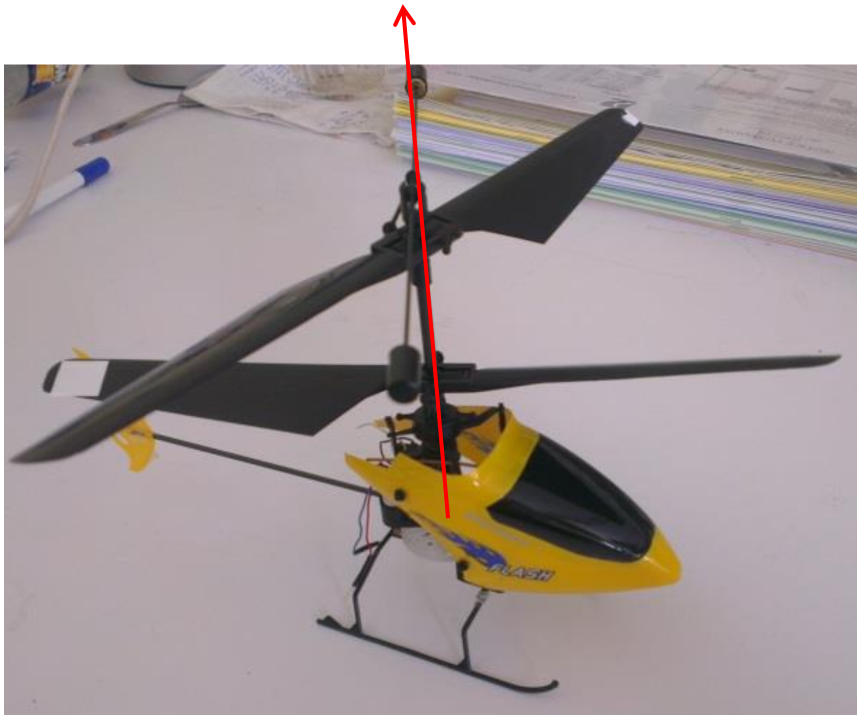
Hélicoptère birotor

1) Du système réel à la maquette

2) Modélisation

3) Asservissement



a) Système réel

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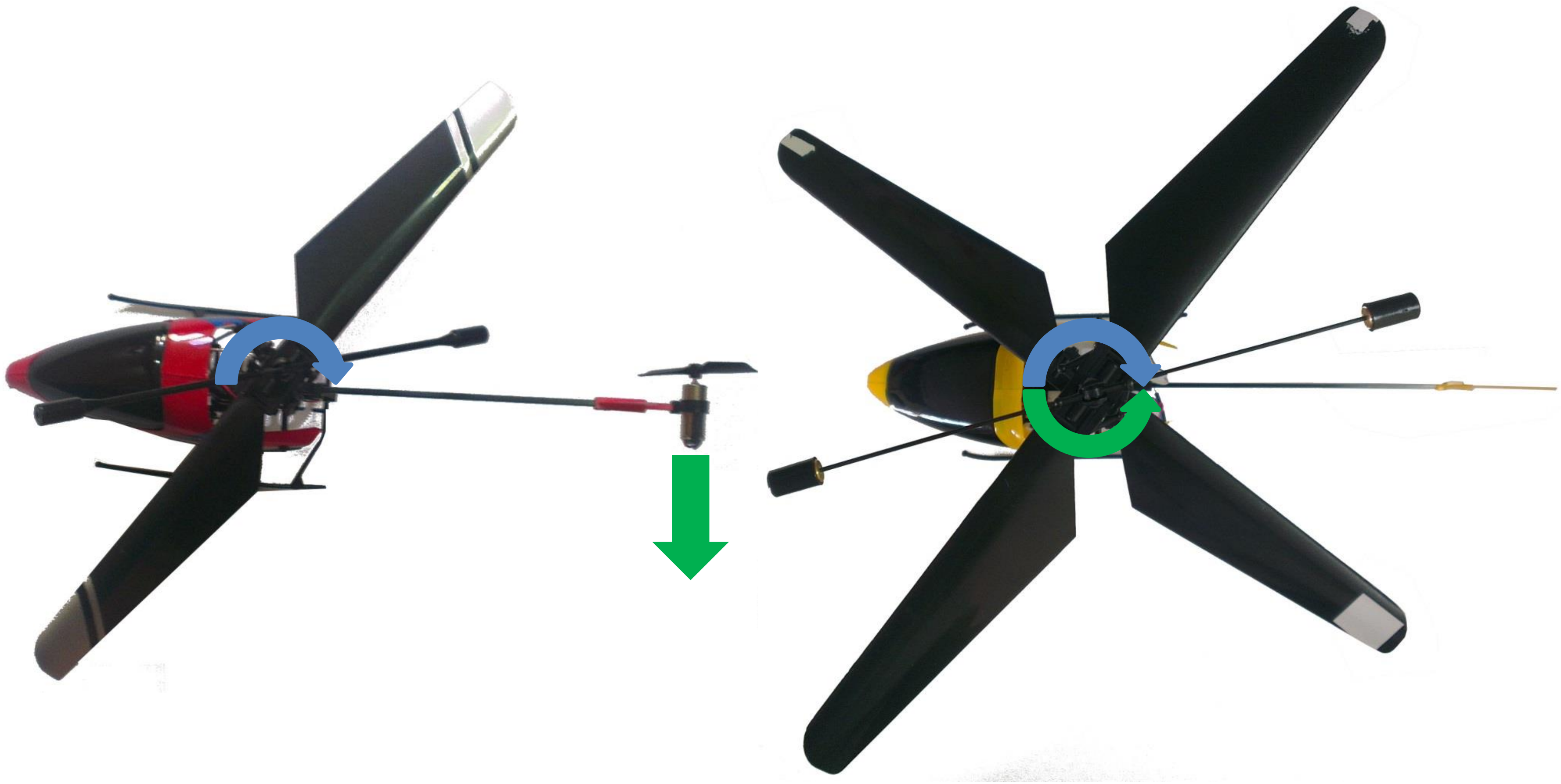
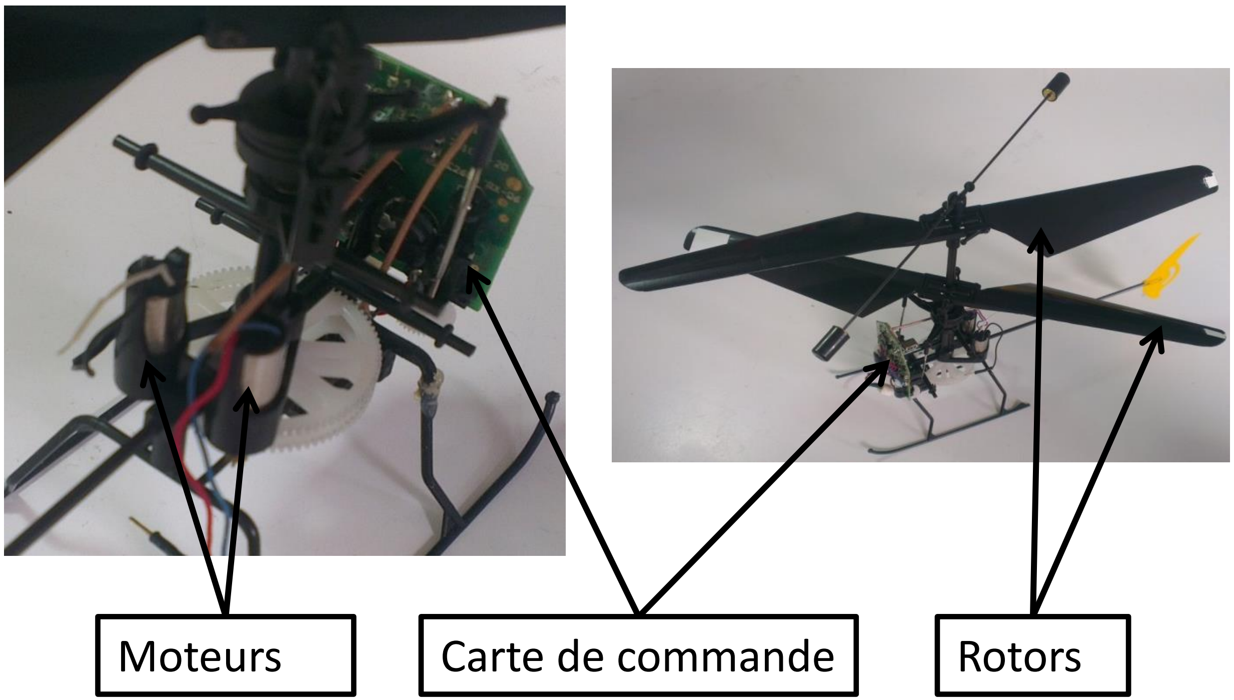
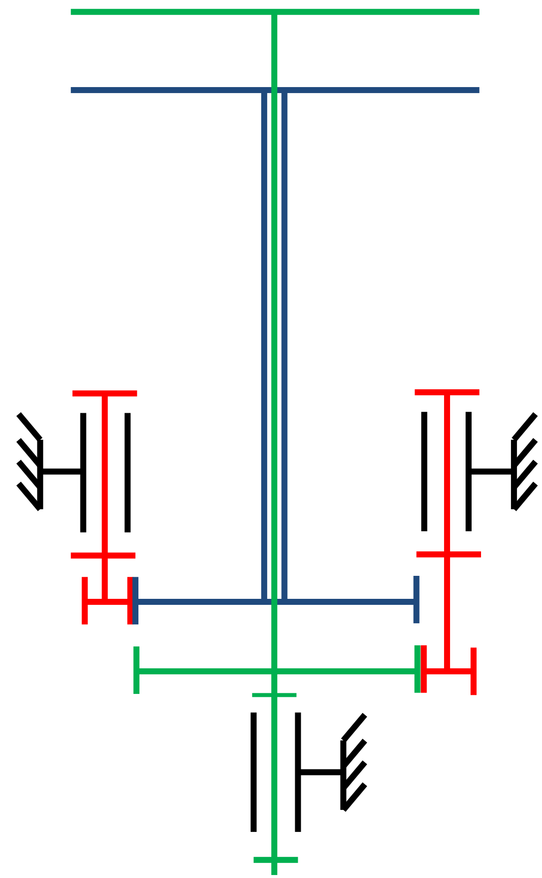
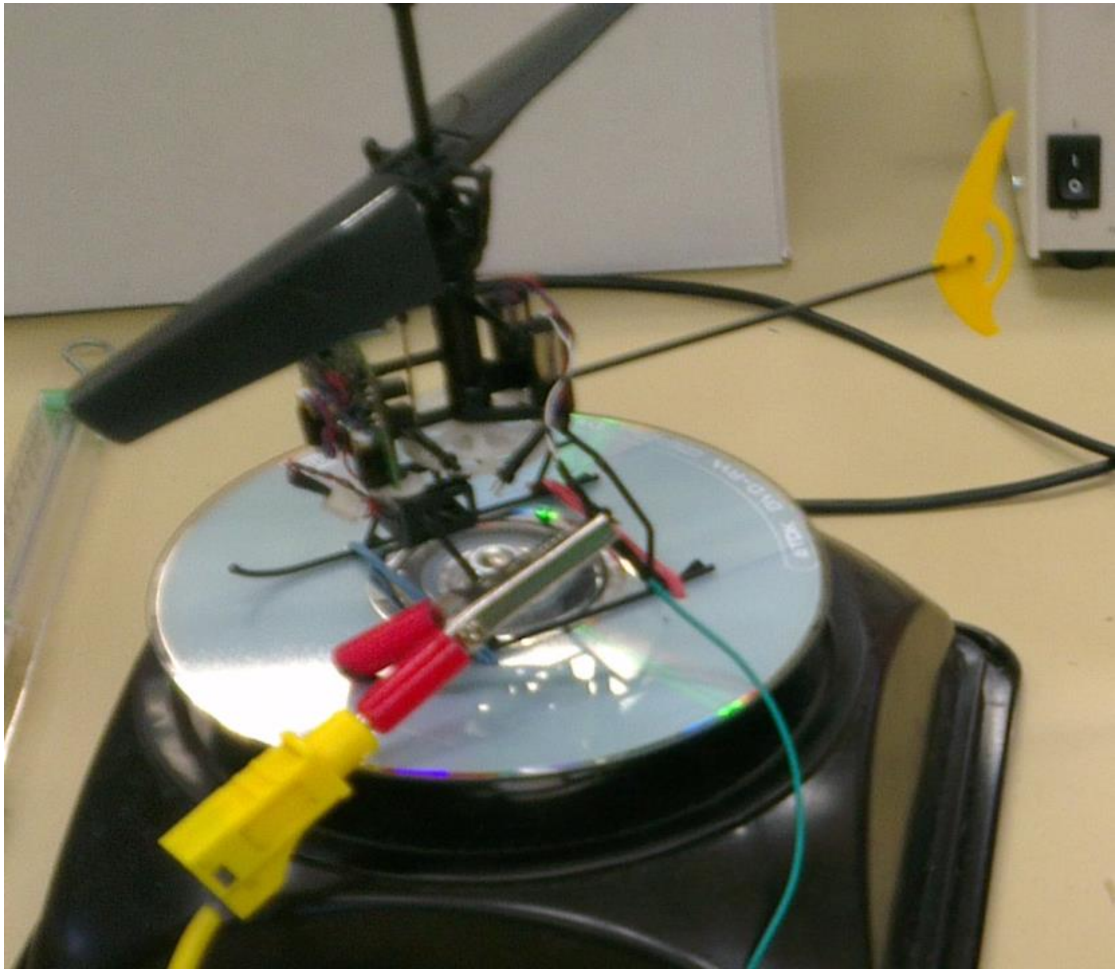


