



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



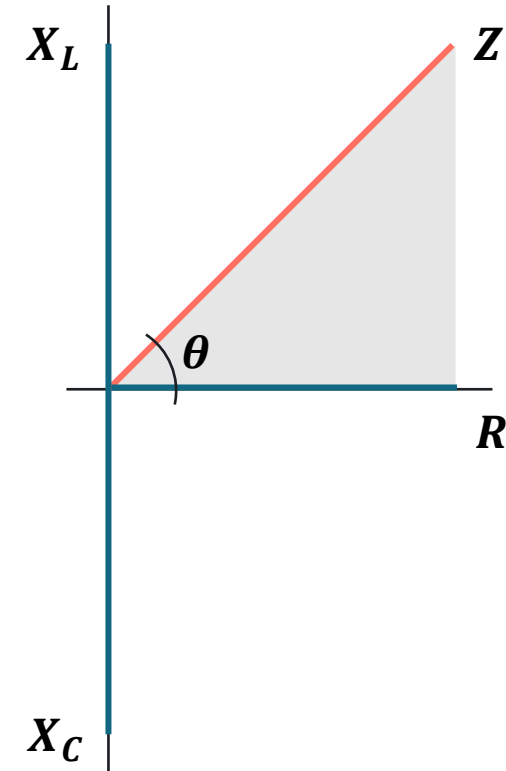
PHASOR DIAGRAM



PHASOR DIAGRAM

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

Phasor Diagram:



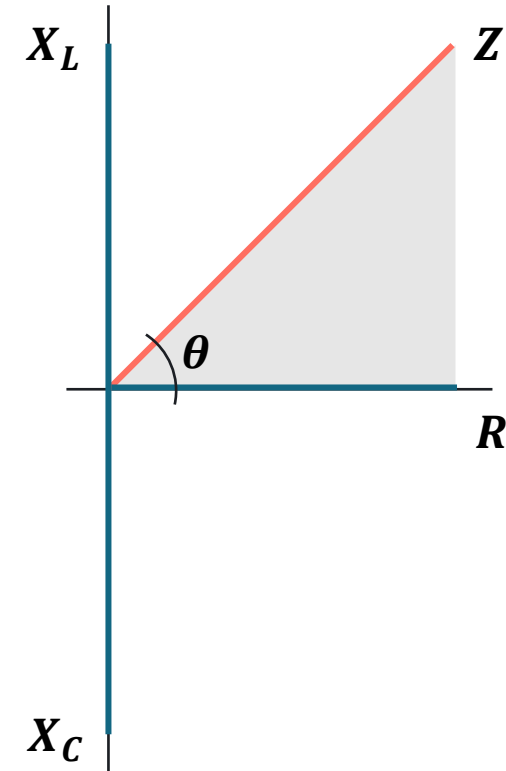
IMPEDANCE

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

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

Formula:

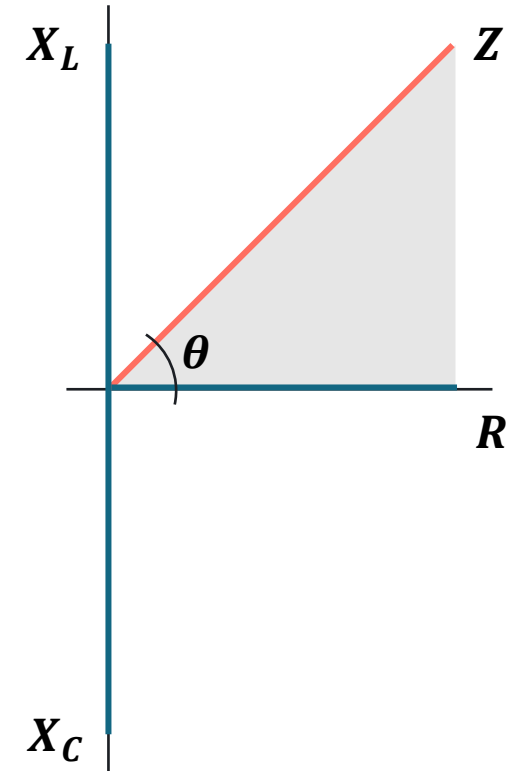
$$X_L = 2\pi fL$$

where:

f = frequency (Hz)

L = inductance (H)

Phasor Diagram:



CAPACITIVE REACTANCE

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

Formula:

