DR. GYURCSEK ISTVÁN

AC Solid State Analysis

Sources and additional materials (recommended)

- *Dr. Gyurcsek – Dr. Elmer: Theories in Electric Circuits, GlobeEdit, 2016, ISBN:978-3-330-71341-3*
- *Ch. Alexander, M. Sadiku: Fundamentals of Electric Circuits, 6th Ed., McGraw Hill NY 2016, ISBN: 978-0078028229*
- *Dr. Selmeczi K. – Schnöller A.: Villamosságtan 1. MK Budapest 2002, TK szám: 49203/I*
- *Dr. Selmeczi K. – Schnöller A.: Villamosságtan 2. TK Budapest 2002, ISBN:9631026043*
- *http://www.electronics-tutorials.ws/accircuits*
- *http://hyperphysics.phy-astr.gsu.edu/hbase/electric/serres.html*
- *https://en.wikipedia.org/wiki/RLC_circuit#Damping*

- ❑ **Pure R, L, C Circuits**
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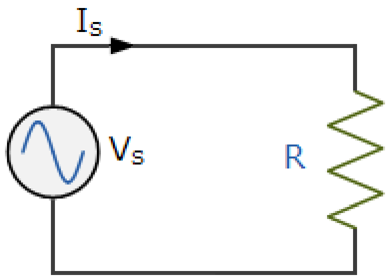
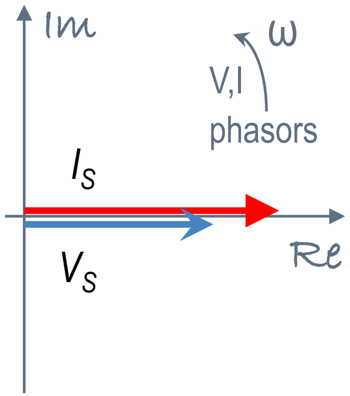
Purely Resistive Circuit

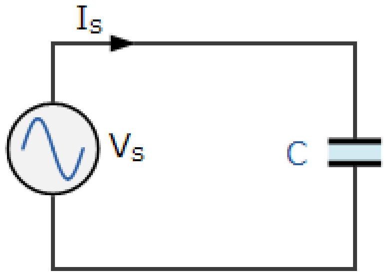


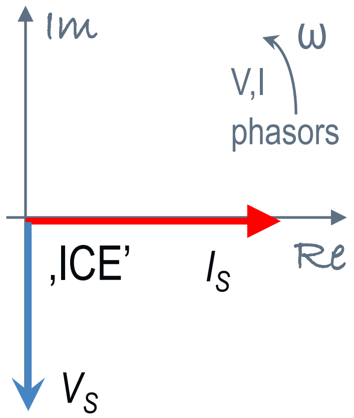


$$\boldsymbol{I}_S = \frac{\boldsymbol{V}_S}{\boldsymbol{Z}_R} = \frac{\boldsymbol{V}_S}{R + j\,0}$$

$$X_R = 0$$

Purely Capacitive Circuit

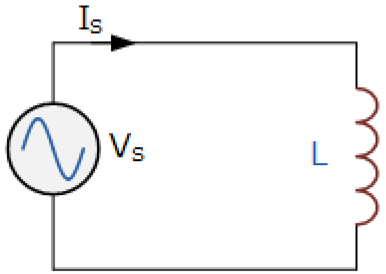


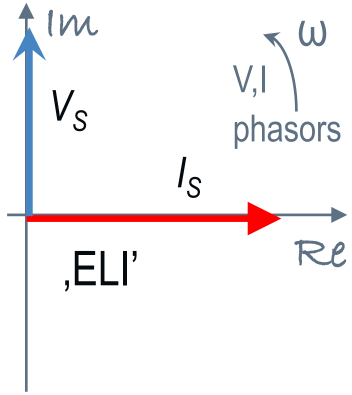


$$I_S = \frac{V_S}{Z_C} = \frac{V_S}{0 - j\,X_C}$$

$$X_C = \frac{1}{\omega C}$$

Purely Inductive Circuit





$$\boldsymbol{I}_S = \frac{\boldsymbol{V}_S}{\boldsymbol{Z}_L} = \frac{\boldsymbol{V}_S}{0 + j\,X_L}$$

