Presentation On AC Fundamentals

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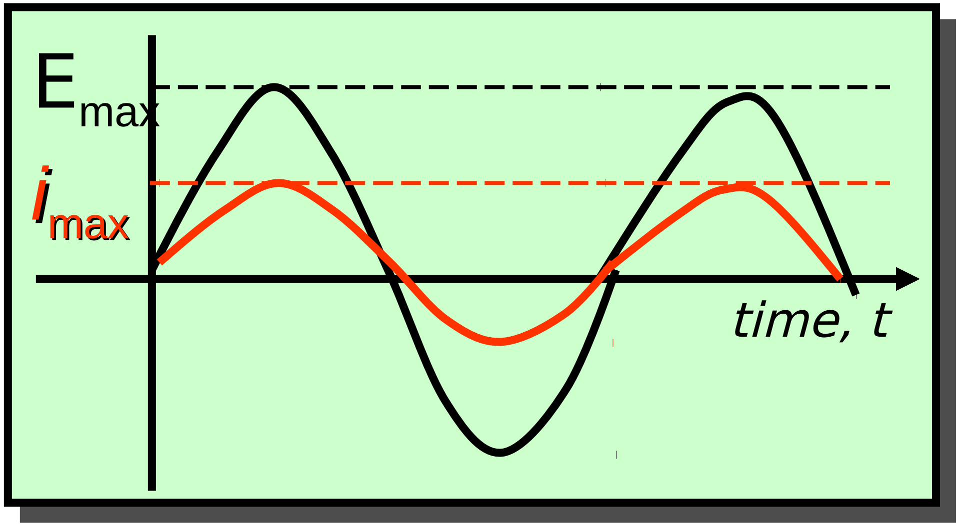
An alternating current such as that produced by a generator has no direction in the sense that direct current has. The magnitudes vary sinusoidally with time as given by:

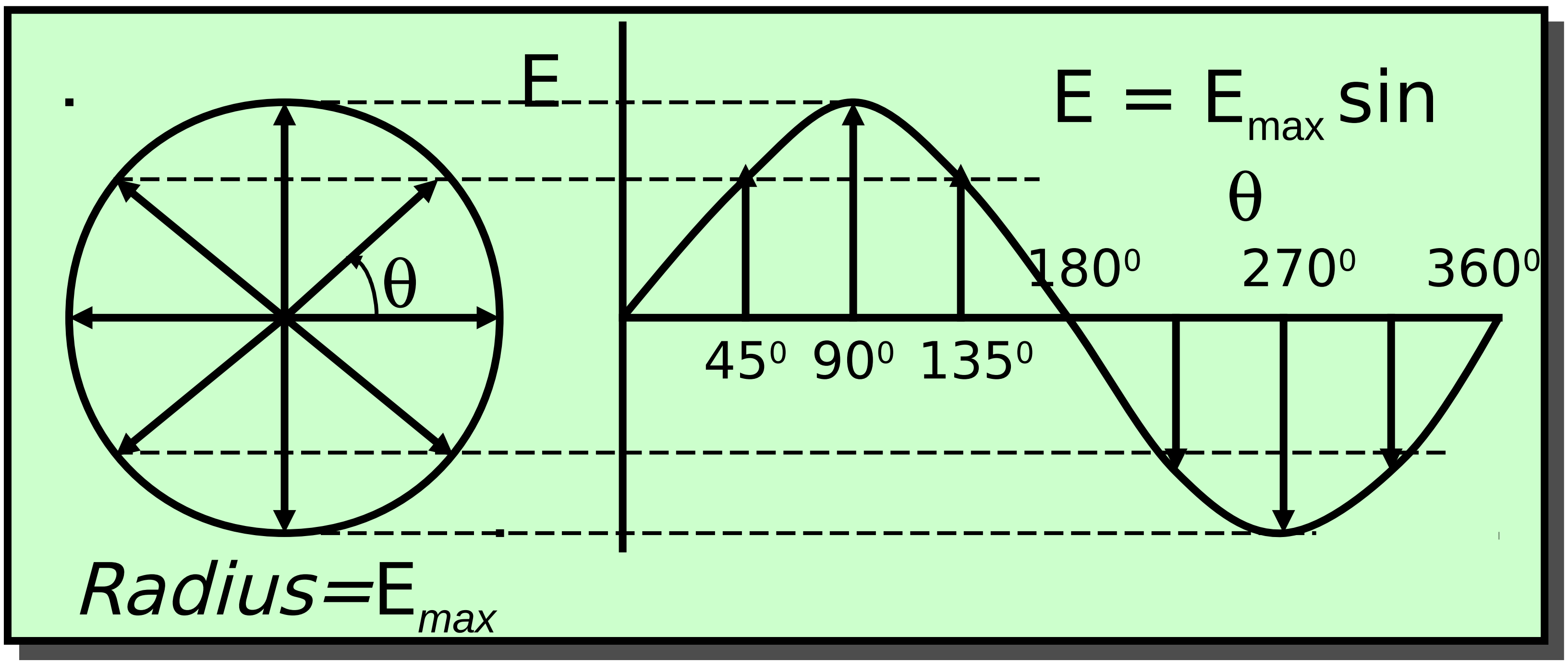
AC-voltage and current

$$E = E_{max} \sin \theta$$

$$i = i_{max} \sin \theta$$



The coordinate of the emf at any instant is the value of E_{max} sin θ. Observe for incremental angles in steps of 45^0. Same is true for *i*.



The average current in a cycle is zero — half + and half. But energy is expended, regardless of direction. So the “root-mean-square” value is useful. The RMS value I_{rms} is sometimes called the effective current I_{eff}.

One effective ampere is that ac current for which the power is the same as for one ampere of dc current.

Effective current: $i_{eff} = 0.707\ i_{max}$

One effective volt is that ac voltage that gives an effective ampere through a resistance of one ohm.

Effective voltage: $V_{eff} = 0.707\ V_{max}$

Example 1: For a particular device, the house ac voltage is 120-V and the ac current is 10 A. What are their maximum values?

$$i_{eff} = 0.707\ i_{max}$$

$$V_{eff} = 0.707\ V_{max}$$

$$i_{max} = \frac{i_{efe}}{0.707} = \frac{10\ A}{0.707}$$

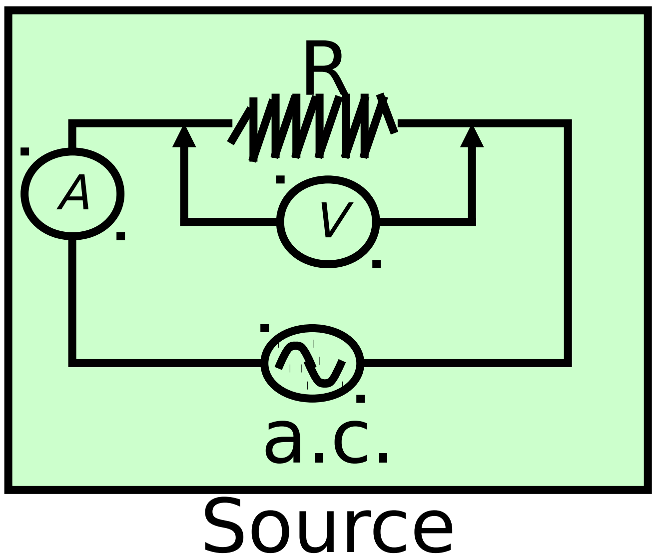
$$V_{max} = \frac{V_{efe}}{0.707} = \frac{120\ A}{0.707}$$

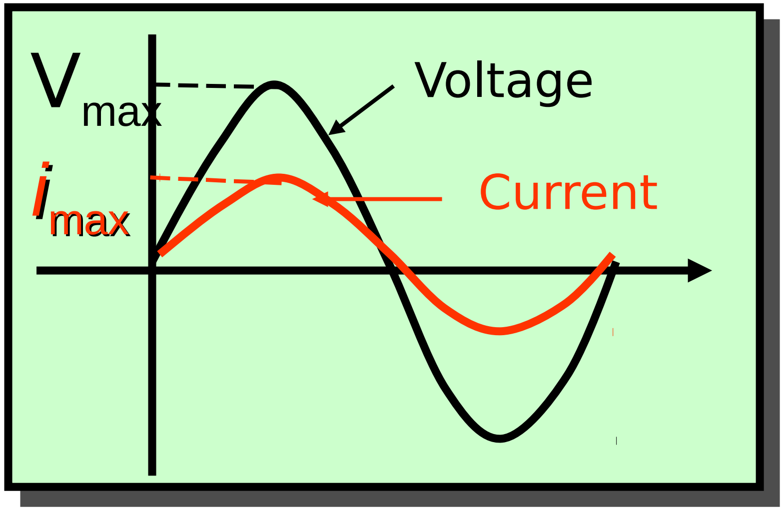
$i_{max} = 14.14$ A

$V_{max} = 170$ V

The ac voltage actually varies from +170 V to -170 V and the current from 14.1 A to –14.1 A.

