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

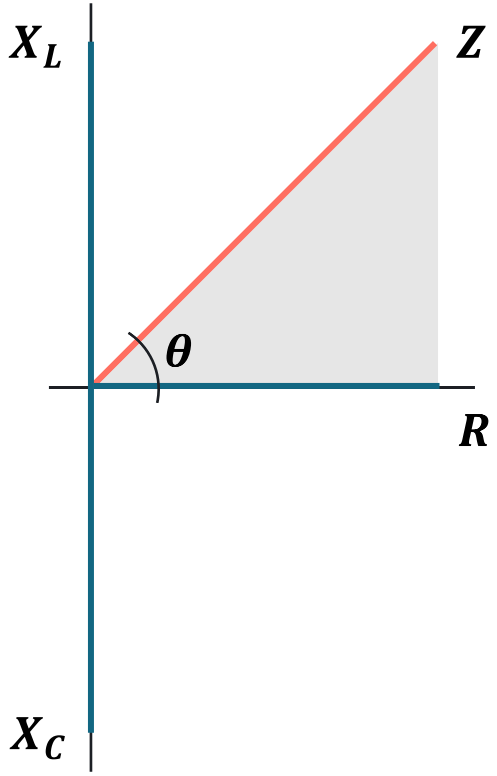
Power Factor

PHASOR DIAGRAM

PHASOR DIAGRAM

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

Phasor Diagram:



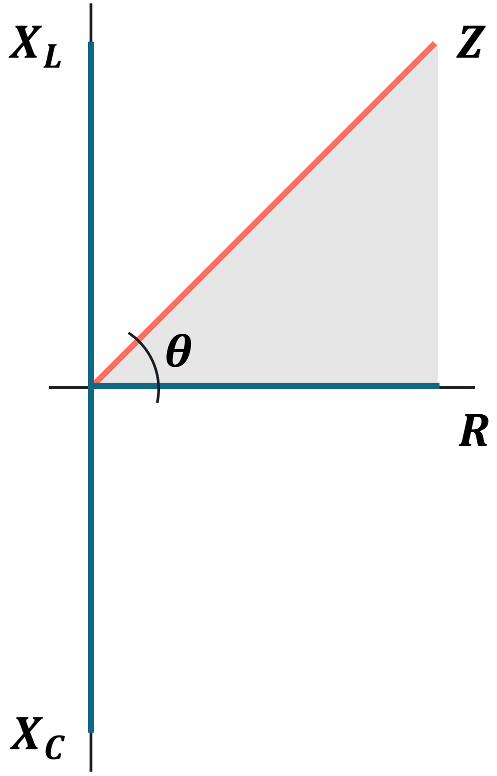
IMPEDANCE

The **impedance** $\boldsymbol{Z}$ 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

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

Formula:

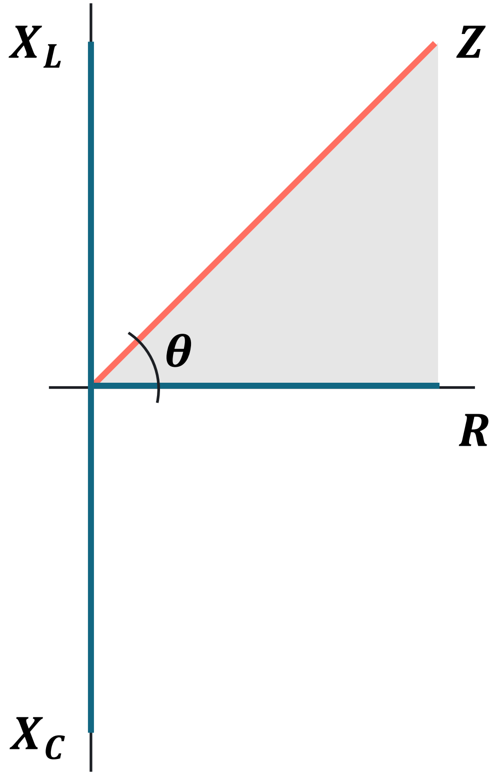
$$X_L = 2\pi f L$$

where:

f = frequency (Hz)

L = inductance (H)

Phasor Diagram:



CAPACITIVE REACTANCE

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

Formula:

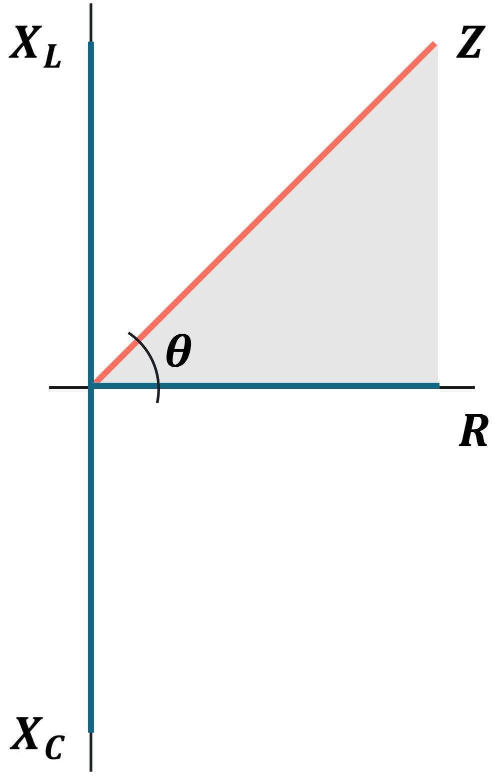
$$X_C = \frac{1}{2\pi f C}$$

where:

f = frequency (Hz)

C = capacitance (F)

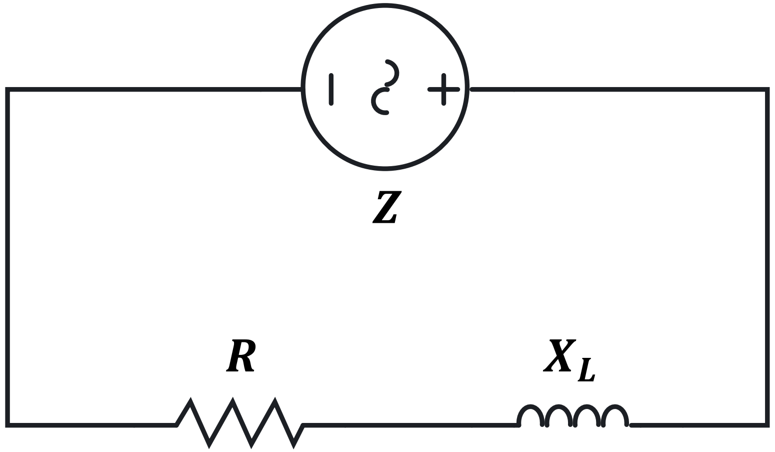
Phasor Diagram:



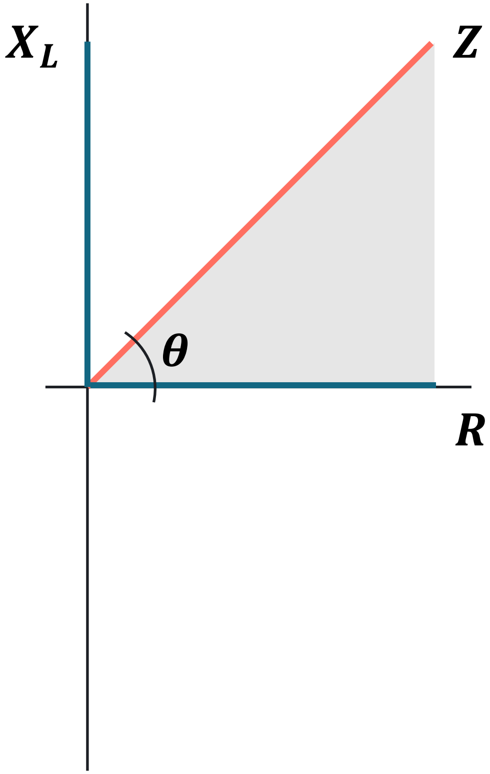
SERIES R-L CIRCUIT

SERIES R-L CIRCUIT

Circuit Diagram:



Impedance Phasor Diagram:

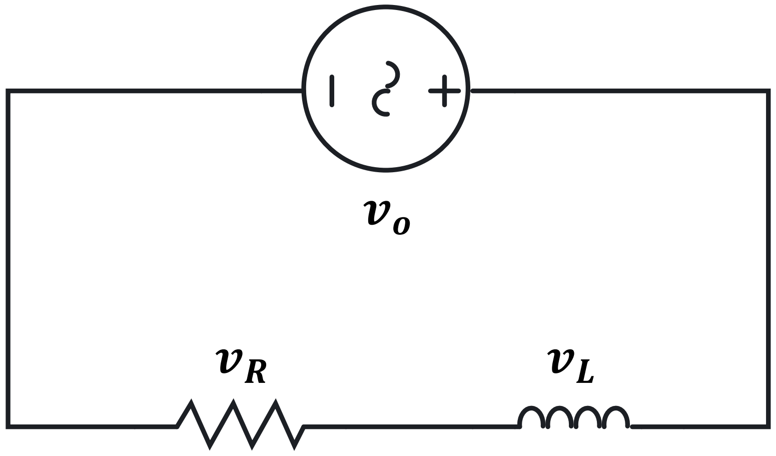


Formula:

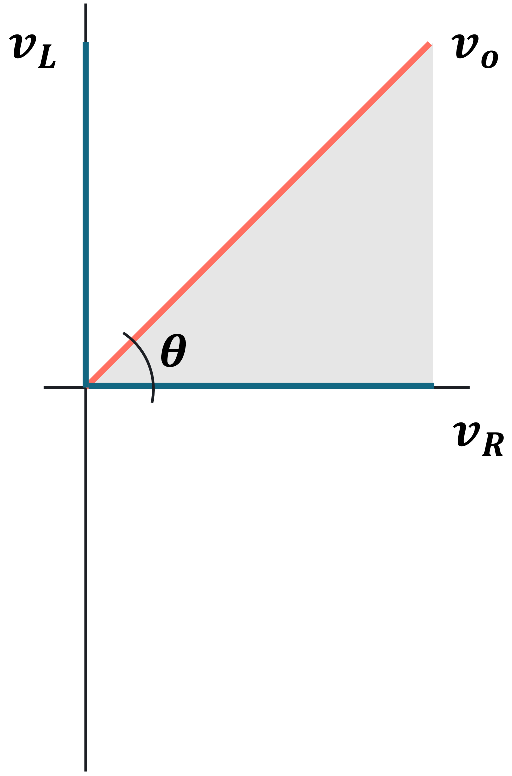
$$Z = R + jX_L$$

SERIES R-L CIRCUIT

Circuit Diagram:



Voltage Phasor Diagram:

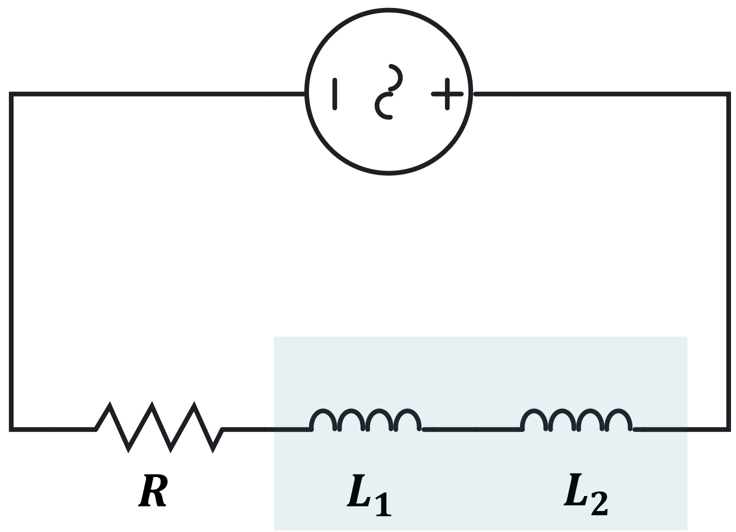


Formula:

$$v_o = v_R + jv_L$$

TOTAL INDUCTANCE

Series network:



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

Formula:

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

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 $\mathbf{0.0477}\ \boldsymbol{H}$.

Determine the following:

a. Impedance $\boldsymbol{Z}$

b. Total current $\boldsymbol{i_o}$

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

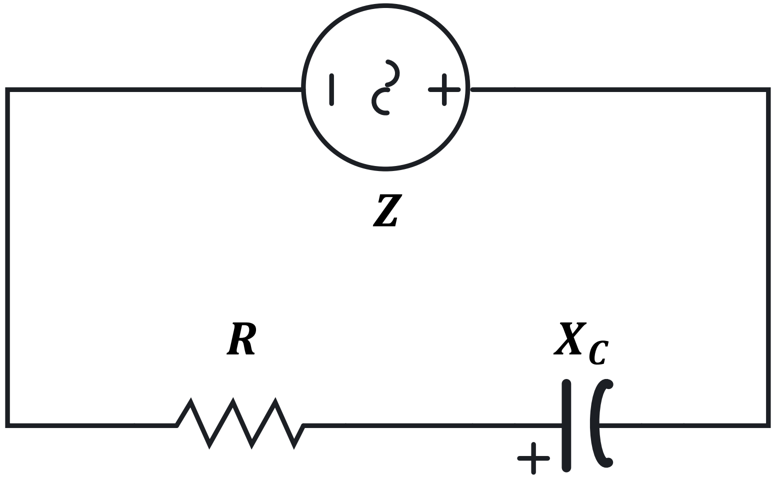
d. Voltage across the inductor $\boldsymbol{v_L}$

