power unit

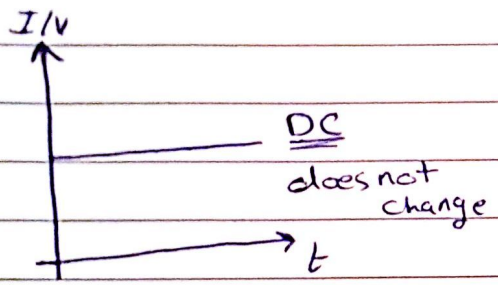
CKT 1:

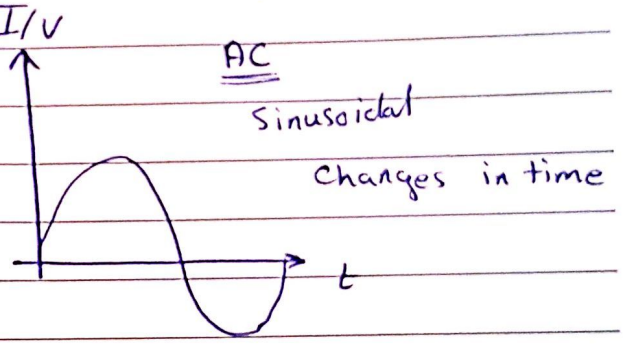
Power Sources

Voltage — Current

DC — AC — DC (dependent)

DC — DC (dependent) — AC

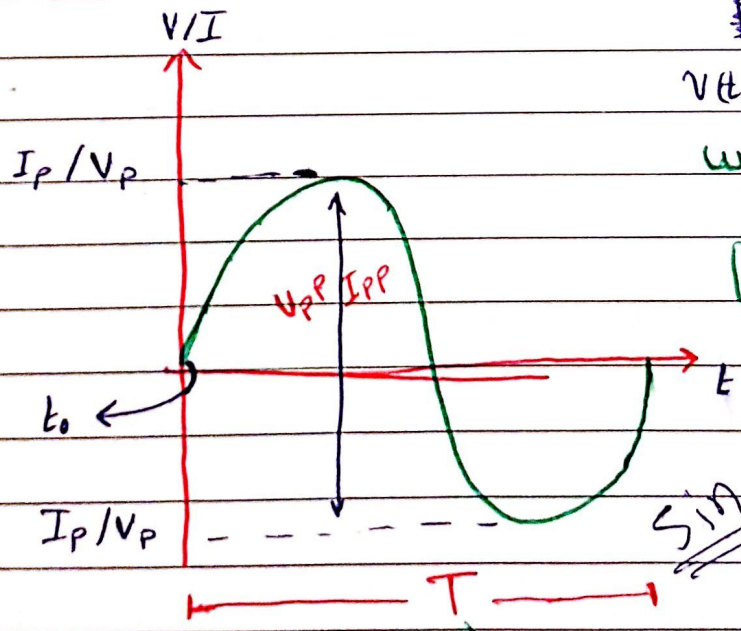




I / V

i(t) / v(t)

Chapter 10: Sinusoidal



$i(t) = i_p \sin(\omega t + \theta)$

$v(t) = v_p \sin(\omega t + \theta)$

ω: angular frequency

$\omega = 2\pi f$

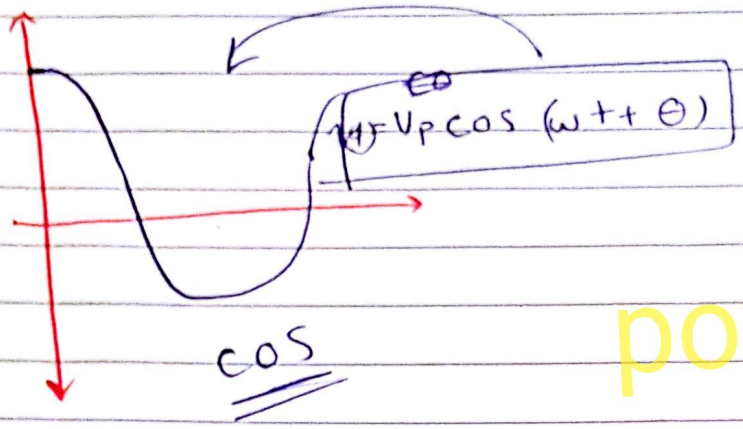
$f = \frac{1}{T}$

θ: phase shift

$\theta = \frac{t_0}{T} \times 360^\circ$

f: frequency

T: time



power unit

$v(t) = v_p \cos(\omega t + \theta_1)$

$i(t) = i_p \cos(\omega t + \theta_2)$

Leads or Lags ??!!

