11-05-2020

DC - Circuits

current :-

$$\boxed{i = \frac{dq}{dt}}$$ ⇒ rate of change of current (or) controlled moment of e

→ Units A (or) C/s

voltage :-

V = work required to move charge.

$$\boxed{V = \frac{dw}{dq}}$$ J/s (or) Volts

Power :-

→ $$\boxed{P = \frac{dw}{dt}} = \frac{dw}{dq} \cdot \frac{dq}{dt} = Vi$$ J/s (or) Watts

→ **resistance :**

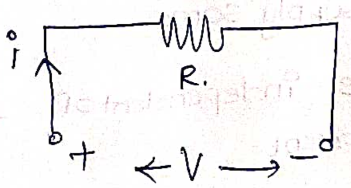
At constant T, $V \propto i$:- By ohm's law

$V = iR$.   R = Resistance (or) ohm's constant

$i = \frac{V}{R}$

G = conductance

$$\boxed{i = GV}$$



Short circuit = R=0 ⇒ practically small resistance
↳ V=0

Open circuit = R = ∞

$R \propto \frac{l}{A}$

$$\boxed{R = \frac{\rho l}{A}}$$

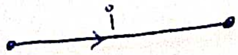
ρ = specific resistance

(or) resistivity.

→ Short circuit

→ voltage is zero

→ current is infinite



Open circuit

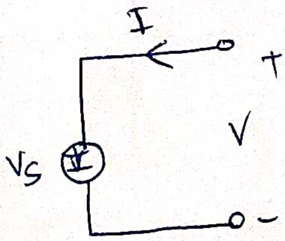
→ Voltage exists

→ Current ~~[illegible]~~ zero

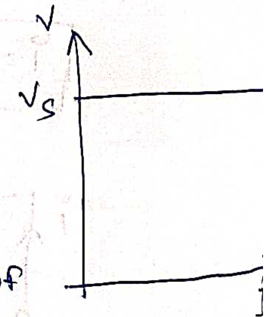
Types of sources → Independent source
→ Dependent source.

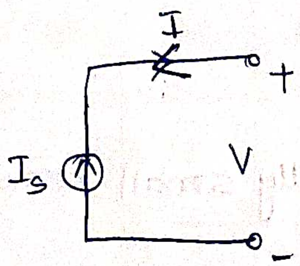
Depending on quantity
→ V.S
→ C.S

Independent source.

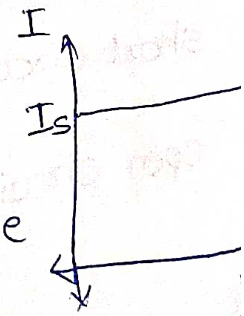


→ voltage source should supply same voltage independent of current





→ Current source should supply same current independent of voltage applied



* ~~Op.~~ Oppisition to the flow of current is called resistance.

* Open Circuit : $R = \infty$; $I = 0$; voltage exists

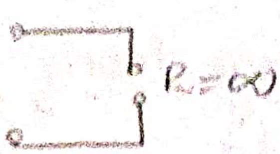
$R \propto \frac{l}{A}$

$\boxed{R = \frac{\rho l}{A}}$

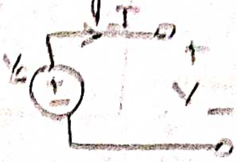
ρ = resistivity (or) Specific resistance

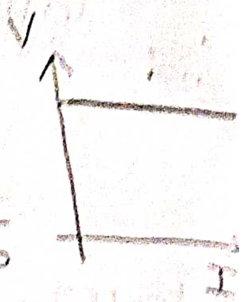
Short Circuit : $R = 0$; $V = 0$
$i = max = \infty$

Open circuit : | Short circuit :

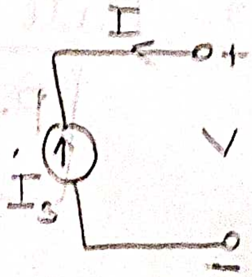


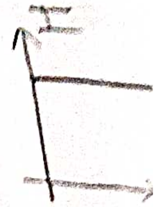
⇒ Types of Sources : for ~~generating~~





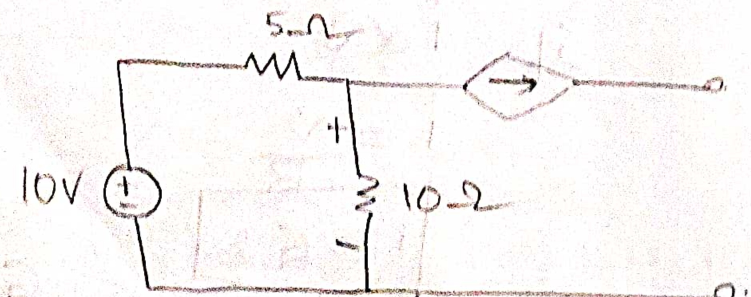
SOURCES : — Quantity → Voltage Source ; → Current Source :





Independent
- Voltage Source
- Current Source.

Dependent
→ Voltage dependent voltage Source.
→ Current dependent voltage source.
→ Voltage dependent Current Source.
→ Current dependent Current Source



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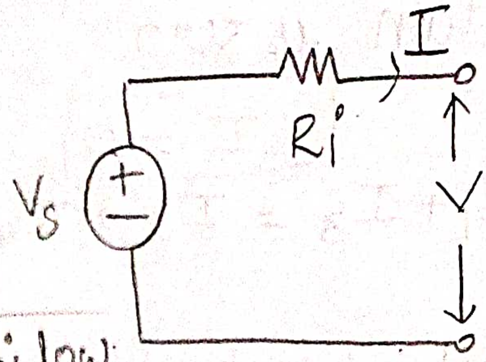
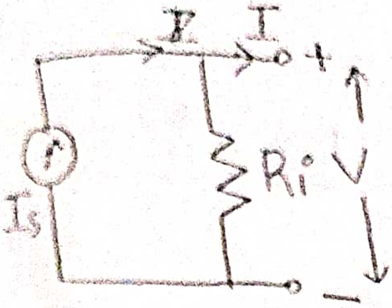
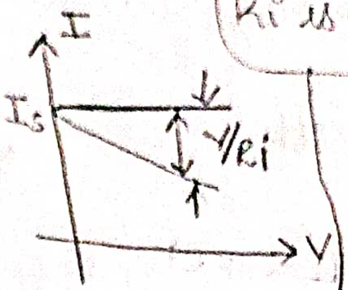
⇒ Sources → Ideal / Practical

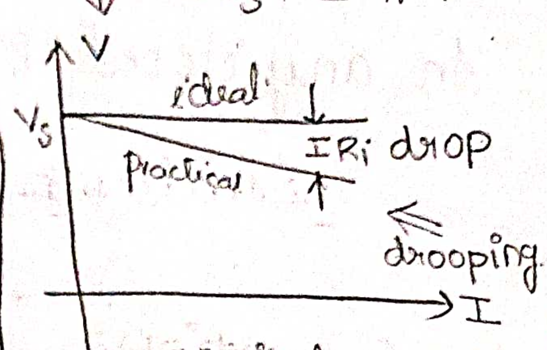


Ri is low

$V = V_s - IR_i$







Ri is high for current source so as to allow large current through terminal.

$I = I_s - \frac{V}{R_i}$ $V = i_s R_i - i R_i$

Ri is low for voltage source so as to reduce voltage drop across Ri

* SOURCE TRANSFORMATION:

Condition for conversion of one source to another source i.e. current to voltage (or) vice versa is TERMINAL CONDITION

$$\boxed{V_s = I_s R_i}$$

* KCL: Kirchoff's Current Law.

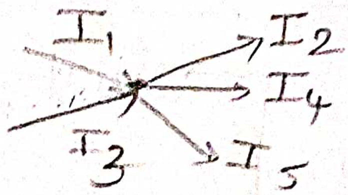
At any junction sum of currents incoming = Sum of currents going out

Algebraic sum of currents meeting at a

junction is zero.

$\boxed{\Sigma I = 0}$

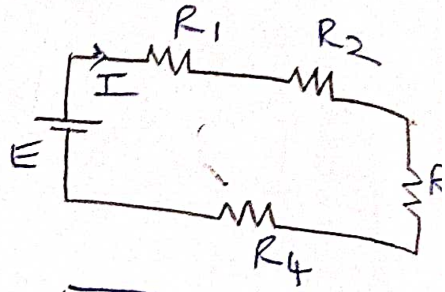
$I_1 + I_3 = I_2 + I_4 + I_5$.



* **KVL**: Kirchoff's voltage law.

In any closed path

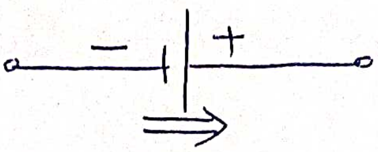
$\Sigma emfs + \Sigma IR = 0$.



$\boxed{E - IR_1 - IR_2 - IR_3 - IR_4 = 0}$

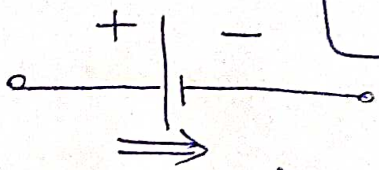
Sign Convention:

1)



(Rise)

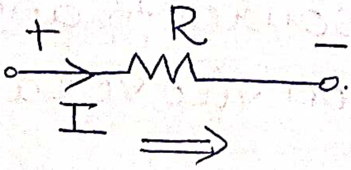
+E



(drop).

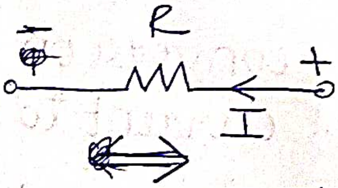
−E

2)



~~Rise~~ drop

~~+I~~ $\boxed{-IR}$



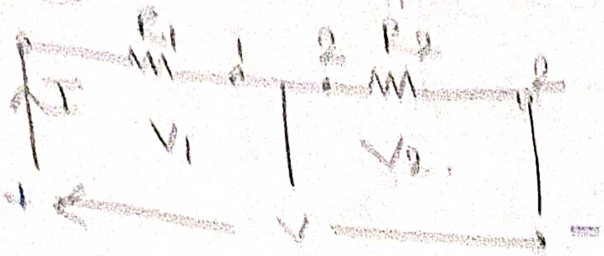
$\boxed{+IR}$

* **SERIES CONNECTION**: Joining end to end.

Bilateral: Device which acts as same in any direction. Ex: Resistor.

Unilateral: Device which acts as ~~so~~ different when connected in different direction.

Ex: Diode



1) i is same

2) V divides

$$\boxed{V = V_1 + V_2}$$

$$I R_{eq} = I R_1 + I R_2$$

$$\boxed{R_{eq} = R_1 + R_2}$$

* **Voltage Division Rule:**

$$\frac{V_1}{V_2} = \frac{R_1}{R_2}$$

$$\frac{V_1}{V - V_1} = \frac{R_1}{R_2}$$

$$V_1 R_2 = (V - V_1) R_1$$

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

$$\boxed{V_1 = \frac{V R_1}{R_1 + R_2}}$$

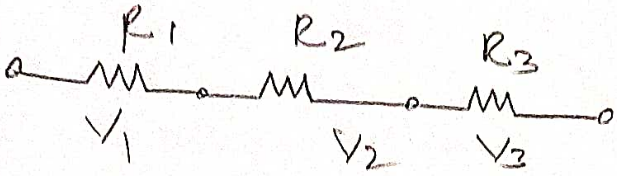
$$\frac{V - V_2}{V_2} = \frac{R_1}{R_2}$$

$$V R_2 - V_2 R_2 = V_2 R_1$$

$$\boxed{V_2 = \frac{V R_2}{R_1 + R_2}}$$

$$\boxed{P = P_1 + P_2}$$

*



$$V_1 = \frac{V R_1}{R_1 + R_2 + R_3}$$

$$V_2 = \frac{V R_2}{R_1 + R_2 + R_3}$$

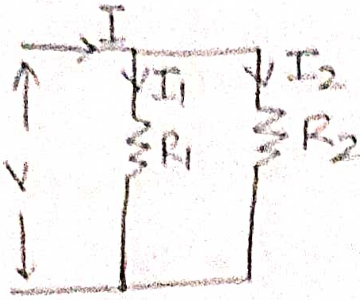
$$V_3 = \frac{V R_3}{R_1 + R_2 + R_3}$$

$$V = V_1 + V_2 + V_3$$

$$R_{eq} = R_1 + R_2 + R_3$$

* **PARALLEL CONNECTION:** Joining all similar ends.

$$\boxed{P = P_1 + P_2}$$



1) V is same

2) I divides

$$I = I_1 + I_2$$

$$\frac{V}{R_{eq}} = \frac{V}{R_1} + \frac{V}{R_2}$$

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2}$$

$$\boxed{R_{eq} = \frac{R_1 R_2}{R_1 + R_2}}$$

* Current division Rule.

$$\frac{I_1}{I_2} = \frac{R_2}{R_1}$$

$$R_1(I - I_2) = R_2 I_2$$

$$\boxed{I_2 = \frac{I R_1}{R_1 + R_2}}$$

$$\boxed{I_1 = \frac{I R_2}{R_1 + R_2}}$$

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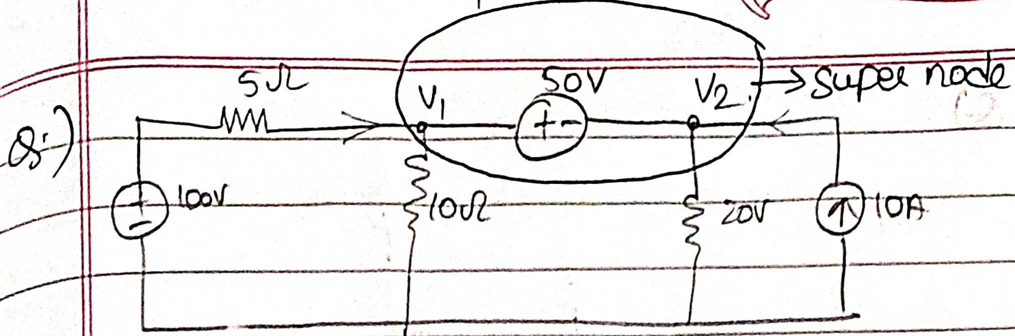
Assume as single node.

