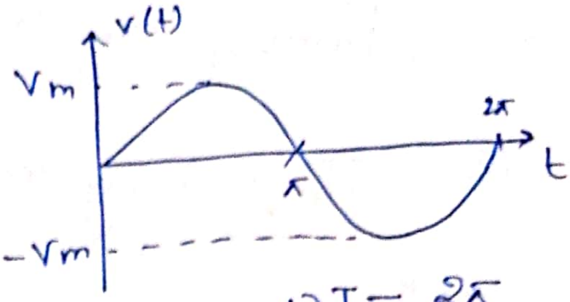
STEADY STATE AC ckt:-

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



$V_m \rightarrow$ maximum or peak value.

$\omega T = 2\pi$

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

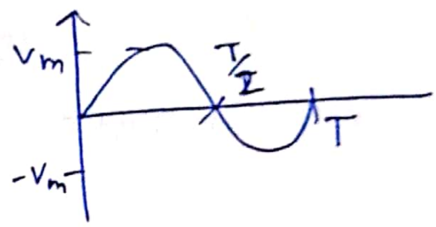
$\omega \rightarrow$ angular frequence (rad/sec)

$\omega t \rightarrow$ argument $\Rightarrow$ unit (rad).

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

$T = \frac{1}{f}$

$\left[f = \frac{\omega}{2\pi}\right]$ Hz



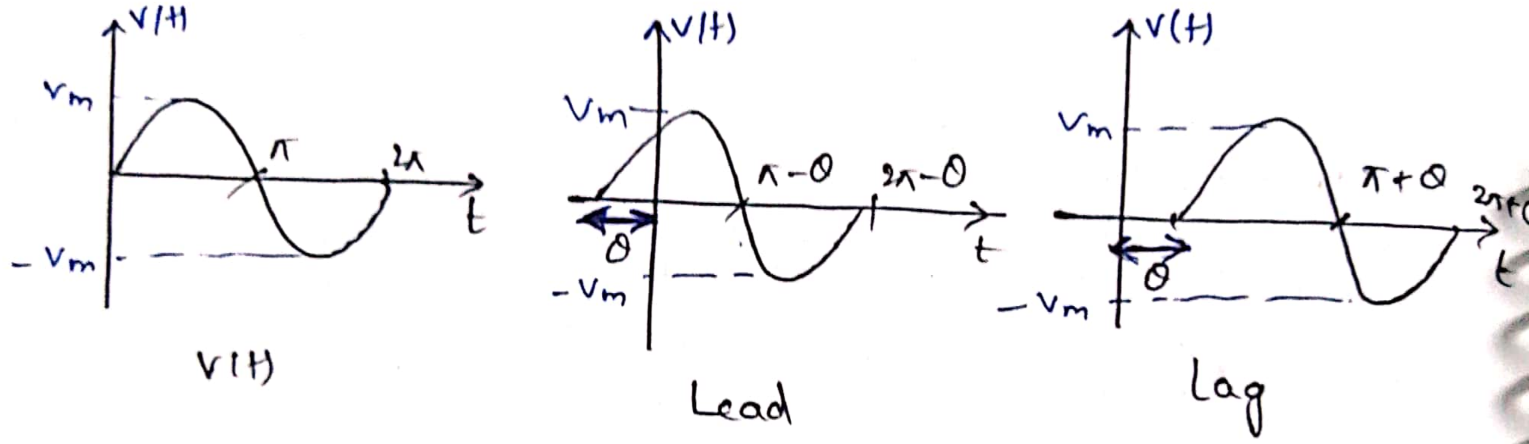
Advantage of sinusoidal waveform:-

① It is easy to handle mathematically (differential of the sine function and integral of the sine function can be rewrite interms of sine function.

② The natural phenomenon like motion of simple pendulum and response of undamped system exhibits sinusoidal charactors.

③ Any periodic waveform can be expressed in terms of sine function by using fourier analysis.

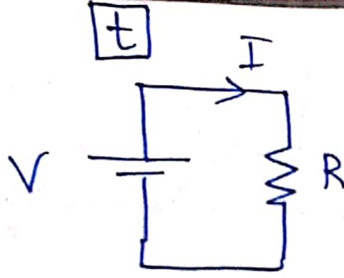
④ It is easy to generate in the laboratory.



$V(t) = V_m \sin\omega t$ $\quad$ $V(t) = V_m \sin(\omega t + \theta)$ $\quad$ $V(t) = V_m \sin(\omega t - \theta)$

⇛ Rms value is defined based on heating effect of waveform.

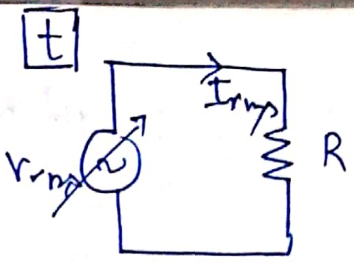
⇛ The voltage at which heat dissipation in ac ckt. is equal to heat dissipation in dc ckt. is called as Vrms. provided both ac. ckt and dc ckt. have equal value of resistance and operate at equal duration of time.