same ω

→ $\theta_1 > \theta_2$ V leads I

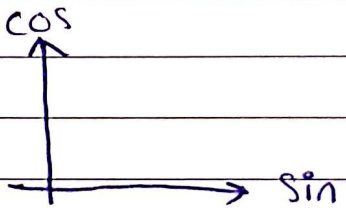
→ $\theta_2 > \theta_1$ I leads V

→ $\theta_1 = \theta_2$ I & V are in phase

Cos ⟶ Sin

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

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



phase shift الـ 90 منظرة cos لـ Sin التحويل من

احفظها هيك

$\sin 90 = \cos 0$

$1 = 1$

$\sin 180 = \cos 90$

$\sin 270 = \cos 180$

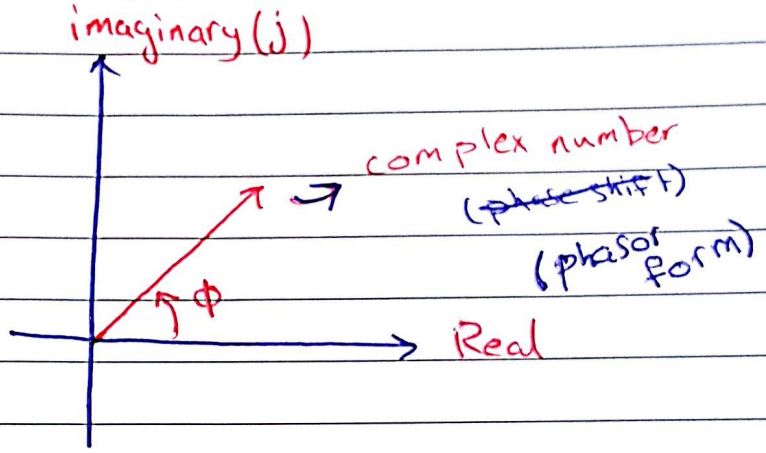
$\sin 0 = \cos 270$

Complex numbers:

في نوعين من الأرقام ← real حقيقية / imaginary خيالية

Imaginary numer is $\sqrt{-1} \Rightarrow$ ويمثل $\sqrt{-1}$ بـ j

Complex numbers ← في وقت دمج الأرقام الحقيقية مع الخيالية (imaginary Real)

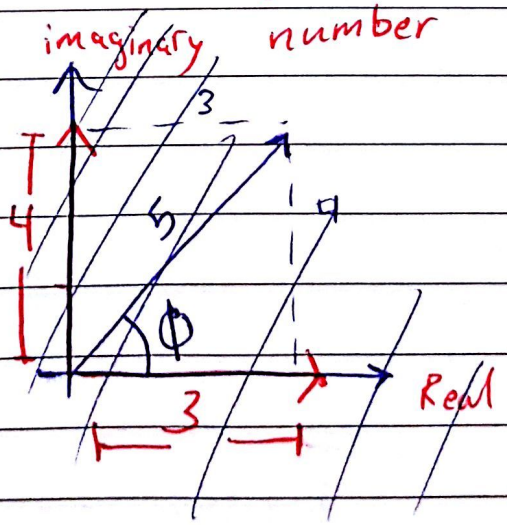


Example on complex numbers:

~~3+4j~~

$$3 + 4j$$

Real number ← 3 — 4 → imaginary

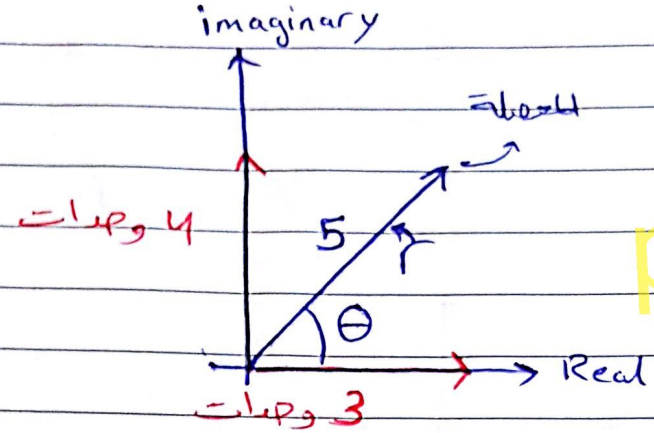


$3 + 4j$ كما قلنا سابقا

الجزء الـ Real

الجزء imaginary

* مثلوا بيانيا :