<u>Solution:</u>

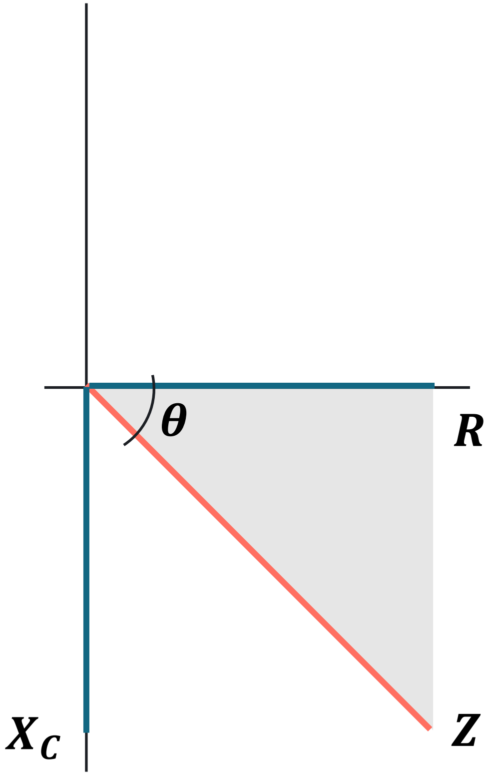
SERIES R-C CIRCUIT

SERIES R-C CIRCUIT

Circuit Diagram:



Impedance Phasor Diagram:

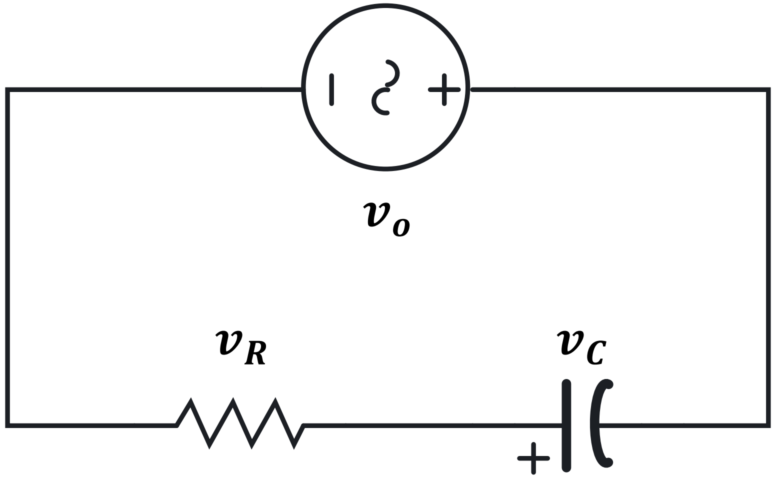


Formula:

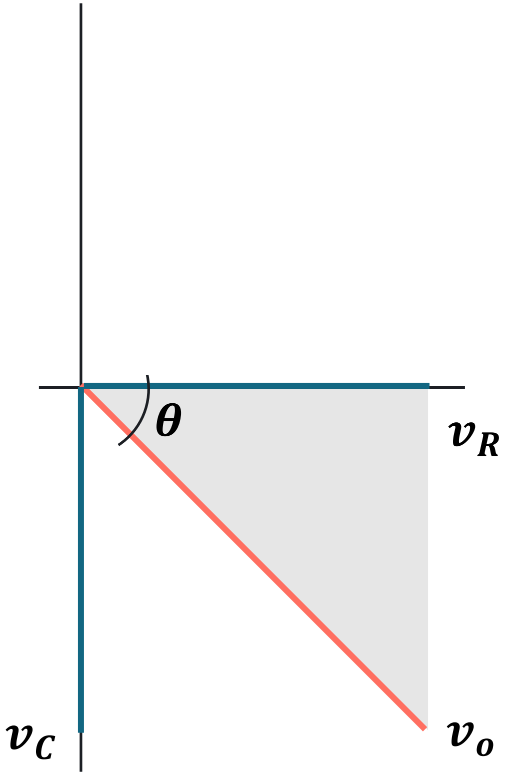
$$Z = R + jX_C$$

SERIES R-C CIRCUIT

Circuit Diagram:



Voltage Phasor Diagram:



Formula:

$$v_o = v_R + j v_C$$

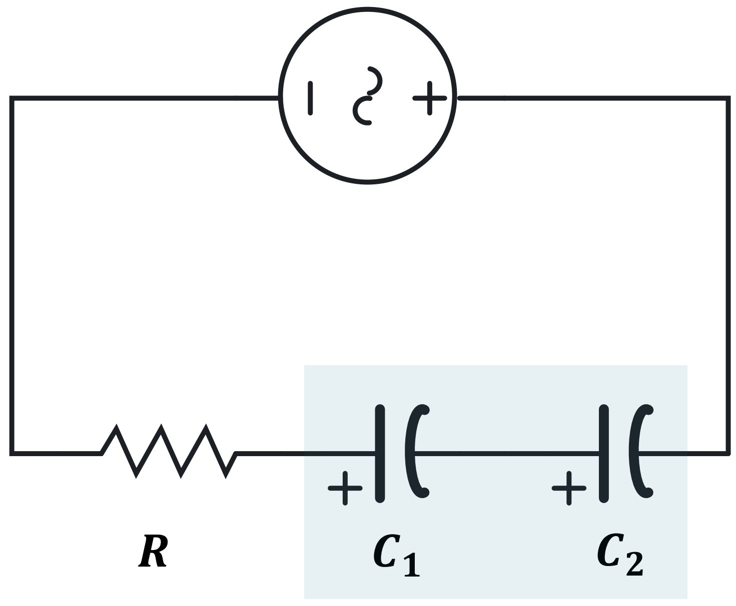
TOTAL CAPACITANCE

In a series circuit, the **total capacitance** $\boldsymbol{C_o}$ is analogous to total resistance in parallel circuit.

