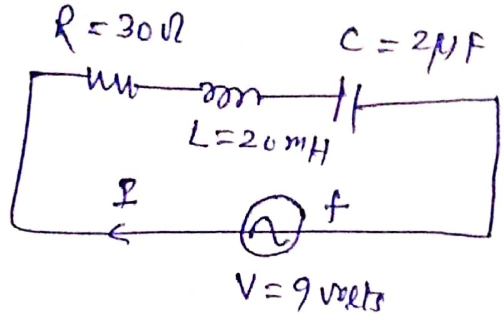
Solution Tutorial 8 ①

Ans 1




(i) Resonant frequency $f_r = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2\pi\sqrt{.02\times2\times10^{-6}}} = 796\ Hz$

(ii) Circuit Current at resonance, $I_m$

$I = \frac{V}{R} = \frac{9}{30} = 0.3\ A$ or $300\ mA$

(iii) Inductive reactance at resonance $X_L$

$X_L = 2\pi f L = 2\pi \times 796 \times .02 = 100\ \Omega$

(iv) Voltage across the Inductor and Capacitor $V_L$ & $V_C$

$V_L = V_C$

$V_L = I \times X_L = 300\ mA \times 100\ \Omega = 30\ volts$

so $V_C = 30$ volts.

(v) Quality factor $Q = \frac{X_L}{R} = \frac{100}{30} = 3.33$

(vi) BandWidth, $BW = \frac{f_r}{Q} = \frac{796}{3.33} = 238\ HZ$

(vii) The upper and lower -3dB frequency points, $f_H$ & $f_L$

$f_L = f_r - \frac{1}{2}BW = 796 - \frac{1}{2}(238) = 677\ Hz$

$f_H = f_r + \frac{1}{2}BW = 796 + \frac{1}{2}(238) = 915\ HZ$

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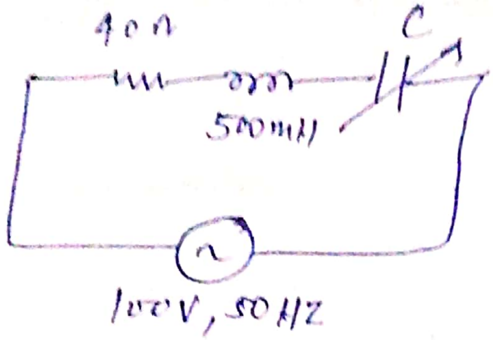
Ans 2.




→ at resonance condition $X_C = X_L$

$$\frac{1}{2\pi f C} = 2\pi f L \Rightarrow C = \frac{1}{(2\pi f)^2 L}$$

$$\cancel{\Rightarrow c = (2\pi)^2 f^2 L}$$

$$C = \frac{1}{(2\pi \times 50)^2 \times .5} = 20.3\,\mu F$$

voltage across the inductor and capacitor ($V_L$ & $V_C$)

$$I_S = \frac{V}{R} = \frac{100}{4} = 25 \text{ amp}$$

at resonance $V_L = V_C$

$$V_L = I_S \times X_L = 25 \times 157.1 = 3927.5 \text{ volts}$$

$$V_C = V_L = 3927.5 \text{ volts.}$$

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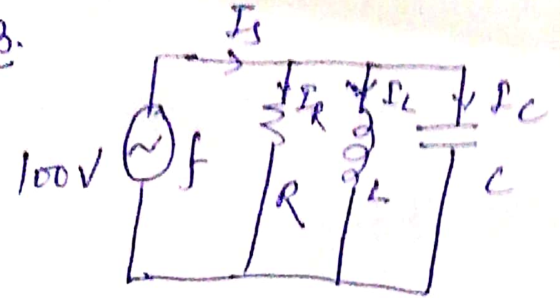
Ans 3.




$R = 600\,\Omega$
$L = 200\,mH$
$C = 120\,\mu F$

→ Resonant frequency $f_r = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2\pi\sqrt{0.2 \times 120 \times 10^{-6}}} = 32.5\,HZ$

→ Inductive Resistance at Resonance $X_L$

$X_L = 2\pi f_r L = 2\pi \times 32.5 \times 0.2 = 40.8\,\Omega$

→ Quality factor $Q = \frac{R}{X_L} = \frac{R}{2\pi/L} = \frac{60}{40.8} = 1.47$

→ BandWidth BW $= \frac{f_r}{Q} = \frac{32.5}{1.47} = 22\,HZ$

→ The upper and lower −3 dB frequency points $f_H$ & $f_L$

$f_L = f_r - \frac{1}{2} BW = 32.5 - \frac{1}{2}(22) = 21.5\,HZ$

$f_H = f_r + \frac{1}{2} BW = 32.5 + \frac{1}{2}(22) = 43.5\,HZ$

→ Circuit Current at resonance $I_T$

$I_T = I_R = \frac{V}{R} = \frac{100}{60} = 1.67\,Amp.$

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Ans 4. $f = 1MHz = 10^6 Hz$ , $C = 400pf = 400 \times 10^{-12} F$

