EPFL Cours d'Electrotechnique I

2. Conventions et les symboles :

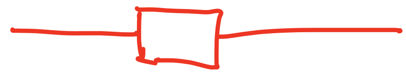
⟶ concepts → modèle

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

unité : [A]

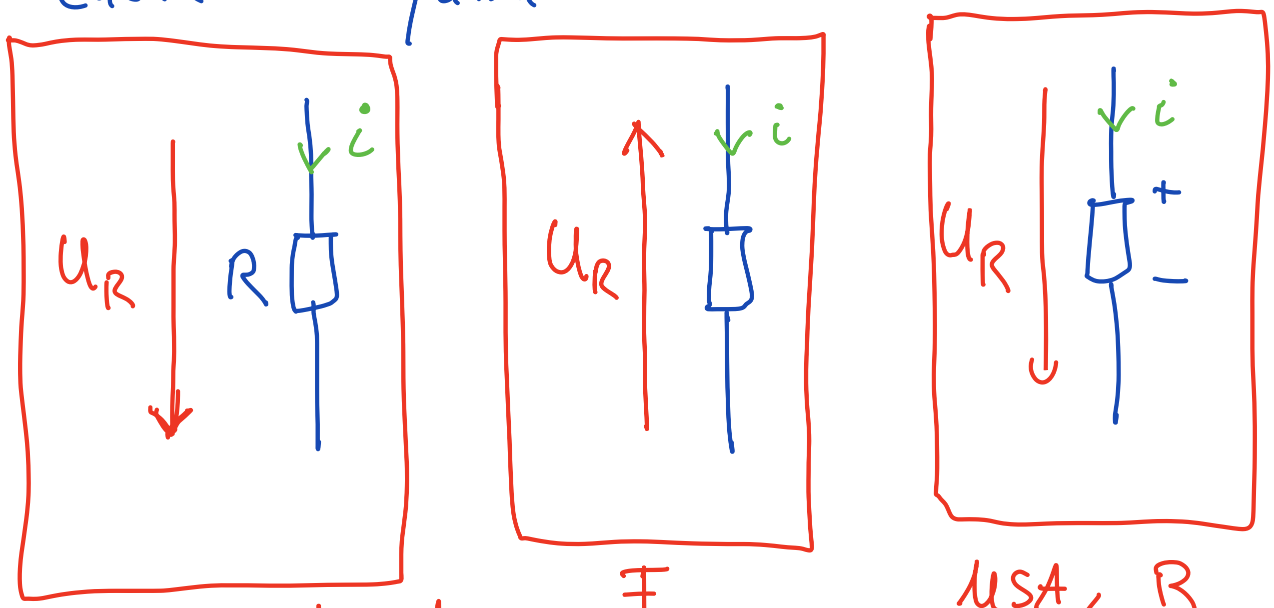
Relations : $U = R \cdot I$

$u = R \cdot i$

Dessin : 

Résistance

Choix à faire :

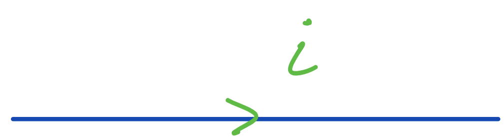


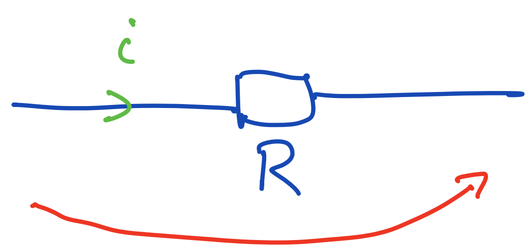
International | Fr | USA, B

Convention moteur : choix

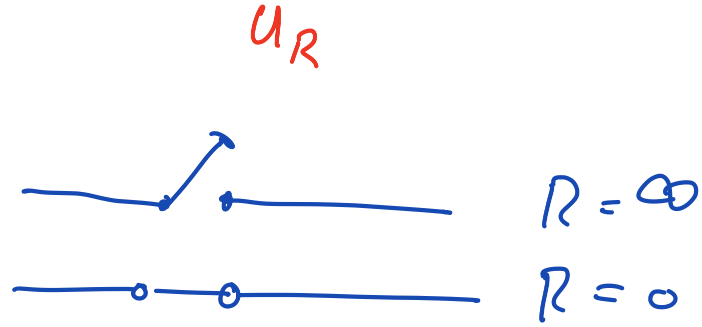
2.2 Représentation graphique :

Conducteur parfait :

Conducteur avec un courant : 

Élément : 

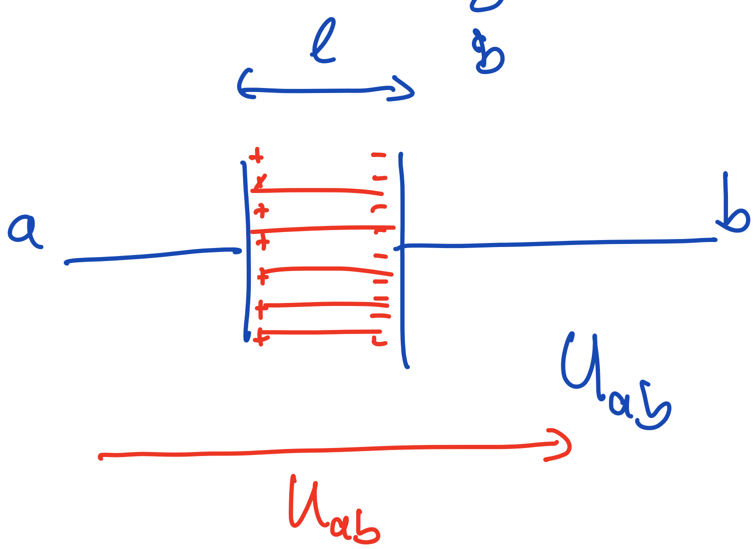
Interrupteur :



3. Lois fondamentales :

Différence de potentiel : Tension [Volt]

$$V_a - V_b = \int_b^a E\,dl = U_{ab} \quad [V]$$



3.2.19 La Capacité :

Définition : Charge électrique : Q

Capacité : $C = \dfrac{Q}{U_{ab}}$

Symbole : 

3.3 Courant électrique :

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

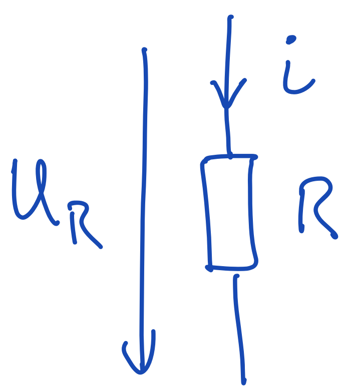
Densité de courant : $J \Rightarrow [A/m^2]$

3.3.4 Pertes Joule :

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

Récap :

Convention Moteur :



→ Puissance positive

→ conv. Moteur consommateur.

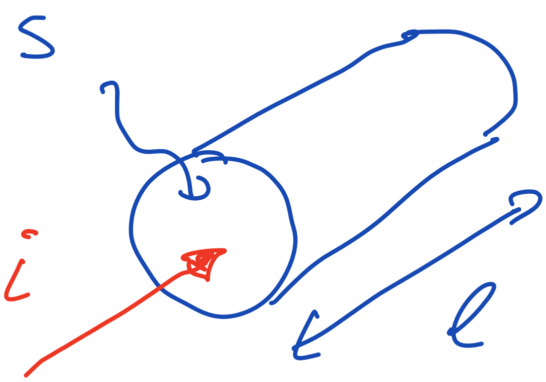
3.3.6 Définition de la résistance :

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

dl ← longueur

S ← surface

ρ ↑ résistivité électrique $[\Omega m]$



Si S est constante sur la longueur

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

3.3.8 Loi d'Ohm :

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

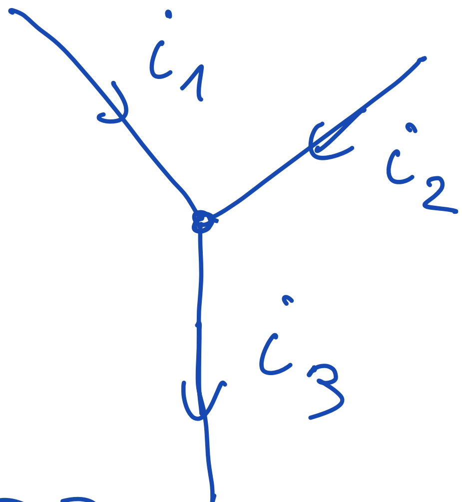
(courant et tension continue)

$u_{ab} = R_{ab} \cdot i$ (courant et tension variable)

