Electrical Engineering Fundamentals

First class

AC

Lecture 7

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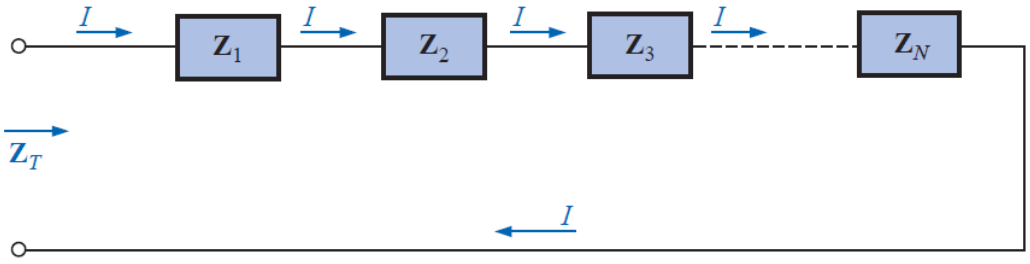
2024-2025

SERIES CONFIGURATION



$$\mathbf{Z}_T = \mathbf{Z}_1 + \mathbf{Z}_2 + \mathbf{Z}_3 + \cdots + \mathbf{Z}_N$$

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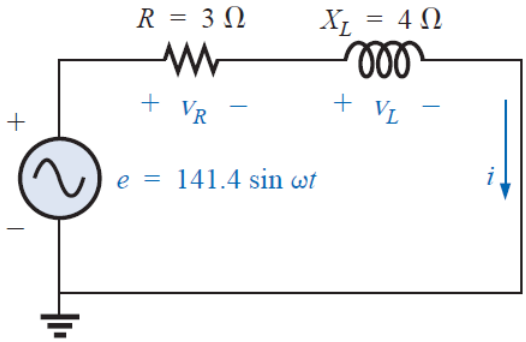
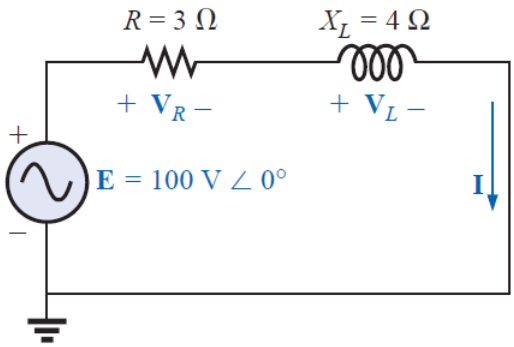
1) R-L

EXAMPLE: Determine the input impedance to the series network and find i , Vr,VL. Draw the impedance diagram.



Solutions:

$e = 141.4 \sin \omega t \Rightarrow \mathbf{E} = 100\,\text{V} \angle 0°$

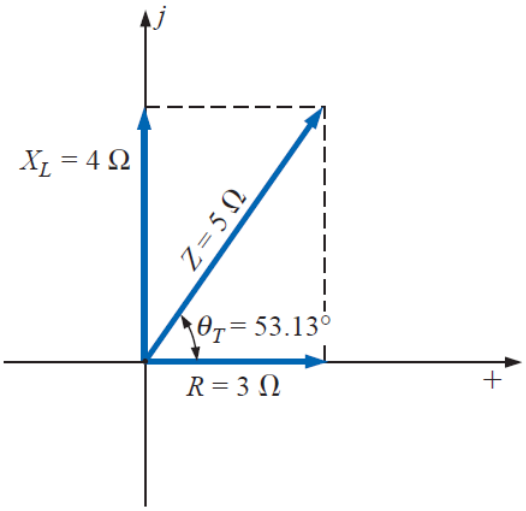


$$\mathbf{Z}_T = \mathbf{Z}_1 + \mathbf{Z}_2 = 3\,\Omega \angle 0° + 4\,\Omega \angle 90° = 3\,\Omega + j4\,\Omega$$

$$\mathbf{Z}_T = \mathbf{5\,\Omega \angle 53.13°}$$

$$\mathbf{I} = \frac{\mathbf{E}}{\mathbf{Z}_T} = \frac{100\,\text{V}\angle 0^\circ}{5\,\Omega\angle 53.13^\circ} = \mathbf{20\,A\angle -53.13^\circ}$$

$$\mathbf{V}_R = \mathbf{IZ}_R = (20\,\text{A}\angle -53.13^\circ)(3\,\Omega\angle 0^\circ)$$
$$= \mathbf{60\,V\angle -53.13^\circ}$$
$$\mathbf{V}_L = \mathbf{IZ}_L = (20\,\text{A}\angle -53.13^\circ)(4\,\Omega\angle 90^\circ)$$
$$= \mathbf{80\,V\angle 36.87^\circ}$$



