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Course EEE 322

d. A parallel resonant circuit has $R = 100 \text{ k}\Omega$, $L = 20 \text{ mH}$ and $C = 5 \text{ nF}$. Calculate ω_0 , ω_1 , ω_2 , Q and B

$$R = 100 \text{ k}\Omega, L = 20 \text{ mH}, C = 5 \text{ nF}$$

$$\omega_0 = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{(20 \times 10^{-3})(5 \times 10^{-9})}} = \frac{1}{\sqrt{1 \times 10^{-10}}} = 1,000,000 \text{ rad/s}$$

$$\omega_0 = 100 \text{ krad/s}$$

$$Q = \frac{R}{\omega_0 L} = \frac{100 \times 10^3}{(100 \times 10^3)(20 \times 10^{-3})} = \frac{1}{20 \times 10^{-3}} = 50$$

$$Q = 50$$

$$B = \frac{\omega_0}{Q} = \frac{100 \times 10^3}{50} = 2000 = 2 \text{ krad/s}$$

$$\text{Since } Q > 10, \omega_1 = \frac{\omega_0 - B}{2} = \frac{100 \times 10^3 - 2000}{2}$$

$$= \frac{100 \times 10^3 - 2000}{2} = 99000$$

$$\omega_1 = 99 \text{ krad/s}$$

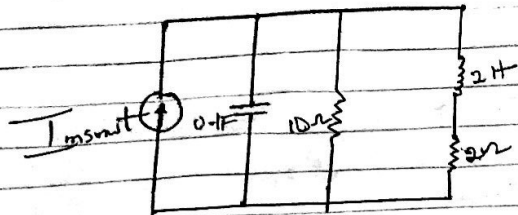
$$\omega_2 = \frac{\omega_0 + B}{2} = \frac{100 \times 10^3 + 2000}{2}$$

$$= \frac{100 \times 10^3 + 2000}{2}$$

$$= 101000$$

$$\omega_2 = 101 \text{ krad/s}$$

(b)



$$Y = \frac{1}{10} + j\omega 0.1 + \frac{1}{2 + j\omega 2} = 0.1 + j\omega 0.1 + \frac{1}{2 + j\omega 2}$$

$$\text{Rationalizing } \frac{1}{2 + j\omega 2} = \frac{1}{2 + j\omega 2} \times \frac{2 - j\omega 2}{2 - j\omega 2} = \frac{2 - j\omega 2}{4 - 4j\omega + 4j\omega + 4\omega^2}$$

$$= \frac{2 - j\omega 2}{4 + 4\omega^2}$$

$$Y = 0.1 + j\omega 0.1 + \frac{2 - j\omega 2}{4 + 4\omega^2} = 0.1 + j\omega 0.1 + \frac{2}{4 + 4\omega^2} - \frac{j\omega 2}{4 + 4\omega^2}$$

$$Y = 0.1 + \frac{2}{4 + 4\omega^2} + j\omega 0.1 - \frac{j\omega 2}{4 + 4\omega^2} = 0.1 + \frac{2}{4 + 4\omega^2} + j\left(\omega 0.1 - \frac{\omega 2}{4 + 4\omega^2}\right)$$

At resonance, $I_r(Y) = 0$

$$\text{Therefore, } \omega_0 0.1 - \frac{\omega_0 2}{4 + 4\omega_0^2} = 0$$

$$0.1 - \frac{2}{4 + 4\omega_0^2} = 0$$

$$0.1 = \frac{2}{4 + 4\omega_0^2}$$

$$0.4 + 0.4\omega_0^2 = 2$$

$$0.4\omega_0^2 = 1.6$$

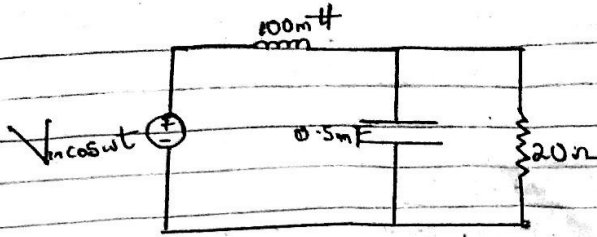
$$\omega_0^2 = 4 \quad \sqrt{\omega_0^2} = \sqrt{4}$$

$$\omega_0 = 2$$

$$\omega_0 = 2 \text{ rad/s}$$

(c)

