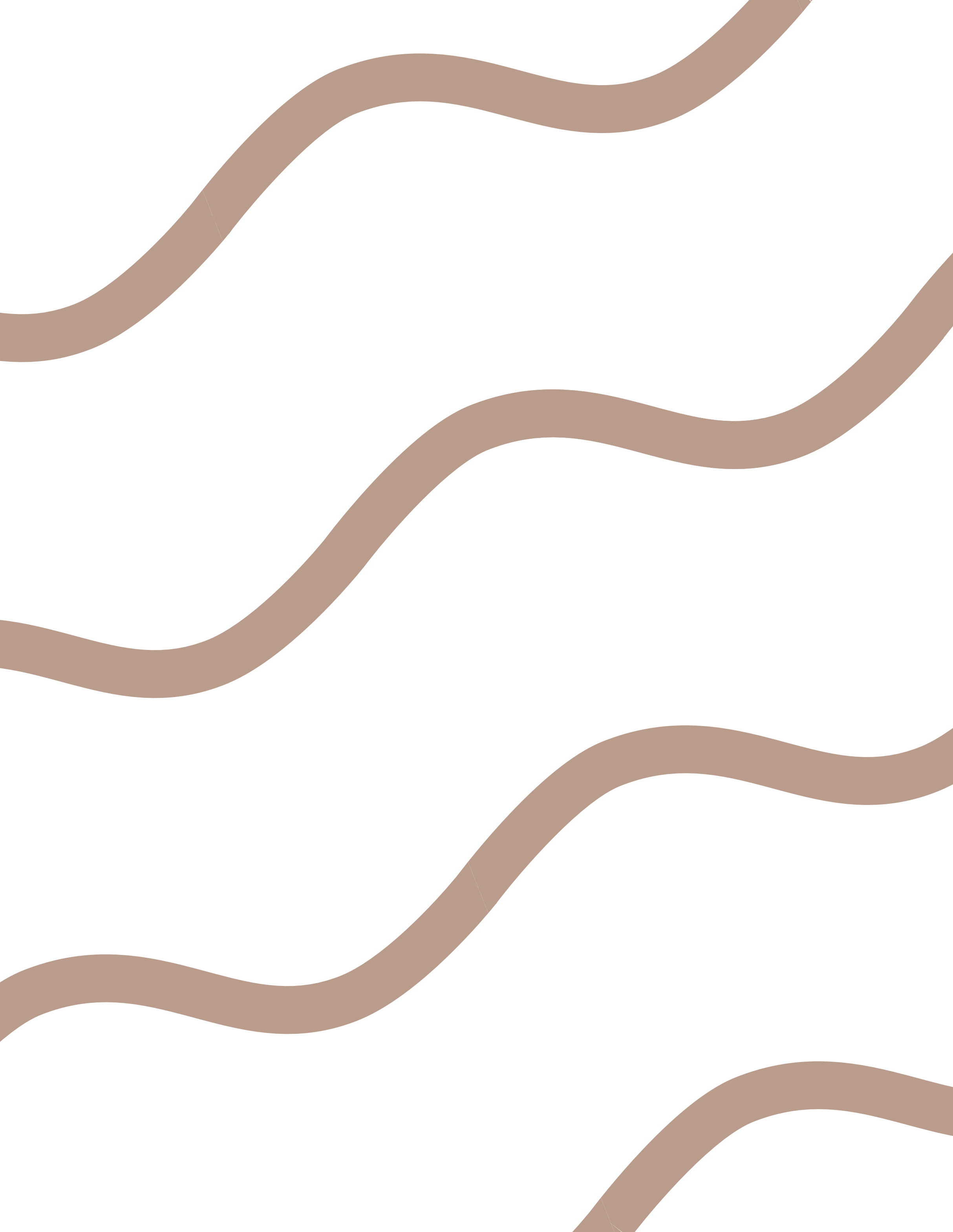
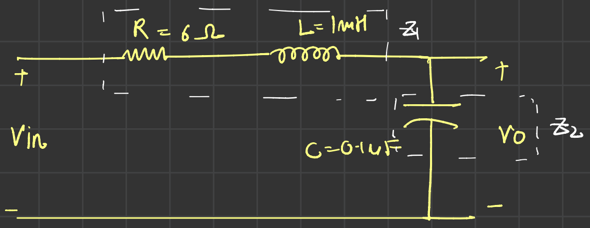


