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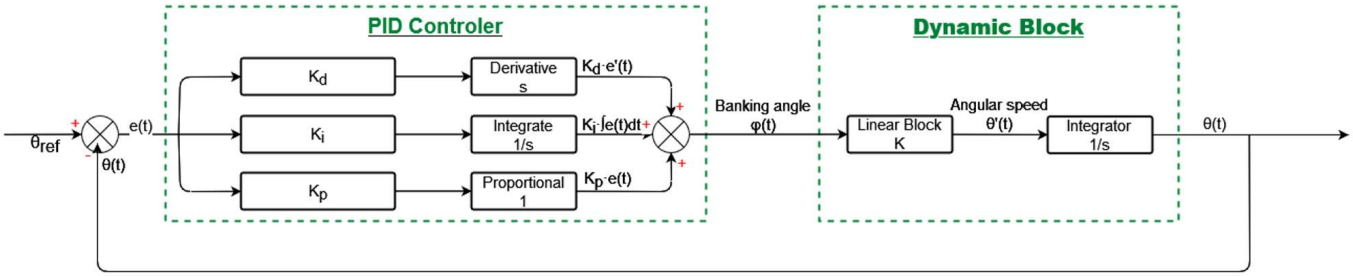
PID Control - Tuning

This notebook is dedicated to the tuning of the PID controler for different models of bird flying on a plane. I will only study the linearized system.

Preliminary calculations

```
s = tf('s'); % variable used for the transfer function
```

Linearized Problem - Control over θ



Create the plant system

```
% Define the open-loop system
sys = 1/s;
```

PID Tuning Options

```
% options = pidtuneOptions('CrossoverFrequency', 10, ...
%                           'PhaseMargin', 60, ...
%                           'DesignFocus', 'reference-tracking');
options = pidtuneOptions('CrossoverFrequency',10) ;
```

PID tuning with `pidtune`

```
% Tuning PID Controler
% [C_pid, info] = pidtune(sys, 'PID', options);
[C_pid, info] = pidtune(sys, 'PID');
```

Let's show the different parameters of the PID Controler.

```
Kp = C_pid.Kp
```

```
Kp = 0.9812
```

```
Ki = C_pid.Ki
```

```
Ki = 0.1929
```

```
Kd = C_pid.Kd
```

```
Kd = 0
```

