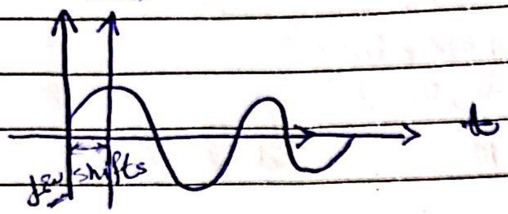
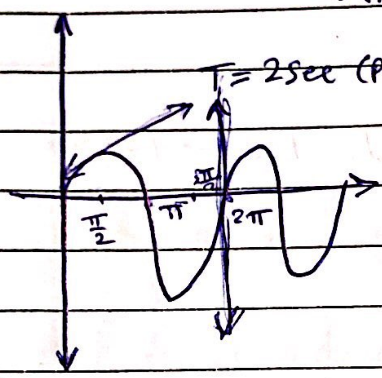
circuits (2):-

lecture (1):-

* AC - CKT:- sinosoidal , periodic.



① periodic :- $v(x) = \sin x$.



* period = T (second). الزمن المستغرق (اللازم) لإتمام دورة كاملة واحدة.

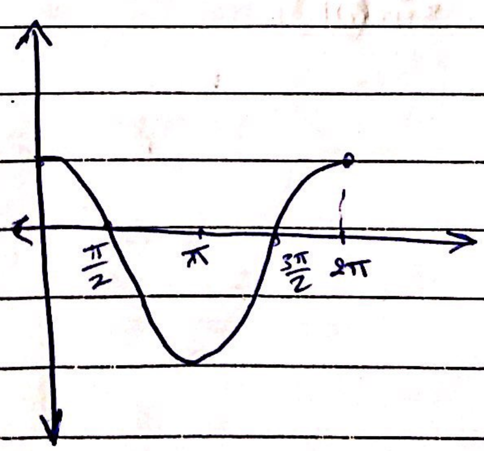
② frequency = # of perids per 1 second. التردد :
عدد الدورات في الثانية الواحدة.

where * T = 2sec.

* $f = \frac{1}{2}$ Hz.

$$\boxed{f = \frac{1}{T}}$$ → velocity. (حركة الموجة).

*

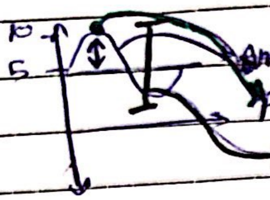


$v(x) = \cos x$.

Circuits (2):-

(3) Peak : (Max value). أعلى قيمة تصل لها الرسمة (المنحنى)

(4) Amplitude . Avg → Max . الرقم الملزوق بال sin.



Amplitude = 5 . كأنه ارتفاع الموجة الوحدة.

Peak = 10 أعلى قيمة (الراس)

Peak - Peak = 10 من القمة للقاع.

(5) peak to peak. (peak - peak) : (Min → Max).

---

x = angle. 1 period needs 1 sec → T = 1 sec

if $2\pi \rightarrow T$ sec

$\alpha \rightarrow$??
(angle)

time ?? $= \dfrac{\alpha T}{2\pi}$ time .

α (angle) $= \dfrac{2\pi}{T}$ (rad/sec) = angular speed = ω : omiga

$\boxed{\alpha = \omega}$ = angular frequency. $\boxed{\omega = 2\pi f}$

While $\dfrac{1}{T} = f$.

which means that $\boxed{\alpha = \omega T}$

$v(x) = \sin x \rightarrow \sin\alpha \rightarrow \sin(\omega t)$.

* note: ω always $\boxed{rad/sec}$

* **Example:-** Motor rotates $300°/sec$, ⓐ how long does it take to complete $360°$:- ⓑ period. ⓒ Frequency.

$\boxed{a}$ $\omega = \frac{300 * \pi}{180} = \boxed{\omega = \frac{10\pi}{6} \ rad/sec.}$

as well as:

$\omega = 2\pi f = \frac{2\pi}{T}$ $\boxed{b}$ $300° \longrightarrow 1 sec$

$360° \longrightarrow ??$ $\longrightarrow \frac{360}{300} = \boxed{1.2 \ sec. \ = T}$

$T = \frac{2\pi}{\omega} = \frac{2\pi}{\frac{10\pi}{6}} = \frac{2\pi}{10\pi} * 6 = \frac{12}{10} = 1.2 sec$ Same

الزمن اللي تاخذه دورة كاملة. (360°) نفس ⓐ

$\boxed{C}$ $\frac{1}{T} = \frac{1}{1.2} = \boxed{\frac{10}{12} \ HZ}$ or $\boxed{\omega = 2\pi f}$

---

* **Example:-** A sinosoidal current has { Amplitude $= 10A$. (T) Period $= 1.2 \ sec$.

Determine the times at which $i = 5A$.

الزمن لا الأزمان

Amplitude.

$i(t) = I \cdot \sin(\omega t) \Longleftrightarrow 10 \sin(\omega t)$.

$\boxed{\omega = \frac{2\pi}{T}} \longrightarrow \omega = \frac{2\pi}{1.2} \ rad/sec \Longrightarrow$

$i(t) = 10 \sin \left(\frac{2\pi}{1.2}\right) t$

* $\sin x = \frac{1}{2}$

$x = \frac{\pi}{6} = 30°$.

$\cancel{5} = \cancel{10} \sin \left(\frac{2\pi}{1.2}\right) t$

نأخذ $\sin^{-1}$ للطرفين

$\left(\frac{1}{2} = \sin \left(\frac{2\pi}{1.2}\right) t\right)$ $\frac{\pi}{6} = \frac{2\pi}{1.2} t$. $\Longrightarrow$

$\boxed{t_1 = 0.1 \ sec}$ # $\longrightarrow$ الزاوية $= \frac{\pi}{6}$ الربع ①

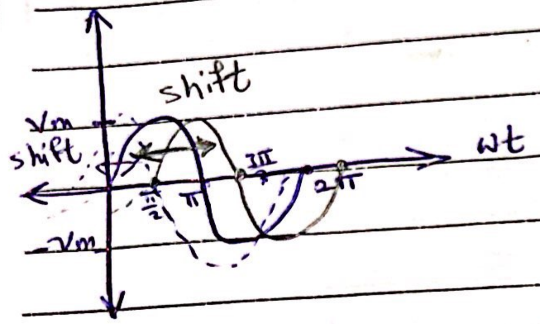
$\boxed{t_2 = \frac{5\pi}{6} \rightarrow 0.5 \ sec}$ #

عكس

* lecture (2):-

Phase shift.

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



$v(t)_* = V_m . \sin(\omega t - \frac{\pi}{2})$: shift to the right.
$\underbrace{\text{phase}}$ shift $\rightarrow (\theta)$

$v(t)_* = V_m . \sin(\omega t + \frac{\pi}{2})$: shift to the left.

* lag $(-\theta)$ $v_*(t) \rightarrow$ lags.
  lead $(+\theta)$ $v_*(t) \rightarrow$ leads.

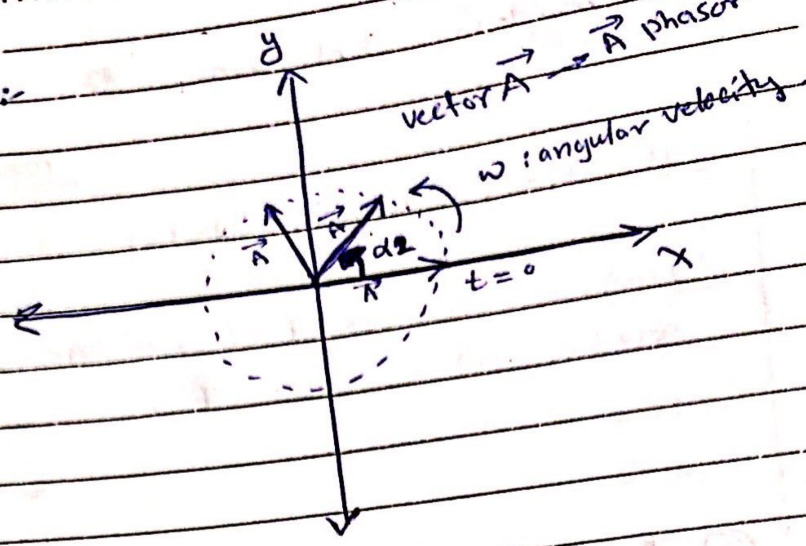
$v(t)$ leads $v_*(t)$ by 90° $(\frac{\pi}{2})$.

$v_*(t)$ lags $v(t)$ by 90° $(\frac{\pi}{2})$.

