SERIES REACTIVE CIRCUITS

AC CIRCUITS

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TOPIC OUTLINE

Phasor Diagram

Series R-L Circuit

Series R-C Circuit

Series R-L-C Circuit

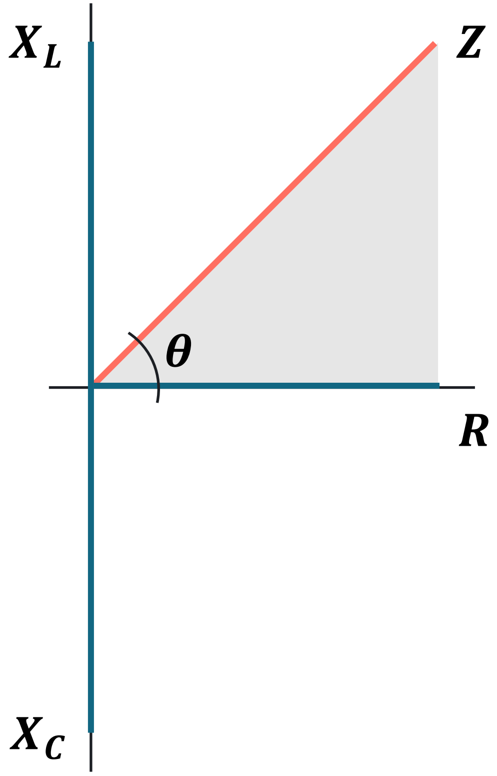
Power Factor

PHASOR DIAGRAM

PHASOR DIAGRAM

Phasor diagram is a graphical representation of **magnitude** and **phase** relationship between sinusoidal quantities.

Phasor Diagram



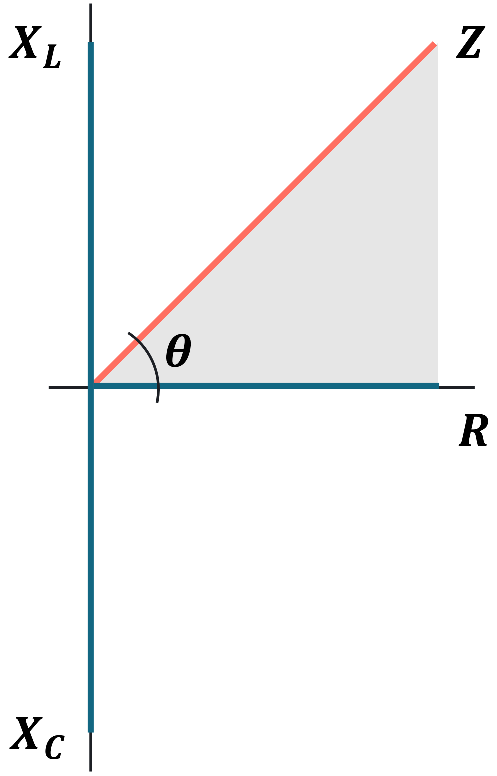
IMPEDANCE

The **impedance** (Z) represents the **total opposition** offered by circuit elements (including resistance and reactance) to the flow of alternating current (AC).

Formula

$$Z = R + j(X_L - X_C)$$

Phasor Diagram



INDUCTIVE REACTANCE

Phasor Diagram

The **inductive reactance** (X_L) represents the opposition offered by the **inductor** to the flow of alternating current (AC).

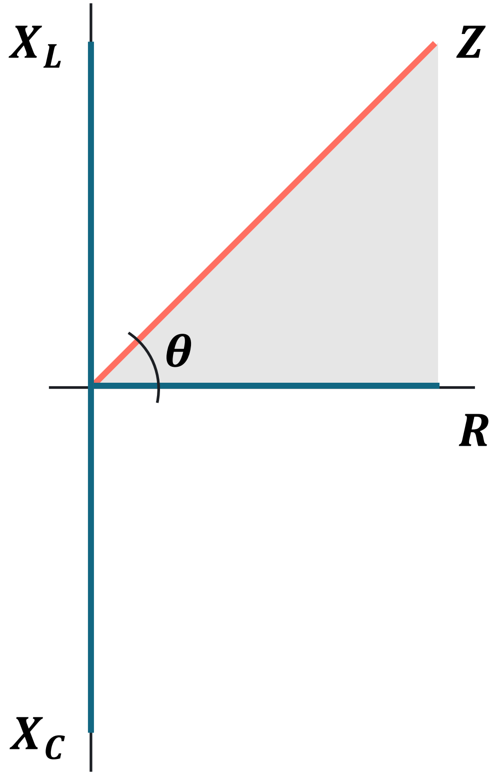
Formula

$$X_L = 2\pi f L$$

where:

f = frequency (Hz)

L = inductance (H)



CAPACITIVE REACTANCE

The **capacitive reactance** (X_C) represents the opposition offered by the **capacitor** to the flow of alternating current (AC).