We can also show bandwidth and phase margin information.

```
info
```

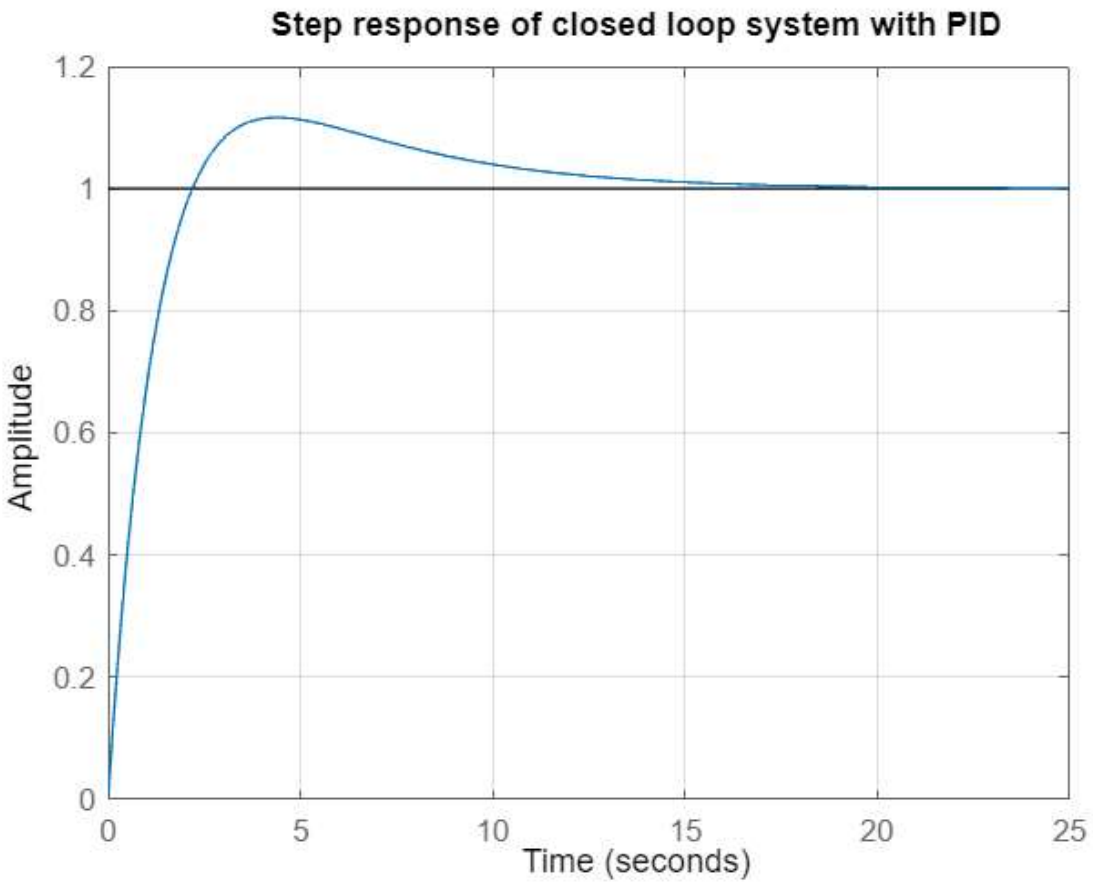
```
info = struct with fields:
                Stable: 1
    CrossoverFrequency: 1
           PhaseMargin: 78.8791
```

Closed loop with the PID Controler

```
closed_loop_sys = feedback(C_pid * sys, 1);
```

Step response of the closed loop system

```
figure;
step(closed_loop_sys);
title('Step response of closed loop system with PID');
grid on;
```




```
% Get the characteristics of the step response
info = stepinfo(closed_loop_sys)
```

```
info = struct with fields:
         RiseTime: 1.5687
    TransientTime: 12.5996
     SettlingTime: 12.5996
      SettlingMin: 0.9031
      SettlingMax: 1.1164
        Overshoot: 11.6370
       Undershoot: 0
             Peak: 1.1164
         PeakTime: 4.4150
```

Interpretation : ???

Bode plot for gain and phase margin analysis

```
[gm, pm, wg, wp] = margin(closed_loop_sys); % Compute phase and gain margins
gm % Gain margin in dB
```

```
gm = Inf
```

```
pm % Phase margin in degrees
```

```
pm = 144.8790
```

