

11-05-2021

DC - Circuits ...

current :-

$$i = \frac{dq}{dt}$$

rate of
change of current (or) controlled

→ Units A (ohm) C/s

moment of
charge

voltage :-

V = Work required to move charge.

$$V = \frac{dw}{dq}$$

J/s (ohm) Volts

Power :-

$$P = \frac{dw}{dt}$$

$$= \frac{dw}{dq} \cdot \frac{da}{dt} = Vi \text{ J/s (ohm) Watts}$$

→ resistance :-

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

$$V = iR.$$

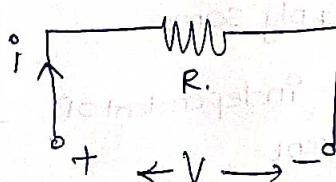
R = Resistance (ohm) Ohm's

constant

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

G = conductance

$$i = GV$$



Short circuit = $R = 0 \Rightarrow$ practically small resistance
 $\downarrow V = 0$

Open circuit = $R = \infty$

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

$$R = \frac{Pl}{A}$$

P = specific resistance

(O) resistivity.

→ short circuit

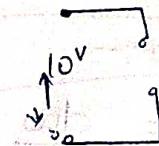
Open circuit

→ voltage is zero

→ voltage exists

→ current is infinite

→ current is zero



Types of sources

depending

Independent source

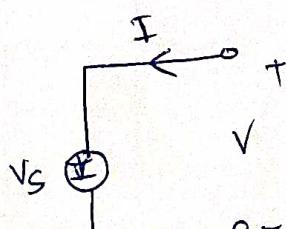
Dependent source.

On quantity

V.S

C.S

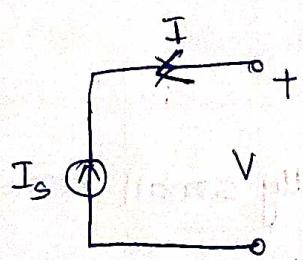
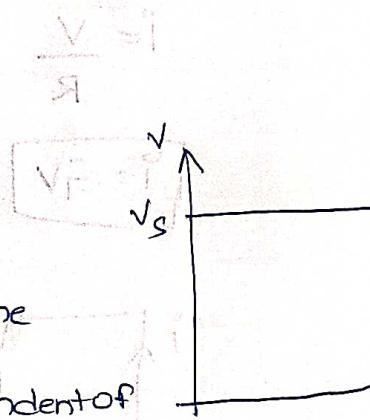
Independent source.



voltage source

Should supply same

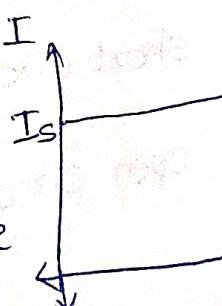
voltage independent of
of current



Current source should
supply same current

independent of voltage

applied



* Opp. Opposition to the flow of current

is called resistance.

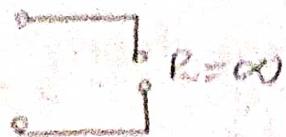
* Open Circuit: $R = \infty$ & $I = 0$; $V = \text{constant}$

Short Circuit: $R = 0$; $V = 0$
 $I = \text{max. value}$

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

P = RVI ,
specific
resistance

Open circuits



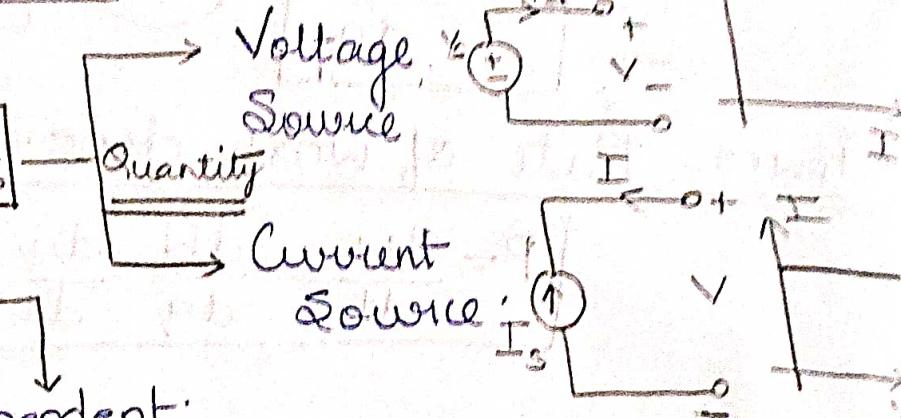
Short circuit:



⇒ Types of Sources for generating

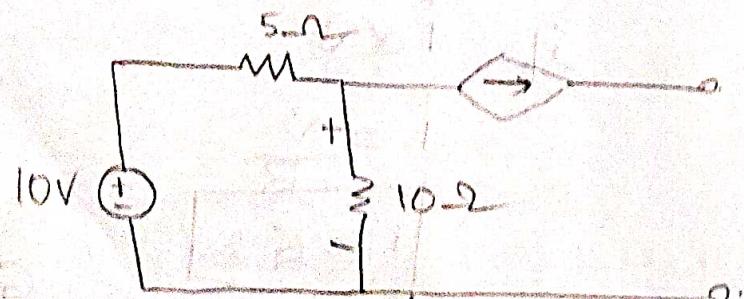
SOURCES:
Independent Dependent

- Voltage
Source

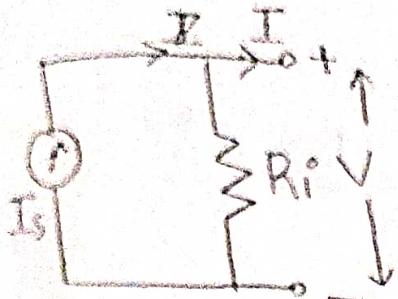
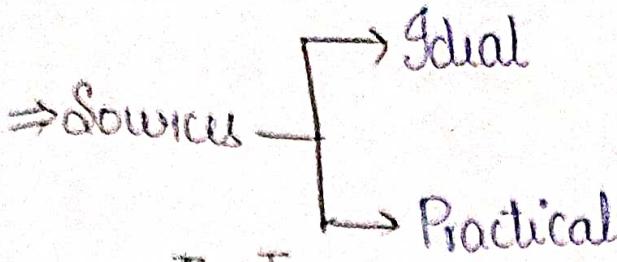


- Current
Source

- Voltage dependent voltage Source.
- Current dependent voltage source.
- Voltage dependent Current Source.
- Current dependent Current Source



13/05/2022



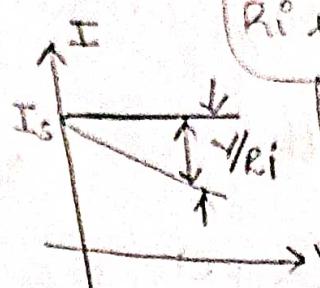
R_i is high

for current source

so as to allow large current through terminal.

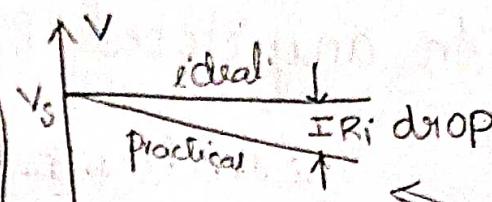
$$I = I_s - \frac{V}{R_i}$$

$$V = I_s R_i - I R_i$$



R_i is low

$$V = V_s - I R_i \uparrow$$



R_i is low for

voltage source

so as to reduce

voltage drop
across R_i

drooping

* SOURCE TRANSFORMATION:

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

TERMINAL CONDITION

$$V_s = I_s R_i$$

* KCL: Kirchhoff's Current Law:

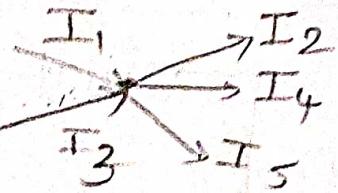
At any junction sum of currents incoming
= Sum of currents going out

Algebraic Sum of currents meeting at a

junction is zero.

$$\boxed{\sum I = 0}$$

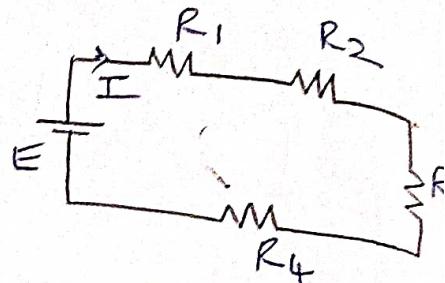
$$I_1 + I_3 = I_2 + I_4 + I_5$$



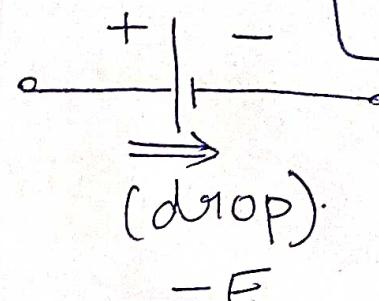
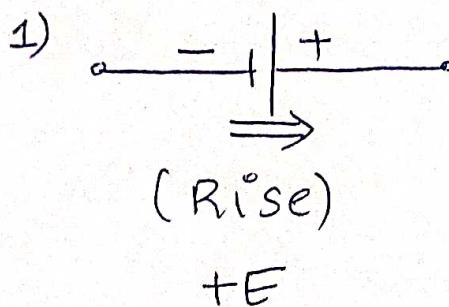
* KVL: Kirchhoff's voltage law.

In any closed path

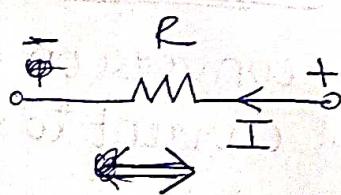
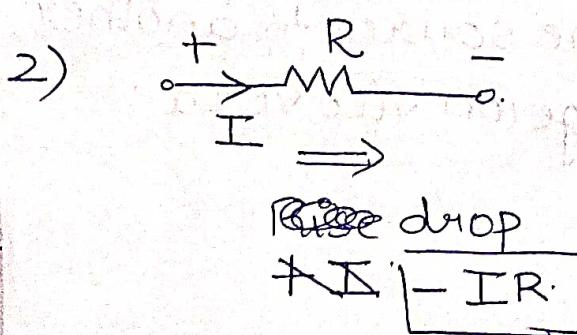
$$\sum emfs + \sum IR = 0$$



Sign Convention:



$$E - IR_1 - IR_2 - IR_3 - IR_4 = 0$$

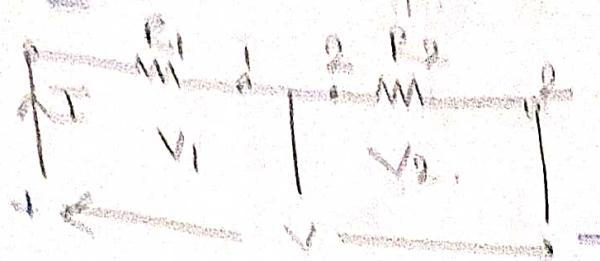


* SERIES CONNECTION: Joining end to end.

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

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

* Diode



1) i is same

2) V divides

$$V = V_1 + V_2$$

$$I_{\text{Req}} = I_{R_1} + I_{R_2}$$

$$R_{\text{Req}} = R_1 + R_2$$

* Voltage Division Rule

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

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

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

$$V_1 (R_1 + R_2) = VR_1$$

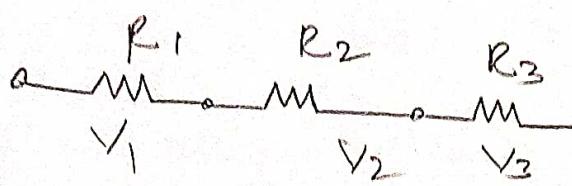
$$V_1 = \frac{VR_1}{R_1 + R_2}$$

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

$$VR_2 - V_2 R_2 = V_2 R_1$$

$$V_2 = \frac{V_0 R_2}{R_1 + R_2}$$

$$P = P_1 + P_2$$



$$V_1 = \frac{VR_1}{R_1 + R_2 + R_3}$$

$$V_2 = \frac{VR_2}{R_1 + R_2 + R_3}$$

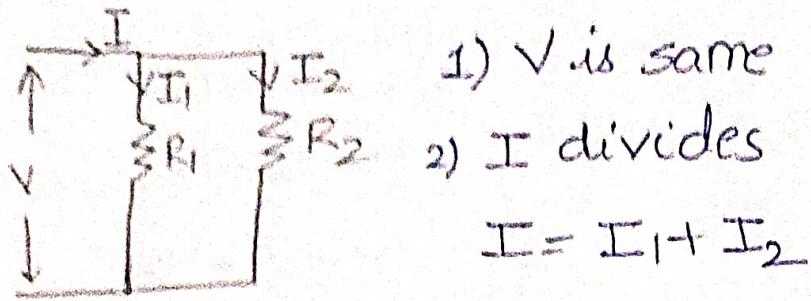
$$V_3 = \frac{VR_3}{R_1 + R_2 + R_3}$$

$$V = V_1 + V_2 + V_3$$

$$R_{\text{Req}} = R_1 + R_2 + R_3$$

* PARALLEL CONNECTION: Joining all similar ends.

$$P = P_1 + P_2$$



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

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

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

* Current division Rule:

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

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

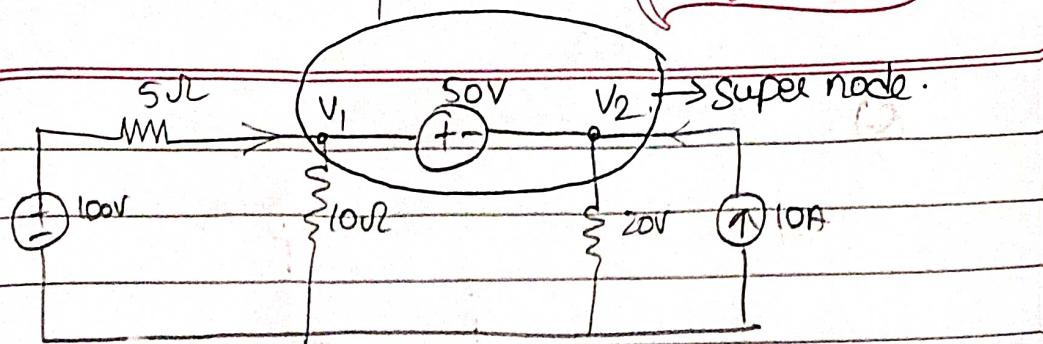
$$I_1 = \frac{IR_2}{R_1 + R_2}$$

$$I_2 = \frac{IR_1}{R_1 + R_2}$$

Assume as single node
classmate

Date _____
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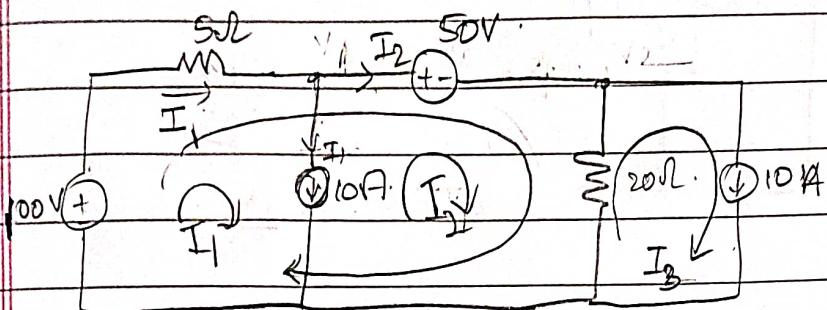
Q:



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

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

Super mesh:-



$$100 - 5I_1 - 50 - (I_3 - I_2)20 = 0$$

$$I_3 + 10 = 0$$

$$I_1 = I_2 + 10$$

* 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.

