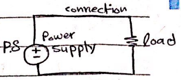
circuits

- electric circuits

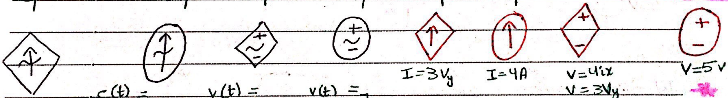


1. power supply →
2. Load → ① Resistor (ohm) ② capacitor ③ Inductor L(H)
   R
   C (F)
3. connections

DC: Direct current
AC: Alternating Current.

Power supply P.S

- AC – power supply
  - current source
    - dep.
    - Indep.
  - V.S
    - dep
    - Indep.
- DC – power supply
  - C.S
    - dep.
    - Indep.
  - voltage source
    - dep.
    - Indep. V.S



$c(t) = 4\sin 10t\, i_z$ $c(t) = 4\sin 10t$ $v(t) = 4\sin 10t\, v_y$ $v(t) = 4\sin 10t$ $I = 3V_y$ $I = 4A$ $V = 4i_x$, $V = 3V_y$ $V = 5V$

ohm's law

$V \propto I \rightarrow \boxed{V = IR}$

$I = dQ/dt$

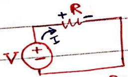
اذا كان عندي one source ال current يخرج من القطب الموجب
الجهة التي يصل لها التيار تكون القطب الموجب (اشارة موجبة)

- $V_{ab} = -V_{ba}$.
- $V_i = \frac{dw}{dq}$

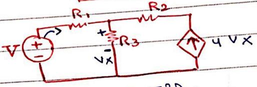
Energy (E) → J.
Power (P) → W.

$P = \frac{dw}{dt} = \cancel{\ }$

$P = VI$ → $V = IR$.

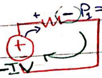


$\boxed{P} = I^2 R = V^2/R$. $P = \frac{dE}{dt} =$



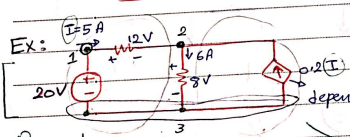
$P_{in} = P_{out} \rightarrow \sum P = 0$.

لما يدخل ال current من قطب موجب يكون ال $\boxed{\text{power}}$ موجب
،، ،، ،، ،، سالب ،، ،، سالب



$P_1 = I^2 R$.
$P_2 = -IV$ $\sum P = 0$.

Ex:



Independent P.S.
dependent (current supply).

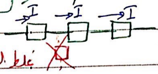
2 nodes
3 nodes

Branch. فرع
Node 3 nodes عقدة
$\boxed{\text{Mesh}}$ 2 meshs حلقة
Loop 3 loops.

ما بتحسبيها loop و معطاها اكتر من loop

جا بالسؤال في $0.2\boxed{I}$ يعني ال current
هو ال control جا بالسؤال ووضح ال I.

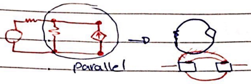
$\boxed{\text{Series}}$ → they have same current.



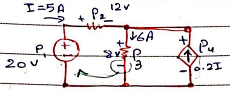
غلط لانه مفتوح

$V_{Total} = V_1 + V_2 + V_3$
$R_T I = IR_1 + IR_2 + IR_3$.
$R_T \cancel{I} = \cancel{I}[R_1 + R_2 + R_3]$
$R_T = R_1 + R_2 + R_3$.

Parallel → they have same voltage.



→ Ex



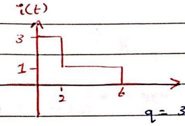
$P_1 = -VI = -5(20) = -100\,w$ (produce)

$P_2 = +VI = 5(12) = +60$ (consumed).

$P_3 = +VI = 6(8) = +48$ (c).

$P_4 = -VI = -8(0.2\times5) = -8\,W$ (produce)

$\Sigma P = 0.$



$i = \frac{dq}{dt} \rightarrow q = \int i\,dt.$

$q = 3(2) + 1(4) = 10\ c.$

10^{-3} m

10^{-6} μ

10^{-9} n

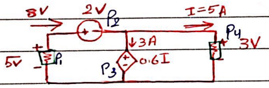
10^{-12} P

10^{3} K

10^{6} M

10^{9} G

10^{12} T



← ممكن ارسمها box

مش عارفة هي R ولا V

$P_1 = -VI = -5(8) = -40\ W$

$P_2 = +VI = 2(8) = 16\ w$

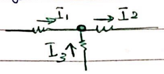
$P_3 = +VI = 3(0.6\times5) = 9\ W$

$P_4 = +VI = 3\times5 = 15\ W$

$\Sigma P = 0$

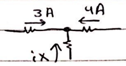
[1] * Kirchhof's Current law * «KCL»

[1] in = out → عند كل Node



$I_1 + I_3 = I_2$

$\sum I = 0$



$3 + 4 + ix = 0$

$7 + ix = 0$

$\boxed{ix = -7}$ ✓

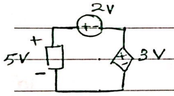
$ix = 7 \downarrow$ ✓

[2] Kirchhof's voltage law * «KVL»

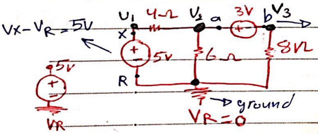
for any loop. , any closed path.

$\sum V = 0$

* اذا دخلنا من سالب فهو سالب voltage



$-5 + 2 + 3 = 0$ ✓



→ $V_a - V_b = 3$ → • نعتبر (V_1, V_2, V_3) أعلى من الـ zero

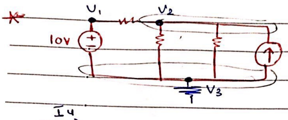
4 Nodes.

أي مقاومة موجودة بال Branch التيار (current) منها نازل ↓

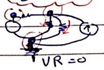
نقدر اتجاه الـ current دائما ماعدا لما يكون موصول بال ground وقبله node.

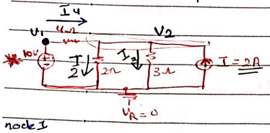
• نوصف الـ node دائماً بال volt $(V_1, V_2, \ldots)$.

*



3 nodes

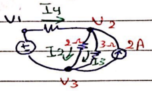




active

لا يكونا عندي فولتيج واحد بحط الـ node عند

بحطهاش ضيفتها.



node I

(1) * $V_1 = 10V$

node 2

(2) * $I_4 + 2 = I_2 + I_3$

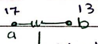
(3) * $I_4 = \frac{V_1 - V_2}{4}$

(4) * $I_2 = \frac{V_2 - \cancel{V_R}^{0}}{2}$

(5) * $I_3 = \frac{V_2}{3}$

• بالقاعدة الـ current ثابت لما مربط

بالـ ground (parallel)



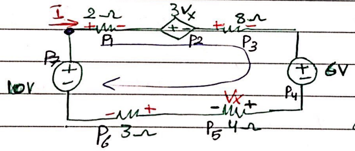
$I = \frac{V}{R} = \frac{V_a - V_b}{R}$

$\hookrightarrow V_R = V_a - V_b$

$17 - 13 = 4$.

• التيار يمشي من الأعلى للأقل.

curren A = current B.



one Mesh (نفس التيار)

By KVL $\sum V = 0$

$3Vx \rightarrow 3 \times 4I$

• $2I + 3Vx + 8I + 6 + 4I + 3I - 10 = 0 \rightarrow 17I + 12I - 10 + 6 = 0$

• $Vx = 4I = 4 \times \frac{4}{29}$

$29 I = 4$

$I = \frac{4}{29}$ A

$P_1 = +VI = +\left(\frac{4}{29}\right)^2 \times 2$ (C)

$\boxed{= +I^2 R}$

$P_2 = +I3Vx = +\left(\frac{4}{29}\right)\left(\frac{16}{29} \times 3\right)$ (g)

$\rightarrow$

$P_3 = +I^2R = \left(\frac{4}{2a}\right)^2 \times 8$ (c)

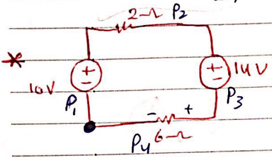
$P_4 = +VI = (6)\left(\frac{4}{2a}\right)$ (c)

* $P_5 = +I^2R = \left(\frac{4}{2a}\right)^2 (4)$ (c)

$P_6 = +I^2R = \left(\frac{4}{2a}\right)^2 (3)$ (c)

$P_7 = -VI = -(10)\left(\frac{4}{2a}\right)$ (p)

*



$P_1 = -VI = -(10)(-0.5) = 5W$ (c)

$P_2 = +I^2R = +(-0.5)^2(2) = 0.5\ W$ (c)

$P_3 = +VI = +(14)(-0.5) = -7\ W$ (p)

$P_4 = +I^2R = +(-0.5)^2(6) = 1.5\ W$ (c)

$\Sigma P = 0$

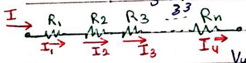
$-10 + 2I + 14 + 6I = 0$

$4 + 8I = 0$

$\boxed{I = -0.5A}$

* Resistor —ww— $R(\Omega)$
* conductance —ww— $G = 1/R$ ($\mho$ مو / S سيمنس)

*



$V_4 = I_4 R_4$

$V_1 = I R_1$ $V_2 = I_2 R_2$

Series

نهاية الاولى بداية الثانية

$I = I_1 = I_2 = I_3 = \dots = I_N$

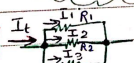
$V_t = V_1 + V_2 + V_3 + \dots V_N$

$\cancel{I} R_t = \cancel{I} R_1 + \cancel{I} R_2 + \cancel{I} R_3 + \dots \cancel{I} R_N$

$\to R_t = R_1 + R_2 + R_3 + \dots R_N$

$\frac{1}{G_t} = \frac{1}{G_1} + \frac{1}{G_2} + \frac{1}{G_3} + \dots \frac{1}{G_N}$

Parallel



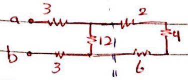
نفس البداية ونفس النهاية

$I_t = I_1 + I_2 + I_3 + \dots I_N$

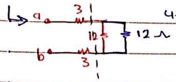
$\frac{\cancel{V_t}}{R_t} = \frac{\cancel{V_1}}{R_1} + \frac{\cancel{V_2}}{R_2} + \frac{\cancel{V_N}}{R_N} \to \frac{1}{R_t} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_N}$

$G_t = G_1 + G_2 + \dots G_N$

Ex :

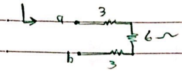


١) ارسم
٢) ناخذ الاربع



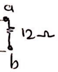
4+2+6

لما يكون عندي parallel باخذ مجموع ال R وباخذ نصهم
نفس القيمة

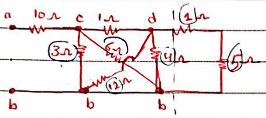


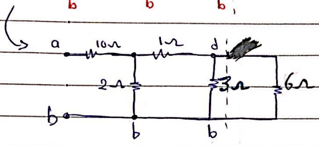
$\frac{12}{2} = 6$

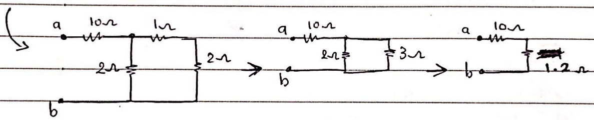
$R_{ab} = 3 + 6 + 3 = 12\ \Omega$



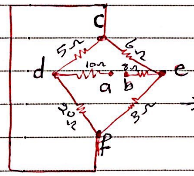
Ex :

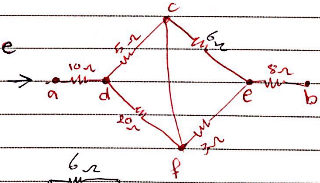


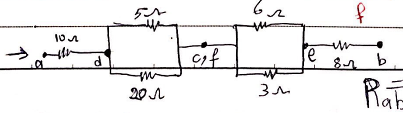




Ex :



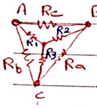




$R_{ab} = 10 + (5 // 20) + (6 // 3) + 8$

$= 10 + 4 + 2 + 8 = \boxed{24\ \Omega}$

$\boxed{Y \leftrightarrow \Delta}$



$\Delta \to Y$ ← مقام ثابت

$$R_1 = \frac{R_b R_c}{R_a + R_b + R_c}$$

$$R_2 = \frac{R_a R_c}{R_a + R_b + R_c}$$

$$R_3 = \frac{R_b R_a}{R_a + R_b + R_c}$$

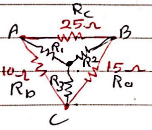
$Y \to \Delta$ البسط ثابتة

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

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

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

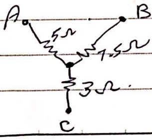
Ex:



$$R_1 = \frac{25 \times 10}{15 + 10 + 25} = 5\,\Omega$$

$$R_2 = \frac{15(25)}{50} = 7.5\,\Omega$$

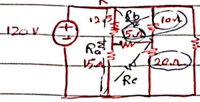
$$R_3 = \frac{150}{50} = 3\,\Omega$$



Scanned with CamScanner

Ex8

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



parallel
series.

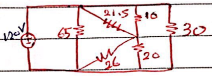
عندي Y وبدي Δ

Y → Δ.

- $R_a = \frac{75 + 62.5 + 187.5}{5} = \frac{325}{5} = 65\,\Omega$

- $R_b = \frac{325}{15} = 21.6\,\Omega$

- $R_c = \frac{325}{12.5} = 26\,\Omega$ →

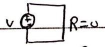


- $R_{eq} = \left[\left[(21.6 \,//\, 10) + (26 \,//\, 20)\right] \,//\, 30\right] \,//\, 65 = 9.62\,\Omega$

- $I = \frac{V}{R_{eq}} = \frac{120}{9.62} = 12.49\,A$

* short circuit * (SC)

- « أي مقاومة parallel مع ال short circuit بتلغيها »
- « التيار بيمشي من أقل R »

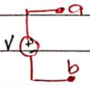


$R_{sc} = 0$

$V_{sc} = 0$

$I = \infty$

* open circuit * (OC)

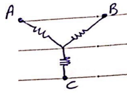


$I_{oc} = 0$

$V_{oc} = V$

$R_{oc} = \frac{V}{I} = \frac{V}{0} = \infty$

Balanced



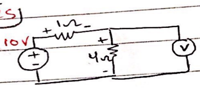
* Measuring Devices *

Voltage → voltmeter —(V)— • connected in parallel with load $R_{int} \to \infty$.

current → Ammeter —(A)—

محتاج بطاريه ؟ ← Resistance

Power → connected in series with load.



