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CMRIT

Internal Assessment Test II – Oct. 2018

Sub:	Network Analysis				Sub Code:	17EC35	Branch:	ECE
Date:	15/10/2018	Duration:	90 min's	Max Marks: 50	Sem / Sec:	3A/3B/3C		OBE

Answer any FIVE FULL Questions

		MARKS	CO	RBT
1	Obtain the relationship between 'y' and 'h' Parameteres Obtain the reciprocity condition for ABCD parameters.	[10]	CO6	L2
2	For the network shown in Fig.2, obtain Z parameters	[10]	CO6	L3
3	For the network shown in Fig.3, obtain ABCD parameters	[10]	CO6	L3
4	Show that the resonant frequency is the geometric mean of the half power frequencies.	[10]	CO5	L2
5	Derive the expression for the resonant frequency of the circuit where R_L resistance in inductor branch and R_C resistance in the capacitor branch. Also show that the circuit will resonate at all frequencies if $R_L=R_C=\sqrt{\frac{L}{C}}$	[10]	CO5	L3
6	A series RLC circuit has R=100Ω, L=0.5H, C=0.4μF. Calculate resonant frequency, half power frequencies, band width and quality factor.	[10]	CO5	L3
7	For the network shown in Fig.7, obtain Z parameters.	[10]	CO6	L3
8	State Reciprocity theorem and verify the same for the given network. (Fig.8)	10	CO3	L3

Q1: $\begin{bmatrix} \frac{1}{h_{11}} & \frac{-h_{12}}{h_{11}} \\ \frac{h_{21}}{h_{11}} & \frac{\Delta h}{h_{11}} \end{bmatrix}$ $AD-BC=1$

Q2:

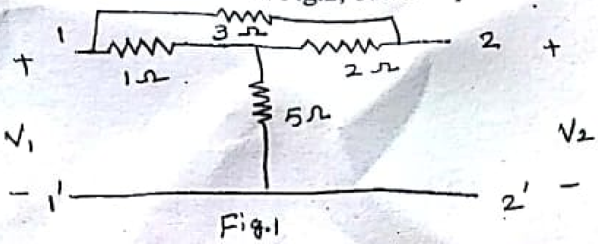

Fig.1

$\begin{bmatrix} 35/6 & 16/3 \\ 16/3 & 19/3 \end{bmatrix}$ (5.83, 5.33, 5.33, 6.33)

Q3:

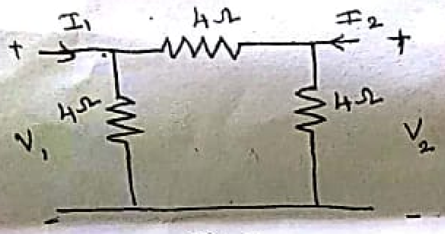

Fig.3

$y = \begin{bmatrix} \frac{1}{2}\times10^{-3} & -\frac{1}{4}\times10^{-3} \\ -\frac{1}{4}\times10^{-3} & \frac{1}{2}\times10^{-3} \end{bmatrix}$

$T = \begin{bmatrix} 2 & 4000 \\ 0.75\times10^{-3} & 2 \end{bmatrix}$

Q6: $f_0 = 355.8$ Hz, $Q_0 = 11.18$, $BW = 31.83$, $f_1 = 340.32$ Hz, $f_2 = 372.15$ Hz

Q7:

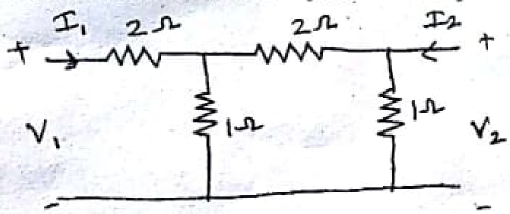

Fig.7

$\begin{bmatrix} 2.75 & 0.25 \\ 0.25 & 0.75 \end{bmatrix}$ (11/4, 1/4, 1/4, 3/4)

Q8:

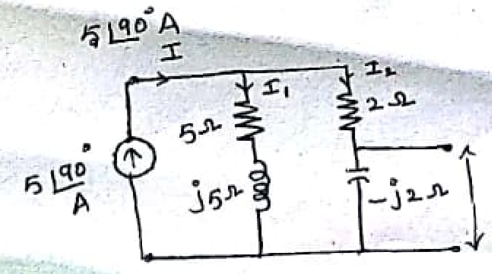

Fig.8

$V_x = 9.28\angle 21.802$ V

$I_2' = 4.64\angle 111.802$

$I_2'' = 1.313\angle -23.198$ A

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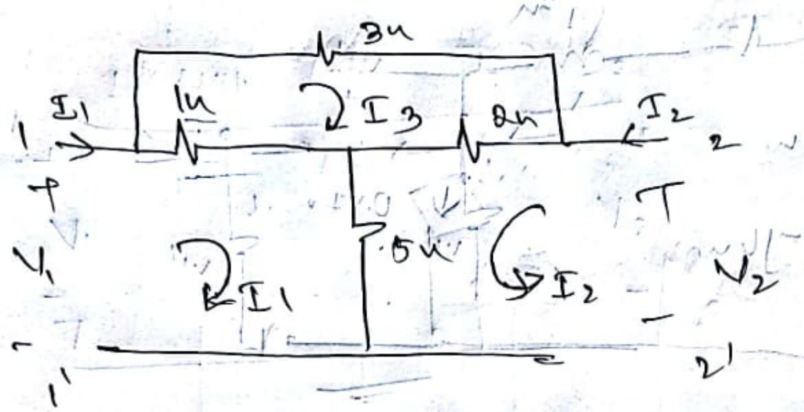
IAT – II

Q)



Applying KVL to loop (1), (2) & (3)

loop (3):

$$0 = 6I_3 - I_1 + 2I_2$$

$$I_3 = \frac{I_1 - 2I_2}{6} \quad \text{——— (1)}$$

loop (1):

$$V_1 = 6I_1 + 5I_2 - I_3$$

from eq (1)

$$V_1 = 6I_1 + 5I_2 - \left(\frac{I_1 - 2I_2}{6}\right)$$

$$V_1 = 6I_1 + 5I_2 - \frac{I_1}{6} + 2I_2/6.$$

$V_1 = 5.83 I_1 + 5.33 I_2$ ——— (2)

loop (2):

$V_2 = 7I_2 + 5I_1 + I_3$

$V_2 = 5I_1 + 7I_2 + \left(\frac{I_1 - 2I_2}{6} \right)$

$V_2 = 5I_1 + 7I_2 + \frac{I_1}{6} - \frac{2I_2}{6}$

10

$V_2 = 5.16 I_1 + 6.67 I_2$ ——— (3)

By the definition of Z, P

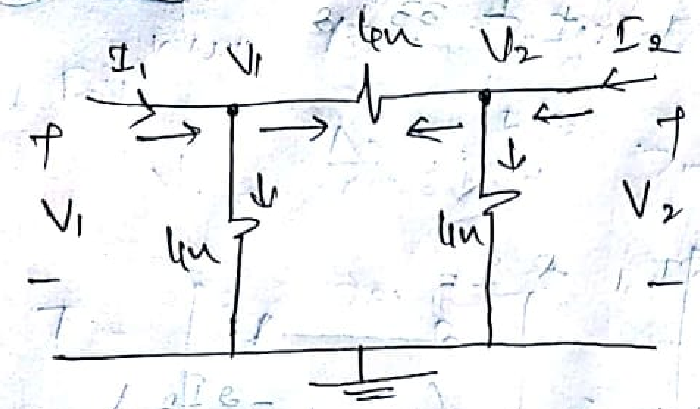
$V_1 = Z_{11} I_1 + Z_{12} I_2$ ——— (4)

$V_2 = Z_{21} I_1 + Z_{22} I_2$ ——— (5)

from eq^n (2), (3), (4) & (5).

$$Z = \begin{bmatrix} Z_{11} & Z_{12} \\ Z_{21} & Z_{22} \end{bmatrix} = \begin{bmatrix} 5.83 & 5.33 \\ 5.16 & 6.67 \end{bmatrix} \Omega$$

3)



