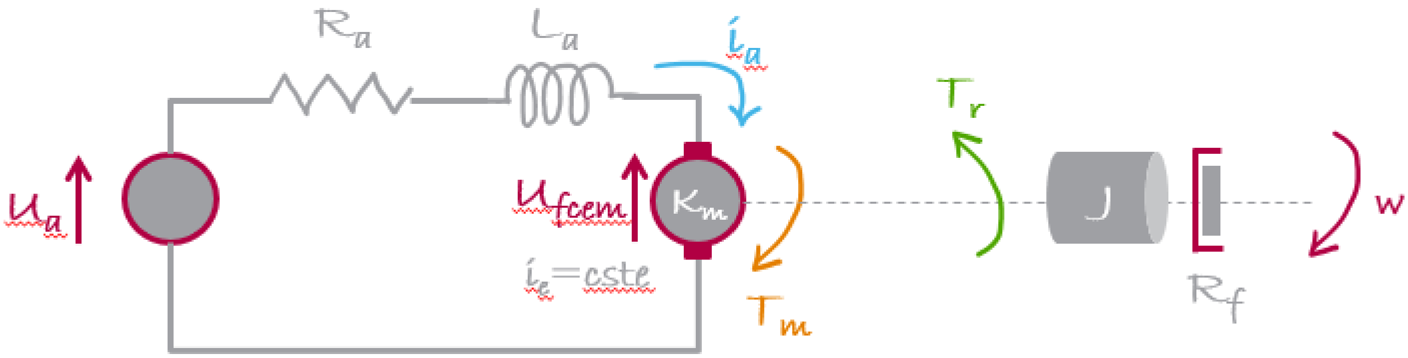
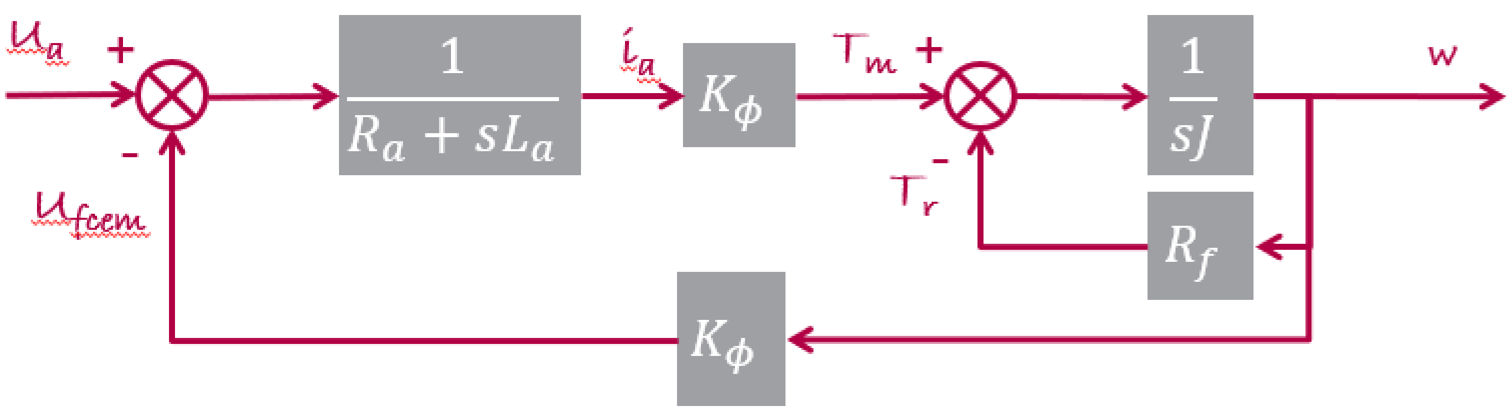
Transfer Functions creation & manipulation. *

Let's imagine a DC motor having the next block-diagram model :



$$\begin{cases} T_m = K_\phi i_a \\ u_a = R_a i_a + L_a \dfrac{di_a}{dt} + u_{fcem} \\ u_{fcem} = K_\phi \omega \end{cases}$$

$$T_m - Tr = J\frac{d\omega}{dt} + R_f\omega$$



Here are the parameters :