$$X_L = \omega L$$

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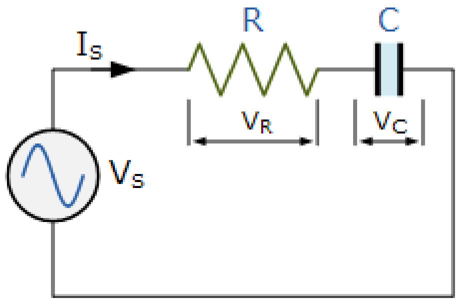
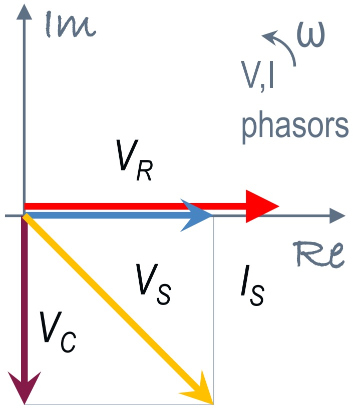
Series RC Circuits



$$\boldsymbol{V_S} = \boldsymbol{V_R} + \boldsymbol{V_C} = \boldsymbol{I_S} \cdot (R - jX_C)$$

$$V_S = \sqrt{V_R^2 + V_C^2}\,, \qquad I_S = \frac{V_S}{\sqrt{R^2 + X_C^2}}$$

$$\boldsymbol{Z} = R - jX_C \rightarrow Z = \sqrt{R^2 + X_C^2}\,, \qquad \varphi_{(-90 \rightarrow 0)} = tan^{-1}\left(-\frac{X_C}{R}\right)$$



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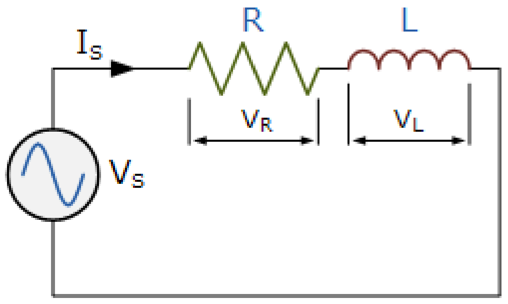
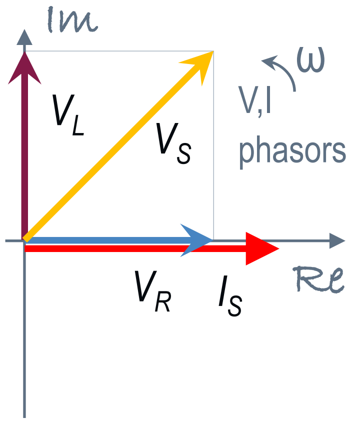
Series RL Circuits



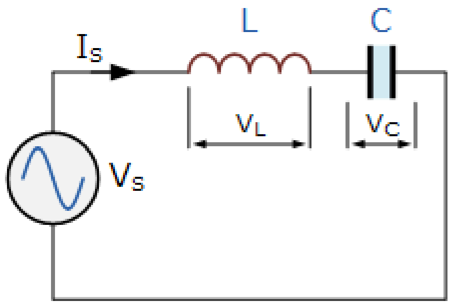
$$\boldsymbol{V}_S = \boldsymbol{V}_R + \boldsymbol{V}_L = \boldsymbol{I}_S \cdot (R + jX_L)$$

$$V_S = \sqrt{V_R^2 + V_L^2}\,, \qquad I_S = \frac{V_S}{\sqrt{R^2 + X_L^2}}$$

$$\boldsymbol{Z} = R + jX_L \rightarrow Z = \sqrt{R^2 + X_L^2}\,, \qquad \varphi_{(0\rightarrow 90)} = tan^{-1}\left(\frac{X_L}{R}\right)$$

