ELEMENTS OF ELECTRICAL ENGINEERING
Course Code : UE25EE141A/B

PES UNIVERSITY

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ELEMENTS OF ELECTRICAL ENGINEERING (UE25EE141A/B)

Analysis of series RC circuit with Impedance and power triangles

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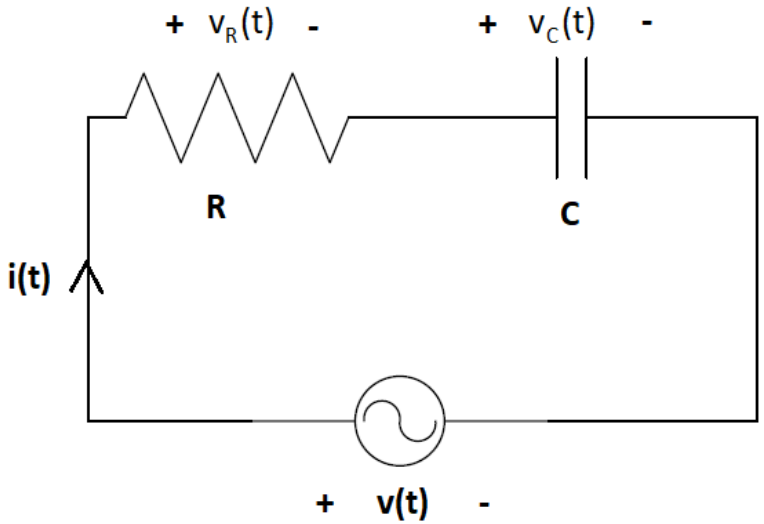
Series RC Circuit



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

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

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

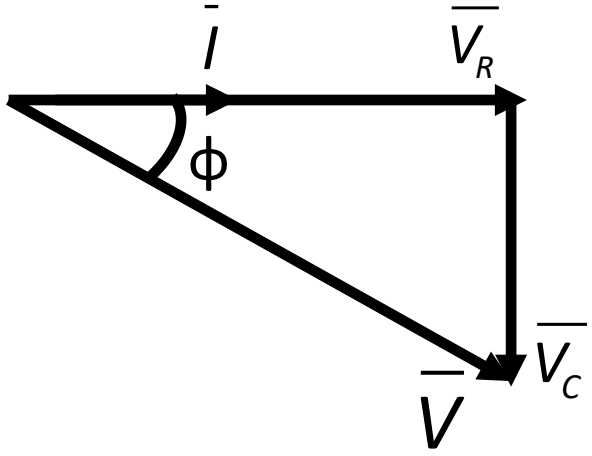
$$\bar{V}_C = \bar{I} * (-jX_C)$$

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

Series RC Circuit

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

Phasor Diagram:



Phase angle of a network is found as

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

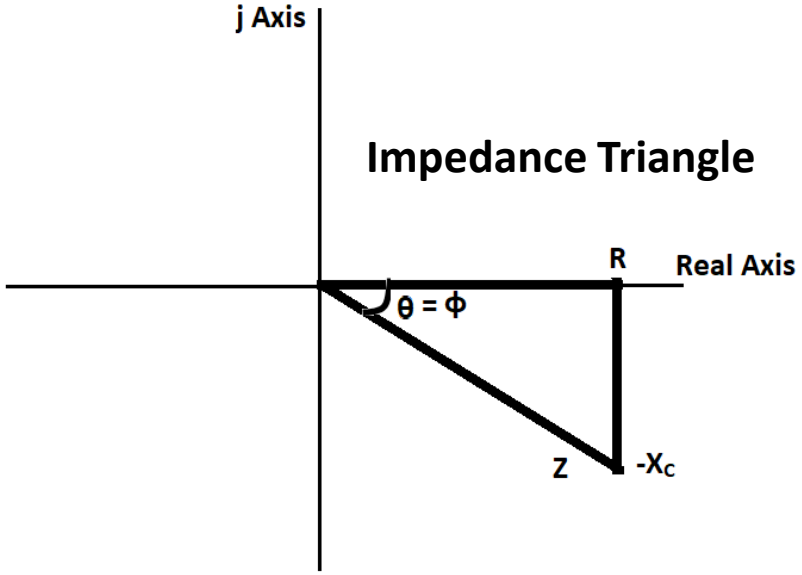
$$\phi = \text{-Tan}^{-1}\left(\frac{|\bar{V}_C|}{|\bar{V}_R|}\right) = \text{-Tan}^{-1}\left(\frac{V_C}{V_R}\right) = \text{-Tan}^{-1}\left(\frac{X_C}{R}\right)$$

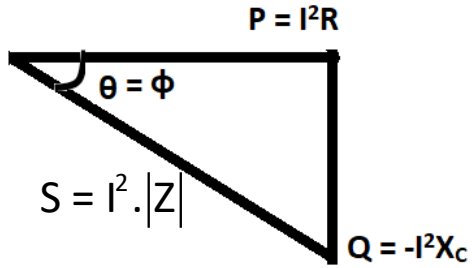
Negative phase angle means voltage lags current.

In series AC networks, phase angle = Impedance angle.

Impedance & Power Triangles – Series RC Circuit

For a series RC circuit, $Z = R - jX_C = \sqrt{R^2 + X_C^2} \angle -\text{Tan}^{-1}\left(\frac{X_C}{R}\right)$





Power Triangle

Impedance Triangle of a series RC circuit lies Quadrant IV of complex plane.

$$P = VI\cos\phi = (I.|Z|).I.\frac{R}{|Z|} = I^2R$$

$$Q = VI\sin\phi = (I.|Z|).I.\frac{-X_C}{|Z|} = -I^2X_C$$

$$S = VI = (I.|Z|).I = I^2|Z|$$

Numerical Example

Question:

A series RC circuit with R = 4Ω , C = 120μF is connected across 230V, 50 Hz supply. Calculate the current drawn by the circuit. Draw the phasor diagram.

Numerical Example

Step 1: Calculate Capacitive Reactance (X_C)

$$X_C = \frac{1}{2\pi f C}$$

$$X_C = \frac{1}{2\pi \times 50 \times 120 \times 10^{-6}}$$

$$X_C = \frac{1}{2\pi \times 0.006}$$

$$X_C = \frac{1}{0.0377}$$

$$X_C \approx 26.5\,\Omega$$

Numerical Example

Step 2: Calculate Total Impedance (Z)

$$Z = \sqrt{R^2 + X_C^2}$$

$$Z = \sqrt{4^2 + 26.5^2} = \sqrt{16 + 702.25} = \sqrt{718.25}$$

$$Z \approx 26.8\,\Omega$$

Step 3: Calculate Circuit Current (I)

$$I = \frac{V}{Z} = \frac{230}{26.8} \approx 8.58\,\text{A}$$

ELEMENTS OF ELECTRICAL ENGINEERING

Text Book & References

Text Book:

1. "Basic Electrical Engineering" S.K Bhattacharya, 1st Edition Pearson India Education Services Pvt. Ltd., 2017
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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