Circuit Analysis Final 25-Jun-21

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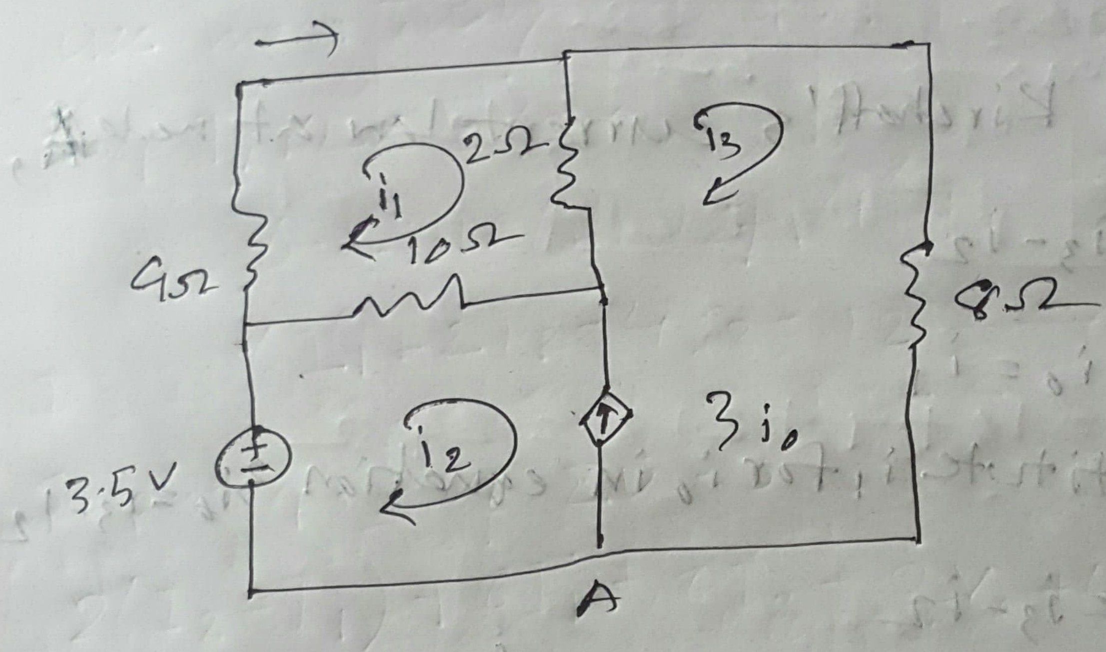
Ans to the Q. No. 1



For mesh 1,

$$4i_1 + 2(i_1 - i_3) + 10(i_1 - i_2) = 0$$

$$\Rightarrow 4i_1 + 2i_1 - 2i_3 + 10i_1 - 10i_2 = 0$$

$$\Rightarrow 16i_1 - 10i_2 - 2i_3 = 0$$

$$\Rightarrow 8i_1 - 5i_2 - i_3 = 0 \quad (1)$$

The meshes 2 and 3 from a super mesh,

$-35 + 10(i_2 - i_1) + 8i_3 = 0$

$-35 + 10i_2 - 10i_1 + 2i_3 - 2i_1 + 8i_3 = 0$

$-12i_1 + 10i_2 + 10i_3 = 35$ —— (2)

Apply Kirchoff's current law at node A,

$3i_0 = i_3 - i_2$

But $i_0 = i_1$

Substitute i_1 for i_0 in equation $3i_0 = i_3 - i_2$

$3i_1 = i_3 - i_2$

$3i_1 + i_2 - i_3 = 0$ —— (3)

Substract equation (3) from (1)

$$
\begin{array}{r}
8i_1 - 5i_2 - i_3 = 0 \\
3i_1 + i_2 - i_3 = 0 \\
\hline
5i_1 - 6i_2 = 0
\end{array}
$$
—— (4)