Applying Nodal Analysis at V_1 & V_2

$$I_1 = \frac{V_1}{4} + \frac{V_1 - V_2}{4}$$

$$I_1 = 0.5 V_1 - 0.25 V_2 \quad \longrightarrow (1).$$

$$I_2 = \frac{V_2 - V_1}{4} + \frac{V_2}{4}$$

$$I_2 = -0.25 V_1 + 0.5 V_2 \quad \longrightarrow (2).$$

from the definition of Y

$I_1 = y_{11}V_1 + y_{12}V_2$ ——— (3)

$I_2 = y_{21}V_1 + y_{22}V_2$ ——— (4)

from eqⁿ (1), (2), (3) & (4)

$$y = \begin{bmatrix} y_{11} & y_{12} \\ y_{21} & y_{22} \end{bmatrix} = \begin{bmatrix} 0.5 & -0.25 \\ -0.25 & 0.5 \end{bmatrix} \Omega^{-1}$$

By the interrelation b/w Z & Y

$$Z = \begin{bmatrix} \frac{y_{22}}{\Delta y} & \frac{-y_{12}}{\Delta y} \\ \frac{-y_{21}}{\Delta y} & \frac{y_{11}}{\Delta y} \end{bmatrix}$$

where $\Delta y = y_{11}y_{22} - y_{21}y_{12}$

$\boxed{\Delta y = 0.1875}$

$$Z = \begin{bmatrix} z_{11} & z_{12} \\ z_{21} & z_{22} \end{bmatrix} = \begin{bmatrix} 2.67 & 1.33 \\ 1.33 & 2.67 \end{bmatrix} \Omega$$

By the interrelation b/w ~~T~~ & Z

$$T = \begin{bmatrix} A & B \\ C & D \end{bmatrix} = \begin{bmatrix} \frac{z_{11}}{z_{21}} & \frac{\Delta z}{z_{21}} \\ \frac{1}{z_{21}} & \frac{z_{22}}{z_{21}} \end{bmatrix}$$

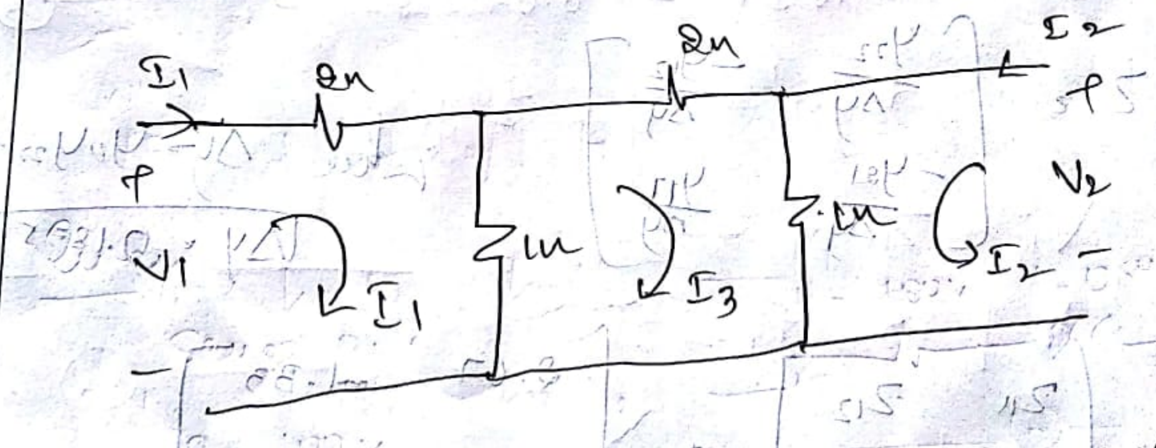
where $\Delta z = z_{11} z_{12} - z_{21} z_{22}$

$\Delta z = 5.36$

$$T = \begin{bmatrix} A & B \\ C & D \end{bmatrix} = \begin{bmatrix} 2 & 4\Omega \\ 0.75\Omega^{-1} & 2 \end{bmatrix}$$

$V_1 = AV_2 - AI_2$

7)



Applying KVL to loop (1), (2) & (3)

Loop (3):

$0 = 4I_3 - I_1 + I_2$

$I_3 = \dfrac{I_1 - I_2}{4}$ —— (1).

