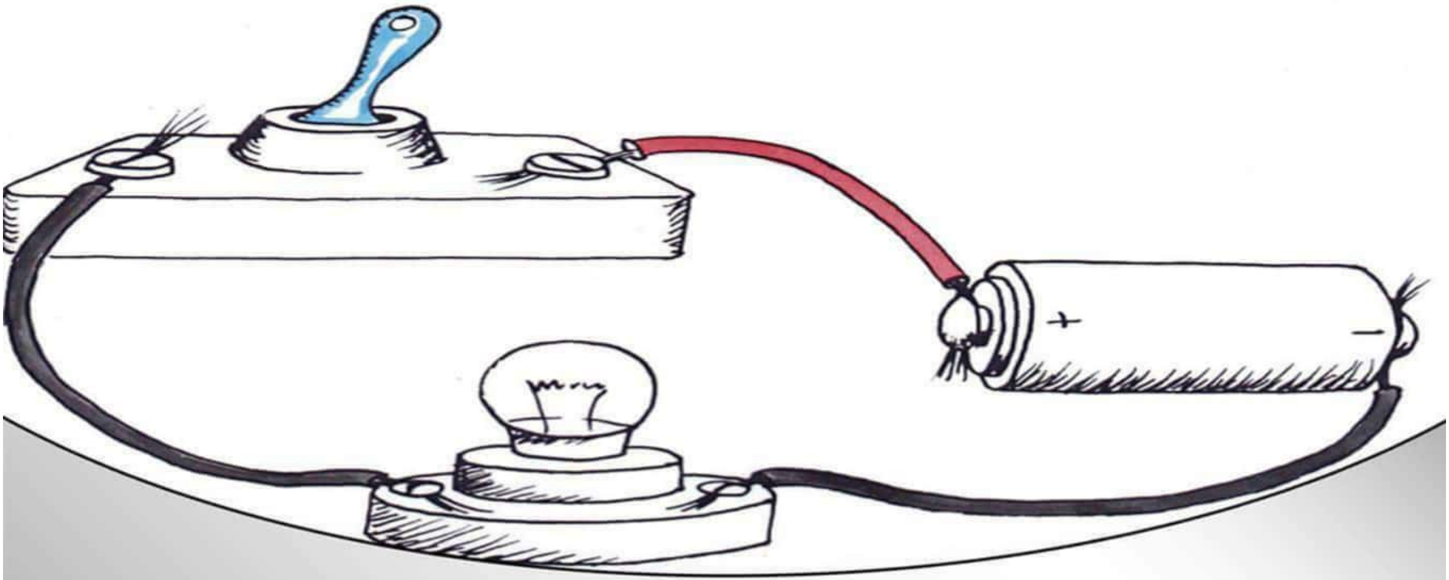


Circuits1

Fall017

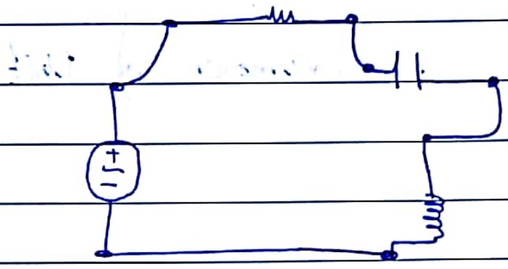
Dr. Ghazi Alsukkar

www Powerunit-ju.com

Circuit Analysis:

Circuit : CKT

Linear circuits ⟺ Non linear Circuits
↓
System.



Physical System $\xleftrightarrow{\text{Modeling}}$ Mathematical equations.

Circuit analysis:

CKT
1- Dc analysis : Direct current (steady state) فترة ثابتة
فترة انتقالية
2- Transient analysis: switching on & off
3- Ac analysis : Alternating current.

4- Frequency analysis.

Analyze the CKT ?

Find: Voltage & Current
- Power
- Energy
- Impedance, Admittance.

$$\text{Voltage} = \text{Current} \times \overset{\text{Resistance}}{\text{Impedance}}$$

Units:

* بنحتاج ٣ أو اكثر ← رقم + وحدة + اتجاه .

To measure any physical quauntity : we need 2 or more things.

Temprеature → Number & Unit

20 °C
75 °F
10 K.

SI units : International system of units.

7 basis units :

Quantity	unit	Appreviation.	
length	meter	m	20 m
mass	kilogram	Kg	
time	Second	s (sec)	
electrical current	Ampere	A	20 A
temprature	kelvin	K	
كمية المادة amount of substance	mole	mol	
شدة الاضاءة luminone intensity	Candela	Cd	

المشتقة Derived units :

ex
Energy → Joule (J)
Power → Watt (W)

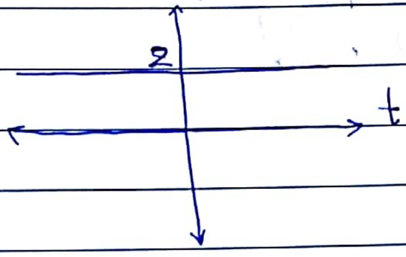
$$\text{Power} = \frac{\text{Energy}}{\text{Time}} = \text{Joule} \mid \text{sec} = \text{Watt}$$

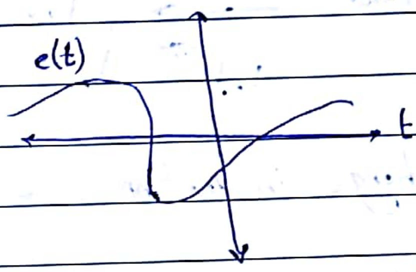
* Physical Quantities:

Energy:
→ E ثابتة
→ e(t) متغيرة

amount of work that can be performed by a force.

$\boxed{E = 2}$





Unit: Joule (J) 1 mile → 10 Kilometer
Calurie: (Cal)

1 calurie = 4.187 J

Power:
→ P
→ p(t)

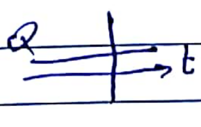
- amount of work done per unit of time.
- Rate at which energy is expended.

$$P = \frac{\Delta W}{\Delta t} \; E \qquad [\text{Watt} = \text{Joule/sec}]$$

$$P = \frac{d\,e(t)}{dt}$$

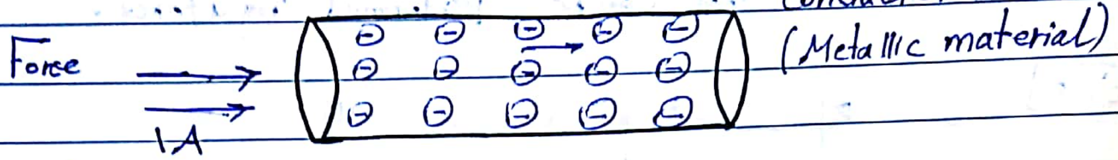
* Basic Electric Quantities:

شحنة
- Charge → Coulomb [C]
  - Q — Constant
  - q(t) → q — time variant



Charge → Positive (+ve) ; Proton

Charge → Negative (-Ve) : Electron.



Charge in motion → Current.

Coulomb:

Number of electrons that Passes through an arbitrary Cross section of a wire during an interval of one second.

$1A \rightarrow 1$ coulomb $= 6.242 \times 10^{18}$ electron.

Electron Charge $= \dfrac{1}{6.242 \times 10^{18}} = -1.602 \times 10^{-19}$ C

Proton Charge $= +1.62 \times 10^{-19}$ C

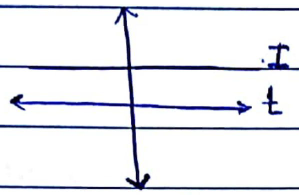
* Charge Conservation:

Total amount of Charge is constant.

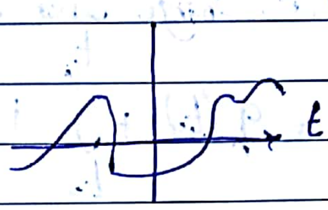
* Current : [A] ⟶ Number, Unit, direction 5A

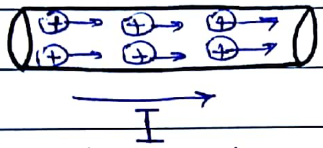
I → $i(t) \equiv i$ ⟶ time varying (Ac)

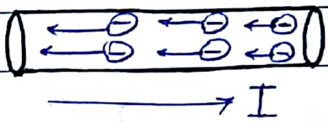
ثابت Dc ⟶ Direct current — Alternating Current



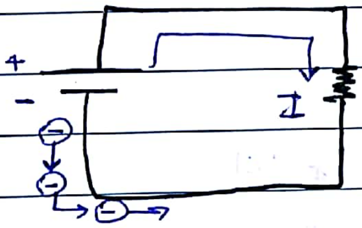
Constant

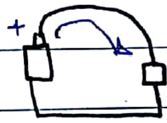






Current Direction
(by convintion)



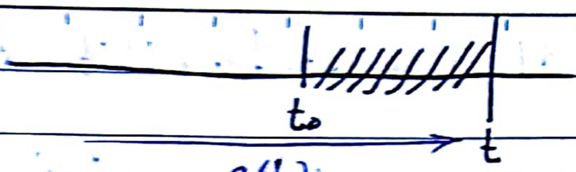


Current Density :
A measure of the rate at which charges are moving.

$$i = \frac{dq}{dt} \quad [C/sec] \equiv A$$

Total Charge transformed between t_0 & t

$$\int_{q(t_0)}^{q(t)} dq = \int_{t_0}^{t} i(t)\, dt$$

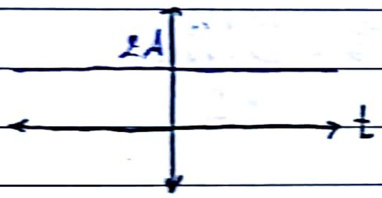


$q(t_0)$

- The over all (total) Charge Over all time :-

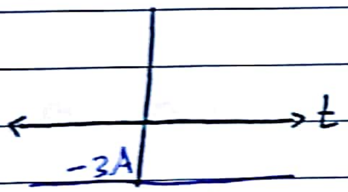
$$\int_{-\infty}^{t} i(t)\,dt = q(t_0) + \int_{t_0}^{t} i(t)\,dt$$

$I_1 = 2A$



Dc

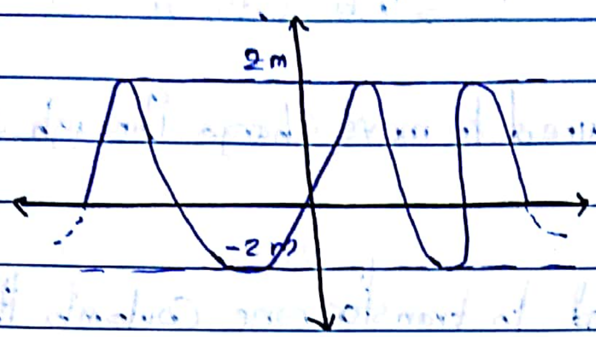
$I_2 = -3A$



Dc ← اي اشي ثابت وعكسه

Ac. ذلك

$i_1 \equiv i_1(t) = 2\sin(5t)\ mA.$



Sinusoidal

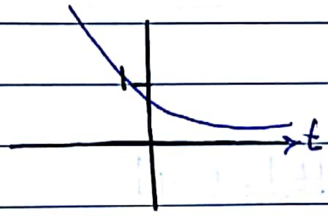
sin — cos

$\omega = 5$

$\frac{2\pi}{T} = 2\pi f = 5$

$\frac{2\pi}{5}$

$i = e^{-2t}\ A$



Exponential

A c

* 5c of +ve Charge is moving in 1 second
* -5c of -ve Charge " " " " ".

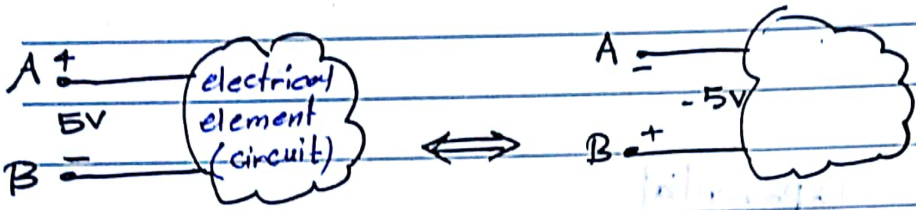
Voltage (Potential Difference) $\rightarrow$ V (DC) ثابت

[Volt] = [V] $\qquad$ $\rightarrow$ V(t) (AC) متغير

- is a measure of the work required to move charge through an element.

→ The amount of energy needed to transfer one Coulomb through an element.

$$1 \text{ volt} = 1\,J / 1\,C$$



* Power → P : constant Power $\qquad$ [Watt] = [W]

$\qquad$ → $p = p(t)$ Instantaneous Power

$$P = \frac{\Delta E}{\Delta t} \quad , \quad p(t) = \frac{de(t)}{dt}$$

Watt = Joule / sec

$$P = \underbrace{\frac{\text{Joule}}{\text{Coulomb}}}_{V} \cdot \underbrace{\frac{\text{Coulomb}}{\text{sec}}}_{A}$$

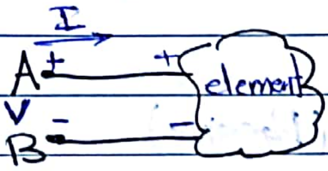
P = number of coulombs transferred per second X energy needed to transfer one coulomb through the element.

P = Current X Voltage.

$$\boxed{P = IV = VI}$$

$$\boxed{P(t) = w(t) \cdot i(t)}$$

Passive sign Convention:



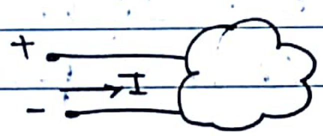
$P = VI$

مستهلك → +ve : amount of Power absorbed by the element (Passive)

معطي طاقة → −ve : amount of Power delivered by the element (active)

active sign convention:

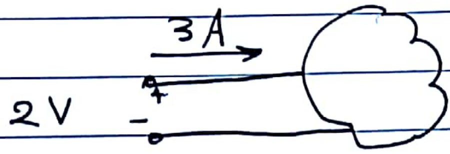
التيار عند السالب



+ve]
−ve] عكس بعض

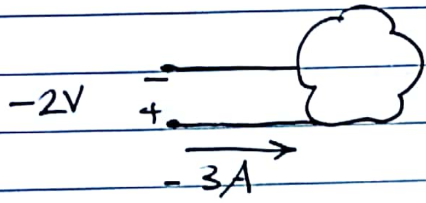
* If one Joule of energy is expended in transfering one Coulomb of charge through the device in one second, then the rate of energy transfer is one Watt.

* Calculate the absorbed Power:



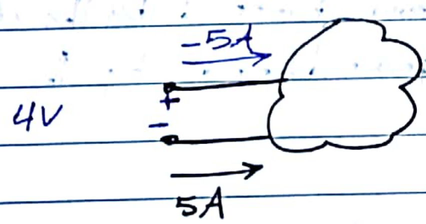
(Passive)

$P = 2 \times 3 = 6\,w$ (absorb)



(Passive)

$P = -2 \times -3 = 6\,w$ (absorb)



(active) → (Passive)

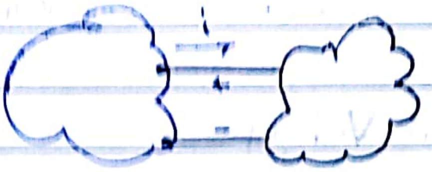
active
تحولها
Passive

$P = 4 \times -5 = -20\,W$ (deliver)

This device absorbes $-20\,W$ of Power.

* Passive sign convention :

P. ?? Absorbed by ...
Delivered by ...

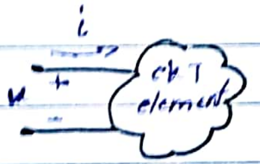


$p = vi$

$p = vI$ → +ve (absorb)
→ -ve (deliver) supply

* CKT elements :-

- Any element is characterized by the relation between the Voltage across its terminals and the current passing through it.



* Power Supply :-

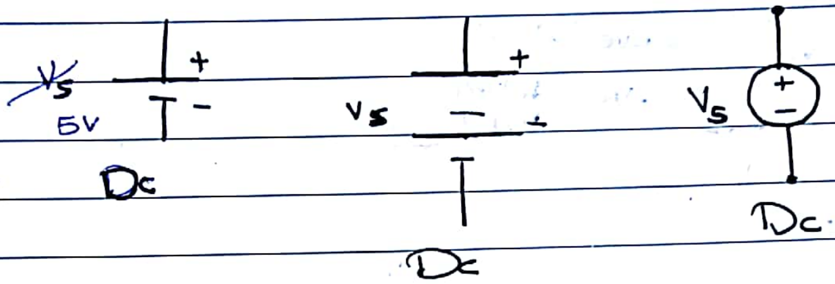
- Voltage source
  - dependent
    - Voltage controlled
    - current controlled
  - Independent
- Current source
  - dependent
    - Voltage controlled
    - current controlled
  - Independent

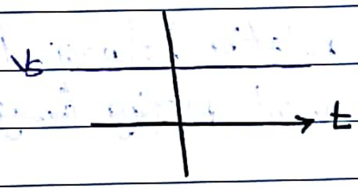
* Independent Voltage source :

- It is Charactrized by a terminal voltage which is completely independent of the current passing through it ⇒ (Ideal)

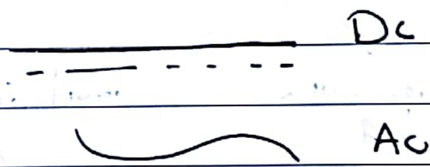
Volt ثابتة ← current متغيرة *

Ideal Voltage sources ⟹ constant Voltage.





$V_s = 2\cos(10t)\,V$



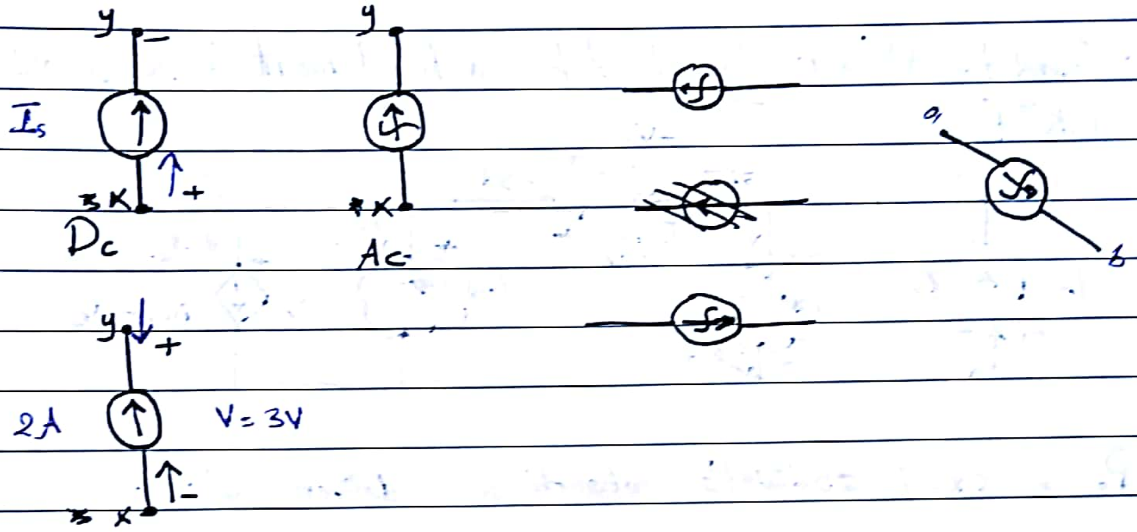
red / Blue (+)
Black (-)

← ويعتمد التيار على الجهد

* Independent current source :

- The current through this element is completely independent of the voltage a cross it. .التيار ثابت والجهد متغير وحسب التيار لا يعتمد عليه

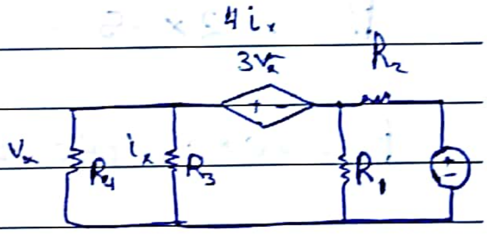
Ideal Current source ⟹ Current constant .