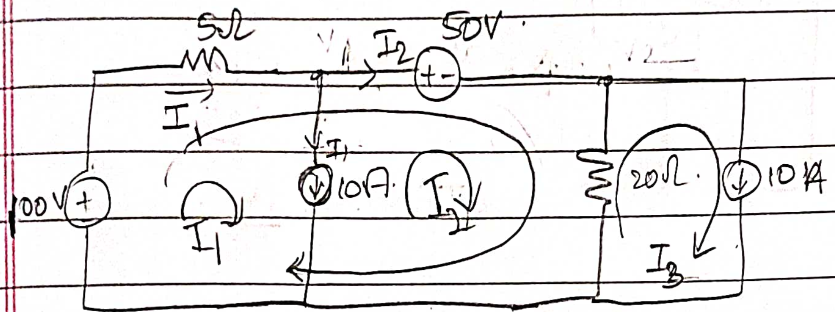
Q:)



$$\frac{100 - V_1}{5} + 10 = \frac{V_1}{10} + \frac{V_2}{20} \rightarrow \text{at super node.}$$

$$V_1 - (V_2 + 50) = 0 \longrightarrow \text{as it is a single node.}$$

Super mesh :-



$$100 - 5I - 50 - (I_3 - I_2)20 = 0$$

$$I_3 + 10 = 0$$

$$I_1 = I_2 + 10$$

* **Super position theorem** :- In any linear bilateral active network containing more than one source, response in any element is equal to sum of individual responses.

---

* **linear** :- output is proportional to input. (V=IR)
* **bilateral** :- element behaves same in both directions.
* **active** :- element which can deliver finite amount of force at infinite tyms. (power station -on)

⇒ diode is a unilateral.

⇒ resisistor is bilateral.

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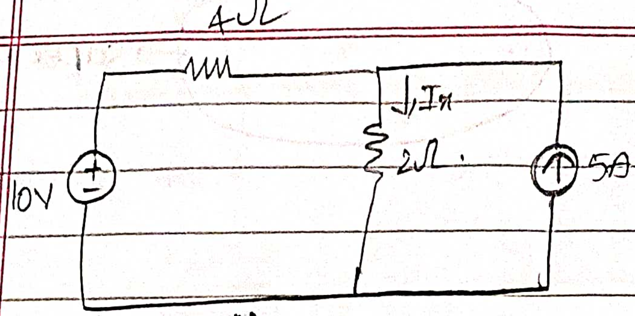
Q-)



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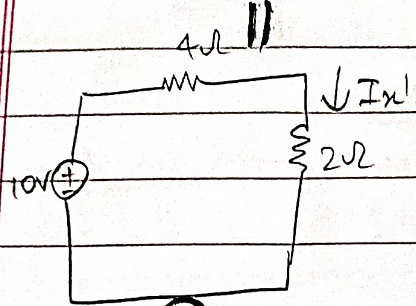
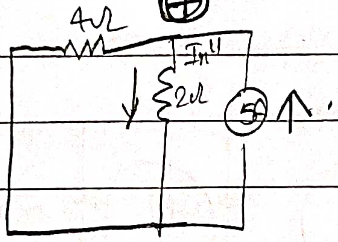


$I_x' = \frac{10}{6} = \frac{5}{3}A.$

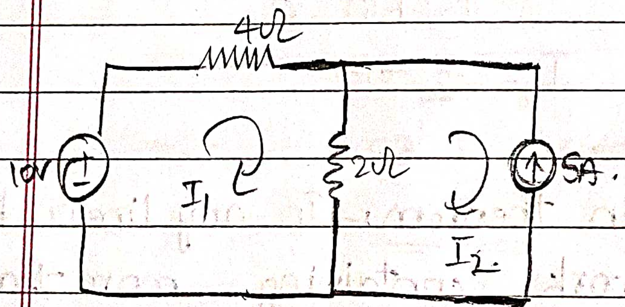
+



$I_x'' \Rightarrow \frac{5\times 4}{4+2}.$

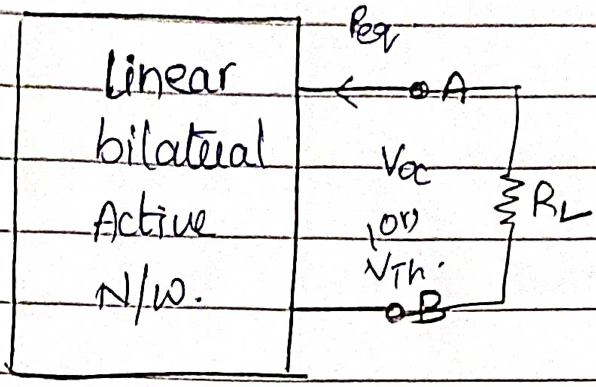
$I_x'' = \frac{20}{6}.$

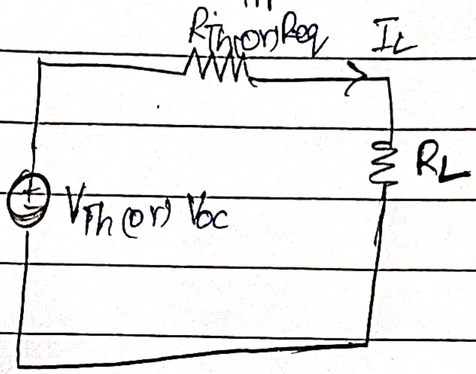
$$\boxed{I = I_x' + I_x'' = \frac{30}{6} = 5A.}$$



$-4I_1 - (I_2 - I_1)2 + 10 = 0.$

~~The~~ Thevenin's Theorem:-





$$I_L = \frac{V_{Th}}{R_{Th}+R_L}$$

Any linear bilateral active complex network btw terminals A and B (across which the load resistance is connected, In which load current (or) responce is to be found) can be replaced by a single voltage source (V_{Th}) in series with single resistance (R_{Th})

V_{Th} can be found by open circuiting load ~~resistance~~ terminals and measure across it.

R_{Th} is equivalent resistance btw A & B by replacing the sources by their internal resistances (for ideal voltage source make it short circuit & for ideal current source make it open circuit).

$-45I_2 + I_3 + 10I_1 = 0$ — (2)

$-45I_3 + 20I_2 = 50$ — (3)

$10I_2 - 15I_1 = 100$ — (1)

$$\Delta = \begin{bmatrix} 10 & -45 & 1 \\ 0 & 20 & -45 \\ -15 & 10 & 0 \end{bmatrix}$$

$15I_1 - 10I_2 = -100$ — (1)

$20I_2 - 45I_3 = 50$ — (3)

$10I_1 + I_3 - 45I_2 = 0$ — (2)

$\cancel{I_1 = \frac{-154}{17}}$ $\cancel{I_2 = +3.5}$

$\cancel{I_3 = +2.7}$

$\cancel{I_1 = 9.05A}$

$\cancel{I_1 = 7.62}$

$I_2 = 1.7A$

$I_3 = +1.9A$

$I_1 = 7.85A$

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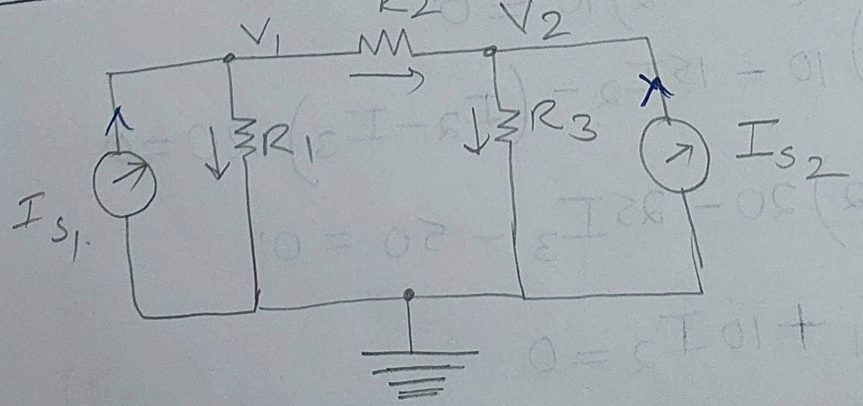
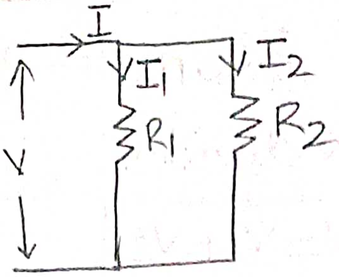
* Nodal Analysis:





1) V is same

2) I divides

$$I = I_1 + I_2$$

$$\frac{V}{R_{eq}} = \frac{V}{R_1} + \frac{V}{R_2}$$

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2}$$

$$\boxed{R_{eq} = \frac{R_1 R_2}{R_1 + R_2}}$$

* Current division Rule.

$$\frac{I_1}{I_2} = \frac{R_2}{R_1}$$

$$R_1(I - I_2) = R_2 I_2$$

$$\boxed{I_2 = \frac{I R_1}{R_1 + R_2}}$$

$$\boxed{I_1 = \frac{I R_2}{R_1 + R_2}}$$

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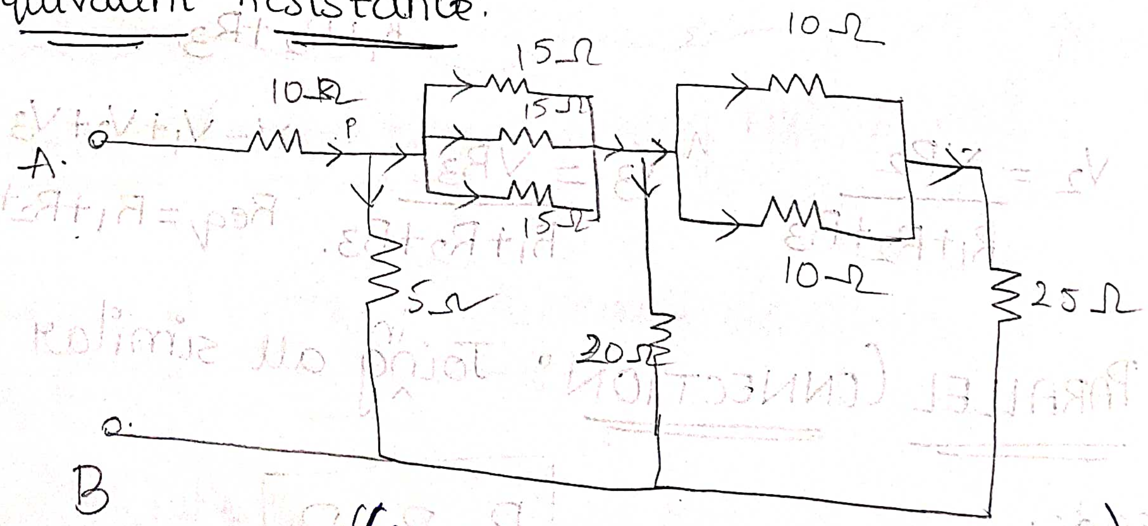
Equivalent Resistance:



$$(R_{eq})_{AB} = \left(\left(\left(25 + \frac{100}{20}\right) \parallel 20\right) + \left(15^{-1} \times 3\right)^{-1}\right) \parallel 5$$

$+10$

$$= \left(\left(\left(\frac{3\cancel{0}\times 2\cancel{0}}{5\cancel{0}}\right) + 0.02\right) \| 5\right) + 10$$

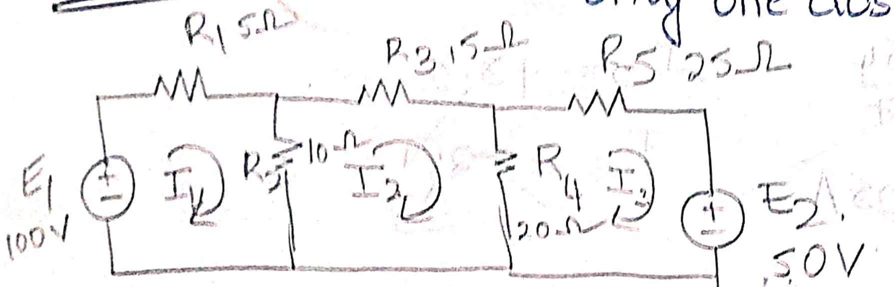
$$= \frac{17.02 \times 5}{22.02} + 10$$

$$\cancel{= 3.54 + 10} \qquad 3.86 + 10$$

$$\cancel{\boxed{R_{eq} = 13.54\ \Omega}} \qquad \boxed{R_{eq} = 13.86\ \Omega}$$

* MESH ANALYSIS: Mesh is an independent loop

· only one closed loop.