Multiply equation (1) by 1.0 and add it to equation (2)

$$80i_1 - 50i_2 - 10i_3 = 0$$

$$-12i_1 + 10i_2 + 10i_3 = 35$$

$$68i_1 - 40i_2 = 35 \quad \text{—— (5)}$$

Solve equation (4) and (5)

$$i_1 = 1.01\ \text{A}$$

$$i_2 = 0.84\ \text{A}$$

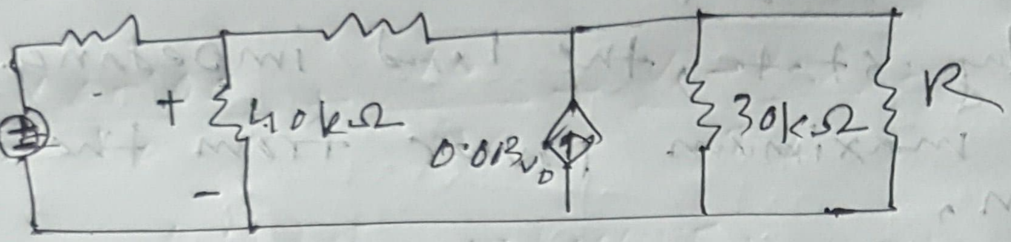
Determine the value of i_0,

$$i_0 = i_1$$

$$= 1.01\ \text{A}$$

Therefore the current i_0 is 1.01 A

Ans. to the Q. No. 2



First we find R_{Th}.

Applying KCL to node (v_t) gives,

$$I_t + 6v_o = \frac{V_t}{30} + \frac{V_t - v_o}{22}$$

$$I_t = 0.6788 V_t - 6.05 v_o \quad \text{—— (1)}$$

Applying KCL to node (v_o) gives,

$$\frac{v_o}{10} + \frac{v_o}{40} + \frac{v_o - V_t}{22} = 0$$

$$0.1705 v_o = 0.0455 V_t$$

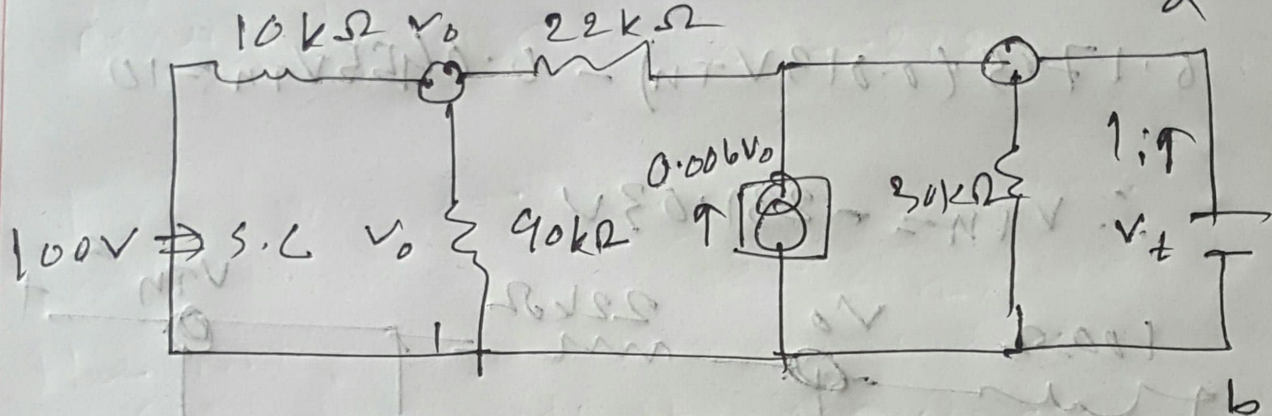
$$v_o = 0.2667 V_t \quad \text{—— (2)}$$

Substituting eq (2) into eq (3)

