VIT
Vellore Institute of Technology

School of Electrical Engineering

Fall Semester 2023-24

Continuous Assessment Test – 1

SLOT: G1+TG1

Programme Name & Branch : B.Tech & CSE

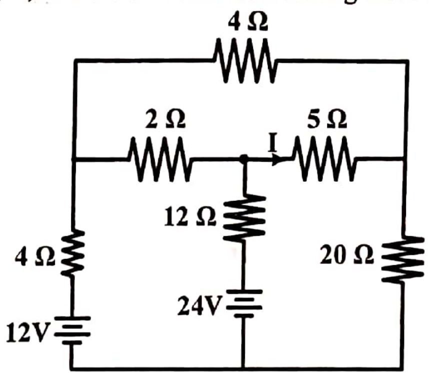
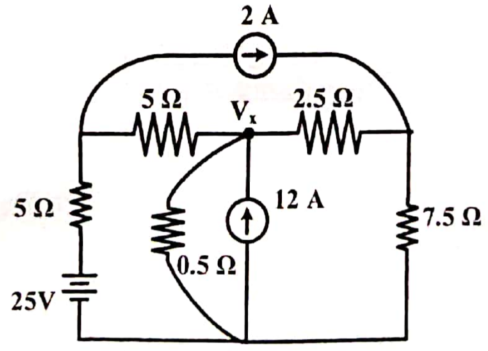
Course Name & code: Basic of Electrical and Electronics Engineering & BEEE102L

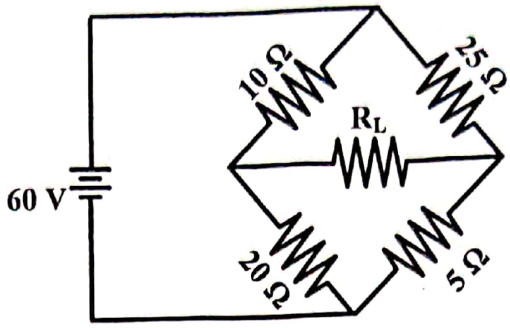
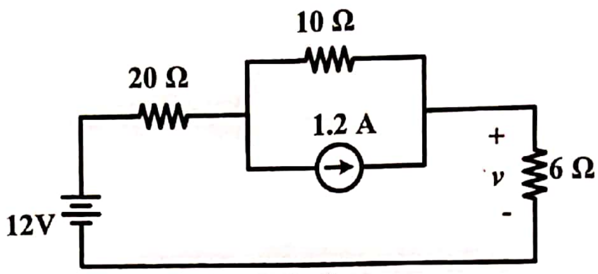
Class Numbers: VL2023240107487, VL2023240107785, VL2023240107779, VL2023240107494, VL2023240107791

Faculty Names: Dr. Suprava Chakraborty, Dr. Venkata Ramana Kasi, Dr. Jakeer Hussain, Dr. Monica Subashini M, Dr. Rajesh Kumar Lenka

Exam Duration: 90 Min. **Maximum Marks: 50**

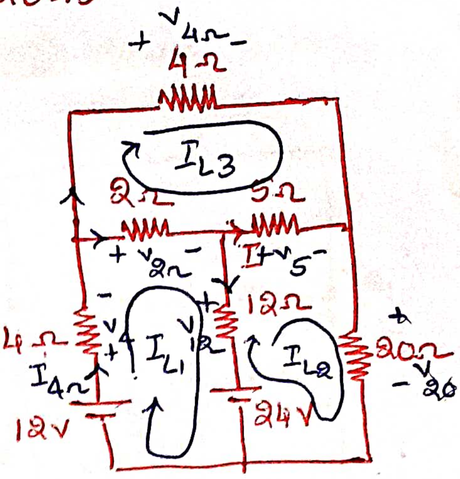
General instruction: Answer all questions

Q.No.	Question	Max Marks
1.	For the circuit in Fig. 1, find the branch current I using mesh current analysis.  **Fig.1**	10
2.	Calculate the node voltage V_x in the circuit shown in Fig. 2, using node voltage analysis.  **Fig.2**	10

3.	Calculate the value of R_L for maximum power transfer in the circuit of Fig. 3. Compute the maximum power absorbed by the R_L.  Fig.3	10
4.	Use Superposition theorem to find v in the circuit of Fig. 4.  Fig.4	10
5.	A coil of inductance 125 mH and negligible resistance is connected in series with a $5\ \Omega$ resistor and 100 μF capacitor to a 300 V, 50 Hz supply. Calculate a. Circuit impedance b. Circuit current c. Circuit phase angle d. Voltage across inductive coil e. Voltage across capacitor	10

G1-Slot- BEEE102L - FALL-2023

[1] Find branch current I, using mesh current analysis.