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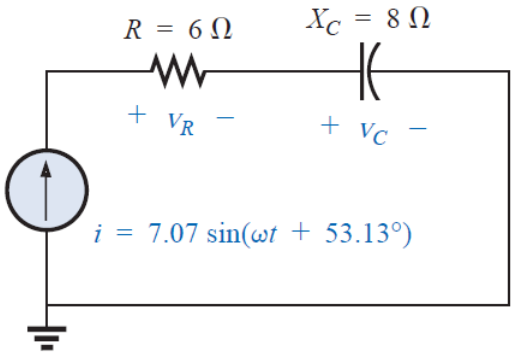
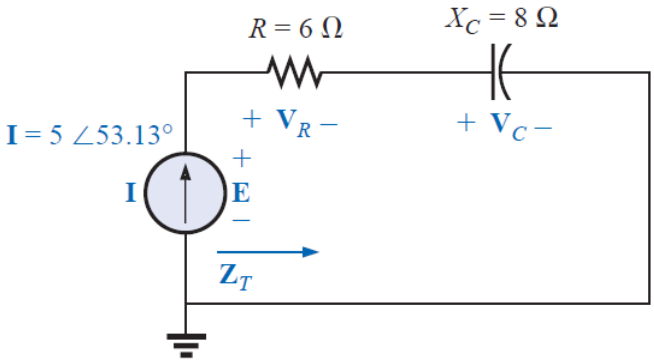
2) R-C

EXAMPLE: Determine the input impedance to the series network and find E , Vr,Vc. Draw the impedance diagram.



Solutions:

$$i = 7.07\sin(\omega t + 53.13^\circ) \Rightarrow \mathbf{I} = 5\,\text{A}\angle 53.13^\circ$$



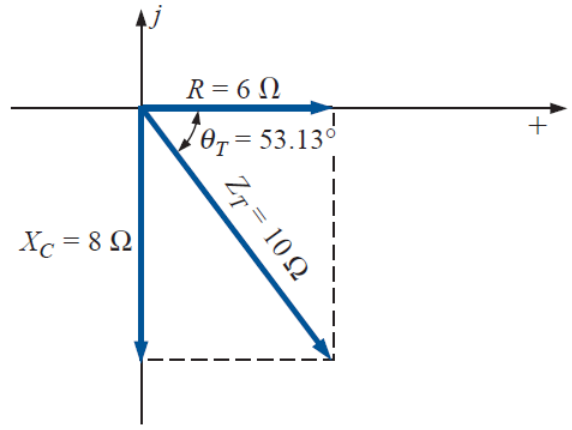
$$\mathbf{Z}_T = \mathbf{Z}_1 + \mathbf{Z}_2 = 6\ \Omega\ \angle 0° + 8\ \Omega\ \angle -90° = 6\ \Omega - j8\ \Omega$$

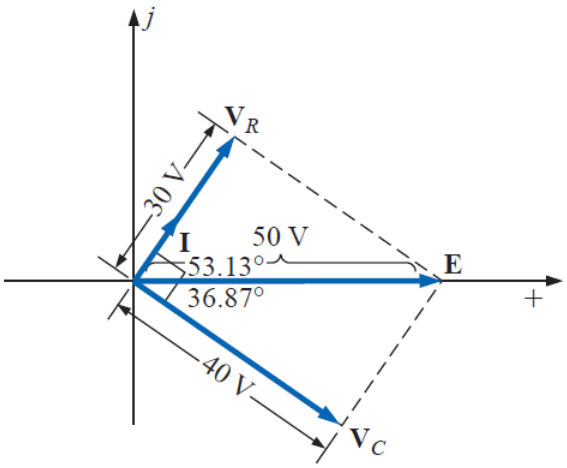
$$\mathbf{Z}_T = \mathbf{10\ \Omega\ \angle -53.13°}$$

$$\mathbf{E} = \mathbf{IZ}_T = (5\text{ A}\ \angle 53.13°)(10\ \Omega\ \angle -53.13°) = \mathbf{50\ V\ \angle 0°}$$

$$\mathbf{V}_R = \mathbf{IZ}_R = (I\ \angle\theta)(R\ \angle 0°) = (5\text{ A}\ \angle 53.13°)(6\ \Omega\ \angle 0°)$$
$$= \mathbf{30\ V\ \angle 53.13°}$$

