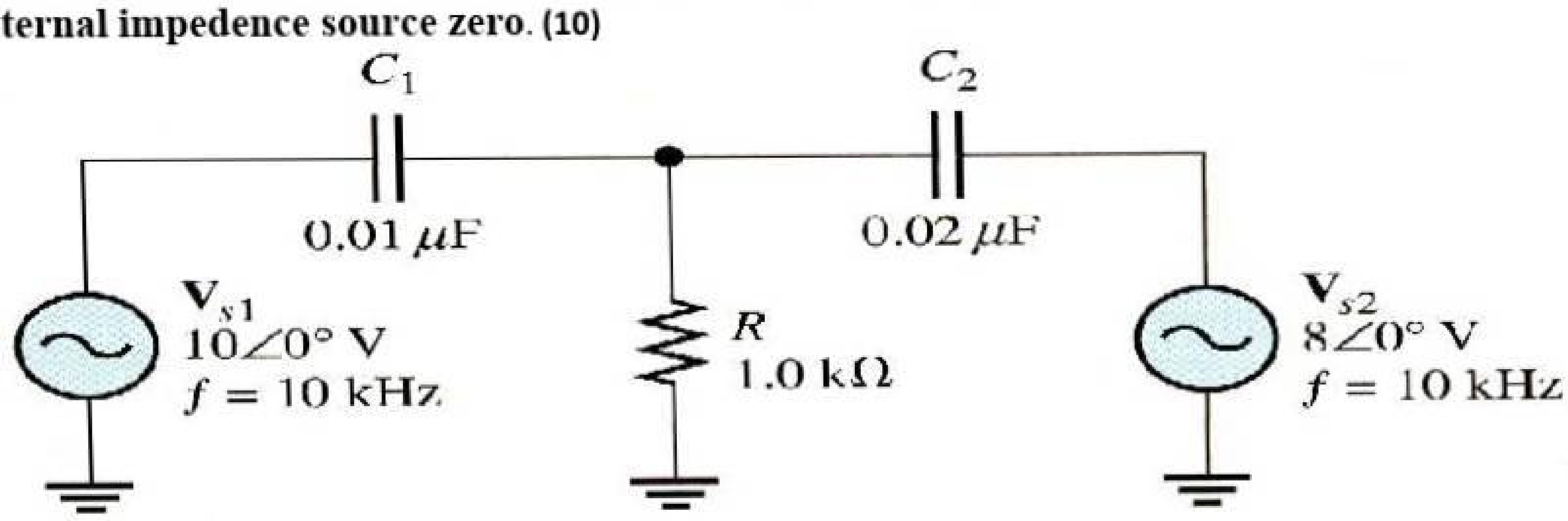
Instructor: Rashid Aleem
Paper: Electrical Network Analysis
Time : 4 Hours

shehriyar khan
13738

Note:

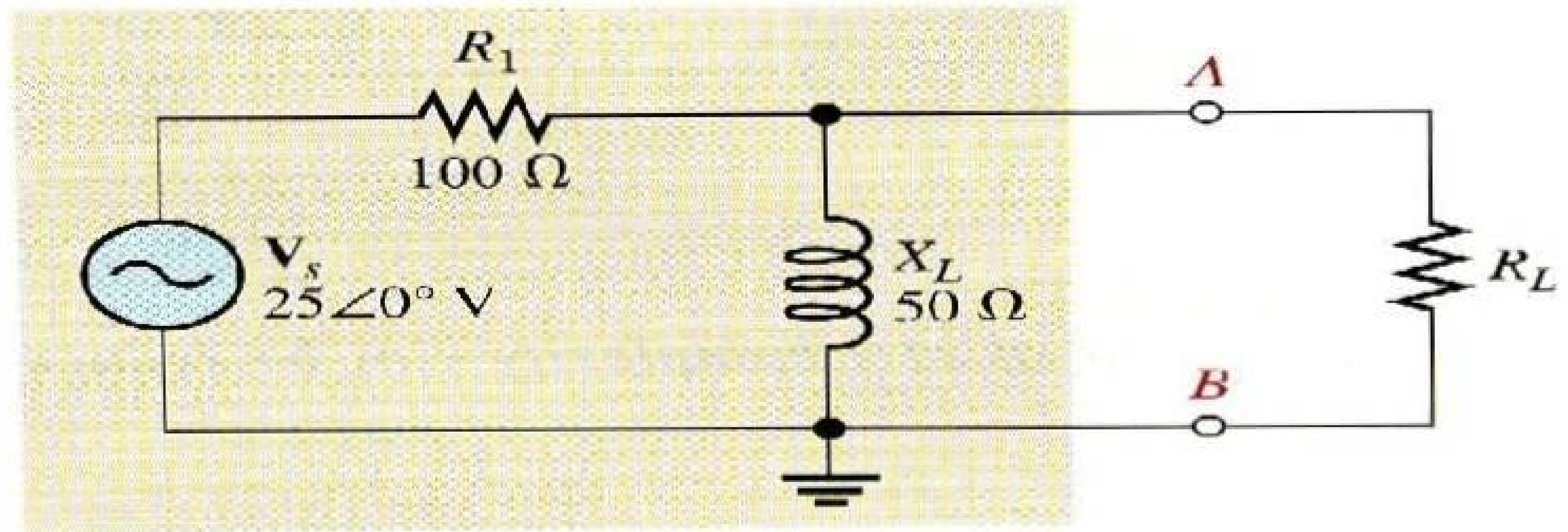
1) Attempt all questions.
2) Assume missing details if required.
3) Draw neat diagrams where required.

Q1: Find the current in R in following fig .using the superposition theorem. Assume the internal impedence source zero. (10)

