MODULE-IV

THREE PHASE NETWORKS AND RESONANCE

Series Resonance

Principle of resonance is used in the application of radio reciever. If we consider a series RLC ckt, wkt current can lag behind or lead. It depends on the value of X_L or X_C. If we consider inductive reactance the current lags behind the supply voltage. If we consider the capacitive reactance the current leads the supply voltage.

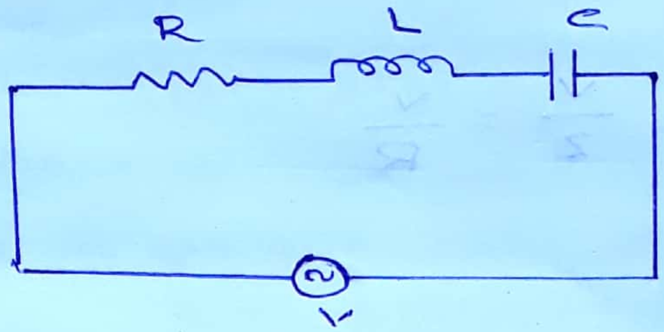
$X_L > X_C$: inductive ckt

$X_C > X_L$: capacitive ckt

A ckt containing reactance is said to be in resonance if the vltg across the ckt is in phase with the current through it.

At resonance, ckt is purely resistive & the net reactance is zero ($X_L = X_C$)

The frequency at which the resonance occurs is called the resonant frequency.



$$\bar{Z} = R + jX_L - jX_C$$

$$= R + j\omega L - \frac{j}{\omega C}$$

$$= R + j\left(\omega L - \frac{1}{\omega C}\right)$$

At resonance, Z is purely resistive.
Therefore condition for resonance is

$$\omega L - \frac{1}{\omega C} = 0$$

$$\omega = \omega_0 = \frac{1}{\sqrt{LC}}$$

$$f_0 = \frac{1}{2\pi\sqrt{LC}}$$

Power Factor

$$\cos\phi = \frac{R}{Z} = \frac{R}{\sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2}}$$

But at resonance $\omega L = \frac{1}{\omega C}$

$$\cos\phi = \frac{R}{R} = 1$$

Current

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

Voltage

At resonance

$$\omega_0 L = \frac{1}{\omega_0 C}$$

$$\omega_0 L I_0 = \frac{I_0}{\omega_0 C}$$

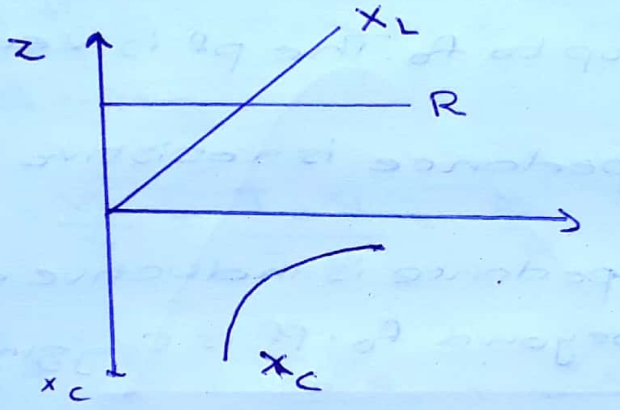
$$V_{L_0} = V_{C_0}$$

Properties of Resonance of RLC Series ckt

- The applied vltg and the resulting current are inphase which also mean that the pf of RLC series ckt is unity.
- The net reactance is zero at resonance and the impedence does have the resistive part only.
- The current in the ckt is maximum.
- At resonance, the ckt has got minimum impedance and maximum admittance.
- Frequency of resonance is $f_0 = \frac{1}{2\pi\sqrt{LC}}$

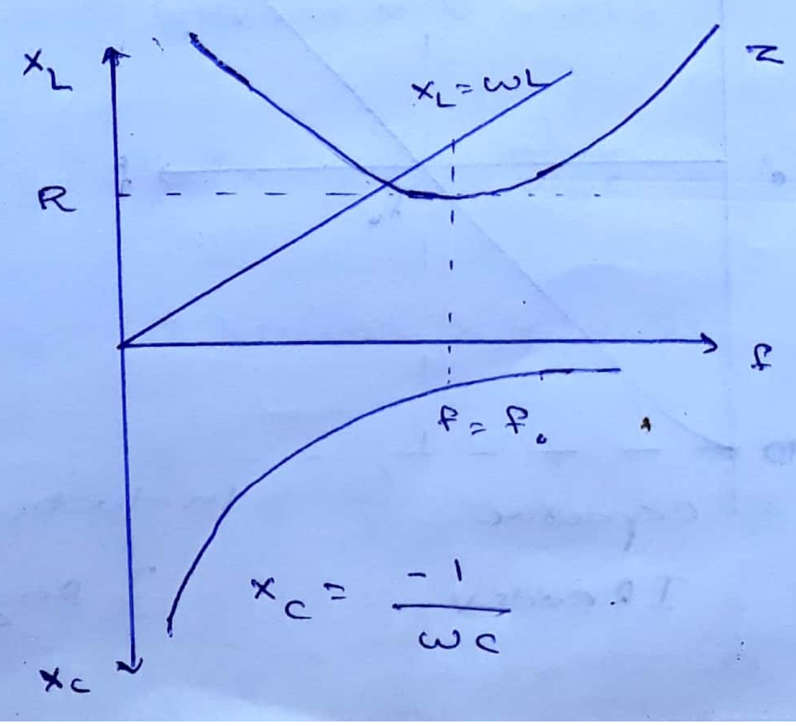
Behaviour of R, L, C with change in frequency

