Network Analysis And Synthesis

circuit :- A closed path for current to flow.

network :- may or may not be closed

* Every circuit is a network but not vice-versa.

→ Various ~~Net~~ Terms.

1) Circuit : A conducting path through which an electric current either flows or is intended to flow, is called a circuit.

2) Linear circuit : A circuit whose parameters are constant or which obey Ohm's law is called linear circuit.

3) Non-linear circuit : A circuit whose parameters change ~~ech~~ with voltage or current or which does not obey Ohm's law, is called non-linear circuit

4) Unilateral circuit : A circuit whose properties or characteristics change with the dirⁿ of voltage or current, is called unilateral circuit.

5) Bilateral circuit : A circuit whose properties or characteristics remains same in either dirⁿ is called bilateral circuit.

6) Active circuit : A circuit which contains one or more than one source of EMF is called an Active circuit.

7) Passive circuit : A circuit which does not contain any source of EMF is called passive circuit.

8) Node : A node is a junction in a circuit where two or more circuit elements are connected together.

9) Branch : The part of a network which lies between two junctions, is called a branch.

* KVL ⇒ No. of eqⁿ = No. of loops
KCL ⇒ No. of eqⁿ = Nodes − 1

Types of sources :-

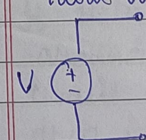
1) Independent Source.

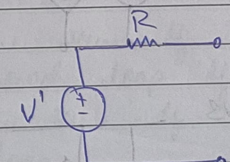
i) Voltage
ii) Current

2) Dependent Source :

i) VDVS
ii) VDCS
iii) CDVS
iv) CDCS

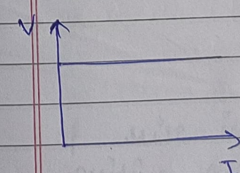
ideal voltage source.

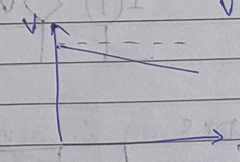




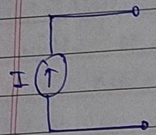
to practical voltage source

$V' = V - IR$

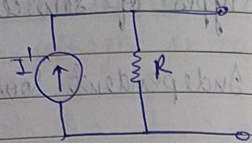


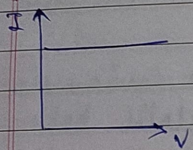


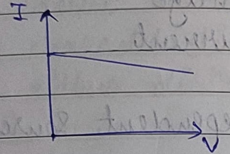
ideal current source



practical current source

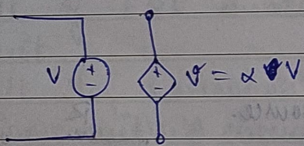




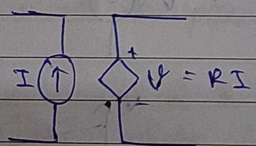


$I' = I - \frac{V}{R}$

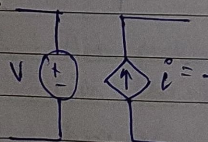
1) VDVS



2) CDVS



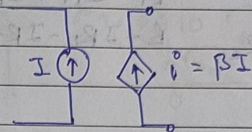
3) VDCS



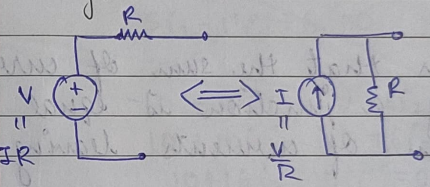
$i = \frac{V}{R} = GV$

conductance

4) CDCS



Voltage - Current source conversion :

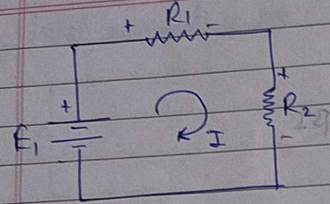


KVL

It states that the sum of EMF around any closed loop of a circuit equals the sum of potential drop in that loop.

OR

If rise in voltage is considered positive and drop in voltage as negative, then the algebraic sum of potential diff. around a closed loop is 0.



$E_1 = IR_1 + IR_2$

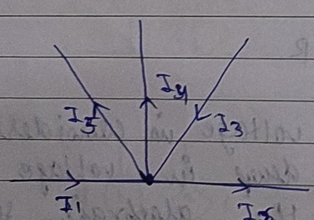
$E - IR_1 - IR_2 = 0$

KCL

It states that the sum of current entering a junction is equal to the sum of currents leaving the junction

OR.

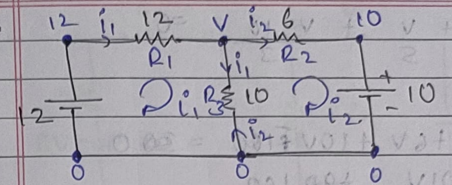
If the currents towards the junction is ~~cent~~ considered the and those away as -ve then the algebraic sum of all currents meeting at a common junction is 0.



$I_1 + I_3 = I_2 + I_4 + I_5$

$I_1 + I_3 - I_2 - I_4 - I_5 = 0$

Q1.



