Hall Ticket Number: **20EE205**

I/IV B.Tech (Regular\Supplementary) DEGREE EXAMINATION

August, 2023 **Electrical and Electronics Engineering**

Second Semester **CIRCUIT THEORY**

Time: Three Hours **Maximum:** 70 Marks

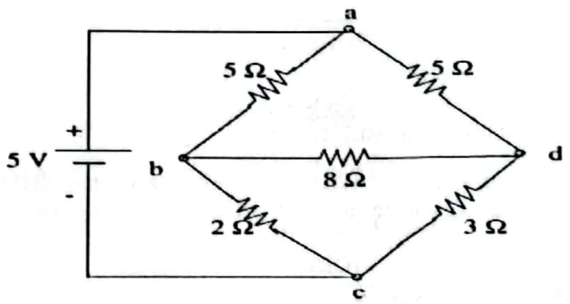
Answer question 1 compulsory. (14X1 = 14Marks)

Answer one question from each unit. (4X14=56 Marks)

			CO	BL	M
1	a)	State Ohm's law.	CO1	L2	1
	b)	Define passive circuit, give an example.	CO1	L1	1
	c)	Define form factor	CO1	L1	1
	d)	What are advantages of sinusoidal waveform in electrical systems?	CO2	L1	1
	e)	Define mesh	CO2	L1	1
	f)	Define Supernode	CO2	L1	1
	g)	What is meant by phase difference?	CO3	L1	1
	h)	Draw the phasor diagram for series RL circuit	CO3	L2	1
	i)	State compensation theorem.	CO4	L2	1
	j)	Write the condition for maximum power in maximum power transfer theorem.	CO4	L2	1
	k)	State Tellegen's theorem.	CO1	L2	1
	l)	What is the value of impedance at resonance?	CO1	L1	1
	m)	What is Band width in series resonance?	CO1	L1	1
	n)	Define Q-factor of an electrical network.	CO2	L1	1

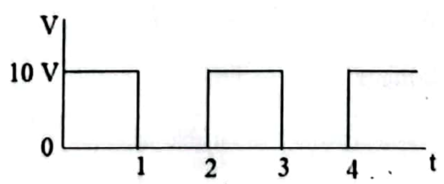
Unit-I

2	a)	State and Explain KVL & KCL with an example.	CO1	L2	7M
	b)	Find the source current in the resistance network shown below by using star-delta transformation.	CO1	L1	7M



(OR)

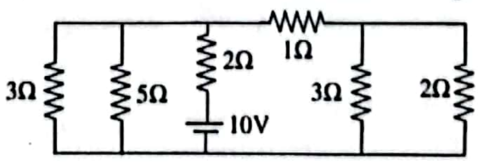
3	a)	Find average & RMS values of the waveform shown below.	CO1	L1	7M



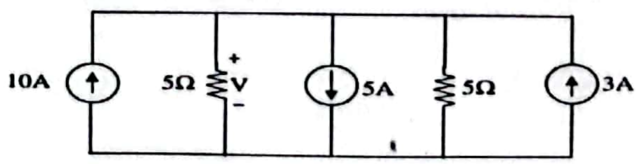
	b)	An impedance Z_1= (6+j8) Ω is connected in series with a parallel combination of impedances Z_2= (10+j6) Ω, Z_3= (8-j10) Ω and is connected to a 300V, 50Hz supply. Find the total active power, reactive power & power factor of the circuit.	CO1	L2	7M

Unit-II

4	a)	What is the magnitude of current drained from the 10V source in the given circuit?	CO2	L1	7M



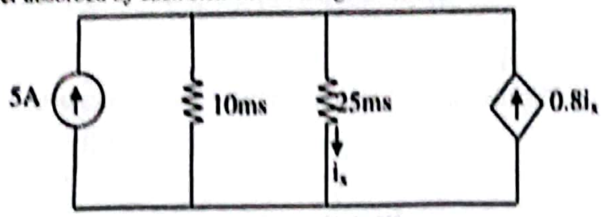
	b)	Determine V in the circuit shown in figure.	CO2	L3	7M



P.T.O

(OR)

5	a)	Explain RL series circuit with pulse excitation.	CO2	L2	7M
	b)	Find the power absorbed by each element for the given circuit.	CO2	L1	7M