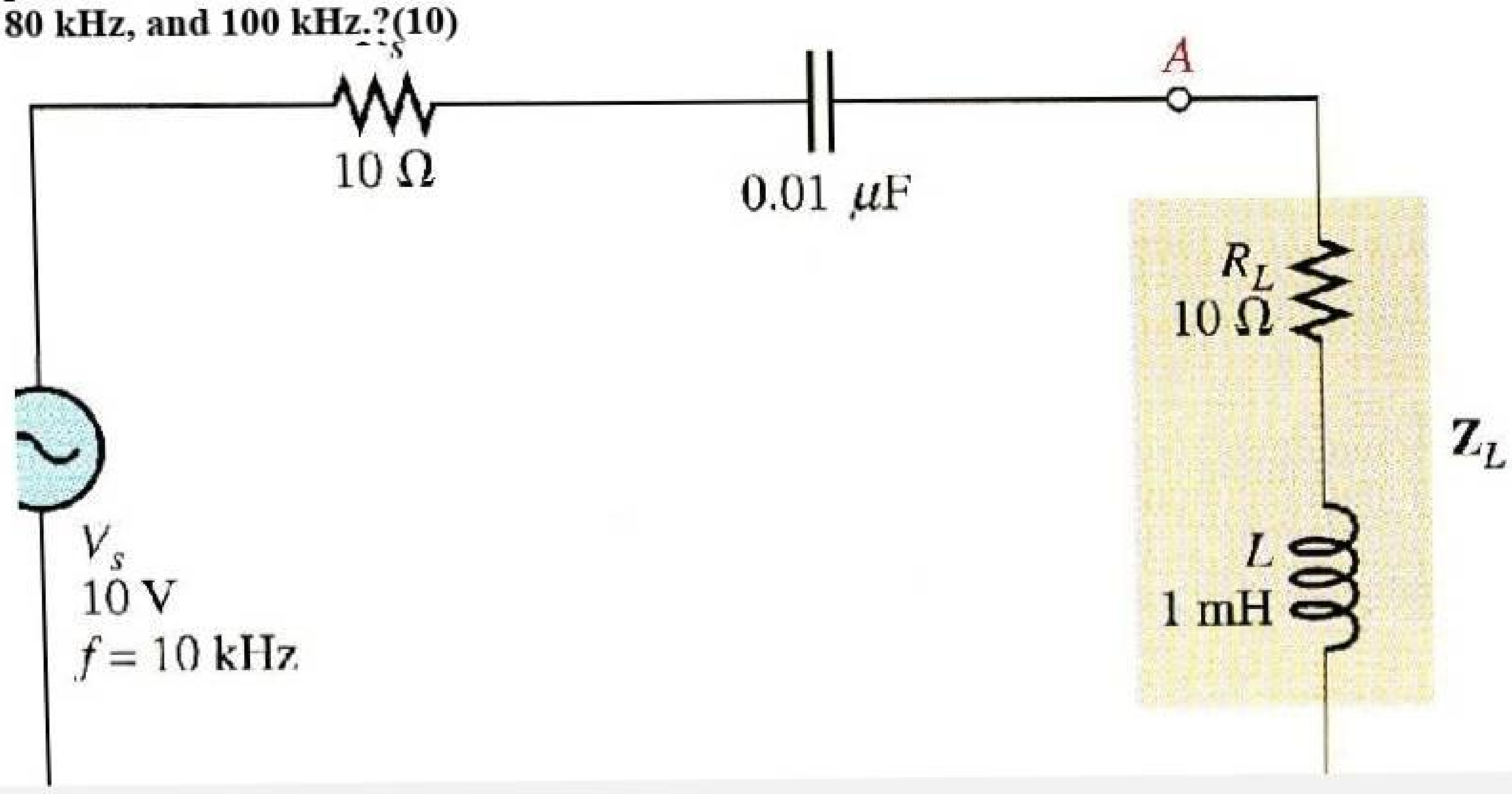


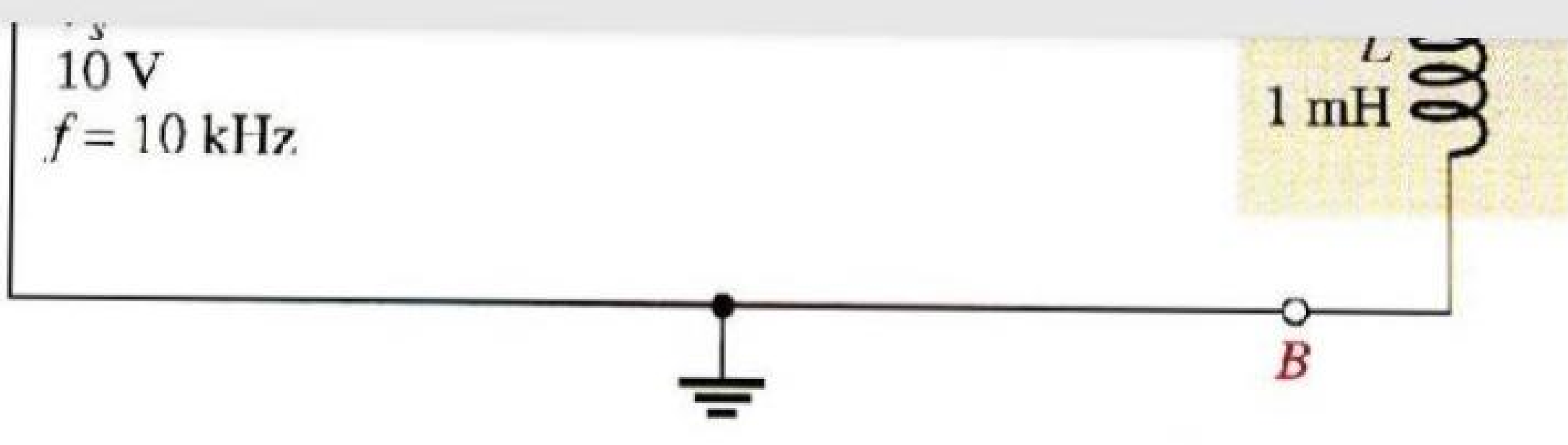
Q2: Determine Vth for the circuit external to RL in Figure . The beige area identifies the portion of the circuit to be thevenized.. (10)

5

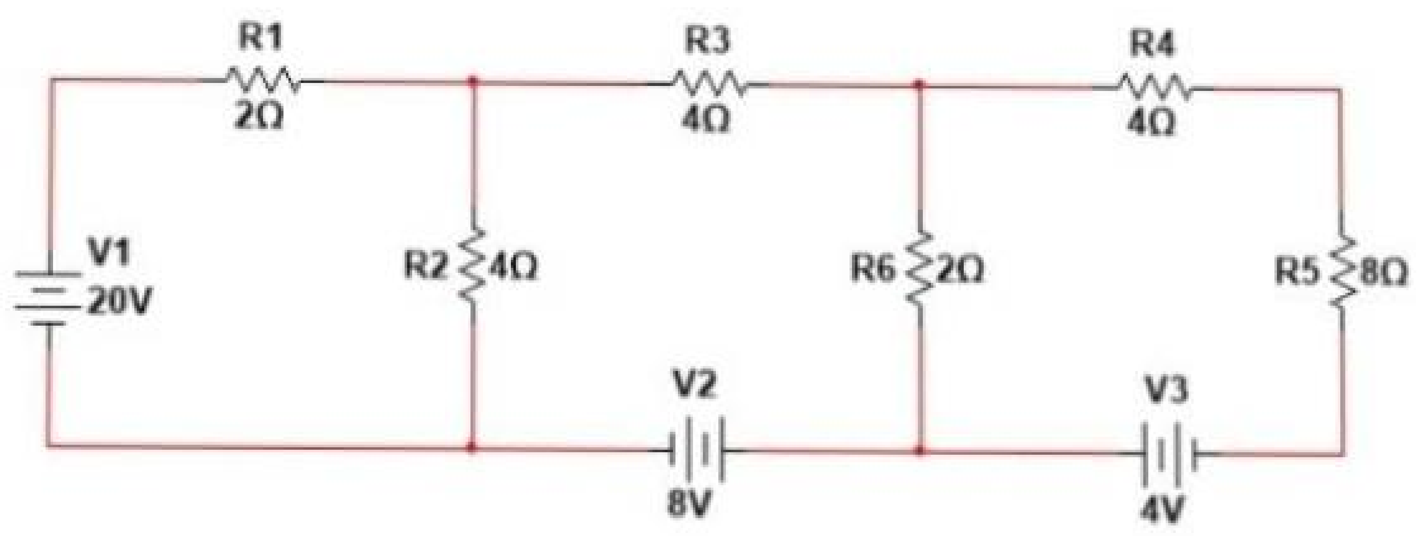


Q3: The circuit to the left of terminals A and B in Figure provides power to the load ZL. This can be viewed as simulating a power amplifier delivering power to a complex load. It is the Thevenin equivalent of a more complex circuit. Calculate and plot a graph of the power delivered to the load for each of the following frequencies:10 kHz, 30 kHz, 50 kHz, 80 kHz, and 100 kHz.?(10)

