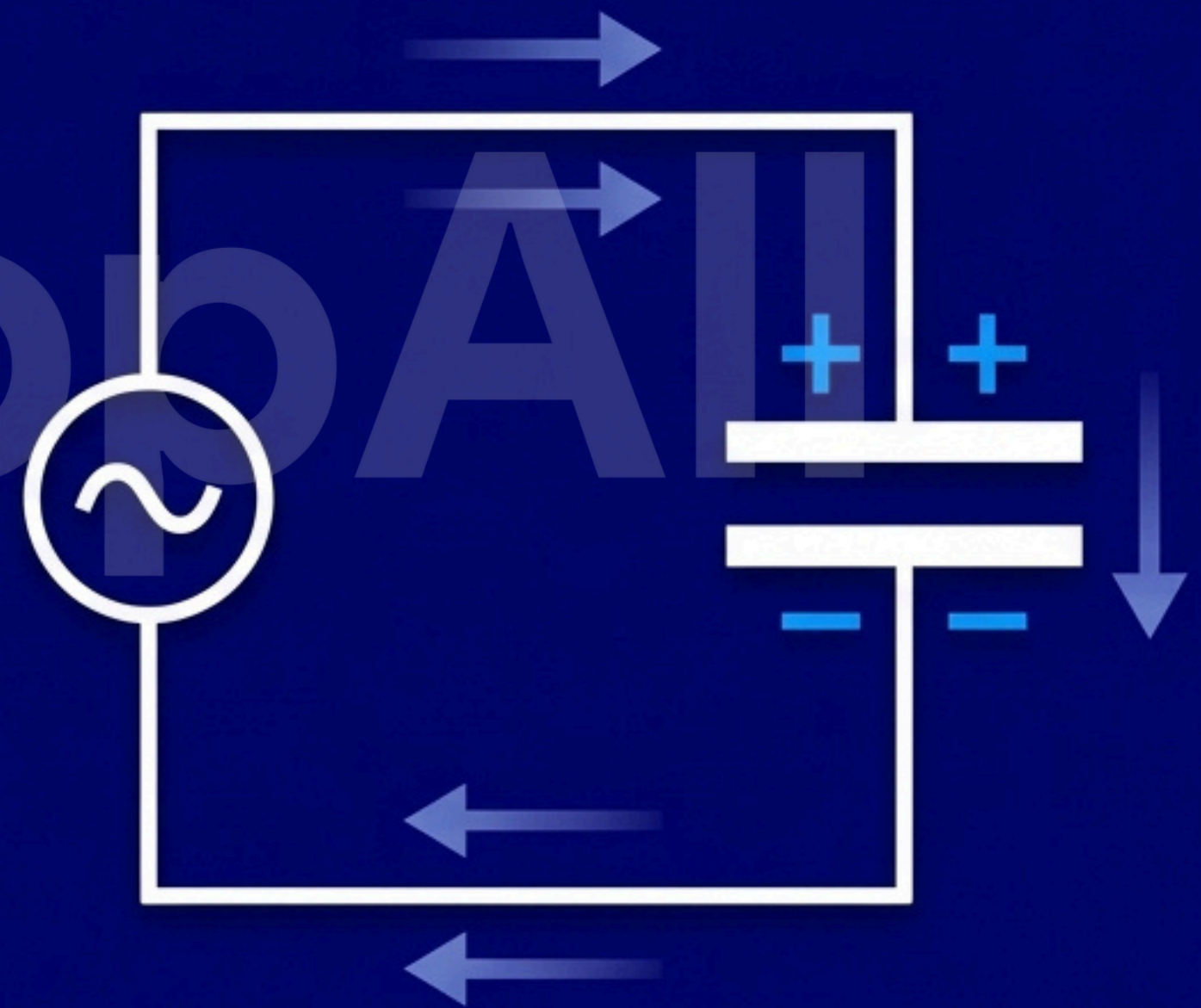


AC Voltage Applied to a Capacitor