Formula

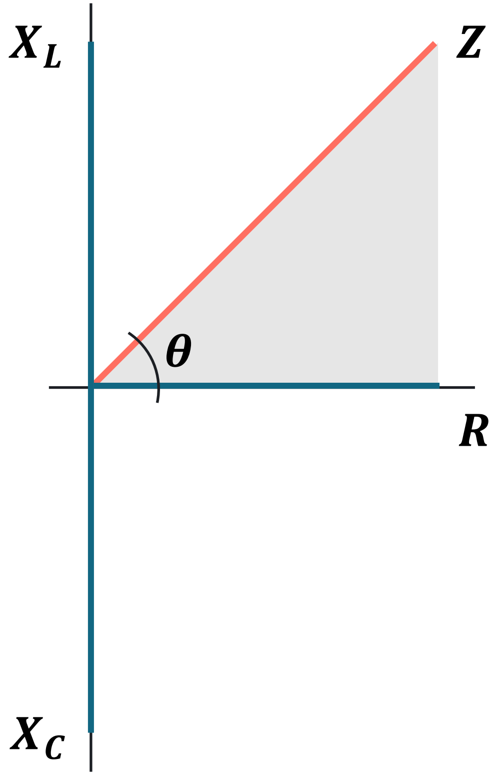
$$X_C = \frac{1}{2\pi f C}$$

where:

f = frequency (Hz)

C = capacitance (F)

