ElCoM
ELECTRICAL COMPUTER MECHATRONICS

أساسيات الدوائر الكهربائية

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للطالبة المبدعة
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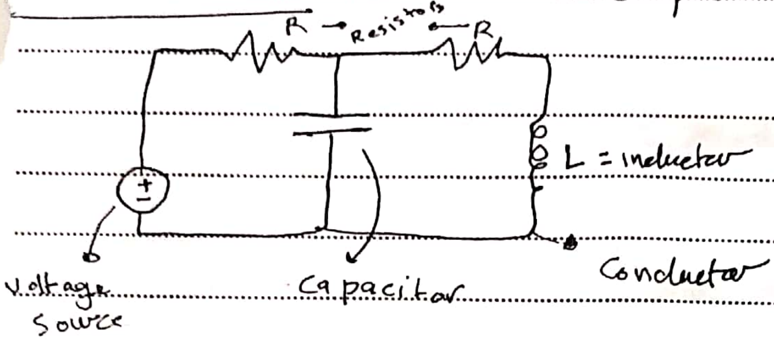
إرادة - ثقة - تغيير

Circuit

subject : circuit

Subject : Circuit 18th July/ 2022

Ch 2 Basic compounent and electrical circuit



Units + scales :

my mesavable quntity can be described by number + unite
like : 3 meter
number ↵ ↳ unite

five something we must know :

(*) charge :-

⇒ +ve → Proton → $+1.602 \times 10^{-19}$ C
-ve → electron → -1.602×10^{-19} C

⇒ unite → Coulomb

⇒ charge → DC → $Q(t)$
↳ AC → $q(t)$

(*) current :-
is the time of flow of electrical charge through a counductor or circuit element

$$I = \frac{dq}{dt}$$

I ⇒ Amper
q ⇒ coulomb
t ⇒ second

$$A = \frac{C}{S}$$

Subject : Complement

Ex : let $q(t) = \cos t$ find $I(t)$ at $t = 3\ ms$?

$$I = \frac{dq}{dt}$$

3240

$$d\, q(t) = -\sin t \Big|_{t = 3\ ms}$$

نحول ونضرب بـ $\times \frac{180}{\pi}$

$$= -\sin(3 \times 10^{-3})$$

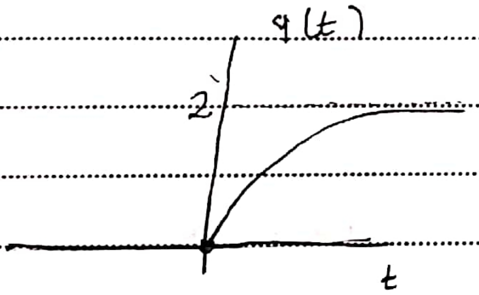
$$= -2.999 \times 10^{-3}\ A$$

$$I(t)\, dt = dq(t)$$

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

$$\int_{t_0}^{t} I(t)\, dt = Q(t) - Q(t_0)$$

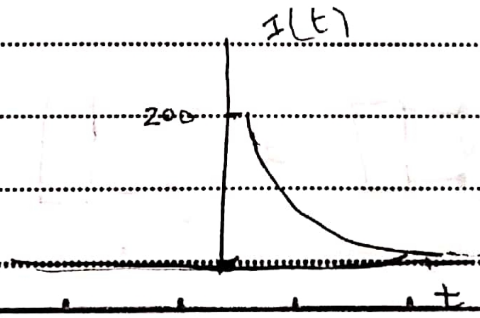
Ex : let $q(t) = \begin{cases} 0 & t < 0 \\ 2 - 2e^{-100t} & t > 0 \end{cases}$ plot $I(t), q(t)$?



اشتق

$$I(t) = \begin{cases} 0 & t < 0 \\ 200e^{-100t} & t > 0 \end{cases}$$

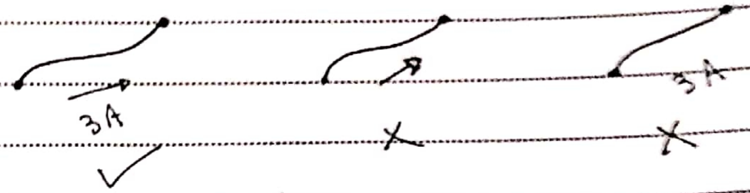
plot



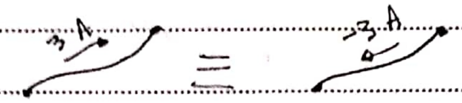
(*) Current is a vector quantity ?

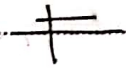
-o magnitude

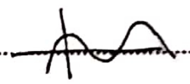
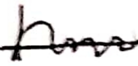
-o direction



also



type of current ⇒ (1) DC  (3) exp 

(2) AC  (4) damping 

(*) Voltage :-

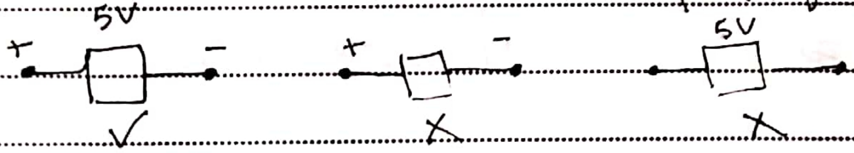
is a measure of the work required to move a charge through element.

1] Unite ⇒ Voltage = V, V

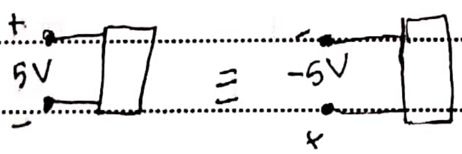
2] the voltage can exsist between of electrical terminal wather the current is flowing or not.

3] voltage determined by: + Voltage Mag.

← polarity



also,

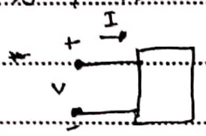


* power

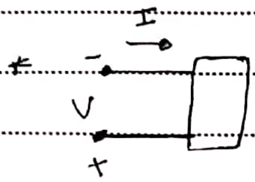
1] unite ⇒ watt = W

2] $P = V\,I$
$W = V * A$

3] passive sign convention :

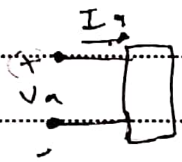


if the current entering +ve terminal of element then the power is absorbed.

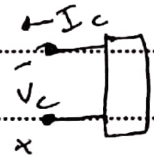


if the current is entering -ve terminal of element then the power is supplied

Ex find the power ?

① 

if $V_a = 12V$
$I_a = 2A$ ⇒ $P = VI$
$= 12 * 2 = 24\ W$ absorbed

② 

$P = VI = 12 * \cancel{3} = \cancel{24}\ -36$ absorbed
36 supplied

$P_{absorbed} = -P_{supplied}$

* Energy :-

1] unite ⇒ Joule

$$w(t) = \int_{t_0}^{t} p(t)\,dt$$

▶ Subject :

Ex find $w(t)$ if the voltage $v(t) = 12V$, $i(t) = 2e^{-t} A$

$0 \le t \le \infty$?

$$w(t) = \int_{t_0}^{t} p(t)\, dt$$

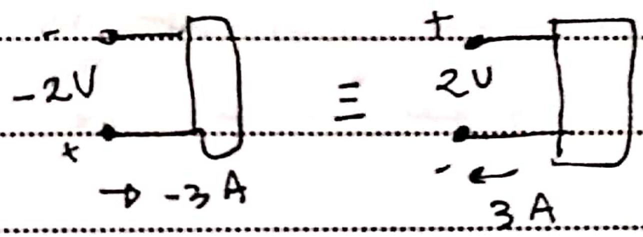
$$P(t) = V(t) I(t) = (12)(2e^{-t}) = 24e^{-t}$$

$$w(t) = \int_{t_0}^{t} p(t)\, dt = \int_{t_0}^{t} 24e^{-t}\, dt = 24\ J$$

Ex Find the power :

$P = VI$

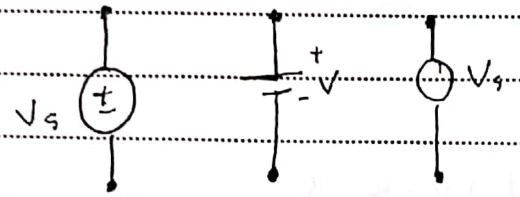
$= 2 * 3 = 6W$ absorbed



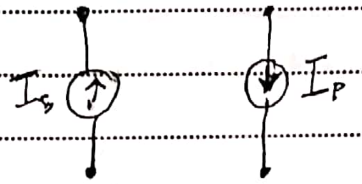
Jul / 19th / 2022

Sources :
- Voltage
  - dep.
  - Indep
- current
  - dep
  - Indep

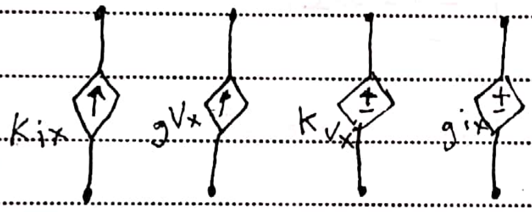
* Indep Voltage source :-



* Indep Current source

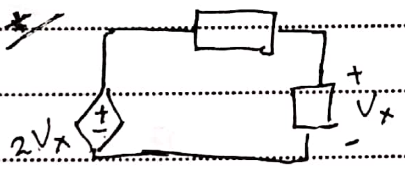


* dep Current and Voltage sources :-



CCC VCC VCV CCV

*

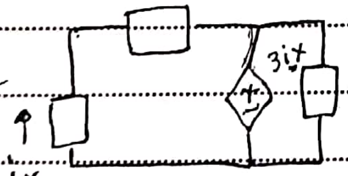


VCV

if $V_x = 2$

then $2V_x = 4$

*

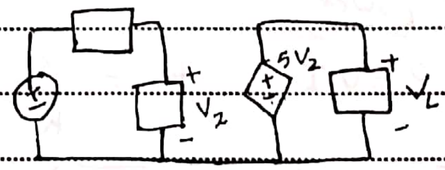


CCV

if $i_x = 3$

then $3i_x = 9$

Ex let $V_2 = 3V$ find V_L



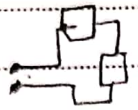
VCV

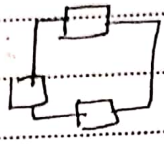
$5V_2 = 5 \times 3 = 15$

so $V_L = 5V_2$ in Parallel

Subject : ....

(*) network , circuite :





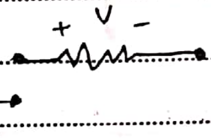
open loop ↓ network

close loop circuite

(*) ohm's Law :-

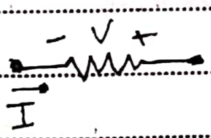
$V = RI$

1



$\{ +V = RI \}$

2



$\{ -V = RI \}$

unites :

V = volt I = Amper R = ohm $\Rightarrow$ ohm $= \frac{V}{A}$

(*) power

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

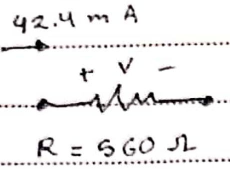
* conductance :-

$G = \frac{1}{R}$ unite : siemens or mho

$\therefore P = \frac{I^2}{G}$

Subject: Complement b

Ex find V, P ?



$+V = RI$

$= 560 \times 42.4 \times 10^{-3}$

$= 23.7\,V$

$P = I^2 R$

$= 1.005\,W$ absorbed

Ch. 3 : KVL + KCL

① node : a point at which tow or more element have common conection

② path : a set of nodes and elements that we pass through without passing throgh node more than once

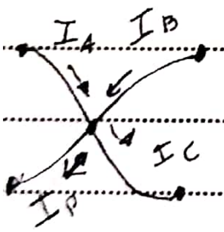
③ loop : if the node at which we started is the same as the node which we end then the path is loop

④ Branch : consist of one node and one element (حالة خاصة من ال path)

Kirchhoff's current law (KCL)

The algebric sum of the current entering any node is zero

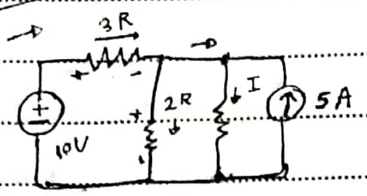
$$\sum_{node} I = 0$$



$$I_A + I_B - I_D - I_C = 0$$

Subject :

Ex find I ?

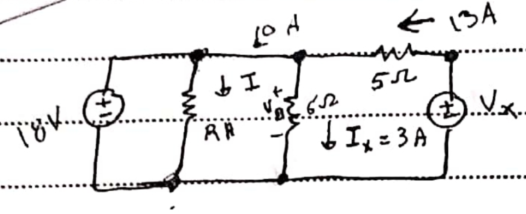


$I = 6\ A$

$+V = RI$

$I = \frac{10}{3}$

Ex



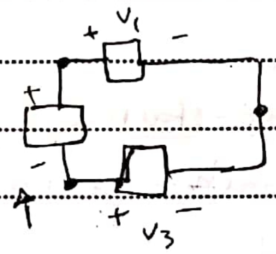
find R_A ?

$R_A = 1\ \Omega$

Kirchhoff's Voltage Law (KVL)

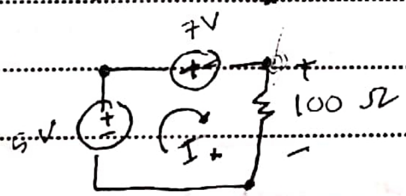
The algebric sum of the voltage around any loop is Zero.

$\sum_{loop} V = 0$



$-V_1 + V_2 - V_3 = 0$

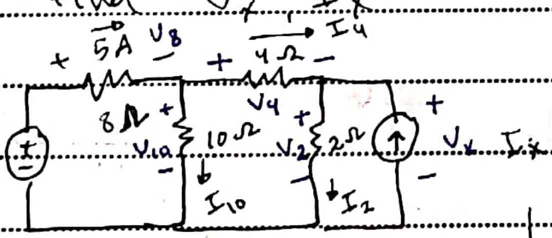
Ex find V_x, I_x ?



$-5 - 7 + V_x = 0 \Rightarrow V_x = 12V$

$I_x = 120mA$

Ex find V_x, I_x



$+V = RI = 8*5 = 40V$

$-60 + 40 + V_{10} = 0 \Rightarrow V_{10} = 20V$

$+V_{10} = I_{10}R \Rightarrow I_{10} = 2A$

$I_4 = -5 + I_{10} \Rightarrow I_4 = 3A$

$+V_4 = I_4 * R = 3*4 = 12V$

$+12 + V_2 - 20 = 0 \Rightarrow V_2 = 8V$

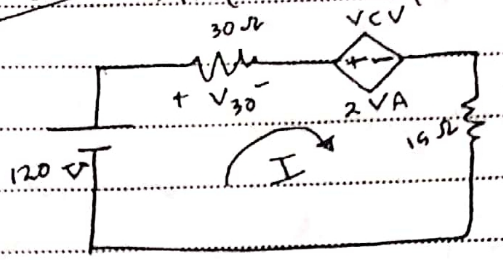
$V_x = V_2 = 8V$

$+V_2 = I_2\, 2 \Rightarrow I_2 = 4\ A$

$I_x = 1\ A$

Subject :

Ex find the power ?



$-120 + V_{30} + 2VA - VA = 0$

$-120 + V_{30} + VA = 0$

$-120 + 30I + (-15I) = 0$

$-120 + 15I = 0 \Rightarrow I = 8A$

$P_{120} = VI = 120 * 8 = 960$ w supplied

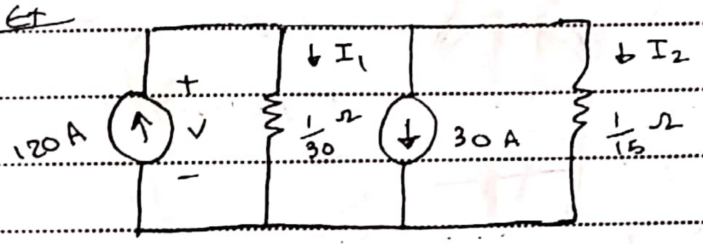
$P_{30} = (+8 * 30) 8 = 1920$ w absorbed

$P_{2VA} = 2(-15*8) * 8 = -1920$ w absorbed

$P_{VA} = -15 \times 8 * 8 = 960$ w absorbed

(*) single node pair circuit :-

Ex



$120 = I_1 + 30 + I_2$

$90 = I_1 + I_2$

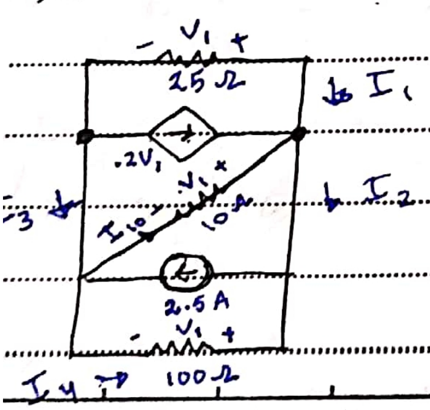
$90 = 30V + 15V$

$90 = 45V \Rightarrow V = 2V$

$I_1 = 30V = 30 \times 2 = 60$ A

$I_2 = 15V = 15 \times 2 = 30$ A

Ex find I_1, I_2, I_3, I_4 ?



$2.5 = I_1 + .2V_1 + I_{10} + I_4$

$2.5 = \frac{-V_1}{25} + .2V_1 + \frac{-V_1}{10} + \frac{-V_1}{100} \Rightarrow V_1 = 50$ V

$I_1 = -2A$

$I_{V_1} = 10$ A

$I_{10} = -5A$

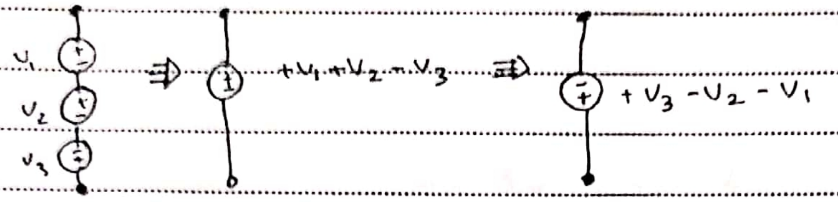
$I_2 = I_1 + I_4 + .2V_1 \Rightarrow 3A$

$I_3 = 2.5 + .5 + 5 = 8$ A

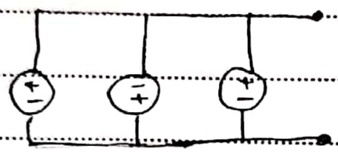
$I_4 = -.5$ A

(*) Sources → series and parallel connected

1] Voltage in series:

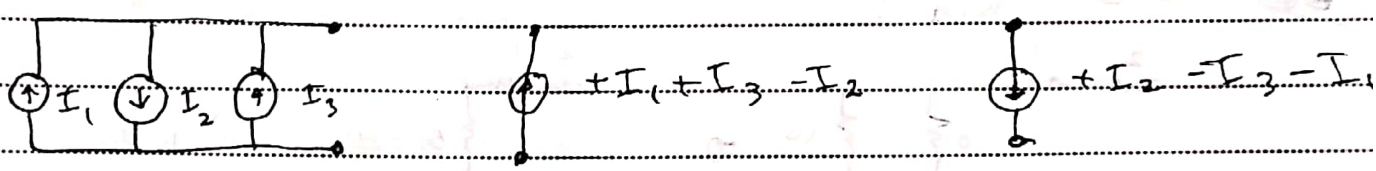


2] Voltage in parallel:



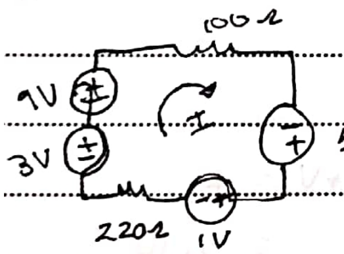
X in reality this is wrong and does not exsit

(*) 1] current in parallel

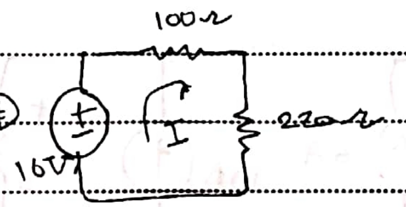


2] current in series :- does not exsit in real life

Ex find I ?



⇒



$-16 + 100I + 220I = 0$

$-16 + 320I = 0$

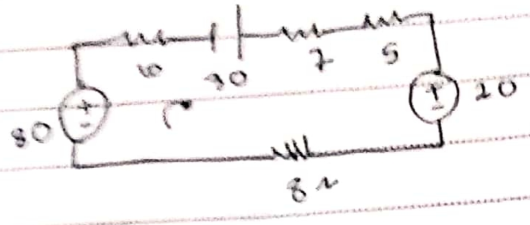
$320I = 16$

$I = 50\,mA$

2) 1] Resistor in series : $R_{eq} = R_1 + R_2 + R_3 \dots$

Subject :

Ex : find I ?