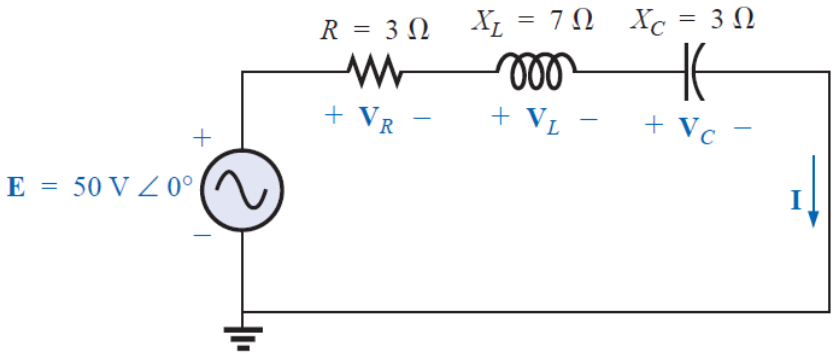
$$\mathbf{V}_C = \mathbf{IZ}_C = (I\ \angle\theta)(X_C\ \angle -90°) = (5\text{ A}\ \angle 53.13°)(8\ \Omega\ \angle -90°)$$
$$= \mathbf{40\ V\ \angle -36.87°}$$





3) R-L-C

EXAMPLE: Determine the input impedance to the series network and find i , Vr, Vc ,VL. Draw the impedance diagram.



Solutions:

$$\mathbf{Z}_T = \mathbf{Z}_1 + \mathbf{Z}_2 + \mathbf{Z}_3 = R\angle 0^\circ + X_L\angle 90^\circ + X_C\angle -90^\circ$$
$$= 3\ \Omega + j\,7\ \Omega - j\,3\ \Omega = 3\ \Omega + j\,4\ \Omega$$

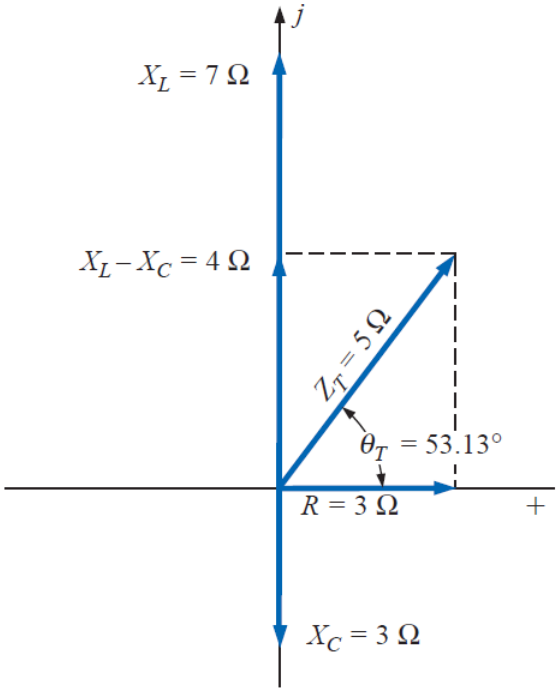
$$\mathbf{Z}_T = \mathbf{5\ \Omega\ \angle 53.13^\circ}$$

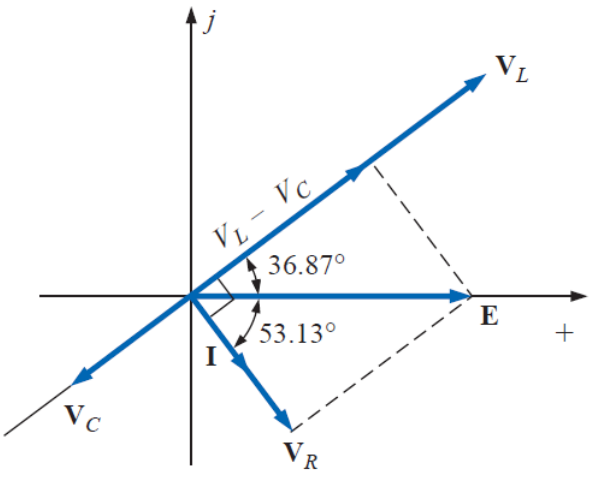
$$\mathbf{I} = \frac{\mathbf{E}}{\mathbf{Z}_T} = \frac{50\ \text{V}\ \angle 0^\circ}{5\ \Omega\ \angle 53.13^\circ} = \mathbf{10\ A\ \angle -53.13^\circ}$$

$$\mathbf{V}_R = \mathbf{I}\mathbf{Z}_R = (I\angle\theta)(R\angle 0^\circ) = (10\ \text{A}\ \angle -53.13^\circ)(3\ \Omega\ \angle 0^\circ)$$
$$= \mathbf{30\ V\ \angle -53.13^\circ}$$

