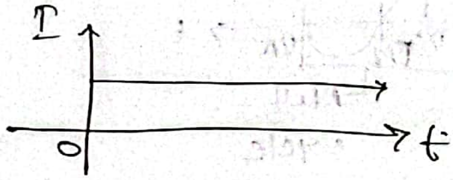
EEE

Chapter-13

SINUSOIDS AND PHASORS:

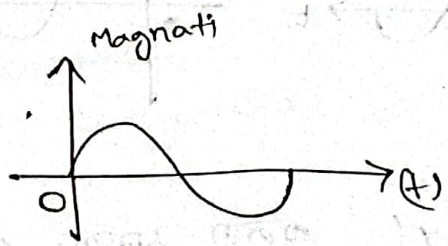
Current দুইপ্রকার,

(i) DC → Direct current



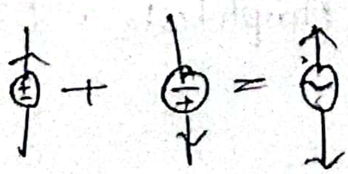
যেখানে current এর দিক পরিবর্তিত হয় না। আর যখনই current এর একটা fixed value পাই।

(ii) AC → Alternative current.

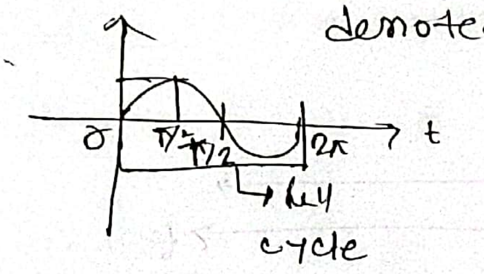


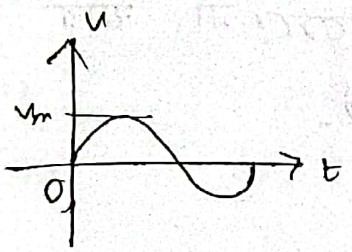
সময়ের সাপেক্ষে current এর দিক পরিবর্তন হয়, তাই আমরা current এর একটা fixed value পাই না, current কিন্তু wave এ বের পাবো

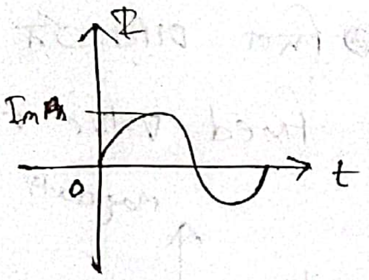
AC current এ supplier এর চিহ্ন হলো   এখানে  এমন ভাবে করে এর পর পাই  এমন ভাবে হবে। তাই AC current এ দুইদিক দিয়েই flow হয় current এর



time period: একটা full wave বা full cycle নিতে যে সময় লাগে তাকে time period বলে। denoted by T.



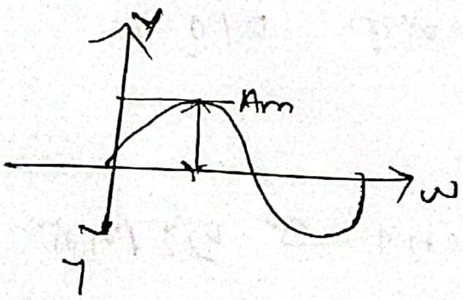




frequency! একক সময়ে যে কয়টা complete cycle শেষ করে wave তাকে frequency বলে। denoted by f.

$f = \frac{1}{t}$, $\omega \rightarrow$ angular frequency

কৌণিক কম্পাঙ্ক।



$A_m = A_{max}$

$A(t) = A_m \sin(\omega t)$

এই Amplitude টা V_{max} / I_{max} ও হতে পারে।

$V = V_m \sin\theta$

$V = V_m \sin\omega t$

$I = I_m \sin\omega t$

$\theta = \cancel{\phi}$

$\omega = \frac{\theta}{t} = \frac{2\pi}{T} = 2\pi n = \frac{2\pi N}{t}$

$\theta = \omega t$

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

$n = \frac{c}{\lambda} = \frac{v}{\lambda}$

c = আলোর বেগ

v = velocity / বেগ

λ = তরঙ্গদৈর্ঘ্য

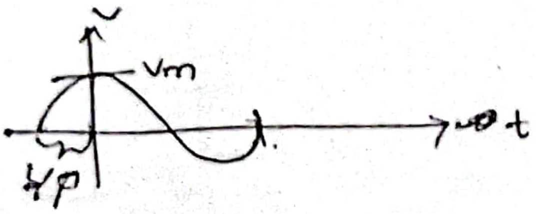
ω = কৌণিক বেগ

T = পর্যায়কাল
time period

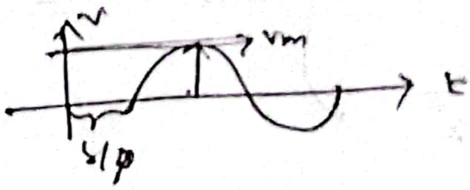
n = কম্পাঙ্ক/frequency

N = কম্পনের সংখ্যা

θ/δ = সরণ কোণ।



$V_2 = V_m \sin(\omega t + \phi)$



$V_3 = V_m \sin(\omega t - \phi)$

ϕ = zero হয় তত বাড়ে যা আগে থেকে wave টা শুরু হয়েছে

যদি zero থেকে শুরু হয় তখন $\phi = 0$।

$V(t) = \cancel{V_m}\ 12\cos(50t + 10^\circ)$

$V_m = 12$, $T = \frac{2\pi}{\omega} = \cancel{.126}\ \cancel{.128}\ .36 s$

$\omega = 50$

$\phi = 10^\circ$

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

$\sin\theta = (\omega t \pm 180^\circ) = \sin\omega t$

~~$\cos\theta = \sin$~~

$\cos(\omega t \pm 180^\circ)$

$\sin(\omega t \pm 180°) = \sin\omega t$

$\cos(\omega t \pm 180°) = -\cos\omega t$

$\sin(\omega t \pm 90°) = \pm\cos\omega t$

$\cos(\omega t \pm 90°) = \mp\sin\omega t$

rms Value and Average value of Voltage:

$V_{rms} = \dfrac{V_m}{\sqrt{2}}$

$I_{rms} = \dfrac{I_m}{\sqrt{2}}$

Sine wave

$V_{rms} = \sqrt{\dfrac{1}{T}\int_0^T V(t)\,dt}$

$V_{avg} = \dfrac{2V_m}{\pi}$

$V_{avg} = \dfrac{1}{\pi}\int_0^{\pi} V_p \sin\theta \, d\theta$

$V_{avg} = \dfrac{V_p}{\pi}\left[-\cos\theta\right]_0^{\pi} = \dfrac{2V_p}{\pi} \doteq 0.637 V_p$

$0.637 V_m$

$V_p \rightarrow$ pick value (V_{max})

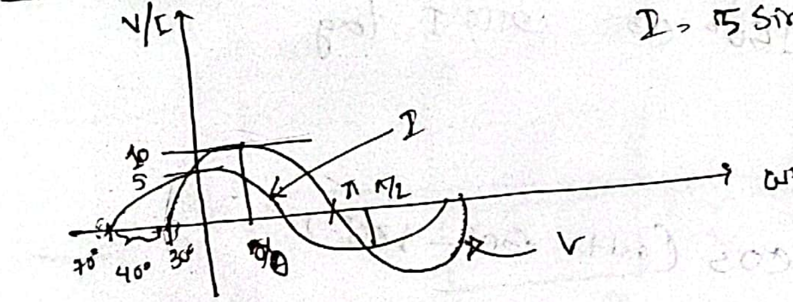
Capacitor: voltage কে change হতে দেয় না Capacitor voltage কে lag করে।

Inductor: current কে change হতে দেয় না current কে lag করে।

Capacitor,

$V = 10\sin(\omega t + 30^\circ)$

$I = 5\sin(\omega t + 70^\circ)$



I lead V by 40°, or V lags i by 40°

এখানে I এর wave V এর wave এর থেকে 40° আগে থেকে শুরু করেছে তাই ওটা lead করতেছে মানে I lead করতেছে V 40° এর পরে শুরু হয়েছে তাই ওটা lag করতেছে।

capacitor আর inductance এ lead/lag দেখা যায়।

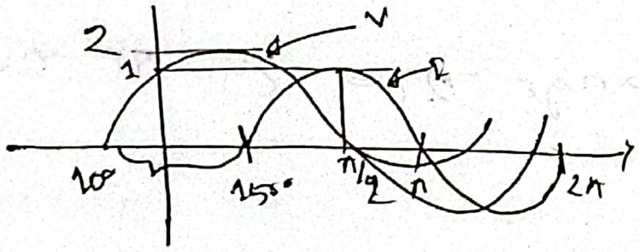
inductance:

$i = -\sin(\omega t + 30^\circ)$

$i = \sin(\omega t + 30^\circ - 180^\circ)$

$= \sin(\omega t - 150^\circ)$

$V = 2\sin(\omega t + 10^\circ)$



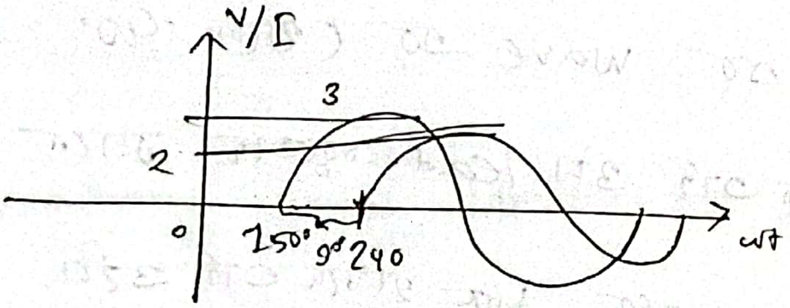
160°

এখানে V lead করেছে 160° তে আর I lag করেছে 160° তে,

$I = -2\cos(\omega t - 60^\circ) = 2\cos(\omega t - 60^\circ - 180^\circ)$

$= 2\cos(\omega t - 240^\circ)$

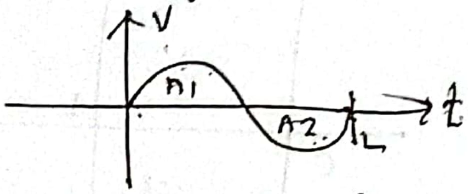
$V = 3\sin(\omega t - 150^\circ)$



phase measurement:

$$\theta = \frac{\text{phase shift (no of div)}}{T\text{(no of div.)}} \times 360^\circ$$

V_{avg} derivation; $V_{avg} = \frac{2V_m}{\pi}$ (Sinosoid হলে wave টা এভাবে অবস্থায় avg value)



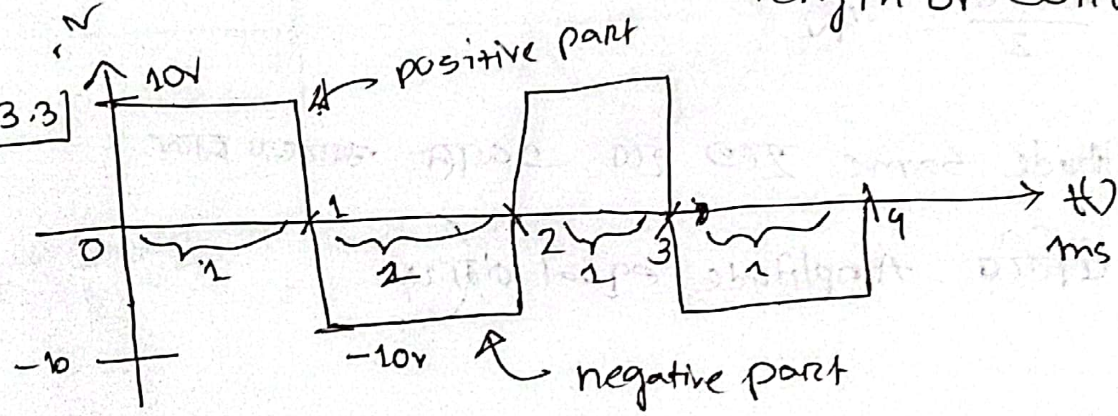
A_1, A_2 = Area

L = length

যেকোনো wave এর avg. value ৪

G (~~averag~~ average value) = $\frac{\text{algebric sum of areas}}{\text{length of curve}}$ (complete cycle)

Ex 13.3

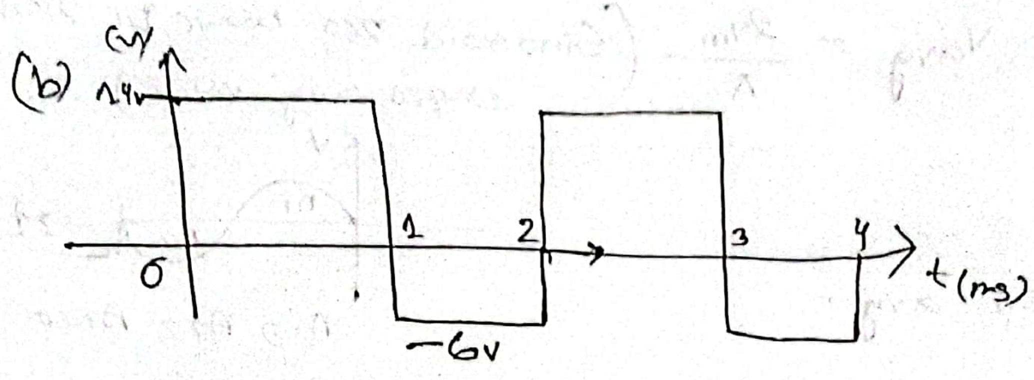


$G = \frac{(10v) \times (1ms) + (-10 \times 1)}{2}$

$= \frac{10 - 10}{2} = \frac{0}{2} = 0v$

একটা complete cycle এর area and length দিয়ে avg বের করতে হবে।

(b)