3.3.11 Lois de Kirchhoff :

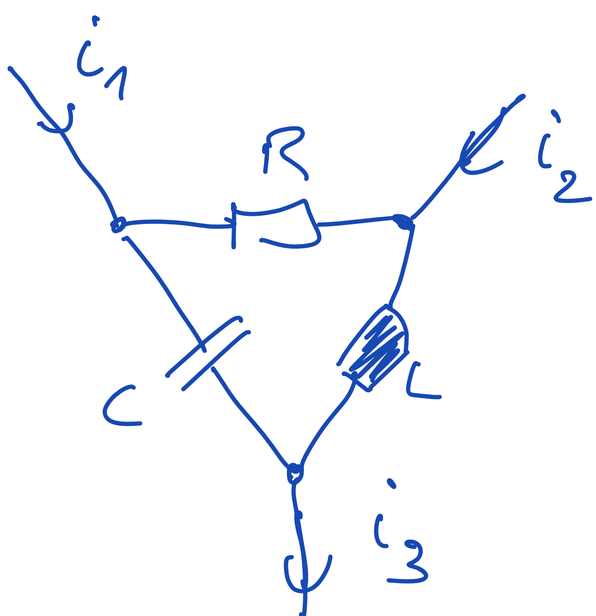
Noeud : Point de convergence d'au moins trois conducteurs

$$\sum i_j = 0$$



$$i_1 + i_2 - i_3 = 0$$

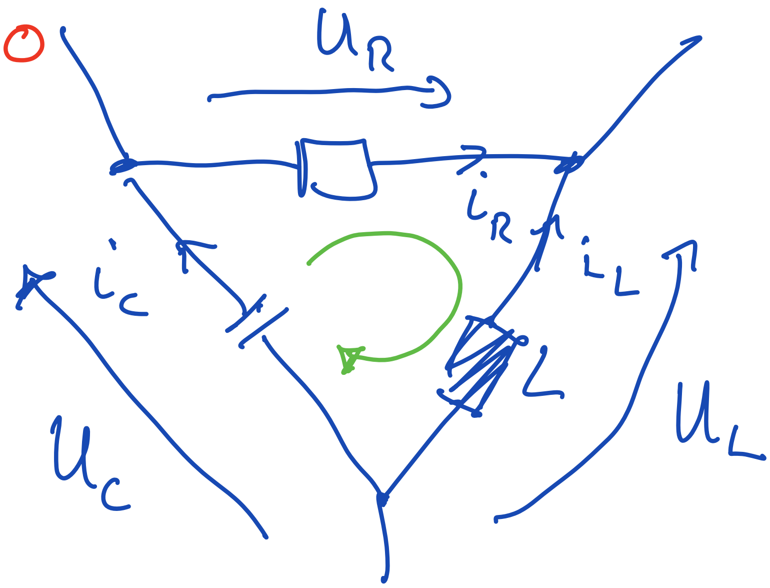
Noeud généralisé :



$$i_1 + i_2 - i_3 = 0$$

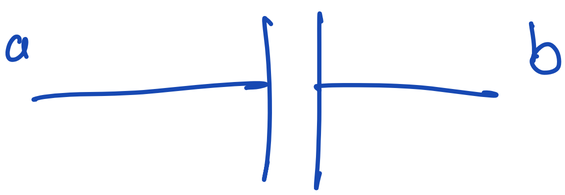
Maille : ensemble de branche partant d'un noeud pour y retourner

$$\sum u_j = 0$$



$$u_R - u_L + u_C = 0$$

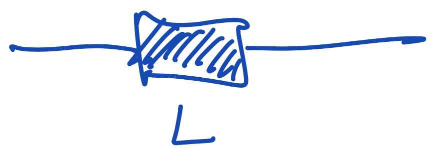
3.5 La Capacité :

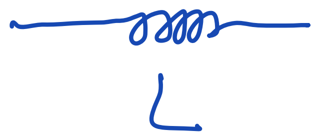


$$C = \frac{Q}{u_{ab}} \qquad Q = \int i \, dt$$

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

3.4 l'inductance :





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

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

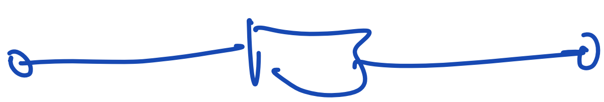
$$\vec{Rot}\,\vec{E} = -\frac{d\vec{B}}{dt}$$

L [H] Henry

4. Eléments de circuit :

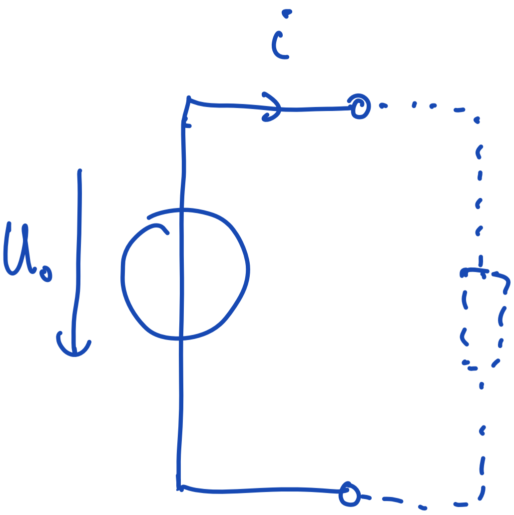
4.1 Dipôle :

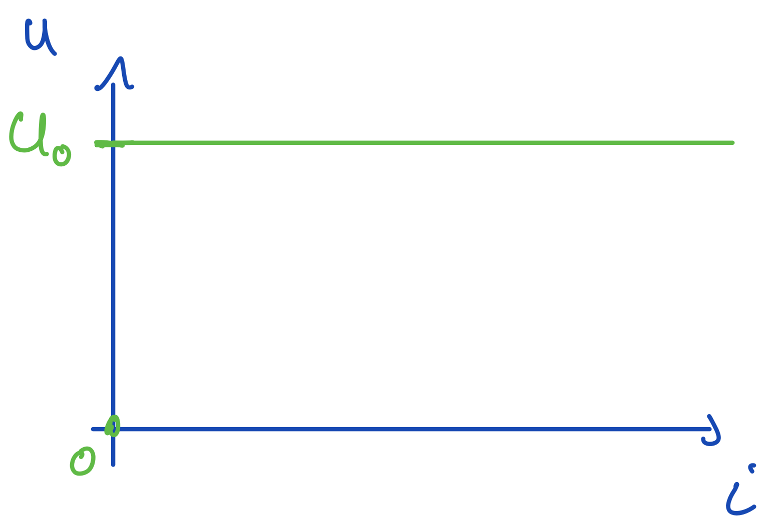
circuit qui possède 2 bornes



4.2 Sources de tension et de courant

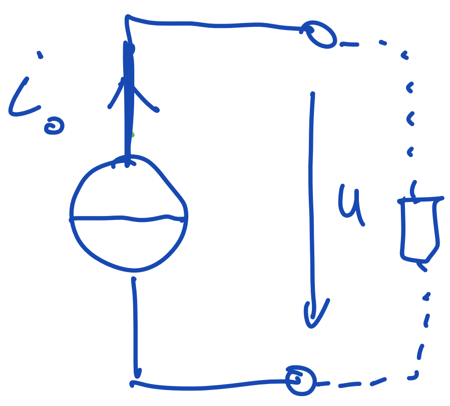
a) Source de tension idéale :

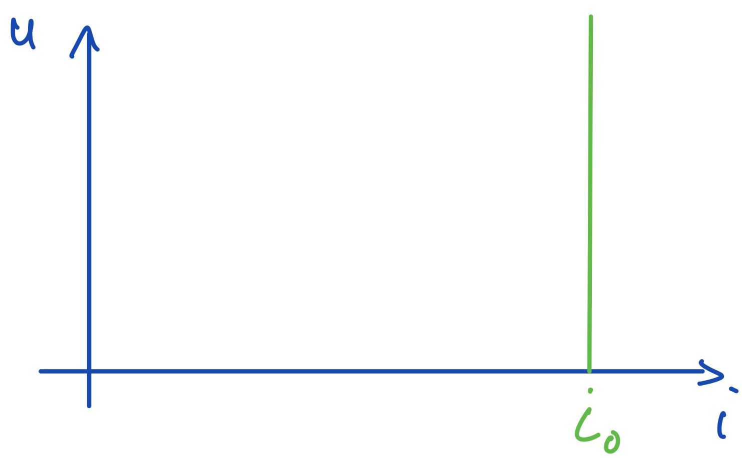




c'est un élément virtuel, idéal et inexistant dans la nature

b) Source de courant idéale :

