UNIT - II

* STEADY STATE ANALYSIS OF SINGLE PHASE AC CIRCUIT

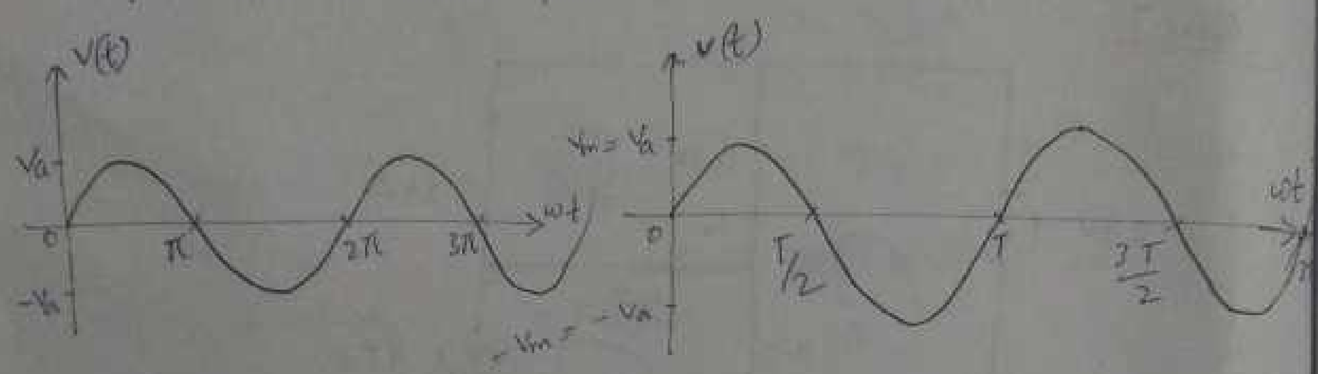
What is steady state analysis?

Single Phase :

- Residential voltage
- Phase wire and neutral wire.

230 V 50 Hz.

* **Sinusoids :** A sinusoid is a signal that has the form of the sine & cosine function.



* **sinusoidal voltage :** $v(t) = V_m \sin\omega t$.

where,

V_m = The amplitude of the sinusoid.
ω = The angular frequency in radians/sec.
ωt = the argument of the sinusoid (rad.)

$$\omega T = 2\pi$$

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

Cycle : A cycle may be defined as one complete set of +ve & -ve values of an alternating quantity repeating at equal intervals.

Periodic Time:

The time taken by an alternating quantity in seconds to trace one complete cycle is called periodic time or time period. It is usually denoted by symbol (T).

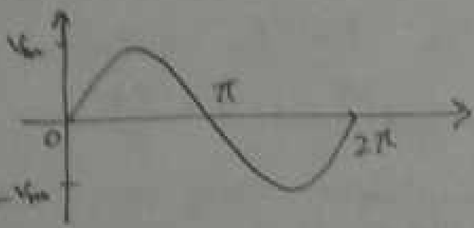
Frequency:

The no. of cycles per second is called frequency and is denoted by symbol f

$$\boxed{\omega = 2\pi f}$$

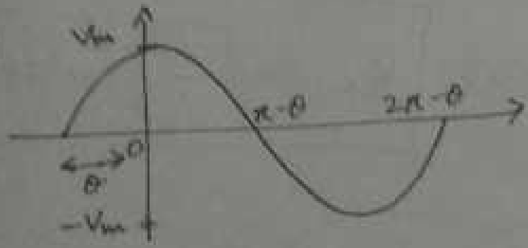
ex:

①



$v(t) = V_m \sin \omega t$

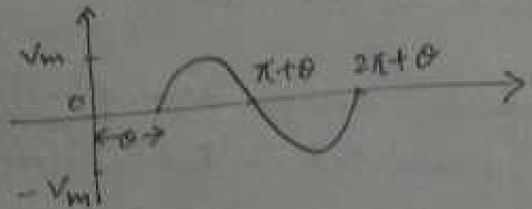
②



$v(t) = V_m \sin(\omega t + \theta)$

↳ leading (+ve sign)

③

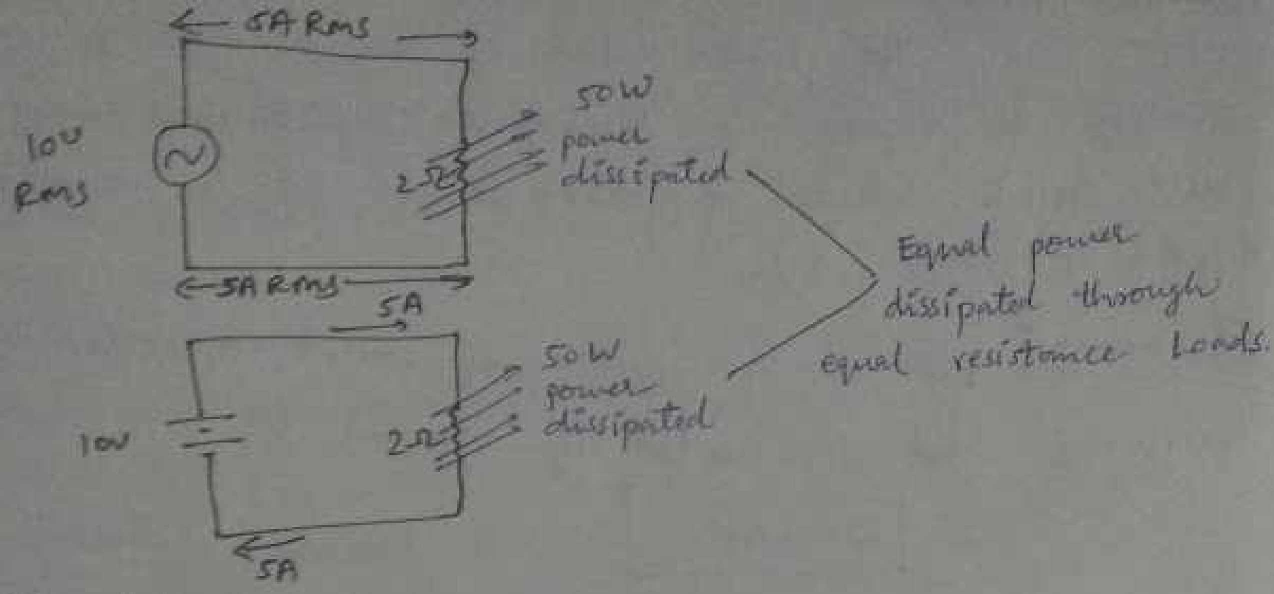


$v(t) = V_m \sin(\omega t - \theta)$

↳ lagging (-ve sign)

* RMS Value:

- RMS value is defined w.r to heating effect of the waveform.
- The voltage at which heat dissipation in A.C circuit is equal to heat dissipation in D.C circuit is called as V_{rms} provided both A.C & D.C circuit have equal value of resistance & operated for the same time.