a) Système réel

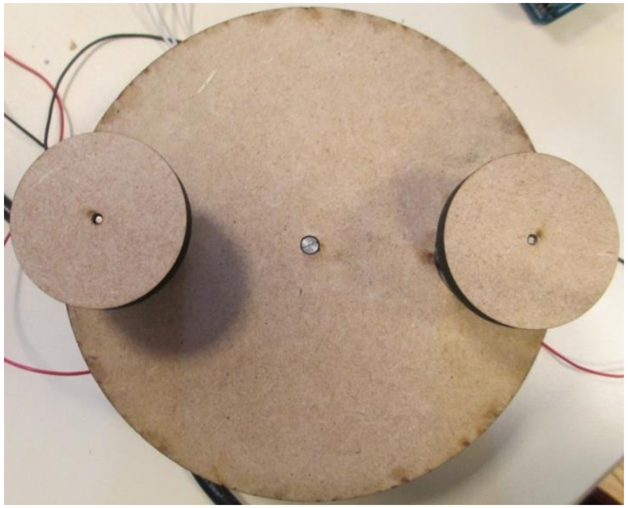


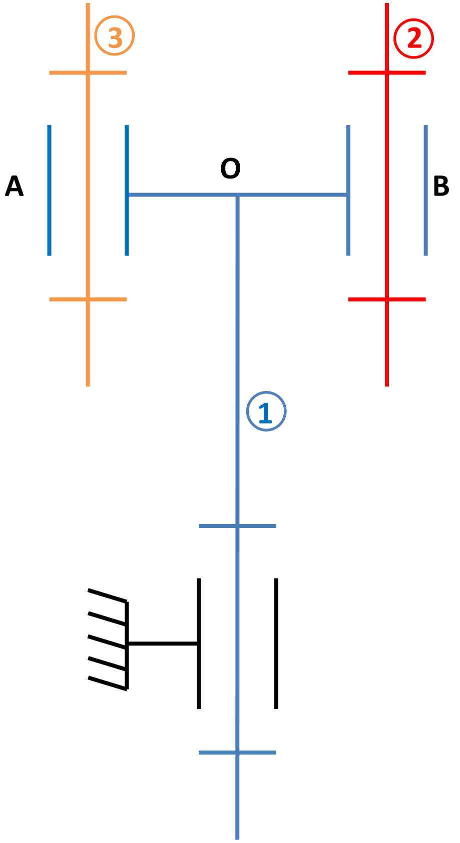


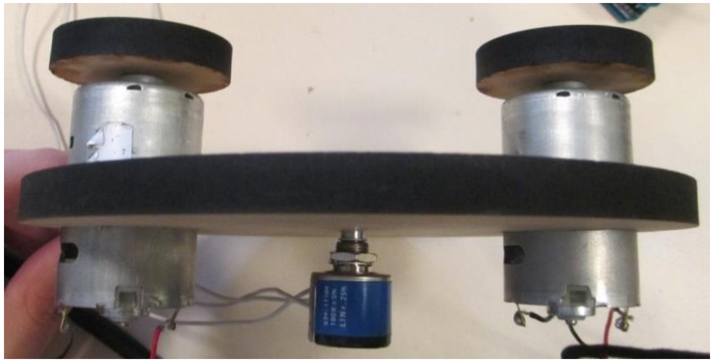
a) Système réel

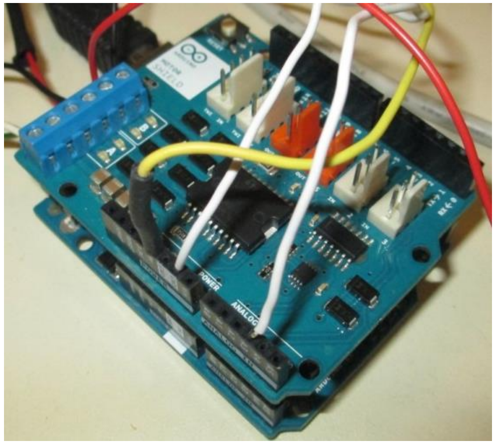


a) Système réel

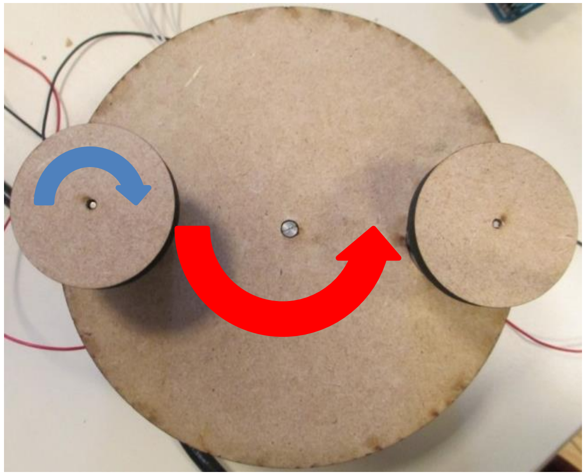


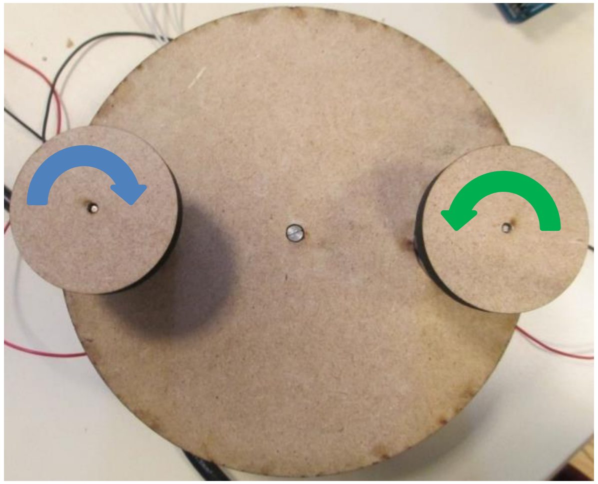






b) Maquette





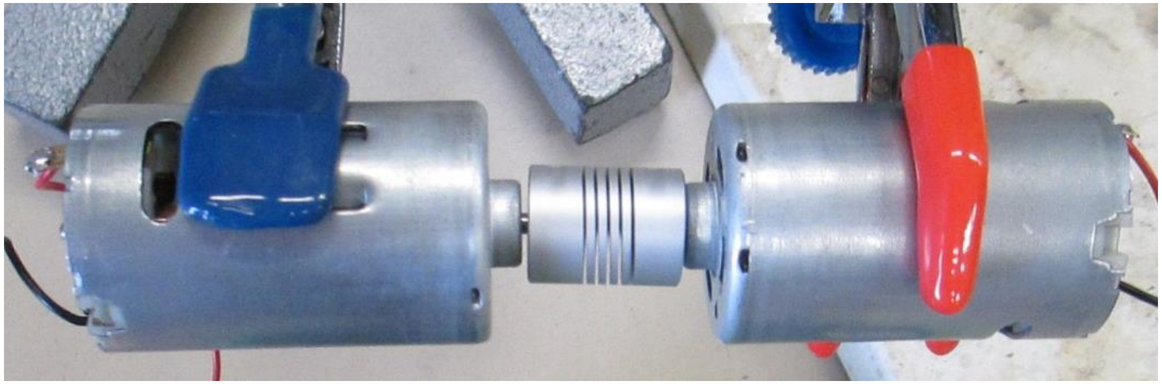
a) Caractéristiques des moteurs

- Dans un moteur à courant continu :

$$U(t) = Ke \cdot \omega(t) + Ri(t) + L\frac{di}{dt}$$

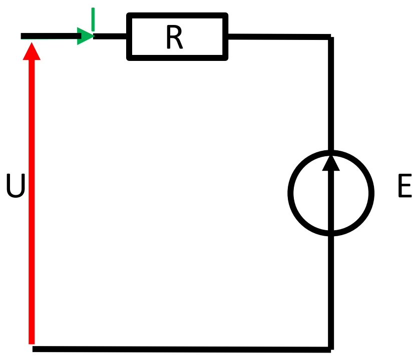
$$J_{mot}\frac{d\omega}{dt} = Kc \cdot i(t) - Cr(t)$$

