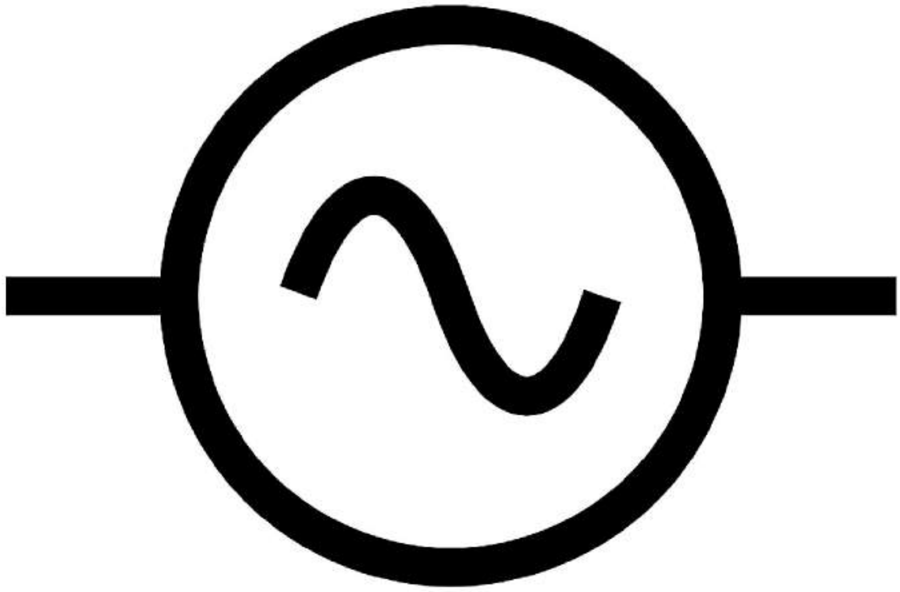
Chapter–7

Alternating Current



CBSE CLASS XII NOTES

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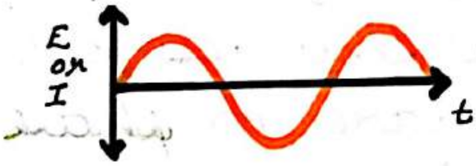
ALTERNATING CURRENT

Alternating current.

Alternating current is one which changes in magnitude and direction periodically.



peak current / current amplitude

The maximum value of current is called peak value of current or current-amplitude. denoted by I_0.

Instantaneous current $I = I_0 \sin\omega t$

Instantaneous emf $E = E_0 \sin\omega t$

Rms value of AC

$I_{rms} = \frac{I_0}{\sqrt{2}}$ $E_{rms} = \frac{E_0}{\sqrt{2}}$

It is defined as that magnitude of the direct current which produces the same heating effect in a given resistance in a given time as the given alternating current.

MEAN VALUE OF CURRENT OF AN AC

It is the mean of all instantaneous values of current or emf during a half cycle of ac

$(I_{mean})_{half\ cycle} = \frac{2I_0}{\pi} = 0.637 I_0$

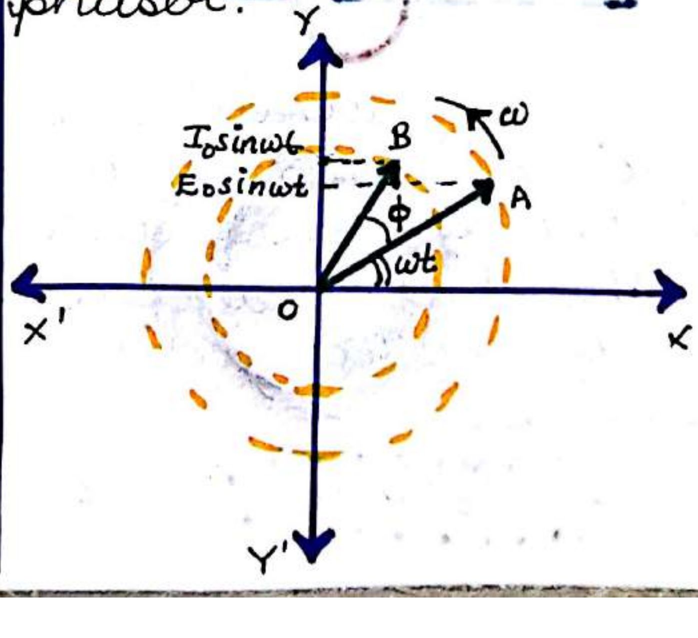
$(E_{mean})_{half\ cycle} = \frac{2E_0}{\pi} = 0.637 E_0$

★ Mean value of a.c over a complete cycle is 'zero'.

$(I_{mean})_{full\ cycle} = 0$

VECTORS – PHASORS

A rotating vector that represents a sinusoidly varying quantity is called a phasor.



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* The diagram representing alternating emf and current (phasors) as the rotating vectors along with the phase angle between them is called phasor diagram.

* not vectors but are scalars.

* The phase angles of emf and current are the angles they make with the X-axis

* Their projection along the Y-axis give their instantaneous sinusoidal values.

AC CIRCUITS

AC circuit containing resistor only.

Consider an AC circuit with a resistor of resistance 'R'. The instantaneous emf of the circuit is given by.

$$E = E_0 \sin\omega t \quad \ldots (1)$$

According to ohm's law

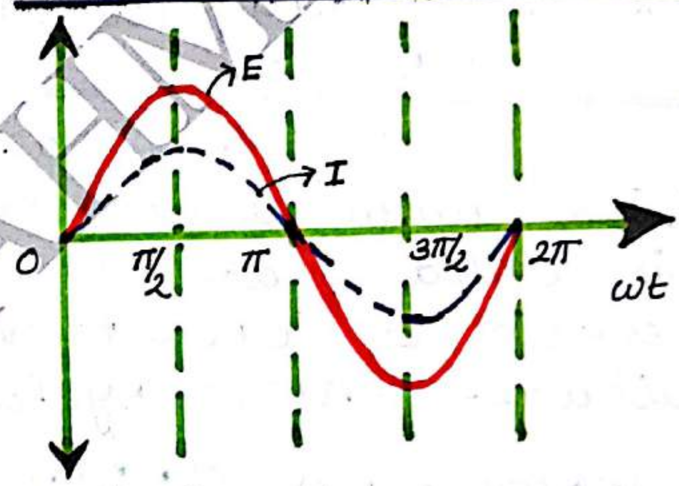
$$I = \frac{E}{R}$$

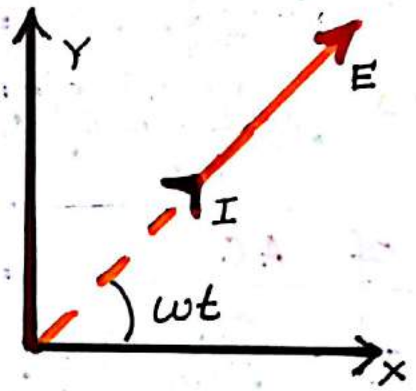
$$I = \frac{E_0 \sin\omega t}{R} \qquad \frac{E_0}{R} = I_0$$

$$I = I_0 \sin\omega t \quad \ldots (2)$$

From (1) and (2) we can say that current and emf are in phase.