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

$P = I^2 R$

$\omega = I^2 R t$
↳ heat



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

$P = I^2 R$

$\omega = I^2 R t$
↓ heat

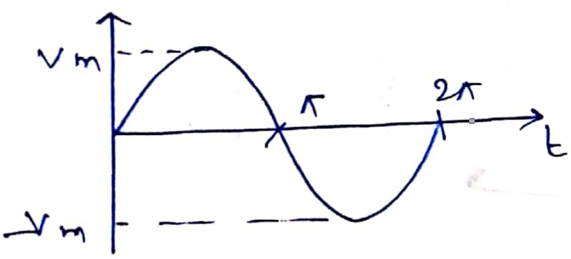
$W_{AC} = W_{DC}.$

$$V_{rms} = \sqrt{\frac{1}{T}\int_0^T V^2 \, dt}$$

$$= \sqrt{\frac{1}{2\pi}\int_0^{2\pi} V^2 \, d\omega t}$$

$\frac{1 - \cos 2\theta}{2}$

①



$$V_{rms}^2 = \frac{1}{T}\int_0^T V_m^2 \sin^2 \omega t \, dt$$

$$= \frac{V_m^2}{\cancel{T}}\left[\frac{1}{2}\cancel{T}\right]$$

$$\boxed{V_{rms} = \frac{V_m}{\sqrt{2}}}$$

$$\cancel{V_{rms}^2 = \frac{1}{T}\int_0^T V_m^2 \sin^2 \omega t \, dt}$$

$$= \frac{V_m^2}{2\pi}\left[\frac{-\cos \omega T}{\omega}\right]$$

$$= \frac{V_m^2}{2\pi} \times \pi$$

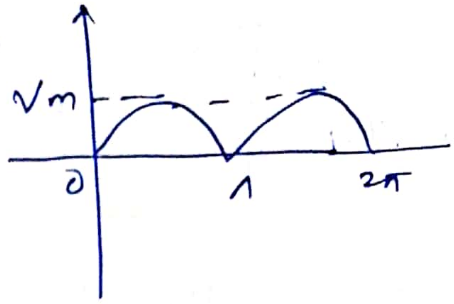
$=$

$\cos 2\theta = \sin^2\theta - \cos^2\theta$

$1 + \cos 2\theta = 2\sin\theta - 1$

(2)

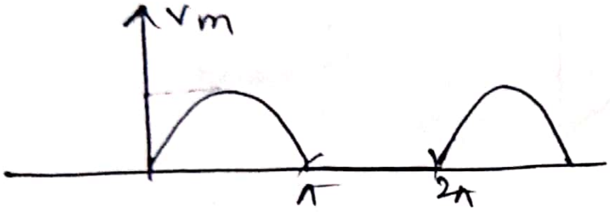
$$V_{rms}^2 = \frac{1}{T}\int_0^T V_m^2 \sin^2 \omega t \, dt$$



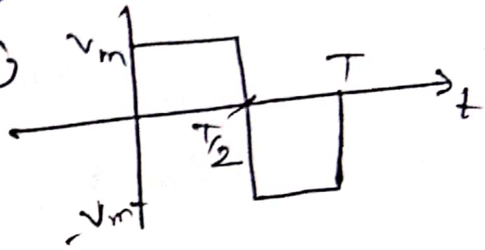
$$= \frac{V_m^2}{T}\left[\frac{1}{2}\right]$$

$$=$$

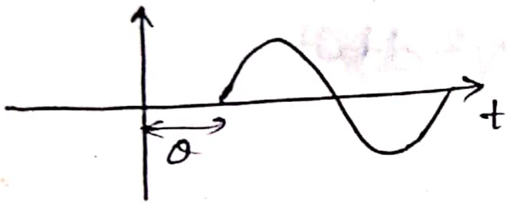
(3)



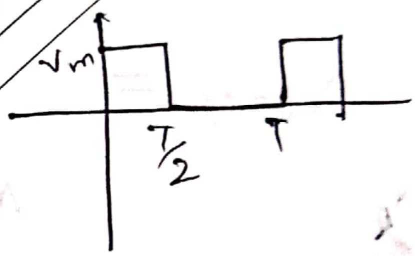
(4)



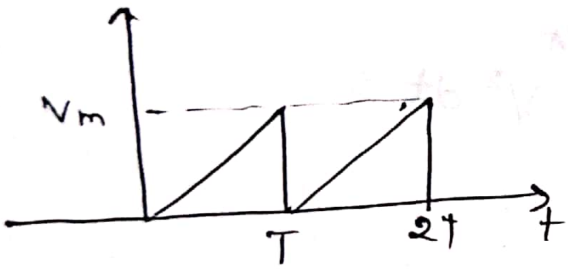
(5)



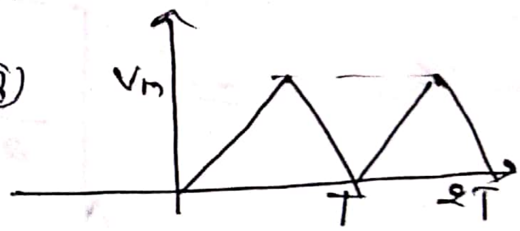
(6)



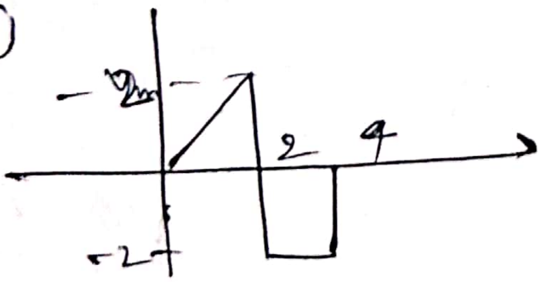
(7)



(8)



(9)



(1)

$$V_{rms} = \sqrt{\frac{1}{2\pi}\int_0^{2\pi} (V_m \sin \omega t)^2 \, d\omega t}$$

$$\boxed{V_{rms} = \frac{V_m}{\sqrt{2}}}$$

$\sin^2 \omega t \leftrightarrow \frac{1 - \cos 2\omega t}{2}$

(2)

$$V_{rms} = \sqrt{\frac{1}{\pi}\int_0^{\pi} (V_m \sin \omega t)^2 \, d\omega t}$$

$$\boxed{V_{rms} = \frac{V_m}{\sqrt{2}}}$$

Full wave rectifier:-

(3) Half wave rectifier:-

$$\boxed{V_{rms} = \frac{V_m}{2}}$$

$$V_{rms} = \sqrt{\frac{V_m^2}{2\pi}\int_0^{\pi} \left(\frac{1 - \cos 2\omega t}{2}\right) d\omega t}.$$

(4) $V(t) = V_m \sin(\omega t - \theta)$

$V_{rms} = \frac{V_m}{\sqrt{2}}$ (it does not change with shifting).

Note:- RMS value is independent of position of starting of waveform. but it depends on shape of the waveform.

