AC FUNDAMENTAL

<u>AC</u> :- Magnitude & Direction changes wrt time.

IMPORTANCE OF AC

Power System :-

Generation → 11 KV

Transmission → 132 KV, 66 KV

Distribution → Primary (11 KV / 440 V) → output (step down) → 3φ

→ Secondary 11 KV 3φ

↓

220 V 1φ / 440 V 3φ

(a) $P = VI\cos\theta$

V, I → constt; $\cos\theta$ → vary

$I \propto$ load

$\frac{P}{V} = \text{const} \Rightarrow V \propto \frac{1}{I}$

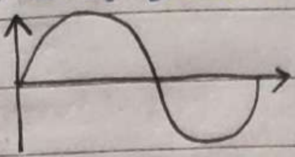
$\boxed{V\uparrow \rightarrow I\downarrow \rightarrow \text{LOSSES}\downarrow}$

(b) less cost & wt of wire bcs these quantities $\propto I$
wt of wire $\propto$ tower size $\propto$ ckt breaker $\propto$ Rating of appliances. I

$I\downarrow$ hence these things are less.

(c) Induction motor works on AC as DC motors cannot do heavy work. Induction motors are robust (no heating on heavy work)

(d) Natural zero break :- Shock prevention



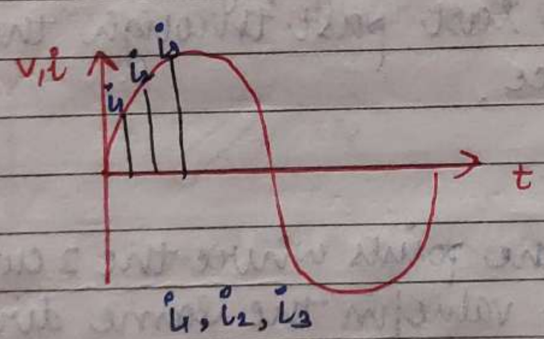
Adv of choosing sinosidal wave form over other

(a) produces less losses
(b) ↓ Harmonics :- less Freq (undesireable)
(c) ↓ Interferences with communication ckt.
(d) ↓ Noise

Important Terms.

(a) Waveform :- Shape of the curve (V or I) when plotted against time.

(b) Instantaneous value :- Value of quantity at any particular instant is called Instantaneous value



all Instantaneous values are written in small letters

(c) Frequency (Hz) :- No. of cycles in 1 sec.

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

(d) Time Period (sec) :-
Time taken to complete one cycle

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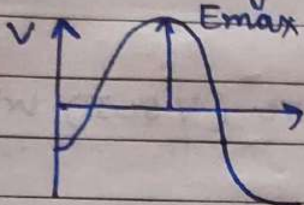
(e) Cycle :- Set of all +ve & -ve instantaneous value is 1 cycle.

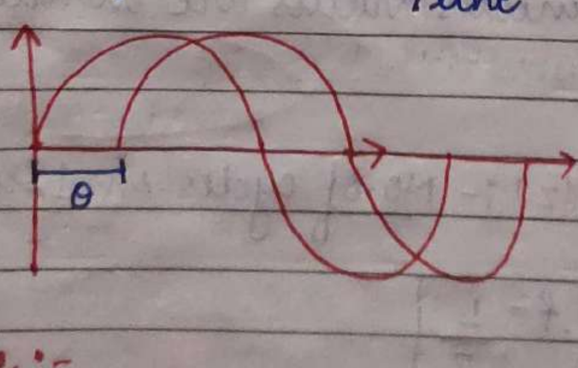
(f) Half cycle / Alternation :- Set of all +ve values → +ve half cycle
Set of all -ve values → -ve half cycle.

(g) Amplitude / Peak value / Crest value / Max value :-
The max mag (+ve / -ve) which an alternating qty attains during one cycle.



(h) Phase / Phase Angle :-
Fraction of T.P of alternating qty that has elapsed since the current last past through the zero position of refrence.

(i) Phase difference :-
Angular dis b/w the points where the 2 curves cross the refrence value / line in the same dir.

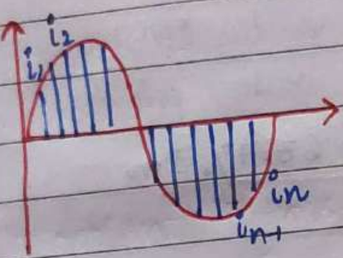


(j) Avg value :-
~~Sum of all instantaneous~~
Arithmatic avg of all inst. values considered of an alternating qty over one cycle.

Iav , Vav → Representation

(k) <u>Symmetrical Alt-qty</u> :-
where +ve half cycle = −ve half cycle.

For Sym. alt. qty, avg value = 0.

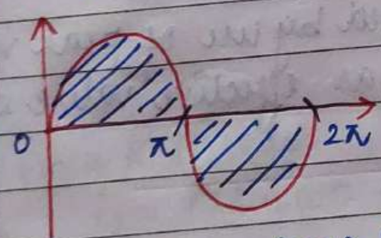


$$avg = \frac{i_1 + i_2 + \cdots - i_{n-1} - i_n}{n} = 0$$

For unsymmetrical alt. qty, avg value ≠ 0

⇒ Integral Calculus Method for Avg value.

= <u>Area under graph</u>
2π = base



$$I_{av} = \frac{\text{Area of alternation}}{\text{base}}$$

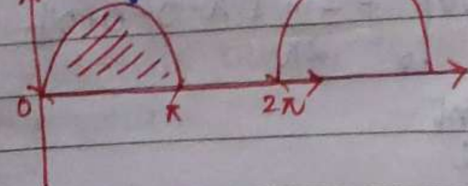
Integration at home

For pure wave form :- we take for half cycle.

$$\boxed{I_{av} = \frac{\int_0^{\pi} I_m \sin\theta}{\pi} = \frac{2I_m}{\pi} = 0.637\, I_m}$$

↳ base half cycle

For unsymmetrical



$$I_{avg} = \frac{\int_0^{\pi} I_m (\text{wave eq}^n)}{2\pi}$$

<u>limit</u> :- where we see actual waveform
<u>base</u> :- when next cycle start.