$I = \frac{10}{4+1} = 2A$

$I' = \frac{10}{1+3.3} = 2.3$

① $\boxed{R_{int}} = 25\Omega \downarrow$

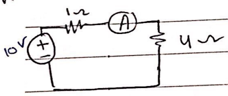
$4 // 25 = \frac{100}{29} \approx 3.3\ \Omega$

② $\boxed{R_{int}} = 1000\ \Omega$

$1000 // 4 = \frac{4000}{1004} = 3.98\ \Omega$

$I =$ [redacted] $= \frac{10}{4.9} \approx 2.$—

* [redacted]



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

① $R_{int} = 3\ \Omega$

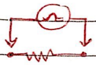
$I' = \frac{10}{5+3} = 1.25\ A$

ابعد عن 2

$R = 0.5\ \Omega$

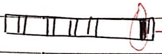
$I'' = \frac{10}{1+4+0.5} = 1.88\ A$

اقرب لل 2



„ لما نقيسها يا بنفصل الـ ـــ مثال circuit

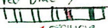
او بنفتح الدارة بنفصل جزء منها „



silver ±10%
gold ±5%
colorless 20%

B	Black	0
B	Brown	1
R	Red	2
O	Orange	3
Y	Yellow	4
G	green	5
B	Blue	6
V	violete	7
G	Gray	8
W	white	9

red Blue Green



orange

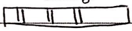
2 6 3 00000

„ كل ما قل نسبة التغير بكون أدق و أعلى „

(more accurate)

Ex:

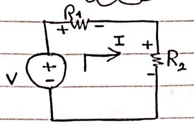
red blue orange



2 6 000 → 26 kΩ

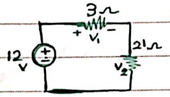
* voltage divider *

R in series



- $V_1 = \dfrac{VR_1}{R_1+R_2}$
- $V_2 = \dfrac{VR_2}{R_1+R_2}$
- $I_T = \dfrac{V_T}{R_1+R_2}$

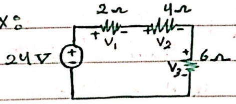
Ex:



- $V_1 = \dfrac{12(3)}{3+21} = \dfrac{36}{24} = 1.5\ V$
- $V_2 \overset{①}{=} 12 - 1.5 = 10.5\ V$

  ↳ $\overset{②}{=} \dfrac{12(21)}{24} = 10.5\ V$

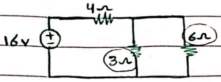
Ex:



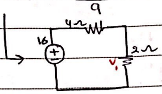
- $V_1 = \dfrac{24(2)}{2+4+6} = 4\ v$
- $V_2 = \dfrac{24(4)}{2+4+6} = 8\ v$
- $V_3 \overset{①}{=} \dfrac{24(6)}{2+4+6} = 12\ v$

  ↳ $\overset{②}{=} 24 - (8+4) = 12\ V$

Ex :

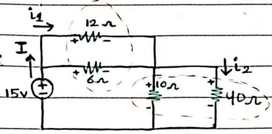


$3 // 6 = \frac{3\times 6}{9} = 2\,\Omega$



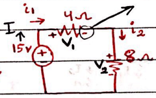
$V_1 = V_{eq} = \frac{16\times 2}{4+2} =$

Ex :



. مهم نكتب الإشارات ...

- $12 // 6 \rightarrow \frac{12\times 6}{12+6} = 4\,\Omega$
- $10 // 40 \rightarrow \frac{10\times 40}{10+40} = 8\,\Omega$



- $V_1 = \frac{15(4)}{4+8} = 5\,V$
- $i_1 = \frac{V_1}{R_{12}} = \frac{5}{12}\,A$

من الرسمة الرئيسية

- $V_2 = \frac{15(8)}{4+8} = \frac{120}{12} = 10\,V$
- $i_2 = \frac{V_2}{R} = \frac{10}{40} = \frac{1}{4}\,A$
- $I_{total} = \frac{V}{R_{eq}} = \frac{15}{12}\,A$

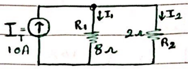
$12 \rightarrow (8+4)$

* Current divider *   R in parallel

• نطبقها عندما يبدأ ال current بالتوزع

• current يتناسب عكسيًا مع R

*



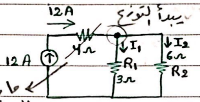
$8 // 2 = \frac{8 \times 2}{8+2} = \frac{16}{10}$

• $I_1 = \frac{I_T \times R_2}{R_1 + R_2} = \frac{10 \times 2}{8+2} = \frac{20}{10} = 2A$

• $I_2 = \frac{I_T \times R_1}{R_1 + R_2} = \frac{10 \times 8}{8+2} = \frac{80}{10} = 8A$

*

يبدأ التوزع

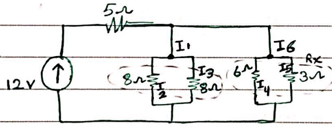


ما بتصير الهم لبعد التوزع

• $I_1 = \frac{12 \times 6}{9} = 8A.$

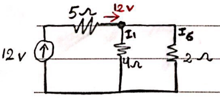
• $I_2 = \frac{12 \times 3}{9} = 4A.$

*



• $3 // 6 \Rightarrow R_x = \frac{3 \times 6}{3+6} = \boxed{2\Omega}$

• $8 // 8 \rightarrow R_y = \frac{8 \times 8}{8+8} = \boxed{4\Omega}$



$I_1 = \frac{12 \times 2}{4+2} = 4A$

$I_6 = \frac{12 \times 4}{6} = 8A$

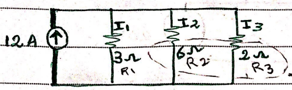
• $I_2 = \frac{4 \times 8}{8+8} = 2A$

• $I_4 = \frac{8 \times 3}{6+3} = \frac{24}{9} A$

• $I_3 = I_2 = 2A$

• $I_5 = \frac{8 \times 6}{9} = \frac{48}{9} A$

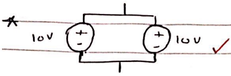
Ex:

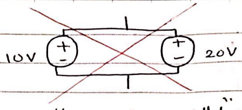


$\rightarrow R_{eq} = \frac{6\times2}{6+2} = \frac{12}{8} = 1.5\,\Omega$

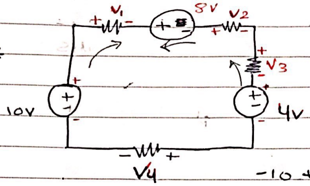
- $I_1 = \frac{I_T \times R_{eq}}{R_1 + R_{eq}} = \frac{12\times1.5}{3+1.5} = \frac{18}{4.5} = 4A$

- $I_{23} = \frac{12\times3}{4.5} = 8A$



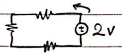


• لما يكون two voltages in parallel
لازم يكونوا نفس الفولتية .

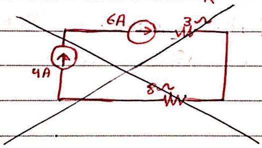


$$-10 + V_1 + 8 + V_2 + V_3 + 4 + V_4 = 0$$

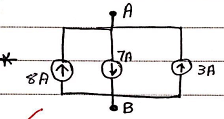
$$V_1 + V_2 + V_3 + V_4 = \boxed{2}$$

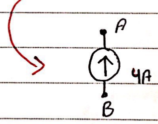


* current sources *



ما بشرط انه يختلف ال current



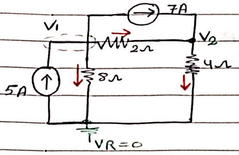


$8-7+3=4A$

CH "3"

* Methods of Analysis. *

• Nodal analysis.



• لما يكون في أكثر من current
الحل بيكون بال nodal analysis

equ = # nodes − 1

① select the ~~active~~ reference node.
↳ (without the reference)

② select the active nodes any sign $(V_1, V_2, \dots V_n)$ for each node.

③ Apply KCL
for each active node.
(n−1) equ.

• (دايما الطاقة الموصولة بين V وال VR ← current بيكون ↓)

④ Solve the equ.

# node 1	# node 2
$I_{in} = I_{out}$	
$5 = 7 + \frac{V_1 - V_R}{8} + \frac{V_1 - V_2}{2}$	$7 + \frac{V_1 - V_2}{2} = \frac{V_2}{4}$
$40 = 56 + V_1 + 4V_1 - 4V_2$	$28 + 2V_1 - 2V_2 = V_2$
$\boxed{5V_1 - 4V_2 = -16}$ ①	$3V_2 - 2V_1 = 28$
	$\boxed{-2V_1 + 3V_2 = 28}$ ②

* calculator
• mod → 5 → 1
وبنحطهم بالترتيب .

• $V_1 = \frac{64}{7}$

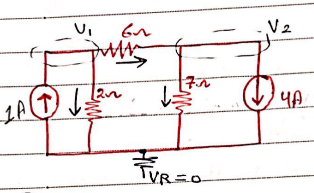
• $V_2 = \frac{108}{7}$

$$\rightarrow I_{8\Omega} = \frac{V_1}{8} = \frac{64}{7} \times 8 \ A$$

$$I_{2\Omega} = \frac{V_1 - V_2}{2} = \left(\frac{\frac{64}{7} - \frac{108}{7}}{2} \right) A$$

$$I_{4\Omega} = \frac{V_2 - V_R}{4} = \frac{108}{7} \times 4 \ A$$

Ex:



Node 1

$$1 = \frac{V_1}{2} + \frac{V_1 - V_2}{6}$$

تبسيط

$$\hookrightarrow 6 = 3V_1 + V_1 - V_2$$

$$4V_1 - V_2 = 6 \quad (1)$$

Node 2

$$\frac{V_1 - V_2}{6} = 4 + \frac{V_2}{7}$$

$$7V_1 - 7V_2 = 168 + 6V_2$$

$$7V_1 - 13V_2 = 168 \quad (2)$$

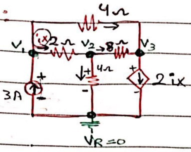
(1+2)

$V_1 = -2$

$V_2 = -14$

- $I_{2\Omega} = \frac{V_1}{2} = \frac{-2}{2} = \boxed{-1\ A}$
- $I_{7\Omega} = \frac{V_2}{7} = \boxed{-2}\ A$
- $I_{6\Omega} = \frac{V_1 - V_2}{6} = \frac{-2-(-14)}{6} = \boxed{2A}$

Ex:



node (1) x4

$$\left(3 = \frac{V_1 - V_2}{2} + \frac{V_1 - V_3}{4}\right)$$

$$12 = 2V_1 - 2V_2 + V_1 - V_3$$

$$12 = 3V_1 - 2V_2 - V_3 \quad \text{------} \quad (1)$$

node (2)

$$\left(\frac{V_1 - V_2}{2} = \frac{V_2 - V_3}{8} + \frac{V_2}{4}\right) \times 8$$

$$4V_1 - 4V_2 = V_2 - V_3 + 2V_2$$

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

node (3) $\rightarrow ix$

$$\left(\frac{V_1 - V_3}{4} + \frac{V_2 - V_3}{8} = \cancel{2}\left(\frac{V_1 - V_2}{\cancel{2}}\right)\right) \times 8$$

$$2V_1 - 2V_3 + V_2 - V_3 = 8V_1 - 8V_2$$

$$0 = 6V_1 - 9V_2 + 3V_3$$

Calculator → $V_1 = 4.8V$, $V_2 = 2.4V$, $V_3 = -2.4V$

* Kremmer's Rule *

$$\begin{bmatrix} 3 & -2 & -1 \\ -4 & 7 & -1 \\ -6 & 9 & -3 \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \\ V_3 \end{bmatrix} = \begin{bmatrix} 12 \\ 0 \\ 0 \end{bmatrix}$$

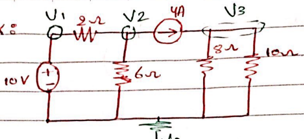
$V_1 = \frac{\Delta 1}{\Delta}$, $V_2 = \frac{\Delta 2}{\Delta}$, $V_3 = \frac{\Delta 3}{\Delta}$

→ $P_{8\Omega} = I^2 R = \left(\frac{V_2 - V_3}{8}\right)^2 \times 8 \; W \rightarrow +\left(\frac{2.4 + 2.4}{8}\right)^2 \times 8 \; W$ (C)

$P_{2ix} = IV = +2ix(V_3) = +2$ ---- (C)

$P_{3A} = -IV = -3(4.9)$ ---- (P)

Ex:

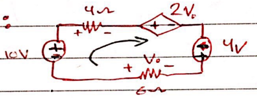


* Node(1): $V_1 = 10V$

* Node(2): $\frac{V_1 - V_2}{2} = 4 + \frac{V_2}{6}$ $V_2 = \checkmark \boxed{\frac{6}{4}}$

* Node(3): $4 = \frac{V_3}{8} + \frac{V_3}{10}$

Ex:



$(V_o = -6I)$

(لما يكون عندي مقاومة بقدر
امشي بالتيار اللي بيمر
اياه واعوضها بشحنات
تانية منها)

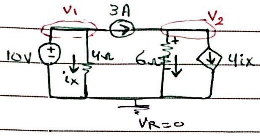
$-10 + 4I + 2V_o - 4 + 6I = 0$

$-10 + 4I + 2(-6I) + 4 + 6I = 0$

Scanned with CamScanner

* Nodal Analysis with Voltage source *

Ex:



* Node # 1.

$V_1 = 10V$ ---- ①

* Node # 2

$\frac{V_2}{6} + 4ix = 3 \rightarrow ix = \frac{V_1}{4} = \frac{10}{4} = 2.5A$

$\frac{V_2}{6} + 4(2.5) = 3.$

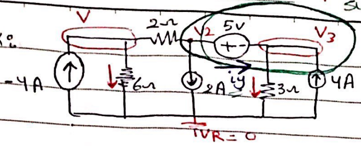
$\frac{V_2}{6} = -7 \rightarrow V_2 = -42V$

- $P_{6\Omega} = +I^2R = +\frac{V^2}{R} = \frac{(-42)^2}{6} =$ w (c)
- $P_{4ix} = IV = 4ix \cdot V_2 = 4(2.5) \times -42 =$ (p)
- $P_{3A} = VI = (V_1 - V_2)(3) =$
- $P_{10V} = -VI = 10(ix+3) = -5.5$ w (p).

Scanned with CamScanner

* super node. *

Ex:



- Node #1

In = out

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

$\times 6$

$$-24 = V_1 + 3V_1 - 3V_2$$

$$4V_1 - 3V_2 = -24 \quad \text{----} \ (1)$$

- Node => Super Node.

$$4 + \frac{V_1 - V_2}{2} = 2 + \frac{V_3}{3}$$

$$24 + 3V_1 - 3V_2 = 12 + 2V_3$$

$$3V_1 - 3V_2 - 2V_3 = -12 \quad \text{----} \ (2)$$

$$V_2 - V_3 = 5 \quad \text{....} \ (3)$$

$\rightarrow V_1 = \frac{-54}{11}$ V. , $V_2 = \frac{16}{19}$ V.

$V_3 = -\frac{39}{11}$ V.

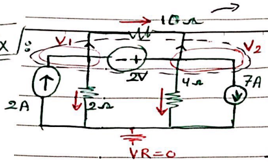
Find i_y: by KCL

$$4 + I_y = \frac{V_3}{3} \longrightarrow I_y = -4 + \frac{\frac{39}{11}}{3} = -5.18 \text{ A}$$

$$*\ P_{I_Y} = +IV = (-5.18) \times 5 = \ldots \ \omega \ (P).$$

"ال 10Ω داخلة وطالعة من ال node التاني فمتلغي عشان هيك ما بحطها"

Ex:



ستكون عندي V بين 2 nodes. بحطها سوبر نود.

$*$ super node: In = out.

$$2 = \frac{V_1}{2} + \frac{V_2}{4} + 7$$

$$-5 = \frac{V_1}{2} + \frac{V_2}{4} \quad \times 8$$

$$-40 = 4V_1 + 2V_2$$

$$-20 = 2V_1 + V_2$$

$$2 = -V_1 + V_2$$

$$-20 = 2V_1 + V_2$$

$$-2 = +V_1 - V_2$$

$$\frac{-22}{3} = \frac{3V_1}{3}$$

$$V_1 = \frac{22}{3}$$

$$V_2 - V_1 = 2$$

$$V_1 = -\frac{22}{3}\,V, \quad V_2 = \frac{-16}{3}\,V.$$

ما بحطها $V_1 - V_2$ لأنه بنحط اول الاقرب لل +

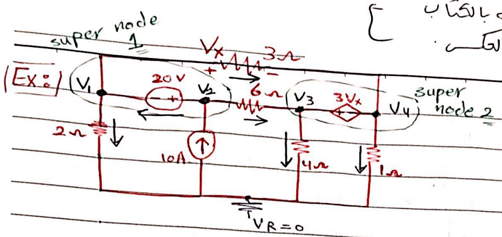
لأنه parallel مع ال V الثانية

$$I_{10\Omega} = \frac{V_1 - V_2}{10} = \frac{-2}{10} = -0.2A$$

فبيكون نفسه بس عكس الاشارة.