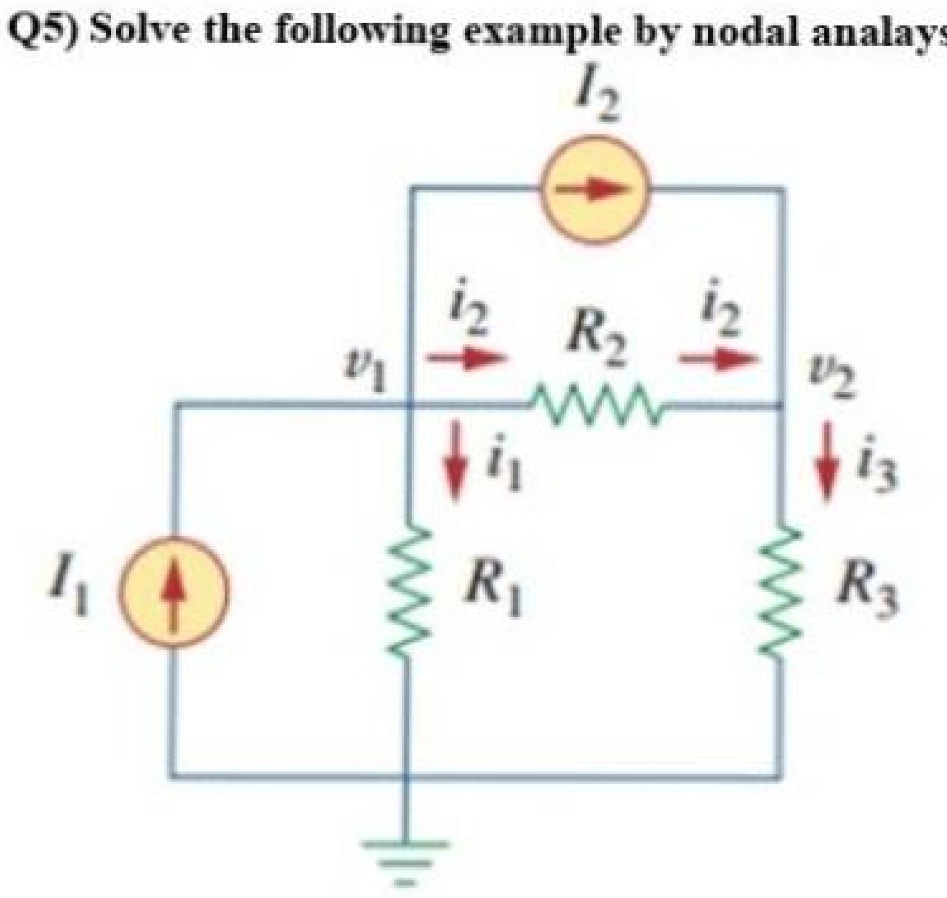




Q4: Using Thevenin's and Norton's theorem, find the currents in 8 Ω resistor in the figure Shown below. (10)



Q5) Solve the following example by nodal analaysis.Write all the general steps?(10)

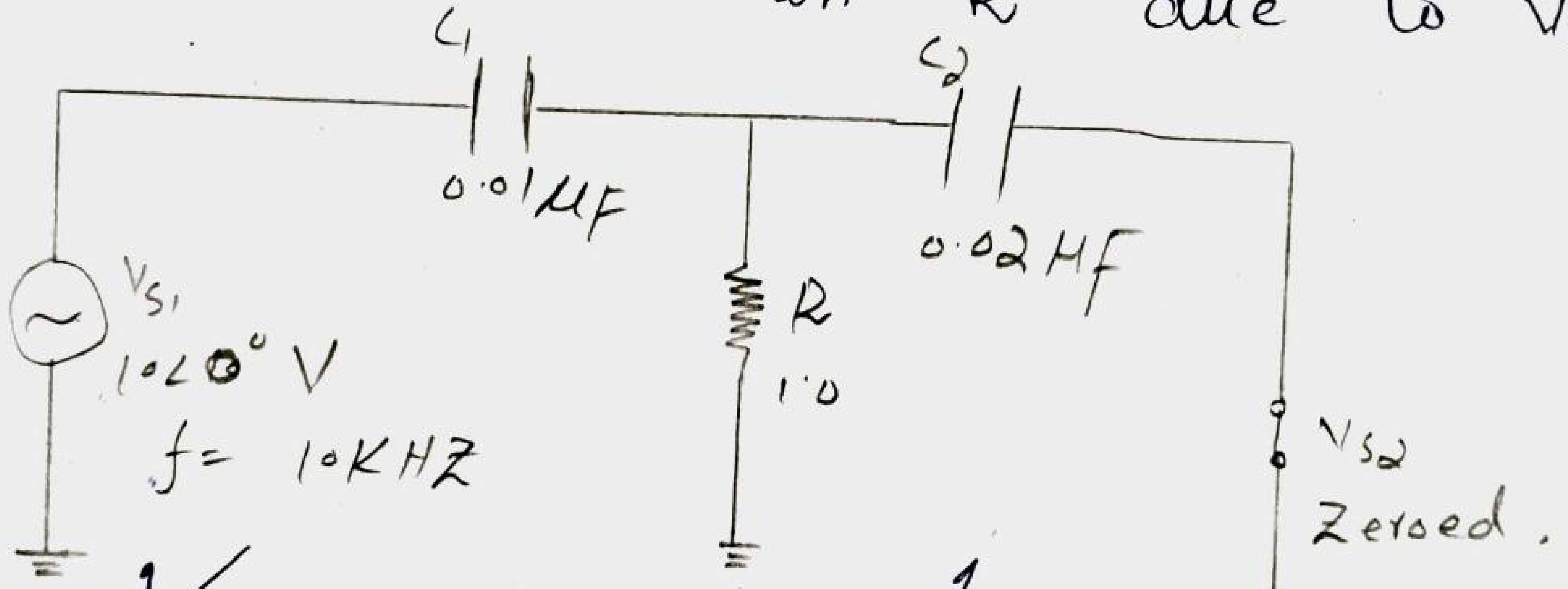


Name : Shehriyar Khan

ID : 13738

Question No (1)

Solution :- Replace V_{s2} with its internal impedence (zero) and find the current in R due to V_{s1}.



$$x_{c_1} = \frac{1}{2\pi f c_1} = \frac{1}{2\pi(10\ KHZ)(0.01\ \mu F)} = 1.59 K\Omega$$

$$X_{C_2} = \frac{1}{2\pi f C_2} = \frac{1}{2\pi(10 KHZ)(0.02\ \mu F)} = 796\ \Omega.$$

