Electrical engineering

These notes were prepared to help students better understand the course. However, please note that they are not sufficient on their own. It is strongly recommended to practice the suggested questions provided by the instructor to fully grasp the material and prepare well for the exam.

Units & power Supply

(*) units:-

time → sec
Electrical current → A
voltage → volt
mass → kg
length → watt
charge → C

(*) prefixes

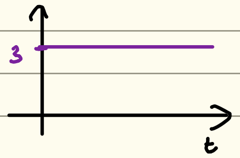
pico → 10^{-12}	kilo → 10^{3}
nano → 10^{-9}	Mega → 10^{6}
Micro → 10^{-6}	giga → 10^{9}
Milli → 10^{-3}	

* power supply :-

a) types:
1) voltage Source
2) current Source

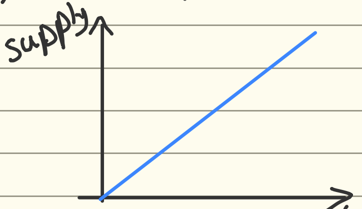
b) output signal

1) DC o/p signal → value of the supply is fixed with time

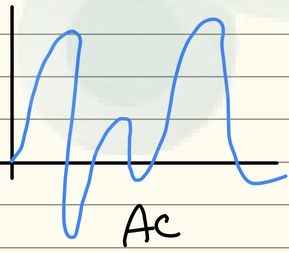


$V = 3V$ → fixed
$I = 2A$ → fixed

2) AC o/p signal :- It's value vary with time



AC



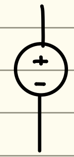
AC

Ex:- $\boxed{\begin{array}{l} v(t) = 3\sin(4t) \\ i(t) = 2e^{-t} \end{array}}$

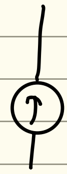
c) Dependency :-

1) independent power supply
does not depend on any element in the ckt

sympol

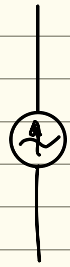


independent DC voltage Source



independent DC current source

independent AC voltage source



independent AC current source.

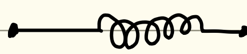
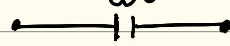
2) It's value depent on of function of voltage & current

sympol:-

Dependent DC voltage Source

dep DC current source

⇒ & the AC is the same but with (~) sign

* Loads → resistance R 
→ inductive L 
→ capacitive C 

(*) → Q

$q_e = 1.6 \times 10^{-19} C$ ⇒ قيمة ثابتة

(*) Electrical current : charges in motion in a wire for a closed loop

$I = \frac{dQ}{dt}$ → slope of the current

unit → Ampere → A, mA, μA

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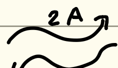
للمقدار &
الاتجاه



$Q(t) = \int_{t_0}^{t} i(\tau) . d\tau$ + initial condition

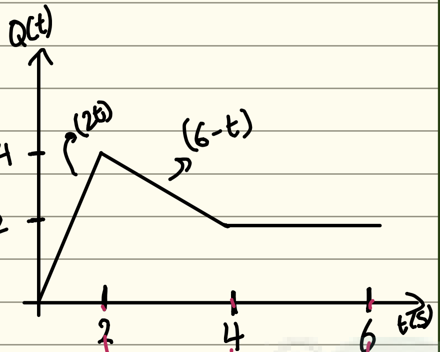
& for graphs it will be area under the curve

Ex: $Q(t) = 3e^{-t}\ c$, find $i(t)$

$$i(t) = \frac{dQ}{dt} = -3e^{-t}$$

$$i(t) = -3e^{-t}$$

Ex: find $i(t)$



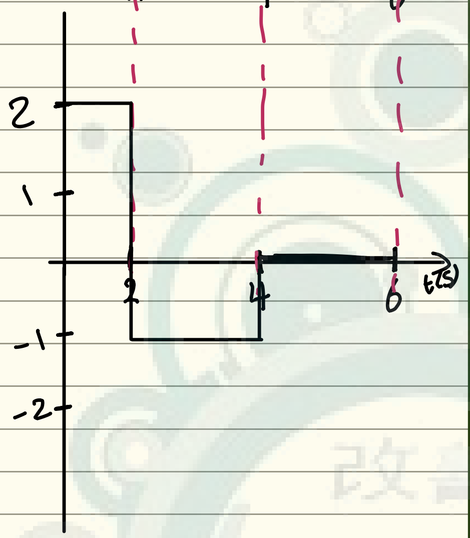
slope 1 = 2

Slope 2 = -1

Slope 3 = 0

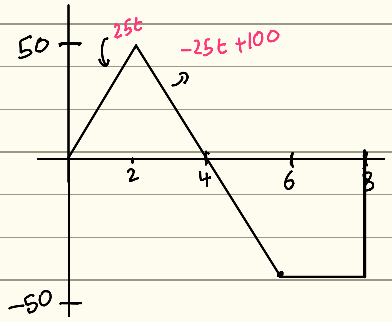
$2 + -1 + 0 = 1$

لـ المعتمدين أكتب تفاصيل أكثر بالحل الورقي



Ex: find the:

a) Total amount of charge $Q(t)$
b) total amount of charge up to $t=6$ sec
c) total amount of charge between $t = 2$ sec to $t = 8$ sec



a) $Q(t) \Rightarrow i(t) = 25t$, initial $= 0 = Q(0)$

$$0 \leq t < 2 \Rightarrow Q(t) = \int_0^t 25t = \frac{25t^2}{2}\Big|_0^t = 12.5t^2$$

$12.5 \times 4 = 50$

$\Rightarrow 2 \leq t \leq 6$

$i(t) + Q$ initial $\rightarrow Q(2)$

$$\int_2^t -25t + 100 = \frac{-25t^2}{2} + 100t + Q(2) = -12.5t^2 + 100t\Big|_2^t + 50$$

$(12.5t^2 + 100t) - (12.5 \times 4 + 200)$

$12.5t^2 + 100t - (50 + 200)$

$-12.5t^2 + 100t - 150 + 50$

$-12.5t^2 + 100t - 100$

$6 < t \leq 8$

$i(t) + Q(6)$

$$\int_6^t -50\,d\tau +$$

$-50t\Big|_6^t + 50$

$-50t - (-50 \times 6) + 50$

$-50t + 300 + 50$

$-50t + 350$

هون من السؤال طالب in general

هون بالورقة

b)

$A = \frac{1}{2} \times 4 \times 50 + \frac{1}{2}(2)(-50)$

$100 + -50 = 50$

b) amount charge up to 6 sec — أسهل

$Q = Q(6) - Q(0)$

$50 - 0 = 50$

c) -100

* voltage :- work needed to move unit charge in a wire

$V = \frac{work}{charge} \rightarrow$ volt

$V_A = 5V$, $V_B = 3$ volt

A ——— B

voltage at ground is zero

$V_{AB} = V_A - V_B$
$= 5 - 3 = 2$

$V_{BA} = V_B - V_A$
$= 3 - 5 = -2$

$V_{AB} = -V_{BA}$

$\Rightarrow V_{a\,ground} = V_A - V_{ground}$
$= 5 - 0 = 5\,V$

* power: work needed per unit time.

$p = \frac{work}{time} \Rightarrow$ watt

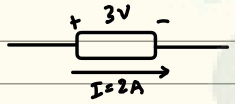
$\boxed{p = I \times V}$

* if sign of power is positive $\Rightarrow$ power is dissipated / consumed

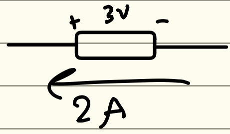
" " " " " negative $\Rightarrow$ power is generated / supplied

* passive sign convension
  - if the current from (+) sign $\Rightarrow p \Rightarrow (+)$
  - " " " " " (-) sign $\Rightarrow p \Rightarrow (-)$

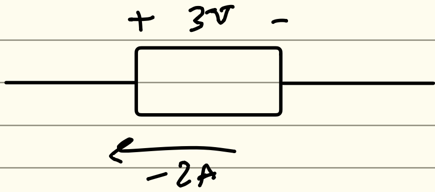
Ex:-



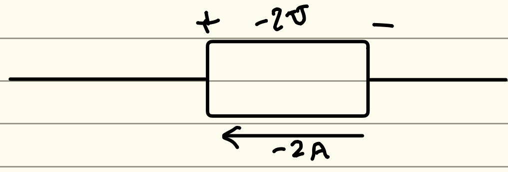
$p = +(2)(3) = +6\,w$ consumed



$p = -(2)(3) = -6\,w$ generated

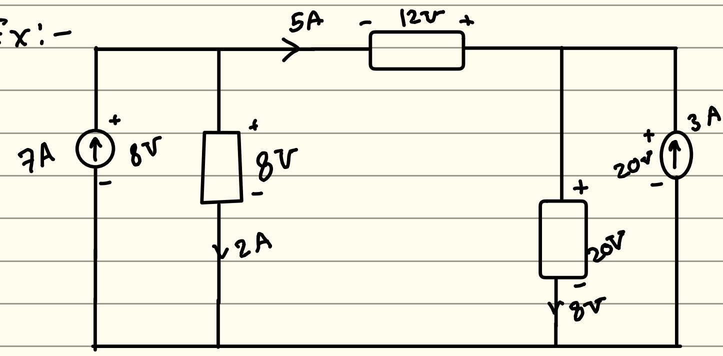


$p = -(-2)(3) = +6w \rightarrow$ consumed



$p = -(-2)(-2) = -4$

Ex:-



find power for each element :-

$-(8)(7) + (8)(2) + -(5)(12) + (8)(20) - (3)(20)$

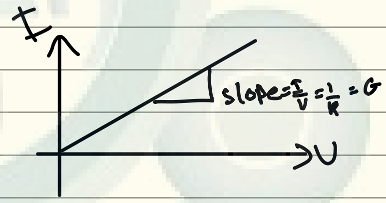
= zero

generated - consumed

176 - 176 = 0

* ohm Law:-

$\Rightarrow$ current that passes in a wire face resistance ⇓ R



$V \propto I$

$V = IR$

$R = \frac{V}{I} \Rightarrow$ resistance (Ω)

ohm's Law : voltage across an element is directly proportional to the current

* conductance: $G = \frac{1}{R}$ $(S, \mho, \Omega^{-1})$ — semens, moho

$p = IV$

$p = I^2 R$

$p = \frac{V^2}{R}$

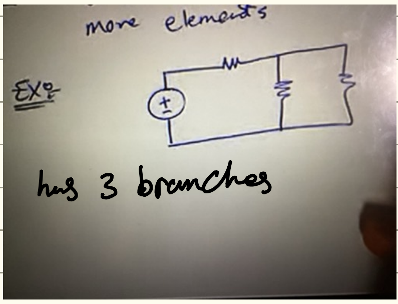
Ex: wire has resistance of 3Ω, pass a current of 2A, find the voltage across the wire

$V = IR$

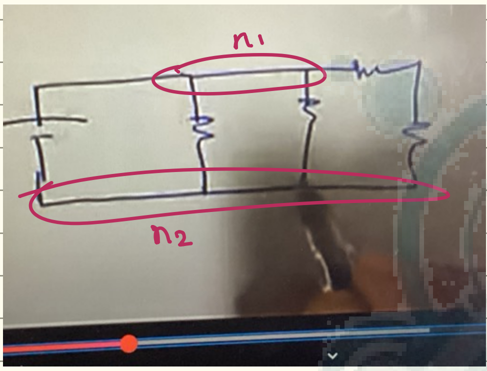
$V = 3 \times 2 = 6V$

Defentions of electrical circuit network

① Branch :- any part of the circuit that has one or more elements

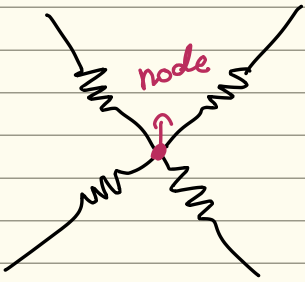


② Node: junction of two or more branches.



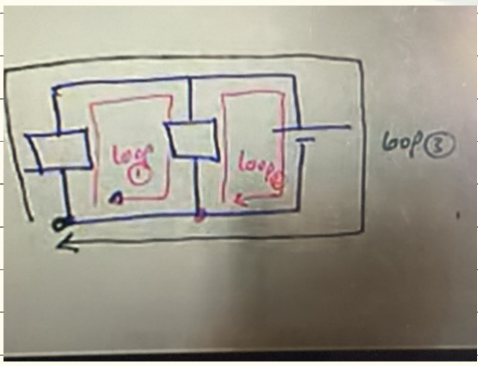
has 2 nodes

Note: If the connection bet nodes has no element → consider as one node



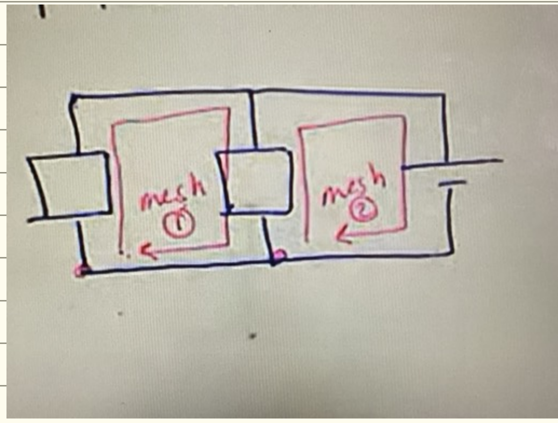
③ Loop: closed connection of Branches

Ex:-



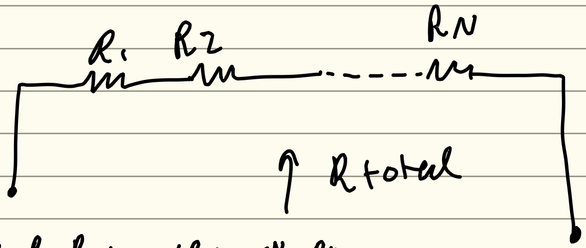
loop that does not contain other loop.

Ex:-



So this ckt has 2 meshes.

series connection of Resistors:-



$R_{Total} = R_1 + R_2 + \dots + R_N = \sum_{n=1}^{N} R_n$

in series connection ⇒ same current pass trough them

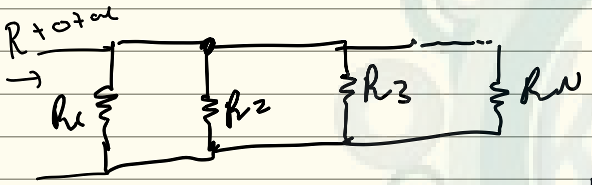
إذا شبكت عليهم voltage source

⇒ in series connection ⇒ Voltage is different for each element.

$V_1 = I \times R_1$
$V_2 = I \times R_2$
$V_3 = I \times R_3$
} the current is the same for all of them

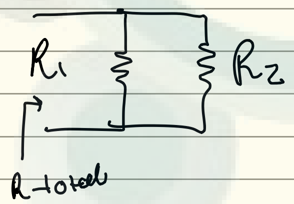
V_{total} = the voltage of the original power supply

parallel connection of Resistors:-



$$\frac{1}{R_{total}} = \frac{1}{R_1} + \frac{1}{R_2} + \dots + \frac{1}{R_N}$$

$$\Rightarrow \frac{1}{R_{total}} = \frac{1}{R_1} + \frac{1}{R_2}$$



$$\frac{1}{R_{total}} = \frac{R_1 + R_2}{R_1 R_2}$$

$$R_{total} = \frac{R_1 R_2}{R_1 + R_2}$$

هاد بس بطبقو عمقاومتين.

* for parallel connection ⇒ current divided between branches

the voltage is the same for all the branches

Resistance

in series

$R_{total} = R_1 + R_2 + \dots R_N$

in parallel

$$\frac{1}{R_{total}} = \frac{1}{R_1} + \frac{1}{R_2} + \dots \frac{1}{R_N}$$

لاتنسي تقلبي

current

in series: the same for all

in parallel: the current will devide

voltage

in series: devided

in parallel: the same for all

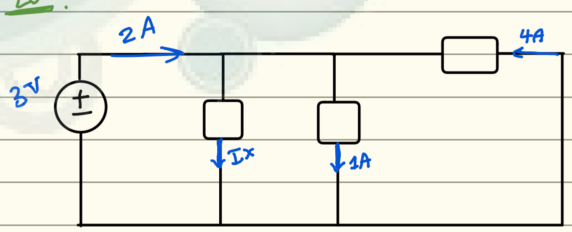
Kirshoff current Law (KCL) :-

the sum of the current at a node must equal to zero

$$\sum I_{node} = 0$$

$$\sum I_{in} = \sum I_{out}$$

Ex:



* How many branches this ckt consist of?

4 branches

* How many nodes?

2 nodes

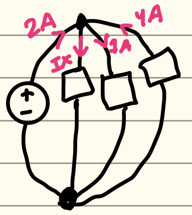
* Loops

6 Loops

* Meshes

3 Meshes

apply KCL to find I_x



$\Sigma I_{in} = \Sigma I_{out}$

$2 + 4 = 1 + I_x$

$6 = \cancel{1} + I_x$

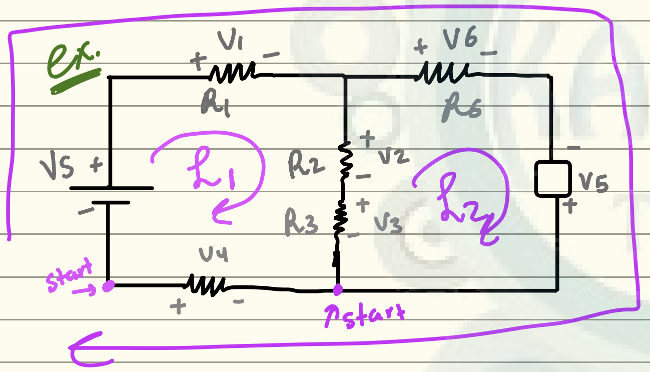
$-1 \quad -\cancel{1}$

$\boxed{I_x = 5A}$

Kirchhoff voltage law (KVL):

the net voltage around a closed ckt sum is zero.

$\Sigma V_{\text{closed loop}} = 0$



#write KVL equasions:-

$\Sigma V = 0$

loop1:-

$-V_s + V_1 + V_2 + V_3 - V_4 = 0$

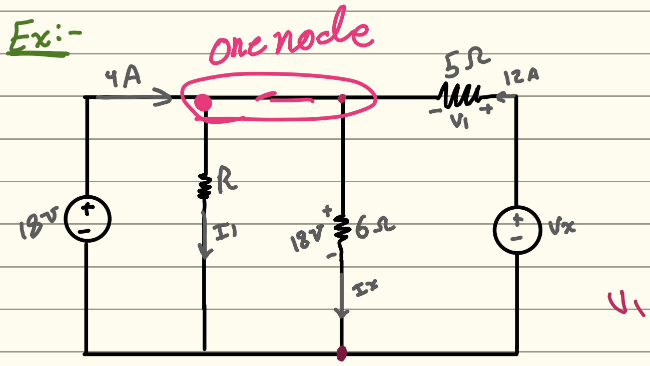
Loop2:-

$-V_3 - V_2 + V_6 - V_5 = 0$

Loop3:-

$-V_s + V_1 + V_6 - V_5 - V_4 = 0$

Ex:-



find: V_1, I_x, V_x, R, I_1

we already say that resistance in parallel has the same voltage

applying ohm's Law to find I_x

$V = IR$

$\frac{18}{6} = \frac{I_x(6)}{6} \Rightarrow \boxed{I_x = 3\ A}$

applying KCL on n_1:-

$12 = I_x + I_0$

$12 = \cancel{3} + I_0$

$-3 \quad -\cancel{3}$

$I_0 = 9\ A$

applying KCL on n_2

$I_0 + 4 = I_1$

$9 + 4 = I_1$

$\boxed{I_1 = 13}\ A$

المفروض أختصرهم بالحل اي تحت لانو node واحد فعليا

applying oh'ms law to find V_1

$V = IR$

$V_1 = 12 \times 5$

$\boxed{V_1 = 60}\ V$

use KCL at the upper node

$\Sigma I_{in} = \Sigma I_{out}$

$4 + 12 = I_x + I_1$

$16 = 3 + I_1 \Rightarrow \boxed{I_1 = 13A}$

$-3 \quad -3$

using ohm's Law to find R

$V = IR$

$\frac{18}{13} = \frac{13 \times R}{13}$

$R = \frac{18}{13} \approx 1.4\,\Omega$

to find Vx we will use KVL:-

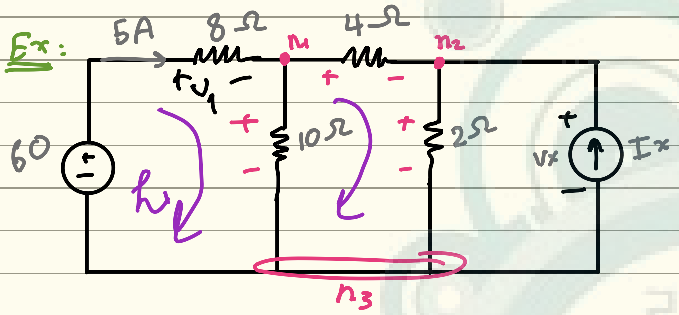
I will start from point •

$-18 - 60 + Vx = 0$

$-78 + Vx = 0$

$Vx = 78$ volt

Ex:



Find : Ix, Vx & power of the current supply

applying ohm's Law on R8Ω

$V = IR$

$V = 5 \times 8 = 40$

$V = 40$

applying KVL on Loop 1

$-60 + 40 + V_{10\Omega} = 0$

$-20 + V_{10\Omega} = 0$

$\boxed{V_{10\Omega} = 20 \text{ volt}}$

now we will apply ohm's Law to find $I_{10\Omega}$

$V = IR$

$\frac{20}{10} = \frac{I_{10\Omega} \times 10}{10}$

$\boxed{I_{10\Omega} = 2\,A}$

applying KCL on node 1:-

$5 = 2 + I_{4\Omega}$
$-2 \quad -2$

$I_{4\Omega} = 3\,A$

applying ohm's Law to find $V_{4\Omega}$

$V = IR$

$V = 3 \times 4 = 12$

$V_{4\Omega} = 12$

applying KVL on Loop 2

$-20 + 12 + V_{2\Omega} = 0$

$-8 + V_{2\Omega} = 0$

$V_{2\Omega} = 8$ volt

& node 2 & the lower wire are connected in parallel (have the same initial & final point)

so $Vx = V_{2\Omega}$

$Vx = 8$ volt

applying KCL to find Ix on node 2:-

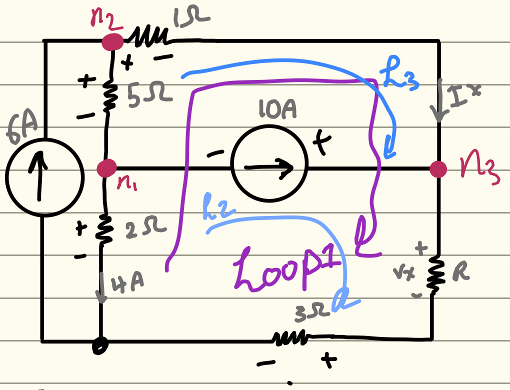
$3 + Ix = \frac{8}{2}$

$3 + Ix = 4$
$-3 \quad -3$

$Ix = 1\,A$

so the power $= IV$

so $= -(8)(1) = -8$ generated



Find I_x, v_x, R

*we we did not use ℓ_2 because we have current source & we don't find the voltage for it ↳ but if we have to we could ⇒

current source ⇐ voltage بقدر ألف Loop2 وأوجد ال

وبعدين برجع بعمل KVL لل Loop2

Loop 3:-

$$(-14\times 5)+(1\times -8)+V_{\text{current source}}=0$$

$$\boxed{V_{\text{current source}}=78}$$

finding v_x using loop2

$$(-4\times 2)-V_1+V_x+(2\times 3)=0$$

$$-8-78+V_x+6=0$$

$$V_x=80\ V$$

$$V=IR$$

$$\frac{80}{2}=\frac{2R}{2}$$

$$R=40\ \Omega$$

applying KCL on n_1:

$$I=4+10$$

$$I_{5\Omega}=14A$$

applying KCL on n_2:

$$6=I_{5\Omega}+I_x$$

$$6=14+I_x$$

$$-14 \quad -14$$

$I_x=-8$ so I_x is in the opposite direction

applying KCL for node 3:-

$$I_x+10A=I_{3\Omega}$$

$$-8+10=I_{3\Omega}$$

$$I_{3\Omega}=2A$$

applying KVL for loop 1

$$(-2\times 4)+(-5\times 14)+(1\times -8)+v_x+(3\times 2)=0$$

في حال التيار دا سالب عشان نعكسه تجي

$$(-8)+(-70)+(-8)+v_x+(6)=0$$

#Q

$$\boxed{V_x=80\ \text{volt}}$$

applying ohm's Law to find R

$$V=IR$$

$$\frac{80}{2}=\frac{2(R)}{2}$$

$$R=40\ \Omega$$

(*) Idealization of Resistance:-

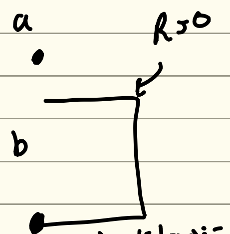
we have already said that current devides in parallel & the voltage is the same

& in series ⟶ the current is the same for all elements & the voltage devides

but we have some Exeptions

① Short ckt ⇒ $R=0\ \Omega$

when $\left.\begin{matrix}R=0\\ V=0\end{matrix}\right\}$ regardless to current



using ohm's Law:-

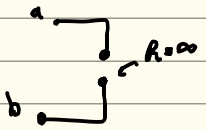
$V=I*R$ ⇒ $V=0$

$=I*0=0$

KAIZEN TEAM 改善

② open ckt :- $\Rightarrow R = \infty\,\Omega$

when $R = \infty \Rightarrow I = 0$
⇓
regardless to voltage across it



apply ohm's Law

$V = IR$

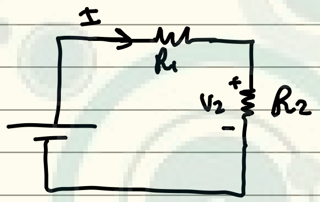
$I = \frac{V}{R} = \frac{V}{\infty} = 0$

so the current = zero A

voltage divider:-
↳ used in series connection

$$V_n = \frac{V_s \times R_n}{\Sigma R}$$

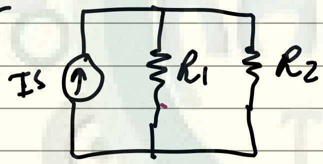
(1, 2, 3)



where
V_n: is the voltage for the resistance that I want to
V_s: voltage for the supply
R_n: المقاومة الي بدي اياها
ΣR: مجموع المقاومات

$$V_2 = \frac{V_s \times R_2}{R_1 + R_2}$$

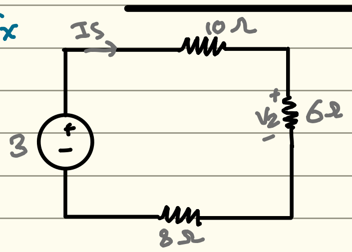
current divider:-
used in parallel



$$I_n = \frac{I_s * \frac{1}{R_n}}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_n}}$$

$$I_2 = \frac{I_s * \frac{1}{R_2}}{\frac{1}{R_1} + \frac{1}{R_2}}$$

Ex

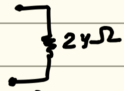


Find I_s, R_{eq}, V_2

to find Req

$R_{eq} = 10 + 6 + 8 = 24\,\Omega$

to find Is



$V = IR$

$\frac{3}{24} = \frac{I_s \times 24}{24}$

$I_s = 0.125\,A$

to find V2

$$V_2 = \frac{V_s * R_2}{R_1 + R_2 + R_3}$$

$$V_2 = \frac{3 * 6}{24}$$

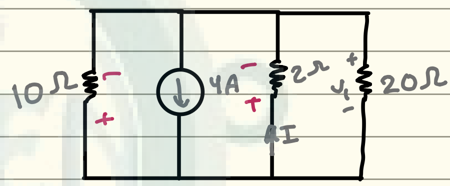
$V_2 = \frac{18}{24} = 0.75$ volt

or I can use ohm's Law

$V_2 = I_s * 6$

$= 0.125 * 6 = 0.75$ volt

Ex:

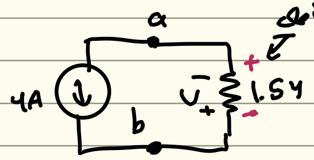


Find Req, V1, I
↳ seen by source

$\frac{1}{R_{eq}} = \frac{1}{2} + \frac{1}{20} + \frac{1}{10} = \frac{10}{20} + \frac{1}{20} + \frac{2}{20} = \frac{13}{20}$

$R_{eq} = \frac{20}{13} = 1.54\,\Omega$

now the ckt looks like this



عكسية

ليه يا عاصل بالرسمة
ال V_1 موقعة عليها أو تعتال (-)
والفكرة هون إنو الvoltage هو
تلك شي إذا الvoltage
العكسي لل V_{tot} نفس الpolarity

$V = 4 \times 1.54 = 6.15$ volt

$V_1 = -V_{\text{عكسية}}$ $\qquad$ $V = -V$ عكسية

$= -6.15$ volt

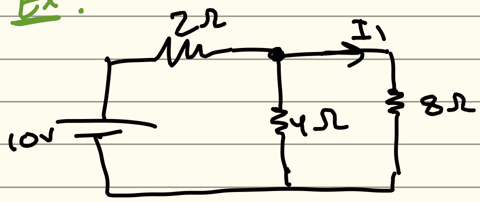
هنا إتجاه ال I الي طالبو بتعمل polarity نفس
اكي أنا حاطه مش هي بنفس الاتجاه

$V_2 = -V_1 = 6.15$ volt

عشان ال polarity عكس.

$I = \frac{V_2}{R} = \frac{6.15}{2} = 3.07\,A$

Ex :



Find I_1

4Ω ∥ 8Ω ⇒ if I find Req for them I can use voltage divider

$\frac{1}{R_{eq}} = \frac{1}{4} + \frac{1}{8} = \frac{2}{8} + \frac{1}{8} = \frac{3}{8}$

$R_{eq} = \frac{8}{3} = 2.7$

now we are going to use voltage divider

$V_{Req} = \frac{V_s * R_{eq}}{2 + 2.7} = \frac{10 * 2.7}{4.7} = \frac{27}{4.7} = 5.74$ volt

& 4Ω ∥ 8Ω so they have the same voltage

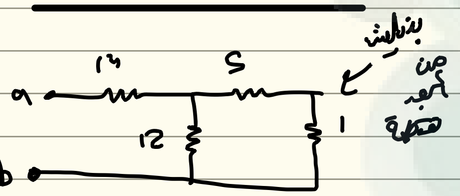
using ohm's Law

$V = I * R$

$\frac{5.74}{8} = \frac{I_1 * 8}{8}$

$I_1 = 0.72\,A$

Ex:



find Req seen from a & b

$R_{eq1} = 5 + 1 = 6\,\Omega$

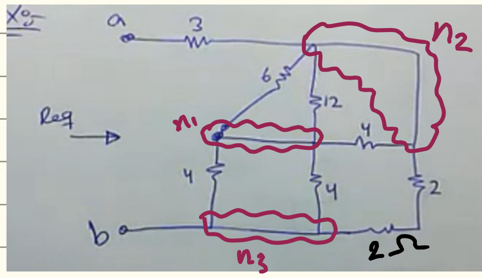
6Ω ∥ 12Ω

$\frac{1}{R_{eq}} = \frac{1}{6} + \frac{1}{12} = \frac{2}{12} + \frac{1}{12} = \frac{3}{12}$

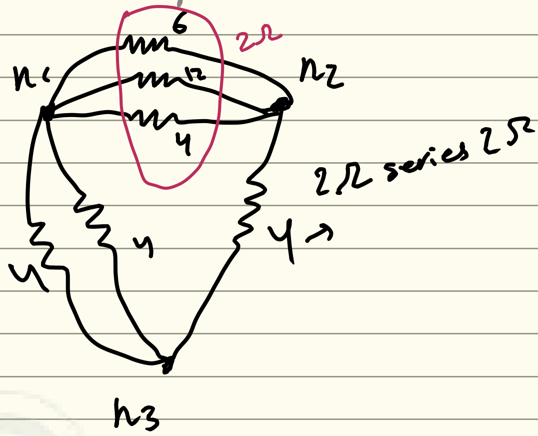
$R_{eq} = \frac{12}{3} = 4\,\Omega$

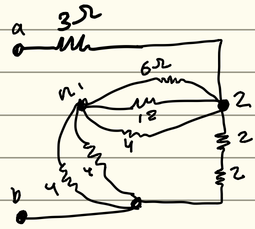
$14 + 4 = 18\,\Omega$

Ex

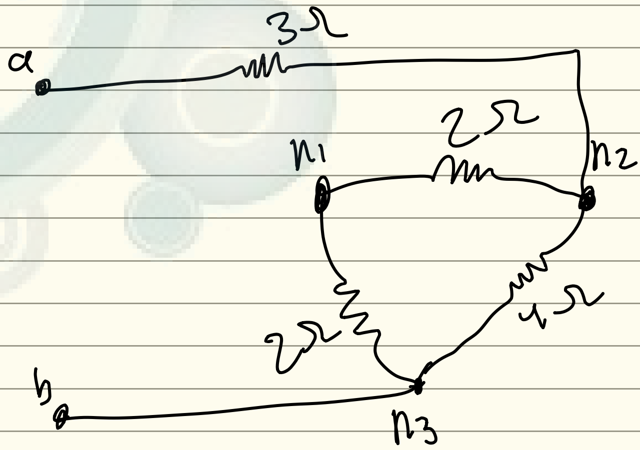


find Req seen from a & B





هيك الرسمة ومفهومة



2Ω series with 2Ω

2Ω + 2Ω = 4Ω

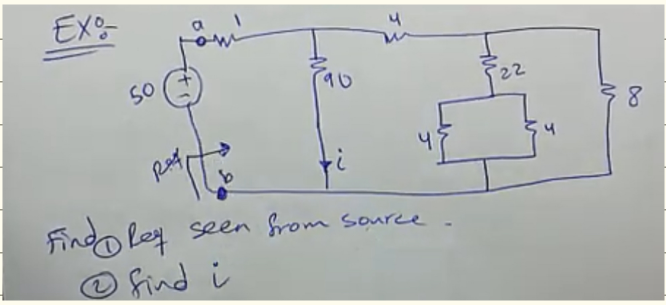
4Ω ∥ 4Ω

$\frac{1}{R_{eq}} = \frac{1}{4} + \frac{1}{4} = \frac{2}{4}$

$R_{eq} = 2\,\Omega$

2Ω in series 3Ω

$2 + 3 = 5\,\Omega$



①

$4\Omega \parallel 4\Omega$

$$\frac{1}{R_{eq}} = \frac{1}{4} + \frac{1}{4} = \frac{2}{4} \qquad R_{eq_1} = 2$$

2Ω & 22Ω series

$22 + 2 = 24\Omega$

$8\Omega \parallel 24\Omega$

$$\frac{1}{R_{eq}} = \frac{1}{8} + \frac{1}{24} = \frac{3}{24} + \frac{1}{24} = \frac{4}{24}$$

$$R_{eq} = \frac{24}{4} = 6\,\Omega$$

4Ω series 6Ω

$4 + 6 = 10\Omega$

$10\Omega \parallel 90\Omega$

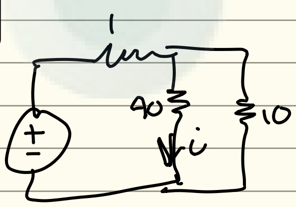
$$\frac{1}{R_{eq}} = \frac{1}{10} + \frac{1}{90} = \frac{9}{90} + \frac{1}{90} = \frac{10}{90}$$

$$R_{eq} = 9\,\Omega$$

1Ω series $9\Omega = 1 + 9 = 10\Omega$

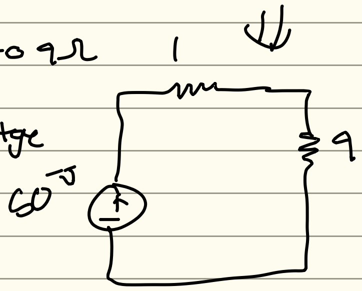
$$\boxed{R_{eq} = 10\,\Omega}$$

we will stop here to find i



i is not related to 9Ω

but if I found the voltge for 9Ω it's the same voltage for 90 & 10Ω



$$V_{9\Omega} = \frac{V_s \times R_{9\Omega}}{\Sigma R}$$

$$V_{9\Omega} = \frac{50(9\Omega)}{10}$$

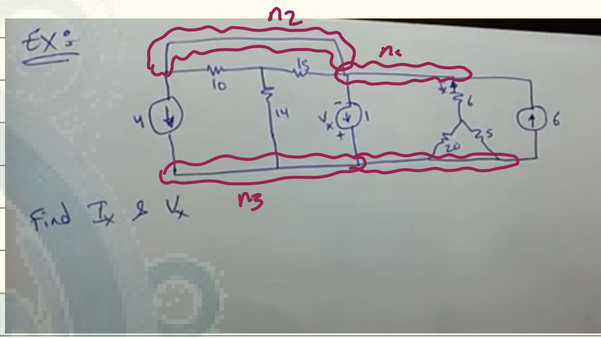
$V_{9\Omega} = 45\,V$

& it's the same for 90Ω & 10Ω because they are connected in parallel

$V = IR$

$$\frac{45}{90} = \frac{I \times 90}{90}$$

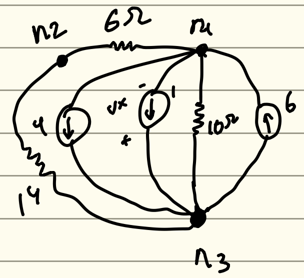
$I = 0.5A$



we can not use KCL / KVL / V/C divider

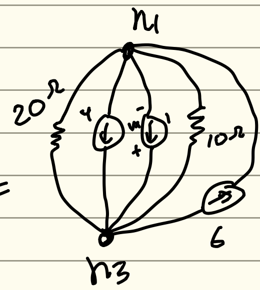
so I will simplify it

I will sea how many nodes I have

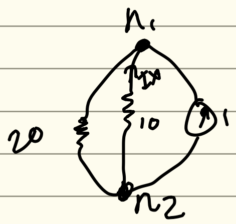


6Ω & 14Ω series

$6 + 14 = 20\Omega$



⇐ نطبق اتحاد الـ current sources



now for Ix current division

$$I_x = \frac{I_S \frac{1}{R}}{\frac{1}{R_N}}$$ ← المقاومة اللي بشغلها

Ix عكس الاتجاه الى داخل كليهما إذاً عندي سالب.

