



DR. GYURCSEK ISTVÁN

AC Solid State Analysis

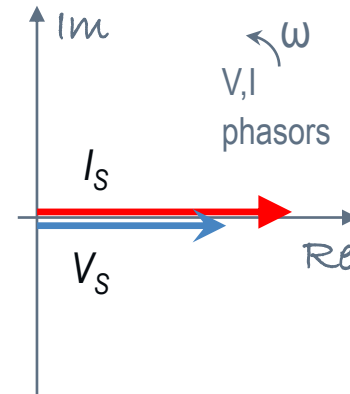
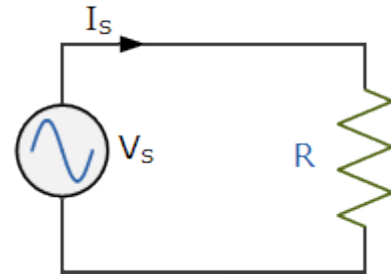
Sources and additional materials (recommended)

- ❑ *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**
- Series RC, RL, LC Circuits
- Parallel RC, RL, LC Circuits
- Series RLC Circuits
- Parallel RLC Circuits

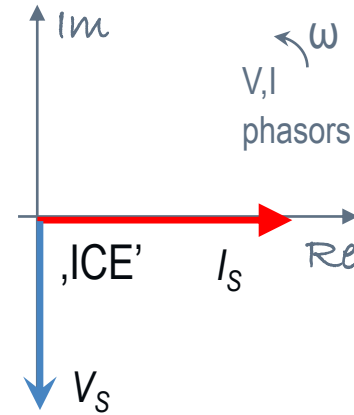
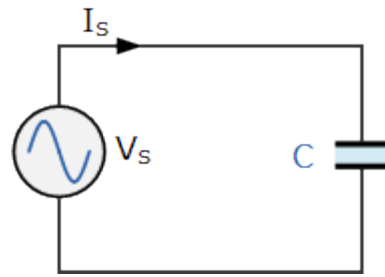
Purely Resistive Circuit



$$I_S = \frac{V_S}{Z_R} = \frac{V_S}{R + j0}$$

$$X_R = 0$$

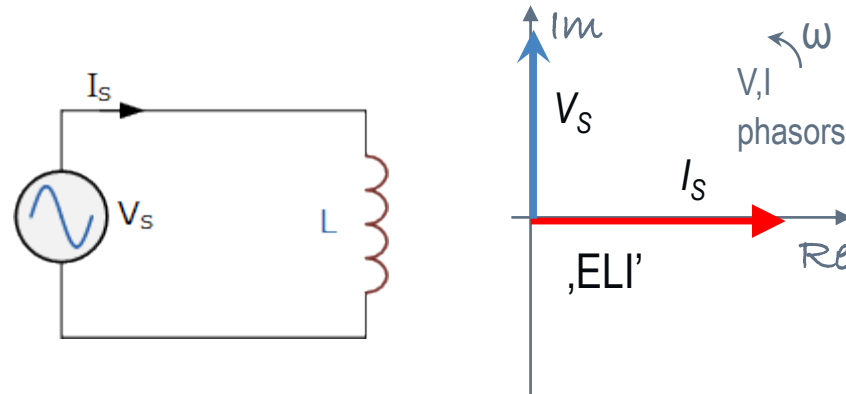
Purely Capacitive Circuit



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

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

Purely Inductive Circuit



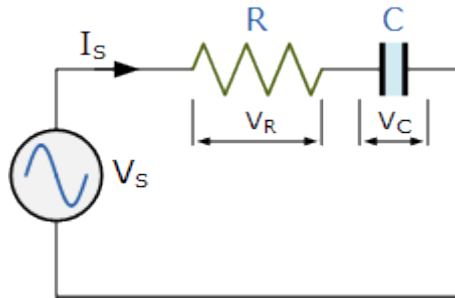
$$I_S = \frac{V_S}{Z_L} = \frac{V_S}{0 + j X_L}$$

$$X_L = \omega L$$



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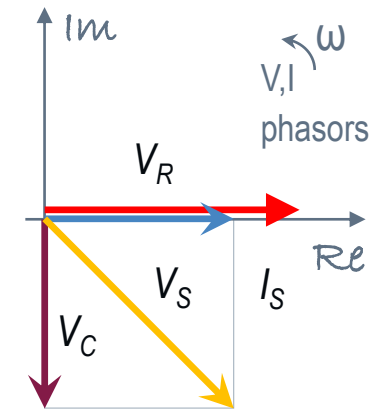
Series RC Circuits