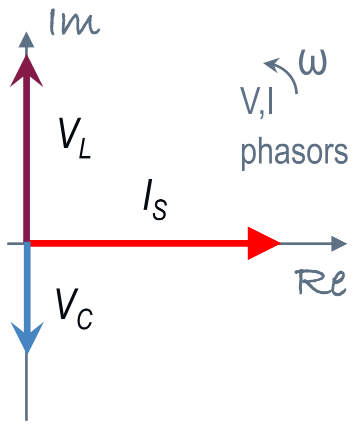


Series LC Circuits



$$\boldsymbol{V}_S = \boldsymbol{V}_L + \boldsymbol{V}_C = \boldsymbol{I}_S \cdot (jX_L - jX_C)$$

$$V_S = |V_L - V_C|\,, \qquad I_S = \frac{V_S}{|X_L - X_C|}$$



$$\boldsymbol{Z} = 0 + j(X_L - X_C) \rightarrow Z = |X_L - X_C|\,, \qquad \varphi = \mp 90$$

$$\left.\begin{matrix} X_L = X_C \\ V_L = V_C \end{matrix}\right\} \rightarrow \omega_r = \frac{1}{\sqrt{LC}}$$

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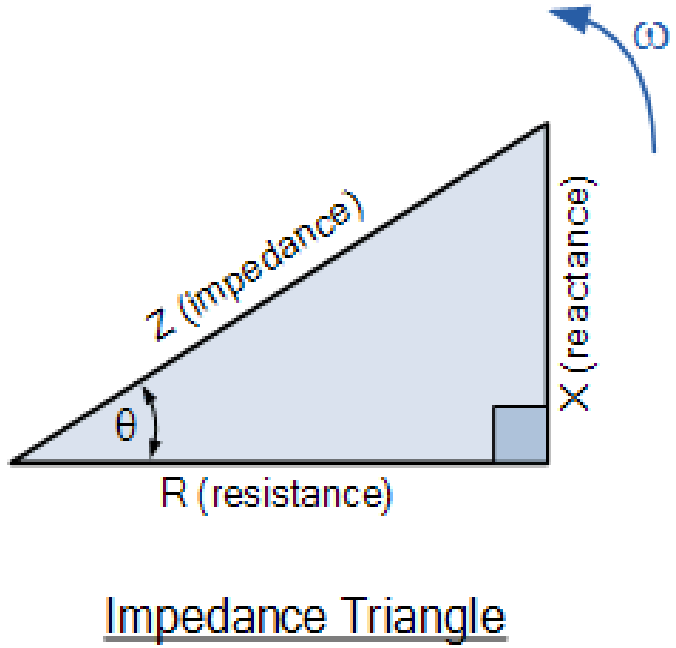
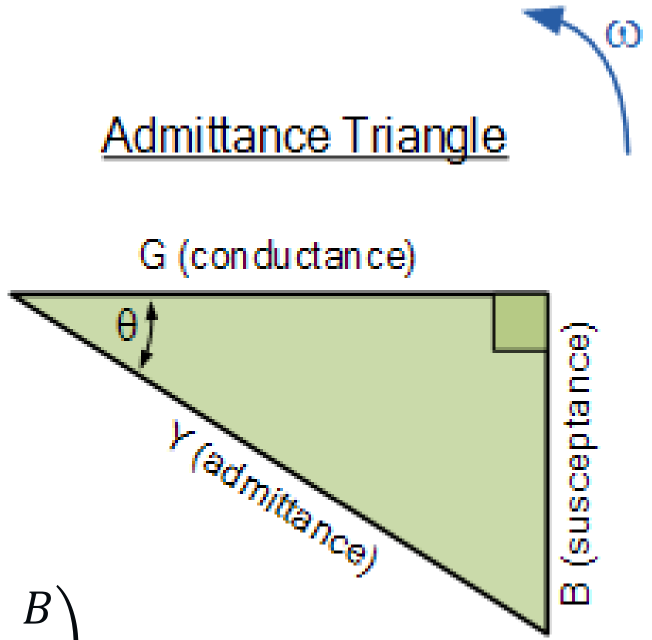
Impedance vs. Admittance

$$\boldsymbol{Z} = R + jX = \mathrm{Z}\, e^{j\Theta}$$

$$\rightarrow Z = \sqrt{R^2 + X^2}$$

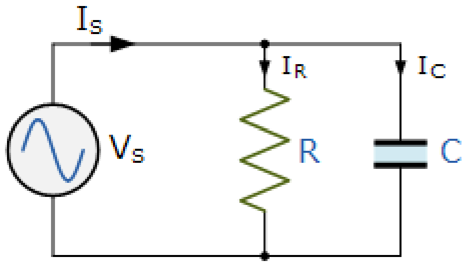
$$\rightarrow \Theta = tan^{-1}\left(\frac{X}{R}\right)$$