~~$I_t = I_t = I_t = 0.0788 V_t - 6.05 \cdot (0.2667)$~~

$$I_t = I_t = I_t = 0.0788 V_t - 6.05 \cdot (0.2667 V_t) = -1.535 V_t$$

$$\therefore R_{Th} = \left| \frac{V_t}{I_t} \right| = 651.58\,\Omega$$



To find V_{Th} consider the circuit shown below,

Applying KCL to node (V_{Th}) gives

$$6 v_o = \frac{V_{Th}}{30} + \frac{V_{Th} - v_o}{22}$$

$$0.0788 V_{Th} = 6.045 v_o$$

$$v_o = 0.013 V_{Th} \quad \text{——— (3)}$$

Applying KCL to node (V_o)

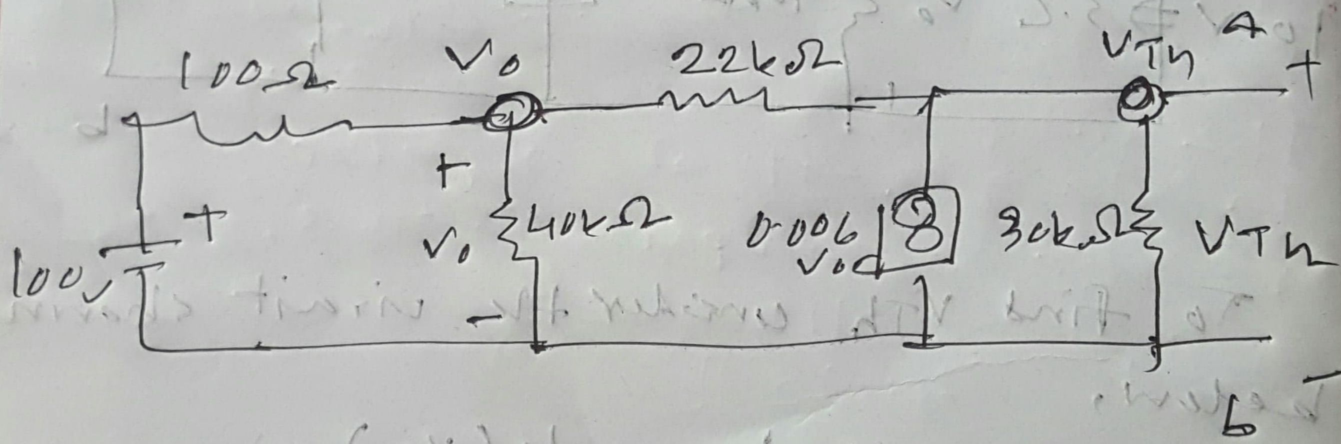
$$\frac{V_o - 100}{10} + \frac{V_o}{40} + \frac{V_o - V_{TN}}{22} = 0$$

$$0.1705 V_o - 0.0455 V_{TN} = 10 \quad \text{—(4)}$$

Substituting Eq (1) into Eq 2.

$$0.1705(0.013 V_{TN}) - 0.0455 V_{TN} = 10$$

$$\therefore V_{TN} = -231.03 V$$



Finally, Maximum power transfer

$$R = R_{TN} = 651.58 \Omega$$

So the maximum power is

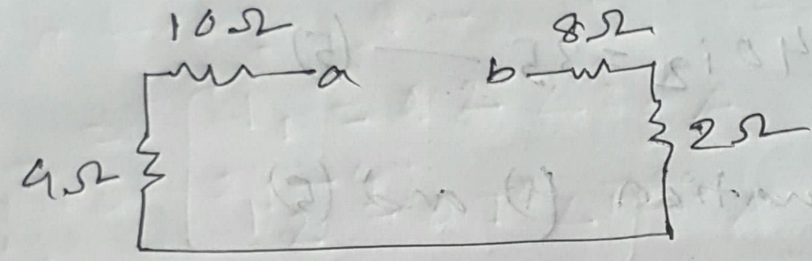
$$P_{max} = \frac{V_{TN}^2}{4R} = \frac{(-231.03)^2}{4 \cdot 651.58}$$