<u>Q</u>. Derivation of avg value of current

$$I_{av} = \int_0^{\pi} \frac{I_0 \sin\theta \, d\theta}{\pi}$$

$$= \frac{I_0 (-\cos\theta)\big|_0^{\pi}}{\pi}$$

$$= \frac{2 I_0}{\pi} = 0.637 I_m = 63.7\% \, I_m$$

Date 24 Dec, 2022

(2) Root Mean Square value :-
(written in capital letters)

$$V = V_m \sin\theta$$

All instruments, Ammeter, Voltmeter measure RMS value. It is used for calculations.

(1) Protective devices are calculated by use of peak values.
(2) RMS value are also known as effective value & virtual value.

$$I_{rms} = \sqrt{\frac{1}{\pi}\int_0^{\pi} i^2 \cdot d\theta}$$

$$I_{rms}^2 = \frac{1}{\pi}\int_0^{\pi} I_m^2 \sin^2\theta \, d\theta = \frac{I_m^2}{\pi}\int_0^{\pi} \sin^2\theta \, d\theta$$

$$= \frac{I_m^2}{\pi}\int_0^{\pi}\left(\frac{1-\cos 2\theta}{2}\right) . d\theta = \frac{I_m^2}{2\pi}\int_0^{\pi}(1-\cos 2\theta)d\theta$$

$$= \frac{I_m^2}{2\pi}\left|\theta - \frac{1}{2}\sin 2\theta\right|_0^{\pi} = \frac{I_m^2}{2\pi}\left|\pi - 0 - 0 + 0\right|$$

$$I_{rms}^2 = \frac{I_m^2}{2}$$

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$\therefore I_{rms} = \frac{I_m}{\sqrt{2}} = 0.707 I_m$

(m) Form factor :-
It is the ratio of RMS value of AC to Avg value of AC for pure sinosidal wave.

$$F.F = \frac{\text{RMS value}}{\text{Avg value}} = \frac{0.707\ I_m}{0.637\ I_m}$$

$$\boxed{K_f = F.F = 1.1}$$

(n) Peak factor / crest factor / Amplitude factor :-
It is the ratio of peak value of AC qty to RMS value of AC qty

$$K_p = \frac{\text{Peak value}}{\text{RMS value}} = \sqrt{2} = 1.414$$

Q1. Find RMS value

$$i_2 = 12 \sin\omega t + 5(\sin\omega t - 3\pi/2) + 8 + 24(\sin\omega t - 5\pi/\ldots$$

Ans. $I_{rms} = \sqrt{\left(\frac{12}{\sqrt{2}}\right)^2 + \left(\frac{5}{\sqrt{2}}\right)^2 + 8^2 + \left(\frac{24}{\sqrt{2}}\right)^2}$

$= \sqrt{\frac{973}{2}} = \sqrt{486.5}$

Q2. A sinosidal varying current AC of 50 Hz max value of 15A. write eqn for instantaneous value.
(2) current after 1/200 sec.
(3) Find time taken to reach 10A for 1st time.
(4) Avg value.

A2:- $\nu = 60 Hz$

$I_m = 15 A$

$\omega = 2\pi\nu = 120\pi$

(ii) $I_{1/200} = I_m \sin \omega t = 15 \sin (120\pi)\left(\frac{1}{200}\right) = 15 \sin\left(\frac{3}{5}\right)$

$= 15 \sin (0.6) = 14.266$

(iii) $I_t = 10 = 15 \sin 120\pi t$

$\sin^{-1}\left(\frac{2}{5}\right) = 120\pi t = \frac{\sin^{-1}(2/5)}{120\pi} = t$

(iv) Avg value $= \frac{2(15)}{\pi} = 9.55 A$

(i) Instantaneous current $= i = 15 \sin 120\pi t$

Q3. An AC source sinosidal has current RMS value of 40A at 50Hz frequency. Write the expression of
(i) Instantaneous Current
(ii) current at 0.02 sec after passing through max +ve value.

A3. $I_{RMS} = 40 A$; $\nu = 50 Hz$

$\frac{I_m}{\sqrt{2}} = I_{RMS} \Rightarrow I_m = \sqrt{2}\, I_{rms} = \sqrt{2}(40) = 40\sqrt{2} A$

$\omega = 2\pi\nu = 100\pi$

$i = I_m \sin \omega t$

$= 40\sqrt{2} \sin 100\pi t$

HW ques

Q. Half wave Rectifier Form factor: 1.57 (Derivation)

Q2. Peak form factor for half wave.