KVL: $12 - 12i_1 - 10(i_1 - i_2) = 0$

$12 - 22i_1 + 10i_2 = 0$

$5i_2 - 11i_1 + 6 = 0$ —— (1)

$-10 - 10(i_2 - i_1) - 6i_2 = 0$

$10 + 10(i_2 - i_1) + 6i_2 = 0$

$10 + 16i_2 - 10i_1 = 0$

$5 + 8i_2 - 5i_1 = 0$ —— (2)

$i_1 = +0.36A$

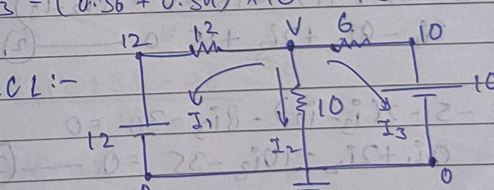
$i_2 = -0.39A$

$V_1 = 0.36 \times 12 = 4.32\ V$

$V_2 = 0.39 \times 6 = 2.34\ V$

$V_3 = (0.36 + 0.39) \times 10 \approx 7.5\ V$

KCL:-



$I_1 + I_2 + I_3 = 0.$

$$\frac{V-12}{12} + \frac{V-0}{10} + \frac{V-10}{6} = 0$$

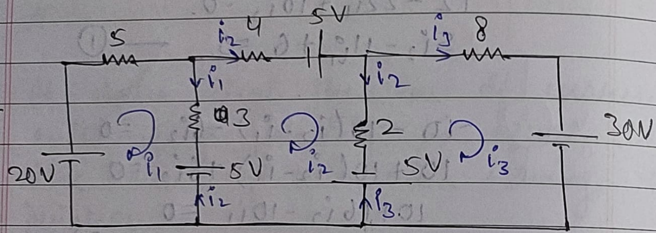
$$\frac{V-12}{6} + \frac{V}{5} + \frac{V-10}{3} = 0$$

$$(5V-60) + 6V + 10V - 100 = \cancel{300}\ 0$$

$$21V = \cancel{140}\ 160$$

$$V = 7.62V$$

Q2.



Solve by Mesh analysis.

KVL: $20 - 5i_1 - 3(i_1 - i_2) - 5 = 0$

$15 - 8i_1 + 3i_2 = 0.$

$-8i_1 + 3i_2 + 0i_3 + 15 = 0$ —— (1)

$5 - 3(i_2 - i_1) - 4i_2 + 5 - 2(i_2 - i_3) + 5 = 0$

$3i_1 - 9i_2 + 2i_3 + 15 = 0$ —— (2)

$-5 - 2(i_3 - i_2) - 8i_3 - 30 = 0$

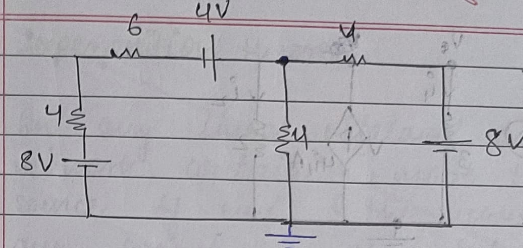
$0i_1 + 2i_2 - 10i_3 - 35 = 0$ —— (3)

$i_1 = 2.55$

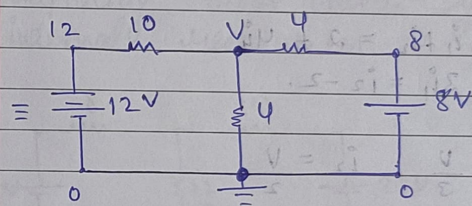
$i_2 = 1.82$

$i_3 = -3.13$

Q3.



Find i through 10 Ω resistor using nodal voltage method.



$$\frac{V-12}{10} + \frac{V}{4} + \frac{V-8}{4} = 0$$

$$\frac{V-12}{10} + \frac{2V-8}{4} = 0$$

$$\frac{V-12}{10} + \frac{\cancel{2}(V-4)}{\cancel{4}\,2} \times \frac{5}{5} = 0$$

$$\frac{V-12+5V-20}{10} = 0$$

$6V = 32$

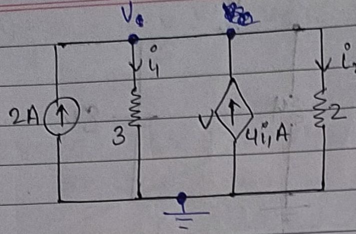
$V = \frac{32}{6} = \frac{16}{3}$

$\boxed{V = 5.33V}$

$$i = \frac{5.33-12}{10}$$

$$= 0.667\,A$$

Q4.



$-2 + \frac{V}{3} + \frac{V}{2}$

KCL:- $i_1 + i_2 = 2 + 4i_1$

$3i_1 = i_2 - 2$.