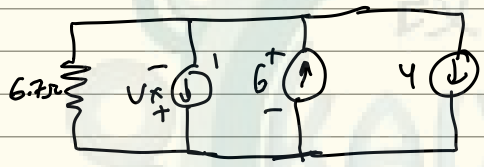
$$I_x = \frac{(1)(10)}{2\cdot\frac{1}{10}+\frac{1}{20}} = \frac{10}{\frac{2}{20}+\frac{1}{20}}$$

$$I_x = \frac{10}{\frac{3}{20}} = 10\times\frac{20}{3} = \frac{200}{3} =$$

$$\boxed{I_x = -66.67A}$$

غلط حل

now we must find Req & redrawing the supplies.



$10\Omega \parallel 20\Omega$

$$\frac{1}{R_{eq}} = \frac{1}{10}+\frac{1}{20} = \frac{2}{20}+\frac{1}{20}$$

$$R_{eq} = \frac{20}{3} = 6.7\Omega$$

Voltage for vx is the same for the resistance & all current sources

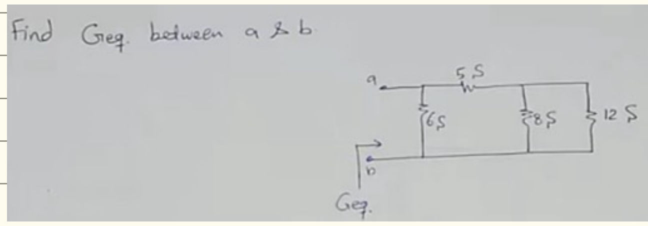
إحنا أصلاً استبدلنا كل الـ current بـ واحد والمجموع المجموعة

$V = IR$

$V = (6.7)(1) = 6.7$ →

$V_x = -6.7V$

لكن الـ voltage الـ polarity تاعو معكوسة إذا دا(2) بالبولاريه



$G = \frac{1}{R}$ ($\mho$, Ω^{-1}, S)

بجيب الـ R وبقلبها.

بنحول كل G الى R

$R_1 = \frac{1}{G} = \frac{1}{12} = 0.083\Omega$

$R_2 = \frac{1}{8} = 0.125\Omega$

$R_3 = \frac{1}{5} = 0.2\Omega$

$R_4 = \frac{1}{6} = 0.167\Omega$

$R_1 \parallel R_2$

$$\frac{1}{0.083}+\frac{1}{0.125} = \frac{1664}{83}$$

$R_{eq} = 0.05\Omega$

0.2 & 0.05 series

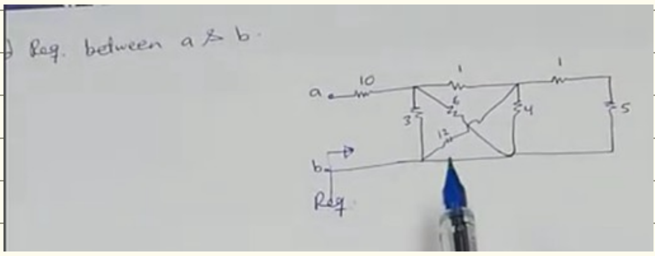
$= 0.25\Omega$

$0.167\Omega \parallel 0.25$

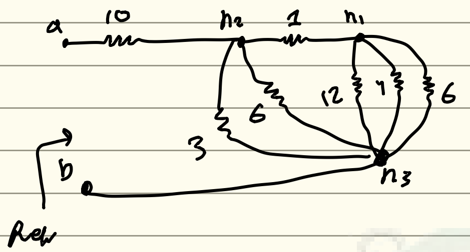
$$= \frac{1}{0.167}+\frac{1}{0.25}$$

$R_{eq} = 0.1$

$G = \frac{1}{R} = \frac{1}{0.1} = 10S$



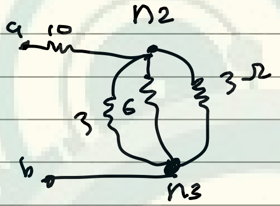
صحيحة بس نزبط شكل الدائرة :-



$4\Omega \parallel 6\Omega \parallel 12\Omega$

$$\frac{1}{4}+\frac{1}{6}+\frac{1}{12}=\frac{3}{12}+\frac{2}{12}+\frac{1}{12}=\frac{6}{12}$$

$R_{eq}=2\Omega$



2Ω & 1Ω series
3Ω

$6\Omega \parallel 3\Omega$

$$\frac{1}{6}+\frac{1}{3}=\frac{1}{6}+\frac{2}{6}=\frac{3}{6}$$

$R_{eq}=2\Omega$

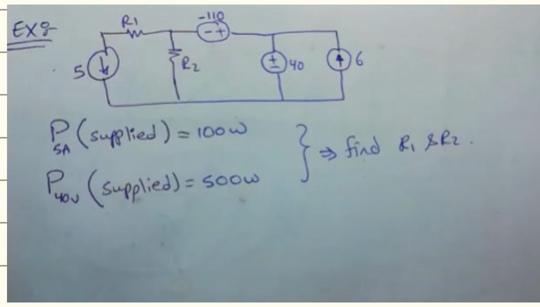
$2\Omega \parallel 3\Omega$

$$\frac{1}{2}+\frac{1}{3}=\frac{3}{6}+\frac{2}{6}=\frac{5}{6}$$

$R_{eq}=1.2$

1.2 & 10 in series

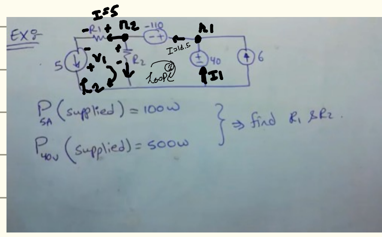
$10+1.2=11.2\Omega$



هون ركزي إنو بحكيلي supplied يعني بدخل من
(−) و بطلع من ال (+) إذا هاد اتجاه التيار

$P_{40V}=500=IV$

$$\frac{500}{40}=\frac{I\,40}{40} \Rightarrow I=12.5A$$



$P_{5A}=100=IV$

$$\frac{100}{5}=\frac{5V}{5} \Rightarrow V=20V$$

now we are going to apply KCL for node1

$\Sigma I_{in}=\Sigma I_{out}$

$I_1+6=I_o$

$12.5+6=I_o$

$I_o=18.5A$

KCL for n2

$\Sigma I_{in}=\Sigma I_{out}$

$18.5=5+x$
-5

$I_{R_2}=13.5\ A$

KVL for loop1

$-13.5\times R_2 - -110+40=0$

$-13.5R_2+110+40=0$

$+13.5R_2=+150$

$$\frac{13.5R_2}{13.5}=\frac{150}{13.5} \Rightarrow R_2=11.11\Omega$$

KVL for loop2

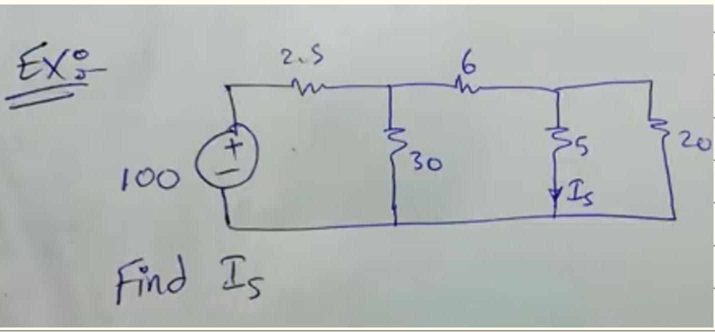
$+20-5R_1+13.5R_2=0$

$20-5R_1+150=0$

$170-5R_1=0$

$$\frac{170}{5}=\frac{5R_1}{5}$$

$R_1=34\Omega$



we will find Req

$$\frac{1}{20}+\frac{1}{5}=\frac{1}{20}+\frac{4}{20}=\frac{5}{20}$$

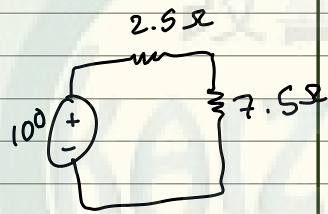
$$Req = 4\,\Omega$$

$$4+6=10\,\Omega$$

$10\,\Omega \parallel 30\,\Omega$

$$\frac{1}{10}+\frac{1}{30}=\frac{3}{30}+\frac{1}{30}=\frac{4}{30}$$

$$Req = \frac{30}{4} = 7.5$$

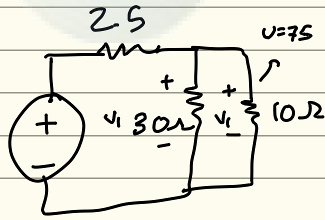


now applying voltage division

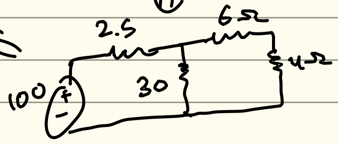
$$V_{7.5\Omega} = \frac{V_s * 7.5}{10}$$

$$= \frac{100 \times 7.5}{10} = 75\,V$$

& this is the same voltage for 30 Ω & 10Ω because they are parallel



now we will consider 30Ω resistance as a supply & apply voltage division



$$V_2 = \frac{V_s * 4}{10} = \frac{75 * 4}{10} = 30\,V$$

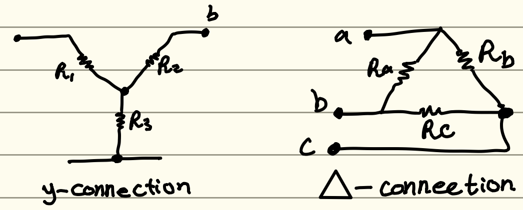
V_2 the same voltage for 5Ω & 20Ω

$$V = IR$$

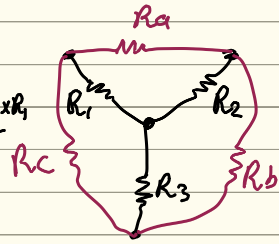
$$\frac{30}{5} = \frac{I * 5}{5}$$

$$\boxed{I_s = 6A}$$

Delta-wye connection for resistors



conversion from y-Δ

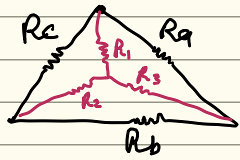


$$R_a = \frac{R_1R_2+R_2R_3+R_3 \times R_1}{R_3}$$

$$R_b = \frac{R_1R_2+R_2R_3+R_1R_3}{R_1}$$

$$R_c = \frac{R_1R_2+R_2R_3+R_1R_3}{R_2}$$

conversion from Δ to y:-

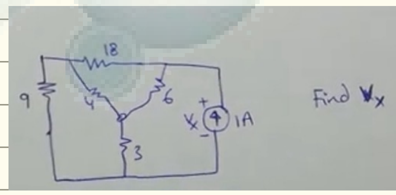


$$R_1 = \frac{R_a R_c}{R_a+R_b+R_c}$$

$$R_2 = \frac{R_c R_b}{R_a+R_b+R_c}$$

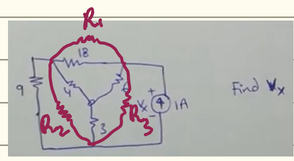
$$R_3 = \frac{R_a R_b}{R_a+R_b+R_c}$$

Ex:



Vx is the same for Req because they connected in parallel

* I will use y-Δ conversion

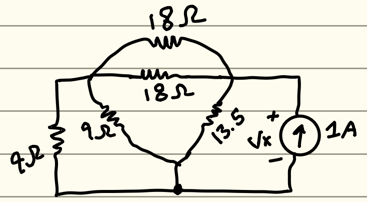


$$R_1 = \frac{(4\times6)+(4\times3)+(3\times6)}{3}$$

$$= \frac{54}{3} = 18\,\Omega$$

$$R_2 = \frac{54}{6} = 9\,\Omega$$

$$R_3 = \frac{54}{4} = 13.5\,\Omega$$



$18\Omega \parallel 18\Omega$

$$\frac{1}{18}+\frac{1}{18}=\frac{2}{18}$$

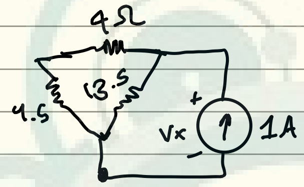
$$R_{eq_1}=\frac{18}{2}=9$$

$9\Omega \parallel 9\Omega$

$$\frac{1}{9}+\frac{1}{9}=\frac{2}{9}$$

$$R_{eq}=\frac{9}{2}=4.5$$

now the new one looks like

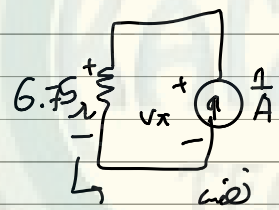


now we have 9Ω series with 4.5Ω

$$R_{eq}=9+4.5=13.5\Omega$$

$$\frac{1}{13.5}+\frac{1}{13.5}$$

$$R_{eq}=6.75\Omega$$



نفس ال polarity إذا نفس الاتجاه

so

$$V=IR$$

$$V=(6.75)\,1=6.75$$

↳ this voltage is the same for (V_x)

fundemental techniques for resistire circuite analysis:-

1. Nodal Analysis
2. Mesh Analysis
3. Super position
4. source transformation
5. Thevenin & norton

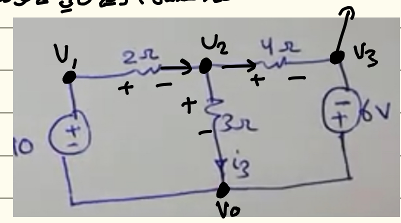
① Nodal analysis

steps:-

1. Determine the nodes
2. assume one of the nodes as a referance
3. name the nodes ⇒ using V_1, V_2, V_3
4. if we have voltage source between node & reference
   ↳ V_i at that node is known
5. Apply KCL at each node

هاي والي زيها عالشمال يصيروا nodes عشان أريح حالي لانو قيمتهم بتصير معي

Ex :



find i_3, $P(2\Omega)=??$
using nodal analysis

$V_1=10\,V$, $V_3=-6\,V$ → لانو السالب فوقه وأنا بدي إياها referance ⇐ V3

apply KCL at node 2

$$\Sigma I_{in}=\Sigma I_{out}$$

$$I_{2\Omega}=I_{4\Omega}+I_{3\Omega}$$

$$\frac{(V_1-V_2)}{2}=\frac{(V_2-V_3)}{4}+\frac{V_2}{3}$$

$$\frac{(10-V_2)}{2}=\frac{(V_2+6)}{4}+\frac{V_2}{3}$$

$$5-\frac{V_2}{2}=\frac{V_2}{4}+\frac{6}{4}+\frac{V_2}{3}$$

$$5-\frac{6}{4}=\frac{V_2}{4}+\frac{V_2}{3}+\frac{V_2}{2}$$

$$\frac{12}{13}\times\frac{7}{2}=\frac{13}{12}V_2\times\frac{12}{13}$$

$$V_2=3.24\,V$$

$i_3 \Rightarrow V=IR$

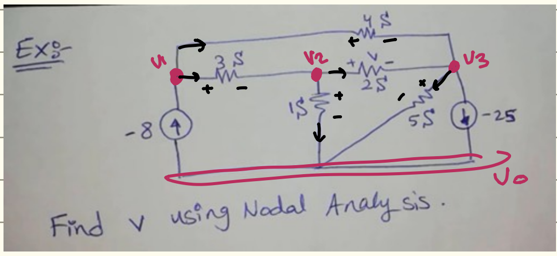
$$3.24=i_3\times 3$$

$$i_3=1.077$$

$P(2\Omega) \Rightarrow V_{2\Omega}=V_1-V_2=10-3.24$

$$V_{2\Omega}=6.76\,V$$

$$P_{2\Omega}=\frac{V^2}{R}=\frac{(6.76)^2}{2}=22.85\,\text{watt}$$



find v using nodal analysis

$$G = \frac{1}{R}$$

$$\boxed{I = V * G}$$

writing nodal equation for node1

$$-8 = (v_1 - v_2)\times 3 + (v_1 - v_3)\times 4$$

writing nodal equation for node 2

$$(v_1 - v_2) * 3 = (v_2 - v_3) * 2 + v_2 * 1$$

writing nodal equation for node3

$$4(v_1 - v_3) + 2(v_2 - v_3) = (v_3 * 5) + -25$$

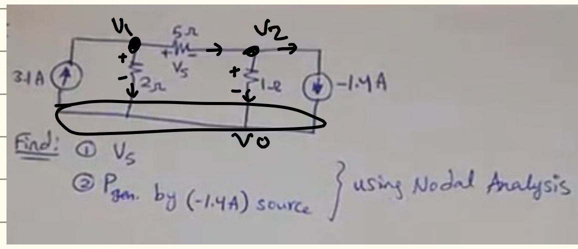
$$4v_1 - 4v_3 + 2v_2 - 2v_3 - 5v_3 = -25$$

$$7v_1 - 3v_2 - 4v_3 = -8$$
$$3v_1 - 6v_2 + 3v_3 = 0$$
$$4v_1 - 11v_2 - 4v_3 = -25$$

$$\begin{Bmatrix} 7 & -3 & -4 \\ 3 & -6 & 3 \\ 4 & -11 & -4 \end{Bmatrix} \begin{Bmatrix} v_1 \\ v_2 \\ v_3 \end{Bmatrix} = \begin{Bmatrix} -8 \\ 0 \\ -25 \end{Bmatrix}$$

$$v_1 = \frac{123}{121}, \quad v_2 = \frac{211}{121}, \quad v_3 = \frac{249}{121}$$

$$V = v_2 - v_3 = -\frac{8}{11}$$



at node 1 apply KCL

$$\Sigma I_{in} = \Sigma I_{out}$$

$$3.1 = \frac{V_1}{2} + \frac{V_1 - V_2}{5}$$

$$3.1 = \frac{V_1}{2} + \frac{V_1}{5} - \frac{V_2}{5}$$

$$3.1 = 0.7v_1 - 0.2V_2$$

at node 2 apply KCL

$$\left(\frac{V_1 - V_2}{5}\right) = -1.4 + \frac{V_2}{1}$$

$$\frac{V_1}{5} - \frac{V_2}{5} = -1.4 + V_2$$
$$-V_2 \qquad -V_2$$

$$\frac{V_1}{5} - \frac{6}{5}V_2 = -1.4$$

$$0.2V_1 - 1.2V_2 = -1.4$$

$$\begin{Bmatrix} 0.7 & -0.2 \\ 0.2 & -1.2 \end{Bmatrix} \begin{Bmatrix} V_1 \\ V_2 \end{Bmatrix} = \begin{Bmatrix} 3.1 \\ -1.4 \end{Bmatrix}$$

$$V_1 = 5V, \quad V_2 = 2V$$

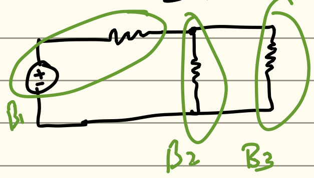
$$V_s = V_1 - V_2 = 5 - 2 = 3V$$

$$P_{(-1.4)} = I\,(2)$$
$$= +(-1.4\times 2) = -2.8 \text{ watt}$$

$$P_{generated} = 2.8 \text{ watt.}$$

*Defentions of electrical ckt Networks

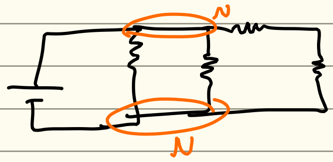
① Branch: any part of the ckt that has one or more elements



3-branches

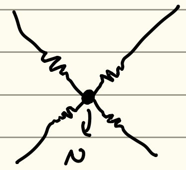
② Node: Junction of two or more Branches
تجمع

there is no elements in this wire we consider them as one node

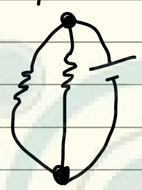


⇒ has two nodes

Ex

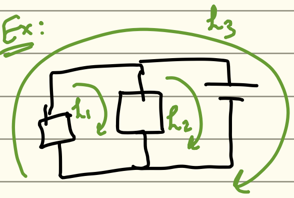


Ex

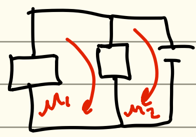


③ Loop: closed connection of Branches

Ex:



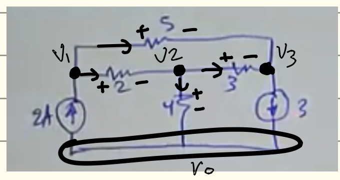
④ Mesh: loop that does not contain other loop.



has 2 meshes

Super node

Ex



writing nodal analysis for node 1:-

$$2 = \frac{(V_1 - V_2)}{2} + \left(\frac{V_1 - V_3}{5}\right)$$

$$2 = \frac{V_1}{2} - \frac{V_2}{2} + \frac{V_1}{5} - \frac{V_3}{5} \Rightarrow 2 = \frac{7}{10}V_1 - \frac{V_2}{2} - \frac{V_3}{5} \quad \text{—①}$$

writing nodal equasion for node 2

$$\left(\frac{V_1 - V_2}{2}\right) = \left(\frac{V_2 - V_3}{3}\right) + \frac{V_2}{4}$$

$$\frac{1}{2}V_1 - \frac{1}{2}V_2 = \frac{V_2}{3} - \frac{V_3}{3} + \frac{V_2}{4}$$

$$\frac{1}{2}V_1 = \frac{V_2}{3} + \frac{V_2}{4} + \frac{1}{2}V_2 - \frac{V_3}{3}$$

$$0 = \frac{13}{12}V_2 - \frac{1}{3}V_3 - \frac{1}{2}V_1$$

writing nodal equasion for node 3

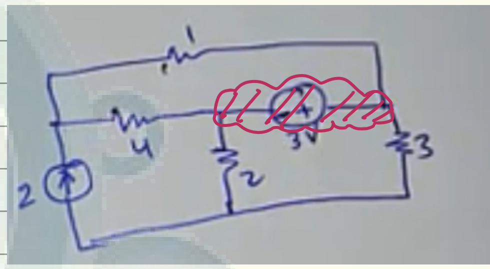
$$\left(\frac{V_1 - V_3}{5}\right) + \left(\frac{V_2 - V_3}{3}\right) = 3$$

$$\frac{V_1}{5} - \frac{V_3}{5} + \frac{V_2}{3} - \frac{V_3}{3} = 3$$

$$\frac{V_1}{5} - \frac{8}{15}V_3 + \frac{V_2}{3} = 3$$

↳ now we are solving the Matrix on calculater

Ex:



if I do the regular solution I will face problem in the second node.

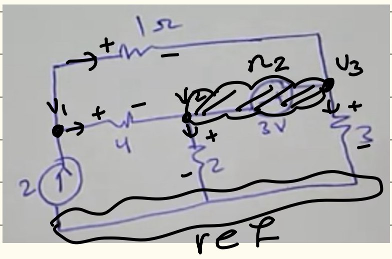
we can not find the current for the voltage supply here

* إذا هاد الحل بعملوا لما يكون عندي voltage source بين 2nodes

solution: we will cosider this wire as super node

example in the second page

Ex



at node 1

$$2 = \left(\frac{V_1-V_2}{4}\right) + \left(\frac{V_1-V_3}{1}\right) \text{ --- } (1)$$

at node 2 ⇒ here I face problem

$$\left(\frac{V_1-V_2}{4}\right) + \left(\frac{V_1-V_3}{1}\right) = \frac{V_3}{3} + \frac{V_2}{2} \text{ --- } (2)$$

I have 3 variables I can not find them using only 2 equations so I will use this equation for super node

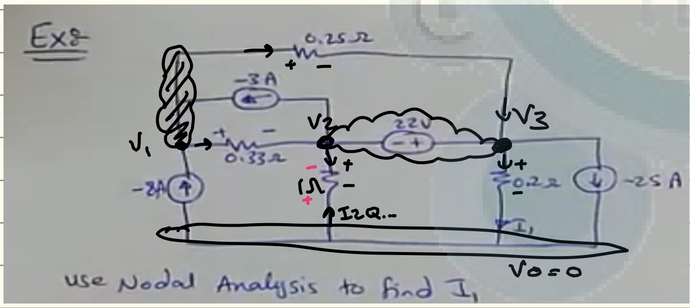
super node :-

$\boxed{V_3 - V_2 = 3}$ -- (3)

solving them using the calculator

so

super node : when there is a voltage source between nodes, we can not know the current as a function of voltage



writing nodal equation for node 1

$$(-8+-3) = \left(\frac{V_1-V_2}{0.33}\right) + \left(\frac{V_1-V_3}{0.25}\right)$$

writing nodal equasion for the supernode

$$\left(\frac{V_1-V_2}{0.33}\right) + \left(\frac{V_1-V_3}{0.25}\right) = -3 + \frac{V_2}{1} + -25 + \frac{V_3}{0.2}$$

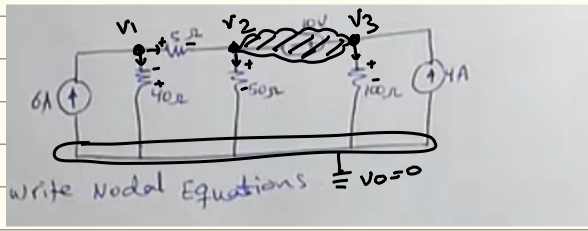
#super node

solving them using the calculater ....

$V_3 - V_2 = 22$ $\quad I_1 = \frac{V_3}{0.2}$

#if I asked to find I_2

$\frac{0-V_2}{1}$ polarity عكس ال



writing nodal equation for node1

$$6 = \left(\frac{V_2-V_1}{5}\right) + \frac{V_1}{40} \text{ ... } (1)$$

writing nodal equasion for super node

$$\left(\frac{V_1-V_2}{5}\right) + 4 = \frac{V_2}{50} + \frac{V_3}{100}$$

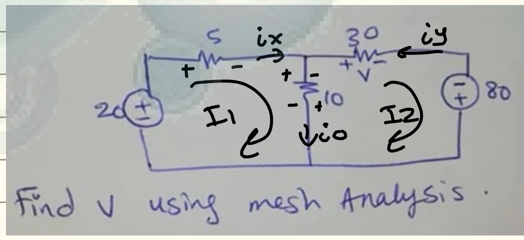
#super node equasion

$\boxed{V_3 - V_2 = 10}$ ⇒ بحتاج ال 3 هين أطرح من 2 هين حسب ال polarity لل voltage source الموجب هو أولتي والسالب هو الي بطرحو.

2 Mesh analysis

steps:-

(1) Define meshs
(2) assign mesh curret (cw) for all meshes
(3) apply KVL for each mesh.
و بعطي معادلاتي قد عدد المجاهيل
(4) Solve equasions



at mesh1

$-20 + 5I_1 + 10I_1 - 10I_2 = 0$ --- (1)

at mesh 2

$10I_2 - 10I_1 + 30I_2 - 80 = 0$ -- (2)

solving them using calculator

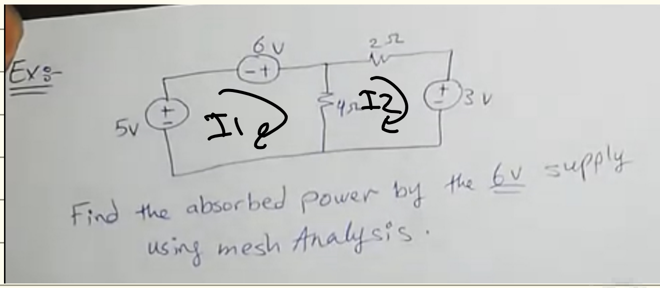
$V = I_2 \times 30$

ممكن يحكيلي السؤال أوجد io ما بتكون :-

$i_o = I_1 - I_2 \Rightarrow$ لأنو ال I هو الي ماشي معو

إذا طلب مني ال ix هي نفسها ال I_1

إذا طلب مني ال iy هي $i_y = -I_2$ لأنو عكسو



at mesh 1

$-5 - 6 + 4I_1 - 4I_2 = 0$ — ①

at mesh 2

$4I_2 - 4I_1 + 2I_2 + 3 = 0$ --- ②

$I_2 = 0.8$, $I_1 = 1.95$

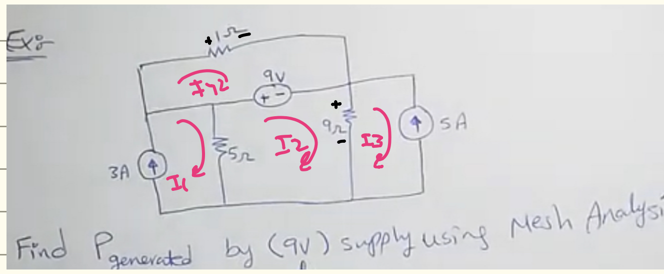
حكينا إذا بدي Pabsorb لازم التيار يدخل بالجهة الموجبة
so I need the same current but in the opposite direction (−)

$P_{abs} = (-I_1)(V)$
$= (-1.95 \times 6) = -11.7$

Note:

+ — $\Rightarrow$ power absorbed

— + $\Rightarrow$ power generated



already we can know that
$I_1 = 3A$
$I_3 = -5A$

at mesh 2

$5I_2 - 5I_1 + 9 + 9I_2 - 9I_3 = 0$

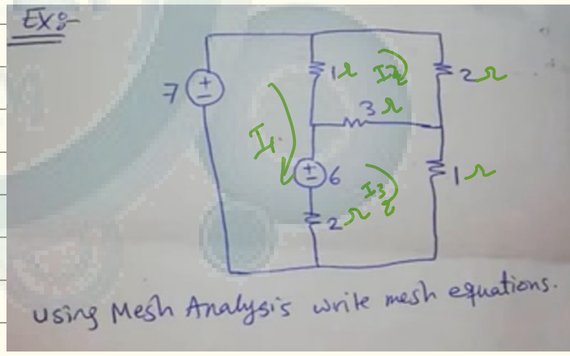
$5I_2 + 9I_2 = -39$ ---- eq①
$I_2 = -2.78571$ so it is ccw

at mesh 4

$I_4 - 9 = 0$
$I_4 = 9$

$P = (I_4 - I_2) \times V$
$= 106.0714286$

هون هو حاكي generated
إذا هو أعطاني أياها generated
فبدي أدخل من السالب وأعتبر
هاد هو التيار الموجب أصلاً



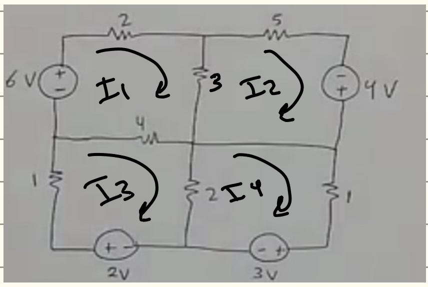
at mesh 1
$-7 + I_1 - I_2 + 6 + 2(I_1) - 2I_3 = 0$ ...①

at mesh 2

$I_2 - I_1 + 2I_2 + 3I_2 = 0$ .... ②

at mesh 3

$2I_3 - 2I_1 - 6 + 3I_3 - 3I_2 + I_3$ --- ③



write mesh equation?

at mesh 1

$-6 + 2I_1 + 3I_1 - 3I_2 + 4I_1 - 4I_3 = 0$ ---- (1)

at mesh 2

$3I_2 - 3I_1 + 5I_2 - 4 = 0$ ---- (2)

at mesh 3

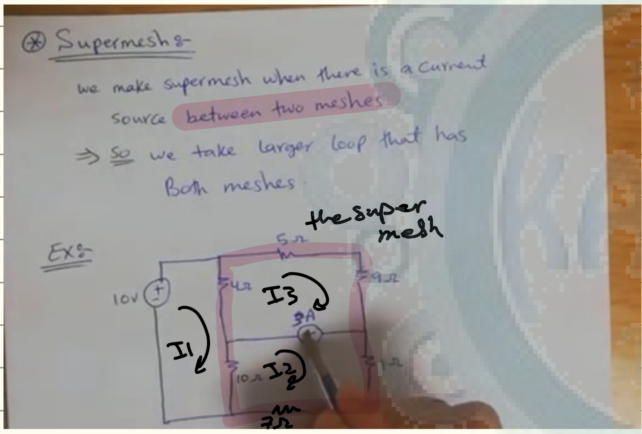
$I_3 + 4I_3 - 4I_1 + 2I_3 - 2I_4 - 2 = 0$ ---- (3)

at mesh 4

$2I_4 + I_4 + 3 - 2I_3 = 0$ ---- (4)

---

super mesh



find the Pgen by the 10V supply using mesh analysis

at mesh 1

$-10 + 4I_1 - 3I_3 + 10I_1 - 10I_2 = 0$

I have a current source between 2 meshs so I am going to apply super mesh

$+10I_2 - 10I_1 + 4I_3 - 4I_1 + 6I_3 + 9I_3 + I_2 + 7I_2 = 0$

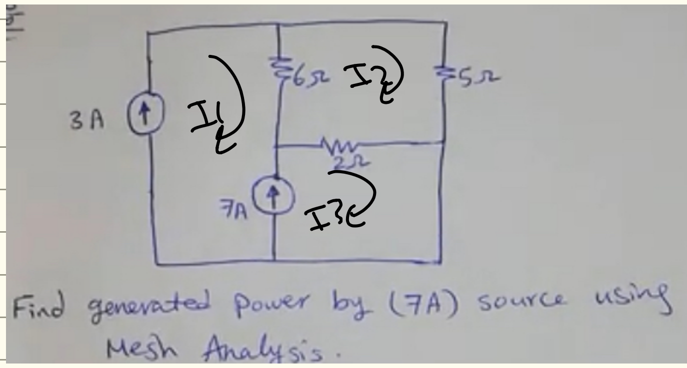
& the current source equation

$I_3 - I_2 = 3$

$P = -(I_1) \times 10$

$P_{gen} = (I_1 \times 10) = \ldots$ watt

$P_{abs\,10V} = -P_{gen}$



$I_1 = 3$

at mesh 2

$6I_2 - 6I_1 + 5I_2 + 2I_2 - 2I_3 = 0$

for the current source

$I_3 - I_1 = 7$

$I_3 = 10$

Back to equation 1

$I_2 = \frac{33}{13}$

$P_{gen} = I \times V$

I_3 already so

V :- KVL

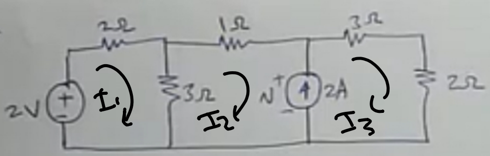
loop 3

$-V + (10 - 4)\,2 = 0$

$-V + 12 = 0$

$V = 12$

$P = -12 \times 7 =$



using Mesh Analysis find ① V

② $P_{gen.}$ by (2A) source.

③ $P_{abs.}$ by (1Ω) resistor.

④ $P_{gen.}$ by (2V) source.

at mesh 1 :-

$$-2 + 2I_1 + 3I_1 - 3I_2 = 0$$

I have current source between 2 mesh

so

$$3I_2 - 2I_1 + I_2 + 3I_3 + 2I_3 = 0$$

super mesh

$$I_3 - I_2 = 2$$

Solving them

$$\begin{Bmatrix} 5 & -3 & 0 \\ -2 & 4 & 5 \\ 0 & -1 & 1 \end{Bmatrix} \begin{Bmatrix} I_1 \\ I_2 \\ I_3 \end{Bmatrix} = \begin{Bmatrix} 2 \\ 0 \\ 0 \end{Bmatrix}$$

$$I_1 = \frac{6}{13}, \quad I_2 = \frac{4}{37}, \quad I_3 = \frac{4}{39}$$

هدول قيمهم غلط بس حطهم عليهم طلعين معها سوالب

① $\underline{V}$

$$-V + 3I_3 + 2I_3 = 0$$

$$-V + \frac{20}{39} = 0 \Rightarrow V = \frac{20}{39}$$

② $P_{gen}(2A) = -(I_3 - I_2) \times \frac{20}{39}$

$$-3 \times \frac{20}{39} = -\frac{20}{13}$$

$$P_{gen} = \frac{20}{13}$$

هون تأكد انك حاطط التربيع

③ P_{obs} by 1Ω register

$$P = (I_2)^2 (1) = 1.49 \text{ watt}$$

④ $P_{gen} = -2(-0.33)$

$$= 0.66 w$$

$$P_{obs} = -P_{ge}$$

$$= -0.66$$

3 Superposition :- $P = I^2R$ ممنوع (استعمالها)

① used for linear circuits & linear quantities (I & V)

when there is multiple sources in the circuit

م بجل عليه لما يكون عندي ٢، ٣ sources ← وإذا طلب مني أحل عليها

steps:

① we will choose one supply & short circuit the other sources as follow:

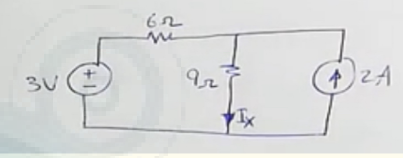
1) current source ⇒ open circuit

2) voltage " ⇒ short circuit

② Find the currents & voltages in the circuit

③ repeat steps (1→2) for other supplies

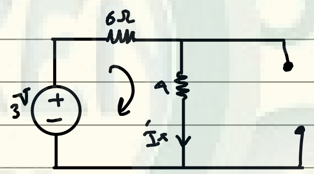
④ the Total current or voltage is the sum of values founded is previous steps.