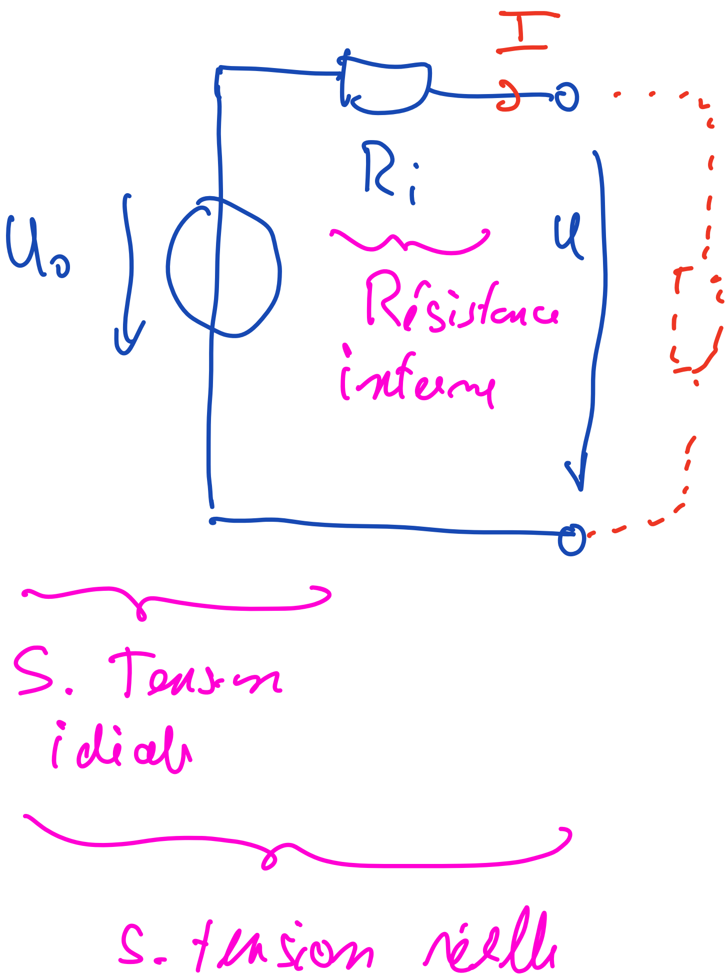




élément virtuel, inexistant dans la nature.

4.2.5 Source de tension réelle :

Déf :

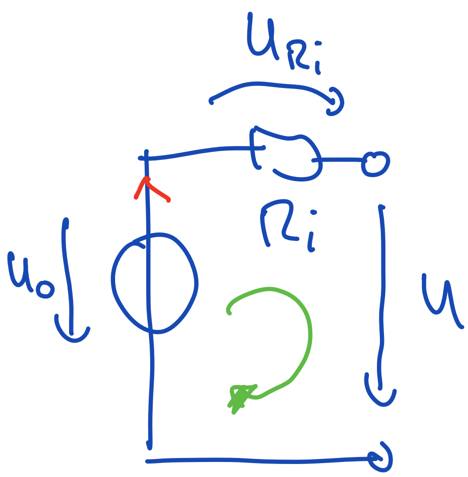


U_0 : Tension de la source idéale

Tension à vide

R_i : Résistance interne

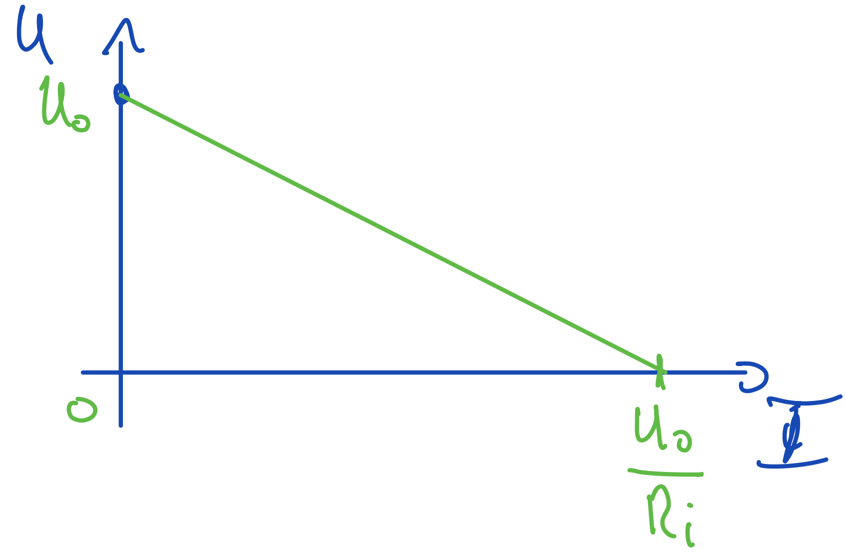
U : Tension de la source



$$\sum U = 0$$

$$-U_0 + U_{R_i} + U = 0 \qquad U_{R_i} = R_i \cdot I$$

$$U = U_0 - R_i \cdot I$$



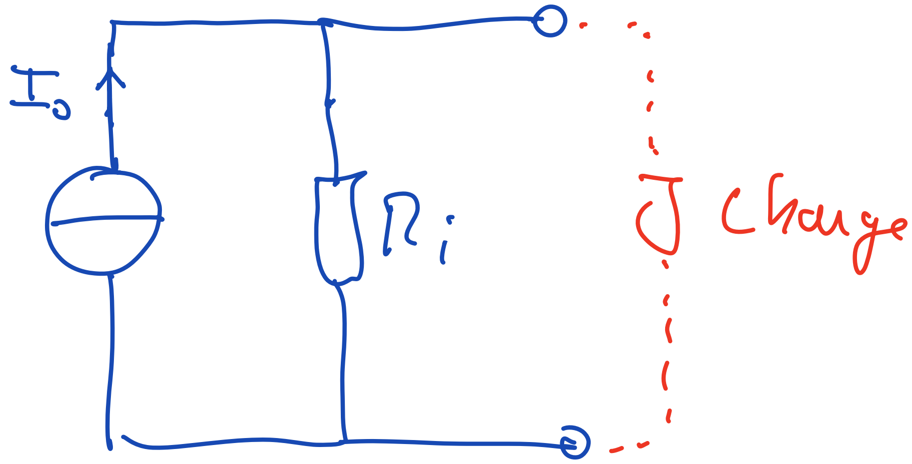
courant max :

$$U = 0$$

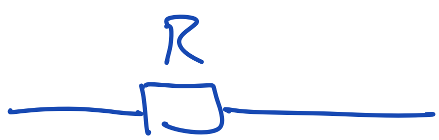
$$0 = U_0 - R_i \cdot I_{cc}$$

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

4.2.6 Source de courant réelle :



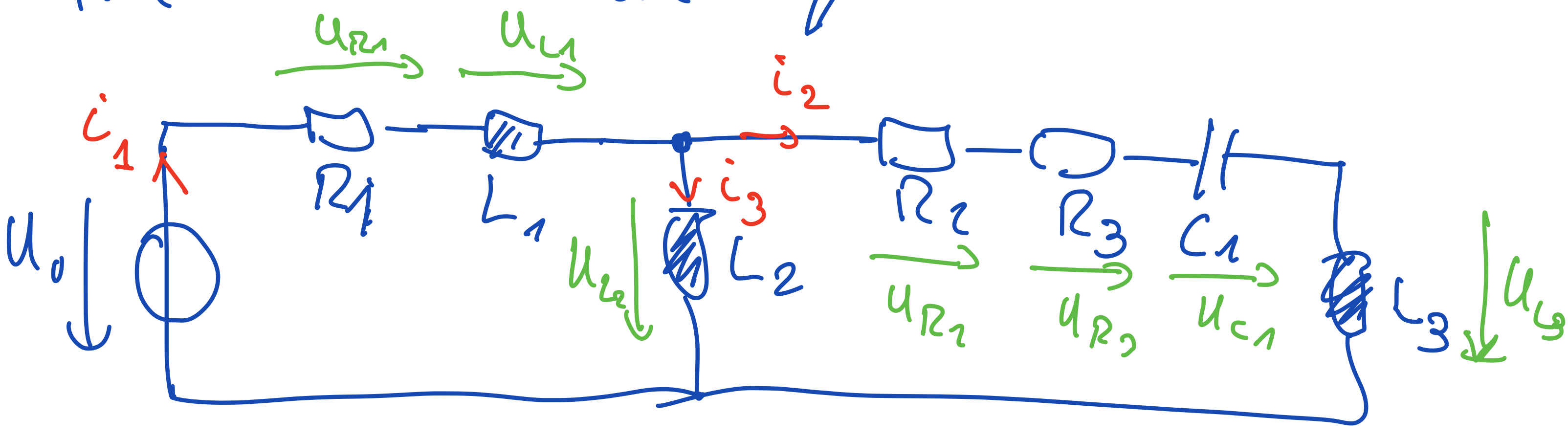
4.3 Élément de base :

Résistance 

Inductance 

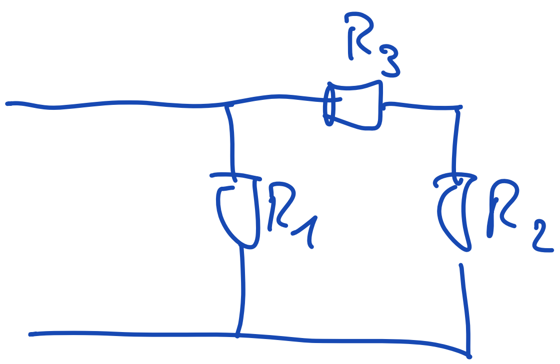
Capacité 

4.4 Schéma électrique :



Recap : Quiz :

4 : // → même tension aux bornes



R_1 n'est pas en // avec R_2 !