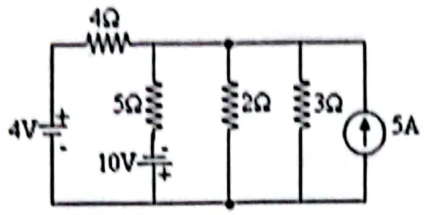


Unit-III

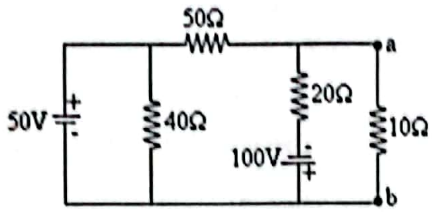
6	a)	State Thevenin's theorem. Write any two advantages of this theorem.	CO3	L1	4M
	b)	State and prove Maximum power transfer theorem for AC and DC excitations	CO3	L2	10M

(OR)

7	a)	Find the current through 2Ω resistor for given circuit using Norton's theorem.	CO3	L1	7M



	b)	Find voltage across 10Ω resistance in the network shown below by using Superposition theorem.	CO3	L2	7M

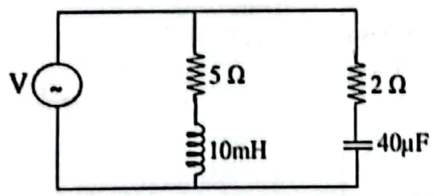


Unit-IV

8	a)	Derive an expression for Bandwidth of Series RLC circuit.	CO4	L3	7M
	b)	An RLC Series circuit consists of R=1kΩ, L=100mH, C=10μF. If a voltage of 100V is applied across the combination, determine resonant frequency, quality factor and bandwidth.	CO4	L2	7M

(OR)

9	a)	Find the resonant frequency for the given circuit.	CO4	L1	7M



	b)	Deduce the current locus diagram of RL series circuit with L as variable parameter.	CO4	L3	7M

Scheme of Evaluation :-

I/IV B.Tech Reg Exam.

Sub code :- 20EE205 Sub :- CIRCUIT THEORY ' Max Marks : 70M.

ONE MARK QUESTIONS : $14 \times 1 = 14M$.

1(a) ohms Law :-

Ohms law states that the voltage across a conductor is directly proportional to current flowing through it provided. all physical cond + temperature remain constant.

$$V = IR.$$

(b) Passive circuit is that donot require any external power source to operate. They can store or dissipate energy.

Ex :- Resistors, Inductor, Capacitor.

(c) Form factor = $\frac{\text{RMS value}}{\text{Average value}}$.

(d) Advantages of sinusoidal waveform in electrical systems :-

(a) production is simple + less expensive.

(b) It is not effected by R, L, C components.

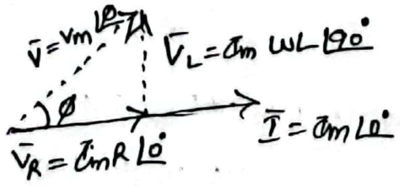
(c) They result in less losses in transformers

(e) Mesh :- A Mesh is a closed path during a circuit which doesn't contain any other closed path in it.

(f) Supernode :- A theoretical Model in which two ref. nodes are considered having an ideal voltage source present b/w them as a single Node.

(g) Phase difference :- It is difference in phase angle b/w two sinusoids or phasors.

(h) Phasor diagram for series RL circuit :-



(i) <u>Compensation Theorem</u>:-

The resistance of any N/w can be replaced by a voltage source, having same voltage as voltage drop across resistance which is replaced.

(j) <u>Condition for Max power transfer in Max power transfer Theorem</u>:-

for DC ckts $R_L = R_S$.

for AC ckts $Z_L = Z_S^*$

(k) <u>Tellegens Theorem</u>:- Sum of instantaneous power consumed by various elements in various branches is zero for any N/w

(l) $Z = R$ at resonance.

(m) Bandwidth $= \frac{f_r}{Q}$ (or) $f_2 - f_1$

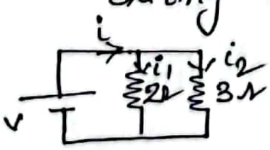
(n) Quality factor $= \frac{\text{electric energy stored in circuit}}{\text{energy dissipated in one period}}$ divided by

UNIT - I

(2a) <u>KCL</u> & <u>KVL</u> with an example :- 7M.

