Electrical Engineering

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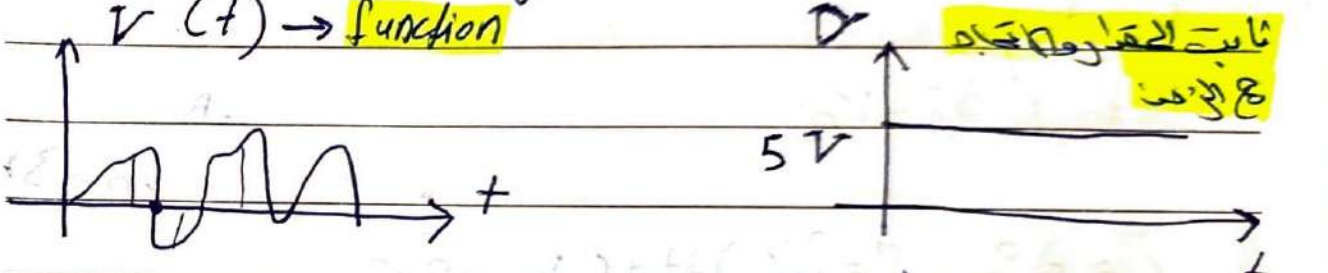
Electrical engineering

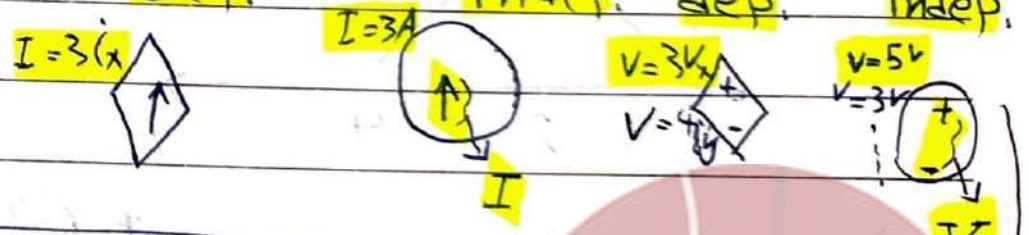
1. power supply → produce energy
2. connections
3. load → consum the energy.

Power supplies (P.S) (source)

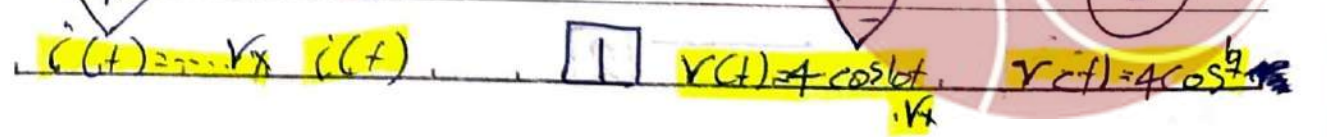
- A.C. (Alternating current)
- D.C. (Direct current)



- Current (I) — A → unit
- Voltage (V) — V → unit

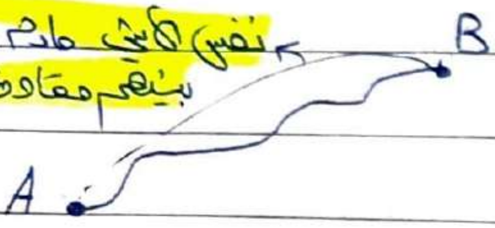


- Current
  - dep.
  - indep.
- Voltage
  - dep.
  - indep.



* load : R (Ω)

نفس الاشي مادام مافي بينهم مقاومة (ideal)



$$R = \frac{\rho \cdot L}{A}$$

الشغل اللازم لنقل شحنة من A الى ال ∞

• A $V_A = 5v$

$$v = \frac{dw}{dq}$$

$$V_{AB} = V_A - V_B$$

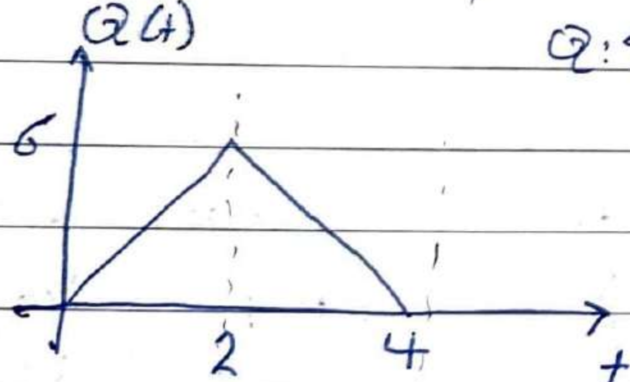
• B $V_B = 3v$

$$i = \frac{dq}{dt} \quad , \quad q = \int i(t)\, dt + c$$

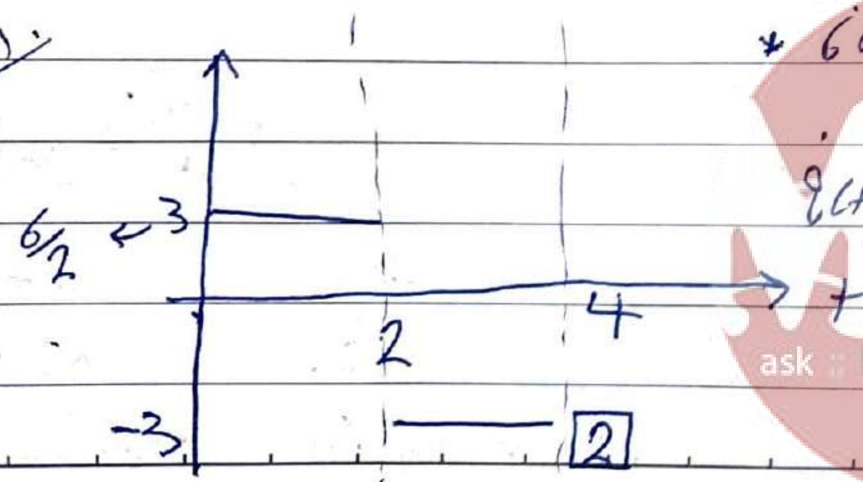
$V_c = -2v$

* سؤال امتحان

Q: sketch the current?? (wave form)

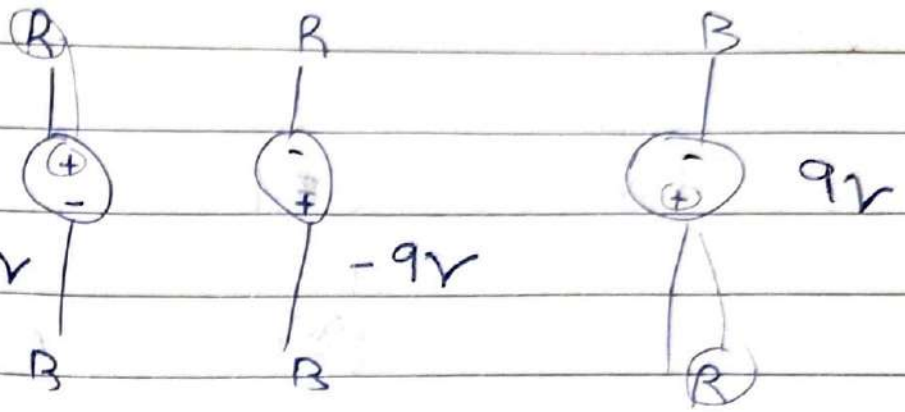


sol:



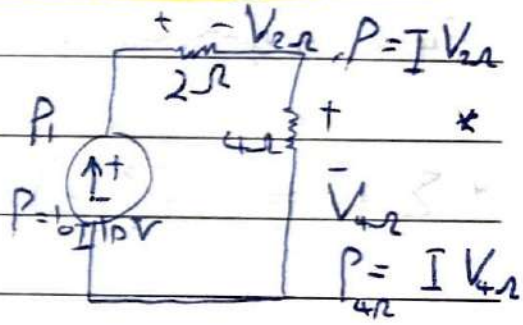
* $i(t) = 3 \sin 6t$

$q(t) = -\frac{3}{6} \cos 6t + c$



* $V = I \cdot R$, $V \propto I$ (ohm's law)

* التيار يخرج من القطب الموجب



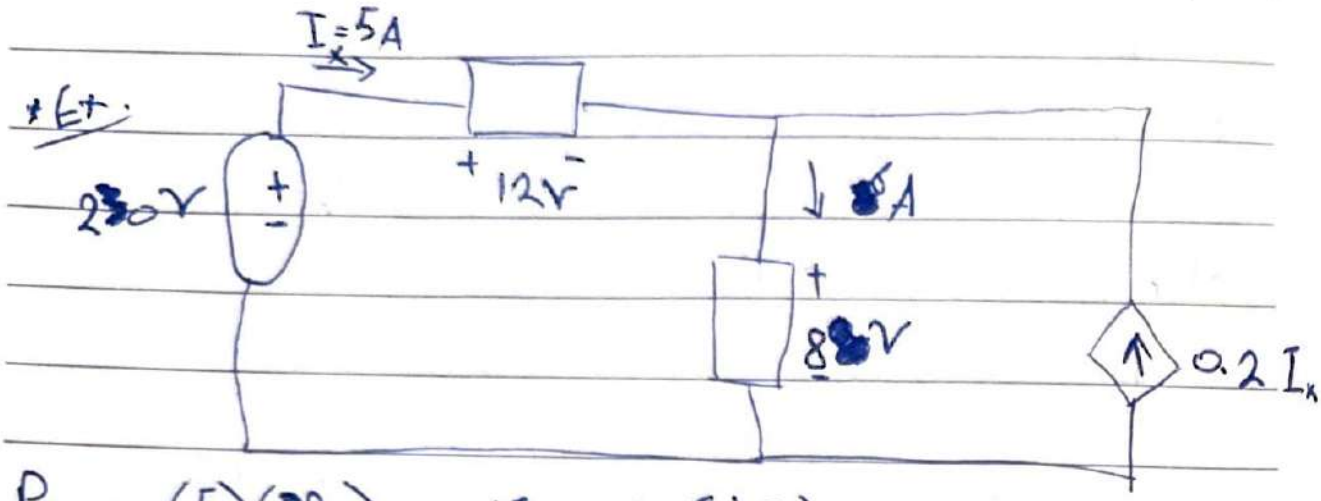
* Power (P) → Watt (W)
* Energy (W, E) → Joule (J)

* $P = \frac{dE}{dt}$, $E = \int P(t) \cdot dt$

* $P = I.V = \frac{V^2}{R} = I^2 R$ (W)

* P(-) produce, deliver انتاج
* P(+) consumed, absorbed استهلاك

* اذا التيار طلع من الـ + يبقى + ويكون consumed (موجب)
* اذا التيار طلع من الـ - يبقى - ويكون Produced



$P_1 = -(5)(32) = -180$ w (de.)

$P_2 = +(5)(12) = +60$ w (cons.)

$P_3 = +(6)(8) = +48$ w (cons.)

$P_4 = -8$ w (de.)

* $\sum P = 0$ (P;S)

* Paralled element have same Volt and same Polarity.

* 700 kwh = 12 + 16 + 20 + 24 = 72 $

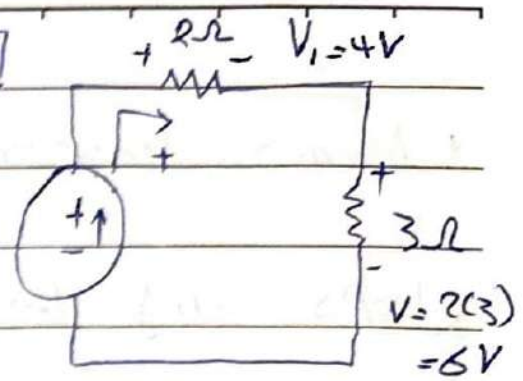
12 $

0-100, 0.16 $

101-300, 0.1 $

301 -> 700, 0.06 $

$I = \frac{10}{5} = 2A$



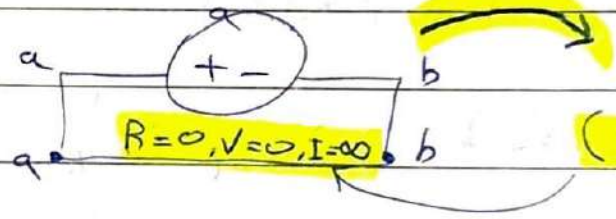
* $P_1 = -(10)(2) = -20$ watt
* $P_2 = +(4)(2) = +8$ watt cons.
* $P_3 + (6)(2) = +12$ watt cons.

* R(Ω) , G : conductance = $\frac{1}{R}$ (S) (ohm), mho

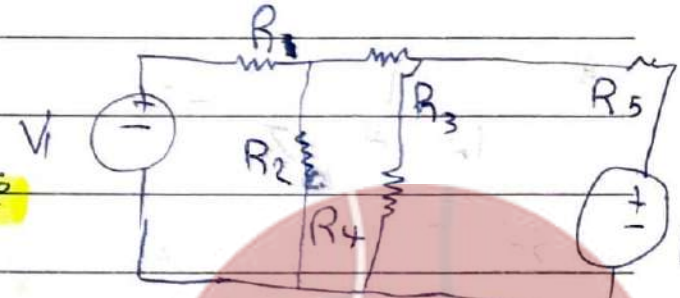
* 

open ckt (O.C) , V = ✓ , I = 0 , $I = \frac{V}{R}$ ← R = ∞ (مقاومة لانهائية)

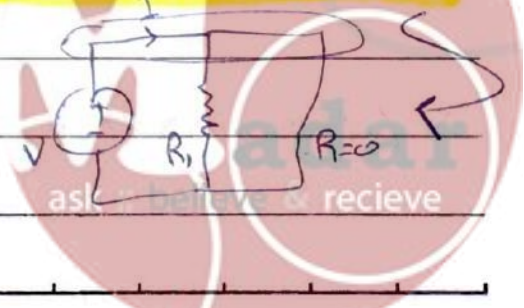
* المؤشر يومض على التوازي مع البطارية
* الأميتر يومض على التوالي مع البطارية

* 

* Branch: Any part of circle have 1 element or more



* Short . C ; any element on paralled with S . C is erase .



* Noodes: connection of two branches or more. (voltage لحساب)

* loops: any closed circle.

* mesh: current لحساب (loop خاص)

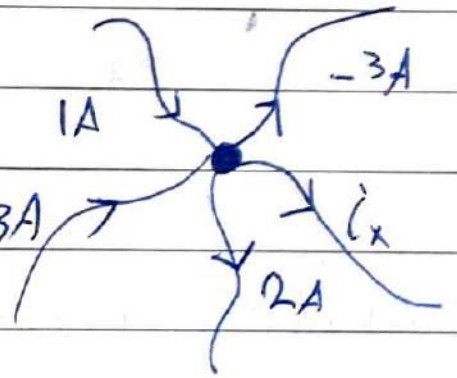
* mesh هو loop وليس كل loop هو mesh

* Reference Nood او ground node لحساب الـ voltage وتكون zero.

* kirchoff's ↔ current law (KCL)
voltage law (KVL)

KCL: at any node → $\Sigma I = 0$, $\Sigma I_{in} = \Sigma I_{out}$

*



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

$3 + 1 = (3) + 2 + i_x$

$\therefore i_x = 5A$

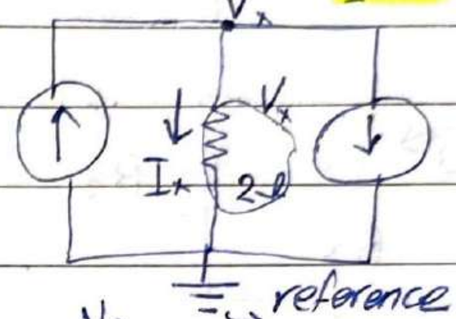
* current sources in parallel can be added.

التوازي

* مصادر التيار على التوازي تجمع و الجهد متساوي

مصادر الجهد على التوالي تجمع والتيار متساوي

*Ex:



Find V_x ??

2 Noods

(single Noods ckt)

↳ 1 active nood

sol:

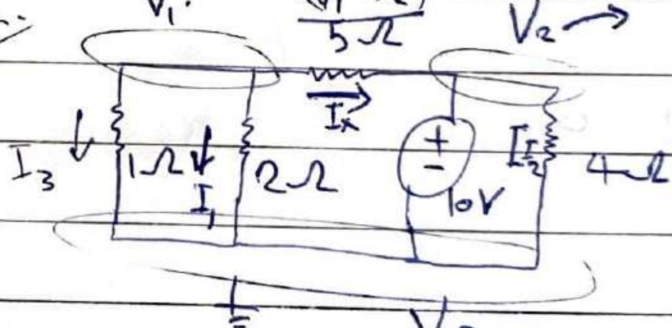
{ لو مقاومة واحدة بين active nood و reference فالتيار لازم

يكون نازل من الـ active nood باتجاه الـ reference }

$3 = i_x + 4$

$3 = \frac{V_x}{2} + 4 \Rightarrow \boxed{V_x = -2V}$

*Ex:



3 Noods

$\frac{V_1}{1} + \frac{V_1}{2} + \frac{V_1 - V_2}{5} = 0$

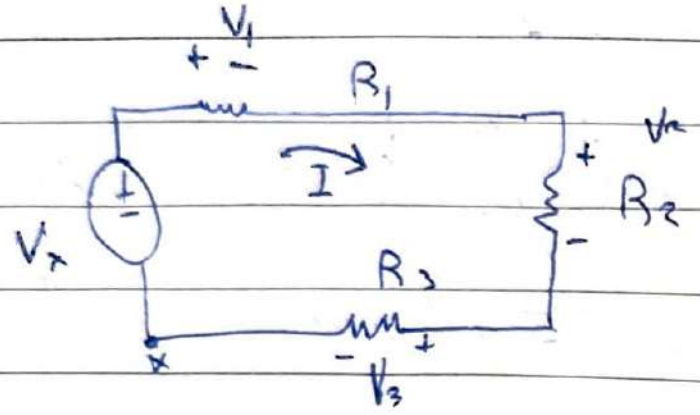
$10V_1 + 5V_1 + 2V_1 - 2V_2 = 0$

$V_1 = 20/17$

{ المقاومة الواصلة بين 2 active noods أي منهم الجاي والتيار متساوي }

VKL: for any closed path the SUM of voltages equal zero.

