Optimiser le rendement d'un propulseur électromagnétique

I/ EXPÉRIMENTATIONS

maquette, essai

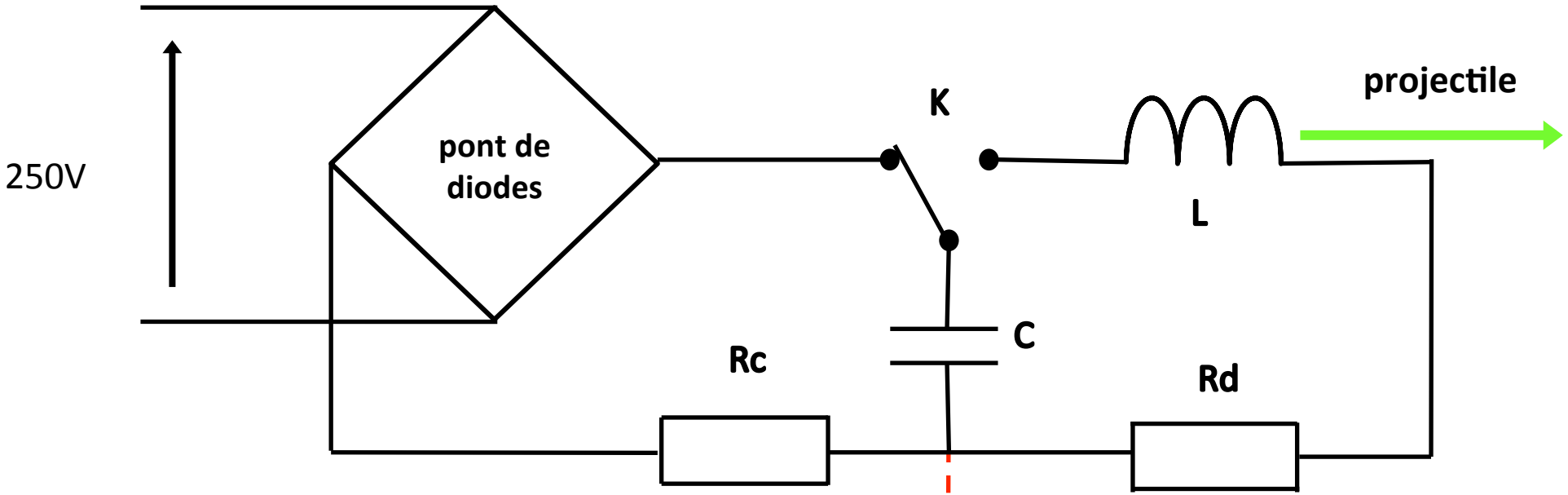
II/ ETUDE THEORIQUE

modèle de simulation

III/ OPTIMISATION

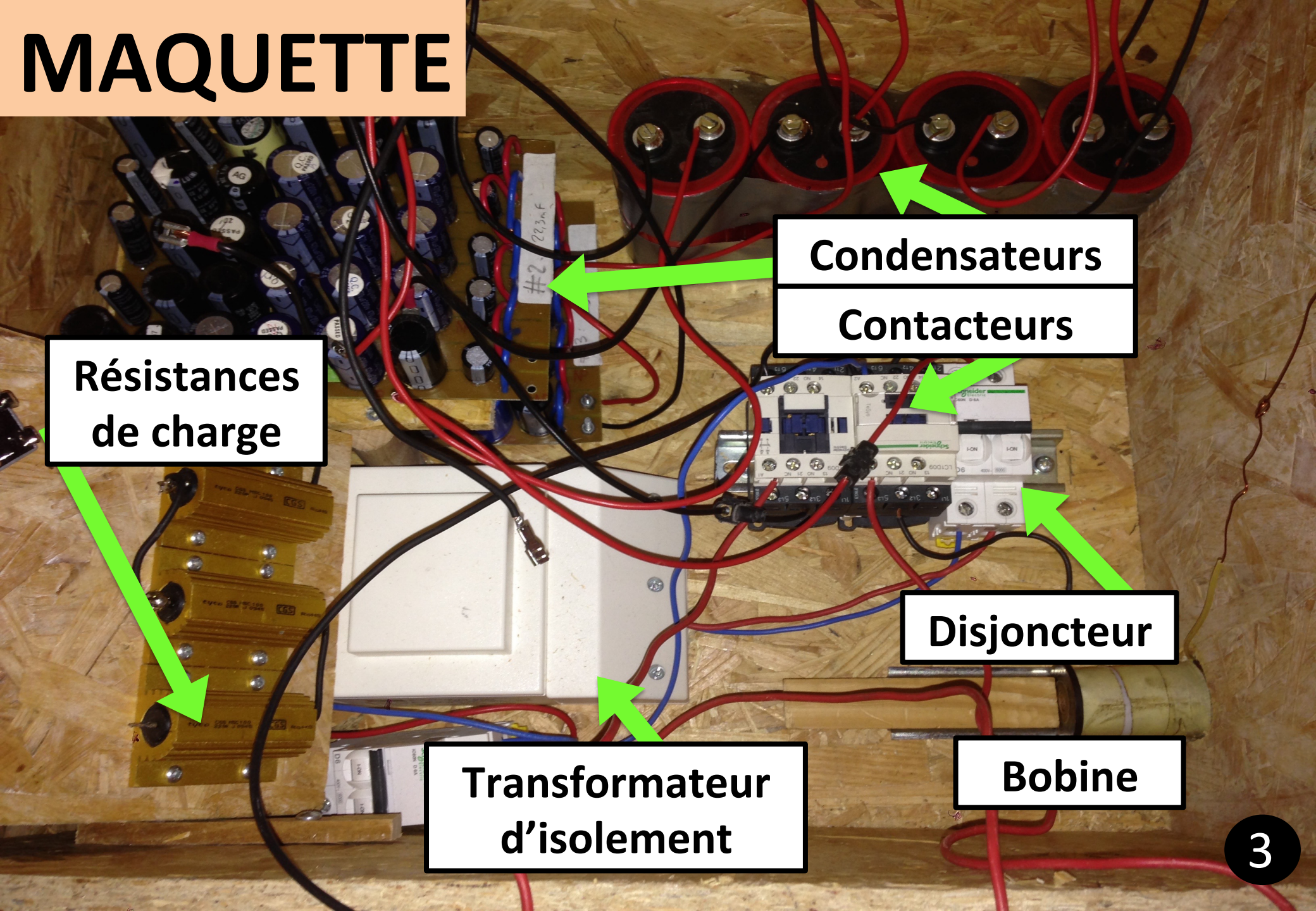
mise en évidence de la synchronisation

CHAÎNE D'ÉNERGIE



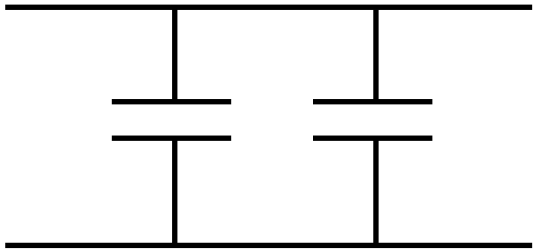
Alternatif → **Continu** → **Stockage** → **Énergie Mécanique**

