Alternating power supply

(parameters, L, C and R)

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$a.c.$ circuits

- Parameters of $a.c.$ circuits
- R, C and L connected to $a.c.$
- Phasor & series combinations
- Power and Power factor
- Resonance and quality factor
- L-C oscillations
- Transformer

Comparison of *d.c.* and *a.c.*

d.c. power supply

- Polarity of terminals is retained
- Magnitude and direction of potential difference remains constant (in steady state)
- Magnitude and direction of current remains constant (in steady state)
- Relatively difficult to generate and convert

a.c. power supply

- Polarity of terminals is not retained
- Magnitude and direction of potential difference varies periodically with time
- Magnitude and direction of current varies periodically with time
- Relatively easy to generate and convert

Power supply in *a.c.* and the equation

Potential difference across the terminals of an a.c. power supply varies periodically as a function of time.

$$V = V_o \sin(\omega t)$$

Instantaneous voltage

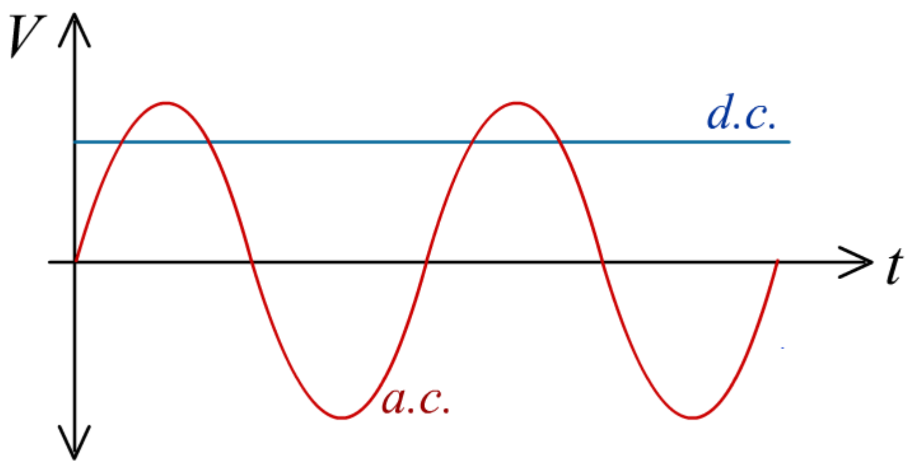
Peak voltage

Angular frequency

time

Note :

$$\omega = 2\pi n = \frac{2\pi}{T}$$

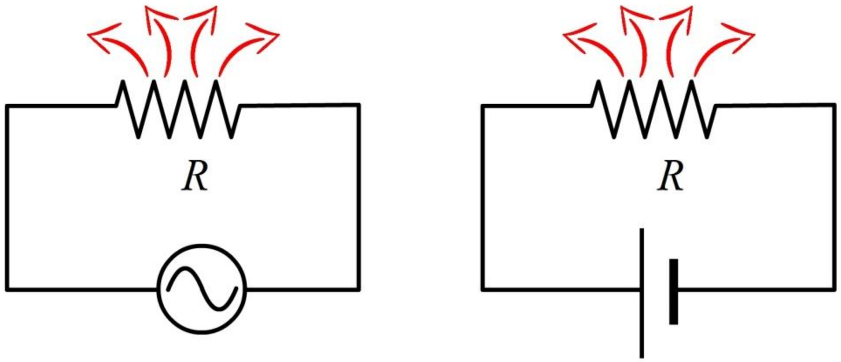


Power socket that you see near you gives a.c.