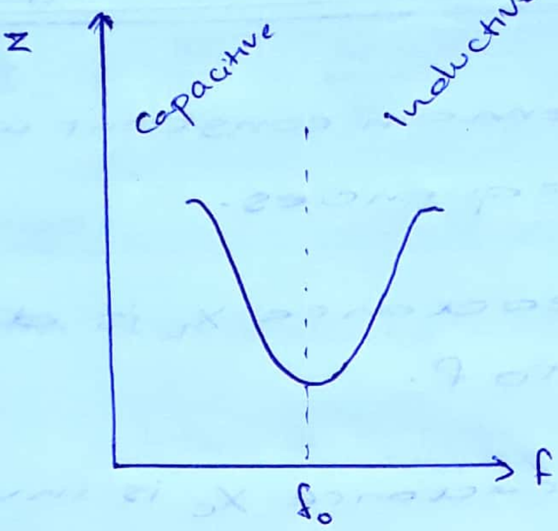
- Resistance remain constant with the change in frequencies.
- Inductive reactance X_L is directly proportional to f.
- Capacitive reactance X_C is inversely proportional to f.



Impedance v/s Frequency

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



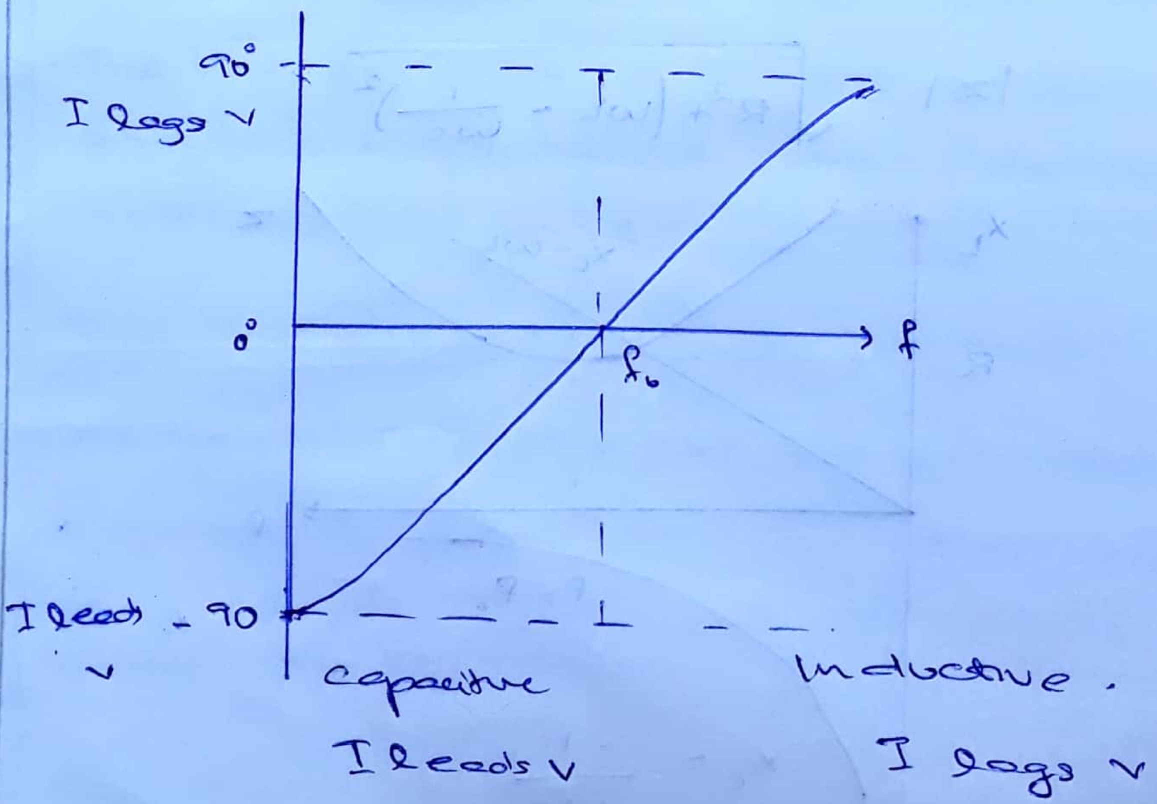


When $f < f_0$, impedance is capacitive and decreases up to f_0. The pf is leading.

At $f = f_0$ impedance is resistive. Pf is unity.

When $f > f_0$, impedance is inductive and goes on increasing beyond f_0. Pf is lagging.