MAQUETTE


Condensateurs
Contacteurs
Résistances de charge
Disjoncteur
Transformateur d'isolement
Bobine

CIRCUIT D'ADJONCTION

les **capacités** s'ajoutent



les **tensions** s'ajoutent

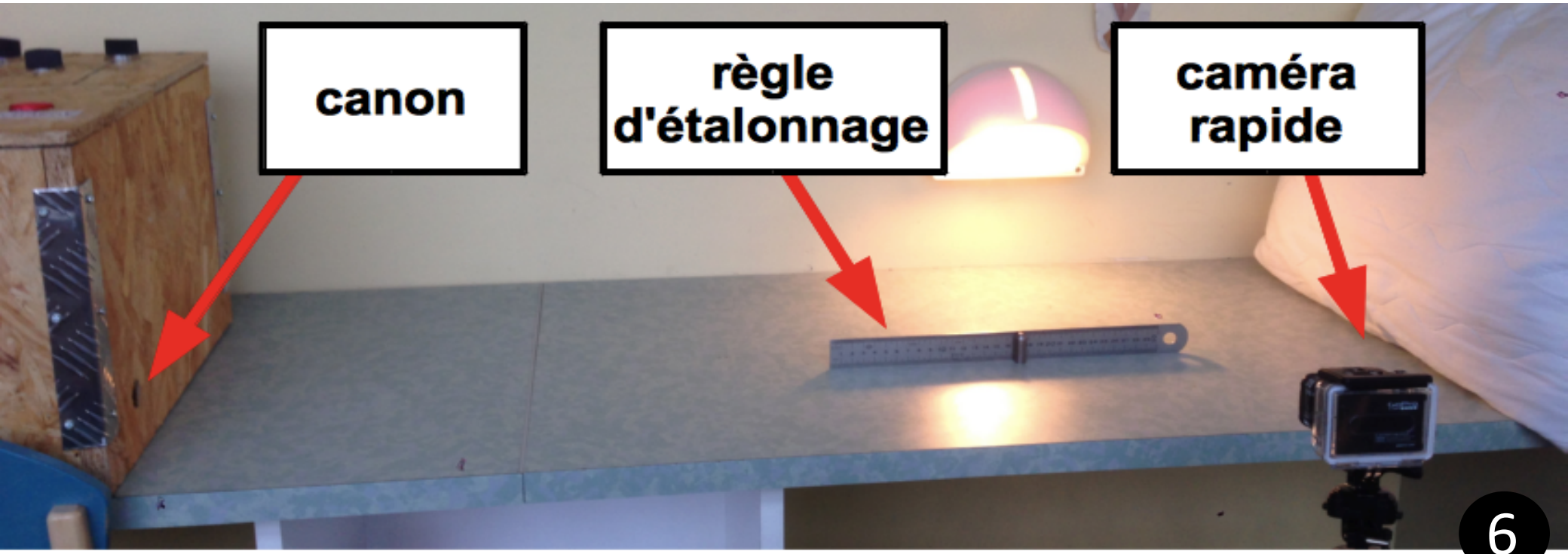
PROJECTILES

Cylindres | Tubes | Effilés | Laiton
Fer aimanté
Aluminium

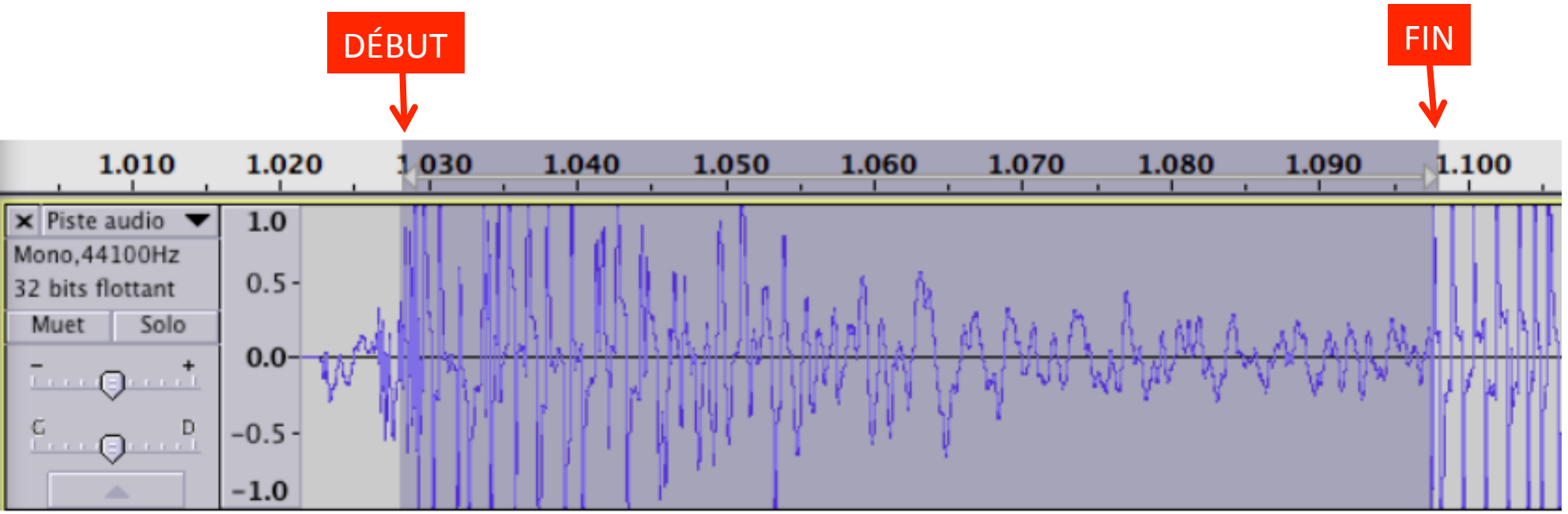
6-25 g
20-25 mm

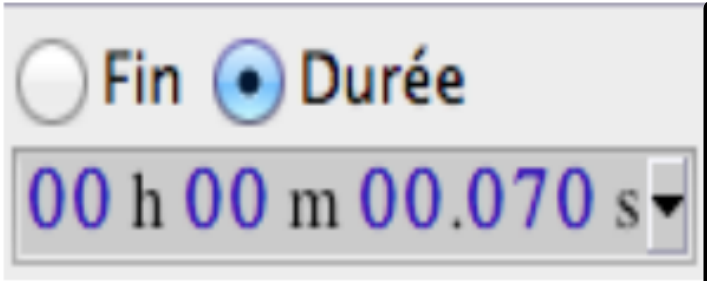
ACQUISITION VIDÉO

$$\text{rendement} = \frac{\text{energie cinetique}}{\text{energie capacitive}} = \frac{m \cdot v^2}{C \cdot U_c^2}$$