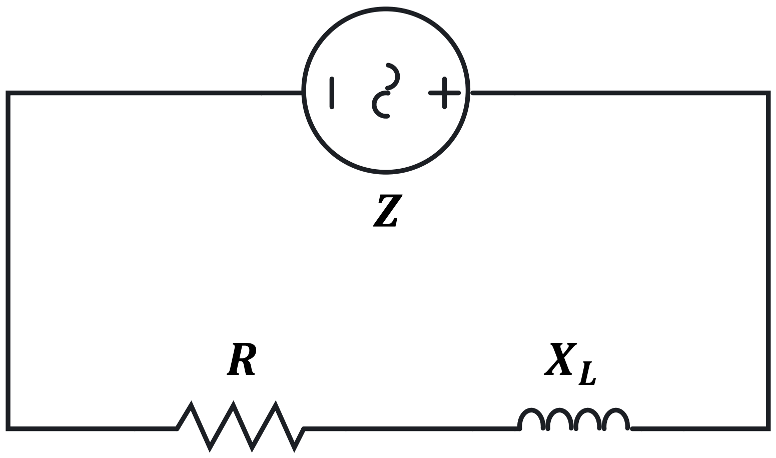
Phasor Diagram



SERIES R-L CIRCUIT

SERIES R-L CIRCUIT

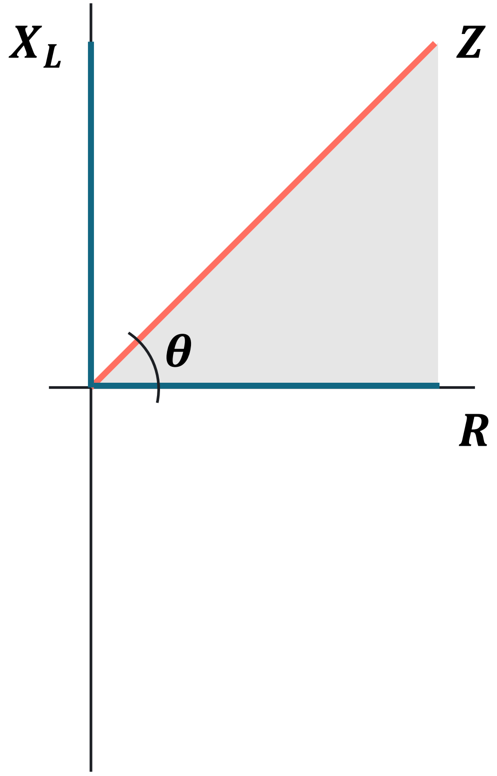
Circuit Diagram



Formula

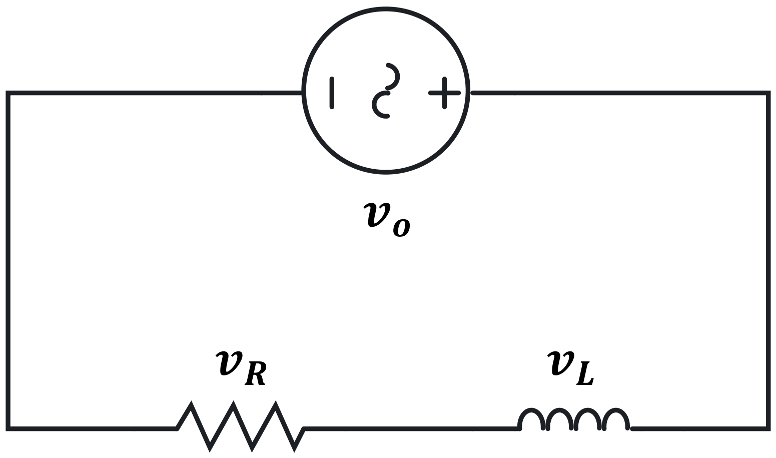
$$Z = R + jX_L$$

Impedance Phasor Diagram



SERIES R-L CIRCUIT

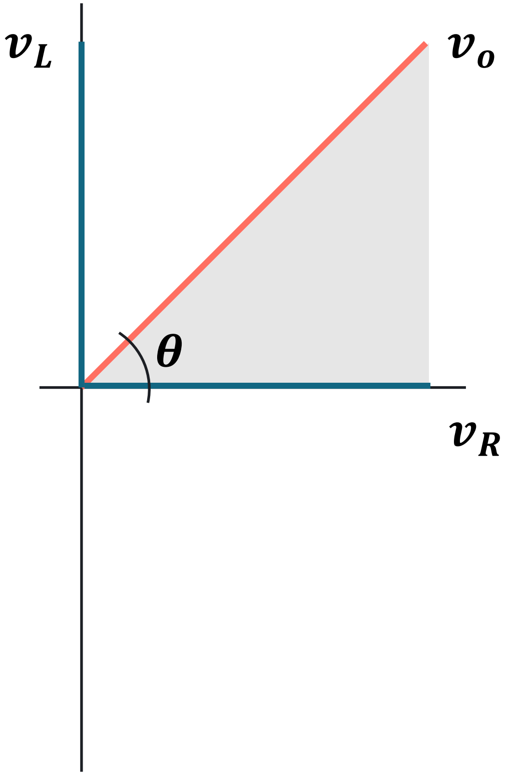
Circuit Diagram



Formula

$$v_o = v_R + jv_L$$

Voltage Phasor Diagram



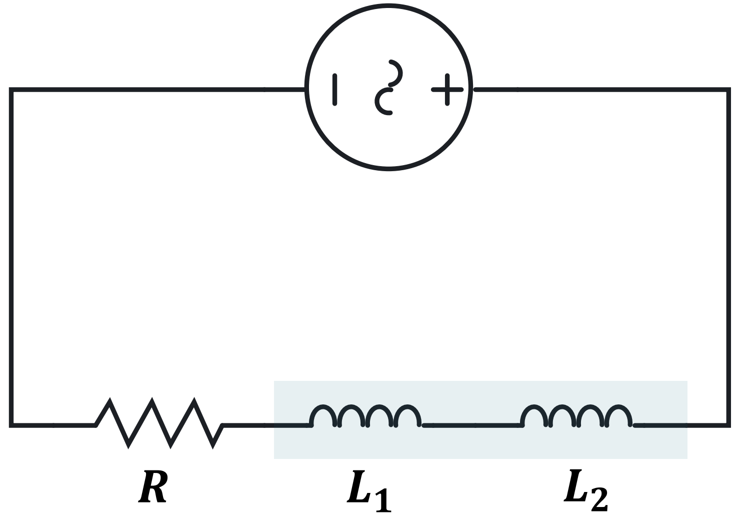
TOTAL INDUCTANCE

In a series circuit, the **total inductance** (L_o) is the **sum** of all individual inductances.

Formula

$$L_o = L_1 + L_2 + L_3 + \cdots L_n$$

Series network



EXERCISE

A $\mathbf{240}\ \boldsymbol{V},\ \mathbf{60}\ \boldsymbol{Hz}$ source is connected to a coil of wire that has a resistance of $\mathbf{7.5}\ \boldsymbol{\Omega}$ and an inductance of $\mathbf{47.7}\ \boldsymbol{mH}$.

Solution

Determine the following:

a. Equivalent impedance $(\boldsymbol{Z})$

b. Total current $(\boldsymbol{i_o})$

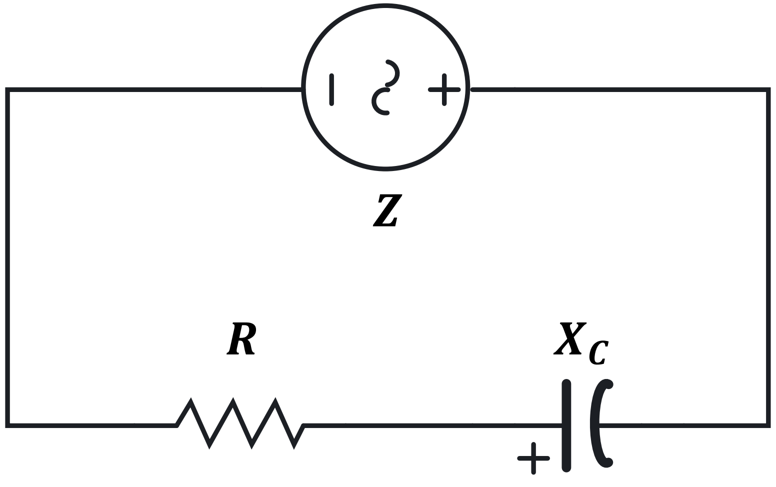
c. Voltage across the resistor $(\boldsymbol{v_R})$