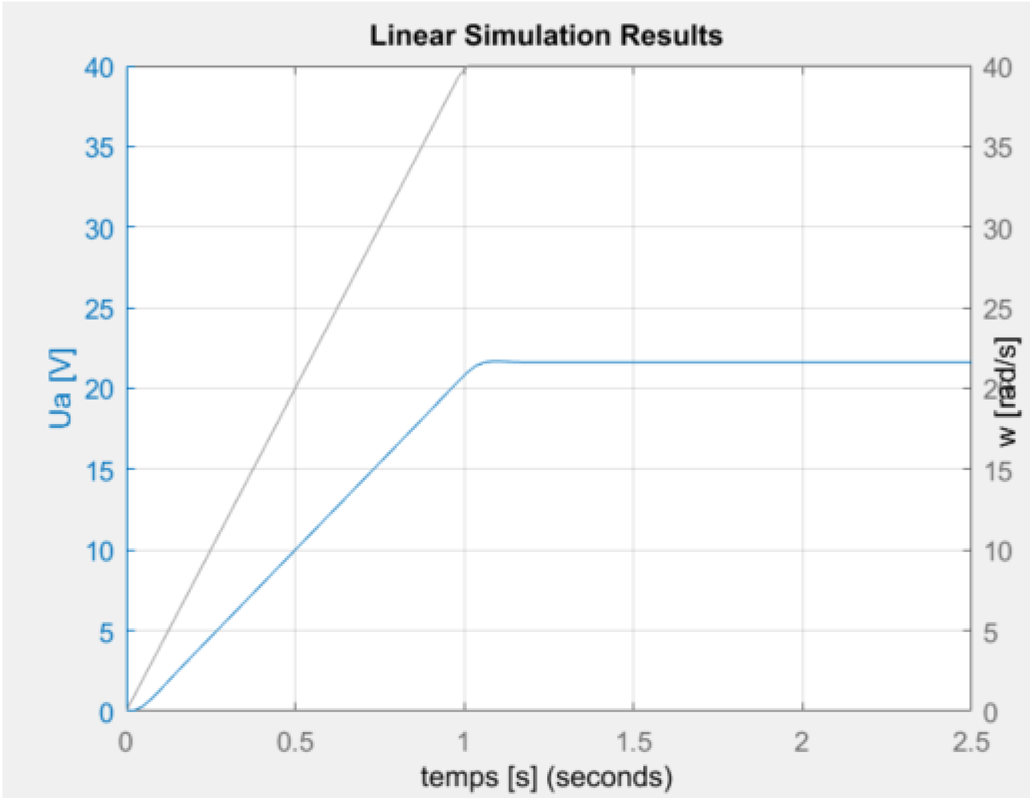
- Ra = 1,6 [Ohms]
- La = 32 [mH]
- Kphi = 1,7 [Nm/A] or [V/rad/s]
- J = 0,07 [kgm²]
- Rf = 0,16 [Nm/rad/s]

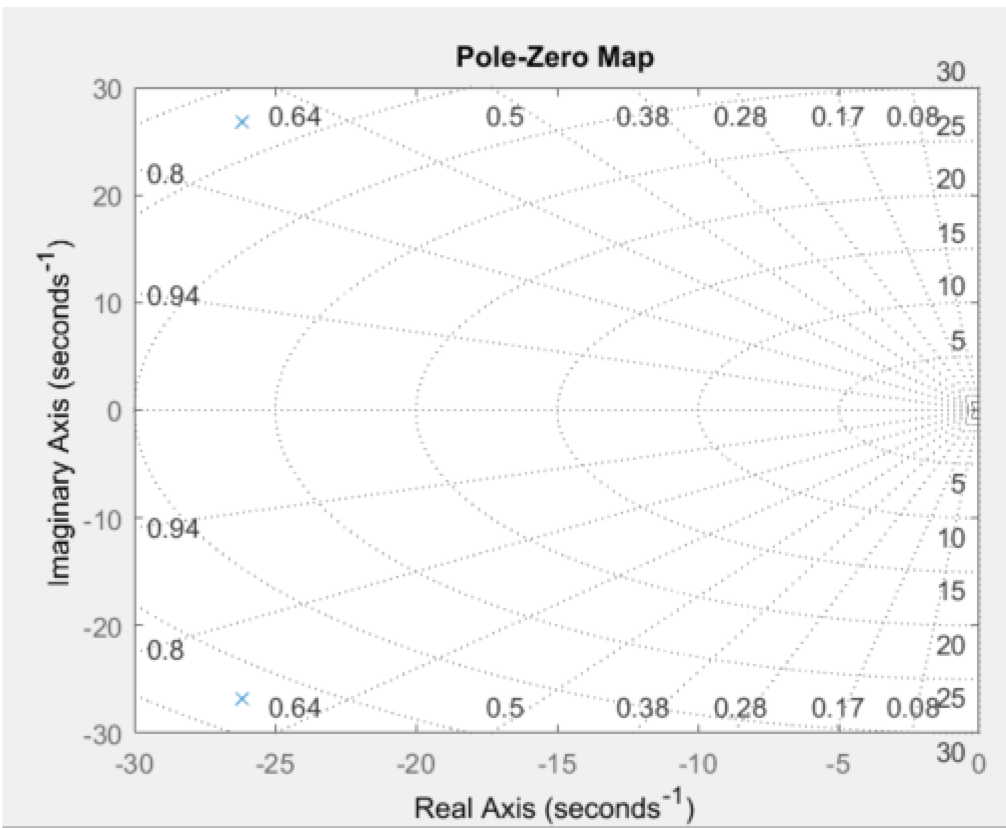
You're asked to :

