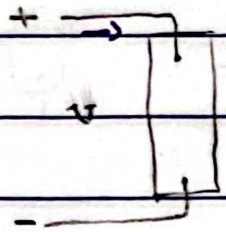
chapter(1):-

passive sign convention:-

$p = \frac{dw}{dt}$

- current direction



$p = vi$ or $-vi$

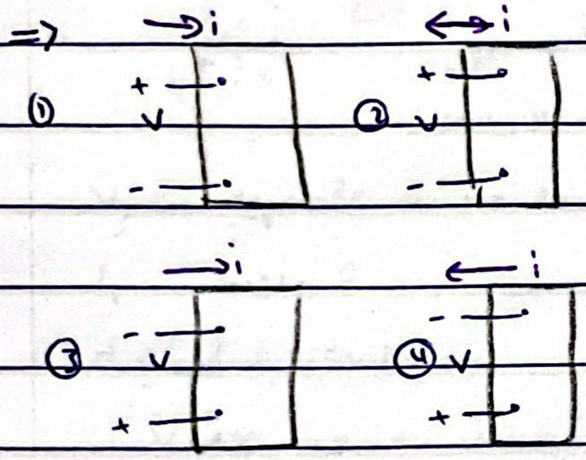
→ can be positive or negative

- if $p > 0$ the element is "يستهلك طاقة" absorbing power.

"absorbed power by the elem

- if $p < 0$ the element "يعطي طاقة" is delivering power.

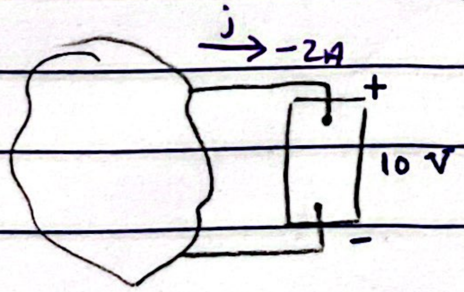
'delivered power by the



1,4 $p = vi$, 2,3 $p = -vi$

→ حسب التيار داخل على + or -

Ex:-



: داخل على (+)

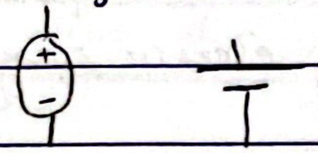
→ $p = vi$

$= (10)(-2)$

$= -20\,W$ del. power

Chapter (2):- Voltage and sources:-

- Ideal Voltage source:

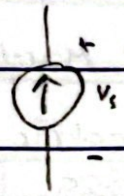
V_s 

independent.

• Voltage ثابتة

• التيار يعتمد على الدارة

- Ideal current source.

i_s  V_s

independent.

• الـ Voltage على أطراف الـ source يعتمد على الدارة

$V_s \to$ depends on the circuit.

$i_s \to$ constant. • التيار ثابت.

Ex:

dependent sources:-

• قيمة الـ current or voltage تعتمد على value sample where in the circuit.

$V_s = A V_x$

• ideal dependent voltage source

• voltage - controlled

$V_s = A i_x$

• ideal dep Volt

• current controlled

$i_s = A V_s$

• ideal dep. curr. so

• Volt - cont.

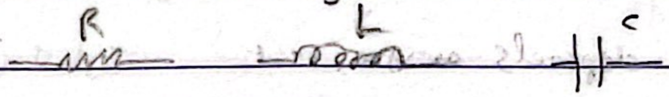
$i_s = A i_x$

• Ideal dep curr - so

• current - cont.

• active element:- one that models a device capable of generating electric energy.

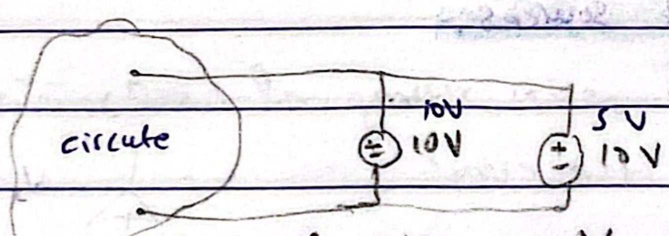
• passive elements:- one that the models a physical device that cannot generate electric energy



Ex:-

Voltage

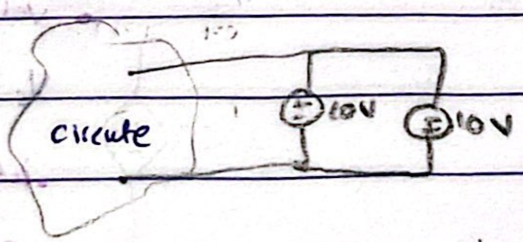
1,3)



α
✓

-يجب ان يكون V متساوي لانه parallel

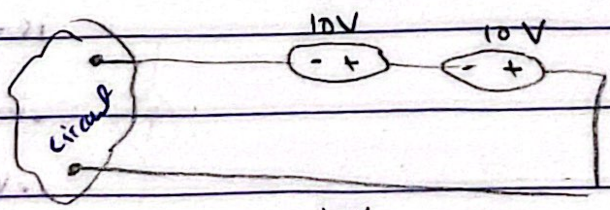
2)



α

ال +/- معكوسة

4)



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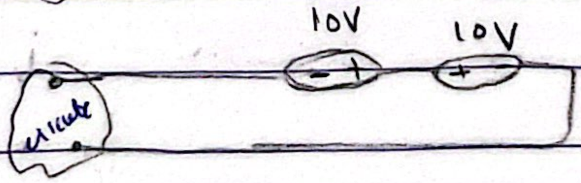
5)



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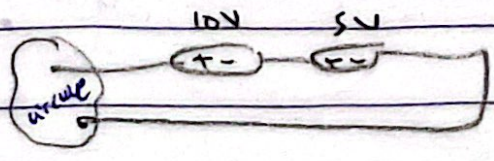
6)



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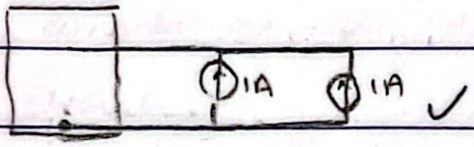
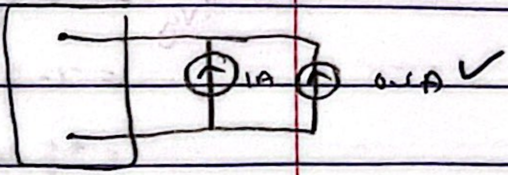
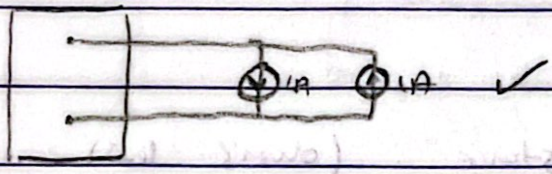
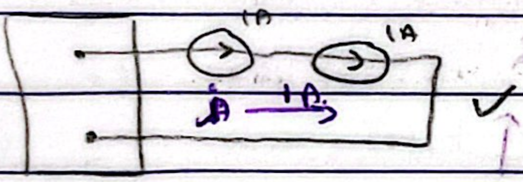
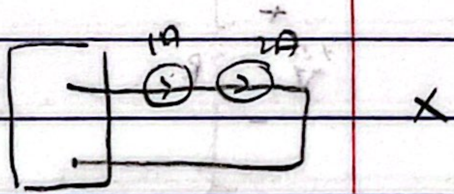
current:

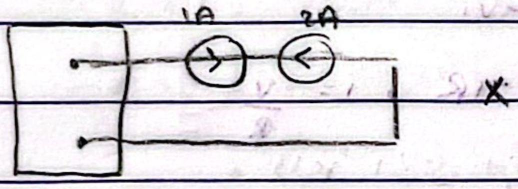










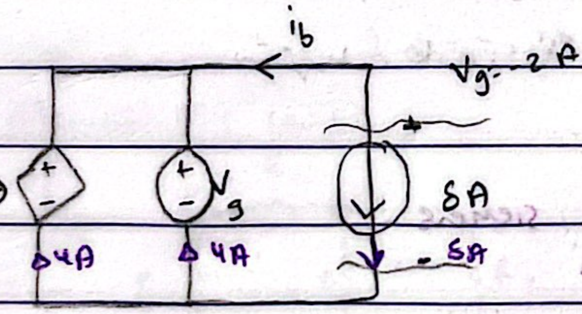


• يكون المخزن بطارية عم تشحن بالتيار

فتحافظ على ال power جوة المخزن .

Ex:-

$i = \frac{i_b}{4}$



. dependent sourse.

. voltage source / current source

a) what value of V_g is required in order for the interconnection to be valid ?

b) for this V_g find the power associated with the 8A source.

a => $i_b = -8A$

$\therefore i = -\frac{8}{4}A = \boxed{-2}$

$\therefore$  $-2V$

$\therefore V_g = -2V$

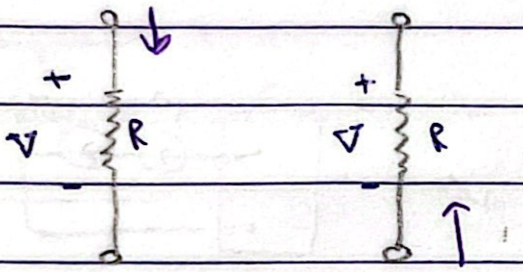
b => $P = vi = (-2)(8) = -16\,W$ (del-power)

يعطي طاقة

$$P_{V_g} = -V_g(11)$$
$$= -(-2)(8)$$
$$= +8\ \omega \quad (\text{abs. power})$$

يستهلك طاقة

(2.2) Electrical resistance . (ohm's law)



$p = vi$, $p = -vi$

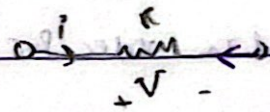
$v = iR$, $i = \frac{v}{R}$, $v = -iR$, $i = \frac{-v}{R}$

• دائماً الجواب النهائي (+) لأن المقاومة

ستهلك طاقة دائماً

Conductance G :-

$G = \frac{1}{R}$ $\left.\frac{S}{\Omega}\right]$ siemens .



$p = vi$ $\qquad$ $p = -vi$

$= (i)^2 R$ $\qquad$ $= (i)^2 R$

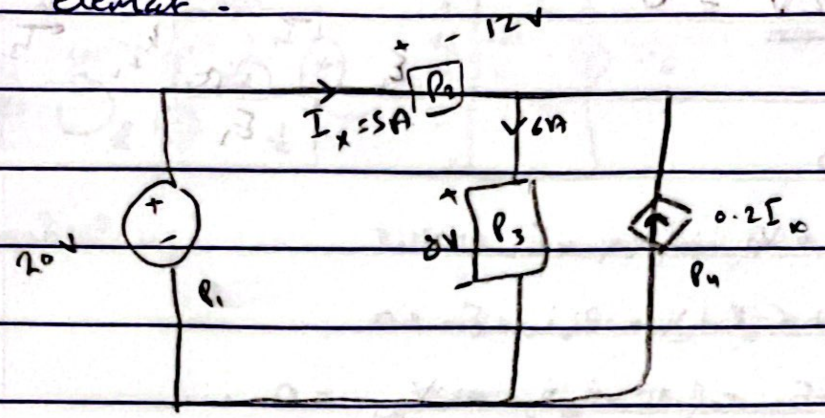
$= \frac{v^2}{R}$ $\qquad$ $= \frac{v^2}{R}$

in $V_R^{(+)}$

• The algebric sum of power in a circute at any instant of time must be zero .

$\sum p(t) = 0$. $\qquad$ $P_{abs} = P_{dep}$.

Ex:- calculate the power absorbed or delivered by each element.



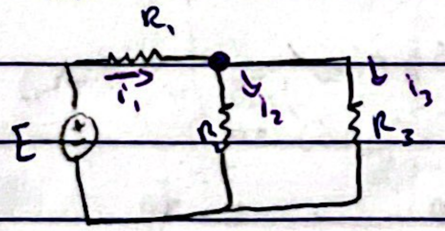
- $P_1 = -VI$ (del) $= -20(5) = -100\,W$
- $P_2 = VI$ (abs) $= 12(5) = 60\,W$

VI

- $P_3 = VI = 8 \times 6 = 48\,W$ (abs)
- $P_4 \Rightarrow -100 + 60 + 48 = 8$ or $P_4 = -VI = 8(0.5.2) = -8\,W$

∴ $P_4 = -8\,W$ (del).

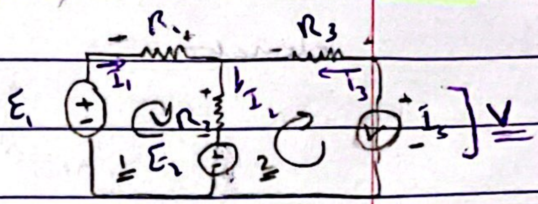
(2.4) Kirchhoff's law's.



- **KCL** "Kirchhoff's current law". [illegible] node x is
  - $\Sigma I_{in} = \Sigma I_{out} \Rightarrow i_1 = i_2 + i_3$
  - $\Sigma I_{out} = 0 \Rightarrow -i_1 + i_2 + i_3 = 0$
  - $\Sigma I_{in} = 0 \Rightarrow i_1 - i_2 - i_3 = 0$

• **KVL :-** "Kirchhoff's Voltage law".

$\sum V = 0$ حول اي مسار مغلق



$KVL_1 \Rightarrow$

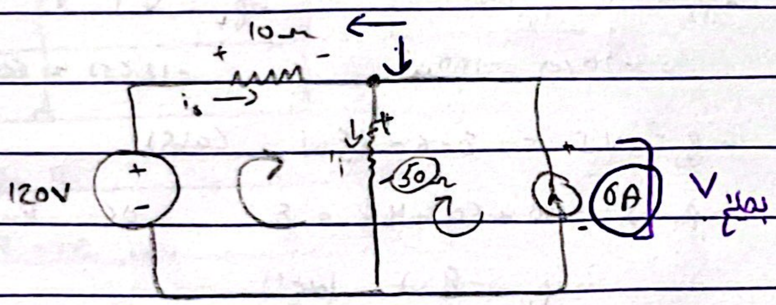
$-E_1 - V_{R_1} - R_2 i_2 + E_2 = 0$.

$-E_1 - (-R_1 i_1) + R_2 i_2 + E_2 = 0$

$KVL_2 \Rightarrow -E_2 - R_2 i_2 - R_3 i_3 + V_{\text{بطلع}} = 0$.

$i_3 = I_s$

Ex:



a) find i_o :

$KVL \Rightarrow \quad -120 + 10 i_o + 50 i_1 = 0$

$KCL \Rightarrow \quad i_o + 6 = i_1$

$-120 + 10 i_o + 50(i_o + 6) = 0$

$\therefore i_o = -3A$, $i_1 = 3A$

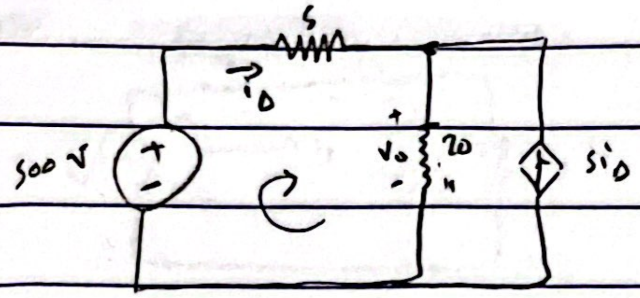
b) $V_{\text{بطلع}}$

$KVL \Rightarrow -50 i_1 + V = 0$

$-50(3) + V = 0$, $\therefore V = 150\,V$

Ex:

1



$\Rightarrow$ find V_0

KVL $\Rightarrow$ $-500 + 5i_0 + V_0 = 0$

KCL $\Rightarrow$ $i_1 = 5i_0 + i_0 = 6i_0$.

$-500 + 5i_0 + 20i_1 = 0$

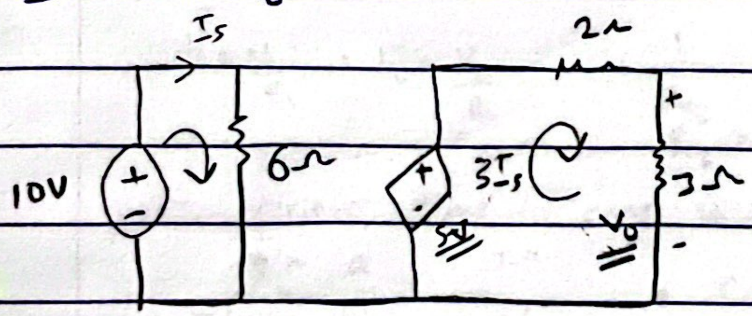
$-500 + 5i_0 + 120i_0 = 0$

$\therefore i_0 = 4A$. , $i_1 = 24A$

$\therefore V_0 = 20i_1$

$= 20(24) = 480V$.

2 Find V_0. Ex(2.10).



KUL $\Rightarrow$ 1) $I_s6 - 10 = 0$

$I_s = \frac{10}{6}$ A.

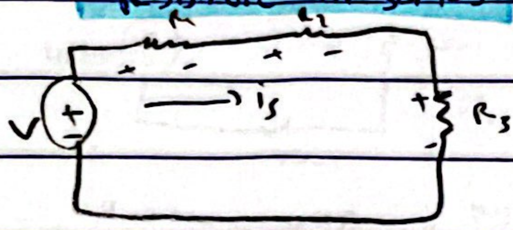
KUL $\Rightarrow$ $0 = -5 + 2i + 3i$.

$\therefore i = 1A$

$\therefore V_0 = 3V$.

chapter(3):-

Resistore in series.



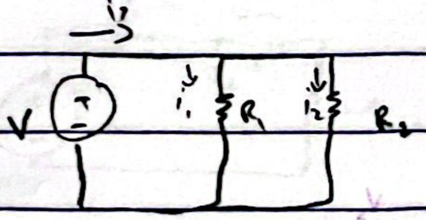
KVL => $-V_s + R_1 i_s + R_2 i_s + R_3 i_s = 0$

$$V_s = \underbrace{(R_1 + R_2 + R_3)}_{R_{eq}} i_s$$

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

series resister have the same current.

Resister in parralel



KCL => $I_s = I_1 + I_2$

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

$$= V_s\left(\frac{1}{R_1} + \frac{1}{R_2}\right)$$

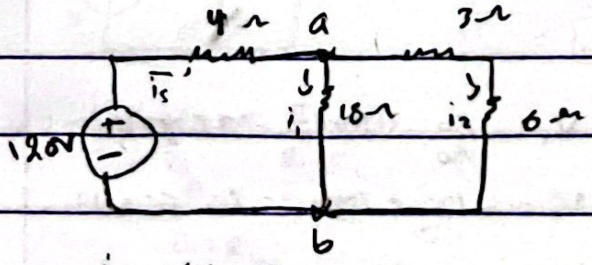
$i_1 = \frac{V_s}{R_1}$, $i_2 = \frac{V_s}{R_2}$

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

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

parallel resister have the same voltage.

Ex:-



- $R_{eq} = [9 \parallel 18] + 4$
  $= 10\ \Omega$
- $I_s = \frac{V}{R} = \frac{120}{10} = 12\ A$.

$i_1 = \frac{(6+3)}{(6+3)+18} \times 12$ current divider rule.

$i_2 = \frac{18}{18+(6+3)} \times 12$

$V_{ab} = ?$

$-120 + (4)(12) + V_{ab} = 0)\quad V_{ab} = 120 - 4 \cdot 12$

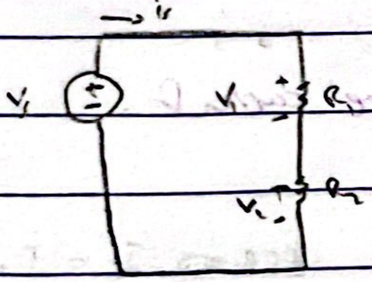
$= 72$ Volt

$\rightarrow i_1 = \frac{72}{18} = 4A$

$\rightarrow i_2 = \frac{72}{6+3} = 8A$

⇒ the Voltage Divider Rule (VDR)

• مصدر جهد يتقسم على مقاومتين على التوالي



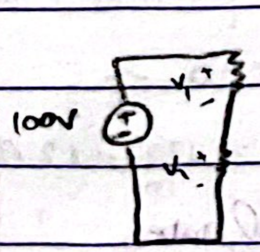
Step(1) $\quad i_s = \frac{V_s}{R_1+R_2}$

Step(2) $\quad V_1 = R_1 i_s = \frac{R_1}{R_1+R_2} V_s$

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

• النفس عن الضغط بس العكس الأكبر بوخذ الجهد المطروح .

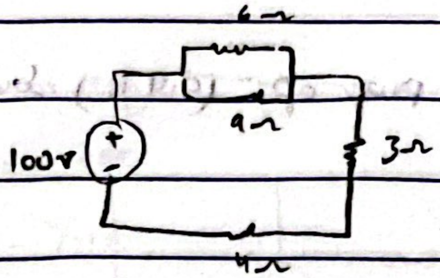
Ex:



$V_1 = \frac{50}{150} \times 100 = 33.33$ Volt

$V_2 = \frac{100}{150} \times 100 = 66.66$ Volt.

Ex:-

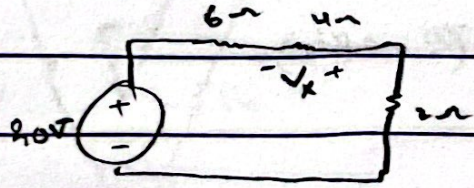


$$V_4 = \frac{4}{4+(3+6\|9)} \times 100 = 37.73\ V$$

$$V_3 = \frac{3}{3+(4+6\|9)} \times 100 = 28.30\ V$$

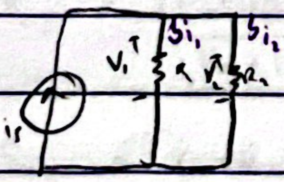
$$V_6 = V_9 = \frac{(6\|9)}{(6\|9)+7} \times 100 = 33.96\ V$$

Ex:-



$$V_x = \frac{-4}{8+4} \times 20 = -6.66\ \text{volt.}$$

⇒ the current divider rule :- (CDR)



$$V_1 = V_2 = V_s$$

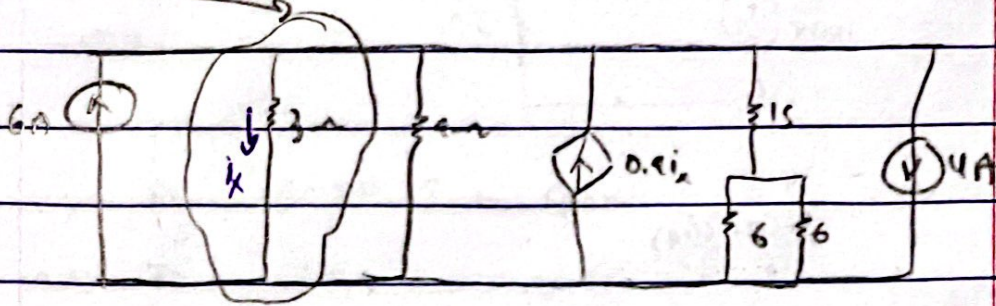
$$V = i_s\ R_{eq}$$

$$= i_s \times \frac{R_1 R_2}{R_1 + R_2}$$

$$i_1 = \frac{V}{R_1} = \frac{R_2}{R_1+R_2}\ i_s$$

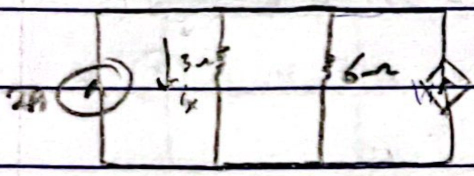
$$i_2 = \frac{R_1}{R_1+R_2}\ i_s$$

Ex:- △ find the power of $(0.9\, i_x)$ source.



1) $(6 // 6) + 15 = 18$

2) $(18 // 9) = 6\ \Omega$



$0.9\, i_x \Rightarrow 0.9(3.33333) = 3A$

CDR $\Rightarrow$ $i_x = \frac{6}{6+3} \cdot (2 + 0.9 i_x)$

$\therefore i_x = 3.333$ A

$\therefore V_x = (3)\, i_x$

$= 3 \times \frac{10}{3} = 10$ volt

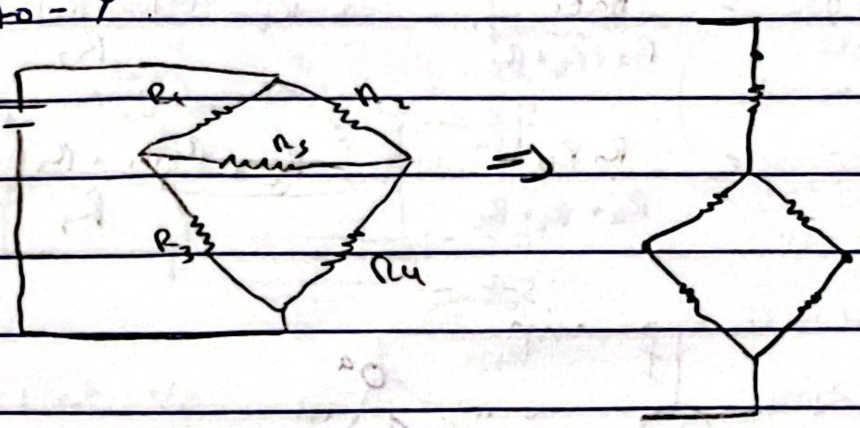
$\therefore P = -Vi = -V_x (3)$

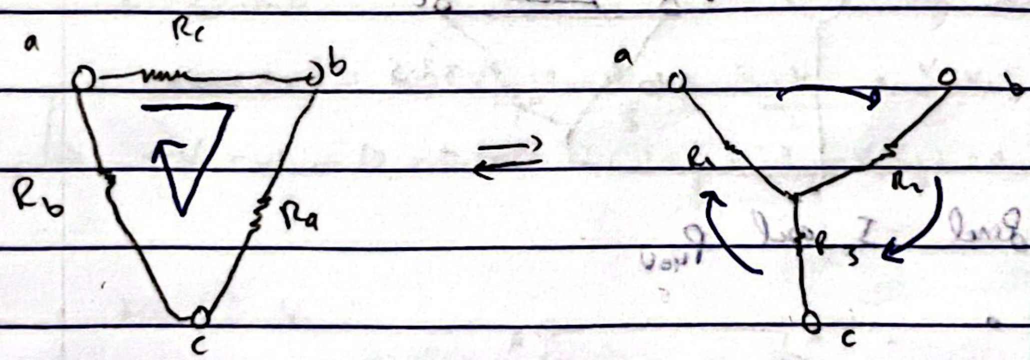
$= -30$ W del

(3.7) Delta-to-wye

Pi-to-tee.

Δ-to-Y





• نفس الشكل، لكن ليس نفس التوصيل، لاختلاف ترتيب وتسمية المقاومات

• $R_{ab} = \dfrac{(R_a + R_b)R_c}{R_a + R_b + R_c} = R_{ab} = R_1 + R_2$

• $R_{bc} = \dfrac{(R_b + R_c)R_a}{R_a + R_b + R_c} = R_{bc} = R_2 + R_3$

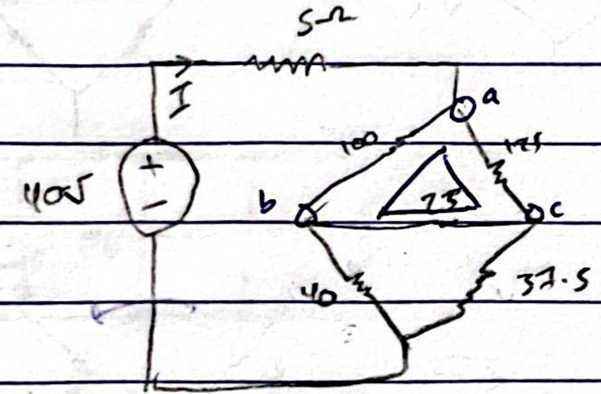
• $R_{ac} = \dfrac{(R_a + R_c)R_b}{R_a + R_b + R_c} = R_{ac} = R_1 + R_3$

- $R_1 = \dfrac{R_b R_c}{R_a + R_b + R_c}$, $R_a = \dfrac{R_1 R_2 + R_2 R_3 + R_3 R_1}{R_1}$

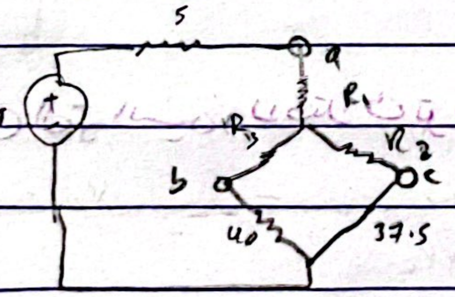
- $R_2 = \dfrac{R_a R_c}{R_a + R_b + R_c}$, $R_b = \dfrac{R_1 R_2 + R_2 R_3 + R_3 R_1}{R_2}$

- $R_3 = \dfrac{R_a R_b}{R_a + R_b + R_c}$, $R_c = \dfrac{R_1 R_2 + R_2 R_3 + R_3 R_1}{R_3}$

Ex:-



find I and P_{40V}.



$R_1 = 100 \times 125 / 100 + 25 + 125 = 50\ \Omega$

$R_2 = 125 \times 25 / 100 + 125 + 25 = 12.5\ \Omega$

$R_3 = 100 \times 25 / 100 + 125 + 25 = 10\ \Omega$

$\Rightarrow R_{eq} = (37.5 + R_2) // (40 + R_3) + R_1 + 5$

$= 80\ \Omega$

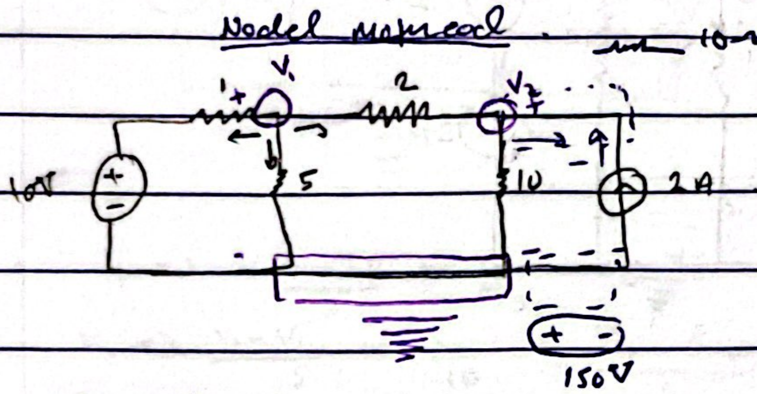
$\therefore I = \dfrac{40}{80} = 0.5\ A$.

$\therefore P_{40V} = -40(0.5) = -20\ W$. ∴ del power.

chapter(4):-

- Node-voltage method

Nodel method



10Ω → at lest btwen 3 element.

1) chose a refernse node

2) essential node

V_1, V_2.

3) write kcl eqs at each node, in terms of the node voltage $V_1, V_2, \dots, V_n$.

- kcl at V_1.

$\Sigma I_{out} = 0$

$i_1 + i_2 + i_3 = 0 \Rightarrow \frac{V_1 - 10}{1} + \frac{V_1}{5} + \frac{V_1 - V_2}{2} = 0$

$-V_1 + V_1 i_1 + 10 = 0 \Rightarrow V_1(1 + \frac{1}{5} + \frac{1}{2}) - V_2(\frac{1}{2}) = 0$ $\boxed{1}$

- KCL at V_2.

$\Sigma I_{out} = \frac{V_2 - V_1}{2} + \frac{V_2}{10} - 2 = 0$

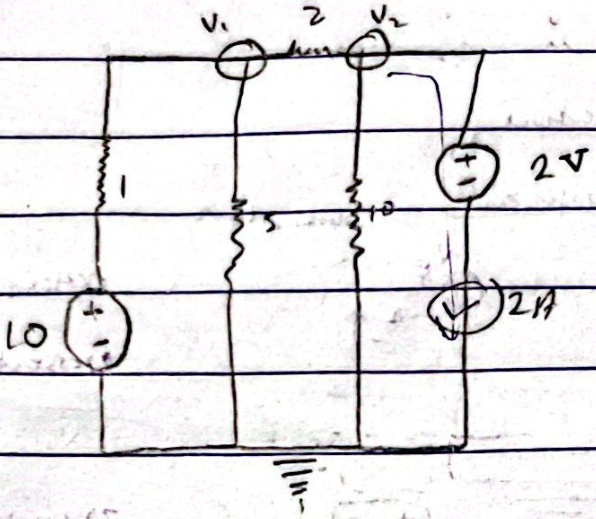
$= -\frac{1}{2}V_1 + V_2(\frac{1}{2} + \frac{1}{10}) = 2$ $\boxed{2}$

$\therefore V_1 = 9.09\ V$.

$V_2 = 10.91\ V$

$\Rightarrow$ Same as upove.