⊠ phasor:- rotation:-

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

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



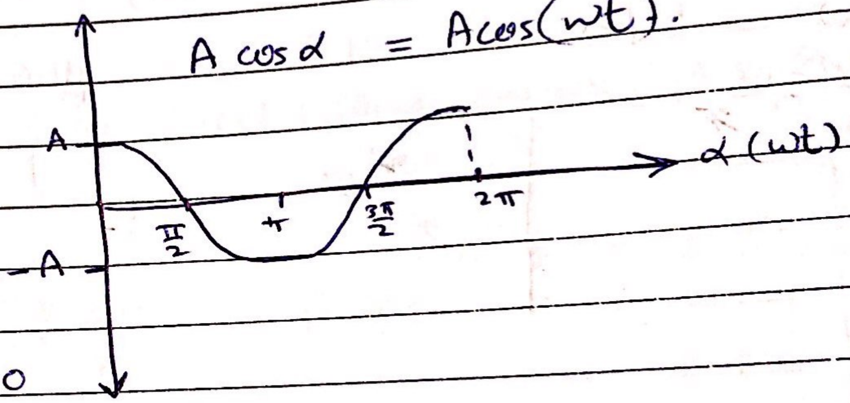
$t = 0 \Rightarrow A\cos(\alpha_1 = 0)$

$t = 1 \Rightarrow A\cos\alpha_2$

$t = t_0 = A\cos\alpha_{t_0}$

$(\alpha = \omega t)$

متغير



phasor. $|A| \angle \theta$ $t=0$

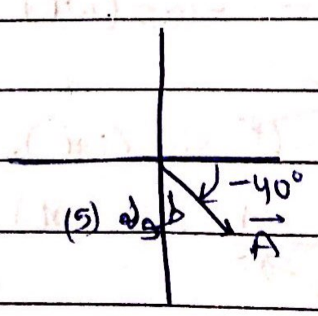
⇓

Time domain. $A\cos(\omega t + \theta)$ → الصورة العامة

يكون phasor ال

(cos)

$\vec{A} = 5\cos(\omega t - 40)$



* Example:- Determine the phasor for the following Sources:- and plot it in phasor diagram.

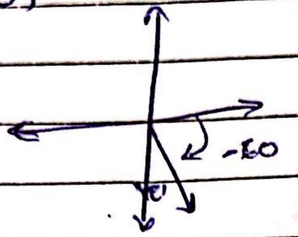
① $v(t) = 10\sin(wt + 30)$

(*) Known Identity:-

$$\sin(x) = \cos\left(x - \frac{\pi}{2}\right)$$

$v(t) = 10\cos(wt + 30 - 90)$

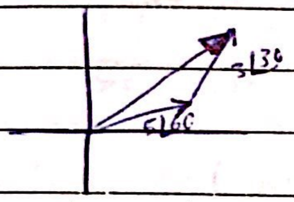
$v(t) = 10\cos(wt - 60)$



② $v(t) = 5\cos(wt+60) + 3\cos(wt+30)$. → حوّل polar لل form.

How عرفت الزاوية

$5\angle 60 + 3\angle 30 = M\angle\theta \rightarrow 7.7\angle 49^\circ$



or polar → rect ثم $\xrightarrow{\text{حوّل}}$ polar

// // //

(*) V.imp Identities:-

لتغيير إشارة الاقتران فقط.

1. $\sin(wt \mp 180) = -\sin(wt)$.
2. $\cos(wt \mp 180) = -\cos(wt)$.

عكس

3. $\cos(wt \mp 90) = \pm\sin(wt)$.
4. $\sin(wt \pm 90) = \pm\cos(wt)$.

Same
نفس

* lecture (3):- Phasor

Vector $\Rightarrow$ polar form.

$|A| \measuredangle \theta \sim t=0$

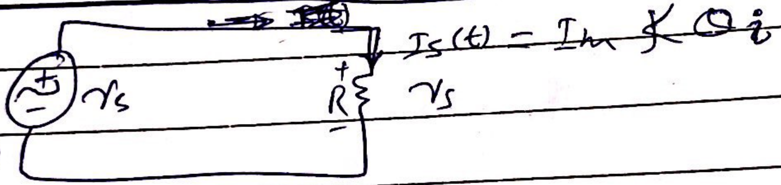
angular speed $= \omega$ rad/sec. = angular frequency.

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

* Euler rule:- $A e^{j(\omega t+\theta)} = A e^{j\omega t} \cdot e^{j\theta}$

$$Re\{A e^{j(\omega t+\theta)}\} = Re\{\cos(\omega t+\theta) + jA \sin(j\omega t$$

* Ac :



Ohm's law:-

$V_s = I_s * R$.

lecture (3) :-

phasor ⇒
vector ⇒ polar form.
$|A| \angle \theta$

* angular speed $= \omega \rightarrow$ (rad/sec) $= \frac{2\pi}{T} = 2\pi f$.

* Euler rule :-

$$A e^{j(\omega t+\theta)} = A \underbrace{e^{j\omega t} \cdot e^{j\theta}}_{\text{جمع الأسس}}$$

$$\text{Real}\{\ \} = \text{Real}\{\underbrace{A\cos(\omega t+\theta)}_{\text{Real part.}} + j\underbrace{A\sin(\omega t+\theta)}_{\text{imaginary part}}\}.$$

$$\text{Real}\{A e^{j(\omega t+\theta)}\} = \underbrace{A\cos(\omega t+\theta)}_{\text{time domain}}$$

vector $\xrightarrow{\text{أعطاني}}$ time domain
بقدر أرجع أحوله

* 2 vectors بقدر أجمعهم لأن لهم نفس ω وقدرت أرسمهم على نفس الـ (Phasor diagram.)

* $A \angle \theta°$ (polar.) # ①
* Real + j imagin (Rectangular) # ②

* Real $= A\cos\theta$.
* Imaginary $= A\sin\theta$

$A = \sqrt{R^2+I^2}$
$\theta = \tan^{-1}\left(\frac{I}{R}\right)$

$\boxed{*}$ العمليات الحسابية :- مثل ضرب / قسمة

الضرب $\xrightarrow[\text{polar}]{\text{نحوله}}$ نضرب المقدارين ونجمع الزاويتين $|A \times B| \angle \theta_1+\theta_2$.

القسمة $\xrightarrow[\text{polar}]{\text{نحوله}}$ نقسم المقدارين ونطرح الزاويتين $\frac{|A|}{|B|} \angle \theta_1-\theta_2$

جمع وطرح $\xrightarrow[\text{Rectangular}]{\text{نحوله}}$ نجمع الـ imagin لحاله والـ Real لحاله.

* Rect:-

$(A+jB).(c+jD) = Ac + jAD + jBC - BC$

نحل المقام

* $\dfrac{A+jB}{c+jD} * \dfrac{c-jD}{c-jD} = \boxed{\dfrac{(A+jB).(c-jD)}{c^2+D^2}}$

* $Ae^{j\theta} = A\cos\theta + jA\sin\theta$

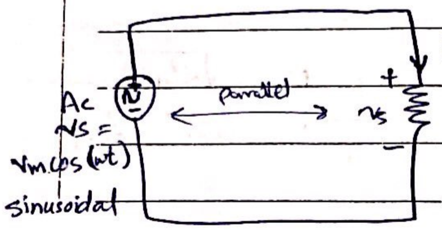
* $\cos\theta = \dfrac{e^{j\theta}+e^{-j\theta}}{2}$

V.imp identities

* $\sin\theta = \dfrac{e^{j\theta}-e^{-j\theta}}{2j}$

// ————— //

* R.L.C - CKT:-



i(t) passive sign convension.

① pure {R}:-

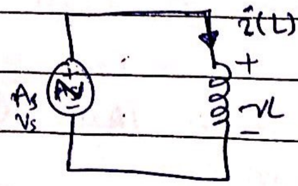
Ohm's law $\Rightarrow V_s = I_s \cdot R$

$V_m \angle 0^\circ = I_m \angle \theta_i$

V_R and I_R in phase.

نفس الزاوية

② inductor {L}:-



$v_L = L\dfrac{di}{dt} \rightarrow$

$i_L = \dfrac{1}{L}\int v_L(t)\,dt$

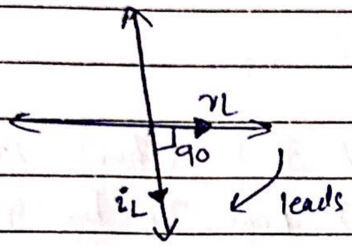
$i_L = \dfrac{1}{L}\int v_m\cos(wt)$

$i_L = \dfrac{V_m}{L}\cdot\dfrac{\sin(wt)}{\omega} \rightarrow \dfrac{V_m}{L}\cos(wt-90^\circ)$

$$\frac{v_L}{i_L} = \frac{v_m \angle 0^\circ}{\frac{v_m}{\omega L}\angle 90^\circ} \rightarrow \frac{v_L}{i_L} = \omega L \angle 90^\circ \rightarrow j\omega L \Rightarrow \text{impedance} = Z = \boxed{j\omega L}$$

---

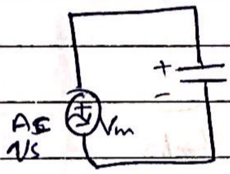
* phasor diagram of the conductor:-



i_L lags v_L by 90°

---

③ Capacitor :-



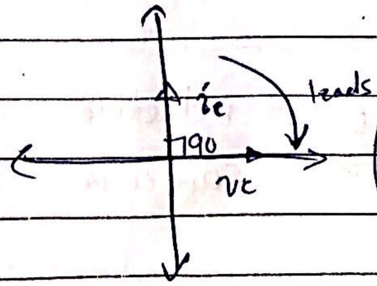
$v_c = v_m \angle 0$

$i_c = C \cdot \frac{dv}{dt} \rightarrow i_c = C \cdot -v_m \sin(\omega t) = -V_m \cdot \omega c \cdot \cos(\omega t - 90)$

$Z = \frac{v_c}{i_c} = \frac{v_m \angle 0^\circ}{-V_m \omega c \angle -90^\circ} \rightarrow \frac{1}{\omega C \angle 90^\circ} = \frac{\angle -90}{\omega C} = \boxed{\frac{-j}{\omega L}}$

---

* Phasor diagram of the capacitor:-



i_c leads v_c by 90°

(ع) *دايمًا الزاوية الأكبر هي ال leads

* lecture (5) :-

phasor

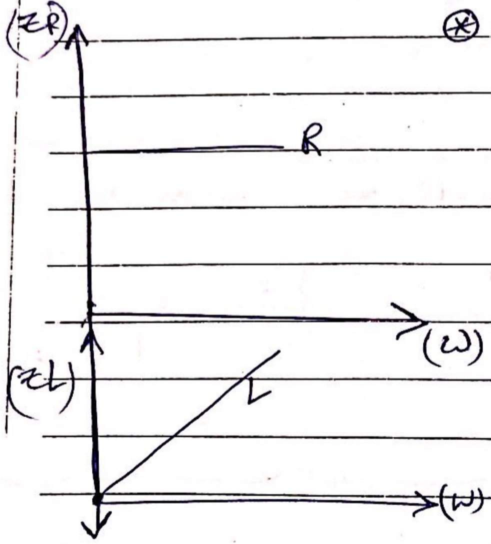
R
L
C → مجموعهم هو impedance.