لايجاد θ

ربع أول / رابع ← $\theta = \tan^{-1}\left(\frac{\text{imaginary}}{\text{Real}}\right)$

$\theta = \tan^{-1}\left(\frac{4}{3}\right) = 53.1$

ربع ثاني / ثالث ← $\theta = \tan^{-1}\left(\frac{\text{imaginary}}{\text{Real}}\right) + 180^\circ$

لايجاد الحصلة

$r = \sqrt{(\text{imaginary})^2 + (\text{Real})^2}$

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

الـ phasor form لـ $3+4j$ بيانيا هو تمثيل

$$3 + 4j = 5 \angle 53.1^\circ$$

$3 + 4j$ ← complex number

$5 \angle 53.1^\circ$ ← phasor form

العمليات الحسابية في الـ complex numbers

$(3+4j) + (5+6j) = 8+10j$

مع بعضهم ← الـ Real
مع بعضهم ← الـ imaginary

$(3+4j).(5+6j)$

$= 15 + 20j + 18j + 6\times4\,(j\times j)$

$= 15 + 38j + 24\,(-1)$

$= -9 + 38j$

$j \times j = -1$

$(\sqrt{-1})^2 = -1$

* conjugate

$z = x + yj$ ← conj.

$z^* = x - yj$

$z \cdot z^* = x^2 + y^2 \Rightarrow$ the magnitude of the vector squared

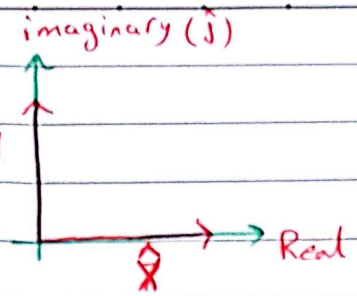
* تقدر تعمل العمليات على الآلة الحاسبة في Youtube.com

~~$\theta = \tan\left(\frac{\text{imaginary}}{\text{Real}}\right)$~~

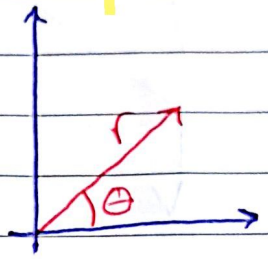
* Complex numbers

$\hat{x} + \hat{y}\,\hat{j}$

Real — imaginary



* phasor form



$r \angle \theta$

للتحويل من complex إلى phasor

$\rightarrow r = \sqrt{(\hat{x})^2 + (\hat{y})^2}$

r: طول السهم (المتجه)

θ: الزاوية بين المحور الحقيقي و r

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

$\theta = \tan^{-1}\left(\frac{y}{x}\right) + 180^\circ$ ربع ثاني أو ثالث

Sinusoidal بتستخدم في الـ phasor form الـ

$v(t) = V_p \cos(\omega t + \theta)$

$V_p \rightarrow r$ ، $\theta \rightarrow \theta$

$v(t) = V_p \cos(\omega t + \theta)$

مثال: $3+4j$

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

$\Rightarrow 5 \angle 53.1$

$\theta = \tan^{-1}\left(\frac{4}{3}\right) = 53.1$

$v(t) = 5 \cos(\omega t + 53.1)$

العمليات الحسابية في ال phasor form

$$r_1 \angle \theta_1 \cdot r_2 \angle \theta_2 = r_1 r_2 \angle \theta_1 + \theta_2$$

$$\frac{r_1 \angle \theta_1}{r_2 \angle \theta_2} = \frac{r_1}{r_2} \angle \theta_1 - \theta_2$$

$r_1 \angle \theta_1 \rightarrow r_1 \angle -\theta_1$ conjugate

$\theta = 0 \rightarrow$ +ve Real number

$\theta = 90 \rightarrow$ +ve imaginary

$\theta = 270 / -90 \rightarrow$ -ve imaginary

$\theta = 180 \rightarrow$ +ve Real $\rightarrow$ ال magnitude ما بينكتب سالب *

فكر فيها $r = \sqrt{x^2 + y^2}$

راسا حتكون موجبة

No.

طيب شو دخلنا بال complex numbers وال phasor form / phase shift ؟؟

ال complex numbers هي عبارة عن جزء Real و imaginary P.