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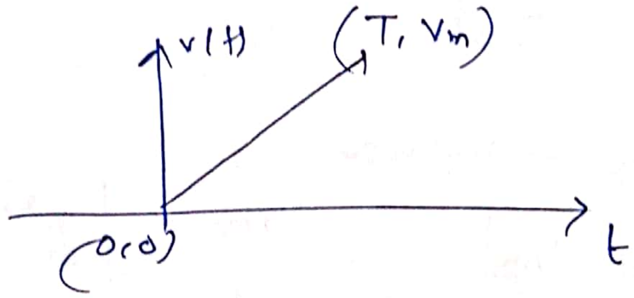
5 $V_{rms} = \sqrt{\frac{1}{T}\int_0^T (V_m)^2 dt}$

$= \sqrt{\frac{V_m^2}{\cancel{T}}\cancel{T}} = \sqrt{V_m^2} = V_m$

6 $V_{rms} = \sqrt{\frac{1}{T}\int_0^{T/2} V_m^2 dt + \int_{T/2}^{T} 0\, dt}$

$= \frac{V_m^2}{\cancel{T}} \cdot \frac{\cancel{T}}{2} = \frac{V_m}{\sqrt{2}}.$

7



$y - \cancel{V_m} = \frac{V_m}{T}(x - 0)$

$y = \frac{V_m}{T} x$

$v(t) = \frac{V_m}{T} t \quad -(1)$

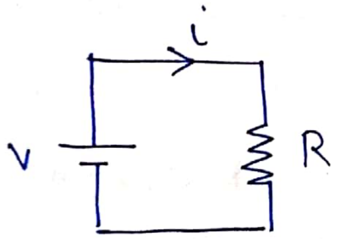
$V_{rms} = \sqrt{\frac{1}{T}\int_0^T \left(\frac{V_m t}{T}\right)^2 dt}$

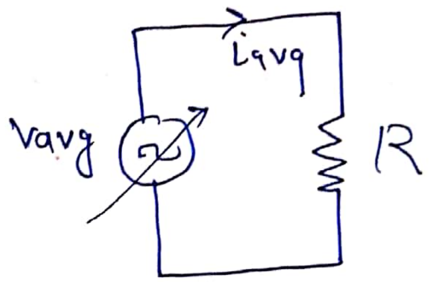
$= \sqrt{\frac{V_m^2}{T^3}\left|\frac{t^3}{3}\right|_0^T} = \frac{V_m}{\sqrt{3}}$

Avg Value :-

(1) Avg value is defined based on charge transfer in the ckt

(2) The voltage at which charge transfer in ac ckt is equal to charge ~~transfer~~ in dc ckt is ~~eqv~~ called as V_{avg}. provided that both acckt and dc ckt have equal value of resistance. and operated for same time.





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

If operate for t sec.

$Q_{dc} = it$

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

$Q_{ac} = it$

$$Q_{ac} = Q_{dc}.$$

$$R = R.$$

then. Voltage is called V_{avg}:

when $\boxed{Q_{ac} = Q_{dc}}$ at $R = R$.

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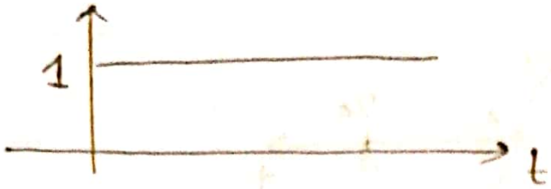
Problem: (1)



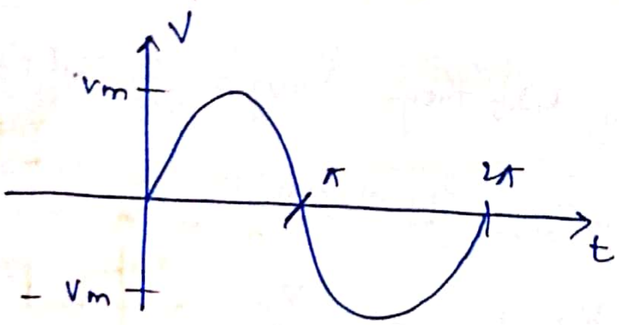
$$V_{avg} = \frac{1}{T}\int_0^T v(t)\,dt$$

$$= \frac{1}{T}\int$$

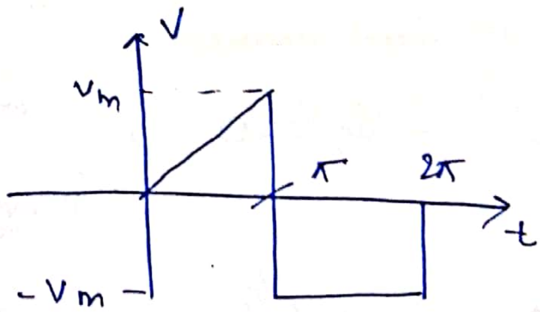
⇒ Avg values of complete cycle of symmetrical wave is equal to '0'

⇒ For analysis purpose while finding avg value of symmetrical wave. only +ve half cycle is considered.

⇒ While finding avg value of unsymmetrical wave angle made by complete cycle is consider.



Symmetric wave.



Unsymmetric wave

$$V_{avg} = \frac{1}{\pi}\int_0^{\pi} V\,d\omega t$$

$$V_{avg} = \frac{1}{2\pi}\left[\int_0^{\pi} V\,d\omega t + \int_{\pi}^{2\pi} V\cdot d\omega t\right.$$

⇒ **FORM FACTOR** is a Ratio of: rms value of waveform to avg. or dc value of waveform

$$\text{Form Factor} = \frac{V_{rms}}{V_{avg}} = \frac{I_{rms}}{I_{avg}}$$

(#) **PEAK FACTOR:-** Ratio of max value of waveform to rms value of waveform.

$$P.F = \frac{V_m}{V_{rms}} = \frac{I_m}{I_{rms}}$$

Note: To justify about shape of waveform F.F and P.F concept are used.

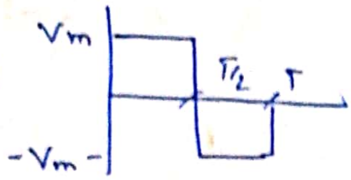
For sine wave. (ideally)

$$\boxed{\begin{aligned} FF &= 1.11 \\ PF &= \sqrt{2} \end{aligned}}$$

If o/p waveform have these value then least distortion is observed

Prob: (1) which of fallowing waveform have FF=PF)

(a)

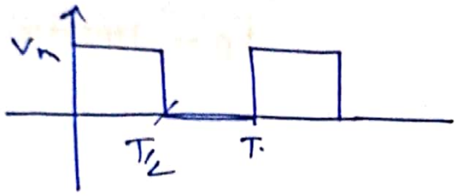


$\Rightarrow$ $V_{avg} = V_{rms} = V_m$.

