5(C) Day 21-09-19

AC circuits

$$v(t) = V_m \cos(\omega t + \phi)$$

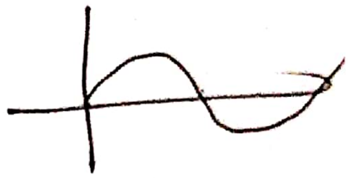
এটা AC signal

একে sinusoidal signal বলে।

Sinusoidal : The signal sine or cosine is called sinusoidal signal.

$V_m \rightarrow$ peak value

$\omega \rightarrow$ Angular frequency



$\phi \rightarrow$ phase angle

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

$$v_1 = 10 \cos(10t + 30^\circ)$$

$$v_2 = 10 \cos(10t + 50^\circ)$$

$$v_T = 10 \left[\cos(10t + 30^\circ) + \cos(10t + 50^\circ)\right]$$

Time domain

~~[illegible]~~ Time কে অন্য কোনো domain এ নিতে হবে। একে বলে phasor

phasor: phasor is complex number representation of a ~~so~~ sinusoidal signal that represents the peak value ~~of~~ and phase angle of a ~~...~~ sinusoidal signal.

In time domain:

$$v(t) = V_m \cos(\omega t + \phi)$$

In phasor

যোগ করতে — time
করতে ,, — phasor

$$V = V_m \angle \phi$$

→ complex number (polar form এ)

phasor

$$\left.\begin{aligned} V_1 &= 10\angle 30^\circ \\ V_2 &= 10\angle 50^\circ \end{aligned}\right\}$$ দুটোর যোগ করে

$$V_T = V_1 + V_2 = 10\angle 30^\circ + 10\angle 50^\circ$$

$$= \cancel{15.088}$$

$$= 19.69\angle 40^\circ$$ → polar

$x + iy$ ← rectangular

$x = r\cos\theta$
$y = r\sin\theta$

$$\sqrt{(10\cos 30 + 10\cos 50)^2 + (10\sin 30 + 10\sin 50)^2}$$
$$= 19.69$$

$$X + iY = \sqrt{X^2 + Y^2} \angle \tan^{-1}\frac{Y}{X}$$

$$\angle\theta = \tan^{-1}\frac{10\sin 30 + 10\sin 50}{10\cos 30 + 10\cos 50}$$
$$= 40^\circ$$

অথবা,
$10\angle 30$
$= 8.66 + 5i$
আবার $10\angle 50$
$= 6.42 + 7.66i$
$\therefore x = 8.66 + 6.42$
$= 15.08$
$y = 5 + 7.66$
$= 12.66$
$\therefore \sqrt{x^2+y^2} = 19.69$
$\theta = \tan^{-1}\frac{y}{x}$
$= \tan^{-1}\left(\frac{12.66}{15.08}\right)$
$= 40^\circ$

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time domain এ

$\therefore V_T(t) = 19.69 \cos(\cancel{\omega t}\ 10t + 40)$

$\omega = 10$ (দেওয়া আছে)

$t = 2$ হলে,

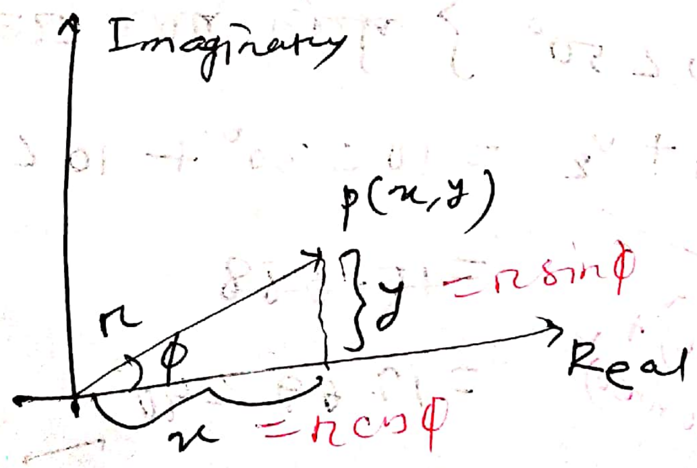
radian এ 20 পাব।
এরে degree তে নিতে হবে
ω আলাদা হলে একটা হলে চলবে না।
দুই দিকেই same আছে।

$V_T(t) = 19.69\cos(10t+40)$
$= 19.69\cos(10\times 2+40)$
$= 19.69\cos(20\times\frac{180}{\pi}+40)$
$= -5.40$

অথবা,
$V_T = 10[\cos(10t+30) + \cos(10t+50)]$
$= 10[\cos(10\times2+30) + \cos(10\times2+50)]$
$= 10[\cos(20\times\frac{180}{\pi}+30) + \cos(20\times\frac{180}{\pi}+50)]$
$= -5.40$

complex number

$z = x + jy$ | i দেওয়া যাবে না।
↓
rectangular form



$z = x + iy$
$= r\angle\phi$

where, $r = \sqrt{x^2+y^2}$

$\phi = \tan^{-1}\frac{y}{x}$

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$\therefore z = x + jy$

$= r\cos\phi + j\, r\sin\phi$

$= r(\cos\phi + j\sin\phi)$

$= r\, e^{j\phi}$

$e^{j\phi} = \angle\phi$

$\cos\theta = Re[e^{j\theta}]$

$\sin\theta = Im[e^{j\theta}]$

#

$v(t) = V_m \cos(\omega t + \phi) = Re[V_m \cos(\omega t + \phi) + j V_m \sin(\omega t + \phi)]$

$= Re[V_m e^{j(\omega t + \phi)}]$

$= Re[V_m e^{j\omega t} \cdot e^{j\phi}]$

$= Re[V_m e^{j\phi} \cdot e^{j\omega t}]$

$= Re[V \cdot e^{j\omega t}]$

$e^{j\phi} = \angle\phi$

where $\underbrace{V}_{\text{phasor}} = V_m e^{j\phi} = V_m \angle\phi$

$v_1(t) = V_{m1}\cos(\omega t + \phi_1)$

$v_2(t) = V_{m2}\cos(\omega t + \phi_2)$

$v_1(t) + v_2(t)$

$= V_{m1}\cos(\omega t + \phi_1) + V_{m2}\cos(\omega t + \phi_2)$

$= Re[V_{m1} e^{j(\omega t + \phi_1)}] + Re[V_{m2} e^{j(\omega t + \phi_2)}]$

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$= Re\,[V_{m1} e^{j(\omega t+\phi_1)} + V_{m2} e^{j(\omega t+\phi_2)}]$

$= Re\,[V_{m1} e^{j\omega t} \cdot e^{j\phi_1} + V_{m2} e^{j\omega t} e^{j\phi_2}]$

$= Re\,[\{(V_{m1} e^{j\phi_1} + V_{m2} e^{j\phi_2})\} e^{j\omega t}]$

$= Re\,[V_T e^{j\phi_T} e^{j\omega t})$ ফেজর যোগ হয়েছে

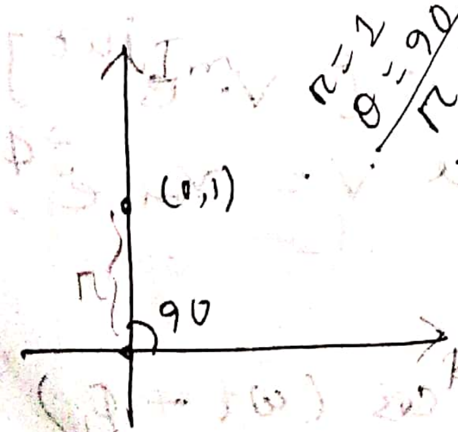
$= Re[V_T e^{j(\omega t+\phi_T)}]$

$= V_T \cos(\omega t + \phi_T)$

<u>(5)-d 22-9-19</u>

$v(t) = V_m \cos(\omega t + \phi) \xrightarrow[\text{phasor}]{} V_m \angle \phi$

$j1 = 1 \angle 90^\circ$



$r = 1$

$\theta = 90^\circ$

$r \angle 90^\circ$

$\Rightarrow 1 \angle 90$

$j^2 = -1$

$\frac{1}{j} = \frac{j}{j^2} = -j$

$z_1 \pm z_2 = (x_1 + jy_1) \pm (x_2 + jy_2)$

$= (x_1 \pm x_2) + j(y_1 \pm y_2)$

$z_1 * z_2 = r_1 \angle \phi_1 \times r_2 \angle \phi_2$ $\quad r_1 e^{j\phi_1} \quad r_2 e^{j\phi_2}$

$= r_1 r_2 \angle \phi_1 + \phi_2$

$\frac{z_1}{z_2} = \frac{r_1 \angle \phi_1}{r_2 \angle \phi_2} = \frac{r_1 e^{j\phi_1}}{r_2 e^{j\phi_2}}$

