AIRO UNIVERSITY FACULTY OF ENGINEERING *Series Resonance*	 *ELECTRIC CIRUITS*	ELECTRONICS AND COMMUNICATION DEPT. *2^{nd} Year* *Sheet (2)*

[1]Draw the normalized resonance curves for the current in a series resonance circuit having a quality factor $Q_s = 20$ in the narrow band near resonance (for $\delta = +1\%$, $+2\%$, ..., $+5\%$). Plot the phase angle of the current in the same band and show the effect of increasing Q_s.

[2]In a series resonance circuit $L = 65\ mH$, $C = 1.56\ nF$ and $R = 5.1\ \Omega$, calculate the resonance frequency, the quality factor of the circuit, the bandwidth and the impedance of the circuit at frequencies 1 % and 10 % above resonance.

[3]For the circuit shown in Fig.1, calculate the frequency at which series resonance occurs (the input impedance is real). At what value of the conductance G will it be impossible to obtain resonance?

[4]A generator is connected to a series oscillating circuit has a frequency of 250 KHz. The oscillating circuit has a constant $L = 600\ \mu H$, $R = 30\ \Omega$ and a variable capacitor C. For which value of the capacitor C will the circuit be at resonance? and for which value of frequency will the current flowing through the circuit decrease to one fourth of its value at resonance.

[5]The cutoff frequencies of a series resonance circuit are 5600 and 6000 Hz:
a)Calculate the B.W. of the circuit and Q_s.
b)If the resistance of the circuit is $2\ \Omega$, calculate X_L, X_C, L and C at resonance.

[6]A series resonance circuit has a resonance frequency of 10KHz. The resistance of the circuit is $5\ \Omega$ and X_C at resonance is $200\ \Omega$, find:
a)The Bandwidth and the cutoff frequencies.
b)Q_s of the circuit.
c)The voltage across the coil and the capacitor at resonance and at a frequency 10% below resonance if the input voltage is $30\angle 0$.
d)The power dessipated in the circuit at resonance and at a frequency 4% above resonance.

[7]Design a series resonance circuit with an input voltage $5\angle 0°\ V$ to have the following specifications:
a)A peak current of 500 mA.
b)A Bandwidth of 120 Hz.
c)A resonance frequency of 8400 Hz.

Calculate the circuit elements and the cutoff frequencies .

[8] A series resonance circuit of L , C and R is required to be at resonance at a frequency of 1 MHz . Its Bandwidth is 5 KHz and its input impedance at resonance is 50 Ω . Calculate L , C and R .

[9] Make the necessary derivations to sketch the magnitude of the current I shown in Fig.2 in amperes against frequency in Hertz showing its value at the resonance frequency F_s and the cutoff frequencies F_1 and F_2 , hence , prove that : $F_s = \sqrt{F_1 F_2}$.

