

MICROPHONE DE GUITARE ELECTRIQUE

Comment fonctionne un microphone de guitare électrique?
Comment intervient-il dans le rendu sonore d'une guitare?

I-Analyse du système

II-Modélisation

III-Expérimentation



Micro double
bobinage

Micro simple bobinage

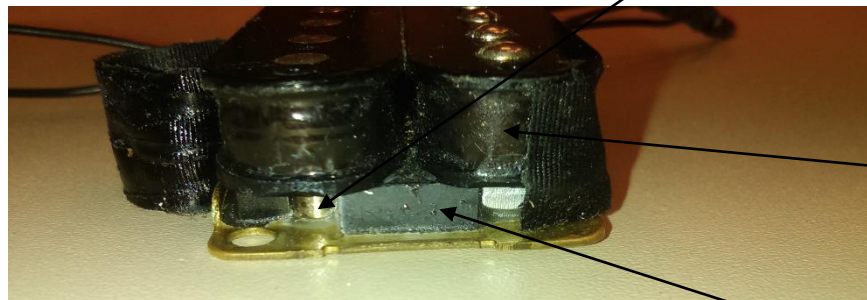
I-Analyse du système

Système étudié: micro double bobinage

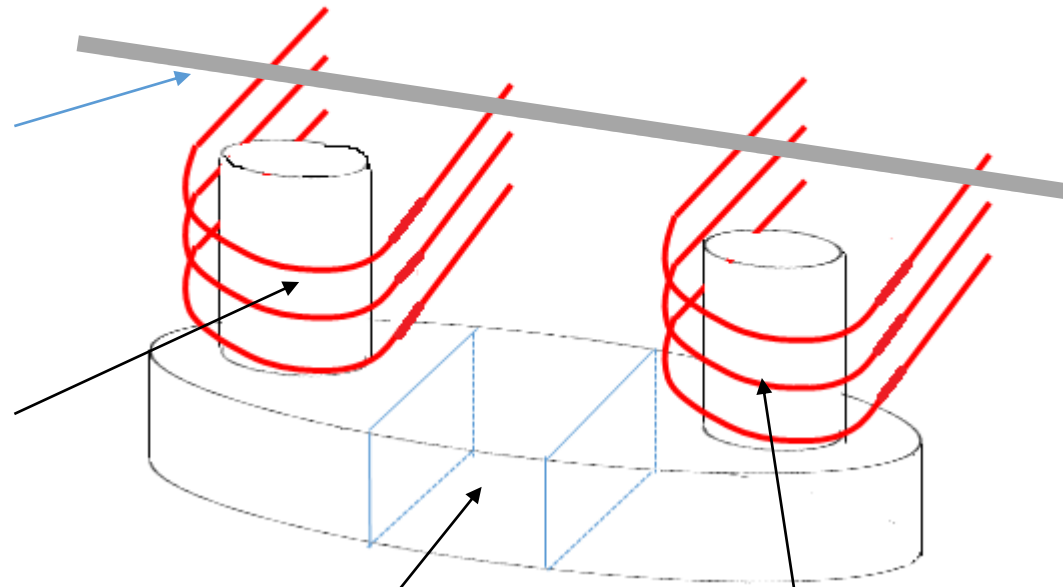


Corde

Plot



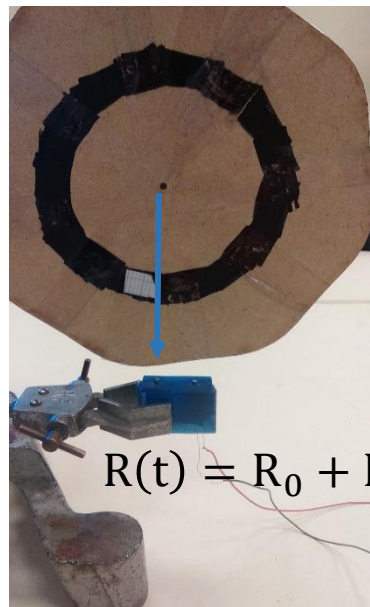
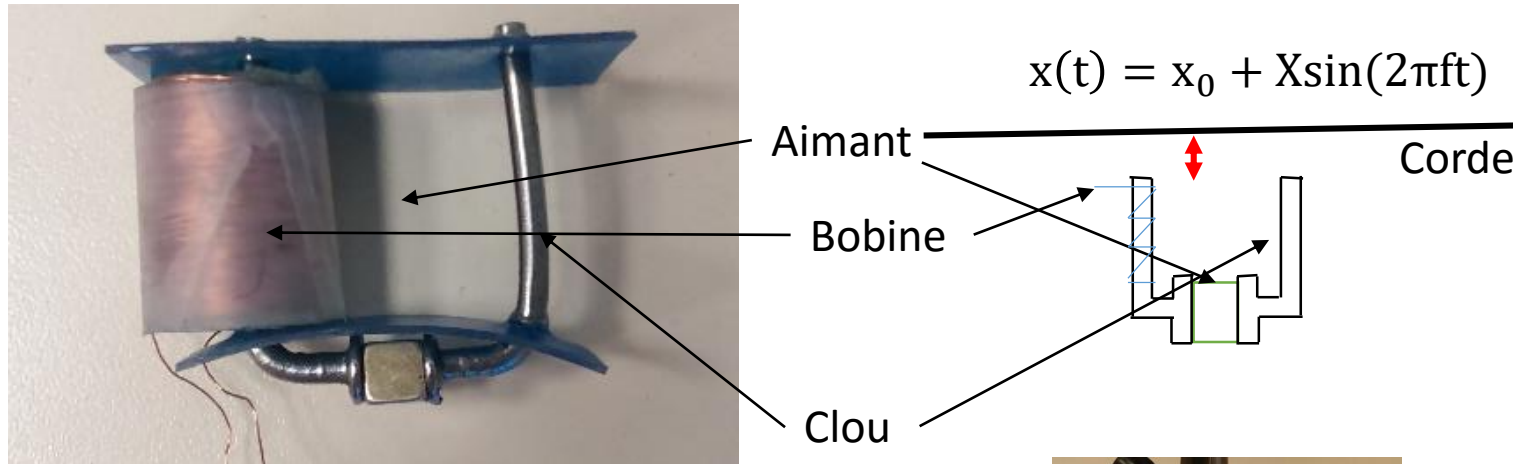
Aimant



