Magnetic circuit :-

A magnetic circuit is made up of one or more loop paths containing a magnetic flux. The flux is usually generated by permanent magnets or electromagnets and confined to the path by magnetic cores consisting of ferromagnetic materials like iron, although there may be air gaps or other materials.

Flux :-

~~Flux is a~~ It may be defined as the total number of magnetic field lines passing through a given circuit area.

It is denoted by the symbol ϕ.
The SI unit of ϕ is weber (wb).

Magnetic flux density :-

It is the number of magnetic field lines passing through per unit area.
It is denoted by 'B'.

$$\text{Magnetic flux density } (B) = \frac{\phi}{A} = \frac{\text{weber}}{m^2}$$

The force that moves the magnetic in a magnetic circuit is called MMF.

Magnetomotive force (MMF) :-

The MMF is defined as the work done in moving a unit magnetic pole once around the magnetic circuit. It is a magnetic pressure that tends to set up magnetic flux in a magnetic circuit.

Mathematically, the MMF is the product of current and no. of turns of a coil.

$$MMF = N \times I$$

SI unit of MMF is AT.

Magnetic field strength :-

Magnetic field strength is a measure of the intensity of a magnetic field in a given area of that field.

It is represented by 'H'

$$H = \frac{MMF}{l} = \frac{B}{\mu}$$

$$\text{unit of } H = \frac{\text{Ampere Turns}}{\text{meter}} = \frac{AT}{m}$$

Reluctance :-

The reluctance of a magnetic material is its ability to oppose the flow of magnetic flux.

It is denoted by (S).

$$S = \frac{MMF}{\phi}$$

$$\text{SI unit of reluctance} = \frac{AT}{Wb}$$

Reluctance in magnetic circuit is analogous to resistance in electric circuit.

Permeance :-

The measure of ease in the flow of magnetic flux offered by a magnetic material is known as permeance. It is also known as magnetic conductance. It helps the magnetic flux in flowing through a magnetic material.

It is denoted by P (P)

$$P = \frac{1}{\text{Reluctance}}$$

Permeance in magnetic circuit is analagous to conductance in electric circuit.

Permeability :-

It is the ability of a material to permit the passes of magnetic lines of force through it.

It is represented by 'μ'.

SI unit = Henry/meter. $\mu = \frac{B}{H}$

Admittance :-

It is the measure of how easily a circuit allows current to flow through impedance, which measures the opposition to the flow of current.

Admittance is represented by the symbol Y and is measured in Siemens (S), high admittance means easier current flow while low admittance indicates more resistance to current flow.

SI unit of admittance is Siemens (S)

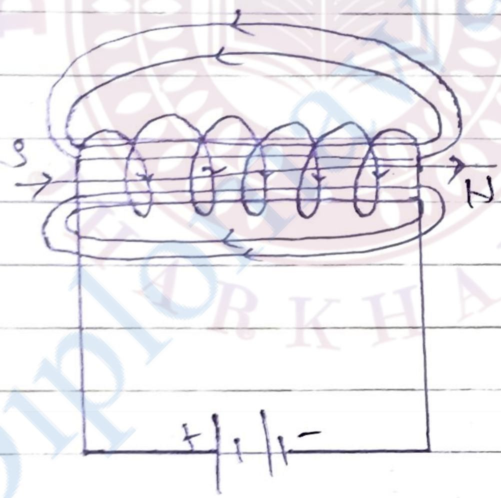
$$Y = \frac{1}{Z}$$

where z is impedance of the circuit.

Solenoid :-

A solenoid is a long coil that contains large number of close turns of insulated copper wire.

The magnetic field pattern produced by a current-carrying solenoid is similar to the magnetic field produced by a bar magnet.



Q. Calculate the MMF required to produce a flux of 0.01 wb across an air gap 2.5 mm long having and effecture area of 200 cm^2.

Ans $\phi = 0.01$ web

$l = 2.5$ mm $= 2.5 \times 10^{-3}$ m

$A = 200 cm^2 = 200 \times 10^{-4} m^2$

$$B = \frac{\phi}{A} = \frac{0.01}{200 \times 10^{-4}} \ wb/m^2$$

$$= \frac{10^{-2+4}}{200} = \frac{10^2}{200} = \frac{\cancel{100}}{2\cancel{00}} = 0.5$$

$$= 0.5 \ wb/m^2$$

$$H = \frac{B}{\mu} = \frac{0.5}{4\pi \times 10^{-7}}$$

$$MMF = H \times l$$

$$= \frac{0.5}{4\pi \times 10^{-7}} \times 2.5 \times 10^{-3}$$

$$= \frac{1.25}{4\pi} \times 10^{7-3} \ AT$$

$$= 0.801 \times 10^{4} \ AT$$

Q. An iron ring of mean length 50 cm has 500 turns of winding, The μ_r of iron is 600 when a current of 3A flow in the winding. calculate the flux density.

$\Rightarrow$ $l = 50\ cm = 0.5\ m$

$N = 500$

$\mu_r = 600$

$B = ?$ $\quad I = 3\,A$

$$H = \frac{NI}{l} = \frac{\cancel{500} \times 3 \times 10}{\cancel{0.5}}$$

100   0.1

$= 3000\ AT/m.$

$B = \mu H$

$= \mu_0 \mu_r H$

$= 4\pi \times 10^{-7} \times 600 \times 3000$

$= 4\pi \times 18 \times 10^{-7+2+3}$

$= 72\pi \times 10^{-2}$

$$\boxed{B = 72\pi \times 10^{-2}\ T}$$

Permeability

① **Absolute Permeability :-** The permeability of free space is defined as the no. of magnetic ~~field~~ lines of force that air / vaccum would allow to pass through it.

Its value is given by -

$$\mu_0 = 4\pi \times 10^{-7} \ H/m$$

② Relative Permeability :-

It is defined as the ratio of permeability of ~~vaccum~~ the medium material to the permeability of the vaccum.

It is a measure of how many magnetic field lines it allow in comparison to vaccum.

$$\boxed{\mu_r = \frac{\mu}{\mu_0}}$$

It has no unit.

Capacitor :-

It is another type of physical component used in electronic circuit.

Typically, it has two conductive plates separated by an Insulator which are used to store and release electrical energy.

Types of Magnet :-

↳ Permanent / Natural magnet :-

They are the naturally occuring material that has the property to repel or attract magnetic material. They are called as permanent as they do not lose their magnetic property once they are magnetized.