$$= 20.48 W$$

Ans. to the Q. No. 3

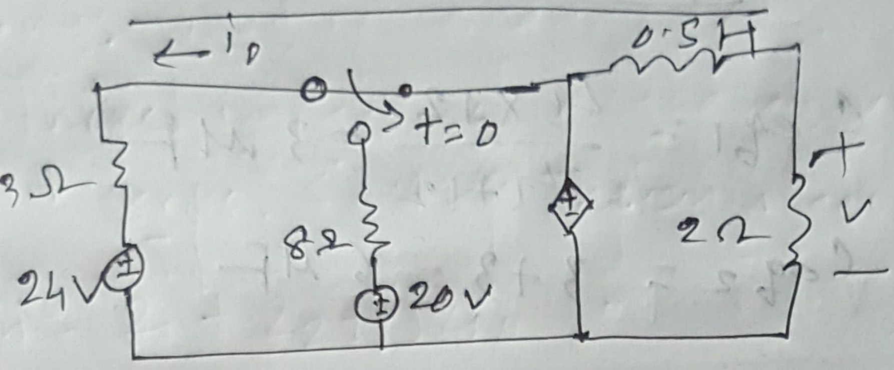
$$5 \parallel 20 = \frac{5 \times 20}{25} = 4\Omega$$

$$6 \parallel 3 = \frac{6 \times 3}{9} = 2\Omega$$



$$R_{ab} = 10 + 4 + 2 + 8 = 24\Omega$$

Ans. to the Q. No. 7



For $t < 0$,

$3i_0 + 24 - 4i_0 = 0 \longrightarrow i_0 = 24$

$v(t) = 4i_0 = 96\,V \quad i = \frac{v}{2} = 48\,A$

For $t > 0$,

$i(t) = i(\infty) + [i(0) - i(\infty)]e^{-t/\tau}$

$i(0) = 48, \; i(\infty) = 0$

$R_{th} = 2\,\Omega, \quad T = \frac{L}{R_{th}} = \frac{0.5}{2} = 1/4$

$i(t) = (48)e^{-4t}$

$v(t) = 2i(t) = 96e^{-4t}\,u(t)\,V$

Ans. to the Q. No. 4

$u^+ = U^- = 4\,mV$

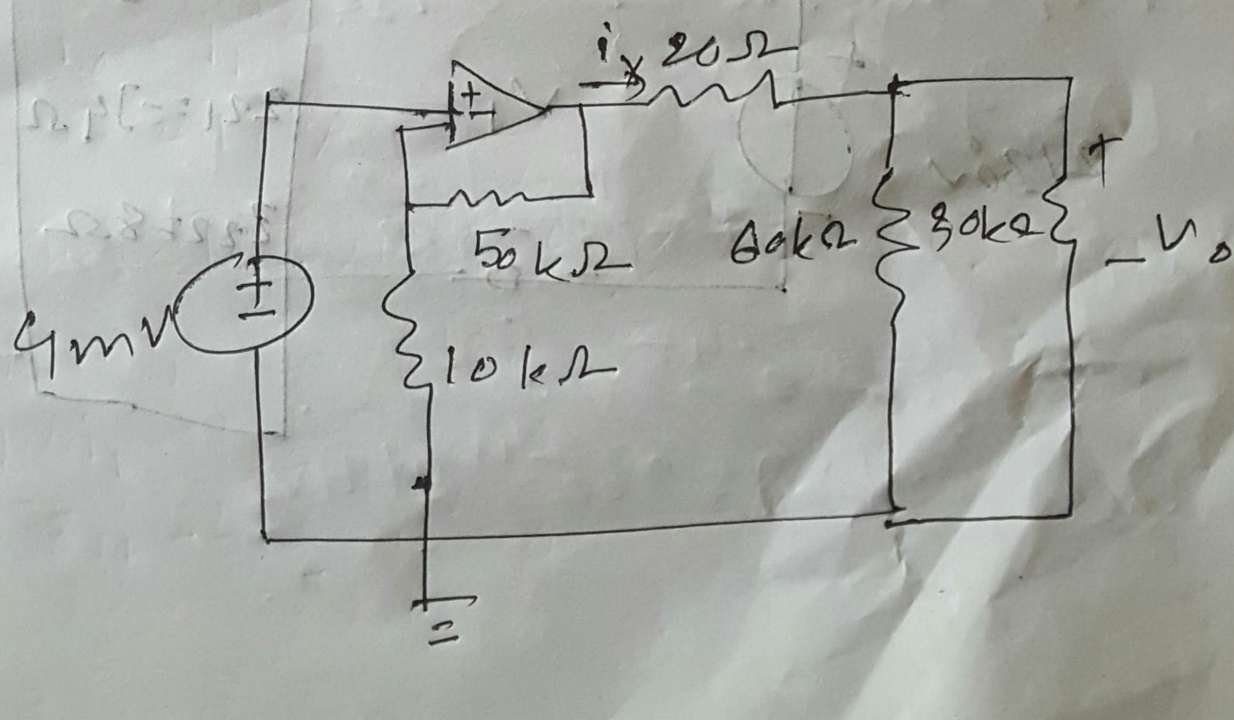
$\therefore V_{o1} = 4 \times \left(1 + \frac{50}{10}\right) = 24\,mV$

