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Electrical

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

No: ------------ Date: 24/9/2019

Power Supplies (Power Sources)

- Current source
  - Ac
    - dep. — $i(t) = 3\sin(wt)V_z$
    - indep. — $i(t) = 3\sin(wt)$
  - Dc
    - dep. — $I = 3i_x$, $I = 6V_z$
    - indep. — $I = 4A$
- Voltage source
  - AC (alternating current)
    - dep. — $v(t) = 3\sin(t)V_x$
    - indep. — $v(t) = 4\cos(t)$
  - DC (direct current)
    - dependent — $V = 3V_y$, $V = 4i_x$
    - independent — $V = 3V$

The only (بطارية) أي real physical model (Source)

AC is a function of time

- if Power Supply → AC → AC circuit
  - → DC → DC circuit
- Electrical circuit consists of :-
  1. Power supply → Delivered Power] net Power = zero
  2. Load → consumed Power — no saving, no more Power required
  3. Connections (wires)
- DC :-

Constant magnitude and direction of time حتى لو طاقة البطارية سوف يبقى فرق جهد ثابت

AC :-

Magnitude & direction change with time

26/9/2019

- Voltage definition — voltage unit ≡ Voltage (V)

voltage at ∞ = zero

↳ The work required to move a charge (1 coloumb) from the infinity to this point (if +ve voltag) if -ve voltage → from this point to ∞

A $V = 5V$ B $V = -3V$ $V_{AB} = V_A - V_B = 8\,V$

C $V = 9V$ $V_{AC} = V_A - V_C = 5 - 9 = -4\,V$

- Current definition I. current unit ≡ Ampere (A)

$i = \frac{dq}{dt}$ change of charges with respect with time

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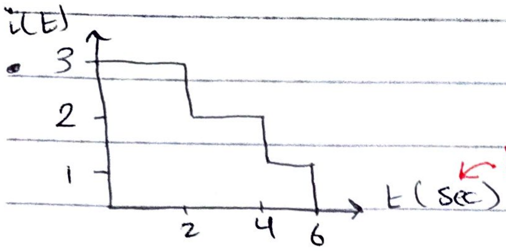
In Exam — Example

- $q = 4e^{-3t}$ Find $i(t)\big|_{t=4\ sec}$

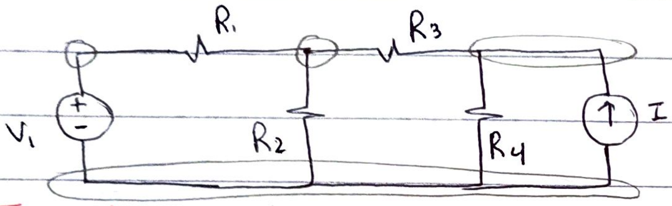
$i = \frac{dq}{dt} = -12e^{-3t}$ $i\big|_{t=4} = -12e^{-3(4)} =$



Be carefull

Find q $q = \int i(t)\,dt$

$q = 2\times3 + 2\times2 + 2\times1 = 11\ C$



6 elements

6 branches OR 5 branches

4 nodes

6 loops 3 meshes

- Teminologies

Imp. mesh — any closed path which doesn't has any closed path inside

elements

branch — any part of circuit have 1 element or more

the same current passes → branch

Imp. node — the connection point of two branches or more

loop — any closed path

- Power Definition P Power unit is Watt (W)

↳ Delivered power (-ve) (Produced)

By power supplies

↳ Absorbed power (+ve) (Consumed)

By Load (resistances)

$\Sigma P = 0$

* Polarity is important, You always must show the sign

$I = 2A$

$V = 5V$ $P = +IV = +2\times5 = +10\ W$ ⇒ Absorbed

* if current passes from: + → +ve Power

− → −ve Power

• every mesh loop but not every loop mesh.

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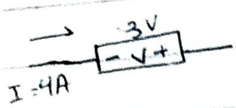
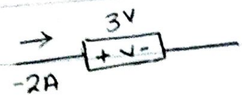
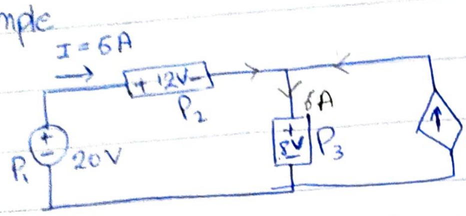


$P = -4 \times 3 = -12W \rightarrow$ Delivered power



$P = +(-2)(3) = -6W \rightarrow$ Delivered

Example — Find the Powers ?



$P_4 = 0.2 \times 5 = 1$

$P_1 = -(5)(20) = -100W$

$P_2 = +(5)(12) = +60W$

$P_3 = +(6)(8) = +48W$

$P_4 = -(8)(1) = -8W$ OR $0 = -100 + 60 + 48 + P_4$ $P_4 = -8$

* Current in ~~mesh~~ will not be changed, voltage is opposite (In ~~parallel~~ series)
* Elements in parallel have the same voltage, current is opposite.
• At any node, sum of current = 0

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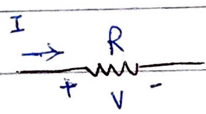
Basic Laws

1* Ohm's Law

V: voltage

I: current

R: resistance



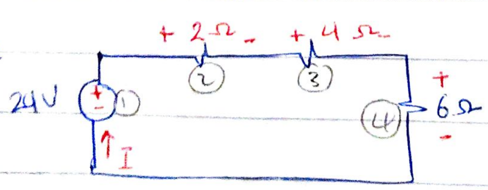
$\boxed{V = I \cdot R}$

"The voltage drop accross any conductor is directly proportional with current intensity passing through the conductor." $V \propto I$ $V = I \cdot R$

• Polarity: in the enter of current $\rightarrow$ +ve polarity (In resistance)

Ex. $R = 4\Omega$ $I = 3A$ $V = (3)(4) = 12V$

Ex.



• we can control the current direction if 1 source, current is out from the +ve polarity of the source (In sources)

$I = \frac{V}{\Sigma R} = \frac{24}{2+4+6} = 2A$

$V_{6\Omega} = 12V$, $V_{4\Omega} = 8V$, $V_{2\Omega} = 4V$, $P_2 = 8W$, $P_3 = 16W$

$P_1 = (-24)(2) = -48W$ $P_4 = 24W$

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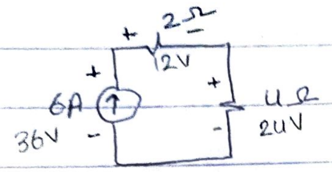
$$\boxed{P = V \cdot I = I^2 R = \frac{V^2}{R}}$$ $[P] = W$

2* Kirchhoff's Laws

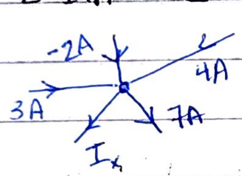


① Kirchhoff's current law (KCL)

"At any node, the algebric sum of the currents equal zero"

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

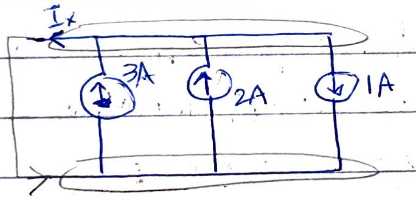
Ex.

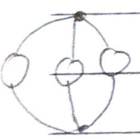


Find I_x $\Sigma I_{in} = \Sigma I_{out}$

$(3) + (-2) + 4 = 7 + I_x$ $\boxed{I_x = -2A}$

Ex.

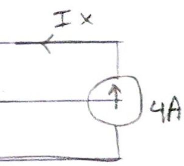




2 nodes

$3 + 2 = 1 + I_x$ $\boxed{I_x = 4A}$

$I_x + 1 = 3 + 2$ $\boxed{I_x = 4A}$



• any element connected up in same node and down on the same node ⟶ connected in parallel. (بداية مع بداية ونهاية مع نهاية)

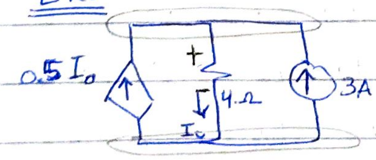
↓

connected in the same node up & down

★ Parallel current sources can be added together.

★ Parall elements have same voltages

Ex.

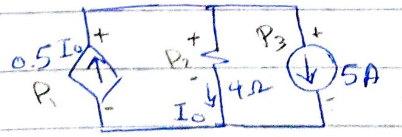


Find I_o? By applying KCL $\Sigma I = 0$ @ node

$3 + 0.5 I_o = I_o$ $0.5 I_o = 3$ $\boxed{I_o = 6A}$

$V_{4\Omega} = (6)(4) = 24V$ ~~$P_{4\Omega} = (6)(24)$~~

★ Since the answer is +ve, the assumed direction is true.



Apply KCL $\Sigma I = 0$ @ node

$0.5 I_o = I_o + 5$ $\boxed{I_o = -10A}$

$V_{4\Omega} = (-10)(4) = -40V$ $P_1 = -(0.5 \times -10)(-40) = -200W$

$P_2 = P_{4\Omega} = (-10)(-40) = 400W$

$P_3 = +(5)(-40) = -200W$

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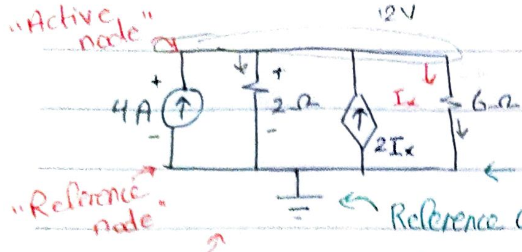


Find the power for each element

2 nodes

← reference node $V_R = 0$ (as a convention, maybe actually $\neq 0$, but as a reference)

Reference (ground) (usually down) assumed to be zero voltage

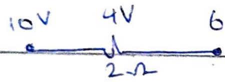
★ Single node ckt Analysis

1- Assign a node (active & reference node)

2- Assign the current in each resistance (resistance between ref. & active node, the current is from active to ref. node, because I assumed $V_{active} > V_{ref.}$ so the current is from high to low voltage)

3- Apply kirchhoff's current law for each active node. KCL

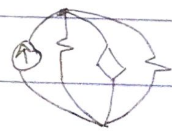
e.g.



$I = V/R = 4/2 = 2A$

solving the above ckt

$4 + 2I_x = \frac{V}{2} + \frac{V}{6}$ $\quad$ $I_x = \frac{V-0}{6}$ since the same direction

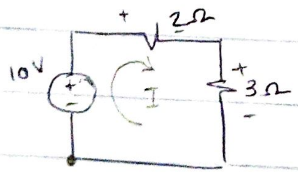


$4 + 2\left(\frac{V}{6}\right) = \frac{V}{2} + \frac{V}{6}$ $\quad$ $4 = \frac{V + 3V - 2V}{6}$ $\quad$ $\frac{2V}{6} = 4$ $\quad$ $\boxed{V = \frac{4 \times 6}{2} = 12V}$

$I_{2\Omega} = 6V$ $\quad$ $I_x = 12/6 = 2A$

$P_{4A} = -(4)(12) = -48\ W$ → delivered power

Example



ابدأ من نقطة وارجع إلى نفس النقطة

$-10 + 2I + 3I = 0$ $\quad$ $I = 2A$ $\quad$ $V_{2\Omega} = 4V$

our assumption of direction is true. $\quad$ $P_S = -(10)(2) = -20W$

$P_{2\Omega} = +(2)^2(2) = 8W$

★ Single mesh ckt Analysis

1. Assign current direction (current exits from +ve pole of battery)
   clockwise or counter clockwise
2. Assign the polarity of each resistance (+ve from enter of current)
3- Apply KVL

if more than 1 source, assume the current clockwise.

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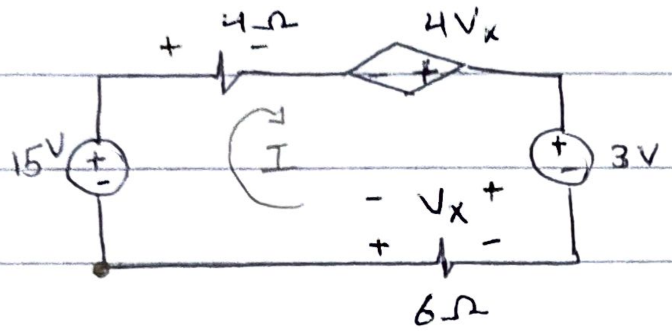
② Kirchhoff's Voltage Law (KVL)

$\Sigma V = 0$ For any closed path , eventhoug in loop

Example "single mesh"



$-15 + 4I - 4V_x + 3 + 6I = 0$

$V_x = -6I$

$-15 + 4I + 24I + 3 + 6I = 0$

$\boxed{I = 12/34 \text{ A}}$ our assumption was correct

H.W show that the total power of the cct = 0

* Resistances Connection

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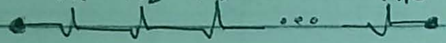
① Series → same current through all resistances.



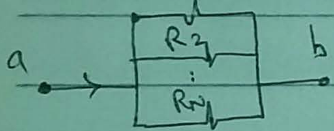
$$\boxed{R_T = R_1 + R_2 + \cdots + R_N}$$ $[R] = \Omega$

$I_1 = I_2 = \cdots = I_N$

Conductance

conductance → $\boxed{G = \frac{1}{R}}$ $[G] = \mho , S$

② Parallel → same voltages

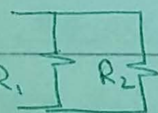


$V_1 = V_2 = \cdots = V_N$

$$\boxed{\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \cdots + \frac{1}{R_N}}$$

$$\boxed{G_T = G_1 + G_2 + \cdots + G_N}$$

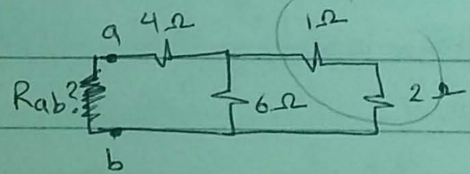
$$\boxed{R_T = \frac{R_1 R_2}{R_1 + R_2}}$$

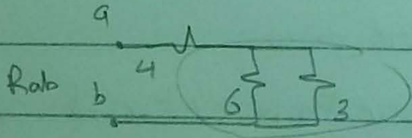


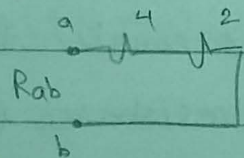
Advice

Start from the end

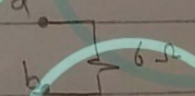
Ex.







$\boxed{R_{ab} = 6\,\Omega}$



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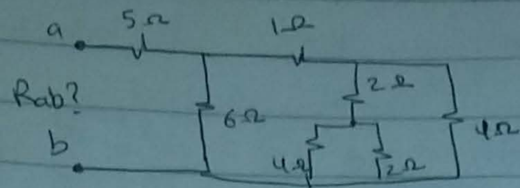
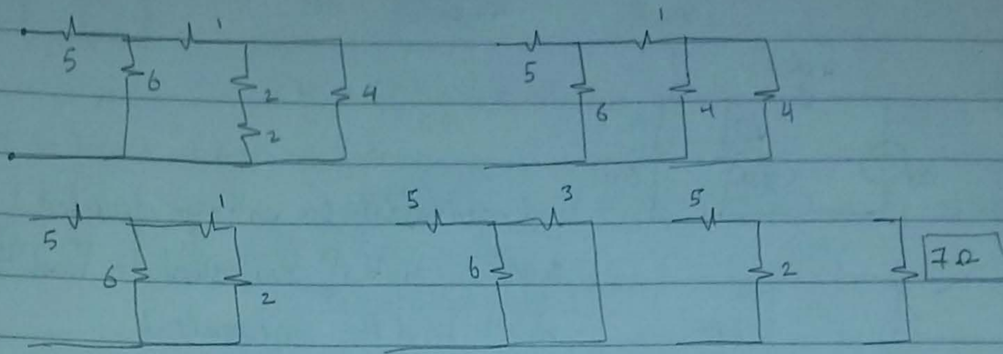
Ex.





Ex.

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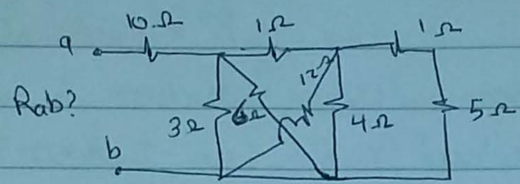
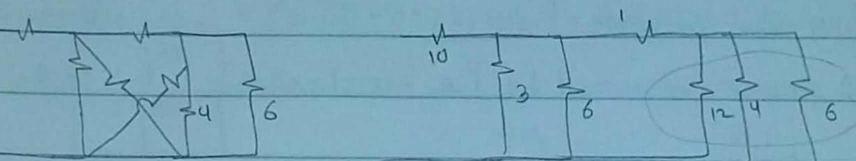
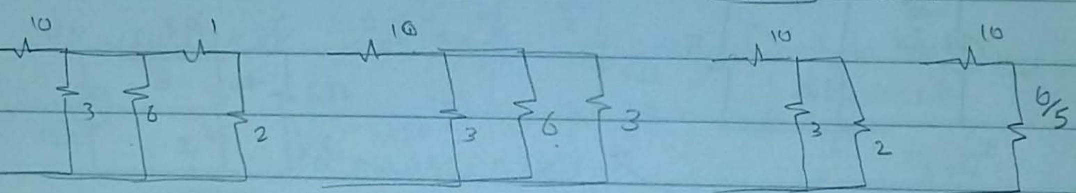
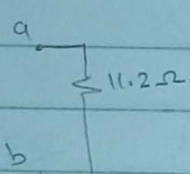




$$\frac{1}{R} = \frac{1}{12} + \frac{1}{4} + \frac{1}{6}$$

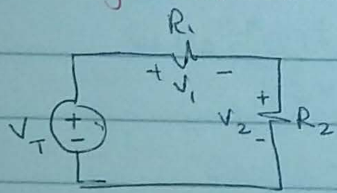
$R = 2\ \Omega$





$\boxed{R_{ab} = 11.2\ \Omega}$

* Voltage divider

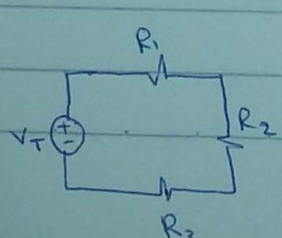


This is the standard ckt (voltage source, 2 R in series)

$$\boxed{V_1 = \frac{V_T R_1}{R_1 + R_2}} \qquad \boxed{V_2 = \frac{V_T R_2}{R_1 + R_2} = V_T - V_1 = I R_2}$$

single mesh $I = \frac{V_T}{R_1 + R_2}$ ✓ $\quad V_1 = I R_1 = \frac{V_T R_1}{R_1 + R_2}$

$-V_T + IR_1 + IR_2 = 0 \quad I = \frac{V_T}{R_1 + R_2}$



$$V_2 = \frac{V_T R_2}{R_1 + R_2 + R_3}$$

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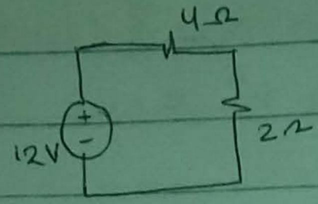
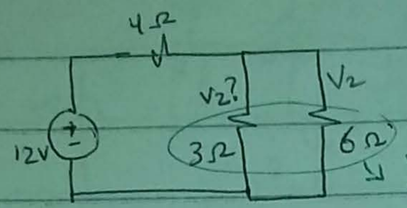
Ex.



$$V_2 = \frac{12 \times 2}{4+2} = 4$$

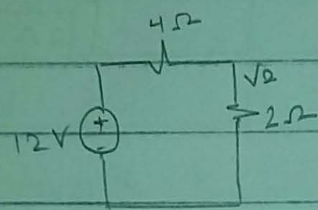
$$V_1 = \frac{(12)(4)}{4+2} = 8$$

Ex.



$$V_2 = \frac{(12)(2)}{2+4} = 4\,V$$

Find equivalent in voltage devider (parallel series), but if you asked to find the current don't find the equivalent.