[السؤال نفسه بالكتاب بس (+-) 20V العكس]

Ex:



* super node "1".

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

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

$$5V_1 + V_2 - V_3 - 2V_4 = 60 \text{ ---- } ①$$

* super node "2".

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

$$V_2 - V_3 + 2V_1 - 2V_4 = 1.5V_3 + 6V_4$$

$$2V_1 + V_2 - 2.5V_3 - 8V_4 = 0 \text{ ---- } ②$$

$V_1 =$

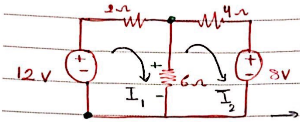
$V_2 =$

$V_3 =$

$$V_2 - V_1 = 20 \text{ --- } ③$$

$$V_3 - V_4 = 3V_x \rightarrow V_3 - V_4 = \frac{3(V_1 - V_4)}{3} \text{ --- } ④$$

* Mesh Analysis *



[1] assign currents $i_1, i_2, \dots i_n$

[2] apply KVL

[3] solve.

→ 2 meshes, 3 loops.

* mesh #1

$-12 + 2I_1 + 6(I_1 - I_2) = 0$

$8I_1 - 6I_2 = 12$ ----- ①

$I_1 = 1.63$

$I_2 = 0.18$

* mesh #2.

$4I_2 + 8 + 6(I_2 - I_1) = 0$

$-6I_1 + 10I_2 = -8$ ----- ②.

نحطها ال matrix:

$$\begin{bmatrix} 8 & -6 \\ -6 & 10 \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} 12 \\ -8 \end{bmatrix}.$$

$\underline{\underline{2\times 2}}$ $\quad$ $\underline{\underline{2\times 1}}$

$I_1 = \frac{\Delta 1}{\Delta} = \frac{42}{44} = 1.6A$

$I_2 = \frac{\Delta 2}{\Delta} = \frac{8}{44} = 0.18 \ A$

$\Delta = 80 - 36 = 44$

$\Delta_1 = \begin{vmatrix} 12 & -6 \\ -8 & 10 \end{vmatrix} = 120 - 48 = 72.$

$\Delta 2 = \begin{vmatrix} 8 & 12 \\ -6 & -8 \end{vmatrix} = -64 + 72 = 8.$

- $P_{6\Omega} = I^2 R = (I_1 - I_2)^2 (6) = \dots$

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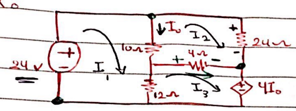
Ex:



3 meshes:

* Mesh #1.

$$-24 + 10(I_1 - I_2) + 12(I_1 - I_3) = 0 \; ---$$

$$22 I_1 - 10 I_2 - 12 I_3 = 24 \; --- \; (1).$$

* Mesh #2.

$$24 I_2 + 4(I_2 - I_3) + 10(I_2 - I_1) = 0$$

$$-10 I_1 + 38 I_2 - 4 I_3 = 0 \; --- \; (2).$$

* Mesh # 3.

$$4I_0 + 12(I_3 - I_1) + 4(I_3 - I_2) = 0$$

but $I_0 = I_1 - I_2$.

[$I_0 \downarrow$, $I_1 \downarrow$ فينزلي
$I_1 > I_2$.]

$$4(I_1 - I_2) + 12(I_3 - I_1) + 4(I_3 - I_2) = 0$$

$$-8 I_1 - 8 I_2 + 16 I_3 = 0 \; --- \; (3)$$

$I_1 = 2.25\,A$, $I_2 = 0.75\,A$, $I_3 = 1.5\,A$.

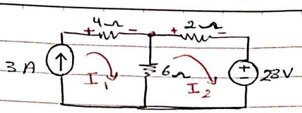
$P_{24V} = -I_1 V = -(2.25)(24) = 54\,W$.

$I_3 > I_2$

$P_{4\Omega} = (I_3 - I_2)^2 \times 4 = \_\_\_\_ \; W \quad (c).$

$P_{4I_0} = +IV = \cancel{4}I_3(4I_0) = I_3(4)(I_1 - I_2).$

Ex:



* $I_1 = 3A$.

معادلة وحدة المتغير بـ I_2 نحصل ..

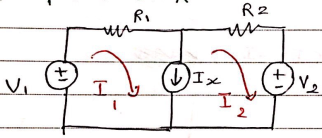
* $2I_2 + 23 + 6(I_2 - I_1) = 0$

$8I_2 = -23 + 18$

$8I_2 = -10$

$I_2 = \frac{-10}{8}\ A$.

* Super Mesh *



" loop "

$R_1 I_1 + R_2 I_2 + V_2 - V_1 = 0$

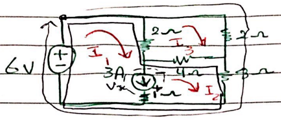
$(I_1 - I_2) = I_x$

(افترضنا $I_1 > I_2$ لأنه نفس اتجاه Ix) .

-- super mesh --

KVL (Mesh analysis)

Ex:



نعتبر اخذ loop الي بدي
او الي بدها

mesh 3.

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

$-2I_1 - 4I_2 + 8I_3 = 0$ —— (1)

* $I_1 - I_2 = 3$ —— (2)

$-6 + 2I_3 + 8I_2 = 0$

$8I_2 + 2I_3 = 6$ —— (3)

$I_1 = 3.47\ A$
$I_2 = 0.47\ A$
$I_3 = 1.1\ A$

$P_{3A} = IV$ mesh 2.

$4(I_2 - I_3) + 8I_2 + 1(I_2 - I_1) + Vx = 0$

$4(0.47 - \cancel{3.47}\ 1.1) + 8(0.47) + 1(0.47 - 3.47) + Vx = 0$

$Vx = 1.49$.

$P_{3A} = -3 \times 1.49 = -4.47\ W$ (P).

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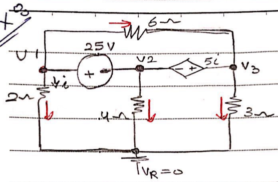
Ex 3

nodal analysis

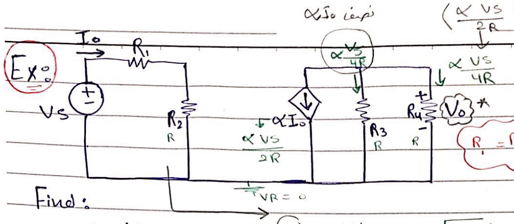


- $\left(\frac{v_1}{2} + \frac{v_2}{4} + \frac{v_3}{3} = 0\right)^{\times 12}$ ---- ① $\rightarrow$ $6v_1 + 3v_2 + 4v_3 = 0$
- $v_1 - v_2 = 25$ ---- ②
- $v_3 - v_2 = 5i = 5\left(\frac{v_1}{2}\right)$ ---- ③

$\left(v_3 - v_2 = \frac{5v_1}{2}\right) \times 2 \rightarrow 5v_1 + 2v_2 - 2v_3 = 0$

$v_1 = 7.6\,V$, $v_2 = -17.3\,V$, $v_3 = 1.63\,V$.

Ex:



$R_1 = R_2 = R_3 = R_4 = R$

Find:

[a] $\frac{V_o}{V_s}$

$$I_o = \frac{V_s}{R_1 + R_2} = \boxed{\frac{V_s}{2R}}$$

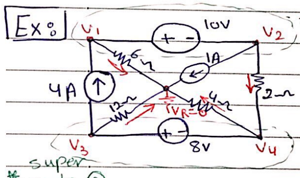
$$V_o = \cancel{R} \cdot \frac{\alpha V_s}{4\cancel{R}} = \frac{\alpha V_s}{4}$$

$$\frac{V_o}{V_s} = \frac{\alpha \cancel{V_s}}{4} \times \frac{1}{\cancel{V_s}} = \boxed{\frac{\alpha}{4}}$$

[b] $\alpha \rightarrow \left|\frac{V_o}{V_s}\right| = 10$.

$$\left|\frac{\alpha}{4}\right| = 10 \rightarrow \alpha = \boxed{40}.$$

Ex:



super node (1)
solve --

* super node (2)

* super node #1.

$$\left(4 = \frac{V_1}{6} + 1 + \frac{V_2 - V_4}{2}\right) \times 6$$

$$24 = V_1 + 6 + 3V_2 - 3V_4$$

$$18 = V_1 + 3V_2 - 3V_4 \quad (1)$$

$$\left(\frac{V_2 - V_4}{2} = \frac{V_4}{4} + \frac{V_3}{12} + 4\right) \times 12$$

$$6V_2 - 6V_4 = 3V_4 + V_3 + 48$$

$$6V_2 - V_3 - 9V_4 = 48 \quad (2)$$

$$V_1 - V_2 = 10 \quad (3)$$

$$V_3 - V_4 = 8 \quad (4)$$

$V_1 = 6V$, $V_2 = -4V$, $V_3 = 0$, $V_4 = -8V$.

* super position principle *

① Independent source
- ⊕ voltage " SC "
- ⊕ current " OC "

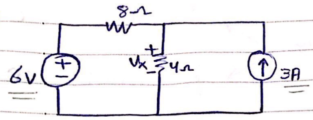
each time you should have one source only

$i_x = i_{x_1} + i_{x_2} + \dots$

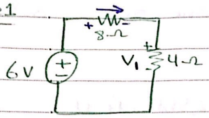
② لا تخلي الدائرة القديمة مشوشة يفرك .. تحليلكم د. مرسي
" ارجع ارسم بعد كل خطوة "

③ انتبه لاتجاهات التيارات الفرعية

Ex:



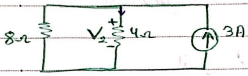
→ Source 1



$V_1 = \frac{6(4)}{12} = 2V$ ${}^{+}_{-}$

" Voltage divider "

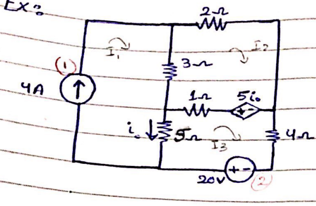
→ Source 2



" current divider "

- $I_{4\Omega} = \frac{3(8)}{12} = 2A$.
- $V_2 = 2 \times 4 = 8V$ ${}^{+}_{-}$
- $V = 8 + 2 = 10v$.

Ex:



* Source # 1 *

$i_1 = 4A$

$\boxed{i_o} = i_1 - i_3$

* $2i_2 - 5i_o + 1(i_2 - i_3) + 3(i_2 - i_1) = 0$

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

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

$-8i_1 + 6i_2 + 4i_3 = 0 \Rightarrow 6i_2 + 4i_3 = 32$ — (1)

* $4i_3 + 5(i_3 - i_1) + 1(i_3 - i_2) + 5i_{o1} = 0$

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

$4i_3 + 5i_3 - 5(4) + i_3 - i_2 + 20 - 5i_3 = 0$

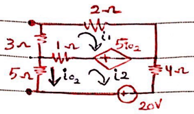
$\boxed{-i_2 + 5i_3 = 0}$ — (2)

$i_{o1} = i_1 - i_3 = 4 - 0.94 = 3\ A \downarrow$

$i_2 = 4.7A$

$i_3 = 0.94\ A$

* Source # 2 *



* $2i_1 + 5i_{o2} + 1(i_1 - i_2) + 3i_1 = 0$

$i_{o2} = -i_2$

$2i_1 + 5(-i_2) + i_1 - i_2 + 3i_1 = 0$

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

$6i_1 + 4i_2 = 0$ —— ①

* $4i_2 - 20 + 5i_2 + 1(i_2 - i_1) + 5(-i_2)$

$-i_1 + 5i_2 = 20$ —— ②

$i_1 = -2.4A$

$i_2 = 3.5A$

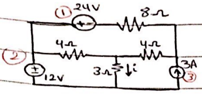
$i_{o2} = -3.5A \downarrow$

$3.5A \uparrow$

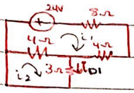
→ $i_o = i_{o1} + i_{o2} = 3.1 - 3.5$

$= -0.4\ A$

Ex:



* Source # 1



* $8i_1 + 4i_1 + 4(i_1 - i_2) + 24 = 0$

$12i_1 + 4i_1 - 4i_2 = -24$

$10i_1 - 4i_2 = -24$ (1)

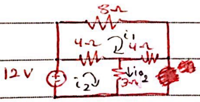
* $4(i_2 - i_1) + 3i_2 = 0$

$4i_2 - 4i_1 + 3i_2 = 0$

$-4i_1 + 7i_2 = 0$ (2)

→ $i_1 = -1.75\ A$, $i_2 = -1\ A$ $\qquad i_{01} = i_2 = -1\ A \downarrow$

* Source # 2



* $8i_1 + 4i_1 + 4(i_1 - i_2)$

$8i_1 + 4i_1 + 4i_1 - 4i_2 = 0$

$16i_1 - 4i_2 = 0$ (1)

* $4(i_2 - i_1) + 3i_2 = 12$

$4i_2 - 4i_1 + 3i_2 = 12$

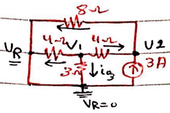
$-4i_1 + 7i_2 = 12$ (2)

$i_1 = 0.5\ A$

$i_2 = 2\ A$

$i_{02}\downarrow = i_2 = 2A$

* Source #3



node #1

$$\left(\frac{V_1}{4} + \frac{V_1 - V_2}{4} + \frac{V_1}{3} = 0\right) \times 12$$

$$3V_1 + 3V_1 - 3V_2 + 4V_1 = 0$$

$$10V_1 - 3V_2 = 0$$

node # 2

$$\left(-3 + \frac{V_2 - V_1}{4} + \frac{V_2}{8}\right) \times 8 = 0$$

$$-24 + 2V_2 - 2V_1 + V_2 = 0$$

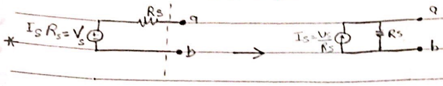
$$-2V_1 + 3V_2 = +24$$

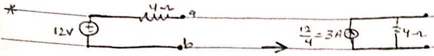
- $V_1 = 3V$
- $V_2 = 10V$
- $i_{ox} = \frac{V_1}{3} = 1A \downarrow$

$\rightarrow i_o = i_{o1} + i_{o2} + i_{o3}$ *

$= -1 + 2 + 1 = 2A \downarrow$

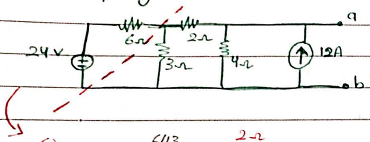
* Source Transformation *

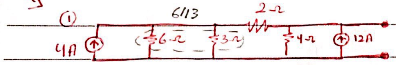


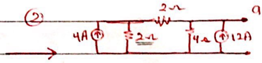


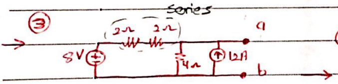
Ex:

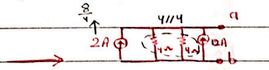
- simplify to one current source and one resistance.



