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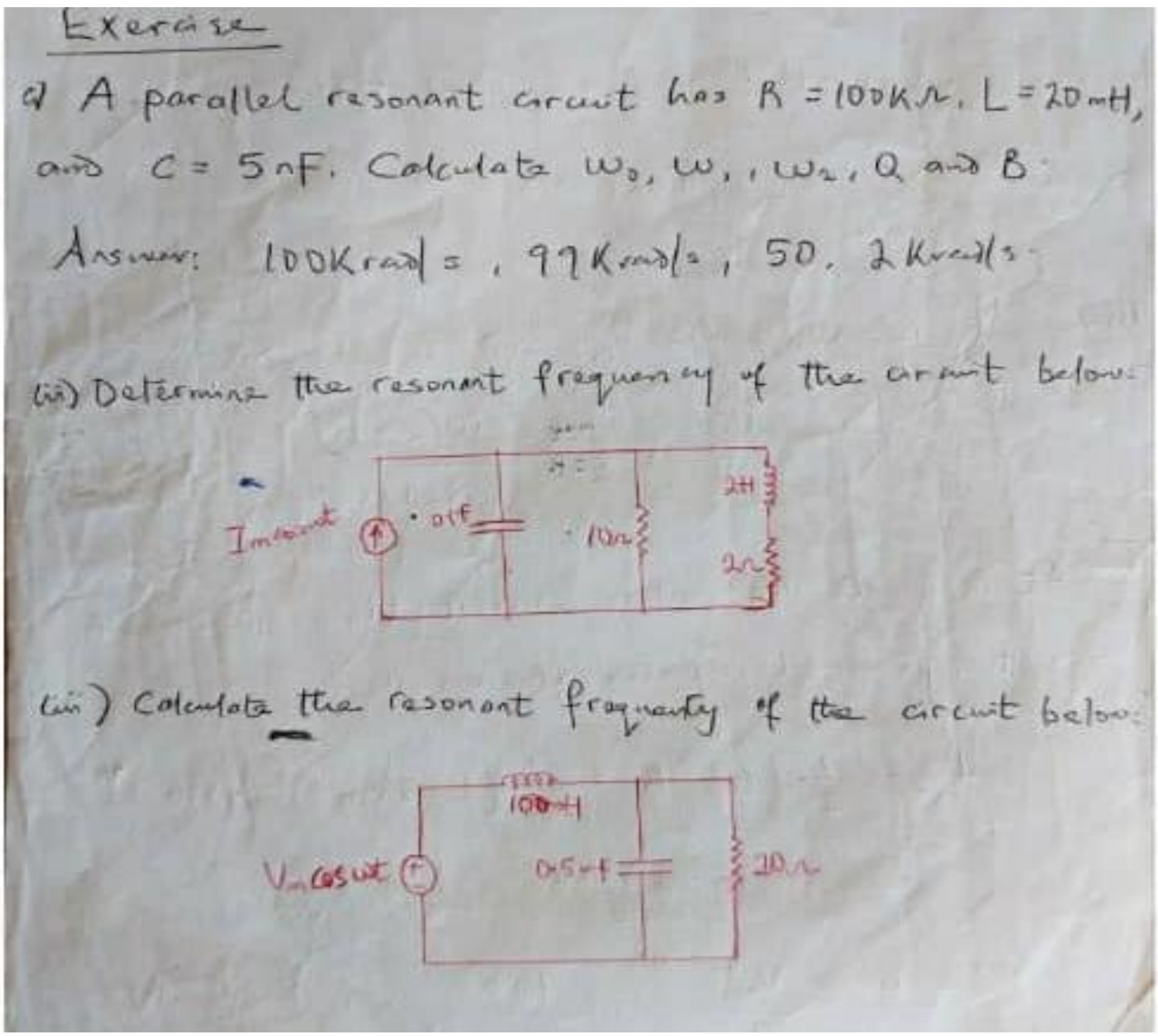
17/ENG04/057

ELECTRICAL ELECTRONICS ENGINEERING

ELECTRICAL CIRCUIT THEORY EEE322

ASSIGNMENT 2

QUESTION:



Exercise

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

Answer: 100Krad/s, 99Krad/s, 50, 2Krad/s.