GRAPHICAL REPRESENTATION





* As the current is in phase with emf, they both are zero at the same instant and both pass their maximum values at the same instant.

vector diagram

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$$I_{rms} = \frac{I_0}{\sqrt{2}} = \frac{E_0}{R\sqrt{2}} = \frac{E_{rms}}{R}$$

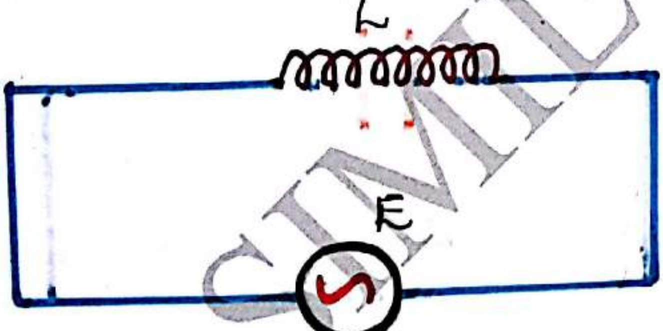
$$I_{rms} = \frac{E_{rms}}{R}$$

R only

$$\boxed{\begin{array}{l} I = I_0 \sin\omega t \\ E = E_0 \sin\omega t \\ E \,\&\, I \text{ in phase} \\ \phi = 0^\circ \\ I_{rms} = \frac{E_{rms}}{R} \\ I_0 = \frac{E_0}{R} \end{array}}$$

INDUCTOR ONLY (L)

consider a circuit with an inductor of Inductance L only.



The Instantaneous emf of the circuit is $E = E_0 \sin\omega t$ ---(1)

Induced emf in the circuit is

$$e = -L\frac{dI}{dt}$$

Applying krichoffs second law in the circuit we get

$$E + e = 0$$

$$E - L\frac{dI}{dt} = 0.$$

$$L\frac{dI}{dt} = E$$

$$L\frac{dI}{dt} = E_0 \sin\omega t$$

$$\frac{dI}{dt} = \frac{E_0}{L}\sin\omega t$$

$$dI = \frac{E_0}{L}\sin\omega t\, dt$$

$$\int dI = \frac{E_0}{L}\int \sin\omega t\, dt$$

$$I = \frac{E_0}{L}\left[-\frac{\cos\omega t}{\omega}\right]$$

$$I = \frac{E_0}{L\omega}\left[-\cos\omega t\right]$$

$$I = \frac{E_0}{L\omega}\left[\sin(\omega t - \frac{\pi}{2})\right]$$

$$I = \frac{E_0}{X_L}\left[\sin(\omega t - \pi/2)\right]$$

$$I = I_0 \sin(\omega t - \pi/2) \quad \text{---(2)} \qquad L\omega = X_L$$

where $X_L = L\omega$ = Inductive reactance

$$X_L = L\, 2\pi f = 2\pi f L$$

"Inductive reactance is the opposition offered by the coil to the flow of alternating current"

comparing (1) & (2)

* E leads I by $\pi/2$

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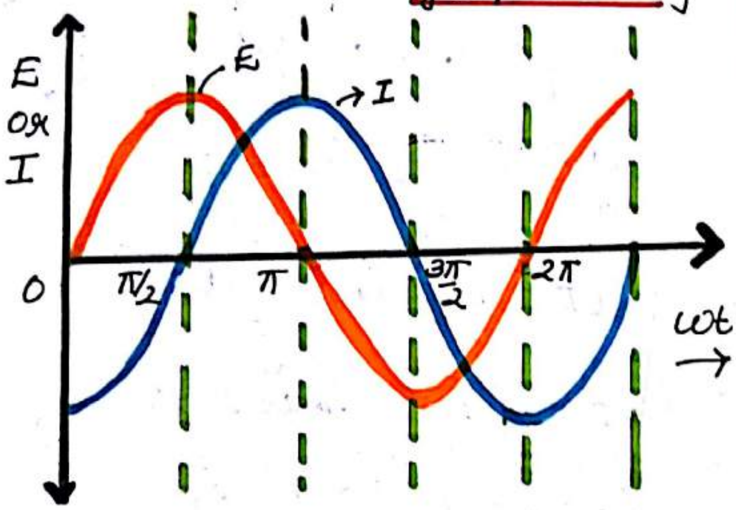
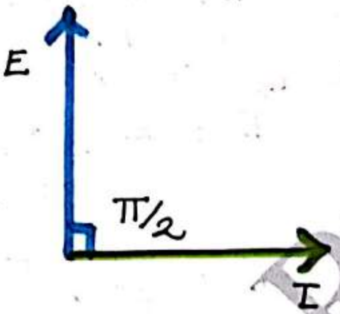
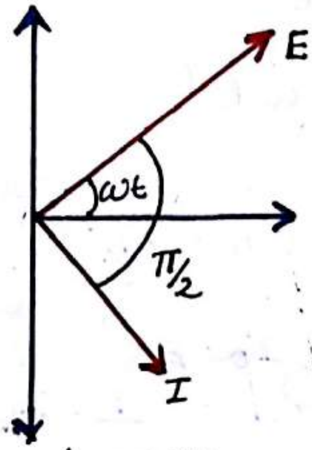
* $\phi = \frac{\pi}{2}$
* I lags behind E by $\frac{\pi}{2}$

* graphically





* phasor diagram



* vector diagram

* $I_{rms} = \frac{I_0}{\sqrt{2}} = \frac{E_0}{\sqrt{2}\, X_L}$

$$I_{rms} = \frac{E_{rms}}{X_L}$$

$E = E_0 \sin \omega t$

$I = I_0 \sin(\omega t - \pi/2)$

$\phi = \pi/2$

E leads I by $\pi/2$

$I_{rms} = \frac{E_{rms}}{X_L} = \frac{E_{rms}}{L\omega}$.