RMS Value:

$$P = I^2 R \qquad\qquad P = i^2 R$$

$$(\text{Heat})\ W_{D.C} = I^2 R t \qquad (\text{Heat})\ W_{A.C} = i^2 R t$$

$$\boxed{W_{D.C} = W_{A.C}}$$

$$\boxed{V_{RMS} = \sqrt{\frac{1}{2\pi}\int_0^{2\pi} v^2\, d\omega t}} \quad \text{or} \quad \boxed{V_{RMS} = \sqrt{\frac{1}{T}\int_0^{T} v^2\, dt}}$$

* Average Value:

Average value is defined w.r to charge transferred in the circuit

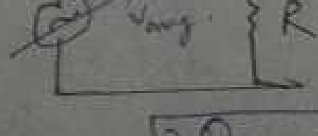
OR

The voltage at which charge transferred in A.C is equal to charge transferred in D.C. circuit is called as V_{avg}, provided both A.C & D.C circuit have equal value of resistance & operated for same time.

ex:

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

$\boxed{Q_{D.C} = It}$
charge



$i = \frac{v}{R}$

$\boxed{Q_{A.C} = it}$

RMS Value : Rating of given source

Average value : D.C component present in a given non-sinusoidal waveform.

Average Value :

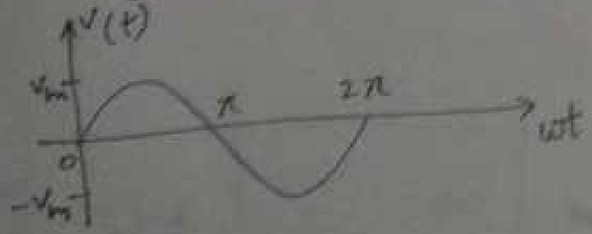
$$\frac{1}{T}\int_0^T f(x)\,dx$$

Note :

- Average value of complete cycle of symmetrical wave is equal to zero.
- While finding average value of symmetrical waveforms for mathematical analysis only half cycle is considered.
- While finding average value of the unsymmetrical wave form; complete cycle is considered.

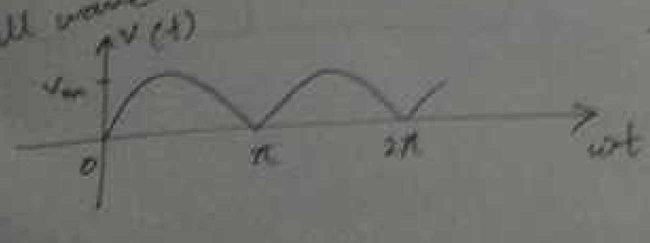
* RMS & Average value of different Wave forms :

1) Sine wave



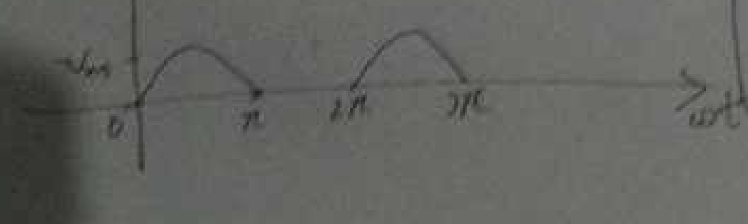
$V_{RMS} = \frac{V_m}{\sqrt{2}}$ | $V_{avg} = \frac{2V_m}{\pi}$

2) Full wave



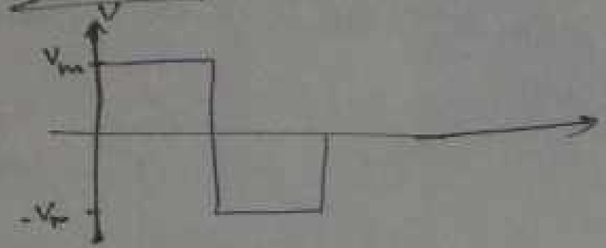
$V_{RMS} = \frac{V_m}{\sqrt{2}}$ | $V_{avg} = \frac{2V_m}{\pi}$

3) Half wave



$V_{RMS} = \frac{V_m}{2}$ | $V_{avg} = \frac{V_m}{\pi}$

4) Square

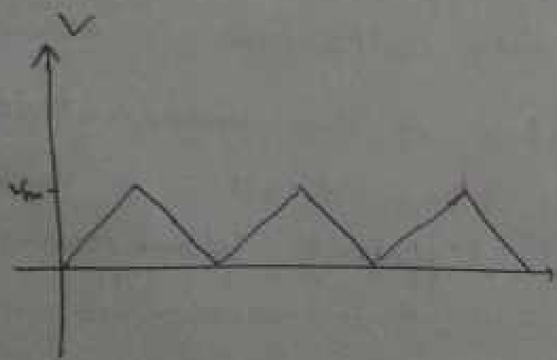


$V_{RMS} = V_m$	$V_{avg.} = V_m$

5) Half wave square

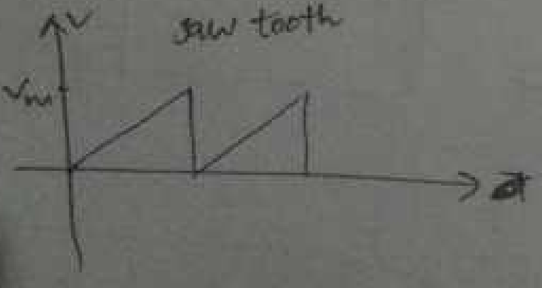
$V_{RMS} = \frac{V_m}{\sqrt{2}}$	$V_{avg} = \frac{V_m}{2}$

6)



$V_{RMS} = \frac{V_m}{\sqrt{3}}$	$V_{avg} = \frac{V_m}{2}$

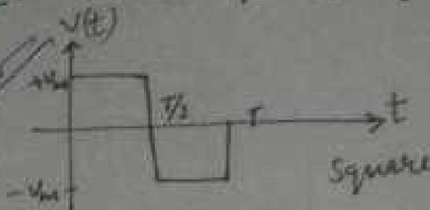
7) saw tooth



$V_{RMS} = \frac{V_m}{\sqrt{3}}$	$V_{avg} = \frac{V_m}{2}$

Ques) which of the following waveform have formfactor = Peakfactor

a)