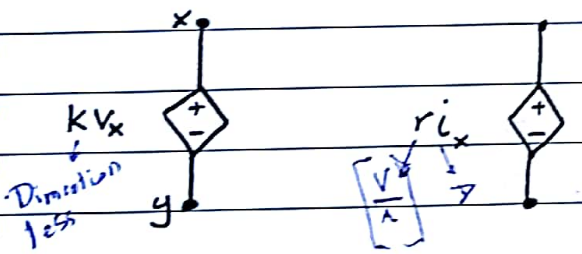


$P = 3 \times -2$

$P = -6$ (deliver)

- Dependent Sources (Controlled) :



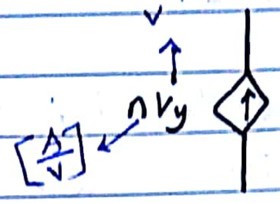


Voltage controlled voltage Source.

Current Controlled Voltage source.

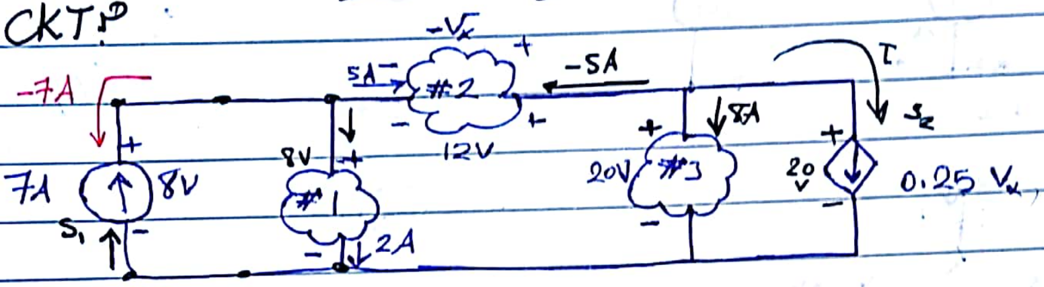
[illegible] $m\, i_y$ Dimentionless

Current - controlled current source



Voltage-controlled Current source.

Ex: Find the Power absorbed by each element in the show CKT?



$P_{S_1} = 8 \times -7 = -56$ watt. (absorb) deliver $\rightarrow (+56)$

عالتوازي V متساوي

$P_1 = 8 \times 2 = 16$ watt

$P_2 = 12 \times -5 = -60$ watt (deliver)

$P_3 = 20 \times 8 = 160$ watt.

$P_{S_2} = 20 \times (0.25\, V_x)$ $\qquad -V_x = 12$

$= 20 \times (0.25 \times -12)$ $\qquad V_x = -12$

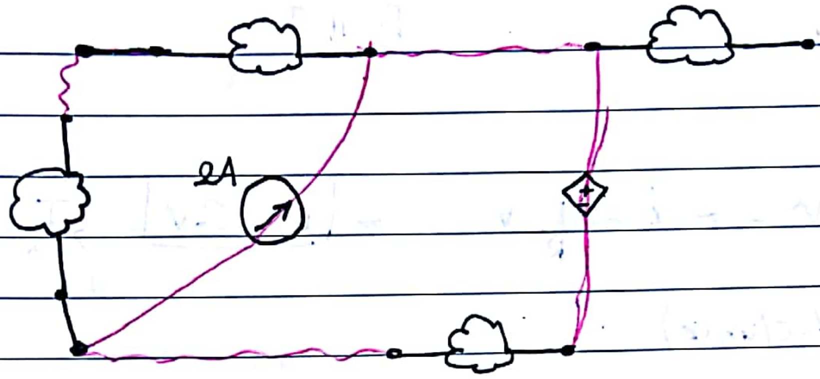
$= -60$ watt.

قانون حفظ الطاقة = + + + ..

= صفر.

* Networks & CKT:

- Two or more CKT elements connected together are called Network.
- A Network that contains at least one closed path is called a circuit.



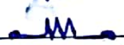
6 terminal (شباك ١٩)

- Any CKT is a network.
- Any Network is not necessarily a CKT.
- A Network with at least one active device.
  ⇒ active network.
- A Network without any active devices
  → passive network.

Ohm's Law:

- voltage across conducting materials is directly proportional to the current flowing (Passing) through the material.

1kΩ



Resistor.

$V \propto i$ → proportionality constant.

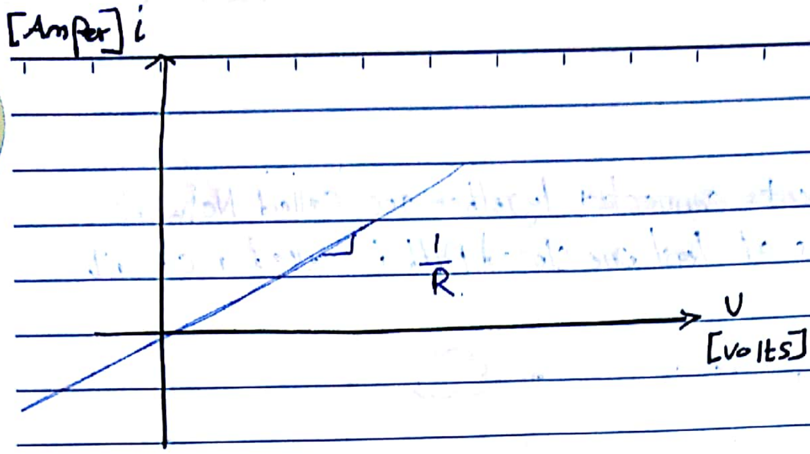
$V = Ri$

↳ Resistance → $R = \frac{V}{i}$ $\left[\frac{V}{A}\right] = [\Omega]$ ohm

$V = RI$ DC

$\vec{V} = Z\vec{I}$

↳ impedence



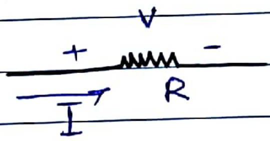
$$i = \frac{V}{R} = \frac{1}{R} v \rightarrow i = \frac{1}{R} v \rightarrow \boxed{i = Gv} \rightarrow I = GV$$

DC

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

[siemens] = [S]

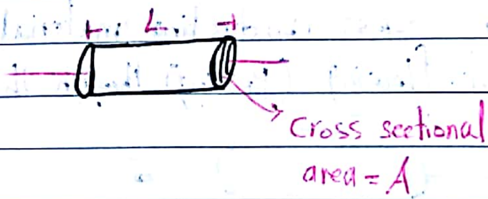
$$1\,S = \frac{1A}{1V} = \frac{1}{\Omega} = \Omega^{-1} = \mho \text{ (mho)}$$

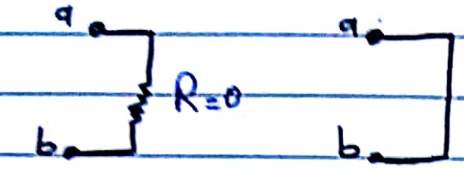


$$V = RI$$

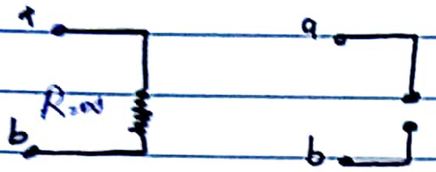
$$R = \frac{\rho L}{A} \quad \frac{m}{m^2}$$

Resistivity $[\Omega . m]$





Short circuit: هيا يشحنات تمر دون تخسر شيء من طاقتها
S.C.



Open circuit التيار هنا لا يمر (الشحنات لا تمر)
O.C

$P = VI$ $\qquad V = RI$

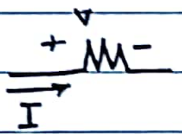
$P = (RI)I = RI^2$

$\boxed{P = RI^2}$ (Power absorbed by the resistor)

$P = V\left(\frac{V}{R}\right) = \frac{V^2}{R}$ (R دائماً موجبة)

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

Ex:



① $R = ?$ if $I = -1.6\ mA$, $V = -6.3\ V$

$V = RI \longrightarrow R = \frac{V}{I} = \frac{-6.3}{-1.6\ mA} = 3.94\ k\Omega$

$= 3940\ \Omega$

② $V = -6.3\ v$, $R = 21\ \Omega$

Find the absorbed Power by R :-

$P = \frac{V^2}{R} = \frac{(-6.3)^2}{21} = 1.89$ watt.

دائماً موجبة
دائماً absorb
سبب طاقة (Passive)

③ $V = -8V$, if R absorbing $0.24\,w$, Find I ?

$P = 0.24$ watt

$V = -8\,V$

$P = VI$

$I = \frac{P}{V} = \frac{0.24}{-8} = -30\ mA$

$= -30 \times 10^{-3} A$

$i(t) = e^{2t}$

$v(t) = \cos(5t)$ Find P :

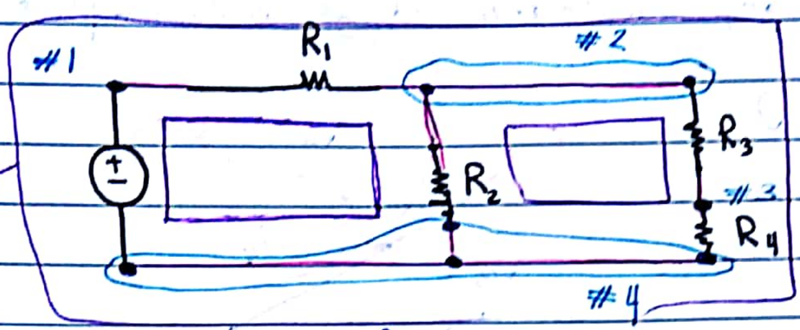
Sol) $p(t) = e^{2t}\cos(5t)$ watt

CH2: KVL , KCL , Series , ParalleL .

نقطة اشتراك لعناصر مع بعضها

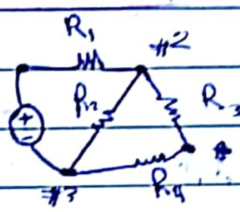
Node : a point at which two or more elements have a common connection.

Loop



How many element ? 5

How many Branches ? 5



S.C في اسلاك بنضم Node

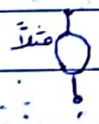
اذاً نفسها

Path : a set of nodes and elements Passed.

Loop : Closed Path . نبدا بنقطة ونرجع لنفس النقطة .

- Loop is a Path.
- Path is not necessarily a loop.

Branch : one element and the node at each end of it .



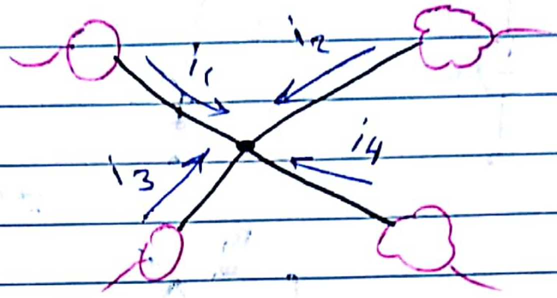
one Branch.

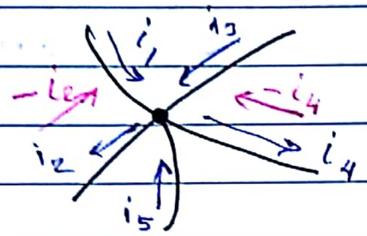
Kirchhoff's Current Law (KCL):

- The algebric sum of the currents entering (Leaving) any node is zero → Charge conservation مجموع التيارات الداخلة يجمع خارجة

$i_1 + i_2 + i_3 + i_4 = 0$

$\sum_{n=1}^{N} i_n = 0$





* بتفصل كل شي

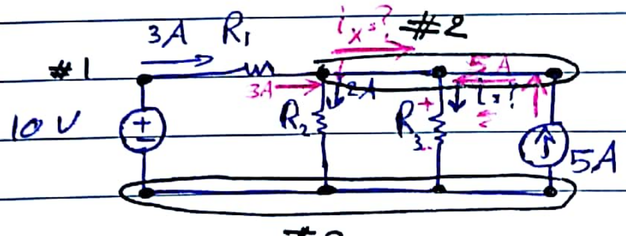
$i_1 - i_2 + i_3 - i_4 + i_5 = 0$

مجموع I الداخلين = مجموع I الخارجين

$i_1 + i_3 + i_5 = i_2 + i_4$

** The sum of currents going in equal to the sum of currents going out. $\sum i_{in} = \sum i_{out}$

Ex: Find the current in R_3, $i = ?$, P_3?

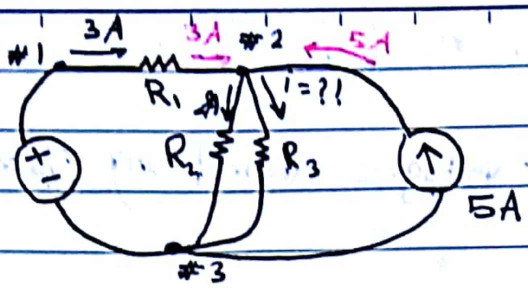


5 Branch.
3 Node
6 loops

$3 = 2 + i_x \longrightarrow \boxed{i_x = 1\,A}$

$i_x + 5 = i$

$1 + 5 = i \longrightarrow \boxed{i = 6\,A}$



Node #2 :

$3 + 5 = 2 + i$

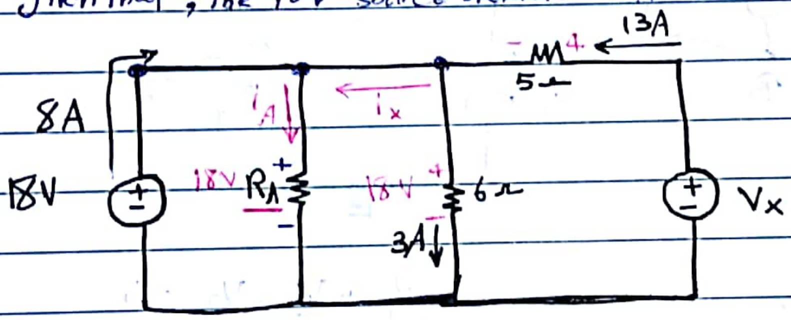
$i = 6\,A$

P_3 ?!

$P_3 = i^2 R_3$

$= (6)^2 R_3$:

ex: Count the number of branches & find $R_A = ?$
given that, the 18V source delivers 8A of current.



$13 = 3 + i_x \longrightarrow i_x = 10\,A$

$8 + 10 = i_A \longrightarrow i_A = 18\,A$

$Ri = V$

$R_A(18) = 18 \longrightarrow R_A = 1\,\Omega$

5 Branches.

$P_A = IV = (18)^2$ watt

Kirchhoff's voltage Law (KVL):

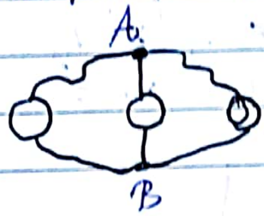
- The algebric sum of the voltages around any closed path is zero.

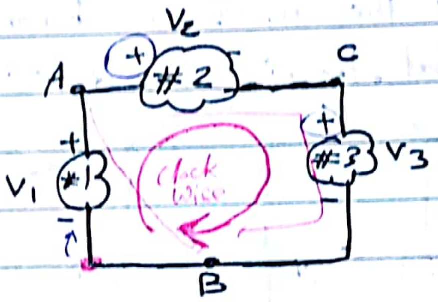
$$\sum_{n=1}^{N} V_n = 0$$

$$\boxed{V_1 + V_2 + V_3 + \cdots + V_N = 0}$$

- energy conservation.

- The energy required to move a unit of charge from point A to point B is Independent of the path chosen to go from A to B.

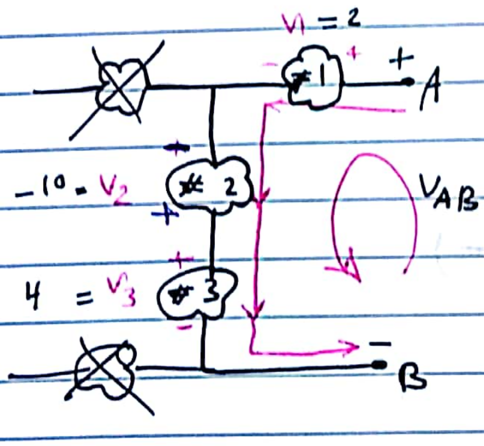




$V_1 = V_2 + V_3$

$-V_1 + V_2 + V_3 = 0$

$\boxed{V_2 + V_3 = V_1}$



$-V_{AB} + V_1 - V_2 + V_3 = 0$

$V_{AB} = V_1 - V_2 + V_3$

$= 2 - (-10) + 4$

$= 16V.$

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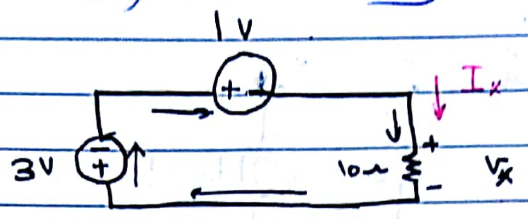
ex : Determine I_x & V_x in the following circuit.



inseries ⟶ التيار متساوي

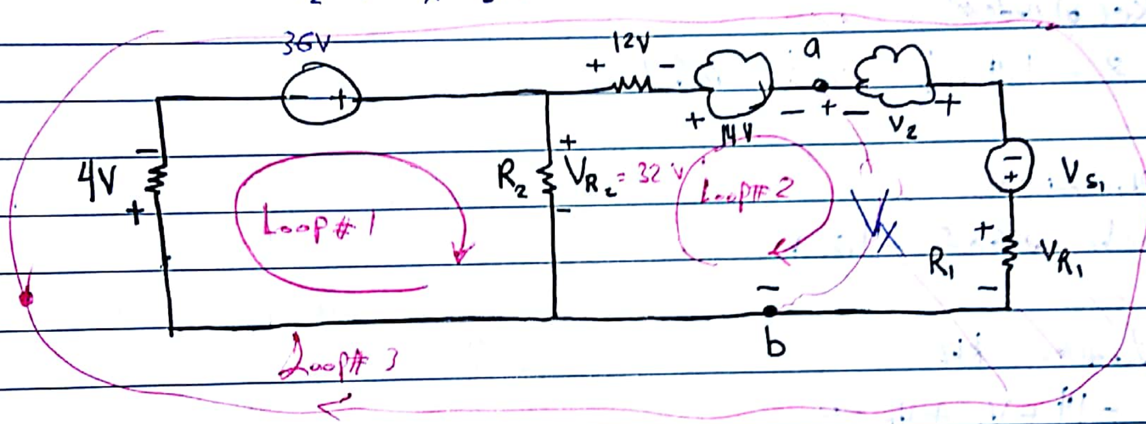
$$+3+1+V_x=0$$

$$V_x=-4V$$

$$10\,I_x=-4 \longrightarrow I_x=\frac{-4}{10}=-0.4\,A$$

$$=-400\,mA$$

ex : Determine V_{R_2} & V_x ?