$\therefore V_o = \frac{V_{o1}}{20 + 60 \| 40} \times (60 \| 30)$

$= 12\,mV$

$i_x = \frac{24 - 12}{20} = 0.6\,\mu A$

$P = \frac{V^2}{R} = 2.4 \times 10^{-9}\,W$

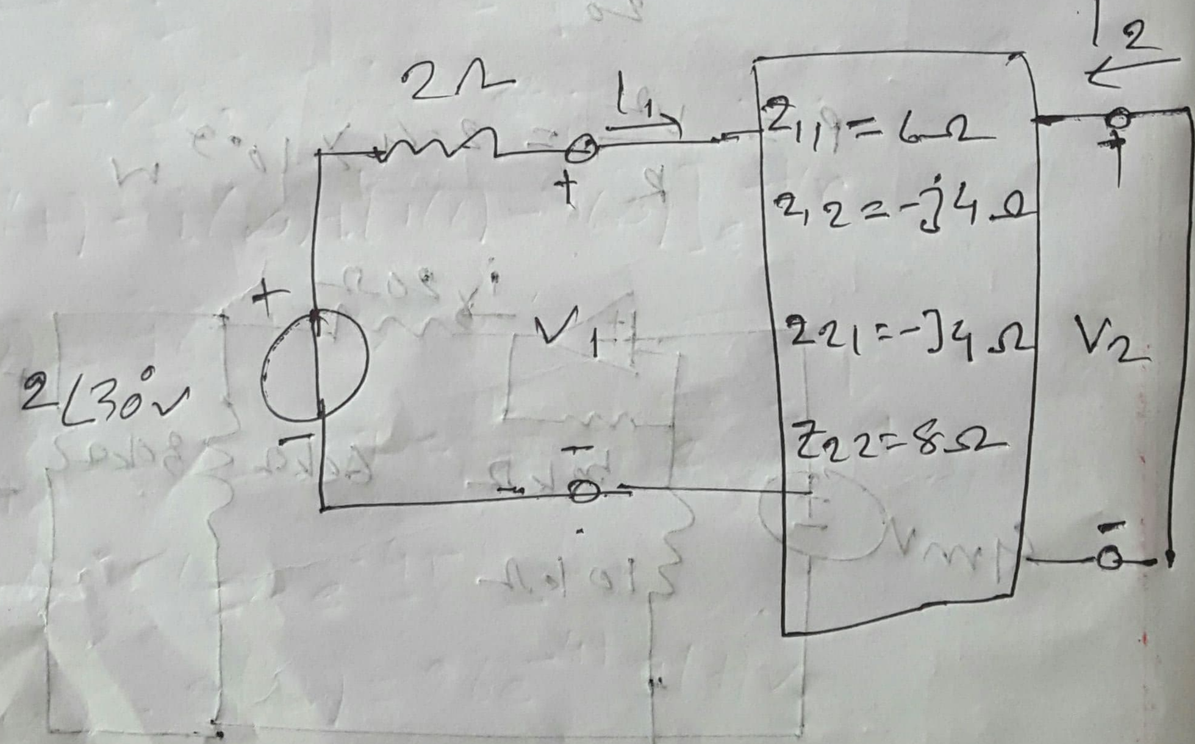


Ans. to the Q. No. 5

$$2\angle 30^\circ - 2I_1 = 6I_1 - j4I_2$$

$$\Rightarrow 0 = -j4I_1 + 8I_2$$

$$\Rightarrow \begin{cases} I_1 = 0.2\angle 30^\circ \text{ A} \\ I_2 = 0.1\angle 120^\circ \text{ A} \end{cases}$$