Phase Angle V/s Frequency.



The phase angle decreases as the frequency approaches the resonant value, and is 0° at resonance.

The phase angle approaches 90° as the frequency goes higher.

Q factor of series resonating ckt.

It is defined as the ratio of voltg across the inductor or capacitor to the applied voltg.

$$Q = \frac{V_L}{V} = \frac{I_0 X_L}{I_0 R} = \frac{X_L}{R} = \frac{\omega_0 L}{R}$$

also $$Q = \frac{V_c}{V} = \frac{I_0 X_c}{I_0 R} = \frac{X_c}{R} = \frac{1}{\omega_0 C R}$$

$$V_L = I_0 X_L = \frac{V}{R} X_L = \frac{V}{R}\omega_0 L = \frac{\omega_0 L}{R} V.$$

V_L = Q factor × V volts.

and $$V_C = I_0 X_C = \frac{V}{R} \cdot \frac{1}{\omega_0 C} = \frac{1}{\omega_0 C R} V$$

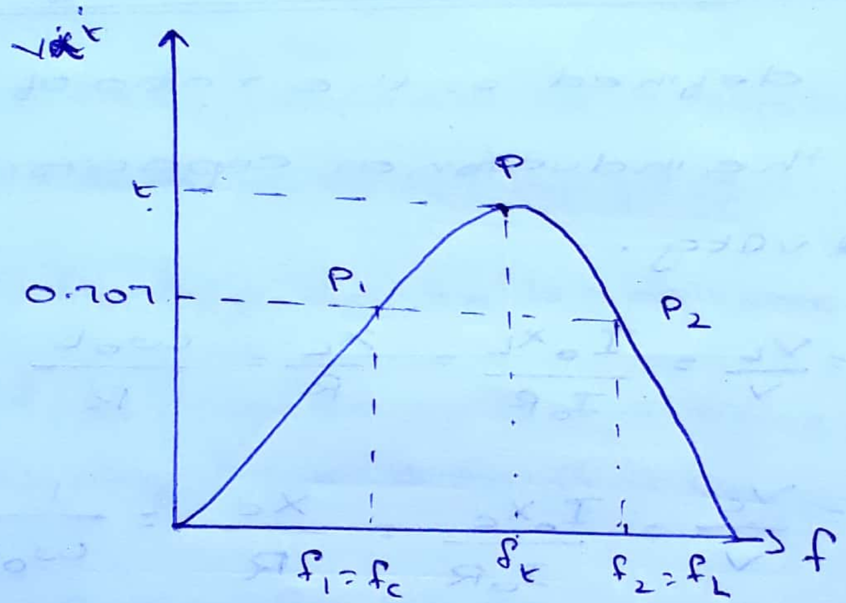
V_c = Q factor × V volts.

$$Q = \frac{\omega_0 L}{R} = \frac{1}{\sqrt{LC}} \cdot \frac{L}{R} = \frac{1}{R}\sqrt{\frac{L}{C}}$$

$$Q = \frac{1}{\omega_0 C R} = \frac{1}{\frac{1}{\sqrt{LC}} \cdot CR} = \frac{1}{R}\sqrt{\frac{L}{C}}$$

Bandwidth Of An RLC Ckt.

The bandwidth of any system is the range of frequencies for which the current or output voltage is equal to 70.7% of its value at the resonant frequency. It is denoted by BW.



$$BW = f_2 - f_1$$

The frequency band within the limits of lower and upper half power frequency is called the band width of the resonant ckt.

At half power frequencies.

$$X = \pm (X_L - X_C) = R$$

i.e., $R = \pm \left(\omega L - \frac{1}{\omega C}\right) = \pm X$

±ve indicate predominance of X_L or X_C.

Let f_1 be frequency when the net ckt reactance be -ve and f_2 be frequency when the net ckt reactance is +ve.

$$\left(\omega_2 L - \frac{1}{\omega_2 C}\right) = R \quad \text{—} (1)$$

$$\left(\omega_1 L - \frac{1}{\omega_1 C}\right) = -R.$$

Adding (1) and (2)

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

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

$$\omega_1 \omega_2 = \frac{1}{LC} \quad \text{—} (3)$$

Substracting (1) - (2)

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

$$(\omega_2 - \omega_1) L + \frac{1}{C}\left(\frac{\omega_2 - \omega_1}{\omega_2 \omega_1}\right) = 2R \quad \text{—} (4)$$

Divide (4) by L

$$\omega_2 - \omega_1 + \frac{1}{LC}\left(\frac{\omega_2 - \omega_1}{\omega_2 \omega_1}\right) = \frac{2R}{L}$$

$$(\omega_2 - \omega_1) + \frac{1}{LC} \frac{\omega_2 - \omega_1}{1/LC} = \frac{2R}{L}$$

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$$2(\omega_2-\omega_1) = \frac{2R}{L}$$

$$\boxed{\text{Bandwidth } (\omega_2-\omega_1) = \frac{R}{L}} \quad \text{—— (5)}$$

$$Q \text{ factor} = \frac{\omega_0 L}{R}$$

$$\frac{\omega_0}{Q} = \frac{R}{L}$$

comparing with (5)

$$\frac{\omega_0}{Q} = \omega_2-\omega_1$$

$$Q = \frac{\omega_0}{\omega_2-\omega_1}$$

$$= \frac{f_0}{f_2-f_1}$$

ie, $\boxed{Q = \frac{f_0}{\text{Bandwidth}}}$

Expression of Half Power Frequencies In RLC Series Resonating Ckt & Relationship B/w f_1, f_2 and f_0.