Ex:- ①

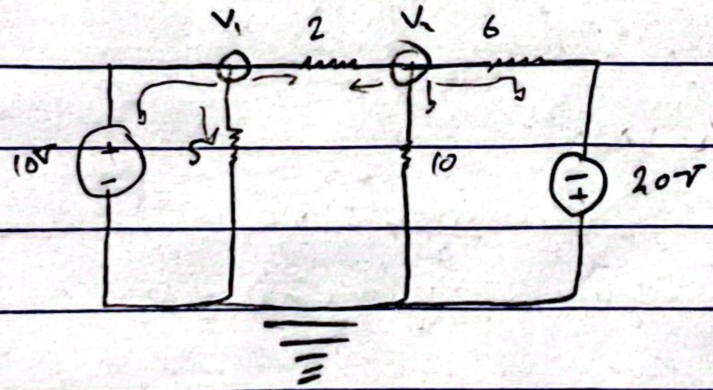


at

- $V_1 \Rightarrow \quad \frac{V_1 + 10}{1} + \frac{V_1}{5} + \frac{V_1 - V_2}{2} = 0$

- $V_2 \Rightarrow \quad \frac{V_2 - V_1}{2} + \frac{V_2}{10} + 2 = 0$

②

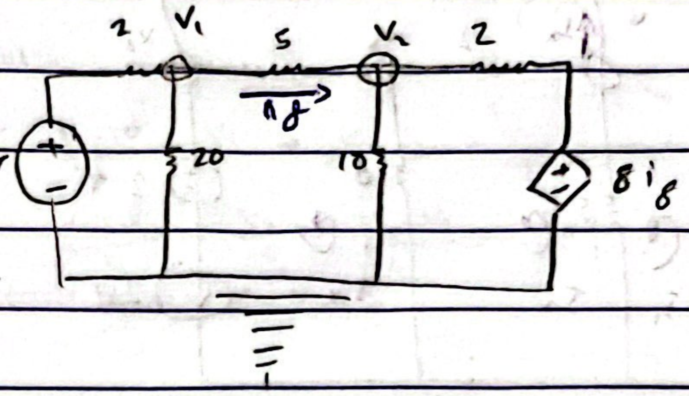


at

- $V_1 = 10\ V$

- $V_2 \Rightarrow \quad \frac{V_2 - 10}{2} + \frac{V_2}{10} + \frac{V_2 + 20}{6} = 0$

3)



at $V_1 \Rightarrow \frac{V_1 - 20}{2} + \frac{V_1}{20} + \frac{V_1 - V_2}{5} = 0$

at $V_2 \Rightarrow \frac{V_2 - V_1}{5} + \frac{V_2}{10} + \frac{V_2 - 8i_g}{2} = 0$

$\Rightarrow i_g = \frac{V_1 - V_2}{5}$

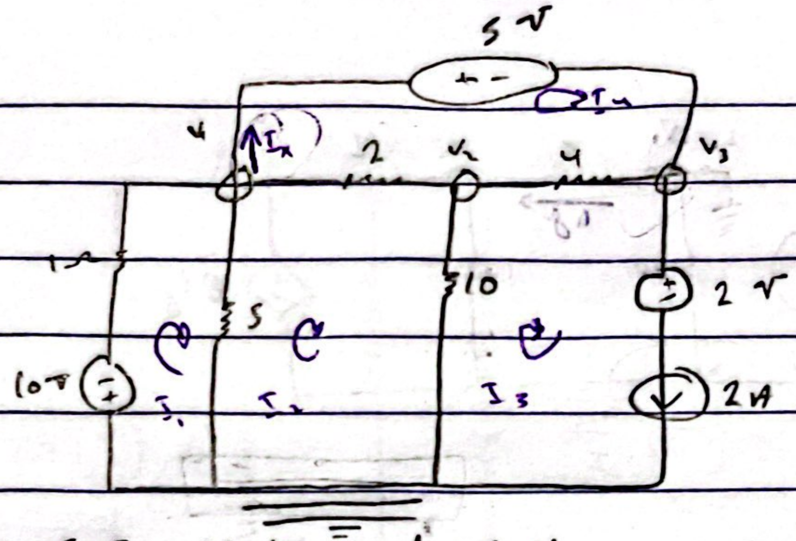
$\therefore \frac{V_2 - V_1}{5} + \frac{V_2}{10} + \frac{V_2 - 8\left(\frac{V_1 - V_2}{5}\right)}{2}$

$\Rightarrow \quad 0.75V_1 - 0.2V_2 = 10$

$-V_1 + 1.6V_2 = 0V$

$\therefore V_1 = 16V \quad V_2 = 10V$

④

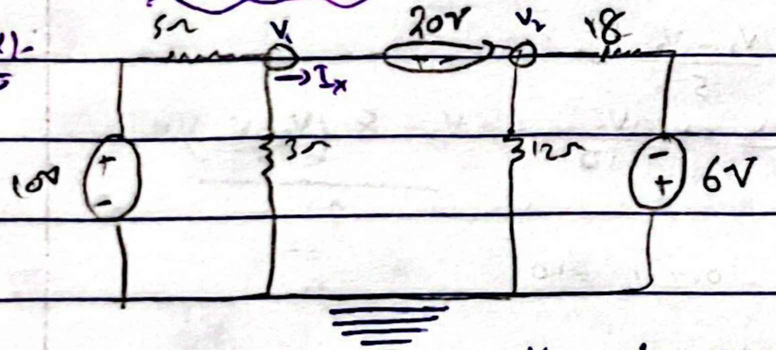


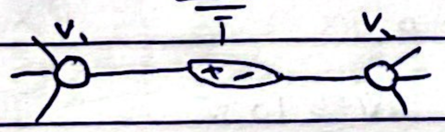
• $V_1 = 5\,V$ id the ground at V_3

special case:-

supernode:-

Ex1:-



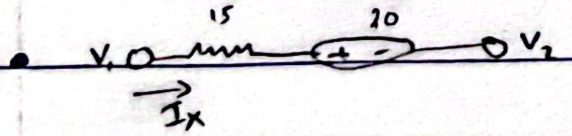


the super node:-

• $\frac{V_1 - 10}{5} + \frac{V_1}{3} + I_x = 0$

• $\frac{V_1 - 10}{5} + \frac{V_1}{3} + \frac{V_2}{12} + \frac{V_2 + 6}{18} = 0$

$\Rightarrow V_1 - V_2 = 20$ (super node eq)



$\frac{V_1 - V_2 + 20}{15}$

(4) Sol:-

I_x

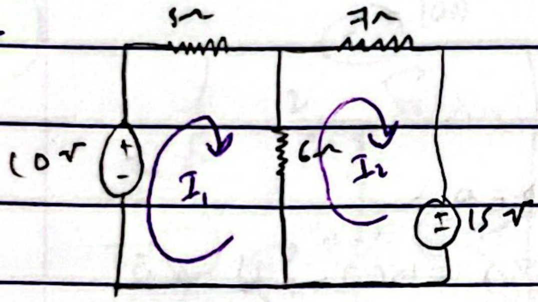
$$V_1 \Rightarrow \frac{V_1-10}{1} + \frac{V_1}{5} + \frac{V_1-V_2}{2} + \frac{V_3-V_2}{4} + 2 = 0$$

$$V_2 \Rightarrow \frac{V_2-V_1}{2} + \frac{V_2}{10} + \frac{V_2-V_3}{4} = 0$$

Super node eq:- $V_1 - V_3 = 5$

Mesh-current method

Ex:-



يجب ان يكون نفس الاتجاه .

→ write mesh current $I_1, I_2, I \ldots$

all cw or all ccw.

→ for each mesh current, write KVL eqs.

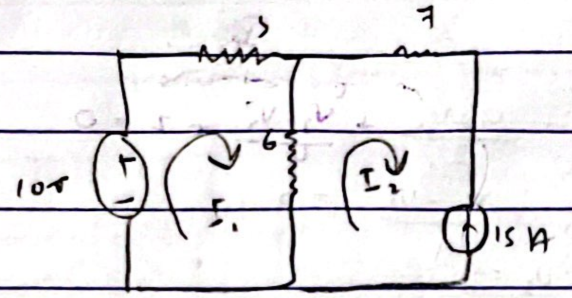
$I_1 \Rightarrow -10 + 5I_1 + 6(I_1 - I_2) = 0$

$11I_1 - 6I_2 = 10$

$I_2 \Rightarrow 15 + 6(I_2 - I_1) + 7I_2 = 0$

$13I_2 - 6I_1 = -15$

Ex:-



$I_2 = -15A$.

$I_1 \Rightarrow -10 + 5I_1 + 6(I_1 + 15) = 0$

$11 I_1 + (15)(6) = 10$

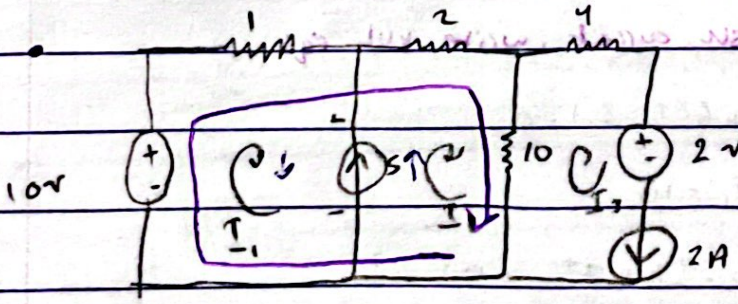
- back to ex 4:-

$I_3 = 2A$.

$I_1 \Rightarrow -10 + I_1 + 5(I_1 - I_2) = 0$

$I_2 \Rightarrow 5(I_2 - I_1) + 2(I_2 - I_4) + 10(I_2 - 2) = 0$

$I_4 \Rightarrow 5 + 4(I_4 - 2) + 2(I_4 - I_2) = 0$



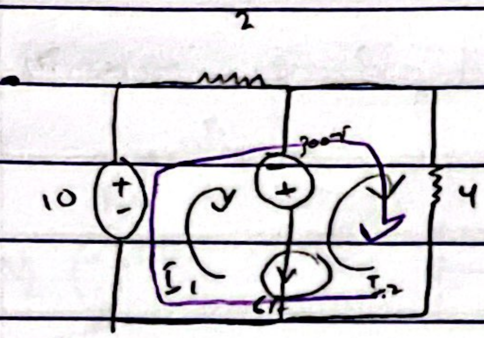
$\boxed{I_3 = 2A}$

$\left.\begin{array}{l} I_1 \Rightarrow -10 + I_1 + V = 0 \\ I_2 \Rightarrow - \end{array}\right] \alpha$

ormal KVL $\Rightarrow -10 + I_1 + 2I_2 + 10(I_2 - 2) = 0$

of mesh current

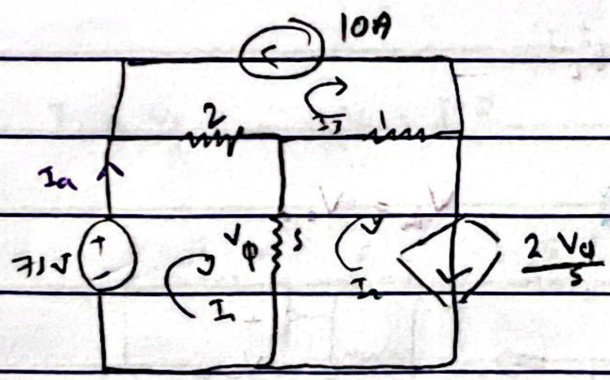
$5 = I_2 - I_1 \Rightarrow$ supper Mesh.



$-10 + 2I_1 + 4I_2 = 0$

$I_1 - I_2 = 6$

4.11 / 128



$\boxed{I_3 = -10\ A}$

$I_2 = \frac{2V_\phi}{5}$

But $V_\phi = 5(I_1 - I_2)$

$\therefore I_2 = 2I_1 - 2I_2$

$2I_1 - 3I_2 = 0$ $\boxed{\therefore I_2 = \frac{2}{3}I_1}$

$I_1 \Rightarrow \quad -75 + 2(I_1 + 10) + 5(I_1 - I_2) = 0.$

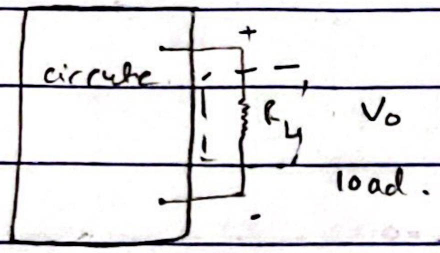
$-75 + 2I_1 + 20 + 5I_1 - 5 \cdot \frac{2}{3}I_1 = 0.$

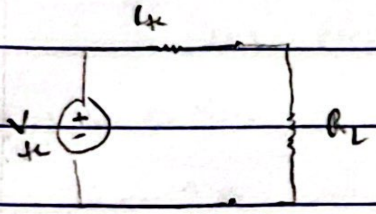
$55 = 7I_1 - \frac{10}{3}I_1.$

$\therefore I_1 = 15\ A.$

$\Rightarrow I_2 = \frac{2}{3} \cdot 15 = 10\ A$

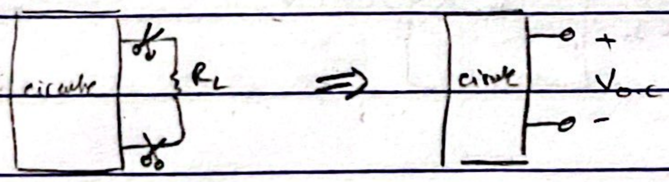
Thevenin's theorem:-





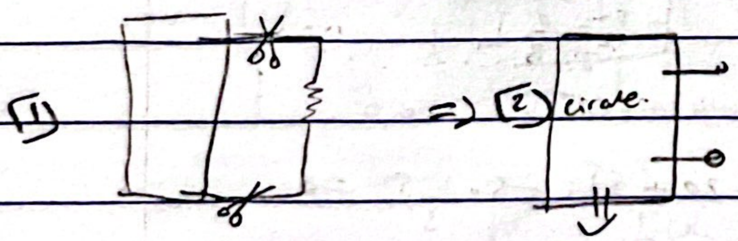
How to find V_{th}

$V_{th} = V_{o.c}$

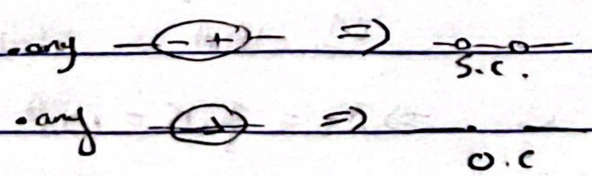


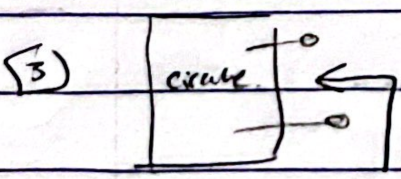
How to find R_{th}

case I :- no dep. sources.



kill all indep. sources (short)

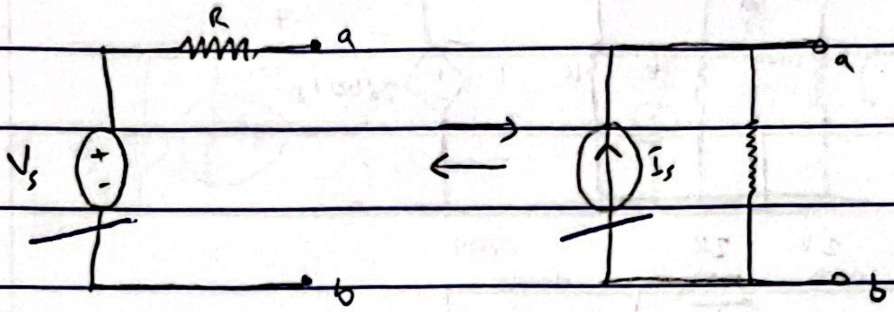




$R_{eq} = R_{th}$

$\Rightarrow$

Source transformation:-

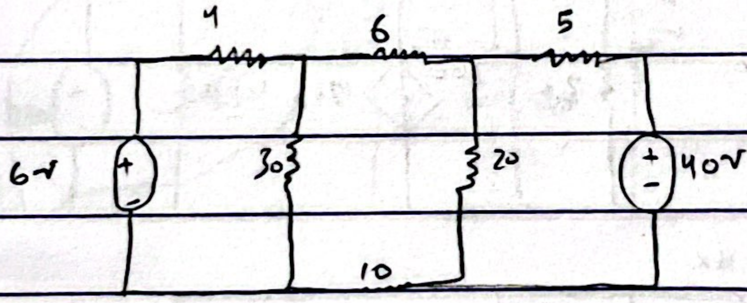


same direction.

التيار مساري في الدارتين.

$I_s = \frac{V_s}{R}$, $V_1 = I_s R$

Ex:-

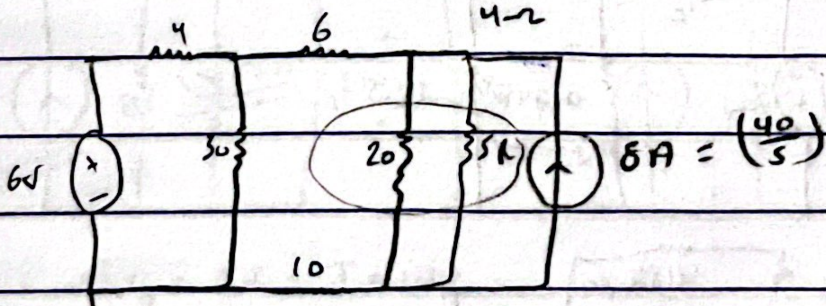


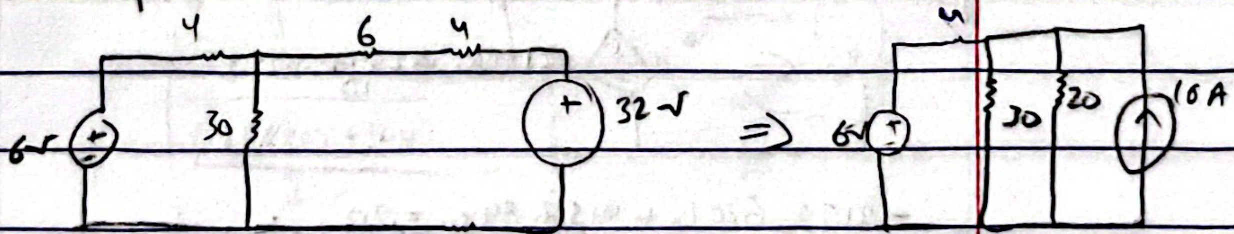
$P_6 = ?$

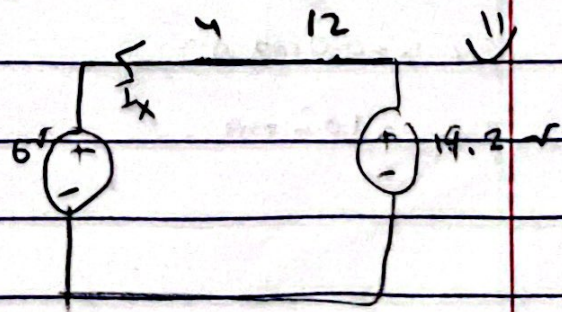
$= V I_x$

$= 6 \times 0.825 = 4.95\,W$

abs.

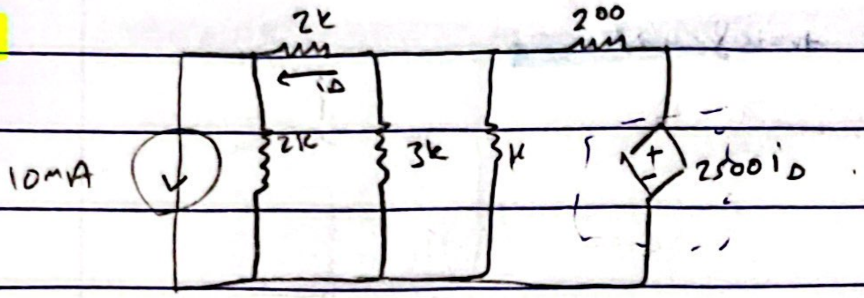


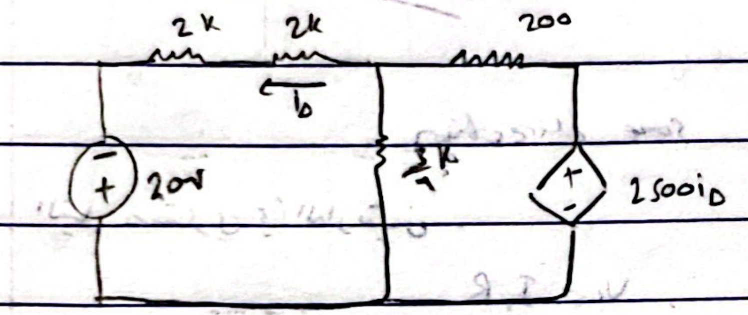


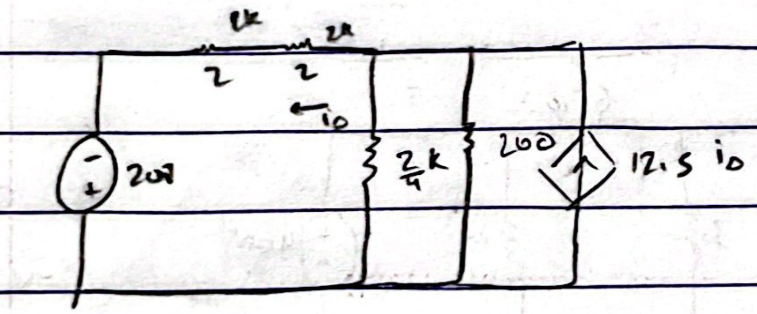


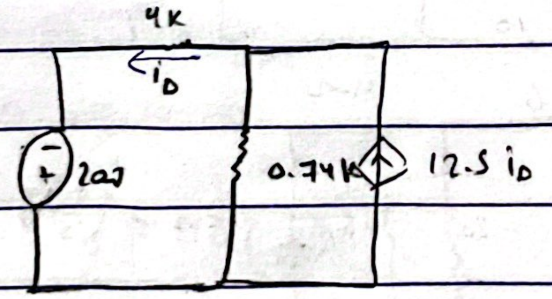
$I_x = \frac{19.2 - 6}{4+12} = 0.825A$

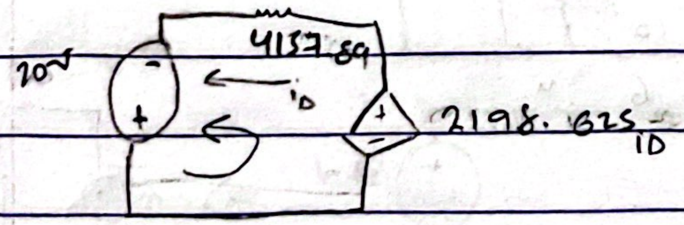
Ex:-









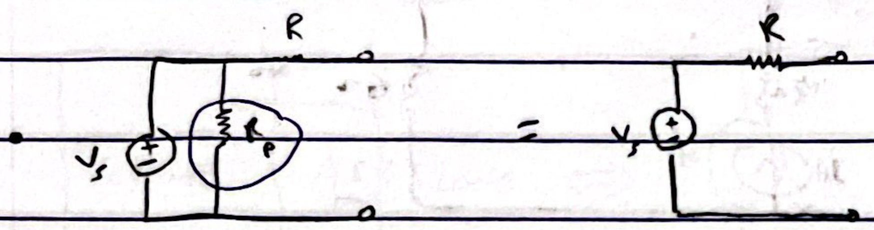


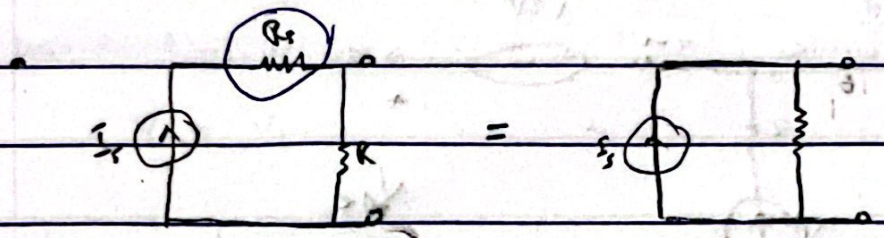
$-2198.625 i_D + 4157.89 i_D = 20$

$i_D = 0.0102 A$

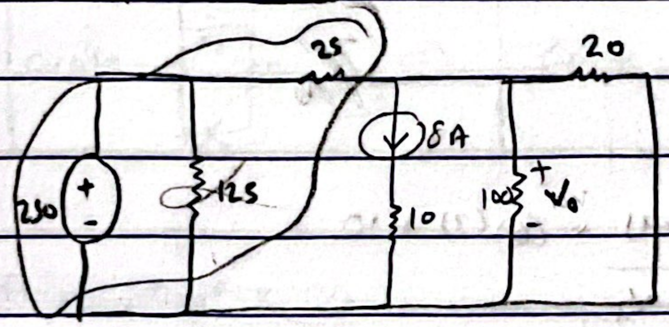
$= 10.2 mA$

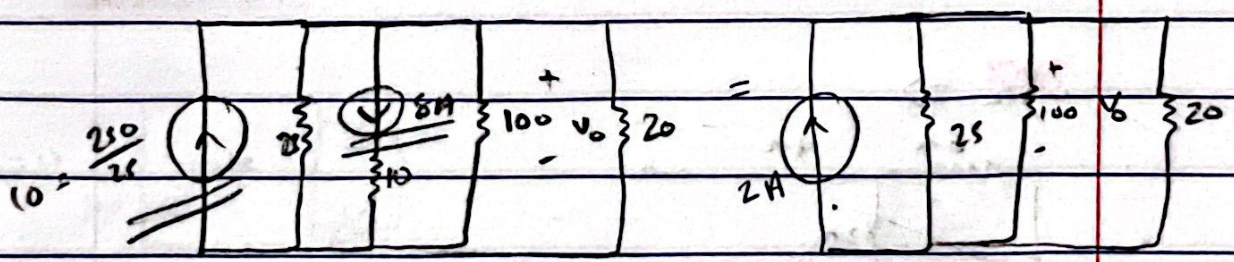
Special cases:





Ex:-

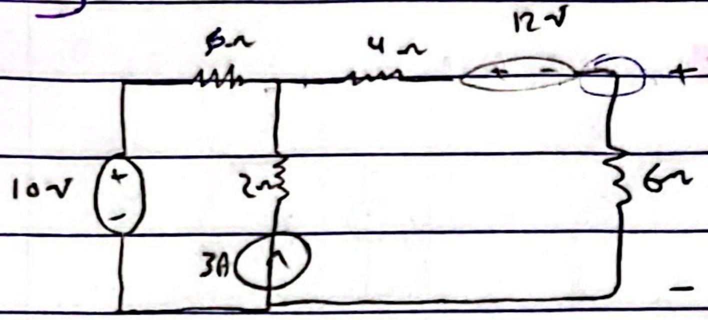




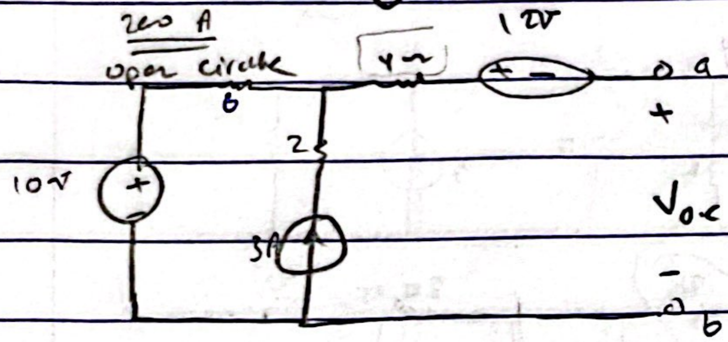
$$V_o = IR = I \times 100$$

$$V_o = \Bigg[\underbrace{\frac{(25 // 20)}{(25 // 20) + 100} \times 2}_{I} \Bigg] \times 100$$

Ex:-



⇓

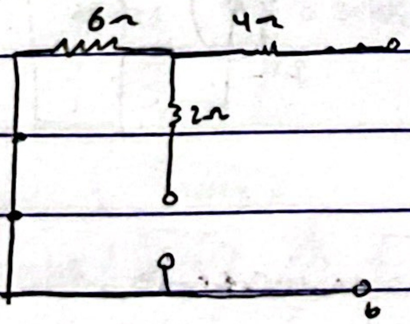


• $V_{th} = V_{oc}$

$V_{oc} = -12 + (0 \cdot 4) + (6)(3) + 10$

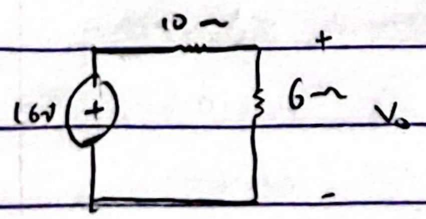
$\boxed{= 16\ V = V_{th}}$

• R_{th} =>



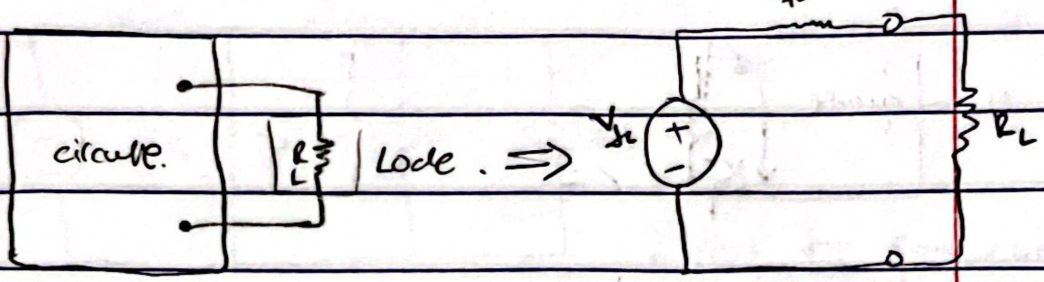
$R_{th} = 6 + 4 = 10\ \Omega$

So =>



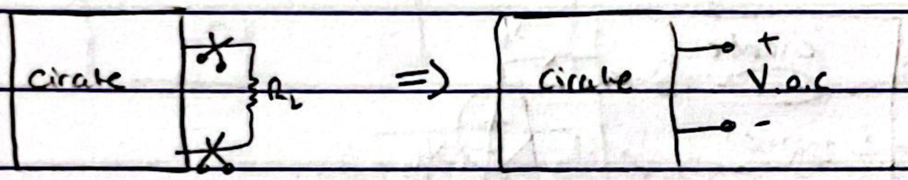
$V_6 = V_0 = \frac{6}{16} \cdot 16 = 6\ V.$

case II :- circute with dep. sources.



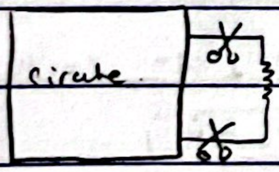
How to find V_{th} :-

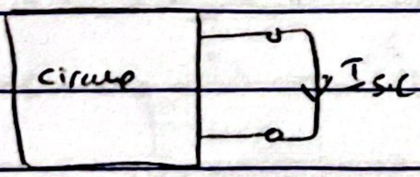
$V_{th} = V_{o.c}$



How to find R_{th} :-

Method A :-

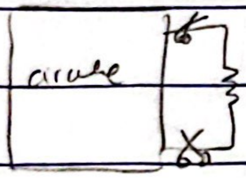
1) 

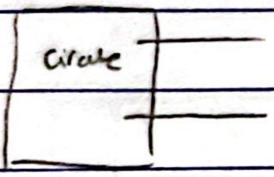
2) 

Find $I_{s.c}$

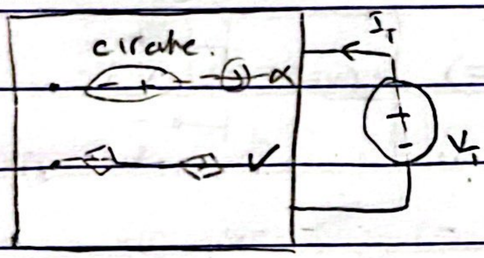
3) $R_{th} = \frac{V_{o.c}}{I_{s.c.}}$

Method B:- Test source methode.

1) 

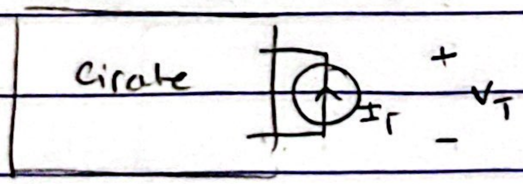
2) 

- kill all indep. sorces.
- leave all dep. sorces.

3) 

- use a test sorces: Voltage source.
  current source.

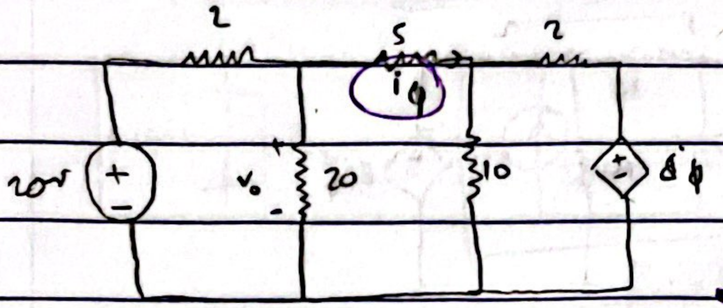
OR



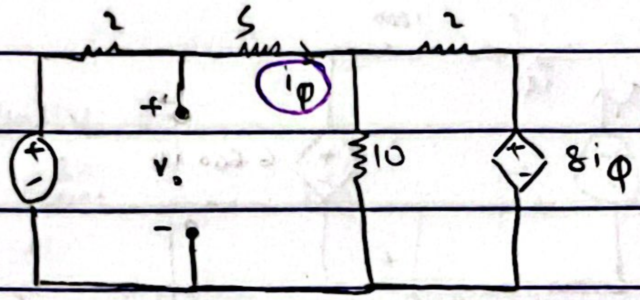
$$R_{th} = \frac{V_T}{I_T}$$

- all indep sorces let to zero.

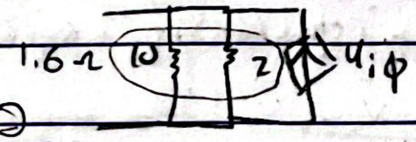
Ex:-

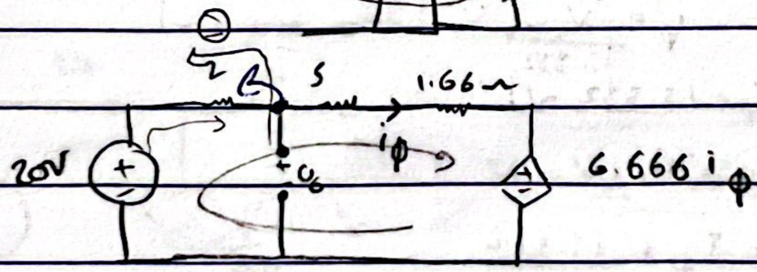


• not the same current



sources transformation.

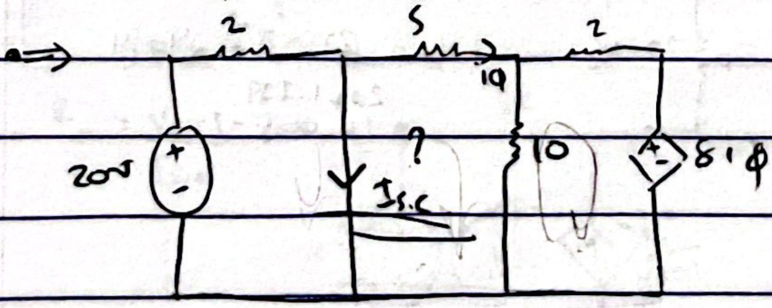




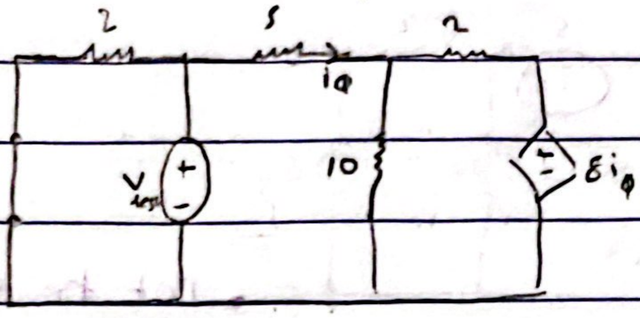
KVL $\Rightarrow$ $-20 + (2+5+1.666)i_\phi + 6.666\, i_\phi = 0$.