d. Voltage across the inductor $(\boldsymbol{v_L})$

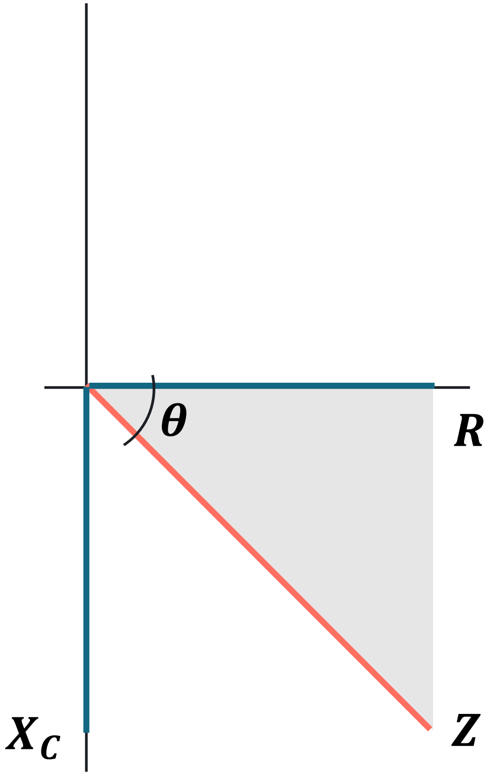
SERIES R-C CIRCUIT

SERIES R-C CIRCUIT

Circuit Diagram



Impedance Phasor Diagram

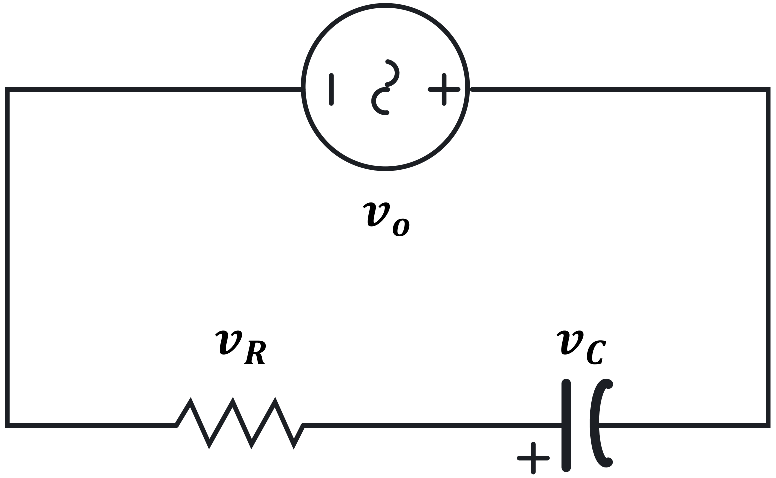


Formula

$$Z = R + jX_C$$

SERIES R-C CIRCUIT

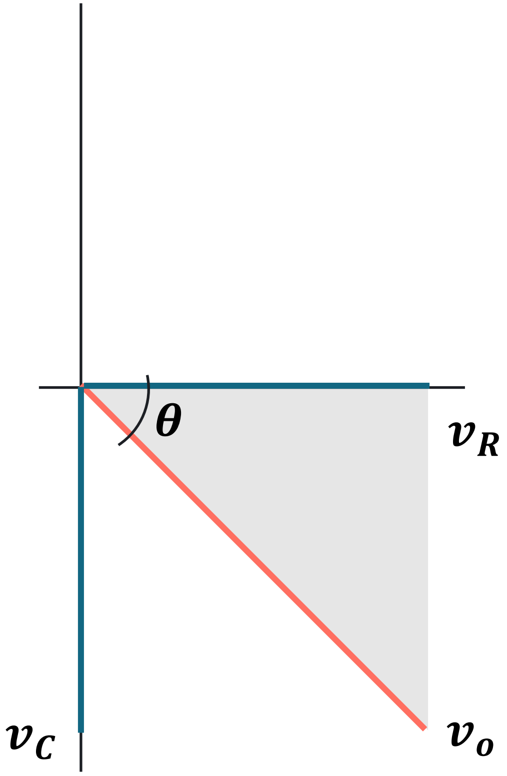
Circuit Diagram



Formula

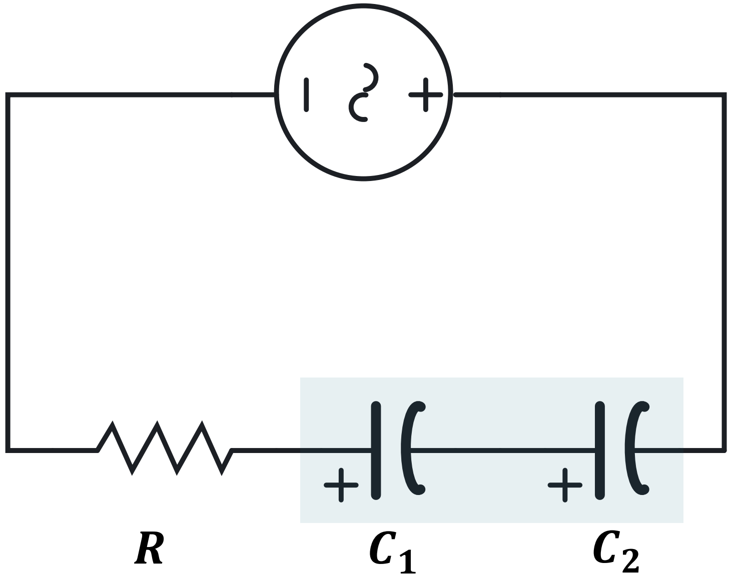
$$v_o = v_R + jv_C$$

Voltage Phasor Diagram



TOTAL CAPACITANCE

Series network



In a series circuit, the **total capacitance** (C_o) is analogous to total resistance in parallel circuit.