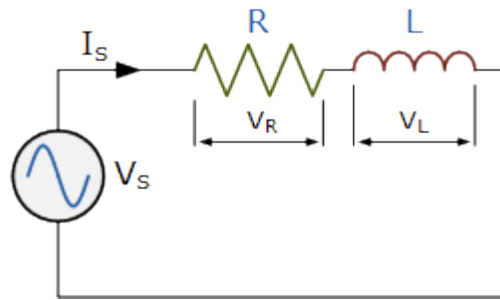
$$V_S = V_R + V_C = I_S \cdot (R - jX_C)$$

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

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



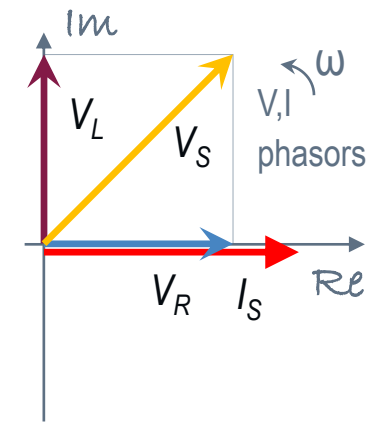
Series RL Circuits



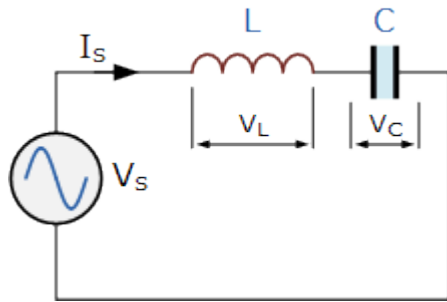
$$\mathbf{V}_S = \mathbf{V}_R + \mathbf{V}_L = \mathbf{I}_S \cdot (R + jX_L)$$

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

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



Series LC Circuits

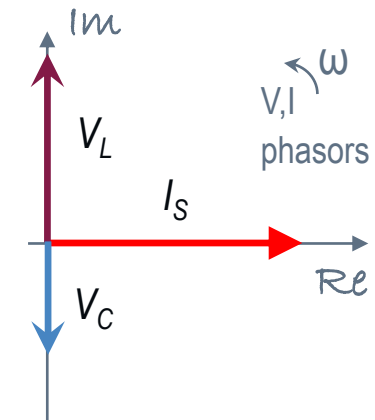


$$V_S = V_L + V_C = I_S \cdot (jX_L - jX_C)$$

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

$$Z = 0 + j(X_L - X_C) \rightarrow Z = |X_L - X_C|, \quad \varphi = \mp 90$$

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





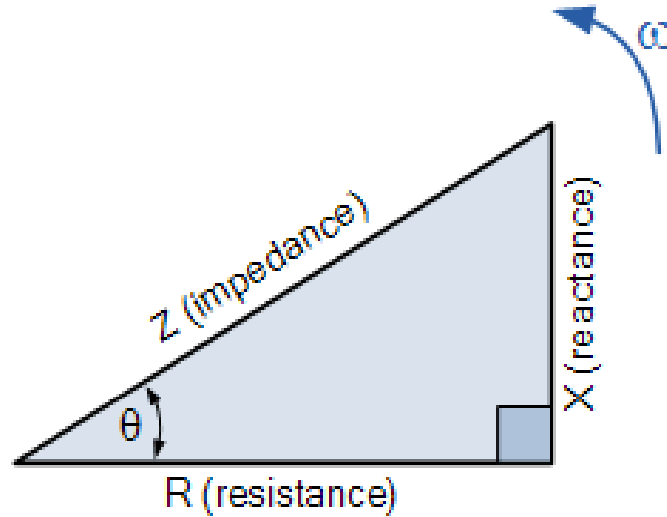
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Impedance vs. Admittance

