TD circuit de Base audio 1

Exo 1 :

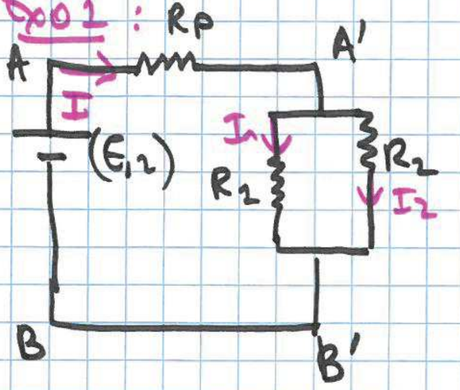
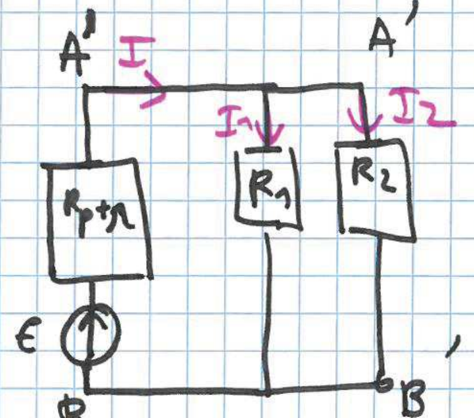


Schéma ⟺ équivalent



$E = 4V$

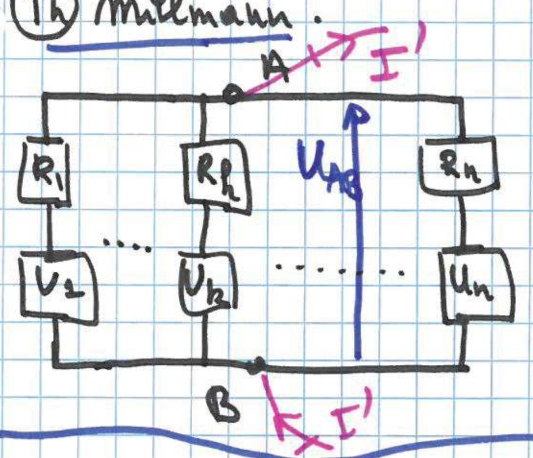
$r + R_p = 16\,\Omega$

$R_1 = 40\,\Omega$

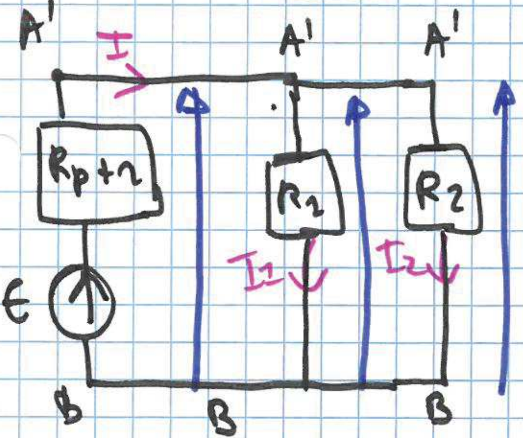
$R_2 = 60\,\Omega$

– Calcul de I, I_1 et I_2 (Millmann).

Th Millmann.



$$U_{AB} = \frac{\sum_{k}^{1} G_k U_k - I'}{\sum_{k}^{1} G_k} \qquad G_k = \frac{1}{R_k}$$



1) $U_{A'B} = E - (R_p + r)\, I$

$U_{A'B} = R_1 I_1$

$U_{A'B} = R_2 I_2$

il suffit de déterminer $U_{A'B}$ par Millmann.

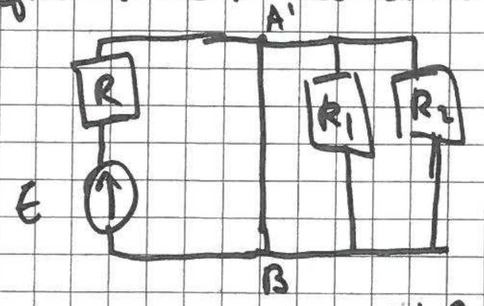
$$U_{A'B} = \frac{E/(R_p+r) + 0 + 0 - 0}{1/(R_p+r) + 1/R_1 + 1/R_2}$$

$$U_{A'B} = \frac{(R_p+r) R_1 R_2}{(R_p+r) R_1 R_2} \cdot \frac{E/(R_p+r)}{1/(R_p+r) + 1/R_1 + 1/R_2}$$

$$U_{A'B} = \frac{E R_1 R_2}{R_1 R_2 + (R_p+r) R_2 + (R_p+r) R_1} \overset{AN}{=} \frac{4 \times 4\cancel{0} \times 6\cancel{0}}{4\cancel{0} \times 6\cancel{0} + \underbrace{16 \times 60 + 16 \times 40}_{16 \times 1\cancel{00}}}$$

$$U_{A'B} = \frac{6 \times 4 \times \cancel{4}}{\cancel{4} \times 6 + \underbrace{16}_{4 \times \cancel{4}}} = \frac{24}{10} = 2{,}4\,V$$

Exo 0001 : le court-circuit



ici $u_{A'B} = 0 \Rightarrow I_1(R_1) = 0$ $I_2(R_2) = 0$

$u_{A'B} = E - RI_{cc} \Rightarrow I_{cc} = \frac{E}{R}$

avec $R = r + R_p = 16\,\Omega$ $I_{cc} = \frac{4}{16} = 250\,mA$

si $R_p = 0 \Rightarrow R = r = 1\,\Omega$ $I_{cc} = 4\,A$

R_p sert à limiter le courant de court-circuit ($u_{A'B} = 0$).

d'où $R_1 I_1 = U_{A'B} \Rightarrow I_1 = \frac{U_{A'B}}{R_1} = \frac{2,4}{40} = 0,06 = 60\,mA$

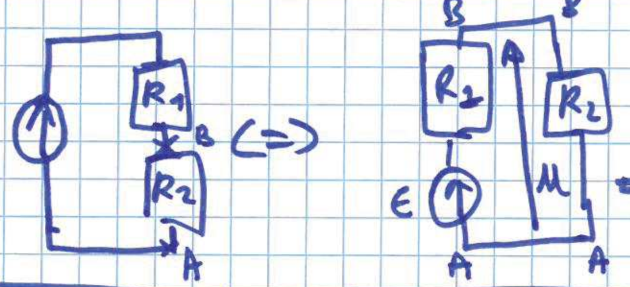
$R_2 I_2 = U_{A'B} \Rightarrow I_2 = \frac{U_{A'B}}{R_2} = \frac{2,4}{60} = 0,04 = 40\,mA$

$E - (R_p + r) I = U_{A'B} \quad I = \frac{E - U_{A'B}}{R_p + r} = \frac{4 - 2,4}{16} = 0,1 = 100\,mA$

et on vérifie la loi des nœuds $I = I_1 + I_2$ $100 = 60 + 40$ ok.