Find I_x using superposition m

2 sources ⇒ I am going to solve it twice

* leave voltage source & kill the current source



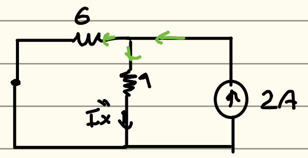
using KVL

$$-3 + 6I_x' + 9I_x' = 0$$

$$-3 + 15I_x' = 0$$

$$\frac{15I_x'}{15} = \frac{3}{15} \Rightarrow I_x' = 0.2A$$

* leave the current source & kill the voltage source



using current division

$$I_x'' = \frac{2 \cdot \frac{1}{9}}{\frac{1}{6} + \frac{1}{9}}$$

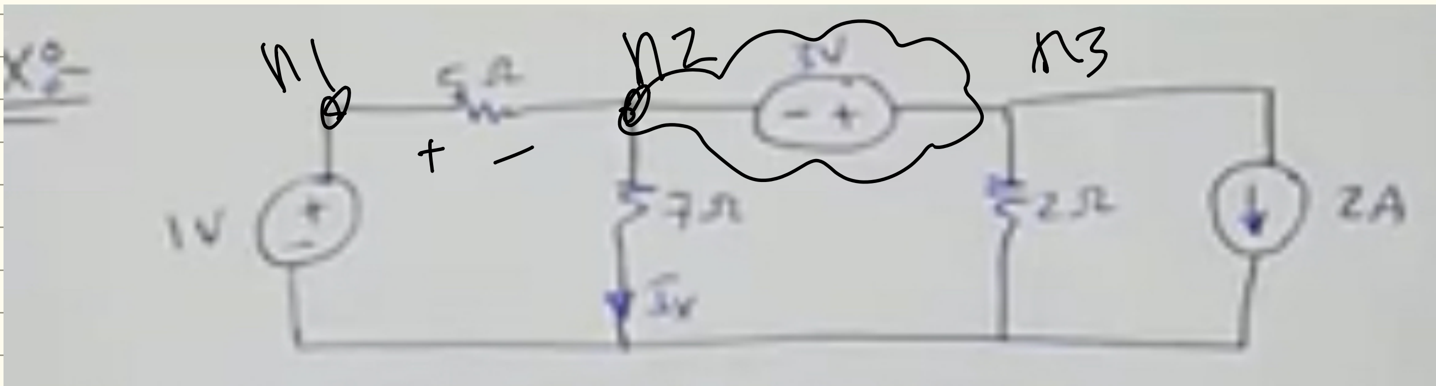
$$I_x'' = 0.8 A$$

So

$$I_x = I_x' + I_x''$$

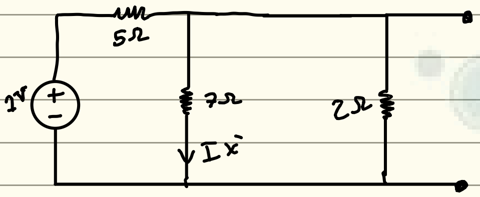
$$= 0.2 + 0.8 = 1A$$

Ex:-



Find I_x using superposition.

\# Keep the 1V & kill (3V & 2A)



$7\Omega \parallel 2\Omega$

$\frac{1}{7}+\frac{1}{2}=\frac{9}{14}$

$R_{eq}=\frac{14}{9}$

$R_{eq}=1.56\,\Omega$

using current division

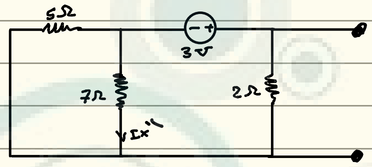
$v_{1.55\Omega}=\frac{(1)(1.56)}{(1.56)+5}=0.24\,V$

$V=IR$

$\frac{0.24}{7}=\frac{I_x \times 7}{7}$

$I_x'=0.034A$

\# Leave (3V) Kill (1V, 2A)



using voltage division

$\frac{1}{5}+\frac{1}{7}$

$R_{eq}=\frac{35}{12}=2.92$

$V=\frac{3\times 2.92}{(2.92)+2}=1.78\,V$

$V=IR$

$\frac{1.78}{7}=\frac{I_x''(7)}{7} \Rightarrow I_x''=-0.254$

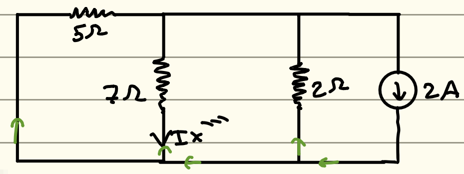
لعوضين أحيت السالب ؟

لما يجي ال current تخش ال polarity

لل voltage source لو 2 يكون على أطرافه

فيدي يي أعطيها (−)

Leave (2A) & Kill (1V & 3V)



by current division

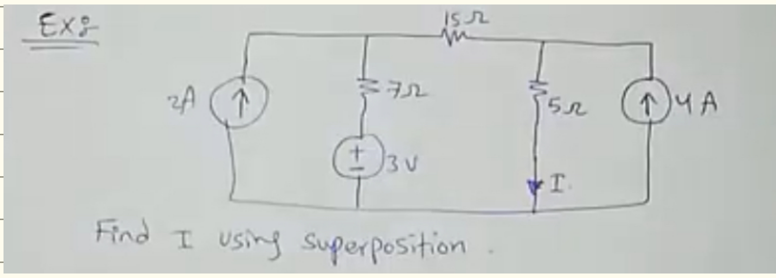
$I'''_x=-\frac{2\times\frac{1}{7}}{\frac{1}{7}+\frac{1}{2}+\frac{1}{5}}=-0.34A$

عكس اتجاه السهم

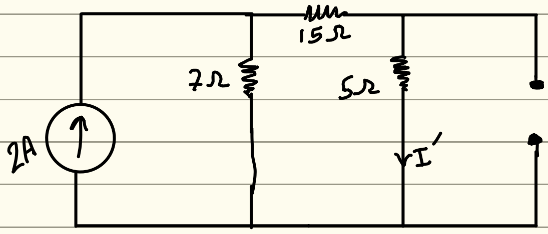
$I_x=I_x'+I_x''+I_x'''=-0.564A$

Nodal analysis أو Mesh analysis لما أتاكد حل يوجا تا بادلي

بحل أو تنيشق .



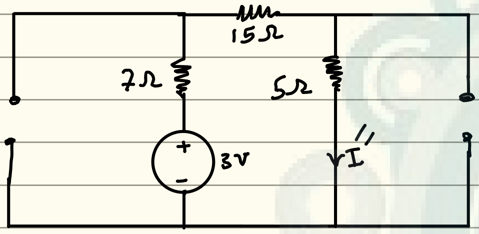
*** Keep (2A) & Kill (3V, 4A)**



Req = 20

$$I' = \frac{2 \times \frac{1}{20}}{\frac{1}{20} + \frac{1}{7}} = \quad I' = 0.52$$

*** Keep (3V) & Kill (2A, 4A)**



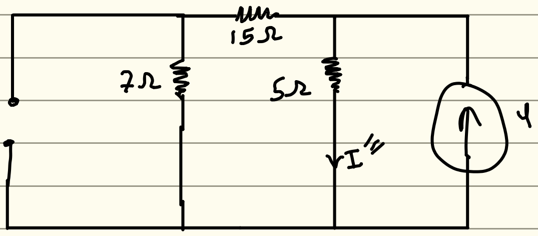
$$-3 + 7I'' + 15I'' + 5I'' = 0$$

$$-3 + 27I'' = 0$$

$$27I'' = 3$$

$$I'' = 0.111 A$$

*** Leave (4A) & Kill (2A, 3V)**

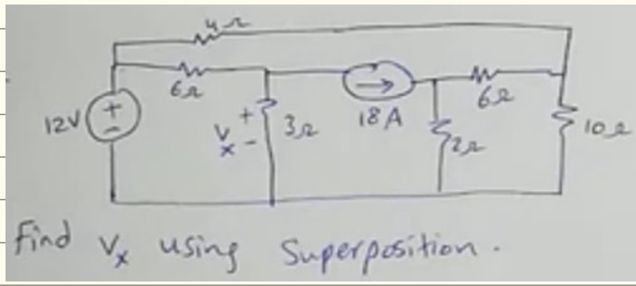


$$I''' = \frac{4\left(\frac{1}{5}\right)}{\frac{1}{5} + \frac{1}{22}} = \frac{88}{27}$$

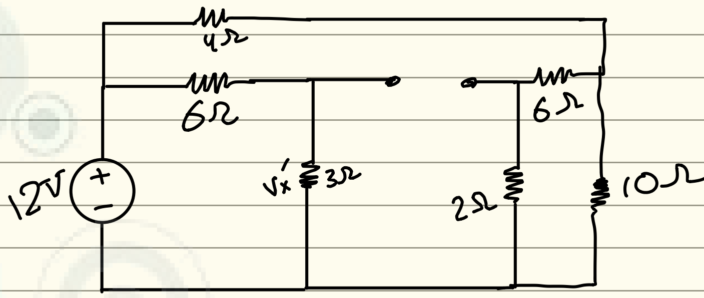
$$I''' = 3.26 A$$

$$I = I' + I'' + I'''$$

$$I = 3.89 A$$



*** Leave 12V & Kill (18A)**



$$-12 + 6Ix + 3Ix = 0$$

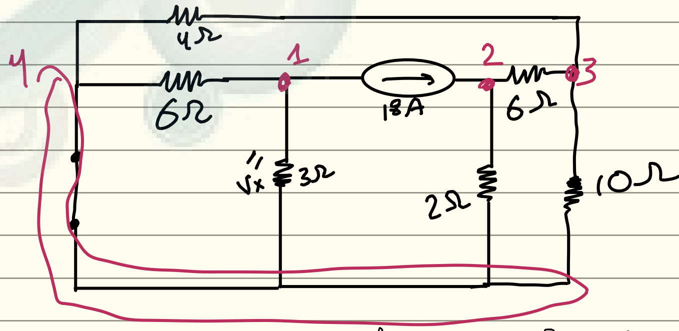
$$9Ix - 12 = 0$$

$$Ix = 1.33 A$$

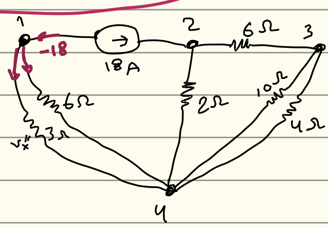
$$V_x = I_x \cdot R$$

$$V_x' = (1.33)(3)$$

$$V_x' = 3.99 \approx 4V$$



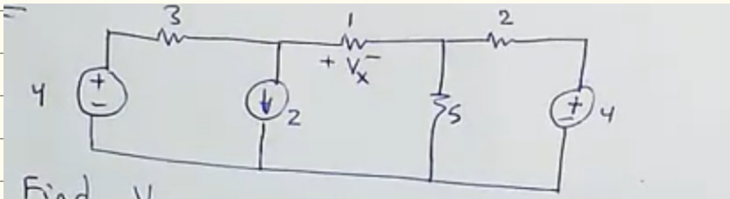
*** By current division**



$$I' = \frac{-18 \cdot \frac{1}{3}}{\frac{1}{6} + \frac{1}{3}} = -12A$$

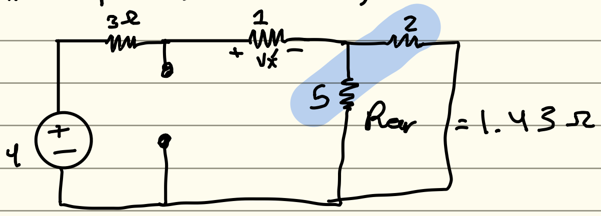
$$V_x'' = -12 \times 3$$
$$= -36$$

$$V_x = V_x' + V_x''$$
$$= 4 + -36$$
$$= -32$$



Find V_x using superposition

* Keep (4 V) & Kill (2 A, 4 V)

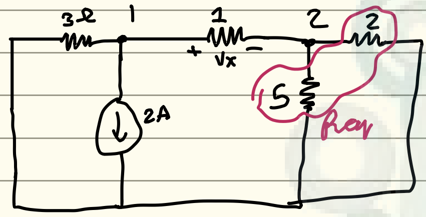


2Ω || 5Ω

$$V_x' = \frac{V_s \times (1)}{(1+3+1.43)} = \frac{4}{5.4286} = 0.74\ V$$

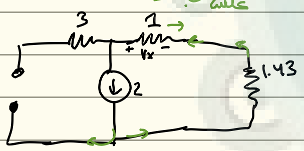
$$\boxed{V_x' = 0.74\ V}$$

* Keep (2A) & Kill (4V, 4V)



$R_{eq} = 1.43\ \Omega$

علشان جهدو إدًا بدي ما أعني السالب



$$I = 2 \times \frac{\frac{1}{2.43}}{\frac{1}{2.43} + \frac{1}{3}}$$

مجموع المقاومتين

current division الـ × نو inseries الـ

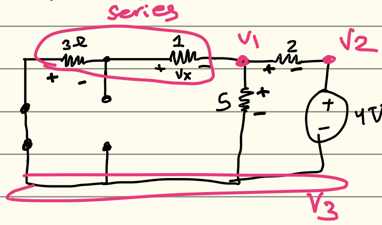
parallel الـ

$I = 1.105\ A$

$V_x = I \times 1$

$V_x = -1.105\ V$

Keep (4 V) & Kill (4 V, 2A)

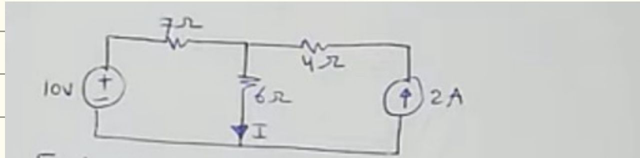


at node 1

$$\left(\frac{V_3 - V_1}{4}\right) = \left(\frac{V_1 - V_3}{5}\right) + \left(\frac{V_1 - V_2}{2}\right)$$

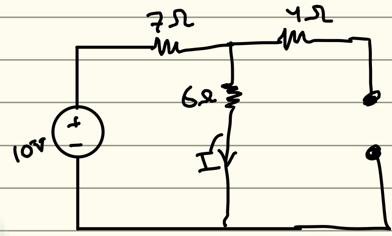
تحت حل وتجيبي الـ V_x''' راح تطلع معاك الـ polarity المطلوبة فتاخذ (−) sign

then $V_x = V_x' + V_x'' + V_x'''$



Find Power of (6Ω) by super position.

* Keep (10 V) & Kill (2A)



using KVL

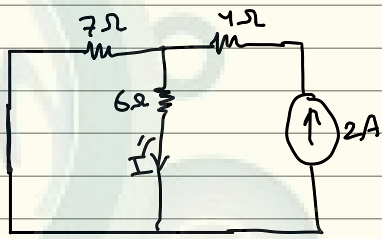
$$-10 + 7I_1 + 6I_1 = 0$$

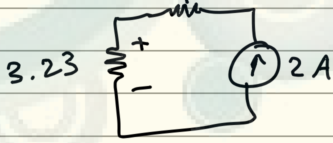
$$-10 + 13I_1 = 0$$

$$\frac{13 I_1}{13} = \frac{10}{13}$$

$I_1' = 0.77\ A$, $P' = (I')^2 \times 6 = 3.56\ W$

* Keep (2A) & Kill (10 V)





$V = I \times R$

$= 6.46\ V$

لأن هو نفس الـ voltage (parallel)

$V = I R$

$$\frac{6.46}{6} = \frac{I \times 6}{6}$$

$I'' = 1.0766$

$P''(6\Omega) = I'' \times 6$

$P'' = 6.99\ W$

الـ super position لا يطبق على الطاقة لأن الـ linear الـ hinear إذا

$I^2 R \neq (I')^2 \times R + (I'')^2 R$

لا نو تربيعي ما بصير أطبق عليه الـ superposition

لم إذا الأولى هي الصح

$I = I' + I'' = 1.85\ A$

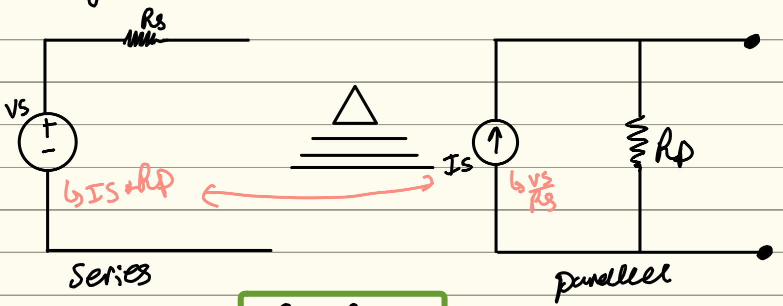
$P(6\Omega) = (1.85)^2 (6) = 20.52\ watt$

$P' + P'' = 3.56 + 6.99\ watt$

مين فيهم صح؟

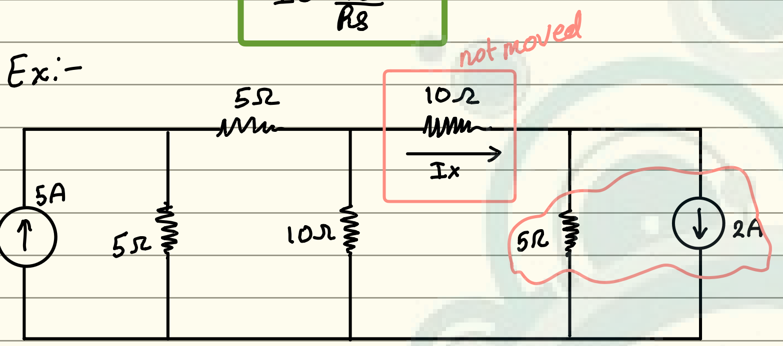
4 Source transformation :-

In some ckt replacing current sources with voltage sources or visa versa make the ckt simple & easy to solve وحدة وحدة



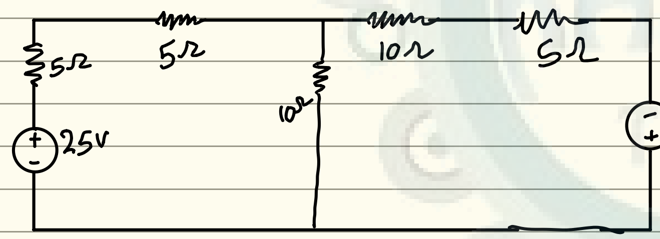
$$\boxed{\begin{aligned} R_s &= R_p \\ V_s &= I_s R_s \\ I_s &= \frac{V_s}{R_s} \end{aligned}}$$

Ex:-

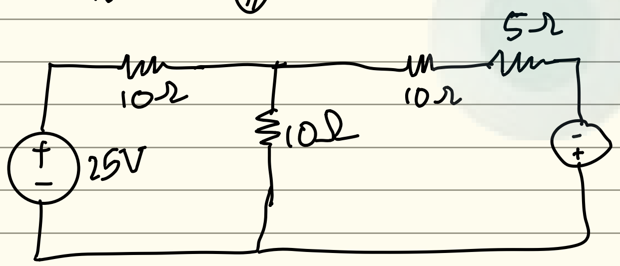


find Ix using source transformation.

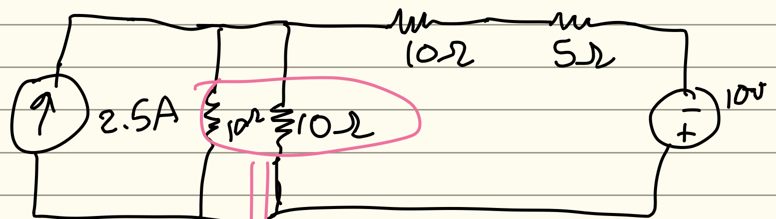
* الbrand اللي طالبين فيه قيمة بتركو ما بشتغل فيه



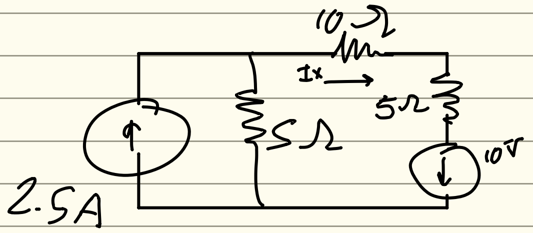
now ⇓

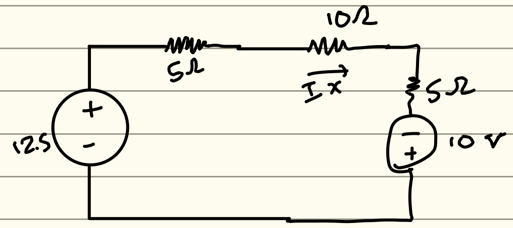


⇓ now



$$\frac{R_1 * R_2}{R_1 + R_2} = \frac{10 \times 10}{20} = \frac{100}{20} = 5\Omega$$





now this ckt is very simple (one loop)

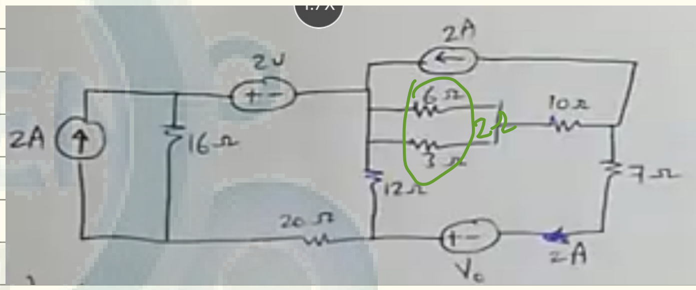
* applying KVL

$$-12.5 + 5I_x + 10I_x + 5I_x - 10 = 0$$

$$-22.5 + 20I_x = 0$$

$$20I_x = 22.5$$

$$\boxed{I_x = 1.125A}$$



find vo by source transformation.

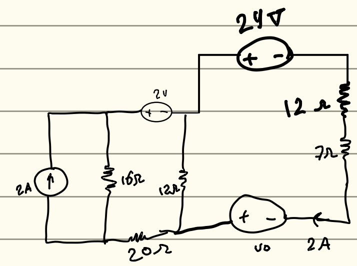
Sol

$6\Omega \parallel 3\Omega$

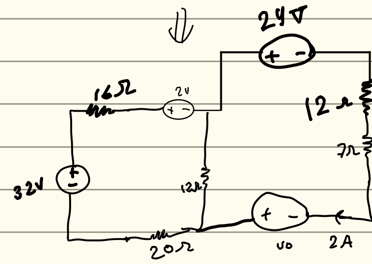
$\frac{6 \times 3}{6+3} = \frac{18}{9} = 2\Omega$

2Ω series 10Ω

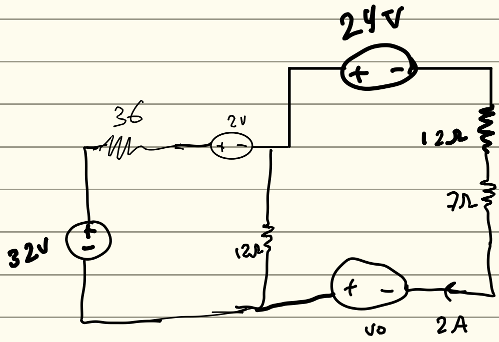
$2 + 10 = 12\Omega$



⇓

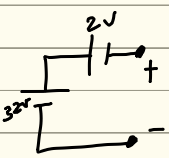


16+20=36 series ⇐ 16Ω & 20Ω



هسا عشي 2 voltage source بنفس القيمة

واتجاهاتهم عكس بعض شو اتجاه ال voltage source الجديد وكم قيمته



طيب على أي أساس نقرر اتجاه ال polarity

بحط KVL does polarity

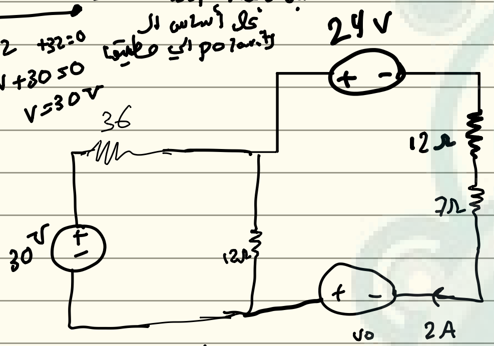
بس بلفة ال loop

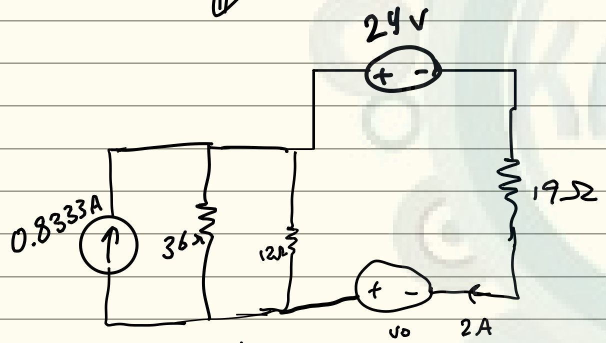
على أساس ال polarity الي حطيتها

$-V-2+32=0$

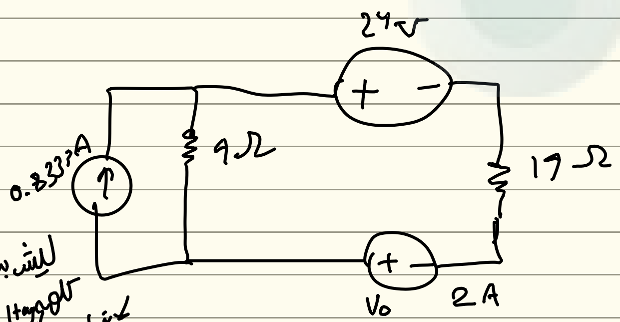
$-V+30=0$

$V=30V$

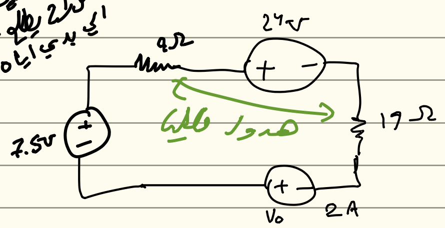




12Ω||36Ω ⇒ 4Ω



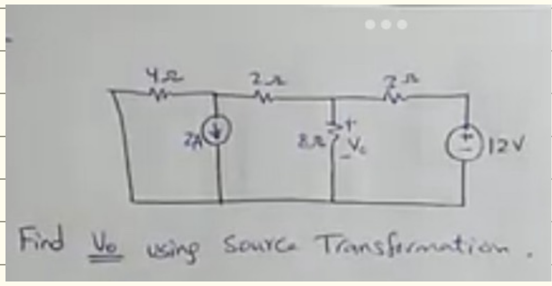
ليش بخليهم voltage؟ لانه بطلع 2 تيار نفس الي بدي اياه

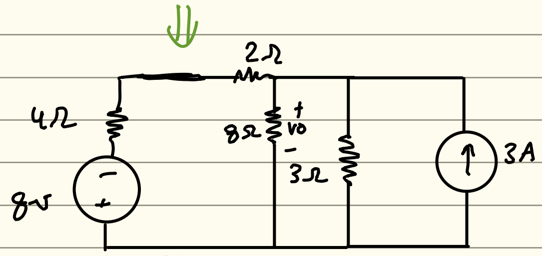


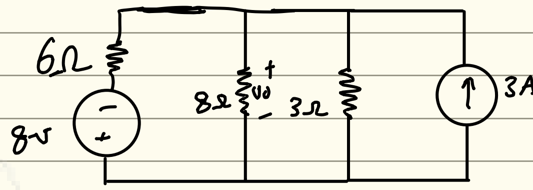
$-7.45+2(4+19)+24-2-V_o=0$

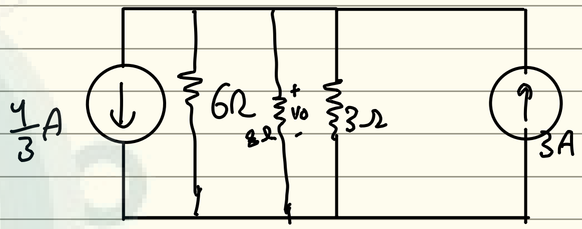
$70.5=V_o$ ⇒

طلعت معي 72.93 Volt

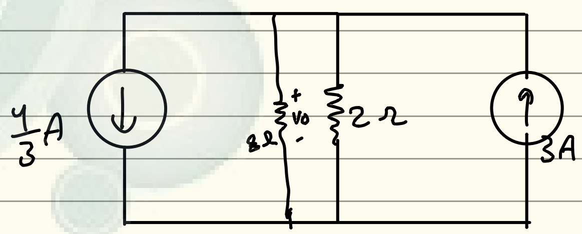




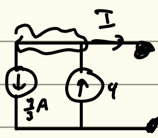




3Ω||6Ω فعلا



now we are having 2 current sources

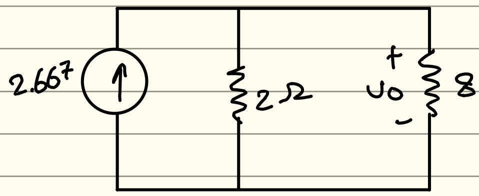


KCL

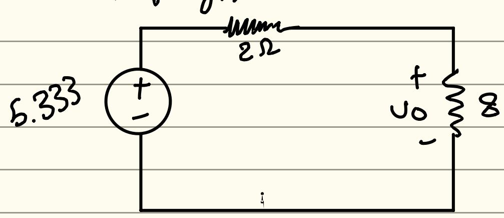
$I+1.33=4$

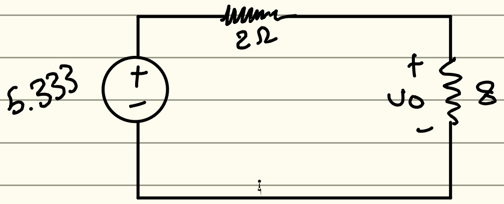
$-1.33 \quad -1.33$

$I=2.6667$



simplify it





now applying kvl

$$-5.333 + 2I_o + 8I_o = 0$$

$$10I_o = 5.333$$

$$I_o = 0.5333A$$

$$V = I_o \times R_o$$

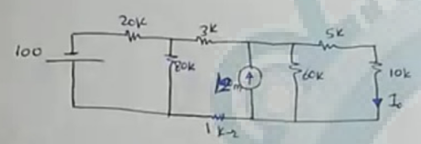
(voice)

$$V_o = 4.266672\ V$$

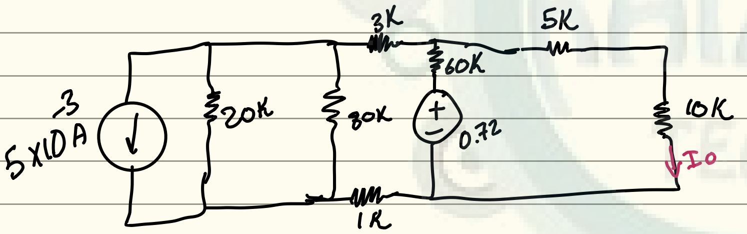
already they have the same polarity so we don't have (-) sign

---

Ex:-

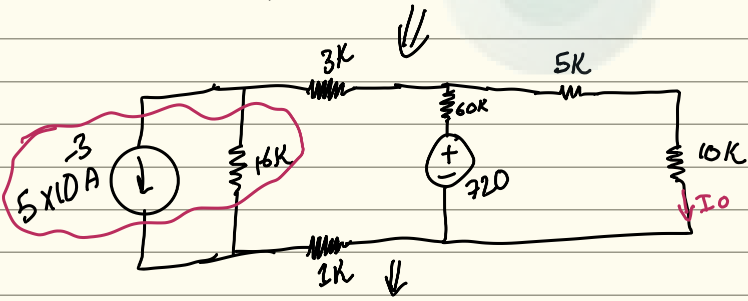


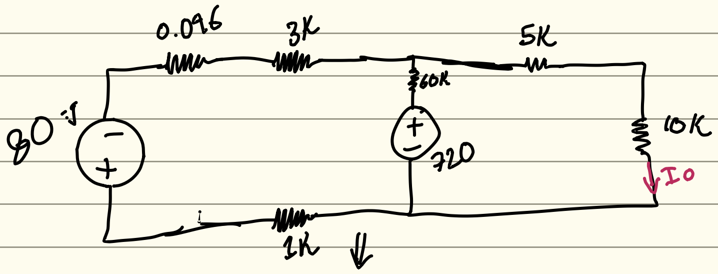
Find I_o using Source Transformation.