$F.F = \frac{V_m}{V_m} = 1$

$P.F = \frac{V_m}{V_m} = 1$

(b)



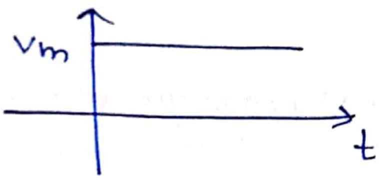
$\Rightarrow$ $V_{rms} = \frac{V_m}{\sqrt{2}}$.

$V_{avg} = \frac{V_m}{2}$.

$F.F = \frac{V_m}{\sqrt{2}} \frac{2}{V_m} = \sqrt{2}$

$P.F = \frac{\cancel{V_m}\sqrt{3}}{\cancel{V_m}} = \sqrt{2}$

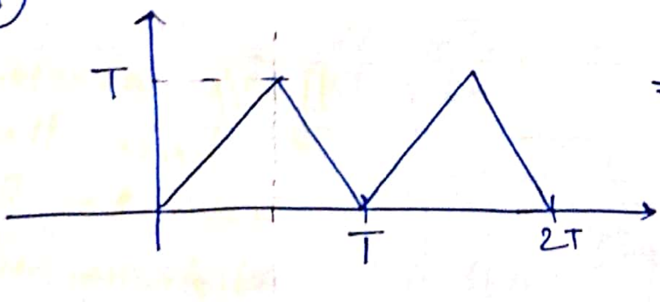
(c)



$\Rightarrow$ $V_{rms} = V_{avg} = V$

$F.F = P.F = 1$

X (d)



$\Rightarrow$ $V_{avg} = \frac{V_m}{2}$

$V_{rms} = \frac{V_m}{\sqrt{3}}$

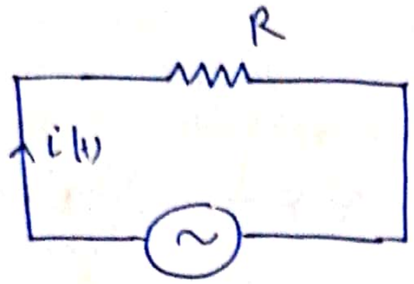
$F.F = \frac{V_m}{\sqrt{3}} \frac{2}{V_m} = \frac{2}{\sqrt{3}}$

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

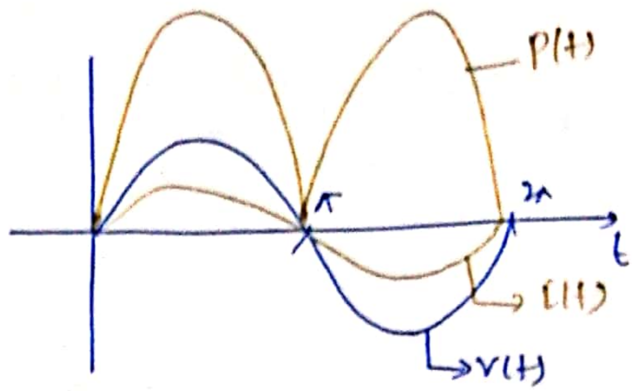
Not

~~Prob-②~~ Case-①

AC SOURCE ACROSS RESISTOR



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



$f = 50\,Hz$

$f_p = 100\,Hz$

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

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

$$i(t) = I_m \sin\omega t \quad -①$$

$$P(t) = v(t)\, i(t) \longrightarrow \text{instantaneous power}$$

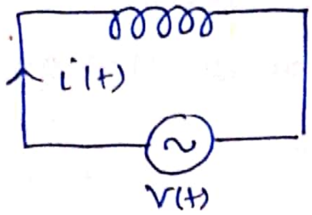
$$P(t) = V_m \sin\omega t \cdot I_m \sin\omega t$$

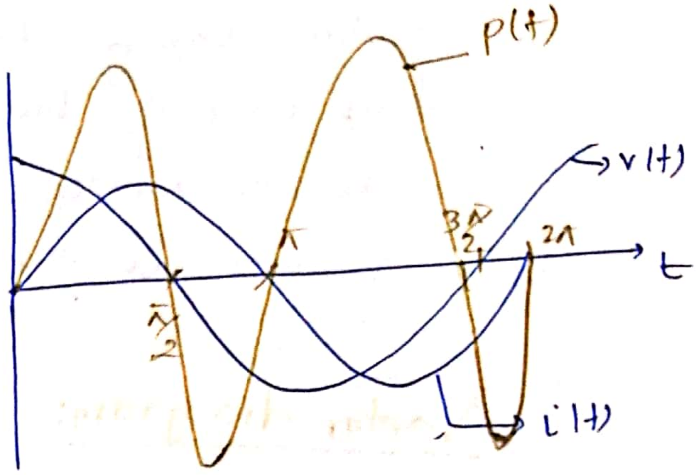
$$\boxed{P(t) = \frac{V_m I_m}{2}\left(1 - \cos 2\omega t\right)}$$

avg. power:
$$\boxed{P_{av} = \frac{I_m V_m}{2} = \frac{I_m}{\sqrt{2}} \frac{V_m}{\sqrt{2}} = V_{rms} \cdot I_{rms}}$$

$$\boxed{P_{av} = \frac{1}{2\pi} \int_0^{2\pi} P(t)\, dt}$$

Pb ③ CASE - ② **AC source across inductor:-**





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

$$\boxed{\begin{array}{l} f = 50\text{Hz} \\ f_p = 100\text{Hz} \end{array}}$$

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

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

****
[V leads by 90°]
in L

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

$$v(t) = \underline{X_L I_m} \sin(90 + \omega t)$$

Instanteneau power p(t):

$$p(t) = v(t)\, I(t)$$

$$= X_L I_m \sin\omega t\, I_m \sin\omega t$$

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

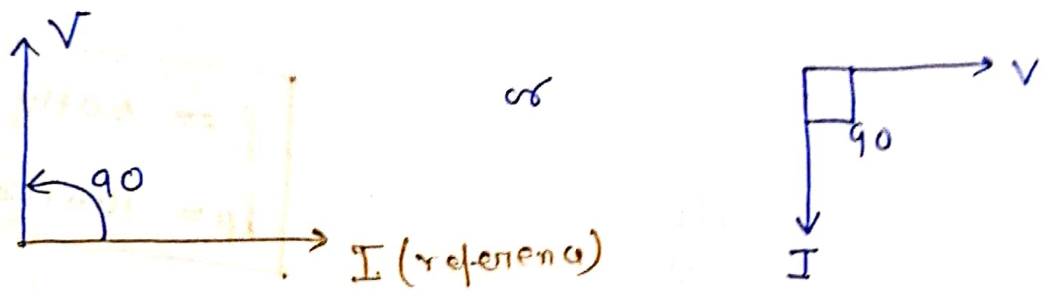
Avg. power $P_{av} = \frac{1}{2\pi}\int_0^{2\pi} p(t)\,dt$

$$\boxed{P_{av} = 0}$$

CONCLUSION:-

① In +ve half cycle of power inductor takes energy from the source and in -ve half cycle of power inductor deliver energy to the source. ∴ Net power taken from source is equal to '0'.