Exo 2 : le diviseur de tension

déf :

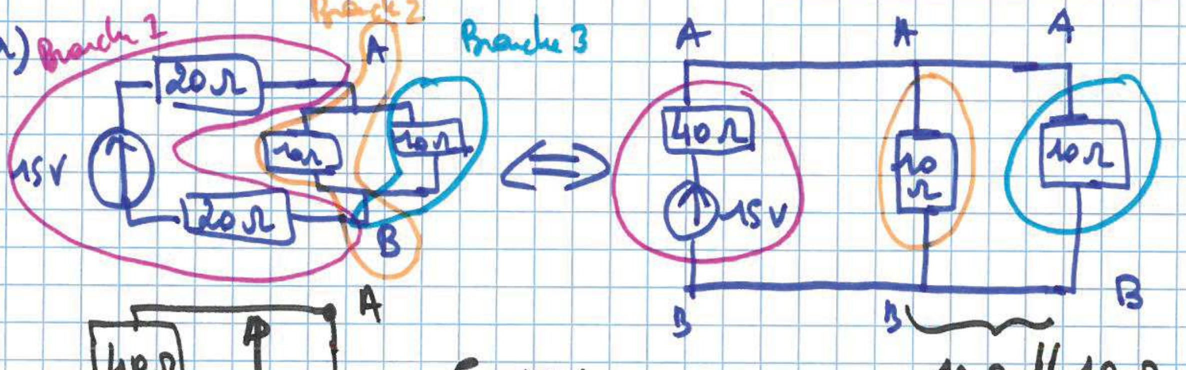


$U = \frac{E/R_1}{1/R_1 + 1/R_2} = E \frac{R_2}{R_1 + R_2}$

$\Rightarrow U < E$ car $\frac{R_2}{R_1 + R_2} < 1$

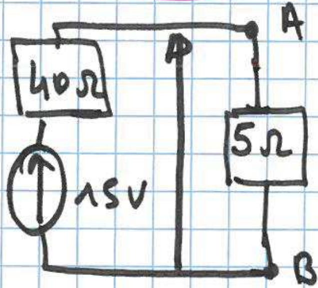
diviseur de tension.

a)



$\frac{1}{R_{eq}} = \frac{1}{10} + \frac{1}{10} = \frac{1}{5}$

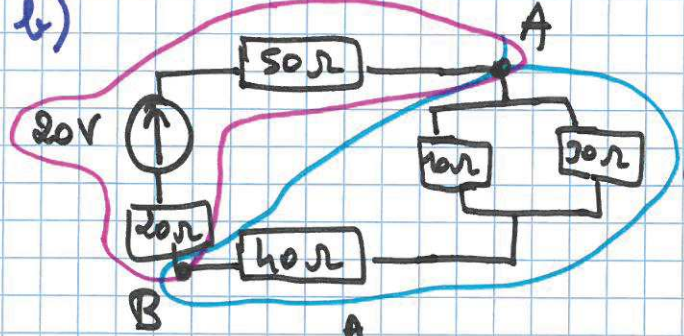
$R_{eq} = 5\,\Omega$

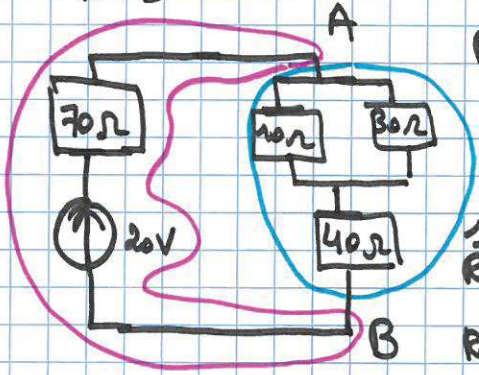


$E = 15V$
$R_1 = 40\,\Omega$
$R_2 = 5\,\Omega$

$U_{AB} = \frac{15 \times 5}{40 + 5} = \frac{5}{3}$ V

b)



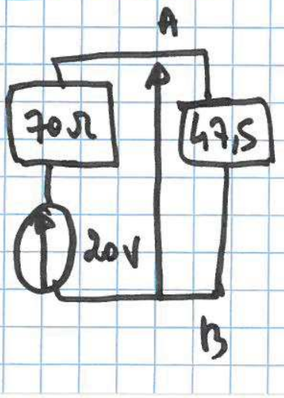


$R_{AB} = 10 // 30 + 40$

$\frac{1}{R_{eq}} = \frac{1}{10} + \frac{1}{30}$

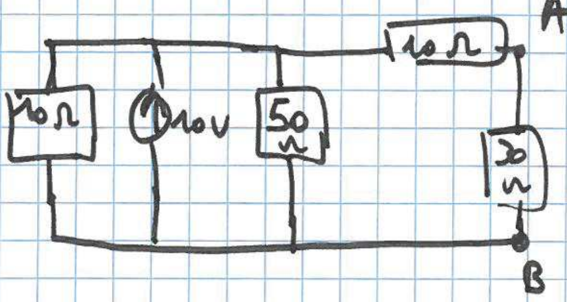
$R_{eq} = \frac{30}{4} = 7,5\,\Omega$

$\Rightarrow R_{AB} = R_2 = 47,5\,\Omega$

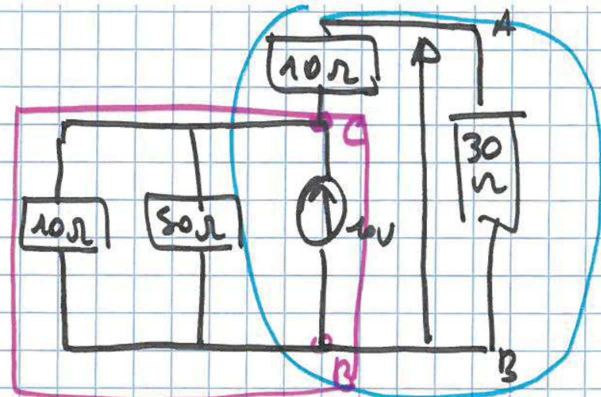


$U_{AB} = \frac{20 \times 47,5}{70 + 47,5} = 8.08\,V$

c)

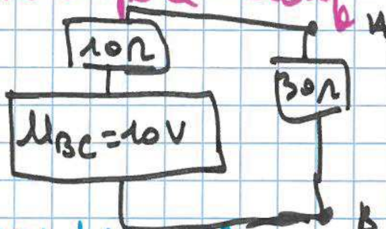


(⇔)



la tension aux bornes de l'él^t C.B $u_{CB} = 10$ V
ceci est donc un dipôle actif

(⇔)

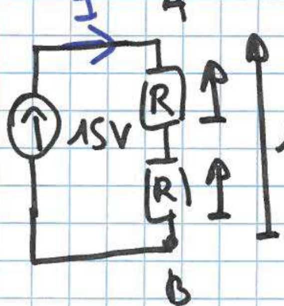


$$u_{AB} = 10 \times \frac{30}{10+30} = 7{,}5\text{ V !}$$

il faudra être capable de reconnaître 1 dipôle actif ds 1 circuit pr "simplifier" les calculs.