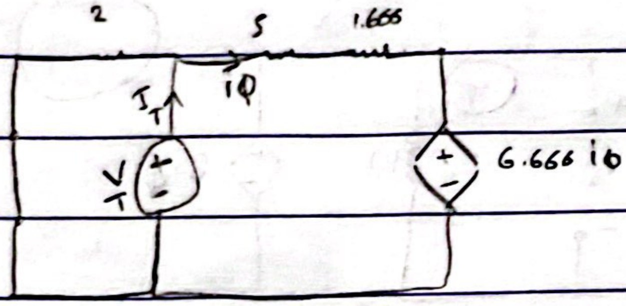
$\therefore i_\phi = 1.3\,A$

$\therefore V_{o.c} = V_{th} = 20-(1.3\times 2) = 17.4\,V$



⇒ Move to method B:





KVL ⇒ $-V_T + (5+1.666)i_\phi + 6.6666\, i_\phi = 0$

$$i_\phi = \frac{V_T}{13.332}$$

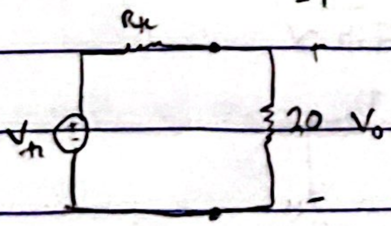
let $V_T = 13.332\ V$

$\therefore i_\phi = 1A$.

$\therefore I_T = I_\phi + \frac{13.332}{2}$

$= 1 + \frac{13.332}{2} = 7.666\,A$

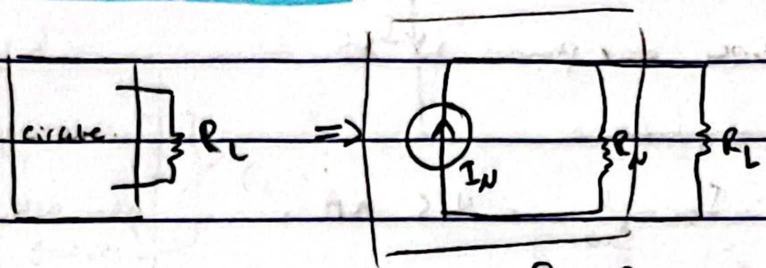
$\therefore R_T = \frac{V_T}{I_T} = 1.739$



$\therefore V_o = \frac{20}{20+1.739} \times 17.4$

$= 16.008\ V$

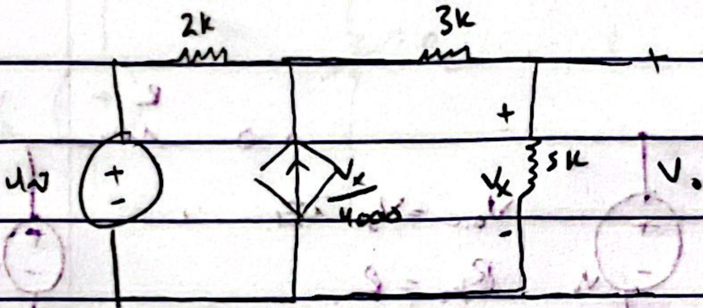
Norton eq circuit:

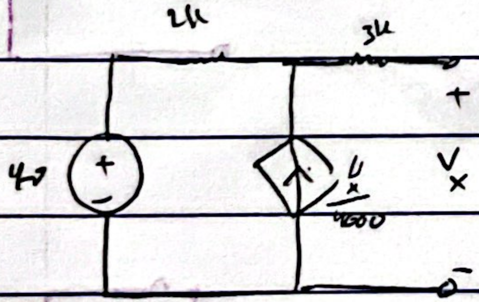


$R_N = R_{th}$

$I_N = I_{s.c}$

Ex: find V_o





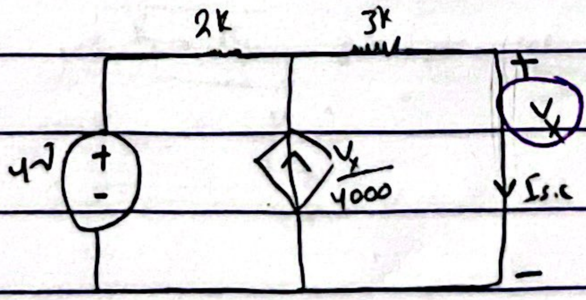
$\boxed{V_x = V_{th} = V_{o.c}}$

$\therefore V_{o.c} = \left(\frac{V_x}{4000}\right) 2k + 4 + (3 \times 0)$

$V_{th} = \frac{V_x}{2} + 4$

$\therefore V_{th} = 8V$

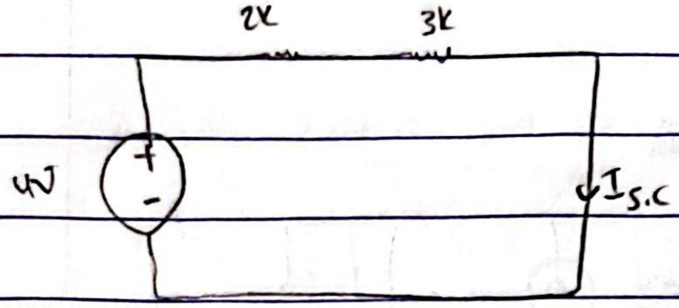
$R_{th} = \frac{V_{o.c}}{I_{s.c}}$



[illegible] short.c

2000 [illegible]

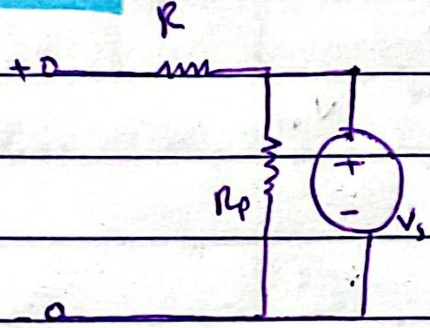
$\therefore V_x = 0$



$\therefore I_{s.c} = \frac{4}{5000} = 4/5$ mA.

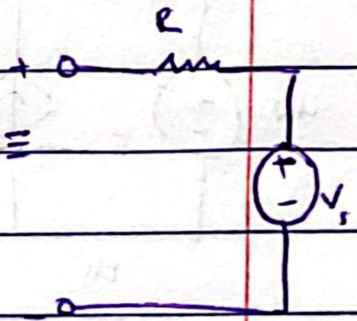
$\therefore R_{th} = \frac{8}{4/5\ m} = 10\ k\Omega$

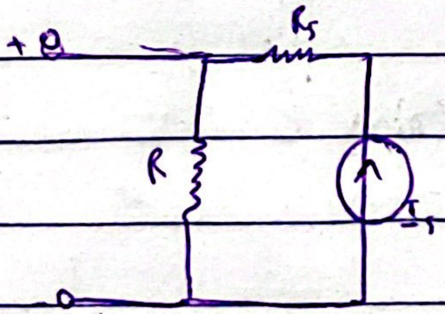
note:-



$V_{o.c} = V_s$ $\equiv$

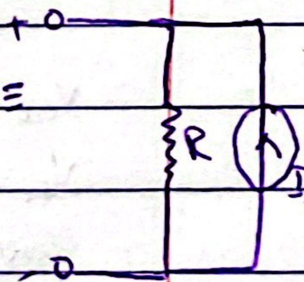
$R_{th} = R$.



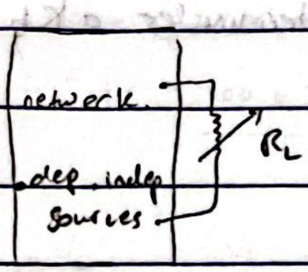


$I_s = I_p = I_{s.c}$ $\equiv$

$R_p = R_{th} = R$

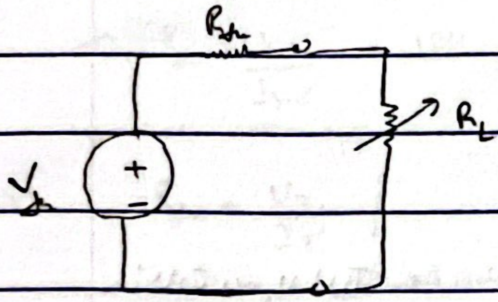


4.12 max power transfer:



⇓

thevin eq circuit.



$$P_{max} = i^2 R_L$$

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

$$\Rightarrow P_{max} = \frac{R_L}{(R_L + R_{th})^2} V_{th}^2$$

$$\frac{\partial P}{\partial R_L} = 0 , \quad \frac{\partial P}{\partial R_L} = \frac{(R_L + R_{th})^2 - 2R_L(R_L + R_{th})}{(R_L + R_{th})^4}$$

$\alpha V_{th}^2 = 0$

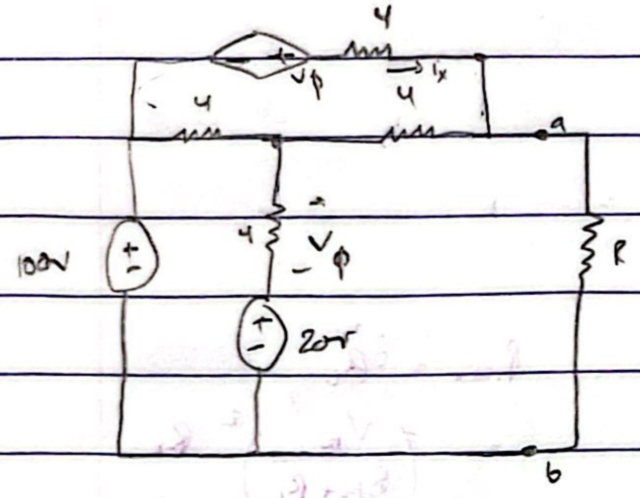
$$\Rightarrow \frac{\partial P}{\partial R_L} = \frac{V_{th}^2 (R_L^2 + \cancel{2R_L R_{th}} + R_{th}^2 - \cancel{2R_L^2} - \cancel{2R_L R_{th}})}{(R_L + R_{th})^4}$$

$$= R_{th}^2 - R_L^2 = 0$$

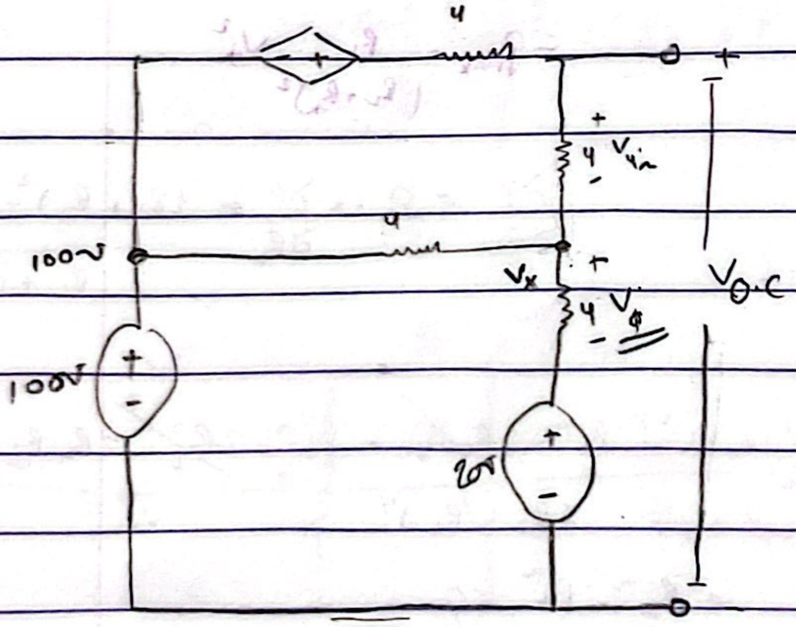
$\boxed{R_L = R_{th}}$ P in max when $R_L = R_{th}$

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

Ex:- find the value of R that enabels the circuit to deliver max.power to the terminales a & b and then find Pmax.



• $V_{th} = V_{o.c}$ خارة رسم للدارة!



node method $\Rightarrow \frac{V_x - 20}{4} + \frac{V_x - 100}{4} + \frac{V_x - 100 - V_\phi}{8} = 0$

But , $V_x = V_\phi + 20$

$\boxed{\therefore V_\phi = V_x - 20}$

$\therefore V_x = 80$ volt.

$\therefore V_{o.c} = V_{4\Omega} + V_x$

$\Rightarrow -100 - V_\phi - 8i_x + V_x = 0$. "to find I_x, KVL"

$\therefore i_x = \dfrac{100 + V_\phi - (V_x)(80)}{8} \Rightarrow I_x = 10\ A$.

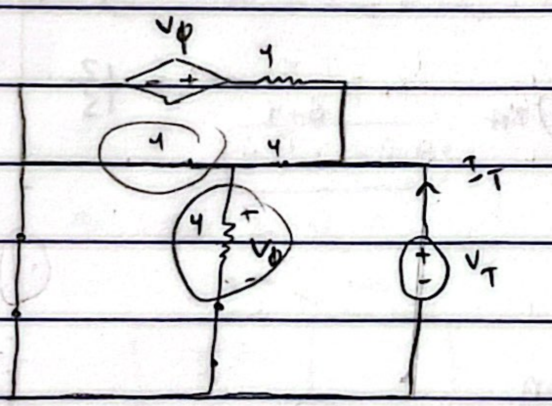
- $\therefore V_{o.c} = V_{4\Omega} + 80$

$= 10 \times 4 + 80 = 120\ V$.

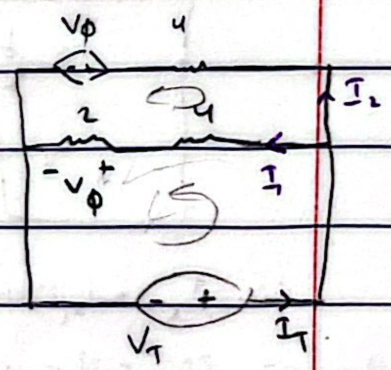
$\Rightarrow R_{th} = \dfrac{V_{o.c}}{I_{s.c}} = \dfrac{120}{}$

$\Rightarrow$. $R_{th} = \dfrac{V_T}{I_T}$ |

all indep. sources set to zero.



$\Rightarrow$



in parallel so same V_ϕ

$\hookrightarrow V_\phi = \dfrac{2}{2+4} V_T = \dfrac{2}{6} V_T$

let $V_T = 6\ V$, $\therefore V_\phi = 2$

$\therefore I_T = I_1 + I_2$

اوجد التيار في السهم عن طريق $\frac{V}{R}$

$= \dfrac{V_T}{6} + \dfrac{V_T - V_\phi}{4}$

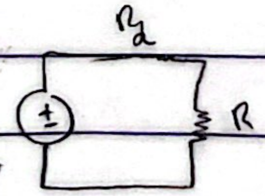
$= \dfrac{6}{6} + \dfrac{6-2}{4}$

$= 1 + 1 = 2A$

$\therefore R_{th} = \dfrac{V_T}{I_T} = \dfrac{6}{2} = 3\ \Omega$

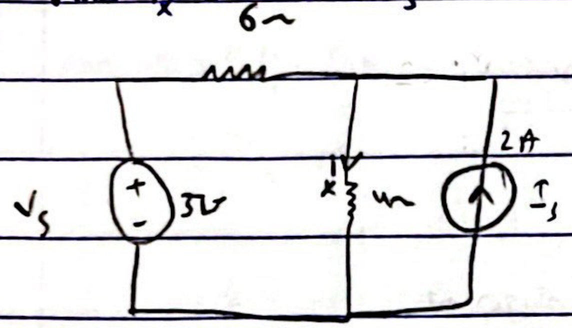
$\therefore P_{max} = \dfrac{V^2}{R} = \dfrac{60^2}{3} = 1.2\ kW$.

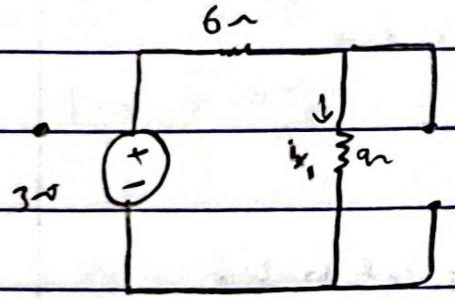
$V_{o.c} = V_{th}$ 120 V



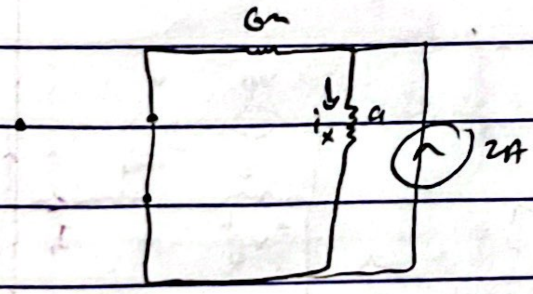
4.13 the super position.

Ex: find i_x due to V_s.





$i_{x_1} = \frac{3}{6+9} = \frac{3}{15} = \frac{1}{5}$ A.

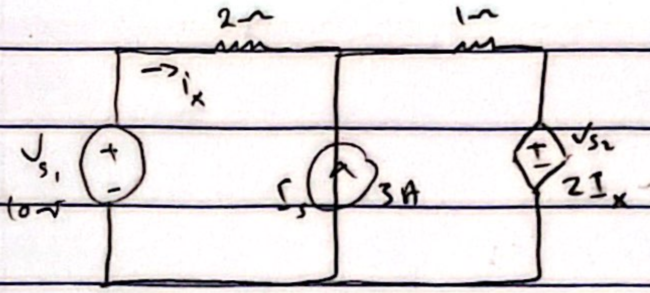


$i_{x_2} = \frac{6}{6+9} \times 2 = \frac{12}{15}$

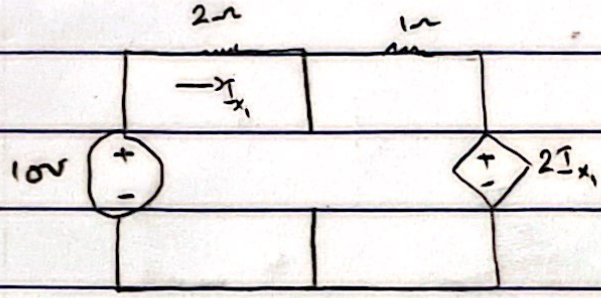
$\therefore I_x = i_{x_1} + i_{x_2}$

$= \frac{3}{15} + \frac{12}{15} = 1A$.

Ex:-



• I_{x_1} due to V_{s_1} :-

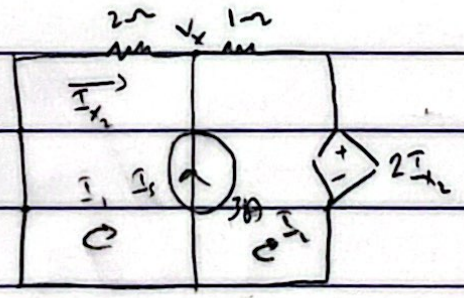


KVL ⟹ $-10 + 2I_x + 1I_{x_1} + 2I_{x_1} = 0$

$10 = 5I_{x_1}$

$\boxed{\therefore I_{x_1} = 2A}$

• I_{x_2} due to V_{s_2} :-



• mesh:-

• $2I_1 + 1I_2 + 2I_1 = 0$, $4I_1 + I_2 = 0$

• $I_2 - I_1 = 3A$

$4I_1 + 3 + I_1 = 0$

$5I_1 + 3 = 0$

$\therefore I_1 = \frac{-3}{5} = -0.6A$

• node:-

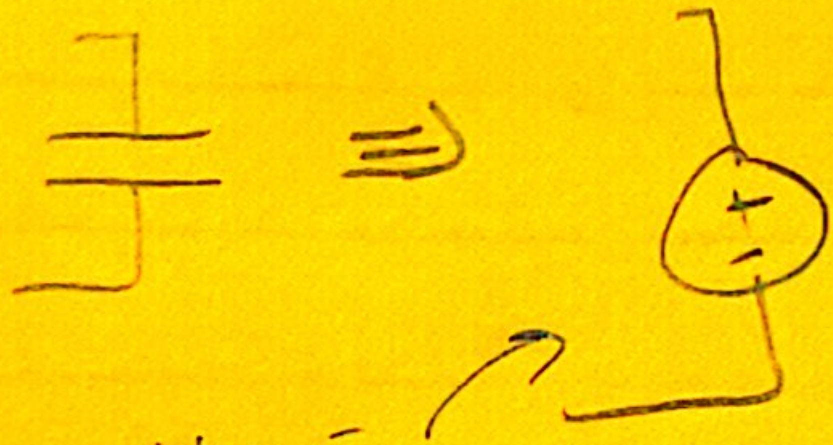
$\cdot I_x = \frac{-V_x}{2}$, $\frac{V_x}{2} - 3A + \frac{V_x - 2I_{x_2}}{1} = 0$

$\Rightarrow I_{x_2} = -0.6A$ $\quad \frac{V_x}{2} - 3 + V_x + \frac{2 \cdot V_x}{2} = 0$

$\frac{V_x}{2} - 3 + 2V_x = 0 \quad \therefore V_x = 1.2V$

$\therefore I_x = I_{x_1} + I_{x_2} = 2 - 0.6 = 1.4A$

• $v_c(0^-) = 10\,V$.



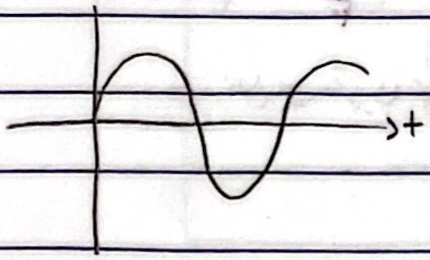
10V

at $t = 0^-$

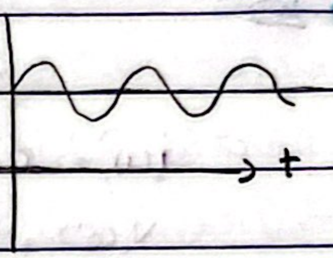
• $i(0^-) = 1\,A$

$\Downarrow$

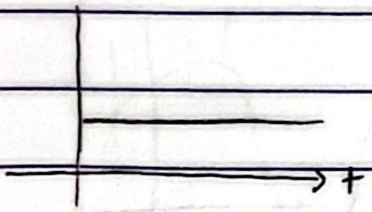
at $t = 0^-$.



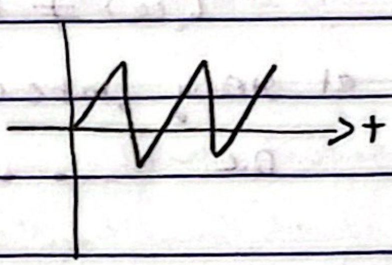
AC



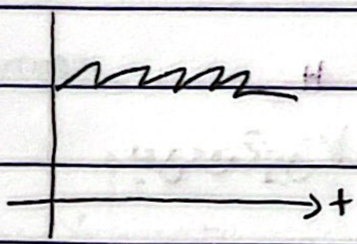
DC



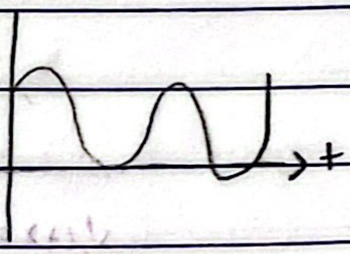
DC



AC



DC



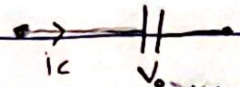
AC

DC:- just positive or negative only

AC:- positive and negative

DC

C



F

يعني بتخزن Voltage

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

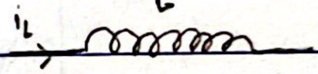
$$V_c(0^-) = V_c(0^+)$$

$$i_c(0^-) \neq i_c(0^+)$$

at steady_state ($t \to \infty$)

O.C

L



H

يعني بتخزن current

$$V_L(t) = L \frac{d}{dt} i_L(t)$$

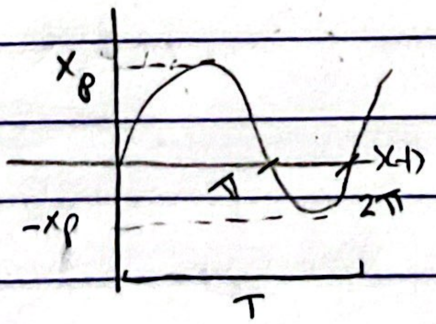
$$i_L(0^-) = i_L(0^+)$$

$$V_L(0^-) \neq V_L(0^+)$$

at steady_state ($t \to \infty$)

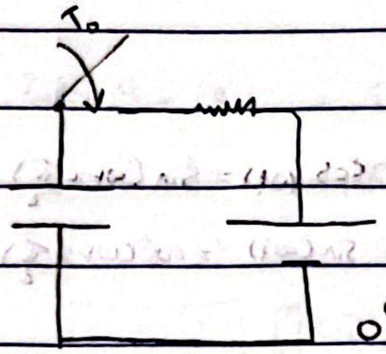
S.C

AC



- $f = \frac{1}{T}$ Hz
- $\underline{\underline{\omega}} = 2\pi f$

rad/sec



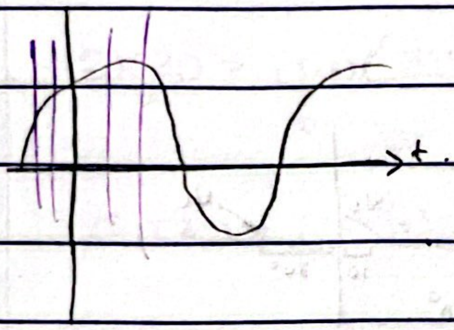
لحظة اغلاق المفتاح 0^+

قبل اغلاق المفتاح 0^-

⇐ في حالة ان C لم تكن مشحونة

يكون الجهد المخزن بلحظة $0^- = 0^+$

ويساوي 0 لانه غير مشحون.

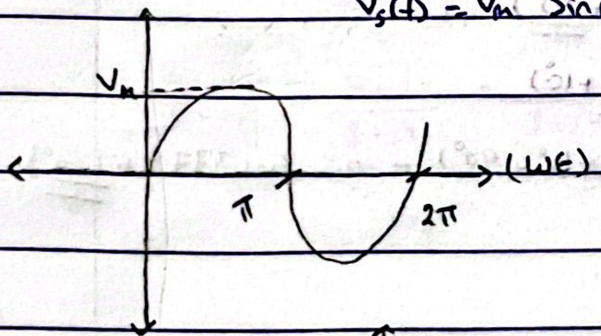


يمكن ان تكون هذه الموجة

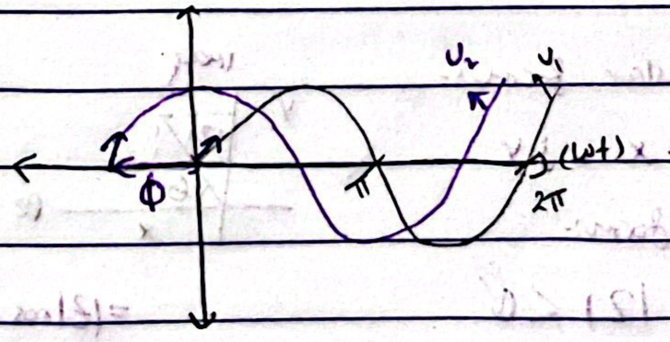
sin او cos حسب المحور العامودي.

chapter(9):-

$V_s(t) = V_m \sin(\omega t)$.



⇒

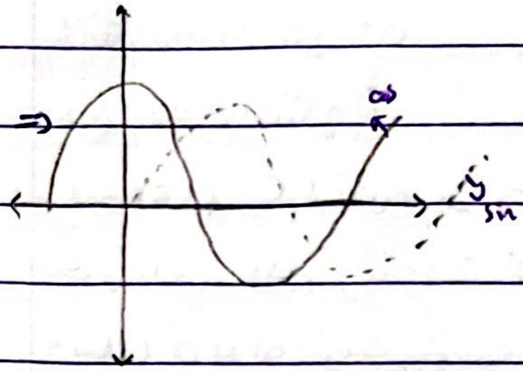


Leads **Lags**

$V_1(t) = V_m \sin(\omega t)$.

$V_2(t) = V_m \sin(\omega t + \phi)$.

- $V_2(t)$ leads $V_1(t)$ by ϕ



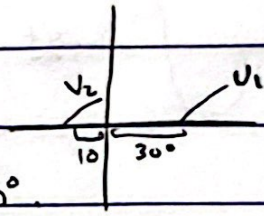
$\cos(\omega t) = \sin(\omega t + \frac{\pi}{2})$

$\sin(\omega t) = \cos(\omega t - \frac{\pi}{2})$

$\Rightarrow$ $V_1(t) = 10 \sin(5t - 30^\circ)$

$V_2(t) = 15 \sin(5t + 10^\circ)$

$\therefore V_2(t)$ leads $V_1(t)$ by 40°.



$\Rightarrow$ $i_1(t) = 2\sin(377t + \underline{\underline{45^\circ}})$

$i_2(t) = 0.5 \cos(377t + 10^\circ)$

$= 0.5 \sin(377t + 10^\circ + 90^\circ) = 0.5 \sin(377t + \underline{\underline{100^\circ}})$.

$\therefore i_2(t)$ leads $i_1(t)$.

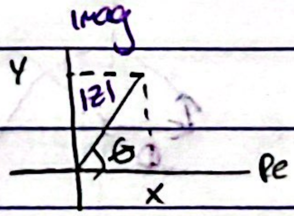
- Rectangular form:-

  $Z = X + jY$

- polar form:-

  $Z = |Z| \angle \theta$ $= |Z|\cos\theta + j|Z|\sin\theta$.

  $= \sqrt{X^2 + Y^2} \angle \tan^{-1}\frac{Y}{X}$.



- $|Z| e^{j\theta}$.

$e^{j\theta} = \cos\theta + j\sin\theta$.

$Z_1 = 4 + j3 \quad = 5 \angle 36.9°$

$Z_2 = 3 + j4 \quad = 5 \angle 53.1$

$\Rightarrow Z = 9 + j4 = 9.84 \angle 23.96°$

$\Rightarrow \boxed{\text{Pol}}\ \boxed{(}\ 9\ \boxed{,}\ 4\ \boxed{)}\ \boxed{=}$, RCL F to find θ

(9 , 4)

- $(Z_1)(Z_2) = (5 \times 5) \angle 36.9 + 53.1$

or

$(Z_1)(Z_2) = (4 + j3)(3 + j4)$. $\boxed{j\,j = -1}$

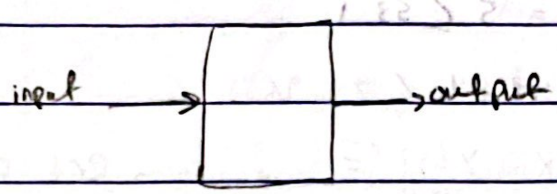
$\Rightarrow$ Same as i in deforashel

- $\frac{Z_1}{Z_2} = \left(\frac{5}{5}\right) \angle 36.9 - 53.1$

or

$\frac{Z_1}{Z_2} = \frac{4 + j3}{3 + j4} \cdot \frac{3 - j4}{3 - j4}$.

phasors:-



$f_{inp} = f_{out}$.

$\omega_{inp} = \omega_{out}$

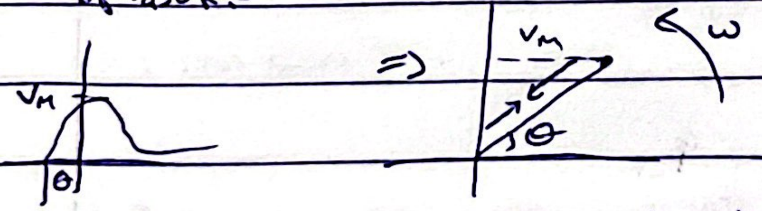
|| / $\angle\theta$ who get change.

phase shift = 0 $\Leftarrow$ in phase • في حالة البزيسية يكون

دالاشياء

• بعد أصلها بين الأمرين يكون out of phase.

• phasor:-



time domain phasor domain.

voltage current.

• let $i(t) = 6\cos(50t - 40°)$. A (time domain)

$\vec{I} = 6\angle{-40°}$ A (phaser).

• let $v(t) = -4\sin(30t + 50°)$ V

$= 4\cos(30t + 140°)$ V. إزالة السالب نهائيا ||

$\vec{V} = 4\angle 140°$ V.

$-4\cos(30t + 50° - 90°)$

$= -4\cos(30t - 40°)$ after that to remove (−) ±180°.

if $\vec{V_x} = 10\angle 120°$ V

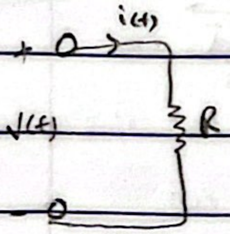
$f = 50$ Hz.

$10\cos(50(2\pi)t + 120°)$ V.

phasor relationships for circuit element.

Resistor:-

Time Domain:- phasor domain:-



$V(t) = i(t)R.$

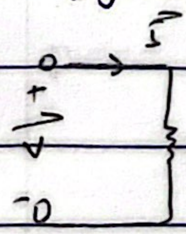
$V_m e^{j(\omega t + \theta_v)} = I_m e^{j(\omega t + \theta_i)} R.$

$V_m e^{j\theta_v} = I_m e^{j\theta_i} R.$

$V_m \angle\theta_v = I_m \angle\theta_i\ R$

$\vec{V} = \vec{I} \cdot R.$

phasor domain:-

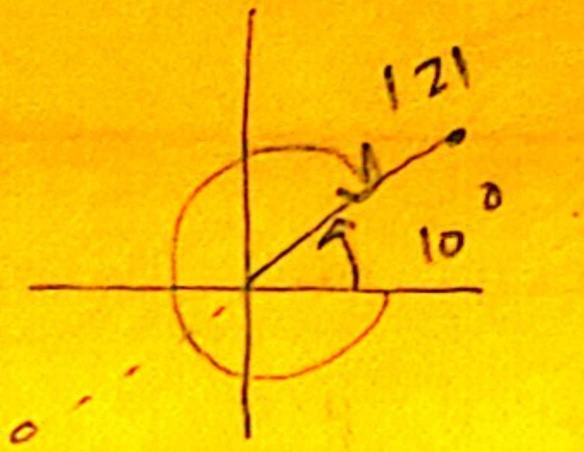


$\boxed{\theta_v = \theta_I}$

Voltage and current they are in phase.

$2\cos(\omega t + 10^\circ)$

$2\cos(\omega t - 350^\circ)$



$-2\cos(\omega t + 10^\circ)$

$+188$

$2\cos(\omega t + 190^\circ)$.