$= \frac{r_1}{r_2} e^{j(\phi_1 - \phi_2)}$

$= \frac{r_1}{r_2} \angle \phi_1 - \phi_2$ $\rightarrow$ polar form

$4 \angle 50$ (রুট করলে) $\frac{1}{2}$ দিয়ে গুণ $\rightarrow$ power
$= 2 \angle 25$

square করলে 2 দিয়ে গুণ হবে $\rightarrow$ power

$\sqrt{z} = \sqrt{r \angle \phi}$

$= \sqrt{r e^{j\phi}}$

$= \sqrt{r}\, e^{j\phi/2}$

$= \sqrt{r} \angle \phi/2$

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conjugate

$\xrightarrow{}$ argument $\tan^{-1}\frac{y}{x}$

$\xrightarrow{}$ argument $= \tan^{-1}\frac{-y}{x}$

$$(z)^* = (x+jy)^* = x - jy$$

$$= (r\angle\phi)^* = r\angle-\phi$$

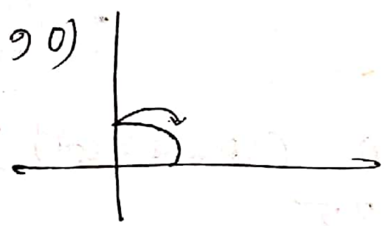
$x(t) = X_m \cos(\omega t + \phi)$

In phasor $X = X_m \angle \phi$

$$\int x(t)\,dt = \int X_m \cos(\omega t + \phi)\,dt$$

$$= X_m \frac{\sin(\omega t + \phi)}{\omega}$$

$$= \frac{X_m}{\omega}\cos(\omega t + \phi - 90)$$



∴ phasor representation of $\int x(t)\,dt$

$$\frac{X_m}{\omega} \angle \phi - 90^\circ$$

~~$\cos(90-\phi) = \sin\phi$~~

$\cos(90-\theta) = \sin\theta$

$\cos(\theta - 90) = \sin\theta$

$\cos(-\theta) = \cos\theta$

$$= \frac{X_m}{\omega} e^{j(\phi-90)}$$

$$= \frac{X_m}{\omega} e^{j\phi} \cdot e^{j(-90)}$$

অর্থাৎ $r = 1$

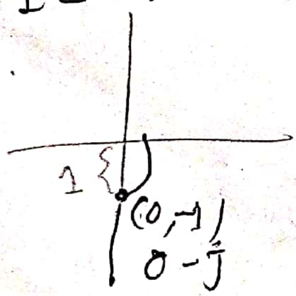
$$= \frac{X_m}{\omega} e^{j\phi} \cdot 1\angle-90^\circ$$

$re^{j\phi} = r\angle\phi$

$e^{j\phi} = 1\angle\phi$

$r\angle\phi = re^{j\phi}$

$r=1$



$$\boxed{e^{j\phi} = \cos\phi + j\sin\phi}$$

$$= -j\frac{X_m}{\omega}e^{j\phi}$$

$$= -j^2 \times \frac{1}{j\omega} X_m\angle\phi$$

$$= \boxed{\frac{X}{j\omega}}$$; where X is the phasor of $x(t)$

এটি হচ্ছে integration এর phasor.

Again,

$$\frac{dx(t)}{dt} = -\omega X_m \sin(\omega t + \phi)$$

অন্তরীকরণ

$$= \omega X_m \cos(90 + \omega t + \phi)$$ [cos এ নিয়ে যাব। কারণ $x(t)$ এর মান cos এ দেওয়া আছে

∴ phasor representation of $\frac{dx(t)}{dt}$

$$= \omega X_m \angle 90 + \phi$$

$$= \omega X_m e^{j(90+\phi)}$$

$$= \omega X_m e^{j90} \cdot e^{j\phi}$$

$$= j\omega X_m e^{j\phi}$$

$$= j\omega X_m \angle\phi$$

$$= \boxed{j\omega X}$$; where X is the phasor of $x(t)$

For AC circuit

3 - loads

(I) Resistor
(II) Inductor
(III) capacitor

voltage current relationship : (time domain)

for resistor:

$$v(t) = i(t)R \Rightarrow i(t) = \frac{1}{R} v(t)$$

Resistance

for inductor:

$$v_L(t) = L \frac{di_L(t)}{dt} \Rightarrow i_L(t) = \frac{1}{L}\int v_L(t)dt$$

inductance

For capacitor:-

$$v_c(t) = \frac{1}{c}\int i_c(t)\,dt \Rightarrow i_c(t) = c\frac{dv_c}{dt}$$

Voltage current relationship (in phasor domain)

if, $i(t) = I_m \cos(\omega t + \phi)$

then, $\mathbf{I} = I_m \angle \phi$

for resistor:

$V = \mathbf{I} R$

$\mathbf{I}$ → phasor of $i(t)$

for inductor:

$V_L = L \cdot j\omega \mathbf{I}$

$j\omega$ → $\frac{d}{dt}$ বদলে $j\omega$ দিতে হবে.

$= j\omega L \mathbf{I}$

For capacitor:

$V_C = \frac{1}{j\omega} \cdot \frac{1}{C} \cdot \mathbf{I}$

$= \frac{\mathbf{I}}{j\omega C}$

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(5)E - 23-09-18

Impedance: বাধা (resistor, capacitor, Inductor)

Impedance is the ratio of voltage phasor and current phasor. ~~is called~~

$$\text{Impedance} = \frac{\text{voltage phasor}}{\text{current phasor}}$$

Impedance is denoted by Z and ~~expressed in oh~~ measured in ohm.

For Resistive load:

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

For inductive load:

$$Z_L = \frac{V}{I} = j\omega L \ (\Omega)$$

L = Inductance
একক হেনরি।

$\omega = 2\pi n$

impedance change হলে frequency change হবে

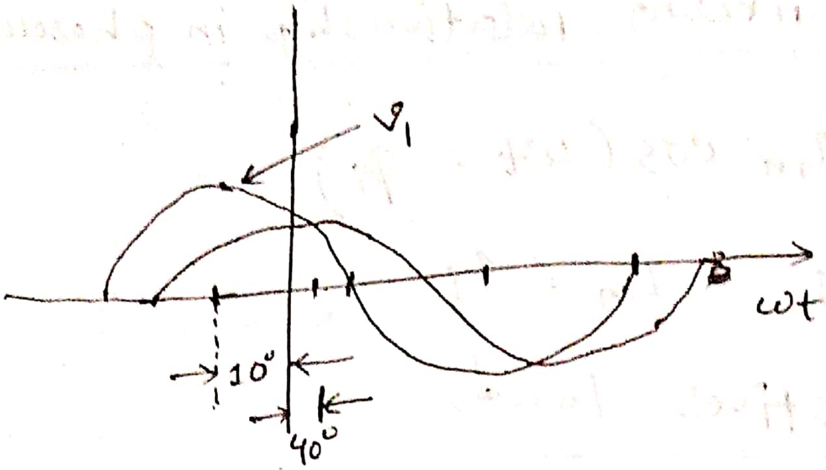
For capacitive load:

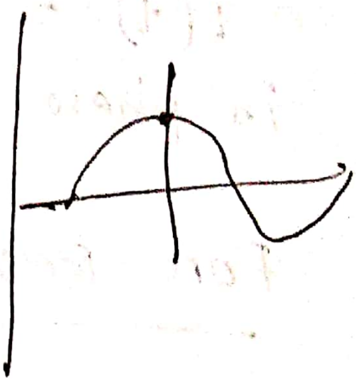
$$Z_C = \frac{V}{I} = \frac{1}{j\omega C} (\Omega)$$

$v_1 = V_{m_1} \cos(\omega t + 10^\circ)$

$v_2 = V_{m2} \cos(\omega t - 40^\circ)$

ωt = −10 হলে maximum value পাওয়া যাবে। কারণ $\cos 0^\circ =$ maximum





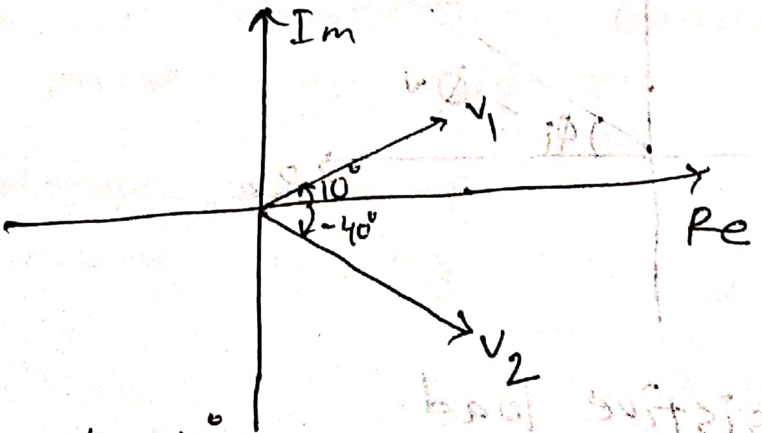
v_1 আগে শুরু হচ্ছে — leading

v_2 পরে " " — laging

v_1 leads v_2 by 50°

v_2 lags v_1 by 50°.