Ex:



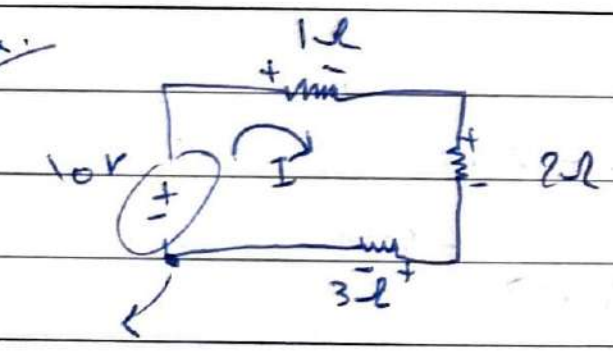
single mesh

G: x الى

$-V_x + V_1 + V_2 + V_3 = 0$

$-V_x + IR_1 + IR_2 + IR_3 = 0$ solve for I

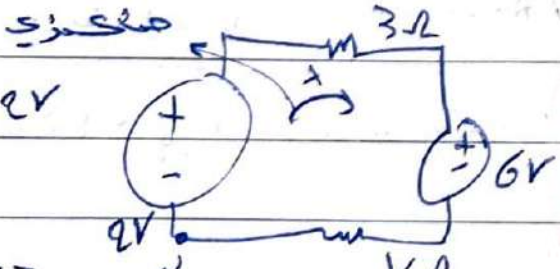
Ex:



$-10 + 1I + 2I + 3I = 0$

$I = \frac{10}{6}\ A$

Ex1

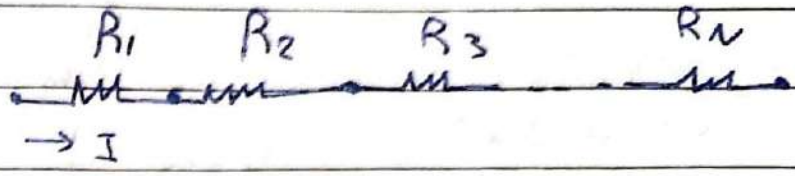


$-2 + 3I + 6 + 8I = 0$

$\therefore I = \frac{-4}{11}$

8

* series:

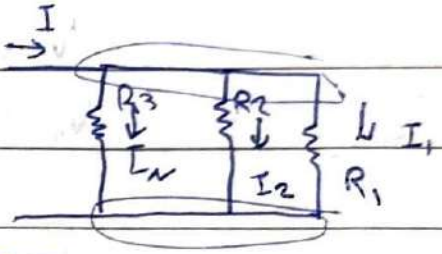


$$I = I_1 = I_2 = \cdots I_N$$

$$V_T = V_1 + V_2 + \cdots V_N$$

$$R_T = R_1 + R_2 + \cdots R_N$$

* parallel:

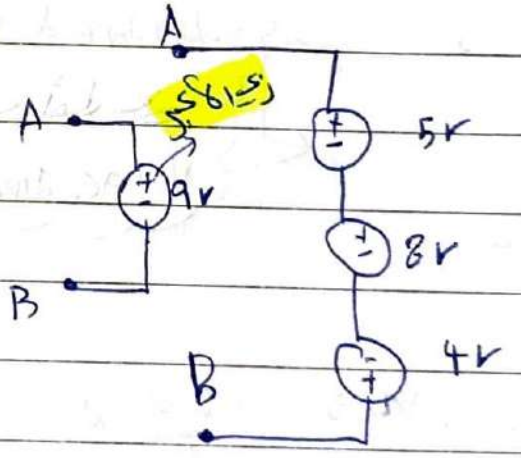


$$I_T = I_1 + I_2 + \cdots I_N$$

$$V_1 = V_2 = \cdots V_N$$

$$1/R_T = 1/R_1 + 1/R_2 + \cdots 1/R_N \quad , \quad R_T = \frac{R_1 \cdot R_2}{R_1 + R_2}$$

*



Voltage divider

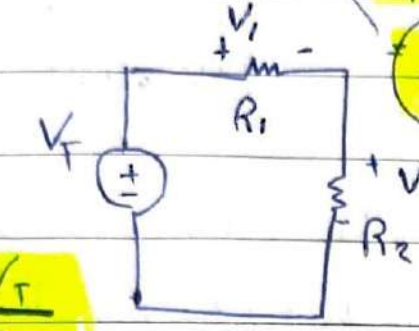
$V_1 = I \cdot R_1$

$\frac{V_T \cdot R_1}{R_1 + R_2}$

* Voltage divider:

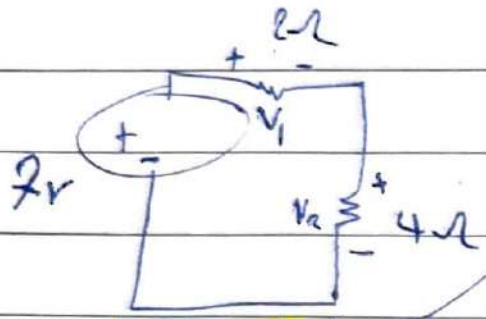
(مبدأ تقسيم الجهد)

(الجهد يكون مقسم على I_T)



$I = \frac{V_T}{R_1 + R_2}$

Ex:



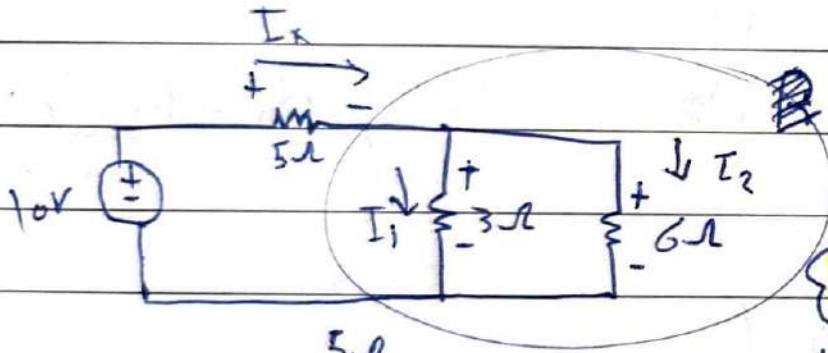
(standered CKT)

$V_1 = \frac{7 \cdot 2}{2+4} = \frac{14}{6}$

$V_2 = \frac{7 \cdot 4}{2+4} = 28/6$

$V_2 - V_T - V_1$

Ex:

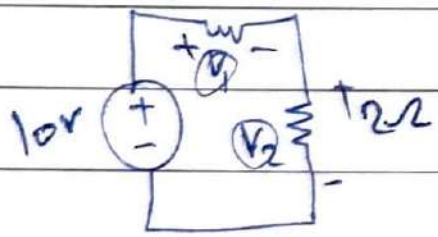


طريقة الحل

standered CKT

عن طريق

Voltage divider



$V_1 = \frac{(10)(5)}{2+5} = 50/7\ V$

$V_2 = \frac{(10)(2)}{2+5} = 20/7\ V$

$I_1 = V_2/3 = \frac{(20/7)}{3}\ A$

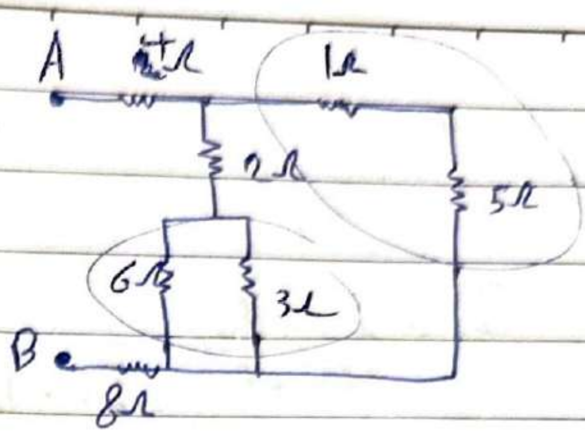
$I_2 = \frac{V_2}{6} = \frac{(20/7)}{6}\ A$

$I_x = I_1 + I_2\ A$

$I_x = V_1/5\ A$

10

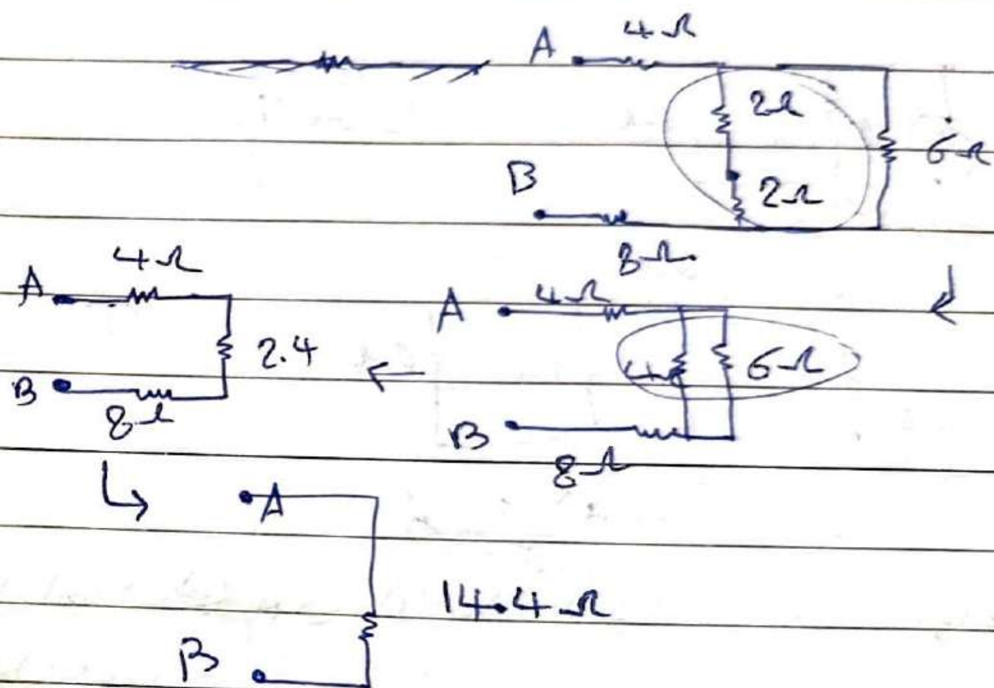
Ex.



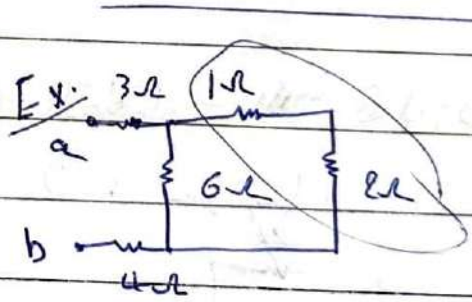
Req ??
R_T
R_{AB}

* دائماً بيبدأ من ابعد نقطة

sol:

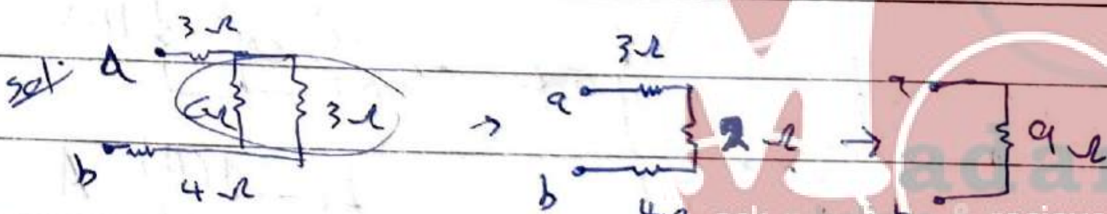


* Ex.

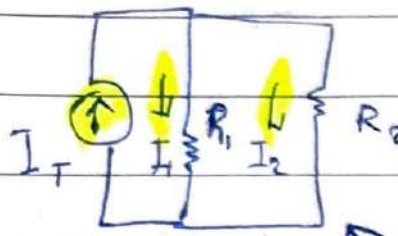


Rab
Req
R_T

sol:



current divider:



(Standard ckt)

$$I_1 = \frac{I_T \cdot R_2}{R_1 + R_2}, \quad I_2 = I_T - I_1$$

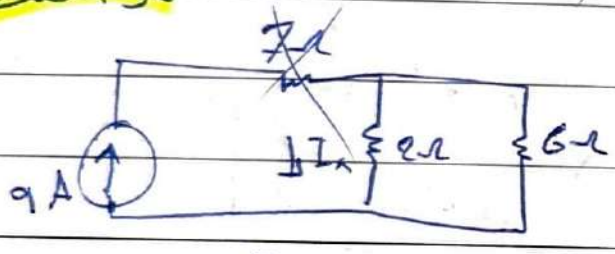
$$I_2 = \frac{I_T \cdot R_1}{R_1 + R_2}$$

Ex1:

$$I_1 = \frac{9 \cdot 6}{8}$$

عزم لست

Ex2:

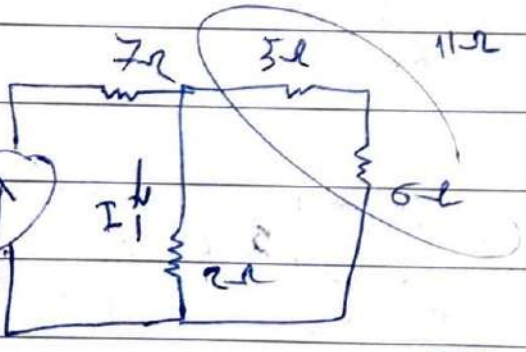


$$I_x = \frac{(9)(6)}{2+6} \text{ A}$$

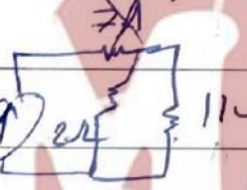
* المقاومة اللي بدي اشتغل عليها هيروح اضربها على توالي وعلى توازي :

* المعادلات اللي هتدار needs ما بتأثر على التيار الكارنط

Ex3:

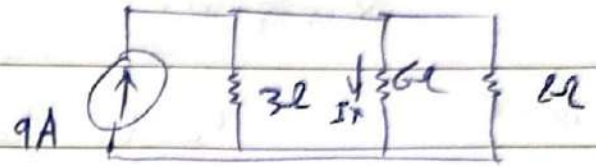


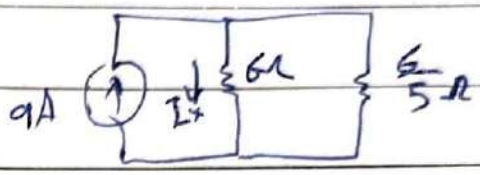
(∵ بعدها)



$$I_1 = \frac{9(11)}{11+2} \text{ A}$$

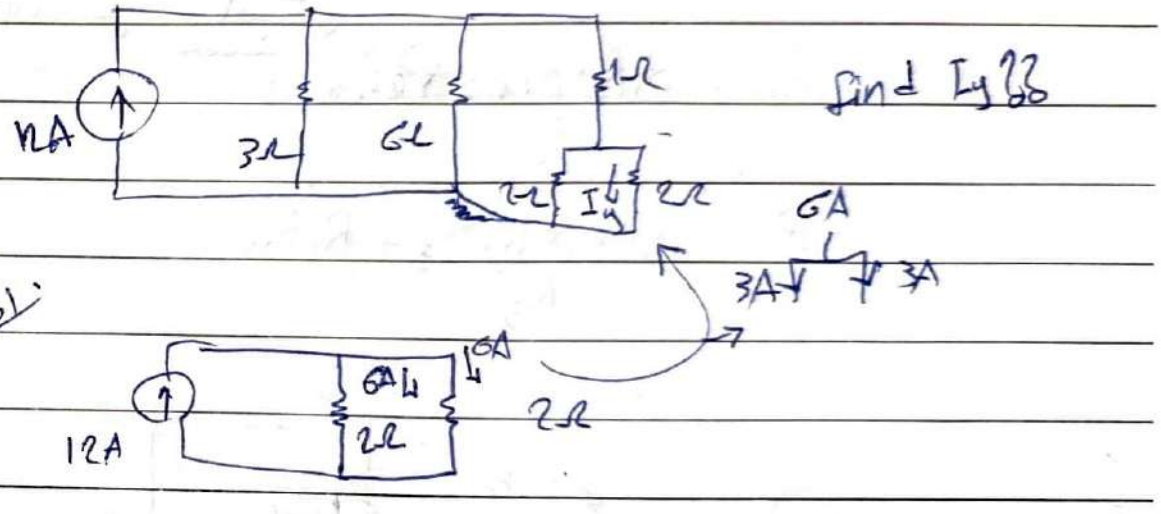
Ex



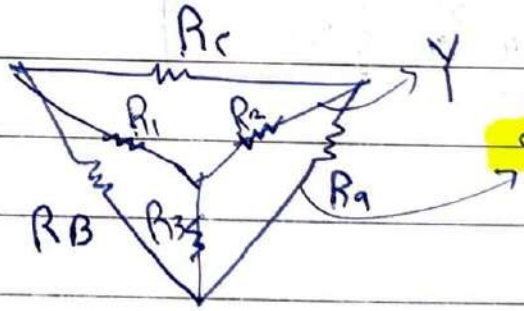


$$I_x = \frac{(9)(\frac{6}{5})}{\frac{6}{5}+6} A$$

Ex:



Sol:



delta to a (D)

* $D \rightarrow Y$: $R_1 = \frac{R_B R_C}{R_A + R_B + R_C}$ ← R_1 مجاورة بين R_2 و R_B

(المقام ثابت)

$$R_2 = \frac{R_A R_C}{R_A + R_B + R_C}$$

$$R_3 = \frac{R_A R_D}{R_A + R_B + R_C}$$

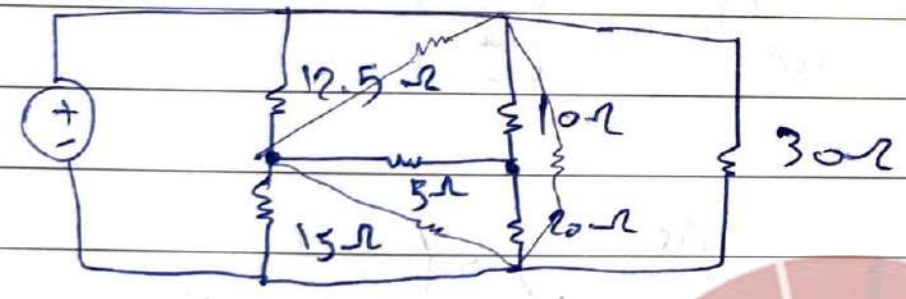
* $Y \rightarrow D$: $R_A = \frac{R_1 R_2 + R_1 R_3 + R_2 R_3}{R_1}$ ← اقسم عدها

(البسط ثابت)

$$R_B = \frac{R_1 R_A + R_1 R_3 + R_2 R_3}{R_2}$$

$$R_C = \frac{R_1 R_2 + R_1 R_3 + R_2 R_3}{R_3}$$

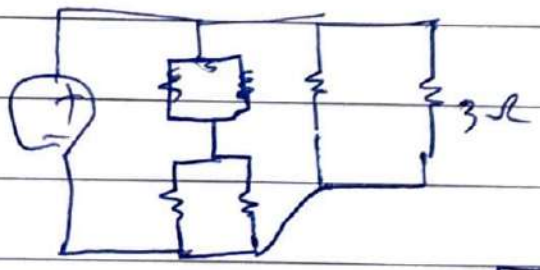
Ex:



120v

T.T 38

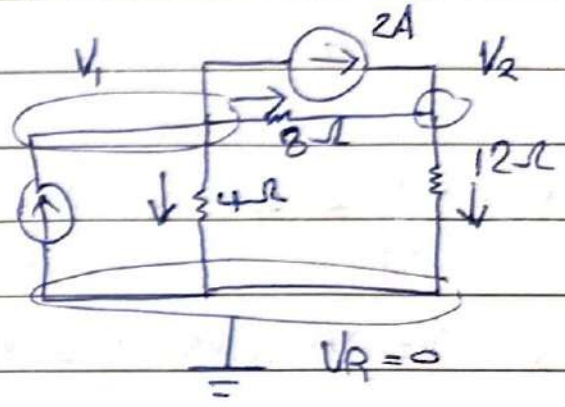
Sol:



* إذا المقاومات على التوازي متساويات ← المقاومة المكافئة = المقاومة على التوازي / عددها

* chp#3 : Nodal analysis

(عدد العقد الفعالة = عدد الـ (Active nods



N1: $2 + \frac{V_1 - V_2}{8} + \frac{V_1}{4} = 6$

$4 = \frac{V_1 - V_2}{8} + \frac{V_1}{4} \rightarrow 32 = V_1 - V_2 + 2V_1 \rightarrow \boxed{3V_1 - V_2 = 32}$ — (1)