Exo 3 : Mesures de tension par voltmètres.

énoncé ⇒

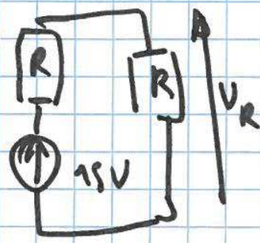


* par l'intuition.

$$u_{AB} = 15 = 2RI = RI + RI = 2U_R$$

$$\Rightarrow U_R = \frac{15}{2} = 7{,}5\text{ V.}$$

" diviseur de tension.



$$u_R = 15 \times \frac{R}{R+R} = \frac{15}{2}\text{ V}$$

" millmann.

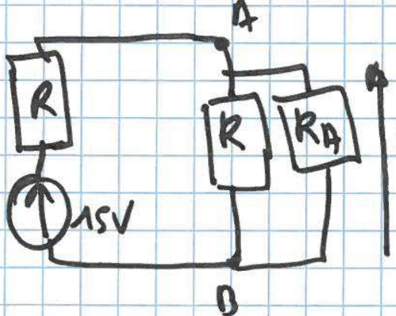
$$U_R = \frac{15/R}{1/R + 1/R} = \frac{15}{2}$$

précision 0,1 V

V_A $R_A = 20\,000\ \Omega/V$ ⇒ calibre 10V $R_A = 200\text{ k}\Omega$

V_N $R_N = 10\text{ M}\Omega$ → calibre 20V 2000pts $\frac{20}{2000}$ ⇒ 0,01 V précision.

a)

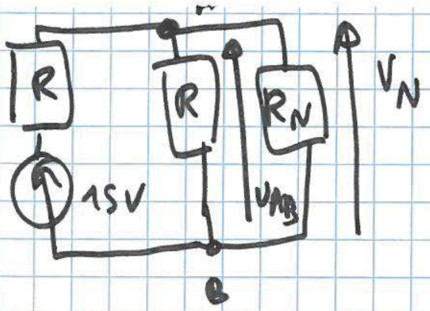


millmann

$$u_{AB} = \frac{15/R}{1/R + 1/R + 1/R_A} = \frac{15\,R_A}{2R_A + R}$$

$$\boxed{V_A = u_{AB} = \frac{15}{2 + R/R_A} = \frac{15}{2 + \frac{56\,10^3}{200\,10^3}} = 6{,}6\text{ V}}$$

b)

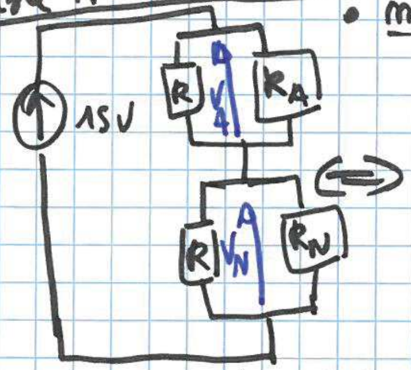


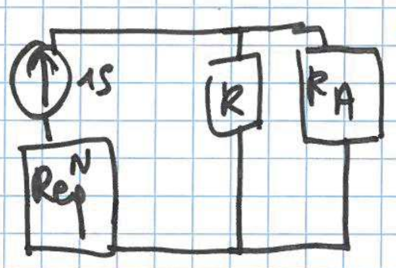
$$u_{AB} = \frac{15/R}{1/R+1/R+1/R_N} = \frac{15}{2+R/R_N}$$

$$\boxed{V_N = \frac{15}{2+\frac{56\,10^3}{10^7}} \simeq 7{,}48\,V}$$

c) <u>Double mesure simultanée</u>

• <u>mesure avec le voltmètre analogique V_A</u>.





$$V_A = \frac{15/R_{eq}^N}{1/R+1/R_A+1/R_{eq}^N}$$

$$V_A = \frac{15/R_{eq}^N}{1/R_{eq}^A+1/R_{eq}^N}$$

$$\frac{1}{R_{eq}^N} = \frac{1}{R}+\frac{1}{R_N} \Rightarrow R_{eq}^N = \frac{R R_N}{R+R_N}$$

$$\frac{1}{R_{eq}^A} = \frac{1}{R}+\frac{1}{R_A} \Rightarrow R_{eq}^A = \frac{R R_A}{R+R_A}$$

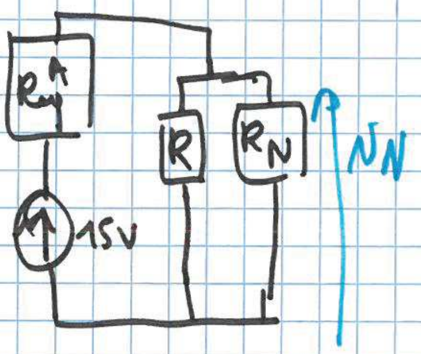
$$V_A = \frac{15}{1+\frac{R_{eq}^N}{R_{eq}^A}}$$

$$\boxed{V_A = 6{,}6\,V}$$

$R_{eq}^N = 55688\,\Omega$

$R_{eq}^A = 43750\,\Omega$

• de $\hat{m}$

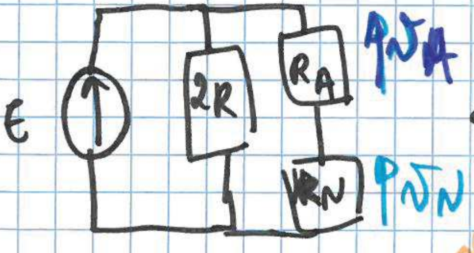


$$V_N = \frac{15}{1+\frac{R_{eq}^A}{R_{eq}^N}}$$

$$\boxed{V_N = 8{,}40\,V}$$

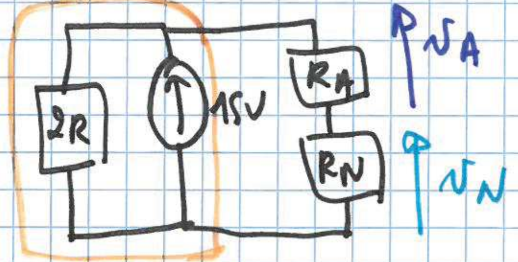
⇒ la double mesure simultanée est mauvaise car elle perturbe trop le système.