Formula

$$\frac{1}{C_o} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \cdots \frac{1}{C_n}$$

EXERCISE

A $\mathbf{125}\ \boldsymbol{V},\ \mathbf{25}\ \boldsymbol{Hz}$ source is connected to a series circuit consisting of a $\mathbf{30}\ \boldsymbol{\Omega}$ and a $\mathbf{159}\ \boldsymbol{\mu F}$ capacitor.

Solution

Determine the following:

a. Equivalent impedance ($\boldsymbol{Z}$)

b. Total current ($\boldsymbol{i_o}$)

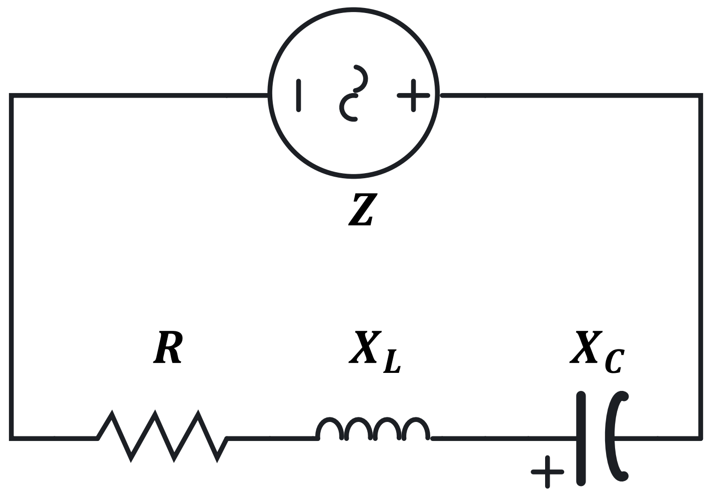
c. Voltage across the resistor ($\boldsymbol{v_R}$)

d. Voltage across the capacitor ($\boldsymbol{v_C}$)

