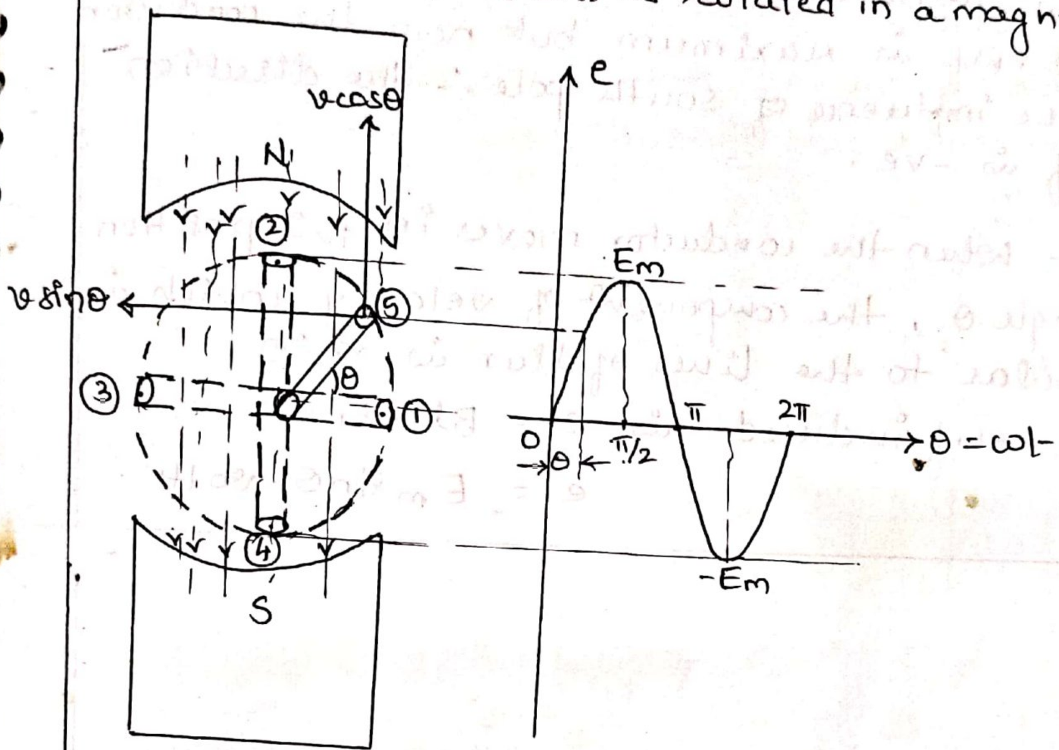
Module I

2) A.C. FUNDAMENTALS

Generation of sinusoidal voltage:-

Q1) With a neat sketch explain how an alternating voltage is produced when a coil is rotated in a magnetic field. (6m)



~~Position 1~~:- consider a magnetic field of constant flux density B wb/mt².

Let a conductor of length l is placed in a magnetic field with velocity v mt/sec.

Position 1 :- At this position the motion of the conductor is parallel to the lines of flux. hence flux cut by the conductor is zero & induced emf is also

Position 2 :- At this position the motion of the conductor is perpendicular to the lines of flux. Hence flux cut by the conductor is maximum & the induced emf is also maximum.

Position 3 :- At this position again the motion of the conductor is parallel to the lines of flux hence the induced emf is zero.

Position 4 :- At this position the motion of the conductor is perpendicular to the lines of flux & the induced emf is maximum but now the conductor is under the influence of south pole ∴ the direction of the emf is -ve.

Position 5 :- When the conductor moves in this position making angle θ, the component of velocity which is perpendicular to the lines of flux is $v \sin\theta$.

Hence the emf induced is $e = Blv \sin\theta$

$$e = E_m \sin\theta \text{ volts.}$$

Module II

1) Single Phase AC Circuits

Definations :-

i) RMS Value :→

The RMS value of an AC is equal to that DC which produces same amount of heat as produced by ac when passed through the same resistance for the same time.

$$I = \frac{I_m}{\sqrt{2}} = 0.707 I_m$$

ii) Average value of an AC :-

The average value of an AC is equal to that DC which transfers same amount of charge as by AC for the same circuit in same time.

$$I_{avg} = \frac{2I_m}{\pi} = 0.637 I_m$$

iii) Form factor :-

It is the ratio of RMS value to the average value of an A.C quantity.

ie; $$\text{form factor} = \frac{\text{RMS Value}}{\text{Avg value}} = \frac{0.707 I_m}{0.637 I_m}$$

$$K_f = 1.11$$

iv) Peak factor :-

It is the ratio of Maximum value to the RMS value of an A.C quantity.

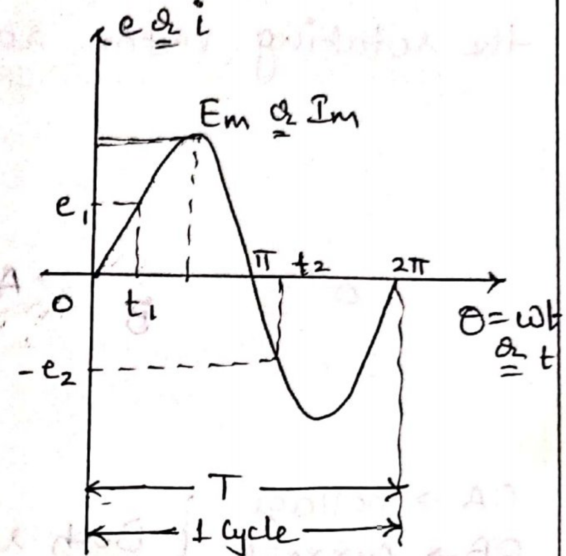
ie; $$\text{Peak factor} = \frac{\text{Max. Value}}{\text{RMS value}} = \frac{I_m}{0.707 I_m}$$

$$K_p = 1.414$$

Frequency of Generated voltage :-

Define the following :- i) frequency ii) Time period iii) Instantaneous value iv) Amplitude.

i) Frequency (f) :-



It is defined as Number of cycles completed by an a.c per second.

ie; $f = \frac{1}{T}$ Hz

It is represented as f and its unit is Hz.

ii) Time Period (T) :-

It is defined as the time taken by an a.c to complete its one cycle.

$$T = \frac{1}{f} \text{ sec.}$$

iii) Instantaneous value :- It is defined as the value of an ac at a perticular instant.

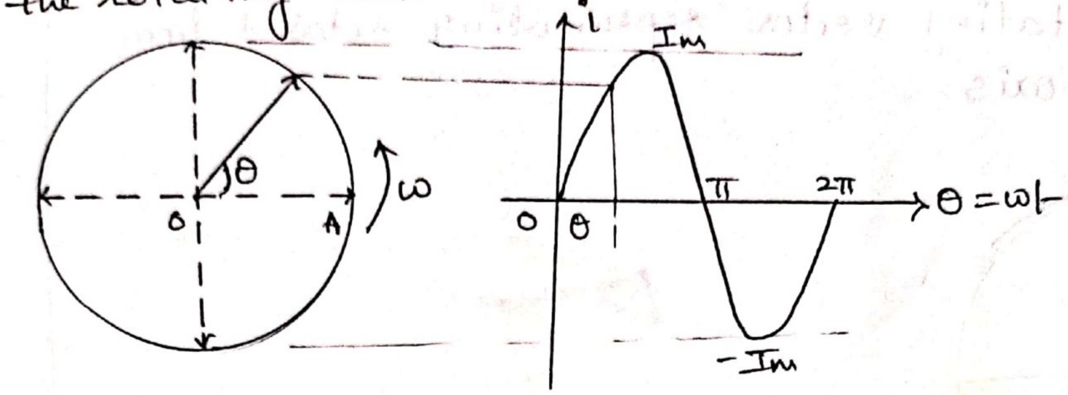
Ex :- e_1 & $-e_2$ at t_1 & t_2.

iv) Amplitude :- The Maximum value of any alternating quantity is known as Amplitude.

Ex :- E_M & I_m.

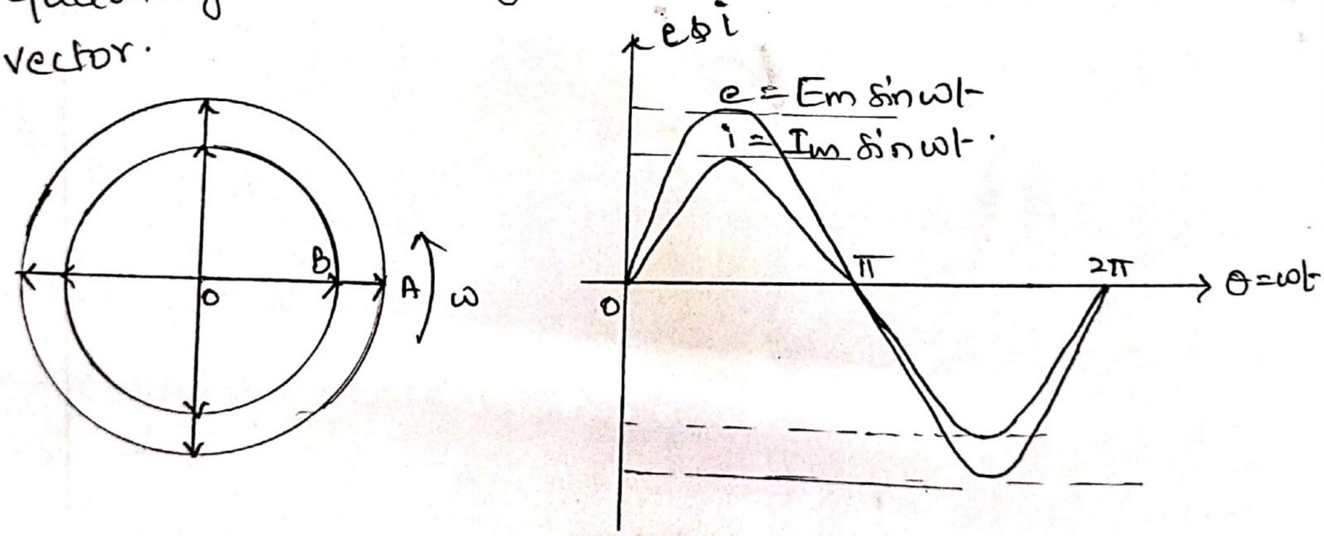
Phase representation of an alternating quantity

Def^{n}:- The phase of an ac is the angle through which the rotating vector rotated from the reference axis.



Phase difference:-

Def^{n}:- The phase difference bet^{n}. two alternating quantity is the angle difference bet^{n} the two rotating vector.

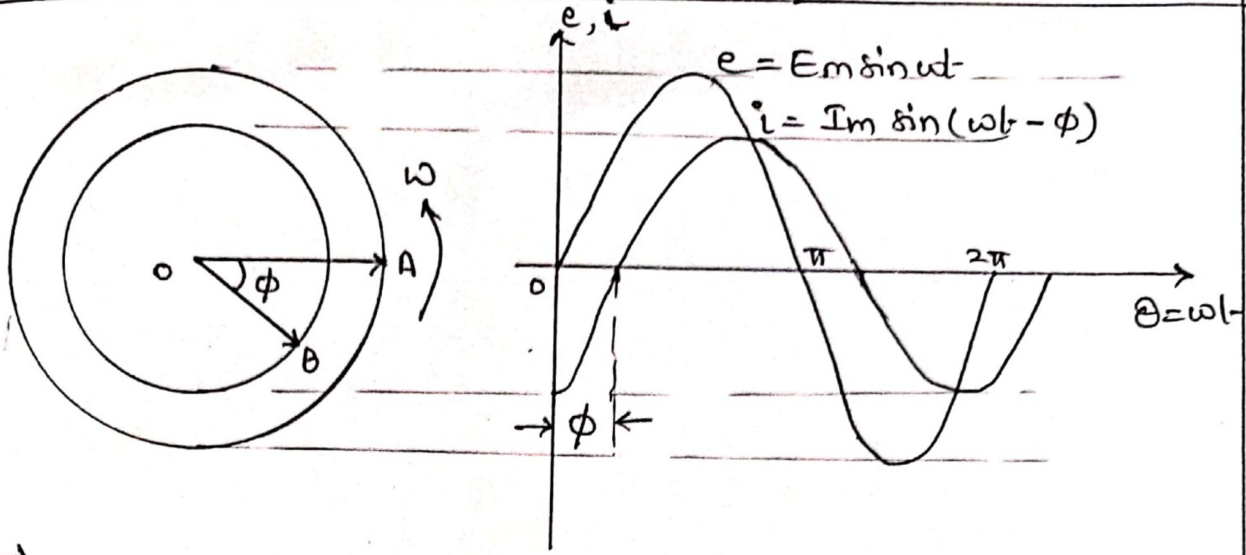


OA → voltage
OB → current } Both rotate together with an angular velocity ω.

∴ The phase difference bet^{n} them is zero.

ie; $e = E_m \sin\omega t$

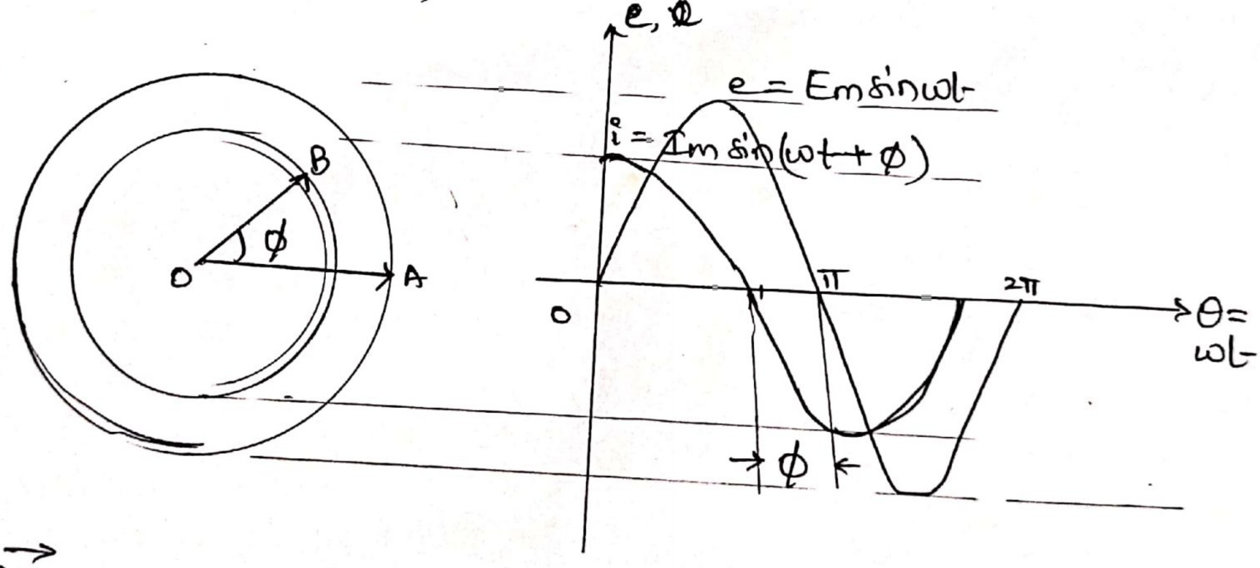
$i = I_m \sin\omega t$.