r m s values

rms value: root of mean of square of the value

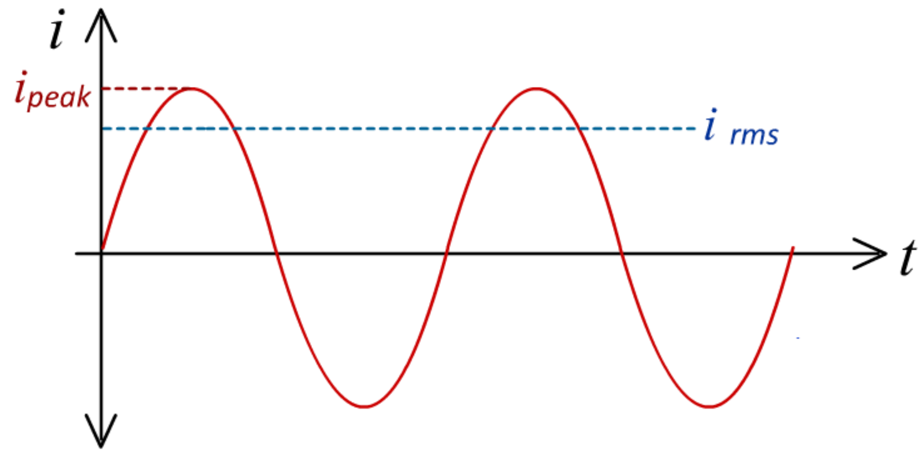
For a peak current I_o of an *a.c.* passing through a resistor, the effective value of *d.c.* current that results in the same dissipation of heat (as in case of *a.c.*) through the resistor is called *rms* value of the *a.c.*



For a pure sinusoidal *a.c.*, *rms* values of current and voltage are related to their peak values as

$$V_{\text{rms}} = \frac{V_o}{\sqrt{2}}$$

$$I_{\text{rms}} = \frac{I_o}{\sqrt{2}}$$



Note : *rms* value is also called *effective* value

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A note of what we will do (for a major part) in this chapter

We study the phenomenon resulting from connecting the following three circuit elements to an *a.c.* power supply.

(a) Resistor (R) It always opposes current, no matter what

(b) Inductor (L) It opposes change in current, (but not constant current !)

(c) Capacitor (C) It 'dances' to the tune of an a.c.

In each case we look at

(a) Variation of current (i) as a function of time

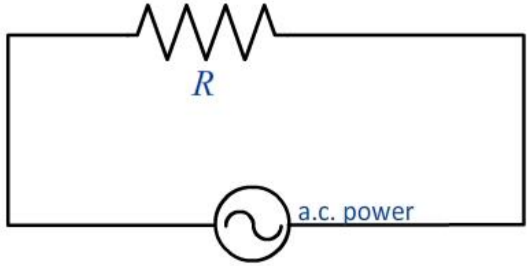
(b) Net opposition called impedance (Z) to flow of current

(c) Peak value of current (i_o)

(d) Phase difference (ϕ) between current and applied potential

(e) Average power dissipated in each cycle of the *a.c.* source

Resistor connected to *a.c.* power supply



Applied voltage : $V = V_o \sin(\omega t)$ — i

Using Kirchhoff's loop law we get

$$V_o \sin(\omega t) - iR = 0$$

$$iR = V_o \sin(\omega t)$$

$$i = \frac{V_o}{R} \sin(\omega t)$$

$$i = i_o \sin(\omega t)$$ — ii

where

$$i_o = \frac{V_o}{R}$$ — iii

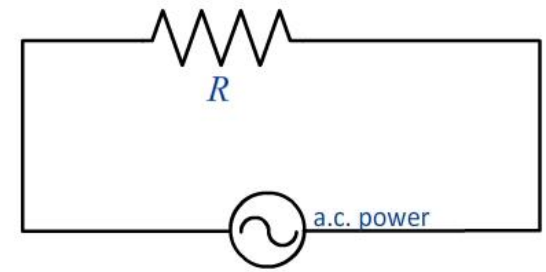
- ❑ Current is in phase with voltage
- ❑ Peak current is directly proportional to applied voltage and inversely proportional to resistance
- ❑ Peak current is independent of frequency of *a.c.*
- ❑ Impedance in the circuit is due to R
- ❑ Impedance is independent of frequency of power supply

