EPFL

Cours Électrotechnique I :

2. Conventions et symboles :

→ concepts

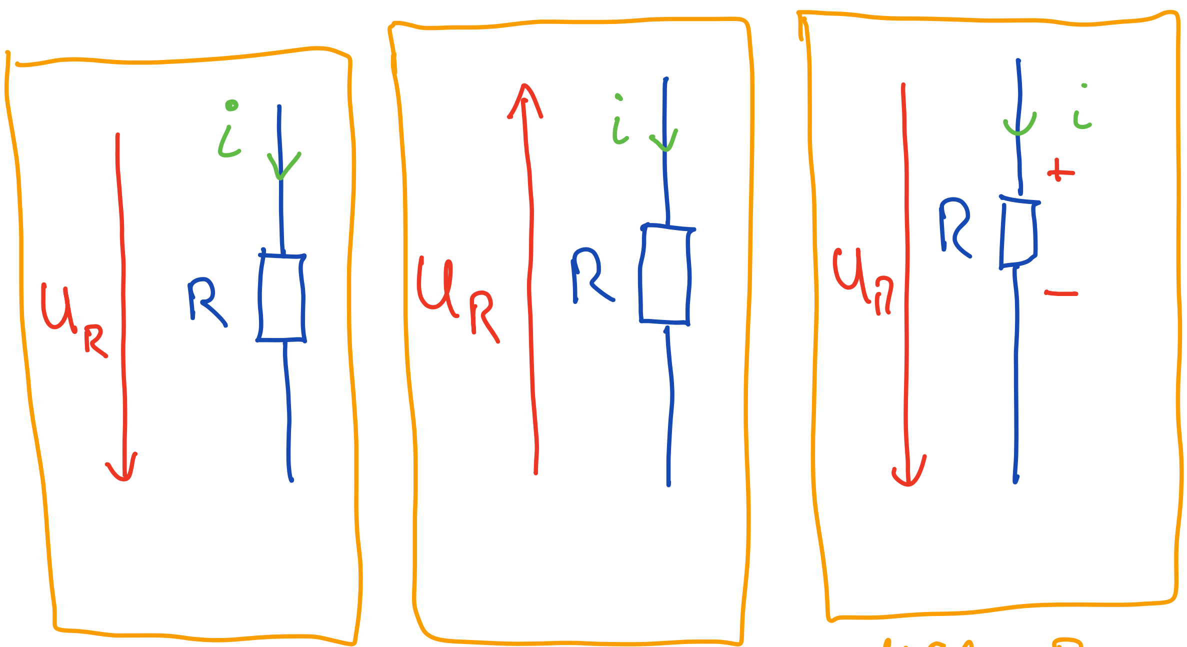
Ex : Courant : i, I, $\hat{I}$, $'i$, $\bar{I}$, $\underline{I}$

unité : [A]

Relations : $U = R \cdot I$

$u = R \cdot i$

Choix : Convention Récepteur



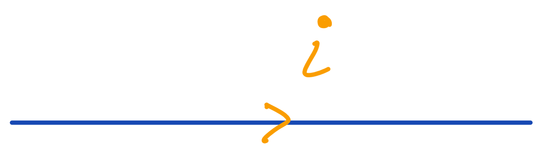
International — France — USA, B

$P_R = R \cdot I^2 = UI =$ positive

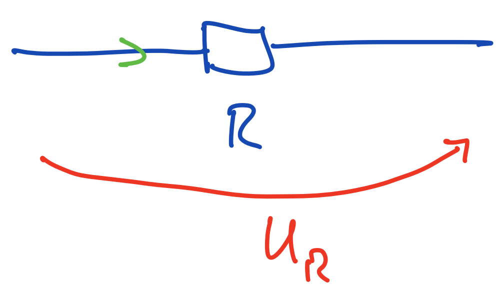
2.2 Représentation graphique :

Conducteur parfait :

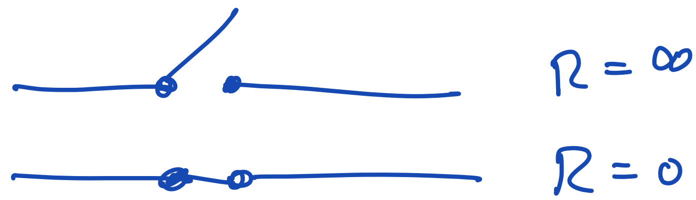
conducteur avec un courant :



Elément :



Interrupteur :

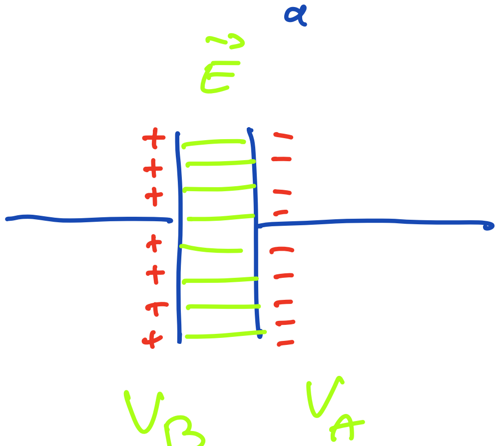


3. Lois fondamentales :

Champ électrique :

Différence de potentiel électriques

$$V_A - V_B = \int_a^b E \, dl = U_{ab}$$



capacité

3.2.19 La Capacité :

Définition : Charge électrique : Q

capacité : $C = \dfrac{Q}{U_{ab}}$ [F] (Farad)

Symbole :

3.3 Courant électrique :

$$i = \frac{dQ}{dt} \quad [A]$$

j = Densité de courant $[A/m^2]$

3.34 Pertes Joule

$$P = R \cdot I^2 \quad [W]$$

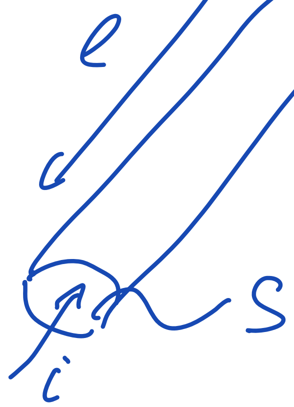
$$P = \rho \int_V j \, dV_{cu}$$

3.3.6 Résistance :

b

$$R_{ab} = \int_a \rho \frac{dl}{S}$$

↑ Résistivité [Ω m]

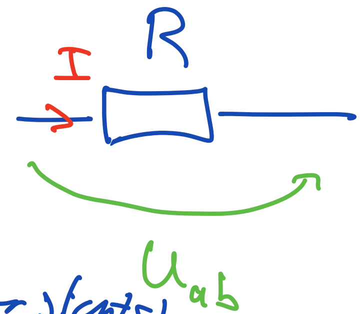


Si on a un milieu homogène et S est cste :

$$R = \frac{\rho \cdot l}{S} \quad [\Omega]$$

3.3.8 Loi d'Ohm :

$$U_{ab} = R_{ab} \cdot I$$



(Tension et le courant sont constants)

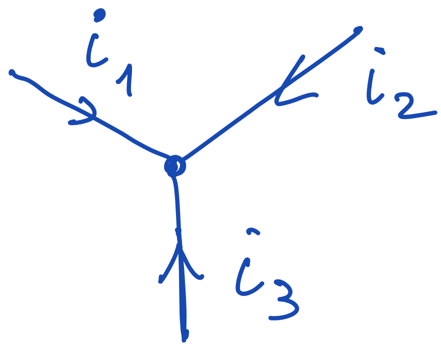
$$u_{ab} = R_{ab} \cdot i$$

(Tension et le courant sont variables)