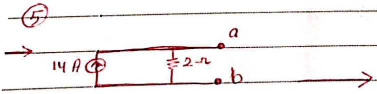


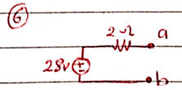


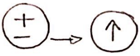




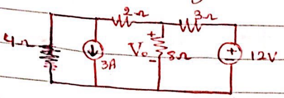
12 + 2 = 14 A

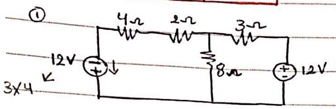


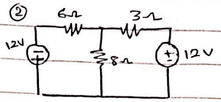


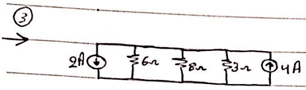


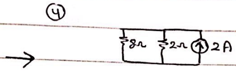
Ex: Find V_o using source transformation







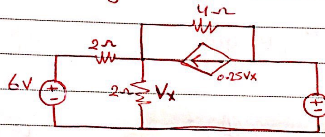




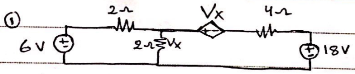
* $I_{8\Omega} = \frac{2(2)}{10} = 0.4\ A$
* $V_{8\Omega} = 0.4(8) = 3.2V$
* $P = -IV = -(2)(3.2)$

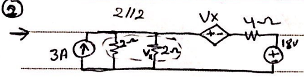
السهم ↑ ⊕ داخل من السالب $= -6.4\ W$

Ex: Find V_x using source transformation.

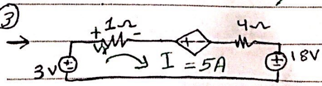


$(0.25V_x) \times 4 = 1V_x$





$V_x = -I + 3 = -5 + 3 = -2$



$-3 + 1(I) + V_x + 4I + 18 = 0$

$-3 + I + (-I+3) + 4I + 18 = 0$

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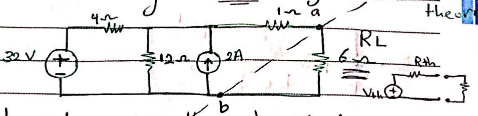
Thevenin's Theorem

* Independent source *

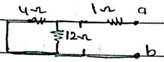
Ex: Find the current through 6Ω (load) by thevenin's theorem.

R_L : Rload



① cut the load and assign the terminal as a,b.

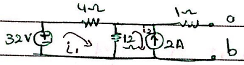
② kill all indp. source → V → SC.
→ I → OC.



$R_{th} = [4 // 12] + 1 = 4\Omega$

③ Reconnect the sources "calculate the voltage between a,b"

$V_{oc} = V_{th}$



$i_2 = -2A$

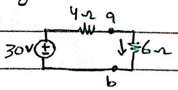
$-32 + 4i_1 + 12(i_1 - (-2)) = 0$

$16 i_1 = 32 - 24 = 8 \rightarrow i_1 = 0.5A$

$V_{ab} = V_{oc} = V_{th} =$

$V_{12\Omega} = 12(i_1 - i_2) = 12(0.5 + 2) = 30V$.

④ Draw thevenin's equivalent "connect the load, do your calculation"



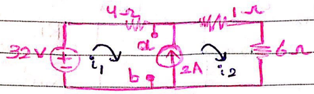
$V_{ab} = V_{oc} = V_{th} = 30V$

$I_{6\Omega} = \frac{30}{4+6} = 3A$

$P_{6\Omega} = I^2 R = 9 \times 6 = 54W$.

* Max power → $R_L = R_{th}$

cont: Ex: Find the current through 12Ω



* super mesh

$4i_1 + 1i_2 + 6i_2 - 32 = 0$

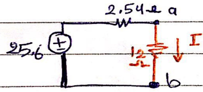
$4i_1 + 7i_2 = 32$ — (1)

$-i_1 + i_2 = 2$ — (2)

$i_1 = 1.6A$

$i_2 = 3.6A$

* $R_{th} = [1+6] // 4 = 2.54\Omega$

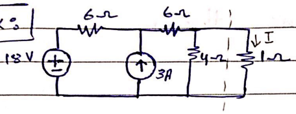


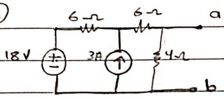
$V_{ab} = V_{oc} = V_{th}$

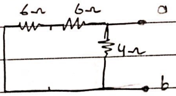
$= -4(1.6) + 32 = 25.6V.$

$I = \frac{25.6}{2.5 + 12}$

Ex:

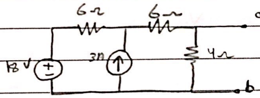


① 

② 

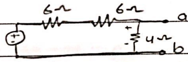
$R_{th} = [6+6] // 4$

$= 3\Omega$

③ 

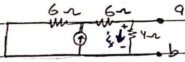
$V_{ob} = V_{th} = V_{ab}$

* Find $V_{oc} = V_{th}$ by superposition. *



by Voltage divider

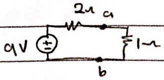
$V_{ab} = V_{4\Omega} = \frac{18(4)}{6+6+4} = \frac{72}{16} = 4.5\,V$



$i_x = \frac{3(6)}{6+6+4} = \frac{18}{16}\,A$

$V_{4\Omega} = \frac{18}{16} \times 4 = \frac{18}{4} = 4.5\,V$

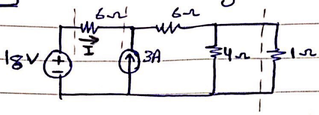
$V_{oc} = 4.5 + 4.5 = 9V$

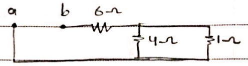


thev. equ.

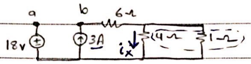
" بنمشي أي طريقة ما في current "

Ex: Find I using thevenin's theorem





$\rightarrow$ $R_{eq} = (4 // 1) + 6 = 6.8\,\Omega$



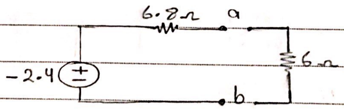
$\rightarrow$ $V_{ab} = V_{th} = V_{oc}$

★ current divider

$\hookrightarrow i_x = \dfrac{3(1)}{4+1} = 0.6A$

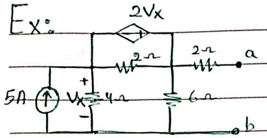
- $V_{6\Omega} = 6 \times 3 = 18V$
- $V_{4\Omega} = 4 \times 0.6 = 2.4V$
- $\underline{V_{ab}} = 18 - 2.4 - 18 = \boxed{-2.4}$

⊕ -2.4 أو ⊖ $+2.4$



* Dep + INDep sources *

Ex:

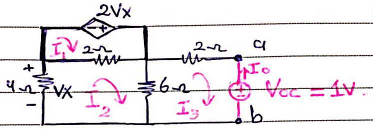


(1) cut the load

(2) kill the indp sources.

(3) connect an excitation source $\begin{bmatrix} V = 1V \\ I = 1A \end{bmatrix}$ between a, b.

(4) calculate $R_{th} = \frac{V_{oc}}{I_o}$



* mesh # 1

$$-2V_x + 2[I_1 - I_2] = 0$$

but $V_x = -4I_2$

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

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

$I_1 = 0.16A$

$I_2 = -0.05A$

$I_3 = -0.16A$

$\rightarrow I_o = -I_3 = +0.16A$

* mesh # 2.

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

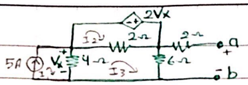
$$-2I_1 + 12I_2 - 6I_3 = 0 \quad (2)$$

* mesh # 3.

$$2I_3 + 1 + 6(I_3 - I_2) = 0$$

$$-6I_2 + 8I_3 = -1 \quad (3)$$

$$\rightarrow R_{th} = \frac{V_{oc}}{I_o} = \frac{1}{0.16} = 6\Omega$$



$V_{oc} = V_{th} = V_{ab} = V_{6\Omega} = \boxed{6I_3}$

(m#1)

* $\boxed{I_1 = 5A}$

(m#2) $-2V_x + 2(I_2 - I_3) = 0$

$\rightarrow V_x = 4(I_1 - I_3) = 20 - 4I_3$

$-2(20 - 4I_3) + 2I_2 - 2I_3 = 0$

$2I_2 + 6I_3 = 40$ — (1)

(m#3)

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

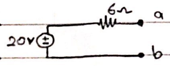
$-20 + 6I_3 + 4I_3 + 2I_3 - 2I_2 = 0$

$-2I_2 + 12I_3 = 20$ — (2)

$I_2 = 10A$

$I_3 = 3.3A$

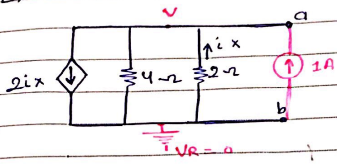
$\rightarrow V_{ab} = V_{th} = V_{oc} = 6I_3 = \boxed{20V}$



* اذا كانت ال circuit كلها dep sources ما يكون فيه V_{th}

* Dep. Source *

Ex : Find Thevenin's equ.



$V_{ab} = V_{2\Omega} = I_{2\Omega}(2)$

by Nodal analysis - -

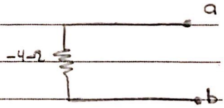
$2i_x + \frac{V}{4} + \frac{V}{2} = 1$ $\qquad i_x = \frac{-V}{2}$

$2\left(\frac{-V}{2}\right) + \frac{V}{4} + \frac{V}{2} = 1$

$-V + \frac{V}{4} + \frac{V}{2} = 1$

$-4V + V + 2V = 4 \qquad -V = 4 \Rightarrow \boxed{V = -4V} = V_{ab}$

$R_{th} = \frac{V_{ab}}{I_{ab}} = \frac{-4}{1} = -4\,\Omega$



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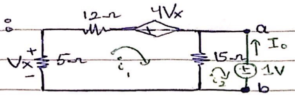
Ex:



$V_x = 5i_1$

mesh#1

$(10+15+5)i_1 - 15i_2 + 4V_x = 0$

$30i_1 - 15i_2 + 4(-i_1 5) = 0$

$30i_1 - 15i_2 - 20i_1 = 0$

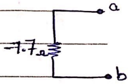
$10i_1 - 15i_2 = 0$ —— (1)

mesh #2

$15i_2 - 15i_1 + 1 = 0$ —— (2)

$i_1 = 0.2A$
$i_2 = 0.13$

$\boxed{i_o} = -i_2 = -0.13\,A$

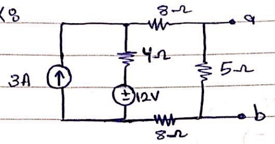


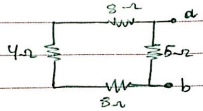
$\boxed{R_{th}} = \frac{1}{-0.13} = -7.7\,\Omega$

* Norton's theorem *

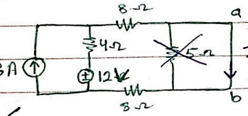
• نفس طريقة حساب thevn. بس بدل (1V, 1A) بطبق "short circuit"

Ex8

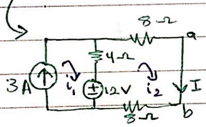




$R_N = (4+8+8) \parallel 5 = 4\Omega$.



$I_N = I_{sc} = I_{ab}$

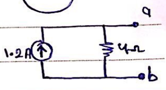


$i_1 = 3A$.

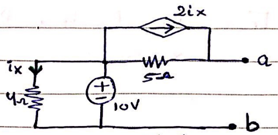
$8i_2 + 8i_2 - 12 + 4(i_2 - i_1) = 0$

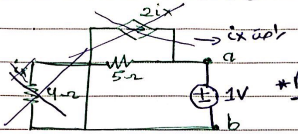
$20 i_2 = 24$

$i_2 = \frac{24}{20} = 1.2A = I_N$

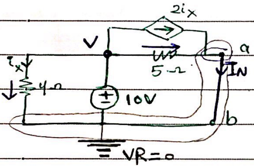


Ex:





$\underrightarrow{* R_N} = R_{th} = 5\Omega$



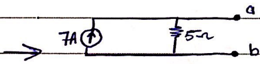
* Nodal...

$V = 10V$

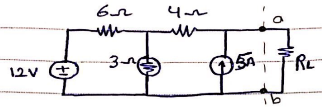
$i_x = \frac{V}{R} = \frac{10}{4} = 2.5A.$

* $I_N = I_{5\Omega} + 2i_x$

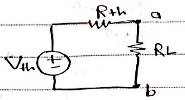
$= \frac{10}{5} + 2(2.5) = 7A.$



Ex:



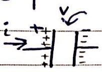
Find R_L to transfer max power :



$R_N = R_{th} = R_L$ (max power).

* Chapter 6 *

Capacitors & Inductors " use to store energy "



A: area of the plate

d: distance

ϵ: permitivity of the dilectric.

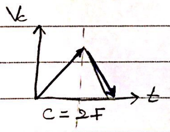
ϵ_o: " " " air .

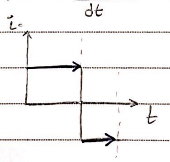
$$* \quad C = \frac{\epsilon A}{d} \quad *$$

$$* \quad q = C V \longrightarrow C = q/v \rightarrow \text{Farad}$$

capacity

$$* \quad i = dq/dt \longrightarrow i = \frac{d\, cv}{dt} \rightarrow \boxed{i_c(t) = C\,\frac{dV_c}{dt}}$$





$$* \quad V_c(t) = \frac{1}{C}\int_{-\infty}^{t} i_c(t)\, dt$$

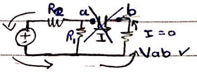
$$* \quad V_c(t) = \frac{1}{C}\int_{t_o}^{t} i_c(t)\, dt + V_o$$

initial Voltage

* $P = VI = V C \frac{dv}{dt}$ (power; $i = C\frac{dv}{dt}$)

* $W = \int_{-\infty}^{t} P \cdot dt = \int C V \frac{dv}{dt} \cdot dt = \boxed{\frac{1}{2} C V^2}$ J. (energy)

* Capacitor acts as "open" Ckt to DC source *

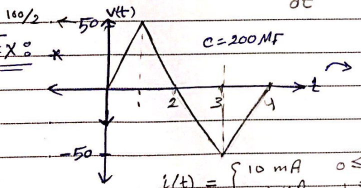


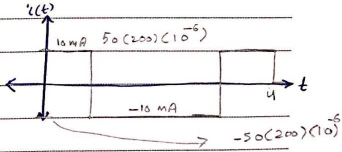
* The voltage across the capacitor can't change abruptly [suddenly] → ch8

* **Ex 6.1** *
$C = 3 pF$
$V = 20 V$
$q = CV = ? = 60 pC$
$w = ? = \frac{1}{2} C V^2 = \frac{1}{2}(3)(20)^2 = 600 pJ.$

* **Ex:** *
$C = 5 \mu F$
$V(t) = 10 \cos 6000t$
Find $i(t) = C \frac{dv}{dt} = -0.3 \sin 6000t$ A.

* **Ex:** *





$$i(t) = \begin{cases} 10\ mA & 0 \le t \le 1 \\ -10\ mA & 1 \le t \le 3 \\ 10\ mA & 3 \le t \le 4 \end{cases}$$

0   O.W

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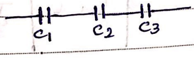
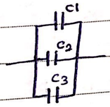
★ Series or parallel capacitors ★

★ 

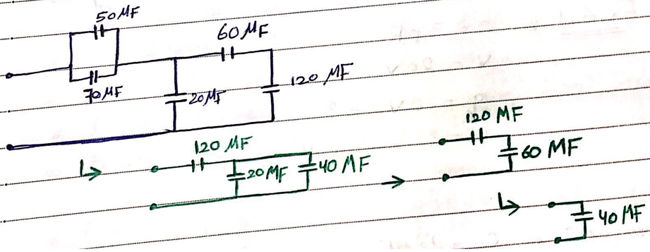
→ $\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \frac{1}{C_N}$

They have same charge.

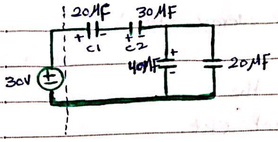
★ 

→ $C_{eq} = C_1 + C_2 + C_3 + \dots C_N.$

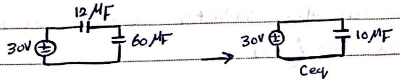
They have same voltage.