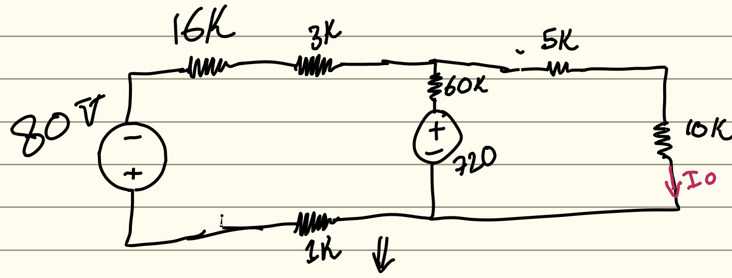


$$20K \parallel 80K$$

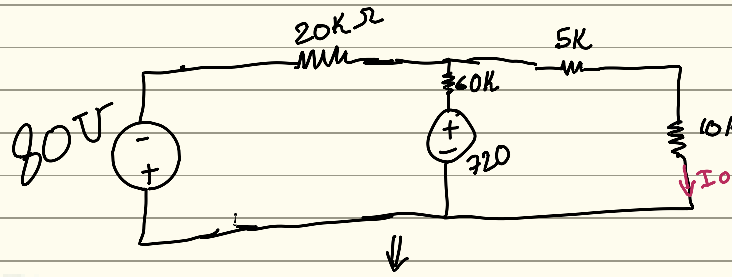
$$= 16K\Omega$$

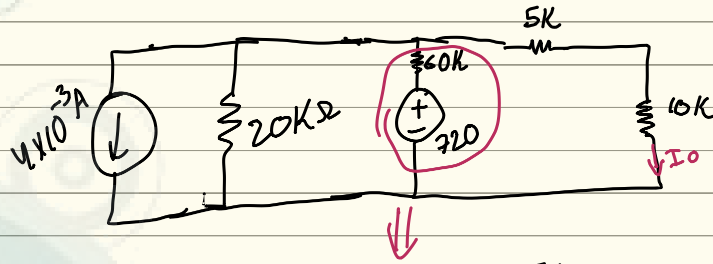


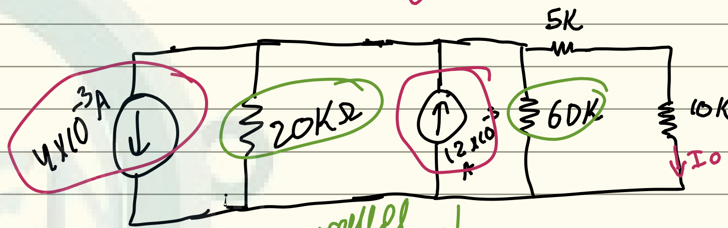




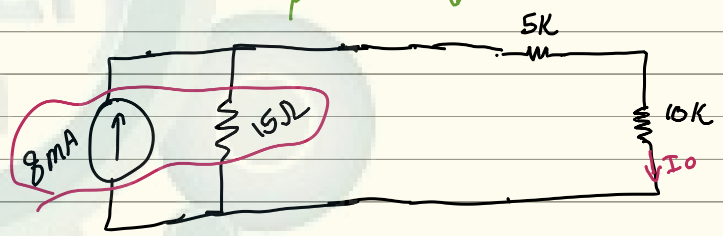
16K & 3K & 1K ⇒ Series



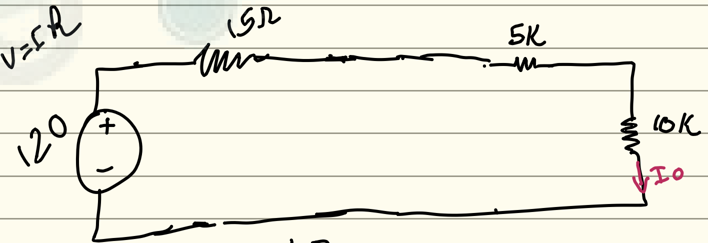


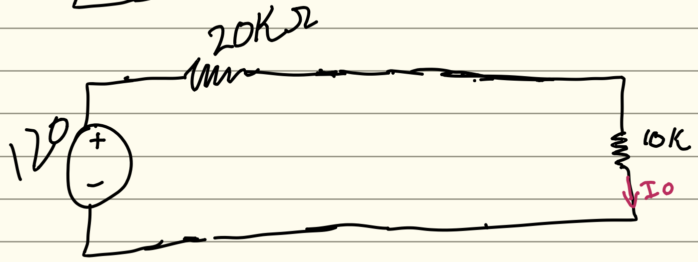


parallel



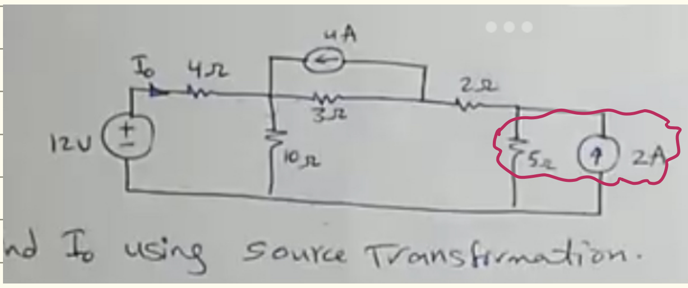
$V = IR$

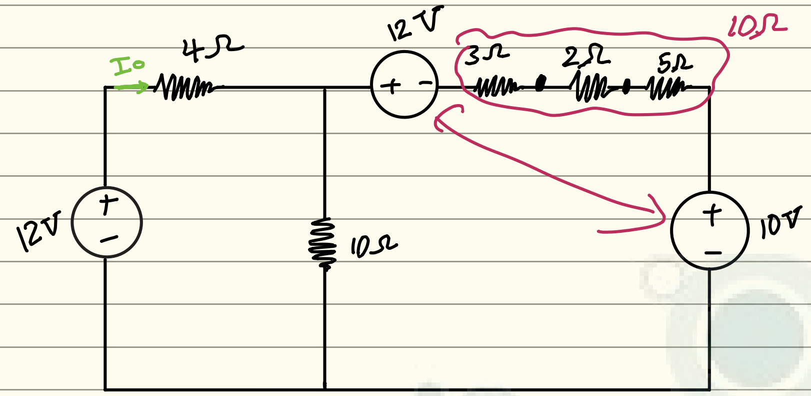


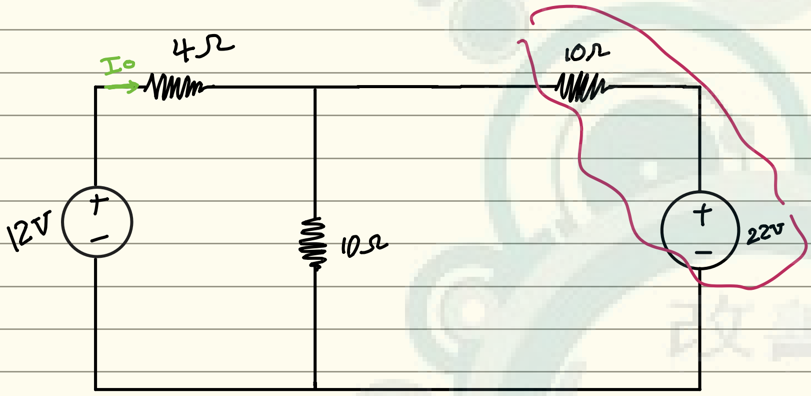


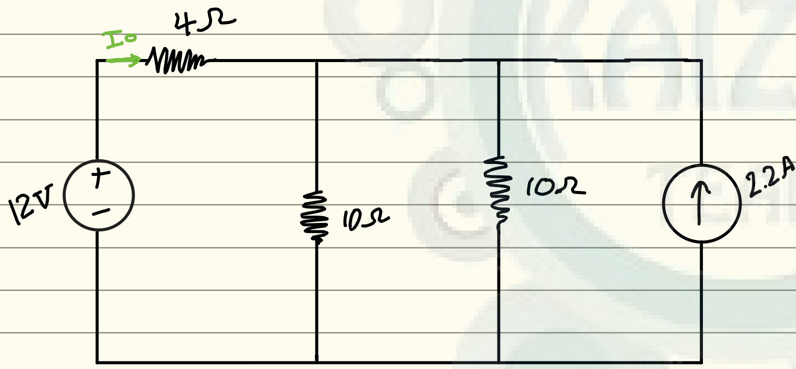
$$-120 + 20\times10^{3} \times I_o + 10 \times I_o = 0$$

$$I_o = 4\times10^{-3} A$$

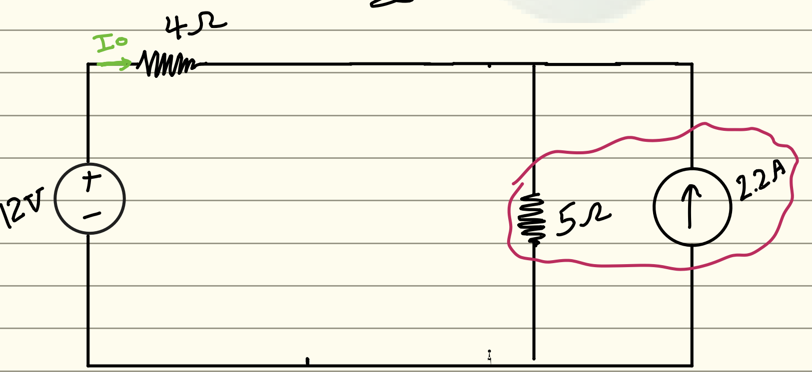


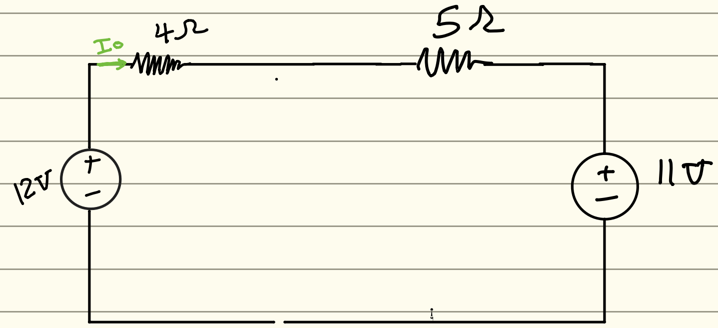






$$10\Omega \parallel 10\Omega = \frac{100}{20} = 5\Omega$$





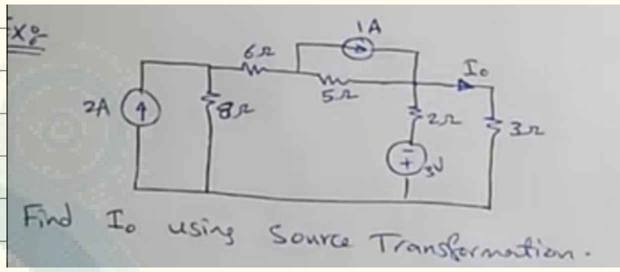
applying KVL

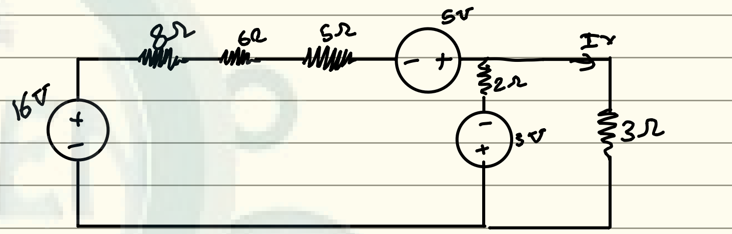
$$-12+4I_o+5I_o+11=0$$

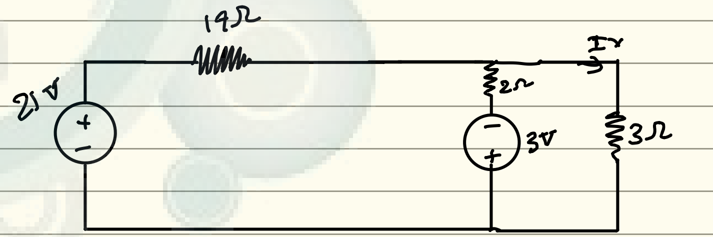
$$-1+9I_o=0$$

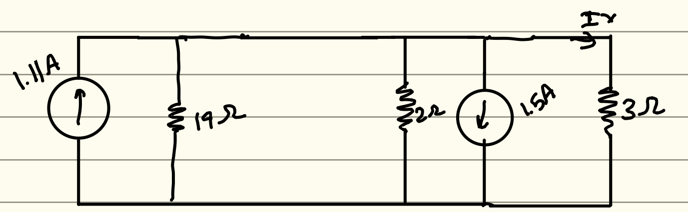
$$I_o=\frac{1}{9}$$

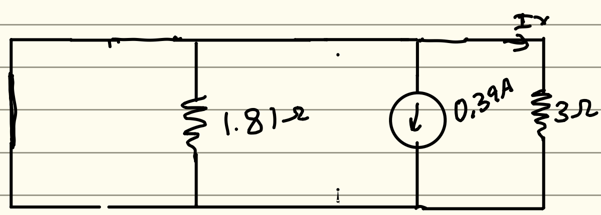
$$I_o=0.1111A$$

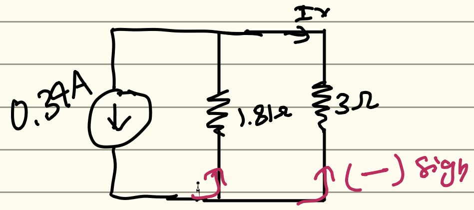












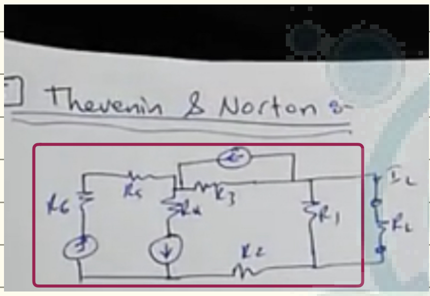
we can use current division

$$I_x = I_s \cdot \frac{\frac{1}{3}}{\frac{1}{3}+\frac{1}{1.81}} = -0.1468\,A$$

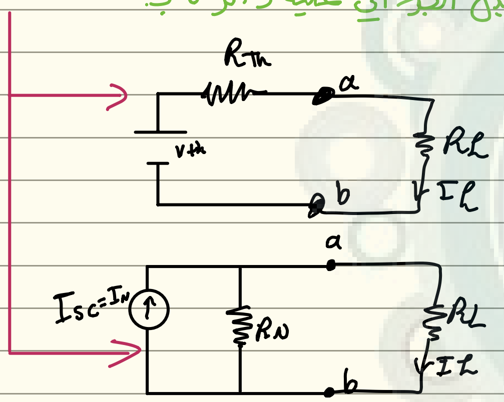
⑤ Thevenin & Norton:-

⇐ بالعربي إذا عندي آشي معقد من مقاومات وأشياء بالدارة وبدي الـ current في مكان معين

Ex:



أصعب أولها فبستبدل الجزء الي عليه دائرة ب:



⇒ Thevenin CKt (KVL)

current division ⇒ Norton CKt

* steps to find ($V_{th} = V_{oc}$)

① Remove R_L

② leave that place open CKt

③ find $V_{oc} = V_{th}$ at that terminals

* steps to find ($I_N = I_{sc}$)

① Remove R_L

② put short CKt in the place of R_L

③ find current in that short CKt (بأي طريقة عادي)

$I_{sc} = I_N$

* Steps to find ($R_{th} = R_N$)

هم نفس الاشي

$$R_{th} = \frac{V_{oc}}{I_{sc}}$$

OC: open CKt

SC: short CKt

or ① Remove R_L

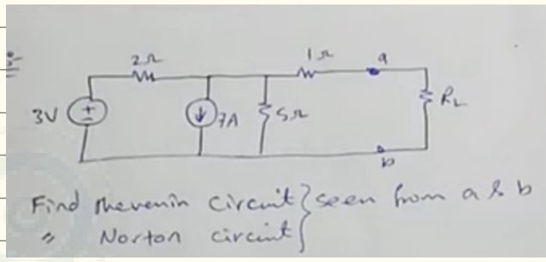
② Kill all CKt → voltage source ⇒ short; → current source ⇒ open

③ find R_{eq} seen at that terminals (place of R_L)

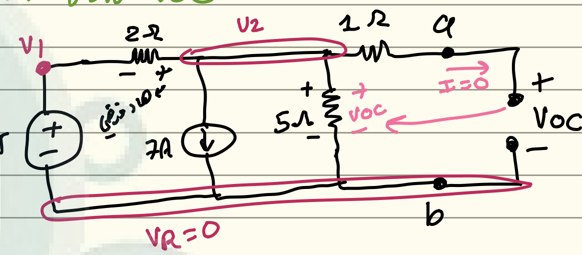
Note:-

$V_{th} = I_N * R_{th}$

$I_{sc} = \frac{V_{th}}{R_{th}}$



* find $V_{th} = V_{oc}$



we will solve it by nodal method

$V_1 = 3V$

at node 2

$$\left(\frac{V_2 - V_1}{2}\right) + 7 + \frac{V_2}{5} = 0$$

$$\frac{V_2}{2} - \frac{3}{2} + 7 + \frac{V_2}{5} = 0$$

$$5.5 + 0.7V_2 = 0$$

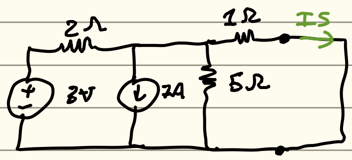
$$V_2 = -7.86\,V$$

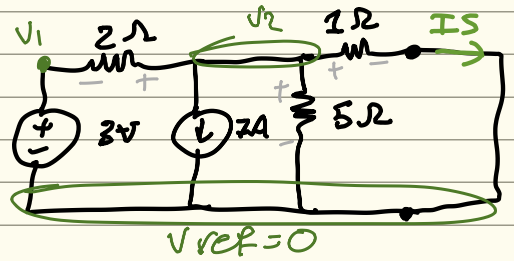
$V_{oc} = V_2$

$V_{oc} = -7.86V$

هيك بنكون أوجدنا V_{th}

* find $I_{sc} = I_N$





$V_1 = 3V$

using nodal method

at V_2

$$\left(\frac{V_2 - V_1}{2}\right) + 7 + V_2 = 0$$

$$\frac{V_2}{2} - \frac{3}{2} + 7 + V_2 = 0$$

$$\frac{3}{2}V_2 + 5.5 = 0$$

$$V_2 = -5.5 \times \frac{2}{3}$$

$$V_2 = -3.6667$$

V for IS = V_2

$$V = IR$$

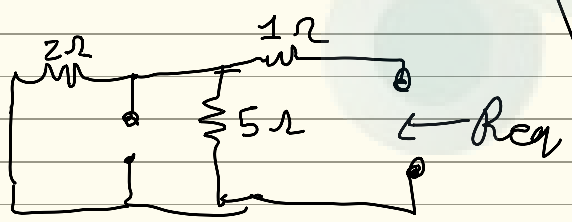
$$-3.667 = I \times 1$$

$$I_{CS} = -3.67A$$

To Find R_{Th}

① $R_{th} = \frac{V_{oc}}{I_{sc}} = \frac{-7.86}{-3.67} = 2.14169\ \Omega$

or ②

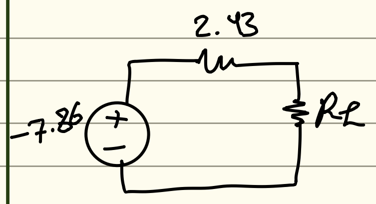


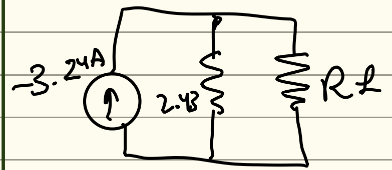
2Ω ∥ 5Ω

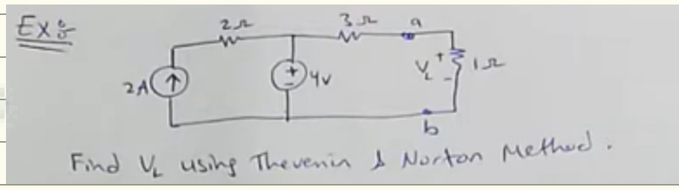
$$\frac{1}{2} + \frac{1}{5} = \frac{5}{10} + \frac{2}{10} = \frac{7}{10}$$ لىه الى فوق اقلبها

$$R_{eq} = \frac{10}{7} = 1.43\ \Omega + 1 = 2.43\ \Omega$$

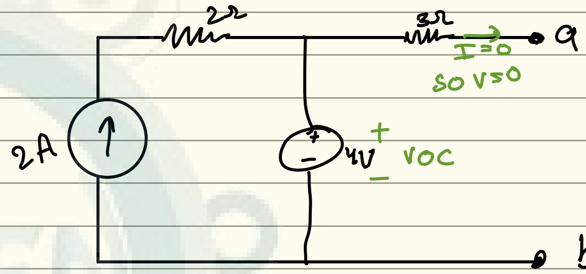
Thevinin Ckt & norton ckt — المطلوب بالسؤال





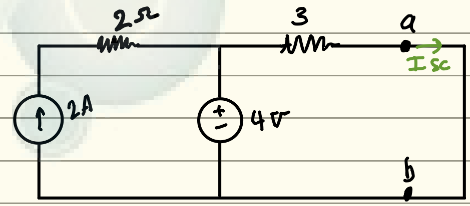


\# Find $V_{th} = V_{OC}$



$V_{oc} = 4V$

\# Find $I_{sc} = I_N$



what is the relation between the right 3Ω & 4V
they are parallel to each other so they have the same voltage

$V_{3\Omega} = 4V$

$V_{sc} = 4V$

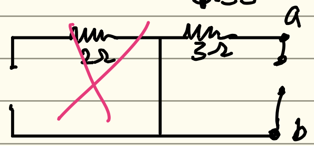
$V = IR$

$$\frac{4}{3} = \frac{I \times 3}{3} \Rightarrow I_{sc} = \frac{4}{3}A = 1.33A$$

$$R_{th} = \frac{V_{oc}}{I_{sc}} = \frac{4}{1.33} = 3\ \Omega$$

or

2Ω cancelled by open ckt

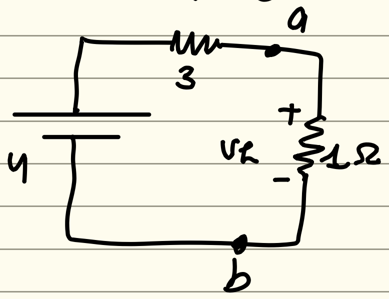


$R_{eq} = 3\Omega$

$R_{th} = 3\Omega$

هو ير و Vo

Thevenin ckt



$-4 + 3 \times I + 1 \times I = 0$

$-4 + 4I = 0$

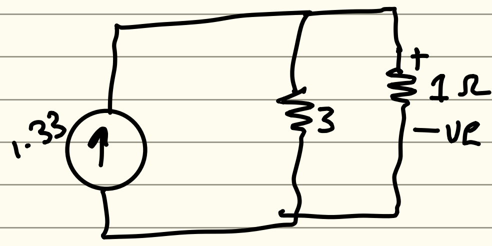
$I = 1A$

$V = IR$

$V = 1 \times 1 = 1V$

or voltage division

Norton ckt



by c.d

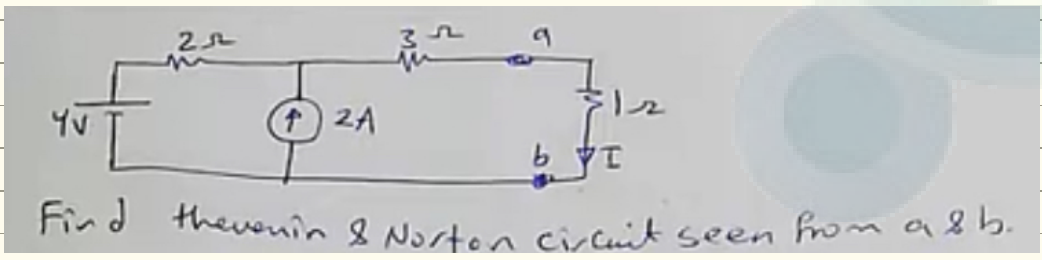
$I = \dfrac{1.33 \times \frac{1}{3}}{\frac{1}{3} + \frac{1}{1}} = 1$

$V = IR$

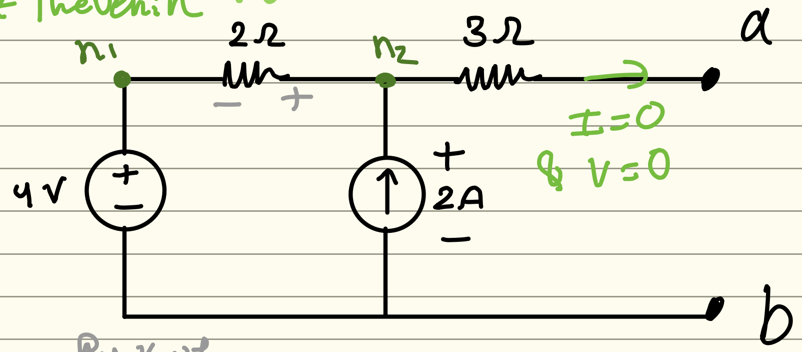
$V = 1 \times 1$

$V = 1\ V$

Ex:-



* Thevenin Vth



By KVL

$-2 \times R + 2 \times 2 + 4 = 0$

$-2 \times R + 4 + 4 = 0$

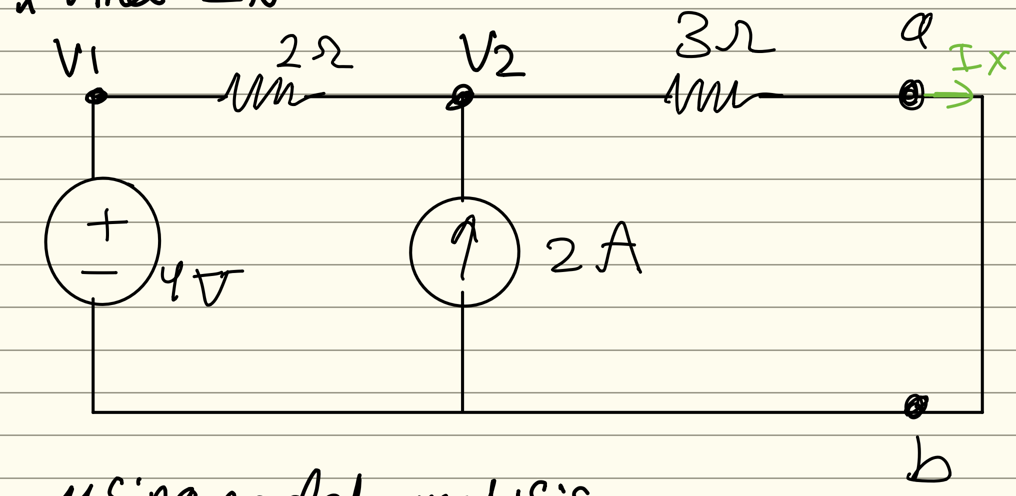
$-2R + 8 = 0$

$\dfrac{2R}{2} = \dfrac{8}{2}$

$R = 4Ω \Rightarrow$ $V = IR$, $V = 4 \times 2$, $\boxed{V = 8V}$

$\boxed{V_{oc} = 8V}$

* Find I_N



using nodal analysis

$V_1 = 4V$

For n_2

$\left(\dfrac{V_1 - V_2}{2}\right) + 2 = \dfrac{V_2}{3}$

$2 - \dfrac{V_2}{2} + 2 = \dfrac{V_2}{3}$

$4 = \dfrac{2V_2}{6} + \dfrac{3V_2}{6}$

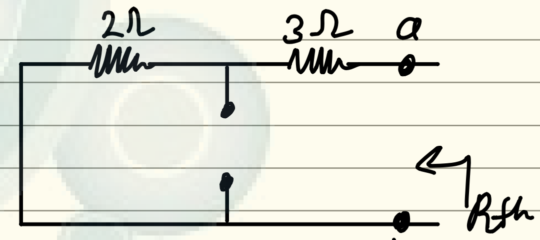
$\dfrac{6}{5} \times 4 = \dfrac{5V_2}{6} \times \dfrac{6}{5} \Rightarrow V_2 = 4.8\ V$

$I_x = \dfrac{V_2 - 0}{3} = \dfrac{4.8}{3} = 1.6\ A$

* find R_{th}

$R_{th} = \dfrac{V_{oc}}{I_{sc}} = \dfrac{8}{1.6} = 5Ω$

or

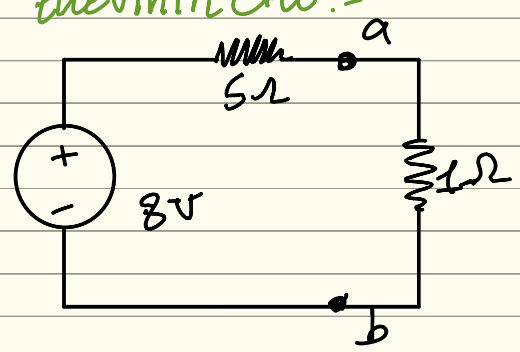


$2Ω + 3Ω$

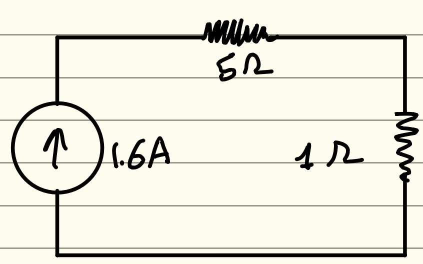
$R_{th} = 5Ω$

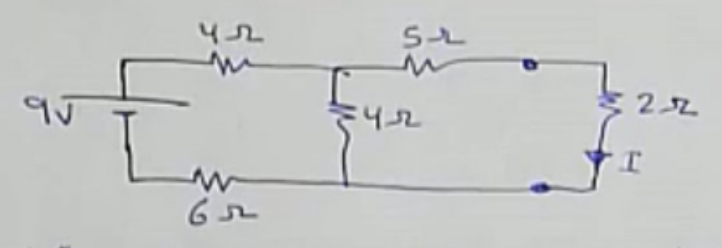
So

thevinin ckt:-



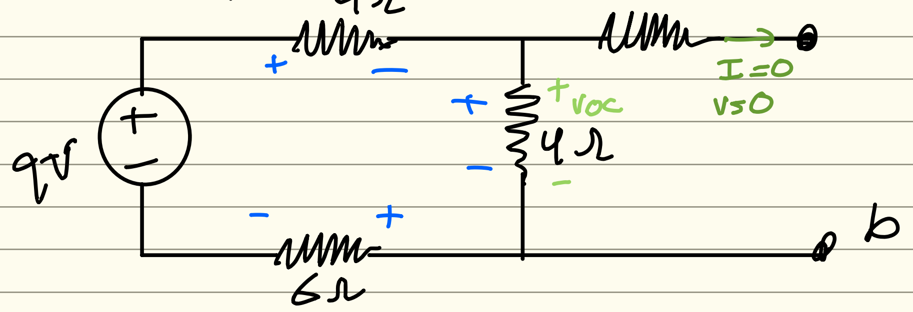
norton ckt





using Thevenin & Norton method Find I

* Find V_{th}



$-9 + 4I + 4I + 6I = 0$

$-9 + 14I = 0$

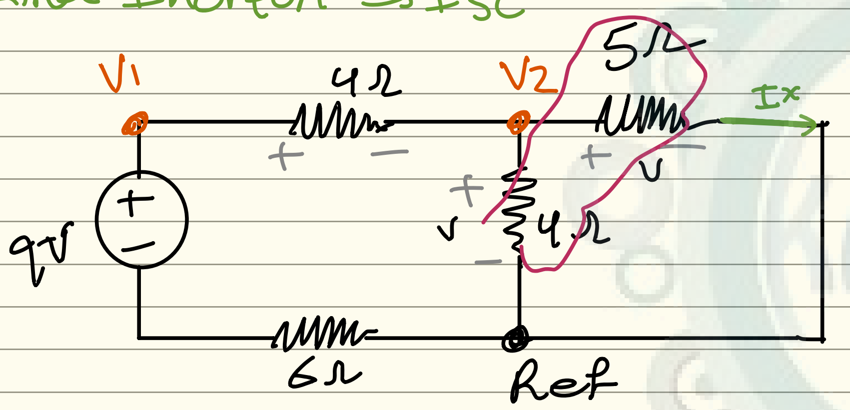
$\frac{14I}{14} = \frac{9}{14} \Rightarrow \boxed{I = 0.643A}$

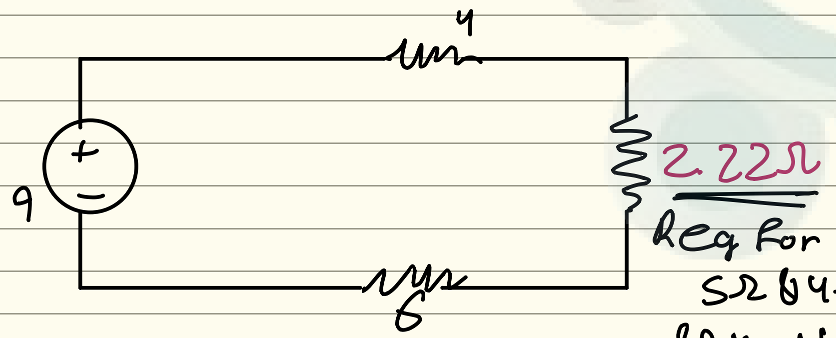
$V = IR$

$V = 0.643 \times 4$

$\boxed{V = 2.57\,V}$

* Find $I_{norton} \Rightarrow I_{sc}$





Req for 5Ω & 4Ω b/c they have the same voltage

By voltage devision

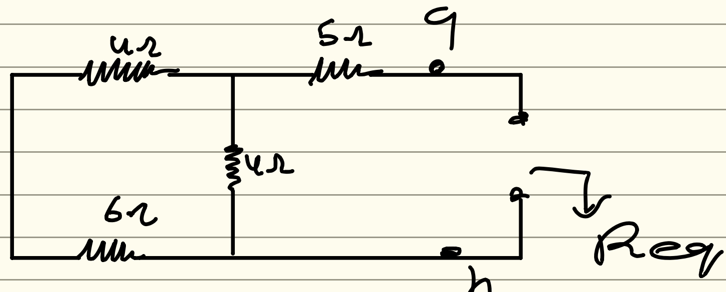
$V = \frac{9 \times 2.22}{4 + 6 + 2.22} = 1.635\,V$

$I_N = \frac{V}{R} = \frac{1.635}{5} = 0.33$

to find R_{th}

$R_{th} = \frac{V_{OC}}{I_{SC}} = 7.86$

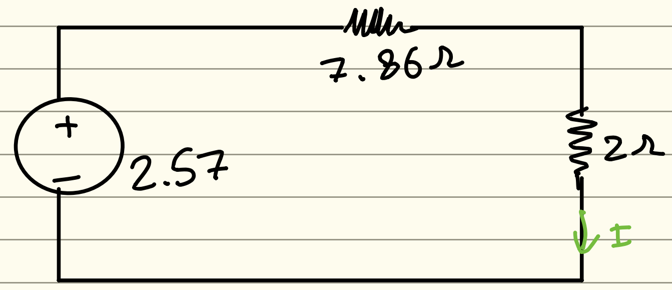
or



$4 + 6 = 10\,\Omega \parallel 4 = 2.85714 + 5 =$
$= 7.86\,\Omega$

* now how to find I?