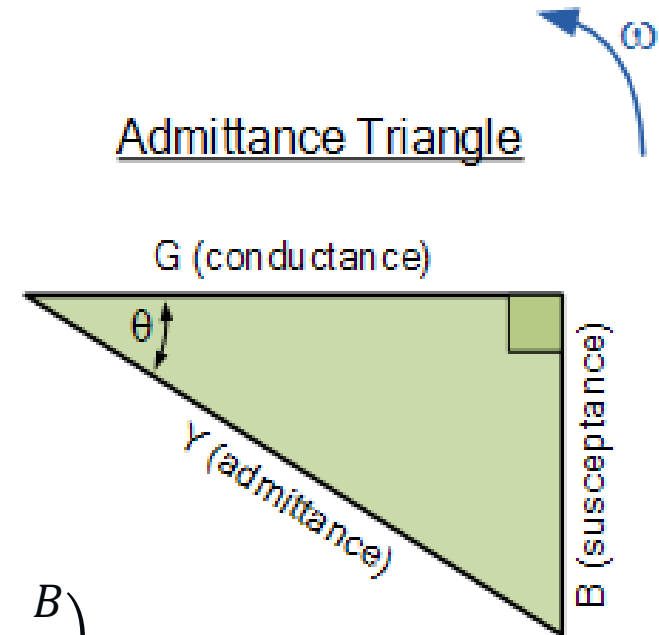
$$Z = R + jX = Z e^{j\theta}$$

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

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



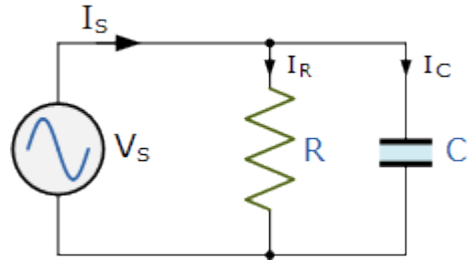
Impedance Triangle



Admittance Triangle

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

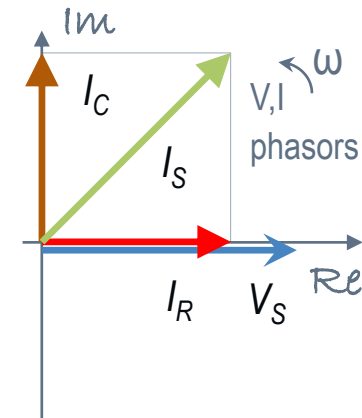
Parallel RC Circuits



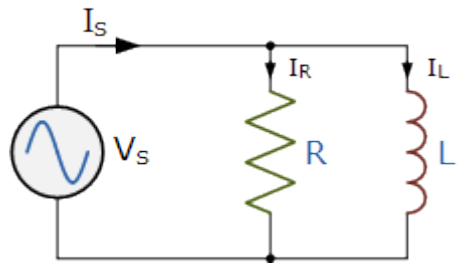
$$I_S = I_R + I_C = V_S \cdot \left(\frac{1}{R} + \frac{1}{-jX_C} \right) = V_S \cdot Y$$

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

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



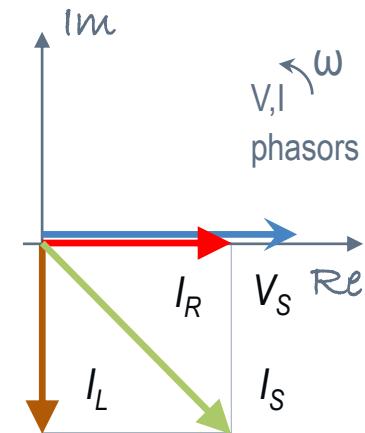
Parallel RL Circuits



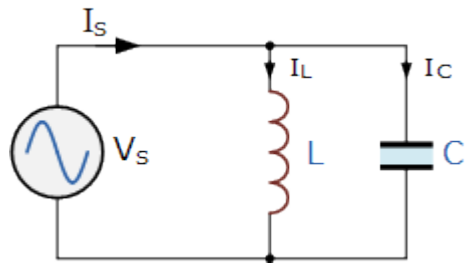
$$I_S = I_R + I_L = V_S \cdot \left(\frac{1}{R} + \frac{1}{jX_L} \right) = V_S \cdot Y$$