Q1)



(a) $V_o = \dfrac{Z_2 \, V_i}{Z_1 + Z_2}$ $\qquad Z_1 = R + jX_L$, $\quad Z_2 = -jX_C$

$$\frac{V_o}{V_i} = \frac{-jX_c}{R + jX_L - jX_c} =$$

$$\frac{V_o}{V_i} = \frac{-j/\omega C}{R + j(\omega L - \frac{1}{\omega C})} = \frac{-j}{\omega C(R + j(\omega L - \frac{1}{\omega C}))}$$

$$\frac{V_o}{V_i} = \frac{-j}{\omega CR + j(\omega^2 LC - 1)} \times \frac{j}{j}$$

$$\frac{V_o}{V_{in}} = \frac{+1}{1 - \omega^2 LC + j\omega CR}$$

$$V_o = \frac{V_i}{1 - \omega^2 LC + j\omega CR}$$

$$H(j\omega) = \frac{1}{1 - \omega^2 LC + j\omega CR} \quad \text{and} \quad |H(j\omega)| = \frac{1}{\sqrt{(1-\omega^2 LC)^2 + (\omega CR)^2}}$$

Resonance occurs when the imaginary part of the denominator is zero

$$\omega L - \frac{1}{\omega C} = 0$$

$$\Rightarrow \omega_0 = \frac{1}{\sqrt{LC}} \quad \text{or} \quad f_0 = \frac{1}{2\pi\sqrt{LC}}$$

$$\tan^{-1}\left(\frac{\omega CR}{1-\omega^2 LC}\right)$$

$$\text{gain} = \frac{1}{1 - \omega^2 LC + j\omega CR}$$

at $\omega = \omega_0$

$$\text{gain} = \frac{1}{1 - 1 + j\omega CR} = \frac{1}{j\omega CR}$$

$$\left| \frac{V_o}{V_i} \right| = \frac{1}{\omega CR}$$

(a) $$f_0 = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2 \times 3.14 \times \sqrt{10^{-3} \times 0.1 \times 10^{-6}}} = 15923.566\,Hz$$

gain at f_0

$$\left| \frac{V_o}{V_i} \right| = \frac{1}{\omega_0 CR} = \frac{1}{2\pi RC} = \frac{1}{2 \times 3.14 \times 0.1 \times 10^{-6} \times 6} = 265{,}392.78$$

$$Q = \frac{X_L}{R} = \frac{15923.566 \times 10^{-3}}{6} = \underline{\underline{2.654}}$$

(b) For corner frequency

$$|H(j\omega)| = \frac{1}{\sqrt{2}}$$

On solving this eqn we get

$$\boxed{\omega_{1,2} = \omega_0 \pm \frac{R}{2L}}$$ and $$\boxed{\text{Band width } (\Delta\omega) = \frac{R}{L}}$$

$$\omega_1 = \omega_0 + \frac{R}{2L}$$

$$= 10^5 + \frac{6}{2 \times 10^{-3}}$$

convert into Hz

$\omega_1 = 103 \times 10^3$ rad/s $\qquad \omega_2 = 97 \times 10^3$ rad/s

$$\text{Bandwidth} = \frac{R}{L} = \frac{6}{10^{-3}} = 6000 \text{ Hz}$$

(c) $$\theta = -\tan^{-1}\left(\frac{\omega CR}{1-\omega^2 LC}\right)$$ $CR = 6 \times 0.1 \times 10^{-6}$

$\omega_1 \Rightarrow f_L$

$\omega_2 \; f_D$

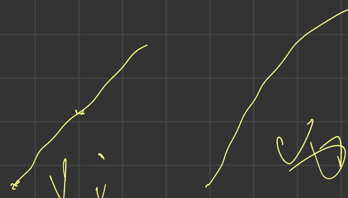
$$\theta = -\tan^{-1}\left(\frac{\omega \times 6 \times 10^{-7}}{1-\omega^2 \times 10^{-10}}\right)$$ $LC = 0.1 \times 10^{-6} \times 10^{-3}$

at higher cutoff frequency

$$\theta = -\tan^{-1}\left(\frac{0.0618}{-0.0609}\right)$$

$$= \tan^{-1}(1.0147)$$

$$\theta = 45.42^\circ \text{ (lags)}$$

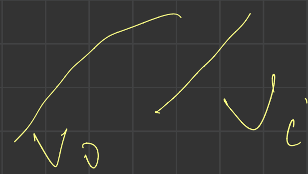


at lower cutoff freq

$$\theta = -\tan^{-1}\left(\frac{47 \times 10^3 \times 6 \times 10^{-7}}{1-(47 \times 10^3)^2 \times 10^{-10}}\right)$$