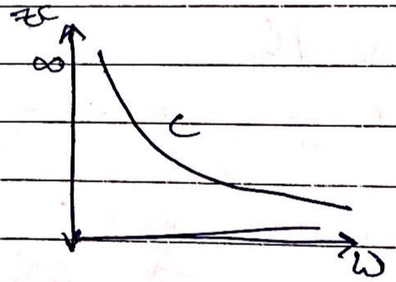
$R \Rightarrow Z_R = 0$ نقيسها بتعاهي (Ω) $\qquad V = ZI$ (ohm's law)

$L \Rightarrow Z_L = j\omega L$ (Ω) $\qquad$ ⊛ I_L Lags V_L by (90°) دائماً في ال inductor

$C \Rightarrow Z_C = j\frac{-1}{\omega C}$ (Ω) $\qquad$ ⊛ I_C leads V_C by (90°) دائماً في ال capacitor

⊛ amplitudes





DC $\Rightarrow$ capacitor $\Rightarrow$ O.C

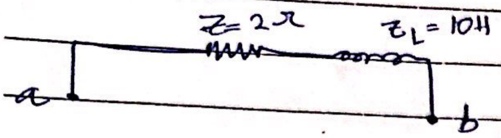
$Z_C = \infty$

$\omega = 0 \Rightarrow f = 0 \Rightarrow$ DC-source $\Rightarrow$ inductor $\Rightarrow$ S.C.

$Z_L = 0$

* $Z = R \mp jX$ → ⊕ inductive load.
→ ⊖ capacitive load.

* Series:-



* parallel :-

$$\frac{1}{Z_{eq}} = \frac{1}{Z_1} + \frac{1}{Z_2} + \cdots$$

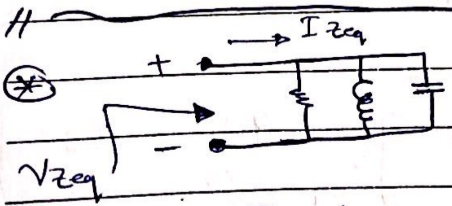
$$Z_{eq} = \frac{Z_1 Z_2}{Z_1 + Z_2}$$

* $Z = \text{Real} \mp \underbrace{j}_{\text{Reactance}} \, \text{imagine}$

$$\boxed{Z = R \mp jX}$$

//

*



$Z_{eq} = 5 + j3$. inductive

I_L lags V_L by θ_{Zeq}.

$Z_{eq} = 5 - j3$. capacitive

I_C leads V_C by $\measuredangle \theta_{Zeq}$

* $\frac{1}{Z} = Y$ (admitance).

$Z = R \pm jX$ (C) (L)

$Y = G \mp jB$ (L) (C)

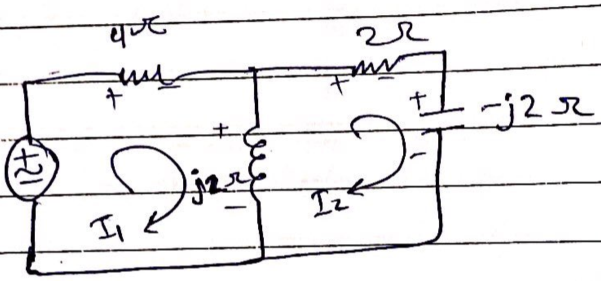
conductance   susbstance

انقلب مقام

$Y = \frac{1}{R \pm jX} * \frac{R \mp jX}{R \mp jX} = \frac{R \mp jX}{R^2 + X^2}$

*** Example:-**

Find the Mesh currents



* Mesh ①:

$5\angle 0^\circ = +(4+j2)I_1 - (j2)\, I_2$

② $= -(j2)I_1 + 2I_2$

$5\angle 0^\circ = (4+j2+2)\,I_1$

$$\boxed{I_1 = \frac{5}{6+j2}\ A}$$

$I_2 = \left(\frac{j2}{2}\right)\left(\frac{5}{6+j2}\right) = \frac{j5}{6+j2}$

$\begin{bmatrix} 5\angle 0 \\ 0 \end{bmatrix} = \begin{bmatrix} 4+j2 & -j2 \\ -j2 & 2 \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \end{bmatrix}$

$\begin{bmatrix} I_1 \\ I_2 \end{bmatrix} = A^{-1} \begin{bmatrix} 5\angle 0 \\ 0 \end{bmatrix} =$

$A^{-1} = \frac{1}{\Delta} \begin{bmatrix} 2 & +j2 \\ +j2 & -4-j2 \end{bmatrix}$

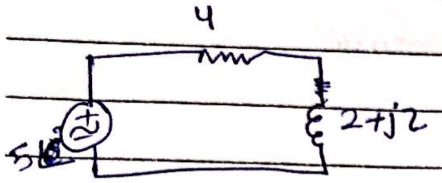
$\Delta = (4+j2) * (2) - (-j2) * (+j2)$

* طريقة ثانية

بدون استخدام Mesh analysis :-

$$(2-j2) \parallel j2.$$

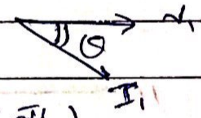
$$\frac{(2-j2)(j2)}{2} = \frac{4j+4}{2} = \boxed{2+j2}$$



$$\longrightarrow I_1 = \frac{5\angle 0^\circ}{6+j2} \quad , \quad I_2 = \frac{I_1 \cdot Z_{eq}}{2-j2}$$

$$I_2 = \frac{5}{6+j2}\left(\frac{2+j2}{2-j2}\right)$$, current division.

$$I_1 = \frac{5\angle 0^\circ}{6+j2} \longrightarrow I_m\angle\theta \quad I_1(t) = I_m \cos(\omega t + \theta)$$

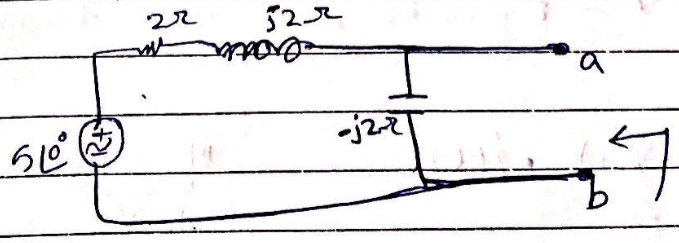


θ (سالب)

~~capacitive~~ inductive load.

I_1 lags V_1

*** Example :-**



find $Z_{thevinin}$

find Z_{Th} from a, b :-

V_{th} , I_{sc}

$$(2+j2) \parallel -j2$$

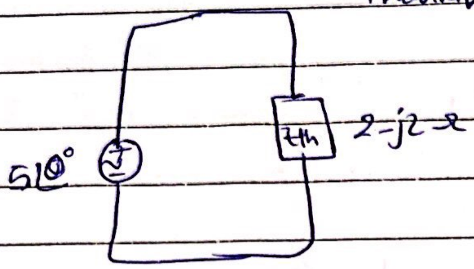
$$\frac{(2+j2)(-j2)}{2} = \frac{-j4+4}{2}$$

$$\boxed{2-j2\ \Omega}$$

$V_{o.c} = V_{ab} = V_C =$

$V_C = \frac{5\angle 0}{2}(-j2) = \quad V_{th} = V_C = -j5V = 5\angle 90°.$

Theviniv equivelnt circuit.



$I_{s.c} = \frac{V_{th}}{Z_{th}} = \frac{-j5}{2-j2}$ #

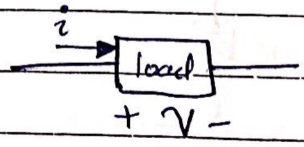
* lecture (6):-

* CH.11 :- power of AC.

$p = VI$ → + : absorb power (load).
→ − : generates power, supply, delivers. (Source).

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

instantaneous power.



⊛ sinosoudal source:-

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

$i(t) = I_m \cos(\omega t + \theta_i)$.