★ 

Ex:



voltage ~~a~~across each capacitor



$q = CV \rightarrow 10 \times 30 = 300\,m$ colum.

at $c_1 \rightarrow q_1 = 300m \rightarrow V_1 = q/c = 15V$

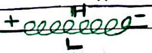
at $c_2 \rightarrow q_2 = 300m \rightarrow V_2 = q/c = 10\,V$

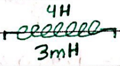
at $(c_3, c_4) \rightarrow V_3 = \frac{300}{60} = 5V.$

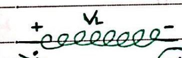
$q_3 = C_3 V_3 = 40(5) = 200$

open ckt → means the current is zero.

$\boxed{\text{* Inductor * ملف}}$







$V_L = L \frac{di}{dt}$

عدد اللفات ~~#~~ of turns

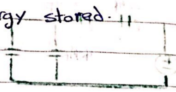
$L = \frac{N^2 \mu A}{l}$ $l \rightarrow$ length

permalpility
«حسب نوع المادة.»

A → cross section Area
L → inductance

$* \; i(t) = \frac{1}{L} \int_{t_0}^{t} V_L(t)\, dt + I_0$

$\boxed{E} = \frac{1}{2} L I^2$ J → energy stored

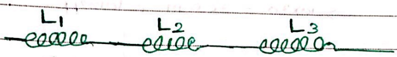


→ Under the DC conditions the inductor acts as a short ckt.

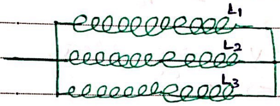
→ The current in the inductor doesn't change suddenly

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

*

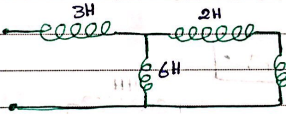


$L_{eq} = L_1 + L_2 + L_3$



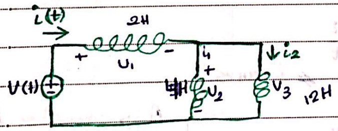
$\frac{1}{L_{eq}} = \frac{1}{L_1} + \frac{1}{L_2} + \frac{1}{L_3} \cdots \frac{1}{L_N}$

* Ex:



* $L_{eq} = [(2+1) // 6] + 3 = 5H$

* Ex:



$\boxed{V_2 = V_3}$

$i(t) = 4(2 - e^{-10t})$ mA

AC → function of time
"current"

$i_2(0) = -1$ mA

→ Find $i_1(0), v(t), V_1(t), V_2(t), i_1(t), i_2(t)$

[1] $i_1(0) \rightarrow$ where $t = \text{zero}$.

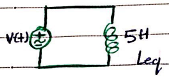
$$i_1(0)\Big|_{t=0} = 4\,mA.$$

$$i(0) = i_1(0) + i_2(0) \qquad \text{"KCL"}$$

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

$$i_1(0) = 4 - (-1) = 5\,mA.$$

[2]



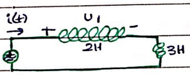
$$\boxed{V(t) = L_{eq}\frac{di(t)}{dt}}$$

$$= 5\frac{d}{dt}(8 - 4e^{-10t})$$

$$= 5(40e^{-10t})$$

$$= 200e^{-10t} \text{ mV}.$$

[3]

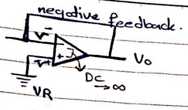


$$v_1(t) = L_1\frac{di}{dt} = 2(40e^{-10t}) = 80e^{-10t} \text{ mV}$$

$$v_2 = V(t) - v_1(t) = 3\frac{di}{dt} = 120e^{-10t} \text{ mV}$$

[4] $$i_1(t) = \frac{1}{4}\int_0^t 120e^{-10t}\,dt + \underbrace{5}_{i_1(0)}$$

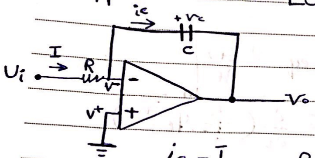
[5] $$i_2(t) = \frac{1}{12}\int_0^t 120e^{-10t}\,dt + \underbrace{(-1)}_{i_2(0)}.$$

* 

(op-Amp) « operation amplifier »

$v^+ = v^-$

* Application of LC:



« Integerator »

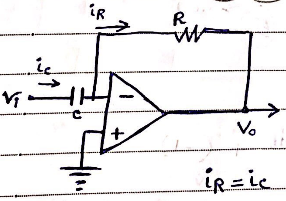
$i_c = I$ * $R_d \to \infty$ *

$V_o = -V_c$

$= -\frac{1}{C}\int i_c(t)\, dt$

$= -\frac{1}{C}\int i(t)\, dt = -\frac{1}{C}\int \frac{v_i(t)}{R}\, dt$

$$V_o = -\frac{1}{RC}\int v_i(t)\, dt$$



differentiator.

$i_R = i_c$

* $V_o = -i_R R$

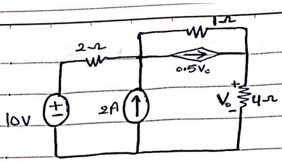
* $V_o = -i_c R = -RC\frac{dv_i}{dt}$

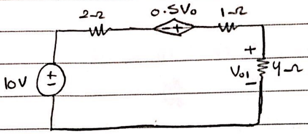
$$V_o = -RC\frac{dv_i}{dt}$$

[نقل الـسؤال ب L
Inductor]

Scanned with CamScanner

Q:



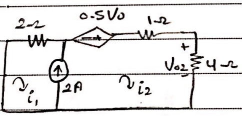


$(V_o = 4i)$

$-10 + 2i - 0.5(4i) + 1i + 4i = 0$

$5i = 10 \rightarrow \boxed{i = 2A}$

$\boxed{V_{o1} = 8V}$



$2i_1 - 0.5(4i_2) + i_2 + 4i_2 = 0$

$\boxed{2i_1 + 3i_2 = 0}$

$\boxed{i_2 - i_1 = 2}$

$5i_2 = 4$

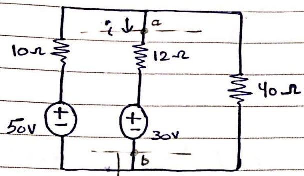
$i_2 = 0.8$ $\quad V_{o2} = 4(0.8)$

$= 3.2\,V$

* $V_o = 8 + 3.2 = 11.2V$

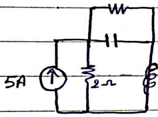
Q:

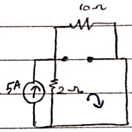
Find i by Thev.



كله بنقصه...

Q:





$E_L = \frac{1}{2}(I)$

$$\frac{1}{2} C V^2 = \frac{1}{2} L I^2$$

$$\cancel{\frac{1}{2}} C \cancel{I^2} R^2 = \cancel{\frac{1}{2}} L \cancel{I^2}$$

$$R = \sqrt{\frac{L}{C}}$$

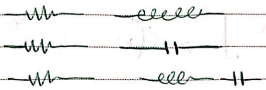
* CH-7 *

- First order Circuits

RL

RC

RLC

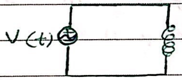


$\int$ ckt with First order differential equations.

$\frac{dv}{dt}$, $\frac{dI}{dt}$

$\rightarrow$ $-V(t) + V_R + V_c = 0$

$-\frac{dv(t)}{dt} + \frac{dr(t)}{dt}$

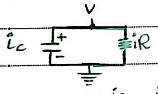


$\rightarrow$ $-V(t) + V_c = 0$

$-V(t) + L$

* Source free RC ckt

There are No external



$i_c + i_R = 0$

$$\frac{c\,dv}{dt} + \frac{V}{R} = 0$$

$$\frac{c\,dv}{dt} = \frac{-V}{R} \rightarrow \frac{dv}{dt} = \frac{-1}{CR}\,dt$$

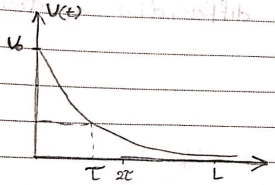
$$\ln V = \frac{-1}{CR}t + k \rightarrow \ln B.$$

$$\left(\left(\ln V - \ln B = \frac{-1}{CR}t\right)\right)$$

$\rightarrow \dfrac{V}{B} = e^{\frac{-1}{CR}t} \longrightarrow \left(\left(V = \underbrace{B}_{V_0 \rightarrow \text{initial Voltage}} e^{\frac{-1}{CR}t}\right)\right)$

$\rightarrow \left[V = V_0 e^{-\frac{1}{CR}t}\right] \longrightarrow \left(\left(V = V_0 e^{\frac{-t}{\tau}}\right)\right)$

τ : time constant , $R_{eq} \cdot C$



$e^0 = 1$
$e^{-\infty} = 0$
$e^{\infty} = \infty$

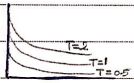
→ $5\tau \approx \infty$

→ الوقت الي بلزم ليوصل 36٪ من شحنته

" completely discharged "

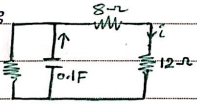
* كلما كانت ال τ أقل بكون يفضي أسرع وبوصل لل ∞ .

لازم نصغر R ---



$e^{-t/\tau}$

Ex:



→ $V_c(0) = 15$

$\left.\begin{array}{l} V_c(t) \\ V_s(t) \\ i_L(t) \end{array}\right\} \rightarrow t > 0$

$\tau = R_{eq} C$

$R_{eq} = (12+8) \parallel 5 = 4\,\Omega$

$\tau = 4(0.1) = 0.4\,s$

$V(t) = V_0 e^{-t/\tau} = 15 e^{\frac{-t}{0.4}}$

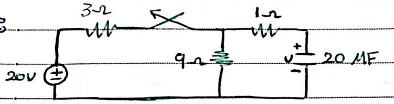
$V_c(t) = 15 e^{-2.5t}$

$\rightarrow V_s(t) = \frac{12}{8+12} V_c(t) \rightarrow$ voltage divider

$= \frac{12}{20} (15) e^{-2.5t} \rightarrow 9e^{-2.5t}$ → discharge

$\rightarrow i_s(t) = \frac{V_s(t)}{R} = \frac{9e^{-2.5t}}{12}$ A.

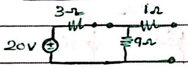
Ex:



• ما أعطانا Vc ...

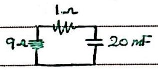
أعطانا بالسؤال "switch" لازم نجيب Vc

$\boxed{t<0}$



• $V_c(0) = \frac{20\times 9}{3+9} = \frac{180}{12} = 15V$

$\boxed{t>0}$

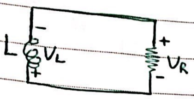


• $R_{eq} = 1+9 = 10\,\Omega$

• $\tau = R_{eq} \cdot C = 10\times 20\times 10^{-3} = 0.2$ sec.

• $V_c(t) = 15e^{\frac{-t}{0.2}t} = 15e^{-5t}$

* Free RL Ckts :



$$V_L + V_R = 0$$

$$L\frac{di}{dt} = -iR$$

$$\int \frac{di}{i} = \int \frac{-R}{L}\,dt \longrightarrow \ln(i) = \frac{-R}{L}t + \ln(k)$$

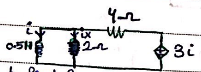
$$\ln(i) - \ln(k) = \frac{-R}{L}t$$

$$\ln\left(\frac{i}{k}\right) = \frac{-R}{L}t \longrightarrow \frac{i}{k} = e^{\frac{-R}{L}t}$$

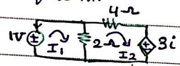
$$i = I_o\, e^{\frac{-t}{\tau}} \qquad \text{"let"}\ \tau = \frac{L}{R_{eq}}$$

Ex: $i(0) = 10A$

$i(t) =$



to find Req use th.



$i(t) = i_o e^{-t/\tau} = 10\, e^{\frac{-t}{1.5}}$

* $-1 + 2I_1 - 2I_2 = 0$

$2I_1 - 2I_2 = 1$ ---- ①

* $2I_2 - 2I_1 + 4I_2 + (-3I_1) = 0$

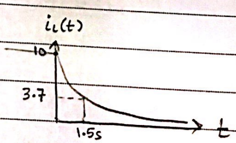
$-5I_1 + 6I_2 = 0$ ---- ②

$I_1 = 3A$

$I_2 = 2.5A$

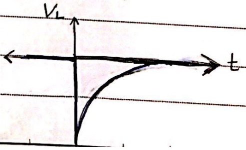
* $R_{eq} = \frac{1}{I_1} = \frac{1}{3}\,\Omega$

* $\tau = \frac{L}{R_{eq}} = \frac{0.5}{\frac{1}{3}} = 1.5\ s$



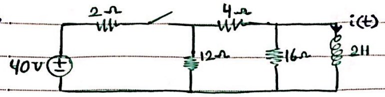
* $V_L = L\frac{di}{dt} = V_y$

$V_L = \frac{-5}{1.5} e^{-t/1.5} = V_x$

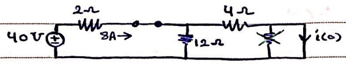


* $i_x = \frac{V_x}{2} = \frac{-5}{3} e^{\frac{-t}{1.5}}\ A$

Ex:

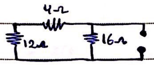


$\boxed{t<0}$



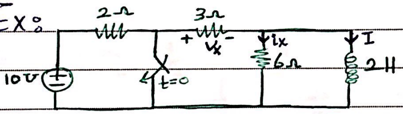
* $I_o = \frac{8\times 12}{16} = 6A$

$\boxed{t>0}$

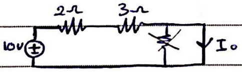


* $R_{eq} = (4+12) // 16 = 8\Omega$
* $\tau = \frac{L}{R_{eq}} = \frac{2}{8} = 0.25$ s.
* $i(t) = I_o e^{-t/\tau} = 6e^{-4t}$ A.

Ex:

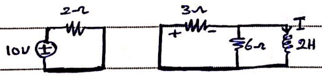


$\boxed{t<0}$



$I_o = \frac{10}{5} = 2A$.