$-80 + 10I + 30 - 7I - 5I + 20 - I8 = 0$

$-80 - 30I - 30 + 20 = 0$

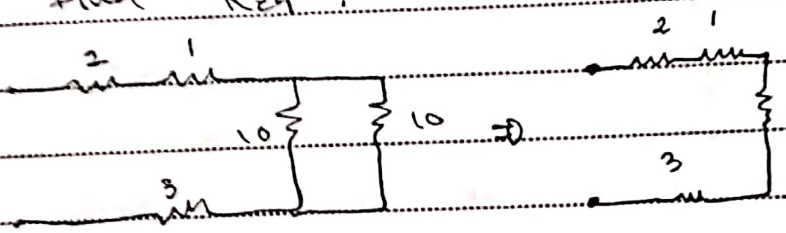
$-30I - 90 = 0$

$I = -3A$

1] Resistor in parallel :-

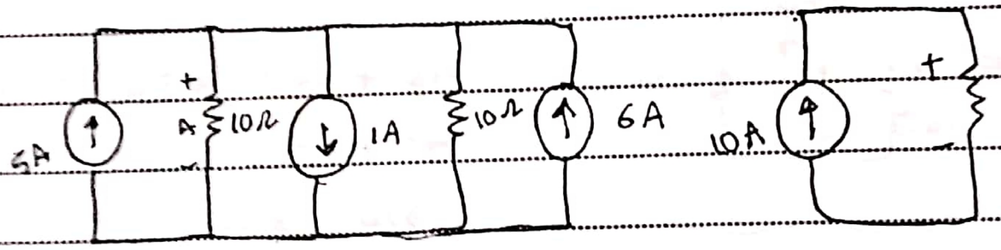
$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \dots$$

Ex : find R_{eq} ?



$\Rightarrow R_{eq} = 11\ \Omega$

Ex : find V?

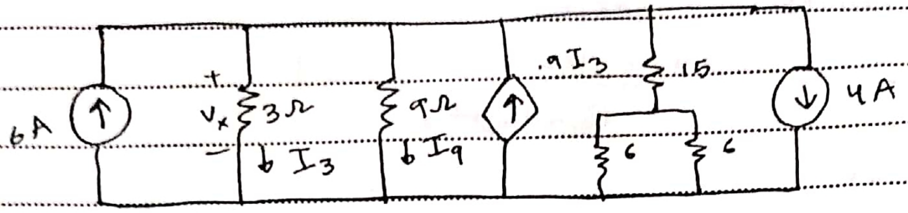


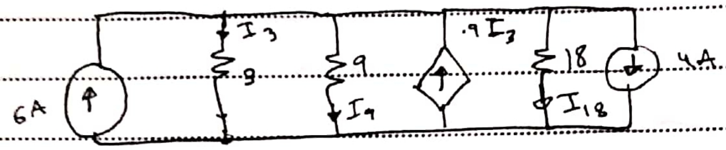
$+V = RI$

$= 5 \times 10$

$= 50V$

G5 Find the power in the dep. source





$P = IV$

$= V_x * .9 I_3$

$= V_x * .9 * \frac{V_x}{3}$

$= .3 (V_x)^2 \longrightarrow = 30$ w supplied

$$\begin{array}{r} 1.0 \\ -0.9 \\ \hline 0.1 \end{array}$$

$6 + .9 I_3 = I_3 + I_9 + I_{18} + 4$

$2 = .1 I_3 + I_9 + I_{18}$

$2 = .1 \left(\frac{V_x}{3}\right) + \frac{V_x}{9} + \frac{V_x}{18}$

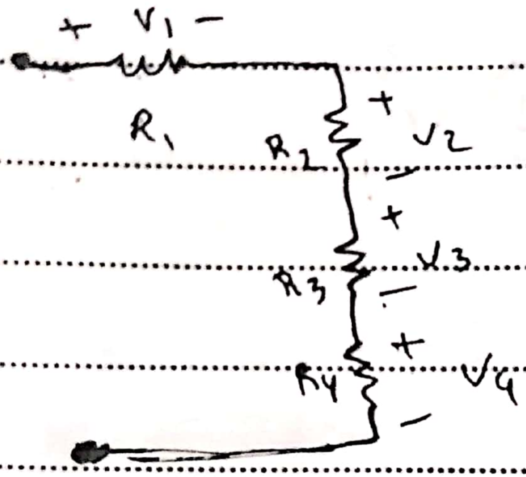
$2 = \frac{.1}{3} V_x + \frac{1}{9} V_x + \frac{1}{18} V_x$

$2 = .2 V_x \Rightarrow V_x = 10$

Subject : Circuit Jul / 24^{th} / 2022

Voltage and current divison :-

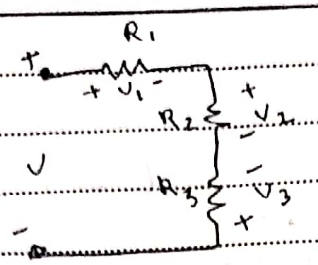
1) voltage for resistor in series :-



$$V_n = \frac{R_n}{R_1 + R_2 + R_3 \dots} \quad [V]$$

Subject : ....

Ex

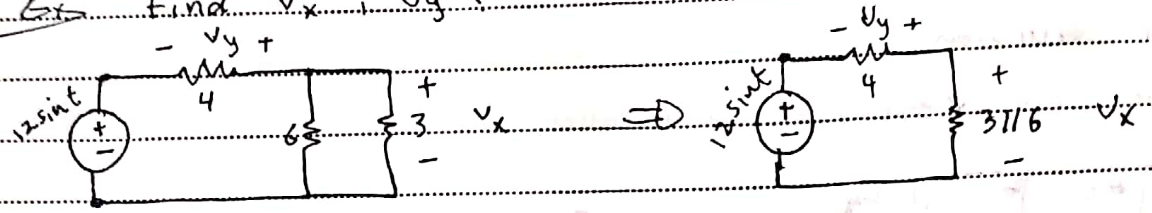


$$V_1 = \frac{R_1}{R_1+R_2+R_3}[V]$$

$$V_2 = \frac{R_2}{R_1+R_2+R_3}[V]$$

$$V_3 = \frac{R_3}{R_1+R_2+R_3}[-V]$$

Ex find V_x , V_y ?



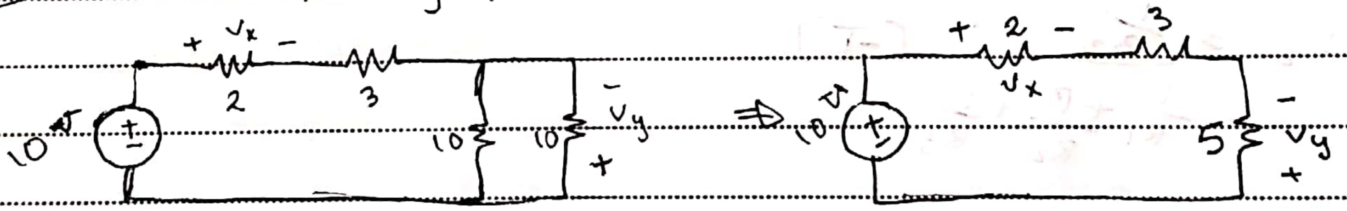
$$R_{eq} = 3//6 = \left[\frac{1}{3}+\frac{1}{6}\right]^{-1}$$

$$= 2$$

then $V_x = \frac{2}{2+4}[12 \sin t] = 4 \sin t \ V$

$V_y = \frac{4}{2+4}[-12 \sin t] = -8 \sin t \ V$

Ex find V_x , V_y ?

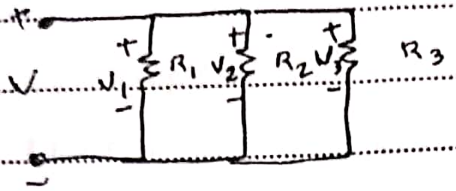


then $V_x = \frac{2}{2+3+5}[10] = 2 \ V$

$V_y = \frac{5}{2+3+5}[-10] = -5 \ V$

Subject :

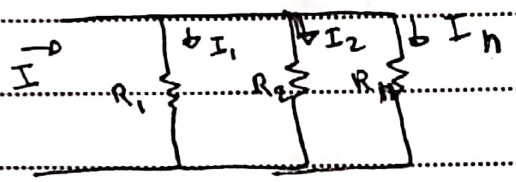
(*) Voltage for resistor in parallel



$$V = V_1 = V_2 = V_3$$

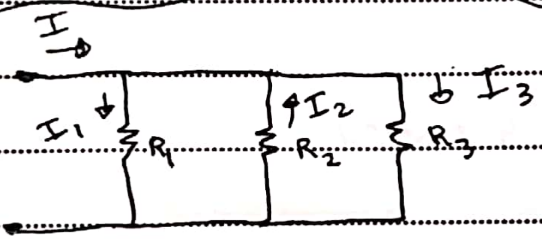
(*) Current division

(1) Current for Resistor in parallel



$$I_n = \frac{\frac{1}{R_n}}{\frac{1}{R_1} + \frac{1}{R_2} \cdots + \frac{1}{R_n}} \quad [I]$$

Ex

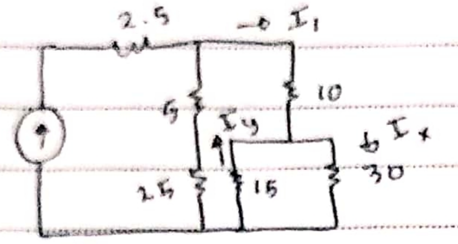


$$I_1 = \frac{\frac{1}{R_1}}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}} \quad [I]$$

$$I_2 = \frac{\frac{1}{R_2}}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}} \quad [I]$$

$$I_3 = \frac{\frac{1}{R_3}}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}} \quad [I]$$

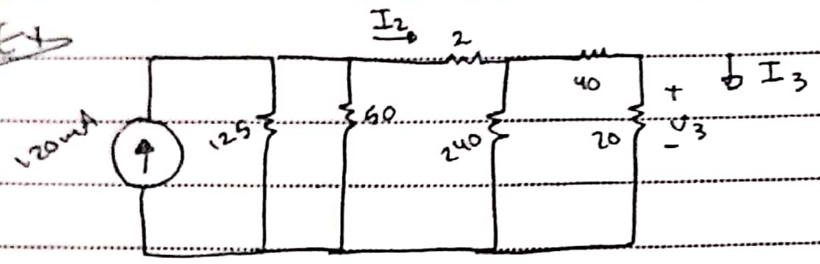
Ex let $I_1 = 100$ mA find I_x, I_y?



$$I_x = \frac{\frac{1}{30}}{\frac{1}{30}+\frac{1}{15}}[100m] = 33.33 \text{ mA}$$

$$I_y = \frac{\frac{1}{15}}{\frac{1}{30}+\frac{1}{15}}[100m] = 76.66 \text{ mA}$$

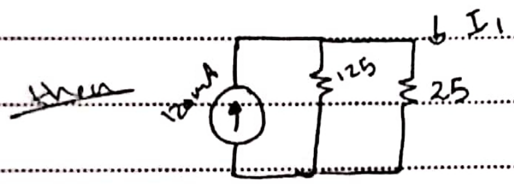
Ex



$$R_{eq_1} = \left[\left[[40+20] \,//\, 240\right]+2\right] \,//\, 50$$

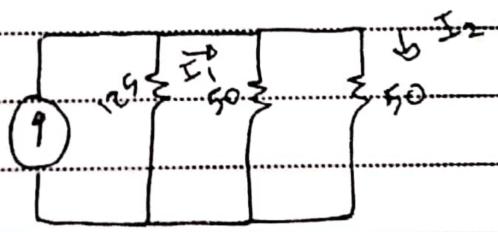
$$= 25$$

then



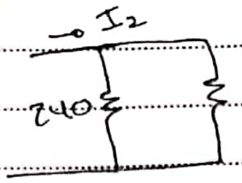
$$I_1 = \frac{\frac{1}{25}}{\frac{1}{125}+\frac{1}{25}}[120m] = 100 \text{ mA}$$

$$R_{eq_2} = \left[[40+20] \,//\, 240\right]+2 = 50$$



$$I_2 = \frac{\frac{1}{50}}{\frac{1}{50}+\frac{1}{50}}[I_1] = 50 \text{ mA}$$

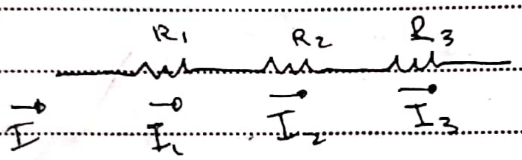
OR $$I_2 = \frac{\frac{1}{50}}{\frac{1}{50}+\frac{1}{50}+\frac{1}{125}}[120m] = 50 \text{ mA}$$



$+V_3 = 20\ I_3$

$I_3 = \dfrac{\frac{1}{60}}{\frac{1}{60} + \frac{1}{240}}$ (50 mA) $\rightarrow +V_3 = 20 * I_3 = 0.8\ V$

(*) current for Resistor in Series :-



$I = I_1 = I_2 = I_3$

CH 4 : nodal and mesh analysis :

solving linear system of equation :

1) $a_1 x_1 = b_1$

2] $a_1 x_1 + a_2 x_2 = b_1$

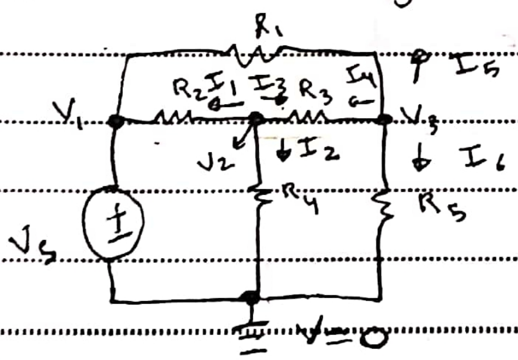
$a_3 x_1 + a_4 x_2 = b_2$

3] $a_1 x_1 + a_2 x_2 \ldots b_1$.

$a_4 x_1 + a_5 x_2 + a_6 x_3 = b_2$

$a_7 x_1 + a_8 x_2 + a_9 x_3 = b_3$

(1) nodal analysis :



(1) assume referance Voltage = below.

(2) assume Voltage on each nodal

(3) assume current entering each Resistor

(4) Apply KCL

at nodal 1 :

$+V_1 - 0 = V_s \Rightarrow V_1 = V_s$

at nodal 2 :

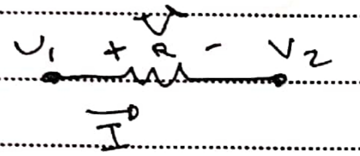
$I_1 + I_2 + I_3 = 0$

$$\frac{V_2 - V_1}{R_2} + \frac{V_2 - 0}{R_4} + \frac{V_2 - V_3}{R_3} = 0 \quad -- (2)$$

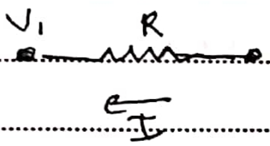
at nodal 3 :

$I_4 + I_5 + I_6 = 0$

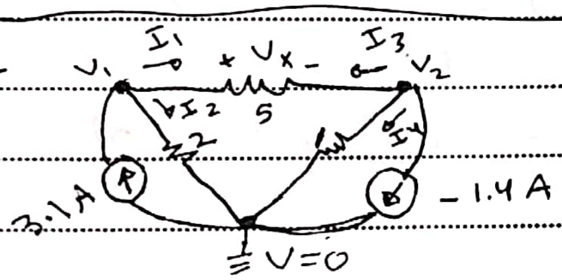
$$\frac{V_3 - V_2}{R_3} + \frac{V_3 - V_1}{R_1} + \frac{V_3 - 0}{R_3} = 0 \quad - (3)$$

⇒ 

$$I = \frac{V}{R} = \frac{+V_1 - V_2}{R}$$

⇒ 

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

Ex 

at nodal 2 :

$I_3 + I_4 + (-1.4) = 0$

$$\frac{V_2 - V_1}{5} + \frac{V_2 - 0}{1} + (-1.4) = 0 \quad - (2)$$

at nodal 1 :

$3.1 = I_2 + I_3$

$$3.1 = \frac{V_1 - V_2}{5} + \frac{V_1 - 0}{2} \quad -- (1)$$

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

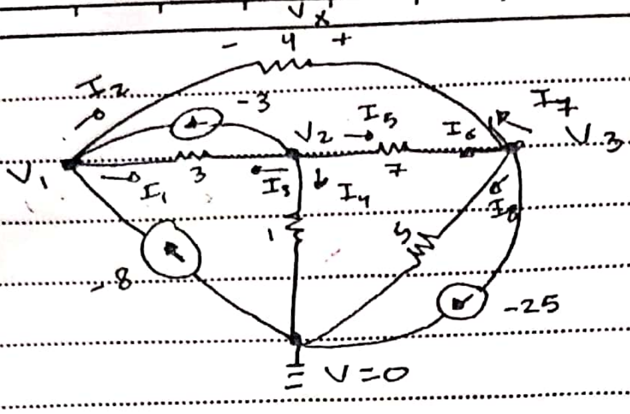
$$I_1 = \frac{V_1 - V_2}{5} = \frac{5-2}{5} = \frac{3}{5} A$$

$V_x = +V_1 - V_2$

$= 5 - 2 = 3V$

Subject :

Ex



at nodal 1 :

$-8 + (-3) = I_1 + I_2$

$$-11 = \frac{V_1 - V_2}{3} + \frac{V_1 - V_3}{4} \quad \text{--} \ (1)$$

at nodal 2 :

$-3 + I_3 + I_4 + I_5 = 0$

$$-3 + \frac{V_2 - V_1}{3} + \frac{V_2 - 0}{1} + \frac{V_2 - V_3}{7} = 0 \quad \text{--} \ (2)$$

at nodal 3 :

$-25 + I_6 + I_7 + I_8 = 0$

$$-25 + \frac{V_3 - V_2}{7} + \frac{V_3 - V_1}{4} + \frac{V_3 - 0}{5} = 0 \quad \text{--} \ (3)$$

$V_1 = 5.412$ V

$V_2 = 7.736$ V

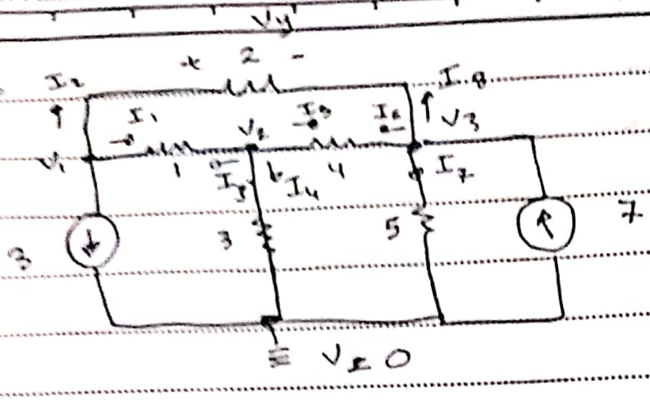
$V_3 = 46.32$ V

$I_5 = \frac{V_2 - V_3}{7} = \square$ A

$V_x = -V_1 + V_3 = \square$ V

Subject :

Ex



at nodal 1 :

$3 + I_1 + I_2 = 0$

$$3 + \frac{V_1 - V_2}{1} + \frac{V_1 - V_3}{2} = 0 \quad \text{--} (1)$$

at nodal 2 :

$I_3 + I_4 + I_5 = 0$

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

at nodal 3 :

$7 = I_6 + I_7 + I_8$

$$7 = \frac{V_3 - V_2}{4} + \frac{V_3 - 0}{5} + \frac{V_3 - V_1}{2} \quad \text{--} (3)$$

$V_1 = 5.235\ V$

$V_2 = 5.12\ V$

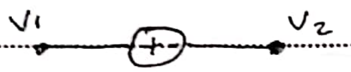
$V_3 = 11.47\ V$

$$I_6 = \frac{V_3 - V_2}{4}$$

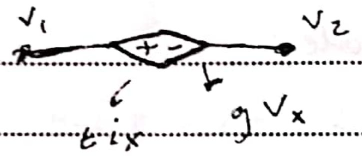
$V_y = +V_1 - V_3$

* super nodal

1]

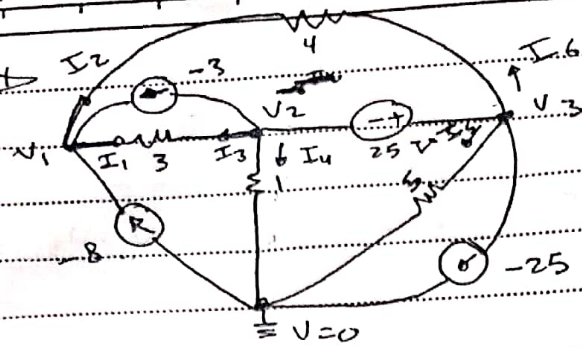


2]