$p(t) = V_m \cdot I_m \cdot \cos(\omega t + \theta_v) \cdot \cos(\omega t + \theta_i) \rightarrow$

إذا عكس نفس الشيء

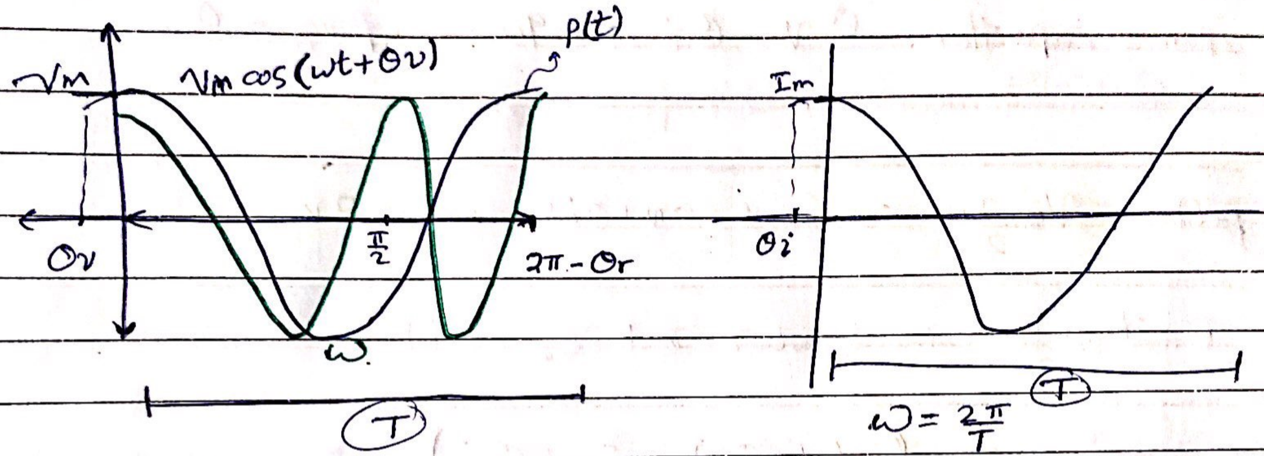
$p(t) = \frac{1}{2} V_m \cdot I_m \left[\cos(2\omega t + \theta_v + \theta_i) + \cos(\theta_v - \theta_i)\right]$

* defn: $\cos x \cdot \cos y = \frac{1}{2}\left[\cos(x+y) + \cos(x-y)\right]$.

$$p(t) = \frac{V_m . I_m}{2}\left[\cos(2\omega t + \theta_v + \theta_i) + \cos(\theta_v - \theta_i)\right] \Rightarrow$$

$$p(t) = \frac{V_m . I_m}{2}\cos(2\omega t + \theta_v + \theta_i) + \underbrace{\frac{V_m . I_m}{2}\cos(\theta_v - \theta_i)}_{\text{constant}}$$

(Average power).



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

$$P_{Peak} = \frac{V_m . I_m}{2} + \frac{V_m . I_m}{2}\cos(\theta_v - \theta_i) \quad \boxed{\omega_p = 2\omega}$$

periodic Function

$$P_{avg} = \frac{1}{T}\int_0^T p(t) . dt \Rightarrow$$

$$\frac{V_m . I_m}{2T}\left[\int_0^T \cos(2\omega t + \theta_v + \theta_i) . dt + \int_0^T \cos(\theta_v - \theta_i) . dt\right].$$

$$\Rightarrow \frac{V_m . I_m}{2\cancel{T}} . \cos(\theta_v - \theta_i)\cancel{T} \Rightarrow \frac{V_m . I_m \cos(\theta_v - \theta_i)}{2}$$

1. Avg power :- $\frac{V_m . I_m}{2} \cos(\theta_v - \theta_i)$

* Pure Resistance : $\theta_v - \theta_i = 0$, $P_{avg} = \frac{V_m . I_m}{2}$.

* Pure inductance : $\theta_v - \theta_i = +90$. , $P_{avg} = 0$.

* Pure capacitor: $\theta_v - \theta_i = -90$. , $P_{avg} = 0$.

$p(t) = \frac{V_m . I_m}{2} \cos(2wt + \theta_v + \theta_i)$, $- \theta_i + \theta_v$.

$\Rightarrow \frac{V_m . I_m}{2} \cos(2wt \mp \theta_v + 2\theta_v + \theta_i)$

$\Rightarrow \frac{V_m . I_m}{2} \cos\left(\underbrace{2(wt + \theta_v)}_{x} \mp \underbrace{\theta_v + \theta_i}_{y}\right) \Rightarrow$

* $\cos(x+y) = \cos x \cos y - \sin x \sin y$.

$\frac{V_m I_m}{2} \cos(2(wt + \theta_i)) . \cos(\theta_v - \theta_i) - \frac{V_m I_m}{2} \sin(2wt + \theta_i)$.
$\sin(\theta_v - \theta_i)$

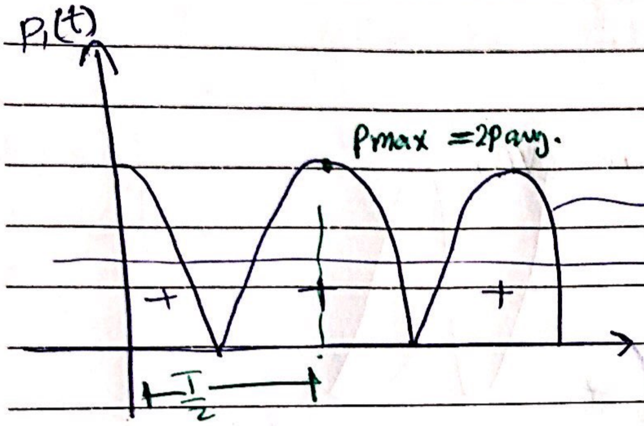
$\boxed{p(t) = \frac{I_m . V_m}{2} \cos(\theta_v - \theta_i) \left[1 + \cos 2(wt + \theta_v) \right]} \rightsquigarrow p_1(t)$.

$+ \boxed{\left[\frac{V_m . I_m}{2} \sin(\theta_v - \theta_i) . \sin 2(wt + \theta_v) \right]} \rightsquigarrow p_2(t)$

$$*\; p_1(t) = \underbrace{\frac{V_m . I_m}{2} \cos(\theta_v - \theta_i)}_{+\text{ positive}} \big[\, 1 + \underbrace{\cos 2(\omega t + \theta_v)}_{>0} \,\big] > 0$$

avg Power.

$$\boxed{-90 < \theta_v - \theta_i < 90}$$



Real power. تستهلك في (R)

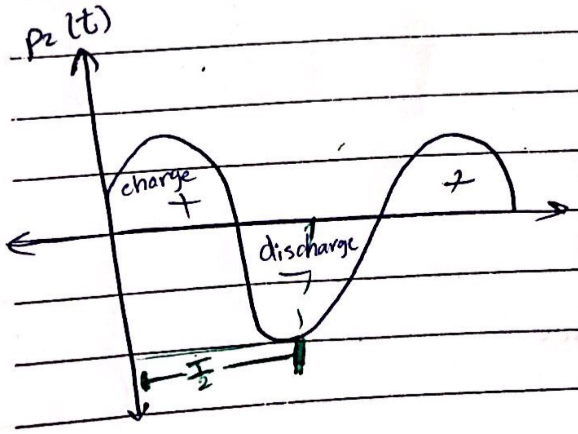
$$p_{avg} = \frac{V_m I_m}{2} \cos(\theta_v - \theta_i).$$

$$p_{max} = \frac{V_m \cdot I_m}{2} \cos(\theta_v - \theta_i)\,[\,1+1\,]. = 2\boxed{p_{avg}.}$$

\+ (positive) reactive power.

$$*\; p_2(t) = \frac{V_m . I_m}{2} \sin(\theta_v - \theta_i) \cdot \sin 2.(\omega t + \theta_v)$$

\+ −



$$p_{avg} = 0$$

$$p_{avg} = \frac{V_m I_m}{2} \cos(\theta_v - \theta_i) \rightarrow \text{real}$$

$$\underline{\underline{Q}} = \frac{V_m I_m}{2} \sin(\theta_v - \theta_i) \rightarrow \text{imag}$$

amplitude of reactive power.

Scanned with CamScanner

$P + j$ img.

$$\frac{V_m I_m}{2}\left[\cos(\theta_v - \theta_i) + j\sin(\theta_v - \theta_i)\right]$$

complex power (VA)

(watt)

$S = P + jQ.$

amp of reactive power (VAr)

$$S = \frac{V_m I_m}{2} \measuredangle \theta_v - \theta_i.$$

$$\boxed{S = \frac{\vec{V}}{2} \cdot I^{*}}$$ ضرب

→ conject.

// ——— // ——— // ——— //

*lecture (7):- $S = \frac{V_m I_m}{2} \measuredangle \theta_v - \theta_i$ (VAr) : voltage Ampere reactive.

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

$$Z = \frac{V \angle \theta_v}{I \angle \theta_i} = \frac{|V|}{|i|} \angle \theta_v - \theta_i$$

① $\theta_Z = \theta_S$.

$\theta_Z = 0$, $\theta_S = 0$ ⟹ Resistance.

$Q = 0$

② $\theta_Z > 0$. $\theta_S > 0$, $Q > 0$. ⟹ Inductive load.

③ $\theta_z < 0$ ⟶ capacitive load.

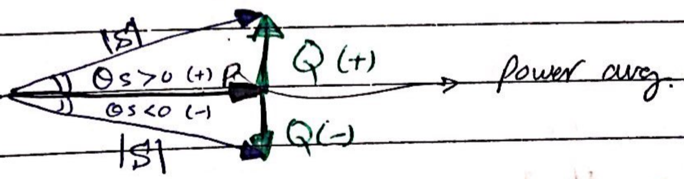
$Q < 0$

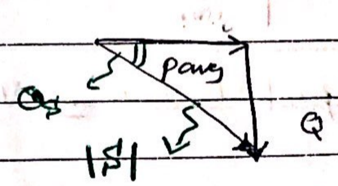
$P_{avg} = 0$ $\xrightarrow{bc}$ pure cap $Q<0$.
$\xrightarrow{or}$ pure indu. $Q>0$.

* P_{avg} = Watt.
* Q = VAr.
* S = VA.