ACQUISITION AUDIO

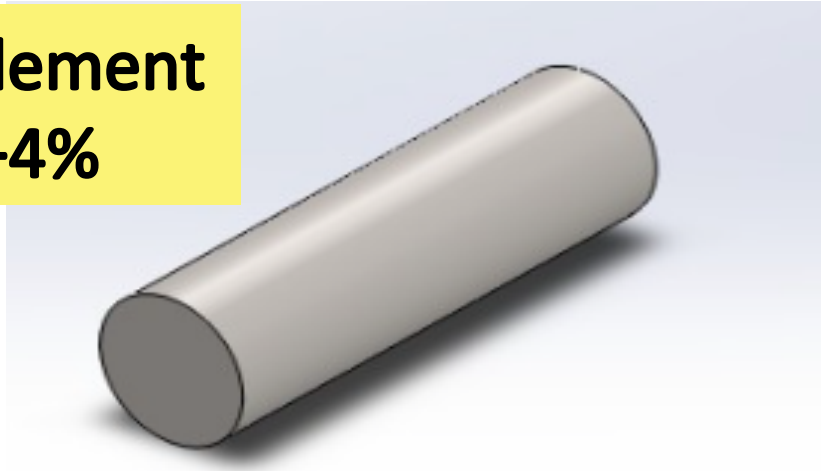




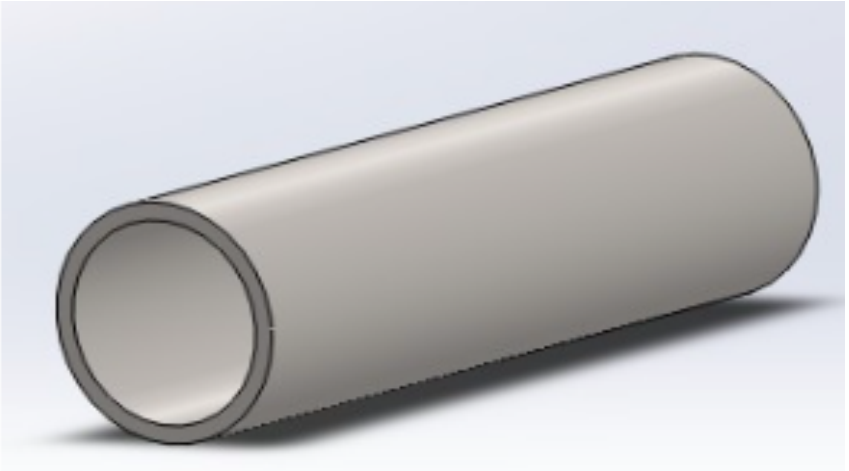
$$
\begin{aligned}
t &\approx 70\text{ms} \\
\Delta t &\approx 2\text{ms} \\
d &\approx 1.20\text{m} \\
\Delta d &\approx 2\text{mm}
\end{aligned}
\Rightarrow
\begin{aligned}
\Delta v/v &= 2.8\% \\
v &= 62 \pm 2\ \text{km/h}
\end{aligned}
$$