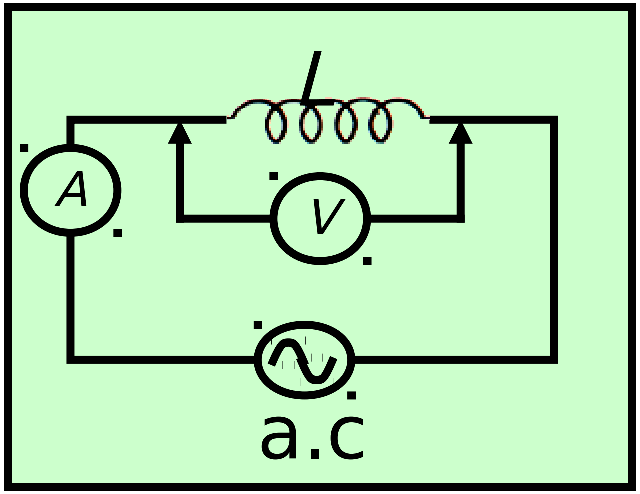
Pure Resistance in AC Circuits

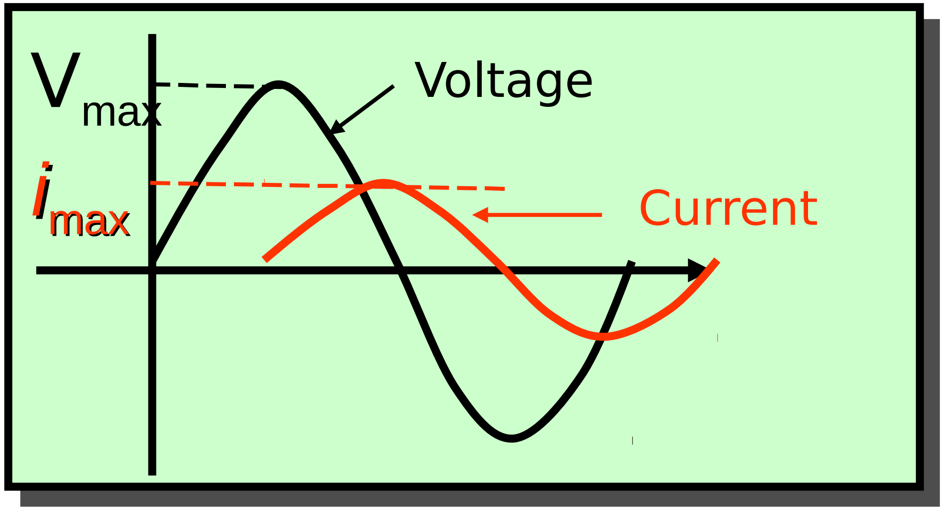




Voltage and current are in phase, and Ohm's law applies for effective currents and voltages.

