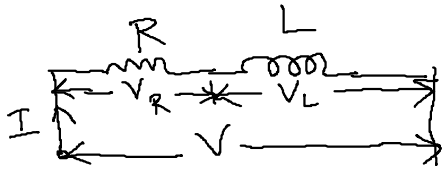
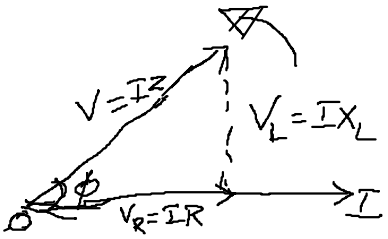
A. C Series Circuits → V & I → t → R, L, C

Series RL Circuit





Phasor diagram

1ϕ, $v = V_{max} \sin \omega t$

$i = I_{max} \sin(\omega t - \phi)$

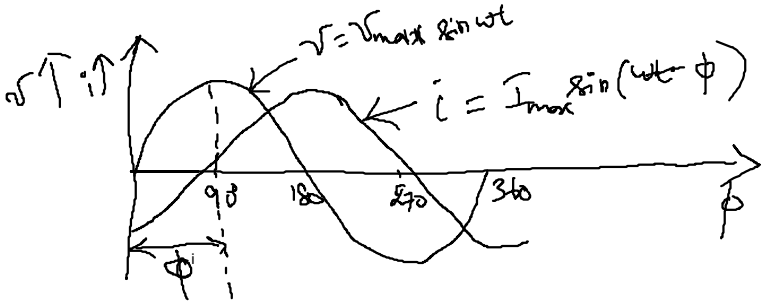
$V = \sqrt{V_R^2 + V_L^2}$; $V_R = IR$; $V_L = IX_L$

$V = \sqrt{(IR)^2 + (IX_L)^2} = I\sqrt{R^2 + X_L^2}$

$I = V / \sqrt{R^2 + X_L^2}$; $Z = \sqrt{R^2 + X_L^2}$; $I = \frac{V}{Z}$

$\phi = \tan^{-1}\left(\frac{V_L}{V_R}\right)$

$\phi = \tan^{-1}\left(\frac{IX_L}{IR}\right) = \tan^{-1}\left(\frac{X_L}{R}\right)$



Q 0.1H, R = 15Ω, V = 230V, 50Hz, 1ϕ ac supply

I = ? , P.F = ? ; $V_{reactor}$ = ? ; V_R

Solution

(i) $I = V/Z = 230 / \sqrt{15^2 + 31.43^2}$; $Z = 34.79$

$I = 6.6A$ //

$X_L = 2\pi f L$

$= 2 \times \pi \times 50 \times 0.1 = 31.43\Omega$

$X_L = 31.43\Omega$

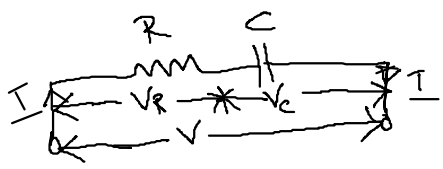
(ii) P.F → $\cos\phi = \frac{R}{Z} = 15/34.79 = 0.431$ (lagging)