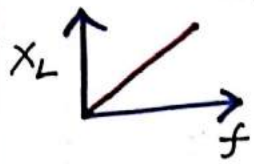
$X_L = L\omega = 2\pi f L$

Behaviour of Inductor to ac and dc

(i) ac

$X_L = 2\pi f L$

$X_L \propto \nu$



(ii) dc

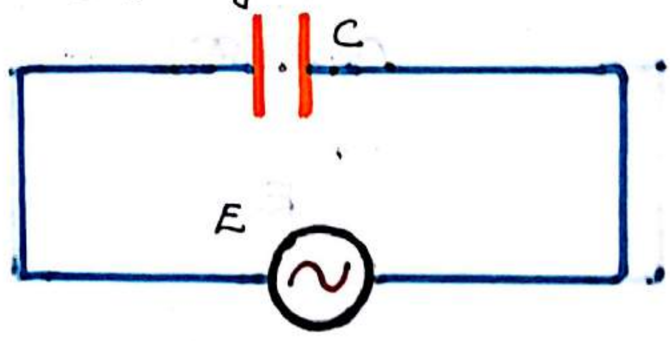
$f = 0$

$\therefore X_L = 0$

* Inductor behaves like a perfect conductor when dc current flows through it.

CAPACITOR ONLY [C]

consider an ac circuit containing capacitor of capacitance C only.



$E = E_0 \sin \omega t$

capacitor charges and discharges. let 'q' be charge on capacitor at time 't'

$E = \frac{q}{C}$

$\therefore \frac{q}{C} = E_0 \sin \omega t$

$q = C E_0 \sin \omega t$

diff w.r.t t

$\frac{dq}{dt} = C E_0 \frac{d}{dt} (\sin \omega t)$

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$I = CE_0\omega \cos\omega t$

$I = \dfrac{E_0}{\frac{1}{C\omega}} \cos\omega t$ $X_C = \dfrac{1}{C\omega}$

$I = \dfrac{E_0}{X_C} \sin(\omega t + \pi/2)$

$\boxed{I = I_0 \sin(\omega t + \pi/2)}$ ...... ②

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

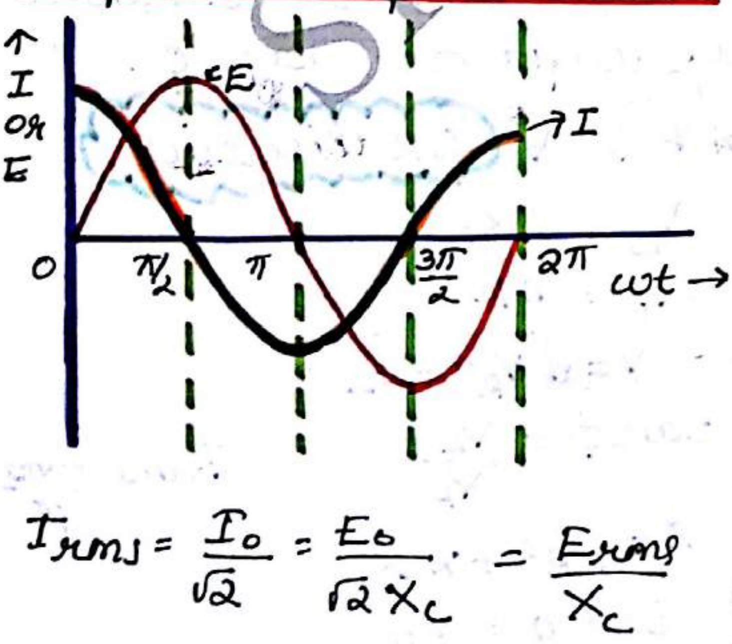
$X_C \rightarrow$ capacitive reactance is the opposition offered by a capacitor to the flow of ac.

* $\boxed{I_0 = \dfrac{E_0}{X_C} = \dfrac{E_0}{1/C\omega}}$

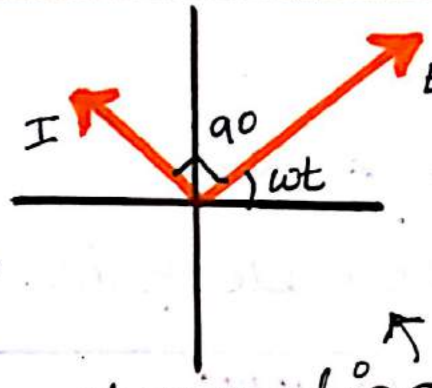
* From eqtns ① and ② its clear that I leads E by $\pi/2$

* so $\phi = \pi/2$, or E lags behind I by $\pi/2$

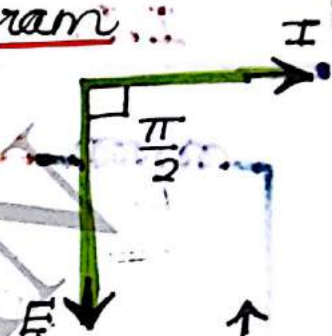
Graphical Representation



$I_{rms} = \dfrac{I_0}{\sqrt{2}} = \dfrac{E_0}{\sqrt{2}X_C} = \dfrac{E_{rms}}{X_C}$



phasor diagram



vector diagram

Summary For C-only

$E = E_0 \sin\omega t$

$I = I_0 \sin(\omega t + \pi/2)$

$\phi = \pi/2$

I leads E by $\pi/2$

E lags I by $\pi/2$

$I_{rms} = \dfrac{E_{rms}}{X_C} = \dfrac{E_{rms}}{1/C\omega}$

$I_0 = \dfrac{E_0}{X_C} = \dfrac{E_0}{1/C\omega}$

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

Behaviour of capacitor to ac and dc

ac

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

$X_C \propto \dfrac{1}{f}$

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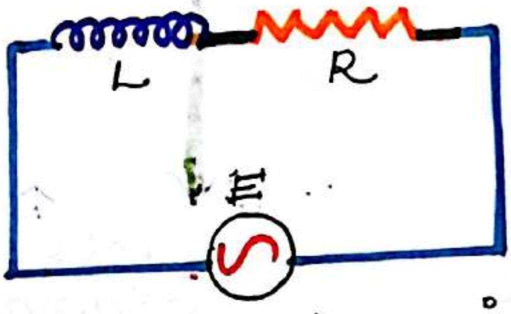
(ii) dc

$f = 0$

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

$\therefore$ capacitor block dc.

