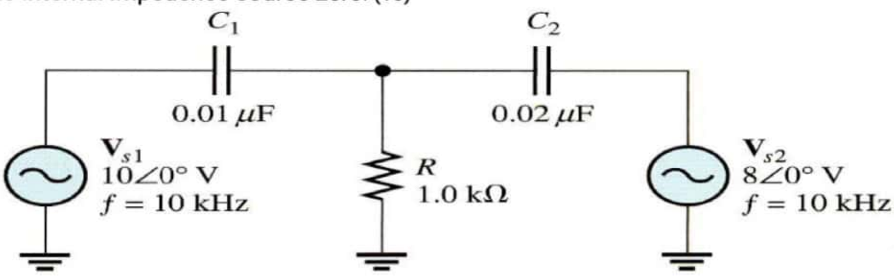
Rafaqatullah
ID 14107

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

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)

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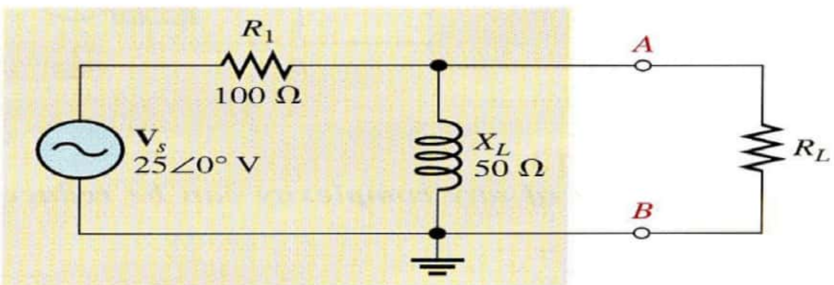
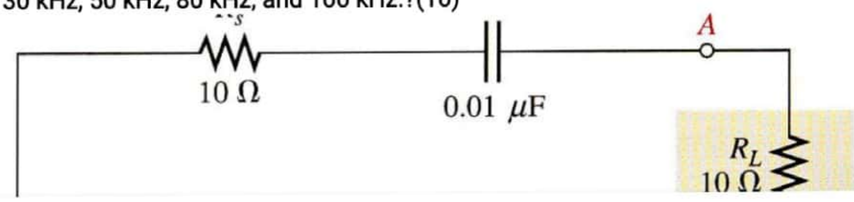


Q3: The circuit to the left of terminals A and B in Figure provides power to the load ZL.

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)



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Name Rafaqatullah Khan
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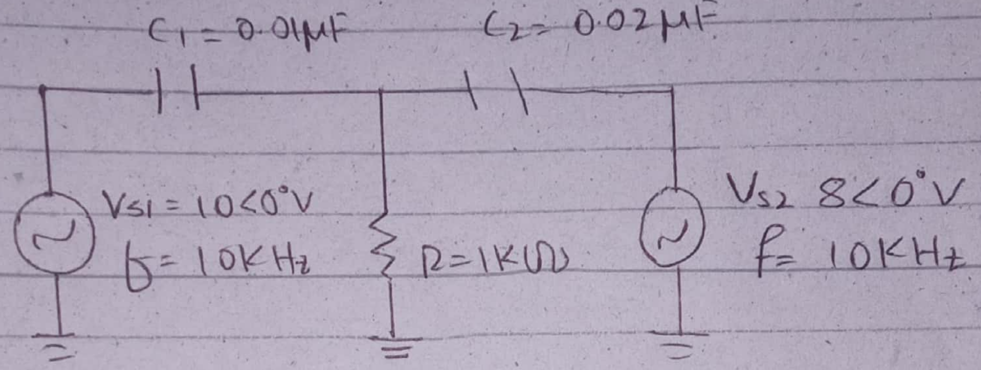
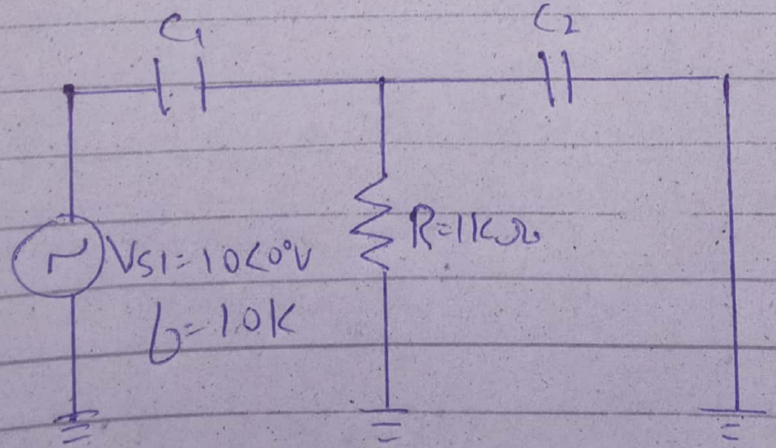
Date 24/Sep/2020