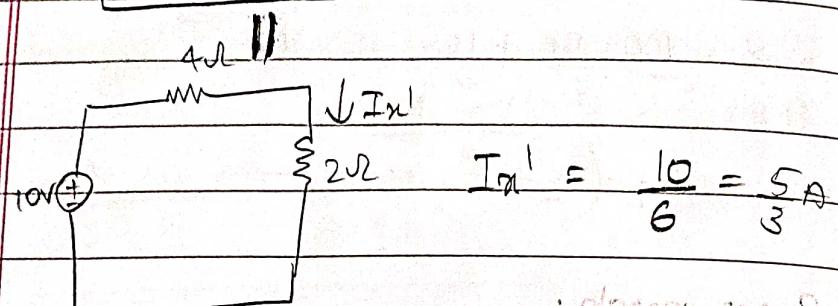
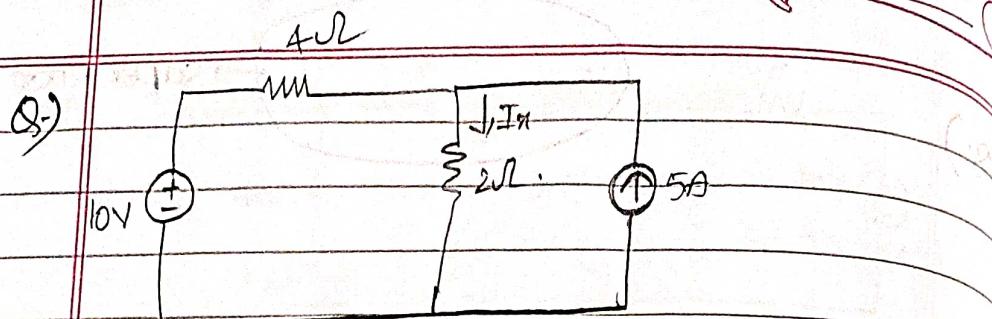
* linear :- output is proportional to input. ($V=IR$)

* bilateral :- element behaves same in both directions.

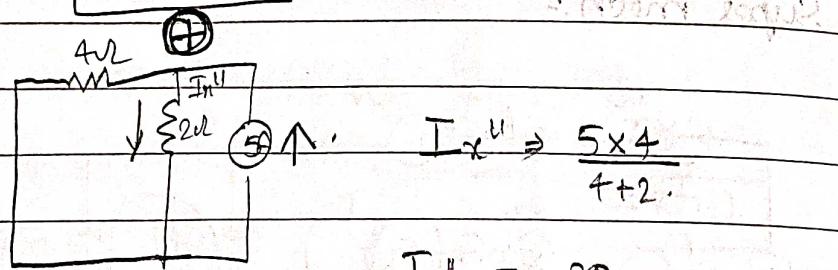
* active :- element which can deliver finite amount of force at infinite times. (powerstat - on)

\Rightarrow diode is a unilateral. ~~ie. open~~

\Rightarrow resistor is bilateral.

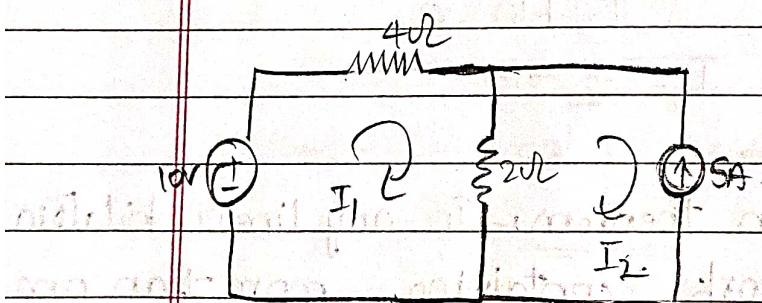


$$I_A' = \frac{10}{6} = \frac{5}{3} A.$$



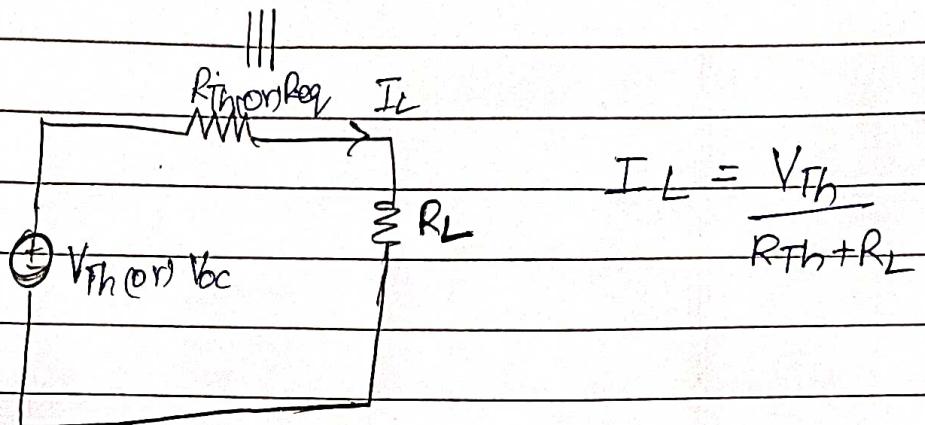
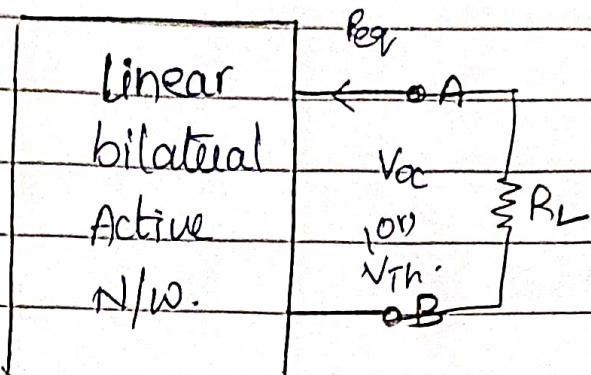
$$I_A'' = \frac{20}{6}.$$

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



$$-4I_1 - (I_2 - I_1) 2 \neq 10 \Rightarrow \text{No solution}$$

The Thevenin's Theorem:-



Any linear bilateral active complex network btw terminals A and B (across which the load resistance is connected, In which load current (or) response 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) 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).

$$\begin{aligned} -25I_2 + I_3 + 10I_1 &= 0 \quad (2) \\ -45I_3 + 20I_2 &= 50 \quad (3) \\ 10I_2 - 15I_1 &= 100 \quad (1) \end{aligned}$$

~~Δ~~

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

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

$$20I_2 - 45I_3 = 50 \quad (3)$$

$$10I_1 + I_3 - 25I_2 = 0 \quad (2)$$

$$\begin{aligned} I_1 &= -15.4 \\ I_2 &= +3.5 \\ I_3 &= +2.7 \\ I_1 &= 9.05A \end{aligned}$$

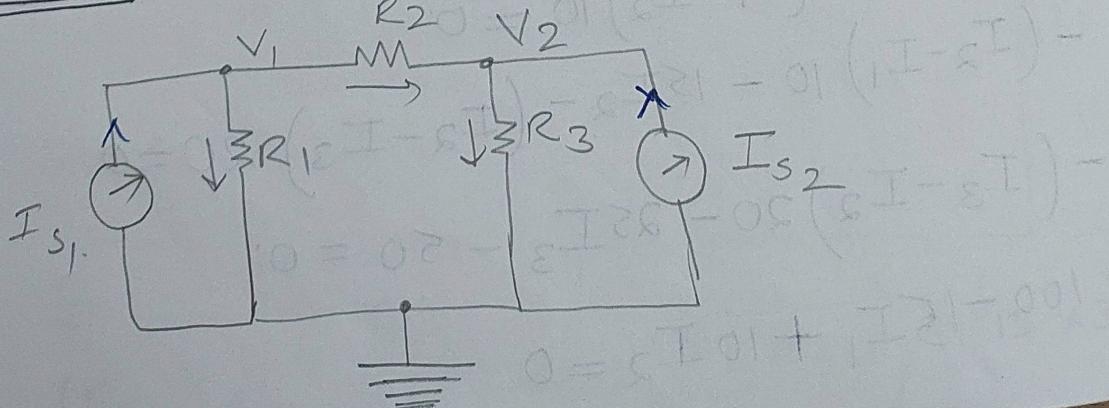
$$I_L = 7.6A$$

$$I_2 = 1.7A$$

$$I_3 = +1.9A$$

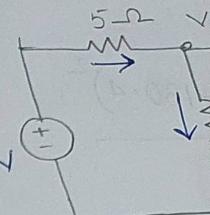
$$I_1 = 7.85A$$

01/06/2022
* Nodal Analysis:



$$I_{S1} = \frac{V_1 - 0}{R_1}$$

$$I_{S2} = \frac{V_1 - V_2}{R_2}$$

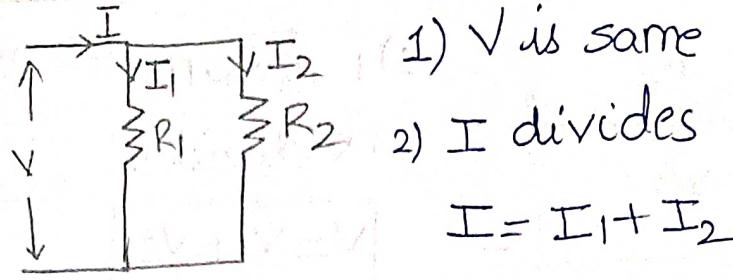


at V_1 : KCL

$$\frac{100 - V_1}{5}$$

10

at V_2



1) ∇ is same

2) I divides

$$I = I_1 + I_2$$

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

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

$$Req = \frac{R_1 R_2}{R_1 + R_2}$$

* Current division Rule:

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

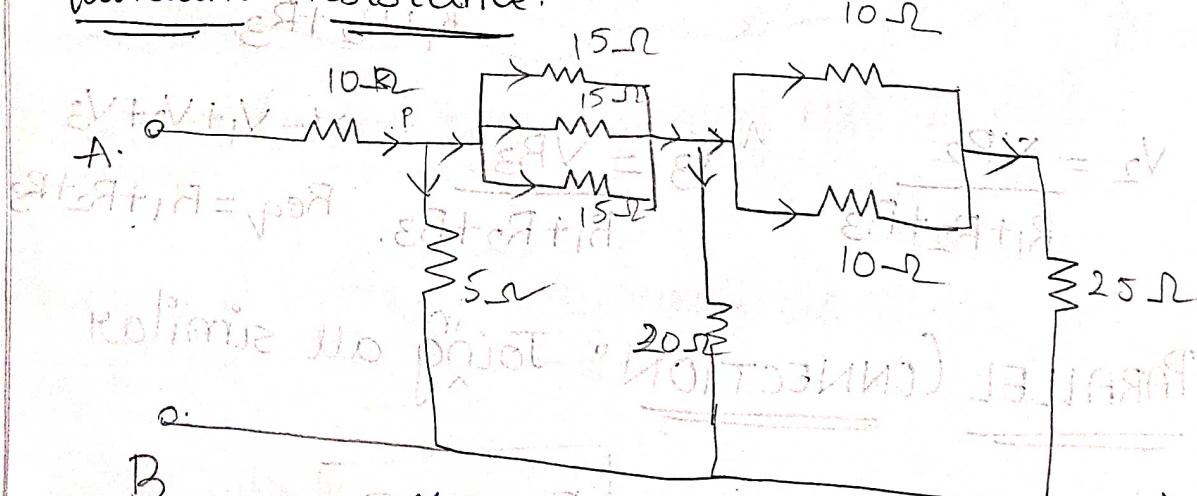
$$I_1 = \frac{IR_2}{R_1 + R_2}$$

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

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

30 | 05 | 2022

Equivalent Resistance



B

$$(Req)_{AB} = \left(25 + \frac{100}{20} \right) || 20 \Bigg) + \left(15^{-1} \times 3 \right)^{-1} \Bigg) || 5$$

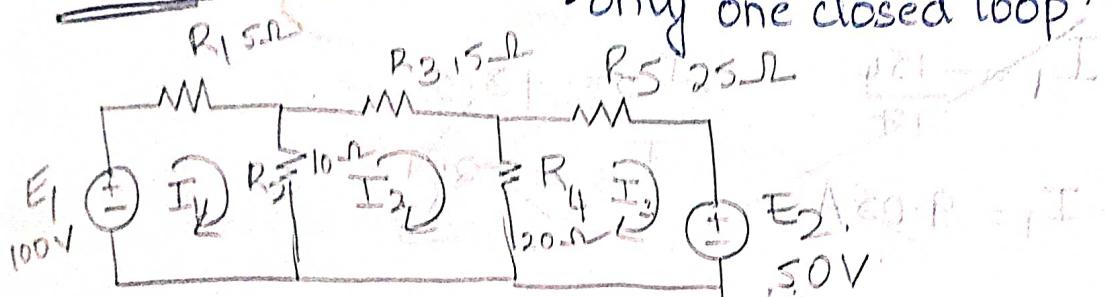
$$= \left(\left(\left(\frac{6}{3.0 \times 2.0} + 0.00 \right) || 5 \right) + 10 \right)$$

$$= \frac{1.9}{10.0} + 10 = 10.19$$

$$\text{Req. } = 13.86 \Omega$$

* MESH ANALYSIS: Mesh is an independent loop

• only one closed loop



KVL:

$$\text{I} \Rightarrow E_1 - I_1 R_1 - (I_1 - I_2) R_2 = 0$$

$$\text{II} \Rightarrow -(I_2 - I_1) R_2 - I_2 R_3 - (I_2 - I_3) R_4 = 0$$

$$\text{III} \Rightarrow -(I_3 - I_2) R_4 - I_3 R_5 - E_2 = 0$$

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

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

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

$$100 - 15I_1 + 10I_2 = 0$$

$$-25I_2 + I_3 + 10I_1 = 0 \quad -\textcircled{2}$$

$$-45I_3 + 20I_2 = 50 \quad -\textcircled{3}$$

$$10I_2 - 15I_1 = 100 \quad -\textcircled{1}$$

~~Δ~~

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

$$15I_1 - 10I_2 = -100 \quad -\textcircled{1}$$

$$20I_2 - 45I_3 = 50 \quad -\textcircled{3}$$

$$10I_1 + I_3 - 25I_2 = 0 \quad -\textcircled{2}$$

$$\begin{aligned} I_1 &= -15A \\ I_2 &= +3.5A \\ I_3 &= +2.7A \\ I_1 &= 9.05A \end{aligned}$$