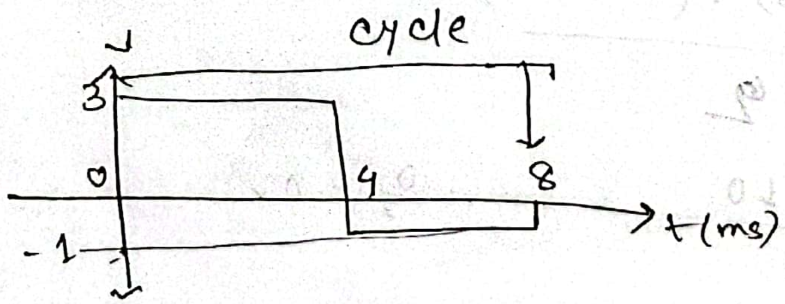
$$G = \frac{(14\times1)+(-6\times1)}{2}$$

$$= \frac{14-6}{2} = 4V$$

Amplitude same হতে হবে এখানে মাঝের মান টা থেকে উভয়ের Amplitude equal করা হয়।

Ans. $V_2 = V_1 + 24v$

13.14

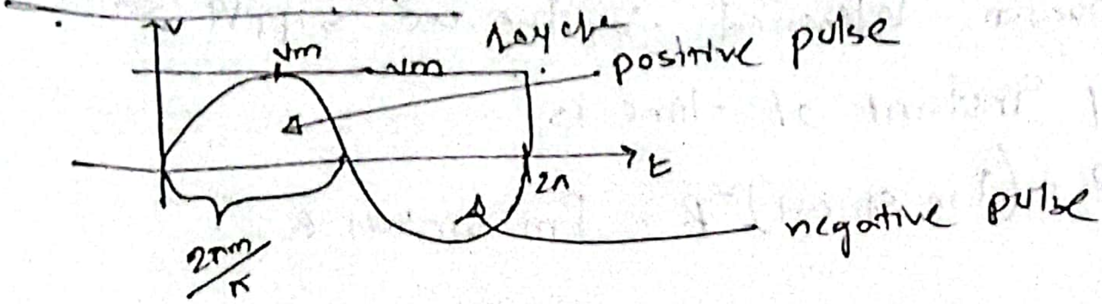


$$G = \frac{(3\times4)+(4\times-1)}{8}$$

$$= \frac{12-4}{8} = 1v$$

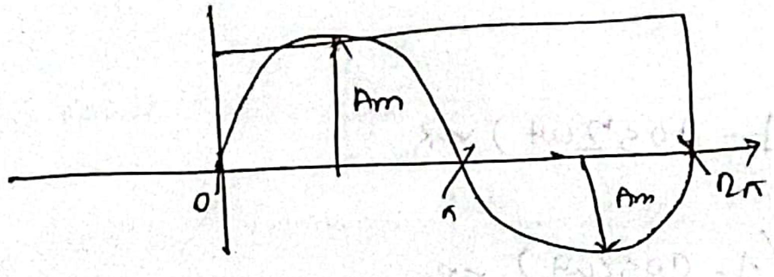
CamScanner

for sine wave:



এটার ক্ষেত্রে $Gr(avg) = \frac{2Am}{\pi} = \frac{2Vm}{\pi}$ [যেকোনো একটার pulse এর ক্ষেত্রে]

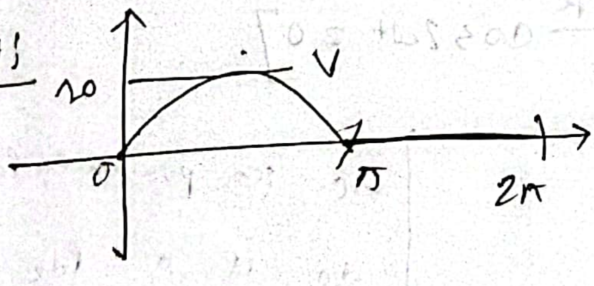
ex 13.15)



$$Gr(avg) = \frac{+2Am - 2Am}{2\pi}$$

$$= 0V$$

13.17)



$$Gr(avg) = \frac{2Am + 0}{2\pi} = \frac{\cancel{2} \times (10V)}{\cancel{2}\pi}$$

$$= \frac{10}{\pi}$$

Vav = dc = (vertical shift in div) × (vertical sensitivity in V)

RMS value / effective value

~~Proof~~ The power delivered by the ac supply at any instant of time is

$P_{ac} = (I_{ac})^2 R = (I_m \sin\omega t)^2 R = I_m^2 \sin^2\omega t \, R$

$\because \cancel{P_{av(ac)} = P_{dc}}$

$P = \frac{1}{2} I_m^2 \, 2\sin^2\omega t \times R$

$= \frac{1}{2} I_m^2 (1 - \cos 2\omega t) \times R$

$= \frac{I_m^2}{2} (1 - \cos 2\omega t) \times R$

$= \frac{I_m^2 R}{2} (1 - \cos 2\omega t)$

$P_{ac} = \frac{I_m^2 R}{2} - \frac{I_m^2 R}{2} \cos 2\omega t$

$P_{ac} = \frac{I_m^2 R}{2}$ $\left[\frac{I_m^2 R}{2} \cos 2\omega t = 0 \right]$

$P_{av(ac)} = P_{dc}$

[ac is power ~~or~~ P_{av}

dc " " P_{dc}]

$\frac{I_m^2 R}{2} = I_{dc}^2 \times R$

$\therefore \frac{I_m}{\sqrt{2}} = I_{dc}$

কোন AC circuit এর sinusoidal current or voltage

যেকোন dc equivalent ~~circuit~~ value $I_{dc} = \frac{I_m}{\sqrt{2}}$

$$V_{dc} = \frac{V_m}{\sqrt{2}}$$

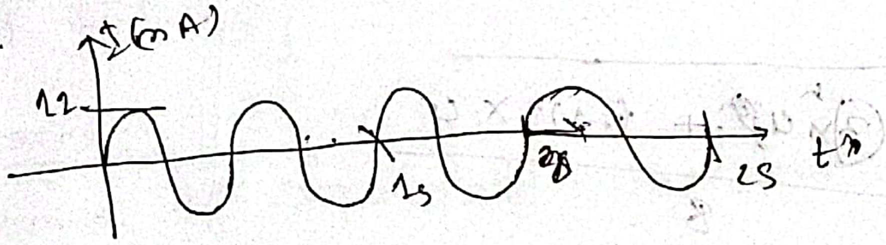
যেটাকে effective value / rms value বলা হয়।

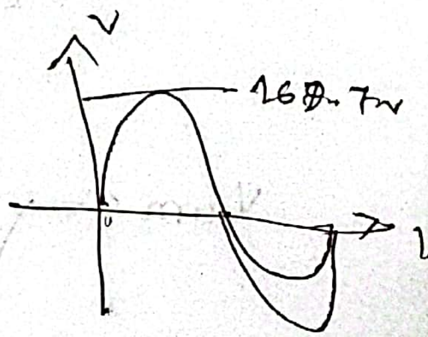
r.m.s value / effective value।

$$V_{eff} / V_{r.m.s} = \frac{V_m}{\sqrt{2}}$$

$$I_{eff} / I_{r.m.s} = \frac{I_m}{\sqrt{2}}$$

13.19)





$$I_{rms} = \frac{I_m}{\sqrt{2}} = \frac{12}{\sqrt{2}}$$

$$= 8.484 \text{ mA}$$

$$V_{r.m.s} = \frac{169.7}{\sqrt{2}}$$

$$= 120 \text{ v}$$

r.m.s : square wave এর length আলাদা / বিভিন্ন

Square wave এর ক্ষেত্রে, Area যখন আলাদা square

total wave

হবে, তখন total length এর same থাকবে।

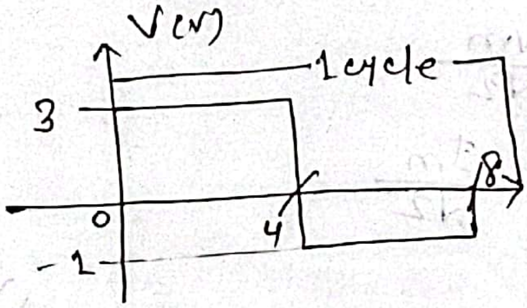
~~L এ বিভিন্ন~~

~~P এ ...~~

$$V_{r.m.s} = \sqrt{\frac{\cancel{(V_m)}}{l}} = \cancel{\sqrt{\frac{(A_1)^2 + (A_2)^2}{l}}} \quad \sqrt{\frac{A_1 + A_2}{l}}$$

$$\cancel{I_{r.m.s} = \sqrt{\frac{(I_m)}{l}}} = \cancel{\sqrt{\frac{(I_1)^2 + (I_2)^2}{l}}} = \sqrt{\frac{(I_1)^2 \times P_1 + (I_2)^2 \times P_2}{l}}$$

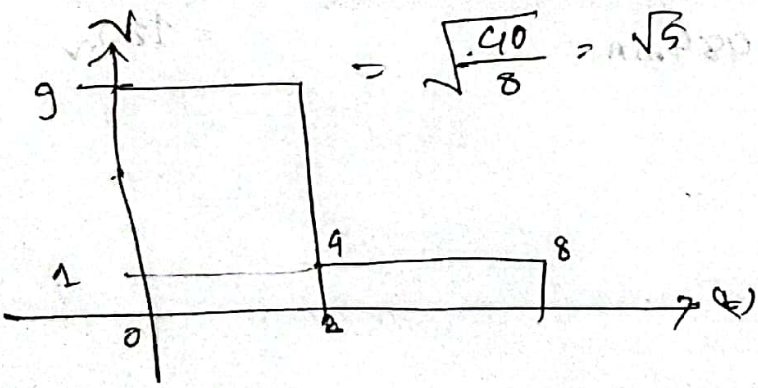
ex: 13.21



$$V_{r.m.s} = \sqrt{\frac{(3)^2 \times 4 + (-1)^2 \times 4}{8}}$$

$$= \sqrt{\frac{9 \times 4 + 1 \times 4}{8}}$$

$$= \sqrt{\frac{40}{8}} = \sqrt{5}$$



$$V_{r.m.s} = \sqrt{\frac{V_m}{l}} = \sqrt{\frac{(L_1)^2 \times P_1 + (L_2)^2 \times P_2}{l}}$$

L = দৈর্ঘ্য

P = সময়

l = total length of ~~distance~~ complete cycle

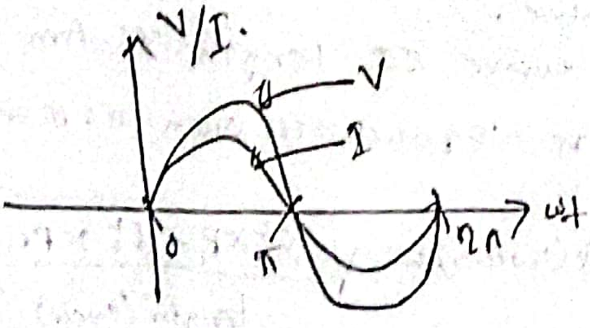
$$I_{r.m.s} = \cancel{\sqrt{\frac{I_m}{l}} = \sqrt{(L_1)^2 \times P +}}$$

$$I_{r.m.s} / I_{eff} = \sqrt{\frac{\text{area}(i^2(t))}{T}}$$

[pure Inductance এবং / pure Capacitor : এর leading angle 90° তে হয়। যেই inductor / capacitor এর Ideal বলা হয়]

Resistance :

Resistance এর ক্ষেত্রে lag / lead কোনটাই থাকে না



এখানে, V এবং I কোনো phase angle নেই বা leading angle / lagging angle নেই

Chapter 13

Resistor:

সূত্র।

$A = A_m \sin\omega t$ ← normal wave formula

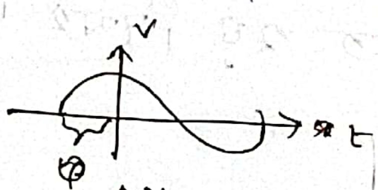
$$\left.\begin{aligned} V &= V_m \sin\omega t \\ I &= I_m \sin\omega t \end{aligned}\right\}$$ resistor এর

Inductor / capacitor,

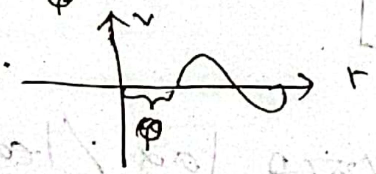
$V = V_m \sin(\omega t \pm \phi)$

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

if $V = V_m \sin(\omega t + \phi)$



if $V = V_m \sin(\omega t - \phi)$.



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

$= 2\pi n = 2\pi \frac{N}{t}$

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

$f/n = \frac{c}{\lambda} = \frac{v}{\lambda}$

ω = angular velocity

θ = angle, t = time

T = time period

λ =

n = frequency

N = number of complete cycle

l_1 = দৈর্ঘ্য $= l_2$

P_1 = উচ্চতা $= P_2$

r.m.s and avg for sine wave,

$V_{r.m.s} = V_{eff} = \frac{V_m}{\sqrt{2}}$

$I_{r.m.s} = I_{eff} = \frac{I_m}{\sqrt{2}}$

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

যেকোনো wave এর r.m.s value,

wave এর length বা Am কে square করে area বের করে

$$G(r.m.s) = \sqrt{\frac{l_1^2 \times P_1 + l_2^2 \times P_2}{\text{length (cycle)}}}$$

যেকোনো wave এর avg:

$$G(\text{average value}) = \left\{\frac{\text{algebric sum of area}}{\text{length of curve}}\right\} \text{(complete cycle)}$$

Chapter 14

The derivate of a sine wave has the same period and frequencey as the original sinusoidal wave form.

$$e(t) = E_m \sin(\omega t \pm \theta)$$

$$\frac{d}{dt} e_t = \omega E_m \cos(\omega t \pm \theta)$$

Sinusoidal wave এর কোনো R, L, C, (Resistor, Inductance, Capacitor

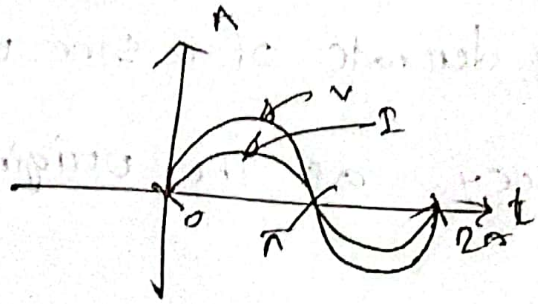
Resistorg

resistance is, for all practical purpose, is unaffacted by the frequency of the applied sinusoidal voltage on current. for this frequencey region, the resistor in can be treated as a constant, and Ohm's Law can be applied.