Looking from V_{s1} the impedence is

$$Z = X_{C_1} + \frac{R X_{C_2}}{R + X_{C_2}} = 1.59\angle -90° K\Omega + \frac{(1.0\angle 0 K\Omega)(796\angle -90)}{1.0\Omega - j796}$$

$= 1.59\angle -90^\circ \text{ K}\Omega + 622\angle -51.5^\circ \Omega$

$= -j1.59 \text{ K}\Omega + 387\,\Omega - j487\,\Omega = 387\Omega - j2.08\text{K}\Omega$

Converting to polar from yeilds

$Z = 2.12\angle -79.5^\circ \text{ K}\Omega.$

The total current from source 1 is

$$I_{S_1} = \frac{V_{S_1}}{Z} = \frac{10\angle 0^\circ \text{V}}{2.12\angle -79.5^\circ \text{K}\Omega} = 4.72\angle 79.5^\circ \text{mA}$$

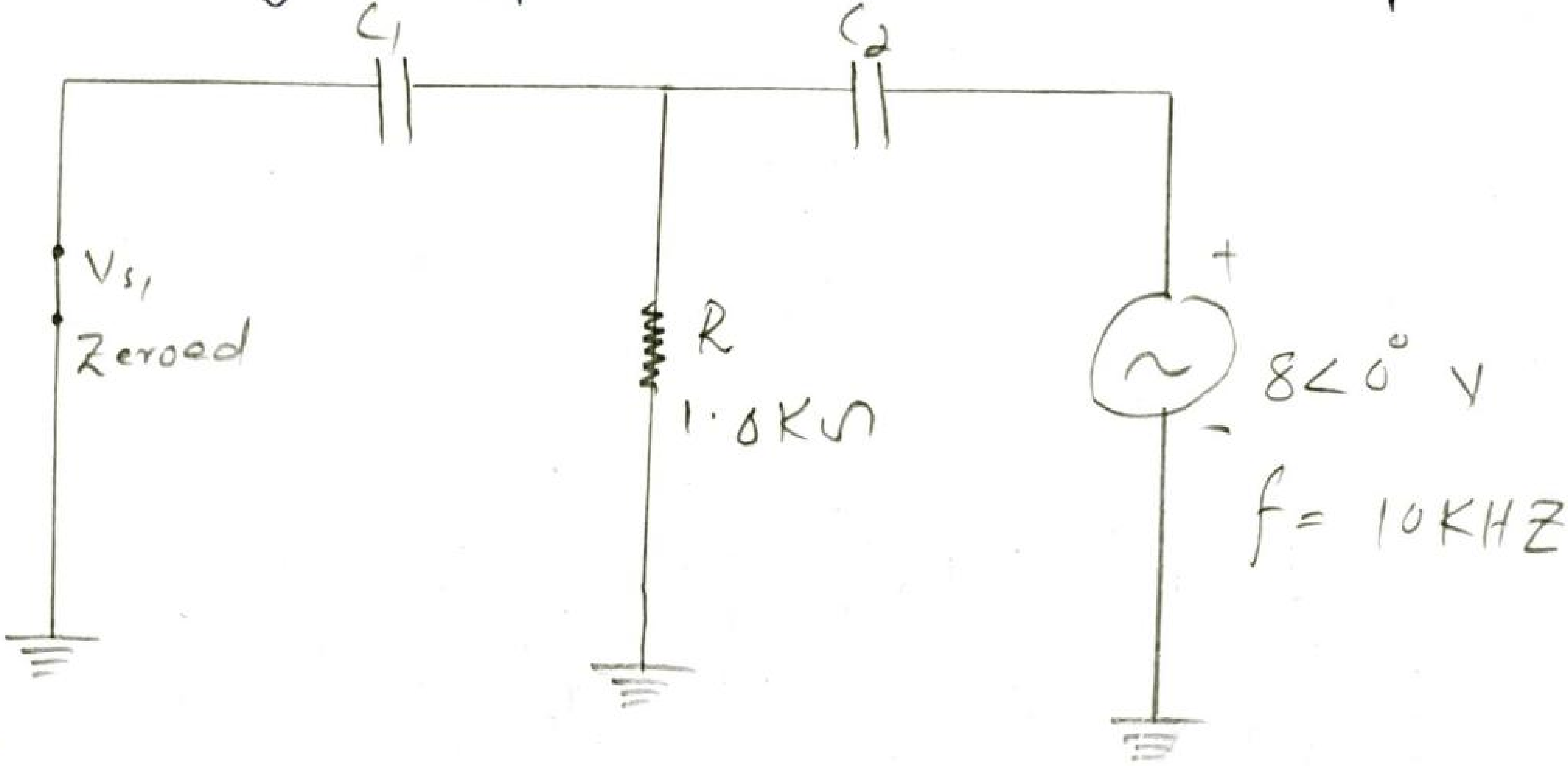
Use the current divider formula. the current through R due to V_{S_1} is

$$I_{R_1} = \left(\frac{X_{C_2}\angle -90^\circ}{R - jX_{C_2}}\right) I_{S_1} = \left(\frac{796\angle -90^\circ \Omega}{1.0\text{K}\Omega - j796\Omega}\right) 4.72\angle 79.5^\circ \text{mA}$$

$= (0.623\angle -51.5^\circ \Omega)(4.72\angle 79.5^\circ \text{mA})$

$= 2.94\angle 28.0^\circ \text{ mA}.$

Find the current in R to source V_{S2} by replacing V_{S1} with internal impedence (zero).



Looking from V_{S2} the impedence is

$$Z = X_{C2} + \frac{R X_{C1}}{R + X_{C1}} = 796\angle -90^\circ \Omega + \frac{(1.0\angle 0^\circ K\Omega)(1.59\angle -90^\circ K\Omega)}{1.0 K\Omega - j1.59 K\Omega}$$

$$= 796\angle -90^\circ \Omega + 847\angle -32.2^\circ \Omega$$

$$= -j796 \Omega + 717 \Omega - j451 \Omega = 717 \Omega - j1247 \Omega$$

Converting to polar from yeilds.

$$Z = 1438\angle -60.1^\circ \Omega$$

The Total current from Source 2 is

$$I_{S2} = \frac{V_{S2}}{Z} = \frac{8\angle 0^\circ V}{1438\angle -60.1^\circ \Omega} = 5.56\angle 60.1^\circ mA$$

Using current - divider formula. The current through R due to V_{s2} is

$$I_{R_2} = \left(\frac{X_{C_1} \angle -90^\circ}{R - jX_{C_1}}\right) I_{s2}$$

$$= \left(\frac{1.59 \angle -90^\circ \, k\Omega}{1.0\,k\Omega - j1.59\,k\Omega}\right) 5.56 \angle 60.1^\circ \, mA$$

$$= 4.70 \angle 27.9^\circ \, mA.$$

Convert two individual resistor current to rectangular form and add to get the total current through R.