3.3.11 Lois de Kirchhoff :

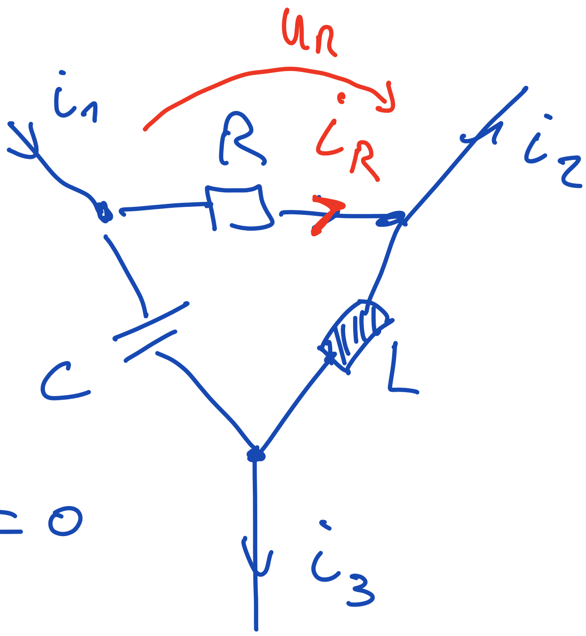
Noeud : Pt de convergence d'au moins 3 conducteurs

$$\sum_j i_j = 0$$



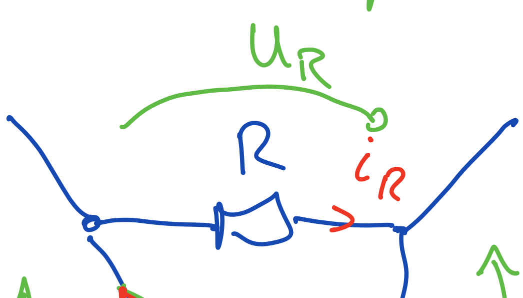
$$i_1 + i_2 + i_3 = 0$$

Noeud généralisé :

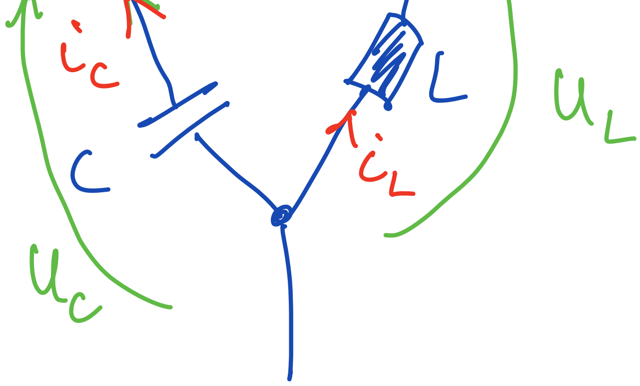


$$i_1 - i_2 - i_3 = 0$$

Maille : Ensemble de branche partant d'un noeud pour y revenir



$$\sum_j U_j = 0$$



$$U_R - U_L + U_c = 0$$

3.4 Inductance :

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

/ $\vec{Rot}\,\vec{H} = \vec{J}$

$\vec{Rot}\,\vec{E} = -\frac{\partial \vec{B}}{\partial t}$

Crée une tension en fonction de la variation du courant

3.5 La Capacité

$$C = \frac{Q}{U_{ab}}$$

$$Q = \int i \, dt$$

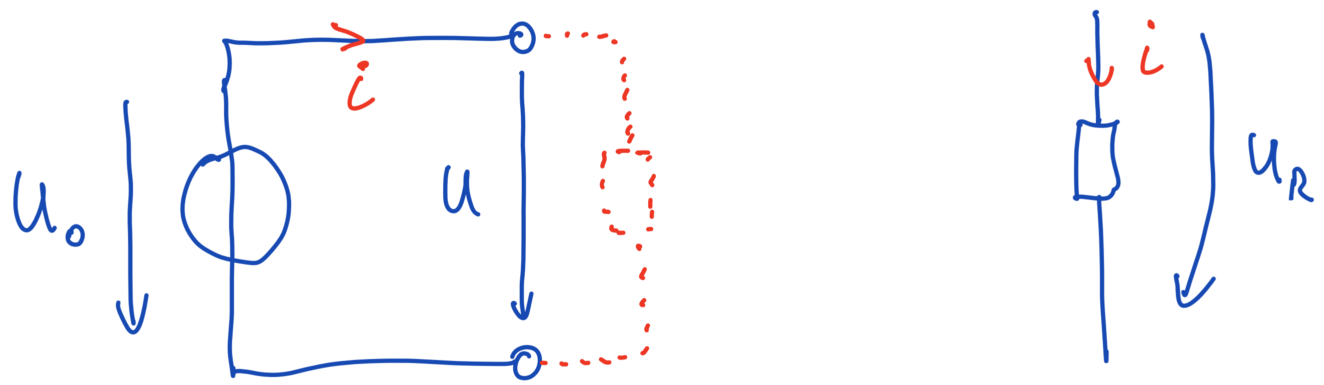
$$u_{ab} = \frac{1}{C} \int i \, dt$$

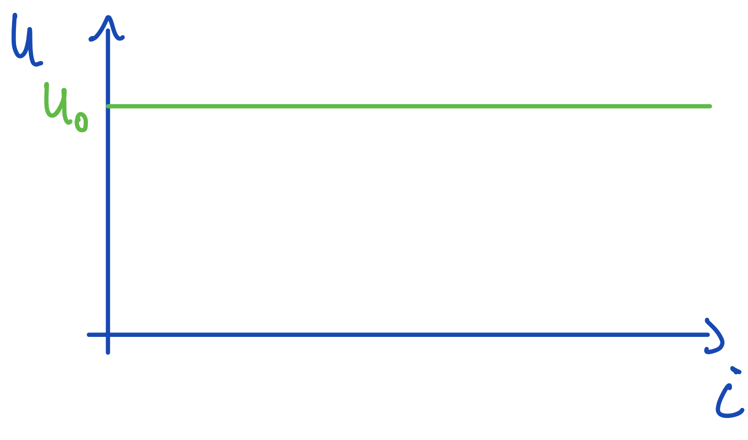
4. Eléments de circuit :

4.1 Définition : Dipôle : circuit qui possède 2 bornes

4.2 Sources de tension et courant :

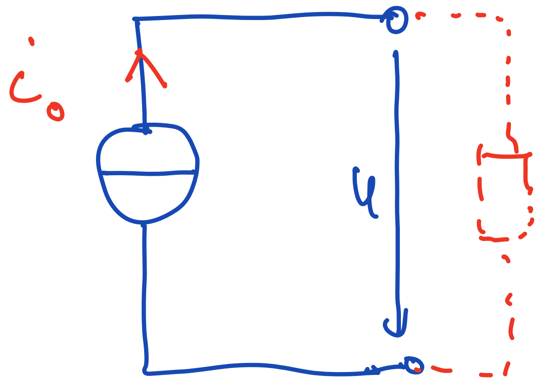
a) Source de tension idéale :



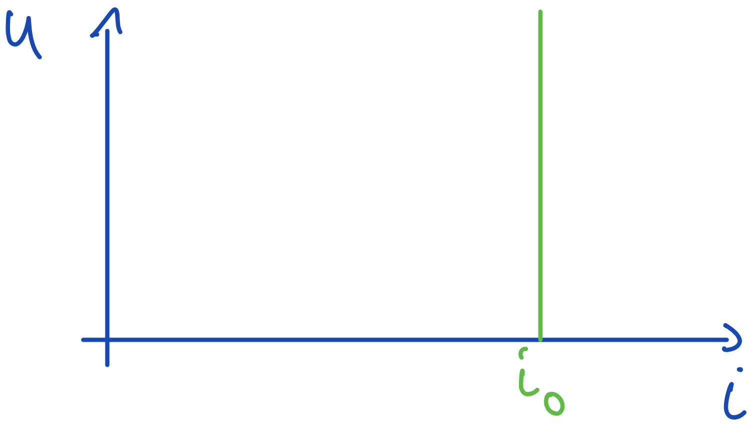


c'est un élément virtuel et inexistant dans la nature

b) Source de courant idéale :

