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Q1:- AIPMT 2011

In an AC circuit an alternating voltage $e = 200\sqrt{2}\sin 100t$ Volt is connected to a capacitor of capacity $1\mu F$. The rms value of the current in the circuit.

(a) 20 mA

(b) 200 mA

(c) 100 mA

(d) 10 mA

$C = 1\times10^{-6}F$.

$X_C = \frac{1}{\omega C}$

$= \frac{1}{100\times10^{-6}}$

$X_C = \frac{10^6}{10^2} = 10^4\,\Omega$

$\mathcal{E} = 200\sqrt{2}\sin 100t$

$\mathcal{E} = \mathcal{E}_0 \sin\omega t$

$V_{rms} = \frac{200\cancel{\sqrt{2}}}{\cancel{\sqrt{2}}} = 200\,\text{Volt}$

$i_{rms} = \frac{V_{rms}}{X_C} = \frac{200}{10^4}$

$= 2\times10^2\times10^{-4} = 2\times10^{-2} = 20\times10^{-3}A$

$= 20\,mA$

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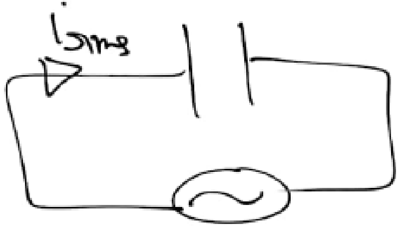
NEET 2020 :- A $40\,\mu F$ Capacitor is connected to a 200V 50Hz ac supply. The rms value of current in the Circuit is nearly.

(a) 2.5 A [✓]

(b) 25.1 A

(c) 1.7 A

(d) 2.05 A



200V, 50Hz

$f = ?$

$V_{rms} = 200V$

$X_C = \frac{1}{\omega C}$

$= \frac{1}{100\pi \times 40 \times 10^{-6}}$

$= \frac{1}{4\pi \times 10^{-3}}$

$= \frac{1000}{4\pi} = \frac{500}{2\pi} = \frac{250}{\pi}\ \Omega$

$\omega = 2\pi f$

$= 2\pi \times 50$

$\boxed{\omega = 100\pi}$

$i_{rms} = \frac{20\cancel{0} \times \pi}{25\cancel{0}}$

$= \frac{4}{5} \times \pi = 0.8 \times 3.1416$

$= \simeq 2.5\,Amp$

Resonance in LCR :-

$\mathcal{E} = \mathcal{E}_0 \sin \omega t$

At resonance

$X_L = X_C$

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

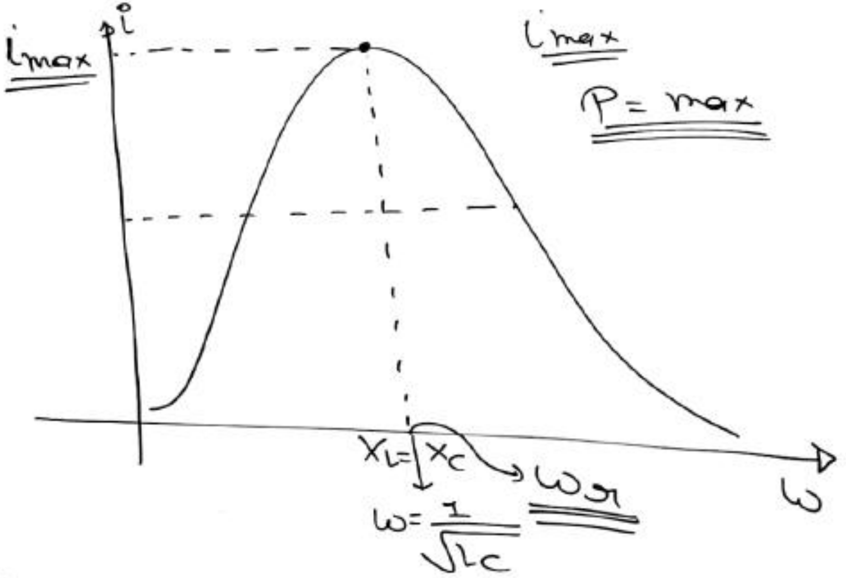
$\omega = \frac{1}{\sqrt{LC}}$

$$\boxed{f = \frac{1}{2\pi\sqrt{LC}}}$$

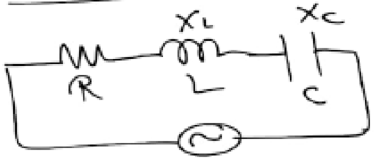
$\Rightarrow$ $\underline{\underline{X_L - X_C = 0}}$ $Z = \sqrt{R^2 + (X_L - X_C)^2}$

$\boxed{Z = R}$ minimum

i_{max} at resonance.