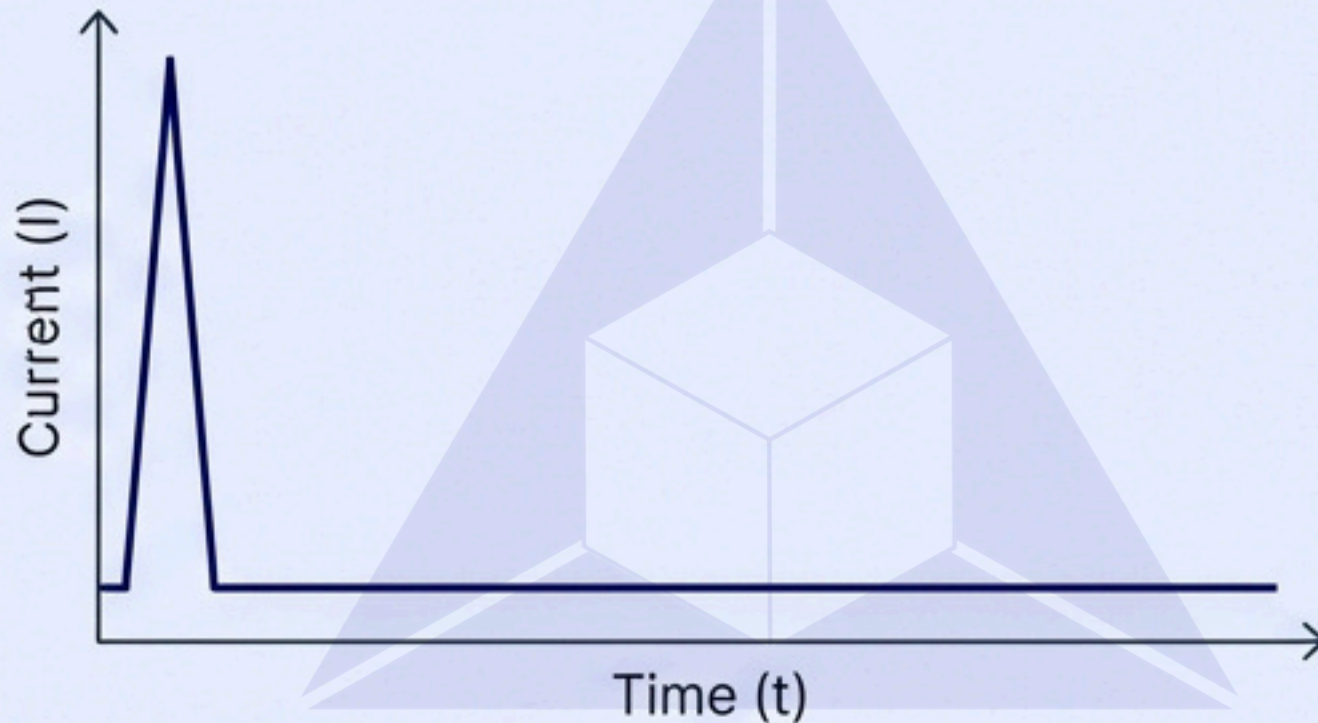
Understanding Phase, Reactance, and Phasor Diagrams