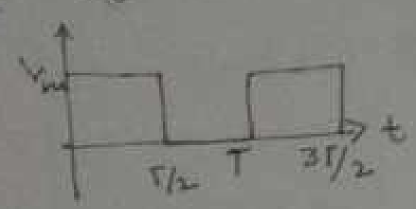


square

$V_{rms} = V_{avg} = V_m$

$\boxed{FF = PF = 1}$

b)



$FF = \frac{\frac{V_m}{\sqrt{2}}}{\frac{V_m}{2}} = \sqrt{2}$

$PF = \frac{V_m}{\frac{V_m}{\sqrt{2}}} = \sqrt{2}$

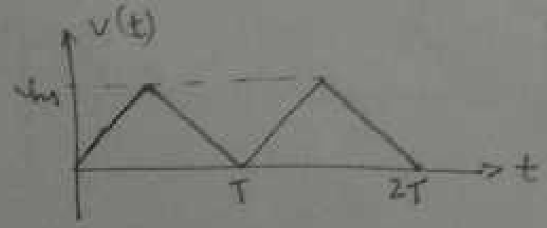
$\boxed{FF = PF = \sqrt{2}}$

c)

$\boxed{V_{rms} = V_{avg} = V_m}$

$\boxed{FF = PF = 1}$

d)

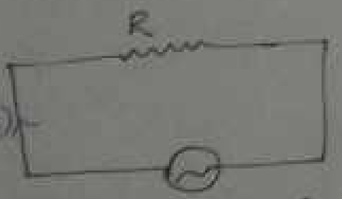


$FF = \frac{V_{rms}}{V_{avg}} = \frac{\frac{V_m}{\sqrt{3}}}{\frac{V_m}{2}} = \frac{2}{\sqrt{3}}$

$P.F = \frac{V_m}{V_{rms}} = \frac{V_m}{\frac{V_m}{\sqrt{3}}} = \sqrt{3}$

* Resistive - Circuit :

$I_m \sin(\omega t) = I(t)$

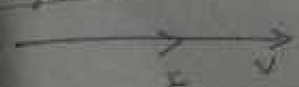


$v(t) = V_m \sin\omega t$

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

$= \frac{V_m}{R} \cdot \sin\omega t = I_m \sin\omega t$

phasor Diagram:



V in phase with I.

$P(t) = v(t)\, i(t) = V_m \sin\omega t \cdot I_m \sin\omega t$

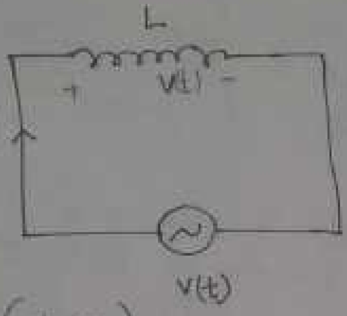
$P(t) = V_m I_m \sin^2 \omega t = V_m I_m \left(\frac{1-\cos 2\omega t}{2}\right)$

Instantaneous power

$\boxed{P(t) = \frac{V_m I_m}{2}\left[1 - \cos 2\omega t\right]}$

* Inductive - Circuit :

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



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

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

$V_L(t) = L\frac{di(t)}{dt} = L\frac{d}{dt}(I_m \sin\omega t)$

$= L\, I_m \cos\omega t \cdot \omega$

$V_L(t) = I_m(\omega L)\cos\omega t$

$(X_L = \omega L)$

$V = IR$

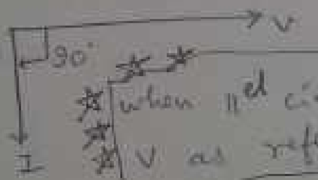
$$\boxed{V_L(t) = V_m \cos\omega t}$$

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

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

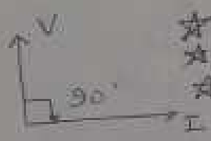
V Leading I

phasor diagram:



(or)

** when $\parallel^{el}$ circuit V as reference



** when series circuit I as reference

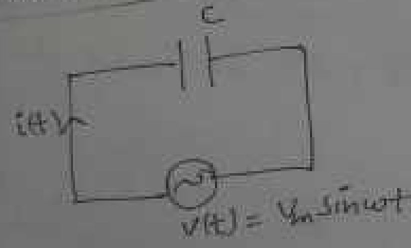
$P(t) = V(t)\cdot i(t) = V_m \cos\omega t\, I_m \sin\omega t$

$= V_m I_m \frac{\sin 2\omega t}{2}$

Instantaneous Power *

$$\boxed{P(t) = \frac{V_m I_m}{2}[\sin 2\omega t]}$$

* Capacitive circuit :



$i = \frac{C\,dV_c(t)}{dt} = C\frac{d}{dt}(V_m \sin\omega t)$

$= V_m C\,\omega \cos\omega t$

$= \omega C \cdot V_m \cos\omega t = \frac{V_m}{1/\omega C}\cos\omega t$

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

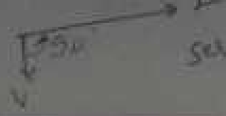
$= \frac{V_m}{X_c}\cos\omega t$

$i(t) = I_m \cos\omega t = I_m \sin\left(\omega t + \frac{\pi}{2}\right)$

voltage lagging current by $\frac{\pi}{2}$ & current leading voltage by $\frac{\pi}{2}$

phasor diagram :

$\parallel^{el}$ circuit V → ref



series circuit I → ref

$P(t) = V(t) \cdot i(t)$

$P(t) = V_m \sin\omega t \cdot I_m \cos\omega t \Rightarrow \boxed{P(t) = \frac{V_m I_m}{2}[\sin 2\omega t]}$

Instantaneous power

* Form factor: The ratio of RMS value to avg value of an alternating quantity is known as form factor.

$$\boxed{FF = \frac{\text{RMS value}}{\text{Avg. value}}}$$

* Peak factor or Crest factor: The ratio of maximum value to the RMS value of an alternating quantity is known as Peak factor.

$$\boxed{PF = \frac{\text{Max value}}{\text{RMS value}}}$$

Note:

The form factor for the various sinusoidal waveforms are;

- Sine wave, $\frac{\pi}{2\sqrt{2}} = 1.11072073$
- Half wave rectified sine wave, $\pi/2 = 1.5707963$
- Full wave rectified sine wave, $\frac{\pi}{2\sqrt{2}} = 1.11072073$
- square wave, it is equal to 1.
- Triangle waveform, $2/\sqrt{3} = 1.15470054$
- Saw-tooth waveform, $\frac{2}{\sqrt{3}} = 1.15470054$