N2: $I_5 + I_3 = I_4 \rightarrow 2 + \frac{V_1 - V_2}{8} = \frac{V_2}{12}$

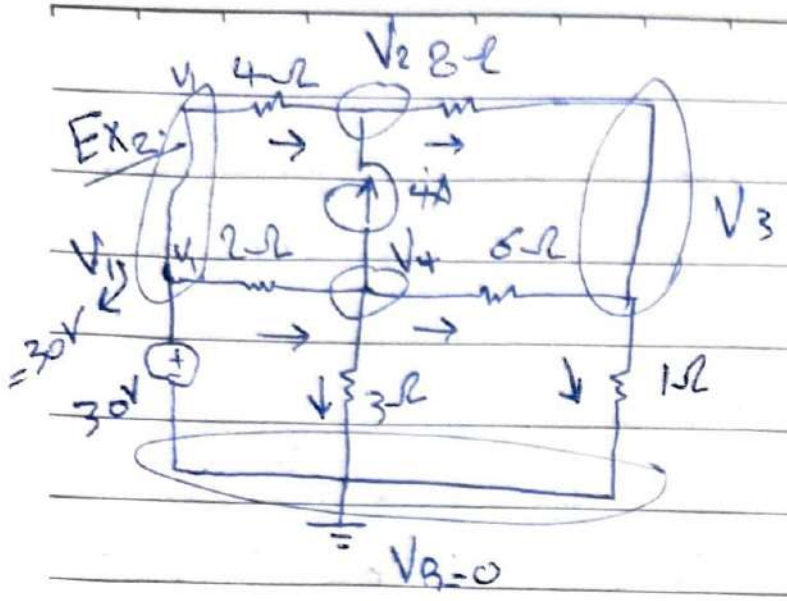
$\boxed{3V_1 - 5V_2 = -48} \leftarrow 48 + 3V_1 - 3V_2 = 2V_2$ — (2)

(1), (2) $\rightarrow$ $3V_1 - V_2 = 32$, $3V_1 - 5V_2 = -48$

$4V_2 = 80 \rightarrow \boxed{V_2 = 20\ V}$

$3V_1 - 20 = 32 \rightarrow \boxed{V_1 = \frac{52}{3}\ V}$

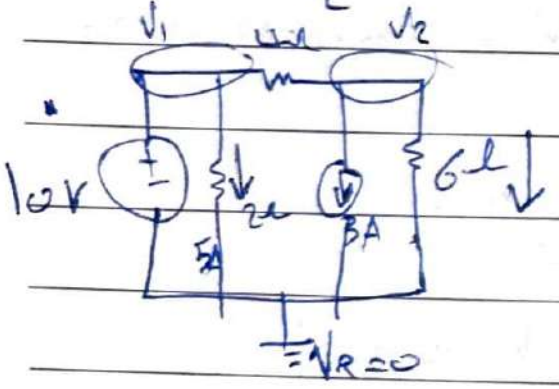
Ex 2:-



N2: $\frac{V_1 - V_2}{4} + 4 = \frac{V_2 - V_3}{8}$ — (1)

N3: $\frac{V_2 - V_3}{8} + \frac{V_4 - V_3}{6} = \frac{V_3}{1}$ — (2)

N4: $\frac{30 - V_4}{2} = 4 + \frac{V_4 - V_3}{6} + \frac{V_4}{3}$ — (3)

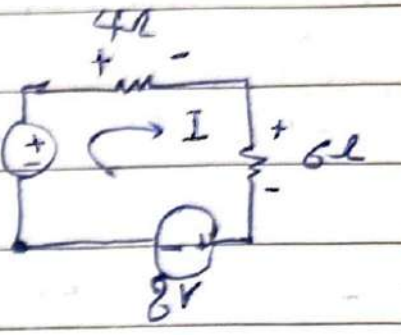


$V_1 = 10$ — (1)

N2: $\frac{10 - V_2}{4} = 3 + \frac{V_2}{6}$ — (2)

* Mesh analysis: (KVL)

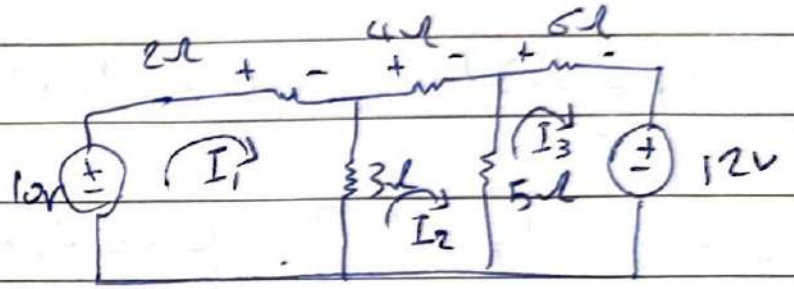
Single mesh →



$-10 + 4I + 6I + 8 = 0$

solvee for I

Ex.



M1: $-10 + 2I_1 + 3(I_1 - I_2) = 0$ — (1)

$5I_1 - 3I_2 = 10$

M2: $= +4I_2 + 5(I_2 - I_3) + 3(I_2 - I_1) = 0$

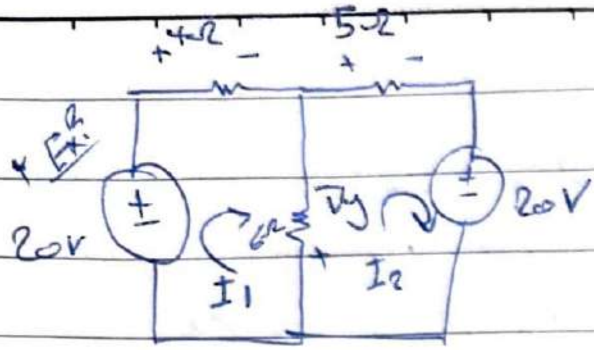
$-3I_1 + 12I_2 - 5I_3 = 0$ — (2)

M3: $6I_3 + 12 + 5(I_3 - I_2) = 0$

$-5I_2 + 11I_3 = -12$ — (3)

$\therefore I_1 = 2.04\,A, \quad I_2 = 0.068\,A, \quad I_3 = -1.06\,A$

* Ex 2:



Vy ??

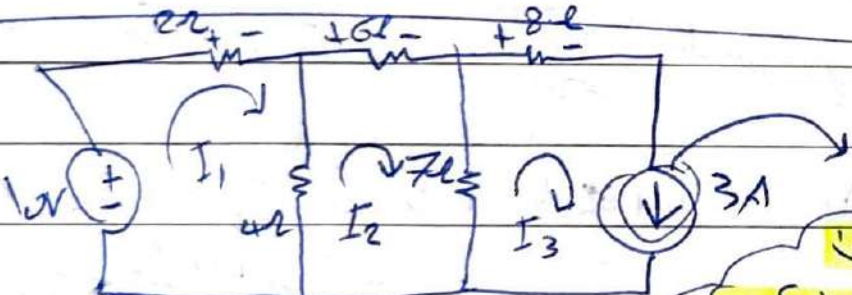
$18 I_1 - 6 I_2 = 20$ — (1)

$-6 I_1 + 11 I_2 = -20$ — (2)

$I_1 = 1.35A, \quad I_2 = -1.08A$

$V_y = 6 [I_2 - I_1]$ ∴ [طلع ال I بعدين بحسب المطلوب]

* Ex 3:



دا لأن
الاتجاه العكس
ف نغير اشارة ال I

$I_3 = 3A$

M1: $-10 + 2 I_1 + 4 (I_1 - I_2) = 0$ — (1)

M2: $6 I_2 + 7 (I_2 - I_3) + 4 (I_2 - I_1) = 0$ — (2) ($I_3 = 3$)

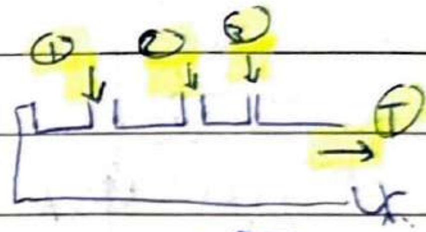
I_1 , I_2 ✓

* أي mesh منها current source لا نستطيع تطبيق KVL عليها ؟؟

لأننا لا نستطيع إيجاد تغير الفولتية (مش مطلوب).

* CHP4 :

super position →



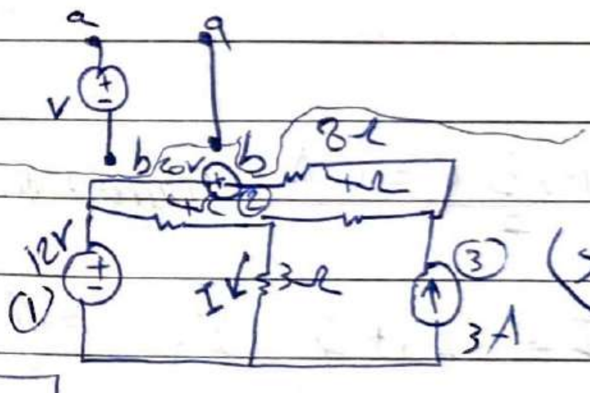
$I = I_1 + I_2 + I_3$ لكل على حدا

Ex: Kill all source except one

V → SC

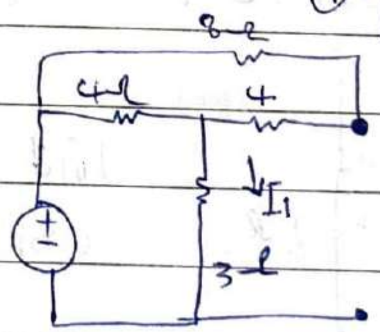
I → O.C

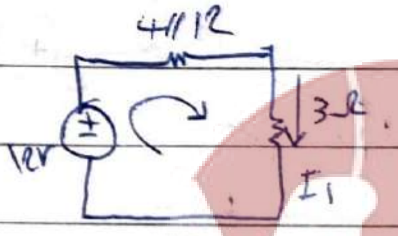
Ex: Find I using SP.



(يرقم الـ sources)

S1:

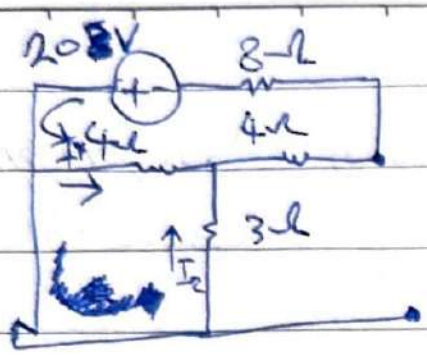


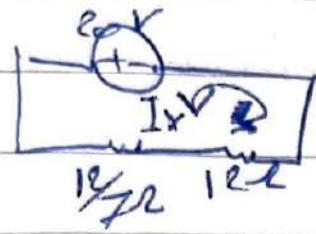


$I_1 = 12/6 = 2A$

يعمل kill لـ (٢),(٣) ونحسب I_1

S2:

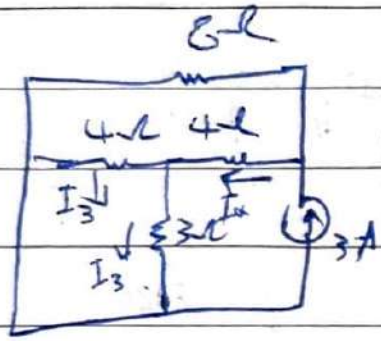


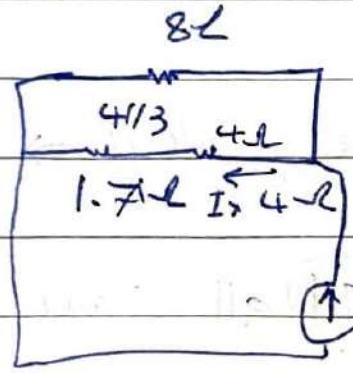


$I_x = 1.45\ A$

$I_2 = \frac{-1.45 \times 4}{4+3} = -0.83\ A$ (current divider)

S3:



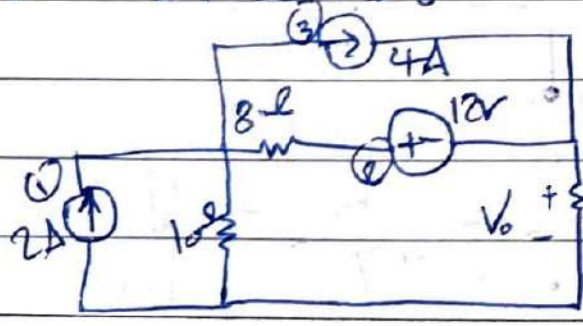


$I_x = \frac{3 \times 8}{8+4+1.7} = 1.75A$

$I_3 = \frac{1.75 \times 4}{7} = 1\ A$ (current divider)

$I = I_1 + I_2 + I_3 = 2 - 0.83 + 1 = 2.17A$

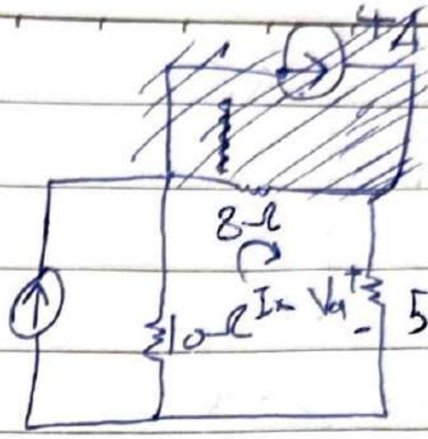
Ex2:



Find V_o using (SP).

لازم الصدهم عشان أعرف أجمع وأجيب الـ Total

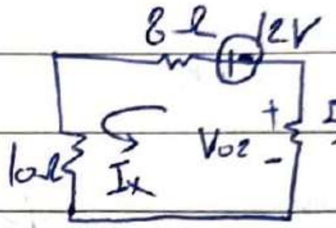
S1:



$I_x = \frac{2(10)}{23} = 20/23\ A$

$V_{o1} = I_x(5) = \frac{100}{23}\ V$ (+)

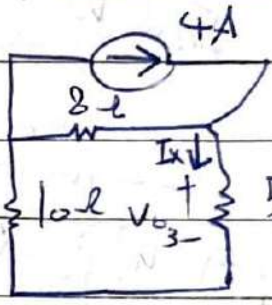
S2:



$I_x = 12/23\ A$

$V_{o2} = \frac{12}{23} \times 5 = \frac{60}{23}$ (−)

S3:



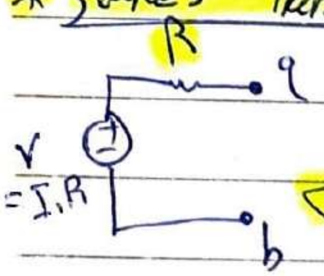
$I_x = \frac{4(8)}{23} = \frac{32}{23}$

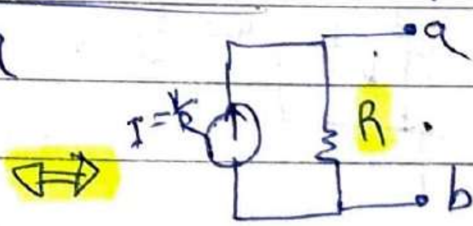
$V_{o3} = I_x(5) = 32/23\,(5) = \frac{160}{23}$ (+)

$V_o = \frac{100}{23} + \frac{160}{23} - \frac{60}{23} = \boxed{8.7\,V}$

*الـ power ممنوع أحسبها individual, لازم أحسب الـ Total [I or V] وبعدين أحسب الـ power.

* Source Transformation.





standard for transform.

Ex: 2Ω, a, 10V, b ⇒ 5A, 2Ω, a, b

Ex: 3A, 6Ω, a, b ⇒ 18V, 6Ω, a, b

Ex: a, 2Ω, 3Ω, 4Ω, 3A, V_o, 8Ω, 1ev, b

Find V_o using S.T.B

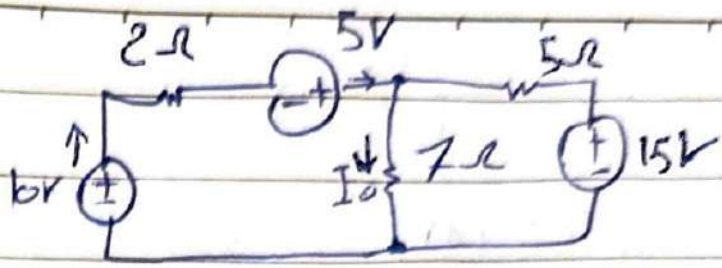
Ex: 4Ω, a, 2Ω, 3Ω, 12V, V_o, 6Ω, 12V, b ⇒ 6Ω, 3Ω, 12V, V_o, 8Ω, 12V

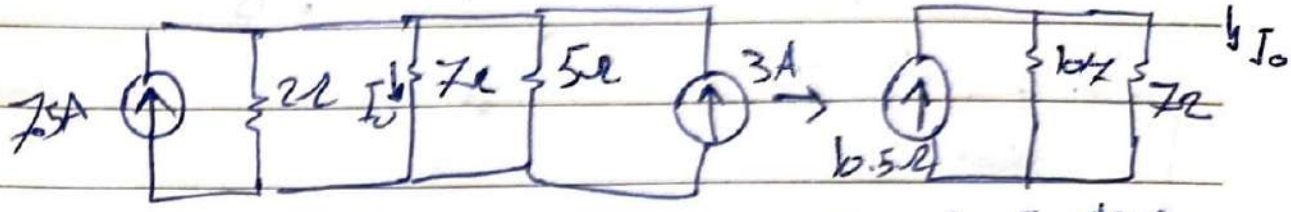
2A, 6Ω, V_o, 2Ω, 3Ω, 4A ⇒ 2A, V_o, 2Ω, 8Ω, I_o

$I_x = \frac{2(2)}{10} = 0.4A$

$V_o = I_x(8) = 0.4(8) = 3.2V$

Ex: 5V, 1Ω, 6Ω, 5A, 3Ω, 2Ω, I_x, 4Ω, 3A

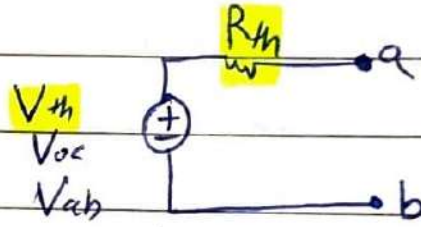




$$I_o = \frac{10.5 \times (10/7)}{7 + 10/7} A$$

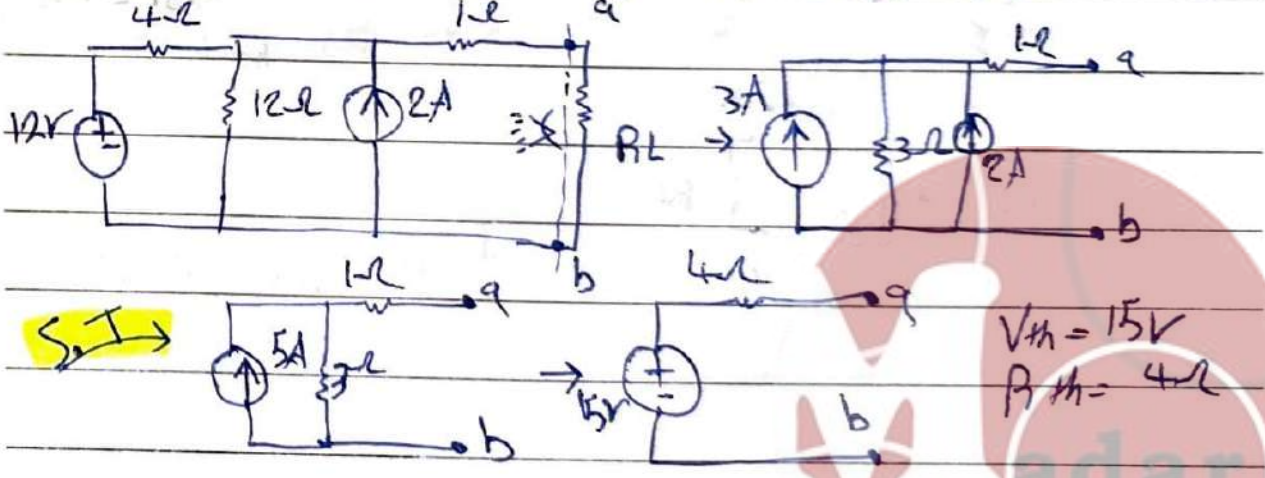
* Thevenin's Theorm.

any network can be retured to

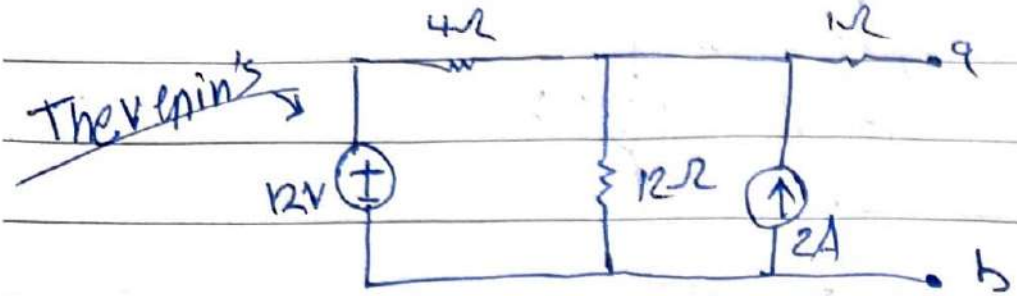


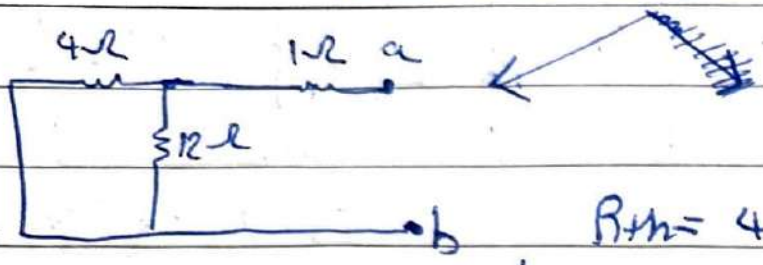
Thevenin's eqv.