(iii) $V_L = IX_L = 6.6 \times 31.43 = 207.4V$

(iv) $V_R = IR = 6.6 \times 15 = 99V$

Series R-C Circuit

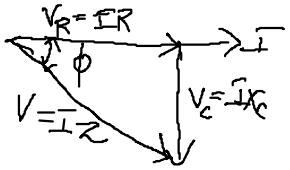
Series R-C Circuit



$V_R = IR$

$V_C = IX_C$

Phasor diagram



p.f → leading

$$V = \sqrt{V_R^2 + V_C^2} = \sqrt{(IR)^2 + (IX_C)^2}$$

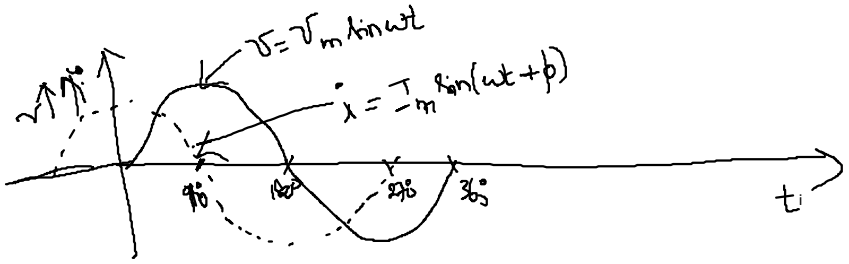
$$V = I\sqrt{R^2 + X_C^2}$$

$$I = \frac{V}{\sqrt{R^2 + X_C^2}} \quad ; \quad Z = \sqrt{R^2 + X_C^2}$$

$I = V/Z$ (I leads V by angle ϕ)

$$\phi = \tan^{-1}\left(\frac{V_C}{V_R}\right) = \tan^{-1}\left(\frac{IX_C}{IR}\right)$$

$$\phi = \tan^{-1}\left(\frac{X_C}{R}\right)$$



Q#2

C = 0.1F ; R = 30Ω , V = 230 V, 50HZ

I = ? ; P.f = ? V_C = ? V_R = ?

Solution

$$Z = \sqrt{R^2 + X_C^2} \quad ; X_C = \frac{1}{2\pi fC} = \frac{1}{2\pi \times 50 \times 0.1}$$

$$Z = \sqrt{30^2 + (0.0318)^2} \qquad X_C = 0.0318$$

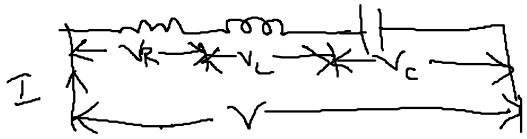
$Z = 30.0016\,\Omega$; $I = 230/30.0016 = 7.67A$

$$\cos\phi = \frac{R}{Z} = \frac{30}{30.0016} = 0.99 \text{ (leading)}$$

$V_C = IX_C = 7.67 \times 0.031 = 0.237V$

$V_R = IR = 7.67 \times 30 = 230.1V$

Series RLC Circuit



Case 1 $(V_L > V_C)$ → Z

$$V = I\sqrt{R^2 + (X_L - X_C)^2}$$

$$I = V/Z$$

$$Z = \sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2}$$

$$X = \left(\omega L - \frac{1}{\omega C}\right) \; ; \; \phi = \tan^{-1}\frac{(X_L - X_C)}{R}$$

$$\phi = \tan^{-1}\frac{(\text{resultant reactance})}{\text{Resistance}}$$

Case 2 $(V_C > V_L)$ → capacitance, P.f → leading

$$V = I\sqrt{R^2 + (X_C - X_L)^2} \rightarrow Z$$

$$I = \frac{V}{Z} \; ; \; Z = \sqrt{R^2 + \left(\frac{1}{\omega C} - \omega L\right)^2}$$

$$X = \left(\frac{1}{\omega C} - \omega L\right)$$

$$\phi = \tan^{-1}\frac{(X_C - X_L)}{R}$$

Q I → coil → $R_{(neg)}$ & L = 60mH, V = 230V, 50HZ, 1ϕ

I = ? (a) decreased to 20HZ ; (b) increased to 60HZ &
(c) increased to 100HZ

Solution

$$X_L = 2\pi f L = 2\pi \times 50 \times 60 \times 10^{-3} = 18.86\,\Omega$$

$$I = V/X_L = 12.2\,A$$

(a) $X_L = 2\pi \times 20 \times 60 \times 10^{-3} = \underline{7.54\,\Omega}$; $I = \underline{30.49\,A}$

(b) $X_L = 2\pi \times 60 \times 60 \times 10^{-3} = \underline{22.63}$; $I = \underline{10.16\,A}$

(c) $X_L = 2\pi \times 100 \times 60 \times 10^{-3} = \underline{37.7\Omega}$; $I = \underline{6.1\,A}$