Bobine

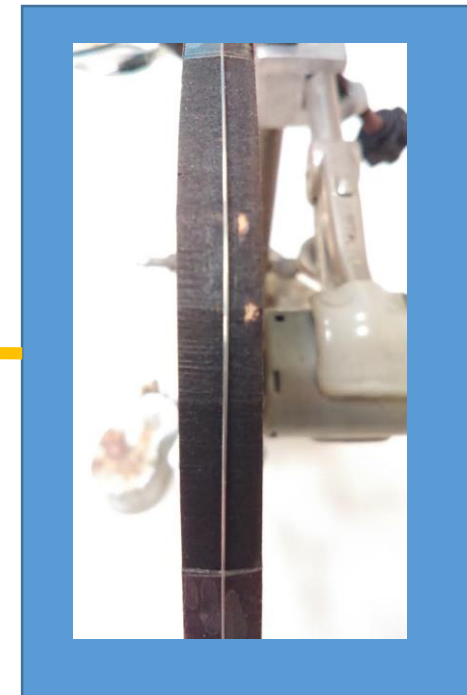
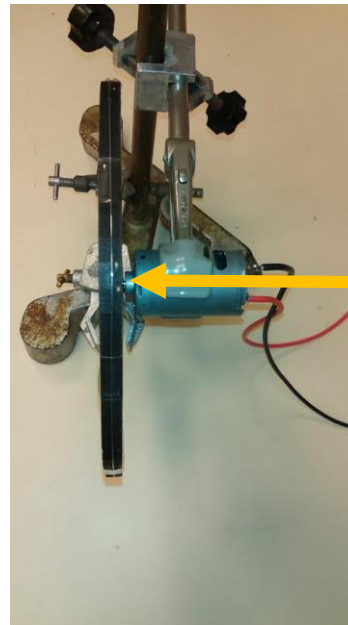
II-Modélisation

Du système réel à la maquette:



$R_0 = 195\text{mm}$

$$R(t) = R_0 + R\sin(2\pi ft)$$



II-Modélisation

Circuit magnétique:

Fer, acier: milieu LHI

$$\mu_p = 4000$$

$$\mu_c = 350$$

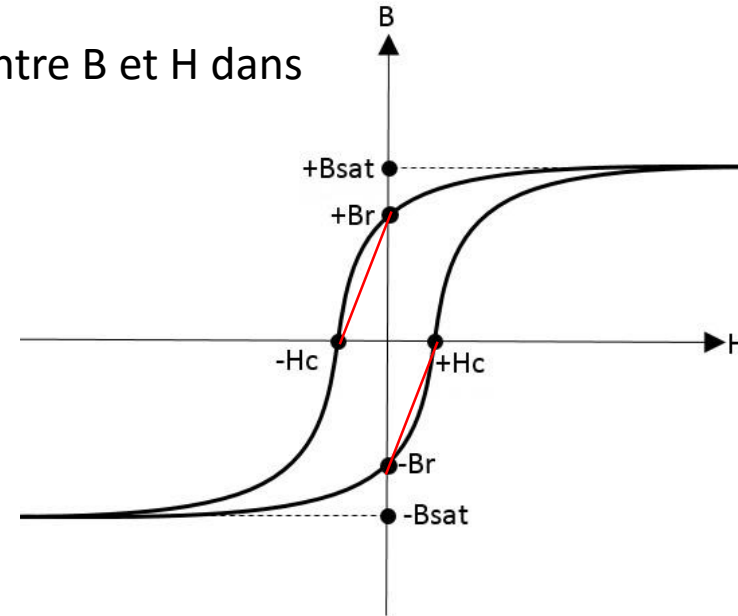
$$\mu_r \gg 1$$

Hypothèses:

- Le circuit magnétique canalise parfaitement les lignes de champ.
- Lignes de champs sortent perpendiculairement aux surfaces

Aimant

Linéarité entre B et H dans l'aimant:



$B_r \# 1.29-1.32 \text{ T}$

$H_c \# 860-955 \text{ kA/m}$

Hypothèse:

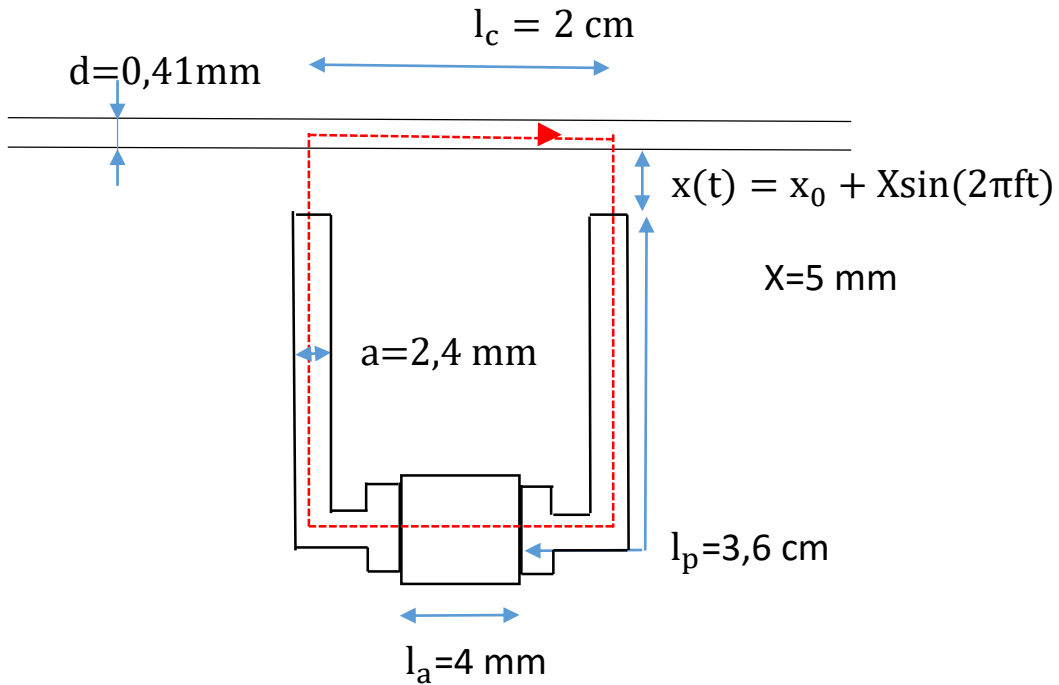
-pour $H < 0$ et $B > 0$ la relation entre B et H est linéaire:

$$\begin{cases} B(-H_c) = 0 \\ B(0) = B_r \end{cases} \quad B(H) = \frac{B_r}{H_c} H + B_r$$