$I_{6\Omega} = \frac{4}{6}\,A$ ← question will ask for $I_{6\Omega}$

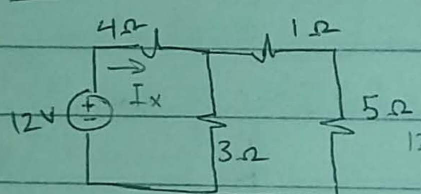
simplify the cct, then go back to the complexed after finding what you want

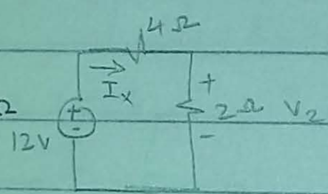
$I_{3\Omega} = \frac{4}{3}\,A$

$I_{4\Omega} = I_{6\Omega} + I_{3\Omega} = 2$

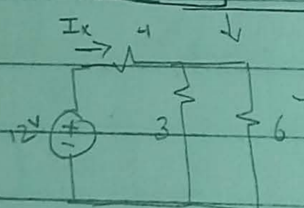
$P_{12V} = -(12)(I_{4\Omega}) = -(12)(2) = -24\,W$

Ex. Find power consumed by 1Ω resistance





$$V_2 = \frac{(12)(2)}{6} = 4\,V$$



$V_{3\Omega} = V_{6\Omega} = 4\,V$

$$V_{1\Omega} = \frac{(4)(1)}{1+5} = \boxed{\frac{4}{6}\,V}$$

$$V_{5\Omega} = \frac{(4)(5)}{1+5} = \boxed{\frac{20}{6}\,V}$$

$I_{1\Omega} = I_{5\Omega} = \frac{4}{6}\,A$

$\boxed{I_x = 2A}$

$$P_{1\Omega} = +\frac{\left(\frac{4}{6}\right)^2}{1} = \boxed{\frac{16}{36}\,W} \text{ absorbed}$$

$$P_{4\Omega} = +\frac{(2)^2}{4} = +1\,W$$

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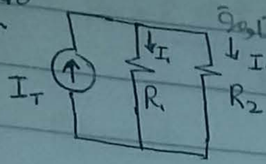
* Current divider rule

$I = \frac{V}{R}$ $I \propto \frac{1}{R}$ المقاومة تقاوم مرور التيار

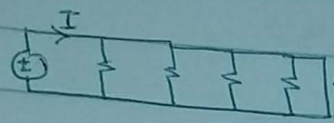
standard Form

تناسب عكسي مع قيمة المقاومة



$$I_1 = \frac{I_T R_2}{R_1 + R_2} \qquad I_2 = \frac{I_T R_1}{R_1 + R_2} = I_T - I_1$$

- Short in home occurs as follows

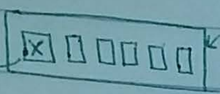


(assuming ideal wire) ← R=0 $I = \frac{V}{0} = \infty$

توصل بين السالب والموجب

cut breakers must exist in each roo[m]

قواطع الغرف



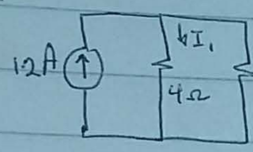
← القاطع الرئيسي

+4-5A

- Difference of resistances prices because of its capacity of power

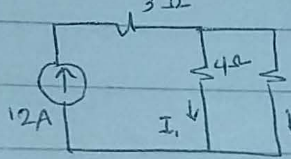
$$P = I^2 R$$

Ex.

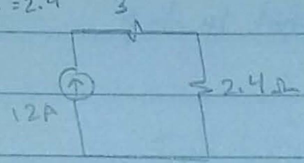


$I_1 = \frac{(12)(16)}{20} = 9.6A$ $I_2 = \frac{(12)(4)}{20} = 2.4A = I_T - I_1$

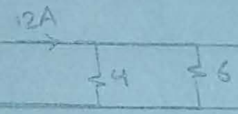
Ex.



$\frac{6 \times 4}{10} = 2.4$

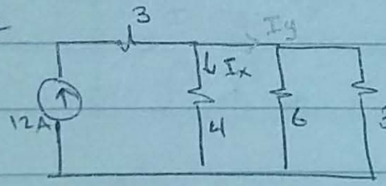


← Don't do that it is current division.

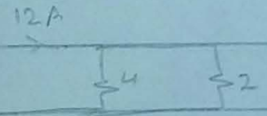


$I_1 = \frac{(12)(6)}{10} = 7.2A$ $I_2 = 12 - 7.2 = 4.8A$

Ex.



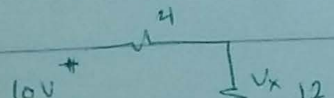
I_x ?



$I_x = \frac{(12)(2)}{4+2} = \frac{24}{6} = 4A$

$I_y = 12 - 4 = 8A$

$I_{6\Omega} = \frac{(8)(3)}{3+6} = \frac{24}{9} A$ $I_{3\Omega} = \frac{(8)(6)}{3+6} = \frac{48}{9} A$

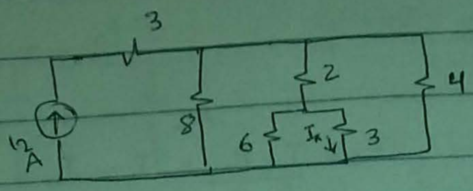


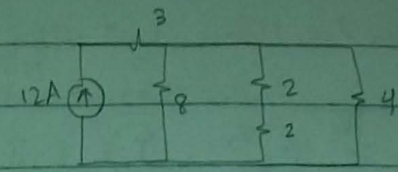
You can find V_x

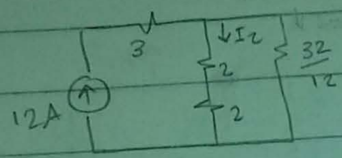
$$V_x = \frac{10 \times 12}{4 + 12} = \frac{120}{16} V$$

No: ------------- Date: -------------

Ex.







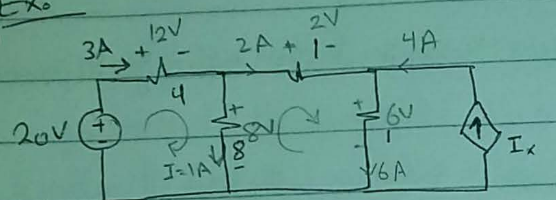
$$I_2 = \frac{(12)\left(\frac{32}{12}\right)}{4+\frac{32}{12}} = 4.8\,A$$

$$I_x = \frac{I_2(6)}{6+3} = 3.2\,A$$

$$I_{6\Omega} = I_2 - I_x$$

In Exam

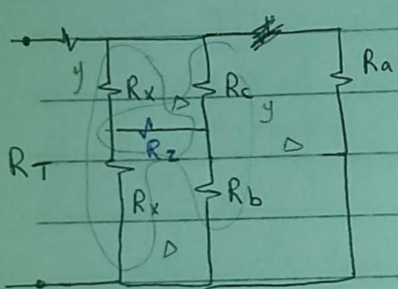
Ex.



Find all unknowns

$I_x = 4A$

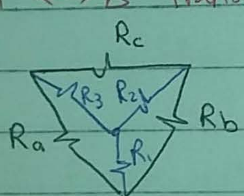
10/10/2019



no parallel, nor series

what to do?

* Y ⟷ Δ Transformation

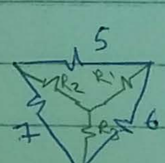


Keep one of them, Y or Δ

Δ → Y transformation • المقام ثابت

$$R_1 = \frac{R_a R_b}{R_a+R_b+R_c} \qquad R_2 = \frac{R_b R_c}{R_a+R_b+R_c} \qquad R_3 = \frac{R_a R_c}{R_a+R_b+R_c}$$

ex.



$$R_1 = \frac{5\times 6}{5+6+7} = \frac{30}{18} \qquad R_2 = \frac{5\times 7}{18} = \frac{35}{18} \qquad R_3 = \frac{6\times 7}{18} = \frac{42}{18}$$

No:-------------- Date:--------------

حاول وشوف اذا تصبح بسيطة أولاً

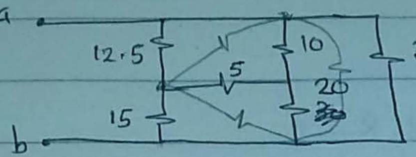
البسط ثابت • $Y \to \Delta$ Transformation

$$R_a = \frac{R_1R_2 + R_1R_3 + R_2R_3}{R_2} \qquad R_b = \frac{R_1R_2 + R_1R_3 + R_2R_3}{R_3} \qquad R_c = \frac{R_1R_2 + R_1R_3 + R_2R_3}{R_1}$$

Example

In exam there will be Y-Δ

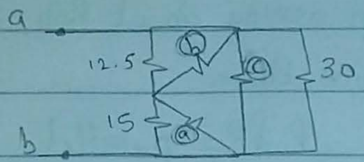
better to solve in Y↔Δ than in loops.



Find Rab ?

$Y \to \Delta$ البسط ثابت 10

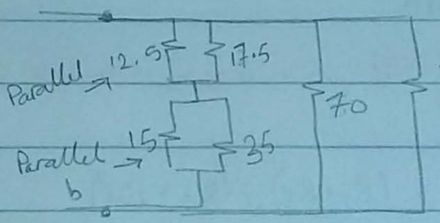
$\frac{5\times10 + 20\times5 + 5\times20}{} = 50+100+100 = 350$



ⓐ $= 350/10 = 35\,\Omega$

ⓑ $= 350/20 = 17.5\,\Omega$

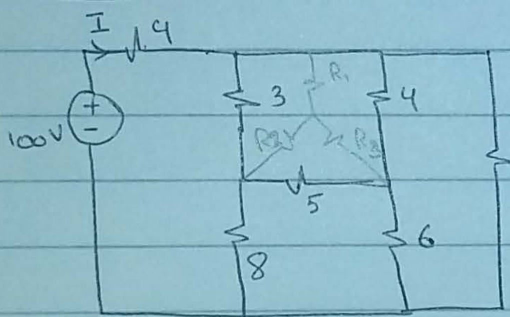
ⓒ $= 350/5 = 70\,\Omega$



Then all parallel

$R_T = 9.63$

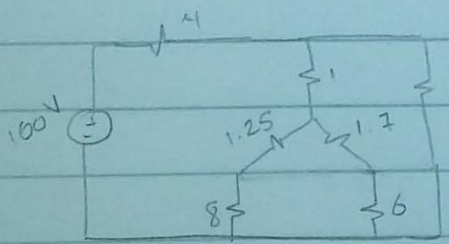
Example

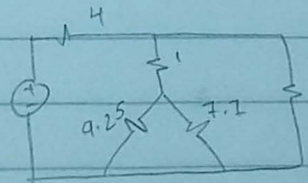


Find I ? $\Delta \to Y$ المقام ثابت $3+4+5=12$

$R_1 = \frac{4\times3}{12} = 1\,\Omega$ $R_2 = \frac{15}{12} = 1.25\,\Omega$

$R_3 = \frac{20}{12} = \frac{5}{3} = 1.7\,\Omega$





$R_T = (((9.25 // 7.7) + 1) // 10) + 4$

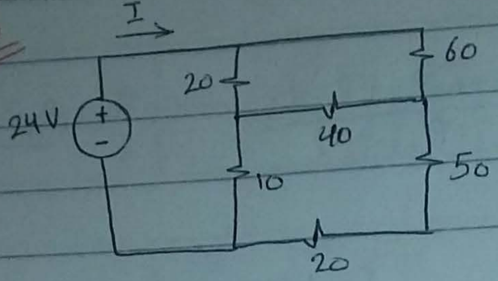
$R_T = 7.42\,\Omega$

$I = \frac{V}{R_T} = \frac{100}{R_T}$

No: ------------ Date: ------------

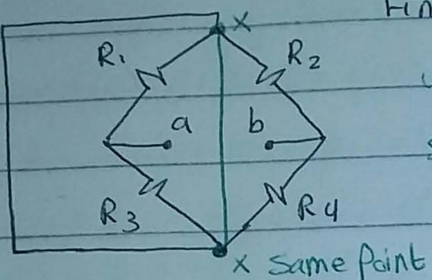
H.W

Find I & Power of the source ?



Example

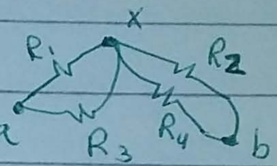
Find Rab ?



when asking about Rab, it is like you put source there

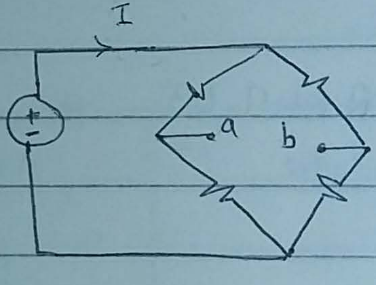
R_1 & R_3 parallel

R_2 & R_4 parallel

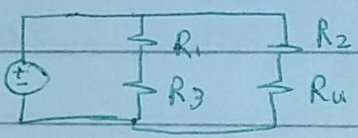


$R_T = ((R_1 // R_3) + (R_2 // R_4))$

★ لا يجوز قياس المقاومات ويوجد مصدر طاقة في الدارة .



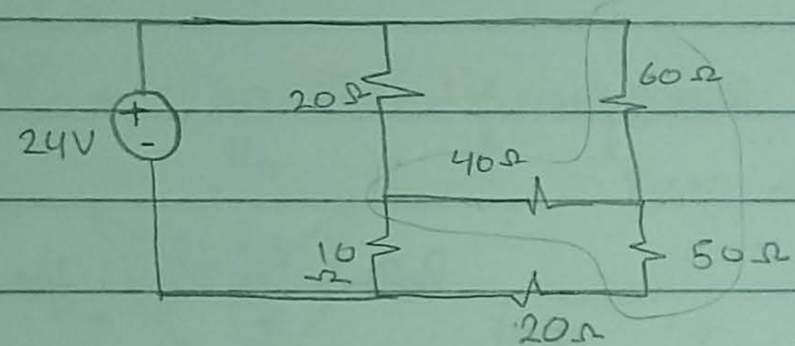
$R_T = (R_1 + R_3) // (R_2 + R_4)$



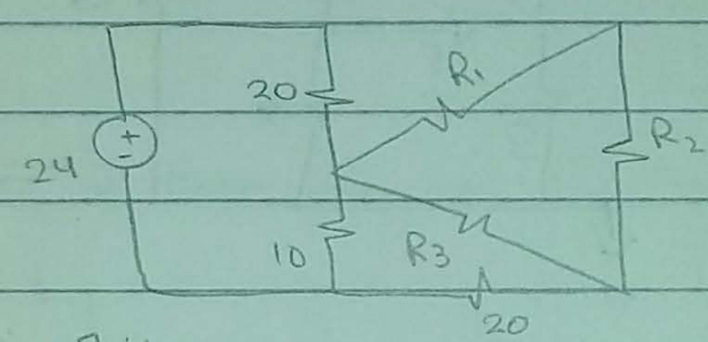
Homework solution

13/10/2019

2Y
1Δ



$Y \Rightarrow \Delta$



$R_1 = 148\ \Omega$

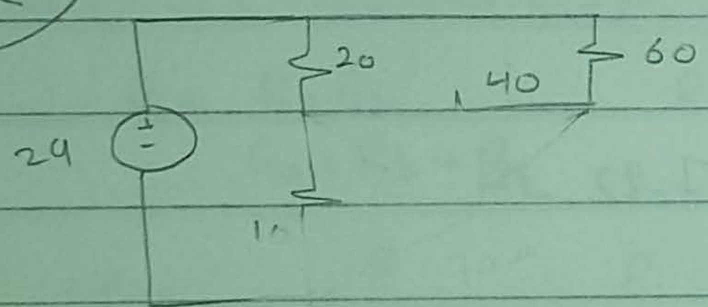
$R_2 = 185\ \Omega$

$R_3 = 123.\bar{3}\ \Omega = \frac{370}{3}$

$40 \times 60 + 40 \times 50 + 60 \times 50 = 7400$

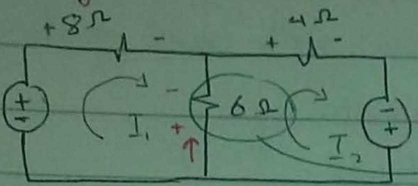
OR

$R_1 = 134\ \Omega \quad R_2 = 235\ \Omega \quad R_3 = 156.7\ \Omega$



No: ------------- Date: -------------

* Mesh analysis for more than 1 mesh



∴ → after solving

→ I don't know the polarity

1. Assign # mesh
2. Assign a current for each mesh (if ∄ 1 source, it is specified)
   Default: clock wise
3. Assign polarity for each resistance
4. Apply KVL for each mesh

KVL Equ.

For Mesh #1:

since we are in mesh 1

$-10 + 8I_1 + 6(I_1 - I_2) = 0$ $14 I_1 - 6 I_2 = 10 \rightarrow (1)$

For mesh #2:

$4I_2 + -12 + 6(I_2 - I_1) = 0$ $-6 I_1 + 10 I_2 = 12 \rightarrow (2)$

* Solving by Cramer's rule:-

$\Delta = \begin{bmatrix} 14 & -6 \\ -6 & 10 \end{bmatrix}$ $\Delta_1 = \begin{bmatrix} 10 & -6 \\ 12 & 10 \end{bmatrix}$ $\Delta_1 = \begin{bmatrix} 14 & 10 \\ -6 & 12 \end{bmatrix}$

Find the determinate

$|\Delta| = 104$ $|\Delta_1| - 172$ $|\Delta_2| = 108$

$I_1 = \frac{\Delta_1}{\Delta} = 1.65$ $I_2 = 2.2 A$

$P_{10V} = -(10)(I_1)$

$P_{6\Omega} = +(I_2 - I_1)^2 6$

Example

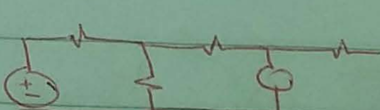
8 تقتي في mesh فيها مصدر تيار

I can't write a mesh equation, I don't know the voltage of source

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

$6I_2 + 7(I_2 - I_3) + 4(I_2 - I_1) = 0$ (2)

$\boxed{I_3 = 3}$ (3)

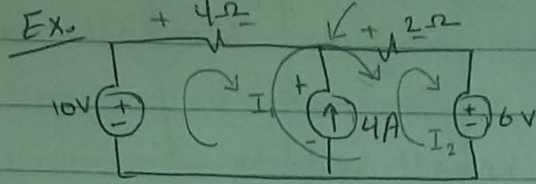


No: ------------- Date: -------------

15/10/2019

special case ★ Super mesh

Ex.



But I can't write mesh equation

2 unknowns

2 equations

write ① Supermesh

$-10 + 4I_1 + 2I_2 + 6 = 0$

$4I_1 + 2I_2 = 4 \rightarrow 1$

② From current source

$I_2 - I_1 = 4 \rightarrow 2$ (like node analysis)

solve equations simultaneously $\boxed{I_1 = \frac{-2}{3} A}$ $\boxed{I_2 = 3.\bar{3} A}$

$V_{4\Omega} = (4)(-2/3) = -8/3 V$ $V_{2\Omega} = (2)(I_2) = 6.67 A$

$P_{10V} = -(10)(-2/3) = +20/3 W$ absorbed (مثل شحن الجهاز)

I can do it here because I know the ~~current~~ and voltage → V_{4A} : $-10 + -8/3 + V_{4A} = 0$ $V_{4A} = 38/3 V = 12.6 V$

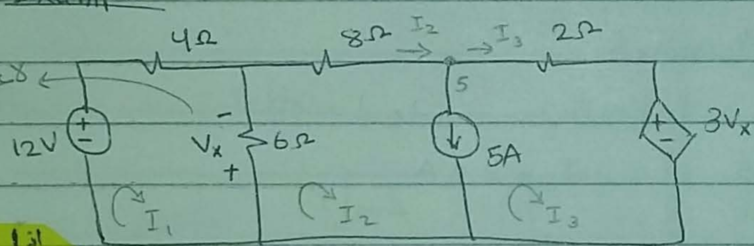
Be careful our ~~direction~~ in the ~~loop~~.

$P_{4A} = -(4)(12.6) = -50.6 W$ according to our assumption

$P_{6V} = +(6)(3.\bar{3}) = +20 W$ absorbed

Example

$I_2 = I_3 + 5$



لا علاقة لـ نقدر كتابة mesh equation

3 unknowns → 3 equations.

2 supermesh 3 meshes

not necessary to go to the big mesh

اذا اخترنا mesh بدل current source يطلع error !

$I_2 - I_3 = 5 \rightarrow 1$

② mesh 1

$-12 + 4I_1 + 6(I_1 - I_2) = 0$ $10I_1 - 6I_2 = 12 \rightarrow 2$

③ Supermesh

$-12 + 4I_1 + 8I_2 + 2I_3 + 3V_x = 0 \rightarrow 3$ $V_x = 6(I_2 - I_1) \rightarrow 4$ OR

KVL around mesh #1

$-12 + 4I_1 - V_x = 0$ $V_x = 4I_1 - 12$

Solve these 4 equations.

H.W

You can make it like this

[illegible]

Find i_1, i_2, i_3?