FORME OPTIMALE

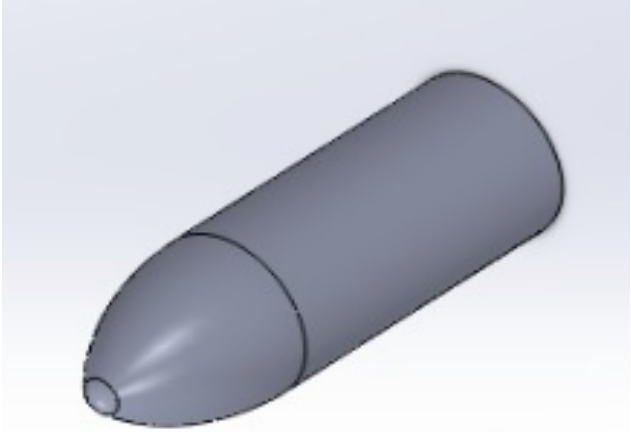
rendement +4%



rendement: 5,8%



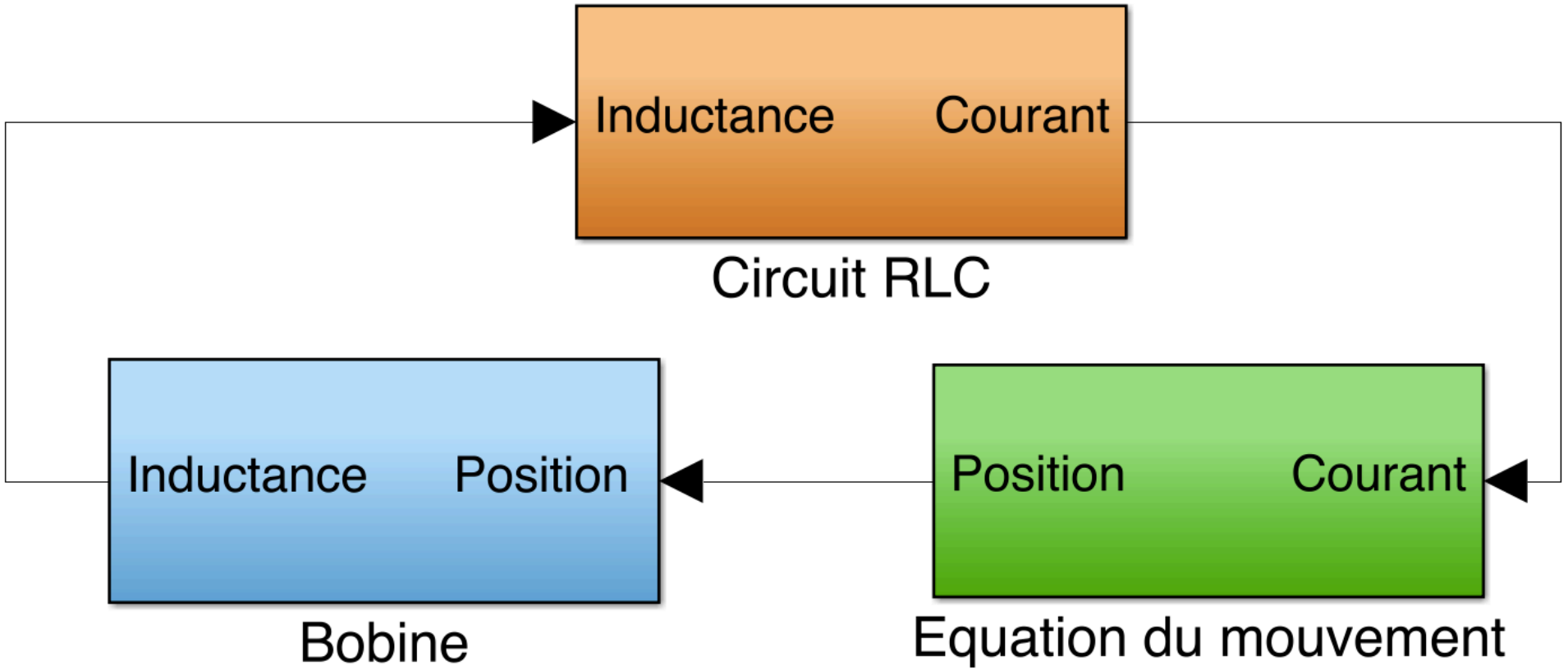
rendement: 2,3%



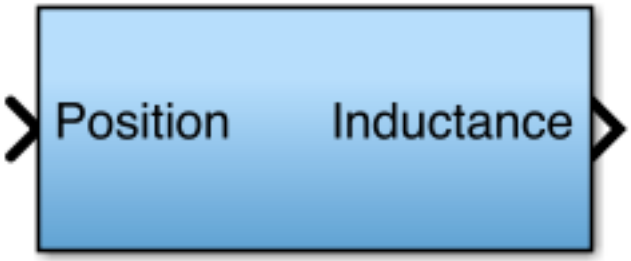
rendement: 5,9%

Les projectiles en aluminium et en laiton ne se déplacent pas sous l'action du champ magnétique

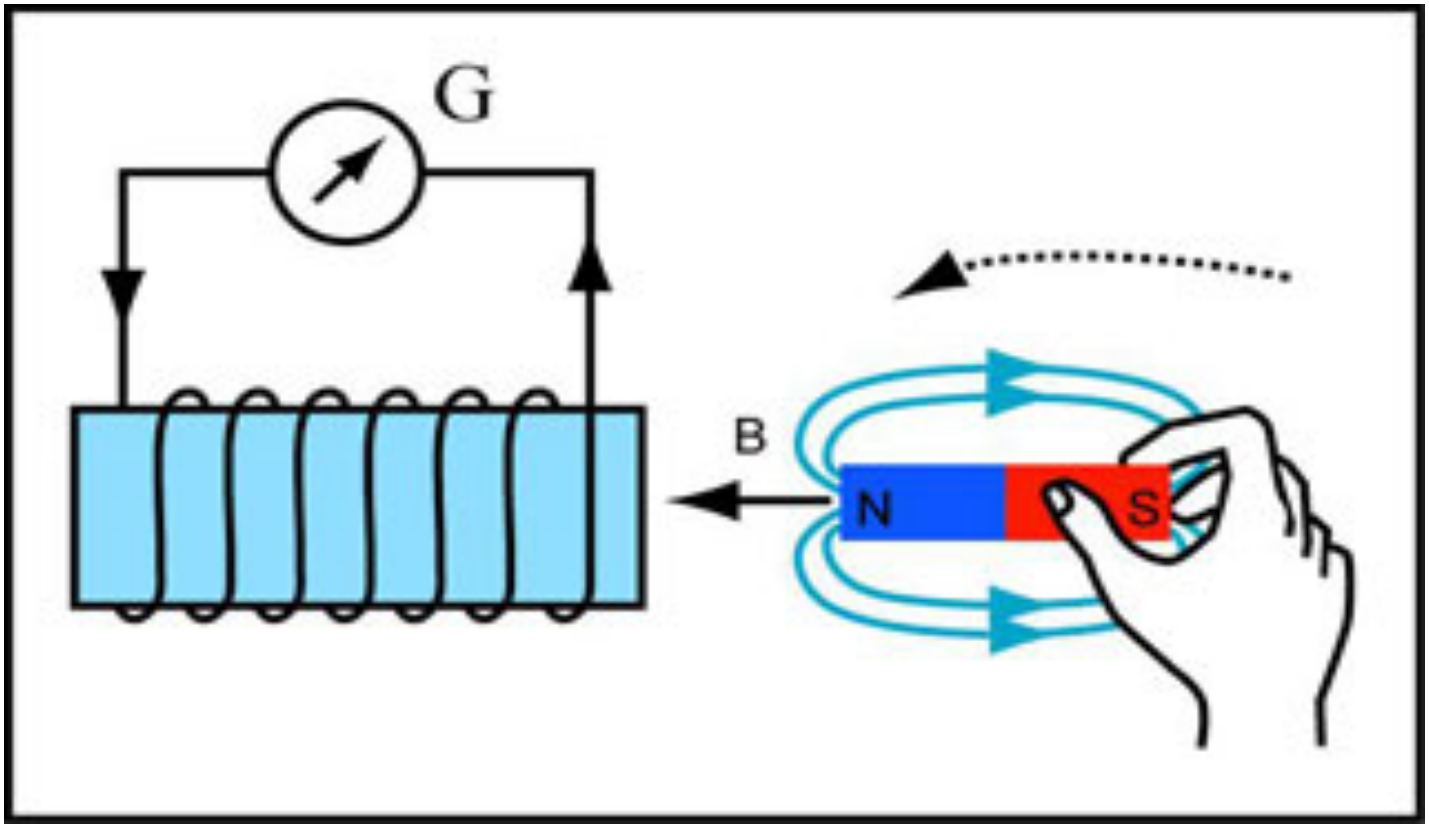
MODÈLE DE SIMULATION



MODÈLE DE L'INDUCTANCE

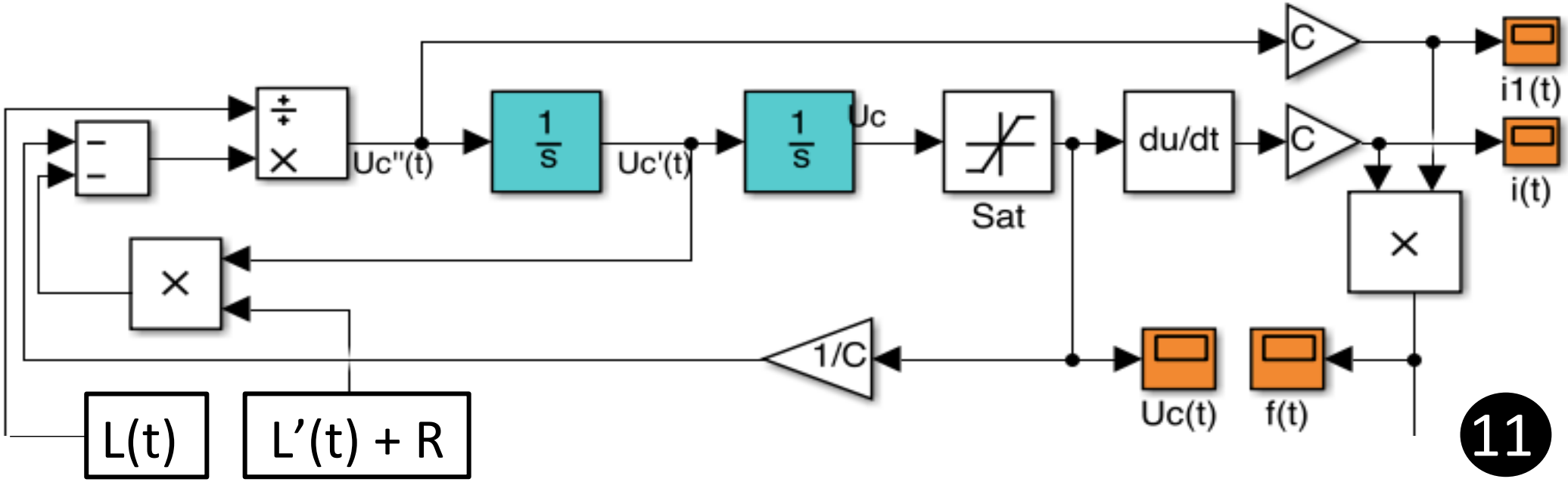


inductance = f(position) ?