يحطوا بوحدة من الشكلين النهائيات
ويحسب ال I

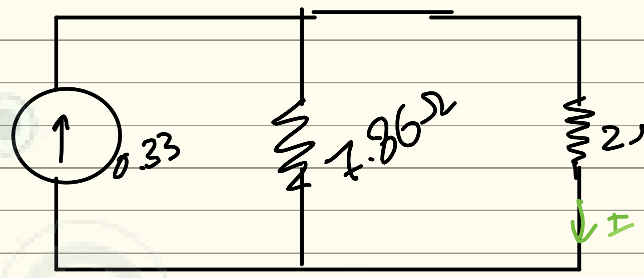


$-2.57 + 7.86I + 2 \times I = 0$

$-2.57 + \frac{69}{7} I = 0$

$\frac{7}{69} \times \frac{69}{7} I = 2.57 \times \frac{7}{69}$

$\boxed{I = 0.261\,A}$

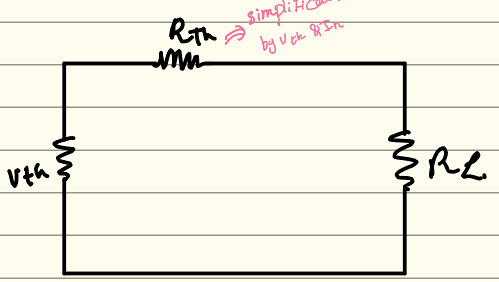


using c.d

$I = 0.33 \times \frac{\frac{1}{2}}{\frac{1}{2} + \frac{1}{7.86}} = 0.24A$

{Maximum power transfer}

* we concern about power consumption by load after simplification of the ck



Maximum power supply إحنا مهتمين كم قيمة ال (RL) الي بدي أوصلها بحيث توفر ال

$P_{load} = I^2 R_L$ ----(1)

$I = \frac{V_{th}}{R_{th} + R_L}$ ----(2)

put (2) in (1)

$P_L = \left(\frac{V_{th}}{R_{th}+R_L}\right)^2 * R_L$ ....(3)

for max P_L

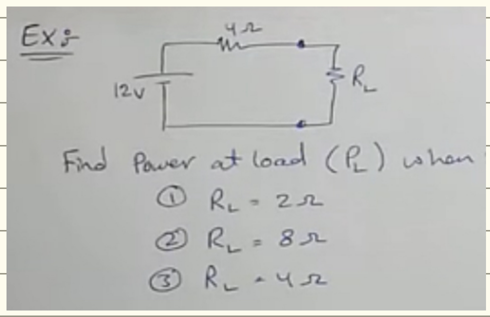
$\frac{dP_L}{dR_L} = 0$

Result $\boxed{R_L = R_{th}}$

for any ckt to get max power at the load $\Rightarrow \boxed{R_L = R_{th}}$ (4)

put (4) in (3)

$$\boxed{P_{L\,max} = \frac{(V_{th})^2}{4R_{th}} = \frac{I_N^2 R_L}{4}}$$



① when $R_L = 2\Omega$

$V_L = \frac{12 \times 2}{6} = 4\,volt$ $\quad P_L = \frac{V^2}{R} = \frac{16}{2} = 8\,watt$

② when $R_L = 8\Omega$

$V_L = \frac{12 \times 8}{12} = 8V$ $\quad P_L = \frac{V^2}{R} = \frac{64}{8} = 8\,watt$

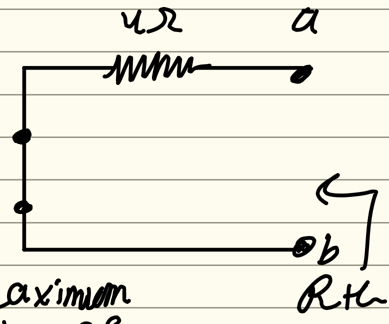
③ when $R_L = 4\Omega$

$V_L = \frac{2 \times 4}{8} = 6V$ $\quad P_L = \frac{36}{4} = 9\,watt.$

max P

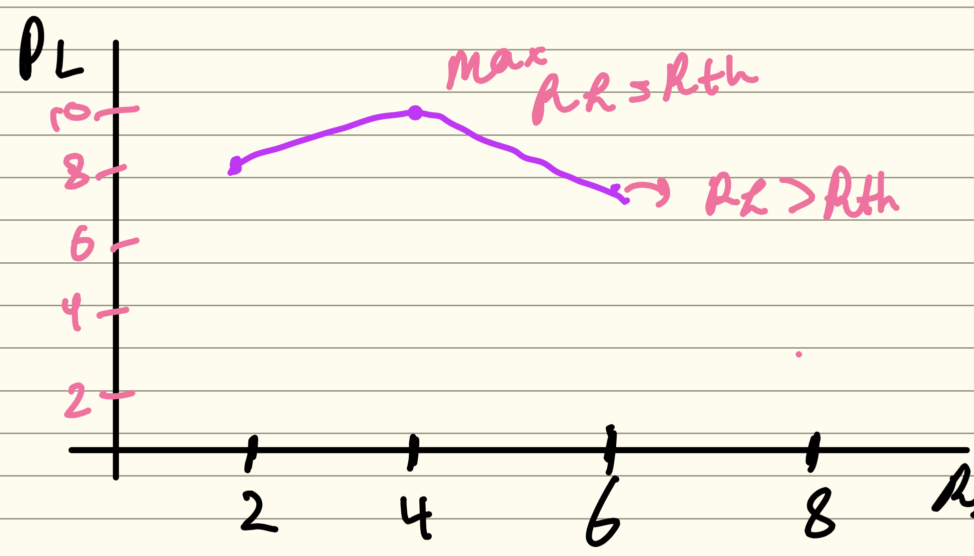
* refer to ckt ⇒ find R_{th}

$R_{th} = 4\Omega$

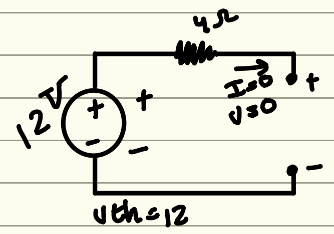


when the $R_L = R_{th} = 4\Omega$ was the maximum power transfer

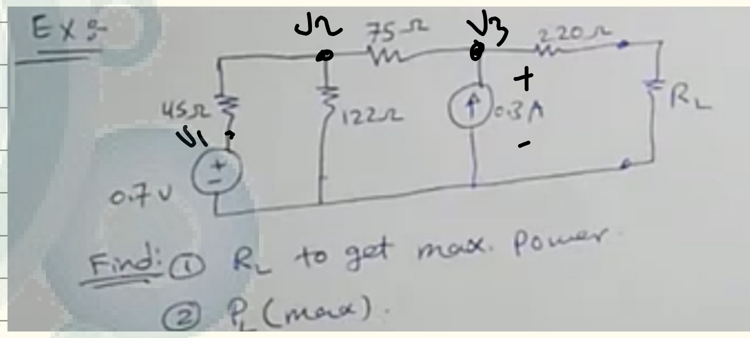
when we upgrade it the power it minimize



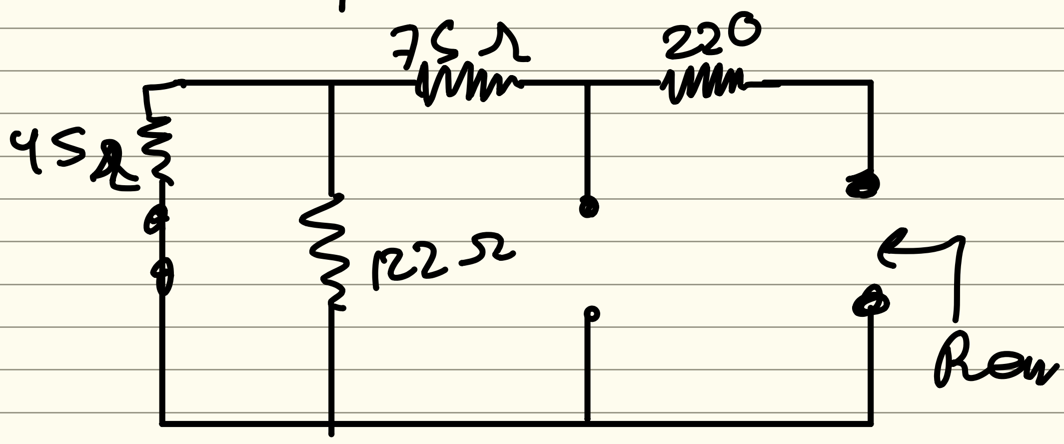
$P_{max} \Rightarrow$ when $R_L = R_{th}$



$$P_{L\,(max)} = \frac{(V_{th})^2}{4R_{th}} = \frac{(12)^2}{4 \times 4} = \frac{144}{16} = 9\,watt$$



⇒ for max power ⇒ $R_L = R_{th}$



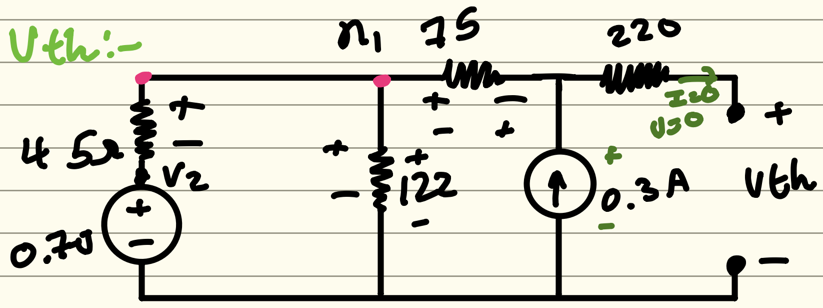
$R_{eq} = 327.9\Omega$

for max power transfer

$\boxed{R_L = 327.9\Omega}$

$P_{L\,max} = \frac{(V_{th})^2}{4R_{th}}$

To find V_{th}:-



$$\boxed{V_2 = 0.7\,V}$$

$$\Sigma I_{in} = \Sigma I_{out}$$

$$0.3 = \frac{V_1 - 0.7}{45} + \frac{V_1}{122}$$

$$V_1 = 10.45$$

By KVL   [illegible]

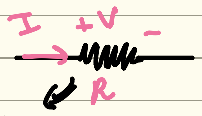
$$-10.45 + 75(0.3) + V_{th}$$

$$V_{th} = 32.45\,V$$

$$P_{L(max)} = 0.842\ \text{watt}$$

{chapter 6}

*AC - Network analysis:-



$\Rightarrow V = IR$

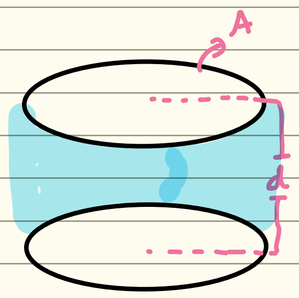
$P = I^2 R$

*we will talk about energy storage elements
- Capacitor
- inductor

1 Capacitor

→ device (element) store energy

→ consists of two parellel plates each plate has cross sectional area (A) & have distance (d) between them



the separation filled with dieelectric material has certain permitivity (ϵ)

$$\boxed{C = \frac{\epsilon A}{d}}$$

→ unit of the Capacitance → Farad (F)

→ Symbol in electric ckt ─┤├─

→ charge on plates of capacitor

الـ V للـ Capacitor مش الـ supply

$\boxed{Q = CV}$ ⇒ fixed voltage ⇒ fixed charge

$q(t) = C\,v(t)$ ⇒ variable voltage ⇒ variable charge

⇒ $i(t) = \frac{d\,q(t)}{dt}$ ⇒ $i_c(t) = C\frac{dv_c(t)}{dt}$

⇒ $V_c(t) = \left[\frac{1}{C}\int_{t_0}^{t} i_c(\tau)\,d\tau\right] + v_c(t_0)$ ↳ inetial condition

⇒ $i_c(t) = C\cdot\frac{dV_c(t)}{dt}$

if $V_c(t)$ = DC value - fixed

so $i_c(t) = 0$.

↳ means that capacitor act like open ckt in DC - ckt ⇒ Also

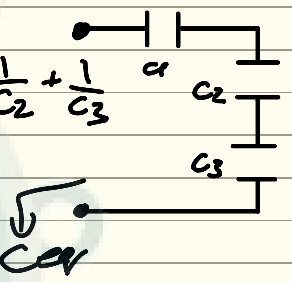
هاد معناها إنو الـ Capacitor بال DC ckt بتكون زي الـ open ما بمر فيه تيار

⇒ Energy stored in capacitor

$$E = \frac{1}{2}CV^2 = \frac{1}{2}QV = \frac{1}{2}\frac{Q^2}{C} \Rightarrow \text{unit joul}$$

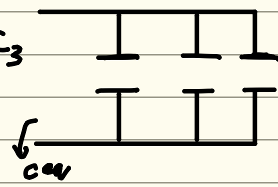
in series

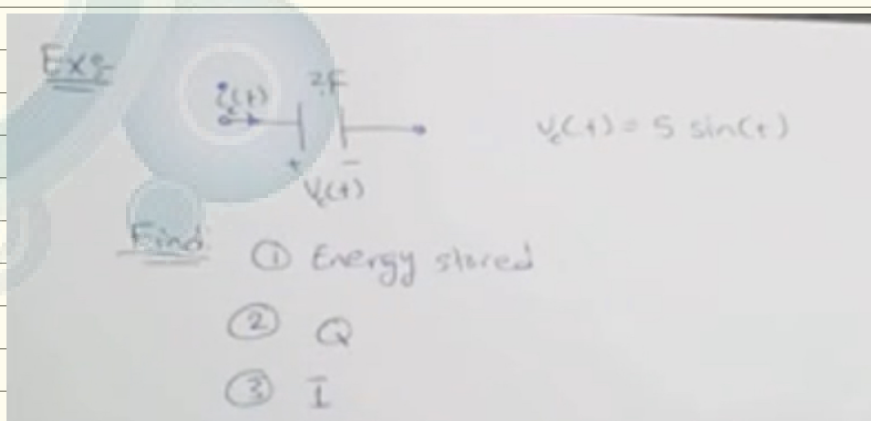
$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$$



in parallel

$$C_{eq} = C_1 + C_2 + C_3$$





① energy stored

$$E = \frac{1}{2}CV^2$$

$$E = \frac{1}{2}(2) \times (5\sin t)^2$$

$$\boxed{E = 25\sin^2 t}\ \text{Joul}$$

② Q

$$Q = C \times V$$

$$= 2 \times (5\sin t)$$

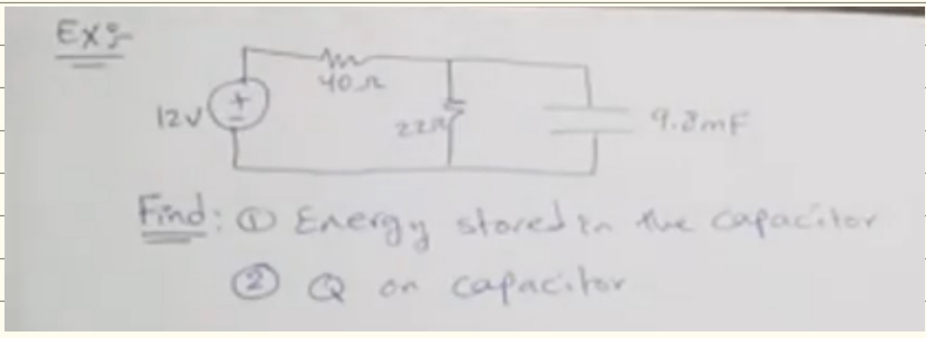
$$= 10\sin t\ \text{coloumb}$$

③ I

$$i_c(t) = C\frac{dV(t)}{dt}$$

$$i_c(t) = 2 \times 5\cos t$$

$$\boxed{i(t) = 10\cos t}\ A$$

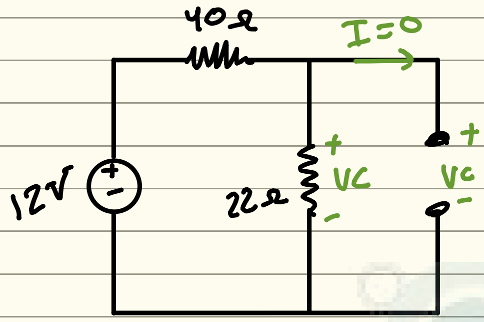


first of all I notice that this supply is DC supply so
capacitor act like open CKt.

IN DC-CKt, the capacitor act like open CKt $I_c = 0$

① $E = \frac{1}{2} C U^2$

now finding v



$-12 + 40I + 22I = 0$

$-12 + 62I = 0$

$62I = 12$

$I = 0.19A$

$V = IR$
$V = 0.19 \times 22$

$V = 4.258\,v$

so $E = \frac{1}{2} C v^2$

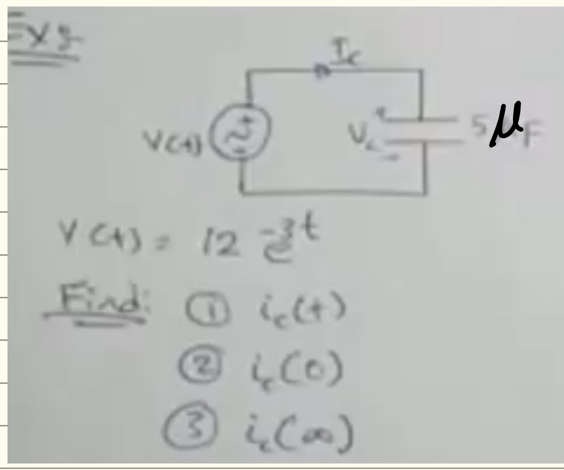
$= \frac{1}{2} \times 9.8 \times 10^{-9} \times (4.26)^2$

$E = 88.92\,mJoul$

now finding Q

$Q = C \times V$

$= 4.8 \times 10^{-3} \times 4.26 = 0.042$ coloumb



voice.

$v(t) = 12 e^{-3t}$

find:-

① $ic(t)$

② $ic(0)$

③ $ic(\infty)$

$Vc(t) = v(t) = 12 e^{-3t}$ (parallel)

$iC(t) = C \times \frac{dv}{dt}$

$= 5 \times 10^{-6} \times -36 e^{-3t}$

$= -180 \times 10^{-6} e^{-3t}$

$= -180 e^{-3t}\ \mu A$

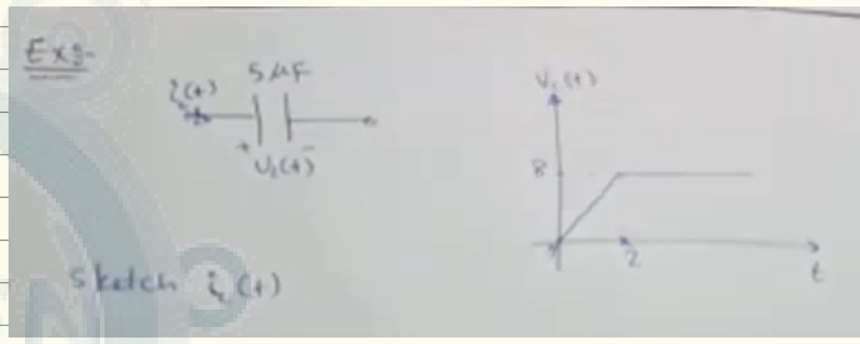
② $ic(0) = -180\,\mu A$

$\boxed{e^{-\infty} = 0}$

$e^{\infty} = \infty$

③ $ic(\infty) = (-180 e^{-\infty})\,\mu A$

$ic(\infty) = 0A$



$ic(t) = C \frac{dv(t)}{dt}$

① for $0 \le t \le 2$

$Vct = 4t$

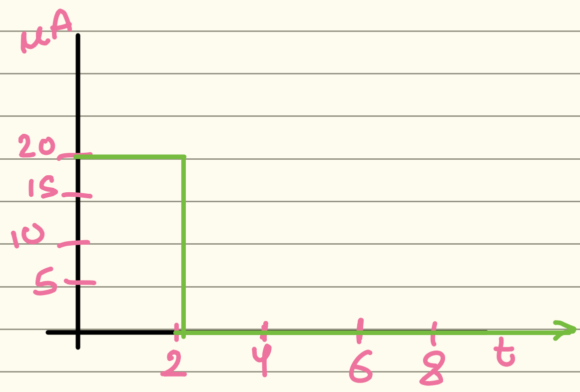
$i c(t) = 5 \times 10^{-6} \times 4t = (20 \times 10^{-6} t)$ A

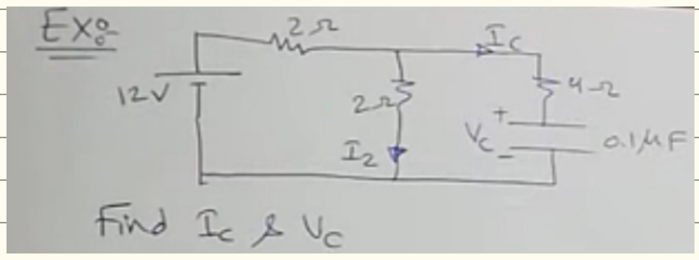
② for $2 \le t < \infty$

$Vc = 8v$

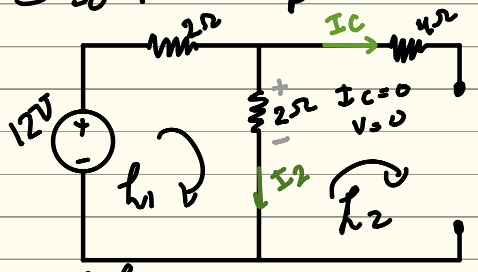
$ic_t = 5 \times 10^{-6} \times 0 = 0$ A

sketch





DC so the capacitor act like open ckt



By KVL l_1

$-12 + I_2 \times 2 + 2 I_2 = 0$

$-12 + 4I_2 = 0$

$\frac{4I_2}{4} = \frac{12}{4} \Rightarrow I_2 = 3A$

$V = IR$
$= 3 \times 2 = 6V$

$V_c = 6V$ & $I_c = 0$

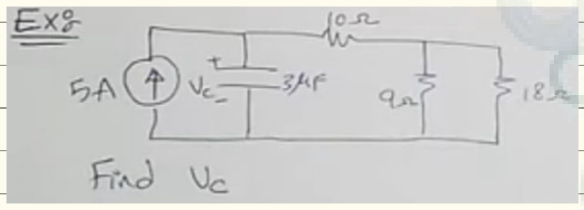
By KVL l_2

$-V + V_C = 0$

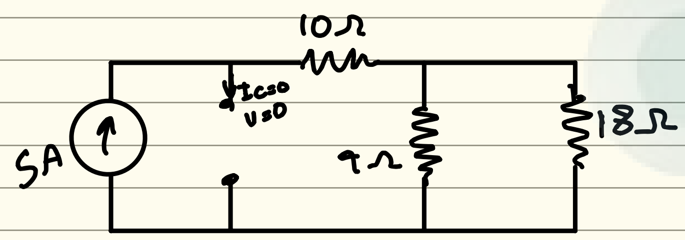
$-6 + V_C = 0$

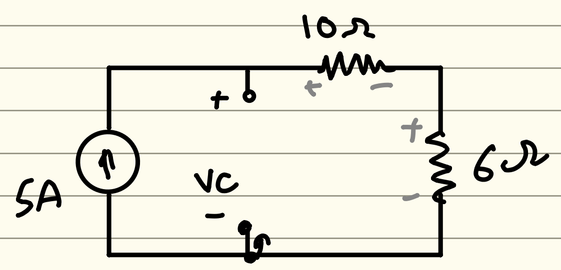
$V_C = 6$

اي هو نفس اي غرفة



DC supply so capaciter will act like open ckt





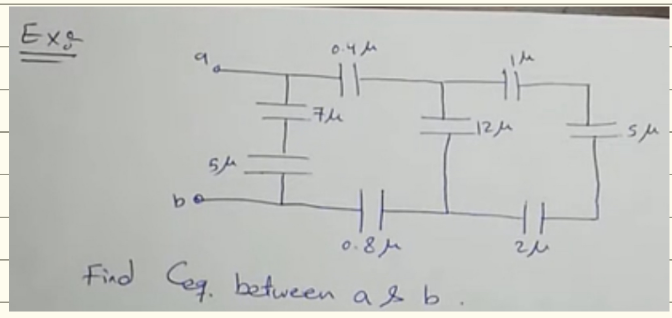
Starting KVL from ↑

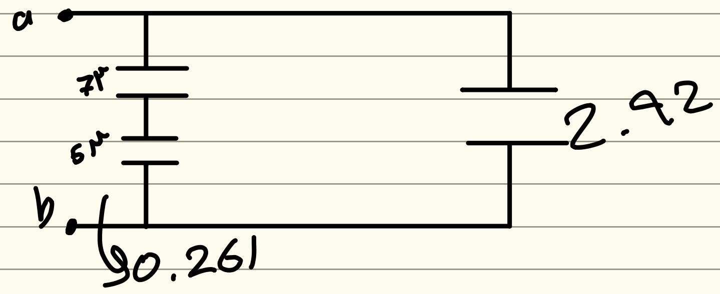
$-V_C + 10 \times 5 + 6 \times 5 = 0$

$-V_C + 50 + 30 = 0$

$-V_C + 80 = 0$

$\boxed{V_C = 80}\ V$





$C_{eq} = 2.92 + 0.261 = 3.18 \mu F$

4 inductor

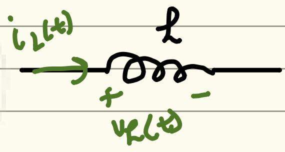
⇒ Store energy ملفوفة

⇒ made of winding coil of wire around a core

core: could be insulator or ferroumagnatic materiel

$\mu \to$ permability

⇒ Symbole



⇒ unit: Henry ⇒ H, mH, μH

$$V_L(t) = L \cdot \frac{di_L(t)}{dt}$$

$$i_L(t) = \left[\frac{1}{L}\int_{t_0}^{t} V_L(\tau)\,d\tau\right] + i_L(t_0)$$

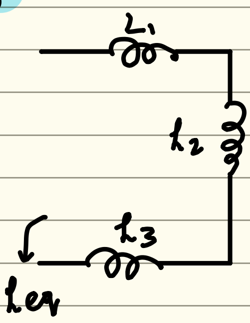
⇒ Energy stored :-

$E = \frac{1}{2} L I^2$ Joul

⇒ In DC-ckt, the inductor act like short ckt $V_L = 0$

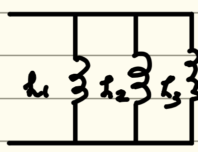
in series

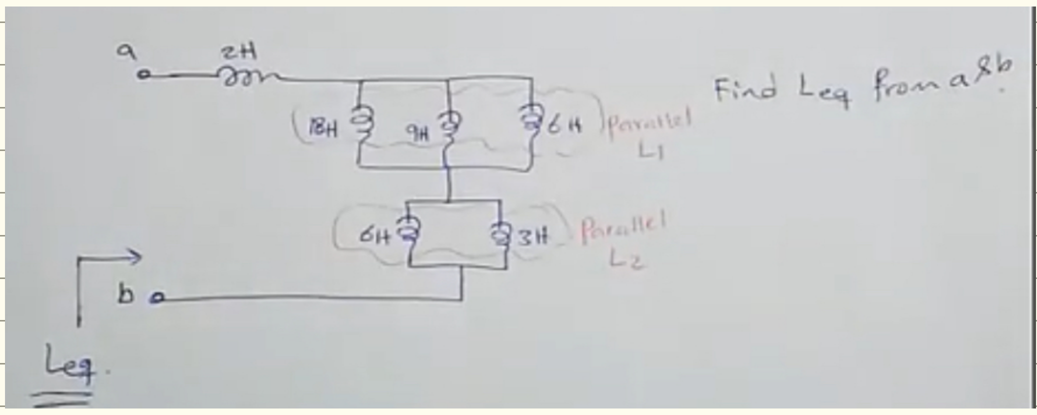
$L_{eq} = L_1 + L_2 + L_3$



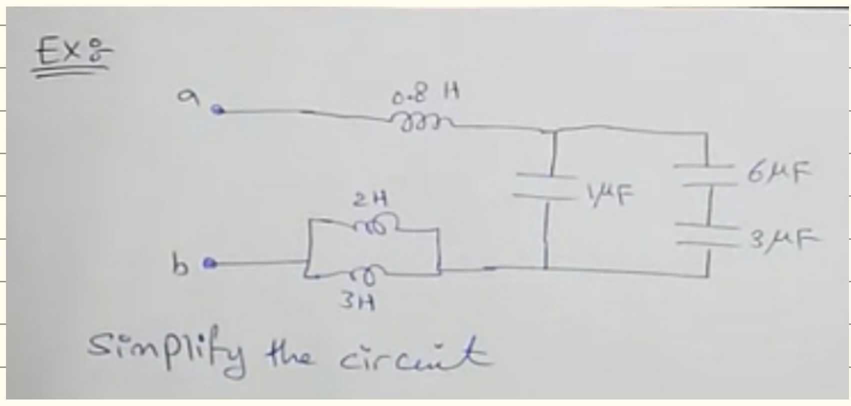
in parallel

$L_{eq} = \frac{1}{L_1} + \frac{1}{L_2} + \frac{1}{L_3}$

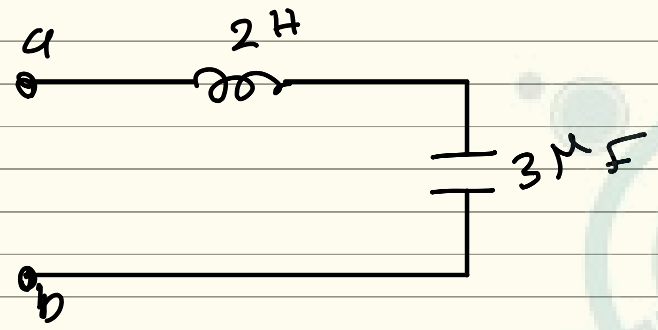


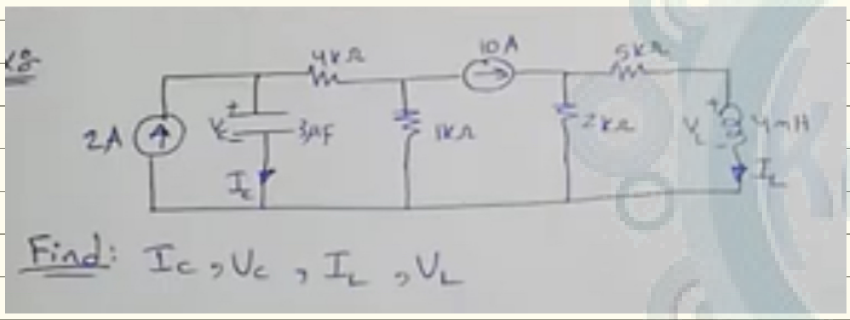


$L_{eq} = 7\ H$



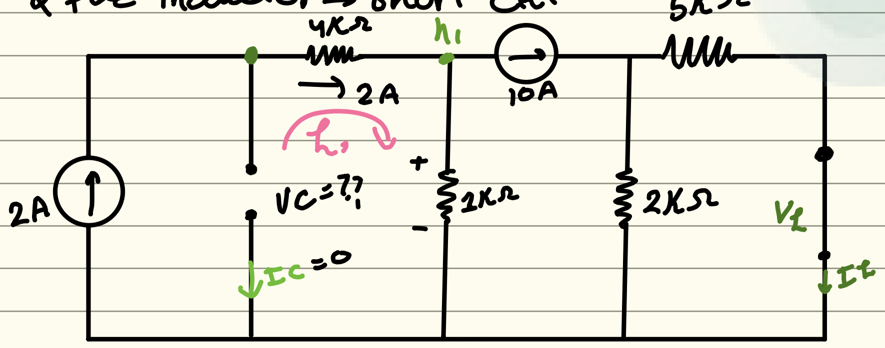
simple ckt





DC supply ⇒ DC-ckt the capacitor will acts as open ckt

& the inductor ⇒ short ckt



now we have $I_C = 0$ & $V_L = 0$

applying KCL for n_1

$2 = I_{1k\Omega} + 10$

$I_{1k\Omega} = -8A$

applying KVL for loop 1

$-V_C + 8 \times 10^3 + 1 \times -8 \times 10^3 = 0$

$-V_C = 0$ $\boxed{V_C = 0}$ $I_C = 0$ لأنه open ckt

now finding I_L

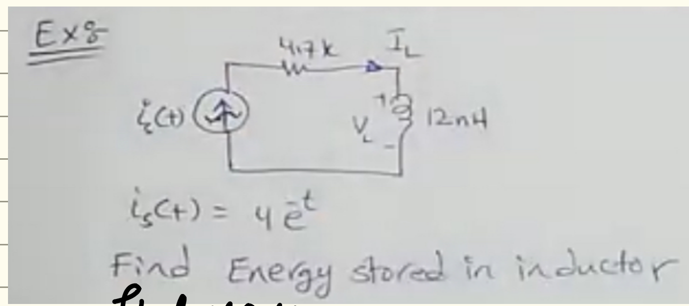
فعليا هون عندي current source بوزع عهم، ومبين

parallel فبنستخدم ال current devision

the same rule

$$I_{5k\Omega} = \frac{10 \times \left(\frac{1}{5}\right)10^3}{\left(\frac{1}{2} \times \frac{1}{5}\right) \times 10^3} = \frac{20}{7} = 2.857\ A$$

$V_L = 0 \Rightarrow$ because its short ckt



Find $V_L(t)$

$E = \frac{1}{2} L I_L^2$

$E = \frac{1}{2} * 12 \times 10^{-9} * (4e^{-t})^2$

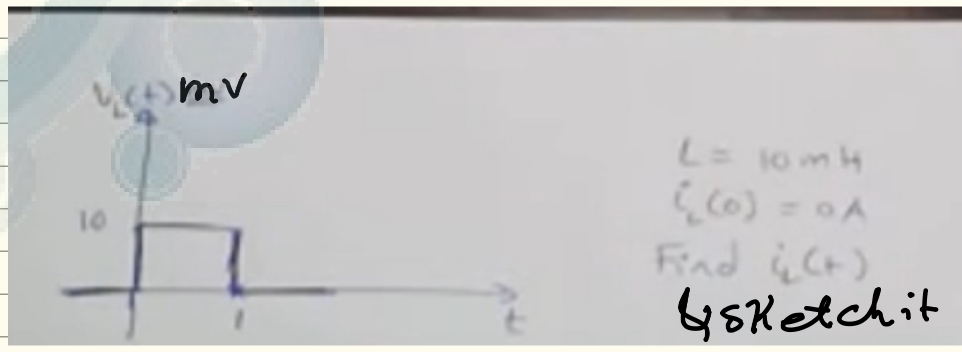
$E = 96 \times 10^{-9}\ e^{-2t}$

$\boxed{E = 96 e^{-2t}\ nJ}$

$V_L(t) = L * \frac{di(t)}{dt}$

$V_L(t) = 12 \times 10^{-9} * -4e^{-t}$

$V_{Lt} = -48 e^{-t}\ nV$



$$i_L(t) = \left(\frac{1}{L}\int_{t_0}^{t} v_L(\tau)d\tau\right) + i_L(t_0)$$

for $t < 0$

$V = 0 \Rightarrow i_L(t) = 0$

for $0 < t < 1$, $i_L(0) = 0$

$V_L(t) = 10mV$

$$i_L(t) = \left\{\frac{1}{10 \times 10^{-3}} \int_0^t (10m)d\tau\right\} + 0$$

$i_L(t) = \frac{1}{10 \times 10^{-3}} \times \cancel{10} \times 10^{-3}\ t + 0$

$i_L(t) = t$

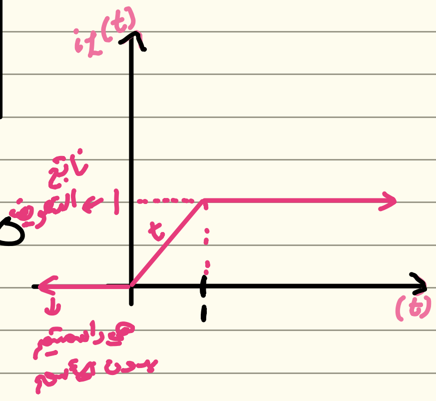
for $t > 1$

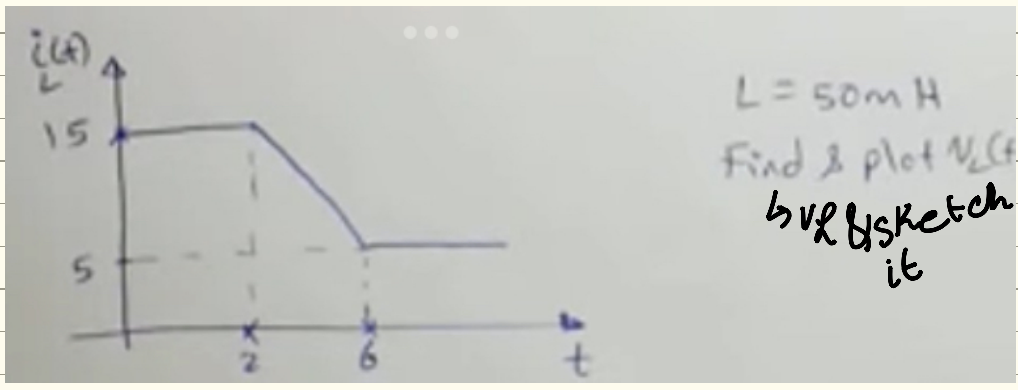
$V_L(t) = 0$

$i_L(t) = \frac{1}{L}\int V_L t + i(1)$

عوضنا بالتكامل

$i_L(t) = 0 + 1 = 1\ A$





$V_L(t) = L * \frac{d\,i(t)}{dt}$

$= 50\times10^{-3} * 0 = 0$

starting from finding the slope

$\text{slope} = \frac{15-5}{2-6} = -\frac{10}{4}$

$y - 5 = -2.5\,(x-6)$

$y = -2.5x + 15 + 5$

$\boxed{y = -2.5x + 20}$

so $V_L(t) = \frac{d\,i(t)}{dt} * L$

$V_L(t) = (-2.5) * 50\times10^{-3}$

$V_L(t) = -0.125$

هو ن مانيزير

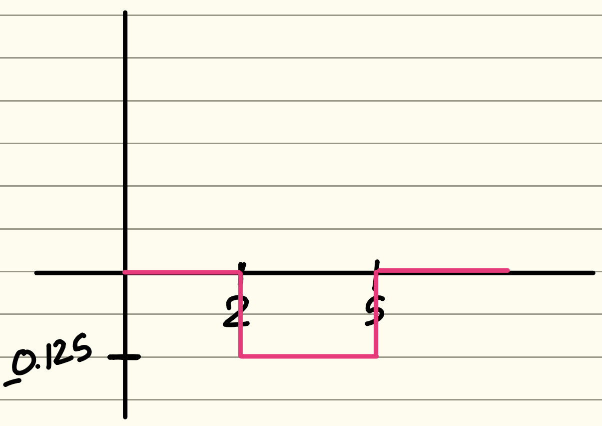
inetial condition))

for $t \geq 6$ ⟹ بس بالتالي

$i(t) = 5$

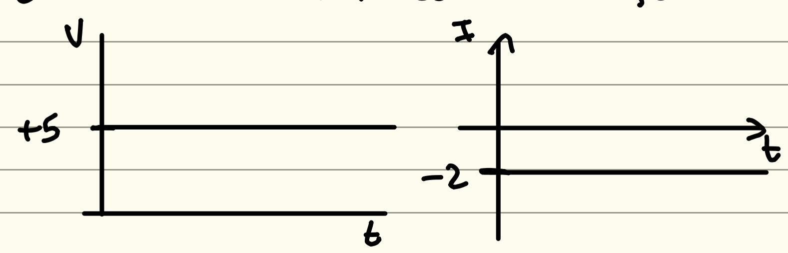
$V_L(t) = 0$

the sketch



Time Dependent signal sources

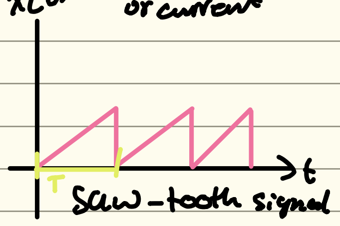
Dc-sources ⟹ fixed value & direction

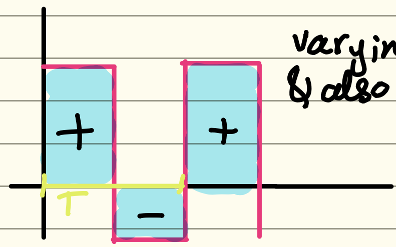


Ac-Sources

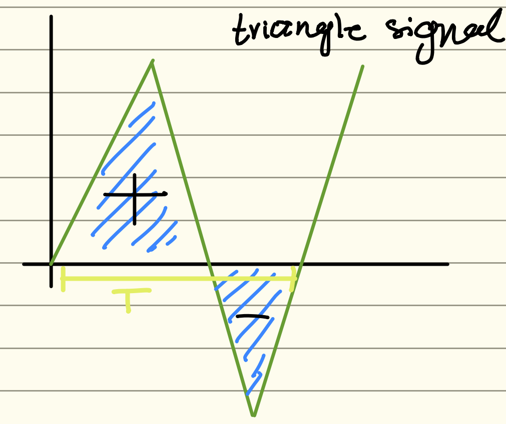
generate voltage or current varying with time.