Resistor connected to *a.c.* power supply

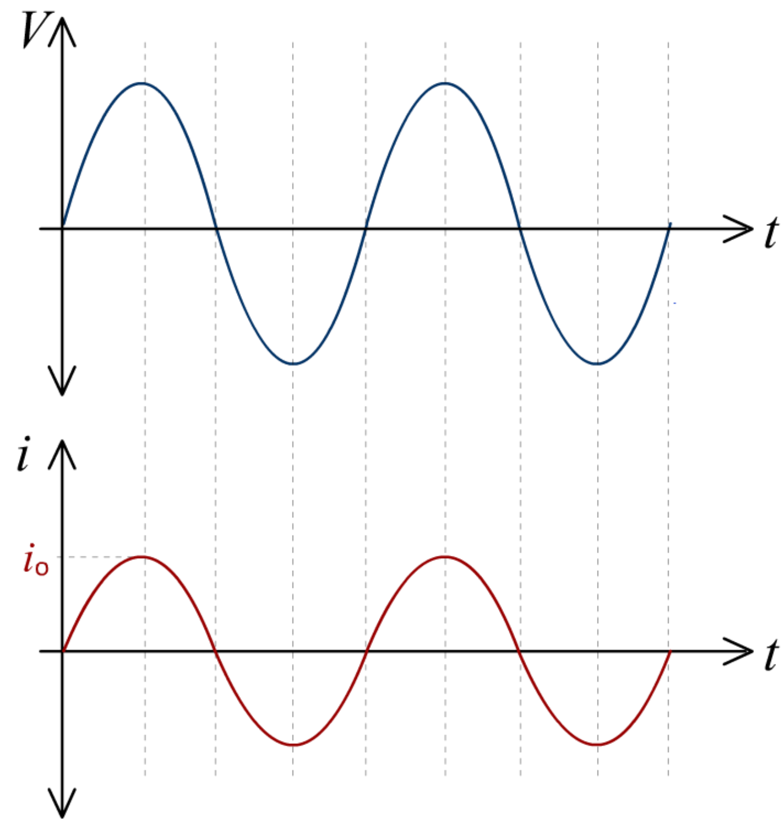
Applied voltage : $V = V_o \sin(\omega t)$ — i

$i = i_o \sin(\omega t)$ — ii

$i_o = \dfrac{V_o}{R}$ — iii



Resistance is independent of frequency of *a.c.* power supply



Current is in phase with voltage

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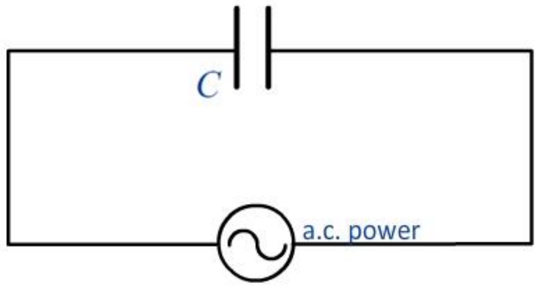
Capacitor connected to *a.c.* power supply



Applied voltage : $V = V_o \sin(\omega t)$ — i

Using Kirchhoff's loop law we get

$$V_o \sin(\omega t) - \frac{q}{C} = 0$$

$$\frac{q}{C} = V_o \sin(\omega t)$$

$$q = CV_o \sin(\omega t)$$

differentiating w.r.t. time

$$\frac{dq}{dt} = CV_o\omega \cos(\omega t)$$

$$i = \frac{V_o}{1/C\omega} \sin\left(\omega t + \frac{\pi}{2}\right)$$

$$i = i_o \sin\left(\omega t + \frac{\pi}{2}\right)$$ — ii

where

$$i_o = \frac{V_o}{X_C}$$ — iii

$$X_C = \frac{1}{C\omega}$$ — iv

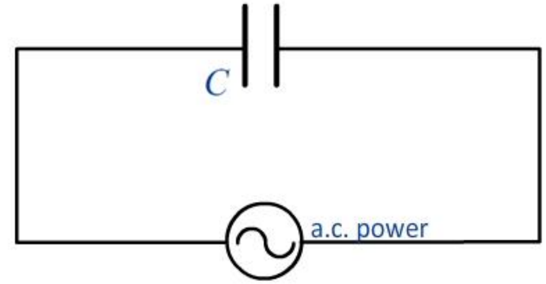
- Phase difference between i and V is $\pi/2$
- Peak current is directly proportional to applied voltage and inversely proportional to capacitive reactance (X_C)
- Impedance in the circuit is due to capacitive reactance i.e. $X_C = 1/C\omega$
- X_C is inversely proportional to frequency of power supply

