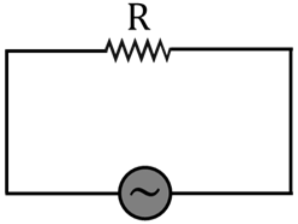
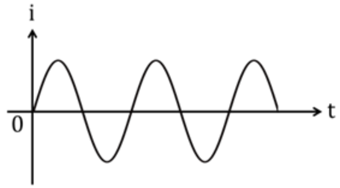
MIND MAP

Alternating current

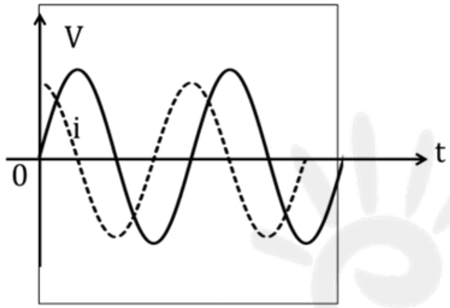
Alternating Current

If the direction of current changes alternately, it is called Alternating Current.





$V = V_0 \sin(\omega t)$



Average Value of a Function

$$<y> = \frac{\int y\,dt}{\int dt}$$

Average value of y

(i) $<\sin(\omega t + \phi)> = 0$

(ii) $<\cos(\omega t + \phi)> = 0$

(iii) $<\sin^2(\omega t + \phi)> = \frac{1}{2}$

(iv) $<\cos^2(\omega t + \phi)> = \frac{1}{2}$

RMS (Root Mean Square) Value of a Function

$$y_{rms} = \sqrt{<y^2>}$$

Where $<y^2> = \frac{\int y^2 dt}{\int dt}$

(i) $\sin(\omega t + \phi)_{rms} = \frac{1}{\sqrt{2}}$

(ii) $\cos(\omega t + \phi)_{rms} = \frac{1}{\sqrt{2}}$

Pure Resistive Circuit

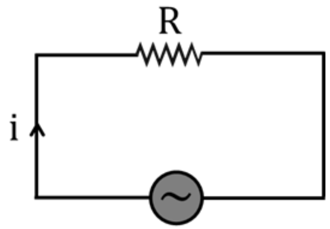
$V = iR$

$i = \frac{V}{R} = \frac{V_0 \sin(\omega t)}{R}$

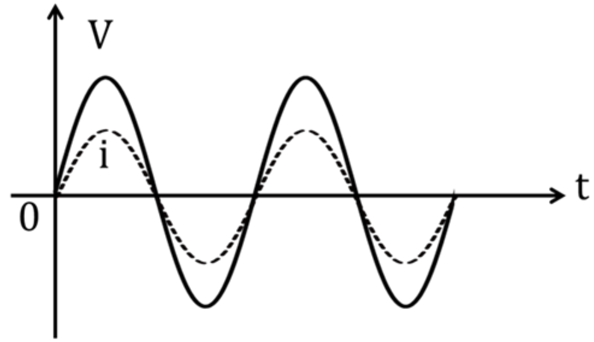
$i = i_0 \sin(\omega t)$

$i_0 = \frac{V_0}{R}$ $i_{rms} = \frac{V_{rms}}{R}$

$i_{rms} = \frac{i_0}{\sqrt{2}}$ $V_{rms} = \frac{V_0}{\sqrt{2}}$



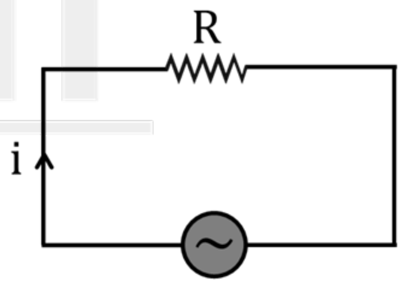
$V = V_0 \sin(\omega t)$



Keypoint

$V = V_0 \sin(\omega t)$ $i = i_0 \sin(\omega t)$

In pure resistive circuit V and i are in same phase.



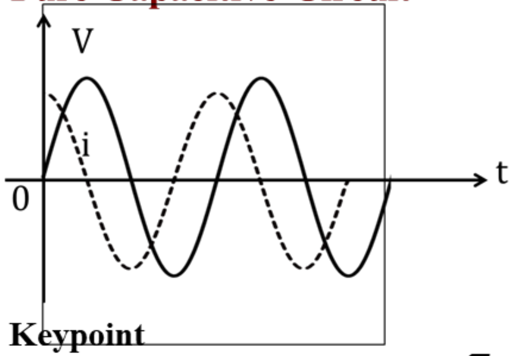
$V = V_0 \sin(\omega t)$

→ 220V is the rms value of Voltage in India.