From eqn (3)

$$\omega_1\omega_2 = \frac{1}{LC} \quad \text{—— (6)}$$

Also at resonance $\omega_0 = \frac{1}{\sqrt{LC}}$ —(7)

Comparing (6) and (7)

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

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

The resonant frequency is the geometric mean of the two half power frequencies.

From (3)

$$\omega_1 \omega_2 = \frac{1}{LC}$$

$$(\omega_2 - \omega_1) = \frac{R}{L}$$

$$\frac{1}{\omega_1 LC} - \omega_1 = \frac{R}{L}$$

$$\frac{1 - \omega_1^2 LC}{\omega_1 LC} = \frac{R}{L}$$

$$1 - \omega_1^2 LC = \omega_1 RC$$

$$\omega_1^2 LC + \omega_1 RC - 1 = 0$$

$$\omega_1 = \frac{-RC \pm \sqrt{R^2C^2 - 4LC}}{2LC}$$

$$= \frac{-R \pm \sqrt{R^2 - 4\,L/C}}{2L}$$

Taking +ve sign of radical,

$$\omega_1 = \frac{-R}{2L} + \sqrt{\left(\frac{R}{2L}\right)^2 - \frac{1}{LC}}$$

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Similarly substituting the value of ω_1 from eqn ③ in ⑤ and on simplification will yields.

$$\omega_2 = \frac{R}{2L} + \sqrt{\left(\frac{R}{2L}\right)^2 + \frac{1}{LC}}$$

Frequency at which V_C & V_L are maximum.

$$V_C = IX_C$$

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

$$V_C^2 = \frac{V^2}{\omega^2 C^2 \left[R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2\right]}$$

$$= \frac{V^2}{\omega^2 C^2 R^2 + (\omega^2 LC - 1)^2}$$

On differenciating;

$$\frac{dV_C^2}{d\omega} = 0 = \frac{-V^2\left[2\omega_0 C^2 R^2 + 2(\omega_0^2 LC - 1) 2\omega_0 LC\right]}{\left[\omega_0^2 C^2 R^2 + (\omega_0^2 LC - 1)^2\right]^2}$$

$$2\omega_0 C^2 R^2 + 2(\omega_0^2 LC - 1) 2\omega_0 LC = 0 \qquad [\because V \neq 0]$$

$$2\omega_0 C^2 R^2 + 4\omega_0^3 L^2 C^2 - 4\omega_0 LC = 0$$

$$2\omega_0 C\left(CR^2+2\omega_0^2L^2C-2L\right)=0$$

$$\therefore\ 2\omega_0^2L^2C+CR^2-2L=0$$

$$\omega_0^2=\frac{1}{LC}-\frac{R^2}{2L^2}$$

$$\omega_0=\sqrt{\frac{1}{LC}-\frac{R^2}{2L^2}}$$

$$\boxed{f_0=\frac{1}{2\pi}\sqrt{\frac{1}{LC}-\frac{R^2}{2L^2}}}$$

The above expression of frequency at which the voltage across the capacitor is maximum.

To find the frequency at which V_L is maximum.

$$V_L=IX_L$$

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

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

$$=\frac{V^2\omega^4L^2C^2}{\omega^2C^2R^2+(\omega^2LC-1)^2}$$

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By differentiating V_L^2 with respect to ω and setting $\frac{dV_L^2}{d\omega} = 0$.

$$2\omega^2 LC - \omega^2 C^2 R^2 - 2 = 0$$

$$\omega^2 (2LC - C^2R^2) = 2$$

$$\omega^2 = \frac{2}{2LC - C^2R^2}$$

$$\omega = \frac{1}{\sqrt{LC - \frac{C^2R^2}{2}}}$$

$$\boxed{f_0 = \frac{1}{2\pi\sqrt{LC - \frac{C^2R^2}{2}}}}$$

Problems

1. A series RLC circuit has $R = 2\,\Omega$, $L = 2.0\,mH$, $C = 10\,\mu F$. Calculate i) Q factor of the ckt. ii) bandwidth iii) resonant frequency and iv) half power frequency f_1 and f_2.

⇒ $R = 2\,\Omega$

$L = 2.0\,mH$

$C = 10\,\mu F$

i) $Q = \frac{1}{R}\sqrt{\frac{L}{C}}$

$= \frac{1}{2}\sqrt{\frac{2\times10^{-3}}{10\times10^{-6}}} = \underline{\underline{7.07}}$

iii) $\omega_0 = \frac{1}{\sqrt{LC}}$

$f_0 = \frac{1}{2\pi\sqrt{LC}}$

$= \frac{1}{2\pi\sqrt{2\times10^{-3}\times10\times10^{-6}}} = \underline{\underline{1125.39\ Hz}}$

ii) $BW = \frac{f_0}{Q}$.