Question#01



Answer:

Replace V_{S2} with its internal impedance (zero) and find the Current in in R due to V_{S1}



(2)

$$X_{C_1} = \frac{1}{2\pi f C_1}$$

$$= \frac{1}{2\pi(10\times10^{3}\,Hz)(0.01\times10^{-6}\,F)}$$

$$X_{C_1} = \frac{1}{(6.28)(0.1)(10^{3-6})}$$

$$X_{C_1} = \frac{1}{0.628\times10^{-3}}$$

$$X_{C_1} = 1.592\,K\Omega$$

$$X_{C_2} = \frac{1}{2\pi f C_2}$$

$$= \frac{1}{(2)(3.14)(10\times10^{3})(0.02\times10^{-6})}$$

$$= \frac{1}{1.256\times10^{-3}}$$

$$X_{C_2} = 796\,\Omega$$

(3)

Coking from V_{S1} the impedenc is

$$Z = X_{C_1} + \frac{R X_{C_2}}{R + X_{C_2}}$$

$$= 159\angle -90^\circ\ K\Omega + \frac{(1.0\angle 0 K\Omega)(796\angle -90)}{1.0\Omega - j796}$$

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

$$= -j1.59 K\Omega + 387\ \Omega - j487\ \Omega$$

$$= 387\ \Omega - j2.08\ K\Omega$$

Converting to polar from yeilds.

$$Z = 2.12\angle -79.5^\circ\ K\Omega$$

The total Current from Source 1 is.

$$I_{S1} = \frac{V_{S1}}{Z} = \frac{10\angle 0^\circ V}{2.12\angle -79.5^\circ K\Omega}$$

$$I_{S1} = 472\angle 79.5^\circ\ mA$$

(4)

Using the Current divider formula the current through R due to V_{S1} is:

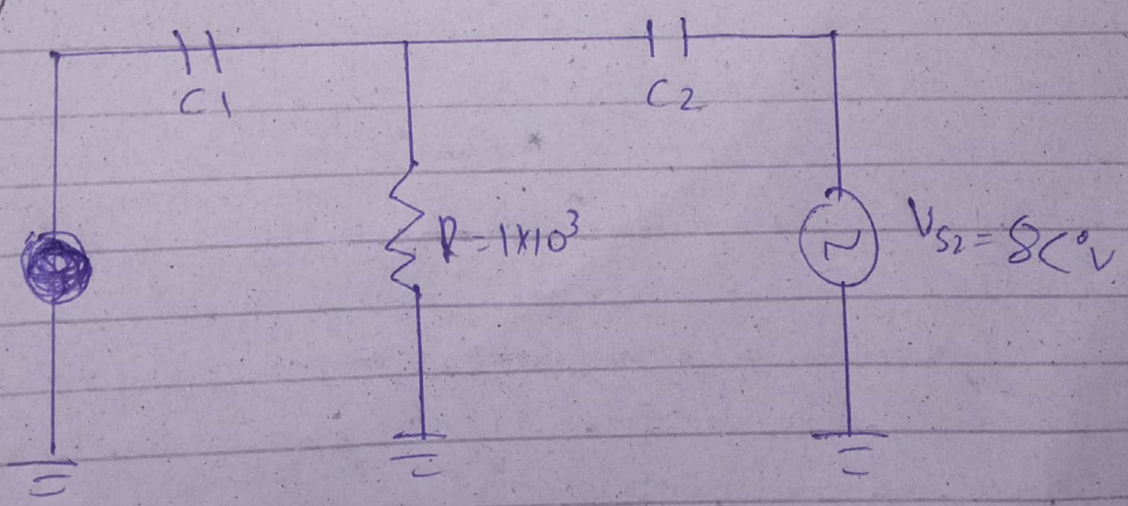
$$I_{R1} = \left(\frac{X_{C2}\angle -90^\circ}{R - jX_{C2}}\right) I_{S1}$$

$$= \left(\frac{796\angle -90^\circ \Omega}{1.0k\Omega - j796\Omega}\right) \times 4.72\angle 79.5 mA$$

$$= (0.623\angle -51.5\Omega)(4.72\angle 79.5)$$

$$I_{R1} = 2.94\angle 28^\circ mA$$

Finding the current in R to source V_{S2} by replacing V_{SI} with internal impedence which is zero.