$$I_{R_1} = 2.94 \angle 28.0^\circ \, mA = 2.60\,mA + j\,1.38\,mA$$

$$I_{R_2} = 4.70 \angle 27.9^\circ \, mA = 4.15\,mA + j2.20\,mA.$$

$$I_R = I_{R_1} + I_{R_2} = 6.75\,mA + j3.58\,mA$$

$$= 7.64 \angle 27.9^\circ \, mA.$$

Q No (2)

Sol:-

Remove R_L and determine the voltage from A to B (V_{th}). In this case the voltage from A to B is th same as the voltage Across X_L. This determined using the voltage-divider method.

$$V_L = \left(\frac{X_L \angle 90^\circ}{R_1 + jX_L}\right) V_s$$

$$= \left(\frac{50 \angle 90^\circ \Omega}{112 \angle 26.6^\circ \Omega}\right) 25 \angle 0^\circ V$$

$$= 11.2 \angle 63.4^\circ V$$

$$V_{th} = V_{AB} = V_L = 11.2 \angle 63.4^\circ V.$$

Q.No (3)

Solution :- For $f = 10\,KHZ$

$$X_C = \frac{1}{2\pi f c} = \frac{1}{2\pi(10KHZ)(0.01\,\mu F)} = 1.59\,K\Omega$$

$$X_L = 2\pi f c = 2\pi(10KHZ)(1mH) = 62.8\,\Omega.$$

The magnitude of total impedence is

$$Z_{tot} = \sqrt{(R_S+R_L)^2+(X_L-X_C)^2} = \sqrt{(20\,\Omega)^2+(1.53K\Omega)^2}$$

$$= 1.53\,K\Omega.$$

The current is

$$I = \frac{V_S}{Z_{tot}} = \frac{10V}{1.53\,K\Omega} = 6.54\,mA.$$

The load power is

$$P_L = I^2 R_L = (6.54\,mA)^2(10\,\Omega)$$

$$= 428\,\mu W.$$

For $f = 30\ KHZ$

$$X_C = \frac{1}{2\pi(30\ KHZ)(0.01\ \mu F)} = 531\ \Omega$$

$$X_L = 2\pi(30\ KHZ)(1mH) = 189\ \Omega.$$

$$Z_t = \sqrt{(20\ \Omega)^2 + (342\ \Omega)^2} = 343\ \Omega$$

$$I = V_s / Z_t = 10V / 343\ \Omega = 29.2\ mA$$

$$P_L = I^2 R_L = (29.2\ mA)^2 (10\ \Omega) = 8.53\ mW.$$

For $f = 50\ KHZ$.

$$X_C = \frac{1}{2\pi(50\ KHZ)(0.01\ \mu F)} = 318\ \Omega$$

$$X_L = 2\pi(50\ KHZ)(1mH) = 314\ \Omega$$

Note that X_C and X_L are very close to being equal which makes the impedences approximately complex conjugates. The exact frequency at which $X_L = X_C$ is 50.3 KHZ.

$$Z_t = \sqrt{(20\,\Omega)^2 + (4\,\Omega)^2} = 20.4\,\Omega.$$

$$I = V_s/Z_t = 10V/20.4\Omega = 490\,mA$$

$$P_L = I^2 R_L = (490\,mA)^2 (10\,\Omega) = 2.40\,W.$$

For $f = 80$ KHZ.

$$X_C = \frac{1}{2\pi(80\,KHZ)(0.01\,\mu F)} = 199\,\Omega$$

$$X_L = 2\pi(80\,KHZ)(1\,mH) = 503\,\Omega$$

$$Z_t = \sqrt{(20\,\Omega)^2 + (304)^2} = 305\,\Omega.$$

$$I = V_s/Z_t = 10V/305\Omega = 32.8\,mA.$$

$$P_L = I^2 R_L = (32.8\,mA)^2 (10\,\Omega) = 10.8\,mW.$$

For $f = 100\ KHZ$

$$X_C = \frac{1}{2\pi(100\ KHZ)(0.01\ \mu F)} = 159\ \Omega$$

$$X_L = 2\pi(100\ KHZ)(1\ mH) = 628\ \Omega$$

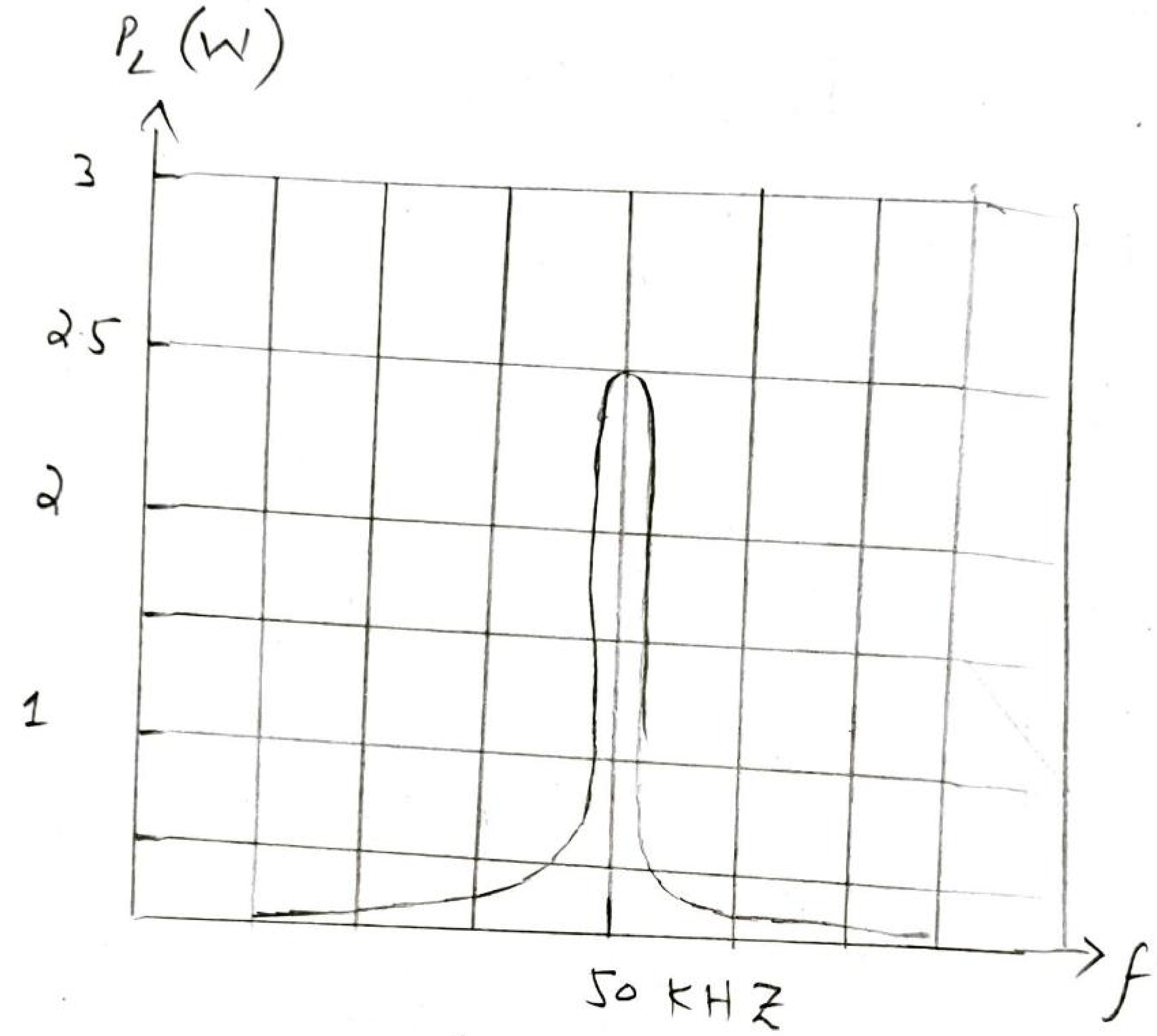
$$Z_t = \sqrt{(20\ \Omega)^2 + (469\ \Omega)^2} = 469\ \Omega$$