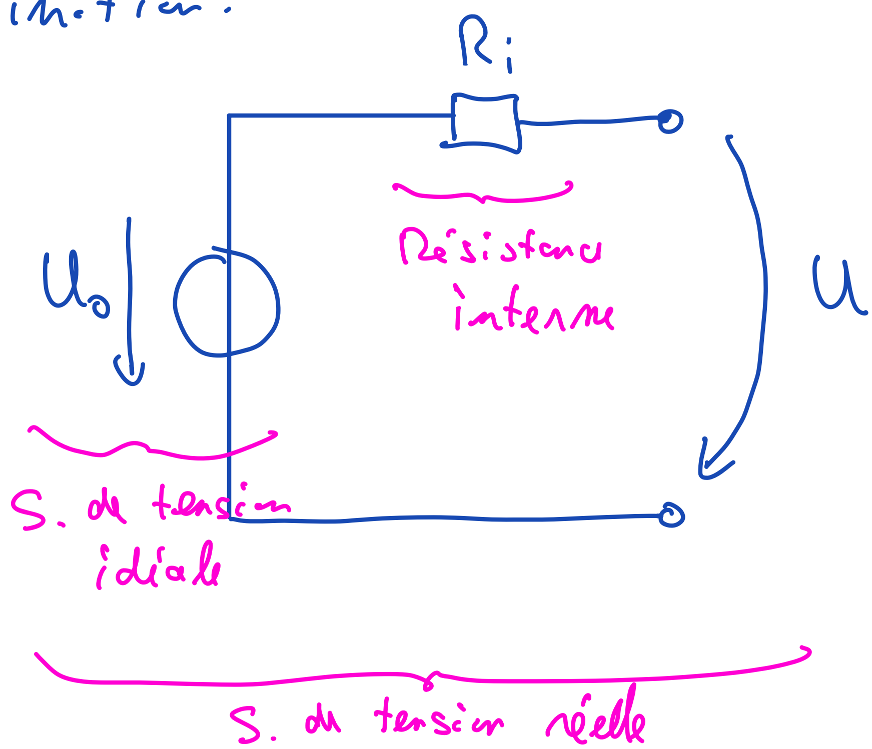


élément idéal inexistant dans la nature



4.2.5 Source de tension réelle :

Définition :



U_0 : Tension à vide (pas de charge connectée)

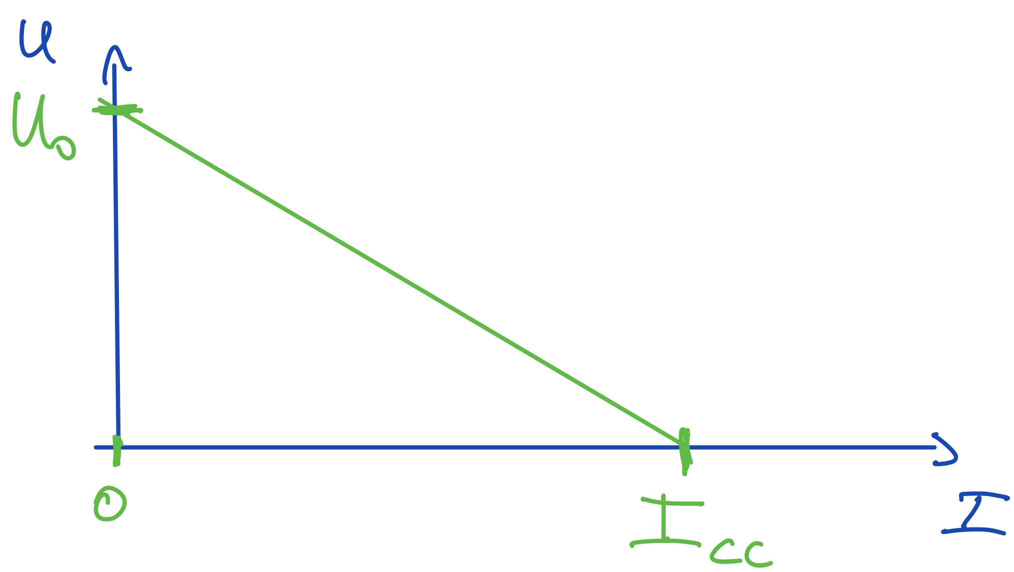
R_i : Résistance interne

U : Tension de la source réelle

$$\sum U = 0$$

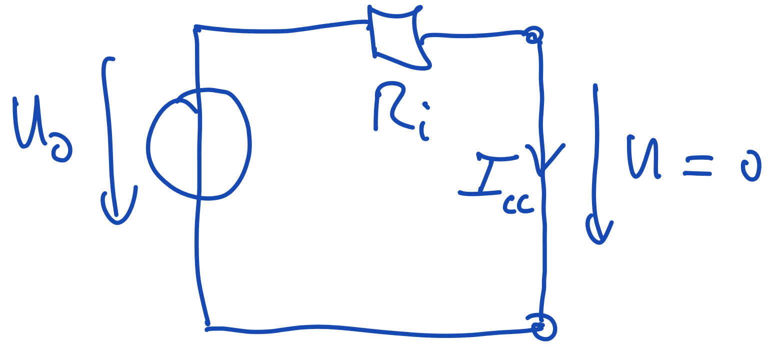
$$\rightarrow \quad -U_0 + R_i \cdot I + U = 0$$

$$U = U_0 - R_i I$$



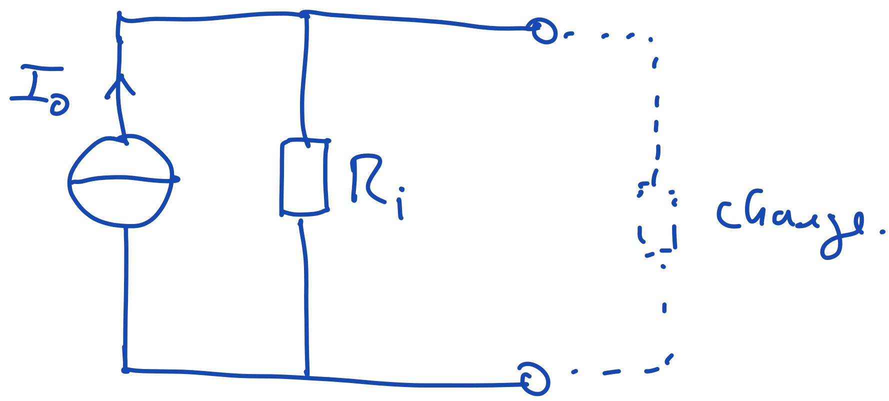
I_{cc} = courant - court circuit

Si on est en court-circuit :

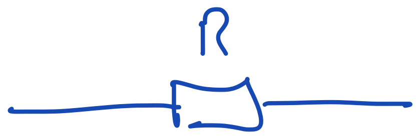


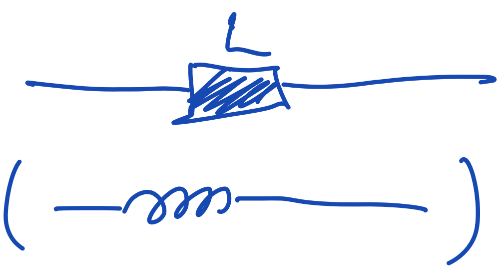
$$I_{cc} = \frac{U_0}{R_i}$$

4.2.6 Source de courant réelle :



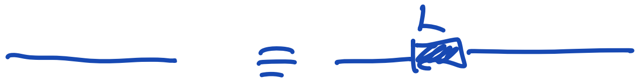
4.3 Éléments de base :

Résistance : 