KVL:

$I \Rightarrow E_1 - I_1R_1 - (I_1 - I_2)R_2 = 0$

$II \Rightarrow -(I_2 - I_1)R_2 - I_2R_3 - (I_2 - I_3)R_4 = 0$

$III \Rightarrow -(I_3 - I_2)R_4 - I_3R_5 - E_2 = 0$

$100 - 5I_1 - (I_1 - I_2)10 = 0$

$-(I_2 - I_1)10 - 15I_2 - (I_2 - I_3)20 = 0$

$-(I_3 - I_2)20 - 25I_3 - 50 = 0$

$100 - 15I_1 + 10I_2 = 0$

$$-\cancel{25}\,45 I_2 + I_3 + 10 I_1 = 0 \quad — (2)$$

$$-45 I_3 + 20 I_2 = 50 \quad — (3)$$

$$10 I_2 - 15 I_1 = 100 \quad — (1)$$

$$\cancel{\Delta =} \quad \Delta = \begin{bmatrix} 10 & -\cancel{25}\,45 & 1 \\ 0 & 20 & -45 \\ -15 & 10 & 0 \end{bmatrix}$$

$$15 I_1 - 10 I_2 = -100 \quad — (1)$$

$$20 I_2 - 45 I_3 = 50 \quad — (3)$$

$$10 I_1 + I_3 - \cancel{25}\,45 I_2 = 0 \quad — (2)$$

$\cancel{I_1 = -\frac{154}{17}}$ $\cancel{I_2 = +3.5}$

$\cancel{I_1 = 9.05A}$ $\cancel{I_3 = +2.7}$

$\cancel{I_1 = 7.62}$

$I_2 = 1.7A$

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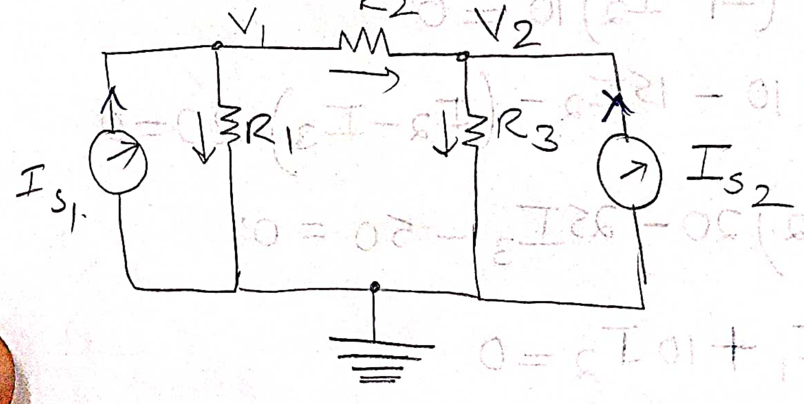
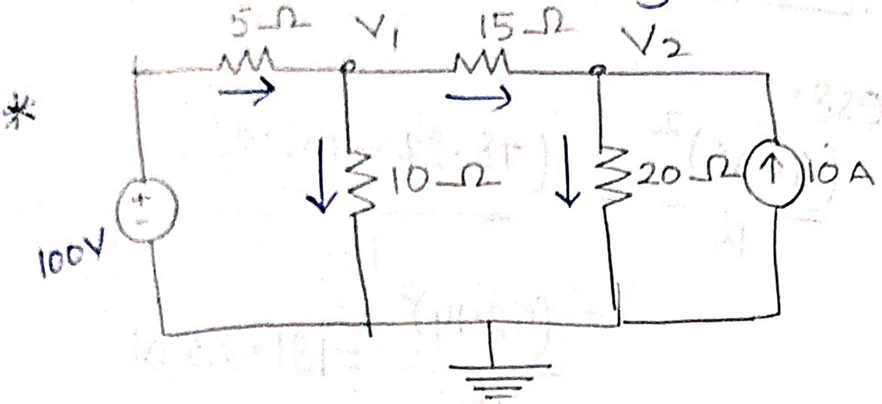
* Nodal Analysis:



$$I_{s_1} = \frac{V_1 - 0}{R_1} + \frac{V_1 - V_2}{R_2}$$

$$I_{s_2} + \frac{V_1 - V_2}{R_2} = \frac{V_2}{R_3}$$

*



at V_1 : KCL

$$\frac{100 - V_1}{\cancel{5}} = \frac{V_1 - 0}{\cancel{10}} + \frac{V_1 - V_2}{15}$$

$$\cancel{200 = 3V_1}$$

$$\cancel{\boxed{V_1 = 66.6V}}$$

$$\frac{100 - V_1}{\cancel{5}} = \frac{3V_1 + 2V_1 - 2V_2}{\cancel{30}\ 6}$$

$$600 - 6V_1 = 5V_1 - 2V_2$$

$$\boxed{11V_1 - 2V_2 = 600}$$

at V_2 : KCL

$$\frac{V_1 - V_2}{15} + 10 = \frac{V_2}{20}$$

$$\frac{V_1 - V_2 + 150}{\cancel{15}\ 3} = \frac{V_2}{\cancel{20}\ 4}$$

$$4V_1 - 4V_2 + 600 = 3V_2$$

$7V_2 - 4V_1 = 600$ — (2)

$V_1 = \frac{1800}{23}$ & $\boxed{V_2 = 130.4V}$

$\boxed{V_1 = 78.26V}$

Power across:

$15\Omega\ R = \frac{(V_1 - V_2)^2}{R} = \frac{(78.26 - 130.4)^2}{15.}$

$= \frac{(52.14)^2}{15.} = 181.23\ W$

100V Supply $\Rightarrow P = \frac{100 - 78.26}{5} \times 100.$

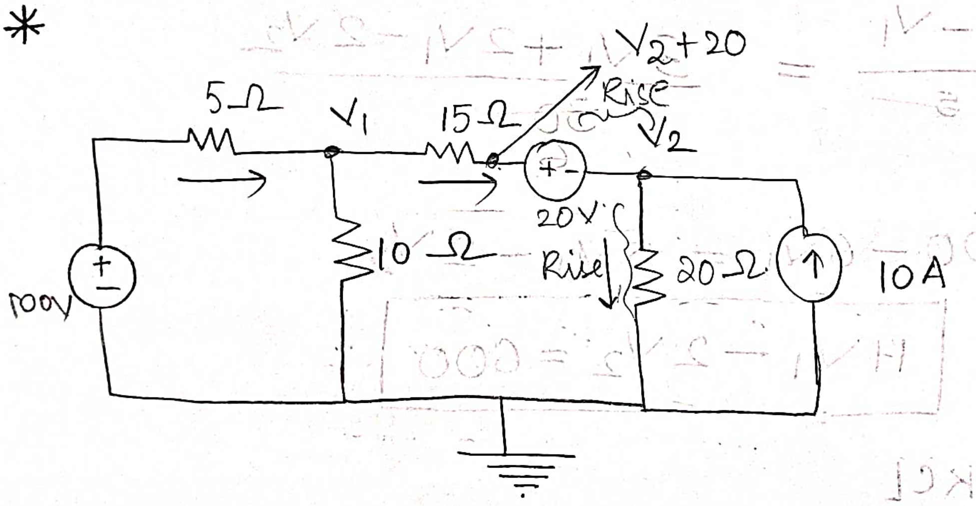
$= 434.8W.$

10A $\Rightarrow P = V_2 \times 10$

$= 130.4 \times 10$

$= \underline{\underline{1304W}}$

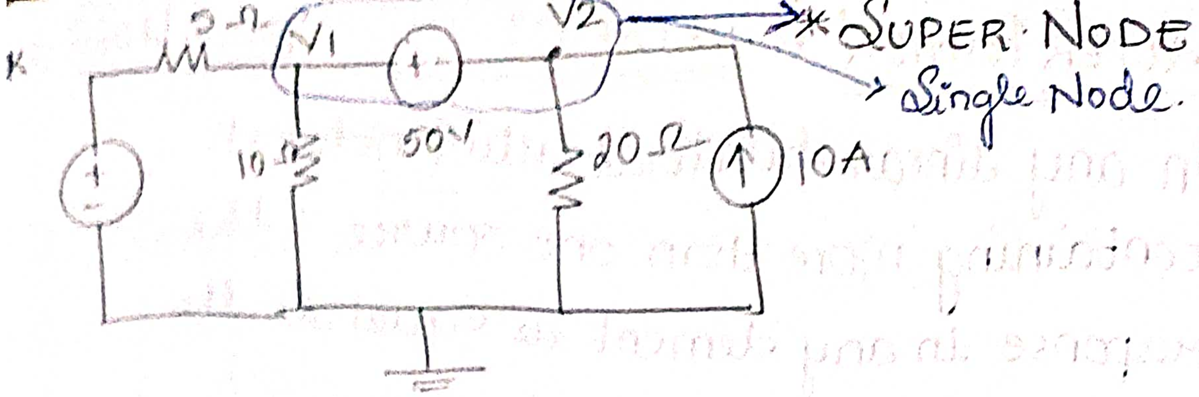
*



$V_1 - 15I - 20 - V_2 = 0$

$15I = V_1 - V_2 - 20$

$I = \frac{V_1 - V_2 - 20}{15.}$



$$\frac{100 - V_1}{5} + 10 = \frac{V_1}{10} + \frac{V_2}{20}$$

$$\boxed{V_1 - V_2 = 50}$$

$$\frac{100 - V_1 + 50}{\cancel{5}} = \frac{2V_1 + V_2}{\cancel{20}\,4}$$

$$400 - 4V_1 + 200 = 2V_1 + V_2$$

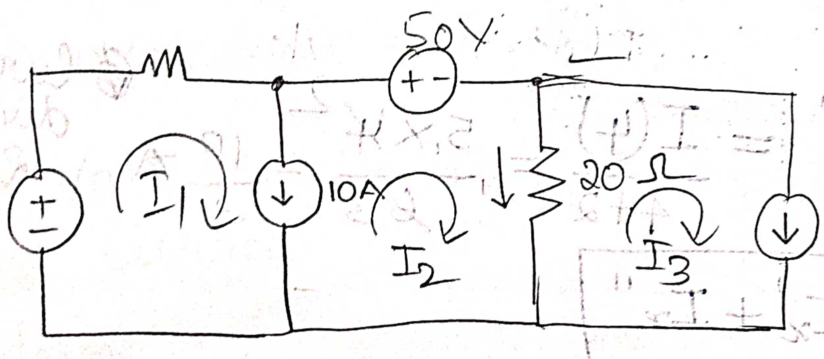
$$\boxed{6V_1 + V_2 = 600}$$

$$7V_1 = 650$$

$$\boxed{V_1 = 92.8\ V}$$

$$\boxed{V_2 = 42.8\ V}$$

* SUPER MESH:



*SUPER POSITION THEOREM:

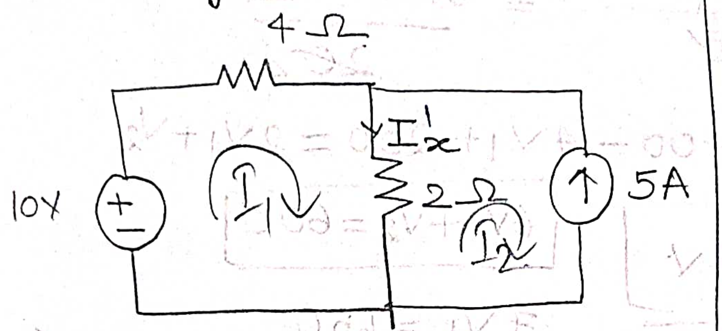
03/06/2022

In any linear bilateral active network containing more than one source ; the response in any element is equal to the sum of individual responses.

Linear : output proportional to input $V = IR$

Bilateral : acts in same way w.r.to polarities

active : deliver a finite amount of power in infinite time.



$10 - 4I_1 - 2(I_1 - I_2) = 0$

$\boxed{I_2 = -5A}$

$\cancel{10} - 4\cancel{I_1} - \cancel{2I}$

$\cancel{10}$

$I_1 = 0A$

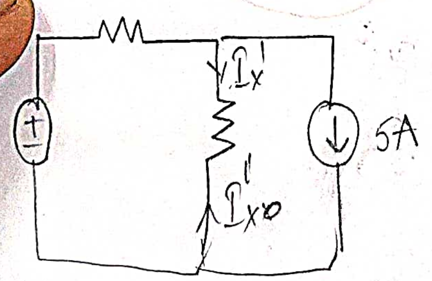
Determine I_x using SPT.