$3+4j$

Resistance ← 3   4j → inductor / ~~conductor~~ capacitor

نستخدم ال complex numbers لتحويل ال inductor conductor إلى Resistance

وبما انه مقاومتي حتكون خيالية imaginary نستخدم j هاد هو

ال impedance

inductor	~~conductor~~ capacitor
$i(t) = \frac{1}{L}\int v(t)\,dt$	$v(t) = \frac{1}{C}\int i(t)\,dt$
$v(t) = L\frac{di(t)}{dt} = LI'$	$i(t) = C\frac{dv(t)}{dt} = CV'$
$v_L = LI'$	$i_c = CV'$
$Z = jwL$	$Z = \frac{1}{jwC}$

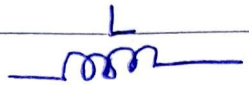
power unit

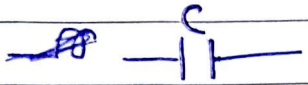
$* \quad -j = \frac{1}{j}$ قاعدة

No.

زي ما أخدنا في 3 أنواع من ال devices

① Resistance ← 

② Inductor ← 

③ conductor ← 

بس أخدنا هم لما يكون dc و v و i
voltage current

طيب لما يكون AC ؟؟!! شو نعمل

رح نحول ال L و ال C لـ impedance

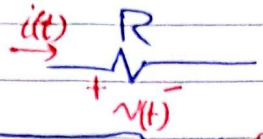
وعشان ال L و ال C ما عندهم Real Resistance

رح نستخدم ال (complex numbers) لتحويل لـ imaginary resistance

impedance means: هو ال L وال C كـ R في ال circuit بكون في ال AC circuits

power unit

① Resistance



$v(t) = i(t).R$ / $v(t)$ & $i(t)$ are in phase

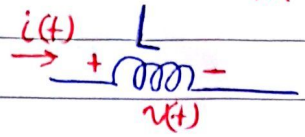
$i(t) = i_m \cos(\omega t + \theta) \Rightarrow i_m \angle\theta$

$v(t) = R.\, i_m \cos(\omega t + \theta) \Rightarrow R i_m \angle\theta$

v_m

$v_m \angle\theta$

② Inductor



power unit

$v(t) = L \frac{di(t)}{dt}$ $\quad i(t) = i_m \cos(\omega t + \theta)$

~~$v(t) = -L\omega \sin(\omega t + \theta)$~~

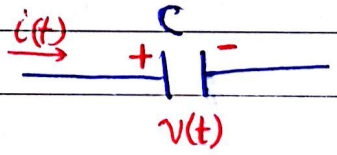
$v(t) = -i_m . \omega L \sin(\omega t + \theta)$

~~ELI~~ v_L leads i_L by 90°

~~ELI~~

~~Impedance of~~

③ Capacitor



$v(t) = \frac{1}{C} \int i(t)\, dt$ $\quad i(t) = i_m \cos(\omega t + \theta)$

$v(t) = \frac{1}{\omega C} \sin(\omega t + \theta)$

i_c leads v_c by 90

* ELI is the ICE man

V L I — V leads I in Inductor

I C V — I leads V in capacitor

No.

power unit

* Impedance

① Inductor $Z = j\omega L$ → هاي اجت من

↓ Angular frequency

$v_L = I_m \omega L \sin(\omega t + \theta)$

$v_L = (j\omega L) * I$

② ~~Conductor~~ Capacitor

$Z = \frac{1}{j\omega C} = \frac{-j}{\omega C}$

$v_C = \left(\frac{-j}{\omega C}\right) I$

هيك بتصير نستخدم Ohm's law

$V = IR$

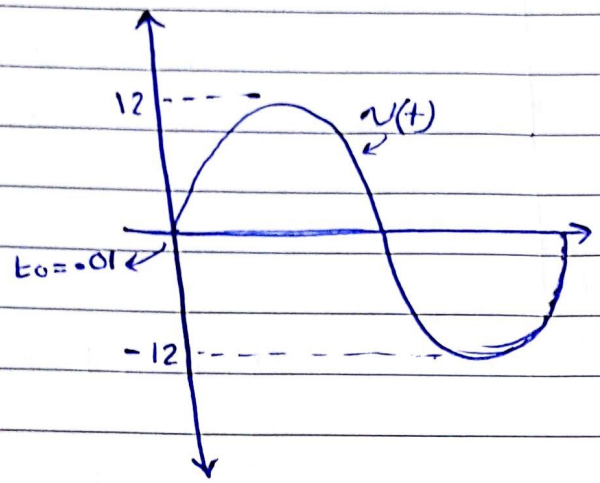
$\Rightarrow V = I \cdot Z$

No.

* Examples & Exercises :

power unit

1



$\omega = 20\pi$

find $v(t)$, v_p, v_{pp}, T, f, θ ?