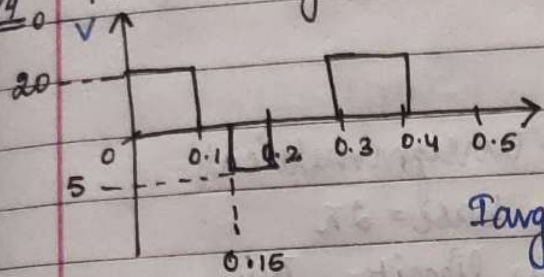
$40\sqrt{2} = 40\sqrt{2}\sin 100\pi t$

$\pi/2 = 100\pi t \quad t = 1/200$

$t = 1/200 + 0.02 = 0.07$

$40\sqrt{2}\sin 7\pi = I_{req} = 0$

Q4. Find Average & RMS value.



$$I_{avg} = \frac{1}{0.3}\left[\int_0^{0.1} 20\,dt + \int_{0.15}^{0.2} -5\,dt\right]$$

$$I_{avg} = \frac{1}{0.3}\left[20t\Big)_0^{0.1} + (-5t\Big]_{0.15}^{0.2}\right]$$

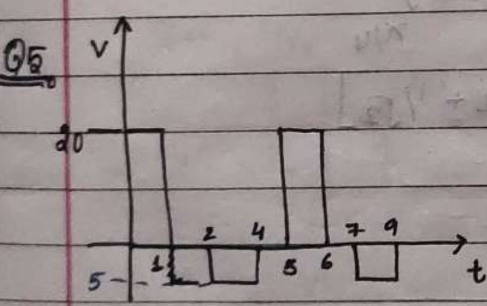
$$= \frac{10}{3}\left[20\cdot(0.1) - (5\cdot(0.2) - 5\cdot(0.15))\right]$$

$$= \frac{10}{3}\left[2 - (1 - 0.75)\right] = \frac{10}{3} \times 1.75 = \frac{17.5}{3} = I_{avg}$$

-: Irms at end :-

Date :- 28 Dec, 2022

Q5. Find Avg & RMS value.



$$V_{avg} = \frac{1}{5}\int V(t)\,dt$$

$$= \frac{1}{5}\left[\int_0^1 (20\cdot dt) + \int_2^4 (-5\,dt)\right]$$

$$= \frac{1}{5}\left[20t\Big]_0^1 - 5t\Big]_2^4\right]$$

$$= \frac{1}{5}\left[20(1) - 20(0) - (5(4) - 5(2))\right]$$

$$= \frac{1}{5}\left[20 - 10\right] = 2$$

$$RMS = \sqrt{(V_{avg})^2} = \sqrt{\frac{1}{5}\left[\int V(t)\right]^2}$$

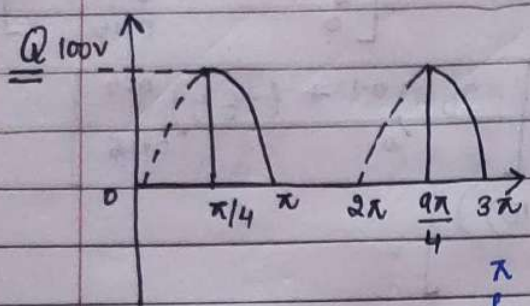
$$= \sqrt{\frac{1}{5}\left[\int_0^1 (20^2 dt) + \int_2^4 (5^2 dt)\right]}$$

$\frac{\theta}{t} = \omega$

$$\sqrt{\frac{1}{5}\left(\int_0^1 400(t) + 25t\Big]_4^2\right)}$$

$$= \sqrt{\frac{1}{5}\left(400 + 50\right)} = \sqrt{\frac{450}{5}} = \sqrt{90}$$

Q



(i) unsymmetrical
(ii) base $= 2\pi$
(iii) limit $= \pi/4 \rightarrow \pi$

$$V_{avg} = \frac{1}{2\pi}\int_{\pi/4}^{\pi} 100 \sin \omega t \, dt$$

$\omega t \rightarrow \theta$
$dt \rightarrow d\theta$

$$= \frac{1}{2\pi}(100)\left(-\cos\theta\right)_{\pi/4}^{\pi}$$

$$= \frac{\cancel{50}\,-50}{\pi}\left[-1 + 1/\sqrt{2}\right]$$

$$= 27.18$$

$$V_{rms} = \sqrt{\frac{1}{2\pi}\int (100)^2 (\sin\theta)^2 \, d\theta}$$

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

$$= \sqrt{\frac{10000}{2\pi}\int_{\pi/4}^{\pi} \sin^2\theta \, d\theta}$$

$$= \sqrt{\frac{10000}{4\pi}\int_{\pi/4}^{\pi}\left(1 - \cos 2\theta\right) d\theta}$$

$$= \sqrt{\frac{2500}{\pi}\left[\theta - \frac{\sin 2\theta}{2}\right]_{\pi/4}^{\pi}}$$

whichever ... put $\pi = 3.14$

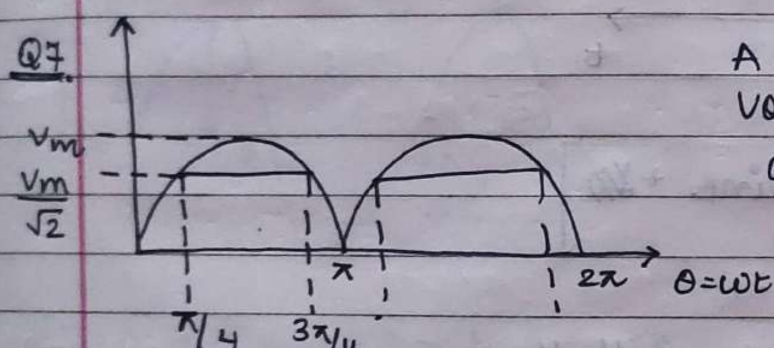
$$= \sqrt{\frac{2500}{\pi}\left[\pi - \cancel{\frac{\sin 2\pi}{2}}^{\,0} - \frac{\pi}{4} + \frac{\sin 2(\pi/4)}{2}\right]}$$

$$= \sqrt{\frac{2500}{\pi}\left[\frac{3\pi}{4} + \frac{1}{2}\right]}$$

$$= \sqrt{\frac{3(25)(\cancel{100})^{25}}{\cancel{4}} + \left(\frac{2500}{\pi}\right)\left(\frac{1}{2}\right)}$$

$$= \sqrt{1875 + 398.08} = \sqrt{2,273.08} = 47.67$$

Q7.