$$I = V_s/Z_L = 10\ V/469\ \Omega = 21.3\ mA.$$

$$P_L = I^2 R_L = (21.3\ mA)^2 (10\ \Omega) = 4.54\ mW.$$

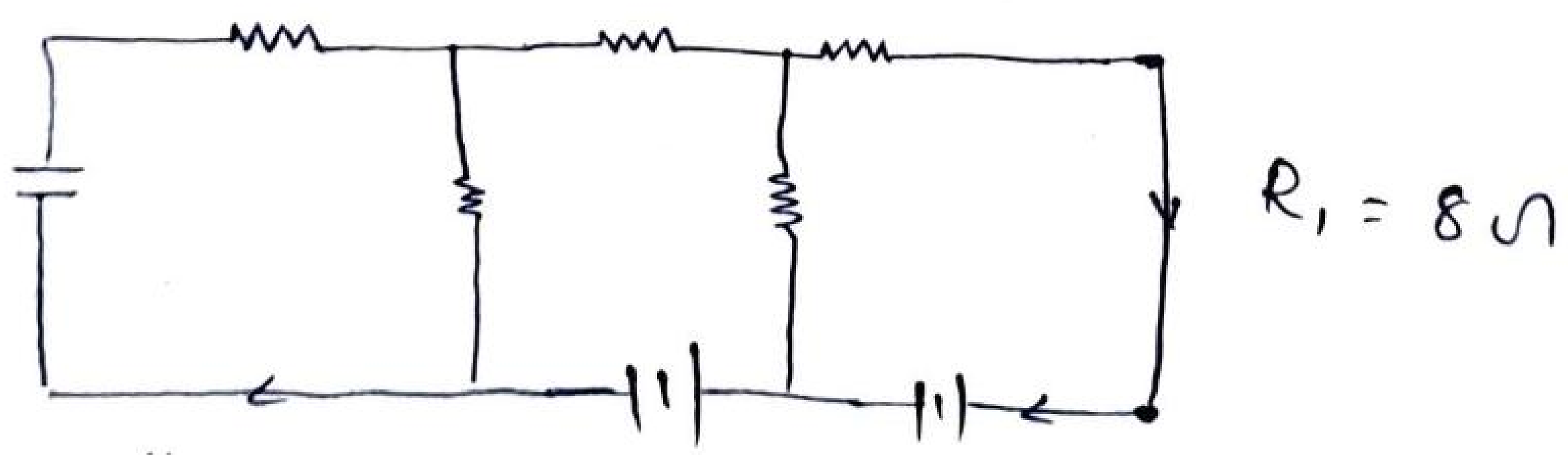
As you can see from the result the power to load peak at the frequency 50 KHZ for which the load impedence is the complex conjugate of the out put impedence. A graph of the load power versus frequency is shown below. Since the maximum power is so much larger than the other values.

an accurate plot is difficult to achieve without intermediate value.



QNo (4)

Sol:-



Northon's theorm.

For Loop I :

$$-2I_1 - 4I_2 + 20 = 0$$

$$I_1 + 2I_2 = +10 \quad \text{——} \quad (1)$$

for loop II

$\Rightarrow -4(I_1 - I_2) - 2(I_1 - I_2 - I_3) - 8 + 4I_2 = 0$

$\Rightarrow -6I_1 + 10I_2 + 2I_3 = 8$

$\Rightarrow -3I_1 + 5I_2 + I_3 = 4$ — (2)

For loop III

$\Rightarrow -4I_3 + 4 + 2(I_1 - I_2 - I_3) = 0$

$\Rightarrow 2I_1 - 2I_2 - 6I_3 = -4$

$\Rightarrow I - I_1 - 3I_3 = -2$ —— (3)

we have to solve this three equation ~~similarly~~ simaltaniously, Now we are not interested in all the values of I_1, I_2 we know that current through A to B shortly

So we find I_3 only.

$I_1 + 2I_2 = 10$ — (1)

$-3I_1 + 5I_2 + I_3 = 4$ — (2)

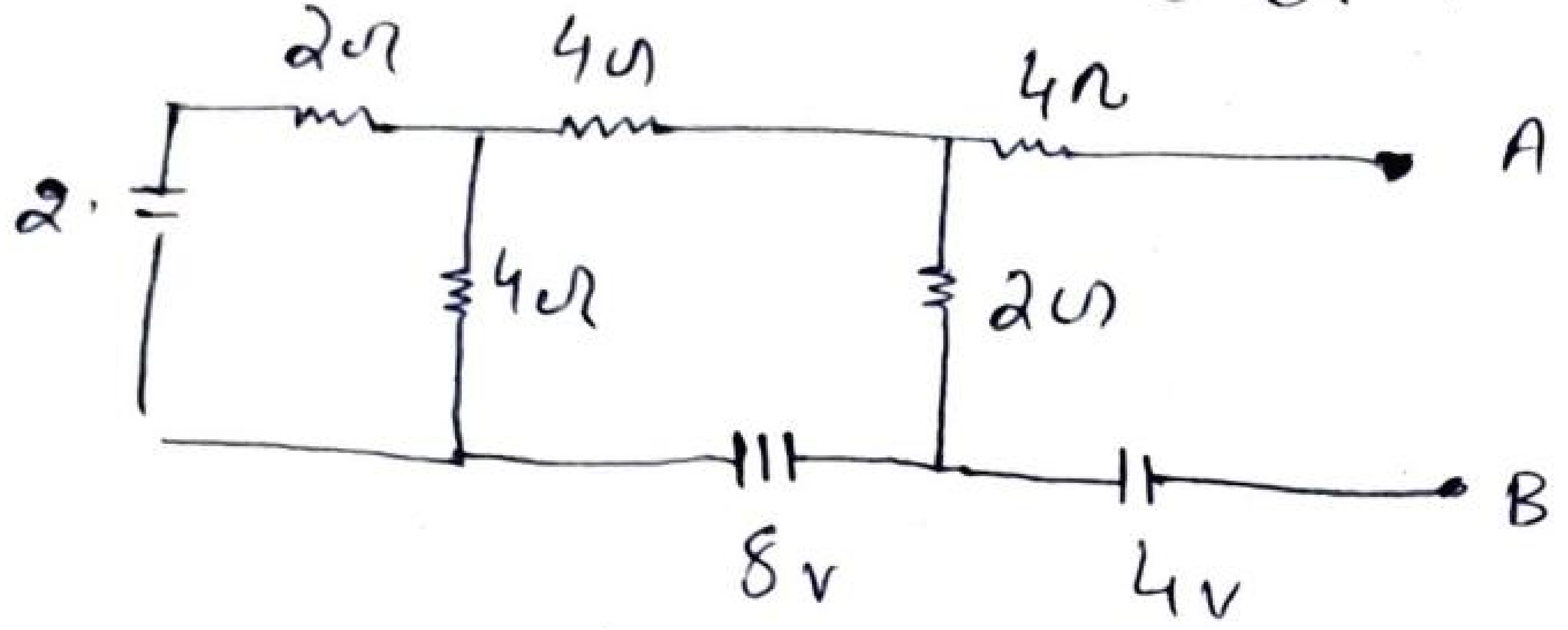
$I_1 - I_2 - 3I_3 = -2$ — (3)