<u>State term</u>:- (4M) (3M) <u>statement & example</u>

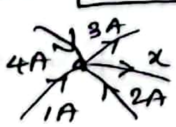
<u>KCL</u>:- Algebraic sum of current ~~entering~~ entering and exiting a node must equal zero.



$i_1 = (2/5)^{-1} A$; $i_2 = (3/5)^{-1} = \frac{5}{3} A$.

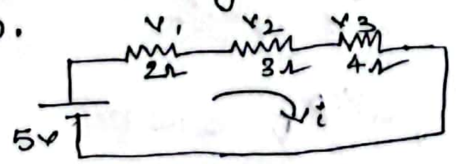
$= \frac{5}{2} = 2.5A$

$i = i_1 + i_2 = 2.5 + 5/3 = 4.16A$.



at node:- $1 + 2 + 4 = 3 + x$; $x = 7 - 3 = 4A$.

<u>KVL</u>:- Algebraic sum of voltages around a closed path is zero.



$i = \frac{5}{9} A$;

$V_1 = iR_1 = 5/9 \times 2 = 10/9 V$

$V_2 = iR_2 = 3 \times 5/9 = 15/9 V$

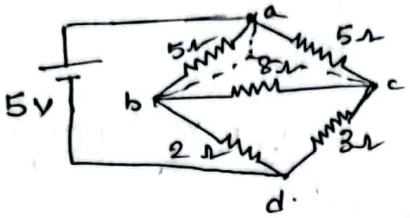
$V_3 = iR_3 = 4 \times 5/9 = 20/9 V$.

$V = V_1 + V_2 + V_3 = 45/9 = 5V$

Hence proved.

(2b) Source Current in N/w using λ – Δ transformation :– (7M)

Solution procedure steps → 4M.
formulae → 2M   Answer :– 1M.

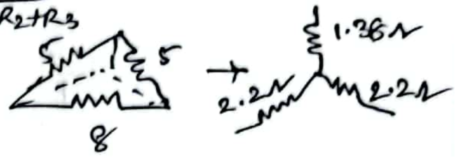


⇒ converting abc Δ to λ

$R_A = \frac{R_1 R_2}{R_1+R_2+R_3}$ $R_B = \frac{R_2 R_3}{R_1+R_2+R_3}$

$R_C = \frac{R_1 R_3}{R_1+R_2+R_3}$ $R_1 = 5$ $R_2 = 5$ $R_3 = 8Ω$

By Transforming



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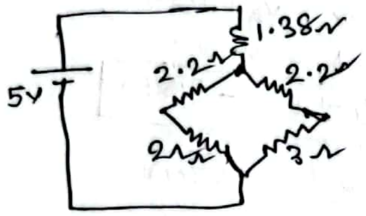


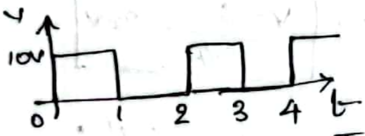
→

$I = \frac{5}{3.71} = 1.347A$

(OR)

3a) Average & RMS value for given waveform :– (7M)

formulae :– (3M)   procedure & sol :– 4M.



$v(t) = 10 \quad 0 < t < 1$
$\quad\ = 0 \quad 1 < t < 2$

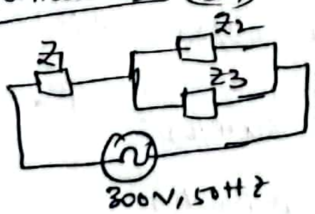
$V_{avg} = 1/T \int_0^T v(t)\, dt = 1/2 \int_0^1 10\, dt + 0 = 10/2 = \boxed{5V}$

$V_{rms} = \sqrt{1/T \int_0^T v(t)^2 dt} = \sqrt{1/2 \int_0^1 100\, dt} = \sqrt{\frac{100}{2}(t)_0^1} = \boxed{7.071V}$

(3b) Z_1, Z_2, Z_3 imp given in series + ||lel ckt :– (7M)

cal P, Q, cos ϕ

formulae :– (3M)   Procedure & sol :– (4M)



$Z_1 = 6+j8Ω$; $Z_2 = 10+j6Ω$
$Z_3 = 8+j10Ω$;

$Z_2 || Z_3 = 4.7 + j4.04Ω$; $Z_1 + (Z_2||Z_3) = 16.1 \angle 48.36 Ω$.