$i_1 = \frac{V}{3}$; $i_2 = \frac{V}{2}$

$\frac{3V}{3} = \frac{V}{2} - 2$

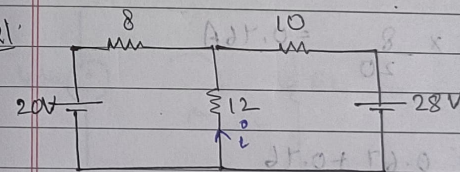
$\frac{V}{2} = -2 \Rightarrow \underline{V = -4}$

$i_1 = \frac{-4}{3} A$ $i_2 = -2A$

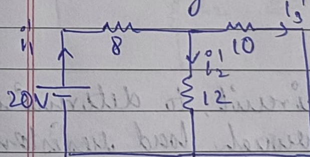
Superposition theorem

In any linear bilateral active network, containing more than one source of emf, the current in any branch is the algebraic sum of a no. of individual currents considering the emf separately replacing other sources by their internal resistances.

Q1.



Considering 20V :-

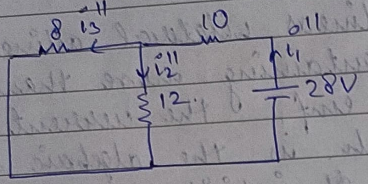


$R = \frac{12\times10}{22} + 8 = 13.45$

$i_1' = \frac{20}{13.45} = 1.48$

$i_2' = 1.48 \times \frac{10}{22} = 0.67 A$

considering 28V source:



$$R = \frac{8 \times 12}{20} + 10 = 14.8$$

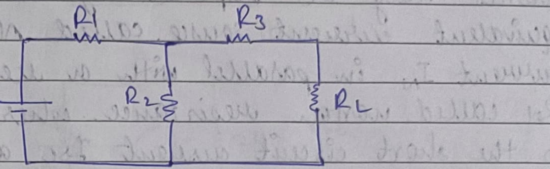
$$i_1'' = \frac{V}{R} = 1.89A$$

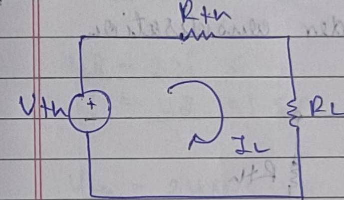
$$i_2'' = 1.89 \times \frac{8}{20} = 0.76A$$

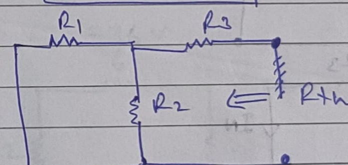
Total $i_2 = 0.67 + 0.76$
$= 1.43A$

3) Thevenin's Theorem

In any linear circuit, to determine the current through load resistor R_L, connected across two terminal of a network, which contain voltage sources and a resistor can be replaced by a single source of emf, called thevenin's voltage V_{th} and a series resistor called thevenin's resistance R_{th}, where V_{th} is the the potential diff. when R_L is removed and R_{th} is the equivalent resistance as seen from the terminal under consideration.







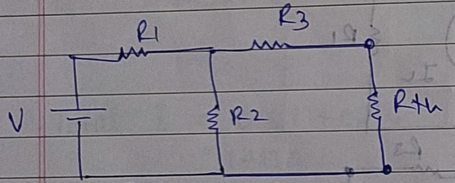
$$V_{th} = \frac{R_2}{R_1 + R_2} \times V$$

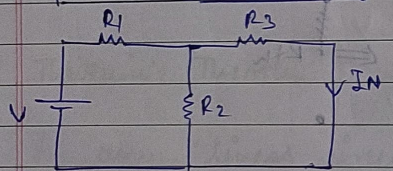
$$R_{th} = R_3 + \frac{R_1 R_2}{R_1 + R_2}$$

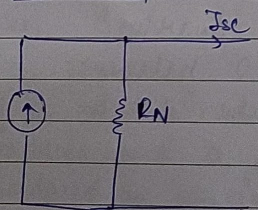
$$I_L = \frac{V_{th}}{R_{th} + R_L}$$

4) Norton's Theorem

In any linear network, containing independent voltage and current sources may be replaced by an equivalent current source, called Norton current I_N in parallel with a resistance R_N called norton resistance, where I_N is the short circuit current I_{sc} and R_N is equivalent resistance as seen from the terminal under consideration.

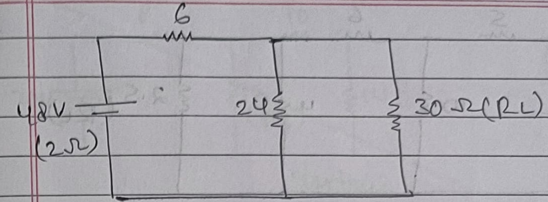




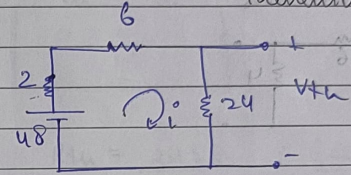


$$I_L = \frac{R_N}{R_N + R_L} \cdot I_N$$

Q1.



