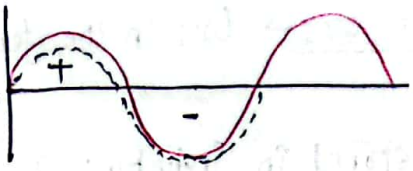
Alternating Current (A.C)

$I = I_0 \sin\omega t$ (instantaneous current, I_0 peak current)

$E = E_0 \sin\omega t$

$\omega = \frac{2\pi}{T}$ or $2\pi f$ (angular frequency)



* Mean or average value of a.c in 1 complete cycle → Zero

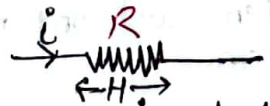
* In half cycle, mean or average value of a.c → (0 to $I_0/2$) or ($I_0/2$ to T)



$I_{av} = \frac{2I_0}{\pi} = 63\%$ of I_0

$E_{av} = \frac{2E_0}{\pi} = 63\%$ of I_0

* RMS value of A.C



R resistance through 't' time समय
steady current (d.c) pass गर्दा → H heat produce गर्यो

i → steady current (d.c)

↓↓

त्यही R through 't' time समय a.c. pass गर्दा त्यती नै Heat produce गराउने A.C. current लाई RMS value भनिने

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

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

→ All a.c. instrument measures rms value.

→ Measured by Hot wire ammeter.

* Reactance

→ Resistance offered by capacitor and inductor.

- Capacitive reactance (X_c) → $\frac{1}{\omega C}$
- Inductive reactance (X_L) = ωL

* Susceptance (S)

Reciprocal of reactance.

$S_L = \frac{1}{X_L}$, $S_C = \frac{1}{X_C}$

* Impedance (Z):- Total resistance offered in the circuit.

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

In Nepal, A.C frequency is 50 Hz

* Admittance (A):- Reciprocal of impedance.

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

- also called conductance

- In one complete cycle → polarity changes 2 times.
  → Direction changes 2 times.
  → current becomes peak 2 times
  → current becomes zero (2 times)

Q. If the frequency of A.C is 50Hz. How many times the current becomes zero or polarity changes in 1 sec?

(a) 50 times (b) 100 times (c) 25 times (d) 200 times

50 Hz → 50 cycles

1 sec → 50 cycle.

1 cycle → 2 times, so, 50 cycle → 2 × 50 = 100 times.

* Circuit consist R only:-

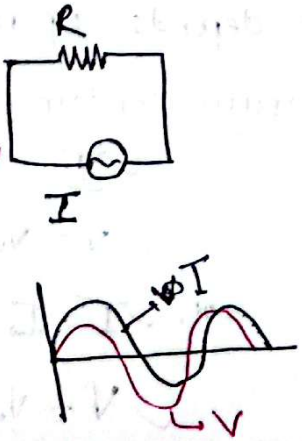
$I = I_0 \sin\omega t$

$V = V_0 \sin\omega t$

→ I & V are in same phase.

→ phase diff (ϕ) = 0

$P_{av} = I_{rms} V_{rms} \cos\phi$ ($\cos\phi$ = power factor)



→ Power factor, $\cos\phi = 1$ → maximum power is consumed by resis

@C I V I L

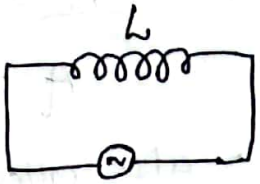
In capacitor → @ CIV

→ I leads V by $\pi/2$. or, V lags I by $\pi/2$.

In inductor (L) @ VIL

→ V leads I by $\pi/2$. or, I lags V by $\pi/2$.

Circuit containing inductor (L) only



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

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

or,

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

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

→ Phase difference (ϕ) = $\pi/2$,

→ Power factor, $\cos\phi = 0$ → No power is consumed by L

→ $X_L = \omega L$

$X_L = 2\pi f L$

For dc, $f = 0$, → d.c completely passes through inductor.

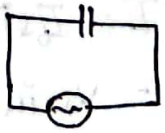
$X_L = 0$

For a.c, $f \neq 0$

→ Inductor makes the d.c circuit closed.

→ depends upon frequency.