Vector diagram:

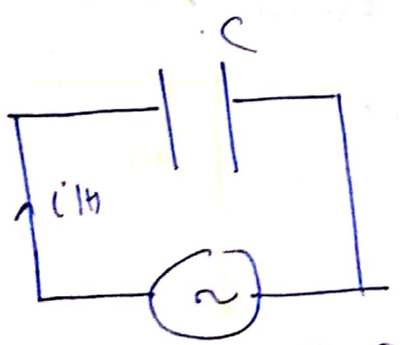


Series: ckt we consider this

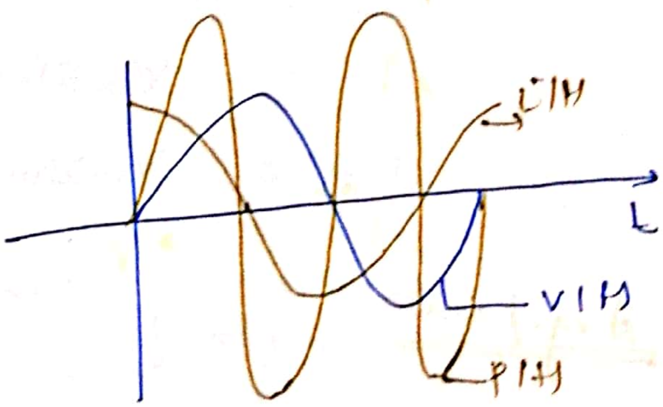
parallel ckt and we consider thin.

Both same but used for our convenience.

Case. ③ Ac. source Across Capacitor



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



$f = 50\,Hz$

$f_p = 100\,Hz$

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

$$\boxed{i = C\frac{dv}{dt}}$$

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

$$i = \frac{V_m}{1/\omega C}\sin(\omega t + 90) \qquad \left(X_C = \frac{1}{\omega C}\right)$$

$$i = I_m \sin(\omega t + 90^\circ) \qquad I_m = \frac{V_m}{\left(\frac{1}{\omega C}\right)}$$

Instantaneous power:-

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

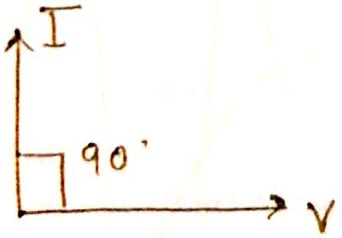
$$P(t) = \frac{V_m I_m}{2}\sin 2\omega t$$

[I Leads V by 90°]

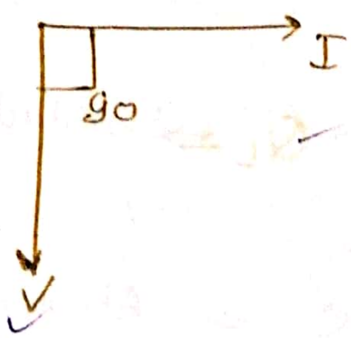
$$P_{avg} = \frac{1}{2\pi}\int_0^{2\pi} P(t)\,dt$$

$$\boxed{P_{avg} = 0}$$

Vector diagram:



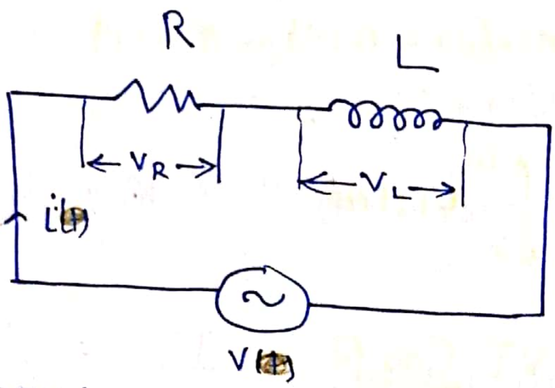
or



Cas. (4)

R – L Series ckt

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



By KVL

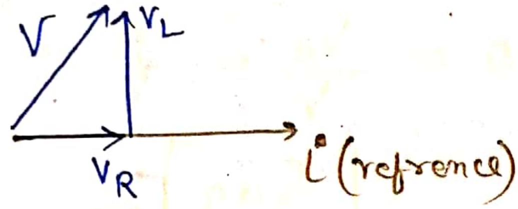
$V = V_R + V_L$

$V = IR + IX_L \angle 90^\circ$

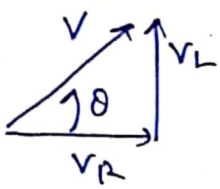
$IZ = I(R + jX_L)$

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

Vector diagram:



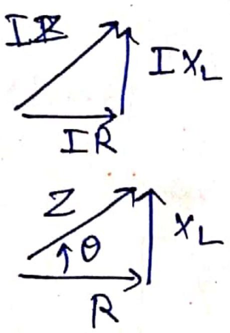
Voltage triagle:-



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

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

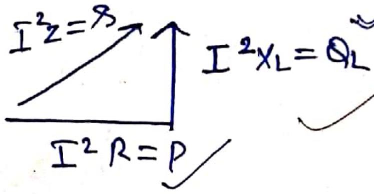
Impedence triagle



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

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

Pawer triangle:



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

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

P → Active pawer or true pawer or Real pawer or Avg pawer or effective pawer [Unit: watt]

Q_L ⇒ inductive reactive pawer [VAR] (Volt Amp. reactive)

S ⇒ Apparent pawer or Complex pawer. (VA) (Volt-ampere)

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

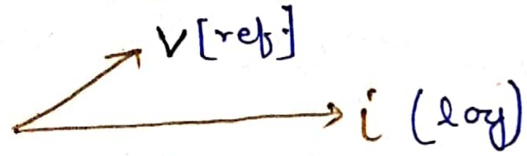
$$P(t) = V_m \sin(\omega t + \theta)\, I_m \sin \omega t$$

$$P_{av} = \frac{1}{2\pi} \int_0^{2\pi} P(t)\, dt$$

$$P_{avg} = VI \underline{\underline{\cos\theta}}$$

$$\text{power factor} = \cos\theta = \frac{V_R}{V} = \frac{R}{Z} = \frac{P}{S} \quad \left(\frac{B}{H}\right)$$

[lag]



Note:- Power factor ~~angle indicates~~ angle made by the current w.r.t voltage.