NEET / JEE PREP



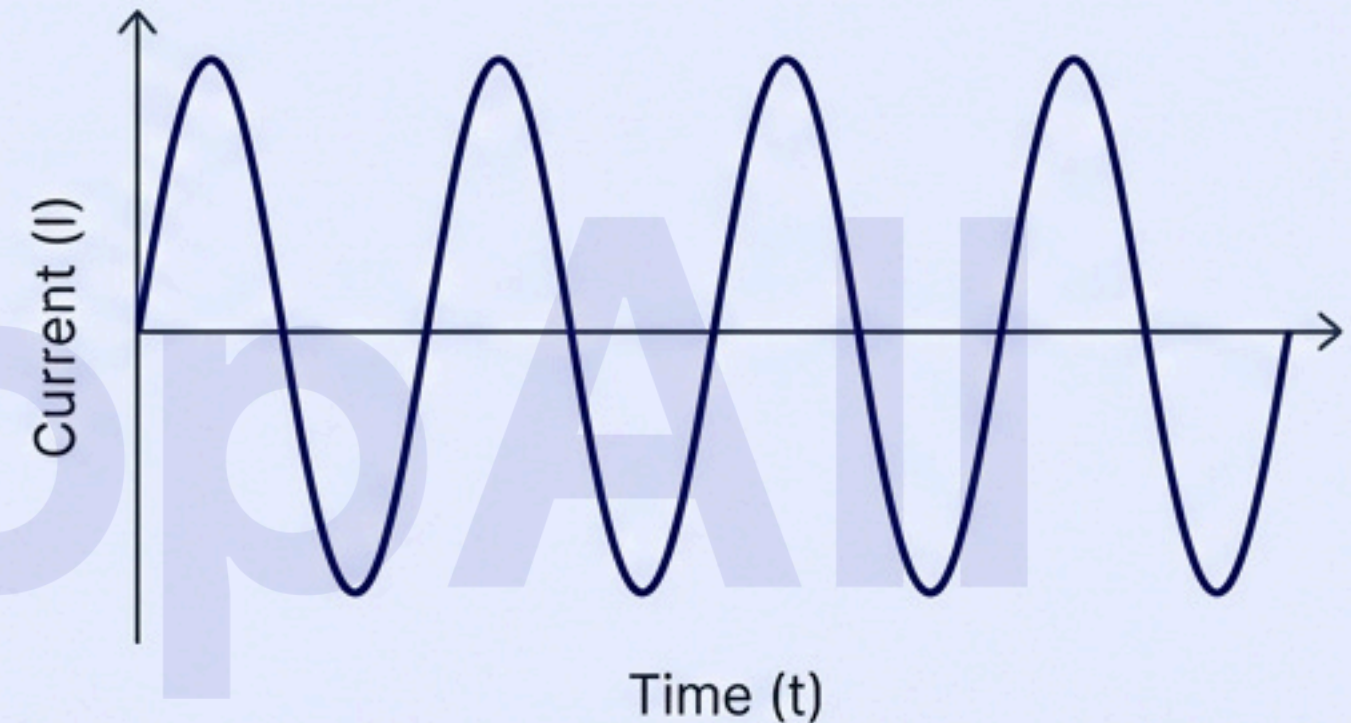
How Does a Capacitor React to AC vs DC?

DC SOURCE



- Current flows only briefly to charge the plates.
- Once fully charged, voltage opposes the current.
- Result: Current drops to zero (capacitor blocks DC)..

AC SOURCE



- Voltage continuously reverses direction.
- Plates alternately charge and discharge.
- Result: Regulates current, but does not prevent the flow of charge.

The Mathematical Proof: Finding Current (i)

Step 1: Source voltage equals capacitor voltage.

$$v = v_m \sin(\omega t) \text{ implies } v = q/C$$



Step 2: Rearrange to find instantaneous charge (q).

$$q = C v_m \sin(\omega t)$$



Step 3: Current is the rate of flow of charge ($i = dq/dt$).

$$i = d/dt [C v_m \sin(\omega t)] = \omega C v_m \cos(\omega t)$$



Step 4: Convert cosine back to sine to compare phase.