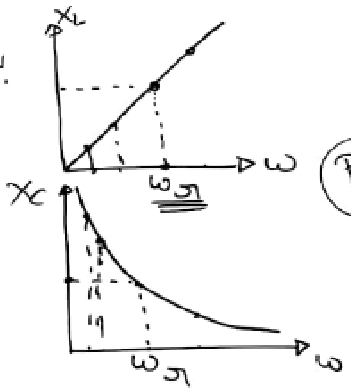


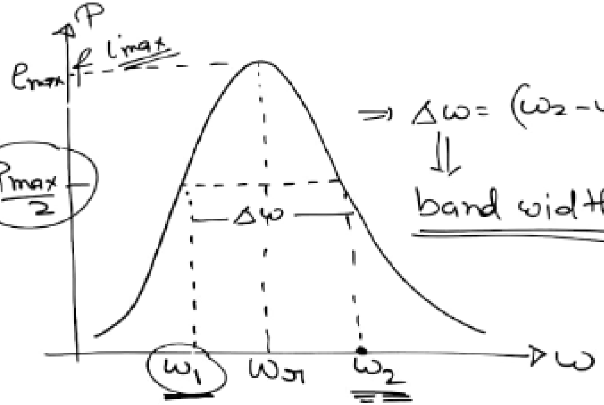
Resonance in LCR :-



$\mathcal{E} = \mathcal{E}_0 \sin\omega t$

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





$\Rightarrow \Delta\omega = (\omega_2 - \omega_1)$

$\Downarrow$

band width

Z_{min} at resonance

$X_L = X_C \longrightarrow Z = R \rightarrow \min$ → i_{max} → max

$\omega = \frac{1}{\sqrt{LC}}$ $\quad f = \frac{1}{2\pi\sqrt{LC}}$

$$\boxed{i = \frac{V_{rms}}{Z}}$$

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

$X_L = \omega L$

$X_C = \frac{1}{\omega C}$

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

$\omega > \omega_r$

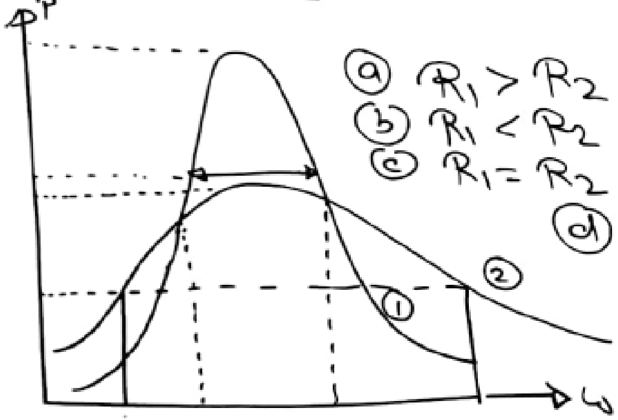
$\omega > \omega_r$ $\quad Z\uparrow$ $\quad X_L\uparrow$ $\quad X_C\downarrow \Rightarrow (X_L - X_C)\uparrow$

$\omega < \omega_r \Rightarrow \omega\downarrow$ $\quad X_C\uparrow$ $\quad X_L\downarrow, (X_L - X_C)^2\uparrow$