(2) While defining power factor for any combination of ckt voltage vector is taken as a reference.

(a) In the real time system only independent voltage source exist (source voltage = const)

(b) In the real time system load are connected in the parallel (Load voltage = constant)

~~Case 5~~

$$\boxed{\begin{aligned} P_{av} &= I^2R = VI\cos\theta \\ Q_L &= I^2 X_L = VI\sin\theta \\ S &= I^2 Z = VI^* \end{aligned}}$$

Ex:- $V = 5\angle 20$, $i = 3\angle 10$

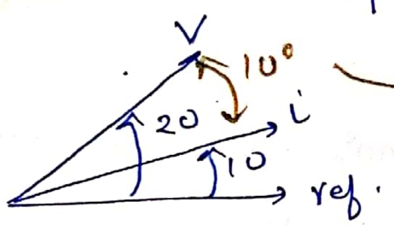
$S = Vi$

$S = 15\angle 30$

$S = Vi^*$

$S = 15\angle 10^\circ$ VA

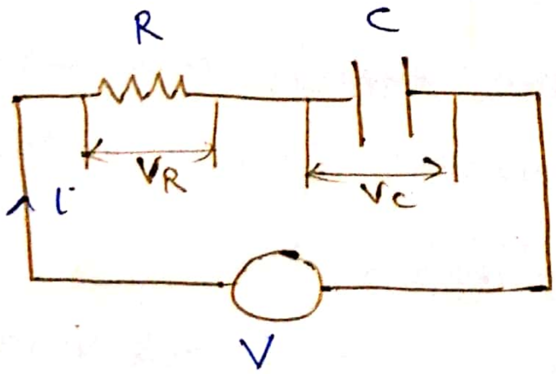
Correct Answer.



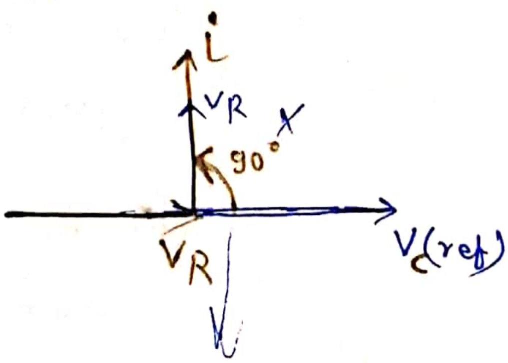
$\boxed{S = VI^*}$

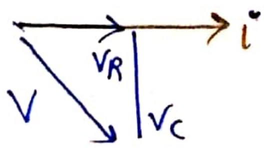
complex power

Case (5) RC Series ckt :



$i = C\frac{dv}{dt}$





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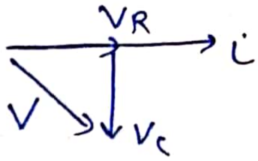
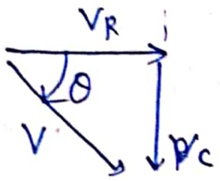
$$V = V_R + V_C$$

$$IZ = IR + IX_L \angle{-90}$$ $\therefore$ $\boxed{V \text{ Lagging}}$

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



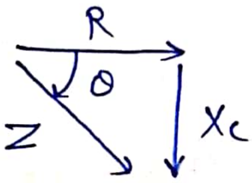
Voltage triangle



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

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

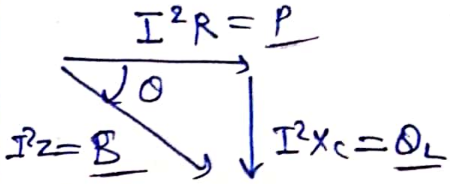
Impedance triangle



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

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

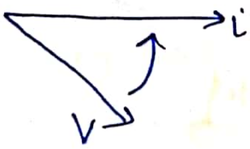
Power triangle



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

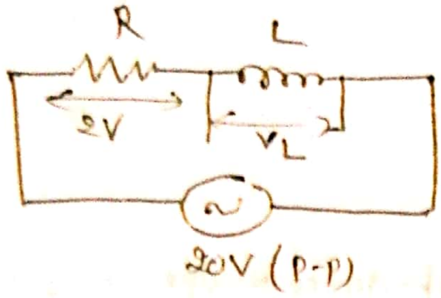
$$\theta = \tan^{-1}\left(\frac{-Q_L}{P}\right)$$

Power factor:- $\cos\theta = \frac{V_R}{V} = \frac{R}{Z} = \frac{P}{S}$ [lead]



"I" Leads the "V"

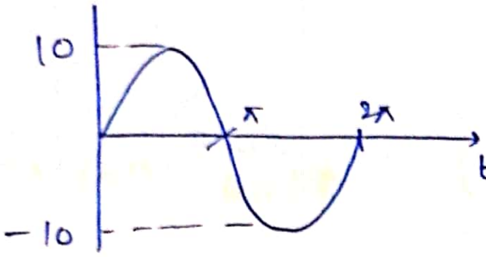
Pro. ① Find Voltage across inductor: -



Can't applied.

