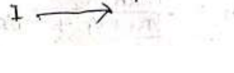
→ Voltage drop sign = −ve



⇒ Voltage drop sign = +ve

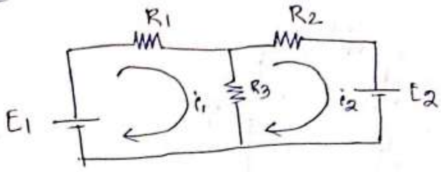


→ Voltage sign = −ve (Drop in potential)



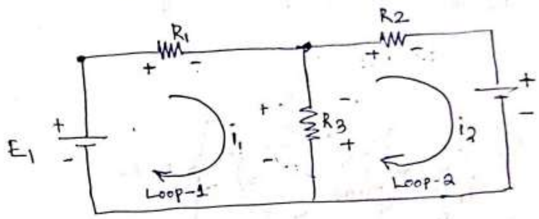
→ Voltage sign = +ve (Rise in potential)

EX.



$IR_1 = ?$
$IR_2 = ?$
$IR_3 = ?$

Take the current direction clockwise.



Apply KVL to Loop-1

$$E_1 - i_1R_1 - i_1R_3 + i_2R_3 = 0$$

$$-(R_1+R_3)i_1 + I_2R_3 = -E_1 \quad (1)$$

$i_1R_1 \to$ Voltage drop across R_1

$R_3I_1 \to$ Voltage drop across R_3 due to I_1

$R_3I_2 \to$ Voltage drop across R_3 due to current i_2

Apply KVL to Loop-2 :

$$-i_2R_2 - E_2 - i_2R_3 + i_1R_3 = 0$$

$$i_1R_3 - i_2(R_2+R_3) = E_2 \quad (2)$$

By solving equation (1) & eq (2)

We get I_1 & I_2

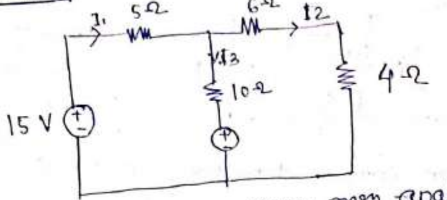
Then we get IR_1, IR_2, IR_3

Current flowing through $R_1 = i_1$

$R_2 = i_2$

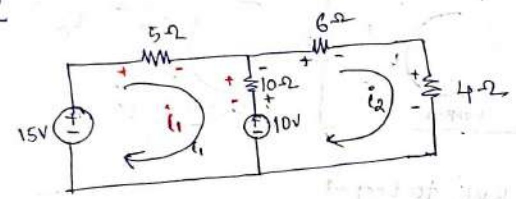
$R_3 = (i_1 - i_2)$ or $(i_2 - i_1)$

Problem -1



Find $I_1, I_2, \& I_3$ using mesh analysis.

Sol^n



Apply KVL for mesh-1

$15 - i_1 5 - i_1 10 + 10 i_2 - 10 = 0$

$\Rightarrow -15 i_1 + 10 i_2 = -5$

$\Rightarrow -3 i_1 + 2 i_2 = -1$ ——— (1)

Apply KVL for mesh-2 :

$-6i_2 - 4i_2 + 10 - 10i_2 + 10i_1 = 0$

$\Rightarrow 10i_1 - 20i_2 = -10$

$\Rightarrow i_1 - 2i_2 = -1$ ——— (2)

By solving eq^n (1) & eq^n (2)

$-3i_1 + 2i_2 = -1$

$(+)\quad i_1 - 2i_2 = -1$

$-2i_1 = -2.$

$\boxed{i_1 = 1A}$

Substituting i_1 in Eq^n (2)

$1 - 2i_2 = -1$

$\Rightarrow \boxed{i_2 = 1}$

So Loop current $i_1 = 1A$ & $i_2 = 1A$.

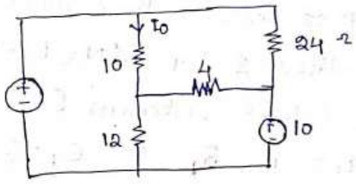
I_1 = same as i_1 = 1A

I_2 = same as i_2 = 1A.