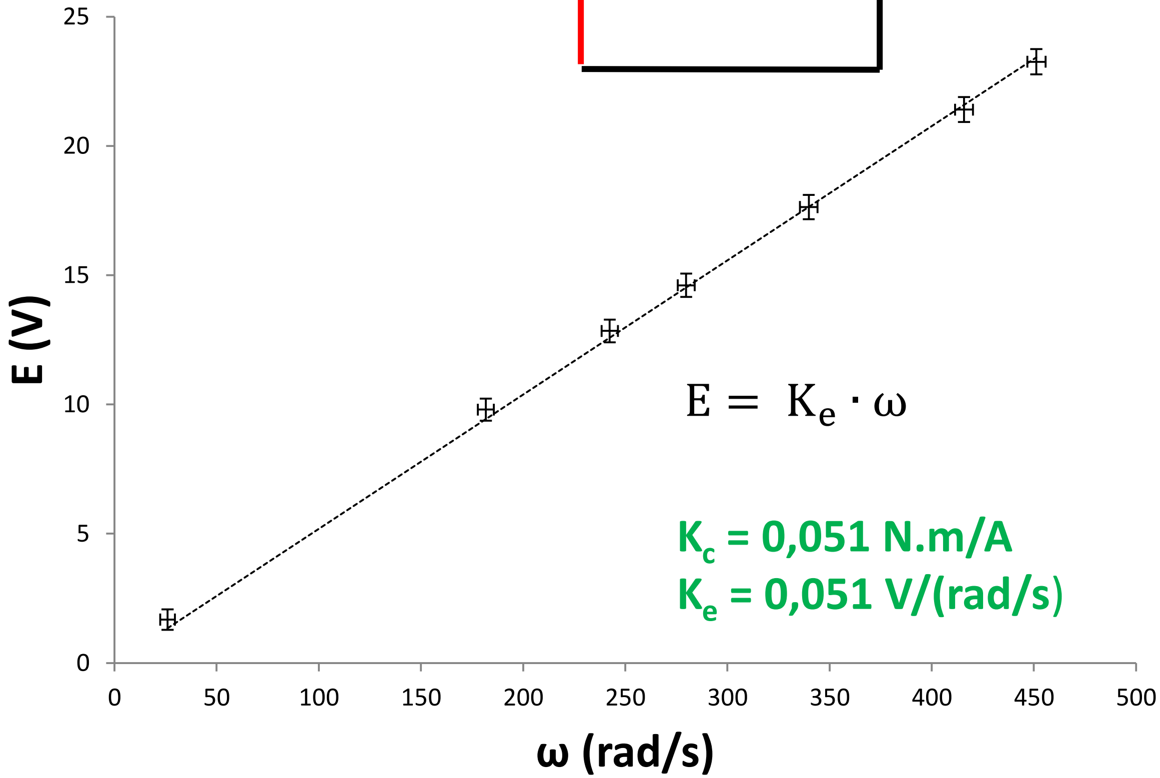
- On néglige l'inductance : L = 0 H
- En bloquant le rotor : R = 9,96 $\pm$0,12 Ω



a) Caractéristiques des moteurs

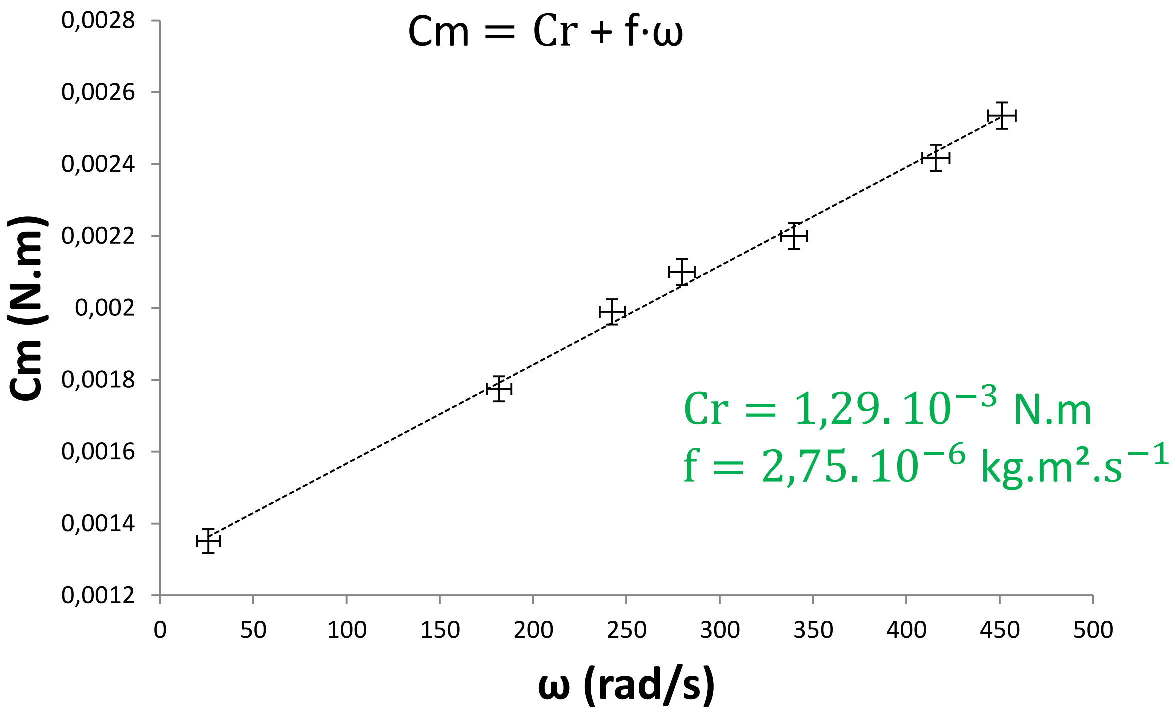
Essai à vide :





a) Caractéristiques des moteurs

Essai à vide :

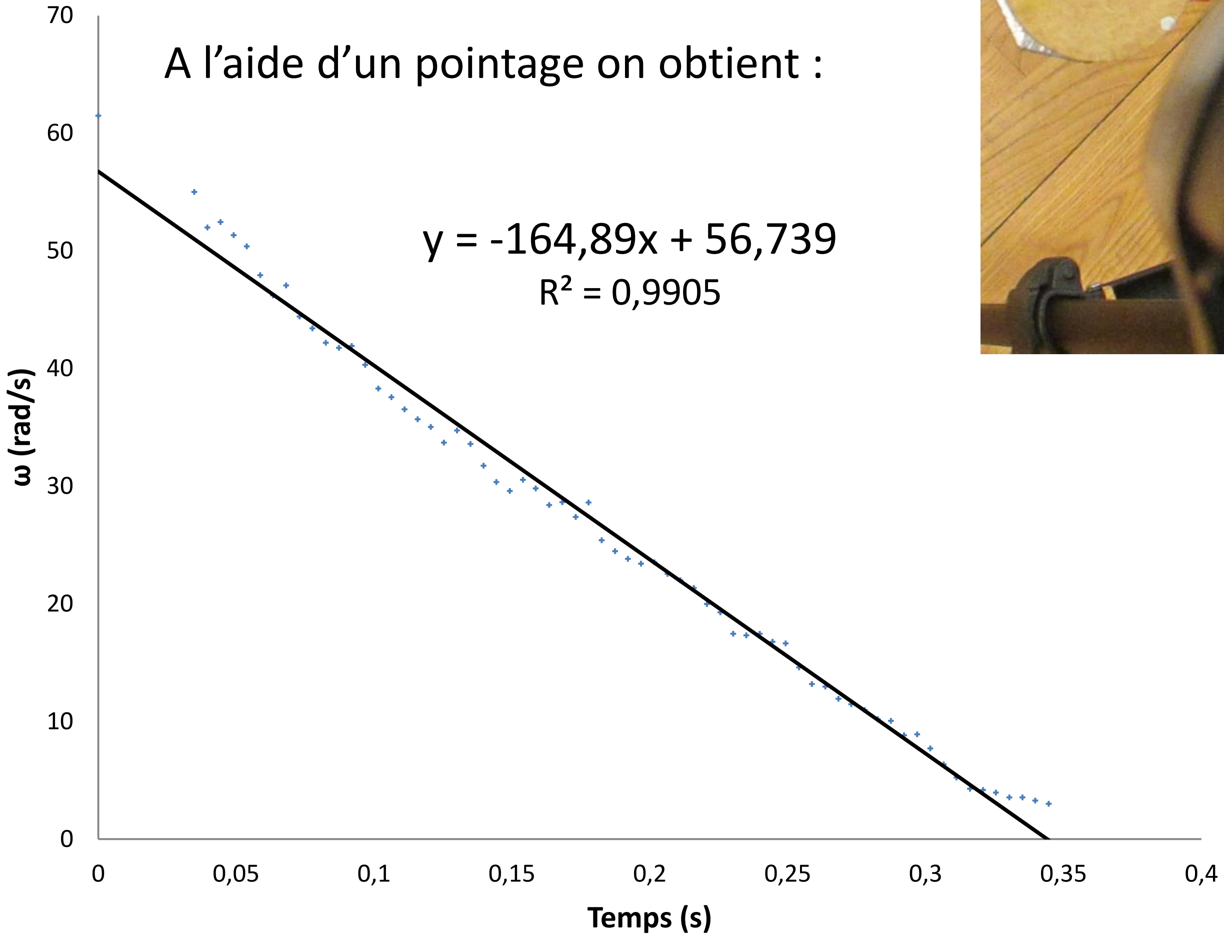


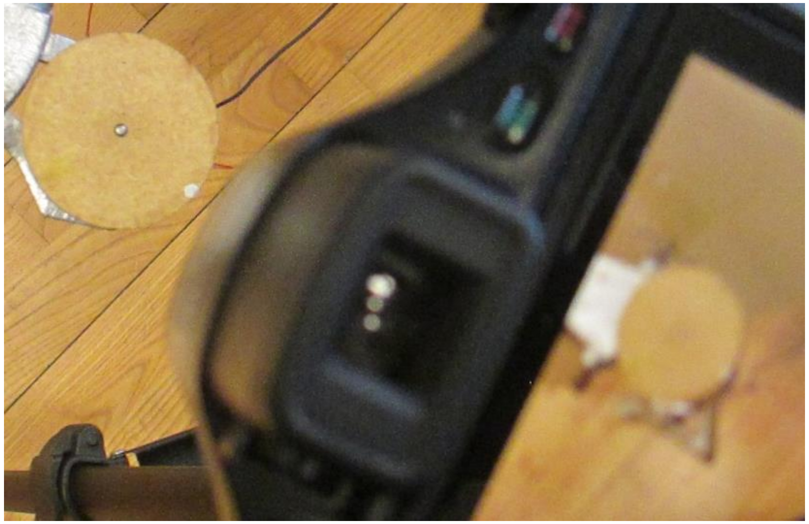
a) Caractéristiques des moteurs

- On effectue un essaie de lâcher:

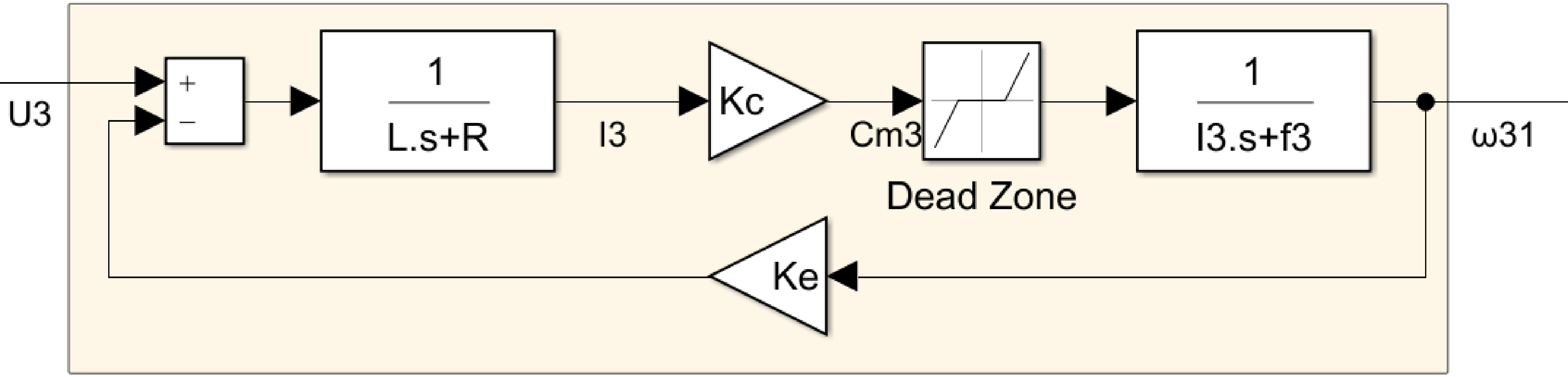
$$I_2 \frac{d\omega}{dt} = -Cr_2(t)$$

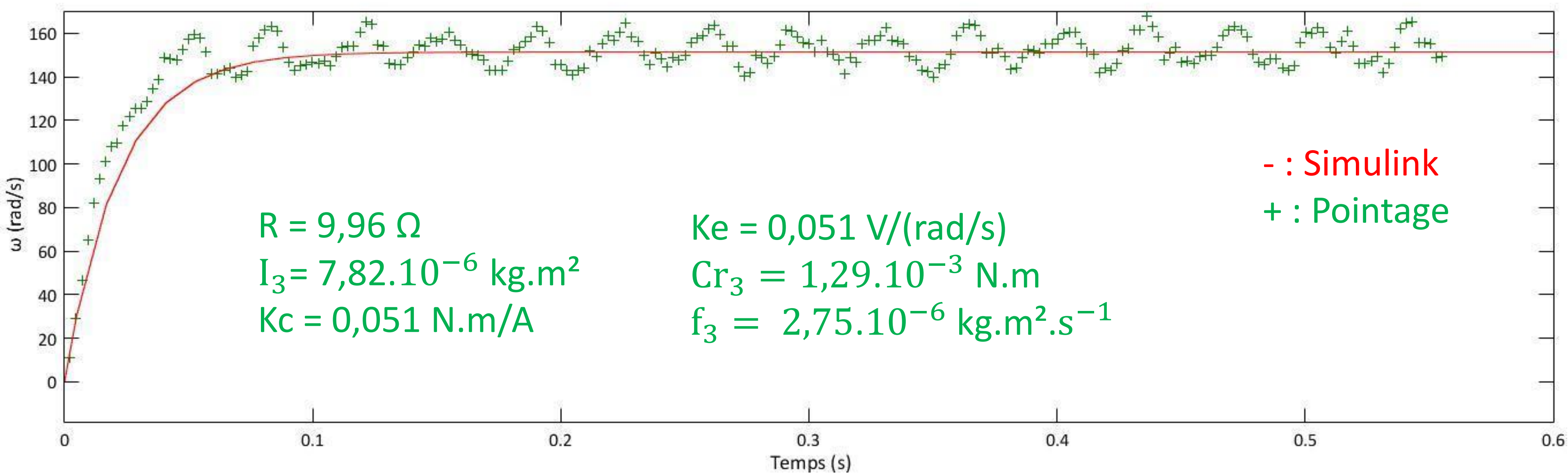
A l'aide d'un pointage on obtient :



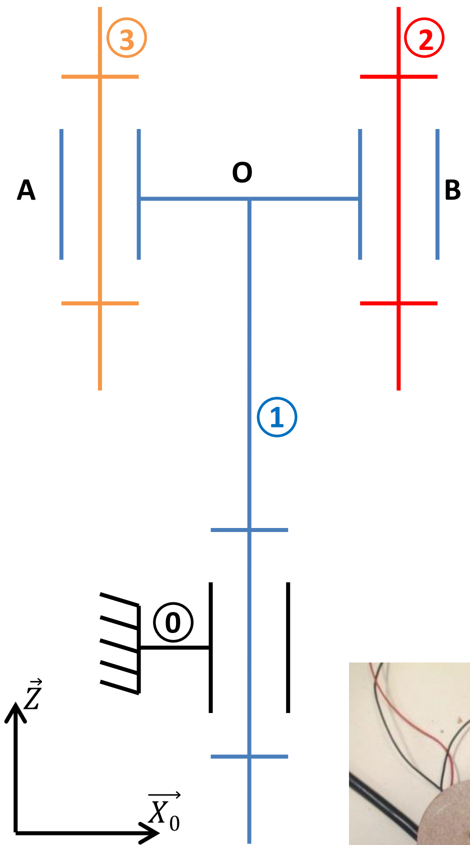


Donc : $I_2 = I_3 = 7{,}82.10^{-6}\ kg.m^2$


U3
+
−
1
L.s+R
I3
Kc
Cm3
Dead Zone
1
I3.s+f3
ω31
Ke


ω (rad/s)
Temps (s)
- : Simulink
+ : Pointage
R = 9,96 Ω
I_3= $7{,}82.10^{-6}$ kg.m²
Kc = 0,051 N.m/A
Ke = 0,051 V/(rad/s)
$Cr_3 = 1{,}29.10^{-3}$ N.m
$f_3 = 2{,}75.10^{-6}$ kg.m².s^{-1}

b) Caractéristiques du plateau



On isole {3} (respectivement {2})

Théorème du moment dynamique en A suivant $\vec{z}$:

$$\mathbf{I_3\dot{\omega}_{31}(t) = Cm_3(t) - Cr_3(t) - f_3\omega_{31}(t) - I_3\dot{\omega}_{10}(t)}$$
$$\mathbf{I_2\dot{\omega}_{21}(t) = Cm_2(t) - Cr_2(t) - f_2\omega_{21}(t) - I_2\dot{\omega}_{10}(t)}$$

On isole {1+2+3}

Théorème du moment dynamique en O suivant $\vec{z}$, en posant $I_{eq} = I_1 + I_2 + m_2 \cdot {r_2}^2 + I_3 + m_3 \cdot {r_3}^2$:

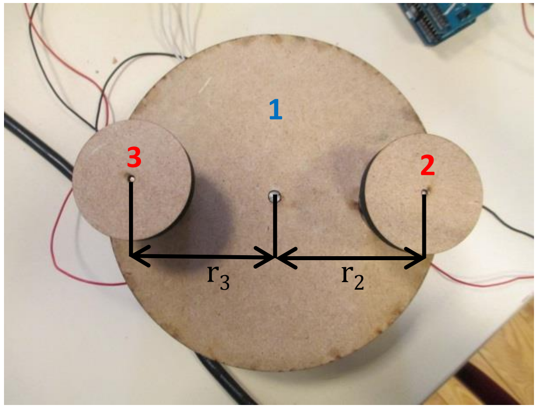
$$\mathbf{I_{eq}\dot{\omega}_{10}(t) = -I_2\dot{\omega}_{21}(t) - I_3\dot{\omega}_{31}(t) - Cr_1(t) - f_1\omega_{10}(t)}$$

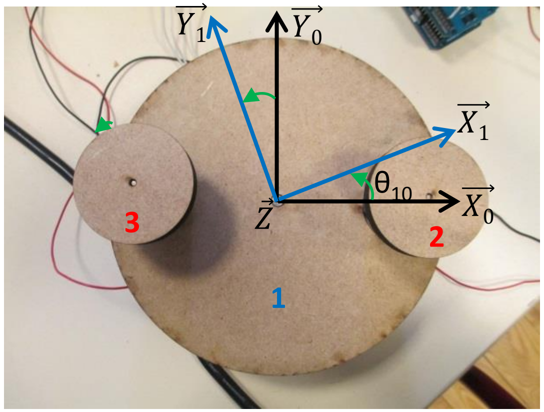
Longueurs :

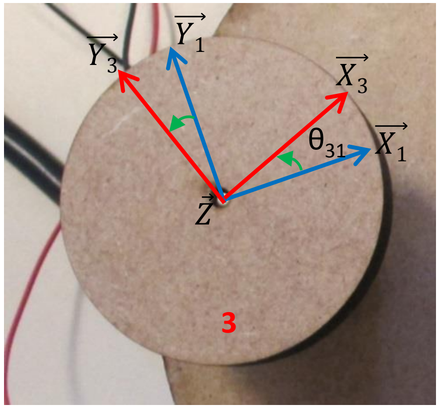
$\overrightarrow{OB} = r_2 \cdot \overrightarrow{x_1}$;

$\overrightarrow{0A} = -r_3 \cdot \overrightarrow{x_1}$

$r_3 = r_2$







b) Caractéristiques du plateau

On considère les composants comme des cylindres d'épaisseur e = 8 mm.