LR CIRCUIT



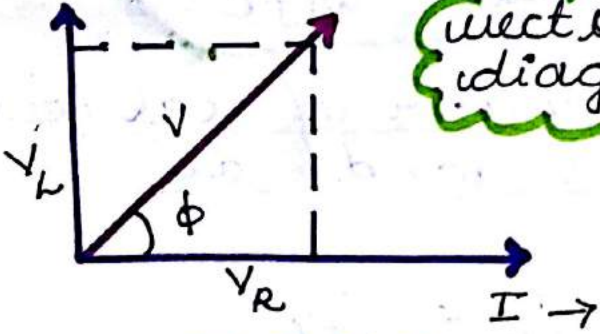
consider an ac circuit consisting of an inductor of inductance (L) and a resistor of resistance (R), connected in series.

voltage drop across R $\boxed{V_R = IR}$

voltage drop across L $V_L = IX_L$

V leads I by $\pi/2$.

vector diagram



$$\boxed{\tan\phi = \frac{V_L}{V_R}}$$

Resultant voltage

$$V = \sqrt{V_R^2 + V_L^2}$$

$$V = \sqrt{(IR)^2 + (IX_L)^2}$$

$$V = I\sqrt{R^2 + X_L^2}$$

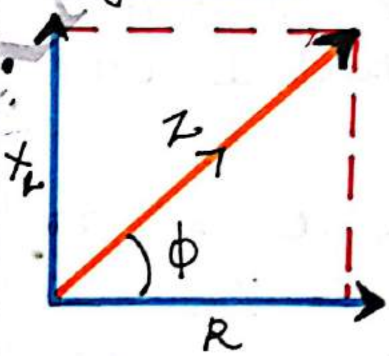
$$\frac{V}{I} = \sqrt{R^2 + X_L^2}$$

This is the effective resistance of the circuit called Impedence

Impedence $\boxed{Z = \sqrt{R^2 + X_L^2}}$

$$Z = \sqrt{R^2 + (L\omega)^2}$$

Impedence vector diagram



$Z = \sqrt{R^2 + X_L^2}$

$\tan\phi = \frac{X_L}{R}$

$\therefore$ voltage is ahead of current by ϕ.

** LR circuit

$V_L = I.X_L$

$V_R = IR$

$V = \sqrt{V_R^2 + V_L^2}$

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

$Z = \sqrt{R^2 + X_L^2}$

$\tan\phi = \frac{X_L}{R}$

$I_{rms} = E_{rms}/Z$

$I_{rms} = \frac{E_{rms}}{Z}$

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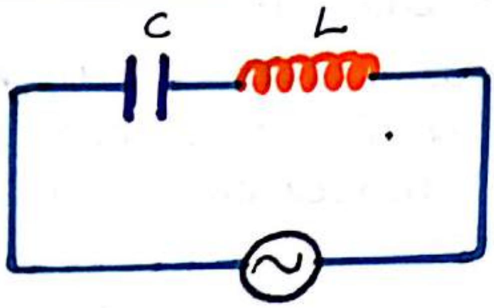
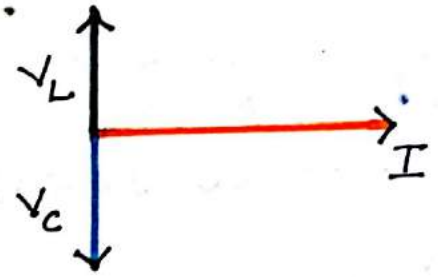
LC CIRCUIT



$V_C = I X_C$

$V_L = I X_L$



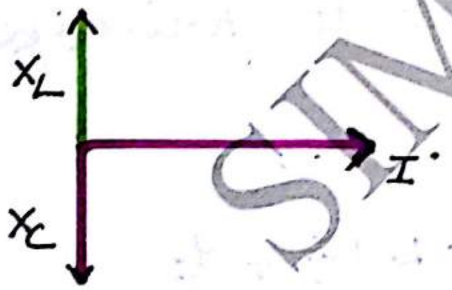
Net voltage

$$V = V_L \sim V_C$$

phase difference b/w V_L and V_C be 180°.

Impedence.

$$Z = X_L \sim X_C$$



Resonance condition

$X_L = X_C$

$Z = 0$

$I \rightarrow$ maximum

$X_L = X_C$

$$L\omega = \frac{1}{C\omega}$$

$$\omega^2 = \frac{1}{LC}$$

$$\omega = \frac{1}{\sqrt{LC}}$$

$$\omega = \frac{1}{\sqrt{LC}}$$

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

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

* This is called resonant frequency of a LC circuit.

LC circuit

$V_L = I X_L$

$V_C = I X_C$

$V = V_L \sim V_C$

$Z = X_L \sim X_C$

@ resonance

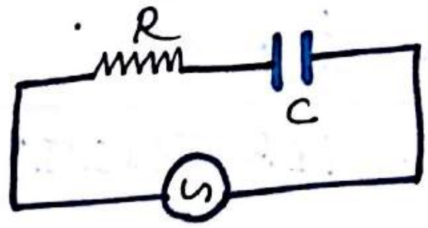
(a) $X_L = X_C$

$Z = 0$.

(b) $f = \frac{1}{2\pi\sqrt{LC}}$

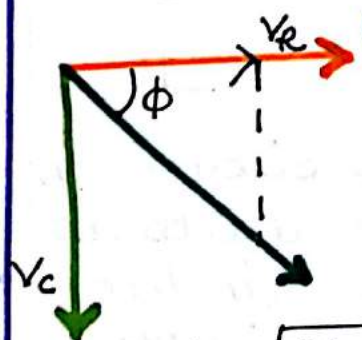
$$I_{rms} = \frac{E_{rms}}{Z}$$

RC CIRCUIT



$V_R = IR$

$V_C = I X_C$



vector diagram

$$V = \sqrt{V_R^2 + V_C^2}$$

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

$$V = \sqrt{V_R^2 + V_C^2}$$

$$V = \sqrt{(IR)^2 + (IX_C)^2}$$

$$V = I\sqrt{R^2 + X_C^2}$$

$$\frac{V}{I} = \sqrt{R^2 + X_C^2}$$

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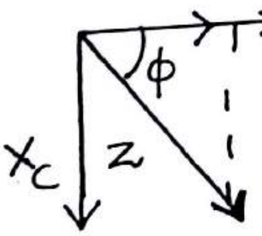
$$Z = \sqrt{R^2 + X_C^2} = \text{Impedence}$$