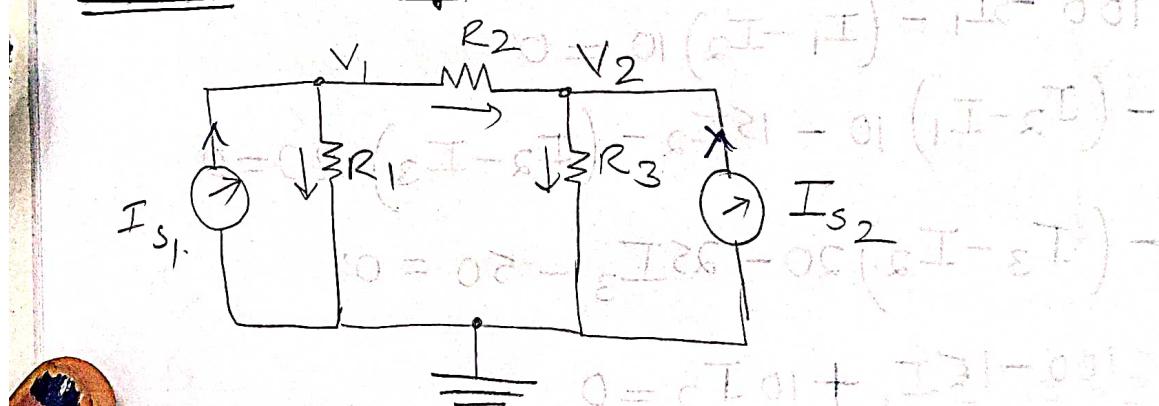
$$I_2 = 1.7A$$

$$I_3 = +1.9A$$

$$I_1 = +7.85A$$

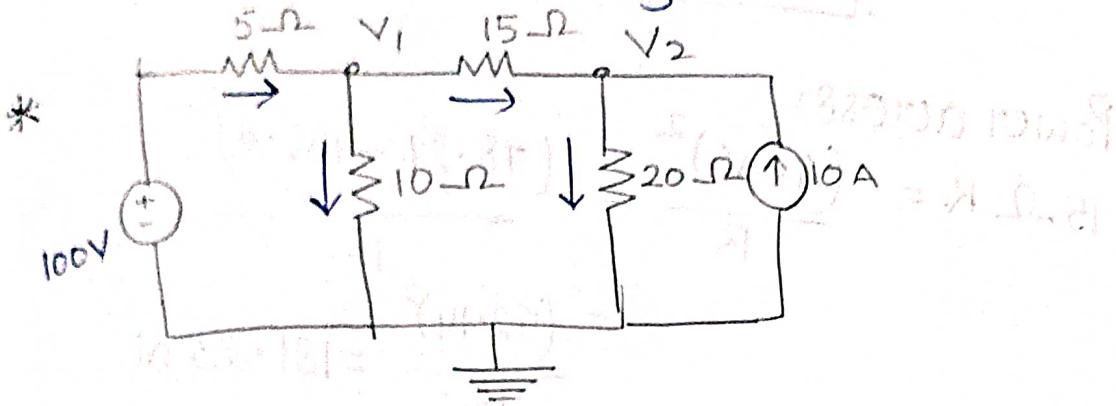
$$01/06/2022$$

* Nodal Analysis:



$$I_{S1} = \frac{V_1 - 0}{R_1} + \frac{V_1 - V_2}{R_2}$$

$$I_{S2} + \frac{V_1 - V_2}{R_2} = \frac{V_2}{R_3}$$



at V_1 : KCL

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

$$200 = 3V_1 \quad \leftarrow \text{Adj}$$

$$V_1 = 66.67 \quad \cancel{\text{V1}} =$$

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

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

$$11V_1 - 2V_2 = 600$$

at V_2 : KCL

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

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

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

$$7V_2 - 4V_1 = 600 \quad \text{---(2)}$$

$$V_1 = \frac{1800}{23}$$

$$V_1 = 78.26 \text{ V}$$

$$V_2 = 130.4 \text{ V}$$

Power across:

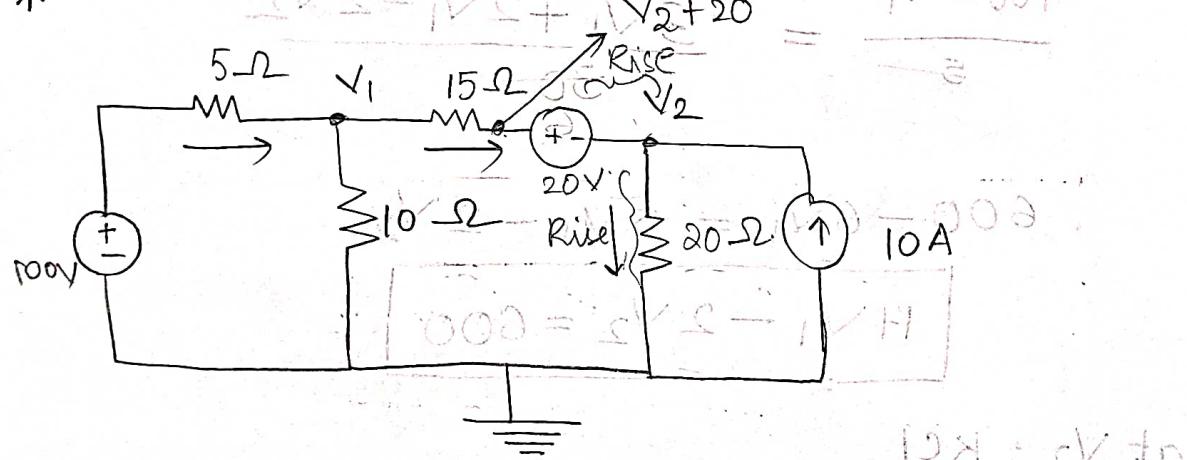
$$15 \Omega R = \frac{(V_1 - V_2)^2}{R} = \frac{(78.26 - 130.4)^2}{15}$$

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

$$100 \text{ V Supply} \Rightarrow P = \frac{100 - 78.26}{5} \times 100 \\ = 434.8 \text{ W}$$

$$10 \text{ A} \Rightarrow P = V_2 \times 10 \\ = 130.4 \times 10 \\ = \underline{\underline{1304 \text{ W}}}$$

*

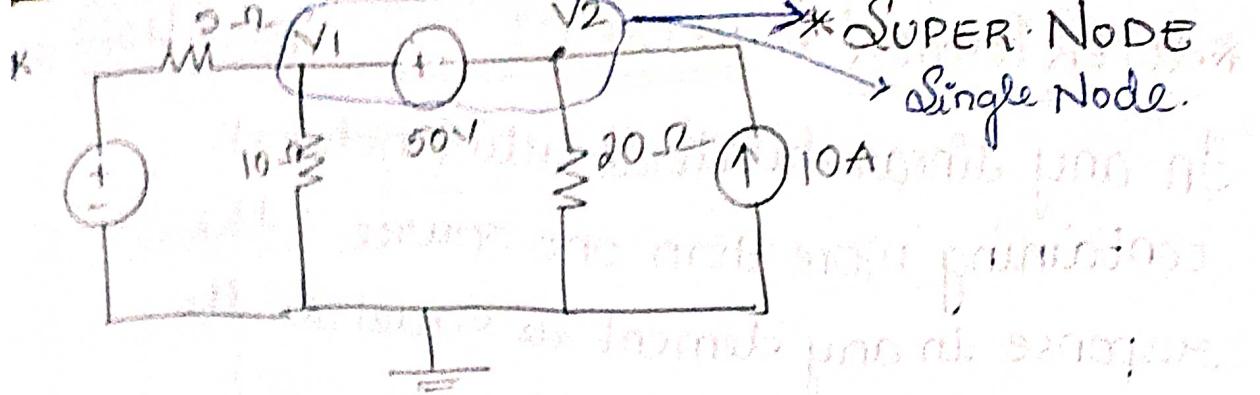


$$V_1 - 15I - 20 = V_2 = 0$$

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

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

$$\Delta V = 0.6 + 15.8 + 1.4 = 23.8$$



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

$$V_1 - V_2 = 50$$

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

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

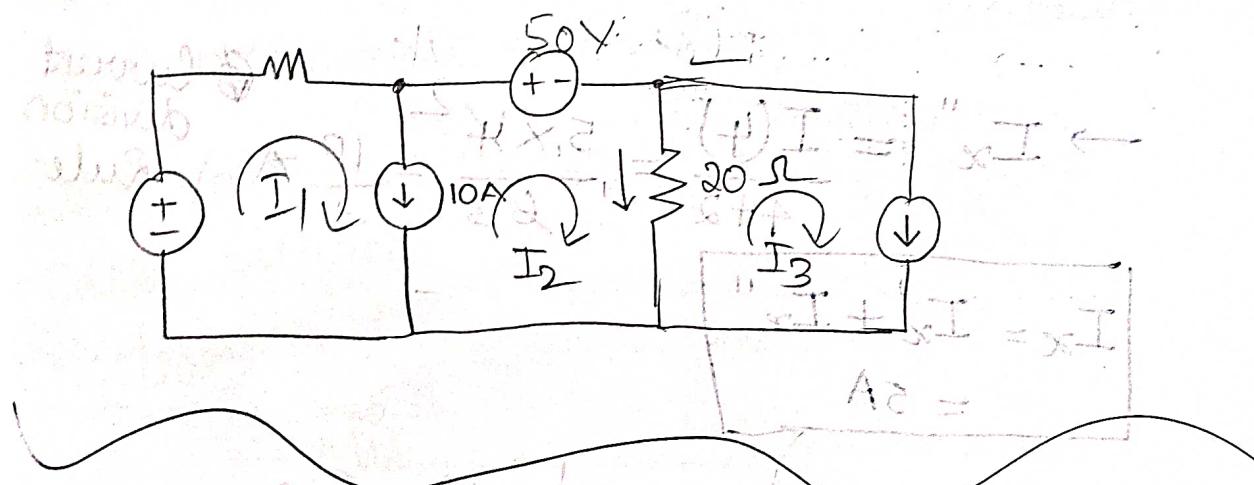
$$V_2 = 42.8 \text{ V}$$

$$6V_1 + V_2 = 600$$

$$7V_1 = 650$$

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

*SUPER MESH:



$$A_{12} = \frac{V_1}{I_1} = \frac{1}{5}$$

$$A_{23} = \frac{V_2}{I_2} = \frac{1}{2}$$

$$A_{31} = \frac{V_3}{I_3} = \frac{1}{10}$$

*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 ~~as~~ in same way wrt. polarity
 Active : deliver a finite amount of power in infinite time



$$\begin{aligned} 10 - 4I_1 \\ - 2(I_1 - I_2) \\ = 0 \end{aligned}$$

$$I_2 = -5A$$

$$10 - 4I_1 - 2I_2$$

$$I_1 = 0A$$

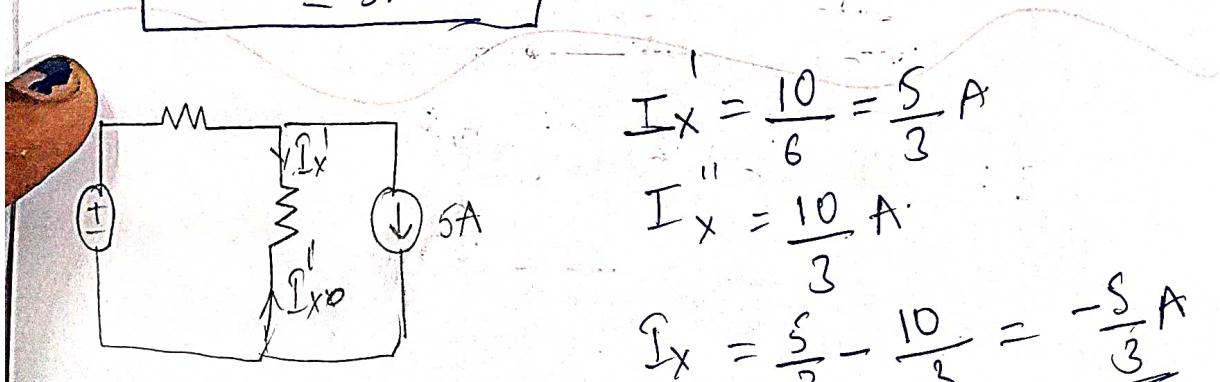
Determine I_x using SPT.

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

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

Current division Rule

$$\boxed{I_x = I_x' + I_x'' = 5A}$$



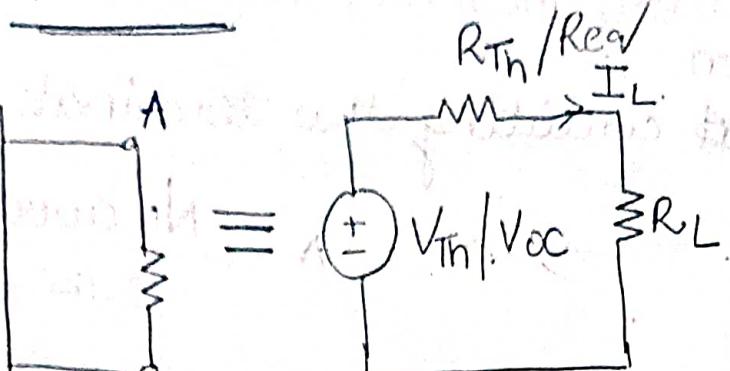
$$I_x' = \frac{10}{6} = \frac{5}{3} A$$

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

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

* THEVENIN'S THEOREM

Linear
Bilateral
Active
network



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

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~~

and measure voltage across it. R_{Th} is eq.