@ Loop#1 : KVL

$$+4-36+V_{R_2}=0$$

$$V_{R_2}=32\,V$$

$$V_x=V_{ab}$$

$$-V_x-V_2-V_{S_1}+V_{R_1}=0$$

$$V_x=-V_2-V_{S_1}+V_{R_1}$$

@ Loop#2 : KVL

$$-32+12+14+V_x=0$$

$$V_x=32-12-14=6V$$

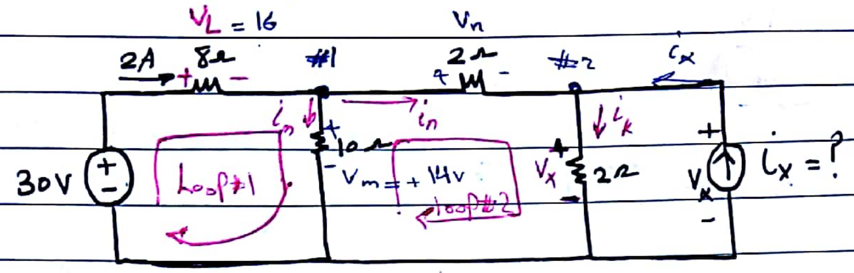
or

@ Loop#3

$$+4-36+12+14+V_x=0$$

$$V_x=6V.$$

Determine V_x & I_x :-



$V_L = 2 \times 8 = 16\ V$

@ Loop#1 : KVL

$-30 + 16 + V_m = 0 \longrightarrow V_m = +14V$

$i_m = \frac{14}{10} = 1.4A$

KCL @ node#1 :

$2 = 1.4 + i_n \longrightarrow i_n = 0.6A$

Ohm Law :

$V_n = 0.6 \times 2 = 1.2\ V$

@ Loop#2 : KVL

$-14 + V_n + V_x = 0$

$-14 + 1.2 + V_x = 0 \longrightarrow \boxed{V_x = 12.8V}$

$i_k = \frac{12.8}{2} = 6.4\ A$

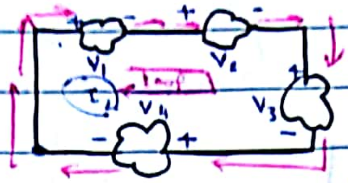
@ Node#2 : KCL

$i_x + 0.6 = 6.4 \longrightarrow \boxed{i_x = 5.8A}$

$P_x = 12.8 \times (-5.8)$ deliver

$P_{30V} = 30(-2)$ deliver

* Single Loop CKT :



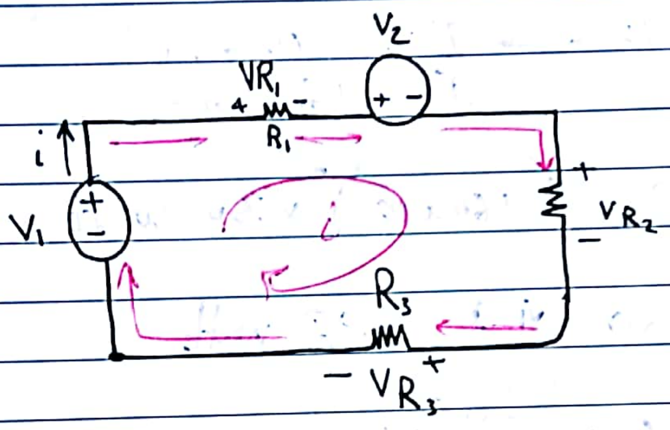
KVL :

$V_1 + V_2 + V_3 + V_4 = 0$

connected in series, $\longrightarrow$ same current.

- Element carrying the same current are said to be connected in series.

I = ?



$-V_1 + V_{R_1} + V_2 + V_{R_2} + V_{R_3} = 0$

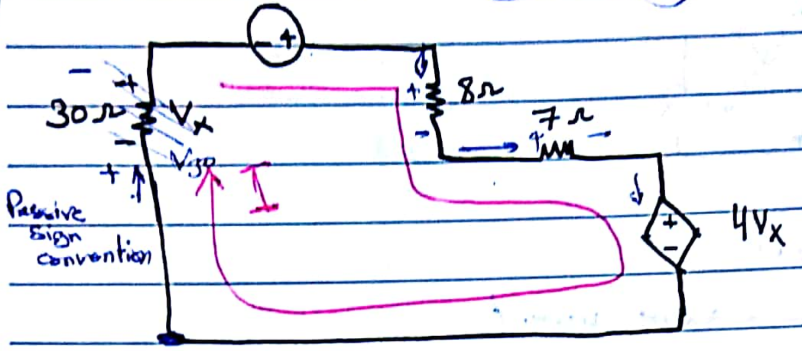
$-V_1 + iR_1 + V_2 + iR_2 + iR_3 = 0$

$iR_1 + iR_2 + iR_3 = V_1 - V_2$

$i(R_1 + R_2 + R_3) = V_1 - V_2$

$$i = \frac{V_1 - V_2}{(R_1 + R_2 + R_3)}$$

ex: Find the 12V Power absorbed by each element:



Voltage source شكلو (غير) مستقل.

$V_x = -V_{30}$

$= -(30I) = -30I$

KVL:

$30I - 12 + 8I + 7I + 4V_x = 0$

$30I - 12 + 8I + 7I + 4(-30I) = 0$

$-75I = 12 \longrightarrow I = -0.16\ A$

$I = -160\ mA$

$P_{30\Omega} = I^2(30) = (-160\times10^{-3})^2 \times 30$ watt $= 0.768\ W$.

$P_{12V} = -(-160\times10^{-3})\times(12) = 1.92$ watt.

$P_{8\Omega} = I^2(8) = (-160\times10^{-3})^2 \times 8 = 0.2048$ watt

$P_{7\Omega} = (-160\times10^{-3})^2 \times 7 = 0.1792$ watt.

$P_{4V_x} = (4V_x)(-160\times10^{-3})$

$= (4\times -30\times -160\times10^{-3})(-160\times10^{-3}) = -3.072\ W$

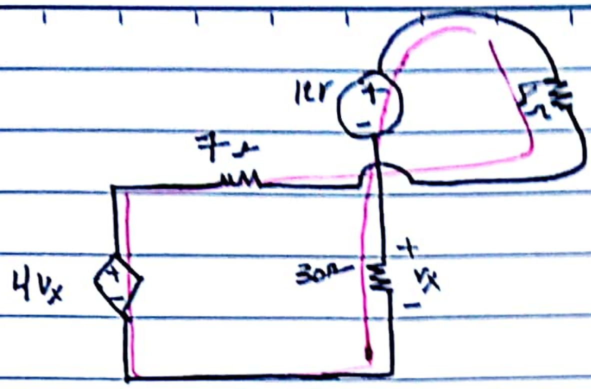
$P_{30} + P_{12V} + P_{8\Omega} + P_{7\Omega} + P_{4V_x} = 0$

- The sum of absorbed power by each element of a CKT is Zero.

$$\sum P_{absorbed} = \sum P_{supplied}$$

الحلقة نفسها متوالين مع بعض

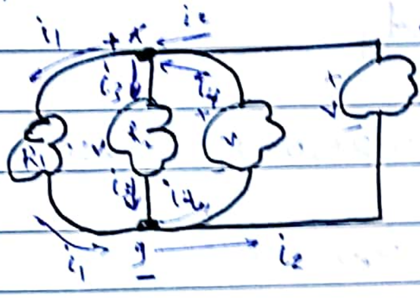
Single loop



* Single Node - Pair CKT :

* من يجيني هيج انا نطبق على جهة واحدة بس

KCL :



$i_2 + i_4 = i_1 + i_3$

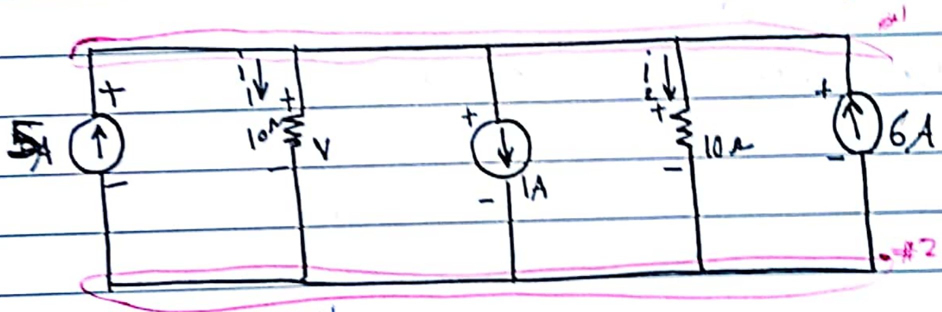
$V = ?$

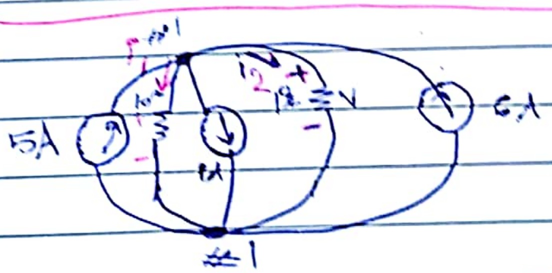
$i_1 = \frac{V}{R_1}$

$i_3 = \frac{V}{R_3}$

- elements connected in a CKT having a common voltage across them are said to be connected in Parallel.

** هنا ماعندي Current Source فقط ولا يوجد Voltage





$$5+6 = 1 + i_1 + i_2$$

$$10 = i_1 + i_2$$

$$10 = \frac{V}{10} + \frac{V}{10}$$

$$10 = \frac{2V}{10}$$

$$\boxed{V = 50\,V}$$

$$\boxed{i_1 = i_2 = \frac{50}{10} = 5A}$$

$$P_{5A} = 50 \times -5 = -250\,W \text{ deliver}$$

$$P_{6A} = 50 \times -6 = -300\,W$$

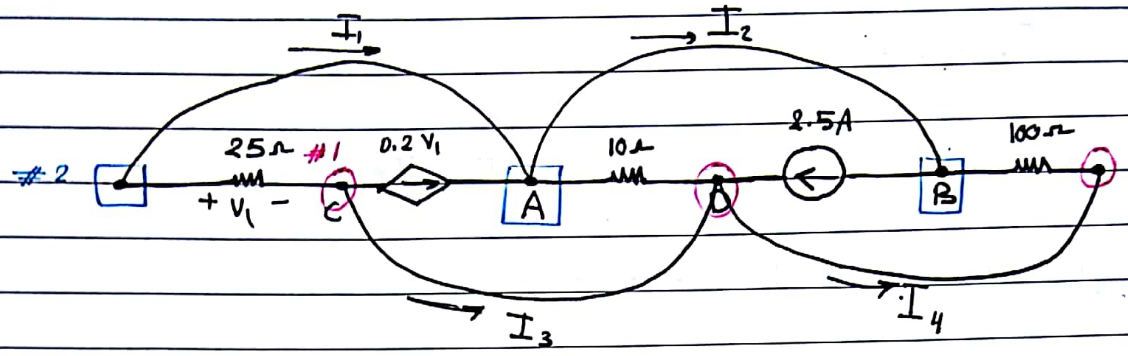
$$P_{1A} = 50 \times 1 = 50\,W$$

$P_{10\Omega}$ الاولى $= \frac{V^2}{10} = \frac{(50)^2}{10} = 250$

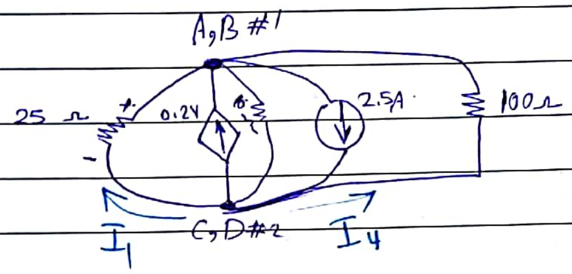
$P_{10\Omega}$ التانية $= \frac{V^2}{10} = \frac{(50)^2}{10} = 250$

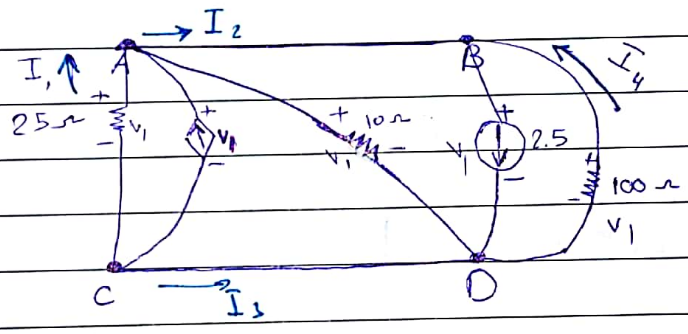
$$500 + 50 - 300 - 250 = 0$$

ex: I_1, I_2, I_3, I_4 ?



2 Node:





① Node A:

$$I_1 + 0.2 V_1 = I_{10} + I_2$$

$$-\frac{V_1}{25} + 0.2 V_1 = \frac{V_1}{10} + I_2$$

$$\frac{-V_1}{25} + 0.2 V_1 - \frac{V_1}{10} = I_2 \dots ①$$

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9) Node B:

$$I_2 + I_4 = 2.5$$

$$I_2 + \frac{-V_1}{100} = 2.5 \rightarrow I_2 = 2.5 + \frac{V}{100} \quad (2)$$

$$-\frac{V_1}{25} + 0.2V_1 - \frac{V_1}{10} = 2.5 + \frac{V_1}{100}$$

$$V_1 = 50V$$

$$I_1 = \frac{-V_1}{25} = \frac{-50}{25} = -2A$$

$$I_2 = 2.5 + \frac{50}{100} = 3A$$

$$I_4 = \frac{-50}{100} = -0.5A$$

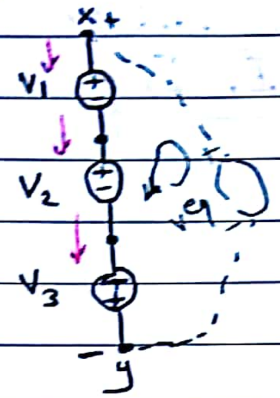
9) Node C:

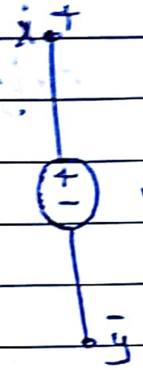
$$I_1 + 0.2(50) + I_3 = 0$$

$$-2 + 0.2(50) = -I_3$$

$$I_3 = -8A.$$

* Series & Parallel Connection of Sources:

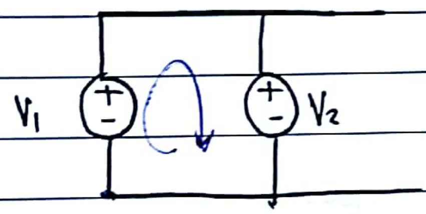




$V_{eq} = V_1 + V_2 - V_3$

$-V_{eq} + V_1 + V_2 - V_3 = 0$

$\boxed{V_{eq} = V_1 + V_2 - V_3}$



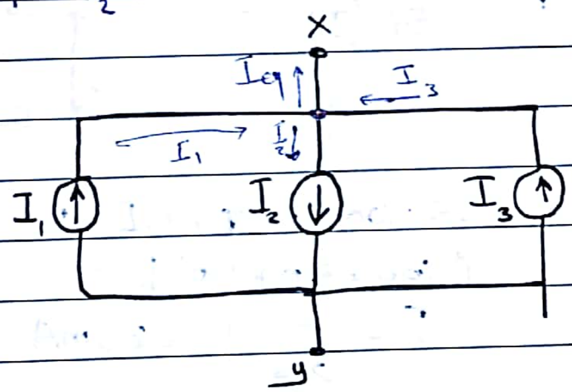
$V_2 \neq V_1$ Problem

only when $V_1 = V_2$

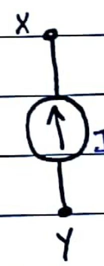
بالتوازي، يجب [illegible]

$-V_1 + V_2 = 0$

$V_1 = V_2$



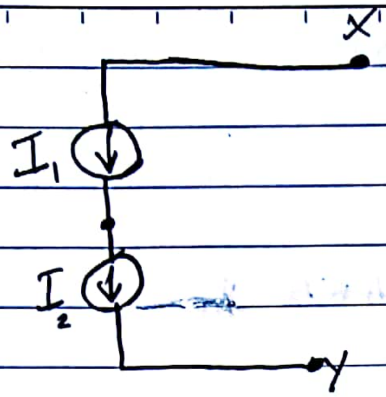
$\Longleftrightarrow$



$I_{eq} = I_1 + I_3 - I_2$

$I_1 + I_3 = I_{eq} + I_2$

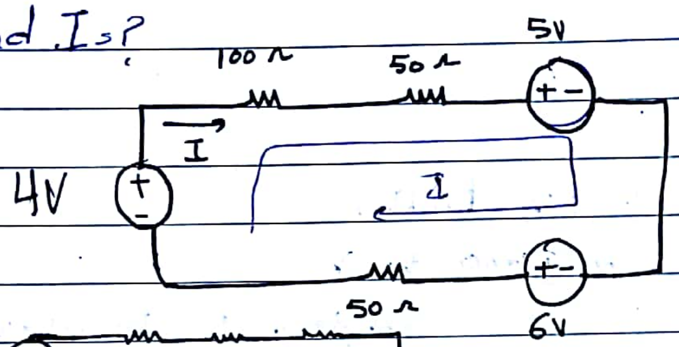
$I_1 + I_3 - I_2 = I_{eq}$

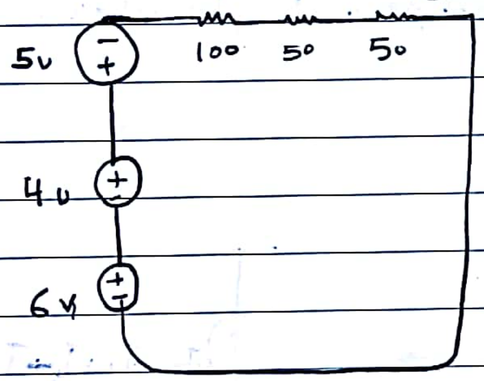


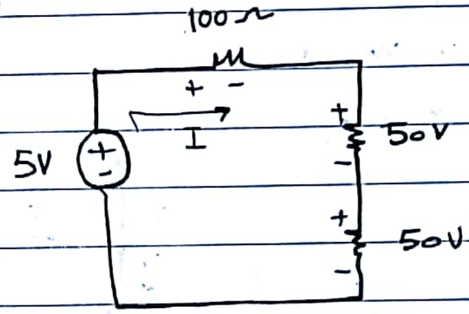
If $I_1 \neq I_2$ Problem
Only if $\boxed{I_1 = I_2}$

$$\boxed{I_1 = I_2}$$

ex: find $I = ?$





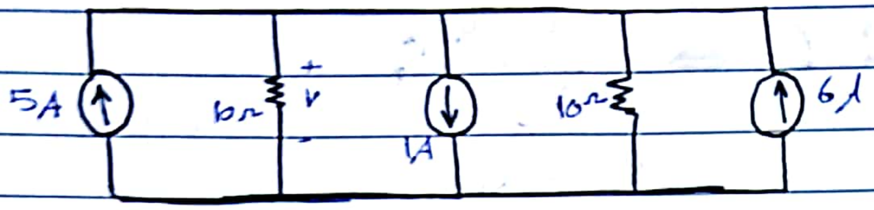


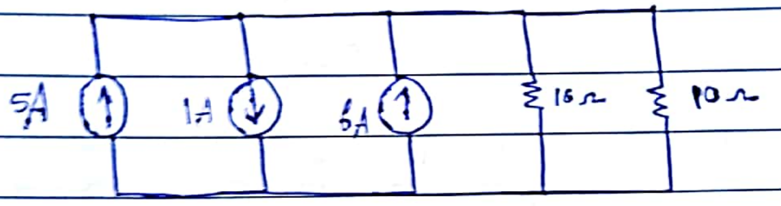
$$-5 + 100I + 5I + 5I = 0$$

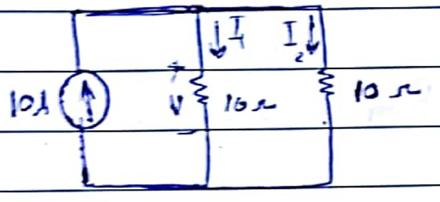
$$(100 + 50 + 50)I = 5$$

$$I = \frac{5}{200} A = 25 mA$$

ex: find V = ?