Put Point from where you start

$3 + i_3 = i_1$

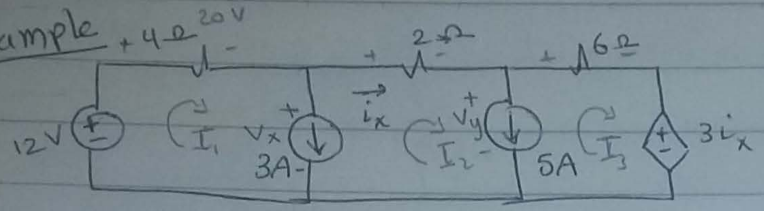
$I_1 + I_2 = I_2 + I_3 + 1$

$I_1 - I_3 = 3$

$-3 - V - 1 + 3.2 =$

20/10/2019

Example



$i_x = I_2$

① $-12 + 4I_1 + 2I_2 + 6I_3 + 3i_x = 0$

② $I_1 - I_2 = 3$

③ $I_2 - I_3 = 5$

$I_1 = 5\ A$
$I_2 = 2\ A$
$I_3 = -3\ A$

$-12 + 20 + V_x = 0 \quad \boxed{V_x = -8V}$ $\qquad -V_x + 2\times 2 + V_y = 0 \quad \boxed{V_y = -12V}$

$P_{3A} = +(3)(-8) = -24W$ (Delivered) $\qquad P_{5A} = +(5)(-12) = -60W$ (Del.)

$P_{3i_x} = +(-3)(3\times 2) = -18W$ (Delivered)

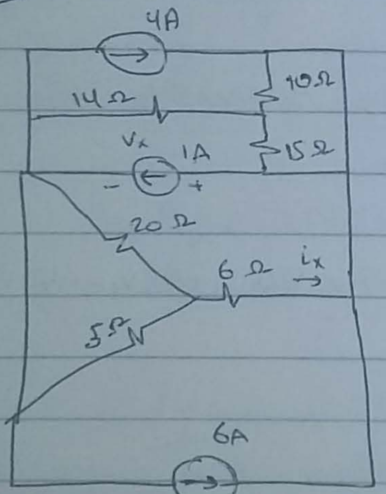
$P_{12V} = -(5)(12) = -60W$ (Delivered)

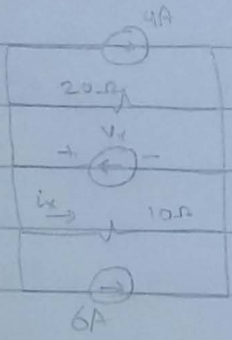
$P_{4\Omega} = +(5)^2 4 = 100W$ (Abs.) $\qquad P_{2\Omega} = +(2)^2(2) = 8W$ (abs.)

$P_{6\Omega} = +(-3)^2(6) = 54W$ (Abs.)

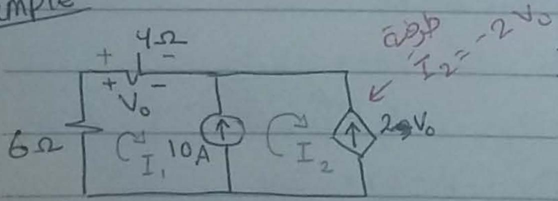
$\Sigma P = 0$ check $\quad -24 - 18 - 60 - 60 + 100 + 54 + 8 = 0$ #

Example



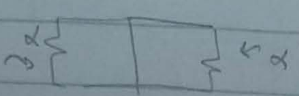


Example

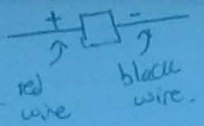


$I_2 - I_1 = 10 \qquad I_2 = -2V_o = -2(4)(I_1) = -8I_1$

$I_1 = -10/9\ A$



* أي شيء على التوازي مع short cut يلغى



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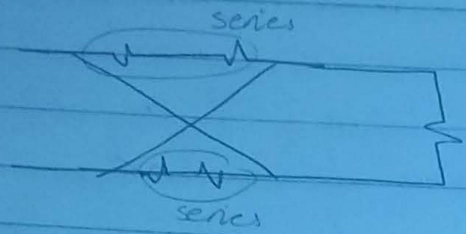
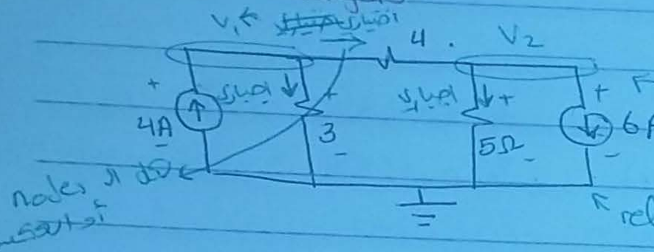


Then in parallel

22/10/2018

* Nodal Analysis



3 nodes
active nodes

reference node $V_R = 0$

* we assum active node voltages $\neq 0$

① Define the nodes

② Assign a voltage for each node

③ Assign a current for each resistor (current must from active to reference)
resistance between two active nodes is up to you

④ Apply KCL for each ACTIVE node.

node ①

$$4 = \frac{V_1 - 0}{3} + \frac{V_1 - V_2}{4}$$ $48 = 4V_1 + 3V_1 - 3V_2$ $7V_1 - 3V_2 = 48 \rightarrow ①$

node ②

$$\frac{V_1 - V_2}{4} = \frac{V_2}{5} + 6$$ $5V_1 - 5V_2 = 4V_2 + 120$ $5V_1 - 9V_2 = 120 \rightarrow ②$

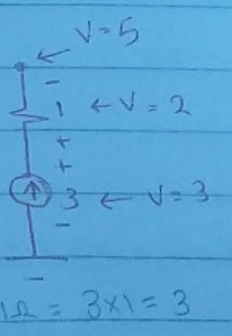
$\boxed{V_1 = 1.5V \quad V_2 = -12.5V}$

$V_{3\Omega} = V_1 = V_{4A}$

$I_{4\Omega} = \frac{V_1 - V_2}{4} = \frac{14}{4} A$

$P_{4A} = -(4)(1.5) = -6W$

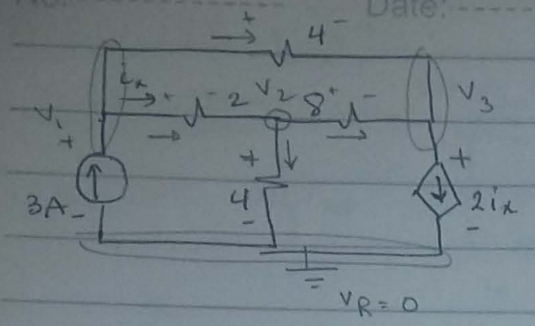
$P_{6A} = +(6)(-12.5)$



$V_{1\Omega} = 3 \times 1 = 3$

V

No: Date:



Power in each element?

4 nodes, 3 active nodes ⟹ 3 equations

branches = # terms in equation

node ①

$$3 = \frac{V_1 - V_2}{2} + \frac{V_1 - V_3}{4} \quad / \times 4 \qquad 12 = 2V_1 - 2V_2 + V_1 - V_3$$

$$\boxed{12 = 3V_1 - 2V_2 - V_3} \rightarrow ①$$

node ②

$$\frac{V_1 - V_2}{2} = \frac{V_2}{4} + \frac{V_2 - V_3}{8} \quad / \times 8 \qquad 4V_1 - 4V_2 = 2V_2 + V_2 - V_3$$

$$\boxed{4V_1 - 7V_2 + V_3 = 0} \rightarrow ②$$

node ③

$$\frac{V_2 - V_3}{8} + \frac{V_1 - V_3}{4} = 2i_x \quad \text{But } i_x = \frac{V_1 - V_2}{2}$$

$$\frac{V_2 - V_3}{8} + \frac{V_1 - V_3}{4} = V_1 - V_2 \quad / \times 8 \qquad V_2 - V_3 + 2V_1 - 2V_3 = 8V_1 - 8V_2$$

$$\boxed{6V_1 - 9V_2 + 3V_3 = 0} \rightarrow ③ \qquad \boxed{V_1 = 4.8\,V \quad V_2 = 2.4\,V \quad V_3 = -2.4\,V}$$

$$P_{3A} = -3(4.8) = -14.4\,W$$

$$P_{dep.} = +(-2.4)\left(\frac{4.8 - 2.4}{2}\right) \times 2 = -5.76\,W$$

$$P_{4\Omega\,down} = V_2^2/4 = 2.4^2/4 = 1.44\,W$$

$$P_{2\Omega} = (V_1 - V_2)^2/2 = 2.88\,W$$

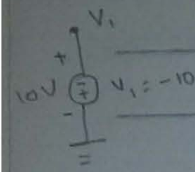
$$P_{8\Omega} = +(V_2 - V_3)^2/8 = 2.88\,W$$

$$P_{4\Omega\,up} = +(V_1 - V_3)^2/4 = 12.96\,W$$

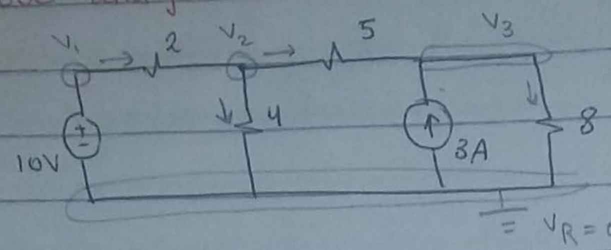
Check $\Sigma P = 0$ ⟹ ✗

No: ---------- Date: ---------- 24/10/2019

* Supernode analysis



Ex.



@ node ① $V_1 = 10\,V \to ①$

@ node ② $\frac{V_1-V_2}{2} = \frac{V_2}{4} + \frac{V_2-V_3}{5}$ $\frac{V_1}{2} - \frac{1}{2}V_2 = \frac{V_2}{4} + \frac{V_2}{5} - \frac{V_3}{5}$ ($V_1 = 10$) $\times 20$

$-19V_2 + 4V_3 = -100 \to ②$

@ node ③ $\frac{V_2-V_3}{5} + 3 = \frac{V_3}{8}$ $8V_2 - 8V_3 + 120 = V_3$ $8V_2 - 9V_3 = -120 \to ③$

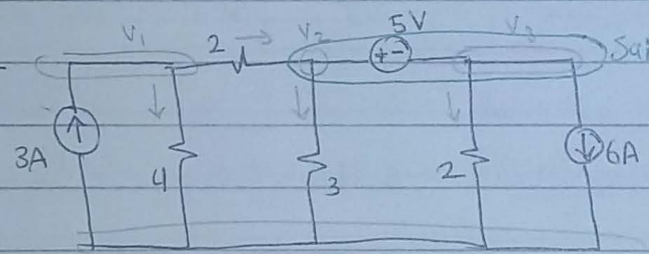
write solution in matrix form

$$\begin{bmatrix} -19 & 4 \\ 8 & -9 \end{bmatrix}\begin{bmatrix} V_2 \\ V_3 \end{bmatrix} = \begin{bmatrix} -100 \\ -120 \end{bmatrix}$$

$a_1 x + b_1 y + C_1 z = D_1$

$$\begin{bmatrix} a_1 & b_1 & C_1 \\ a_2 & b_2 & C_2 \\ a_3 & b_3 & C_3 \end{bmatrix}\begin{bmatrix} x \\ y \\ z \end{bmatrix} = \begin{bmatrix} D_1 \\ D_2 \\ D_3 \end{bmatrix}$$

Ex.



Supernode

write available nodes

Supernode → 1 equation

@ node ① $3 = \frac{V_1}{4} + \frac{V_1-V_2}{2}$ $12 = 3V_1 + 2V_1 - 2V_2$

$5V_1 - 2V_2 = 12 \to ①$

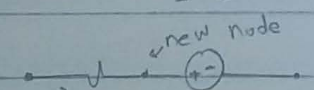
@ super node $\frac{V_1-V_2}{2} = \frac{V_2}{3} + \frac{V_3}{2} + 6$ $-3V_2 + 3V_1 = 2V_2 + 3V_3 + 36$

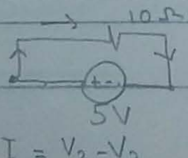
$-3V_1 + 5V_2 + 3V_3 = +36 \to ②$

@ voltage source $V_2 - V_3 = 5$

matrix
$$\begin{bmatrix} 3 & -2 & 0 \\ 3 & -5 & -3 \\ 0 & 1 & -1 \end{bmatrix}\begin{bmatrix} V_1 \\ V_2 \\ V_3 \end{bmatrix} = \begin{bmatrix} 12 \\ 36 \\ 5 \end{bmatrix}$$

!



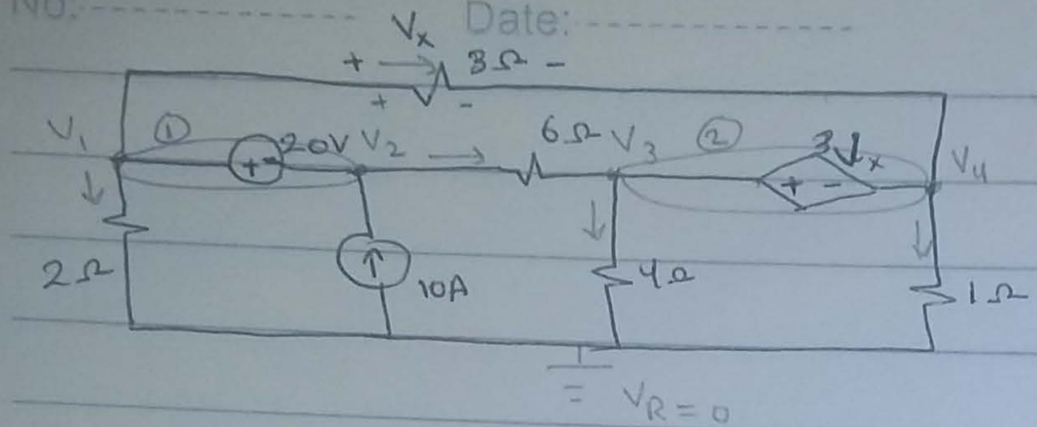


نشتغل بدون supernode $I = \frac{V_2 - V_3}{10}$

YASSIN

* But at end you can find current in voltage source, by applying KCL around the node.

No: .... Date: ....



① Supernode ①

$$\frac{V_1}{2} + \frac{V_1 - V_4}{3} + \frac{V_2 - V_3}{6} = 10 \quad \times 6$$

$$3V_1 + 2V_1 - 2V_4 + V_2 - V_3 = 60$$

$$5V_1 + V_2 - V_3 + 2V_4 = 60 \rightarrow ①$$

② Supernode ②

$$\frac{V_2 - V_3}{6} + \frac{V_1 - V_4}{3} = \frac{V_4}{1} + \frac{V_3}{4} \quad \times 12$$

$$2V_2 - 2V_3 + 4V_1 - 4V_4 = 12V_4 + 3V_3$$

$$4V_1 + 2V_2 - 5V_3 - 16V_4 = 0 \rightarrow ②$$

③ $V_1 - V_2 = 20 \rightarrow ③$

④ $V_3 - V_4 = 3V_x$ But $V_x = V_1 - V_4$

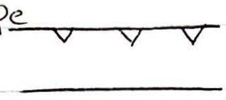
$$V_3 - V_4 = 3V_1 - 3V_4$$

$$3V_1 - V_3 - 2V_4 = 0 \rightarrow ④$$

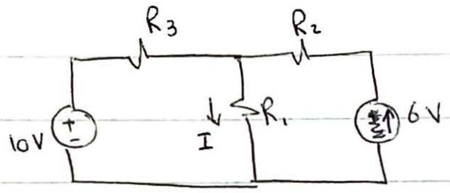
5/11/2019

* Superposition technique نظرية التراكيب

Pipe



effect of each one ~~equal~~ when added together is the same for all of them together



I is summation of the two sources every time one ~~depend~~ independent source

"kill all the <u>INDEPENDET</u> sources except one"

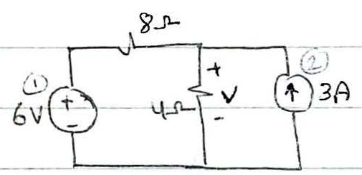
kill → Voltage independent source → Short cct

Current independent source → Open cct

NOT POWER - To calculate voltage of currents, it consists of many components

Advice: Each time you solve draw, number the sources, you have to control the direction (polarity)

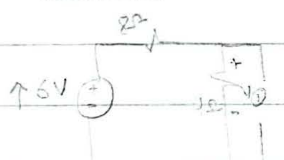
Example:



Find V using superposition (S.P)

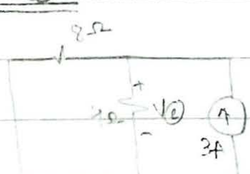
Find the current coming from source #1 → Requires superposition.

Source 1



$V_{①} = \frac{6\times4}{8+4} = \boxed{2V}$

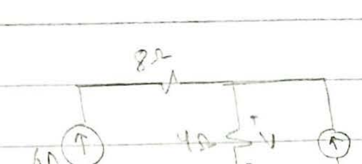
Source 2



$V_{②} = 2(4) = \boxed{8V}$

$I_{4\Omega} = \frac{3\times8}{12} = 2A$

→ $V = V_{①} + V_{②} = 2+8 = \boxed{10V}$

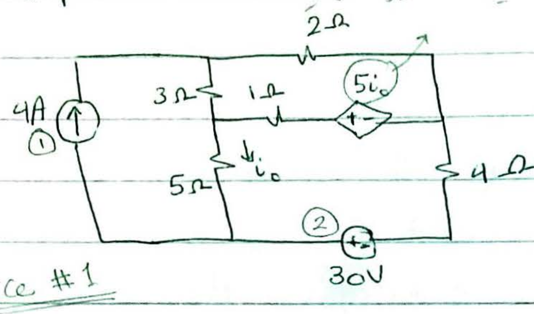


Source 1

$V_{①} = 24V$

No: .... Date: ....

Example يعتبر على التيار المار في 5Ω



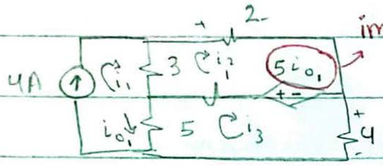
Find i_o by S.P

3 sources

2 ind. sources

twice SP.

Source #1



$i_{o1} = 4 - 0.94 = \boxed{3.05A\downarrow}$

Mesh analysis :-

#1 $i_1 = 4A \rightarrow ①$

#2 $2i_2 - 5i_{o1} + (i_2 - i_3) + 3(i_2 - i_1) = 0$

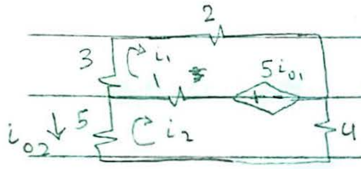
$i_{o1} = i_1 - i_3$

$2i_2 - 5i_1 + 5i_3 + i_2 - i_3 + 3i_2 - 3i_1 = 0$

$6i_2 + 4i_3 = 32 \rightarrow ②$

#3 $5(i_3 - i_1) + (i_3 - i_2) + 5(i_1 - i_3) + 4i_3 = 0$

$-i_2 + 5i_3 = 0 \rightarrow ③$



$i_{o2} = -i_2$

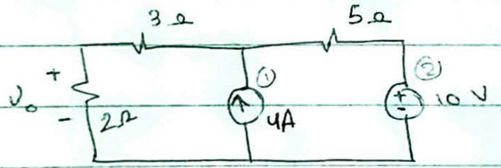
Source #2

#1 $6i_1 - i_2 - 5(-i_2) = 0 \quad 6i_1 + 4i_2 = 0 \rightarrow ①$

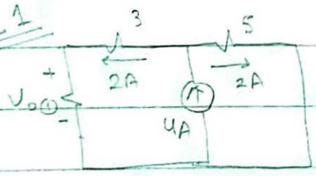
#2 $5i_2 + i_2 - i_1 + -5(-i_2) + 4i_2 = 30 \quad -i_1 + 5i_2 = 30 \rightarrow ②$

$\boxed{i_1 = -3.5 \quad i_2 = 5.3A}$ $\boxed{i_{o2} = -5.3A\downarrow}$ $\boxed{i_o = i_{o1} + i_{o2} = -2.25A}$

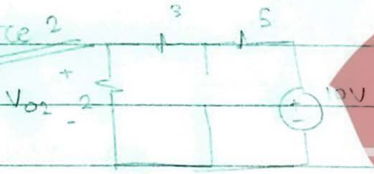
Example



Source 1



Source 2



$V_{o1} = 2 \times 2 = \boxed{4V}$

$V_{o2} = \frac{10 \times 2}{10} = \boxed{2V}$

$\Rightarrow V_o = V_{o1} + V_{o2} = 4 + 2 = \boxed{6V}$

Imp * why I can't apply power?

