B.Tech - Even Sem : Semester in Exam-I
Academic Year:2024-2025

23EC1203 - BASIC ELECTRICAL AND ELECTRONIC CIRCUITS

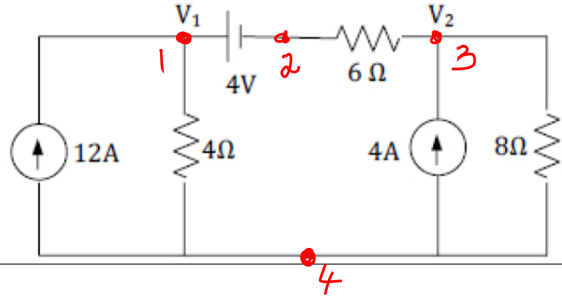
Set No: 2

Time: **Max.Marks: 50**

S.NO	Answer All Questions	Choice	Options	Marks	CO	CO BTL	COI BTL
1.	ANSWER ALL QUESTIONS (6 X 2 = 12 M)			12Marks	CO1	2	2
1.A.	Write the V-I relation of a Inductor.			2Marks	CO1	2	2

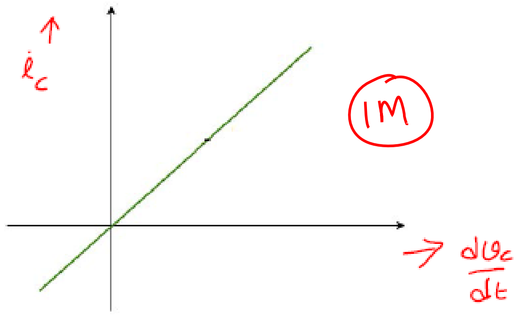
Volatge $v\,(t) = L\,\frac{di(t)}{dt}$ — 1M

Current $i\,(t) = \frac{1}{L}\int v\,(t)dt$ — 1M

S.NO	Answer All Questions	Choice	Options	Marks	CO	CO BTL	COI BTL
1.B.	Identify the number of Nodes in the circuit shown below. 			2Marks	CO1	2	2

no of nodes are 4. node 1, node 2, node 3 and node 4. 2M

S.NO	Answer All Questions	Choice	Options	Marks	CO	CO BTL	COI BTL
1.C.	Plot the V-I characteristics of a Capacitor.			2Marks	CO1	2	2



1M

$i_c = C\frac{dv_c}{dt}$ 1M

S.NO	Answer All Questions	Choice	Options	Marks	CO	CO BTL	COI BTL
1.D.	Mention the Form factor and Peak factor of the Sinusoidal signal.			2Marks	CO2	2	1

For sinusoidal signal, $V_{rms} = \frac{V_m}{\sqrt{2}}$

$V_{avg} = \frac{2V_m}{\pi}$

by def Form Factor $= \frac{V_{rms}}{V_{avg}} = \frac{V_m\,\pi}{\sqrt{2}\;2V_m} = \frac{\pi}{2\sqrt{2}} = 1.11$ — 1M

by def Peak Factor $= \frac{V_m}{V_{rms}} = \frac{V_m\sqrt{2}}{V_m} = \sqrt{2} = 1.414$ — 1M

1.E.	Define Impedance and Reactance.			2Marks	CO2	2	1

Impedance is the total opposition that a circuit offers to the flow of alternating current (AC). It consists of both resistance (R) and reactance (X) and is represented as a complex number. 1M

Reactance is the opposition to AC current caused by inductors (L) and capacitors (C). It does not cause power dissipation (unlike resistance) but affects the phase of the current. 1M

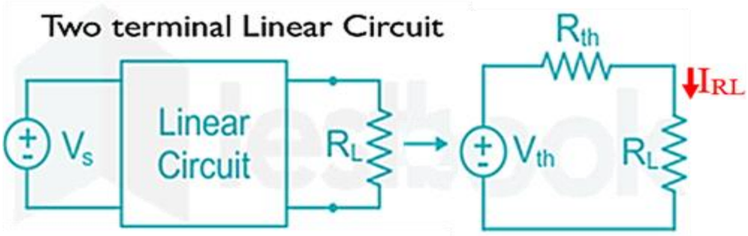
1.F.	Mention the impedance in a series resonance circuit at resonance frequency.			2Marks	CO2	2	1

At the **resonance frequency** in a series resonance circuit, the inductive and capacitive reactance's cancel each other out So the impedance reduces to only the resistance: 1M