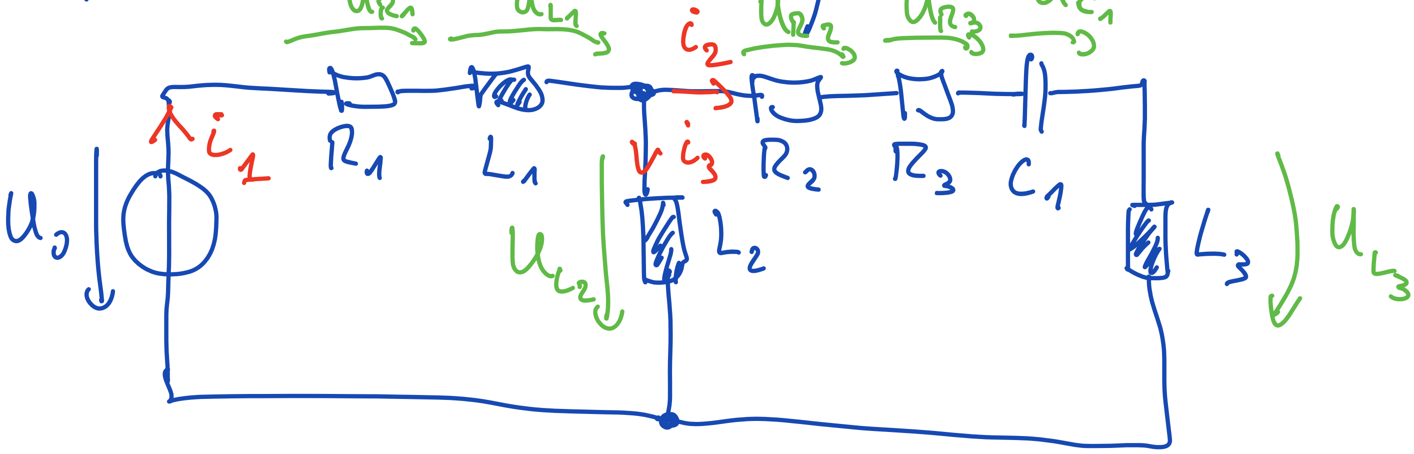
Inductance : 

capacité : 

Rappel : $u_L = L \frac{di}{dt}$ en continu $u_L = 0$

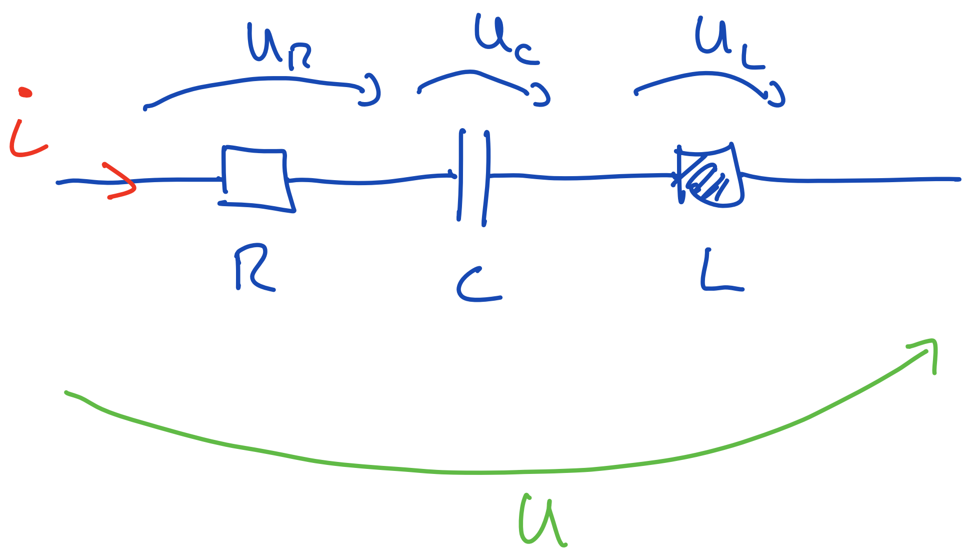


4.4 Schéma électrique :



5. Combinaison simple d'éléments linéaires

5.2 Mise en série :

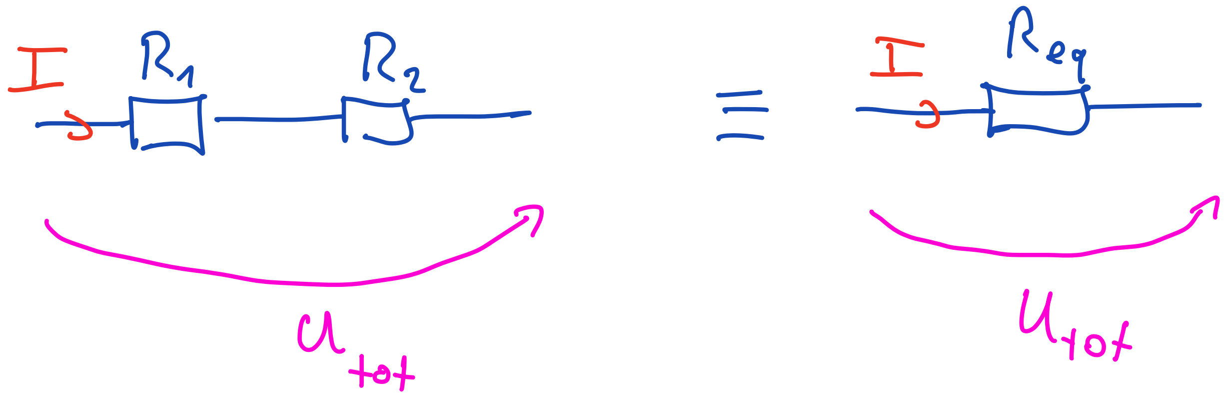


Série : parcouru par le même courant

$$i_R = i_C = i_L$$

$$u = u_R + u_C + u_L$$

5.2.2 Mise en série de R :



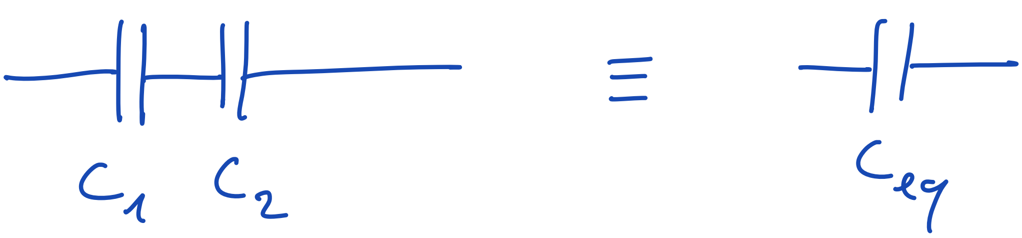
$$U_{tot} = U_{R_1} + U_{R_2} \qquad U_{tot} = U_{R_{eq}}$$

$$= R_1 \cdot I + R_2 \cdot I$$

$$U_{tot} = \underbrace{(R_1 + R_2)}_{R_{eq}} \cdot I$$

Série $\quad R_{eq} = \sum_{k=1}^{n} R_k \quad$ (n = nb de R en série)

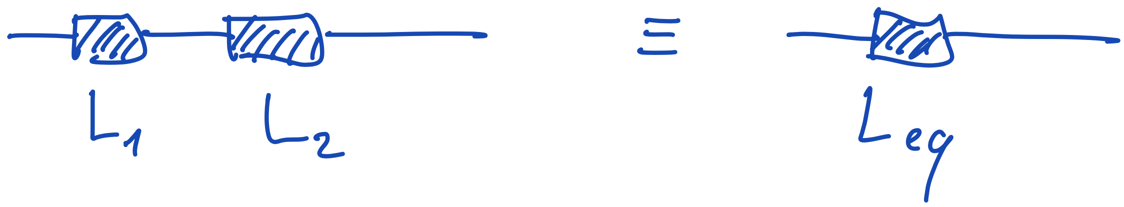
5.2.3 Mise en série des C



Série $\quad C_{eq} = \dfrac{1}{\sum^{n} 1 \ldots} \quad$ (n = nb de C)