A full Rectified Sinosidal voltage clipped at $1/\sqrt{2}$ of ~~at~~ its max value.

$$V_{avg} = \frac{1}{\pi}\left[\int_0^{\pi/4} V_m \sin\theta \, d\theta + \int_{\pi/4}^{3\pi/4} V_m \, d\theta + \int_{3\pi/4}^{\pi} V_m \sin\theta \, d\theta\right]$$

$$= \frac{1}{\pi}\left[V_m\left[-\cos\theta\right]_0^{\pi/4} + \frac{V_m}{\sqrt{2}}\left[\theta\right]_{\pi/4}^{3\pi/4} + V_m\left[-\cos\theta\right]_{3\pi/4}^{\pi}\right]$$

$$= \frac{1}{\pi}\left[-V_m\left[\cos\frac{\pi}{4} - \cos 0\right] + \frac{V_m}{\sqrt{2}}\left[\frac{3\pi}{4} - \frac{\pi}{4}\right] + V_m\left[\cos\pi - \cos\frac{3\pi}{4}\right]\right]$$

$$= \frac{1}{\pi}\left[-V_m\left[\frac{1}{\sqrt{2}} - \frac{\sqrt{2}}{\sqrt{2}}\right] + \frac{V_m}{\sqrt{2}}\left[\frac{\pi}{2}\right] - V_m\left[-1 - \left(-\frac{1}{\sqrt{2}}\right)\right]\right]$$

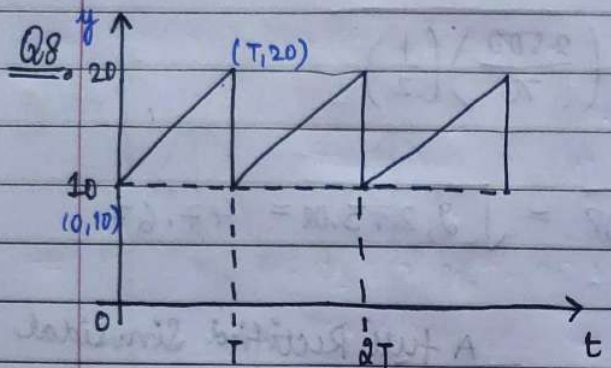
$$= \frac{1}{\pi}\left[-V_m\left[\frac{1-\sqrt{2}}{\sqrt{2}}\right] - V_m\left[\frac{-\sqrt{2}+1}{\sqrt{2}}\right] + \frac{V_m \pi}{2\sqrt{2}}\right]$$

$$= \frac{1}{\pi}\left[-2V_m\left[\frac{1-\sqrt{2}}{\sqrt{2}}\right] + \frac{V_m \pi}{2\sqrt{2}}\right] = V_m\left[\frac{-2}{\pi}\left(\frac{1-\sqrt{2}}{\sqrt{2}}\right) + \frac{1}{2\sqrt{2}}\right]$$

$$V_m\left(\frac{(-0.636)(-0.414)}{1.414} + 0.353\right)$$

$$V_m\left(0.186 + 0.353\right) = V_m(0.54)$$

Q8.



Ans = 15

$$y_{avg} = \frac{1}{T}\int_0^T \left[y_{line} + \cancel{10}\right]$$

eqn of line $\Rightarrow$ $\dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{y - y_1}{x - x_1}$

$$\frac{20-10}{T-0} = \frac{y-10}{x-0}$$

$$\frac{10}{T} = \frac{y-10}{x}$$

$$10x = yT - 10T$$

$$10(t) = yT - 10T \qquad (x = t)$$

$$\frac{10(t) + 10(T)}{T} = y$$

$$y = \frac{10t}{T} + 10$$

$$y_{avg} = \frac{1}{T}\left[\int_0^T \left(\frac{10t}{T} \cancel{+10}\right)dt + \int_0^T 10\,dt\right]$$

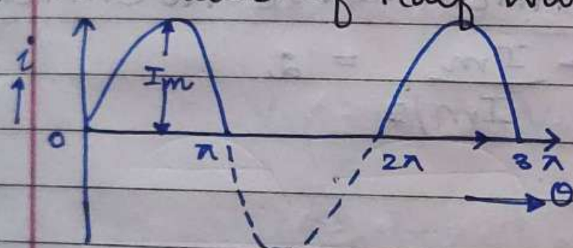
$$\frac{1}{T}\left[\int_0^T \left(\frac{10t}{T}\right) + \int_0^T 10\right]$$

$$\frac{1}{T}\left[\frac{10}{T}\left(\frac{t^2}{2}\right)_0^T + 10T\right]$$

$$\frac{1}{T}\left[\frac{10}{\cancel{T}}\left(\frac{T^{\cancel{2}}}{2}\right) + 10T\right]$$

$$5 + 10 = 15$$

RMS value of Half Wave Rectifier



$$I_{RMS} = \sqrt{\frac{1}{2\pi}\int_0^{\pi} I_m^2 \sin^2\theta \, d\theta}$$

$$= \sqrt{\frac{I_m^2}{2\pi}\int\left[\frac{1-\cos 2\theta}{2}\right]_0^{\pi} d\theta}$$

$$= \sqrt{\frac{I_m^2}{2\pi}\left(\frac{\theta}{2} + \frac{\sin 2\theta}{4}\right)_0^{\pi}}$$

$$= \frac{I_m}{2}\sqrt{\frac{1}{\pi}\left(\pi - \frac{\cancel{\sin 2\pi}}{2} - 0 - \frac{\cancel{\sin 0(2)}}{2}\right)}$$

$$I_{RMS} = \frac{I_m}{2}$$

AVERAGE VALUE OF HALF WAVE RECTIFIER :-

$$I_{av} = \frac{1}{2\pi}\int_0^{\pi} I_m \sin\theta \, d\theta$$

$$= \frac{I_m}{2\pi}\Big[-\cos\theta\Big]_0^{\pi} = \frac{I_m}{\pi}$$

FORM FACTOR OF HALF WAVE RECTIFIER :-

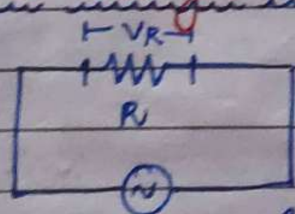
$$F.F = \frac{\text{RMS value}}{\cancel{\text{Peak}}\ \text{Avg value}} = \frac{I_m/2}{I_m/\pi} = \frac{\pi}{2} = 1.57$$