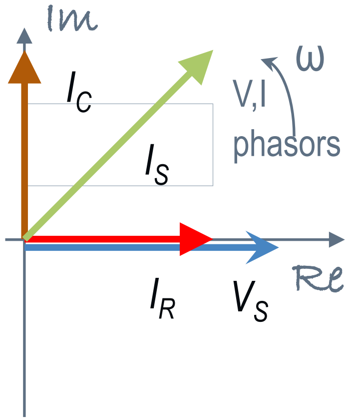


$$\boldsymbol{Y} = \frac{1}{\boldsymbol{Z}} = \frac{1}{\mathrm{Z}}\, e^{-j\Theta} = G - jB \rightarrow Y = \sqrt{G^2 + B^2}\,, \qquad \Theta = tan^{-1}\left(-\frac{B}{G}\right)$$

Parallel RC Circuits



$$\boldsymbol{I_S} = \boldsymbol{I_R} + \boldsymbol{I_C} = \boldsymbol{V_S} \cdot \left(\frac{1}{R} + \frac{1}{-jX_C}\right) = \boldsymbol{V_S} \cdot \boldsymbol{Y}$$



$$\boldsymbol{Y} = \frac{1}{\boldsymbol{Z}} = G + jB_C \rightarrow Y = \sqrt{G^2 + B_C^2}, \qquad \varphi_{Y(0\rightarrow 90)} = tan^{-1}\left(\frac{B_C}{R}\right)$$

$$\varphi_Z = \varphi_{(-90\rightarrow 0)} = tan^{-1}\left(-\frac{I_C}{I_R}\right)$$

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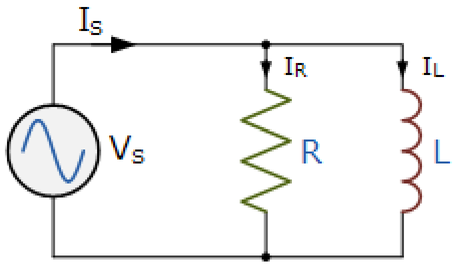
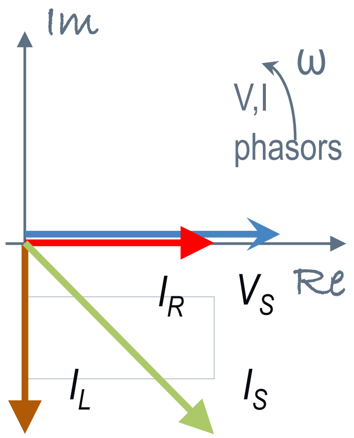
Parallel RL Circuits



$$\boldsymbol{I_S} = \boldsymbol{I_R} + \boldsymbol{I_L} = \boldsymbol{V_S} \cdot \left(\frac{1}{R} + \frac{1}{jX_L}\right) = \boldsymbol{V_S} \cdot \boldsymbol{Y}$$

$$\boldsymbol{Y} = \frac{1}{\boldsymbol{Z}} = G - jB_L \rightarrow Y = \sqrt{G^2 + B_L^2}\,, \qquad \varphi_{Y(-90\rightarrow 0)} = tan^{-1}\left(-\frac{B_L}{R}\right)$$

$$\varphi_Z = \varphi_{(0\rightarrow 90)} = tan^{-1}\left(\frac{I_L}{I_R}\right)$$



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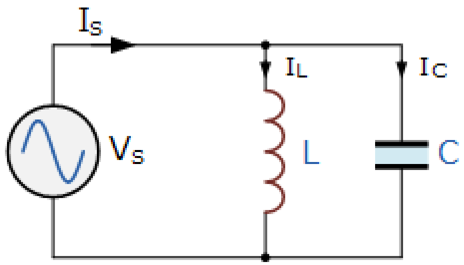
Parallel LC Circuits