vector diagram - Z

$$\tan\phi = \frac{X_C}{R}$$

$$\tan\phi = \frac{1}{C\omega R}$$

** RC-circuit.

$$V_R = IR$$

$$V_C = I X_C$$

$$V = \sqrt{V_R^2 + V_C^2}$$

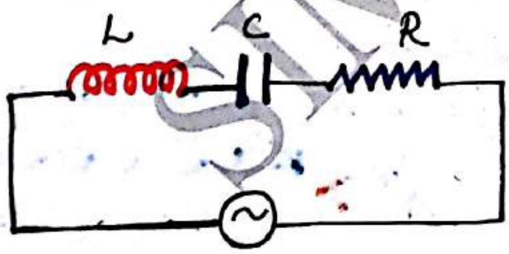
$$Z = \sqrt{R^2 + X_C^2}$$

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

$$\tan\phi = \frac{X_C}{R} = \frac{1}{C\omega R}$$

$$I_{rms} = \frac{E_{rms}}{Z}$$

** LCR CIRCUIT



consider an ac circuit with an inductor of inductance 'L', capacitor of capacitance 'c' and resistor of resistance 'R', connected in series. The instantaneous voltag of LCR circuit

$E = E_0 \sin \omega t$.

let I be the current flowing in the circuit [same through all elements]

But P.D across L, C and R are different

* Voltage across resistor

$$V_R = IR$$

I & R same phase.

* Voltage across Inductor

$$V_L = I X_L$$

V leads I by $\pi/2$.

* Voltage across capacitor.

$$V_C = I X_C$$

I leads V. by $\pi/2$

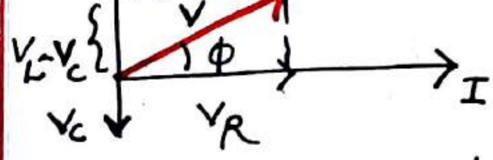
According to krichoffs rule

$$V = V_R + V_L + V_C$$

$$V = IR + L\frac{dI}{dt} + \frac{q}{c}$$

chose freq such that $V_L > V_C$

vector diagram - voltage



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

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The resultant voltage of the LCR circuit.

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

$$V = \sqrt{(IR)^2 + (IX_L - IX_C)^2}$$

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

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

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

Impedence

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

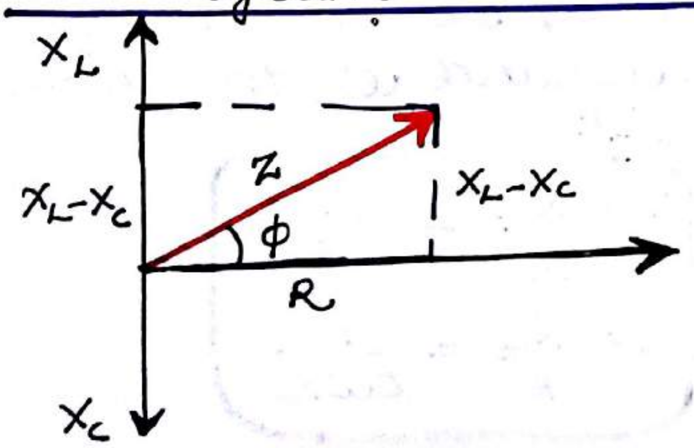
The phase difference between voltage and current [from vector diagram]

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

$$\tan\phi = \frac{IX_L - IX_C}{IR}$$

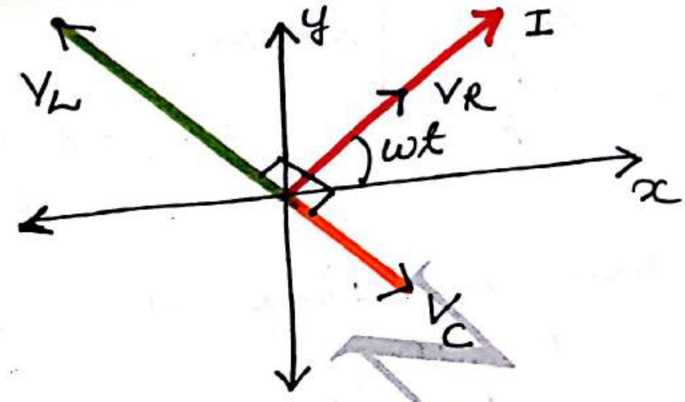
$$\tan\phi = \frac{X_L - X_C}{R}$$

Impedence - vector diagram



$$\tan\phi = \frac{X_L - X_C}{R}$$

Phasor diagram



* Instantaneous current in the circuit is

$$I = I_0 \sin(\omega t \mp \phi)$$

* If current leads emf $V_C > V_L$
* If current lags behind emf $V_L > V_C$

** Recap

LCR circuit
$V_R = IR$
$V_C = IX_C$
$V_L = IX_L$
$V = \sqrt{V_R^2 + (V_L - V_C)^2}$
$Z = \sqrt{R^2 + (X_L - X_C)^2}$
$\tan\phi = \frac{V_L - V_C}{V_R}$
$\tan\phi = \frac{X_L - X_C}{R}$
$I_{rms} = \frac{E_{rms}}{Z}$

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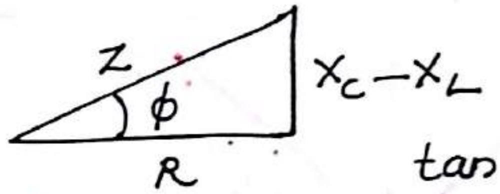
Impedence triangle

if $X_C > X_L$



$\tan\phi = \frac{X_C - X_L}{R}$

uses of Impedence triangle

* To find impedence value in circuit
* To find ϕ b/w V & I.
* To find power factor $\cos\phi$.

LCR- circuit condition for resonance & Resonant frequency.