Subject :

Ex



at nodal I :-

$-8-3 = I_1 + I_2$

$-11 = \frac{V_1 - V_2}{3} + \frac{V_1 - V_3}{4}$ -- ①

at super node :

~~$V_2 + V_3 = 22$~~

$-3 + I_3 + I_4 + I_5 + I_6 + (-25) = 0$

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

from super node

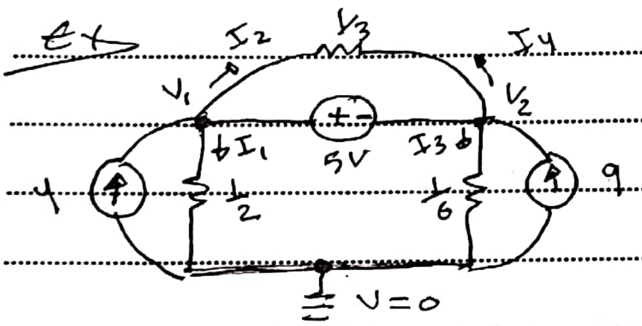
$-V_2 + V_3 = 22$ -- ③

$V_1 = 1.071$ V

$V_2 =$

$V_3 =$

Ex



at super node:

$4 + 9 = I_1 + I_2 + I_3 + I_4$

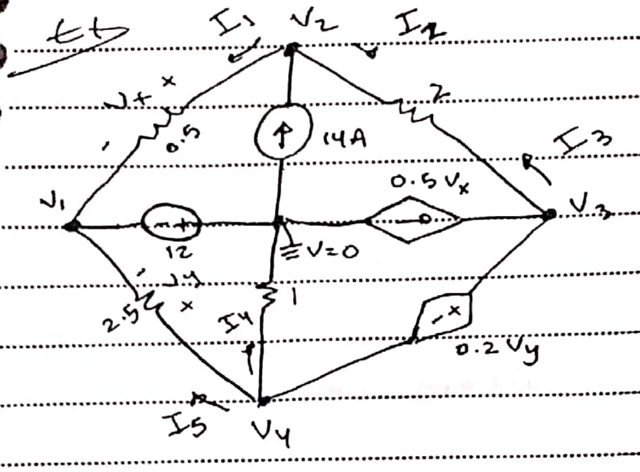
$13 = \frac{V_1 - 0}{1/2} + \frac{V_1 - V_2}{1/3} + \frac{V_2 - 0}{1/6} + \frac{V_2 - V_1}{1/3}$

$+V_1 - V_2 = 5$ -- ②

$V_1 = 5.375$ V

$V_2 = 375$ mV

Ex



at super node 1

$-V_1 + 0 = 12$

$V_1 = -12$ V ...(1)

at node 2:

$14 = I_1 + I_2$

$14 = \frac{V_2 - V_1}{0.5} + \frac{V_2 - V_3}{2}$ ...(2)

at super node 2:

$I_3 + I_4 + I_5 = 0.5 V_x$

$\frac{V_3 - V_2}{2} + \frac{V_4 - 0}{1} + \frac{V_4 - V_1}{2.5} = 0.5[-V + V_2]$ ...(3)

⇒ $-V_4 + V_3 = 0.2 V_y$

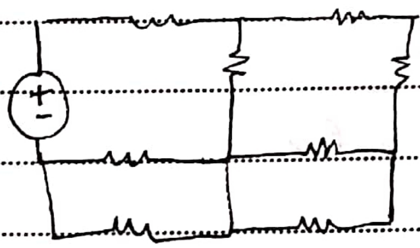
$-V_4 + V_3 = 0.2[-V_1 + V_4]$ ...(4)

$V_1 = -12$ V $\quad V_3 = 0$ V $\quad V_x = -V_1 + V_2 = 12 - 4 = 8$ V

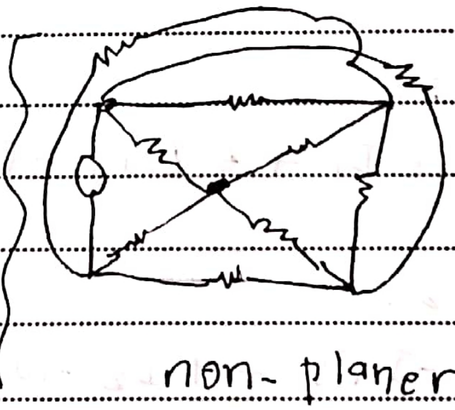
$V_2 = -4$ V $\quad V_4 = -2$ V $\quad V_y = -V_1 + V_4 = 12 - 2 = 10$ V

mesh analysis:

* mesh analysis is applicable only to planer circuit.

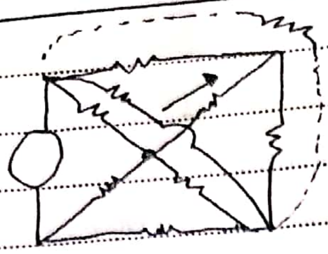


Planer circuit



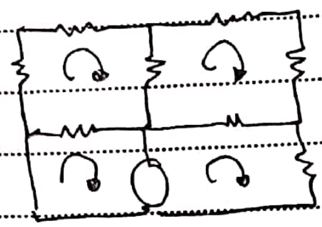
non-planer circuit

Subject :



Planer

*) mesh = loop that does not contain any other loop

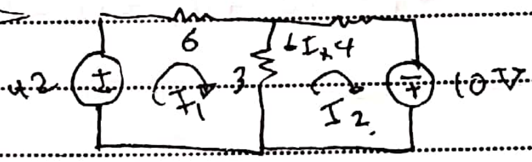


*) mesh analysis:

1) assume current on each loop

2) apply KVL

Ex



$I_x = I_1 - I_2$

at loop 1:

$-42 + 6I_1 + 3[I_1 - I_2] = 0$ -- (1)

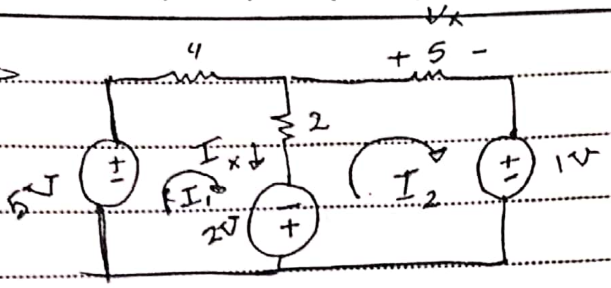
at loop 2:

$3[I_2 - I_1] + 4I_2 - 10 = 0$ -- (2)

$I_1 = 6A$ $\quad I_2 = 4A$

Subject : .... / /

Ex



at loop 1 :-

$-5 + 4I_1 + 2[I_1 - I_2] - 2 = 0$ -- ①

at loop 2 :-

$2 + 2[I_2 - I_1] + 5I_2 + 1 = 0$ -- ②

$I_1 = 1.132$ A $I_2 = -0.1053$ A

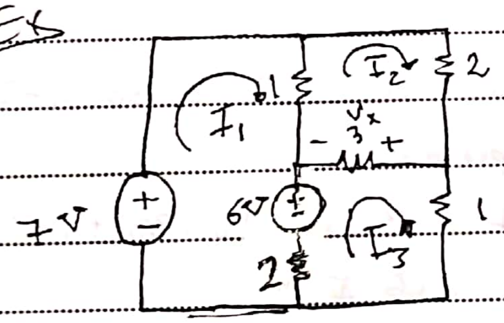
$+V_x = 5I_2 = \_\_\_ V$

$P_{2V} = VI = 2(I_x)$

$= 2[+I_1 - I_2]$

$= \_\_\_$ W supplied

Ex



at loop1:-

$-7 + 1[I_1 - I_2] + 6 + 2[I_1 - I_3] = 0$

at loop 2 :

$1[I_2 - I_1] + 2I_2 + 3[I_2 - I_3] = 0$

at loop 3 :

$2[I_3 - I_1] - 6 + 3[I_3 - I_2] + 1I_3 = 0$

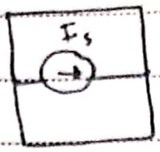
$I_1 = 3A$ $I_2 = 2A$ $I_3 = 3A$

$I_x = I_3 - I_2 = 3 - 2 = 1A$

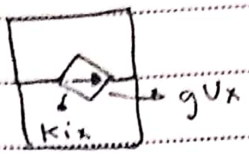
$-V_x = 3I_x = 3(1) \Rightarrow V_x = -3V$

* super mesh :

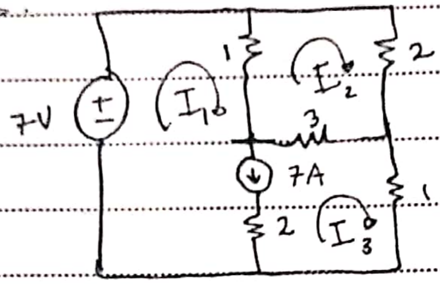
(1)



(2)



Ex :



at supermesh :

$-7 + 1[I_1 - I_2] + 3[I_3 - I_2] + 1 I_3 = 0$ -- (1)

at loop 2 :

$1[I_2 - I_1] + 2[I_2] + 3[I_2 - I_3] = 0$ -- (2)

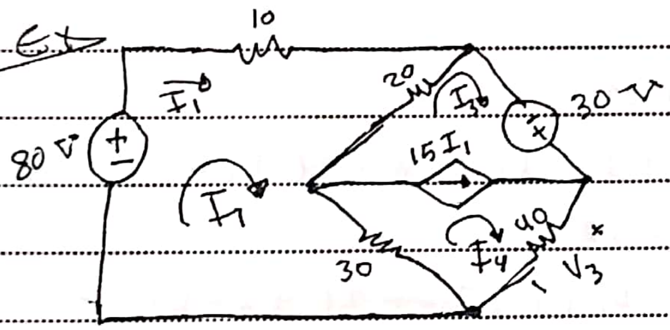
$+I_1 - I_3 = 7$ -- (3)

$I_1 = 9A$ $I_2 = 2.5\,A$ $I_3 = 2\,A$

$I_y = +I_1 - I_2 = 9 - 2.5 = 6.5\,A$

$+V_y = 1[I_y] = 6.5\,V$

Ex :



at loop 1 :

$-80 + 10 I_1 + 20(I_1 - I_3) + 30(I_1 - I_4) = 0$

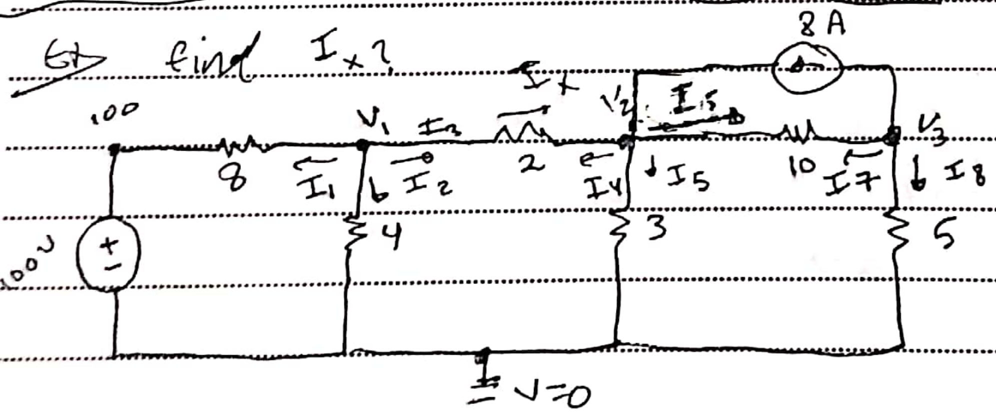
at supermesh :

$20(I_3 - I_1) - 30 + 40 I_4 + 30(I_4 - I_1) = 0$

$+I_4 - I_3 = 15 I_1$

$I_1 = 0.584\,A$ $I_3 = -6.15\,A$ $I_4 = 2.605\,A$ $V_3 = 104.2\,V$

Ex find I_x?



using nodal analysis:

at nodal 1

$I_1 + I_2 + I_3 = 0$

$= \frac{V_1 - 100}{8} + \frac{V_1 - 0}{4} + \frac{V_1 - V_2}{2} = 0$

Subject : .... / /

at node 2 :

$8 = I_4 + I_5 + I_6$

$8 = \frac{V_2 - V_1}{2} + \frac{V_2 - 0}{3} + \frac{V_2 - V_3}{10}$ --- (2)

at node 3 :

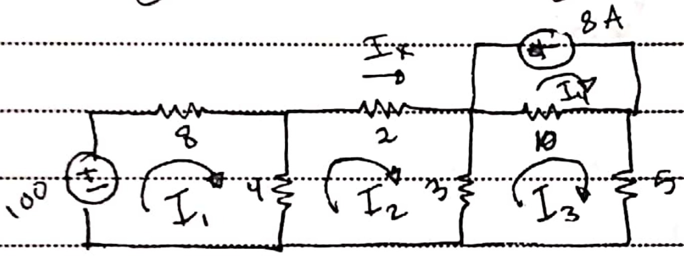
$8 + I_7 + I_8 = 0$

$8 + \frac{V_3 - V_2}{10} + \frac{V_3 - 0}{5} = 0$ --- (3)

$V_1 = 25.89$ V $V_2 = 20.31$ V $V_3 =$ ____ V

$I_x = \frac{V_1 - V_2}{2} = 2.79$ V

Using mesh analysis :



$I_4 = -8$ A

at loop 1 :

$-100 + 8I_1 + 4[I_1 - I_2] = 0$

at loop 2 :

$4[I_2 - I_1] + 2I_2 + 3[I_2 - I_3] = 0$

at loop 3 :

$3[I_3 - I_2] + 10[I_3 + 8] + 5I_3 = 0$

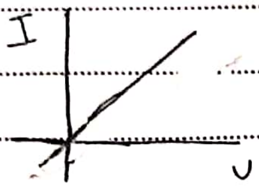
So $I_2 = 2.79$ A $I_1 =$ ____ A $I_3 =$ ____ A

$I_x = I_2 = 2.79$ A

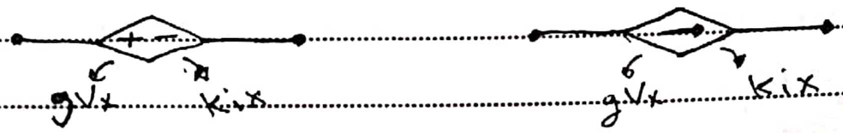
CH 5 :

linear element and linear Circuit

1) linear element : is passive element
that has linear voltage - current relationship



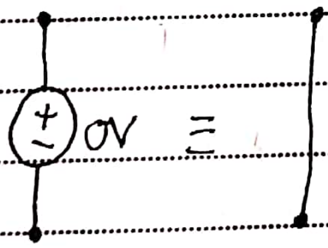
2] linear dep. source :
is dep. current or voltage whose output current or voltage
is proportional to the first power of voltage or current



3] linear circuit : composed
1] indep. source
2] linear dep. source
3] linear element

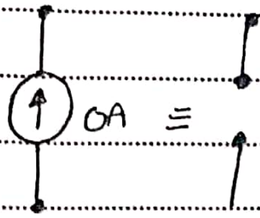
* super position :
the responce in a linear circuit having more than one indep. source can be obtained by adding the responses caused by the sparate Indep. source acting alone

(1)



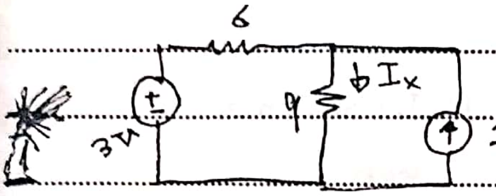
S.C ≡ short circuit

②

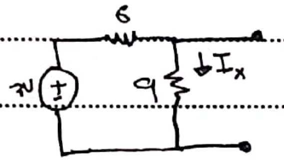


0A ≡ O.C ≡ open circuit

Ex find I_x using super position



$I_x = I_x \downarrow_{3V} + I_x \downarrow_{2A}$



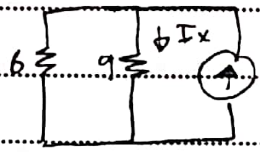
$I_x \downarrow_{3V}$

using KVL:

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

$15 I_x = 3 \Rightarrow I_x = .2\ A$

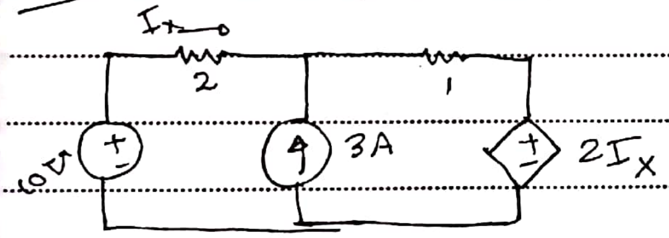
$I_x \downarrow_{2A}$



$I_x = \dfrac{\frac{1}{9}}{\frac{1}{9}+\frac{1}{6}}(2) = .8A$

$I_{x\ total} = .2 + .8 = 1A$

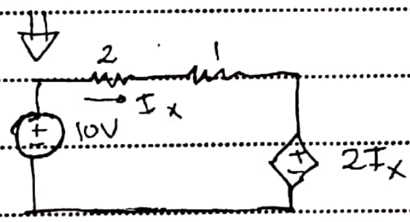
Ex find I_x?



$I_x = I_x \downarrow_{10V} + I_x \downarrow_{3A}$

$= 2 + (-.6)$

$\therefore = 1.4\ A$

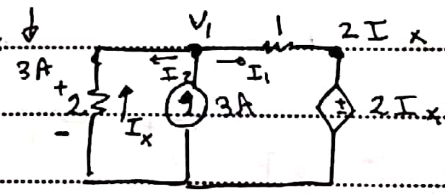


$I_x \downarrow_{10V} \Rightarrow$

Using KVL

$-10 + 2I_x + 1I_x + 2I_x = 0 \Rightarrow I_x = 2A$

$I_x \downarrow_{3A}$

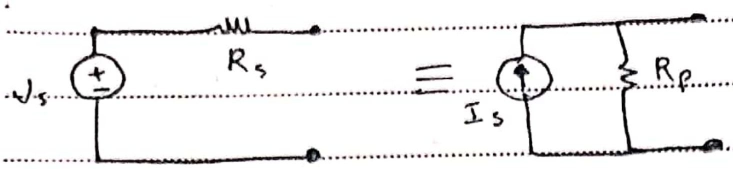


using nodal analysis:

$3 = I_1 + I_2 \Rightarrow 3 = \dfrac{V_1 - 2I_x}{1} + \dfrac{V_1 - 0}{2}$

$-V_1 = I_x(2) \Rightarrow V_1 = -2I_x \Rightarrow \boxed{I_x = -.6}$

Source transformation :

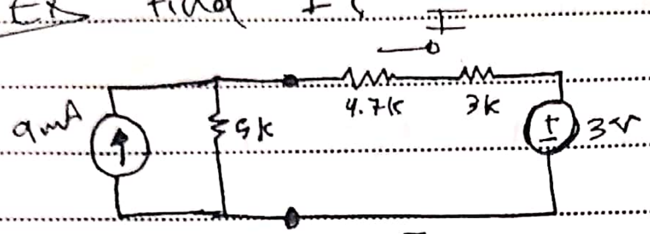


① $R_s = R_p$

② $V_s = I_s R_p$

③ $I_s = \frac{V_s}{R_s}$

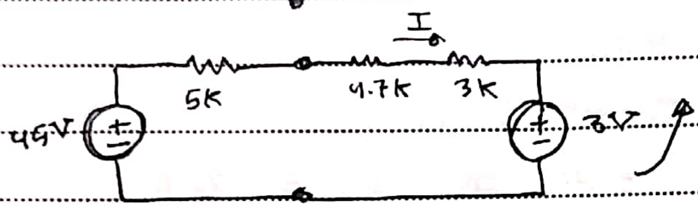
Ex find I ?