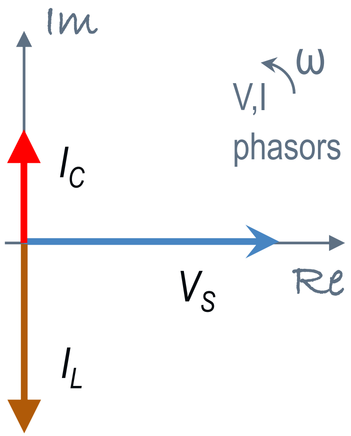


$$\boldsymbol{I}_S = \boldsymbol{I}_L + \boldsymbol{I}_C = \boldsymbol{V}_S \cdot (jB_C - jB_L)$$

$$I_S = |I_C - I_L| \,, \qquad I_S = \frac{V_S}{|X_L - X_C|}$$

$$\boldsymbol{Y} = 0 + j(B_C - B_L) \rightarrow Y = |B_C - B_L|, \qquad \varphi_Y = \mp 90$$

$$\left.\begin{matrix} B_L = B_C \\ I_L = I_C \end{matrix}\right\} \rightarrow \omega_r = \frac{1}{\sqrt{LC}}$$



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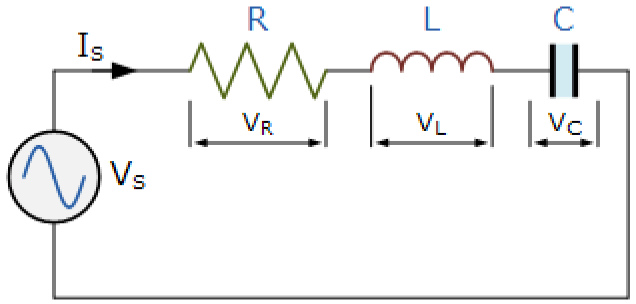
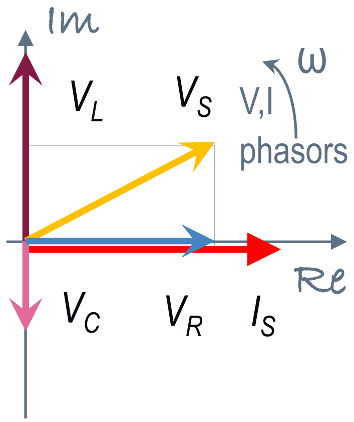
Series RLC Circuits





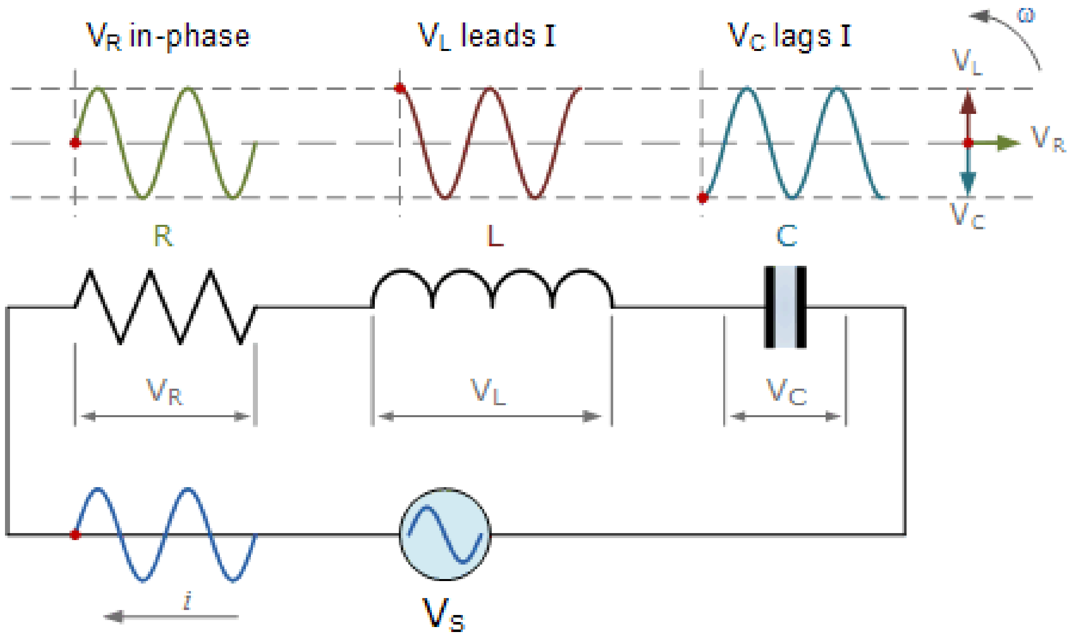
$$\boldsymbol{V}_S = \boldsymbol{V}_R + \boldsymbol{V}_L + \boldsymbol{V}_C = \boldsymbol{I}_S \cdot (R + jX_L - jX_C)$$

$$\boldsymbol{Z} = R + jX_L - jX_C \rightarrow Z = \sqrt{R^2 + (X_L - X_C)^2}\,, \qquad \varphi_{(-90\rightarrow 90)} = tan^{-1}\left(\frac{X_L - X_C}{R}\right)$$