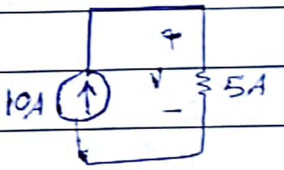




KCL:

$10 = I_1 + I_2$

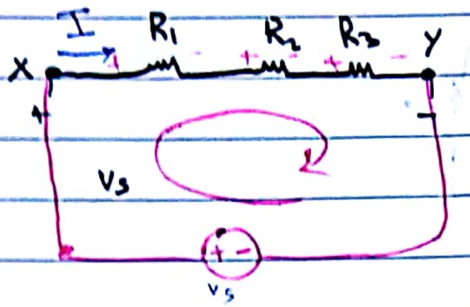
$10 = \frac{V}{10} + \frac{V}{10}$

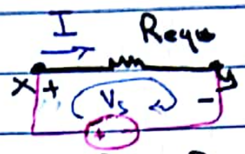


$10 = V\left(\frac{1}{10} + \frac{1}{10}\right)$

$V = 50\,V$

* Resistors in series & Parallel:





$$R_{eq} = R_1 + R_2 + R_3$$

$$-V_s + IR_{eq} = 0$$

$$V_s = IR_{eq}$$

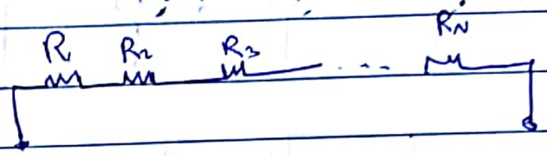
KVL:

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

$$V_s = V_1 + V_2 + V_3$$

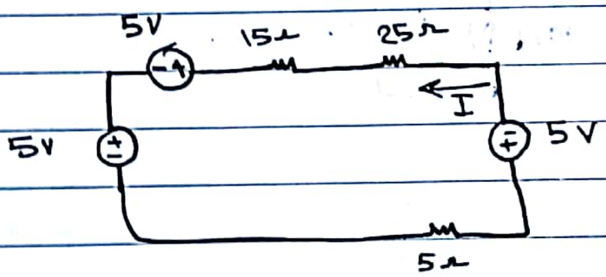
$$= IR_1 + IR_2 + IR_3$$

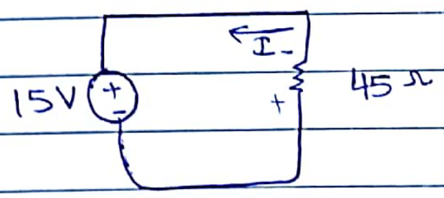
$$V_s = I(R_1 + R_2 + R_3)$$



$$R_{eq} = \sum_{n=1}^{N} R_n$$

ex: Determine I in the shown ckt & $P_{15\Omega}$



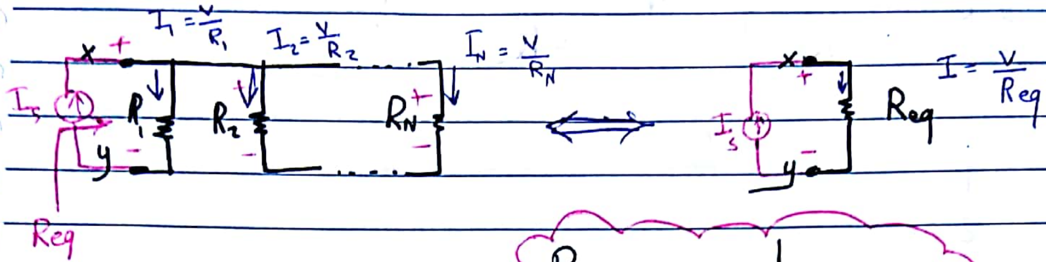


$$P_{15\Omega} = \left(\frac{-15}{45}\right)^2 (15)\ W.$$

$$-15 - I(45) = 0$$

$$I = \frac{-15}{45}$$

* Parallel Resistors :



$$R_{eq} = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \cdots \frac{1}{R_N}}$$

KCL :

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

$$I_s = \frac{V}{R_1} + \frac{V}{R_2} + \cdots \frac{V}{R_N}$$

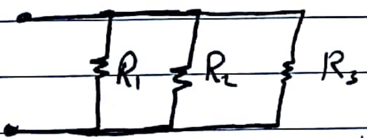
$$I_s = V\left(\frac{1}{R_1} + \frac{1}{R_2} + \cdots + \frac{1}{R_N}\right)$$

$$I_s = V\left(\frac{1}{R_{eq}}\right)$$

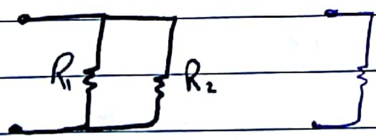
$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \cdots + \frac{1}{R_N}$$

$$\boxed{G_{eq} = G_1 + G_2 + \cdots + G_N}$$

$$G_{eq} = \sum_{n=1}^{N} G_n$$



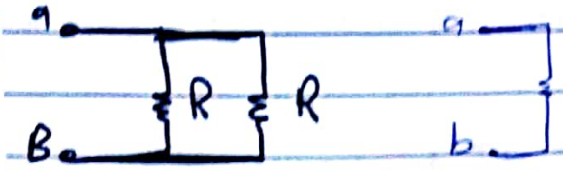
$$R_1 \parallel R_2 \parallel R_3 = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}}$$



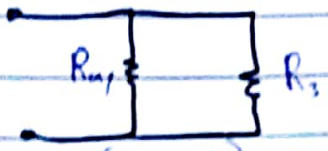
$$R_{eq} = R_1 \parallel R_2$$

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

$$R_{eq} = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2}} = \frac{1}{\frac{R_2 + R_1}{R_1 R_2}} \longrightarrow R_{eq} = \frac{R_1 R_2}{R_1 + R_2}$$



$R_{eq} = \frac{R^2}{2R} = \frac{R}{2}$

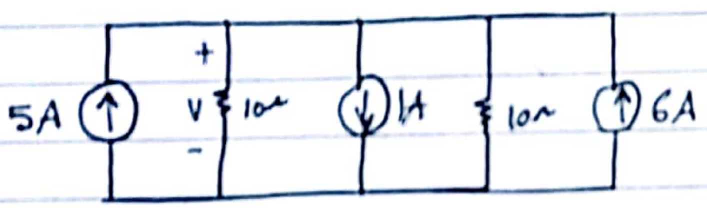


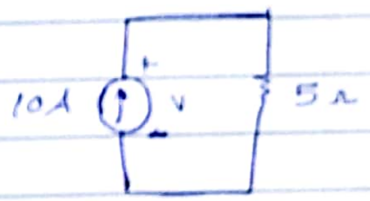
$((R_1 \,//\, R_2) \,//\, R_3) =$

$$R_{eq_1} = \frac{R_1 R_2}{R_1 + R_2}$$

$$R_{eq_2} = \frac{R_{eq_1} \cdot R_3}{R_{eq_1} + R_3}$$

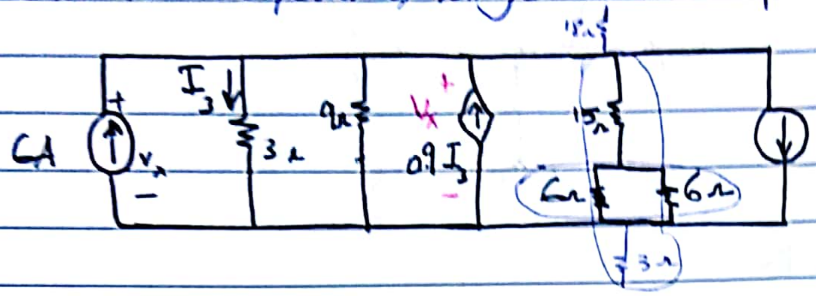
ex: Determine V in the CKT:





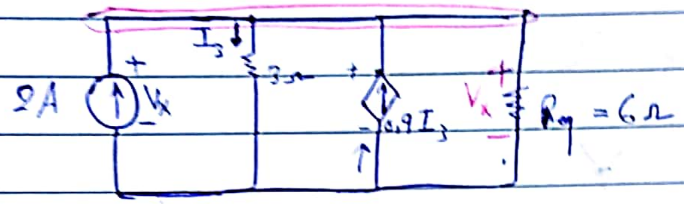
$V = 10 \times 5 = 50\,V$

Ex: Calculate the Power & Voltage of the dependent Source :



15Ω, 3Ω series
15 + 3 = 18Ω

$$R_{eq} = \frac{18 \times 9}{18 + 9} = 6\,\Omega$$



$$I_3 = \frac{V_x}{3}$$

KCL :

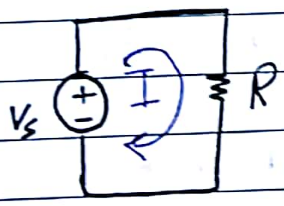
$$2 + 0.9 I_3 = I_3 + \frac{V_x}{6}$$

$$2 + 0.9\left(\frac{V_x}{3}\right) = \frac{V_x}{3} + \frac{V_x}{6}$$

$$\boxed{V_x = 10\ V} \quad , \quad I_3 = \frac{10}{3}\ A$$

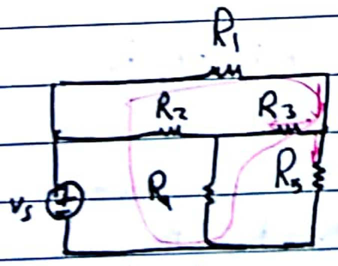
$$P = -\left(0.9 \times \frac{10}{3}\right)(10)$$

$$= -30\ \text{Watt (deliver)}.$$



Series or Parallel ?

Series and Parallel التيار متساوي + متوازي



Series & Parallel ✗

$R_3, R_2, R_4 \longrightarrow T$

$R_1, R_3, R_5 \longrightarrow T$

$R_3, R_4, R_5 \longrightarrow \pi$

$R_1, R_2, R_3 \longrightarrow \pi/\Delta$

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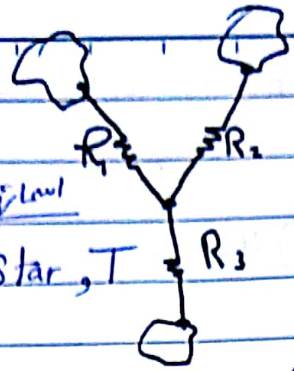
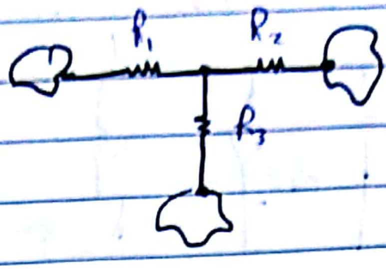
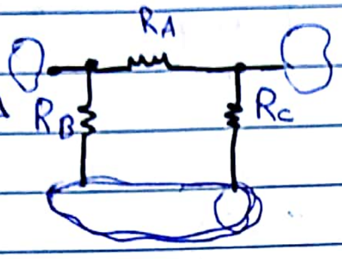
اسماء اخرى

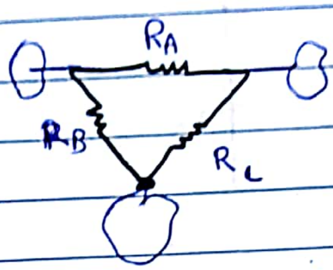
Y , Star , T

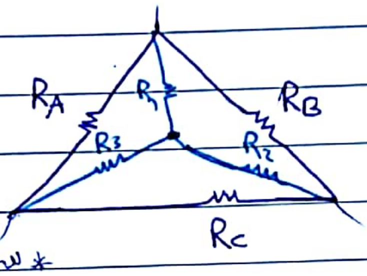




π, Δ







للتحويل *

$\Delta \rightarrow Y$:

$$R_1 = \frac{R_A R_B}{R_A + R_B + R_C}$$

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

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

البسط ← على طرفين للمقاومة كل وحدة .

if $R_A = R_B = R_C = R$

$R_1 = \frac{R}{3}$

$R_2 = \frac{R}{3}$

$R_3 = \frac{R}{3}$

$Y \rightarrow \Delta$:

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

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

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

المقام ← ابعد مقاومة عليها .

if $R_1 = R_2 = R_3 = R$

$R_A = 3R$

$R_B = 3R$

$R_C = 3R$

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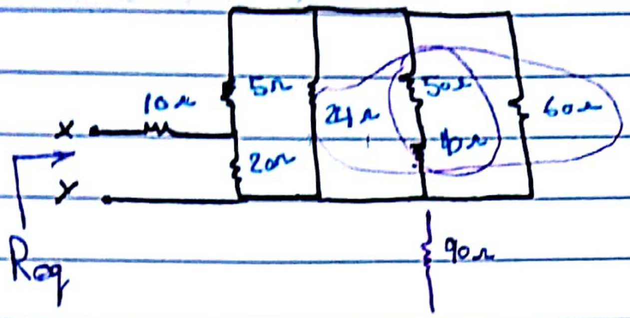
Req مش لازم الشيء ← Independent

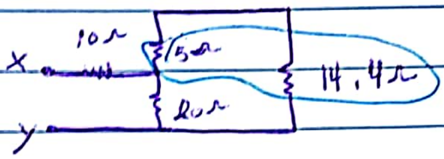
Current source ← بعمله open ckt وبشيلها

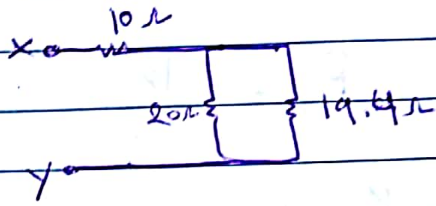
Voltage ← // Short ckt //

ex: Find Req between x & y :



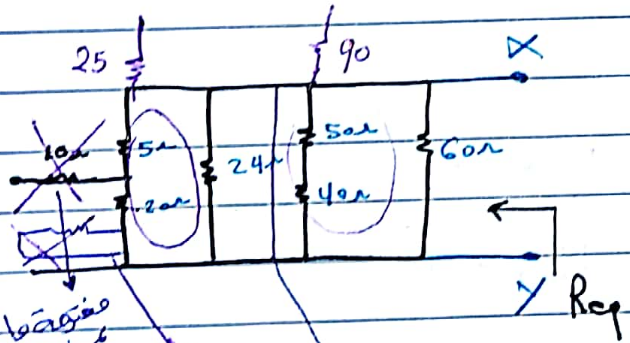
$$R = \frac{1}{\frac{1}{60} + \frac{1}{90} + \frac{1}{24}} = 14.4\,\Omega$$





$$R = \frac{20 \times 19.4}{20 + 19.4} = 9.85\,\Omega$$

$$R_{eq} = 10 + 9.85 = 19.85\,\Omega.$$



مفتوحة ما بمرضها I

طرفين مشتركين على نفس المكان shortckT.

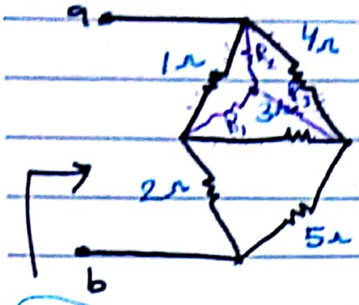
$$R_{eq} = \frac{1}{\frac{1}{25} + \frac{1}{24} + \frac{1}{90} + \frac{1}{60}}$$

دايمًا بروح الى آخر الدارة بدور على المكان.

=

Short ckT بمر I فيها وطرفين جميع المقاومات

ما في series ولا Parallel ← اذا التحويل Δ/Y.. وهكذا.
ابسط شي هدنا Δ .



Rab

$$R_1 = \frac{3}{8} = \frac{3\Omega \cdot 3\Omega}{8}$$ مجموع 1Ω , 4Ω , 3Ω

$$R_2 = \frac{4}{8} = \frac{1}{2}\,\Omega$$

$$R_3 = \frac{12}{8} = \frac{3}{2}\,\Omega$$

R_1 , 2Ω → Series

$$2 + \frac{3}{8} = \frac{19}{8}\,\Omega$$

R_3 , 5Ω → Series

$$\frac{3}{2} + 5 = 6.5\,\Omega$$

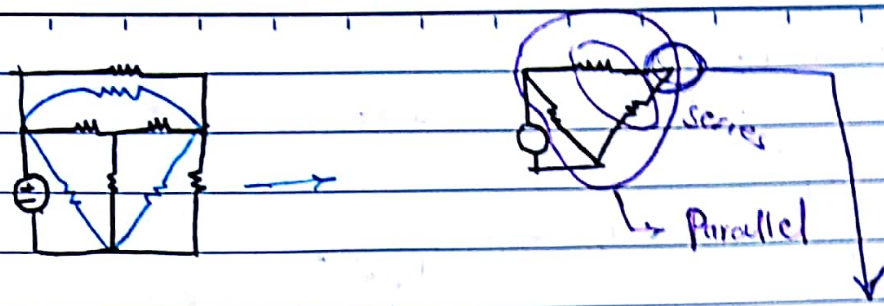
6.5 , $\frac{19}{8}$ → Parallel

$$R_L = \frac{19}{8} \parallel 6.5 \rightarrow \frac{\frac{19}{8} \times 6.5}{\frac{19}{8} + 6.5}$$

R_L , R_2 → Series

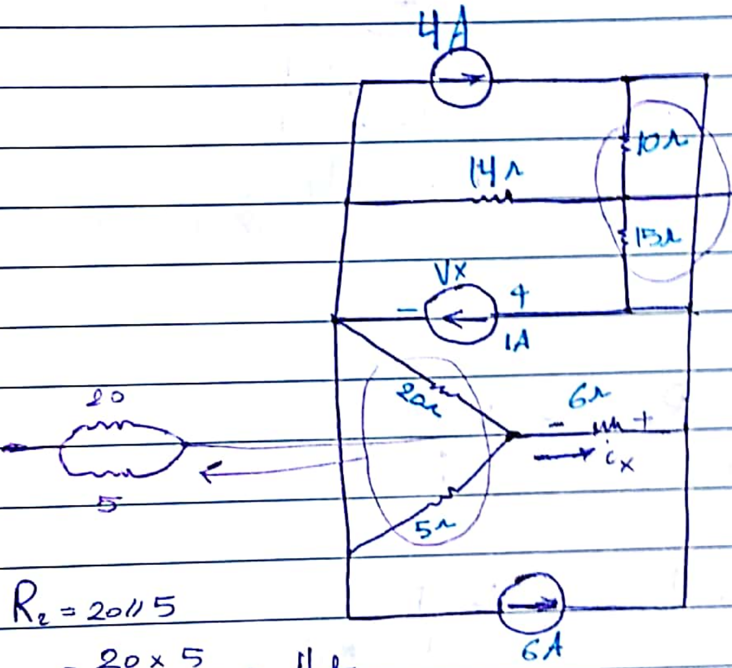
$$R_L + R_2 = R_{eq}$$

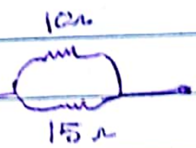
$$+\,2 = R_{eq}$$



هنا ما نقدر نطبقها لـ Y لانو فينا الطرف غير موصول مع اشي.

ex: Find V_x and i_x:





$R_1 = 10 // 15 = \frac{10 \times 15}{10+15} = 6\,\Omega$

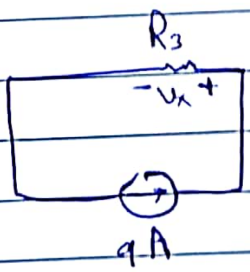
$6 + 14 = 20\,\Omega$

$R_2 = 20 // 5$

$= \frac{20 \times 5}{20+5} = 4\,\Omega$

$4\,\Omega, 6\,\Omega \rightarrow$ Series $= 10\,\Omega$

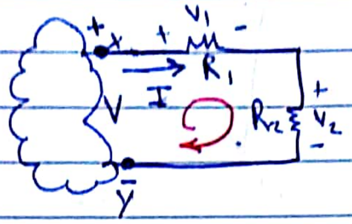
$R_3 = 20 // 10 = \frac{20 \times 10}{20+10} = \frac{20}{3}\,\Omega$



$V_x = \cancel{9}^{3} \times \frac{20}{\cancel{3}} = 60$ Volt.

