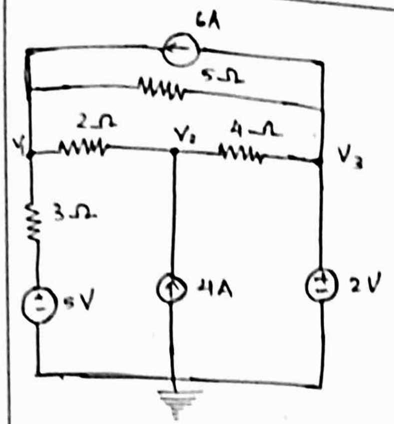
22/11/2021

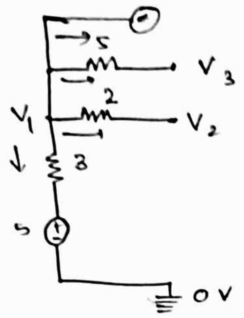
Module - 1

Qn 1)



using nodal method, find the current through the resistors in the circuit.

consider 1st node



$V_3 = 2V$

$$\frac{V_1 - 5}{3} + \frac{V_1 - V_2}{2} + \frac{V_1 - V_3}{5} - 6 = 0$$

$$\frac{V_1 - 5}{3\times 2} + \frac{V_1 - V_2}{2\times 3} + \frac{V_1 - 2}{5} = 6$$

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

$$\cancel{4V_1 - 10 + 5V_1 - 5V_2 = 60}$$

$$\cancel{9V_1 - 5V_2 = 70}$$

$$\frac{2V_1 - 10 + 3V_1 - 3V_2}{6} + \frac{V_1 - 2}{5} = 6$$

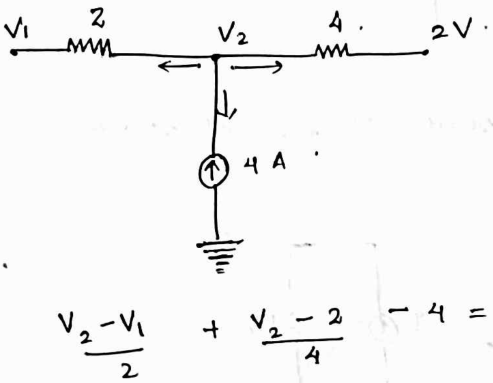
$$\frac{5V_1 - 3V_2 - 10}{6} + \frac{V_1 - 2}{5} = 6$$

$$3\ \cancel{5V_1 - 3V_2}$$

$$25V_1 - 15V_2 - 50 + 6V_1 - 12 = 180$$

$$31V_1 - 15V_2 = 242$$

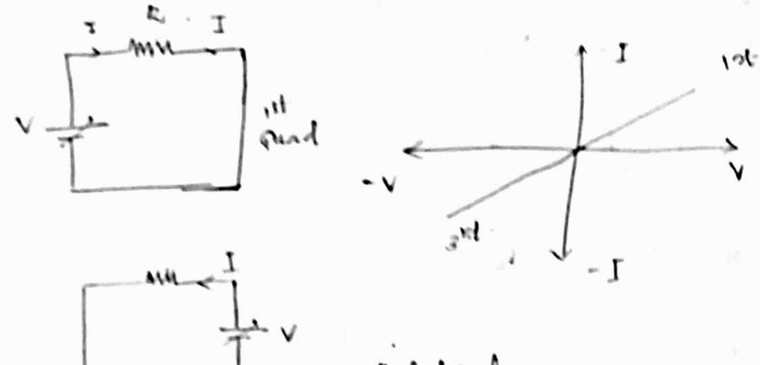
consider 2nd node



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

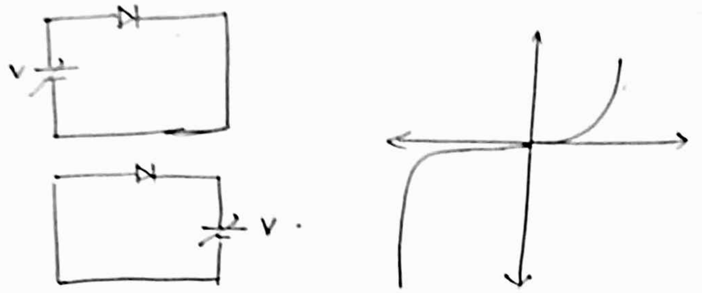
$$2V_2 - 2V_1 + V_2 - 2 = 16$$

$$3V_2 - 2V_1 = 18$$



Bilateral

The graph on the 1st & 3rd quadrant are the same
∴ Bilateral

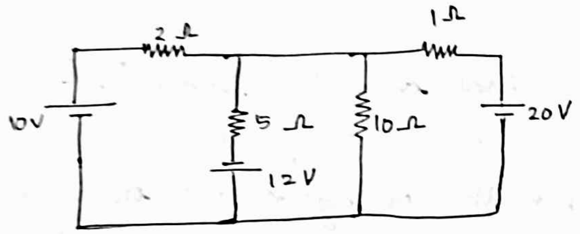


Lateral

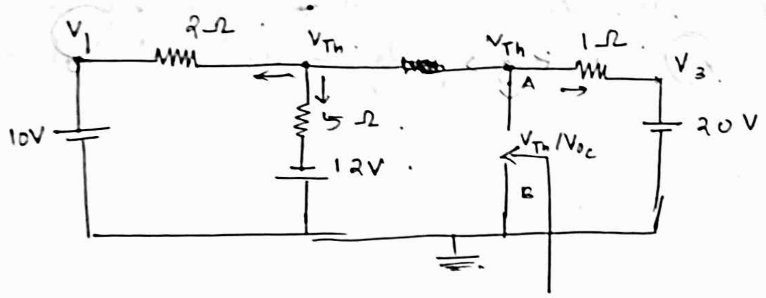
The graph on the 1st & 3rd quadrant are different.
∴ Unilateral

Thevenine theorem can be applied only to → linear and bilateral.

Sn 3)



Find the current through the 10 Ω resistor, utilizing Thevenins theorem.



$V_1 = 10V$, $V_3 = 20V$, wrt the reference.

$$\frac{V_{Th}+12}{5} + \frac{V_{Th}-10}{2} + \frac{V_{Th}-V_3}{1} = 0$$

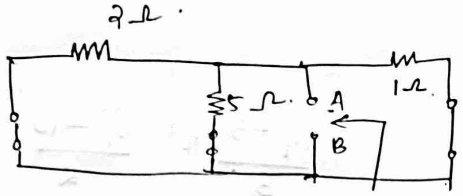
$$\frac{2V_{Th}+24+5V_{Th}-50}{10} + V_{Th}-20 = 0$$

$$7V_{Th} - 26 + 10V_{Th} - 200 = 0$$

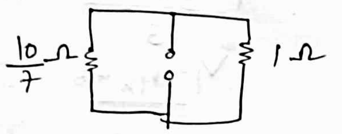
$17 V_{Th} = 226$

$V_{Th} = 13.29V$

short all the voltages

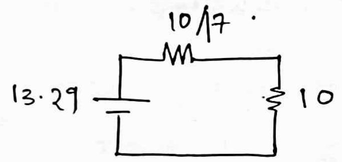


$2 \parallel 5$



$\frac{10}{7} \parallel 1$

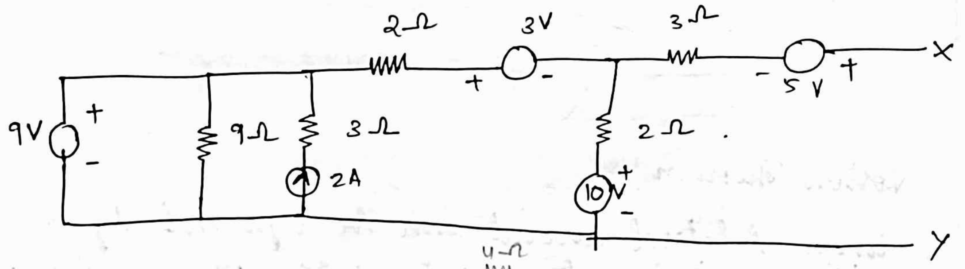
$\therefore R_{Th} = 0.588\,\Omega$

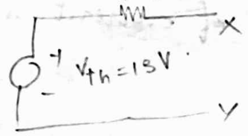


$R = \frac{10}{17} + 10 = \frac{180}{17}$

$I = \frac{13.29}{180/17} = 1.255\text{ A}$

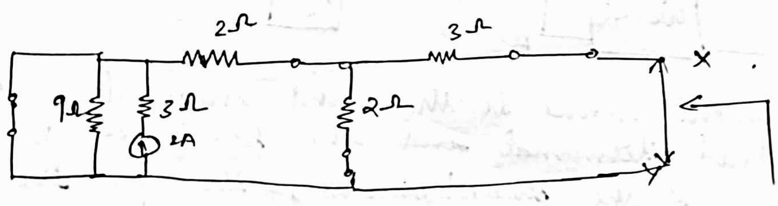
Qn 4)