এইভাবে phasor diagram এ করলে,



v_1 এর ক্ষেত্রে length $= V_{m_1}$, $\theta = 10^\circ$

anticlockwise ঘোরে

v_1 — lead হচ্ছে

v_2 — lag "

$v_1 = V_{m_1} \angle 10^\circ$

$v_2 = V_{m2} \angle -40^\circ$

v_1 leads v_2 by 50°
v_2 lags v_1 by 50°

anticlockwise ঘোরালে lead
clockwise " lag

voltage current relationship in phasor diagram:

ধরি,

$$i(t) = I_m \cos(\omega t + \phi_i)$$

in phasor,

$$I = I_m \angle \phi_i$$

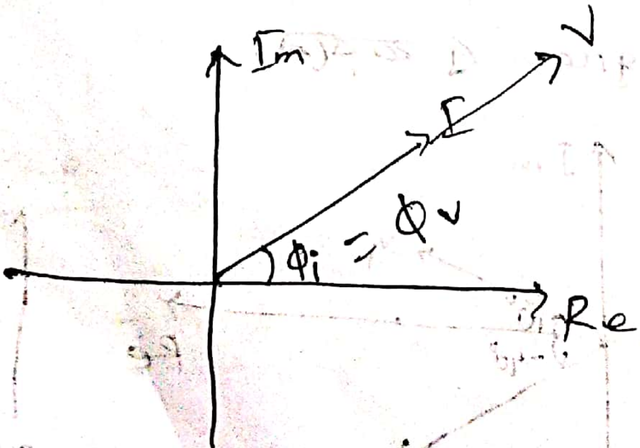
For Resistive load,

$$V = IR = R I_m \angle \phi_i$$

$$= V_m \angle \phi_v$$

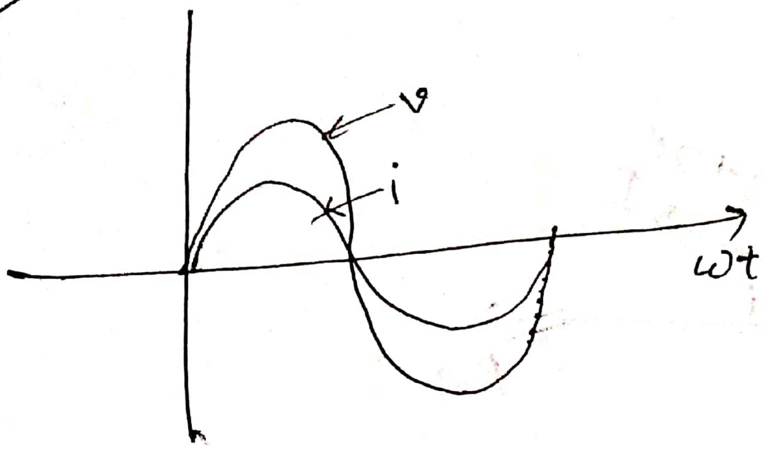
where, $V_m = I_m R$

$$\phi_v = \phi_i$$



For resistive load
The phase angle of voltage and current are equal.

time dependence



ωt phase angle একই amplitude আলাদা

For Inductive load :

$$V_L = j\omega L I$$
$$= j\omega L I_m \angle \phi_i$$
$$= 1\angle 90^\circ \, \omega L I_m \angle \phi_i$$
$$= \omega L I_m \angle \phi_i + 90$$
$$= V_m \angle \phi_v$$

$j = 1\angle 90^\circ$

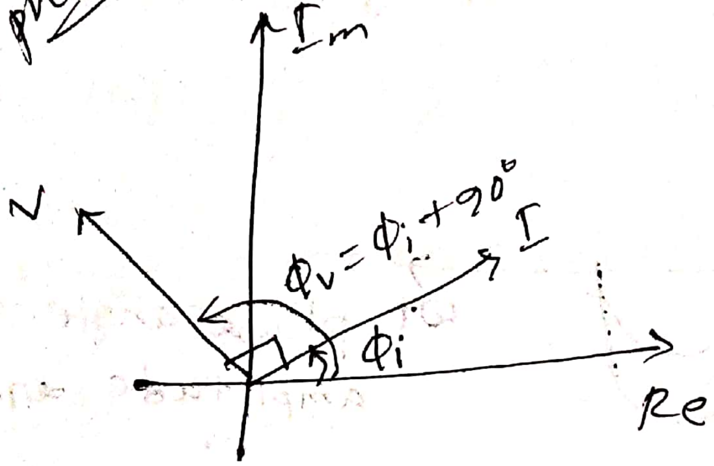
where, $V_m = \omega L I_m$

& $\phi_v = \phi_i + 90$

এখানে voltage এবং current এর phase angle একই না।

এখানে voltage leading
current lagging

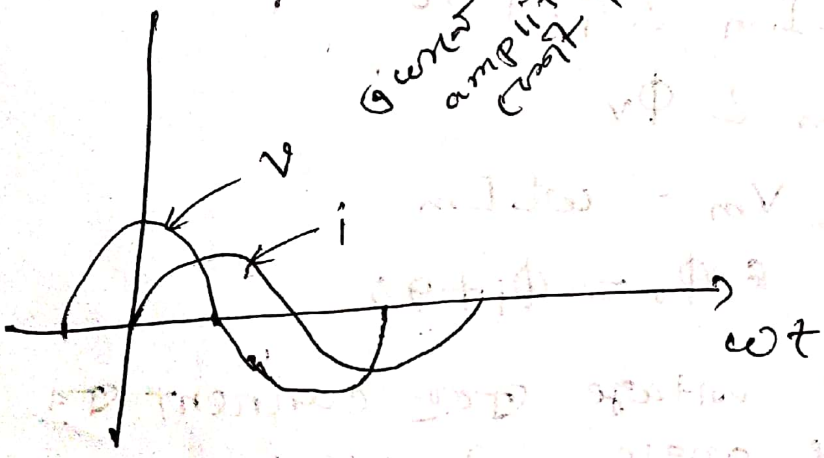
phasor



anticlockwise,
For Inductive load voltage leads current by 90° or current lags voltage by 90°

anticlockwise
যেটা ঘুরে
আগে সেটি
lead

এখানে v এর amplitude বেশি।



voltage 90° আগে শুরু হবে।

For capacitive load:

$$V_c = \frac{I}{j\omega C}$$

$$= \frac{I_m \angle \phi_i}{j\omega C}$$

$$= \frac{I_m \angle \phi_i}{1\angle 90^\circ \omega C}$$

$$= \frac{I_m}{\omega C} \angle \phi_i - 90^\circ$$

$$= V_m \angle \phi_v$$

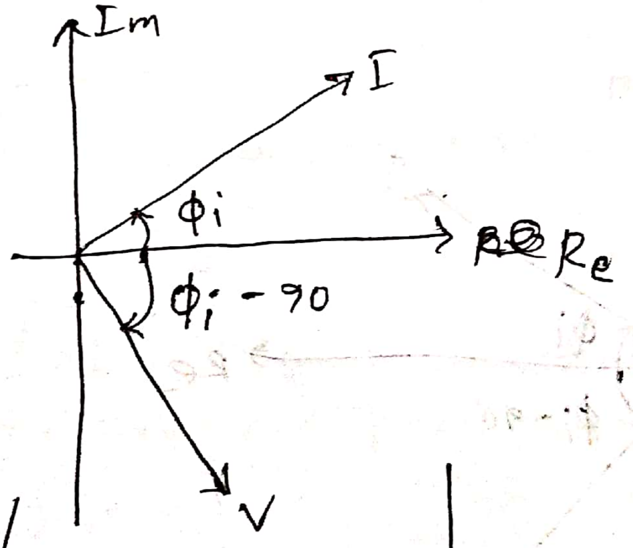
$$\frac{1}{j} = -j$$

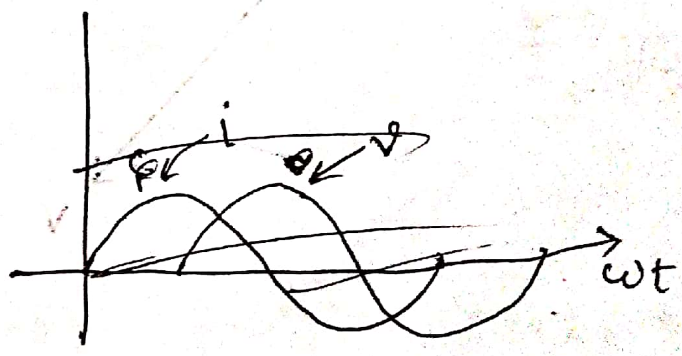
$$-j = 1\angle -90^\circ$$

where, $V_m = \frac{I_m}{\omega C}$ → peak value

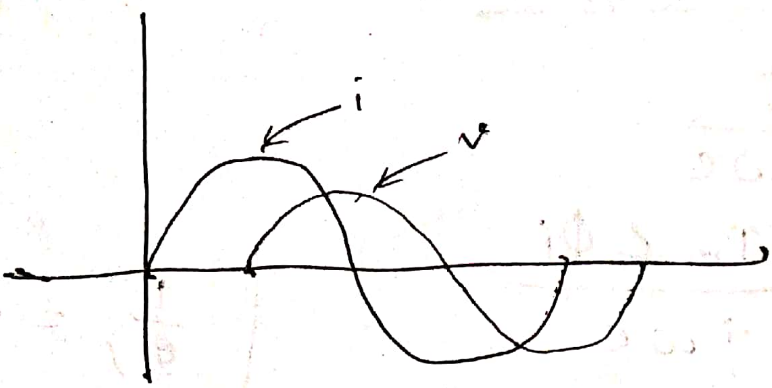
$\phi_v = \phi_i - 90$

phasor





ঘুরবে anticlockwise
I আগে ঘূর্ণন হচ্ছে।
তাই I হচ্ছে leading



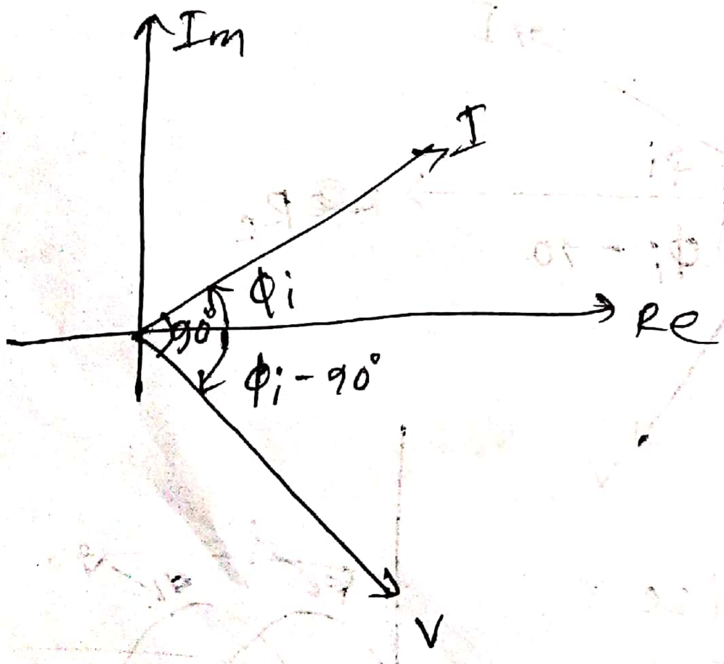
এখানে i এর amplitude বেশি

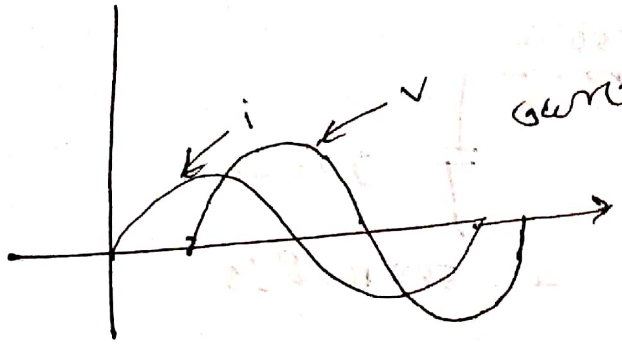
For capacitive load:

$$V = \frac{I_m}{\omega C} \angle \phi_i - 90^\circ$$

$$= V_m \angle \phi_v$$

where, $\phi_v = \phi_i - 90^\circ$



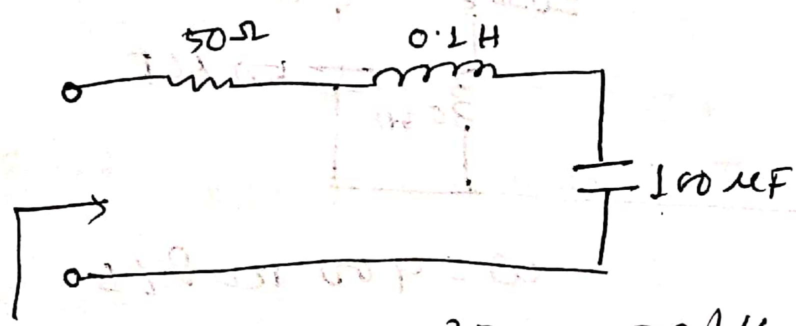


Current, ~~voltage~~ amplitude ইকুয়াল দেওয়া আছে

v এর চেয়ে i কোণে দিকে অগ্রবর্তী আছে।

6(D)-day 29-09-19

Equivalent Impedance



$Z_{eq} = ?$ $\qquad \omega = 500$ rad/s

Impedance এর একক Ω

Inductor এর বেলায় $j\omega L$ = impedance

For resistor, $\frac{V}{I} = R\ \Omega$

Inductor, $\frac{V}{I} = j\omega L\ \Omega$

Capacitor, $\frac{V}{I} = \frac{1}{j\omega C}\ \Omega$

$0.1\ H \Rightarrow j\omega L$

$= j \times 500 \times 0.1$

$= j\, 50\ \Omega$

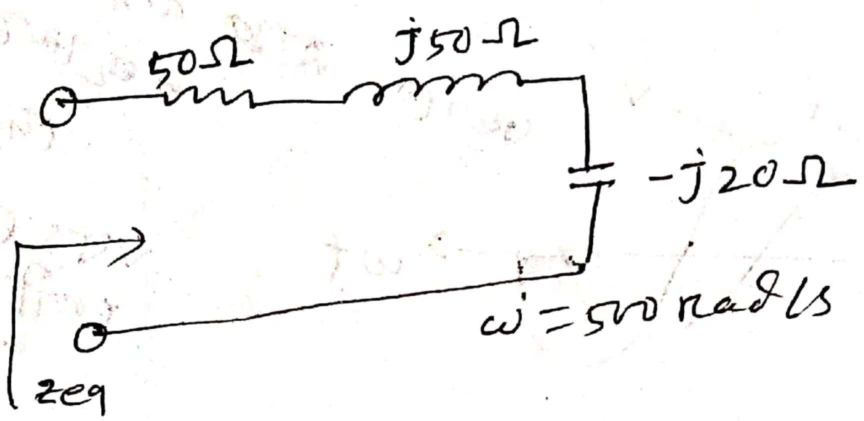
Inductor ও capacitor এর ক্ষেত্রে angular velocity এর উপর depend করে।

$100\ \mu F \Rightarrow \frac{1}{j\omega C}$

$= \frac{1}{j \times 500 \times 100 \times 10^{-6}}$

$= -j\, 20\ \Omega$

$\frac{1}{j} = -j = 1\angle -90^\circ$



$\therefore Z_{eq} = 50 + j50 - j20$

$= 50 + j30\ \Omega$

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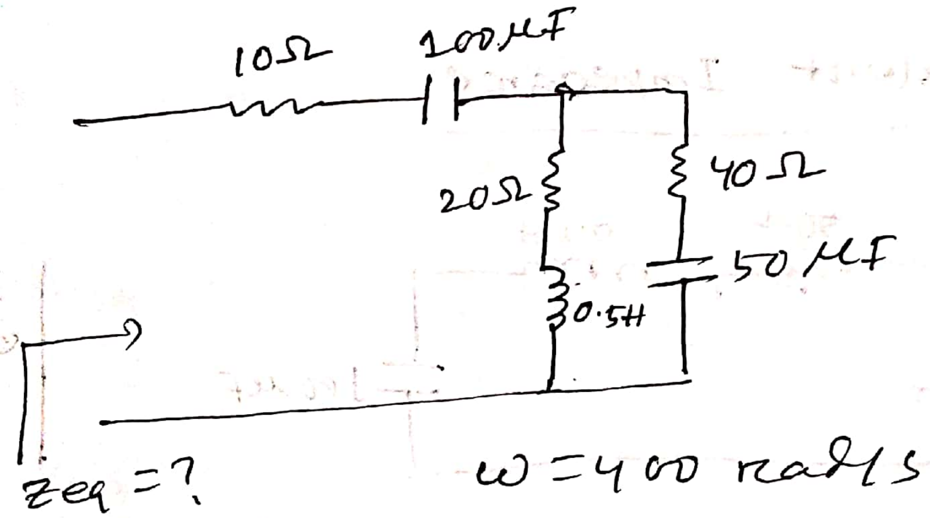


equivalent impedance = ?

$100\,\mu F \Rightarrow \frac{1}{j\omega C}$

$= \frac{1}{j \times 400 \times 100 \times 10^{-6}}$

$= -j25\ \Omega$

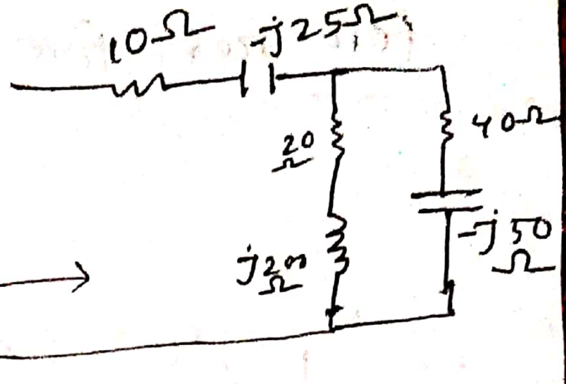
$50\,\mu F \Rightarrow \frac{1}{j \times 400 \times 50 \times 10^{-6}}$

$= -j50\ \Omega$

$0.5\,H \Rightarrow j\omega L$

$= j \times 400 \times 0.5$

$= j200\,\Omega$



$\therefore 40 + (-j50)$

$= 40 - j50$

$\therefore 20 + j200$

$z_{eq} = 10 - j25 + (20 + j200) \,||\, (40 - j50)$

$\therefore \cancel{\dfrac{1}{20+j200}} + \dfrac{1}{40 - j50}$

$10 - j25 + \dfrac{(20+j200)(40-j50)}{20+j200+40-j50}$

$= 75.05 - j70.97\ \Omega$

shift দেবে আবার equal দেখাতে হবে

Instantaneous power

$v(t) = V_m \cos(\omega t + \phi_v)$

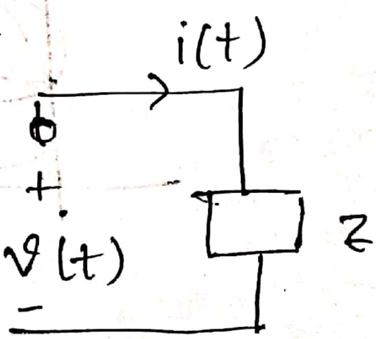
$i(t) = I_m \cos(\omega t + \phi_i)$

$p(t) = v(t) \cdot i(t)$

$= V_m I_m \cos(\omega t + \phi_v) \cos(\omega t + \phi_i)$

$= \frac{1}{2} V_m I_m [\cos(\phi_v - \phi_i) + \cos(2\omega t + \phi_v + \phi_i)]$

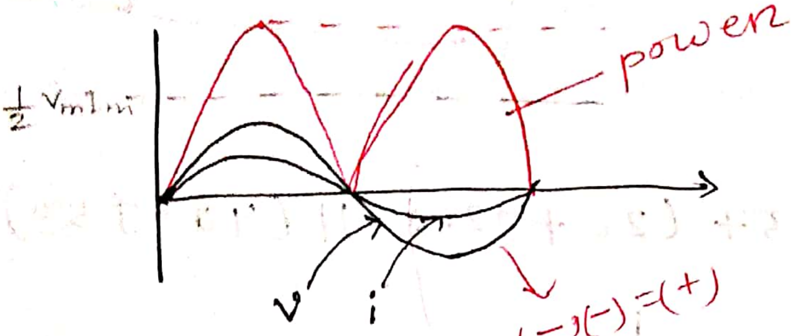
$\cos A \cos B = \frac{1}{2}[\cos(A-B) + \cos(A+B)]$



$$= \frac{1}{2}V_m I_m \cos(\phi_v - \phi_i) + \frac{1}{2}V_m I_m \cos(2\omega t + (\phi_v + \phi_i))$$

angular frequency 2ω (দ্বিগুণ)