Circuit containing capacitor only



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

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

or,

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

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

→ $X_c = \frac{1}{\omega C} = \frac{1}{2\pi f C}$

→ phase difference $(\phi) = \pi/2$

→ power factor, $\cos\phi = 0$

→ for d.c , frequency $(f) = 0$

$$X_c = \infty$$

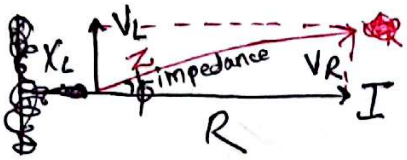
capacitor completely blocks for d.c.

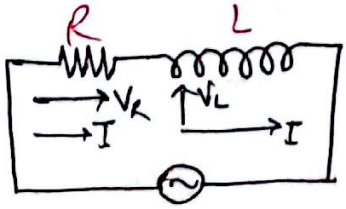
or, capacitor act as perfect insulator for d.c.

I_{dc} —||— = → $(I_{dc} = \text{zero})$

→ makes d.c. → open circuit

circuit containing R & L in series





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

$$Z = \frac{V_{rms}}{I_{rms}} = \frac{V_0/\sqrt{2}}{I_0/\sqrt{2}} = \frac{V_0}{I_0}$$

$V_{rms} = I_{rms} Z$

$V_{rms} = I_{rms} \sqrt{R^2 + X_c^2}$

$V_{rms} = \sqrt{I_{rms}^2 R^2 + X_L^2 I_{rms}^2}$

$\therefore V_R = I_{rms} R$

$V_L = I_{rms} X_L$

$$\boxed{V_{rms} = \sqrt{V_R^2 + V_L^2}}$$

→ Power factor, $\cos\phi = \frac{R}{Z} = \frac{R}{\sqrt{R^2 + X_L^2}}$

$$\text{Tan}\,\phi = \frac{X_L}{R}$$

Q. The power factor in RL series circuit is 0.5. If $R = 100\,\Omega$ and $f = 100$ Hz. Find $L = ?$

→

$\because \cos\phi = 0.5 = \frac{1}{2} \quad \therefore \phi = 60^\circ$

or, $\frac{R}{\sqrt{X_L^2 + R^2}} = 0.5$

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

$\tan 60^\circ = \frac{2\pi f L}{R}$

$L = \frac{\sqrt{3} \times 100}{2\pi \times 100} = \frac{\sqrt{3}}{2\pi}$

$\therefore L = \sqrt{3}/\pi$

Q. The ac. voltage, $E = 200\sqrt{2}\sin 100t$ Volt (V_0, ω) is connected to a $1\mu F$ capacitor through a.c. ammeter. The reading of ammeter is:-

→

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

$I_{rms} = \frac{V_{rms}}{Z} = \frac{V_0/\sqrt{2}}{X_C} = \frac{200\sqrt{2}/\sqrt{2}}{\frac{1}{\omega C}} = 200\,\omega C$

(Z = only capacitor)

$= 200 \times 100 \times 1 \times 10^{-6}$

$\boxed{I_{rms} = 2 \times 10^{-2}\ A}$

Q. In L-R circuit, ac. source has voltage 10 V. If pot. difference across the inductor is 6V. Find the potential difference across resistor?

