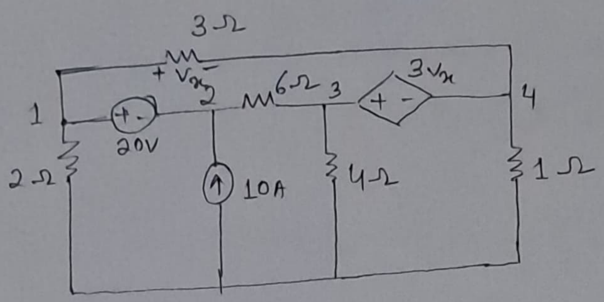
Q1



At Supernode 1-2,

KCL $\quad i_3 + 10 = i_1 + i_2$

Or node voltages; $\quad \dfrac{V_3 - V_2}{6} + 10 = \dfrac{V_1 - V_4}{3} + \dfrac{V_1}{2}$

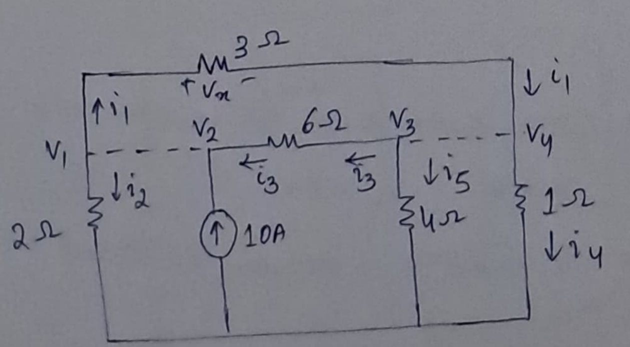
$$\Rightarrow 5V_1 + V_2 - V_3 - 2V_4 = 60 \quad \text{——} (1)$$

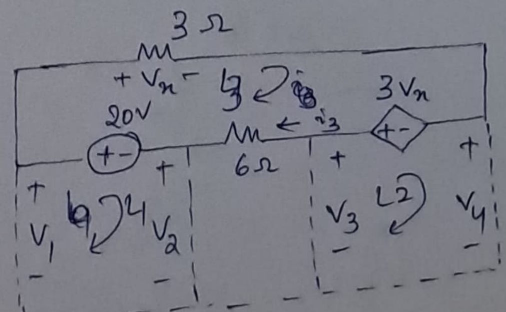
At Supernode 3-4,

$$i_1 = i_3 + i_4 + i_5$$

$$\Rightarrow \frac{V_1 - V_4}{3} = \frac{V_3 - V_2}{6} + \frac{V_4}{1} + \frac{V_3}{4}$$

$$\Rightarrow 4V_1 + 2V_2 - 5V_3 - 16V_4 = 0 \quad \text{——} (2)$$





For Loop 1 $\quad -V_1 + 20 + V_2 = 0 \Rightarrow V_1 - V_2 = 20 \quad \text{——} (3)$

L2 $\quad -V_3 + 3V_x + V_4 = 0 \quad (\because V_x = V_1 - V_4)$

$$\Rightarrow 3V_1 - V_3 - 2V_4 = 0 \quad \text{——} (4)$$

L3 $\quad V_x - 3V_x + 6i_3 - 20 = 0 \quad (\because 6i_3 = V_3 - V_2;\ V_x = V_1 - V_4)$

$$\Rightarrow -2V_1 - V_2 + V_3 + 2V_4 = 20 \quad \text{——} (5)$$

→ So, total '5' equations but '4' unknowns
(V_1, V_2, V_3, V_4)

Substituting '3' in '1' & '2'.

$$6V_1 - V_3 - 2V_4 = 80 \quad -(6)$$

and

$$6V_1 - 5V_3 - 16V_4 = 40 \quad -(7)$$

eqn (4), (6) & (7) in matrix form

$$\begin{bmatrix} 3 & -1 & -2 \\ 6 & -1 & -2 \\ 6 & -5 & -16 \end{bmatrix} \begin{bmatrix} V_1 \\ V_3 \\ V_4 \end{bmatrix} = \begin{bmatrix} 0 \\ 80 \\ 40 \end{bmatrix}$$