<u>For resistive load</u>

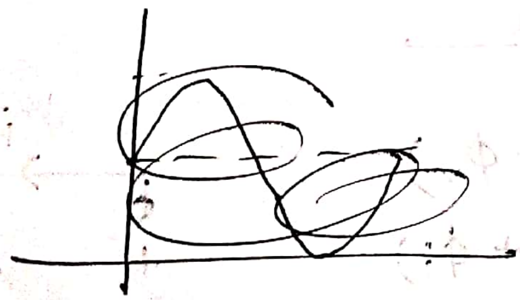


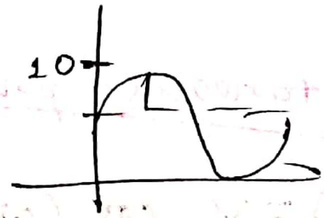
power এর frequency voltage এর current এর দ্বিগুণ

v এবং i এর এক cycle = power এর 2 cycle

For resistive load $(\phi_v - \phi_i) = 0$

#1 $5 + 5 \sin \omega t$





7(c) - day
12-10-19

Instantaneous power:

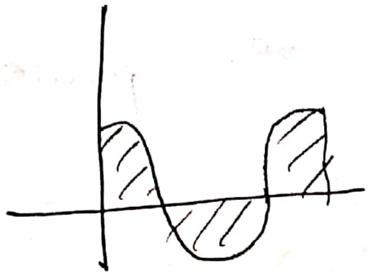
$$P(t) = \frac{1}{2} V_m I_m \cos(\phi_v - \phi_i) + \frac{1}{2} V_m I_m \cos(2\omega t + \phi_v + \phi_i)$$

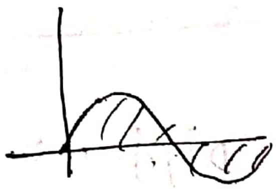
$$P_{av} = \frac{1}{T}\int_0^T p(t)\,dt$$

$$= \frac{1}{T}\int_0^T \frac{1}{2} V_m I_m \cos(\phi_v - \phi_i)\,dt + \frac{1}{T}\int_0^T \frac{1}{2} V_m I_m \cos(2\omega t + \phi_v + \phi_i)\,dt$$

$$= \frac{1}{2} V_m I_m \cos(\phi_v - \phi_i) + 0$$

$$= \frac{1}{2} V_m I_m \cos(\phi_v - \phi_i)$$





উপরের ও নিচের area সমান। তাই যোগ (integrate) করলে 0 হবে।

∴ Average power,

$$P_{av} = \frac{1}{2} V_m I_m \cos(\phi_v - \phi_i)$$

where,

$V_m \rightarrow$ peak value of voltage

$I_m \rightarrow$ peak value of current

ϕ_v = phase angle of voltage

ϕ_i = phase angle of current

এখন

$\cos(\phi_v - \phi_i) \rightarrow$ power factor

Power factor is the cosine of the difference between phase angle of the voltage and current.

power factor এর minimum value হচ্ছে zero.

" " " maximum " " 1.

power factor Negative হতে না।

<u>For resistive load:</u>

$\phi_v = \phi_i$

So, power factor $= \cos 0°$ | phase angle একই।

$= 1$

<u>For capacitive and inductive load:</u>

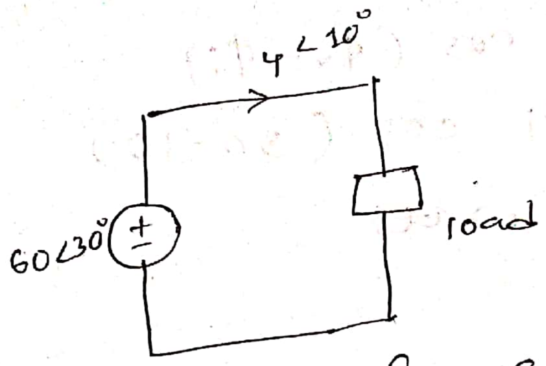
Difference between the phase angle of voltage and current is $90°$.

$\phi_v \sim \phi_i = 90°$

$\therefore$ power factor $= \cos 90°$

$= 0$

#



find i) load impedance
ii) power absorbed by load

Ans

load impedance, $Z = \frac{V}{I}$

$= \frac{60\angle 30°}{4\angle 10°}$

$= 15\angle 20$

$= 14.09 + j5.13\,\Omega$

impedance কে সব সময় rectangular এ প্রকাশ হয়। $(x+iy)$

current এবং voltage কে সব সময় polar এ প্রকাশ হয়।

power absorb এবং average power একই কথা।

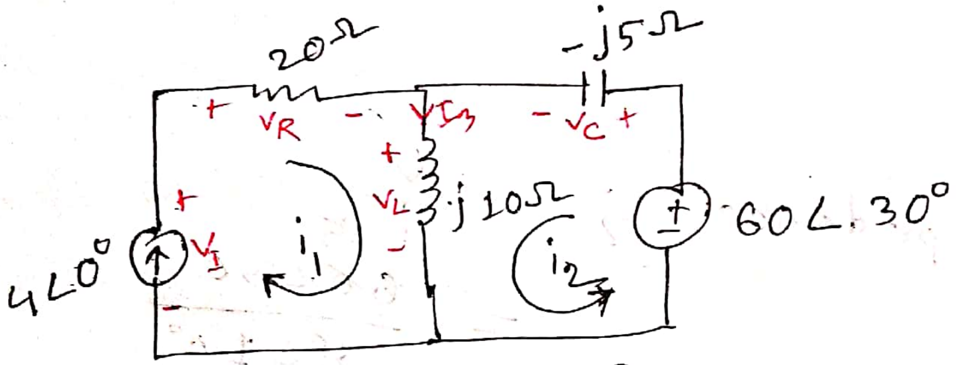
ii)

$\phi_v = 30°$

$\phi_i = 10°$

$$P_{av} = \frac{1}{2} V_m I_m \cos(\phi_v - \phi_i)$$
$$= \frac{1}{2} \times 60 \times 4 \cos(30 - 10)$$
$$= 112.76 \text{ watt}$$

#



প্রত্যেক element কতটুকু power absorb করছে তা বের কর।

voltage এবং current জানতে হবে।

KVL [mesh analysis] করতে হবে।

$$I_1 = 4\angle 0^\circ$$

$$-60\angle 30^\circ - j5I_2 + j10(I_2 + I_1) = 0$$
$$\Rightarrow -60\angle 30^\circ + j5I_2 + j10I_1 = 0$$
$$\Rightarrow j5I_2 = 60\angle 30^\circ - j10I_1$$

$\Rightarrow \cancel{I_2 = 11.93\angle -99.04^\circ}$

$\Rightarrow I_2 = 10.58\angle -100.89^\circ$

$I_3 = I_1 + I_2 = 4\angle 0^\circ + 10.58\angle -100.89^\circ$

$\cancel{= 14.58\angle -100.89^\circ}$

$= 10.58\angle -79.11^\circ$

\# Inductor, capacitor এবং resistors are called passive element.

\# voltage and current sources are called active element.

voltage এর বড় অংশের যেদিক দিয়ে current ঢুকবে সেদিকে (+ve) ধরব।

$V_R = 20 I_1$

$= 20 \times 4\angle 0^\circ$

$= 80\angle 0^\circ$

$V_C = -j5\, I_2$

$= -j5 \times 10.58\angle -100.89^\circ$

$= 52.9\angle 169.11^\circ$

$V_L = j10\, I_3$

$= j10 \times 10.58\angle -79.11^\circ$

$= 105.8\angle 10.9^\circ$

Applying KVL at mesh-1

$V_I = V_R + V_L$ / $V_I = V_R - V_C + 60\angle 30^\circ$

$= 80 + 105.8 \angle 10.9^\circ$

$= 184.97 \angle 6.21^\circ$

$P_R = \frac{1}{2} \times 80 \times 4 \cos(0^\circ - 0^\circ)$

$= 160$ W

$P_L = \frac{1}{2} \times 105.8 \times 10.58 \cos(10.9 + 79.11^\circ)$

$= 0$

$P_C = \frac{1}{2} \times 52.9 \times 10.58 \times \cos(169.11 + 100.89)$

$= 0$

$P_V = (-)\frac{1}{2} \times 60 \times 10.58 \cos(30 + 100.89^\circ)$ | P_V = Power absorbed by voltage source