Z=R, This means the circuit behaves like a pure resistor at resonance. 1M

2.	ANSWER ALL QUESTIONS (4 X 4 = 16 M)			16Marks	CO2	2	2
2.A.	State and explain Thevenn's theorem.			4Marks	CO1	2	2

Any two-terminal linear circuit having a number of voltage current sources and resistances can be replaced by a simple equivalent circuit consisting of a single voltage source (V_{th}) in series with a resistance (R_{th}). 2M



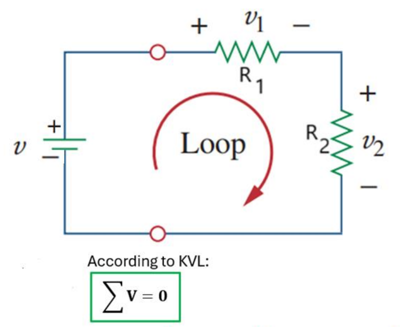
2M

2.B.	State and explain Kirchoff's laws.			4Marks	CO1	2	2

Kirchhoff's Voltage Law (KVL) states that the total voltage around any closed loop in a circuit is zero.

The algebraic sum of voltages around each loop is zero.

Σ Voltage Drops - Σ Voltage Rises = 0



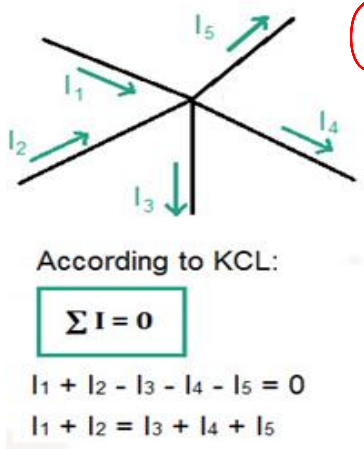
2M

$$-v + v_1 + v_2 = 0$$

Kirchhoff's Current Law (KCL) states that the total current entering a node in an electrical circuit is equal to the total current leaving the node.

The algebraic sum of currents entering a node is zero.

Σ Currents In - Σ Currents Out = 0



2M

2.C.	Two sinusoidal signals i1 = 10Sin100t and i2 = 10Sin(100t+30°).Calculate i = i1 * i2.			4Marks	CO2	2	2

given that $i_1 = 10 \sin 100t$ and $i_2 = 100 \sin(100t + 30^\circ)$.

Expressing i_1 and i_2 into polar form,

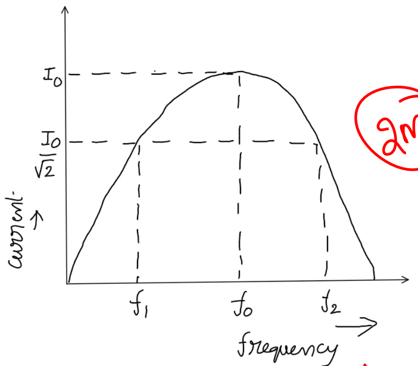
Then $I_1 = 10 \angle -90^\circ$ and $I_2 = 10 \sin \angle -60^\circ$ — 2M

Now $I_1 * I_2 = 10\angle{-90^\circ} * 10\angle{-60^\circ} = 100\angle{-150^\circ}$ — 2M

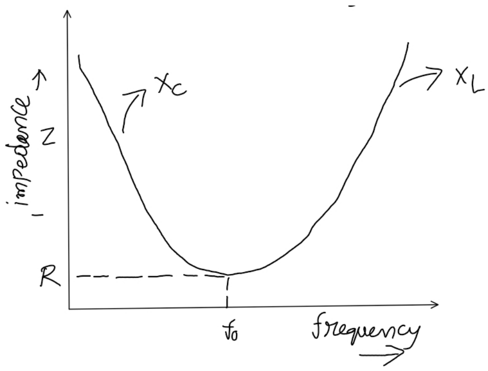
Now expressing the above signal in time domain

$i = i_1 * i_2 = 100\sin(100t - 60^\circ)$

2.D.	Plot the frequency-current and frequency-impedance response curves of a series resonance circuit.			4Marks	CO2	2	2



2M



2M

below f_0, X is -ve
i.e capacitive
above f_0, X is +ve
i.e inductive

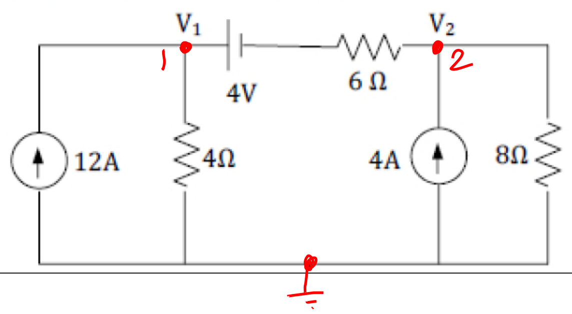
where X is net reactance

at f_0 current is maximum

$I_0 = \frac{V_m}{Z} = \frac{V_m}{R}$

at f_1 and f_2 current is equal to $0.707\, I_0$. where f_1 & f_2 are known as half-power frequencies

$f_1 \rightarrow$ lower half-power & $f_2 \rightarrow$ upper half-power frequencies.