(5)

From V_{S2} the impedenc is

$$Z = X_{C2} + \frac{R X_{C1}}{R + X_{C1}}$$

$$= 796\angle -90^\circ + \frac{(1.0\angle 0^\circ \times 10^3)(1.59\angle -90^\circ \times 10^3)}{1.0 \times 10^3\ \Omega - j1.59 \times 10^3}$$

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

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

$$= 717\ \Omega - j1247\ \Omega$$

Converting to polar from yeild:

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

The total Current from Source 2 is

$$I_{S2} = \frac{V_{S2}}{Z}$$

$$= \frac{8\angle 0^\circ\ V}{1438\angle -60.1^\circ\ \Omega}$$

$$I_{S2} = 557\angle 60.1^\circ\ mA$$

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(6)

Using Current-divider Rule the Current through R due to V_{S2} is

$$I_{R2} = \left(\frac{X_{C1} \angle -90^\circ}{R - jX_{C1}}\right) I_{S2}$$

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

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

The total Current through R is:-

$$I_{R1} = 294 \angle 28^\circ \, mA$$
$$\cong 2.60 \, mA + j1.38 \, mA$$

$$I_{R2} = 4.70 \angle 27.9^\circ \, mA$$
$$= 4.15 \, mA + j2.20 \, mA$$

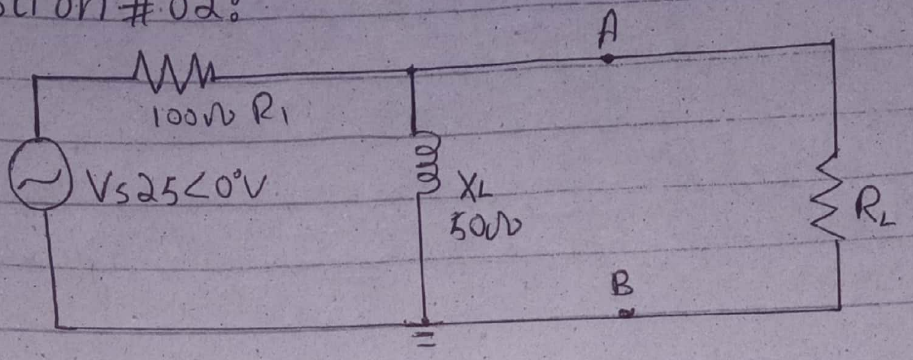
$$I_R = I_{R1} + I_{R2}$$

$$= 6.75 \, mA + j3.58 \, mA$$

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

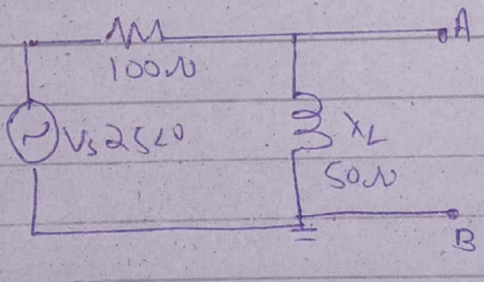
⑦

Question # 02:



Answer:

First we will Remove R_L and than determine the Voltage from A to B (V_{th}). In this Case the Voltage from A to B is the Same as the Voltage across X_L. This determine using the Voltage divider Rule:

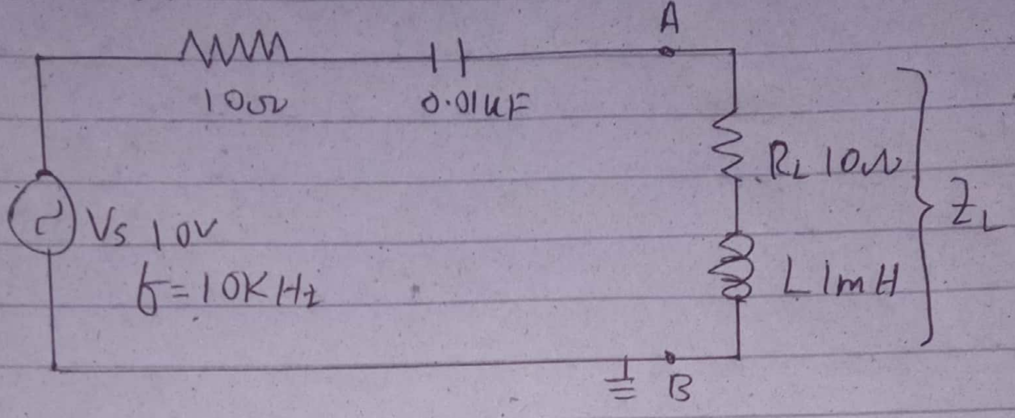


$$V_L = \left(\frac{X_L\angle 90^\circ}{R_1 + jX_L}\right) V_s$$

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

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

Question # 03



Solution:

frequency $= 10\times10^3\,Hz$

$$X_C = \frac{1}{2\pi fC}$$

$$= \frac{1}{2(3.14)(10\times10^3)(0.01\times10^{-6})}$$

$$= 1.59\times10^3\,\Omega$$

$$X_L = 2\pi fC$$

$$= 2(3.14)(10\times10^3)(1\times10^{-3})$$

$$X_L = 62.8\,\Omega$$

(9)

Magnitude of total impedence is:

$$Z_T = \sqrt{(R_S+R_L)^2+(X_L-X_C)^2}$$

$$= \sqrt{(20)^2+(1.53)^2}$$

$$Z_T = 1.53K\Omega.$$

Current is:

$$I = \frac{V_S}{Z_t}$$

$$= \frac{10}{1.53}$$

$$I = 6.54\ mA$$

Load power is:

$$P_L = I^2 R_L$$

$$= (6.54\ mA)^2 (10)$$

$$P_L = 428\ \mu W$$

For $30 \times 10^3 Hz$

$$X_C = \frac{1}{2\pi (30 \times 10^3)(0.01 \times 10^{-6})}$$

$$X_C = 531 \Omega$$

$$X_L = 2\pi (30 \times 10^3)(1 \times 10^{-3})$$

$$X_L = 189 \Omega$$

$$I = \frac{V_S}{Z_t}$$

$$= \frac{10V}{343}$$

$$I = 29.2 mA$$

$$P_L = I^2 R_L$$

$$= (29.2)^2 (10)$$

$$P_L = 8.53 mW$$

(11)

For $f = 50KHz$

$$X_C = \frac{1}{2\pi(50\times10^{3})(0.01\times10^{-6})}$$

$X_C = 318\Omega$

$X_L = 2(3.14)(50\times10^{3})(1\times10^{-3})$

$X_L = 314\Omega$

X_C and X_L are very close to being equal which makes the impedence approximately complex conjugate. The exact frequency at which $X_L = X_C$ is $50.3KHz$.

$Z_t = \sqrt{(20)^2 + (4)^2}$

$= 20.4\Omega$

$$I = \frac{V_s}{Z_t}$$

$$= \frac{10}{20.4\Omega}$$

$I = 490mA$

(12)

$P_L = I^2 R_L$

$= (490mA)^2(10)$
$= 2.40W$

For frequency = 80KHz

$$X_C = \frac{1}{2(3.14)(80\times10^3)(0.01\times10^{-6})}$$

$X_C = 199\,\Omega$

$X_L = 2(3.14)(80\times10^3)(1\times10^{-3})$
$= 503\,\Omega$

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

$$I = \frac{V_s}{Z_t}$$

$$= \frac{10}{305}$$

$= 32.8mA$

$P_L = I^2 R_L$
$= (32.8mA)^2(10)$
$P_L = 10.8mW$

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(13)