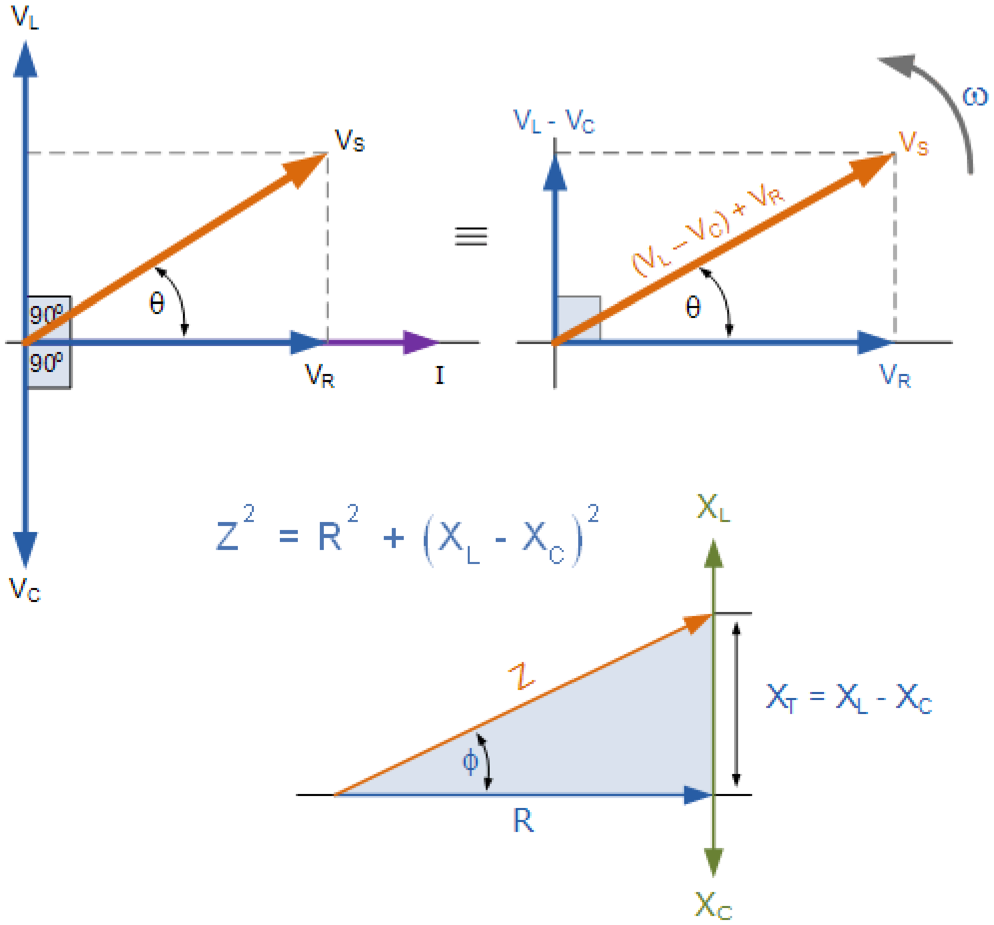
resonance

$$V_S = I_S \cdot Z\,, \qquad V_R = I_S \cdot R\,, \qquad V_L = I_S \cdot X_L\,, \qquad V_C = I_S \cdot X_C$$

Series RLC in Time and Phasor Domains



$$i(t) = I_m \sin\,(\omega t)$$



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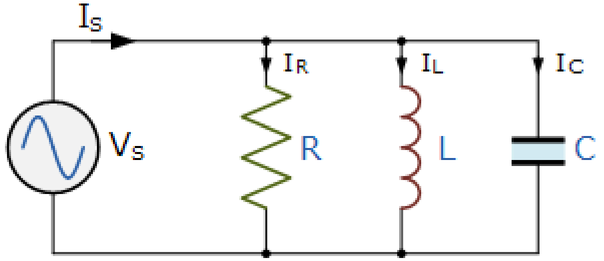
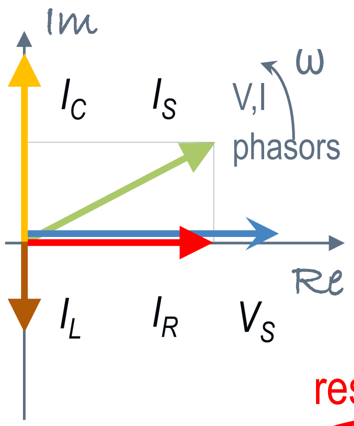
Parallel RLC Circuits