loop (1):

$$V_1 = 3I_1 - I_3$$

from eq^n (1)

$$V_1 = 3I_1 - \left(\frac{I_1 - I_2}{4}\right)$$

$$V_1 = 3I_1 - \frac{I_1}{4} + \frac{I_2}{4}$$

$$V_1 = 2.75 I_1 + 0.25 I_2 \quad \text{——— (2)}$$

loop (2):

$$V_2 = I_2 + I_3$$

$$V_2 = I_2 + \left(\frac{I_1 - I_2}{4}\right)$$

$$V_2 = I_2 + \frac{I_1}{4} - \frac{I_2}{4}$$

$$V_2 = 0.25 I_1 + 0.75 I_2 \quad \text{——— (3)}$$

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By the definition of Z

$$V_1 = Z_{11} I_1 + Z_{12} I_2 \quad \text{——} \quad (4)$$

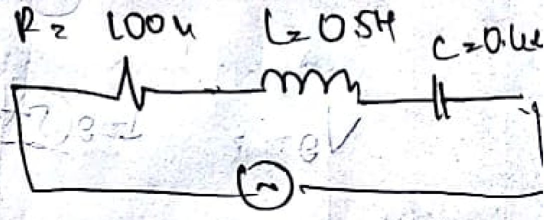
$$V_2 = Z_{21} I_1 + Z_{22} I_2 \quad \text{——} \quad (5)$$

from eqⁿ (2), (3), (4) & (5)

$$Z = \begin{bmatrix} Z_{11} & Z_{12} \\ Z_{21} & Z_{22} \end{bmatrix} = \begin{bmatrix} 0.75 & 0.25 \\ 0.25 & 0.75 \end{bmatrix} \Omega$$

6) Given,

Series RLC



$R = 100\,\Omega$

$L = 0.5\,H$

$C = 0.4\,\mu F$

(a). Resonant frequency, $f_0 = \dfrac{1}{2\pi\sqrt{LC}}$

$$f_0 = \frac{1}{2\pi\sqrt{0.5\times 0.4\mu}}$$

$$\boxed{f_0 = 355.88\ Hz}$$

(B) Band width, $B.W = \dfrac{R}{2\pi L}$

$$B.W = \frac{100}{2\pi(0.5)} = \boxed{31.83\ Hz}$$

(C) Quality factor, $Q = \dfrac{1}{R}\left(\sqrt{\dfrac{L}{C}}\right)$

$$Q = \frac{1}{100}\sqrt{\frac{0.5}{0.4\times10^{-6}}}$$

$$\boxed{Q = 11.18}$$

(D) half power frequency, $f_1 = ?$

$f_2 = ?$

WKT $B.W = 2\Delta f$

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$$\Delta f = \frac{B.W}{2} = \frac{31.83}{2} = \boxed{15.915\ Hz}$$

$$f_1 = f_0 - \Delta f = 355.88 - 15.915 = \boxed{339.965\ Hz}$$

$$f_2 = f_0 + \Delta f = 355.88 + 15.915 = \boxed{371.795\ Hz}$$

1) Y in terms of h :-

WKT

By defination of h

$V_1 = h_{11} I_1 + h_{12} V_2$ —— (1)

$I_2 = h_{21} I_1 + h_{22} V_2$ —— (2)

We need, By defination of Y

~~$V_1 = Z_{11} I_1 + Z_{12} I_2$ —— (3)~~

~~$V_2 = Z_{21} I_1 + Z_{22} I_2$ —— (4)~~

$I_1 = y_{11} V_1 + y_{12} V_2$ —— (3)

$I_2 = y_{21} V_1 + y_{22} V_2$ —— (4)

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from eq^n (1)

$V_1 = h_{11} I_1 + h_{12} V_2$

$h_{11} I_1 = V_1 - h_{12} V_2$

$$I_1 = \frac{1}{h_{11}} V_1 - \frac{h_{12}}{h_{11}} V_2 \quad \text{——— (5)}$$

from eq^n (2)

$I_2 = h_{21} I_1 + h_{22} V_2$

Substituting the eq^n (5) in above eq^n

$$I_2 = h_{21} \left[\frac{1}{h_{11}} V_1 - \frac{h_{12}}{h_{11}} V_2 \right] + h_{22} V_2$$

$$I_2 = \frac{h_{21}}{h_{11}} V_1 - \frac{h_{21} h_{12}}{h_{11}} V_2 + h_{22} V_2$$

$$I_2 = \frac{h_{21}}{h_{11}} V_1 + \left(\frac{h_{11} h_{22} - h_{12} h_{21}}{h_{11}} \right) V_2 \quad \text{——— (6)}$$