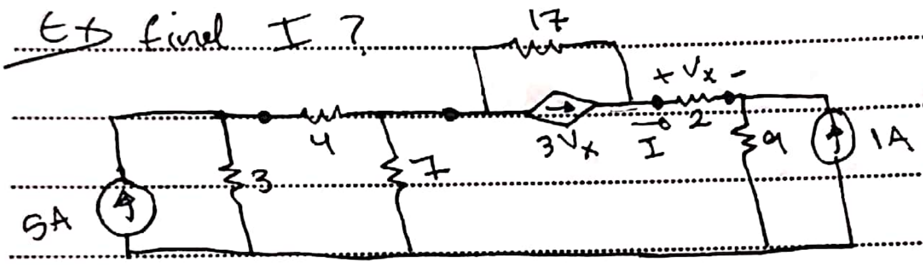
Using KVL :

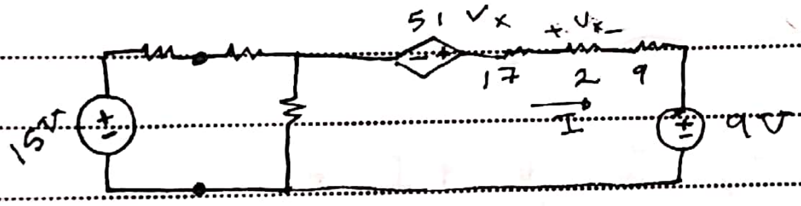
$-45 + 5kI + 4.7kI + 3kI + 3 = 0$

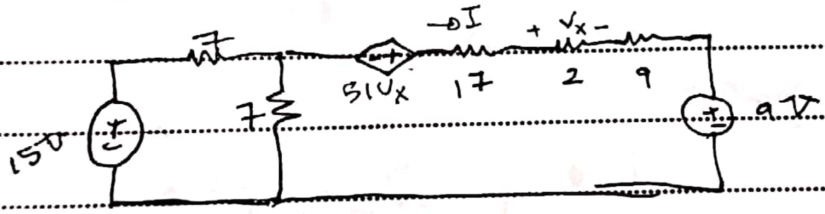
$I = 3.307\ mA$

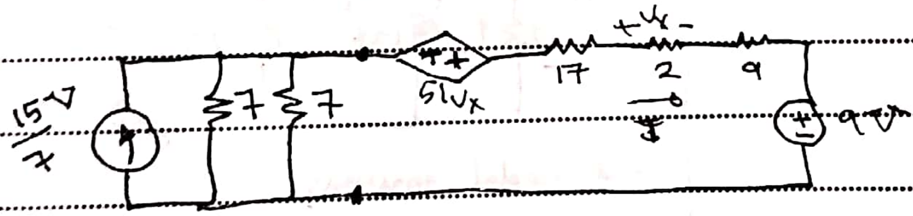


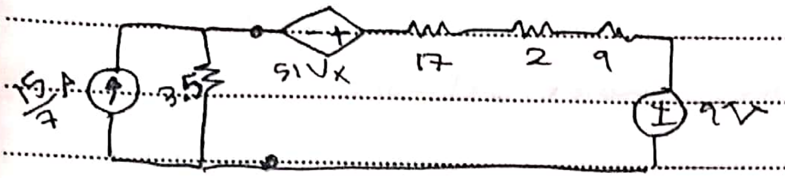
Ex find I ?

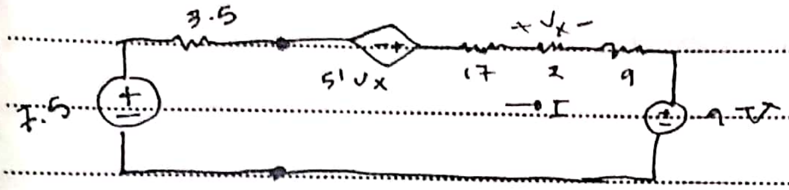












Now using KVL:

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

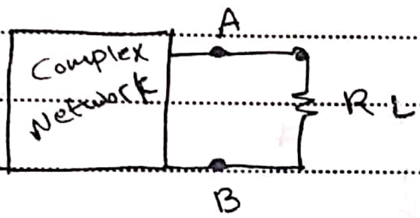
$\because V_x = 2I$

then

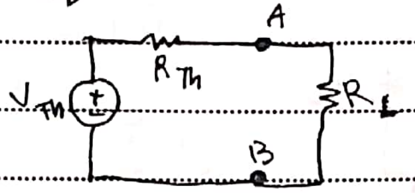
$I = 21.28$ mA

$V_x = 42.4$ mV

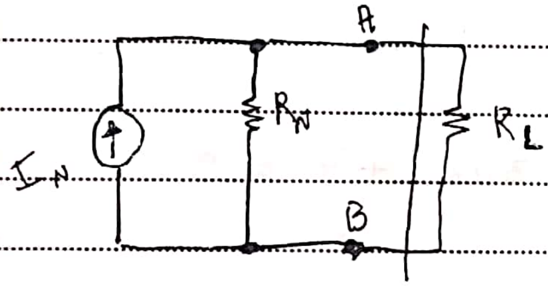
Thevenin + norton equivelent :



$\Rightarrow$ Thevenin:



norton equivelant :



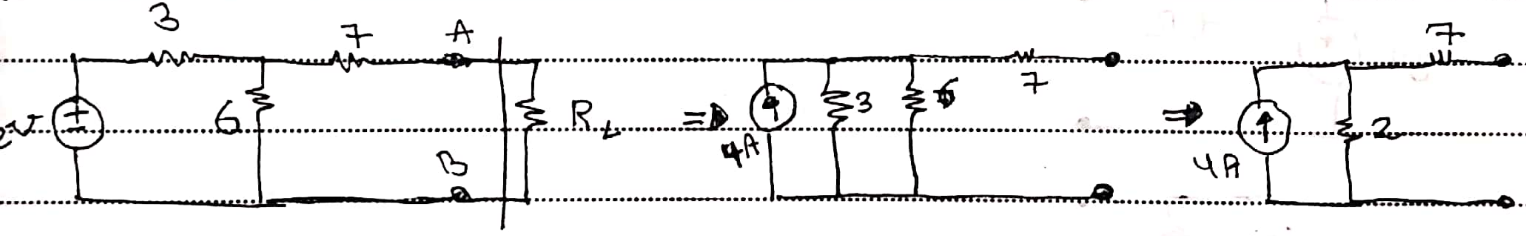
using source transformation :

① $R_{Th} = R_N$

② $V_{Th} = I_N R_N$

③ $I_N = \frac{V_{Th}}{R_{Th}}$

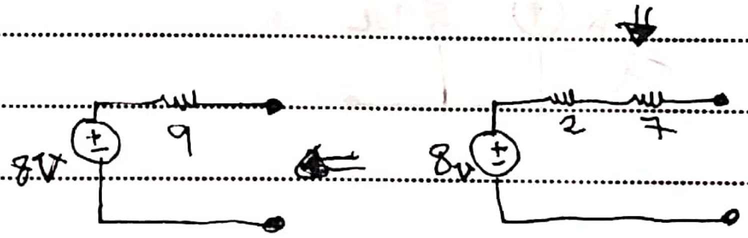
Ex find Thevenin :-



$R_{Th} = 9\Omega$

$V_{Th} = 8V$

then



* Case one :

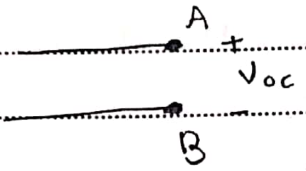
only Indep. source in the complex network

① $V_{th} = V_{oc}$

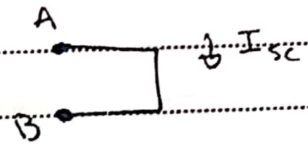
② $R_{th} = R_{eq}$ after killing all source

3) $I_N = I_{sc}$

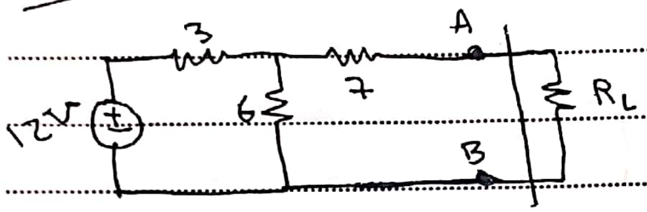
① V_{oc}



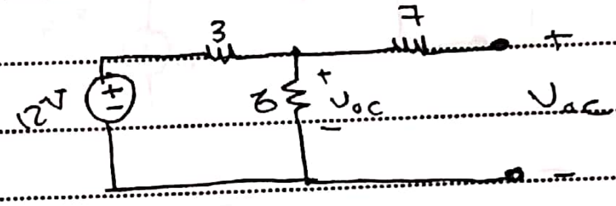
② I_{sc}



Ex find Thevenin :

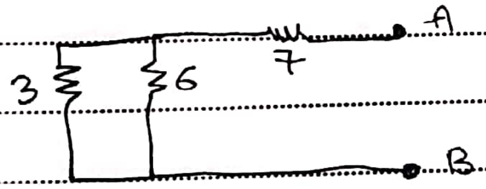


① $V_{th} = V_{oc}$

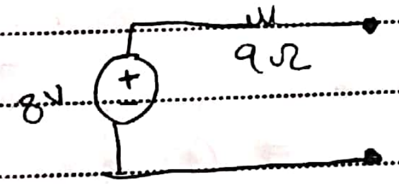


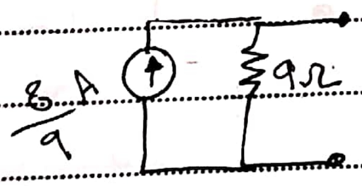
then $V_{oc} = \frac{6}{6+3}(12) = 8\,V$

② $R_{th} =$

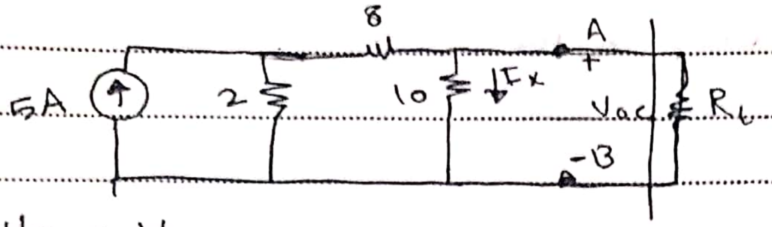


$\Rightarrow R_{th} = R_{eq} = (3 \parallel 6) + 7 = 9\,\Omega$





Ex: find thevenin + norton:

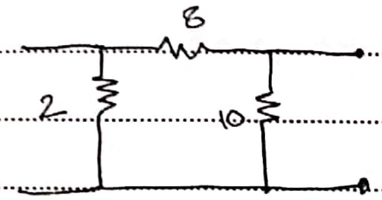


① $V_{Th} = V_{o.c}$

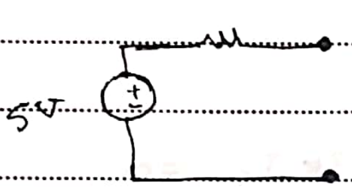
$V_{oc} = 10\, I_x$

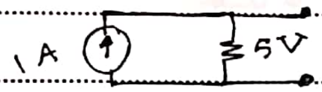
$$= 10 \left(\frac{\frac{1}{18}}{\frac{1}{18} + \frac{1}{2}} \right) [5] = 5V$$

② $R_{Th} = R_{eq}$ After killing all sources

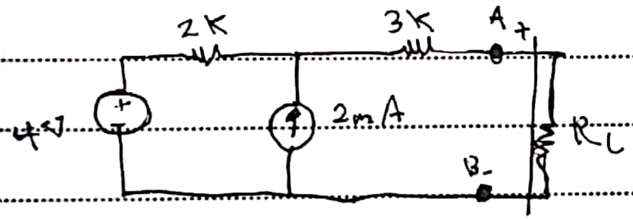


$R_{eq} = (2+8) \parallel 10 = 5\,\Omega$





Ex find thevenin:

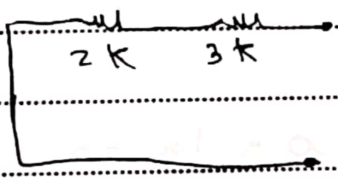


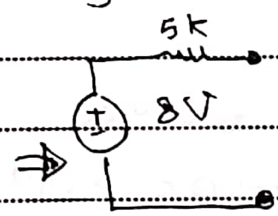
1] $V_{Th} = V_{oc}$

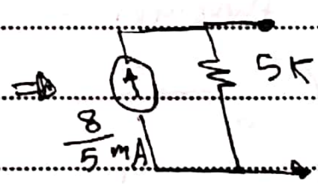
$-4 + 2K(-2m) + 3K(0) + V_{oc} = 0$

$V_{oc} = 8V$

2] $R_{Th} = R_{eq}$ after killing all sources







$R_{eq} = 2K + 3K = 5K$

Case two:

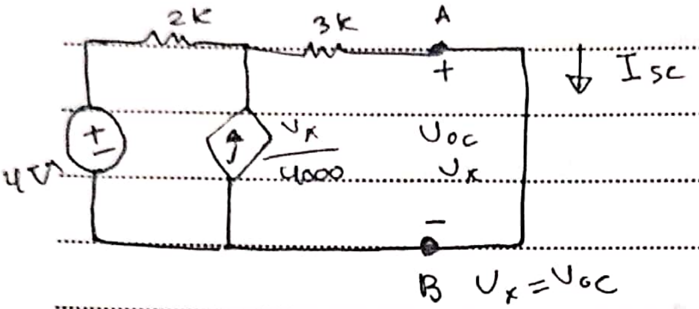
only dep + Indep sources in the complex network

1] $V_{th} = V_{oc}$

2] $I_N = I_{sc}$

3] $R_{Th} = \dfrac{V_{oc}}{I_{sc}}$

Ex find thevenin:

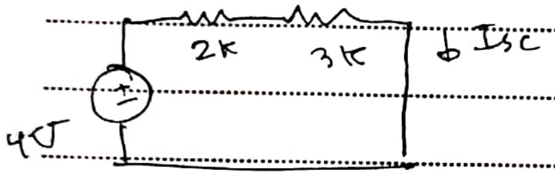


1] $V_{th} = V_{oc}$

$-4 + 2k\left(\frac{-V_x}{4000}\right) + 3k(0) + V_{oc} = 0$

$V_{oc} = 8V$

2 $I_N = I_{sc}$

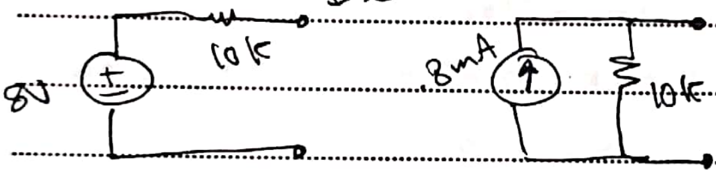


using KVL:

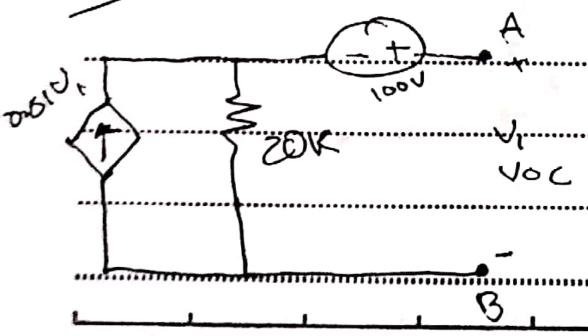
$-4 + 2k\, I_{sc} + 3k\, I_{sc} = 0$

$I_{sc} = 0.8\ mA$

3] $R_{th} = \dfrac{V_{oc}}{I_{sc}} = \dfrac{8}{.8m} = 10\ k\Omega$



Ex find thevenin:-



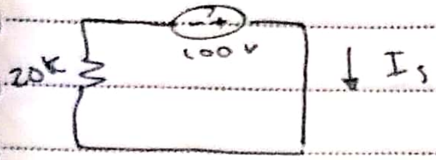
$V_{Th} = V_{oc}$

$-20k(0.01V_1) - 100 + V_{oc} = 0$

$V_{oc} = V_1$

$\therefore V_{oc} = -0.503\ V$

2] $I_N = I_{sc}$

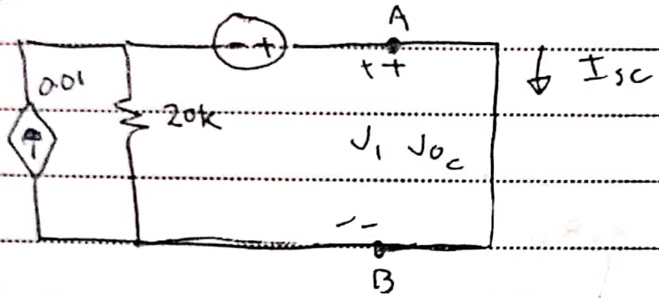


$20k\, I_{sc} - 100 = 0$

$I_{sc} = 5mA$

3] $R_{Th} = \frac{V_{oc}}{I_{sc}} = \frac{-0.503}{5m} = -100.5\,\Omega$ unstable circuit

Ex: find Thevenin :



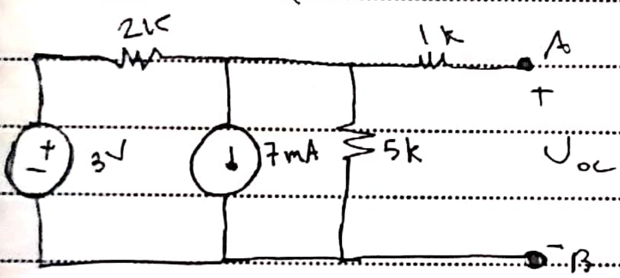
① $V_{Th} = V_{oc}$

$-20k(0.01V_1) - 100 + V_{oc} = 0$

$V_{oc} = V_1$

$\therefore V_{oc} = -0.503\ V$

Ex: find thevenin:



1] $V_{Th} = V_{oc}$

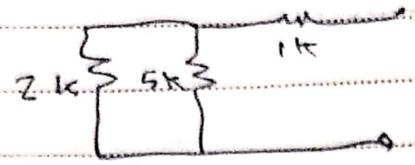
$V_{oc} \Rightarrow$ using super positon

$V_{oc} = V_{oc}\big|_{3V} + V_{oc}\big|_{7mA}$

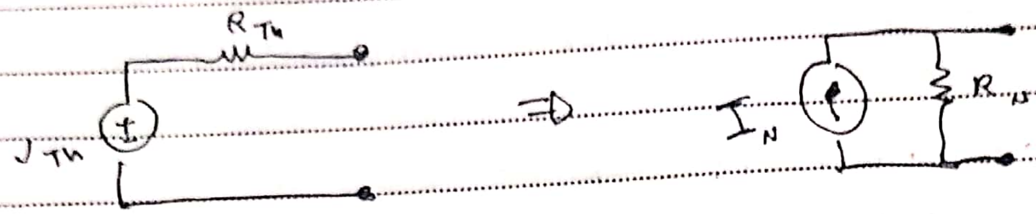
$= \left(\frac{5k}{5k+2k}\right)(3) + \frac{\frac{1}{5k}}{\frac{1}{5k}+\frac{1}{2k}}(-7m)(5k)$

$= \_\_\_\_\_\_\ V$

② $R_{Th} = R_{eq}$ after killing all sources



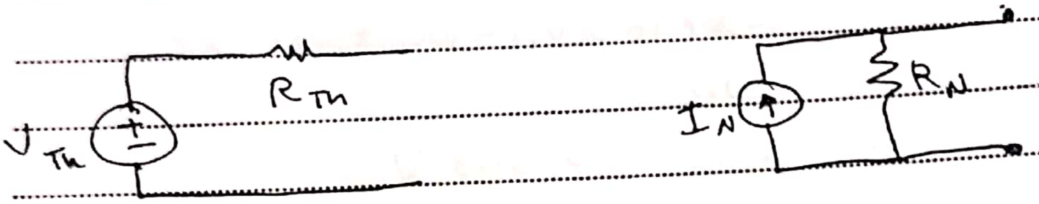
$R_{eq} = (5k \parallel 2k) + 1k = \_\_\_\_\_\_ \Omega$



Thevenin + norton :

Thevenin :

norton :



using source transformation

1] $R_{Th} = R_n$

2] $V_{Th} = I_N R_N$

3] $I_N = \dfrac{V_{Th}}{R_{Th}}$

① case one :

only Indep. source in complex network

1] $V_{Th} = V_{oc}$

2] $R_{Th} = R_{eq}$ After killing all sources.