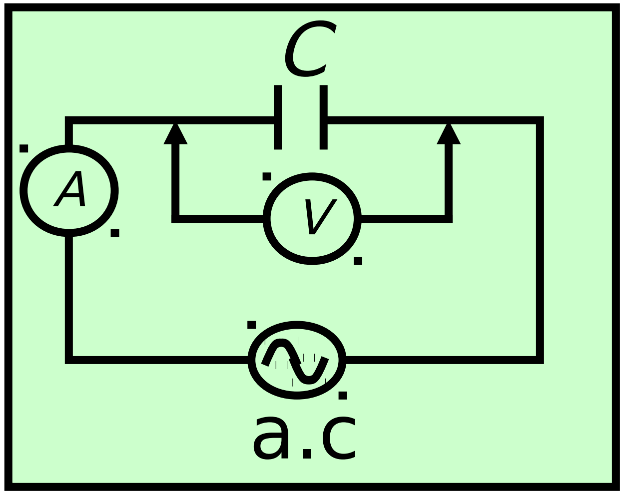
A Pure Inductor in AC Circuit

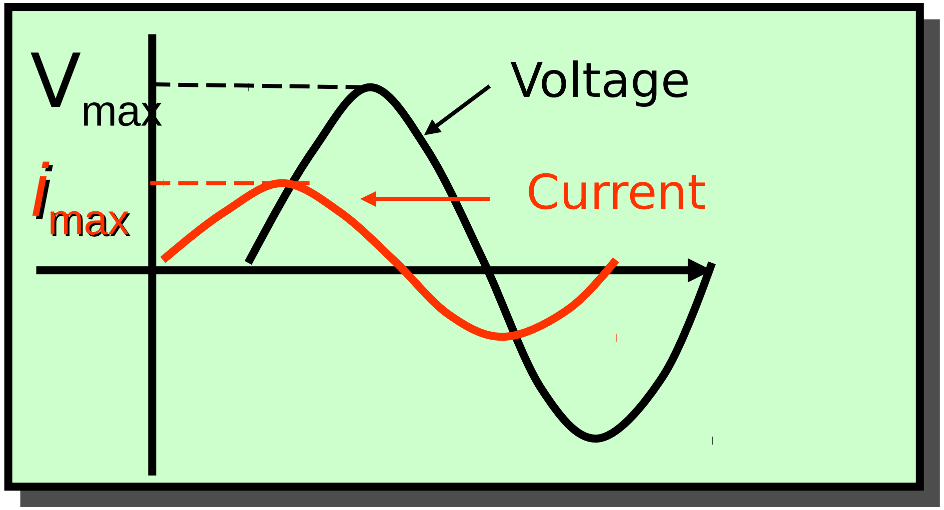




The voltage peaks 90^0 before the current peaks. One builds as the other falls and vice versa.

A Pure Capacitor in AC Circuit





The voltage peaks 90^0 after the current peaks. One builds as the other falls and vice versa.

Memory Aid for AC Elements

An old, but very effective, way to remember the phase differences for inductors and capacitors is :

"E L I" the "*i* C E" Man

Emf E is before current *i* in inductors L; Emf E is after current *i* in capacitors C.

Frequency and AC Circuits

Resistance *R* is constant and not affected by *f*.

Inductive Reactance X_L varies directly with frequency as expected since E ∝ $\Delta i/\Delta t$.

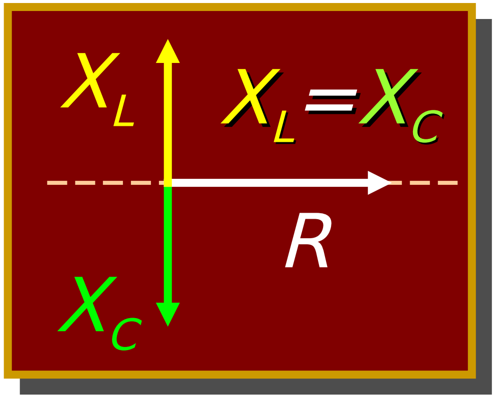
$$X_L = 2\pi fL$$

Capacitive reactance X_C varies inversely with *f* since rapid ac allows little time for charge to build up on capacitors.

$$X_C = \frac{1}{2\pi fC}$$

Resonant Frequency

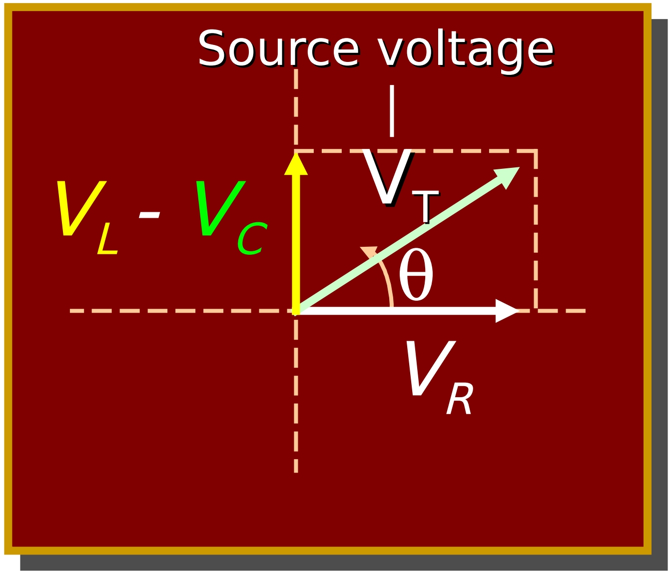
Because inductance causes the voltage to lead the current and capacitance causes it to lag the current, they tend to cancel each other out.



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

$$f_r = \frac{1}{2\pi\sqrt{LC}}$$

Calculating Total Source Voltage



$$V_T = \sqrt{V_R^2 + (V_L - V_C)^2}$$

$$\tan\phi = \frac{V_L - V_C}{V_R}$$

Now recall that:

$V_R = iR$; $V_L = iX_L$; and $V_C = iV_C$

Substitution into the above voltage equation gives:

$$V_T = i\sqrt{R^2 + (X_L - X_C)^2}$$