$10 = 2V + V_L$ ✗

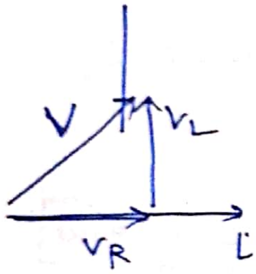
$V_L =$



Actual m-I

$V_m = 10V \Rightarrow V_{rms} = \frac{V_m}{\sqrt{2}} = \frac{10}{\sqrt{2}}$

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



Voltage triangle:

$\left(\frac{10}{\sqrt{2}}\right)^2 = V_R^2 + V_L^2$

$\frac{100}{2} = V_R^2 + V_L^2$

$\frac{100}{2} = (2V)^2 + V_L^2$

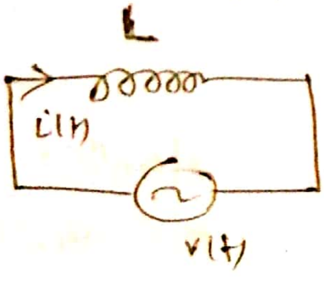
$\boxed{V_L = \sqrt{46}}$

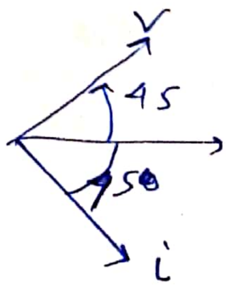
Prob ② Find ckt element for given voltage and current equation

sol

$v(t) = 9 \sin(t + 45)$

$i(t) = 3 \sin(t - 45^\circ)$





V leads i.

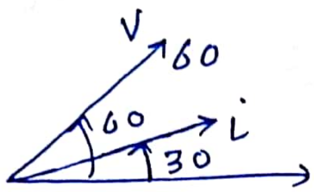
inductor.

$$X_L = \frac{V_{rms}}{I_{rms}} = \frac{\frac{V_m}{\sqrt{2}}}{\frac{I_m}{\sqrt{2}}} = \frac{V_m}{I_m} = 9/3 = 3$$

$X_L = \omega L = 3 \quad \therefore \quad \omega = 1$

$$\boxed{L = 3H.}$$

Prob. (3) $v(t) = 9\sin(2t + 60)$ Find ckt eleme
$i(t) = 3\sin(t + 30)$

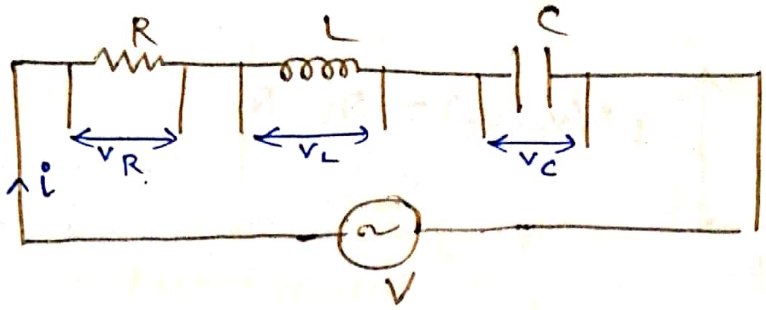


Note :— when voltage and current equation have different frequency it is not possible to find ckt element

~~Prob~~ 6

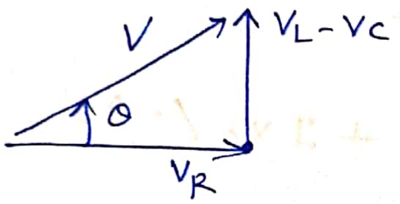
case:-

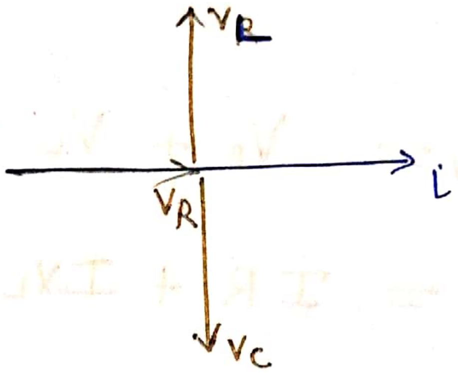
RLC series ckt



Vector diagram:-

Case:-① $V_L > V_C$



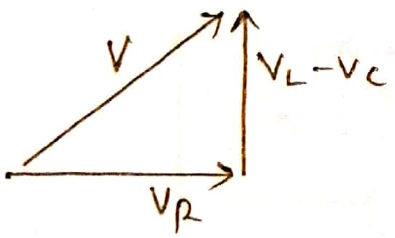


$\angle 90^\circ \quad \angle -90^\circ$

$$V = V_R + V_L + V_C$$

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

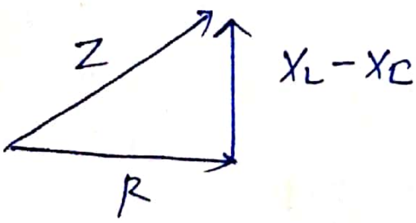
⇒ Voltage triangle.



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

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

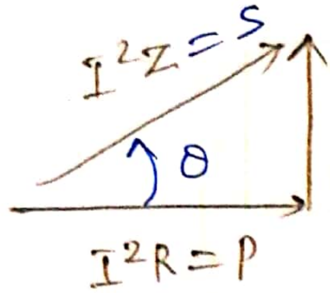
⇒ Impedance triangle.



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

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

Power triangle:-



$I^2(X_L - X_C) = Q_L - Q_C =$

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

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

Imp: Concept:-

$$V = V_R + V_L + V_C$$

$$IZ = IR + IX_L\angle 90^\circ + IX_C\angle -90^\circ$$

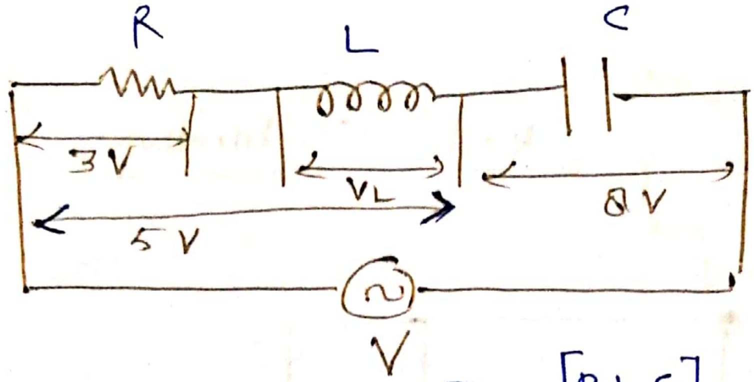
$$Z = R + jX_L - jX_C$$

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

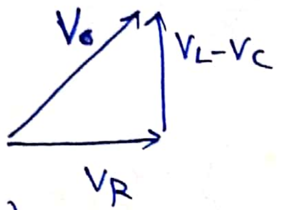
$$|Z| = \sqrt{R^2 + (X_L - X_C)^2}$$

$$\boxed{\cos\theta = p.f = \frac{R}{|Z|}}$$

Pro. (1)



Find. V_L and V.