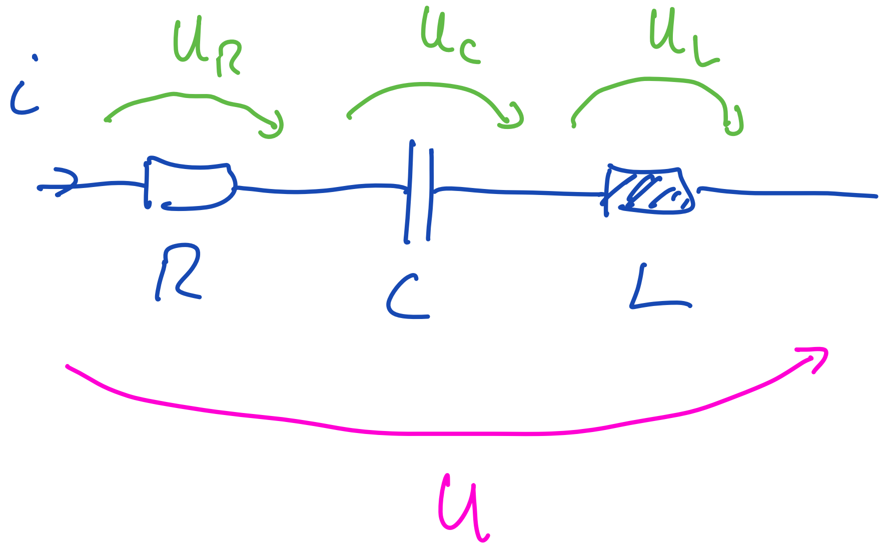
7 : Source idéale seule impossible.

8 : Source idéale est toujours constante

9 : Impossible de mettre des sources de courant en série.

5. Combinaison simple d'éléments linéaires

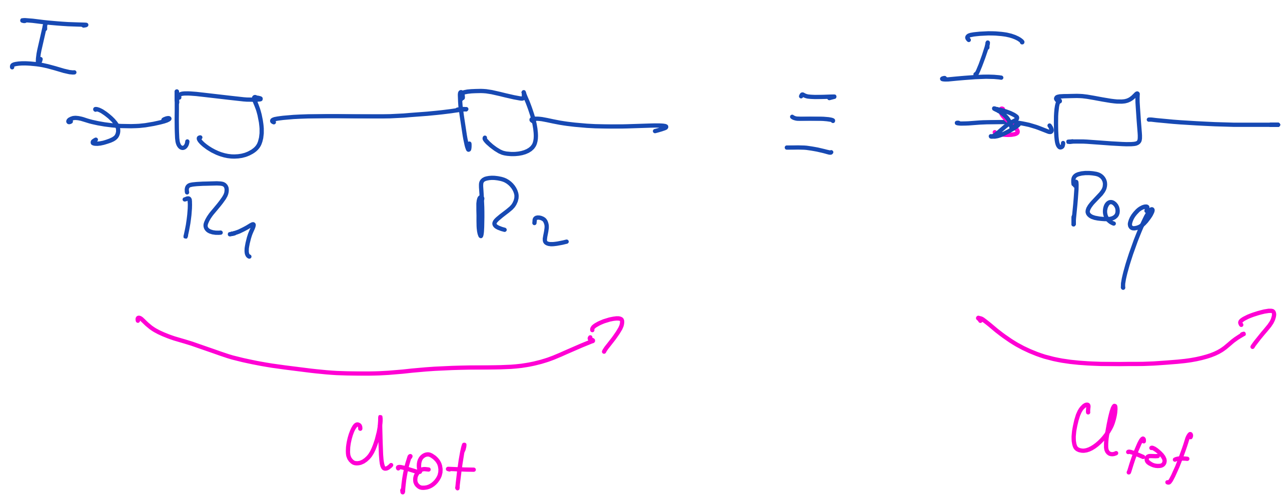
5.2 Mise en série :



Série : parcouru par le même courant

$$i_R = i_L = i_C \rightarrow \text{Série}$$

5.2.2 Mise en série de la résistance



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

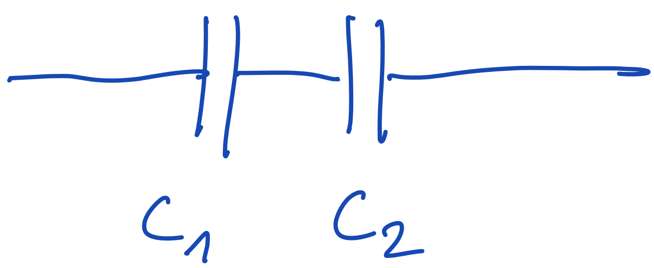
$$= R_1 I + R_2 I$$

$$= (R_1 + R_2) I = R_{eq} \cdot I$$

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

En série $R_{eq} = \sum_{K=1}^{n} R_K$ (n = nb de R)

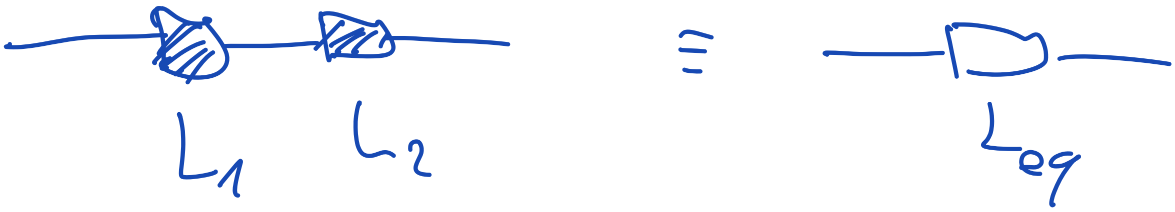
5.2.3 Mise en série des C



$\equiv$ $C_{eq} = ?$

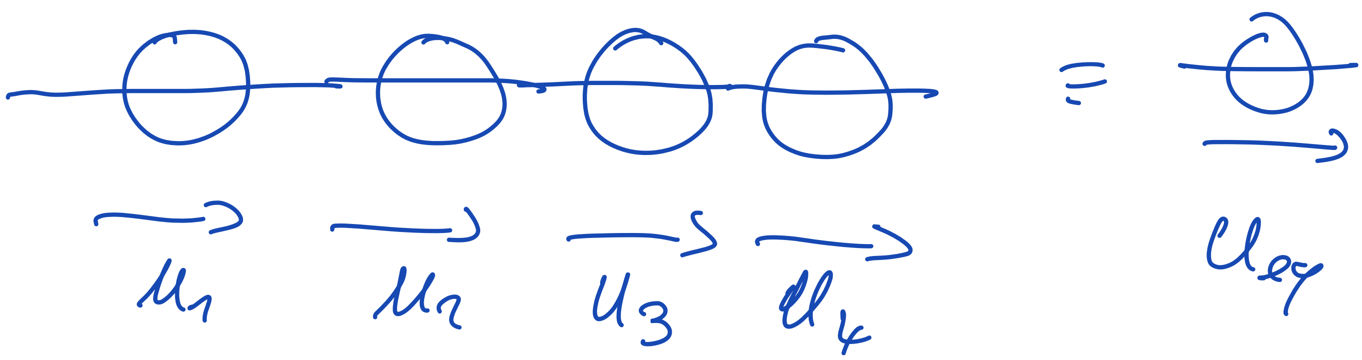
Série $C_{eq} = \dfrac{1}{\sum_{K=1}^{n} \frac{1}{C_K}}$ n = nb de C