↳ Temporary magnets (Electromagnet) :-

They are magnetized in the presence of a magnetic field. when the magnetic field is removed, these materials lose their magnetic property.

Examples :- Iron nails, paper clips.

Electromagnet consist of a coil of wire wrapped around the metal core made from iron. when this material is exposed to an electric current a magnetic field is generated, making the material behave like a magnet. The strength of the magnetic field can be controlled by controlling the electric current.

Q. Determine MMF required to set up a flux density of 1.2 wb/m² in an iron ring having dimension of 25 cm long. The cross-sectional area of ring is 25 cm² and relative permeability of iron is 1000.

Solve:-

$\mu_r = 1000$

$B = 1.2\ wb/m^2$

$l = 25\ cm = 0.25\ m$

$A = 25\ cm^2 = 25 \times 10^{-4}\ m^2$

$mmf = ?$

$$H = \frac{B}{\mu} = \frac{1.2\ wb/m^2}{4\pi \times 10^{-7} \times 1000\ N/m}$$

$$= \frac{0.3}{\pi} \times 10^{7-3}$$

$$= \frac{3}{3.14} \times 10^3\ At/m.$$

$MMF = Hl$

$$= \frac{3}{3.14} \times 10^3 \times 0.25\ At$$

$$= \frac{3}{314} \times 10^3 \times 25\ At$$

$$= \frac{75000}{314} = 238.8\ At.$$

Write about passive element - R, L, C.

Components / Elements

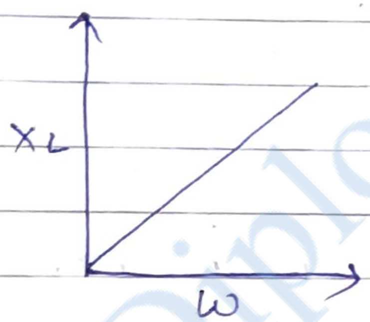
Active

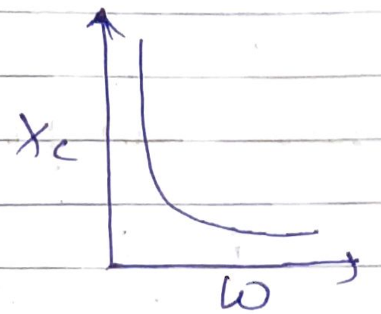
No ext. source req.
energy deliver

Passive

Ext. source req.
energy consumed

Oppose current → Resistance R (Ω)
opp. sudden change in I, ϕ → Inductor (L).
store E, opp. V, → capacitor (C)
(F)
Store (H)





$X_L = \omega L$

$X_C = \frac{1}{\omega c}$

Active components :-

An electric circuit element which can supply electric power to the circuit or power gain in the circuit, is known as active component.

Examples :- Energy sources, generat... transistors, ...

The active element are the circuit components which are entirely respons... for the flow of electric current in the circuit.

They behave as source of power in the circuit. They can deliver as well as absorb electrical power. for ex:- battery; during charging absorb energy and deliver during discharging.

Passive components :-

The circuit element which can only absorb electrical energy and dissipates it in the form of heat or stores in either magnetic field or electric field.

A passive component cannot provide power in a electric circuit.
eg:- Resistor, inductor, capacitor, etc.

They act as a load in the circuit.

It can only absorb electrical power.

* **Resistors :-**

It is a primary type of physical component that is used in electronic circuit.

It opposes the flow of current in circuit.

The amount of that opposition is called its resistance, which is measured in Ω.

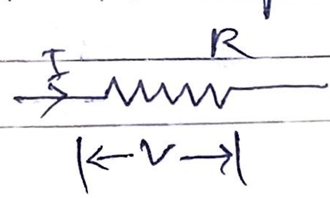
It is used to control the current in various areas and to manage voltage levels at different points.

It is represented by R.

By using ohm's law, we can calculate the value of current, voltage and resistance.

Mathematically, it is expressed as:

$\boxed{V = IR}$;



V → voltage , I = current , R = Resistance

* capacitors :-

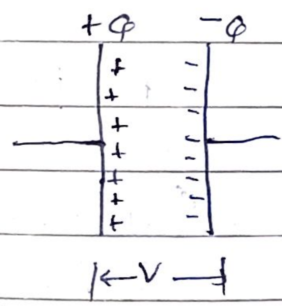
It is another type of physical component used in electronic circuit.
Typically, it has two conductive plates separated by an insulator which are used to store and release electrical energy.

A capacitor's ability to store charge is referred to as its capacitance, measured in farads (F).

A capacitor does pass AC only and does not used for DC circuit.

$$\boxed{C = \frac{Q}{V}}$$

Q → charge
C → capacitance
V → Pot. diff.



An Alternating voltage causes the capacitor to repeatedly charge & discharge, storing and releasing energy.

also, $\boxed{C = \frac{\epsilon_0 A}{d}}$ [A = area of plate]

* Inductor :-

It has one or more windings (loops) of conducting wires.

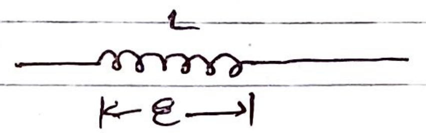
It is often but not necessarily farmed around a core of iron or steel or same other magnetic material.

current through the coil induces a magnetic field that serves as a source of energy.

Inductance is measured in Henry (H).

If ϕ is the flux induced by passing current through the coil and $\mathcal{E}$ be the induced emf Then inductance is given by :-

$$\boxed{\mathcal{E} = -L \frac{dI}{dt}}$$



Resistance provide opposition to the flow of current in DC circuit while inductors and capacitors provide resistance to AC which is termed as reactance.

Reactance :-

It is the measurement of capacitance and inductance's resistance to the flow of alternating current.

There will be reactance when there is either an inductor or a capacitor in the circuit.

It is represented by 'X'. Inductive reactance is given by 'X_L' and capacitive reactance is given by 'X_C'.

$$X_L = \omega L \quad ; \quad X_C = \frac{1}{\omega C}$$

$\omega \rightarrow$ angular frequency
$L \rightarrow$ inductance
$C \rightarrow$ capacitance.

The unit ohm (Ω) is used to express the reactance.

The resistance offered by inductor to the flow of ac is called as inductive reactance.
The resistance offered by capacitor to the follow of ac is called as capacitive reactance.

Impedance (z) :-

It is the combination of resistance and reactance. which measure the overall resistance of the ac. circuit.

It is measured in ohm (Ω).