$I = \frac{V}{Z} = \frac{300}{16.1 \angle 48.36} = 18.6 \angle -48.36$

$P = VI\cos ϕ = 300 \times 18.6 \times \cos(48.36) = \boxed{3.71 KW}$

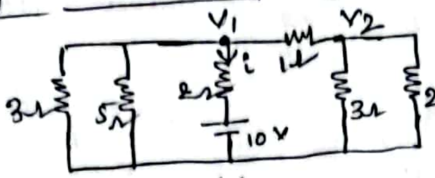
$Q = VI \sin ϕ = 300 \times 18.6 \times \sin(48.36) = \boxed{4.17 KVAR}$

$\cos ϕ = \cos(48.36) = \boxed{0.664}$

UNIT-II

(4a) Mag of current drained from Source 10V :- (7M)

Steps :- 4M sol :- 3M.



by app Nodal analysis :- $V_1/3 + V_1/5 + \frac{V_1 - 10}{2} + \frac{V_1 - V_2}{1} = 0;$

$2.03 V_1 - V_2 = 5$ — (1)

$\frac{V_2 - V_1}{1} + \frac{V_2}{3} + \frac{V_2}{2} = 0; \rightarrow -V_1 + 1.83 V_2 = 0;$ — (2)

By solving (1) + (2)

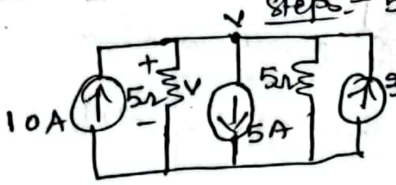
$V_1 = 3.36\,V; \quad V_2 = 1.84\,V.$

Current drained by source.

$$\boxed{i = \frac{V_1 - 10}{2} = -3.316A}$$

(4b) Det V in circuit shown in fig :- (7M)

Steps :- 5M; sol :- 2M



By applying Nodal analysis

$\rightarrow \quad -10 + V/5 + 5 + V/5 - 3 = 0;$

$-10 + 0.2V + 5 + 0.2V - 3 = 0;$

$0.4V = 8; \quad \boxed{V = \frac{8}{0.4} = 20V}$

OR

(5a) RL series ckt with pulse excitation :- (7M).

Diagram :- (2M) Analysis + Steps :- (5M).

$E(t) = E\{u(t) - u(t-T)\}$

By KVL

$L\{E(u(t) - u(t-T))\} = L\{R\,i(t) + L\frac{di(t)}{dt}\}.$

By applying Laplace Transform on both sides

$E/s - E/s\, e^{-sT} = R I(s) + L(s I(s) - i(0^+))$

as $i(0^+) = 0$

$E/s(1 - e^{-sT}) = R I(s) + s L I(s)$; $I(s) = \frac{E(1 - e^{-sT})}{s(R + Ls)}$

$= 1 - e^{-sT}.\ E/L \frac{1}{s(s + R/L)} = \frac{(1 - e^{-sT}) E/L}{s(R/L + s)} = \frac{A}{s} + \frac{B}{s + R/L}$

by solving using P. Fractions

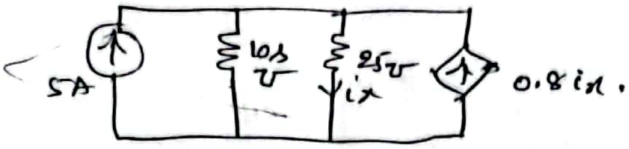
$A = E/R \; ; \; B = -E/R.$

Then $L^{-1}\{I(s)\} = L^{-1}\{-e^{-sT}(E/R/s + \frac{-E/R}{s + R/L})\} - e^{-sT} E/R_s + e^{-sT}\frac{E/R}{s + R/L}$

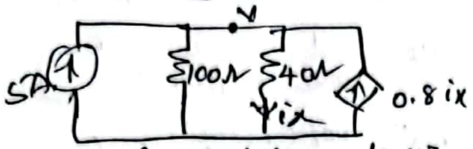
$$\boxed{i(t) = \frac{E}{R} u(t) - E/R\, u(t - T) - \frac{E}{R} e^{-R/L\,t} + E/R\, e^{-R/L\,t}\, u(t - T)}$$

(5b) find power absorbed by each element :- (7M)

Procedural steps :- (5M) Rol :- 2M.



Transforming conductance to resistance.