(ii) Determine the resonant frequency of the circuit below:

(iii) Calculate the resonant frequency of the circuit below:

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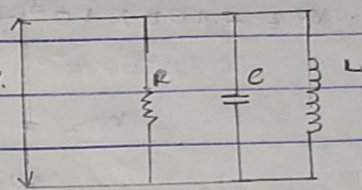
ELECTRICAL ELECTRONICS ENGINEERING
ELECTRICAL CIRCUIT THEORY II EEE 322 (ASS II).

Question 1.

① A Parallel resonant Circuit has $R = 100 K\Omega$, $L = 20mH$, and $C = 5nF$. Calculate w_0, w_1, w_2, Q and B.

Solution;

Representing a Parallel resonant Circuit.



Step 1; Calculating resonant frequency w_0;
using the formula for w_0 of Parallel Cct;

$$w_0 = \frac{1}{\sqrt{LC}}$$

∴ Where; $L = 20\times10^{-3}$, $C = 5\times10^{-9}$

$$\therefore w_0 = \frac{1}{\sqrt{20\times10^{-3}\times5\times10^{-9}}}$$

$$w_0 = 100000$$

$$w_0 = 100K \text{ rad/s}.$$

Step 2; Calculating the Quality factor; Q;
using the formula for Q of a parallel Circuit;

$$Q = \frac{R}{W_0 L}$$ Where; $R = 100K\Omega$, $L = 20\times10^{-3}$, $w_0 = 100k \text{ rad/s}$

$$Q = \frac{100\times10^3}{100\times10^3\times20\times10^{-3}}$$

$$Q = 50$$

Step 3; Calculating the bandwidth B;
using the formula for Bandwidth;

$$B = \frac{w_0}{Q}$$ $w_0 = 100K$ rad/s, $Q = 50$

$$B = \frac{100\times10^3}{50} = 2000$$

∴ Bandwidth $B = 2K$ rad/s.

Step 4: Calculating w_1, w_2.

$\therefore$ Recall that when $Q \geq 10$ High Q occurs;

$\therefore$ $w_1 = w_0 - B/2$.

$w_2 = w_0 + B/2$.

$w_0 = 100k$ rad/s, $B = 2k$ rad/s.

$\therefore$ $w_1 = 100 \times 10^3 - \frac{2 \times 10^3}{2}$

$w_1 = 99000$

$w_1 = 99k$ rad s^{-1}

$\therefore$ $w_2 = 100 \times 10^3 + \frac{2 \times 10^3}{2}$

$w_2 = 101000$

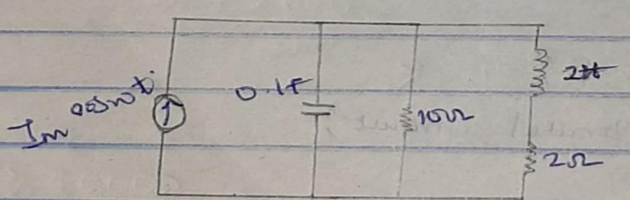
$w_2 = 101k$ rad s^{-1}.

In conclusion;

$w_0 = 100k$ rad s^{-1}, $Q = 50$, $B = 2k$ rad s^{-1}, $w_1 = 99k$ rad s^{-1}, $w_2 = 101k$ rad

QUESTION 2;

Determine the resonant frequency of the circuit below;



Solution;

Recall that;

Admittance; $Y = H(w) = I/V$ (Current being supplied)

In an R-L-C Parallel circuit; (Admittance).

$Y = H(w) = I/V = 1/R + jwC + 1/jwL$.

From the Circuit given Above;

$\therefore$ $Y = H(w) = jwC + 1/R_1 + 1/(R_2 + jwL)$. --- (i)

Where; $C = 0.1$, $R_1 = 10$, $R_2 = 2$, $L = 2$

Inserting These Values into eq (i)

$\therefore Y = H(\omega) = j\omega(0.1) + \frac{1}{10} + \frac{1}{2 + j\omega 2}$ — eqn(2)

From eq(2)

$$\frac{1}{2+j\omega 2} \Rightarrow \frac{1}{2+j\omega 2} * \frac{2-j\omega 2}{2-j\omega 2}$$

$$\Rightarrow \frac{2-j\omega 2}{4+4\omega^2} \quad \text{— (3)}$$

$\therefore$ Replace eq(3) in eqn (2)

$$\therefore Y = H(\omega) = j\omega(0.1) + \frac{1}{10} + \frac{2-j\omega}{4+4\omega^2}$$

Seperating into the real and imaginary part;