$\vec{OA} \rightarrow$ voltage } Current is lagging the voltage by
$\vec{OB} \rightarrow$ current } an angle ϕ.

$\therefore$ $e = E_m \sin \omega t$

& $i = I_m \sin(\omega t - \phi)$



$\vec{OA} \rightarrow$ voltage } Current is leading the voltage by
$\vec{OB} \rightarrow$ current } an angle ϕ

$\therefore$ $e = E_m \sin \omega t$

& $i = I_m \sin(\omega t + \phi)$

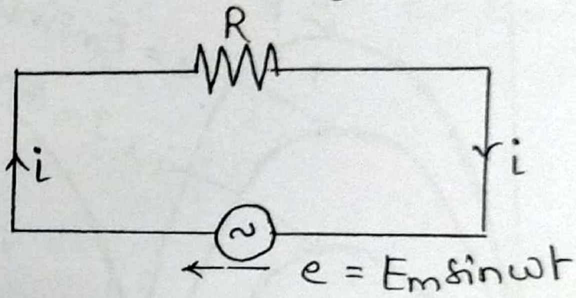
1) Analysis with phasor diagram of

i) Pure Resistance circuit (R-circuit).

Q1) With the help of phasor diagram and waveform comment on the phase relation between voltage and current in purely resistive circuit.

OR

Derive an expression for the instantaneous power in a pure resistor energised by sinusoidal voltage.



$e = E_m \sin\omega t$ — (1)

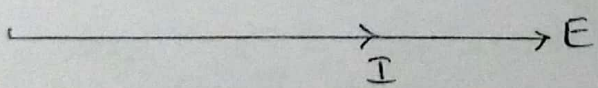
By ohm's law.

$i = \frac{e}{R} = \frac{E_m \sin\omega t}{R}$

$i = I_m \sin\omega t$ — (2) $[\because I_m = E_m/R]$

from eq^n (1) & (2)

$e = E_m \sin\omega t$
$i = I_m \sin\omega t$
} Hence the current and voltage are in phase in a purely resistive circuit.



WKT:- $P = ei = E_m \sin\omega t \, I_m \sin\omega t = E_m I_m \sin^2\omega t$

$P = E_m I_m \left[\frac{1-\cos 2\omega t}{2}\right]$

$P = \frac{1}{2} E_m I_m - \frac{1}{2} E_m I_m \cos 2\omega t$ — (3)

In above eq^n. the second part is

*) Periodically varying quantity

*) It's frequency is twice the applied voltage frequency.

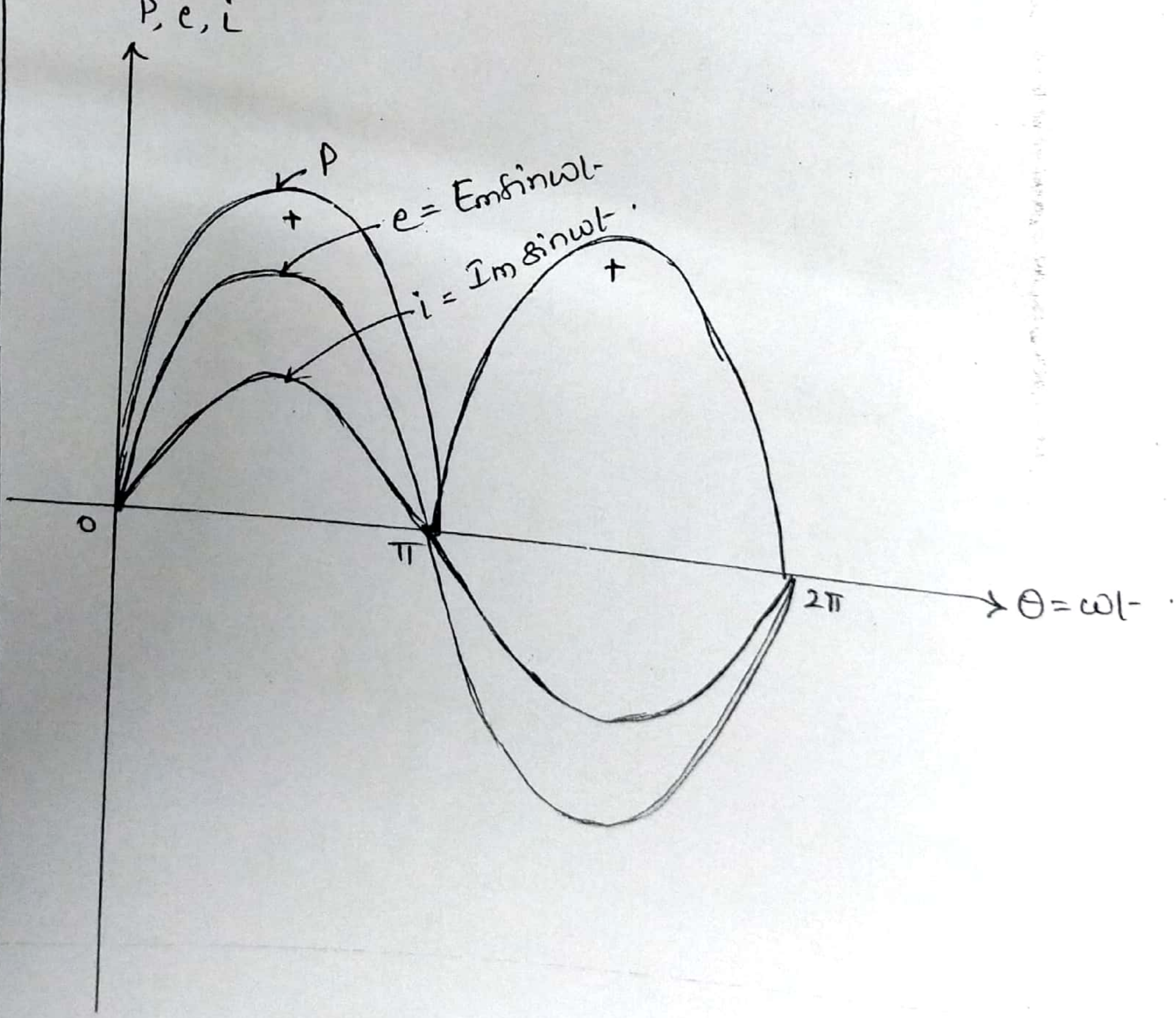
*) It's average voltage over a period of time is zero.

$$\therefore \quad P = \frac{1}{2} E_m I_m$$

$$= \frac{E_m}{\sqrt{2}} \times \frac{I_m}{\sqrt{2}}$$

$$\left\{ \because \frac{E_m}{\sqrt{2}} = E_{rms} = E \quad \& \quad \frac{I_m}{\sqrt{2}} = I_{rms} = I \right\}$$

$$\boxed{P = E I} \text{ watts.}$$

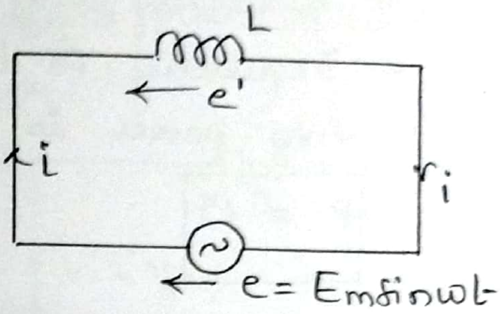


2) Pure Inductive circuit :- (L-circuit)

Q2) Prove that in a purely inductive circuit current lags voltage by 90°.

&

Prove that in a purely inductive circuit power consumed by the circuit is zero.



WKT :- $e = E_m \sin\omega t$ —— (1)

From faraday's laws

$$e' = -L\frac{di}{dt} = -e$$

$$\therefore e = L\frac{di}{dt}$$

$$di = \frac{e}{L}dt = \frac{E_m}{L}\sin\omega t\, dt$$

$$i = \frac{E_m}{L}\int \sin\omega t\, dt = \frac{E_m}{\omega L}(-\cos\omega t)$$

$$i = \frac{E_m}{\omega L}\sin(\omega t - \pi/2) = \frac{E_m}{X_L}\sin(\omega t - \pi/2)$$

$$i = I_m \sin(\omega t - \pi/2) \quad \text{—— (2)} \qquad \left(\because I_m = \frac{E_m}{X_L}\right)$$

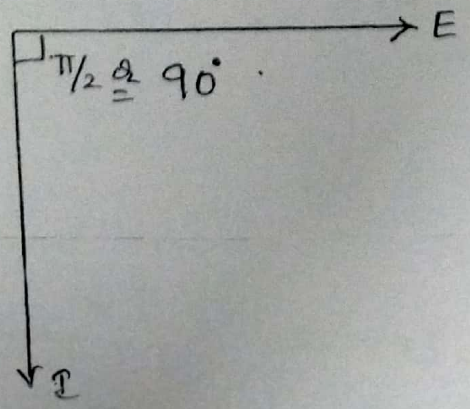
where $X_L = \omega L = 2\pi f L$

$X_L \rightarrow$ Inductive reactance in Ω.

From eq^n. (1) & (2)

$e = E_m \sin\omega t$

$i = I_m \sin(\omega t - \pi/2)$



Comment :- current lags voltage by an angle 90° & $\pi/2$

WKT :- $P = ei = E_m \sin\omega t \; I_m \sin(\omega t - \pi/2)$

$P = E_m I_m \sin\omega t(-\cos\omega t)$

$P = -\frac{1}{2} E_m I_m \sin 2\omega t$ —— (3)

{ ie; $\sin A \cos B = \frac{1}{2}[\sin(A+B) + \sin(A-B)]$ }

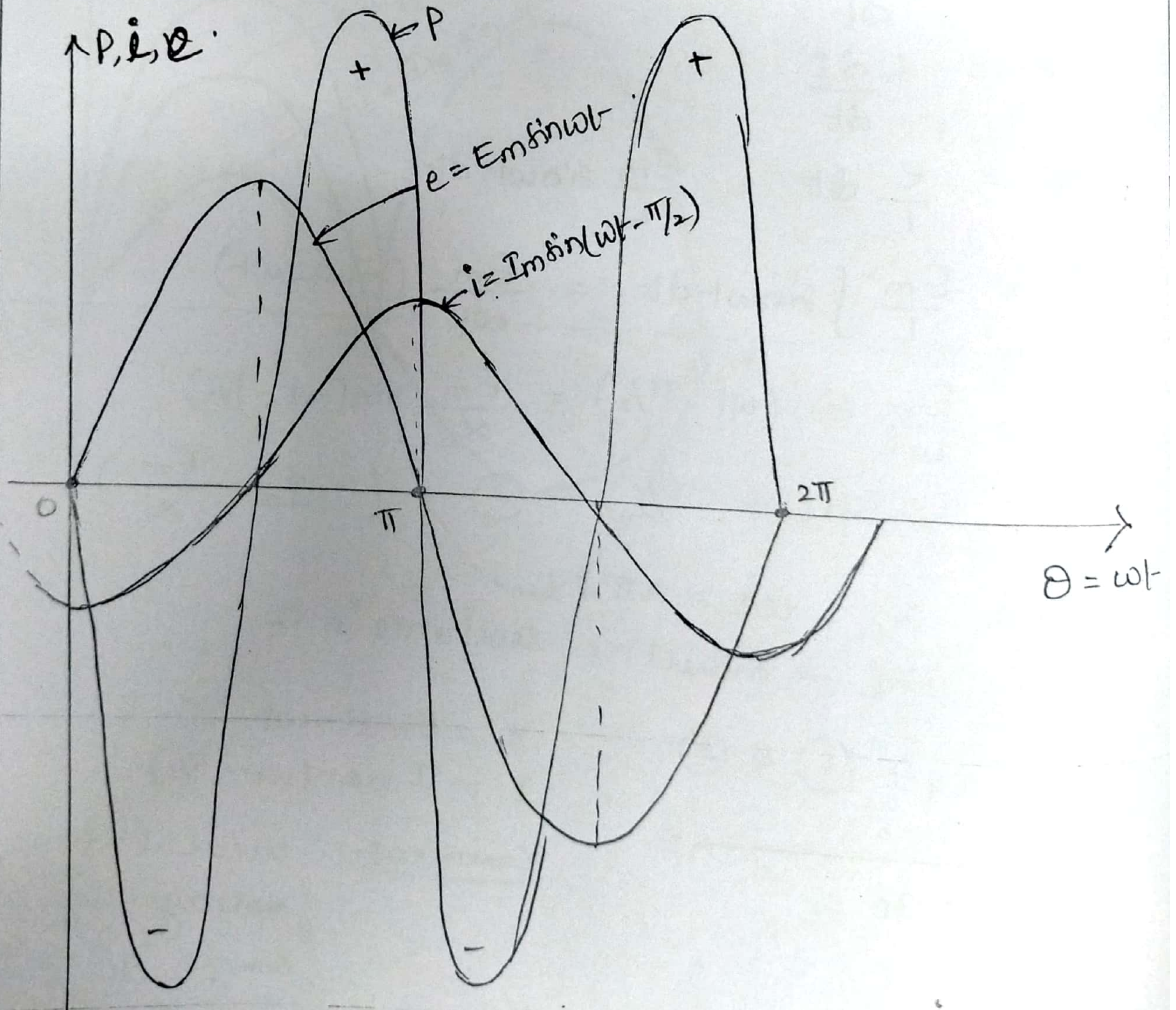
The eq^n (3) is

*> Periodically varying quantity.

*> frequency is twice the supply frequency

*> Avg power is zero. over a period.

$\therefore \boxed{P = 0}$ //

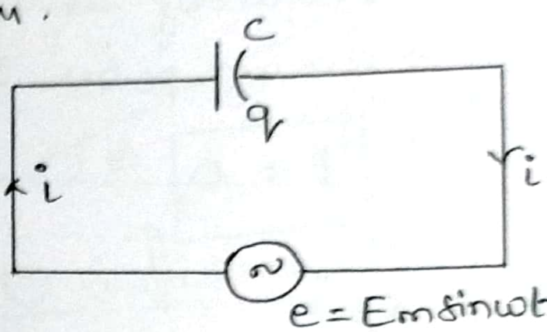


3> Pure Capacitive circuit (C-ckt) :-

Q3> With the help of neat wave form and phasor diagram show that in a pure capacitance the current leads the voltage by 90°

or

Show that the power consumed by a pure capacitance is zero with neat circuit diagram.