2 Sol:

$v_{pp} = 12 - -12 = 24$ volt → من الرسمة للقاع

$v_p = \frac{v_{pp}}{2} = 12$ volt

$v(t) = v_p \sin(\omega t + \theta)$ → اخترت sin عشان الرسمة

$\theta = \frac{t_o}{T} \times 360°$ | $T = \frac{1}{f}$

$= \frac{.01}{.1} \times 360$ | $f = \frac{\omega}{2\pi} = \frac{20\pi}{2\pi} = 10$ Hz

$\theta = 36°$

$T = \frac{1}{10} = .1$ sec

$v(t) = 12 \sin(20\pi t + 36)$ volt | $f = 10$ Hz

$\theta = 36°$ | $T = .1$ Sec

$v_p = 12$ volt | $v_{pp} = 24$ volt

No.

Sketch

power unit

Sinusoid Signals

$v(t) = V_p \cos(\omega t + \theta)$

$v(t) = A\cos(\omega t + \theta)$: Time domain form

$v(t) = Ae^{j(\omega t + \theta)} = Ae^{j\omega t} \cdot e^{j\theta} = Ae^{j\theta}$: frequency domain form

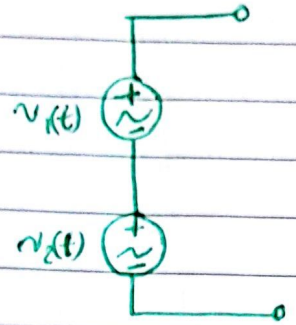
($e^{j\omega t} = 1$)

$v(t) = A\cos(\omega t + \theta) \rightarrow A\angle\theta = Ae^{j\theta}$

No.

power unit

[2] Calculate V_{eq} ?



$v_1(t) = 15\cos(377t + \pi/4)$

$v_2(t) = 15\cos(377t + \pi/12)$

Sol: $v_1(t) = 15\angle \pi/4$

$v_2(t) = 15\angle \pi/12$

$v_s = v_1 + v_2 = 15\angle 45 + 15\angle 15$

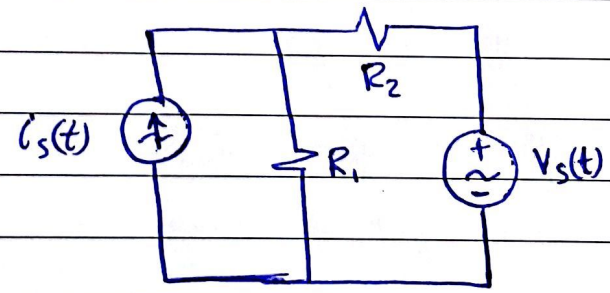
$= 25 + 14.5i$

$\Rightarrow 29\angle 30$

~~$v_s = 25\cos(377t$~~

$v_s = 29\cos(377t + 30)$

[3] compute the resistor voltages?



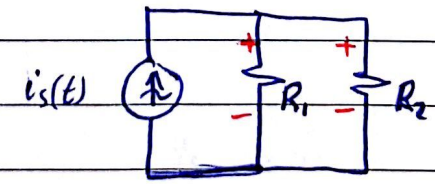
$i_s(t) = 0.5\cos(200\pi t)$ A

$v_s(t) = 20\cos(2000\pi t)$ V

$R_1 = 150\Omega \,/\, R_2 = 50\Omega$

we use superposition $\Rightarrow$ different frequencies

1- Kill V_s



$i'_{R_1} = i_s(t) * \dfrac{R_2}{R_1 + R_2}$

$= \frac{1}{4} \times \frac{1}{2}\cos(200\pi t)$

$i'_{R_1} = 0.125\cos(200\pi t)$

$i'_{R_2} = i_s - i'_{R_1}$

$= (.5 - .125)\cos(200\pi t)$

$= .375\cos(200\pi t)$ A

$V'_{R_2} = i'R_2$

$= 18.75\cos(200\pi t)$ Volt

$V'_{R_1} = i'R_1$

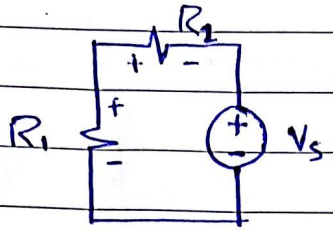
$= 150\,(.125\cos 200\pi t)$

$V'_{R_1} = (18.75 * \cos 200\pi t)$ Volt

No.