Que-1 Find RMS value of the following function

$$V(t) = 3 + \sin t + \sin 3t$$

$V_m = 1$ — $\sin t \Rightarrow V_m = \frac{1}{\sqrt{2}}$, $\sin 3t \Rightarrow V_m = \frac{1}{\sqrt{2}}$

$$\cancel{(V_{rms})_{eff} = \sqrt{V_{rms}^2}} = \sqrt{\int_0^{2\pi} V_m^2\, dt}$$

$$= \sqrt{\int_0^{2\pi} \cancel{(9 + \sin^2 t + \sin^2 3t + 6\sin t + 2\sin t \sin 3t + 6\sin 3t}}$$

Effective RMS:

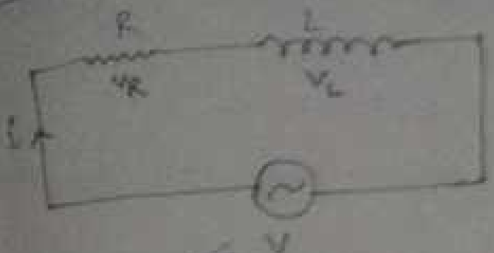
$$V_{RMS} = \sqrt{V_{RMS_1}^2 + V_{RMS_2}^2 + V_{RMS_3}^2 + \cdots + V_{RMS_n}^2 + \cdots}$$

$$V_{RMS} = \sqrt{(3)^2 + \left(\frac{1}{\sqrt{2}}\right)^2 + \left(\frac{1}{\sqrt{2}}\right)^2}$$

$$= \sqrt{9 + \frac{1}{2} + \frac{1}{2}} = \sqrt{9+1} = \sqrt{10} \quad \text{Ans}$$

$$= 3.16$$

* **RL series circuit:**

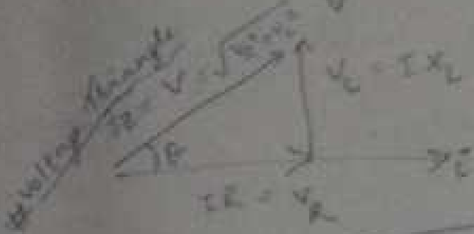


By KVL

$$V = V_R \angle 0^\circ + V_L \angle 90^\circ$$

$$ZI = IR + jIX_L$$

$$\boxed{Z = R + jX_L}$$



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

$$\theta = \tan^{-1}\left(\frac{V_L}{V_R}\right)$$

Impedance Triangle:

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

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

Instantaneous power:

$$P(t) = V(t)\, i(t)$$

$$P(t) = V_m \sin(\omega t + \theta)\, I_m \sin\omega t$$

$$P_{avg} = \frac{1}{2\pi}\int_0^{2\pi} P(t)\, d\omega t$$

$$P_{avg} = \frac{V_m I_m}{2} \cos\theta = \frac{V_m}{\sqrt{2}} \frac{I_m}{\sqrt{2}} \cos\theta$$

$$\boxed{P_{avg} = V_{rms} I_{rms} \cos\theta}$$

* **Power factor:**

The power factor is defined as the ratio of resistance to the impedance of an RL circuit

$$\boxed{\cos\theta = \frac{V_R}{V}} \boxed{= \frac{IR}{IZ} = \frac{R}{Z}} \boxed{= \frac{P}{S}}$$

Note: • [illegible] to the [illegible] voltage [illegible]

• Because,
 source voltage is constant
 • For the parallel system loads are connected in parallel
 (load voltage is constant)

Active, Reactive and Apparent Power:

Active Power:

• The power which is actually consumed or utilised in an AC circuit is called true power or active power or real power.
• It is measured in kilowatt (kW) or MW.
• It is the actual outcomes of the electrical system which runs the electric circuit or load.

Active power, $P = VI\cos\phi$

Reactive Power:

• The power which flows back and forth that means it moves in both the directions in the circuit or reacts upon itself, is called Reactive power.
• The reactive power is measured in kilo volt ampere reactive (kVAR) or MVAR.

Reactive Power, $Q = VI\sin\phi$

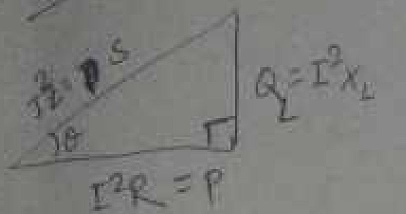
Apparent Power:

• The product of root mean square (RMS) value of voltage and current is known as apparent power.

• This power is measured in kVA or MVA.

Apparent Power, $S = [illegible]$

Power Triangle:



$$\boxed{S = \sqrt{P^2 + Q^2}}$$

$$\boxed{\theta = \tan^{-1}\left(\frac{Q_L}{P}\right) = \frac{X_L}{R}}$$

* Difference b/w Leading & Lagging Power factor:

Leading Power Factor:

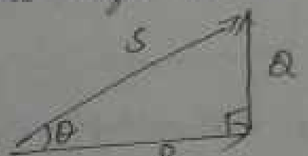
- The leading power factor in an ac electrical circuit is attained by the use of capacitive load in the circuit.
- In the presence of a purely capacitive load or combination of resistive - capacitive load, the current leads supplied voltage.

S ⇒ Apparent Power
P ⇒ Real Power
Q ⇒ Reactive power.

- This gives rise to the power factor generally said to be leading in nature.

Lagging Power Factor:

- In ac circuits lagging power factor is achieved when the load is inductive in nature.
- This is so because when a purely inductive or resistive-inductive load is present then there exists a phase difference b/w voltage and current in which the current lags the voltage.

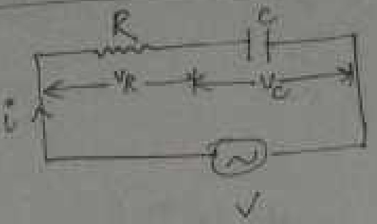


- Thus the power factor of such circuits is of lagging in nature

* Difference between Resistance & Reactance:

- Resistance is the hindrance to the flow of electric current by only resistor.
- Reactance is the opposition to the change in current by either inductor or capacitor.
- The obstruction to the flow of electrical current in any circuit is defined as impedance.
- Impedance is a complex term and is a combination of real & imaginary values.