5.2.6 Mise en série des L

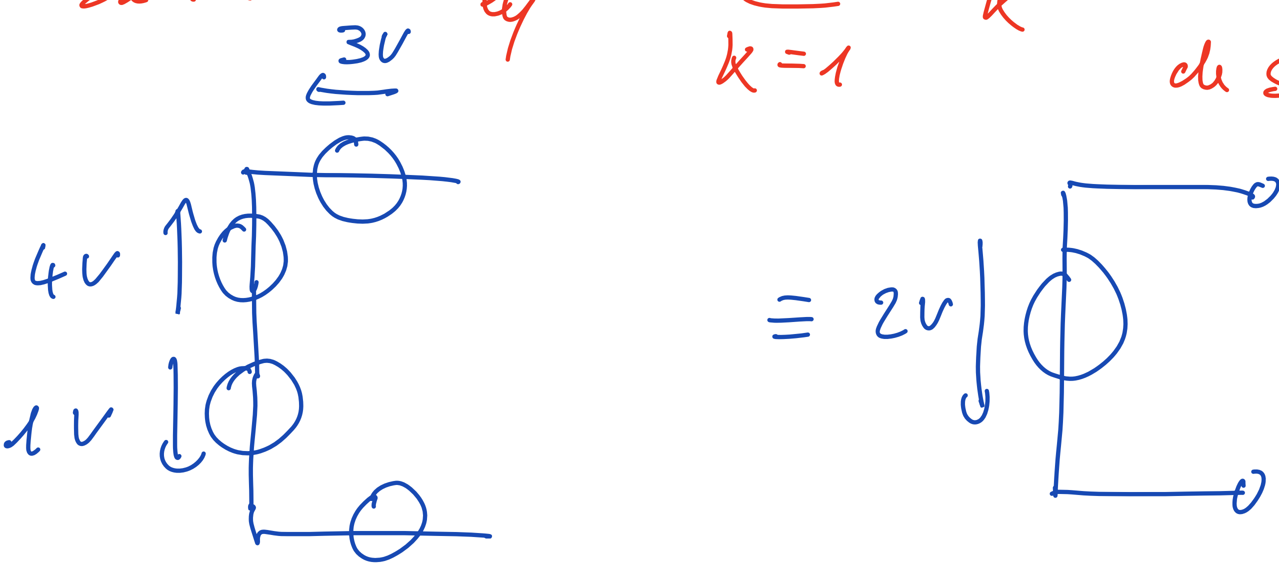


Série $L_{eq} = \sum_{k=1}^{n} L_k$ n = nb de L

5.2.7 Mise en série de source de tension

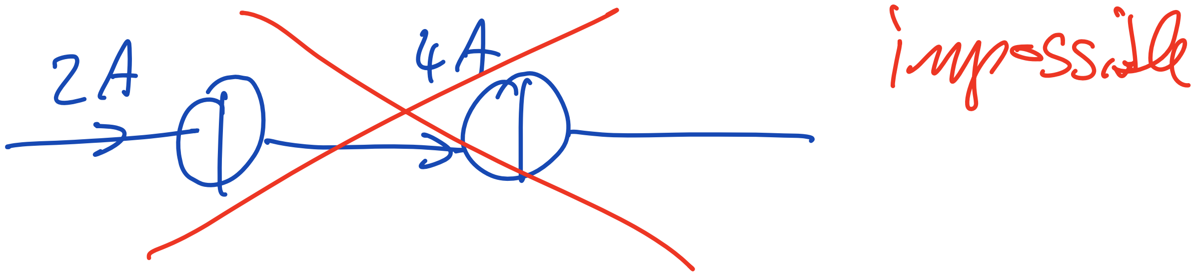


Série $U_{eq} = \sum_{k=1}^{n} U_k$ n = nb de source



$\overrightarrow{2U}$

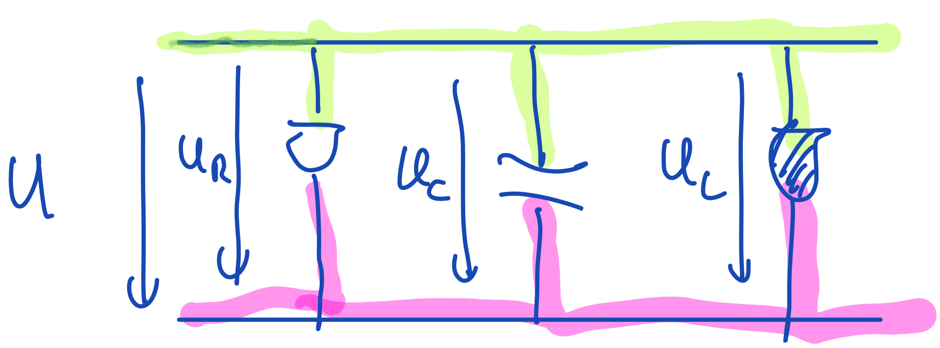
5.2.9 Mise en série de source de courant



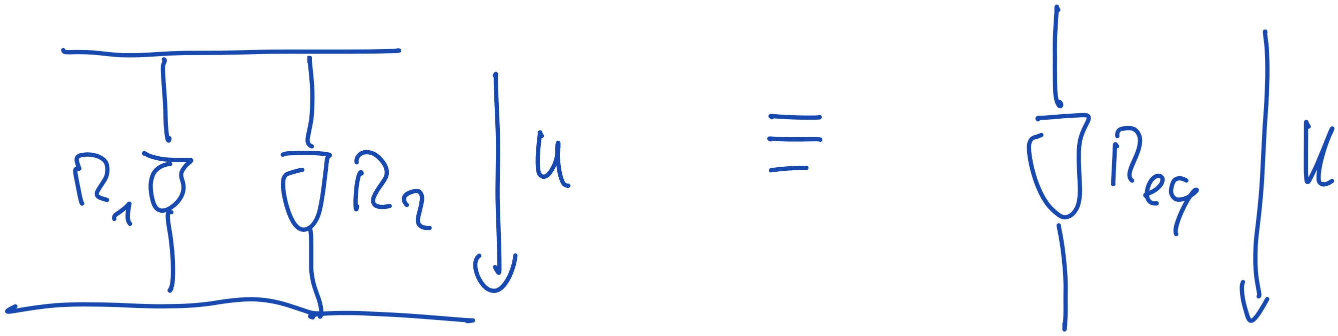
⇒ Impossible sauf si toutes les sources ont le même courant

5.3.2 Mise en // des R :

Définition : Toutes les bornes des éléments sont au même potentiel



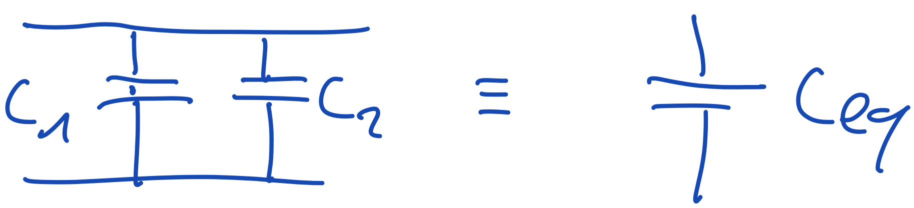
$$U_R = U_C = U_L$$



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

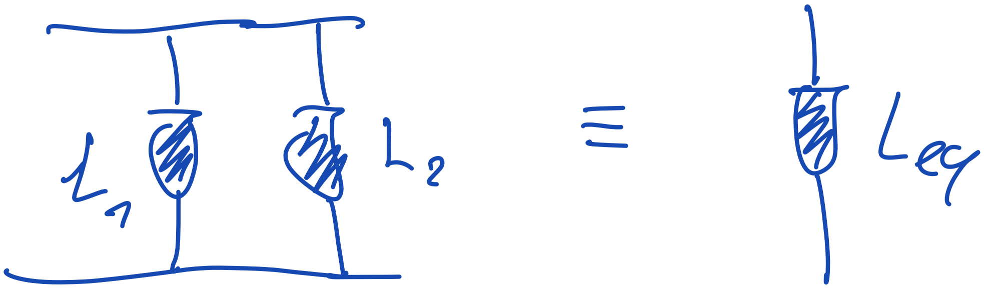
$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} \Rightarrow R_{eq} = \frac{R_1 \cdot R_2}{R_1 + R_2}$$

5.3.5 Mise en // des C :



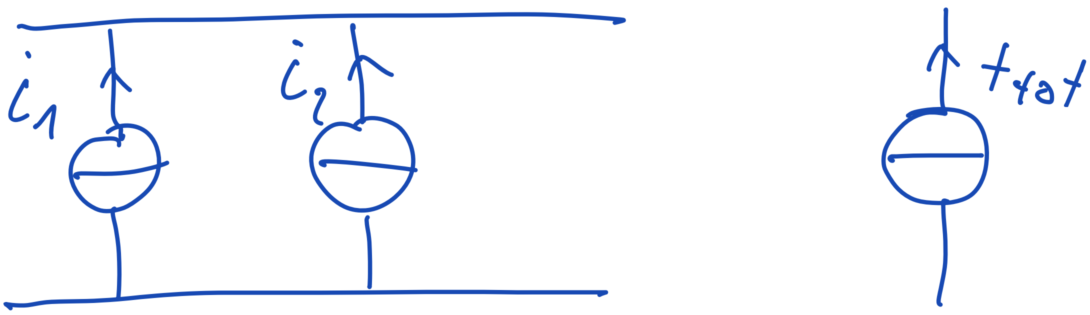
// $C_{eq} = \sum_{k=1}^{n} C_k$ $n = $ nb de C