3.	List out the steps followed in the Nodal analysis. Using Nodal analysis, determine V1 and V2 in the circuit shown below. 	choice Q-4		11Marks	CO1	2	2

Identify Nodes:

➢ Identify all the principal nodes in the circuit. A node is a point where two or more circuit elements are connected.

Select a Reference Node:

➢ Choose one node as the reference node (usually the one with the most connections) and assign it a potential of zero volts.

Assign Node Voltages:

➢ Assign voltage variables to the remaining non-reference nodes. These voltages are measured with respect to the reference node.

Apply Kirchhoff's Current Law (KCL):

➢ Write KCL equations for each non-reference node by summing the currents leaving the node and setting the sum to zero. Express the currents in terms of the node voltages using Ohm's Law (I = V/R).

Solve the Equations:

➢ Solve the system of linear equations obtained from the KCL equations to find the node voltages.

Determine Branch Currents and Voltages:

➢ Use the node voltages to determine the currents and voltages in individual branches of the circuit.

4M

1, 2 and 3 are nodes, node is the refference node. with respect to node 3, the Voltages V_1, V_2 are node Voltages at node 1 and node 2 respectively.

writing KCL at Node 1

$$\frac{V_1}{4} + \frac{V_1 - 4 - V_2}{6} = 12 \quad (2M)$$

writing KCL at Node 2

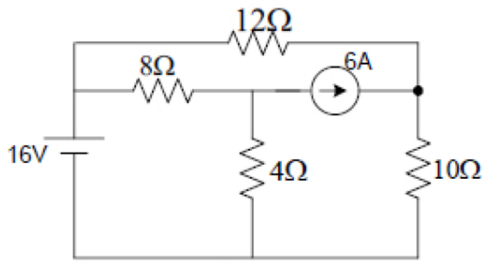
$$\frac{V_2}{8} + \frac{V_2 + 4 - V_1}{6} = 4 \quad (2M)$$

$$\begin{bmatrix} 4^{-1}+6^{-1} & -6^{-1} \\ -6^{-1} & 6^{-1}+8^{-1} \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \end{bmatrix} = \begin{bmatrix} 12+\frac{2}{3} \\ 4-\frac{2}{3} \end{bmatrix}$$

Solving we get (3M)

$V_1 = 45.333\,V$

$V_2 = 37.333\,V$

4.	List out the steps followed to determine Norton's equivalent circuit. Using Norton's theorem, determine the current flowing through the 10Ω resistor of the network shown below. 			11Marks	CO1	2	2

Statement: Norton's theorem states that any linear, bilateral electrical network with voltage and current sources and resistances can be replaced by an equivalent circuit consisting of a single current source in parallel with a single resistor. The current source is called the Norton equivalent current (I_N), and the resistor is called the Norton equivalent resistance (R_N).

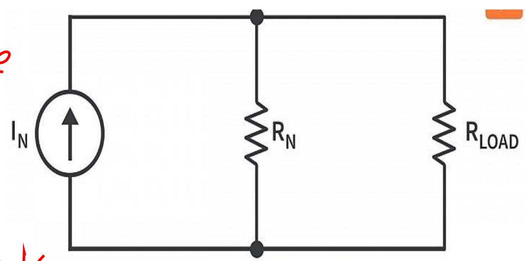
Step 1: Remove the load resistor and replace it with a short circuit. (4M)

Step 2: Calculate the Norton current—the current through the short circuit.

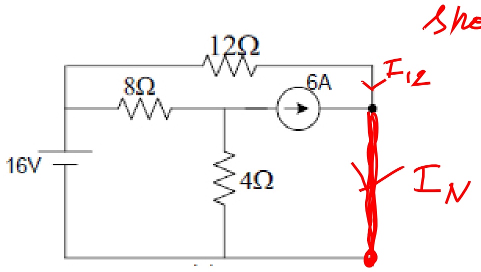
Step 3: All voltage sources are replaced with short circuits, and all current sources are replaced with open circuits.

Step 4: Calculate the Norton resistance —the total resistance between the open circuit connection points after all sources have been removed.