Ex: Draw thevenin's eq. as seen (a,b).

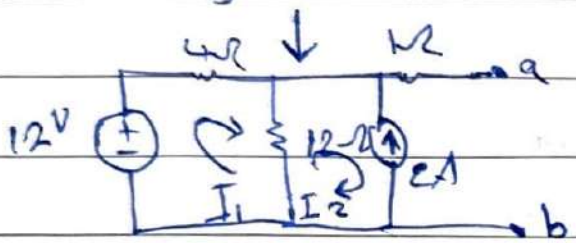


Thevenin's





$R_{th} = 4\Omega$



$I_2 = 2A$

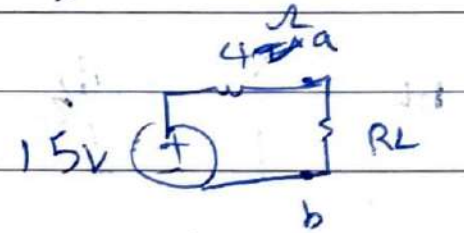
$-12 + 4I_1 + 12(I_1 - I_2) = 0$

$-12 + 16I_1 + 24 = 0$

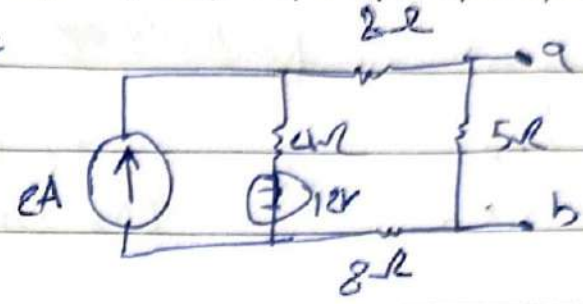
$I_1 = \frac{-12}{16} = -0.75\ A$

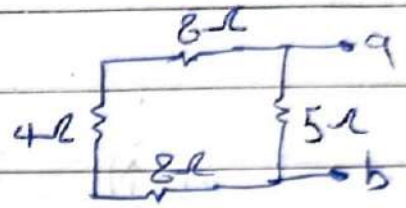
$V_{ab} = V_{12} + V_{4\Omega} + 12 = 0 + (-)(-0.75)(4) + 12 = 15V = V_{th}$

load



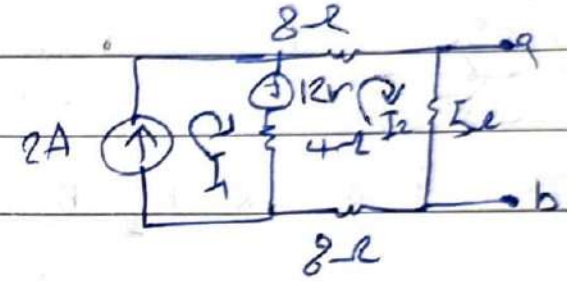
Ex.





$R_{th} = (8+4+8) \| 5$

$= 4\Omega$

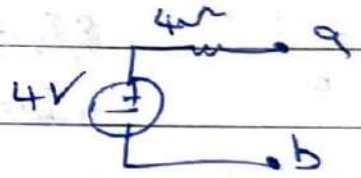


$V_{ab} = V_{5\Omega} = 5 I_2$

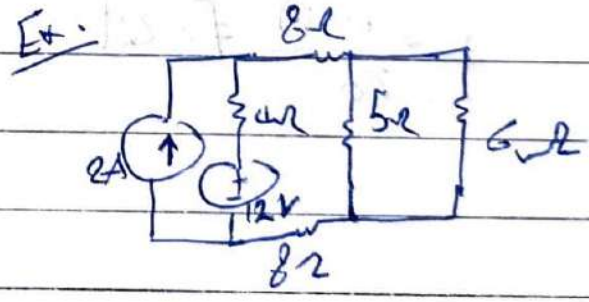
$8 I_2 + 5 I_2 + 8 I_2 + 4(I_2 - I_1) - 12 = 0$

$25 I_2 = 12 + 8 \Rightarrow I_2 = \frac{20}{25} = 0.8A$

$\therefore V_{oc} = V_{5\Omega} = V_{th} = V_{ab} = 0.8(5) = \boxed{4V}$



Ex.



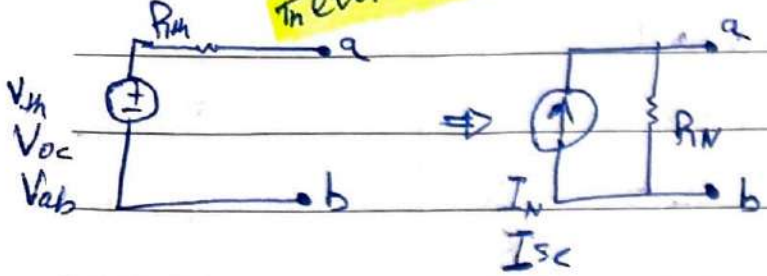
find I in 4Ω ??

$R_{th} = 18.7\Omega$

$V_{ab} = V_{th} = 25.5V$

$I = (25.5 / 28.7)\ A$

Thevenin eq.

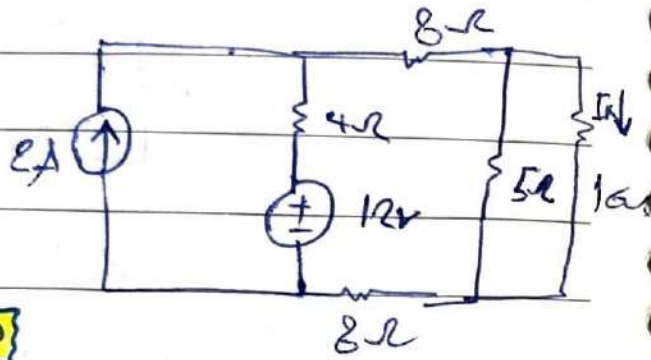


Norton's eq.

$[R_N = R_{th}]$

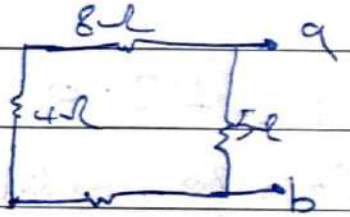
Ex.

1) cut the load
2) kill all sources
3) find R_N
4) restore all sources
5) find I_N
6) Draw norton's eq.

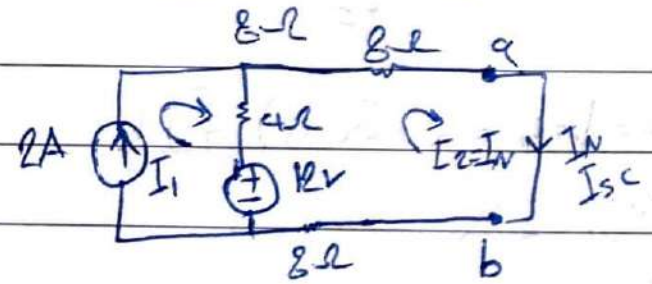


Find I_x by norton's th.

sol:



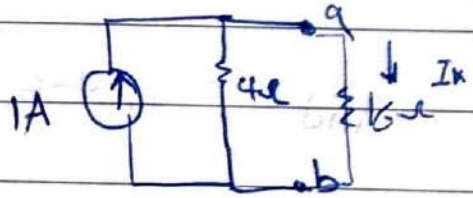
$R_N = (4+8+8) \,//\, 5 = 4\Omega$



$I_1 = 2A$

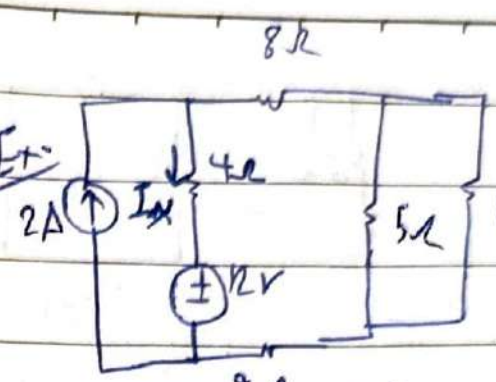
$8I_N + 8I_N - 12 + 4(I_N - 2) = 0$

$\boxed{I_N = 1A}$

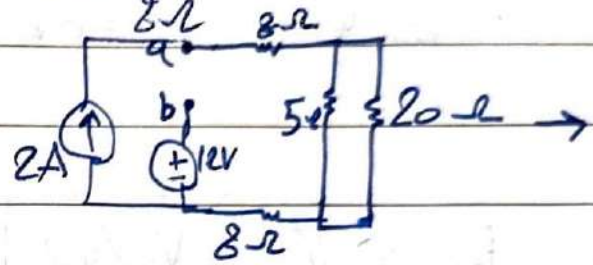


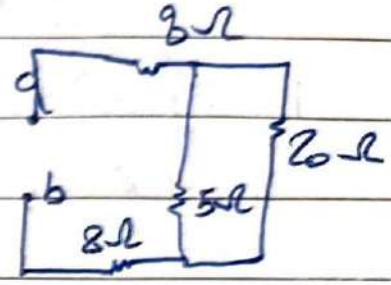
$I_x = \frac{1(4)}{20} = \boxed{0.2A}$

Ex: Find I_x ($I_{4\Omega}$) ??

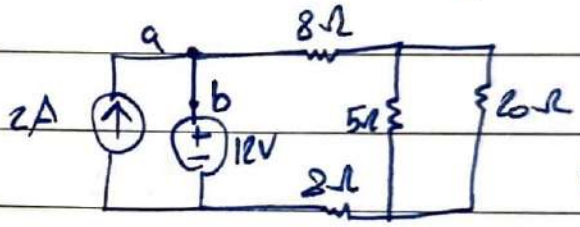


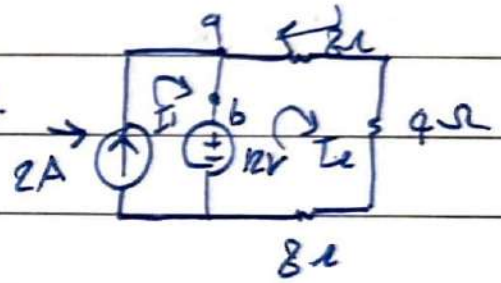
Sol:





$$R_N = (20 \| 15) + 8 + 8 = 20\,\Omega$$

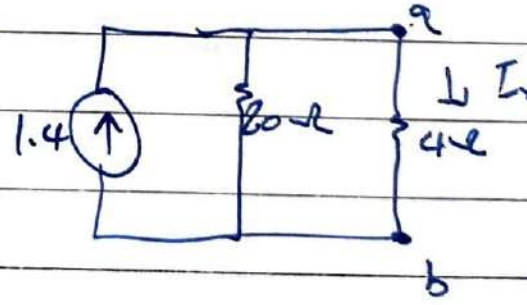




$I_1 = 2A$, $-12V + 8I_2 + 4I_2 + 8I_2 = 0$

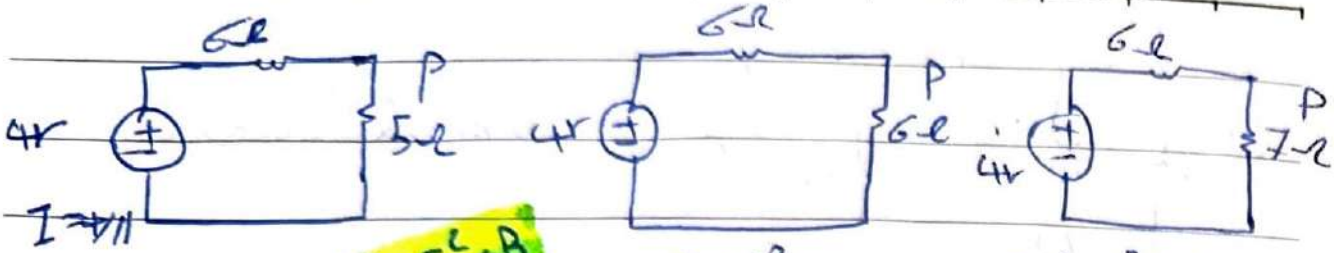
$20 I_2 = 12 \Rightarrow \boxed{I_2 = 0.6A}$

$I_{N} = I_1 - I_2 = 2 - 0.6 = \boxed{1.4\,A}$



$$\boxed{I_x = \frac{(1.4)(20)}{24}\,A}$$

• Max. power at $R_{th} = R_L$



$P = I^2 R$

$P = (\frac{4}{11})^2 (5) =$ 0.66 W

$P = (4/2)^2 6$ = 0.66 W

$P = (\frac{4}{13})^2 (7)$ $P = 0.66^2$ W

* $P_{max} = I^2 R_{th} = \frac{V_{th}^2}{4R_{th}^2} \cdot R_{th} \Rightarrow P_{max} = V_{th}^2 / 4R_{th}$

$I = V_{th} / 2R_{th}$

* اذا فيه current source بال mesh مصادفة راطبق KVL

* $R_y = \frac{R_\Delta}{3}$ (اذا كانت المقاومات متساوية)

* Energy storage elements:

(loads)

capacitor ⊣⊢ , Inductor ─ꝏ─

* capacitor ⊣⊢ Two plates ±

capacity C (farad) F

μF , nF

PF , mF

$C = \epsilon_0 \frac{A}{d}$, ϵ_0 : permitivity

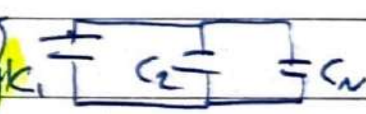
A: Area of the plate

d: distance between two plates.

series: C_1 C_2 ... C_N ⊣⊢⊣⊢ ... ⊣⊢

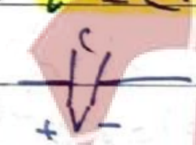
$$\frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_2} + \dots + \frac{1}{C_N}$$

parallel:



$$C_T = C_1 + C_2 + \dots + C_N$$

charge stored in the capacitor : $q = C.V$



$q = C.V$

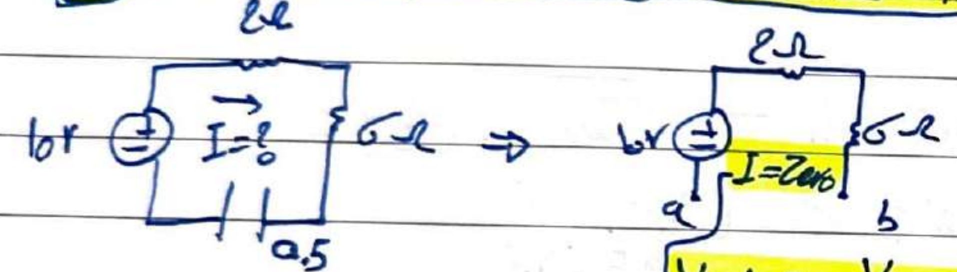
$$\frac{dq}{dt} = C\frac{dv}{dt} \Rightarrow \boxed{I_c = C\frac{dv_c}{dt}}$$ مهم

$\Rightarrow V_c = \frac{1}{c} \int I_c(t) + V_0$

* The energy stored in the capacitor:

$$W = E = \frac{1}{2} C V^2 \ (J)$$

* إذا كانت المصدر D.C ⟸ الـ capacitor تصبح O.C



$V_{ab} = V_c = 10V$

$E = \frac{1}{2} C V^2 = 25$ [redacted] J

$q = C \cdot V = 5$ [redacted] C

* Ex1: $V = 20V$

$C = 3 P.F$

$\Rightarrow q = C \cdot V = 60 PC$

* Ex2: $C = 5 MF$ Find i_c?

sol: $V_c(t) = 10 \cos(6000t)$

$i_c = C \frac{dv}{dt} = 5 \times 10^{-6} (\sin(6000t) \times -10 \times 6000)$

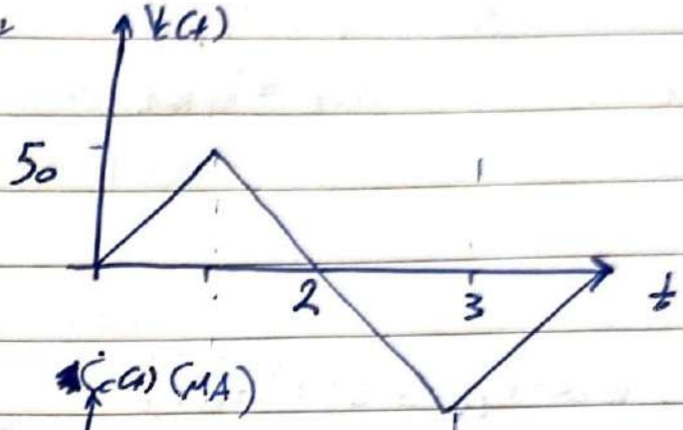
* Ex3: $C = 2 MF$ $V_0 = 0$?

$i(t) = 6 e^{-3000t}$ mA V_c??

sol: $V_c = \frac{1}{c} \int I_c(t) + V_0 = \frac{1}{2 \times 10^{-6}} \int 6 e^{-3000t} + 0$

$= \frac{6}{2 \times 10^{-6}} \frac{e^{-3000t}}{-3000}$ V

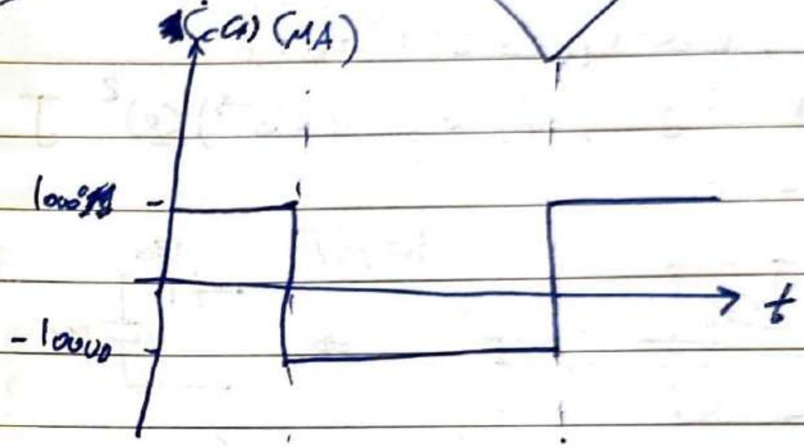
* Ex 4:



Sketch the current wave form?