5.3.6 Mise en // des L



// $L_{eq} = \dfrac{1}{\sum_{k=1}^{m} \dfrac{1}{L_k}}$ $\quad m$ = nb de L

5.3.7 Mise en // des sources de courant

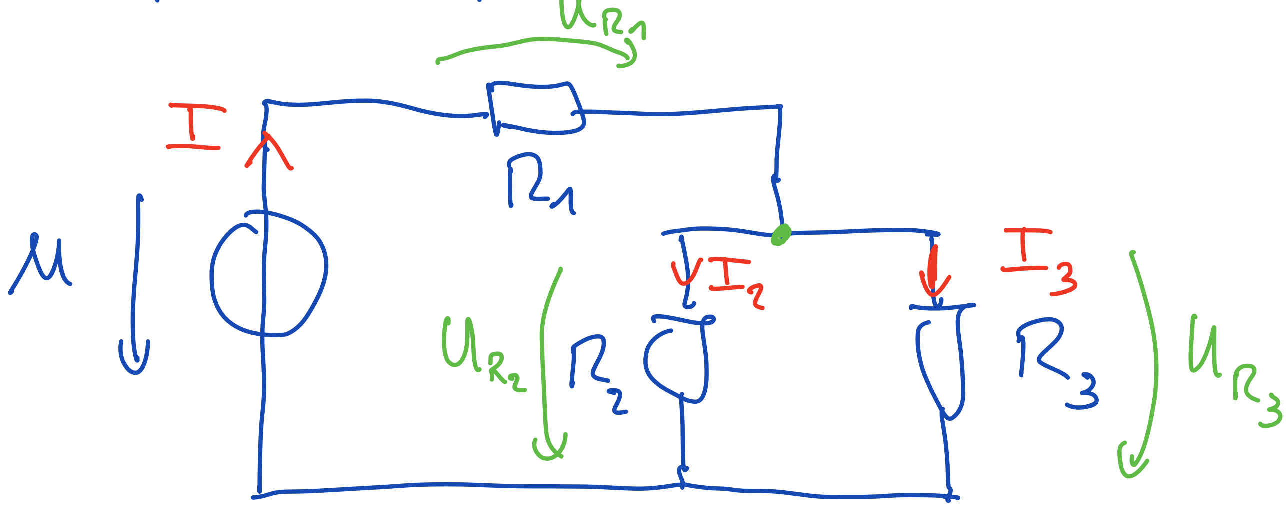


$$i_{tot} = \sum_{k=1}^{m} i_k$$

Mise en // de sources de tension

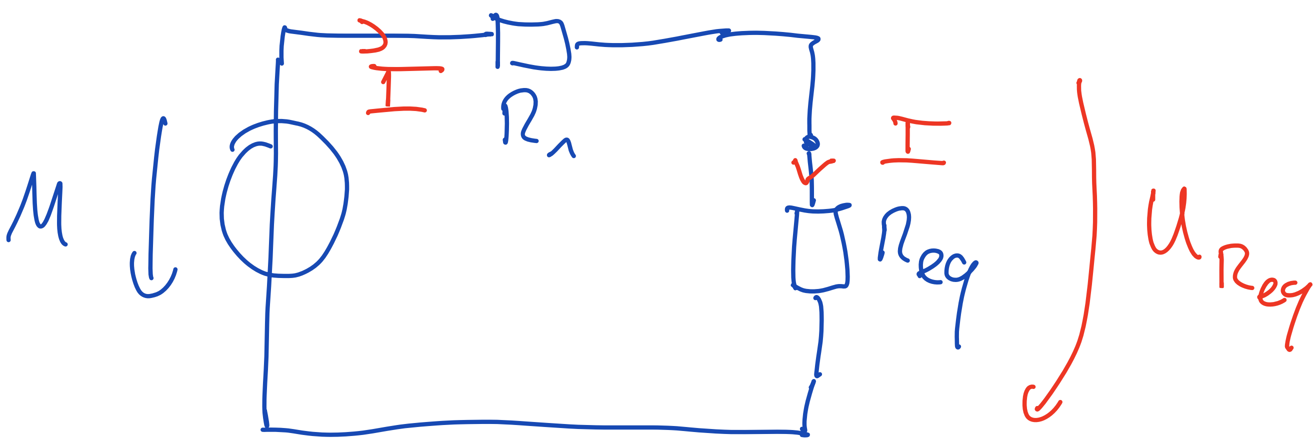
est impossible sauf si toutes les tension ont la même valeur

5.4 Circuits combinés :

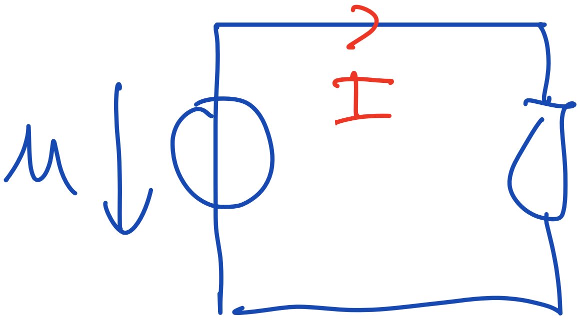


$I = ?$ I_2 ? I_3 ?

$R_2 // R_3$



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



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

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

$$U = R_{tot} \cdot I$$

$$I = \frac{U}{R_{tot}}$$

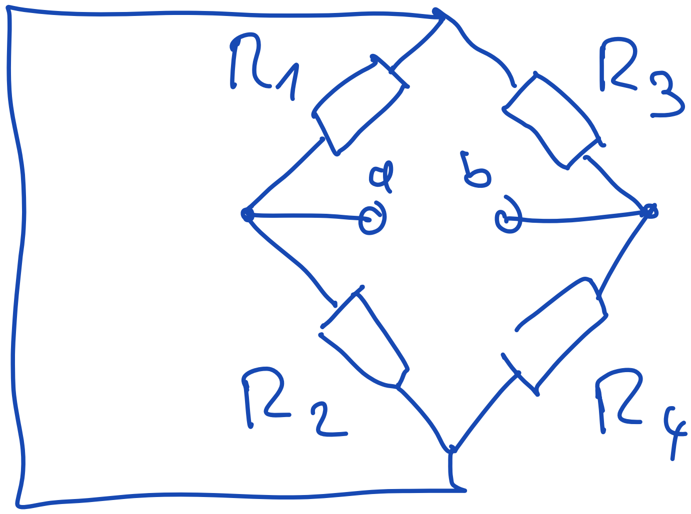
$$U_{R_2} = U_{R_3} = U_{R_{eq}} = R_{eq} \cdot I$$

$$= R_{eq} \cdot \frac{U}{R_{tot}}$$

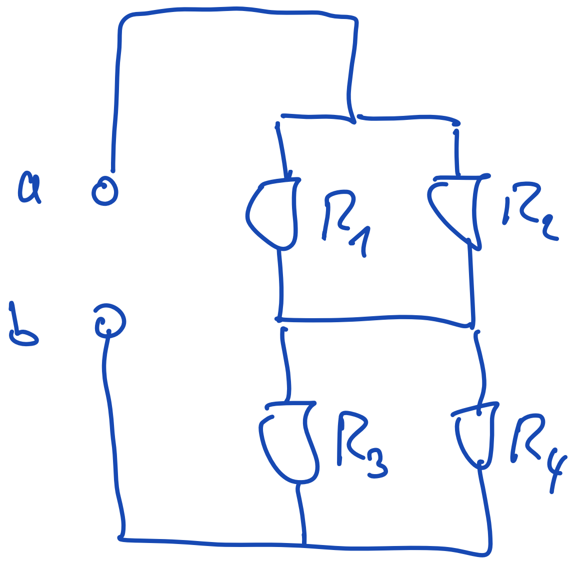
$$I_2 = \frac{U_{R_2}}{R_2} = \frac{U_{R_{eq}}}{R_2}$$

$$I_3 = \frac{U_{R_3}}{R_3} = \frac{U_{R_{eq}}}{R_3}$$

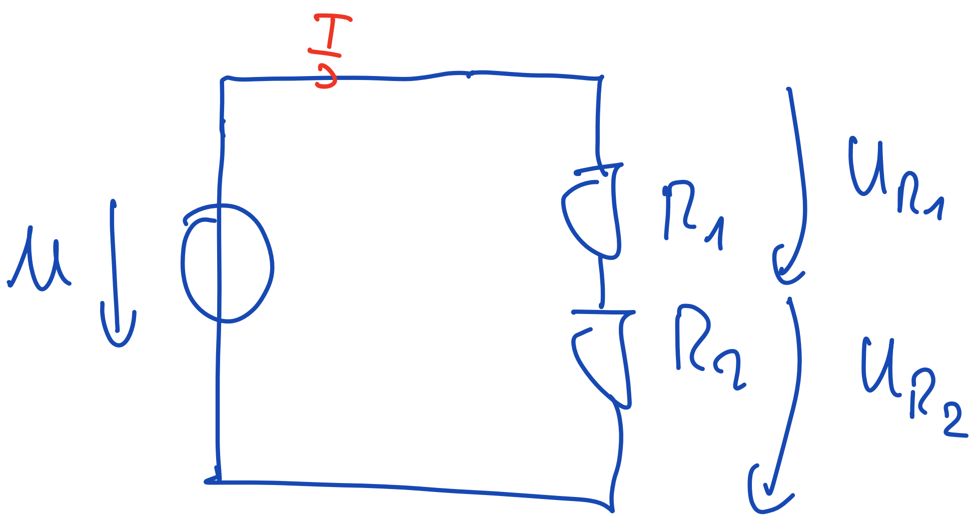
5.4.3 Exemple :