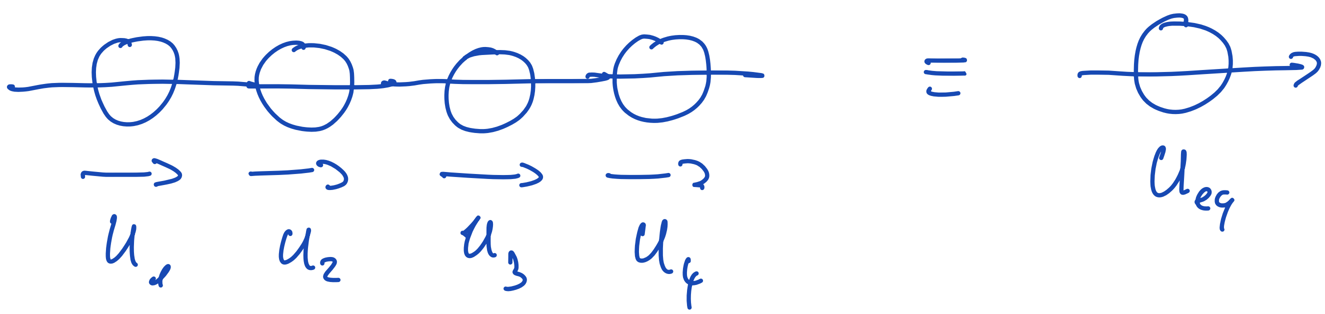
$k=1 \qquad C_k$

5.2.6 Mise en série des L

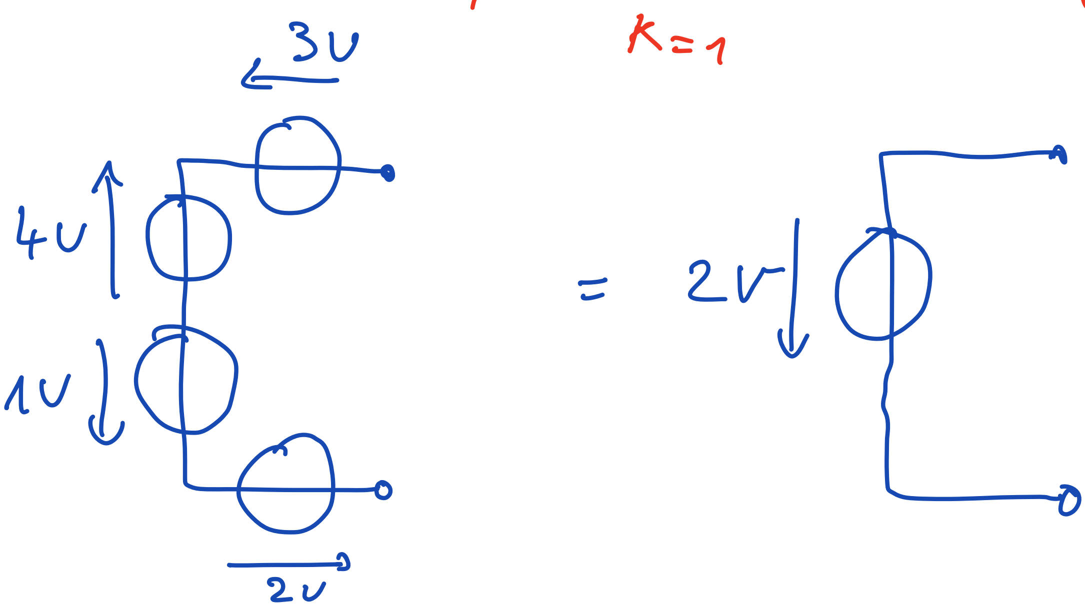


Série : $L_{eq} = \sum_{k=1}^{m} L_k$ (m = nb de L)

5.2.7 Mise en série des source de tension :



Série $U_{eq} = \sum_{k=1}^{m} U_k$ (m sources)

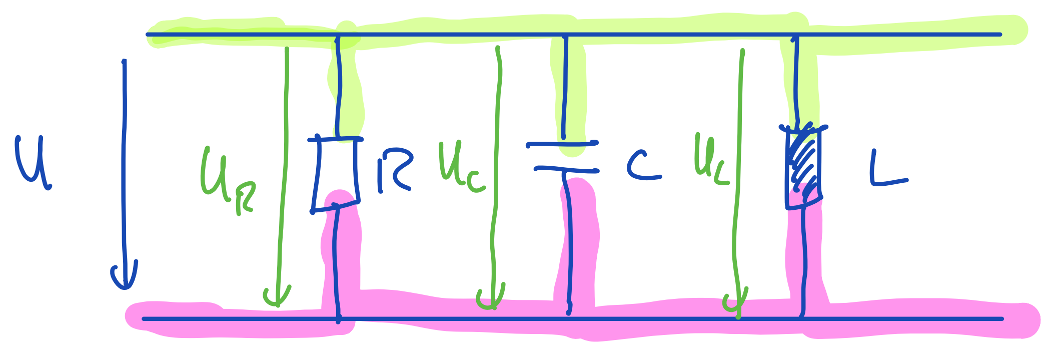


5.2.9 Mise en série des sources de courant

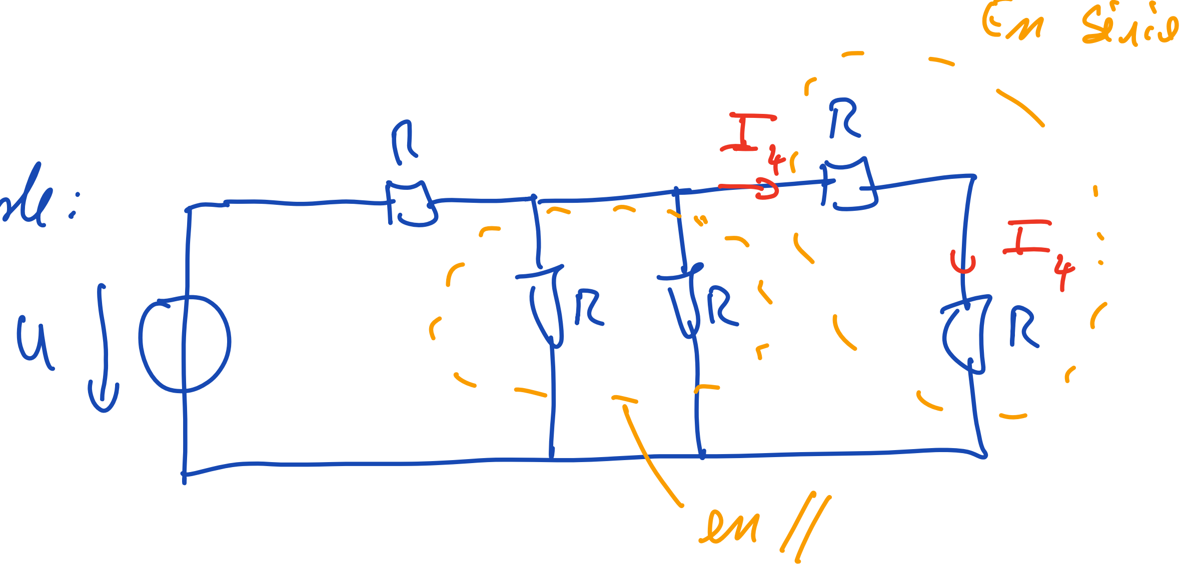
⇒ Impossible sauf si toutes les sources ont la même valeur !

5.3 Mise en parallèle :

Définition : Toutes les bornes des éléments sont au même potentiel



Exemple :



5.3.2 Mise en // des R :

$$R_{eq} = \frac{1}{\sum_{k=1}^{n} \frac{1}{R_k}}$$ n = nb de R

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} \Rightarrow R_{eq} = \frac{R_1 \cdot R_2}{R_1 + R_2}$$