For, $V = V_m \sin \omega t$.

R এর ভিতর যাওয়ায় frequence এর কোনো প্রভাব নেই তাই current এবং voltage এর wave প্রতি point থেকে শুরু হয় এবং — প্রতি point এ শেষ হয়।

এদের মধ্যে leading / lagging angle থাকে zero.



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

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

$I = I_m \sin \omega t$

$V = IR = I_m \sin \omega t \, R = V_m \sin \omega t$

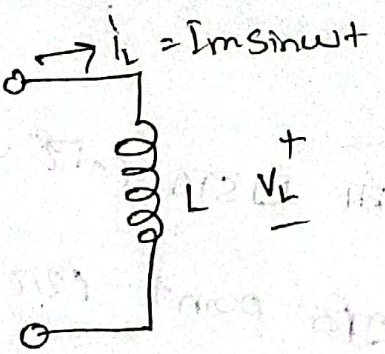
$$\left.\begin{aligned} I_m &= \frac{V_m}{R} \\ V_m &= I_m \times R \end{aligned}\right\} \text{Ohm' Law (AC circuit)}$$

যদি purely resistive হয় তাহলে,

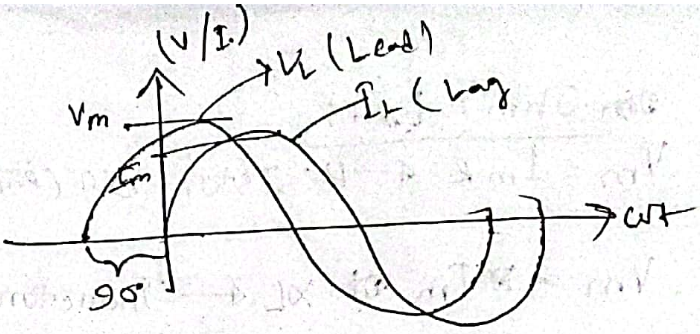
(i) voltage, current এর ~~peak~~ phase same থাকবে,

(ii) তাদের peak's value Ohm's Law মেনে চলবে,

Inductor



Inductance current abruptly change হতে দেয় না, Inductor এর current Lag করে



$$V_L = L \frac{di_L}{dt}$$

$$\frac{di_L}{dt} = \frac{d}{dt}(I_m \sin\omega t) = \omega I_m \cos\omega t$$

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

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

$$\cancel{V_L = V_m \sin(\omega t + 90^\circ)}$$

$$V_L = L\omega I_m \sin(\omega t + 90^\circ)$$

$$V_L = V_m \sin(\omega t + 90^\circ)$$

$I_m =$

$\omega =$ angular velocity

$L =$ Inductance

$X_L =$ Inductive reactance

$$\boxed{V_m = I_m \times \omega \times L}$$

$[\omega = 2\pi f]$

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

$\omega =$ angular velocity - $L =$ inductance

$X_L = \omega \times L$

$V_m = \omega L I_m$

বা, $V_m = X_L I_m$

বা, $X_L = \frac{V_m}{I_m}$ (unit ohm)

for inductance, V_L lead i_L by 90°, or i_L lags V_L by 90°

$V_L =$ lead করে,

$i_L =$ lag "

X_L inductor এ resistor এর মতো কাজ করে,

$$\boxed{X_L = L \times \omega}$$

$V = I \times R$

$V_m = I \times X_L$

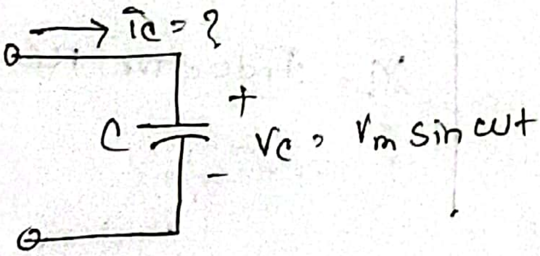
~~Ohm~~ Ohm's Law:

$V_m = I_m R$ ← Resiston এর ক্ষেত্রে

$V_m = I_m X_L$ ← Inductor এর ক্ষেত্রে।

Inductive reactive is the opposition to the flow of current which is denoted by X_L and unit Ohm's

Capacitong



Capacition voltage abruptly change হতে দেয় না Capaciton এর voltage lag করে।

$$I_c = C\frac{dv_c}{dt}$$

$$\frac{dv_c}{dt} = \frac{d}{dt}(V_m \sin \omega t) = \omega V_m \cos \omega t$$ ← voltage

$$I_c = C(\omega V_m \cos \omega t)$$

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

$\cancel{I_c = I_m \cos \omega t}$

$$I_c = C.\omega.V_m \sin(\omega t + 90^\circ)$$

$$I_c = I_m \sin(\omega t + 90^\circ)$$

C = Capaciton

V_m = maximum voltage

$I_m = V_m \times C \times \omega$

X_C = Capaciton reactor

CamScanner

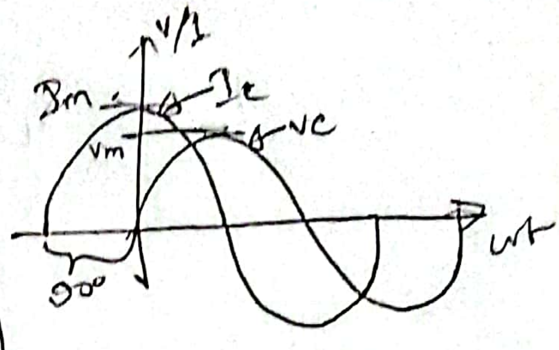
$\cancel{X_C = \omega \times C}$

$$V_m = \frac{I_m}{\omega \times C} = \frac{I_m}{\cancel{X_C}} = I_m \times X_C$$

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

$$V_m = \frac{I_m}{\omega \times C} = I_m \times X_C$$

$$\frac{V_m}{I_m} = X_C$$ [capacitor এ resistor এর মতো কাজ করে



Capacitor

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

X_C = capacitor এ resistor এর মতো কাজ করে।

Capacitor এ current 90° lead করে voltage 90° lag করে।

$$\boxed{\text{opposition} \rightarrow \frac{V_m}{I_m} = \frac{\cancel{V_m}}{\cancel{V_m} \times \omega \times C} = \frac{1}{\omega C} = X_C}$$

Ideal capacitor/Inductor এর voltage/current 90° lead বা lag করে।

$V = 30 \sin 400t$

L: $V_L = L \times \omega \times I_m \sin(\omega t + 90^\circ)$

$= V_m \sin(\omega t + 90)$

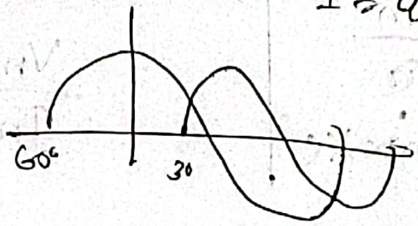
$\frac{V_L}{X_L} = I_m$

$I_c = \frac{V_c}{X_c}$

$= V_c \omega c$

$I = 40 \sin(500t + 60^\circ)$

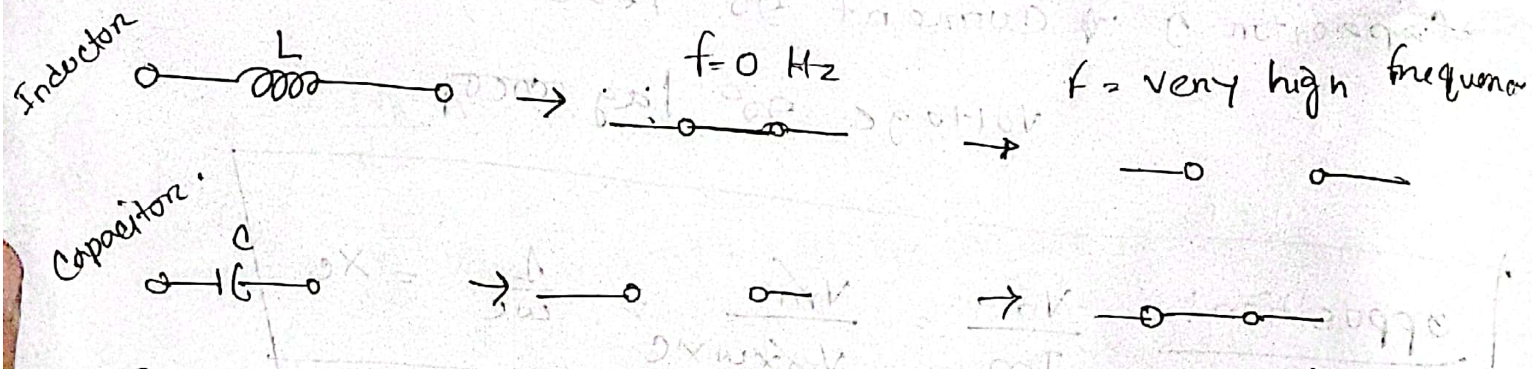
$I_c = \frac{V_c}{X_c}$



$I_c \times X_c = V_c$

$\frac{I_c}{\omega c} = V_c$

dc, High, Low frequency Effects on L and C



(inductive/capacitive reactant = Resistor এর মত)

dc circuit এ ∵ frequence = zero

Inductor:

$X_L = \omega L$

$= 2\pi f L = 2\pi(0)L = 0$

reactance zero যখন $f = 0$

যখন $f = 0$,

Inductor short circuit আচরণ করে

capacitor: $f = 0$

a ~~f = very~~ high frequency

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

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

$= \frac{1}{2\pi \times 0 \times c} = \infty$

$f =$ high $X_c =$ open circuit

যখন f = very high frequency

Inductors

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

f = high, X_L = high

Inductor open circuit এর মতো কাজ করে

f = very high frequency

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

যখন f = high তখন X_C = Low হয়

তখন Capacitor short circuit এর মতো কাজ করে।

III Average power and power factor

~~$P = vi$~~ The magnitude of average power delivered is independent of whether v leads i or i leads v.

$$p = vi = \frac{V_m}{2} I_m \cos(\theta_v - \theta_i)$$

$\theta_v \to$ voltage

$\theta_i \to$ current

$$= \frac{V_m I_m \cos\theta}{2}$$

$$= \frac{V_m}{\sqrt{2}} \times \frac{I_m}{\sqrt{2}} \cos\theta = V_{eff} I_{eff} \cos\theta$$

Resistor এর ক্ষেত্রে i and v এর মধ্যে angle difference থাকে 0, তাই $\cos 0^\circ = 1$

$$P = V_{eff} \cdot I_{eff} \times 1$$

$$P = \frac{V_{eff}^2}{R} = I_{eff}^2 R$$

Inductor: Since purely Inductive circuit, v leads i 90°, $\therefore |\theta_v - \theta_i| = |-90°| = 90°$

$$P = \frac{I_m V_m}{2} \cos 90° = 0 \, W$$

Capacitor: i leads v 90°, $|\theta_v - \theta_i| = |90° - 0°| = 90°$

$$P = \frac{I_m V_m}{2} \cos 90° = 0 \, W$$

power factor: v and i এর মধ্যে যে angle difference থাকে তার cosine মান power factor.

$$F_P = \cos\theta$$

$$P = \frac{V_m I_m}{2} \cos\theta = P$$

$$P = \frac{V_m I_m}{2} F_P$$

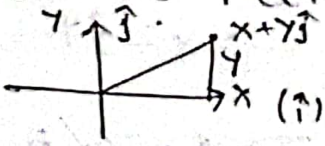
$$\frac{2P}{V_m \times I_m} = F_P$$

Complex numbers

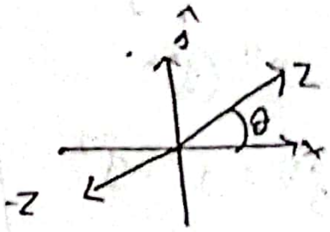
Rectangular form:

The format for the rectangular form is

$C = x + \hat{j}y$.



polar form = $C = \cancel{z\angle\theta}\ Z\angle\theta$



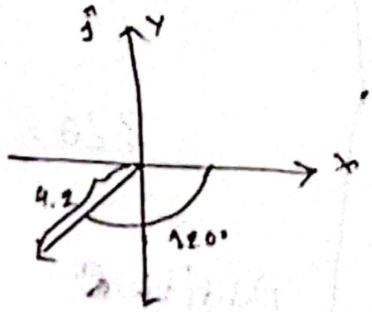
$-C = -Z\angle\theta$

$= Z\angle\theta \pm 180^\circ$

$C = -4.2\angle 60^\circ$

$= 4.2\angle 60^\circ - 180^\circ$

$= 4.2\angle -120^\circ$



Rectangular to polar:

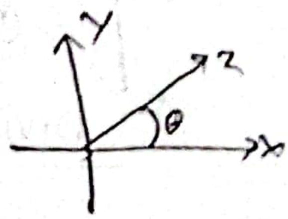
$C = x + \hat{j}y$

$[Z = r]$

$Z = \sqrt{x^2 + y^2}$

$\theta = \tan^{-1}\left(\frac{y}{x}\right)$

polar to Rectangular:



$x = Z\cos\theta$

$y = Z\sin\theta$

$\hat{j} = \sqrt{-1}$

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

$j^3 = j \times -1$

$= -j$

$j^4 = (-1)^2$

$j^5 = j^3 \cdot j^2$

$= -j \cdot (-1)$

$= j$

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

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

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

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

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

Complex conjugate:

$C = x + jy$

$= x - jy$

so $C = Z\angle\theta$

$= Z\angle-\theta$

Reciprocals $C = x + jy$

$= \frac{1}{x + jy}$

$Z\angle\theta = \frac{1}{Z\angle\theta}$

Addition:

$C_1 + C_2 = (x_1 + x_2) + \hat{j}(y_1 + y_2)$

Substraction:

$C_1 - C_2 = (x_1 - x_2) + \hat{j}(y_1 - y_2)$

multiplication:

$C_1 C_2 = (x_1 x_2 - y_1 y_2) + j(y_1 x_2 + x_1 y_2)$

Division: $\frac{C_1}{C_2} = \frac{x_1 x_2 + y_1 y_2}{x_2^2 + y_2^2} + \hat{j}\,\frac{x_2 y_1 - x_1 y_2}{x_2^2 + y_2^2}$

যোগ বিয়োগ polar forms

যদি দুইটি polar form এর angle same হয় বা তাদের মধ্যে angle difference যদি 180° হয়ে থাকে, এদের substraction বা multiplication করা যায়।

ex: $2\angle 45^\circ + 3\angle 45^\circ = 5\angle 45^\circ$

$$2\angle 0^\circ - 4\angle 180^\circ = 6\angle 0^\circ$$

multiplication: $C_1 = Z_1\angle\theta_1$, $C_2 = Z_2\angle\theta_2$

$$C_1 \cdot C_2 = Z_1 Z_2 \angle \theta_1 + \theta_2$$

Division: $C_1 = Z_1\angle\theta_1$, $C_2 = Z_2\angle\theta_2$

$$\frac{C_1}{C_2} = \frac{Z_1\angle\theta_1}{Z_2\angle\theta_2} = \frac{Z_1}{Z_2}\angle\theta_1 - \theta_2$$

Chapter - 14

সূত্র

Sine wave এর formula:

$$e(t) = E_m \sin(\omega t + \theta)$$

$\omega = \frac{\theta}{t} = \frac{2\pi}{T} = 2\pi f$
$= 2\pi n$

n/f = frequency

pure resistor এর ক্ষেত্রে

$V = V_m \sin\omega t$
$I = I_m \sin\omega t$

$\phi = 0$

Ohm's Law: ~~$V = \frac{I}{R}$~~ $I = \frac{V}{R}$

$I_m = \frac{V_m}{R}$

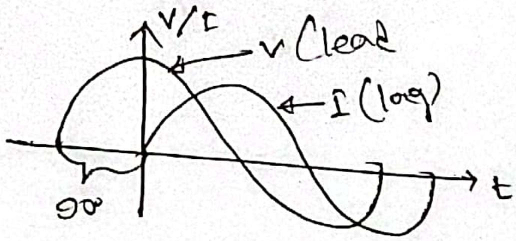
pure inductor এর ক্ষেত্রে

V and i এর angle difference $\theta = 90°$.

~~$V = V_m \sin$~~. $I = I_m \sin(\omega t + 90°)$

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

(2) $V = V_m \sin(\omega t + 90°)$



(3) $V_L = L \times \frac{di_L}{dt}$

(4) $V_m = I_m \times \omega \times L$
$= I_m \times X_L$

ω = angular velocity
$I_m = I_{max}$; $V_m = V_{max}$
L = inductor (unit H)
X_L = Inductive reactant

(5) $X_L = \omega L$ ← (inductive reactant যেটা resistor এর মতো কাজ করে।

2πf

2πn

$X_L = \omega L$

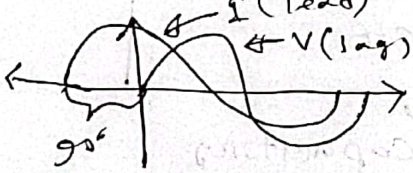
$= 2\pi f L$

$I_m = \dfrac{V_m}{X_L}$ (Ohm's Law)

X_L = (Unit Ohm) Resistor মতো কাজ করে inductor এ But angle

Capacitor:

(1) $V_C = V_m \sin \omega t$



(2) $I_C = I_m \sin(\omega t + 90°)$

(3) ~~Rest~~ $I_m = V_m \times \omega \times C$

(4) $I_m = \dfrac{V_m}{X_C}$

(5) $X_C = \dfrac{1}{\omega C}$

↳ (Capacitor এর resistor এর মতো কাজ করে But এর angle difference আছে)

(6) $X_C = \dfrac{1}{2\pi f C}$

V_C = Voltage of capacitor

I_C = current " "

$I_m = I_{max}$, $V_m = V_{max}$

X_C = capacitive reactant
↳ resistor এর মতো কাজ করে।

f/n = frequency

c = capacitor (unit F)

power:

$$P = \frac{V_m I_m}{2} \cos\theta$$

$$= V_{eff} I_{eff} \cos\theta$$

$$F_p = \cos\theta$$

F_p = power factor

θ = V and i এর মধ্যে angle difference

$$V_{eff} = V_{r.m.s} = \frac{V_m}{\sqrt{2}}$$

$$I_{eff} = I_{r.m.s} = \frac{I_m}{\sqrt{2}}$$

$$\theta = |\theta_v - \theta_i|$$

$$= \{ \quad \}$$

resistor: $\theta = 0^\circ$ (v and i এর differ)

$$\cos 0^\circ = 1$$

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

$$P = V_{eff} \cdot I_{eff}$$

pure Inductor/capacitor:

$$\theta = 90^\circ$$

$$\cos 90^\circ = 0$$

$$P = \frac{V_m I_m}{2} \times 0 = 0$$

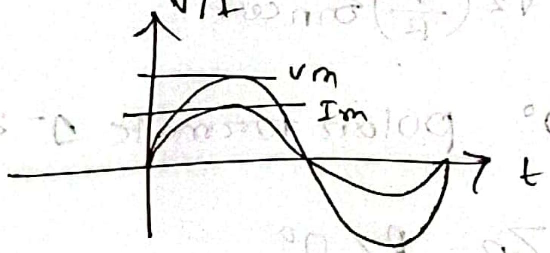
$$\left.\begin{aligned} F_p \rightarrow P &= \frac{V_m I_m}{2} \cos\theta \\ P &= \frac{V_m I_m}{2} F_p \\ F_p &= \frac{2P}{V_m I_m} \end{aligned}\right\} \text{power factor}$$

Chapter - 15:

Series AC circuits (Impedance and phasor form)

Resistive Elements: $\varphi = 0$ (V and i এর angle difference)

for purely resistive



$$I_m = \frac{V_m}{R}$$

$$V_m = I_m R$$

$$V_R = V_m \sin\omega t = V\angle 0^\circ \quad \left[\text{where } V = \frac{V_m}{\sqrt{2}}\right]$$

$$I_R = I_m \sin\omega t = I\angle 0^\circ \quad \left[\text{where } I = \frac{I_m}{\sqrt{2}}\right]$$

$$\boxed{V = \frac{V_m}{\sqrt{2}} \qquad \sqrt{2}\,V = V_m}$$

$$\left[I = \frac{I_m}{\sqrt{2}} \qquad I \times \sqrt{2} = I_m\right]$$

Using phasor Diagram and applying Ohm's Law।

$$I = \frac{V}{R} = \frac{V\angle 0^\circ}{R\angle \theta_R}$$

যেহেতু V এবং I এর angle difference 0° তাই $i\angle 0^\circ$

$$\theta_R = 0^\circ$$

$$I = \frac{V}{R} = \frac{V\angle 0^\circ}{R\angle 0^\circ} = \frac{V}{R}\angle 0^\circ - 0^\circ$$

$$= \frac{V}{R}\angle 0^\circ$$

$$I_m = \frac{V_m}{R}$$

$$= \sqrt{2}\left(\frac{V}{R}\right)$$

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

$$= \sqrt{2}\left(\frac{V}{R}\right)\sin\omega t$$

$\theta_R = 0^\circ$ polar formate এ বসিয়ে পাই। (for proper phasor ~~Relat~~. ~~Relat~~ Relation ship between V and i)

$Z_R = R\angle 0^\circ$

Z_R : Impedance of a resistive element

Impedance বলতে বুঝায় যে কি পরিমাণ ~~element~~ ~~কে বাধা দিতে~~ charge এর flow কে বাধা দিতে একটা element এর। Impedance কিছুটা resistor এর মতো। এর unit ohm.

Z_R phasor না।

exp: $V_m = 100V$ $I_m = 20A$

$V = V_m \sin\omega t$ $I = 20 \sin\omega t$

$= 100 \sin\omega t$

$V = 100 \sin \omega t \rightarrow \cancel{\text{(phasor form)}}$

$$V = \frac{V_m}{\sqrt{2}} \angle 0°$$

$$V = \frac{100}{\sqrt{2}} \angle 0°$$ (phasor form)

$$V = 70.71 \angle 0°$$

$$R = \frac{V}{I} = \frac{100V}{20A} = \frac{V_m}{I_m}$$

$$= 5\Omega$$

$$I = \frac{V\angle 0°}{ZR} = \frac{V\angle 0°}{R\angle 0°} = \frac{70.71\angle 0°}{5\angle 0°}$$

$$= 14.14\angle 0°$$

$$i = \sqrt{2}\left(\frac{V}{R}\right) \sin \omega t$$

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

$$= \frac{100}{5} \sin \omega t$$

$$= 20 \sin \omega t$$

exp: 15.2] $i = 4 \sin(\omega t + 30°)$ & $V = ?$

$R = 2\Omega$

$\cancel{i = \frac{V}{R}}$ $\quad i \cdot$ $I_m = \frac{V_m}{R}$

$4 \times 2 = V_m = 8$

$V = 8 \sin(\omega t + 30°)$

$\cancel{V} \; I_m = \frac{\sqrt{2}\,V}{R}$

$\frac{4 \times 2}{\sqrt{2}} = V$

$5.656 \angle 0° = V$

$\cancel{I = \sqrt{2} \times 4}$.

$$I = \frac{I_m}{\sqrt{2}} = \frac{4}{\sqrt{2}} = 2.828$$

$$I = I_m \sin(\omega t + 30^\circ)$$

$$= I\angle 0^\circ$$

$$= 2.828\angle 0^\circ$$

$$I = \frac{V\angle 0^\circ}{R\angle 0^\circ}$$

$$V = I\angle 0^\circ \times R\angle 0^\circ$$

$$= 2.828\angle 0^\circ \times 2\angle 0^\circ$$

$$= 5.656\angle 0^\circ$$

$\boxed{iii}$ Inductor এর ক্ষেত্রে (pure inductor এর ক্ষেত্রে)

Inductive Reactant $X_L = \omega L$

V and i angle difference $\theta = 90^\circ$

Inductor এ Voltage lead করে।

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

$$= V\angle 0^\circ$$

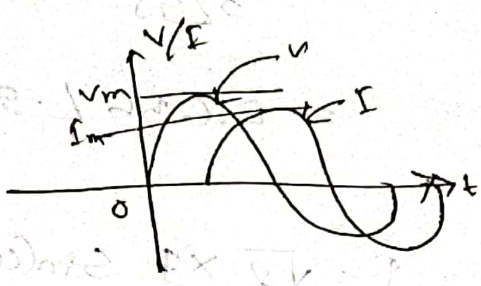
$$I = \frac{V\angle 0^\circ}{X_L\angle \theta_L} = \frac{V}{X_L}\angle 0^\circ - \theta_L$$

since V leads i by 90°. i must have an angle of -90°

$\theta_L = 90°$

$$I = \frac{V\angle 0°}{X_L\angle\theta_L} = \frac{V\angle 0°}{X_L\angle 90°} = \frac{V}{X_L}\angle 0°-90°$$

$$I = \frac{V}{X_L}\angle -90°$$



$$i = \frac{\sqrt{2}V}{X_L}\sin(\omega t - 90°)$$

X_L = inductance এর Resistor এর মত কাজ করে। But angle আছে।

$Z_L = X_L\angle 90°$ → impedence

Z_L এর Unit ~~Ohm~~ Ohms. It measured how much the inductive element will "control or impede" the level of current through the network (বাধা)

exp: 15.3

$V_m = 24V$ $\theta = 90°$ $X_L = 3\Omega$

~~$I_m = 8A$~~

$V = 16.97\angle 0°$

$$V = \frac{24}{\sqrt{2}} = 16.97V$$

~~$I = 5.657\angle 90°$~~

~~$I = \frac{I_m}{\sqrt{2}} = 5.6567$~~

~~$X_L =$~~

$$I = \frac{V\angle 0^\circ}{X_L\angle 90^\circ} \qquad I_m = \sqrt{2}\times I$$

$$= \frac{16.97\angle 0^\circ}{3\angle 90^\circ}$$

$$I = 5.656\angle -90^\circ$$

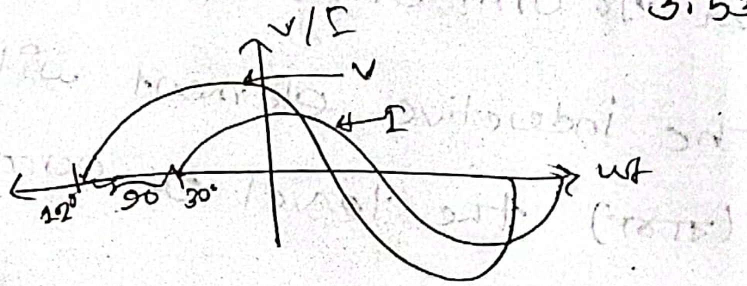
$$I = \sqrt{2}\times I \;\sin(\omega t - 90^\circ)$$

$$= \sqrt{2}\,(5.656)\,\sin(\omega t - 90^\circ)$$

$$= 8\,\sin(\omega t - 90^\circ)$$

$\boxed{13\text{-}4}$ $i = 5\sin(\omega t + 30^\circ)$ $\left[\cancel{I_m \times \sqrt{2} = I}\right]$ $\left[I = \frac{I_m}{\sqrt{2}} = \frac{5}{\sqrt{2}}\right.$ $= 3.535$