(c)



$$Z = j\omega 100 \times 10^{-3} + \left(\frac{20}{j\omega(0.5 \times 10^{-3})} \parallel \left(\frac{20}{1} + \frac{1}{0.5 \times 10^{-3} j\omega} \right) \right)$$

$$= j\omega(100 \times 10^{-3}) + \left(\frac{20}{j\omega(0.5 \times 10^{-3})} \parallel \left(\frac{0.01j\omega + 1}{0.5 \times 10^{-3} j\omega} \right) \right)$$

$$= j\omega(100 \times 10^{-3}) + \left(\frac{20}{j\omega(0.5 \times 10^{-3})} \times \frac{j\omega(0.5 \times 10^{-3})}{0.01j\omega + 1} \right)$$

$$= j\omega(100 \times 10^{-3}) + \left(\frac{20}{0.01j\omega + 1} \right)$$

Rationalizing $\frac{20}{0.01j\omega + 1} = \frac{20}{0.01j\omega + 1} \times \frac{0.01j\omega - 1}{0.01j\omega - 1}$

$$= \frac{j\omega 0.2 - 20}{-1 \times 10^{-4} \omega^2 - j\omega 0.01 + j\omega 0.01 - 1}$$

$$= \frac{j\omega 0.2 - 20}{-1 \times 10^{-4} \omega^2 - 1} = \frac{-20 + j\omega 0.2}{-1 \times 10^{-4} \omega^2 - 1}$$

$$= \frac{j(20 - 0.2j\omega)}{-(1 \times 10^{-4} \omega^2 + 1)} = \frac{20 - 0.2j\omega}{1 + 1 \times 10^{-4} \omega^2} = \frac{20}{1 + 1 \times 10^{-4} \omega^2} + \frac{j\omega 0.2}{1 + 1 \times 10^{-4} \omega^2}$$

$$Z = j\omega(100 \times 10^{-3}) + \frac{20}{1 + 1 \times 10^{-4} \omega^2} - \frac{0.2j\omega}{1 + 1 \times 10^{-4} \omega^2} = \frac{20}{1 + 1 \times 10^{-4} \omega^2} + j \left(\frac{\omega(100 \times 10^{-3}) - 0.2\omega}{1 + 1 \times 10^{-4} \omega^2} \right)$$

$$Z = \frac{20}{1 + 1 \times 10^{-4} \omega^2} + j\omega(100 \times 10^{-3}) - \frac{0.2j\omega}{1 + 1 \times 10^{-4} \omega^2}$$

$$Z = \frac{20}{1 + 1 \times 10^{-4} \omega^2} + j \left(\frac{\omega(100 \times 10^{-3}) - 0.2\omega}{1 + 1 \times 10^{-4} \omega^2} \right)$$

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At resonance the imaginary part of $Z_{in}(s) = 0$

$$= \omega_0 (100 \times 10^{-3}) - \frac{0.2 \omega_0}{1 + 1 \times 10^{-4} \omega_0^2} = 0$$

$$\omega_0 (100 \times 10^{-3}) = \frac{0.2 \omega_0}{1 + 1 \times 10^{-4} \omega_0^2}$$

Cross multiply

$$\omega_0 (100 \times 10^{-3}) (1 + 1 \times 10^{-4} \omega_0^2) = 0.2 \omega_0$$

$$= 0.1 + 1 \times 10^{-5} \omega_0^2 = 0.2$$

$$= 1 \times 10^{-5} \omega_0^2 = 0.2 - 0.1$$

$$\omega_0^2 = \frac{0.1}{1 \times 10^{-5}}$$

$$\omega_0^2 = 10000$$

$$\omega_0 = \sqrt{10000}$$

$$\omega_0 = 100 \text{ rad/s}$$