- Compute, using Matlab, the transfer function between the motor's speed w and the voltage Ua
- Plot the speed evolution for 2.5 seconds, if the voltage Ua is a ramp (with a slope of 40V/s) during 1 second and then stays constant.
- Plot the poles of the transfer function in the complex plane

Solution :

- ***$H(s)=758.9 / (s^2+52.29\ s + 1404)$***






```
clear all
close all
```

```
% Transfer Function computation
Ra=1.6; La=0.032; Rf=0.16; Kphi=1.7; J=0.07;

Te=La/Ra
```

```
Te = 0.0200
```

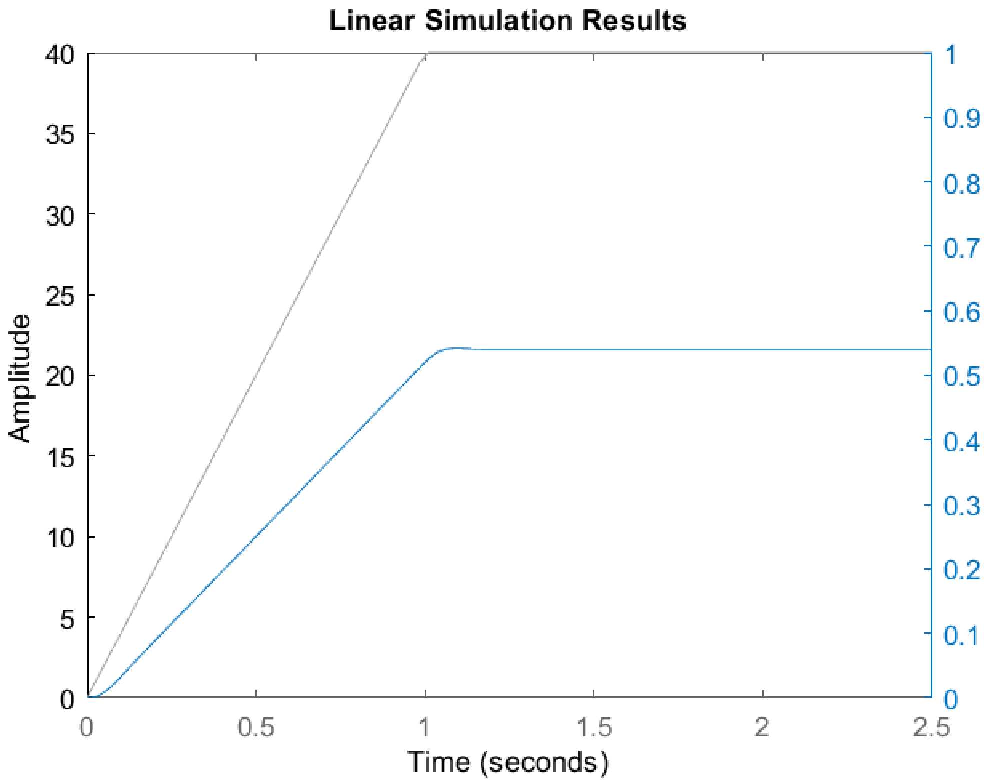
```
Tm=J/Rf
```

```
Tm = 0.4375
```

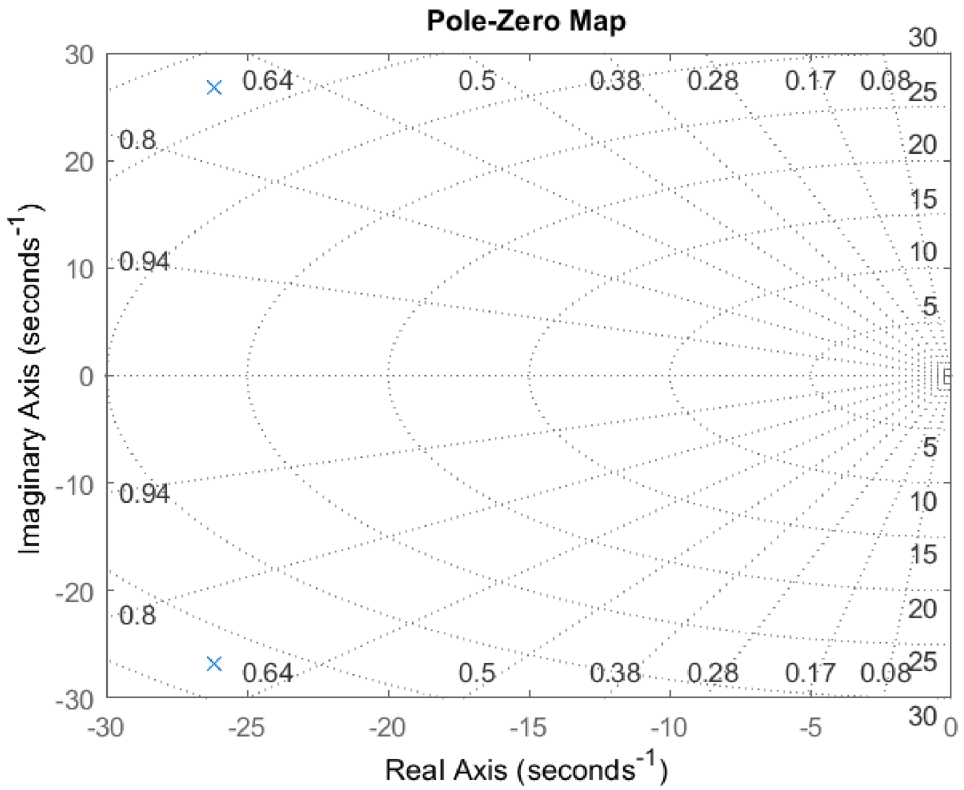
```
s=tf('s');
H1=Kphi/(Ra+s*La);
H2=1/(s*J);
H3=minreal(H2/(1+H2*Rf)); % or with H3=feedback(H2,Rf)
H4=H1*H3;
H=H4/(1+H4*Kphi); % or with H=feedback(H4,Kv)
H=minreal(H)
```

```
H =

         758.9
  --------------------
  s^2 + 52.29 s + 1404

Continuous-time transfer function.
```

```
% Alternative
% H1=Kphi*(1/Ra)/(1+s*La/Ra);
% H2=(1/Rf)/(1+s*J/Rf);
% H3=H1*H2;
% H= minreal(H1*H2/(1+H1*H2*Kphi))
% Time response
t=linspace(0,2.5,100);
u=40*t; u(t>1)=40;
lsim(H,u,t)
yyaxis left
plot(t,u);
```




```
ylabel('Ua [V]');
yyaxis right
ylabel('w [rad/s]');
xlabel('temps [s]');
grid, grid minor
% Poles
pzmap(H)
grid, grid minor
```




```
pole(H) % One can see that the imaginery part is almost the same as the real
part, so the damping ratio = 0,707 (or theta = 45°) and the overshoot is
almost not discernable (4%)
```

```
ans = 2×1 complex
 -26.1429 +26.8517i
 -26.1429 -26.8517i
```