$I_{max} = \frac{V}{r}$ as $X_L = X_C$ (at resonance)

$$2\pi f L = \frac{1}{2\pi f C} = \frac{1}{2\pi \times 10^6 \times 400 \times 10^{-12}}$$

$$= 398 \Omega$$

So $L = \frac{1}{2\pi f} \times 398 = \frac{398}{2\pi \times 10^6} = 63.34 \mu H$

So $\boxed{L = 63.34 \mu H}$

→ Now when $C = 450 pF$, the current is reduced to $\frac{1}{\sqrt{2}}$ of $I_{max}$.

$C_1 = 450 pF$, $X_{C_1} = \frac{1}{2\pi \times 10^6 \times 450 \times 10^{-12}} = 353.7 \Omega$

Impedance of the circuit in this condition

$$Z\angle\theta = r + j(X_L - X_{C_1}) = r + j(398 - 353.7)$$

$$= (r + j\,44.3)\Omega$$

Now current $I = \frac{I_{max}}{\sqrt{2}} = \frac{V}{\sqrt{2}\, r} = \frac{V}{Z} = \frac{V}{\sqrt{r^2 + (44.3)^2}}$

On solving

$\Rightarrow$

$$\sqrt{2}\, r = \sqrt{r^2 + (44.3)^2}$$

$$\Rightarrow \boxed{r = 44.3 \Omega}$$

→ The Quality factor of the coil $Q = \frac{X_L}{r} = \frac{398}{44.3} = 8.984$

→ The Bandwidth $\Delta f = f_2 - f_1 = \frac{r}{2\pi L} = \frac{44.3}{2\pi \times 63.34 \times 10^{-6}}$

$$= 111.3 KHz$$

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Ans 5: Solution :-

For the first circuit

$f_1 = 50\,Hz$ , $V = 200\,V$ , $R = 15\,\Omega$ , $L = 0.75H$

from the condition of resonance at 50Hz in the series circuit.

$$X_{L_1} = \omega_1 L = 2\pi f_1 L = X_{C_1} = \frac{1}{2\pi f_1 C_1}$$

$$\Rightarrow C_1 = \frac{1}{(2\pi f_1)^2 L} = \frac{1}{(2\pi \times 50)^2 \times .75} = 13.5\times 10^{-6}\,F$$

$$\boxed{C_1 = 13.5\mu F}$$

The maximum current drawn from the supply is

$$I_{max} = \frac{V}{R} = \frac{200}{15} = 13.33\ \text{amp}$$

Now for the second circuit (Fig 5.2)

$$f_2 = 100\,Hz,\quad \omega_2 = 2\pi f_2 = 2\pi\times 100 = 628.3\ \text{rad/s}$$

$$X_{L_2} = 2\pi f_2 L = 2\pi \times 100\times .75 = 471.24\,\Omega$$

$$X_{C_2} = \frac{1}{2\pi f_2 C_1} = \frac{1}{2\pi\times 100\times 13.5\times 10^{-6}} = 117.8\,\Omega$$

$$Z_1\angle\phi_1 = R + j(X_{L_2} - X_{C_2}) = 15 + j(471.24 - 117.8)$$

$$= 15 + j353.44 = 353.75\angle 87.57^\circ$$

$$Y_1\angle -\phi_1 = \frac{1}{Z_1\angle\phi_1} = \frac{1}{15+j353.44} = \frac{1}{353.75\angle 87.57} = 2.827\times 10^{-3}\angle -87.57^\circ$$

$$= (0.12 - j2.824)\times 10^{-3}\ \Omega^{-1}$$

$$Y_2 = \frac{1}{Z_2} = j(\omega_2 C_2)$$

As the combination is resistive in nature, the total admittance is $Y\angle 0^\circ = Y + j0 = Y_1 + Y_2 = (0.12 - j2.824)\times 10^{-3} + j\omega_2 C_2$

So from above $\omega_2 C_2 = 628.3 \cdot C_2 = 2.824\times 10^{-3}$

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So $\boxed{C_2 = \frac{2.824 \times 10^{-3}}{628.3} = 4.5 \times 10^{-6} = 4.5\,\mu F}$

So Total Admittance is $\boxed{Y = 0.12 \times 10^{-3}\ \Omega^{-1}}$

Total impedance is $\boxed{Z = \frac{1}{Y} = 8.33 \times 10^{3}\ \Omega}$

→ ~~Then~~ The Total current drawn from the Supply is

$I = V \cdot Y = \frac{V}{Z} = 200 \times 0.12 \times 10^{-3} = 0.024$ amp

$\boxed{I = 24\,mA}$

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