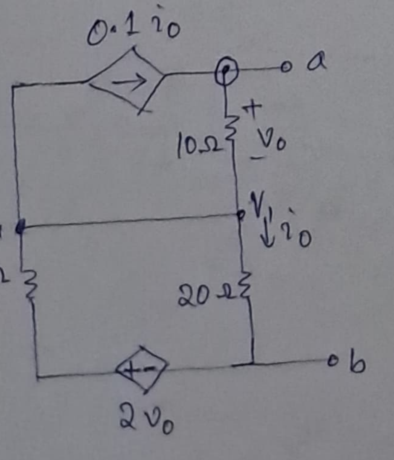
By solving it ⇒ $V_1 = 26.67\,V$

$V_3 = 173.33\,V$

$V_4 = -46.67\,V.$

Then $V_2 = V_1 - 20 = 6.667\,V.$

Q2

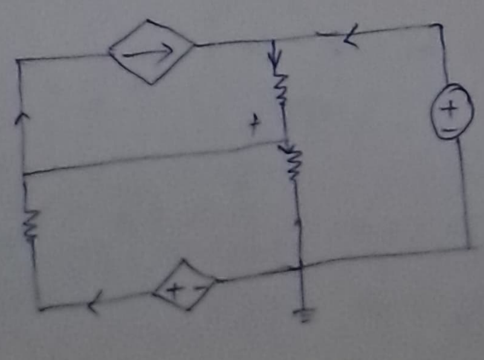


* Since there are no independent sources, $V_{th} = 0V$.

* To obtain R_{th}, consider the circuit below.

This is doubt. How 1V ??

→



At node 2

$i_x + 0.1\,i_o = (1 - V_1)/10$

or $10 i_x + i_o = 1 - V_1 \quad -(1)$

node 1

$$V_1/20 + 0.1\,i_o = \frac{(2v_o - V_1)}{40} + \frac{(1 - V_1)}{10} \quad -(2)$$

$i_o = \frac{V_1}{20}$ and $V_0 = 1 - V_1$

eq^n (2)

$1.1\, V_1/20 = [(2-3V_1)/40] + [(1-V_1)/10]$

$\Rightarrow 2.2V_1 = 2 - 3V_1 + 4 - 4V_1 = 6 - 7V_1$

$\Rightarrow V_1 = 6/9.2$ — (3)

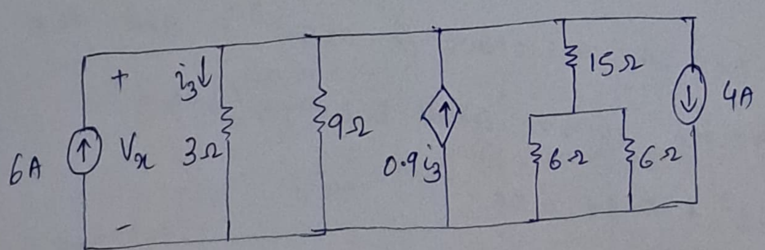
eq^n (1) & (3)