→ $f = 50Hz$

→ $\omega = 2\pi f = 100\pi$

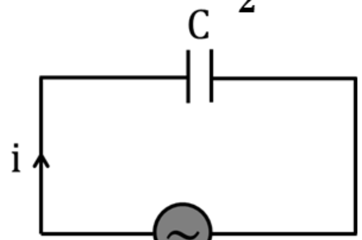
Pure Capacitive Circuit



Keypoint

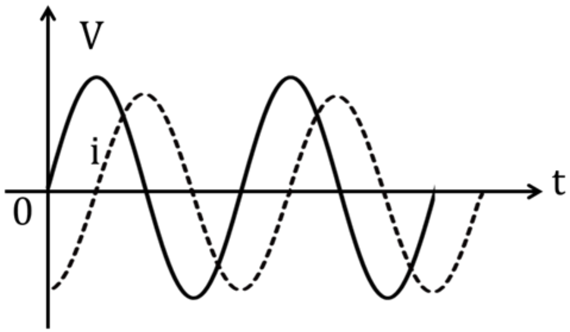
$V = V_0 \sin(\omega t)\ i = i_0 \sin\left(\omega t + \frac{\pi}{2}\right)$

In pure Capacitive circuit Current leads Voltage by phase $\frac{\pi}{2}$



$V = V_0 \sin(\omega t)$

Pure Inductive Circuit



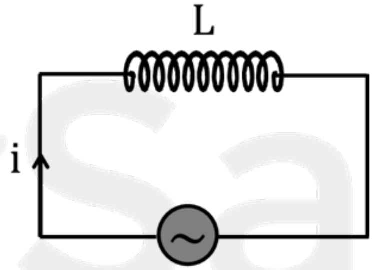
MIND MAP

Alternating current

Keypoint

$V = V_0 \sin(\omega t)\ \ i = i_0 \sin\left(\omega t - \frac{\pi}{2}\right)$

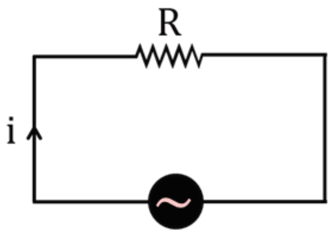
In pure Inductive circuit Voltage leads Current by phase $\frac{\pi}{2}$



$V = V_0 \sin(\omega t)$

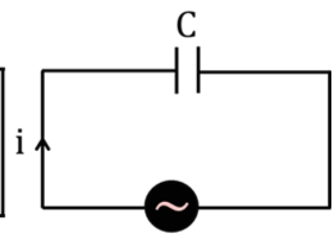
Impedance

$i_0 = \frac{V_0}{R}$



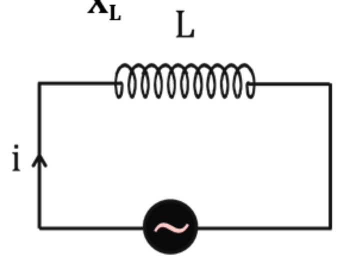
$V = V_0 \sin(\omega t)$

$i_0 = \frac{V0}{X_C}$



$V = V_0 \sin(\omega t)$

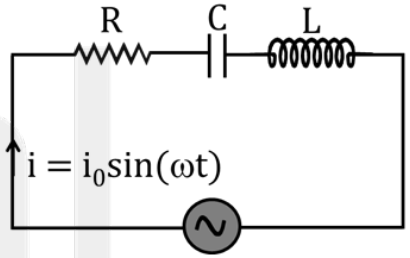
$i_0 = \frac{V0}{X_L}$



$V = V_0 \sin(\omega t)$

$i_0 = \frac{V_0}{Z}$ → **Impedance**

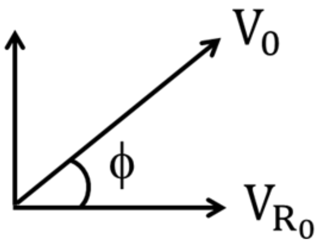
L–C–R Circuit



$i = i_0 \sin(\omega t)$

$V = V_0 \sin(\omega t + \phi)$

$V_{L_0} - V_{C_0}$

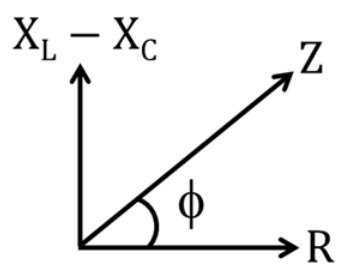


$i_0 = \frac{V_0}{Z}\quad i_{rms} = \frac{V_{rms}}{Z}$

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

MIND MAP

Alternating current



If $X_L > X_C$ circuit is predominantly Inductive (V leads i)

If $X_L < X_C$ circuit is predominantly Capacitive (i leads V)