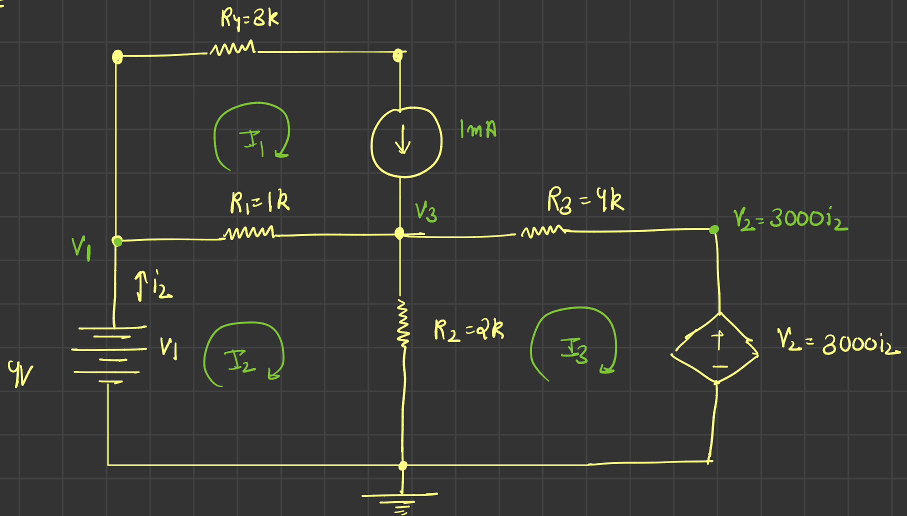
$$\theta = -44.56^\circ \text{ (lags)}$$

in this configuration output voltage always lags the input voltage



Q2)

(a)



$I_1 = 1mA$

In mesh 2,

$10^3(I_2 - I_1) - 2\times10^3(I_2 - I_3) + 4 = 0$

$I_2 - I_1 - 2I_2 + 2I_3 + 4\times10^{-3} = 0$

$-I_2 + 2I_3 + 3\times10^{-3} = 0$ —(i)

In mesh 3,

$4\times10^3 I_3 - 3000 I_2 - 2\times10^3(I_3 - I_2) = 0$

$4I_3 - 3I_2 - 2I_3 + 2I_2 = 0$

$-5I_2 + 2I_3 = 0$ —(iii)

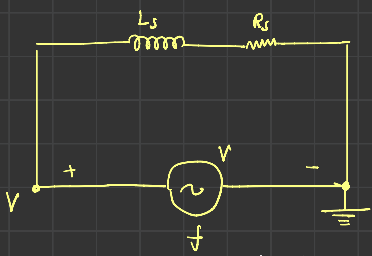
On solving (i) and (iii)

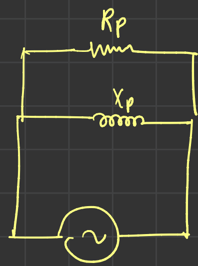
$I_2 = -7.5\times10^{-4}$ A $\quad I_3 = -1.875\times10^{-3}$ A

Power dissipated in R_2 $= (+1.875\times10^{-3} - 7.5\times10^{-4})\times 2\times10^{3}$

$= 2.25$ Watt

(b)





Impedance of series LCR circuit

$$Z_1 = R_s + jX_L$$

$$Z_1 = R_s + jX_s$$

Impedance of parallel LCR circuit

$$Z_2 = R_p \parallel jX_p$$

$$Z_2 = \cfrac{1}{\cfrac{1}{R_p} + \cfrac{1}{jX_p}}$$

Converting series impedance into admittance

$$Y_s = \frac{1}{Z_s} = \frac{1}{R_s + jX_s} = \frac{R - jX_s}{R_s^2 + X_s^2} \quad \text{(on rationalising)}$$

$$Y_s = Z_2$$

$$\frac{R_s}{R_s^2 + X_s^2} - j\frac{X_s}{R_s^2 + X_s^2} = \frac{1}{R_p} + \frac{1}{jX_p}$$