$= \frac{1125.39}{7.07} = \underline{\underline{159.23\ Hz}}$

iv) $f_1 = \frac{-R \pm \sqrt{R^2+4L/C}}{4\pi L}$

$= \frac{-2 \pm \sqrt{4+4\left(\frac{2\times10^{-3}}{10\times10^{-6}}\right)}}{4\times\pi\times2\times10^{-3}}$

$= \underline{\underline{1048.62\ Hz}}$

$$f_2 = \frac{R + \sqrt{R^2 + 4L/C}}{4\pi L}$$

$$= \frac{2 + \sqrt{4 + 4(2\times10^{-3}\times10^{5})}}{4\pi \times 2\times10^{-3}}$$

$$= 1208.4 Hz$$

OR

f_1 and f_2 can be determined by using

$$f_2 = f_r + \frac{Bandwidth}{2}$$

$$f_1 = f_r - \frac{Bandwidth}{2}$$

2. Obtain the values of R, L, C in a series RLC circuit that resonates at 1.5 kHz and consumes 50 W from a 50 V ac source operating at the resonant frequency. Calculate the inductance and capacitance of the circuit. The BW is 0.75 kHz.

⇒ $BW = f_2 - f_1$

For a series ckt at resonance.

$$V_R = V_{supply} = 50V$$

$$P_{loss} = \frac{V_R^2}{R} = \frac{50^2}{R}$$

$$50 = \frac{50^2}{R}$$

$$R = \underline{\underline{50\,\Omega}}.$$

$$Q = \frac{f_0}{BW} = \frac{1.5}{0.75} = \underline{\underline{2}}$$

$$Q = \frac{L\omega_0}{R} = \frac{2\pi f_0 L}{R}$$

$$2 = \frac{2\pi \times 1.5 \times 10^{3} L}{50}$$

$$\frac{2 \times 50}{2\pi \times 1.5 \times 10^{3}} = L$$

$$L = \underline{\underline{0.0106 H}}$$

$$f_0 = \frac{1}{2\pi\sqrt{LC}}$$

$$1.5 \times 10^{3} \times 2\pi = \frac{1}{\sqrt{L}.\sqrt{C}}.$$

$$\sqrt{C} = \frac{1}{1.5 \times 10^{3} \times 2\pi \times \sqrt{0.0106}}$$

$$C = 1.061 \times 10^{-6} F$$

3. A series resonating circuit has $R = 1k\Omega$, half power frequencies of 10 and 90 KHz. Determine the band width and the resonant frequency. Calculate the inductance and capacitance of the circuit.

⟹ $BW = f_2 - f_1 = 90 - 10 = 80 KHZ.$

$$f_0 = \sqrt{f_1 f_2} = \sqrt{90 \times 10} = \sqrt{900} = 30 KHZ$$

$$Q = \frac{f_0}{BW} = \frac{30}{80} = \frac{3}{8}$$

$$Q = \frac{2\pi f_0 L}{R}$$

$$\frac{3}{8} = \frac{2\pi \times 30 \times 10^{-3} \times L}{1000}$$

$$2mH = L$$

At series resonance.

$$f_0 = \frac{1}{2\pi\sqrt{LC}}$$

$$30 \times 10^{3} = \frac{1}{2\pi \sqrt{2\times 10^{-3}}\sqrt{C}}$$

$$\sqrt{C} = \cancel{\frac{30 \times 10^{3} \times 2\pi \sqrt{2 \times 10^{-3}}}{1}}$$

$$C = 0.014\ \mu F$$

4. A voltage $v(t) = 10 \sin\omega t$ is applied to a series RLC circuit. At resonant frequency of the circuit the maximum voltage across the capacitor is found to be 500V. Moreover the bandwidth is known to 400 rad/s and the impedance at resonance is 100 Ω. Find the resonant frequency. Also find the values of L and C of the circuit.

⇒ The applied voltage to the circuit is.

$$V_{max} = 10\,V$$

$$V_{rms} = \frac{10}{\sqrt{2}} = 7.07\,V$$

$$V_C = 500\,V$$

$$Q = \frac{V_C}{V} = \frac{500}{7.07} = 70.7$$

$$BW = \omega_2 - \omega_1 = 400\ rad/s.$$

At resonance $Z = R = 100\,\Omega$.

$$Q = \frac{\omega_0}{BW} = \frac{\omega_0}{\omega_2 - \omega_1}$$

$$\omega_0 = Q(\omega_2 - \omega_1)$$

$$= 28280 \text{ rad/s}$$

$$f_0 = \frac{28280}{2\pi} = \underline{\underline{4499 \text{ Hz}}}$$

$$BW = \omega_2 - \omega_1 = \frac{R}{L}$$

$$L = \frac{R}{\omega_2 - \omega_1}$$

$$= \frac{100}{400} = \underline{\underline{0.25 \text{ H}}}$$

$$f_0 = \frac{1}{2\pi\sqrt{LC}}$$

$$C = \frac{1}{(2\pi f_0)^2 L} = \frac{1}{(2\pi \times 4499)^2 \times 0.25}$$

$$C = \underline{5 \text{ nF}}$$

5. A constant voltage at a frequency of 1 MHz is applied to an inductor in series with a variable capacitor. When the capacitor is set to 500 pF, the current has its maximum value while it is reduced to one-half when the capacitance is 600 pF. Find R, L and Q factor of the inductor.