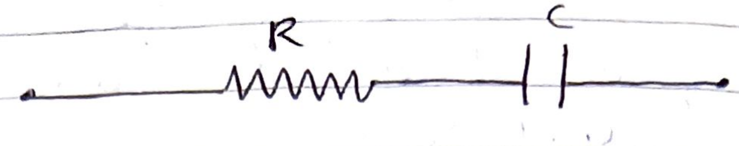
$z = \sqrt{R^2 + X_L^2}$ - [for series RL ckt]

$z = \sqrt{R^2 + X_C^2}$ - [for series RC ckt]

$z = \sqrt{R^2 + (X_L - X_C)^2}$ - [for series LCR ckt]

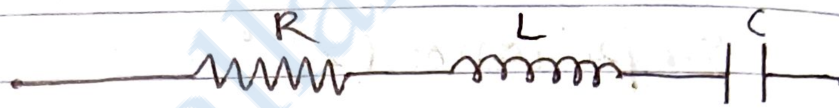
RL Comb^n :

RC Comb^n :



LC Comb^n :

LCR Comb^n :



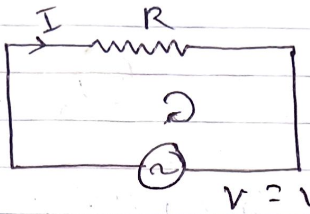
Pure resistive circuit contain only Resistor (R) in the AC circuit and not other elements like capacitor & inductor.

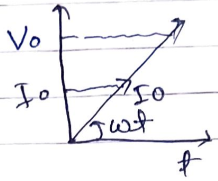
The alternating voltage and current flows a ~~shop~~ shape of sine wave or known as sinosoidal waveform.

The power is disscipitated by the resistor and the phase of the voltage and current remain same i.e, both I and V reach their max^n and min^n value at the same time.

The avg. power in purely resistive circuit is not zero.

Pure resistive circuit :-





$V = V_0 \sin\omega t$

Applying KVL,

$$V - IR = 0$$

$$V = IR$$

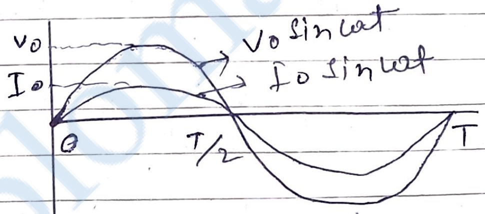
$$I = \frac{V}{R} = \frac{V_0 \sin\omega t}{R}$$

$$\boxed{I = I_0 \sin\omega t}$$

Power $= VI$

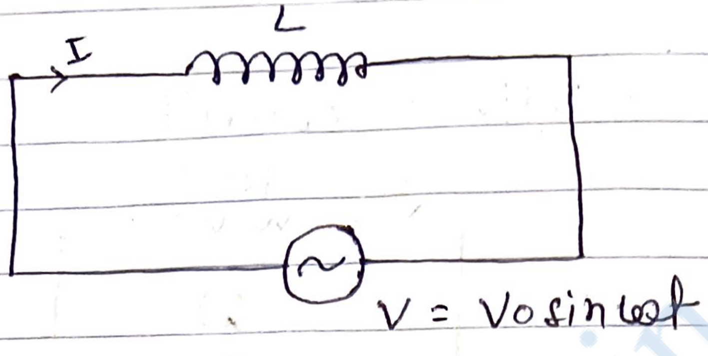
$$\boxed{P = V_0 \sin\omega t \cdot I_0 \sin\omega t}$$

Wave form:



power factor : $\cos\phi = \cos 0° = 1$
(Cosine is of voltage & current)

* Pure Inductive circuit :



$$|\varepsilon| = L\frac{dI}{dt}$$

In pure inductive circuit, a circuit which contain only inductance (L) and does not contain any other component like resistance and capacitor in the circuit.

Applying KVL,

$$V - \varepsilon = 0$$

$$V = \varepsilon$$

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

$$dI = \frac{V}{L}\,dt$$

$$\int dI = \int \frac{V_0}{L} \sin\omega t \, dt$$

$$I = \frac{V_0}{L}\int \sin\omega t \cdot dt$$

$$I = \frac{V_0}{L}\frac{(-\cos\omega t)}{\omega}$$

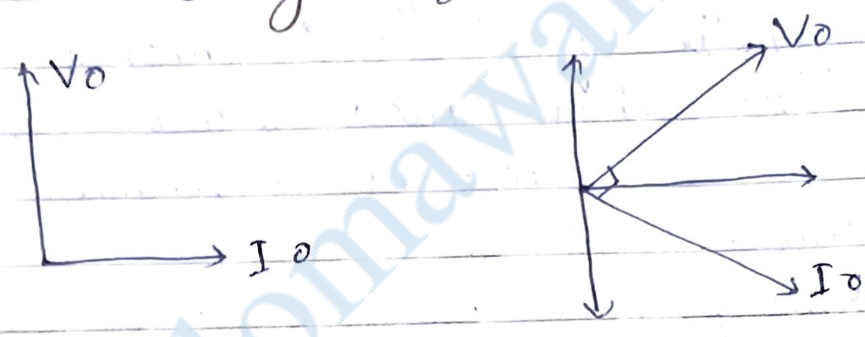
$$I = \frac{-V_0}{\omega_L} \cos\omega t$$

$$I = \frac{-V_0}{X_L} \sin(90 - \omega t)$$

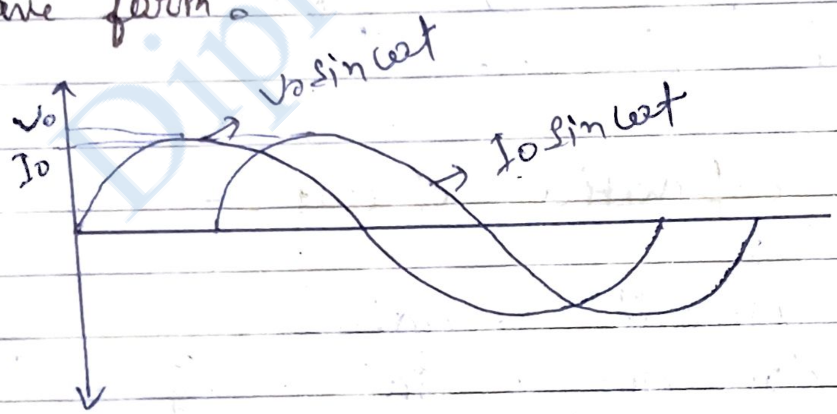
$$I = \frac{V_0}{X_L} \sin(\omega t - 90)$$

$$\boxed{I = I_0 \sin(\omega t - 90)}$$

Phasor diagram:



wave form:



In pure inductive circuit, avg. power is zero.
current is lagging with voltage by 90°.

$$P = (V_m \sin \omega t)\{I_m \sin(\omega t - \tfrac{\pi}{2})\}$$

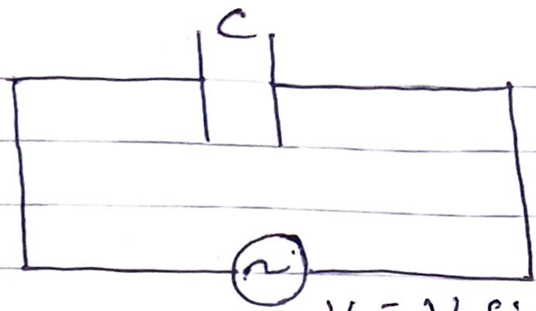
$$= V_m I_m \sin \omega t \times \sin(\omega t - \tfrac{\pi}{2}).$$

In purely inductive circuit, during the first quatter cycle. the power is supplied by the source is stored in the magnetic field set up around the coil.

In the next quarter cycle, the magnetic field diminishes and the power that was stored in the first quarter cycle is returned to the source.
This power continuous in every cycle and thus, no power is consumed in the circuit.

* Pure capacitive circuit :-

This circuit contain only capacitor (c) and does not contain any other components like resistor and inductor. It stores electrical power in the electric field.



$V = V_0 \sin \omega t$

charge of capacitor at any instant of time given as :-

$$q = CV \quad — (1)$$

current following through the circuit is

$$I = \frac{dq}{dt}$$

$$= \frac{d(cv)}{dv}$$

$$I = c\frac{dv}{dt}$$

$$I = \frac{c\, d\, v_0 \sin \omega t}{dt}$$

$$I = \frac{C V_0\, d \sin \omega t}{dt}$$

$$I = C V_0 \times \cos \omega t \times \omega$$

$$I = \frac{V_0}{\frac{1}{\omega C}} \times \cos \omega t$$

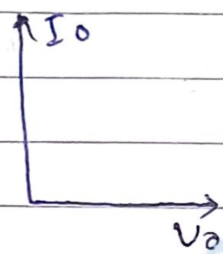
$$I = \frac{V_0}{X_C} \cdot \cos\omega t$$

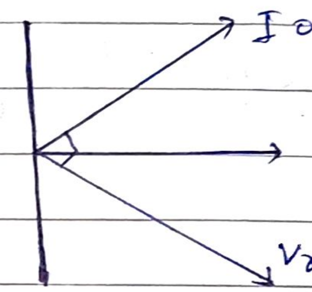
$$I = I_0 \cos\omega t$$

$$\boxed{I = I_0 \sin\left(\omega t + \frac{\pi}{2}\right)}$$

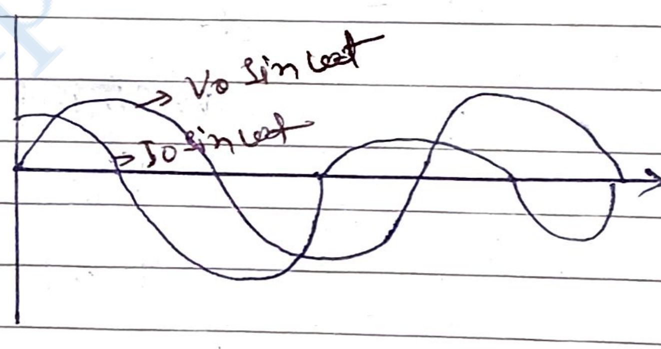
$\therefore$ Current leads voltage by $\pi/2$.

Phasor diagram:





Wave form:



$$P = VI$$

$$= (V_0 \sin\omega t) \cdot I_0 \sin\left(\frac{\pi}{2} + \omega t\right)$$

$$= V_0 I_0 \cdot \sin\omega t \times \sin\left(\frac{\pi}{2} + \omega t\right)$$

$$= V_0 I_0 \cdot \frac{2 \sin \omega t \times \cos \omega t}{2}$$

$$= \frac{V_0 I_0}{2} \times \sin 2\omega t$$

$$= \frac{V_0}{\sqrt{2}} \times \frac{I_0}{\sqrt{2}} \times \sin 2\omega t$$

$$\boxed{P = V_{rms} \times I_{rms} \times \sin \omega t}$$

The average power in the capacitive circuit is zero.

In the first quarter cycle, the power which is supplied by the source is stored in the electric field set up between the capacitor plates.

In the another next quarter cycle, the electric field diminishes, and thus the power stored in the field is returned to the source.

This process is repeated continuosly and therefore, no power is consumed by the capacitive circuit.

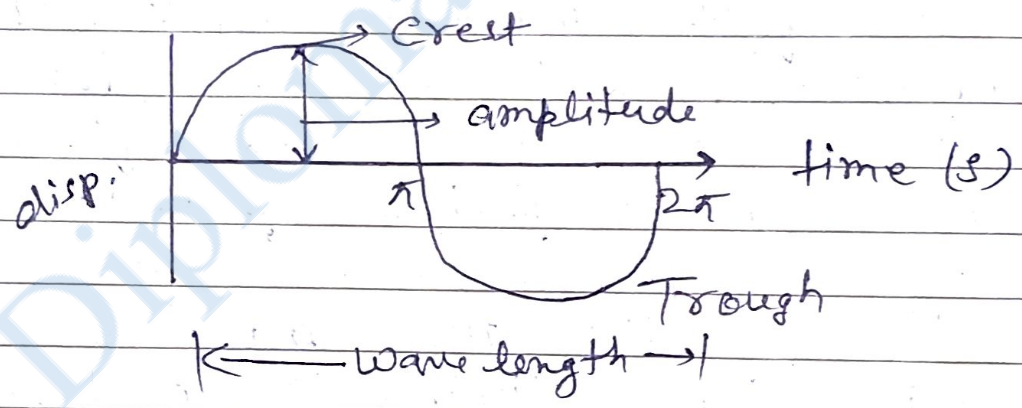
Power factor : $\cos\phi = \cos 90° = 0$

* Wave :-

A wave is a distance in a medium that carries energy without a net movement of particles.

wave carries / transmit information or energy from one point to another in the form of signals.

eg :- Sea wave, sound wave, etc.



↳ Frequency :- The no. of waves passing by a specific point per second is called its frequency. Hertz is the unit of frequency.

It is denoted by 'f' or ν.