3] $I_N = I_{sc}$

2) case two :

dep. + Indep. source In complex network

1] $V_{Th} = V_{oc}$

2] $I_N = I_{sc}$

3] $R_{Th} = R_N = \dfrac{V_{oc}}{I_{sc}}$

3) case three :

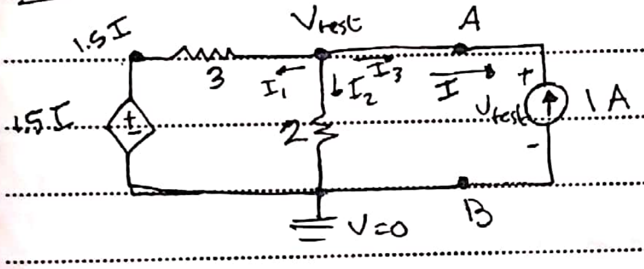
dep. source only In complex network

1) assume $I_{test} = 1\,A$ oR $V_{test} = 1\,V$

2] find V_{test} oR I_{test}

$R_{Th} = \dfrac{V_{test}}{I_{test}}$ oR $\dfrac{V_{test}}{I_{test}}$

Ex : find thevenin :



assume current 1 A

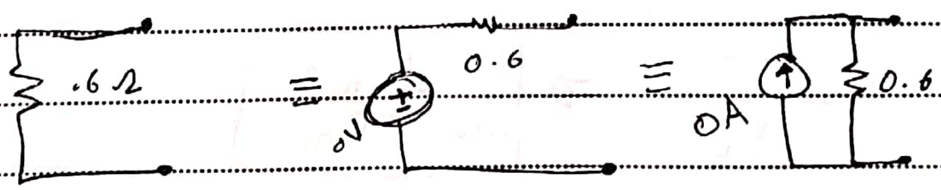
$\boxed{I = -1\,A}$

using nodal analysis :

$I_1 + I_2 + I_3 = 0$

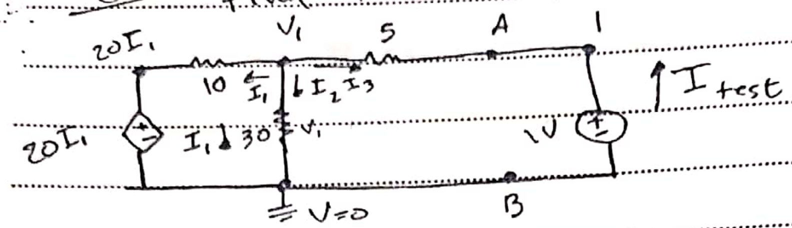
$\dfrac{V_{test} - 1.5I}{3} + \dfrac{V_{test} - 0}{2} + (-1) = 0 \Rightarrow V_{test} = 0.6$

$R_{Th} = \dfrac{V_{test}}{I_{test}} = \dfrac{0.6}{1} = .6\,\Omega$



Subject :

Ex Find thevenin :



$R_{Th} = \dfrac{V_{test}}{I_{test}} = \dfrac{1}{I_{test}}$

لذا علشان نطلع I_{test}

using nodal analysis :

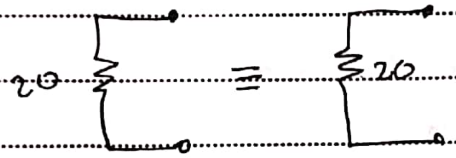
$I_1 + I_2 + I_3 = 0$

$\dfrac{V_1 - 20I_1}{10} + \dfrac{V_1 - 0}{30} + \dfrac{V_1 - 1}{5} = 0$ ① $\quad V_1 = 30 I_1$ ②

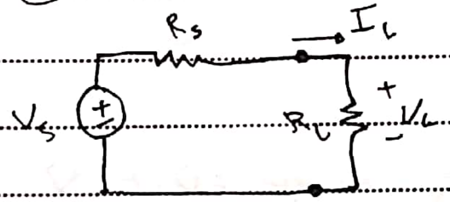
$\therefore V_1 = 0.75\ V$

$I_{test} = -I_3 = -\left(\dfrac{V_1 - 1}{5}\right) = 50\ mA$

$R_{Th} = \dfrac{1}{50m} = 20\ \Omega$



Max power transfe to Load :-



$P_L = I_L^2 R_L$

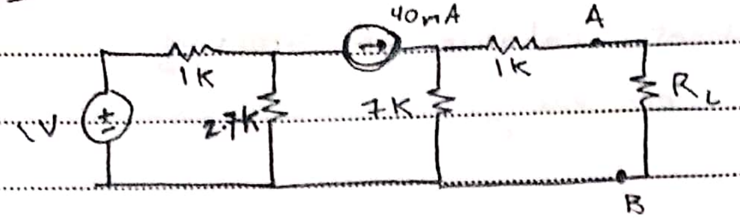
$= \left[\dfrac{V_s}{R_s + R_L}\right]^2 R_L$

$\dfrac{dP_L}{dR_L} = 0 \Rightarrow \boxed{R_s = R_L}$

$\Rightarrow P_{R_L} = \left[\dfrac{V_s}{2R_L}\right]^2 R_L$

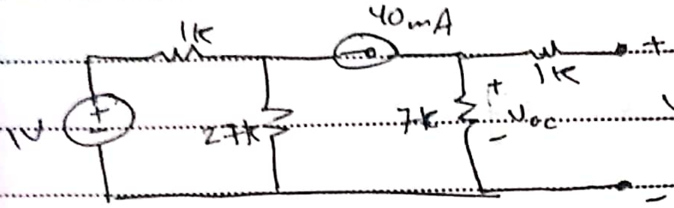
$= \dfrac{V_s^2}{4R_L^2} * R_L = \dfrac{V_s^2}{4R_L} \Rightarrow \boxed{P_{L\,max} = \dfrac{V_{th}^2}{4R_{Th}}}$

Ex find Max power transfer to load.



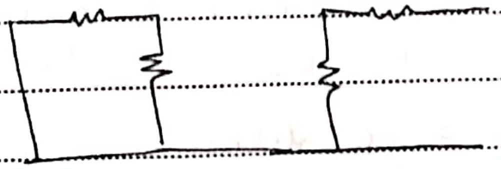
$$P_{max} = \frac{V_{th}^2}{4R_{Th}}$$

$V_{Th} = V_{oc}$



$+V_{oc} = [7K][40mA] = 280\ V$

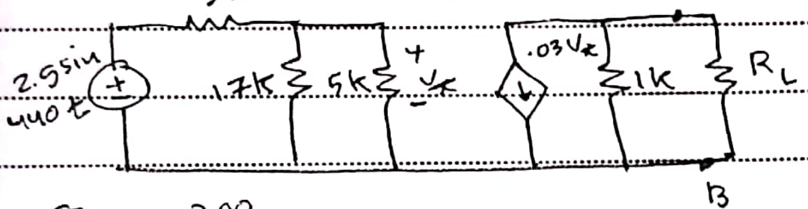
$R_{th} = R_{eq}$ After killing All --



$R_{eq} = 1K + 7K = 8K\ \Omega$

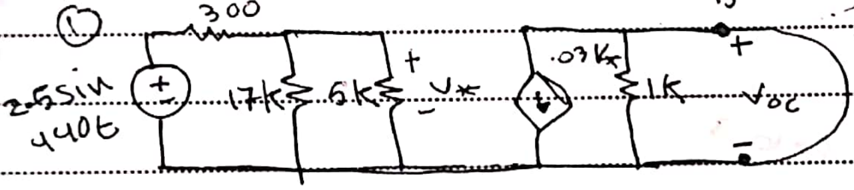
$$\therefore P_{max} = \frac{(280)^2}{4*[8K]} = 2.45\ w$$

Ex: find Power max transfer to load.



I_{sc}

(1)



$-V_{oc} = 1K[.03V_x]$

$V_{oc} = -30\ V_x$

(2) $I_N = I_{sc} = -0.03\ V_x$

(3) $R_{Th} = \frac{V_{oc}}{I_{sc}} = \frac{-30\ V_x}{-0.03\ V_x} = 1K$

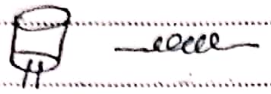
$$P_{max} = \frac{V_{Th}^2}{4R_{Th}} = \frac{[-30\ V_x]^2}{4[1K]}$$

$V_x = \frac{5K // 17K}{300 + 5K // 17K}\ [2.5\sin 440t\ mV]$

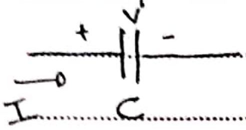
$P_{max} = 1.211 \sin^2(440\ t)\ MW$

CH 7 : Capacitors and Inductors

Both are passive element that capable of storing and deliving finite amount of energy



Capacitor :



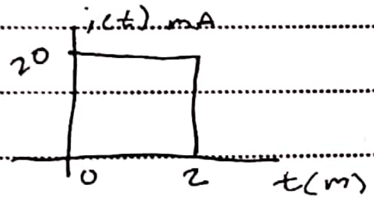
Unite of capacitor ≡ farad 'f'

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

$$\int_{t_0}^{t} i(t)\,dt = \int_{t_0}^{t} C\,dv(t)$$

$$\boxed{\frac{1}{C}\int_{t_0}^{t} i(t)\,dt = V(t) - V(t_0)}$$

Ex find $V(t)$ on the capacitor



$C = 5\mu f$

$V(-\infty) = 0$

$$i(t) = \begin{cases} 0 & -\infty \le t \le 0 \\ 20 * 10^{-3} & 0 \le t \le 2*10^{-3} \\ 0 & 2*10^{-3} \le t \le \infty \end{cases}$$

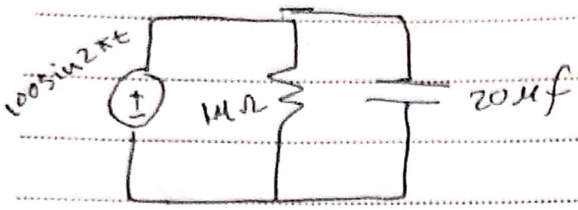
1) $V(t) - V(-\infty) = \frac{1}{5\times10^{-6}}\int_{-\infty}^{t} 0\,dt \Rightarrow V(t) = 0$

2) $V(t) - V(0) = \frac{1}{5\mu}\int_{0}^{t} 20 * 10^{-3}\,dt \Rightarrow V(t) = 4000t$

3) $V(t) - V(2*10^{-3}) = \frac{1}{5\mu}\int_{2\times10^{-3}}^{t} 0\,dt \Rightarrow V(t) = 8V$

Subject : / /

Ex find $W_c(t) \Big|_{t=\frac{1}{4}s}$, $W_R(t)$ & $0 \le t \le 0.5$



① $W_c(t) = \frac{1}{2} C v^2(t)$

$= \frac{1}{2} [20 \times 10^{-6}] (100 \sin 2\pi (\frac{1}{4}))^2$

$= 100 \text{ mJ}$

② $W_R(t) = \int_{t_0}^{t} p(t)\, dt$

$p(t) = \frac{v^2(t)}{R} = \frac{[100 \sin 2\pi t]^2}{1 \times 10^6}$

$W_R(t) = \int_0^{.5} \frac{(100 \sin(2\pi t))^2}{1 \times 10^6} dt$

$= 2.5 \text{ mJ}$

Ex find $W_c(t) = ??$ $C = 1000\,\mu f$ $t = 50\,\mu s$ $v(t) = 1.5 \cos 10^5 t$ V

Solu:

$W_c(t) = \frac{1}{2} C v^2$

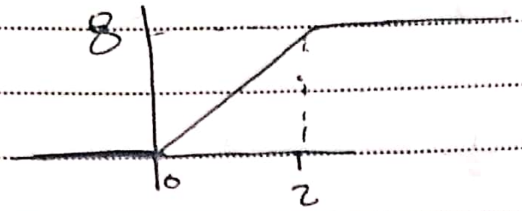
$= \frac{1}{2} (1000 \times 10^{-6}) (1.5 \cos 10^5 (50\mu))^2$

$=$ ______ J

*) characteristic of Ideal capacitor,

1) There is no current through the capcitor if the voltage cross it is not changing with time

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



Ex: let $C = 5f$ and $v(t) = \sin t$, find $i(t)$ at $t = 10^{-3}$ s

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

$= 5 [\cos t]$

$= 5 [\cos(10^{-3} \times \frac{180}{\pi})]$

$=$ ______ A

(*) power :

$P = VI$

$= V \left[C \frac{dv(t)}{dt} \right]$

(*) Energy

$w(t) = \int_{t_0}^{t} p(t) dt$

$= \int_{t_0}^{t} vC \frac{dv(t)}{dt} dt$

$= C \int_{t_0}^{t} v \, dv(t)$

$= C \left[\frac{V^2}{2} \right] \Big|_{t_0}^{t}$

$= \frac{1}{2} C [v^2(t) - v^2(t_0)]$

Now let $v(t_0) = 0 \Rightarrow$ $\boxed{W_c(t) = \frac{1}{2} C V^2}$ ##

② a finit amount of energy can be stored in a capacitor even if the current through capacitor is zero, such as the voltage across it is constant.

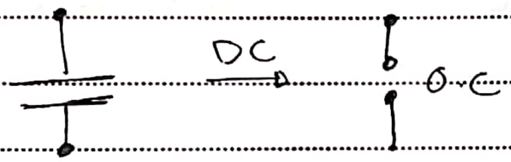
$$W_c(t) = \frac{1}{2} C V^2$$

③ it is impossible to change the voltage across capacitor by finite amount in zero time

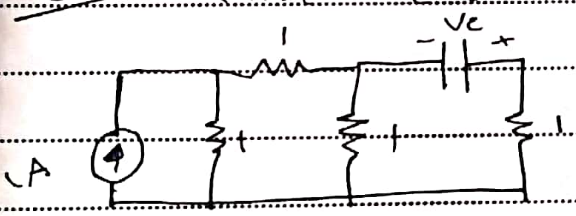
$$V_c(0^+) = V_c(0^-)$$

④ a capacitor never disspate energy, but only store it although this is true for math. model it is not true for a physical model due to finite resistance

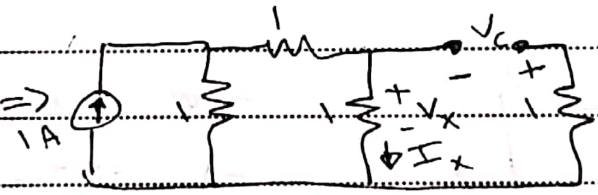
⑤ Capacitor In DC-analysis is open circuit



Ex find V_c ?



=>



$$-V_x - V_c + 1(0) = 0$$

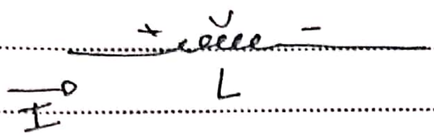
$$V_c = -V_x$$

$$\Rightarrow V_x = 1 I_x = 1\left[\frac{\frac{1}{2}}{\frac{1}{2}+\frac{1}{1}}\right][1] = \frac{1}{3}$$

$$\therefore V_c = -V_x = -\frac{1}{3}\ V$$

Inductor :

unite = heneris

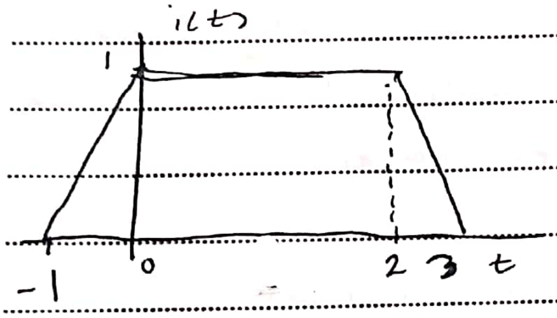


$$v(t) = L \frac{di(t)}{dt}$$

$$\int_{t_0}^{t} v(t)\,dt = \int_{t_0}^{t} L\, d\,i(t)$$

$$\Rightarrow I(t) - I(t_0) = \frac{1}{L} \int_{t_0}^{t} v(t)\,dt$$

Ex let $L = 3H$ find $V(t)$



$$i(t) = \begin{cases} 0 & -\infty \le t < -1 \\ t+1 & -1 \le t \le 0 \\ 1 & 0 \le t \le 3 \\ -t+3 & 2 \le t \le 3 \\ 0 & 3 \le t \le \infty \end{cases}$$

$y - y_1 = m(x - x_1)$

$\overset{t}{(0}, \overset{I}{1)}$ $\qquad$ $\overset{t}{(2}, \overset{I}{1)}$

$(-1, 0)$ $\qquad$ $(3, 0)$

$y - 0 = \frac{1}{1}[t+1]$ $\qquad$ $I - 0 = -1(t-3)$

$I = t+1$ $\qquad$ $I = -t+3$

$$\frac{di(t)}{dt} = \begin{cases} 0 & -\infty \le t \le -1 \\ 1 & -1 \le t \le 0 \\ 0 & 0 \le t \le 2 \\ -1 & 2 \le t \le 3 \\ 0 & 3 \le t \le \infty \end{cases}$$

$$v(t) = \begin{cases} 0 & '' \\ 3 & '' \\ 0 & '' \\ -3 & '' \\ 0 & '' \end{cases}$$

Ex : $L = 2H$ $\quad v(t) = 6\cos 5t$ v $\quad$ find $I(t)$, $I(-\frac{\pi}{2}) = 1A$

$$I(t) - I(-\tfrac{\pi}{2}) = \frac{1}{2}\int_{-\frac{\pi}{2}}^{t} 6\cos 5t \, dt$$

$$I(t) = 6\sin 5t + 1.6 \quad A$$

*) Power :

$$P = VI$$

$$= L\frac{dI(t)}{dt} I$$

*) Energy :

$$W_L(t) = \int_{t_0}^{t} p(t)\, dt$$

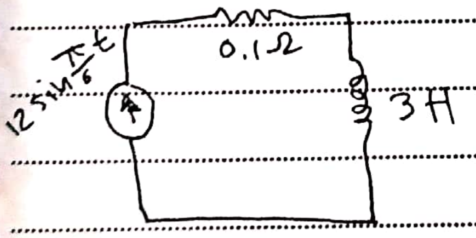
$$= \int_{t_0}^{t} L\frac{dI(t)}{dt} I \, dt$$

$$= L\int_{t_0}^{t} I \, dI(t)$$

$$= \frac{1}{2} L \left[I(t)^2 - I(t_0)^2 \right] \quad \text{let } I(t_0) = 0$$

then $\boxed{W_L(t) = \frac{1}{2} L I^2(t)}$

Ex : find $W_L(t)$ @ $t = 3s$, $W_R(t)$ @ $0 < t \leq 6$



1) $W_L(t) = \frac{1}{2} L I^2(t)$

$$= \frac{1}{2}[3][12\sin\tfrac{\pi}{6} t]^2$$

$$W_L(3) = 216 \text{ J}$$

Subject :

2) $\omega_R(t) = \int_{t_0}^{t} P_R(t)\, dt$

$= \int_0^6 [12 \sin \frac{\pi}{6} t]^2 (0.1)\, dt$

$= 43.2\ J$

CamScanner

(*) characteristic of Ideal Inductor :

1] There is no voltage across inductor if the current through it is not charging with time.

$$v(t) = L \frac{d\, I(t)}{dt}$$

2] a finite amount of energy can be stored in an Inductor even if the voltage across inductor is Zero.

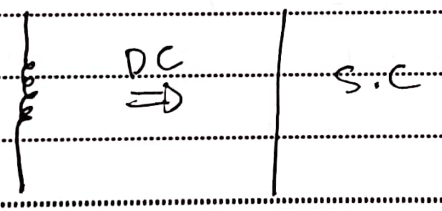
$$w_L(t) = \frac{1}{2} L\, I^2(t)$$

3] It is impossible to charge the current through inductor by finite amount in Zero time.

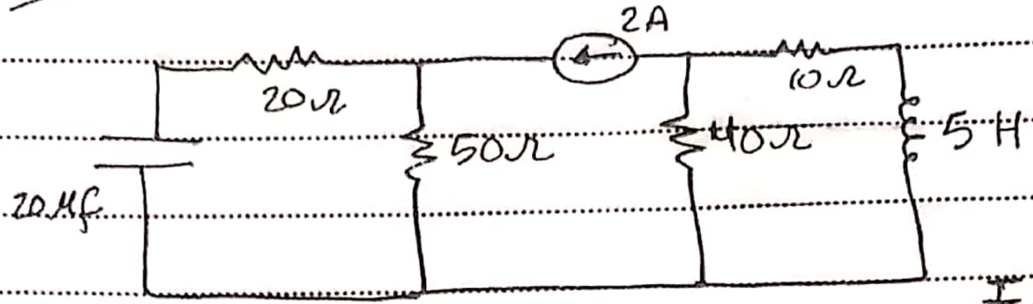
$$I_L(0^+) = I_L(0^-)$$

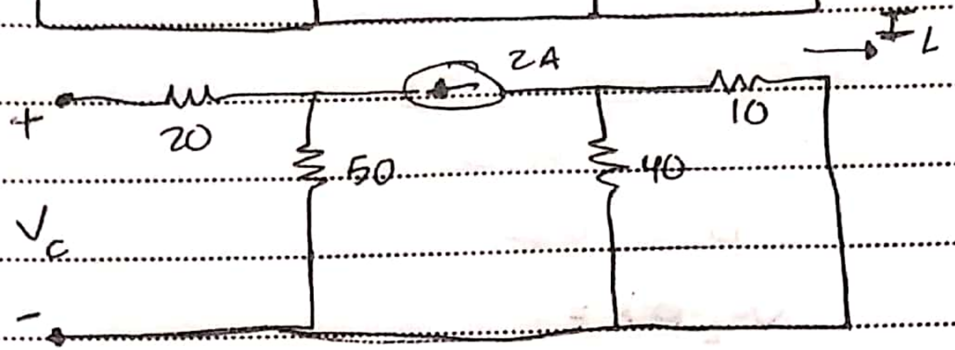
4] the Inductor never dispate energy but only store it even this is true for math Model it is not true for physical Model due to finit resistance.