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$\Rightarrow$ $f_0 = 1 MHz$

$C_1 = 500 pF$

$C_2 = 600 pF$

$C = 500 pF$

$$f_0 = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2\pi\sqrt{L \times 500 \times 10^{-12}}}$$

$$10^6 = \frac{1}{2\pi\sqrt{L \times 500 \times 10^{-12}}}$$

$$L = \underline{\underline{0.05 mH}}$$

$$X_L = 2\pi f_0 L = 2\pi \times 10^6 \times 0.05 \times 10^{-3} = \underline{\underline{314.16 \Omega}}$$

When capacitance is 600 pF, the current reduces to one half of the current as resonance.

$$X_C = \frac{1}{2\pi f C}$$

$$= \frac{1}{2\pi \times 10^6 \times 600 \times 10^{-12}} = \underline{\underline{265.26 \Omega}}$$

$$I = \frac{1}{2} I_0$$

$$\therefore \frac{V}{2} = \frac{1}{2}\frac{V}{R}$$

$$Z = 2R.$$

$$\sqrt{R^2 + (X_L - X_C)^2} = 2R$$

$$R^2 + (314.16 - 265.26)^2 = 4R^2$$

$$3R^2 = 2391.21$$

$$\therefore R = \underline{\underline{28.23\,\Omega}}$$

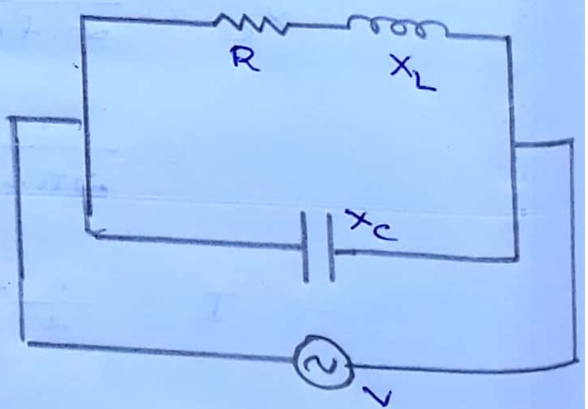
$$Q_0 = \frac{1}{R}\sqrt{\frac{L}{C}} \quad \text{or} \quad \frac{X_L}{R}$$

$$= \frac{1}{28.23}\sqrt{\frac{0.05\times10^{-3}}{500\times10^{-12}}}$$

$$= \underline{\underline{11.2}}$$

Parallel Resonance.

Consider a parallel circuit consisting of a coil and capacitor as shown in fig. The impedance of two branches are:-



$$\bar{Z}_1 = R + jX_L$$

$$\bar{Z}_2 = -jX_C$$

$$\bar{Y}_1 = \frac{1}{\bar{Z}_1} = \frac{1}{R+jX_L}$$

$$= \frac{R - jX_L}{R^2 + X_L^2}$$

$$\bar{Y}_2 = \frac{1}{\bar{Z}_2} = \frac{1}{-jX_C} = \frac{jX_C}{X_C^2}$$

$$= \frac{j}{X_C}$$

Admittance of the circuit, $\bar{Y}$.

$$\bar{Y} = \bar{Y}_1 + \bar{Y}_2$$

$$= \frac{R - jX_L}{R^2 + X_L^2} + j\frac{1}{X_C}$$

$$= \frac{R}{R^2+X_L^2} - j\left(\frac{X_L}{R^2+X_L^2} - \frac{1}{X_C}\right)$$

At resonance circuit is purely resistive. ∴ the condition for resonance is

$$\frac{X_L}{R^2 + X_L^2} = \frac{1}{X_C}$$

$$X_L X_C = R^2 + X_L^2$$

$$\omega_0 L \frac{1}{C\omega_0} = R^2 + \omega_0^2 L^2$$

$$\omega_0^2 L^2 = \frac{L}{C} - R^2$$

$$\omega_0^2 = \frac{1}{LC} - \frac{R^2}{L^2}$$

$$\omega_0 = \sqrt{\frac{1}{LC} - \frac{R^2}{L^2}}$$

$$\boxed{f_0 = \frac{1}{2\pi}\sqrt{\frac{1}{LC} - \frac{R^2}{L^2}}}$$

f_0 is called the resonant frequency of the ckt.

if R is very small as compared to L then

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$$f_0 = \frac{1}{2\pi\sqrt{LC}}$$

Dynamic Impedance of Parallel Circuit.

At resonance, the circuit is purely resistive.