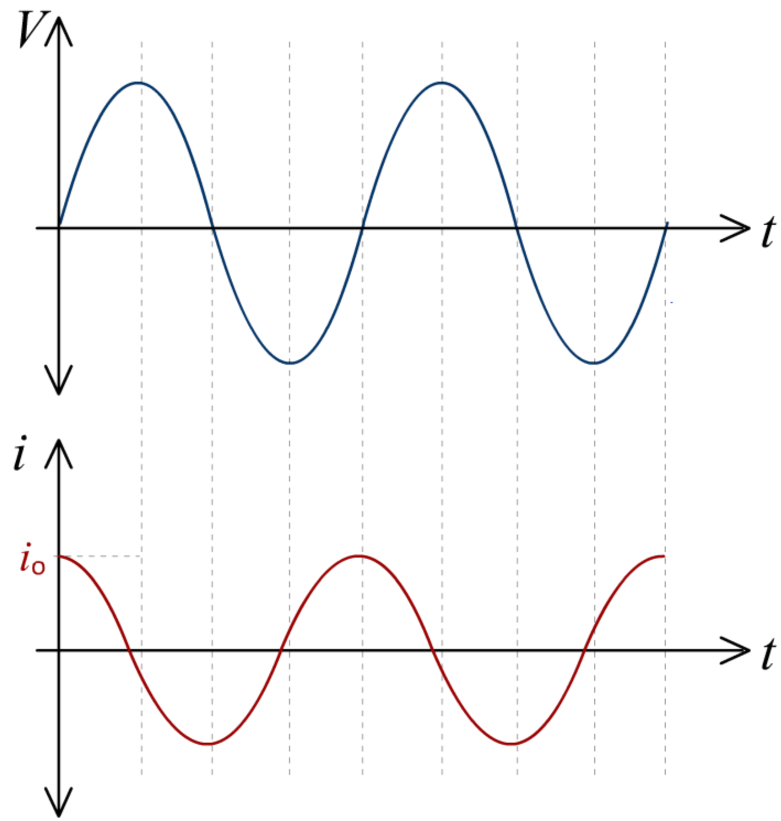
Capacitor connected to *a.c.* power supply

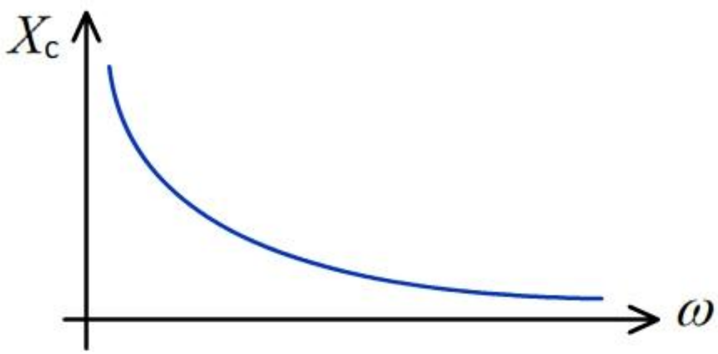
Applied voltage : $V = V_o \sin(\omega t)$ — i

$$i = i_o \sin\left(\omega t + \frac{\pi}{2}\right) \qquad \text{ii}$$

$$i_o = \frac{V_o}{X_C} \qquad \text{iii} \qquad\qquad X_C = \frac{1}{C\omega} \qquad \text{iv}$$







Capacitive reactance decreases with increase in frequency of *a.c.* power

Current leads voltage by $\pi/2$

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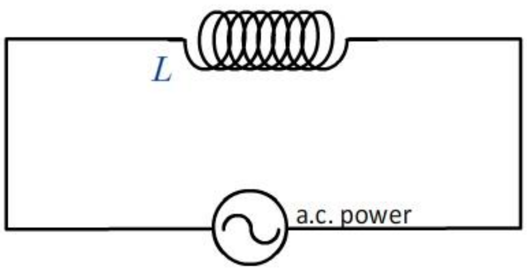
Inductor connected to *a.c.* power supply