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from eq^n (3), (4), (5) & (6)

$$Y = \begin{bmatrix} y_{11} & y_{12} \\ y_{21} & y_{22} \end{bmatrix} = \begin{bmatrix} 1/h_{11} & -h_{12}/h_{11} \\ \frac{h_{21}}{h_{11}} & \frac{\Delta h}{h_{11}} \end{bmatrix}$$

where $\Delta h = h_{11}h_{22} - h_{12}h_{21}$

Reciprocity condition for ABCD parameters

By the defination of Reciprocity condition

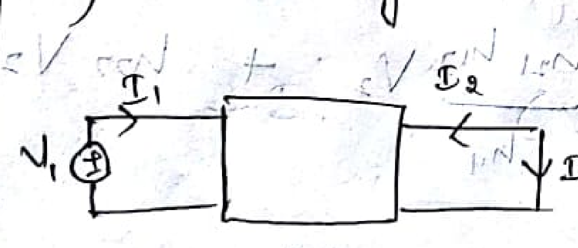

fig (a)

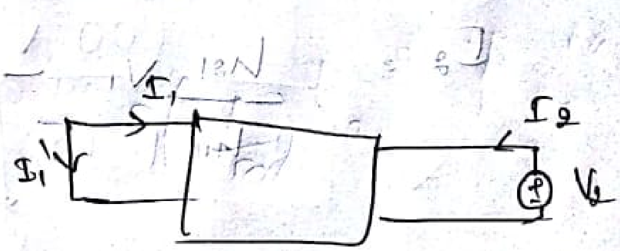

fig (b)

$V_1 = V_s$ $\quad I_2 = -I_2'$ $\quad V_2 = V_s$ $\quad I_1 = -I_1'$

$V_2 = 0$ $\quad I_2'/V_1$ $\quad V_1 = 0$. $\quad I_1'/V_2$

for Reciprocity,

$$\boxed{\frac{I_2'}{V_1} = \frac{I_1'}{V_2}}$$

$$= \boxed{\frac{I_2'}{V_s} = \frac{I_1'}{V_s}}.$$

Consider ABCD parameter eq^n

$$V_1 = AV_2 - BI_2 \quad \text{——} ①$$

$$I_1 = CV_2 - DI_2 \quad \text{——} ②.$$

Case ①:

$V_2 = 0$, $V_1 = V_s$. $I_2 = -I_2'$

from eq^n ①

$$V_1 = A(0) - B(-I_2')$$

$$V_1 = BI_2'$$

$$\frac{I_2'}{V_1} = \frac{I_2'}{V_s} = 1/B \quad \text{——} ③.$$

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Case (ii): $V_1 = 0 \quad V_2 = V_2 \quad I_1' = -I_1$

from eq^n (1)

$$I_1 = CV_2 - DI_2$$

$$-I_1' = CV_2 - DI_2 \quad \text{—— (4)}$$

from eq^n (1)

$$0 = AV_2 - BI_2$$

$$AV_2 = BI_2$$

$$I_2 = \frac{A}{B}V_2$$

Substituting in eq^n (4)

$$-I_1' = CV_2 - D\left(\frac{A}{B}\right)V_2$$

$$-I_1' = V_2\left(\frac{BC - AD}{B}\right)$$

$$I_1' = V_2\left(\frac{AD - BC}{B}\right)$$

$$\frac{I_1'}{V_2} = \frac{AD - BC}{B} \quad \text{—— (5)}$$

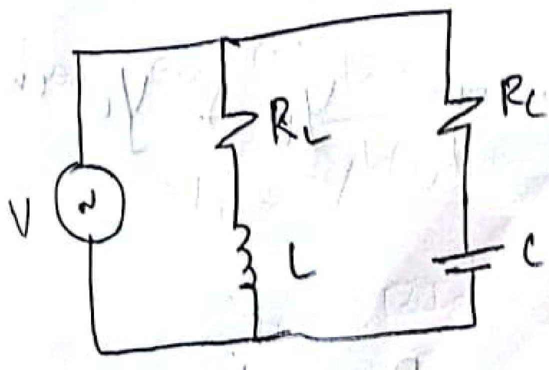
∴ for Reciprocity Condition,

$$eq^n\ (3) = eq^n\ (5)$$

ie $$\frac{1}{\cancel{B}} = \frac{AD - BC}{\cancel{B}}$$

∴ $$\boxed{AD - BC = 1}$$

or $\boxed{\Delta T = 1}$ where $\Delta T = AD - BC$.