- if opposite polarities, power will be added not substracted ($\frac{V^2}{R}$ / I^2R is +ve

- we calculate it after finding the overall current/~~or~~ voltage

Solve H.W on Facebook

No: ---------- Date: ----------

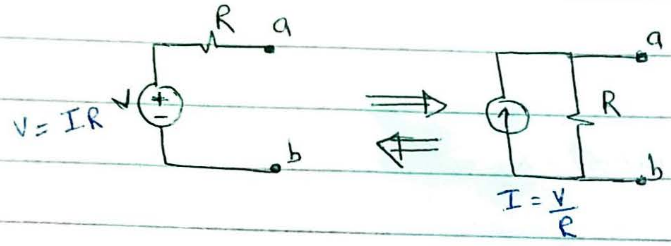
7/11/2019

H.W Answer

the second source ; current division rule is easier than mesh analysis

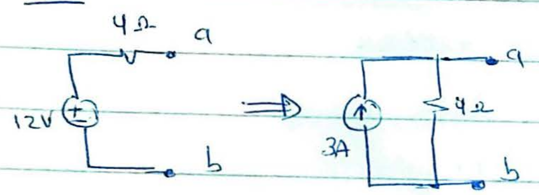
In exam: The contribution of current source is ____ (Apply superposition)

⇒ Sources Transformation



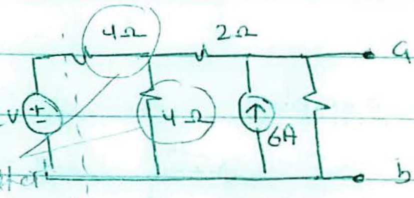
R the same value but not the same R (not the same charateristic, like current and voltage)

Ex.

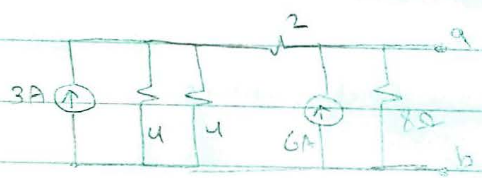


You transfer because of a reason

Ex.

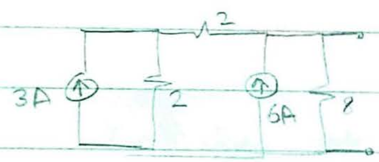


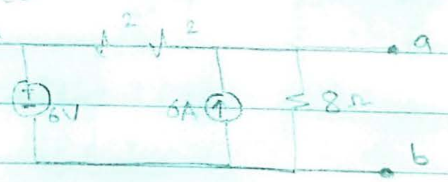
Simplify ckt to 1 voltage source and one ~~set~~ resistance

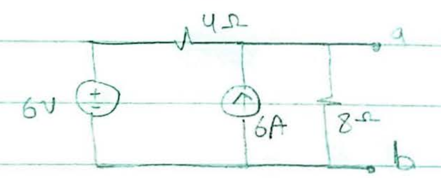


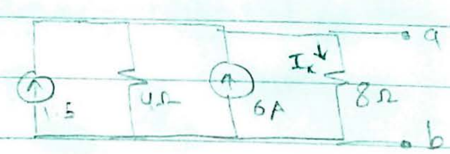
because not on the same node

we can't add current sources

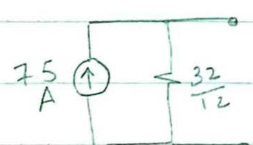




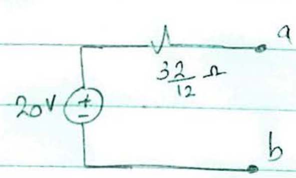




stop here if you want I_x, solve by current devision. But not all source transformation lead to the final result. It is not a technique but to reduce the ckt.



Norton's Equivalent



Relation between them is source transformation

"any ckt can be converted to 1 current source and resistance in parallel" Norton's Equivalent

any ckt can be reduced to 1 voltage source and resistance is series"

Thevenin's Equivalent

يغير شكل
شكله
صورة و تحول

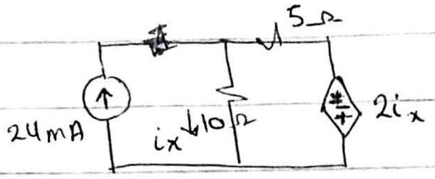
we can apply source transformation to dependent sources

الشغلة الي نريد أن نشتغل عليها صنع إنجازاتها.

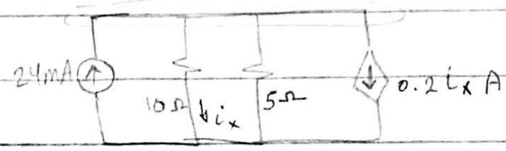
دائماً ابدأ من أبعد نقطة.

YASSIN

Example



Find i_x?



Single node

$$10^{-3} \times 24 = \frac{V}{10} + \frac{V}{5} + 0.2\, i_x \qquad i_x = \frac{V}{10}$$

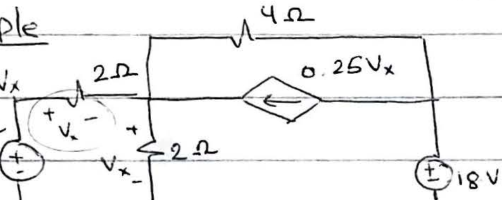
$$24 \times 10^{-3} = \frac{V}{10} + \frac{V}{5} + \frac{2\,V}{50} \qquad \frac{24 \times 10^{-3} \times 50}{17} = V$$

$\boxed{V = 70.6\ mV}$

$\boxed{i_x = 7.06\ mA}$

Example

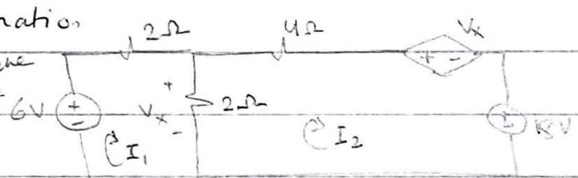
if here V_x You can't include it, depending source depends on it, after transformation there will not have the same voltage



Find V_x?

By superposition, if not you can make it by nodal analysis

By mesh analysis



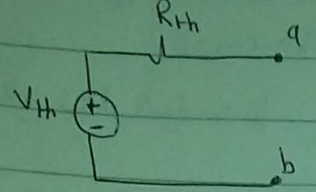
#1 $\quad -6 + 2I_1 + 2(I_1 - I_2) = 0$

#2 $\quad 2(I_2 - I_1) + 4I_2 + V_x + 18 = 0 \qquad V_x = 2(I_1 - I_2)$

$\boxed{I_1 = -0.75A}$ $\boxed{I_2 = -4.5A}$ $\boxed{V_x = 2(-0.75 + 4.5) = 7.5V}$

تحليل ckts * Thevenin's Theorm

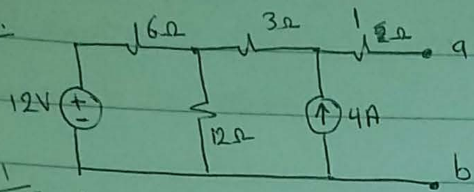
Tuesday 12/11/2019



" Thevenin's equivalent "

not all source transformation can be solved

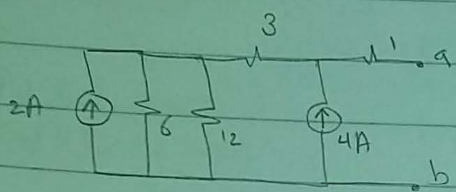
Ex.

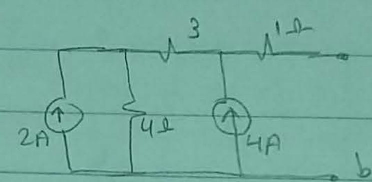


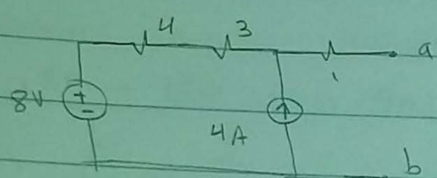
Find Thevenin's equivalent

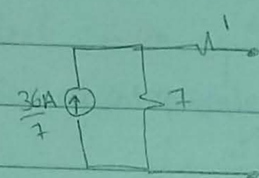
way 1

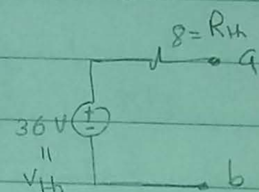
Source Transformation









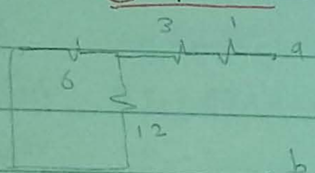


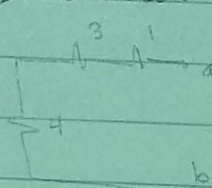
way 2

Thevenin's equivalent

- STEPS :

1. kill all the independent sources & Calculate R_{th}



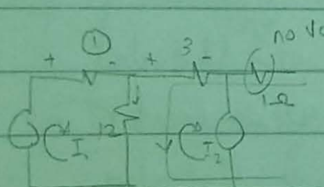


$R_{th} = 8\,\Omega$

between a & b open ckt

2. Reconnect all the independent sources and calculate (V_{th}, V_{oc}, V_{ab})

3 choices we have: Through current source → we can't; 1, 3, 12Ω ①; 1, 3, 6Ω 12V



متكتبش في الامتحان

mesh or nodal or any way

$\boxed{I_2 = -4}$

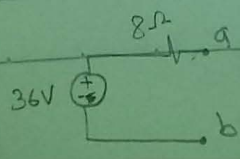
$-12 + 6I_1 + 12(I_1 - I_2) = 0 \qquad -12 + 12 \times 4 = 18 I_1 \qquad \boxed{I_1 = -2A}$

$V_{ab} = V_{th} = V_{oc} = V_{1\Omega} + V_{3\Omega} + V_{12\Omega}$

$= 0 + 12 + 12(I_1 - I_2)$ ($3 \times -I_2$)

$= 0 + 12 + 12(-2 + 4) = \boxed{36V}$

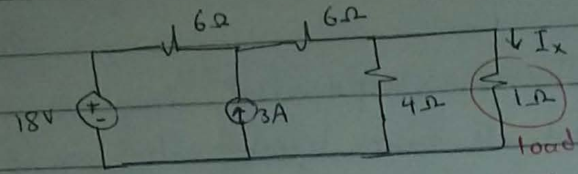
3. Draw Thevenin's equivalent



No: ---------- Date: ----------

سيجمر

Ex.

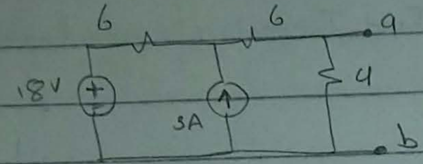


Find I_x using Thevenin's theorm

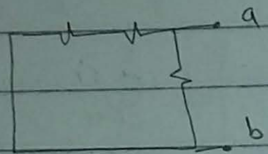
* المقاومة الي بتشغل عليها مقطعها وبرميها

1. cut the load and put a, b
2. Find Thevenin's equivalent

source transformation باشترط

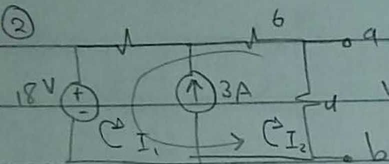


①



$R_{th} = (6+6) \parallel 4 = 3\,\Omega$

②



Vab?

2 choices

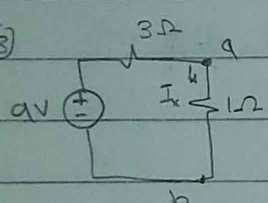
no mesh can be used

$V_{th} = V_{oc} = V_{ab} = V_{4\Omega} = 4 I_2 = \boxed{9V}$

$-18 + 6I_1 + 6I_2 + 4I_2 = 0$ $\quad 6I_1 + 10I_2 = 18 \rightarrow (1)$ $\quad I_1 =$

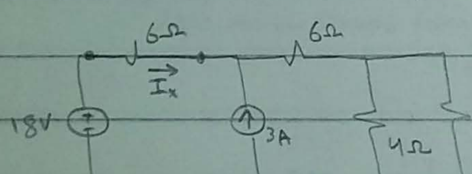
$I_2 - I_1 = 3 \rightarrow (2)$ $\quad I_2 = \frac{9}{4}\,A$

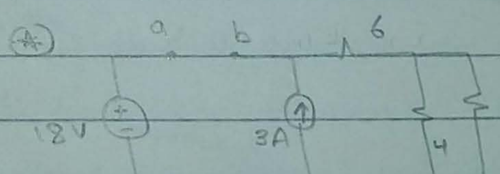
③



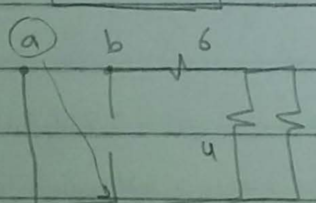
$\boxed{I_x = \frac{9}{4}\,A}$

Find I_x on 6Ω (the first one)



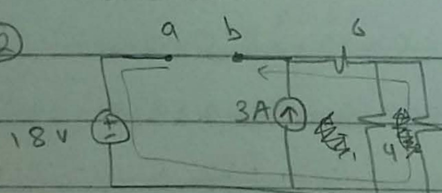


①



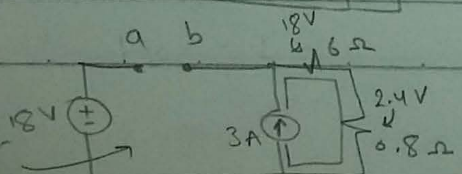
$R_{th} = (4 \parallel 1) + 6 = \frac{4}{5} + 6 = \boxed{6.8\,\Omega}$

②



2 choices

$V_{ab} = V_{oc} = V_{th} = 18 - 24 - 18 = \boxed{-2.4V}$



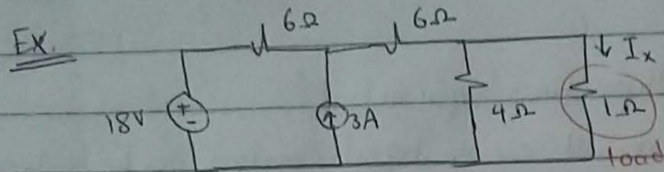
no current

YASSIN

في الامتحان ~~؟؟؟~~ dependent سيحضر

No: Date:

Ex.

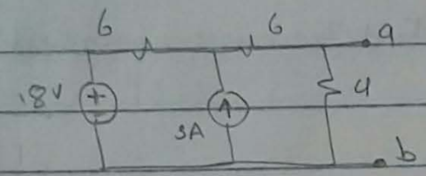


Find I_x using Thevenin's theorm

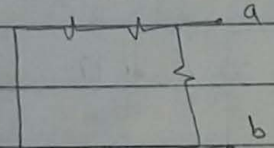
* المقاومة الي بتشغل عليها مقطعها و بدمجها

1. cut the load and put a, b
2. Find Thevenin's equivalent

باشترط source transformation

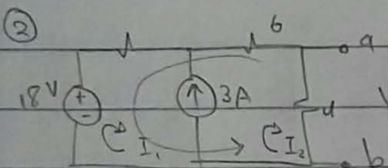


①



$R_{th} = (6+6) \| 4 = 3\,\Omega$

②



Vab?

2 choices

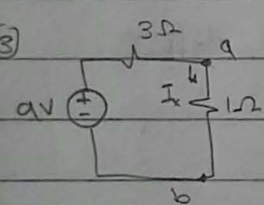
no mesh can be used

$V_{th} = V_{oc} = V_{ab} = V_{4\Omega} = 4 I_2 = \boxed{9V}$

$-18 + 6I_1 + 6I_2 + 4I_2 = 0$ $\quad 6I_1 + 10 I_2 = 18 \rightarrow ①$ $\quad I_1 =$

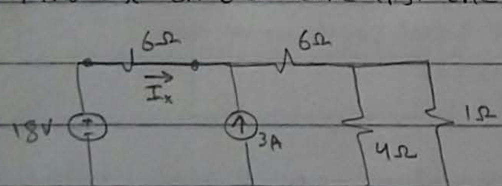
$I_2 - I_1 = 3 \rightarrow ②$ $\quad I_2 = \frac{9}{4} A$

③

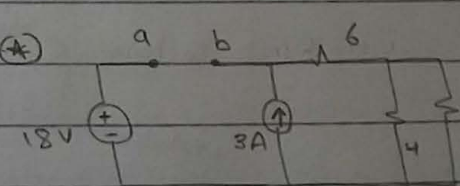


$\boxed{I_x = \frac{9}{4} A}$

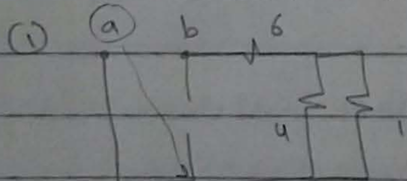
Find I_x on 6Ω (the first one)



(*)

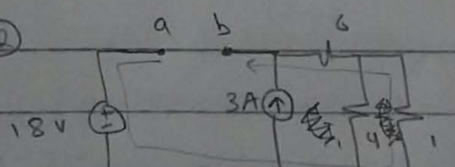


①



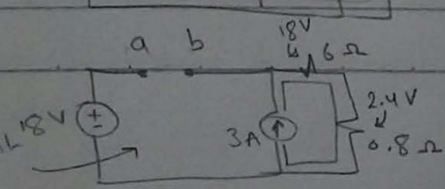
$R_{th} = (4 \| 1) + 6 = \frac{4}{5} + 6 = \boxed{6.8\,\Omega}$

②



2 choices

$V_{ab} = V_{oc} = V_{th} = 18 - 24 = \boxed{-2.4V}$

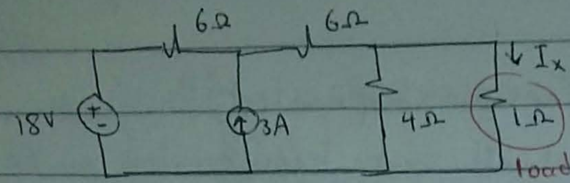


no current passes

في الامتحان: تقريبا dependent سيحضر

No: .... Date: ....

Ex.

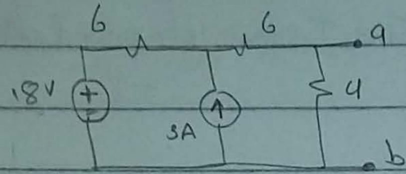


Find I_x using Thevenin's theorm

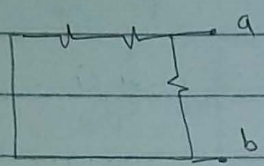
★ المقاومة الي بشتغل عليها بقطعها و بارميها

1. cut the load and put a, b
2. Find Thevenin's equivalent

source transformation ما بنزبط

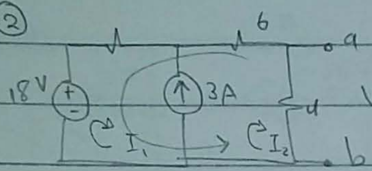


①



$R_{th} = (6+6) \| 4 = 3\,\Omega$

②



Vab?

2 choices

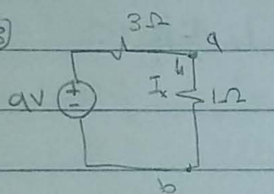
no mesh can be used

$V_{th} = V_{oc} = V_{ab} = V_{4\Omega} = 4 I_2 = \boxed{9V}$

$-18 + 6I_1 + 6I_2 + 4I_2 = 0$ $\qquad 6I_1 + 10I_2 = 18 \rightarrow ①$ $\qquad I_1 =$

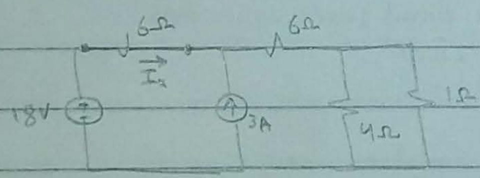
$I_2 - I_1 = 3 \rightarrow ②$ $\qquad I_2 = \frac{9}{4}A$

③

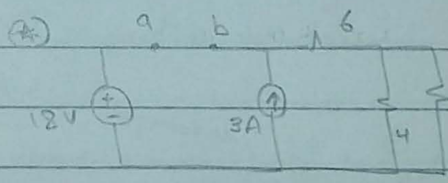


$\boxed{I_x = \frac{9}{4}A}$

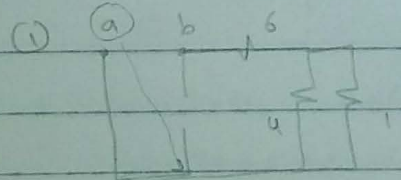
Find I_x on 6Ω (the first one)



✱

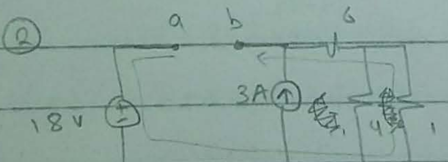


①



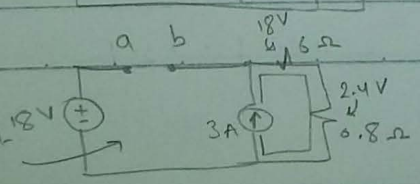
$R_{th} = (4 \| 1) + 6 = \frac{4}{5} + 6 = \boxed{6.8\,\Omega}$

②



2 choices

$V_{ab} = V_{oc} = V_{th} = 18 - 24 - 18 = \boxed{-2.4V}$



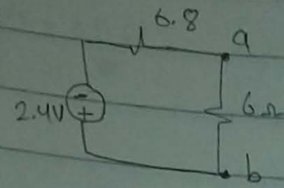
no current passes

No:

Date:

$V = IR$

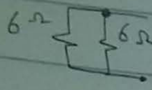
3



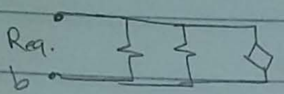
$I_x = \frac{-2.4}{12.8}$ A

14/11/2019

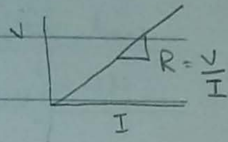
- Only Physical source is the independent voltage source
- Dependent source is a resistance



Req. = 3



$R_{eq.} = \frac{V}{I}$

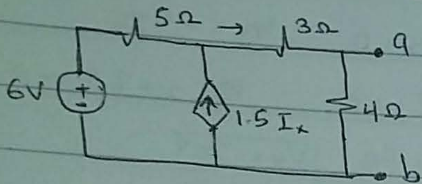


Put test source < voltage → find current (1A) ; current → find voltage (1V)

Find R for the black box

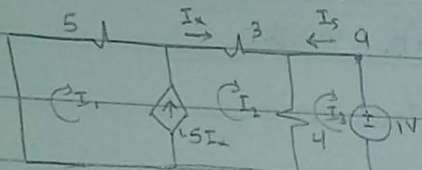
optimize your choice / amount is not a must / linear relation between I&V → same Req. results

* Thevenin's Theorm with dependent source



Find Thevenin's equivalent ckt

① Find Req. → By test source



Find I_s , By mesh analysis

* You can use it also if there is no dependent source.