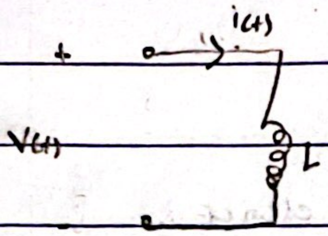
- $e^{j\theta} = \cos\theta + j\sin\theta$

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

$V_m e^{j(\omega t + \theta_v)}$.

Inductor:-

Time domain:-



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

$$V_m e^{j(\omega t+\theta_v)} = L\frac{d}{dt}\left(I_m e^{j(\omega t+\theta_i)}\right)$$

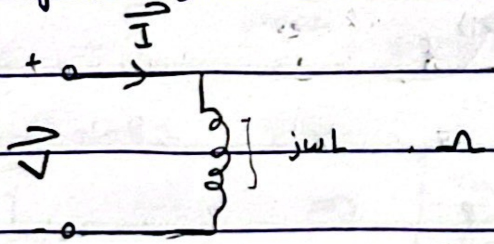
$$V_m \cancel{e^{j(\omega t+\theta_v)}} = L I_m (j\omega) \cancel{e^{j(\omega t+\theta_i)}}$$

$$V_m e^{\theta_v} = L I_m (j\omega) e^{j\theta_i}$$

$$V_m e^{j\theta_v} = (j\omega L) I_m e^{j\theta_i}$$

• $\vec{V} = (j\omega L)\, \vec{I}$

phasor domain:



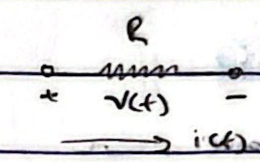
• $j\omega L = \omega L \angle 90^\circ$

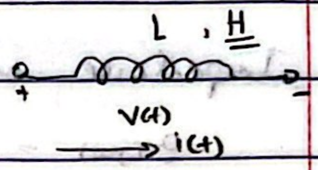
$$(V_m \angle \theta_v) = (j\omega L)(I_m \angle \theta_i)$$

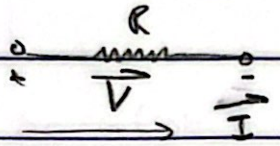
$$\theta_v = \theta_i + 90^\circ$$

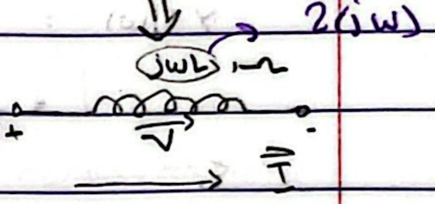
• i lags v by 90°

• v leads i by 90°

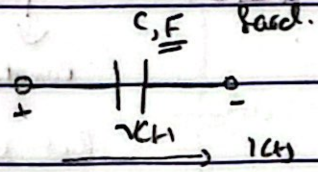
⇒ 

⇒ 

⇓ 

⇓ 

capacitor:-



Time domain.

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

$$I_m e^{j(\omega t+\theta_i)} = C \frac{d}{dt} V_m e^{j(\omega t+\theta_v)}$$

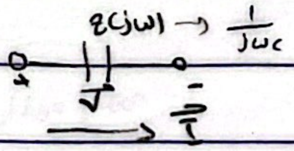
$$I_m \cancel{e^{j\omega t}} e^{j\theta_i} = C V_m j\omega \cancel{e^{j\omega t}} e^{j\theta_v}$$

$$I_m e^{j\theta_i} = j\omega C \, V_m e^{j\theta_v}$$

$$\vec{I} = (j\omega C)\,\vec{V}$$

$$\frac{\vec{V}}{\vec{I}} = \frac{1}{j\omega C} = \frac{-j}{\omega C} \ (\Omega)$$

phasor domain:-



$$\vec{V} = \left(-\frac{1}{\omega C} j\right) \vec{I}$$

$$\theta_i = \theta_v + 90°$$

$$\theta_v = \theta_i - 90°.$$

- i Leads v by 90°.
- v lags i by 90°.

Impedance and admittance :

$Z(j\omega) = \frac{\vec{V}}{\vec{I}}$ impedance , Ω

$Y(j\omega) = \frac{\vec{I}}{\vec{V}}$ Admittance , $\mho$

$= \frac{1}{Z(j\omega)}$

$\hookrightarrow Z(j\omega) = \frac{\vec{V}}{\vec{I}} = \frac{V_m \angle \theta_v}{I_m \angle \theta_i} = \underbrace{\frac{V_m}{I_m} \angle \theta_v - \theta_i}_{\text{complex}}$

V, C just the phasor. $= R + jI_m$

$= R + jX$ But Not A phasor !!!

$R \to R$, $X \to C$ ($-v_e$), L ($+v_e$)

$\to Z(j\omega) = \frac{\vec{V}}{\vec{I}} = \frac{V_m}{I_m} \angle \theta_v - \theta_i$

$= R + jX$

R = Resistive part.

X = Reactive part.

$\hookrightarrow Z(\omega) = |Z| \angle \theta_z$

$= R + jX$.

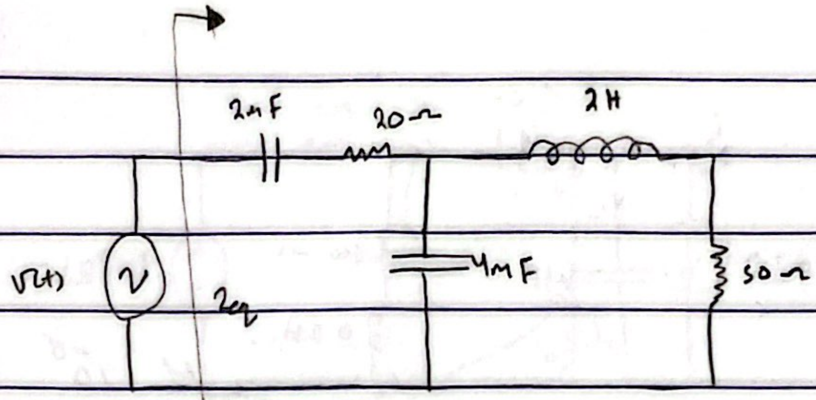
$|Z(\omega)| = \sqrt{R^2 + X^2}$

$\theta_z = \tan^{-1} \frac{X}{R}$

$R = |Z| \cos \theta_z$

$X = |Z| \sin \theta_z$

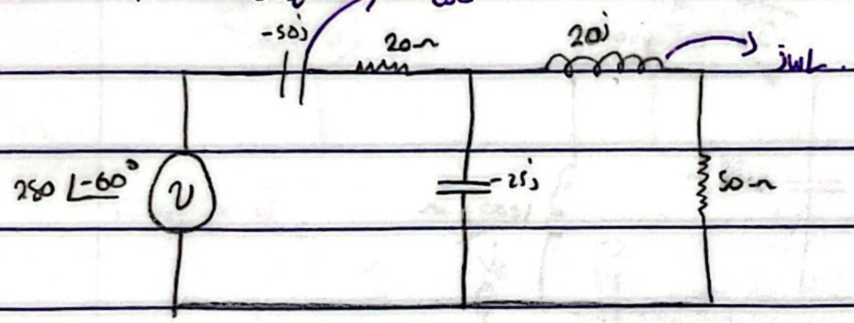
Ex:-



$v(t) = 280 \sin(10t + 30^\circ) = 280 \cos(10t + 30 - 90)$

$= 280 \cos(10t - 60^\circ)$

Find Z_{eq}. $\frac{-j}{wC}$

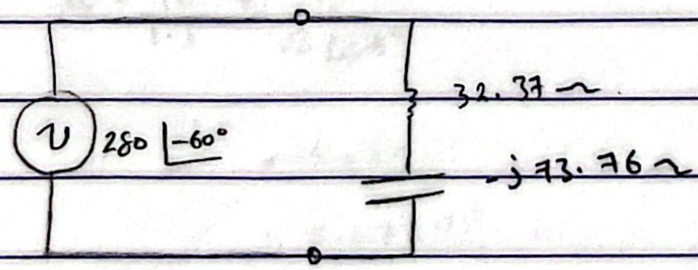


$Z_{eq} = (50 + 20j) // (-25j) + (20 - 50j)$

$= \left[\frac{500 - 1250j}{50 - 5j} \right] + (20 - 50j)$

$= \left(\frac{1346.29 \angle -68.2^\circ}{50.249 \angle -5.71^\circ} \right) + (20 - 50j)$

$= 32.37^\circ - j73.76\ \Omega$

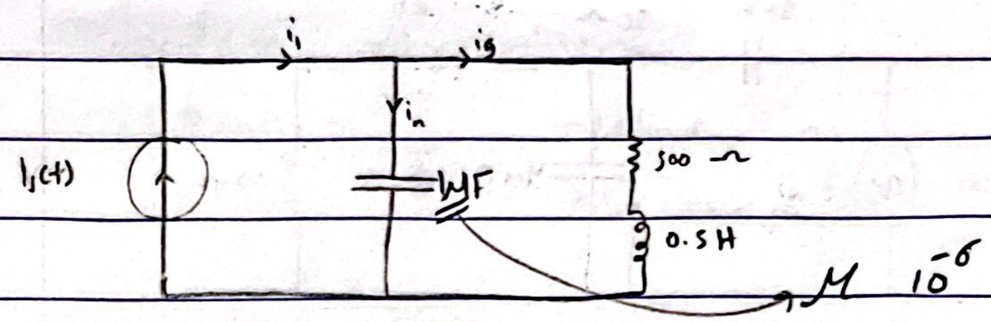


- $\frac{1}{wC} = 73.76$

  $\frac{1}{10C} = 73.76$

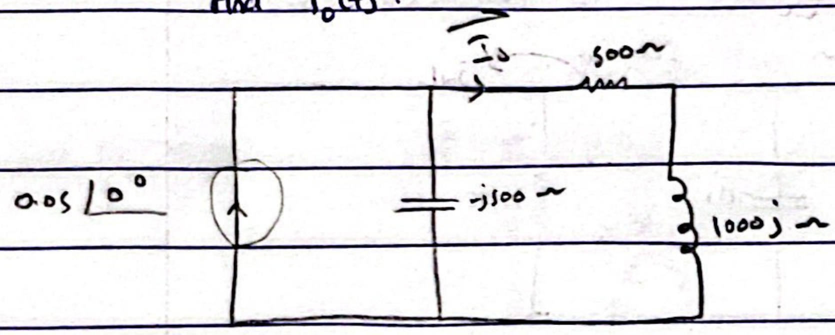
- $C = \frac{1}{737.6}\ F$

Ex:-



if $I_1(t) = 0.05\cos(2000t)$ A.

find $I_0(t)$.



$$\vec{I}_0 = \frac{-500j}{j1000 + 500 - 500j} \cdot (0.05)$$

$$= \frac{-500j}{500j + 500} \cdot (0.05)$$

$$= 0.03535 \angle -135^\circ \text{ A}.$$

$I_0(t) = 0.03535\cos(2000t - 135^\circ)$ A.

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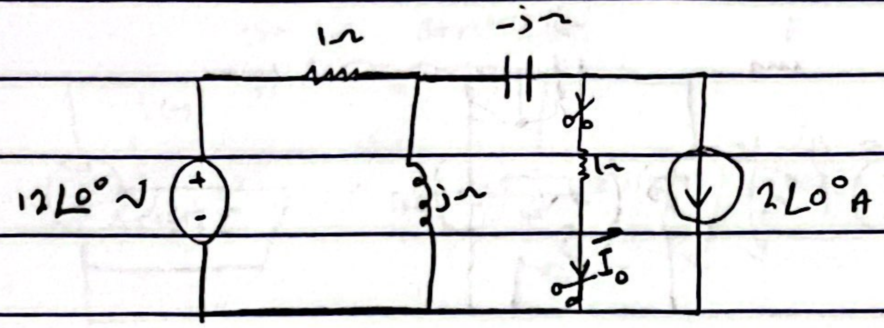
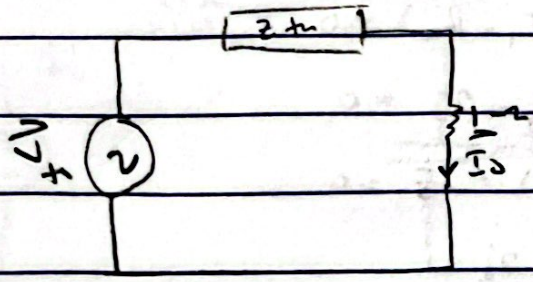
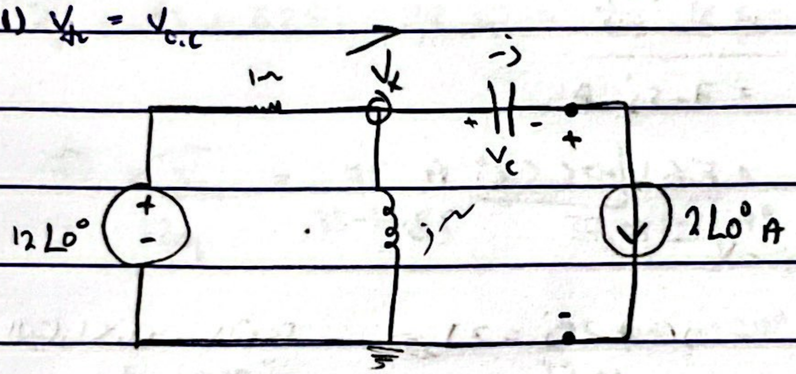
Ex:-





1) $V_{th} = V_{o.c}$



Nodal:-

$$\frac{\vec{V}_x - 12}{1} + \frac{\vec{V}_x}{j} + 2 = 0$$

$$\vec{V}_x (1 - j) = 10$$

$$V_x = \frac{10}{1-j} = \frac{10}{\sqrt{2}\angle -45^\circ}$$

$$= 5 + j5$$

$$= 7.07\angle 45^\circ \ V$$

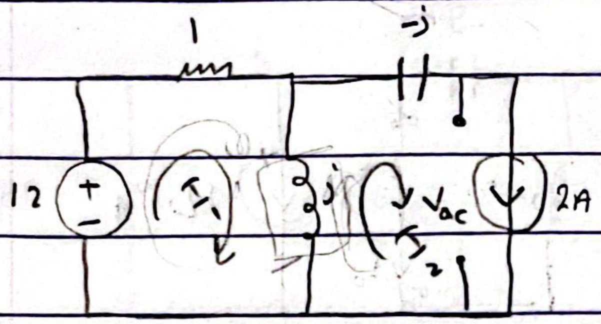
$$V_{th} = V_{oc} = V_x - V_c$$

$$= 5 + j5 - (2)(-j)$$

$$= 5 + 7j$$

$$= 8.6\angle 54.46^\circ \text{ Volt}$$

Mesh:



$\boxed{I_2 = 2A}$

$\rightarrow -12 + I_1 + j(I_1 - I_2) = 0$

$-12 + I_1 + jI_1 - 2j = 0$

$-12 + I_1(j+1) - 2j = 0$

$\Rightarrow I_1 = \dfrac{12+2j}{1+j}$

$= 7 - 5j \ A$

$= 8.6 \angle -35.53^\circ \ A$

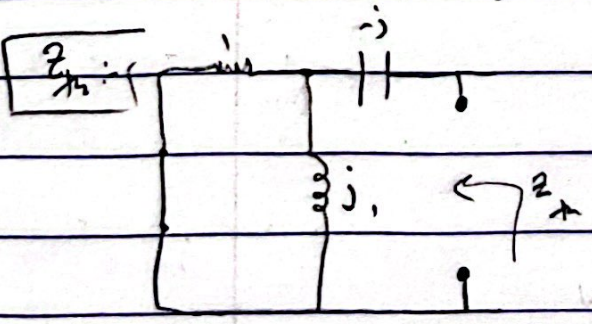
$V_{oc} = V_{j} - V_c$

$= 2j + j(7 - 5j - 2)$ التيار الكلي - التيار super mesh.

$= 2j + j(5 - 5j)$

$= 2j + 5j + 5$

$= 5 + 7j$ Volt.



$Z_{th} = (1 // j) - j$

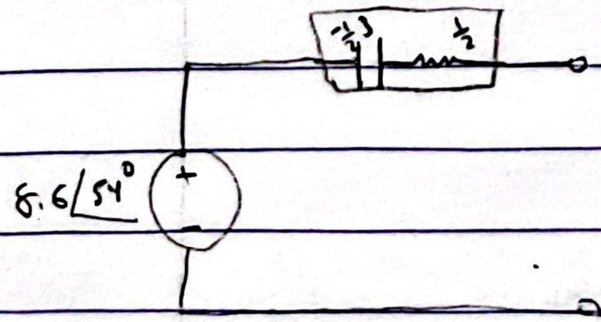
$= \dfrac{j}{j+1} - j$

$= \dfrac{1 \angle 90^\circ}{\sqrt{2} \angle 45^\circ} - j$

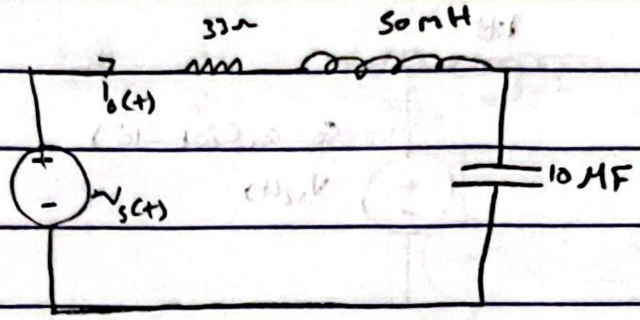
$= \dfrac{1}{\sqrt{2}} \angle 45^\circ - j$

$= \dfrac{1}{2} + \dfrac{1}{2}j - j$

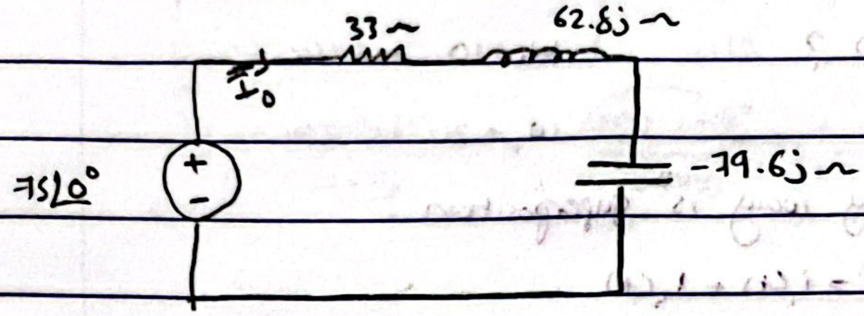
$= \dfrac{1}{2} - \dfrac{1}{2}j$



Ex:-



$v_{s}(t) = 75\cos(400\pi t)$



$\boxed{\mu = 10^{-6}}$

$Z_{th} = 33 + 62.8j - 79.6j = \underline{33 - 16.8j}$ complex.

$$\vec{I_o} = \frac{\vec{V_s}}{Z_{eq}} = \frac{75}{33-16.8j} = \frac{75\angle 0^\circ}{37.03\angle -26.9^\circ}$$

$$= \frac{75}{37.03}\angle 0^\circ - -27^\circ$$

$$= 2.03\angle 27^\circ \ A.$$

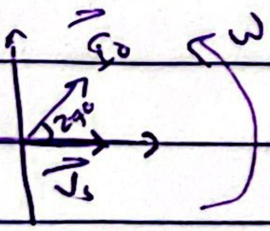
I_o leads $\vec{V_s}$ by 27°.

- $V_R = R I_o$

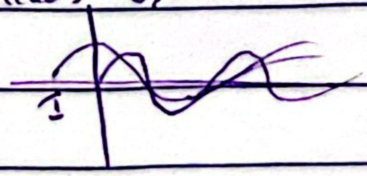
  $= 33 \cdot 2.03\angle 27^\circ$

  $= 67\angle 27^\circ$ V . "$\theta_v = \theta_i$".

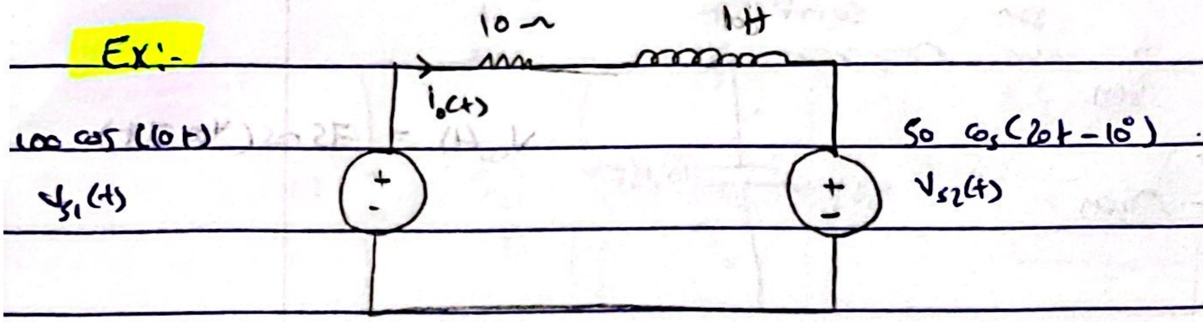
- $V_L = (62.8j)\vec{I_o} = 127\angle 117^\circ$ V $\Rightarrow$ "$\theta_v - \theta_i = 117 - 27 = 90^\circ$"
- $V_C = 162\angle -63^\circ$ V $\Rightarrow$ "$\theta_v - \theta_i = -63 - 27 = -90^\circ$"



I_o leads $\vec{V_s}$



Ex:-



find $i_o(t)$?

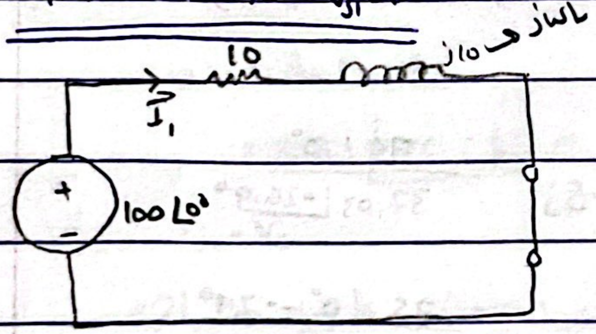
$\omega_1 = 10$ rad / sec

$\omega_2 = 20$ rad / sec

The only way is superposition.

$i_o(t) = i_1(t) + i_2(t)$.

$i_1(t)$ due to $v_{s1}(t)$.

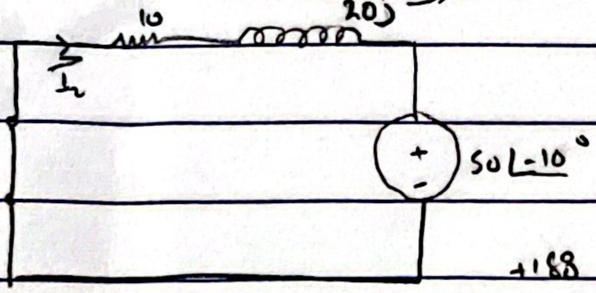


$\vec{I}_1 = \frac{100\angle 0°}{10 + 10j} = \frac{100\angle 0°}{14.14\angle 45°} = 7.07\angle -45°$ A.

$\therefore i_1(t) = 7.07 \cos(10t - 45°)$ A

$i_2(t)$ due to $V_{s2}(t)$

$20j \rightarrow j\omega L$



+180

$$\vec{I}_2 = \frac{-V_{s2}(t)}{10+10j} = \frac{-50\angle -10°}{10+10j} = \frac{50\angle 170°}{10+20j}$$

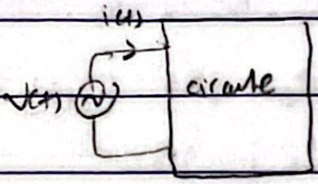
$$= \frac{50\angle 170°}{22.36\angle 63.43}$$

$$= 2.24\angle 106.57° \ A.$$

$\therefore i_2(t) = 2.24\cos(20t + 106.57°)\ A$

$\therefore i_o(t) = 7.07\cos(10t - 45°) + 2.24\cos(20t + 106.57°)\ A.$

chapter (10) :- power calculation.



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

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

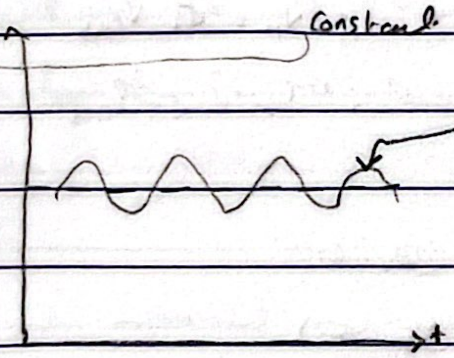
→ instantaneous power $p(t)$.

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

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

$= \underbrace{\frac{1}{2} V_m I_m \cos(\theta_v - \theta_i)}_{\text{constant}} + \underbrace{\frac{1}{2} V_m I_m \cos(2\omega t + \theta_v + \theta_i)}_{\text{function of time}}$

twice the operating freq.



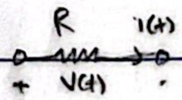
→ Average power.

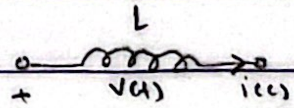
Real power.

$P_{av} = \frac{1}{T}\int_0^T p(t)\,dt = \frac{1}{2} V_m I_m \cos(\theta_v - \theta_i)$

$\theta_v - \theta_i = \theta_z$

$$\boxed{\therefore P_{av} = \frac{1}{2} V_m I_m \cos(\theta_v - \theta_i)} \quad W_{\text{watt}}$$

→ 

→ 

$\theta_v - \theta_i = 0$, $\theta_z = 0$

$\cos(\theta_v - \theta_i) = 1$

$\therefore P_{av} = \frac{1}{2} V_m I_m$

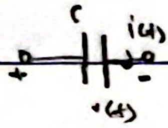
$= \frac{1}{2}\frac{V_m^2}{R} = \frac{1}{2} I_m^2 R$

$\theta_v - \theta_i = 90°$

$\theta_z = 90°$ $(j\omega L)$

$\cos(90°) = 0$

$\therefore P_{av} = \text{zero}$

→  , $\theta_v - \theta_i = -90°$.

$\theta_Z = -90°$ $\left(\frac{-j}{wC}\right)$

$\cos(-90°) = 0$

$\therefore P_{avg} = \text{zero}.$

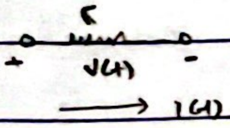
→ Effective of rms value.
root mean squer.

$V_{eff} = V_{rms} = \frac{V_m}{\sqrt{2}}$, $V_m = \sqrt{2}\, V_{rms}$

$I_{eff} = I_{rms} = \frac{I_m}{\sqrt{2}}$, $I_m = \sqrt{2}\, I_{rms}$

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

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

 , $P_{avg} = V_{rms} I_{rms} \cos(0)$

$= V_{rms} I_{rms}$

$= \frac{V_{rms}^2}{R}$

$= I_{rms}^2 R$

Apparent power and power factor.

$$P_{av} = \underbrace{V_{rms}\ I_{rms}}_{\text{Apparent power}}\ \underbrace{\cos(\theta_v - \theta_i)}_{\text{Power factor}}$$

Apparent power: P_a "VA" (الوحدة)

Power factor: PF

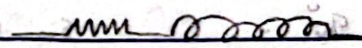
$P_{av} = P_a P_f$

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

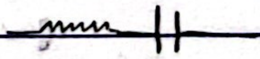
→ P_f of R is 1 "unity P_f"

→ P_f of L is 0

→ P_f of C is 0°

-  : $90^{\circ} > \theta_v - \theta_i > 0$

  $1 > \cos\theta > 0$ lagging PF.

-  $0 > \theta_v - \theta_i > -90^{\circ}$

  $1 > \cos\theta > 0$ leading PF.

  - depend on the current.

Complex power. $\vec{S}$

$\vec{S} = \vec{V}_{rms}\ \vec{I}^{*}_{rms}$ المرافق

- $\vec{V}_{rms} = V_{rms} \angle \theta_v$
- $\vec{I}_{rms} = I_{rms} \angle \theta_i$

$\vec{S} = (V_{rms} \angle \theta_v)(I_{rms} \angle \theta_i)$

(Polar form) $= V_{rms}\ I_{rms} \angle \theta_v - \theta_i$ "VA" الوحدة

(Rectangular form) $= \underbrace{V_{rms}\ I_{rms} \cos(\theta_v - \theta_i)}_{\text{Average power (W)}} + j\underbrace{V_{rms}\ I_{rms} \sin(\theta_v - \theta_i)}_{Q}$

Q: Reactive Power (VAR)

$\therefore \vec{S} = P + jQ$

P: W, Q: VAR

$\rightarrow P_{av} = Re\{\vec{S}\}$, $\rightarrow Q = I_{mag}\{\vec{S}\}$

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

$Q = j\ V_{rms} I_{rms} \sin(\theta_v - \theta_i)$

$\vec{S} = \sqrt{P_{av}^2 + Q^2} \angle \tan^{-1} \frac{Q}{P_{av}}$

note:-

R	L	C
$\theta_v - \theta_i = 0$	$\theta_v - \theta_i = 90^\circ$	$\theta_v - \theta_i = -90^\circ$
$\cos 0 = 1$	$\cos 90^\circ = 0$	$\cos -90 = 0$
$\sin 0 = 0$	$\sin 90^\circ = 1$	$\sin(-90^\circ) = -1$
$P_{av} = V_{rms} I_{rms}$	$P_{av} = 0$	$P_{av} = 0$
$Q = 0$	$Q_L = V_{rms} I_{rms}$	$Q_c = -V_{rms} I_{rms}$
$P_{av} = \frac{V_{rms}^2}{R} = I_{rms}^2 R$	$V_{rm} = (wL) I_{rms}$	$V_{rm} = (\frac{-1}{wc}) I_{rms}$
	$Q_L = (wL) I_{rms}^2 = \frac{V_{rms}^2}{wL}$	$Q_c = \frac{-I_{rms}^2}{wc} = -V_{rms}^2 (wc)$
	$\rightarrow X_L = wL$	$\rightarrow X_c = \frac{-1}{wc}$

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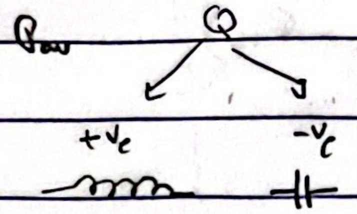
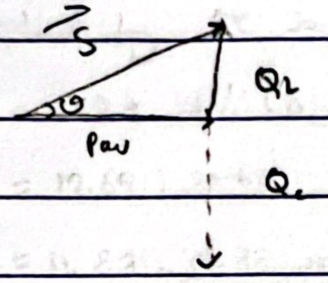
Power Triangle

$\vec{S}$



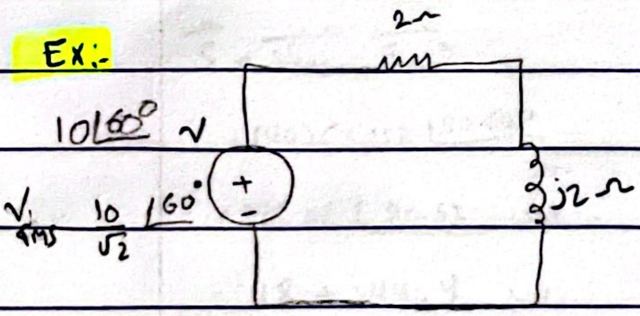


- $\vec{S} = V_{rms} I_{rms} \angle \theta_v - \theta_i$
- $\cos\theta = \dfrac{P_{av}}{|\vec{S}|} = P.F$
- $P_a = |\vec{S}| = \sqrt{P_{av}^2 + Q^2}$

$\tan\theta = \dfrac{Q}{P_{av}}$

$\theta = \tan^{-1} \dfrac{Q}{P_{av}}$

Ex:-



find the avg power absorbed by each element.

$\vec{I}_{rms} = \dfrac{10/\sqrt{2} \angle 60^\circ}{2 + 2j} = 2.5 \angle 15^\circ$ A

- P_{av} del $= V_{rms} I_{rms} \cos(\theta_v - \theta_i)$.

$= \left(\dfrac{10}{\sqrt{2}}\right)(2.5) \cos(60^\circ - 15^\circ)$

$= 12.5$ W.

- $|\vec{S}| = \vec{V}_{rms} \vec{I}^*_{rms} = \left(\dfrac{10}{\sqrt{2}} \angle 60^\circ\right)(2.5 \angle -15^\circ)$.

$= 12.5 + 12.5j$

- $P_{av} + jQ$.

$Q_L = V_{rms_L} I_{rms_L} \sin(\theta_{V_L} - \theta_{I_L})$

- $\vec{V}_{rms_L} = \frac{j2}{j2+2} \cdot \frac{10}{\sqrt{2}} \angle 60^\circ$

$= -1.294 + j4.829$

$= 5 \angle 105^\circ \quad V_{rms}$

$Q_L = (5)(2.5) \sin(105-15)$

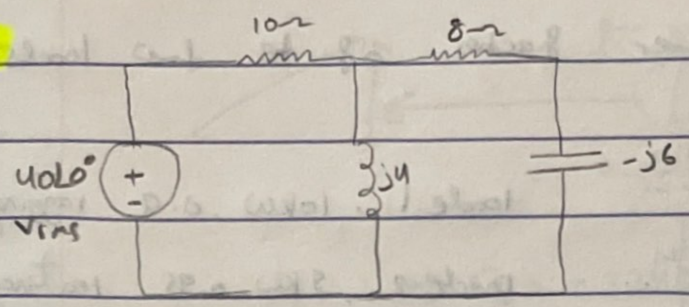
$= 12.5$ VAR

$Q_L = I_{rms}^2 X_L$

$= (2.5)^2 (2)$

$= 12.5$ VAR.

Ex:-



calculate the PF seen by the sourse and the avg power supplied by the sourse.

- $Z_{in} = 10 + j4 // (8 - j6)$

$= 12.69 \angle 20.62° \ \Omega$

$= 11.87 + j4.47 \ \Omega$

- $\vec{I}_{rms} = \dfrac{40\angle 0°}{12.69\angle 20.62°} = 3.152\angle -20.62° \ A$

- $\vec{S} = \vec{V}_{rms}\ \vec{I}_{rms}^{*}$

$= (40)(3.152\angle 20.62°)$

$= 126.08 \angle 20.62 \ VA$

$= 118 + j44.4 \ VA$

- $P_{av} = Re\{\vec{S}\} = 118 \ VA$

1) $PF = \cos\theta = \cos(\theta_v - \theta_i)$

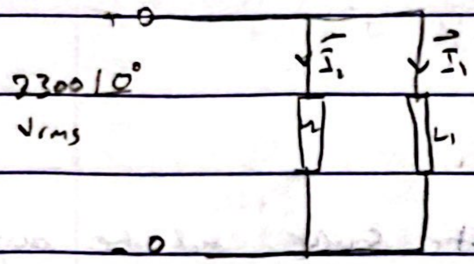
$= \cos(\tan^{-1}\frac{Q}{P})$

two way $= \cos \tan^{-1}\left(\frac{44.4}{118}\right)$

$= 0.937$ lagging

2) $PF = \cos(\theta_v - \theta_i) = \cos(0 + 20.62°) = 0.937°$ lagging.