* RC series circuit :

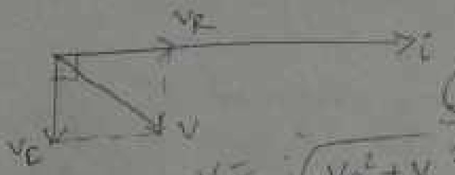


By KVL :

$$V = V_R \angle 0 + V_C \angle -90$$

$$V = IZ = IR - jIX_C$$

$$\boxed{Z = R - jX_C}$$



V △

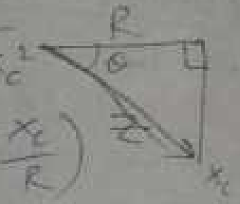
$$V = \sqrt{V_R^2 + V_C^2}$$

$$\theta = \tan^{-1}\left(\frac{-V_C}{V_R}\right)$$

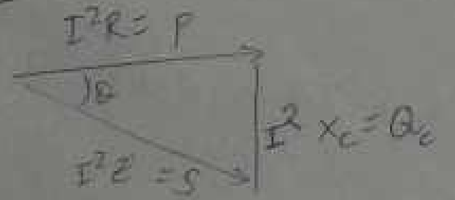
Impedance △ :

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

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



Power △ :



$$\boxed{S = \sqrt{P^2 + Q_C^2}}$$

$$\boxed{\theta = \tan^{-1}\left(\frac{-Q_C}{P}\right)}$$

Power factor :

$$\boxed{\cos\theta = \frac{V_R}{V} = \frac{R}{Z} = \frac{P}{S}}$$ ⟸ Leading ⇒ capacitive load

Que-1 Find Average value of the following fn :

① $v(t) = 6 + \sin t.$

$$\boxed{V_{avg} = 6}$$

→ d.c. component

② $v(t) = 10 \sin\omega t$.

$$V_{avg} = \frac{2V_m}{\pi} = \frac{2 \times 10}{\pi} = \frac{20}{\pi} =$$

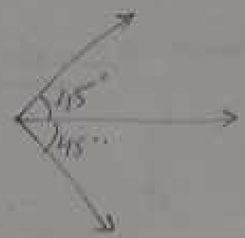
(3) $v(t) = \sin t + \sin 3t$.

$\boxed{V_{avg} = 0}$ NO D.C component

Que.] Find circuit element by using following equ^n:

$$v(t) = 9\sin(t + 45^\circ) \quad \boxed{\omega = 1}$$
$$i(t) = 3\sin(t - 45^\circ)$$

w.r.to voltage current lag by 90°
$\Rightarrow$ inductive circuit

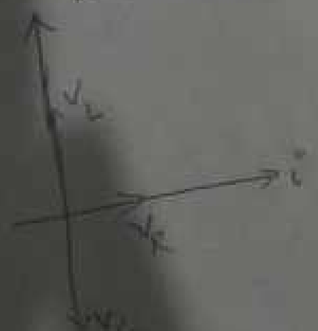


$V_m = 9$
$I_m = 3$

$$(\because \text{only inductor}) \quad X_L = \frac{V_m}{I_m} = \frac{9}{3} = 3\,\Omega$$
$$X_L = \omega L$$
$$3 = 1 \times L$$
$$\boxed{L = 3H} \text{ Ans}$$

* R-L-C series circuit:

Case-1) $\boxed{V_L > V_C}$ Inductive Nature.



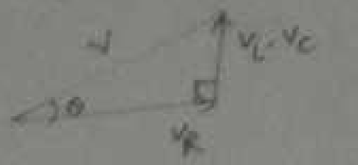
$\Rightarrow$

By KVL: $V = V_R\angle 0 + V_L\angle 90^\circ + V_C\angle -90^\circ$

$$V = V_R + jV_L - jV_C$$
$$IZ = IR + jIX_L - jIX_C$$

$$\boxed{Z = R + j(X_L - X_C)}$$

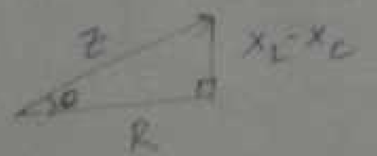
Voltage Triangle:



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

$$\boxed{\theta = \tan^{-1}\left(\frac{V_L - V_C}{V_R}\right)}$$

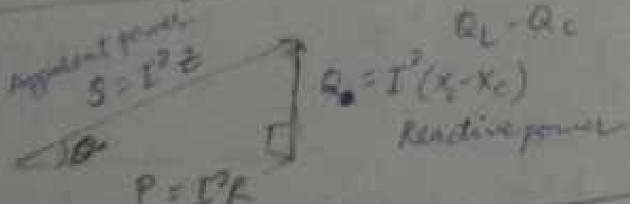
Impedance Triangle:



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

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

Power Triangle:



$$\boxed{S = \sqrt{P^2 + (Q_L - Q_C)^2}}$$

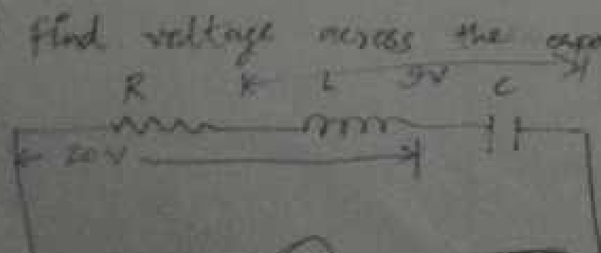
$$\boxed{\theta = \tan^{-1}\left(\frac{Q_L - Q_C}{P}\right)}$$

power factor:

$$\boxed{\cos\theta = \frac{P}{S} = \frac{V_R}{V} = \frac{R}{Z}}$$

Inductive (lagging)

Que) Find voltage across the capacitor of the network shown:



Sol:

15 V

~~$(V_R + V_L + V_C = 15\text{ V}) \times 2$~~

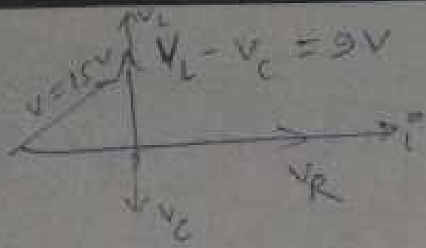
~~$2V_R + 2V_L + 2V_C = 30$~~

~~$V_R + V_L = 20$~~

~~$V_L = 9 - V_C$~~

~~$V_R + V_L + V_C = 30$~~

~~$20 + 9 + V_C$~~



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

$$15 = \sqrt{V_R^2 + 81}$$

$$225 = V_R^2 + 81$$

$$\boxed{V_R = \sqrt{144} = 12\,V}$$

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

$$20 = \sqrt{12^2 + V_L^2}$$

$$\boxed{V_L = 16}$$

$V_L - V_C = 9$

$V_L - V_C = \pm 9$

if +ve :

$V_C = V_L - 9$
$= 16 - 9$
$\boxed{V_C = 7V}$

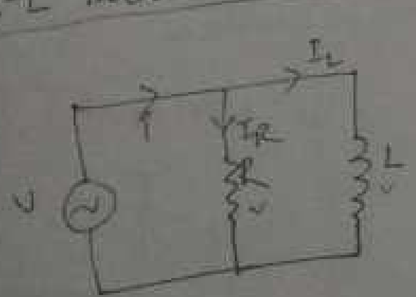
-ve :