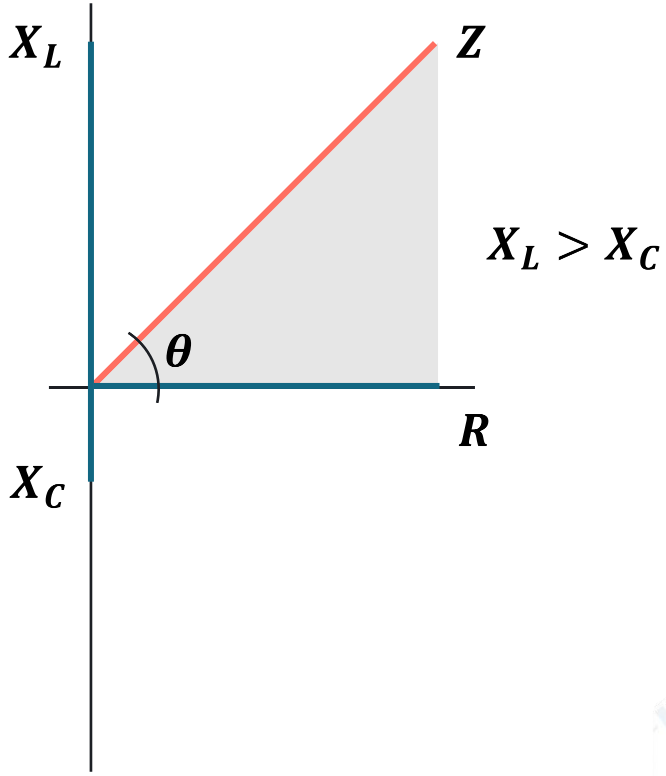
SERIES R-L-C CIRCUIT

SERIES R-L-C CIRCUIT

Circuit Diagram



Impedance Phasor Diagram

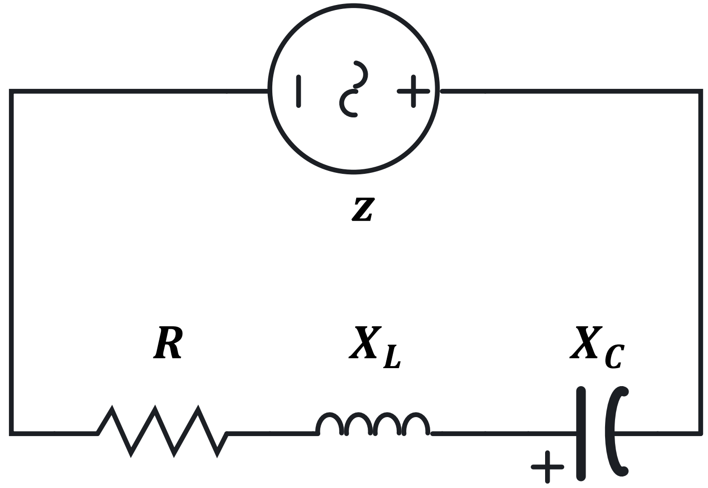


Formula

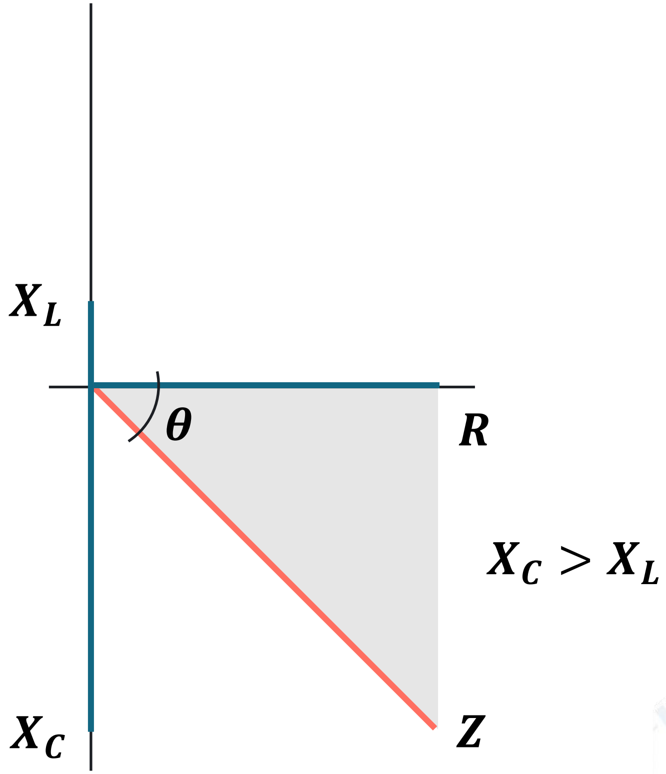
$$Z = R + j(X_L - X_C)$$

SERIES R-L-C CIRCUIT

Circuit Diagram



Impedance Phasor Diagram

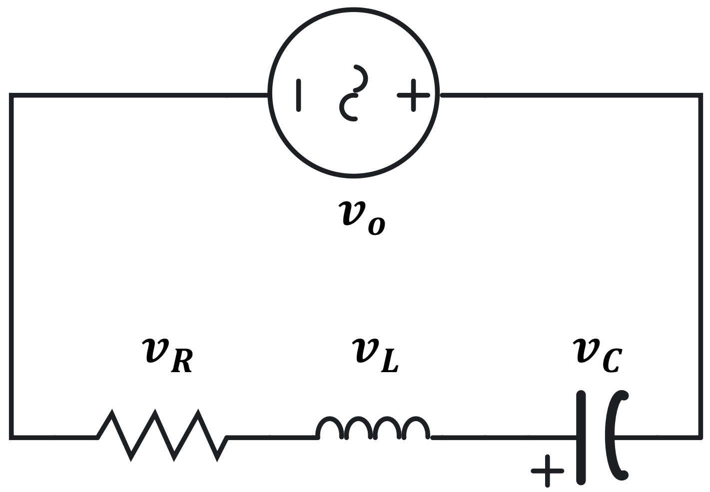


Formula

$$Z = R + j(X_L - X_C)$$

SERIES R-L-C CIRCUIT

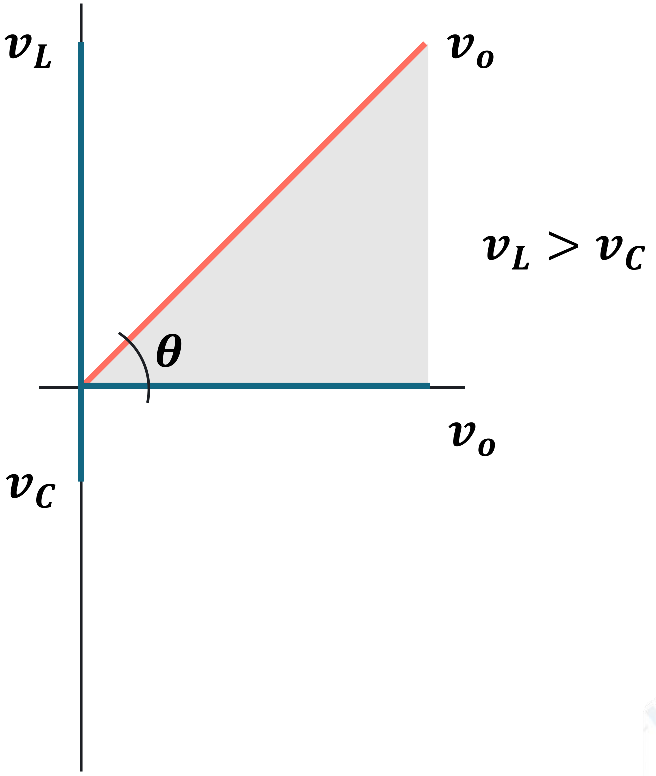
Circuit Diagram



Formula

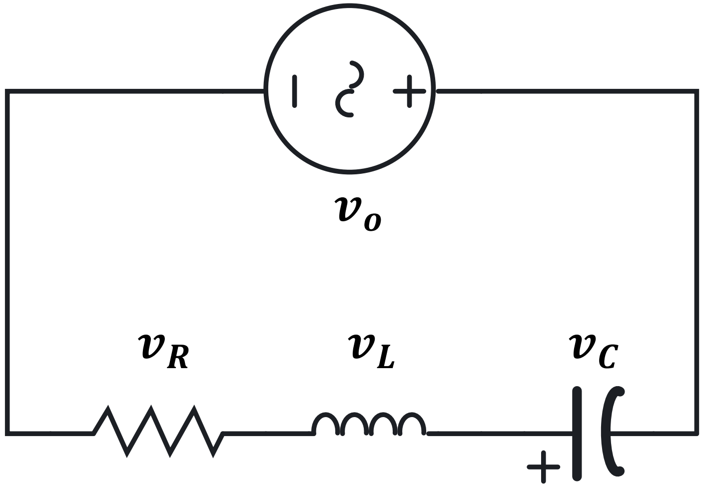
$$v_o = v_R + j(v_L - v_C)$$

Voltage Phasor Diagram



SERIES R-L-C CIRCUIT

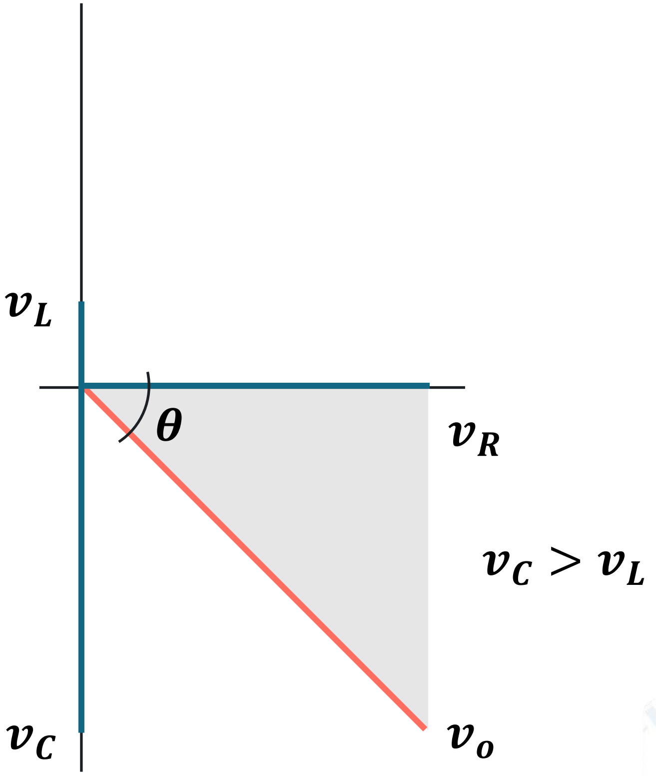
Circuit Diagram



Formula

$$v_o = v_R + j(v_L - v_C)$$