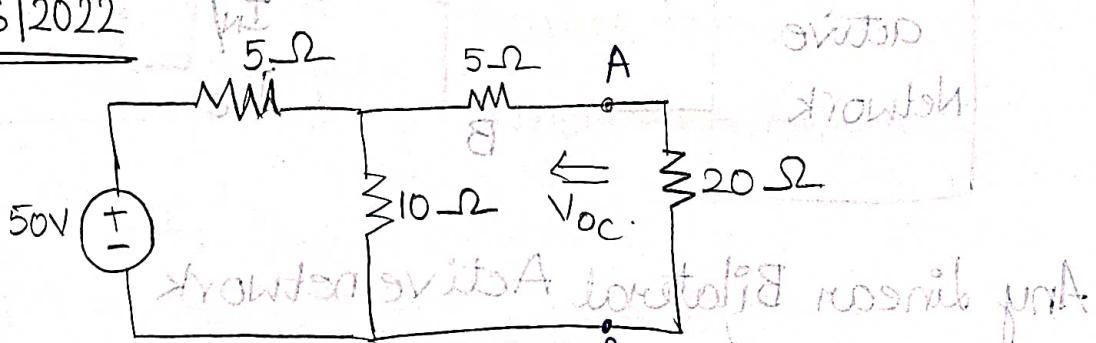
resistance between terminals A & B by replacing

the sources with their internal resistance.

Ideal Voltage Source: Short Circuit

Ideal Current Source: Open Circuit

07/06/2022

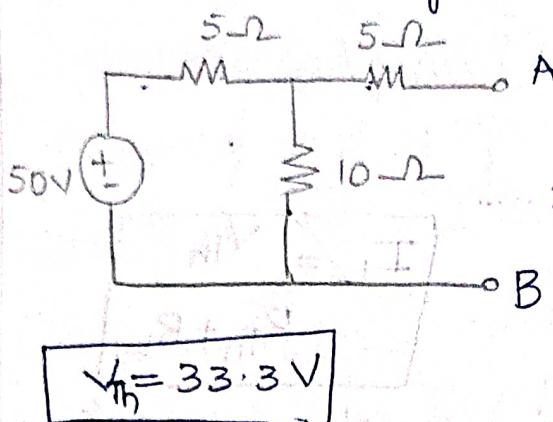


Determine the current through 20Ω resistor from A

Using Thevenin's theorem:

Open:

* ~~short~~ circuiting the terminals A & B



No current through
5Ω resistance.

$$R = 15\Omega$$

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

$$V = \frac{V_1}{R} \times 10$$

$$R_{Th} = 10 \times \frac{2}{3} + 5$$

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

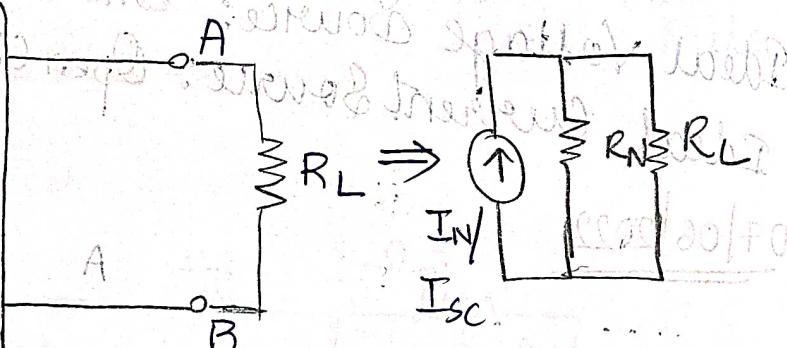
$$V = 50 \times \frac{2}{3}$$

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

$$I_{Th} = 1.176A$$

* NORTON'S THEOREM:

linear
Bilateral
active
Network

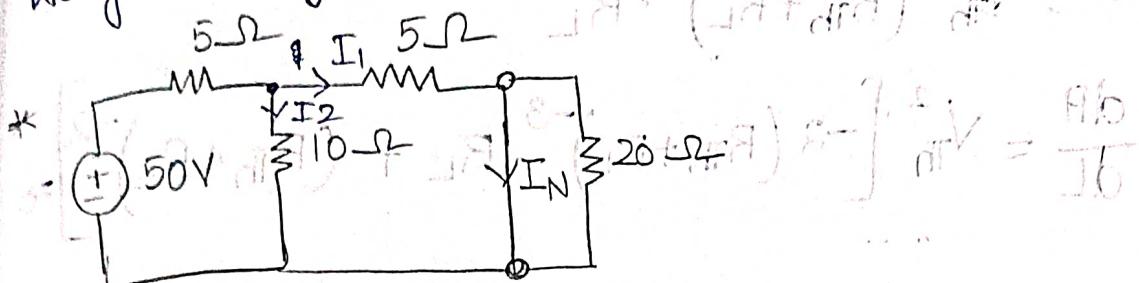


Any Linear Bilateral Active network

between terminals A & B can be replaced

by a single current source (I_N) in parallel to a single resistance (R_N):

We get I_N by short circuiting the load terminals.



$$R_{eq} = \frac{25}{3} \Omega = R_N$$

$$I = \frac{50}{25} = 2A$$

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

$$I_N = \frac{6 \times 10}{10 + 5} = \frac{60}{15} = 4A$$

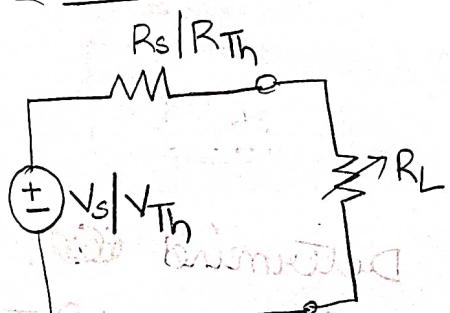
$$\boxed{I_N = 4A}$$

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

$$I_L = \frac{4 \times \frac{25}{3}}{\frac{25}{3} + 20} = \frac{100}{148.33} = \frac{100}{148.33} = 1.176A$$

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

* MAXIMUM POWER TRANSFER THEOREM:



Maximum Power will be

transferred from source to load

when $R_L = R_s / R_{Th}$

$$P = I_L^2 R_L$$

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

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

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

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

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

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

$$R_L = R_{Th}$$

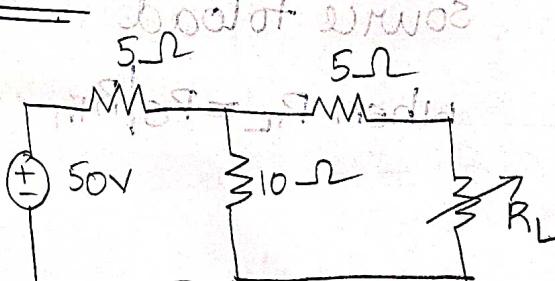
$$P_{out} = P_{max}$$

$$P_{in} = V_{Th} \cdot I_L = \frac{V_{Th}}{2R_{Th}} \cdot I_L = \frac{P_{out}}{P_{in}}$$

$$= V_{Th} \cdot \frac{V_{Th}}{2R_{Th}} = \frac{1}{2} = 50\%$$

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

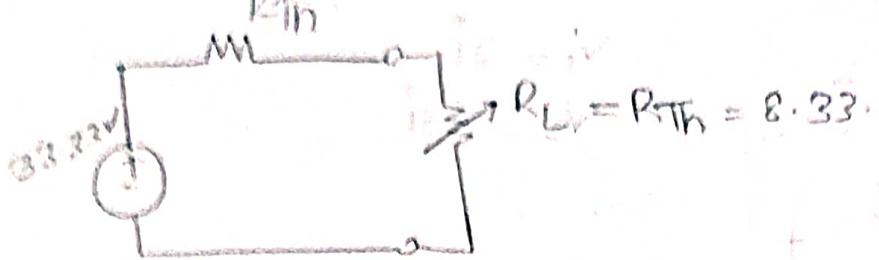
08/06/2022



Determine ~~for~~ R_L for MPT.

and MPT

$$\frac{1}{R_{Th}} = \frac{1}{5} + \frac{1}{10} = \frac{3}{10}$$



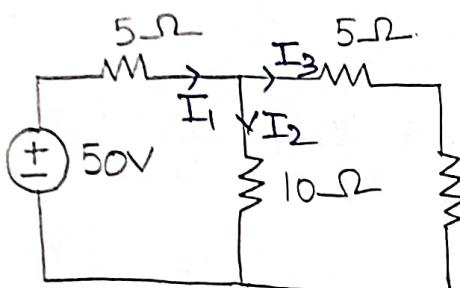
$$P_{in} = \frac{V_{Th}^2}{2R_{Th}} = 66.68 \text{ V}$$

$$0 = i_1 + i_2 + 8A$$

$$0 = i_1 + i_2 - 8A$$

* TELEGEN'S THEOREM:

$$\sum \text{Power (P)} = 0$$



$$V_8 - I_1 = \frac{50}{5 + \left(\frac{10 \times 20}{30} \right)} = \frac{50}{5 + 50/7} = 4.11 \text{ A}$$

$$I_2 = \frac{4.11 \times 20}{30} = 2.93 \text{ A}$$

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

$$\begin{aligned} I_2 &= 0.58 \text{ A} \\ I_3 &= 4.11 \times 1 \\ I_2 &= 2.93 \text{ A} \end{aligned}$$

$$\begin{aligned} I_3 &= I_1 - I_2 \\ &= 4.11 - 2.93 \end{aligned}$$

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

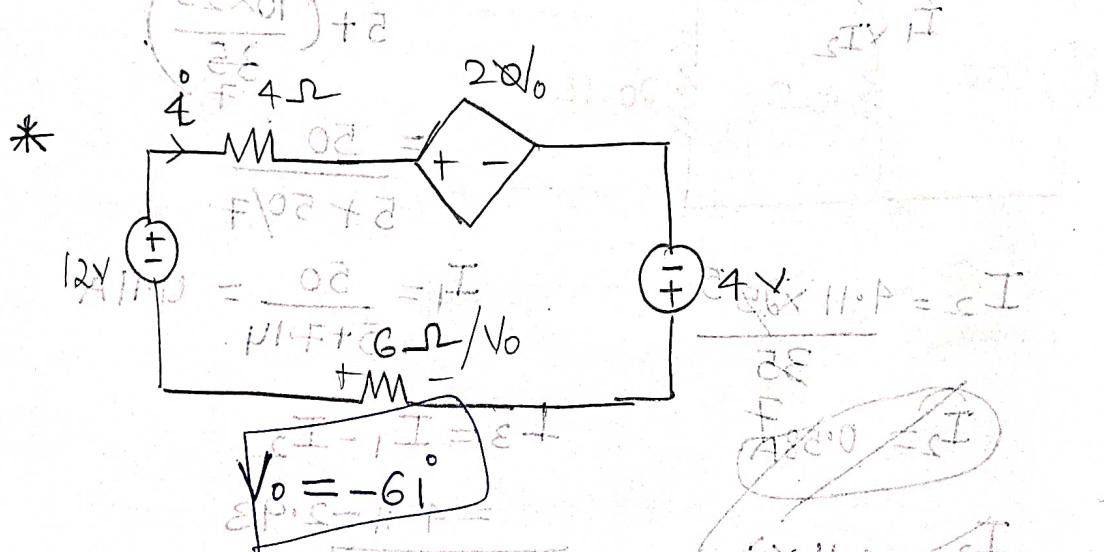
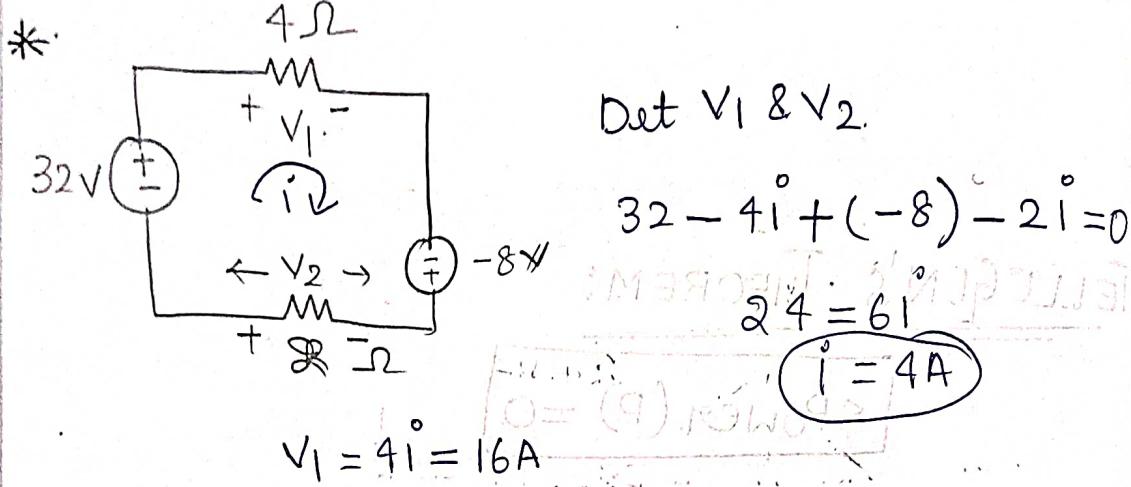
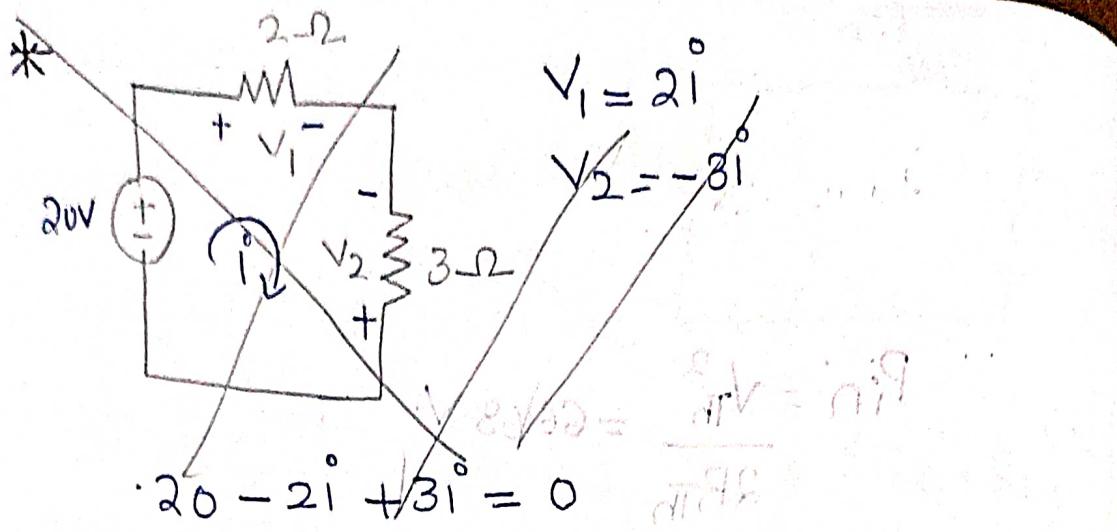
$$P = 50I_1 = 205.5 \text{ W}$$