PEAK FORM FACTOR OF HALF WAVE RECTIFIER

$$P.F = \frac{\text{Peak value}}{\text{RMS value}} = \frac{I_m}{I_m/2} = 2$$

Date :- 29 Dec, 2022.

AC through Pure RESISTIVE CIRCUIT



$V = V_m \sin\omega t$

Voltage $= V_m \sin\omega t = v$ — 2

Instantaneous current $= i$

V drop across R is $V_R = iR$ — 1

for equilibrium 1 = 2

$$V_R = iR = V_m \sin\omega t$$

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

for $\sin\omega t = 1$ $\qquad i = \frac{V_m}{R} = I_m$

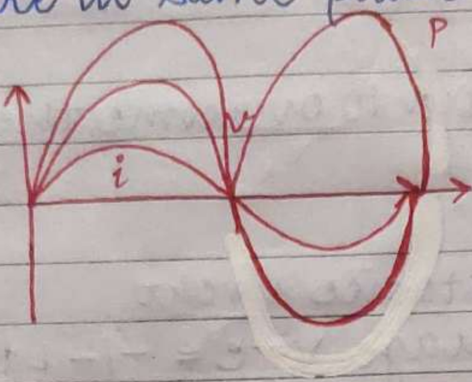
$$i = I_m \sin\omega t \quad — 3$$

comparing (2) & (3)

for $v = V_m \sin\omega t$

$I = i = I_m \sin\omega t$

v, i are in same phase. for only R ckt



Instantaneous power $= vi = P$

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

$= V_m I_m \sin^2 \omega t$

$= \underset{\text{const}}{V_m I_m} \left(\frac{1 - \cos 2\omega t}{2} \right)$

$= \frac{V_m I_m}{2} - \frac{V_m I_m}{2} \underset{\text{variable}}{\cos 2\omega t}$ — (4)

For average power.

over complete cycle, the variable part in 4 is zero. We are left with only $\frac{V_m I_m}{2}$

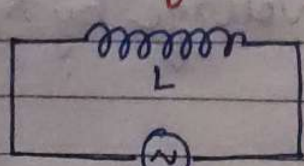
$$P = \frac{V_m I_m}{2} = \frac{V_m}{\sqrt{2}} \frac{I_m}{\sqrt{2}} = V_{rms} \cdot I_{rms}$$

$$P_{avg} = V \cdot I$$

(a) Power is always +ve and the expression of Power is $V_{rms} I_{rms}$. Unit = Watts

(b) No part of power cycle becomes -ve at any time. and power is never zero in purely resistive ckt.

AC through purely INDUCTIVE CIRCUIT



$V = V \sin \omega t$

~~when an~~ alternating voltage

all this voltage is used to overcome the self Induced emf. $e = -L\frac{di}{dt}$.

As there is no resistance in ckt.
Hence applied voltage $V = -e = -\left(-L\frac{di}{dt}\right) = L\frac{di}{dt}$

$$V_m \sin\omega t = L\frac{di}{dt}$$

$$\int di = \int \frac{V_m}{L} \sin\omega t \; dt$$

$$I = \frac{V_m}{\omega L} \sin(\omega t - \pi/2)$$

$$I = \frac{V_m}{X_L} \sin(\omega t - \pi/2)$$

$\omega L = X_L$ = Inductive reactance = Ω
Inductive reactance is the resistance offered by Inductor to alternating current

for $\sin(\omega t - \pi/2)$

$$i = \frac{V_m}{X_L} = I_m$$

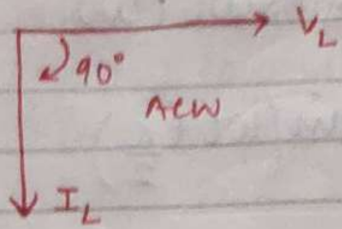
In a L ckt

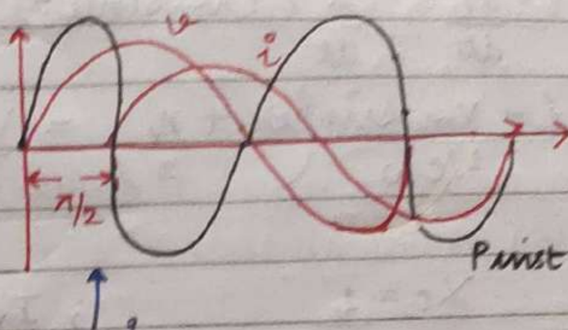
$V = V_m \sin\omega t$

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

current lags the applied voltage by $\pi/2$

AC through pure Capacitance
H.W.





(Jiska max phle vo leading)

Instantaneous Power $= v \cdot i$

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

$$= -V_m I_m \sin \omega t \cos \omega t$$

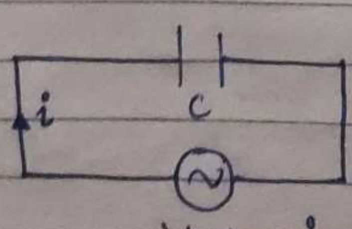
$$= -\frac{V_m I_m}{2} \sin 2\omega t \rightarrow \text{fluctuating (variable)}$$

Avg Power $= 0$

In a pure Inductive & capactive ckt, average power across full cycle is zero. (NO consumption of Power in pure L & C in avg but at instant it consumes power).