So eq 3 becomes.

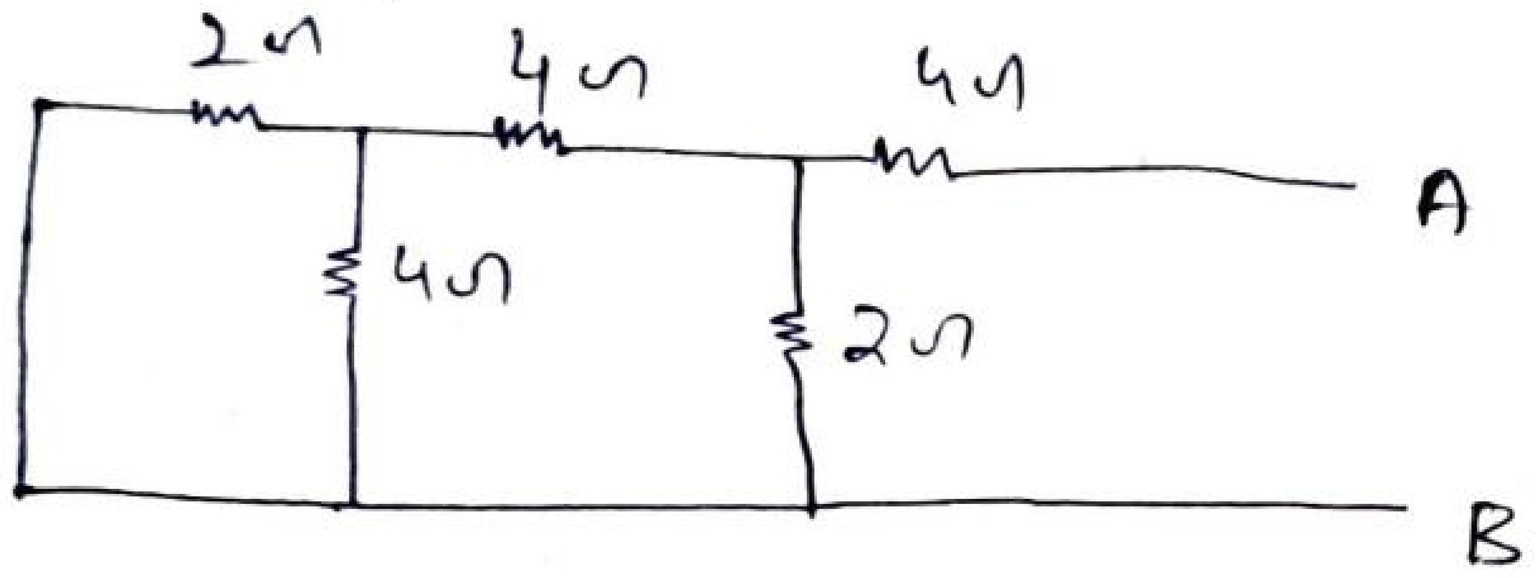
$$(I_2 + 3I_3 - 2) - (-I_1 + 3I_3 - 2) - 3I_3 = -2$$