$$\boldsymbol{I_S} = \boldsymbol{I_R} + \boldsymbol{I_L} + \boldsymbol{I_C} = \boldsymbol{V_S} \cdot (G - jB_L + jB_C)$$

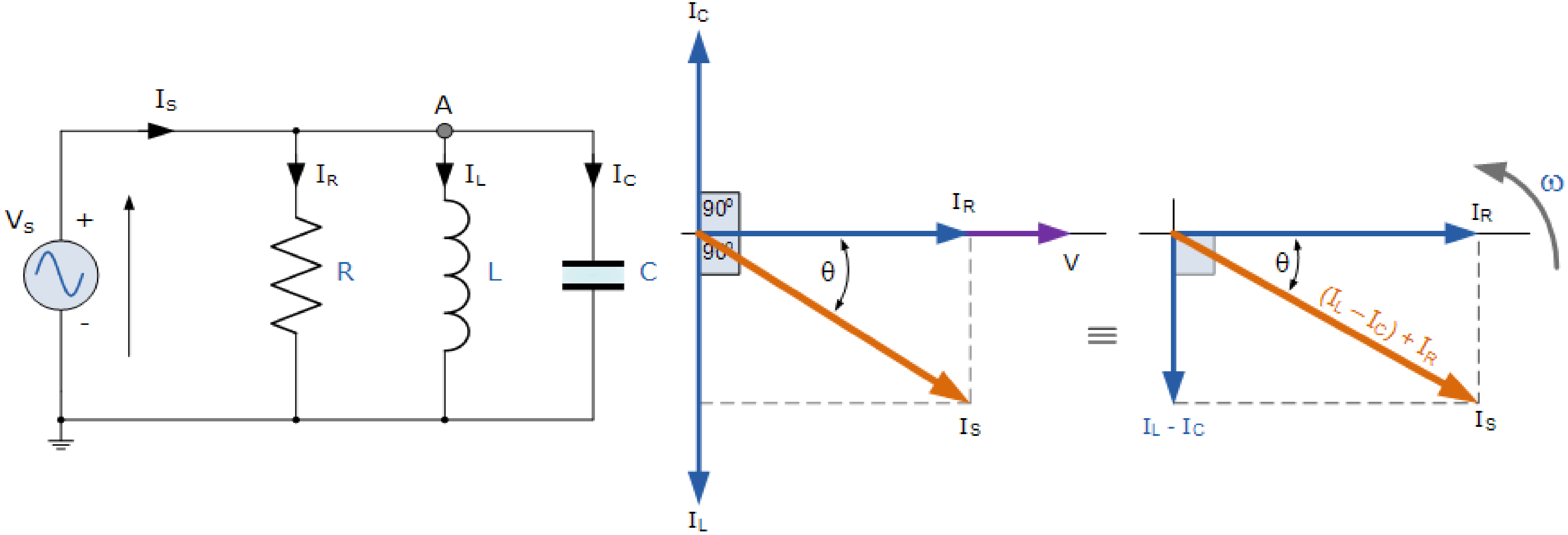
resonance

$$\boldsymbol{Y} = G + jB_C - jB_L \rightarrow Y = \sqrt{G^2 + (B_C - B_L)^2}\,, \qquad \varphi_{Y(-90\rightarrow 90)} = tan^{-1}\left(\frac{B_C - B_L}{G}\right)$$

$$\varphi_Z = \varphi_{(90\rightarrow -90)} = tan^{-1}\left(\frac{B_C - B_L}{G}\right)$$

$$I_S = V_S \cdot Y\,, \qquad I_R = V_S \cdot G\,, \qquad I_L = V_S \cdot B_L\,, \qquad I_C = V_S \cdot B_C$$

Phasor Diagram of Parallel RLC Circuits



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Questions