frequency = 100 KHz

$$X_C = \frac{1}{2(3.14)(100\times10^3)(0.01\times10^{-6})}$$

$X_C = 159\,\Omega$

$X_L = 2(3.14)(100\times10^3)(1\times10^{-3})$
$X_L = 628\,\Omega$

$$I = \frac{V_s}{Z_t}$$

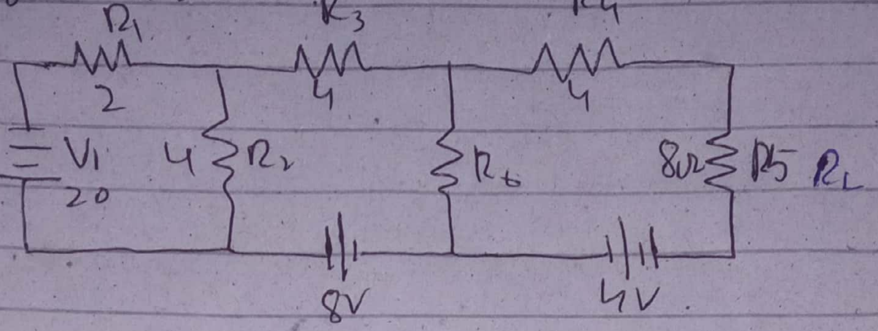
$$= \frac{10}{469}$$

$I = 21.3\,mA$
$P_L = I^2 R$
$= (21.3\times10^{-3})^2(10)$
$P_L = 4.54\,mW$

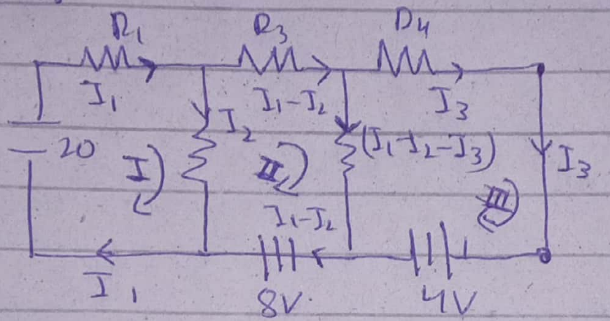
from all result power to load peak the frequency 50KHz for which the load impedence is the complex conjuagte of the out-put impendence. A graph of load power versus frequency is shown below since the maximum power is so much larger than the other values an accurate plot is differcilt to achieve without intermidiate values.

(14)

Question # 04:



Answer:



$R_L = 8\Omega$

Norton's theorm.

For Loop I:

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

$$I_1 + 2I_2 = 10 \quad — (1)$$

For Loop II:

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

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

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

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For loop III:

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

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

$$I_1 - I_2 - 3I_3 = -2 \quad \text{--- (3)}$$

We have to sol this three equation simaltaniouly, Now we are not intersented in all the values of I_1, I_2,
We know that current through shotedly A to B.
So we will find only I_3
thus

$$I_1 + 2I_2 = 10 \quad \text{-(i)}$$
$$-3I_1 + 5I_2 + I_3 = 4 \quad \text{-(ii)}$$
$$I_1 - I_2 - 3I_3 = -2 \quad \text{-(iii)}$$

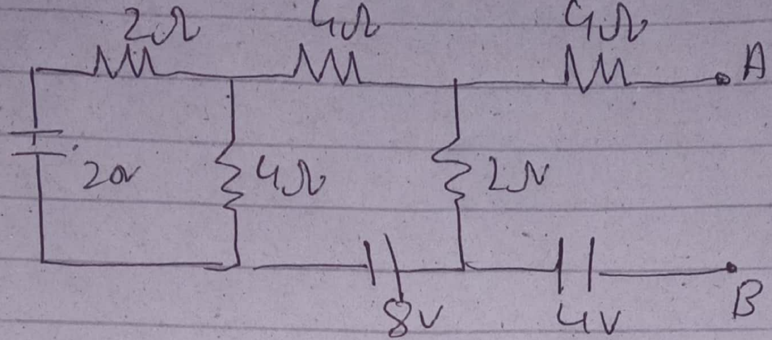
So eq (3) become

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

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

(16)

Remove R_L Circuit.



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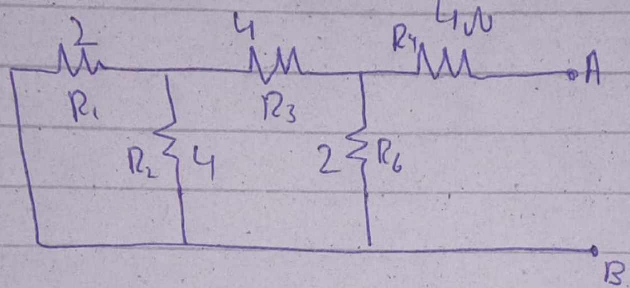
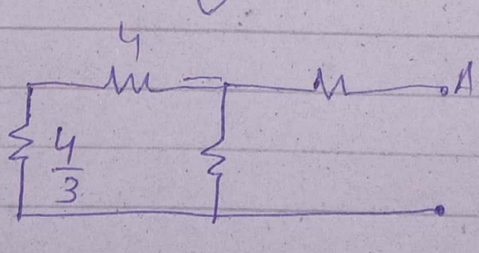