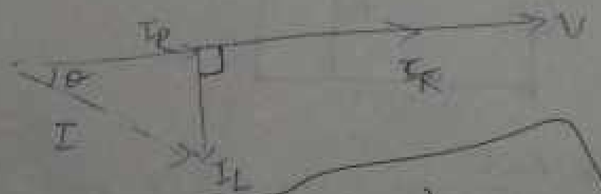
$V_C = V_L + 9$ V
$= 16 + 9$
$\boxed{V_C = 25V}$

Ans

* R-L Parallel Circuit :

voltage lead current in inductive parallel ⇒ V as reference





By KCL :

$$I = I_R\angle 0° + I_L\angle -90°$$

$$I = I_R - jI_L$$

$$\frac{V}{Z} = \frac{V}{R} - j\frac{V}{X_L}$$

$$\boxed{\frac{1}{Z} = \frac{1}{R} - \frac{j}{X_L}}$$

☆ $$\boxed{\frac{1}{Z} = \frac{1}{R} - \frac{j}{\omega L}}$$

$\frac{1}{R} = G$ (conductance)

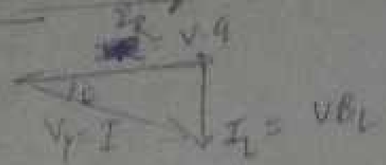
$\frac{1}{Z} = Y$ (Admitance)

$\frac{1}{X_L} = B_L$ (Inductive susceptance)

☆ $$\boxed{Y = G - jB_L}$$

$$\boxed{VY = VG - jVB_L}$$

Current Triangle:



$$I = \sqrt{I_R^2 + I_L^2}$$

$$\theta = \tan^{-1}\left(\frac{-I_L}{I_R}\right)$$

Impedance Triangle:

$$Y = \sqrt{G^2 + B_L^2}$$

$$\theta = \tan^{-1}\left(\frac{-B_L}{G}\right)$$

Power Triangle:

$$S = \sqrt{P^2 + Q_L^2}$$

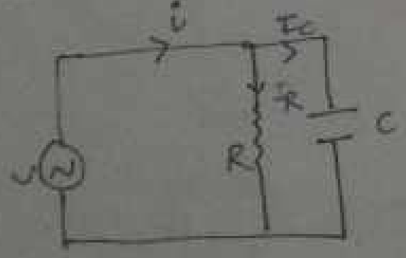
$$\theta = \tan^{-1}\left(\frac{-B_L}{P}\right)$$

Power Factor:

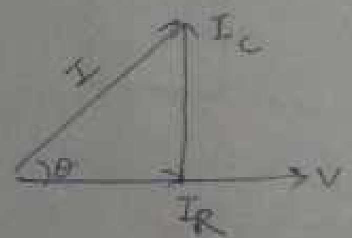
$$\boxed{\cos\theta = \frac{I_R}{I} = \frac{G}{Y} = \frac{P}{S}}$$

current (Lag)

R-C Parallel Circuit:



v as reference (‖el)



By KCL:

$$I = I_R\angle 0^\circ + I_C\angle 90^\circ$$

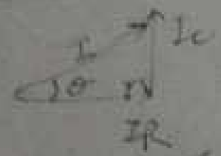
$$\frac{V}{Z} = \frac{V}{R} + j\frac{V}{X_C}$$

$\frac{1}{X_C} = B_C$ (susceptive cap.)

$$VY = VG + jVB_C$$

$$\boxed{Y = G + jB_C}$$

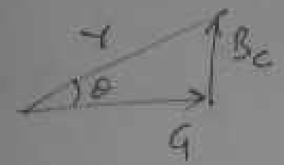
Current Δ:



$$I = \sqrt{I_R^2 + I_C^2}$$

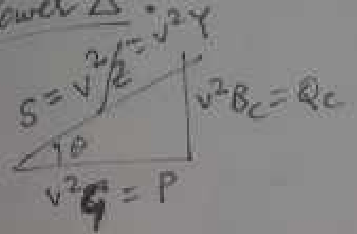
$$\theta = \tan^{-1}\left(\frac{I_C}{I_R}\right)$$

Impedance Δ:



$$\boxed{Y = \sqrt{G^2 + B_c^2}}$$
$$\theta = \tan^{-1}\left(\frac{B_c}{G}\right)$$

Power Δ:



$$S = \sqrt{P^2 + Q_c^2}$$
$$\theta = \tan^{-1}\left(\frac{B_c}{P}\right)$$

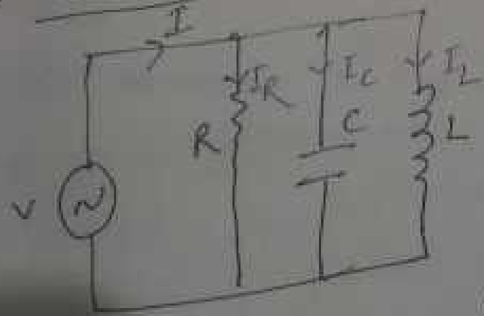
Power factor:

$$\boxed{\cos\theta = \frac{I_R}{I} = \frac{G}{Y} = \frac{P}{S}}$$ (leading)

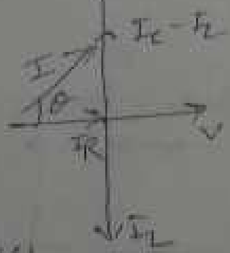
Capacitance ⇒ power factor leading

Inductance ⇒ power factor lagging

* R-L-C Parallel Circuit:



(case-2) $I_L < I_c$. (case-3) $I_L = I_c$



(capacitive) (case-1) $I_L > I_c$

$$\boxed{Y = G + j(B_L - B_c)}$$

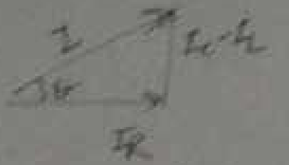
By KCL

$$I = I_R\angle 0^\circ + I_c\angle +90^\circ + I_L\angle -90^\circ$$

$$\frac{V}{Z} = \frac{V}{R} + j\frac{V}{X_c} - j\frac{V}{X_L}$$

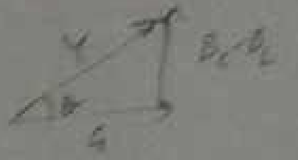
$$\boxed{Y = G + j(B_c - B_L)}$$

C-2) $Y = G + j(B_C - B_L)$



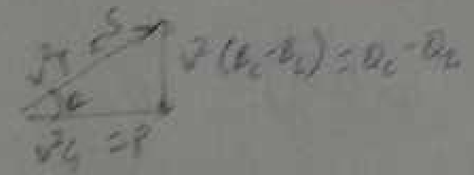
$$I = \sqrt{I_R^2 + (I_C - I_L)^2}$$

$$\theta = \tan^{-1}\left(\frac{I_C - I_L}{I_R}\right)$$



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

$$\theta = \tan^{-1}\left(\frac{B_C - B_L}{G}\right)$$



$$S = \sqrt{P^2 + (Q_C - Q_L)^2}$$

$$\theta = \tan^{-1}\left(\frac{Q_C - Q_L}{P}\right)$$

* Power factor:

$$\cos\theta = \frac{I_R}{I} = \frac{G}{Y} = \frac{P}{S}$$

case-1) $I_L > I_C$ lagging ~~leading~~

C-2) $I_C > I_L$ leading

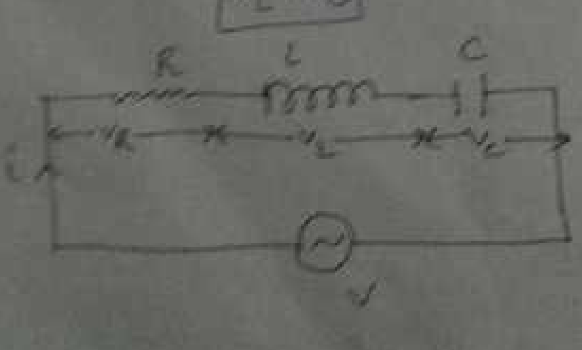
C-3) $I_C = I_L$ unit power factor (UPF)

* Resonance: The circuit is said to be at resonance, when the source current is in phase with source voltage

$$Z = R + j\underbrace{(X_L - X_C)}_{\to 0}$$

$X_L - X_C = 0$

$\boxed{X_L = X_C}$



By KVL:

$$V = V_R\angle 0^\circ + \underbrace{V_L\angle 90^\circ + V_C\angle -90^\circ}_{\text{for Resonance} \to 0}$$

$\boxed{V_L = V_C}$

$I X_L = I X_C$

$\boxed{X_L = X_C}$

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

$\omega = \omega_0$

$$\omega_0^2 = \frac{1}{LC}$$

Resonant frequency $\boxed{\omega_0 = \frac{1}{\sqrt{LC}}}$ rad/sec.

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

For occurence of resonance in any system two energies in R-L-C series circuit having inductor which will store energy in the form of magnetic field and capacitor which having energy in the form of electric field

① $Z = R + j\underbrace{(X_L - X_C)}_{0}$.

$Z_{min} = R$

② $I_{max} = \frac{V}{Z_{min}} = \frac{V}{R}$

power factor $= \frac{R}{Z} = \frac{R}{R} = 1$

U.P.F.

③ $V_R = V$

④ Net Reacting voltage $\Rightarrow V_L - V_C = 0$

* **Applications :**

① Designing of Oscillators.

② Analysis of Filters.

③ Tuning circuit

$V_C = IX_C$, $V_L = IX_L$

Variation of voltage across Inductor & voltage across capacitor w.r.to frequency:

$V_C = IX_C$, $V_L = IX_L$.

$X_L = 2\pi fL$

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

① $f = 0$, $X_L = 0$, $X_C = \infty$

$|X_L - X_C| = \infty$, $Z = \infty \Rightarrow I = 0$, $V_C = V$.

GRAPH: Resonance:

$$Z = R + j\underbrace{(X_L - X_C)}_{\to 0}$$

$$\boxed{\cos\theta = 1}$$

$$\boxed{V_R = V}$$

$$Z_{min} = R$$

$$I_{max} = \frac{V}{Z_{min}} = \frac{V}{R}$$

$$V_C = I X_C \quad , \quad V_L = I X_L$$

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

1) If $f = 0$, $X_L = 0$, $X_C \to \infty$, $Z \to \infty$, $I = 0$, $V_L = 0$, $V_C = V$.

2) $f \uparrow$ing, $X_L \Rightarrow \uparrow$ing, $X_C \downarrow$ing. X_C is more dec than X_L increasing

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

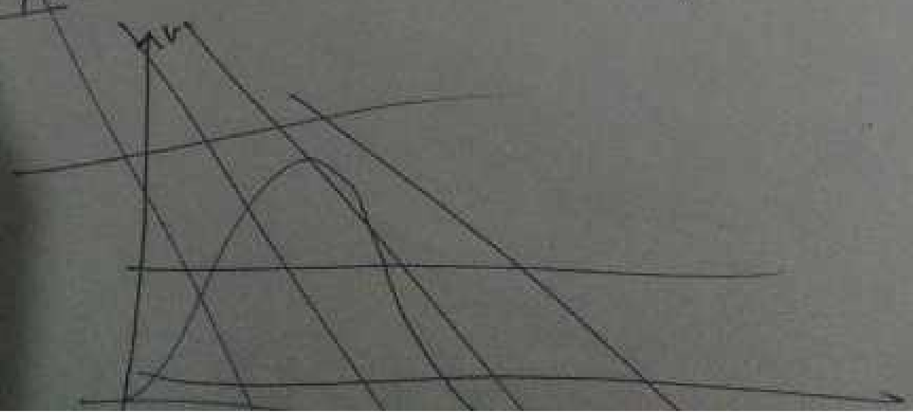
$$|X| = |(X_L - X_C)| \downarrow\downarrow$$

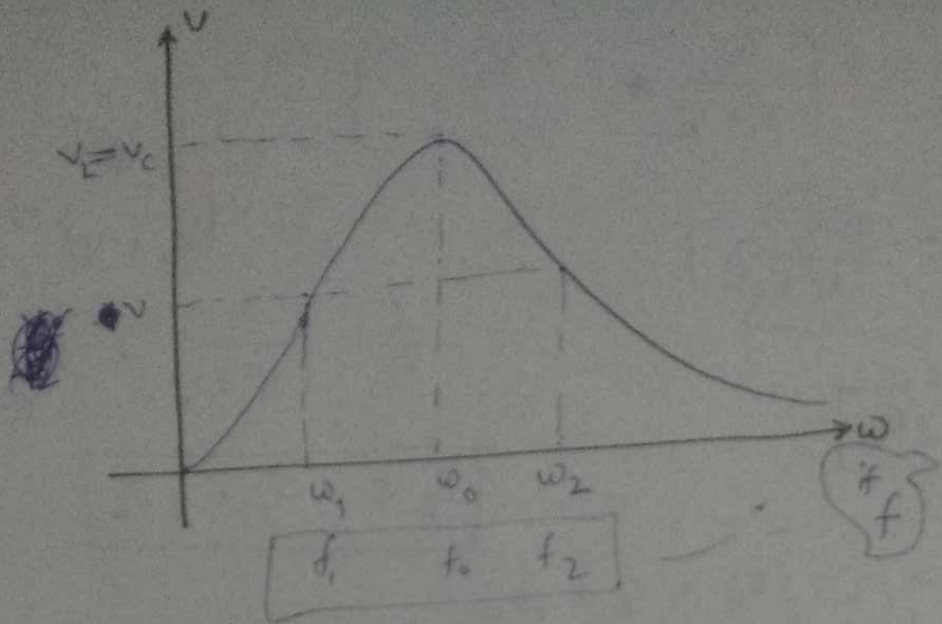
$Z \downarrow\downarrow \quad I \uparrow\uparrow \quad V_L \uparrow \quad V_C \uparrow$