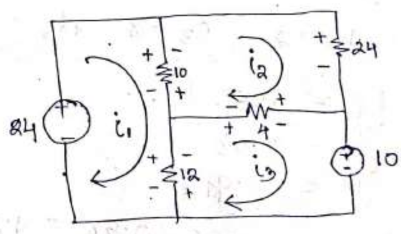
$I_3 = i_1 - i_2$ or $i_2 - i_1 = 1 - 1 = 0A$. (Ans)

Problem-2

Find Io by using mesh analysis in the circuit as shown in figure.



Sol^n



KVL in mesh-1:

$24 - 10i_1 + 10i_2 - 12i_1 + 12i_3 = 0$

$\Rightarrow -22i_1 + 10i_2 + 12i_3 = -24$ ——— (1)

$\Rightarrow -11i_1 + 5i_2 + 6i_3 = -12$

KVL in mesh-2

$$-24i_2 - 4i_2 + 4i_3 - 10i_2 + 10i_1 = 0$$

$$\Rightarrow 10i_1 - 38i_2 + 4i_3 = 0 \quad \text{——— (2)}$$

$$\Rightarrow 5i_1 - 19i_2 + 2i_3 = 0$$

KVL in mesh-3

$$-4i_3 + 4i_2 - 10 - 12i_3 + 12i_1 = 0$$

$$\Rightarrow 12i_1 + 4i_2 - 16i_3 = 10 \quad \text{——— (3)}$$

$$\Rightarrow 6i_1 + 2i_2 - 8i_3 = 5$$

Solve the eqn By Camer's rule or-

By using calculator solve the eqn :-

→ go to mode → Press three times.

→ Press 1 for EQN (Equation)

→ Select unknowns (3)

$a_1 = -11$, $b_1 = 5$, $c_1 = 6$, $d_1 = -12$

$a_2 = 5$ $b_2 = -19$ $c_2 = 2$ $d_2 = 0$

$a_3 = 6$, $b_3 = 2$, $c_3 = -8$ $d_3 = 5$

By solving $\boxed{i_1 = 1.86}$

$\boxed{i_2 = 0.58}$

$\boxed{i_3 = 0.91}$

$$I_0 = I_1 - I_2 = 1.86 - 0.58 = 1.28\,A$$

$\boxed{I_0 = 1.28\,A}$ (Ans)

MESH ANALYSIS WITH CURRENT SOURCES:

Case-1: When a current source exists only in one mesh. take the assigned current in that mesh as the value of the current source.

Ex1-

Find the branch currents ?

Sol? $\boxed{i_2 = -5A}$ ——— (1)

Now Apply KVL in mesh-1

$$10 - 4i_1 - 6i_1 + 6i_2 = 0$$

$$\Rightarrow 10 - 4i_1 - 6i_1 + 6 \times (-5) = 0$$

$$\Rightarrow 10 - 10i_1 - 30 = 0$$

$$\Rightarrow -10i_1 = 30 - 10 = 20$$

$$\Rightarrow i_1 = -\frac{20}{10}$$

$\boxed{i_1 = -2A}$

Case-II (Supermesh Concept)

When there is a current source in common then it is known as a suppermesh.

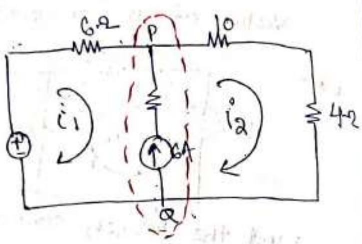
(Super Mesh)

Properties of supermesh :-

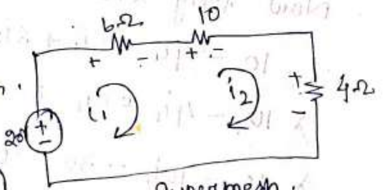
(i) A super mesh has no current of its own

(ii) It requires the application of both KVL & KCL.

Ex:- Solve for the Loop currents i_1 & i_2 using mesh analysis for the fig as shown.



Soln There is a supermesh formed as 6A current source is common to both the meshes.

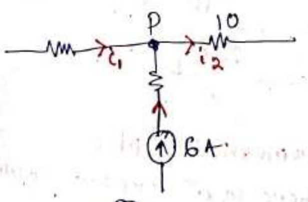


Applying KVL in supermesh.

$20 - 6i_1 - 10i_2 - 4i_2 = 0$ ——— (i)

$\Rightarrow -6i_1 - 14i_2 = -20$

Apply KCL at the nodes 'P' or 'Q'



$i_1 + 6 = i_2$ ——— (ii)

By solving $\boxed{i_1 = -3.2A, \ \& \ i_2 = 2.8 A}$ Ans.