Formula:

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

Series network:



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.

Determine the following:

a. Impedance $\boldsymbol{Z}$

b. Total current $\boldsymbol{i_o}$

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

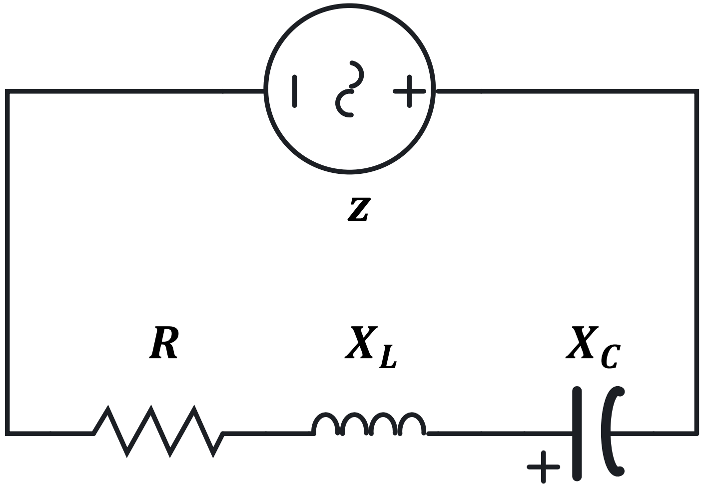
d. Voltage across the capacitor $\boldsymbol{v_C}$

Solution:

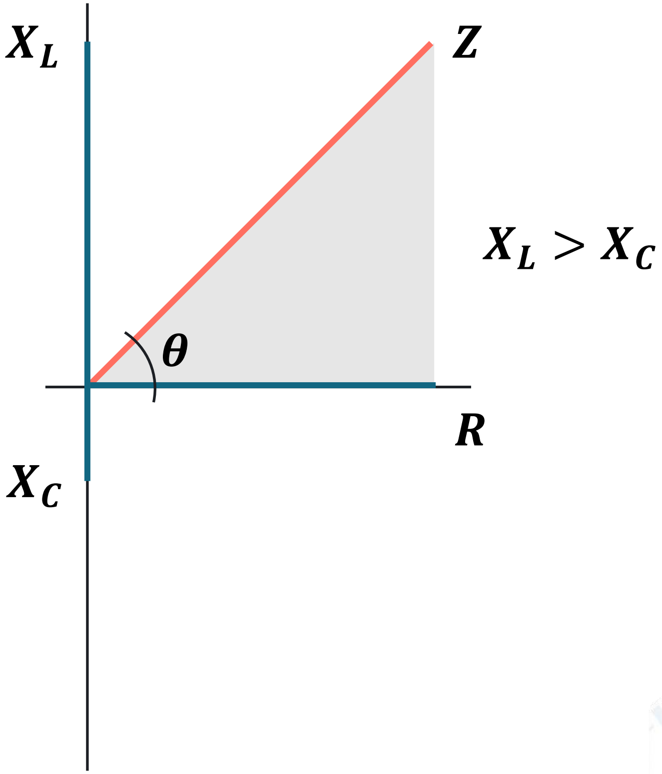
SERIES R-L-C CIRCUIT

SERIES R-L-C CIRCUIT

Circuit Diagram:



Impedance Phasor Diagram:

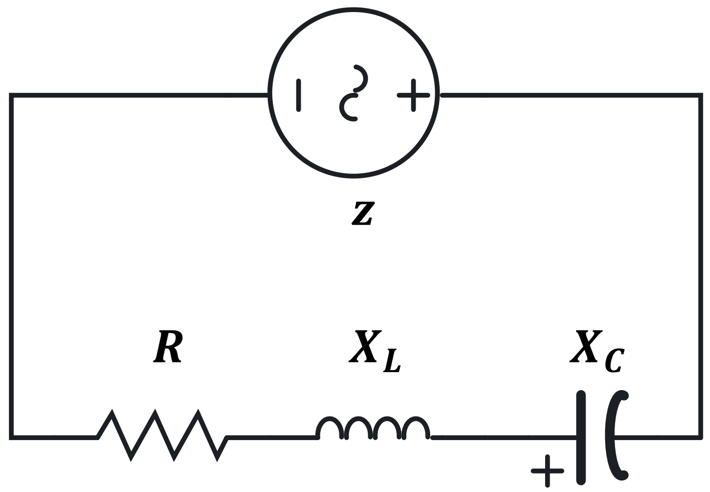


Formula:

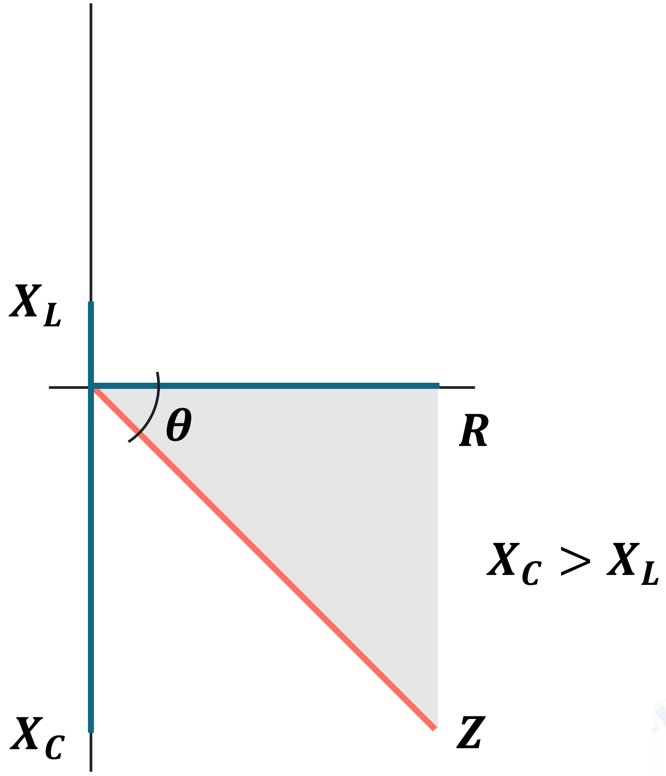
$$Z = R + j(X_L - X_C)$$

SERIES R-L-C CIRCUIT

Circuit Diagram:



Impedance Phasor Diagram:

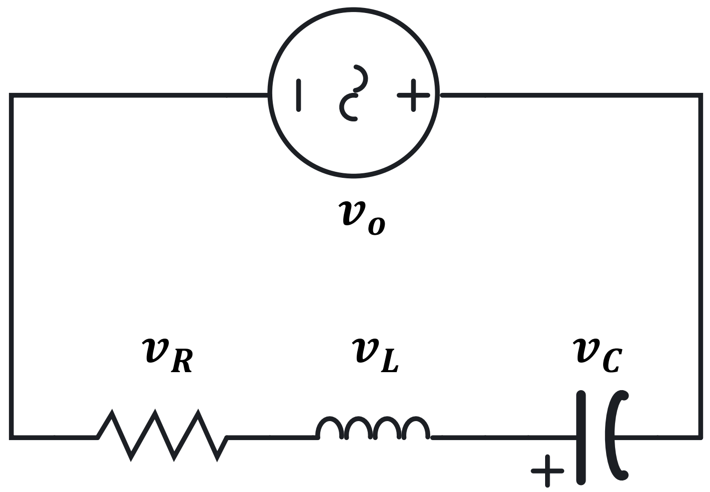


Formula:

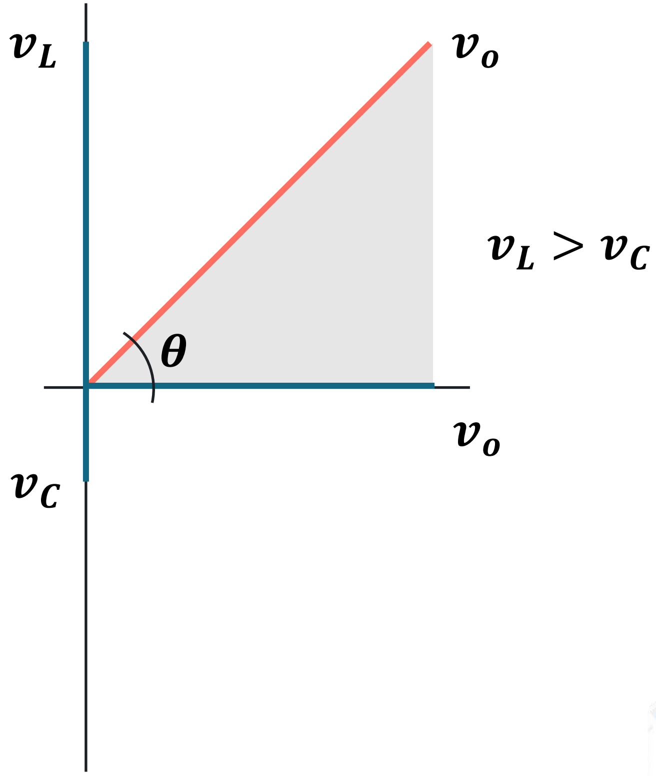
$$Z = R + j(X_L - X_C)$$

SERIES R-L-C CIRCUIT

Circuit Diagram:



Voltage Phasor Diagram:

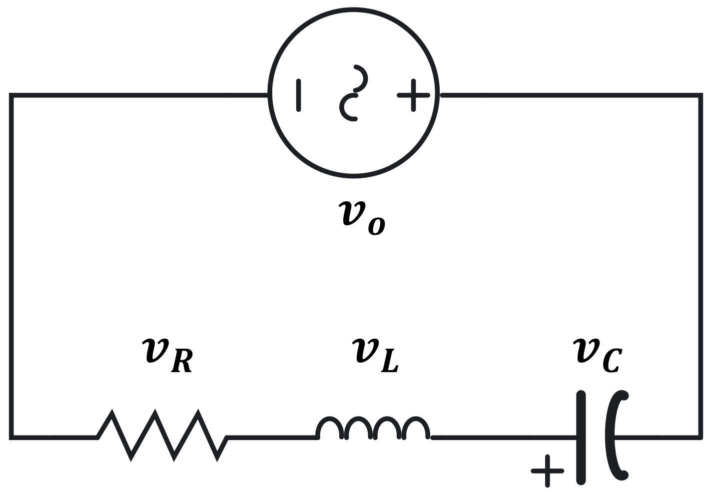


Formula:

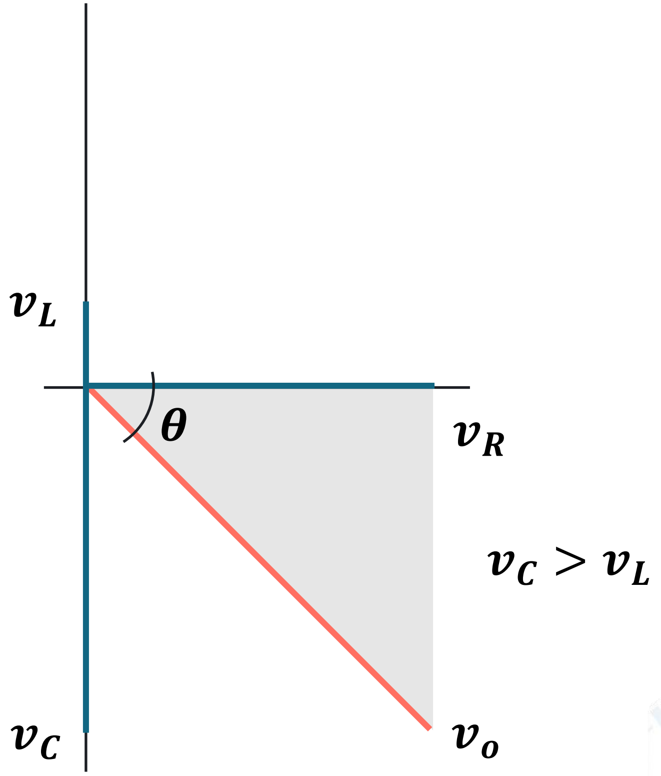
$$v_o = v_R + j(v_L - v_C)$$

SERIES R-L-C CIRCUIT

Circuit Diagram:



Voltage Phasor Diagram:



Formula:

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

EXERCISE

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

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 $\boldsymbol{v_L}$

Solution:

EXERCISE

A series circuit consisting of a $\mathbf{30\ \mu F}$ capacitor, and a $\mathbf{0.155\ H}$ inductor is connected to a $\mathbf{120\ V}$ $\mathbf{60\ Hz}$ source. Calculate the circuit **current** and indicate whether it **lags** or **leads** the voltage.

Solution:

EXERCISE

If a variable **inductor** is substituted for the one in the previous problem, what should be its value if an **equal current** is to **lag** behind the voltage? Assume all other conditions to remain unchanged.

Solution:

POWER FACTOR

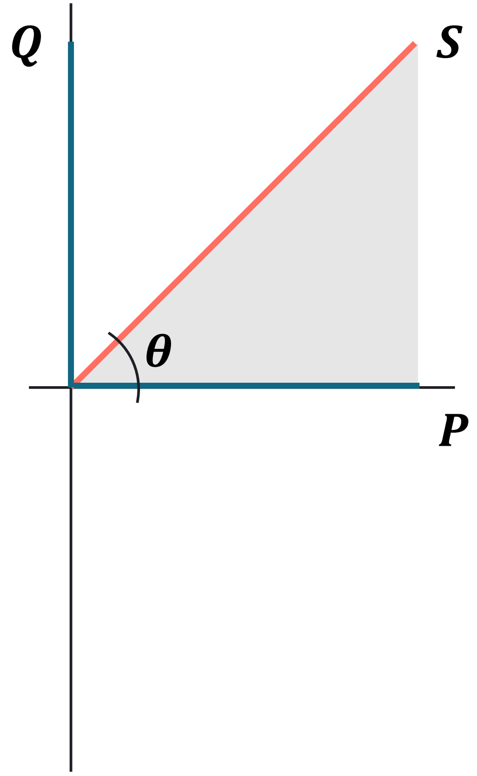
POWER FACTOR

The **power factor** represents the ratio of true power to apparent power.