power unit

2- kill I_s



$$V_{R_1}'' = V_s * \frac{R_1}{R_1+R_2}$$

$$= 26\cos(2000\pi t) * \frac{15\Omega}{20\Omega}$$

$$V_{R_1}'' = 15\cos(2000\pi t) \text{ Volt}$$

$$V_{R_2}'' = V_s - V_{R_1}''$$

$$= (20-15)\cos(2000\pi t)$$

$$V_{R_2}'' = 5\cos(2000\pi t) \text{ Volt}$$

$$V_{R_1} = V_{R_1}' + V_{R_1}''$$

$$= (18.75\cos(200\pi t) + 15\cos(2000\pi t)) \text{ Volt}$$

$$V_{R_2} = V_{R_2}' + V_{R_2}''$$

$$= (18.75\cos(200\pi t) - 5\cos(2000\pi t)) \text{ Volt}$$

3 10.1.3 Exercise

determine the Angle by which V_1 leads I_1 ?

$$V_1 = 10\cos(10t - 45)$$

a) $i_1 = 5\cos(10t)$

V_1 leads i_1 by $360 - 45$

$= \boxed{315^\circ}$

b) $i_1 = 5\cos(10t - 80)$

V_1 leads i_1 by 35°

d) $i_1 = 5\cos(10t + 40)$

V_1 leads i_1 by 275°

e) $i_1 = 5\sin(10t - 19)$

$i_1 = 5\cos(10t - 109)$

V_1 leads i_1 by 64°

$\theta = -109 \rightarrow 251$

$\theta = -45 \rightarrow 315 \Rightarrow 315 - 251$

$-45^\circ \rightarrow 315^\circ$

$315 - 40 = 275^\circ$

No.

[4] find $i_s(t)$

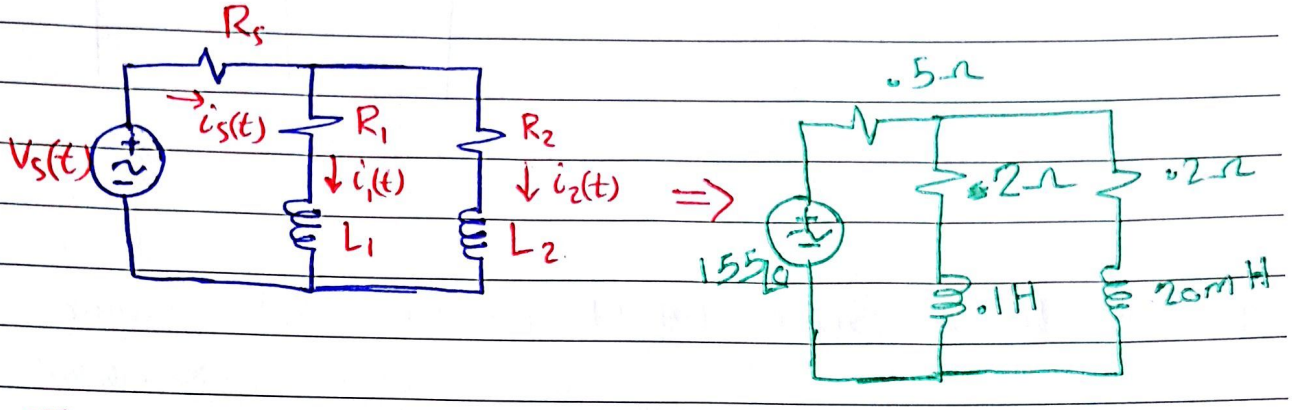
$V_s(t) = 10 \sin(\omega t + 90)$ volt

power unit

5 find i_1 & i_2

$v_s(t) = 155\cos \omega t$ $\quad R_s = .5\Omega$ $\quad R_2 = .2\Omega$

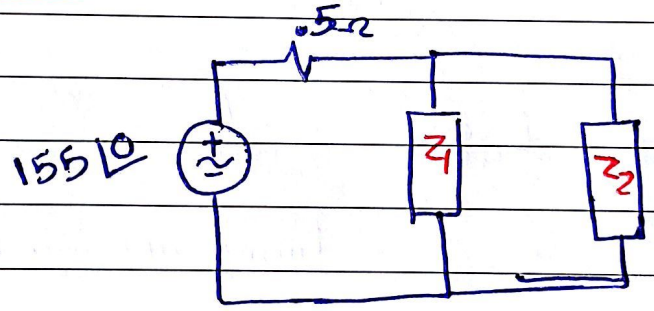
$\omega = 377$ rad/s $\quad R_1 = 2\Omega$ $\quad L_1 = .1H$ $\quad L_2 = 20mH$