Thevenin's

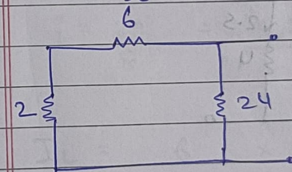


$48 - 32i = 0$

$i = \frac{48}{32} = 1.5\text{ A}$

$V_{th} = 24 \times 1.5$

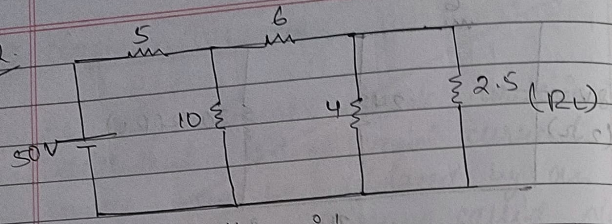
$= 36\text{ V}.$



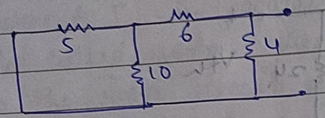
$R_{th} = \frac{\cancel{24}^{6} \times 8}{\cancel{32}} = 6\ \Omega.$

$I_L = \frac{V_{th}}{R_{th} + R_L} = \frac{36}{6 + 30} = 1\text{ A}.$

Q2.

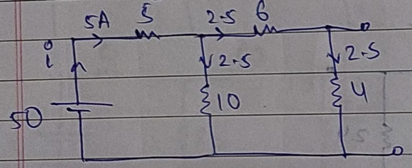


Thevenin's



$\frac{10 \times 5}{15} = \frac{10}{3} + 6 = \frac{28}{3}$

$R_{th} = \frac{\frac{28}{3} \times 4}{\frac{28}{3} + 4} = \frac{37.33}{13.33} = 2.8$

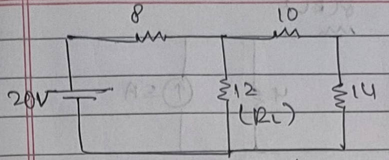


$i = \frac{50}{10} = 5A$

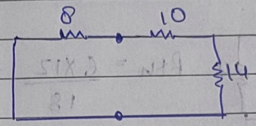
$V_{th} = 2.5 \times 4 = 10V$

$I_L = \frac{10}{2.8 + 2.5} = 1.88A$

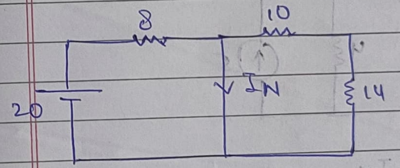
Q3.



Norton's



$R_{th} = \frac{24 \times 8}{24 + 8} = 6\Omega = R_N$

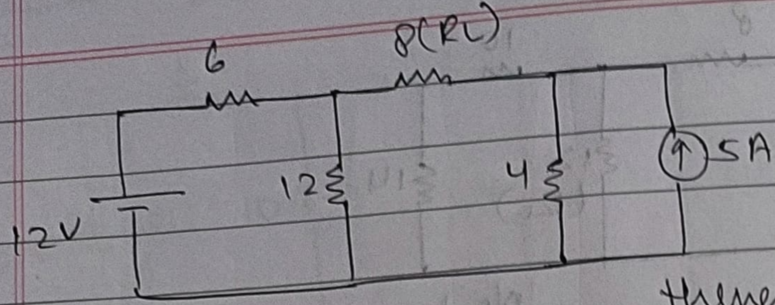


$i = \frac{20}{8} = 2.5A = I_N$

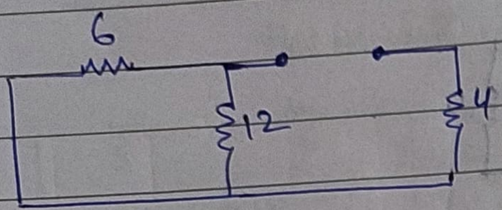
$I_L = \frac{6}{6 + 12} \times 2.5$

$= 0.83A$

Q4.

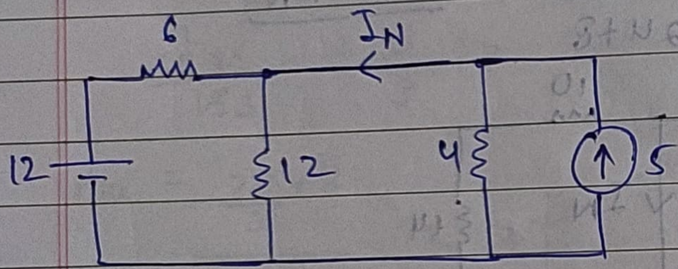


thevenin's



$$R_{th} = \frac{6 \times 12}{18} + 4$$

$$= 8\,\Omega$$



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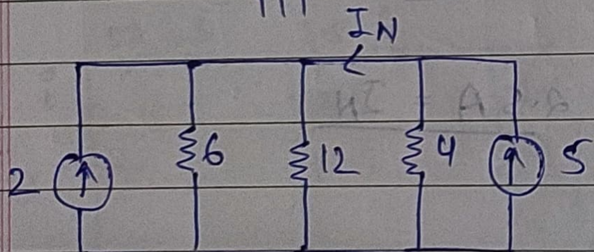
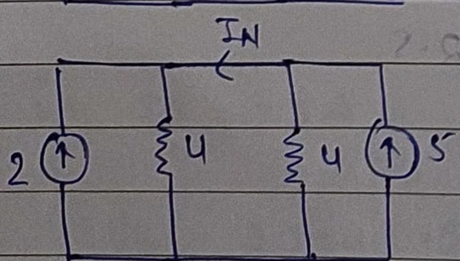
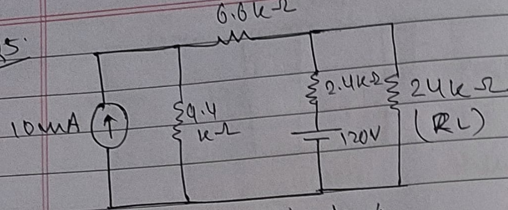