Find the Thevenins equivalent circuit

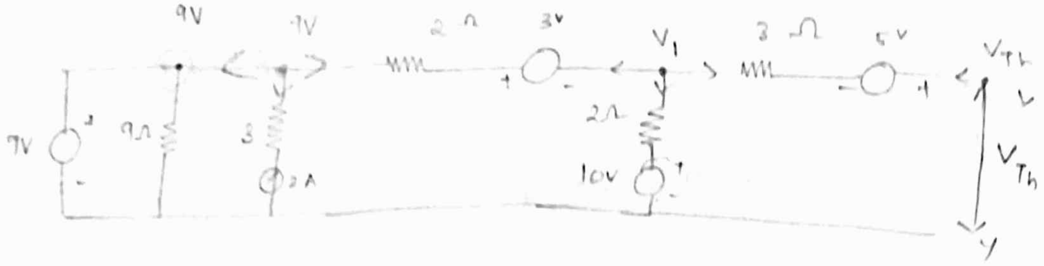
To find R_{Th}



$2 \parallel 2 = 1$

$1 + 3 = 4$

$\therefore R_{Th} = 4\,\Omega$



$$\frac{V_{Th}-5-V_1}{3}=0$$

$$V_{Th}-V_1=5 \quad -(1)$$

$$\frac{V_1+5-V_{Th}}{3}+\frac{V_1-10}{2}+\frac{V_1+3-9}{2}=0$$

$$\frac{V_1-V_{Th}+5}{3}+\frac{2V_1-16}{2}=0$$

$$\frac{V_1-V_{Th}+5}{3}+V_1-8=0$$

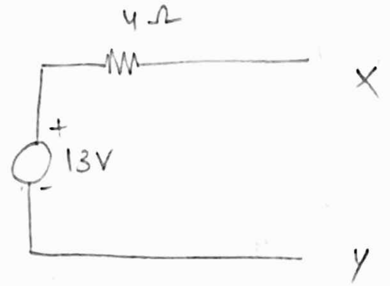
$$V_1-V_{Th}+5+3V_1-24=0$$

$$-V_{Th}+4V_1=19 \quad -(2)$$

On solving

$V_{Th} = 13\,V$

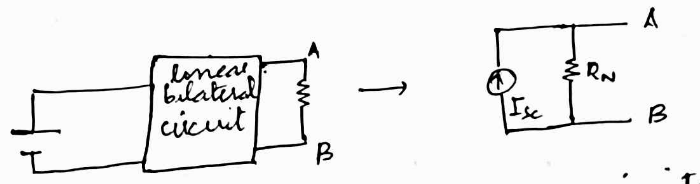
$V_1 = 8\,V$.



1/12/2021

Norton Theorem

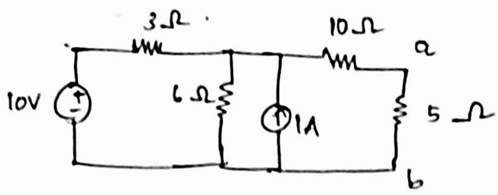
A linear bilateral circuit can be replaced by an equivalent circuit consisting of current source in parallel with a resistance.

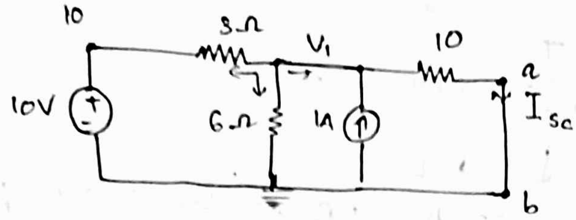


The current source be the short circuited current through the load terminal and the resistance be the internal resistance of the source network looking through the open circuited load terminal.

$R_N = R_{Th}$

Qn 1) Find the Norton current in the 5 Ω resistance using Norton Theorem





$$\frac{V_1 - 10 \times 2}{3 \times 2} + \frac{V_1}{6} - 1 + I_{sc} = 0 \quad \text{— (1)}$$

$$\frac{2V_1 - 20 + V_1}{6} - 1 + I_{sc} = 0$$

$$3V_1 - 20 - 6 + 6I_{sc} = 0$$

$$3V_1 + 6I_{sc} - 26 = 0$$

$$3V_1 + 6I_{sc} = 26$$

$$I_{sc} = \frac{V_1}{10} \quad \text{— (2)}$$

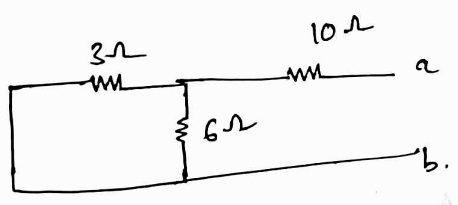
$$3V_1 + \overset{3}{\cancel{6}} \times \frac{V_1}{\cancel{10}\,5} = 26$$

$$\frac{15V_1 + 3V_1}{5} = 26$$

$$18V_1 = 130$$

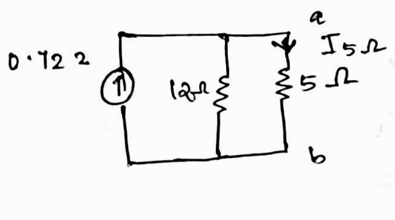
$$V_1 = 7.2 \text{ V}$$

$$I_{sc} = 0.722 \text{ A}$$



$$3 \| 6 \quad \frac{\overset{2}{\cancel{6}} \times 3}{\cancel{9}\,3} = 2$$

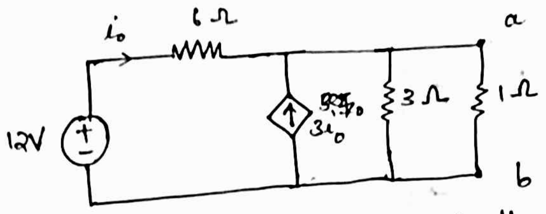
$$2 + 10 = 12\ \Omega$$



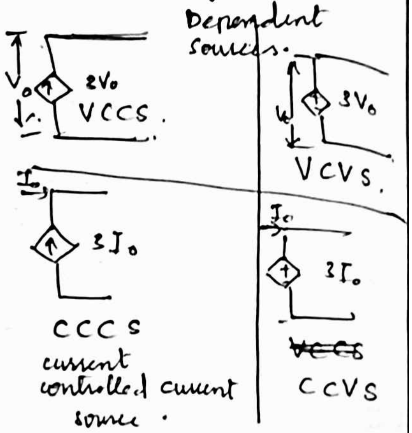
$$I_{5\Omega} = \frac{0.722 \times 12}{12+5}$$

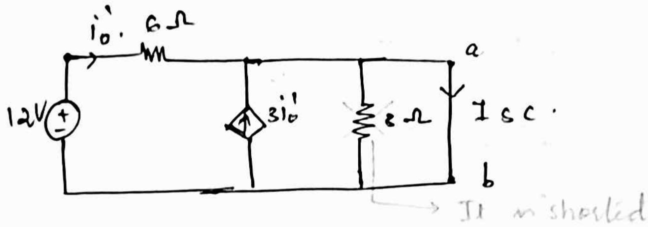
$$= 0.5096 \text{ A}$$

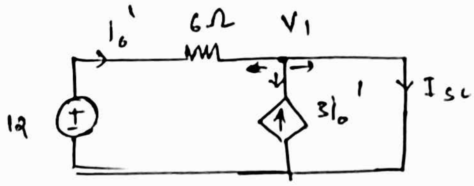
Qn 2)