WKT :- $e = E_m \sin \omega t$ —— (1)

WKT :- $i = \dfrac{dq}{dt} = \dfrac{d[ce]}{dt}$.

$i = c\dfrac{de}{dt} = \dfrac{c\, d\, E_m \sin\omega t}{dt}$

$\left\{ \begin{array}{l} \because q = ce \\ \therefore c = q/e \\ \& \; e = q/c \end{array} \right\}$

$i = c\omega E_m \cos\omega t$

$= \omega c E_m (\sin(\omega t + \pi/2))$

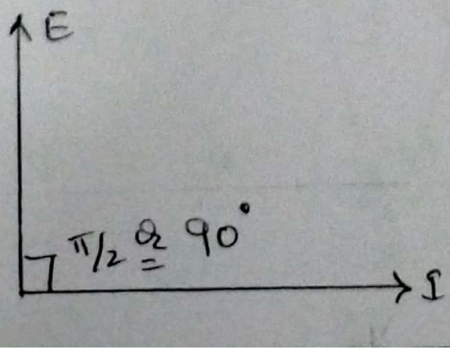
$= \dfrac{E_m}{\frac{1}{\omega C}} \sin[\omega t + \pi/2] = \dfrac{E_m}{X_c} \sin(\omega t + \pi/2)$

$i = I_m \sin(\omega t + \pi/2)$ —— (2) $\left[\because I_m = \dfrac{E_m}{X_c}\right]$

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

$X_c \rightarrow$ capacitive reactance in Ω.

from eqⁿ: (1) & (2)



WKT :- $P = ei = E_m \sin\omega t \cdot I_m \sin(\omega t + \pi/2)$

$P = E_m I_m \sin\omega t \cos\omega t$

$P = \frac{1}{2} E_m I_m \sin 2\omega t$ —— (3)

$\left\{ \because \sin A \cos B = \sin(A+B) + \sin(A-B) \right\}$

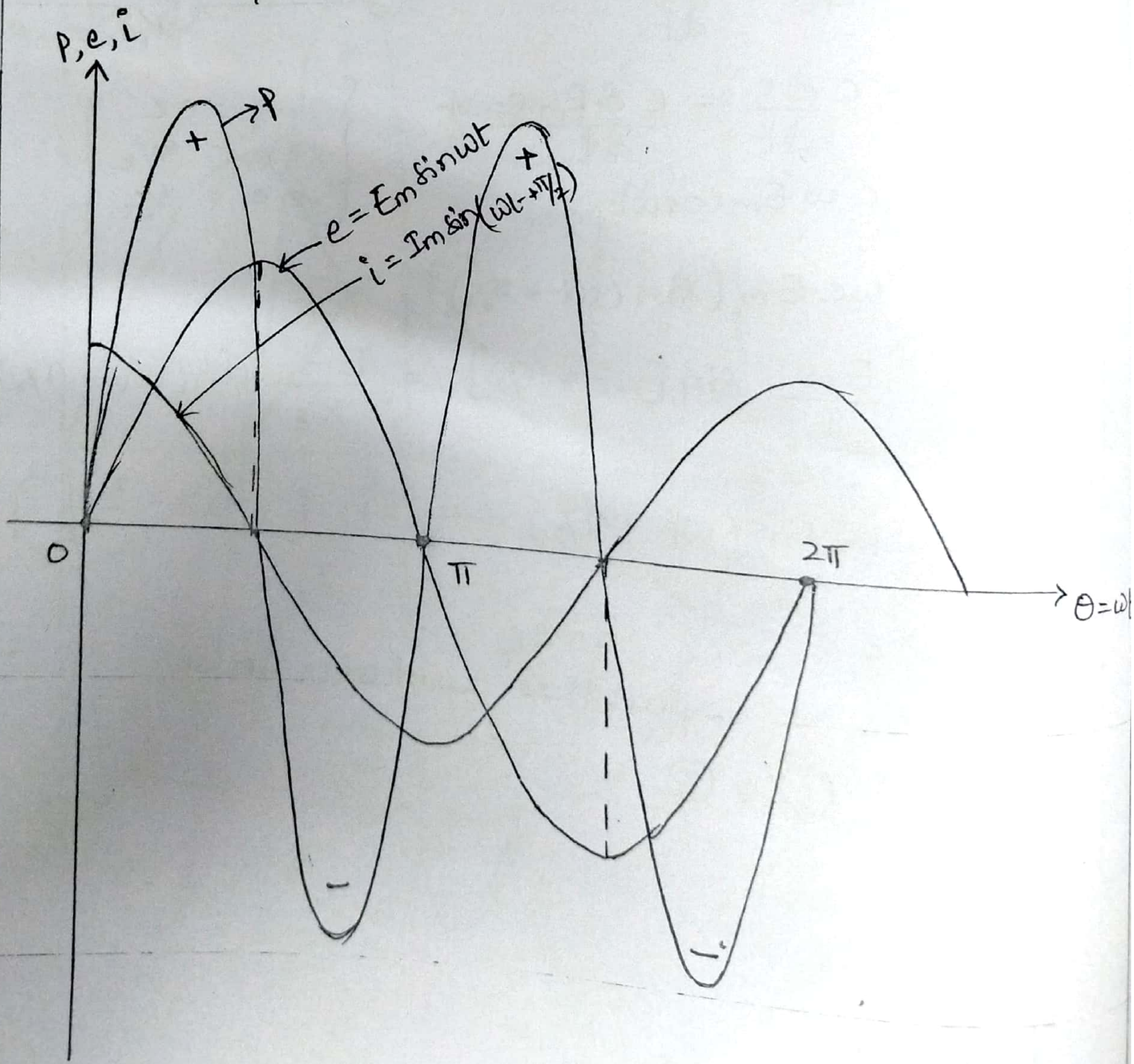
The eqⁿ (3) is

*) Periodically varying quantity

*) Frequency is twice the supply frequency.

*) average power is zero, over a period.

$\therefore \boxed{P = 0}$



4) R-L series circuit

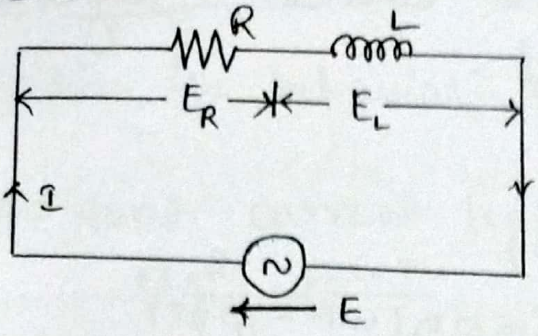
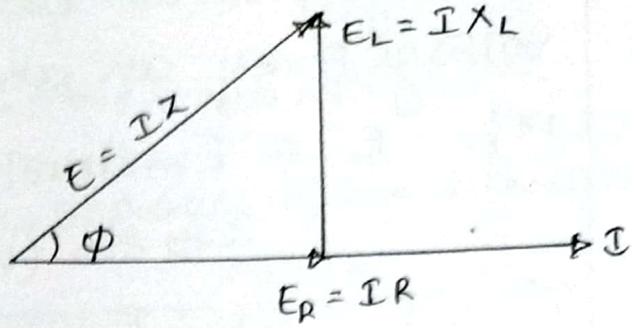
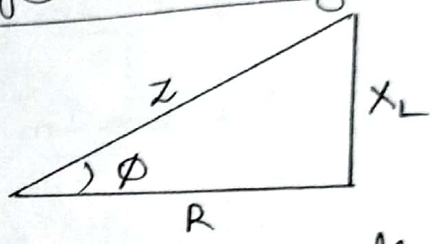


fig ① circuit diagram



fig② vector diagram.



fig③ Impedance ∆le.

fig ② shows the vector diagram where I is taken as the reference ($\because$ in series ckt I is same)

It consists of three voltages, $E_R = IR$ is in phase with the current

$E_L = IX_L$ leads the current by 90°.

$E = IZ$ vector sum of E_R & E_L.

from fig ②.

$$E = IZ$$

$$\therefore I = \frac{E}{Z} \quad \text{--- (1)}$$

from fig ③

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

where ϕ is the power factor angle ϕ is given by.

$$\tan\phi = \frac{X_L}{R} \quad \cancel{\phi} \quad \cancel{\phi} \neq \cancel{\tan}$$

$$\phi = \tan^{-1}\left(\frac{X_L}{R}\right) \quad \text{--- (3)}$$

from fig (2) it is clear that current I lags the voltage E by an angle ϕ.

ie; $e = E_m \sin \omega t$

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

$\therefore \; P = ei = E_m \sin\omega t \; I_m \sin(\omega t - \phi)$

$$P = \frac{E_m I_m}{2}\left[\cos\phi - \cos(2\omega t - \phi)\right]$$

$$P = \frac{E_m I_m}{2}\cos\phi - \frac{E_m I_m}{2}\cos(2\omega t - \phi) \quad \text{— (4)}$$

In eq^n (4) the second term is

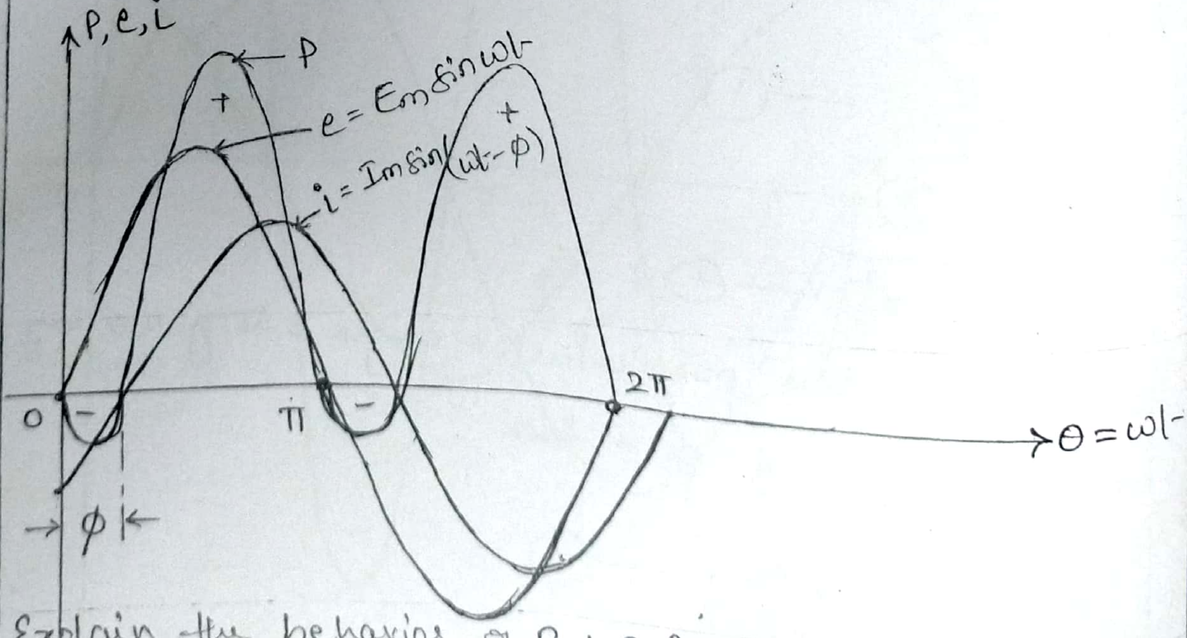
*) Periodically varying quantity.

*) Frequency is twice the supply frequency.

*) The average power over a period is zero.

$$\therefore \; P = \frac{E_m I_m}{2}\cos\phi = \frac{E_m}{\sqrt{2}}\,\frac{I_m}{\sqrt{2}}\cos\phi$$

$\boxed{P = EI\cos\phi}$ where $\cos\phi$ - Power factor.



Q) Explain the behavior of R-L Series circuit

or

Show that current lags behind the voltage in R-L series circuit.

5) R-C series circuit :-

Q57) Explain the behavior of R-C series circuit.

or

Show that current leads the voltage in R-C series circuit

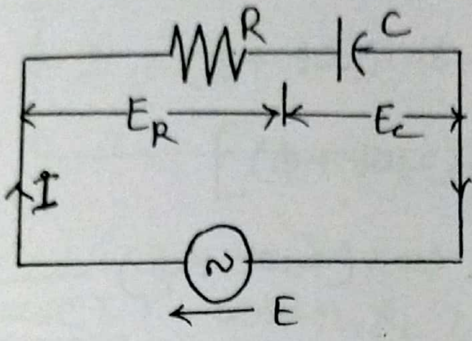


fig ① circuit diagram

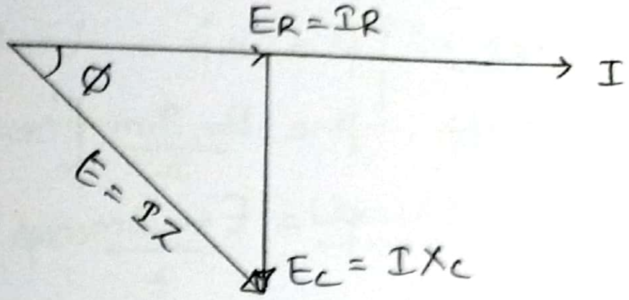


fig ② Vector diagram

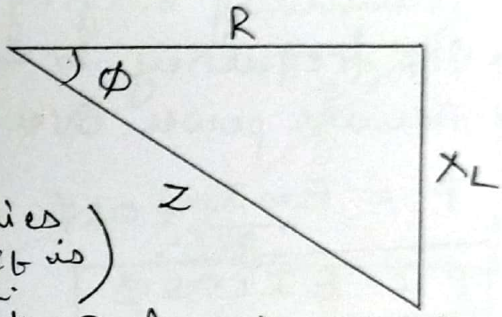


fig ③ Impedance triangle

Fig ② shows the vector diagram where I is taken as the reference (∵ In series ckt-ct is same.) It consists of three voltages, ~~E = IR~~

$E_R = IR$ is in phase with current

$E_C = IX_C$ lags the current by 90°

$E = IZ$ vector sum of E_R & E_C.

from fig ②

$$E = IZ \quad \& \quad I = \frac{E}{Z} \quad — ①$$

from fig ③

$$Z = \sqrt{R^2 + X_C^2} \quad — ②$$

where ϕ is the power factor angle is given by

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

$$\phi = \tan^{-1}\left(\frac{X_C}{R}\right) \quad — ③$$

From fig (2) it is clear that the current I leads the voltage E by an angle ϕ.

ie; $e = E_m \sin \omega t$

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

WKT :- $P = ei = E_m \sin \omega t \, I_m \sin(\omega t + \phi)$

$$P = \frac{E_m I_m}{2}\left[\cos\phi - \cos(2\omega t + \phi)\right]$$

$$P = \frac{E_m I_m \cos\phi}{2} - \frac{E_m I_m}{2}\cos(2\omega t + \phi) \quad \text{--- (4)}$$