$$P_1 = I_1^2 R_1 = 84.4 \text{ W}$$

$$P_2 = I_2^2 R_2 = 85.84 \text{ W}$$

$$P_3 = I_3^2 R_3 = 34.81 \text{ W}$$

$$P = P_1 + P_2 + P_3$$

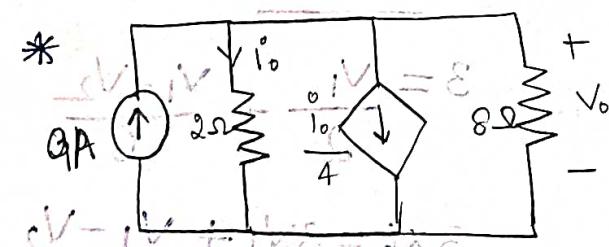
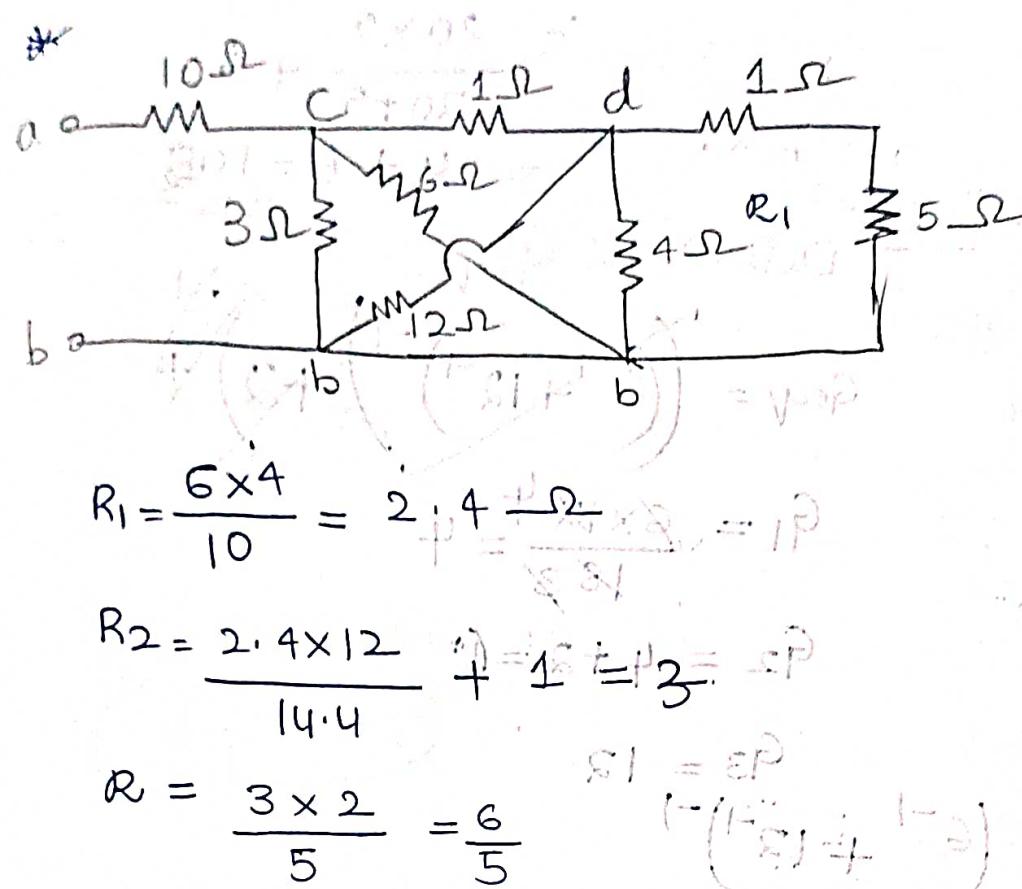
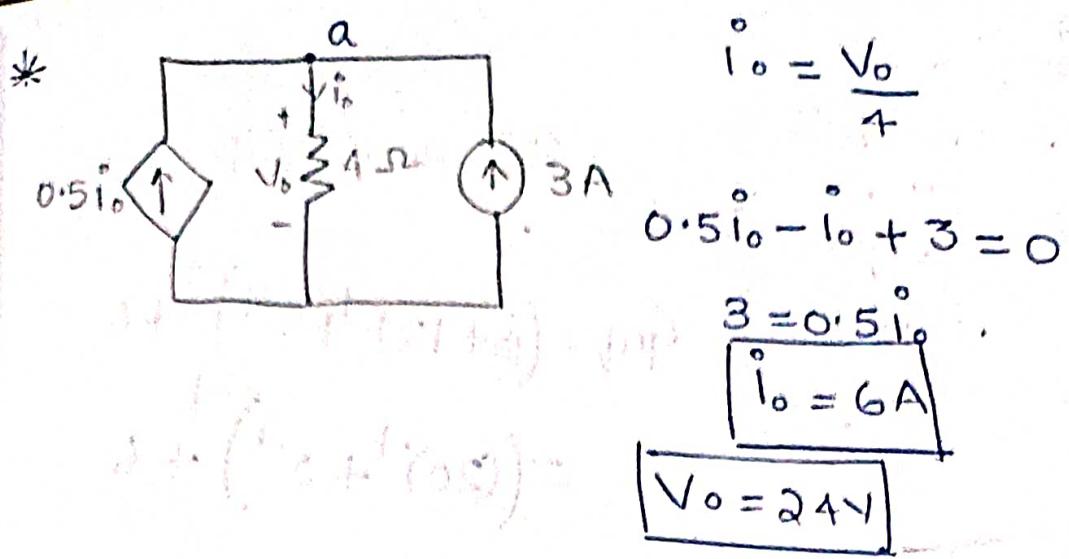


$$16 - 2V_0 - 10i = 0$$

$$16 + 2i = 0$$

$$i = -8A$$

$$V_0 = 14.8V$$



$$2V = 2V - i_o/2$$

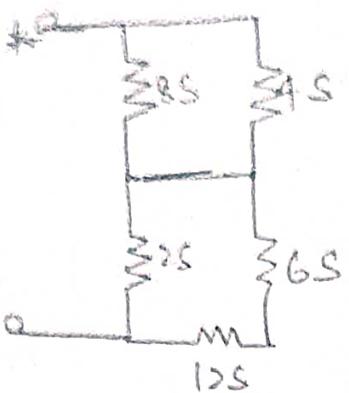


10/06/2022



Determine Geq

$$\begin{aligned}
 G_{eq} &= ((8+12)^{-1} + 5^{-1})^{-1} + 6 \\
 &= (20^{-1} + 5^{-1})^{-1} + 6 \\
 &= \frac{20 \times 5}{20+5} + 6 \\
 &= 4 + 6 = 10S
 \end{aligned}$$



Determine Geq

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

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

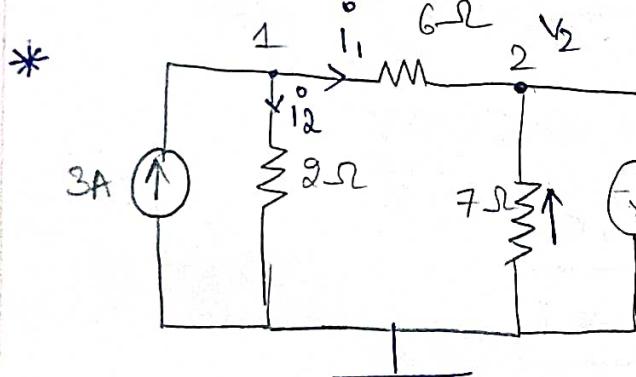
$$G_2 = 4 + 2 = 6$$

$$G_3 = 12$$

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

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

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



at node 2. $+12 = \frac{V_2}{4}$

at node 1:

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

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

$$4V_1 - V_2 = 18$$

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

$$V = \frac{4V}{3} + \frac{V - A}{4}$$

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

~~$$-V_2 = 84A$$~~

~~$$V_2 = -84A$$~~

~~$$4V_1 = 18 + \frac{V_2}{2}$$~~

~~$$4V_1 = 18 - 84$$~~

~~$$4V_1 = 66$$~~

~~$$\frac{-V_2}{7} + \frac{V_2 - V_1}{6} = 12 + 18$$~~

~~$$-6V_2 + 7V_2 - 7V_1 = 12 \times 42$$~~

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

~~$$V_2 - 7V_1 = 504$$~~

~~$$= -\frac{V_2}{7}$$~~

~~$$-V_2 + 4V_1 = 18$$~~

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

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

~~$$\begin{array}{r} 142 \\ \times 12 \\ \hline 184 \\ 142 \\ \hline 504 \end{array}$$~~

$$V_2 = -24 - 18$$

$$V_2 = -42V$$

$$7V_1 - 13V_2 = 504$$

$$4V_1 - V_2 = 18$$

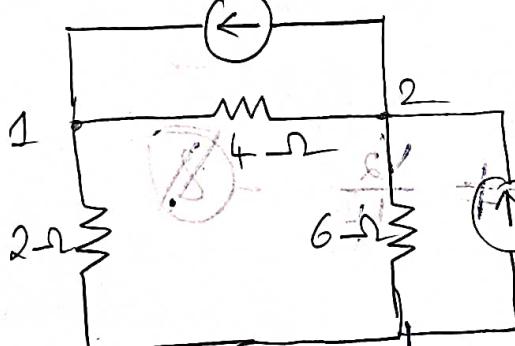
~~$$7V_1 - 13V_2 = 504$$~~

$$E = \frac{7V_1 - 5.2V_1 + 13V_2}{4} = 234$$

$$-4.5V_1 = 270$$

$$V_1 = 6V$$

*



at node 1:

$$\frac{E - V_1}{1} + \frac{V_1 - V_2}{4} + \frac{V_1}{2} = 0$$

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

at node 2:

$$5 + \frac{V_2 - V_1}{4} + \frac{V_2}{6} = 10 + 2V + 1V + 1V$$

$$3V_1 - V_2 = 20$$

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

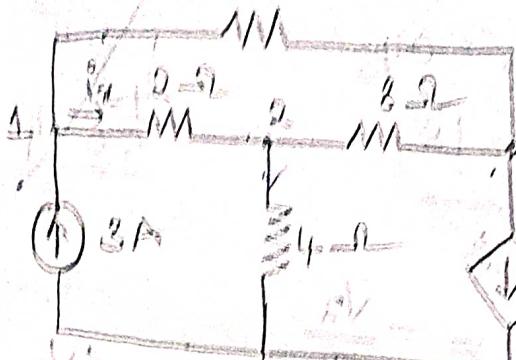
$$6V_2 - 6V_1 + 4V_2 = 120$$

$$10V_2 - 6V_1 = 120$$

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

$$24V_1 = 320$$

$$V_1 = \frac{14.0}{3} = 13.33V$$



$$I_x = V_1 - V_2 / 2V$$

$$I_x = \frac{V_1 - V_2}{2} / 2V$$

at node 1:

$$V_1 - V_2 / 2V = 3$$

$$\frac{V_1 - V_2}{2} + 12V_1 - V_2 / 4 = 3$$

$$3V_1 - 2V_2 - V_3 = 12 \quad \textcircled{1}$$

at node 1/2:

~~$$V_1 - V_2 / 2V$$~~

$$\frac{V_1 - V_2}{2} + \frac{V_2 - V_3}{8} + \frac{V_2}{4} = 0$$

or

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

$$\left[\frac{4V_1 - 7V_2 + V_3}{8} = 0 \right] \quad \textcircled{2}$$

at node 3

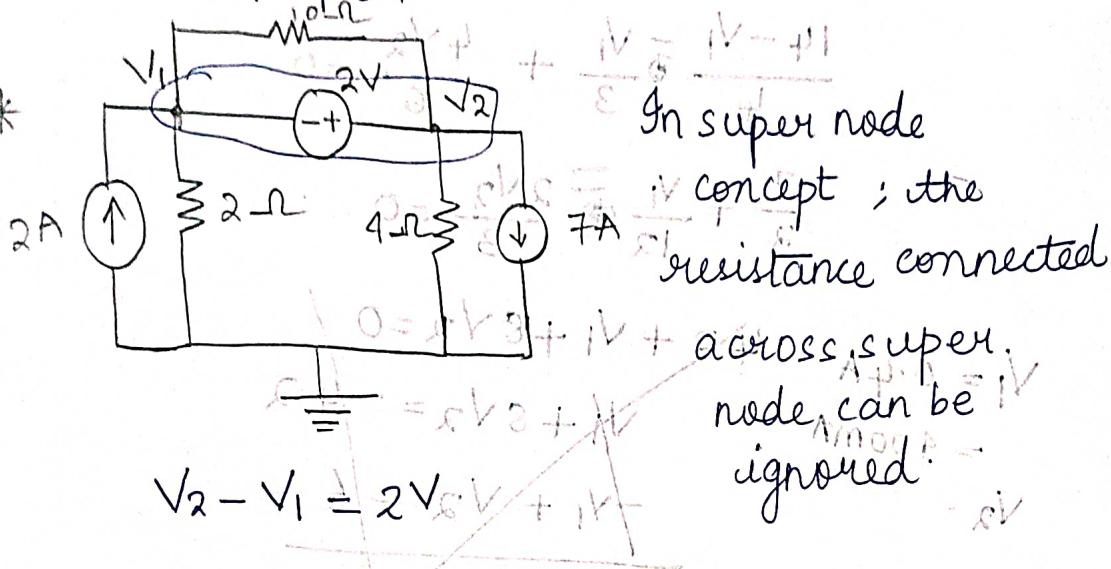
$$\frac{V_1 - V_3}{4} + \frac{V_2 - V_3}{8} = 2\left(\frac{V_1 - V_2}{2}\right)$$