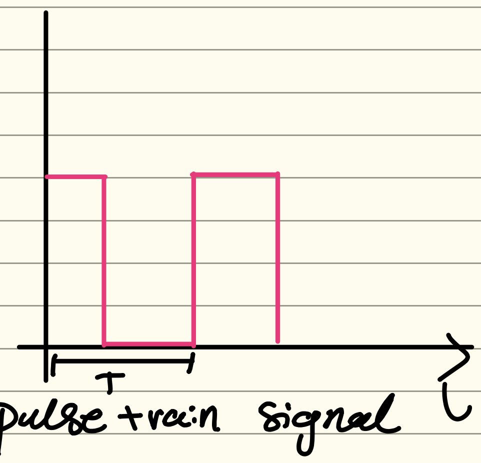
$x(t) \to$ voltage or current



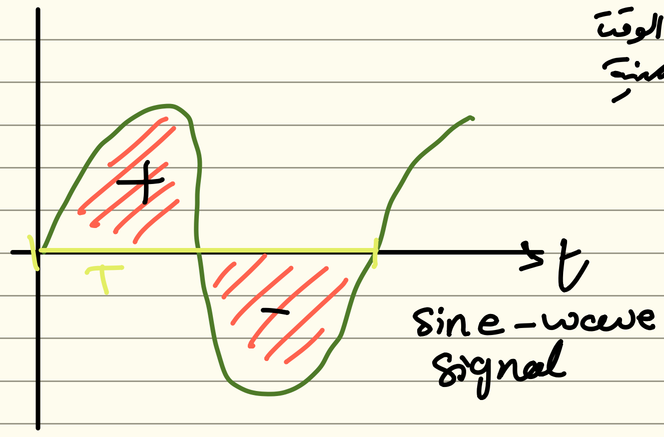


varying with time & also the direction





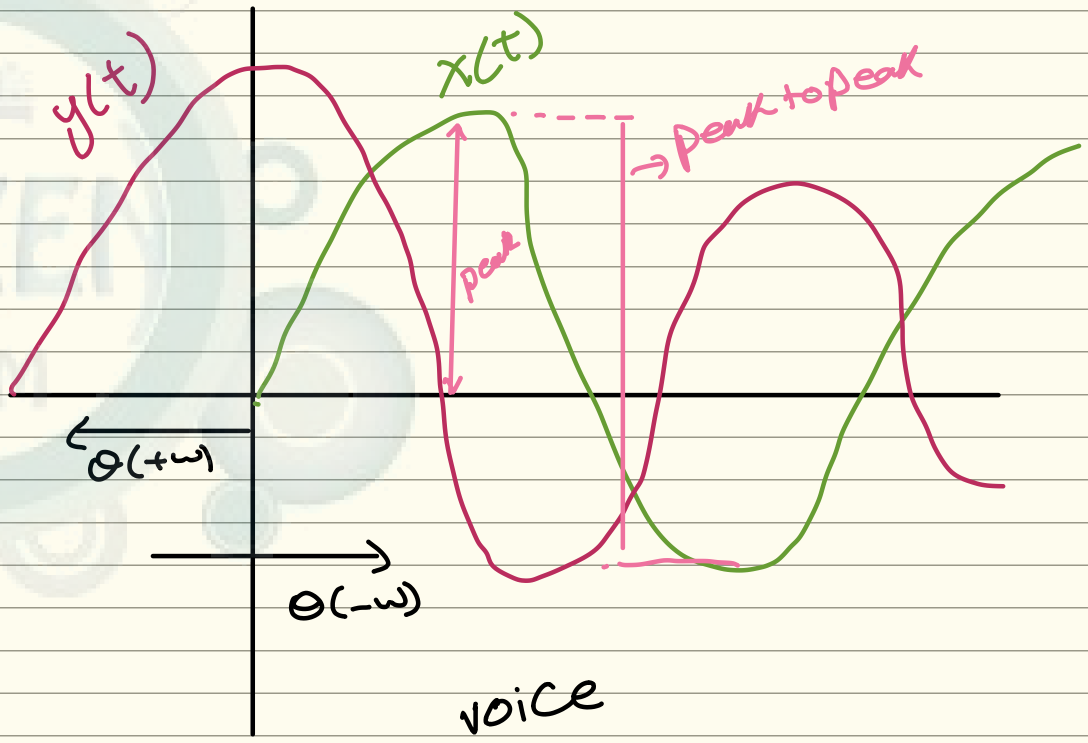
بتتغير مع الوقت وبنفس الوقت بس بتعطي إشارة مدة زمنية قاطعة بعدين بترجع (0)



T : الزمن الي بحتاجو علشان يرجع يكرر نفس عالرسمة.

periodic-signal Repeat itself after one periode (T)

random signal ما بتعيد حالها.



$x(t) = A\cos(wt - \theta)$

$y(t) = B\cos(wt)$

A: amplitude of signal ⟹ peak value

$\boxed{\text{peak to peak} = 2 * \text{peak} = 2A}$

w: radian freq ⟹ unit Rad/s

distance between two signal in sec

$\boxed{w = 2\pi f}$

where :-

$\theta = \frac{\Delta T * 360}{T}$ → period

f: Natural freq ⟹ unit Hz

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

$\boxed{\theta : \text{phase shift}}$ ⟹

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

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

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

قديش الزاوية الي تحركتها

حاكي بال Real

Ex $i(t) = 10\cos(377t + 30°)$

find: I_{peak}, $I_{peak\ to\ peak}$, ω, f, period θ, $i(0.1)$ sec, graph this function

$I_{peak} = 10\,A$

$I_{peak\ to\ peak} = 2 \times 10 = 20\,A$

$\omega = 377$

$\omega = 2\pi f$

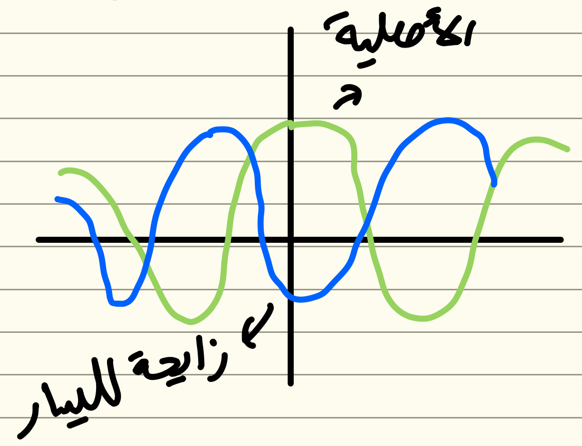
$\frac{377}{2\pi} = \frac{2\pi f}{2\pi} \Rightarrow f = \frac{377}{2\pi} = 60\,Hz$

$T = \frac{1}{f} = \frac{1}{60} = 0.016$ sec

$\theta = 30°$ لازم تركز حط راديان Radian

$i(0.1)$ sec $= 4.657\,A$

this shift of (+30) means that it is shifted to the left



Complex numbers:-

j or $i = \sqrt{-1}$

$(j)^2 = -1$

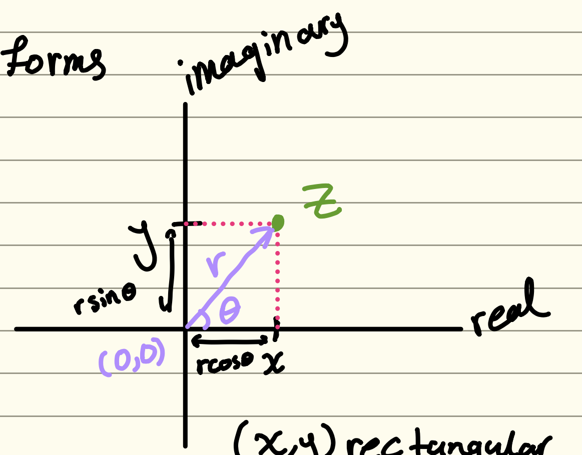
complex number has two forms

① Rectangular form

$z = x + jy$

② polar form:

$z = r \angle \theta$



(x, y) rectangular

(r, θ) polar.

\# Conversion from Rect. to polar

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

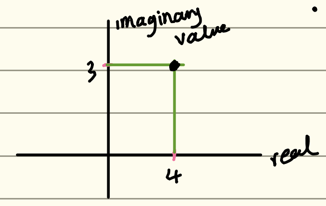
$\theta = \tan^{-1}\left(\frac{y}{x}\right)$ → الربع الأول والرابع فقط

\# Conversion from polar to Rect

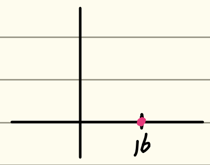
$x = r\cos(\theta)$

$y = r\sin(\theta)$

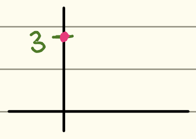
Ex:- $z_1 = 4 + 3j$ (real, imaginary)



$z_2 = 16$



$z_3 = 3j$



Mathematical

$x_1 = a + jb \quad , x_2 = c + jd$

\# addition

$x_1 + x_2 = (a + c) + (b + d)j$

\# Subtraction

$x_1 - x_2$

$a + jb - c - jd$

$(a - c) + (b - d)j$

\# multiplication:-

$x_1 * x_2 = (a + jb) * (c + jd)$

$= ac + adj + cbj - bd$

$(ac - bd) + (ad + cb)j$

④ Division

$\frac{x_1}{x_2} = \frac{a + jb}{c + jd} * \frac{c - jd}{c - jd}$

$= \frac{ac - adj + cbj + bd}{c^2 - d^2}$

$= \frac{ac + bd}{c^2 - d^2} + \left(\frac{cb - ad}{c^2 - d^2}\right)j$

that's when we are doing mathmatic for complex numbers in rectangular form

In polar form

$x_1 = r_1 \angle \theta_1 \quad , \quad x_2 = r_2 \angle \theta_2$

$x_1 * x_2 = (r_1 \angle \theta_1) * (r_2 \angle \theta_2)$

$= r_1 * r_2 \angle (\theta_1 + \theta_2)$

$\frac{x_1}{x_2} = \frac{r_1 \angle \theta_1}{r_2 \angle \theta_2} = \frac{r_1}{r_2} \angle (\theta_1 - \theta_2)$

$x_1 \pm x_2 = r_1 \angle \theta_1 \pm r_2 \angle \theta_2$

↳ convert to rectangular then compute

*using calculator to Solve complex numbers:-

$x = 3+2j$

$y = 5+j$

$\Rightarrow x * y = (3+2j)*(5+j)$

$= 13+13i$

$= 13\sqrt{2}\,(\frac{\pi}{4})$

$\Rightarrow x \div y = \frac{(3+2j)}{5+j} = \frac{17}{26} + \frac{7}{26} i \Rightarrow \frac{\sqrt{2}}{2}\,(0.39)$

but if It is already in polar form

$* 3\angle 20 + 4\angle 15$

$= 6.68 - 4.2\times10^{-3} j$

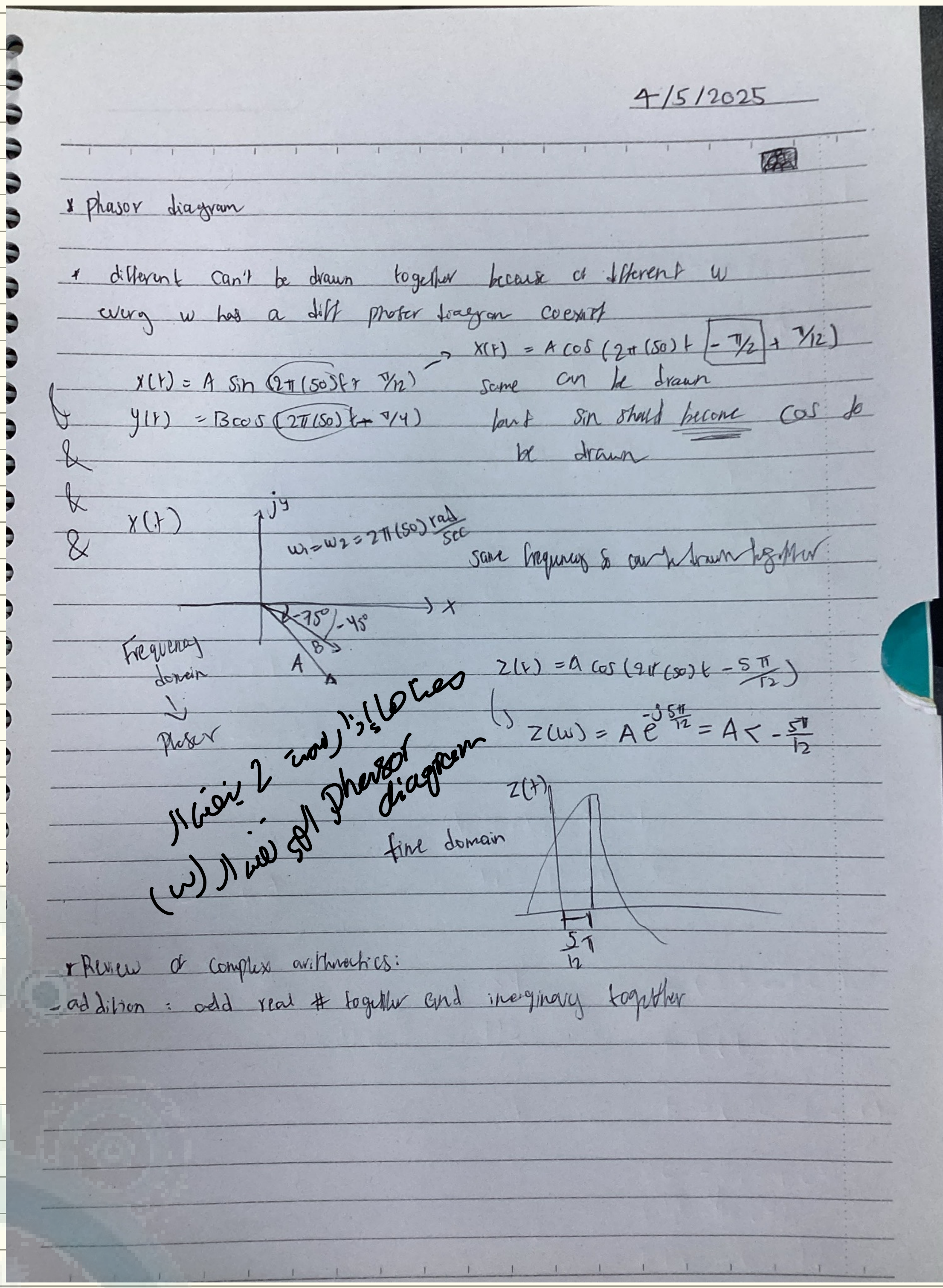
$6.68 \angle 0.08$

$* \frac{3\angle 20}{4\angle 15} = 0.614 + 0.43j$

$\frac{3}{4}\angle 35$

إذا كانت 2signals
& each one of them has there own (w) we can not combine them in one phaser diagram.

So if I have $\left.\begin{aligned} z(t) &= A\cos(\omega t + \theta_1) \\ z(\omega) &= Ae^{j\theta_1} = A\angle\theta_1 \end{aligned}\right\}$ we could not draw them in the same diagram



4/5/2025

* phasor diagram

* different can't be drawn together because of different w every w has a diff phasor diagram coexist

$x(t) = A\sin(2\pi(50)t + \pi/12)$ → $x(t) = A\cos(2\pi(50)t \boxed{-\pi/2} + \pi/12)$

$y(t) = B\cos(2\pi(50)t + \pi/4)$

same can be drawn but sin should become cos to be drawn

$x(t)$ $\omega_1 = \omega_2 = 2\pi(50)\,\frac{rad}{sec}$

same frequency so can be drawn together

Frequency domain → Phasor

$z(t) = A\cos(2\pi(50)t - \frac{5\pi}{12})$

$z(\omega) = Ae^{-j\frac{5\pi}{12}} = A\angle -\frac{5\pi}{12}$

بنفس ال (w) اذا عندي 2 signals phasor diagram

time domain

* Review of complex arithmetics:

- addition : add real # together and imaginary together

* Sinusoidal signals in freq. domain:-

Time domain ⇒ $x(t) = A\cos(\omega t+\theta)$

frequency domain ⇒ $X(j\omega) = A\angle\theta$ → phase shift refrenced to cosine signal

peak value

Ex: $V_1(t) = 15\cos(377t+\frac{\pi}{4})\,v$

$V_2(t) = 15\cos(377t+\frac{\pi}{12})\,v$

find $V_s(t) = v_1(t)+v_2(t)$

sol

الحل باستخدام المتطابقات المثلثية كثير صعب فبنحولهم (complex)

إذا sin بحولها بعدين بوخذ زاوية بنيها

⇒ frequency domain هاد الحل الي بحولو هسا ل

قبل ما أوخذ الزاوية بتيا ل(cos)

$V_1(j\omega) = 15\angle\frac{\pi}{4} = 10.61 + 10.61i$

$V_2(j\omega) = 15\angle\frac{\pi}{12} = 14.489 + 3.88229i$

$V_s(j\omega) = v_1(j\omega)+v_2(j\omega)$

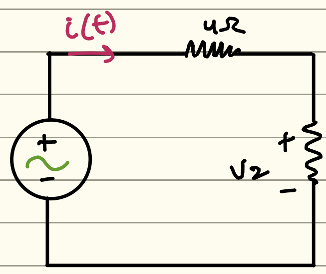
$= 25.0988 + 14.492i$

$= 28.9824\angle 0.523641693$

$V_s(t) = 28.98\cos(377t+\frac{\pi}{6})$

المهم نفس الfrequency منكبتو

Ex:- مجرد ما الsupply ⇐ Ac ⇐ sin wave



$V(t) = 12\cos(377t+40^\circ)\,v$

find $i(t)$, $v_2(t)$

sol

we already took this type of ckt & we solve it by voltage division

now we are going to solve it using voltage division

كل سين بدل ما كان رقم هسا صار رقم وزاوية

$V_1(j\omega) = 12\angle\frac{2\pi}{9}$

$V_2(j\omega) = \frac{(12\angle\frac{2\pi}{9}).2}{2+4} = 4\angle\frac{2\pi}{9}$

$V_2(t) = 4\cos(377t+\frac{2\pi}{9})\,v$

$4\angle\frac{2\pi}{9}$

$i(j\omega) = \frac{4\angle\frac{2\pi}{9}}{2} = 2\angle\frac{2\pi}{9}\,A$

هو بدو إياها بال time domain

$i(t) = 2\cos(377t+\frac{2\pi}{9})$

* Impedance:- $Z(j\omega)$

هنا لما كنا بالـ Dc supply ⇐ بصير الcapacitor ⇐ open ckt
الinductor ⇐ short ckt

⇒ we will describe the ckt elements (R, L, C)

in AC-ckt ⇒ they will have impedence

1 Resistor

if $v(t) = V_m\cos(\omega t+\theta)$

$V(j\omega) = V_m\angle\theta$

to find $I(j\omega) = \frac{V(j\omega)}{R} = \frac{V_m\angle\theta}{R} = \frac{V_m}{R}\angle\theta$ ← same phase shift between volt & current

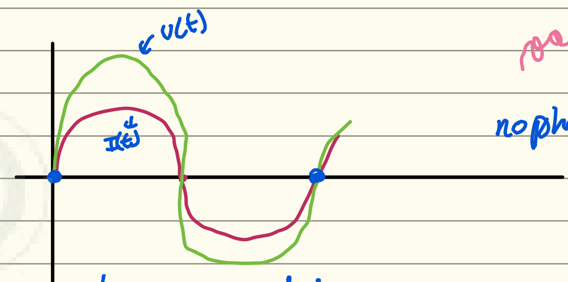
$\Rightarrow i(t) = \frac{V_m}{R}\cos(\omega t+\theta)$

$\Rightarrow Z(j\omega) = \frac{V(j\omega)}{I(j\omega)} = \frac{V_m\angle\theta}{\frac{V_m}{R}\angle\theta} = R\angle 0$ → so there is no phase shift

$\boxed{Z_R(j\omega) = R\ \Omega}$

إذا ما في تغير بتعامل المقاومة زي ما هي

يعني لو بدي أرسم



no phase shift because it is Resistance.

ما في phase shift بيبلشو مع بعض وبخلصو مع بعض

2 Inductor:-

$V(t) = L\frac{di_L(t)}{dt}$

if $i_L(t) = I_m\cos(\omega t+\theta)$

نشتق $I_L(j\omega) = I_m\angle\theta$

cos → −sin

so $V(t) = I_m(\omega L)(-\sin(\omega t))$

$= I_m(\omega L)\cos(\omega t+\theta+90^\circ)$

$V(j\omega) = I_m(\omega L)\angle\theta+90^\circ$

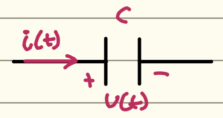
$Z_L(j\omega) = \frac{V(j\omega)}{I(j\omega)} = \frac{I_m(\omega L)\angle\theta+90}{I_m\angle\theta}$

$Z_L(j\omega) = (\omega L)\angle\theta+90-\theta$

$Z_L(j\omega) = \omega L\angle 90 = j\omega L\ \Omega$

$\boxed{Z_L(j\omega) = j\omega L\ \Omega}$

& that means that $Z_L(j\omega)$ is frequency dependent $\quad \omega = 2\pi f$

3 Capacitor 

$i_c(t) = c\,\dfrac{dv_c(t)}{dt}$

frequency domain

if $v_c(t) = V_m \cos(\omega t+\theta) \Rightarrow V_c(j\omega) = V_m\angle\theta$

$i_c(t) = V_m\,(c\omega)(-\sin(\omega t+\theta))$

$= (c\omega)\,V_m \cos(\omega t+\theta+90)$

$I_c(j\omega) = (c\omega)\;V_m\angle\theta+90^\circ$

$Z_c(j\omega) = \dfrac{V_c(j\omega)}{I_c(j\omega)} = \dfrac{V_m\angle\theta}{c\omega\,V_m\angle\theta+90}$

$\dfrac{1}{c\omega}\angle\theta-\theta-90$

$Z_c(j\omega) = \dfrac{1}{c\omega}\angle-90 = \dfrac{-j}{\omega c}\ \Omega$

$$\boxed{Z_c(j\omega) = \dfrac{-j}{\omega c}\ \Omega}$$

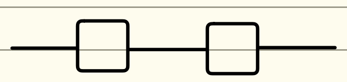
Review :-

$Z_R(j\omega) = R \Rightarrow$ fixed with frequency variation

$Z_L(j\omega) = j\omega L = \omega L\angle 90$

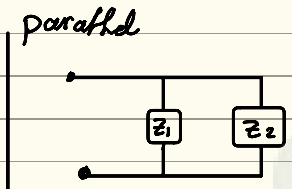
$Z_c(j\omega) = \dfrac{-j}{\omega c} = \dfrac{1}{\omega c}\angle-90$

series

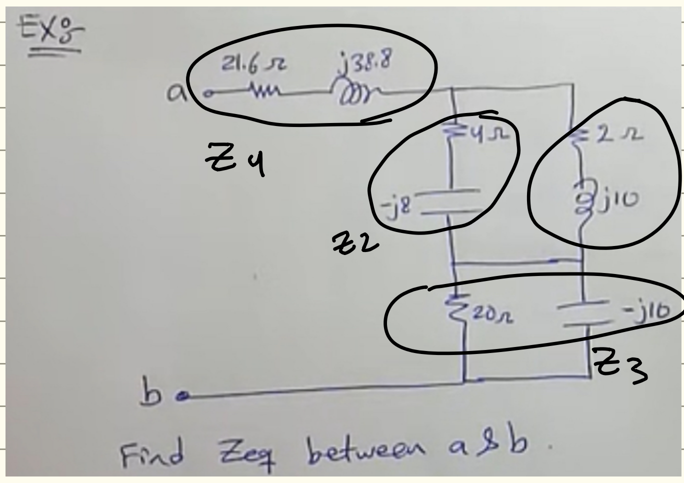


$Z_{total} = Z_1 + Z_2$

parallel



$\dfrac{1}{Z_{tot}} = \dfrac{1}{Z_1} + \dfrac{1}{Z_2}$



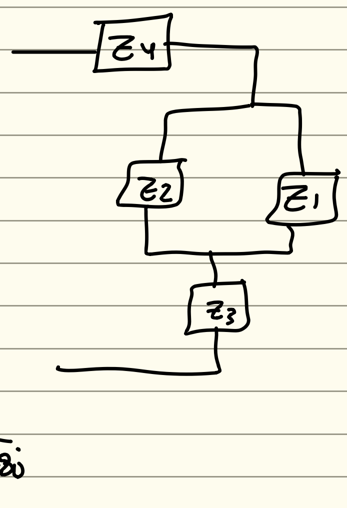
$Z_1 = 2 + j10$

$Z_2 = 4 - 8j$

$Z_3 \Rightarrow \dfrac{1}{Z_3} = \dfrac{1}{20} + \dfrac{1}{-j10}$

$Z_3 = 4 - 8i$

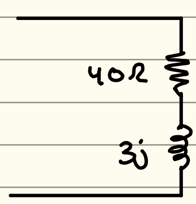
$Z_4 = 21.6 + 38.8j$



for $Z_1 \& Z_2$

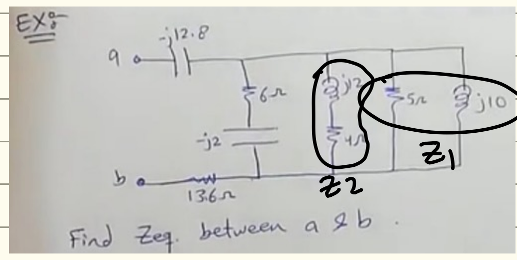
$\dfrac{1}{Z_{eq}} = \dfrac{1}{Z_1} + \dfrac{1}{Z_2} = \dfrac{1}{2+10j} + \dfrac{1}{4-8i}$

$Z_{eq} = 14.4 - 0.8j$



$Z_{total\,eq} = (4-8j) + (21.6+38.8j) + (14.4-0.8j)$

$Z_{eq} = 40 + 30i$ & that means that we have only resistant & inductor



$Z_1 = \dfrac{1}{5} + \dfrac{1}{10j}$

$Z_1 = 4 + 2i$

$Z_2 = 12j + 4$

نعكس في غلط جو

$Z_1 \parallel Z_2$

$\dfrac{1}{4+2i} + \dfrac{1}{12i+4} = 2.76923 + 2.153846154i$

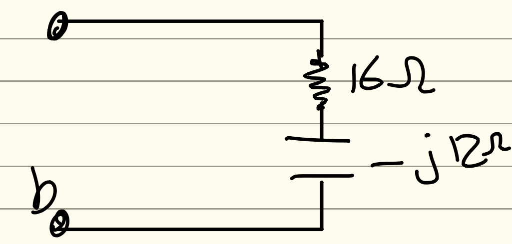
$Z_3 = 6 - 2j \parallel (2.76923 + 2.153841154i)$

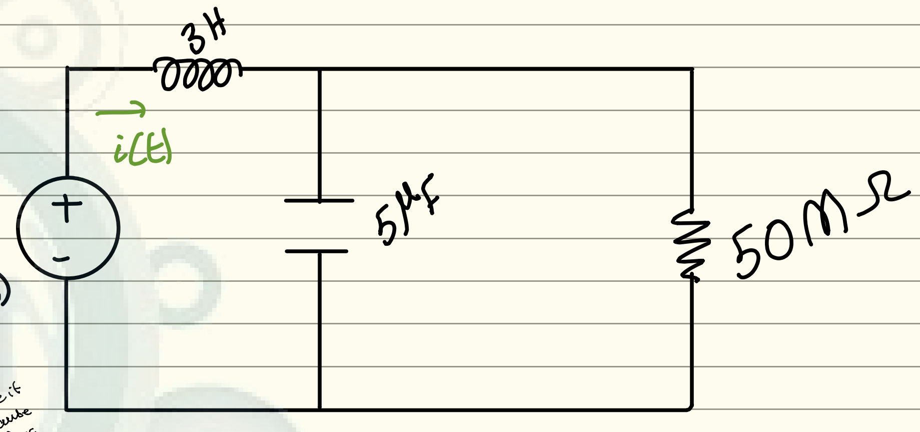
$Z_4 = 2.4 + 0.8i$

& $2.4 + 0.8i - 12.8j + 13$

$Z_{eq} = 16 - 12j$

that mean that we have





we will change it to cos because it is our refrence

$V_L(t) = 5\sin\left(2\pi 50t + \dfrac{\pi}{6}\right)$ volts

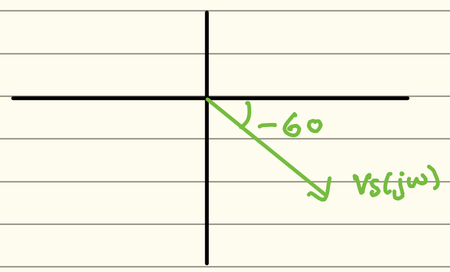
$Z_c = \dfrac{-j}{\omega c} = \dfrac{1}{\omega c}\angle-90 = \dfrac{-j}{2\pi 50\times 5\times10^{-6}}$

$-j\,636.619\ \Omega$

$Z_L = jL\omega = j\times 3\times 2\pi\times 50 = 942.42j\,\Omega$

$Z_R = 50\times10^6$

$V_s(j\omega) = 5\,e^{-j\frac{2\pi}{6}} = 5\angle\dfrac{-2\pi}{6}$ volts



$Z_{eq_1} = 8.1056\times10^{-3} - j636.62$

$Z_{eq_2} = 305.8520\angle 89.99848$

دايما أحس انك تنسي

ال impedance ⇐ rectangular

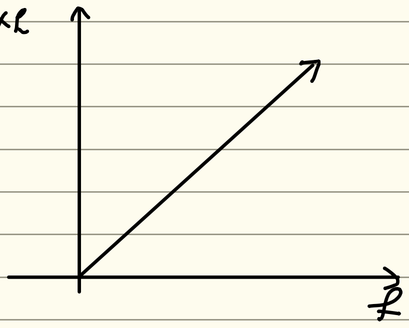
notes on Chapter 4

$\Rightarrow Z_L(j\omega) = j\omega L = \omega L \angle 90$

$X_L = \omega L \Rightarrow$ reactance

$\omega = 2\pi f$

$X_L = (2\pi f)L$



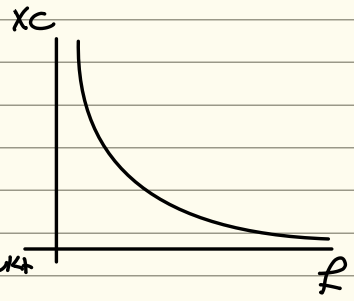
so that reactance depends on frequency

① at $f=0 \Rightarrow$ at DC

$\boxed{X_L = 0\,\Omega} \Rightarrow$ & because of this we said that the conductor acts like short ckt in DC supply

② at $f = \infty \Rightarrow X_L = \infty\,\Omega \Rightarrow$ open ckt

$\Rightarrow Z_C(j\omega) = \frac{-j}{\omega C} = \frac{1}{\omega C} \angle -90$



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

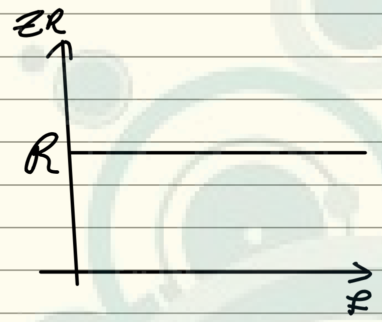
① at $f=0$ (DC) $\Rightarrow X_C = \infty\,\Omega$

capacitor acts like open ckt DC

② at $f = \infty \Rightarrow X_C = 0$

↳ like short ckt

$\Rightarrow Z_R(j\omega) = R \Rightarrow$ independent of freq



$\Rightarrow Z = R + jX$

Resistance ↳ Reactances

a) if $Z = R$

assume $V = V_m \angle \theta$ ($V_m \rightarrow$ vmax)

so $I = \frac{V_m \angle \theta}{R} = \frac{V_m}{R} \angle \theta$

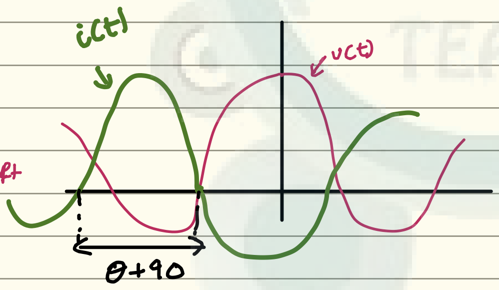
same angle so there is no phase between voltage & current across resistor

phase shift between V & I = 0

b) if $Z = -jX_C \Rightarrow$ pure capacitive

assume $V = V_m \angle \theta$

so $I = \frac{V_m \angle \theta}{X_C \angle -90} = \frac{V_m}{X_C} \angle \theta + 90$ (shift to left)



$\Rightarrow$ current I lead voltage by 90°

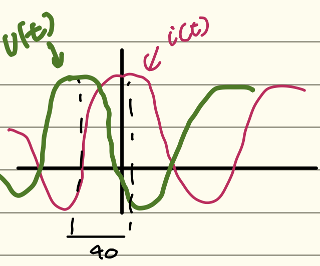
or $\Rightarrow$ V lag I by 90°

c) if $Z = jX_L \Rightarrow$ pure inductive

assume $V = V_m \angle \theta$

so $V = V_m \angle \theta$

$I = \frac{V_m \angle \theta}{X_L \angle 90} = \frac{V_m}{X_L} \angle -90$ (shift to right)



$\Rightarrow$ V leads I by 90°

or $\Rightarrow$ I lags the V by 90

if $Z = R + jX_L \Rightarrow$ behave like inductive (pure بس مش)

so here $0 < \theta < 90$

if $Z = R - jX_C \Rightarrow$ behave like capacitive (pure يعني مش)

$-90 < \theta < 0$

Admitance

$Z = R \pm jX$

impedance, Resistance, Reactance (X_L or X_C)

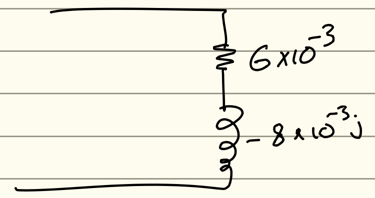
$Y = G \pm jB$, $Y = \frac{1}{Z}$ which means that $G \neq \frac{1}{R}$, $B \neq \frac{1}{X}$

admittance, conductance, susceptance

Example:- $Z = 100 \angle 53°$, find Y

$\Rightarrow Y = \frac{1}{Z} = \frac{1}{100 \angle 53} = \underbrace{6.02 \times 10^{-3}}_{G} - \underbrace{8 \times 10^{-3} j}_{B_L}$

B_L (عكس ال G الجعبل ال L ساب)



The Average value

↳ method measuring the mean (average) of the voltage or current over a period of time (T)

هاد كمان اسم ال average بنعبر

$\langle X(t) \rangle = \frac{1}{T} \int_0^T x(\tau)\, d(\tau)$ ↳ integral of the signal (wave form) over period of time

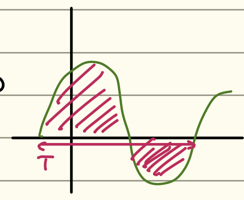
Example: $x(t) = A\cos(\omega t + \theta)$

Find $\langle x(t) \rangle$

$\langle x(t) \rangle = \frac{1}{T} \int_0^t A\cos(\omega \tau + \theta)\, d\tau = 0$

$= \frac{A}{T} \sin(\omega t + \theta) \Big|_0^t$

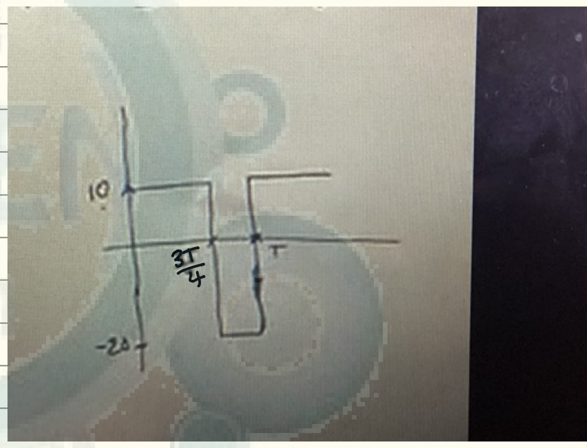
$= \frac{A}{T} \sin(\omega t + \theta)$



كأنو بنوجد المساحة تحت المنحنى (المساحة من فوقه ⊕ ومن تحت سالب) ومتساويات ⇐ إذا صفر

Note: the average of the sinusiodal signal is zero independent of amplitude or frequency

Example:-



$\langle x(t) \rangle = \frac{1}{T} \int_0^t x(\tau)\, d\tau$

$= \frac{1}{T} \left[\int_0^{3T/4} 10\, d\tau + \int_{3T/4}^{T} -20\, d\tau \right]$

$= \frac{1}{T} \left[[10t] \Big|_0^{3T/4} + [-20t] \Big|_{3T/4}^{T} \right]$

$= \frac{1}{T} \left[10\left(\frac{3T}{4}\right) + -20\left(T - \frac{3T}{4}\right) \right]$

$= \frac{1}{T} \left[\frac{15}{2}T + -20T + 15T \right]$

$= \frac{1}{T} \left[\frac{5}{2}T \right]$

$= \frac{5}{2} = 2.5$

Root mean square (RMS):-

RMS: effective value of varying voltage or current

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

effective value of لما يحكيلي اعطيني ال

current → لاستعمال القانون

Ex: $x(t) = A\cos(\omega t)$

$$X_{rms} = \sqrt{\frac{1}{T}\int_0^t A^2\cos^2(\omega t)\,dt}$$

$$X_{rms} = \sqrt{\frac{A^2}{T}\int_0^t \cos^2(\omega t)\,dt}$$

$$X_{rms} = \sqrt{\frac{A^2}{T}\int_0^t \left(\frac{1}{2}\left(1+\cos(\omega t)\right)\right)dt}$$

تكامله هاي — حكينا انو التكامل لل T لل cos يطلع صفر

$$X_{rms} = \sqrt{\frac{A^2}{2T}\left[T+0\right]}$$

$$X_{rms} = \sqrt{\frac{A^2}{2T}\cdot T}$$

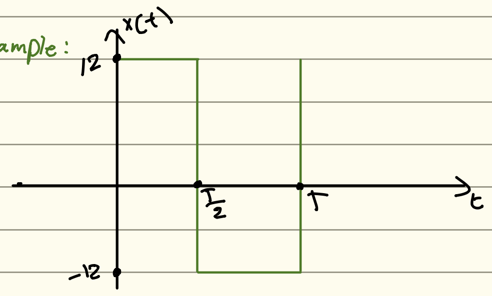
$$X_{rms} = \frac{A}{\sqrt{2}}$$

تحت الصافي

Note: for sinusoidal signal

$$X_{rms} = \frac{\text{Peak value}}{\sqrt{2}}$$

Example:



$$x(t) = \begin{cases} 12, & 0 \le t \le \frac{T}{2} \\ -12, & \frac{T}{2} \le t \le T \end{cases}$$