Ans. to the Q. No. 6

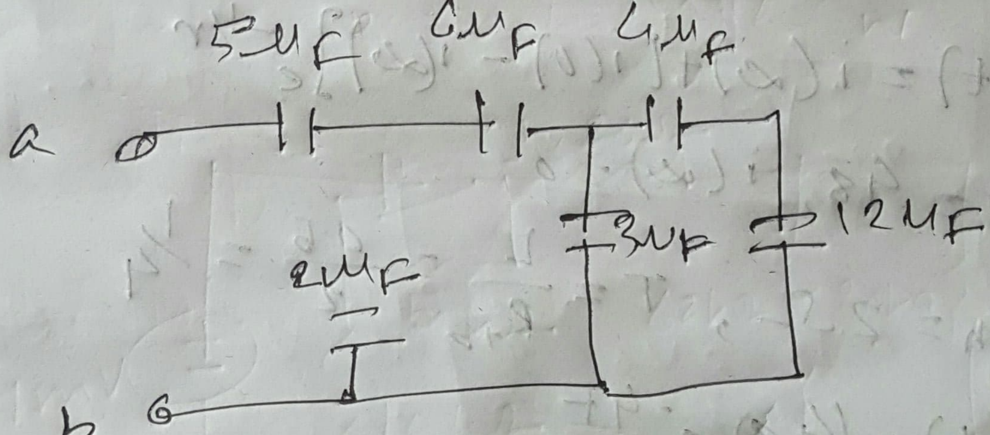
$$C_{eq1} = \frac{4 \times 12}{4+12} = 3\,\mu F$$

$$C_{eq2} = 3+3 = 6\,\mu F$$

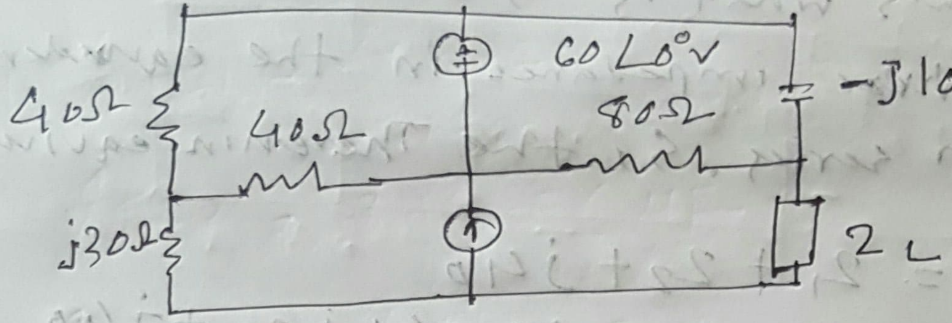
$$C_{eq3} = \frac{6 \times 6}{6+6} = 3\,\mu F$$

$$C_{eq4} = 2+3 = 5\,\mu F$$

$$C_{ef} = \frac{5 \times 5}{5+5} = 2.5\,\mu F$$



Ans. to the Q. No. 9.



For the circuit shown in fig we need to obtain the value of Z_L.