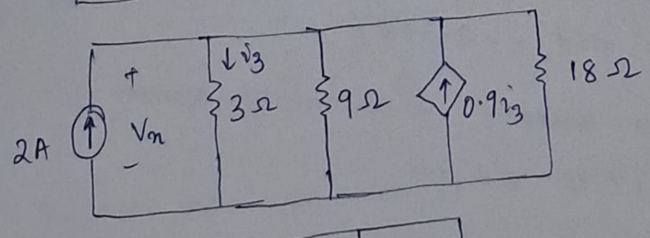
$10\, i_x + \frac{V_1}{20} = 1 - V_1$

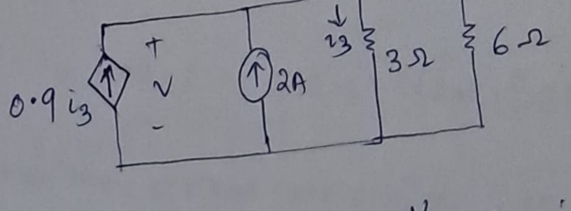
$\Rightarrow 10 i_x = 1 - V_1 - \frac{V_1}{20} = 1 - \left(\frac{21}{20}\right) V_1 = 1 - \left(\frac{21}{20}\right)(6/9.2)$

$\Rightarrow i_x = 31.52$ mA ; $R_{th} = \frac{1}{i_x} = 31.73$ ohms.

(4)







$-0.9 i_3 - 2 + i_3 + \frac{V}{6} = 0$; $V = 3 i_3$

$\Rightarrow i_3 / 2$

$\Rightarrow i_3 = \frac{10}{3}$ A

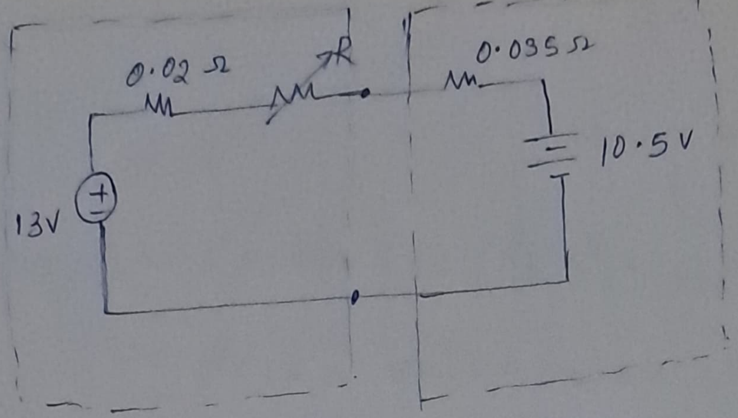
$V = 3 i_3 = 10$V

* Power Dependent Source $= V \times 0.9 i_3 \Rightarrow 10\,(0.9)\left(\frac{10}{3}\right)$

$= 30$W

Then Tellegence Theorem

Q5



Battery Charger

Battery

'R' = ? (a) Charging current of 4A flows

$-13 + 0.02i + Ri + 0.035i + 10.5 = 0$

required $i = 4A$; $R = 570\,m\Omega$.

(b) The total power delivered to the battery consists of the power absorbed by the 0.035 Ω resistance $(0.035\,i^2)$ and the power absorbed by the 10.5 V ideal battery $(10.5\,i)$.

$0.035\,i^2 + 10.5\,i = 25$

$i = -302.4\,A$ and $i = 2.362\,A$

idea is to charge the battery ⇒ absorbing power ⇒ 'i' is positive

$i = 2.362A$

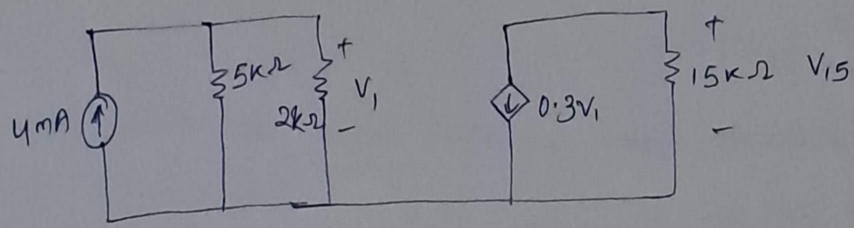
$R = [13 - 10.5 - 0.055(2.362)] / 2.362 = 1.003\,\Omega$