$$\text{EXAM TIP: } \cos(\omega t) = \sin(\omega t + \pi/2)$$

$$i = i_m \sin(\omega t + \pi/2)$$



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$$E=mc^2$$



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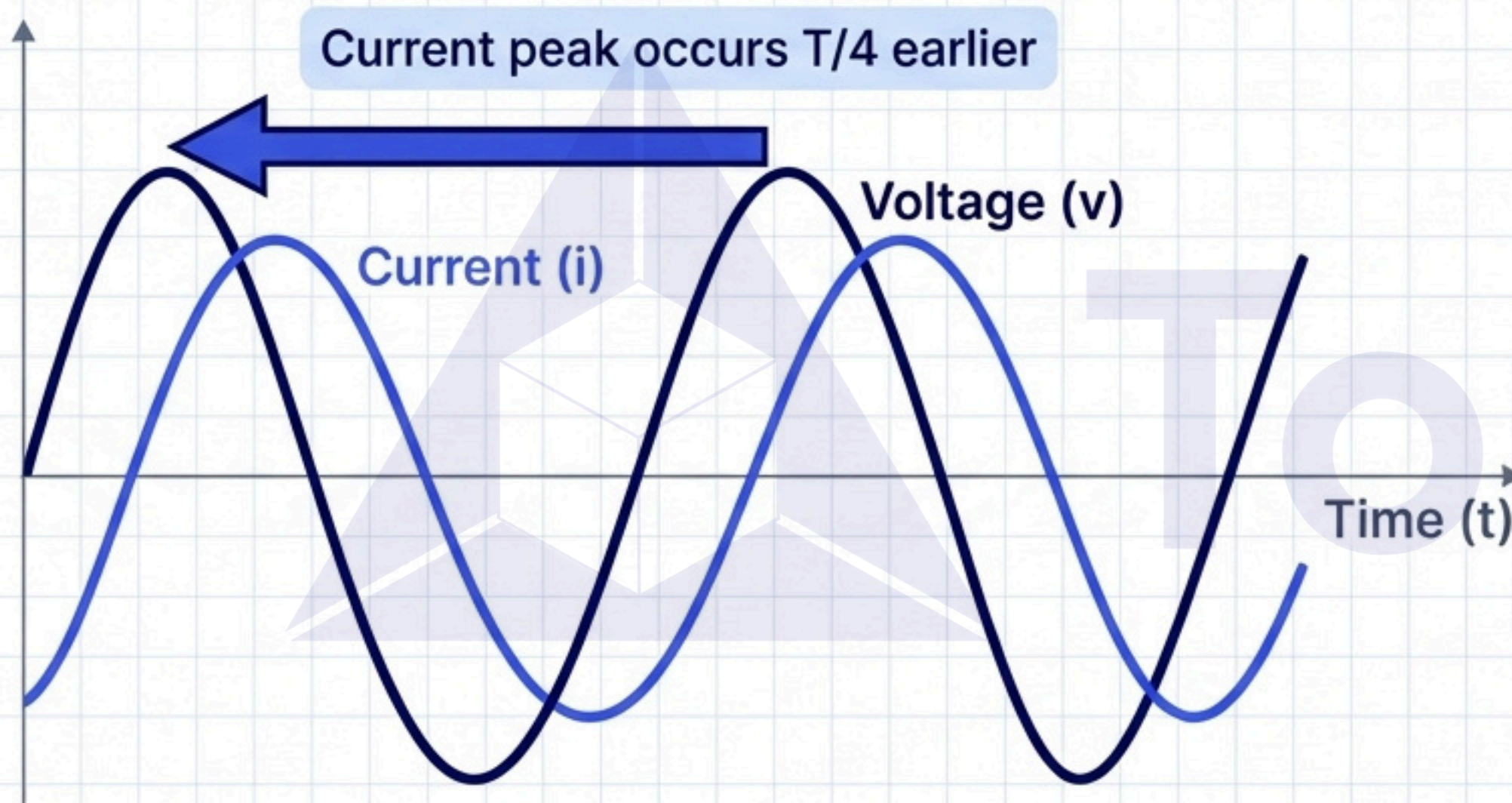
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The Phase Shift: Current Leads Voltage

What does '+ $\pi/2$ ' actually mean?



- Comparing $v = v_m \sin(\omega t)$ and $i = i_m \sin(\omega t + \pi/2)$
- The current reaches its maximum value one-fourth of a period ($T/4$) earlier than the voltage.
- In a purely capacitive circuit, Current leads Voltage by $\pi/2$ (90 degrees).

CONCEPT: MAXIMUM CURRENT happens when VOLTAGE is ZERO (and changing fastest).