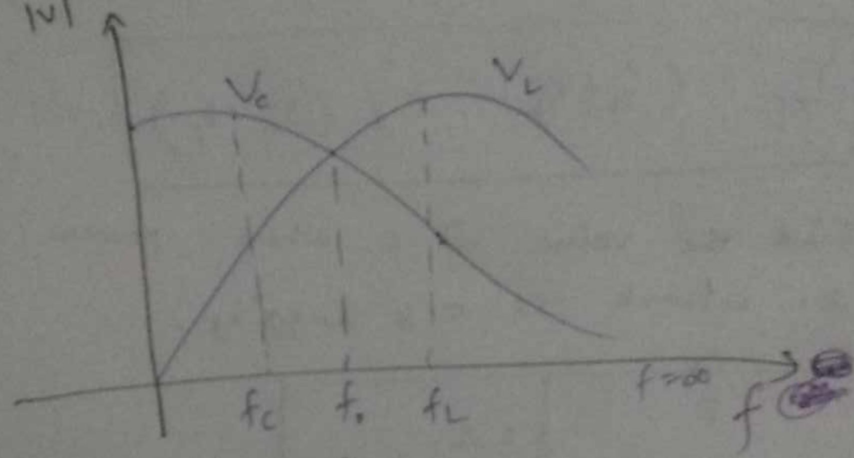
3) $f \uparrow\uparrow$, $X_L \uparrow\uparrow$, $X_C \downarrow\downarrow$ (very low), $Z \uparrow\uparrow$ (⊕ comp...)

$I \downarrow\downarrow$, $V_L \downarrow$, $V_C \downarrow$

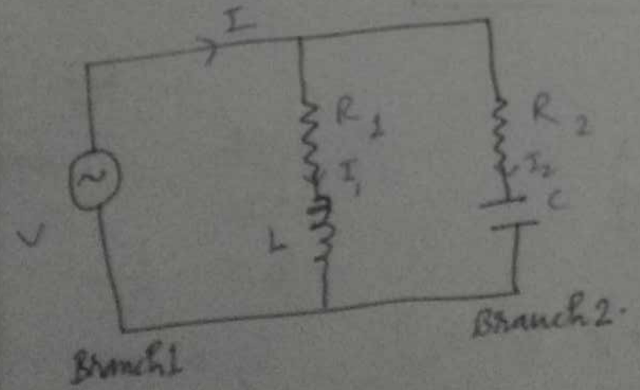
★ **Graph:**







☆ <u>combination of Elements</u> :



$$I_1 = \frac{V}{R_1 + jX_L} \times \frac{R_1 - jX_L}{R_1 - jX_L} \qquad \boxed{I_2 = \frac{V}{R_2 - jX_C}} \times \frac{R_2 + jX_C}{R_2 + jX_C}$$

$$I_1 = \frac{(R_1 - jX_L)V}{R_1^2 + X_L^2} \qquad I_2 = \frac{(R_2 + jX_C)V}{R_2^2 + X_C^2}$$

$$\frac{V}{Z_1} = V\left[\frac{R_1}{R_1^2+X_L^2} - \frac{jX_L}{R_1^2+X_L^2}\right]$$

$$\frac{V}{Z_2} = V\left[\frac{R_2}{R_2^2+X^2} + j\,\frac{X_c}{R_2^2+X_c^2}\right]$$

$$\frac{1}{Z_1} = \left[\frac{R_1}{R_1^2+X_L^2} - \frac{jX_L}{R_1^2+X_L^2}\right]$$

$$\frac{1}{Z_2} = \left[\frac{R_2}{R_2^2+X_c^2} + j\,\frac{X_c}{R_2^2+X_c^2}\right]$$

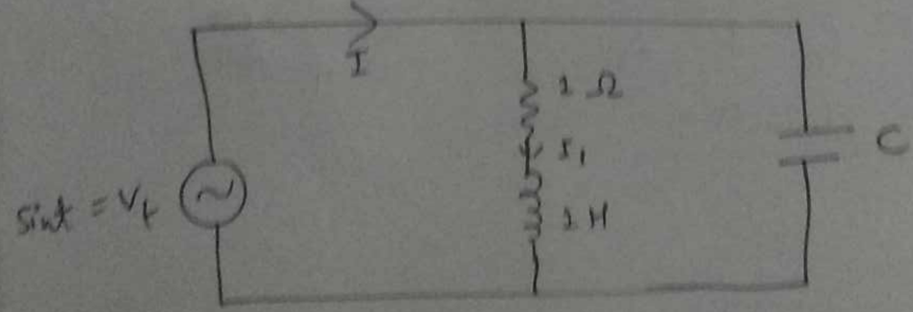
$$\boxed{Y_1 = G_1 - jB_L}$$

$$\boxed{Y_2 = G_2 + jB_c}$$

$$Y_{eq.} = (G_1 - jB_L) + G_2 + jB_c$$

$$\boxed{Y_{eq.} = (G_1 + G_2) + j(B_c - B_L)}$$

Que.] Find the value of c when power factor of the network is 0.8 lagging.



Ans
$\boxed{C = 0.11}$

$\boxed{R_2 = 0}$

$V_t = \sin t$ $\boxed{\omega = 1}$

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

$$B_L = \frac{1}{2}$$

$$X_L = \omega L = 1$$

$$G_1 = \frac{1}{2}$$

$$G_2 = 0$$

$$Y_{eq} = (G_1 + G_2) + j(B_c - B_L)$$

$$Y_1 = G_1 - jB_L \qquad Y_2 = jB_c = \frac{j}{X_c}$$

$$Y_{eq} = G_1 - jB_1 + jC$$

$$= \frac{1}{2} - j\frac{1}{2} + jC$$