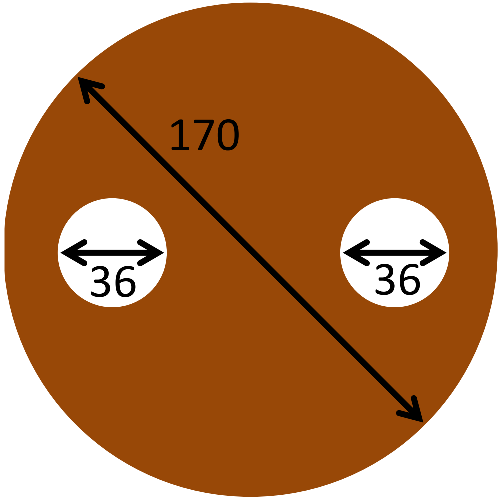
Masses :

M_{moteur} = 210,7 g

M_{volant} = 12,8 g

$M_{plateau}$ = 130,8 g

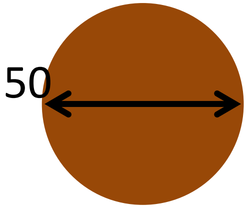
Plateau



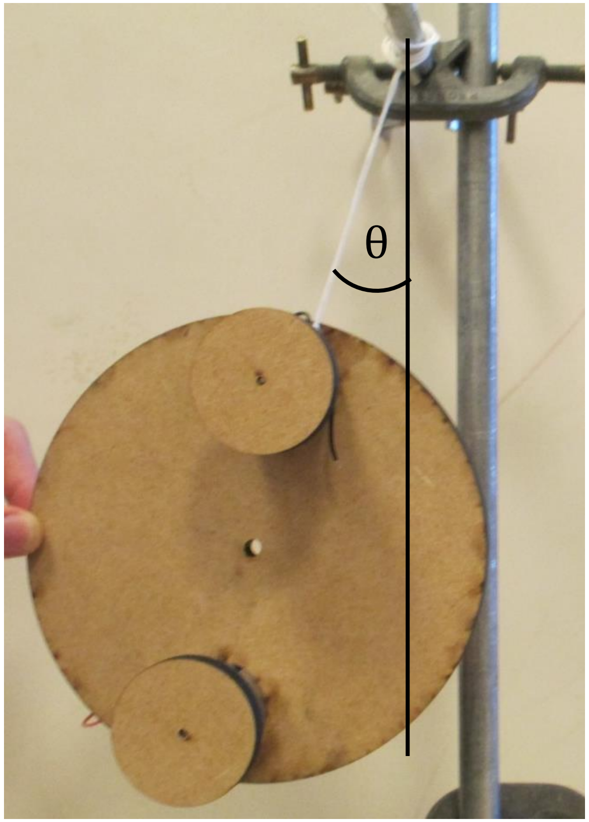
Plateau : $I_1 = 2{,}05.10^{-3}$ kg.m²

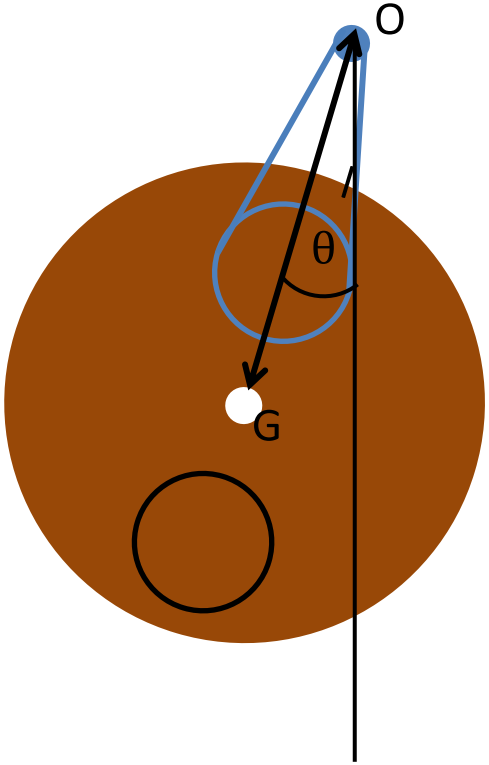
Inertie équivalente : $I_{eq} = 3{,}6.10^{-3}$ kg.m²

Volants d'inertie



b) Caractéristiques du plateau





On mesure la période d'oscillation de l'ensemble, et on en déduit le moment d'inertie en O, on le transporte en G :

$$J = mgl * \frac{T^2}{4\pi^2}$$

On mesure :