$X_L = 4\Omega$



$i \times X_L = V_L$

$i\angle 30^\circ \times X_L\angle 90^\circ = V_L$

$3.533\angle 30^\circ \times 4\angle 90^\circ = V_L$

$14.14\angle 120^\circ = V_L$

$$V_L = \sqrt{2}\times(14.14)\;\sin(\omega t + 120^\circ)$$

$$= \cancel{100}.20\;\sin(\omega t + 120^\circ)$$

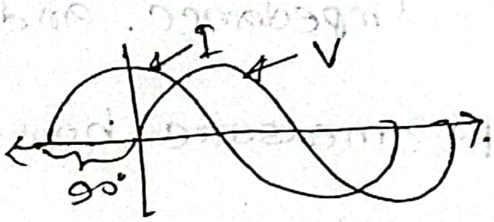
Capacitors

(Capacitive Reactance :) :

for pure capacitor current leads voltage by $90°$

angle difference between V and I ; $\theta = 90°$

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



$V = V_m \sin\omega t$

phasor form $V = V\angle 0°$ $\left[V = \frac{V_m}{\sqrt{2}}\right]$

Applying Ohm's Law and using phasor algebra.

$$I = \frac{V\angle 0°}{X_C\angle\theta_C} = \frac{V}{X_C}\angle 0-\theta_C$$

I lead V by $90°$, I must have an angle $90°$.

so, $\theta_C = -90°$

$$I = \frac{V\angle 0°}{X_C\angle -90°} = \frac{V}{X_C}\angle 0-(-90°)$$

$$I = \frac{V}{X_C}\angle 90°$$

$$I = I_m \sin(\omega t + 90°)$$

$$= \left(\frac{\sqrt{2}V}{X_C}\right)\sin(\omega t + 90°)$$

$$\boxed{Z_C = X_C\angle -90°}$$ → Impedance

X_C = Capacitive reactant (যেটা Resistor এর মতো

But angle আছে.

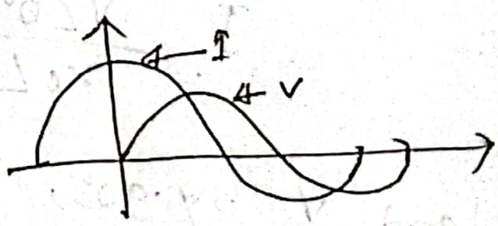
Z_C = Impedance. and it's unit ohm's.

It measure how much the capacitor element will "control and impede" (বাধা) the lend of current through the network.

exp) 15.5

$X_C = 2\Omega$

$V = 15 \sin \omega t$



$\therefore V = \frac{15}{\sqrt{2}} \angle 0^\circ$

$= 10.61 \angle 0^\circ$

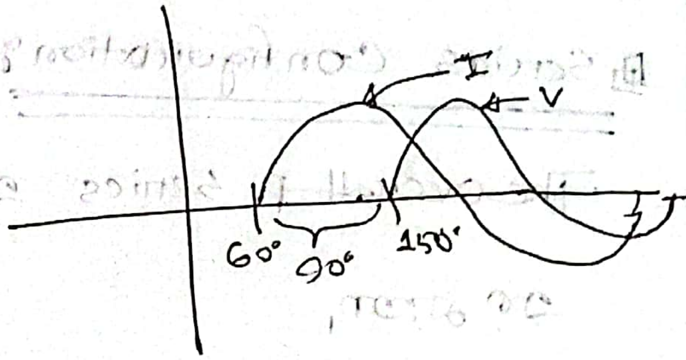
$I_C = \frac{\cancel{V} 10.61 \angle 0^\circ}{2 \angle -90^\circ} = 5.303 \angle 0^\circ - (-90)^\circ$

$I = 5.303 \angle 90^\circ$

$i = \sqrt{2} \times (5.303) \sin(\omega t + 90^\circ)$

$= 7.5 \sin(\omega t + 90^\circ)$

15.6 $i = 6\sin(\omega t - 60^\circ)$



$X_C = 0.5\,\Omega$

$i = \frac{6}{\sqrt{2}} = 4.243$

$i = 4.243\angle -60^\circ$

$Z_C = 0.5\angle -90^\circ$

$i \times Z_C = V_C$

$4.243\angle -60^\circ \times 0.5\angle -90^\circ = V_C$

$2.121\angle -150^\circ = V_C$

$V_C = \sqrt{2}(2.121)\sin(\omega t - 150^\circ)$

$= 3\sin(\omega t - 150^\circ)$

impedance:

(1) $Z_R = R\angle 0^\circ$ ohm

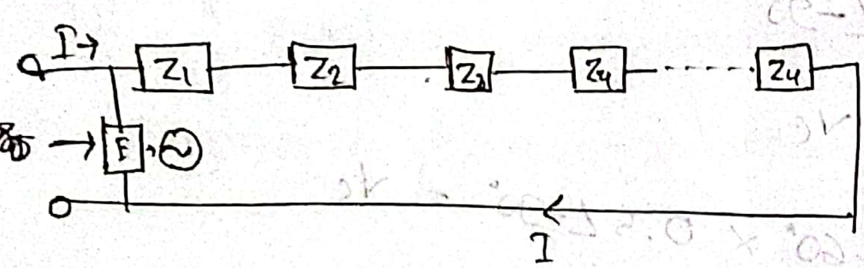
(2) $Z_L = X_L\angle 90^\circ$ ohm

(3) $Z_C = X_C\angle -90^\circ$ ohm

Series Configuration:

~~The overall p~~ series এর (সময়) ac circuit dc circuit এর মতো,

$$Z_T(\text{total}) = Z_1 + Z_2 + Z_3 + Z_4 + \cdots + Z_n$$



App. : $I = \dfrac{E}{Z_T}$

E = Supply voltage (AC supply)

Z_T = total impedance

The voltage across the each element can then be found by another application of Ohm's Law:

$V_1 = I Z_1$

$V_2 = I Z_2$

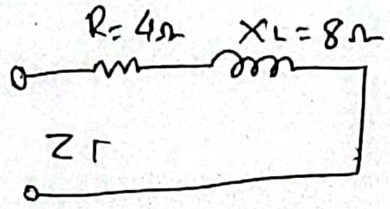
$E = V_1 + V_2$

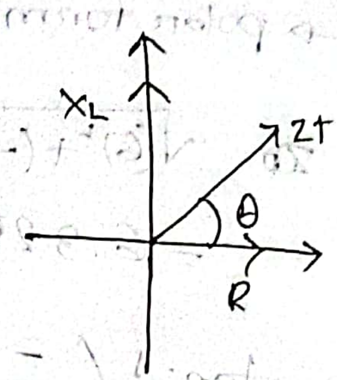
θ_T = angle difference between V and I

Power to the circuit (series connection):

$$P = EI\cos\theta_T$$

exp 15.7)





$Z_T = Z_R + Z_L$

$= R\angle 0^\circ + X_L \angle 90^\circ$

$= R + \hat{j} X_L$

$= 4 + \hat{j} 8\Omega$

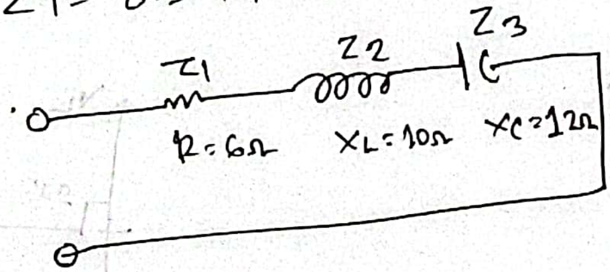
ZT → polar form

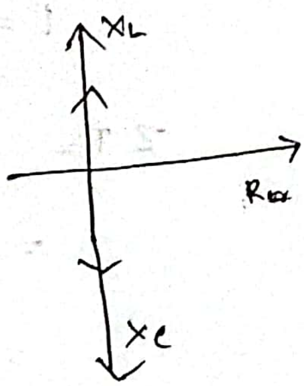
$\therefore \sqrt{(4)^2 + (8)^2} = 8.944$

$\theta = \tan^{-1}\left(\frac{8}{4}\right) = 63.43^\circ$

$Z_T = 8.944 \angle 63.43^\circ$

15.8)





$Z_T = Z_1 + Z_2 + Z_3$

$= R\angle 0^\circ + X_L\angle 90^\circ + X_C\angle -90^\circ$

$= R + \hat{j} X_L - \hat{j} X_C$

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

$= 6 + \hat{j}(10 - 12) = 6 - \hat{j}\,2$

$Z_T \rightarrow$ polar form

$$Z = \sqrt{(6)^2 + (-2)^2}$$

$$= 6.325$$

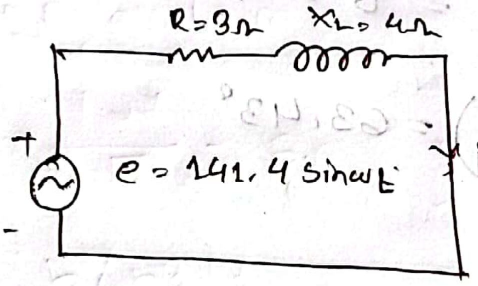
$$\theta = \tan^{-1}\left(\frac{-2}{6}\right)$$

$$= -18.43^\circ$$

$$Z_T = 6.325 \angle -18.43^\circ$$

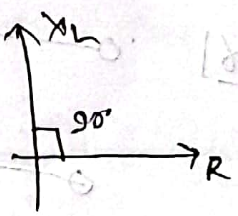
[ii] R–L:

(Math)



$$e = 141.4 \sin\omega t$$

$$E = 100 \angle 0^\circ$$



$$Z_T = Z_R + Z_L$$

$$= R\angle 0^\circ + X_L \angle 90^\circ$$

$$= 3\angle 0^\circ + 4\angle 90^\circ$$

$$= 3 + j4$$

Z_T polar form: $\sqrt{9+16} = 5$

$$\tan^{-1}\left(\frac{4}{3}\right) = 53.13$$

$ZT = 5\angle 53.13^\circ$

$I = \dfrac{100\angle 0^\circ}{5\angle 53.13^\circ}$

$= 20\angle -53.13^\circ$

$\cancel{I = \dfrac{E}{Z_T}} = \cancel{\dfrac{100\angle 0^\circ}{20\angle -53.13^\circ}}$

$V_R = I Z_R$

$= 20\angle -53.13 \times 3\angle 0^\circ$

$= 60\angle -53.13$

$V_L = I Z_L$

$= 20\angle -53.13 \times 4\angle 90^\circ$

$= 80\angle 36.87^\circ$

$P = EI\cos\theta_T$

$= E_{eff} I_{eff} \cos\theta_T$

$E_{r.m.s} = E_{eff} = \dfrac{E_m}{\sqrt{2}}$

$= \dfrac{141.4}{\sqrt{2}} = 100V$

$\theta_T = (\theta_v - \theta_i)$

$= |(0^\circ - (-53.13))|$

$= |53.13| = 53.13$

$I_{r.m.s} = I_{eff} = \dfrac{I_m}{\sqrt{2}} = 20A$

$P = E_{eff} I_{eff} \cos\theta_T$

$= (100\times 20)\cos 53.13$

$= 1200W$

R এর power

$P_R = V_R I \cos\theta_R$

$= (60\times 20)\cos 0^\circ$

$= 1200$

L এর power

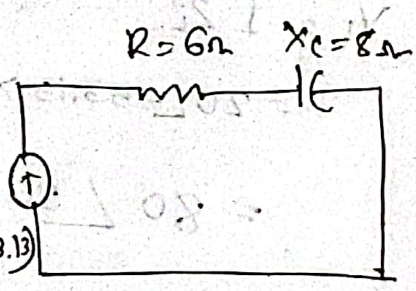
$P_L = V_L I \cos\theta_L$

$= (80\times 20)\cos 90^\circ$

$= 0$

$P_T = P_R + P_L = 1200 + 0 = 1200 W$

R–C: Math



$I = 7.07 \sin(\omega t + 53.13)$

$I = 7.07 \sin(\omega t + 53.13)$

$I \rightarrow$ polar form

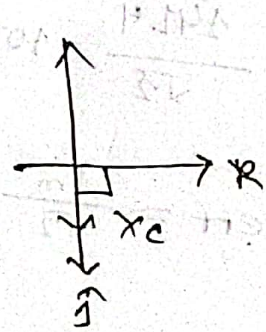
$I = \frac{7.07}{\sqrt{2}} = 5 A$ $\quad \tan \theta = 53.13$

$= 5 \angle 53.13$

$Z_T = Z_R + Z_C$

$= 6\angle 0° + 8 \angle -90°$

$= 6 - \hat{j}8$



$Z_T \rightarrow$ polar form

$Z_T = 6 - j8$

$\sqrt{36+64} = 10$ $\quad Z_T$

$\theta = \tan^{-1}\left(\frac{-8}{6}\right) = -53.13$

$Z_T = 10 \angle -53.13$

$\underline{I}$?