In eqn (4) the second term is

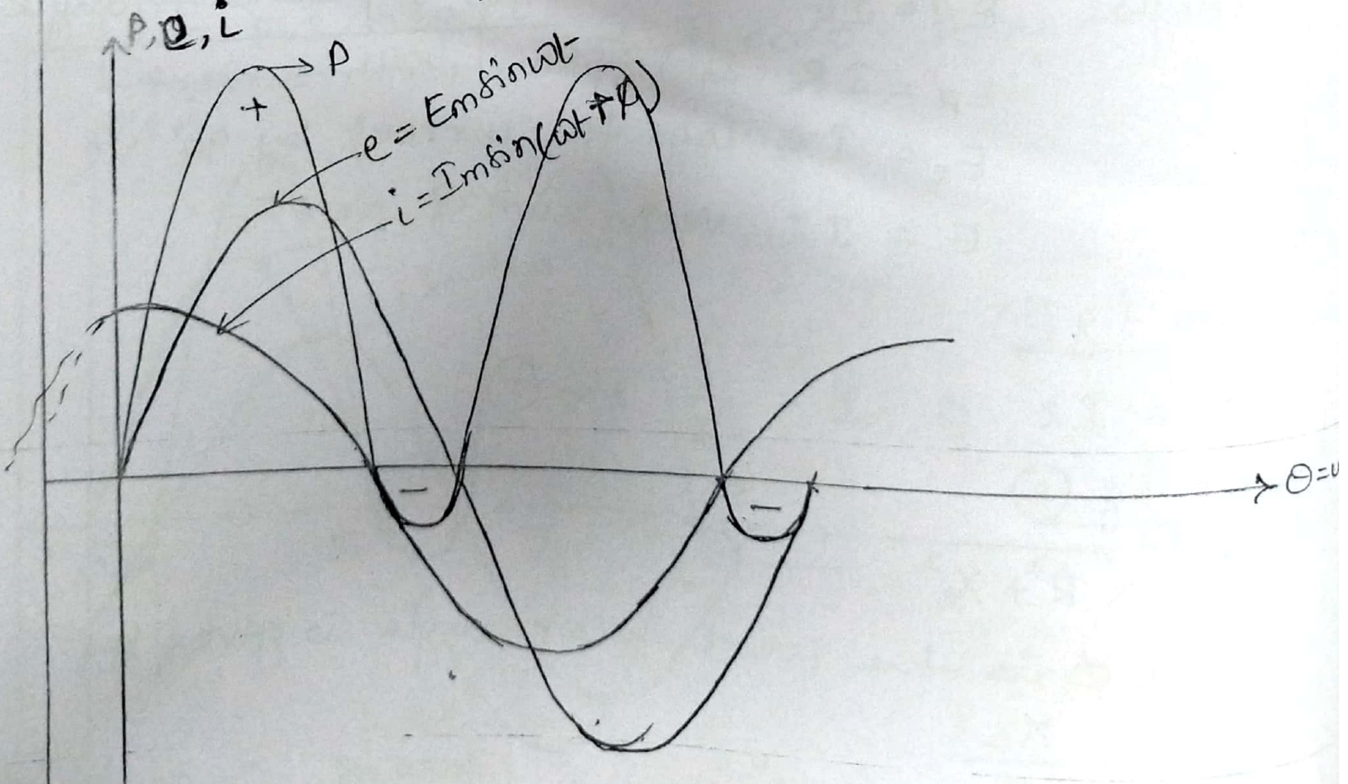
*> Periodically varying quantity.

*> It's frequency is twice the supply frequency

*> Average power over a period is zero.

$\therefore P = \frac{E_m I_m \cos\phi}{2} = \frac{E_m}{\sqrt{2}} \frac{I_m}{\sqrt{2}} \cos\phi$

$\boxed{P = EI\cos\phi}$ where $\cos\phi \rightarrow$ Power factor.



6> R-L-C Series circuit :- Q6> For a RLC series circuit discuss the nature of Power factor i> $X_L > X_C$

ii> $X_L < X_C$

iii> $X_L = X_C$.

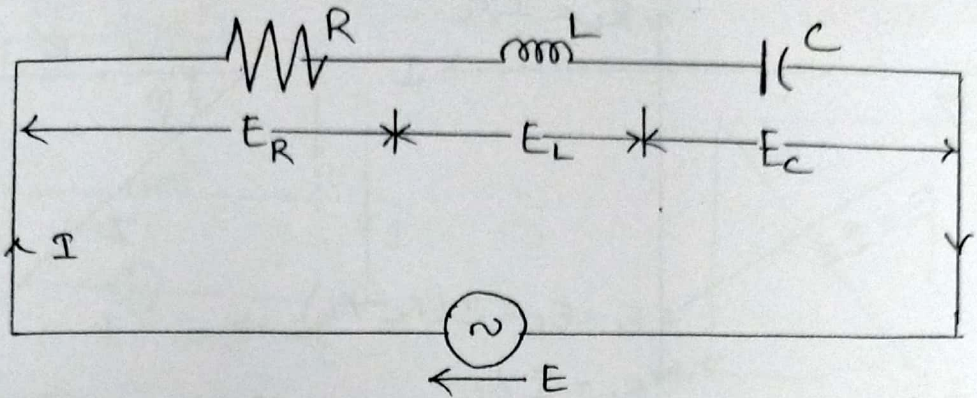


fig ① Circuit diagram.

Case 1 :- When $X_L > X_C$.

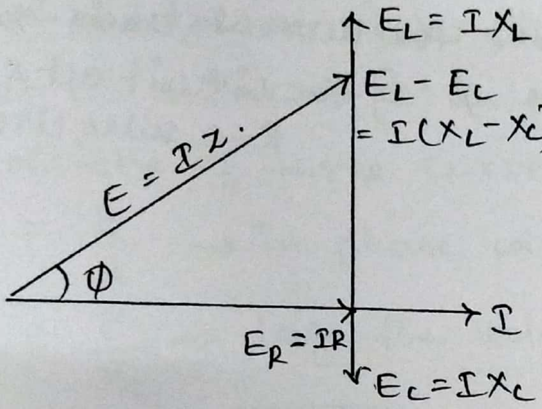


fig ② Vector diagram

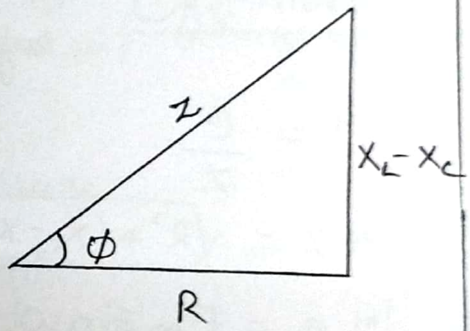


fig ③ Impedance Δ^{le}

from fig ② :→ It is clear that the current lags the voltage by an angle ϕ & circuit acts as R-L series circuit

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

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

If $e = E_m \sin \omega t$

then $i = I_m \sin(\omega t - \phi)$

$\therefore P = EI \cos\phi$.

Case 2 :- when $X_C > X_L$

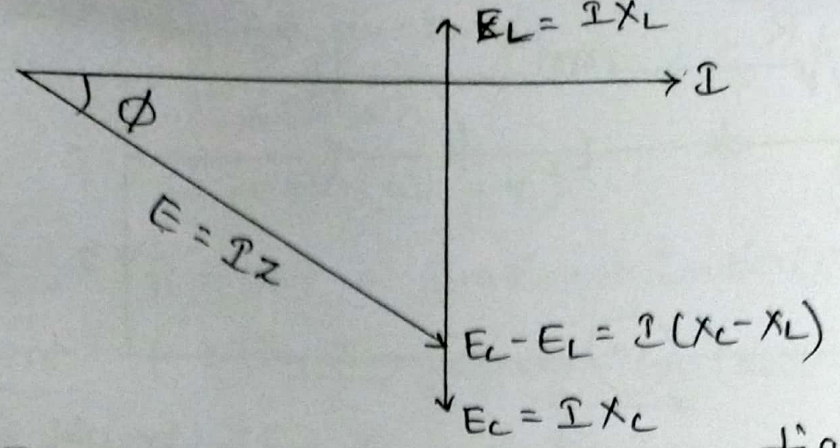


fig ④ vector diagram

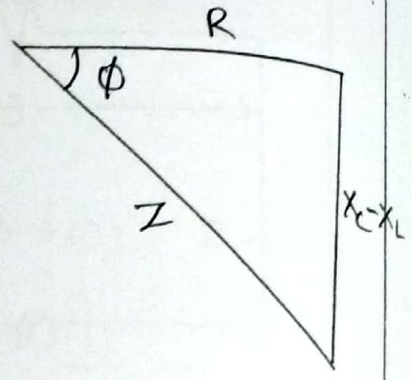


fig ⑤ Impedance Δ^{le}

from fig ②:- It is clear that the current leads the voltage by an angle ϕ & the circuit acts as R-C series circuit.

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

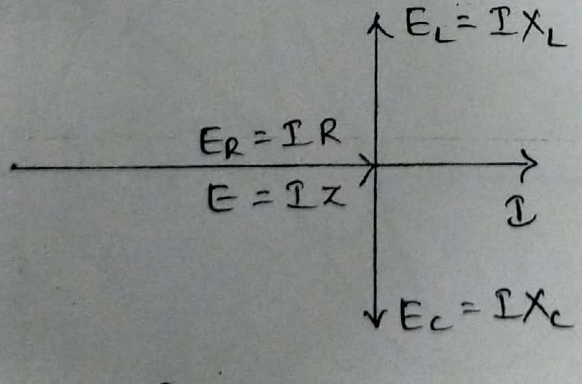
$$Z = \sqrt{R^2 + (X_C - X_L)^2}$$

If $e = E_m \sin \omega t$

then $i = I_m \sin(\omega t + \phi)$

$\therefore P = EI\cos\phi$

Case 3 :- when $X_L = X_C$



when $X_L = X_C$ then E_L & E_C cancel each other and the circuit acts as pure R-circuit hence current I is in phase with voltage E.

$\therefore Z = R$

$E_R = IR$

$E = IZ$

If $e = E_m \sin \omega t$ then $i = I_m \sin \omega t$

$\therefore P = EI$

8) Power and Power triangle

Q1) Draw the power triangle and Define i) Real power ii) Reactive power iii) Apparent Power.

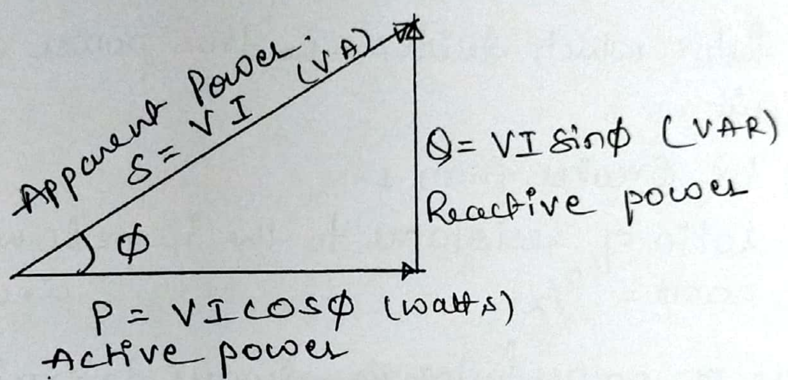
WKT $P = VI\cos\phi$ watts.

& $V = V_R + V_L$.

Multiply both sides by I

$\therefore VI = V_R I + V_L I = V\cos\phi I + V\sin\phi I$

from this equation the power triangle canbe obtained as:



i) Real power & Active power (P) :-

It is the product of applied voltage and the active component of the current.

ie; $P = VI\cos\phi$ watts.

ii) Reactive Power (Q) :-

It is the product of applied voltage and the reactive component of the current.

ie; $Q = VI\sin\phi$ VAR.

iii) Apparent power & Total power (S) :-

It is the product of the rms values of voltage and current.

ie; $S = VI$ VA.

9) Power factor :-

Q8) Define power factor and explain its significance in AC circuit.

It is the ratio of true power to apparent power.

$$\text{Power factor} = \frac{\text{True power}}{\text{Apparent power}} = \frac{VI\cos\phi}{VI} = \cos\phi$$

or It is the cosine angle between voltage and current.

Significance of power factor in a.c circuit :-

*) It is the factor which decides the true power consumption in the circuit.

*) It cannot be greater than 1.

*) It is the ratio of resistance to the impedance of the circuit.
ie; $\cos\phi = R/Z$.

*) The nature of powerfactor is always determined by position of current with respect to the voltage.

*) If current lags voltage then the power factor is said to be lagging and the inductive loads have the lagging power factor.

*) If current leads voltage then the power factor is said to be leading and the capacitive loads have the leading power factor.

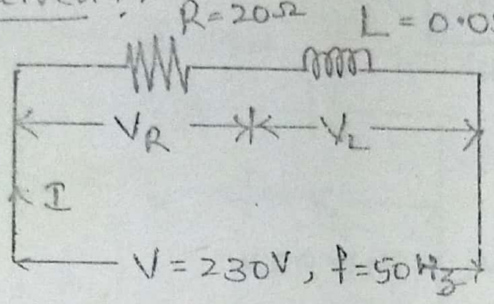
*) So, for pure inductance, the power factor is $\cos(90^\circ)=0$ ie; zero lagging. while for pure capacitance, the power factor is $\cos(90^\circ)=0$ but leading.

*) For a pure resistive circuit the voltage and current are in phase hence the power factor $\cos(0^\circ)=1$. ie; unity power factor.

Numericals of 1ϕ AC circuit :-

Ex ① A circuit consists of a resistance of 20Ω, an inductance of 0.05 H connected in series. A supply of 230V at 50 Hz is applied across the circuit. Find
i) Current ii) power factor iii) power consumed by the circuit
iv) Voltage drop across R & L v) Draw the vector diagram.