$\rightarrow I_x' = \frac{10}{6} = \frac{5}{3}$ A

$\rightarrow I_x'' = \frac{I(4)}{4+2} = \frac{5 \times \cancel{4}^{2}}{\cancel{6}\,3} = \frac{10}{3}$ A

Current division Rule.

$$\boxed{\begin{aligned} I_x &= I_x' + I_x'' \\ &= 5A \end{aligned}}$$

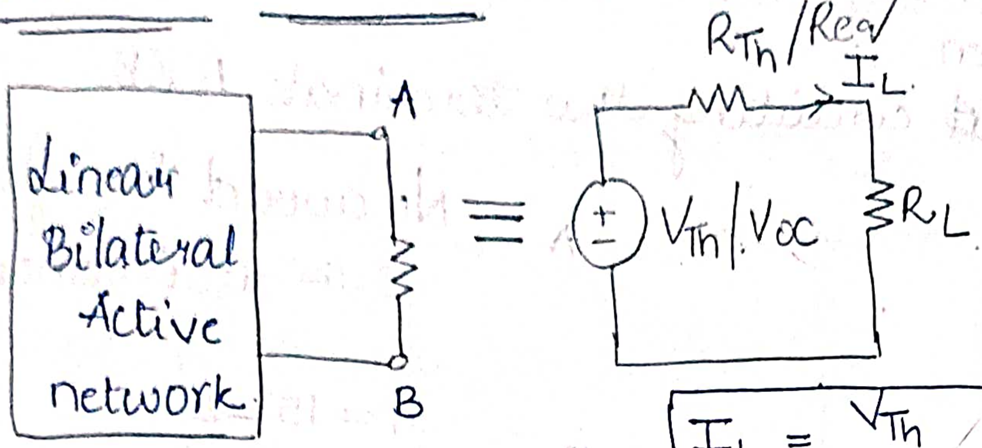


$I_x' = \frac{10}{6} = \frac{5}{3}$ A

$I_x'' = \frac{10}{3}$ A

$I_x = \frac{5}{3} - \frac{10}{3} = \frac{-5}{3}$ A

* THEVENIN'S THEOREM:



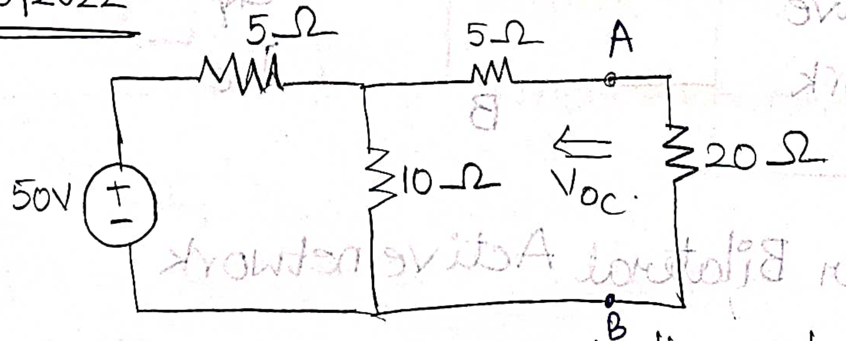
$$\boxed{I_L = \frac{V_{Th}}{R_{Th}+R_L}}$$

Any linear bilateral active complex network between terminals A and B (across which the load resistance is connected; in which load current/response is to be found) can be replaced by a single voltage source (V_{Th}) in series with the single resistance (R_{Th}). V_{Th} can be found by open circuiting the load ~~resistance~~ terminals and measure voltage across it. R_{Th} is eq. resistance between terminals A & B by replacing the sources with their internal resistance.

Ideal Voltage Source: Short Circuit

Ideal Current Source: Open Circuit.

07/06/2022

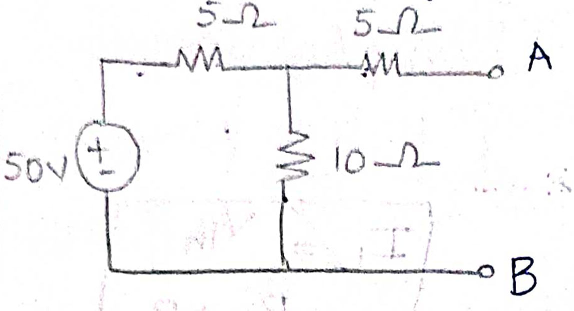


Determine the current through 20Ω

Using Thevenin's theorem:

Open

* circuiting the terminals A & B



No current through 5Ω resistance.

$R = 15\,\Omega$

$I = \frac{V}{R}$

$V = \frac{V_1}{\cancel{15}_{3}} \times \cancel{10}^{2}$

$V = 50 \times \frac{2}{3}$

$= \frac{100}{3} = 33.33$

$\boxed{V_{Th} = 33.3\,V}$

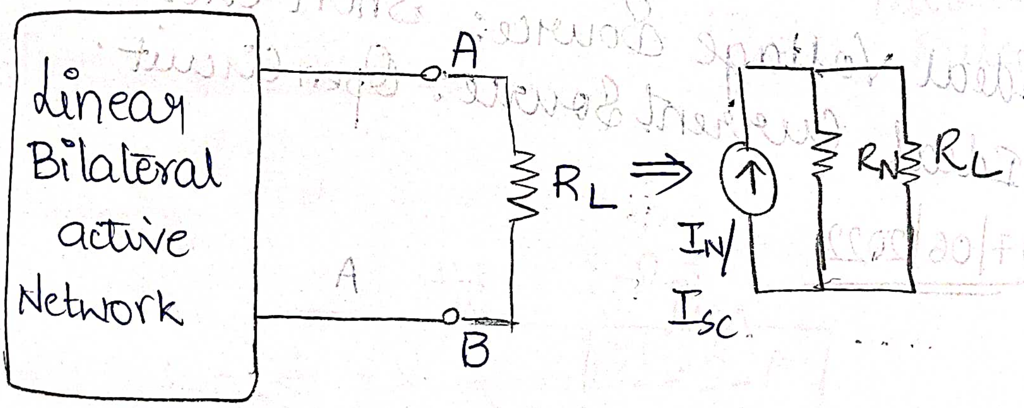
$R_{Th} = \frac{10 \times \cancel{5}}{\cancel{15}\,3} + 5$

$\boxed{R_{Th} = \frac{25}{3}}$

$I_{Th} = \frac{100/3}{\frac{25}{3} + 20} = \frac{100}{85} = \frac{20}{17}$

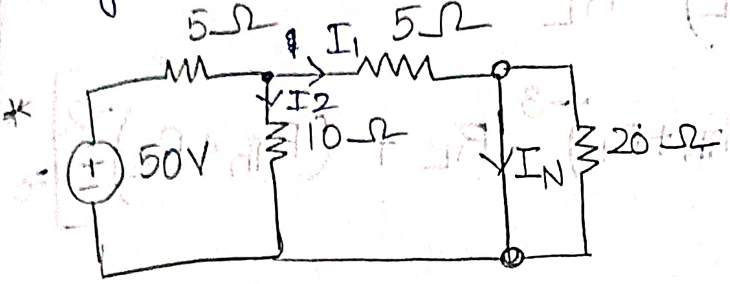
$\boxed{I_{Th} = 1.176A}$

* NORTON'S THEOREM:



Any Linear Bilateral Active network between terminals A & B can be replaced by a single current source (I_N) in parallel to single resistance (R_N).

We get I_N by short circuiting the load terminals.

* 

$$Req = \frac{25}{3}\,\Omega = R_N$$

$$I = \frac{50}{25} \times 3$$

$$\boxed{I = 6A}$$

$$I_N = 6 \times \frac{10}{10+5}$$

$$= \frac{60}{15} = 4A$$

$$\boxed{I_N = 4A}$$

$$I_L = \frac{I_N \cdot R_N}{R_N + R_L}$$

$$= \frac{4 \times \frac{25}{3}}{\frac{25}{3} + 20} = \frac{100}{85} = 1.176A$$

$$\boxed{I_L = 1.176A}$$

* MAXIMUM POWER TRANSFER THEOREM:

Maximum Power will be transferred from source to load when $R_L = R_S | R_{Th}$

$$P = I_L^2 R_L$$

$$P = \left(\frac{V_{Th}}{R_{Th} + R_L}\right)^2 R_L$$

$$\frac{dP}{dR_L} = 0$$

$$P = V_{Th}^2 \left(R_{Th} + R_L\right)^{-2} \cdot R_L$$

$$\frac{dP}{dL} = V_{Th}^2 \left[-2\left(R_{Th}+R_L\right)^{-3} \cdot R_L + \left(R_{Th}+R_L\right)^{-2} \right] = 0$$

$$\frac{2R_L}{\left(R_{Th}+R_L\right)^{\cancel{3}}} = \frac{1}{\left(R_{Th}+\cancel{R_L}\right)^{\cancel{2}}}$$

$$2R_L = R_{Th} + R_L$$

$$\boxed{R_L = R_{Th}}$$

$P_{out} = P_{max}$

$P_{in} = V_{Th} \cdot I_L$

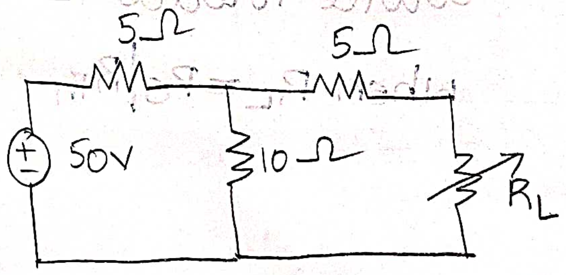
$= V_{Th} \cdot \frac{V_{Th}}{2R_{Th}}$

$$\cancel{R_S} = \boxed{\frac{V_{Th}^2}{2R_{Th}} = P_{in}}$$

$$\eta = \frac{P_{out}}{P_{in}}$$

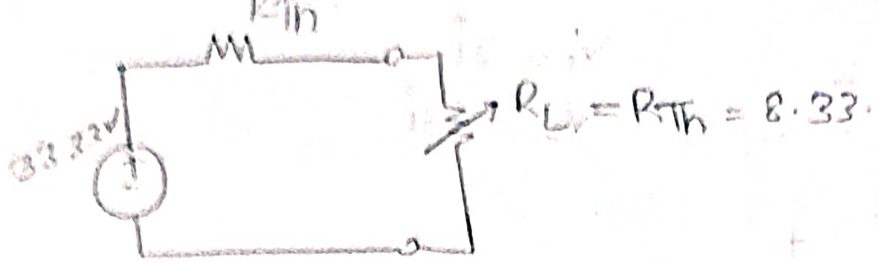
$$= \frac{1}{2} = 50\%$$

<u>08/06/2022</u>



Determine ~~for~~ R_L for MPT.

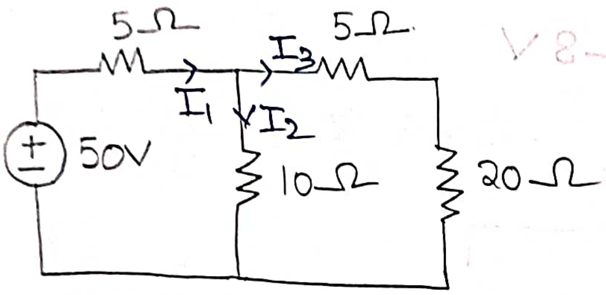
and MPT



$$P_{in} = \frac{V_{Th}^2}{2R_{Th}} = 66.68\,V.$$

* TELLEGEN'S THEOREM:

$$\boxed{\Sigma \text{Power}\,(P) = 0}$$



$$I_1 = \frac{50}{5 + \left(\frac{10 \times 25}{35}\right)}$$

$$= \frac{50}{5 + 50/7}$$

$$I_1 = \frac{50}{5 + 7.14} = 4.11A.$$

$$I_2 = \frac{4.11 \times \cancel{25}\,5}{\cancel{35}\,7}$$

$\cancel{I_2 = 0.58A}$

$\cancel{I_3 = 4.11 \times}$

$$\boxed{I_2 = 2.93A}$$

$$I_3 = I_1 - I_2$$

$$= 4.11 - 2.93$$

$$\boxed{I_3 = 1.18A}$$

$$\boxed{P = 50 I_1 = 205.5\,W}$$

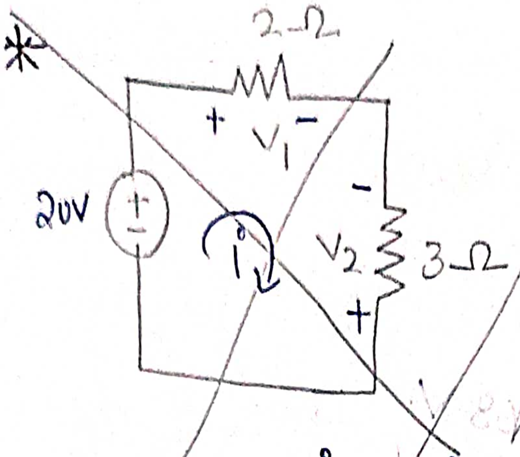
$$P = P_1 + P_2 + P_3$$

$$P_1 = I_1^2 R_1 = 84.4W$$

$$P_2 = I_2^2 R_2 = 85.84W$$

$$P_3 = I_3^2 R_3 = 34.81$$

*

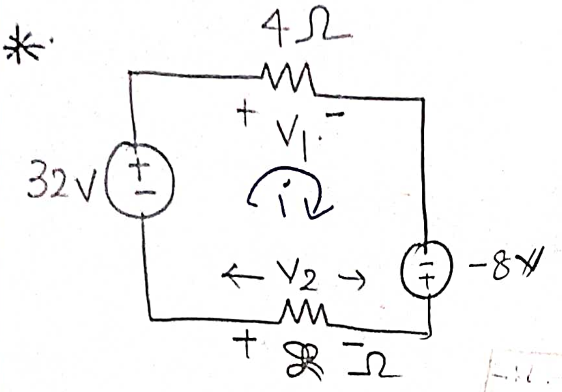


$V_1 = 2i$

$V_2 = -8i$

$20 - 2i + 3i = 0$

*



Det V_1 & V_2.