$= 207.77$ W

current (I_2) (−) দিয়ে বুঝায়

$P_I = (-)\frac{1}{2} \times 184.97 \times 4 \cos(6.21 - 0^\circ)$

$= (-)367.77$ W

current (−) দিয়ে বুঝায়

তাই power supply দিচ্ছে

voltage source power absorb করছে

current " " supply "

power absorb এবং power supply সমান হবে।

13-10-19
7(D)-day

Average power / real power → normally power বলতে বুঝায়

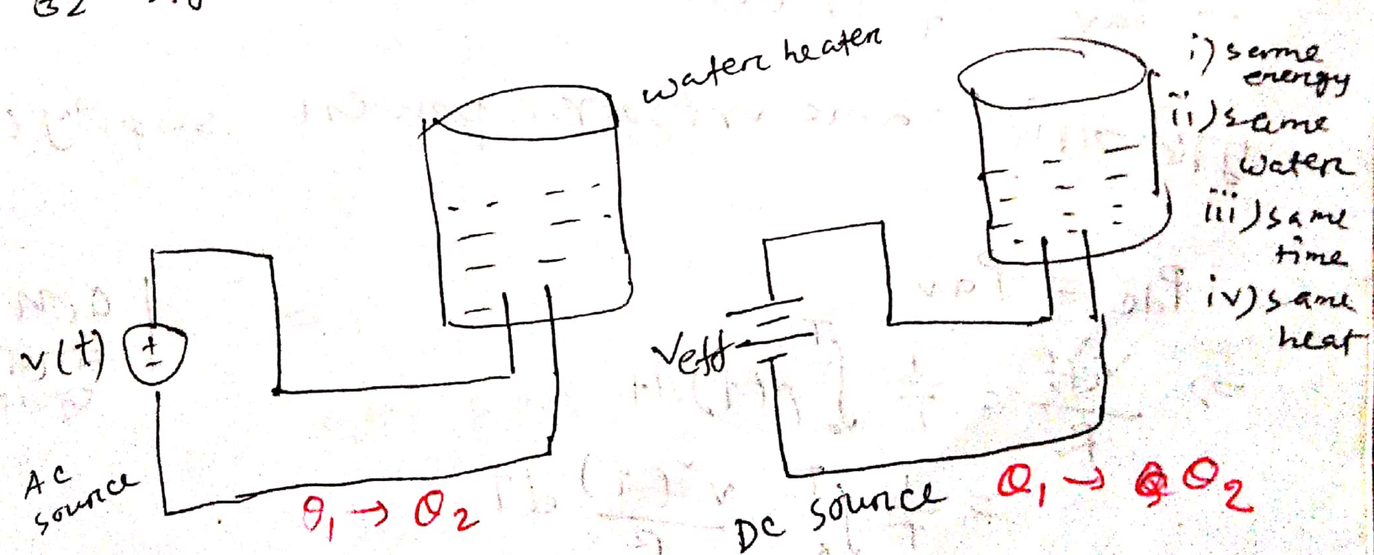
AC ও DC এর Node ও Mesh Analysis একই, শুধু এগুলো জানতে হবে।

EX-10.1-10.4

practice problem - 10.1-10.4
দুটি করে node Analysis এবং Mesh Analysis ([illegible]) আসবে

একই জিনিস

RMS value: Root Mean square (effective value)
একটি signal এর RMS value বলতে বুঝায় ওই signal DC equivalent value.



দুইটিতে পানির পরিমাণ সমান

হিট + সময়

ধরো ই 20°C → 100°C নেবো

একই পরিমাণ energy supply দিচ্ছে source দুটি।

∴ DC এবং AC হচ্ছে equivalent (সমান)

DC source হচ্ছে AC source এর effective

AC signal এর DC equivalent হচ্ছে V_{eff} value.

For DC source,

$$P_{dc} = \frac{V_{eff}^2}{R}$$

For AC source,

$$p(t) = \frac{v^2(t)}{R}$$

↓

intantaneous power

AC এর ক্ষেত্রে power এর জন্য Average power

$$\therefore P_{av} = \frac{1}{T}\int_0^T p(t)\,dt$$

দুটি যদি same পরিমাণ power supply দেয়,

$$P_{dc} = P_{av}$$

$$\Rightarrow \frac{V_{eff}^2}{R} = \frac{1}{T}\int_0^T p(t)\,dt$$

$$= \frac{1}{T}\int_0^T \frac{v^2(t)}{R}\,dt$$

0 থেকে T পর্যন্ত এক cycle

$$\Rightarrow v_{eff}^2 = \frac{1}{T}\int_0^T v^2(t)\,dt$$

$$\Rightarrow v_{eff} = \sqrt{\frac{1}{T}\int_0^T v^2(t)\,dt}$$

↳ AC signal {v(t)}

এটি হচ্ছে কোনো একটি signal এর effective value বের করার process.

v_{eff} value মানে DC ~~eff~~ equivalent

So, the RMS value of $x(t)$

$$X_{rms} = X_{eff} = \sqrt{\frac{1}{T}\int_0^T x^2(t)\,dt}$$

এটি generalise expression.

If, $x(t) = X_m \sin\omega t$

$$X_{eff} = \sqrt{\frac{1}{T}\int_0^T x^2(t)\,dt}$$

$$= \sqrt{\frac{1}{T}\int_0^T X_m^2 \sin^2\omega t\,dt}$$

$$= \sqrt{\frac{X_m^2}{2T}\int_0^T 2\sin^2\omega t\,dt}$$

$$= \sqrt{\frac{X_m^2}{2T}\int_0^T (1-\cos 2\omega t)\,dt}$$

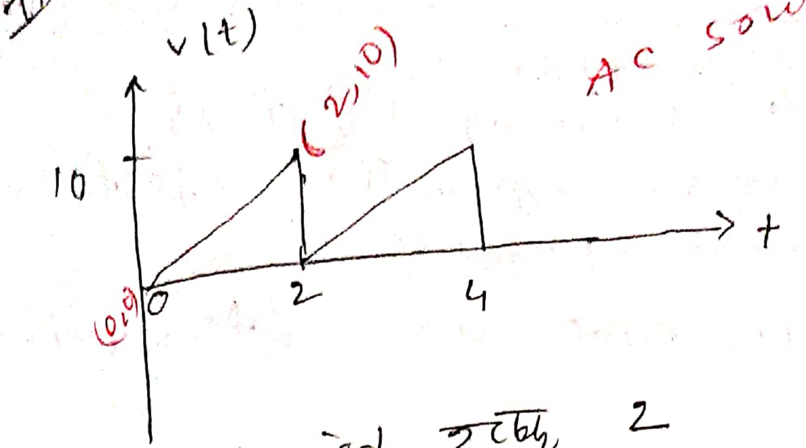
sin বা cos কে একটি cycle এ integrate করলে zero হয়

$$= \sqrt{\frac{X_m^2}{2T}(T-0)}$$

$$= \frac{X_m}{\sqrt{2}}$$

এটি RMS value বা effective value.

II



AC source

$$y = \frac{y_1 - y_2}{x_1 - x_2} = \frac{0 - 10}{0 - 2} = 5$$

এর period হচ্ছে 2

* Find the RMS value of the given signal

উপরের expression না দিলে wave form দেখে করতে। এই expression বের করতে হবে। এক cycle এ বের করতে হবে।

$y = mx$

$v(t) = 5t \quad 0 < t < 2$ | cycle করতে হবে

$$V_{rms} = \sqrt{\frac{1}{T}\int_0^T v^2(t)\,dt}$$

| এখানে পরিবর্তন v আছে

$$= \sqrt{\frac{1}{2}\int_0^2 25\,t^2\,dt}$$

$$= \sqrt{\frac{25}{2}\left[\frac{t^3}{3}\right]_0^2}$$

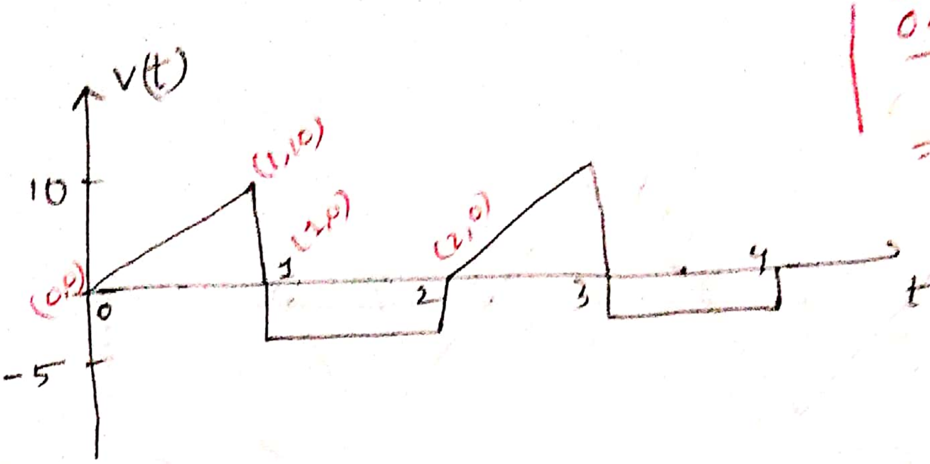
$$= \sqrt{\frac{25}{2} \times \frac{8}{3}}$$

$$= 5.773$$

(DC source)

5.773 মানে DC source এ power supply দেয়, AC source ও একই power supply দেয়

A



১ম রেখা, $0<1<t$,

$$y-y_1 = \frac{y_1-y_2}{x_1-x_2}(x-x_1)$$

$$\Rightarrow v-0 = \frac{0-10}{0-1}(t-0)$$

$$\Rightarrow v = 10t$$

২য় রেখা,

$$y-0 = \frac{0-0}{1-2}(x-1)$$

$$\Rightarrow y = 0$$

x অক্ষের সমান্তরাল

এর period 2 (0 থেকে 2 পর্যন্ত একটি period)

$$v(t) = \overset{y=mx}{10t} \qquad 0<t<1$$

$$= \overset{y=b}{-5} \qquad 1<t<2$$

(x অক্ষের সমান্তরাল সমীকরণ)

প্রতি 2টিতে একটা cycle এর মধ্যে expression.