$C = 200\,\mu F$

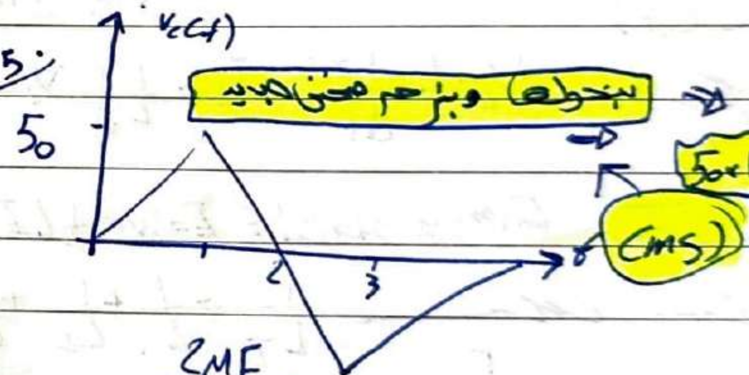
sol:

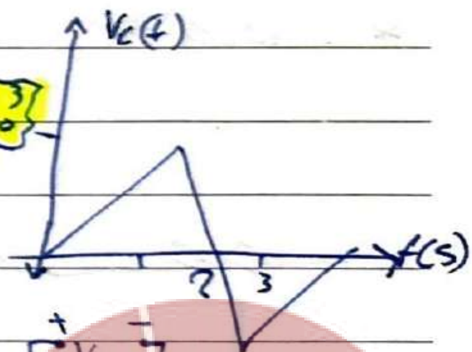


$E_{t=4} = \frac{1}{2} C V^2 = 0$, $E_{t=1} = (50\,V)^2 \times \frac{1}{2} \times 200 \times 10^{-6}$

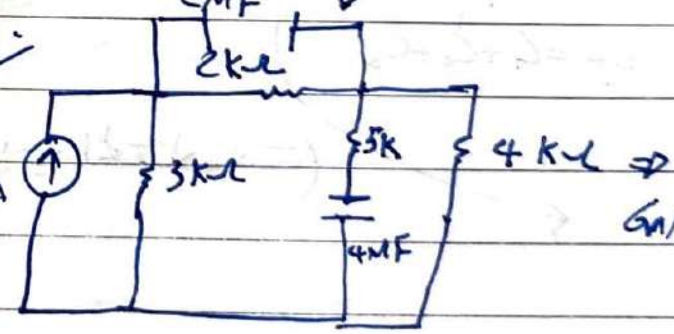
* Ex 5:

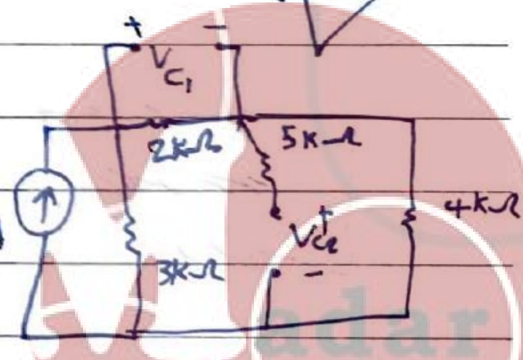
مهم

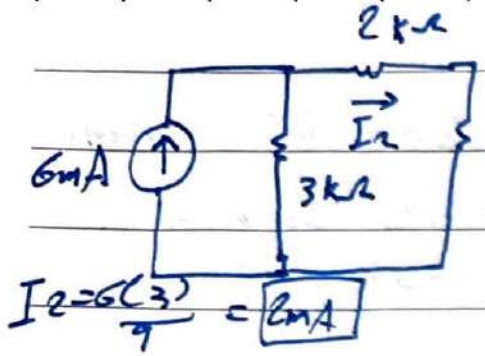




* Ex 6:







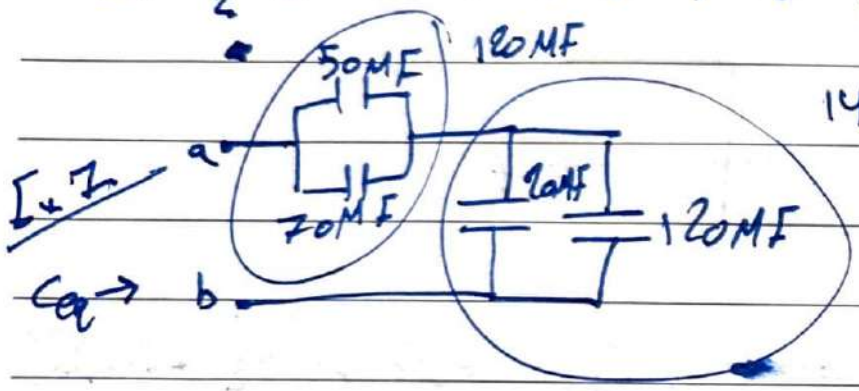
$I_2 = \frac{6(3)}{9} = \boxed{2mA}$

$V_{C1} = V_{2k\Omega}$

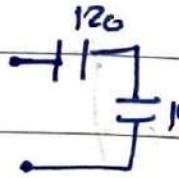
$V_{C2} = V_{4k\Omega}$

$V_{2k\Omega} = V_1 = \boxed{4V}$, $V_{C2} = V_{4k} = 2(4) = \boxed{8V}$

$E_1 = \frac{1}{2}(2\times10^{-3})(4)^2$ J , $E_2 = \frac{1}{2}(4\cdot10^{-3})(8)^2$ J



140 MF



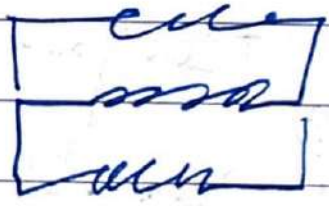
$\therefore C_{eq} = \left(\frac{120\cdot140}{120+140}\right)\mu F$

* Inductor — $V_L = L\frac{dI}{dt}$, $I_L = \frac{1}{L}\int V_L(t)dt + I_0$ — L (H)

Energy stored = $E = W = \frac{1}{2}LI^2$

$\frac{1}{L_T} = \frac{1}{L_1} + \frac{1}{L_2} + \frac{1}{L_3}$

$L_T = L_1 + L_2 + L_3$



(توازي المقاومات)

* The inductor act as a short CKT with D.C power supply.

* Ex1: $i(t) = 10t\,e^{-5t}$, $L = 0.1$ H, V ?, $E = $? $\Big|_{t=5}$?

$$V_{L(t)} = L\frac{di}{dt} = 0.1\left[10e^{-5t} - 50te^{-5t}\right]$$

$$E = \frac{1}{2}LI^2 = \frac{1}{2}(0.1)\left[10(5)\cdot e^{-25}\right)^2 \text{ J}$$

Ex2: $L = 5$ H, $I_o = $ Zero

$$v(t) = \begin{cases} 3_0 t^2 & t > 0 \\ 0 & t < 0 \end{cases}$$

$i(t)$? $\Big|_{t=5}$, E ? $\Big|_{t=5}$?

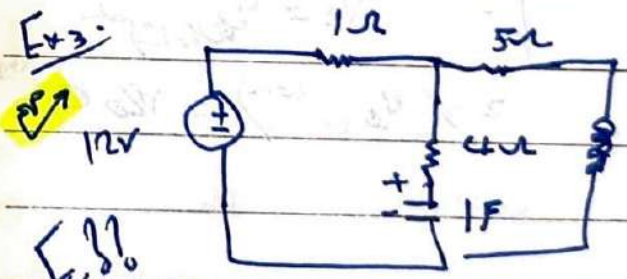
$$i_{(t)} = \frac{1}{L}\int_0^t V_L(t)\,dt + I_o$$

$$= \frac{1}{5}\int_0^t 3_0 \lambda^2\,d\lambda = 6\left[\frac{\lambda^3}{3}\right]_0^t = 2t^3\Big]_0^t$$

$$\begin{cases} 2t^3 & t > 0 \\ 0 & t < 0 \end{cases}$$, at $t = 5 = 2(125) = 250$ A

$$W\Big|_{t=5} = \frac{1}{2}LI^2 = \frac{1}{2}(5)(250)^2 \text{ J}$$

Ex3:



E_{L} ?

E_{L} ?

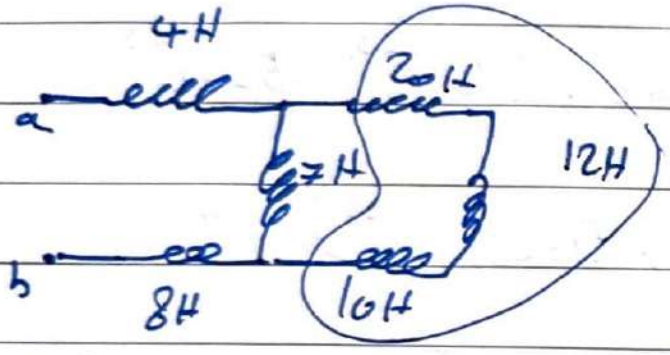
$I = I_c = \frac{12V}{6\Omega} = 2A$, $E_{ind} = \frac{1}{2} L I^2$

$= \frac{1}{2}(2)(2)^2 = 4J$

$V_c = V_{5\Omega} = I(5) = \boxed{10V}$

$\therefore E_c = \frac{1}{2} C V^2 = \frac{1}{2} \times 1 \times 100 = \boxed{50J}$

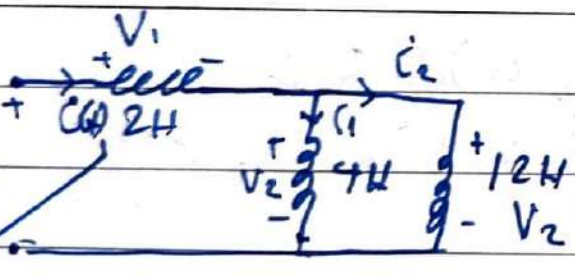
Ex4:



Leq:

$L_{eq} = (4 \| 12 \| 7) + 4 + 8 = \boxed{18H}$

Ex5:



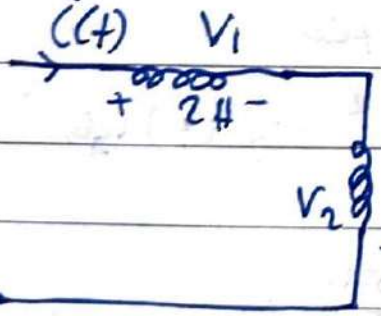
$i_1(0)$ $i_1(t)$

$V(t)$ $i_2(t)$

$V_1(t)$??

$= 8 - 4e^{-10t}$

$i_2(0) = -1mA$



$V_1 = 2\frac{di}{dt} = 80e^{-10t}$

$V_2 = L_{eq}\frac{di}{dt}$

$= 3(40e^{-10t}) = 120e^{-10t}$

$i(t) = i_1(t) + i_2(t)$

$i(0) = i_1(0) + i_2(0)$

$4 = i_1(0) + (-1)$

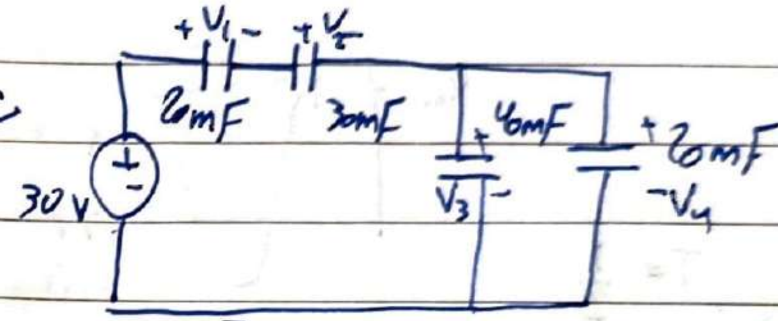
$\boxed{i_1(0) = 5mA}$

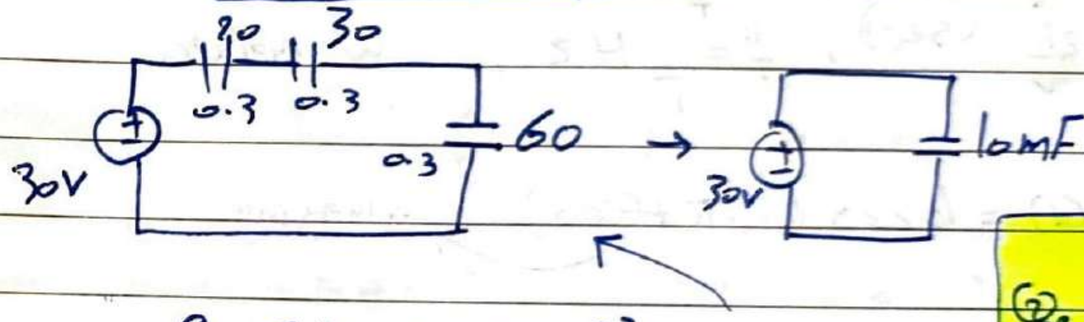
$$i_1(t) = \frac{1}{4}\int v_2(t)\,dt + i_1(0) = \frac{1}{4}\int_0^t 120 e^{-10k}\,dk + 5$$

$$= \frac{30}{-10} e^{-10k}\Big]_0^t + 5 = \left[\frac{30e^{-10t}}{-10} - \frac{30}{-10}\right] + 5$$

$$= 3 - 3e^{-10t} + 5 = 8 - 3e^{-10t}$$

Ex6:





ملاحظة

$Q_{20mF} = Q_{30mF} = Q_{40mF}$

$V_3 = V_4$

$$Q = q = C \cdot V = 30 \times 10 \times 10^{-3} = 0.3\,C$$

$$V_1 = \frac{Q}{C_1} = \frac{0.3}{20 \times 10^{-3}}\,V \quad , \quad V_2 = \frac{Q}{C_2} = \frac{0.3}{30 \times 10^{-3}}\,V$$

$$V_3 = \frac{Q}{C_3} = \frac{0.3}{60 \times 10^{-3}} = 5V \quad , \quad Q_{40} = 40 \times 10^{-3} \times 5 = 0.2\,C$$

$$Q_{20} = 0.1\,C$$

* بربط ادخل بلعبة توالي وتوازي بس لما parallel وبهي ٣٣

*CH9. Sinusoidal & phasor

cos ^ sin

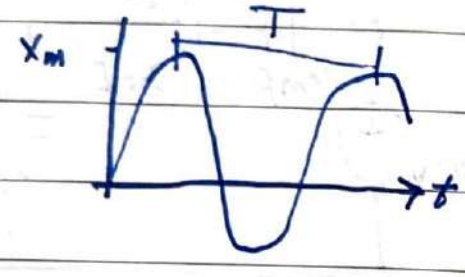
$v(t) = V_m \cos[\omega t + \theta_1]$

$i(t) = I_m \sin[\omega t + \theta_2]$

$x_{(t)} = x_m \cos(\omega t + \theta)$ ← phase shift

x_m: peak value or max-value

ω: radial freq. (omega)



$\omega = \frac{2\pi}{T}$, $T = \frac{1}{f}$

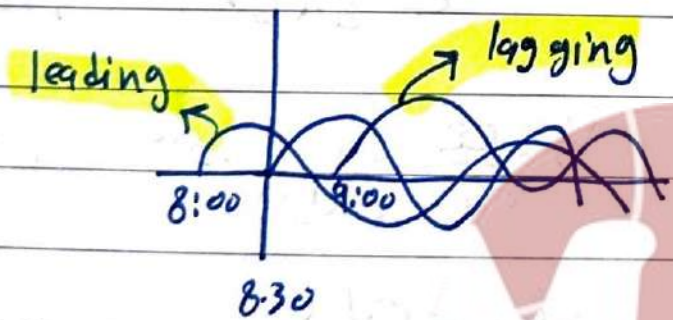
$T = \frac{2\pi}{\omega}$ (sec), $f = \frac{1}{T}$ Hz, ω rad/sec

Ex: $i(t) = 10\cos(100\pi t + 60)$ ∴ lagging

sol:

$I_{max} = 10$, $\omega = 100\pi$, $f = \frac{\omega}{2\pi} = \frac{100\pi}{2\pi} = 50$ Hz

$T = \frac{1}{50}$ sec, θ: phase shift $= -60°$



* عشان اقارن بين 2-signals لازم يكونوا
1) ω 2) sin or cos

* $\sin(\omega t - 30^\circ) \Rightarrow \cos(\omega t - 30 - 90^\circ) = \cos(\omega t - 120^\circ)$

* $-\cos(x) = \cos(x \pm 180)$

Ex: $V_1(t) = -10\cos(\omega t + 50)$

$V_2(t) = 12\sin(\omega t - 10)$

sol: $V_1(t) = 10\cos(\omega t - 130)$

$V_2(t) = 12\cos(\omega t - 100)$

$\therefore V_2$ leads V_1 by 30°
or V_1 lags by 30°

* $V(t) = V_m \cos(\omega t + \theta)$ phasor

$V = V_m \angle\theta$ (phasor polar) (vector)

Ex: $i(t) = 5\cos(\omega t - 30)$

sol: $I = 5\angle -30^\circ$ A

Ex: $i(t) = 6\sin(20\pi t + 16^\circ) \Rightarrow 6\cos(20\pi t - 74)$

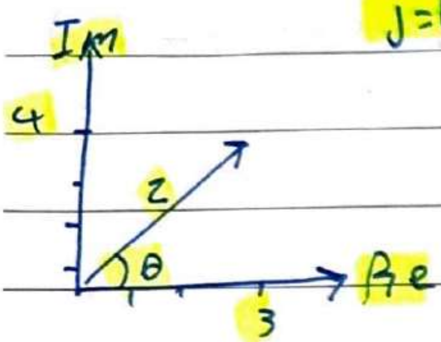
sol: $I = 6\angle -74^\circ$ A

* complex (Phasor / Poler)

cartizi | Poler, Phasor

$a + jb \rightarrow \boxed{3 + j4} = \boxed{5\angle 53.13^\circ}$

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



$z = \sqrt{a^2 + b^2}$, $\theta = \tan^{-1}\frac{a}{b}$

* Sinusoidal → cos , $V(t) = 6\cos(20\pi t - 60^\circ) \Rightarrow$
$V = 6\angle -60$

مهم Ex: $V_1(t) = 6\cos(20t + 30^\circ)$

$V_2(t) = 4\sin(20t + 50^\circ)$ find $V_4(t) = V_1(t) + V_2(t) + V_3(t) + V_4(t)$

$V_3(t) = 12\cos(20t)$

ممنوع اشتغل إلا أحول على الـ Phasor

Sol: $V_1 = 6\angle 30^\circ$

$V_2 = 4\angle -40^\circ$

$V_3 = 12\angle 0$

$\therefore V_4 = 20\angle 1.2 \Rightarrow V_4(t) = 20\cos(20t + 1.2^\circ)$

* AC ckT loads :

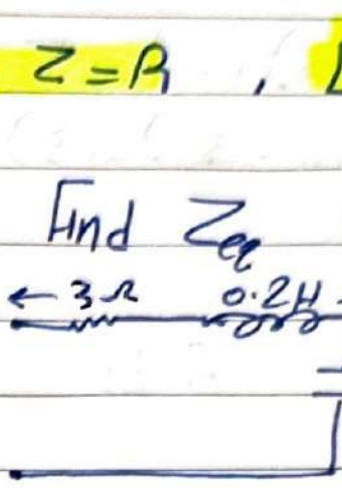
① resistors ③ inductor

② capacitor

[Impedance Z]
unit: (Ω)

$R \rightarrow Z = R$, $L \rightarrow Z_L = j\omega L$, $C \rightarrow Z_C = \frac{-j}{\omega C}$