II-Modélisation

Résolution

Expression du champ magnétique



Théorème d'ampère:

$$\oint_{\text{circuit}} \vec{H} \cdot d\vec{l} = \sum I = 0$$

$$\int_{\text{aimant}} \vec{H} \cdot d\vec{l} + \int_{\text{plot}} \vec{H} \cdot d\vec{l} + \int_{\text{air}} \vec{H} \cdot d\vec{l} + \int_{\text{corde}} \vec{H} \cdot d\vec{l} = 0$$

Conservation du flux

$$\Phi_a = l_a^2 B_a \quad \Phi_{\text{air}} = \pi \frac{a^2}{4} B_{\text{air}}$$

$$\Phi_c = \pi \frac{d^2}{4} B_c \quad \Phi_p = \pi \frac{a^2}{4} B_p$$

Relation dans les milieux:

$$B_p = \mu_0 \mu_p H_p$$

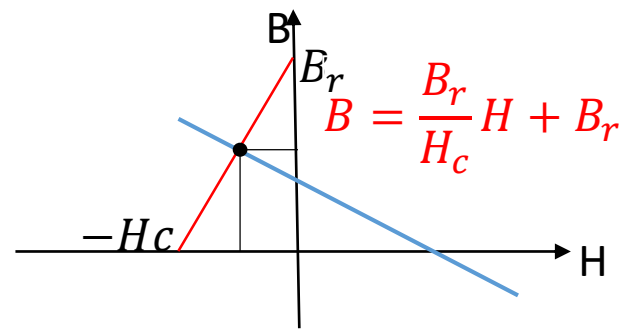
$$B_c = \mu_0 \mu_c H_c$$

$$B_{\text{air}} = \mu_0 H_{\text{air}}$$

$$H_a l_a + 2H_p l_p + H_c l_c + 2H_{\text{air}} x(t) = 0$$

$$B_a = - \frac{\mu_0 \pi}{4l_a \left(\frac{2l_p}{\mu_p a^2} + \frac{l_c}{\mu_c d^2} + \frac{2x(t)}{a^2} \right)} H_a$$

Tension induite:


$$B_a = B_r - \frac{B_r^2}{H_c \left(\frac{\mu_0 \pi}{4l_a \left(\frac{2l_p}{\mu_p a^2} + \frac{l_c}{\mu_c d^2} + \frac{2x(t)}{a^2} \right)} + \frac{B_r}{H_c} \right)}$$
$$e_{ind} = -\frac{d\phi}{dt} = -N s \frac{4l_a^2}{\pi a^2} \frac{dB_a}{dt}$$

avec $s = \pi \frac{a^2}{4}$

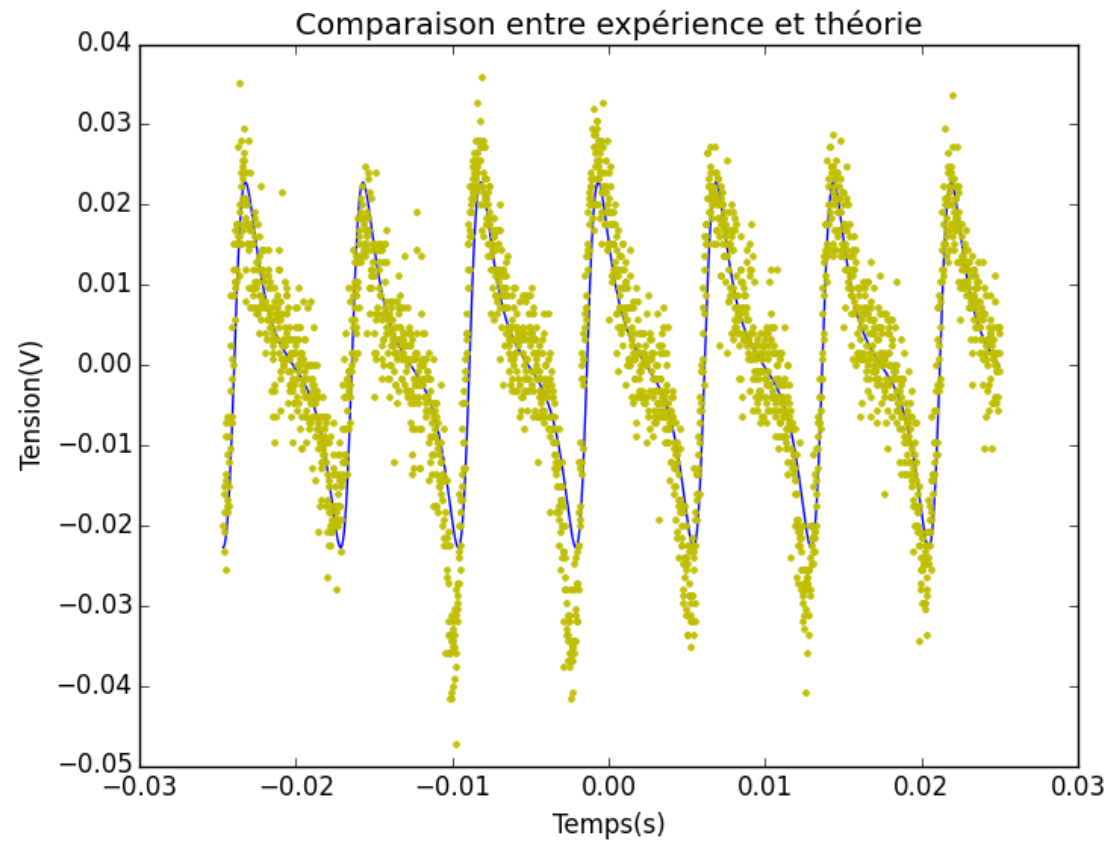
e_{ind} est fonction de \dot{x} et x_0

III-Expérimentation

Analyse du signal généré:

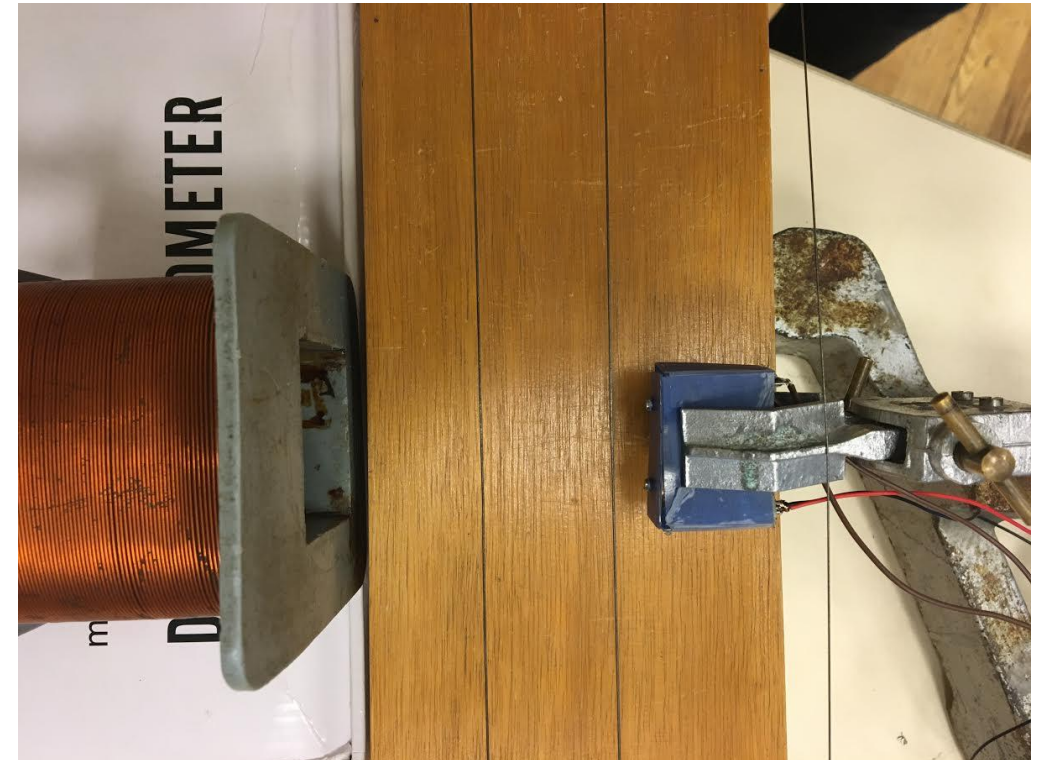
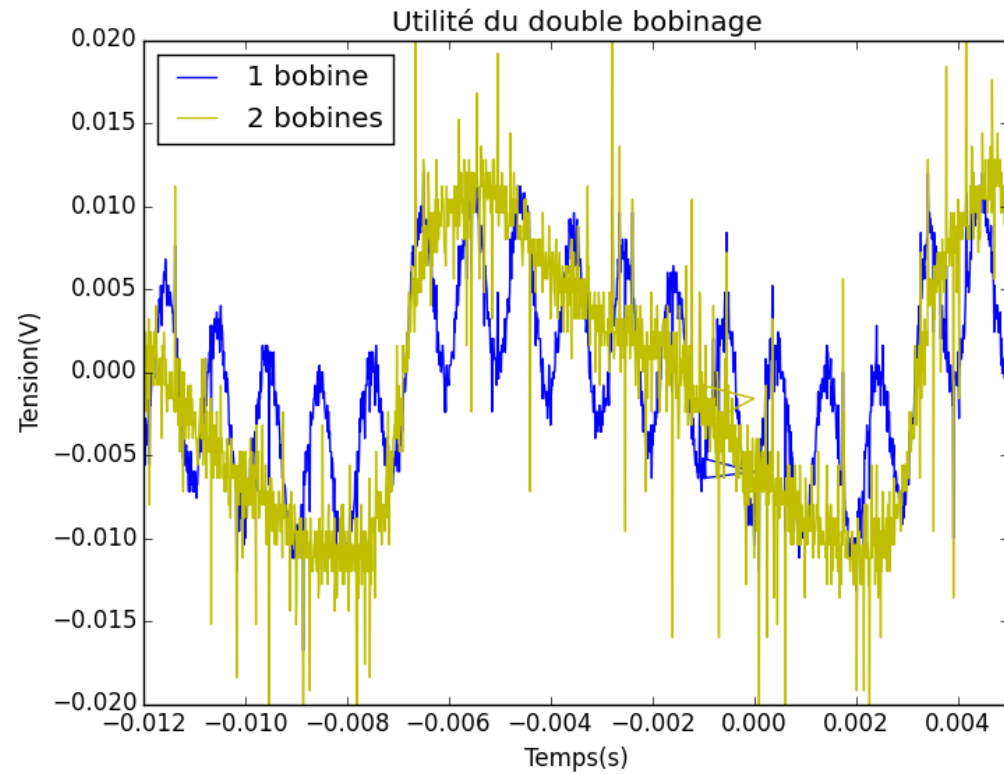
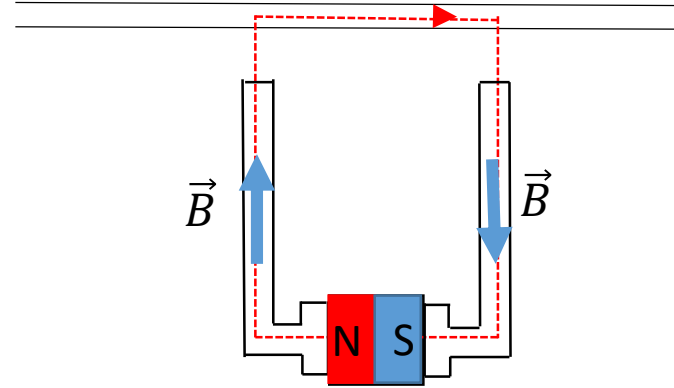
-Expérimentale

-Théorique



III-Expérimentation

Utilité du double bobinage:

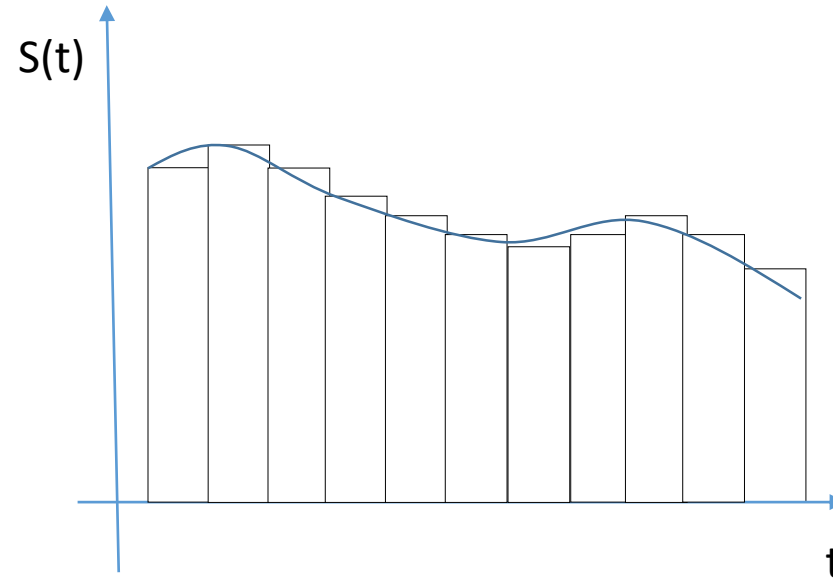


III-Expérimentation

Calcul de la valeur efficace:

$$S_{\text{eff}} = \sqrt{\frac{1}{T} \int_0^T s^2(t) dt}$$

```
def valeur_efficace(L_signal,f):  
    n=len(L_signal)  
    pas= 1/(n*f)  
    somme=0  
    for i in range (n):  
        somme=somme+L_signal[i]**2  
    return sqrt(f*somme*pas)
```

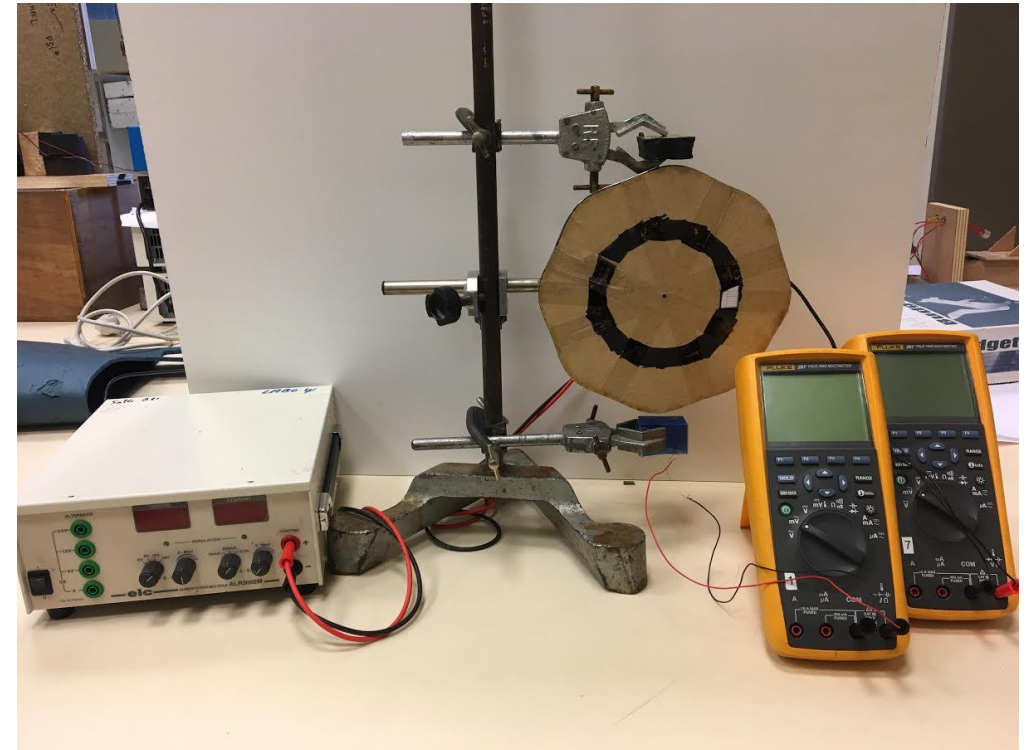
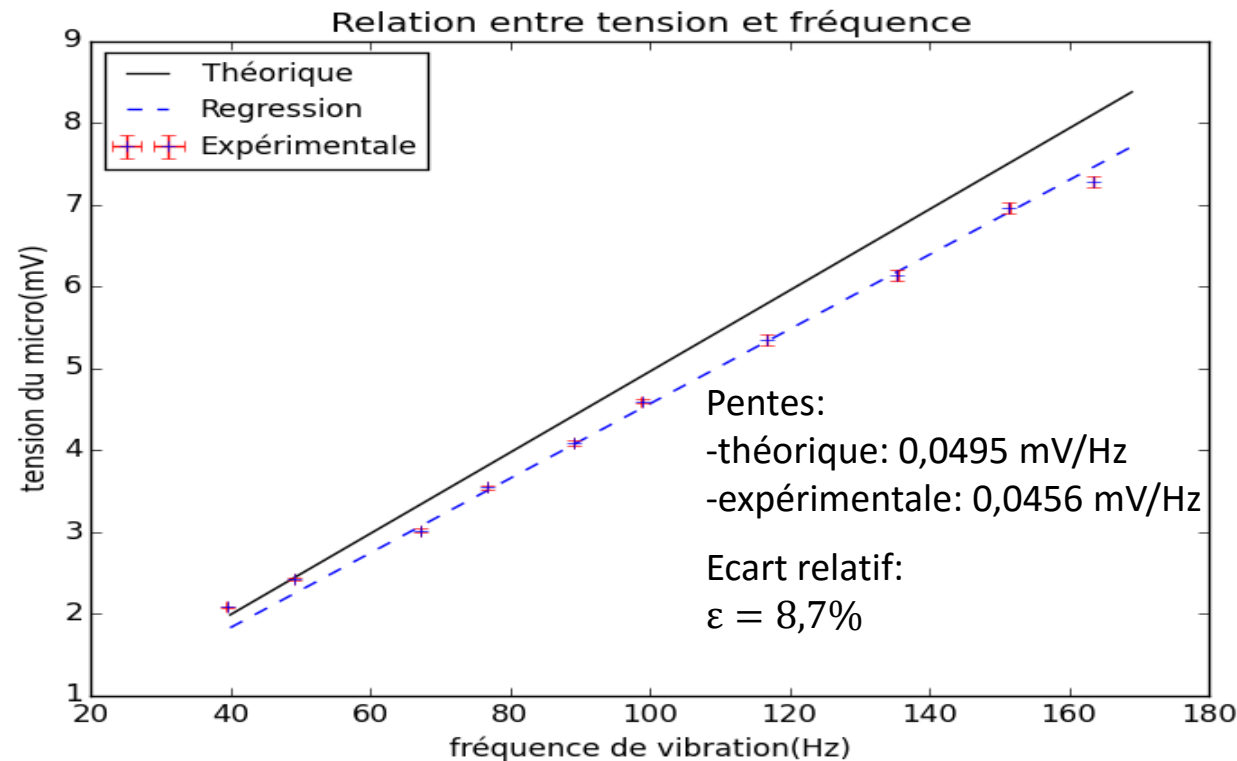