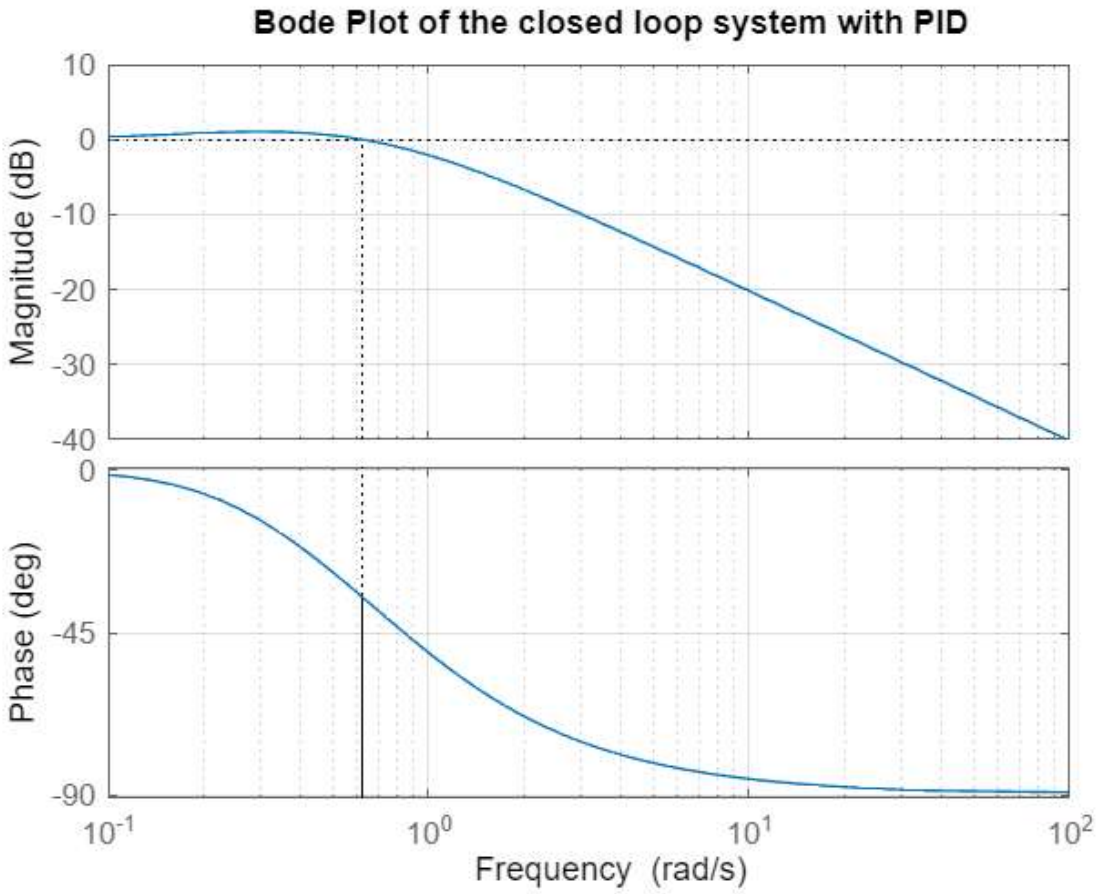
```
wg % Frequency at the gain margin, in rad/s
```

```
wg = NaN
```

```
wp % Frequency at the phase margin, in rad/s
```

```
wp = 0.6210
```

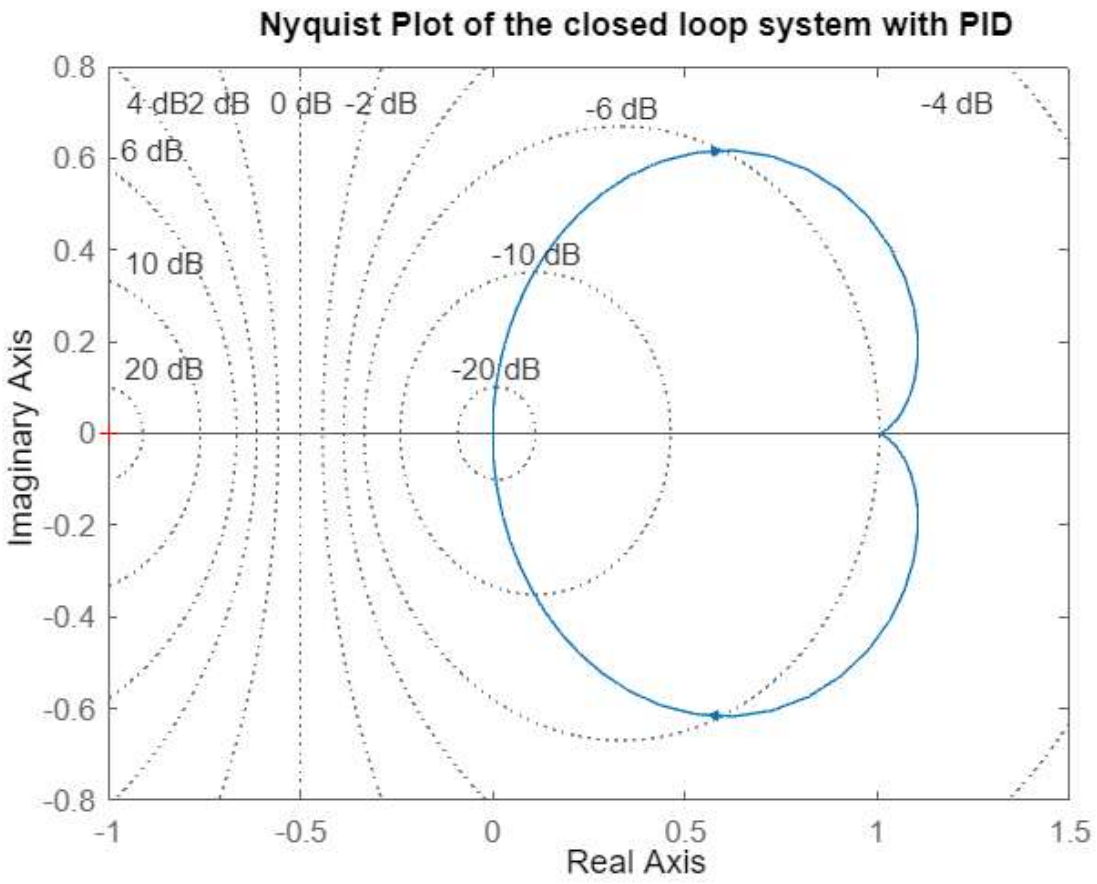
```
figure;
margin(closed_loop_sys);
title('Bode Plot of the closed loop system with PID');
grid on;
```