$32 - 4i + (-8) - 2i = 0$

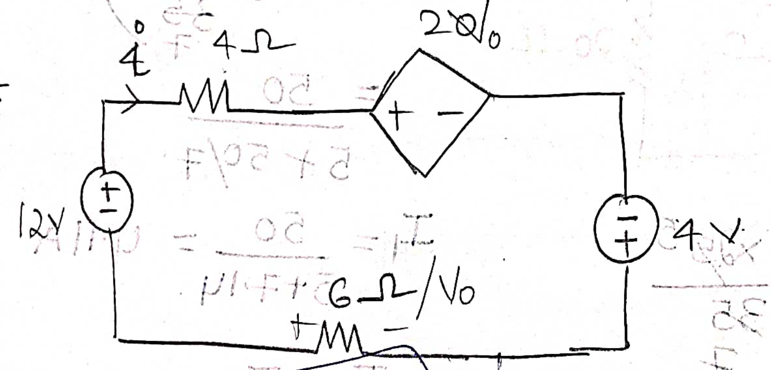
$24 = 6i$

$i = 4A$

$V_1 = 4i = 16A$

$V_2 = -2i = -8V$

*



$\boxed{V_0 = -6i}$

$12 - 4i - 2V_0 + 4 - 6i = 0$

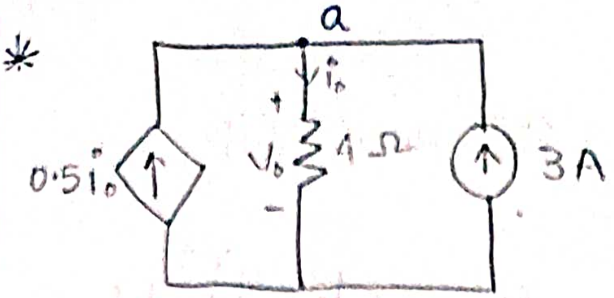
$16 - 2V_0 - 10i = 0$

$16 + 2i = 0$

$\boxed{i = -8A}$

$V_0 = 48V$

*



$$i_o = \frac{V_o}{4}$$

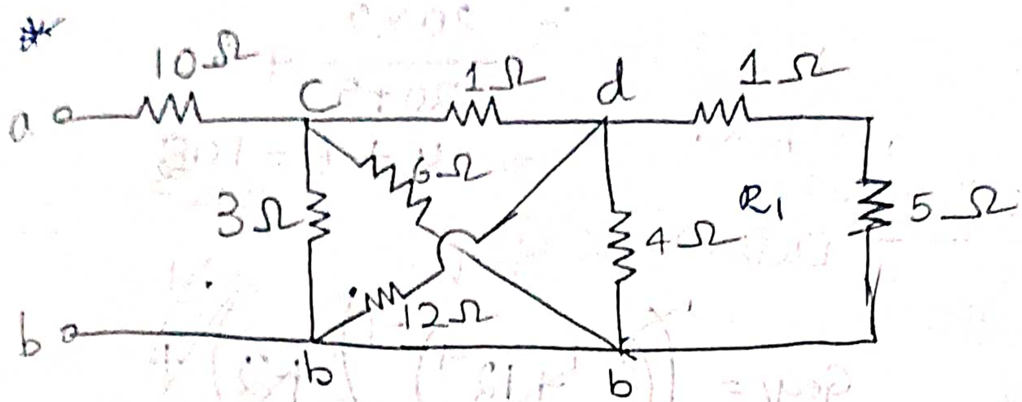
$$0.5 i_o - i_o + 3 = 0$$

$$3 = 0.5 i_o$$

$$\boxed{i_o = 6A}$$

$$\boxed{V_o = 24V}$$

*



$$R_1 = \frac{6 \times 4}{10} = 2.4\ \Omega$$

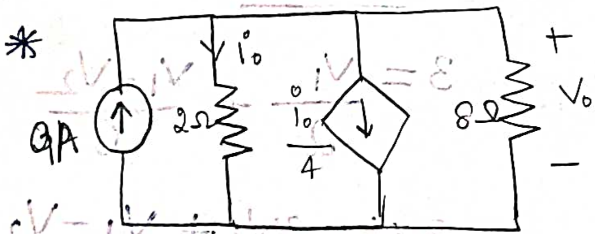
$$R_2 = \frac{2.4 \times 12}{14.4} + 1 = 3$$

$$R = \frac{3 \times 2}{5} = \frac{6}{5}$$

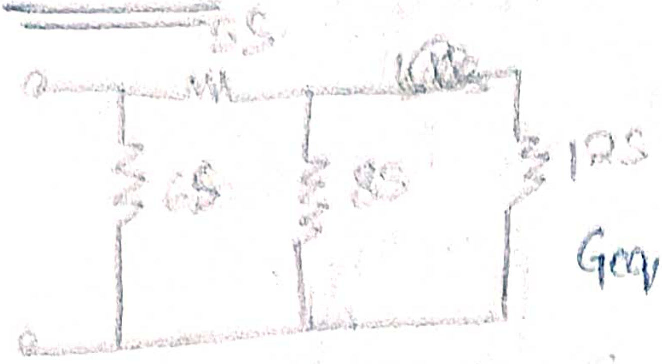
$$R_{ab} = \frac{6}{5} + 10$$

$$= \frac{56}{5} = 11.2\ \Omega$$

*



10/06/2022



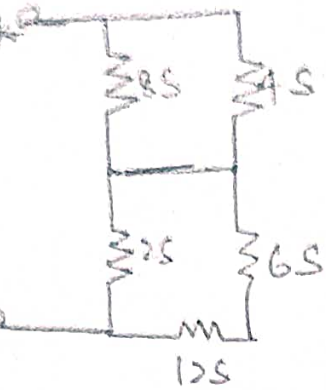
Determine Geq

$$G_{eq} = \left((8+12)^{-1} + 5^{-1}\right)^{-1} + 6$$

$$= \left((20)^{-1} + 5^{-1}\right)^{-1} + 6$$

$$= \frac{20 \times 5}{20+5} + 6$$

$$= 4 + 6 = \underline{\underline{10S}}$$

* 

Determine Geq

$$G_{eq} = \cancel{\left(\left(6^{-1} + 12^{-1}\right)^{-1} + 2\right)^{-1}}$$

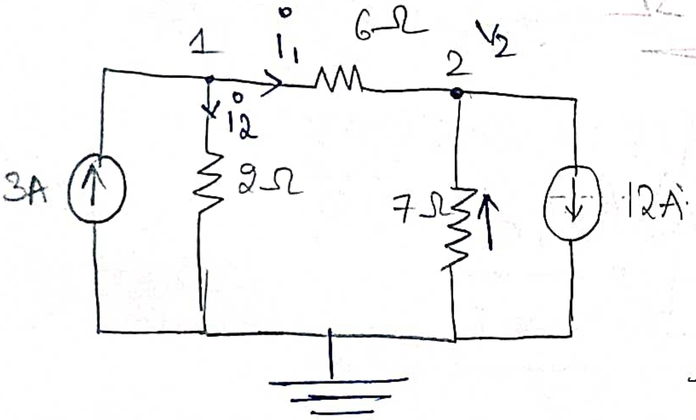
$$G_1 = \frac{6 \times 12}{18} = 4$$

$$G_2 = 4 + 2 = 6$$

$$G_3 = 12$$

$$G_{eq} = \left(6^{-1} + 12^{-1}\right)^{-1}$$

$$= \frac{6 \times 12}{18} = \underline{\underline{4S}}$$

* 

at node 1:

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

$$3 \times 6 = 3V_1 + V_1 - V_2$$

$$\boxed{4V_1 - V_2 = 18}$$

at node 2. $\cancel{+12 = \frac{V_2}{7}}$

$\cancel{\boxed{V_2 = 84A}}$

$\cancel{\frac{-V_2}{7} = 12 +}$

$\cancel{-V_2 = 84A}$

$\cancel{V_2 = -84A}$

$\cancel{4V_1 = 18 + V_2}$

$\cancel{= 18 - 84}$

$\cancel{4V_1 = 66}$

$\cancel{-\frac{V_2}{7} - \frac{V_2 - V_1}{6} = 12}$

$\cancel{-6V_2 + 7V_2 - 7V_1 = 12 \times 42}$

$\cancel{V_2 - 7V_1 = 504}$

$\cancel{-V_2 + 4V_1 = 18}$

$\cancel{-3V_1 =}$

$\cancel{\begin{array}{r} 42 \\ \times 12 \\ \hline 84 \\ 42 \\ \hline 504 \end{array}}$

$12 + \frac{V_2 - V_1}{6} = -\frac{V_2}{7}$

$\Rightarrow \frac{72 + V_2 - V_1}{6} = -\frac{V_2}{7}$

$504 + 7V_2 - 7V_1 = -6V_2$

$7V_1 - 13V_2 = 504$

$4V_1 - V_2 = 18$

$7V_1 - 13V_2 = 504$

$52V_1 - 13V_2 = 234$

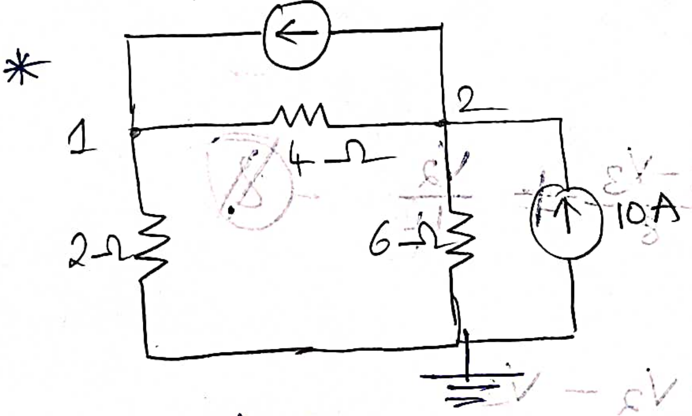
$-45V_1 = 270$

$\boxed{V_1 = 6V}$

$V_2 = -24 - 18$

$V_2 = -42V$

*



at node 1

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

$5 \times 4 = V_1 - V_2 + 2V_1$

$3V_1 - V_2 = 20$

at node 2:

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

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

$$6V_2 - 6V_1 + 4V_2 = 120$$

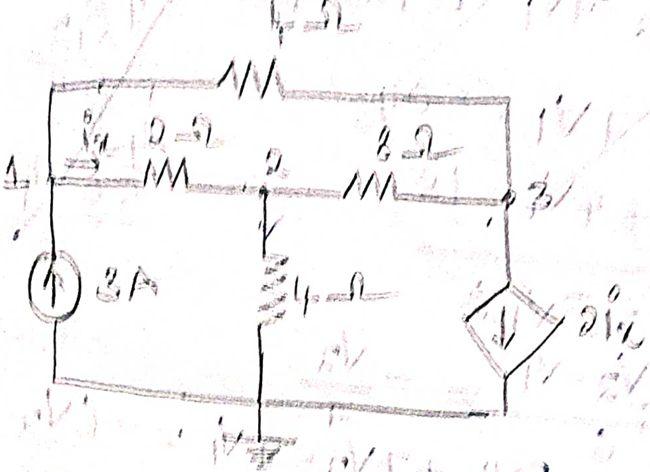
$$10V_2 - 6V_1 = 120$$

$$(-V_2 + 3V_1 = 20) \times 10$$

$$24V_1 = 320$$

$$V_1 = \frac{40}{3} = 13.33V$$

*



$$i_x = \frac{V_1 - V_2}{2}$$

at node 1:

$$\frac{V_1 - V_2}{2} + \frac{V_1 - V_3}{4} = 3$$

$$3V_1 - 2V_2 - V_3 = 12 \quad — (1)$$

at node 2:

$$\frac{V_1 - V_2}{2} = \frac{V_2 - V_3}{8} + \frac{V_2}{4}$$

$$\frac{V_1 - V_2}{\cancel{2}} = \frac{3V_2 - V_3}{\cancel{8}\,4}$$

$$\boxed{4V_1 - 7V_2 + V_3 = 0} \quad — (2)$$

at node 3

$$\frac{V_1-V_3}{4} + \frac{V_2-V_3}{8} = \cancel{8}\left(\frac{V_1-V_2}{\cancel{2}}\right)$$