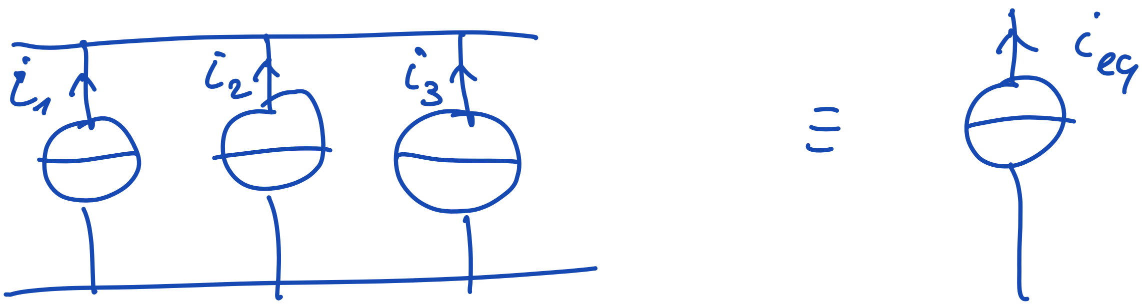
5.3.5 Mise en // des C :

$$C_{eq} = \sum_{k=1}^{n} C_k$$ n = nb de C

5.3.6 Mise en // des L :

$$L_{eq} = \frac{1}{\sum_{k=1}^{n} \frac{1}{L_k}}$$ n = nb de L

5.3.7 Mise en // des sources de courant.

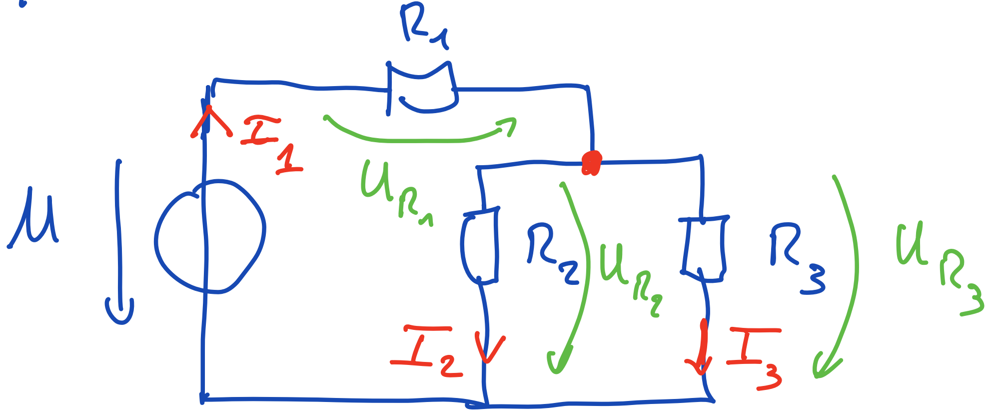


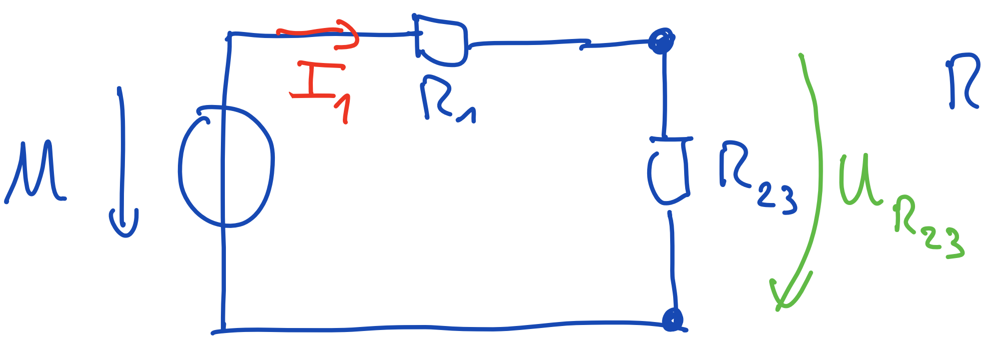
$$i_{tot} = i_{eq} = \sum_{k=1}^{m} i_k$$

Mise en // des sources de tensions est impossible ! Sauf si toutes les tensions ont même valeur !

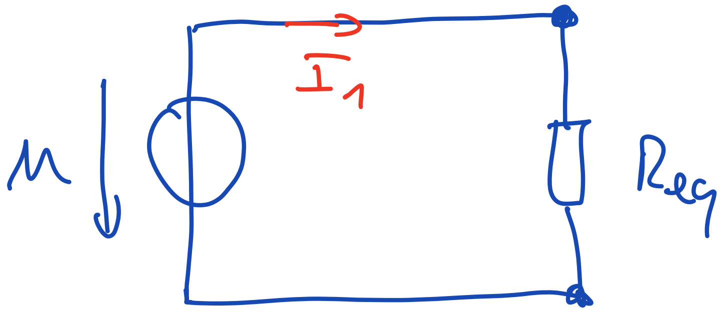
5.4 Circuits Combinés :

$$I_1 = I_2 + I_3$$





$$R_{23} = \frac{R_2 \cdot R_3}{R_2 + R_3}$$



$$R_{eq} = R_1 + R_{23}$$

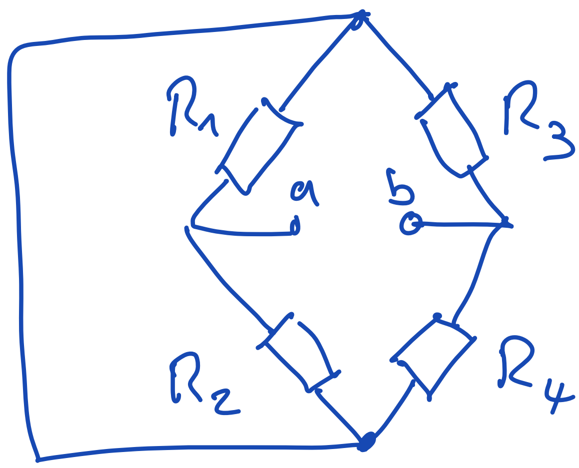
$$U = R_{eq} \cdot I_1 \quad \rightarrow \quad I_1 = \frac{U}{R_{eq}}$$

$$U_{R_1} = U_{R_3} = U_{R_{23}}$$

$$U_{R_{23}} = R_{23} \cdot I_1 = U_{R_2}$$

$$I_2 = \frac{U_{R_2}}{R_2}$$

5.4.3 Exemple :



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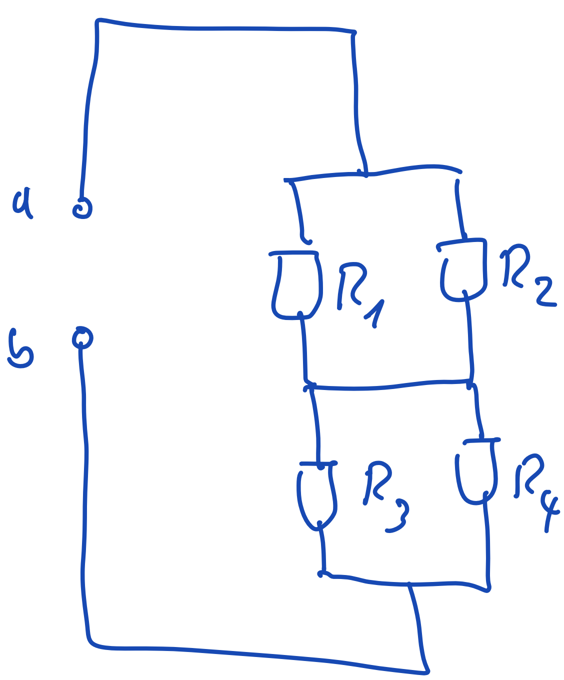
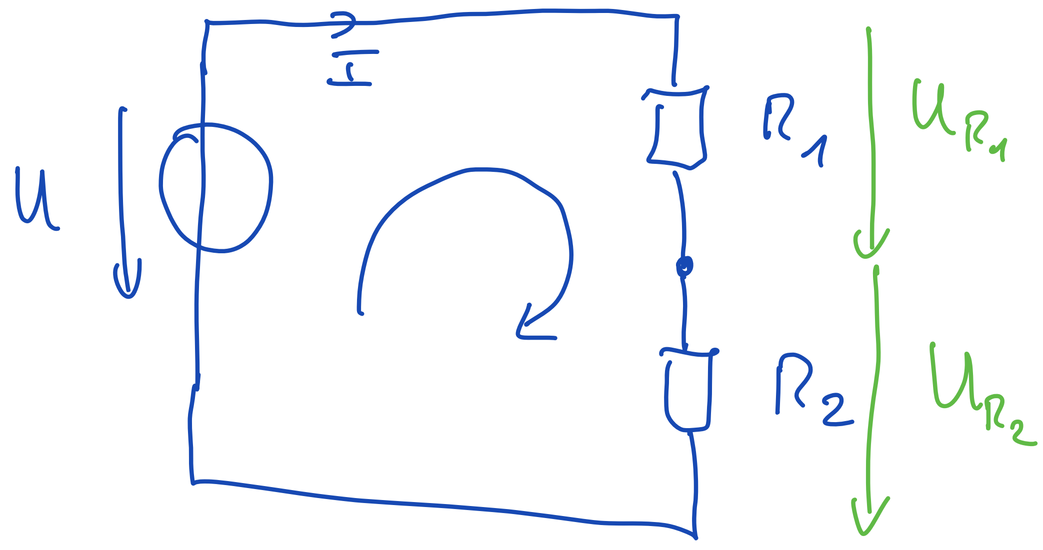