KVL @ loop-1 :

$$12 = V_{4\Omega} + V_{2\Omega} + V_{12\Omega} + 24$$

$$-12 = 4I_{L1} + 2(I_{L1} - I_{L3}) + 12(I_{L1} - I_{L2})$$

$$-12 = 18I_{L1} - 12I_{L2} - 2I_{L3} \quad \text{— (1)}$$

$V_{4\Omega} = 4I_{L1}$

$V_{2\Omega} = 2(I_{L1} - I_{L3})$

$V_{12\Omega} = 12(I_{L1} - I_{L2})$

$V_{5\Omega} = 5(I_{L2} - I_{L3})$

$V_{20\Omega} = 20I_{L2}$

$V_{4\Omega} = 4I_{L3}$

KVL @ loop-2 :

$$24 + V_{12\Omega} = V_{5\Omega} + V_{20\Omega}$$

$$24 + 12(I_{L1} - I_{L2}) = 5(I_{L2} - I_{L3}) + 20I_{L2}$$

$$24 = -12I_{L1} + 37I_{L2} - 5I_{L3} \quad \text{— (2)}$$

KVL @ loop-3 :

$$V_{5\Omega} + V_{2\Omega} = V_{4\Omega}$$

$$5(I_{L2} - I_{L3}) + 2(I_{L1} - I_{L3}) = 4I_{L3}$$

$$0 = -2I_{L1} - 5I_{L2} + 11I_{L3} \quad \text{— (3)}$$

=> (1), (2), (3):

$$\begin{bmatrix} 18 & -12 & -2 \\ -12 & 37 & -5 \\ -2 & -5 & 11 \end{bmatrix} \begin{bmatrix} I_{L1} \\ I_{L2} \\ I_{L3} \end{bmatrix} = \begin{bmatrix} -12 \\ 24 \\ 0 \end{bmatrix}$$

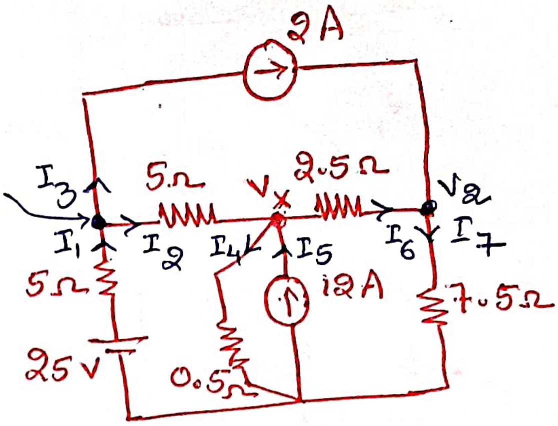
$AX = B$

$X = A^{-1}B.$

$$\Rightarrow \begin{bmatrix} I_{L1} \\ I_{L2} \\ I_{L3} \end{bmatrix} = \begin{bmatrix} -0.24 \\ 0.602 \\ 0.23 \end{bmatrix}$$

$$\therefore I_{5\Omega} = I_{L2} - I_{L3} = 0.372\ A$$

[2] Calculate the node voltage V_x using node voltage analysis:



KCL @ node-1:

$$I_1 = I_2 + I_3$$

$$\frac{25 - V_1}{5} = \frac{V_1 - V_x}{5} + 2$$

$$3 = 0.4 V_1 - 0.2 V_x \quad \text{—} \ (1)$$

$I_1 = \frac{25 - V_1}{5}$

$I_2 = \frac{V_1 - V_x}{5}$

$I_3 = 2A$

$I_4 = \frac{V_x}{0.5}$

$I_5 = 12A$

$I_6 = \frac{V_x - V_2}{2.5}$

$I_7 = V_2/7.5$

KCL @ node-x:

$$I_2 + I_5 = I_4 + I_6$$

$$\frac{V_1 - V_x}{5} + 12 = \frac{V_x}{0.5} + \frac{V_x - V_2}{2.5}$$

$$12 = -0.2 V_1 + 2.6 V_x - 0.4 V_2 \quad \text{—} \ (2)$$

KCL @ node-2: $I_6 + I_3 = I_7$

$$\frac{V_x - V_2}{2.5} + 2 = \frac{V_2}{7.5}$$

$$2 = -0.4 V_x + 0.534 V_2 \quad \text{—} \ (3)$$

=> (1), (2), (3):

$$\begin{bmatrix} 0.4 & -0.2 & 0 \\ -0.2 & 2.6 & -0.4 \\ 0 & -0.4 & 0.534 \end{bmatrix} \begin{bmatrix} V_1 \\ V_x \\ V_2 \end{bmatrix} = \begin{bmatrix} 3 \\ 12 \\ 2 \end{bmatrix}$$