Ex:- Find the power factor of the two loads.



load 1, 10kW, 0.9 lagging PF

load 2, 5kW, 0.95 leading PF

- **load 1**

P_{av}, PF = 0.9 lagging

$P_{av} = V_{rms} I_{rms}$ P.F

$10{,}000 = 2300\ I_{rms}(0.9)$

$\therefore I_{rms} = 4.83\,A$.

$\vec{I}_{rms} = 4.83\angle -\cos^{-1}0.9\ A$

$= 4.83\angle -25.84^\circ\ A$.

- **load 2**

$\vec{I}_{2rms} = \dfrac{5000}{2300 \cdot 0.95}\angle +\cos^{-1}0.95$

$= 2.282\angle 18.195^\circ\ A_{rms}$.

$\vec{I}_{tot} = \vec{I}_{1rms} + \vec{I}_{2rms} = 6.78\angle -12\ A_{rms}$.

- $PF = \cos(\theta_v - \theta_i)$

$= \cos(0 - (-12))$

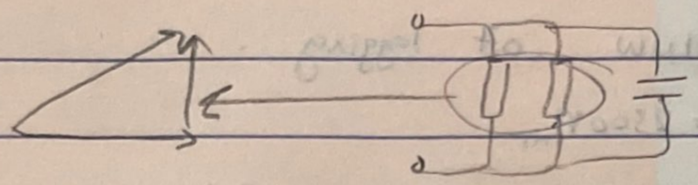
$= 0.978$ lagging

- $\vec{V} = 2300\angle 0^\circ$.
- $\vec{I} = 6.78^\circ\angle -12^\circ$

$\vec{S} = (2300\angle 0^\circ)(6.78\angle -12^\circ)$

$= 15253.23 + j3242.17$.

:x3



$-||- \Rightarrow Q_c = -3242.17$ VAR.

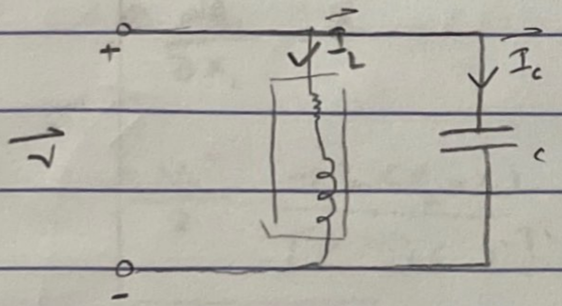
$\vec{I}_{rms\,new} \Rightarrow \quad \vec{S}_{new} = \vec{I}^*_{rms}\ \vec{V}_{rms}$

$15253.23 = \vec{I}^*_{rms}\,(23000\angle 0)$

$\therefore \vec{I}^*_{rms} = 6.63\angle 0^\circ$

$\vec{I}_{rms} = 6.63\angle 0^\circ$.

power factor correction:-



$PF = \cos(\theta_v - \theta_i)$.

R —mm— $PF = 1$.

$Q_c = Q_{final} - Q_{init}$.

✓ ω

$Q_c = \dfrac{V_{rms}^2}{X_c} = -\omega C\, V_{rms}^2$.

$\therefore C = -\dfrac{Q_c}{\omega V_{rms}^2}$.

Ex:-

$P = 1\,MW$, 0.7 lagging.

$V = 2300\,V_{rms}$.

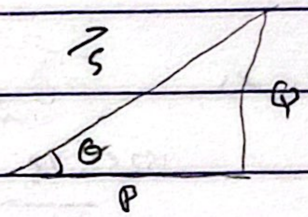
~~45~~

page

من تصميم الاجابة

$C = ??$ $\qquad PF_{new} = 0.9$ lagging.

$\omega = 377$ rad/sec.



$\tan\theta = \frac{Q}{P}$

$Q = P\tan\theta$

$Q = P\tan\cos^{-1}PF$

- $Q_{init} = (1\times10^{6})\tan\cos^{-1}0.7$

$= 1.02\,M\ VAR$.

- $Q_{Final} = (1\times10^{6})\tan\cos^{-1}0.9$

$= 0.484\,M\ VAR$.

$Q_c = Q_{Final} - Q_{init}$.

$= -0.536\,M\ VAR$.

$\therefore C = \frac{-Q_c}{\omega V_{rms}^2} = 269\,\mu F$.

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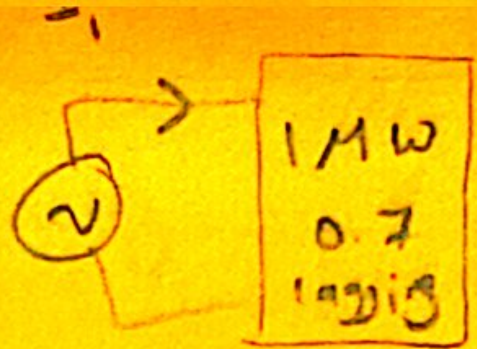
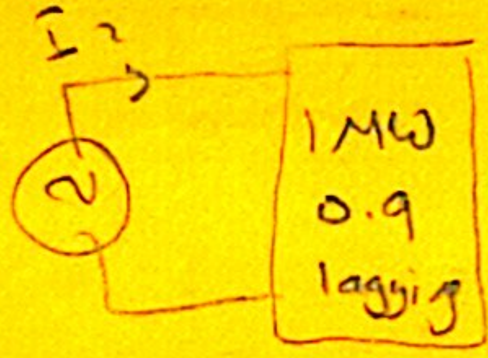
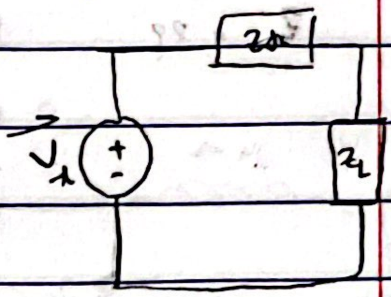




$$I_1 = \frac{P}{V\cos\theta} = \frac{10^6}{2300 \times 0.7} = 621 \ A_{rms}$$

$$I_2 = \frac{10^6}{2300 \times 0.9} = 483 \ A_{rms}$$

Max power transfer.



$Z_{th} = R_{th} + jX_{th}$

$Z_L = R_L + jX_L$

$P_{avg} = 0$.

- $\vec{I} = \dfrac{\vec{V}_{th}}{(R_{th}+R_L) + j(X_{th}+X_L)}$
- $\vec{V}_{th} = V_{th,M} \angle \theta v$

$P_{av} = \frac{1}{2} I_m^2 R_L$

$= \frac{1}{2}\left(\dfrac{V_{th}}{\sqrt{(R_{th}+R_L)^2 + (X_{th}+X_L)^2}}\right)^2 R_L = \frac{1}{2}\dfrac{V_{th}^2}{(R_{th}+R_L)^2 + (X_{th}+X_L)^2} R_L$

① $\dfrac{\partial P_{av}}{\partial X_L} = 0$

$= \dfrac{V_{th}^2}{2} \dfrac{-2R_L(X_{th}+X_L)}{[(\ )^2 + (\ )^2]^2} = 0$.

$\boxed{X_L = -X_{th}}$

② $\dfrac{\partial P_{av}}{\partial R_L} = 0$.

$= \dfrac{V_{th}^2}{2} \dfrac{(\ +\ )^2 + (\ +\ )^2 - 2R_L(R_{th}+R_L)}{[(\ )^2 + (\ )^2]^2}$

$(R_{th}+R_L)^2 = 2R_L(R_{th}+R_L)$

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

∴ for $P_{avg,max} \rightarrow R_L = R_{th}$

$\rightarrow X_L = -X_{th}$.

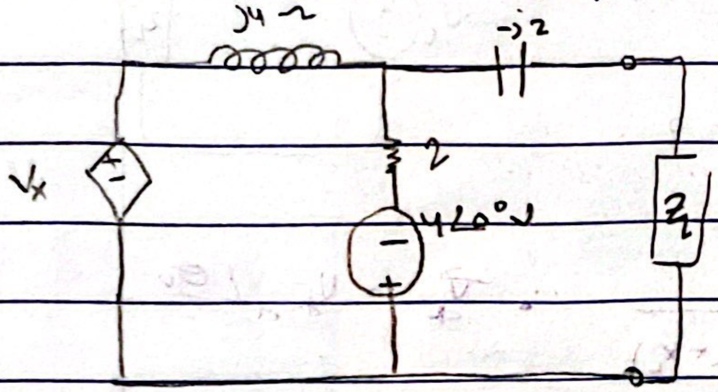
$\boxed{Z_L = Z_{th}^*}$

$P_{avg,max} = \dfrac{V_m^2}{8R_{th}} = \dfrac{V_{th,rms}^2}{4R_{th}}$.

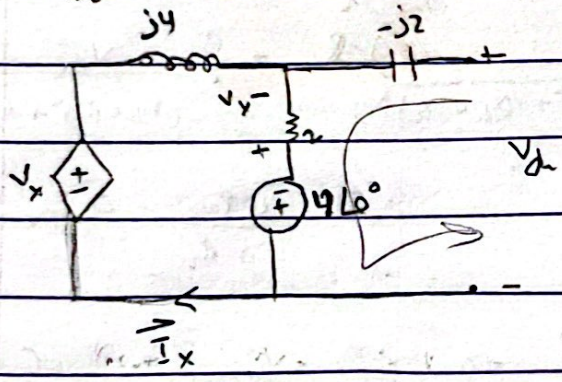
Ex:-

$Z_L = ??$ for $P_{av,\,max}$

$P_{av,\,max} = ?$



• $V_{th} = V_{oc}$



to change from pol to rec

rec (x,y) = X

RCL F = θ

KVL ⇒ $-V_x + j4I_x + 2I_x - 4 = 0.$ $\boxed{V_x = -2I_x}$

$-4 + 2I_x + j4I_x + 2I_x = 0.$

$(4+4j)\, I_x = 4$

$I_x = \dfrac{4}{4+4j} = \dfrac{4}{5.656\angle 45°} = 0.707\angle -45°$ A.

$= 0.5 - 0.5j$

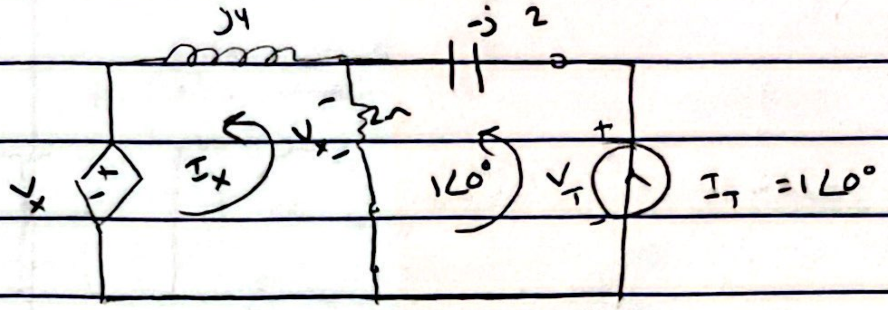
⇒ $V_{th} = 2\vec{I}_x - 4$

$= 2(\tfrac{1}{2} - \tfrac{1}{2}j) - 4 = -3 - j$

$= 3.16\angle -161.56°$ ~

$$Z_{th} = \frac{V_T}{I_T}$$

all indep set to 0.



$$+V_x + 2(I_x - 1) + j4I_x = 0.$$

$$4(I_x - 1) + 4j\,I_x = 0.$$

$$\underline{4I_x - 4} + \underline{4j\,I_x} = 0.$$

$$(4+4j)I_x = 4$$

$$\therefore I_x = 0.5 - 0.5j$$

$\therefore \vec{V_T} \Rightarrow \underline{KVL}$ $\quad -V_T - j2(1) + 2(1 - I_x) = 0$

$$V_T = -2j + 2 - 2\left(\tfrac{1}{2} - \tfrac{1}{2}j\right)$$

$$= -2j + 2 - 1 - j$$

$$= 1 - j$$

$$\therefore Z_{th} = 1 - j\ \Omega.$$

$$Z_L = Z_{th}^* = 1 + j.$$

$$\Rightarrow P_{avg}\ max = \frac{V_{th}^2}{8\,R_{th}} = \frac{(3.16)^2}{8(1)} = 1.25\ W.$$

$i(t), v(t) = Ae^{st}$.

(L) $s = -\frac{R}{L}$, $\tau = \frac{L}{R}$

- $Ae^{\frac{-t}{\tau}}$
- A from $t \to 0^+$

(C) $s = \frac{-1}{RC}$, $\tau = RC$

$V(0^-) = V_s \, e^{\frac{-t}{\tau}}$

<u>general. sol</u> :-

$x(\infty) + [x(0^+) - x(\infty)] e^{\frac{-t}{\tau}}$

$t \to \infty$. $L \Rightarrow$

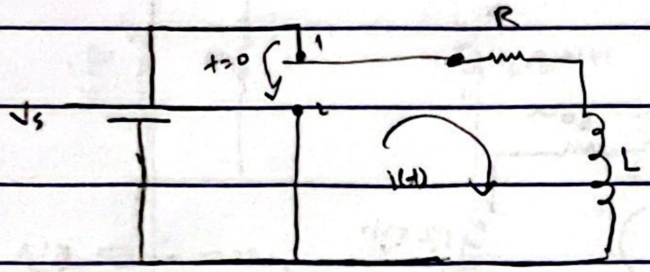
$C \Rightarrow$

$t \to 0^+$. deg. sources.

- V value or I value from $t<0$.
- R_{eq} from $t>0$.
- constant from $t>0^+$.

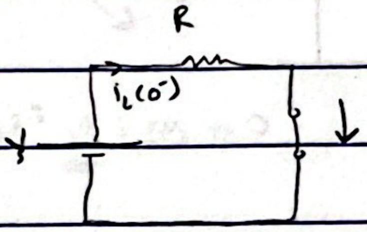
chapter (7): Natural Response of 1^{st} order circuits.

Ex: find $i(t)$ of $t>0$.

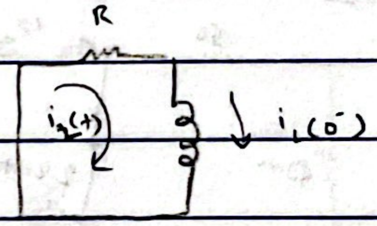


$\boxed{\text{for } t<0}$

$$i_L(0^-) = \frac{V_s}{R}$$



$\boxed{\text{for } t>0}$



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

$$i_L(t) = Ae^{st}$$

$$\Rightarrow RAe^{st} + LASe^{st} = 0$$

$$Ae^{st}(R + LS) = 0 \qquad \therefore S = -\frac{R}{L}$$

$$\therefore i_L(t) = Ae^{-\frac{R}{L}t}, \quad t>0$$

How to find A.

(A) from $t = 0^+$.

$0^- = 0^+$ عند البناء

$\neq$ " الجهد

بس عند الـ Voltage

$0^- \neq 0^+$

$$i_L(0^+) = i_L(0^-) = \frac{V_s}{R}$$

sub in $i_L(t) = Ae^{-\frac{R}{L}0^+} = \frac{V_s}{R}$

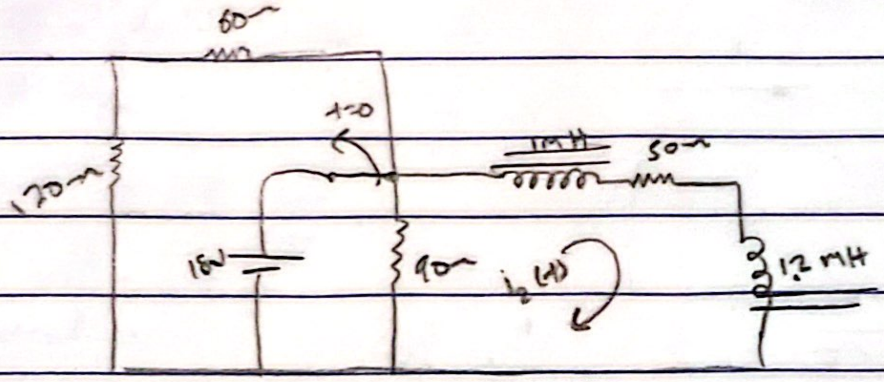
$$\therefore A = \frac{V_s}{R}$$

$$i_L(t) = \frac{V_s}{R}e^{-\frac{R}{L}t}, \quad t>0$$

$\boxed{\tau = \frac{L}{R}}$ time constant

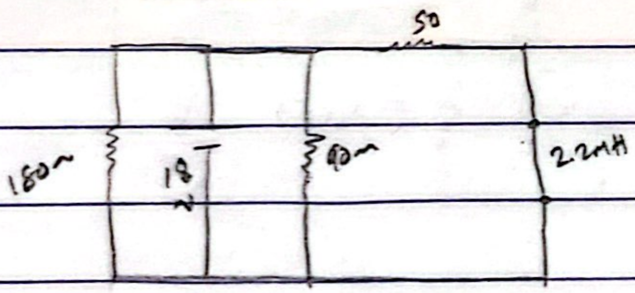
$$i_L(t) = Ae^{-\frac{t}{\tau}}$$

Ex:- find $i_L(t)$ for $t>0$.



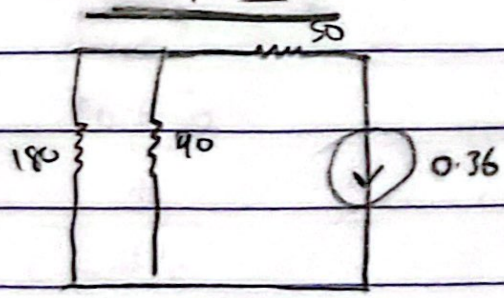
توالي ← نجمعهم

for $t<0$

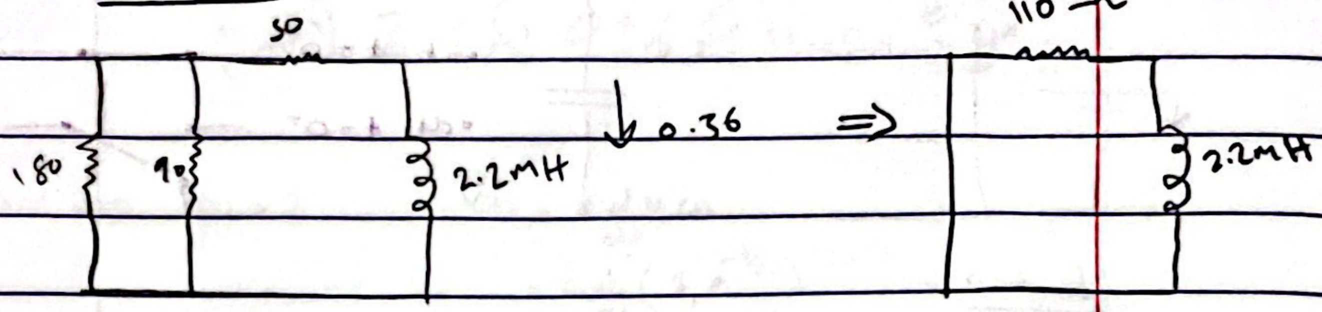


$$i_L(0^-) = \frac{18\,V}{50\,\Omega} = 0.36A$$

for $t=0^+$



For $t>0$



$i_2(t) = ?$

KVL $\Rightarrow$ $110\, i_2(t) + 2.2\times10^{-3} \frac{d}{dt} i_2(t) = 0.$

$i_2(t) = Ae^{st}$

$110\, Ae^{st} + 2.2\times10^{-3} AS\, e^{st} = 0.$

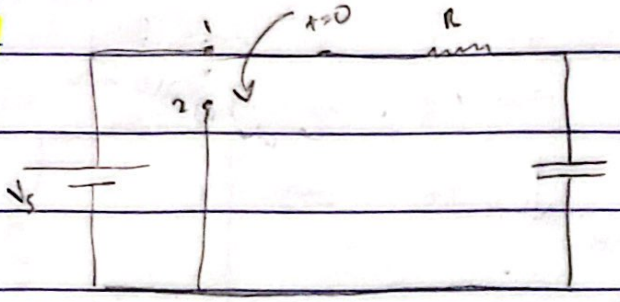
$110 + 2.2\times10^{-3} S = 0$

$\therefore S = \frac{-110}{2.2\times10^{-3}}$ OR $\tau = \frac{L}{R} = \frac{2.2mH}{110} = 20\mu$ sec.

$\therefore i_L(t) = Ae^{-\frac{t}{\tau}}$

$= 0.36\, e^{-50000\, t}$ for $t>0$.

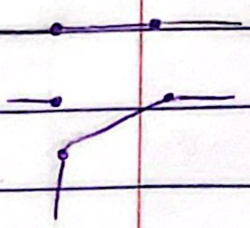
Ex:-



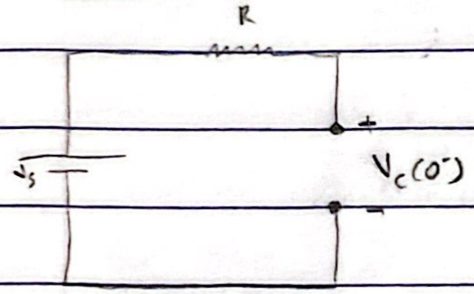
Find $i(t)$ for $t>0$.

- at $t=0^-$

- at $t=0^+$

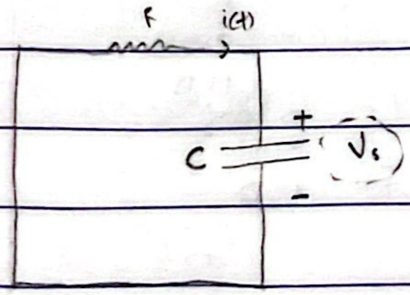


for $t<0$



$V_c(0^-) = V_s$

for $t>0$.



- $i(t) = C \frac{d}{dt} V_c(t)$.

KVL: $R\, i(t) + V_c(t) = 0$

$RC \frac{d}{dt} V_c(t) + V_c(t) = 0$

$V_c(t) = Ae^{st}$

- $\tau = RC$, $S = \frac{-1}{RC}$

$V_c(t) = A e^{\frac{-t}{RC}}$, $t>0$.

$\Rightarrow RCASe^{st} + Ae^{st} = 0$.

$Ae^{st}(RCS+1) = 0$

$S = \frac{-1}{RC}$

$A = ?$ $\Rightarrow t=0^+$

@ $t=0^+ \Rightarrow V_c(0^+) = V_s$

$\therefore V_c(0^+) = Ae^{\frac{-t}{RC}} = V_s$

$= Ae^0 = V_s$ $\boxed{\therefore A = V_s}$

$\therefore V_c(t) = V_s e^{\frac{-t}{RC}}$ volt, $t>0$.

لاحظي I عند 0^- بكون كانت صفر
ولكن عندما تكون 0^+ تكون I_2 أخرى

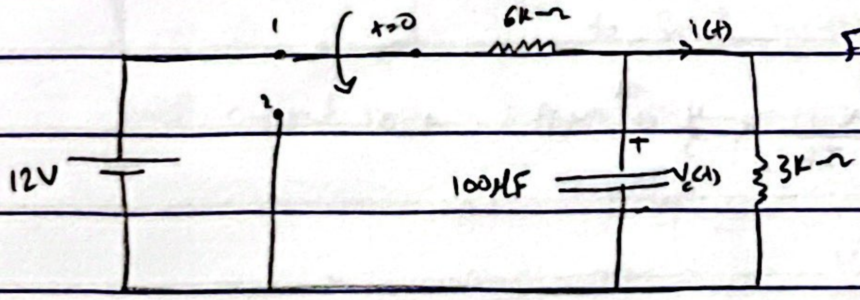
continue $\Longrightarrow$ $i(t) = ?$, $i(t) = C \frac{d}{dt} V_c(t)$

$$= C \frac{d}{dt}\left(V_s e^{-t/RC}\right)$$

$$= \frac{-CV_s}{RC} e^{-t/RC}$$

$$\boxed{\therefore i(t) = \frac{-V_s}{R} e^{-t/RC} \quad , t>0}$$

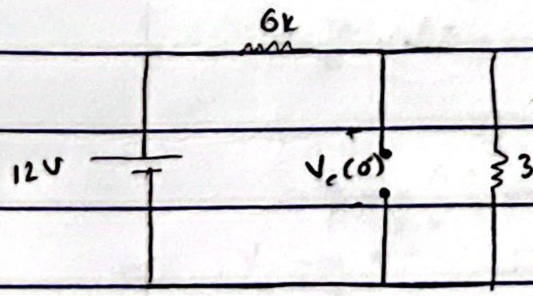
Ex:



Find $V_c(t)$ and $i(t)$ for $t>0$

$V_c(t) = A e^{-t/RC}$, $t>0$

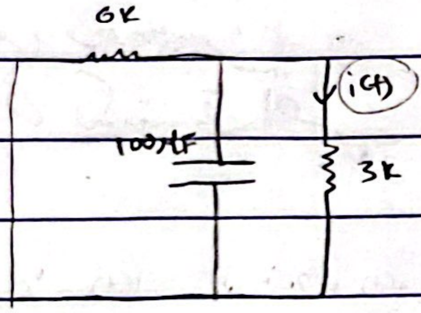
for $t<0$ (0^-)



$V_c(0^-) = \frac{3}{3+9} \cdot 12 = 4$ Volt.

$[V_c(0^-) = V_c(0^+) = 4$ Volt.

for $t>0$



$\tau = R_{eq} C$

$C = 10\mu F$

$R_{eq} = ?$

$R_{eq} = 3 \parallel 6 = 2K\Omega$

$\therefore \tau = 100\times10^{-6} \times 2\times10^{3}$

$= 0.2$ sec.

$\Rightarrow V_c(t) = V_s(t)\, e^{-\frac{1}{RC}t}$ $\qquad \frac{-1}{RC} = \frac{-1}{2000\times10^{-6}\times100} = -5$

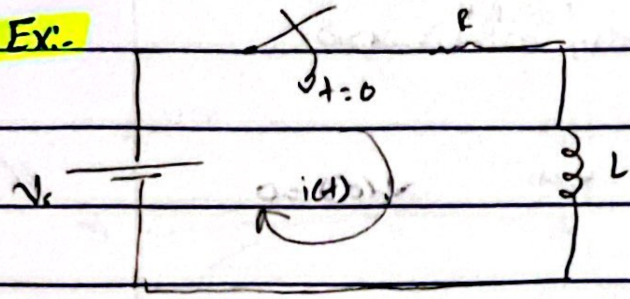
$= 4e^{-5t}, \; t>0$ $\qquad = 5.$

$\Rightarrow i(t) = \frac{V_c(t)}{3K} = \frac{4}{3} e^{-5t}$ mA, $t>0$.

. forced + natural.

⇒ The Step Response :-

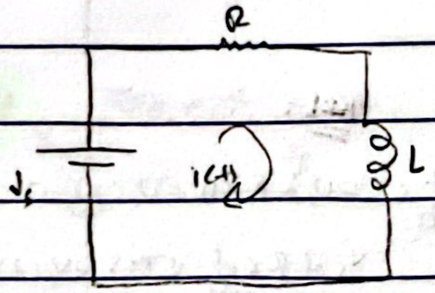
Ex.



$\boxed{i_L(0^-)=0}$.

Find $i(t)$ for $t>0$.

for $t>0$

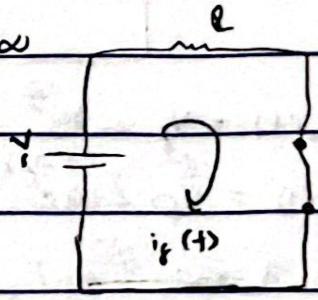


$V_s = R\,i(t) + L\frac{d}{dt}i(t)$.

. $i(t) = \underbrace{i_n(t)}_{\text{natural}} + \underbrace{i_f(t)}_{\text{forced}}$.

to find $i_f(t)$: constant

final current state . from $t\to\infty$



$\Rightarrow i(t) = \frac{V_s}{R} + Ae^{st}$.

$= \frac{V_s}{R} + Ae^{-t/\tau}$. $\tau = \frac{L}{R_{eq}}$

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

$\therefore i_f(t) = \frac{V_s}{R}$ $\boxed{\text{final Value}}$

. $i_L(0^-) = i_L(0^+) = 0$

$= \frac{V_s}{R} + Ae^{-\frac{R}{L}t}$

. to find A: $t=0^+$.

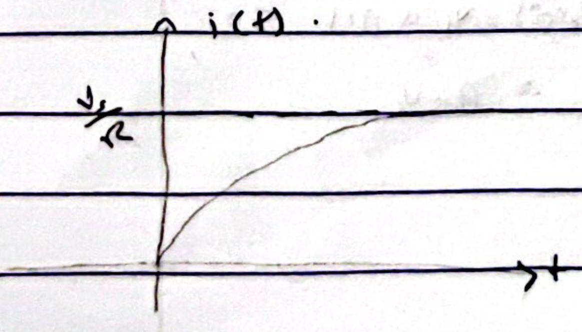
$\therefore i(0^+) = \frac{V_s}{R} + A\cdot 1 = 0$

$= \frac{V_s}{R} + A = 0$

$\therefore A = \frac{-V_s}{R}$.

$\Rightarrow \frac{V_s}{R} - \frac{V_s}{R}e^{-\frac{R}{L}t}$, $t\geq 0$

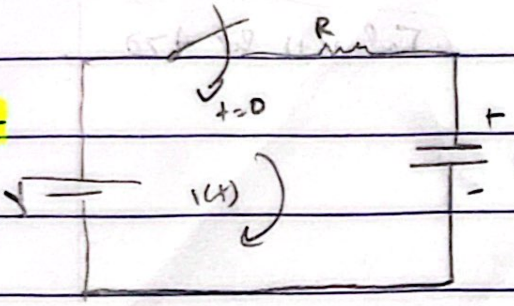
$\frac{V_s}{R}\left(1 - e^{-\frac{R}{L}t}\right)$, $t\geq 0$.



$$V_L(t) = L\frac{d}{dt}i(t) = L\left(\frac{V_s}{L}e^{-\frac{R}{L}t}\right)$$

$$= V_s e^{-\frac{R}{L}t}, \quad t>0.$$

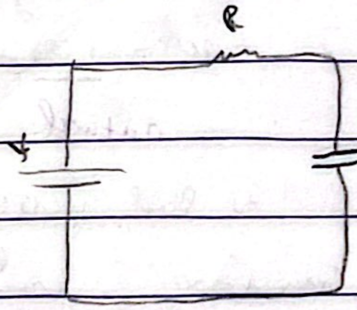
Ex:-



$V_c(0^-) = 0$

Find $i(t)$ for $t>0$.

$t>0$



KVL:

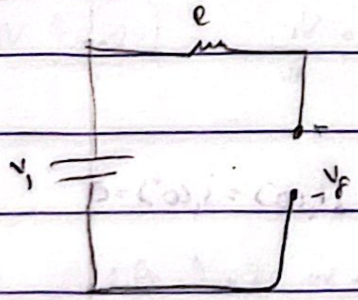
$-V_s + Ri(t) + V_c(t) = 0.$

$V_s = RC\frac{d}{dt}V_c(t) + V_c(t) = 0$

$$\therefore V_c(t) = V_f + Ae^{-\frac{t}{\tau}}, \quad \tau = RC$$

$$V_c(t) = V_f + Ae^{-\frac{1}{RC}t}, \quad t\geq 0.$$

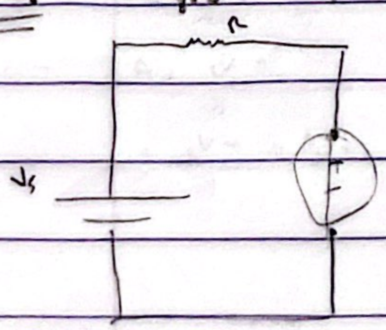
to find V_f: from $t\to\infty$.



$\therefore V_f = V_s.$

$\therefore V_c = V_s + Ae^{-\frac{1}{RC}t}, \quad t\geq 0. \to *$

to find A: from $t=0^+$



O.C
or
S.C

$V_c(0^+) = 0$ from S.C.

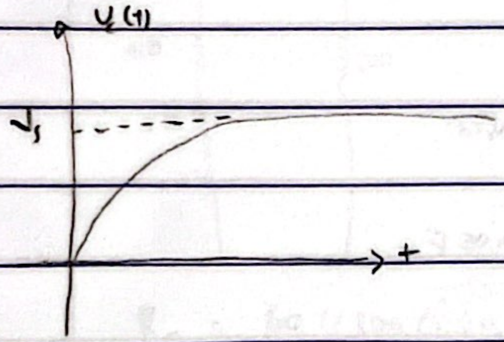
$t\to 0^+$ in eq *

$V_c(0^+) = V_s + A\cdot 1 = 0$

$\therefore A = V_s.$

$V_c(t) = V_s - V_s e^{\frac{-1}{RC}t}$, $t \geq 0$.

$= V_s (1 - e^{\frac{-1}{RC}t})$, $t \geq 0$.



$i(t) = C \frac{d}{dt} V_c(t) = \cancel{C} \frac{V_s}{R\cancel{C}} e^{\frac{-1}{RC}t}$, $t > 0$

Impor

General sol:-

$X(t) = \overset{x_f}{X(\infty)} + [X(0^+) - \overset{x_f}{X(\infty)}] e^{-t/\tau}$

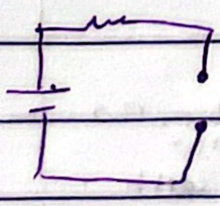
$\tau = \frac{L}{R_{eq}}$ or $\tau = R_{eq} C$.

ex:- like the last circuit:-

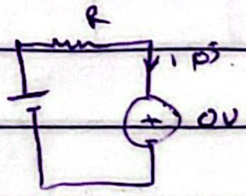
$i(t) = i(\infty) + [i(0^+) - i(\infty)] e^{-\frac{t}{\tau}}$

$= i_f + [i(0^+) - i_f] e^{-\frac{t}{\tau}}$.

↳ $i_f = 0$.