NODAL ANALYSIS

It provides a general procedure for analyzing circuits using node voltages as the circuit variables.

Steps to determine node voltages :-

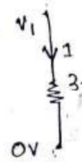
→ Identification of nodes (more than two branches are connected).

→ Select a node as the reference node. This node usually has most elements tied to it. The voltage of a node is taken as zero.

→ Assign voltages $V_1, V_2, \ldots V_{n-1}$ to the remaining (n-1) nodes. The voltages are referenced with respect to the reference node.

→ Apply KCL to each of the (n-1) non-reference nodes. Use ohm's Law to express branch current in terms of node voltages.

(1)



$\boxed{I = \frac{V_1 - 0}{3\Omega}}$

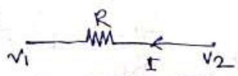
(2)

$\boxed{I = \frac{0 - V_1}{3\Omega}}$

(3)

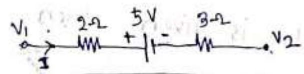
$\boxed{I = \frac{V_1 - V_2}{R}}$

(4)



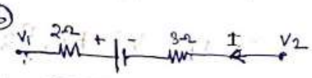
$\boxed{I = \frac{V_2 - V_1}{R}}$

(5)



$\boxed{I = \frac{V_1 - 5 - V_2}{5\Omega}}$

(6)

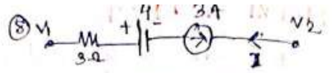


$\boxed{I = \frac{V_2 + 5 - V_1}{5\Omega}}$

⑦

$\boxed{I = 3A}$

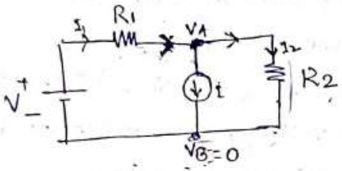
⑧



$\boxed{I = -3A}$

⇒ Solve the simultaneous equations to obtain the unknown node voltages.

Ex-1



$I_1R_1 = ?$
$I_2R_2 = ?$

V_A = non reference node

V_B = Reference node = 0V.

Apply KCL at node A.

$$\frac{0 - V_A + V}{R_1} = I + \frac{V_A - V_B}{R_2}$$

$$\Rightarrow \frac{-V_A}{R_1} + \frac{V}{R_1} = I + \frac{V_A}{R_2} - \frac{0}{R_2}$$

$$\Rightarrow \frac{V}{R_1} - I = \frac{V_A}{R_2} + \frac{V_A}{R_1}$$

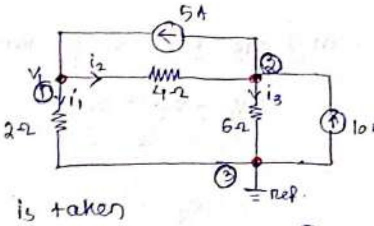
$$\Rightarrow \frac{V}{R_1} - I = V_A\left(\frac{1}{R_1} + \frac{1}{R_2}\right)$$

If V, R_1, R_2 value is given, then value for V_A can be calculated.

$$\boxed{I_1 = \frac{0 - V_A + V}{R_1}} \qquad \boxed{I_2 = \frac{V_A - 0}{R_2}}$$

Then I_1R_1 & I_2R_2 can be determined.

Ex-2 Calculate the node voltages in the circuit shown.



Sol^n In the figure node ③ is taken as reference node. The voltage of node ① & ② are V_1 & V_2 respectively. The current direction is assumed as shown in the figure.

By KCL at node ① :-

$$5 = i_1 + i_2$$

$$\Rightarrow 5 = \frac{V_1 - 0}{2} + \frac{V_1 - V_2}{4}$$

$$\Rightarrow 5 = \frac{2V_1 + V_1 - V_2}{4}$$

$$\Rightarrow 20 = 2V_1 + V_1 - V_2$$

$$\Rightarrow 3V_1 - V_2 = 20 \quad \text{——— ①}$$

By KCL at node - ②

$$10 + i_2 = 5 + i_3$$

$$\Rightarrow 10 + \frac{V_1 - V_2}{4} = 5 + \frac{V_2 - 0}{6}$$

$$\Rightarrow \frac{40 + V_1 - V_2}{4} = \frac{30 + V_2}{6}$$

$$\Rightarrow 240 + 6V_1 - 6V_2 = 120 + 4V_2$$

$$\Rightarrow 120 = -6V_1 + 10V_2$$

$$\Rightarrow -3V_1 + 5V_2 = 60 \quad \text{——— ②}$$

Methode - I (Using elimination technique) :-

$$3V_1 - V_2 = 20 \quad \text{——} ①$$
$$-3V_1 + 5V_2 = 60 \quad \text{——} ②$$
$$+ \overline{\qquad\qquad\qquad}$$
$$4V_2 = 80$$
$$\Rightarrow V_2 = 80/4 = 20\,V$$