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

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

$$V_1 = 4.8V \quad V_2 = 2.4V \quad V_3 = -9.6V$$

$$V_1 = 4.8V$$



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

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

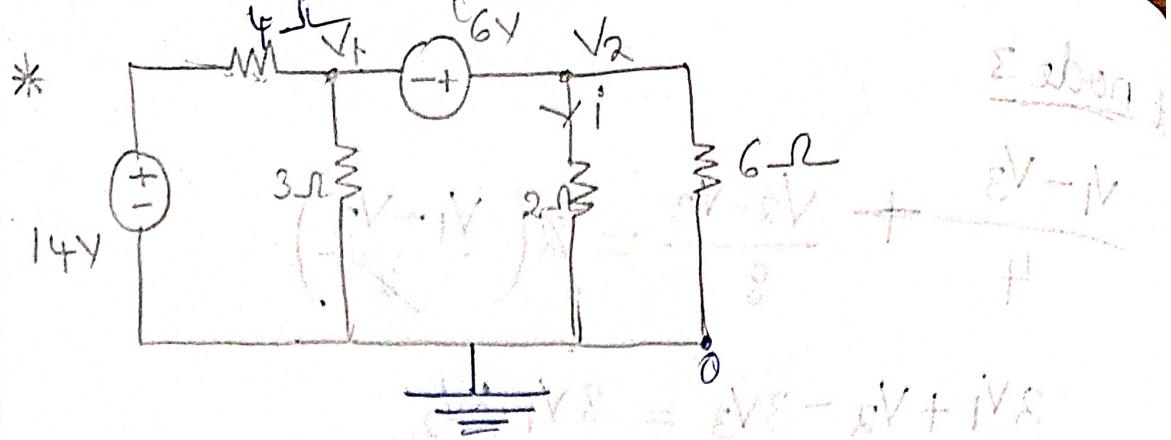
$$2V_1 + V_2 = -20$$

$$\begin{array}{r} -V_1 + V_2 = 2 \\ +V_1 + V_2 = -2 \end{array}$$

$$3V_1 = -22$$

$$V_2 = -5.33V$$

$$V_1 = -7.33V$$



$$V_2 - V_1 = 6V$$

$$0 = 8V_2 + 6V_1 - 14V_0$$

$$\frac{14 - V_1}{4} = \frac{V_1}{3} + \frac{V_2}{2} + \frac{V_3}{6}$$

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

~~shear negat. m.~~

$$\text{so: } \frac{7}{2} + \frac{V_1}{12} - \frac{2V_2}{3} = 0$$

~~$$V_1 = 0.4A$$~~

~~500mA aber~~

~~verwirrt~~

~~$$V_1 + 8V_2 = -4$$~~

~~$$-V_1 + V_2 = 6V - 8V$$~~

~~$$+ 9V_2 - 36V = 8$$~~

~~$$V_2 = -4V$$~~

~~$$8V + 8V + 1V = 8$$~~

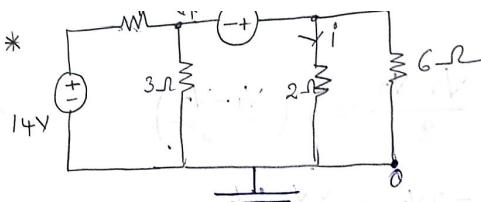
~~$$V_1 = -10V$$~~

~~$$0.8 = 5V + 1V$$~~

~~$$0.8 = 6V$$~~

~~$$6.8 = 1V$$~~

~~$$V_{EF} = 1V$$~~



$$V_2 - V_1 = 6 \text{ V}$$

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

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

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

$$V_1 = 0.4 \text{ A}$$

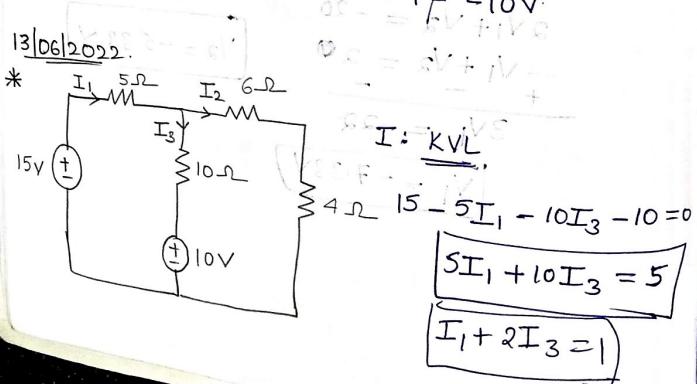
$$= 400 \text{ mV}$$

$$I = 2.8 \text{ A}$$

~~$$9V_2 = -36 \text{ V}$$~~

~~$$V_2 = -4 \text{ V}$$~~

~~$$V_1 = -10 \text{ V}$$~~



I: KVL

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

$$5I_1 + 10I_3 = 5$$

$$I_1 + 2I_3 = 1$$

$$\text{II: } 10 - 10I_3 - 6I_2 - 4I_2 = 0$$

$$10 = 10I_3 + 10I_2$$

$$I_3 + I_2 = 1$$

$$I_1 + 2I_1 - 2I_2 = 1$$

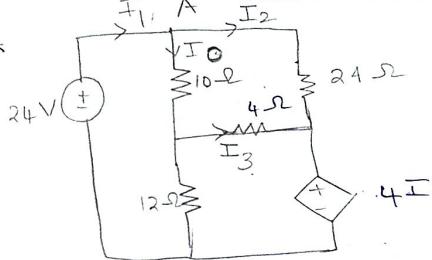
$$3I_1 - 2I_2 = 1$$

$$I_3 = I_1 - I_2$$

$$I_1 = 1 \text{ A}$$

$$3I_1 - 1 = 2I_2$$

$$I_2 = 1 \text{ A}$$



$$\text{I: } -24 + 10(I_1 - I_2) + 12(I_1 - I_3) = 0$$

$$-24 + 22I_1 - 12I_2 - 12I_3 = 0 \quad \textcircled{1}$$

$$+ 4(I_2 - I_3)$$

$$\text{II: } 24I_2 + 10(I_1 - I_2) = 0$$

$$-10I_1 + 14I_2 = 0 \quad \textcircled{2}$$

$$-18I_2 + 10I_1 + 4I_3 = 0 \quad \textcircled{2}$$

$$\text{III: } -4(I_3 - I_2) - 4(I_1 - I_2) + 12(I_3 - I_1) = 0$$

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

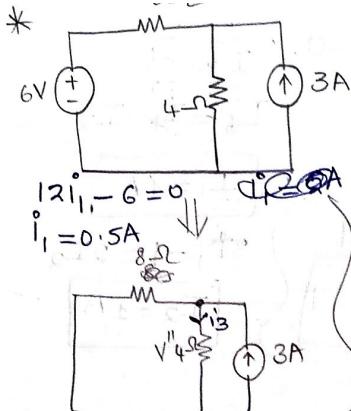
$$8I_1 + 8I_2 - 16I_3 = 0$$

$$[I_1 + I_2 - 2I_3 = 0] - \textcircled{3}$$

$$I_1 = 6 \text{ A}$$

~~$$I_2 = 4.5 \text{ A}$$~~

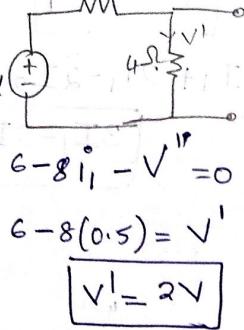
$$I_3 = 5.25 \text{ A}$$



Determine V_o using

SPT

$$8\Omega$$



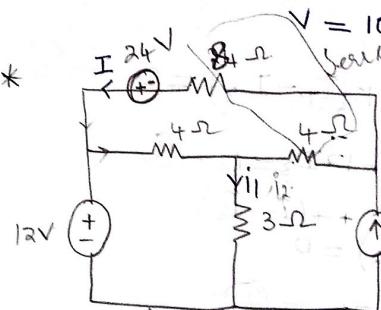
$$6 - 8i_1 - V' = 0$$

$$6 - 8(0.5) = V'$$

$$V' = 2V$$

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

$$i_3 = 2A \quad V'' = 4 \times 2 = 8V$$



Determine I^o using
SPT

24V removed.

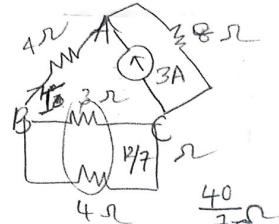
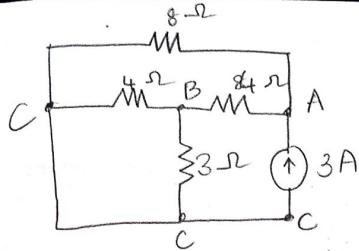
$$i_1 = \frac{12}{4+12} = \frac{12}{16} = \frac{3}{4}A = 0.75A$$

s.c.

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

$$I = \frac{24}{(4+12)+4} = \frac{24}{16} = 1.5A$$

$$= \frac{24 \times 7}{12 + 12 \times 7} = \frac{2 \times 7}{8} = \frac{7}{4}A$$

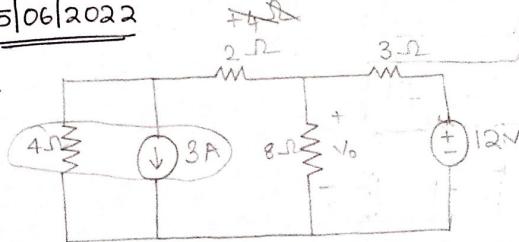


$$i_3 = \frac{4 \times 7}{4+7} = \frac{28}{11} = 1A$$

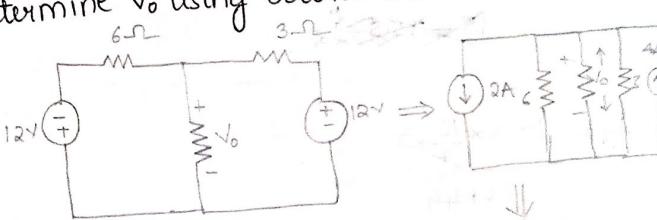
$$I = \frac{3 \times 8}{8+40} = \frac{24}{48} = \frac{1}{2}A$$

$$I = \frac{7}{4}A$$

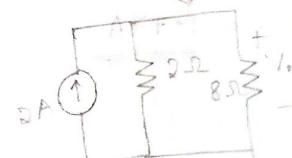
15/06/2022

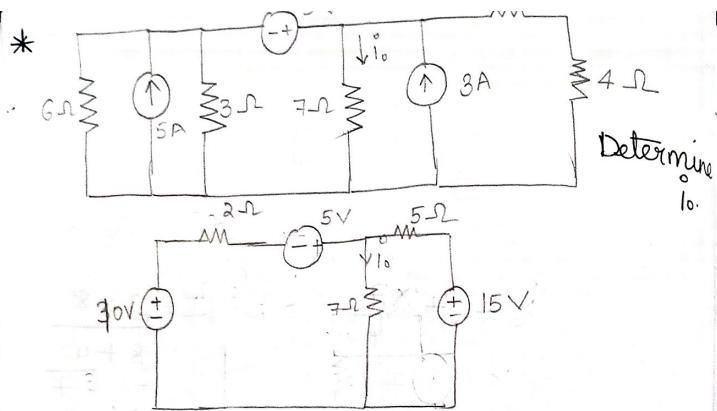


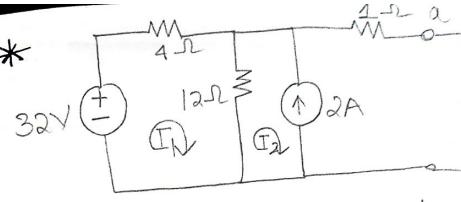
Determine V_o using source transformation.



$$V_o = (2)(\frac{16}{5}) = 3.2V$$





* 

$R_L = 6\Omega$

$I_2 = -2A$

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

$32 - 16I_1 - 24 = 0$

$16I_1 = 8$

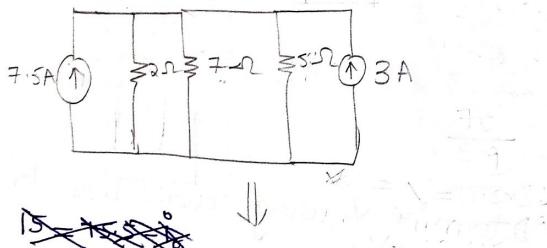
$I_1 = 0.5A$

$\text{QOC} = (I_1 - I_2)12$

QOC
 $(4 \parallel (12+1))$
 $R_{Th} = \frac{4 \times 12}{16}$
 $= 4\Omega$

Voltage across 12Ω is same as QOC .