$\boxed{t>0}$



$R_{eq} = 2\Omega$

$\tau = \frac{2}{2} = 1s$

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

* $V_x = -V_L = -L\frac{di}{dt}$
$= -2(2)(-1)e^{-t} = 4e^{-t}$ V

* $V_{6\Omega} = V_L = -V_x = -4e^{-t}$
* $i_x = \frac{V_x}{R} = \frac{-4}{6} e^{-t}$

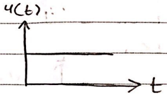
- $V_x = \begin{cases} 6 & t<0 \\ 4e^{-t} & t>0 \end{cases}$

- $V_L = \begin{cases} 0 & t<0 \\ -4e^{-t} & t>0 \end{cases}$

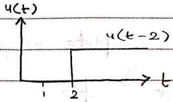
- $i(t) = \begin{cases} 2 & t<0 \\ 2e^{-t} & t>0 \end{cases}$

* unit step function *

- $u(t) = \begin{cases} 0 & t<0 \\ 1 & t>0 \end{cases}$

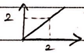


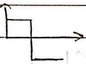
- $u(t) = \begin{cases} 0 & t<2 \\ 1 & t>2 \end{cases}$

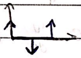


- $S(t) = \frac{d\,u(t)}{dt}$ ↑ unit inpulse « نبضة »

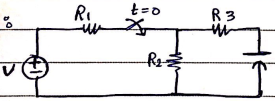
- Ramp $f(t) = \begin{cases} t & t>0 \\ 0 & t<0 \end{cases}$

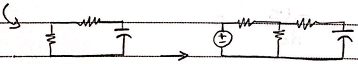




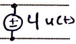


Ex :

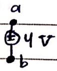


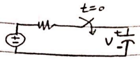


$V(t) = 4\ u(t)$



$V(t) = \begin{cases} 0 & t<0 \\ 4 & t>0 \end{cases}$

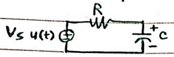




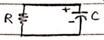
$t<0$

$V_c(0)^+ = V_c(0)^- = V_c(0) = V_0$

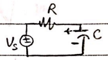
- complete response $= \underbrace{\text{natural response}}_{\text{stored energy}} + \underbrace{\text{Forced response}}_{\text{ind. PS.}}$



* $t<0$



* $t>0$



" KCL "

$$C\frac{dv}{dt} + \frac{v-v_s}{R} = 0$$

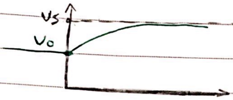
$$C\frac{dv}{dt} + \frac{v}{R} - \frac{v_s}{R} = 0$$

$$\frac{dv}{dt} + \frac{v}{RC} + \frac{-v_s}{RC} = 0$$

$$\frac{dv}{dt} + \frac{v}{RC} = \frac{v_s}{RC}$$

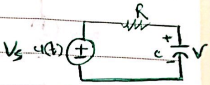
$$V(t) = \begin{cases} V_0 & t<0 \\ V_s + (V_0 - V_s)e^{\frac{-t}{\tau}} & t>0 \end{cases}$$

Scanned with CamScanner



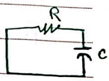
if $V_o = 0$

$$V(t) = \begin{cases} 0 & t < 0 \\ V_s(1-e^{\frac{-t}{\tau}}) & t > 0 \end{cases}$$

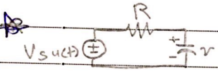


$$V(t) = \begin{cases} V_o & t<0 \\ V_s + V_o e^{\frac{-t}{\tau}} - V_s e^{\frac{-t}{\tau}} \end{cases}$$

t<0



$$V = \underbrace{\left(V_s - V_s e^{\frac{-t}{\tau}}\right)}_{V_s[1-e^{-t/\tau}] \text{ "forced" } V_F} + \underbrace{V_o e^{\frac{-t}{\tau}}}_{\text{nat } V_n}$$

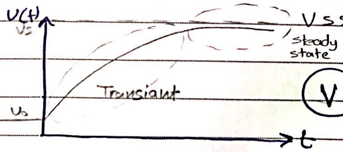


$$v = V_n + V_f$$

$$V(t) = \begin{cases} V_o & t<0 \\ V_s + (V_o - V_s)e^{\frac{-t}{\tau}} & t>0 \end{cases}$$

$$= V_s(1-e^{-t/\tau}) + V_o e^{\frac{-t}{\tau}}$$

$$= V_s + V_o e^{\frac{-t}{\tau}} - V_s e^{\frac{-t}{\tau}}$$



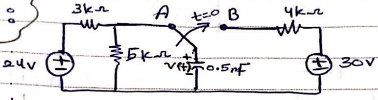
V = Transiant state + Steady state

$$V = \underbrace{V(\infty)}_{t>0} + \left[\underbrace{V(0)}_{t<0} - \underbrace{V(\infty)}_{t>0}\right] e^{\frac{-t}{\tau}} \rightarrow \tau = R_{eq}\cdot C \quad t>0$$

* $v(t) = V_s + [V_0 - V_s]\, e^{\frac{-t}{\tau}}$ →

* $i_{(c)} = C \frac{dq}{dt} = C\left[0 + \frac{1}{\tau}[V_0 - V_s]\right] e^{\frac{-t}{\tau}}$

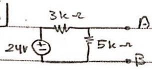
Ex 7-10:



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

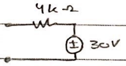
Find $v(t)\big|_{t=1s,\ t=4s}$

$\boxed{t<0}$



$V_0 = \frac{24(5)}{8} = 15v.$

$\boxed{t>0}$



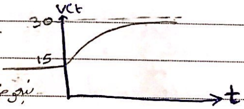
$V(\infty) = 30v.$

$R_{eq} = 4k\Omega$

$\tau = R_{eq} \cdot C = 4(0.5) = 2s.$

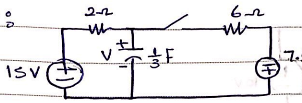
→ $v(t) = 30 + (15 - 30)\, e^{\frac{-t}{2}}$

↑ بنعوض ∞, 0



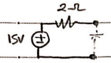
7-10

Ex:



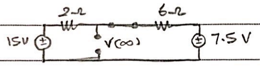
* Find $v(t)$ for $t>0$ *

$\boxed{t<0}$



$V_0 = 15V$

$\boxed{t>0}$



$I = \frac{15-(-7.5)}{8} = \frac{22.5}{8} = 2.8\ A$

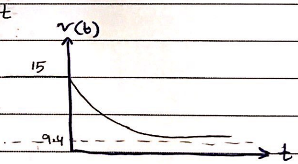
$V(\infty) = -2(2.8)+15 = 9.4V.$

$R_{eq} = 2//6 = 1.5\,\Omega$

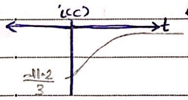
$\tau = 1.5(\frac{1}{3}) = \frac{1}{2}s.$

* $V(t) = 9.4 + (15-9.4)e^{-2t}$

$= 9.4 + 5.6e^{-2t}$

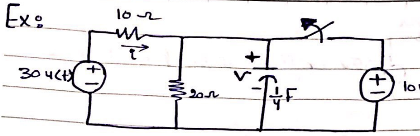


* $i = C\frac{dv}{dt} = -11.2e^{-2t}$

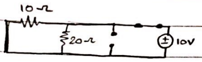


7-11

Ex:

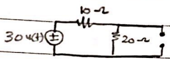


$\boxed{t<0}$



$V(0) = 10\,V$

$\boxed{t>0}$



* $V(\infty) = \dfrac{30\,(20)}{30} = 20\,V$
* $R_{eq} = \dfrac{200}{30} = \dfrac{20}{3}\,\Omega$
* $\tau = \dfrac{1}{4}\left(\dfrac{20}{3}\right) = 1.67\,s = \dfrac{5}{3}$
* $v(t) = V(\infty) + (V(0) - V(\infty))\,e^{\frac{-t}{\tau}}$

$= 20 + (10 - 20)\,e^{\frac{-3}{5}t}$

$= 20 - 10\,e^{\frac{-3t}{5}}$

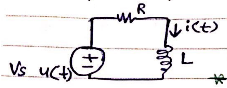
* $i = i_R + i_C$

$= \dfrac{v(t)}{20} + \dfrac{C\,dv}{dt} = \dfrac{(20 - 10e^{\frac{-3}{5}t})}{20} + \dfrac{1}{4}\dfrac{d}{dt}(20 - 10e^{\frac{-3t}{5}})$

* $v(t) = \begin{cases} 10 & t<0 \\ 20 - 10e^{\frac{-3t}{5}} & t>0 \end{cases}$

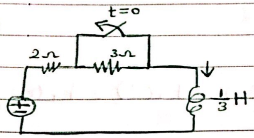
* $i(t) = \begin{cases} -1 & t<0 \\ 20 - 10e^{\frac{-3t}{5}} & t>0 \end{cases}$

* Step Response of RL Ckts



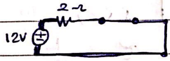
$$* \; i(t) = \underbrace{I(\infty)}_{ss.} + \underbrace{[I(0) - I(\infty)]\, e^{\frac{-t}{\tau}}}_{\text{transient}}$$

Ex:



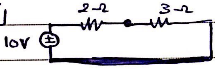
$t > 0$

$\boxed{t<0}$



$I(0^-) = I(0^+) = I(0) = \frac{10}{2} = 5A.$

$\boxed{t>0}$

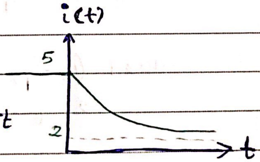


$I(\infty) = \frac{10}{5} = 2A.$

$R_{eq} = 5\Omega$

$\tau = \frac{L}{R_{eq}} = \frac{1}{15}\ s.$

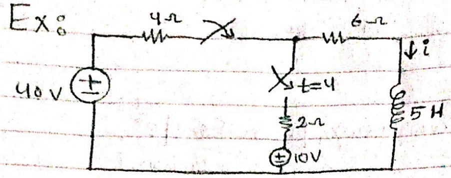
$* \; i_L(t) = 2 + (5-2)e^{-15t} \ A.$



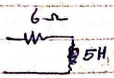
$* \; V_c = c\frac{di}{dt} = 0 + 3(-15)\cdot\frac{1}{3}e^{-15t}$

$\hookrightarrow = -15e^{-15t}$

Ex:

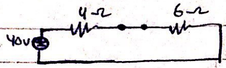


① $\boxed{t<0}$



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

② $\boxed{4 > t > 0}$



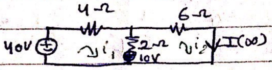
$I(\infty) = \frac{40}{10} = 4A$

$\tau = \frac{L}{R_{eq}} = \frac{5}{10} = \frac{1}{2}\,s$

$i_L(t) = 4 + (0-4)e^{-2t}$

$= 4 - 4e^{-2t}$

③ $\boxed{t>4}$



$-40 + 4i_1 + 2(i_1 - i_2) + 10 = 0$

$6i_1 - 2i_2 = 30$ ——— ①

$-10 + 2(i_2 - i_1) + 6i_2 = 0$

$-2i_1 + 8i_2 = 10$ ——— ②

$i_2 = 2.7\,A = i(\infty)$

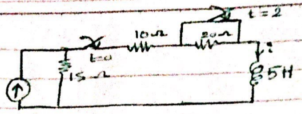
$R_{eq} = (4 // 2) + 6 = 7.3$

$\tau = \frac{L}{R_{eq}} = \frac{5}{7.3}\,s$

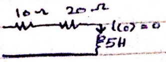
$i_L(t) = 2.7 + (4 - 2.7)e^{-\frac{28t}{5}}$

$$i_L(t) = \begin{cases} 0 & t<0 \\ 4(1-e^{-2t}) & 0 \le t \le 4 \\ 2.7 + 1.3e^{-\frac{28(t-4)}{5}} & t>4 \end{cases}$$

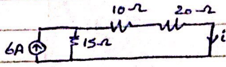
Ex:



① $t<0$



② $0\leq t\leq 2$



$$* \; I(2^-) = I(2^+) = I(2) \; *$$

$$= \frac{6\times 15}{45} = 2A.$$

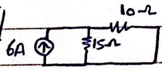
$$R_{eq} = 10+20+15 = 45\,\Omega$$

$$\tau = \frac{5}{45} = \frac{1}{9}.$$

$$i(t) = 20+(0-2)e^{-9t}$$

$$= 2(1-e^{-9t})\,A.$$

③ $t>2$



$$I(\infty) = \frac{6\times 15}{25} = \frac{18}{5} = 3.6\,A$$

$$R_{eq} = 25\,\Omega$$

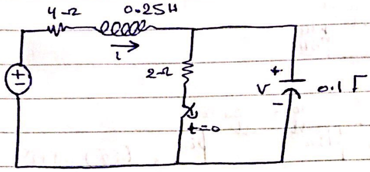
$$\tau = \frac{5}{25} = \frac{1}{5}\,s$$

$$i_L(t) = 3.6+(2-3.6)e^{-5(t-2)}\;A.$$

* CH8 *

2nd order. CKts.

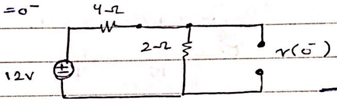
Ex:



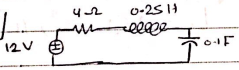
$i(0^+)$, $v(0^+)$, $\frac{di(0^+)}{dt}$, $\frac{dv(0^+)}{dt}$, $i(\infty)$, $v(\infty)$

$\boxed{t<0}$

$t=0^-$



$\boxed{t=0^-}$



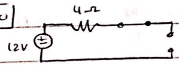
$i_L(0^-) = \frac{12}{6} = 2A$

$V_c(0^-) = 2 \times 2 = 4V$.

$\boxed{t>0}$

$t=0^+$

$t=\infty$



- $i_L(0^+) = i_L(0^-) = 2A$
- $v_c(0^+) = 4V$
- $I_c(0^+) = 2A$.
- $i_c = C\frac{\partial v}{\partial t} \Rightarrow \frac{\partial v}{\partial t} = \frac{i_c}{C}$

$$\frac{\partial v(0^+)}{\partial t} = \frac{i_c(0^+)}{C} = \frac{2}{0.1} = 20\ V/s.$$

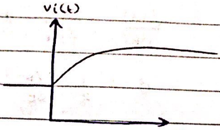
• $\frac{di(0^+)}{dt} = \frac{V_L(0^+)}{L}$

$-12+4(2)+V_L(0^+)+V_C(0^+)=0$

$-12+8+V_L(0^+)+4=0$

$\rightarrow V_L(0^+)=0$

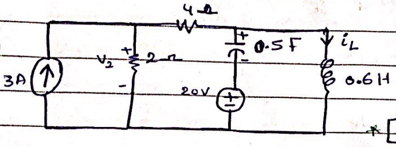
$\rightarrow \frac{di(0^+)}{dt} = 0$ A/s.



• $i(\infty) = 0$

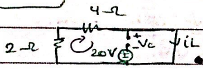
• $V(\infty) = 12V.$

Ex:



* [$i_L(0^+), V_C(0^+), \frac{dV_C(0^+)}{dt}, \frac{di_L(0^+)}{dt}, \frac{dV_R(0^+)}{dt}, i_L(\infty), V_C(\infty), V_R(\infty)$] = ? *

$\boxed{t=0^-}$

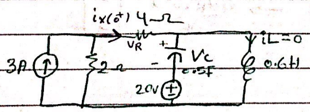


• $i_L(0^-)=0$

• $V_C(0^-) = V_C(0^-)+20+0+0 = V_C(0^-) = -20V.$

• $V_R(0^-)=0$

$\boxed{t=0^+}$



• $i_x(0^+) = \frac{3\times2}{6} = 1A$

• $V_{R_x}(0^+) = 1(4) = 4V.$

• $-V_R(0^+)+V_x(0^+)+V_C(0^+)+20=0$

$\rightarrow V_x(0^+) = V_R(0^+) = 4V.$

• $V_L(0^+)=0$

• $\frac{di_L(0^+)}{dt} = \frac{V_L(0^+)}{L} = \frac{0}{0.5} = 0$ A/s

• $i_C(0^+) = C\frac{dV_C(0^+)}{dt} = \frac{i_C(0^+)}{C}$

Practice
Prb. 8.2

by KCL

$i_x(0^+) = i_c(0^+) + \cancel{i_L(0^+)}^{0}$

$1 = 1$

* $3 = \frac{V_R}{2} + \frac{V_x}{4}$

$\frac{d(3)}{dt} = \frac{dV_R}{2\,dt} + \frac{dV_x}{4\,dt}$

$0 = \frac{1}{2}\frac{dV_R}{dt} + \frac{1}{4}\frac{dV_x}{dt}$

$\frac{2\,dV_x}{dt} = -4\frac{dV_R}{dt}$

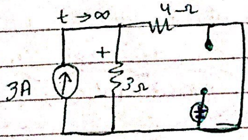
$\frac{dV_x}{dt} = -2\frac{dV_R}{dt}$

$\rightarrow \frac{-dV_R(0^+)}{dt} + \frac{dV_x(0^+)}{dt} + \frac{dV_c(0^+)}{dt} + 0 = 0$

$\rightarrow \frac{-dV_R(0^+)}{dt} + \frac{(-2)dV_R}{dt} = -4$

$\rightarrow \frac{-3\,dV_R(0^+)}{dt} = -2 \rightarrow \frac{dV_R(0^+)}{dt} = \boxed{\frac{2}{3}}$

$t \to \infty$

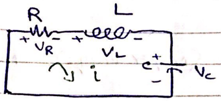


$i_L(\infty) = 1A$

$V_c(\infty) + 20 + -4 + 4$

$V_c(\infty) = 20\ V$

"Free sources RLC Ckt"



$$V_R + V_L + V_C = 0$$

$$iR + L\frac{di}{dt} + \frac{1}{C}\int i(t)\,dt = 0$$

$$R\frac{di}{dt} + L\frac{di^2}{dt^2} + \frac{1}{C}i = 0$$

$$\frac{di^2}{dt^2} + \frac{R}{L}\frac{di}{dt} + \frac{1}{C}i = 0$$

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

$$S_1 = \frac{R}{2L} + \sqrt{\left(\frac{R}{2L}\right)^2 - \frac{1}{LC}}$$

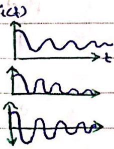
$$* \quad S_1 = -\alpha + \sqrt{\alpha^2 - \omega_0^2} \quad *$$

$$S_2 = \frac{-R}{2L} - \sqrt{\left(\frac{R}{2L}\right)^2 - \frac{1}{LC}}$$

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

- $\alpha = \frac{R}{2L}$: damping factor (Neper freq.) NP/s.
- $\omega_o = \frac{1}{\sqrt{LC}}$: resonant freq (undamped) rad/sec
  natural freq.
- S_1, S_2 : Natural freq. NP/S.
- ζ : $\frac{\alpha}{\omega_o}$ damping Radio.