$\equiv$



5.5.1 Diviseur de tension :

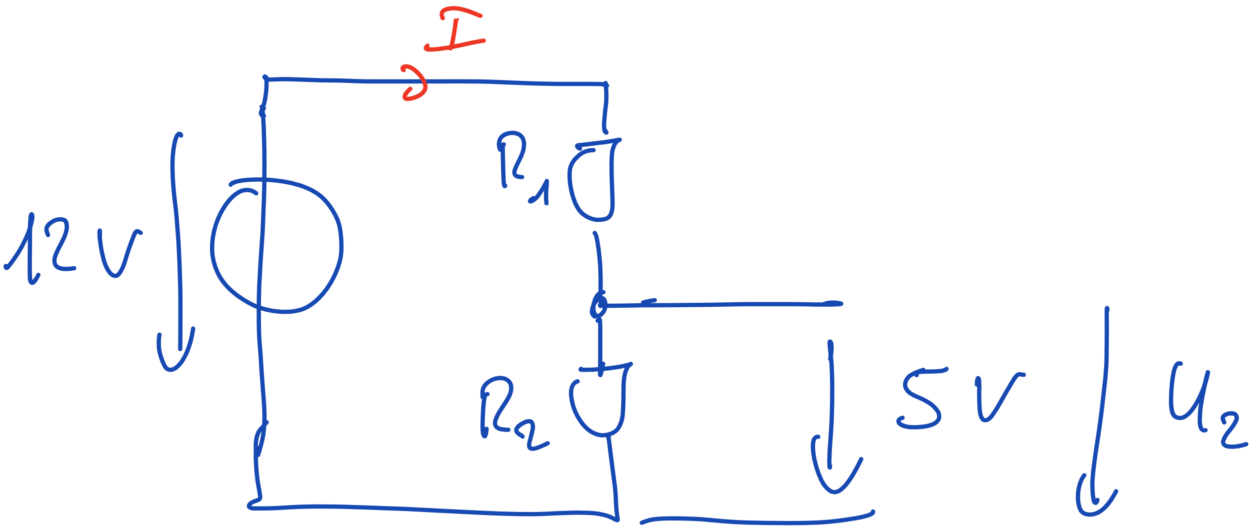


$$U = U_{R_1} + U_{R_2}$$

$$= (R_1 + R_2)\, I$$

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

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



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

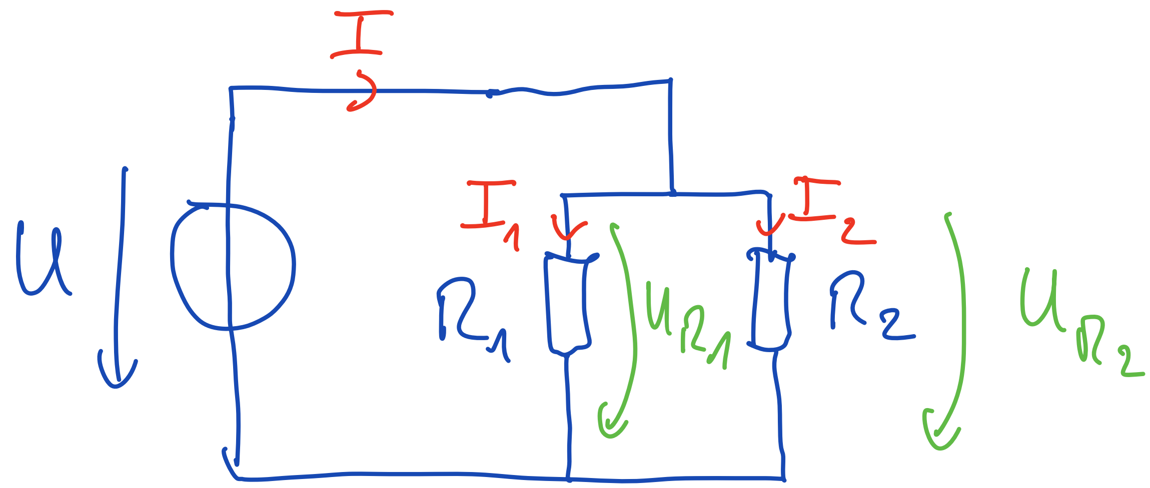
$$5 = \frac{R_2}{R_1 + R_2} \cdot 12$$

$$5 R_1 = 7 R_2$$

$$R_1 = 100 \text{ k}\Omega$$

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

5.5.4 Diviseur de courant :



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

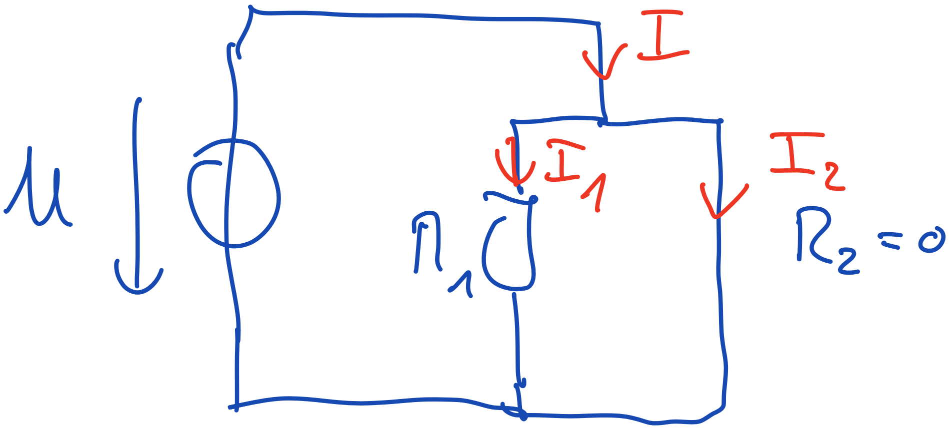
$$R_{eq} = \frac{R_1 \cdot R_2}{R_1 + R_2} \qquad I = \frac{U}{R_{eq}}$$

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

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

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

Si :