$$I_3 = 1\,A \quad (\text{from } A \text{ to } B)$$

Remove R_2 circuit

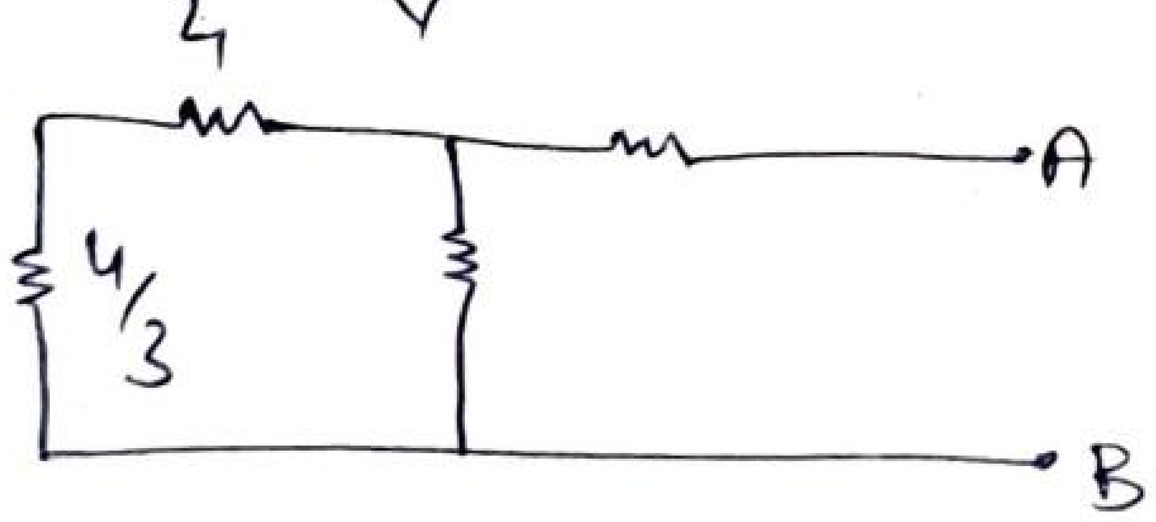


$\Downarrow$



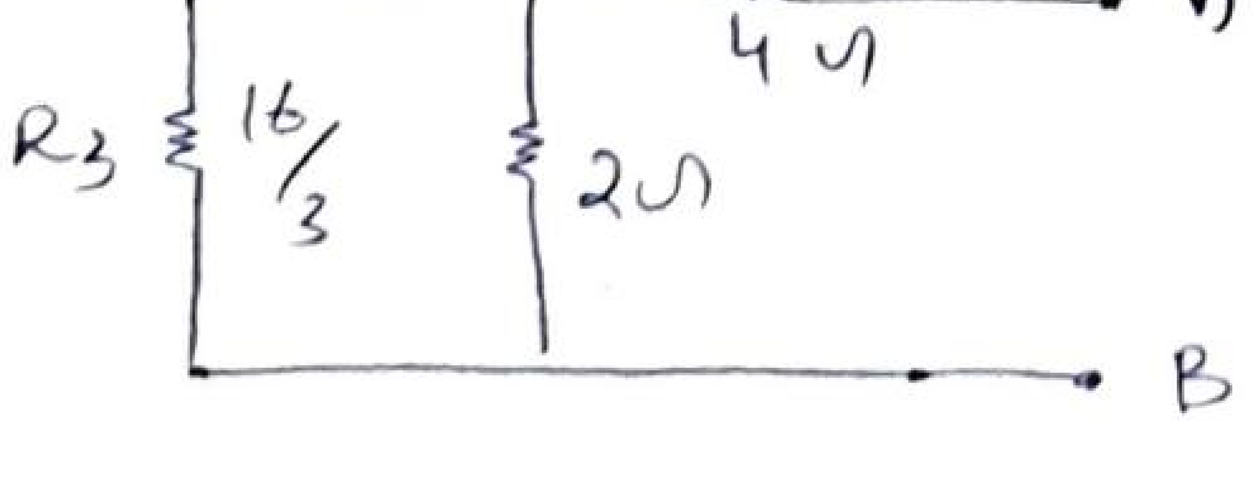
$$R_1 \parallel R_2 = \frac{2 \times 4}{2+4} = 8/6 = 4/3$$

$\Downarrow$



$R_3 + R_4$

$$= 4/3 + 4 = 16/3$$

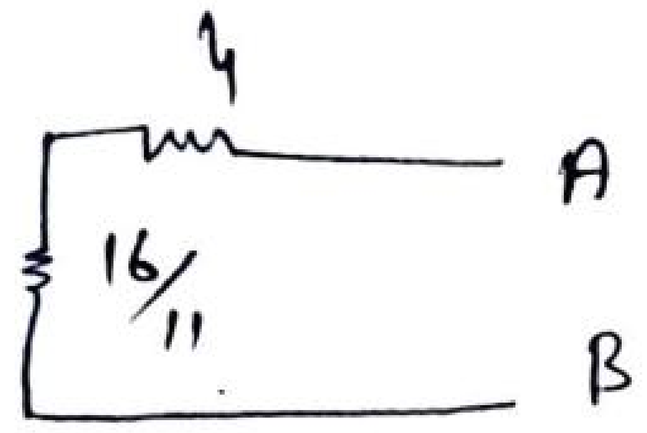


$$R_3 + R_4 = \frac{16/3 \times 2}{16/3 + 2}$$

$$= \frac{32/3}{32/3}$$

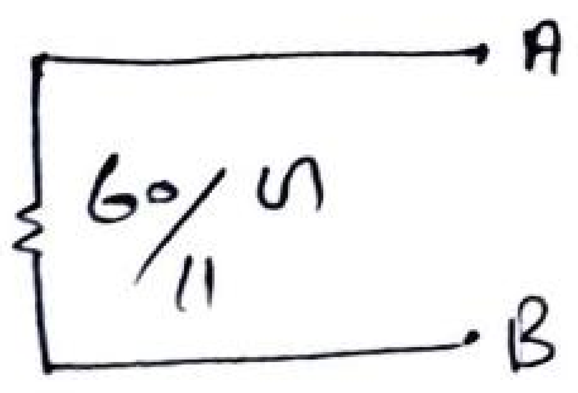
$$= \frac{16}{11}\ \Omega$$

$R_4 + R_6 =$

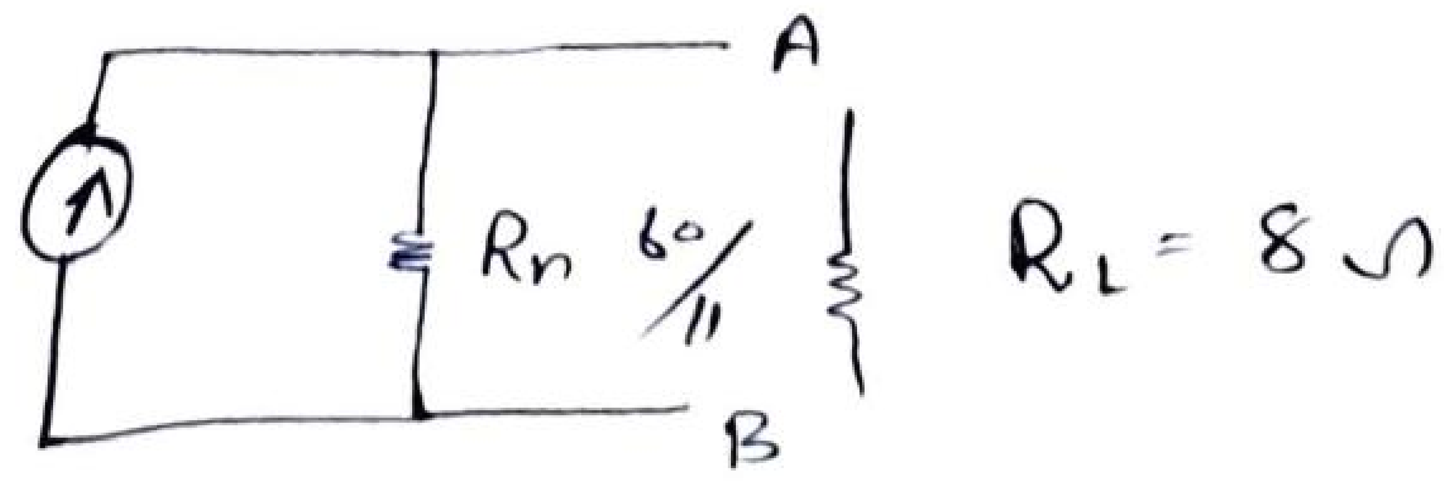


$$= 4 + \frac{16}{11}$$

$$= \frac{60}{11}\ \Omega$$



$$R_n = \frac{60}{11}\ \Omega$$



$$I = I_N \left[\frac{R_N}{R_N + R_L} \right]$$

$$= 1\left[\frac{60/11}{60/11 + 8}\right]$$

$$= \frac{60/11}{148/11}$$

$$= \frac{60}{148}$$

$$I = \frac{15}{37}$$

$$I = 0.4\ A.$$

QNo 5 :-

Answer:- In the following circuit we have 3 nodes from which one is reference node and other is two are non reference nodes - Node 1 and node 2.

Step I. Assign the nodes voltage as V_1 and V_2 also mark the direction of branch currents with respect to the reference - nodes.

Step II: Apply KCL Nodes 1 and 2

KCL at node 1

$$i_1 = i_2 + i_3 \quad \text{— (1)}$$

KCL at node 2

$$i_2 + i_4 = i_1 + i_5 \quad \text{— (2)}$$

Step III Apply ohm's law to KCL equations

ohm's law to KCL equation at Node 1

$$i_1 = i_2 + i_3 \Rightarrow \frac{V_1 - V_2}{4_1}$$

Now ohm's law to Kcl equation at Node 2

$i_2 + i_4 = i_1 + i_5 \Rightarrow \frac{V_1 - V_2}{4}$

Step (IV) Now Solve the equations to get the values of V_1 and V_2.