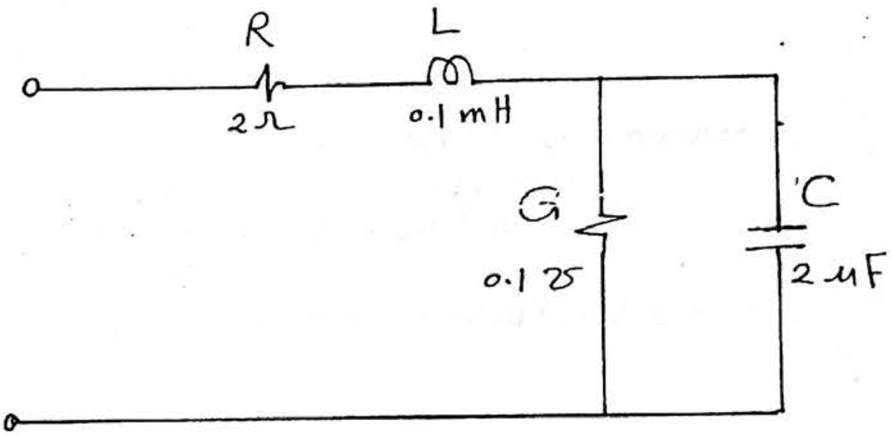


Fig.1

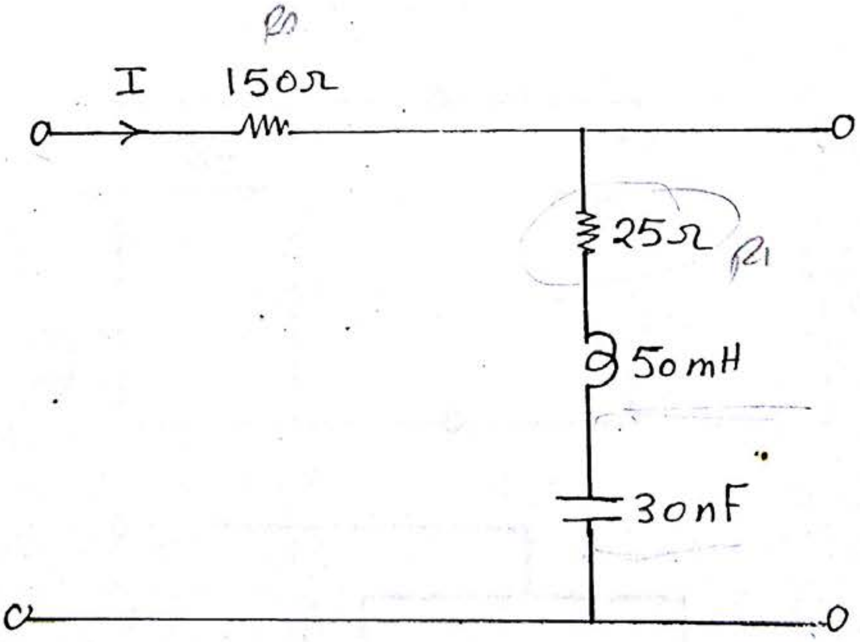


Fig.2

Sheet 2

* Series Resonance *

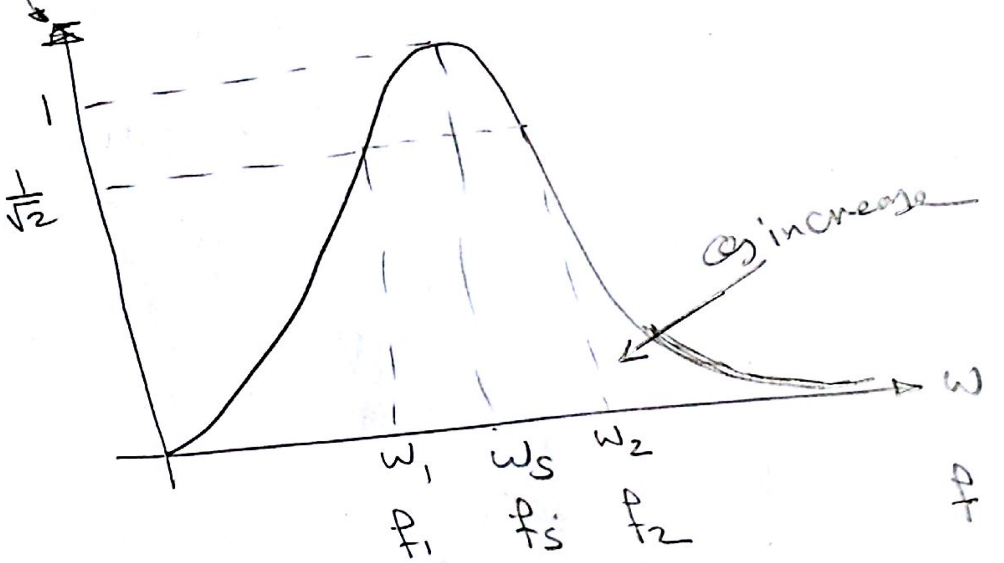
1) $\delta = 0.01 \rightarrow 0.05 \leq 0.05$

$\therefore \Omega = 2\delta$

$Q_s = 20 \rightarrow$ high quality

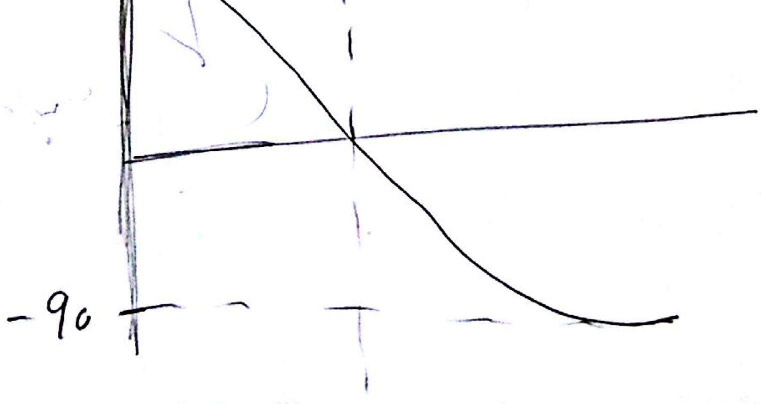
$\therefore w_s$ at the middle of cut off frequencies

$$\left|\frac{I}{I_s}\right| = \frac{1}{\sqrt{1 + 4Q_s^2\delta^2}}$$



when Q_s increases, $\left|\frac{I}{I_s}\right|$ (decreases)

So the curve compresses.