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

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



Parallel LC Circuits

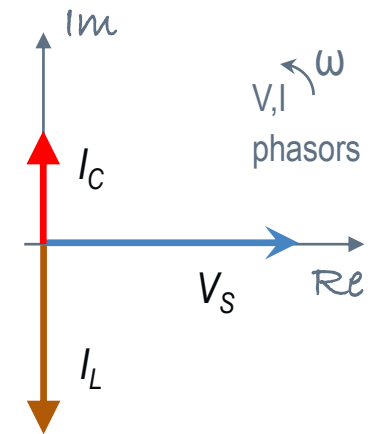


$$I_S = I_L + I_C = V_S \cdot (jB_C - jB_L)$$

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

$$Y = 0 + j(B_C - B_L) \rightarrow Y = |B_C - B_L|, \quad \varphi_Y = \mp 90$$

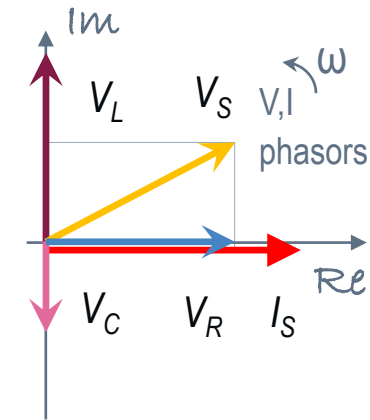
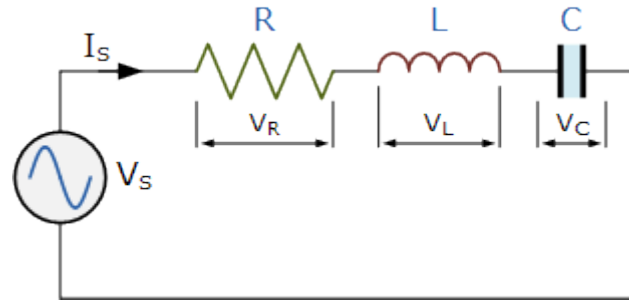
$$\left. \begin{array}{l} B_L = B_C \\ I_L = I_C \end{array} \right\} \rightarrow \omega_r = \frac{1}{\sqrt{LC}}$$





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Series RLC Circuits



$$V_S = V_R + V_L + V_C = I_S \cdot (R + jX_L - jX_C)$$

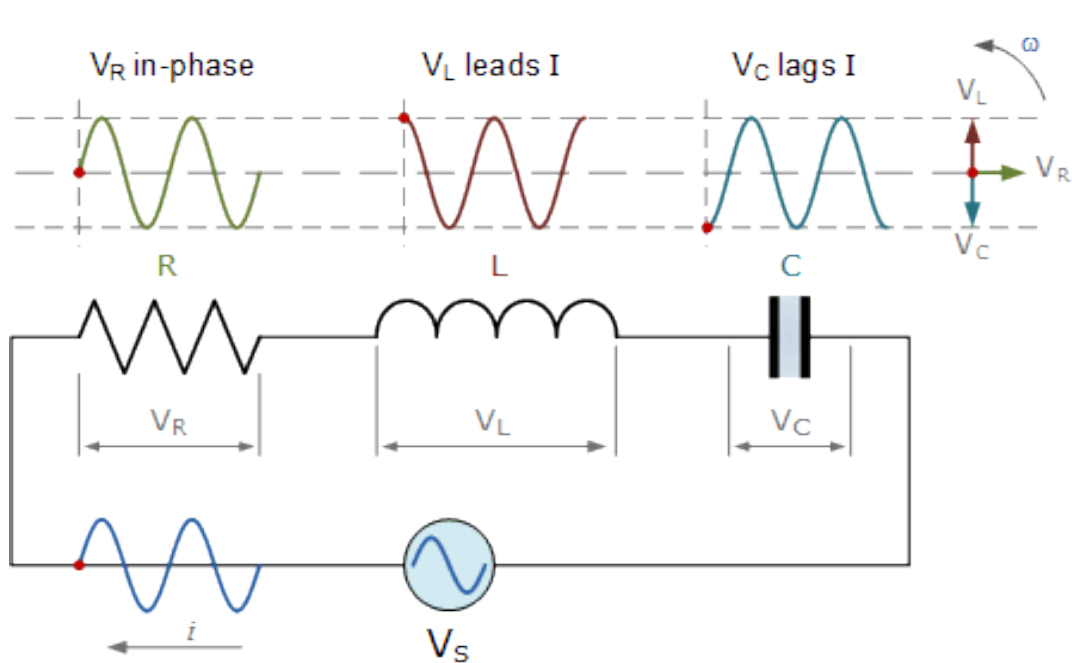
$$Z = R + jX_L - jX_C \rightarrow Z = \sqrt{R^2 + (X_L - X_C)^2},$$