Consider the circuit as shown in figure.

Now

$$Y = Y_L + Y_C \quad \text{—— (1)}$$

$$Y_L = \frac{1}{Z_L} = \frac{1}{R_L + jX_L} = \frac{R_L - jX_L}{R_L^2 + X_L^2}$$

$$Y_L = \frac{R_L - jLW}{R_L^2 + W^2L^2} \qquad (\because X_L = LW)$$

$$Y_C = \frac{1}{Z_C} = \frac{1}{R_C - jX_C} = \frac{R_C + jX_C}{R_C^2 + X_C^2}$$

$$Y_C = \frac{R_C + j/CW}{R_C^2 + 1/C^2W^2}$$

Substituting the value of Y_L & Y_C in eq^n (1)

$$Y = \frac{R_L - jLW}{R_L^2 + W^2L^2} + \frac{R_C + j/CW}{R_C^2 + 1/C^2W^2}$$

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$$\cancel{f_{ar} = \frac{1}{2\pi}\sqrt{\frac{1}{LC} - \frac{R_L^2}{L^2}}}$$

$$\cancel{f_{ar} = \frac{1}{2\pi LC}\sqrt{LC - R_L^2 C^2 L^2}}$$

At resonance

$$\frac{L W_{ar}}{R_L^2 + W_{ar}^2 L^2} = \frac{1/C W_{ar}}{R_C^2 + 1/C^2 W_{ar}^2}$$

$$L W_{ar}\left(R_C^2 + \frac{1}{C^2 W_{ar}^2}\right) = \frac{1}{C W_{ar}}\left(R_L^2 + W_{ar}^2 L^2\right)$$

$$L \cancel{W_{ar}}\left(\frac{R_C^2 C^2 W_{ar}^2 + 1}{C^2 \cancel{W_{ar}^2}}\right) = \frac{1}{\cancel{C W_{ar}}}\left(R_L^2 + W_{ar}^2 L^2\right)$$

$$\frac{L}{C}\left(R_C^2 C^2 W_{ar}^2 + 1\right) = R_L^2 + W_{ar}^2 L^2$$

$$L\left(R_C^2 C^2 W_{ar}^2 + 1\right) = C\left(R_L^2 + W_{ar}^2 L^2\right)$$

$$R_C^2 C^2 W_{ar}^2 L + L = R_L^2 C + W_{ar}^2 L^2 C$$

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$$R_C^2 C^2 W_{0a}^2 L - W_{0a}^2 L^2 C = R_L^2 C - L$$

$$W_{0a}^2 \left(R_C^2 C^2 L - L^2 C \right) = R_L^2 C - L$$

$$W_{0a}^2 = \frac{R_L^2 C - L}{R_C^2 C^2 L - L^2 C}$$

$$W_{0a}^2 = \frac{1}{LC} \left(\frac{R_L^2 C - L}{R_C^2 C - L} \right)$$

$$W_{0a}^2 = \frac{1}{LC} \left(\frac{R_L^2 - L/C}{R_C^2 - L/C} \right)$$

$$W_{0a} = \sqrt{\frac{1}{LC} \left(\frac{R_L^2 - L/C}{R_C^2 - L/C} \right)}$$

$$W_{0a} = \frac{1}{\sqrt{LC}} \sqrt{\left(\frac{R_L^2 - L/C}{R_C^2 - L/C} \right)}$$

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$$\boxed{f_{or} = \frac{1}{2\pi\sqrt{LC}}\sqrt{\frac{R_L^2 - L/C}{R_C^2 - L/C}}}$$