$\text{QOC} = 2.5 \times 12$
 $\boxed{\text{QOC} = 30V} = V_{Th}$
 $I_{Th} = \frac{V_{Th}}{R_{Th} + R_L} = \frac{V_{Th}}{R_{Th} + R_L}$



$I_1 = \frac{10.5 \times 10 \times 7}{10 + 49} = 0.5A$

$I_1 = 1.77A$

$R_L = 16\Omega$

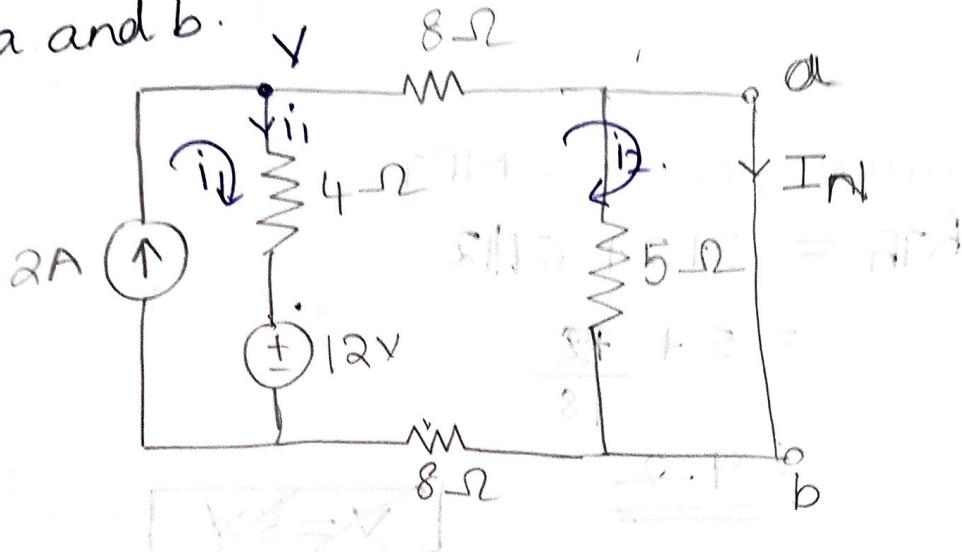
$I_{Th} = \frac{30}{2\Omega} = 1.5A$

$R_L = 36\Omega$

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

17/06/2022

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



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

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

$$5V = 80$$

~~$$V = 16V$$~~

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

~~$$= \frac{20 \times 5}{25}$$~~

~~$$R_N = 4\Omega$$~~

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

~~$0 = 3A - 8 + V$~~
 $\therefore 5\Omega$ resistor is

~~ignored~~

~~$$\therefore 2A = i_1 - i_2 \quad 20i_2 - 4i_1 - 12 = 0$$~~

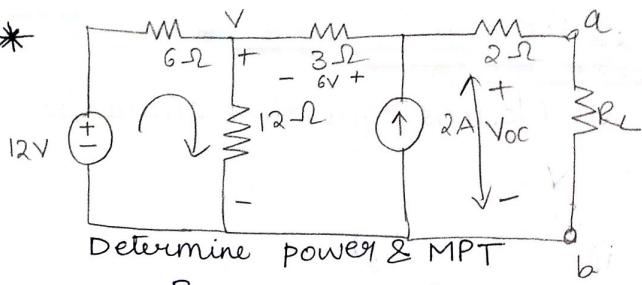
~~$$I_N = \frac{3}{2} A$$~~

$$20i_2 - 8 - 12 = 0$$

$$\boxed{I_N = 1A}$$

$$\boxed{i_2 = 1A}$$

$$\frac{V - 12}{4} = I_N = \frac{16 - 12}{4} = 1A$$

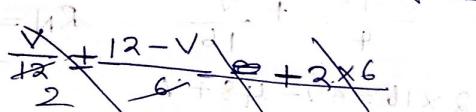


$$R_{Th} = 3 + 2 + 6 \parallel 2$$

$$= 5 + \frac{12}{18}$$

$$= 9 \Omega$$

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



$$V = 24 - 2V$$

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

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

$$V = 48 - 2V$$

$$3V = 48$$

$$\boxed{V = 16V}$$

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

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

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

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

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

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

* Capacitor:

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- 2 metallic plates separated by dielectric material.

- Stores energy in the form of charge / electric field.

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

$q \propto V$
charge \propto voltage.

$$\boxed{q = CV}$$

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

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

$$\boxed{W = \int pdt}$$

$$W = \int P dt$$

P = power

$$W = \int VI dt$$

$$W = \int V \cdot C \frac{dv}{dt} dt \Rightarrow W = \int Cv dv$$

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

$$v = \frac{1}{C} \int_0^t idt$$

$$v = \frac{1}{C} \left[\int_{-\infty}^0 idt + \int_0^t idt + \int_t^\infty idt \right]$$

$$v = V_0 + 0 + \int_0^t idt$$

$$\boxed{v = V_0 + \int_0^t idt}$$

* 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.

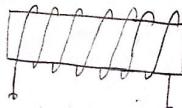
* Capacitor do not allow sudden changes in voltage.

* 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.



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

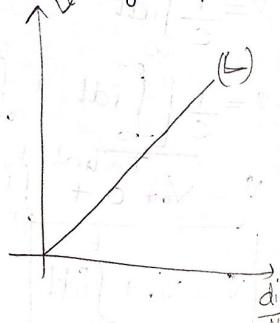
$$V = L \frac{di}{dt} \quad \boxed{= N \frac{d\phi}{dt}}$$

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

N = No. of turns

A = area of the bar

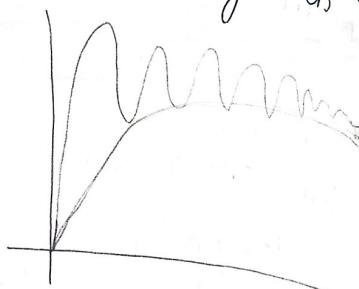
l = length of bar.



* Inductor is a passive element.

* Active elements provide energy for infinite time.

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



$$L = \frac{\text{Flux Linkage}}{\text{Amperes}}$$

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

$$i = \frac{1}{L} \int v dt$$

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

$$I = I_0 + \int v dt$$

* Inductor acts as current source under initial conditions.

⇒ Inductor do not allow sudden changes in current.

* Inductor acts as short circuit under final conditions.

$$* \boxed{L_1 + L_2 = L} \rightarrow \text{Series}$$

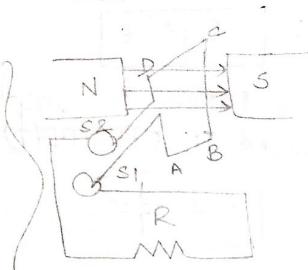
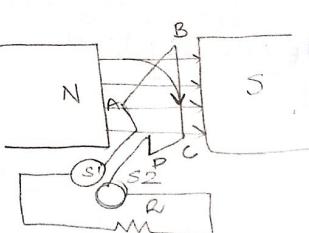
$$\boxed{L = \frac{L_1 L_2}{L_1 + L_2}} \rightarrow \text{Parallel}$$

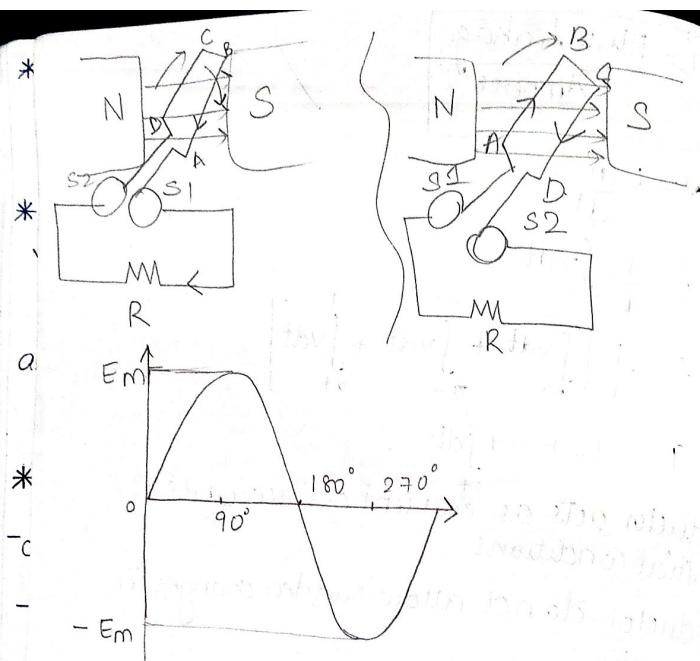
$$* \boxed{C_1 + C_2 = C} \rightarrow \text{Parallel}$$

$$\boxed{C = \frac{C_1 C_2}{C_1 + C_2}} \rightarrow \text{Series}$$

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* AC GENERATOR :





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

Ex: Transformer

$$e = E_m \sin \omega t$$

ω = Angular frequency / velocity

$$\omega = \theta / t$$

θ = Angular displacement

$$\theta = \omega t$$

$$\Rightarrow e = E_m \sin \theta$$

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

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

* No. of cycles per second is called FREQUENCY.

$$f = 50 \text{ Hz} \quad T = 20 \text{ msec} \Rightarrow \text{Complete cycle.}$$

$$T = 10 \text{ msec} \Rightarrow \text{Half cycle.}$$

$$\boxed{\omega = 2\pi/T}$$

$$\omega = \frac{2\pi}{T}$$

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

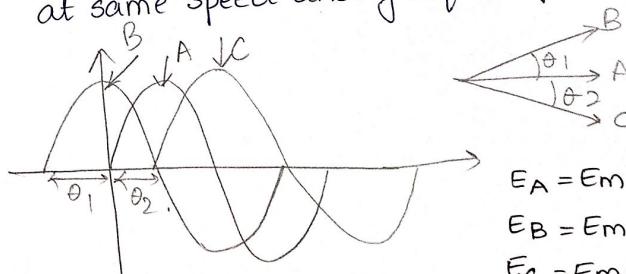
$$\boxed{\omega = 2\pi f}$$

$$\boxed{\omega = 2\pi f} \quad \boxed{f = \frac{\omega}{2\pi}}$$

* 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.

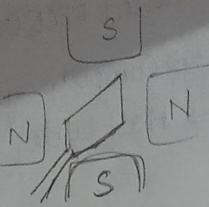
To compare 2 waves; both waves should be at same speed and frequency.



$$E_A = E_m \sin \theta$$

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

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



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

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

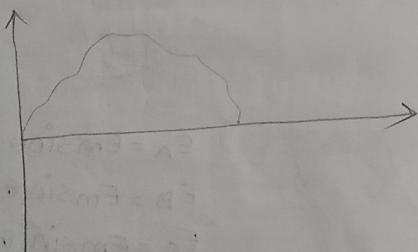
$$50 = \frac{PN}{60}$$

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

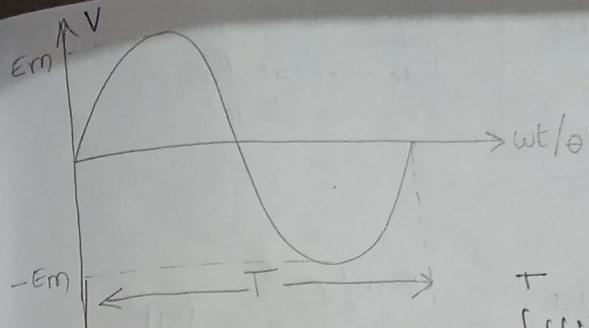
$$N = \frac{50 \times 60}{1}$$

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

* Average Value of a sinusoid:



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



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

$$\begin{aligned} * \text{Take only half cycle.} \quad E_{av} &= \frac{1}{\pi} \int_0^{\pi} E_m \sin \theta d\theta \\ &= \frac{E_m}{\pi} (-1) (-1) \end{aligned}$$

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

$$* \underline{\text{RMS Value:}} \quad \sqrt{\frac{F_1^2 + F_2^2 + \dots + F_n^2}{n^2}}$$

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

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

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

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

* Average Value

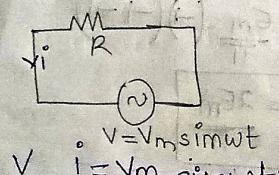
$$I_{dc} \rightarrow Q, t \\ I_{ac} \rightarrow "$$

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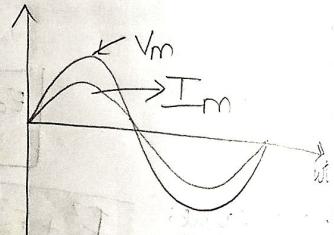
* Form Factor:

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

* AC through pure resistance:



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



$$\phi = \frac{1}{2} \pi$$

$$P_{av} = \frac{1}{T} \int_0^T V_m I_m \sin^2 \omega t dt = 0 \\ = \frac{V_m I_m}{2\pi} \int_0^{\pi} (1 - \cos 2\omega t) dt.$$

$$= \frac{V_m I_m}{2\pi} \left[\omega t - \frac{1}{2} \sin 2\omega t \right]_0^{\pi}$$

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

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

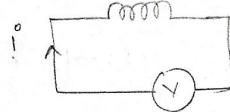
$$P = \sqrt{V_{rms} \times I_{rms}}$$

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

\Rightarrow In half cycle, 2ω completes full cycle. \Rightarrow avg $= 0$

\Rightarrow In half cycle, 2ω completes full cycle. \Rightarrow avg $= 0$

* AC through pure inductance

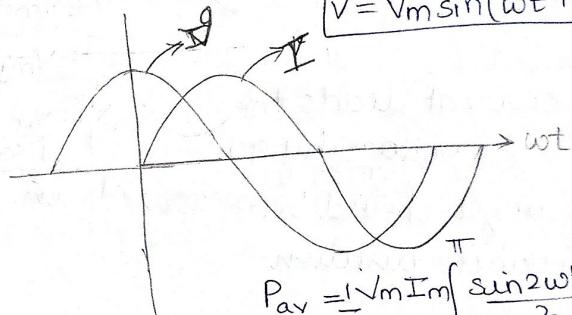


$$V = L \frac{di}{dt}$$

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

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

$$V = V_m \sin(\omega t + 90^\circ)$$



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

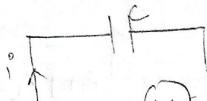
$$= \frac{V_m I_m}{\pi} \frac{1}{2} (0)$$

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

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

current lagging voltage by 90°

* AC through pure capacitance:



$$V = V_m \sin \omega t$$

$$i = c \frac{dy}{dt}$$

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

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

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

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

$$I = -j X_C V_m e^{j\omega t}$$

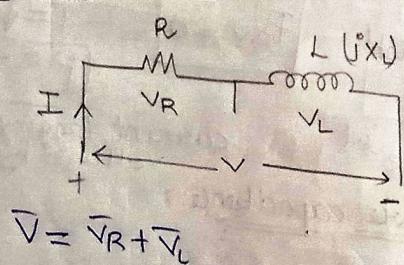
$$\begin{aligned} V &= V_m e^{j\omega t} \\ i &= I_m e^{j\omega t} \\ I &= I_m e^{j\omega t} / j X_C \end{aligned}$$

current leads the voltage by 90° .