Power system :-

AC through Pure Capacitive Alone



$V = V_m \sin \omega t$

Let $V = V_m \sin \omega t$
V = pot diff across plates
q = charge on plates

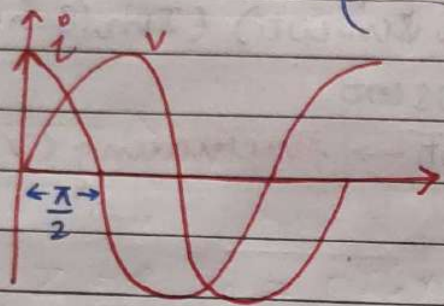
$$q = CV$$
$$= C V_m \sin \omega t$$

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

$$i = \frac{V_m}{1/C\omega} \sin\left(\omega t + \frac{\pi}{2}\right) = \frac{V_m}{X_C} \sin\left(\omega t + \frac{\pi}{2}\right)$$

$$X_C = \frac{1}{\omega C} \quad ; \quad I_m = \frac{V_m}{X_C}$$

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



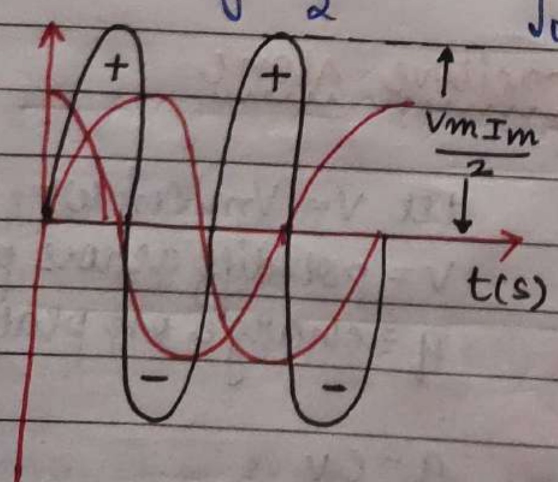
Instantaneous Power

$$p = vi = (V_m \sin\omega t)(I_m \sin(\omega t + 90^\circ))$$

$$= V_m I_m \sin\omega t \cos\omega t$$

$$= \frac{1}{2} V_m I_m \sin 2\omega t$$

$$\text{Power}_{avg} = \frac{1}{2} V_m I_m \int_0^{2\pi} \sin 2\omega t \, dt = 0$$



1 Horse power = 786 Watt

POWER SYSTEM

(i) Apparent Power (S)

It is given by the product of rms values of applied voltage and circuit current.

$$\therefore S = VI = (IZ)\cdot I = I^2 Z = \text{volt amperes (VA)}$$

(ii) Active / Real Power (P)

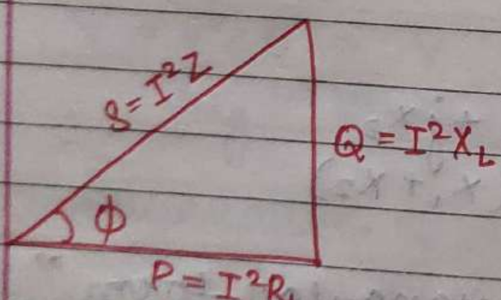
It is the power which is actually dissipated by circuit Resistances.

$$P = I^2 R = VI\cos\phi = \text{Watt}.$$

(iii) Reactive Power (Q)

It is the power developed in the inductive reactance of the circuit / capacitance reactance.
(consume in one half cycle, give back in other half cycle)

$$Q = I^2 X_L = I^2 \cdot Z\sin\phi = I\cdot(IZ)\sin\phi = VI\sin\phi$$
$$= \text{volt-amperes-reactive}.$$



$$S^2 = P^2 + Q^2$$
$$S = \sqrt{P^2 + Q^2}$$
$$\cos\phi = \frac{P}{S}$$

Q4. continue

$$I_{rms} = \sqrt{\frac{10}{3}\left[\int_0^{0.1} 400\,dt + \int_{0.15}^{0.2} 25\,dt\right]}$$

$$= \sqrt{\frac{10}{3}\left(400 \times \frac{0.1}{10} + 25\left(\frac{0.2}{10}\right) - 25\left(\frac{0.15}{100}\right)\right)}$$