d)



⟺

les 2 R sont court-circuitées -



dipôle actif de 15V

$$V_A = \frac{15/R_N}{1/R_A+1/R_N}$$

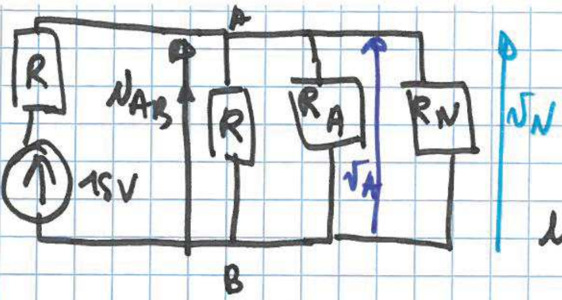
et

$$V_N = \frac{15/R_A}{1/R_A+1/R_N} = \frac{15}{1+\frac{R_A}{R_N}}$$

$$\boxed{V_A = \frac{15}{1+\frac{R_N}{R_A}} = 0{,}3\,V}$$

$$\boxed{V_N = 14{,}70\,V}$$

2)



$$u_{AB} = v_A = v_N = \frac{E/R}{1/R + 1/R + 1/R_A + 1/R_N}$$

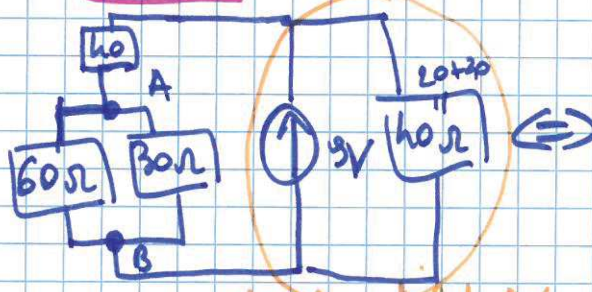
$$u_{AB} = \frac{15}{2 + \frac{R}{R_A} + \frac{R}{R_N}}$$

$R_A \to 200\,10^3$, $R_N \to 10^7$

$\boxed{v_A = 6{,}6\,V}$ $\boxed{v_N = 6{,}56\,V}$ $\neq 7{,}5\,V$

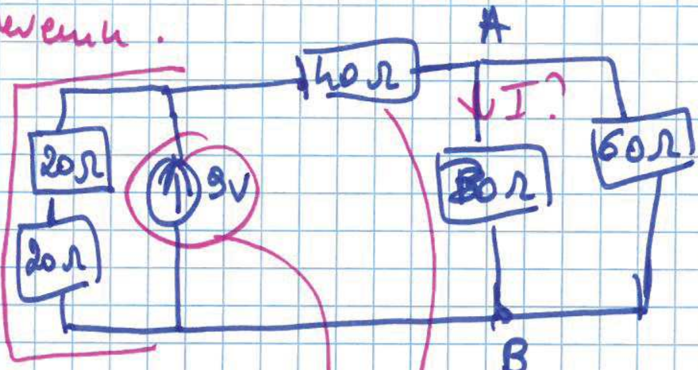
Pour faire une mesure il faut choisir le bon appareil compte tenu de la précision que l'on souhaite. Il faut aussi faire attention à ne pas "perturber" le système que l'on souhaite évaluer.

Exercice 4 : Millman et Thevenin.



dipôle actif de 9V

$\Leftrightarrow$



$$u_{AB} = 30 \times I \Rightarrow I = \frac{u_{AB}}{30}$$

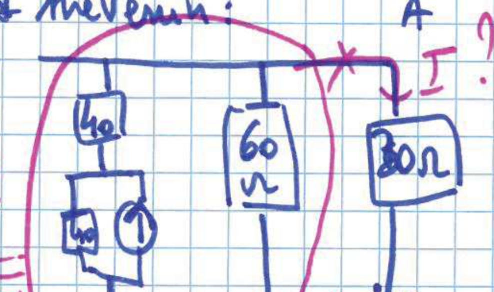
$$I = \frac{3}{30} = 0{,}1\,A$$

* Millman

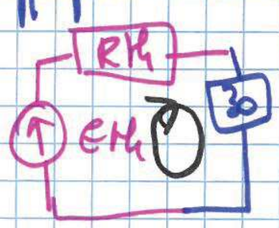
$$u_{AB} = \frac{9/40}{1/40 + 1/30 + \frac{1}{60}} = \frac{9}{1 + \frac{4}{3} + \frac{4}{6}} = \frac{9 \times 6}{18}$$

$u_{AB} = 3V$

* Thevenin :



I ? on applique Thevenin

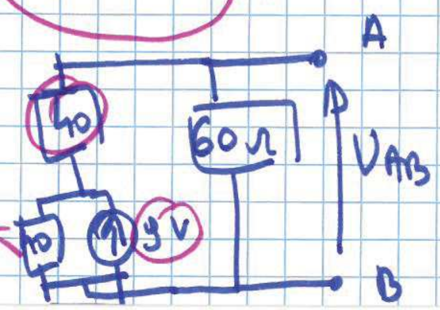


loi des mailles

$$E_{th} - (R_{th} + 30) I = 0$$

$$\Rightarrow I = \frac{E_{th}}{R_{th} + 30}$$

cette résistance est court-circuitée élément à ne pas !!!



$$u_{AB} = E_{th} = \frac{9/40}{1/40 + 1/60} = \frac{9}{\frac{4}{6} + 1} = 5{,}4\,V$$

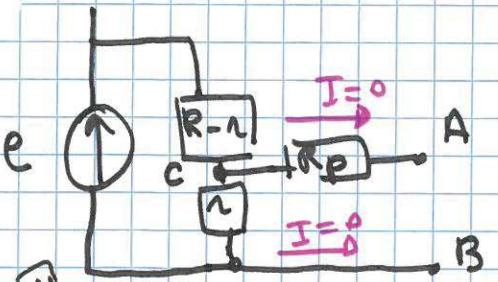
$$R_{th} = 40 \| 60 = \frac{60 \times 40}{100} = 24\,\Omega$$

$$I = \frac{5{,}4}{54}$$

$$I = 0{,}1\,A$$

Exo5 : montage diviseur de tension :

1/

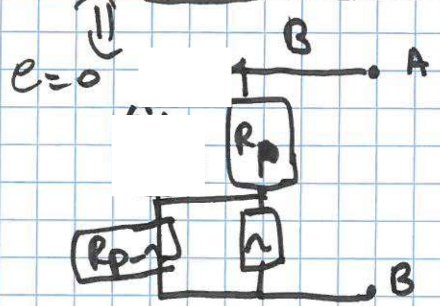


$u_{AB} = V_A - V_B$ $\quad$ or $V_C = V_A$ $\quad$ $u_{AB} = V_C - V_B = V_{CB}$