First we get Thevenin impedance at the load terminals. To get Z_{Th}, we set the independent sources to zero as shown in (a). The $-j10\Omega$ capacitor and the 80Ω resistor are in parallel. Thus,

$$Z_1 = j10 \parallel 80$$

$$= \frac{-j10 \cdot 80}{-j10 + 80}$$

$$= 1.231 - j9.846\ \Omega$$

Similarly the two 40Ω resistor are in parallel, so,

$$Z_2 = 40 \parallel 40 = \frac{40}{20} = 20\ \Omega$$

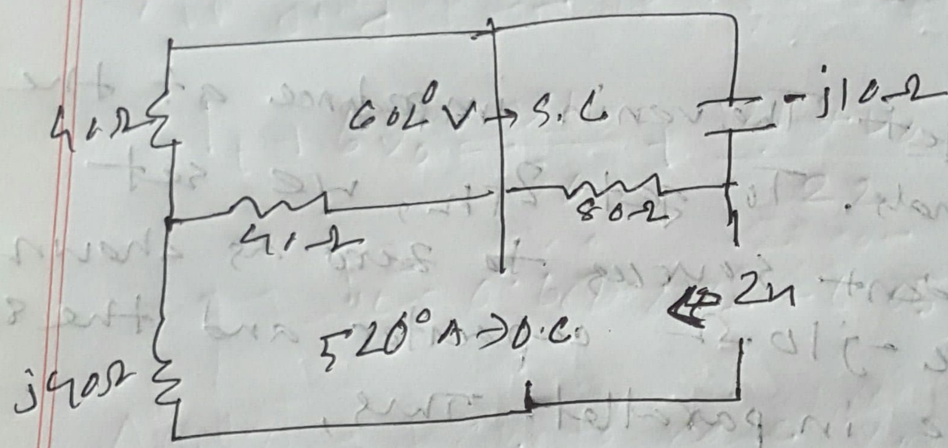
Therefore the circuit shown below in (a) becomes what is shown in (b).

The three impedance in the equivalent are in series. So the Thevenin equivalent is,

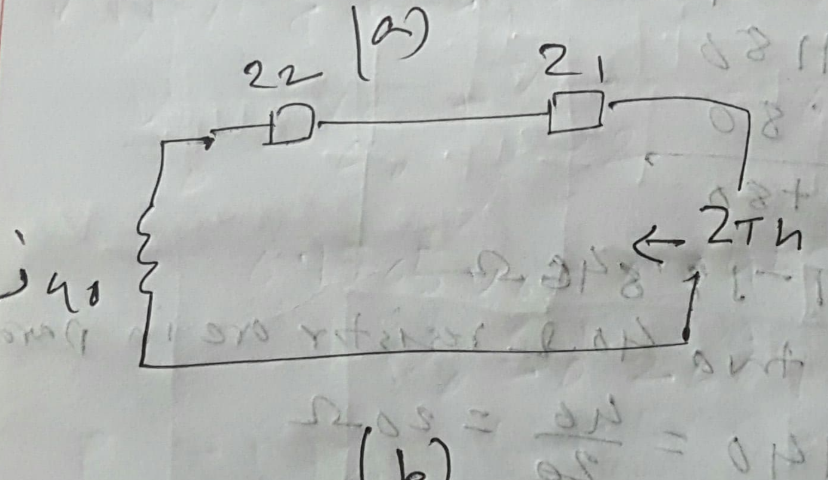
$$Z_{Th} = Z_1 + Z_2 + j40$$

$$= 1.231 - j9.846 + 20 + j40$$

$$= 21.231 + j30.154\ \Omega$$



(a)



(b)

According to the maximum average power transfer theorem for the sinusoidal steady state, the load impedance draws the maximum power from the circuit when,

$$Z_L = Z_{Th} = 21.231 - j30.154\,\Omega$$

$\therefore$ The load impedance for maximum power transfer is $Z_L = 21.231 - j30.154\,\Omega$