// ——— // ——— // ——— //

* complex power [power Triangle]:-





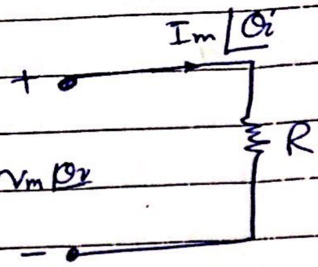
$\theta_v - \theta_i = \theta_s$

$|S| = \sqrt{P^2 + Q^2}$

$\theta_s = \tan^{-1}\left(\frac{|Q|}{|P|}\right)$

أي كمية تجيبها من
المثلث صحيحة.

*Ex:



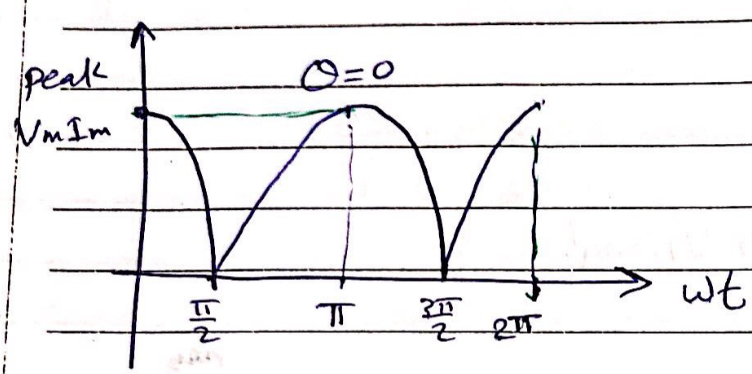
plot p(t) by R.

1. $\cos(\theta_v - \theta_i) = 1$. Pure Resistance.

$\theta_v = \theta_i = \theta$.

$$p(t) = \frac{1}{2} V_m I_m + \frac{1}{2} V_m I_m \cos(2\omega t + 2\theta)$$

$$= \frac{1}{2} V_m I_m \left[\underbrace{1 + \cos 2(\omega t + \theta)}_{\geq 0} \right]$$



peak (max) = $V_m I_m$.

Peak to peak = $2|S|$ = $V_m I_m$

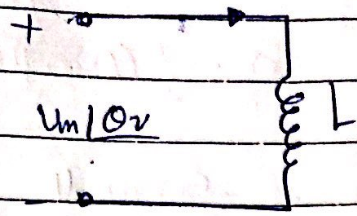
$$\boxed{S = \frac{V_m I_m}{2}}$$ [illegible]

Peak

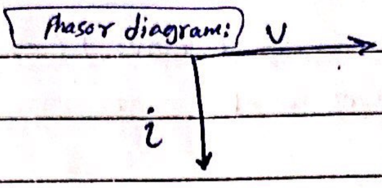
Peak-Peak

$$p_{avg} = \frac{V_m I_m}{2}$$

* Ex:-



$\theta v - \theta i = +90.$

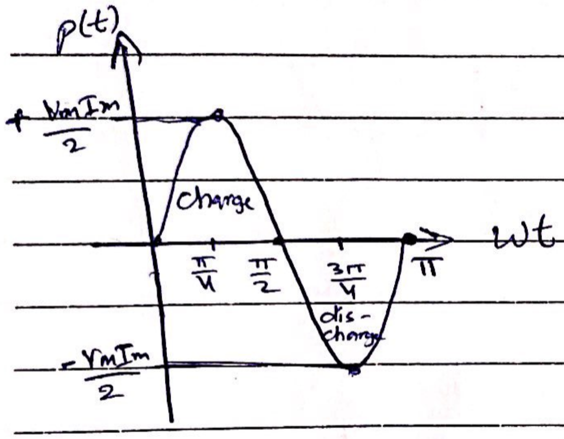


$p(t) = 0 + \frac{1}{2} V_m I_m \cos(2wt - 90°)$

Assume $\theta v = 0 \Rightarrow \theta i = -90$

avg power = 0

peak - Peak = $V_m I_m$



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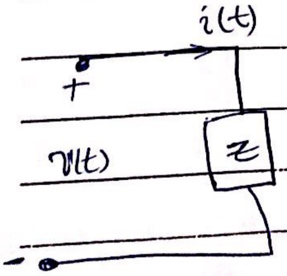
* lecture (7):-

* Ex:- $v(t) = 100\sqrt{2}\cos(wt)$

$i(t) = \sqrt{2}\cos(wt - 60)$



* Plot p(t) and show: Max, Min, Zero crossing.

$p(t) = \underbrace{\frac{1}{2} V_m I_m \cos(\theta v - \theta i)}_{Pavg.} + \frac{1}{2} V_m I_m \cos(2wt + \theta v + \theta i)$

$Pavg = \frac{1}{2}(100\sqrt{2})(\sqrt{2})\cos(0 \pm 60) \Rightarrow 100 \cos 60. = \boxed{50 \text{ watt}}$

....

bcz $\cos\theta = 1$

P_{Max} :- $p_{avg} + \frac{1}{2} V_m I_m = 50 + \frac{1}{2}(100\sqrt{2})(\sqrt{2}) = 150$ watt

P_{Min} :- $50 - \frac{1}{2}(100\sqrt{2})(\sqrt{2}) = -50$ watt.

↳ bcz $\cos\theta = -1$

① $p(t) = p_{avg}$. $wt = ??$

$\cos(2wt - 60) = 0$

$2wt - 60^\circ = 90^\circ$

$wt = \frac{90 + 60}{2} = 75^\circ$

② $p(t) = 50$ $wt = ??$

$\cos(2wt - 60) = \cancel{0}$

$2wt - 60 = 0$

$wt = \frac{60}{2} = 30^\circ$

③ $p(wt = ??) = -50$

$\cos(2wt - 60) = -1$

$2wt - 60 = 180$

$wt = \frac{180 + 60}{2} = \frac{240}{2} = 120^\circ$

Zero - crossing :-

$-50 = \frac{1}{2}(100\sqrt{2})(\sqrt{2})\cos(2wt - 60)$

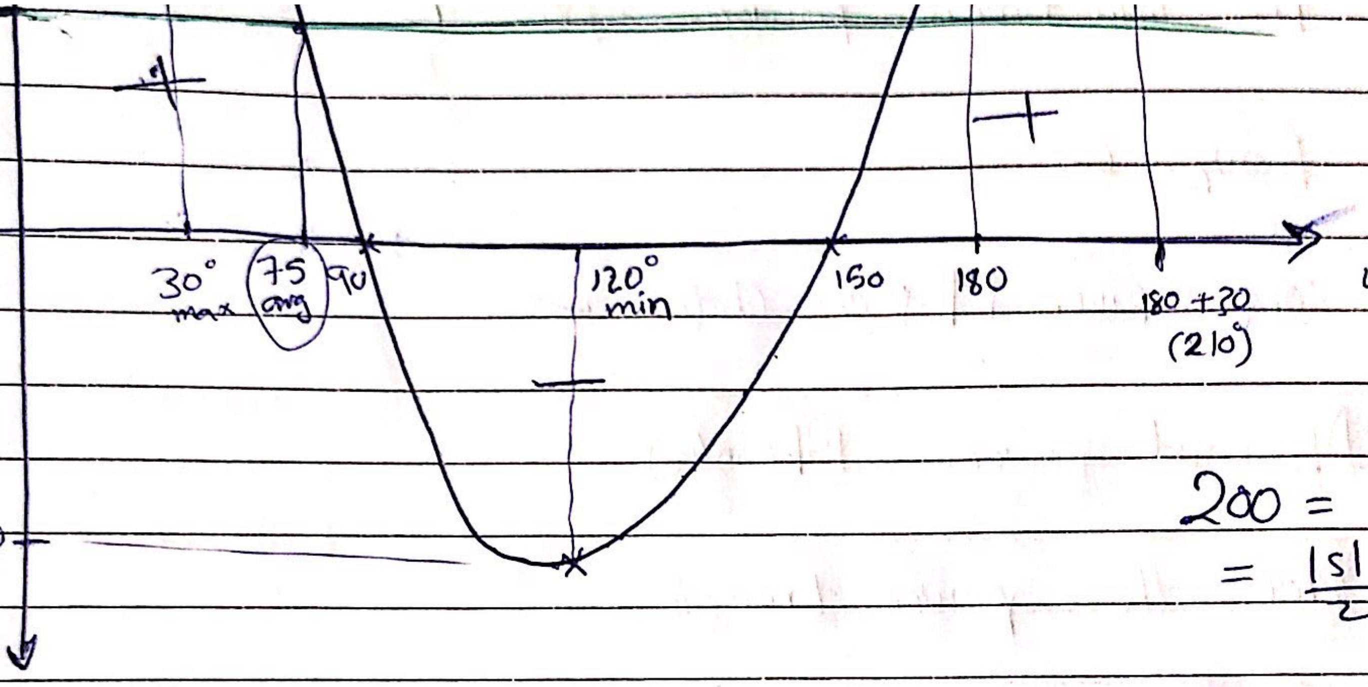
$\frac{-50}{100} = -0.5 = \cos(2wt - 60)$

$120^\circ = 2wt - 60$

$wt = \frac{120 + 60}{2} = 90^\circ$

$240 = 2wt - 60^\circ$

$wt = \frac{300}{2} = 150^\circ$



200 = Peak to Peak

$= \frac{|S|}{2}$

$v(t) = 100\sqrt{2} \cos(\omega t)$

$i(t) = \sqrt{2} \cos(\omega t - 60°)$

→ draw it.

need :- we get from p(t)

(t) ⟹ peak − peak = 2|S|

$|S| = \frac{P-P}{2}$

avg ⟹ P max = Pavg + |S|

θi ⟹ P max ⟹ p(t) = Pavg + |S| cos(2ωt + θv + θi)

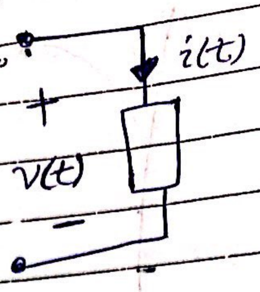
v(t) ⟹ θv.