By Nodal analysis.

$$\frac{V}{100} + \frac{V}{40} = 5 + 0.8\,V/40.$$

$0.015V = 5;$ $V = 333.33V$

P_{absor} by source $= (333.3)(-5) =$ **−1.66kW**

$P_{10Ω} = \frac{V^2}{R} = \frac{333.33^2}{100} =$ **1.11 kW**

$i_x = \frac{333.33}{40} = 8.33$

$P_{40Ω} = \frac{V^2}{R} = \frac{333.33^2}{40} =$ **2.77kW**

$P_{Dep\,Sour} = (-0.8 i_x) \times V = 0.8 \times -8.33 \times 333.33$

$P_{Dep.} =$ **−2.22 kW**

UNIT – III

(6a) Thevenin's Theorem :- Advantages :- (2M) –4M.
(2M)

Thevenin's theorem :- Any linear circuit can be simplified, irrespective of how complex it is, to an equivalent circuit with a single voltage source and a series resistance.

Advantages :- ① used in analyzing linear ckt only & in power systems also.

② used in source modelling.

③ used in resistance measurement using wheatstone bridge.

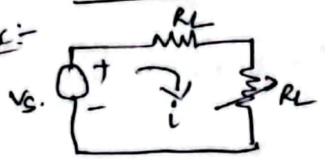
④ reduces a complex circuit to a simple ckt.

⑤ It enables us to view action of o/p part directly.

(6b) Max power Transfer theorem proof for DC + AC excitation:- (10M)

DC excitation proof :- 5M   AC excitation proof :- (5M)

Proof :- DC :-



$$I = \frac{V_s}{R_s + R_L}$$

$$P_{R_L} = I^2 R_L = \frac{V_s^2 R_L}{(R_s + R_L)^2}$$

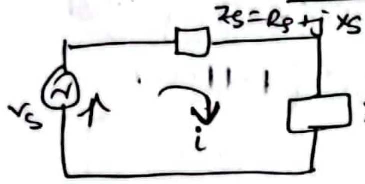
$$\frac{dP}{dR_L} = 0; \quad \frac{d}{dR_L}\left[\frac{V_s^2}{(R_s+R_L)^2} R_L\right]$$

$$\frac{V_s^2\left((R_s+R_L)^2 - 2R_L(R_s+R_L)\right)}{(R_s+R_L)^4} = 0;$$

$$\therefore (R_s+R_L)^2 - 2R_L(R_s+R_L) = 0;$$

$$\therefore \boxed{R_s = R_L}$$

for AC :-



$Z_L = R_L + jX_L$.

$$I = \frac{V_s}{(R_s + jX_s) + (R_L + jX_L)}$$

$$|I| = \frac{V_s}{\sqrt{(R_s+R_L)^2 + (X_s+X_L)^2}}$$

$$P = I^2 R_L = \frac{V_s^2 R_L}{(R_s+R_L)^2 + (X_s+X_L)^2}$$ if R_L is fixed the value of P maximum when $\boxed{X_s = -X_L}$.

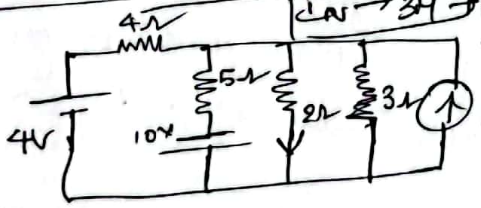
i.e. $\boxed{Z_L = Z_s^*}$

(OR)

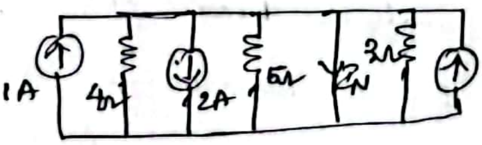
(7a) Norton's theorem Current calculation through 2Ω res :- (7M)

$I_N \to 3M$ + $R_N \to 3M$

$I_{2\Omega} \to 1M$



for I_N :-

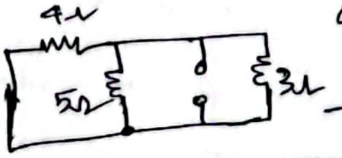


→

Hence $\boxed{I_N = 3A}$

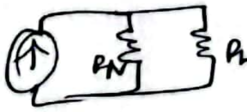
open circuit sources & short ckt volt sources and disconnect load.