Ex: Find Z_{eq} if $\omega = 10$ rad/sec



$Z_L = j\omega L = j(10)(0.2) = j2\Omega$

$Z_C = \frac{-j}{\omega C} = -j5\Omega$

$Z_T = 3 + j2 - j5$

$= 3 - j3 = 4.2 \angle -45°$

① $3 - 3i$

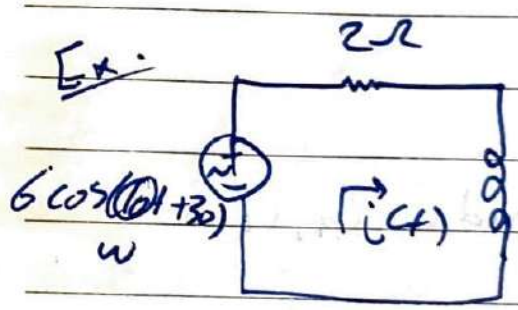
② OPTN

③ ↓ on calculator

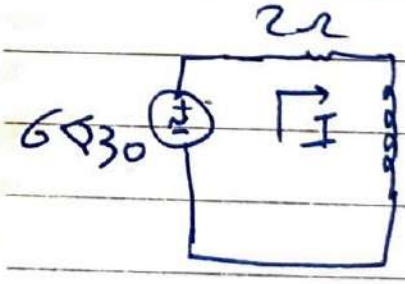
④ 1

⑤ =

Ex:



$0.3H \rightarrow j\omega L = j3\Omega$



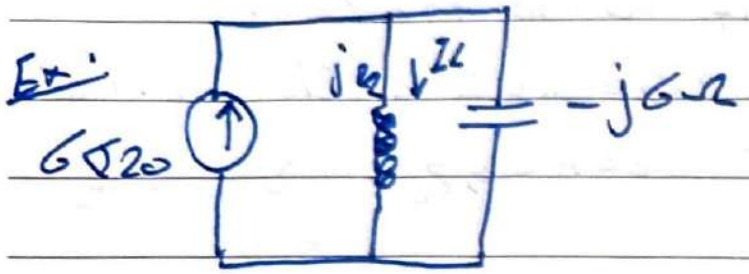
$I = \frac{V}{Z_T} = \frac{6\angle 30}{2 + j3} = 1.66 \angle -26.3A$

$i(t) = 1.66\cos(10t - 26.3A)$

$V_{2\Omega} = I \cdot Z_R = (1.66 \angle -26.3)(2)$ V

$V_{j3\Omega} = I \, Z_L = (1.66 \angle -26.3)(j3)$ V

Ex:



I_L ??

sol:

$$I_L = \frac{[6\angle 20][-j6]}{j2 - j6} = 9\angle 20$$

Ex:

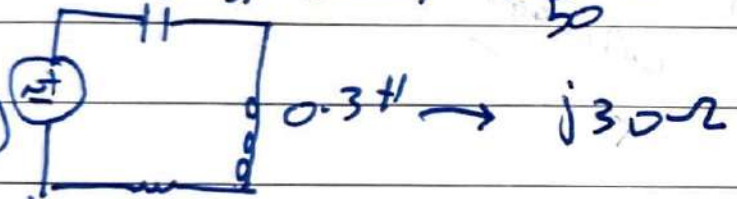
$10\sin(100t + 60)$

$\downarrow$

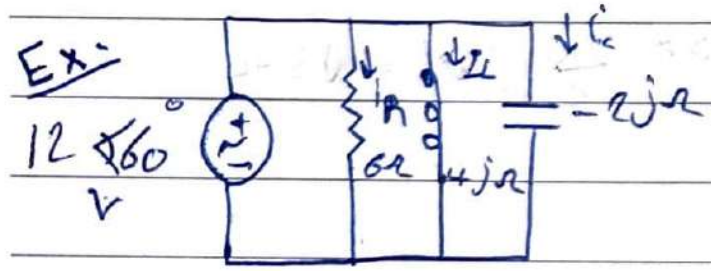
$10\cos(100t - 150)$

$\downarrow$

$10 \angle -150$



Ex:



find i_L, i_R, i_C ?

$V_R = i_R \cdot Z_R \Rightarrow i_R = 12\angle 60 / 6 = 2\angle 60$ A

same (II) $V_L = i_L \cdot Z_L \Rightarrow i_L = 12\angle 60 / 4j = 3\angle -30$ A

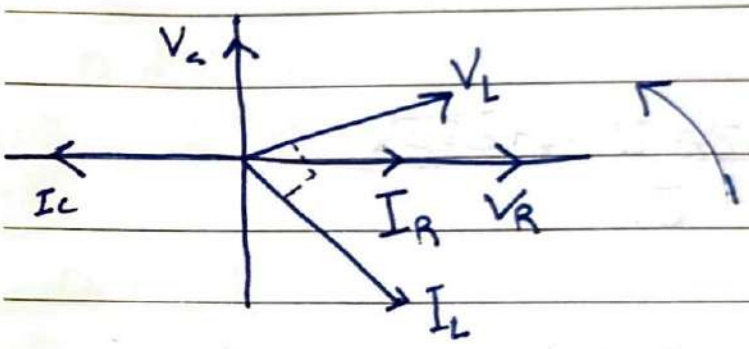
$V_C = i_C \cdot Z_C \Rightarrow i_C = 12\angle 60 / -2j = 6\angle 150$ A

R : V_R, I_R inphase ($\theta_v = \theta_i$)

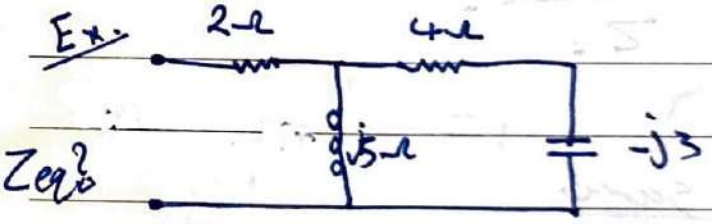
L : V_L leads I_L by 90°

C : I_C leads V_C by 90°

phase Angle = $\theta_v - \theta_i$



Ex:



Z_{eq}?

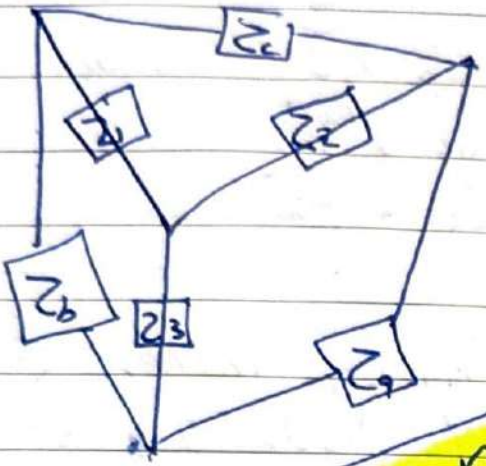
$Z_{eq} = [(4 - 3j) \,||\, 5j] + 2 = 7.43 \angle 19.65$

$= 7 + 2.5j$

* $3 - j2 \Rightarrow$  [capacitive]

* $3 + j2 \Rightarrow$  [inductive]

D → Y:



same the resistance

$$Z_1 = \frac{Z_b Z_c}{Z_a + Z_b + Z_c}$$

$$Z_2 = \frac{Z_a Z_c}{\text{same.}}$$

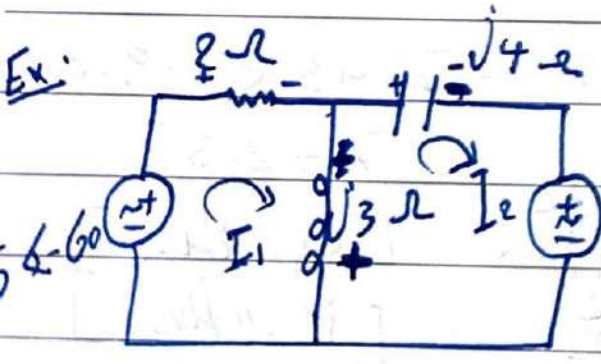
$$Z_3 = \frac{Z_a Z_b}{\text{same}}$$

$$Y \longrightarrow D : Z_a = \frac{Z_1 Z_2 + Z_1 Z_3 + Z_2 Z_3}{Z_1}$$

$$Z_b = \frac{\text{same.}}{Z_2}$$

$$Z_c = \frac{\text{same}}{Z_3}$$

Ex:



Find I_1, I_2 ??

+2

M1: $-5\angle -60 + 2I_1 + 3j(I_1 - I_2) = 0$ ... ①

M2: $-4jI_2 + 6\angle 20^\circ + 3j(I_2 - I_1) = 0$

كتابة على شكل

$\frac{j3}{-j3} = 3\angle 90^\circ$ مقلوب $\frac{-3}{3} = 3\angle 180^\circ$

$-4jI_2 + 6\angle 20^\circ + 3jI_2 - 3jI_1 = 0$

$-jI_2 - 3jI_1 + 6\angle 20^\circ = 0 \Rightarrow -3jI_1 - jI_2 = 6\angle -160^\circ$ ... ②

$$D = \begin{bmatrix} (2+3j) & -3j \\ -3j & -j \end{bmatrix} = 12.2\angle -9.5$$

$$D_1 = \begin{bmatrix} 5\angle -60 & -3j \\ 6\angle -160 & -j \end{bmatrix} = 19.5\angle -84.6$$

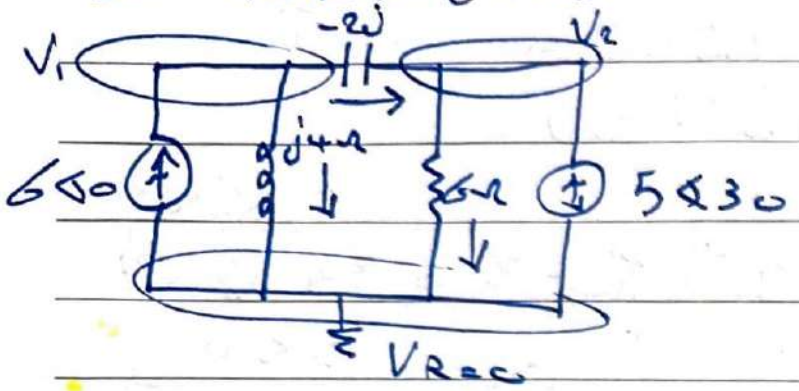
Apply Cramer's rule

$$D_2 = \begin{bmatrix} 2+3j & 5\angle -60 \\ -3j & 6\angle -160 \end{bmatrix} = 15.6\angle -59.8$$

$I_1 = \frac{D_1}{D} = 1.6\angle -75.1$, $I_2 = \frac{D_2}{D} = 1.28\angle -50.3$

$V_c = [I_2 \cdot (-j4)]V$, $V_L = [(I_1 - I_2)(-j3)]V$

Ex: (Nodal) . (KVL) :



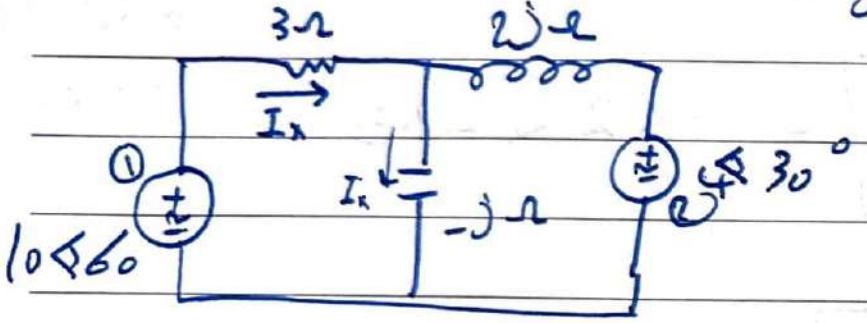
N1 :

$$6\angle 0 = \frac{V_1 - V_2}{-2j} + \frac{V_1}{j4}$$

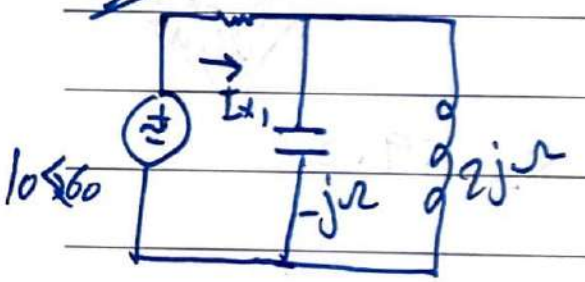
N2 :

$$5\angle 30 + \frac{V_2}{6} = \frac{V_1 - V_2}{-2j}$$

* super position : Find I_x using SP?



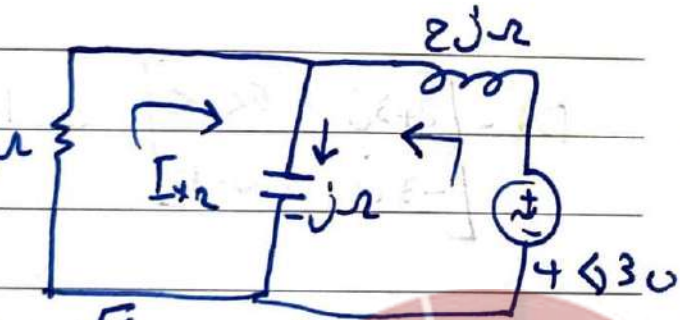
S1 :



$$Z_{eq} = [[-j \,||\, 2j] + 3\Omega] = \boxed{3.6\angle -33\,\Omega}$$

$$I_{x1} = \frac{10\angle 60}{3.6\angle -33} = \boxed{2.78\angle 93\,A}$$

S2 :

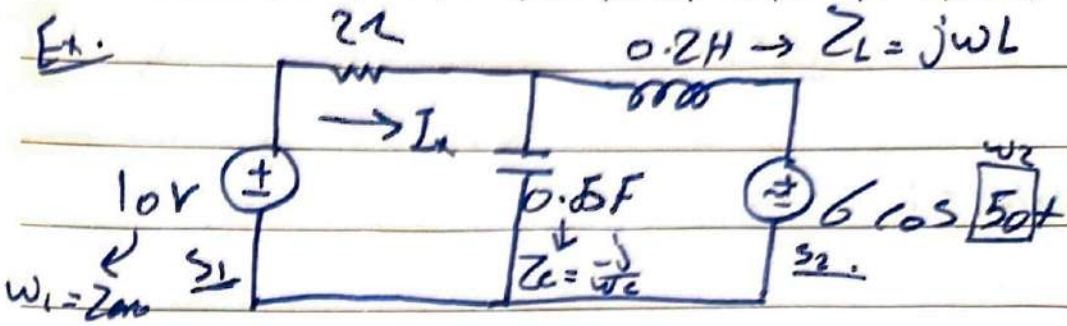


$$Z_{eq} = [(3 \,||\, -j) + 2j]\,\Omega = \boxed{1.14\angle 74\,\Omega}$$

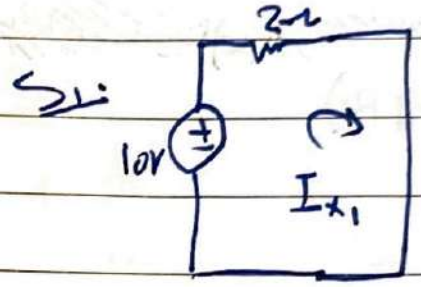
$$I_{x2} = \frac{4\angle 30}{1.14\angle 74} = \boxed{3.5\angle -44.7\,A}$$

$$\therefore I_x = I_{x1} + I_{x2} = \boxed{2.4\angle 8.2\,A} = \underline{2.38 + 0.34j\ A}$$

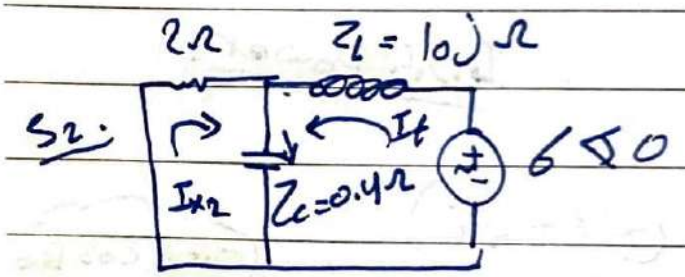
Ex:



* اذا كانت ω مختلفة ⇐ اطبق لكل S.P
* الـ D.C ⇐ العناصر فيها الـ ω تساوي Zero



$$I_{x_1} = \frac{10}{2} = 5A$$



$$I_{x_2} = \frac{I_t(-0.4j)}{Z_T}$$

$$I_T = \frac{6\angle 0}{Z_T}$$

CH II. No.

AC- Power:

4 types of AC - power:

1. Instantenous power , $P(t)$ (w)
2. Average [mean, real] power, $P(w)$
3. Reactive - power , Q (VAR)
4. complex power , S (VA)
5. Apparant power , S (VA)

1. $P(t) = i(t) * v(t)$ — Inst. power.

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

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

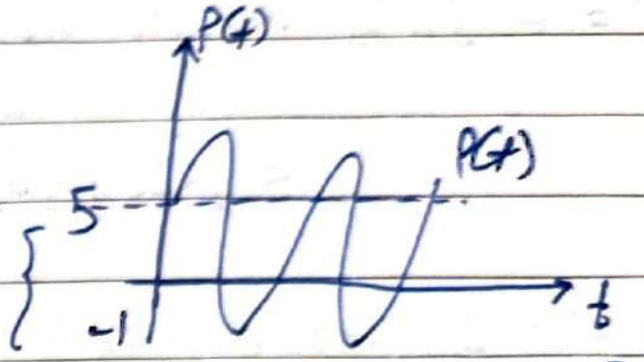
$\cos A \cos B = \frac{1}{2}\cos(A+B) + \frac{1}{2}\cos(A-B)$

$\therefore P(t) = i(t) * v(t) = I_m \cos(\omega t + \theta_i) * V_m \cos(\omega t + \theta_v)$

$= \frac{I_m V_m}{2}\cos(\omega t + \theta_i + \theta_v) + \frac{V_m I_m}{2}\cos(\theta_i - \theta_v)$ → constant (Avg. Power)

Inst. power ←

$\therefore P = \frac{1}{2} V_m I_m \cos(\theta_v - \theta_i)$ (w)



$\therefore P = 2w$

Ex: $v(t) = 120 \cos[377t + 45°]v$

$I(t) = 10 \cos[377t - 60]$ find $p(t)$, $P_{avg.}$

Sol: ① $P_{avg.} = \frac{1}{2}[120][10]\cos[45 - (-60)] = 344.2w.$

② $P(t) = \frac{1}{2}[120][10]\cos(754t + 35) + 344.2$

④ $I = I_m \angle \theta_i$

$V = V_m \angle \theta_v$

$\rightarrow P = \frac{1}{2} I_m V_m \cos(\theta_v - \theta_i)$

$P = \frac{1}{2} \vec{V} \vec{I}^{(*)}$ → conjugate ↔ $I = 5\angle 60 \rightarrow I^* = 5\angle -60$

$I = 3 - j4 \rightarrow I^* = 3 + j4$

Ex: $Z = 30 - j70\ \Omega$

$V = 120 \angle 0$ find P?

sol: $I = V/Z = \frac{120 \angle 0}{30 - j70} = 1.58 \angle 66.8$

$\therefore P = \frac{1}{2} I_m V_m \cos(\theta_v - \theta_i) = \frac{1}{2}(1.58)(120)\cos(0 - 66.8)$

$= \boxed{37.24 \text{ w}}$

* $P = \frac{1}{2}|V_m||I_m| \cos(\theta_v - \theta_i)$

$Q = \frac{1}{2}|V_m||I_m| \sin(\theta_v - \theta_i)$

—w— : in phase $\theta_v = \theta_i$

—||— : I lead V by 90° ($\theta_v - \theta_i = -90°$)

—ooo— : V lead I by 90° ($\theta_v - \theta_i = +90°$)

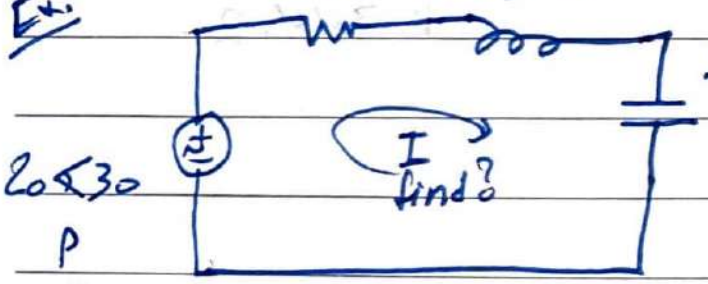
$Q_R = 0$ $P_R = 0$

$Q_C = -$ (−) $P_C = 0$ P_R ✓

$Q_L = +$ (+)