Real part $= \left(1/10 + 2/4+4\omega^2\right)$

Imaginary part $= \left(j\omega(0.1) - 2j\omega/4+4\omega^2\right)$

Recall; at resonance; Imaginary Part $= 0$.

$$\therefore j\omega_o(0.1) - \frac{2j\omega_o}{4+4\omega_o^2} = 0$$

$$\therefore j\left(\omega_o(0.1) - \frac{2\omega_o}{4+4\omega_o^2}\right) = 0$$

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

$$0.1\omega_o(4+4\omega_o^2) - 2\omega_o = 0$$

$$0.4\omega_o + 0.4\omega_o^3 - 2\omega_o = 0$$

$$0.4\omega_o^3 = 1.6\omega_o$$

$$0.4\omega_o^2 = 1.6$$

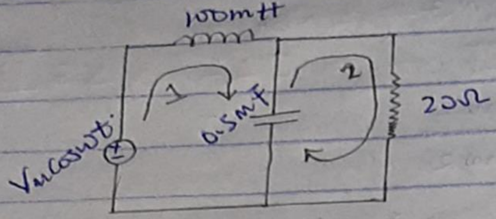
$$\omega_o^2 = 4$$

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

$\therefore$ The resonant Freqrency $\omega_o = 2$ rad/s.

Question 3;

Determine the resonant frequency of the circuit bellow;



Solution;

Resolving the circuit above;

Convert Parameters to S-domain;

$\therefore$ $R = 20\Omega$

$$C = \frac{1}{j\omega(0.5\times10^{-3})}$$

$$C = \frac{2000}{j\omega}$$

$$L = j\omega(100\times10^{-3})$$

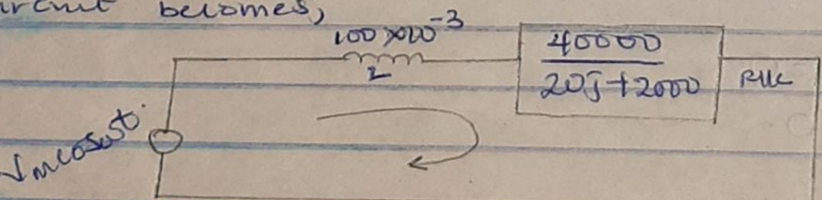
$\therefore$ From Loop 2; R ‖ C

$$\therefore \frac{20 * \frac{2000}{j\omega}}{20 + \frac{2000}{j\omega}}$$

$$\Rightarrow \frac{40000 / \cancel{j\omega}}{(20j\omega + 2000)/\cancel{j\omega}}$$

$$R\|C \Rightarrow \frac{40000}{20j\omega + 2000}$$

Circuit becomes;



From circuit; L in Series with (R‖C)

$$H(\omega) = \frac{V}{I} = \frac{40000}{20j\omega + 2000} + (100\times10^{-3}\, j\omega)$$

$$\frac{V}{I} = \frac{40000}{20j\omega + 2000} + j\omega\, 0.1$$

where; $\frac{40000}{20j+2000} \Rightarrow \frac{40000}{20j\omega+2000} * \frac{(20j-2000)}{(20j\omega-2000)}$

$$\Rightarrow \frac{800000j\omega - 80000000}{-400\omega^2 - 4000000}$$

$\therefore \frac{V}{I}$ become;

$$\frac{V}{I} = \frac{800000j\omega - 80000000}{-400\omega^2 - 4000000} + j\omega(0.1)$$

Seperating Real and imaginary part;

$\frac{V}{I}$; Real ; $(-80000000 / -400\omega^2 - 4000000)$

Imaginary ; $(800000j\omega / -400\omega^2 - 4000000) + j\omega(0.1)$

Recall at Resonance Imaginary Part = 0

$$\therefore \frac{800000j\omega_0}{-400\omega_0^2 - 4000000} + 0.1j\omega = 0.$$

$$j\left(\frac{800000\omega}{-400\omega_0^2 - 4000000} + 0.1\omega\right) = 0.$$

$$\therefore 800000\omega_0 + 0.1\omega_0(-400\omega_0^2 - 4000000) = 0$$

$$800000\omega_0 - 40\omega_0^3 - 400000\omega_0 = 0.$$

$$400000\omega_0 - 40\omega_0^3 = 0$$

$$400000\cancel{\omega_0} = 40\omega^3$$

$$400000 = 40\omega^2.$$

$$\omega^2 = 10000$$

$$\omega = \sqrt{10000}$$

$$\omega = 100 \text{ rad/s}.$$