Interpretation : (margins, ...)

Nyquist plot for the study of stability

```
figure;
nyquist(closed_loop_sys);
title('Nyquist Plot of the closed loop system with PID');
grid on;
```



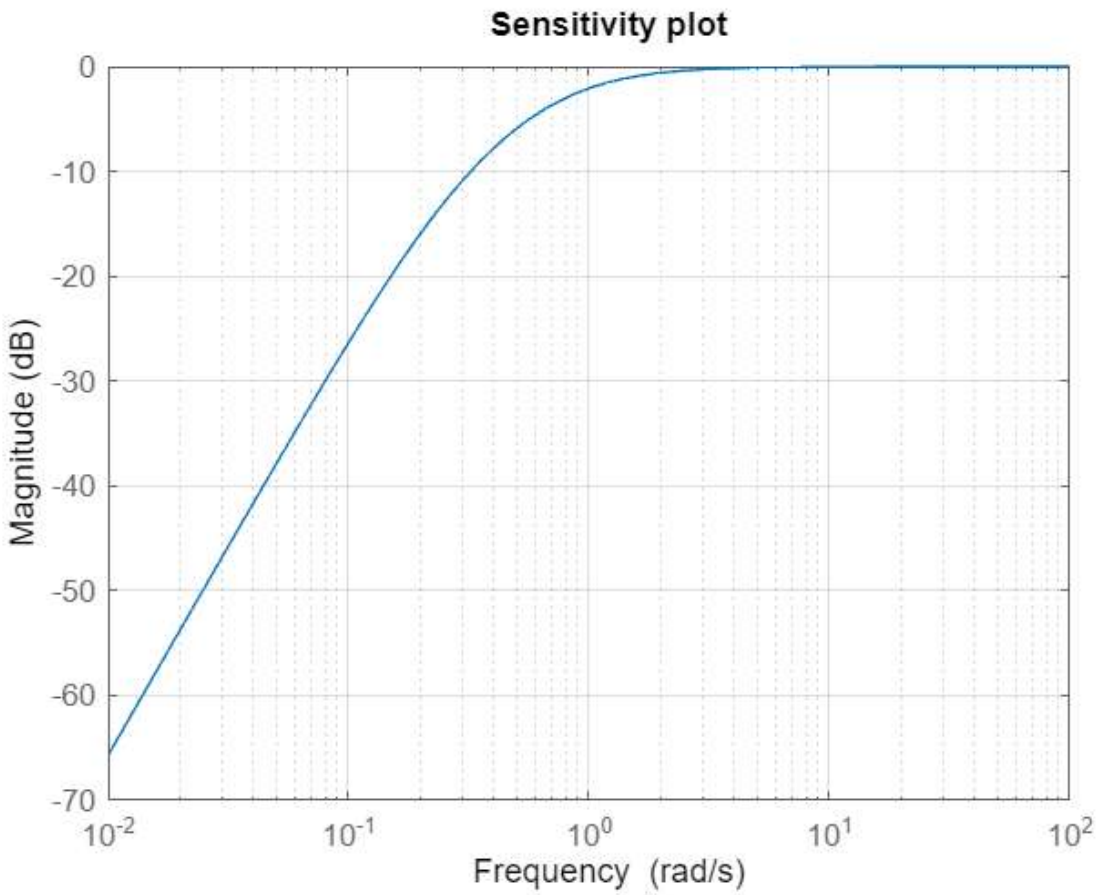
Interpretation : (Nyquist Criterion, etc.)