① If $\alpha > \omega_o$ overdamped
② " $\alpha = \omega_o$ critical damped
③ " $\alpha < \omega_o$ Under damped



$* i(t) = A_1 e^{S_1 t} + A_2 e^{S_2 t}$, $C > \frac{4L}{R^2}$

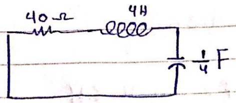
$C = \frac{4L}{R^2}$, $S_1 = S_2 = -\alpha = -\frac{R}{2L}$.

$* i(t) = (A_2 + A_1 t) e^{-\alpha t}$.

$\alpha < \omega_o \rightarrow \omega_d = \sqrt{\omega_o^2 - \alpha^2}$ damping natural freq.

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

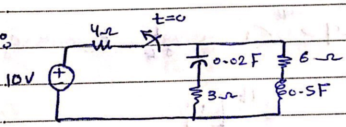
Ex :



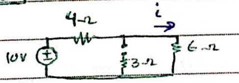
- $\alpha = \frac{R}{2L} = \frac{40}{8} = 5$
- $\omega_0 = \frac{1}{\sqrt{LC}} = 1$
- $\alpha > \omega$ overdamp.
- $S_{1,2} = -\alpha \pm \sqrt{\alpha^2 - \omega_0^2}$

$S_1 = -0.101$.
$S_2 = -9.899$.

Ex :

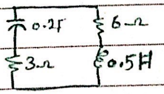


$\boxed{t = 0^-}$



$i(0^-) = i(0^+) = 1A$

$\boxed{t = 0^+}$



- $\alpha = \frac{R}{2L} = \frac{9}{1} = 9$
- $W_0 = \frac{1}{\sqrt{LC}} = 10$.

since $\omega_0 > \alpha$ " underdamped "

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

• $\omega_d = \sqrt{10^2 - 9^2} = \sqrt{19} = 4.36$

* $i(t) = e^{-9t}\left[B_1 \cos 4.36t + B_2 \sin 4.36t\right]$

• $i(0) = 1\left[B_1 \cos 0 + B_2 \sin 0\right] = 1$

$\boxed{B_1 = 1A}$

* $v_c(0) = 6v.$

$6(1) + V_L(0^+) + 3(1) - 6 = 0$

* $V_L(0^+) = -3V.$ *

* $\frac{V_L(0)}{L} = \frac{di(0)}{dt} = \frac{-3}{0.5} = \frac{di(0)}{dt} = -6$

under — $\left.\frac{di}{dt}\right|_{t=0} = -9e^{-9t}(1 \cos \omega_d t + B_2 \cos \omega_d t) +$

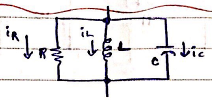
$e^{-9t}\left[-\omega_d \sin \omega_d t + B_2 \omega_d \cos \omega_d t\right] = -6$

$= -9(1+0) + (0 + B_2 \overset{4.36}{\cancel{\omega_d}}] = -6$

* $B_2 = \frac{-6+9}{4.36}$ *

* The source Force parallel RLC ckt *

" KCL "



$i_R + i_L + i_C = 0$

$$\frac{v}{R} + \frac{1}{L}\int v(t)\,dt + C\frac{dv}{dt} = 0$$

$$\left(\frac{dv}{R\,dt} + \frac{1}{L}v(t)\,dt + C\frac{d^2v}{d^2t} = 0\right) \div C$$

$$\frac{d^2v}{dt} + \frac{1}{RC}\frac{dv}{dt} + \frac{1}{LC}v = 0$$

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

let $\alpha = \frac{1}{2RC}$, $\omega_o = \frac{1}{\sqrt{LC}}$

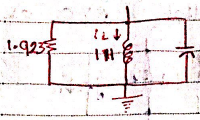
$$s^2 + 2\alpha s + \omega_o^2 = 0$$

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

- $\alpha > \omega_o \rightarrow$ overdamping $\quad v(t) = A_1 e^{s_1 t} + A_2 e^{s_2 t}$
- $\alpha < \omega_o \rightarrow$ under damping $\quad v(t) = (A_1 + A_2 t)\,e^{-\alpha t}$
- $\alpha = \omega_o \rightarrow$ critical damp $\quad v(t) = e^{-\alpha t}(B_1\cos\omega_o t + B_2 \sin\omega_o t)$

$$\omega_d = \sqrt{\omega_o^2 - \alpha^2}$$

Ex :



$V(0) = 5$

$i_L(0) = 0$

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

- $\alpha = \frac{1}{RC} = 26$, $\omega_0 = \frac{1}{\sqrt{LC}} = 10$

- $\alpha > \omega_0$ over damping
- $S_1, S_2 = -\alpha \pm \sqrt{\alpha^2 - \omega_0^2}$

  $S_1 = -2$, $S_2 = -50$

$v(t) = A_1 e^{-2t} + A_2 e^{-50t}$

$\frac{dv}{dt} = -2A_1 e^{-2t} - 50 A_2 e^{-50t}$

- $i_L + i_R + i_C = 0$

$i_C = -[i_R + i_L] \longrightarrow i_C = -\left(\frac{5}{1.923} + 0\right)$

- $\frac{dv(0^+)}{dt} = \frac{i_C(0^+)}{C} = \frac{-2.6}{10 \times 10^{-3}} = -260$ V/s.

$V(0^+) = A_1 + A_2 = 5$

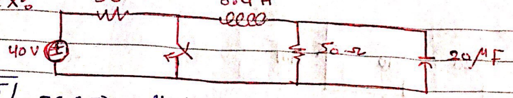
$\frac{dv(0^+)}{dt} = -2A_1 - 50A_2 = -260.$

$A_1 = -0.2$, $A_2 = 5.2$

$V(t) = -0.2 e^{-2t} + 5.2 e^{-50t}$

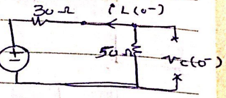
Scanned with CamScanner

Ex:

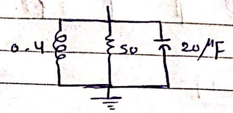


$\boxed{t=0^-}$ • $v_C(0^-) = \frac{40(50)}{80} = 25V = v_C(0^+)$

• $i_L(0^-) = \frac{-40}{80} = -0.5A = i_L(0^+)$



$\boxed{t=0^+}$ * $\alpha = \frac{1}{2RC} = 500$



* $\omega_0 = \frac{1}{\sqrt{LC}} = 324.$

* $\alpha > \omega_0 \rightarrow$ over.

$s_1, s_2 = -\alpha \pm \sqrt{\alpha^2 - \omega_0^2}$

$= -500 \pm \sqrt{500^2 - 324^2} = -824, -146.$

* $v(t) = A_1 e^{-824t} + A_2 e^{-146t}$

$\frac{dv}{dt} = -824 A_1 e^{-824t} - 146 A_2 e^{-146t}$

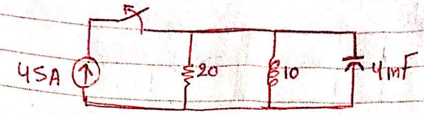
* $i_C + i_R + i_L = 0 \rightarrow i_C = \frac{-25}{50} - (-0.5) = 0$

$\frac{dv(0^+)}{dt} = 0$ $\quad v(0) = 25$

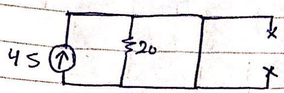
$A_1 = -5.156V$

$A_2 = 30.16V$ $\rightarrow v(t) = -5.156\, e^{-854t} + 30.16\, e^{-146t}$

Practice 8.6



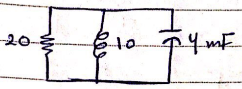
$\boxed{t = 0^-}$



$I_c(0) = 45\,A$

$V_c(0) = 0$

$\boxed{t = 0^+}$



* $\alpha = \frac{1}{2RC} = 6.25$

* $w_o = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{10 \times 4 \times 10^{-3}}} = 5.$

* $\alpha > w_o \longrightarrow$ over.

$S_1, S_2 = -\alpha \pm \sqrt{\alpha^2 - w_o^2} = -10, -2.5$

* $v(t) = A_1 e^{-10t} + A_2 e^{-2.5t}$

$\frac{dv}{dt} = -10 A_1 e^{-10t} - 2.5 A_2 e^{-2.5t}$

* $i_c + i_R + i_L = 0$

$i_c = -i_R - i_L = 0 - 4.5$

* $\frac{dv(0^+)}{dt} = \frac{i_c(0^+)}{C} = \frac{-4.5}{4 \times 10^{-3}} = -1125$

$V(0) = A_1 + A_2 = 0$

$-10 A_1 - 2.5 A_2 = -1125$

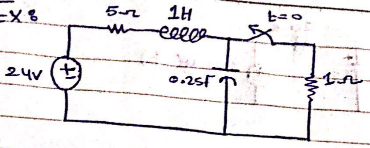
* $A_1 = 150$, $A_2 = -150$

$v(t) = 150 e^{-10t} - 150 e^{-2.5t}$

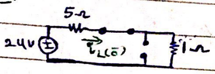
$v(t) = 150 \left(e^{-10t} - e^{-2.5t}\right).$

Scanned with CamScanner

Ex:

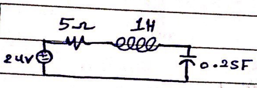


$\boxed{t = 0^-}$



- $i(0^-) = \frac{24}{6} = 4A = i_L(0^+)$
- $v(0^-) = V_c(0^+) = 4V$

$\boxed{t = 0^+}$



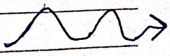
$-24 + V_R(0^+) + V_L(0^+) + V_c(0^+) = 0$

$-24 + 20 + V_L(0^+) + 4 = 0$

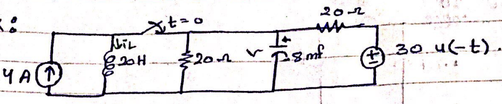
- $V_L = 0$
- $\alpha = \frac{R}{2L} = \frac{5}{2} = 2.5$
- $w_0 = \frac{1}{\sqrt{LC}} = 2$
- $\alpha > w_0 \rightarrow$ over
- $S_1, S_2 = -\alpha \pm \sqrt{\alpha^2 - w_0^2} \rightarrow S_1 = -1, S_2 = -4.$
- $V_{ss} = V(\infty) = 24V.$
- $v(t) = V_{ss} + A_1 e^{S_1 t} + A_2 e^{S_2 t}$

$= 4.$

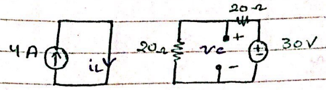
- $\frac{dv(t)}{dt} = \frac{i_c(0^+)}{C} = \frac{4}{0.25} = 16.$



Ex:

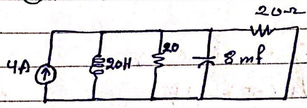


① $t = 0^-$



- $i_L(0^-) = i_L(0^+) = 4A.$
- $v_c(0^-) = v_c(0^+) = \frac{30}{40} \cdot 20 = 15V.$

② $t = 0^+$



- $\alpha = \frac{1}{2RC} = \frac{1}{2(10)(8\times10^{-3})} = 6.25.$

- $\omega_o = \frac{1}{\sqrt{LC}} = 2.5$

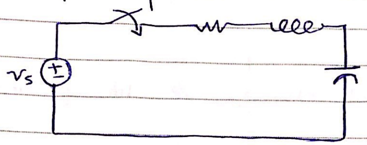
- $\alpha > \omega_o$ " over..

- $S_1, S_2 = \overset{S_1 =}{-6.25}, \quad S_2 = -0.5218.$

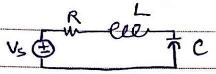
$i_L(t) = I_s + A_1 e^{S_1 t} + A_2 e^{S_2 t}$

$= \frac{di_L(0)}{dt} = \frac{V_L(0^+)}{L} = \frac{15}{20}$

* step response of series RLC



① $\boxed{t = 0^+}$



$$-V_s + V_R + V_L + V_C = 0$$

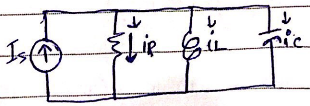
$$-V_s + iR + L\frac{di}{dt} + \frac{1}{C}\int i(t)\,dt = 0$$

$$-\frac{dV_s}{dt} + R\frac{di}{dt} + L\frac{di}{dt} + \frac{1}{C}i = 0$$

$$V(t) = V_{ss} + V$$

$$= V_s + \begin{cases} A_1 e^{s_1 t} + A_2 e^{s_2 t} \\ \vdots \end{cases}$$

* step response of parallel RLC *



$$i(t) = I_s + \begin{cases} --- \\ --- \\ --- \end{cases}$$

Ch-9"

[lag متأخر
lead مسابق

* sinusoidal & phasor
  ↳ sin, cos

* Ac : the original change of value & direction

$$x(t) = \underbrace{A}_{\text{amplitute}} \sin(\underline{\omega} t + \underline{\theta})$$

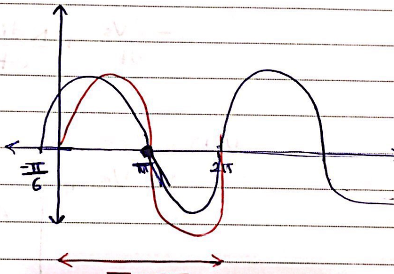
θ → phase shift

ω ↳ angular velocity

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

Ex: $x(t) = 4(\sin(t+30^\circ))$

* $A = 4$
* $\omega = 1$ rad/sec
* $T = \frac{2\pi}{\omega} = 2\pi$
* $\theta = 30^\circ$



* $\sin x = \cos(x - 90^\circ)$
* $-\sin x = \sin(x \pm 180^\circ) = \cos(x + 90^\circ)$
* $-\cos x = \cos(x - 180^\circ)$

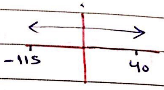
* $10\sin(30t - 40) = 10\cos(\underbrace{30t - 40 - 90}_{30t - 130^\circ})$

Ex: Find the phase angle.

- $i_1 = -4\sin(377t + 25°) = -4\cos(377t + 25 + 90)$
  $= -4\cos(377t + 115)$
- $i_2 = 5\cos(377t - 40°)$

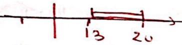
$\to 115 - (-40) = \underbrace{155°}_{\text{phase}}$

- $\omega = 2\pi F$
- $f = \dfrac{\omega}{2\pi} = \dfrac{377}{2\pi} = 60$ Hz.
- i_1 leads i_2 by 115.