Substituting V_2 in eq^n ①

$$3V_1 - 20 = 20$$
$$\Rightarrow V_1 = \frac{40}{3} = 13.33\,V$$

Methode - II (Using cramer's rule) :-

$$\begin{bmatrix} 3 & -1 \\ -3 & 5 \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \end{bmatrix} = \begin{bmatrix} 20 \\ 60 \end{bmatrix}$$

$$\Delta = \begin{bmatrix} 3 & -1 \\ -3 & 5 \end{bmatrix} = 15 - 3 = 12$$

$$\Delta_1 = \begin{bmatrix} 20 & -1 \\ 60 & 5 \end{bmatrix} = 100 - (-60) = 160$$

$$\Delta_2 = \begin{bmatrix} 3 & 20 \\ -3 & 60 \end{bmatrix} = 180 - (-60) = 240$$

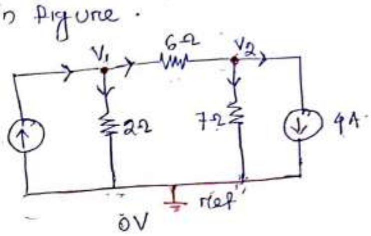
$$V_1 = \frac{\Delta_1}{\Delta} = \frac{160}{12} = 13.33\,V$$

$$V_2 = \frac{\Delta_2}{\Delta} = \frac{240}{12} = 20\,V$$

Method - III Directly using calculator :-

$\boxed{V_1 = 13.33\,V}$ & $\boxed{V_2 = 20\,V}$

Ex-3 Obtain the node voltages in the circuit as shown in figure.



Applying KCL at node ①.

$$1 = \frac{V_1 - 0}{2} + \frac{V_1 - V_2}{6}$$
$$\Rightarrow 1 = \frac{V_1}{2} + \frac{V_1 - V_2}{6}$$
$$\Rightarrow 1 = \frac{3V_1 + V_1 - V_2}{6}$$
$$\Rightarrow 4V_1 - V_2 = 6 \quad \text{——} ①$$

Apply KCL at node - ②

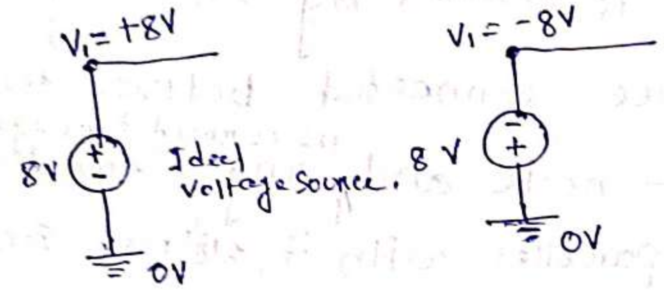
$$\frac{V_1 - V_2}{6} = \frac{V_2 - 0}{7} + 4$$
$$\Rightarrow \frac{V_1 - V_2}{6} - \frac{V_2}{7} = 4$$
$$\Rightarrow \frac{7V_1 - 7V_2 - 6V_2}{42} = 4$$
$$\Rightarrow 7V_1 - 13V_2 = 168 \quad \text{——} ②$$