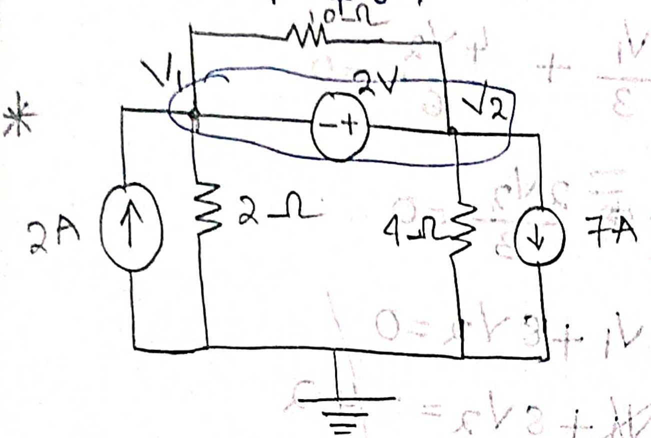
$$2V_1 + V_2 - 3V_3 = 8V_1 - 8V_2$$

$$6V_1 - 9V_2 + 3V_3 = 0$$

$\cancel{V_1 = 2V}$ $V_2 = 2.4V$ $V_3 = -28.84V$

$V_1 = 4.8V$

*



In super node concept ; the resistance connected across super node can be ignored.

$$V_2 - V_1 = 2V$$

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

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

$$2V_1 + V_2 = -20$$

$$-V_1 + V_2 = 2$$

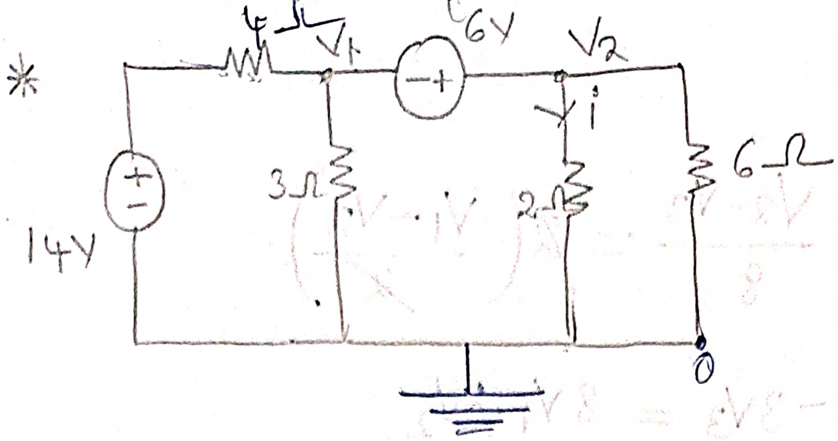
$$\underline{+ \quad - \quad\quad -}$$

$$3V_1 = -22$$

$$\boxed{V_1 = -7.33V}$$

$$\boxed{V_2 = -5.33V}$$

*



$$V_2 - V_1 = 6V$$

$$\frac{14-V_1}{4} = \frac{V_1}{3} + \frac{V_2}{2} + \frac{V_2}{6} \cancel{=0}$$

$$\frac{14-V_1}{4} = \frac{V_1}{3} + \frac{4V_2}{6} = 0$$

$$\frac{7}{2} + \frac{V_1}{12} = \frac{2V_2}{3} = 0$$

$$42 + V_1 + 8V_2 = 0$$

$V_1 = 0.4A$

$= 400mA$

V_2 -

$$V_1 + 8V_2 = -42$$

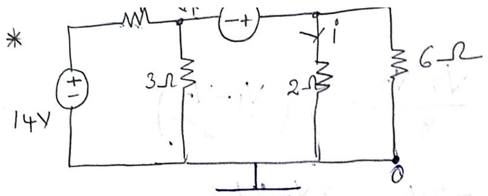
$$-V_1 + V_2 = 6$$

$$9V_2 = -36$$

$$V_2 = -4V$$

$$V_1 = -10V$$

*



$V_2 - V_1 = 6V$

$$\frac{14-V_1}{4} = \frac{V_1}{3} + \frac{V_2}{2} + \frac{V_2}{6}$$

$$\frac{14-V_1}{4} = \frac{V_1}{3} + \frac{4V_2}{6} = 0$$

$$\frac{7}{2} + \frac{V_1}{12} = \frac{2V_2}{3} = 0$$

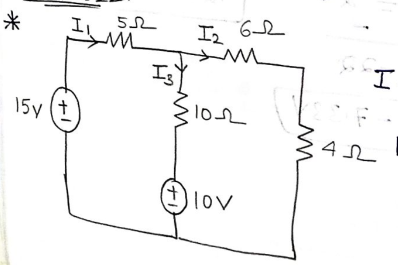
$V_1 = 0.4A$
$= 400mA$

$i = 2.8A$

~~$42 + V_1 + 8V_2 = 0$~~
~~$V_1 + 8V_2 = -42$~~
~~$-V_1 + V_2 = 6$~~
~~$9V_2 = -36$~~
~~$V_2 = -4V$~~
~~$V_1 = -10V$~~

13/06/2022

*



I: KVL

$15 - 5I_1 - 10I_3 - 10 = 0$

$\boxed{5I_1 + 10I_3 = 5}$

$\boxed{I_1 + 2I_3 = 1}$

II: $10 - 10I_3 - 6I_2 - 4I_2 = 0$

$10 = 10I_3 + 10I_2$

$\boxed{I_3 + I_2 = 1}$

$I_1 + 2I_1 - 2I_2 = 1$

$\boxed{3I_1 - 2I_2 = 1}$

$I_3 = 0$

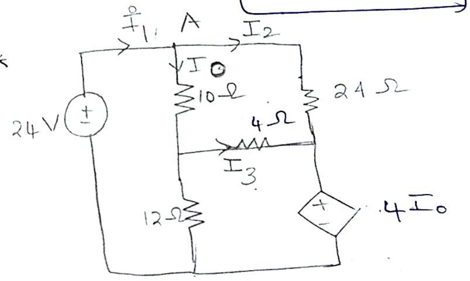
$I_3 = I_1 - I_2$

$\boxed{I_1 = 1A}$

$3I_1 - 1 = 2I_2$

$\boxed{I_2 = 1A}$

*



I: $-24 + 10(I_1 - I_2) + 12(I_1 - I_3) = 0$

$-24 + 22I_1 - 10I_2 - 12I_3 = 0$ — (1)

II: $24I_2 + 10(I_1 - I_2) + 4(I_2 - I_3) = 0$

~~$10I_1 + 14I_2 = 0$ — (2)~~

$-18I_2 + 10I_1 + 4I_3 = 0$ — (2)

III: $-4(I_3 - I_2) - 4(I_1 - I_2) - 12(I_3 - I_1) = 0$

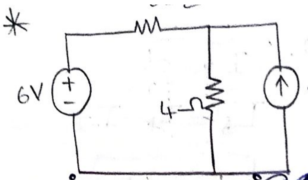
$-16I_3 + 8I_2 + 8I_1 = 0$

$8I_1 + 8I_2 - 16I_3 = 0$

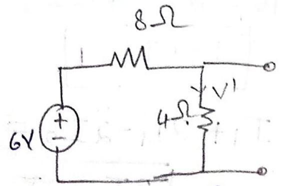
$\boxed{I_1 + I_2 - 2I_3 = 0}$ — (3)

$I_1 = 6A$ $I_2 = 4.5A$
$I_3 = 5.25A$

*

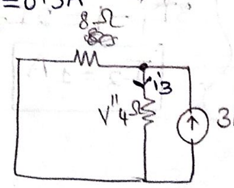


Determine V_o using SPT



$12i_1 - 6 = 0$

$i_1 = 0.5A$



$6 - 8i_1 - V'' = 0$

$6 - 8(0.5) = V'$

$\boxed{V' = 2V}$

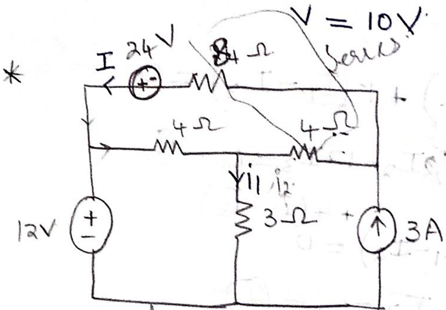
$i_3 = \frac{3 \times 8}{12}$

$i_3 = 2A$

$V'' = 4 \times 2 = 8V$

$V = 10V$

*



Determine 'i' using SPT

24V removed
S.C

$i_1 = \frac{12}{4 \| (3+12) \, 6} = \frac{\cancel{12} \times 19}{\cancel{4} \times \cancel{15}} = 3.8A = 2A$

$(4 \| 12) + 3 = \frac{48}{16} = 3 + 3$

12V
S.C

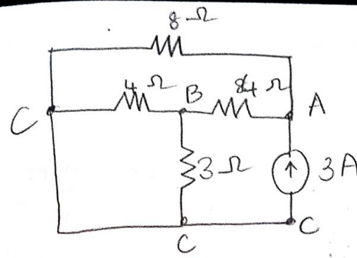
$i_2 = \frac{\frac{7}{4} \times 4}{7} = 1A$

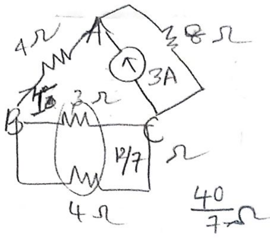
$I = \frac{24}{(4 \| 3) + 4}$

$= \frac{24 \times 7}{12 + 12 \times 7}$

$= \frac{2 \times 7}{8}$

$= \frac{7}{4}$





$i_3 = \frac{4 \times \frac{7}{4}}{7}$

$= 1A$

$I = \frac{3 \times 8}{8 + \frac{40}{7}}$

$= \frac{24 \times 7}{96}$

$\boxed{I = 7/4\ A}$

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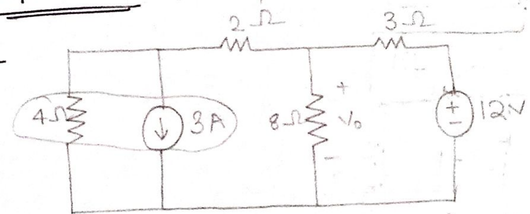
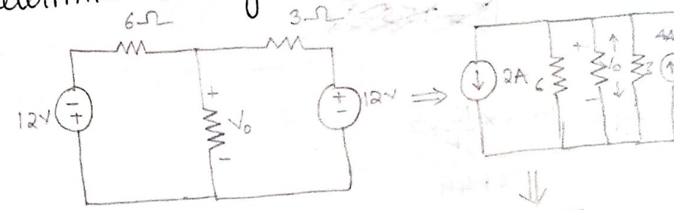
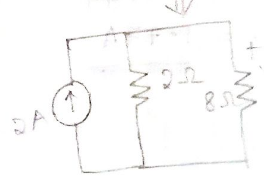
*



Determine V_o using source transformation.

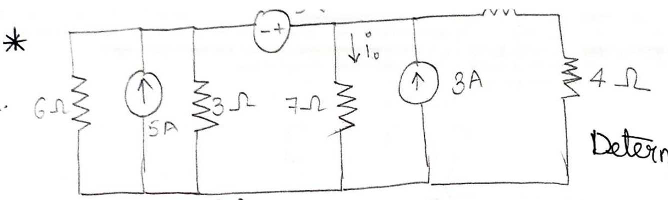




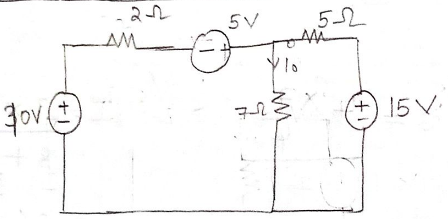
$V_o = (2)\left(\frac{16}{10}\right)$

$= 3.2V$

*



Determine i_0.