$E_{th} = u_{AB} = u_{CB}$

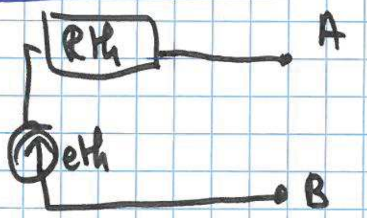
$$u_{CB} = \frac{e/(R-r)}{\frac{1}{(R-r)} + \frac{1}{r}} = \frac{e}{1 + \frac{R-r}{r}} = e\frac{r}{R}$$

$R_{th} \hat{=}$



$R_{th} = \text{"}R_p\text{"} + (R-r) \,//\, r$

$$R_{th} = R_p + \frac{r(R-r)}{r + R - r} = R_p + \frac{r}{R}(R-r)$$



$e_{th} = e\frac{r}{R}$

$R_{th} = R_p + \frac{r}{R}(R-r)$

Générateur de Thevenin entre A et B

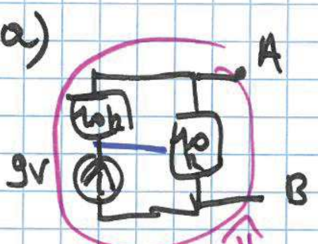
2/ AN : on veut $e_{th} = 2V$ $\quad$ $R = 10\,k\Omega$ et $R_p = 2\,k\Omega$ $\quad$ $e = 15V$

$$\Rightarrow \frac{e\,r}{R} = 2 \Rightarrow r = \frac{2R}{e} = 2\,\frac{10\,k\Omega}{15} = 1{,}33\,k\Omega$$

$$\text{et } R_{th} = 2\,10^3 + \frac{4/3\,10^3}{10^4}\left(10 - \frac{4}{3}\right)10^3 = 3{,}16\,k\Omega$$

Exo6 : Thevenin Applicat°.

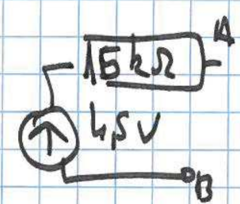
a)



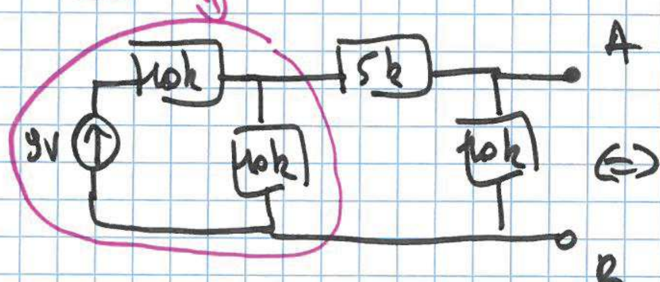
$$E_{th} = u_{AB} = \frac{9/10k}{1/10k + \frac{1}{10k}} = \frac{9}{2} = 4{,}5V$$

$R_{th} = 10\,k\Omega \,//\, 10\,k\Omega = 5\,k\Omega$

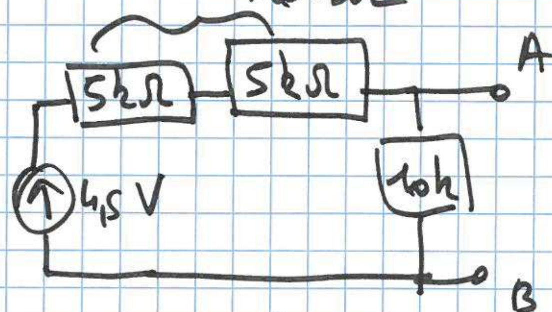
$\Leftrightarrow$



b)

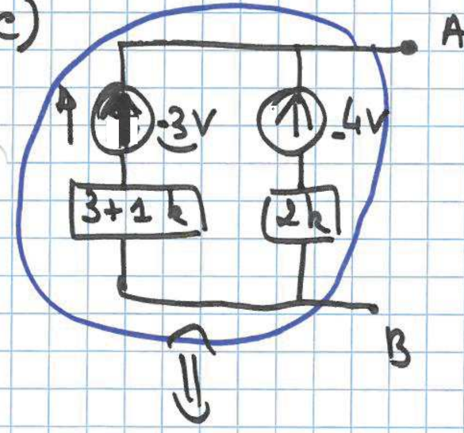


$\Leftrightarrow$



$$\Rightarrow E_{th} = \frac{4{,}5}{2} = 2{,}25\,V \text{ et } R_{th} = 10\,k\Omega \,//\, 10\,k\Omega = 5\,k\Omega$$

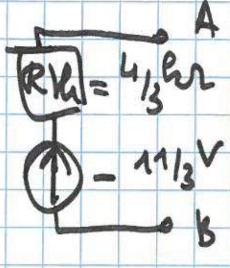
c)



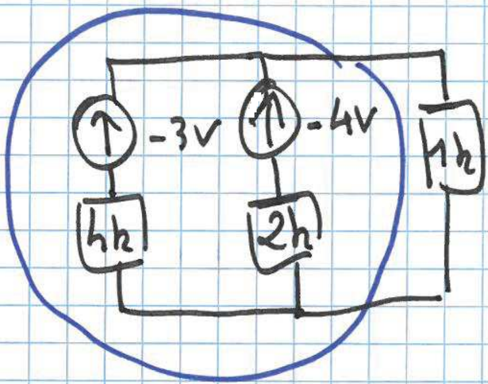
$$E_{th} = u_{AB} = \frac{-3/4k - 4/2k}{1/4k + 1/2k}$$

$$E_{th} = \frac{-3 - 8}{1 + 2} = -\frac{11}{3}\ V$$

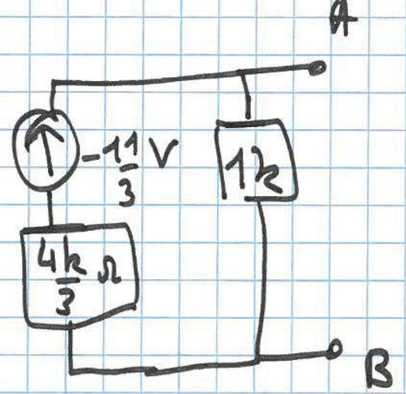
$$R_{th} = 4k\Omega \parallel 2k\Omega = \frac{4k \times \cancel{2k}}{{}_3\cancel{6}\cancel{k}} = \frac{4}{3}\ k\Omega$$



d)