$\Delta\omega \rightarrow$ band width

$$\Delta\omega = \frac{R}{L}$$

Imp Question

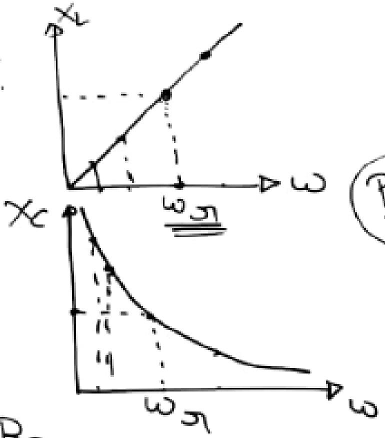


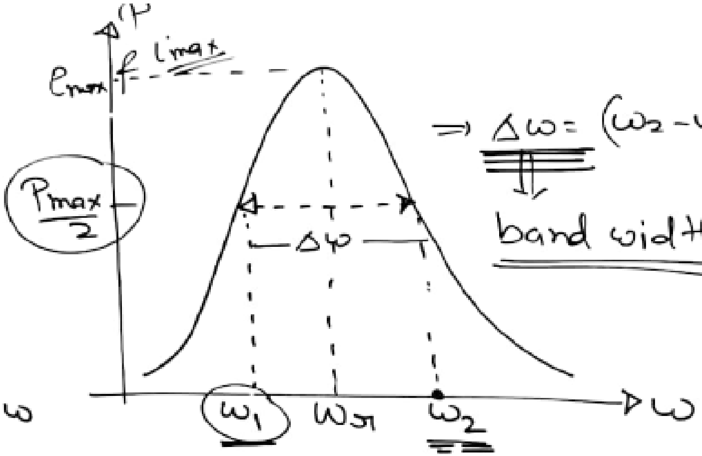
(a) $R_1 > R_2$

(b) $R_1 < R_2$

(c) $R_1 = R_2$

(d) N.O.T.





$\Rightarrow \Delta\omega = (\omega_2 - \omega_1)$

band width

(2) $(\Delta\omega)_2 > (\Delta\omega)_1$

$$R_2 > R_1$$

$\Delta\omega \rightarrow$ band width

$$\Delta\omega = \frac{R}{L}$$

$\Rightarrow$ Quality factor (Q)

$$\boxed{Q = \frac{\omega_r}{\Delta\omega}}$$

$$= \frac{1}{\sqrt{LC} \times \frac{R}{L}}$$

$$= \frac{1}{\sqrt{\frac{LC}{L^2}} \times R} = \frac{1}{R}\sqrt{\frac{L}{C}}$$

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

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

$R \rightarrow$ Resistance

$L \rightarrow$ Inductance

$C \rightarrow$ Capacitance

$\boxed{\text{for } Q \text{ High}}$

$\Rightarrow$ $R \rightarrow$ Low

$\rightarrow$ $L \rightarrow$ High

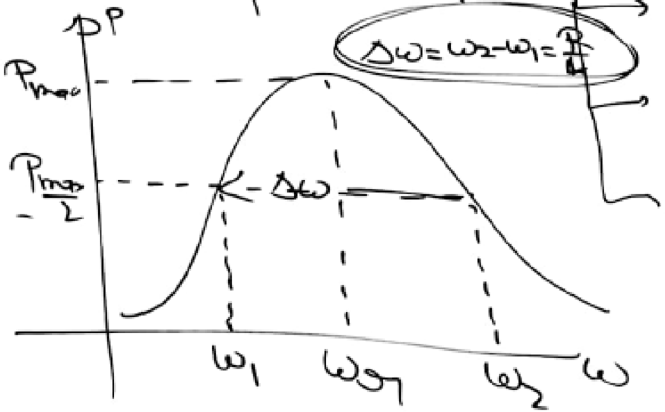
$\rightarrow$ $C \rightarrow$ Low

$\Rightarrow$ $\boxed{Q \rightarrow \text{Low}}$

$\rightarrow$ R High

$\rightarrow$ $L \rightarrow$ low

$\rightarrow$ $C \rightarrow$ High.



Q) Which of the following combination should be selected for better tuning of an L-C-R ckt used for communication.