(c) To obtain a voltage of 11 V across the battery, we apply KVL

$0.035i + 10.5 = 11$ so that $i = 14.29\,A$

$R = [13 - 10.5 - 0.055(14.29)] / 14.29 = 119.9\,m\Omega$

Q6



$$P_{15\Omega} = \frac{(V_{15})^2}{15\times10^3}$$

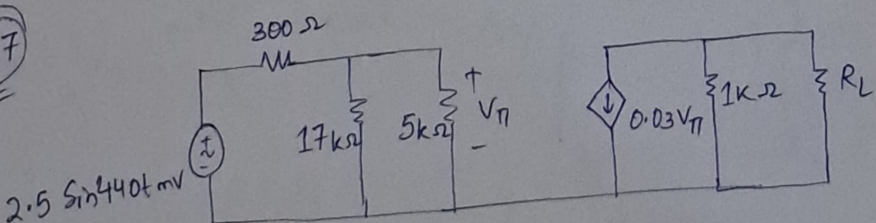
$$V_{15} = 15\times10^3\,(-0.3V_1)$$

where $V_1 = [4\times5/5+2]\cdot2 = 5.714\ V$

Therefore $V_{15} = -25714\ V$

and $P_{15} = 44.08\ kW$

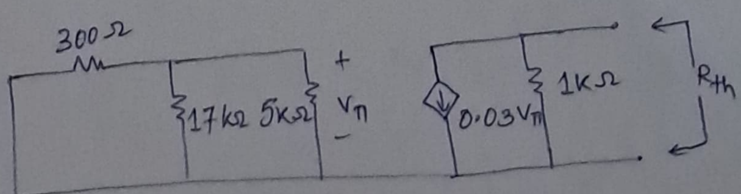
Q7



MPT for R_L

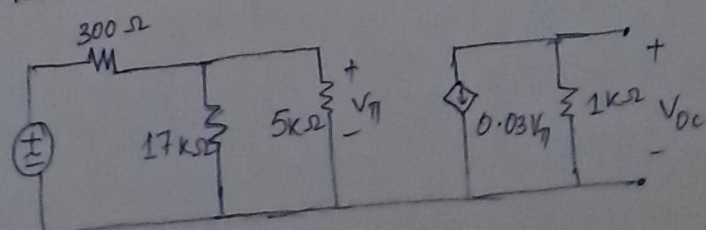
→ Thevenin eqⁿ → since it is asked 'R_L'

(ckt 1) S.C



(ckt 2)

2.5 Sin440t mV



(Ckt 1)

Since $V_\pi = 0$, the dependent current source is an open ckt

$R_{th} = 1k\Omega$

so, in order to obtain maximum power delivered on to the load

R_L should be set to $\boxed{R_{th} = 1k\Omega}$

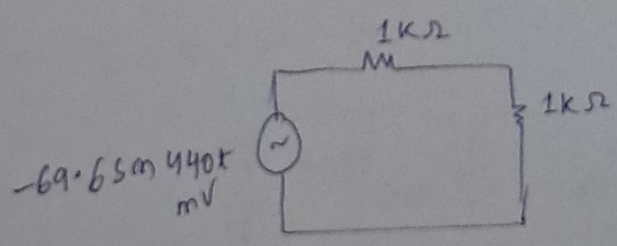
(Ckt 2)

$V_{oc} = -0.03 V_\pi (1000) = -30 V_\pi$

V_π can be found from voltage division

$V_\pi = (2.5 \times 10^{-3} \sin 440t) \left(\dfrac{3864}{300 + 3864} \right)$

$V_{oc} = -69.6 \sin 440t$ mV



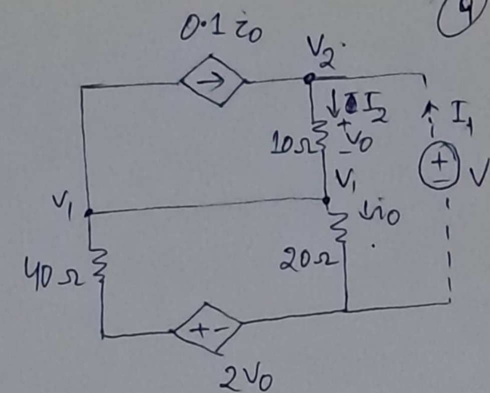
$P_{max} = \dfrac{V_{th}^2}{4R_{th}}$

$= 1.211 \sin^2 440t$ μW

(9) No. of loops $= b - n + 1$

$= 8 - 5 + 1 = 4$ (minimum no. of eqn)