↳ Amplitude :- It is the distance between the resting position and the maximum displacement of the wave. It is the measure of how big the wave its is.

↳ Time period :-
It is the time taken for one cycle to complete.

↳ Wavelength :- The distance from a particular height on the wave to the next spot on the wave where it is at the same height and going in same direction. usually, it is measured in metre.

↳ cycle :-
One Oscillation of a wave is known to be one wave cycle.
one complete set of positive and negative values of alternating quantities is known as cycle.

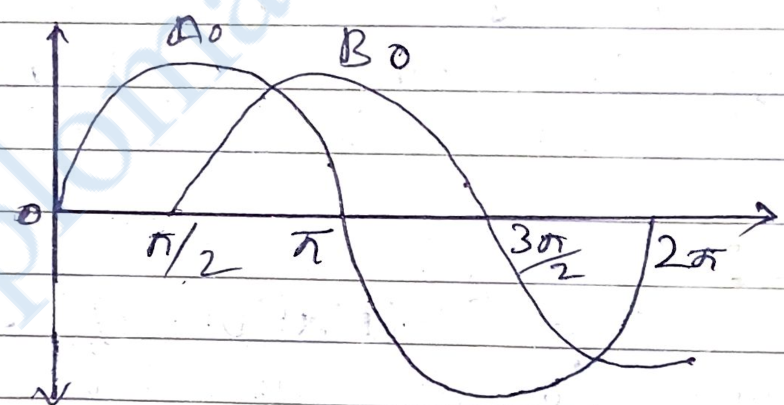
↳ Phase :- It is a part of time period after the alternative quantity passed through 0 (zero) position.

or.

It is the phase angle position of ac quantity.

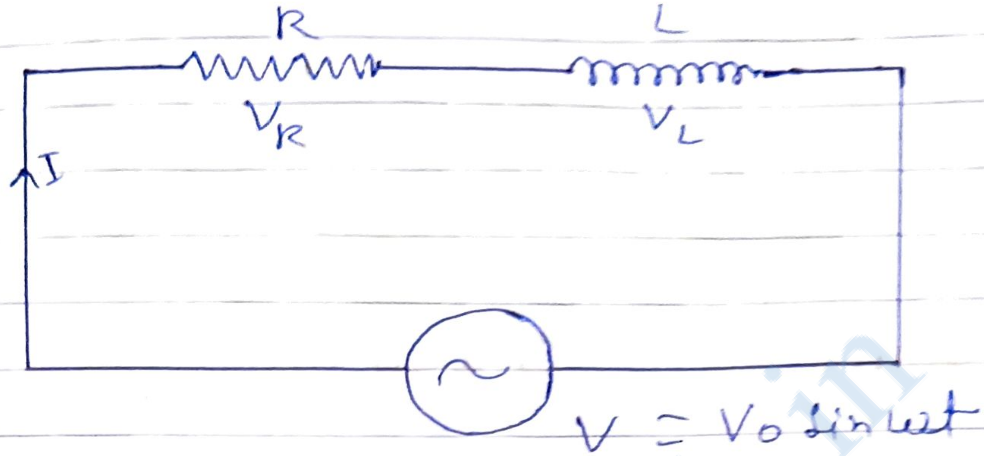
* Phase difference :- If two alternating quantities do not reach their 0 value at the same direction simultaneosly then they have phase difference.

✓ The difference of phase angle between two AC quantities on the same reference axis is known as phase difference.



Phase diff.

* Series L-R circuit :-



$$V_R = (V_0)_R \sin\omega t$$

$$V_L = (V_0)_L \sin\left(\omega t + \frac{\pi}{2}\right)$$

$$(V_0)^2 = (V_0)_R^2 + (V_0)_L^2$$

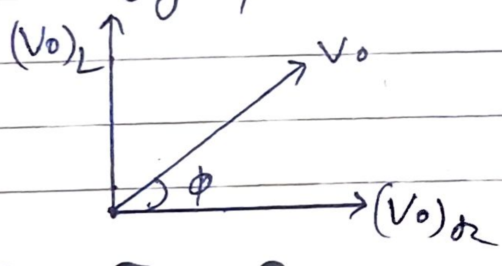
$$V_0 = \sqrt{(V_0)_R^2 + (V_0)_L^2}$$

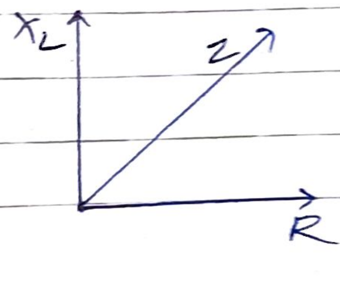
$$V_0 = \sqrt{(I_0 R)^2 + (I_0 X_L)^2}$$

$$V_0 = I_0 \sqrt{R^2 + (X_L)^2}$$

$$V_0 = I_0 Z$$

Current lags behind potential difference by ϕ.

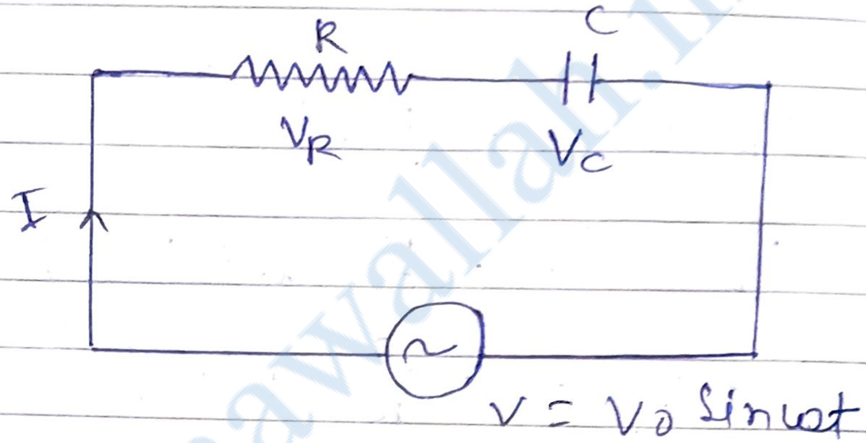




$$Z = \sqrt{R^2 + X_L^2}$$

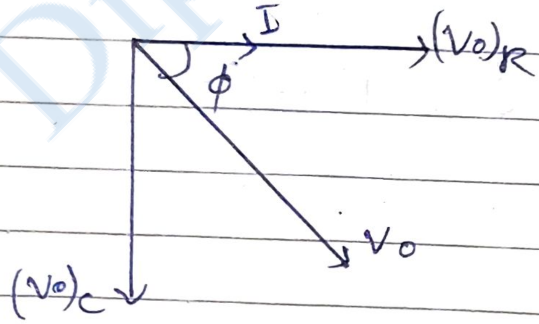
$$\boxed{\tan\phi = \frac{X_L}{R}}$$

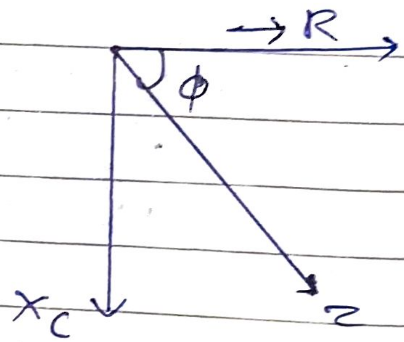
* Series C-R circuit :