Find the current through the 1Ω resistance using Norton Theorem.







$$\frac{V_1 - 12}{6} = -i_o'$$

$$\frac{V_1 - 12}{6} - 3i_o' + I_{sc} = 0$$

$$-i_o' - 3i_o' + I_{sc} = 0$$

$$-4i_o' + I_{sc} = 0$$

$$I_{sc} = 4i_o' \quad —(1)$$

$V_1 = 0$

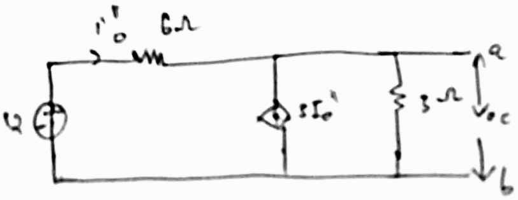
$$-i_o' = \frac{V_1 - 12}{6}$$

$$i_o' = \frac{12 - V_1}{6}$$

$$i_o' = \frac{12}{6} = 2 \text{ A}$$

$$I_{sc} = 4 \times 2 = 8\text{A}$$

$$R_N = \frac{V_{oc}}{I_{sc}}$$



$$\frac{V_{Th} - 0}{3} + \frac{V_{Th} - 12}{6} - 3 i_0 = 0$$

$$\frac{V_{Th}}{3} - i_0' - 3 i_0'' = 0$$

$$\frac{V_{Th}}{3} = 9 i_0''$$

$$V_{Th} = 12 i_0''$$

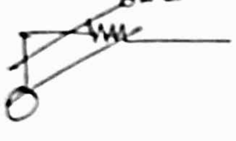
$$V_{Th} = \cancel{12}^{2} \left(\frac{12 - V_{Th}}{6} \right)$$

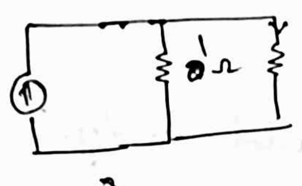
$$V_{Th} = 24 - 2V_{Th}.$$

$$3V_{Th} = 24$$

$$\underline{\underline{V_{Th} = 8V}}$$

$$R_N = \frac{V_{Th}}{I_{sc}} = \frac{8V}{8A} = \underline{\underline{1\Omega}}.$$

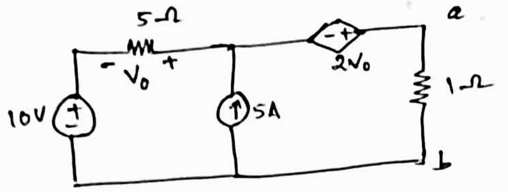




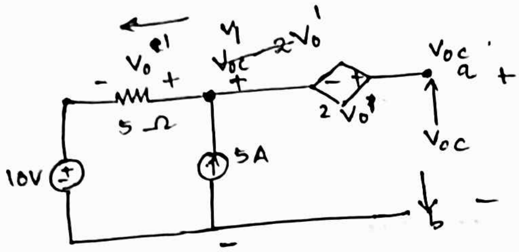
$$I_{1\Omega} = \frac{\cancel{8}^{2} \times 3}{\cancel{4}} = \frac{8 \times 1}{2} = \underline{\underline{4\ A}}$$

Alternate method

Qn 3)



Find the current through the 1Ω resistor using Norton theorem.



$\cancel{V_{oc} - 2V_0'}$

$\frac{V_0' - 10}{5} + 5 = 0$

$\cancel{V_0' \frac{-10}{5} + 2V_0'}$

$\frac{V_0' - 10}{5} = 5$

$V_0' - 10 = 25$

$V_0' = \cancel{35}$

$\cancel{\frac{V_0' - 10}{5} - 5 = 0}$

$\cancel{V_0'}$

$i_{5\Omega} = \frac{V_0'}{5}$

Applying nodal analysis

$\cancel{\frac{V_0'}{5} - 5 = 0}$

$\cancel{\frac{V_0'}{5} = 5}$

$\cancel{V_0' = 25V}$

$\frac{V_0'}{5} - 5 = 0$

$V_0' = 25V$

25 - 10

$10 + 25 - V_1 = 0$

$V_1 = 35$

$\cancel{V_{oc} - 2V_0' = \frac{V_0' - 10}{5}}$

$\cancel{V_{oc} - 50 =}$

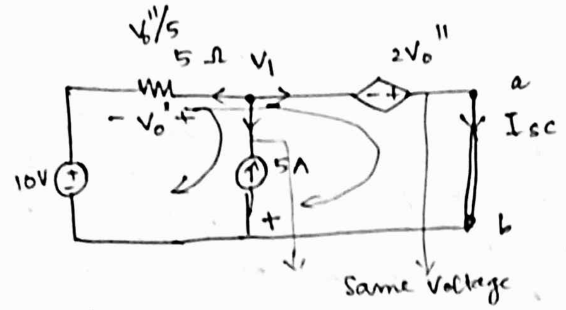
$V_1 = V_{oc} - 2V_0'$

$V_{oc} = V_1 + 2V_0'$

$= 35 + 2 \times 25$

$= 50 + 35$

$= 85V$



|| branches have same polarity.

$$\frac{V_0''}{5} - 5 + I_{sc} = 0$$

$$I_{sc} = 5 - \frac{V_0''}{5} \quad \text{—(1)}$$

V_0''

$$10 + V_0'' + 2V_0'' = 0$$

$$10 + V_0'' + 2V_0'' = 0$$

$$3V_0'' = -10$$

$$V_0'' = \frac{-10}{3}$$

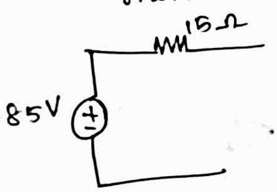
$$I_{sc} = 5 - \frac{-10}{3\times5}$$

$$= 5 + \frac{10}{3\times5}$$

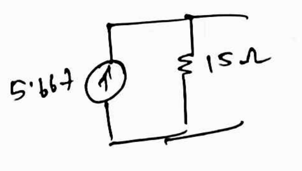
$$= \frac{15+10}{3} = \frac{25}{3} \qquad 5.667\ \text{A}$$

$$R_N = \frac{V_{oc}}{I_{sc}} = \frac{85}{17/3} = \frac{85\times3}{17} = 15\ \Omega$$

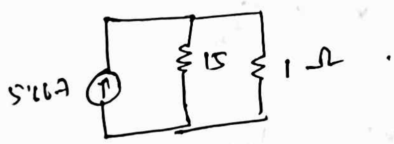
Thevenin's



Norton

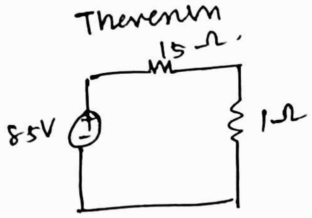


Norton



$$I_{1\Omega} = \frac{5.667\times15}{16} = 5.3\ \text{A}$$

Thevenin



$$R = 15 + 1 = 16\ \Omega$$

$$I = \frac{V}{R} = \frac{85}{16} = 5.3\ \text{A}$$

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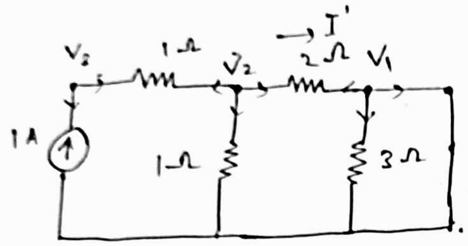
Superposition Theorem

If a number of voltage or current sources are active simultaneously, the resultant current in any branch is the algebraic sum of the currents that ~~will~~ would be produced in it when each source act alone replacing all other independent sources by their internal impendance.

Qn 1)

Find the current I in the circuit using superposition theorem.