5] Inductor in DC - analysis is short circuit



EX: find $W_L(t)$, $W_C(t)$





$V_c = 50(2) = 100\ V$

$W_c(t) = \frac{1}{2} CV^2 = \frac{1}{2}[20\times10^{-6}][100]^2$

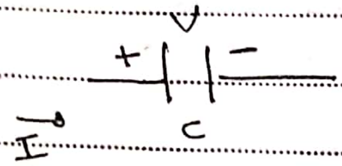
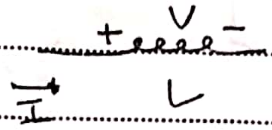
$= 0.1\ J$

$W_L(t) = \frac{1}{2} L\, I^2(t)$

$I_L = \dfrac{\frac{1}{10}}{\frac{1}{10}+\frac{1}{40}}[-2] = -1.6\ A$

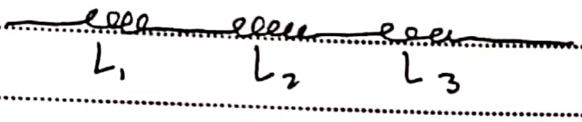
$= \frac{1}{2}[5][-1.6]^2$

$= 6.4\ J$

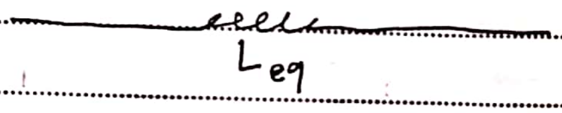
Capacitor	Inductor
	
$I(t) = C\dfrac{dV(t)}{dt}$	$V(t) = L\dfrac{dI(t)}{dt}$
$P = VI$	$P = VI$
$W_c = \frac{1}{2} C V^2$	$W_L(t) = \frac{1}{2} L I^2$
$V_c(0^+) = V_c(0^-)$	$I_L(0^+) = I_L(0^-)$
DC $\Rightarrow$ O.C	DC $\Rightarrow$ S.C

Inductors:

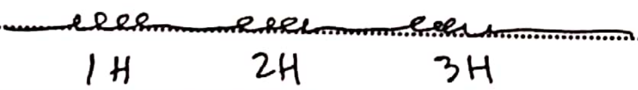
A) Inductors In Series:



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

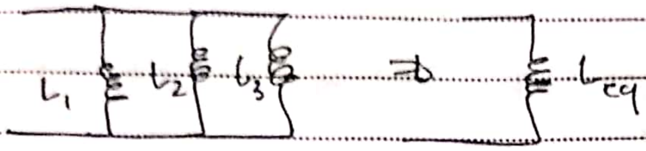


Ex find L_{eq}



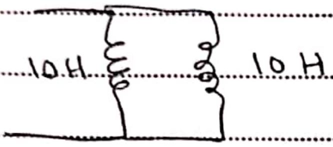
$L_{eq} = 6H$

B] Inductors In Parallel :



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

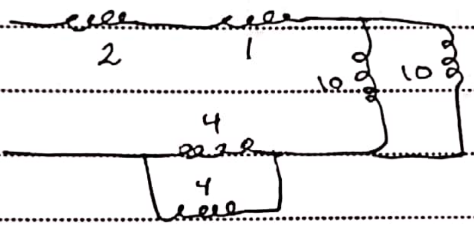
Ex find L_{eq} ?



$$\Rightarrow \frac{1}{L_{eq}} = \frac{1}{10} + \frac{1}{10}$$

$$L_{eq} = 5H$$

Ex find L_{eq} ?

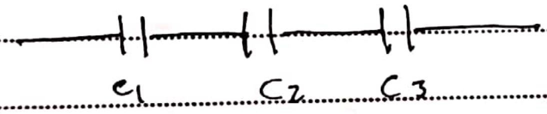


$$L_{eq} = 1 + 2 + [10 // 10] + [4 // 4]$$

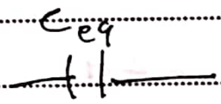
$$= 10 \quad H$$

*) Capacitors :

A) Capacitors in Series :-

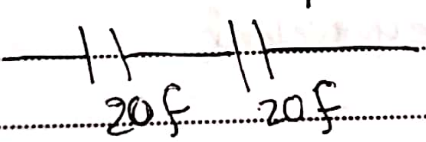


$\Rightarrow$



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

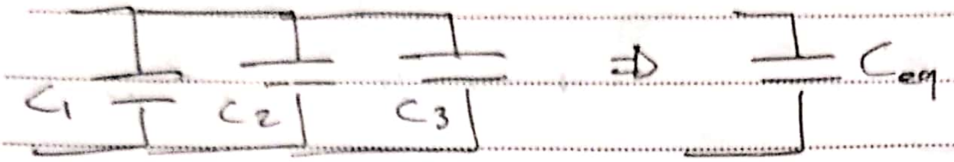
Ex find C_{eq} ?



$$\frac{1}{C_{eq}} = \frac{1}{20} + \frac{1}{20}$$

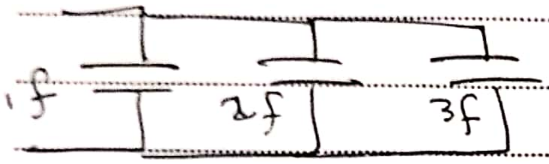
$$C_{eq} = 10 f$$

B) Capacitors in parallel:



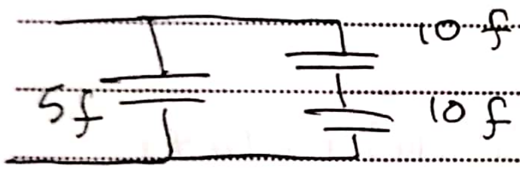
$\Rightarrow C_{eq} = C_1 + C_2 + C_3$

Ex: find C_{eq}?



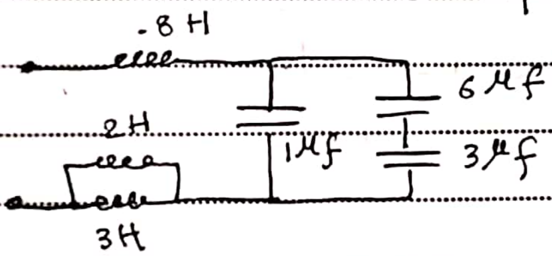
$C_{eq} = 6\ f$

Ex: find C_{eq}?



$C_{eq} = 5 + [10 // 10]$
$= 10\ f$

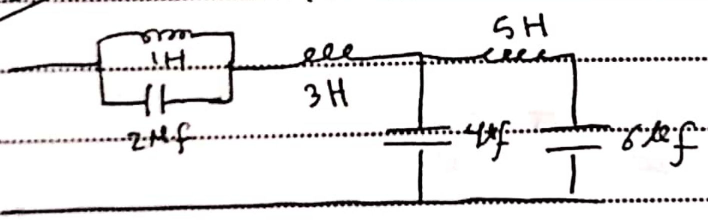
Ex: find the equi. circuit



$C_{eq} = [6 // 3] + 1$
$= 3\ \mu f$

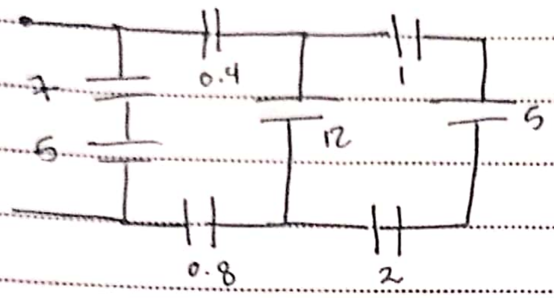
$L_{eq} = [2 // 3] + .8 = 2H$

Ex: find equ. circuit



No equivelent

Ex : Find Ceq ? All values in μf



$$C_{eq} = [7 \| 5] + [.8 \| .4 \| [12 + (1 \| 5 \| 2)]]$$

$$= 3\ \mu f$$

CH 8 : RL + RC - Circuit.

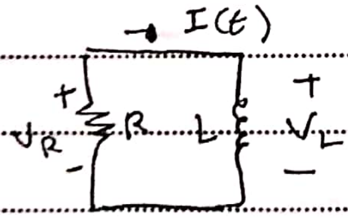
① Free Source RL and RC circuit
② general RL and RC circuit
③ Driven RL and RC circuit

Ⓐ natural response : depend on general nature of circuit, types, size, numbers

Ⓑ transient response : any real circuit we construct can not store energy for ever the interval resistance will convert to heat and the signal will die out

Ⓒ forced response : depend on Inep. source acting on a circuit

Ⓔ source - Free RL- Circuit :



using KVL :

$$-V_R + V_L = 0$$

$$-V_R = R\,I(t) \quad \text{..①}$$

$$V_L(t) = L\frac{dI(t)}{dt} \quad \text{..②}$$

$$R\,I(t) + L\frac{d\,I(t)}{dt} = 0$$

$$\frac{d\,I(t)}{I(t)} + \frac{R}{L}\,dt = 0$$

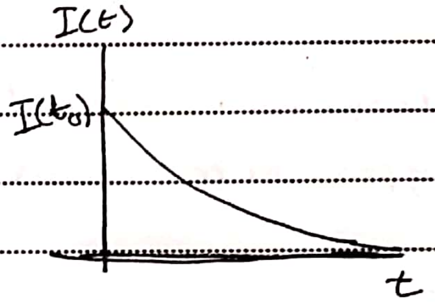
$$\int_{t_0}^{t} \frac{d\,I(t)}{I(t)} = \int_{0}^{t} -\frac{R}{L}\,dt$$

$$\ln[I(t)]\Big|_{t_0}^{t} = \frac{-R}{L}[t-0]$$

$$\ln I(t) - \ln I(t_0) = \frac{-R}{L}\,t$$

$$\ln \frac{I(t)}{I(t_0)} = \frac{-R}{L}\,t$$

$$\therefore \boxed{I(t) = I(t_0)\,e^{-R/L\ t}}$$

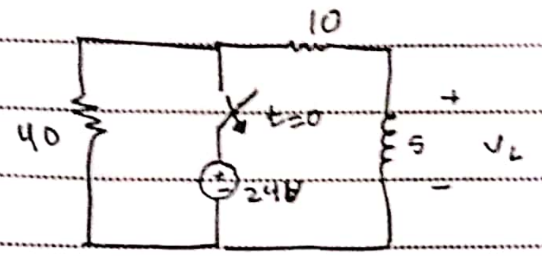


$$P_R = I^2 R = [I(t_0)\,e^{-R/L\,t}]^2\,R$$

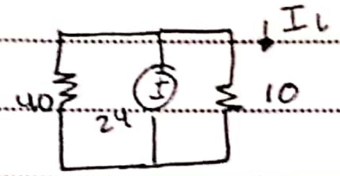
$$W_R(t) = \int_0^{\infty} P_R\,dt = \int_0^{\infty} [I(t_0)\,e^{-R/L\,t}]^2\,R\,dt$$

$$= 1/2\ L\,I^2(t_0)$$

Ex: find $I_L(t)$, $V_L(t)$ $L = 5H$ $t = 200ms$



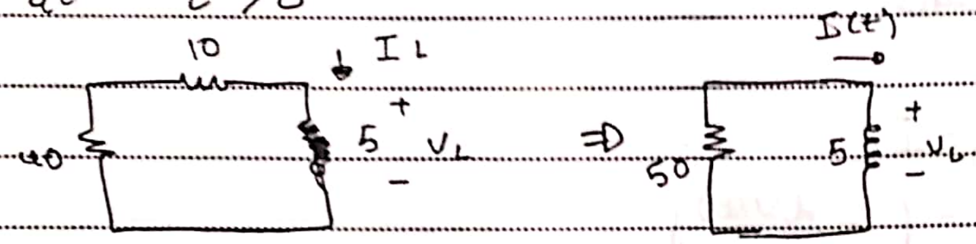
at $t < 0$



$I_L(0^-) = \frac{24}{10} = 2.4\ A$

$I_L(0^+) = I_L(0^-) = 2.4\ A$

at $t > 0$



$I(t) = I(t_o)\, e^{-R/L\ t}$

$= 2.4\, e^{-50/5\ t}$

$= 2.4\, e^{-10t}$

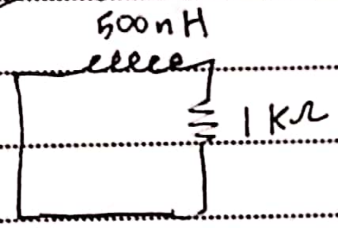
$I(200m) = 324.8\ mA$

Now $V_L(t) = L \frac{dI(t)}{dt}$

$V_L(t) = 5\left[\frac{d[2.4e^{-10t}]}{dt}\right]$

$V_L(200m) = -16.24\ V$

Ex find $W_L(t)$ | $t = 2ns$ $W_L(0) = 7\mu J$



$I(t) = I(t_o)\, e^{-R/L\ t}$

$= I(t_o)\, e^{-1K/500n\ t}$

$\Rightarrow W_L(0) = \frac{1}{2} L I^2(0)$

$7\mu = \frac{1}{2}[500n][I(0)]^2$

$I(0) = 5.292\ A$

$I(2n) = 5.292\, e^{-1k/500n\,[2n]}$

$= 96.93\ mA$

Now $W_L(2n) = \frac{1}{2} L\, I^2(2n)$

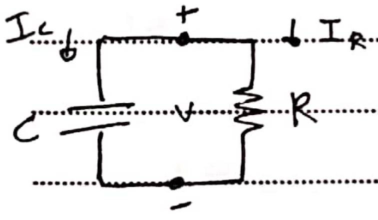
$= 2.349\ nJ$

⇒ Time constant of RL-circuit

$\tau = \frac{L}{R}$

$\therefore\ I(t) = I(t_0)\, e^{-R/L\, t} = I(t_0)\, e^{-\frac{t}{\tau}}$

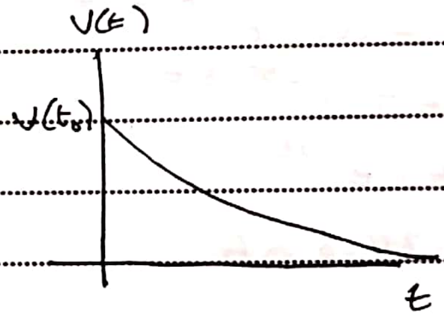
(*) Source free RC-circuit :



$I_R = -I_R$

$\frac{V}{R} = -\left[C \frac{dV(t)}{dt}\right]$

$C\frac{dV(t)}{dt} + \frac{V}{R} = 0$



$\therefore\ \boxed{V(t) = V(t_0)\, e^{-\frac{t}{RC}}}$

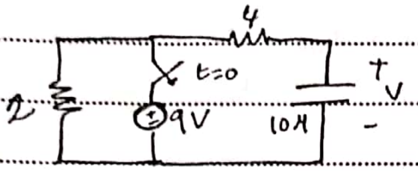
$V_c(0^+) = V_c(0^-)$

(*) Time constant RC-circuit

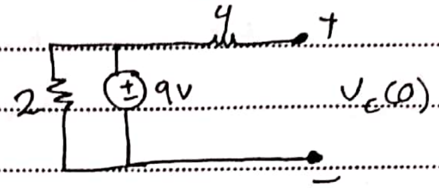
$\tau = RC$

$\therefore\ V(t) = V(t_0)\, e^{-t/\tau}$

Ex: find $V(t)$ | $t = 200\mu s$



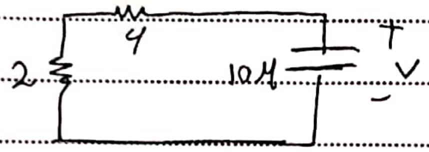
at $t < 0$



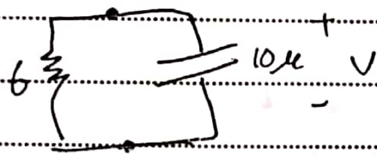
$V_c(0^-) = 9V$

$V_c(0^+) = V_c(0^-) = 9V$

at $t > 0$



$\Downarrow$

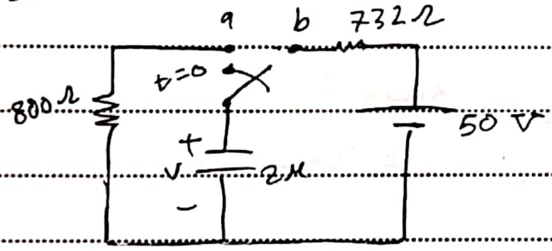


$$\Rightarrow V(t) = V(t_0)\, e^{-t/RC}$$

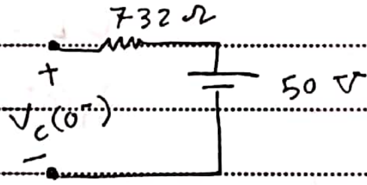
$$= 9\, e^{-t/6*10\mu}$$

$$V(200\mu) = 321.1\ mV$$

Ex: find $V(0)$, $V(2ms)$



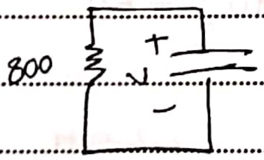
at $t<0 = b$



$V_c(0^-) = 50\ V$

$V_c(0^+) = V_c(0^-) = 50V$

at $t > 0$



$$V(t) = V(t_0)\, e^{-t/RC}$$

$$= 50\, e^{-t/800*2\mu}$$

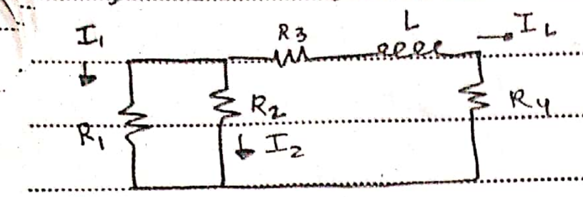
$$V(2m) = 50\, e^{\frac{-2\times10^{-3}}{800\times2\times10^{-6}}}$$

$$= 50\, e^{\frac{-10^3}{800}}$$

$$= 14.32\ V$$

Subject :

General RL - Circuit



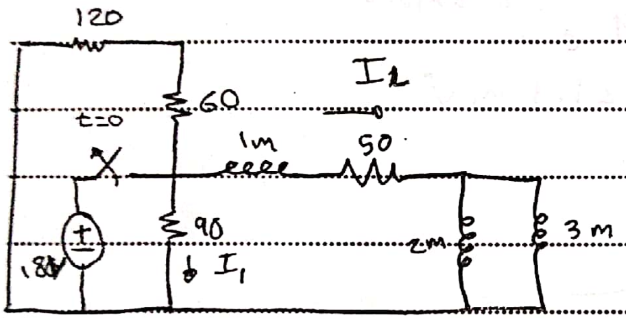
$L_{eq} = L$

$R_{eq} = (R_1 \| R_2) + R_3 + R_4$

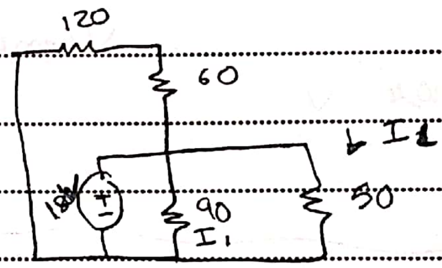
$I_L(t) = I_L(t_0)\, e^{-R_{eq}/L_{eq}\, t}$

$I_1 = \dfrac{\frac{1}{R_1}}{\frac{1}{R_1} + \frac{1}{R_2}} [-I_L]$ $\qquad$ $I_2 = \dfrac{\frac{1}{R_2}}{\frac{1}{R_2} + \frac{1}{R_1}} [-I_L]$

Ex: find I_1, I_L ?