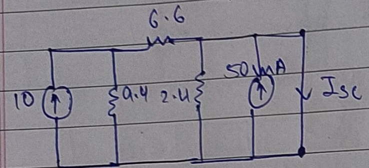


Q5.



Norton's

$\frac{1200}{24} = 50\ mA$



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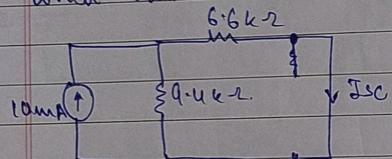
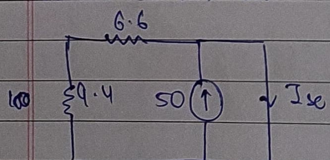
when 10 mA current source works:



$I_{sc_1} = 10 \times \frac{9.4}{16} = 5.875\ mA$

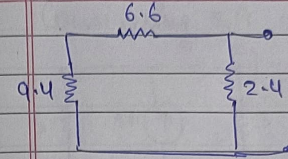
when 50 mA works:-



$I_{sc_2} = 50\ mA.$

$I_{sc} = I_{sc_1} + I_{sc_2}$

$= 55.875\ mA.$



$R_{th} = \frac{16 \times 2.4}{18.4}$

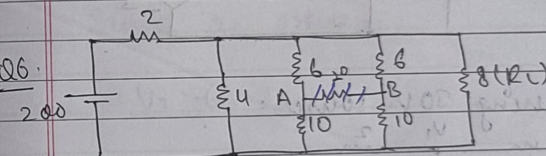
$= 2.087\ k\Omega.$

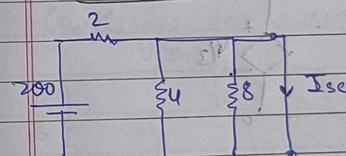
$I_L = I_N \frac{R_{th}}{R_{th} + R_L}$

$= 55.875 \times \frac{2.087}{26.087}$

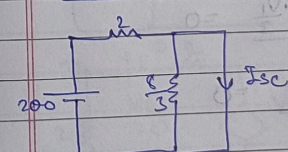
$= 4.47\ mA$

Q6.

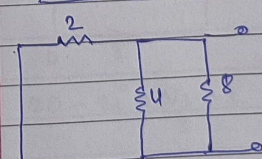




$\frac{8 \cdot 4}{12} = \frac{8}{3}$



$I_{sc} = \frac{200}{2} = 100\ A.$



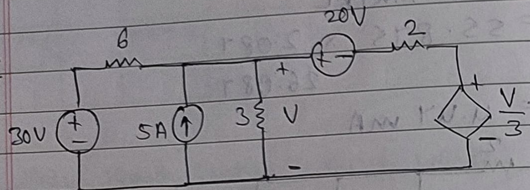
$R_{th} = \frac{\frac{8}{3} \times 2}{\frac{14}{3}} = 1.14\ \Omega.$

$$I_L = I_{sc} \cdot \frac{R_{th}}{R_{th}+R_L}$$

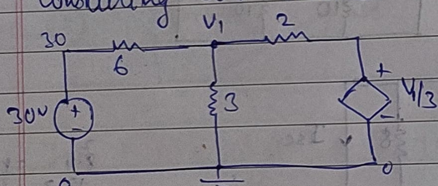
$$= 100 \times \frac{1.14}{9.14}$$

$$= 12.5$$

Q7.



Considering 30V source:



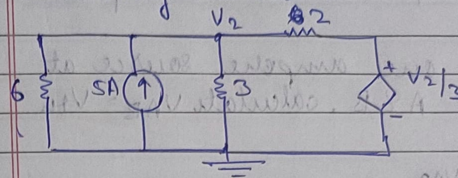
$$\frac{V_1-30}{6} + \frac{V_1}{3} + \frac{V_1 - \frac{V_1}{3}}{2} = 0$$

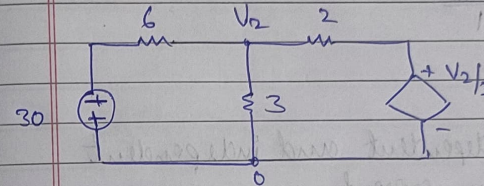
$$\frac{V_1-30}{6} + \frac{2V_1}{6} + \frac{2V_1}{6} = 0$$

$$5V_1 = 30$$

$$\underline{V_1 = 6\,V}$$

Considering 5A source.