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

$$= \sqrt{\frac{1}{T}\left[\int_0^{T/2}(12)^2\,dt + \int_{T/2}^{T}(-12)^2\,dt\right]}$$

$$= \sqrt{\frac{1}{T}\left[144t\Big|_0^{T/2} + 144t\Big|_{T/2}^{T}\right]}$$

$$= \sqrt{\frac{1}{T}\left[\frac{144T}{2} + \left(144T - \frac{144T}{2}\right)\right]}$$

$$= \sqrt{\frac{1}{T}\left[72T + 144T - 72T\right]}$$

$$= \sqrt{\frac{1}{T}\left[144T\right]}$$

$$= \sqrt{144} = 12$$

Note: ① for square wave signal

$X_{rms} = A \leftarrow$ max value

② for traingular signal

$$X_{rms} = \frac{A}{\sqrt{3}}$$

③ for Dc-signal

$X_{rms} = Dc$

Example: $V_{rms} = 220$ volt

$V_{peak} = 220 \times \sqrt{2}$

$= 311$ volt

Note:- لو كان عندي إشارة مركبة

$$v(t) = V_1\cos(\omega t) + V_2\sin(\omega t) + \text{----} + V_0$$

$V_0 \rightarrow$ Dc value

$$V_{rms} = \sqrt{(V_{DC})^2 + \frac{\sum_{i=1}^{N} V_i^2}{2}}$$

$$Rms\ (total) = \sqrt{(Rms)_1^2 + (Rms)_2^2 + (Rms)_3^2}$$

Example: $x(t) = 3 + 2\cos(\omega t)$

$3 \rightarrow Dc$

$x_{rms} = 3$

$2\cos(\omega t) \rightarrow$ sinosondal

$\frac{A}{\sqrt{2}} = \frac{2}{\sqrt{2}} = \frac{1}{\sqrt{2}}$

$$X_{rms} = \sqrt{9 + \left(\frac{2}{\sqrt{2}}\right)^2}$$

$$= \sqrt{9 + 2} = \sqrt{11}$$

Example: $v(t) = 4\cos(100t) + 12\sin(100t) - 6\cos(300t) + 5$

$$X_{rms} = \sqrt{\left(\frac{4}{\sqrt{2}}\right)^2 + \left(\frac{12}{\sqrt{2}}\right)^2 + \left(\frac{6}{\sqrt{2}}\right)^2 + 5^2}$$

$$X_{rms} = \sqrt{123} = 11.1$$

For sinusiondal: $\frac{4}{\sqrt{2}}$, $\frac{12}{\sqrt{2}}$, $\frac{6}{\sqrt{2}}$

For Dc 5

ما بفرقة معي sin أو cos

Ac-analysis steps:-

① Note the frequency of the sinusoidal exitation
  ال frequency لكل مصادر الطاقة، كم قيمة

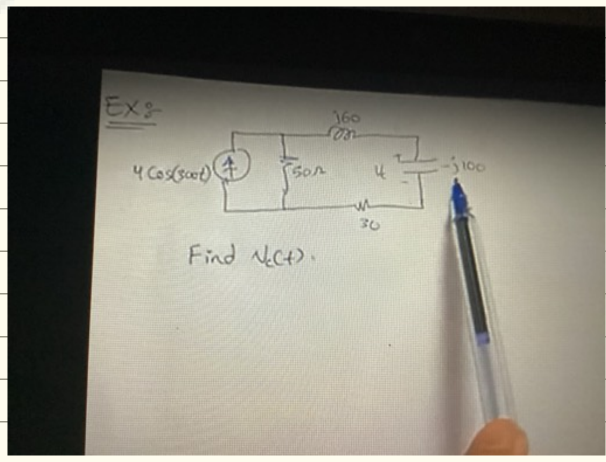
② convert all sources to phasor form (freq domain) ولازم نرجعهم ل cos عشان نبلش نشتغل

③ convert each ckt element to impedance form

④ solve the resulting phasor ckt using any method (mesh, nodal, superposition, source transformation, Norton & thevenin, voltage Division, current division, KCL, KVL, ohm's Law)

⑤ convert to tim domain

Example:



step 1: find ω ⇐ عشان نحول ال impedance بس هم هون جاهزين

$\omega = 300$ rad/s $\omega = 2\pi f$ =

$$\frac{300}{2\pi} = \frac{2\pi f}{2\pi} \rightarrow f = 47.746$$

step 2: أحول كل شي impedance
بسهولة

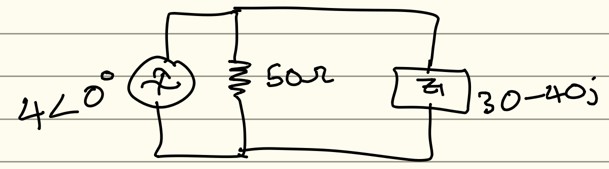
step 3: نوخذ ال sources ونحولهم
لل frequency domain

$4\cos(300t) \Rightarrow 4\angle 0° A$

هسا ببلش أحل بالدائرة

$Z_1 = 60j - 100j + 30$

$Z_1 = 30 - 40j$



by current division

$$I_{Z_1} = \frac{(4\angle 0)\cdot \frac{1}{30-40j}}{\left(\frac{1}{50}\right)+\left(\frac{1}{30-40j}\right)} = 2+j$$

$V_C = I \times -j100$

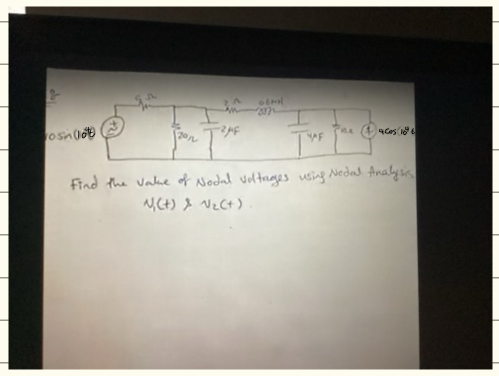
$= 2+j \times -j100$

$V_C = 223.6 \angle -63.4^\circ$ V

بس لازم أطلع الجواب بالآخر بال time domain

$$\boxed{V_C = 223.6\,(\cos(300t - 63.4))}$$

Example:



لازم ال supplies الهم نفس ال frequency

step 1 ⇒ $\omega = 10^4$

⇒ step 2 نحول كل ال sources ل frequency domain

$10\sin(10^4 t) = 10\cos(10^4 - 90)$

$= 10\angle -90^\circ$

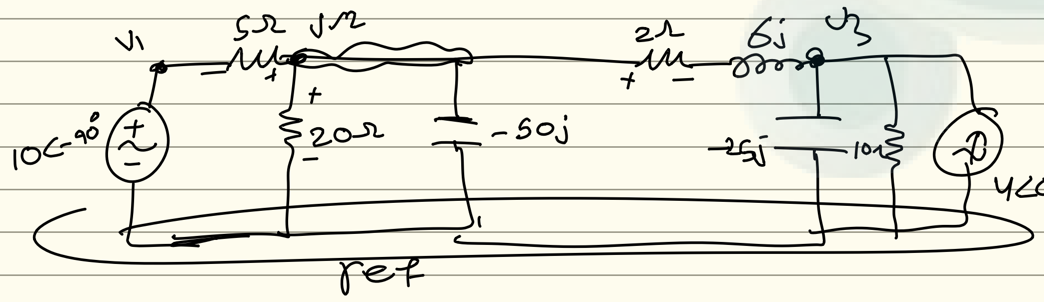
$4\cos(10^4 t) = 4\angle 0$

⇒ step 3: impedance ⇐ نحول كل ال CKt elements

$2\mu F \Rightarrow Z = \frac{-j}{\omega C} = \frac{-j}{10^4 \times 2\times 10^{-6}} = -50i$

$0.6\,mH \Rightarrow Z = j\omega L = j \times 0.6\times 10^{-3} \times 10^4 = 6j$

$4\mu F = \frac{-j}{\omega C} = \frac{-j}{4\times 10^{-6} \times 10^4} = -25j$



$V_1 = 10\angle -90^\circ$

for node 2

$$\frac{V_2 - 10\angle -90^\circ}{5} + \frac{V_2}{20} + \frac{V_2}{-50j} + \frac{V_2 - V_3}{2+6j}$$

$$\frac{V_2}{5} - 2i + \frac{V_2}{20} + \frac{V_2}{-50j} + \frac{V_2}{2+6j} - \frac{V_3}{2+6j}$$

$$0.33\angle -23.43\, V_2 - 2i - \frac{V_3}{2+6j} = 0$$

$$0.33\angle -23.43 V_2 + 0.158113883\angle 108.435 = 2i$$

for node 3

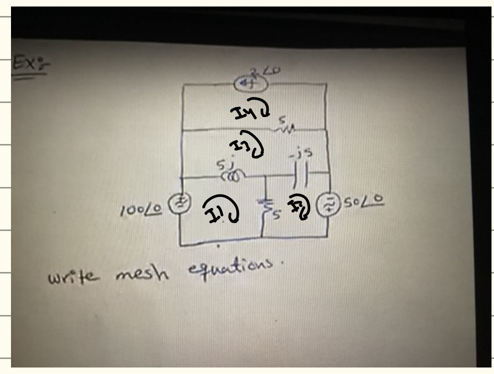
$$\frac{V_2 - V_3}{2+6j} + 4\angle 0 = \frac{V_3}{-25j} + \frac{V_3}{10}$$

$$0.158\angle -71.565\, V_2 - 0.158\angle -71.565\, V_3 + 0.04\angle 90\, V_3 - 0.1 V_3 = -4\angle 0$$

$V_1 = 14.28\angle -54.8$ volt $\Rightarrow 14.28\cos(10^4 t - 54.8)$

$V_2 = 17.33\angle 1.99$ volt $\quad 17.33\cos(10^4 t + 1.99)$

Example



⇒ step 1 done

⇒ step 2 done

⇒ step 3 done

خلص حل دغري

$I_4 = -2\angle 0 A$

for loop 1

$-100\angle 0 + 5j(I_1 - I_3) + 5(I_1 - I_2) = 0$

for loop 2

$5(I_2 - I_1) - 5j(I_2 - I_3) - 50\angle 0$

for loop 3

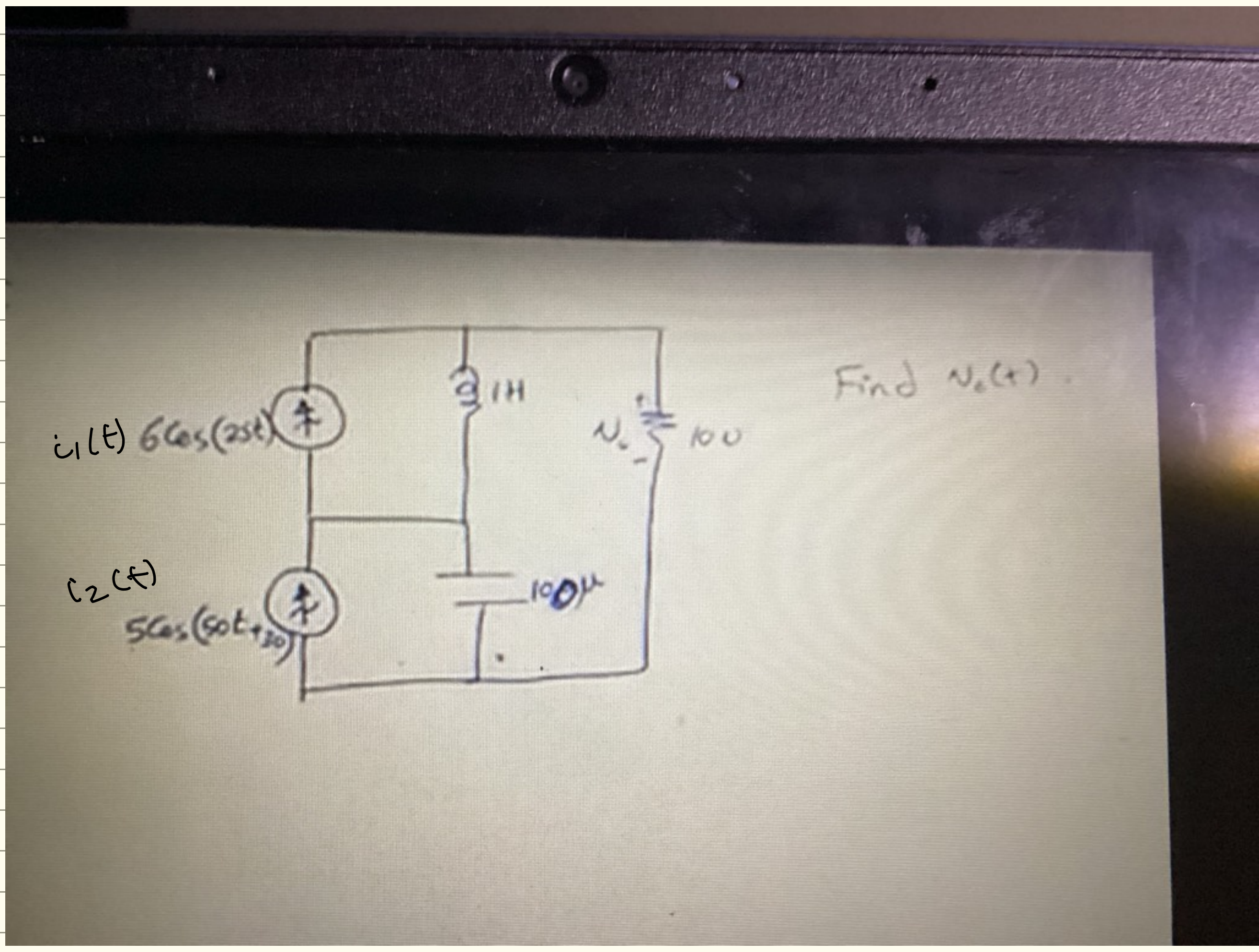
$5(I_3 - I_4) - 5j(I_3 - I_2) + 5j(I_3 - I_1) = 0$

بالعادة الحل هيك عال calculator كثير صعب منا بنطلب two

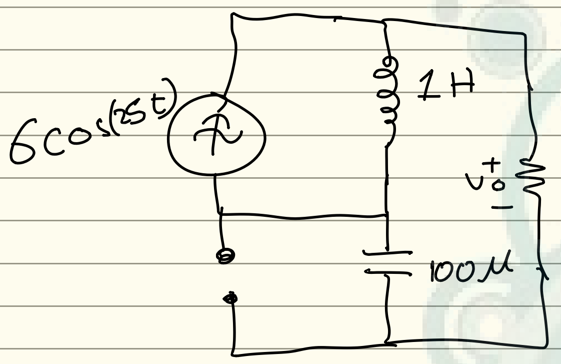
ملاحظة :-

الـ س إذا ما كانت نفس القوة
تلك الـ supplies إجباري
أحل بالـ superposition

Example:-



Keep $i_1(t)$ & Kill $i_2(t)$



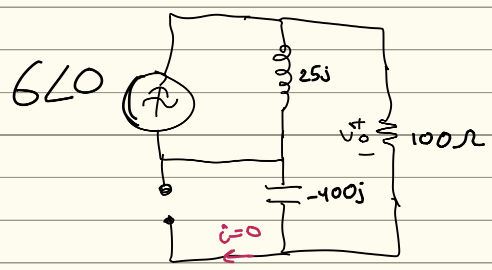
⇒ Step 1

$6\angle 0$

⇒ Step 2 $\omega = 25$

$1H \to Z = j\omega L = j\,25 \times 1 = 25j\ \Omega$

$100\mu \Rightarrow Z = \frac{-j}{\omega C} = \frac{-j}{100\times10^{-6} \times 25} = -400j\ \Omega$



By current division

$I_{100\Omega} = \dfrac{6\angle 0 \cdot \frac{1}{100}}{\frac{1}{100-400j} + \frac{1}{25j}} = 1.6\angle 89.1$

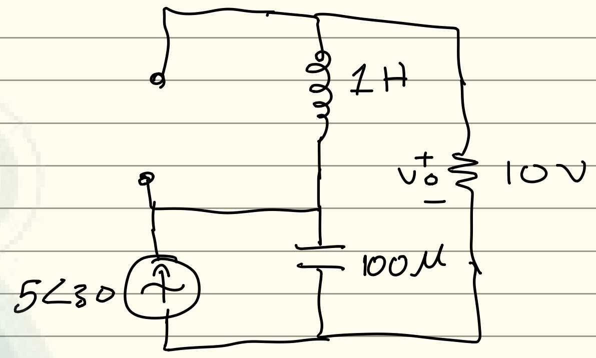
$V = IR$

$V_o' = 1.6\angle 89.1 \times 100$

$V_o' = 159.35\angle 89.1$

أكيد رح يكون
مش نفس الموجودة

Keep $i_2(t)$ & Kill $i_1(t)$

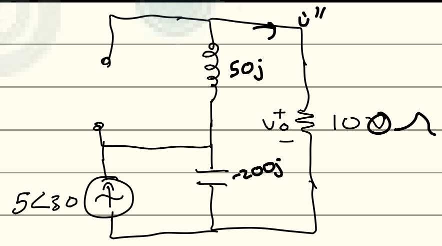


⇒ Step 1 ⇒ done

⇒ Step 2 $\omega = 50$

$1H \to Z = j\omega L = j \times 50 \times 1 = 50j\ \Omega$

$100\mu \Rightarrow Z = \frac{-j}{\omega C} = \frac{-j}{100\times10^{-6}\times 50} = -200j\ \Omega$



by current division

$I_{100\Omega - 200j} = \dfrac{5\angle 30 \times \frac{1}{100-200j}}{\frac{1}{100-200j} + \frac{1}{50j}}$

$1.3867\angle 176.31$

$V = I \times R$

$= I \times 100$

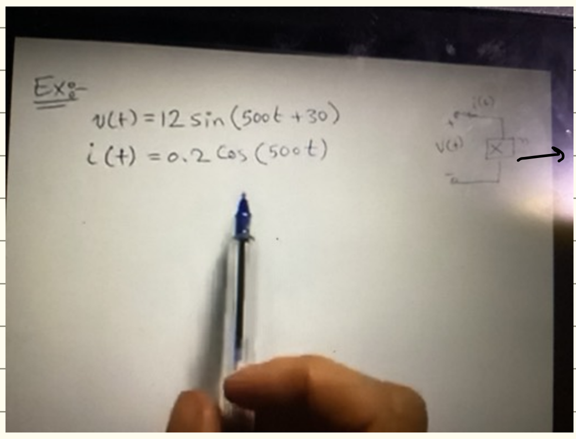
$V'' = 138.67\angle 176.309$

$V_o \neq V_o' + V_o''$

↳ due to different freq

بنحطهم بطريقة الـ cos و بجمعهم

Example:-



where this device is unknown how to find it?

نفس الـ Frequency بيشتغل طلنا مش نفس الـ Frequency بالزبط

$v(t) = 12\cos(500t - 60)$

$v(t) = 12\angle -60$ volt

$i(t) = 0.2\angle 0$ A

$$X = \frac{v}{i} = \frac{12\angle -60}{0.2\angle 0}$$

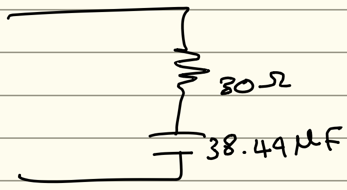
$$X = 60\angle -60\ \Omega$$

$$X = \underbrace{30}_{R} - 51.961j\ \Omega$$

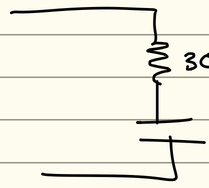
$$X_c = \frac{1}{wc}$$

$$51.961 = \frac{1}{500xc}$$

$$c = 38.49\ \mu F$$



or



$-51.9j$ ⇒ as impedance

* Max power transfer in Ac-ckt is:-

Value of load to find max power transfer

$$Z_L = Z_{th}^{*}$$ ← المرافق Conjigte

Ex: $z_1 = 3+2j$

$z_1^{*} = 3-2j$ conjeget

↳ only change the sign of the imaginary part

بالـ traingular بغير إشارة الـ Imaginary part

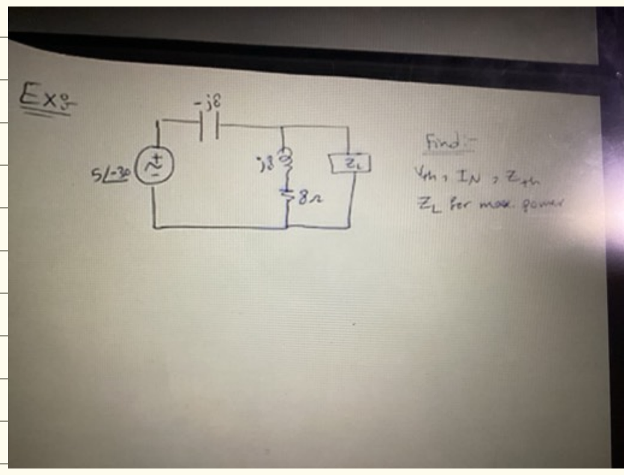
بالـ polar بتغير إشارة الزاوية

Ex: $z_1 = 12\angle -60°$

$z_1^{*} = 12\angle 60°$

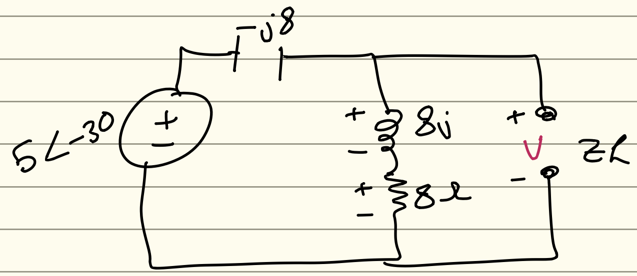
↳ only change the sign

Example



Find $V_{th} = V_{oc}$

كل شي جاهز، مكتوبين على شكل impedance



by voltage division

$$V_{8\Omega} = \frac{5\angle -30 \times 8}{8} = 5\angle -30$$

$$V_{8j} = \frac{5\angle -30 \times 8j}{8} = 5\angle 60$$

$$-5\angle -30 - 5\angle 60 + V = 0$$

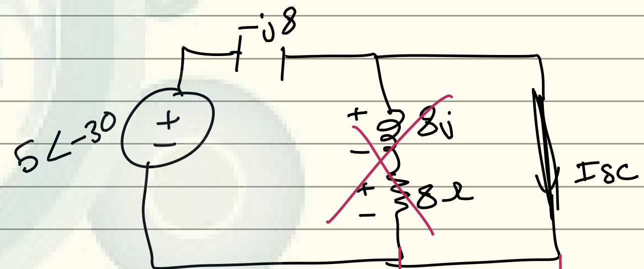
$$\left(\frac{5\sqrt{3}}{2} - \frac{5}{2}i\right) - \left(\frac{5}{2} + \frac{5\sqrt{3}}{2}i\right) + v = 0$$

$$7.07\angle -75 + V = 0$$

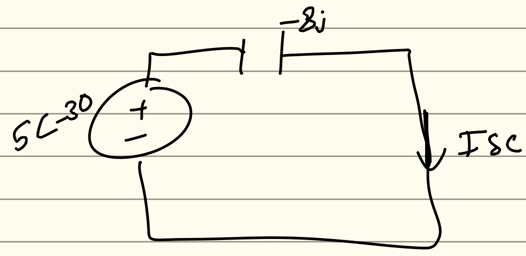
$$V_1 = -(\text{Ans})$$

$$V_{th} = 7.07\angle 15^{\circ}$$

Find IN



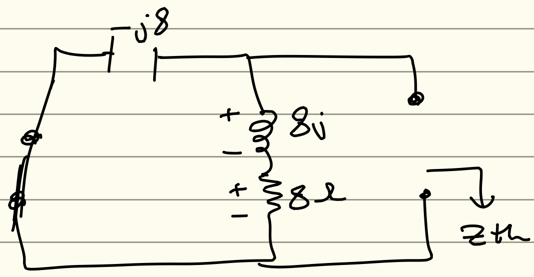
هاد Parallel مع هاد فبتصير المقاومة بهذا الـ branch صفر



$$I_{SC} = \frac{V}{R} = \frac{5\angle -30}{-8j}$$

$$= 0.625\angle 60\ A$$

Find Zth



$$Z_{th} = 8 - 8i\ \Omega$$

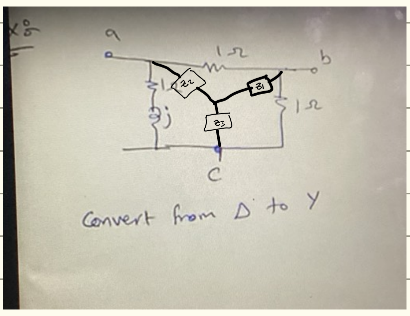
the value for Zload for maximum power transfer

$$Z_L = 8 + 8i\ \Omega$$

delta & wye in Ac

نفس الطريقة تبعت ال DC

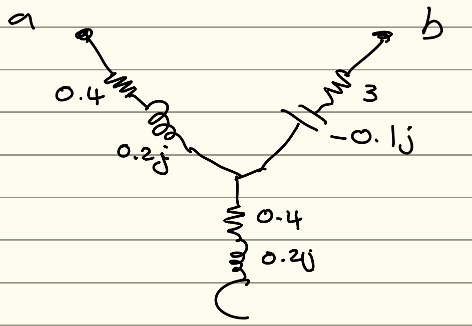
Example



$Z_1 = \frac{(1)(1)}{1+1+(1+j)} = \frac{1}{3+j} = 0.3 - 0.1j\ \Omega$

$Z_2 = \frac{(1)(1+j)}{3+j} = 0.4 + 0.2i\ \Omega$

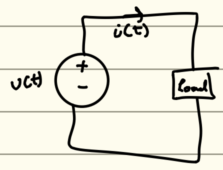
$Z_3 = \frac{1+j}{3+j} = 0.4 + 0.2i\ \Omega$



power in Ac ckt

1. Instintanuous power:- p(t)

if $v(t) = V_m \cos(\omega t + \theta_v)$ — peak value, phase



if $i(t) = I_m \cos(\omega t + \theta_i)$ — peak value, phase

$\cos\theta_1 * \cos\theta_2$

$\frac{1}{2}\cos(\theta_1+\theta_2) + \frac{1}{2}\cos(\theta_1-\theta_2)$

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

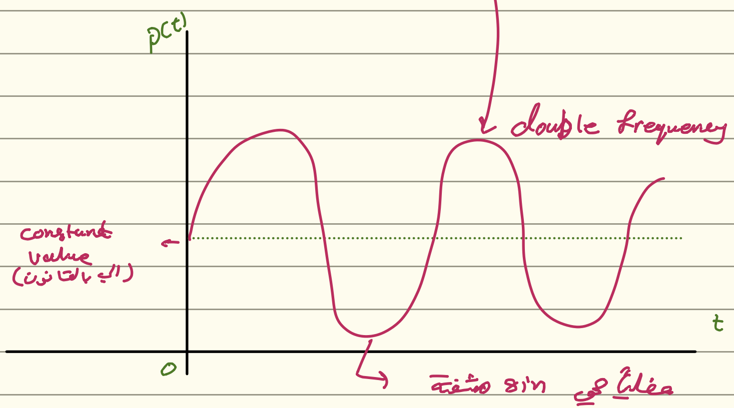
$= V_m \cos(\omega t + \theta_v) * I_m \cos(\omega t + \theta_i)$

$$\boxed{p(t) = \frac{V_m * I_m}{2} \cdot \underbrace{\cos(2\omega t + \theta_v + \theta_i)}_{\text{oscillating signal with double frequency}} + \frac{I_m \times V_m}{2} \underbrace{\cos(\theta_v - \theta_i)}_{\text{Constant value (average power)}}}$$

$\omega t - \omega t = 0$

(بتحرك و بتتغير و ال freq دبل)

Graph p(t)



Average power

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

$= \frac{1}{T}\int_0^t \left[\frac{V_m I_m}{2}\cos(2\omega t + \theta_v + \theta_i) + \frac{V_m I_m}{2}\cos(\theta_v - \theta_i)\right]dt$

$= \frac{V_m I_m}{2T}\int_0^t \cos(2\omega t + \theta_v + \theta_i) + \int_0^t \cos(\theta_v - \theta_i)$

تكامل ال cos لانه 0 الناتج = 0

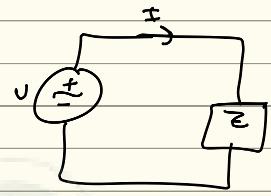
$= \frac{V_m I_m}{2T}\int_0^t \cos(\theta_v - \theta_v)$

$= \frac{V_m I_m}{2T} \cdot \left(\cos(\theta_v - \theta_i)\, t\right)\Big|_0^t$

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

$= \frac{V_m I_m}{2}\cos(\theta_v - \theta_i)$ ⟹ هاي بالنسبة لل Source

لوحا عشي وحدة ال Vm و ال Im تكتبه أحيانا؟



$I = I_m \angle \theta_i$

$V = V_m \angle \theta_v$

$Z = \frac{V}{I} = \frac{V_m \angle \theta_v}{I_m \angle \theta_i} = \frac{V_m}{I_m}\angle \theta_v - \theta_i$

$|Z| = \frac{V_m}{I_m}$, $\theta_z = \theta_v - \theta_v$

$P_{average} = \frac{1}{2} I_m^2 |Z| \cos(\theta_v - \theta_i)$] Power for the load (average)

$= \frac{1}{2}\frac{(V_m)^2}{|Z|}\cos(\theta_v - \theta_i)$

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

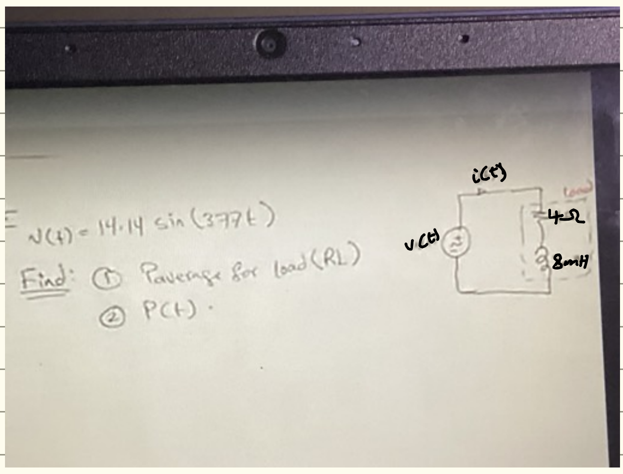
$I_{rms} = \frac{I_m}{\sqrt{2}}$

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

$= I_{rms}^2 |Z| \cos(\theta_v - \theta_i)$

$= \frac{V_{rms}^2}{|Z|}\cos(\theta_v - \theta_i)$

Example



$v(t) = 14.14\cos(377t - 90) \Rightarrow v(t) = 14.14\angle -90\ v$

$\hookrightarrow V_m = 14.14$

$\omega = 377$

$\theta_v = -90$

$8\,mH \rightarrow Z = jL\omega = j \times 8\times10^{-3} \times 377 = 3j\ \Omega$

$Z_{load} = R + jX_L$

$= 4 + 3j = 5\angle 36.84\ \Omega$

$|Z| = 5, \quad \theta_z = 36.9$

$\hookrightarrow \theta_v - \theta_i$

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

$I = \frac{14.14\angle -90}{5\angle 36.9} = 2.83\angle -126.9$

$\hookrightarrow I_m = 2.83$

$\theta_i = -126.9$

$P_{average} = \frac{1}{2} I_m \times V_m \times \cos(\theta_v - \theta_i)$

$= \frac{1}{2} \times 2.83 \times 14.14 \times \cos(-90 + 126.9)$

$P_{average} = 16$ watt

or $P_{average} = \frac{1}{2} I_m |Z| \cos(\theta_v - \theta_i) = 16$ watt

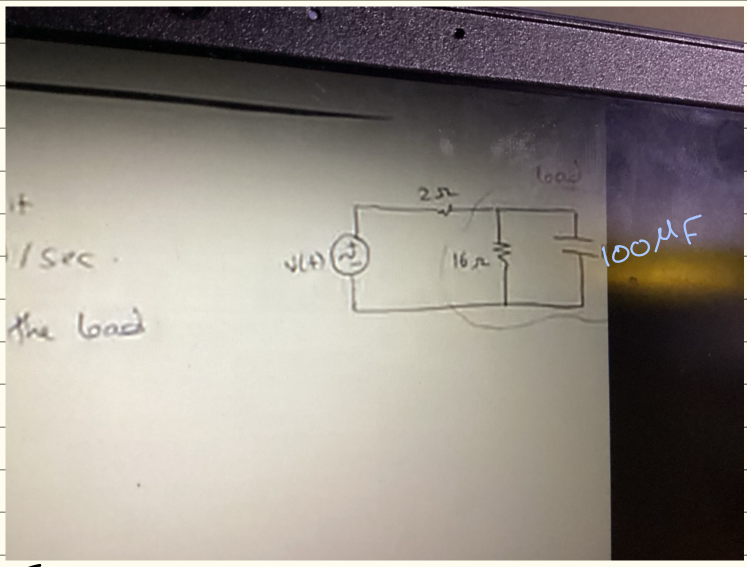
or $P_{av} = \frac{1}{2}\frac{V_m^2}{|Z|}\cos(\theta_v - \theta_i) = 16$ watt

$p(t) = v(t) * i(t) \rightarrow$ بدنا نجيب ال i(t)

$14.14\cos(377t - 90) \times 2.83\cos(377t - 126.9)$

$\frac{1}{2}\, 14.14 \times 2.83 \left[\cos(377t - 216.9) + \cos(377t + 36.9)\right]$

Example :



تكملة السؤال

$V = 110\angle 0$ volt

$w = 377$ rad/sec

Find power for the Load

$$Z = \frac{-j}{C\omega} = \frac{-j}{100\times10^{-6}\times 377} = -26.5252i$$

$$\text{Load} = 11.732 - 7.076i$$

$$= 13.7\angle -31.0983$$

$|Z| = 13.7$ $\qquad$ $\theta_z = -31.0983$

$\theta_v - \theta_i$

$V = IR$

by voltage division

$$P_{avg} = \frac{1}{2}\frac{V_m^2}{|Z|}\cos(\theta_v - \theta_i) \Rightarrow V_L = \frac{(110\angle 0)\times -26.525i}{}$$

$$= \frac{1}{2}\frac{(97.65)^2}{13.7}\cos(-31.0983) \qquad V_L = 97.65\angle -3.85$$

V_m $\qquad$ θ_v

$= 296.8$ watt

complex power

product of the rms voltage and the complex conjegate of the rms current

⇒ if voltage ⇒ $V_{rms} \angle \theta_v$

current ⇒ $I_{rms} \angle \theta_i$

$$\Rightarrow \underset{\text{complex power}}{S} = (V_{rms} \angle \theta_v) \times (\overset{\text{conjegate}}{I_{rms}^*})$$

$$= (V_{rms} \angle \theta_v) \times I_{rms} \angle -\theta_i$$

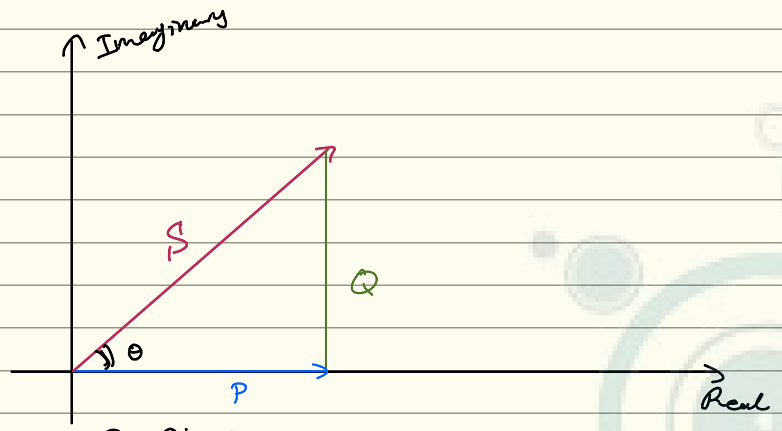
$$\boxed{S = V_{rms} \times I_{rms} \angle \theta_v - \theta_i} \Rightarrow \text{polar form}$$

$$S = \overbrace{V_{rms} \times I_{rms} \cos(\theta_v - \theta_i)}^{P} + j \overbrace{V_{rms} I_{rms} \sin(\theta_v - \theta_i)}^{Q}$$

Apparent power (V.A)

Real power
average power (w)
Dissipated power
طاقة ضائعة

reactive power
(وحدته) → (VAR)
Volt.Ampere.Reactive



$\theta = \theta_i - \theta_v$

$S = I_{rms} V_{rms} \cos(\theta_v - \theta_i) + I_{rms} V_{rms} \sin(\theta_v - \theta_i)$

$S = V_{rms} I_{rms}^* \Rightarrow P = V_{rms} I_{rms} \cos(\theta_v - \theta_i)$ w