$S = |S| \angle \theta v - \theta i = Pavg + jQ.$

⑦ $Z = \frac{V \angle \theta v}{I \angle \theta i}$

⑧ $I = \frac{2 \cdot Pavg}{Vm \cos(\theta v - \theta i)}$

Ex: $v(t) = 80\cos(10t + 20^\circ)$ $80\angle 20^\circ$
$i(t) = 15\cos(10t - 30^\circ)$ $15\angle -30^\circ$



Find:

ⓐ The instantaneous power:- → $p(t)$:-

ⓑ P_{avg}.

ⓒ complex power. $|S| \measuredangle \theta_s$ (both)

ⓓ Apperant power. $|S|$ (only)

ⓔ Plot the power triangle.

ⓕ plot the phasor diagram.

Sol:

$\boxed{a}$ $p(t) = \frac{1}{2} \cdot V_m \cdot I_m \cos(\theta_v - \theta_i) + \frac{1}{2} V_m \cdot I_m \cos(2\omega t + \theta_v + \theta_i) =$

$p(t) = \frac{1}{2} * (80)(15)\cos(20 - (-30)) + \frac{1}{2}(80)(15)\cos(2*10t + 20 - 30)$

$p(t) = \underline{385.5} + 600\cos(20t - 10^\circ)$ watts.

$\boxed{b}$ $P_{avg} = 385.5$ watt.

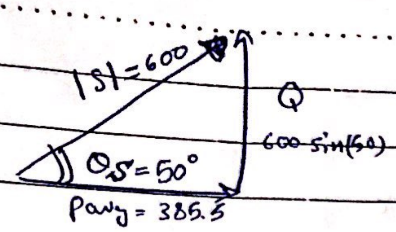
$\boxed{c}$ $S = \frac{1}{2} \vec{V} \cdot \vec{I}^* = \frac{1}{2} * (80\angle 20) * (15\angle 30^\circ) = S = 600\angle +50^\circ$ VA

because $\theta_s = +$ → so lags → i lags v so inductive load in the ckt

$S_{(VA)} = \underbrace{600\cos(50)}_{P_{avg} = 385.5\text{ watt}} + j\underbrace{600\sin(50)}_{Q\ (VAr)}$

$\boxed{d}$ 600 V.A

e



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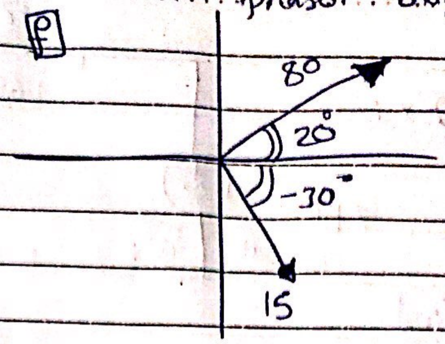
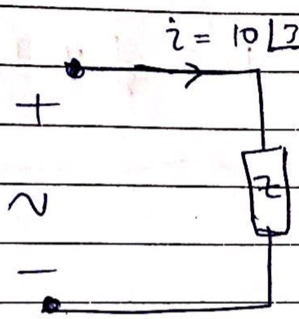
phasor diagram:-



i lags V by $(50°)$

* Ex:-



$20\angle -22°\ \Omega \Rightarrow R - jX = \underbrace{20\cos(-22)}_{R} + j\,20\sin(-22)$

$P_{avg} = ?? = \frac{1}{2} V_m I_m \cos(\theta_v - \theta_i)$.

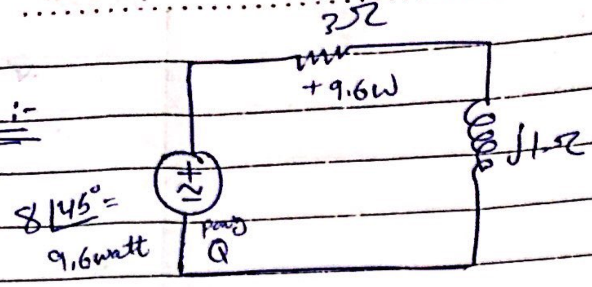
$V = I.Z \Rightarrow (10\angle 30°)(20\angle -22) = \boxed{V = 200\angle 8°}$

$P_{avg} = \frac{1}{2}(200)(10)\cos(-22) = 927$ watt

* $P_{avg} = \frac{1}{2} . I^2 . R \Rightarrow P_{avg} = \frac{1}{2}(10)^2 \times 20\cos(-22)$ watt.

$Q = \frac{1}{2} I^2 X = \frac{1}{2}(10)^2 . 20\cos(-22)$ VAr.

*Ex :-



Find :-

(a) avg power absorbed by 3Ω, $j1\Omega$;

(b) " " supplied by the source :

(c) Find reactive power (Q) supplied by the source :-

$$Q = -\frac{1}{2} I^2 X = -\frac{1}{2}(2.53)^2 * 1 = \frac{1}{2} V_1 \cdot I_1 \cdot \sin(\theta v - \theta i)$$

// ——— // ——— // ——— //

(a) ~~[illegible]~~ $p_{avg} = \frac{1}{2} \cdot I^2 \cdot R(3)$

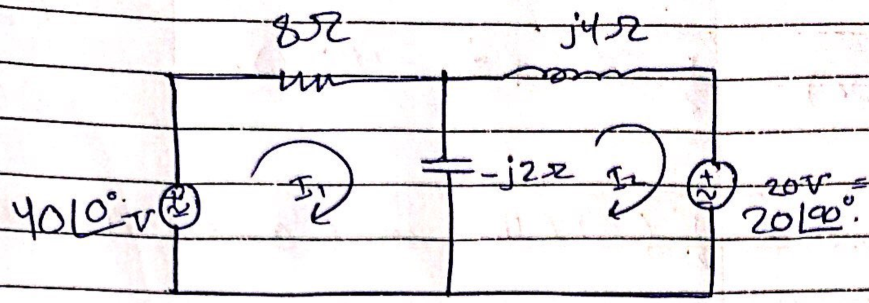
$$I = \frac{8\angle 45^\circ}{3+j} = 2.53\angle 26.56^\circ$$

$p = \frac{1}{2}(2.53)^2 * 3 = 9.6W.$ → same source supplied

$P(j1\Omega) = 0.$

// ——— // ——— // ——— //

*Ex:



* Calculate the avg power absorbed / generated by each given element :-

$P_{avg(8\Omega)} = \frac{1}{2} I_1^2 * 8 =$

$P_{avg(j1\Omega)} = \frac{-1}{2} V_1 I_1 \cos(\theta v - \theta i)$

$P_{avg(20V)} = +\frac{1}{2} V \cdot I_2 \cos(90 - \theta i_2)$

// — // — // — //

$40\angle 0° = (8 - j2) I_1 - (-j2) I_2.$

$-j20 = -(-j2) I_1 + (-j2 + j4) I_2.$

$40 = (8 - j2) I_1 + \cancel{j2 I_2}$

$(-j20 = +j2 I_1 + \cancel{j2 I_2}) * -1$

$I_1 = \frac{40 + j20}{8 - j4} = 5\angle 53.14°$

$\longrightarrow$

$I_2 = 13.6 \angle 17.11°$

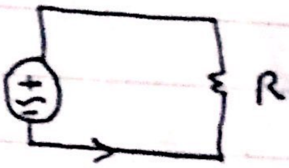
$P(8\Omega) = \frac{1}{2}(5)^2 \times 8 = +100\,W.$

$P(40V) = -\frac{1}{2}(5)(40)\cos(0 - 53.14) = -60\,W$

$P(j20) = +\frac{1}{2}(13.6)(20)\cos(90 + 17.11) = -40\,W$

effective Value

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

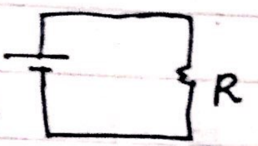


$P_{avg} = \frac{1}{2} I_m^2 R$

$i(t) = I_m \cos(\omega t)$ $\quad P_{avg} = \frac{1}{2} \frac{V_m^2}{R}$

$\Longleftrightarrow$ pavg.

V_{DC}



$$P = \frac{V_{DC}^2}{R}$$

$$\downarrow$$

$$\frac{1}{2} \frac{V_m^2}{R} = \frac{V_{DC}^2}{R}$$

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

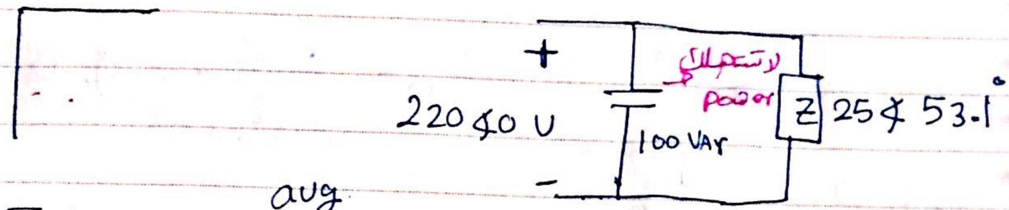
$$I_{effec}^2 R = P_{avg} = \frac{1}{T} \int_0^T I^2(t) R \, dt$$

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

Root mean Square

$$P = \frac{1}{2} \frac{V_m^2}{R} = \frac{\frac{1}{2} (V_{rms} \sqrt{2})^2}{R}$$

No.