for R_N :-



→ $R_N = (4 \| 5 \| 3) = \boxed{1.276\Omega}$

Current through 2Ω load :-



→

$$i_2 = \frac{3 \times 1.276}{2 + 1.276}$$

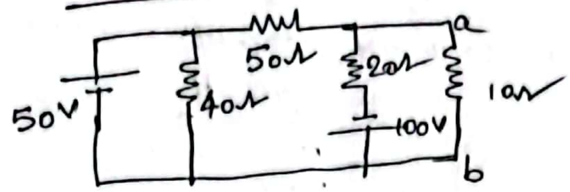
$$\boxed{i_{2\Omega} = 1.168A}$$

(7b) Voltage across 10Ω resistor using superposition theorem: (7M)

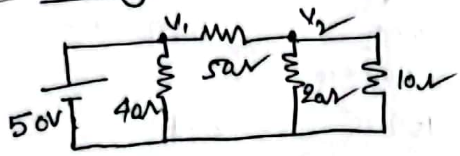
First source acting alone :- 3M

second source acting alone :- 3M

sol :- 1M. Answer



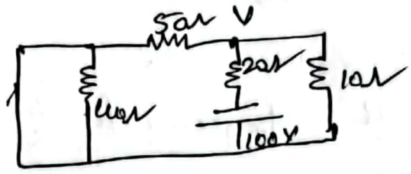
first source Acting alone :-



$V_1 = 50; \quad \frac{V_2 - V_1}{50} + \frac{V_2}{20} + \frac{V_2}{10} = 0.$

solving $V_2 = 5.88\,V.$

second source acting alone :-



$$\frac{V}{50} + \frac{V+100}{20} + \frac{V}{10} = 0;$$

$$0.02V + 0.05V + 5 + 0.1V = 0;$$

$$0.17V = -5$$

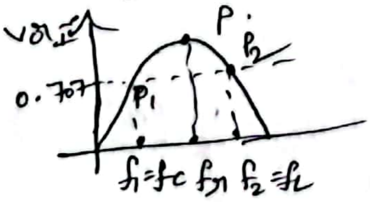
$$V = \frac{-5}{0.17} = -29.41V.$$

$$\boxed{V = V_1 + V_2 = 5.88 - 29.41 = -23.53V};$$

UNIT – IV

(8a) Band width of series RLC circuit :- (7M)

Diag:- 2M Procedure + sol :- 5M.



Bandwidth of system is range of freq for which current or o/p volt is equal to 70.7% of its value at res. frequency.

$B.W = f_2 - f_1$

Hence $\frac{1}{\omega_1 C} - \omega_1 L = R; \rightarrow (1) \quad \omega_2 L - \frac{1}{\omega_2 C} = R; \rightarrow (2)$

$1 = 2 \quad ; \quad \frac{1}{\omega_1 C} - \omega_1 L = \omega_2 L - \frac{1}{\omega_2 C} \rightarrow L(\omega_1 + \omega_2) = \frac{1}{C}\left(\frac{\omega_1 + \omega_2}{\omega_1 \omega_2}\right);$

$\omega_1 \omega_2 = \frac{1}{LC}; \quad \omega_r^2 = \frac{1}{LC}; \quad \omega_r^2 = \omega_1 \omega_2$

add (1) + (2) $\quad \frac{1}{\omega_1 C} - \omega_1 L + \omega_2 L - \frac{1}{\omega_2 C} = 2R;$

$(\omega_2 - \omega_1)L + \frac{1}{C}\frac{(\omega_2 - \omega_1)}{\omega_1 \omega_2} = 2R; \quad \because C = \frac{1}{\omega_r^2 L}, \quad \omega_1 \omega_2 = \omega_r^2$

$(\omega_2 - \omega_1)L + \omega_r^2 L \frac{(\omega_1 - \omega_2)}{\omega_r^2} = 2R; \therefore \boxed{f_2 - f_1 = R/2\pi L; \text{ or } B.W = R/2\pi L}$

(8b) Series RLC ckt Resonance :- (7M).

f_r Q.f B.W - formula :- 4M.

sol :- (3M)

$R = 1K\Omega$; $L = 100mH$; $C = 10\mu F$; $V = 100\Omega$

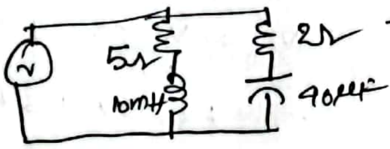
$$f_r = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2\pi\sqrt{(100\times10^{-3})(10\times10^{-6})}} = 159.15 Hz$$

$$B.W = \frac{R}{2\pi L} = \frac{1000}{2\pi\times100\times10^{-3}} = 1.59 KHZ.$$

$$Q\ f = \frac{f_r}{BW} = \frac{159.15}{1.59\times10^{3}} = 0.1$$

(OR)

(9a) Resonant frequency for given circuit :-

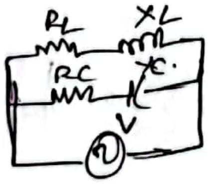


Tank ckt

f_r der → 4M.