Sol^n :- Given :- $R = 20\Omega$ $L = 0.05H$



Find :- i) $I = ?$
ii) $P.f = \cos\phi = ?$
iii) $P = ?$
iv) V_R & $V_L = ?$

i) WKT :- $I = \dfrac{V}{Z}$ —— ①

WKT :- $Z = \sqrt{R^2 + X_L^2}$ —— ②

WKT :- $X_L = 2\pi f L = 2\pi \times 50 \times 0.05 = 15.7\,\Omega$

∴ ② ⇒ $Z = \sqrt{(20)^2 + (15.7)^2} = 25.42\,\Omega$

∴ ① ⇒ $I = \dfrac{230}{25.42} = 9.04\,A$

$$\boxed{I = 9.04\,A}$$

ii) WKT :- $P.f = \cos\phi = \dfrac{R}{Z} = \dfrac{20}{25.42} = 0.786$

$\boxed{P.f = \cos\phi = 0.786}$ (lagging)

iii) WKT :- $P = VI\cos\phi = 230 \times 9.04 \times 0.786$

$$\boxed{P = 1634.43 \text{ watts}}$$

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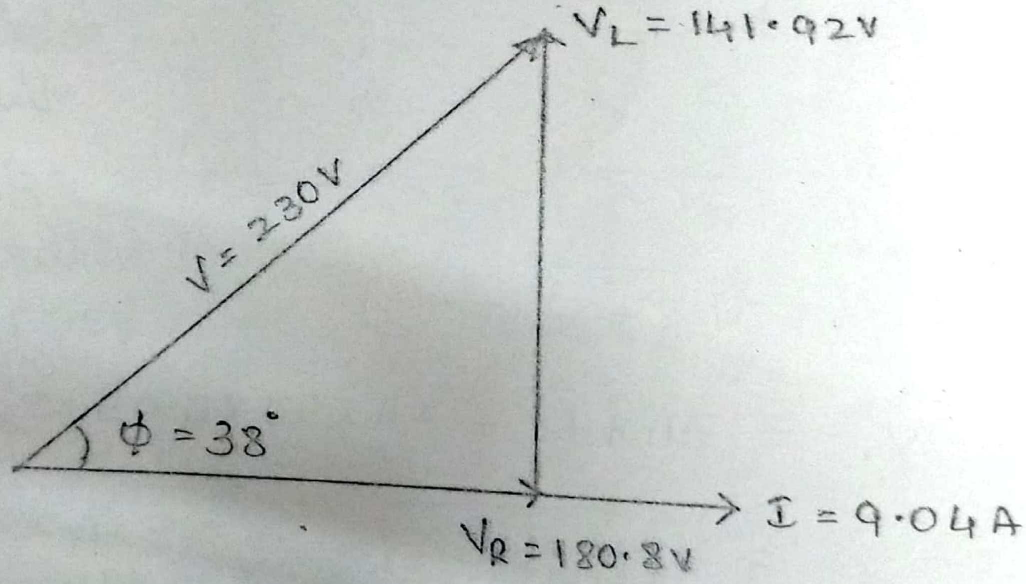
iv) WKT :- $V_R = IR = 9.04 \times 20 = 180.8\,V$

$$\boxed{V_R = 180.8 \text{ Volts}}$$

WKT :- $V_L = I X_L = 9.04 \times 15.7 = 141.92\,V$

$$\boxed{V_L = 141.92 \text{ Volts.}}$$

v) Phasor / Vector diagram



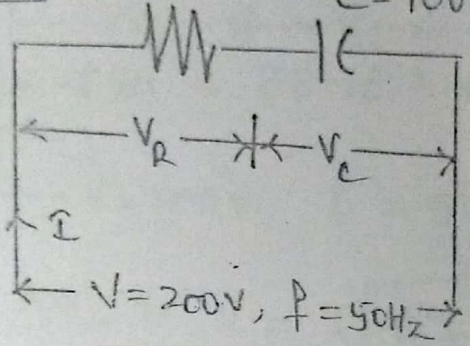
WKT :- $\cos\phi = 0.786$

$\phi = \cos^{-1}(0.786)$

$\phi = 38°$

Ex ② A circuit consists of a resistance of 25 Ω and a capacitance of 100 μF connected in series. A supply of 200 V, 50 Hz is applied across the circuit. Find i) Impedance ii) Current iii) power factor iv) power v) Voltage drop across R & C vi) Vector diagram.

Sol^n:- Given:- $R = 25\,\Omega$ $\quad C = 100\times10^{-6}\,F$



Find:-
i) $Z = ?$
ii) $I = ?$
iii) $P.f = \cos\phi = ?$
iv) $P = ?$
v) V_R & $V_C = ?$

i) WKT:- $Z = \sqrt{R^2 + X_c^2}$ — ①

WKT:- $X_c = \dfrac{1}{2\pi f C} = \dfrac{1}{2\pi \times 50 \times 100\times10^{-6}} = \dfrac{10^6}{100\pi \times 100}$

$X_c = 31.85\,\Omega$

∴ ① ⇒ $Z = \sqrt{(25)^2 + (31.85)^2} = 40.48\,\Omega$

$$\boxed{Z = 40.48\,\Omega}$$

ii) WKT:- $I = \dfrac{V}{Z} = \dfrac{200}{40.48} = 4.94\,A$

$$\boxed{I = 4.94\,A}$$

iii) WKT:- $P.f = \cos\phi = \dfrac{R}{Z} = \dfrac{25}{40.48} = 0.617$ leading

$$\boxed{P.f = \cos\phi = 0.617 \text{ leading}}$$

iv) WKT :- $P = VI\cos\phi = 200 \times 4.94 \times 0.617$

$$\boxed{P = 609.59 \text{ watts}}$$

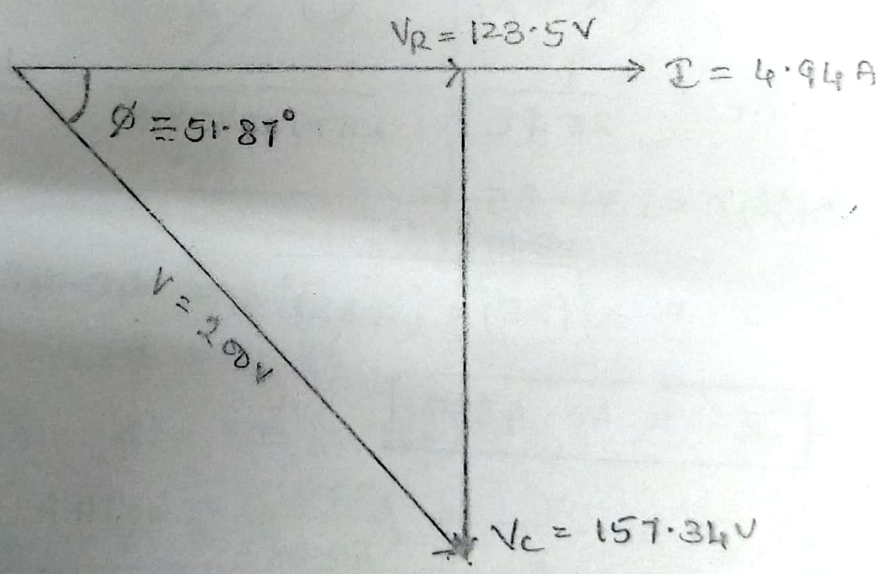
v) WKT :- $V_R = IR = 4.94 \times 25 = 123.5\,V$

$$\boxed{V_R = 123.5\,V}$$

WKT :- $V_c = I X_c = 4.94 \times 31.85 = 157.34\,V$

$$\boxed{V_c = 157.34\,V}$$

vi) Phasor diagram :-



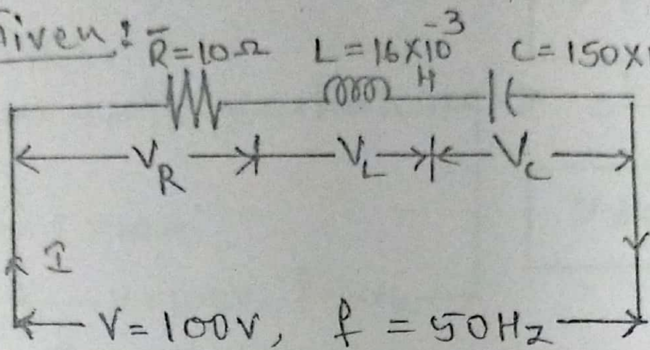
WKT :- $\cos\phi = 0.617$

$\therefore \phi = \cos^{-1}(0.617)$

$\phi = 51.87^\circ$

Ex ③ A circuit consists of a resistance of 10Ω an inductance of $16mH$ & a capacitance of $150\mu F$ connected in series. A supply of $100V$ at $50Hz$ is given to the circuit. Find
i) Impedance ii) Current iii) power factor iv) power
v) Voltage drop across R, L & C vi) Draw phasor diagram

Solⁿ :- Given :



find :- i) $Z = ?$
ii) $I = ?$
iii) $P.f = \cos\phi = ?$
iv) $P = ?$
v) V_R, V_L & $V_C = ?$

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

$\therefore$ WKT :- $X_L = 2\pi f L = 2\pi \times 50 \times 16 \times 10^{-3} = 5.024\Omega$

WKT :- $X_C = \dfrac{1}{2\pi f C} = \dfrac{1}{2\pi \times 50 \times 150 \times 10^{-6}} = 21.23\Omega$

ie; $X_C > X_L$

$\therefore$ $Z = \sqrt{R^2 + (X_C - X_L)^2} = \sqrt{10^2 + (21.23 - 5.024)^2}$

$$\boxed{Z = 19.04\Omega}$$

ii) WKT :- $I = \dfrac{V}{Z} = \dfrac{100}{19.04} = 5.25A$

$$\boxed{I = 5.25A}$$

iii) WKT :- $P.f = \cos\phi = \dfrac{R}{Z} = \dfrac{10}{19.04} = 0.525$

$$\boxed{P.f = 0.525 \text{ (leading)}}$$

iv) WKT :- $P = VI\cos\phi = 100 \times 5.25 \times 0.525$

$$\boxed{P = 275.625 \text{ watts}}$$

v) WKT :- $V_R = IR = 5.25 \times 10 = 52.5\ V$

WKT :- $\boxed{V_R = 52.5\ V}$

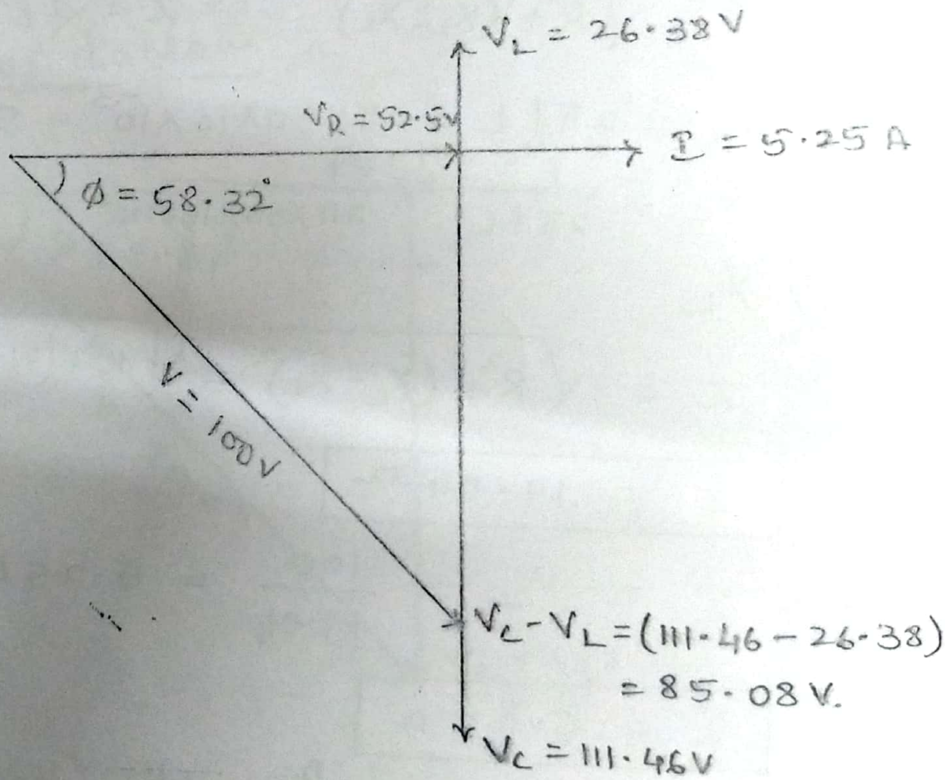
WKT :- $V_L = IX_L = 5.25 \times 5.024 = 26.38\ V$

$\boxed{V_L = 26.38\ V}$

WKT :- $V_C = IX_C = 5.25 \times 21.23 = 111.46\ V$

$\boxed{V_C = 111.46\ V}$

vi) Phasor diagram :-



WKT :- $\cos\phi = 0.525$

$\therefore\ \phi = \cos^{-1}(0.525)$

$\phi = 58.32^{\circ}$

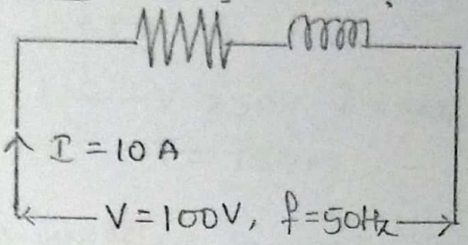
Ex (4) An inductive coil takes a current of 10 A from a supply of 100V, 50Hz and it lags the voltage by 30°. Calculate

i) parameters of the circuit.

ii) Power factor

iii) Active power, reactive power and apparent power.

Sol^n:- Given:- $R = ?$ $\quad L = ?$



$\phi = 30°$

Find:- i) $R \& L = ?$

ii) $P.f = \cos\phi = ?$

iii) $P = ?, Q = ? \& S = ?$

i) WKT:- $Z = \frac{V}{I} = \frac{100}{10} = 10\Omega$

WKT:- $R = Z\cos\phi = 10\cos(30) = 8.66\Omega$

$$\boxed{R = 8.66\Omega}$$

WKT:- $X_L = Z\sin\phi = 10\sin(30) = 5\Omega$

WKT:- $X_L = 2\pi f L$

WKT:- $L = \frac{X_L}{2\pi f} = \frac{5}{2\pi \times 50} = 0.0159 H$

$$\boxed{L = 0.0159 H}$$

ii) WKT:- $P.f = \cos\phi = \cos(30°) = 0.866$

$$\boxed{P.f = 0.866 \text{ lagging}}$$

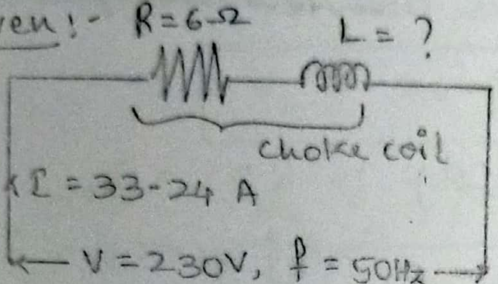
iii) Active power $P = VI\cos\phi = 100 \times 10 \times 0.866 = \boxed{866 \text{ watts}}$

Reactive power $Q = VI\sin\phi = 100 \times 10 \times 0.5 = \boxed{500 \text{ VAR}}$

Apparent Power $S = VI = 100 \times 10 = \boxed{1000 \text{ VA}}$

(5) An inductive coil takes a current of 33.24 A from 230V, 50Hz supply. If the resistance of the coil is 6Ω, calculate the inductance of the coil and the power taken by the coil.