The voltage source is shorted

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

$$2V_1 + 3V_1 - 3V_2 = 0$$

$$5V_1 - 3V_2 = 0$$

$$\frac{V_2}{1} + \frac{V_2 - V_1}{2} + \frac{V_2 - V_3}{1} = 0$$

$$\frac{2V_2 - V_3}{1} + \frac{V_2 - V_1}{2} = 0$$

$$4V_2 - 2V_3 + V_2 - V_1 = 0$$

$$-V_1 + 5V_2 - 2V_3 = 0$$

$\cancel{V_3}$

$$\frac{V_3 - V_2}{1} - 1 = 0$$

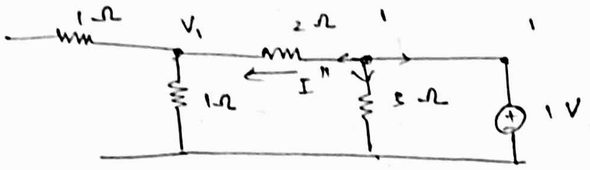
$$V_3 - V_2 = 1$$

$V_1 = \cancel{1/2}$ $\quad$ $V_2 = \cancel{5/6}$. $V_3 = 11/6$

$I' = \cancel{V_2 - V}$ $\frac{V_2 - V_1}{2} =$

$$I' = \frac{1 \times 1}{1+2} = \underline{\underline{1/3}}$$

The current source is opened.



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

$$V_1 - 1 + 2V_1 = 0$$

$$3V_1 = 1$$

$$V_1 = 1/3$$

$$I'' = \frac{1 - V_1}{2}$$

$$= 1/3\ A$$

$$\cancel{\frac{1 - V_1}{2} + \frac{1}{3} = 0}$$

$$\cancel{I'' = 1/3\ A}$$

$$\cancel{V_1 = 1}$$

$$\therefore I'' = 1/3\ A$$

$$\cancel{I = I' - I''}$$

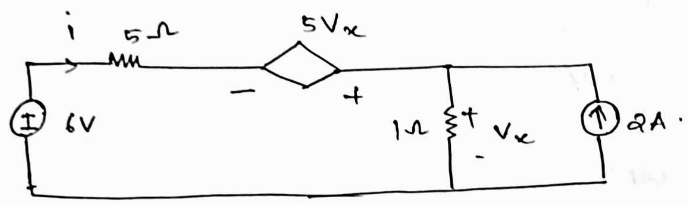
$$\cancel{= \frac{1}{3} + \frac{1}{2}}$$

$$\cancel{= \frac{1}{3}\ A}$$

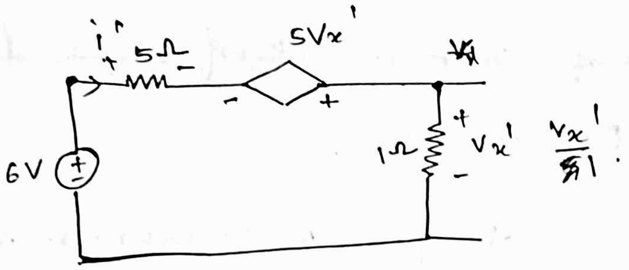
$$I = I' - I''$$

$$= 0$$

Qn 2)



Find current I using ~~supp~~ super position.



$$6 + 5V_x' - 5i' - V_x' = 0$$

$$4V_x' - 5i' = -6 \quad \text{—} (1)$$

$$V_x' = i'$$

$$\cancel{\frac{V_1}{1} + \frac{V_1 - 5V_x' - 6}{5} = 0}$$

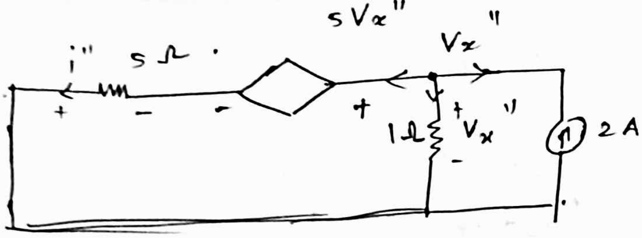
$$5V_1 + V_1 - 5V_x' = 6$$

$$6V_1 - 5V_x' = 6$$

$$4i' - 5i' = -6$$

$$-i' = -6$$

$$i' = 6\ A$$



i =

$$-5V_x'' - 5i'' + \frac{V_x''}{1} = 0$$

$$\cancel{-6V_x'' + 5i'' = 2}$$

$$-5V_x'' + V_x'' - 5i'' = 0$$

$$-4V_x'' = 5i''$$

$$V_x'' = -\frac{5i''}{4}$$

$$i'' - \frac{5i''}{4} = 2$$

$$(4-5)\,i'' = 8$$

$$\underline{i'' = -8\ A}$$

$$i = i' - i''$$
$$= 6 + 8$$
$$= \underline{14A}$$

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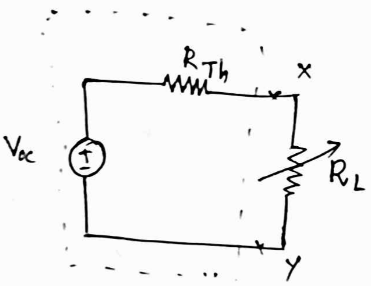
Imp for Exam

Maximum Power Transfer Theorem (Proof required)

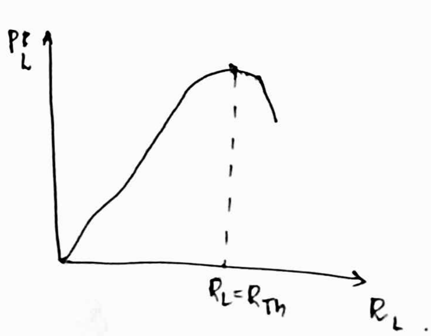
DC Analysis



The power is maximum when $R_{Th} = R_L$

$$P_L = I_L^2 R_L$$

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



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

$$P_L = \frac{V_{oc}^2 R_L}{(R_{Th}+R_L)^2}$$

$$\frac{dP_L}{dR_L} = \frac{(R_{Th}+R_L)^2 V_{oc}^2 - 2(R_{Th}+R_L) V_{oc}^2 R_L}{(R_{Th}+R_L)^4} = 0$$

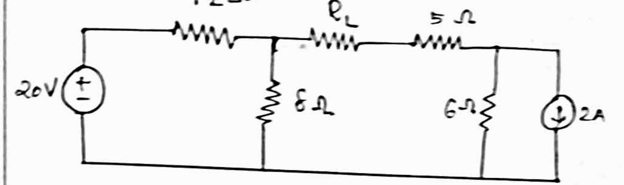
$$(R_{Th}+R_L) V_{oc}^2 (R_{Th}+R_L-2R_L) = 0$$

$$-R_L + R_{Th} = 0$$

$\boxed{R_{Th} = R_L.}$, at this condition power is maximum

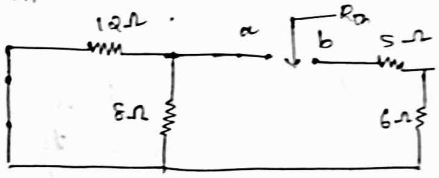
Here A resistance load be connected to a dc network receives maximum power when the load resistance (R_L) is equal to the Thevenin equivalent resistance (R_{Th}). $\boxed{P_{max} = V_{oc}^2/4R_{Th}}$

Qn 1)



What is the maximum power that would be dissipated in the resistance R_L?

R_{Th}



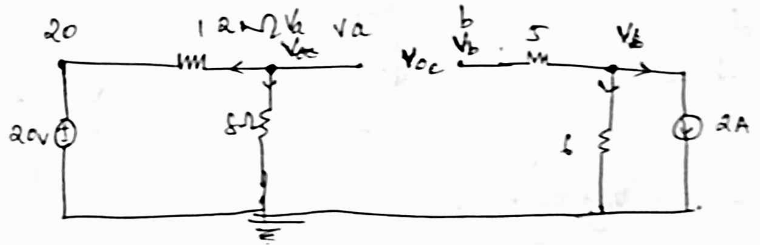
Using Thevenin's Theorem.

$R_{Th} = \cancel{\frac{12\times8}{12+8}} +$

$12 \| 8 = \frac{24}{5}\ \Omega$

$5 \& 6 = 11\ \Omega$.