$Q = 0$, $P = \frac{V^2}{2\Omega}$ $P = 0$, $Q = +$, $j2\Omega$

Ex:



$2\angle 30$

P

Q

$Q = -$ ✓

$P = 0$

$I = \frac{2 \angle 30}{2 + j4 - j3} = \underline{8.9 \angle 3.43 A}$

$P_R = \frac{1}{2} I_m \bar{V}_m = \frac{1}{2} * I_m^2 * R = \frac{1}{2}(8.9)^2(2) = 79.6W$

$P_s = \frac{1}{2} V_m I_m \cos(\theta_v - \theta_i) = \frac{1}{2}(20)(8.9)\cos(30 - 3.43)$

$= 79.6W$

$Q_s = \frac{1}{2}(20)(8.9)\sin(30 - 3.43) = 39.8VAR$

$Q_L = \frac{1}{2} |I_L|^2 |Z_L| = \frac{1}{2}(8.9)^2(4) = 158.42$ VAR

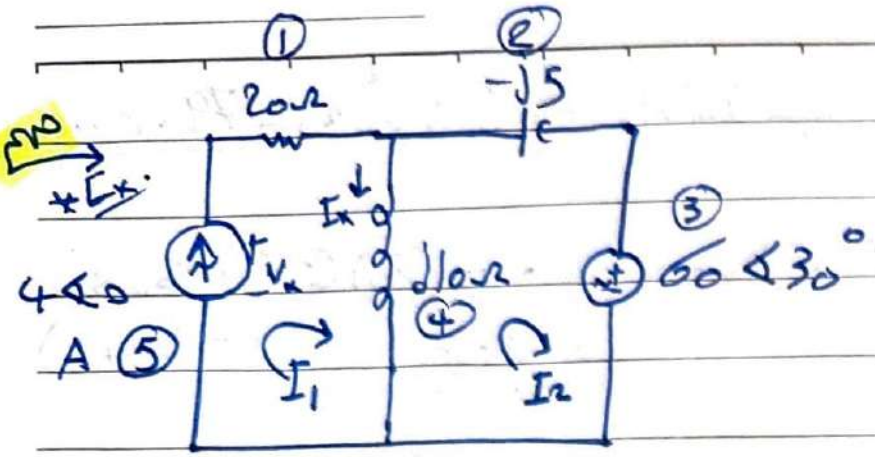
$Q_c = \frac{1}{2} |I_c|^2 |Z_c| = \frac{1}{2}(8.9)^2(3) = -118.8VAR$

$\frac{1}{2}|V_m|\cos(\theta_v - \theta_i)$ ↑ P

$Q = \frac{1}{2}|I_m||V_m|\sin(\theta_v - \theta_i)$ → Q

* Conclusion:

	P	Q
R	✓	X
L	X	+Q
C	X	-Q



$I_1 = 4\angle 0\ A$

$$-j5 I_2 + 60\angle 30 + j10\,[I_2 - \underbrace{I_1}_{4\angle 0}] = 0$$

$$P_1 = \frac{1}{2}|I_1|^2 R = \frac{1}{2}(4)^2(20) = 160\ W$$

$$Q_1 = 0$$

$$P_2 = 0$$

$$Q_2 = \frac{1}{2}|I_2||Z_c| = -\left(\frac{1}{2}\right)(10.58)^2 \cdot (5) = -279.8\ VAR$$

$$P_3 = \frac{1}{2}|I_2||V|\cos(\theta_v - \theta_i)$$

$$= \frac{1}{2}(10.58)(60)\cos[30 - 79.1] = 207.8\ W$$

$$Q_3 = \frac{1}{2}|I_2||V_s|\sin(30 - 79.1) = -239.9\ VAR$$

$$P_4 = 0$$

$$Q_4 = \frac{1}{2}(|I_x|)^2 |Z_L| = \frac{1}{2}(10.58)^2(10) = 559.08\ VAR$$

$\Rightarrow I_x = 4\angle 0 - 10.58\angle 79.1 = 10.58\angle -79.1\ A$

$-V_x + 20 I_1 + I_x (j10) = 0$ KVL

$V_x = 184.98 \angle 6.3$

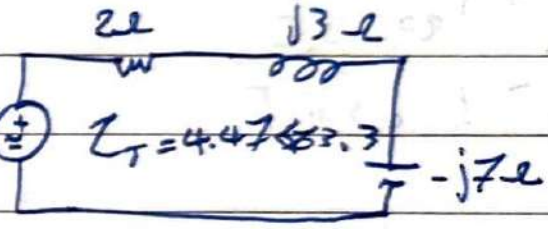
$\therefore P_s = \frac{1}{2} |I_1||V_x| \cos(\theta_V - \theta_I) = 367.8\ W$

$Q_s = \frac{1}{2} |I_1||V_x| \sin(\theta_V - \theta_I) = 40\ VAR$

---

* $\vec{S} = P \mp jQ$, R: , L: , C:

* Ex.



$P_{\frac{7}{R}} = \frac{1}{2} |2.23|^2 (2)$

$= 4.97\ W$

$P_L = 0$, $P_C = 0$, $P_s = \frac{1}{2} |10||2.23| \cos|30 - 93.4| =$

$= 4.99\ W$

$Q_s = \frac{1}{2} |2.23||10| \sin[30 - 93.4] = -j\,9.96\ VAR$

$P_L = 0$, $P_C = 0$

$Q_L = \frac{1}{2} [2.23]^2 \times 3 = 7.4\ VAR$

$Q_c = \frac{1}{2}(2.23)^2(-7) = -17.4$ VAR

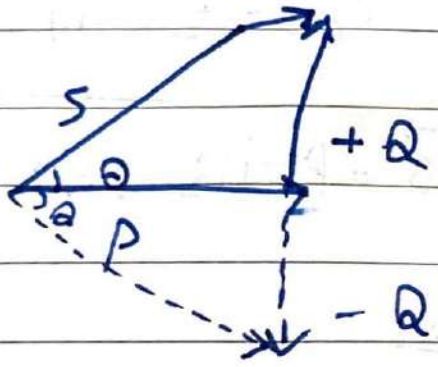
* $S_L = 0 + j7.46$ VAR

$S_c = -j17.4$ VAR

$S_R = P + jQ = 5$

$S_s = 5 - j9.96$ VAR

* power triangle :



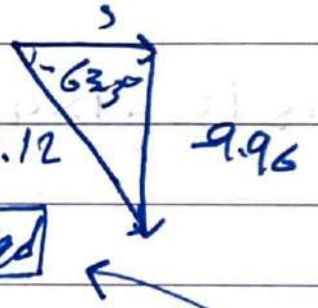
$\cos\theta$ = power factor (P.F)

$0 \leq P.F \leq 1$

Q + lag P.F

Q - leads P.F

$S_s = 5 - j9.96 = 11.12 \angle -63.3$



$P.F = \cos\theta = 0.449$

* To correct the P.F we have to decrease the (Q) and keep (P) as it is, [so we have to add a capacitor in parallel with the voltage source]

$*Z_{eq.} = S_s$] نفس الإجابة

* Root mean squared value (RMS):

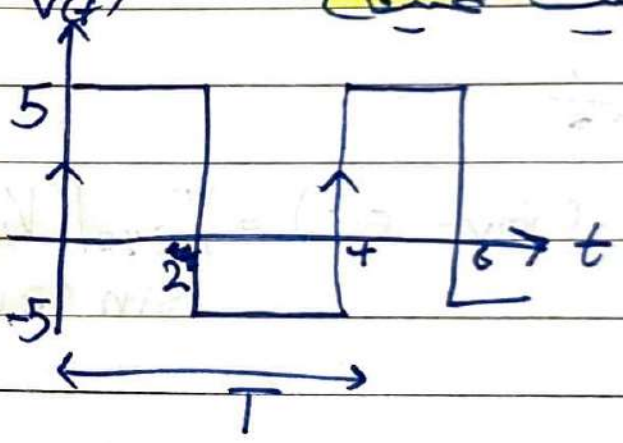
$$X_{max} = \sqrt{\frac{1}{T}\int x^2(t)\,dt} \quad , \quad x(t) \leftarrow \begin{matrix} v(t) \\ i(t) \end{matrix}$$

* special case: $v(t) = V_m \cos(\omega t + \theta)$

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

Ex: $i(t) = 6\sin(2\omega t)$, $I_m = 6$, $I_{rms} = \frac{6}{\sqrt{2}} = 4.24$

* T: الزمن اللازم لانجاز دورة واحدة (periodtime)
(او المسافة بين قمتين)



$$V_{rms} = \sqrt{\frac{1}{4}\left[\int_0^2 (5)^2\,dt + \int_2^4 (-5)^2\,dt\right]}$$

$$= \sqrt{\frac{1}{4}\left[25t\Big]_0^2 + 25t\Big]_2^4\right]} \qquad = \sqrt{\frac{1}{4}[50+50]}$$

$$= \sqrt{25} = \boxed{5v}$$

$$P = \frac{1}{2}|V_m||I_m|\cos(\theta_v - \theta_i)$$

$$= \frac{1}{2}\sqrt{2}\, V_{rms} \cdot \sqrt{2}\, I_{rms} \cos(\theta_v - \theta_i)$$

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

* Thevinin's equevilent in AC:

* $V_m, I_m \rightarrow P = \frac{1}{2}|I_m||V_m|\cos(\theta_v - \theta_i)$
  $V_{RMS}, I_{RMS} \rightarrow P = |I_m||V_m|\cos(\theta_v - \theta_i)$

* Sinsoidel $\rightarrow V_{RMS} = \frac{V_m}{\sqrt{2}}$

* $Q = \frac{1}{2}|I_m||V_m|\sin(\theta_v - \theta_i) = |I_{RMS}||V_{RMS}|\sin(\theta_v - \theta_i)$

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

to have P_{max}

* in DC: $R_L = R_{th}$

$$P_{max} = \frac{V_{th}^2}{4R_{th}}$$

* in AC: $Z_L = Z_{th}^*$

$$P_{max} = \frac{|V_{th}|^2}{8R_{th}}$$

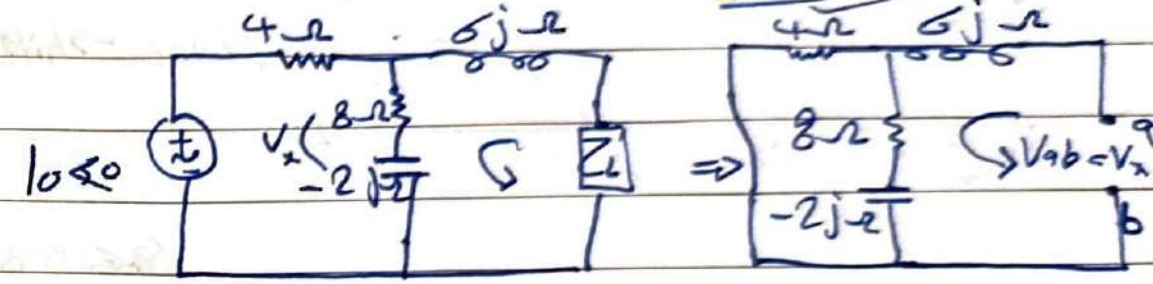
* Ex. if $Z = 6 \angle 30$, $w = 10$, find R, L?

Sol.

$Z = 5.2 + 3j$ $\therefore R = 5.2$

$wL = 3 \Rightarrow L = \frac{3}{w}$

* Ex: find Z_L to have P_{max} ?? → thevinin

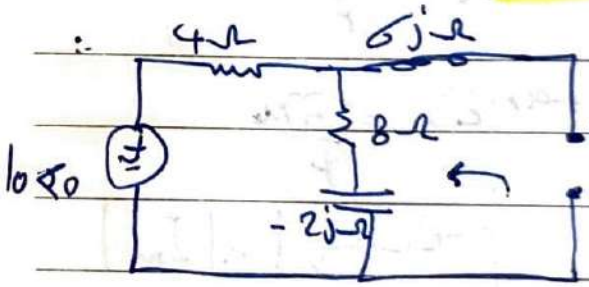


(Cartesian بيفضل حلي الجواب بال)

$Z_{eq} = 2.7 + 5.7j$

R_{th}

$\therefore Z_L = Z_{th}^* = 2.7 - 5.7j$



$V_{th} = V_{ab} = V_x = \frac{(10\angle 0)(8-2j)}{4+8-2j}$

$= 6.77 \angle -4.5°$

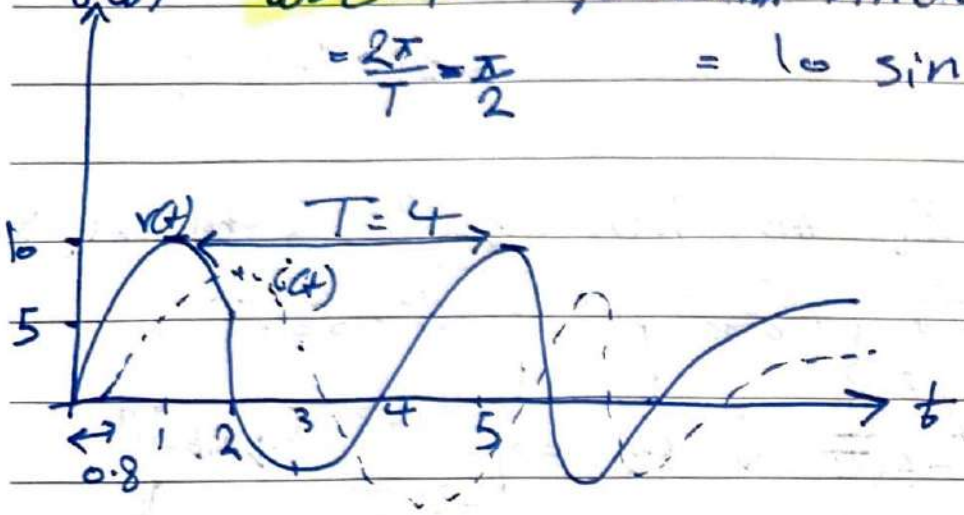
$\therefore P_{max} = \frac{|V_{th}|^2}{8 R_{th}} = \frac{|6.77|^2}{8(2.7)}$ W

(10-12 marks in final)

* How to calculate phase shift ??

$v_c(t)$ $\omega = 2\pi f$, $v(t) = V_m \sin(\omega t + \phi)$

$= \frac{2\pi}{T} = \frac{\pi}{2}$ $= 10 \sin(\frac{\pi}{2}$ [redacted]

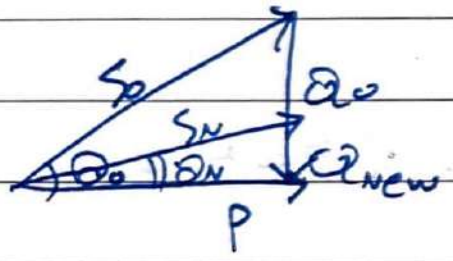


phase-shift

$i(t) = 5 \sin(\frac{\pi}{2}t - 72°)$ ← (360)(0.8) / 4 → T / = 72

(سالب = تأخير)

*



$\cos\theta = P.F$; $0 \le P.F \le 1$

$\tan\theta_0 = \frac{Q_0}{P}$

$\tan\theta_N = \frac{Q_{new}}{P}$

$Q_c = Q_0 - Q_N$

$Q_c = P\tan\theta_0 - P\tan\theta_N$

$= P[\tan\theta_0 - \tan\theta_N]$

$\therefore C = \frac{P[\tan\theta_0 - \tan\theta_N]}{\omega V_{rms}^2}$

$Q_c = \frac{1}{2}|V_m||I_m|$

$= \frac{1}{2}\frac{|V_m|^2}{|Z_c|}$

$= \frac{1}{2}\frac{|V_m|^2}{\omega C}$

Ex: $V_{rms} = 120\ V$, $f = 60\ Hz$, $P = 4\ kW$

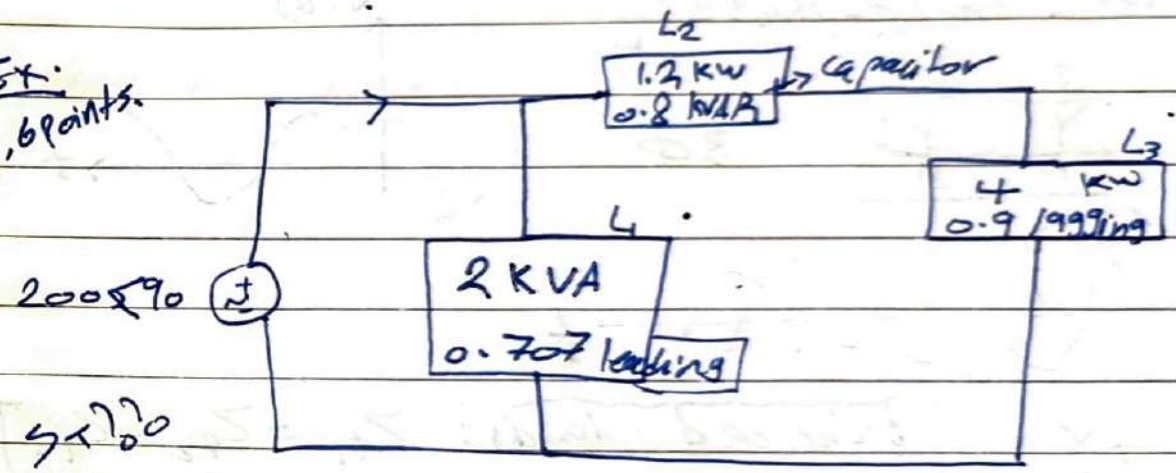
$P.F_o = 0.8$ lags , $P.F_N = 0.95$, $C = ?$

Sol: $C = \dfrac{P[\tan\theta_o - \tan\theta_N]}{\omega V_{rms}^2}$

$= \dfrac{4000\,[\tan(36.8) - \tan(18.5)]}{(2\pi(60))(120)^2}$

$= 305 * 10^{-6}\ F = 305\ \mu F$

Ex: , 6 points.