T = 0,70 s

l = 0,098 m

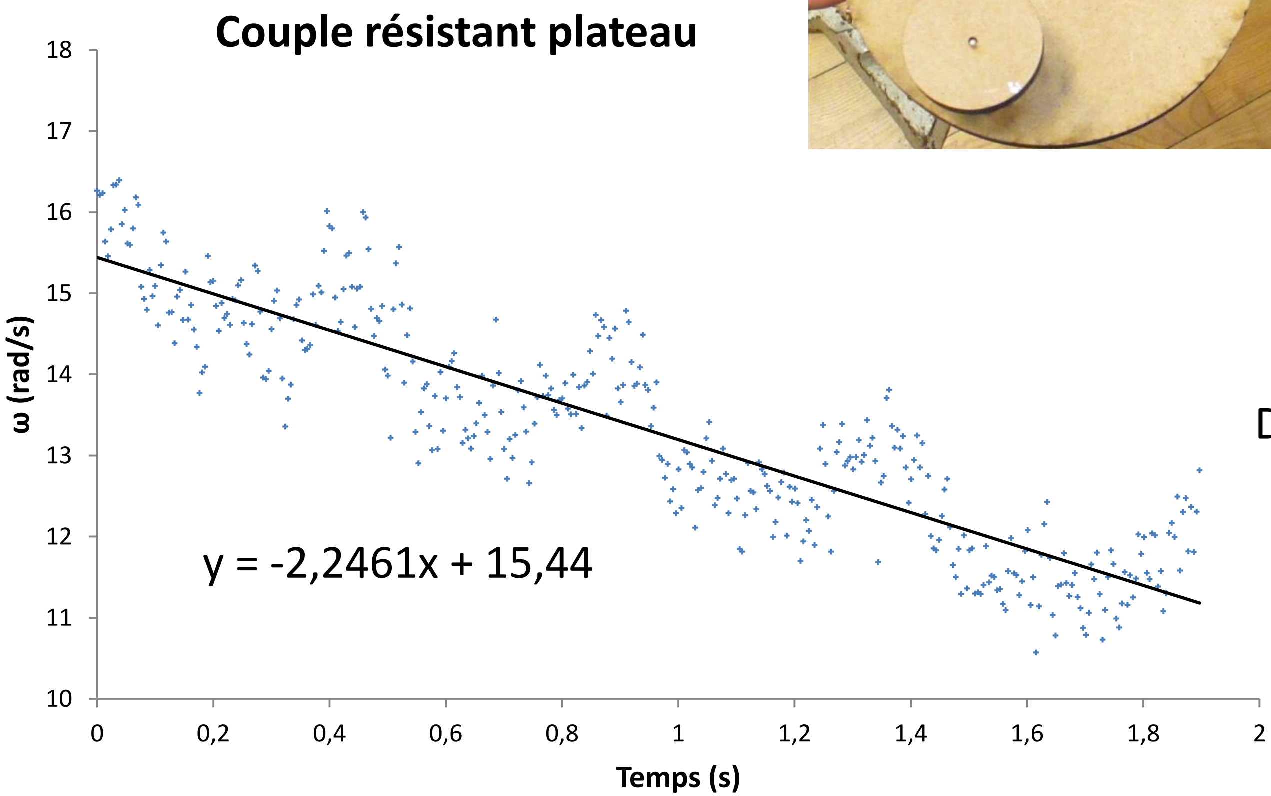
m = 0,552 kg

Donc I_{eq} = $1{,}4.10^{-3}$ kg.m^2

$$I_{eq} = I_1 + I_2 + I_3 + m_2 \cdot {r_2}^2 + m_3 \cdot {r_3}^2$$

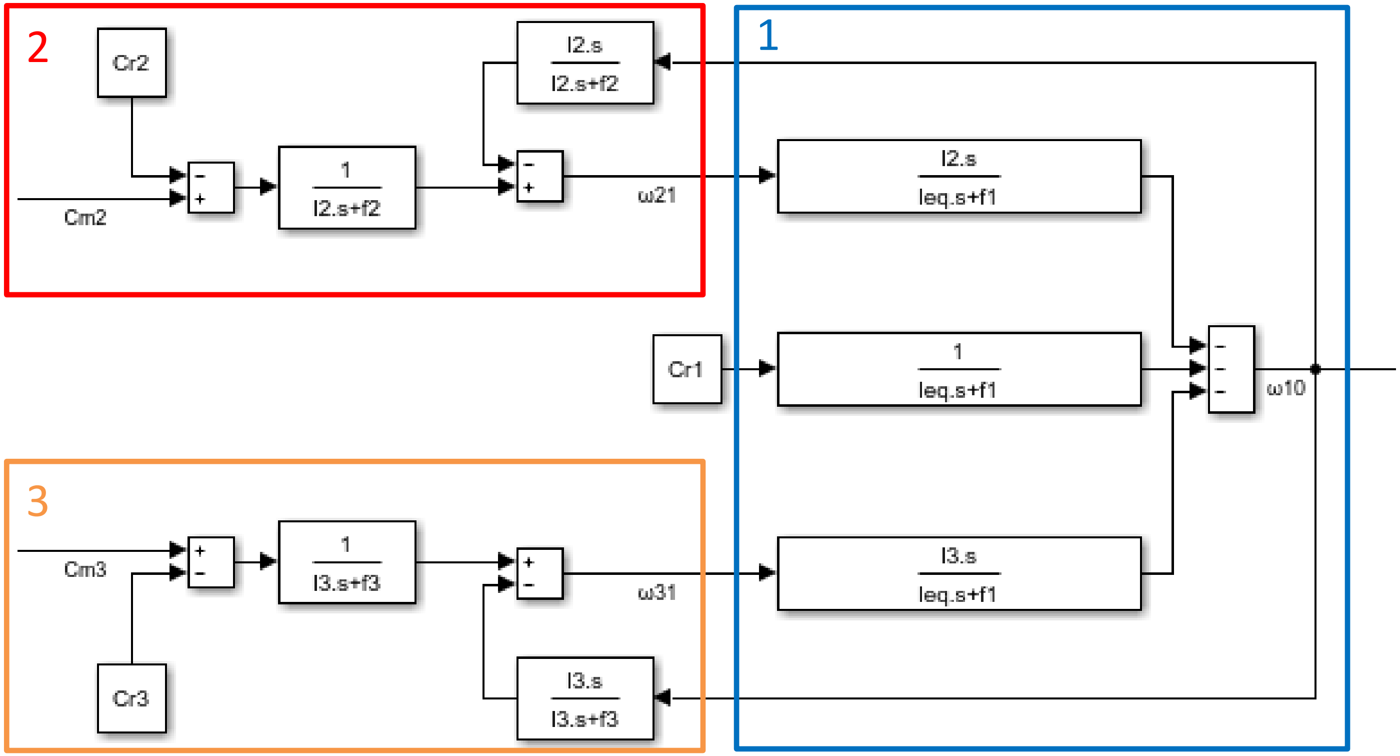
b) Caractéristiques du plateau

- $I_{eq}\frac{d\omega}{dt} = Cr_1(t)$



Donc : $Cr_1 = 8.10^{-3} N.m$

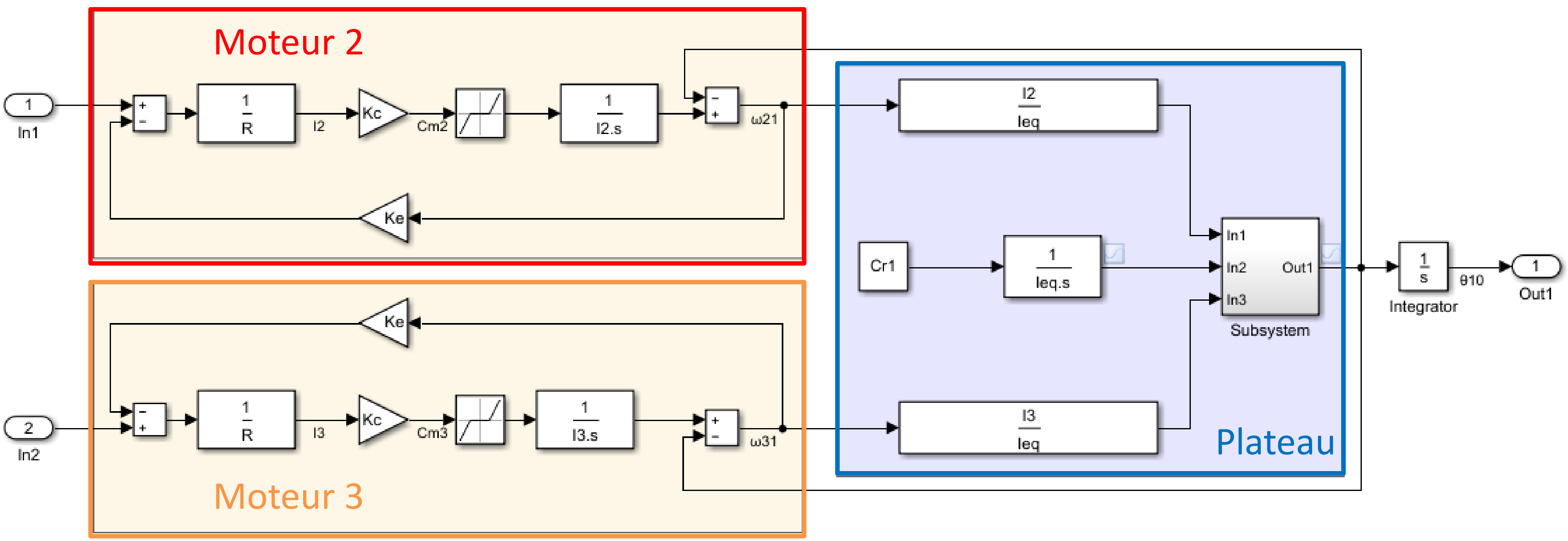
b) Caractéristiques du plateau



$I_2 = I_3 = 7{,}82.10^{-6}$ kg.m²
$I_{eq} = 3{,}6.10^{-3}$ kg.m²
$Cr_2 = Cr_3 = 1{,}29.10^{-3}$ N.m

$Cr_1 = 8\,.10^{-3}$ N.m
$f_2 = f_3 = 2{,}75.10^{-6}$ kg.m².s^{-1}

c) Validation

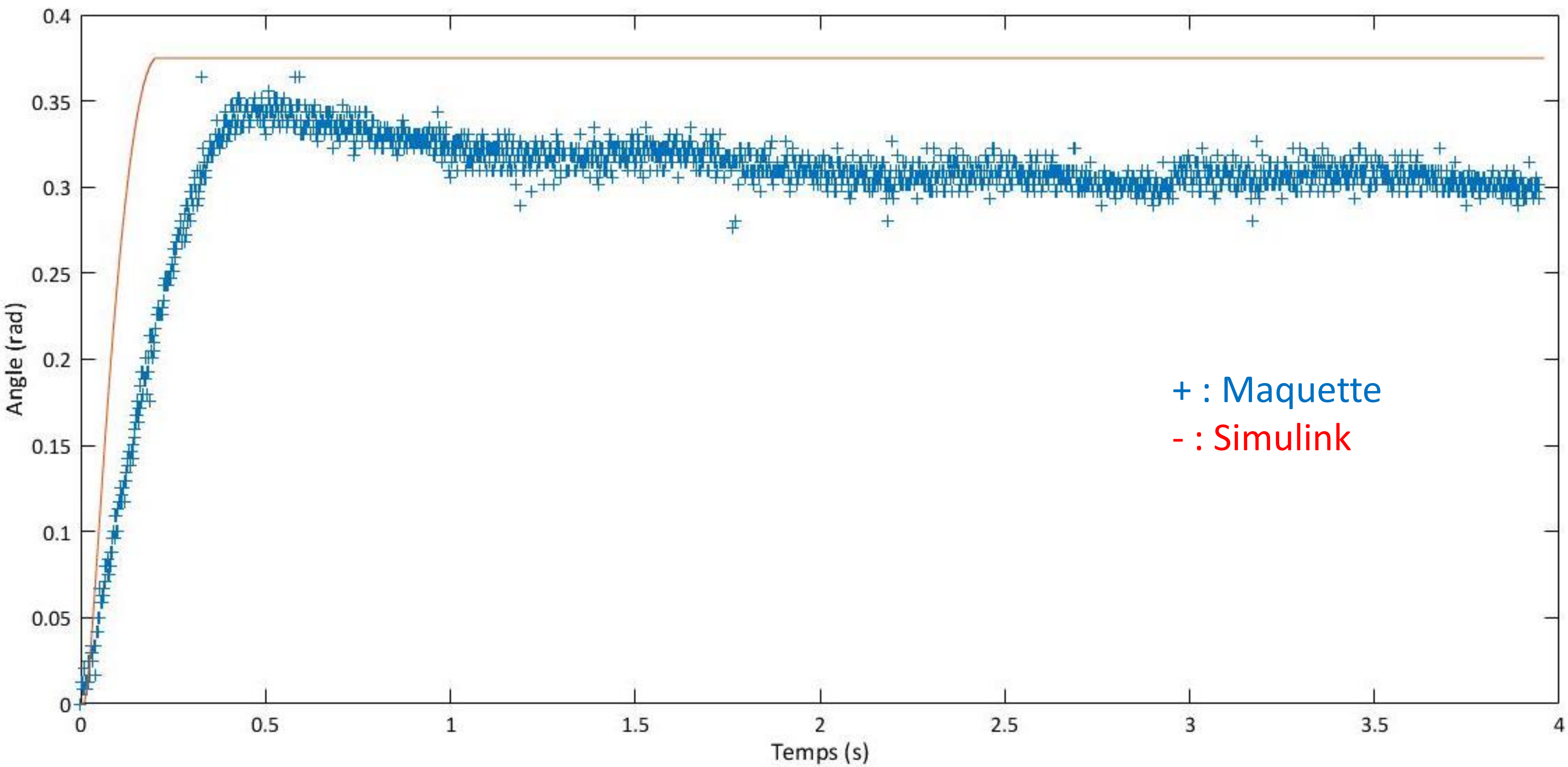


$R = 9{,}96\ \Omega$
$Kc = 0{,}051$ N.m/A
$Ke = 0{,}051$ V/(rad/s)

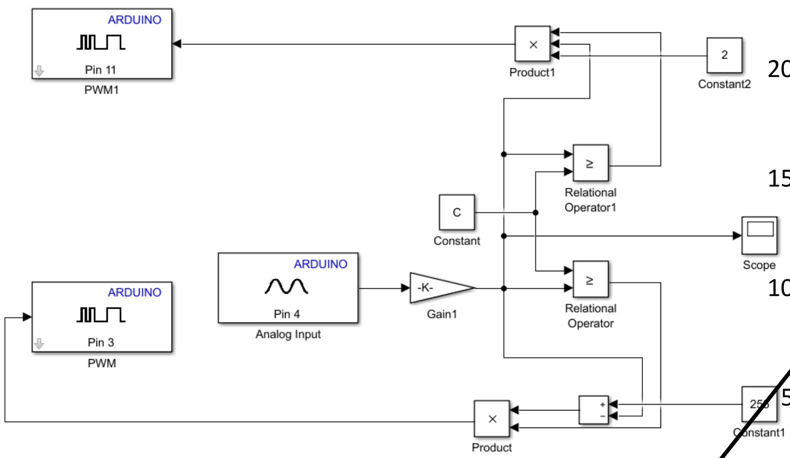
$I_1 = 2{,}05.10^{-3}$ kg.m²
$I_2 = I_3 = 4{,}18.10^{-6}$ kg.m²
$I_{eq} = 3{,}6.10^{-3}$ kg.m²