By solving eq ① & eq ②

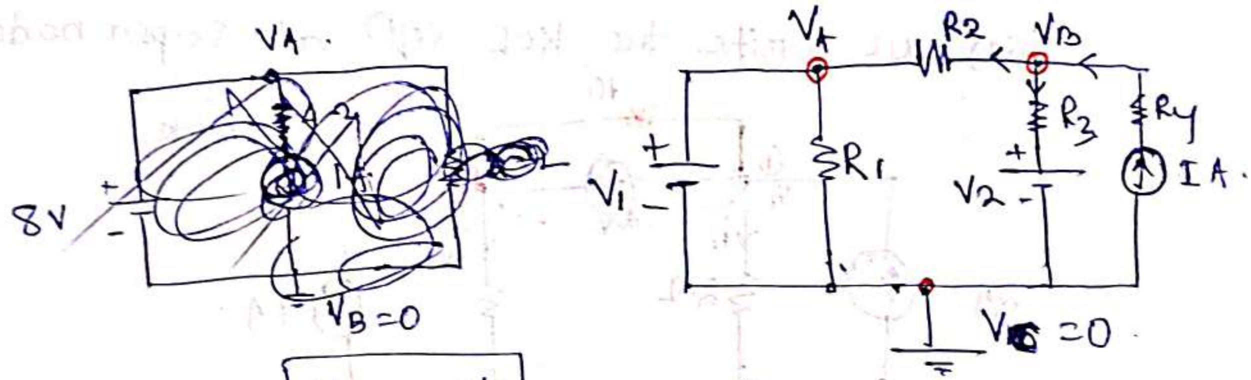
$\boxed{V_1 = -2}$ & $\boxed{V_2 = -14}$

Nodal Analysis with voltage sources :-

Case-1 : If a voltage source is connected betn the reference node & a non reference node, then the voltage at the non-reference node is equal to the voltage of the voltage source.



Ex



Here $\boxed{V_A = V_1}$ —— (1)

Apply KCL at node-B.

$$\frac{V_B - V_A}{R_2} + \frac{V_B - V_C - V_2}{R_3} = IA \quad (2)$$

$$\Rightarrow \frac{V_B - V_1}{R_2} + \frac{V_B - V_2}{R_3} = IA$$

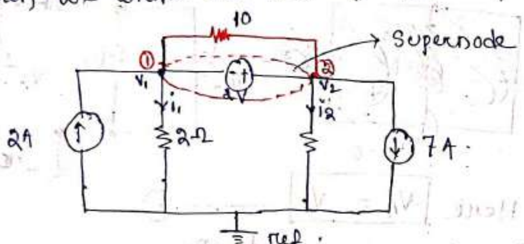
By solving Eq(1) & Eq(2)

We can get the value of node voltage V_B.

Case-II (Super node concept)

→ If the voltage source is connected between two non reference nodes, then two non-reference nodes form a supernode.

→ A super node is formed by enclosing a voltage source connected between two non-reference node and the current through any elements connected in parallel with it, will not consider, when we write the KCL eqn at super node.



In this figure the 10 Ω resistor will not consider when we write the eqn at supernode.

Properties of a super node:

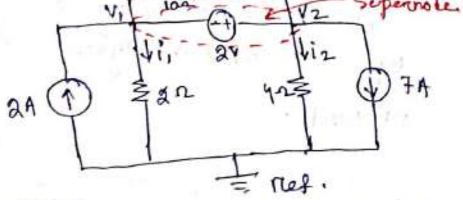
→ It has no voltage of its own.

→ It requires the application of both KCL & KVL.

→ Always the difference between the voltage of two non-reference nodes is known as Supernode.

→ Any element can be connected in parallel with the voltage source forming the supernode.

Ex. For the circuit shown in figure, find the node voltages.



Soln

Here supernode contains node ①, & node ② & the 2V source, the 10 Ω resistor.

Applying KCL at supernode.

$$2 = i_1 + i_2 + 7 \qquad \text{[Here current through } 10\Omega \text{ is not consider]}$$

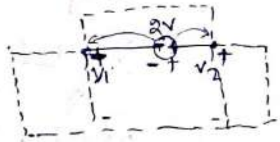
$$\Rightarrow 2 = \frac{V_1 - 0}{2} + \frac{V_2 - 0}{4} + 7$$