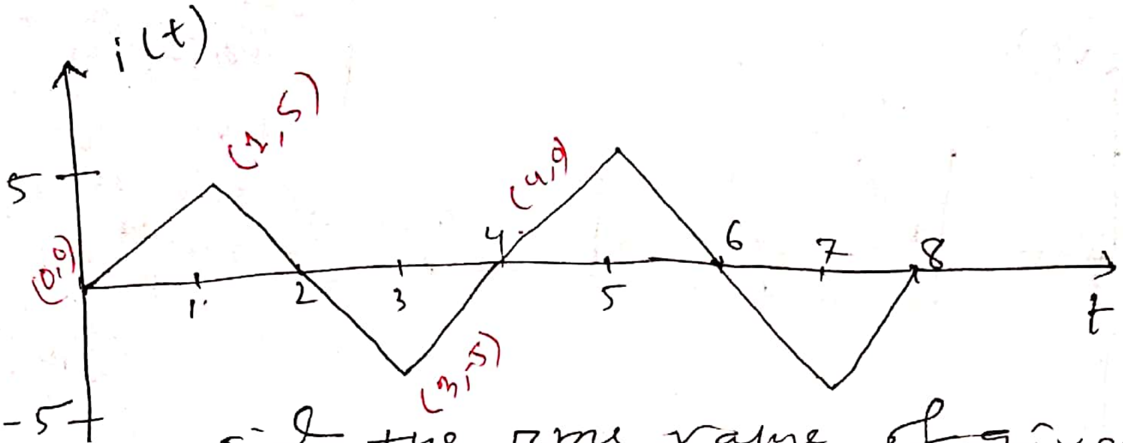
$$V_{rms} = \sqrt{\frac{1}{T}\int_0^T v^2(t)\,dt}$$

$$= \sqrt{\frac{1}{2}\int_0^2 v^2(t)\,dt}$$

$$= \sqrt{\frac{1}{2}\left[\int_0^1 (10t)^2 dt + \int_1^2 (-5)^2 dt\right]}$$

$$= \sqrt{\frac{1}{2}\left[100\frac{t^3}{3}\right]_0^1 + [25T]_2^1}$$

$$= \sqrt{\frac{1}{2}\left[100\ \cancel{6}\ \frac{1^3}{3}\right] + 25(2-1)}$$



Find the rms value of given signal

এখানে period হচ্ছে 0 থেকে 4 পর্যন্ত।

$\therefore T = 4$

এখানে 0 থেকে 4 এর মধ্যে function expression করলাম,

$i(t) = 5t \qquad 0 < t < 1$

$= -5t + 10 \qquad 1 < t < 3$

$= 5t - 20 \qquad 3 < t < 4$

$-5t + 10$

↓

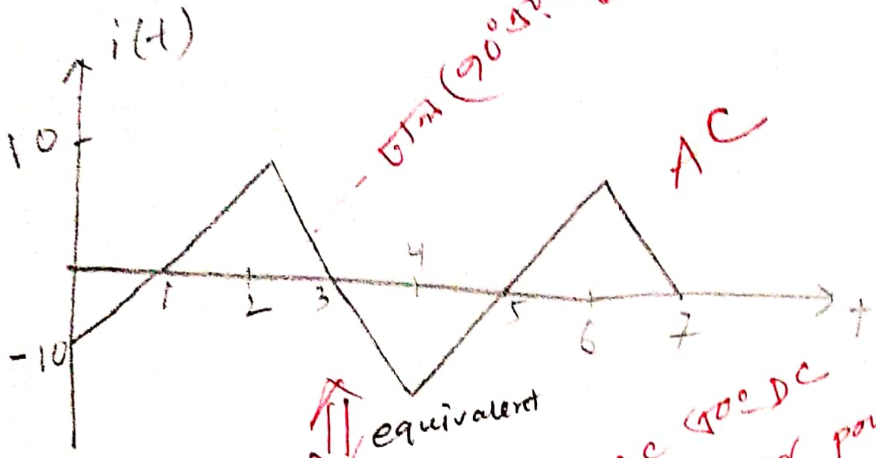
t = 2 বসালে শূন্য হয়, t = 0 থেকে বসালে, i এর মান 10 আসে তাই 2~

$$I_{eff} = \sqrt{\frac{1}{T}\int_0^T i^2(t)\,dt}$$

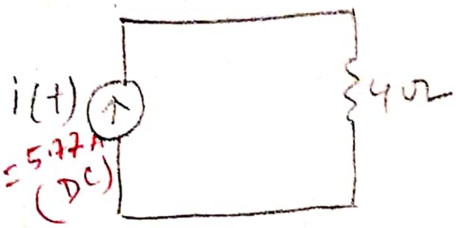
$$= \sqrt{\frac{1}{4}\left[\int_0^1 (5t)^2 dt + \int_1^3 (-5t+10)^2 dt + \int_0^4 (5t-20)\,dt\right]}$$

7(E)-Day

14-10-19



⇕ equivalent



AC এবং DC same পরিমাণ power supply দিবে

4Ω resistor কতটুকু power absorb করবে।
কারণ source কতটুকু power supply দিবে 4Ω resistor এ ?

Irms বের করতে হবে।

$T = 4$

$t = 1$ এ $i = 0$

সমীকরণ, $y-(-10) = \frac{-10-10}{0-2}(x-0)$
$\Rightarrow y+10 = 10x$
$\Rightarrow y = 10x-10$
$\Rightarrow i(t) = 10t-10$

$$i(t) = 10t - 10 \qquad 0 < t < 2$$
$$= -10t + 30 \qquad 2 < t < 4$$

$$I_{rms} = \sqrt{\frac{1}{T}\int_0^T i^2(t)\,dt}$$
$$= \sqrt{\frac{1}{4}\left[\int_0^2 (10t-10)^2\,dt + \int_2^4 (-10t+30)^2\,dt\right]}$$
$$= \sqrt{\frac{1}{4}(66.67 + 66.67)}$$
$$= 5.77\,A$$

$P = I_{rms}^2 R$ | $P = \frac{V^2}{R}$ — voltage দেওয়া থাকলে

$= 5.77^2 \times 4$

$= \ldots W$

এই related pb গুলো দেখে রাখতে হবে।

টিচার বলেছে অবশ্যই একটা pb পরীক্ষায় আসবে।

(chapter - 11)

Apparent power:

$$S = \frac{1}{2} V_m I_m$$

$$= \frac{V_m}{\sqrt{2}} \cdot \frac{I_m}{\sqrt{2}}$$

& Apparent power:

if, $v(t) = V_m \sin(\omega t + \phi_v)$

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

then Apparent power, $S = \frac{1}{2} V_m I_m$

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

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

Unit ~~pow~~ of apparent power is VA

এক V_{rms} এবং I_{rms} এর (ভোল্টেজ ও current) product হলো Apparent power

power factor, $pf = \cos(\phi_v - \phi_i)$

power factor এর maximum value 1
minimum " 0

resistive load এর ক্ষেত্রে power factor

capa এবং Induc

Average power or Real power,

$$P = P_{av} = \frac{1}{2} V_m I_m \cos(\phi_v - \phi_i)$$

$$\Rightarrow P = S \times pf$$

$$\Rightarrow pf = \frac{P}{S}$$

pf বেশি হলে, ~~App~~ Apparent power এর তত বেশি অংশকে real power এ convert করতে পারবে

complex power:

প্রশ্ন অনেকবার এসেছে

$$\underline{S} = \frac{1}{2} V I^*$$

I^* = current এর complex conjugate

The product of the phasor of voltage and complex conjugate of current is complex power.

$$= \frac{1}{2} V_m \angle \phi_v \; I_m \angle -\phi_i$$

$$= \frac{1}{2} V_m I_m \angle \phi_v - \phi_i$$

$$= \frac{1}{2} V_m I_m \cos(\phi_v - \phi_i) + j \frac{1}{2} V_m I_m \sin(\phi_v - \phi_i)$$

$$= \underset{\substack{\downarrow \\ \text{real power}}}{P} + jQ$$

where, $P \rightarrow$ Real power / average power

$Q \rightarrow$ Reactive power

for resistive load,

$\phi_v - \phi_i = 0^\circ$ এক্ষেত্রে reactive power থাকবে না।

inductive অথবা capacitive load,

$\phi_v - \phi_i = 90^\circ$

এ ক্ষেত্রে Reactive power থাকবে

unit of Real power = watt

" Reactive power = VAR $\longrightarrow$ volt ampere reactive

" " complex " = VA

Impedance:

$$\text{Impedance}, Z = \frac{V}{I}$$

$$= \frac{V_m \angle \phi_v}{I_m \angle \phi_i}$$

$$= \frac{V_m}{I_m} \angle \phi_v - \phi_i$$

$$= \frac{V_m/\sqrt{2}}{I_m/\sqrt{2}} \angle \phi_v - \phi_i$$

$$= \frac{V_{rms}}{I_{rms}} \angle \phi_v - \phi_i \;\; \Omega$$

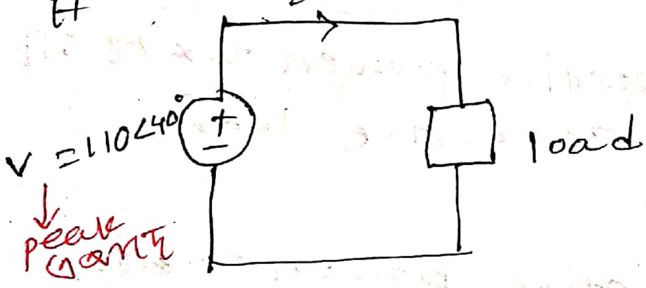
$$\Rightarrow \boxed{Z = \frac{V_m}{I_m} \angle \phi_v - \phi_i = \frac{V_{rms}}{I_{rms}} \angle \phi_v - \phi_i}$$

I_m: এগুলো peak value

I_{rms}: rms value

Impedance এর একক Ω।

$I = 2 \angle 30^\circ$ (rms) — rms দেওয়া



find, (i) load impedance, Z

(ii) Apparent power

(iii) Real and reactive power

(iv) complex power

(v) power factor, pf

দুটোকেই rms / দুটোকেই peak value তে আগে নিয়ে যেতে হবে।

Z এর value rectangular format এ লিখতে হবে (Ans এ)

~~i) $Z = \frac{V}{I} = 55.67$~~

i) $13.30 + j\,36.92\ \Omega$

Apparent power $= \frac{1}{2} V_m I_m$
অথবা $V_{rms} \cdot I_{rms}$

~~153~~

i) $V_{rms} = \frac{110}{\sqrt{2}} \angle 40^\circ$

$=$

$Z = \frac{110}{\sqrt{2}} \angle 40 + 30^\circ$

$= 38.89 \angle 70$ — polar

$= 13.30 + j\,36.92$ — reactangular

এই type এর অনেক pb পরীক্ষায় আসবে

Example 11.9 - 11.12 practice pb

11.9 - 11.12 পর্যন্ত ভালোভাবে related pb পড়তে হবে।

ii) Apparent power. $= \frac{1}{2} V_m I_m$

$= \frac{1}{2} \times 110 \times 2\sqrt{2}$

$= 155.56$

Syllabus: AC থেকে rms এর আগে পর্যন্ত

8(c) - day
19-10-19 (রেকর্ড [illegible] procee class)

power factor correction:

Power factor correction is a process ~~the pro~~ by which the power factor of the system can be improved without changing the original load current or voltage.