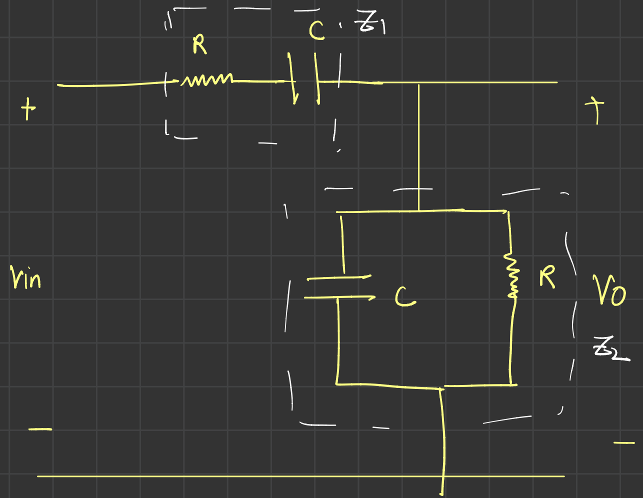
$$\frac{R_s}{R_s^2 + X_s^2} + \frac{X_s}{j(R_s^2 + X_s^2)} = \frac{1}{R_p} + \frac{1}{jX_p}$$

$$\Rightarrow \quad \boxed{R_p = \frac{R_s^2 + X_s^2}{R_s}} \qquad \boxed{X_p = \frac{R_s^2 + X_s^2}{X_s}}$$

Moreover $X_s = \omega L_s$

$$R_p = \frac{R_s^2 + (\omega L_s)^2}{R_s} \qquad \omega L_p = \frac{R_s^2 + (\omega L_s)^2}{\omega L_s}$$

Q3



$$Z_1 = R + \frac{1}{j\omega C} \qquad Z_2 = \frac{R/j\omega C}{R + \frac{1}{j\omega C}}$$

$$Z_1 \; \frac{1+j\omega CR}{j\omega C} \qquad Z_2 = \frac{R}{j\omega CR + 1}$$

$$\frac{V_o}{V_{in}} = \frac{R}{1+j\omega CR} \times \frac{1}{\frac{1+j\omega CR}{j\omega C} + \frac{R}{1+j\omega CR}}$$

$$= \frac{R \times \cancel{(1+j\omega CR)} \times j\omega C}{\cancel{(1+j\omega CR)}\left((1+j\omega CR)^2 + j\omega CR\right)}$$

$$= \frac{j\omega RC}{1-\omega^2C^2R^2 + 2j\omega CR + j\omega CR} = \frac{1}{\frac{1}{j\omega RC} - \frac{\omega RC}{j} + 3} = \frac{1}{3 + j\left(\omega RC - \frac{1}{\omega RC}\right)}$$

$$H(j\omega) = \frac{j\omega RC}{1-\omega^2C^2R^2 + 3j\omega CR}$$

$$|H(j\omega)| = \frac{\omega RC}{\sqrt{(1-\omega^2C^2R^2)^2 + 9\omega^2C^2R^2}}$$