**3 $\quad 1 + 4I_3 - 4I_2 = 0 \qquad -4I_2 + 4I_3 = -1 \rightarrow ①$

Supermesh $\quad 5I_1 + 3I_2 + 4I_2 - 4I_3 = 0 \qquad 5I_1 + 7I_2 - 4I_3 = 0 \rightarrow ②$

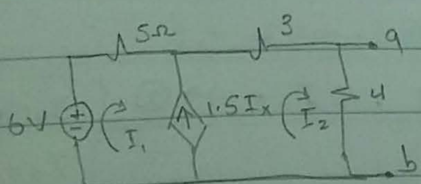
Branch $\quad I_2 - I_1 = 1.5\,I_x = 1.5\,I_2 \qquad -I_1 - 0.5\,I_2 = 0 \rightarrow ③$

$I_1 = 1A \quad I_2 = -2A \quad I_3 = -2.25\,A \qquad I_s = -I_3 = 2.25\,A$

$R_T = R_{Th} = 1/2.25 = \boxed{0.4\,\Omega} = V_s / I_s$

1. To calculate R_{Th}, add a test source (voltage or current) then kill the independent sources and calculate R_{TH}
2. Disconnect the test source and reconnect the independent source and calculate $V_{th} = V_{oc} = V_{ab}$

② Find Vth



$V_{ab} = V_{th} = V_{oc} = V_{4\Omega}$

By mesh analysis

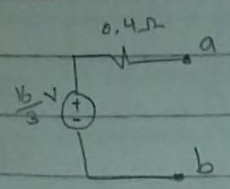
Super mesh $\quad -6 + 5I_1 + 3I_2 + 4I_2 = 0 \qquad 5I_1 + 7I_2 = 6 \rightarrow ①$

Branch $\quad I_2 - I_1 = 1.5\,I_x = 1.5\,I_2 \qquad -I_1 - 0.5\,I_2 = 0 \rightarrow ②$

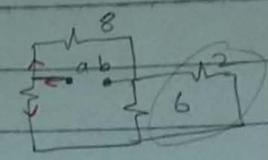
$I_1 = -\frac{2}{3}\,A \quad I_2 = \frac{4}{3}\,A \quad V_{ab} = V_{th} = V_{oc} = \frac{4}{3} \times 4 = \frac{16}{3}\,V$

No: ------------- Date: -------------

③ Draw out

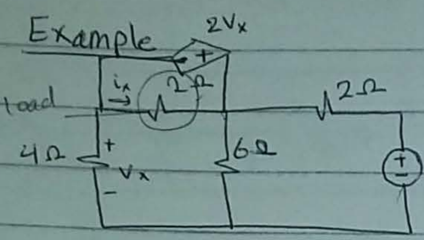


if



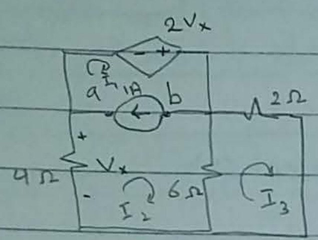
$(2 \| 6 + 4) \| 12$

Example



Find i_x using Thevenin's theorm

① Take off the load ② Find Req



#3 $2I_3 + 6I_3 - 6I_2 = 0$ $-6I_2 + 8I_3 = 0 \rightarrow ①$

Branch $I_1 - I_2 = 1 \rightarrow ②$

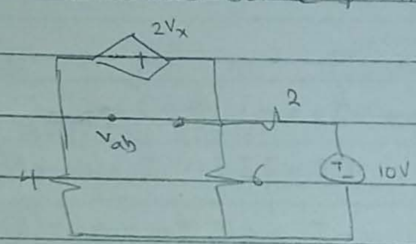
super mesh (external loop) $-2V_x + 2I_3 + 4I_2 = 0$ $V_x = -4I_2$

$8I_2 + 2I_3 + 4I_2 = 0$ $12I_2 + 2I_3 = 0 \rightarrow ③$

~~[illegible]~~ $\rightarrow I_1 = 1A$ $I_2 = 0A$ $I_3 = 0A$ Assume $I_2 = 5A$ $\boxed{V_x = -20V}$

$V_{dependent} = -40V$ $V_s = 40V$ $\boxed{R_{th} = 40/1 = 40\Omega}$

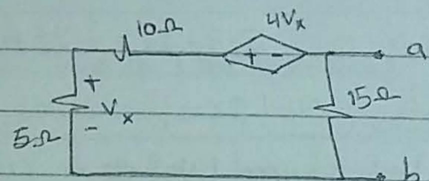
③ Disconnect test source & connect ind. source



2 meshes

Imp.

In exam



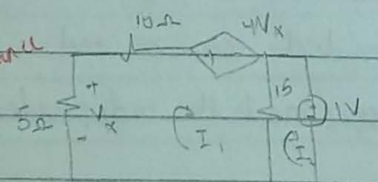
V_{th} comes from independent source, if no independent source $V_{th} = 0$

R_{th} comes from resistances and dependent sources

Here Thevenin's Equivalent consists only of R_{th}

There is -ve resistance

Transistor has -ve resistor



#1 $5I_1 + 10I_1 + 4V_x + 15I_1 - 15I_2 = 0$

$V_x = -5I_1$

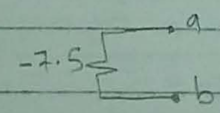
$10I_1 - 15I_2 = 0 \rightarrow ①$

#2 $1 + 15I_2 - 15I_1 = 0$

$-15I_1 + 15I_2 = -1 \rightarrow ②$

$I_1 = 0.2A$

$I_2 = 0.13A$

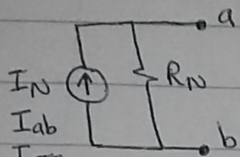


Because we don't have any independent source.

$I_s = -0.13$ $R_{th} = \frac{1}{-0.13} = \boxed{-7.5\Omega}$

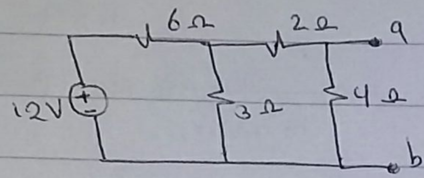
No:------------ Date:-------------

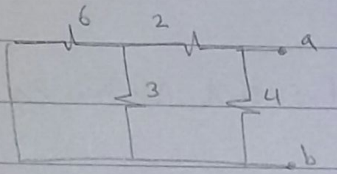
→ Norton Theorm



R_N by the same way of Thevenin
① cut the load
② kill the independent sources & Find R_N as seen between a&b
③ Reconnect all the independent sources & Find I_N → making sc between a and b
④ Draw Norton equivalent

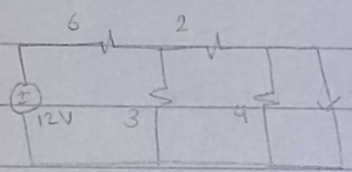
Ex. Find Norton equivalent

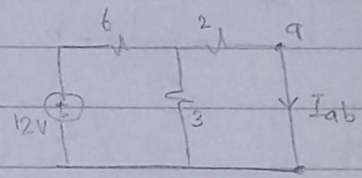




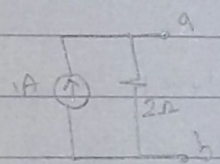
$R_N = ((6 \parallel 3)+2) \parallel 4 = 2\,\Omega$

In Exam I_N:
short cut between a & b
أي شي ع التوازي معه بروح.



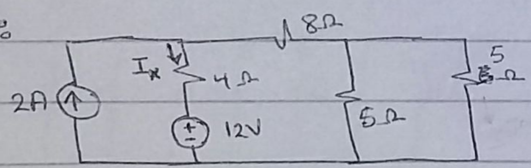


voltage division
~~then after delta~~
$2 \parallel 3 = \frac{6}{5}$
$V_{\frac{6}{5}} = V_{2\Omega} = 2V$
$I_N = I_{ab} = I_{sc} = I_{2\Omega} = 2/2 = 1A$

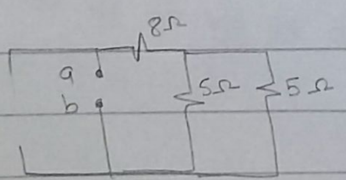


Example: Find I_x using Norton theorm.

• You can convert Thevenin to Norton By source Transformation



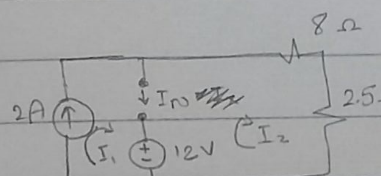
① kill load and ind. source



$R_N = (5 \parallel 5) + 8 = 10.5\,\Omega$

② Reconnect

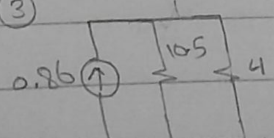
• even I_N pass through where I_x pass, It is NOT the same, to calculate it.



$I_x =$ $-12 + 10.5 I_2 = 0$ $I_2 = 1.14$ A

$I_{ab} = I_N = I_{sc} =$ $2 - 1.14 = 0.86A$

③ Draw Norton equivalent



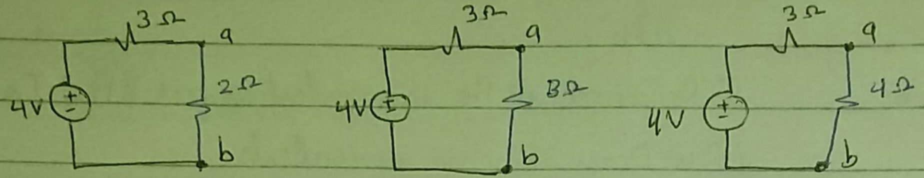
$I_x = \frac{0.86 \times 10.5}{14.5} =$

No: ------------- Date: -------------

Norton خطوة
short ckt في

if load is 8Ω , $R_N = 6.5\,\Omega$

Imp. max. power → when $R_L = R_{th}$

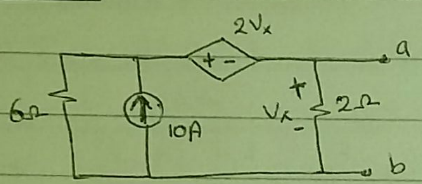


$P_1 = 1.28\ W$ $P_2 = 1.33\ W$ $P_3 = 1.31\ W$

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

Find R ~~which will have~~ max. power to transfer

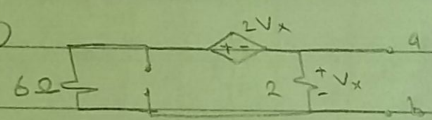
Example



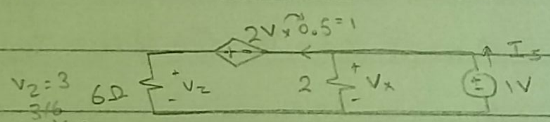
In exam

Find and sketch Norton equivalent

(1)



Put test source



$V_x = 1\ V$

$-V_2 + 2V_x + 1 = 0$ $V_2 = 3V$

OR

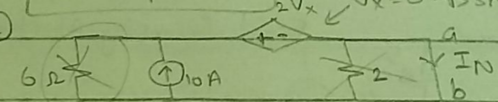
$I_{6\Omega} = 3/6 = 0.5\ A$

$I_x = 0.5\ A$ $I_s = 0.5 + 0.5 = 1\ A$

$\boxed{R_N = \frac{1}{1} = 1\,\Omega}$

Imp. (2)

Repeat

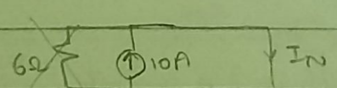


$V_x = 0$ → short ckt

$V_x = 0$

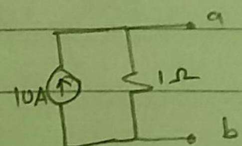
$I_N = 10\ A$

no current passes here



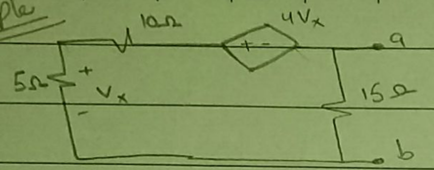
$I_N = 10\ A$

(3)



19/11/2019

Example



if ~~no~~ independent → no V_{th}, no I_N

CHAPTER #6 : Energy storage elements

* Energy storage elements → capacitor [C] = F (Faraday)
  ↳ inductor [L] = H (Henry)

(1) Capacitor → used to store charges $q = C \cdot V$

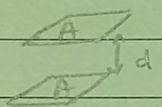
A: Area of plate

d: distance between two plates

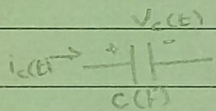
ϵ_0: permittivity 8.8

ϵ_R: relative permittivity

C: capacitance



$$\boxed{C = \frac{\epsilon_0 A}{d}}$$



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

4 cos (wt)

$V_c(t) = 4\cos(10t)$ $C = 3F$ $i_c(t) = 3 \times -4 \times 10 \sin(10t) = -120\sin(10t)$

Calculator in rad. $\omega \frac{rad}{s} \times s = rad$

$i(3) = -120\sin(30t)$

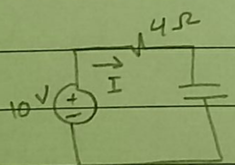
Imp. if voltage drop DC Not AC

Voltage DC → constant → derivative of constant = 0

i = 0 → open cct

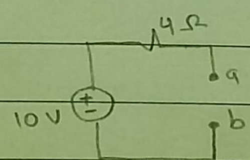
In DC cct the capacitor is open cct BECAUSE i = 0

CAPACITOR works as OC in cct.

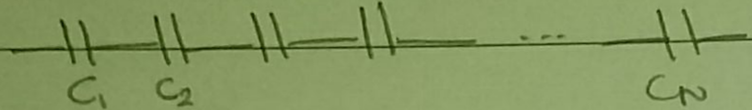


$I_c = 0$

$V_c = 10$

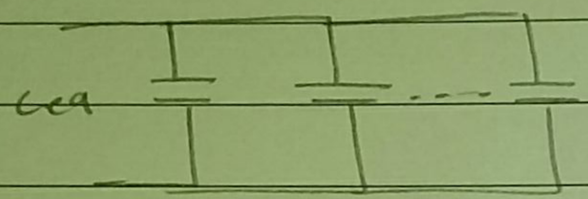


* AC is a fun(time), while DC NOT (it is constant).

Series 

$q_T = q_1 = q_2 = q_3 = \cdots = q_N$ شحن بالتلاش

$$\frac{1}{C_{eq.}} = \frac{1}{C_1} + \frac{1}{C_2} + \cdots + \frac{1}{C_N}$$

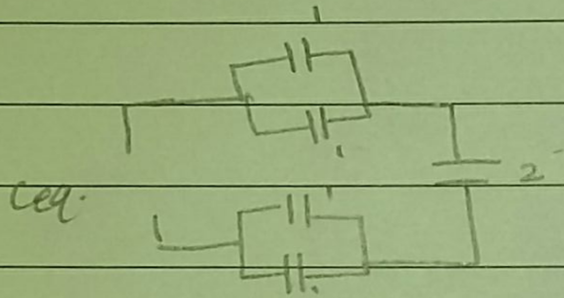
Parallel 

$q_T = q_1 + q_2 + \cdots + q_N$

$C_{eq.} = C_1 + C_2 + \cdots + C_N$

Example

Find $C_{eq.}$



$$\frac{1}{C_{eq.}} = \frac{1}{2} + \frac{1}{2} + \frac{1}{2} = \frac{3}{2}$$

$$\boxed{C_{eq.} = \frac{2}{3}\,F}$$

open cct $I = 0$ $V \neq 0$
Short cct $V = 0$ $I \neq 0$

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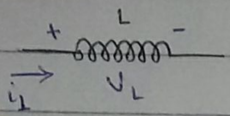
The inductor

Big question in exam

What about q?



$[L] = H$ (Henry) $\qquad V_L = L \dfrac{di}{dt} \qquad I_L = \dfrac{1}{L}\int_0^t V_L(t)\,dt + I_0$

initial current

if energy stored initially $= 0 \longrightarrow I_0 = 0$

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

inductors acts as

If DC power supply $\rightarrow$ Short cct

Existance of 1 DC in huge # of AC $\rightarrow$ acts like this (SC)

Example

(1) $I_L = 3A \qquad L = 4mH$

$E = W = \frac{1}{2} \times 4 \times 3^2 \times 10^{-3}$ J

$V_L = 0$

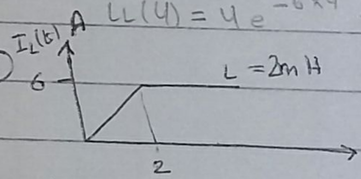
(2) $i_L(t) = 4e^{-6t} \qquad L = 3H$

$V_L(t) = L\,di/dt = 3(4)(-6)e^{-6t} = -72e^{-6t}$

$E|_{t=4s} = \frac{1}{2} \times 3 \times (i_L(4))^2 = \frac{1}{2} \times 3 \times (4e^{-24})^2$ J

$i_L(4) = 4e^{-6\times4} = 4e^{-24}$

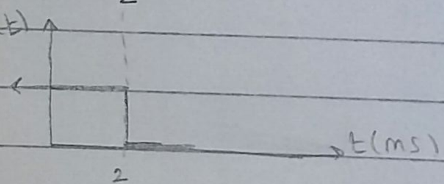
(3)



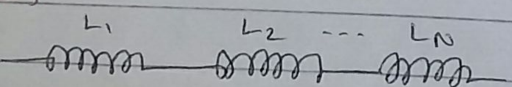
sketch voltage wave form?

$\frac{5\times10^{-3} \times 6}{2\times~~10^{-3}~~}$

$= 0.015$

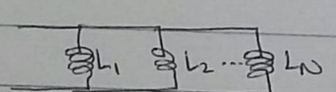


Series



$L_{eq} = L_1 + L_2 + \dots + L_N$

Parallel



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

calculator in radient for sin and cos ....

$L = N \frac{d\Phi}{dt}$

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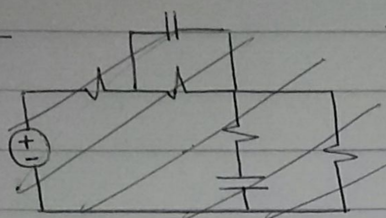
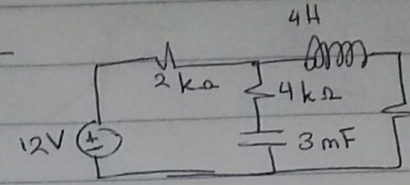
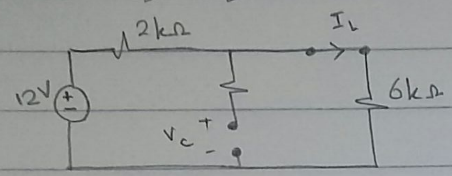
Ex.