Sensitivity function

```
S = 1/(1+C_pid*sys)
```

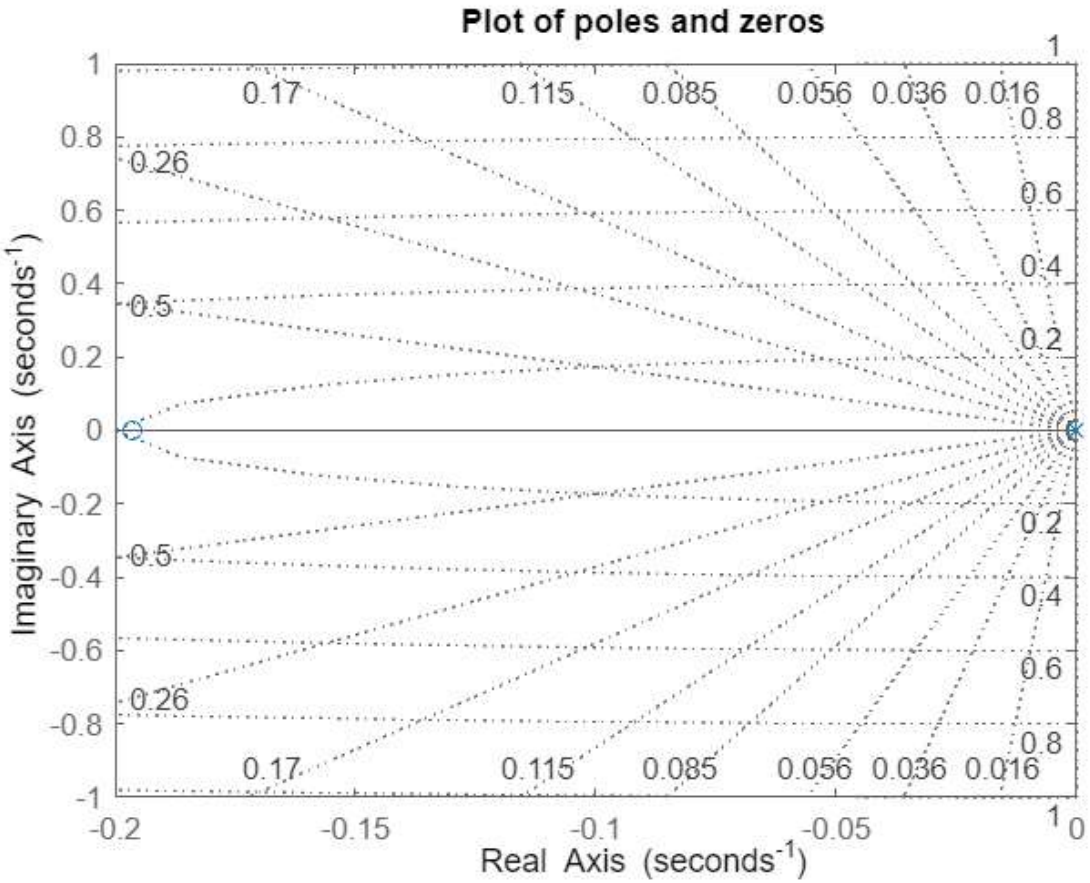
```
S =

           s^2
  ----------------------
  s^2 + 0.9812 s + 0.1929

Continuous-time transfer function.
Model Properties
```

```
figure;
bodemag(S);
title('Sensitivity plot');
grid on;
```