Ex: $i_1 = 2\sin(10t - 13°)$
$i_2 = 4\sin(10t - 20°)$

i_1 leads i_2 by $7°$ $\quad (-13 - (-20)) = 7°$



phaser (polar)

$A\cos(\omega t + \theta) \longrightarrow A\angle\theta.$

the signal should be in cos form.

Ex: $4\cos(\omega t) = 4\angle 0$

$4\cos(\omega t - 30) = 4\angle -30°$

$4\cos(\omega t + 50) = 4\angle 50.$

$-4\cos(\omega t + 50) = 4\cos(\omega t - 130°) = 4\angle -130°.$

$\sin(\omega t) = \cos(\omega t - 90°) = 1\angle -90°.$

$-4\sin(\omega t + 60°) = 4\cos(\omega t + 150°) = 4\angle 150.$

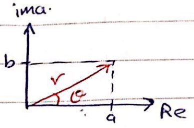
.(mode → 2 → ENG i → shift 2 → 3 → =)

* complex numbers *

* $Z = a + jb$ complex form, cartezian.

real ↙ ↘ imaginary,

$= r\angle\theta$ → polar, phasor.



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

* $\theta = \tan^{-1}\frac{b}{a}$.

* $Z = 3 + 4j \quad = r\angle\theta$.

$r = \sqrt{3^2 + 4^2} = 5$

$\theta = \tan^{-1}\frac{4}{3} = 53^\circ \longrightarrow 5\angle 53^\circ$.

* $10\angle 36.7^\circ$

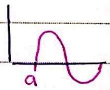
$a = r\cos\theta = 10\cos 36.7$

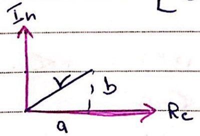
$b = r\sin\theta = 10\sin 36.7$.

* $\omega = 2\pi f$

* $f = \frac{1}{T}$ Hz.

$A\cos[\omega t + \theta] \longrightarrow A\angle\theta$





$a = r\cos\theta$

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

$Z = a + jb$ $\theta = \tan^{-1}\frac{b}{a}$

$Z = r\angle\theta$

- $a + jb \longrightarrow r\angle\theta = re^{j\theta}$
- $re \longrightarrow r\cos\theta \mp j\, r\sin\theta$
- $1e^{\mp j\theta} \longrightarrow \cos\theta \mp j\sin\theta$

Ex:

* $1e^{-j30} = \cos 30 - j\sin 30 = 1\angle -30°$
$= \sqrt{3}/2 - j\,1/2$

* $5\angle 36°$
$(4+j3) \times (5\angle 60) \longrightarrow 25\angle 96.7°$

$$\frac{3+j6}{8\angle 53° + (17+90)} = 0.3\angle 3.7$$

* $r(t) = A\cos(\omega t + \theta)$
$V = A\angle\theta$

$$\frac{dr(t)}{dt} = \frac{d}{dt}[V(t)]$$

phasor $= j\omega V$

$$\frac{di}{dt} = j\omega I$$

$(j \cdot j = -1)$

$$\frac{di^2}{dt} = j\omega j\omega I$$

$$\frac{d^2 i}{dt} = -\omega^2 I$$

* $\int i(t)\, dt = \dfrac{I}{j\omega}$

* $\int v(t)\, dt = \dfrac{V}{j\omega}$

* ~~###~~ Impedence.

3 types of load.

1) Resistance — R
2) Inductor — L
3) capacitor — C

حالة Impedence لـ phasor (polar).

بالتحويل R.

$Z_L = j\omega L \;(\Omega)$

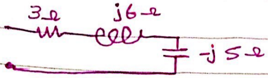
$Z_C = \dfrac{-j}{\omega C}$

Ex: 3H, $\omega = 10$ rad/sec $\rightarrow j\omega L = j\,30\,\Omega$

$0 + j3 = 3 \angle 90$.

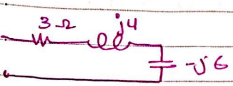
0.5F, $\omega = 4$ rad/sec $\rightarrow \dfrac{-j}{2} = -j0.5$

$-j5 = 5 \angle -90$.

* 

$Z_{eq} = 3 + j6 - j5 = 3 + j = \sqrt{10} \angle (+) 18 \ \Omega$

Inductive

* 

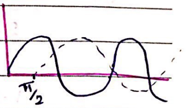
capacitive

$Z_{eq} = 3 + j4 - j6 = 3 - j2 = \sqrt{13} \angle (-) 33$

* اذا كانت الزاوية =0 بيسميه « Resistive »

* $V_L = L \frac{di}{dt}$

* $V_L = j\omega L \ I$.



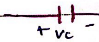
* $\frac{V}{I} = Z = j\omega L = \omega L \angle 90^{\circ}$

- In the Inductor V leads I by 90°.
- In " Capaciter I leads V.

* R (Resistive load) *

$R = \frac{V}{I} \rightarrow R \angle 0$

I, V Inphase.

* 

$\frac{V_C}{I_C} = \frac{1}{\omega C} \angle -90$

$V = \frac{1}{C} \int i \rightarrow V = \frac{1}{C} \cdot \frac{1}{j\omega} I = \frac{V_C}{I_C} = Z_C = \frac{1}{j\omega C}$

$= \frac{-j}{\omega C}$

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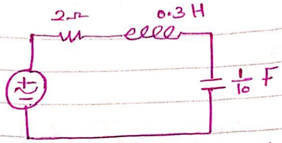
Ex:

$v(t) = 4 \sin 10t$

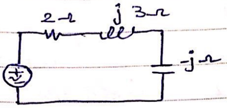


$\downarrow$

Find $V_R(t)$, $V_L(t)$, $V_C(t)$.

$v(t) = 4\cos(10t - 90^\circ)$

$4\angle -90$



$$V_R = \frac{(4\angle -90^\circ)(2)}{2 + j3 - j}$$

$$V_L = \frac{(4\angle -90)(j3)}{2 + j3 - j} = 4.24 \angle -45^\circ \text{ V.}$$

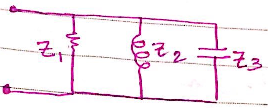
$$V_C = \frac{(4\angle -90)(-j)}{2 + 3j - j} = 1.41 \angle 135^\circ \text{ V.}$$

- $V_R(t) = 2.8 \cos(10t - 135^\circ)$
- $V_L(t) = 4.24 \cos(10t - 45^\circ)$
- $V_C(t) = 1.4 \cos(10t + 135)$

- $I = I_C = C\dfrac{dV_C}{dt}$, $\omega = \dfrac{1}{2} C V^2$ $(t = 3)$.

* Admittance Y

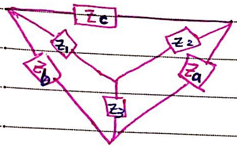
$Y = \frac{1}{Z}$ ℧ moe



$$\frac{1}{Z_T} = \frac{1}{Z_1} + \frac{1}{Z_2} + \frac{1}{Z_3}$$

$$Y_T = Y_1 + Y_2 + Y_3$$

* $\boxed{\Delta \rightarrow Y}$ *

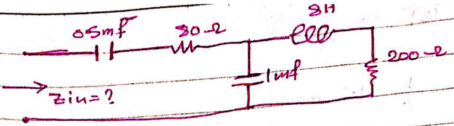


- $Z_1 = \dfrac{Z_b Z_c}{Z_a + Z_b + Z_c}$
- $Z_2 = \dfrac{Z_a Z_c}{Z_a + Z_b + Z_c}$
- $Z_3 = \dfrac{Z_a Z_b}{Z_a + Z_b + Z_c}$

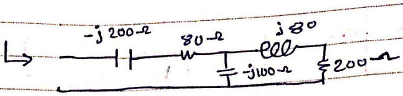
* $\boxed{Y \rightarrow \Delta}$ *

- $Z_a = \dfrac{Z_1 Z_2 + Z_1 Z_3 + Z_2 Z_3}{Z_1}$
- $Z_b = \dfrac{Z_1 Z_2 + Z_1 Z_3 + Z_2 Z_3}{Z_2}$
- $Z_c = \dfrac{Z_1 Z_2 + Z_1 Z_3 + Z_2 Z_3}{Z_3}$

Ex:



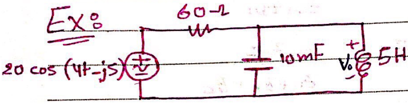
$\omega = 10$ rad/sec

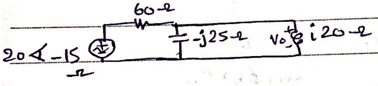


$$\frac{(j80 + 200) * (-j100)}{j80 + 200 - j100} + 80 - j200 = Z_{in}$$

$$Z_{in} = 129.52 - j292 \ \Omega$$

Ex:





$$j20 \,//\, (-j25) = j100$$

$$V_o = \frac{(20\angle -15^\circ)(j100)}{60 + j100} = 17.15 \angle 15.96$$

* $v(t) = 17.15 \cos(4t + 15.96)$ V

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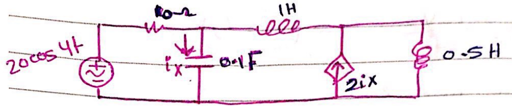
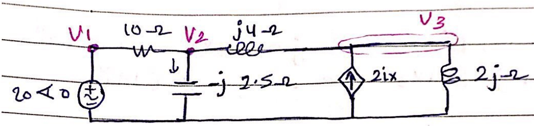
* Ch 10 *

Steady state Analysis.

* Nodal analysis

Ex: Find i_x in time DC.





node #1

$V_1 = 20 \angle 0$.

node #2

$$\frac{V_1 - V_2}{10} = \frac{V_2}{-j2.5} + \frac{V_2 - V_3}{j4}$$

$$0.1V_1 - 0.1V_2 = j0.4V_2 - j0.25V_2 + j0.25V_3$$

$$2\angle 0 - 0.1V_2 - j0.4V_2 + j0.25V_2 - j0.25V_3 = 0$$

$$(-0.1 - 0.15j)V_2 - j0.25V_3 = 2\angle 188.$$

node #3

$$I_x = \frac{V_2}{-j0.25}$$

$$\frac{V_2 - V_3}{j4} + 2I_x = \frac{V_3}{j2}$$

→

$\rightarrow$

$$\frac{V_2 - V_3}{j4} + 2\left[\frac{V_2}{-j2.5}\right] = \frac{V_2}{j2}$$

$$-j\,0.25V_2 + j\,0.25\,V_3 + 0.8j\,V_2 = -j\,0.5\,V_3$$

$$j\,0.55\,V_2 + j\,6.75V_3 = 0$$

$$V_2 = \frac{-j\,0.75V_3}{j0.55} = \boxed{1.3\,V_3}$$

sub in node 2

$$(-0.1 - 0.15j)(-1.3V_2) - j\,0.25\,V_3 = 2\angle 180^\circ$$

$$0.13V_3 + j\,0.19V_3 - j\,0.25V_3 = 2\angle 180^\circ$$

$$(0.18 - j\,0.06)V_3 = 2\angle 180^\circ$$

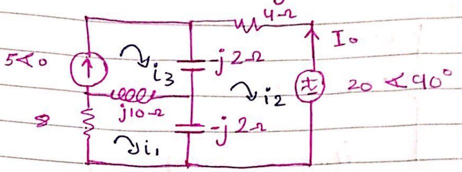
$$V_3 = \frac{2\angle 180^\circ}{0.13 - j\,0.06}$$

$$= 13.96\angle -155^\circ\ V$$

$$V_2 = -1.3V_3 = 18\angle 25^\circ\ V$$

$$* \quad I_x = \frac{V_2}{-j2.5} = \frac{18\angle 25}{-j\,2.5} = 7.2\angle 155^\circ\ A$$

* Mesh Analysis *



- mesh # 3

$$I_3 = 5\angle 0°$$

- mesh # 2

$$-j2[I_2 - I_1] - j2[I_2 - I_3] + 4I_2 + 20\angle 90° = 0$$

$$\boxed{j2I_1 + [4-j4]I_2 = 26\angle -90°}$$

$$j2I_1 + [4-4j]I_2 + \underbrace{j2I_3} = 20\angle -90°$$

$$\left[\underbrace{(j2)}_{2\angle 90} 15\angle 0° \quad = 10\angle 90 \right.$$

$$\left[\begin{array}{l} A\angle \theta_1 , \; B\angle\theta_2 \\ |AB| \angle \theta_1 + \theta_2 \end{array} \right.$$

- mesh # 1

$$8I_1 + j10(I_1 - \underbrace{I_3}_{5\angle 0}) - j2[I - I_2] = 0$$

$$[8+j8]I_1 + j2I_2 = 50\angle 90$$

Kremmer's Rule :

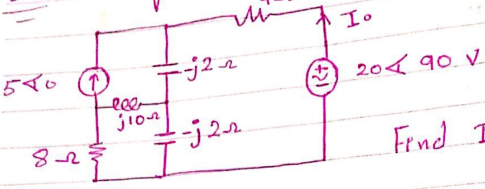
$$\begin{bmatrix} 8+j8 & j2 \\ j2 & 4-j4 \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} j50 \\ -j50 \end{bmatrix}$$

$$I_1 = \frac{\Delta 1}{\Delta}$$

$$I_2 = \frac{\Delta 2}{\Delta}$$

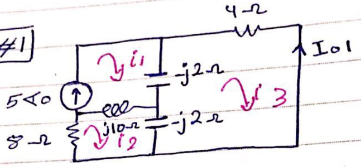
$$I_o = -I_2$$

Ex: Super position.



Find Io using S.P

S #1



- Mesh #1

$I_1 = 5\angle 0$

- Mesh #2.

$(8+j8)\,I_2 - j2\,I_3 = -j50$

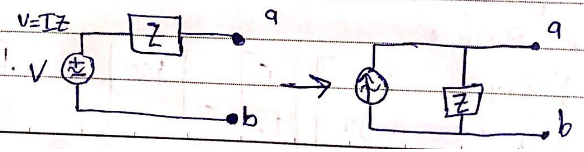
- Mesh #3.

$j2 I_2 + (4-j4)\, I_3 = -j16$

Kremmer's Rule:

$$\begin{bmatrix} 8+8j & j2 \\ j2 & 4-4j \end{bmatrix} \begin{bmatrix} I_2 \\ I_3 \end{bmatrix} = \begin{bmatrix} -j50 \\ -j10 \end{bmatrix}$$

S #2



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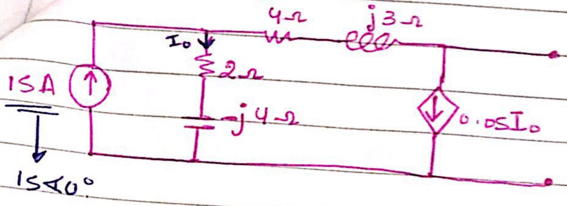
Thevenins



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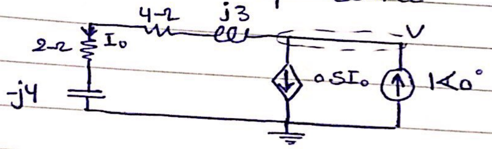

$$1\angle 0 = 0.5 I_o + \frac{V}{4+2+j3-j3}$$

$$1\angle 0 = \frac{1.5V}{(6-j)}$$

$$V = 1(6-j) = \frac{6.08}{1.5} \angle -9.4^\circ \ V$$

* $Z_{th} = \dfrac{V}{1\angle 0} = 4.05 \angle -9.4 \ \Omega$

* $V_{th} = V_{ab} =$

$$15\angle 0 = I_o + 0.5 I_o = 1.5$$

$$\boxed{I_o = 10\angle 0 \ A}$$

$$V_{ab} = -[4+j3](0.5 I_o) + (2-j4) I_o$$