Step 5: Draw the Norton equivalent circuit, with the Norton current source in parallel with the Norton resistance. The load resistor re-attaches between the two open points of the equivalent circuit.



In order to calculate I_N, 10Ω resistor to be shorted, then

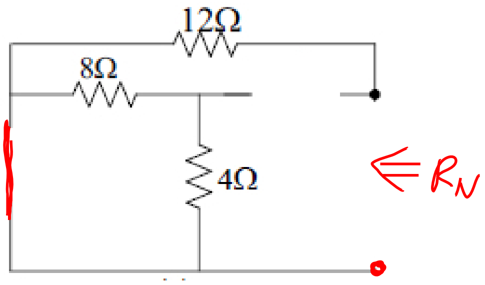


Now

$$I_N = 6 + I_{12} = 6 + \frac{16}{12}$$

$$= 6 + \frac{4}{3} = \frac{22}{3}\,A \quad (2M)$$

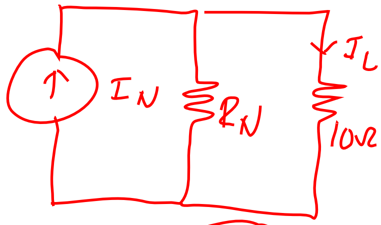
Inorder to find R_N, open 6A current source and short the 16V voltage source, then



$$R_N = 0 \| (8+4) + 12$$
$$= 0 + 12 = 12\Omega$$

2M

Hence Norton's Equivalent ckt is



3M

$$\text{Hence } I_L = \frac{I_N R_N}{R_N + 10} = \frac{\frac{22}{3} \times 12}{12 + 10}$$
$$= 4A$$

5.	Define rms and average value as applied to AC voltage. Determine the RMS and Average values for a HWR signal.Prove that in the pure capacitive circuit, current leads before applied voltage at an angle of 90°.	choice Q-6		11Marks	CO2	2	2

Average value: It is defined as the average of all instantaneous value of alternating quantities over a half cycle.

$$V_{avg} = \frac{1}{T}\int_0^T v(t)\,dt \quad \text{if } v(t) \text{ is not symmetrical along the time axis}$$

$$= \frac{2}{T}\int_0^{T/2} v(t)\,dt \quad \text{if } v(t) \text{ is symmetrical along the time axis}$$

2M

Symmetrical means area of +ve half cycle = area of -ve half cycle.

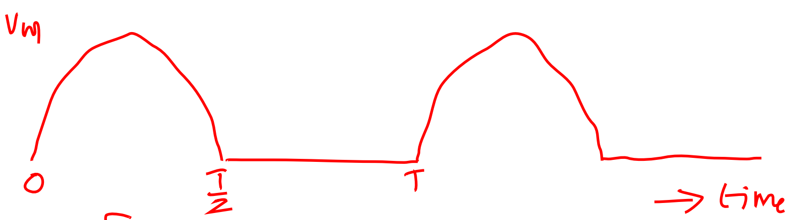
Root Mean Square (RMS) Value:It is the equivalent dc current which when flowing through a given circuit for a given time produces same amount of heat as produced by an alternating current when flowing through the same circuit for the same time.

$$V_{RMS} = \sqrt{\frac{1}{T}\int_0^T v^2(t)\,dt}$$

2M

Consider an HWR signal

$$v(t) = V_m \sin\omega t \quad 0 \le t \le \frac{T}{2}$$
$$= 0 \quad \frac{T}{2} \le t \le T$$



$$\text{Now } V_{avg} = \frac{1}{T}\int_0^T v(t)\,dt = \frac{1}{T}\left[\int_0^{T/2} v(t)\,dt + \int_{T/2}^{T} v(t)\,dt\right]$$

$$= \frac{1}{T}\int_0^{T/2} V_m \sin\omega t\,dt \qquad \because \int_{T/2}^{T} v(t)\,dt = 0$$

2M

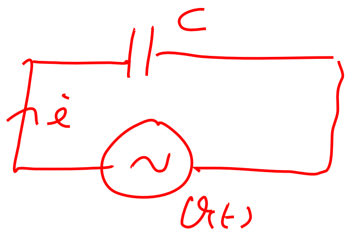
$$= \frac{V_m}{T}\left[\frac{\cos\omega t}{-\omega}\right]_0^{T/2} = \frac{V_m}{\pi} = 0.318\,V_m$$

$$V_{RMS} = \sqrt{\frac{1}{T}\int_0^T v^2(t)\,dt} = \sqrt{\frac{V_m^2}{T}\int_0^{T/2} \sin^2\omega t\,dt}$$ (2M)

$$= \sqrt{\frac{V_m^2}{2T}\int_0^{T/2}(1-\cos 2\omega t)\,dt} = \sqrt{\frac{V_m^2}{2T}\cdot\frac{T}{2}} = \frac{V_m}{2} = 0.5V_m$$