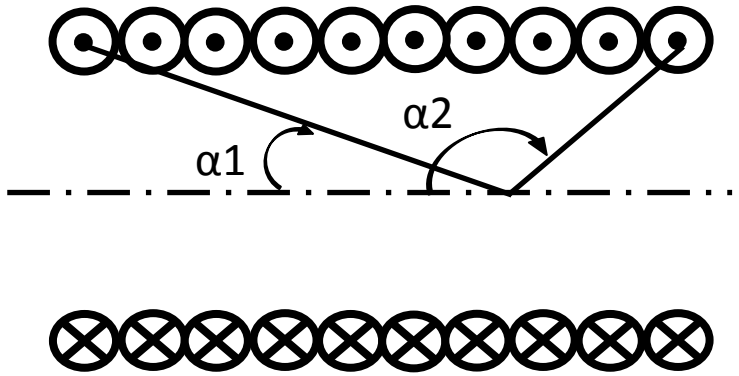


CIRCUIT RLC

$$\ddot{U}_c = -\left(\frac{R+\dot{L}}{L}\right)\cdot\dot{U}_c - \frac{1}{LC}\cdot U_c$$



EQUATION DU MOUVEMENT



Champ magnétique axial

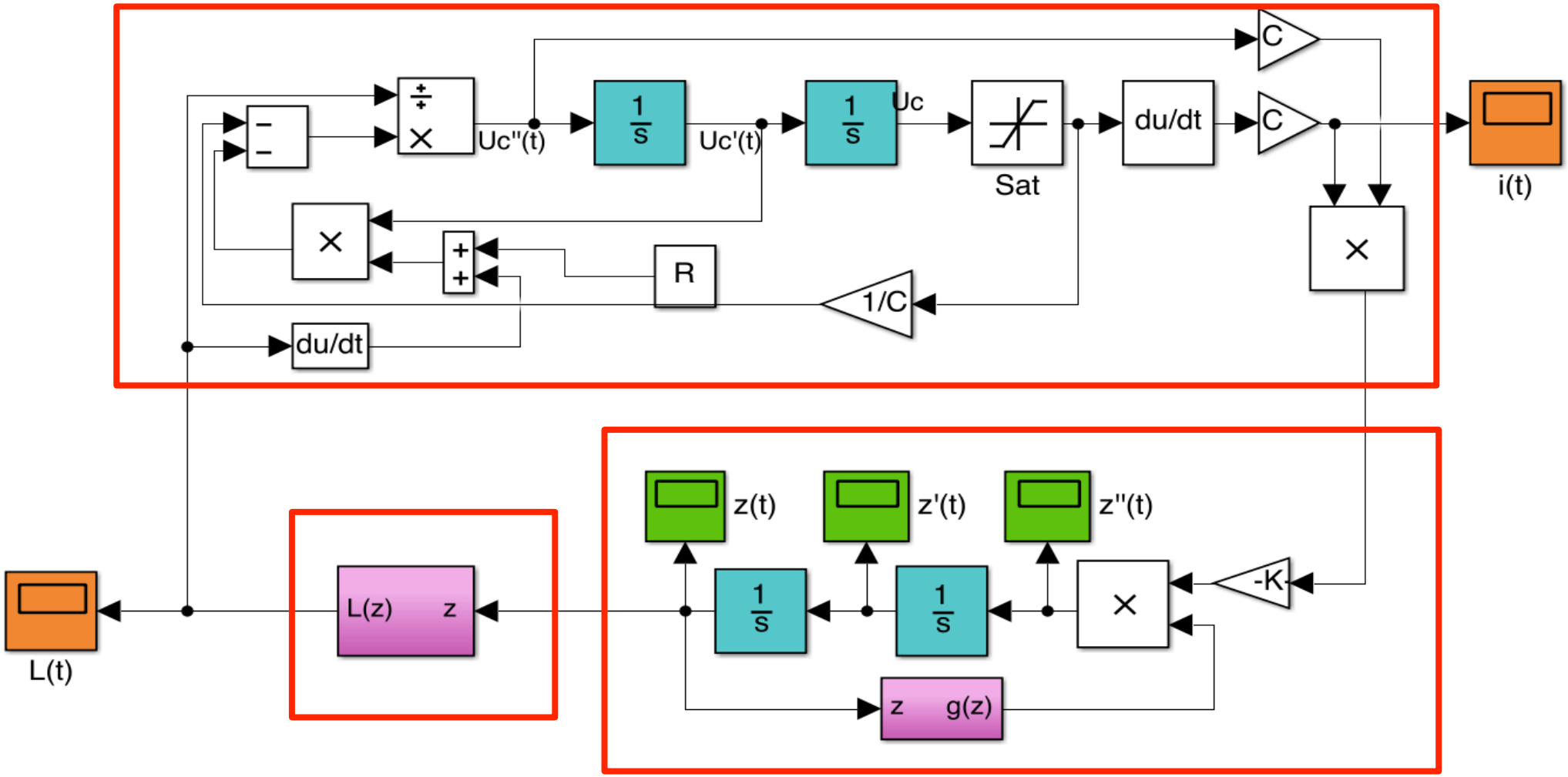
$$B_z = \frac{\mu n I}{2}(\cos(\alpha_1) - \cos(\alpha_2))$$