III-Expérimentation

Proportionnalité tension/fréquence

$$e_{\text{ind}} = \frac{\frac{2Nsl_a B_r^2 \mu_0 \dot{x}}{H_c a^4}}{\left(\frac{\mu_0 \pi}{4l_a} + \frac{B_r}{H_c} \left(\frac{2l_p}{\mu_p a^2} + \frac{l_c}{\mu_c d^2} + \frac{2(x_0 + X \sin(2\pi f t))}{a^2} \right) \right)^2}$$

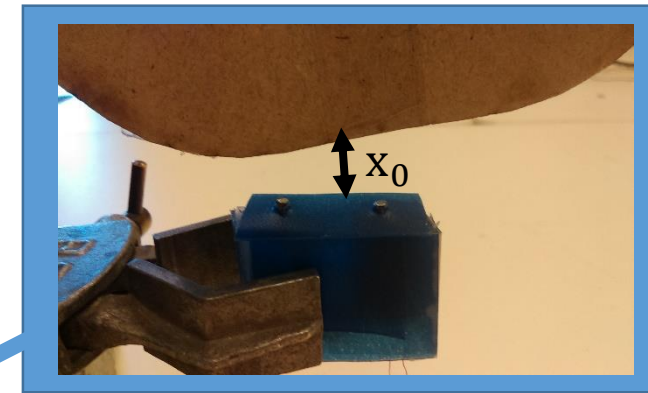
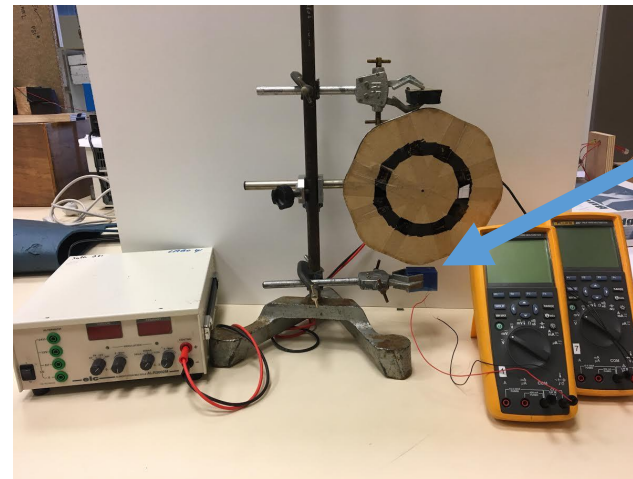
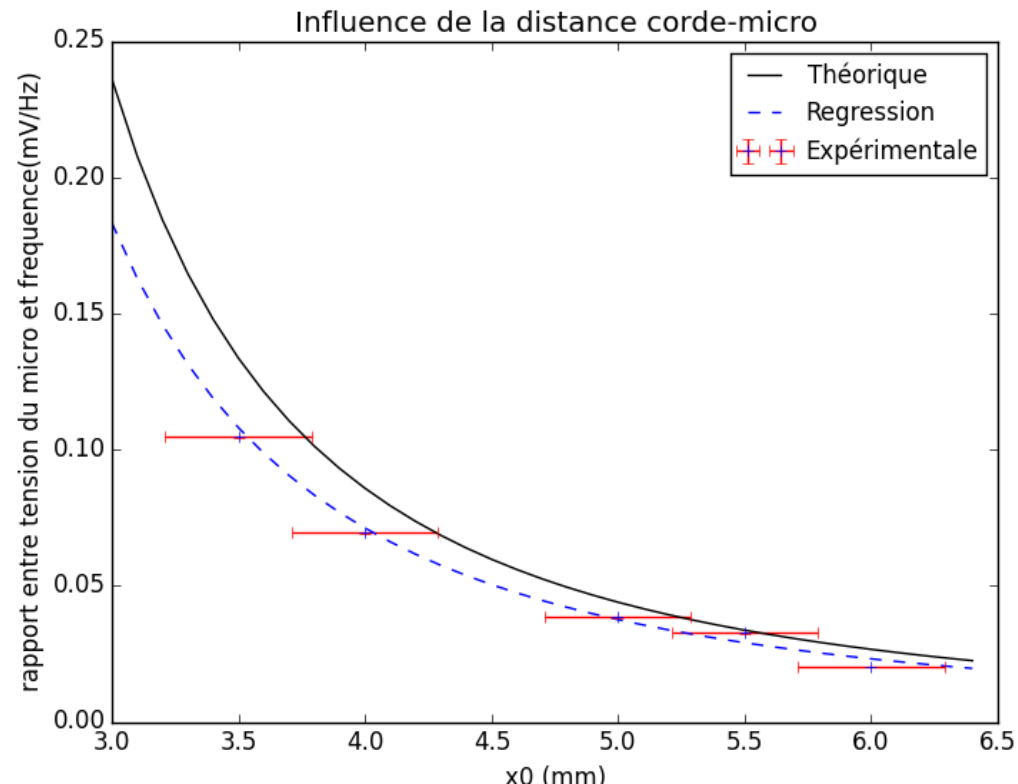
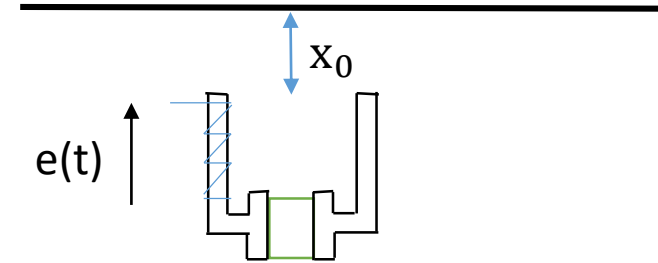
$$x_0 = 3,5 \text{ mm}$$



