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17/ENG04/043 Electrical Electronics Engineering

EEE 322 ELECTRICAL CIRCUIT THEORY

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

Solution:

$$\omega_0 = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{20\times10^{-3} \times 5\times10^{-9}}}$$

$$= 100000 \text{ rad/s}$$

$$= 100 \text{ Krad/s}.$$

$$Q = \frac{R}{\omega_0 L} = \frac{100 \times 10^3}{100\times10^3 \times 20\times10^{-3}}$$

$$= 50$$

$$B = \frac{\omega_0}{Q} = \frac{100\times10^3}{50} = 2000 \text{ rad/s} = 2 \text{ Krad/s}$$

Since $Q \geq 10$

$$\omega_1 = \omega_0 - \frac{B}{2} = 100000 - \frac{2000}{2}$$

$$\omega_1 = 99000 \text{ rad/s}$$

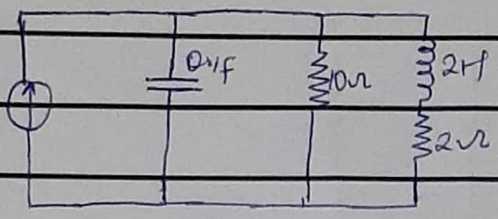
$$= 99 \text{ Krad/s}$$

$$\omega_2 = \omega_0 + \frac{B}{2} = 100000 + \frac{2000}{2}$$

$$\omega_2 = 101000 \text{ rad/s}$$

$$= 101 \text{ Krad/s}$$

ii) Determine the resonant frequency of the circuit below



Solution.

$$X_C = \frac{1}{2\pi f_C} = \frac{1}{\omega_C} = \frac{1}{j\omega 0.1}$$

$$X_L = 2\pi f_L = \omega L = j\omega 2$$

$$\frac{1}{Z} = Y = \frac{1}{X_C} + \frac{1}{R} + \frac{1}{X_C + R}$$

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

$$= 0.1 + j\omega 0.1 + \left[\frac{1}{2+j\omega 2} \times \frac{2-j\omega 2}{2-j\omega 2}\right]$$

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

at resonace, Imaginary of admittance = 0

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

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

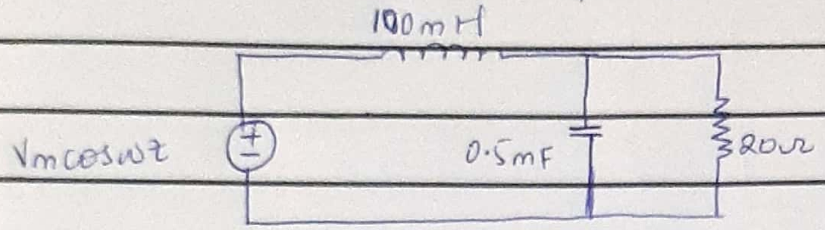
$$0.4\omega_0 + 0.4\omega_0^3 + 2\omega_0 = 0$$

$$0.4\omega_0^3 - 1.6\omega_0 = 0$$

solving quadratically

$\omega_0 = 2$ rad/s   frequency can't be -ve.

iii) Calculate the resonant frequency of the circuit below.



Solution.

$X_C = \frac{1}{2\pi f c} = \frac{1}{j\omega c} = \frac{1}{j\omega 0.0005}$

$X_L = 2\pi f L = \omega L = j\omega 0.1$

$Z = X_L + \left(\frac{X_C \cdot R}{X_C + R}\right)$

$Z = j\omega 0.1 + \left[20 \times \frac{1}{j\omega 0.0005} \div 20 + \frac{1}{j\omega 0.0005}\right]$

$Z = j\omega 0.1 + \left[\frac{20}{j\omega 0.0005} \div \frac{20(j\omega 0.0005) + 1}{j\omega 0.0005}\right]$

$Z = j\omega 0.1 + \left[\frac{20}{j\omega 0.0005} \times \frac{j\omega 0.0005}{j\omega 0.01 + 1}\right]$

$Z = j\omega 0.1 + \left[\frac{20}{1 + j\omega 0.01}\right]$

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

$\frac{20 - j\omega 0.2}{1 + 0.0001\omega^2}$

$Z = j\omega 0.1 + \frac{20 - j\omega 0.2}{1 + 0.0001\omega^2}$

$$Z = j\omega 0.1 + \frac{20}{1+0.0001\omega^2} - \frac{j\omega 0.2}{1+0.0001\omega^2}$$

$$Z = \frac{20}{1+0.0001\omega^2} + j\omega 0.1 - \frac{j\omega 0.2}{1+0.0001\omega^2}$$

$$Z = \frac{20}{1+0.0001\omega^2} + j\left[\omega 0.1 - \frac{\omega 0.2}{1+0.0001\omega^2}\right]$$

At resonance Imaginary $(Z) = 0$

$$\omega_0 0.1 - \frac{\omega_0 0.2}{1+0.0001\omega_0^2} = 0$$

$$\frac{\omega_0 0.1(1+0.0001\omega_0^2) - \omega_0 0.2}{1+0.0001\omega_0^2} = 0$$

$$\omega_0 0.1 + 0.00001\omega_0^3 - \omega_0 0.2 = 0$$

$$0.00001\omega_0^3 - 0.1\omega_0 = 0$$

Solving using quadratic equation

$\omega_0 = 100$ rad/s

frequency can't be negative