Find the net avg. power Supplied by the Source.

$$I = \frac{220 \angle 0}{25 \angle 53.1} = 8.8 \angle -53.1^\circ$$

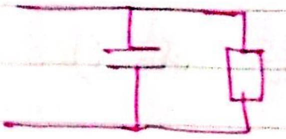
$$Z = \underbrace{25 \cos 53}_{R} + \underbrace{25j \sin 53.1}_{XL}$$

$$P = (8.8)^2 * 25 \cos 53.1 \text{ watt.}$$

$$S = P + jQ \qquad Q_L = I^2 \left(\frac{\omega L}{XL} \right)$$

$$= (8.8)^2 \left(25 \sin 53.1 \right)$$

No.



* parallel

ميحافظ على قيمة (P) ثابتة :

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

$P = I^2R$

*الحمل

$VAr \rightarrow F$

$P_{old} = P_{new} = 10MW$

$Q_{old} = P_{old} \tan\theta_{old} = 10M \tan(53.1) = +13.3VAr$

$Q_{new} = P \tan\theta_{new} = 10MW \tan(18.12)$
$= 3.29\ MVAr.$

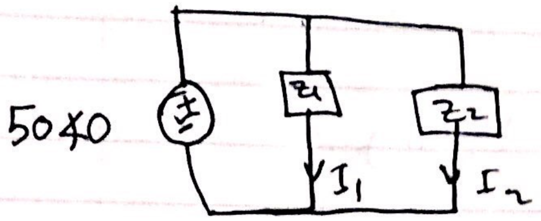
$Q_C = Q_{old} - Q_{new}$
$= 13.3 - 3.3 \cong 10MVAr.$

$Q = \frac{V^2}{X} = \frac{V^2}{\frac{1}{\omega C}} \rightarrow Q = \omega C V^2$

$10M = (2\pi * 50)\, C\, (\cancel{33}\ 66k)^2$

$\overline{\overline{C}}$ كهربا ٨ ارت

$\boxed{\theta_s = \theta_x}$



$Z_1 = 50 \measuredangle 45^\circ$

$Z_2 = 25 \measuredangle 30^\circ$

PF :- الزاوية تبعها
or Z_1
Z_2. ind lag cap load

ⓐ Find I_1, I_2, I

$I_1 = \dfrac{50 \measuredangle 0}{50 \measuredangle 45} = 1 \measuredangle -45^\circ$

$PF_{Z_1} = \cos \theta_{Z_1}$
$= \cos(45)$
$= .707$ lag.

$I_2 = \dfrac{50 \measuredangle 0}{25 \measuredangle 30^\circ} = 2 \measuredangle -30^\circ$

$I = I_1 + I_2 =$

$\boxed{b}$ S_{Z_1} ., S_{Z_2}

$S_{Z_1} = V_{rms} I^*_{rms} = 50 \measuredangle 0 \ (1 \measuredangle +45^\circ) \ 50 \measuredangle 45^\circ$ V.A

$S_{Z_2} = V_{rms} I^*_{rms} = 50 \measuredangle 0 \ (2 \measuredangle 30) = 100 \measuredangle 30^\circ$ V.A

$\boxed{c}$ S_{source}

$S_1 + S_2$.

$\boxed{D}$ PF source

$\cos(0) = 1$

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

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

$$S = \frac{1}{\sqrt{2}\,\sqrt{2}} V_m I_m^* = V_{rms} I_{rms}^*$$

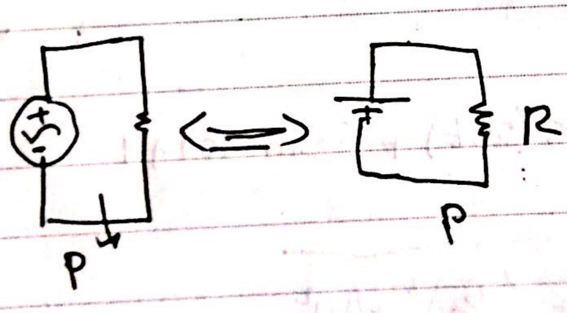
$$P_{avg} = V_{rms} I_{rms} \cos(\theta_v - \theta_i)$$

* With different frequency:

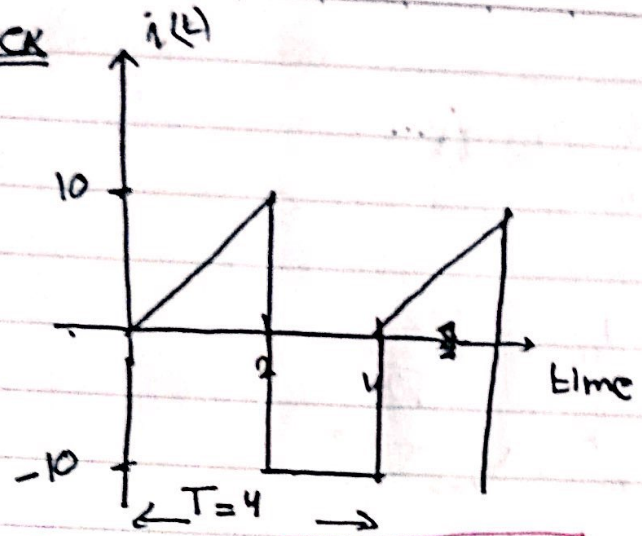
$$v(t) = V_1 \cos \omega_1 t + V_2 \cos \omega_2 t + \cdots$$

$$V_{rms} = \sqrt{\left(\frac{V_1}{\sqrt{2}}\right)^2 + \left(\frac{V_2}{\sqrt{2}}\right)^2 + \cdots}$$

$$V_{rms} = V_{DC}$$



Ex



* Find I_{rms}

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

$i(t) = \begin{cases} \frac{10}{2}t, & 0<t<2 \\ -10, & 2<t\le 4 \end{cases}$

$= \sqrt{\frac{1}{4}\left(\int_0^2 \left(\frac{10t}{2}\right)^2 dt + \int_2^4 (-10)^2\,dt\right)}$

$= \sqrt{\frac{1}{4}\left[\frac{25}{3}(2)^3 + 200\right]} = 8165 \text{ Amp.}$

Ex $v(t) = 6\cos(25t) + 5\sin 30t + 4$

V_{rms}?

$V_{rms} = \sqrt{\left(\frac{6}{\sqrt{2}}\right)^2 + \left(\frac{5}{\sqrt{2}}\right)^2 + (4)^2} = 6.82\ V_{rms}$

Ex $v(t) = 6\cos 25t + 4\sin(25t + 30^\circ)$, V_{rms}?

-90

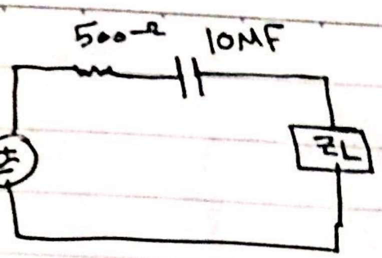
$6\angle 0 + 4\angle -60$

$= 8.717\angle -23^\circ$

$V_{rms} = \frac{8.717}{\sqrt{2}} = 6.16\ V_{rms}$

No.

$3\cos(100t - 3)$



What is the Value of the inductive components of Z_L to max power obsorbed

$Z_L = Z_{Th}^{*} \rightarrow Z_{Th} = 500 - \frac{j}{100(10 \times 10^{-6})}$

$Z_{Th} = 500 - j1000\,\Omega$

$Z_L = 500 + j\underbrace{1000}_{XL}\,\Omega$

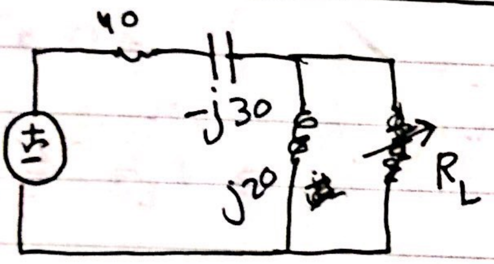
$X_L = \boxed{jL} \rightarrow L = \frac{1000}{100} = 10\,H$

??

$P_{max} = \frac{1}{8}\frac{(3)^2}{500} = \frac{9}{4000}$ watt

---

$150\angle 30^\circ$



① Find R_L that will obsorb the maximum power from the Source

② Find P_{max}

$R_L = |Z_{Th}|$

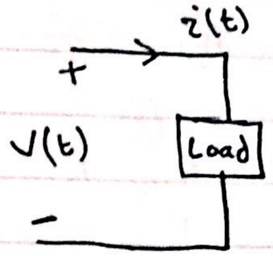
$(40 - 30j) \,//\, 20j$

$Z_{Th} = \frac{(40-30j)(20j)}{40 - j30 + 20j} = 9.412 + 22.35j\,\Omega$

$R_L = |Z_{Th}| = \sqrt{(9.412)^2 + (2.35)^2} = 24.25\,\Omega$

No.

Ex



$v(t) = 110 \cos(\omega t + 65^\circ)$

$i(t) = 15 \sin(\omega t - 20^\circ)$

(a) $p(t)$ (b) P_{avg} (c) reactive power

(D) PF.