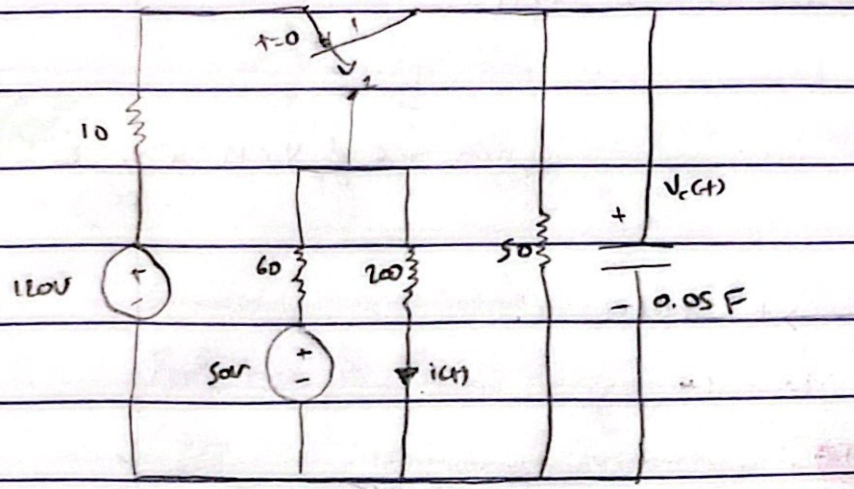
↳ $i(0^+) = \frac{V_s}{R}$



$\therefore i(t) = 0 + \{\frac{V_s}{R} - 0\} e^{-\frac{t}{\tau}}$.

$= \frac{V_s}{R} e^{-t/RC}$, $t > 0$

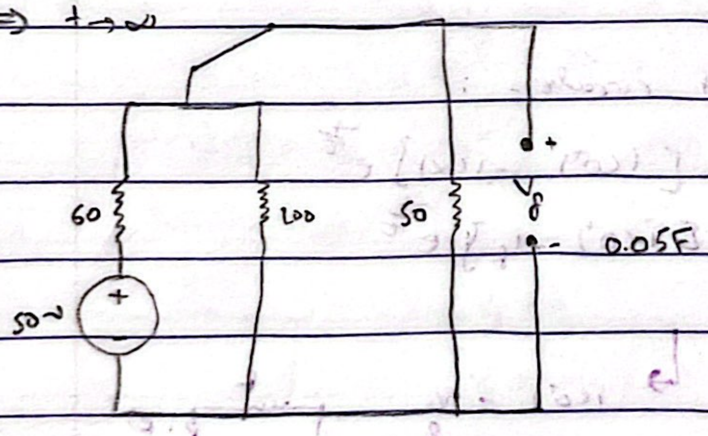
Ex:- Find $i(t)$ for $t>0$



$V_c(t) = \_\_\_\_$, then $i(t) = \frac{V_c(t)}{200}$

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

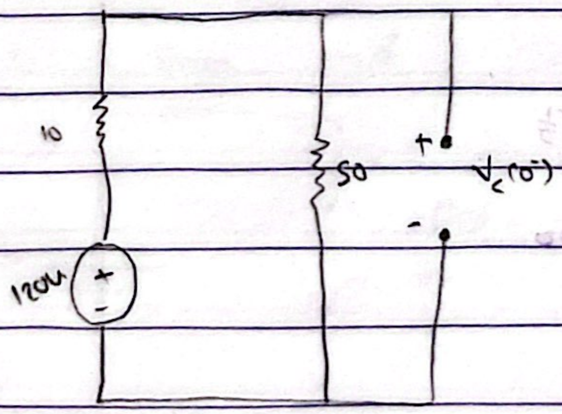
$\boxed{V_f} \Rightarrow t \to \infty$



$V_f = \frac{50 \| 200}{(50\|200)+60} \times 50$

$= 20$ volt.

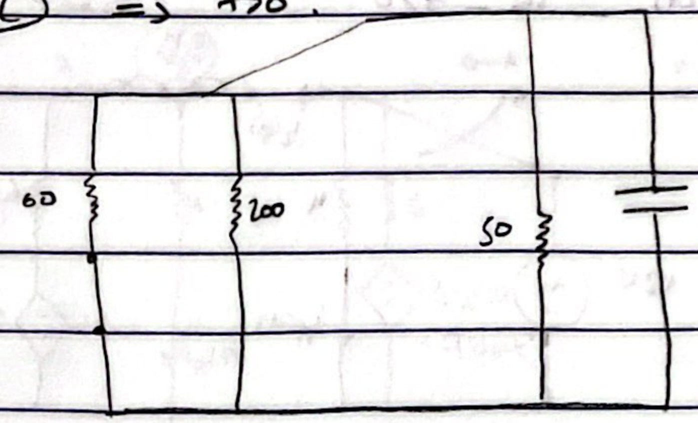
$\boxed{V_c(0^-)} \Rightarrow t \to 0^-$



$V_c(0^-) = \frac{50}{50+10} \cdot 120$

$= 100$ volt.

$\boxed{C}$ $\Rightarrow$ $t>0$.



$R_{eq} = 60 \parallel 200 \parallel 50$

$= 24\ \Omega$

$\therefore \tau = 0.05 \cdot 24$

$= 1.2$ Sec.

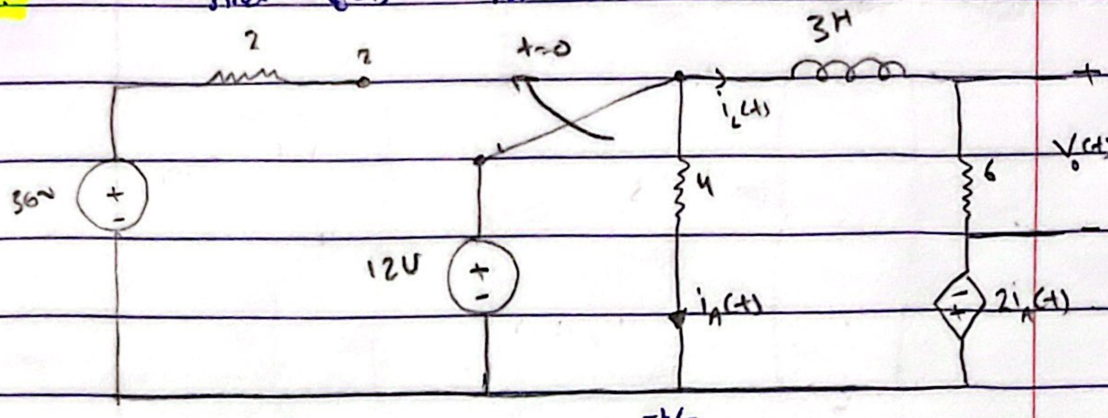
$\Rightarrow v_c(t) = 20 [100 - 20] e^{\frac{-t}{1.2}}$

$= 20 + 80 e^{\frac{-t}{1.2}}, \quad t \geq 0$

$\Rightarrow i(t) = \frac{v_c(t)}{200} = \frac{20}{200} + \frac{80}{200} e^{\frac{-t}{1.2}}$

$= 0.1 + 0.4 e^{\frac{-t}{1.2}}, \quad t > 0.$

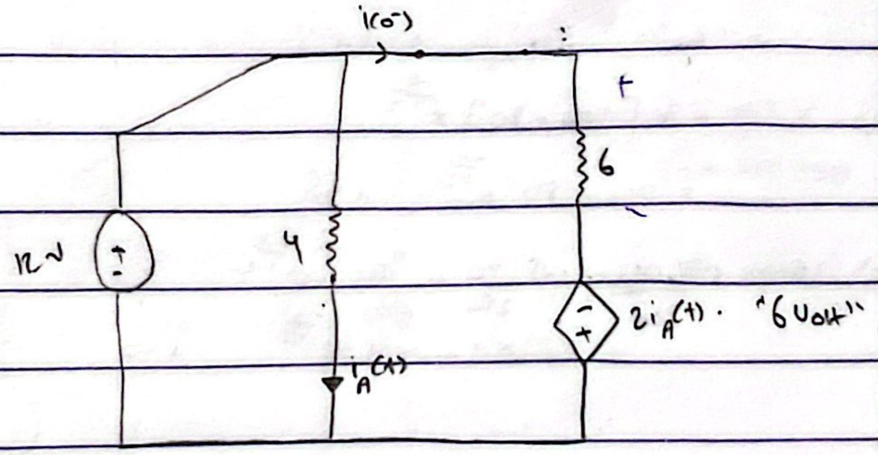
Ex:- Find $V_o(t)$ for $t>0$.



$$i_L(t) = i_f + [i(0^+) - i_f] e^{-t/\tau}$$

for $V_o(t) = 6 \cdot i_L(t)$.

$\boxed{i(0^+) = i(0^-)}$ ⇒ from 0^-

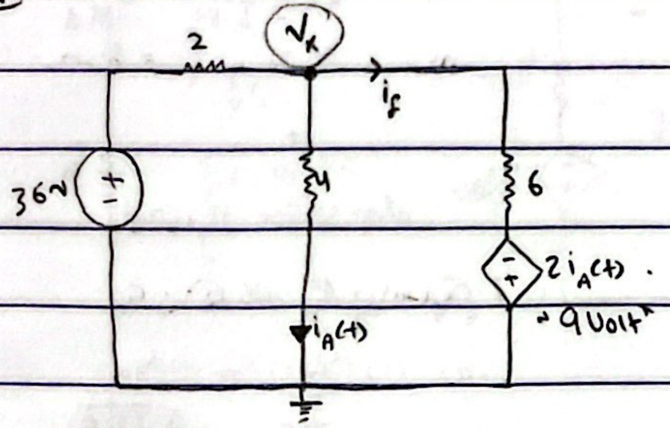


$$i_A(t) = \frac{12}{4} = 3A$$

$$\therefore i(0^-) = \frac{12+6}{6} = 3A.$$

$\boxed{i(0^-) = 3A}$

$\boxed{i_f}$ $\Rightarrow t \to \infty$.



$\cdot\, i_A(t) = \frac{V_x}{4}$

$\Rightarrow 2i_A(t) = \frac{2 \cdot V_x}{4} = \frac{V_x}{2}$

nodal $\frac{V_x - 36}{2} + \frac{V_x}{4} + \frac{V_x + \overbrace{2i_A(t)}^{\frac{V_x}{2}}}{6} = 0$

$\boxed{\therefore V_x = 18\ Volt}$

$\Rightarrow i_A(t) = \frac{18}{4} = 4.5\,A$.

$i_f \Rightarrow \frac{18+9}{6} = 4.5\,A$

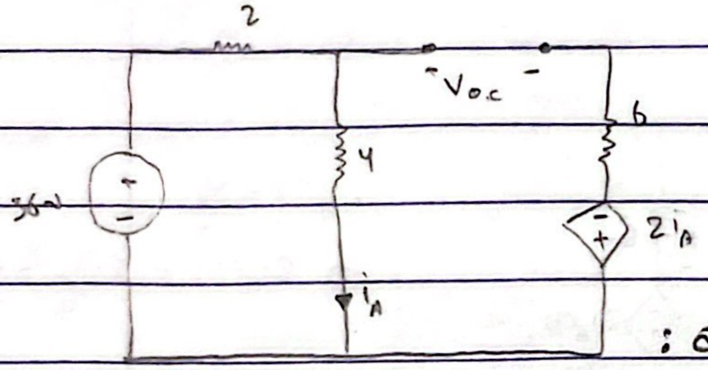
$i(t) = 4.5 + [3 - 4.5]\,e^{-\frac{t}{\tau}}$

$= 4.5 - 1.5\,e^{-\frac{t}{\tau}}$ A

$\therefore v_o(t) = 6(4.5 - 1.5\,e^{-\frac{t}{\tau}})$

$= 27 - 9\,e^{-\frac{t}{\tau}}$ Volt.

T : t>0 .



$R_{eq} = \frac{V_{o.c}}{I_{sc}} = \frac{36}{4.5}$

$= 8\,\Omega$

dep. source لوجود ال

يمكن ان نجد R_{th} بواسطة :

$\frac{V_T}{I_T}$ or $\boxed{\frac{V_{o.c}}{I_{s.c}}}$

⇒ already found

$V_{o.c} = V_{4\Omega} + 2i_A$

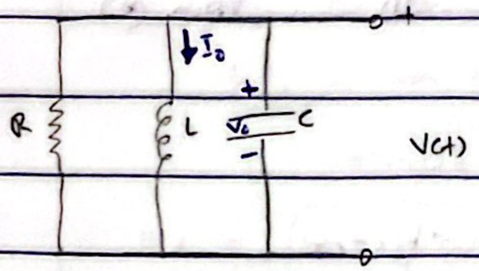
$= \frac{4}{4+2} \cdot 36 + 2 \cdot \frac{36}{6}$

$= 36$ volt

$\boxed{\therefore T = 3/8}$

$\boxed{I_{s.c} = I_R}$

chapter(8): Natural Response of Parallel RLC circuit.



Find V(t) for t>0.

KCL $i_R(t) + i_C(t) + i_L(t) = 0$

$\cdot V_L = L \frac{d}{dt} i_L$

$i_L = \frac{1}{L}\int V_L \, dt + I_0$

$\frac{d}{dt}\left(\frac{V(t)}{R} + \underbrace{\frac{1}{L}\int V(t)dt + I_0}\right) + C\frac{d}{dt}V(t) = 0$

$\frac{1}{R}\frac{d}{dt}V(t) + \frac{1}{L}V(t) + C\frac{d^2}{dt^2}V(t) = 0$.

$\Rightarrow$ Let $V(t) = Ae^{st}$

$\rightarrow \frac{1}{R}ASe^{st} + \frac{1}{L}Ae^{st} + CAS^2e^{st} = 0$

$Ae^{st}\left(\frac{1}{R}S + \frac{1}{L} + CS^2\right) = 0$

$\rightarrow \frac{1}{R}S + \frac{1}{L} + CS^2 = 0$

$S^2 + \frac{1}{CL} + \frac{1}{RC}S = 0$

$\frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

$S_{1,2} = \frac{-1}{2RC} \pm \sqrt{\left(\frac{1}{2RC}\right)^2 - \left(\frac{1}{\sqrt{LC}}\right)^2}$

- $\omega_0 = \frac{1}{\sqrt{LC}}$ responce freq.
- $\alpha = \frac{1}{2RC}$ damping freq.

$S_{1,2} = -\alpha \pm \sqrt{\alpha^2 - \omega_0^2}$.

i) if $\alpha > \omega_0$ overdamped responce.

$S_{1,2}$ real and distrinct.

$S_1 = -\alpha + \sqrt{\alpha^2 - \omega_0^2}$, $S_2 = -\alpha - \sqrt{\alpha^2 - \omega_0^2}$

$\therefore V(t) = A_1 e^{s_1 t} + A_2 e^{s_2 t}$.

to find A_1 and A_2 $\Rightarrow$ from $V(0^+)$ and $\frac{d}{dt}V(0^+)$

circuit

$V(0^+) = V_0 = A_1 + A_2$ ... (1) from (K)

Circuit:

$i_R(0^+) + i_L(0^+) + i_C(0^+) = 0.$

$$\frac{V(0^+)}{R} + I_0 + \boxed{C\frac{d}{dt}V(0^+)} = 0$$

$$\boxed{\frac{d}{dt}V(0^+) = \frac{-I_0}{C} - \frac{V(0^+)}{RC}}$$

from eq (*).

$$\frac{d}{dt}V(0^+) = A_1 S_1 e^{S_1 0^+} + A_2 S_2 e^{S_2 0^+}.$$

$$\boxed{A_1 S_1 + A_2 S_2 = \frac{-I_0}{C} - \frac{V_0}{RC}} \quad (2)$$

Solve for A_1 and A_2 from (1) and (2)

(ii) if $\alpha = \omega_0$ critically damped.

$S_1 = S_2 = S = -\alpha$, repeated

$\therefore V(t) = A_1 t e^{-\alpha t} + A_2 e^{-\alpha t}$

$V(0^+) = \boxed{A_2 = V_0}$

$$\frac{d}{dt}V(0^+) = \boxed{\frac{-I_0}{C} - \frac{V_0}{RC} = -\alpha A_2 + A_1}$$

III) if $\alpha < \omega_0$ underdamped responce.

$S_{1,2}$ complex.

$$S_{1,2} = -\alpha \pm j\sqrt{\omega_0^2 - \alpha^2}$$

$$= -\alpha \pm j\omega_d.$$

$\omega_d = \sqrt{\omega_0^2 - \alpha^2}$ damped freq ~~...~~ of oscillation.

$$v(t) = e^{-\alpha t}\left[B_1 \cos \omega_d t + B_2 \sin \omega_d t\right]$$

$$v(0^+) \boxed{= V_0 = B_1}$$

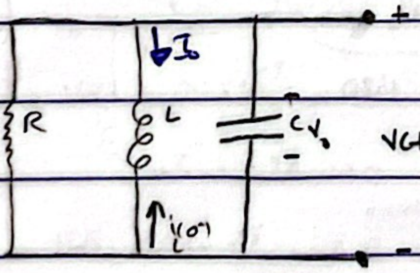
$$\frac{d}{dt} v(0^+) = \boxed{\frac{-I_0}{C} - \frac{V_0}{RC} = -\alpha B_1 + \omega_d B_2}$$

Ex:-

$R = 6\,\Omega$, $L = 7\,H$, $C = \frac{1}{42}\,F$.

$v_c(0^-) = 0$.

$i_L(0^-) = 10\,A$.



find $v(t)$ for $t > 0$?

$\alpha = \frac{1}{2RC} = 3.5$ rad/sec

$\omega_0 = \frac{1}{\sqrt{LC}} = \sqrt{6}$ rad/sec

$= 2.45$

$S_1 = -\alpha + \sqrt{\alpha^2 - \omega_0^2} = -1$. $\therefore \alpha > \omega_0 \Rightarrow$ overdamped.

$S_2 = -\alpha - \sqrt{\alpha^2 - \omega_0^2} = -6$

$$\boxed{v(t) = A_1 e^{-t} + A_2 e^{-6t}}$$

$v(0^+) = A_1 + A_2 = v_0 = v_c(0^-) = 0$

$\therefore A_1 + A_2 = 0$ ... (1)

$$\frac{d}{dt} V(0^+) = \frac{-I_0}{C} - \frac{V_0}{RC}$$

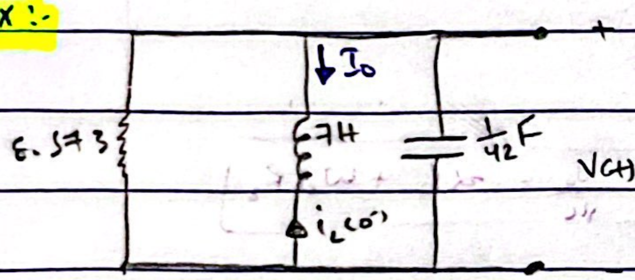
$$= \frac{-(-10)}{1/42} - 0 = 420$$

$\therefore 420 = -A_1 - 6A_2$ ...... ②

$\Rightarrow A_1 = 84 \quad , A_2 = -84$

$V(t) = 84 (e^{-t} - e^{-6t})$ Volt , $t > 0$

Ex:-



$V_c(0) = 0$

$i_L(0^-) = 10A$.

find $V(t)$ for $t > 0$.

$\alpha = \sqrt{6} \quad , \omega_0 = \sqrt{6}$

$\therefore \alpha = \omega_0 \Rightarrow$ critically damped.

مش الدينيرتال $V(t) = A_1 t e^{-\alpha t} + A_2 e^{-\alpha t}$

لأنا الفرق مشكلة $V(0) = 0 + A_2 \quad \therefore A_2 = 0$

نضرب ب t . $\frac{d}{dt} V(0^+) = \frac{-I_0}{C} - \frac{V_0}{RC} = 420$

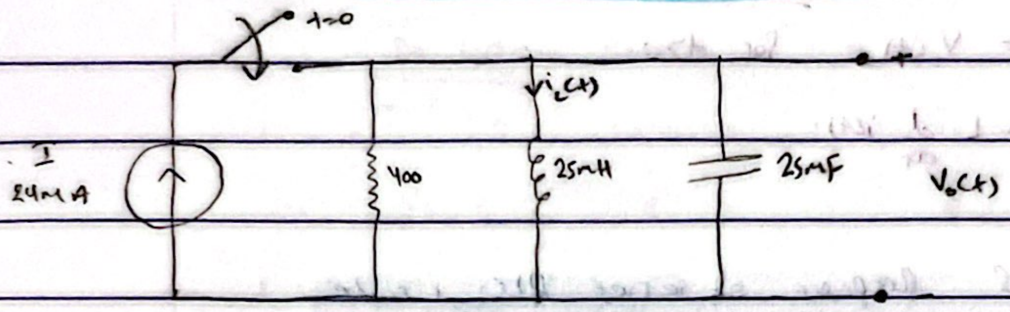
$\frac{d}{dt} V(t^+) = A_1 \frac{d}{dt} (t e^{-\alpha t})$

$= A_1 (e^{-\alpha t} - \alpha t e^{-\alpha t})$.

$\frac{d}{dt}(0^+) = A_1 = 420$

$\therefore V(t) = 420 t e^{-\sqrt{6}t}$ Volt.

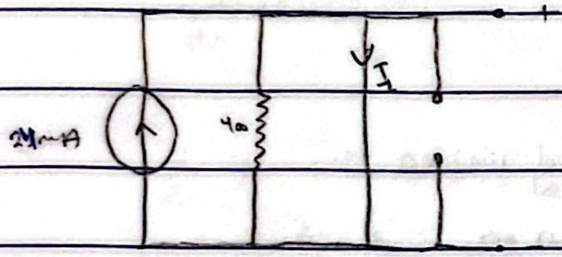
Step Response of Parallel RLC circuits.



$i_L(0^-) = 0$, $V_c(0^-) = 0$, find $i_L(t)$.

$i(t) = i_f(t) + i_n(t)$

$i_f(t) = 24\,mA$ $(t \to \infty)$



$\alpha = \frac{1}{2RC} = 50{,}000$

$\omega_0 = \frac{1}{\sqrt{LC}} = 40{,}000$ $\therefore \alpha > \omega_0 \to$ overdamped.

$i(t) = 24 \times 10^{-3} + A_1 e^{s_1 t} + A_2 e^{s_2 t}$.

$\therefore S_1 = -20{,}000$, $S_2 = -80{,}000$.

$i(t) = 24 \times 10^{-3} + A_1 e^{-10000t} + A_2 e^{-80000t}$

from $i(0^+)$ $\Rightarrow -24 \times 10^{-3} = A_1 + A_2$ $\boxed{1}$

$\Rightarrow \frac{d}{dt} i(0^+)$, $V_L(t) = L \frac{d}{dt} i_L(t)$

$\frac{d}{dt} i_L(t) = \frac{1}{L} \cancel{V_L(0^+)} = 0$

$\frac{d}{dt} i(0^+) = -20000 A_1 - 80000 A_2 = 0$. $\boxed{2}$

$\therefore A_1 = -32\,mA$, $A_2 = 8\,mA$.

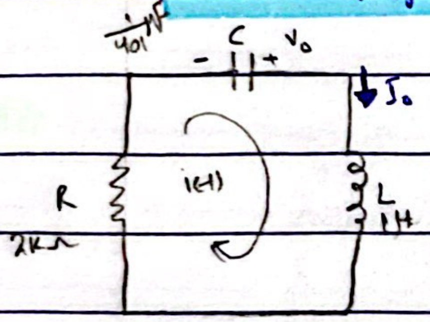
$i_L(t) = 24 - 32 e^{-20000t} + 8 e^{-80000t}$ mA for $t > 0$.

find $V_L(t) = ??$

$V_L(t) = V_L(t)$ for $t>0$ not ∞

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

Natural Responce of series RLC circuit



$V_c(0^-) = V_0$, $i_L(0^+) = I_0$

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

$R\, i(t) + \frac{1}{C}\int_0^t i(t)\, dt - V_0 + L \frac{d}{dt} i(t) = 0$

$R \frac{d}{dt} i(t) + \frac{1}{C} i(t) + L \frac{d^2}{dt^2} i(t) = 0$

let $i(t) = Ae^{st}$

$\Rightarrow sRAe^{st} + \frac{1}{C} Ae^{st} + Ls^2 Ae^{st} = 0$

$Ae^{st}\left(Rs + \frac{1}{C} + Ls^2\right) = 0$

$s^2 + \frac{R}{L} s + \frac{1}{LC} = 0$

$s_{1,2} = \frac{-R}{2L} \pm \sqrt{\left(\frac{R}{2L}\right)^2 - \left(\frac{1}{\sqrt{LC}}\right)^2}$, $\alpha = \frac{R}{2L}$

$= -\alpha \pm \sqrt{\alpha^2 - \omega^2}$, $\omega_0 = \frac{1}{\sqrt{LC}}$

let $V_0 = 2$ volt , $I_0 = 2mA$

$\alpha = 1000$, $\omega_0 = 20025$

$\therefore \alpha < \omega \Rightarrow$ underdamped

Ex

$$i(t) = e^{\alpha t}\left[\beta_1 \cos \omega_d t + \beta_2 \sin \omega_d t\right].$$

$$\bullet\ \omega_d = \sqrt{\omega_0^2 - \alpha^2} = 20{,}000$$

$$i(t) = e^{-1000t}\left[\beta_1 \cos(20{,}000)t + \beta_2 \sin(20{,}000)t.\right]$$

$$\Rightarrow i(0^+) = i(0^-) = 2mA = \beta_1$$ ↑ تعريف (0) في الملفات

$$\Rightarrow \frac{d}{dt} i(0^+) = ??$$

$$V_L(0^+) = L\frac{d}{dt} i(0^+).$$

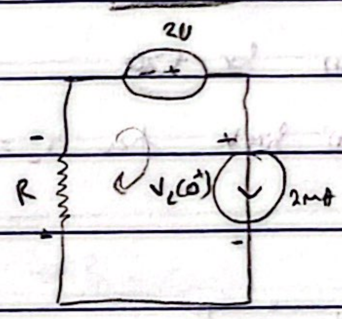
$$\Downarrow$$

$$+V_1 - RI_0 = L\frac{d}{dt} i(0^+)$$

$$2 - 2K \cdot 2m = \frac{d}{dt} i(0^+).$$

$$\therefore \frac{d}{dt} i(0^+) = -2.$$

$t = 0^+$

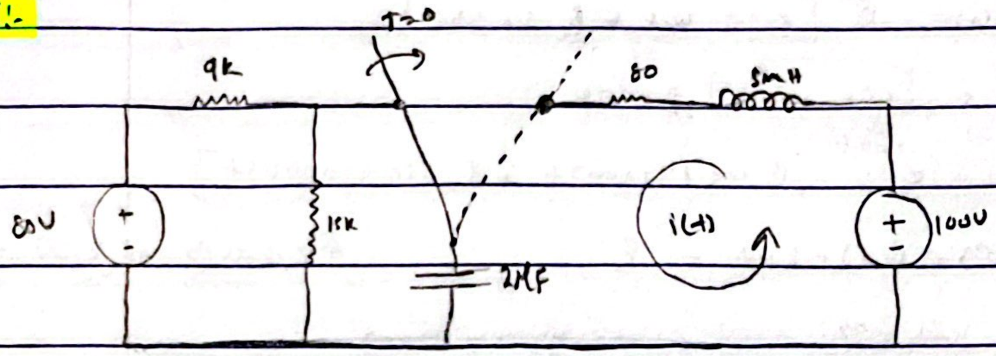


$$\frac{d}{dt} i(t) = -\alpha\beta_1 + \omega_d\beta_2.$$

$$\therefore \beta_2 = 0.$$

$$\therefore i(t) = 2e^{-1000t}\cos(20{,}000)t \quad mA, \quad t>0.$$

Ex:-

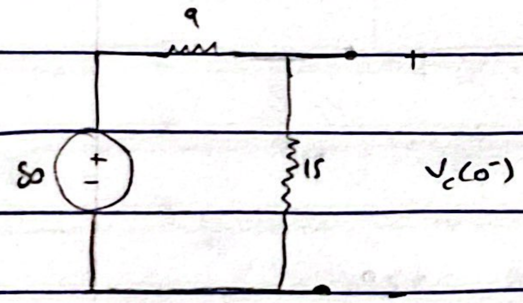


find $i_L(t)$ for $t>0$. , $I_0 = 0$, $V_0 = ?$

find $V_c(t)$ for $t>0$.

- find $V_c(t)$ first then $i_c = c \frac{d}{dt} V_c(t)$.

at $t=0^-$:

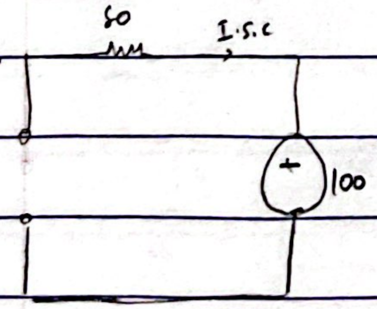


$V_c(0^-) = V_0 = \frac{15}{15+9} \cdot 80$

$\boxed{= 50 \text{ Volt.}}$

$\Rightarrow V_c(t) = V_f + V_n(t)$.

V_f , $t = \infty$,



$\therefore V_f = 100V$.

- $\alpha = \frac{R}{2L} = 8000$

- $\omega_0 = \frac{1}{\sqrt{LC}} = 10{,}000$ $\therefore \alpha < \omega_0 \Rightarrow$ underdamped.

$\therefore v(t) = V_f + e^{\alpha t}\,[B_1 \cos \omega_d t + B_2 \sin \omega_d t]$.

$\hookrightarrow \omega_d = \sqrt{\omega_0^2 - \alpha^2} = 6000$

$\Rightarrow \quad 100 + e^{-8000t}\,[B_1 \cos 6000t + B_2 \sin 6000t]$

$v(0^+) = v(0^-) = 50 = 100 + B_1$

$\boxed{\therefore B_1 = -50}$

$\Rightarrow \quad \frac{d}{dt} v_c(0^+) = ??$

$i_c(0^+) = C \frac{d}{dt} v_c(0^+)$

$\hookrightarrow = i(0^-) = 0 \quad \Rightarrow -\alpha B_1 + \omega_d B_2$

$\therefore \frac{d}{dt} v_c(0^+) = 0 = -8000 B_1 + 6000 B_2$

$\boxed{\therefore B_2 = -66.67}$

$v_c(t) = 100 - e^{-8000t}\left[50 \cos 6000t + 66.67 \sin 6000t\right]$

$\longrightarrow$ to find $i(t)$.

$i(t) = C \frac{d}{dt} v_c(t)$.

$= 2\times10^{-6}\left[e^{-8000t}\left[-3\times10^5 \sin 6000t + 400020 \cos 6000t\right] + 8000\,e^{-8000t}\left[50 \cos 6000t + 66.67 \sin 6000t\right]\right]$

$= e^{-8000t}\left[-4\times10^{-5} \cos 6000t + 1.666 \sin 6000t\right]$

⟹ from the book.

- table (12.1) — 435
- table (12.2) — 440

chapter (12):-

- $v(t) = (k)(t) \Rightarrow V(s) = (k)(s)$

constant ⟹ still the same

Ex:-

$$F(s) = \frac{96(s+5)(s+12)}{s(s+8)(s+6)}$$

$$\rightarrow \frac{k_1}{s} + \frac{k_2}{(s+8)} + \frac{k_3}{(s+6)} \Rightarrow$$

- $k_1 = 120$.
- $k_2 = -72$.
- $k_3 = 48$.

$$\Rightarrow \frac{120}{s} - \frac{72}{(s+8)} + \frac{48}{(s+6)}$$

$$f(t) = (120 - 72e^{-8t} + 48e^{-6t})\,u(t).$$

نعوض بدل الـ t =
كيف نتأكد إذا t=0 يكون 0 . بدنا نجرب بالإجابة .

Ex:-

$$F(s) = \frac{100(s+3)}{(s+6)(s^2+6s+25)} = \frac{A}{s+6} + \frac{Bs+C}{s^2+6s+25}$$

$$= As^2 + A6s + 25A + Bs^2 + Cs + 6Bs + 6C = 100s + 300$$

- $25A + 6C = 300$.
- $A + B = 0$
- $6A + 6B + C = 100 \rightarrow 6(A+B) + C = 100$

$\therefore C = 100$, $A = -12$, $B = 12$

$$\frac{-12}{s+6} + \frac{12s+100}{s^2+6s+25} \nearrow (s+3)^2 + 16$$

الحل مربعين .

$$\frac{-12}{s+6} + \frac{12s+100}{(s+3)^2+16} \Rightarrow 12 \cdot \frac{s + \frac{25}{3} + 3 - 3}{(s+3)^2+16}$$

$$\Downarrow$$

$$-12e^{-6t}$$

$$12 \cdot \frac{(s+3) + 16/3}{(s+3)^2+16}$$

$$12 \left[\frac{(s+3)}{(s+3)^2+16} + \frac{16/3}{(s+3)^2+16} \right]$$

$$12 \left[\cos 4t\, e^{-3t} + \frac{4}{3} \sin 4t\, e^{-3t} \right]$$

$$12e^{-3t} \cos 4t + 16 e^{-3t} \sin 4t$$

$$\Rightarrow -12e^{-6t} + 12e^{-3t} \cos 4t + 16 e^{-3t} \cos(4t - 90^\circ)$$

$$\Downarrow \qquad \Downarrow$$

$$e^{-3t}(12\angle 0^\circ + 16\angle{-90^\circ})$$

$$e^{-3t}(12 - 16j)$$

$$-12e^{-6t} + e^{-3t}(20\angle{-53.13^\circ})$$

$$\left(-12e^{-6t} + 20e^{-3t} \cos(4t - 53.13^\circ)\right) u(t).$$

Ex:

$$F(s) = \frac{100(s+25)}{(s+5)^3}$$

$$\frac{K_1}{s} + \frac{K_2}{(s+5)^3} + \frac{K_3}{(s+5)^2} + \frac{K_4}{(s+5)}$$

• توحيد مقامات

$K_1(s+5)^3 + K_2 s + K_3 s + 5K_3 + K_4 (s+5)^2$ • $(s+5)^3$

$K_1 s^3 + 15K_1 s^2 + 75K_1 s + 125K_1 + K_3 s^2 + 5K_3 s + K_2 s +$ $(s+5)(s^2+10s+25)$

$K_4 s^3 + 10K_4 s^2 + 25K_4 s = 100s + 2500$ $s^3 + 10s^2 + 25s +$

$\Rightarrow 125K_1 = 2500$ $5s^2 + 50s + 125$

$\therefore K_1 = 20$ $\Rightarrow s^3 + 15s^2 + 75s + 125$

$K_4 = -20$ • $K_4 s(s+5)^2$

$\Rightarrow 15K_1 + 10K_4 + K_3 = 0$ $K_4(s^3 + 10s^2 + 25s)$

$300 - 200 + K_3 = 0$

$\therefore K_3 = -100$

$\Rightarrow 75\cdot 20 + -500 + K_2 - 500 = 100$

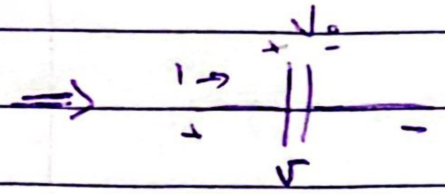
$500 + K_2 = 100$

$-500 \quad\quad -500$

$\therefore K_2 = -400$

$$\Rightarrow \frac{20}{s} - \frac{400}{(s+5)^3} - \frac{100}{(s+5)^2} - \frac{20}{s+5}$$

$$\left[20 - 200t^2e^{-5t} - 100te^{-5t} - 20e^{-5t}\right]u(t)$$

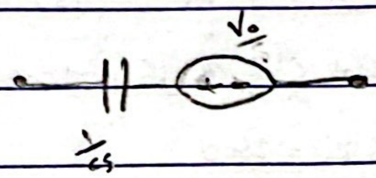


$$I = C\frac{d}{dt}v(t)$$

$$I = C(SV - V_0)$$

$$\therefore I = CSV - V_0$$

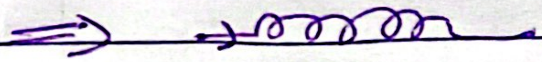
$$V = \frac{I}{CS} + \frac{V_0}{S}$$



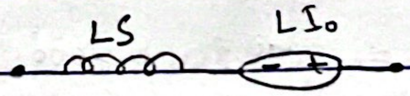
Voltage.

$$V = ZI \quad \therefore Z = \frac{1}{CS}$$

jw



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



current Source

$$V = L(SI - I_0)$$

$$V = LSI - LI_0$$

Z

⇒ without initial condition.