$S_T = S_{L1} + S_{L2} + S_{L3} \Rightarrow$

$S_{L1} = 2000 \angle -45°$ VA

$S_{L2} = 1200 - j800$ VA

$S_{L3} = 4444.4 \angle 25.8$ VA,

$\therefore S_T = S_{L1} + S_{L2} + S_{L3} =$ [redacted] 57

662.5 ∠ 12[redacted] VA

$S = \dfrac{P}{\cos\theta} = \dfrac{4000}{0.9} = 4444.44$

$S = \frac{1}{2} \vec{V} \; I^* \Rightarrow 66\,21.5 \angle -2.4 = \frac{1}{2} (200 \angle 90) I^*$

$\therefore I^* = 66.2 \angle -92.4^\circ$

$\therefore I = 66.2 \angle 92.4^\circ$

* 11.27 , 11.12 , 11.63 ← مهم جدا   مسميث للفاينل :

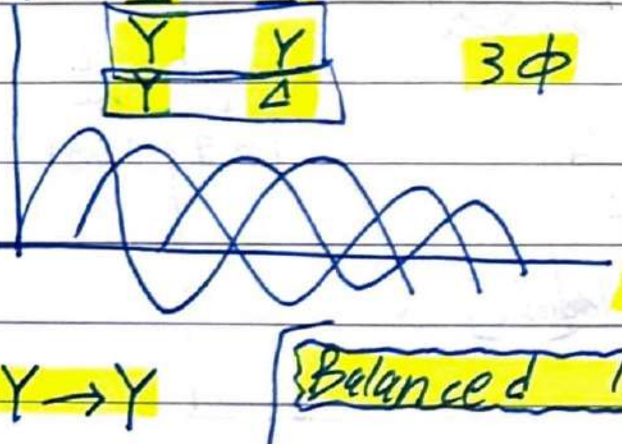
* P.F for system ⇒ $Z_{ToT.}$ or $S_{ToT.}$ نفسه لا

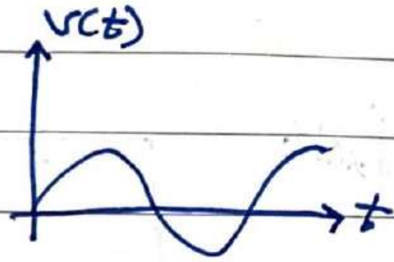
*CH 12 : Three-phase : Z

v(t)

S	L
Y	Y
Y	Δ

3Φ





* Y → Y   [Balanced load : $Z_{\phi_1} = Z_{\phi_2} = Z_{\phi_3}$]

Vab (line voltage)

تذكر +ve : $|V_{an}| = |V_{bn}| = |V_{cn}|$

Phase Voltage:

$V_{an} = V \angle 0$

$V_{bn} = V \angle -120^\circ$

$V_{cn} = V \angle -240^\circ$

-ve : $V_{an} = V\angle 0$

$V_{bn} = V\angle +120^\circ$

$V_{cn} = V\angle +240^\circ$

$V_{ab} = V_{an} - V_{bn} = \sqrt{3}\,|V_{an}|\,\angle +30^\circ$

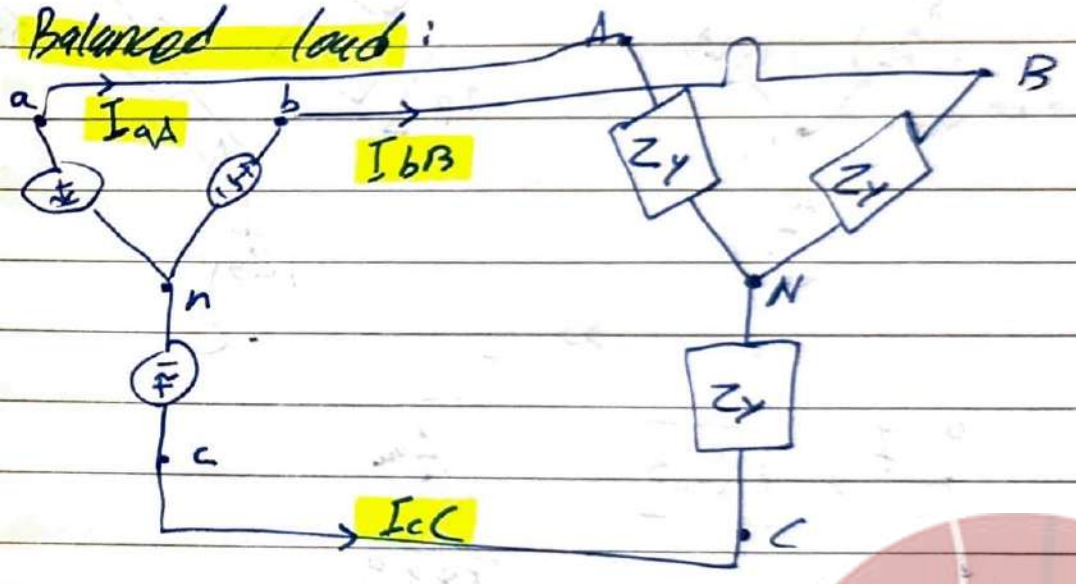
Ex: $V_{an} = 5\angle 60^\circ \Rightarrow V_{ab} = (\sqrt{3})(5)(\angle 90^\circ)$

$V_{bn} = 5\angle -60^\circ \Rightarrow V_{bc} = (\sqrt{3})(5)(\angle -30^\circ)$

$V_{cn} = 5\angle -180^\circ \Rightarrow V_{ca} = (\sqrt{3})(5)(\angle 150^\circ)$

line voltage

* Balanced load :



* Y-Y : $I_L = I_P$, $V_L \neq V_P$ (اذا متساوية بالكميات)

$V_L = \sqrt{3}\,V_P \angle \pm 30^\circ$

$I_{aA} = I \angle 0$

$I_{bB} = I \angle -120°$

$I_{cC} = I \angle -120°$

* a

$I_{aA} = \frac{V_{an}}{Z_y}$ A

Z_y

n N

مفتاح الحل

* ثانياً:

I_{aA} $2-j3$ a b A I_{bB} B

Z_y Z_y $5\angle 30°$

I_p

$V_{an} = 100\angle 60$ n N

Z_y

C

I_{cC}

ثالثاً:

a I_{aA} $2-j3$ A

$100\angle 60$ $5\angle 30°$

n N

60

[+ve]: $V_{an} = 100 \angle 60$, $V_{ab} = 100\sqrt{3} \angle 90$

$V_{bn} = 100 \angle -60$, $V_{bc} = 100\sqrt{3} \angle -30$

$V_{cn} = 100 \angle -180$, $V_{cb} = 100\sqrt{3} \angle -150$

* $I_{aA} = 15.7 \angle 64.5$
$I_{bB} = 15.7 \angle -55.5$
$I_{cC} = 15.7 \angle -175.5$

$I_{aA} = \dfrac{100 \angle 60}{(2-3j) + (5 \angle 30)}$
$= 15.7 \angle 64.5$

V.D

* $V_{AN} = 78.74 \angle 94.5$
$V_{BN} = 78.7 \angle -25.5$
$V_{CN} = 78.7 \angle -145.5$

$V_{AN} = \dfrac{(5 \angle 30)(100 \angle 60)}{(2-3j) + (5 \angle 30)}$
$= 78.7 \angle 94.5$

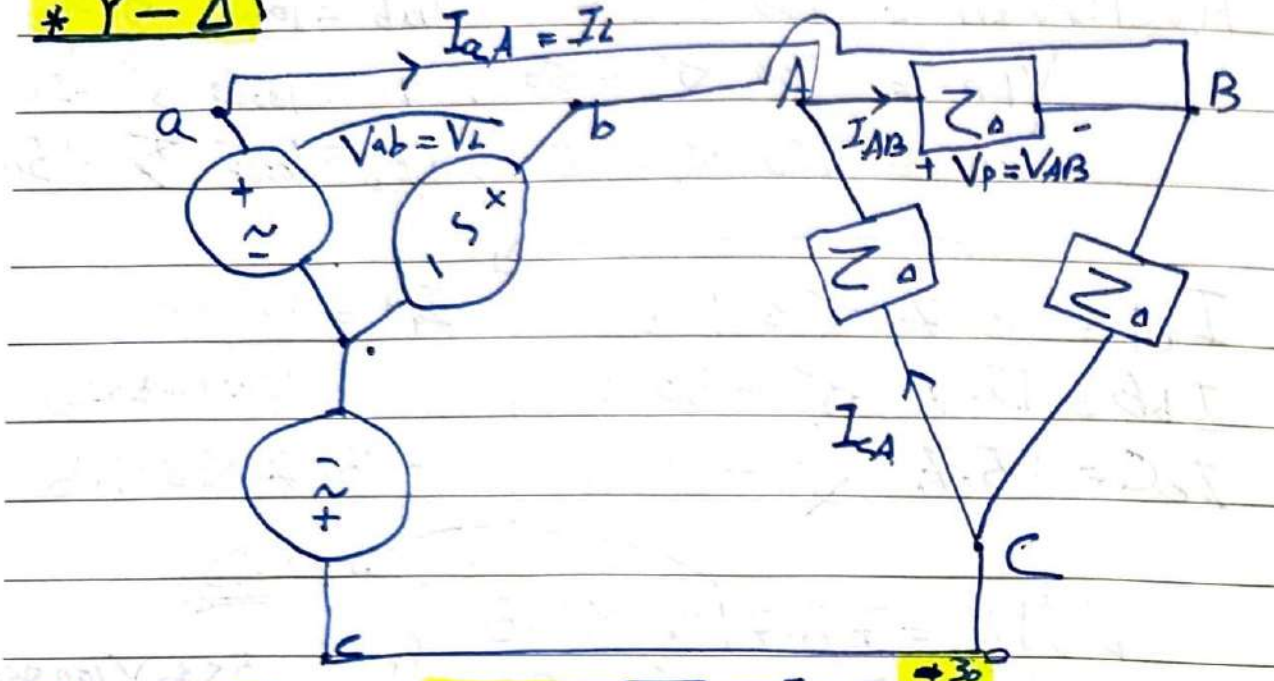
* $S_{\phi} = 3 \frac{1}{2} V_{AN} \cdot I_{aA}^{*} = \frac{3}{2} * 15.7 \angle -64.5 * 78.7 \angle 94.5$
$= 1853.4 \angle 30.5$

* $P.F = \cos(30.5) = 0.85$ (lags)

* اي اشي طالع load عمل phase ∢

* $I_{Nn} = I_{aA} + I_{bB} + I_{cC} = 0$ [Balanced load]

* Y − Δ



$Z_Y = \frac{Z_\Delta}{3}$, $I_{LA} = \sqrt{3}\ I_{AB} \angle -30$

$I_{AB} = \frac{V_{AB}}{Z_\Delta}$

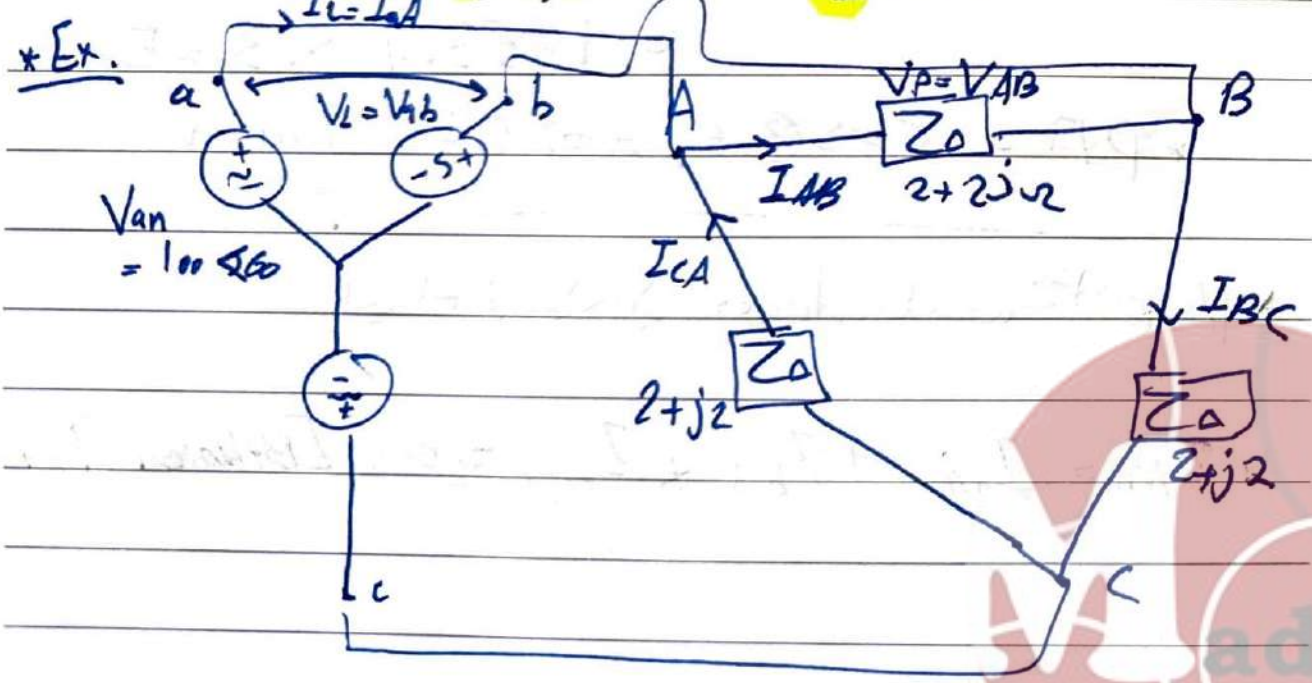
$V_L = V_P$

$I_L \neq I_P$

$I_{BC} = \downarrow \angle -120$

$I_{CA} = \downarrow \angle -120$

* Ex.



* $V_{an} = 100 \angle 60$ V

$V_{bn} = 100 \angle -60$ V

$V_{cn} = 100 \angle -180$ V

* $V_{ab} = V_{AB} = 100\sqrt{3} \angle 90$ V

$V_{bc} = V_{BC} = 100\sqrt{3} \angle -30$ V

$V_{ca} = V_{CA} = 100\sqrt{3} \angle -150$ V

* $I_{AB} = \frac{V_{AB}}{Z_\Delta} = \frac{100\sqrt{3} \angle 90}{2+2j} = 61.2 \angle 45$ A

phasl
- $I_{BC} = 61.2 \angle -75$ A
- $I_{CA} = 61.2 \angle -195$ A

* $I_{aA} = \sqrt{3}(61.2) \angle 15$

$I_{bB} = 106 \angle -105$

$I_{cC} = 106 \angle -225$

* $S_L = 3 * \frac{1}{2} * V_{AB}^* I_{AB}^*$

$= \frac{3}{2} * (100\sqrt{3} \angle 90)(61.2 \angle -45)$

$= 15900.2 \angle 45$ VA

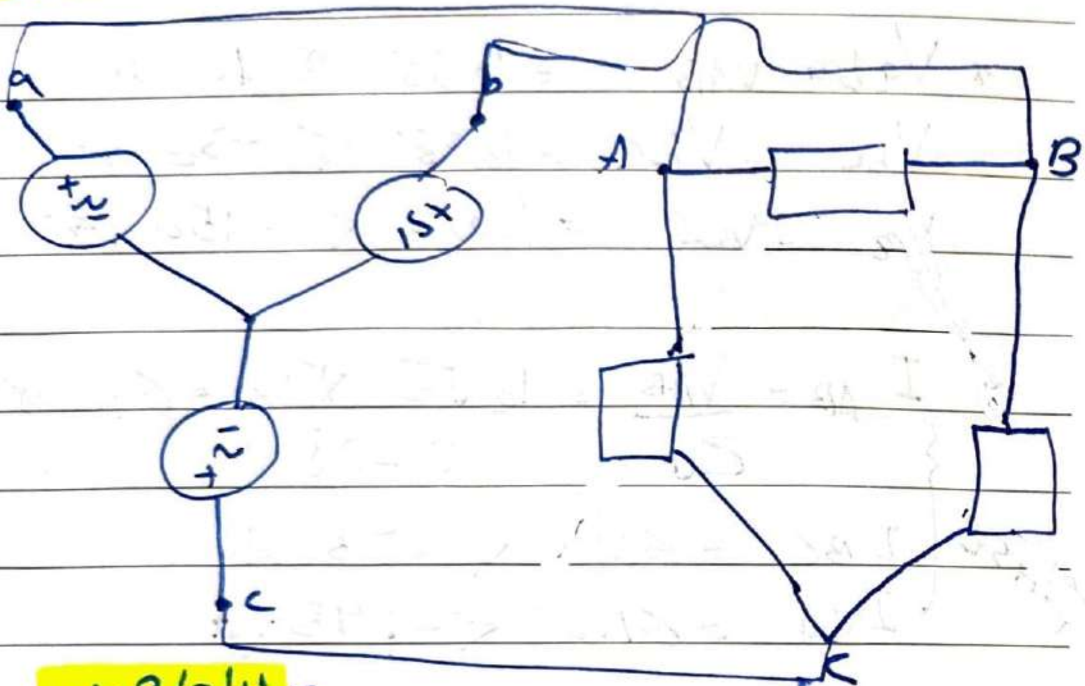
اذا ما حدد

Ex** Y – Δ Balanced, $V_{ab} = V_{line\,(source)} = 204$

load draws 18 KW , P.F = 0.8 lags.

← بشكل (مجموع 3)

sol:



اذا ما حدد

$V_{ab} = V_{AB} = 204 \angle 0$

* $V_{an} = \frac{V_{ab}}{\sqrt{3}} \angle -30 = \frac{204}{\sqrt{3}} \angle -30 = 118 \angle -30$

* $P_{Load} = 18$ KW , $P_{phase} = 18/3 = 6$ KW

* $S = \frac{P}{\cos\theta} = \frac{6000}{0.8} = 7500 \angle (\cos^{-1}(0.8)) = 7500 \angle 36.9$

* $S = 7500 \angle 36.9 = \frac{1}{2} V_{AB} I_{AB}^*$

$\therefore I_{AB}^* = 73.5 \angle 36.9$

$I_{AB} = 73.5 \angle -36.9$

$\therefore Z_\Delta = V_{AB} / I_{AB} = 2.22 - 1.67j$

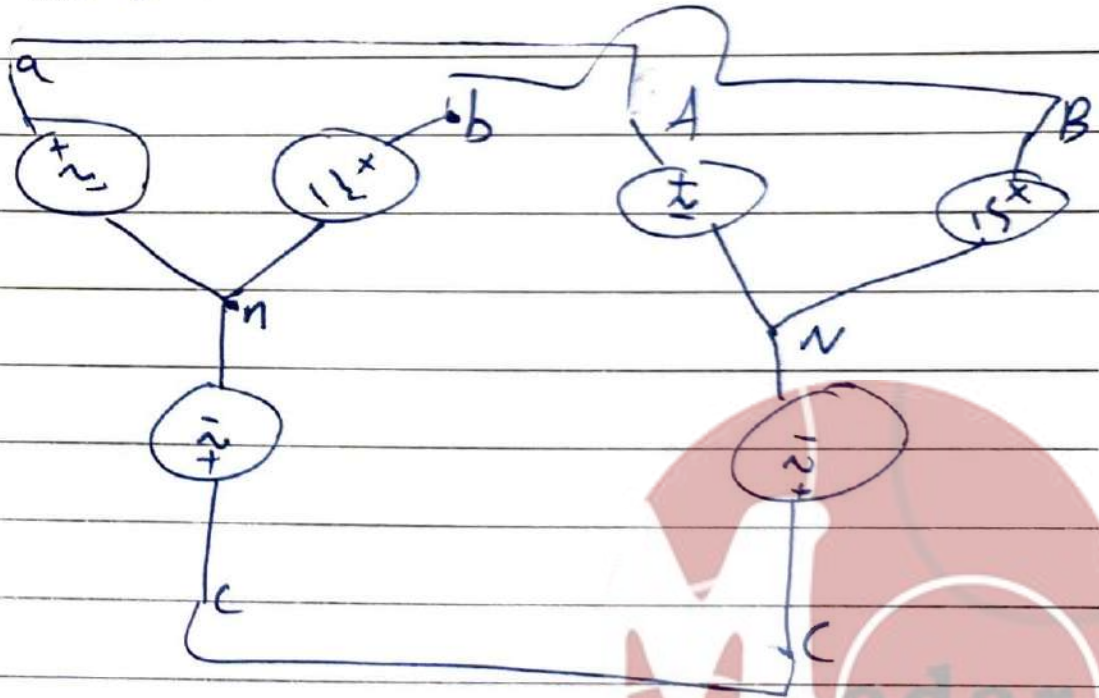
* $S_s = 3 * \frac{1}{2} * V_{an} I_{aA}^* = 22533 \angle -96.5$

$I_{aA} = \sqrt{3} * 73.5 \angle -66.5$

** P.F = 0.8 lags , Y-Y , S_L = ? KVA

$V_{line} = 204\ V$

Sol:



* $V_{ab} = 204 \angle 0$

* $V_{an} = \frac{204}{\sqrt{3}} \angle -30 = 118 \angle -30$

* $S_p = \frac{4.8}{3} = 1.6$ kVA

* $S_p = 1600 \angle 36.8$

* $S_p = \frac{1}{2} \cdot V_{an} I_{aA}^{*} \Rightarrow I_{aA} = 27.1 \angle -66.8$

* $Z = \frac{V_{an}}{I_{aA}} = 2.49 + 2.6j$