Voltage Phasor Diagram



EXERCISE

A series circuit consisting an $\mathbf{80\ \Omega}$ resistor, a $\boldsymbol{0.3\ H}$ inductor, and a $\boldsymbol{50\ \mu F}$ capacitor is connected to a $\boldsymbol{120\ V}$, $\boldsymbol{60\ Hz}$ source.

Solution

Determine the following:

a. Equivalent impedance $(\boldsymbol{Z})$

b. Total current $(\boldsymbol{i_o})$

c. Voltage drop across the resistor $(\boldsymbol{v_R})$

d. Voltage drop across the capacitor $(\boldsymbol{v_C})$

e. Voltage drop across the inductor $(\boldsymbol{v_L})$

POWER FACTOR

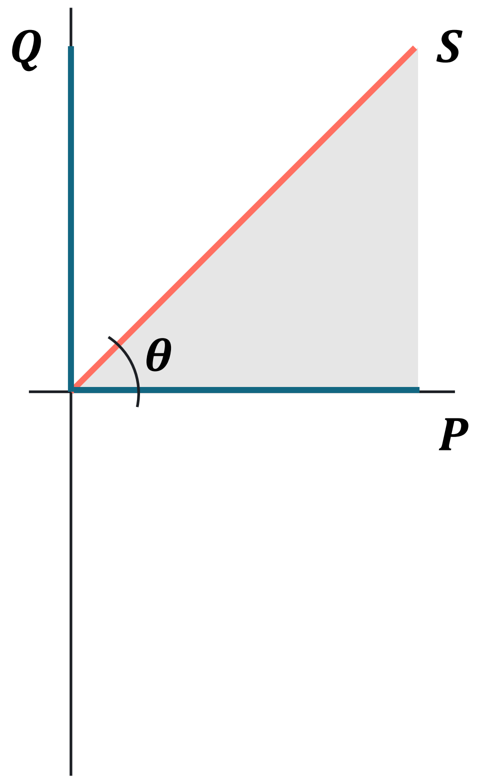
POWER FACTOR

The **power factor** $(\cos\theta)$ represents the ratio of true power to apparent power.