Force de Laplace

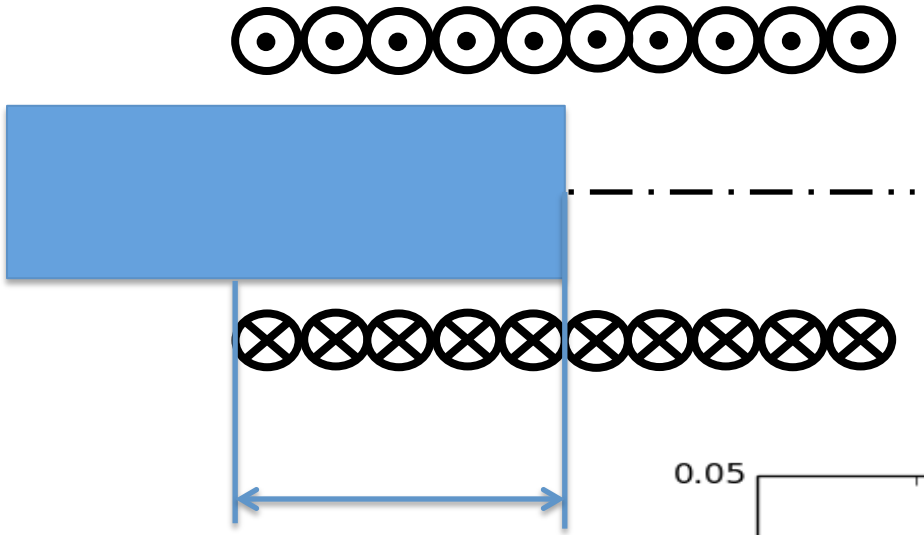
$$\vec{F} = \iiint_V \vec{j} \cdot \mathrm{d}\tau \wedge \vec{B} = \iiint_V -j_\theta \cdot B_r \cdot \mathrm{d}\tau \cdot \vec{e_z}$$