$\phi = \tan^{-1} 2Q_s\delta$

[2] $f_s = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2\pi\sqrt{65*10^{-3}*1.56*10^{-9}}} = 15.8 * 10^3$ HZ

$\cong 15.8$ KHZ

$Q_s = \frac{1}{R}\sqrt{\frac{L}{C}} = \frac{1}{5.1} * \sqrt{\frac{65*10^{-3}}{1.56*10^{-9}}} = 1265.68 > 10$

$BW = \frac{f_s}{Q_s} \cong$ 12.4834 HZ

1% above Resonance

$\delta = 0.01 < 0.05$

∴ we are near resonance

$Z_T = R(1 + j2\delta Q_s)$

$Z_T = 5.1(1 + j25.3136) = 5.1 + j129.099\ \Omega$

10% above resonance

$\delta = 0.1$

$\Omega = \frac{\delta(\delta+2)}{\delta+1} = 0.1909$

$Z_T = R(1 + jQ_s\Omega)$

$Z_T = 5.1 + j1232.25\ \Omega$

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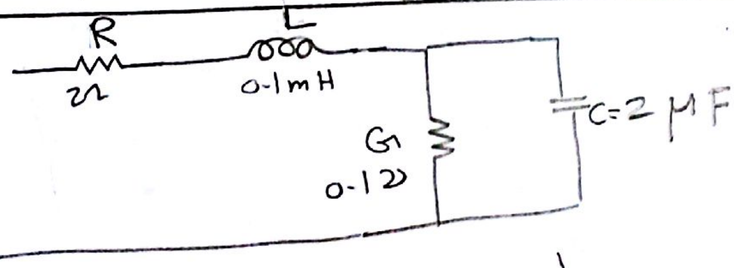
[3]



$Z_{in} = R + jwL + \frac{\frac{1}{G} * \frac{1}{jwC}}{\frac{1}{G} + \frac{1}{jwC}}$

$Z_{in} = R + jwL + \frac{1}{jwC + G}$

$Z_{in} = R + jwL + \frac{G - jwC}{G^2 + w^2C^2}$

$Z_{in} = R + \frac{G}{G^2 + w^2C^2} + j\left(wL - \frac{wC}{G^2 + w^2C^2}\right)$

AT Resonance, Zin is areal

∴ $Im(Z) = 0 \Rightarrow$ ∴ $L = \frac{C}{w_s^2C^2 + G^2}$

∴ $G^2 + w_s^2C^2 = \frac{C}{L}$

$$W_S^2 C^2 = \frac{C}{L} - G^2$$

$$W_S^2 = \frac{1}{CL} - \frac{G^2}{C^2}$$

$$W_S = \sqrt{\frac{1}{LC} - \frac{G^2}{C^2}}$$

$$\therefore W_S = \sqrt{\frac{1}{0.1*10^{-3}*2*10^{-6}} - \frac{(0.1)^2}{(2*10^{-6})^2}}$$

$$\therefore W_S = 5*10^4 \text{ rad/s}$$

$$f_S = \frac{W_S}{2\pi} = \underline{7957.747} \text{ Hz}$$

It's **possible** to obtain Resonance if W_S exists

(So)

$$\frac{G^2}{C^2} < \frac{1}{LC}$$

$$\frac{G^2}{C} < \frac{1}{L} \Rightarrow G^2 < \frac{C}{L} \Rightarrow G < \sqrt{\frac{C}{L}}$$

So if $G \geq \sqrt{\frac{C}{L}}$ it's impossible to obtain Resonance

$G \geq \frac{\sqrt{2}}{10}$, $\boxed{G \geq 0.1412}$

(4)

$$f_s = 250\ KHZ = \frac{1}{2\pi\sqrt{LC}}$$

$$\therefore \sqrt{LC} = 6.36619 * 10^{-7}$$

$$LC = 4.052847 * 10^{-13}$$

$$C = \frac{4.052847 * 10^{-13}}{600 * 10^{-6}} = 6.754 * 10^{-10}\ F$$

$$= 0.6754\ nF$$

$$Q_s = \frac{1}{R}\sqrt{\frac{L}{C}} = 31.4159 > 10$$

$$\left|\frac{I}{I_s}\right| = \frac{1}{\sqrt{1+Q_s^2 \Omega^2}}$$

$$\frac{\frac{1}{4} I_s}{I_s} = \frac{1}{\sqrt{1+Q_s^2 \Omega^2}} \Rightarrow \frac{1}{16} = \frac{1}{1+Q_s^2 \Omega^2}$$