$$\varphi_{(-90 \rightarrow 90)} = \tan^{-1} \left(\frac{X_L - X_C}{R} \right)$$

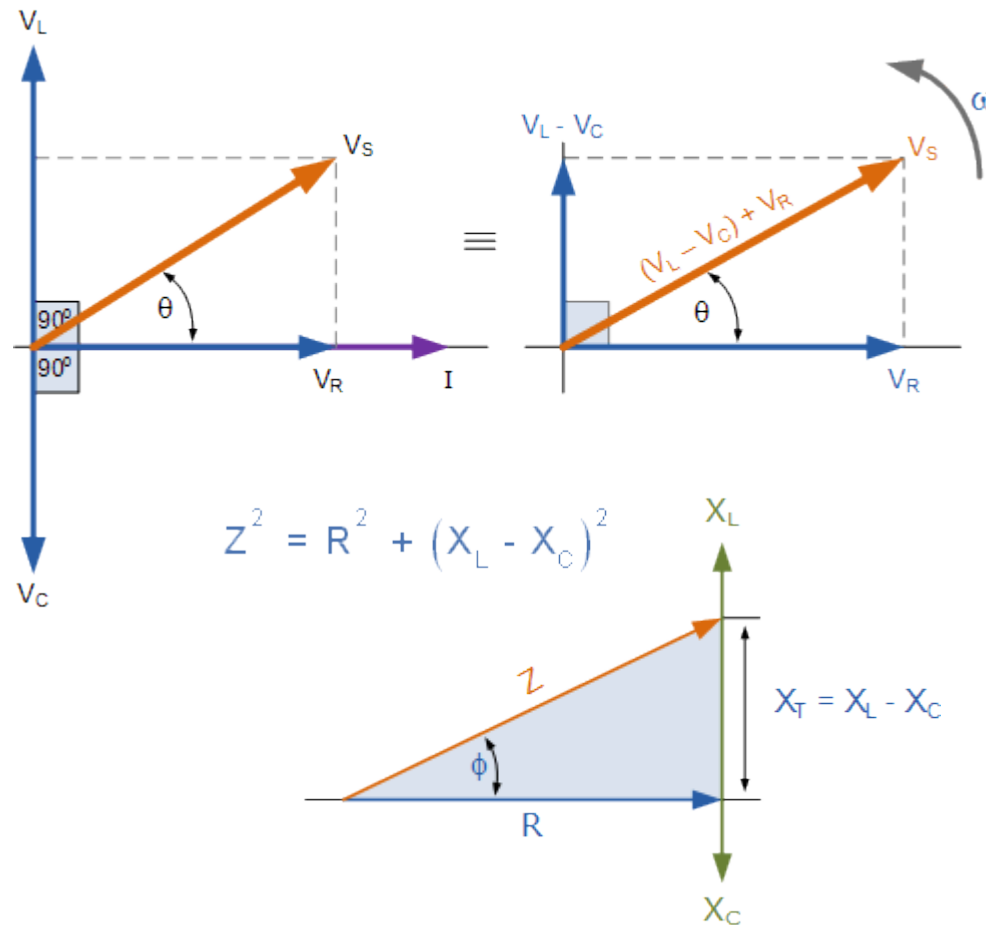
resonance

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

Series RLC in Time and Phasor Domains



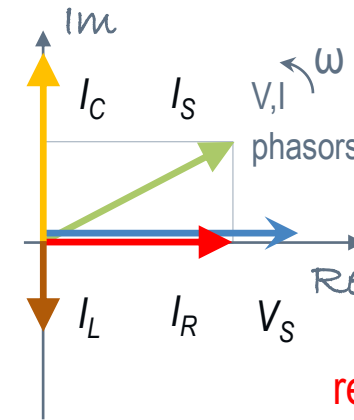
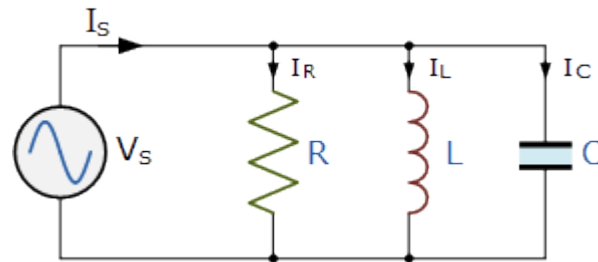
$$i(t) = I_m \sin(\omega t)$$





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Parallel RLC Circuits