$\frac{24}{5} + 11 = 15.8\ \Omega$

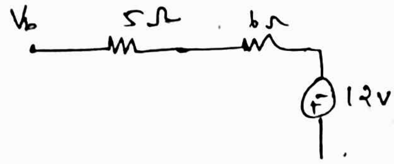


$$\frac{V_a - 20}{12} + \frac{V_a}{8} = 0$$

$$8V_a - 160 + 12V_a = 0$$

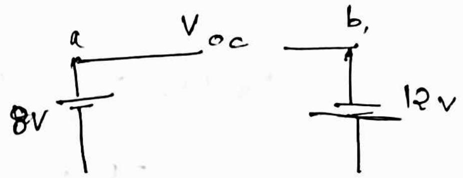
$$20V_a = 160$$

$$V_a = 8\ V$$

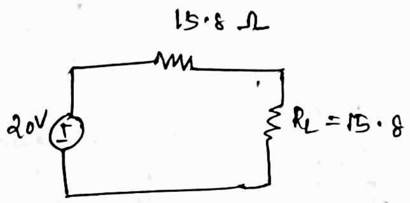


$$\frac{V_b + 12}{11} = 0$$

$$V_b = -12$$



$$V_{oc} = V_a - V_b$$
$$= 8 + 12$$
$$= 20V$$

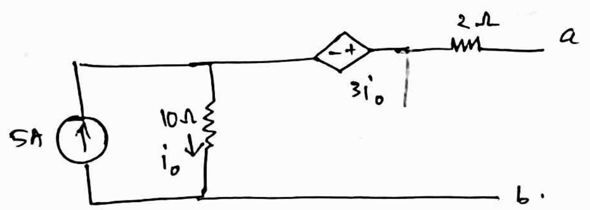


$$P = \frac{V_{oc}^2}{4R_{Th}} = \frac{20^2}{4 \times 15.8}$$

$$= 6.329\ W$$
$$= 6.33W$$

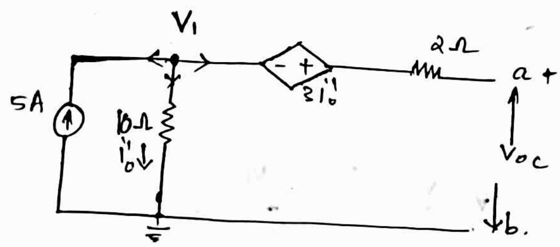
Q7

2)



Find the maximum power that can be drawn from the circuit across a & b.

Since there is ~~an~~ dependent source, we have to perform both Thevenin and Nortons Theorem.



$$\frac{V_1}{10} = i_0'$$

$$V_1 = 10 i_0'$$

$$\frac{V_1 - 0}{10} - 5 + \frac{V_1 + 3i_0' - V_{Th}}{2} = 0$$

$$i_0' - 5 + \frac{V_1 + 3i_0 - V_{Th}}{2} = 0$$

$$2i_0' - 10 + V_1 + 3i_0' - V_{Th} = 0$$

$$2i_0' - 10 + 10i_0' + 3i_0' - V_{Th} = 0$$

$$15 i_0' - V_{Th} = 10$$

$$\frac{V_{Th} - 3i_o' - V_1}{2} = 0$$

$$V_{Th} - 3i_o' - 10i_o' = 0$$

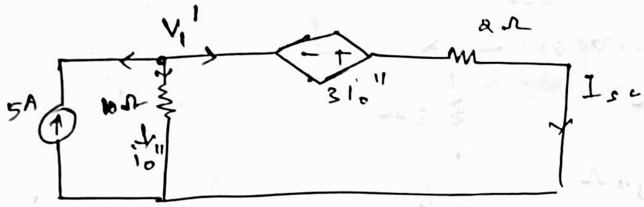
$$V_{Th} = 13i_o'$$

$$15i_o' - 13i_o' = 10$$

$$2i_o' = 10$$

$$i_o' = 5A$$

$$V_{Th} = 65V$$



$$\frac{V_1' - 0}{10} = i_o''$$

$$V_1' = 10i_o''$$

$$\frac{V_1' - 0}{10} - 5 + I_{sc} = 0$$

$$i_o'' - 5 + I_{sc} = 0$$

$$I_{sc} = 5 - i_o''$$

5

~~$V_1' = 10i_o''$~~

$$5 + \frac{V_1 + 3i_o''}{2} - I_{sc} = 0$$

$$10 + V_1 + 3i_o'' = 2I_{sc}$$

$$10 + 10i_o'' + 3i_o'' = 2I_{sc}$$

$$\frac{13i_o'' + 10}{2} = I_{sc}$$

$$5 - i_o'$$

$$\frac{V_1' - 0}{10} - 5 + I_{sc} = 0$$

$$I_{sc} = 5 - i_o''$$

$$5 - i_o'' = \frac{13i_o'' + 10}{2}$$

$$10 - 2i_o'' = 13i_o'' + 10$$

$$V_1' = 10i_o''$$

$$-5 + \frac{V_1' - 0}{10} + \frac{V_1' + 3i_o''}{2} = 0$$

$$-5 + \frac{10i_o''}{10} + \frac{10i_o'' + 3i_o''}{2} = 0$$

$$-5 + i_o'' + \frac{13i_o''}{2} = 0$$

$$-10 + 2i_o'' + 13i_o'' = 0$$

$$15i_o'' = 10 \qquad i_o'' = 2/3.$$

$$\frac{V_1' + 3i_o''}{2} = I_{sc}$$

$$I_{sc} = \frac{13 \times \frac{2}{3}}{2} = \frac{26}{2 \times 3} = \frac{13}{3} A$$

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

$$R_{Th} = \frac{V_{oc}}{I_{sc}} = \frac{65}{13/3} = \underline{\underline{15\,\Omega}}$$

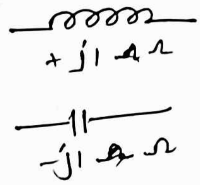
$$P_{max} = \frac{65^2}{4 \times 15} = \underline{\underline{70.416\text{ W}}}$$

15/12/2021

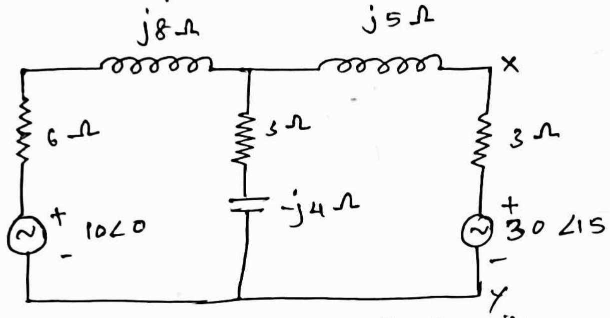
AC analysis.

$x + jy$ - rectangular

$r\angle\theta$ - polar

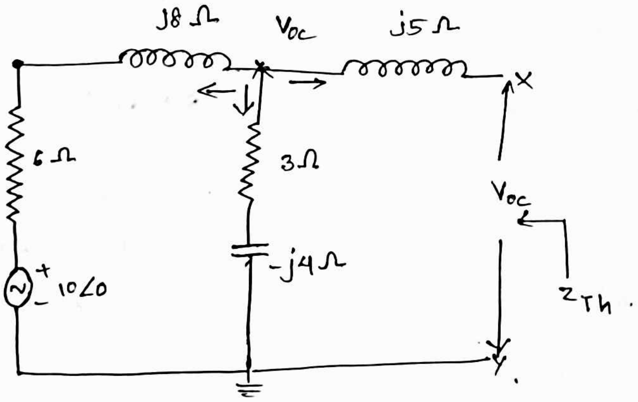


Qn 1)



The polarity given is at an instant.

