ELEMENTS OF ELECTRICAL ENGINEERING
Course Code : UE25EE141A/B

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ELEMENTS OF ELECTRICAL ENGINEERING (UE25EE141A/B)

Analysis of Series RLC circuit ; Impedance and Power Triangles

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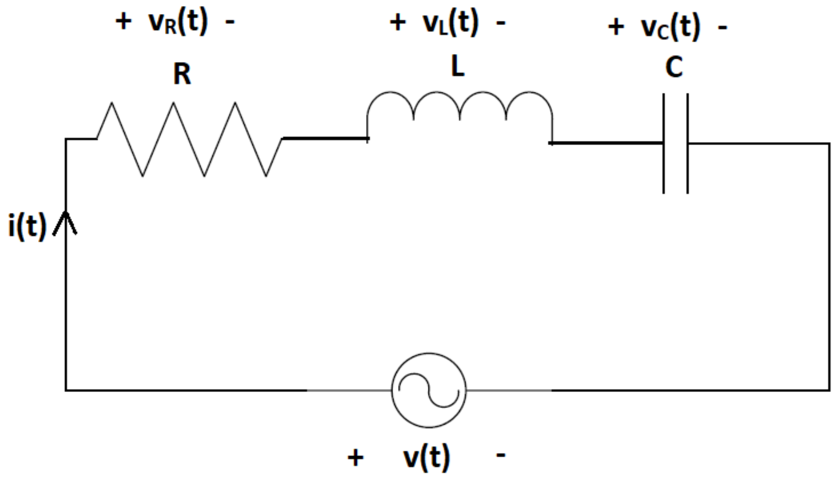
Series RLC Circuit



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

In Phasor form, $\overline{V} = \overline{V_R} + \overline{V_L} + \overline{V_c}$

$\overline{V_R} = \bar{I} * R \qquad \overline{V_L} = \bar{I} * (jX_L) \qquad \overline{V_C} = \bar{I} * (-jX_C)$

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

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

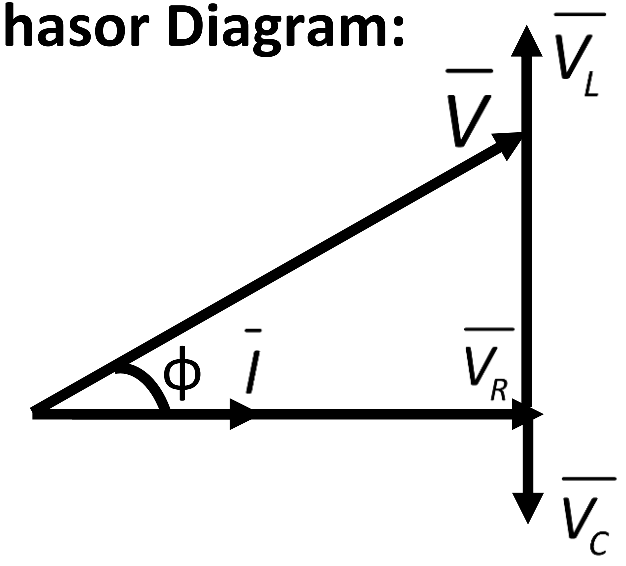
Case 1: $X_L > X_C$

If $X_L > X_C$ then $IX_L > IX_C$

i.e., $|\overline{V_L}| > |\overline{V_C}|$

The circuit behaves effectively as inductive circuit i.e., series RL type.

Phasor Diagram:



$$\phi = Tan^{-1}\left(\frac{|\overline{V_L}| - |\overline{V_C}|}{|\overline{V_R}|}\right) = Tan^{-1}\left(\frac{V_L - V_C}{V_R}\right)$$

$$= Tan^{-1}\left(\frac{X_L - X_C}{R}\right)$$

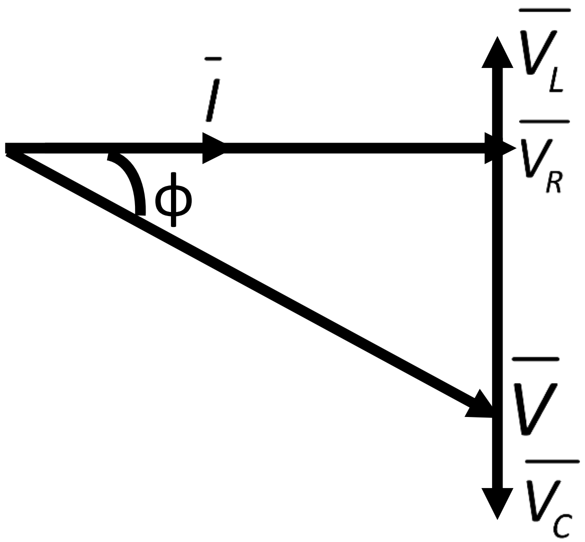
Case 2: $X_C > X_L$

If $X_C > X_L$ then $IX_C > IX_L$

i.e., $\left|\overline{V_C}\right| > \left|\overline{V_L}\right|$

The circuit behaves effectively as a capacitive circuit i.e., series RC type.