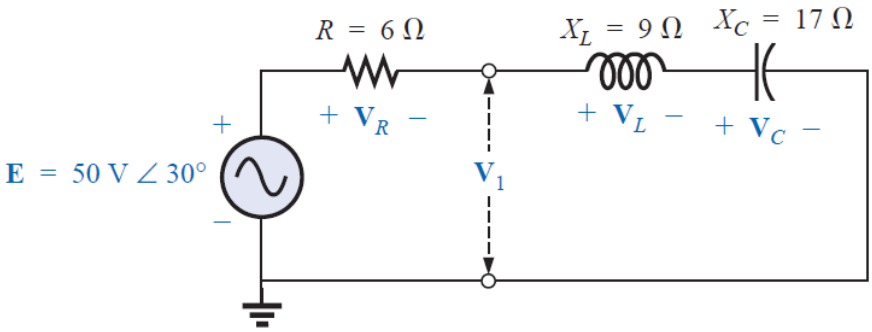
$$\mathbf{V}_L = \mathbf{I}\mathbf{Z}_L = (I\angle\theta)(X_L\angle 90^\circ) = (10\ \text{A}\ \angle -53.13^\circ)(7\ \Omega\ \angle 90^\circ)$$
$$= \mathbf{70\ V\ \angle 36.87^\circ}$$

$$\mathbf{V}_C = \mathbf{I}\mathbf{Z}_C = (I\angle\theta)(X_C\angle -90^\circ) = (10\ \text{A}\ \angle -53.13^\circ)(3\ \Omega\ \angle -90^\circ)$$
$$= \mathbf{30\ V\ \angle -143.13^\circ}$$





EXAMPLE: Using the voltage divider rule, find the unknown voltages VR, VL, VC, and V1 for the circuit.



Solutions:

$$\mathbf{V}_R = \frac{\mathbf{Z}_R\mathbf{E}}{\mathbf{Z}_R + \mathbf{Z}_L + \mathbf{Z}_C} = \frac{(6\ \Omega \angle 0°)(50\ \text{V} \angle 30°)}{6\ \Omega \angle 0° + 9\ \Omega \angle 90° + 17\ \Omega \angle -90°}$$

$$= \frac{300 \angle 30°}{6 + j\,9 - j\,17} = \frac{300 \angle 30°}{6 - j\,8}$$

$$= \frac{300 \angle 30°}{10 \angle -53.13°} = \mathbf{30\ V \angle 83.13°}$$

$$\mathbf{V}_L = \frac{\mathbf{Z}_L\mathbf{E}}{\mathbf{Z}_T} = \frac{(9\ \Omega\ \angle 90°)(50\ \text{V}\ \angle 30°)}{10\ \Omega\ \angle -53.13°} = \frac{450\ \text{V}\angle 120°}{10\ \angle -53.13°}$$
$$= \mathbf{45\ V\ \angle 173.13°}$$

$$\mathbf{V}_C = \frac{\mathbf{Z}_C\mathbf{E}}{\mathbf{Z}_T} = \frac{(17\ \Omega\ \angle -90°)(50\ \text{V}\ \angle 30°)}{10\ \Omega\ \angle -53.13°} = \frac{850\ \text{V}\angle -60°}{10\ \angle -53°}$$
$$= \mathbf{85\ V\ \angle -6.87°}$$

$$\mathbf{V}_1 = \frac{(\mathbf{Z}_L + \mathbf{Z}_C)\mathbf{E}}{\mathbf{Z}_T} = \frac{(9\ \Omega\ \angle 90° + 17\ \Omega\ \angle -90°)(50\ \text{V}\ \angle 30°)}{10\ \Omega\ \angle -53.13°}$$
$$= \frac{(8\ \angle -90°)(50\ \angle 30°)}{10\ \angle -53.13°}$$
$$= \frac{400\ \angle -60°}{10\ \angle -53.13°} = \mathbf{40\ V\ \angle -6.87°}$$