at $t < 0$

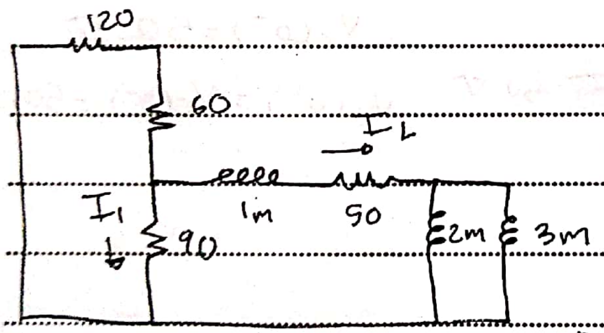


$I_1 = \dfrac{18}{90} = 200\ mA$

at $t > 0$

$I_L = \dfrac{18}{50} = 360\ mA$

$I_L(0^+) = I_L(0^-) = 360\ mA$



$I_L(t) = I_L(t_0)\, e^{-R_{eq}/L_{eq}\, t}$

$= 360\, e^{-t/20\mu}\ mA$

$= 360\, e^{-50000t}\ mA$

$R_{eq} = [[(60+120)] \| 90] + 50$

$= 110\ \Omega$

$L_{eq} = [2 \| 3] + 1 = 2.2\ mH$

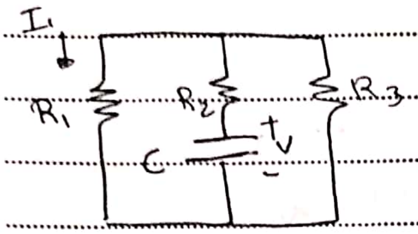
$I_1(t) = \dfrac{1/90}{1/90 + \frac{1}{180}} [-360\, e^{-50000t}]\ mA$

$\tau = \dfrac{L_{eq}}{R_{eq}} = 20\ \mu s$

$= -240\, e^{-50000t}\ mA$

Subject : .... / /

⊛ General RC- Circuit :

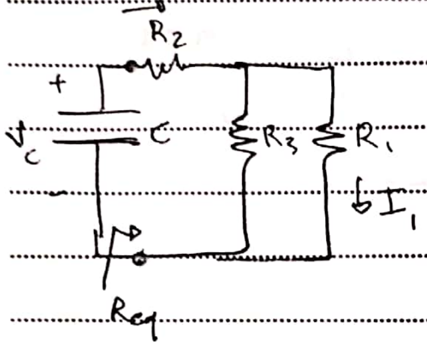


find $V(t)$, $I(t)$?

$$V_c(t) = V_c(t_o)\, e^{-t/R_{eq}C_{eq}}$$

$$C_{eq} = C$$

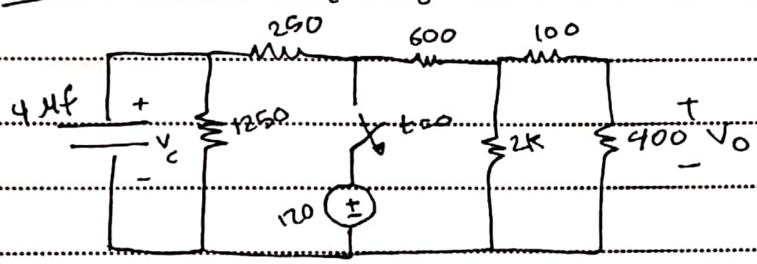
$$R_{eq} = R_1 \,//\, R_3 + R_2$$



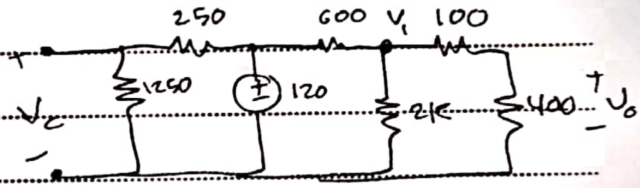
$$I = \frac{V_c(t)}{R_{eq}} \qquad R_{eq} = R_2 + R_3 // R_1$$

$$I_1 = \frac{\frac{1}{R_1}}{\frac{1}{R_1} + \frac{1}{R_3}} [I]$$

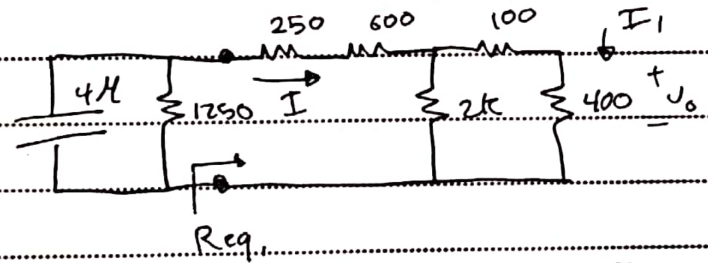
Ex: find V_c, V_o at $t = 0^+, 0^-, 1.3$ ms :



at $t < 0$



at $t > 0$



$$V_c = \frac{1250}{1250 + 250} [120] = 100 \text{ V}$$

$$V_c(0^+) = V_c(0^-) = 100 \text{ V}$$

$$V_o = \frac{400}{100 + 400} [V_1]$$

$$R_{eq_1} = [[(100 + 400) // 2K] + 600 + 250] = 1250\,\Omega$$

$$I = \frac{100}{R_{eq_1}} = \frac{100}{1250} = .08 \text{ A}$$

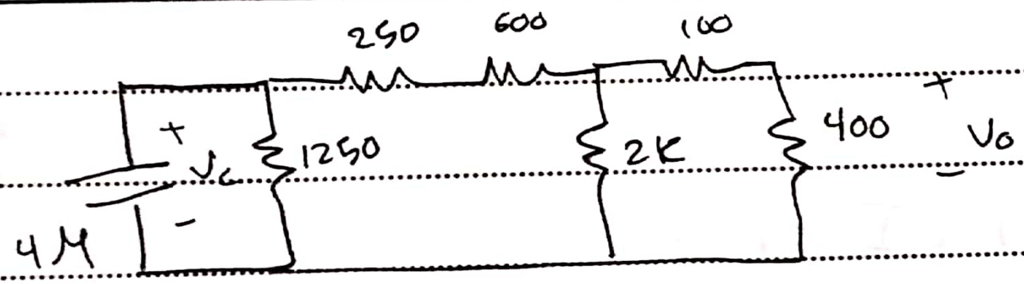
$$V_1 = \frac{500 // 2K}{500//2K + 600} [120]$$

$$I_1 = \frac{\frac{1}{500}}{\frac{1}{500} + \frac{1}{2K}} [I] = 0.064 \text{ A}$$

then $V_o = 38.4$ V

$$V_o = 400 I_1 = 25.6 \text{ V}$$

Subject :



at $t = 1.3$ ms

$V_c(t) = V_c(t_o)\, e^{-t/RC}$

$C_{eq} = 4\mu f$

$R_{eq} = 1250 \parallel R_{eq_1} = 625$

$\tau = RC = .0025$

$V_c(t) = 100\, e^{-t/.0025}$ V

$= 100\, e^{-400t}$ V

$V_c(1.3m) = 59.45$ V

$V_o(t) = V_o(t_o)\, e^{-t/R_{eq}C_{eq}}$

$= 25.6\, e^{-400t}$ V

$V_o(1.3m) = 15.22$ V

Forced RL - circuit

1) with all indep. source zeroed out simplify the circuit to find R_{eq} , L_{eq}

$$\tau = \frac{L_{eq}}{R_{eq}}$$

2) as L_{eq} as short circuit use DC - analysis to find $I_L(0^-)$

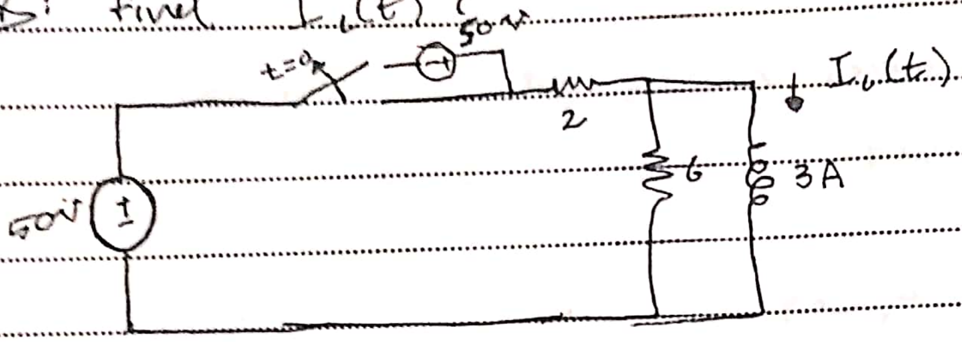
3) with L_{eq} as short circuit use DC - analysis to find $I_L(\infty)$

4) $I_L(0^+) = I_L(0^-)$

5) $I_L(t) = I_L(\infty) + [I_L(0^+) - I_L(\infty)] e^{-t/\tau}$

Subject : ....

Ex: find $I_L(t)$?



at $t<0$

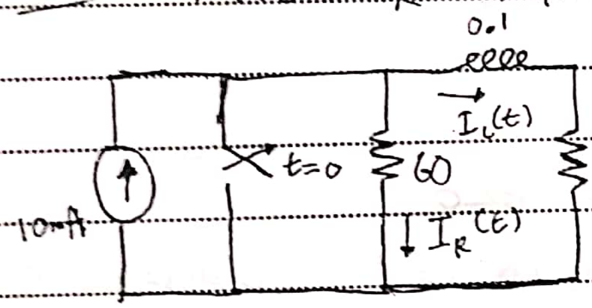
$I_L(0^-) = \frac{50}{2} = 25\ A$ $\qquad -50-50+2I(t)=0$

$I_L(0^+) = I_L(0^-) = 25\ A$ $\qquad \tau = \frac{L_{eq}}{R_{eq}} = \frac{3}{2 \parallel 6} = 25$

at $t>0$ $\qquad I_L(t) = 50 + [25-50]e^{-t/2}$

$I_L(\infty) = \frac{100}{2} = 50A$ $\qquad = 50 - 25e^{-t/2}\ A$

Ex: find $I_R(t)$?



at $t<0$

$I_R(0^-) = 0\ A$

$I_L(0^-) = 0\ A$

at $t>0$

$I_R(0^+) = 10\ mA$

$I_R(\infty) = \frac{\frac{1}{60}}{\frac{1}{60}+\frac{1}{40}}[10m] = 4\ mA$

$\tau = \frac{L_{eq}}{R_{eq}} = \frac{0.1}{60+40} = 1ms$

$I_R(t) = 4 + [10-4]e^{-t/1m}\ mA$

$I_R(1.5m) = 5.339\ mA$

Forced RC Circuit :

1] with all indep. sources zeroed out simplify the circuit to find R_{eq} , C_{eq}

$$\tau = R_{eq} C_{eq}$$

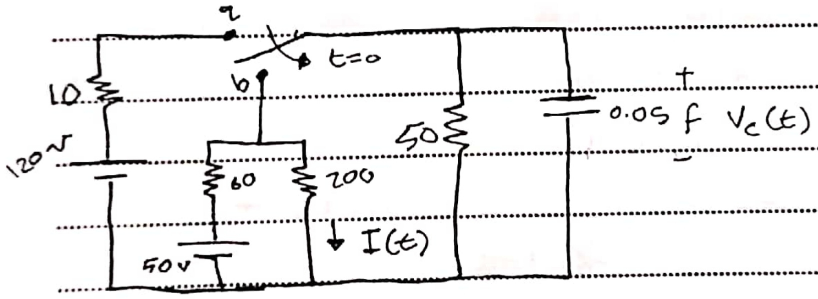
2] as C_{eq} as open circuit use DC-analysis to find $V_c(0^-)$

3] with C_{eq} as open circuit use DC-analysis to find $V_c(\infty)$

4) $V_c(0^+) = V_c(0^-)$

5) $V_c(t) = V_c(\infty) + [V_c(0^+) - V_c(\infty)]\, e^{-t/\tau}$

Ex: find $V_c(t)$, $I(t)$?



at $t<0$

$$V_c(0^-) = \frac{50}{50+10}[120] = 100\ V$$

$$I(0^-) = \frac{50}{260} = 192.3\ mA$$

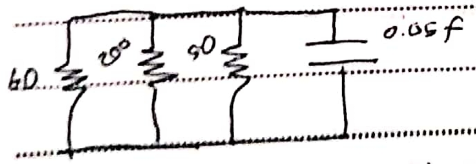
at $t>0$

$$V_c(\infty) = \frac{50 \parallel 200}{50 \parallel 200 + 60}[50] = 20\ V$$

$$V_c(0^+) = V_c(0^-) = 100\ V$$

$$I(t) = \frac{V_c(t)}{200} = 0.1 + 0.4\, e^{-t/1.2}\ A$$

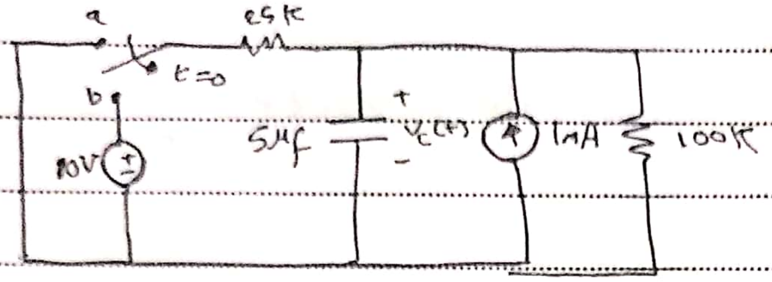
$$\tau = R_{eq} C_{eq}$$



$$= [60 \parallel 200 \parallel 50][0.05] = 1.25$$

$$V_c(t) = 20 + [100 - 20]\, e^{-t/1.2}$$

Ex: find $V_c(t)$?

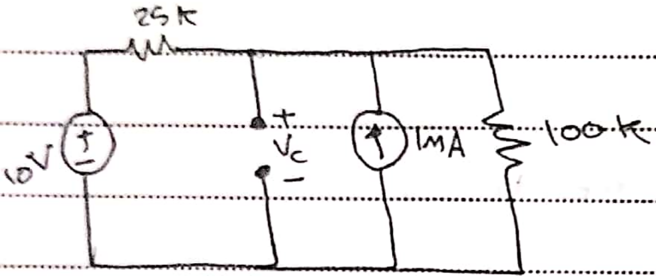


at $t<0$

$V_c(0^-) = (100k // 25k)(1m) = 20V$

$V_c(0^+) = V_c(0^-) = 20\ V$

at $t>0$



$V_c(\infty) = V_c|_{10V} + V_c|_{1mA}$

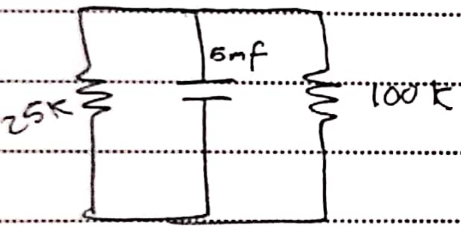
$= \frac{100k}{125k}[10] + ((100k // 25k)(1m))$

$= 28\ V$

$\tau = R_{eq} C_{eq}$

$= [25k // 100k][5mf]$

$= 100\ mS$



$V_c(t) = 28 + [20-28]e^{-t/1m}$

$V_c(80m) = 24.41\ V$

CH.10 :

Sinusoidal steady state analysis

$V(t) = V_m \sin(\omega t + \theta)$

V_m = amplitude

ωt = argument

θ = phase

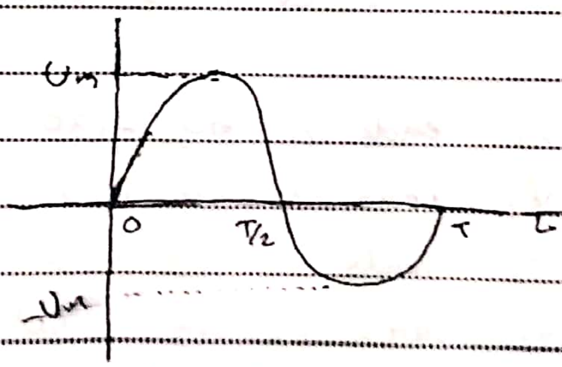
ω = angular freq.

Ex: $V(t) = 100 \sin(2\pi t - 30$

$V_m = 100$ $\qquad f = \frac{1}{t}$

$\omega = 2\pi$

$\theta = -30$ $\qquad \omega = 2\pi f$



$v(t) = 100\sin(2\pi 1000t - \pi/6)$ $\qquad \theta_{rad} = \theta_{deg} * \frac{\pi}{180}$

$V(t) = 100\sin(2\pi 1000t - 30)$

$t = 1 * 10^{-4}$ $\qquad \theta_{deg} = \theta_{rad} * \frac{180}{\pi}$

$V(t) = 100\sin(2\pi 1000 * 1 * 10^{-4} - 30)$

$= 100\sin(.2\pi * \frac{180}{\pi} - 30)$

$= 10.45 \ V$

*) lagging and leading singnal :

Two sinosoidal waves whoes phases are to be compered must :

1] Both be written as sine or cosine waves.

2] Both be written with positive amplitude

3] each have same freq.

4] $\theta_{front} - \theta_{back}$

1] $-\sin(wt) = \sin(wt \pm 180)$

2] $-\cos(wt) = \cos(wt \pm 180)$

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

4] $\pm \cos(wt) = \sin(wt \pm 90)$

Ex: let $V_1(t) = U_{m_1}\cos(5t + 10)$

$U_2(t) = U_{m_2}\sin(5t - 30)$

$V_1(t) = U_{m_1}\sin(5t + 100)$

1] V_2 leads V_1 by -130

2] V_2 legs V_1 by 130

3] V_1 leads V_2 by 130

4] V_1 lggs V_2 by -130

Subject: ...

Ex: find by which I_1 lags V_1 :-

$$V_1(t) = 120\cos(120\pi t - 40)$$

ⓐ $I_1(t) = 2.5\cos(120\pi t + 20)$

I_1 lags V_1 by -60

ⓑ $I_1(t) = 1.4\sin(120\pi t - 70)$

$= 1.4\cos(120\pi t - 160)$

I_1 lags V_1 by 120

ⓒ $I_1(t) = -0.8\cos(120\pi t - 110)$

$= 0.8\cos(120\pi t + 70)$

I_1 lags V_1 by -110

ⓓ $I_1(t) = 2\cos(40\pi t - 30)$

(Can not be compered)

Euler formula :-

$$e^{i\theta} = \cos\theta + \sin\theta$$

any complex number Z

$$Z = x + iy$$

$$x = \text{Real}[Z] \qquad y = IM[Z]$$

1] Rectangler form $\Rightarrow Z = x + iy$

2] Polar form $\Rightarrow Z = r\angle\theta$

3] exp. form $\Rightarrow Z = re^{i\theta}$

$$r = \sqrt{x^2 + y^2} \qquad \theta = \tan^{-1}\left[\frac{y}{x}\right] \qquad x = r\cos\theta \qquad y = r\sin\theta$$

Subject :

$Z_1 = x_1 + iy_1 = r_1 \angle \theta_1$

$Z_2 = x_2 + iy_2 = r_2 \angle \theta_2$

1] $Z_1 + Z_2 = (x_1 + x_2) + i(y_1 + y_2)$

2] $Z_1 - Z_2 = (x_1 - x_2) + i(y_1 - y_2)$

3] $Z_1 Z_2 = r_1 r_2 \angle \theta_1 + \theta_2$

4] $\dfrac{Z_1}{Z_2} = \dfrac{r_1}{r_2} \angle \theta_1 - \theta_2$

5] $\dfrac{1}{Z_1} = \dfrac{1}{r_1} \angle -\theta_1$

6] Conjegat of complex number

$\overline{Z_1} = x_1 - iy_1$

Ex :

1] $(2\angle 30)(5\angle -110)(1+2j) =$

$= (10 \angle -80)\left(\sqrt{1^2+2^2} \angle \tan^{-1}(2/1)\right)$

$= 22.36 \angle -16.57$

$= 22.36 \cos(-16.57) + i\, 22.36 \sin(-16.57)$

$= 21.43 - i\, 6.377$

CamScanner

Subject: complete

(b) $5\angle -200 + 4\angle 20 =$

$= (5\cos(-200) + i\,5\sin(-200)) + (4\cos(20) + 4\sin(20))$

$= -0.939 + i\,3.078$

(c) $\dfrac{2-j7}{3-j} = \dfrac{\sqrt{2^2+7^2}\ \angle \tan^{-1}(-7/3)}{\sqrt{1^2+3^2}\ \angle \tan^{-1}(-1/3)} = 2.302\angle -55.62^\circ$

phasor transformation :-

1) $V(t) = V_m \cos(\omega t + \theta_1)$

$V = V_m \angle \theta_1$

2) $I(t) = I_m \cos(\omega t + \theta_2)$

$I = I_m \angle \theta_2$

Ex: time $\rightarrow$ phasor

1) $-5\sin(580t - 110)$

$\Rightarrow 5\cos(580t - 20)$

$\therefore 5\angle -20$

2) $3\cos(600t) - 5\sin(600t + 110)$

$= 3\angle 0 + 5\cos(600t + 200)$

$= 3\angle 0 + 5\angle 200$

$3\cos(0) + i\,3\sin(0) + 5\cos(200) + i\,5\sin(200)$

$= 2.41\angle -134.8$

Ex: phasor → time

$\omega = 2000$ rad/s

$t = 1$ ms

1] $j10 \Rightarrow 0 + j10 = \sqrt{0^2 + 10^2} \angle \tan^{-1}(10/0)$

$= 10\angle 90$

$\Rightarrow 10\cos(2000t + 90) = 10\cos(2000(1m) + 90)$

$= 10\cos(2 * \frac{180}{\pi} + 90)$

$= -9.093$ A

2] $20 + j[10\angle 20] =$

$(0 + j1) = 1\angle 90$

$= 20 + [1\angle 90][10\angle 20]$

$= 20 + 10\angle 110$

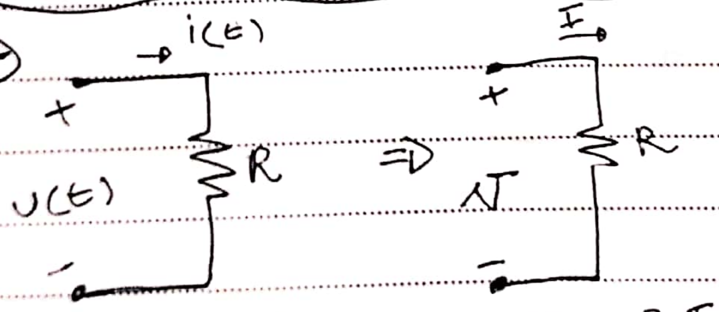
$= 20 + 10\cos(110) + j\,10\sin(110)$

$= 19.06\angle 29.54$ A

$\Rightarrow 19.06\cos((29.54) + 2000t)\Big|_{t = 1ms}$

$= 19.06\cos(2 * \frac{180}{\pi} + 29.54)$

$= -15.45$ A

⇒ 

(2)