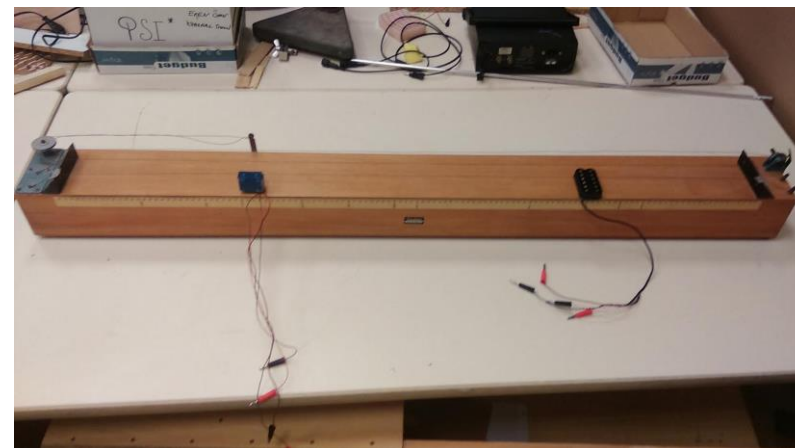
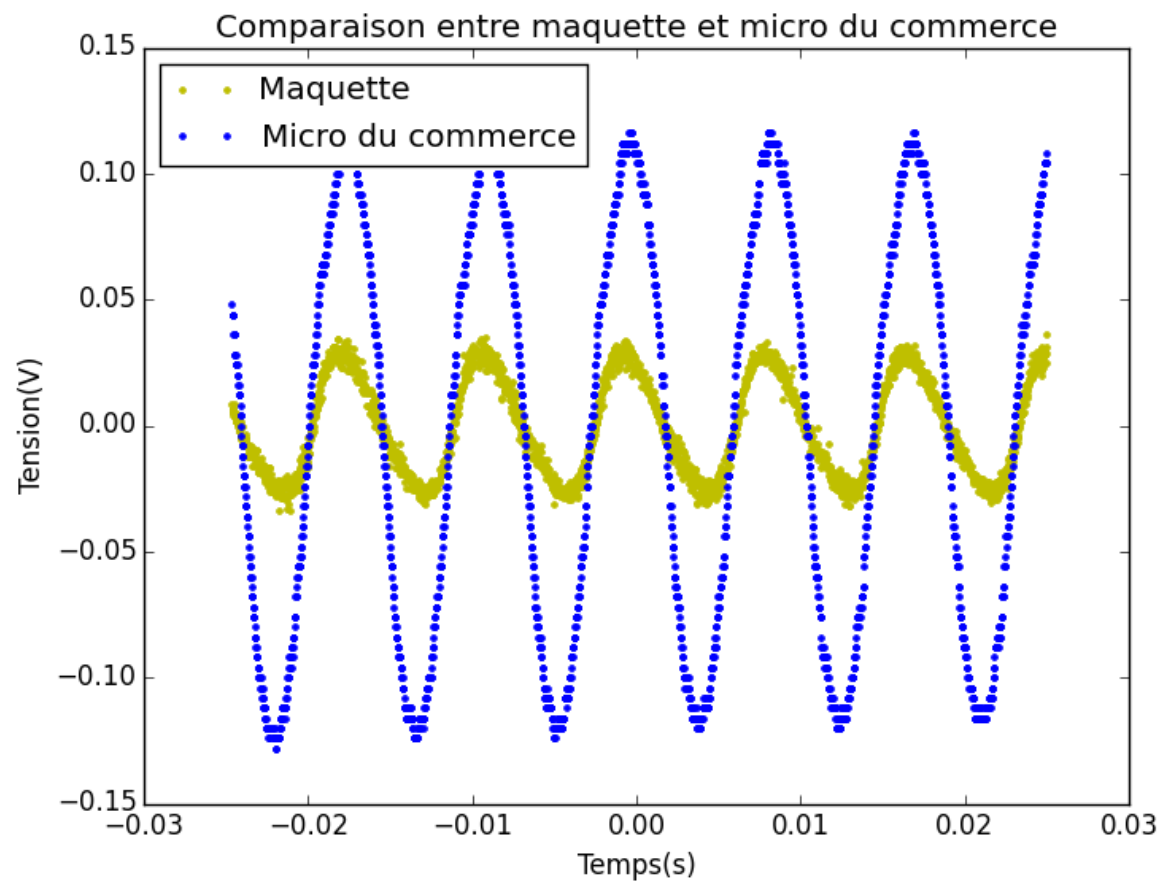
III-Expérimentation

Influence de la distance corde micro x_0 :