~~Find energy stored~~

Find I_L, V_c, E_L, E_c





$I_L = \frac{12}{8 \times 10^{+3}} = 1.5\,mA$

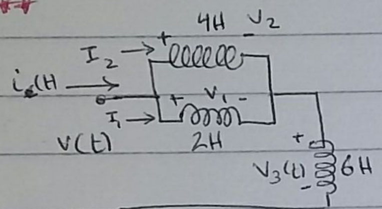
$V_c = V_{6k\Omega} = 1.5 \times 6 = 9V$ or voltage division

$E_L = \frac{1}{2} \times 4 \times 1.5 \times 10^{-3} =$

$E_c = \frac{1}{2} \times 3 \times 10^{-3} \times 9^2 =$

Imp. Ex.***

Repeat



let $i_1(t) = 0.6e^{-4t}$

$i(0) = 1.4\,A$

Find $i_2(0)$, $v_1(t)$, $v_2(t)$, $v_3(t)$, $i_2(t)$, $i(t)$, energy stored in 4H inductor at $t = 3s$,

طرفين total $v(t)$

→ $i(t) = i_1(t) + i_2(t)$ $\quad i(0) = 1.4 \quad i_1(0) = 0.6$

$i_2(0) = 1.4 - 0.6 = \boxed{0.8A}$

→ $i_2(t)$

Because Parallel $V_1(t) = V_2(t) = L\, di_1/dt = 2 \times -4 \times 0.6e^{-4t} = -4.8e^{-4t}\,V$

~~$i_2(t) = C_2 \frac{dv_2(t)}{dt} + i_2(0) = 4 \times -4.8 \times -4e^{-4t}$~~

$i_2(t) = \frac{1}{4} \times \int_0^t -4.8e^{-4t} + 0.8 = \frac{+4.8}{16} e^{-4t}\Big|_0^t = 0.3e^{-4t} - 0.3 + 0.8$

$\boxed{i_2(t) = 0.3e^{-4t} + 0.5\ A}$

→ $V_3(t)$

$i(t) = i_1(t) + i_2(t) = 0.6e^{-4t} + 0.3e^{-4t} + 0.5 = 0.9e^{-4t} + 0.5$

$V_3(t) = L_3 \frac{di}{dt} = 6 \times 0.9 \times -4e^{-4t} = \boxed{-21.6e^{-4t}\,V}$

→ $V(t) = V_1(t) + V_3(t)$ OR $V_2(t) + V_3(t)$ OR equivalent L

$L_{equ} = (4 \parallel 2) + 6 = 7.33\,H$ $\qquad V = L_{equ} \frac{i(t)}{dt}$

$V(t) = 7.33 \times \frac{di(t)}{dt} = 7.33 \times 0.9 \times -4e^{-4t} = -26.28e^{-4t}\,V$

→ $E_{4H}|_{t=3s} = \frac{1}{2} \times 4 \times (i_2(3))^2 = \frac{1}{2} \times 4 \times (0.3 \times e^{-4\times3} + 0.5)^2 = \boxed{0.5J}$

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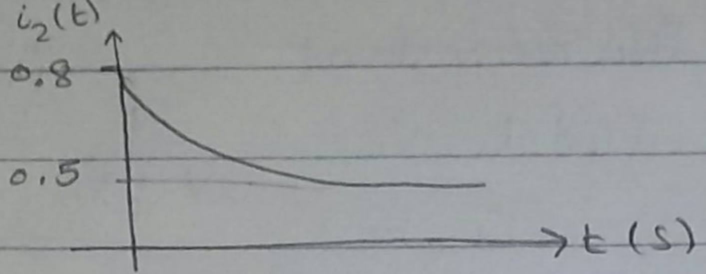
sketch $i_2(t)$

$i_2(0) = 0.8$



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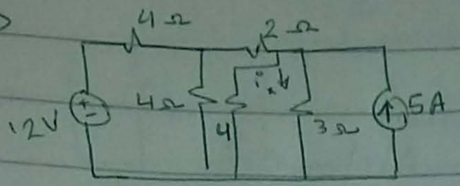
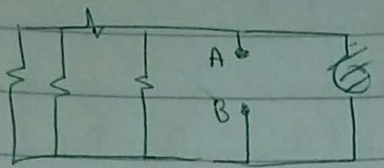
Revision for mid

resistance → cancel

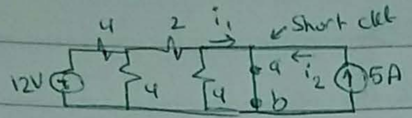
Parallel < current / Voltage

→ i_x with Norton



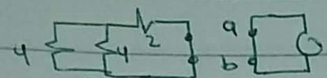


$R_N = 2\,\Omega$

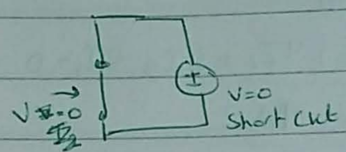


→ like sum of two ckts $I_N = i_1 + i_2 = 5 + \frac{3}{2} = 6.5$

~~5+i~~



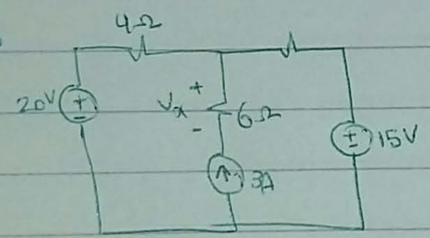
if voltage source it will be voltage source → only i_1



→ Capacitor: Parallel → same voltage; Series → same current

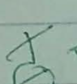
→ if no independent source → max. power = 0 / Power = 0

→



contribution of 20 V source on V_x is equal to?

→

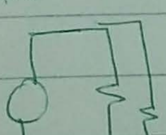


Thevenin

$I = \frac{V}{2R_{th}}$

$P = I^2 \cdot R_{th} = \frac{V^2}{4R_{th}} \cdot R_{th} = \boxed{\frac{V_{th}^2}{4R_{th}}}$

Norton



$I_L = \frac{I_N R_N}{2R_N}$

$P = \left(\frac{I_N}{2}\right)^2 R_N$

$P = \boxed{\frac{I_N^2 R_N}{4}}$

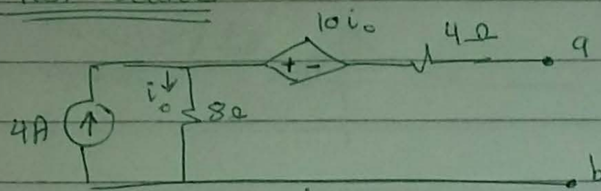
$\boxed{V_{th} = I_N R_N}$

No: ------------- Date: ------------- Capacitor

Series → same q

Parallel → summation.

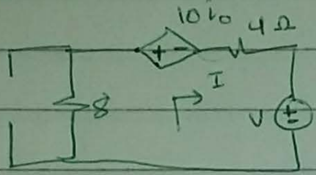
Test Source



Norton ckt

(1)

single mesh & voltage

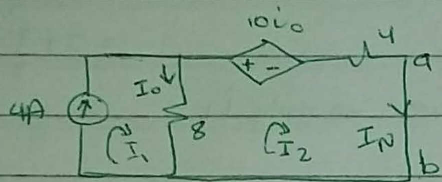


$I_s = I_o = -I$

$4I + 8I + 10I_o + 1 = 0$ $\qquad I_o = -I$

$I_s = -0.5A$

$R_N = \frac{1}{0.5} = 2\,\Omega$

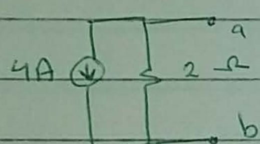


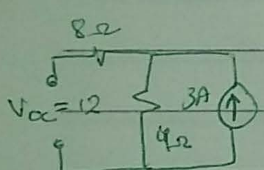
I_N

$\boxed{I_1 = 4A}$

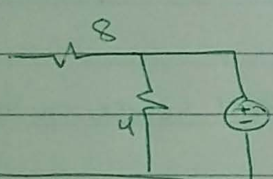
$10i_o + 4I_2 + 8I_2 - 8I_1 = 0$ $\qquad I_o = I_1 - I_2$

$\boxed{I_2 = -4A}$ $\qquad I_o = 4 - I_2$

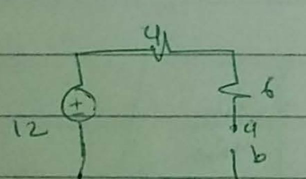




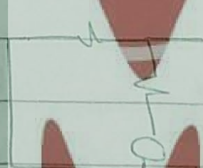
$R_{eq} = 4 + 8 = 12\,\Omega$



$R_{Th} = 8$



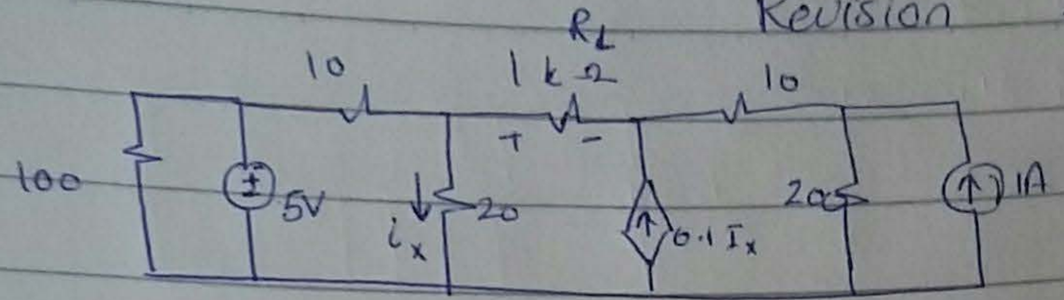
$V_{ab} = V_{source}$

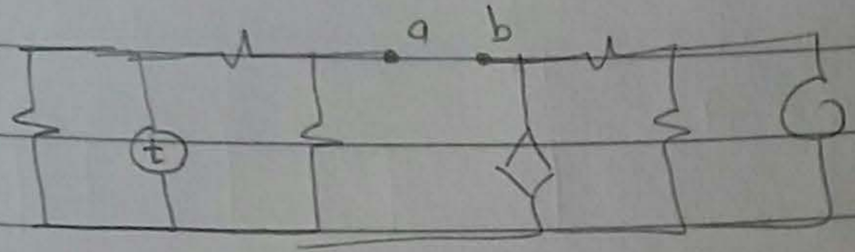


R_{th} = series

No:------------- Date:-------------

Revision 26/11/2019





$r \angle \theta$

Euler Identity $r e^{-j\theta} = r\cos\theta + jr\sin\theta$

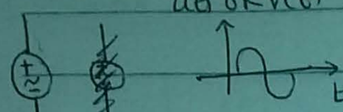
No: ------------- Date: -------------

1/12/2019

AC - ANALYSIS (complex, Polar, work)

Polar ⇕ Phasor

i(t) OR v(t)



changing value & direction

Sources OR

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

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

V_m : amplitude (max. value)

ω : angular frequency (rad/s)

θ : phase shift.

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

Time domain signal

We will use it as a vector

$V = V_m \angle \theta$

$I = I_m \angle \theta$

even in sin. Find parameters according to sin, don't convert to cos.

Loads
1. R
2. L
3. C

OR combination of them

Identity $\cos(x) = \frac{e^{jx} + e^{-jx}}{2}$ $\sin(x) = \frac{e^{jx} - e^{-jx}}{2j}$

Euler identity : $e^{\pm jx} = \cos x \pm j \sin x$

e.g $i(t) = 4\cos(2\pi t + 30)$ (Time domain)

if you want to find i(1), convert all to radian degree

$I_{max} = 4A$ $\omega = 2\pi$ $f = 1\,H$ $T = \frac{1}{f} = 1\,s$ $\theta = 30°$

in polar coordinates $I = 4 \angle 30°$

- T : periodic time , time needs the signal to repeat itself
- ONLY transfer to polar if cos ~~Time domain~~, if sin, convert

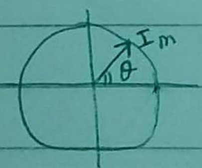
Source must be in cos

Imp. $\sin x = \cos(x - 90°)$

$-\sin x = \cos(x + 90°)$

$-\cos(x) = \cos(x \pm 180°)$ up to you + or -

cos OR sin

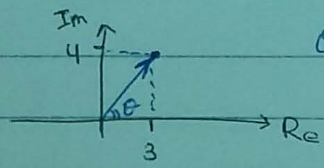


vertical $I_m \sin\theta$

horizontal $I_m \cos\theta$

cartazian ~~cartesian~~ (complex)

$3 + 4j$



$\theta = \tan^{-1}(4/3)$

$3 + 4j = 5 \angle 53°$

Cartazian complex — Polar phasor

$a + jb = r \angle \theta$

$r = \sqrt{a^2 + b^2}$ $a = r\cos\theta$

$\theta = \tan^{-1}\frac{b}{a}$ $b = r\sin\theta$

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No signals adding in time domain

⇒ Adding & Substracting & multiplication & Dividing

$(3 \angle 60^\circ) \cdot (5 \angle 70) = 15 \angle 130^\circ$

$\dfrac{(3 \angle 60^\circ)}{(5 \angle 70^\circ)} = \dfrac{3}{5} \angle -10$

- multiplication $r_1 \angle \theta_1 \cdot r_2 \angle \theta_2 = r_1 r_2 \angle \theta_1 + \theta_2$
- Division $\dfrac{r_1 \angle \theta_1}{r_2 \angle \theta_2} = \dfrac{r_1}{r_2} \angle \theta_1 - \theta_2$
- adding & substracting only in cartazian form

<u>Example</u> $i(t) = 6 \sin(100t - 30^\circ)$

$i(t) = 6 \cos(100t - 120) = 6 \angle -120^\circ$ A

Imp. In Exam

<u>Example</u> $v_1(t) = 4 \cos 10t \rightarrow 4 \angle 0$

$v_2(t) = 3 \sin 10t \rightarrow 3 \cos(10t - 90) \rightarrow 3 \angle -90^\circ$

يفضل الزاوية بين $0<\theta<180$

$v_3(t) = -\cos(10t + 30^\circ) \rightarrow \cos(10t - 150^\circ) \rightarrow 1 \angle -150^\circ$

let $v(t) = v_1 + v_2 + v_3$

Find $v(t)$

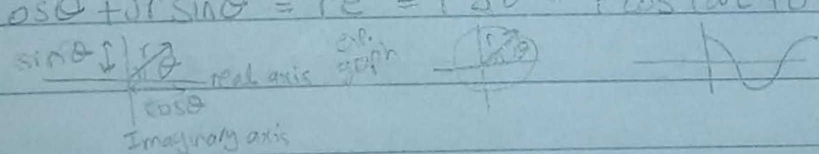
You can't add Time domain → $\overset{\text{convert to}}{\text{Frequency}}$ domain → return in time domain

$V = 4 \angle 0 + 3 \angle -90^\circ + 1 \angle -150^\circ = 4.7 \angle -48^\circ = 4.7 \cos(10t - 48^\circ)$ V

All Formulas

complex — Euler — polar — time domain

$r\cos\theta + jr\sin\theta = re^{j\theta} = r \angle \theta = r\cos(\omega t + \theta)$



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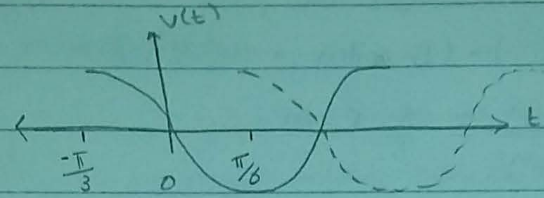
Frequency ≡ Polar ≡ phasor

متقدم متأخر

⇒ Lead & Lag

--- $v_1(t) = 4\cos(10t - 30°)$

— $v_2(t) = 3\cos(10t + 60°)$ = متقدم



v_2 leads v_1 by $90°$ $((60 - -30) = 90°)$

v_1 lags v_2 by $90°$

$v_1(t) = 4\sin(10t + 30°)$

$v_2(t) = 2\sin(10t + 50°)$

v_2 leads v_1 by $20°$

. Circumstances to compare the signals

* They should have the same ω and form
  f & T — both sin or cos

You can compare current and voltage together.

$i(t) = 4\sin(10t - 30°)$ → You can't compare
$v(t) = 5\sin(100t + 60°)$

الأكثر موجبة هي التي تسبق

$v = 4\sin(10t) \rightarrow 4\cos(10t - 90°)$
$i = 5\cos(10t - 100)$

v leads i by $10°$

A-ω 9.9

- Excersites on calculator
- $4\angle 30° + 6\angle -50° - 2\angle 30° =$ ~~$9.19\angle -10°$~~ $6.6\angle -32° = 5.59 - 3.6j$
- $\frac{(3+j4)(2-j2)}{6+j5} = 1.81\angle -31°$
- $5\angle 30° \rightarrow 5\cos(\omega t + 30°)$

⇒ Loads (converting to frequency domain)

time	Freq. / Polar. / phasor	
R (Ω)	R (Ω)	
L (H)	$Z_L = j\omega L$ (Ω)	$= \omega L \angle 90°$
C (F)	$Z_L = \frac{1}{j\omega C}$ (Ω)	$= \frac{1}{\omega C} \angle -90°$

Impedence — نطبق معادلة المقاومة في series & Parallel

مكثف — ملف

الثلاثاء والخميس القادمين
لا يوجد محاضرة

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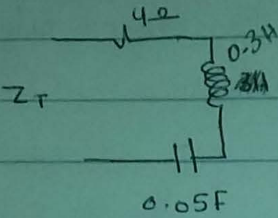
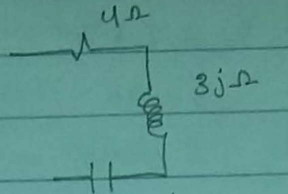
$j^2 = 1 \qquad j = \sqrt{-1} \qquad \frac{1}{j} = -j$

e.g. ①



$\omega = 10$

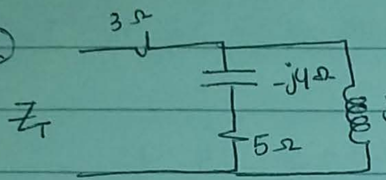
Find Z_T ?



$\frac{1}{j(10)(0.05)} = -j2\,\Omega$

$Z_T = 4 + j3 + -j2 = \boxed{4 + j\,\Omega} = 4.12\angle 14^\circ\,\Omega$

②



no need for ω since They are impedences

$\left(\frac{(5-j4)(j8)}{5-j4+j8}\right) + 3 = \boxed{10.9\angle 9.2^\circ\,\Omega}$

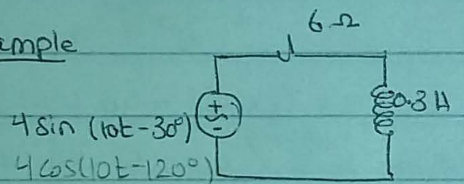
$v = IZ$ in AC not IR

⟹ Admittance

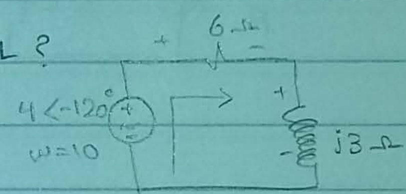
Y : admittance ℧

$Y = \frac{1}{Z}$ ℧ (seimen's , mho)

Example



Find I, V_L ?



$Z_L = j\omega L = j(10)(0.3) = 3j\,\Omega$ $\qquad -4\angle -120^\circ + 6I + 3jI = 0$

$I = \frac{4\angle -120^\circ}{6 + j3} = \boxed{0.6\angle -146^\circ.5\,A} = I_L$

$V_L = 0.6\angle -146^\circ.5 \times 3j = 1.8\angle -56^\circ\,V$

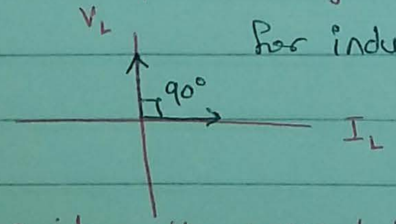
$V_R = 6 \times 0.6\angle -146.5^\circ = 3.6\angle -146.5^\circ V$

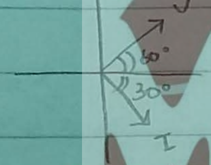
I_L angle $\begin{cases} I & -146.5^\circ \\ V & -56.5^\circ \end{cases}$ ⟹ V lead by 90°

Very Imp

- In the inductor, the voltage leads the current by 90°.
- In the resistor, the voltage and current are in-phase

For inductor





- In the capacitor, the current leads the voltage by 90°

$105 \equiv -225$

$P = -4W$
OR
$P = 4W$ delivered

$(3\angle -180)^{0.5} =$
$\downarrow \quad \downarrow$
$3^{0.5} \quad \frac{180}{2}$

lead or lag
the same difference

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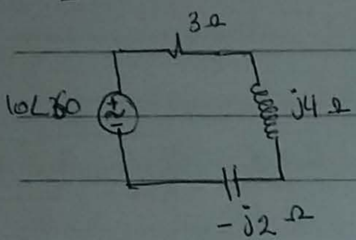
$-3 \rightarrow \; \& \; 3\angle +180°$

$3j \rightarrow \; 3\angle 90$

$-3j \rightarrow \; 3\angle -90°$

• we must use Cramer's rule to find the unknowns.