Obtain Thevenin equivalent with respect to the terminal X Y



$$\frac{V_{oc} - 0}{3-4j} + \frac{V_{oc} - 10}{6+8j} = 0$$

$$\frac{V_{oc}}{3-4j} + \frac{V_{oc}}{6+8j} - \frac{10}{6+8j} = 0$$

$$\frac{V_{oc}}{3-4j} + \frac{V_{oc}}{6+8j} = \frac{10}{6+8j}$$

$$V_{oc}\left[\frac{1}{3-4j} + \frac{1}{6+8j}\right] = \frac{10}{6+8j}$$

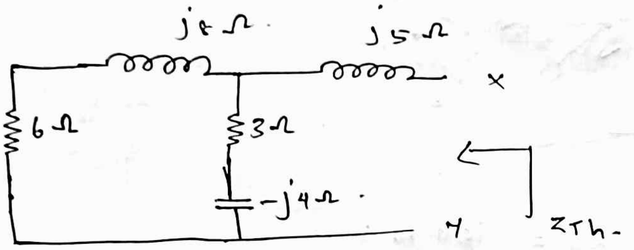
$$V_{oc}\left[\frac{6+8j+3-4j}{(6+8j)(3-4j)}\right]=\frac{10}{6+8j}$$

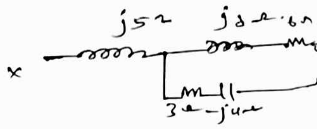
$$V_{oc}=\frac{10(3-4j)}{9+j4}$$

$$=1.13-4.94j$$

$$=\cancel{50}$$

$$=5.076\angle -77.092\,V$$





$$\frac{(6+j8)(3-j4)}{6+j8+3-j4}=\frac{(6+j8)(3-j4)}{9+4j}$$

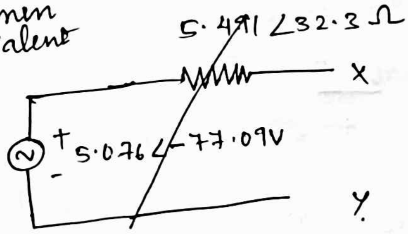
$$=\frac{450}{97}-\frac{200}{97}j$$

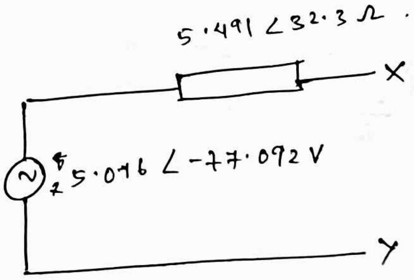
$$Z_{Th}=\frac{450}{97}-\frac{200}{97}j+5j$$

$$=\frac{450}{97}+\frac{285}{97}j$$

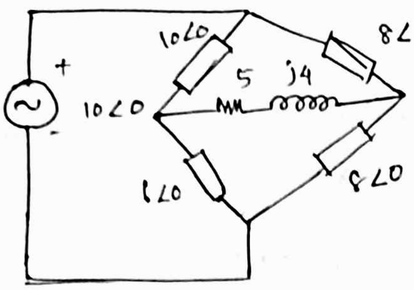
$$=5.491\angle 32.3\,\Omega$$

Thevenin Equivalent



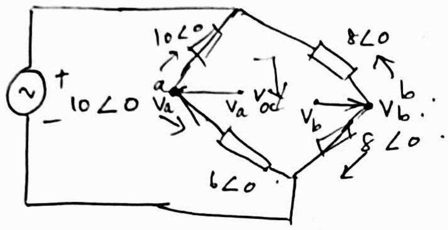


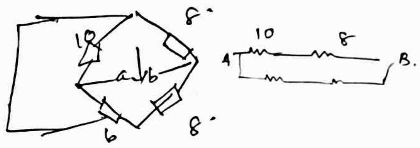
Qn 2)



Using Thevenin's theorem find the current through the coil 5+j4 Ω in the bridge circuit

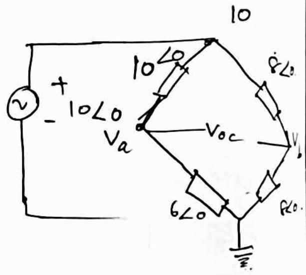
Every coil consist of a resistance in series with an inductance





I_1 $Z_{th} = 10 \| 6 + 8 \| 8$

$= 7.8\ \Omega$



$V_{oc} = V_a - V_b.$

$$\frac{V_a}{6} + \frac{V_a - 10}{10} = 0$$

$10 V_a + 6 V_a - 60 = 0.$

$16 V_a = 60$

$V_a = \underline{\underline{3.75 V}}$

$$\frac{V_b}{8} + \frac{V_b - 10}{8} = 0$$

$2V_b = 10$

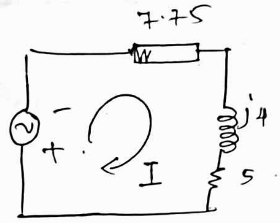
$V_b = \underline{\underline{5 V}}$

$V_{oc} = V_a - V_b$

$= 3.75 - 5$

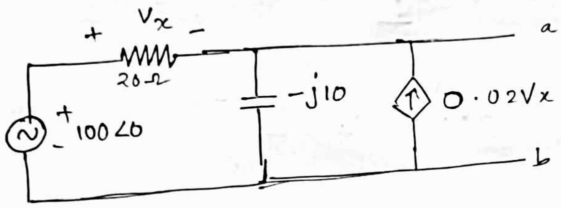
$= \underline{\underline{-1.25 \angle 0\ V}}$

$$I = \frac{1.25}{7.8+5+4i}$$

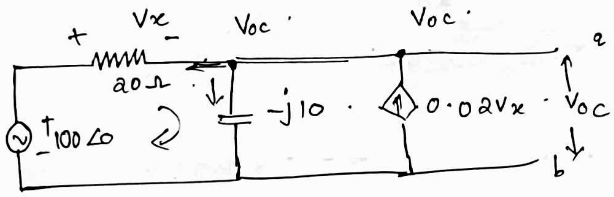


$$= 0.0932\angle{-17.35}$$

17/12/2021



Find the Thevenin equivalent of the circuit wrt a & b.



$$-0.02V_x + \frac{V_{oc}}{\cancel{j10}-j10} + \frac{V_{oc}-100}{20} = 0$$

$$\frac{V_{oc}}{-j10} + \frac{V_{oc}-100}{20} = 0.02V_x$$

$100 - V_x - V_{oc} = 0.$

$V_x = 100 - V_{oc}.$

$$\frac{V_{oc}}{-j10} + \frac{V_{oc}-100}{20} = 0.02(100-V_{oc})$$

$$\frac{V_{oc}}{-j10} + \frac{V_{oc}-100}{20} = 2 - 0.02V_{oc}$$

$$\frac{V_{oc}}{-j10} + \frac{V_{oc}-100}{20} + 0.02V_{oc} = 2.$$

$$V_{oc}\left[\frac{1}{-j10} + 0.02\right] + \frac{V_{oc}-100}{20} = 2.$$

$$V_{oc}\left[\frac{1+0.02j10}{-j10}\right] + \frac{V_{oc}-100}{20} = 2.$$

~~1+0.2.~~

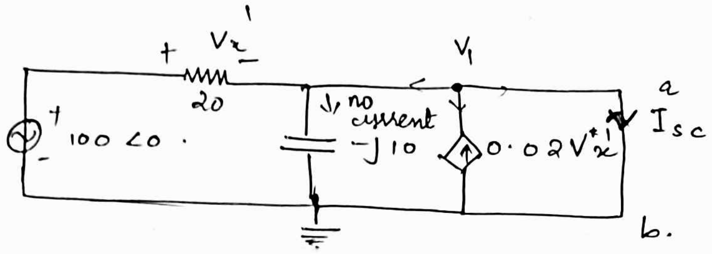
$$V_{oc}\left[\frac{1}{-j10} + 0.02 + \frac{1}{20}\right] - 5 = 2.$$

$$V_{oc} = \cancel{\left[\frac{1+0.02-j10}{-j10} + \frac{1}{20}\right]} = 7.$$

$$V_{oc}\left[\frac{20+0.4-200j-j10}{20-j10}\right] = 7$$

$$V_{oc} = \left[0.122 \angle 55\right] = 7$$

$$V_{oc} = \underline{\underline{57.34 \angle -55.0079}}$$



$$-0.02V_x' + \frac{\overbrace{V_1}^{0} + V_x' - 100}{20} = 0$$

$$-\frac{100}{20} - 0.02V_x' + I_{sc} = 0$$

$$-5 - 0.02V_x' + I_{sc} = 0$$

$$V_x' = 100 - 0$$

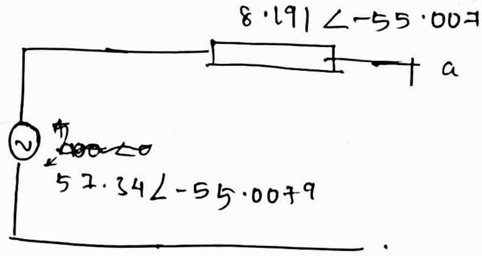
$$V_x' = 100$$

$$-5 - 0.02 \times 100 + I_{sc} = 0$$

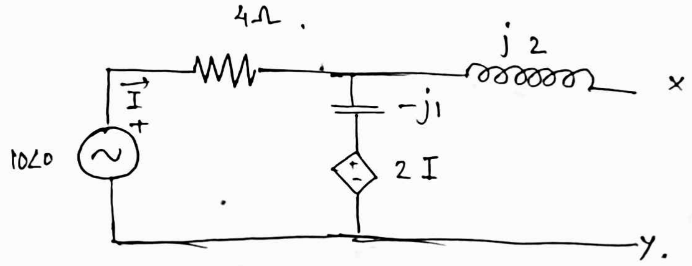
$$\underline{\underline{I_{sc} = 7\,A}}$$