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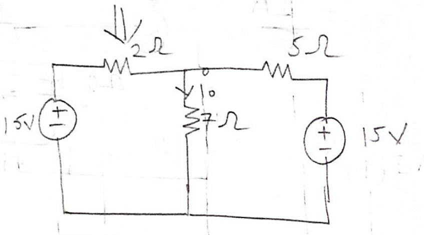

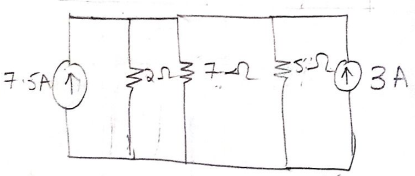

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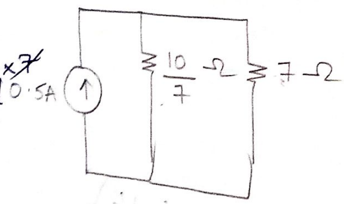
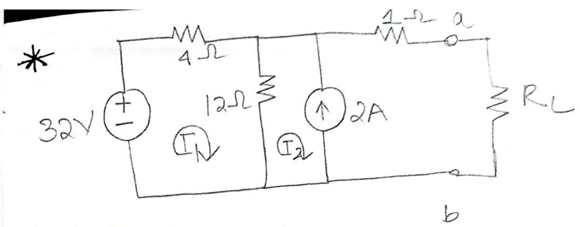


$$I_1 = \frac{10.5 \times \frac{10}{7} \times \cancel{7}}{10+49}$$

$= 1.77A$

*



$R_L = 6Ω$

$I_2 = -2A$

$32 - 4I_1 - 12(I_1 + 2) = 0$

$32 - 16I_1 - 24 = 0$

$16I_1 = 8$

$\boxed{I_1 = 0.5A}$

$(4 \| 12) + 1$

$R_{Th} = \frac{4 \times 12}{16} + 1$

$= 4Ω$

$V_{oc} = (I_1 - I_2)(12)$

Voltage across 12Ω is same as V_{oc}.

$V_{oc} = 2.5 \times 12$

$\boxed{V_{oc} = 30V} = V_{Th}$

$I_{Th} = \frac{V_{oc}}{R_{Th} + R_L} = \frac{V_{Th}}{R_{Th} + R_L}$

$\boxed{I_{Th} = \frac{30}{4+6} = 3A}$

$R_L = 16Ω$

$I_{Th} = \frac{30}{20} = 1.5A$

$R_L = 36Ω$

$I_{Th} = \frac{30}{40} = 0.75A$

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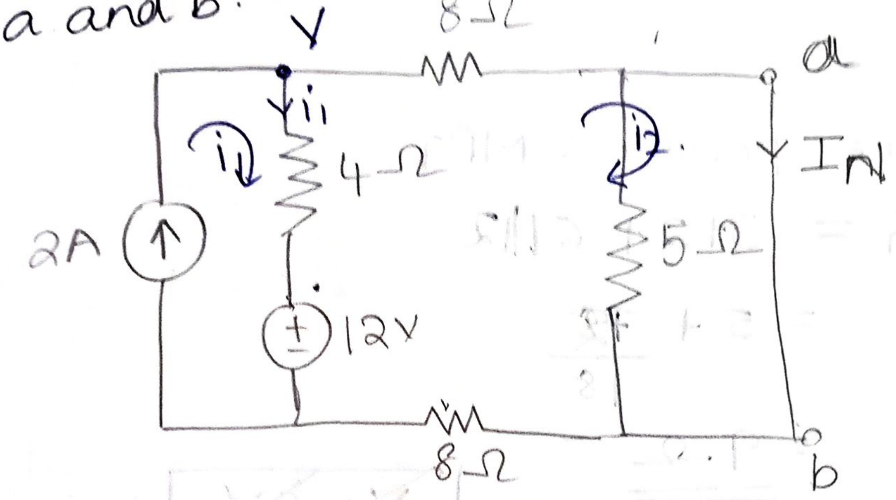
* Determine Norton's equivalent circuit b/w a and b.



$2 = \frac{V-12}{4} + \frac{V}{16}$

$2 \times 16 = 4V - 48 + V$

$5V = 80$

$V = 16V$

$\because$ 5Ω resistor is ignored

$\therefore$ ~~I~~ $2A = i_1$

$\cancel{I_N = 2 \times 5}$

$\boxed{I_N = 1A}$

$R_N = 5 \| (8+4+8)$

$= \frac{\cancel{20}^{4} \times \cancel{5}}{\cancel{25}_{5}}$

$R_N = 4\Omega$.

$\cancel{I = \frac{12}{4} = 3A}$

$20i_2 - 4i_1 - 12 = 0$

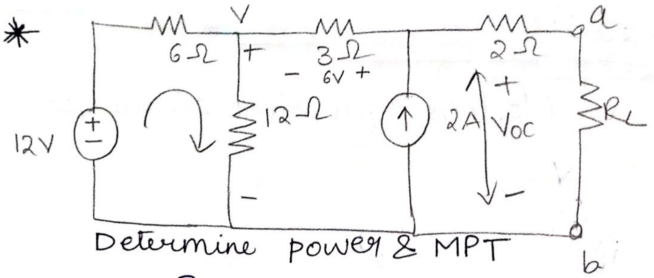
$20i_2 - 8 - 12 = 0$

$\boxed{i_2 = 1A}$

$\frac{V-12}{4} = I_N = \frac{16-12}{4}$

$= \underline{1A}$

*



Determine power & MPT

$R_{Th} = 3+2+6\|12$

$= 5 + \frac{\cancel{72}}{18}$

$= 9\,\Omega$

$\boxed{\cancel{V = 8V}}$

$\cancel{\frac{V}{\cancel{12}\,2} + \frac{12-V}{6} - 0 + 2\times 6}$

$\cancel{V = 24 - 2V}$

$\frac{V}{12} = \frac{12-V}{6} + 2$

$\frac{V}{\cancel{12}\,2} = \frac{12-V+12}{\cancel{6}}$

$V = 48 - 2V$

$3V = 48$

$V = 16V$

$V + 6 - V_{oc} = 0$

$V_{oc} = V_{Th} = 22V$

$P_{max} = \frac{V_{Th}^2}{4R_{Th}}$

$= \frac{(22)^2}{4\times 9}$

$= \frac{(22)^2}{36}$

$\boxed{P_{max} = 13.44W}$

* Capacitor:

20/06/2022

- 2 metallic plates separated by di-electric material.
- Stores energy in the form of charge / electric field.

$\boxed{C = \frac{\epsilon A}{d}}$ F

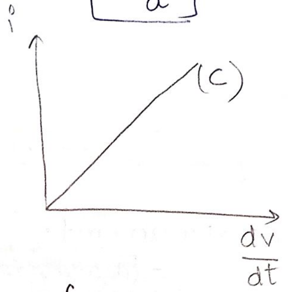
$q \propto v$

charge $\propto$ voltage.

$\boxed{q = CV}$

$\frac{dq}{dt} = C\frac{dv}{dt}$

$\boxed{i = C\frac{dv}{dt}}$



$\cancel{W = \int P dt}$

$W = \int P dt$ P = power

$W = \int VI\,dt$

$W = \int v \cdot C\frac{dv}{dt}\cdot dt \Rightarrow W = \int CV\,dv$

$\boxed{W = \frac{CV^2}{2}}$

$v = \frac{1}{C}\int_{-\infty}^{t} i\,dt$

$v = \frac{1}{C}\left[\int_{-\infty}^{0-} i\,dt + \int_{0-}^{0+} i\,dt + \int_{0+}^{t} i\,dt\right]$

$v = \underbrace{V_0}_{\text{Initial}} + 0 + \int_{0+}^{t} i\,dt$

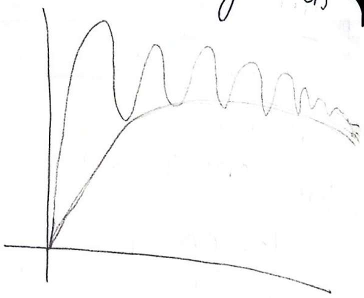
$\boxed{v = V_0 + \int_{0+}^{t} i\,dt}$

Capacitor delivers energy only for short time. ∴ It is a passive element

* When we apply DC; the capacitor acts as open circuit

* Response oscillates over the final condition until the steady state where it attains a steady state/value.

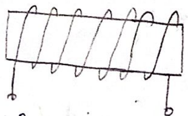
* Capacitor do not allow sudden changes in voltage.



* Capacitor acts as voltage source under initial conditions and acts as open circuit under final conditions.

* **Inductance : (L)**

- Stores energy in the form of magnetic field.
- Rate of change of flux generates an emf. — Faraday's Law

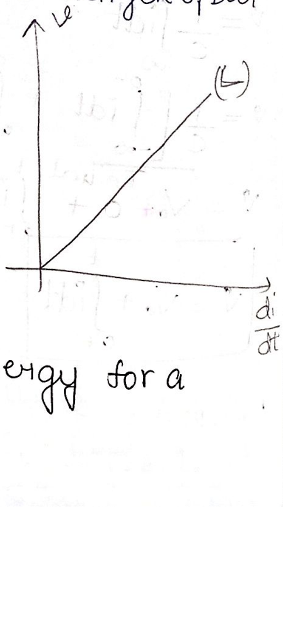


$v \propto \frac{di}{dt}$

$\boxed{v = L\frac{di}{dt}} \boxed{= N\frac{d\phi}{dt}}$

$\boxed{L = \frac{N^2 \mu A}{l}}$

N = No. of turns
A = area of the bar
l = length of bar.



* Inductor is a passive element.

* Active elements provide energy for infinite time.

* Passive elements provide energy for a short interval of time.

$\boxed{L = \frac{\text{Flux Linkage}}{\text{Ampere}}}$

$v = L\frac{di}{dt}$

$i = \frac{1}{L}\int_{-\infty}^{} v\,dt$

$I = \frac{1}{L}\left[\int_{-\infty}^{0^-} v\,dt + \int_{0^-}^{0^+} v\,dt + \int_{0^+}^{t} v\,dt\right]$

$I = I_0 + 0 + \int_{0^+}^{t} v\,dt$

* Inductor acts as current source under initial conditions.

⇒ Inductor do not allow sudden changes in current.

* Inductor acts as short circuit under final conditions.

* $\boxed{L_1 + L_2 = L}$ → Series $\boxed{L = \frac{L_1 L_2}{L_1 + L_2}}$ → Parallel

* $\boxed{C_1 + C_2 = C}$ → Parallel $\boxed{C = \frac{C_1 C_2}{C_1 + C_2}}$ → Series

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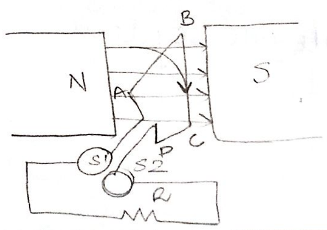
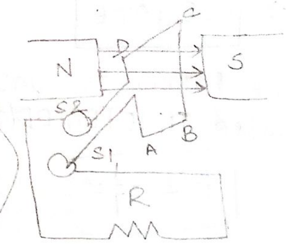
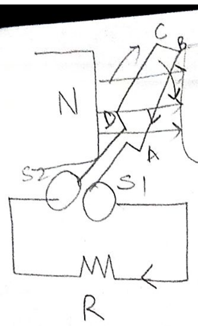
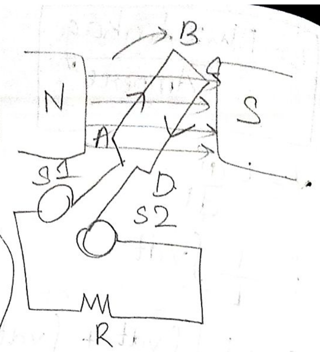
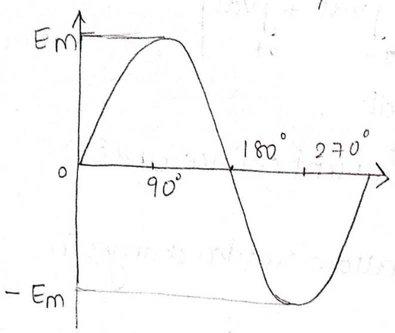
* **AC GENERATOR :**











→ AC can be transmitted to a higher voltage frequencies due to which it is very economical:
Ex: Transformer

$\boxed{e = E_m \sin \omega t}$ ω = Angular frequency / velocity

$\boxed{\omega = \frac{\theta}{t}}$ θ = Angular displacement

$\boxed{\theta = \omega t}$

$\Rightarrow \boxed{e = E_m \sin\theta}$

* Time taken to complete one cycle is called TIMEPERIOD(T)

$$\boxed{f = \frac{1}{T}}$$

* No. of cycles per second is called FREQUENCY.

$f = 50Hz$ $T = 20 msec \Rightarrow$ Complete cycle.

$T = 10 msec \Rightarrow$ Half cycle.

$\frac{415}{\sqrt{3}}$

$\cancel{\boxed{\omega = 2\pi(T)}}$

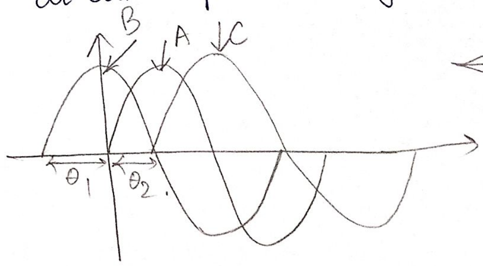
$\cancel{\omega = \frac{2\pi}{f}}$ $\cancel{f = \frac{2\pi}{\omega}}$

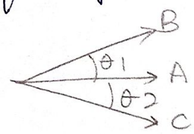
$\boxed{\omega = \frac{2\pi}{T}}$ $\boxed{\omega = 2\pi f \qquad f = \frac{\omega}{2\pi}}$

* Grid has the capability to take the excess power as well as to provide it if it is in deficiency for a customer.