Power Factor

$$<P> = i_{rms}V_{rms}\cos\phi$$

$$\cos\phi = \frac{R}{z}$$

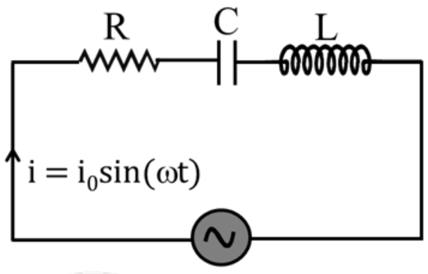
Energy loss in pure capacitance in AC circuit is zero

Power dissipated in pure inductance in AC circuit is zero

Power Factor of L–R circuit is

$$\cos\phi = \frac{R}{Z} = \frac{R}{\sqrt{R^2 + x_L^2}}$$

Resonance in LCR Circuit



$$V = V_0\sin(\omega t + \phi)$$

$$i_0 = \frac{V_0}{Z} = \frac{V_0}{\sqrt{(X_L - X_C)^2 + R^2}}$$

$$f_0 = \frac{1}{2\pi\sqrt{LC}}$$

i_0 will be maximum when $X_L = X_C$

$$\Rightarrow \omega L = \frac{1}{\omega C} \Rightarrow \omega_0 = \frac{1}{\sqrt{LC}}$$

$$i_0 = \frac{V_0}{\sqrt{(X_L - X_C)^2 + R^2}}$$

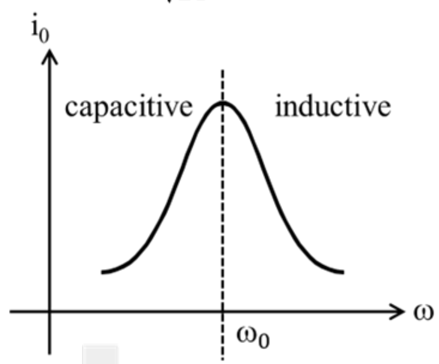
$$= \frac{V_0}{\sqrt{\left(\omega L - \frac{1}{\omega C}\right)^2 + R^2}}$$

At Resonance

(1) i_0 will be maximum (2) $X_L = X_C$

(3) Z=R (4) $\cos\phi = 1$

(5) $\omega_0 = \frac{1}{\sqrt{LC}}$

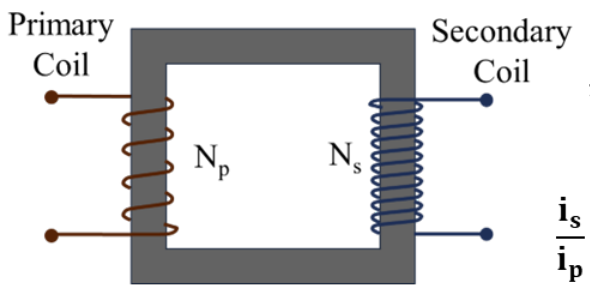


Transformers

Transformer is used to change (i.e. transform) an alternating voltage from one value to another using principle of mutual induction.