For. [RLC]

$$V = \sqrt{V_R^2 + (V_L - V_C)^2} \quad —(1)$$

First (R-L)

$$5 = \sqrt{9 + V_L^2}$$

~~25 = 9 + V_L^2~~

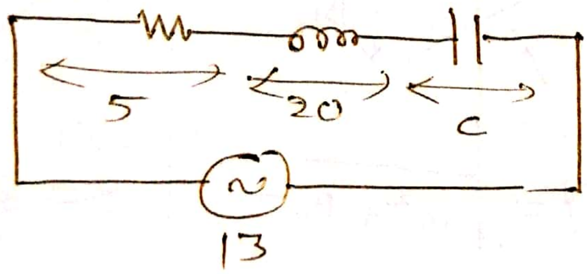
$$V_L = 4$$

$$V_C = 8V$$

$$V = \sqrt{9 + (4-8)^2}$$

$$V = 5$$

Prob: (2) Find valtage across capaciter of ckt



Both: 8, and 32

$$V = \sqrt{5^2 + (20 - V_C)^2}$$

$$169 - 25 = (20 - V_C)^2$$

If $V_L > V_C$ $\pm 12 = 20 - V_C$

$$\boxed{V_C = 8}$$

or

If $V_C > V_L$

$$12 = V_C - 20$$

$$\boxed{V_C = 32}$$

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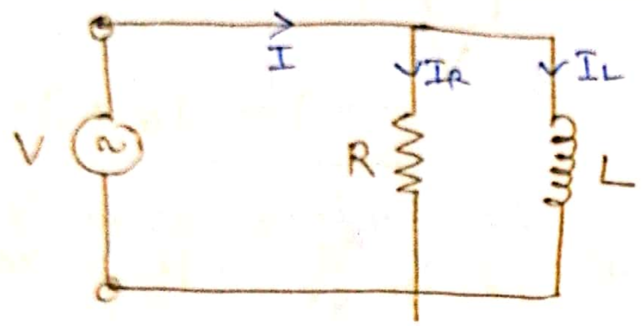
PARALLEL COMBINATION:

# #

Case ① **R - L Combination**



$I = I_R + I_L$

$\frac{V}{\cancel{Z}} = \frac{V}{R} + \frac{V}{X_L}\angle -90^\circ$

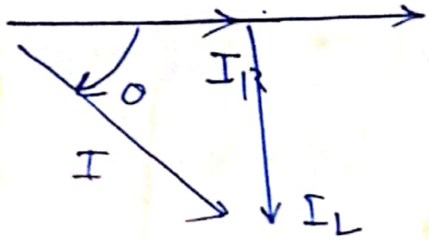
$\frac{V}{Z} =$

$V\cancel{Y} = VG - jB_L$

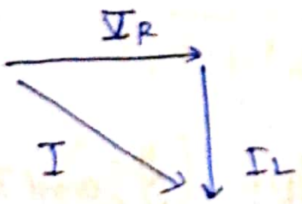
$\boxed{Y = G - jB_L}$

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

$G = 1/R$



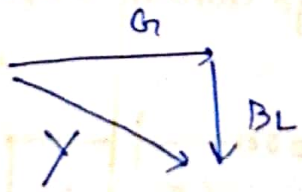
I - Tri.



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

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

Z - tri.

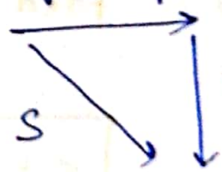


$Y = \sqrt{G^2 + B_L^2}$

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

Po - tri.

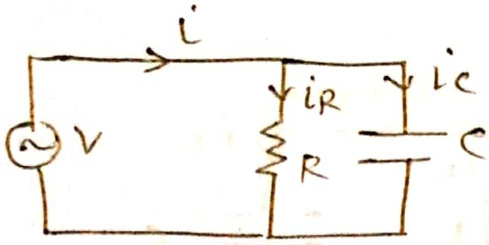
$V^2G = P$

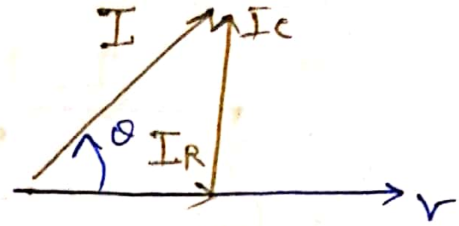


$S = \sqrt{P^2 + Q_L^2}$

$\tan\theta = -\frac{Q_L}{P}$

② R–C parallel ckt:





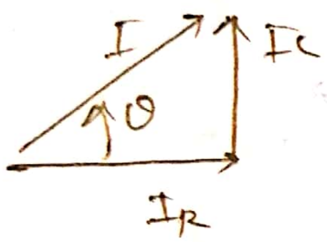
$$I = I_R + I_c$$

$$\frac{V}{Z} = \frac{V}{R} + \frac{V}{X_C}\angle 90^\circ$$

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

$$\boxed{\because \; B_c = \omega C}$$

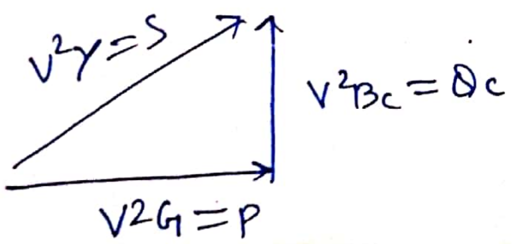
⇒ I – tri



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

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

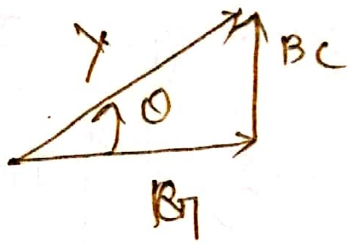
⇒ Power triangle:



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

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

~~impedance~~ or admitt



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

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