Consider a circuit consists of pure capacitor and ac is applied

$v(t) = V_m \sin\omega t$



Hence the current $i = C\frac{dv}{dt}$ (2M)

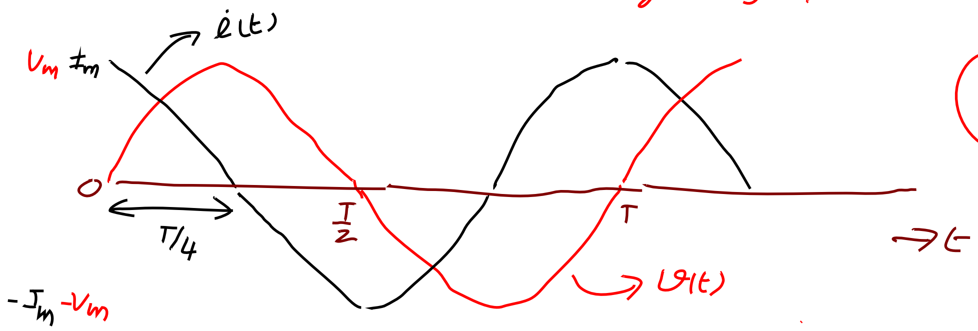
$= \omega C V_m \cos\omega t$

$$= \frac{V_m}{1/\omega C}\cos\omega t = \frac{V_m}{X_c}\sin(\omega t + 90^\circ) = I_m \sin(\omega t + 90^\circ)$$

where $X_c = \frac{1}{\omega C}$.

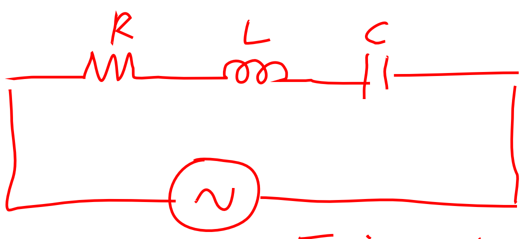
$v(t) = V_m \sin\omega t$

$i(t) = I_m \sin(\omega t + 90^\circ)$. Hence in pure capacitor current leads over voltage by 90°.



(1M)

6.	A series circuit with R = 10 Ω, L = 50 mH and C = 100 μF is supplied with 200V,50 Hz. Determine the impedance, current, power factor resonance frequency, Q-factor and bandwidth of the circuit.			11Marks	CO2	2	2



$v = 200\sqrt{2}\sin 100\pi t$ — (1M)

Here $V_m = 200\sqrt{2}\,V$

$f = 50Hz$

$\omega = 2\pi f = 100\pi$ rad/sec

impedance $Z = R + jX$ where $X = X_L - X_c$

Now $R = 10\Omega$, $X_L = \omega L = 100\pi \times 50\times10^{-3} = 15.71\Omega$

$X_c = \frac{1}{\omega C} = \frac{1}{100\pi\times100\times10^{-6}} = 31.83\Omega$ (2M)

Hence $Z = 10 + j15.71 - j31.83 = 10 - j16.12\,\Omega = 18.97\angle{-58.19}$

The current $I = \frac{V_m}{Z}$

given that $v = 200\sqrt{2}\sin 100\pi t = 200\sqrt{2}\angle{-90^\circ}$ V

Hence current $I = \frac{200\sqrt{2}\angle{-90^\circ}}{18.97\angle{-58.19^\circ}} = 14.91\angle{-31.81^\circ}$ A

or $i = 14.91\sin(100\pi t + 58.19^\circ)$ A — 2M

at resonance the net reactance $X = 0$ means current and voltage are in phase and impedance of the circuit becomes pure resistance. Hence phase angle is zero.

Hence Power factor $PF = \cos 0^\circ = 1$ — 2M

The resonance frequency $f_0 = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2\pi\sqrt{50\times10^{-3}\times100\times10^{-6}}}$

$= 71.18$ Hz — 2M

Q-factor $= \frac{\omega_0 L}{R} = \frac{1}{\omega_0 RC} = \frac{1}{R}\sqrt{\frac{L}{C}} = 2.24$ — 1M

Band width $\Delta f = f_2 - f_1 = \frac{R}{2\pi L} = \frac{f_0}{Q} = 31.83$ Hz — 1M