~~Impe~~ convert to impedance phasor form

$Z_L = j\omega L$

$Z_{L_1} = 37.7j$ / $Z_{L_2} = 7.54j$



$Z_1 = 2 + 37.7j$

$Z_2 = .2 + 7.54j$

$Z_{eq_1} = \left(\frac{1}{Z_1} + \frac{1}{Z_2}\right)^{-1}$

$= 0.694 + 6.28j$

$Z_{eq} = 0.694 + 6.28j$

$i_s(t) = \frac{V_s(t)}{Z_{eq}} = \frac{155\angle 0}{0.694 + 6.28j}$

$i_s(t) = 24.5\angle -83.7$

$i_1 = i_s(t)\frac{Z_2}{Z_1 + Z_2}$

$i_2 = i_s(t)\frac{Z_1}{Z_1 + Z_2}$

$i_1 = 4.08\angle -82.4$

$i_1 = 4.08\cos(377t - 82.4^\circ)$ $\quad i_2 = 20.42\angle -83.95$

$i_2 = 20.42\cos(377t - 83.95^\circ)$

power unit

No.

[6] find $i_a(t)$ & $i_b(t)$

power unit

① و ② بنود

$$15\angle 0 = (0.125 - .122j)\, i_b + (100 - 666.7j)\, i_b + 666.7j\, i_b$$

$$15\angle 0 = (575.3\angle 96.9)\, i_b$$

$$i_b = 0.026\angle -96.9$$

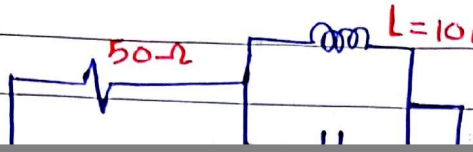
$$i_a = (0.125 - 0.122j)(0.026\angle -96.9)$$

power unit

No.

7 Find V_{th}

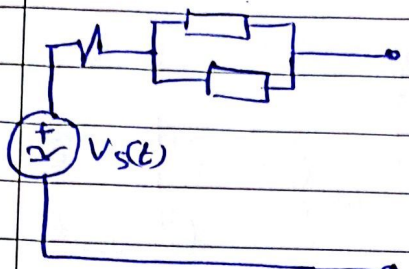
$f = 10^3$ Hz / $R_S = 50\Omega$ / $R_{LD} = 50\Omega$ / $L = 10$mH / $C = 0.1\mu f$



power unit

No.

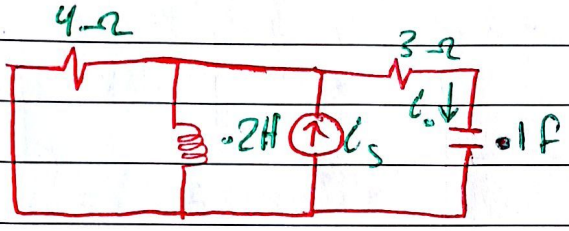
find V_{th} / $V_{th} = V_{oc} = V_{ld}$



$V_{th} = V_{oc} = V_s = V_{ld}$

Problem 1:

$i_s = 5\cos(10t + 40°)$ A find i_o ??



No.

① $i_1(3-j) + (2j)i_2 = 0$

② $i_1 = 5\angle 40 + i_2$

③ $\frac{i_2}{1-2j} = i_3$

power unit

$(5\angle 40 + i_2)(3-j) + (2j)i_2$

$((3.8+3.2j)+i_2)(3-j)+(2j)i_2$

$(3-j)i_2 + 14.6 + 5.8j + (2j)i_2 = 0$

$(3+j)i_2 = -14.6 - 5.8j$

$i_2 = (4.97\angle -176.8°)\ A$ $\quad i_3 = (2.22\angle -113.4°)\ A$

$i_1 = (3.15\angle 111.1°)\ A$

$i_o = i_1 = 3.15\cos(10t + 111.1°)$

No.

power unit

10.18

No.

$$8\angle 45^\circ = (0.58 - .06j)V_2 - (.08 - .06j)V_1 \quad -(1)$$

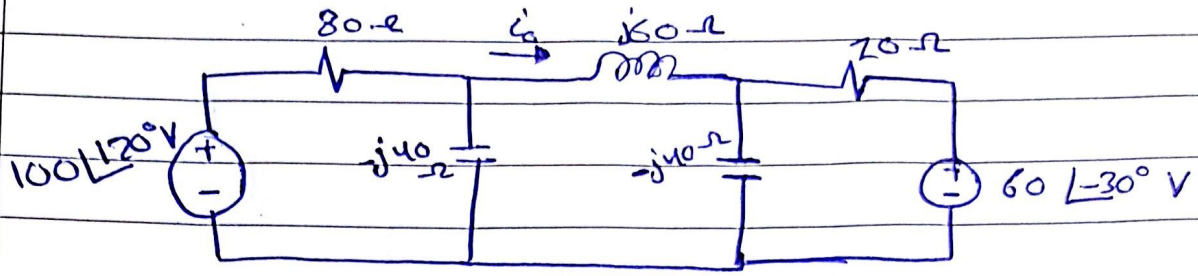
$$V_1 = (2.43\angle -75.3^\circ)V_2 \quad -(2)$$