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

01/07/2022

* SERIES R-L circuit:



$$V = V_R + V_L$$

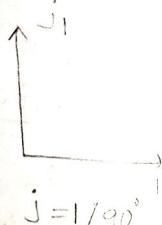
$$= IR + I(jX_L)$$

$$V = I(R + jX_L)$$

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

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

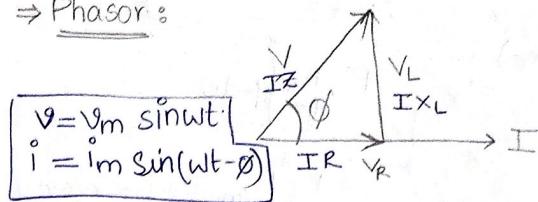
$$\text{Admittance } Y = \frac{1}{Z}$$



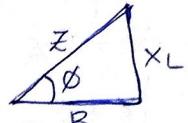
$$j = 1 \angle 90^\circ$$

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

⇒ Phasor:



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



Impedance Δ

clockwise → \rightarrow lagging angle

cosine

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

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

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

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

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

$\cos \phi = \text{Power factor}$

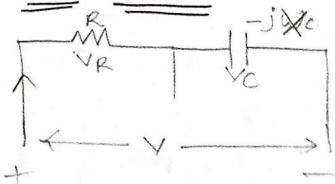
$$P = \frac{V_m I_m \cos \phi}{2}$$

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

$$P = VI \cos \phi$$

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

* SERIES RC CIRCUIT:



$$V = V_R + V_C$$

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

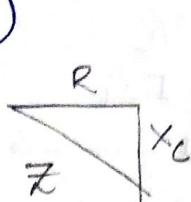
$$Z = R - jX_C$$

$$= I(R - jX_C)$$

$$V = IZ$$

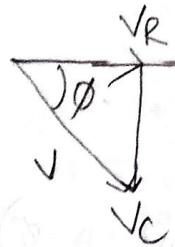
$$Z = \frac{V}{I}$$

$$P = VI$$



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

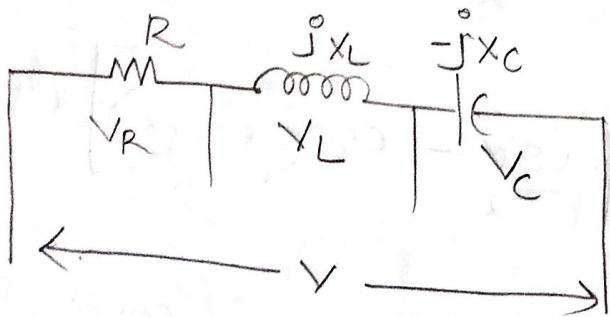
$$= \frac{1}{\pi} \int_0^{\pi} V_m \sin\theta \cdot I_m \sin(\theta - \phi) d\theta$$



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

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

* SERIES LCR CIRCUIT:

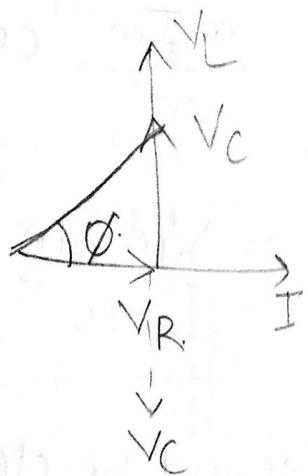


$$V = V_R + V_L + V_C$$

$$= IR + IjX_L - IjX_C$$

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

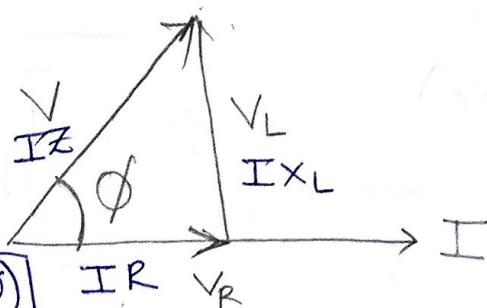
$$V = I(R + j(X_L - X_C))$$



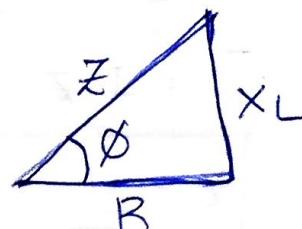
→ For pure resistance; V & I are at 0°
i.e. V & I are in phase.

→ Phasor:

$$\begin{aligned} v &= V_m \sin \omega t \\ i &= I_m \sin(\omega t - \phi) \end{aligned}$$



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



Impedance Δ

Clockwise → ve → lagging angle

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

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

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

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

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

$\cos \phi$ = Power factor

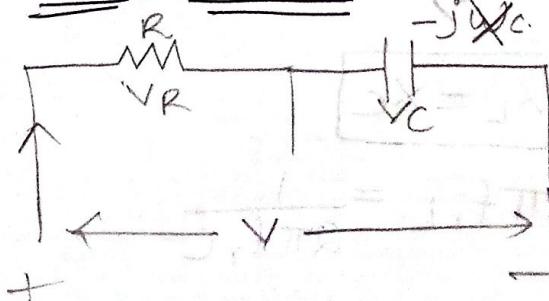
$$P = \frac{V_m I_m}{2} \cos \phi$$

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

$$P = VI \cos \phi$$

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

* SERIES RC CIRCUIT:



$$(R + jX)I + R = V$$

$$\begin{aligned} 1/R + jX/R &= V \\ 1/R &= V - jX \end{aligned}$$

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

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

$$= I(R - jx_C)$$

$$\bar{V} = IZ$$

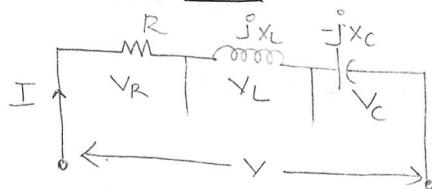
$$Z = \frac{\bar{V}}{I}$$

$$P = VI$$

$$Z = R - jx_C$$

$$\begin{aligned} P &= \frac{1}{\pi} \int_0^\pi P d\theta \\ &= \frac{1}{\pi} \int_0^\pi V_m \sin \theta \cdot I_m \sin(\theta) d\theta \\ &= \frac{V_m I_m}{\pi} \int_0^\pi \sin \theta \cdot \sin(\theta - \phi) d\theta \\ &= \frac{V_m I_m}{2} \cos \phi \end{aligned}$$

* SERIES LCR CIRCUIT:



$$V = V_R + V_L + V_C$$

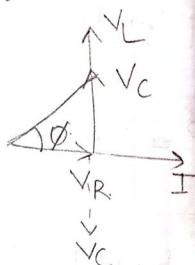
$$= IR + Ijx_L - Ijx_C$$

$$= IR + Ij(x_L - x_C)$$

$$V = I(R + j(x_L - x_C))$$

$$Z = R + j(x_L - x_C)$$

$$\begin{aligned} x_L &= 2\pi f L \\ x_C &= \frac{1}{2\pi f C} \end{aligned} \quad \left. \begin{aligned} x_L &= x_C \\ 2\pi f_r L &= \frac{1}{2\pi f_r C} \end{aligned} \right.$$

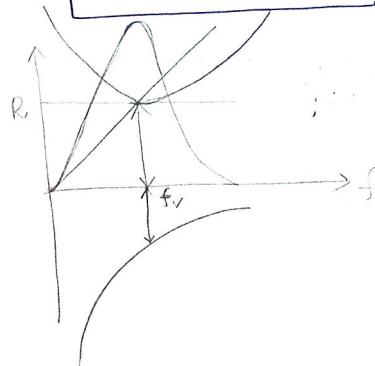


05/07/2022

$$f_r^2 = \frac{1}{4\pi^2 LC} \Rightarrow f_r = \frac{1}{2\pi\sqrt{LC}}$$

at $Z = R$ i.e. $x_L = x_C = 0$

$$I_{max} = \frac{V}{Z} = \frac{V}{R}$$



$$* f = 50 \text{ Hz} \quad R = 10 \Omega \quad L = 10 \text{ mH} ; C = 10 \mu\text{F} \quad V = 250 \text{ V}$$

$$x_L = \frac{2\pi f L}{= 314 \times 10 \times 10^{-3}}$$

$$\boxed{x_L = 3.14 \Omega}$$

$$x_C = \frac{1}{2\pi f C} = \frac{1}{314 \times 10^{-5}} = \frac{10^5}{314}$$

$$\omega = \frac{1}{2\pi\sqrt{LC}}$$

$$f_r = \frac{1}{2\pi\sqrt{LC}}$$

$$= 80.18 \text{ Hz} \quad 503.54 \text{ Hz}$$

$$I = \frac{250}{10} = 25 \text{ A}$$

$$(x_L)_r = 31.622 \Omega \quad (x_C)_r = \frac{1}{2\pi f_r C}$$

$$V_L = 25 \times 31.622 \quad V_C = 31.622 \Omega \\ = 790.57 \text{ V} \quad = 790.57 \text{ V}$$

$$* R = 7 \Omega; L = 31.8 \text{ mH}; V = 230V; f = 50 \text{ Hz}$$

$$X_L = 2 \times 3.14 \times 50 \times 31.8 \times 10^{-3} = 12.2 \Omega$$

$$= 9.98 \Omega$$

$$jX_L = 9.98 j$$

$$= 10j$$

$$I = \frac{230}{7+10j} = \frac{230}{7+10j} = 18.85 A$$

$$\tan \phi = \frac{X_L}{R} = \frac{12.2}{7} = \frac{10}{7} =$$

$$\phi = 55^\circ$$

$$\cos \phi = 0.57$$

$$P = VI \cos \phi = 247.23 W$$

$$\text{Voltage across } R = IR = 18.85 \times 7 = 131.95 V$$

$$\text{across } L = I \times L = 188.5 V$$

$$* V = 250V; f = 50 \text{ Hz}; I = 5A; P = 750W$$

$$\cos \phi = \frac{P}{VI} = \frac{750}{250 \times 5} = \frac{3}{5}, \text{ lag}$$

$$Z = \frac{V}{I} = 50 \Omega$$

$$I^2 R = 750 \quad \text{no power through}$$

$$R = \frac{750}{25} = 30 \Omega$$

$$Z^2 = R^2 + X_L^2$$

$$(R^2 + X_L^2) = 2500 - 900 = 1600$$

$$X_L^2 = 1600$$

$$X_L = 40 \Omega$$

$$2\pi f L = 40$$

$$L = \frac{40}{2 \times 3.14 \times 50} =$$

$$L = 0.127 H$$

$$* i(t) = 5 \sin(314t + 2\pi/3)$$

$$v(t) = 15 \sin(314t + 5\pi/6)$$

- (i) Impedance (ii) Inductance (iii) average Power
 (iv) Power factor ($\cos \phi$).
 (v) Resistance

$$\phi = \frac{5\pi}{6} - \frac{2\pi}{3} = \frac{\pi}{6} = 30^\circ$$

current lags the voltage applied by 30° .

$$Z = \frac{V_m}{I_m} = \frac{15}{5} = 3 \Omega$$

$$Z^2 = X_L^2 + R^2$$

$$X_L^2 = 9 - \frac{9 \times 3}{4}$$

$$X_L^2 = \frac{36 - 27}{4}$$

$$X_L = \frac{3}{2}$$

$$L = \frac{3}{2} \times \frac{1}{2\pi \times 314}$$

$$= 4.7 \times 10^{-3}$$

$$= 4.7 \text{ mH}$$

$$\omega = 314 = 2\pi f$$

$$P = I^2 R = VI \cos \phi = \frac{15}{\sqrt{2}} \cdot \frac{5}{\sqrt{2}} \cos 30^\circ = \frac{75 \times \sqrt{3}}{2}$$

$$P = 75 \sqrt{3}/4$$

$$* C = 79.5 \mu F \quad R = 30 \Omega \quad V = 100 V$$

$$f = 50 \text{ Hz} \quad Z = \sqrt{R^2 + X_C^2} = \sqrt{30^2 + X_C^2}$$

$$X_C = \frac{1}{\omega C} = \frac{1}{2\pi f C} = 40 \Omega$$

$$Z = \sqrt{900 + 1600} = 50 \Omega$$

$$I = \frac{V}{Z} = 2 A$$

$$\cos \phi = \frac{R}{Z} \Rightarrow \phi = \cos^{-1}\left(\frac{R}{Z}\right) = \cos^{-1}\left(\frac{30}{50}\right) = 53^\circ \text{ lead.}$$

$$I_m = 2\sqrt{2} A$$

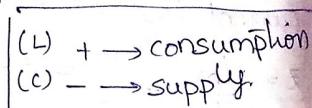
$$\omega = 2\pi f = 314 \text{ rad/sec}$$

$$I = 2.428 \sin(314t + 53)$$

07/07/2022

* COMPLEX POWER(S): \Rightarrow Apparent Power:

$$S = VI^* \rightarrow \text{conjugate.}$$



$$V = V L O$$

$$I = I L - \phi$$

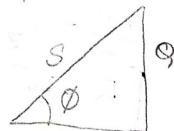
$$S = VI L - \phi$$

$$S = VI^* = VI L \phi = VI \cos \phi + j VI \sin \phi$$

$VI \cos \phi$ = Active Power (P)

$VI \sin \phi$ = Reactive Power (Q)

VI = Apparent Power (S)



$$* V = 100 \sin 500t$$

$$I = 25 \sin(500t - 30^\circ)$$

Determine circuit elements & their values;
Determine P, Q, S.

$$Z = \frac{V}{I} = 40 \angle 30^\circ = 3.46 + 2j$$

$$I_{rms} = \frac{25}{\sqrt{2}} \angle -30^\circ$$

$$2\pi f L = 2 \Omega$$

$$L = \frac{2\Omega}{500} = [4 \times 10^{-3} \text{ H}]$$

$$P = VI \cos \phi = \frac{2500}{2} \angle -30^\circ \cos \phi \cdot \frac{\sqrt{3}}{2}$$

$$= 1082.53 + 625j$$

$$S = VI^* = \frac{2500}{2} \angle 30^\circ = 1082.53 + 625j$$

$$VI \cos \phi = P = 1082.53 \text{ W}$$

$$VI \sin \phi = Q = 625$$

$$VI = S = 1250$$

* $V(t) = 100 \sin 314t$; $R = 10 \Omega$; $L = 0.0318 + j$,
 $C = 63.6 \mu F$
 $i(t)$, ϕ , power factor, active power, peak value
of pulsating power.

$$X_L = \omega L = 314 \times 0.0318 = 9.98 \approx 10$$

$$X_C = \frac{1}{\omega C} = \frac{1}{314 \times 63.6} = 5 \times 10^{-5} \times 10^6 = 50$$

$$X = X_L - X_C = -40$$

$$Z = \sqrt{R^2 + Z^2} = \sqrt{(10)^2 + (-40)^2} = \sqrt{100 + 1600}$$

$$Z = \underline{\underline{41.2\Omega}}$$

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

$$= \frac{100/\sqrt{2}}{41.2} = \underline{\underline{1.716A}}$$

$$I_m = \sqrt{2} I = 1.414 \times 1.716 = \underline{\underline{2.426A}}$$

$$\phi = \tan^{-1}(-40/10) = \tan^{-1}(-4) = 76^\circ \text{ lead}$$

$$i = I_m \sin(314t + \phi)$$

$$= 2.43 \sin(314t + 76^\circ)$$

~~$$\cos \phi = \cos 76^\circ = \underline{\underline{0.24}}$$~~

$$VI = 100 \sin 314t \cdot 2.43 \sin(314t + 76^\circ)$$

$$= 243 [\cos(76^\circ) - \cos(628t + 76^\circ)]$$

$$= [58.78 - 243 \cos(628t + 76^\circ)]$$

$$= 58.78 - 243 \sin(90^\circ - 628t - 76^\circ)$$

$$= \frac{58.78}{2} + \frac{243}{2} \sin(628t - 14^\circ)$$

$$= \underline{\underline{29.39 + 121.5 \sin(628t - 14^\circ)}}$$