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

if * $X_L = X_C$

* $Z = R$
* $\tan\phi = 0$ [V&I same phase]
* $I \rightarrow$ maximum

$X_L = X_C$

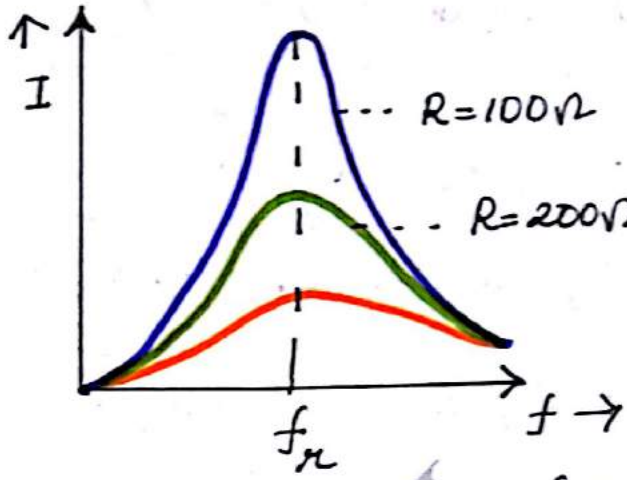
$L\omega = \frac{1}{C\omega}$

$\omega^2 = \frac{1}{LC}$

$\omega = \frac{1}{\sqrt{LC}}$

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

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



$f_r \rightarrow$ frequency of Resonance

Q - factor.

The sharpness of tuning at resonance is measured by Q-factor or Quality factor:

$$Q = \frac{1}{R}\sqrt{\frac{L}{C}} = \frac{X_L}{R} = \frac{X_C}{R}$$

* Q - factor of a circuit is defined as the ratio of reactance of either the Inductance or capacitance at the resonant frequency to the total resistance of the circuit.

$$Q = \frac{X_L}{R} = \frac{L\omega}{R}$$

$$Q = \frac{X_C}{R} = \frac{1}{C\omega R}$$

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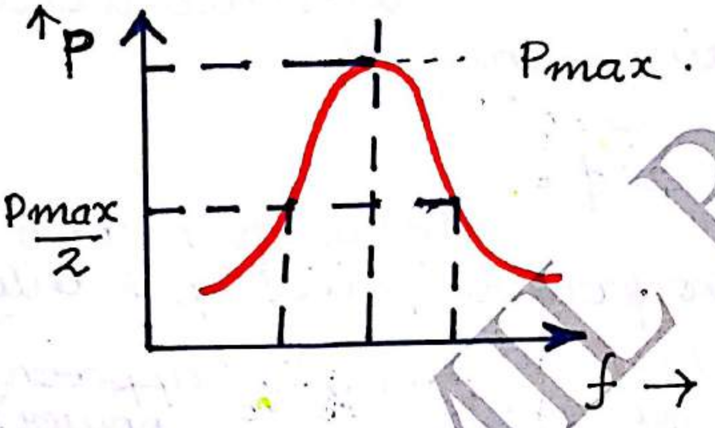
$$Q = \frac{V_L}{V_R}, \quad Q = \frac{V_C}{V_R}$$

$$Q = \frac{f_r}{f_1 - f_2} = \frac{\omega_r}{\omega_1 - \omega_2}$$

where f_1 and f_2 are called lower and upper half power frequencies at which power dissipation in the circuit drops to one half of its resonance value.



POWER IN AN AC CIRCUIT

Power in an ac circuit can be defined as the product of alternating voltage and alternating current. It is measured in watt.

Instantaneous emf and current in an ac circuit are given by

$$E = E_0 \sin \omega t.$$

$$I = I_0 \sin(\omega t - \phi)$$

* current lags behind emf by phase angle ϕ.
* power at any instant t

$$\frac{dw}{dt} = EI = P \quad \dots (1)$$

$$P = EI$$

$$P = E_0 \sin \omega t \cdot I_0 \sin(\omega t - \phi)$$

$$\sin(A - B) = \sin A \cos B - \sin B \cos A$$

$$P = E_0 I_0 \sin \omega t \, [\sin \omega t \cos \phi - \sin \phi \cos \omega t]$$

$$\frac{dw}{dt} = E_0 I_0 \sin^2 \omega t \cos \phi - E_0 I_0 \sin \phi \sin \omega t \cos \omega t$$

$$\sin A \cos A = \frac{\sin 2A}{2}$$

$$\frac{dw}{dt} = E_0 I_0 \cos \phi \sin^2 \omega t - \frac{E_0 I_0 \sin 2\omega t \sin \phi}{2}$$

$$dw = E_0 I_0 \sin^2 \omega t \cos \phi - E_0 I_0 \frac{\sin 2\omega t}{2} \sin \phi \, dt$$

$$\int dw = E_0 I_0 \cos \phi \int_0^T \sin^2 \omega t \, dt - \frac{E_0 I_0 \sin \phi}{2} \int_0^T \sin 2\omega t \, dt$$

$$w = E_0 I_0 \cos \phi \left(\frac{T}{2}\right) - \frac{E_0 I_0}{2} \sin \phi [0]$$

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as $\int_0^T \sin^2 \omega t\,dt = \frac{T}{2}$

and

$\int_0^T \sin 2\omega t\,dt = 0$

$$W = E_0 I_0 \cos\phi \cdot \frac{T}{2}$$

$$P = \frac{W}{T} = \frac{E_0 I_0 \cos\phi}{T} \cdot \frac{T}{2}$$

$$P = \frac{E_0 I_0}{2} \cos\phi$$

$$P = \frac{E_0}{\sqrt{2}} \cdot \frac{I_0}{\sqrt{2}} \cos\phi$$

$$P_{av} = E_{rms} \cdot I_{rms} \cos\phi.$$

Average Power = True power.

$$\boxed{P_{av} = E_{rms} I_{rms} \cos\phi}$$

$$\boxed{P_{av} = E_v I_v \cos\phi}$$

The terms $E_{rms} I_{rms}$ is called apparent power and $\cos\phi$ is called power factor.

Power factor

power factor $[\cos\phi]$ = $\frac{\text{True Power}}{\text{apparent power}}$

$$\boxed{\cos\phi = \frac{R}{Z}}$$

power factor in the following circuits

$[\cos\phi]$

(i) R only
(ii) L only
(iii) C only
(iv) LCR circuit at resonance.

(i) R only.

circuit contains only R.

$\phi = 0$
$\cos\phi = 1$

There is maximum Power dissipation if R only

(True power) $P = E_{rms} I_{rms}$ (apparent power)

(ii) L only / C only

In L only

$\phi = \pi/2$
$\therefore \cos\phi = 0$

$P = I_{rms} E_{rms} \cos \pi/2$

$\therefore P = 0$

No power is dissipated even though current flows in the circuit. This current is called as wattless current.

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LCR series circuit..

$$\tan\phi = \frac{X_L - X_C}{R}$$

$$\phi = \tan^{-1}\left(\frac{X_L - X_C}{R}\right)$$

ϕ may not be zero in RC, RL or LCR circuit. Even then; power is dissipated only in resistor.