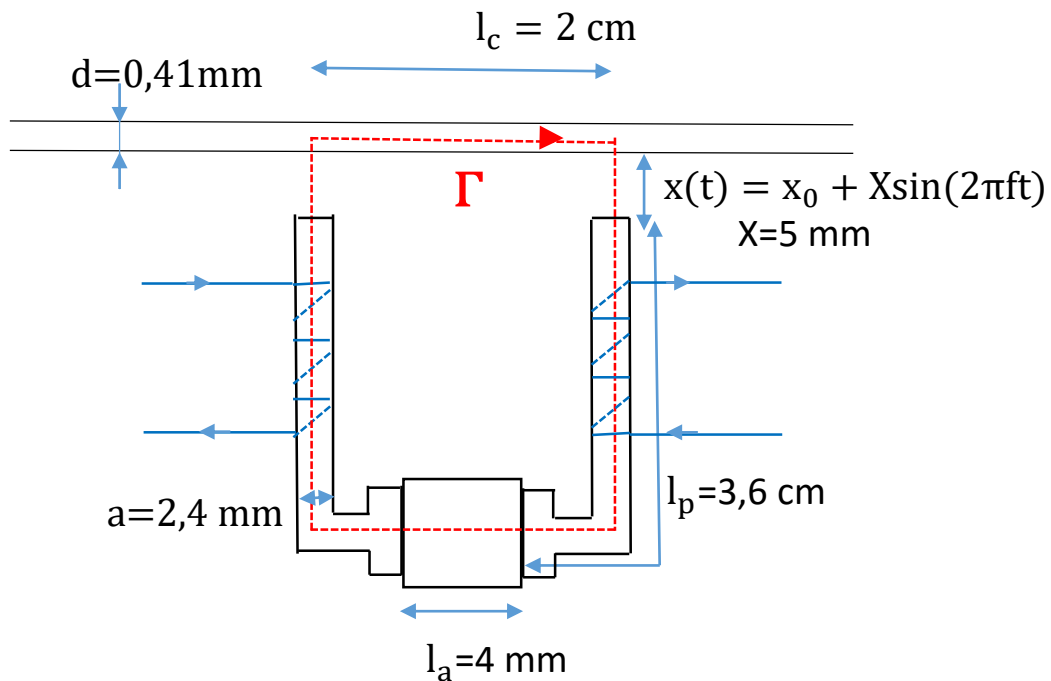
$$e_{\text{ind}} = \frac{\frac{2Nsl_a B_r^2 \mu_0 \dot{x}}{H_c a^4}}{\left(\frac{\mu_0 \pi}{4l_a} + \frac{B_r}{H_c} \left(\frac{2l_p}{\mu_p a^2} + \frac{l_c}{\mu_c d^2} + \frac{2(x_0 + X \sin(2\pi f t))}{a^2} \right) \right)^2}$$



Conclusion



Annexe



Détermination des équations du modèle:

Théorème d'ampère:

$$\oint_{\text{circuit}} \vec{H} \cdot d\vec{l} = \sum I = 0$$

$$\int_{\text{aimant}} \vec{H} \cdot d\vec{l} + \int_{\text{plot}} \vec{H} \cdot d\vec{l} + \int_{\text{air}} \vec{H} \cdot d\vec{l} + \int_{\text{corde}} \vec{H} \cdot d\vec{l} = 0$$

$$H_a l_a + 2H_p l_p + H_c l_c + 2H_{\text{air}} x(t) = 0$$

Relation dans les milieux:

$$B_p = \mu_0 \mu_p H_p$$

$$B_c = \mu_0 \mu_c H_c$$

$$B_{\text{air}} = \mu_0 H_{\text{air}}$$

Flux:

$$\Phi_a = l_a^2 B_a$$

$$\Phi_p = \pi \frac{a^2}{4} B_p$$

$$\Phi_c = \pi \frac{d^2}{4} B_c$$

$$\Phi_{\text{air}} = \pi \frac{a^2}{4} B_{\text{air}}$$

Conservation du flux:

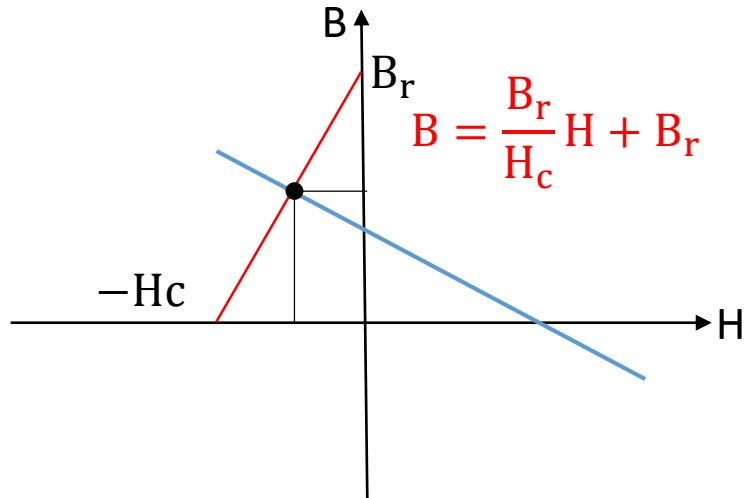
$$\Phi_a = \Phi_p = \Phi_c = \Phi_{\text{air}}$$

$$B_a = - \frac{\mu_0 \pi}{4 l_a \left(\frac{2 l_p}{\mu_p a^2} + \frac{l_c}{\mu_c d^2} + \frac{2 x(t)}{a^2} \right)} H_a$$

Point de fonctionnement:

$$B_a = - \frac{\mu_0 \pi}{4l_a \left(\frac{2l_p}{\mu_p a^2} + \frac{l_c}{\mu_c d^2} + \frac{2x(t)}{a^2} \right)} H_a = \frac{B_r}{H_c} H_a + B_r$$

$$B_a = B_r - \frac{B_r^2}{H_c \left(\frac{\mu_0 \pi}{4l_a \left(\frac{2l_p}{\mu_p a^2} + \frac{l_c}{\mu_c d^2} + \frac{2x(t)}{a^2} \right)} + \frac{B_r}{H_c} \right)}$$



$$\Phi_a = \Phi_p$$

$$l_a^2 B_a = \pi \frac{a^2}{4} B_p$$

$$B_p = \frac{4l_a^2}{\pi a^2} B_a$$

Tension induite:

$$e_{\text{ind}} = - \frac{d\phi}{dt} = -N s \frac{4l_a^2}{\pi a^2} \frac{dB_a}{dt} \quad \text{avec } s = \pi \frac{a^2}{4}$$

$$e_{\text{ind}} = \frac{\frac{2Nsl_a B_r^2 \mu_0 \dot{x}}{H_c a^4}}{\left(\frac{\mu_0 \pi}{4l_a} + \frac{B_r}{H_c} \left(\frac{2l_p}{\mu_p a^2} + \frac{l_c}{\mu_c d^2} + \frac{2x(t)}{a^2} \right) \right)^2}$$