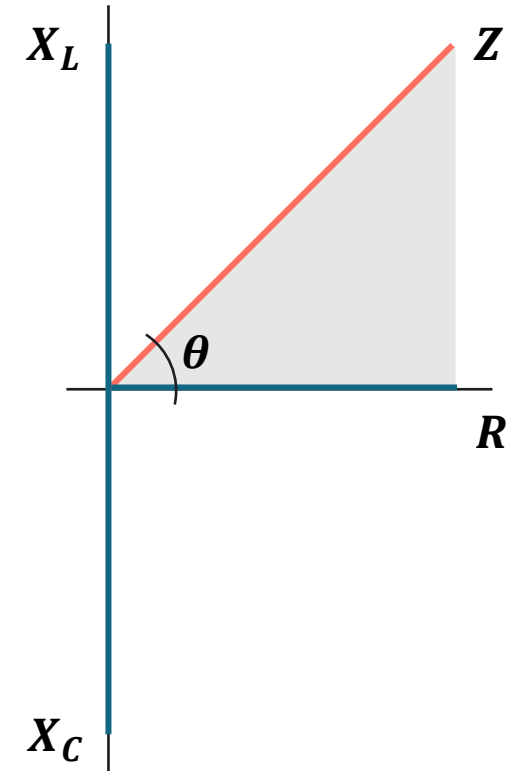
$$X_C = \frac{1}{2\pi f C}$$

where:

f = frequency (Hz)

C = capacitance (F)

Phasor Diagram:

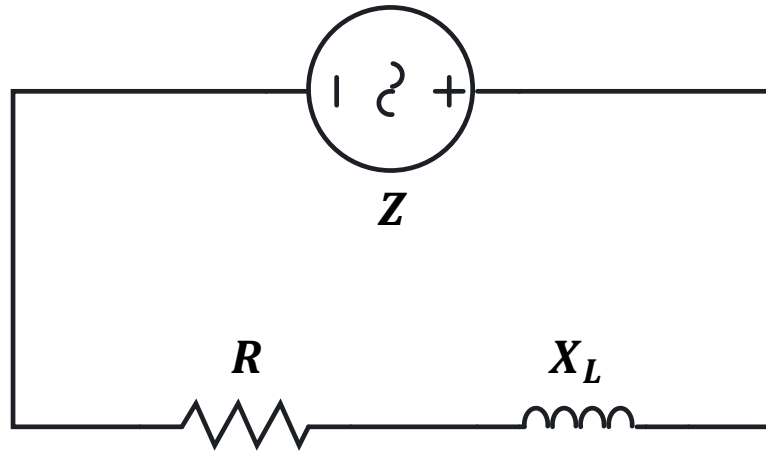


SERIES R-L CIRCUIT



SERIES R-L CIRCUIT

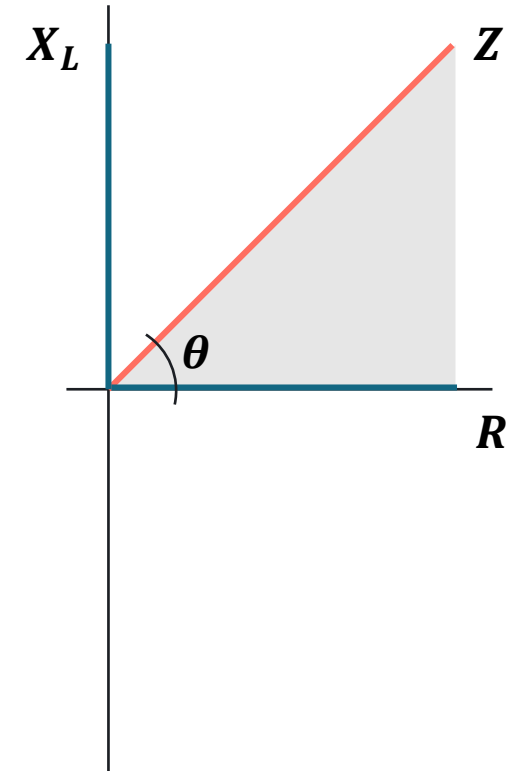
Circuit Diagram:



Formula:

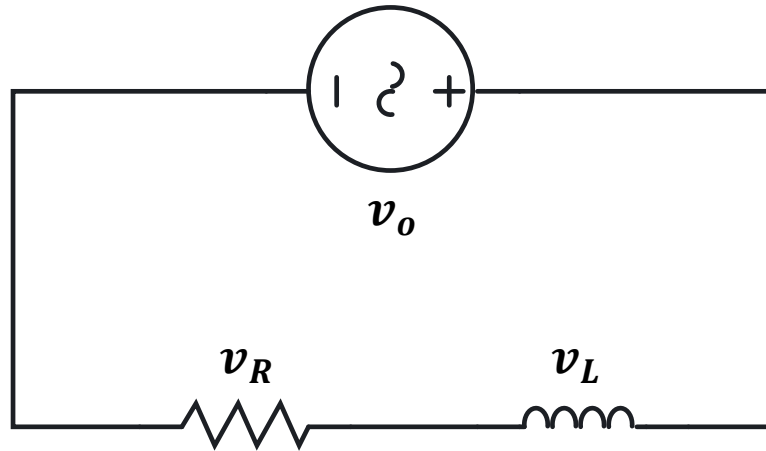
$$Z = R + jX_L$$

Impedance Phasor Diagram:



SERIES R-L CIRCUIT

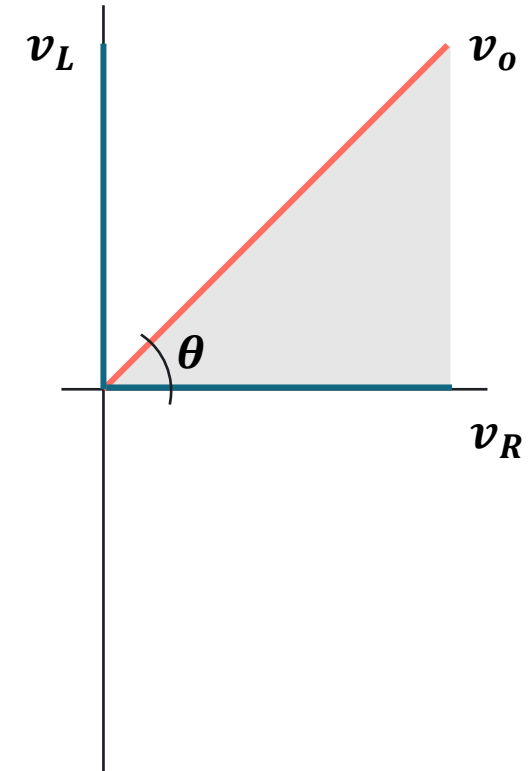
Circuit Diagram:



Formula:

$$v_o = v_R + jv_L$$

Voltage Phasor Diagram:



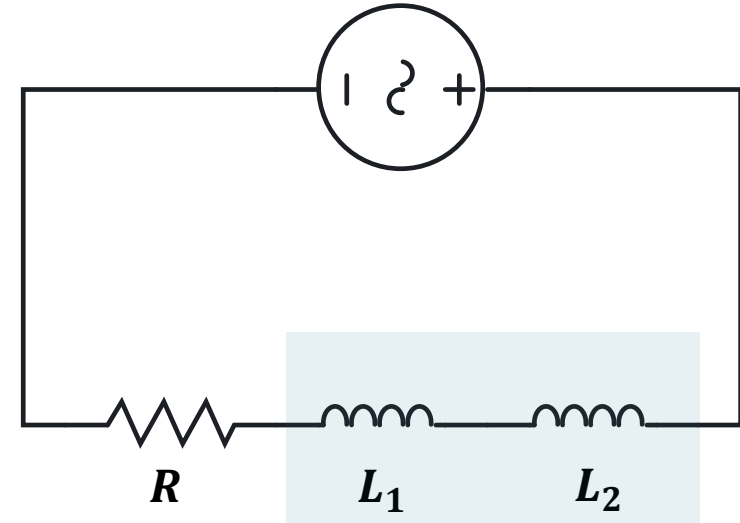
TOTAL INDUCTANCE

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 **240 V, 60 Hz** source is connected to a coil of wire that has a resistance of **7.5 Ω** and an inductance of **0.0477 H**.

Determine the following:

- a. Impedance **Z**
- b. Total current **i_o**
- c. Voltage across the resistor **v_R**
- d. Voltage across the inductor **v_L**

Solution:

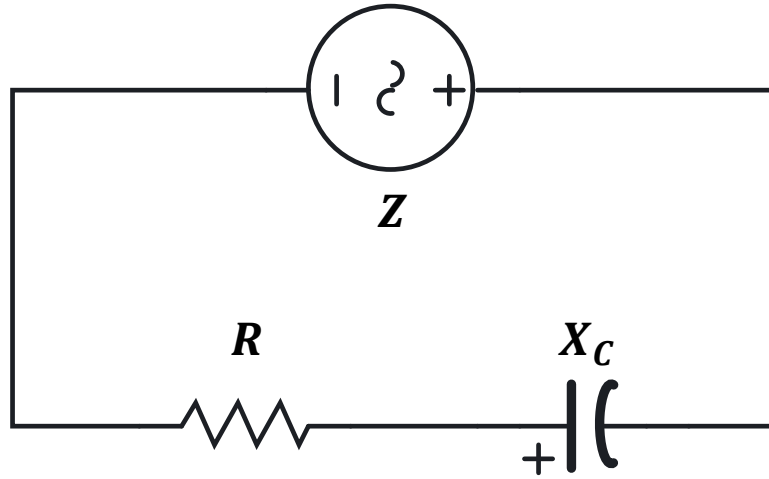


SERIES R-C CIRCUIT



SERIES R-C CIRCUIT

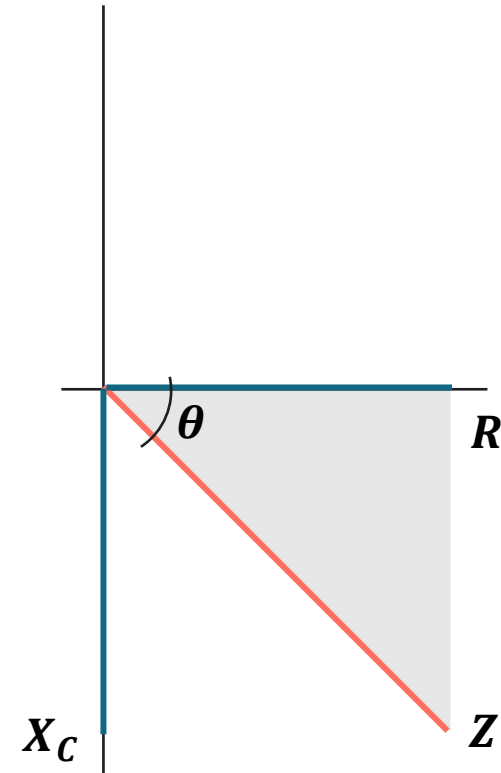
Circuit Diagram:



Formula:

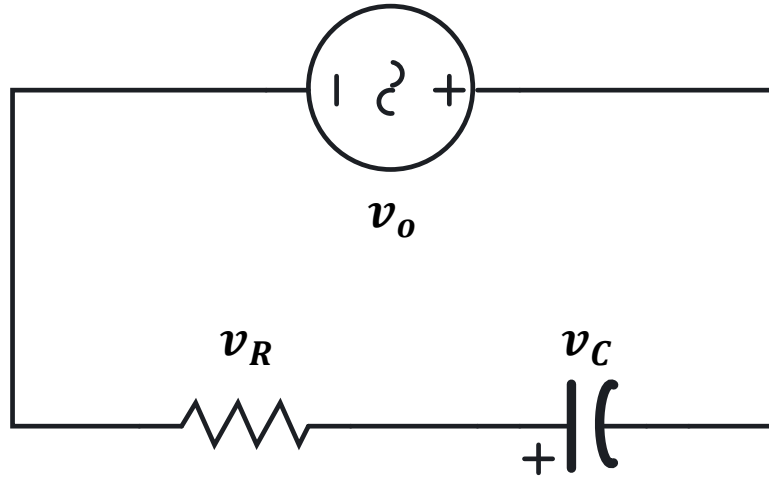
$$Z = R + jX_C$$

Impedance Phasor Diagram:



SERIES R-C CIRCUIT

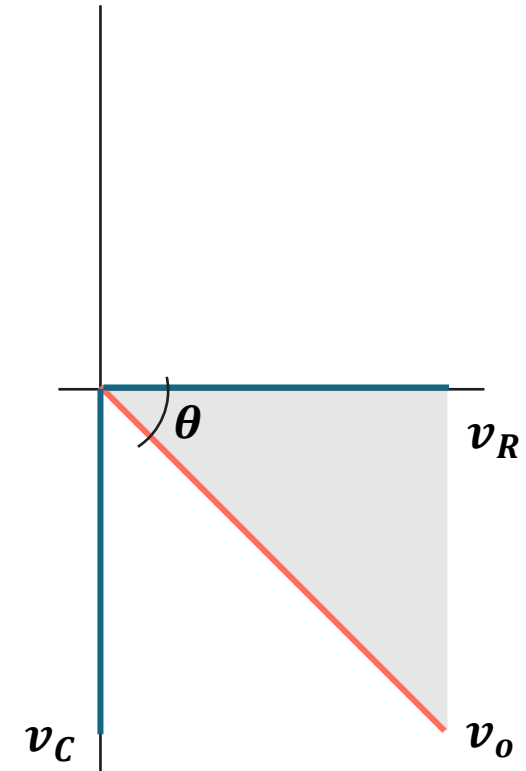
Circuit Diagram:



Formula:

$$v_o = v_R + jv_C$$

Voltage Phasor Diagram:



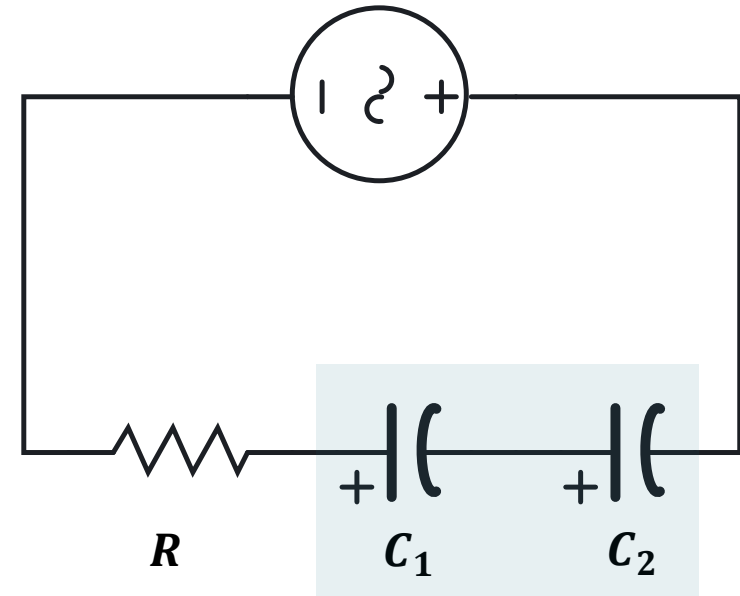
TOTAL CAPACITANCE

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

Formula:

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

Series network:



EXERCISE

A **125 V**, **25 Hz** source is connected to a series circuit consisting of a **30 Ω** and a **159 μF** capacitor.