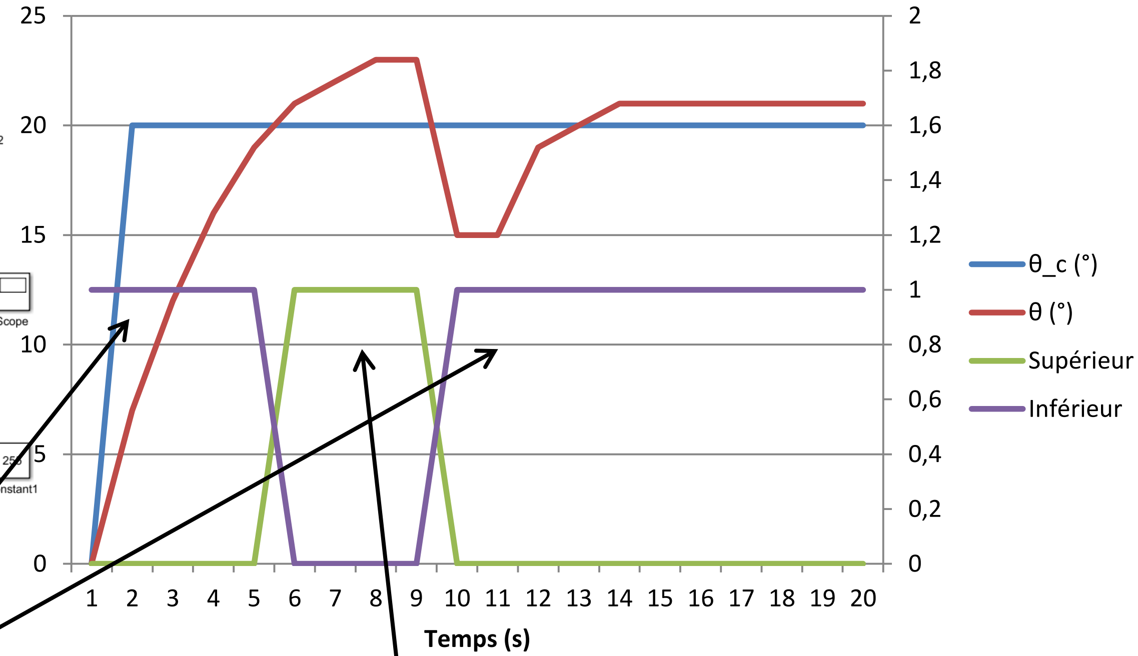
$Cr_1 = 0{,}008$ N.m
$Cr_2 = Cr_3 = 0{,}0007$ N.m

c) Validation



a) Avec MatLab

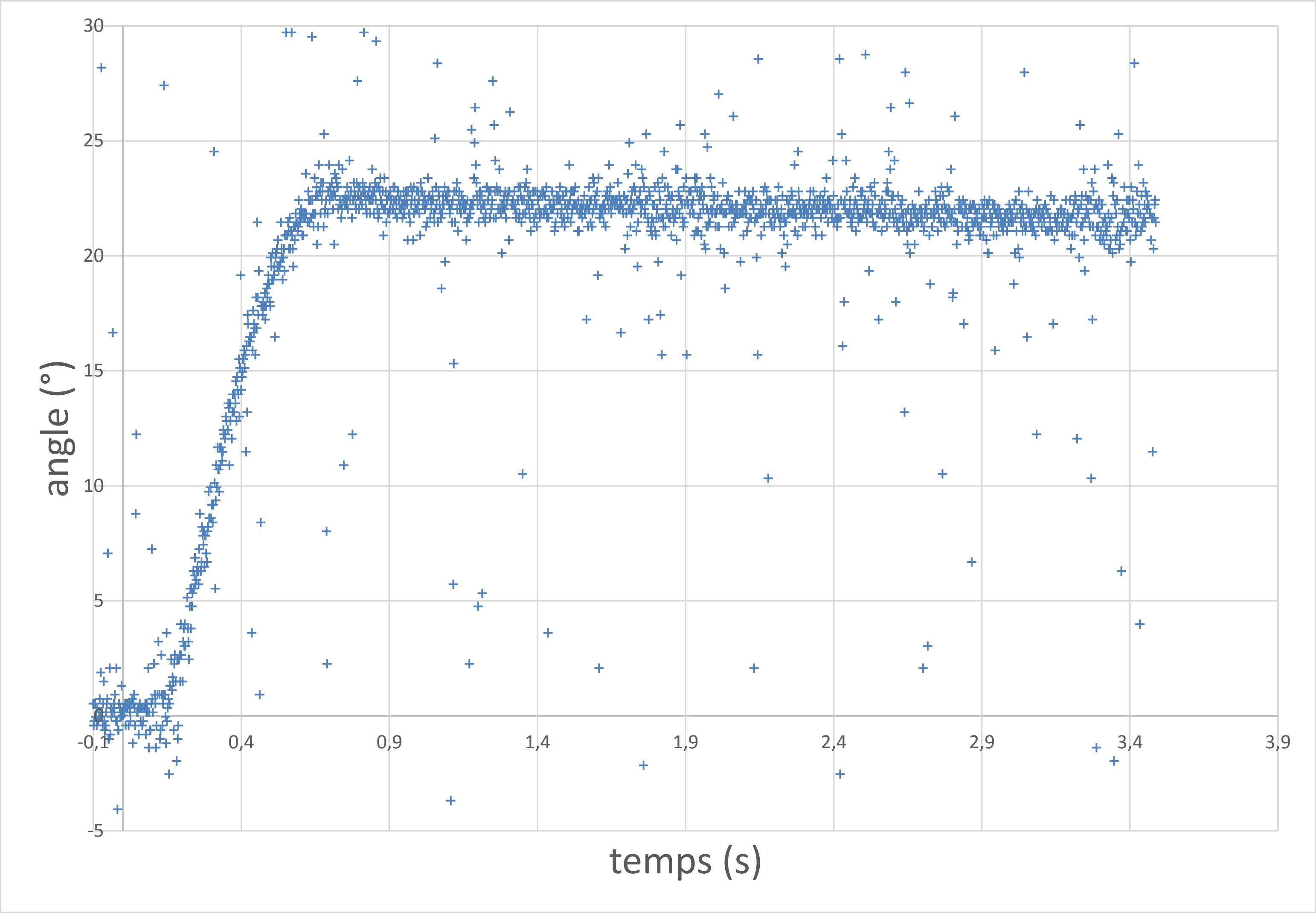




$\theta_c > \theta$: On alimente le moteur 1

$\theta_c < \theta$: On alimente le moteur 2

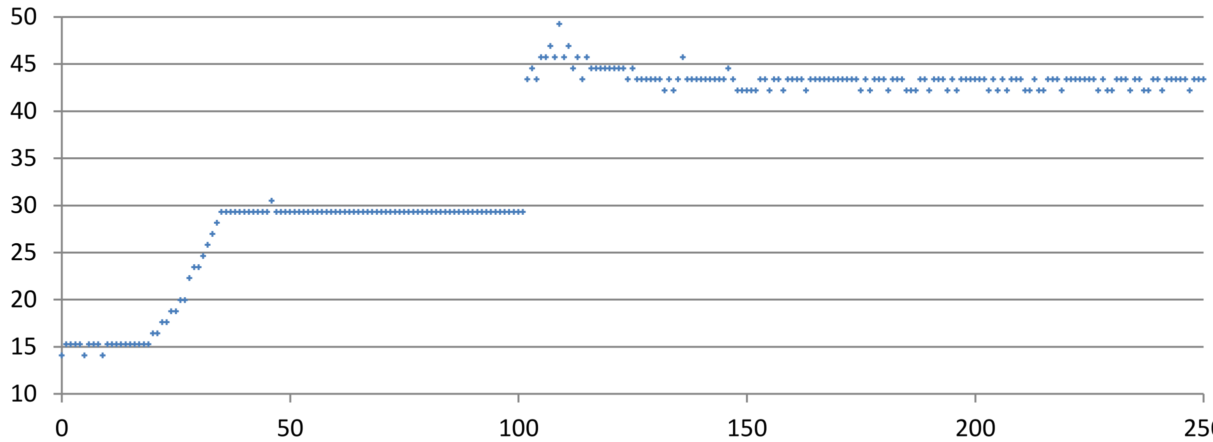
a) Avec MatLab

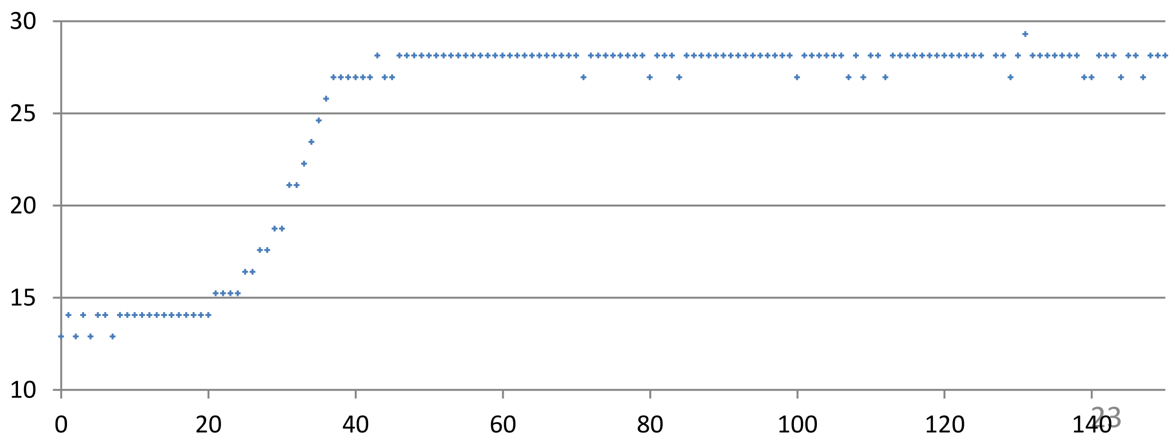


b) Avec Arduino

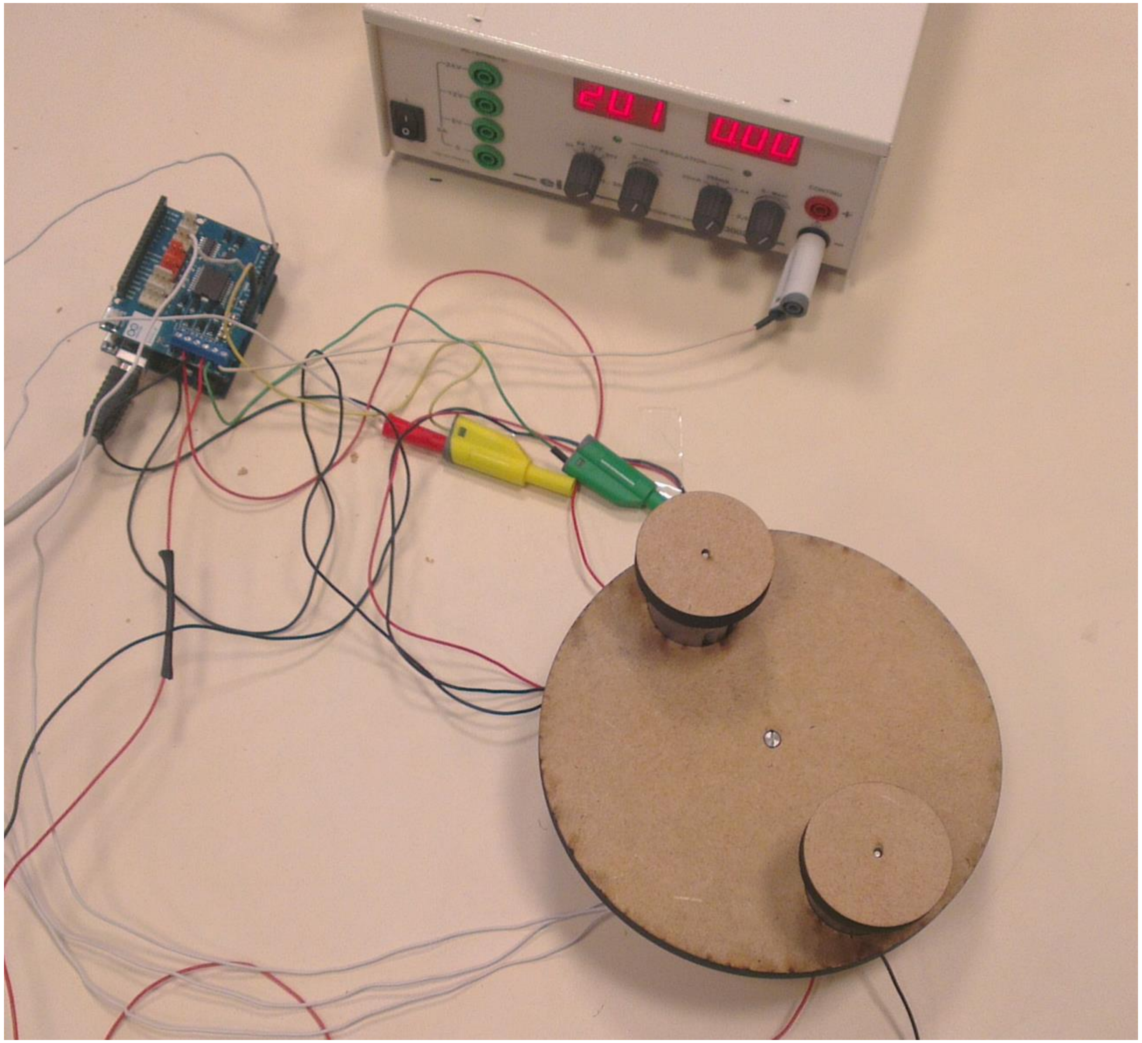
```
while (abs(angle-C) > 2)
{
   //Acceleration variable, a augmente
   a = 3*abs(Consigne-abs(angle-C))+5;
 //Serial.println("while");

   //Acceleration
   if (C>angle)
   {
       pwma += 5;
       analogWrite(Va,pwma);
       delay(a);
       angle = analogRead(pot);
   Serial.println(angle);
   }

   //Arret
   if (pwma >= 250)
   {
       for (int i=0; i<=50; i++)
       {
           pwma -=5;
           analogWrite(Va,pwma);
           Serial.println(angle);
           delay(d); // on définit d p
       }
       pwma = 0;
       analogWrite(Va,pwma);
   }
```