$$\ddot{z} = K \cdot I(t) \cdot \dot{I}(t) \cdot g(z)$$

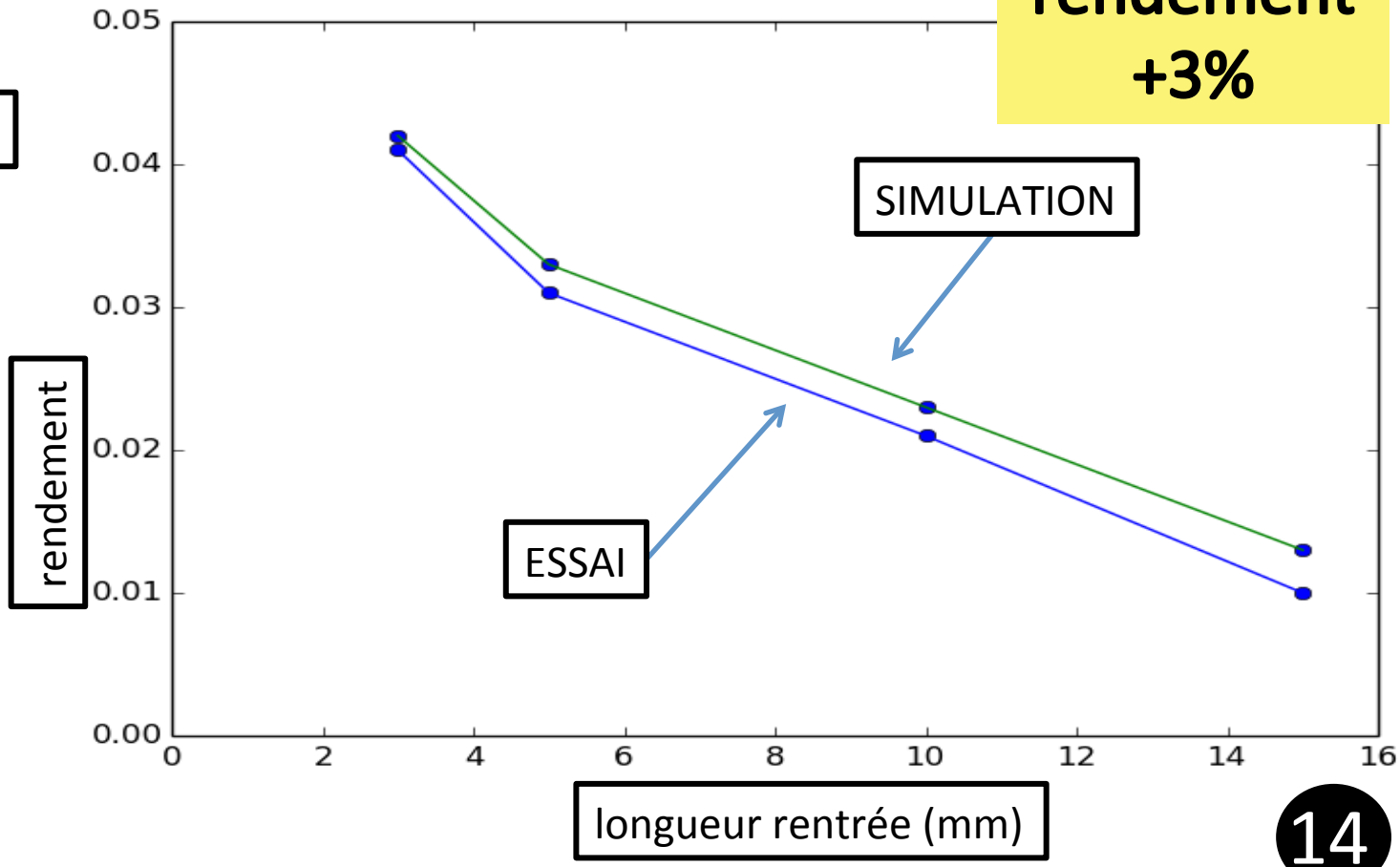
MODÈLE FINAL



VALIDATION DU MODÈLE

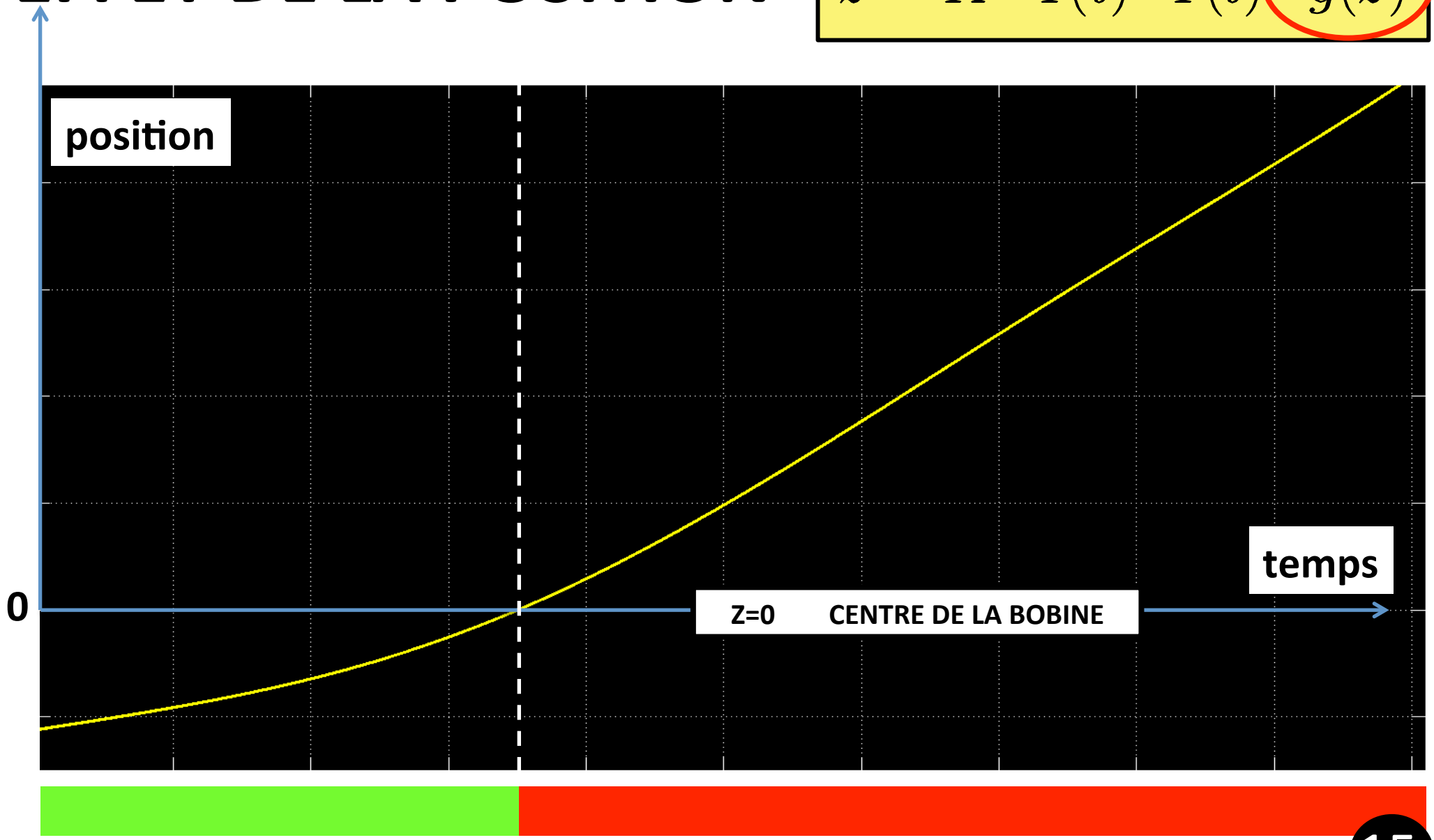


rendement +3%



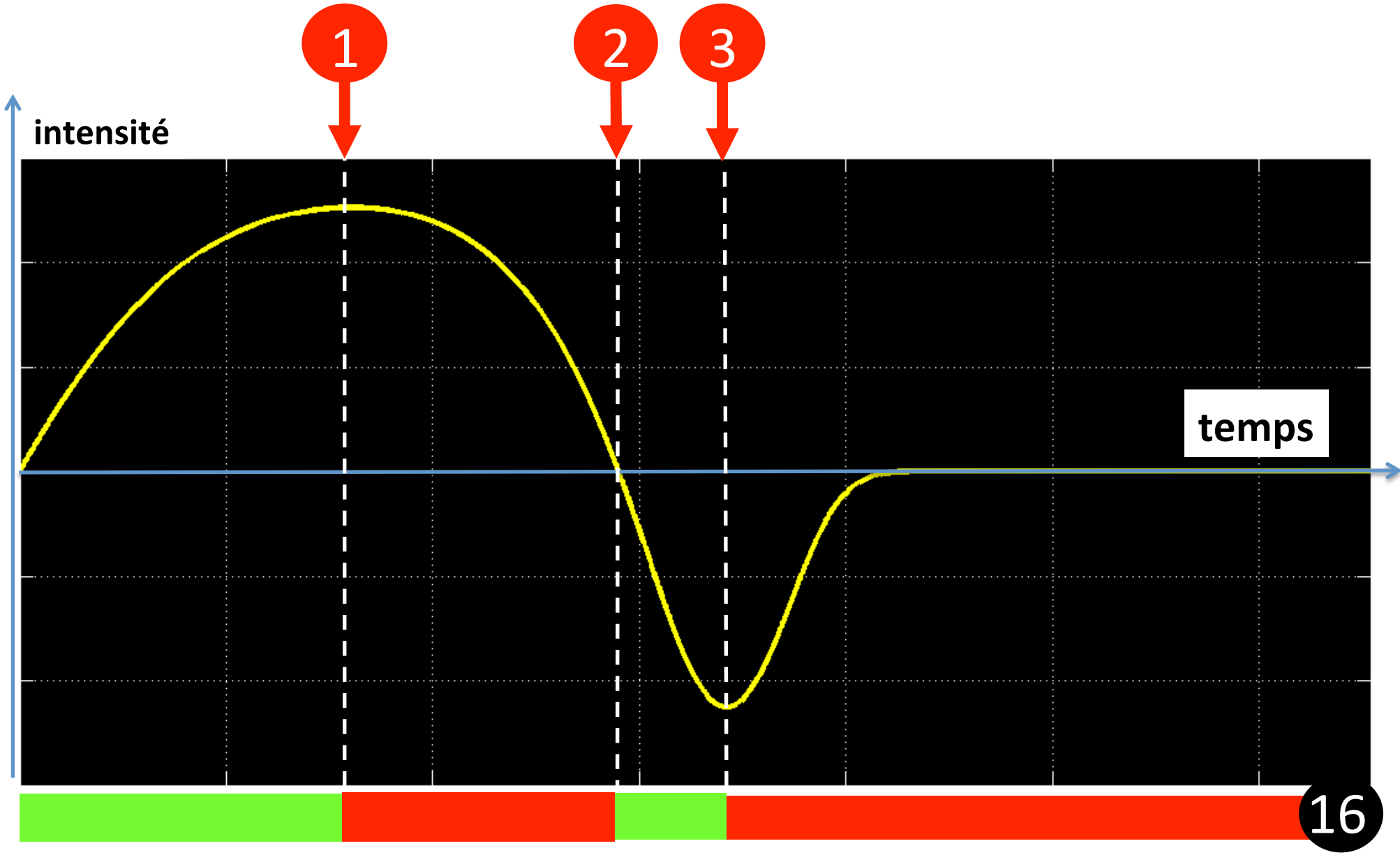
EFFET DE LA POSITION