$i_x = \frac{-60}{10} = -6A$

* Voltage Division :-



$V_1 = ?$

$V_2 = ?$

$$V = V_1 + V_2$$

$$V = IR_1 + IR_2$$

$$V = I(R_1 + R_2)$$

$$I = \frac{V}{(R_1 + R_2)}$$

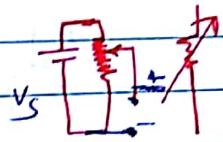
$$V_1 = IR_1 = \frac{V}{(R_1+R_2)} R_1 = \frac{V R_1}{(R_1+R_2)}$$

$$V_2 = IR_2 = \frac{V}{(R_1+R_2)} \cdot R_2 = \frac{V R_2}{(R_1+R_2)}$$

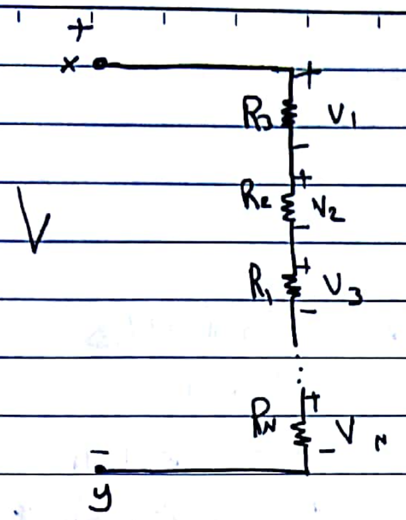
Voltage Divider

$$V_1 = V \cdot \frac{R_1}{(R_1+R_2)}$$

$$V_2 = V \cdot \frac{R_2}{(R_1+R_2)}$$

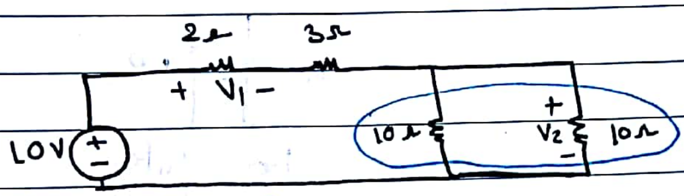


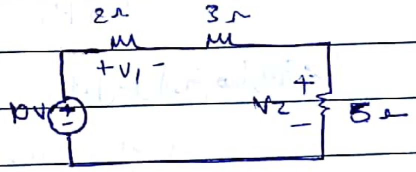
Potentiometer.



$$V_k = V \frac{R_k}{\sum_{n=1}^{N} R_n}$$

ex: Find V_1 & V_2 :



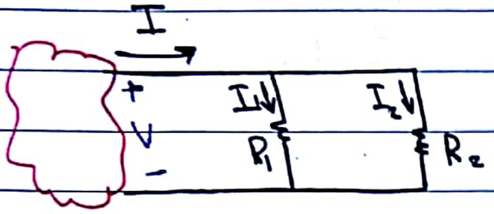


$$V_1 = 10 \cdot \frac{2}{2+3+5} = 2 \text{ volt}$$

$$V_2 = 10 \times \frac{5}{10} = 5 \text{ volt}$$

$V_{2\Omega}$ = 3 volt ⟶ $V_{\text{الكلي}}$ = 10 . وزعنا

* Current Division:



هنا المقاومة بأخذها الى عالجهة التانية مش المقاومة الموجود عليها التيار الي بدخاله .

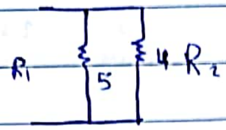
التيار عكسي مع المقاومات

* بالجهد طردي مع المقاومات .

Voltage Division

$$I_1 = I \cdot \frac{R_2}{(R_1 + R_2)}$$

$$I_2 = I \cdot \frac{R_1}{(R_1 + R_2)}$$



$$V = I\,(R_1 \parallel R_2)$$

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

$$V = I \, \frac{R_1 R_2}{R_1 + R_2}$$

المقاومة المكافئة اقل من اصغر مقاومة فيهم

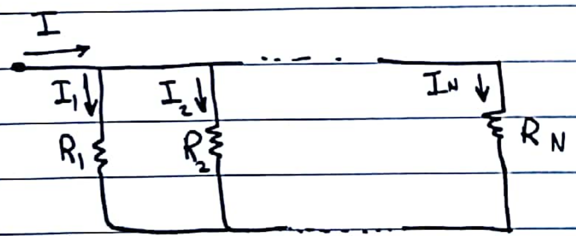
(هنا اقل من 4 Ω)

$$I_1 = \frac{V}{R_1} = \frac{I\,\cancel{R_1} R_2}{(R_1 + R_2)} \cdot \frac{1}{\cancel{R_1}}$$

$$I_1 = \frac{I R_1}{(R_1 + R_2)}$$

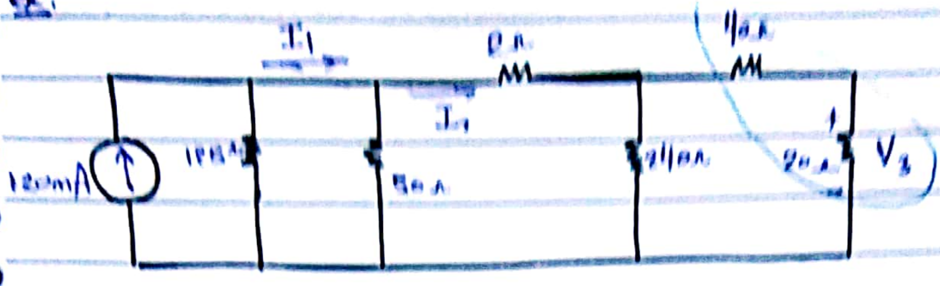
$$I_2 = \frac{V}{R_2} = \frac{I\,R_1 \cancel{R_2}}{(R_1 + R_2)} \cdot \frac{1}{\cancel{R_2}} = \frac{I R_1}{(R_1 + R_2)}$$

kcl

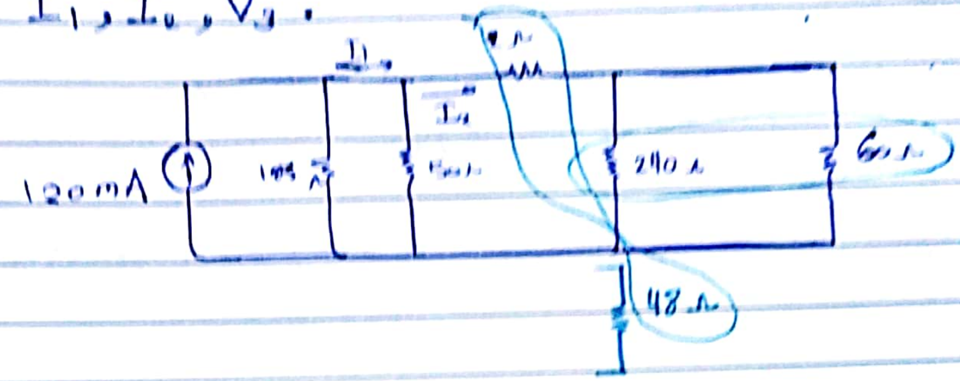


$$I_k = \frac{(1/R_k)\, I}{\sum_{n=1}^{N} \frac{1}{R_n}} = \frac{G_k \, I}{\sum_{n=1}^{N} G_n}$$

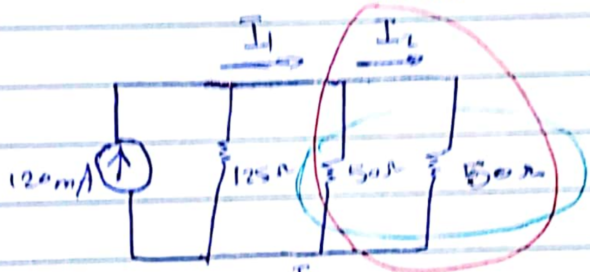
Ex:

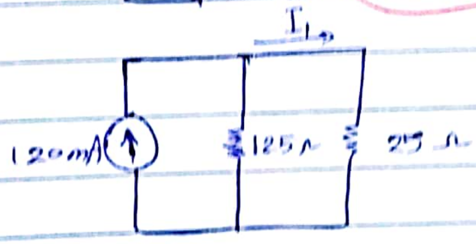


find I_1, I_2, V_3.



$$60 /\!/ 240 = \frac{60\times 240}{60+240} = 48\Omega$$



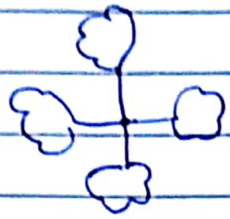


$$I_1 = 120\times 10^{-3} \times \frac{125}{125+25} = 100\ mA$$

$$I_2 = I_1 \cdot \frac{50}{50+50} = 100\ m \cdot \frac{1}{2} = 50\ mA$$

$$V_3 = 48 \times 50\ m \cdot \frac{20}{60} = 0.8\ V$$

CH3 : Nodal Analysis :



KCL :

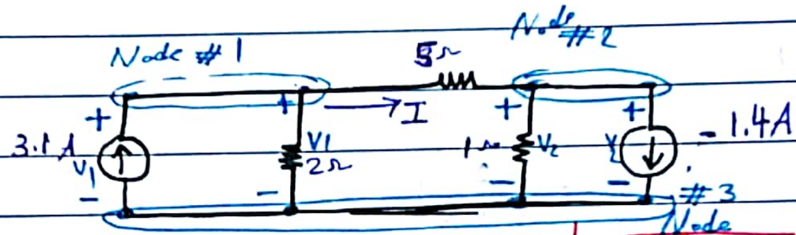
- N nodes → we need (N − 1) equtions (eq.)

  unknown are voltages → (Nodal) Voltages

~~Reference~~

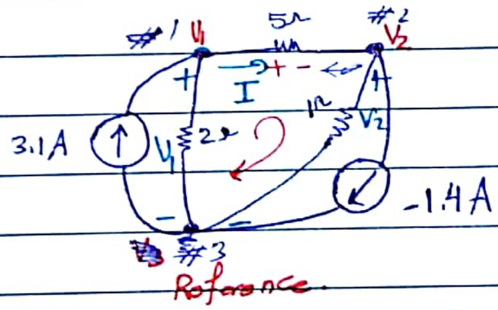
Reference Node : the node with the greatest number of branches Connected to it.

current source.



Reference 4 branches موصول لها

الباقي 3 branchs بناخذ الاكثر



2 equ / 2 unknown voltage.

Reference [illegible]

$$V = I(5)$$

$$-V_1 + V + V_2 = 0$$

$$V = V_1 - V_2$$

$$I = \frac{V_1 - V_2}{5}$$

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التيار اتجاه خارج من المقاومة

① node #1 :

$$\frac{V_1 - V_2}{5} + \frac{V_1 - 0}{2} = 3.1$$

$$0.7\,V_1 - 0.2\,V_2 = 3.1 \quad \ldots ①$$

② node #2 :

$$\frac{V_2 - V_1}{5} + \frac{V_2 - 0}{1} - 1.4 = 0$$

$$-0.2\,V_1 + 1.2\,V_2 = 1.4 \quad \ldots ②$$

Cramer's Rule:

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

Solve:

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

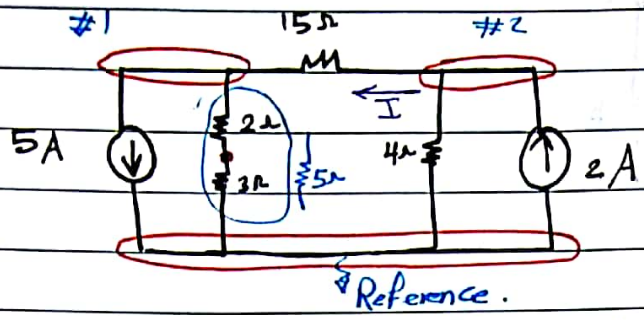
$\downarrow$

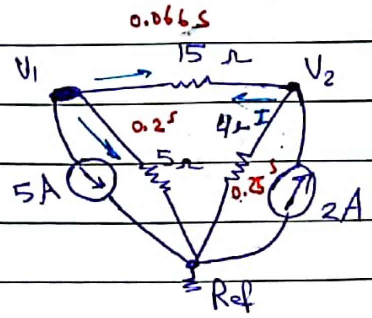
Nodal voltages.

$$I = \frac{V_1 - V_2}{5} = \frac{3}{5}\,A$$

$$P_{5\Omega} = \left(\frac{3}{5}\right)^2 \times 5 = \frac{9}{\cancel{25}\ 5} \times \cancel{5} \text{ watt}$$

ex: Find $I = ?$





① Node#1 :

$$5 + \frac{V_1}{5} + \frac{V_1 - V_2}{15} = 0$$

$$5 + 0.2\,V_1 + 0.066(V_2 - V_1) = 0$$

$$\frac{4}{15} V_1 - \frac{1}{15} V_2 = -5 \quad \ldots ①$$

اذا اعطانا الدارة بال S ~~conductance~~

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

② Node#2 :

$$\frac{V_2 - V_1}{15} + \frac{V_2}{4} = 2$$

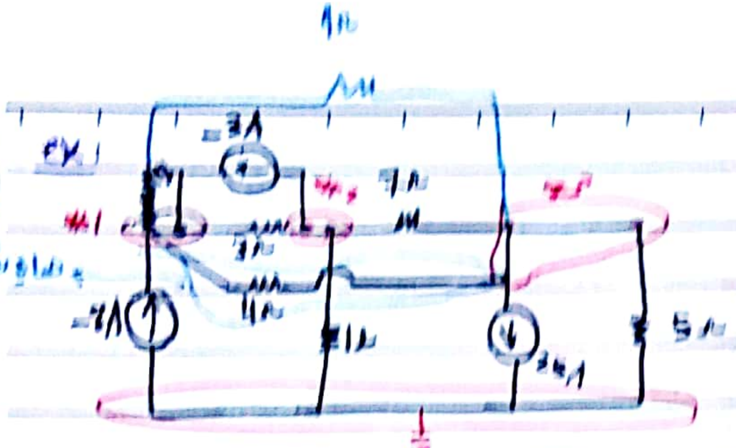
$$0.066(V_2 - V_1) + 0.25\,V_2 = 2$$

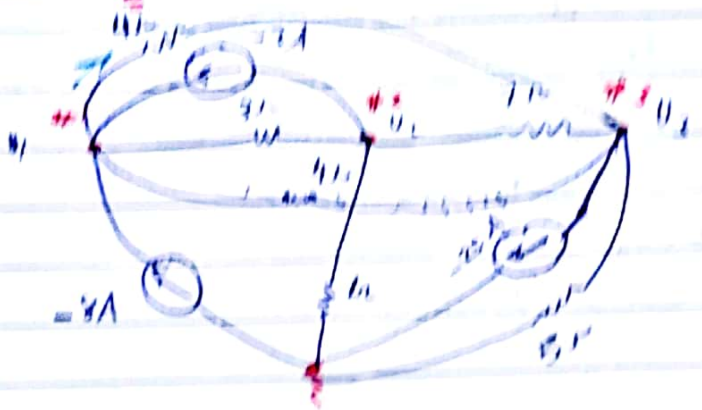
$$\frac{-1}{15} V_1 + \frac{19}{60} V_2 = 2 \quad \ldots ②$$

$$V_1 = \frac{-145}{8} \text{ V} \qquad V_2 = \frac{5}{2} \text{ V}$$

$$I = \frac{V_2 - V_1}{15} = 2.578 \text{ A}$$

Scanned by CamScanner





@ Node #1 :

$$\frac{V_1 - V_2}{4} + \frac{V_1 - V_2}{3} = -3 + -8$$

$$\frac{7}{12} V_1 - \frac{1}{3} V_2 - \frac{1}{4} V_2 = -11 \quad \ldots (1)$$

@ Node #2 :

$$-3 + \frac{V_2 - V_1}{3} + \frac{V_2}{1} + \frac{V_2 - V_2}{7} = 0$$

$$-\frac{1}{3} V_1 + \frac{31}{21} V_2 - \frac{1}{7} V_2 = 3 \quad \ldots (2)$$

& Node #3 :

$$\frac{V_3 - V_2}{7} + \frac{V_3 - V_1}{4} + \frac{V_3}{5} - 25 = 0$$

$$-\frac{1}{4} V_1 - \frac{1}{7} V_2 + \frac{83}{140} V_3 = 25 \quad \ldots (3)$$

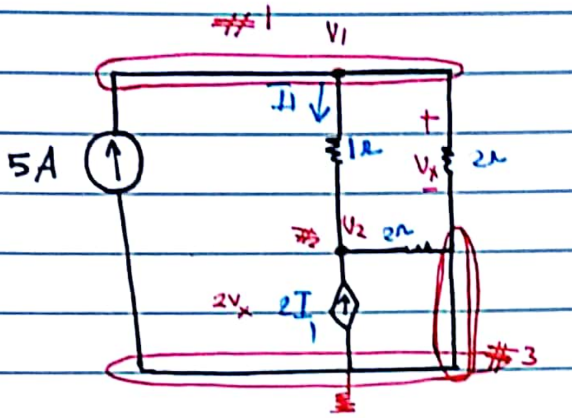
Cramer's Rule:

$V_1 = 5.412\ V$

$V_2 = 7.736\ V$

$V_3 = 46.32\ V.$

Ex:



@ Node #1:

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

$$\frac{3}{2}V_1 - V_2 = 5 \quad \ldots (1)$$

@ Node#2:

$$\frac{V_2 - V_1}{1} + \frac{V_2}{2} = 2I_1$$

$$\frac{V_2 - V_1}{1} + \frac{V_2}{2} = 2\frac{(V_1 - V_2)}{1}$$

$$-3V_1 + \frac{7}{2}V_2 = 0 \quad \ldots (2)$$

$$V_1 = \frac{70}{9}, \quad V_2 = \frac{20}{3}$$

عملنا تغيير وطلعنا بدل I_1 ← V_x

@ Node#1:

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

$$\frac{3}{2}V_1 - V_2 = 5 \quad \ldots (1)$$

@ Node#2:

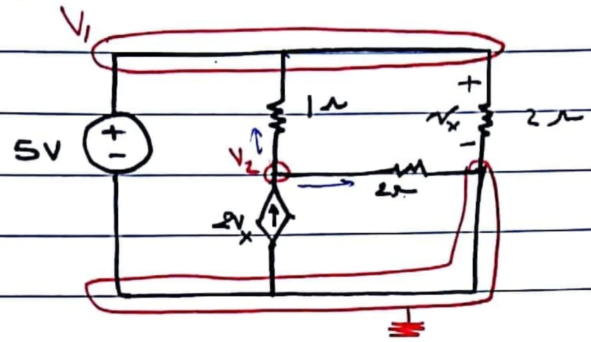
$$\frac{V_2}{2} + \frac{V_2 - V_1}{1} = 2V_x \qquad V_x = V_1$$

$$= 2V_1$$

$$-3V_1 + \frac{3}{2}V_2 = 0 \quad \ldots (2)$$

$V_1 = -10\ V,\ V_2 = -20\ V$

Q:



① Node#1

$V_1 = 5V$

② Node#2 : KCL

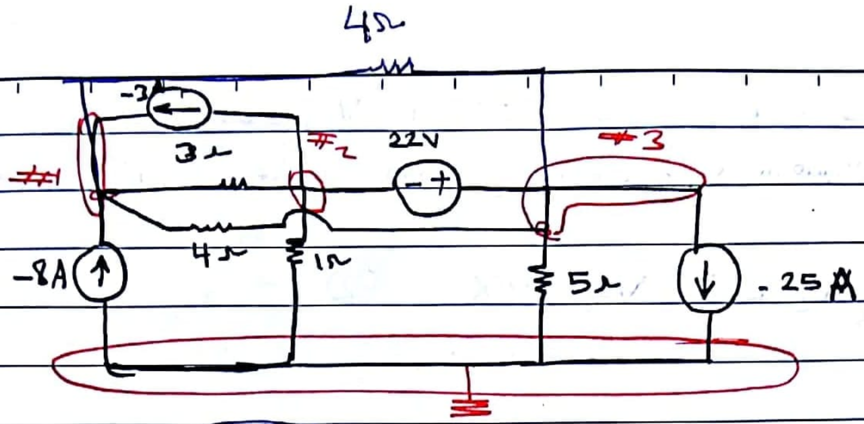
$\frac{V_2}{2} + \frac{V_2 - 5}{1} = 2V_x$, $V_x = V_1 = 5$

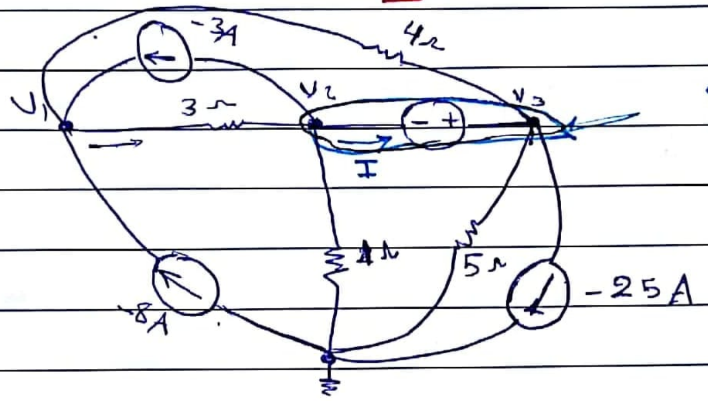
$\frac{V_2}{2} + V_2 - 5 = 10$

$V_2 = \frac{30}{7} V$

Nodal Voltage is a Voltage source.

ex:





Super Node

Voltagesource بين 2 Node

Node#1 :-

$$\frac{V_1 - V_2}{3} + \frac{V_1 - V_3}{4} = -3 - 8$$

$$\boxed{\frac{7}{12} V_1 - \frac{1}{3} V_2 - \frac{1}{4} V_3 = -11} \quad .. (1)$$

Node#2 ;

$$\frac{V_2}{1} + \frac{V_2 - V_1}{3} + -3 + \cancel{I} = 0 \quad .. *$$

Node#3 :

$$\frac{V_3}{5} + -25 + \frac{V_3 - V_1}{4} + \cancel{-I} = 0 \quad ... *$$

$$\frac{V_2 - V_1}{3} + \frac{V_2}{1} + \frac{V_3}{5} + -25 + \frac{V_3 - V_1}{4} = 0 \quad .. (2)$$

تلغى عند وجود Super Node.

$$\frac{V_2 - V_1}{3} + \frac{V_2}{1} - 3 + \frac{V_3}{5} + -25 + \frac{V_3 - V_1}{4} = 0$$

مجموع I الخارجين V_1 + مجموع I الخارجين V_2 = مجموع I الداخلين V_1 + مجموع I الداخلين V_2

$$\boxed{-\frac{7}{12} V_1 + \frac{4}{3} V_2 + \frac{9}{20} V_3 = 28} \quad \dots (2)$$

$$V_3 - V_2 = 22$$

$$\boxed{-V_2 + V_3 = 22} \quad \dots (3)$$

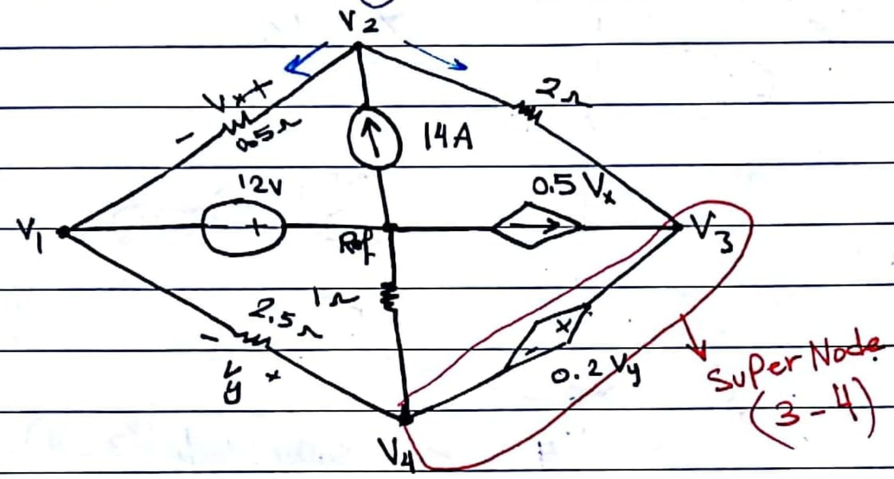
Sol :

$V_1 = 1.071 \, V$

$V_2 = 10.5 \, V$

$V_3 = 32.5 \, V$

ex: Determine the Nodal Voltage in the CRT:



Node #1 :

$V_1 = -12$ Volt.

Node #2 : Kcl

$$\frac{V_2-(-12)}{0.5} + \frac{V_2 - V_3}{2} = 14$$

$$\boxed{2.5\, V_2 - 0.5\, V_3 = -10.} \quad \dots (1)$$

super Node #(3-4) :

$$\frac{V_3 - V_2}{2} + \frac{V_4}{1} + \frac{V_4-(-12)}{2.5} = 0.5\, V_x$$

$\boxed{V_x = V_2 - V_1}$

$V_x = V_2 + 12$ (*)

$$\frac{V_3 - V_2}{2} + V_4 + \frac{V_4 + 12}{2.5} = 0.5(V_2+12)$$

$$\boxed{-V_2 + \frac{1}{2} V_3 + \frac{7}{5} V_4 = 1.2} \quad \dots (2)$$

$V_3 - V_4 = 0.2\, V_y$

$V_y = V_4 - V_1$

$V_3 - V_4 = 0.2(V_4 + 12)$

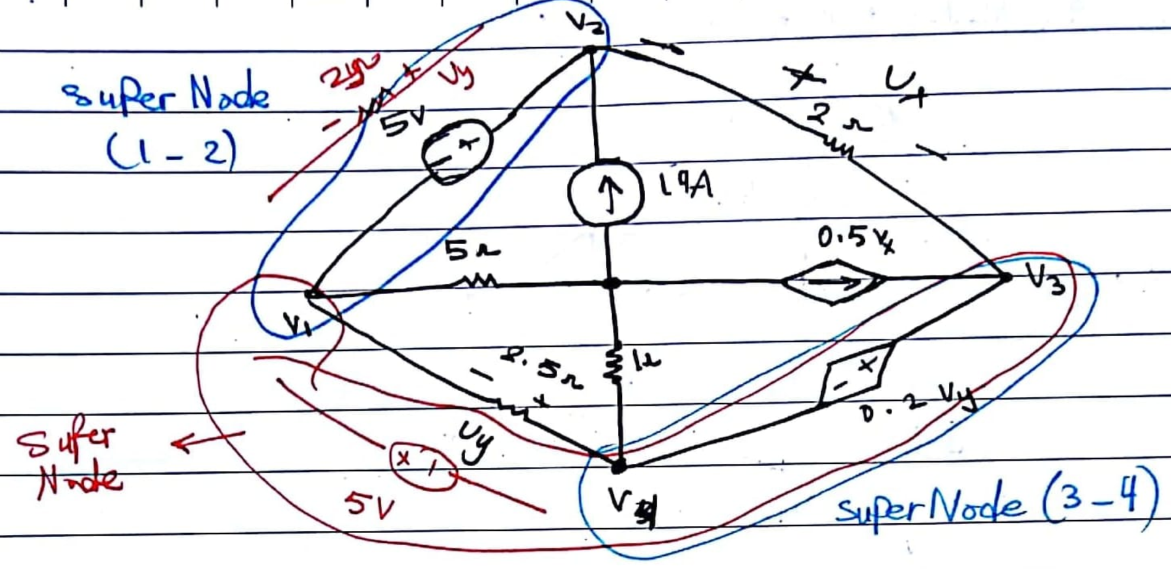
$V_y = V_4 + 12$

$$\boxed{V_3 - \frac{6}{5} V_4 = 2.4} \quad \dots (3)$$

superficial Node,

~~$V_2 = 4$~~

~~$V_3 =$~~



(a) Super Node (1_2) :

$$\frac{V_1}{5} + \frac{V_1 - V_4}{2.5} + \frac{V_2 - V_3}{2} = 14 \quad ..(1)$$

$$V_2 - V_1 = 5 \quad ..(2)$$

(b) Super Node (3_4)

$$\frac{V_3 - V_2}{2} + \frac{V_4}{1} + \frac{V_4 - V_1}{2.5} = 0.5(V_2 - V_3) \quad ..(3)$$

$$V_3 - V_4 = 0.2(V_4 - V_1) \quad .(4)$$

* CKT غلط بال

(a) super Node (1, 3, 4) :

$$\frac{V_1 - V_2}{2} + \frac{V_1}{5} + \frac{V_4}{1} + \frac{V_3 - V_2}{2} = 0.5(V_2 - V_3) \quad ..(1)$$

$$V_3 - V_4 = 0.2(V_2 - V_1) \quad — (2)$$

$$V_1 - V_4 = 5 \quad ...(3)$$

(b) Node #2 :

$$\frac{V_2 - V_1}{2} + \frac{V_2 - V_3}{2} = 14 \quad ... (4)$$

* Mesh Analysis:

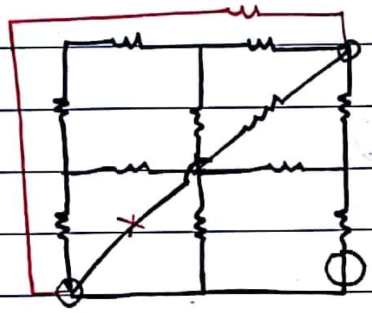
(KVL)

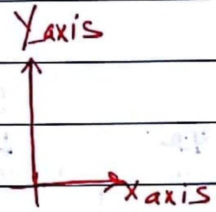
في شروط لاستخدامها مش لكل CKT

يشترط:

هاد الشرط

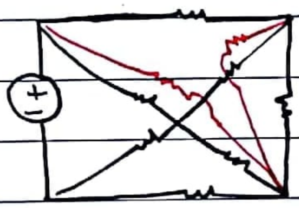
- Planar CKT: a CKT which can be drawn in a plane surface.



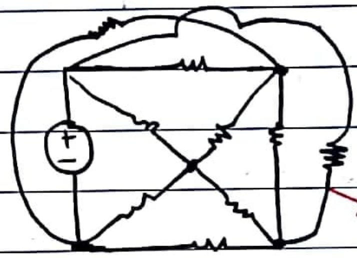


Planar.

4 – Meshes → ٤ لوب بكون ما فيهم لوب داخلهم



Planar.



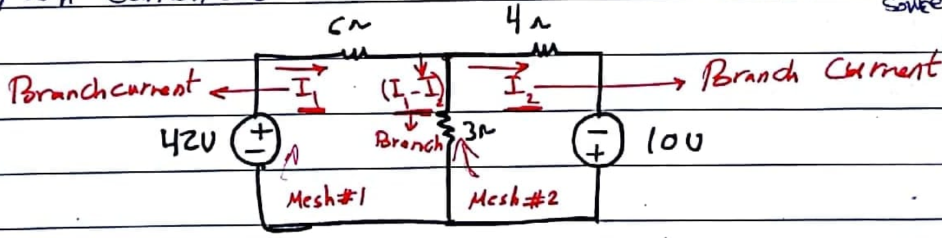
هاي بدها تربط على Z-axis

Non planar.

Mesh: a loop that does not contain any other loop within it.

* Mesh Current:-

اذا كان Current Source ← Current Mesh



1) Mesh #1:

$$-42+6I_1+3(I_1-I_2)=0$$

$$9I_1-3I_2=42 \quad \ldots (1)$$

Mesh #2 :

$3(I_2 - I_1) + 4I_2 - 10 = 0$

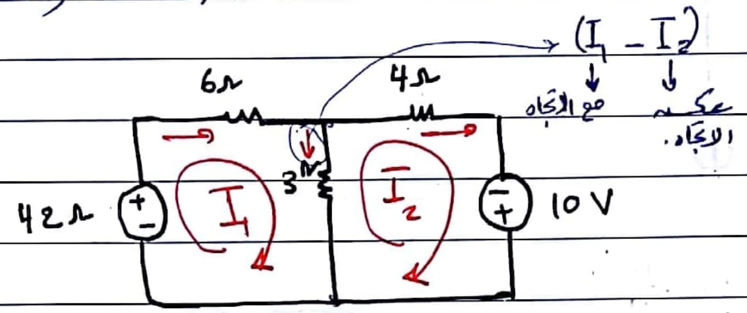
$-3I_1 + 7I_2 = 10 \quad \ldots (2)$

$I_1 = 6A$

$I_2 = 4A$

$(I_1 - I_2) = 2A$

ex :



I_1 mesh current.

I_2 mesh current.

Mesh #1 :

$-42 + 6I_1 + 3(I_1 - I_2) = 0$

$9I_1 - 3I_2 = 42 \quad \ldots (1)$

Mesh #2 :

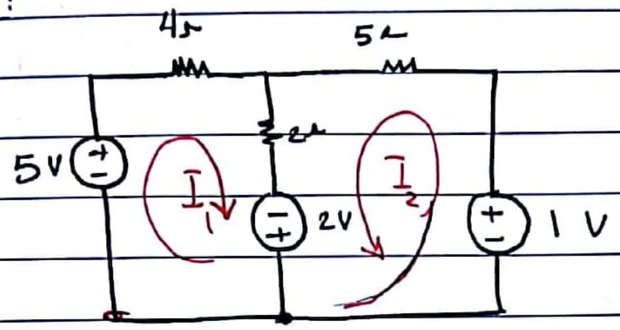
$3(I_2 - I_1) + 4I_2 - 10 = 0$

$-3I_1 + 7I_2 = 10 \ldots (2)$

$P_{3\Omega} = (I_2 - I_1)^2 \times 3$

$V_{3\Omega} = (I_2 - I_1) \times 3$

ex:



9 Mesh #1:

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

$$6I_1 + 2I_2 = 7 \quad \cdots (1)$$

9 Mesh #2:

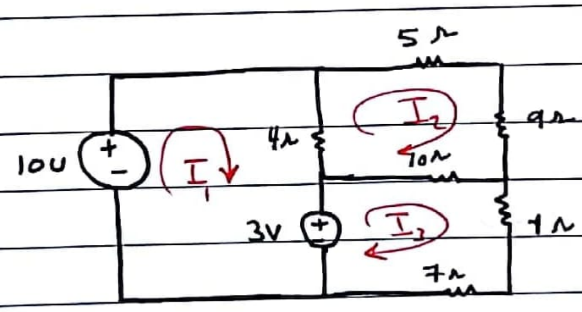
$$-1 + 5I_2 + 2(I_2 + I_1) - 2 = 0$$

$$2I_1 + 7I_2 = 3$$

$$I_1 = \frac{43}{38}\,A \,, \quad I_2 = \frac{2}{19}\,A$$

$$P_{1V} = -I_2(1)$$

ex: Determine I_1, I_2, I_3:



Mesh = 3 Equ

Node = 7 - 1 → 6equ

9) Mesh #1 :

$$-10 + 4(I_1 - I_2) + 3 = 0$$

$$4I_1 - 4I_2 = 7 \quad \ldots (1)$$

9) Mesh #2 :

$$4(I_2 - I_1) + 5I_2 + 9I_2 + 10(I_2 - I_3) = 0$$

$$-4I_1 + 28I_2 - 10I_3 = 0 \quad \ldots (2)$$

9) Mesh #3 :

$$-3 + 10(I_3 - I_2) + 1I_3 + 7I_3 = 0$$

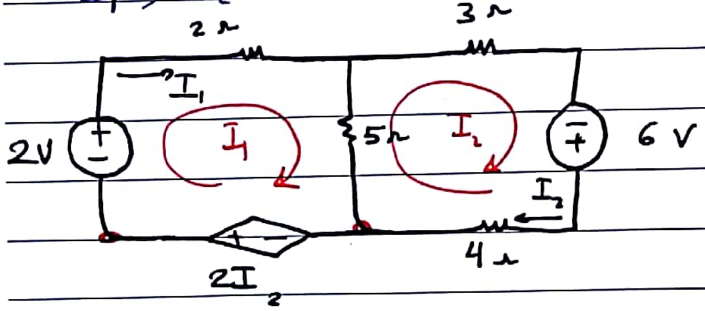
$$-10I_2 + 18I_3 = 3 \quad \ldots (3)$$

$I_1 = 2.22A$

$I_2 = 470mA$

$I_3 = 427.7\ mA$

ex; I_1, I_2



9) Mesh #1 :

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

$$7I_1 - 7I_2 = 2 \quad \ldots (1)$$

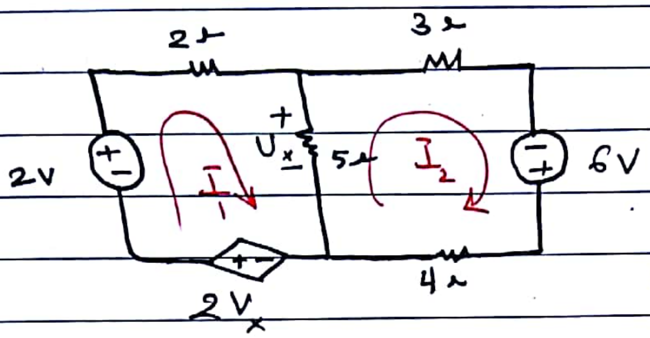
9) Mesh #2 :

$$5(I_2 - I_1) + 3I_2 - 6 + 4I_2 = 0$$

$$-5I_1 + 12I_2 = 6 \quad \ldots (2)$$

$I_1 = \frac{66}{49}A$ $\quad$ $I_2 = \frac{56}{49}A$

ex :