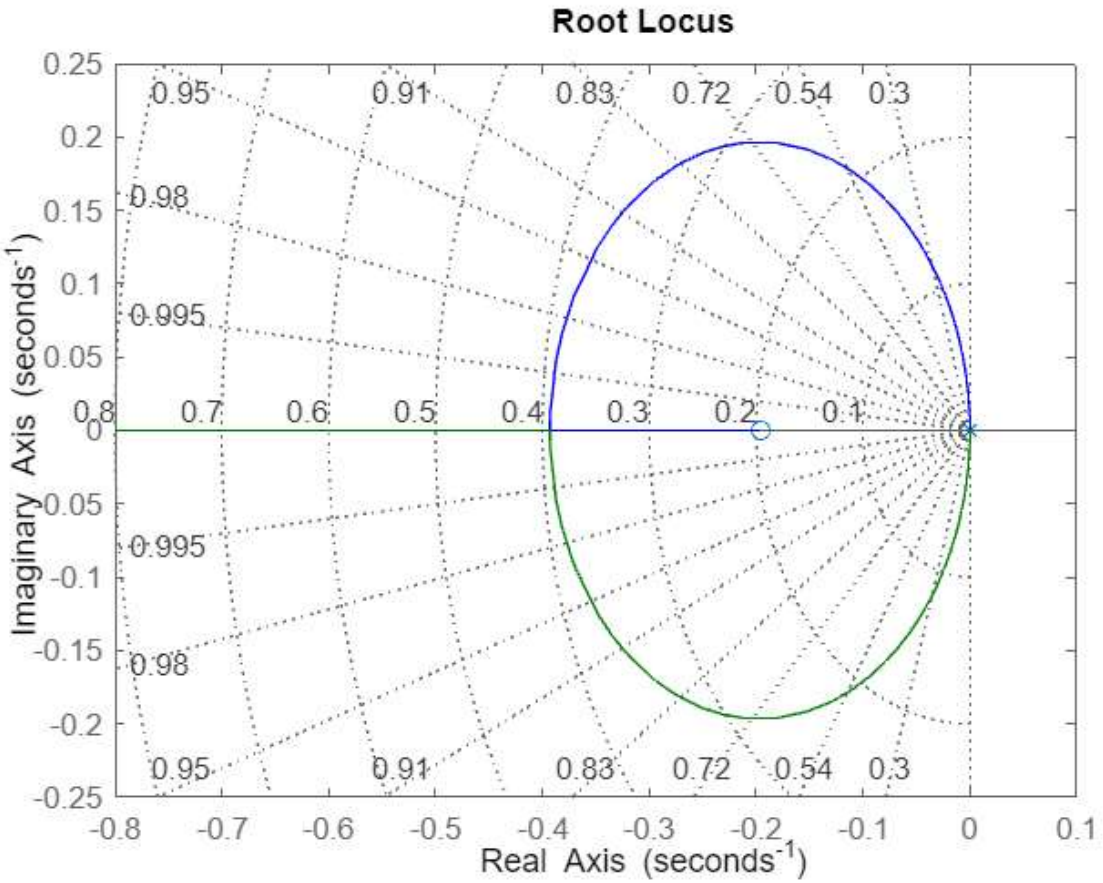
Poles and zeros of the transfer function

```
% Tracer les pôles et les zéros
figure;
pzmap(sys * C_pid);
title('Plot of poles and zeros');
grid on;
```