$$\Rightarrow 2 = \frac{V_1}{2} + \frac{V_2}{4} + 7$$

$$\Rightarrow 2 = \frac{2V_1 + V_2 + 28}{4}$$

$$\Rightarrow 8 = 2V_1 + V_2 + 28$$

$$\Rightarrow 2V_1 + V_2 = -20 \quad \text{—— ①}$$



Applying KVL in supernode

$$V_1 + 2 - V_2 = 0$$

$$\Rightarrow V_1 - V_2 = -2$$

$$\Rightarrow V_2 - V_1 = 2 \quad \text{—— ②}$$

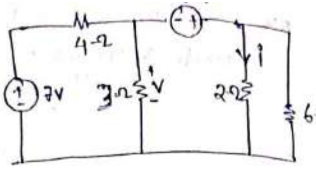
Substracting eqn ① & ②, $3V_1 = -22$

$$\Rightarrow \boxed{V_1 = \frac{-22}{3} = -7.33\,V}$$

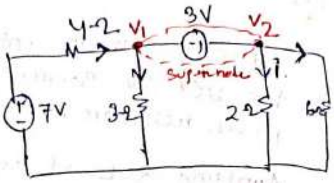
Substituting in eqn ②

$$V_2 - (-7.33) = 2 \Rightarrow \boxed{V_2 = -5.33\,V}$$

Ex-2 Find V & i in the circuit shown in the figure by using nodal analysis method.



Sol^n At super node



$V_2 - V_1 = 3\,V$

$V_1 - V_2 = -3\,V$ —— ①

KCL at super node:

As per the current direction given, KCL will be at super node,

$$\frac{0 - V_1 + 7}{4} = \frac{V_1}{3} + \frac{V_2}{2} + \frac{V_2}{6}$$

$$\Rightarrow \frac{7 - V_1}{4} = \frac{2V_1 + 3V_2 + V_2}{6}$$

$$\Rightarrow \frac{7 - V_1}{4} = \frac{2V_1 + 4V_2}{6}$$

$$\Rightarrow \frac{7 - V_1}{2} = \frac{2V_1 + 4V_2}{3}$$

$$\Rightarrow 21 - 3V_1 = 4V_1 + 8V_2$$

$$\Rightarrow 7V_1 + 8V_2 = 21 \quad \text{——— ②}$$

Solving Eq① & Eq②

$V_1 = -0.2\,V$ & $V_2 = 2.8\,V$

$I_{2\Omega} = \frac{V_2}{2} = \frac{2.8}{2} \Rightarrow \boxed{I_{2\Omega} = 1.4}$

Voltage across 3Ω $= V_1 - 0$ $\Rightarrow \boxed{V = -0.2}$

Nodal Vs Mesh Analysis:

Given a network to be analyzed, How do we know which methods is better or more efficient.

→ The ~~choi~~ choice of the better method depends on two factors:

① Nature of a particular N/w:

→ If network contains many series connected elements, voltage source or super meshes, then use mesh analysis. If network contains many Parallel connected elements, current sources or super nodes then use ~~Node~~ Nodal analysis.

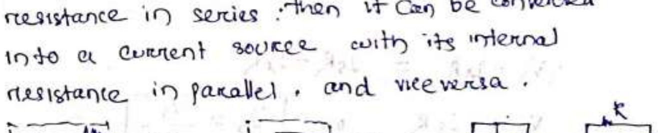
→ If a circuit has less no of nodes than no of meshes, then better to use nodal analysis, whereas if it has less meshes than nodes, then use mesh analysis.

(ii) Information required:

→ If node voltage required then use nodal analysis, whereas if branch currents or mesh currents required then use mesh analysis.

Source transformation Technique:

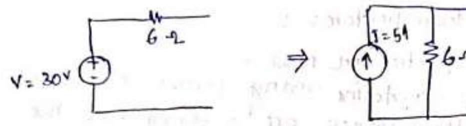
If there is a voltage source with its internal resistance in series, then it can be converted into a current source with its internal resistance in parallel, and viceversa.



(Voltage source) (Current source) C.S. V.S.

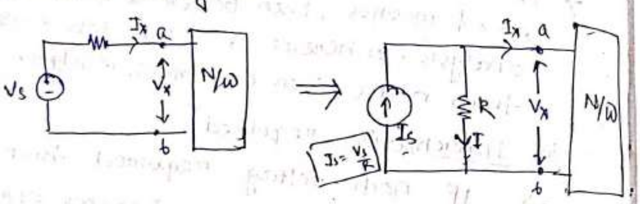
Problem

Convert a voltage source of 30 Volts along with an iternal resistance of 6 Ω to a current source.



The value of $I = V/R = 30/6 = 5A$.