(a) Mesh #1 :

$$-2+2I_1+5(I_1-I_2)-2(V_x)=0 \qquad V_x=5(I_1-I_2)$$

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

$$-3I_1+5I_2=2 \quad \ldots (1)$$

(a) Mesh # 2 :

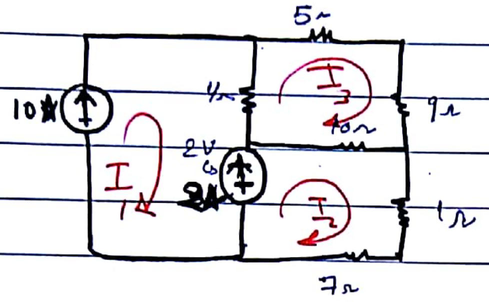
$$5(I_2-I_1)+3I_2-6+4I_2=0$$

$$-5I_1+12I_2=6 \quad \ldots (2)$$

$$I_1=\frac{6}{11}A \quad , \quad I_2=\frac{8}{11}A$$

ex:

وجود Current Source ← يعني ~~...~~ مع الـ Reference يسهل علينا الحل



KVL:

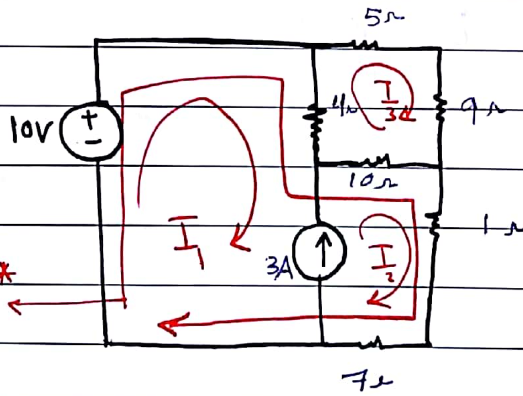
Mesh #1: $I_1 = 10A$

Mesh #2:

$$-2 + 10(I_2 - I_3) + I_2 + 7I_2 = 0 \quad ..(2)$$

Mesh #3:

$$4(I_3 - I_1) + 5I_3 + 9I_3 + 10(I_3 - I_2) = 0 \quad ..(3)$$



current source بيقسم *

Mesh #1:

$$-10 + 4(I_1 - I_3) + \cancel{V} = 0 \quad ..(1)$$

+

Mesh #2:

$$\cancel{-V} + 10(I_2 - I_3) + I_2 + 7I_2 = 0 \quad ...$$

$$-10 + 4(I_1 - I_3) + 10(I_2 - I_3) + I_2 + 7I_2 = 0 \quad ..(1)$$

Mesh #3:

$$4(I_3 - I_1) + 5I_3 + 9I_3 + 10(I_3 - I_2) = 0$$

$$-4I_1 - 10I_2 + 3I_3 = 0 \quad .. \ (2)$$

$$3 = I_2 - I_1 \longrightarrow \boxed{-I_1 + I_2 = 3} \quad .. \ (3)$$

Super Mesh (1-2):

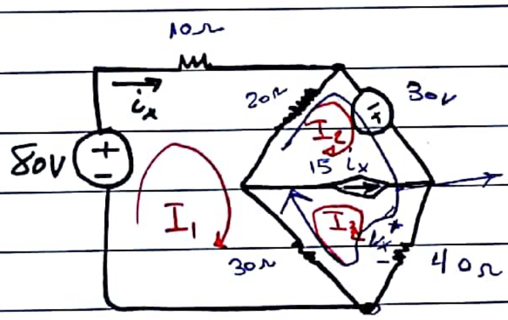
KVL:

$$-10 + 4(I_1 - I_3) + 10(I_2 - I_3) + 1I_2 + 7I_2 = 0$$

$$4I_1 + 18I_2 - 14I_3 = 10 \quad .. \ (1)$$

$$-I_1 + I_2 = 3 \quad .. \ (2)$$

ex: $V_x = ?$



→ Super Mesh (2-3)

3 unknow → 3 Equ

Mesh #1:

$$-80 + 10I_1 + 20(I_1 - I_2) + 30(I_1 - I_3) = 0$$

$$60I_1 - 20I_2 - 30I_3 = 80 \quad .. \ (1)$$

$V_x = 40I_3$

$= 104.16$ Volt

Super Mesh (2-3):

$$30(I_3 - I_1) + 20(I_2 - I_1) - 30 + 40I_3 = 0$$

$$-50I_1 + 20I_2 + 70I_3 = 30 \quad .. \ (2)$$

$$15 i_x = I_3 - I_2 \qquad i_x = I_1$$

$$15I_1 + I_2 - I_3 = 0 \quad .. \ (3)$$

$I_1 = \frac{87}{149}$ A

$I_2 = -\frac{917}{149}$ A

$I_3 = \frac{388}{149}$ A

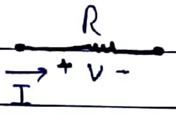
* Linearity & Superposition:

لازم اطبقة على Linear CKT.

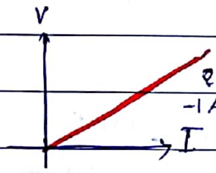
* **Linear CKT:** Composed of linear elements

* **Linear element:** an element that has a linear voltage - current relationship.

* **Resistor:** (Linear element)



$V = IR$



ازاي دا

2A , 10V
-1A , 2V] 1 , 12 V

let $I_{new} = kI$, k constant.

$\rightarrow V_{new} = RI_{new}$

$= R(kI) = k(RI)$

$$\boxed{V_{new} = kV}$$

$V_1 = RI_1$, $V_2 = RI_2$

$I_{new} = I_1 + I_2$

$V_{new} = R(I_{new})$

$= R(I_1 + I_2) = RI_1 + RI_2$

$$\boxed{V_{new} = V_1 + V_2}$$

* Independent Source $\rightarrow$ Linear.

Scanned by CamScanner

* Dependent Sources : → linear
→ non-linear.

↓

Linear V_s, I_s $\propto$ first power of the variable.

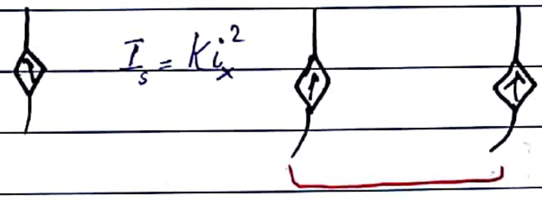
$I_s = k I_x$

$I_s = \alpha V_x$

Linear

$I_s = k i_x^2$

$I_s = 2 i_x \, 2 i_x$ ↓ ضرب



non Linear.

$V_s = 3 i_x$

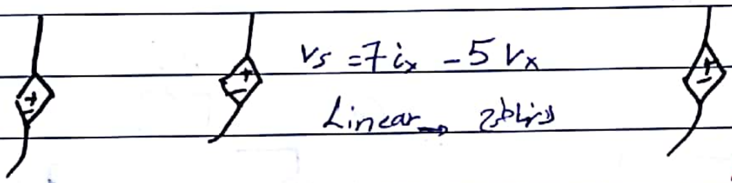
Linear

$V_s = 7 i_x - 5 V_x$

Linear → ثوابت

$V_s = V_x^2 + 1$

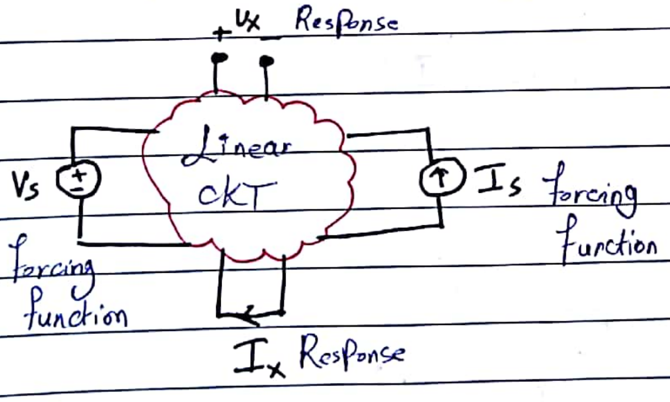
Non linear

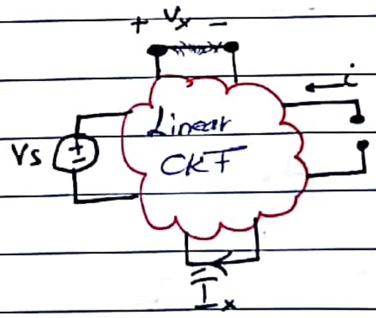


→ Linear ckT : Then we can apply Superposition

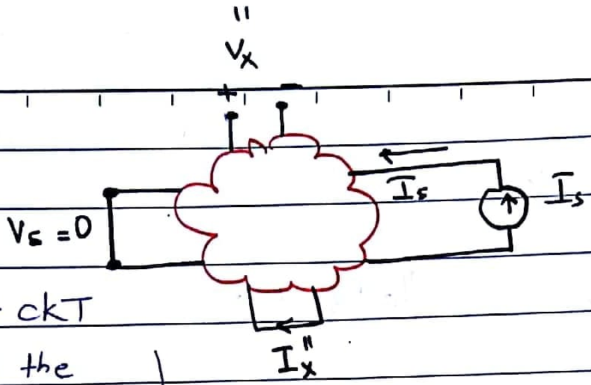
* Super Position :

The response in a linear CKT having more than one independent source can be obtained by adding the responses caused by the separate independent sources acting alone.





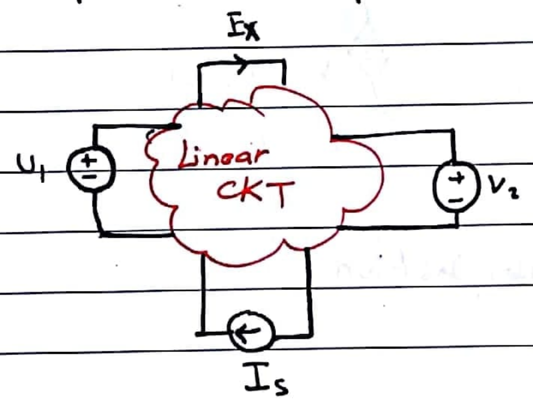
open ckT
(kill the current)
Source



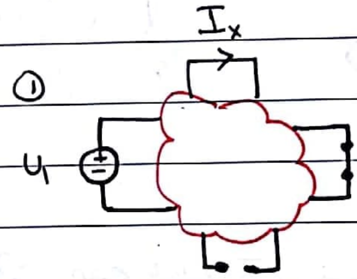
Short ckT
(kill the
voltage source)

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

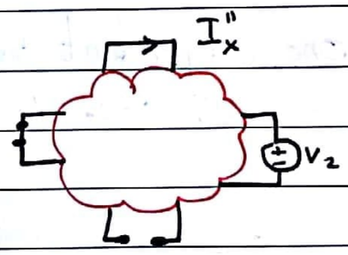
* Superposition Principle:



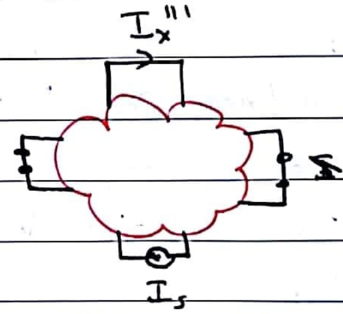
①



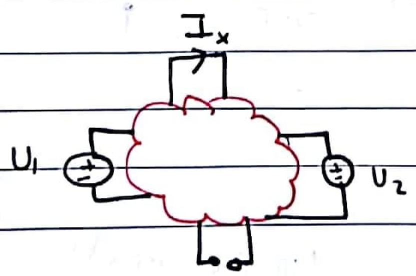
②



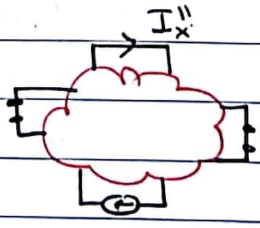
③



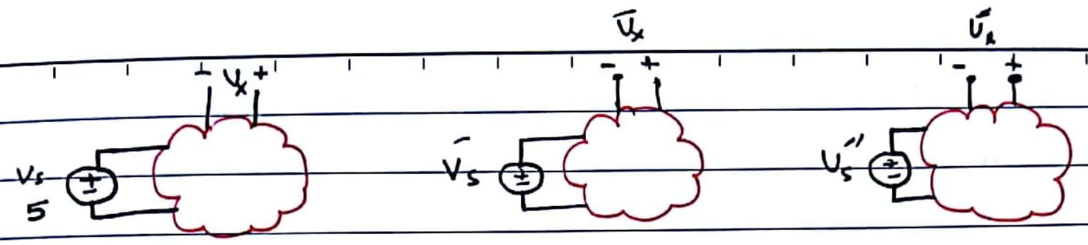
$$I_x = I_x' + I_x'' + I_x'''$$



* ممكن اشيل كل Source وبخلي واحد

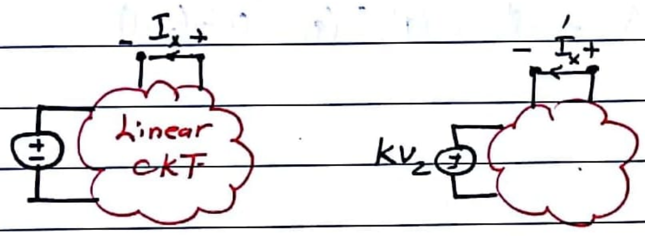


$$I_x = I_x' + I_x''$$



$V_s = V_s' + V_s''$

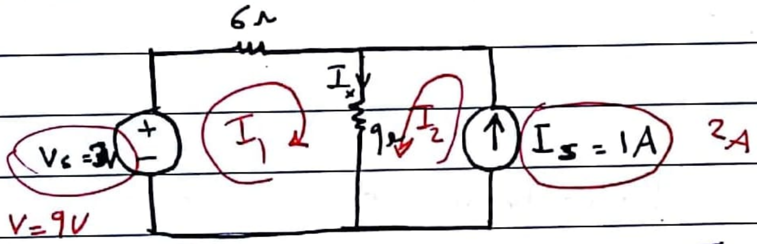
$V_x = V_x' + V_x''$



بضرب الجهة بعدد، على الجهة الثانية

$I_x' = \underline{k} I_x$

ex: I_x , P_x



$I_2 = 1$

① Mesh #1:

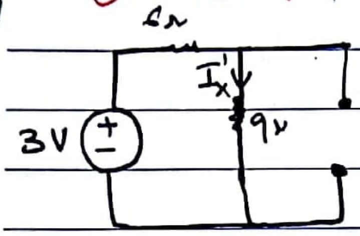
$-3 + 6I_1 + 9(I_1 + 1) = 0$

$15I_1 = -6 \longrightarrow I_1 = \frac{-6}{15} A$

$I_x = I_1 + 1 = \frac{-6}{15} + 1 = 0.6A$

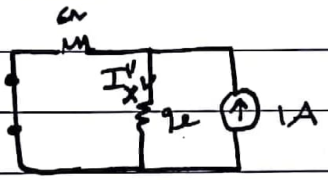
$P_x = 9I_x^2 = 9(0.6)^2 = 3.24 W.$

by Superposition:



← Kill current Source

$$I'_x = \frac{3}{6+9} = \frac{3}{15} = 0.2\,A \rightarrow P'_x = (I'_x)^2 (9) = 0.36\,W$$



$$I''_x = \frac{1 \times 6}{6+9} = 0.4\,A \rightarrow P''_x = (I''_x)^2 9 = 1.44\,W$$

$$I'_x + I''_x = 0.6\,A$$ ✓

$$P'_x + P''_x \stackrel{?}{=} P_x$$

✗ $0.36 + 1.44 \stackrel{?}{=} 3.24$ → non linear

مشان هيك ما بطلعو متساويين

Voltage and Current → Linear

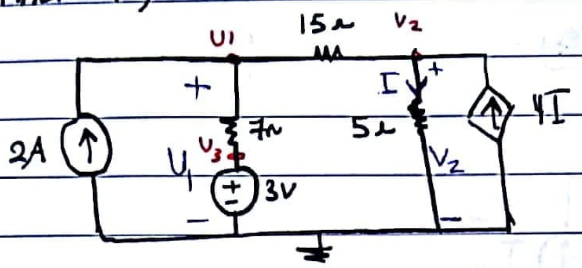
find $I_{x_{new}}$ When $V_s = 9V$ & $I_s = 2A$

$$I_{x_{new}} = 3(I'_x) + 2(I''_x)$$

$$= 3(0.2) + 2(0.4) = 1.4\,A$$

ex: find V_1 & V_2 :

kill → dependent



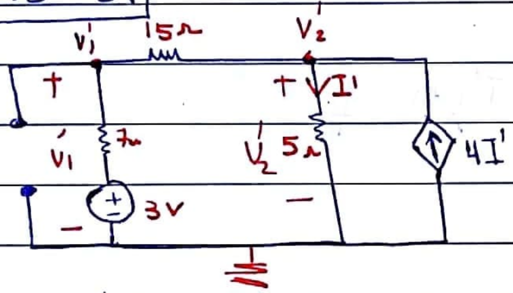
والحل الاسهل والمختصر :-

$$\frac{V_1-3}{7}+\frac{V_1-V_2}{15}=2 \quad ..(1)$$

$$\frac{V_2-V_1}{15}+\frac{V_2}{5}=4\left(\frac{V_2}{5}\right) \quad ..(2)$$

$\boxed{V_3 = 3V}$

Sol)



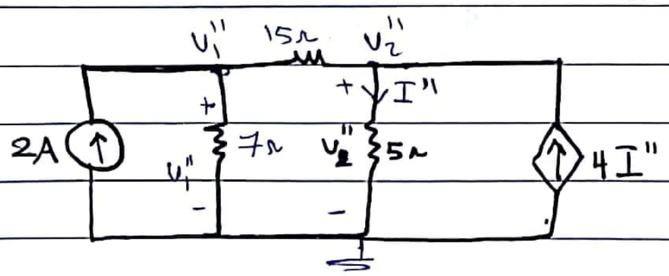
(a) Node #1 :

$$\frac{(V_1'-3)}{7}+\frac{V_1'-V_2'}{15}=0 \quad (1)$$

(b) Node #2 :

$$\left(\frac{V_2'-V_1'}{15}\right)+\frac{V_2'}{5}=4I'$$

$$\frac{V_2'-V_1'}{15}+\frac{V_2'}{5}=4\left(\frac{V_2'}{5}\right) \quad ..(2)$$



(a) Node 1 :

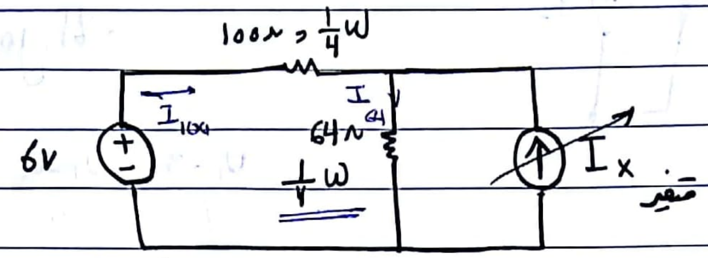
$$\frac{V_1''}{7}+\frac{(V_1''-V_2'')}{15}=2 \quad ..(1)$$

$$\frac{V_2''}{5}+\frac{V_2''-V_1''}{15}=4\left(\frac{V_2''}{5}\right) \quad (2)$$

$$V_1 = V_1' + V_1''$$

$$V_2 = V_2' + V_2''$$

ex: Find the maximum current (I_x) such that the resisters do not exceed their power rating. اقصى Power ممكن تتحمله المقاومة.