$$\theta = -\tan^{-1}\left(\frac{\omega RC - \frac{1}{\omega RC}}{3}\right)$$

For $\theta = 0°$

$$\omega RC = \frac{1}{\omega RC}$$

$$\omega^2 = \frac{1}{R^2C^2}$$

$$\boxed{\omega = \frac{1}{RC}}$$ → for this ω $\theta = 0°$

$$= f = \frac{1}{2\pi RC}$$

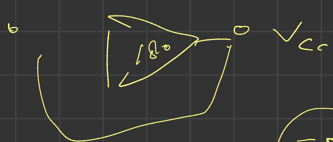
<u>Weign bridge oscillator</u>

At $\omega = \omega_0 = \dfrac{1}{RC}$

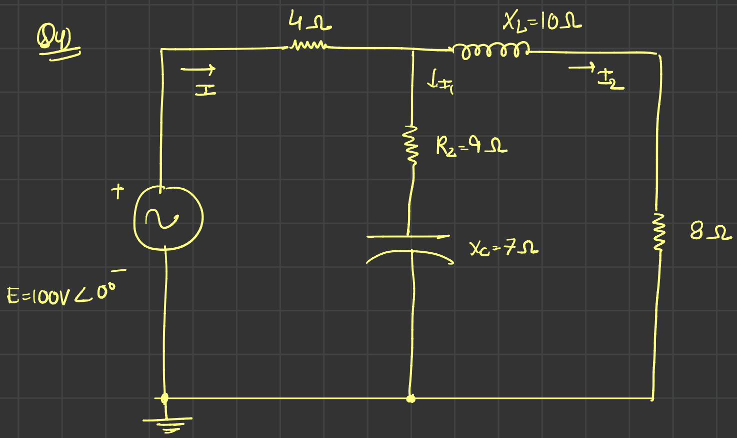
$$\frac{V_o}{V_{in}} = \frac{1}{3}$$

$\theta = V_i$ & V_o $180°$

$30°$



Q4)



(a) $Z_T = (8+j10) \parallel (9-j7) + 4$

$$\frac{142+34i}{17+j3} + 4$$

$$\boxed{Z_T = 12.44 + 0.51j}$$

(b) $I = \dfrac{V}{Z_T} = \dfrac{100\angle 0}{12.45\angle 2.347^\circ} = 8.032\text{ A}\angle -2.347^\circ$

$$I_1 = \frac{8+j10}{17+j3} \times (8.032\angle -2.347^\circ)$$

$$I_1 = 4.631\text{A}\angle 3.7486^\circ$$

$$I_2 = \frac{9-j7}{17+j3} \times (8.032\angle -2.347)$$

$$I_2 = 4.584\text{A}\angle -2.669^\circ$$

(C) $P = I_{rms}^2 \times R$

$= (4.584)^2 \times 8$

$= 168.104$ Watt

(d) |Reactive Power| $= V_{rms} \times I_{rms} \times \sin\phi$

$= 100 \times 8.082 \times \sin(+2.347^\circ)$

|Reactive Power| $= 32.892$ Watt

(e) Power factor $= \cos(2.347)$

$= \underline{\underline{0.999}}$

Q1) (d)

Q2) $P_{max} = I_{rms}^2 \times R$

$= \frac{V_{rms}^2}{R} = \frac{100^2}{5}$

$= \frac{100 \times \overset{20}{\cancel{100}}}{\cancel{5}} = 2000$ Watt

Q3) (c)

$\frac{100 \times 5}{100+5} = \frac{\overset{100}{\cancel{500}}}{\underset{21}{\cancel{105}}}$

Q4) $\omega = \frac{1}{\sqrt{LC}}$

Q5) (d)

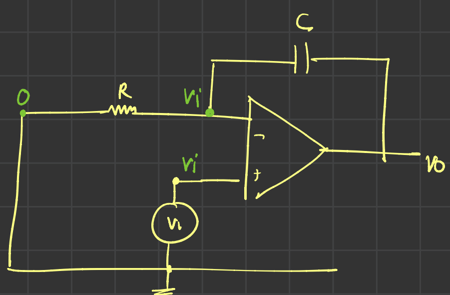
Q6) $E = 207.84\angle 30°$

$Z = j10$

$I = \frac{E}{Z} = 20.784\angle -60°$

$I_{rms} = 20.784A$

Q7)



Applying nodal at

$\frac{v_i - 0}{R} = \frac{v_i - v_o}{\frac{1}{j\omega C}}$

$\frac{v_i}{R} = (v_i - v_o)j\omega C$

$\frac{v_i}{j\omega CR} = v_i - v_o$

$v_o = v_i - \frac{v_i}{j\omega CR}$

$v_o = v_i\left(1 - \frac{1}{j\omega CR}\right)$

$v_o = v_i\left(\frac{j\omega CR - 1}{j\omega CR}\right)$

$\frac{V_o}{V_i} = \frac{jwCR-1}{jwCR}$

$|H(jw)| = \frac{\sqrt{(wCR)^2+1}}{w^2C^2R^2}$

a in steady state $w=0$

$|H(jw)| =$

$|H(jw)| = \frac{\sqrt{1+\cancel{w^2}C^2R^2}}{wCR}$

(7) ?

$w = \frac{1}{RC}$

$\frac{\sqrt{2}}{1}$

Q3)

$5 + 10 \| 5$

$5 + \frac{\cancel{50}\ 10}{\cancel{15}\ 3}$

$\frac{15+10}{3} = \underline{\underline{25/3\ \Omega}}$

Q4)

10V