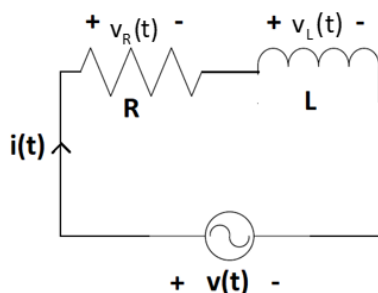


NOTES -Class 25

Analysis of Series RL and Series RC Circuits:

Series RL Circuit:



By KVL, $v(t) = v_R(t) + v_L(t)$

In Phasor form, $\bar{V} = \bar{V}_R + \bar{V}_L$

In general for any element,

(Voltage Phasor) = (Current Phasor)*(Impedance)

$$\bar{V}_R = \bar{I} * R$$

$$\bar{V}_L = \bar{I} * (jX_L)$$

$$\bar{V} = \bar{I} * (R + jX_L)$$

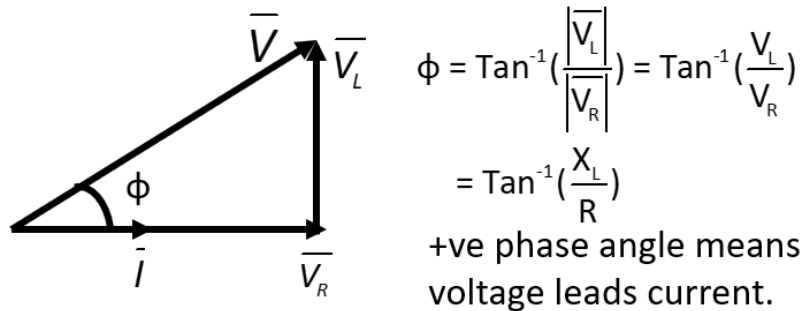
$$Z_T = \frac{\bar{V}}{\bar{I}} = (R + jX_L) = \sqrt{R^2 + X_L^2} \angle \tan^{-1}\left(\frac{X_L}{R}\right)$$

It can be observed that the total impedance of a series AC network is equal to the sum of individual element impedances.

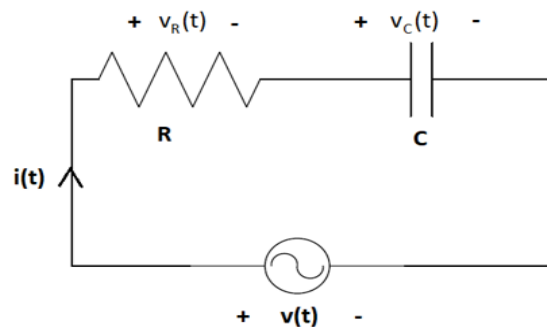
Unit II : Single Phase AC Circuits

Phasor Diagram:

Note: While drawing phasor diagram for a series AC network, considering current phasor as reference is preferable.



Series RC Circuit:



By KVL, $v(t) = v_R(t) + v_C(t)$

In Phasor form, $\bar{V} = \bar{V}_R + \bar{V}_C$

$$\bar{V}_R = \bar{I} * R$$

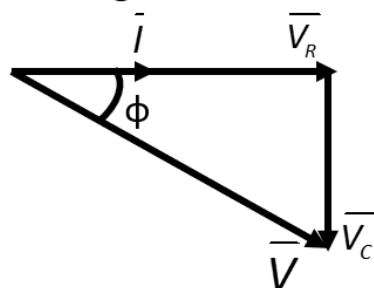
$$\bar{V}_C = \bar{I} * (-jX_C)$$

$$\bar{V} = \bar{I} * (R - jX_C)$$

$$Z_T = \frac{\bar{V}}{\bar{I}} = (R - jX_C) = \sqrt{R^2 + X_C^2} \angle -\tan^{-1}\left(\frac{X_C}{R}\right)$$

Unit II : Single Phase AC Circuits

Phasor Diagram:



Phase angle of a network is found as

$$\phi = \angle \bar{V} - \angle \bar{I}$$

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

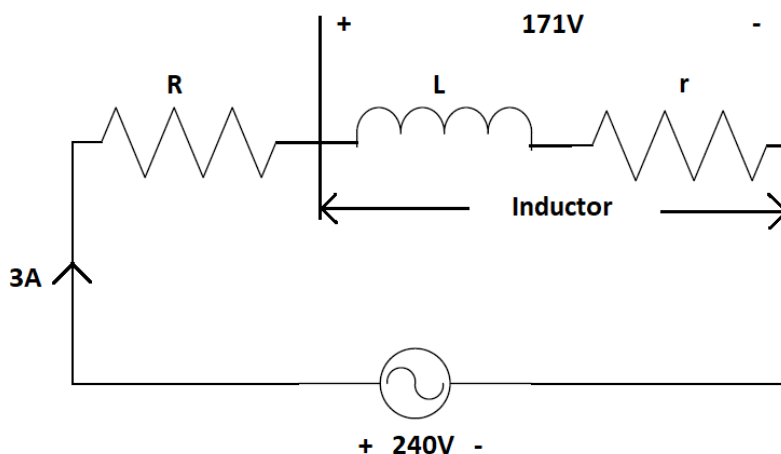
Negative phase angle means voltage lags current.

In series AC networks, phase angle = Impedance angle.

Question 7:

When a resistor and an inductor in series are connected to a 240V supply, a current of 3A flows lagging 37° behind the supply voltage, while the voltage across the inductor is 171V. Find the resistance of the resistor, and the resistance and reactance of the inductor. Find the power factor of the circuit.

Solution:



Note: In AC systems, if voltage and current are given as numerical values, they represent RMS values.

Unit II : Single Phase AC Circuits

Let us consider current as reference.

$$\text{i.e., } \bar{I} = 3 \angle 0^\circ \text{ A}$$

Therefore, supply voltage phasor, $\bar{V} = 240 \angle 37^\circ \text{ V}$

$$Z_T = \frac{\bar{V}}{\bar{I}} = \frac{240 \angle 37^\circ}{3 \angle 0^\circ}$$

$$= 80 \angle 37^\circ \Omega$$

$$= (63.89 + j48.14) \Omega \text{ ---- (1)}$$

$$= R + (r + jX_L) \text{ ---- (2)}$$

Comparing Real and Imaginary parts in (1) & (2), $X_L = 48.14 \Omega$

$$\text{Also, } (R+r) = 63.89 \Omega \text{ --- (3)}$$

$$\text{Across Inductor, } \frac{|V_{inductor}|}{|\bar{I}|} = \frac{171}{3} = \sqrt{r^2 + X_L^2} \text{ ---- (4)}$$

Solving (3) & (4), $r = 30.52 \Omega$; $R = 33.37 \Omega$

$$\text{Power factor} = \frac{(R+r)}{|Z_T|} = 0.798 \text{ Lag}$$