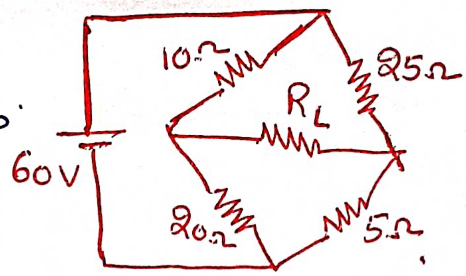
$$Ax = B$$

$$x = A^{-1} B$$

$$\therefore \begin{bmatrix} V_1 \\ V_x \\ V_2 \end{bmatrix} = \begin{bmatrix} 10.91 \\ 6.81 \\ 8.85 \end{bmatrix}$$

$\therefore V_x = 6.81V$

[3] Calculate R_{Lopt} for $P_{R_{L max}}$.

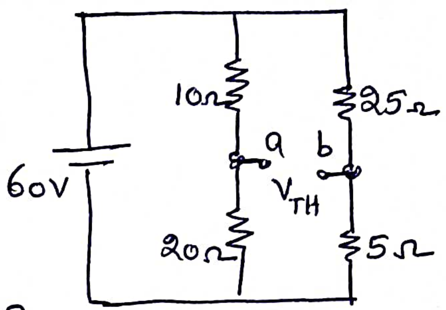


V_{TH} Calculations : $V_{TH} = V_{ab} = V_a - V_b$.

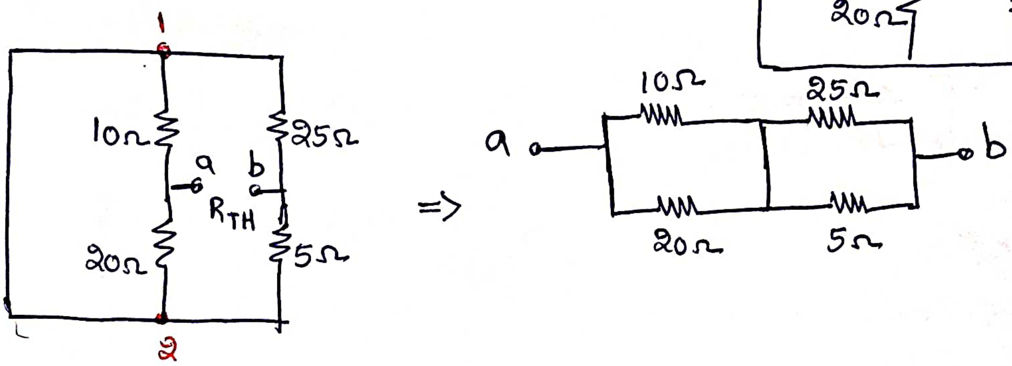
$$V_a = 60 * \frac{20}{30} = 40\ V$$

$$V_b = 60 * \frac{5}{30} = 10\ V$$

$\therefore\ V_{TH} = V_{ab} = 30\ V$ — ①



R_{TH} Calculation :

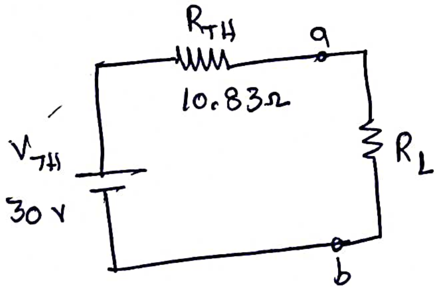


$$R_{TH} = R_{ab} = (10 \| 20) + (25 \| 5)$$

$$= 6.667 + 4.1667$$

$$= 10.83\Omega \quad — ②$$

Thevenin ckt :