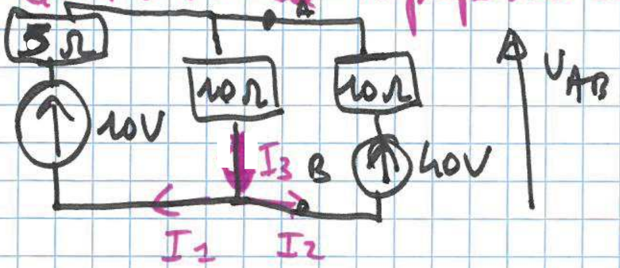
$\Leftrightarrow$



$$E_{th} = \frac{(-11/3)/(4k/3)}{\frac{3}{4k} + \frac{1}{1k}} = \frac{-11/4k}{\frac{3}{4k} + \frac{1}{1k}} = \frac{-11}{3+4} = -\frac{11}{7}\ V$$

$$R_{th} = 1k \parallel \frac{4k}{3} \Rightarrow \frac{1}{R_{th}} = \frac{1}{1k} + \frac{3}{4k} = \frac{7}{4k} \Rightarrow R_{th} = \frac{4k}{7}\ \Omega$$

Ex07 : Loi de superposit° des courants.



$$U_{AB} = \frac{10/5 + 40/10}{1/5 + \frac{1}{10} + \frac{1}{10}} \quad \times \frac{10}{10}$$

$$U_{AB} = \frac{20 + 40}{2 + 2} = 15V$$

1/ $U_{AB} = R_3 I_3 \Rightarrow I_3 = \frac{U_{AB}}{10} = 1,5\ A$

$U_{AB} = 40 - 10 I_2 \Rightarrow \quad I_2 = \frac{40 - U_{AB}}{10} = 2,5\ A$

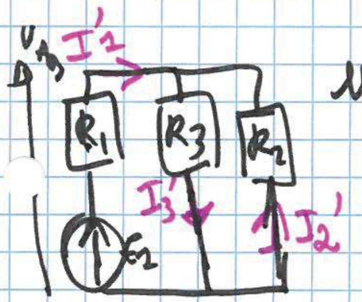
$U_{AB} = 10 - 5 I_1 \Rightarrow \quad I_1 = \frac{10 - U_{AB}}{5} = -1\ A$

le courant I_1 circule ds l'autre sens.

2/ Superposit° des régimes permanents

	E_1 on E_2 off	E_1 off E_2 ON	Σ
"I_1"	1	-2	-1 A
"I_2"	-0,5	3 A	+2,5 A
"I_3"	0,5	1	1,5 A

E_1 ON / E_2 off



$$U'_{AB} = \frac{10/5}{1/5 + \frac{1}{10} + \frac{1}{10}}$$

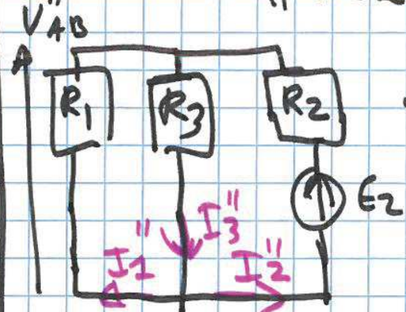
$U'_{AB} = 5V$

$5V = 10 - 5I'_1 \Rightarrow I'_1 = \frac{10-5}{5} = 1A$

$5V = 10 \times I'_3 \Rightarrow I'_3 = \frac{5}{10} = 0,5\ A$

$5V = -10 \times I'_2 \Rightarrow I'_2 = -0,5A$

E_1 off / E_2 ON



$$U''_{AB} = \frac{40/10}{\frac{1}{10} + \frac{1}{10} + \frac{1}{5}}$$

$U''_{AB} = 10V$

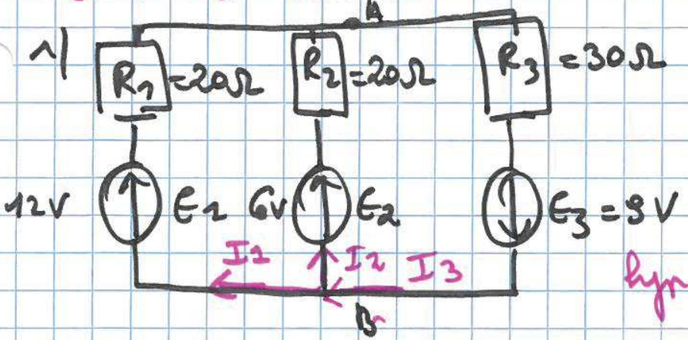
$10V = -5I''_1 \Rightarrow I''_1 = -2A$

$10V = R_3 I''_3 \Rightarrow I''_3 = 1\ A$

$10V = 40 - 10I''_2 \Rightarrow I''_2 = \frac{40-10}{10} = 3A$

Exo 8 ⇒ circuit.

1/



hyp pour le calcul.

2/ Calcul de I_1, I_2, I_3 avec millmann.

a/ millmann

$$U_{AB} = \frac{12/20 + 6/20 - 9/30}{1/20 + 1/20 + 1/30} = \frac{6/10 + 3/10 - 3/10}{1/10 + 1/30}$$

$$U_{AB} = \frac{6}{1 + 1/3} = \frac{18}{4} = 4{,}5\,V$$

$12 - 20I_1 = 4{,}5 \Rightarrow \boxed{I_1 = \frac{12 - 4{,}5}{20} = \frac{7{,}5}{20} = 375\,mA}$

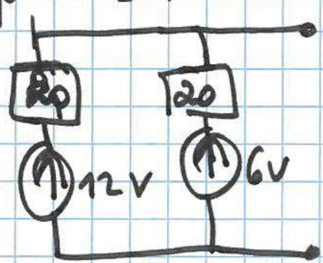
$6 - 20I_2 = 4{,}5 \Rightarrow \boxed{I_2 = \frac{6 - 4{,}5}{20} = \frac{1{,}5}{20} = 75\,mA}$

$-9 + 30I_3 = 4{,}5 \Rightarrow \boxed{I_3 = \frac{4{,}5 + 9}{30} = 0{,}15 + 0{,}3 = 0{,}45\,A = 450\,mA}$

$I_3 = I_1 + I_2$ OK.

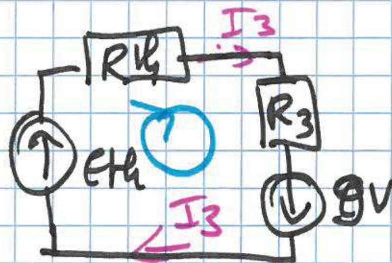
b) Par thevenin appliqué 3 fois.