$$\ddot{z} = K \cdot I(t) \cdot \dot{I}(t) \cdot g(z)$$

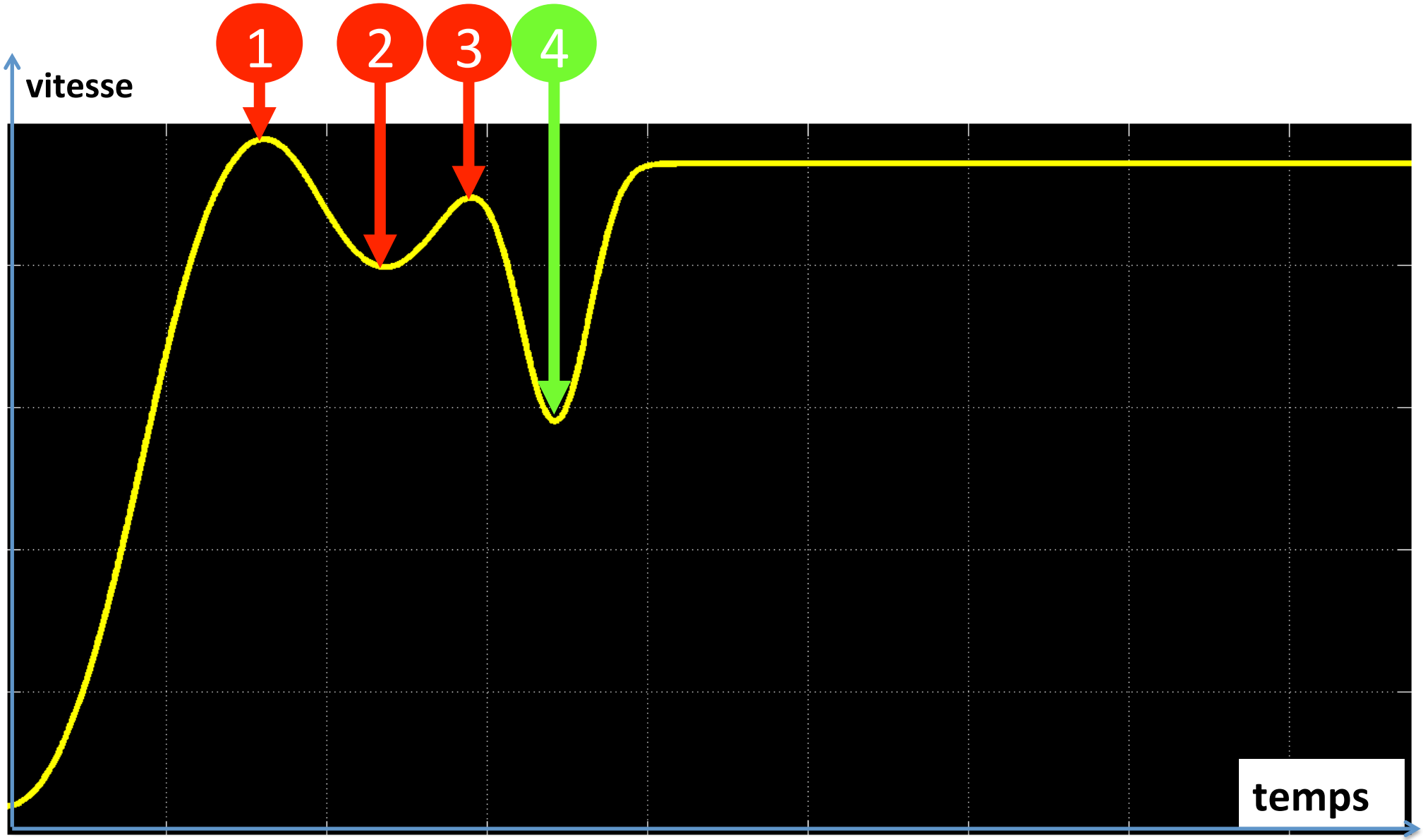


EFFET DE L'INTENSITÉ

$$\ddot{z} = K \cdot I(t) \cdot \dot{I}(t) \cdot g(z)$$

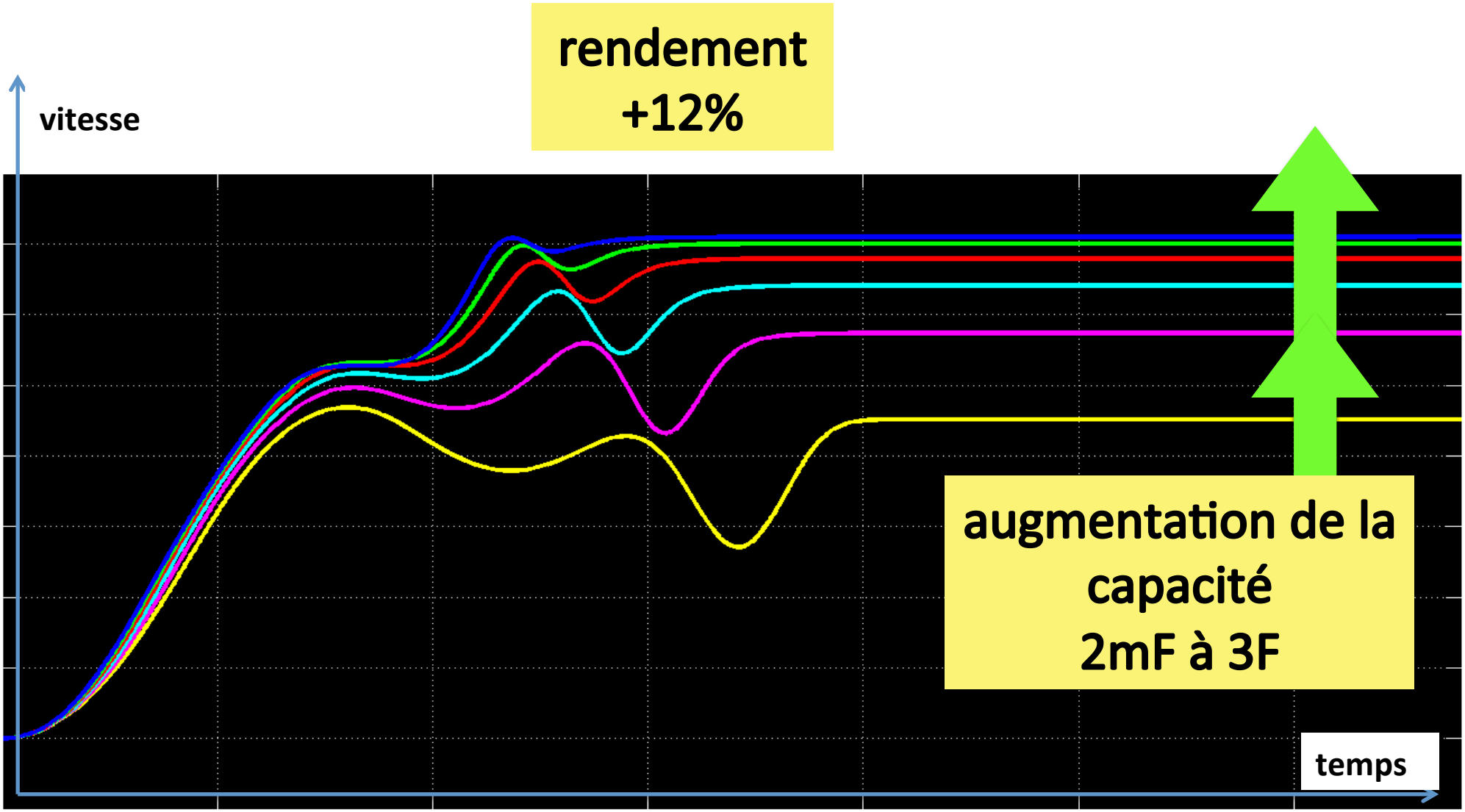


COURBE DE VITESSE



Time offset: 0

SYNCHRONISATION DU CIRCUIT



UTILISATIONS POTENTIELLES