$$= \sqrt{\frac{10}{3}\left(40 + 5 - 3.75\right)}$$

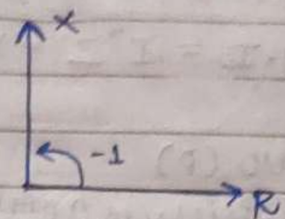
$$= \sqrt{137.5}\ \text{A}$$

Mathematical Representation of Phasors

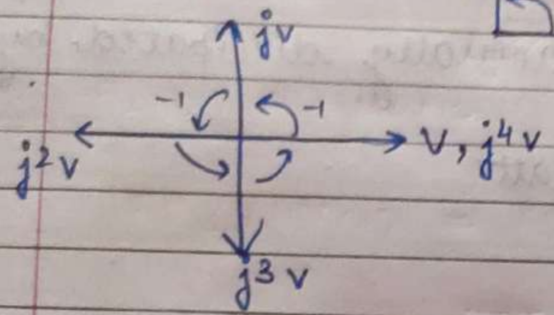
(A) Rectangular form

$j^2 = -1$

$j = \sqrt{-1}$



$Z = R + jX$



$Z = a + jb = R + jX$

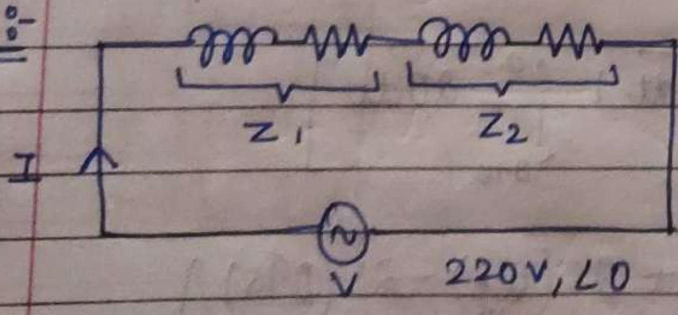
a = Real part
b = Imaginary part

$Z_1 = R_1 + jX_1 \; ; \; Z_2 = R_2 + jX_2$

$Z_1 + Z_2 = (R_1 + R_2) + j(X_1 + X_2)$

" Add / Sub we go it in Rectangular form "

g:-



net Impedence $= Z_1 + Z_2$

$$|Z| = \sqrt{R^2 + X^2}$$
$$\tan\phi = \frac{X}{R}$$

(B) TRIGONOMETRICAL FORM

Real part $= a = V\cos\phi$

Img. part $= b = V\sin\phi$

$$\vec{V} = V\cos\phi + Vj\sin\phi$$
$$\vec{V} = V(\cos\phi + j\sin\phi)$$

(C) Exponential form

$$e^{j\phi} = \cos\phi + j\sin\phi$$
$$e^{-j\phi} = \cos\phi - j\sin\phi$$
$$e^{j(\phi+\theta)} = \cos(\theta+\phi) + j\sin(\theta+\phi)$$

(D) Polar form

$$\vec{V} = \underbrace{V}_{\text{mag}}\angle\underbrace{\theta}_{\text{Phase } \angle} = V\angle{-\theta}$$

"Multiplication of phasors" "Divide of phasors".

$$A\angle\theta,\ B\angle\alpha$$
$$A \cdot B = AB\angle(\theta + \alpha)$$
$$\frac{A}{B} = \frac{A}{B}\angle(\theta - \alpha)$$

Q. $Z = 3 + j5$; $V = 220V, \angle 0$; $I = ?$

Ans.
$$I = \frac{V}{Z}$$
$$|Z| = \sqrt{3^2 + 5^2} = \cancel{4}Y \qquad \theta = \tan^{-1}\left(\frac{5}{3}\right)$$
$$Z = \cancel{Y}\angle\theta, \quad V = 220\angle 0$$

coil = $r + X_L$

Lead & lag

CLASSTIME Pg. No.
Date / /

$I = \frac{220}{Y} \angle(0-\theta)$

$A\angle\theta \rightarrow n^{th}$ power

$A^n \angle n\theta$

n^{th} root $A^{1/n} \angle \frac{\theta}{n}$

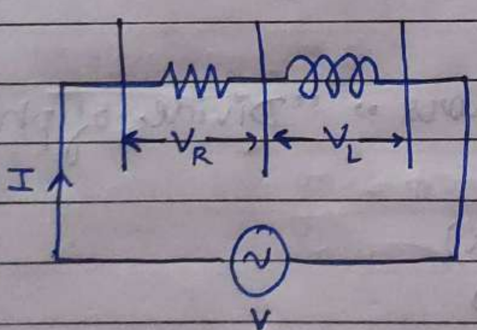
Eg:- $5\angle 60$, 4^{th} power

$5^4 \angle (4)(60) = 625\angle 240$

4^{th} root $= (5)^{1/4} \angle \frac{60}{4} = \sqrt[4]{5} \angle 15$

R-L-Series Circuit :-

R-L-series :- coil



$V = \sqrt{V_R^2 + V_L^2} = \sqrt{(IR)^2 + (IX_L)^2}$

$V = I\sqrt{R^2 + X_L^2}$

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

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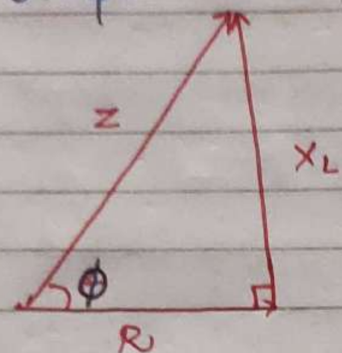
Impedence = $\sqrt{R^2 + X_L^2}$

$\tan\theta = \frac{X_L}{R} = \frac{\omega L}{R}$

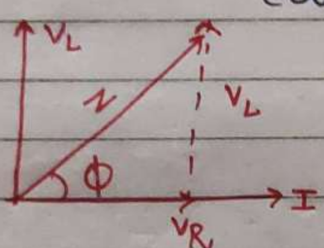
Impedence Δ,



$\cos\phi = \frac{R}{Z} = \frac{\text{Resistance}}{\text{Impedence}}$

$0 \leq \cos\phi \leq 1$

bcs base ckts are pure Resistive ($\cos\phi = 1$) and pure Inductive/Capacitive ($\cos\phi = 0$)



Applied V & I are not in phase
I is lagging is by ϕ with V.

If $V_m \sin\theta = V$
$I = I_m \sin(\theta - \phi)$

$p = vi = V_m \sin\theta \times I_m \sin(\theta - \phi)$
$= V_m I_m \sin\theta \sin(\theta - \phi)$

$= \underbrace{\frac{V_m}{\sqrt{2}} \frac{I_m}{\sqrt{2}} \cos\phi}_{\text{constt}} - \frac{V_m}{\sqrt{2}} \frac{I_m}{\sqrt{2}} \underbrace{\cos(2\omega t - \phi)}_{\text{fluctuating}}$

$P = P_{avg} = \frac{V_m}{\sqrt{2}} \frac{I_m}{\sqrt{2}} \cos\phi = V_{rms} I_{rms} \cos\phi$

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$P = VI\cos\phi = VI.\frac{R}{Z} = \frac{V}{Z}.I.R = I^2R$ watt.