$V = IRZ_T \quad E = I \times Z_T$

$E = 5\angle 53.13 \times 10\angle -53.13$

$= 50\angle 0°$

$V_R = IZ_R = 5\angle 53.13 \times 6\angle 0°$

$= 30\angle 53.13$

$V_C = IZ_C = 5\angle 53.13 \times 8\angle -90°$

$= 40\angle -36.86°$

$\underline{P_T (\text{total})}$:

$P_T = E_{eff}\, I_{eff} \cos\theta_T$

$\theta_T = (\theta_v - \theta_i) = (0 - 53.13)$

$= |-53.13°| = 53.13$

$E_{eff} = \frac{E}{\sqrt{2}} = 50,$

$I_{eff} = \frac{I}{\sqrt{2}} = 5$

$P = (50 \times 5) \cos 53.13$

$= 250 \cos 53.13$

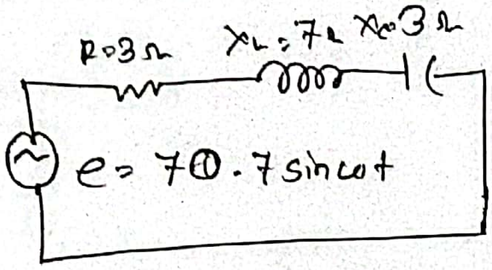
$= 150$

$P_R = V_R I \cos\theta_R = \cancel{5 \times} (30 \times 5) \cos 0°$

$= 150 \times 1$

$P_C = V_C I \cos\theta_C = (40 \times 5) \cos\angle -90° = 0$

R-L-C Math



$e = 70.7 \sin\omega t$ → ~~polar form~~ phasor Diagram

$E = \frac{70.7}{\sqrt{2}} \angle 0°$

$= 50\angle 0°$

~~$X_L = 7\Omega, X_C =$~~

~~$X_L = 7\angle 90°$~~

~~$X_C = 3\angle -90°$~~

~~$R = R$~~

$X_L = 7\Omega, X_C = 3, R = 3\Omega$

$Z_T = Z_R + Z_L + Z_C$

$= R\angle 0° + X_L\angle 90° + X_C\angle -90°$

$= 3\angle 0° + 7\angle 90° + 3\angle -90°$

$Z_T = \cancel{3\angle 0°} \cdot 3 + j7 - \hat{j}3 = 3 + 4\hat{j}$

Z_T → polar form

$Z_T = 3 + 4\hat{j}$

$\sqrt{(3)^2 + (4)^2} = 5$

$\tan^{-1}\left(\frac{4}{3}\right) = 53.13$

$Z_T = 5 \angle 53.13$

$I = \frac{E}{Z_T} = \frac{50 \angle 0°}{5 \angle 53.13°}$

$= 10 \angle -53.13°$

$V_R = I \, Z_R$

$= 10 \angle -53.13° \times 3 \angle 0°$

$= 30 \angle -53.13 + 0 = 30 \angle -53.13$

$V_L = I Z_L = 10 \angle -53.13 \times 7 \angle 90°$

$= 70 \angle 36.87$

$V_C = I Z_C = 10 \angle -53.13 \times 3 \angle -90°$

$= 30 \angle 143.13$

power: $P = EI \cos \theta_T$

$\theta_T = |(\theta v - \theta i)| = |(0 - 53.13)|$

$= 53.13$

$E_{eff} = \frac{E}{\sqrt{2}} = 50$

$I_{eff} = \frac{I}{\sqrt{2}} = 10$

$P = (50 \times 10) \cos 53.13°$

$= 300 \, W$

☐ power factor:

$$F_P = \cos\theta \qquad Z_T = \frac{E}{I}$$

$$P = EI\cos\theta$$

$$\frac{P}{EI} = \cos\theta$$

$$\frac{I^2R}{EI} = \cos\theta$$

$$\frac{R}{\frac{EI}{I^2}} = \cos\theta$$

$$\Rightarrow \frac{R}{\frac{E}{I}} = \cos\theta$$

$$\Rightarrow \frac{R}{Z_T} = \cos\theta$$

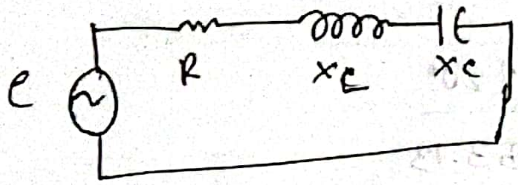
$$\frac{R}{Z_T} = F_P$$

$$\boxed{F_P = \cos\theta = \frac{R}{Z_T}}$$

☐ voltage divider rules:

dc circuit এর voltage divider rule ও, ac circuit এর voltage divider rules same

$$V_x = \frac{Z_x E}{Z_T}$$

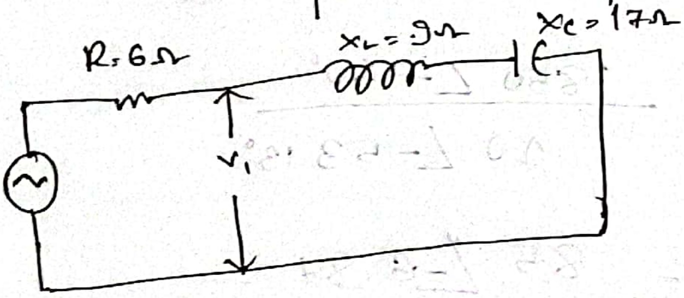


$$Z_T = Z_R + Z_L + Z_C$$

$e = E$,

$$V_R = \frac{Z_R \times E}{Z_T} \quad \Bigg| \quad V_L = \frac{Z_L \times E}{Z_T} \quad \Bigg| \quad V_C = \frac{Z_C \times E}{Z_T}$$

15.10



$$V_R = \frac{Z_R E}{Z_R + Z_C + Z_L} = \frac{6 \angle 0^\circ \cdot (50 \angle 30^\circ)}{6 \angle 0^\circ + 9 \angle 90^\circ + 17 \angle -90^\circ}$$

$$= \frac{30 \angle 30^\circ}{6 + 9\hat{j} - 17\hat{j}}$$

$$= \frac{30 \angle 30^\circ}{6 - 8\hat{j}} = \frac{30 \angle 30^\circ}{10 \angle -53.13}$$

$$= 3 \angle 83.13^\circ$$

Z_T polar forming

$Z_T = 6 - 8j$ Ω : $\sqrt{(6)^2 + (8)^2} = 10$

$$\tan^{-1}\left(-\frac{8}{6}\right) = -53.13$$

$$V_L = \frac{Z_L \times E}{Z_T} = \frac{9\angle 90^\circ \times 50\angle 30^\circ}{10\angle -53.13^\circ}$$

$$= \frac{450\angle 120^\circ}{10\angle -53.13}$$

$$= 45\angle 173.13$$

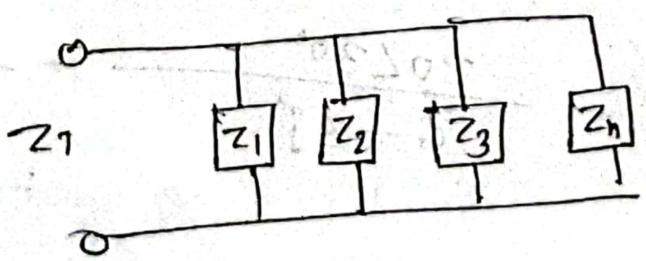
$$V_C = \frac{Z_C E}{Z_T} = \frac{17\angle 90^\circ \times 50\angle 30^\circ}{10\angle -53.13}$$

$$= \frac{850\angle -60^\circ}{10\angle -53.13^\circ}$$

$$= 85\angle -6.87$$

Parallel ac circuits:

... parallel এ ac circuit হলো dc circuit এর মতো,



$$\frac{1}{Z_T} = \frac{1}{Z_1} + \frac{1}{Z_2} + \frac{1}{Z_3} + \cdots + \frac{1}{Z_N}$$

$$\frac{1}{Z_T} = \frac{1}{Z_1} + \frac{1}{Z_2}$$

$$Z_T = \frac{Z_1 \times Z_2}{Z_1 + Z_2}$$

⊛ $I_1 = \frac{E}{Z_1}$, $I_2 = \frac{E}{Z_2}$

⊛ $I = I + I_2$

degree: angle!

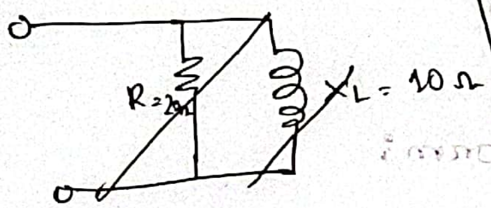
∴ $\frac{1}{Z_R} = \frac{1}{R\angle 0^\circ} = G\angle 0^\circ$

G = conductance

∴ $\frac{1}{Z_L} = \frac{1}{X_L\angle 90^\circ} = \frac{1}{X_L}\angle -90^\circ$

∴ $\frac{1}{Z_C} = \frac{1}{X_C\angle -90^\circ} = \frac{1}{X_C}\angle +90^\circ$

15.12

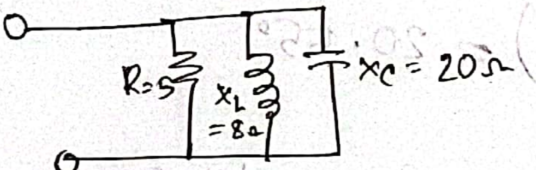


$$\cancel{Z_T = \frac{1}{Z_T} = \frac{1}{Z_R} + \frac{1}{Z_L}}$$

⊛ power for parallel circuits

$$p = EI\cos\theta_T$$

15.13



$$\frac{1}{Z_T} = \frac{1}{Z_R} + \frac{1}{Z_{X_L}} + \frac{1}{Z_{X_C}}$$

$$= \frac{1}{R\angle 0^\circ} + \frac{1}{8\angle 90^\circ} + \frac{1}{20\angle -90^\circ}$$

$$= \frac{(8\angle 90^\circ \times 20\angle -90^\circ) + (5\angle 0^\circ \times 20\angle -90^\circ) + (5\angle 0^\circ \times 8\angle 90^\circ)}{5\angle 0^\circ \times 8\angle 90^\circ \times 20\angle -90^\circ}$$

$$\frac{1}{Z_T} = \frac{160\angle 0^\circ + 100\angle -90^\circ + 40\angle 90^\circ}{800\angle 0^\circ}$$

$$Z_T = \frac{800\angle 0^\circ}{160\angle 0^\circ + 100\angle -90^\circ + 40\angle 90^\circ}$$

$$= \frac{800\angle 0^\circ}{160 - 100\hat{j} + 40\hat{j}}$$

$$= \frac{800\angle 0^\circ}{160 - 60\hat{j}}$$

$160 + 60\hat{j}$ to polar form:

$$\sqrt{(160)^2 + (60)^2}$$

$$= 170.88$$

$$\theta = \tan^{-1}\left(\frac{-60}{160}\right) = 20.55^\circ$$

$160 - 60\hat{j}$ polar form $170.88\angle -20.55^\circ$

$$Z_T = \frac{800\angle 0^\circ}{170.88\angle -20.55^\circ}$$

$$= 4.68\angle +20.55^\circ$$

~~10~~ power factor for parallel

$F_P = \cos\theta$

$P = EI\cos\theta$

or, $P = EI F_P$

or, $\frac{P}{EI} = F_P$

or, $F_P = \frac{E^2}{R \times EI}$

$= \frac{E}{RI}$

$= \frac{1}{R} \times \frac{E}{I}$

$= G \times \frac{1}{\frac{I}{E}}$

$= G \times \frac{1}{\frac{1}{Z_T}} = \cancel{G \times \frac{1}{Z_T}}$

$= \frac{G}{Z_T}$

$F_P = G \times Z_T$

$= \frac{Z_T}{R}$

$P = \frac{V^2}{R} = I^2 R$

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

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

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

$\frac{I}{E} = \frac{1}{Z_T}$

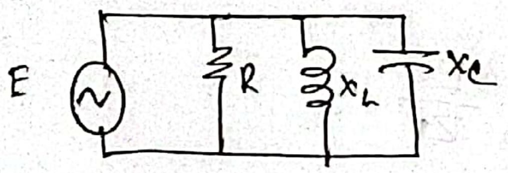
Current Divider Rule:

current divider rule is same for ~~ac~~ dc and dc circuit.

$$I_1 = \frac{Z_2 I_T}{Z_1 + Z_2}, \quad I_2 = \frac{Z_1 I_T}{Z_1 + Z_2}$$

Math Param

R–C–L 9   15.71



8. $E = \sqrt{2}(100)\sin(\omega t + 53.13°) = 100 \angle 53.13°$

$P = 70.7 \sin \omega t$

$X_L = 1.43\,\Omega$, $R = 3.33\,\Omega$, $X_C = 3.33\,\Omega$

$$\frac{1}{Z_T} = \frac{1}{Z_R} + \frac{1}{Z_C} + \frac{1}{Z_L}$$

$$= \frac{1}{R\angle 0°} + \frac{1}{X_C\angle -90°} + \frac{1}{X_L \angle 90°}$$

$$= \frac{1}{3.33\angle 0°} + \frac{1}{3.33\angle -90°} + \frac{1}{1.43\angle 90°}$$

$$= 0.3\angle 0° + 0.3\angle -(-90°) + 0.7\angle -90°$$

$$= 0.3\angle 0° + 0.3\angle 90° + 0.7\angle -90°$$

$$= 0.3 + 0.3j - 0.7j$$

$$\frac{1}{Z_T} = 0.3 - 0.4\hat{j}$$

$\frac{1}{Z_T}$ in polar form $0.3 - 0.4\hat{j}$

$$\sqrt{(0.3)^2 + (0.4)^2} = 0.5$$

$$\theta = \tan^{-1}\left(\frac{-0.4}{0.3}\right) = -53.13$$

$$\Rightarrow \frac{1}{Z_T} = 0.5 \angle -53.13^\circ$$

$$\Rightarrow \frac{1}{0.5 \angle -53.13} = Z_T$$

$$\Rightarrow 2 \angle -(-53.13) = Z_T$$

$$\Rightarrow 2 \angle 53.13 = Z_T$$

$$I = \frac{E}{Z_T} = \frac{100 \angle 53.13^\circ}{2 \angle 53.13^\circ} = 50 \angle 0^\circ$$