* A rotating vector is called PHASOR.

To compare 2 waves; both waves should be at same speed and frequency.





$E_A = E_m \sin\theta$

$E_B = E_m \sin(\theta + \theta_1)$

$E_C = E_m \sin(\theta - \theta_2)$

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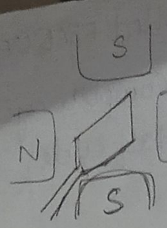


$$f = \frac{\text{no. of cycles}}{\text{sec}} = \frac{\text{no. of cycles}}{\text{no. of revolutions}} \times \frac{\text{no. of revolutions}}{\text{sec}}$$

$$= \frac{P}{2} \times \frac{N}{60}$$

$$\boxed{f = \frac{NP}{120}}$$

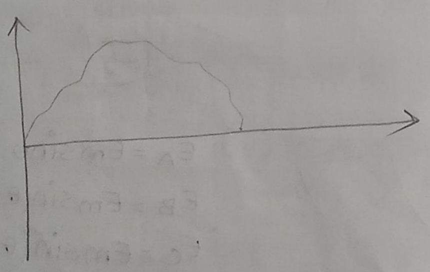
$$50 = \frac{PN}{60}$$

$$N = \frac{50 \times 60}{1}$$

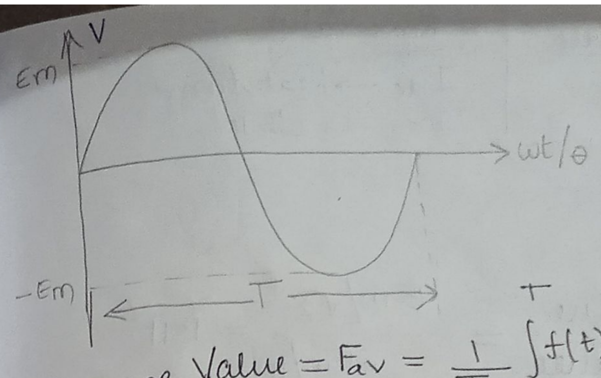
$$= 3000\,\text{rpm}$$

Mechanically it completes half cycle and electrically it completes complete cycle.

* Average Value of a sinusoid:



$$F_{av} = \frac{\text{area under curve}}{\text{length of the time base}}$$



$$\text{Average Value} = F_{av} = \frac{1}{T}\int_0^T f(t)\,dt$$

*Take only half cycle.

$$E_{av} = \frac{1}{\pi}\int_0^{\pi} E_m \sin\theta\, d\theta$$

$$= \frac{E_m}{\pi}(-1)(-1-1)$$

$$\boxed{E_{av} = \frac{2E_m}{\pi}}$$

*RMS value: $\sqrt{\frac{F_1^2 + F_2^2 + \cdots + F_n^2}{n^2}}$

$$F_{rms} = \sqrt{\frac{1}{T}\int_0^T f^2(t)\,dt}$$

$$E_{rms} = \sqrt{\frac{1}{\pi}\int_0^{\pi} E_m^2 \sin^2\theta\, d\theta}$$

$$= \sqrt{\frac{E_m^2}{\pi}\int_0^{\pi} \frac{1-\cos 2\theta}{2}}$$

$$= \sqrt{\frac{E_m^2}{2\pi}(\pi - 0)} = \frac{E_m}{\sqrt{2}} = \frac{E_m}{\sqrt{2}}$$

* Average Value

$I_{dc} \rightarrow Q, t$

$I_{ac} \rightarrow$ " "

* Rms Value

$I_{dc} \rightarrow$ heat, time

$I_{ac} \rightarrow$ ~~H~~ "

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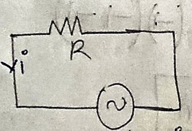
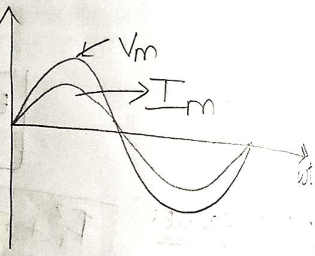
* Form Factor:

$$= \frac{\text{Rms Value}}{\text{Avg Value}} = \frac{E_m/\sqrt{2}}{2E_m/\pi} = 1.11$$

* AC through pure resistance:



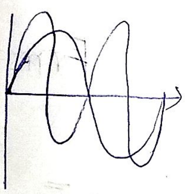
$V = V_m \sin \omega t$



$$\frac{V}{R} = i = \frac{V_m}{R} \sin \omega t$$

$$\boxed{I = I_m \sin \omega t}$$

$\phi = \measuredangle I$
$= 0°$



$$P_{av} = \frac{1}{\pi} \int_0^{\pi} V_m I_m \sin^2\theta \, d\theta$$

$$= \frac{V_m I_m}{2\pi} \int_0^{\pi} (1 - \cos 2\theta) \, d\theta$$

$\Rightarrow$ In half cycle; 2ω completes full cycle.

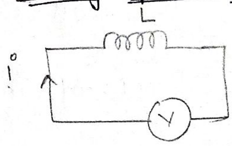
$\Rightarrow$ avg $= 0$

$$= \frac{V_m I_m}{2\pi} (\pi - 0)$$

$$= \frac{V_m I_m}{2} \Rightarrow P = \frac{V_m}{\sqrt{2}} \times \frac{I_m}{\sqrt{2}}$$

$$\boxed{P = V_{rms} \times I_{rms}}$$

* AC through pure inductance:



$$V = L \frac{di}{dt}$$

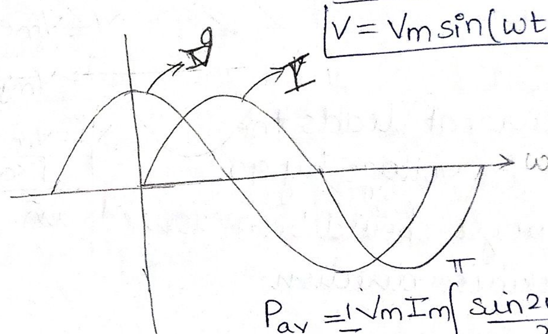
$\omega L = 2\pi f L$
$= X_L$

$$= L\omega I_m \cos \omega t$$

$V_m = X_L I_m$

$$V = V_m \cos \omega t$$

$$\boxed{V = V_m \sin(\omega t + 90°)}$$



$$P_{av} = \frac{1}{\pi} V_m I_m \int_0^{\pi} \frac{\sin 2\omega t}{2} \, d\omega t$$

$$= \frac{V_m I_m}{\pi} \frac{1}{4} (0)$$

$$\boxed{P_{av} = 0}$$

Inductor will not consume any power.

$$\Rightarrow i = I_m e^{j\omega t}$$

$$\boxed{V = I_m j\omega L e^{j\omega t}}$$

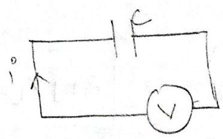
$$V = j X_L I_m e^{j\omega t}$$

$j = \sqrt{-1}$

$\boxed{j^2 = -1}$

current lagging voltage by 90°.

* AC through pure capacitance:



$V = V_m \sin \omega t$

$$i = C \frac{dV}{dt}$$

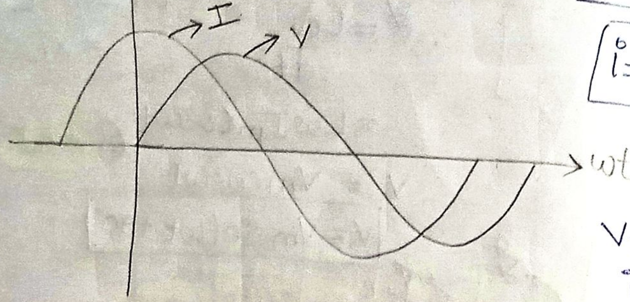
$$i = C V_m \omega \cos \omega t$$

$$\boxed{i = V_m X_c \cos \omega t}$$

$I = I_m \sin(\omega t + 90^\circ)$.

$\boxed{X_C = \frac{1}{2\pi f C}}$

$\boxed{i = -jX_C V_m e^{j\omega t}}$



$V = V_m e^{j\omega t}$

$i = V_m j \omega t$

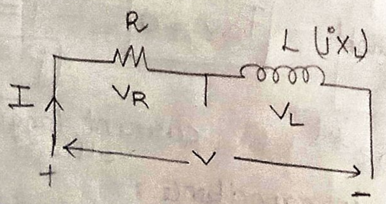
$\boxed{i = \frac{V_m}{jX_C} e^{j\omega t}}$

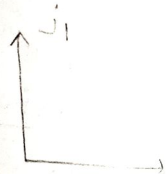
current leads the voltage by 90°.

→ Leading angle should be measured in anti-clockwise direction.

01/07/2022

* SERIES R-L circuit:





$j = 1\angle 90^\circ$

$\bar{V} = \bar{V}_R + \bar{V}_L$

$= IR + I(jX_L)$

$V = I(R + jX_L)$

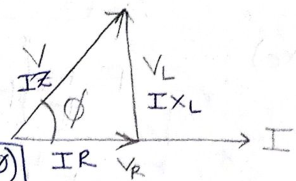
$\boxed{Z = \frac{V}{I}}$

$\boxed{R + jX_L = Z}$ (impedance)

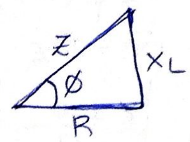
$\boxed{\text{Admittance } (Y) = \frac{1}{Z}}$

→ For pure resistance; V & I are at 0° i.e. V & I are in phase.

⇒ Phasor:



$\boxed{\phi = 0 \text{ to } 90^\circ}$



Impedance Δle.

$\boxed{v = V_m \sin \omega t \quad i = I_m \sin(\omega t - \phi)}$

clockwise → -ve → lagging angle

$P = \frac{1}{\pi}\int_0^{\pi} p\, d\theta$

$= \frac{1}{\pi}\int_0^{\pi} V_m I_m \sin\theta \sin(\theta - \phi)\, d\theta$

$= \frac{V_m I_m}{\pi}\int_0^{\pi}\left[\frac{\cos(\phi)}{2} - \frac{\cos(2\theta - \phi)}{2}\right] d\theta$

$= \frac{V_m I_m}{\pi}\int_0^{\pi}\left[\frac{\cos\phi}{2} - \frac{\cos(2\theta - \phi)}{2}\right] d\theta$

$= \frac{V_m I_m}{2\pi} \cdot \cos\phi \cdot \pi$

$\boxed{P = \frac{V_m I_m}{2}\cos\phi}$

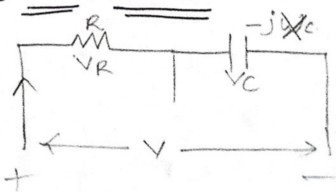
$\cos\phi$ = Power factor

$P = V_{rms} I_{rms} \cos\phi$

$\boxed{P = VI\cos\phi}$

* ø should be close to 0° so as to get max. power.

* SERIES RC CIRCUIT:



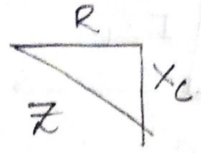
$$\bar{V} = \bar{V}_R + \bar{V}_C$$

$$= IR + I(-jX_C)$$

$$\boxed{Z = R - jX_C}$$

$$= I(R - jX_C)$$

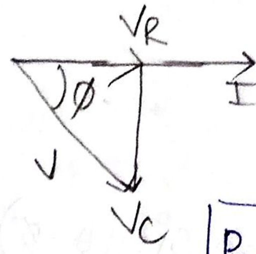
$$\bar{V} = IZ$$



$$\boxed{Z = \frac{V}{I}}$$

$$P = \frac{1}{\pi}\int_0^{\pi} p\, d\theta$$

$$= \frac{1}{\pi}\int_0^{\pi} V_m \sin\theta \cdot I_m \sin(\theta$$

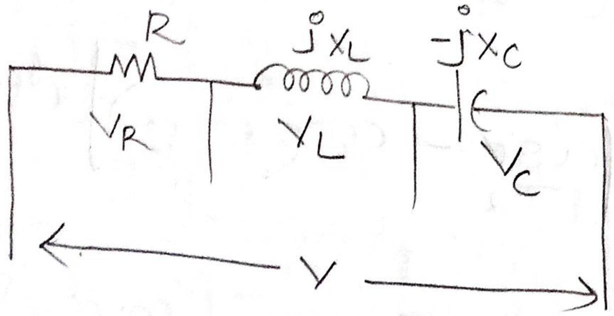


$$\boxed{P = VI}$$

$$= \frac{V_m I_m}{\pi}\int_0^{\pi} \sin\theta \cdot \sin(\theta - \phi)\, d$$

$$\boxed{P = \frac{V_m I_m}{2}\cos\phi}$$

* SERIES LCR CIRCUIT:



$$V = V_R + V_L + V_C$$

$$= IR + IjX_L - IjX_C$$

$$= IR + Ij(X_L - X_C).$$

$$V = I\left(R + j(X_L - X_C)\right)$$