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17/Eng04/052

Electrical/Electronics

Course EEE322

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

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

$$\omega_0 = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{20\times10^{-3}(5\times10^{-9})}} = \frac{1}{\sqrt{1\times10^{-10}}}$$

$= 100000\ rad/s$

$\omega_0 = 100k\ rad/s$

$$Q = \frac{R}{\omega_0 L} = \frac{100\times10^3}{(100\times10^3)(20\times10^{-3})} = \frac{1}{2\times10^{-3}}$$

$= 50$

$Q = 50$

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

Since $Q > 10$, $\omega_1 = \omega_0 - \frac{B}{2} = \frac{100\times10^3 - 2000}{2}$

$= 100\times10^3 - 1000 = 99000$

$\omega_1 = 99k\ rad/s$

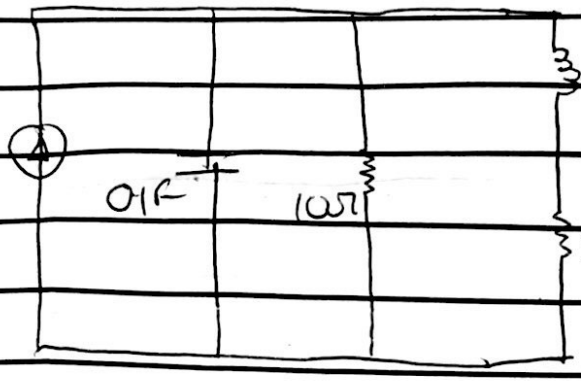
$\omega_2 = \omega_0 + B_0/2 = 100\times10^3 + 2000/2$

$= 100 \times 10^3 + 1000$

$= 101000$

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

(b)



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

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

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

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

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

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

At resonance $Im(Y) = 0$

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

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

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

$0.4 + 0.4\omega^2 = 2$

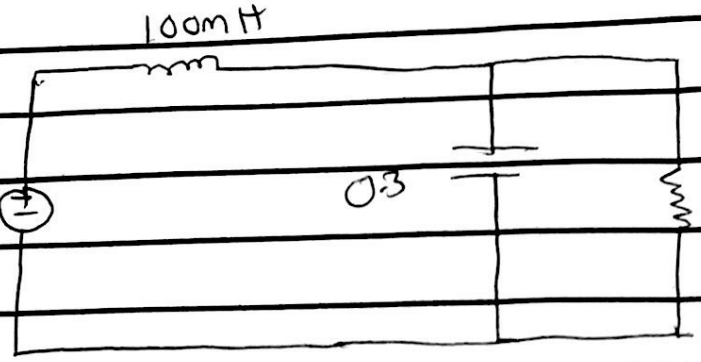
$0.4\omega^2 = 1.6$

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

$\omega_c = 2$

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

(c)



$$2 = j\omega 100 \times 10^{-3} + \left(\frac{20}{j\omega 0.5 \times 10^{-3}} \div \left(\frac{20 + 1}{1 \quad 0.5 \times 10^{-3} j\omega}\right)\right.$$

$$2 = j\omega 100 \times 10^{-3} + \left(\frac{20}{j\omega 0.5 \times 10^{-3}} \div \frac{0.01j + 1}{0.5 \times 10^{-3} j\omega}\right.$$

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

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

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

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

$$= j\omega 0.2 - 20$$

$$-1 \times 10^{-4}\omega^2 - j\omega 0.01 + j\omega 0.01 - 1$$

$$= j\omega 0.2 - 20 \qquad = -20 - j\omega 0.2$$

$$-1 \times 10^{-4}\omega^2 - 1 \qquad -1 \times 10^{-4}\omega^2 - 1$$

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

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

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

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

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

At resonance the imaginary part of Z

$$Im\{Z\} = 0$$

$$= w_0(100 \times 10^{-3}) - \frac{0.2w}{1 + 1 \times 10^{-4}w_0^2} = 0$$

3.4 → 3F

$$w_0(100 \times 10^{-3}) = \frac{0.2w_0}{1 + 1 \times 10^{-4}w_0^2}$$

Cross multiply

$$w_0^2(100 \times 10^{-3})(1 + 1 \times 10^{-4}w_0^2) = 0.2w_0$$

$$= 0.1 + 1 \times 10^{-5}w_0^2 = 0.2$$

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

$$w_0^2 = \frac{0.1}{1 \times 10^{-5}}$$

$$w_0^2 = 10000$$

$$w_0 = \sqrt{10000} = 100 \text{ rad/s}$$