LCR circuit at resonance.

$$X_L = X_C$$

$$X_L \sim X_C = 0.$$

$$\tan\phi = \frac{X_L - X_C}{R} = 0$$

$$\phi = 0$$

but $\cos\phi = 1$

$$P = I^2 Z$$
$$P = I^2 R$$

$\therefore$ maximum power is dissipated at resonance

$$P = E_{rms} I_{rms} \cos 0^\circ$$

$$P = E_{rms} I_{rms}$$

summary

R only $\phi = 0^\circ$ $\cos\phi = 1$	C- only $\phi = \pi/2$ $\cos\phi = 0$
L only $\phi = \pi/2$ $\cos\phi = 0$.	LCR at Resonance $\phi = 0$ $\cos\phi = 1$

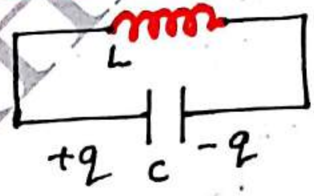
WATTLESS CURRENT

If circuit is purely Inductive or capacitive $\phi = \frac{\pi}{2}$.

$\therefore P = 0$

The current through Inductor or capacitor which consumes no power is called wattless current

LC OSCILLATIONS



LC circuit is also called as Tank circuit produces oscillations (damped). Frequency of oscillation

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

Energy stored in the capacitor in the form of electric field b/w its two plates

$$U_C = \frac{1}{2}\frac{q_0^2}{C}$$

Energy stored in L

$$U_L = \frac{1}{2} L I^2$$

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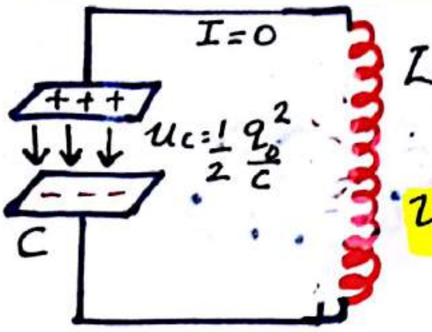
(a) At $t = 0$.



$q_0 \to$ initial charge of 'C'.

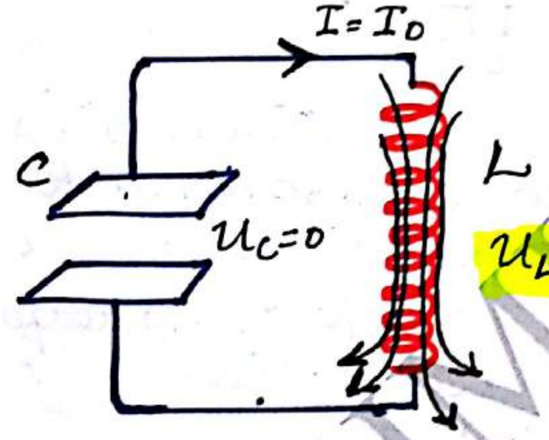
$u_L = 0$

'C' - fully charged. current through the inductor is zero.

$I = 0$

$u_c = \frac{1}{2}\frac{q_0^2}{c}$ $u_L = 0$

(b) At $t = T/4$



$u_L = \frac{1}{2} L I^2$

C - discharges

$I = I_0$

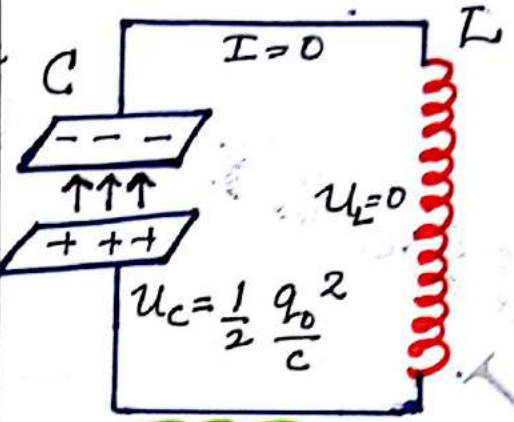
$u_c = 0$

energy is the Inductor 'L' is in the form of magnetic energy.

The current sets up magnetic field inside the Inductor.

$u_L = \frac{1}{2} L I^2$.

(c) At $t = T/2$

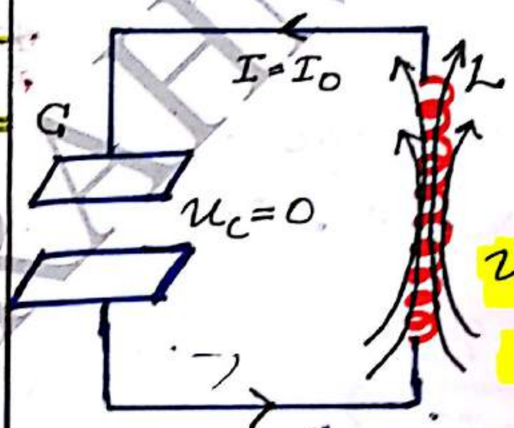


L charges 'C' in opposite polarity

$u_c = \frac{1}{2}\frac{q_0^2}{c}$

$u_L = 0$
$I = 0$

(d) At $t = 3T/4$



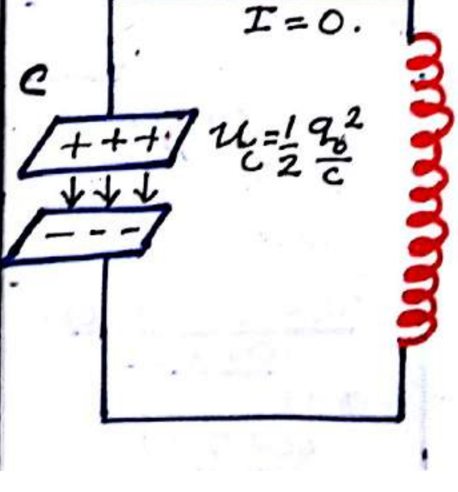
$u_L = \frac{1}{2} L I^2$

$I = I_0$.