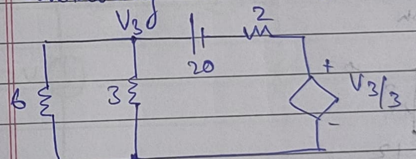


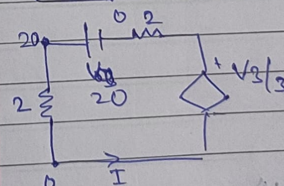


Same as previous

$$\underline{V_2 = -6V.}$$

Considering 20V source:-





$$20 - 2i + \frac{V_3}{3} + 2$$

* If only dependent source is present

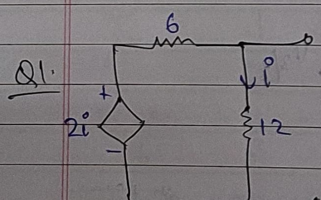
1. Connect one ampere source at terminal A & B, calculate $V_{AB} = V_{th}$

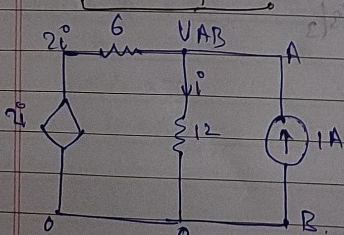
2. $R_{th} = \frac{V_{AB}}{1}$

* If both dependent and independent source is present

1. Find V_{th} across AB
2. For R_{th}, short circuit AB and find I_{SH}, ~~then~~ R_{th}
3. $R_{th} = \frac{V_{th}}{I_{sh}}$

Q1.





$$\frac{V_{AB} - 2i}{6} + \frac{V_{AB}}{12} = 1$$

$$i = \frac{V_{AB}}{12}$$

$$\Rightarrow \frac{V_{AB} - \frac{V_{AB}}{6}}{6} + \frac{V_{AB}}{12} = 1$$

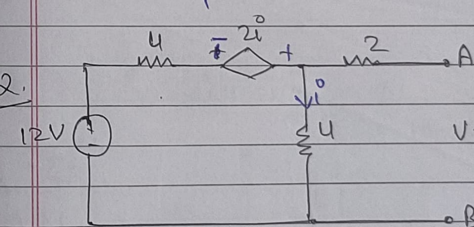
$$\frac{5V_{AB}}{36} + \frac{3V_{AB}}{36} = 1$$

$$8V_{AB} = 36$$

$$V_{AB} = \frac{36}{8} = \boxed{4.5 = V_{th}}$$

$$R_{th} = \frac{V_{AB}}{1} = 4.5\,\Omega.$$

Q2.

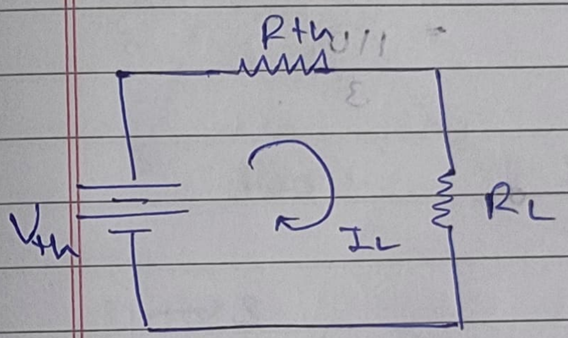


V_{th}.

Ans:- $V_{th} = 8V$ $R_{th} = 10$

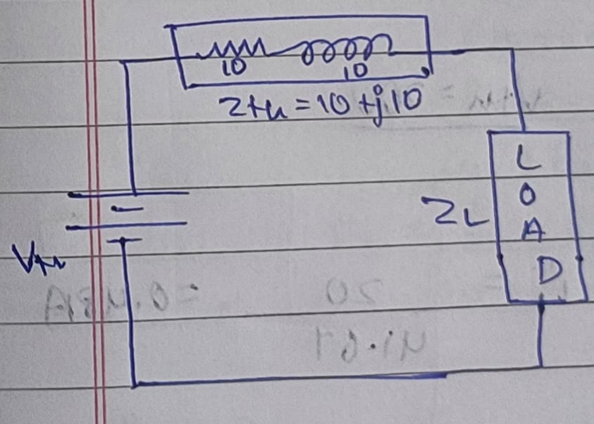
V Max Power Transfer Theorem

It states that max power output is obtained from a network when the load resistance is equal to the output resistance of the network as seen from the terminals of the load.



$R_{th} = R_L$

$$P_{max} = \frac{V_{th}^2}{4R_L}$$

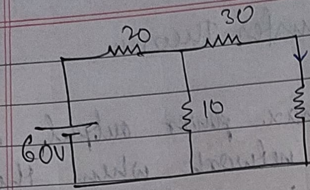


$Z_L = 10 - j10$

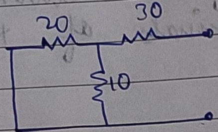
$Z_{th} = x + jy$

$Z_L = x - jy$

Q1.