• pour I_3 :



$$E_{th}^{(3)} = \frac{12/20 + 6/20}{1/20 + 1/20} = 9\,V$$

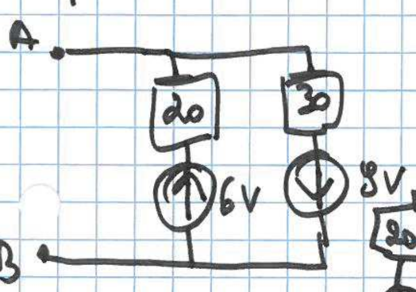
$R_{th}^{(3)} = 20\Omega // 20\,\Omega = 10\,\Omega$



loi des mailles ⇒ $9V - (10 + 30)I_3 + 9 = 0$

$$\boxed{I_3 = \frac{9+9}{10+30} = \frac{18}{40} = \frac{9}{20} = 0{,}45 = 450\,mA}$$

• pour I_1

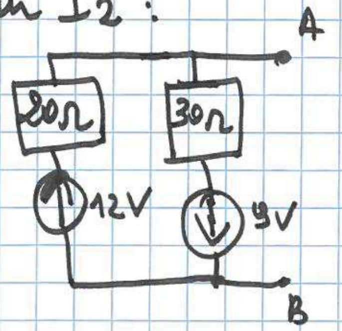


$$E_{th}^{(1)} = \frac{6/20 - 9/30}{1/20 + 1/30} = 0\,V$$

$$R_{th} = 20\Omega // 30\,\Omega = \frac{20 \times 30}{20 + 30} = \frac{600}{50} = 12\,\Omega$$

$12 - (20 + 12)I_1 = 0$ $\boxed{I_1 = \frac{12}{32} = \frac{3}{8} = 375\,mA}$

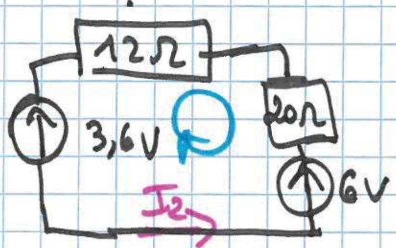
pour I_2 :



$$E_{th} = \frac{12/20 - 9/30}{1/20 + 1/30} = \frac{+3/10}{1/20 + 1/30} = \frac{3}{\frac{1}{2}+\frac{1}{3}} = \frac{3\times 6}{5}$$

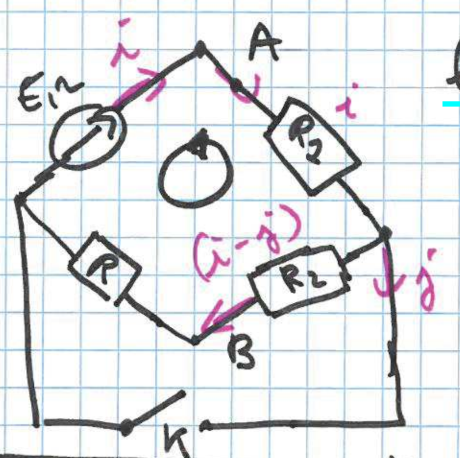
$$E_{th} = 3{,}6\,V$$

$$R_{th} = 20\Omega \parallel 30\Omega = \frac{20\times 30}{50} = 12\,\Omega$$



$$3{,}6V + (20+12)I_2 - 6 = 0 \qquad I_2 = \frac{6-3{,}6}{32} = 0{,}075 \boxed{= 75\,mA}$$

Exercice 9 : Pont de Mance -



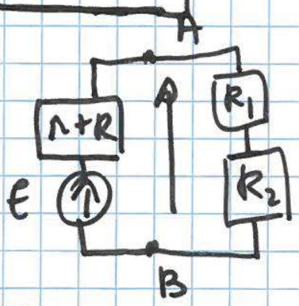
loi des mailles

$$R_1 i + R_2(i-j) + R(i-j) + r i - E = 0$$

$$(R_1 + R_2 + R + r)\,i - j(R_2 + R) = E \quad (1)$$

Mesurons U_{AB} que K soit ouvert ou fermé.

$\boxed{\text{K ouvert :}}$



$$U_{AB}^{ouvert} = \frac{E/(r+R)}{\frac{1}{r+R} + \frac{1}{R_1+R_2}}$$

$$U_{AB} = \frac{E\,(R_1+R_2)}{(R_1+R_2) + R + r}$$

$\boxed{\text{K fermé}}$

$$U_{AB} = E - (r+R)\,i + R\,j$$

$$U_{AB} = (R_1+R_2)\,i - R_2\,j \quad (2)$$

PB ici on a i et j

Mais la loi des maille (1)

$$i = \frac{E}{R_1+R_2+R+r} + j\,\frac{R_2+R}{R_1+R_2+R+r}$$

$$(2) \Rightarrow U_{AB}^{fermé} = (R_1+R_2)\left(\frac{E}{R_1+R_2+R+r} + j\,\frac{R_2+R}{R_1+R_2+R+r}\right) - R_2\,j$$

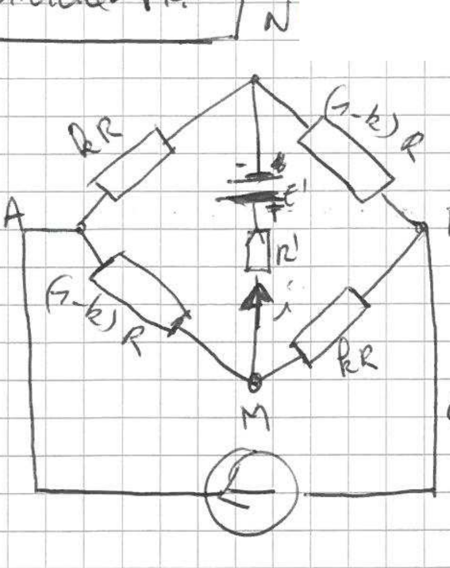
$$U_{AB}^{fermé} = E\,\frac{R_1+R_2}{R_1+R_2+R+r} + j\left[\frac{(R_2+R)(R_1+R_2)}{R_1+R_2+R+r} - R_2\right]$$

$$U_{AB}^{ouvert} = U_{AB}^{fermé} \Rightarrow (R_2+R)(R_1+R_2) = R_2(R_1+R_2+R+r)$$

$$R_2R_1 + \cancel{R_2^2} + RR_1 + \cancel{RR_2} = R_2R_1 + \cancel{R_2^2} + \cancel{R_2R} + R_2\,r$$

$$\boxed{R_2\,r = R\,R_1}$$

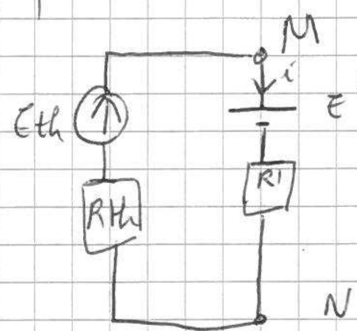
Exercice 10



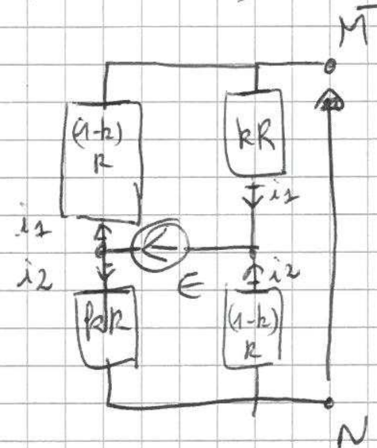
on cherche i qui circule dans la branche MN.