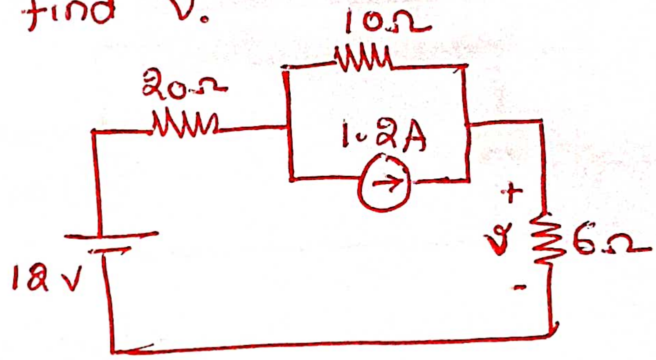


According to max power transfer theorem, $R_{Lopt} = R_{TH}$ for $P_{R_{Lmax}}$

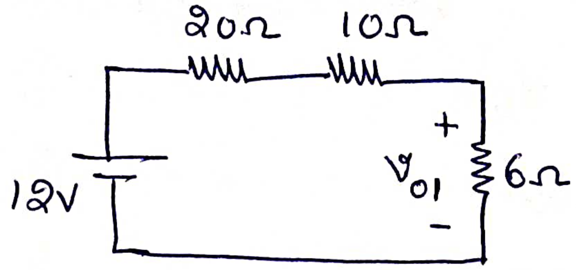
$\therefore\ R_{Lopt} = 10.83\Omega$ //

$$P_{R_{Lmax}} = \frac{V_{TH}^2}{4 R_{TH}} = \frac{(30)^2}{4\ (10.83)} = 20.77\ W //$$

[4] using superposition theorem, find v.

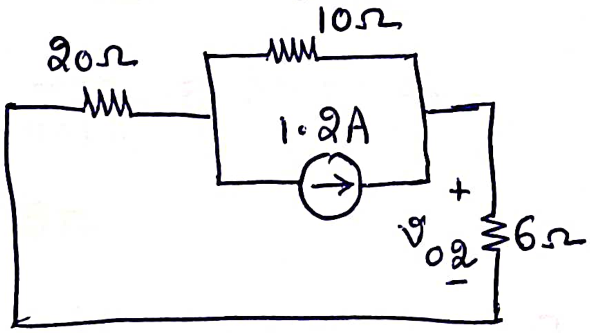


with 12V alone :

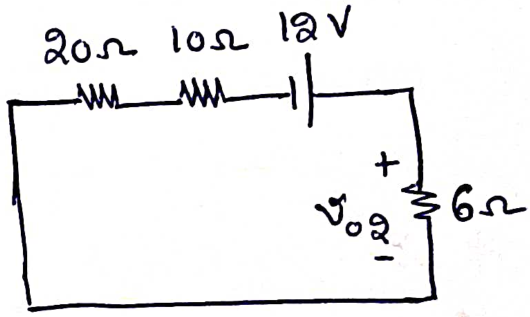


$$v_{01} = 12 * \frac{6}{20+10+6} = 2V \quad — (1)$$

with 1.2A alone :



=>



$$v_{02} = 12 * \frac{6}{20+10+6} = 2V \quad — (2)$$

$\therefore \quad v_0 = v_{01} + v_{02} = 4V$ ||

[5] Calculate

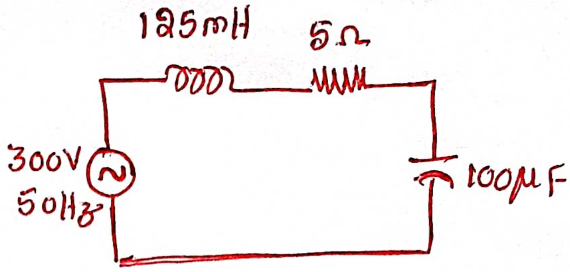
ⓐ Circuit impedance

② Circuit Current

③ Circuit phase angle

④ Voltage across inductive coil

⑤ Voltage across capacitor



$\bar{V}_s = 300\sqrt{2} \angle 0^\circ$

$X_L = 2\pi f L = 39.27\,\Omega$

$X_C = \dfrac{1}{2\pi f C} = 31.83\,\Omega$

$R = 5\,\Omega$

ⓐ Impedance : $Z = R + j[X_L - X_C] = 5 + j7.44 = 8.96 \angle 56.1^\circ\,\Omega$ //

ⓑ Circuit current : $\bar{I} = \dfrac{\bar{V}}{Z} = \dfrac{300\sqrt{2} \angle 0}{8.96 \angle 56.1} = 47.35 \angle -56.1^\circ\,A$ //

$I_{Rms} = \dfrac{47.35}{\sqrt{2}} = 33.48\,A$ //

ⓒ Circuit phase angle : $\phi = -56.1^\circ$ //

ⓓ Voltage across inductive coil : $V_L = I_L X_L$

$= (47.35 \angle -56.1)(39.27 \angle 90^\circ)$

$= 1859.43 \angle 33.9^\circ\,V$ //

ⓔ voltage across capacitive element : $V_c = I_c X_c$

$= (47.35 \angle -56.1)(31.83 \angle -90^\circ)$

$= 1507.1 \angle -146.1^\circ\,V$ //