5.5.1 Diviseur de tension :



$$-U + U_{R_1} + U_{R_2} = 0$$

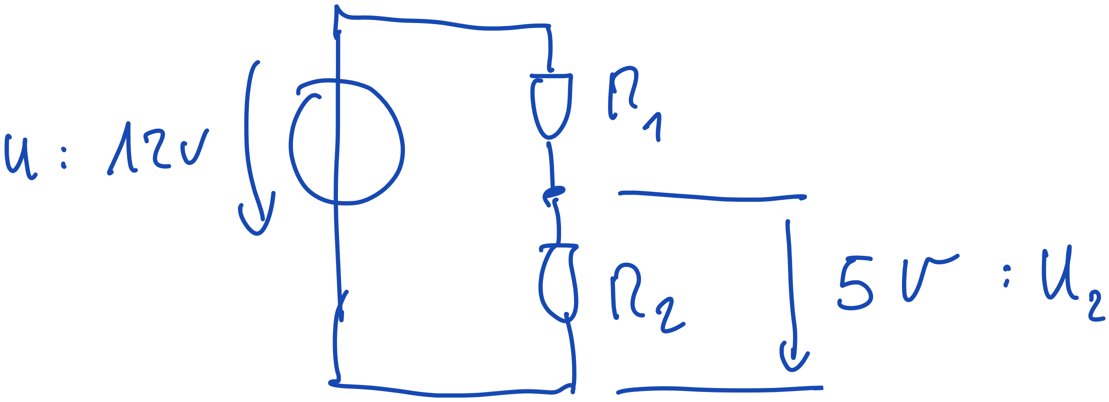
$$U = U_{R_1} + U_{R_2}$$

$$U = R_1 \cdot I + R_2 \cdot I = (R_1 + R_2) I$$

$$I = \frac{U}{R_1 + R_2}$$

$$U_{R_2} = R_2 \cdot I = U \cdot \frac{R_2}{R_1 + R_2}$$

$$U_{R_1} = R_1 \cdot I = U \frac{R_1}{R_1 + R_2}$$



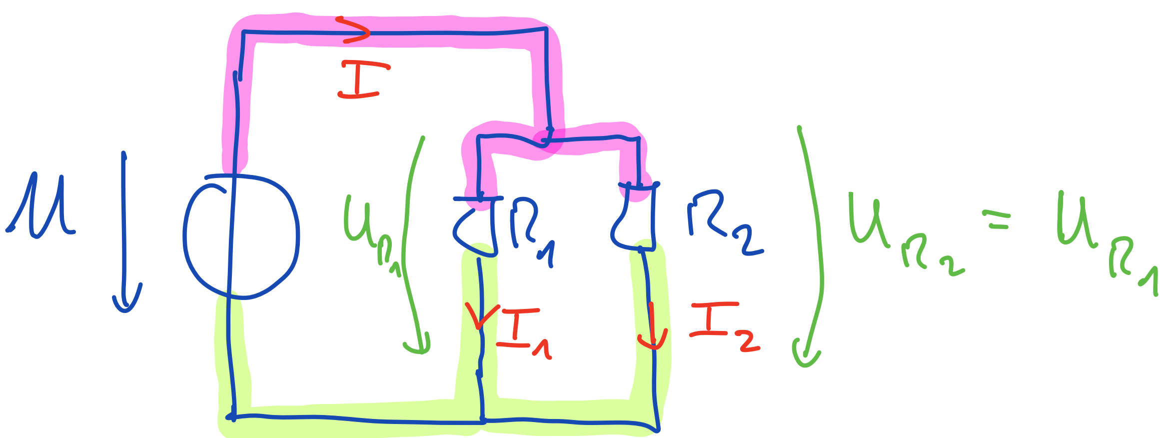
$$U_2 = \frac{R_1}{R_1 + R_2} \cdot U$$

$$5 = \frac{R_2}{R_1 + R_2} \cdot 12 \quad \Rightarrow \quad 5 R_1 = 7 R_2$$

$R_1 = 100 \; k\Omega$

$R_2 = 71{,}5 \; k\Omega$

5.5.4 Diviseur de courant :



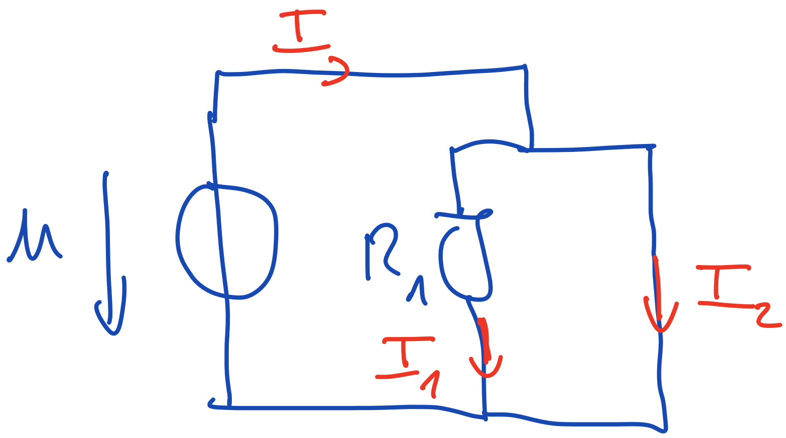
$$I = \frac{U}{R_{eq}} \qquad R_{eq} = \frac{R_1 \cdot R_2}{R_1 + R_2}$$