power unit

$$8\angle 45^\circ = (0.58 - .06j)V_2 - (.08 - .06j)(2.43\angle -75.3^\circ)V_2$$

$$8\angle 45^\circ = (0.69\angle 13.8^\circ)V_2$$

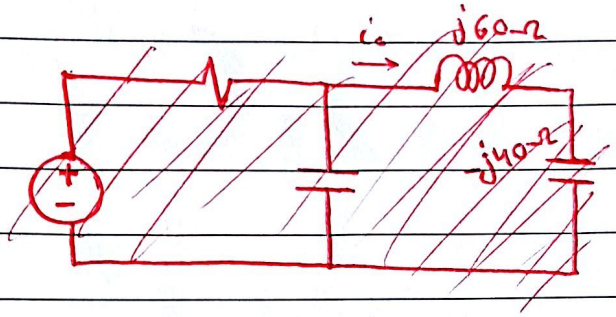
10.31

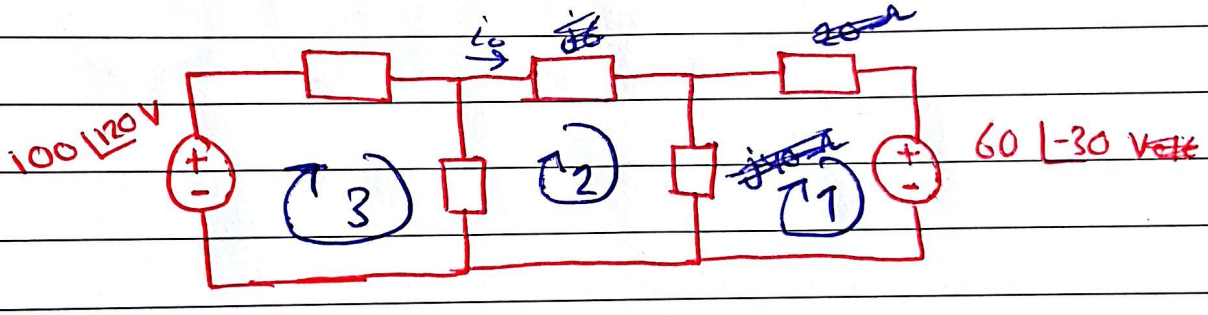


Use mesh Determine I_o:

Sol:

power unit





@ Mesh1

$$60\angle -30 = +(20 - j40)i_1 + (j40)i_2 = 0 \quad -①$$

$51.96 - 30j$

@ Mesh2

$$i_2(60j - 40j - 40j) + (40j)i_3 = 0 \quad -②$$

$+(40j)i_1$

@ Mesh3

$$100\angle 120 = (80 - 40j)i_3 + (40j)i_2 \quad -③$$

$-50 + 86.6j$

$$(-20j)\,i_2 + (40j)\,i_1 + (40j)\,i_3 = 0 \quad \text{— (1)}$$

$$i_2 = \frac{(-20+40j)\,i_1 - 51.96+30j}{40j}$$

$$i_1 = \frac{-40j\,i_2 - 51.96+30j}{20-40j}$$

$$i_1 = (.8-.4j)\,i_2 - 1.12 - 0.74j \quad \text{— (II)}$$

$$i_3 = \frac{-50+86.6j-(40j)\,i_2}{80-40j}$$

power unit

$$i_3 = -0.93 + 0.61j + (0.2-0.4j)\,i_2 \quad \text{— (III)}$$

$$0 = (-20j)\,i_2 + (40j)((.8-.4j)\,i_2 - 1.12 - 0.74j)) + 40j(-0.93 + 0.61j + (0.2-0.4j)$$

$$(16+12j)\,i_2$$

$$0 = (32+20j)\,i_2 + 29.6 - 44.8j - 24.4 - 37.2j$$

$$i_2 = \frac{5.2-82j}{32+20j}$$

$$i_2 = -1.034 - 1.91j$$

$$i_2 = 2.177 \angle -118.38^\circ \text{ Amperes} = i_o$$