C - discharges in opposite direction which results in magnetic field Inside Inductor (due to emf)

$u_c = 0$, $u_L = \frac{1}{2} L I^2$

(e) At $t = T$



$u_L = 0$

L charges C

$u_L = 0$,

$u_c = \frac{1}{2}\frac{q_0^2}{c}$

$I = 0$

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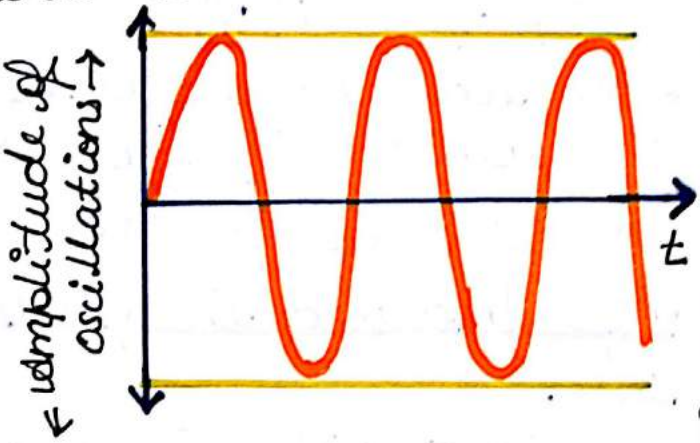
Thus energy in the system oscillates between capacitor and Inductor. This LC circuit which produces oscillations are called tank circuit.



If there is no resistance, it produces undamped oscillations. However due to finite resistance in the circuit (heat energy) damped oscillations are produced.

frequency of LC oscillations

$$\boxed{f = \frac{1}{2\pi\sqrt{LC}}}$$

TRANSFORMER

A transformer is a device used to change voltage of an alternating current (ac)

Principle

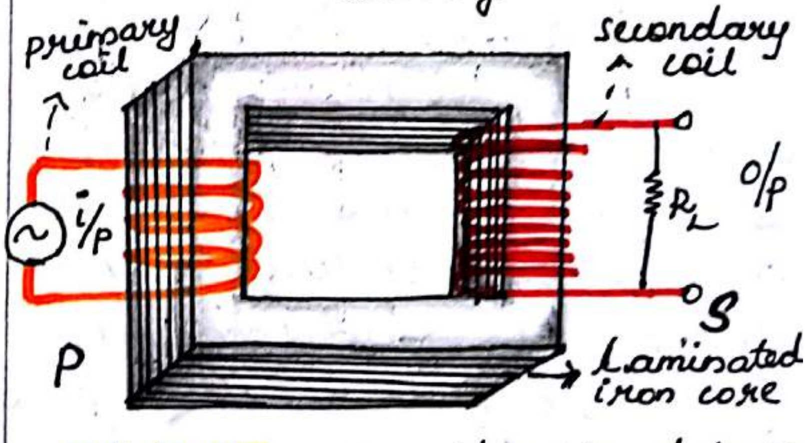
mutual Induction when I (current) changes in one coil emf is induced in other coil.

Construction

* A transformer consists of a rectangular core of soft iron core
* primary coils and secondary coils mounded on the iron core.

Types

step up – Increases voltage



$N_s > N_p$

$E_s > E_p$

$I_s < I_p$

$N_p \rightarrow$ No of turns in primary

$N_s \rightarrow$ No of turns in secondary.

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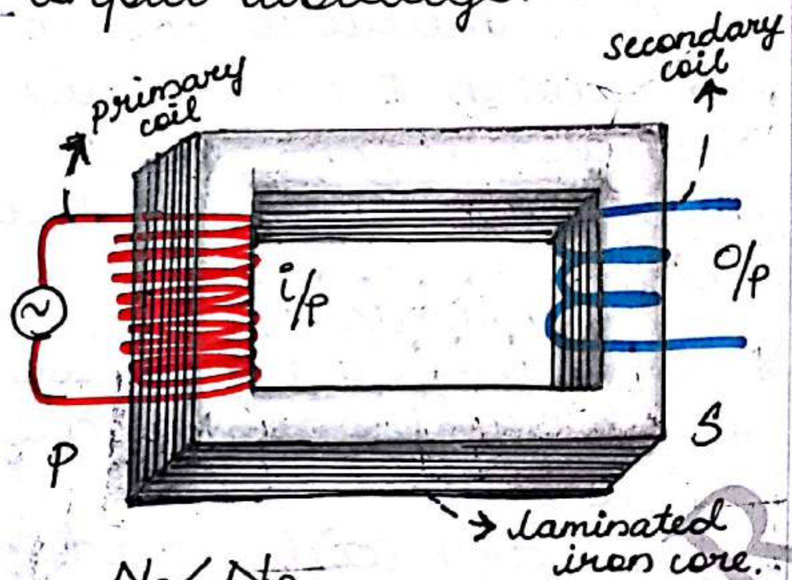
$E_s, E_p \rightarrow$ Emf in secondary and primary

$I_s, I_p \rightarrow$ current in secondary & primary.

step down

decreases the input voltage.



$N_S < N_P$

$E_S < E_P$

$I_S > I_P$

working

when an alternating emf is applied to the primary, the magnetic flux associated with the secondary also changes and an emf is Induced in the secondary.

Induced emf in the secondary depends upon the no of turns in secondary

if $N_s \uparrow$ $E_s \uparrow$

$N_s \downarrow$ $E_s \downarrow$

* For an ideal Transformer

i/p power = o/p power

$E_p I_p = E_s I_s$

* actual transformers

o/p power < i/p power

due to power loss

emf Induced in primary

$$E_p = -N_p \frac{d\phi}{dt} \quad \ldots (1)$$

emf Induced in secondary

$$E_s = -N_s \frac{d\phi}{dt} \quad \ldots (2)$$

(1) ÷ (2)

$$\boxed{\frac{E_p}{E_s} = \frac{N_p}{N_s}} \quad \ldots (3)$$

i/p power = o/p power

$E_p I_p = E_s I_s$

$$\boxed{\frac{E_p}{E_s} = \frac{I_s}{I_p}} \quad \ldots (4)$$

from (3) & (4)

$$\boxed{\frac{E_p}{E_s} = \frac{N_p}{N_s} = \frac{I_s}{I_p}}$$

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$$\text{Efficiency } \eta = \frac{\text{output power}}{\text{Input power}}$$

$$\eta = \frac{E_s I_s}{E_p I_p}$$

Energy losses in Transformer.

copper loss - Due to heating effect - resistance of copper.

* minimised by using thick wires.

Eddy current loss / iron loss: Eddy currents are produced in the iron core of the transformer and heat is produced. This loss is known as iron loss.

* lamination of iron core minimises these loses.

flux leakage:

The entire magnetic flux produced by the primary does not link with the secondary.

* minimised by winding primary and secondary one over other.

Eddy current loss:

Heating due to hysteriesis when the iron core undergoes a cycle of magnetisation.

9

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