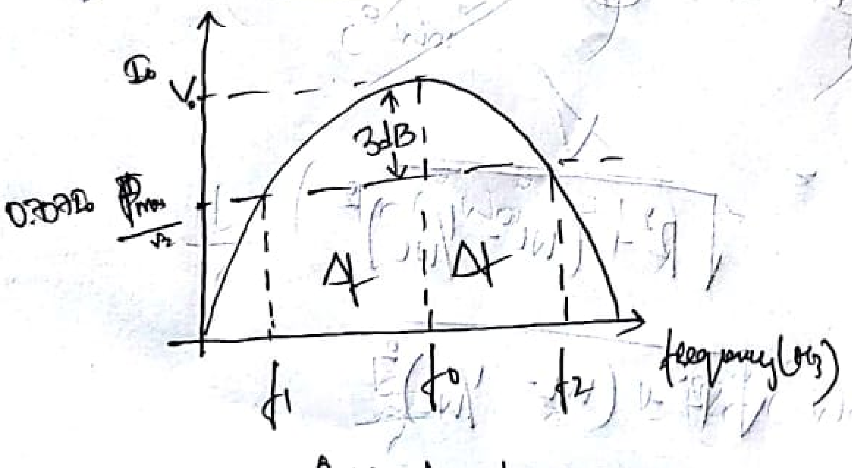
∴ ~~if~~ The circuit will resonate at all frequency

if $R_L = R_C = \sqrt{L/C}$

$$\cancel{f_{or}} = \cancel{f_0}\sqrt{\frac{\cancel{R_L^2} - L/C}{R_C^2 - \cancel{L/C}}}$$

$$\cancel{f_{or}} = \cancel{f_0}\cancel{\sqrt{R_L}}$$

4)



B.W = $f_2 - f_1$

wer

$$I = \frac{V}{Z}$$

$$I_0 = \frac{V}{\sqrt{R^2 + \left(\omega L - 1/\omega C\right)^2}} \quad \text{—— (1)} \quad \text{At Resonance.}$$

Also At Resonance

$$I = \frac{I_0}{\sqrt{2}}$$

Also $\quad I_0 = V/R$

$$I = \frac{V}{\sqrt{2}R} \quad \text{—— (2)}$$

from eqn (1) & (2)

$$\frac{\cancel{V}}{\sqrt{2}R} = \frac{\cancel{V}}{\sqrt{R^2 + \left(\omega L - 1/\omega C\right)^2}}$$

$$\sqrt{2}R = \sqrt{R^2 + \left(\omega L - 1/\omega C\right)^2}$$

On squaring

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$$2R^2 + R^2 + \left(WL - \frac{1}{WC}\right)^2$$

$$2R^2 - R^2 = \left(WL - \frac{1}{WC}\right)^2$$

$$R^2 = \left(WL - \frac{1}{WC}\right)^2$$

$$\Rightarrow \left(WL - \frac{1}{WC}\right) = \pm R$$

$$\rightarrow \left(W_1L - \frac{1}{W_1C}\right) = +R \quad \text{——— (3)}$$

$$\left(W_2L - \frac{1}{W_2C}\right) = -R \quad \text{——— (4)}$$

Adding eq^n (3) & (4)

$$W_1L - \frac{1}{W_1C} + W_2L - \frac{1}{W_2C} = 0.$$

$$L(\omega_1+\omega_2) - \frac{1}{C}\left(\frac{1}{\omega_1}+\frac{1}{\omega_2}\right) = 0$$

$$L(\omega_1+\omega_2) = \frac{1}{C}\left(\frac{\omega_1+\omega_2}{\omega_1\omega_2}\right)$$

$$\cancel{(\omega_1+\omega_2)} = \frac{1}{LC}\frac{\cancel{(\omega_1+\omega_2)}}{(\omega_1\omega_2)}$$

$$\omega_1\omega_2 = \frac{1}{LC} = \omega_0 \qquad \left(\because \omega_0 = \frac{1}{\sqrt{LC}}\right)$$

$$\omega_0^2 = \omega_1\omega_2$$

$$\boxed{\omega_0 = \sqrt{\omega_1\omega_2}}$$

$$\Rightarrow \boxed{f_0 = \sqrt{f_1 f_2}}$$