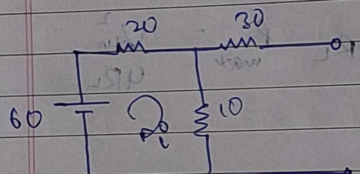


Cal value of R_L for which power is max. Find this max power.



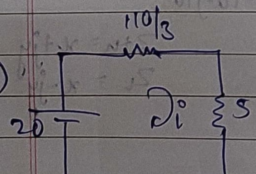
$$R_{th} = 30 + \frac{20 \cdot 10}{30}$$

$$= \frac{110}{3}$$

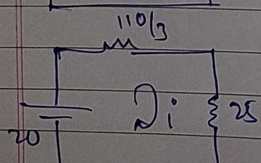


$$i = \frac{60}{30} = 2A \qquad V_{th} = 20V$$

i)



$$i_1 = \frac{20}{41.67} = 0.48A$$

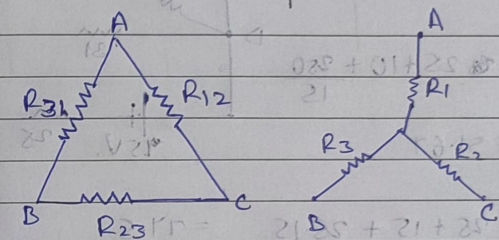


$$i_2 = \frac{20}{61.67} = 0.324$$

For max power, $R_{th} = R_L = 36.67$

$$P_{max} = \frac{400}{4 \times 36.67} = 2.72\,W$$

VI Star delta Transformation



$D \longrightarrow S$,

$$R_1 = \frac{R_{12} R_{31}}{R_{12} + R_{23} + R_{31}}$$

$$R_2 = \frac{R_{12} \cdot R_{23}}{R_{12} + R_{23} + R_{31}}$$

$$R_3 = \frac{R_{23} \cdot R_{31}}{R_{12} + R_{23} + R_{31}}$$

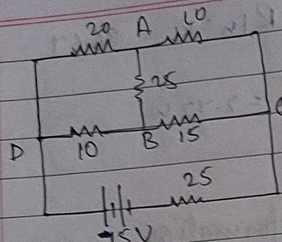
$S \longrightarrow D$,

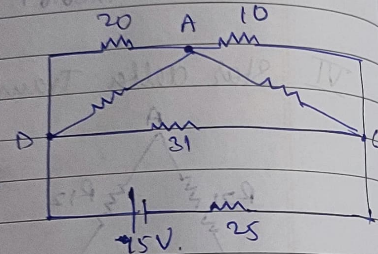
$$R_{12} = \frac{R_1 R_2 + R_2 R_3 + R_3 R_1}{R_3}$$

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

7.21.06

Q1.





$R_{AD} = 25 + 10 + \frac{250}{15}$

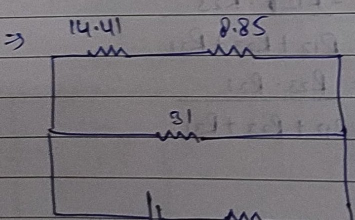
$= 51.67$

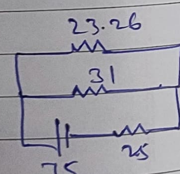
$R_{AC} = 25 + 15 + \frac{25 \cdot 15}{10} = 77.5$

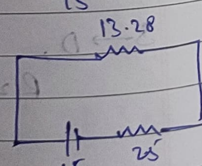
$R_{CD} = 10 + 15 + \frac{150}{25}$

$= 31$

$\Rightarrow$



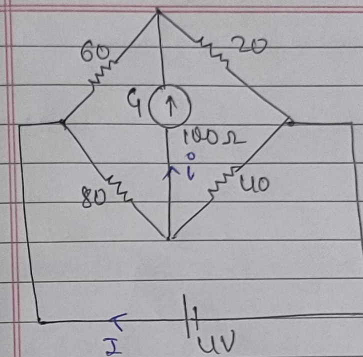




$i = \frac{15}{\cancel{38.28}\ 15.78} = \cancel{0.391\,A}$

$= 0.95$

Q2.

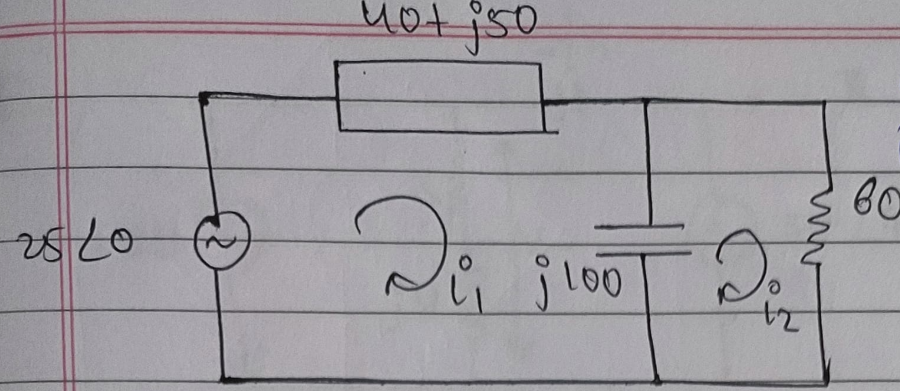


$R_{eq} = 47.9$

$I = 0.083$

$i = 2.36$ mA

Q.