Capacitive Reactance: Opposing the Flow

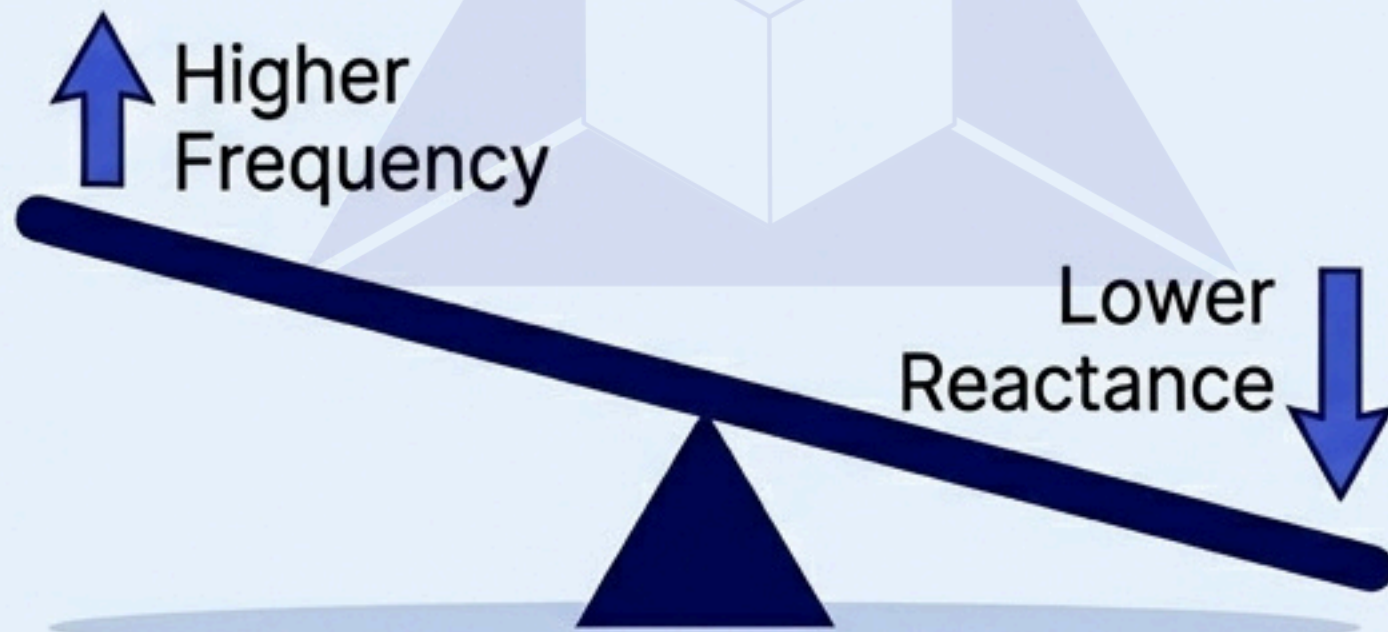
The Capacitor's Version of Resistance

The capacitor limits the amplitude of the current similar to how a resistor limits DC.