→

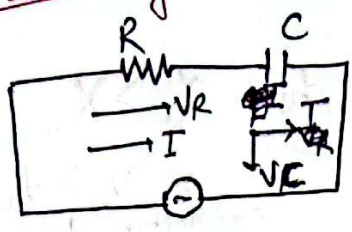
$V = \sqrt{V_R^2 + V_L^2}$

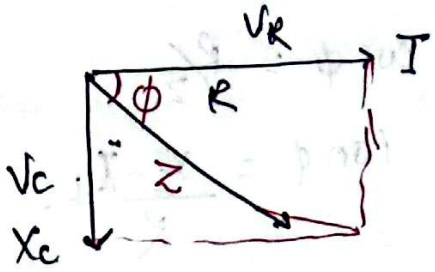
$10 = \sqrt{V_R^2 + 6^2}$

$\therefore V_R^2 = 64\ V$

$\therefore V_R = 8\ V.$

circuit containing R & C series



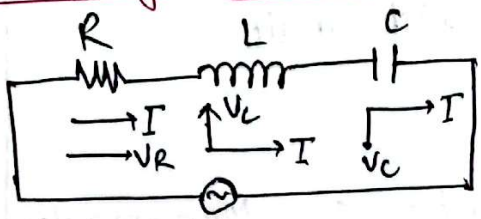


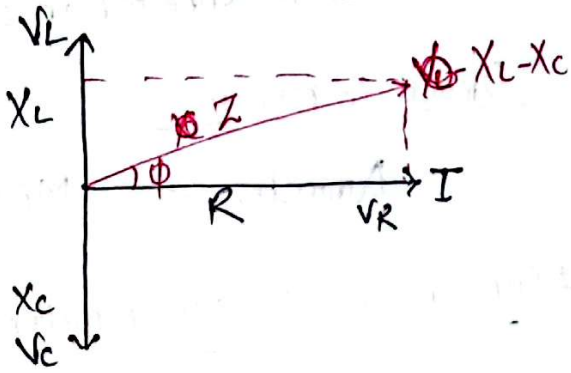
$$Z = \sqrt{R^2 + X_c}$$

$$V_{rms} = \sqrt{V_R^2 + V_C^2}$$

$$\cos\phi = R/Z \quad , \quad \tan\phi = \frac{X_c}{R}$$

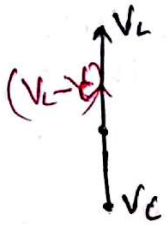
circuit containing R, L & C in series





→ Across L & C, there is phase diff. of 180° with respect to alternating voltage. However the alternating current are in same phase.

→ Inductor dominated → $X_L > X_c$



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

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

→ power factor, $\cos\phi = \frac{R}{Z}$, $\tan\phi = \frac{X_L - X_C}{R}$

- If $X_L = X_C$, $\tan\phi = 0$

  $\therefore \phi = 0$

- If $X_C > X_L$ →

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

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

$$\cos\phi = R/Z$$

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

for; $X_C > X_L$
or, $V_C > V_L$
capacitor dominated

Galvanometer :- Detects the small current.

Ammeter :- Current measuring device.

- → It has low resistance.
- → Ideal ammeter has zero resistance.
- → It is connected in series with circuit.

Order of resistance

Ammeter < Milliammeter < Microammeter

Conversion of galvanometer into ammeter

- L & C → voltage −180°
  current → same phase

Q. In LCR series ckt, the applied a.c voltage is 20V. The voltage across inductor is 8V, the voltage across capacitor is 6V. And the voltage across resistor?

$V_{rms} = 20V$. $V_R = ?$

$V_L = 8V$, $V_C = 6V$.

$$\therefore V_{rms} = \sqrt{V_R^2 + (V_L - V_C)^2}$$

$$20^2 = V_R^2 + (8-6)^2$$

$$V_R^2 = 400 - 4$$

$$V_R^2 = 396$$

$$\therefore V_R = \sqrt{396}\ V$$

If $V_L = V_C$ or $X_L = X_C$

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

$Z = R \Rightarrow$ minimum resistance then current will be maximum.

→ It is called resonant circuit.

→ It act as ~~pure~~ only resistor containing ~~ref~~ circuit.

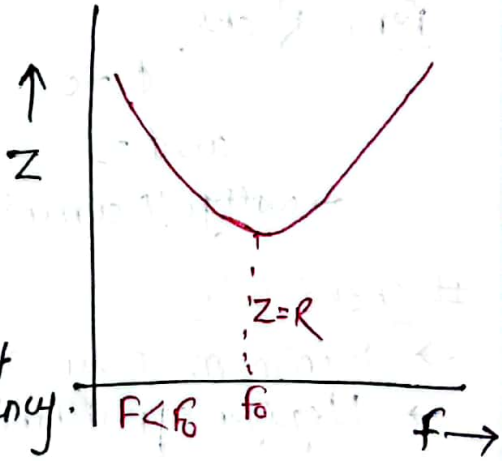
→ I & V are in same phase.

-At resonant condition, $X_L = X_C$

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

or, $\boxed{\omega = \frac{1}{\sqrt{LC}}}$

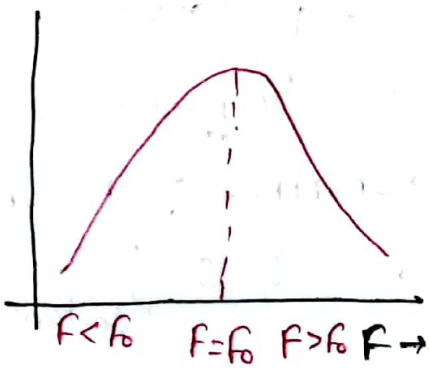
or, $\boxed{F = \frac{1}{2\pi\sqrt{LC}}}$ → resonant frequency.