Sol: Given :-



find :- i) L = ?
ii) P = ?

i) WKT $X_L = 2\pi f L$

$\therefore L = \dfrac{X_L}{2\pi f}$ —— (1)

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

$\therefore X_L = \sqrt{Z^2 - R^2}$ —— (2)

WKT :- $Z = \dfrac{V}{I} = \dfrac{230}{33.24} = 6.92\,\Omega$

$\therefore$ (2) $\Rightarrow X_L = \sqrt{(6.92)^2 - (6)^2} = 3.45\,\Omega$

(1) $\Rightarrow L = \dfrac{3.45}{2\pi \times 50} = 0.01098\,H$

$$\boxed{L = 0.01098\,H}$$

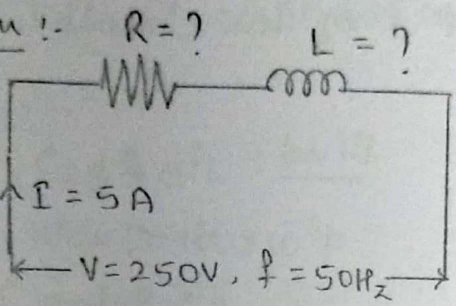
ii) WKT :- $P = I^2 R = (33.24)^2 \times 6$

$$\boxed{P = 6629.38 \text{ watts}}$$

Note :- In a choke coil ie; R-L series circuit only the R component ie; Resistance consumes the power hence $P = I^2 R$

Ex ⑥ An inductive coil is connected to supply of 250V at 50Hz and takes a current of 5A. The coil dissipates 750w Calculate power factor, resistance and inductance of the coil.

Soln. Given :-



P = 750 w

Find :- i) R = ?
ii) L = ?
iii) P.f = ?

i) WKT :- $P = I^2 R$

$$\therefore R = \frac{P}{I^2} = \frac{750}{(5)^2} = 30\Omega$$

$$\boxed{R = 30\Omega}$$

ii) WKT :- $X_L = 2\pi f L$

$$L = \frac{X_L}{2\pi f} \quad \text{--- (1)}$$

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

$$\therefore X_L = \sqrt{Z^2 - R^2} \quad \text{--- (2)}$$

WKT :- $Z = \frac{V}{I} = \frac{250}{5} = 50\Omega$

$$\therefore (2) \Rightarrow X_L = \sqrt{(50)^2 - (30)^2} = 40\Omega$$

$$\therefore (1) \Rightarrow L = \frac{40}{2\pi \times 50} = 127.32 \times 10^{-3} H$$

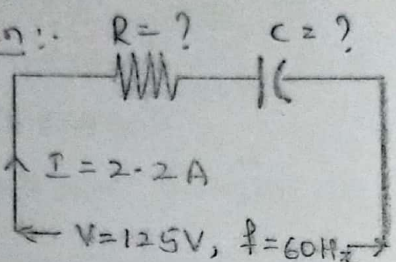
$$\boxed{L = 127.32 mH}$$

iii) WKT :- $P.f = \cos\phi = \frac{R}{Z} = \frac{30}{50} = 0.6$

$$\boxed{P.f = 0.6 \text{ lagging}}$$

Ex (7) A 125V, 60Hz is applied across a capacitance connected in series with a non-inductive resistor. The combination carries a current of 2.2 A and consumes a power of 96.8 watts. Calculate the R & C of the circuit and P.f of the circuit.

Sol: Given :-



P = 96.8 W

Find :- i) R = ?
ii) C = ?
iii) P.f = ?

i) WKT :- $P = I^2 R$

$\therefore R = \frac{P}{I^2} = \frac{96.8}{(2.2)^2} = 20\Omega$

$\boxed{R = 20\Omega}$

ii) WKT :- $X_c = \frac{1}{2\pi f C}$

$\therefore C = \frac{1}{2\pi f X_c}$ —— (1)

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

$\therefore X_c = \sqrt{Z^2 - R^2}$ —— (2)

WKT :- $Z = \frac{V}{I} = \frac{125}{2.2} = 56.81\Omega$

$\therefore$ (2) $\Rightarrow X_c = \sqrt{(56.81)^2 - (20)^2} = 53.18\Omega$

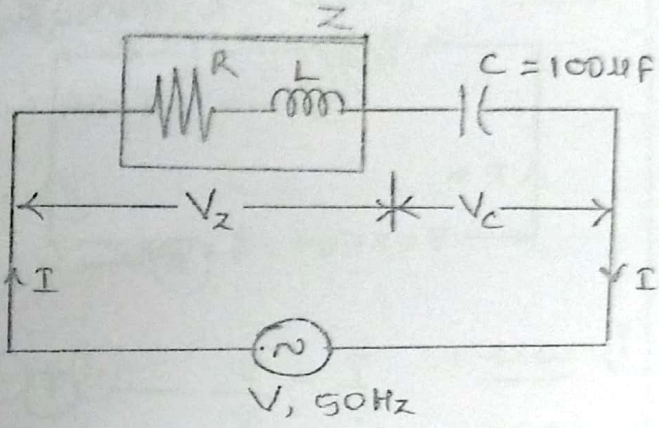
(1) $\Rightarrow C = \frac{1}{2\pi \times 60 \times 53.18} = 4.98 \times 10^{-5}$ F

$\boxed{C = 49.8\,\mu F \simeq 50\,\mu F}$

iii) WKT :- $P.f = \cos\phi = \frac{R}{Z} = \frac{20}{56.81} = \boxed{0.352 \text{ leading}}$

Ex (8) A coil of power factor 0.6 is in series with a 100µF capacitor. When connected to a 50Hz supply, the Potential difference across the coil is equal to the potential difference across the capacitor. Find the resistance and inductance of the coil.

Sol^n:- Given:-



$P.f = \cos\phi = 0.6$

$C = 100\mu F = 100\times10^{-6}F$

$f = 50Hz$

$V_Z = V_C$

Find:- R & L = ?

Given that $V_Z = V_C$

$$\cancel{I}Z = \cancel{I}X_C$$

$$Z = X_C = \frac{1}{2\pi f C} = \frac{1}{2\pi\times50\times100\times10^{-6}}$$

$$Z = 31.83\,\Omega$$

WKT:- $R = Z\cos\phi = 31.83\times0.6 = 19.098\,\Omega$

$$\boxed{R = 19.098\,\Omega}$$

WKT:- $X_L = Z\sin\phi = 31.83\sin[\cos^{-1}(0.6)] = 25.46\,\Omega$

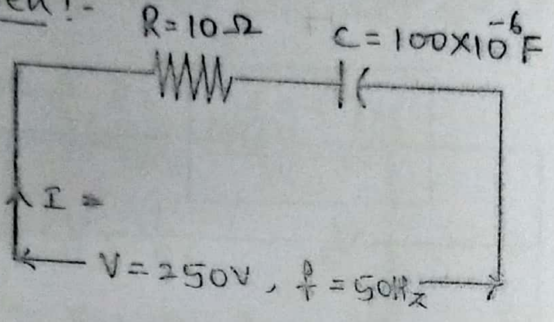
WKT:- $X_L = 2\pi f L$

$$\therefore L = \frac{X_L}{2\pi f} = \frac{25.46}{2\pi\times50} = 0.081\,H$$

$$\boxed{L = 0.081\,H}$$

Ex (9) A non-inductive resistor of 10Ω is in series with a capacitor of 100μF across a 250V/50Hz supply. Determine the current taken by the capacitor and power factor of the circuit.

Sol^n:- Given:-



Find:- i) $I = ?$

ii) $P.f = \cos\phi = ?$

i) WKT:- $I = \dfrac{V}{Z}$ —— (1)

WKT:- $Z = \sqrt{R^2 + X_c^2}$ —— (2)

WKT:- $X_c = \dfrac{1}{2\pi f C} = \dfrac{10^6}{2\pi \times 50 \times 100} = 31.83\,\Omega$

∴ (2) ⇒ $Z = \sqrt{(10)^2 + (31.83)^2} = 33.36\,\Omega$

∴ (1) ⇒ $I = \dfrac{250}{33.36} = 7.493\ A$

$\boxed{I = 7.49\ A}$

ii) WKT:- $P.f = \cos\phi = \dfrac{R}{Z} = \dfrac{10}{33.36} = 0.299 \approx 0.3$

$\boxed{P.f = \cos\phi = 0.3 \text{ leading}}$

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Ex (10) Given $v = 200\sin 377t$ volts and $i = 8\sin(377t - 30^\circ)$ Amps for an a.c circuit. determine.
i) Power factor ii) True power iii) Apparent power iv) Reactive power. Indicate the unit of power calculated.

Sol^n:- Given :- $v = (200\sin 377t)$ volts —— (1)

$i = 8\sin(377t - 30^\circ)$ Amps —— (2)

WKT :- $v = V_m \sin\omega t$ —— (3)

$i = I_m \sin(\omega t - \phi)$ —— (4)

compare (1) & (3) and (2) & (4).

we get $V_m = 200\,V$, $I_m = 8\,A$, $\phi = 30^\circ$ & $\omega = 377$.

WKT :- $V = \dfrac{V_m}{\sqrt{2}} = \dfrac{200}{\sqrt{2}} = 141.42$ Volts.

WKT :- $I = \dfrac{I_m}{\sqrt{2}} = \dfrac{8}{\sqrt{2}} = 5.656$ Amps.

WKT :- $\omega = 2\pi f = 377$

$\therefore f = \dfrac{377}{2\pi} = 60\,Hz$

i) WKT $p.f = \cos\phi = \cos(-30) = 0.866$

$$\boxed{p.f = 0.866 \text{ (lagging)}}$$

ii) WKT $P = VI\cos\phi = 141.42 \times 5.656 \times 0.866$

$$\boxed{P = 692.8 \text{ watts}}$$

iii) WKT $S = VI = 141.42 \times 5.656$

$$\boxed{S = 799.87\ VA}$$

iv) WKT $Q = VI\sin\phi = 141.42 \times 5.656 \times \sin(30^\circ)$

$$\boxed{Q = 399.93\ VAR \simeq 400\,VAR}$$

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Ex (11) An emf whose instantaneous value is $100\sin(314t - \pi/2)$ V is applied to a circuit and the current flowing through it is $20\sin(314t - 1.5708)$ A. Find the frequency and the values of circuit elements assuming series combination of circuit elements.

Soln:- Given :- $v = 100\sin(314t - \pi/2)\,V = 100\sin(314t - 45°)\,V$ — (1)

$i = 20\sin(314t - 1.5708)\,A = 20\sin(314t - 90°)\,A$ — (2)

WKT :- $v = V_m\sin(\omega t - \phi_1)$ — (3)

& $i = I_m\sin(\omega t - \phi_2)$ — (4)

Note :- π rad — $180°$

1.5708 rad — ?

$\therefore \frac{1.5708 \times 180}{\pi} = 90°$

Compare (1) with (3) & (2) with (4)

we get $V_m = 100\,V$, $I_m = 20\,A$, & $\phi = \phi_1 - \phi_2 = -45 - (-90°)$

$\phi = 45°$.

i) WKT :- $\omega = 2\pi f = 314$

$\therefore f = \frac{314}{2\pi}$ ~~$\frac{314}{4}$~~

$\boxed{f = 50\,Hz}$.

ii) WKT :- $V = \frac{V_m}{\sqrt{2}} = \frac{100}{\sqrt{2}} = 70.71\,V = 70.71\angle -45°$

WKT :- $I = \frac{I_m}{\sqrt{2}} = \frac{20}{\sqrt{2}} = 14.142\,A = 14.142\angle -90°$

WKT :- $Z = \frac{V}{I} = \frac{70.71\angle -45°}{14.142\angle -90°} = 5\angle -45° + 90°$

$Z = 5\angle 45°\,\Omega = 3.5355 + j3.5355\,\Omega$ — (5).

WKT :- $Z = R + jX_L$ — (6)

Compare (5) & (6) $\therefore$ $\boxed{R = 3.5355\,\Omega}$

& $X_L = 3.5355\,\Omega = 2\pi f L$.

$\therefore L = \frac{X_L}{2\pi f} = \frac{3.5355}{2\pi \times 50}$

$\boxed{L = 11.25\,H}$

Ex Q 12) An ac voltage of $100\sin(314t+60^\circ)$ V is applied to a circuit which carries a current of $20\sin(314t+30^\circ)$ A. Calculate i) rms values of voltage and current. ii) Impedance iii) Power factor iv) Active, reactive & apparent power.

Soln:- Given:-

$$v = 100\sin(314t+60^\circ)\,v \quad \text{--- (1)}$$
$$i = 20\sin(314t+30^\circ)\,A \quad \text{--- (2)}$$

Find:- i) $V_{rms} = V = ?$ iii) $p.f = \cos\phi = ?$

ii) $Z = ?$ i) $I_{rms} = I = ?$ iv) P, Q & $S = ?$

WKT:-
$$v = V_m \sin(\omega t+\phi_1)\,v \quad \text{--- (3)}$$
$$i = I_m \sin(\omega t+\phi_2)\,A \quad \text{--- (4)}$$

Compare (1) & (3) and (2) & (4).

we get:- $V_m = 100V$, $I_m = 20A$, $\omega = 314 = 2\pi f$.

$$\therefore f = \frac{314}{2\pi} = 50Hz.$$

i) WKT:- $V_{rms} = V = \frac{V_m}{\sqrt{2}} = \frac{100}{\sqrt{2}} = 70.71v$

$$\boxed{V = 70.71v} \quad \text{or} \quad V = 70.71\angle 60^\circ$$

WKT:- $I_{rms} = I = \frac{I_m}{\sqrt{2}} = \frac{20}{\sqrt{2}} = 14.14A$

$$\boxed{I = 14.14A} \quad \text{or} \quad I = 14.14\angle 30^\circ$$

ii) WKT:- $Z = \frac{V}{I} = \frac{70.71\angle 60^\circ}{14.14\angle 30^\circ} = 5\angle 30^\circ\,\Omega$

$$\boxed{Z = 5\angle 30^\circ\,\Omega} = 4.33 + j2.5\,\Omega \quad \text{--- (5)}$$

WKT:-
$$Z = R + jX_L \quad \text{--- (6)}$$

Compare (5) & (6) we get

$$\boxed{R = 4.33\,\Omega}$$

$X_L = 2.5\,\Omega$

<u>WKT</u> :- $X_L = 2\pi f L$

$\therefore \quad L = \dfrac{X_L}{2\pi f} = \dfrac{2.5}{2\pi \times 50} = 7.95 \times 10^{-3}\,H$

$$\boxed{L = 7.95\,mH}$$

iv) P.f. <u>WKT</u> :- $P.f = \cos\phi = \dfrac{R}{Z} = \dfrac{4.33}{5} = 0.866$ lagging

or <u>WKT</u> :- $\boxed{P.f = \cos \angle 30^\circ = 0.866 \text{ lagging}}$

v) <u>WKT</u> :- $P = VI\cos\phi = 70.71 \times 14.14 \times 0.866$

$$\boxed{P = 865.86 \text{ watts}}$$

<u>WKT</u> :- $Q = VI\sin\phi = 70.71 \times 14.14 \times \sin(30^\circ)$

$$\boxed{Q = 499.91\ VAR \approx 500\,VAR}$$

<u>WKT</u> :- $S = VI = 70.71 \times 14.14$

$$\boxed{S = 999.839\ VA \approx 1000\ VA}$$

Ex (13) A single phase AC series circuit has an emf of $100\cos(314t - 60^\circ)V$ and current of $20\sin(314t - 0.5)A$. Find the parameters of the circuit.