Determine the following:

- a. Impedance **Z**
- b. Total current **i_o**
- c. Voltage across the resistor **v_R**
- d. Voltage across the capacitor **v_C**

Solution:

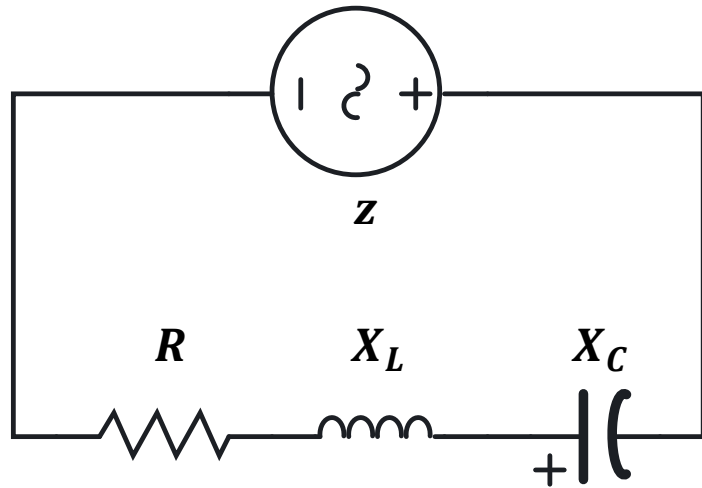


SERIES R-L-C CIRCUIT



SERIES R-L-C CIRCUIT

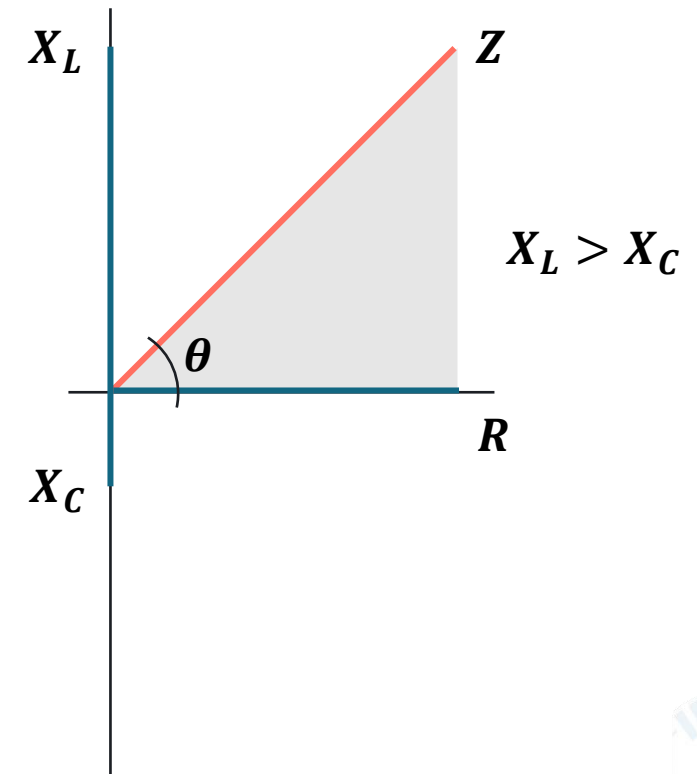
Circuit Diagram:



Formula:

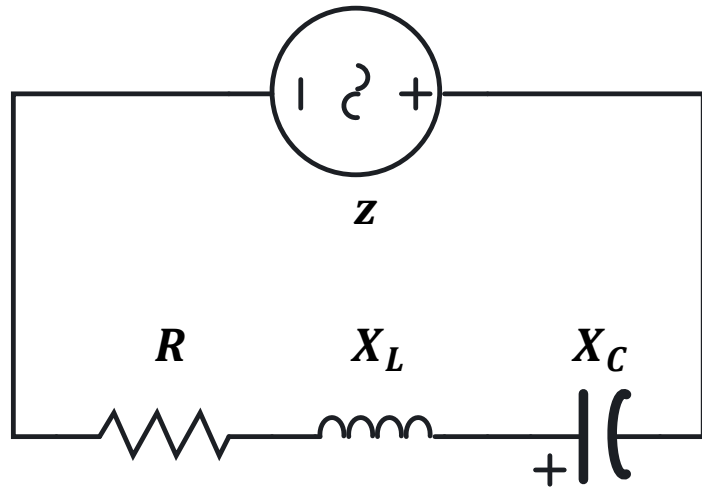
$$Z = R + j(X_L - X_C)$$

Impedance Phasor Diagram:



SERIES R-L-C CIRCUIT

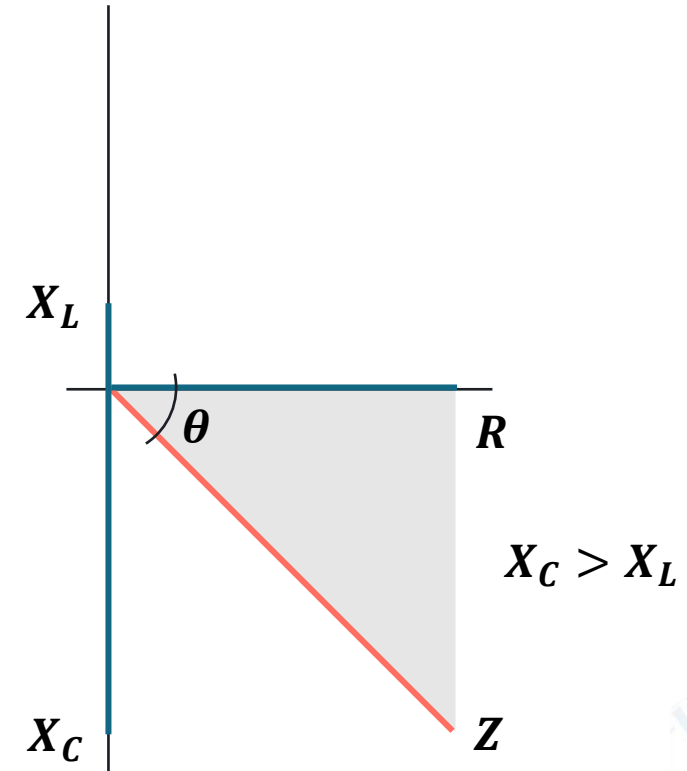
Circuit Diagram:



Formula:

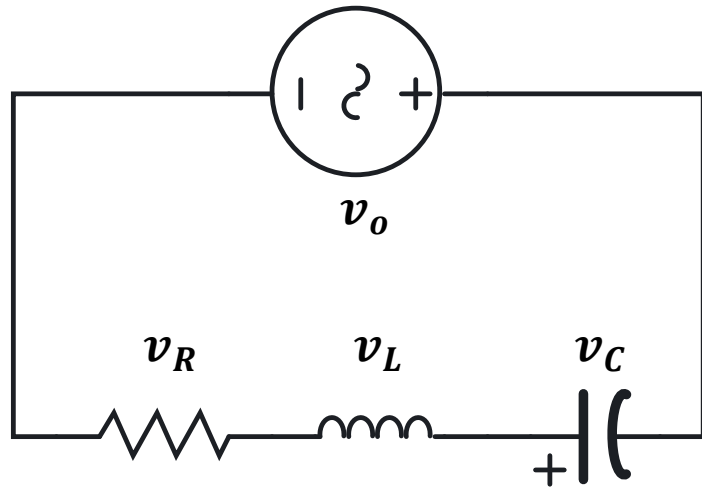
$$Z = R + j(X_L - X_C)$$

Impedance Phasor Diagram:



SERIES R-L-C CIRCUIT

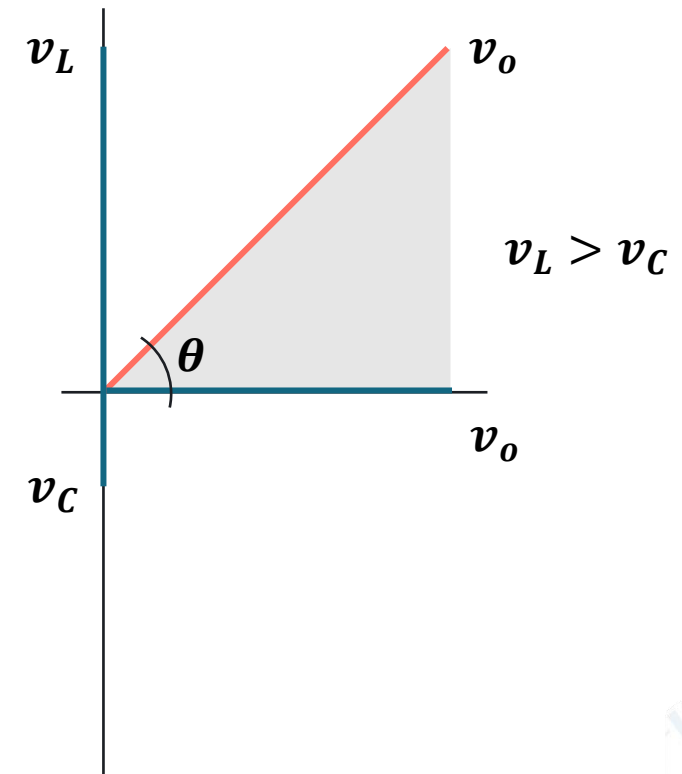
Circuit Diagram:



Formula:

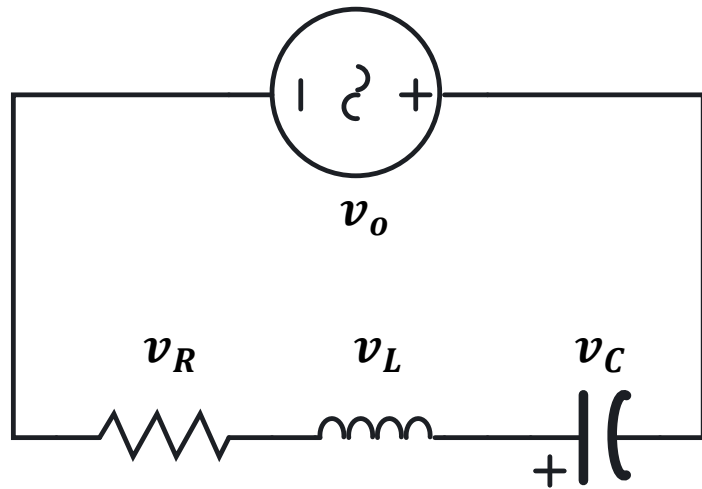
$$v_o = v_R + j(v_L - v_C)$$

Voltage Phasor Diagram:



SERIES R-L-C CIRCUIT

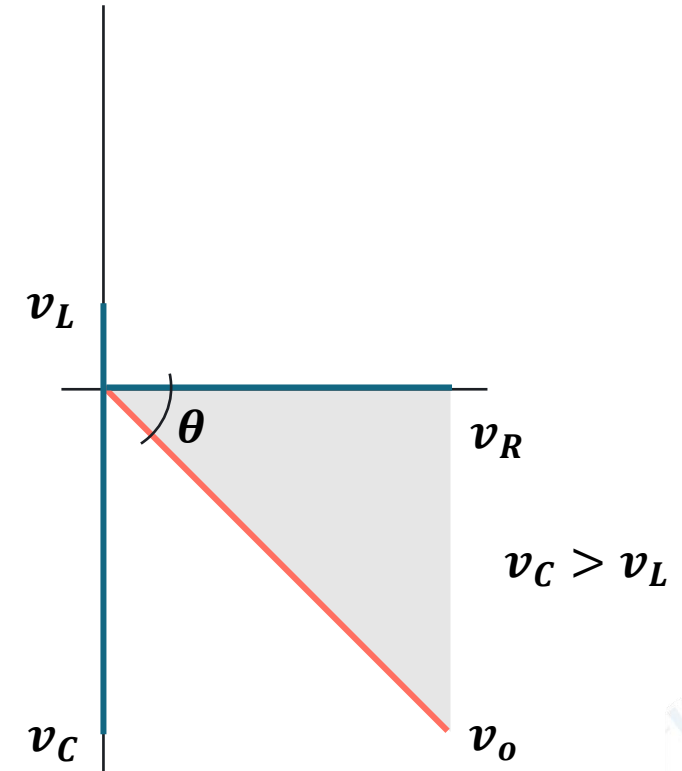
Circuit Diagram:



Formula:

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

Voltage Phasor Diagram:



EXERCISE

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

Determine the following:

- a. Equivalent impedance **Z**
- b. Total current **i_o**
- c. Voltage drop across the resistor **v_R**
- d. Voltage drop across the capacitor **v_C**
- e. Voltage drop across the inductor **v_L**

Solution:



EXERCISE

A series circuit consisting of a **$30\ \mu\text{F}$** capacitor, and a **$0.155\ \text{H}$** inductor is connected to a **$120\ \text{V}$** **$60\ \text{Hz}$** 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



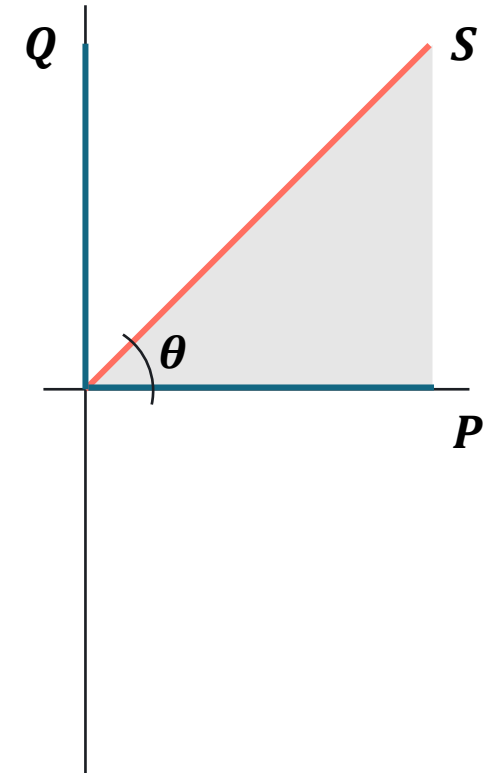
POWER FACTOR

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

Formula:

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

Power Triangle:



TRUE POWER

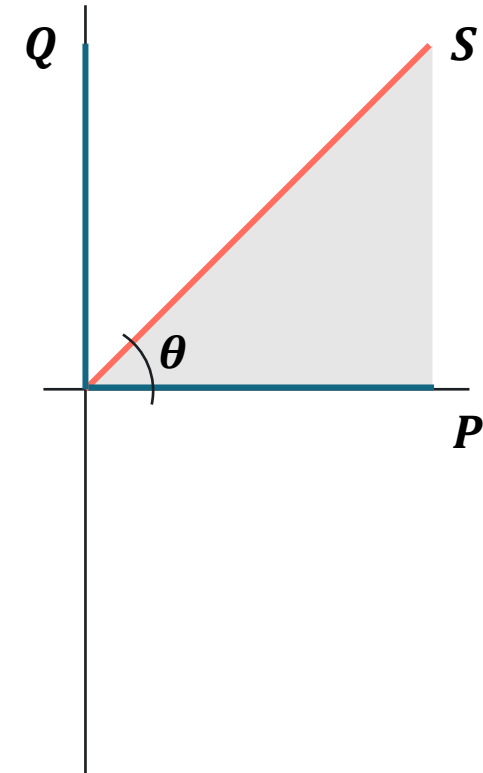
The true power P is the actual power consumed by resistive components of a circuit.

Formula:

$$P = vi \cos \theta$$

unit: Watt (W)

Power Triangle:



REACTIVE POWER

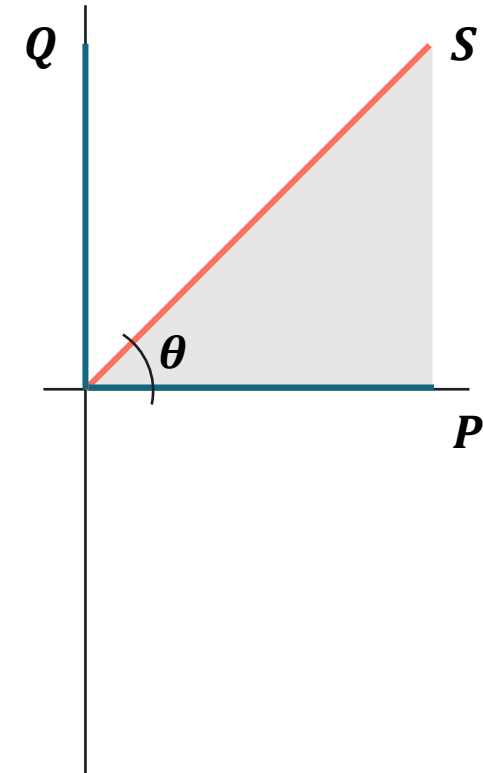
The reactive power Q is the power consumed by inductive or capacitive components of a circuit.

Formula:

$$Q = vi \sin \theta$$

unit: Volt-Ampere Reactive (VAR)

Power Triangle:



APPARENT POWER

Power Triangle:

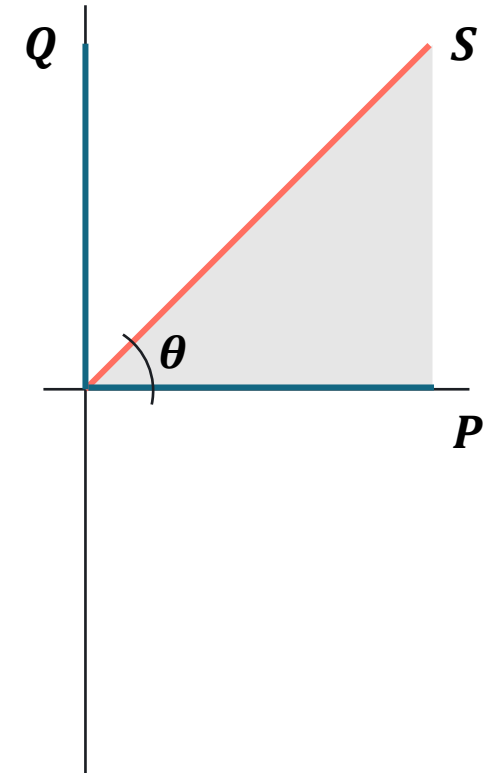
The apparent power S is the vector sum of true power and reactive power, representing the total power supplied by the source.

Formula:

$$S = P + jQ$$

$$S = vi$$

unit: Volt-Ampere (VA)



EXERCISE

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

Determine the following:

- a. Power factor **$\cos \theta$**
- b. True power **P**
- c. Reactive power **Q**
- d. Apparent power **S**

Solution:



LABORATORY