Formula:

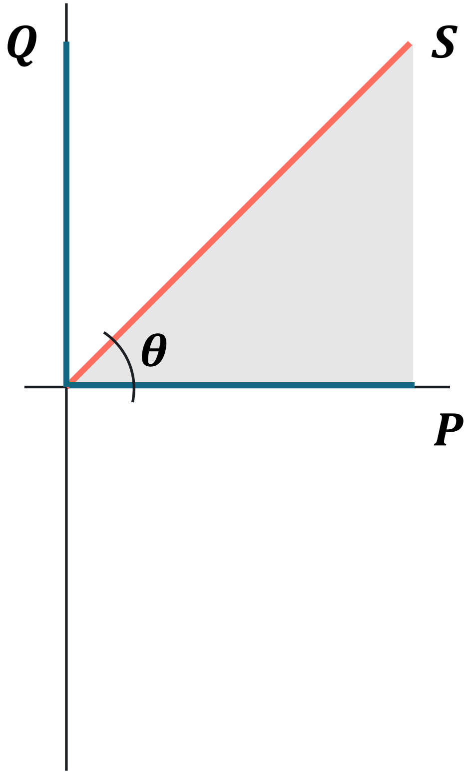
$$\cos\theta = \frac{P}{S}$$

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

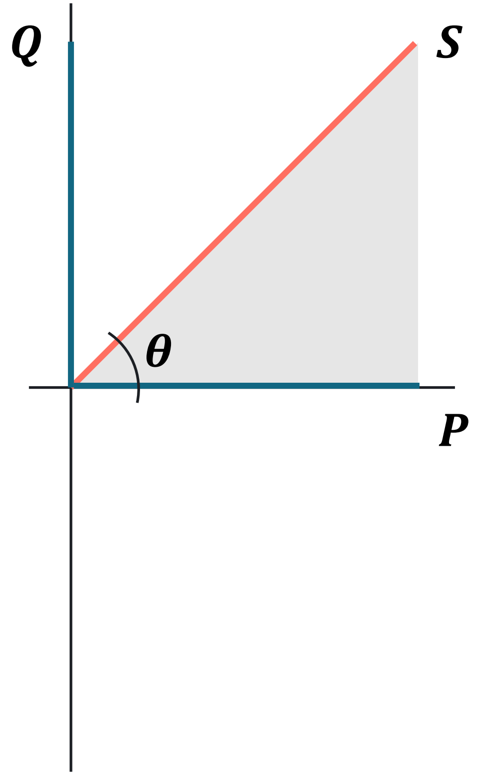
The **reactive power** $\boldsymbol{Q}$ is the power consumed by **inductive** or **capacitive** components of a circuit.

Formula:

$$Q = vi \sin\theta$$

unit: Volt-Ampere Reactive (VAR)

Power Triangle:



APPARENT POWER

The **apparent power** $\boldsymbol{S}$ is the vector sum of true power and reactive power, representing the **total power** supplied by the source.

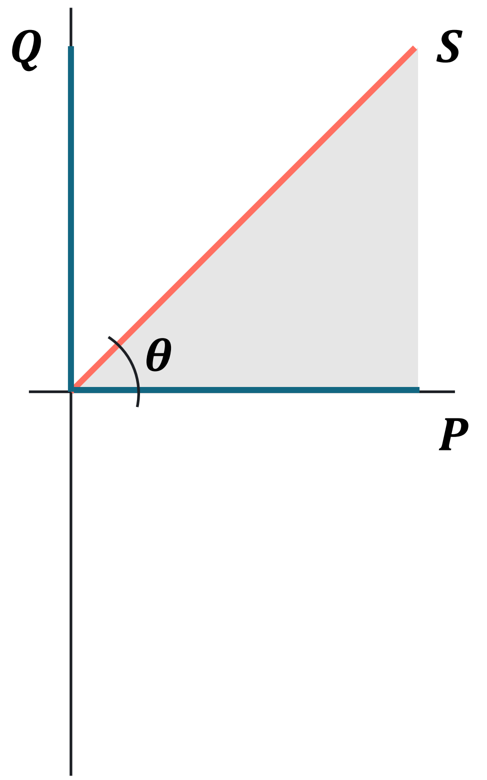
Formula:

$$S = P + jQ$$

$$S = vi$$

unit: Volt-Ampere (VA)

Power Triangle:



EXERCISE

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

Determine the following:

a. Power factor $\mathbf{cos}\,\boldsymbol{\theta}$

b. True power $\boldsymbol{P}$

c. Reactive power $\boldsymbol{Q}$

d. Apparent power $\boldsymbol{S}$

<u>Solution:</u>

LABORATORY