$P_{av} = S \times pf$ $\quad$ $pf = \cos(\phi_v - \phi_i)$

$S = \dfrac{P_{av}}{pf}$ $\quad$ S = apparent

$L_1 = 100\ W,\ pf = 0.9$

$L_2 = 100\ W,\ pf = 0.5$

Real power same

ধরি, voltage = 220 V (rms)

$P = V_{rms} I_{rms} \cos(\phi_v - \phi_i)$

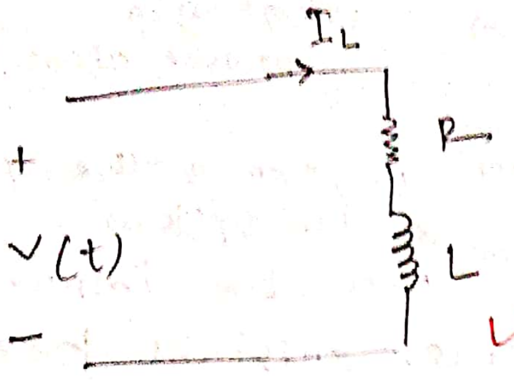
$= V_{rms} I_{rms}\, pf$

$I_{rms_1} = \dfrac{100}{220 \times 0.9} = 0.505\ A$ ~~(rms)~~ (rms)

$I_{rms_2} = \dfrac{100}{220 \times 0.5} = 0.91\ A$ ~~(rms)~~ (rms)

i^2R loss হবে

pf বেশী হলে লাইনের কারেন্ট কম হবে।

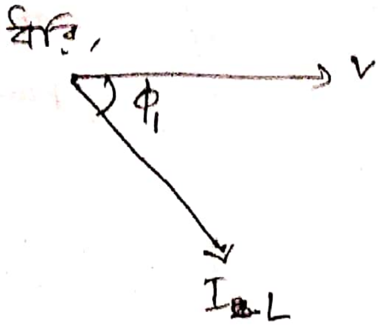


reactive power ভোগ করে

L এর reactive power (+ve)

inductor অনেক angle 90° হবে। V থেকে পিছিয়ে থাকে

যদি,



$R + j\omega L$

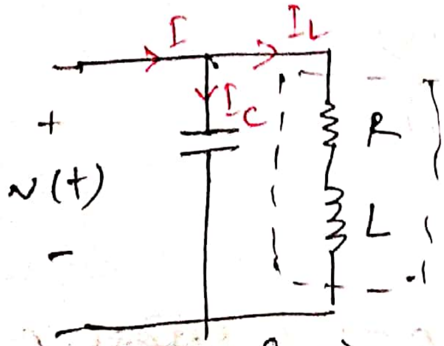
$\tan^{-1}\frac{\omega L}{R}$

সুতরাং $\tan^{-1}\frac{\omega L}{R}$

$R = 0$ হলে

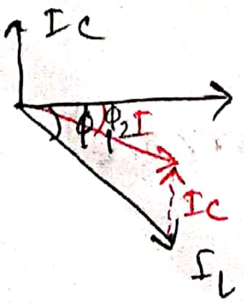
$\tan^{-1}(\infty) = 90$

reactive power যোগান দেয় capacitor এর reactive power (−ve)



modified circuit

capacitor current voltage কে lead করে।



Total current $= I_C + I_L$

ϕ_2 কমা মানে pf বাড়বে।

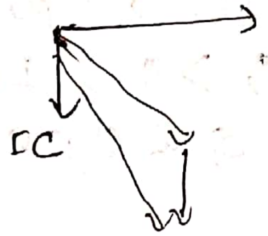
pf বাড়ানোর জন্য capacitor লাগানো হয়েছে

original $pf = \cos\phi_1$

new $pf = \cos\phi_2$

power factor সংশোধনের জন্য ক্যাপাসিটরের value বের করেছি।

Inductor দিলে,



Inductor এর ক্ষেত্রে,

$$R + j\omega L = r\angle\phi$$

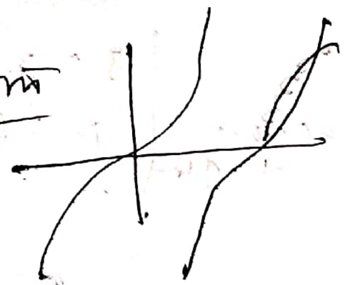
$$r = \sqrt{R^2 + (\omega L)^2}$$

$$\phi = \tan^{-1}\frac{\omega L}{R}$$

If, $R = 0$, $\phi = 90^\circ$

∴ R এর কোনো real মান না থাকলে $\phi = 90^\circ$ এর মত হয়ে যায়।

tan এর গ্রাফ



Reactive power:

$$Q = V_{rms} I_{rms} \sin(\phi_v - \phi_i)$$

$$= S \sin(\phi_v - \phi_i)$$

| $\frac{1}{2} V_m I_m$ অথবা $V_{rms} I_{rms}$ একই কথা

For resistive load,

$Q = 0$

for resistive load,

| $\phi_v - \phi_i = 0$

$\sin 0 = 0$

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For inductive load,

$Q = S$

For capacitive load,

$Q = -S$

$\therefore$ $Q = 0$, resistive

$Q > 0$, Inductive

$Q < 0$, capacitive

complex power,

$\underline{S} = P + jQ$

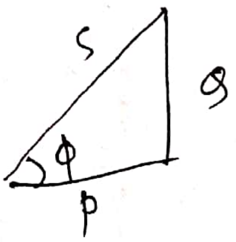
apparent power, $S = V_{rms} I_{rms} = \sqrt{P^2 + Q^2}$

~~complex p=~~

~~$P_{rms} = \quad \cos(\phi_v - \phi_i)$~~

$Q = P_{rms} I_{rms} \sin(\phi_v - \phi_i)$

$P = P_{rms} I_{rms} \cos(\phi_v - \phi_i)$



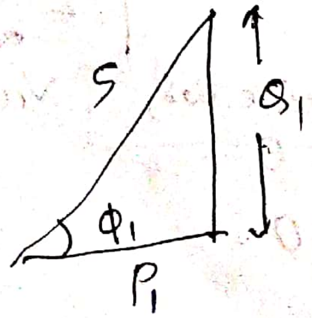
ϕ = power factor angle

$P = S \cos \phi$

$Q = S \sin \phi$

এখানে,

ϕ মানে $\phi_v - \phi_i$

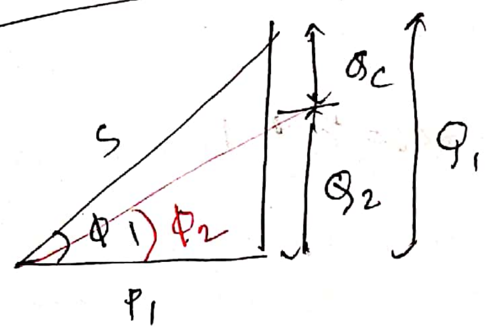


১ম figure

$Q_1 = P_1 \tan \phi_1$

সূত্রেও প্রশ্ন আসতেপারে

2nd figure



real power same থাকবে
reactive ,, কমাবো।
apparent power =

$Q_2 = P_1 \tan\phi_2$

$Q_c = Q_1 - Q_2$
$= P_1(\tan\phi_1 - \tan\phi_2)$

আবার,

$Q_c = \frac{V_{rms}^2}{X_c}$ | reactive power হতে পাই। main সূত্র $= \frac{V^2}{R}$

$= \frac{V_{rms}^2}{\frac{1}{\omega c}}$

$= \omega c V_{rms}^2$

$\therefore \omega c V_{rms}^2 = P_1(\tan\phi_1 - \tan\phi_2)$

$c = \frac{P_1(\tan\phi_1 - \tan\phi_2)}{\omega V_{rms}^2}$ — power factor নয়, power factor এর angle

তাহলে capacitance calculate করা যাবে।

যেখানে দিয়ে দেওয়া থাকবে $f = 50$ Hz

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chapter 11

এর এই topic
এর EX গুলো এবং অন্যান্য
1st Example practice pb করতে হবে
এবং এই সূত্র ব্যবহার করতে হবে।

AC circuit এর জন্য node এবং mesh এ তিনটি equation
এর প্রত্যেক অংশ তিনটি circuit এর
মূল সমাধান হবে, যদি ও কোনো প্রশ্ন নাই