$$\therefore \frac{1}{16} = \frac{1}{1+Q_s^2 \Omega^2}$$

$$\therefore Q_s^2 \Omega^2 = 15$$

$$\Omega = \pm \frac{\sqrt{15}}{Q_s}$$

$$\frac{f}{f_s} - \frac{f_s}{f} = \pm \frac{\sqrt{15}}{10\pi} \quad * f f_s$$

$$f^2 - f_s^2 = \pm \frac{\sqrt{15}}{10\pi} f f_s$$

$$f^2 \mp \frac{\sqrt{15}}{10\pi} f f_s - f_s^2 = 0$$

$$f^2 \mp 30820.2222 f - 6.25 * 10^{10} = 0$$

$f_1 = 265.884$ KHZ

$f = -235.064$ KHZ مرفوض

$f_2 = 235.064$ KHZ

$f = -265.84$ مرفوض

5

$f_1 = 5600$ HZ

$f_2 = 6000$ HZ

$\sqrt{f_1 f_2} = 5796.55$ Hz

$\therefore w_s = \underline{36420.8}$

$BW = f_2 - f_1 = 400$ HZ $= \frac{f_s}{Q_s}$

$Q_s = \frac{5796.55}{400} = 14.49 = \frac{X_L}{R}$

$14.49 = \frac{w_s L}{R}$

$28.96 = 36420.8\ L$

$L = 7.9569 * 10^{-4} = 795.699\ \mu H$

$X_L = w_s L = 29 = X_C$

$Q_s = \frac{1}{R}\sqrt{\frac{L}{C}}$

$(28.96)^2 = \frac{7.9569 * 10^{-4}}{C}$

$C = 9.48739 * 10^{-7}$ F

$\cong \boxed{948.739}$ nF

(or) $X_C = \frac{1}{w_s C}$

$C = \frac{1}{X_C w_s}$ ($X_L \leftarrow X_C$)

$C = \frac{1}{28.96 * 36420.8}$

$\cong \boxed{948.095}$ nF

5

$f_s = 10\ \text{KHZ} = 10^4\ \text{HZ}$

$R = 5\Omega$

$X_L = X_C = 200\Omega$

$L = 3.183\ \text{mH}$

$C = 79.57\ \text{nF}$

$$BW = \frac{f_s}{Q_s} = \frac{f_s}{\frac{X_L}{R}} = \frac{10^4}{\frac{200}{5}} = 250\ \text{Hz}$$

$Q_s = 40 > 10 \Rightarrow$ high Quality

$$\therefore f_1 = f_s - \frac{BW}{2} = 10^4 - 125 = 9875\ \text{Hz}$$

$$f_2 = f_s + \frac{BW}{2} = 10^4 + 125 = 10125\ \text{Hz}$$

$$I_s = \frac{V}{R} = \frac{30}{5} = 6\angle 0^\circ\ A$$

$$V_L = I_s * jX_L = 1200\angle 90^\circ\ V$$

$$V_C = 1200\angle -90^\circ\ V$$

$$P_{at\ Resonance} = |I_s|^2 R = 36 * 5 = 180\ \text{Watt}$$

@ 10% below Res. $\delta = -0.1$

$\Omega = \frac{-19}{90} \approx -0.21 = \frac{W}{W_s} - \frac{W_s}{W}$

$W = 56548.66776$ rad/sec

$X_L = 180\ \Omega$

$Z_T = R(1 + jQ_s\Omega) = 5 - j\frac{380}{9}$

$I = \frac{E}{Z_T} = 0.7056\angle 83.246^\circ$

$V_L = I * jX_L = 127\angle 173.246^\circ$ Volts

$X_C = 222.222\ \Omega$

$V_C = I * (-jX_C)$

$V_C = 156.8\angle -6.75^\circ$ Volts

10 9
200 (180)

$\frac{1}{10}$ $\frac{1}{9}$
200 (200/9)

$\Rightarrow$ at 4% above Resonance

$\delta = 0.04 < 0.05$

$\therefore \Omega = 2\delta$

$$Z_T = R(1 + 2j\delta Q_s)$$

$$= 5(1 + 2j * 0.04 * 40) = 5 + j16\ \Omega$$

$$I = \frac{V}{Z_T} = \frac{30}{5 + j16} = 1.789649959\angle -72.64597^\circ\ A$$

$$P_{at\ Resonance}^{4\%\ above} = |I|^2 * R \simeq 16.014\ \text{watt}$$