Let We have a voltage source



$V_x = V_s - I_x R$ — (i)

$V_x = IR$

$I = I_s - I_x$

$V_x = (I_s - I_x) R$

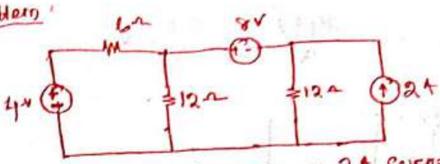
$V_x = I_s R - I_x R$ — (ii)

By Compareing eq (i) & eq (ii)

$V_s - \cancel{I_x R} = I_s R - \cancel{I_x R}$

$V_s = I_s R$ or $\boxed{I_s = \frac{V_s}{R}}$

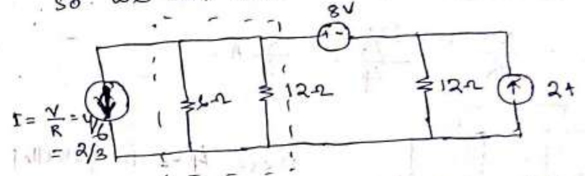
Problem



Find the voltage drop across 2A current source.

Sol^n

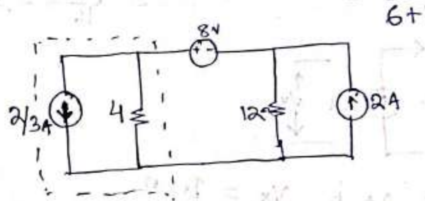
Convert 4V voltage source connected series with 6 Ω so we can convert into a current source.



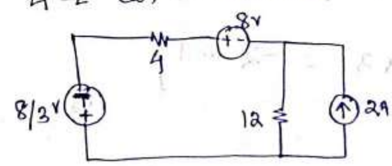
Now 6 Ω resistor is parallel with 12 Ω

So equivalent resistance $= 6 \,||\, 12$

$= \frac{6\times12}{6+12} = 4\,\Omega$



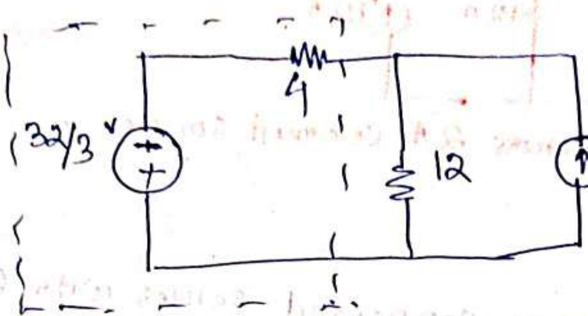
2/3 A current source with internal resistance 4 Ω can be converted into a voltage source.



$V = IR = \frac{2}{3} \times 4 = \frac{8}{3}$ V

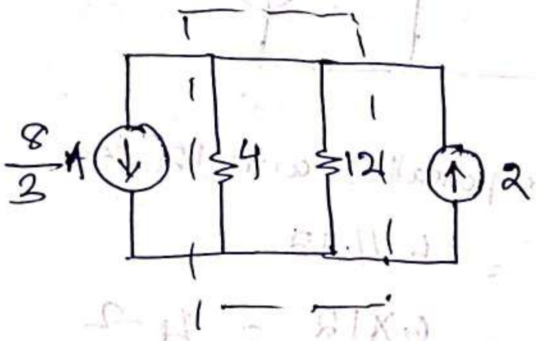
Now 8/3 V & 8 V are in series. So we can replace with single voltage source.

$$\frac{8}{3} + 8 = \frac{24+8}{3} = \frac{32}{3}\ \text{V}.$$



Now this 32/3 V voltage source can be converted into the current source

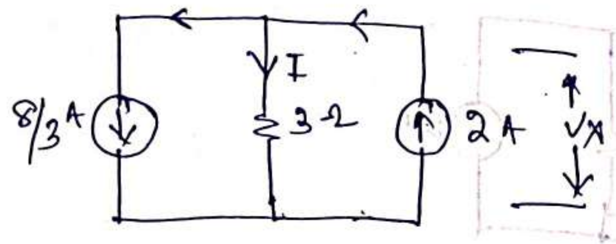
$$I = \frac{V}{R} = \frac{32/3}{4} = \frac{8}{3}\ \text{A}.$$



Here 4 Ω is parallel with 12 Ω

So Net resistance $= \frac{4 \times 12}{4+12}$

$$= \frac{48}{16} = 3\ \Omega$$



Voltage across 2A is $V_x = I \times 3\ \Omega$.

$$I = 2\text{A} - 8/3\ \text{A} = -2/3\ \text{A}$$

$$\boxed{V_x = \frac{-2}{3} \times 3 = -2\ \text{Volt}}$$