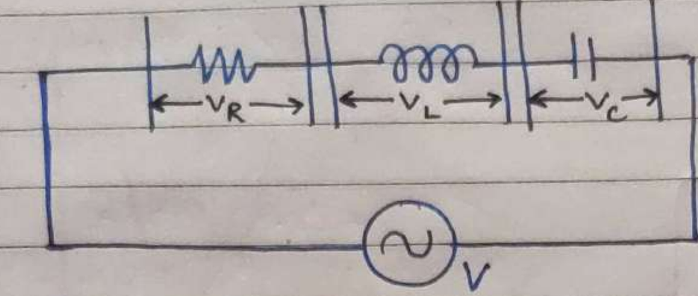
power is only consumed by ckt.

R-C series circuit

Date :- 31 Dec, 2022

CLASSTIME Pg. No.
Date / /

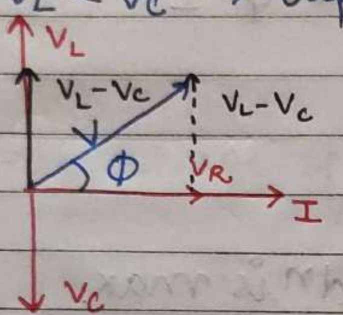
R-L-C Series Circuit



$V_L > V_C \Rightarrow$ Inductive ckt

$V_L < V_C \Rightarrow$ capacitive ckt

FOR $V_L > V_C$



I lags applied voltage by ϕ angle

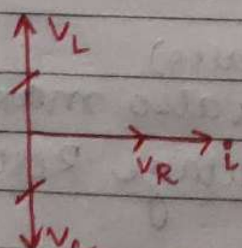
$$Z = \sqrt{R^2 + (X_L - X_C)^2}$$

SERIES RESONANCE :-

condition :- $X_L = X_C$ or $V_L = V_C$

Resonance :- Any ac circuit when behaves like purely resistive circuit i.e. V & I are in same phase. i.e net reactive component of circuit is zero.

$V_L - V_C = 0$



Total voltage is around resistive part of ckt.

V is in phase with I.

$V_R = V$

At Resonance

$V_L = V_C$

$I X_L = I X_C$

$$\boxed{X_L = X_C}$$

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

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

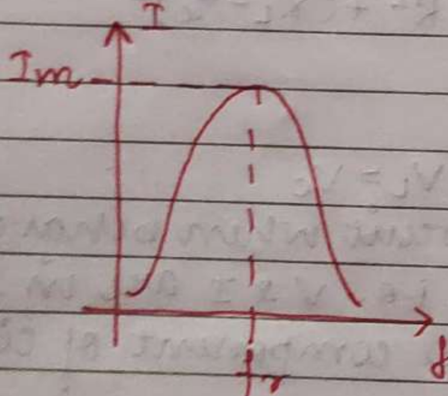
$$\boxed{f = \frac{1}{2\pi\sqrt{LC}}}$$

→ As V_R is in phase with I → $\cos\phi = 1$

→ $Z = \sqrt{R^2 + (X_L - X_C)^2}$

$$\boxed{Z = R}$$

→ current at Resonating condⁿ is max.



Radio & Communication ckt Applications.

(voltage Magnification ckt)

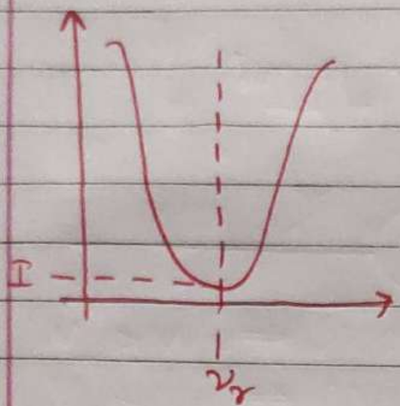
Series Resonance is also called Voltage Resonance & acceptor circuit.

(L, C also)

Voltage across each component is also maximum with current hence called Voltage Resonance

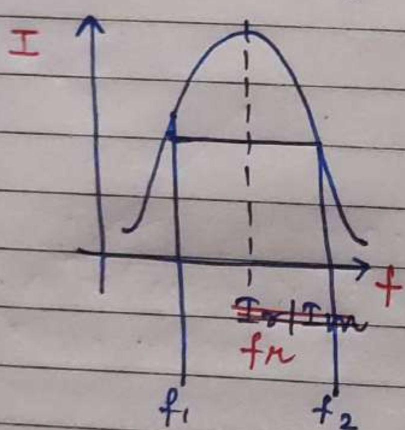
As ~~ckt~~ R accepts max current from the ckt It is acceptor circuit.

Parallel Resonance (current/ rejector resonance)



BANDWITH :-

The range of freq where $I = 70.7\% \, I_r$



$BW = f_2 - f_1$

f_1 & f_2 are half power points

Power drawn is half at these points.

$$f_r = \sqrt{f_1 f_2}$$

Q-factor (Quality factor of coil) :-

$$\frac{V \text{ developed across } L \text{ or } C}{\text{Applied voltage}} = \frac{I_r X_L}{I_r R} = \frac{1}{R}\sqrt{\frac{L}{C}}$$ Der.

$$Q = \frac{\text{Resonating frequency}}{\text{Bandwidth}}.$$

Q factor decides designing of coil

It doesnot depend upon frequency.