$$Z_{Th} = \frac{57.34 \angle -55.0079}{7}$$

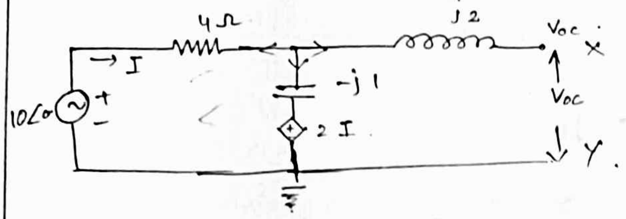
$$= \underline{\underline{8.191 \angle -55.0079\ \Omega}}$$



Qn)



obtain the Thevenin & Norton equivalent circuit



$$\frac{V_{oc} - 10}{4} = I$$

$$V_{oc} - 10$$

$$\frac{V_{oc} - 2I}{-j1} + \frac{V_{oc} - 10}{4} = 0$$

$$\frac{V_{oc} - 2I - 2\left(\frac{V_{oc} - 10}{4}\right)}{-j1} + \frac{V_o - 10}{4} = 0.$$

$$\frac{2V_{oc} - V_{oc} + 10}{-j2} + \frac{V_{oc} - 10}{4} = 0.$$

$$\frac{V_{oc}}{-j1} + \frac{V_{oc}}{4} + \frac{10}{-j1} - \frac{5}{2} = 0.$$

$$V_{oc}\left[\frac{1}{-j1} + \frac{1}{4}\right) = \frac{5}{2} - \frac{10}{-j1}$$

$$V_{oc} = 3.674\angle -17.1 \ \text{V}.$$

$I_{sc} = 2.71 \angle -102.53$

$Z_{TH} = 1.356\angle 85.43\,\Omega$

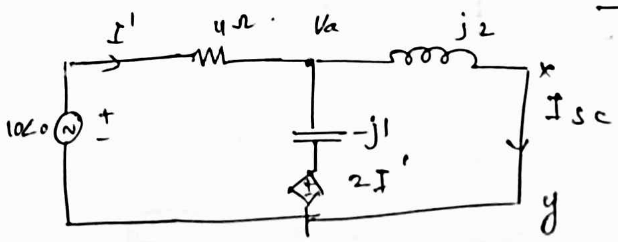
$$\frac{V_{oc} - 2\left(\frac{10 - V_{oc}}{4}\right)}{-j1} + \frac{V_{oc} - 10}{4} = 0.$$

$$\frac{2V_{oc} - 10 + V_{oc}}{-j2} + \frac{V_{oc} - 10}{4} = 0.$$

$$\frac{3V_{oc}}{-j2} - \frac{10}{-j2} + \frac{V_{oc}}{4} - \frac{10}{4} = 0.$$

$$V_{oc}\left[\frac{3}{-j2} + \frac{1}{4}\right) = \frac{5}{2} + \frac{10}{-j2}.$$

$$= 3.174\angle -17.1\,\text{V}$$



$$I_{sc} - J' - \frac{V_a - 2J'}{-j1} = 0$$

$$\frac{V_a}{j2} = I_{sc}.$$

$$I_{sc} - \left(\frac{10 - V_a}{4}\right) - \left(\frac{V_a - \frac{2(10 - V_a)}{4}}{-j}\right) = 0$$

$$I_{sc} - \frac{10}{4} + \frac{V_a}{4} + \frac{V_a}{-j} - \frac{1}{2j}(10 - V_a) = 0.$$

$$I_{sc}\left(\frac{1 + j2 + 2 + j2}{j2}\right) - \frac{10}{4} + \frac{10}{2j} = 0$$

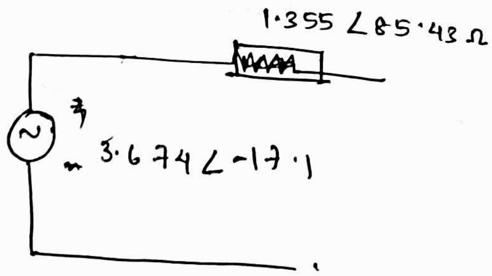
$$I_{sc}\left[4 + j2\right] = \frac{5}{2} - \frac{10}{2j}$$

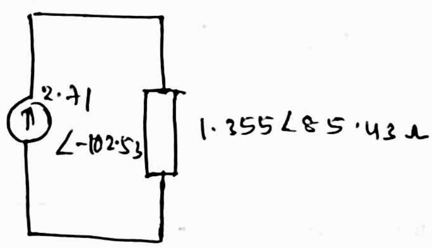
$$I_{sc} = \frac{5.59 \angle 63.43}{4 + 2j}$$

$$= 2.71 \angle -102.53$$

$$Z_{Th} = \frac{3.674 \angle -17.1}{2.71 \angle -102.53}$$

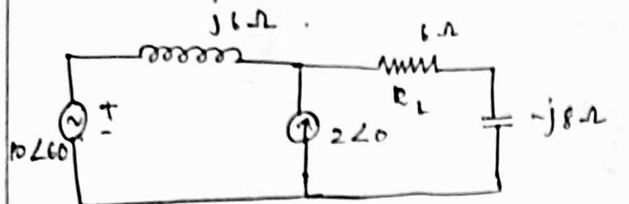
$$= 1.355 \angle 85.43 \ \Omega$$





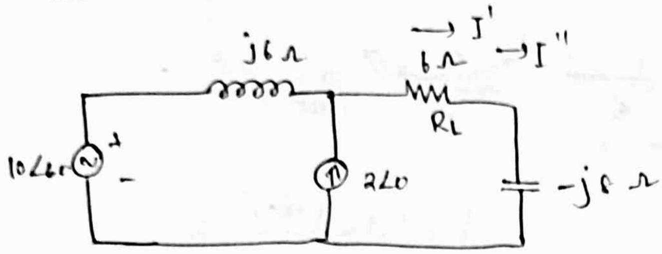
Superposition Theorem :

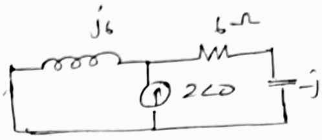
Qn



Find the current through the resistor R_L using superposition

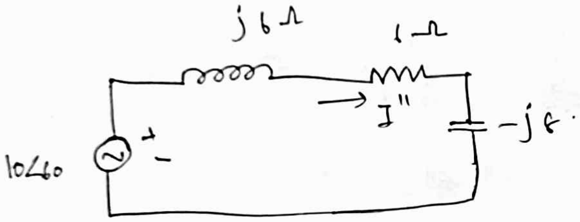
$I = 3.362\angle 94.78^\circ A$





$$I = I' + I''$$

$$I' = \frac{2\angle 0 \times j6}{j6 + 6 - j8} = 1.9\angle 108.43^\circ$$

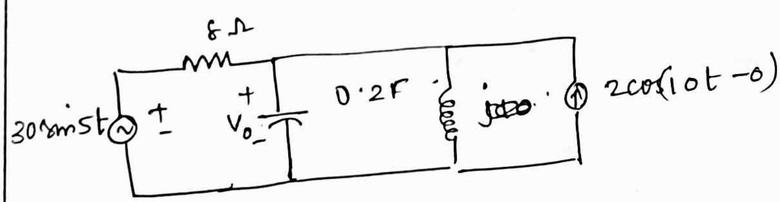


$$I'' = \frac{10\angle 60}{6 + j6 - j8} = \frac{10\angle 60}{6 - j2} = 1.58\angle 78.43^\circ A$$

$$I = I' + I''$$

$$= 3.362\angle 94.78^\circ A$$

Qn)



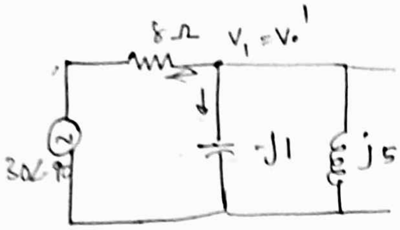
Voltage source : $30\sin 5t$

$= 30\cos(5t - 90)$

$\therefore 30\angle -90^\circ$

Current source $2\cos(10t - 0)$.