$\Rightarrow$ puisqu'on cherche i dans la branche MN (il ne s'agit pas ici d'équilibrer le pont!) on applique le théorème de Thevenin en isolant la branche MN.

$\Leftrightarrow$



Thevenin $\Rightarrow$ $\underline{U_{MN} = E_{th}}$



on ne peut pas appliquer Millmann.

dans chaque maille on a $E = kR\,i_1 + (1-k)R\,i_1$

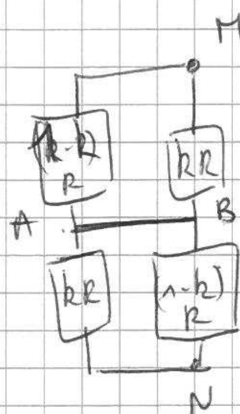
$E = (1-k)R\,i_2 + kR\,i_2$

(Symétrie du problème) $\Rightarrow i_1 = i_2 = \dfrac{E}{R}$

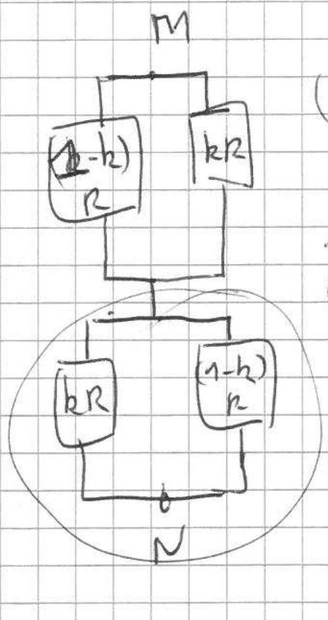
$U_{MN} = kR\,i_1 - (1-k)R\,i_2 = \dfrac{E}{R}\left(kR - R + kR\right)$

$$\boxed{U_{MN} = (2k-1)E}$$

$\Rightarrow R_{th}$ (on éteint la source E) $\underline{R_{th} = R_{MN}}$



$\Leftrightarrow$



Req

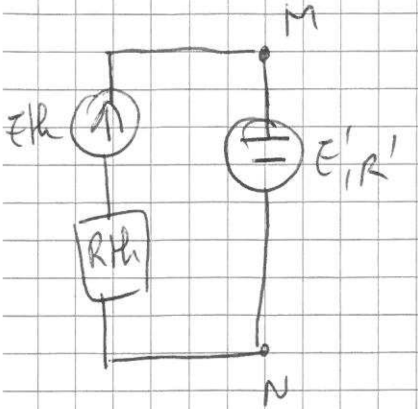
$(1-k)R \,//\, kR + (1-k)R \,//\, kR$

$= 2\,R_{eq}$.

$\dfrac{1}{R_{eq}} = \dfrac{1}{(1-k)R} + \dfrac{1}{kR} = \dfrac{1}{Rk(1-k)}$

$R_{eq} = Rk(1-k)$

$$\boxed{R_{MN} = 2Rk(1-k)}$$



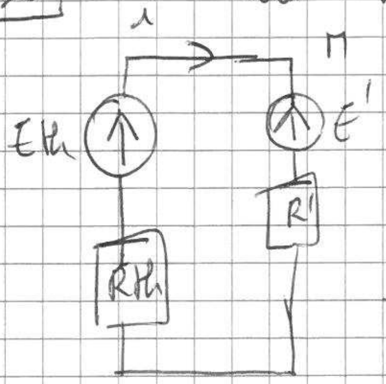
$E_{Th} = (2k-1)\,E$ et $R_{Th} = 2R\,k(1-k)$

attention suivant les valeurs de k il peut être >0 ou <0

il faut envisager 2 cas

Cas 1 : si $E_{Th} \geq E'$ càd $E_{Th} \geq 1V \Rightarrow (2k-1)\times 5V \geq 1$

$\boxed{i>0}$ alors $k \geq 0,6$



$E_{Th} - E' - (R'+R_{Th})\,i = 0$ $R = 6\,\Omega$ $R' = 2\,\Omega$

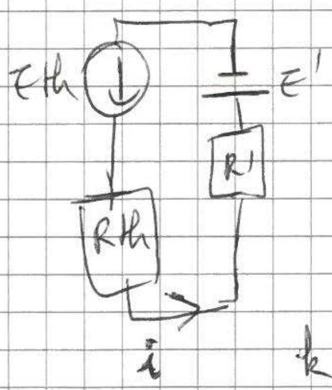
$(2k-1)5 - 1 - [2 + 12k(1-k)]\,i = 0$

$$\to i = \frac{10k-6}{2+12k(1-k)} = \frac{5k-3}{6k(1-k)+1}$$

avec $k\ [0,6 , 1]$ valeurs limites sont $k = 0,6$ $i = 0$; $k = 1$ $i = 2A$

dans l'autre cas

Cas 2 : $\boxed{i<0}$ E_{Th} et E' sont en oppositon.



$E' + (R'+R_{Th})\,i - E = 0 \Rightarrow i = \dfrac{E_{Th}-E'}{R'+R_{Th}}$

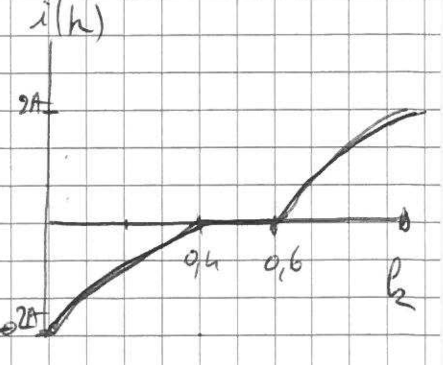
attention $i \leq 0$ si $E_{Th} < E'$ avec E' en opposition

càd $E' = 1V$ $(2k-1)5 \leq -1\,V$

$10k \leq 4V$ $\boxed{k \leq 0,4}$

$k \in [0, 0,4]$

$$i = \frac{10k-5+1}{2+12k(1-k)} = \frac{10k-4}{2+12k(1-k)} = \frac{5k-2}{1+6k(1-k)}$$



valeurs limites $k = 0 \to i = -2A$

$k = 0,4 \to i = 0\,A$.

entre $k = 0,4$ et $k = 0,6$ $|E_{Th}| < |E'|$ donc la tension n'est pas suffisante pour qu'il y ait du courant qui circule $\Rightarrow i = 0$.