Phasor Diagram:



$$\phi = Tan^{-1}\left(\frac{\left|\overline{V_L}\right| - \left|\overline{V_C}\right|}{\left|\overline{V_R}\right|}\right) = Tan^{-1}\left(\frac{V_L - V_C}{V_R}\right)$$

$$= Tan^{-1}\left(\frac{X_L - X_C}{R}\right)$$

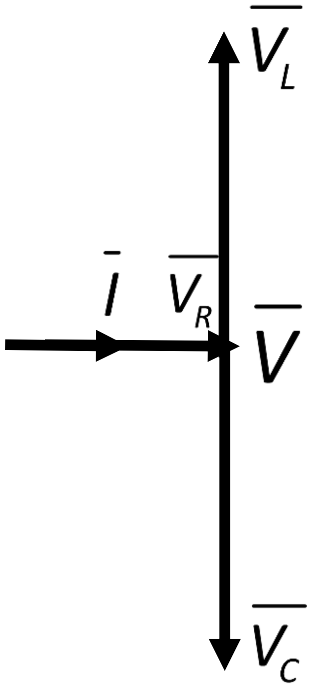
Note: ϕ will be negative in this case since $X_L < X_C$

Case 3: $X_L = X_C$

If $X_L = X_C$ then $IX_L = IX_C$ $\quad |\overline{V_L}| = |\overline{V_C}|$

The circuit behaves effectively as a purely resistive circuit. This case is called **'Series Resonance'** case.

Phasor Diagram:



$$\overline{V} = \overline{V_R}$$

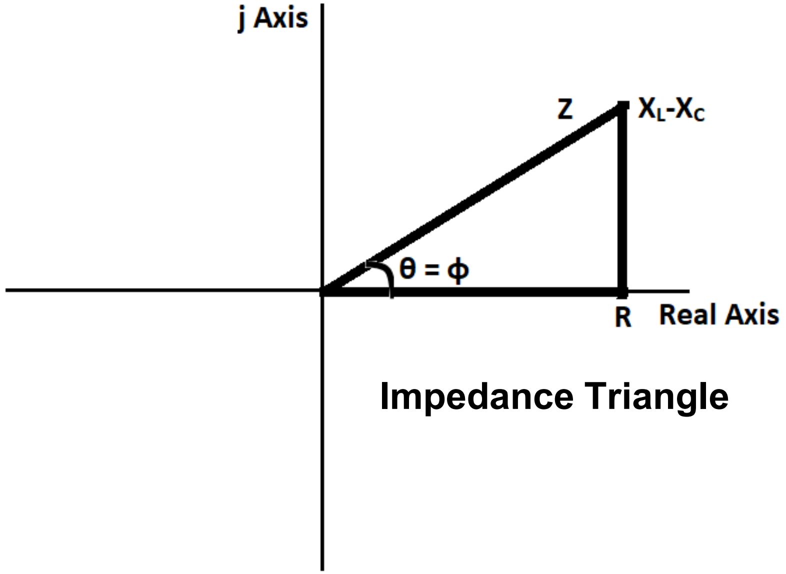
$$Z = R$$

$$\phi = 0^\circ$$

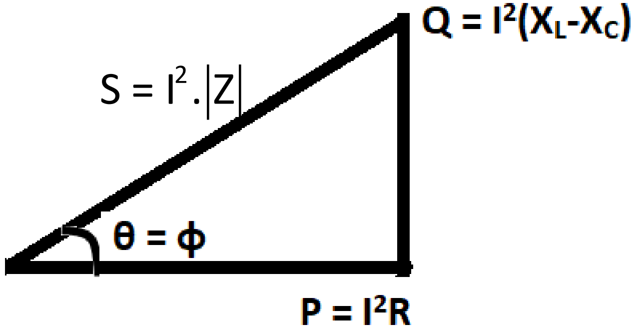
Impedance & Power Triangles – Series RLC Circuit

For a series RLC circuit, $Z = R + j(X_L - X_C) = \sqrt{R^2 + (X_L - X_C)^2} \angle \mathrm{Tan}^{-1}\left(\frac{X_L - X_C}{R}\right)$

Case i) $X_L > X_C$



Impedance Triangle



Power Triangle

$P = VI\cos\phi = I^2R$

$Q = VI\sin\phi = I^2(X_L - X_C)$

$S = VI = I^2|Z|$

Impedance Triangle of a series RLC circuit for $X_L > X_C$ lies in Quadrant I of complex plane.

Text Book & References

Text Book:

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2. "Basic Electrical Engineering", D. C. Kulshreshta, 2nd Edition, McGraw-Hill. 2019
3. "Special Electrical Machines" E G Janardanan, PHI Learning Pvt. Ltd., 2014

Reference Books:

1. "Engineering Circuit Analysis" William Hayt, Jack Kemmerly, Jamie Phillips and Steven Durbin, 10th Edition McGraw Hill, 2023

2. "Electrical and Electronic Technology" E. Hughes (Revised by J. Hiley, K. Brown & I.M Smith), 12th Edition, Pearson Education, 2016.

THANK YOU

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