$2\angle 0$

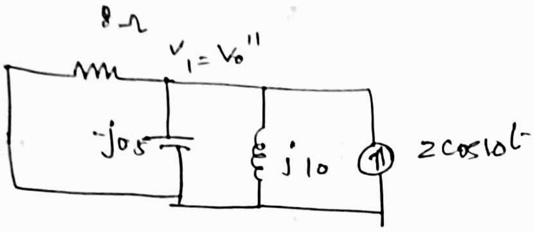


$$X_L = \frac{1}{j w c} = \frac{-j}{5 \times 0.2} = -j1$$

$$X_L = j w L = j \times 5 \times 1 = 5j$$

$$\frac{V_o' - 30\angle -90^\circ}{8} + \frac{V_o'}{-j1} + \frac{V_o'}{j5} = 0$$

$$V_o' = 4.681 \angle -171.1^\circ$$



$$X_L = \frac{1}{j w c} = \frac{1}{j10 \times 0.2} = -j0.5$$

$$X_L = j w L = j \times 10 \times 1 = j10$$

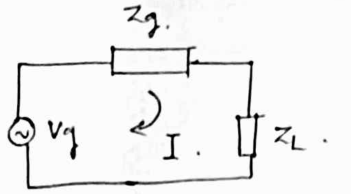
$$\frac{V_o''}{8} + \frac{V_o'' - 0}{-j0.5} + \frac{V_o''}{j10} = 2$$

$$V_o'' = 1.05 \angle -86.24^\circ$$

$$V_o = V_o' + V_o''$$

$$= 4.631 \cos(5t \cancel{+} 171.1^\circ) + 1.05 \cos(10t - 86.24^\circ)$$

Maximum power transfer theorem (AC).



$$I = \frac{V_g}{Z_g + Z_L} = \frac{V_g}{(R_g + jX_g) + (R_L + jX_L)}$$

$$P_L = I^2 R_L = \frac{V_g^2 R_L}{(R_g + R_L)^2 + (X_g + X_L)^2}.$$

Assume R_L is fixed,

For maximum power transfer $\frac{\partial P_L}{\partial X_L} = 0$

$$\frac{\partial P_L}{\partial X_L} = \frac{0 - V_g^2 R_L \times 2(X_g + X_L)}{\left[(R_g + R_L)^2 + (X_g + X_L)^2\right]^2} = 0$$

$$X_g = -X_L \quad \text{—} ①$$

$$P_L = \frac{V_g^2 R_L}{(R_g + R_L)^2}.$$

Assume R_L is variable $\frac{\partial P_L}{\partial R_L} = 0$

$$\frac{\partial P_L}{\partial R_L} = \frac{(R_g + R_L)^2 \cancel{V_g^2} - \cancel{V_g^2} R_L \, 2(R_g + R_L)}{(R_g + R_L)^4} = 0.$$

$$R_g + R_L - 2R_L = 0$$

$$R_g = R_L$$

$$Z_L = Z_g$$

$$= R_s + j X_g$$

$$= R_s - j X_g.$$

In AC circuits ~~power is~~ Pmax occurs only when

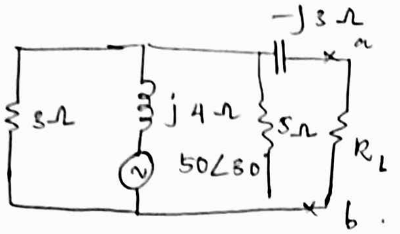
$$R_g = R_L \quad \& \quad X_g = -X_L$$

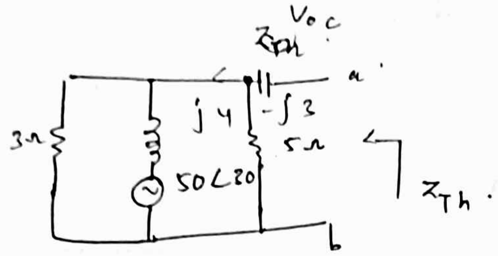
$$\text{or} \quad Z_g = Z_L^*$$

$$P_L = \frac{V_g^2}{4R_L} = \frac{V_g^2}{4R_g}$$

when load impedance is the complex conjugate of source impedance Power max transfer occurs.

Q n) What should be the value of R_L so the max power can be transferred from the source to R_L.





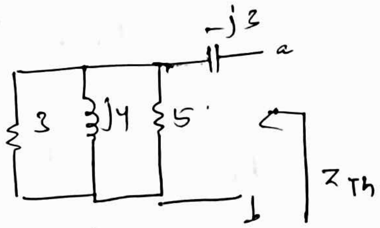
$$\frac{V_{oc}}{5} + \frac{V_{oc} - 50\angle 30}{j4} + \frac{V_{oc}}{3} = 0$$

$$\frac{V_{oc}}{j4} + \frac{V_{oc}}{5} + \frac{V_{oc}}{3} = \frac{50\angle 30}{j4}$$

$$V_{oc}\left[\frac{1}{j4} + \frac{8}{15}\right] = \frac{50\angle 30}{j4}$$

$$V_{oc}\left[\frac{1}{j4} + \frac{8}{15}\right] = \frac{25}{2}\angle -60$$

$$V_{oc} = \underline{\underline{21.22\angle -34.88^\circ}}$$



$$Z_{Th} = -j3 + (3 \| j4 \| 5)$$

$$= \cancel{-j3} +$$

$$= (1.537 - 2.27j)\ \Omega$$

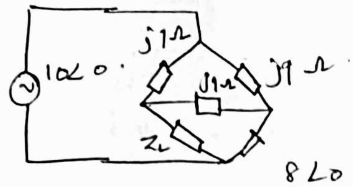
$$Z_L = Z_g^*$$

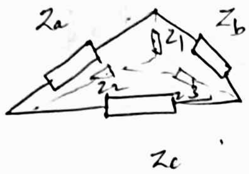
$$R_L = R_g$$

$$X_L = -X_g$$

$$P_{max} = \frac{V_{oc}^2}{4R_L} = \frac{(21.22)^2}{4 \times 1.54} = \underline{73.13\,W}$$

Find the value of Z_L to have maximum power transfer from $10\angle 0°$ voltage source. Also determine the amount of maximum power.



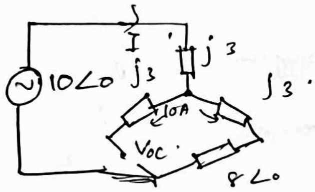


Delta to star

$$Z_1 = \frac{Z_a Z_b}{Z_a + Z_b + Z_c}$$

$$Z_2 = \frac{Z_a Z_c}{Z_a + Z_b + Z_c}$$

$$Z_3 = \frac{Z_b Z_c}{Z_a + Z_b + Z_c}$$

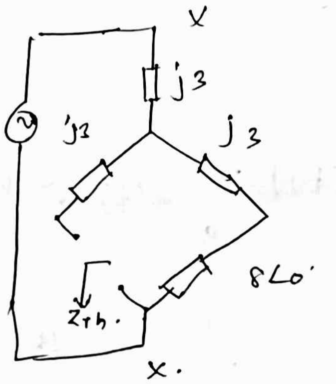


$$I = \frac{10}{j3 + j3 + 8}$$

$$V_{OC} = I(j3 + 8)$$

$$= \frac{10}{j3 + j3 + 8}(j3 + 8)$$

$$= 8.54\angle -16.21$$



$$Z_{Th} = \frac{j3 \times (8 + j3)}{8 + j3 + j3} + j3$$

$$= (0.72 + j5.46)\,\Omega$$

$$Z_L = 0.72 - j5.46$$

$$P_{max} = \frac{V_{oc}^2}{4R_L} = \frac{(8.54)^2}{4 \times 0.72} = \underline{25.32\,W}$$