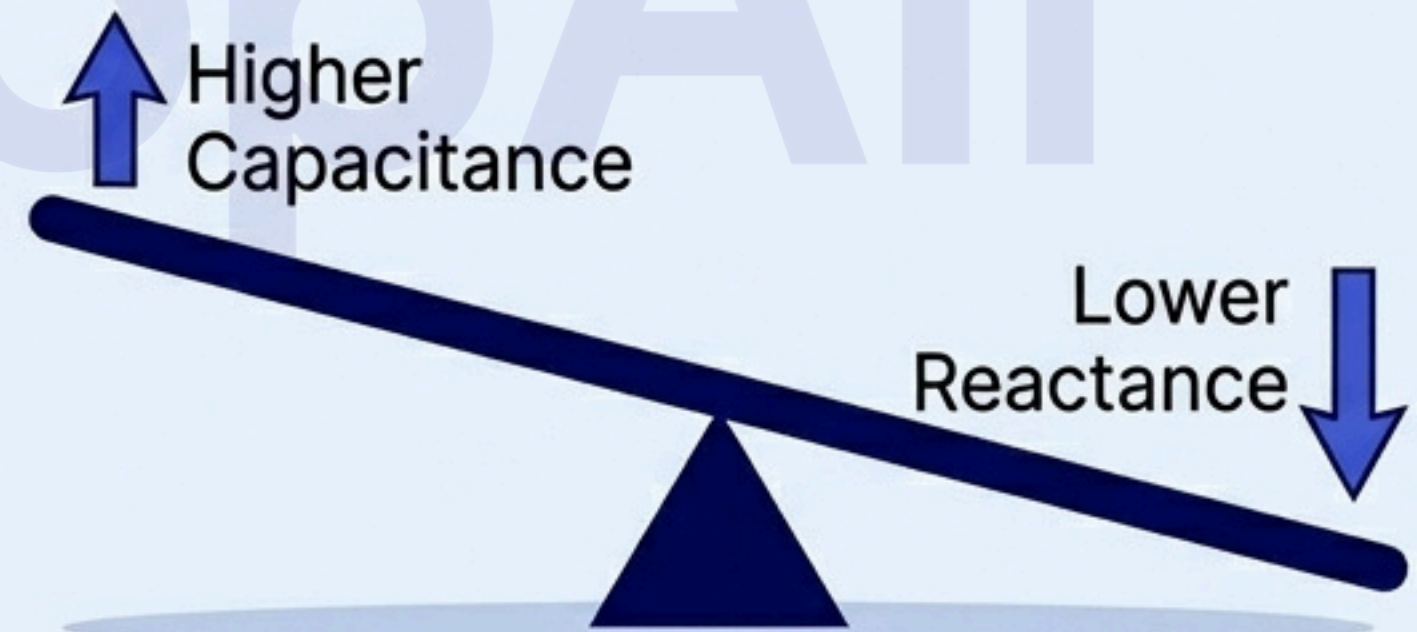
SI Unit: Ohm

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

Current Amplitude:
 $i_m = v_m / X_C$

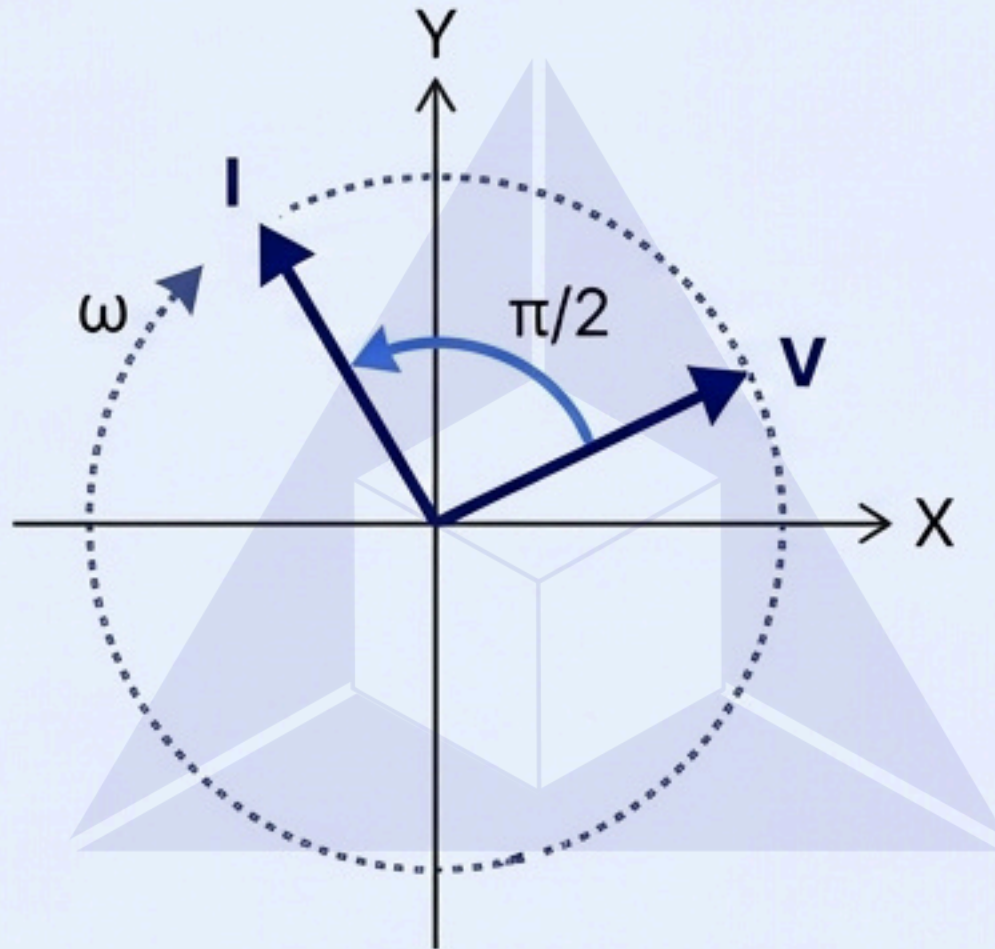


(Passes high-frequency AC)