Ex.



Find i, V_L, V_R, V_C

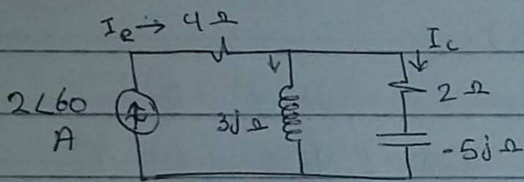
$I = \frac{V}{\Sigma Z} = \frac{10\angle 60}{3.6\angle 33.7} = 2.77\angle 26.3° = I_R = I_L = I_C$

$V_R = 3 \times 2.77\angle 26.3° = 8.3\angle 26°$ V

$V_L = 11.08\angle 116.3°$ V is leading by $90°$

$V_C = 5.54\angle -63.7°$ V is lagging by $90°$ ← phase shift

Ex.



Find I_C?

$I_C = \frac{2\angle 60 \times 3j}{2-5j+3j} = 2.12\angle -165° A$

قارن الزوايا بغض الإشارة

$V_C = I_C \times -5j = 10.6\angle -255°$ V

عشان نعرف lead and lag.

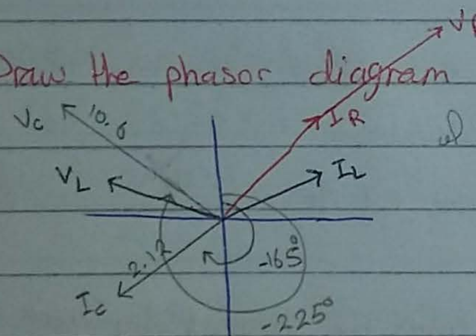
※ voltage ~~leading~~ lagging current by $90°$

$V_L = 3j\, I_L = 11.4\angle 126°$ V

※ Voltage lead current by $90°$.

$I_L = I_T - I_C = 3.8\angle 36.8°$ A

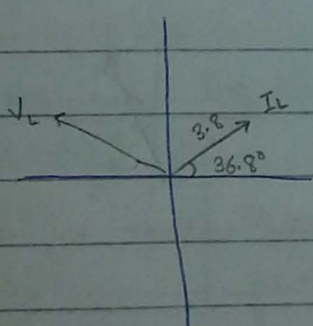
⇒ Draw the phasor diagram



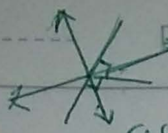
length must be scaled

ل $I_C \,\&\, V_C$

I_C سيضطرب بالموجب ليش؟

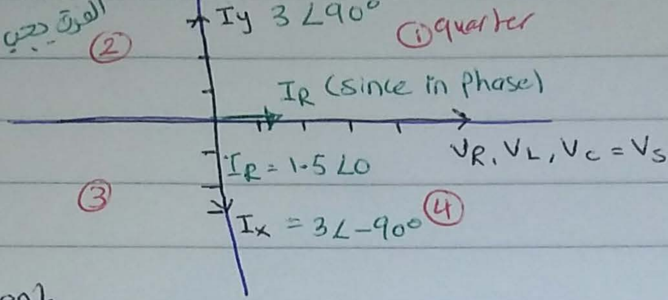


no comparing between I_L and I_C



الفرق يجب يكون ٩٠°

In exam (2)



each division equals 1V

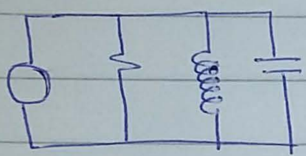
$v = 4V\angle 0$

Draw ckt (3)

Find value of

each component

∵ 3 components, R, L, C are in parallel (since same Voltage)



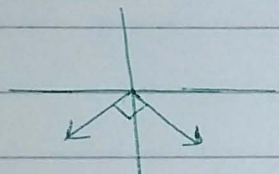
$I_y = I_C$

$I_x = I_L$

$R = V_R / I_R$

$Z_C = V_C / I_C$

$Z_L = V_L / I_L$



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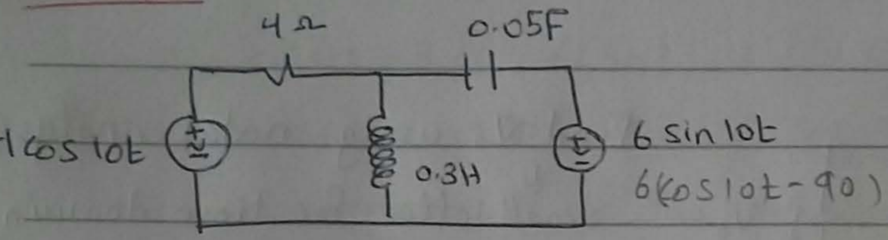
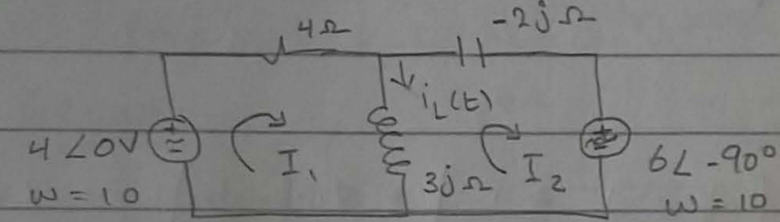
Example



use meshanalysis to find $i_L(t)$?



mesh #1

$-4\angle 0 + 4I_1 + 3jI_1 - 3JI_2 = 0$ $\qquad (4+3j)I_1 - 3jI_2 = 4\angle 0 \rightarrow (1)$

mesh #2

(زائد، ناقص 180 بنفس أنيكون نفس 180) same $6\angle 90°$

$-2jI_2 + 6\angle -90 + 3jI_2 - 3JI_1 = 0$ $\qquad -3jI_1 + jI_2 = -6\angle 90° \rightarrow (2)$

Using Cramer's rule

$$\Delta = \begin{bmatrix} 4+3j & -3j \\ -3j & j \end{bmatrix} = 6+4j \qquad \Delta_1 = \begin{bmatrix} 4\angle 0° & -3j \\ 6\angle 90° & j \end{bmatrix} = -18+4j$$

$$\Delta_2 = \begin{bmatrix} 4+3j & 4\angle 0° \\ -3j & 6\angle 90° \end{bmatrix} = -18+36j$$

$I_1 = \dfrac{\Delta_1}{\Delta} = 2.5\angle -21° \text{ A} \qquad I_2 = 5.5\angle 82° \text{ A} \qquad I_L = I_1 - I_2 = 6.5\angle -90°$

$$\boxed{\therefore\ i_L(t) = 6.5\cos(10t - 76)}$$

ما ح يجيب سؤال أكثر من معادلتين

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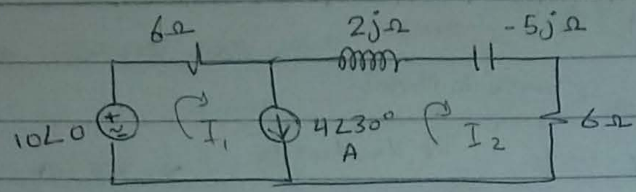
Ex.



Find V_L By mesh analysis

Big loop

$-10\angle 0 + 6I_2 + 2jI_2 - 5j\, I_2 + 6I_2 = 0$

$6I_1 + (6-3j)\, I_2 = 10\angle 0 \rightarrow (1)$

Branch

$I_1 - I_2 = 4\angle 30° \rightarrow (2)$

$\Delta = \begin{bmatrix} 6 & 6-3j \\ 1 & -1 \end{bmatrix} = \cancel{12.37\angle 184.4}$ $-12+j3$ $\quad \Delta_2 = \begin{bmatrix} 6 & 10\angle 0 \\ 1 & 4\angle 30° \end{bmatrix} = 16.7 + 12j$

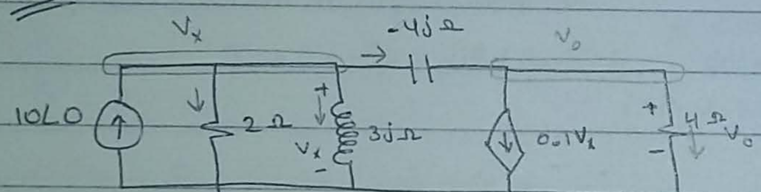
$\Delta_1 = \begin{bmatrix} 10\angle 0 & 6-3j \\ 4\angle 30 & -1 \end{bmatrix} = \cancel{32.36\angle -184}$ $-36.8 - 1.6j$

$I_1 = \Delta_1 / \Delta =$

$V_L = 2.6\angle -27.7°$

$V_L(t) = 2.6 \cos(\omega t - 27.7°)$

Ex.



Find V_o using nodal analysis
small letter for time domain

Node Vx

$10\angle 0 = \frac{V_x}{2} + \frac{V_x}{3j} + \frac{V_x - V_o}{-j4} \quad V_x\left[\frac{1}{2} + \frac{1}{3j} + \frac{1}{-j4}\right] + V_o\left[\frac{1}{j4}\right] = 10\angle 0$

$V_x(0.51\angle -9.46) + V_o(-0.25j) = 10\angle 0 \rightarrow (1)$

Node Vo

$\frac{V_x - V_o}{-4j} = 0.01V_x + \frac{V_o}{4} \quad V_x\left[\frac{1}{4j} + \frac{1}{10}\right] + V_o\left[\frac{1}{4} - \frac{1}{j4}\right] = 0$

$V_x(0.27\angle -68.2°) + (0.35\angle 45)V_o = 0 \rightarrow (2)$

$\Delta = \begin{bmatrix} 0.51\angle -9.46 & -0.25j \\ 0.27\angle -68 & 0.34\angle 45 \end{bmatrix}$

$V_x = \frac{\Delta_1}{\Delta} \quad V_o = \frac{\Delta_2}{\Delta}$

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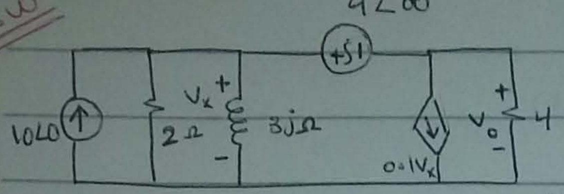
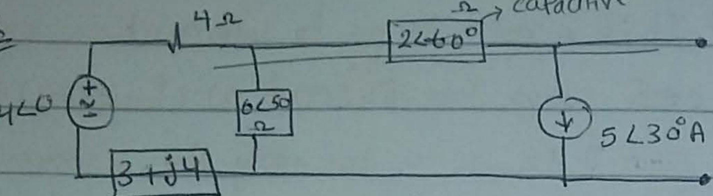
source transformation is the same principle in AC

H.W



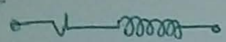
By supernode, Find V_x & V_o

Ex



↓ R+L

series



3 Ω   4j Ω

series $2-2j$

R & C

↓ 2 Ω   ↓ $-2j$ Ω

Polar form :-

+ve angle → R & L   inductive load

-ve angle → R & C   capacitive load

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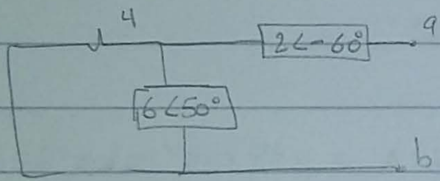
Find Norton equivalent

① killing → impedence Z_{th}

بالأمن أو مقتوح



$Z_{th} = \left[(4+3+j4) \,//\, 6\angle 50\right] + 2\angle -60° =$

$3.67\angle 9.05$ Ω

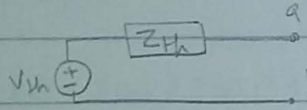
② $V_{ab} = V_{th}$

$I_2 = 5\angle 30°$

$-4\angle 0 + 4 I_1 + 6\angle 50 I_1 - 6\angle 50 \times 5\angle 30° + (3+j4) I_1 = 0$ $I_1 = 0.447\angle -34.3°$

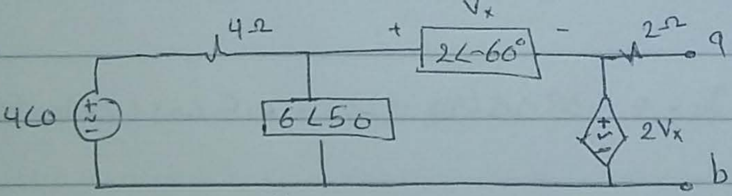
$V_{ab} = (-2\angle -60) I_2 + 6\angle 50 (I_1 - I_2) = V_{th}$

③



You can convert it by source transformation

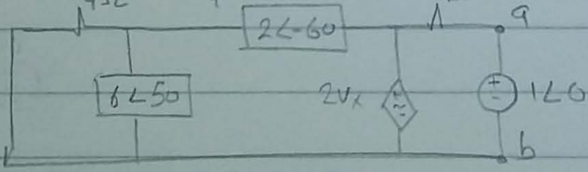
Example



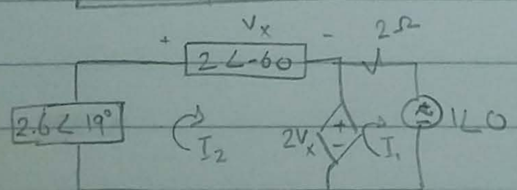
Find Thevenin's equivalent

الحل

①



To avoid 3 meshes, add the impedences



$V_x = 2\angle -60\, I_1$

$(2.6\angle 19° + 2\angle -60)\, I_2 = -2V_x$

$-2V_x + 2 I_1 + 1\angle 0 = 0 \rightarrow -2(2\angle -60) I_1 +$

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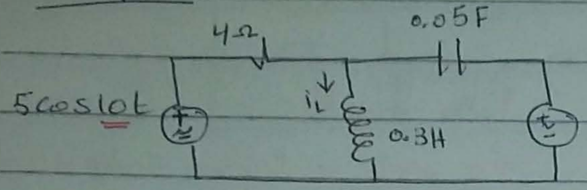
when one source, mesh is long

Imp. **Example**

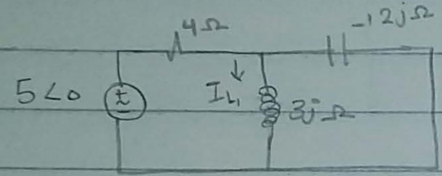


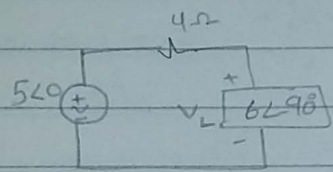
Find $I_L(t)$

* It is a must to go to superposition, since each source has different ω (frequency) value even if DC, ω = 0, but apply the contrains (open and close cct)

Apply superposition

1. Source 1

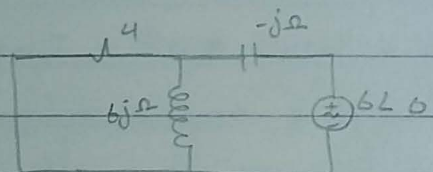




$$V_{L_1} = \frac{5\angle 0\,(6\angle -90^\circ)}{4+6\angle -90} = 4.1\angle -33^\circ$$

$$I_{L_1} = \frac{4.1\angle -33}{3j} = 1.38\angle -123\,A = 1.38\cos(10t-123)$$

2.



$V_{L_2} = 3.3\angle 33.7$ $\quad I_{L_2} = 0.5\angle -56^\circ\ A = 0.5\cos(20t-56)$

Superposition

$I_L = I_{L_1} + I_{L_2} = 1.38\cos(10t-123) + 0.5\cos(20t-56)\ A$

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AC - Power

22/12/2019

In DC $\quad P = IV = I^2R = V^2/R \quad [P] = W$

In AC → Instantaneous power $\quad P(t) = i(t) \cdot v(t) \quad [P(t)] = W$

القيمة ~~دخولة~~ التي تستفيد منها في الدارة → Average power (Real / mean / Active power) $\quad P = \frac{1}{2} |I||V| \cos(\theta_v - \theta_i) \quad [P] = W$

can't be negative because $\cos(\theta) = \cos(-\theta)$

Example $\quad I = 4\angle 30$

$V = 6\angle -15$

$P = \frac{1}{2} \times 4 \times 6 \times \cos(-15 - 30) = 12\cos(-45) = \boxed{12/\sqrt{2}\ W} = 8.4 W$

القدرة ~~الكلفة~~ التي لا نستفيد منها

Reactive power $\quad Q = \frac{1}{2} |I||V| \sin(\theta_v - \theta_i) \quad [Q] = VAR$ Volt Ampere Reactive

e.g. $Q = \frac{1}{2} \times 4 \times 6 \times \sin(-45^\circ) = \frac{-12}{\sqrt{2}}$ VAR → capacitive load $= -8.4$ VAR

Q in resistance, the phase shift $= 0$ $\quad (\theta_v = \theta_i)$

		P	Q
R	resistor	½ IV	0
L	inductor	0	+ve
C	capacitor	0	-ve

$\theta_v - \theta_i = 0 \quad \cos(0) = 1$
$\theta_v - \theta_i = 0 \quad \sin(0) = 0$

$\theta_v - \theta_i = 90 \quad \cos(90) = 0$
$\theta_v - \theta_i = +90 \quad \sin(\theta_v - \theta_i)$ +ve

على شكل طاقة مغناطيسية

$\cos(-90) = 0$
$\sin(-90)$ -ve

مفروضة للحكومة

Complex Power

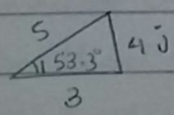
$\underset{}{S} = \overset{\text{real}}{P} \pm j\overset{\text{reactive}}{Q} \quad [S] = VA$ Volt Ampere

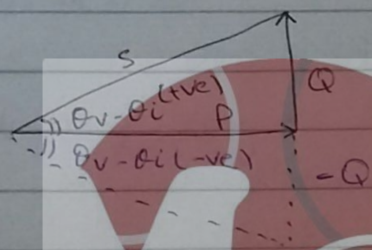
in the previous example $\quad S = 8.4 - j8.4$ VA $= 11.87\angle -45^\circ$ VA

$|S|$: Apparent Power $\quad |S| = 11.87$ VA

Power Triangle

$3 + j4$





Also, As vectors $\quad S = \frac{1}{2} V I^*$ (*) Change the sign of angle $(\cdot)$

$S = \frac{1}{2} \times 6\angle -15 \times 4\angle -30 = 12\angle -45^\circ$ VA

$S = \frac{1}{2} \times V \times \frac{V}{Z} = \frac{1}{2} V \times \frac{V^*}{Z}$

$= \frac{1}{2} V I^* \qquad \frac{1}{2} V \times V^* / Z^* \qquad \frac{V^*}{Z^*}$

$I = 4\angle 30$
$V = 6\angle -15 \qquad S = 12\angle -45 = 12\angle -45$
~~$Z = 2\angle 30$~~
$Z = 1.5\angle -45$

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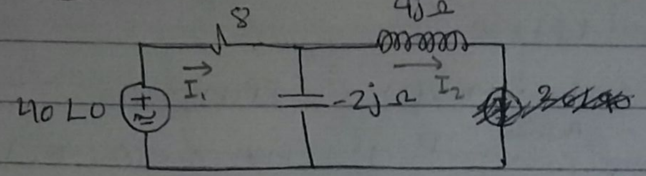
$\frac{1}{2}|I||V|$
$= \frac{1}{2} \times |I||I||Z|$

Example

Find P, Q, S Per each element



$\frac{(j4)(-j2)}{2j} = 4\angle -90^\circ$ $\quad Z_T = 8 - j4$

$I_1 = \frac{40\angle 0}{8-4j} = 4.47\angle 26.5^\circ$ $\quad I_2 = \cancel{40\angle 0}\ \frac{I_1(-2j)}{4j-2j} = 4.47\angle -153.4^\circ$ A

$P_{j4\Omega} = 0$ $\quad P_{-2j\Omega} = 0$ $\quad Q_R = 0$

$V_2 = 17.88\angle -63.4$

$Q_L = \frac{1}{2} \times |4.47||17.88| \sin(\underbrace{-63.4 - 153.4}_{+90}) = 39.97$ VAR

$S_L = 0 + 39.9j$ VA $\quad S_L = \frac{1}{2} \times 17.88\angle -63.4 \times 4.47\angle +153.4 = 39.9\angle 90$ VA

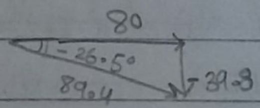
$S_R = P_R = \frac{1}{2} \times |V_R| \times |I_R|$

→ S in the source, two ways

① $P_{source} = \sum P_{loads}$ $\quad Q_{source} = \sum Q$

or ② $S = \frac{1}{2} V I^* = \frac{1}{2} \times 40\angle 0 \times 4.47\angle -26.5 = 89.4\angle -26.5 = \underbrace{80}_{P_R} + \underbrace{-39.9j}_{Q_R = Q_S - Q_L}$ VA

Source Power Triangle



→ $\cos(\theta_v - \theta_i)$ ⇒ Power Factor (PF) $\quad 0 \le PF \le 1$

cos is an even function.