$v_c(0^-) = 0$

$i_L(0^-) = 0$.

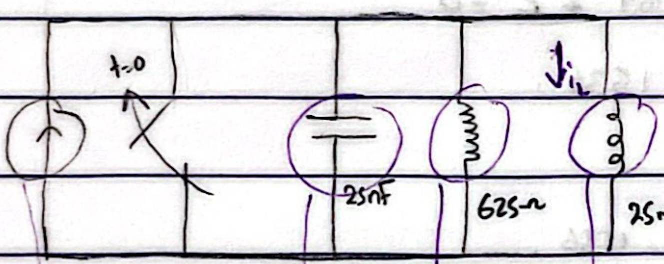
		$\underline{\underline{Z}}$	$\underline{\underline{G}}$
• C	→	$\frac{1}{SC}$	SC
• L	→	SL	$\frac{1}{SL}$
• R	→	R	$\frac{1}{R}$

Ex:- Step response of a parallel RLC

→ Find $i_L(t)$.

$V_c(0^-) = 0$

$i_L(0^-) = 0$



constant so it's will become $\frac{24m}{S}$, $\frac{1}{SC}$, $S_0 e$, SL will become.

→ constant ≠ الـ function يكون v_g أو i_g دون ما تصبح $I(S)$ أو $V(S)$.

Sol:-

CD:- بدنا $i_L(S)$:

1) $\frac{\frac{1}{SC} \cdot R}{\frac{1}{SC} + R} = \frac{R}{RCS+1}$

2) $\frac{\frac{R}{RCS+1}}{\frac{R}{RCS+1} + SL} \cdot \left(\frac{24m}{S}\right) \cdot \frac{RCS+1}{RCS+1}$

$\frac{R}{R + S^2 LRC + LS} \cdot \frac{24m}{S} = \frac{24m \cdot R}{S(R + RLC S^2 + LS)}$ تقسيم RLC

$$\Rightarrow \frac{1/LC}{S\left(S^2+\frac{1}{RC}S+\frac{1}{LC}\right)} = \frac{3.84\times10^{7}}{S\left[S^2+(6.4\times10^{4})S+(1.6\times10^{9})\right]}$$

$$= \frac{A}{S} + \frac{BS+C}{S^2+(6.4\times10^{4})S+(1.6\times10^{9})}$$

$$= AS^2 + A(6.4\times10^{4})S + (1.6\times10^{9})A + BS^2 + CS = 3.84\times10^{7}.$$

$A(1.6\times10^{9}) = 3.84\times10^{7}$.

$\therefore A = 0.024$.

$\Rightarrow A + B = 0$

$\therefore B = -0.024$.

$(0.024)(6.4\times10^{4}) + C = 0$

$\therefore C = -1536$.

$$\Rightarrow \frac{0.024}{S} - \frac{0.024S + 1536}{\underbrace{S^2+(6.4\times10^{4})S+(1.6\times10^{9})}}$$

الحال مربعين.

$$(S+32\times10^{3})^2 + 576\times10^{6}$$

$$\Rightarrow \frac{0.024}{S} - 0.024\left[\frac{S+64\times10^{3}}{(S+(32\times10^{3}))^2+576\times10^{6}}\right] \quad \div 2$$

$$\frac{0.024}{S} - 0.012\left[\frac{S+(32\times10^{3})}{(S+(32\times10^{3}))^2+576\times10^{6}}\right].$$

$$0.024 - 0.012\, e^{-32\times10^{3}t}\cos(24\times10^{3})t$$

$$0.024 - 24000\angle 90^\circ \quad . \quad A \quad ✓$$

2.17 • KCL $\Rightarrow$ $0.02 = i_1 + i_2$

• KVL $\Rightarrow$ $-v_0 + v_1 - 5 = 0$

$5 = -5000 i_1 + 2000 i_2$

$5 = -5000 i_1 + 2000(0.02 - i_1)$

$5 = -5000 i_1 + 40 - 2000 i_1$

$5 = -7000 i_1 + 40$

$35 = 7000 i_1$

$\therefore i_1 = 0.005\ A = 5\ mA$

$\therefore 5000 \cdot 5 \times 10^{-3} = 25\ V = v_0$

$\Rightarrow i_2 = 0.02 - 0.005 = 0.015\ A$

<u>the test:-</u>

• $P_{20} = -(20 \times 10^{-3})(25) = -0.5\ W$

$P = iV$, $V = iR$, $= Ri^2$

$P_2 = (2000)(0.015)^2 = 0.45\ W$

$P_5 = (5000)(0.005)^2 = 0.125\ W$

$P_{5v} = -5(0.015) = -0.075\ W$

• $0.45 + 0.125 - 0.075 - 0.5 = 0$

2.20

• KCL ⇒ $50\times10^{-3} = i_1 + i_2$

[1] • KVL ⇒ $-250i_2 + 200i_1 + 175i_1 = 0$

$-250i_2 + 375i_1 = 0.$

$-250(0.05 - i_1) + 375i_1 = 0.$

$-12.5 + 250i_1 + 375i_1 = 0$

$12.5 = 625i_1$

$\boxed{\therefore i_1 = 0.02\,A}$

$v_1 = 250i_2 = 250(0.05 - 0.02)$

$= \boxed{7.5\,V}$

[2] • KVL ⇒ $-v_g + 50i_x + v_1 = 0.$

$-v_g + 50(0.05) + 7.5 = 0$

$\boxed{\therefore v_g = 10\,V}$

$P_g = (-0.05)(10) = \boxed{-0.5\,W}$ " delivering power "

2.27 a) $P_{ap} = -(147)(28) = -4116\,W$

$P_x = -(147)(21) = -3087\,W$

b) abs $\Rightarrow (28)^2 + (21)^2(5) + (7)^2(2) + (14)^2(10)$ $\quad P = Vi$

$+ (21)^2 + (7)(35) = 7203\,W$ $\quad = IRi$

del $\Rightarrow 7203\,W$. $\quad = i^2R$.

therefore $\Sigma P_{abs} = \Sigma P_{del}$.

2.32

- KCL $\Rightarrow 45 = i_x + i$.
- KVL $\Rightarrow -i_x 6 + 2i + 2i_x = 0$.

$-4i_x + 2(45 - i_x) = 0$

$90 - 6i_x = 0 \quad \therefore \underline{\underline{i_x = 15A}}$.

$\therefore i = 30\,A$.

$V_o = 2i = 2(30) = 60\,V$.

$V_x = 6i_x = 6(15) = 90\,V$.

$\Rightarrow P_{45} = -Vi = (-90)(45) = -4050\,W$.

$P_{2i_x} = Vi = (2i_x)(i) = (2 \cdot 15)(30) = 900\,W$.

So the source who supplying power is P_{45} by 4050 W.

2.33

① KVL ⇒ $-20 + 450i + 150i = 0$.

$20 = 600i$, ∴ $i = 0.033333$ A.

∴ $V_x = 0.03333 \times 150 = 5$ V.

$V_o = \left(\frac{V_x}{100}\right) 300$

$= (0.5)\,300 = 15$ V

⇒ power:-

$P_{20} = -20(0.03333) = -0.667$ W

$P_{450} = 450(0.0333)^2 = \underline{0.5\text{ W}}$

$P_{150} = 150(0.0333)^2 = \underline{0.1667\text{ W}}$

$P_{300} = 300(0.5)^2 = \underline{0.75\text{ W}}$

$P_p = -V_o(0.05) = -0.75$ W

∴ the $\Sigma P_{abs} = 1.4167$ W.

2.34

- $V_1 = (4000)(10\times10^{-3}) = 40$ V
- KVL ⇒ $-20 + 2000 i_o + 6000 i_o = 0$

∴ $20 = 8000 i_o$

∴ $i_o = 2.5$ mA $= 0.0025$

⇒ power:-

$P_4 = (4000)(10\times10^{-3})^2 = \underline{0.4\text{ W}}$

$P_2 = (2000)(0.0025)^2 = \underline{0.0125\text{ W}}$

$P_6 = (6000)(0.0025)^2 = \underline{0.0375\text{ W}}$

$P_1 = (-10\times10^{-3})(40) = -0.4$ W

$P_{\frac{V_1}{2}} = (0.0025)(20) = -0.05$ W

∴ $\Sigma P_{abs} = 0.45$ W. $\Sigma P_{del} = 0.45$ W so it's the same

3.5 a) $R = 12\,\Omega$

$V = 18\,V$

$V = iR \quad \therefore I = \frac{18}{12}$

$\therefore I = 1.5\,A.$

$\Rightarrow P = (-1.5)(18) = -27\,W.$

b) $R = 900\,\Omega$

$V = 27\,V$

$\therefore I = \frac{27}{900}$

$\therefore I = 0.03\,A$

$\Rightarrow P = (-0.03)(27)$

$= -0.81\,W.$

c) $R = 30\,\Omega$

$V = 90\,V$

$\therefore I = \frac{90}{30}$

$\therefore I = 3\,A.$

$\Rightarrow P = (-3)(90)$

$= -270\,W.$

d) $R = 120\,\Omega$

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

$\therefore V = 30 \times 10^{-3} \times 120 = 3.6\,V$

$\Rightarrow P = (-30 \times 10^{-3}) \times 3.6 = -0.108\,W$

3.6 a) $R = 36\,\Omega$

$V = 18\,V$

$\therefore I = \frac{18}{36} = 0.5A.$

$P \Rightarrow (0.5)(18) = 9W$

b) $R = 60\,\Omega$

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

$\therefore V = (30 \times 10^{-3})(60) = 1.8\,V$

$P \Rightarrow (30 \times 10^{-3})(1.8) = 0.054\,W$

c) $R = 150\,k\Omega.$

$V = 60\,V$

$\therefore I = \frac{60}{150 \times 10^{3}} = 4 \times 10^{-4}\,A.$

$P \Rightarrow (4 \times 10^{-4})(60) = 0.024\,W$

d) $R = 3250\,\Omega$

$V = 65\,V$

$\therefore I = \frac{65}{3250} = 0.02A.$

$P \Rightarrow (0.02)(65) = 1.3\,W.$

3.21

a) $R_1 = \frac{K-\alpha}{\alpha K} R_o$

$v_o = K v_s = \frac{R_2}{R_1+R_2} v_s$ no lode

$v_o = \alpha v_s = \frac{R_e}{R_1+R_e} \cdot v_s$ full lode

$\Rightarrow R_e = \frac{R_2 R_o}{R_2+R_o}$

$\therefore K = \frac{R_2}{R_1+R_2} \Rightarrow \therefore R_1 = \frac{R_2(1-K)}{K}$

$\therefore \alpha = \frac{R_e}{R_1+R_e} \Rightarrow \therefore R_1 = \frac{R_e(1-\alpha)}{\alpha}$

thats mean :- $\left(\frac{1-K}{K}\right) R_2 = \left(\frac{1-\alpha}{\alpha}\right) R_e \left[\frac{R_2 R_o}{R_2+R_o}\right]$

$\Rightarrow$ So $R_2 = \left(\frac{K-\alpha}{\alpha(1-K)}\right) R_o$

$R_1 = \left(\frac{\cancel{1-K}}{K}\right)\left(\frac{K-\alpha}{\alpha\cancel{(1-K)}}\right) R_o = \frac{K-\alpha}{\alpha K} R_o$.

b) $R_1 = \left(\frac{K-\alpha}{\alpha K}\right) R_o \Rightarrow \frac{0.85-0.80}{(0.85)(0.80)} \cdot 34\times10^3 = 2.5K\Omega$

$R_2 = \left(\frac{K-\alpha}{\alpha(1-K)}\right) R_o \Rightarrow \left(\frac{0.85-0.80}{0.80(1-0.85)}\right) \cdot 34\times10^3 = 14.167\ \Omega$

3.23

a) $R = 12\,k\Omega$

$I = 1.5A$.

$V_6 = \frac{4k}{4k+8k}(18) = 6V$

b) $V = 6V$

$R = 12V$

$\therefore I = 0.5\,A$.

$V = (0.5)(5) = 2.5V$.

3.24

a) $R = 120\,\Omega$

$I = 30\times10^{-3}\,A$

$V = 3.6\,V$

$I_{50} = \frac{120}{60+90+50}(30\times10^{-3}) = 0.018A$.

b) $\frac{60}{80+70} \times 0.018 = 7.2\,mA$.

3.25

a) $\frac{25}{25+10+25} \times 30 = 12.5\,V$

b) $V = iR \Rightarrow i = \frac{12.5}{25} = 0.5\,A$.

c) $\frac{(12+18+20)\|50}{50} \times 0.5 = 0.25\,A$.

d) $V = iR \Rightarrow 0.25 \times 50 = 12.5\,V$

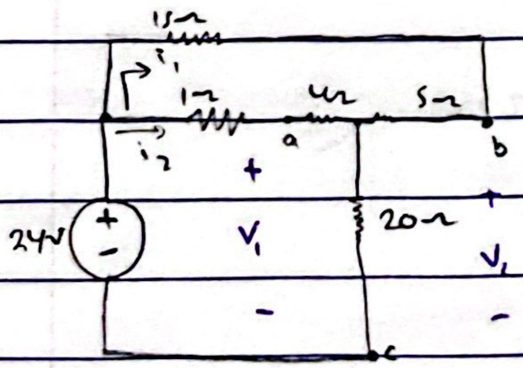
e) $\frac{12}{12+8+20} \times 12.5 = 3\,V$.

3.31

- $i_g = \frac{V}{R} = \frac{125}{10} = 12.5\,A$.
- $\frac{40\|10}{10} \times 12.5 = 10\,A$.

$i_o = \frac{4}{20} \times 10 = 2\,A$.

3.59



$R_1 = 10 \cdot 40/100 = 4\Omega$

$R_2 = 50 \cdot 10/100 = 5\Omega$

$R_3 = 40 \cdot 50/100 = 20\Omega$

- $R_{eq} = 24\Omega$

$\therefore I = 1A$.

- $i_1 = \frac{(20\|5)}{20} \cdot 1 = 0.2A$
- $i_2 = 1 - 0.2 = 0.8\,A$.

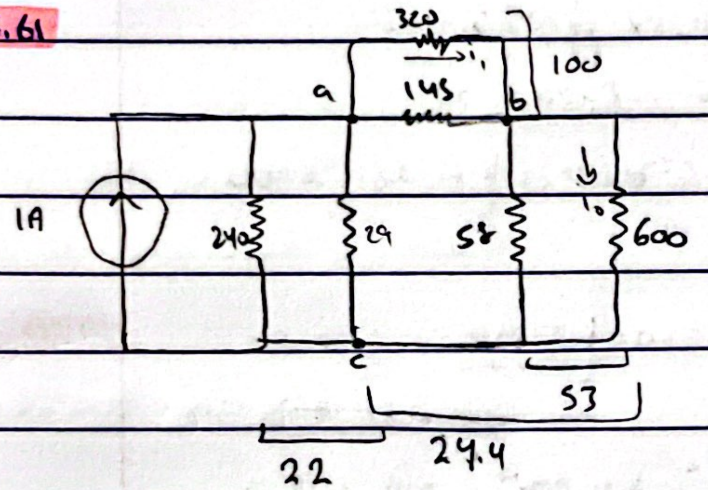
• $V_1 \Rightarrow$ 　　20Ω , 4Ω بتيدي

$$4i_1 + 20i = 4 \cdot 0.8 + 20$$
$$= 23.2\ V$$

• $V_2 \Rightarrow$ 　　5Ω , 20Ω هيدي

$$5i_1 + 20i = 5 \times (0.2) + 20$$
$$= 21\ V$$

3.61



$$R_a = \frac{2900}{20} = 145\ \Omega$$

$$R_b = \frac{2900}{50} = 58\ \Omega$$

$$R_c = \frac{2900}{100} = 29\ \Omega$$

$i_0 =$

4

Q(6):- $\frac{V_x - 24}{100} + \frac{V_x}{25} + 40\times10^{-3} = 0$ (nodal)

$\frac{V_x}{100} - \frac{24}{100} + \frac{4V_x}{100} + 40\times10^{-3} = 0$

$\cancel{?}\ \frac{V_x}{20} = (\frac{24}{100} - 40\times10^{-3})\times 20$

$\therefore V_x = 4\,V = V_o$

• mesh:- $-24 + 20I_1 + 80I_1 + 25(I_1 + 40\times10^{-3}) = 0$

$-24 + 100I_1 + 25I_1 - 1 = 0$

$25 = 125I_1, \therefore I_1 = 0.2\,A$

$\therefore V_o = 25(0.2 - 40\times10^{-3}) = 4\,V$

Q(9):- $-2 + \frac{V_x}{50} + \frac{V_x - 45}{1} = 0$, $\frac{51V_x}{50} = 47$

$\therefore V_x = 46$

$\therefore P$ at $2A = -2\times 46 = -92W$ delivers

Q(11):-

$V_1 \Rightarrow$ $\frac{V_1 - 128}{5} + \frac{V_1}{60} + \frac{V_1 - V_2}{4} = 0$, $\frac{12V_1}{5} + \frac{V_1}{60} + \frac{15V_1}{4} - \frac{V_2}{4} = \frac{128}{5}$

$\frac{28}{60}V_1 - \frac{1V_2}{4} = \frac{128}{5}$. $\Rightarrow 0.466V_1 - 0.25V_2 = 25.6$ / 1.45

$V_2 \Rightarrow$ $\frac{V_2 - V_1}{4} + \frac{V_2}{80} + \frac{V_2 - 320}{10} = 0$, $\frac{V_2}{20,4} - \frac{V_1}{4} + \frac{V_2}{80} + \frac{V_2}{8\cdot10} = 32$

$\frac{29}{80}V_2 - \frac{1}{4}V_1 = 32 \Rightarrow 0.3625V_2 - 0.25V_1 = 32$.

$0.6757V_1 - \cancel{0.3625}V_2 = 37.12$

$+$

$\cancel{0.3625}V_2 - 0.25V_1 = 32$

$= 0.4257V_1 = 69.12 \quad \therefore V_1 = 162\,V$.

$\therefore V_2 = 200\,V$

a) $i_a \Rightarrow \frac{128-162}{5} = -6.8A$, $i_c \Rightarrow \frac{162-200}{4} = -9.5A$

$i_b = \frac{162}{60} = 2.7A$, $i_d \Rightarrow \frac{200}{80} = 2.5A$.

$i_e = \frac{200-320}{10} = -12\ A$.

b) $-(-6.8)(128) = 870.4\,W$, $V(-12)(320) = -3840\,W$

Q(8):-

$V_1 \Rightarrow \frac{V_1-125}{} + \frac{V_1-V_2}{6} = 0$

$\frac{V_1}{24} + \frac{24V_1}{24} + \frac{4}{24}V_1 - \frac{V_2}{6} = 125$, $1.2083V_1 - 0.1666V_2 = 125 \,/\, 0.1379$

$= 0.1666V_1 - 0.02297V_2 = 17.23$

$V_2 \Rightarrow \frac{V_2-V_1}{6} + \frac{V_2}{2} + \frac{V_2-V_3}{12} = 0$ { +

$\frac{2V_2}{12} - \frac{V_1}{6}\ \frac{6V_2}{12} + \frac{V_2}{12} - \frac{V_3}{12} = 0$, $0.75V_2 - 0.1666V_1 - 0.0833V_3 = 0$

$V_3 \Rightarrow \frac{V_3-V_2}{12} + \frac{V_3}{24} + \frac{V_3+125}{1} = 0$

$\frac{2V_3}{24} - \frac{V_2}{12} + \frac{V_3}{24} + \frac{24V_3}{24} = -125$. $1.125V_3 - 0.0833V_2 = -125$

$\rightarrow 0.727V_2 - 0.0833V_3 = 17.23$

$1.125V_3 - 0.0833V_2 = -125 \,/\, 0.074$

$\Rightarrow$

$0.727V_2 - \cancel{0.0833V_3} = 17.23$

$+ \ \cancel{0.088V_3} - 6.17\times10^{-3}V_2 = 9.255$

$\Rightarrow 0.72083V_2 = 7.975$ $\therefore V_2 = 11\,v$

$V_3 = -110\,v$

$V_1 = 104\,v$

a) • $I_1 \Rightarrow 125 - 104 = 21\,A$ • $I_4 \Rightarrow \frac{104 - 11}{6} = 15.5\,A$

• $I_2 \Rightarrow \frac{11}{2} = 5.5\,A$ • $I_5 \Rightarrow \frac{11 - -110}{12} = 10.08\,A$

• $I_3 \Rightarrow -110 + 125 = 15\,A$ • $I_6 \Rightarrow \frac{104 - -110}{24} = 8.9\,A$

b) del $\Rightarrow (125 \times -21) + (125 \times -15) = -4500\,w$

abs $\Rightarrow 441 + 60.5 + 225 + 1441.5 + 1219.2768 + 1901.04$

$5288.3168\,w$

there is something wrong with calculation

Q(17):- $V_0 \Rightarrow -3 + \frac{V_0}{200} + \frac{V_0 + 5i_0}{10} + \frac{V_0 - 80}{20} = 0$

$i_0 = \frac{V_0 - 80}{20}$

$\rightarrow 3 = \frac{V_0}{200} + \frac{V_0}{10} + \frac{1}{2} \times \left(\frac{V_0 - 80}{20}\right) + \frac{V_0}{20} - 4 = 0$

$7 = \frac{21 V_0}{200} + \frac{1}{40} V_0 - 2 + \frac{V_0}{20} = 0$

$9 = \frac{26 V_0}{200} + \frac{V_0}{20} \Rightarrow 9 = \frac{36 V_0}{200}$

a) $\therefore V_0 = 50\,V$

$\Rightarrow i_0 = \frac{50 - 80}{20} = -1.5\,A$

$\therefore 5i_0 = -7.5\,V$, $i_{ab} = \frac{50 - 7.5}{10} = 4.25\,A$

b) $\therefore P = 7.5(4.25) = 31.875\,W$

$V = iR$

$P = IV$

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

• $P_3 = -3 \times 50 = 150\,w$, $P_{20} = -1.5 \times 80 = -120\,w$

$\therefore 270\,W$ c)

Q(8):-

$V_1 \Rightarrow \quad -5i_0 + \frac{V_1}{20} + \frac{V_1 - V_2}{5} = 0 \quad , \quad i_0 = \frac{V_2}{40}$

$-\frac{5 \times V_2}{40} + \frac{V_1}{20} + \frac{4V_1}{20} - \frac{V_2}{5} = 0$

$\frac{-V_2}{8} + \frac{5V_1}{20} - \frac{V_2}{5} = 0$

$-0.325V_2 + 0.25V_1 = 0 \quad / 4.4 \quad (2)$

$V_2 \Rightarrow \quad \frac{V_2 - V_1}{5} + \frac{V_2}{40} + \frac{V_2 - V_3}{10} = 0$

$\frac{8 \times V_2}{8 \times 5} - \frac{V_1}{5} + \frac{V_2}{40} + \frac{4 \times V_2}{4 \times 10} - \frac{V_3}{10} = 0$

$\frac{13V_2}{40} - \frac{V_1}{5} - \frac{V_3}{10} = 0$

$0.325V_2 - 0.2V_1 - 0.1V_3 = 0 \quad / 5.5 \quad (1)$

$V_3 \Rightarrow \quad \frac{V_3 - V_2}{10} + \frac{V_3 - 11.5i_0}{5} + \frac{V_3 - 96}{4} = 0$

$\frac{V_3}{10} - \frac{V_2}{10} + \frac{V_3}{5} - \frac{11.5 \times \frac{V_2}{40}}{5} + \frac{V_3}{4} - \frac{96}{4} = 0$

$0.55V_3 - 0.1575V_2 = 24$

$\Rightarrow \quad 1.7875V_2 - 1.1V_1 - \cancel{0.55V_3} = 0$

$+ \quad \cancel{0.55V_3} - 0.1575V_2 = 24$

$1.63V_2 - \cancel{1.1V_1} = 24$

$+ \quad -1.43V_2 \cancel{+1.1V_1} = 0$

$\Rightarrow \quad 0.2V_2 = 24 \quad \therefore V_2 = 120\ V$

9) $\therefore V_3 = 78\ V$

$\therefore V_1 = 156\ V$

$P_{5i_0} \Rightarrow 156 \times 5i_0$, $i_0 = \frac{120}{40} = 3A$.

$156 \times 15 = ^{-}2340\,W$.

$P_{4.5i_0} \Rightarrow (4.5 \times 3)(8.7)$, $I = 8.7\,A$.

$= ^{+}300.15\,W$

$P_{96} \Rightarrow (96)(-4.5)$, $I = -4.5\,A$.

$= -432\,W$

b) $\therefore \Sigma P_{del} = 432 + 2340 = 2772\,W$

Q(28):-

$V_1 = 4V$.

$V_2 = -2V_x\ V$. , $V_x = V_2 - V_1 = -2V_x - 4$

$V_0 \Rightarrow 7 + \frac{V_0}{3} + \frac{V_0 - V_2}{1} = 0$, $V_x = -2V_x - 4$

$7 + \frac{V_0}{3} + V_0 + 2V_x = 0$. $\therefore V_x = \frac{-4}{3}\ V$.

$7 + \frac{V_0}{3} + \frac{3}{3}V_0 + 2\left(\frac{-4}{3}\right) = 0$

$7 + \frac{4}{3}V_0 - \frac{8}{3} = 0$

$\frac{8}{3} - \frac{21}{3} = \frac{4}{3}V_0$

$\frac{-13}{\cancel{3}} = \frac{4}{\cancel{3}}V_0$

$V_0 = \frac{-13}{3}\ V$

Q(30) :-

$\cdot\ V_4 = 3.125\, V_0$, $V_0 = \frac{V_2 - V_3}{1} = V_2 - V_3$

$\cdot\ V_2 = 20\ V$ $= 20 - V_3$

$V_1 \Rightarrow \frac{V_1}{20} + \frac{V_1 - V_2}{2} + \frac{V_4 - V_3}{4} + \frac{V_4}{80} + 3.125\, V_0 = 0$

$\frac{11 V_1}{20} - 10 + \frac{3.125 V_0}{4} - \frac{V_3}{4} + \frac{3.125 V_0}{80} + 3.125 V_0 = 0$

$0.55 V_1 - 10 + 3.9453\, V_0 - 0.25\, V_3 = 0$

$0.55 V_1 + 3.9453\,(20 - V_3) - 0.25 V_3 = 10$

$0.55 V_1 + 78.906 - 3.9453 V_3 - 0.25 V_3 = 10$

$\cdot\ 0.55 V_1 - 4.1953\, V_3 = -68.906$

$V_3 \Rightarrow \frac{V_3 - V_2}{1} + \frac{V_3 - V_4}{4} + \frac{V_3}{40} = 0$

$V_3 - 20 + \frac{V_3}{4} - \frac{3.125\, V_0}{4} + \frac{V_3}{40} = 0$

$1.275 V_3 - 0.78125\,(20 - V_3) = 20$

$2.05625\, V_3 - 15.625 = 20$

$\therefore V_3 =$

Q(33):- (Mesh)

$I_1 \Rightarrow \quad -128 + 5I_1 + 60(I_1 - I_2) = 0$

$65I_1 - 60I_2 = 128.$

$I_2 \Rightarrow \quad 60I_2 - 60I_1 + 4I_2 + 80I_2 - 80I_3 = 0.$

$144I_2 - 60I_1 - 80I_3 = 0.$

$I_3 \Rightarrow \quad 80I_3 - 80I_2 + 10I_3 + 320 = 0.$

$90I_3 - 80I_2 = -320.$

$\Rightarrow \quad 65I_1 - 60I_2 = 128$

$-60I_1 + 144I_2 - 80I_3 = 0 \quad / 1.08333$

$\cancel{65I_1} - 60I_2 = 128.$

$+$

$\cancel{-65I_1} + 156I_2 - 86.6667I_3 = 0$

$96I_2 - 86.6667I_3 = 128$

$\Rightarrow \quad 96I_2 - 86.6667I_3 = 128$

$-80I_2 + 90I_3 = -320 / 1.2$

$\cancel{96I_2} - 86.6667I_3 = 128$

$+$

$\cancel{-96I_2} + 108I_3 = -384$

$21.333I_3 = -256$

a) $\therefore I_3 = -12A, \quad \underset{I_c}{I_2} = -9.5A, \quad \underset{I_a}{I_1} = -6.8A.$

$\Rightarrow I_b = -6.8 + 9.5 = 2.7A$

$I_d = -9.5 + 12 = 2.5A.$

b) $P_{320} = (320)(-12) = \boxed{-3840\ W}$

$P_{128} = -(128)(-68) = 870.4\ W$

Q(34):-

$I_1 \Rightarrow -125 + I_1 + 6I_1 - 6I_3 + 2I_1 - 2I_2 = 0.$

$9I_1 - 2I_2 - 6I_3 = 125$

$I_2 \Rightarrow -125 + 2I_2 - 2I_1 + 12I_2 - 12I_3 + I_2 = 0.$

$15I_2 - 2I_1 - 12I_3 = 125.$

$I_3 \Rightarrow \frac{42I_3}{6} - \frac{6I_1}{6} - \frac{12I_2}{6} = \frac{0}{6}$

$= 7I_3 - I_1 - 2I_2 = 0$

$I_1 = 23.76A$, $\underset{i_3}{I_2} = 18.43\ A$, $\underset{i_0}{I_3} = 8.66A.$

$i_2 = 23.76 - 18.43 = 5.33\ A.$

a) $i_4 = 23.76 - 8.66 = 15.10A.$

$i_5 = 18.43 - 8.66 = 9.77\ A.$

b) del $\Rightarrow -(125)(23.76) + (-125)(18.43) = -5273.75$

abs $\Rightarrow 5273.75\ W.$

Q(40):-

$I_1 \Rightarrow -660 + 5I_1 + 15I_1 - 15I_3 + 10I_1 - 10I_2 = 0$

$30I_1 - 10I_2 - 15I_3 = 660 \quad /5$

$I_2 \Rightarrow -20 i_\phi + 10I_2 - 10I_1 + 50I_2 - 50I_3 = 0$

$-20(I_2 - I_3)$

$-20I_2 + 20I_3 + 60I_2 - 10I_1 - 50I_3 = 0$

$-10I_1 + 40I_2 - 30I_3 = 0 \quad /5$

$I_3 \Rightarrow -15I_1 - 50I_2 + 90I_3 = 0 \quad /5$

$\Rightarrow 6I_1 - 2I_2 - 3I_3 = 132$

$-2I_1 + 8I_2 - 6I_3 = 0 \quad /2$

$-3I_1 - 10I_2 + 18I_3 = 0$

$6I_1 - 2I_2 - \cancel{3I_3} = 132$

$-$

$-I_1 + 4I_2 - \cancel{3I_3} = 0$

$7I_1 - 6I_2 = 132$

⋮

$I_1 = 42\,A \quad , \quad I_2 = 27\,A \quad , \quad I_3 = 22\,A$

$i_\phi = 5A$

$\Rightarrow P = (-20 \times 5)(27) = 2700\ W$

Q(40):-

$I_1 \Rightarrow \quad -40 + 425 I_1 - 300 I_D = 0$

$425 I_1 - 300 I_D = 40.$

$I_2 \Rightarrow \quad -500 i_D + 250 I_2 = 0$

$250 I_2 = 500 i_D.$

$\boxed{I_2 = 2 i_D}$

$I_D \Rightarrow \quad 400 i_D - 300 I_1 = 0$

$400 i_D = 300 I_1$

$\Rightarrow \boxed{4 i_D = 3 I_1}$

- $i_D = \frac{3}{4} I_1$
- $I_2 = 2 i_D = 2 \cdot \frac{3}{4} I_1 = \frac{3}{2} I_1$

$\rightarrow 425 I_1 - 300 \cdot \frac{3}{4} I_1 = 40$

$\therefore I_1 = 0.2 A \quad , I_D = 0.15A.$

$I_2 = 0.3 A.$

$P = (-0.3)(500)(0.15) = -22.5 W.$

Q(42):-

$\boxed{i_o = I_1 - I_2}$

$I_1 \Rightarrow \quad -30 + 30I_1 - 3I_3 - 20I_2 = 0.$

$30I_1 - 20I_2 - 3I_3 = 30.$

$I_2 \Rightarrow \quad -30 + 27I_2 - 20I_1 - 5I_3 = 0$

$-20I_1 + 27I_2 - 5I_3 = 30.$

$I_3 \Rightarrow \quad 5I_3 + 53i_o - 3I_1 - 5I_2 = 0.$

$-3I_1 - 5I_2 + 5I_3 + 53(I_1 - I_2) = 0$

$50I_1 - 58I_2 + 5I_3 = 0.$

$\therefore I_1 = 52 \quad , \quad I_2 = 60A \quad , \quad I_3 = 110A \quad , \quad i_o = -8A.$

$\Rightarrow P = (110)(53)(-8) = -46640 \, W.$

Q(48):-

$I_1 \Rightarrow \quad -50 + 2I_1 + 4I_1 - 4I_2 + 9i_o = 0$

$6I_1 - 4I_2 + 9i_o \Rightarrow 50 , \; 6I_1 + 5I_2 = 50$

$I_2 \Rightarrow \quad -9i_o + 4I_2 - 4I_1 + 5i_2 + 20I_2 - 20I_3 = 0$

$\left[\begin{array}{l} \cdot \, V_o = 2I_1 \\ \cdot \, I_2 = i_o \\ \cdot \, 9I_o = 144V \end{array} \right]$

$\cancel{-9I_2 + 9I_2} - 4I_1 + 20I_2 - 20I_3 = 0$

$-4I_1 + 20I_2 - 20I_3 = 0.$

$I_3 \Rightarrow \quad I_3 = -1.7V_o = -1.7(2I_1)$

$= -34I_1$

$\Rightarrow \quad 6I_1 + 5I_2 = 50 \qquad \Rightarrow \qquad 6I_1 + \cancel{8}I_2 = 50$

$64I_1 + 20I_2 = 0 \,/\, 4 \qquad\qquad 16I_1 + \cancel{8}I_2 = 0.$

$-10I_1 = 50 \qquad \therefore I_1 = -5A$

$I_2 = 16A = I_o$

$I_3 = 17A.$

$\Rightarrow \quad P_{50} = (-50)(-5) = +250\,W$

✓ $\quad P_{9i_\Delta} = (-144)(16 - -5) = -3024\,W$ $\quad \boxed{I_2 - I_1}$

✓ $\quad P_{1.7v_\Delta} = -(1.7)(2\cdot -5)(20)(16-17) = (17)(-20) = -340\,W$

$\therefore \sum P_{del} = 3364\,W.$

(mix)

Q(13):-

- $-6 + \frac{V_1}{40} + \frac{V_1 - V_2}{8} = 0$

- $-1 + \frac{V_2}{120} + \frac{V_2 - V_1}{8} + \frac{V_2}{80} = 0$

$\therefore V_1 = 120\,V \quad , \quad V_2 = 96\,V.$

Q(14):-

- $\frac{V_1 - 40}{4} + \frac{V_1}{40} + \frac{V_1 - V_2}{2} = 0$

- $\frac{V_2 - V_1}{2} - 28 + \frac{V_2 - V_3}{4} = 0$

- $28 + \frac{V_3}{2} + \frac{V_3 - V_2}{4} = 0$

a) $\therefore V_1 = 60\,V \quad , V_2 = 73\,V \quad , V_3 = -13\,V.$

b) $I = \frac{(160-40)}{4} = 5A$.