$$V_R = (V_0)_R \sin\omega t$$

$$V_C = (V_0)_C \sin\left(\omega t - \frac{\pi}{2}\right)$$





$$V_0 = \sqrt{(V_0)_R^2 + (V_0)_C^2}$$

$$V_0 = \sqrt{I_0^2 R^2 + I_0^2 X_C^2}$$

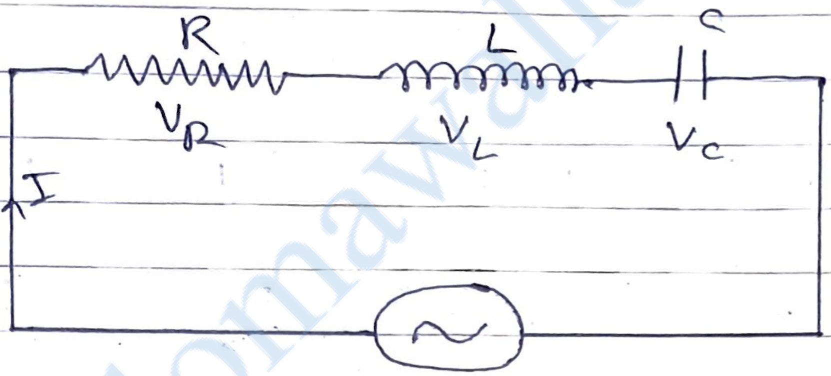
$$V_0 = I_0 \sqrt{R^2 + X_c^2}$$

$$V_0 = I_0 Z$$

current leads potential difference by ϕ

$$\tan\phi = \frac{X_c}{R}, \quad Z = \sqrt{R^2 + X_c^2}$$

(*) Series L-C-R circuit :-

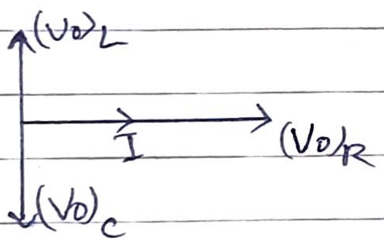


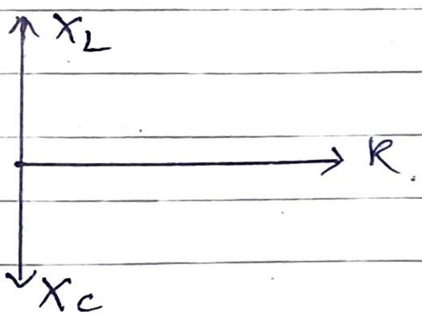
$$V_R = (V_0)_R \sin\omega t \qquad , (V_0)_R = I_0 R$$

$$V_L = (V_0)_L \sin\left(\omega t + \frac{\pi}{2}\right) \qquad , (V_0)_L = I_0 X_L$$

$$V_C = (V_0)_C \sin\left(\omega t - \frac{\pi}{2}\right) \qquad , (V_0)_C = I_0 X_C$$

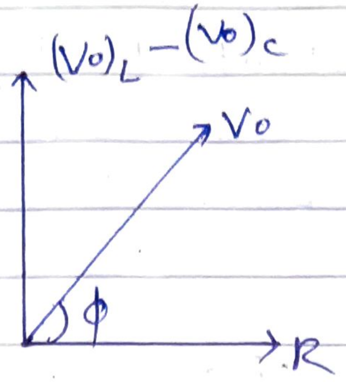
Phasor diagram :-

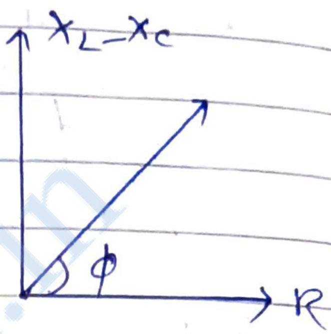




Case I :

$(V_0)_L > (V_0)_C$ or $X_L > X_C$





$$(V_0)^2 = (V_0)_R^2 + \{(V_0)_L - (V_0)_C\}^2$$

$$(V_0)^2 = I_0^2 R^2 + \{I_0 X_L - I_0 X_C\}^2$$

$$(V_0)^2 = I_0^2 R^2 + I_0^2 (X_L - X_C)^2$$

$$(V_0)^2 = I_0^2 [R^2 + (X_L - X_C)^2]$$

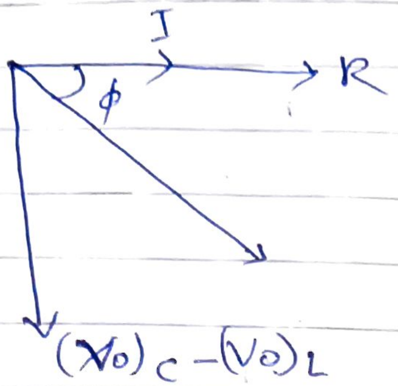
$$V_0 = I_0 \sqrt{R^2 + (X_L - X_C)^2}$$

$$V_0 = I_0 Z$$

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

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

Case II : $(V_0)_L < (V_0)_C$ or $X_L < X_C$



$$V_0^2 = (V_0)_R^2 + [(V_0)_C - (V_0)_L]^2$$

$$V_0^2 = I_0^2 R^2 + [I_0 X_C - I_0 X_L]^2$$

$$V_0^2 = I_0^2 R^2 + I_0^2 [X_C - X_L]^2$$

$$V_0^2 = I_0 [R^2 + (X_C - X_L)^2]$$

$$V_0 = I_0 \sqrt{R^2 + (X_C - X_L)^2}$$

$$V_0 = I_0 Z$$

where,

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

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

Case III : $(V_0)_L = (V_0)_C$ or $X_L = X_C$

$$\xrightarrow[I]{\quad\quad} (V_0)_R$$

$$V_0 = (V_0)_R$$

Pure Resistive circuit

$$\boxed{V_0 = I_0 Z}$$

where $Z = R$

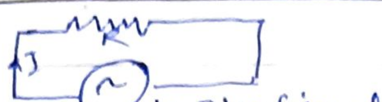
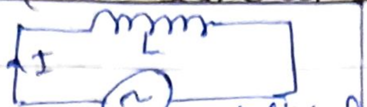
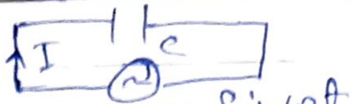
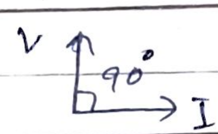
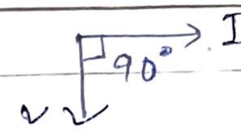
∵ It is called Resonance condition.