Sol?: Given :- $v = 100\cos(314t - 60^\circ)V$ & $i = 20\sin(314t - 0.5)A$

WKT :- $v = 100\sin(314t - 60^\circ + 90^\circ)V = 100\sin(314t + 30^\circ)V$ — (1)

WKT :- $i = 20\sin(314t - 28.647^\circ)A$ — (2)

WKT :- $v = V_m\sin(\omega t + \phi_1)$ — (3)

& $i = I_m\sin(\omega t - \phi_2)$ — (4)

Note :- π rad $= 180^\circ$
∴ 0.5 rad = ?
$= \frac{0.5 \times 180}{\pi} = 28.647^\circ$

compare (1) & (2) and (3) & (4)

we get :- $V_m = 100V$, $I_m = 20A$, $\omega = 314 = 2\pi f$

$\therefore f = \frac{314}{2\pi} = 50Hz$.

Parameters of the circuit :-

WKT :- $I_{rms} = \frac{I_m}{\sqrt{2}} = \frac{20}{\sqrt{2}} = 14.14A$

WKT :- $V_{rms} = \frac{V_m}{\sqrt{2}} = \frac{100}{\sqrt{2}} = 70.71V$.

but C/t and V/t can be written in polar form.

ie; $I = 14.14\angle -28.647 \, A$ & $V = 70.71\angle 30^\circ \, V$.

WKT :- $Z = \frac{V}{I} = \frac{70.71\angle 30}{14.14\angle -28.647} = 5\angle 30 + 28.647$

$Z = 5\angle 58.647^\circ \, \Omega = 2.6 + j4.269\Omega$ — (5)

WKT :- $Z = R + jX_L$ — (6)

compare (5) & (6) we get.

$R = 2.6\Omega$ & $X_L = 4.269\Omega$

WKT :- $X_L = 2\pi f L$

$$L = \frac{X_L}{2\pi f} = \frac{4.269}{2\pi \times 50} = 0.0135\,H$$

$L = 0.0135\,H$.

$\therefore$ the parameters of the circuit are

$$\boxed{\begin{aligned} R &= 2.6\,\Omega \\ \& \quad L &= 0.0135\,H \end{aligned}}$$

Ex (14) A single phase voltage of $(160+j120)$ V is applied across a circuit which carries a current of $(6+j8)$ A. Draw the vector diagram and find.

i) The elements of the circuit when the frequency is 50Hz.

ii) power factor of the circuit.

iii) Power consumed by the circuit.

Soln:- Given :- $V = (160+j120)\,V = 200\angle 36.86\,V$

$I = (6+j8)\,A = 10\angle 53.13\,A$.

i) Elements of the ckt

wkt :- $Z = \dfrac{V}{I} = \dfrac{200\angle 36.86}{10\angle 53.13} = 20\angle 36.86-53.13$

$Z = 20\angle -16.27 = 19.19 - j5.6\,\Omega$ —— (1)

wkt :- $Z = R - jX_C$ —— (2)

compare (1) & (2) we get.

$$\boxed{R = 19.19\,\Omega}$$

& $X_C = 5.6\,\Omega$

wkt :- $X_C = \dfrac{1}{2\pi f C}$

$\therefore\ C = \dfrac{1}{2\pi f X_C} = \dfrac{1}{2\pi \times 50 \times 5.6} = 5.68\times 10^{-4} F$

$$\boxed{C = 568\,\mu F.}$$

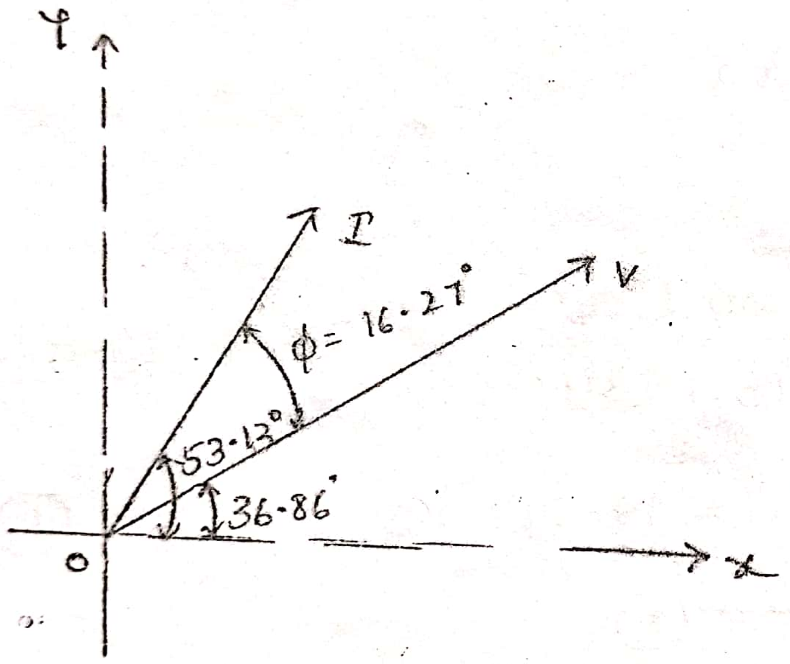
ii) w.k.t :- $p.f = \cos\phi = \frac{R}{Z} = \frac{19.19}{20} = 0.9595$ leading

or $p.f = \cos\phi = \cos(-16.27) = \boxed{0.9595 \text{ leading}}$

iii) w.k.t :- $P = VI\cos\phi = 200 \times 10 \times 0.9595$

$\boxed{P = 1919.9 \text{ watts}}$

Vector diagram :-



Ex (15) An voltage of $(40-j30)V$ is applied to a circuit which caries a current of $(3-j3)A$. Draw the vector diagram and find.

i) The elements of the circuit when the frequency is 50Hz

ii) power factor iii) power.

Sol. Given :- $V = (40-j30)V = 50\angle{-36.869^\circ}\,V$.

$I = (3-j3)A = 4.242\angle{-45^\circ}\,A$.

i) Parameters of the circuit :-

WKT :- $Z = \dfrac{V}{I} = \dfrac{50\angle{-36.869}}{4.242\angle{-45}} = 11.786\angle{-36.869+45}$

$Z = 11.786\angle{8.131}\,\Omega = (11.667 + j1.666)\,\Omega$ —— (1)

WKT :- $Z = R + jX_L$ —— (2)

Compare (1) & (2) we get

$\boxed{R = 11.667\,\Omega}$

$X_L = 1.666\,\Omega$

WKT :- $X_L = 2\pi f L$

$L = \dfrac{X_L}{2\pi f} = \dfrac{1.666}{2\pi \times 50} = 5.3 \times 10^{-3}\,H$

$\boxed{L = 5.3\,mH}$.

ii) ~~Pow~~ WKT :- $p.f = \cos\phi = \dfrac{R}{Z} = \dfrac{11.667}{11.786} = 0.9899$

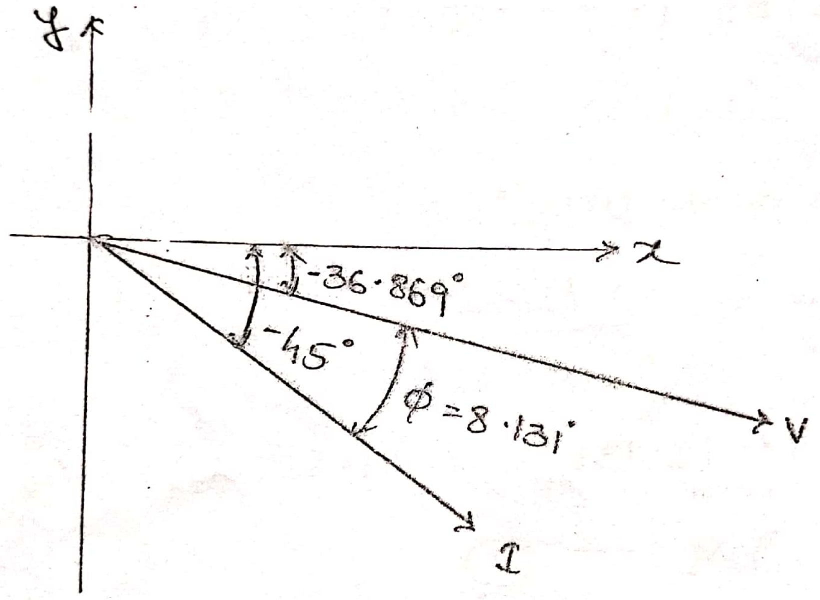
$\boxed{p.f = 0.9899 \text{ lagging}}$.

or $p.f = \cos(8.131) = 0.9899$ lagging.

iii) work :- $P = VI\cos\phi = 50 \times 4.242 \times 0.9899 = 209.9W$

$$\boxed{P = 210 \text{ watts}}$$

iv). Vector diagram :-

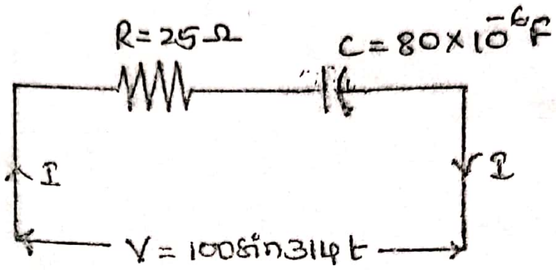


Question papers Numericals of 1ϕ AC circuits.

Q 1) A voltage $V = 100\sin 314t$ is applied to a circuit consisting of 25Ω resistor and $80\mu F$ capacitor in series. Determine i) Peak value of current ii) power factor iii) Total power consumed by the circuit.

Dec/Jan 2015 (8 marks)

Sol^{n}: Given :-



Find :-

i) $I_m = ?$

ii) $P.f = ?$

iii) $P = ?$

Given that :- $V = 100\sin 314t$ —— (1)

wkt :- $V = V_m \sin \omega t$ —— (2)

Compare (1) & (2)

$\Rightarrow V_m = 100\,V$

$\Rightarrow V_{rms} = V = \frac{V_m}{\sqrt{2}} = \frac{100}{\sqrt{2}} = 70.71\,V$

$\Rightarrow \omega = 2\pi f = 314$

$f = \frac{314}{2\pi} = 50\,Hz$

$\Rightarrow X_c = \frac{1}{2\pi f C} = \frac{10^6}{2\pi \times 50 \times 80}$

$X_c = 39.788\,\Omega$

$\Rightarrow Z = \sqrt{R^2 + X_c^2} = \sqrt{(25)^2 + (39.788)^2} = 46.99\,\Omega$

i) wkt :- $I_m = \frac{V_m}{Z} = \frac{100}{46.99} = 2.128\,A$

$$\boxed{I_m = 2.128\,A}$$

wkt :- $I = \frac{V}{Z} = \frac{70.71}{46.99} = 1.5..\,A$

or $I = I_m/\sqrt{2} = 2.12/\sqrt{2} = 1.5..\,A$

ii) wkt :- $P.f = \cos\phi = R/Z = 25/46.99 = 0.532$

$$\boxed{P.f = 0.532 \text{ leading}}$$

iii) wkt :- $P = VI\cos\phi = 70.71 \times 1.5.. \times 0.532$

$$\boxed{P = 56.426 \text{ watts}}$$

Q.2) Also find voltage across the capacitor when current is half of its maximum value (June/July 2018)(8 marks)

Sol: WKT $I_m = \frac{V_m}{Z} = \frac{100}{46.99} = 2.128\ A$

$I = \frac{1}{2} \times I_m$ (ie; half of Max current)

$I = \frac{2.128}{2} = 1.064\ A$

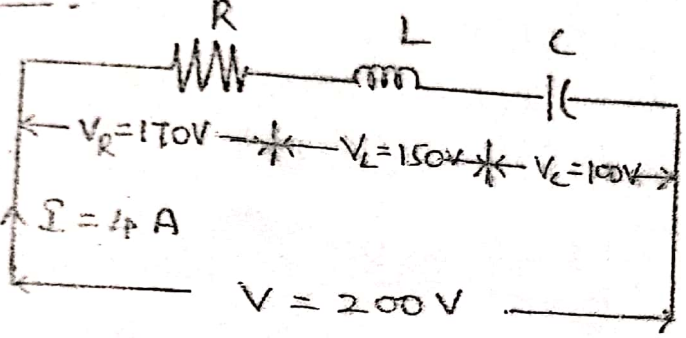
WKT:- $V_c = I X_c = 1.064 \times 39.788$

$$\boxed{V_c = 42.33\ V}$$

(3) A voltage of 200V is applied to a series circuit consisting of a resistor, an inductor and capacitor. The respective voltages across these components are 170V, 150V & 100V and the current is 4A. Find: i) power factor ii) resistance iii) Impedance iv) inductive reactance & capacitive reactance

Dec2014/2015 (8 marks)

Given :-



Find :-
i) P.f ii) R iii) Z
iv) X_L v) X_C

iii) wkt :- $Z = \frac{V}{I} = \frac{200}{4} = 50\Omega$

$$\boxed{Z = 50\Omega}$$

ii) wkt :- $R = \frac{V_R}{I} = \frac{170}{4} = 42.5\Omega$ ie; $\boxed{R = 42.5\Omega}$

iv) wkt :- $X_L = \frac{V_L}{I} = \frac{150}{4} = 37.5\Omega$ ie; $\boxed{X_L = 37.5\Omega}$

v) wkt :- $X_C = \frac{V_C}{I} = \frac{100}{4} = 25\Omega$ ie; $\boxed{X_C = 25\Omega}$

i) wkt :- $P.f = \cos\phi = \frac{R}{Z} = \frac{42.5}{50} = 0.85$

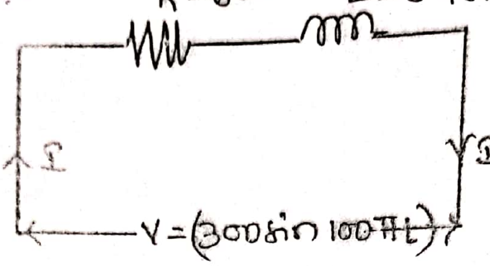
$$\boxed{P.f = 0.85 \text{ lagging}}$$

$\{\because X_L > X_C\}$

Ex (5) Find an expression for the current and calculate power when a voltage $V = 300 \sin 100\pi t$ is applied to a coil having $R = 60\,\Omega$ and $L = 0.16\,H$.