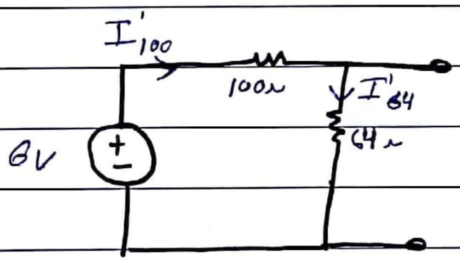
$$P_{100} = \frac{1}{4} = I_{100}^2(100)$$

$$P_{64} = I_{64}^2(64) = \frac{1}{4}$$

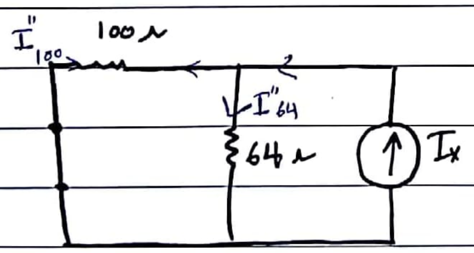
Power rating → max Power.

$$I_{100\,max} = \sqrt{\frac{1}{400}} = 50\,mA$$

$$I_{64\,max} = \sqrt{\frac{1}{4\times 64}} = 625\,mA$$



$$I'_{100} = I'_{64} = \frac{6}{164} = 36.59\,mA$$



$$I''_{64} = I_x \frac{100}{164} \qquad I''_{100} = -I_x \frac{64}{164}$$

$$I'_{64} + I''_{64} \leq 65.5\,mA$$

$$I''_{64} \leq 62.5\,m - 36.59\,m$$

$$I_x \frac{100}{164} \leqslant 25.91\ m$$

$$\boxed{I_x \leqslant 42.49\,mA}$$

$$I'_{100} + I''_{100} \leqslant 50\ m$$

$$I''_{100} \leqslant 50\ m - 36.59\ m$$

$$-I_x \frac{64}{164} \leqslant (50 - 36.59)\ m$$

$$-I_x \leqslant 34.36$$

$$\boxed{I_x \geqslant -34.36\ m}$$

$$I_{x\,max} = 42.49\ mA$$

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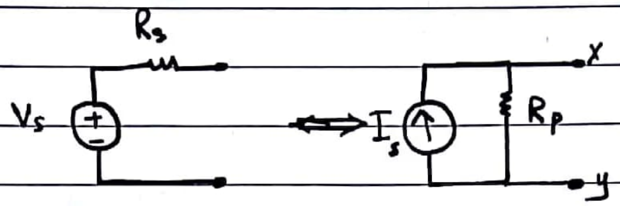
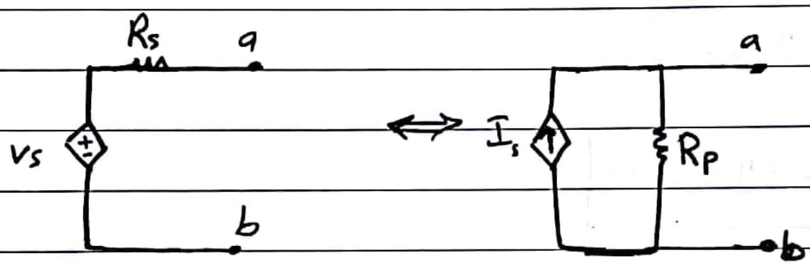
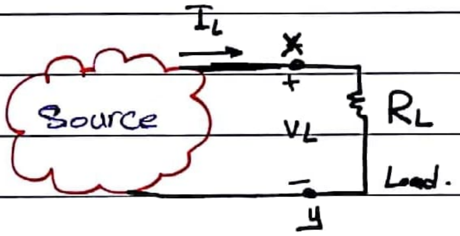
* Source Transformation:

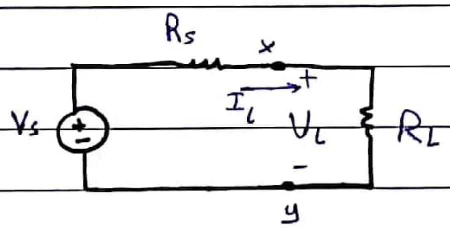
الانتباه للاسهم $(\pm\ \uparrow)$

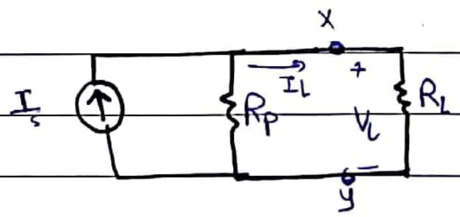


$$R_s = R_p$$
$$V_s = I_s R_s$$









$$V_L = V_s \frac{R_L}{R_s + R_L}$$

$$V_L = I_L R_L$$

$$V_L = I_s \left(\frac{R_p}{R_p + R_L}\right) \cdot R_L$$

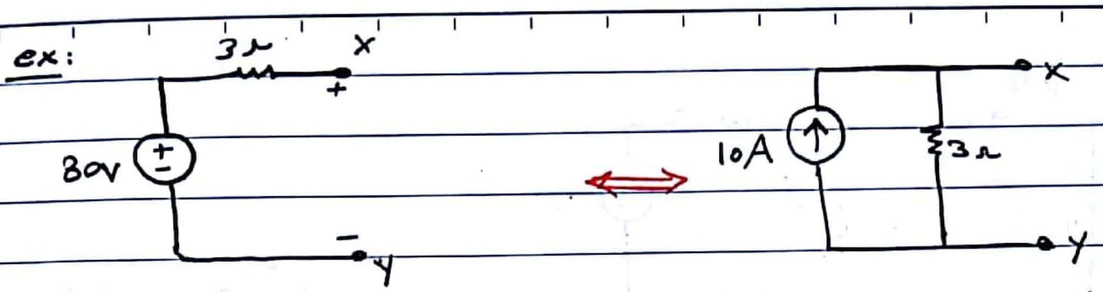
$$= I_s R_p \left(\frac{R_L}{R_p + R_L}\right)$$

if $V_s = I_s R_p$ & $R_s = R_p$

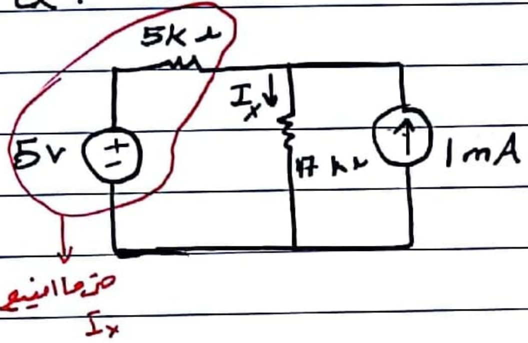
Voltage source $\xrightarrow{\text{in series}}$ with resistors

Current source $\xrightarrow{\text{in Parallel}}$ with R

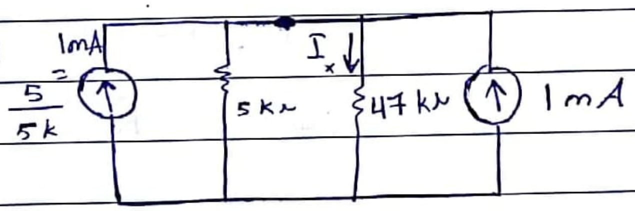
ex:

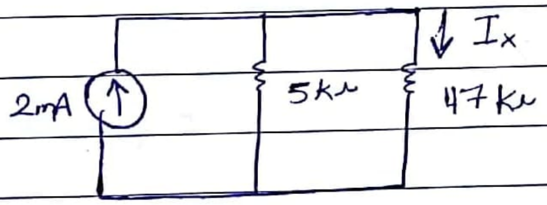


ex : $I_x = ?!$



Sol)





$$I_x = 2\times10^{-3}\,\frac{5}{5+47} = 1.92\times10^{-4}\ A$$

$= .192\ mA$

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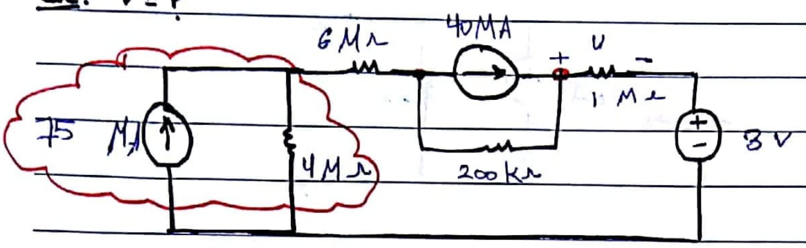
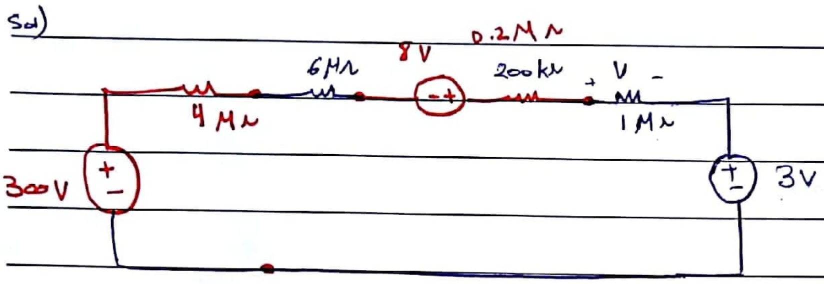
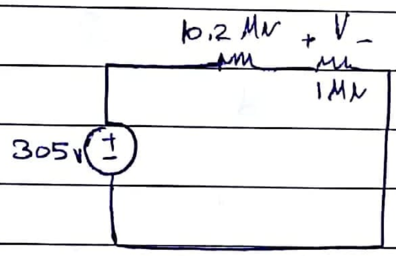
ex: V = ?



$40^{M} \times 200k = 8$ Volt

Sol)





حولنا لـ CKT بسيطة

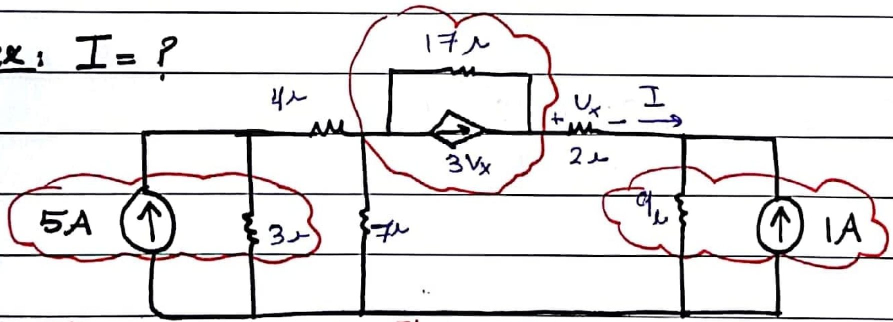
Source مع R

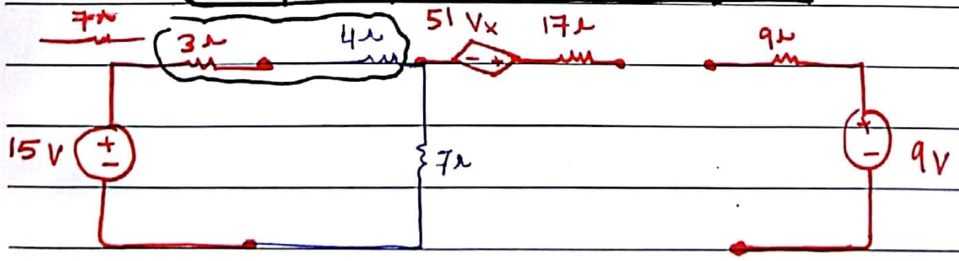
$$V = 305 \times \frac{1}{(10.2 + 1)} = 27.23 \text{ V}$$

Single loop → نحول ال currents Source → voltage source

± ↑ الموجب مع اتجاه I

ex: I = ?





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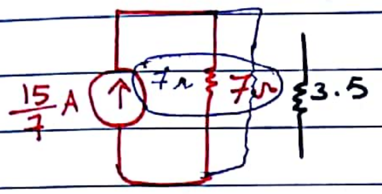
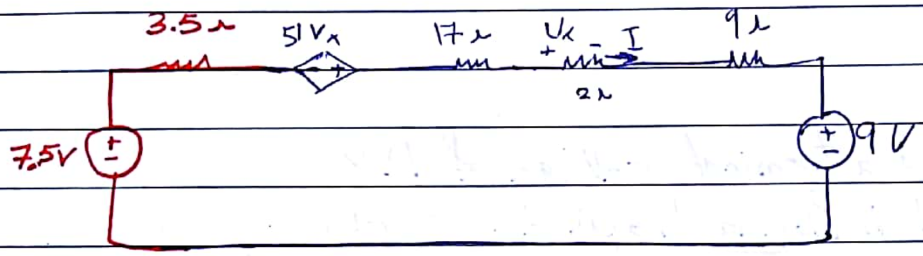




$$-7.5 + 3.5I - 51V_x + 17I + 2I + 9I + 9 = 0$$

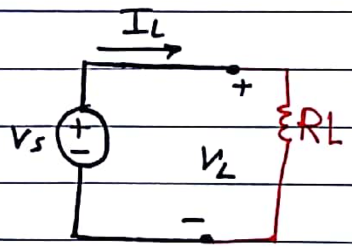
$$-7.5 + 3.5I - 51(2I) + 17I + 2I + 9I + 9 = 0$$

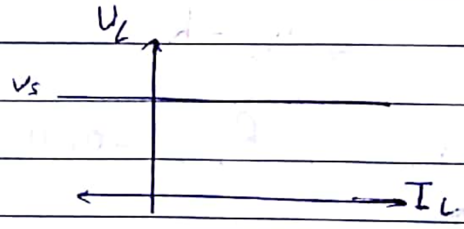
$$I = 21.276\ mA$$

$$V_x = 2I$$

* Practical Sources:
  * Practical Voltage Source:

Ideal: a device where terminal voltage is independent of the current through it.





Let $V_s = 1V$

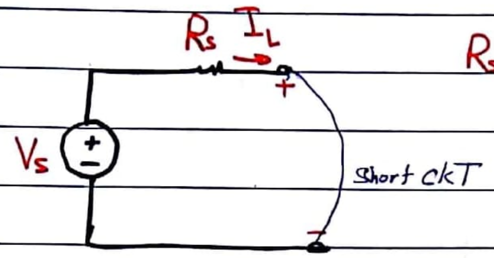
if $R_L = 1\Omega \rightarrow I_L = 1A \rightarrow P = 1W$.

if $R_L = 1M\Omega \rightarrow I_L = 1MA \rightarrow P = 1\times10^6\ W$

Mega $= 1MW$

Provide unlimitted amount of Power.

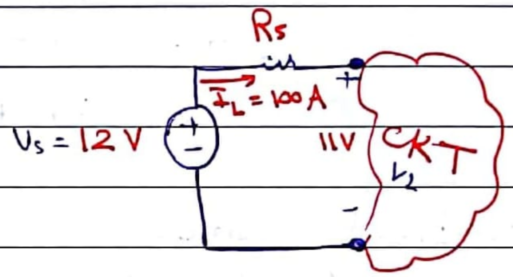
- Practical :



R_s : Internal Resistance. (Output).

ex : Car battery how a terminal voltage of 12 V.
When no current is flowing through it. Open CKT
This terminal voltage reduced to 11 V when 100 A is flowing.

$-V_s + R_s I_L + V_L = 0$



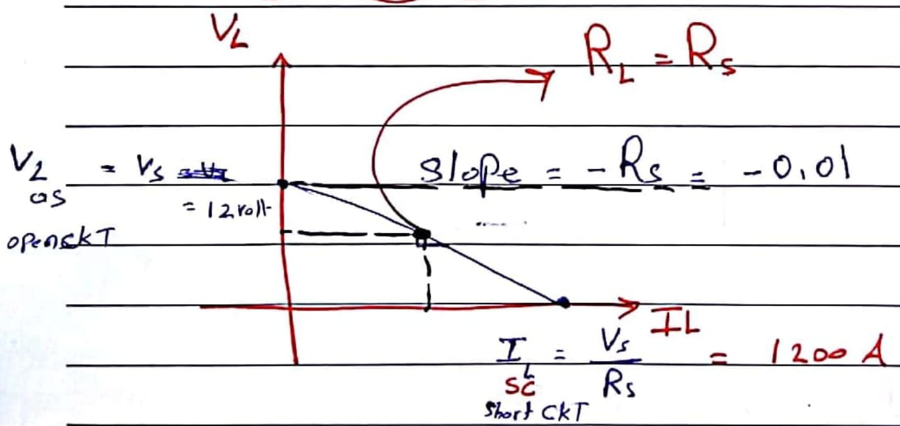
$$\boxed{V_L = V_s - R_s I_L}$$

$11 = 12 - R_s (100)$

$R_s = 0.01\,\Omega$

$V_L = 0 \longrightarrow I_L = \dfrac{V_s}{R_s}$

$V_L = 12 - 0.01\, I_L$



$I_L = 0$ when $R_L = \infty$ open CkT $\longrightarrow V_{L\,oc} = V_s$

$V_L = 0$ when $R_L = 0$ short ckT $\longrightarrow I_{L\,sc} = \dfrac{V_s}{R_s}$

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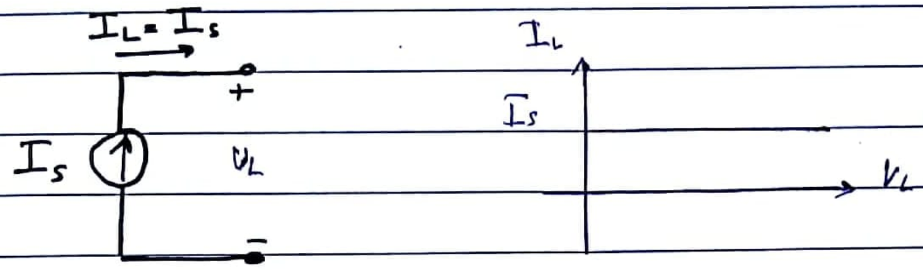
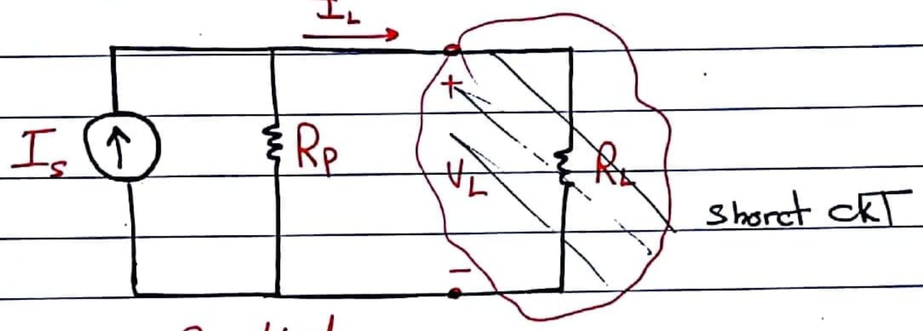
* Practical Current Source Representation:



Ideal



Practical

KCL:

$$\boxed{I_L = I_s - \frac{V_L}{R_p}}$$