$v(t) = R\,I(t)$ $\quad V = R\,I$

$V_m \angle \theta_1 = R\,I_m \angle \theta_2$

Ex: let $V(t) = 8\cos(100t - 50)\,V$, $R = 4\,\Omega$, find $I(t)$

$I(t) = \dfrac{V(t)}{R} = 2\cos(100t - 50)\,A$

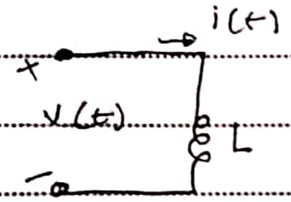
then: $I = 2\angle -50\ A$

$V = RI$

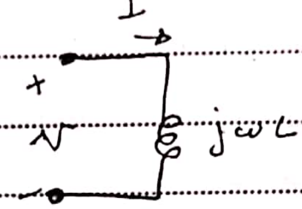
$\Rightarrow I = \dfrac{V}{R} = \dfrac{8\angle -50}{4} = 2\angle -50\ A$

$\therefore i(t) = 2\cos(100t - 50)\ A$

Inductor :-



$\Rightarrow$



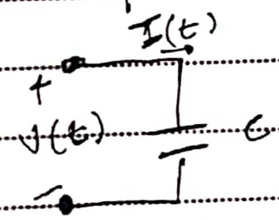
$v(t) = L\dfrac{dI(t)}{dt}$ $\qquad$ $V = [j\omega L]\,I$

Ex: $V = 8\angle -50\ V$, $\omega = 100$ rad/s, $L = 4H$ find I and $i(t)$

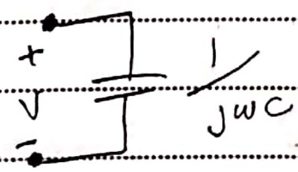
$I = \dfrac{V}{j\omega L} = \dfrac{8\angle -50}{j[100][4]} = .02\angle -140^\circ\ A$

$i(t) = .02\cos(100t - 140)\ A$

Capacitor :-

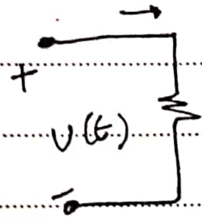


$\Rightarrow$

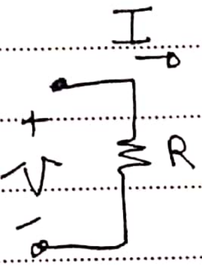


$i(t) = C\dfrac{dV(t)}{dt}$ $\qquad$ $V = \dfrac{1}{j\omega C}\,I$

⊕ $i(t)$



$\Rightarrow$



$v(t) = R\,I(t)$

$V = R\,I$

$V_m \angle \theta_1 = R\, I_m \angle \theta_2$

Ex: let $v(t) = 8\cos(100t - 50)$ V, $R = 4\,\Omega$
find $I(t)$?

$I(t) = \dfrac{v(t)}{R} = 2\cos(100t - 50)$ A

$I = 2\angle -50$ A

⊕ General ohm law:

$V = Z\,I$, $Z_R = R$

$Z_L = j\omega L$

$Z_C = \dfrac{1}{j\omega C}$

$\boxed{\text{time}} \rightarrow \boxed{\text{frq}} \rightarrow \boxed{\text{analysis}}$

$\downarrow$

$\boxed{\text{time}} \leftarrow \boxed{\text{frq}}$

Ex: $V = 8\angle -50$ V, $\omega = 100$ rad/s, $L = 4H$ find I, $i(t)$

$I = \dfrac{V}{j\omega L} = \dfrac{8\angle -50}{j[100][4]} = .02\angle -140^\circ$ A

$i(t) = .02\cos(100t - 140)$ A

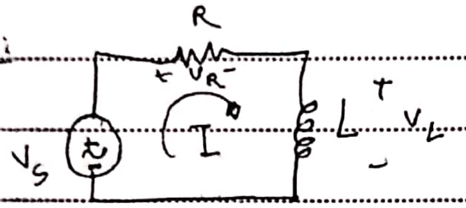
(*) KVL :-

$\sum_{loop} v(t) = 0 \qquad \sum_{loop} V = 0$

(*) KCL :-

$\sum_{node} i(t) = 0 \qquad \sum_{node} I = 0$

Ex :



using KVL :

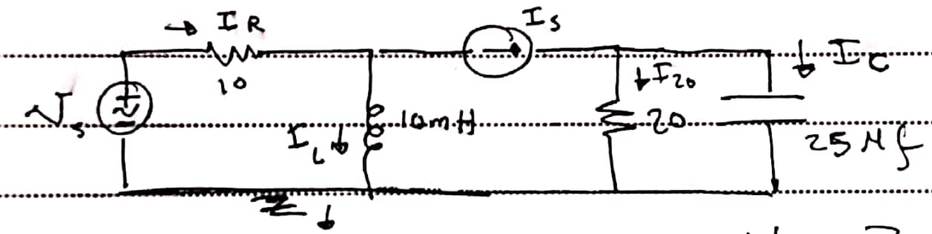
$-V_s + V_R + V_L = 0$

$-V_s + RI + j\omega L I = 0$

$I = \dfrac{V_s}{R + j\omega L}$

Ex : $\omega = 1200$ rad/s , $I_c = 1.2\angle 28$ A , $I_L = 3\angle 53$ A

I_s , V_s , $i_R(t) \Rightarrow$ find



$10 \rightarrow 10$

$20 \rightarrow 20$

$10\,mH \rightarrow j\omega L \rightarrow 12j$

$25\,\mu f \rightarrow \dfrac{1}{j\omega C} \rightarrow -33.33j$

using KVL :-

$-V_s + 10 I_R + 12j[3\angle 53] = 0$

$V_s = 34.86\angle 74.91$ V

$V_c = Z_c I_c = [-33.33j][1.2\angle 28]$

$= 40\angle -62$ V

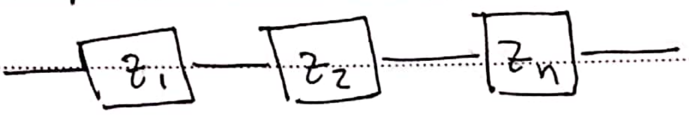
$I_{20} = \dfrac{40\angle -62}{20} = 2\angle -62$ A

$I_s = I_{20} + I_c = 2.33\angle -31.04$ A

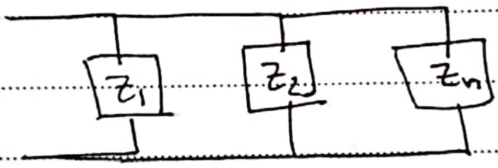
$I_R = I_s + I_L = 3.98\angle 17.42$ A

$i_R(t) = 3.98\cos(1200t + 17.42)$ A

Impedance:

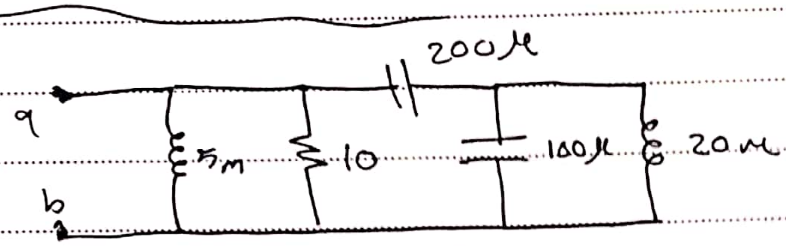


$Z_{eq} = Z_1 + Z_2 + \dots + Z_n$



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

Ex:



$\omega = 1000$ rad/s

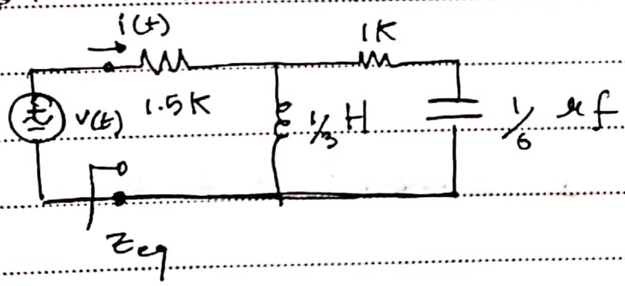
$5mH \to j5$ $\quad$ $100\mu f \to -j10$

$20mH \to 20j$ $\quad$ $10 \to 10$

$200\mu f \to -j5$ $\quad$ then: $Z_{eq} = \left[[20j \,//\, -j10] + [-j5]\right] // 10 // j5$

$= 2.809 + j\,4.49\ \Omega$

Ex: find $i(t)$?



$v(t) = 40 \sin 3000t$

$\Rightarrow 40 \cos(3000t - 90)$

$40 \angle -90$

$1.5K \to 1.5K$ $\quad$ $1/3\,H \to 1kj\ \Omega$

$1K \to 1K$ $\quad$ $1/6\,\mu f \to -j2\ \Omega$

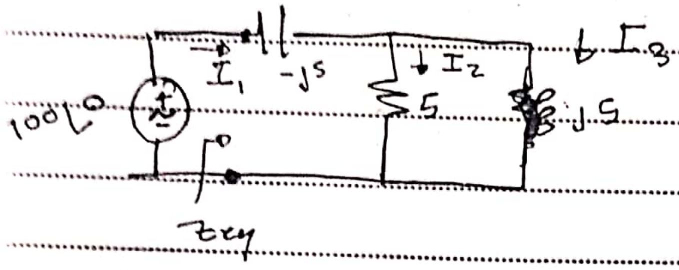
$\therefore Z_{eq} = \left[[-j2 + 1k] \,//\, 1kj\right] + 1.5K = 2.5 \angle 36.87\ K\Omega$

$$I = \frac{V_s}{Z_{eq}} = \frac{40 \angle -90}{2.5 \angle 36.87}$$

$= 16 \angle -126.9$ mA

$i(t) = 16 \cos(3000t - 126.9)$ mA

Ex: find I_1, I_2, I_3



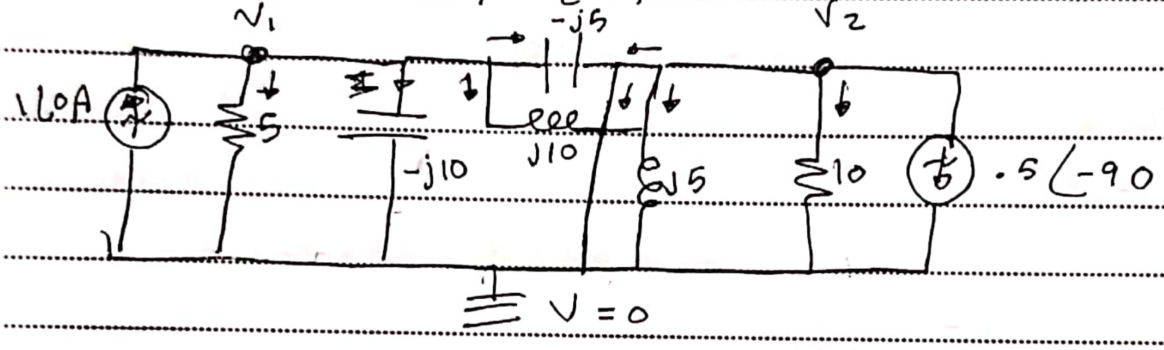
$Z_{eq} = [5 // j5] + [-j5]$

$I_1 = \frac{100\angle 0}{Z_{eq}} = 28.28\angle 45\ A$

$I_2 = \frac{1/5}{\frac{1}{5} + \frac{1}{j5}} [28.28\angle 45]$ $\qquad I_3 = 20\angle 0\ A$

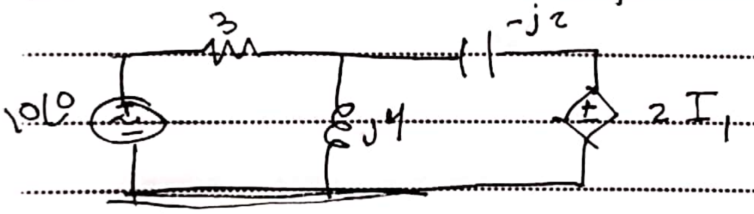
$= 20\angle 90\ A$

Ex: find V_1, V_2 ?



$V_1 = 2.24\angle -63.4\ V$ $\qquad V_2 = 4.47\angle 116.6\ V$

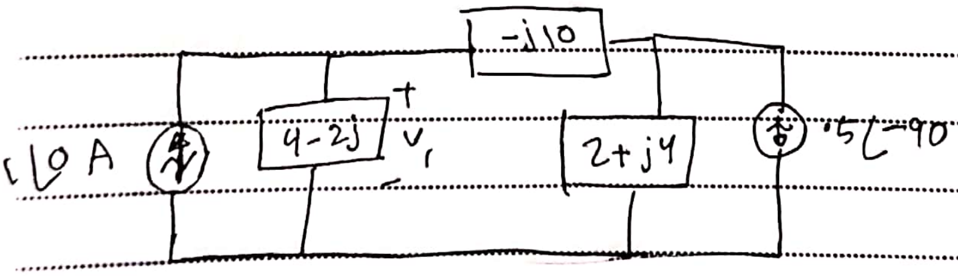
Ex: find I_1, I_2 ?



$I_1 = 1.24\angle 29.7\ A$

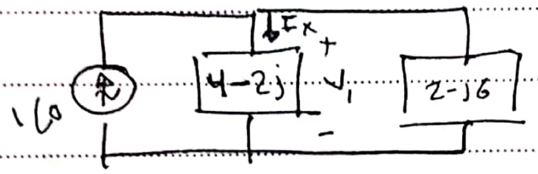
$I_2 = 2.77\angle 56.3\ A$

Ex: find V_1



$V_1 = V_1\big|_{1\angle 0} + V_1\big|_{.5\angle -90}$

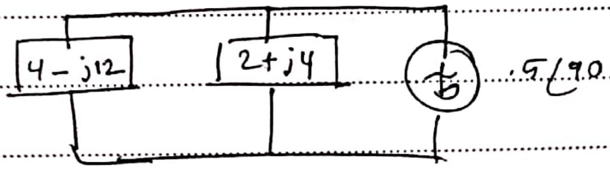
V_1 due to $1\angle 0$ =



$V_1 = [4-j2]\, I_x \quad I_x = \dfrac{\frac{1}{4-j2}}{\frac{1}{4-j2}+\frac{1}{2-6j}} [1\angle 0]$

$V_1 = 2-2j\ V$

V_1 due to $.5\angle -90$:



$V_1 = [4-2j]\ I_y$

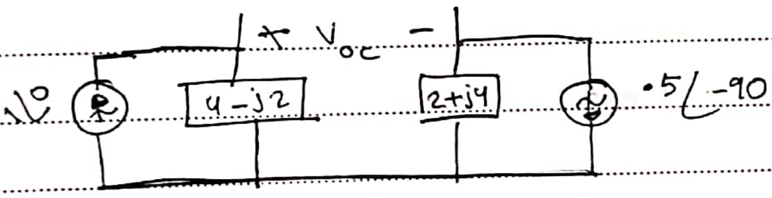
$I_y = \dfrac{1/4-12j}{(1/4-12j)+(1/2+4j)} \quad [-0.5\angle -90]$

$= -1\ A$

$V_1 = 2-2j + -1$

$= 1-2j\ V$

Ex: find thevenin



① $V_{Th} = V_{oc}$

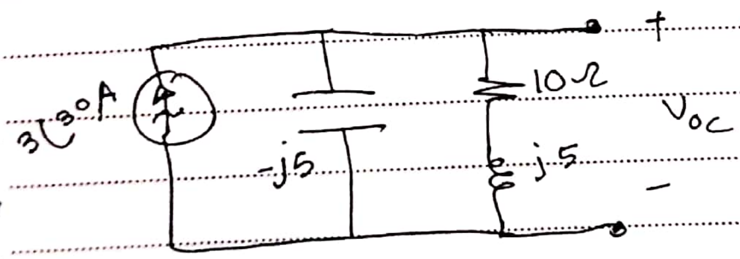
$V_{oc} = 1\angle 0\ [4-j2] + 0.5\angle -90\ [2+4j]$

$= 6 - j3\ V$

② $Z_{Th} = 4-j2+2+j4 = 6+j2\ \Omega$

③ $I_{Norton} = \dfrac{V_{Th}}{Z_{Th}} = \dfrac{6-j3}{6+j2} = \rule{2cm}{0.4pt}\ A$

Ex: find thevenin:



$V_{Th} = V_{oc}$

$V_{oc} = [[10+j5]\,//\,-j5]\ 3\angle 30$

$= 16.77\angle -33.43\ V$

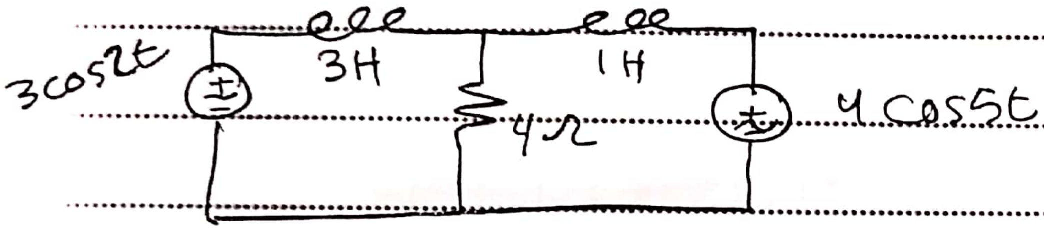
$Z_{Th} = [10+js]\,//\,[-j5]$

$= 5.59\angle -63.43\ \Omega$

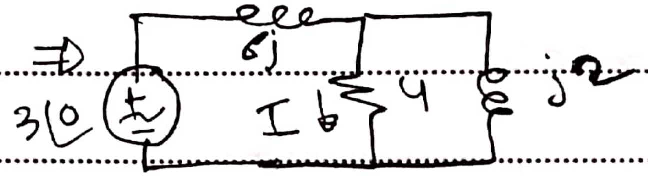
$I_N = I_{sc} = 3\angle 30\ A$

Ex: find I ?

$I = I_{3\cos 2t} + I_{4\cos 5t}$



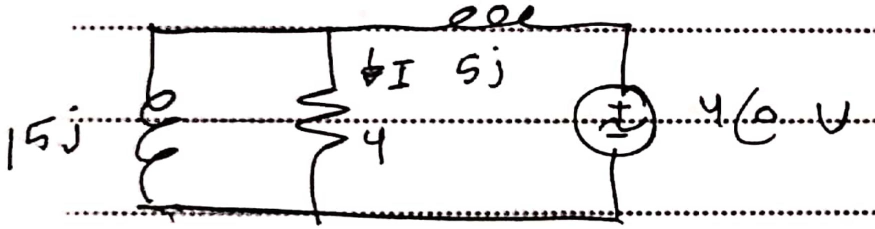
$\Rightarrow$



$$I = \frac{V}{4} = \frac{1}{4}\left[\frac{j2 \,||\, 4}{4 \,||\, j2 + 6j}\right][3\angle 0]$$

$$= 175.6\angle -20.56 \text{ mA}$$

$\Downarrow$



$$I = 547.1\angle -43.15 \text{ mA}$$

$$i(t) = 175.6\cos(2t - 20.56)$$
$$+\ 547.1\cos(5t - 43.15) \text{ mA}$$