$P = (5)(40) = 200\ W$.

Q(19):-

$20m + \frac{V_1}{1k} + \frac{V_1 - V_2}{1250} = 0$

$i_D = \frac{V_2 - V_1}{1250}$.

$\frac{V_2 - V_1}{1250} + \frac{V_2}{4k} + \frac{V_2}{2k} + \frac{V_2 - 2500\, i_D}{200} = 0$

$\therefore V_1 = 60\ V$, $V_2 = 160\ V$, $I_D = 80\ mA$.

a) $P_{20mA} = (20\times10^{-3})(60) = 1.2\ W$ abs.

$P_{2500\, i_D} = (2500\, i_D)\ \frac{160 - 2500(80\times10^{-3})}{200}$

$= -40\ W$ del.

$\therefore$ it's -40 del.

b) $P_{1k} = \frac{(60)^2}{1000} = 3.6\ W$. , $P_{2k} = \frac{(160)^2}{2000} = 12.8\ W$.

$P_{1250} = \frac{(160-60)^2}{1250} = 8W$ $P_{200} = \frac{(160 - (2500(80\times10^{-3})))^2}{200} = 8W$.

$P_{4k} = \frac{(160)^2}{4000} = 6.4\ W$.

$\therefore$ it's $= 3.6 + 8 + 6.4 + 12.8 + 8 + 1.2$

$= 40\ W$.

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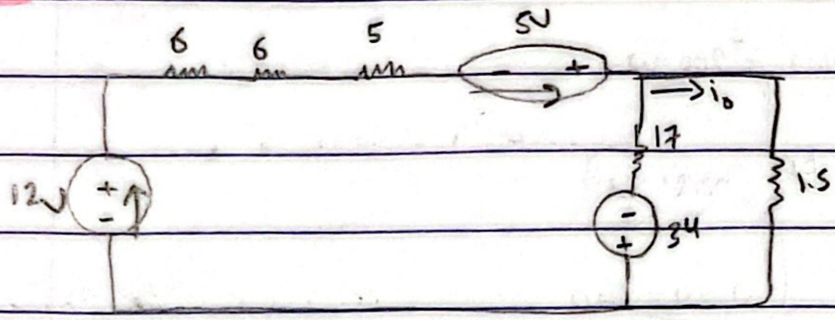
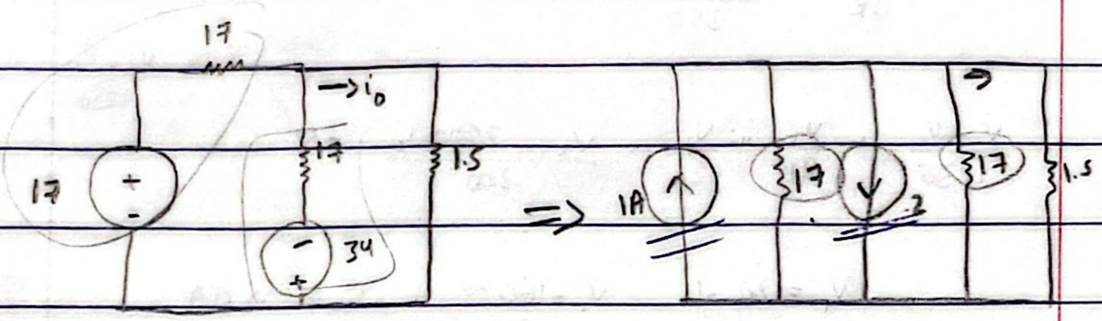
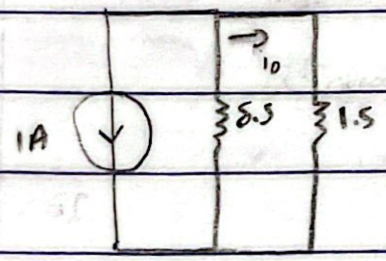
Q(62):-





a)



$\therefore i_o = -\dfrac{8.5}{8.5+1.5} * 1 = -0.85\,A$

b)

- $6(I_1-2) + 6I_1 + 5(I_1-1) + 17(I_1-I_2) - 34 = 0$

$6I_1 - 12 + 6I_1 + 5I_1 - 5 + 17I_1 - 17I_2 - 34 = 0$

$34I_1 - 17I_2 = 51$

- $34 + 17(I_2-I_1) + 1.5I_2 = 0$

$34 + 17I_2 - 17I_1 + 1.5I_2 = 0$

$-17I_1 + 18.5I_2 = -34$

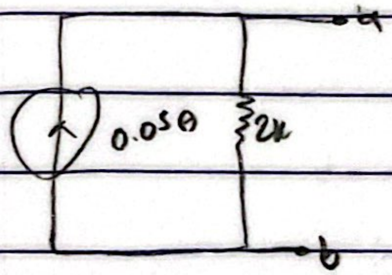
$\therefore i_o = -0.85\,A$

Q(65):-

- $R_N = R_{th} = 4k // 2k$

$= 2k\ \Omega.$

- $CD \Rightarrow \frac{(4//2)k}{2k}(75\times10^{-3}) = 0.05\ A.$



- we can solve it by mesh too.

Q(66):-

- $I_3 = 4A.$

$\Rightarrow -60 + 10(I_1 - 4) + 40(I_1 - I_2) = 0.$

$-60 + 50I_1 - 40 - 40I_2 = 0$

$100 = 50I_1 - 40I_2 \Rightarrow 5I_1 - 4I_2 = 10.$

$\Rightarrow 40(I_2 - I_1) + 8(I_2 - 4) = 0$

$40I_2 - 40I_1 + 8I_2 - 32 = 0$

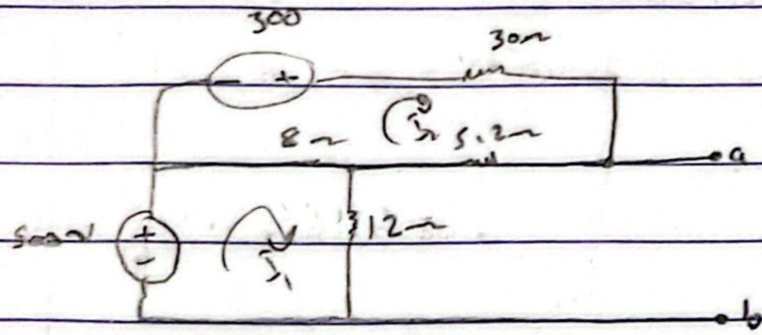
$32 = 48I_2 - 40I_1 \Rightarrow 6I_2 - 5I_1 = 4.$

$\Rightarrow \cancel{5I_1} - 4I_2 = 10 \quad . \quad 2I_2 = 14 \quad \boxed{\therefore I_2 = 7\ A = I_{sc}}$

$+ \quad \cancel{-5I_1} + 6I_2 = 4.$

$\Rightarrow R_{th} = R_N = (10//40) + 8 = 16\ \Omega.$

Q(67):- we start with source transformation :-



$\Rightarrow -500 + 20I_1 - 8I_2 = 0.$

$\dfrac{20I_1 - 8I_2 = 500}{5}$. $= 4I_1 - 1.6I_2 = 100.$

$\Rightarrow -300 + 35.2I_2 + 8I_2 - 8I_1 = 0.$

$\dfrac{43.2I_2 - 8I_1 = 300}{2}$ $= 21.6I_2 - 4I_1 = 150$

$\therefore 20I_2 = 250$

$\therefore I_2 = 12.5\,A.$

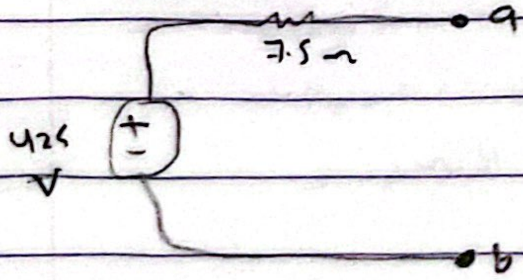
$\cdot\ 4I_1 - (1.6)(12.5) = 100.$

$\therefore I_1 = 30\,A.$

$\Rightarrow V_{th} = 5.2(12.5) + 12(30) = 425\ V$

$R_{th} = ((8 \| 12) + 5.2) \| 30$

$= 7.5\,\Omega$



Q(74):-

mesh ⇒ $-100 + 2500 i_1 + 625 (i_1 + 10^{-3} v_2) = 0$

$100 = 2500 i_1 + 625 i_1 + 10^{-3} v_2 (625)$

$100 = 3125 i_1 + 0.625 v_2$

$100 = 3125 i_1 + 0.625 (6000 I_3)$

$100 = 3125 i_1 + 3750 i_3$

$100 = 3125 i_1 + 3750 (0.5) i_1$

$\boxed{\therefore i_1 = 0.02 A}$

⇒ $-5000 i_1 + 4000 I_3 + 6000 I_3 = 0$

$-5000 i_1 + 10000 I_3 = 0$

$I_3 = \frac{5000}{10000} i_1 = 0.5 I_1$ $\boxed{\therefore I_3 = 0.01}$

⇒ $V_{th} = V_{o.c} = V_2 = 6000 \times 0.01 = \underline{\underline{60V}}$

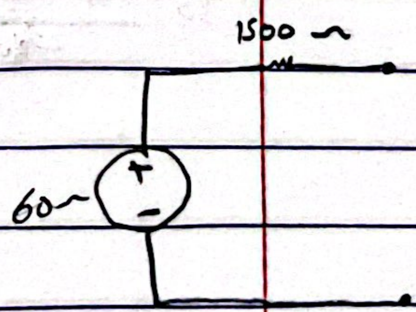
- $V = IR$

$5000 i_1 = 4000 I_{sc}$

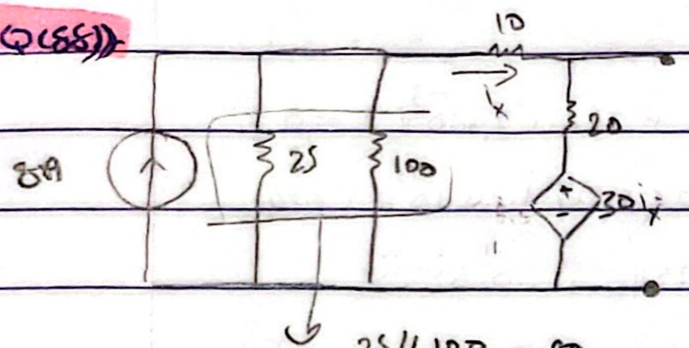
$\therefore I_{s.c} = \frac{5000}{4000} i_1$ ⇒ $0.04 A$

- $i_1 = \frac{100}{2500+625} = 0.032 A$

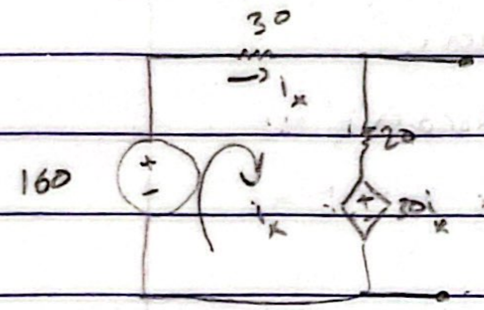
$\therefore R_{th} = \frac{60}{0.04} = 1500 \Omega$



Q(88)



$25 \parallel 100 = 20$



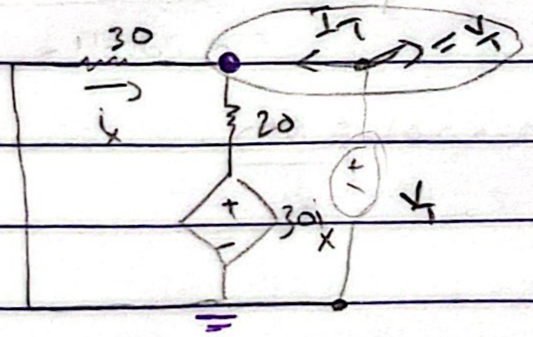
KVL ⇒

$-160 + 30 i_x + 20 i_x + 30 i_x = 0$

$160 = 80 i_x$

$\boxed{\therefore i_x = 2\,A}$

$\Rightarrow V_{th} = 50(2) = 100\ V.$



Same point.

$$\frac{V_T}{30} + \frac{V_T - 30 i_x}{20} - I_T = 0$$

$$\frac{V_T}{30} + \frac{V_T - 30(-V_T/30)}{20} = I_T \Rightarrow \frac{V_T}{30} + \frac{V_T + \frac{30 V_T}{30}}{20} = I_T$$

$$\frac{V_T}{30} + \frac{2V_T}{20} = I_T$$

$$\frac{I_T}{V_T} = \frac{1}{30} + \frac{1}{10} = 0.1333$$

$\boxed{\therefore R_{th} = 7.5\,\Omega.}$

$$\Rightarrow P_{max} = \left(\frac{V_{th}}{R_{th}+R_L}\right)^2 R_L = 250$$

$$= \left(\frac{100}{7.5+R_L}\right)^2 R_L = \frac{10000}{56.25+R_L^2+15R_L} R_L = 250$$

$$0.025 = \frac{R_L}{\cancel{\ }}$$

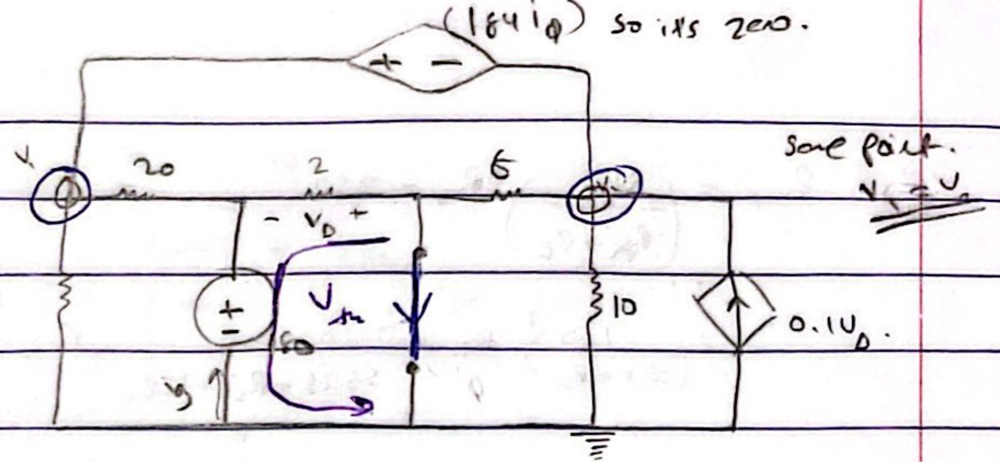
$$0.025R_L^2 + 0.375R_L + 1.40625 = R_L$$

$$0.025R_L^2 - 0.625R_L + 1.40625 = 0$$

$$R_L^2 - 25R_L + 56.25 = 0.$$

$$(R_L - 22.5)(R_L - 2.5)$$

$$\therefore R_L = 22.5 \,/\, 2.5 \ \Omega$$



Q(89):-

a)

Nodal:-

$$\frac{V_1}{16} + \frac{V_1-180}{20} + \frac{V_1}{10} + \frac{V_1-180}{10} - 0.1V_D = 0$$

$$\frac{V_1}{16} + \frac{V_1}{20} - 9 + \frac{V_1}{10} + \frac{V_1}{10} - 18 - 0.1V_D = 0$$

$$0.3125V_1 - 27 - 0.1(0.2V_1 - 36) = 0$$

$$0.3125V_1 - 27 - 0.02V_1 + 3.6 = 0$$

$$0.2925V_1 = 23.4$$

$V_D = \frac{(V_1 - 180) \times 2}{10} = \frac{V_1}{5} - 36 = 0.2V_1 - 36$

$$\boxed{\therefore V_1 = 80V}$$

$$\Downarrow$$

$$V_D = -20V$$

$$V_{th} = V_{bc} = 180 + V_D$$

$$= 180 - 20 \boxed{= 160V}$$

$$\Rightarrow \cdot \frac{V_1}{16} + \frac{V_1-180}{20} + \frac{V_2}{8} + \frac{V_2}{10} - 0.1V_D = 0$$

$$\cdot\ V_1 - V_2 = 184 i_\phi$$

$$\boxed{i_\phi = \frac{V_2}{8} + \frac{180}{2} = 90 + 0.125V_2}$$

$$V_1 = V_2 + 184 i_\phi.$$

$$\frac{V_1}{16} + \frac{V_1}{20} - 9 + \frac{V_2}{8} + \frac{V_2}{10} - 0.1(-180) = 0.$$

$$= 0.1125V_1 - 9 + 0.225V_2 + 18 = 0 = 0.1125V_1 + 0.225V_2 = -9$$

$$\Rightarrow V_1 = V_2 + 184(0.125V_2 + 90)$$

$$= V_2 + 23V_2 + 16560$$

$\Rightarrow \quad 0.1125(24V_2 + 16560) + 0.225V_2 = -9$

$2.7V_2 + 1863 + 0.225V_2 = -9$

$2.925\ V_2 = -1872$

$\boxed{\therefore V_2 = -640\ V}$

$V_1 = 24V_2 + 16560 = 24(-640) + 16560$

$\boxed{\therefore V_1 = 1200\ V}$

$\Rightarrow i_\phi = I_{sc} = 90 + 0.125(-640)$

$\underline{\underline{= 10\ A}}$

$\therefore R_{th} = \dfrac{V_{th}}{I_{sc}} = \dfrac{160}{10}\ \boxed{= 16\ \Omega} = R_o = R_L$.

b) $P_{max} = \dfrac{(160)^2}{(16)(4)} = 400\ W$.

c) • the Voltage at $R_o = \dfrac{16}{16+16} \cdot 160 \Rightarrow$ from thevenin form.

$= 80\ V$.

• we should found i_g

• $\dfrac{V_1}{16} + \dfrac{V_1 - 180}{20} + \dfrac{V_2 - 80}{8} + \dfrac{V_2}{10} - 0.1(80 - 180) = 0$.

• $V_1 = V_2 + 184\ i_\phi$ • $i_\phi = \dfrac{80}{16} = 5A$.

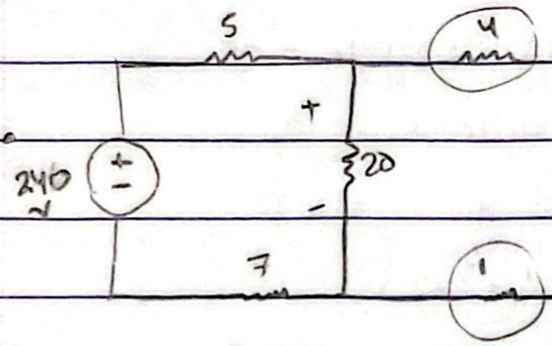
$V_1 = V_2 + 920$.

$\therefore V_1 = 640\ V \ ,\ V_2 = -280\ V$

$\Rightarrow i_g = \dfrac{160 - 80}{2} + \dfrac{180 - 640}{20}\ \underline{\underline{= 27A}}$.

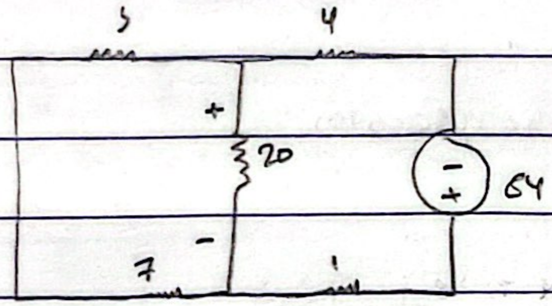
$\therefore P = 27 \cdot 180 = 4860\ w$

Q(9b):-



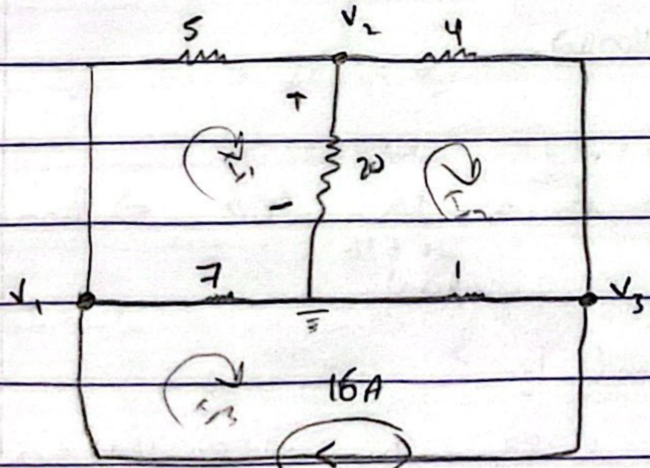
4+1 = 5 Ω.

1) $\frac{20\|5}{(20\|5)+12} \cdot 240 = 60V$



5+7 = 12.

2) $\frac{(12\|20)}{(12\|20)+5} \cdot -84 = -50.4\ V$



- $\frac{V_1-V_2}{5}+\frac{V_1}{7}-16=0 \Rightarrow 0.34V_1-0.2V_2=16$
- $\frac{V_2-V_1}{5}+\frac{V_2-V_3}{4}+\frac{V_2}{20}=0 \Rightarrow 0.5V_2-0.2V_1-0.25V_3=0$ ×5
- $\frac{V_3-V_2}{4}+\frac{V_3}{1}+16=0 \Rightarrow 1.25V_3-0.25V_2=-16$

$\rightarrow 2.5V_2-V_1-1.25V_3=0$

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$\Rightarrow \quad 2.5V_2 - V_1 - \cancel{1.25V_3} = 0$

$+ \quad \cancel{1.25V_3} - 0.25V_2 = -16$

$2.25V_2 - V_1 = -16 \quad / 0.34$

$\Rightarrow \quad 0.765V_2 - \cancel{0.34V_1} = 5.44$

$+ \quad 0.2V_2 + \cancel{0.34V_1} = 16$

$0.969V_2 = 21.44$

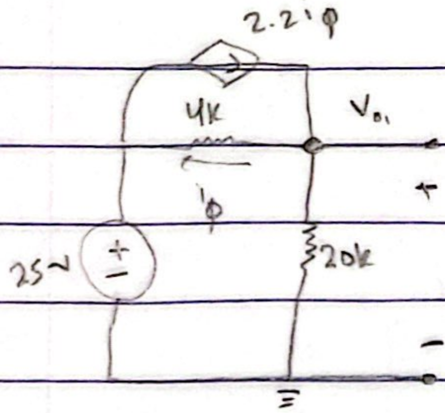
$\therefore V_2 = 22.2 = (3)$. somthing wrong in calculation of V_L

$\therefore V_o = 1 + 2 + 3$

$= 60 - 50.4 + \underline{\underline{18.4}}$

$= 28V$

Q(97):-



$i_\phi = \frac{V_{o1} - 25}{4000}$

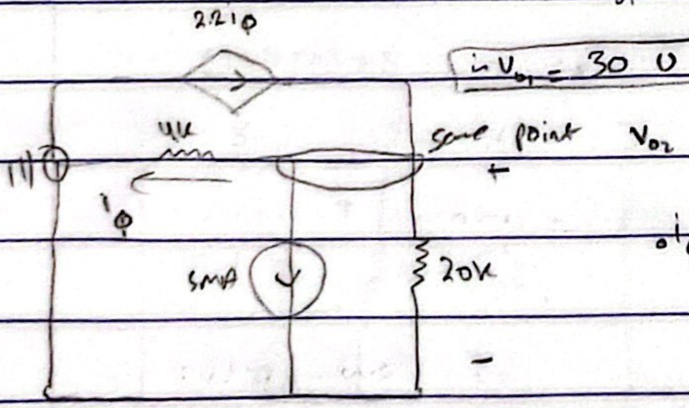
$$V_{o1} \Rightarrow \frac{V_{o1} - 25}{4000} + \frac{V_{o1}}{20000} - 2.2\, i_\phi = 0$$

$$= \frac{V_{o1}}{4000} - \frac{25}{4000} + \frac{V_{o1}}{20000} - 2.2\left(\frac{V_{o1} - 25}{4000}\right) = 0$$

$$3\times10^{-4} V_{o1} - 6.25\times10^{-3} - 5.5\times10^{-4} V_{o1} + 0.01375 = 0$$

$$+2.5\times10^{-4} V_{o1} = +7.5\times10^{-3}$$

$$\boxed{\therefore V_{o1} = 30\ V}$$



$i_\phi = \frac{V_{o2}}{4000}$

$$V_{o2} \Rightarrow \frac{V_{o2}}{4000} + \frac{V_{o2}}{20000} + 5\times10^{-3} - 2.2\left(\frac{V_{o2}}{4000}\right) = 0$$

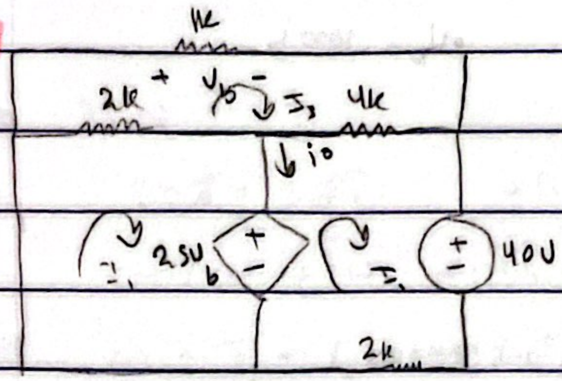
$$-2.5\times10^{-4} V_{o2} = -5\times10^{-3}$$

$$\boxed{\therefore V_{o2} = 20\ V}$$

$$\therefore V_o = V_{o1} + V_{o2} = 30 + 20$$

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

Q(98):-



1)

- $V_b = 1000 i_3$

- $2000(i_1 - i_3) + 2.5V_b = 0 \Rightarrow 2000i_1 - 2000i_3 + 2.5V_b = 0$

  $2000i_1 - 2000i_3 + 2.5(1000 i_3) = 0 \Rightarrow 2000i_1 + 500i_3 = 0$

- $6000 i_2 - 4000i_3 = 2.5V_b = -40 \Rightarrow 6000i_2 - 1500i_3 = -40$

- $7000i_3 - 4000i_2 - 2000i_1 = 0$

$-\cancel{2000}i_1 - 4000i_2 + 7000i_3 = 0$

$+$ $\cancel{2000}i_1 + 500i_3 = 0$

$-4000i_2 + \cancel{7500}i_3 = 0$

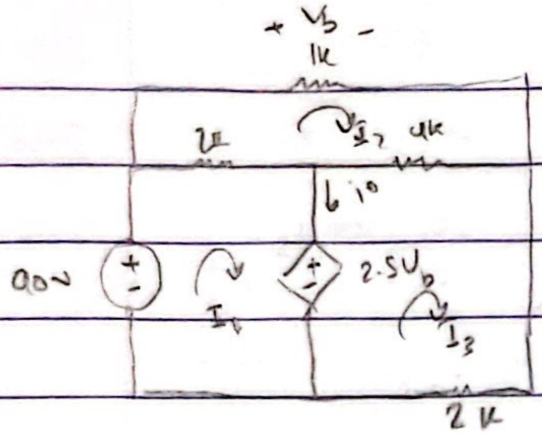
$+$ $6000i_2 - 15000i_3 = -40 \cdot /5$

$30000i_2 - \cancel{7500}i_3 = 200$

$26000 i_2 = -200$

$\therefore i_2 =$

$i^\circ = I_1 - I_3 = 17.895\ A$



$v_b = 1000 i_2$.

$90 = 2000 i_1 - 2000 i_2 + 2.5(1000 i_2)$

$90 = 2000 i_1 + 500 i_2$

$7000 i_2 - 4000 i_3 - 2000 i_1 = 0$

$6000 i_3 - 4000 i_2 - 2.5(1000 i_2) = 0$

$6000 i_3 - 6500 i_2 = 0$

$\Rightarrow \cancel{2000 i_1} + 500 i_2 = 90$

$+ \quad \cancel{-2000 i_1} + 7000 i_2 - 4000 i_3 = 0$

$7500 i_2 - 4000 i_3 = 90 \; / 1.5$

$11250 i_2 - \cancel{6000 i_3} = 135$

$+ \quad -6500 i_2 + \cancel{6000 i_3} = 0$

$4750 i_2 = 135$

$i_2 = 0.0284$ A.

$i_3 = 0.03078$ A

$i_1 = 0.03865$ A

$i^o = i_1 - i_3 = 7.87$ mA.

$\underline{I = 7.87m + 17.895 = 25 \text{ mA}}$.

9

Q(3):-

a) 25 V.

b) $400\pi = 2\pi f$. $\therefore f = 200$ Hz.

c) rad / sec $\therefore$ W $= 1256.6$ rad/sec.

d) $60 \times \frac{\pi}{180} = 1.047$ rad.

e) 60°

f) $\frac{1}{200} = 5$ msec.

g) $0 = 25\cos(400\pi t + 60^\circ)$.

$\cos^{-1} 0 = 400\pi t + 60^\circ$.

$90 - 60 = 400\pi t$.

$\therefore t = 0.02387^\circ$ ×

$\Rightarrow \frac{\pi}{2} - \frac{\pi}{3} = 400\pi t$.

$\frac{\pi}{6} = 400\pi t$.

$\frac{1}{2400} = t = 4.166 \times 10^{-3}$.

h) $25\cos\left(400\pi\left[t - \frac{0.005}{6}\right] + \frac{\pi}{3}\right)$ shift to the right so (-)

$25\cos\left(400\pi t - \frac{\pi}{3} + \frac{\pi}{3}\right) = 25\cos(400\pi t)$.

i)

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Q(6):-

$V_m = \sqrt{2}\, V_{rms} = \sqrt{2}\ 240$

$= 339.41\ V.$

Q(7):-

$-\sin \xrightarrow{+90} \cos$

$\sin \xrightarrow{-90}$

$-\cos \xrightarrow{180}$

Q(11):-

a) $y = 30\cos(200t - 160^\circ) + 15\cos(200t + 70^\circ).$

$= 30\angle -160^\circ + 15\angle 70^\circ$

$= -30\angle 20^\circ + 15\angle 70^\circ$

$= -28.19 + 10j + 5.13 + 14.09$

$= 33.32 + 24.09$

$= 33.32\angle 134^\circ$

$30\angle -160 + 15\angle 70$

$-\sin\ (30)$

$-100\ \angle -60^\circ$

$100\ \angle 120$

$-28.19 + 10j + 5 + 14j$

$-23.19 + 24j$

Q(a):-

a) $Z = \frac{300}{6} \angle 78^\circ - 33^\circ$

$= 50 \angle 45^\circ$ I leads V by 45°

b) $2\pi f = 5000\pi$

$\therefore f = 2500$ Hz $\Rightarrow T = 4\times10^{-4}$ sec.

$= 400\ \mu$sec.

$\frac{45^\circ}{360^\circ} \times 400\mu = 50\ \mu$sec.

Q(22):- $(5 + j8 + 10 \parallel -j20) + (8 + j16) \parallel (40 - j80)$.

$(15 + j8 \parallel -j20) + (8 + j16) \parallel (40 - j80)$.

$$\frac{-j20\,(15 + j8)}{15 + j8 - j20} + \frac{(8 + j16)(40 - j80)}{8 + j16 + 40 - j80}$$

$$= \frac{-300j + 160}{15 - 12j} +$$

and so on

$$i_t = 32.02\angle 38.66^\circ$$

Q(29):- $V_g = 60\cos(8000t - 90^\circ)$

$$\frac{50 \parallel -25j}{2j + (50 \parallel -25j)} \Rightarrow \frac{\frac{-1250j}{50 - 25j}}{25j + \frac{-1250j}{50 - 25j}}$$

$$\Rightarrow \frac{1250\angle -90}{55.9\angle -26.56} = 22.36\angle -63.44$$

$$= 9.997 - 20j$$

$$\Rightarrow \frac{22.36\angle -63.44}{9.997 + 5j} = \frac{22.36\angle -63.44}{11.177\angle 26.57}$$

$$= 2\angle -90^\circ$$

$$\therefore 2\angle -90^\circ \cdot 60\angle -90^\circ$$

$$= 120\angle -180^\circ.$$