Formula

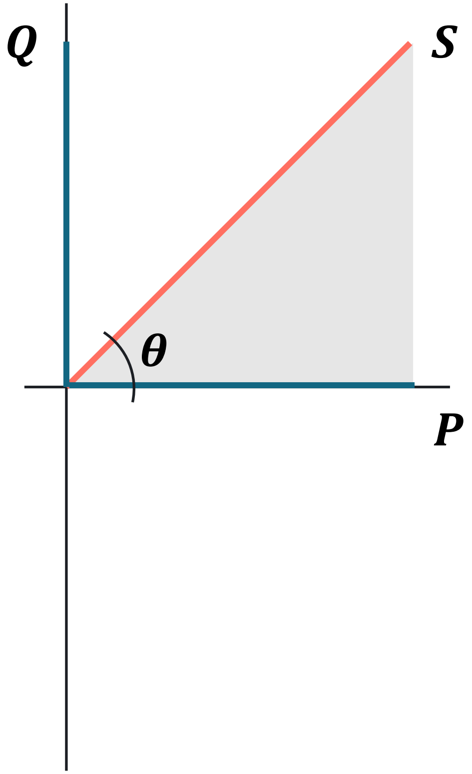
$$\cos\theta = \frac{P}{S}$$

Power Triangle



TRUE POWER

Power Triangle



The **true power** (P) is the **actual power** consumed by resistive components of a circuit.

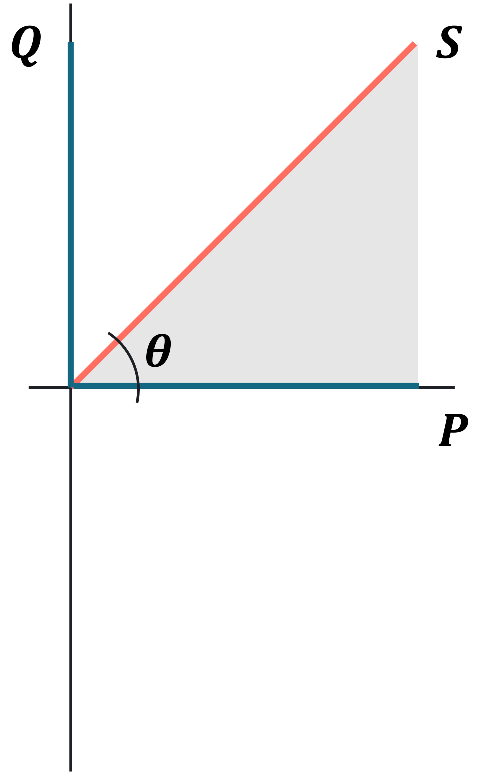
Formula

$$P = vi\cos\theta$$

unit: Watt (W)

REACTIVE POWER

Power Triangle



The **reactive power** (Q) is the power consumed by **inductive** or **capacitive** components of a circuit.

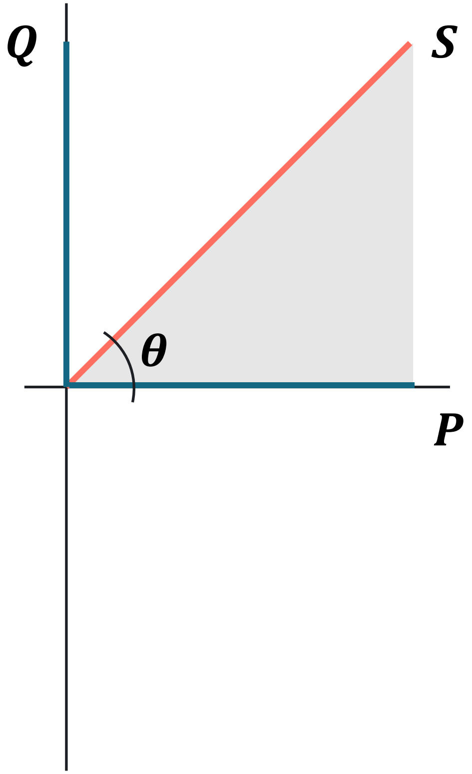
Formula

$$Q = vi \sin\theta$$

unit: Volt-Ampere Reactive (VAR)

APPARENT POWER

Power Triangle



The **apparent power** (S) is the vector sum of true power and reactive power, representing the **total power** supplied by the source.

Formula

$$S = P + jQ$$

$$S = vi$$

unit: Volt-Ampere (VA)

EXERCISE

A series circuit consisting an $\mathbf{80\ \Omega}$ resistor, a $\mathbf{0.3\ H}$ inductor, and a $\mathbf{50\ \mu F}$ capacitor is connected to a $\mathbf{120\ V}$, $\mathbf{60\ Hz}$ source.

Solution

Determine the following:

a. Power factor $(\mathbf{\cos\theta})$

b. True power $(\boldsymbol{P})$

c. Reactive power $(\boldsymbol{Q})$

d. Apparent power $(\boldsymbol{S})$

LABORATORY