$$V_p = -N_p\frac{d\phi}{dt} \qquad V_s = -N_s\frac{d\phi}{dt}$$

$$P = vi$$



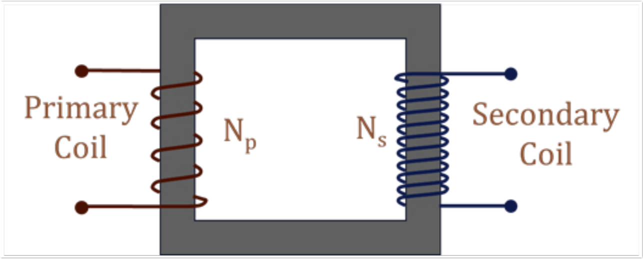
$$\frac{V_s}{V_p} = \frac{N_s}{N_p}$$

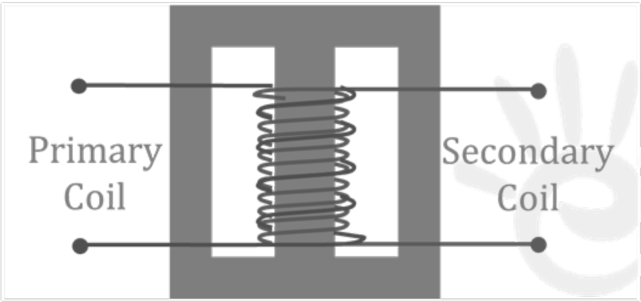
$$V_p i_p = V_s i_s$$

$$\frac{i_s}{i_p} = \frac{V_p}{V_s} = \frac{N_p}{N_s}$$

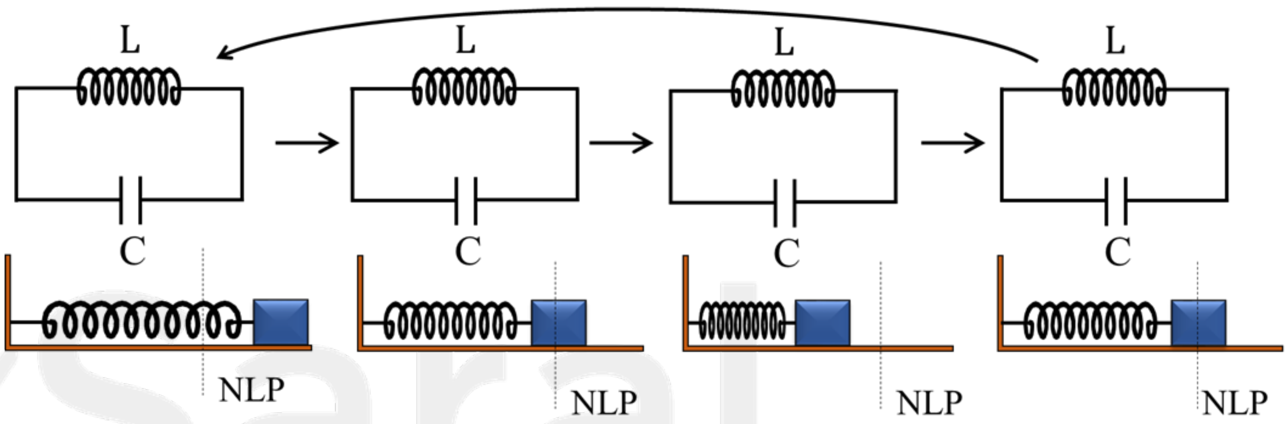
MIND MAP

Alternating current





LC Oscillations



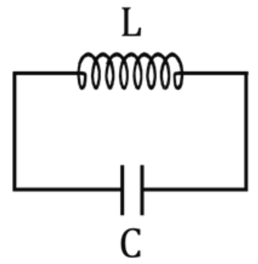
Cause	Rectification
(1) Flux Leakage: Due to poor design and air gaps in the core, all the flux due to primary does not pass through the secondary.	(1) By winding the primary and secondary coil one over the other.
(2) Resistance of the windings: causes heat loss.	(2) In high current, low voltage windings, these are minimized by using thick wire.

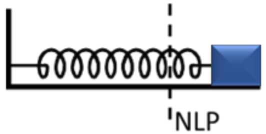
Cause	Rectification
(3) Eddy Currents: The alternating magnetic flux induces eddy currents in the core and causes heating.	(3) By using laminated core it can be reduced.
(4) Hysteresis: Alternating magnetization of core cause hysteresis loss.	(4) It is kept minimum by using a magnetic material having low hysteresis loss.

MIND MAP

Alternating current

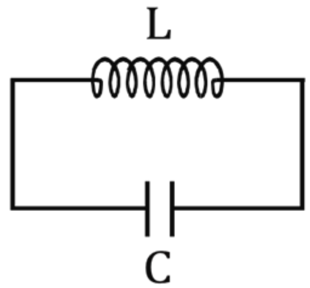
LC & Spring Block





LC	Spring Block
Q	x
i	v
$\frac{1}{C}$	k
L	m
Electrical energy $\frac{Q^2}{2C}$	Potential energy $\frac{1}{2}kx^2$
Magnetic energy $\frac{1}{2}Li^2$	Kinetic energy $\frac{1}{2}mv^2$

$$\frac{Q_0^2}{2C} = \frac{1}{2}L\,i_0^2 = \frac{Q^2}{2C} + \frac{1}{2}L\,i^2 \qquad \frac{1}{2}RA^2 = \frac{1}{2}mv_{man}^2 = \frac{1}{2}kn^2\frac{\pi}{2}m_{v^2}$$

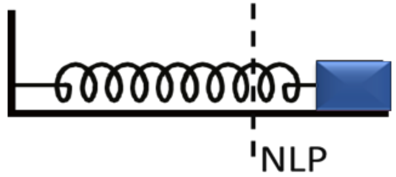


Q, i, L, 1/C

$$i = \omega\sqrt{Q_0^2 - Q^2}$$

$$i_{max} = \omega\, Q_0$$

$$\omega = \frac{1}{\sqrt{LC}} \quad ; \; T = 2\pi\sqrt{LC}$$



x, v, m, k

$$v = \omega\sqrt{A^2 - x^2}$$

$$v_{max} = \omega\, A$$

$$\omega = \sqrt{\frac{k}{m}} \quad ; \; T = 2\pi\sqrt{\frac{m}{k}}$$