Sol :- (3M)

Der f_r :-



$$Y = \frac{1}{Z_L} + \frac{1}{Z_C}; \quad Z_L = R_L + j\omega L \quad Z_C = R_C - j/\omega C$$

$$Y = \frac{1}{R_L + j\omega L} \times \frac{R_L - j\omega L}{R_L - j\omega L} + \frac{1}{R_C - j/\omega C} \times \frac{R_C + j/\omega C}{R_C + j/\omega C}.$$

$$Y = \frac{R_L - j\omega L}{R_L^2 - j^2\omega^2 L^2} + \frac{R_C + j/\omega C}{R_C^2 - j^2/(\omega C)^2}$$

extracting ima part 4 at resonance net susceptance is zero.

$$\frac{1/\omega C}{R_C^2 + 1/\omega^2 C^2} - \frac{\omega L}{R_L^2 + \omega^2 L^2} = 0.$$

By simplifying $\omega_0^2(R_C^2 - L/C) = \frac{1}{LC}(R_L^2 - L/C)$

$$\omega_0^2 = \frac{1}{LC}\left[\frac{R_L^2 - L/C}{R_C^2 - L/C}\right]$$

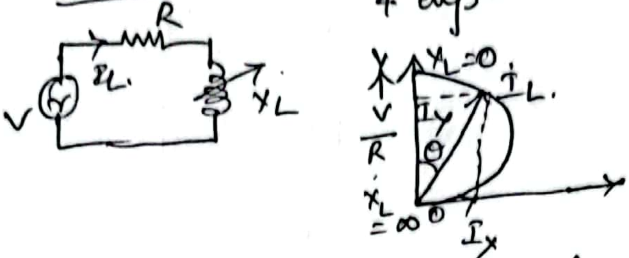
$$\therefore f_r = \frac{1}{2\pi\sqrt{LC}}\left[\frac{R_L^2 - L/C}{R_C^2 - L/C}\right]^{1/2}.$$

By sub $R_L = 5\Omega$; $L = 10mH$; $R_C = 2\Omega$; $R_C = 40\mu F$ + simplifying.

$$\boxed{f_r = 240.5 Hz}$$

(9b) Current locus diag of RL series ckt with X_L variable parameter :- (7M)

Diagram :- (3M) Theory :- (4M) + exp



when $X_L = 0$; I_L assumes $\frac{V}{R}$ & $\theta = 0$; $pf = 1$

as $X_L \uparrow$, from zero; I_L is reduced and finally when X_L is ∞, current becomes zero and θ will be lagging behind voltage by 90° as shown in fig. Current vector describes a semi circle with diameter $\frac{V}{R}$ and lies in right hand side of volt vector OV. The active comp of current OI_L and θ is proportional to power consumed in RL circuit.

eqn. of circle; $I_x^2 + I_y^2 = \frac{V^2}{R^2 + X_L^2}$.

$Z^2 = R^2 + X_L^2 = VR/I_y$; $I_x^2 + I_y^2 = \frac{V}{R} I_y$

$I_x^2 + I_y^2 - \frac{V}{R} I_y = 0$;

$I_x^2 + \left(I_y - \frac{V}{2R}\right)^2 = (V/2R)^2$.

Radius is $\frac{V}{2R}$; and Coordinates are $0, V/2R$;

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Sig of Staff :-

(1) Dr. N. Karthik
[signature]
Assoc Prof in Dept of EEE

(2) Dr. N. Rama Devi
[signature]
Prof & Head, Dep of EEE

Sig of HOD of Dept of EEE

[signature]
(1) Dr. N. Rama Devi
Prof & Head, Dep of EEE

Head of the Department
Electrical & Electronics Engg.
Bapatla Engineering College
BAPATLA - 522101.