$$U = U_2 = \frac{R_1 \cdot R_2}{R_1 + R_2} \cdot I = R_2 \cdot I_2$$

$$I_2 = \frac{R_1}{R_1 + R_2} \cdot I$$

$$I_1 = \frac{R_2}{R_1 + R_2} \cdot I$$

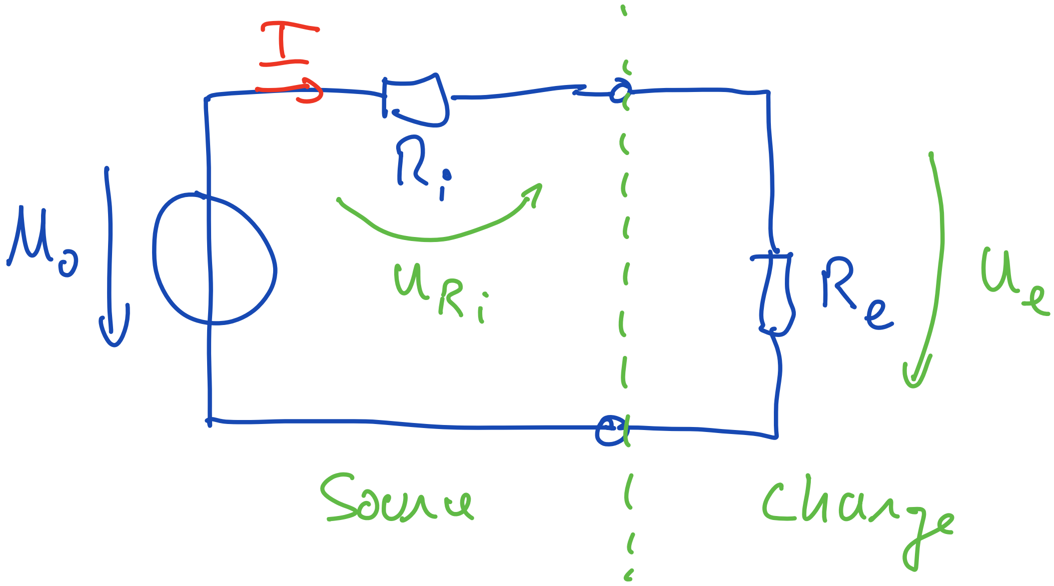
Si



5.6 Méthodes de Résolution :

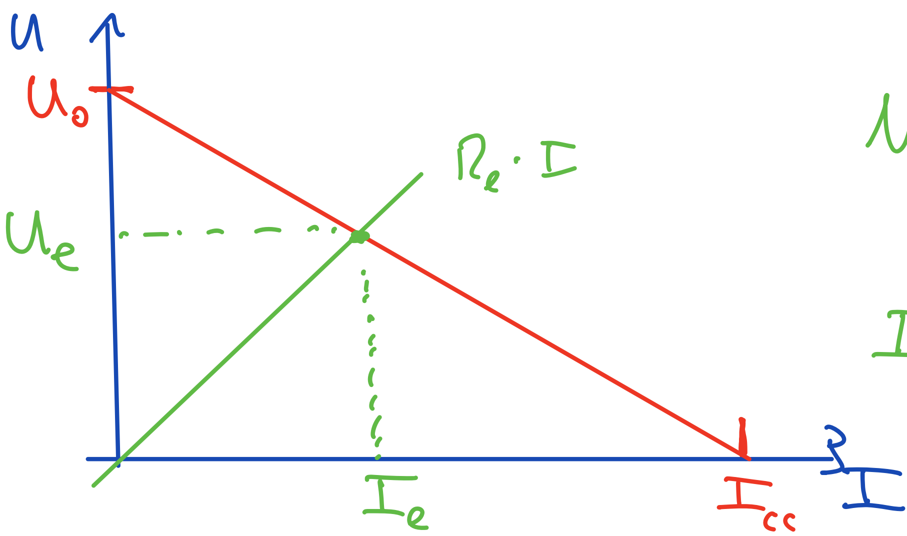
- Redessiner le schéma
- Définir toutes les grandeurs (U, I, i)
- " les sens
- Réduire le schéma
- Analyse

5.6.2 Source de tension réelle :



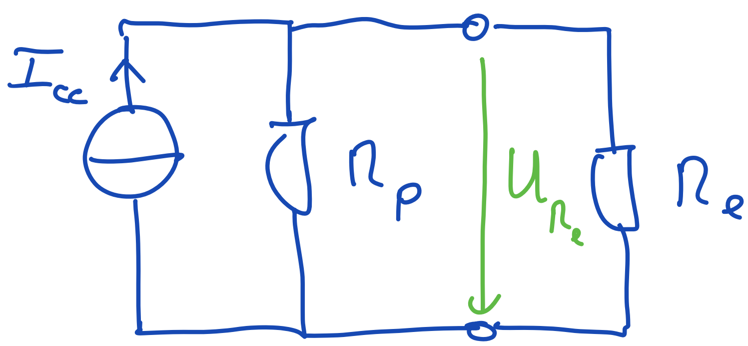
$$U_e = U_0 - U_{R_i} = U_0 - R_i \cdot I$$

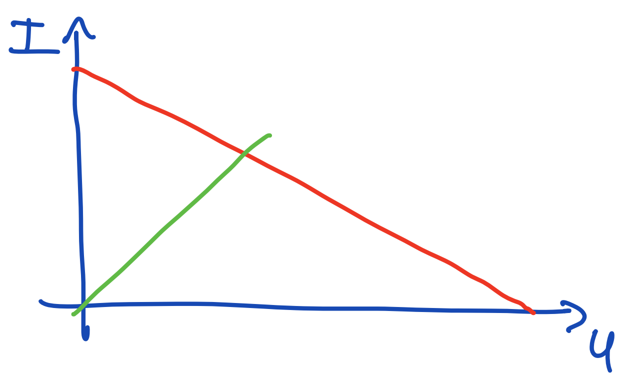
$$U_e = \qquad = R_e \cdot I$$



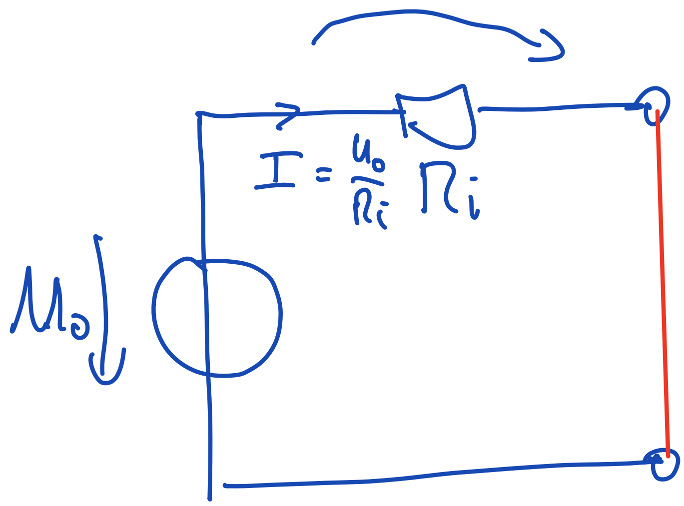
$$U_e = U_0 \cdot \frac{R_e}{R_e + R_i}$$

$$I_e = \frac{U_0}{R_i + R_e}$$

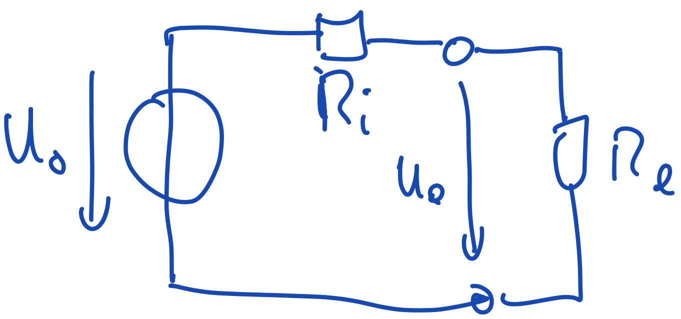


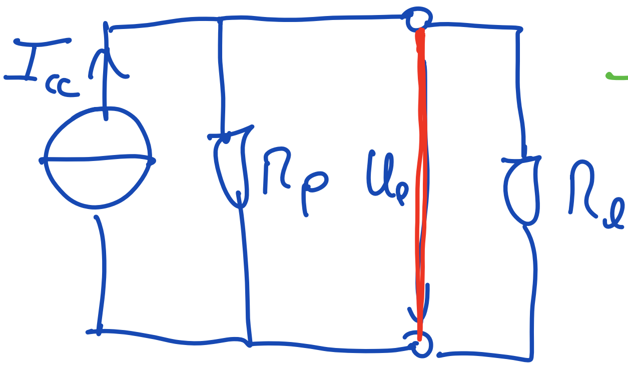


5.6.3 Equivalence des sources de tension et courant



$U = 0$





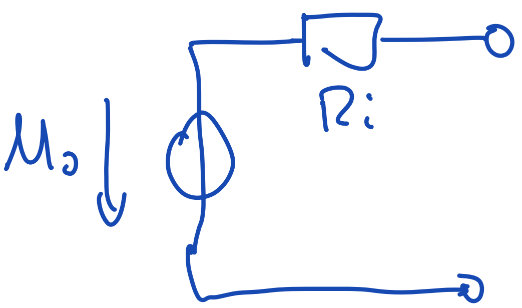
court-circuit	circuit ouvert (pas de R_e)
$R_e = 0$	
$U_{e\,cc} = 0$	$U_{e_0} = U_0$
$I_{cc} = \frac{U_0}{R_i}$	
$I_{e\,cc} = I_{cc}$	$U_{e_0} = R_p I_{cc}$
$U_{e_c} = 0$	

On pose $U_{e0} = R_p I_{cc} = U_0$

$$I_{cc} = \frac{U_0}{R_i} = I_{e\,cc}$$

$$R_p = \frac{u_0}{I_{cc}} = \frac{u_0}{u_0/R_i} = R_i$$

En résumé :



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