$i(t) = 15 \cos(\omega t - 110^\circ)$

(B) + (A) $p(t) = \underbrace{\frac{1}{2}(110)(15)\cos(65^\circ - -110^\circ)}_{P_{avg}} + \frac{1}{2}(110)(15)\cos(2\omega t + 65 - 110^\circ)$

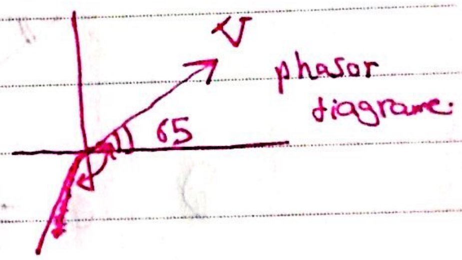
→ reactive.

as amplitude.

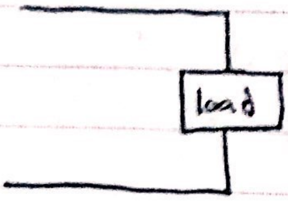
(C) $\frac{1}{2}(110)(15)\sin 175 = +71.9$ VAr (obsorb)

generate power $= -821.9$ watt

(D)



i lag v



10 MW
.6 P.F lagging

Ⓐ power, Q absorbed by the load

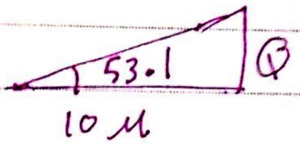
$P = 10\ MW$

lagging $\Rightarrow \cos\theta_s = .6$

$\Rightarrow \cos^{-1} .6 = \theta_s$

$\theta_s = 53.1$

Ⓑ Draw power trirgle



$\tan\theta_s = \frac{Q}{P} \Rightarrow Q = P\tan\theta_s$

$13.33\ MVAr = 10M\tan(53.1)$

No.

Power factor

$p(t) + P_1(t)$ active power

reactive power $P_2(t)$.

$\underset{\sim}{S} = \underbrace{P_{avg}}_{\text{active}} + jQ$

complex power

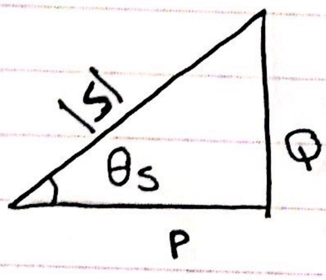
$|S| \rightarrow$ apperant power

$$P.F = \frac{P_{avg}}{|S|} = \frac{P_{avg}}{\sqrt{(P_{avg})^2 + Q^2}}$$

(The Best) $PF = 1 \rightarrow Q = 0 \rightarrow$ Unity PF (pure resistive).

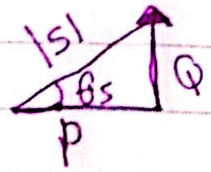
(ممكن تكون فيه L و C بس ممكن لغوا بعض)

$$\frac{P_{avg}}{\sqrt{(P_{avg})^2 + Q^2}} = \frac{\cos(\theta_s)}{\cos(\theta_v - \theta_i)}$$

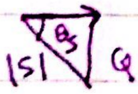


$0 \leq PF \leq 1$

i Lag $V \Rightarrow$ ind



i lead $V \Rightarrow$ capa



unity $\Rightarrow$ resister (inphase) $\rightarrow P$

No.

power factor correction

$PF = \frac{P}{|S|}$ $\quad$ PF = unity (optimal)

- Max power transfer → Min lossess
  pure resistance

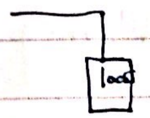
Inductive load

$PF < 1$

$PF_{min} = .85$

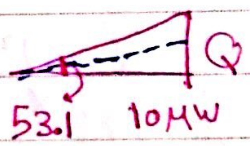
$.88$

ex



.6 pf lagging. → $P_{F new} = .95$ lagging

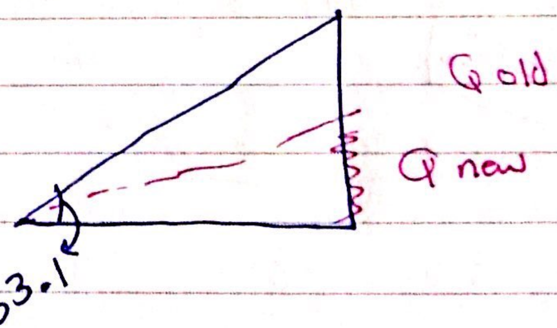
$\theta_S = + \cos^{-1}(.6) = 53.1°$

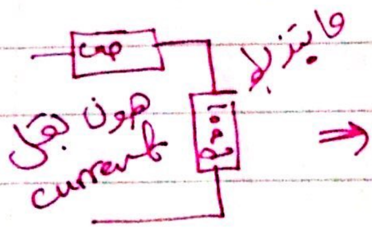


$+ \cos^{-1}(.95) = 18.7°$

* adds capacitor $\quad$ * بتبقى P ثابتة

$Q_{old} + \underbrace{Q_c}_{neg} = Q\ new$





⇒

$I_{new} = \frac{V_s}{|Z|} = \quad Z \downarrow \ I \uparrow \ P \uparrow$ $\quad$ so, مش فعالة

$|Z| = \sqrt{R^2 + (\omega L - \frac{1}{\omega c})^2}$

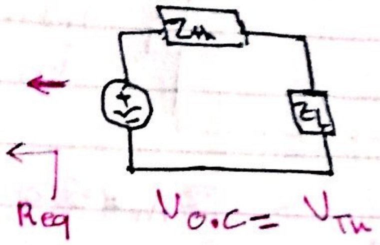
Thevenin ckt

↓

kill all Sources. ←

U.S ⇒ S.C

I.S ⇒ O.C



$V_{o.c} = V_{Th}$

Max power transfer

$$P_{\substack{max \\ avg}} = \frac{1}{2} V_m I_m \cos(\theta_v - \theta_i)$$

Load.max

$$Z_L = R_L + jX_L \qquad Z_{th} = R_{th} + jX_{th}$$

$$P = \frac{1}{2} I_m^2 R_L$$

$$I = \frac{V_{Th} \angle \theta_v}{Z_{th} + Z_L}$$

$$\frac{dP}{dZ_L} = 0 \Rightarrow Z_L$$

$$\Rightarrow Z_L = Z_{th}^*$$

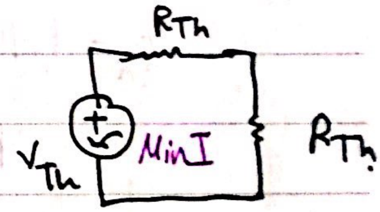
* If $Z_{th} = R_{th} + jX_{th}$

$$Z_L = Z_{Th}^* = R_{Th} - jX_{th}$$

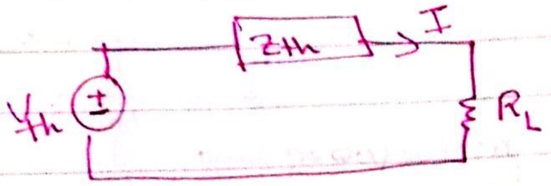
$$P_{max} = \frac{1}{2} \left(\frac{V_{th}}{2R_{Th}} \right)^2 * R_{Th}$$

$$= \frac{1}{2} \frac{V_{th}^2}{4R_{Th}^2} * R_{Th}$$

$$= \frac{1}{8} \frac{V_{th}^2}{R_{Th}}$$



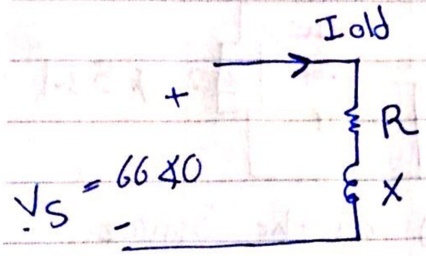
No.



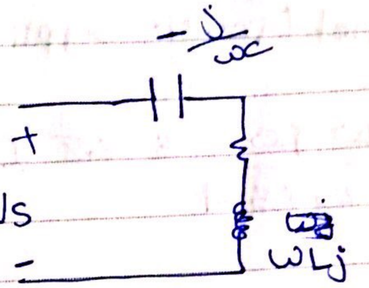
$$P = \frac{1}{2} * I^2 * R_L$$

$$= \frac{1}{2}\left(\frac{V_{th}}{Z_{th} + |Z_{th}|}\right)^2 * |Z_{th}|$$

No.



$$I_{old} = \frac{66\angle 0}{\sqrt{R^2+X^2}} \quad \angle\, 0-53.1^\circ$$



$$Z = R + j\omega L - \frac{j}{\omega c}$$

$$Z = R + j\left(\omega L - \frac{1}{\omega c}\right)$$

$$I = \frac{66\angle 0}{\sqrt{R^2+\left(\omega L-\frac{1}{\omega c}\right)^2}} \rightarrow \text{نقل Z} \qquad I\uparrow \; pf\uparrow$$

Add capacitance in series to improve PF to unity
Find value of cap

$$j\omega L = \frac{1}{j\omega c} \rightarrow \omega L = \frac{1}{\omega c}$$

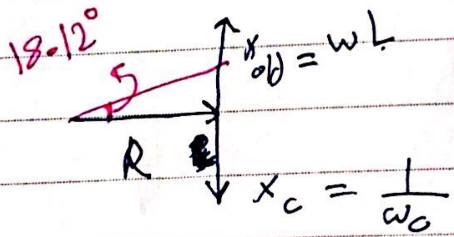
$$C = \frac{1}{\omega^2 L}$$

$(2\pi * 50)$

PF = .95PF → add series cap.

$$\theta_{s_{new}} = \theta_Z = 18.1^\circ$$

$\boxed{R \rightarrow \text{Constant}}$



$$X_{new} = R\tan(18.12)$$

$$=$$

$$X_c = X_{old} - X_{new} =$$

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