(a) $R = 25\Omega$ $L = 2.5H$ $C = 45\mu F$

(b) $R = 20\Omega$ $L = 1.5H$ $C = 35\mu F$

(c) $R = 25\Omega$ $L = 1.5H$ $C = 45\mu F$

(d) $\underline{R = 15\Omega}$ $\underline{L = 3.5H}$ $\underline{C = 30\mu F}$

Q_1 Q_2 Q_3 Q_4

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

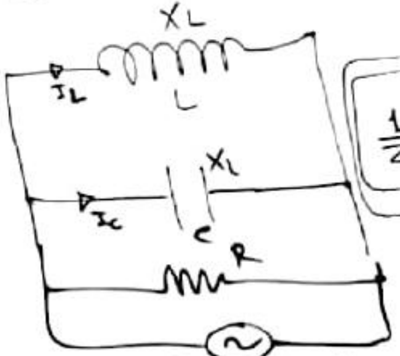
Q - High

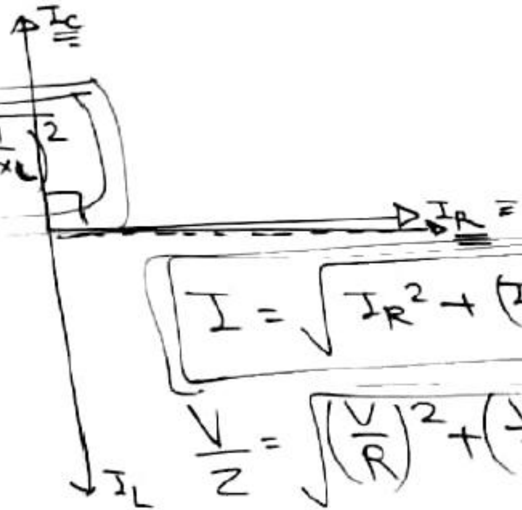
$R \to$ Low

$L \to$ High

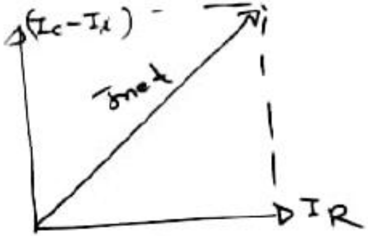
$C \to$ low

L-C-R In parallel :-





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



$$\boxed{I = \sqrt{I_R^2 + (I_C - I_L)^2}}$$

$$\frac{V}{Z} = \sqrt{\left(\frac{V}{R}\right)^2 + \left(\frac{V}{X_C} - \frac{V}{X_L}\right)^2}$$

$$\frac{V}{Z} = \sqrt{\frac{V^2}{R^2} + V^2\left(\frac{1}{X_C} - \frac{1}{X_C}\right)^2}$$

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

$\varepsilon = \varepsilon_0 \sin\omega t$

$i = i_0 \sin\omega t$

$\varepsilon = \varepsilon_0 \sin\omega t$

$i = \frac{\varepsilon_0}{X_C}\sin\left(\omega t + \frac{\pi}{2}\right)$

$i = i_0 \sin\left(\omega t + \frac{\pi}{2}\right)$

$\varepsilon = \varepsilon_0 \sin\omega t$

$i = \frac{\varepsilon_0}{X_L}\sin\left(\omega t - \frac{\pi}{2}\right)$

Q1)

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

$= \frac{60}{100} = \frac{3}{5}$

$V_{rms} = \frac{\mathcal{E}_0}{\sqrt{2}} = 220V$ $\quad \mathcal{E} = \underbrace{220\sqrt{2}}_{\mathcal{E}_0} \sin 100\pi t$

(i) $Z = ?$

(ii) I_{rms}

(iii) V_{rms}

(iv) P_{avg}:

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

$Z = \sqrt{(60)^2 + (120-40)^2}$

$= \sqrt{(60)^2 + (80)^2}$

$Z = 100\Omega$

$P_{av} = \frac{V_0 I_0}{2} \cos\phi$

$I_{rms} = \frac{V_{rms}}{Z} = \frac{220}{100} = 2.2$ Amp

$= V_{rms} I_{rms} \cos\phi$

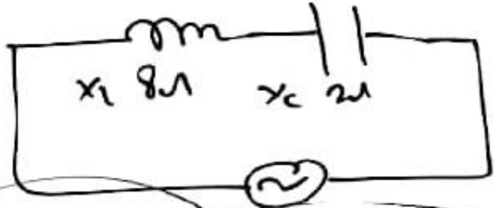
$= 220 \times 2.2 \times \frac{3}{5}$

(iii) $V_{rms} = \frac{\mathcal{E}_0}{\sqrt{2}} = \frac{220\sqrt{2}}{\sqrt{2}} = 220V$

$= \frac{22 \times 22 \times 3}{5}$

$= 290.4$ watt

Q2)



220V, 50Hz

(a) i_{rms} (b) $Z = ?$

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

$= \sqrt{(8-2)^2}$

$= \sqrt{(6)^2} = 6\Omega$

$i_{rms} = \frac{V_{rms}}{Z} = \frac{220}{6}$

$i_{rms} = \frac{110}{3}$ Amp