$\cancel{I_R = \frac{I_L I_C X}{E}}$

for I_R: $I_R = \frac{Z_L \times Z_C \times I}{Z_T} = \cancel{\frac{1.43 \angle 90^\circ \times 3.33 \angle -90^\circ \times}{2 \angle 53.13}}$

$$= \cancel{119.05} \angle -53.13^\circ$$

CamScanner

For I_R: $I_R = \frac{E}{Z_R}$

$$= \frac{100\angle 53.13}{3.33\angle 0^\circ}$$

$$= 30\angle 53.13^\circ$$

For I_L: $I_L = \frac{E}{Z_L}$

$$= \frac{100\angle 53.13^\circ}{1.43\angle 90^\circ}$$

$$= 70\angle -36.87$$

For I_C: $\frac{E}{Z_C} = \frac{100\angle 53.13}{3.33\angle -90^\circ}$

$$= 70\angle 143.13^\circ$$

Formula:

(1) Resistor: $\theta = 0$

- $I_m = \frac{V_m}{R}$, $V = \frac{V_m}{\sqrt{2}}$, $I = \frac{I_m}{\sqrt{2}}$
- $I = I_m \sin\omega t = I' \angle 0^\circ$ $\left[I' = \frac{I_m}{\sqrt{2}} \right]$
- $V = V_m \sin\omega t = V' \angle 0^\circ$ $\left[V' = \frac{V_m}{\sqrt{2}} \right]$
- $Z_R = R \angle 0^\circ$
- $I = \frac{V \angle 0^\circ}{R \angle 0^\circ} = \frac{V}{R} \angle 0 - 0^\circ = \frac{V}{R} \angle 0^\circ$
- $I_m = \frac{\sqrt{2}\, V}{R}$
- $I = \sqrt{2}\left(\frac{V}{R}\right) \sin\omega t$

(2) Inductor: pure inductor এ angle difference 90° V and i

অর্থাৎ $\theta = 90^\circ$

- $X_L = \omega L$ (inductive reactant
- ~~Z~~ $Z_L = X_L \angle 90^\circ$ (impedance)
- $V = V_m \sin\omega t = V \angle 0^\circ$
- $I = I_m \sin(\omega t - 90^\circ) = I \angle -90^\circ$
- $I = \frac{V}{Z_L} = \frac{V \angle 0^\circ}{X_L \angle \theta_L} = \frac{V \angle 0^\circ}{X_L \angle 90^\circ}$

$i = \frac{\sqrt{2}\, V}{X_L} \sin(\omega t - 90^\circ)$

Capacitive: pure capacitor এ v and i এর angle difference 90°.

- $X_C = \frac{1}{\omega C}$ (capacitive reactant

- $Z_C = X_C \angle -90^\circ$ (impedance)

- $v = V_m \sin\omega t = V\angle 0^\circ$

- $I = \frac{V}{Z_C} = \frac{V\angle 0^\circ}{X_C\angle -90^\circ} = \frac{V}{X_C}\angle 90^\circ$

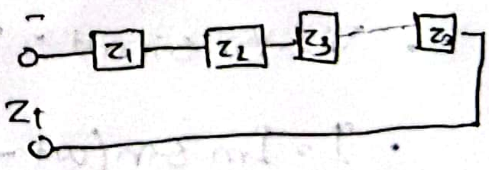
- $I = I_m \sin(\omega t + 90^\circ)$

- $I = \frac{\sqrt{2}\,V_m}{X_C}\sin(\omega t + 90^\circ)$

impedance:

- $Z_R = R\angle 0^\circ$
- $Z_L = X_L \angle 90^\circ$
- $Z_C = X_C \angle -90^\circ$

* **element গুলো যখন series এ থাকে:**



- $Z_T = Z_1 + Z_2 + Z_3 + \cdots + Z_n$

Z_T (Total)

- $I = \frac{E}{Z_T}$

supply voltage → E

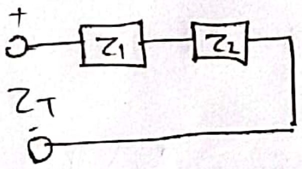
Z_T → Total Impedance

$V_1 = I Z_1$

$V_2 = I Z_2$

$E = V_1 + V_2$

voltage divider rules:

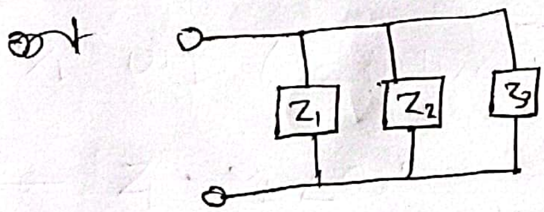


$V_1 = I Z_1$

$$V_1 = \frac{E Z_1}{Z_1 + Z_2} = \frac{Z_1 E}{Z_T}$$

$$V_2 = \frac{E Z_2}{Z_1 + Z_2} = \frac{Z_2 E}{Z_T}$$

~~powers~~ parallel:



- $$\frac{1}{Z_T} = \frac{1}{Z_1} + \frac{1}{Z_2} + \frac{1}{Z_3}$$

$$\frac{1}{Z_T} = \frac{Z_2 Z_3 + Z_1 Z_3 + Z_1 Z_2}{Z_1 Z_2 Z_3}$$

$$Z_T = \frac{Z_1 Z_2 Z_3}{Z_2 Z_3 \cdot Z_1}$$

- $I_1 = \frac{E}{Z_1}$, $I_2 = \frac{E}{Z_2}$
- $I = I_1 + I_2$
- $$\frac{1}{Z_R} = \frac{1}{R\angle 0^\circ} = \frac{1}{R}\angle 0^\circ$$
- $$\frac{1}{Z_L} = \frac{1}{X_L \angle 90^\circ} = \frac{1}{X_L}\angle -90^\circ$$
- $$\frac{1}{Z_C} = \frac{1}{X_C \angle -90^\circ} = \frac{1}{X_C}\angle 90^\circ$$

Current Divider rule:

$$I_1 = \frac{Z_2 I_T}{Z_1+Z_2} , \quad I_2 = \frac{Z_1 I_T}{Z_1+Z_2}$$

Power:

$P = EI\cos\theta_r$

$E = E_{eff} = E_{r.m.s} = \frac{E_m}{\sqrt{2}}$

$I = I_{eff} = I_{r.m.s} = \frac{I_m}{\sqrt{2}}$

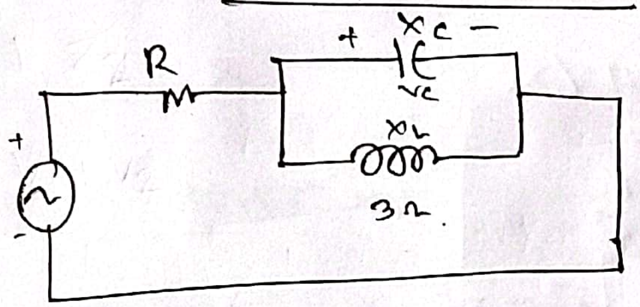
θ_r = angle difference between V and i.

Power factor:

- $F_p = \cos\theta$
- $P = EI\cos\theta_1$
- $\cancel{\frac{P}{EI} = \cos\theta}$ $\frac{P}{EI} = F_p$
- $F_p = \cos\theta = \frac{R}{Z_T}$ [series]
- $F_p = \cos\theta = \frac{Z_T}{R}$ [parallel]

Chapter – 16

16.1|



$E = 120V\angle 0°$, ~~$X_L = 3\angle 90°$, $X_C = 2\angle -90°$~~

$X_L = 3\Omega$, $X_C = 2\Omega$; $R = 1\Omega$

$Z_L = 3\angle 90°$, $Z_C = 2\angle -90°$, $Z_R = 1\angle 0°$

(a) Calculate Z_T:

$$Z_T = Z_R + Z_C \parallel Z_L$$

$$Z' = \frac{Z_C \times Z_L}{Z_C + Z_L}$$

$$= \frac{2\angle -90° \times 3\angle 90°}{2\angle -90° + 3\angle 90°}$$

$$= \frac{6\angle 0°}{\cancel{-2\hat{j}+3\hat{j}}\ -2\hat{j}+3\hat{j}} = \frac{6\angle 0°}{\hat{j}}$$

$$= \frac{6\angle 0°}{1\angle 90°}$$

$$= 6\angle -90°$$

~~$-2\hat{j}+3\hat{j}$ in polar form:~~

~~$\sqrt{(-2)^2+(3)^2} = 3.61$~~

~~$\tan^{-1}($~~

$Z_T = 1\angle 0° + 6\angle -90°$

$= 1 + -6j$

$1-6j$ → polar form

$\sqrt{(1)^2+(-6)^2} = \sqrt{1+36} = 6.083$

$\theta = \tan^{-1}\left(\frac{-6}{1}\right) = -80.53°$

$Z_T = 6.083 \angle -80.53°$

(b) Determine I_s?

$$I_s = \frac{E}{Z_T} = \frac{120\angle 0°}{6.083\angle -80.53°}$$

$$= 19.74\angle 80.53°$$

(c) $V_R = I Z_R$ (Calculate V_C and V_R)

$= 19.74\angle 80.53° \times 1\angle 0°$

$= 19.74\angle 80.53°$

$\cancel{V_C = I Z_C} = \cancel{V_C = I (Z_C \parallel Z_L)}$

$\cancel{V_C = V_R - E}$

$\cancel{V_c = E - V}$

$V_c = I_s (Z_c \| Z_L)$

$= 19.74 \angle 80.53^\circ \times Z'$

$= 19.74 \angle 80.53^\circ \times 6 \angle -90^\circ$

$= 118.44 \angle -9.47^\circ$

(d) Find I_c :

$$I_c = \frac{V_c}{Z_c} = \frac{118.44 \angle -9.47^\circ}{2 \angle -90^\circ}$$

$= 59.22 \angle 80.53^\circ$

(e) Total powering P

$\cancel{P = E \times I \cos}$: $P = P_R + P_C + P_L$

$= I_{eff} \times e_{ff} \cos 0^\circ + I_{eff}\, e_{ff} \cos 90^\circ +$ $\cancel{I_{eff}\, e_{ff} \cos(}$ $I_{eff}\, e_{ff} \cos(-90^\circ)$

$= I_{eff}\, E_{eff} \times 1 + 0 + 0$

R এর ক্ষেত্রে,

$I_{eff} = 19.74 \cancel{\angle 80.53^\circ}$

$E_{eff} = 19.74 \cancel{\angle 80.53^\circ}$

$P = \cancel{I_{eff} \times E_{eff}}$

$= \cancel{19.74 \angle 80.53 \times 19.74 \angle 80.53}$

$= \cancel{389.67 \angle 161.06°}$

$=$

$P = I_{eff} \times E_{eff}$

$= (19.74) \times (19.74)$

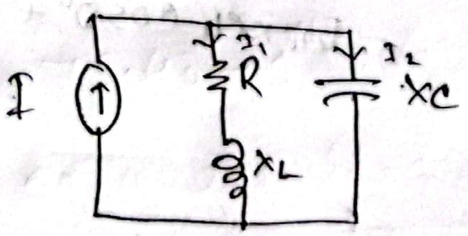
$= 389.67 \, W$

(f) Calculate Fp:

$Fp = \cos\theta = \cos 80.54°$

$= 0.164$ leading

16.2 | exp:



$R = 3\Omega, \; X_L = 4\Omega, \; X_C = 8\Omega$

$I = 50 \angle 30°$

$Z_R = 3 \angle 0°, \; Z_{X_L} = 4 \angle 90°, \; Z_{X_C} = 8 \angle -90°$

(a) (a) Calculated I_1 using current divider rule:

$Z' = Z_R + Z_L$

$= 3\angle 0^\circ + 4\angle 90^\circ = 3 + 4\hat{j}$

$$I_1 = \frac{Z_C \times I}{Z_C + Z'} = \frac{8\angle -90^\circ \times 50\angle 30^\circ}{-8\hat{j} + 3 + 4\hat{j}}$$

$$= \frac{400\angle -60^\circ}{3 - 4\hat{j}}$$

$3 - 4\hat{j}$ to polar form: $\sqrt{(3)^2 + (-4)^2} = 5$

$\theta = \tan^{-1}\left(-\frac{4}{3}\right) = -53.13^\circ$

$$I_1 = \frac{400\angle -60^\circ}{5\angle -53.13^\circ} = 80\angle -6.87^\circ$$

(b) Calculate I_2 (current divider) rule:

$Z' = 3 + 4\hat{j}$

$= 5\angle 53.13^\circ$

$$I_2 = \frac{Z' \times I}{Z' + Z_C}$$

$$= \frac{5\angle 53.13 \times 50\angle 30^\circ}{3 - 4\hat{j}}$$

$$= \frac{250\angle 83.13}{5\angle -53.13}$$

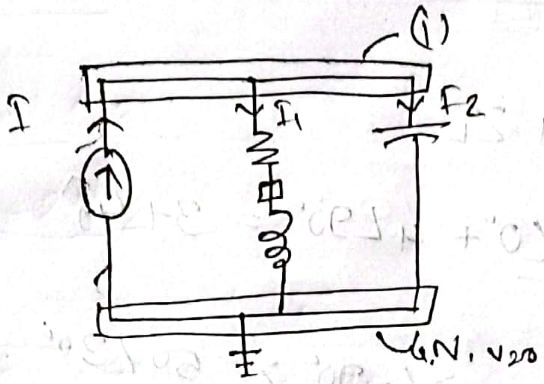
$$= 50\angle 136.26^\circ$$

$\sqrt{(3)^2 + (4)^2} = 5$

$\theta = \tan^{-1}\left(\frac{4}{3}\right)$

$= 53.13$

(C) verify ~~ver~~. KCL at one node



NODE: 1

$I = I_1 + I_2$

$50\angle 30^\circ = 80\angle -6.87^\circ + 50\angle 136.26^\circ$

$80\angle -6.87^\circ$ কার্তেসীয় form:

$X = 80\cos(-6.87^\circ) = 79.43$

$Y = 80\sin(-6.87^\circ) = -9.57$

$\therefore I_1 = 79.43 - j\,9.57$

I_2 এর কার্তেসীয় form:

$X = 50\cos(136.26^\circ) = -36.12$

$Y = 50\sin(136.26) = 34.57$

$I_2 = -36.12 + 34.57j$

$I = I_1 + I_2$

$= 79.43 - 9.57\hat{j} \cancel{+} - 36.12 + 34.57\hat{j}$

$= 43.31 + 25\hat{j}$

I ~~of~~ polar form

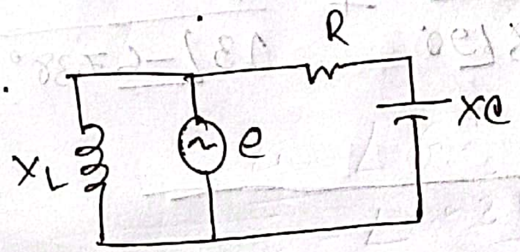
$\sqrt{(43.31)^2 + (25)^2} = 50$

$\theta = \tan^{-1}\left(\frac{25}{43.31}\right) = 30^\circ$

~~$\theta = 50$~~

$I = 50 \angle 30^\circ$

16.3



$E = 20\angle 20^\circ$, $R = 5\Omega$; $X_C = 12\Omega$, $X_L = 8\Omega$

(a) V_C (voltage Divider rule)

$V_C = \frac{E \times Z_C}{Z_C + Z_R} = \frac{20\angle 20^\circ \times 12\angle -90^\circ}{5\angle 0^\circ + 12\angle -90^\circ}$

$= \frac{240\angle -70^\circ}{5 - 12\hat{j}}$

$5 - 12\hat{j}$ polar form :

$\sqrt{(5)^2 + (12)^2} = 13$, $\theta = \tan^{-1}\left(\frac{-12}{5}\right)$

$= -67.4^\circ$

$$V_C = \frac{240 \angle -70^\circ}{13 \angle -67.38^\circ}$$

$$= 18.46 \angle -2.62$$

(b) Calculate current I_s

$$\frac{1}{Z_T} = \frac{1}{Z_L} + \frac{1}{Z_R + Z_C}$$

$$= \frac{1}{8\angle 90^\circ} + \frac{1}{13\angle -67.38^\circ}$$

$$= 0.125\angle -90^\circ + 0.077\angle 67.38^\circ$$

$$= -0.125\hat{j} + 0.077\angle 67.38^\circ$$

$0.077\angle 67.38^\circ$ কে কার্তেসীয় form এ নিলে,

$$x = 0.077\cos(67.38^\circ) = 0.03$$

$$y = 0.077\sin(67.38^\circ) = 0.071$$

$$\frac{1}{Z_T} = -0.125\hat{j} + 0.03 + 0.071\hat{j}$$

$$= -0.048\hat{j} + 0.03$$

$\frac{1}{Z_T}$ কে polar form:

$$\sqrt{(0.048)^2 + (0.03)^2} = 0.06$$

$$\theta = \tan^{-1}\left(\frac{-0.048}{0.03}\right) = -58^\circ$$

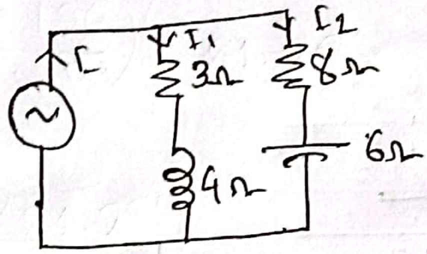
$$\frac{1}{Z_T} = 0.06 \angle -58^\circ$$

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

$$= 20\angle 20^\circ \times 0.06 \angle -58^\circ$$

$$= 1.2 \angle -38^\circ$$

16.4



$E = 100\angle 0^\circ$, $R_1 = 3\Omega$, $R_2 = 8\Omega$

$X_L = 4\Omega$; $X_C = 6\Omega$

(a) Calculate the current I_s:

$Z_{R_1} = 3\angle 0^\circ$, $Z_{R_2} = 8\angle 0^\circ$, $Z_L = 4\angle 90^\circ$, $Z_C = 6\angle -90^\circ$

$$Z_1 = Z_{R_1} + Z_L = 3\angle 0^\circ + 4\angle 90^\circ$$

$$= 3 + 4\hat{j} = 5\angle 53.13$$

$$Z_2 = Z_{R_2} + Z_C = 8\angle 0^\circ + 6\angle -90^\circ = 8 - 6\hat{j}$$

$$= 10\angle -36.87^\circ$$

$$Z_T = \frac{Z_1 \times Z_2}{Z_1 + Z_2}$$

$$= \frac{5\angle 53.13 \times 10\angle -36.87}{3+4\hat{j}+8-6\hat{j}}$$

$$= \frac{50\angle 16.26}{11 - 2\hat{j}}$$

$11 - 2\hat{j}$ in polar form;

$$\sqrt{(11)^2+(-2)^2} = \sqrt{125} = 5\sqrt{5} = 11.18$$

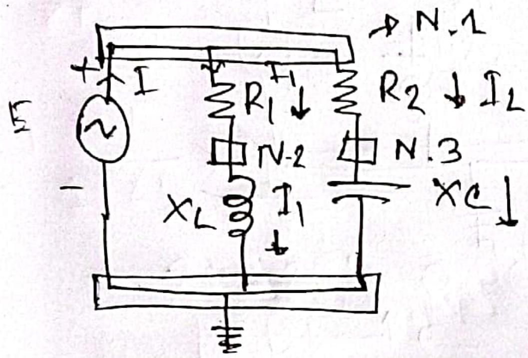
$$\theta = \tan^{-1}\left(\frac{-2}{11}\right) = -10.30$$

$$Z_T = \frac{50\angle 16.26}{11.18\angle -10.30}$$

$$= \cancel{4.46\angle 26.56} \quad 4.472\angle 26.56°$$

$$I = \frac{E}{Z_T} = \frac{100\angle 0°}{4.472\angle 26.56°} = 22.36\angle -26.56°$$

(b) Find the voltage V_{ab} :



$E = 100\angle 0^\circ$

$Z_{R_1} = 3\angle 0^\circ$

$Z_{R_2} = 8\angle 0^\circ$

$Z_L = 4\angle 90^\circ$

$Z_C = 6\angle -90^\circ$

NODE 1: $E = 100\angle 0^\circ$

NODE : 2 :

$$I_1 = \frac{V_2 - V_0}{Z_L}$$

$$\Rightarrow \frac{E - V_2}{Z_{R_1}} = \frac{V_2}{Z_L}$$

$$\Rightarrow Z_L E - V_2 Z_L = V_2 Z_{R_1}$$

$$\Rightarrow Z_L E = V_2 (Z_L + Z_{R_1})$$

$$\Rightarrow \frac{E\ Z_L}{Z_L + Z_{R_1}} = V_2 \quad \text{—(i)}$$

NODE - 3 :

$$I_2 = \frac{V_3 - V_0}{Z_C}$$

$$\frac{E - V_3}{Z_{R_2}} = \frac{V_3}{Z_C}$$

$$Z_C E - V_3 Z_C = V_3 Z_{R_2}$$

$$Z_C \times E = V_3 (Z_C + Z_{R_2})$$

$$\frac{Z_C \times E}{Z_C + Z_{R_2}} = V_3 \quad \text{—(ii)}$$

$$V_{ab} = V_3 - V_2 \quad \text{—(iii)}$$

for (i) ,

$$V_2 = \frac{E \times Z_L}{Z_{R1} + Z_L}$$

$$= \frac{100\angle 0^\circ \times 4\angle 90^\circ}{3\angle 0^\circ + 4\angle 90^\circ}$$

$$= \frac{400\angle 90^\circ}{3 + 4\hat{j}}$$

$$= \frac{400\angle 90^\circ}{5\angle 53.13}$$

$$= 80\angle 90^\circ - 53.13$$

$$= 80\angle 36.87$$

V_2 কার্তেশীয় নিয়ম,

$$X = 80\cos(36.87) = 64$$

$$Y = 80\sin(36.87) = 48$$

$$V_2 = 64 + 48\hat{j} \quad \text{—(iv)}$$

for (ii), $V_3 = \frac{E \times Z_C}{Z_C + Z_{R_2}}$

$= \frac{100\angle 0^\circ \times 6\angle -90^\circ}{6\angle -90^\circ + 8\angle 0^\circ}$

$= \frac{600\angle -90^\circ}{-6\hat{j} + 8}$

$= \frac{600\angle -90^\circ}{10\angle -36.87^\circ}$

$= 60\angle -53.13$

$60\angle -53.13$ এর কার্তেসীয় form

$x = 60 \cos(-53.13) = 36$

$y = 60 \sin(-53.13) = -48$

$V_3 = 36 - 48\hat{j}$ —(v)

for (iii), ~~$V_{ab} = V_3 - V_2$~~ ~~$V_{ab} = V_2 = V_3$~~

~~$= 36 - 48\hat{j} - 64 - 48\hat{j}$~~

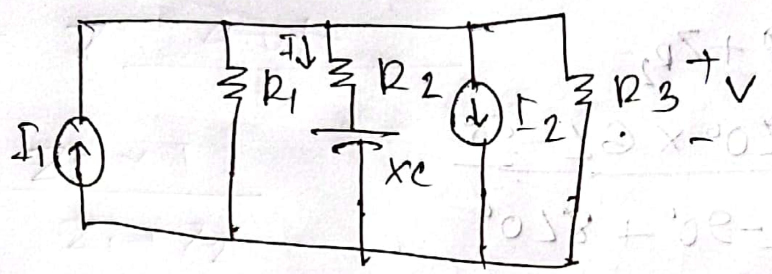
$V_{ab} = V_2 - V_3 = 64 + 48\hat{j} - 36 + 48\hat{j}$

$= 28 + 96\hat{j}$

$= 100\angle 73.74^\circ$

(Ans:)

16.6

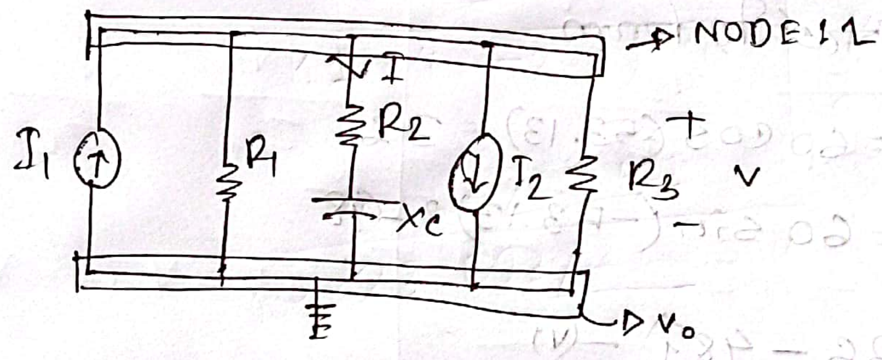


$I_1 = 6\angle 20^\circ$, $Z_{R_1} = 2\angle 0^\circ$, $Z_{R_2} = 10\angle 0^\circ$

$Z_{R_3} = 6.8\angle 0^\circ$, $Z_C = 20\angle -90^\circ$

$I_2 = 4\angle 0^\circ$

(a) Determine the current I?



$I_T = 6\angle 20^\circ - 4\angle 0^\circ$

$6\angle 20^\circ$ এর কার্তেসিয়ান form এ $x = 6\cos 20^\circ = 5.638$

$y = 6\sin 20^\circ = 2.052$

$I_T = 5.638 + 2.052j - 4$

$= 1.638 + 2.052j = 2.626\angle 51.402^\circ$

~~= 2.625∠51.34°~~

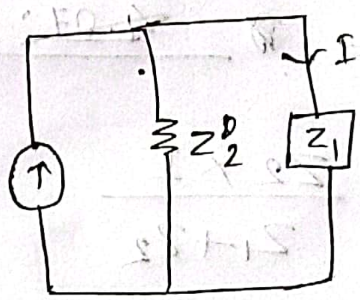
3)

NODE 1:

$$I_1 = I' + I + I_2 + I''$$

$$I_1 - I_2 = I' + I + I''$$

$$2.625\angle 51.34^\circ =$$



$$Z_1 = Z_{R_2} + Z_C$$

$$= 10\angle 0^\circ + 20\angle -90^\circ$$

$$= 10 - 20j$$

$$= 22.36\angle -63.43$$

$$Z_2 = \frac{Z_{R_1} \times Z_{R_3}}{Z_{R_1} + Z_{R_3}}$$

$$= \frac{2\angle 0^\circ \times 6.8\angle 0^\circ}{2\angle 0^\circ + 6.8\angle 0^\circ}$$

$$= \frac{13.6\angle 0^\circ}{8.8\angle 0^\circ} = 1.545\angle 0^\circ$$

$$\cancel{= 1.55\angle 0^\circ = 1.55}$$

$$I = \frac{Z_2 \times I_T}{Z_2 + Z_1}$$

$$= \frac{\cancel{1.55\angle 0^\circ \times 2.625\angle 51.34^\circ}}{}$$

$$= \frac{1.55\angle 0^\circ \times 2.626\angle 51.402}{1.55\angle 0^\circ + 10 - 20j}$$

$I \rightarrow \cancel{4.07}$

$$I = \frac{Z_2 \times I}{Z_1 + Z_2}$$

$$= \frac{1.545\angle 0^\circ \times (2.626\angle 51.402^\circ)}{1.545\angle 0^\circ + 10 - 20\hat{j}}$$

$$= \frac{4.057\angle 51.402}{1.545 + 10 - 20\hat{j}}$$

$$= \frac{4.057\angle 51.402}{(11.545 - 20j) \times 10^3}$$

$$= \frac{4.057\angle 51.402}{10^3 \times 23.093\angle -60.004^\circ}$$

$$= 0.176\angle 111.406^\circ$$

~~4.057~~(

1.545 kΩ

2.626 mA

4.057A

তাই নিচে 10^3

(b) $V = I Z_2$

$$= (0.176\angle 111.906) \times (22.36\angle -63.4859)$$

$$= \cancel{3.6}\ \cancel{3.96}\ 3.936\angle 47.971^\circ$$