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

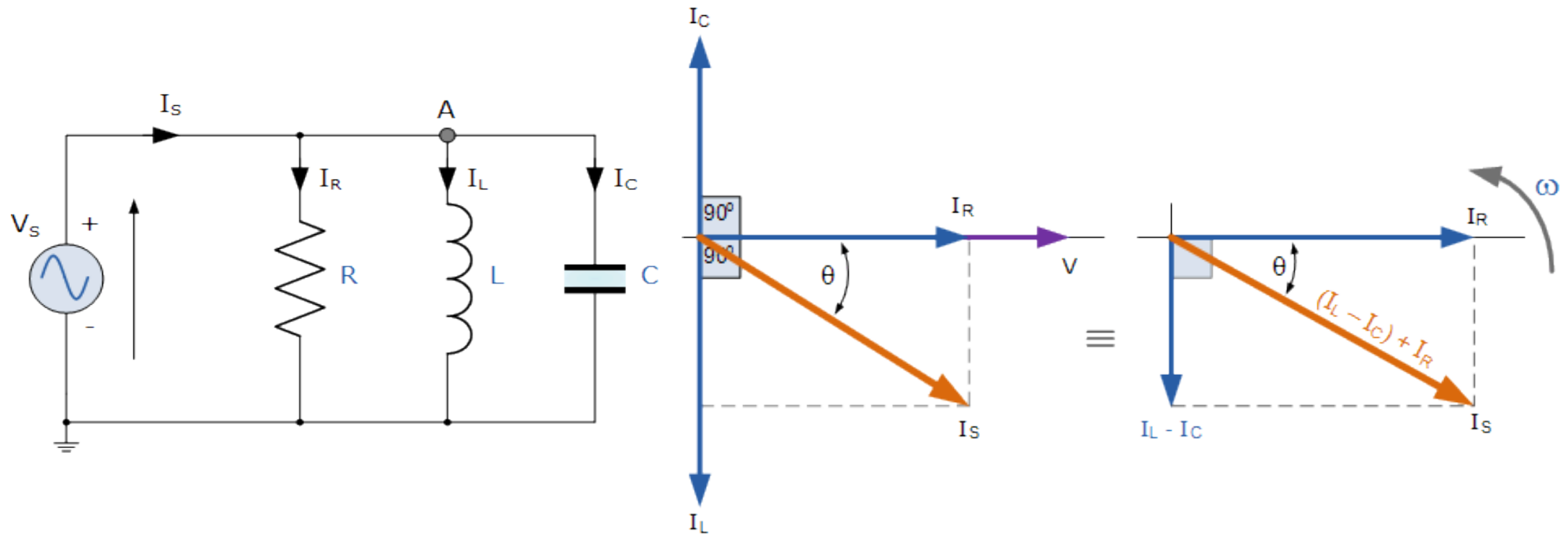
$$Y = G + jB_C - jB_L \rightarrow Y = \sqrt{G^2 + (B_C - B_L)^2}, \quad \varphi_{Y(-90 \rightarrow 90)} = \tan^{-1} \left(\frac{B_C - B_L}{G} \right)$$

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

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

resonance

Phasor Diagram of Parallel RLC Circuits



Questions