Q2 (4)



$R_{th} = \frac{V}{I_1}$

$I_2 = I_1 + 0.1 i_0$ —— (1)

$V_0 = I_2 \times 10\Omega = (I_1 + 0.1 i_0)\,10$ —— (2)

$V_2 - V_0 = V_1$ —— (3)

$\cancel{V = V_2 - V_0 - V_1 - 20 i_0}$ —— (4)

$I_1 + 0.1 i_0 = \frac{V_2 - V_1}{10}$ —— (5)

$\Rightarrow \boxed{10 I_1 + 0.1 i_0 = V_2 - V_1}$ —— (6)

$\boxed{\frac{V_1}{20} + 0.1 i_0 = \frac{2V_0 - V_1}{40} + \frac{V_2 - V_1}{10}}$ —— (7)

$i_0 = \frac{V_1}{20}$; $V_0 = V_2 - V_1$

$10 I_1 + 0.1 i_0 = V_2 - \frac{i_0}{20}$

$\Rightarrow 200 I_1 + 2 i_0 = 20 V_2 - i_0 \Rightarrow 200 I_1 + 3 i_0 = 20 V_2$

$\frac{20 i_0}{20} + 0.1 i_0 = \frac{2V_0 - 20 i_0}{40} + \frac{V_0}{10}$

$\Rightarrow 1.1 i_0 = \frac{2V_0 - 20 i_0 + 4V_0}{40} \Rightarrow 1.1 i_0 \times 40 = 6V_0 - 20 i_0$

$\Rightarrow 44 i_0 + 20 i_0 = 6 V_0$

$\Rightarrow \boxed{64/6\; i_0 = V_0}$

$\boxed{\frac{V_0}{i_0} = \frac{64}{6}}$

$200 I_1 + 3 i_0 = 20V - 400 i_0 + 20 V_1$

$\Rightarrow 200 I_1 + 403 i_0 = 20V + 20V_1$

$\Rightarrow 200 I_1 + 403 i_0 = 20V + 400 i_0$

$\Rightarrow 200 I_1 + 3 i_0 = 20V$

$\Rightarrow 200 + 3\frac{i_0}{I_1} = 20 R_{th}$

$i_0 = \frac{V_1}{20}$

$\Rightarrow \boxed{R_{th} = 10 + 3\frac{i_0}{I_1}}$

$\boxed{V = V_0 + 20 i_0}$

$R_{th} = 10 + \frac{3 i_0}{0.1 i_0 + I_2}$

$R_{th} = 10 + \frac{3 i_0}{0.1 i_0 + \frac{V_0}{10}}$

$= 10 + \frac{30 i_0}{i_0 + V_0}$

$= \frac{40 i_0 + 10 V_0}{i_0 + V_0}$

$\Rightarrow \boxed{R_{th} = \frac{40 + 10 V_0/i_0}{1 + V_0/i_0}}$

$\Rightarrow 200 I_1 + 3 i_0 = 20(V_0 + V_1)$

$\Rightarrow 200 I_1 + 3 i_0 = 20(V - 20 i_0 + V_1)$

$$R_{th} = \frac{40 + 10\left(\frac{64}{6}\right)}{1 + \left(\frac{64}{6}\right)}$$

$$= \frac{40 + \frac{640}{6}}{1 + \frac{64}{6}} = \frac{\frac{240 + 640}{\cancel{6}}}{\frac{69}{\cancel{6}}} = \frac{880}{69}$$

$$= 12.75 \text{ ohm}$$