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

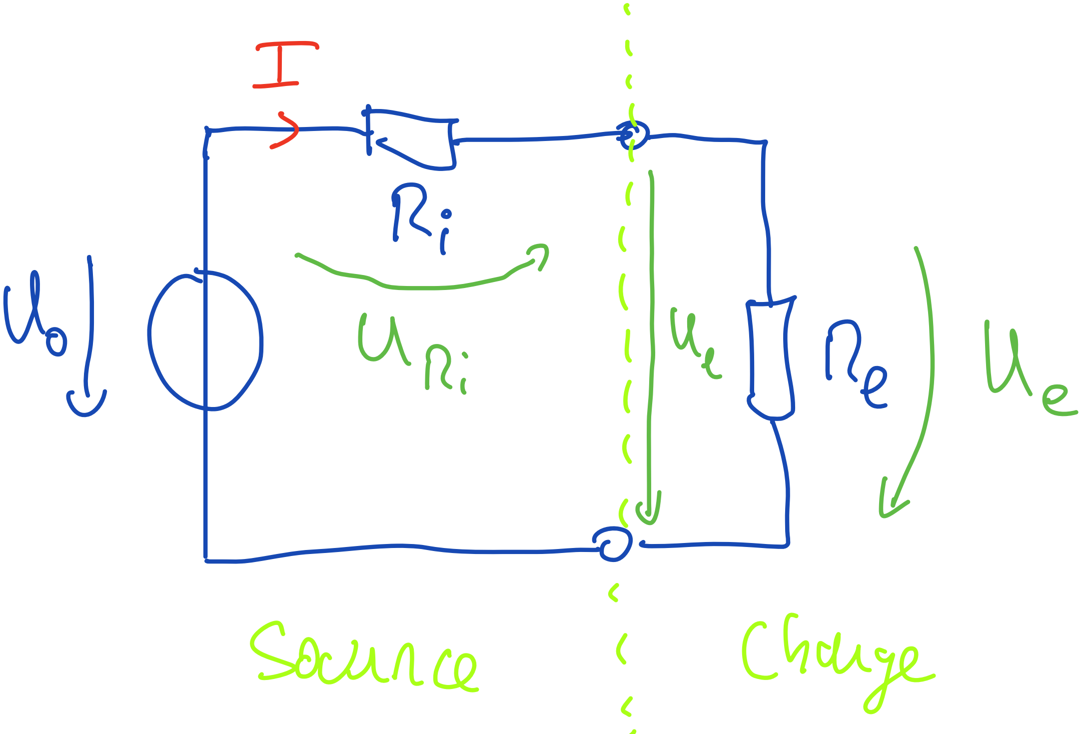
$$I_1 = 0$$

5.6 Méthodes de résolution :

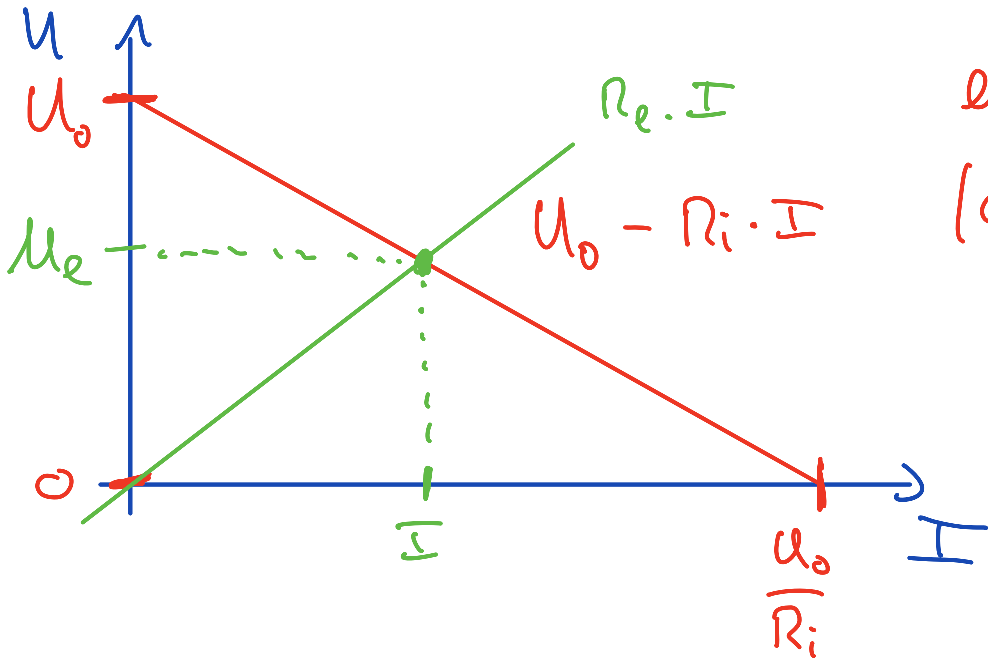
- Redessiner le schéma
- Définir toutes les grandeurs
  U, I, → indice
- Définir le sens des flèches
- Réduire le schéma, série ou //

• Analyse !

5.6.2 Source de tension réelle :



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



en court-circuit (cc) : $U_e = 0$

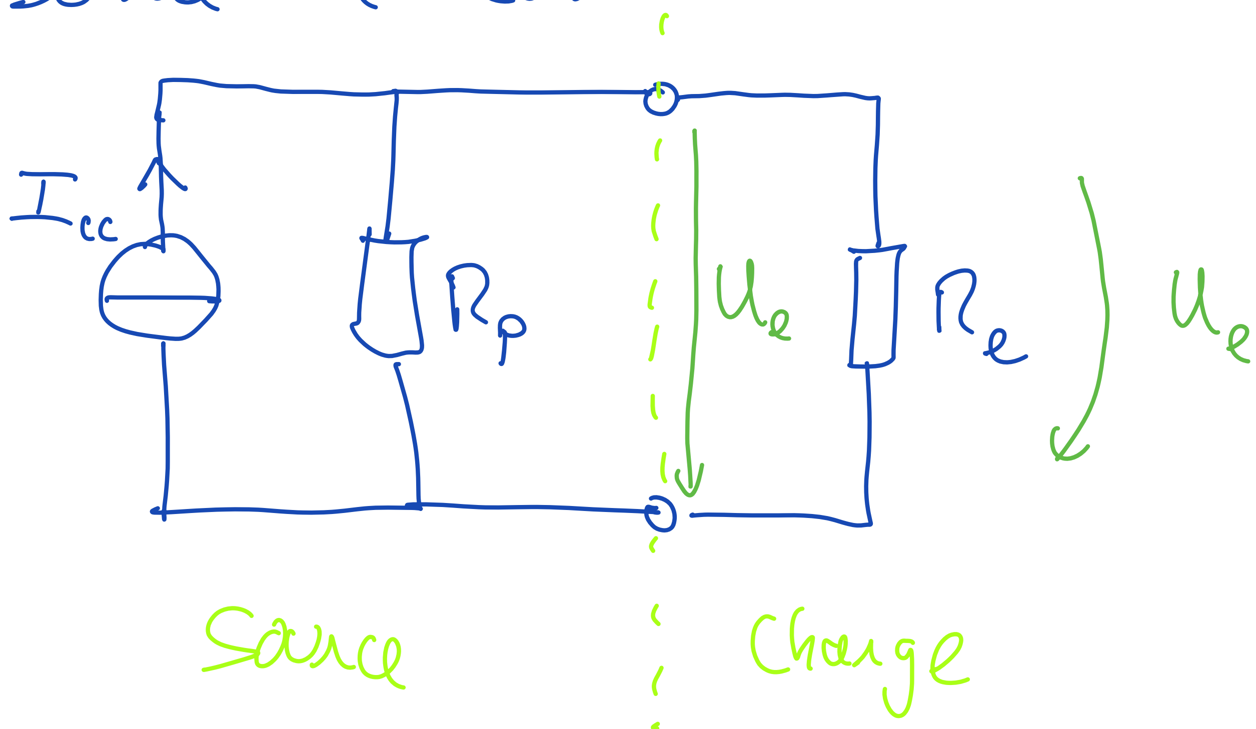
$$I_{cc} = \frac{U_0}{R_i}$$

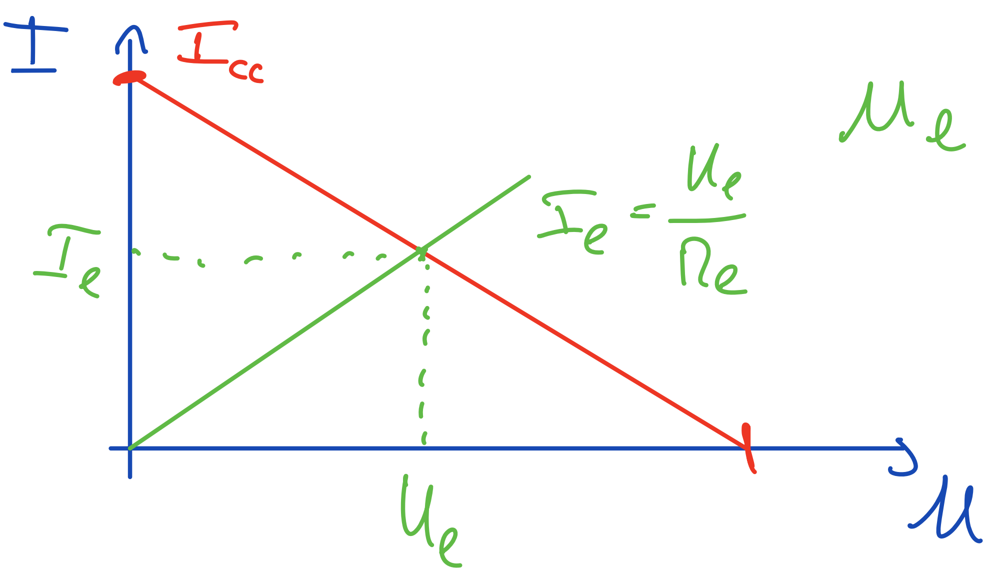
eq de la charge $\quad U_e = R_e \cdot I$

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

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

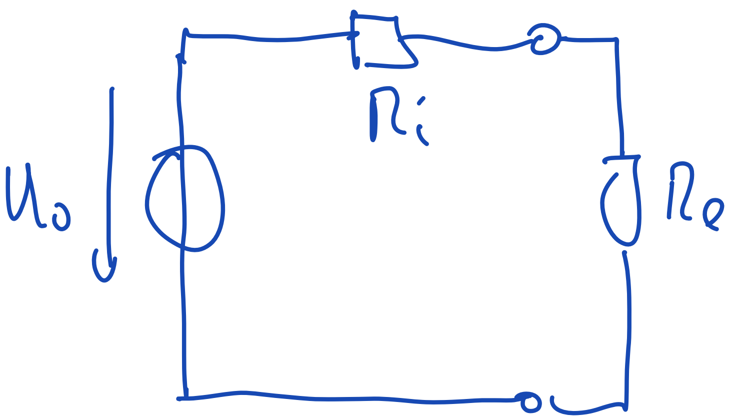
Source de courant réelle :

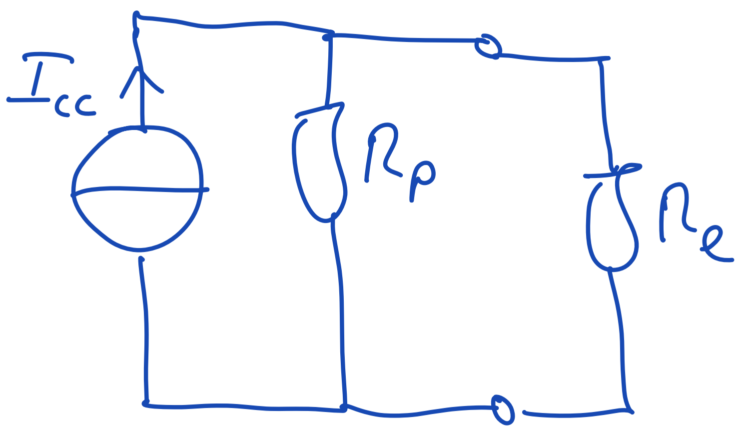




$$U_e = R_e \cdot I_e$$

5.6.3 Equivalence des sources de tension et courant réelles





court-circuit $R_e = 0$	circuit ouvert $R_e \to \infty$
	$U_{e_0} = U_0$