$\therefore$ Dynamic impedance at resonance.

$$\cancel{Z = \frac{R}{R^2 + X_L^2}}$$

$$Z = \frac{R^2 + X_L^2}{R}$$

At resonance.

$$R^2 + X_L^2 = X_L X_C$$

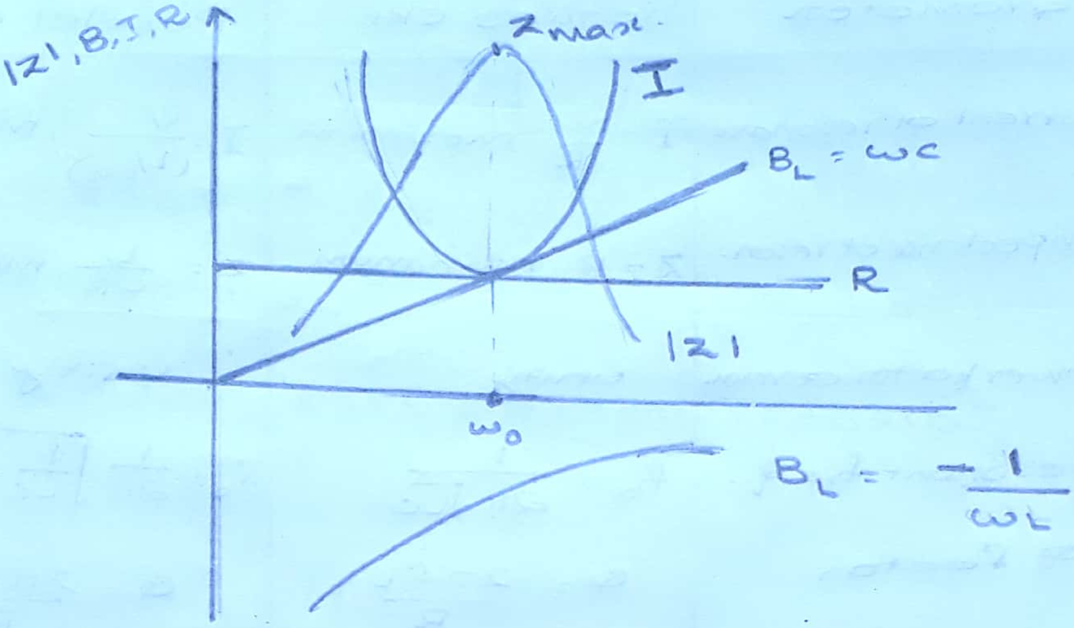
$$= L\omega \cdot \frac{1}{C\omega} = \frac{L}{C}$$

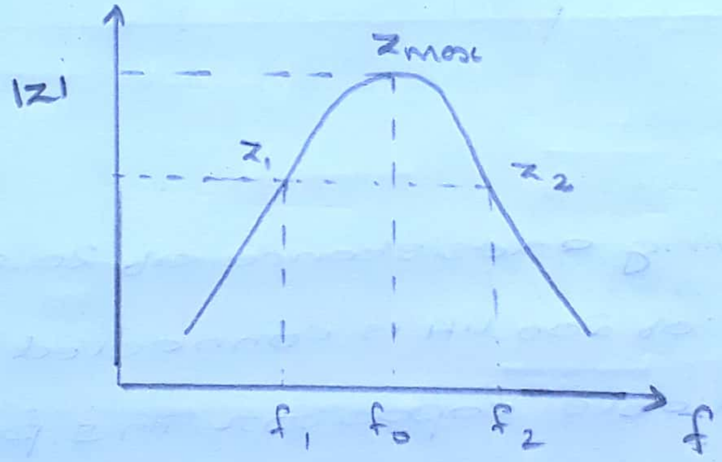
$$\therefore\ Z = \frac{L}{CR}$$

Properties of Resonance of Parallel LRC ckt.

* Power factor is unity.
* Current at resonance $[V/(L/CR)]$ is minimum.
* Net impedance at resonance of parallel circuit is maximum at equal to $(L/CR)\,\Omega$.
* The admittance is minimum.
* The resonant frequency of this ckt $f_0 = \frac{1}{2\pi}\sqrt{\frac{1}{LC} - \frac{R^2}{L^2}}$

Variation of Capacitive and Inductive Susceptance Impedance And Current With Frequency.





Q factor of Parallel Resonating circuit (I magnification at resonance)

$$Q = \frac{I_c}{I} = \frac{V/x_c}{V/z} = \frac{z}{x_c} = \frac{L}{CR} \times \omega_0 C$$

$$\boxed{Q = \frac{L\omega_0}{R}}$$

ckt also known as: rejector ckt

anti resonant ckt

tuned ckt.