Relation between magnetic flux, MMF and Relectance.

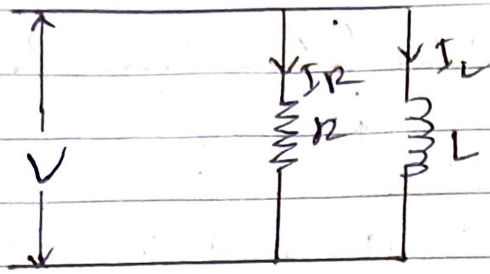
⇒ $$\text{Magnetic flux} = \frac{\text{mmf}}{\text{Reluctance}}$$

$$\boxed{\phi = \frac{\text{mmf}}{S}}$$

R, L and C circuit

Circuit characteristic	Purely resistive circuit (R-circuit)	Purely inductive circuit (L-circuit)	Purely capacitive circuit (C-circuit)
(i) circuit	 $V = V_0 \sin\omega t$	 $V = V_0 \sin\omega t$	 $V = V_0 \sin\omega t$
(ii) current	$I = I_0 \sin\omega t$	$I = I_0 \sin(\omega t - \frac{\pi}{2})$	$I = I_0 \sin(\omega t + \frac{\pi}{2})$
(iii) peak current	$I_0 = \frac{V_0}{R}$	$I_0 = \frac{V_0}{X_L} = \frac{V_0}{\omega L} = \frac{V_0}{2\pi f L}$	$I_0 = \frac{V_0}{X_C} = V_0 \omega C = V_0 \cdot 2\pi f C$
(iv) phase difference	$\phi = 0°$	$\phi = 90°$	$\phi = 90°$
(v) power factor	$\cos\phi = 1$	$\cos\phi = 0$	$\cos\phi = 0$
(vi) Power	$P = V_{rms} I_{rms} = \frac{V_0 I_0}{2}$	$P = 0$	$P = 0$
(vii) Power loss	Maximum	No power loss	No power loss
(viii) leading quantity.	Both are in same phase	voltage	current
(ix) Phasor diagram.			

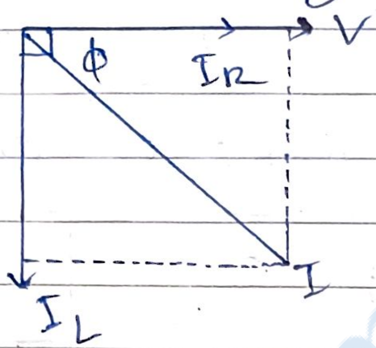
A Parallel R-L circuit :-



$$I_R = \frac{V}{R} \text{ (amp)}$$

$$I_L = \frac{V}{jX_L} \text{ (amp)}$$

1. Phasor diagram



2. Admitance

$$I = I_R + I_L$$

$$I = \frac{V}{R} + \frac{V}{jX_L}$$

$$I = V\left(\frac{1}{R} + \frac{1}{jX_L}\right)$$

$$\frac{I}{V} = \frac{1}{R} + \frac{1}{jX_L}$$

$$Y = G - jB_L$$

$$\boxed{|Y| = \sqrt{G^2 + (B_L)^2}}$$

3. Power factor

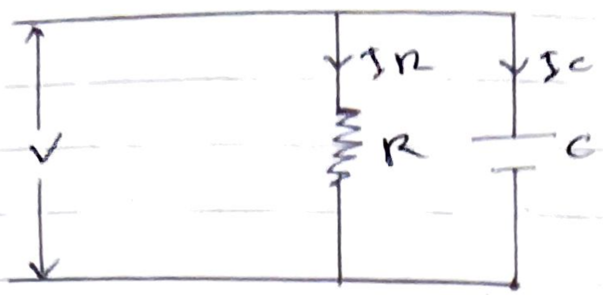
$$\cos\phi = \frac{I_R}{I}$$

$$= \frac{\cancel{V}/R}{\cancel{V}Y}$$

$$= \frac{1}{RY}$$

$$\boxed{\cos\phi = \frac{G}{Y}}$$

Parallel R-C circuit :-

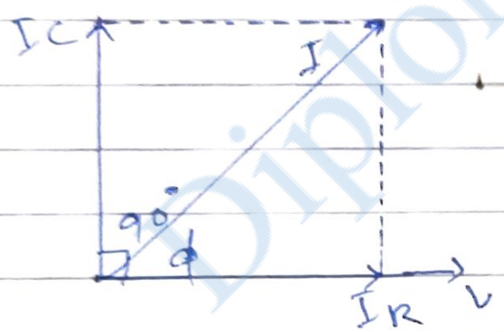


$I_R = \frac{V}{R}$ (amp)

$I_C = \frac{jV}{X_C}$ (amp)

C = capacitance
R = Resistance
I_C = current across capacitance
I_R = current across Resistance
I = current through the circuit
V = voltage