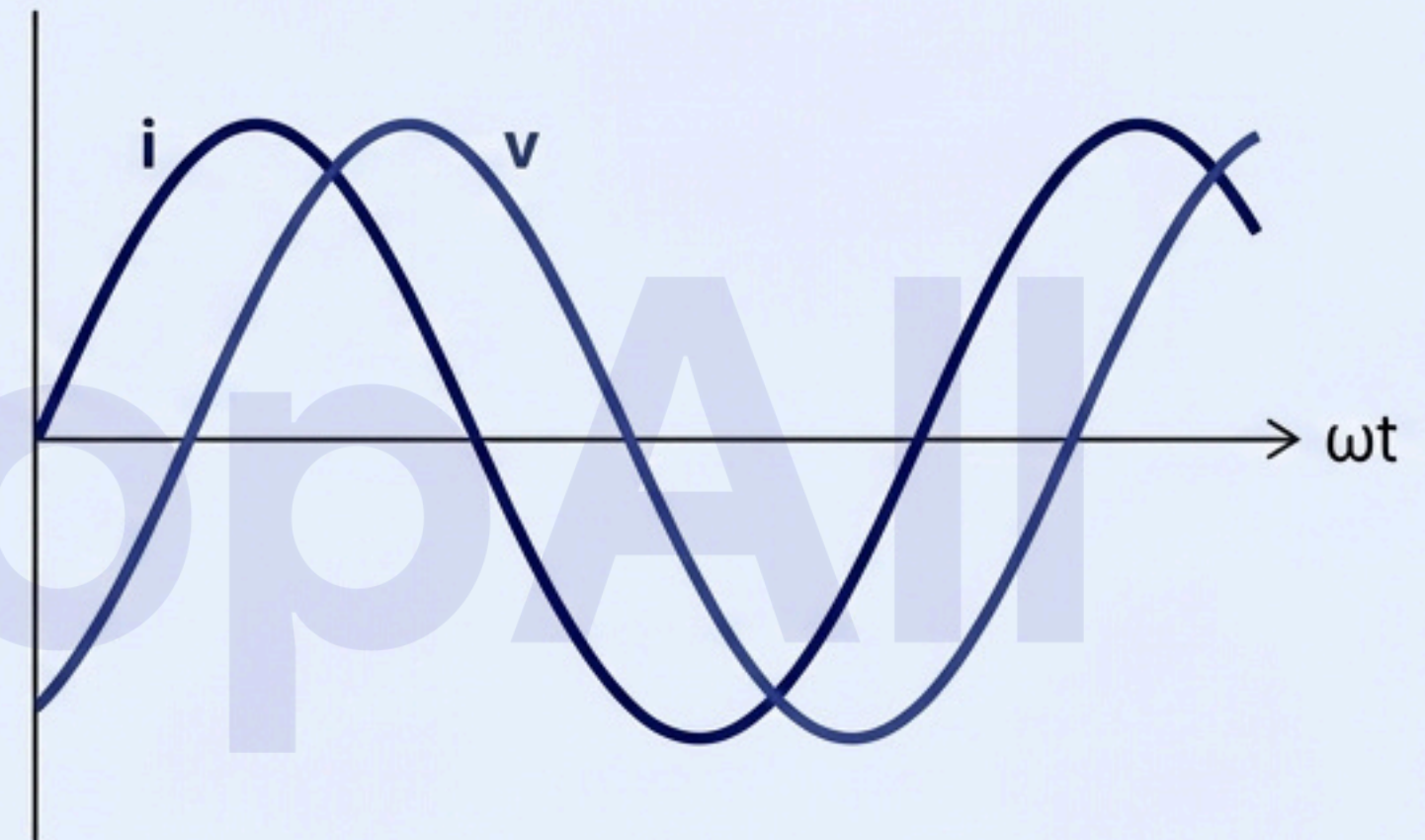


Phasor Diagram & Waveform

FIGURE 7.8 | PHASOR REPRESENTATION



Vector **I** is exactly $\pi/2$ ahead of Vector **V**. Both rotate counter-clockwise with angular speed ω .



Vertical components represent the instantaneous values **v** and **i**. At any instant, current is 90 degrees ahead.

Core Concept Mastery

Phase Rule

**Current LEADS voltage
by $\pi/2$**

(Compare: Inductor =
Current LAGS by $\pi/2$)

Reactance Rule

$$X_C = 1 / \omega C$$

Inversely proportional to
frequency. (Blocks DC,
passes high-frequency AC)

Average Power

Average power is ZERO

Over one complete cycle,
power supplied is zero.
Power absorbed during
charging is returned during
discharging.

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