$$R_1 \parallel R_2 = \frac{2\times4}{2+4} = \frac{8}{6} = \frac{4}{3}$$

⇓



$$R_3 + R_4 = \frac{4}{3} + 4$$

$$= \frac{16}{3}$$

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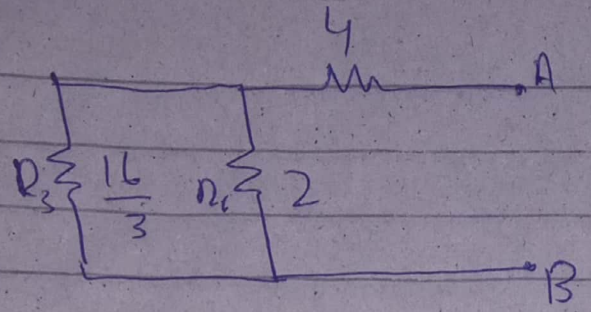
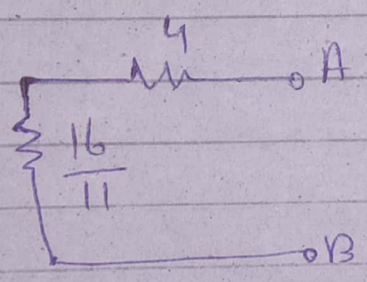


$$R_3 + R_6 = \frac{\frac{16}{3} \times 2}{\frac{16}{3} + 2}$$

$$= \frac{32/3}{22/3}$$

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

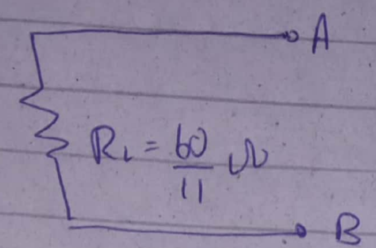
$R_4 + R_6 =$



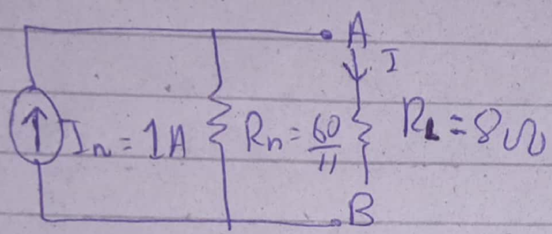
$$R_4 + R_6 = 4 + \frac{16}{11}$$

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

(18)



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



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

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

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

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

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

$$\boxed{I = 0.4A}$$

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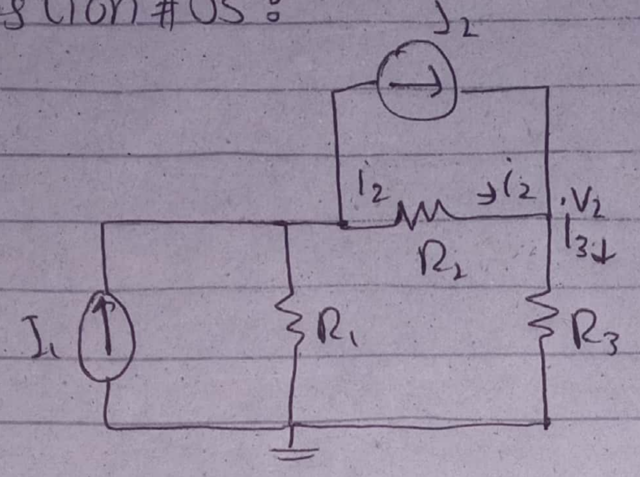
(19)

Question #05:



Sol:

In the upper Circuit we have 3 nodes from which one is refrence node and other is two are non- refrence nodes- Node 1 & Node 2.

Step 1:

Assign the nodes Voltage as V_1 & V_2 also mark the direction of branch Current with respect to the reference.

Step 2:

Apply KCL Nodes 1 & 2

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(20)

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 eq:

ohm's law to KCL eq at node 1

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

Now ohm's law to KCL eq at node 2

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

Step 4:

Now sol the eq to get the values of V_1 & V_2.