$i_1 = 0.285 \angle -15.6^\circ$

$i_2 = \cancel{0.452}$

$0.245 \angle -46.6$

$(40 - j50)\, i_1 + j100\, i_2 = 25 \angle 0$

$+j100\, i_1 + (60 - j100)\, i_2 = 0$

Polar form : $M \angle \theta$

Rectangular form :

$x + jy$

$M = \sqrt{x^2 + y^2}$

$\theta = \tan^{-1}\left(\frac{y}{x}\right)$

$+, - \rightarrow$ Rect

$\times, \div \rightarrow$ Polar.

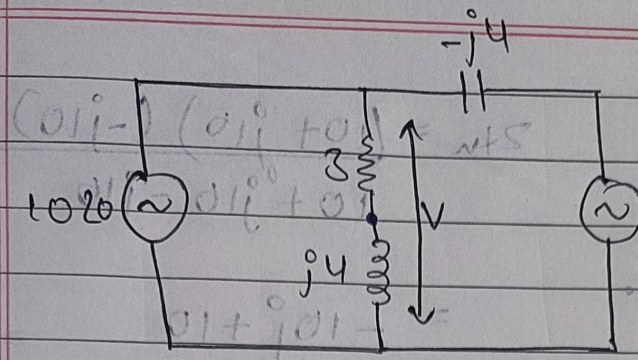
eg:- $\frac{10 \angle 30}{5 \angle 10}$

$= 2 \angle 20$

$10 \angle 30 \times 5 \angle 10$

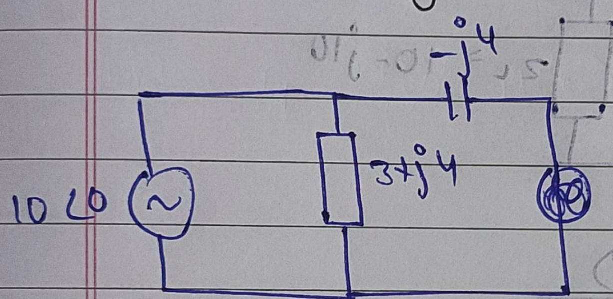
$= 50 \angle 40$

Q4.



$= V_1 = 16.7 \angle 143.3^\circ$

Solve for V using superposⁿ theorem

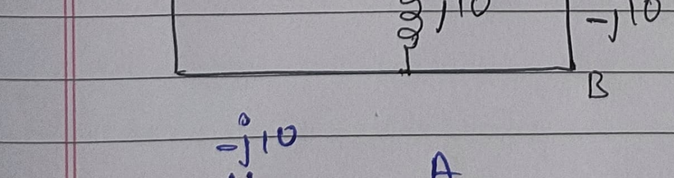


$$R_{eq} = \frac{(3+j4)(-j4)}{3+j4-j4}$$

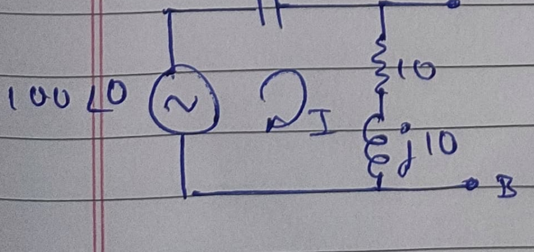
$$= \frac{-12j+16}{3}$$

$$I = \frac{10\angle 0}{R_{eq}}$$

Q5.



Find i through AB using thevenins theorem and also calculate power.

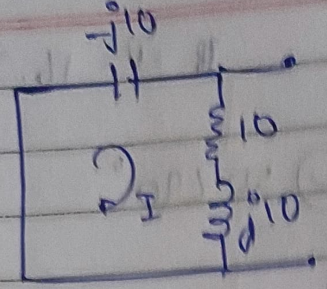


$$I = \frac{100\angle 0}{10} = 10$$

$$V_{th} = 10(10+j10)$$

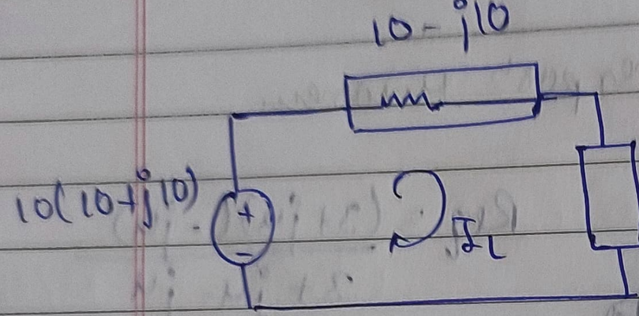
$I_L = 5\angle 90$

$P = 250W$



$$Z_{th} = \frac{(10+j10)(-j10)}{10+j10-j10}$$

$$= -10j + 10$$



$$I_L = \frac{(10+j10)}{10-j10}$$