1. Phasor diagram



$\left\{ \frac{1}{R} = G \text{ conductance} \right\}$

$\left\{ \frac{1}{X_C} = B_C \text{ } \right\}$ ~~Acceptance~~ susceptance

2. Admitance

$I = I_R + I_C$

$I = \frac{V}{R} + \frac{jV}{X_C}$

$I = V\left(\frac{1}{R} + \frac{j}{X_C}\right)$

$\frac{I}{V} = (G + jB_C)$

$\frac{1}{Z} = (G + jB_C)$

$Y = G + jB_C$

$\boxed{|Y| = \sqrt{G^2 + B^2}}$

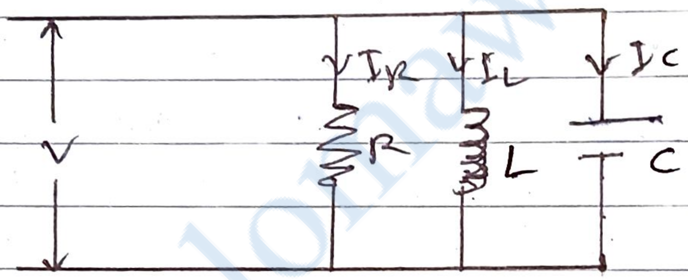
3. Power factor

$$\cos\phi = \frac{I_R}{I}$$

$$\cos\phi = \frac{V/R}{VY}$$

$$\boxed{\cos\phi = \frac{G}{Y}}$$

Parallel L-C-R circuit :-



$$I_R = \frac{V}{R}$$

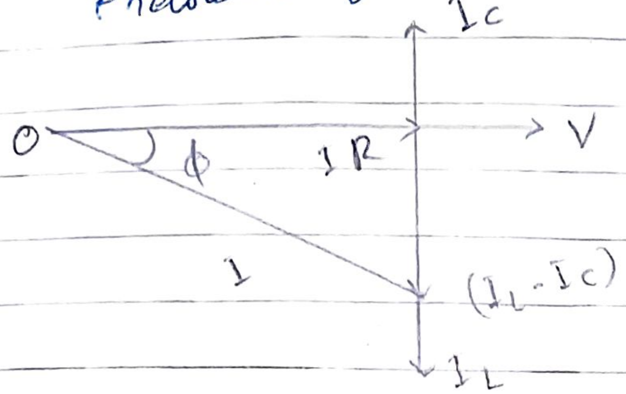
$$I_L = \frac{V}{jX_L}$$

$$I_C = \frac{jV}{X_C}$$

R = Resistance
L = Inductance
C = capacitance
I_R = current across Resistance
I_C = " " capacitance
I_L = " " Inductance
I = current across circuit.

Case-I $I_L > I_C$

Phasor diagram.



$$I^2 = I_R^2 + (I_L - I_C)^2$$

$$I = \sqrt{I_R^2 + (I_L - I_C)^2}$$

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

$$I = V\sqrt{\left(\frac{1}{R}\right)^2 + \left(\frac{1}{X_L} - \frac{1}{X_C}\right)^2}$$

$$\frac{I}{V} = \sqrt{\left(\frac{1}{R}\right)^2 + \left(\frac{1}{X_L} - \frac{1}{X_C}\right)^2}$$

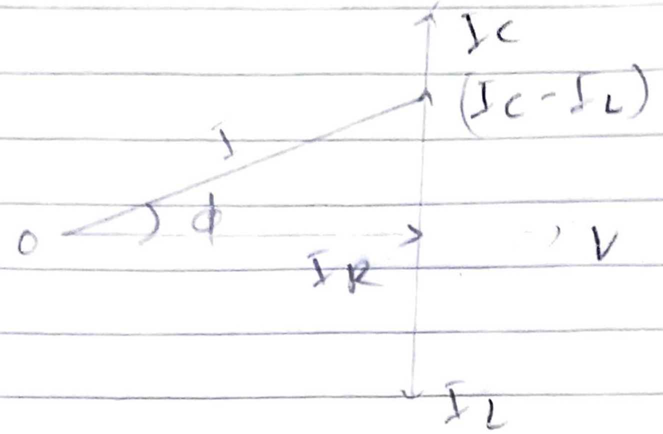
$$\boxed{Y = \sqrt{G^2 + (B_L - B_C)^2}}$$

Power factor

$$\cos\phi = \frac{I_R}{I} = \frac{\cancel{V}/R}{\cancel{V}\cdot Y} = \frac{1}{RY} = \frac{G}{Y}$$

$$\boxed{\cos\phi = \frac{G}{Y}}$$

Case-II $\quad I_C > I_L$



$$I^2 = I_R^2 + (I_C - I_L)^2$$

$$I = \sqrt{I_R^2 + (I_C - I_L)^2}$$

$$I = \sqrt{\left(\frac{V}{R}\right)^2 + \left(\frac{V}{X_C} - \frac{1}{X_L}\right)^2}$$

$$I = V\sqrt{\left(\frac{1}{R}\right)^2 + \left(\frac{1}{X_C} - \frac{1}{X_L}\right)^2}$$

$$\frac{I}{V} = \sqrt{\left(\frac{1}{R}\right)^2 + \left(\frac{1}{X_C} - \frac{1}{X_L}\right)^2}$$

$$\boxed{Y = \sqrt{G^2 + (B_C - B_L)^2}}$$

Power factor

$$\cos\phi = \frac{I_R}{I} \Rightarrow \boxed{\cos\phi = \frac{G}{Y}}$$

Case-III $I_C = I_L$

$$\xrightarrow[I_R]{\hspace{3em}} V$$

- → circuit will be purely Resistive
- → This is called parallel Resonance case.
- → L // C behaves like open circuit
- → But $I_C > I$ & $I_L > I$

Since,

$$Y = \sqrt{\left(\frac{1}{R}\right)^2 + \left(\frac{1}{X_L} - \frac{1}{X_C}\right)^2}$$

at parallel Resonance $X_L = X_C$

$$\therefore Y = \frac{1}{R} = G$$

$$\boxed{Y = G}$$

power factor.

$\cos\phi = \cos 0° = 1$ unity

Reasonance circuit :-

A circuit in which inductance L, capacitance (C) and Resistance R are connected in series and the circuit admits maximum current corresponding to a given frequency of A.C is called series Resonance circuit.

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

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

At very low frequency inductive reactance (X_L) is negligible but capacitive reactance becomes very high at a particular value of.

$X_L = \omega L$ $\qquad$ $X_C = \frac{1}{\omega C} = \frac{1}{2\pi \nu C}$

$= 2\pi \nu L$

$X_L \propto \nu$ $\qquad$ $X_C \propto \frac{1}{\nu}$

$\nu \uparrow$ $\quad$ $X_L \uparrow$ $\quad$ $X_C \downarrow$

$\nu \downarrow$ $\quad$ $X_L \downarrow$ $\quad$ $X_C \uparrow$

$\boxed{X_L = X_C}$ Resonance condition.

Application of Resonance :-

1. Filter design
2. Oscillators
3. Tuned Amplifiers
4. Radio Transmitters
5. Radio Receivers
6. Mobile phones
7. MRI machines
8. Ultrasound Machines
9. TV
10. Computers
11. Audio equipment.