$S = P + jQ \qquad Q = V_{rms} I_{rms} \sin(\theta_v - \theta_i)$ var

بس نربطها بال |Z|

$$Z = R + jX$$

$$Z = \frac{V_{rms}}{I_{rms}}$$

$$\Rightarrow V_{rms} = Z\, I_{rms}$$

$$S = I_{rms}^* (Z \times I_{rms})$$

$$S = |I_{rms}|^2 \times Z$$

$$S = |I_{rms}|^2 \times (R + jX)$$

$$S = \underbrace{|I_{rms}|^2 R}_{P} + j \underbrace{|I_{rms}|^2 X}_{Q}$$

dissipated power

measure the energy exchange between the source & the reactive impedance

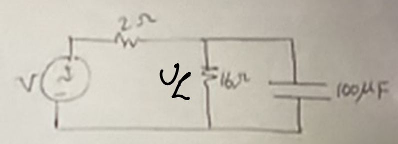
Summery

$$S = V_{rms} I_{rms}^*$$
$$= V_{rms} I_{rms} \cos(\theta_v - \theta_i) + j I_{rms} V_{rms} \sin(\theta_v - \theta_i)$$
$$= |I_{rms}|^2 R + j |I_{rms}|^2 X$$

Ex:-

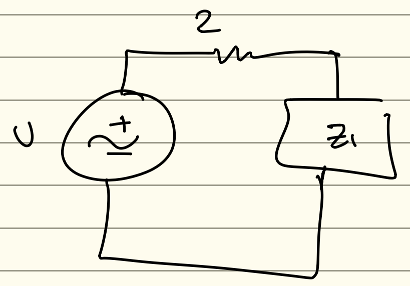
$V = 110\angle 0$, $\omega = 377$ rad/s

↳ peak



Find S, P, Q, PF

$$100\times10^{-6} \Rightarrow Z = \frac{-j}{377\times10^{-6}\times100} = -26.53i$$



$13.7\angle-31.1$

$$I = \frac{V}{Z_1+2} = 7.12\angle 27.26$$

↳ peak

$$V_{rms} = \frac{110\angle 0}{\sqrt{2}} = 77.782$$

$$I_{rms} = \frac{7.12\angle 27.26}{\sqrt{2}} =$$

$$I_{rms} = 5.035\angle 27.26$$

$$S = I_{rms}^* \, V_{rms}$$

$$(5.035\angle-27.26) \times 77.782$$

$$S = 391.63\angle-27.26$$

$$S = 348.13 - 179.379j$$

↳ here $Q < 0$ so this means that this capacitive load but not pure

So that

$P = 348.13$ watt

$Q = -j\,179.37$ var

عشان نتأكد من حلنا

$$V_L = \frac{V\times Z_1}{2+Z_1} = 97.5\angle-3.87$$

$$Q = \frac{|V_L|^2}{X_C} = \frac{\left(\frac{97.5}{\sqrt{2}}\right)^2}{26.5} = 179.4 \text{ var}$$

$$P_{total} = P_{2\Omega} + P_{load}$$

$$P_{2\Omega} = |I_{rms}|^2 (2)$$

$$= \left(\frac{7.116}{\sqrt{2}}\right)^2 \times 2 = 50.64\,W$$

$$P(16\,\Omega) = \frac{|V_{rms}|^2}{16} = \frac{\left(\frac{97.5}{\sqrt{2}}\right)^2}{16} = 297.1 \text{ watt}$$

$$P_{total} = 297.1 + 50.64$$

$$= 347.7 \text{ watt}$$

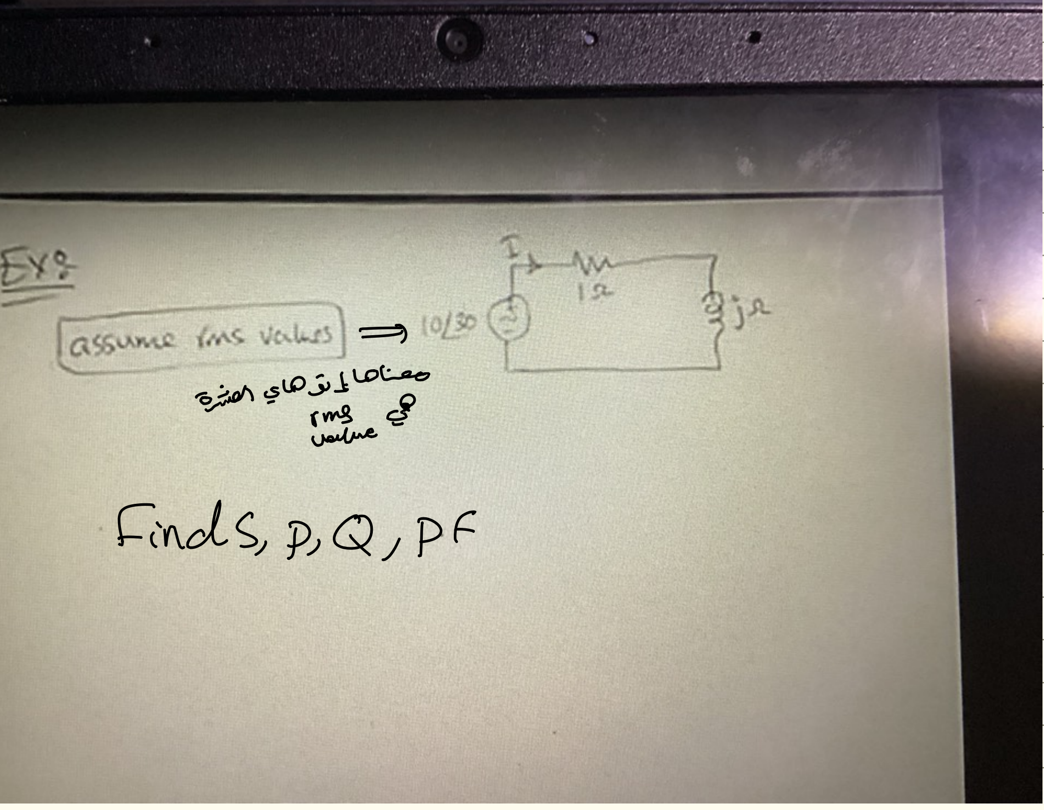
$$pf = \cos(\theta_v - \theta_i)$$

$$pf = \cos(0 - 27.35)$$

$pf = 0.89$ leading → عشان capacitive

↳ power factor → الزاوية

改善 KAIZEN TEAM



$Z = 1 + j = 1.41 \angle 45$

$I = \dfrac{V}{1.41\angle 45} = \dfrac{10\angle 30}{1.41\angle 45} = 7.07\angle -15$ A rms

$S = V_{rms} \times I^{*}_{rms}$
$= 10\angle 30 \times 7.07 \angle 15$

$S = 50 + 50i$ → P, Q → as inductive

$P = 50W$

$pf = \cos(\theta_v - \theta_i)$ $Q = 50$ var بيمثل ال j

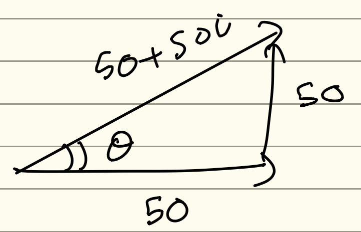
$pF = \cos(30 + 15)$

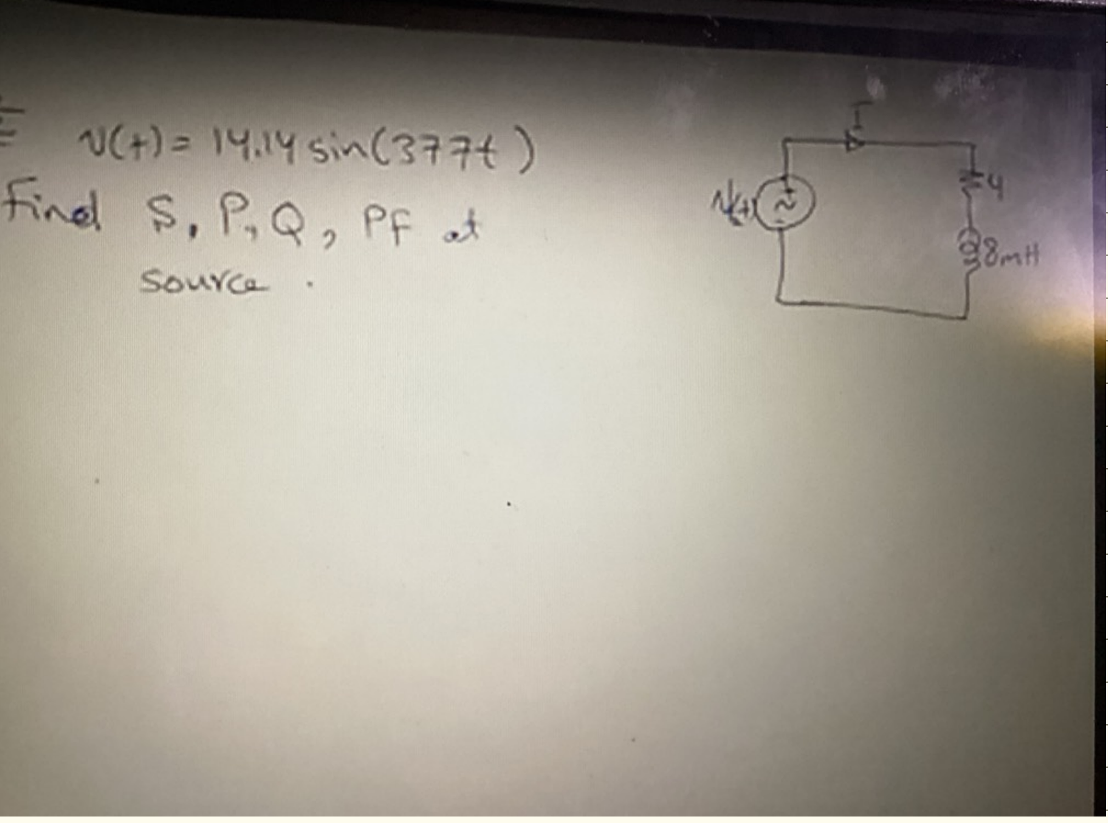
$pf = 0.707$ → Lag { لتيار ⇒ as inductive لأن

$P = (I_{rms})^2 R$ inductive load.

$P = (7.07)^2 \times 1 = 50W$

$Q = (I_{rms})^2 \times (1) = 50W$
so my answer is correct





$Z = j\omega L = j \times 8 \times 10^{-3} \times 377$

$Z = 3.016i$

$V = IR$

$P = V$

$v(t) = 14\cos(377t - 90)$

peak قيمة → $14\angle -90$

$I = \dfrac{v(t)}{3.016i + 4} = 2.8\angle -127.02$

قيمة peak

$P = |I_{rms}|^2 \times R$

$= (1.98\angle -127.02)^2 \times 4$

$V_{rms} = \dfrac{14\angle -90}{\sqrt{2}} = 4.9\angle 90$

$I_{rms} = \dfrac{2.8\angle -127.02}{\sqrt{2}}$

$I_{rms} = 1.48\angle -127.02$

$S = I_{rms}^{*} \times rms$

$S' = (9.9\angle 90) \times 1.98\angle -127.02$

ملغية

$S' = \underbrace{15.65}_{P} + \underbrace{11.8j}_{Q}$

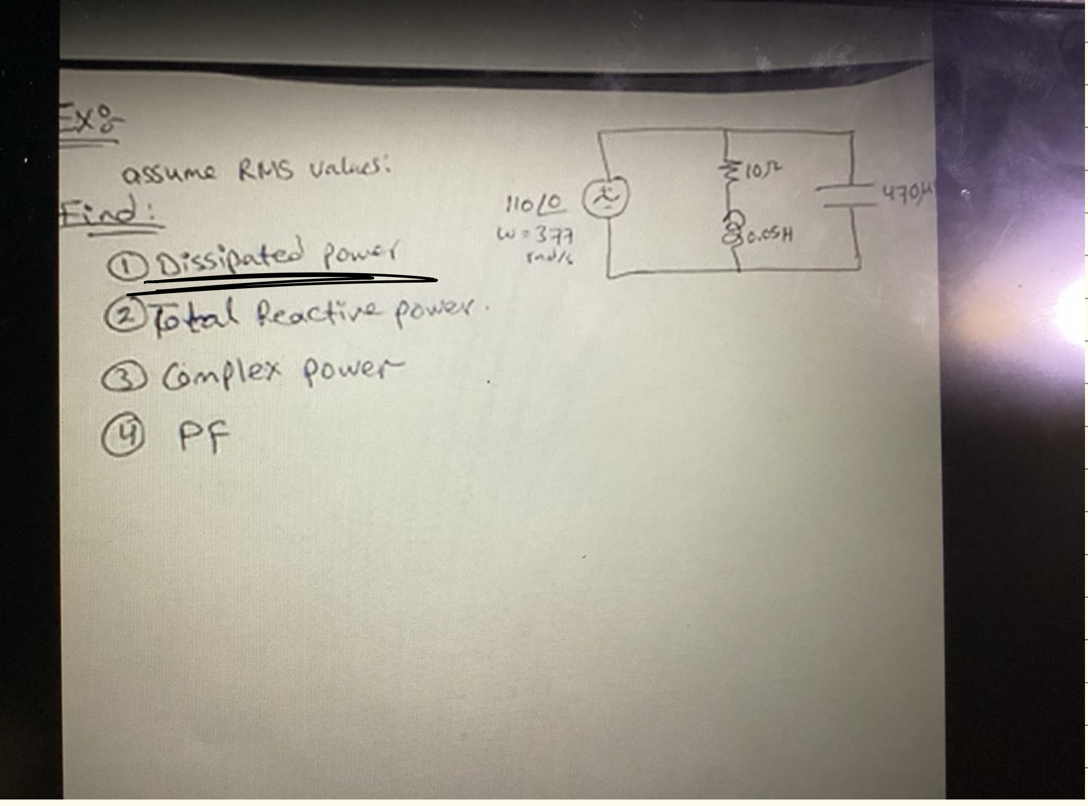
السالب

$P = 16$

$Q = 12\,Var$

↳ act as inductance

$PF = 0.79 \rightarrow$ Lags



Dissipated power
بحكي C في ا R دايماً

$470\mu f \rightarrow Z = \frac{-j}{470\times10^{-6}\times377} = 5.644j$

$0.05\ H \rightarrow Z = j\omega L = j \times 377 \times 0.05 = 18.85j$

$Z = 1.16 - 7.17i$

$Z = 7.27\angle{-80}$

$I = \frac{V}{Z} = \frac{110\angle 0}{116 - 7.17i}$

$I_{rms} = 0.946\angle 3.537$

$V = 110\angle 0$

to find pdissapated

$V_R = \frac{110\angle 0 \times 10}{10 + 18.85i}$

$V_R = 51.55\angle{-62.05}$ volt

$P = \frac{|V_R|^2}{R} = \frac{(51.55)^2}{10} = 265.74$ ← بس بال P وال Q ما بتعوض ال z

عشان أنا آخدت مرافقه

$S = V_{rms} \times I_{rms}^*$

$= 110\angle 0 * 0.946\angle 3.537$

وعليه

② Reactive power
بدها تكون بال capacity inductor

$Q_L = \frac{|V_L|^2}{Z}$

Complexpower $= 2.65074 - 1659i$

$V_L = \frac{110\angle 0(18.85)}{18.85 + 10}$

$V_L = 97.1727\angle{-62.05}$

$pf = \cos(\theta_v - \theta_i)$

$pf = \cos(0 - 80)$

$\theta_Z = 0$

$\theta_I = \angle 80 \rightarrow$ طالعة عالنص عشان هيك

$pf = 0.173648 \rightarrow$ leading

$Q_L = \frac{|V_L|^2}{Z} = \frac{(97.1727)^2}{18.85} = 501$ var

parallel 110 supply

$Q_C = \frac{|V_C|^2}{Z} = \frac{(110)^2}{5.6} = 2160.7$ var

بس هون هيك حطيتها

$Q_{total} = 501j - 2160j$

$\boxed{= -1659i\ VAR}$

power factor

$pf = \cos(\theta_v - \theta_i)$

$0 < pf < 1$

$S = \underbrace{V_{rms} I_{rms} \cos(\theta_v - \theta_i)}_{P} + V_{rms} I_{rms} \sin(\theta_v - \theta_i)$

$P = V_{rms} I_{rms} \underbrace{\cos(\theta_v - \theta_i)}_{pf}$

$$pf = \frac{P}{V_{rms} I_{rms}} = \frac{P}{|S|}$$

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

Cases for power factor

① when $pf = 1$ ⇒ pure resistive load

$\theta_v - \theta_i$

$\cos(\theta_v - \theta_i) = \cos(0) = 1$

$\underbrace{\sin(\theta_v - \theta_i) = 0}_{Q = 0}$

$Q = 0$ → كون الدارة ما فيها غير مقاومات

② when $pf = 0$

⇒ either inductive load

$Q > 0$

$pf \rightarrow lag$

$\underbrace{pf = 0}_{\text{special case}} \Rightarrow \cos(\theta_v - \theta_i) = \cos(90) = 0$

special case

& only in pure inductive load

→ pure capacitive load

$Q < 0$

$pf = \cos(\theta_v - \theta_i) = \cos 90 = 0$

③ inductive load (pure ملف) $pf \rightarrow lag$

④ Capacitive Load (pure مكثف) $pf \rightarrow leading$

Example:

$pf = 0.8$ Lag , $|S| = 1000\,VA$

↓

inductive Load

$S = |S| \angle + \cos^{-1}(pf)$

$\cos(\theta_v - \theta_i) = pf$

$\theta_v - \theta_i = \cos^{-1}(pf)$

Lagging ⇒ θ_s is possitive

Example:

$|S| = 1000\,VA$, $pf = 0.8$ lead

↓

$\theta_v - \theta_i = \cos^{-1}(pf)$ capacitive

so $Q < 0$

$S = |S| \angle -\cos^{-1}(pf)$

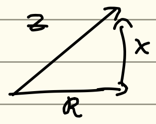
↳ because it's lead.

leading ⇒ θ_s ⇒ is negative

important Facts related to complex power:-

impedence traingle

$z = R + jx$



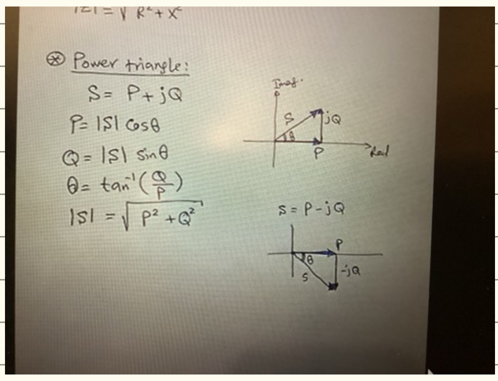
$R = |z| \cos\theta$

$x = |z| \sin\theta$

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

$|z| = \sqrt{R^2 + x^2}$

power traingle



$|z| = \sqrt{R^2+x^2}$

Power triangle:

$S = P + jQ$

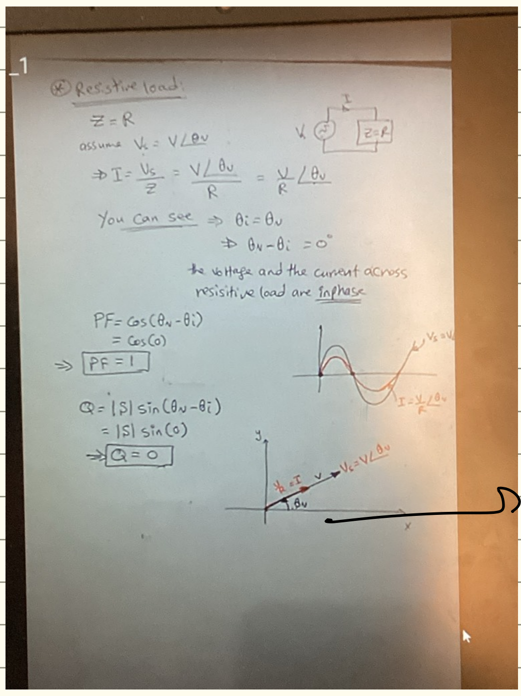
$P = |S| \cos\theta$

$Q = |S| \sin\theta$

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

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

Resistive Load.



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Resistive load:

$Z = R$

assume $V_s = V\angle\theta_v$

$\Rightarrow I = \frac{V_s}{Z} = \frac{V\angle\theta_v}{R} = \frac{V}{R}\angle\theta_v$

You can see $\Rightarrow \theta_i = \theta_v$

$\Rightarrow \theta_v - \theta_i = 0°$

the voltage and the current across resisitive load are inphase

$PF = \cos(\theta_v - \theta_i)$

$= \cos(0)$

$\Rightarrow \boxed{PF = 1}$

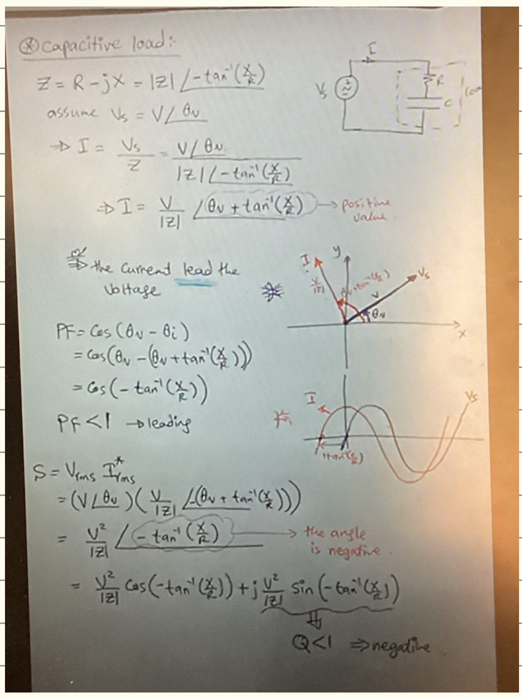
$Q = |S| \sin(\theta_v - \theta_i)$

$= |S| \sin(0)$

$\Rightarrow \boxed{Q = 0}$

ليش فوق بعض؟
لأنه ال
phase shift
بيساوي صفر

capacitive Load



capacitive load:

$Z = R - jX = |Z|\angle -\tan^{-1}\left(\frac{X}{R}\right)$

assume $V_s = V\angle\theta_v$

$\Rightarrow I = \frac{V_s}{Z} = \frac{V\angle\theta_v}{|Z|\angle -\tan^{-1}\left(\frac{X}{R}\right)}$

$\Rightarrow I = \frac{V}{|Z|}\angle\left(\theta_v + \tan^{-1}\left(\frac{X}{R}\right)\right)$ → positive value

$\Rightarrow$ the current lead the voltage

$PF = \cos(\theta_v - \theta_i)$

$= \cos\left(\theta_v - \left(\theta_v + \tan^{-1}\left(\frac{X}{R}\right)\right)\right)$

$= \cos\left(-\tan^{-1}\left(\frac{X}{R}\right)\right)$

$PF < 1 \rightarrow$ leading

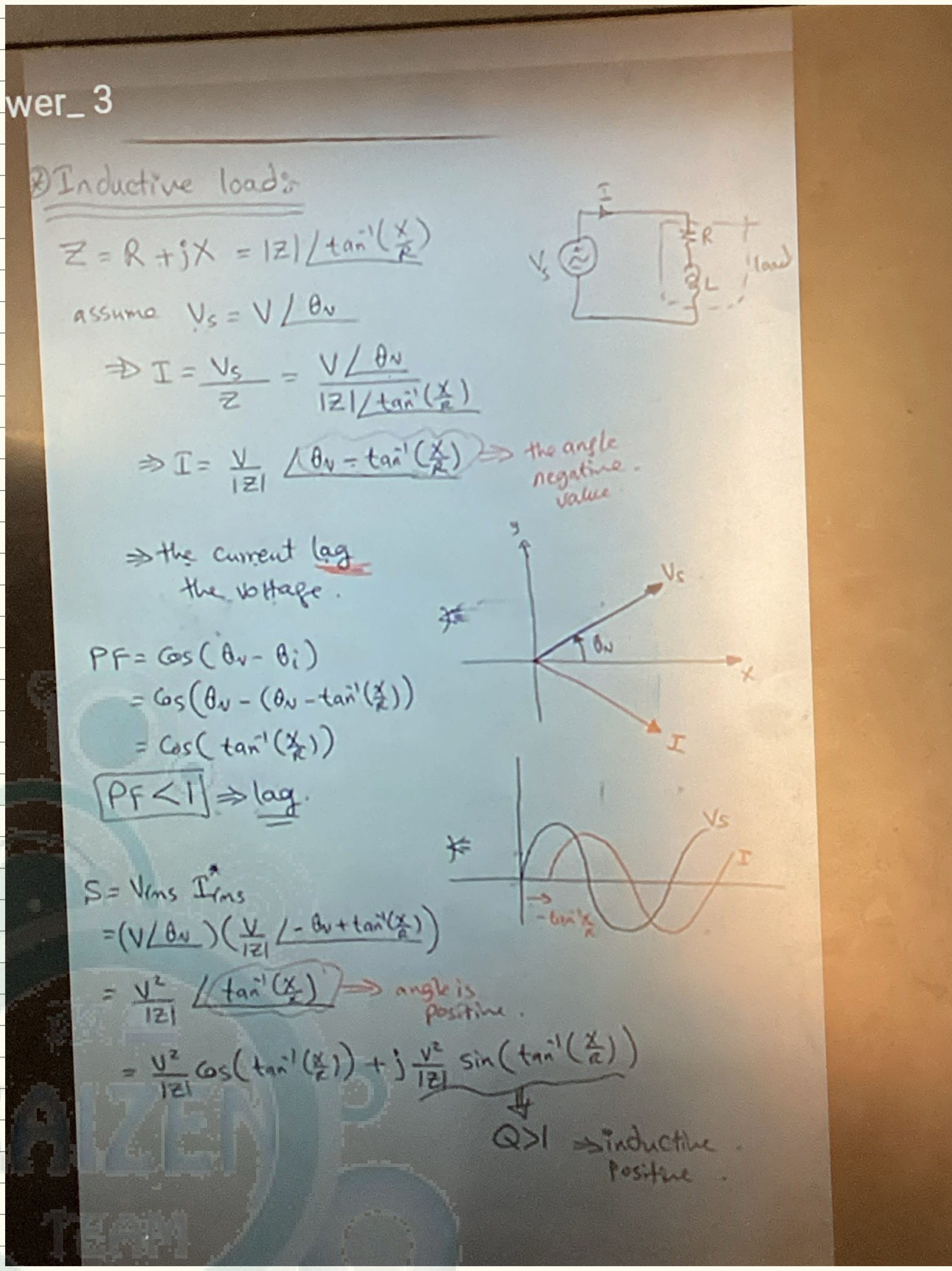
$S = V_{rms} I^*_{rms}$

$= (V\angle\theta_v)\left(\frac{V}{|Z|}\angle -\left(\theta_v + \tan^{-1}\left(\frac{X}{R}\right)\right)\right)$

$= \frac{V^2}{|Z|}\angle\left(-\tan^{-1}\left(\frac{X}{R}\right)\right)$ → the angle is negative.

$= \frac{V^2}{|Z|}\cos\left(-\tan^{-1}\left(\frac{X}{R}\right)\right) + j\underbrace{\frac{V^2}{|Z|}\sin\left(-\tan^{-1}\left(\frac{X}{R}\right)\right)}_{Q<1 \Rightarrow \text{negative}}$

inductive Load:-



wer_3

Inductive load:

$Z = R + jX = |Z|\angle\tan^{-1}\left(\frac{X}{R}\right)$

assume $V_s = V\angle\theta_v$

$\Rightarrow I = \frac{V_s}{Z} = \frac{V\angle\theta_v}{|Z|\angle\tan^{-1}\left(\frac{X}{R}\right)}$

$\Rightarrow I = \frac{V}{|Z|}\angle\left(\theta_v - \tan^{-1}\left(\frac{X}{R}\right)\right)$ → the angle negative value

$\Rightarrow$ the current lag the voltage.

$PF = \cos(\theta_v - \theta_i)$

$= \cos\left(\theta_v - \left(\theta_v - \tan^{-1}\left(\frac{X}{R}\right)\right)\right)$

$= \cos\left(\tan^{-1}\left(\frac{X}{R}\right)\right)$

$\boxed{PF < 1} \Rightarrow$ lag.

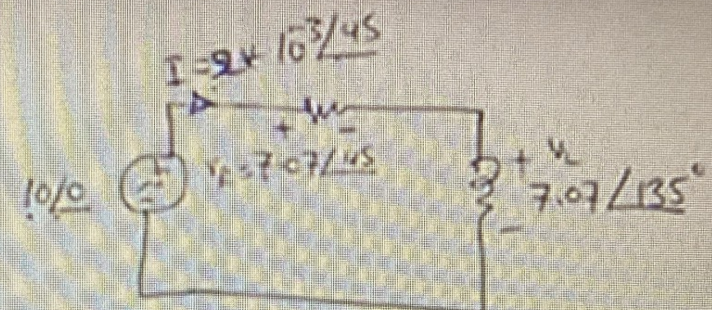
$S = V_{rms} I^*_{rms}$

$= (V\angle\theta_v)\left(\frac{V}{|Z|}\angle -\theta_v + \tan^{-1}\left(\frac{X}{R}\right)\right)$

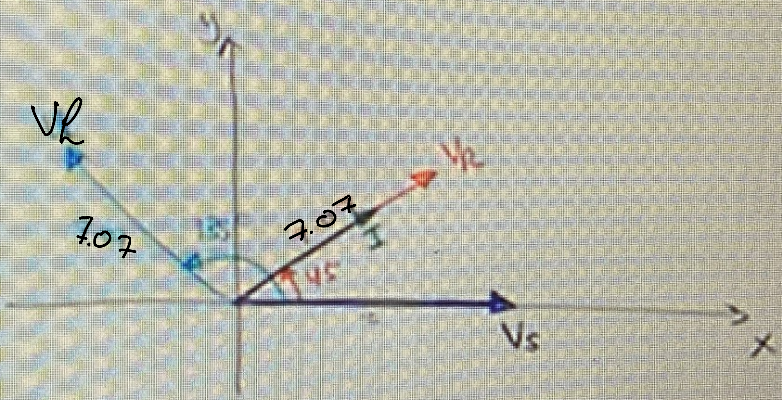
$= \frac{V^2}{|Z|}\angle\tan^{-1}\left(\frac{X}{R}\right)$ → angle is positive.

$= \frac{V^2}{|Z|}\cos\left(\tan^{-1}\left(\frac{X}{R}\right)\right) + j\underbrace{\frac{V^2}{|Z|}\sin\left(\tan^{-1}\left(\frac{X}{R}\right)\right)}_{Q>1 \Rightarrow \text{inductive Positive.}}$

Ex:



Draw phasor Diagram.



* أول إشي بنلاحظ إنو ال VR و I بنفس ال phase

* تاني شي بنلاحظ إنو ال VL

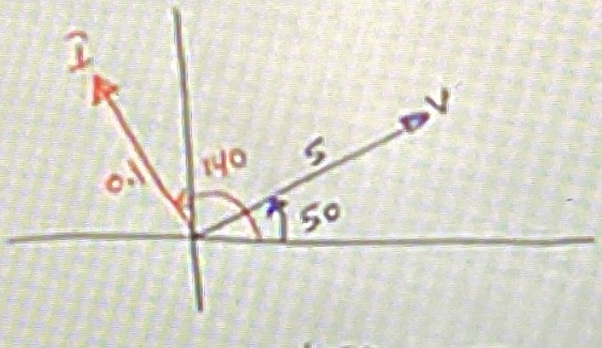
current Lags the voltage with 90°

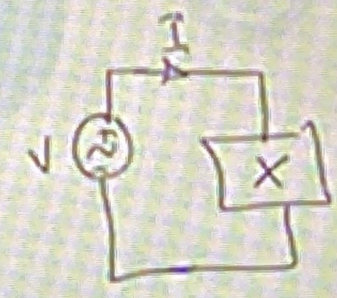
لأنو inductor

* بس إذا بدو بالنسبة لل Vs ⇐ supply

current Lead Vs with 45°

Ex:





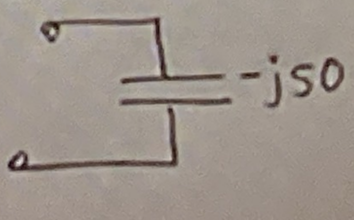
$$V = 5\angle 50, \quad I = 0.1\angle 140 \quad \Bigg\} \quad X = \frac{V}{I} = \frac{5\angle 50}{0.1\angle 140}$$

$$\boxed{X = 50\angle -90}$$

$$\Downarrow$$

$$\boxed{X = -j50}$$

It's pure capacitive.



Power factor correction:-

$pf = \cos(\theta_v - \theta_i)$

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

$S = P + jQ = |S| \angle \theta$

Ex: $S = \underbrace{600}_{\text{لم الي أنا بدفعهم}} + j800 = \underbrace{1000\angle 53.13^\circ}_{\text{الي شركة الكهربا بتدفعهم}}$

pf is poor (Ex pf = cos(53.13 = 0.6)

if $pf = 1 \Rightarrow P = |S|$ بتصير شركة الكهربا تحاسب بالزبط عقد الطاقة الي أنا استهلكها

↳ Ideal case

يعني بدنا نعدل مقدار Q بحيث نزعج قيمة الـ power

Power factor correction: a method to reduce the Lagging power reactive in the inductive Load by fixing a high value capacitor

because it has negative power reactive which cancel the positive reactive in the inducting Load

$\Rightarrow Q_{Total} \simeq 0$

$pf \simeq 1$

⇒ capacitor added in parallel with the Load

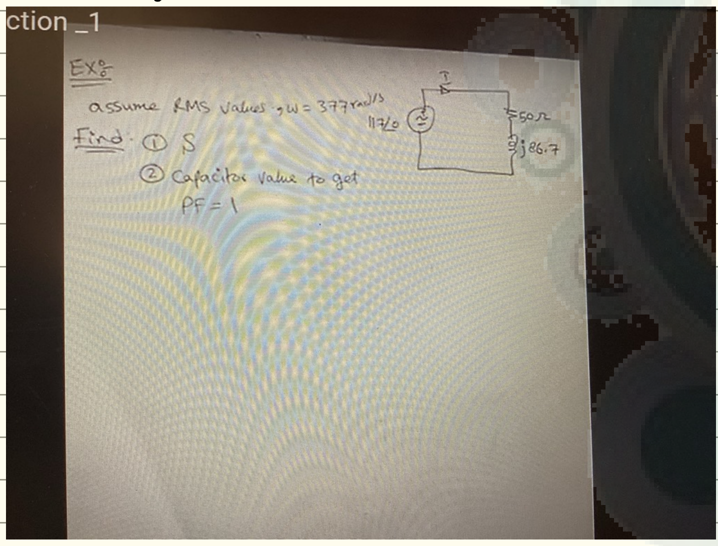
Capacitor الـ قيمة لـ تحسب كيف بدنا

$C = \dfrac{\overset{power}{P} \times (\tan(\overset{before}{\theta_1}) - \tan(\overset{after}{\theta_2}))}{\omega |V_{rms}|^2}$

θ هي الـ (S)

supply الـ تبع الـ قيمة لـ الي ع

Example



$I = \frac{V}{50 + 86.7j} = 1.169 \angle -60.0279$

① $S = I^*_{rms} \times V_{rms}$

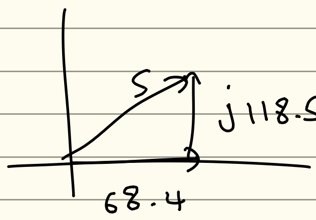
$1.169 \angle 60.0279 \times V_{rms}$

$= \underbrace{68.32881}_{\text{أنا بحاسب}} + j118.5i = \underbrace{136.7}_{\text{شركة الكهربا}} \angle 60$

② $pf = \cos(\theta_v - \theta_i) = \cos(0 + 60.0279)$ | $(\theta_v - \theta_i)_{old} = 60.03$

pf = 0.5 lagging

poor



$\Rightarrow$ need $pf = 1 \Rightarrow (\theta_v - \theta_i)_n$

need to add capacitor

with $Q = -j118.5$

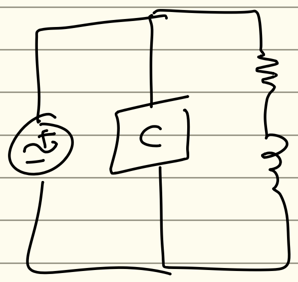
such that $Q_{total} = 0$

$118.5 = (I_{rms})^2 X_C$

$$X_C = \frac{118.5}{(1.17)^2} = 115.22$$

$$115.52 = \frac{1}{\omega C}$$

$C = 23.1\ \mu F$



$$C = \frac{P_r(\tan(\theta_{befor}) - \tan(\theta_{after}))}{\omega |V_{rms}|^2}$$

I [illegible]

[illegible]

$$C = \frac{P_r(\tan(60.03) - \tan(0))}{377 \times (117\angle 0)}$$

$$C = \frac{(68.4)(\tan(60.03) - \tan 0)}{(377)(117)^2}$$

$C = 23.1\ \mu F$