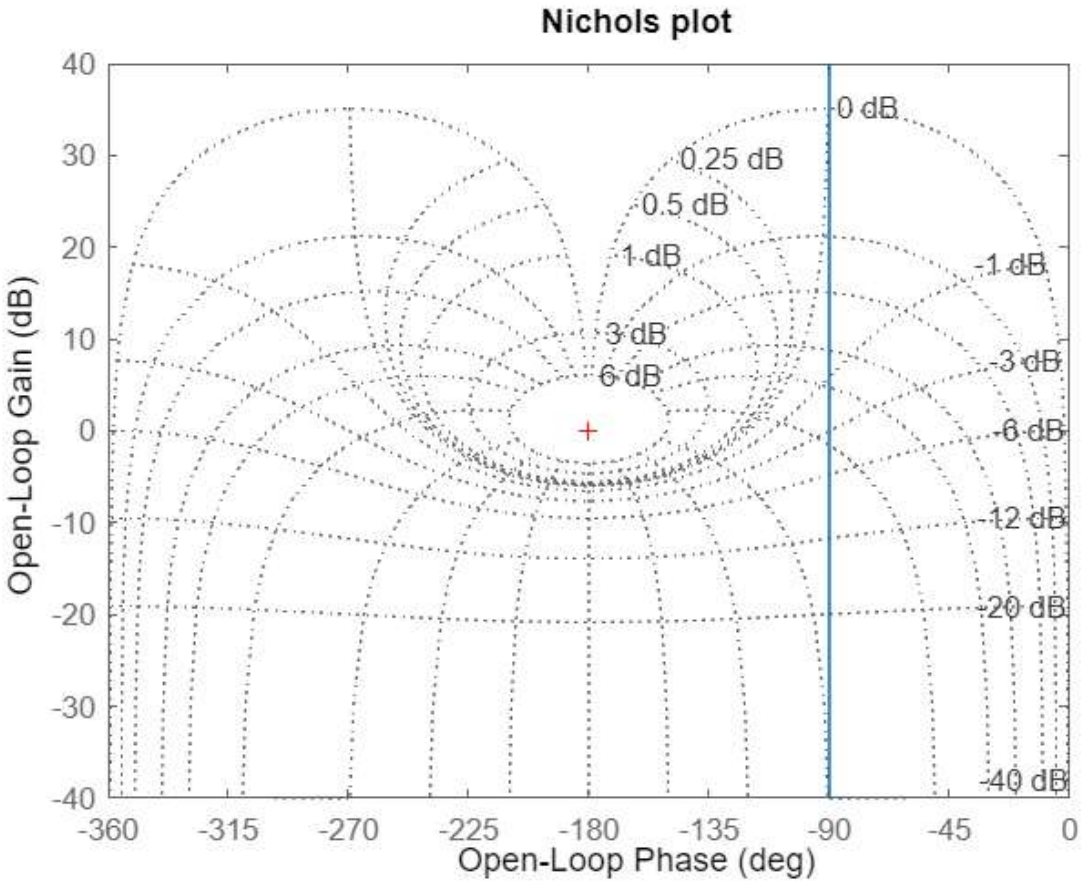
Root Locus Analysis

```
% Tracer le lieu des racines
figure;
rlocus(sys * C_pid);
title('Root Locus');
grid on;
```



Nichols Chart

```
% Tracer le diagramme de Nichols
figure;
nichols(sys);
title('Nichols plot');
grid on;
```


Nichols plot
Open-Loop Gain (dB)
Open-Loop Phase (deg)
40
30
20
10
0
-10
-20
-30
-40
-360
-315
-270
-225
-180
-135
-90
-45
0
0 dB
0.25 dB
0.5 dB
1 dB
3 dB
6 dB
-1 dB
-3 dB
-6 dB
-12 dB
-20 dB
-40 dB