. If $F < f_0$, then Z decreases. → I ↑es.

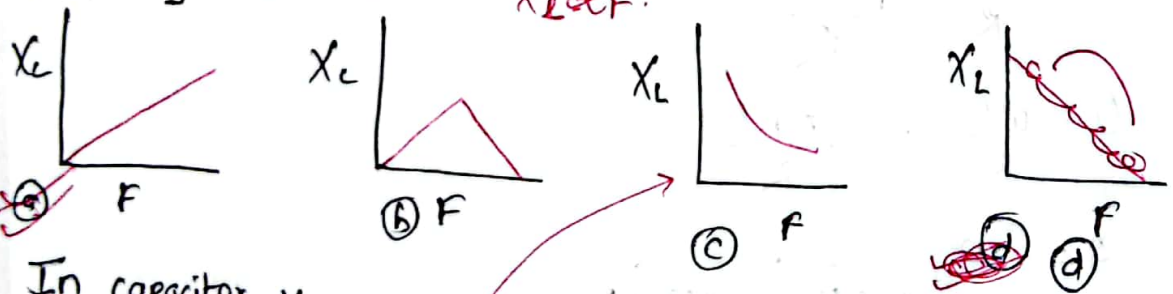
· If $F = f_0$, then Z minimum. → I max.

· If $F > f_0$, then Z ↑es. → I ↓es.



In inductor, inductive reactance and frequency are related. $X_L = 2\pi fL$

$X_L \propto f$.



In capacitor, X_C and f are related as:-

(a) (b) (c) (d)

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

$\therefore X_C \propto \frac{1}{F}$

Power consumed in a.c. circuit

$P_{av} = I_{rms} V_{rms} \cos\phi$

P_{av} → true power; I_{rms} → apparent power; $\cos\phi$ → power factor

$\because \cos\phi = \frac{R}{Z}$ — true power / App. power

$P_{av} = \frac{I_0 V_0}{2} \cos\phi$

So, $\cos\phi$ (power factor) $= \frac{\text{true power}}{\text{apparent power}}$

For, R ckt,

$\phi = 0$

$\cos\phi = 1$.

→ wattfull current

For L & C ckt

$\phi = \pi/2$

$\cos\phi = 0$, wattless current

Choke coil

→ Minimum power consumed / loss → ~~principle~~ principle

→ Negligeable resistance and high inductance.

→ based on → self inductance (1st priority)

→ wattless current (2nd priority)

Quality Factor (Q)

→ sharpness of the current.

→ $Q \propto \frac{1}{\text{Resistance}}$

$Q = \frac{X_L}{R}$ or $\frac{X_C}{R}$

$Q = \frac{\omega L}{R} = \frac{2\pi f L}{R}$

$Q = \frac{1}{\omega C R} = \frac{1}{2\pi f C R}$

$Q = \frac{I X_L}{I R} = \frac{V_L}{V_R}$ or, $Q = \frac{I X_C}{I R} = \frac{V_C}{R}$

* AC Advantage

- Long distance transmission (step up).
- Low power loss.
- → AC can be easily converted into d.c. (rectifier ले)

Note: AC को shock → attractive @ AA

D.C को shock → repulsive

Electrostatics

charge or electron — at rest

→ Charge
- +ve → Deficiency of electron in neutral matter.
- −ve → Excessive of e^- in neutral matter.

$ne = np$
└ele. neutral

Q. If the matter is +vely (e^- defic) its mass:—

(a) ↑es (b) ↓es (c) (d) none

−vely charged → ↑es

A+ < B−
└mass less └mass more

Q. If a ~~soap~~ soap bubble is +vely charged, then its radius:—

(a) ↑es (b) ↓es (d) unchanged (d) Fluctuate



surface tension → decreases.

Note:- If the bubble is −vely charged then also radius ↑es.

- Like charge → Repel
- Unlike charge → Attract
- charged body & neutral body → Attract

Q. ~~Force betw~~ Two like charged body:—

(a) always attract (b) always repel

(c) may repel or attract (d) None

Like charge को repulsive force लाई inductive force ले cancel गर्‍यो
↓
So, attract.