- Si l'angle est supérieur à la consigne, on accélère le moteur 1
- Quand le moteur tourne à la vitesse maximum, on l'arrête progressivement

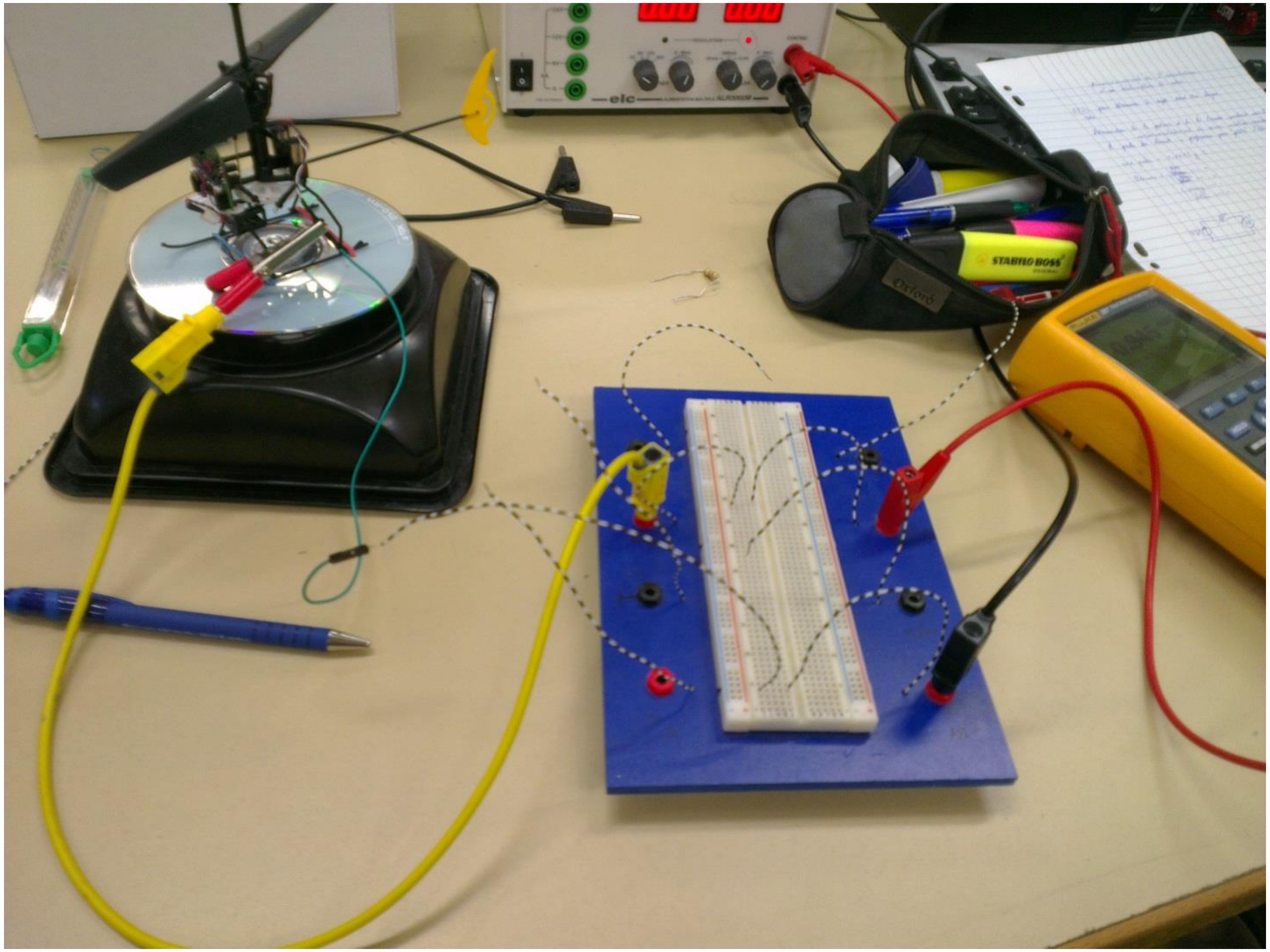




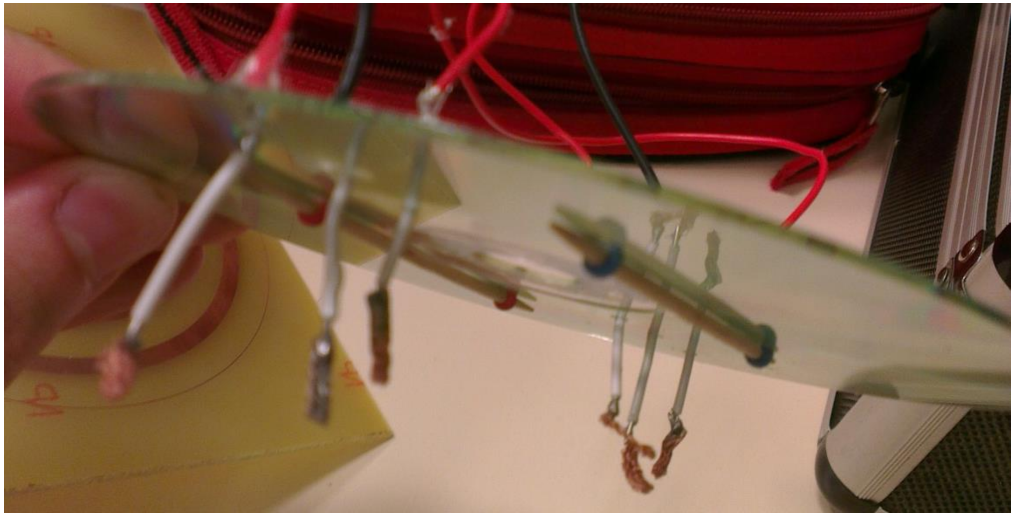
Conclusion



Annexe



Annexe



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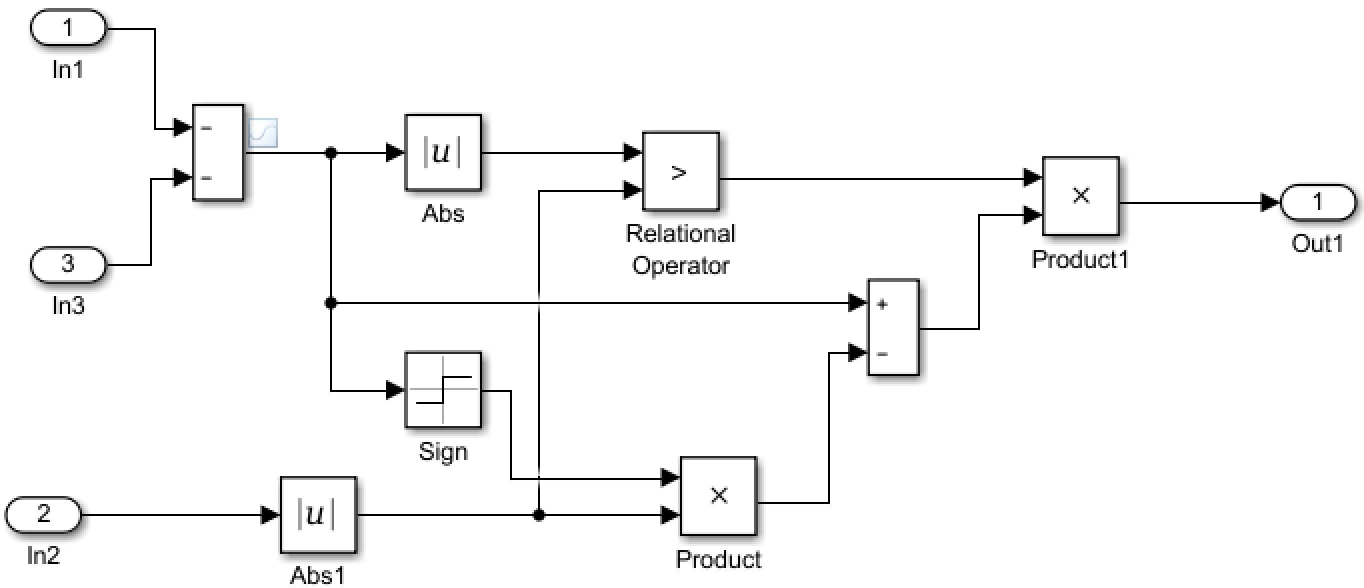

1
In1
3
In3
2
In2
|u|
Abs
Relational
Operator
Sign
|u|
Abs1
Product
Product1
1
Out1