June / July 2016 (8 marks)

Sol^n: Given :-



find :-

i) $I = ? \rightarrow$ expression

ii) $P = ?$

Given that $V = 300 \sin 100\pi t$ —— (1)

wkt $v = V_m \sin \omega t$ —— (2)

compare (1) & (2)

$\therefore V_m = 300\,V$

$\therefore V = \frac{V_m}{\sqrt{2}} = \frac{300}{\sqrt{2}} = 212.13\,V$

$\omega = 2\pi f = 100\pi$

$\therefore f = \frac{100\pi}{2\pi} = 50\,Hz$

$X_L = 2\pi f L = 2\pi \times 50 \times 0.16 = 50.265\,\Omega$

$Z = \sqrt{R^2 + X_L^2} = \sqrt{(60)^2 + (50.262)^2} = 78.27\,\Omega$

i) wkt :- $I = \frac{V}{Z} = \frac{212.13}{78.27} = 2.71\,A$

$I_m = 3.832\,A \Rightarrow (\because I_m = I \times \sqrt{2})$

wkt $p.f = \cos\phi = \frac{R}{Z} = \frac{60}{78.27} = 0.766$ lagging

$\therefore \phi = \cos^{-1}(0.766) = 40^\circ$

wkt :- $i = I_m \sin(\omega t - \phi)$

$\boxed{i = 3.832 \sin(100\pi t - 40^\circ)\,A}$

ii) wkt :- $P = VI\cos\phi = 212.13 \times 2.71 \times 0.766$

$\boxed{P = 440.39\,W}$

Ex ⑥ An alternating voltage $(80+j60)$ V is applied to a circuit and the current flowing is $(-4+j10)$ A. find:
i) the impedance of the circuit ii) the phase angle
iii) power consumed. Dec 2015/2016 (5 marks)

Sol: Given :- $V = (80+j60)V = 100 \angle 36.86$ V

$\dot{I} = (-4+j10)A = 10.77 \angle 111.80$ A

find :- i) $Z = ?$ ii) $\phi = ?$ iii) $P = ?$

i) wkt $Z = \frac{V}{I} = \frac{100 \angle 36.86}{10.77 \angle 111.80} = 0.928 \angle -74.94$

$$\boxed{Z = 0.928 \angle -74.94 \ \Omega}$$

ii) wkt :- $\phi = \phi_1 - \phi_2 = 36.86 - 111.8 = -74.94°$

$$\boxed{\phi = 74.94°}$$ (-ve sign represents I leads V)

iii) wkt $P = VI\cos\phi = \cancel{100 \angle 36.86 \times 10.77 \angle 111.8 \times \cos(-74...}$

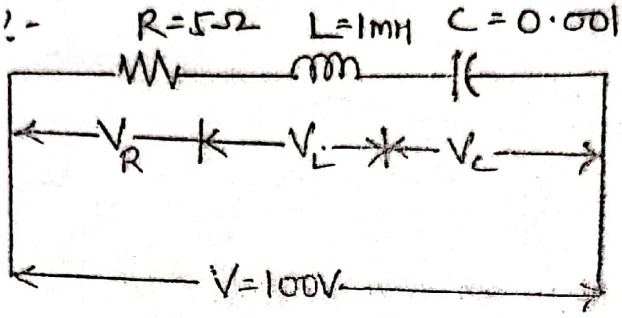
~~P = 1077~~

$P = 100 \times 10.77 \times \cos(-74.94)$

$$\boxed{P = 279.83 \text{ watts}}$$

Ex 9 A resonant series circuit with $R = 5\Omega$, $L = 1mH$ and $C = 0.001\mu F$ is connected to a 100V supply. find. i) the drop across L and ii) drop across C. Take the supply as reference phasor.

sol^n: Given:-



find:-

i) $V_L = ?$

ii) $V_C = ?$

Assume $f = 50Hz$

Given that $L = 1\times10^{-3} H$

$C = 0.001\times10^{-6} F$.

$\therefore X_L = 2\pi f L = 2\pi\times50\times10^{-3}$

$X_L = 314.15\times10^{-3}\Omega = 0.31415\Omega$

$X_C = \dfrac{1}{2\pi f C} = \dfrac{10^{6}}{2\pi\times50\times0.001} = 3183098.862\Omega$

$X_C > X_L$

$\therefore Z = \sqrt{R^2+(X_C-X_L)^2} = \sqrt{(5)^2+(3183098-548)^2}$

$Z = 3183098.548\,\Omega$

$\therefore I = \dfrac{V}{Z} = \dfrac{100}{3183098.548} = 3.141\times10^{-5} A$

i) WKT $V_L = I X_L = 3.141\times10^{-5}\times0.3141$

$\boxed{V_L = 9.867\times10^{-6} V}$.

ii) WKT $V_C = I X_C = 3.141\times10^{-5}\times3183098.862$

$\boxed{V_C = 99.98 V}$

Module 2> THREE PHASE BALANCED CIRCUITS

I **Introduction** :- Advantages of 3ϕ circuits.

*> The output of 3ϕ Machine is always greater than 1ϕ Machine ie; 1.5 times for same size of Machine.

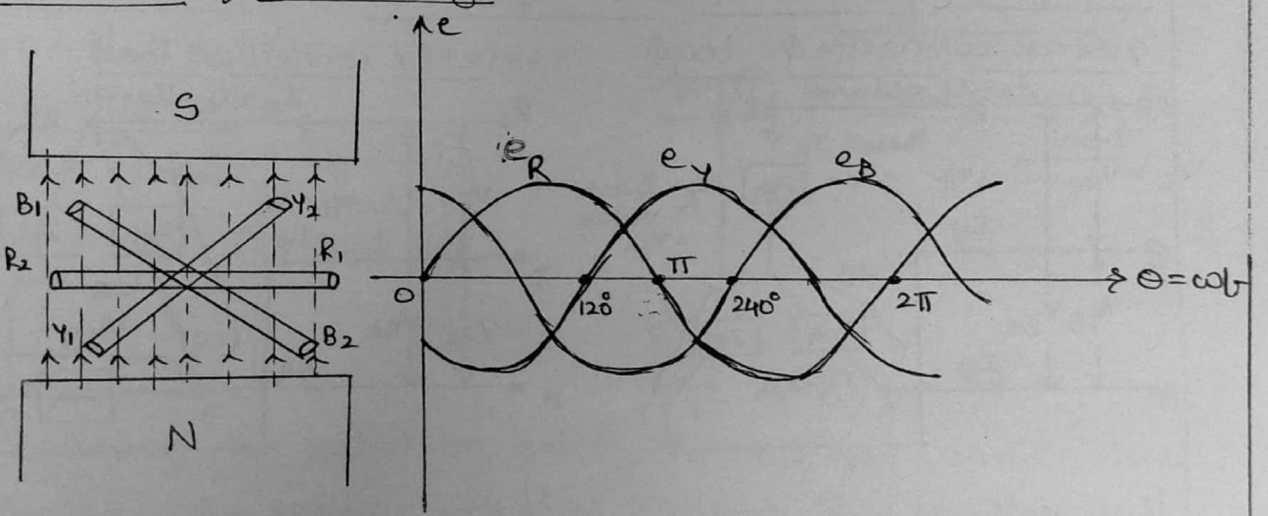
*> 3ϕ Machine occupies less space and less cost.

*> For transmission and distribution 3ϕ system needs less copper hence economical

*> It is possible to produce RM by using 3ϕ system.

*> 3ϕ system gives steady output and improved power factor

Generation of 3ϕ voltage :-



*> The three coils (windings) are placed in a magnetic field named as R (Red), Y (yellow), B (Blue).

*> Let e_R, e_Y, e_B are the three voltages induced in the coils R, Y, B.

*> All the three coils are displaced by 120° electrical.

*> Suppose ~~&~~ if e_R is assumed to be the reference and is zero for the instant shown in waveform then at the same time e_Y will be displaced by 120° from e_R & e_B will be displaced by 240° from e_R & 120° from e_B.

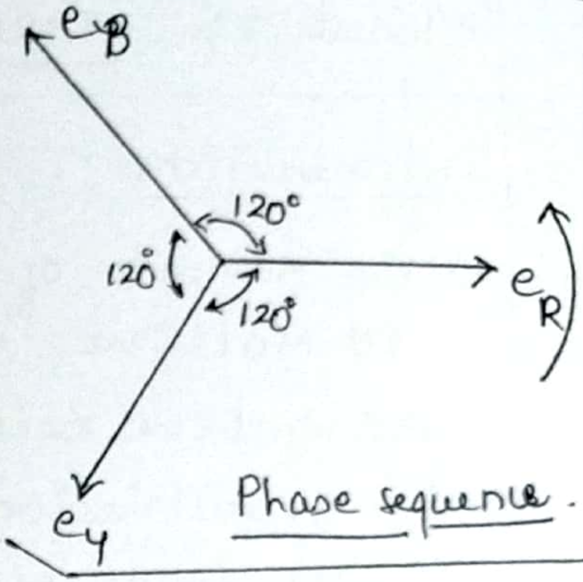
The Mathematical eq^{n}s are.

$e_R = E_m \sin \omega t$

$e_Y = E_m \sin(\omega t - 120^\circ)$

$e_B = E_m \sin(\omega t - 240^\circ)$

$\therefore \bar{e}_R + \bar{e}_Y + \bar{e}_B = 0$



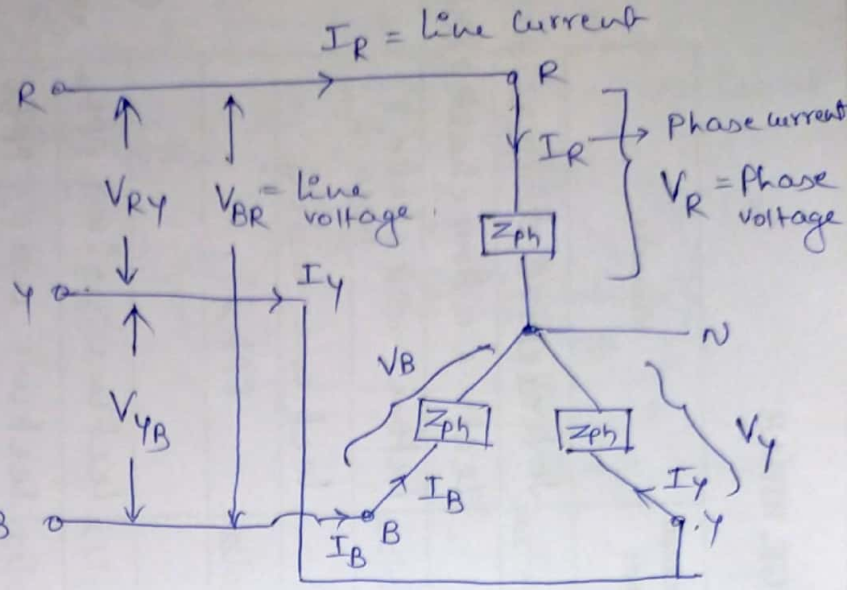
Phase sequence.

Q1) Define phase sequency of 3ϕ AC (2m)

Def^n:

The sequence in which the voltages reach their maximum +ve value is called phase sequence.

Star connected load



Line values

* Line current (I_L)

$I_R = I_Y = I_B = I_L$

* Line voltage (V_L)

$V_{RY} = V_{YB} = V_{BR} = V_L$

Phase values

* Phase current (I_{ph})

$I_R = I_Y = I_B = I_{ph}$

* Phase voltage (V_{ph})

$V_R = V_Y = V_B = V_{ph}$.

In star connected load.

* Line current = Phase current

ie; $\boxed{I_L = I_{ph}}$ Amps

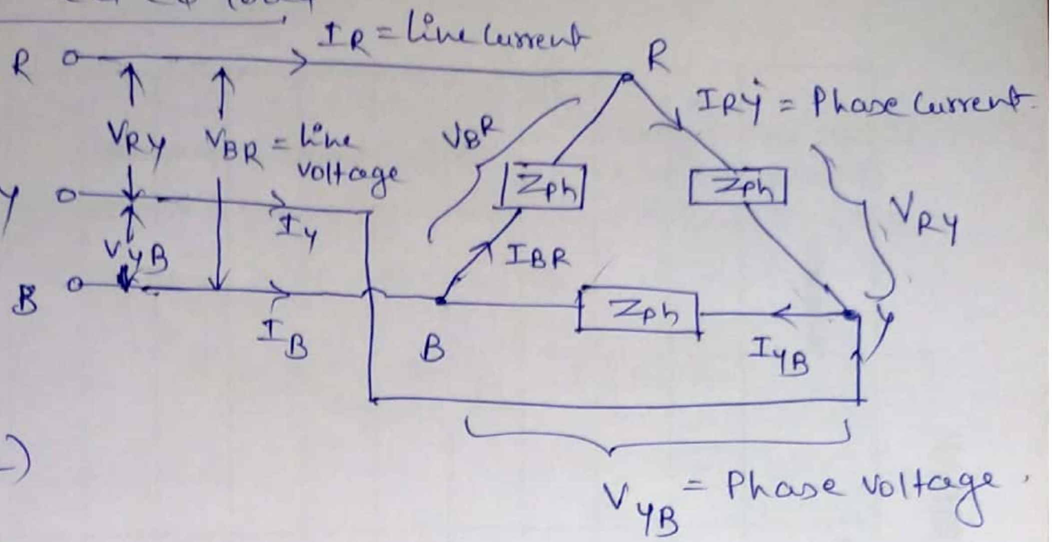
* Line voltage = $\sqrt{3}$ times of Phase voltage.

ie; $\boxed{V_L = \sqrt{3}\, V_{ph}}$ volts

* The Power $\boxed{P = \sqrt{3}\, V_L I_L \cos\phi}$ watts.

Where $\cos\phi$ – Power factor.

Delta connected load



Line values

*) Line current (I_L)

$$I_R = I_Y = I_B = I_L$$

*) Line voltage (V_L)

$$V_{RY} = V_{YB} = V_{BR} = V_L$$

Phase values :-

*) Phase current (I_{ph})

$$I_{RY} = I_{YB} = I_{BR} = I_{ph}$$

*) Phase Voltage (V_{ph})

$$V_{RY} = V_{YB} = V_{BR} = V_{ph}$$

In Delta connected load.

*) Line voltage = Phase Voltage.

ie; $\boxed{V_L = V_{ph}}$ volts

*) Line current = $\sqrt{3}$ times phase current.

ie; $\boxed{I_L = \sqrt{3}\, I_{ph}}$ Amps

*) The Power $\boxed{P = \sqrt{3}\, V_L I_L \cos\phi}$ watts.

where $\cos\phi$ - Power factor.