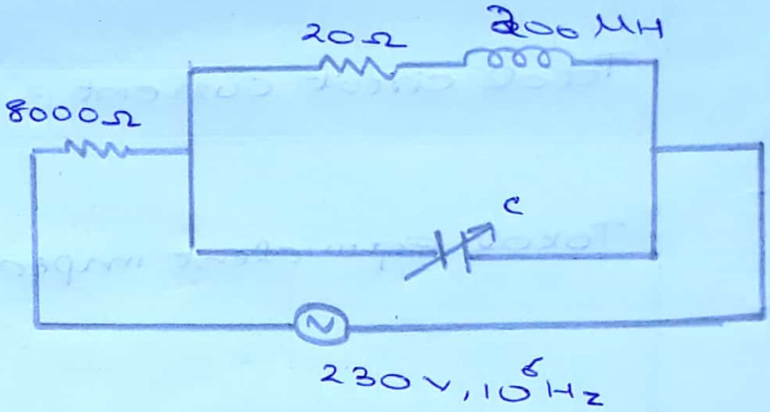
Comparison of Series & Parallel Resonant Ckt

Parameter	Series Ckt	Parallel ckt.
Current at resonance	$I = \frac{V}{R}$, maximum	$I = \frac{V}{(L/CR)}$, minimum.
Impedance at reson.	$Z = R$, minimum	$Z = \frac{L}{CR}$, maximum.
Power factor at reson.	unity	unity
Resonant freq.	$f_0 = \frac{1}{2\pi\sqrt{LC}}$	$f_0 = \frac{1}{2\pi}\sqrt{\frac{1}{LC} - \frac{R^2}{L^2}}$
Q factor	$Q = \frac{2\pi f L}{R}$	$Q = \frac{2\pi f L}{R}$
It magnifies	Vltg across L&C	Current across L&C

Problems

1. A coil having a resistance of $20\,\Omega$ and an inductance of $200\,\mu H$ is connected in parallel with a variable capacitor. This parallel combination is connected in series with a resistance of $8000\,\Omega$. A voltage of 230V at a frequency of 10^6 Hz is applied across the circuit. Calculate the value of capacitance at resonance b) Q factor of the circuit. c) dynamic impedance of the circuit. d) total circuit current

⇒ $R = 20\,\Omega$



$L = 200\,\mu H$

$f = 10^6\,Hz$

$V = 230\,V$

$R_s = 8000\,\Omega$

$X_L = L\omega = 2\pi f L = 2 \times \pi \times 10^6 \times 200 \times 10^{-6}$

$= 1256.6\,\Omega$

$$f_0 = \frac{1}{2\pi}\sqrt{\frac{1}{LC} - \frac{R^2}{L^2}}$$

$$10^6 = \frac{1}{2\pi}\sqrt{\frac{1}{200\times10^{-6}\times C} - \frac{20^2}{(200\times10^{-6})^2}}$$

$C = 126.65\times10^{-12}\,F = \underline{\underline{126.65\,pF}}$

Q factor $Q_0 = \dfrac{2\pi f L}{R}$

$$= \frac{2\pi \times 10^6 \times 200\times10^{-6}}{20}$$

$= 62.83.$

Dynamic impedence $Z = \dfrac{L}{CR}$

$$= \frac{200\times10^{-6}}{126.65\times10^{-12}\times 20} = \underline{\underline{78958\,\Omega}}$$

Total circuit current $= \dfrac{230}{\text{total } Z}$

Total equivalent impedance $= 78958 + 8000$

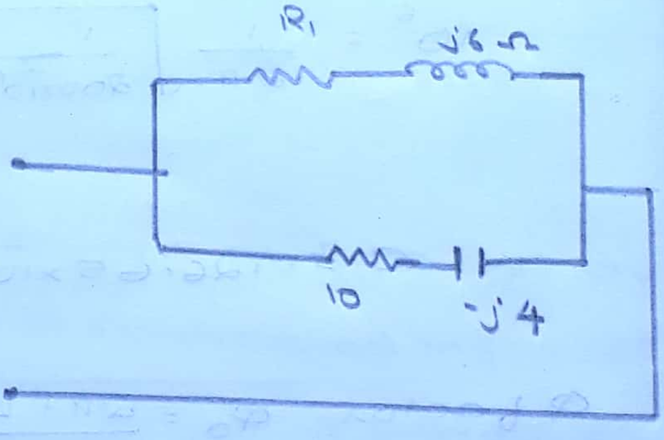
$= 86958\ \Omega$

$\therefore$ Total circuit current $= \dfrac{230}{86958}$

$= 2.645 \times 10^{-3}$ A

$= 2.65$ mA

2. Find the value of R_1 such that the circuit given in figure is resonant.



$\Rightarrow$

$$y = \frac{1}{R_1 + j6} + \frac{1}{10 - j4}$$

$$= \frac{R_1 - j6}{R_1^2 + 36} + \frac{10 + j4}{10^2 + 16}$$

$$= \frac{R_1}{R_1^2 + 36} + \frac{10}{10^2 + 16} + j\left(\frac{4}{10^2 + 16} - \frac{6}{R_1^2 + 36}\right)$$

During resonance imaginary part of $y = 0$.

$$\frac{4}{10^2 + 16} = \frac{6}{R_1^2 + 36}$$

$$R_1^2 + 36 = \frac{116}{4} \times 6$$

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$R_1 = \underline{\underline{11.75\,\Omega}}$