$P.F = \cos(-26.5) = 0.89$ leads $\quad$ generally, the dominant in the ckt is the capacitive load (because -ve angle sign)

S angle w.r.t → +ve P.F lags

-ve P.F leads → ckt behaves like a capacitive load.

$P_{source} = P_{load}$

$Q_{source} = Q_{load}$

No: ---------- Date: ---------- $S_{source} = S_{load}$

useful → P 241121

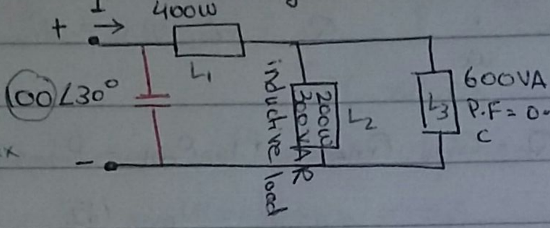
$\vec{S} = P \pm jQ$ (+ L, − C)

من أجل توفير S ، لا نفرق إذا loads على التوالي
أو على التوازي

$\vec{S} = \frac{1}{2}\vec{V}\vec{I}^*$ $\vec{S}_{Total} = \sum S_i$

Imp.

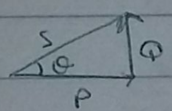
Example



Every load, given 2 informations → find P, Q, S, θ from P.F

$P = S\cos\theta$ Find the total S ($\vec{S}$ source, PF source, I)

$S = \frac{Q}{\sin\theta}$ $\boxed{S = \frac{P}{P.F}}$



$P = S\cos\theta = S \times P.F$ $S = P / P.F$

Load #1 $S_1 = \frac{400}{0.8} = 500$ $S_1 = 500\angle 36.86°$ VA

$\cos^{-1}(0.8) = 36.86°$

Load #2 $P = 200W$ $S_2 = P + jQ$

$Q = 300VAR$ $= 200 + 300j = 360.5\angle 56.3°$ VA

Load #3 $S = 600$ VA $S = 600\angle -45.6°$ VA

⇒ $S_{Total} = S_1 + S_2 + S_3$ regardless of type of connection.

→ $S_{source} = S_{total} = \boxed{850\angle 40.9 \text{ VA}} = 642.5 + 556.5j$ VA

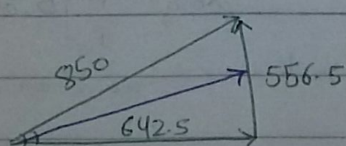
→ $P.F_{source} = \cos(40.9) = 0.76$ lags

→ $P_{Total} = \boxed{642.5 \text{ W}}$ → $S = \frac{1}{2}VI^*$ $850\angle 40.9 = \frac{1}{2} \times 100\angle 30°\ I^*$

$Q_{Total} = \boxed{556.5 \text{ VAR}}$ $I^* = 17\angle 10.9$ $\boxed{I = 17\angle -10.9 \text{ A}}$

Imp. ↓ Pay ↓ S by ↓ Q & keep P value

↓ θ ↑ P.F (↑ cos θ)



In exam

How to correct the P.F ?

* To improve the P.F, we have to add a capacitor in PARALLEL with the POWER SUPPLY. (in order to know its voltage)

Imp. Ideal case → P.F = 1 θ = 0

In exam What is the value of the capacitor to be added to improve the P.F to 0.95?

اشتقاق القانون assuming f = 60 Hz

in final there is $Y \leftrightarrow \Delta$

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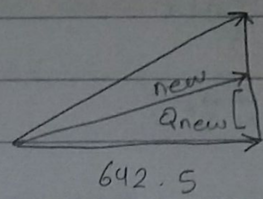
1. Find $\theta_{new} = \cos^{-1}(P.F_{new}) = 18.2°$

2. $Q_{new} = P \times \tan\theta = 211.2$ VAR

3. $Q_{capacitor} = Q_{old} - Q_{new} = 345.3$ VAR



~~it is the~~ voltage drop of capacitor

4. $Q_c = \dfrac{V_{rms}^2}{X_c}$ $X_c = \dfrac{1}{wc}$ $Q_c = V_{rms}^2 \, w C = V_{rms}^2 \, 2\pi f C$

$\boxed{C = \dfrac{Q_c}{V_{rms}^2 \, w}}$ $Q_c = Q_{old} - Q_{new} = P\tan\theta_{old} - P\tan\theta_{new}$

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

$\boxed{C = \dfrac{P(\tan\theta_{old} - \tan\theta_{new})}{V_{rms}^2 \, 2\pi f}}$ Find C to make the P.F unity $\rightarrow Q_c = Q_{old}$

$C = 1.8 \times 10^{-4}$ F $= \boxed{180\,\mu F}$

$\rightarrow V_{rms}$ root mean squared value - rms - effective

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

- physically, it means if replaced with DC device, it gives the same power that was putted for the same AC device.

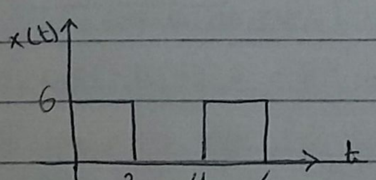
For sinusoidal sign $\begin{cases}\sin \\ \cos\end{cases}$, $V_{rms} = \dfrac{V_{max}}{\sqrt{2}}$

e.g $I(t) = 6\sin(10t)$

$I_{rms} = 6/\sqrt{2}$

$v(t) = 10\cos(wt)$

$V_{rms} = 10/\sqrt{2}$



$T = 4$

$X_{avg} = \dfrac{1}{4}\int_0^2 6.\,dt$

~~for~~ $2 \rightarrow 4 = 0$

$X_{rms} = \sqrt{\dfrac{1}{4}\int_0^2 6^2.\,dt} = \sqrt{1/4 \; 36t |_0^2} = \sqrt{18}$

Not $X_{rms} = X_{max} / \sqrt{2}$ BECAUSE Not Sinusoidal function.

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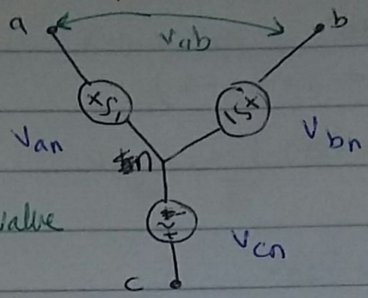
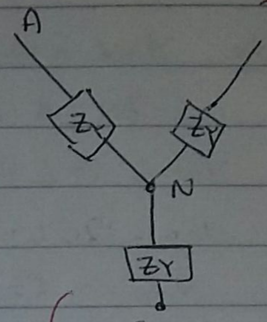
26/12/2019

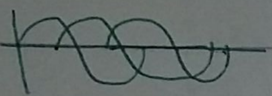
3-phase system

Source	Load
Y	Y
Y	Δ





اجماع وقيمة صفر
& impossible to find a point at zero value



Y - source

Y - Load

-120 with clock → clock wise → +ve sequence

Balanced load (equal Z_Y)

θ difference $= 120°$

$$\boxed{\begin{aligned} V_{an} &= 10\angle 0 \\ V_{bn} &= 10\angle -120 \\ V_{cn} &= 10\angle -240 \end{aligned}}$$

"Phase Voltage"

$V_{ab} = 10\sqrt{3}\angle 30$
$V_{bc} = \sqrt{3}\times 10\angle -90$
$V_{ca} = \sqrt{3}\times 10\angle -210$
difference -120

"line voltage" → $V_{ab} = \sqrt{3}\, V_{an}\angle \theta + 30°$

Ex. $V_{an} = 100\angle 60°$ — $V_{ab} = 100\sqrt{3}\angle 90°$ — if V_{ba} (- vector)

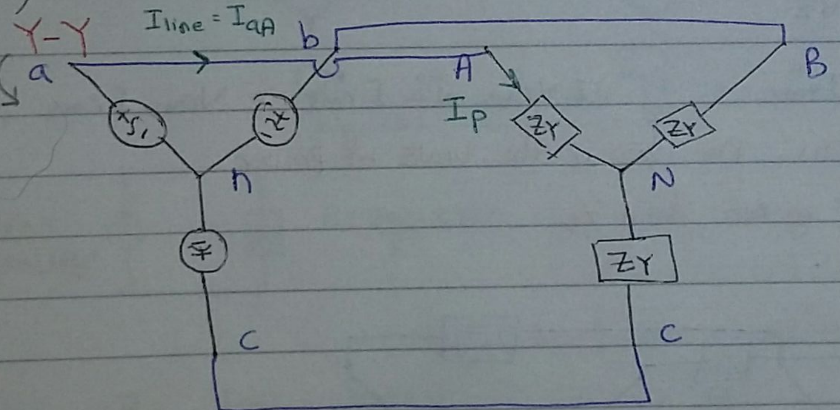
$V_{bn} = 100\angle -60°$ — $V_{bc} = 100\sqrt{3}\angle -30$

$V_{cn} = 100\angle -180°$ — $V_{ca} = 100\sqrt{3}\angle -150°$

التوتيش
مهم

V_p "Phase voltage" — "Line voltage" V_L

[1] Y-Y

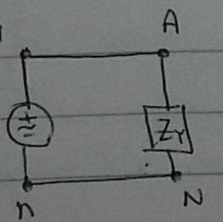


in Y-Y

$I_{Line} = I_{phase}$

$V_{line} = \sqrt{3}\, V_{phase}\angle\theta + 30° = \dfrac{V_{an}}{Z_Y}$

since balanced load



• $I_{aA} = \dfrac{V_{an}}{Z_Y}$

I_{bB} Just $-120°$ I_{aA}

I_{cC} Just $-240°$ I_{aA}

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<u>Example</u> $V_{bn} = 120 \angle 70^\circ$

$Z_Y = 4 \angle 10^\circ$

$V_{an} = 120 \angle 190^\circ = V_{AN}$

$V_{cn} = 120 \angle -50^\circ$

$V_{ab} = \sqrt{3}\,120 \angle 220^\circ$

$V_{bc} = \sqrt{3}\,120 \angle 100^\circ$

$V_{ca} = \sqrt{3}\,120 \angle -20^\circ$

$I_{aA} = \dfrac{V_{an}}{Z_Y} = \dfrac{120 \angle 190}{4 \angle 10} = 30 \angle 180^\circ$

$I_{bB} = 30 \angle 60^\circ$

$I_{cC} = 30 \angle -60^\circ$

→ $I_{aA} + I_{bB} + I_{cC} = 0 = I_{nN}$ ONLY in balanced load

Find the complex power in load

$S = \frac{1}{2} V I^* \Leftarrow$ for 1 phase

For 3 phase → $S = 3 \times \frac{1}{2} \times \boxed{V_{an}}_{max} \boxed{I_{aA}^*}$

$S = 1.5 \times (120 \angle 190^\circ)(30 \angle -180^\circ) = 5400 \angle 10^\circ$ VA

→ With rms

$V_{rms} = \dfrac{V_{max}}{\sqrt{2}}$ $\qquad V_{max} = \sqrt{2}\, V_{rms}$

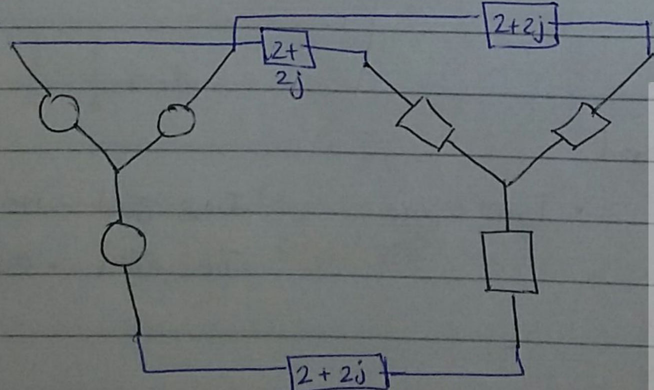
$\frac{1}{2} V_{max} I_{max}^* = \frac{1}{2} \sqrt{2} V_{rms} \sqrt{2} I_{rms}^* = V_{rms} I_{rms}$

if with rms, no 1/2 in the laws of power

→ if complex power given, find Z_L

<u>Example</u>

impedence on line



$V_{ab_{rms}} = 173 \angle 30^\circ$ V $\qquad Z_Y = 4 \angle 10^\circ$ $\qquad$ Show $I_{nN} = 0$, & S_{load}?

~~$S = 210 \angle 75^\circ$ VA~~ ⇐ ~~Complex power consumed by the load.~~

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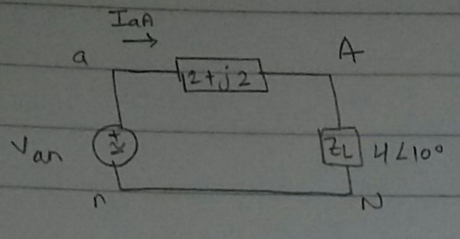
اذا ما حكى collectively rms
بتكون max



$I_{aA} = \dfrac{V_{an}}{(2+2j)+4\angle 10} = 15\angle -24$ A

$V_{an,rms} = \dfrac{173\angle 0}{\sqrt{3}} = 100\angle 0$

$I_{bB} = 15\angle -144$

$I_{cC} = 15\angle -264$

Complex Power consumed by load $\quad \theta_s = \theta_z$

$S = 3 \times V_{AN\,load}\, I_{aA}^{*}$

NOT Van, there is voltage consuming

$V_{AN} = I_{aA} Z_Y = 15\angle -24 \cdot 4\angle 10 = 60\angle -14$ V

$S = 3 \times 60\angle -14 \times 15\angle 24 = 2700\angle 10$ VA

P.F load = cos(10) lag

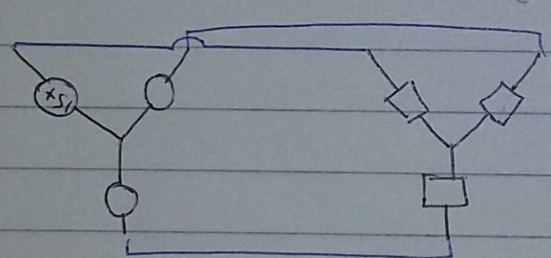
→ complex Power ~~consumed~~ delivered by the source

$S_{source} = 3 V_{an} I_{aA}^{*} = 3 \times (100\angle 0) \times (15\angle 24) = 4500\angle 24$

$P.F_{source} = \cos(24)$ lag

→ Complex power consumed by line $\quad S_{line}^{transmission} = S_{source} - S_{load}$

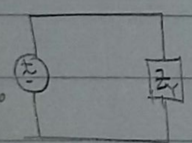
Example



$V_{an,rms} = 100\angle 45°$ V

$S_{load} = 200\angle 60°$ VA

Find Z, I_{aA}, P.F source



$V_{an} = 100\angle 45°$ $\quad S = \dfrac{200\angle 60°}{3}$

$S_{Total} = 3 V_{an} I_{aA}^{*}$

$200\angle 60 = 3(100\angle 45)\, I_{aA}^{*}$

$\boxed{I_{aA} = 0.67\angle -15° \text{A}}$

$Z_Y = \dfrac{V_{AN}}{I_{aA}} = \dfrac{100\angle 45}{0.67\angle -15} = 150\angle 60\ \Omega$

$P.F_L = \cos(60)$ lag

$S_{Load} = S_{source}$ ONLY for ideal transmission

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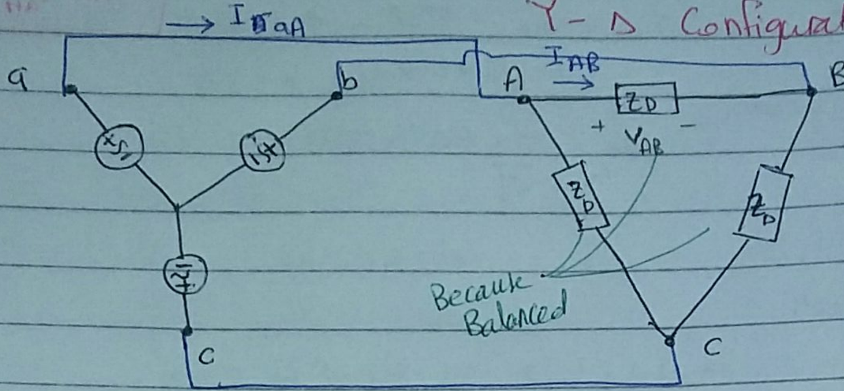
Y-Δ Configuration



* I can't draw single mesh, no I_{ab}, no n, no N

You can convert Δ to Y $\quad Z_Y = Z_\Delta / 3$

$I_{aA} = \sqrt{3}\, I_{AB} \angle -30°$ $\quad V_{an} \rightarrow V_{ab} \rightarrow V_{AB} \rightarrow I_{AB} = \dfrac{V_{AB}}{Z_\Delta} \rightarrow I_{aA}$

$V_{ab} = V_{AB}$

~~Z_Δ given → Find I_{aA}~~

Example

$Z_\Delta = 4 \angle 15°$

$V_{an} = 100 \angle 60°$

Complex power consumed by load? delivered by source?

$V_{an} \rightarrow V_{ab}$

$V_{ab} = \sqrt{3}\, V_{an} \angle +30° \rightarrow V_{ab} = 173 \angle 90°\ V$ $\quad \boxed{\sqrt{3}(100) \angle 90}$

$V_{ab} = V_{AB}$

$I_{AB} = \dfrac{V_{AB}}{Z_\Delta} = \dfrac{173 \angle 90}{4 \angle 15} = 43.25 \angle 75\ A$

$S_{load} = \frac{1}{2} \times \underline{3} \times V_{AB} \times I_{AB}^* = 11223.4 \angle \underline{15}\ VA$

consumed by phas AB, for 1 load, without 3 $\quad \theta_{S\,load} = \theta_{Z\,load}$

$S_{source} = \frac{1}{2} \times 3 \times V_{an} \times I_{aA}^* = S_{load} = S\ delivered = 11223.4 \angle 15\ VA$

$I_{aA} = \sqrt{3} \times 43.25 \angle 45° = 74.9 \angle 45°\ A$ $\quad$ لو طلع سالب

$I_{cC} = 74.9 \angle 45 - 240$ $\quad S_{load}$ vector

$V_{BC} = V_{AB} \angle -120 + \theta$

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Y-Y

$I_L = I_P \quad I_{aA} = I_{AN}$

$V_L = \sqrt{3} V_P \quad V_{ab} = \sqrt{3} V_{an}$

Y-Δ

$I_L = \sqrt{3} I_P \quad I_{aA} = \sqrt{3} I_{AB}$

$V_L = V_P \quad V_{ab} = V_{AB}$

Imp. Example

Find line current → I_{aA}, I_{bB}, I_{cC}, same source phase current

load يمر بال phase current → I_{AB}, I_{BC}, I_{CA}

Phase voltage → V_{AB}

line voltage → V_{ab}

Avg. Power → P

Given

$V_{an\,rms} = 220\angle 0 \qquad \tilde{V}_{bn} = 220\angle -120 \qquad \tilde{V}_{cn} = 220\angle 120 \ (\text{or} -240)$

$Z_\Delta = 9 - j6$

$\tilde{V}_{ab} = 381\angle 30 = \tilde{V}_{AB} \qquad \tilde{V}_{bc} = 381\angle -90 = \tilde{V}_{BC} \qquad \tilde{V}_{ca} = 381\angle -210 = \tilde{V}_{CA}$

$I_{AB} = \dfrac{V_{AB}}{Z_A} = 35.2\angle 63.7 \qquad I_{BC} = 35.2\angle -56.4 \qquad I_{CA} = 35.2\angle -176.4\ A$

$I_{aA} = \sqrt{3}\, I_{AB} \angle^{-30}\!+\theta$

$I_{aA} = 60.9\angle 33.6 \qquad I_{bB} = 60.9\angle -86.4 \qquad I_{cC} = 60.9\angle -206.4\ A$

to ← $S_{source} = 3\tilde{V}\tilde{I}^* = 3\tilde{V}_{an} I_{aA}^* = 3(220\angle 0)(60.9\angle -33.6) = 40194\angle -33.6$ VA

vg $\quad P.F_{source} = \cos(-33.6) = 0.83$ leading

$S_{load} = S_{source}$

$S_{1phase} = S_{source}/3$

→ if the power delivered by load $= 40194\angle -33.6$, given V_{an}, find Z_Δ?

$S_{1phase} = S/3 \rightarrow S = \tilde{V}\tilde{I}^*$

✓ ✓ ↓

find $I \rightarrow \dfrac{V}{I} = Z_\Delta$