Applied voltage : $V = V_o \sin(\omega t)$ — i

Using Kirchhoff's loop law we get

$$V_o \sin(\omega t) - L\frac{di}{dt} = 0$$

$$L\frac{di}{dt} = V_o \sin(\omega t)$$

$$di = \frac{V_o}{L}\sin(\omega t)\,dt$$

Integrating the above eq we get

$$i = -\frac{V_o}{L\omega}\cos(\omega t)$$

$$i = i_o \sin\left(\omega t - \frac{\pi}{2}\right)$$ — ii

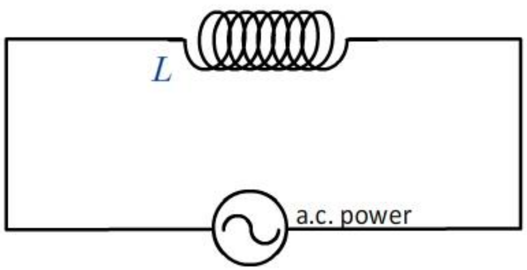
where

$$i_o = \frac{V_o}{X_L}$$ — iii

$$X_L = L\omega$$ — iv

- Phase difference between i and V is $-\pi/2$
- Peak current is directly proportional to applied voltage and inversely proportional to inductive reactance (X_L)
- Impedance in the circuit is due to inductive reactance i.e. $X_L = L\omega$
- X_L is directly proportional to frequency of power supply

Inductor connected to *a.c.* power supply

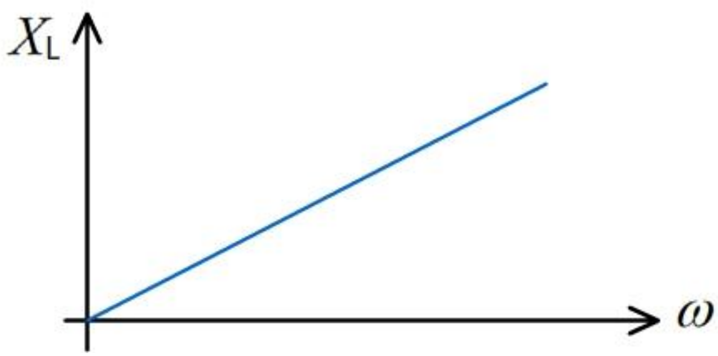


Applied voltage : $V = V_o \sin(\omega t)$ — i

$$i = i_o \sin\left(\omega t - \frac{\pi}{2}\right)$$ — ii

$$i_o = \frac{V_o}{X_L}$$ — iii

$$X_L = L\omega$$ — iv



Inductive reactance increases with increase in frequency of *a.c.* power

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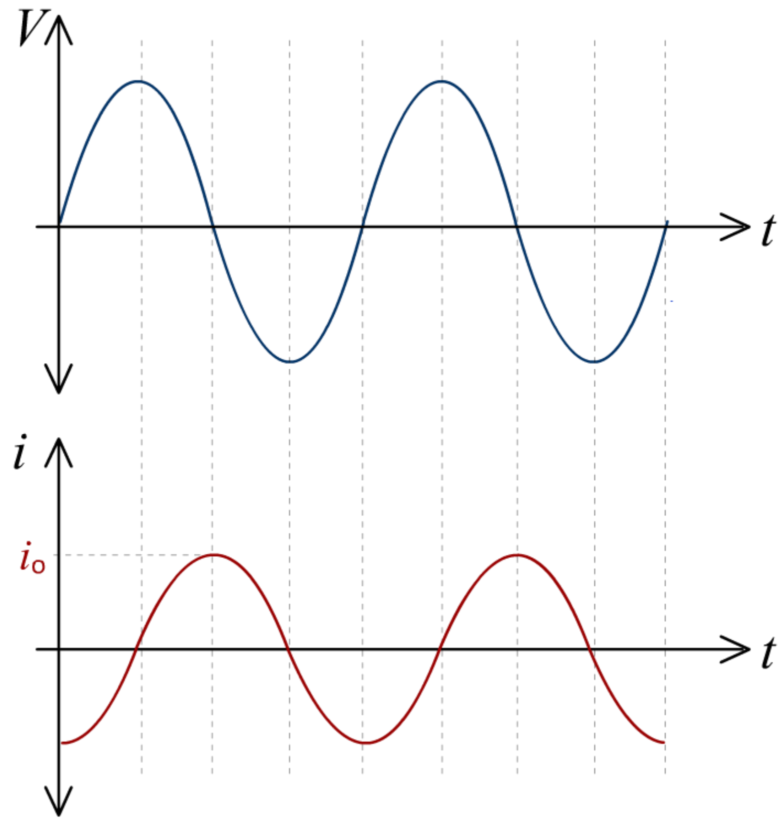

Current lags behind voltage by $\pi/2$