Stability of the linear, dynamic systems

1. Scope

Analysis of the stability of the LTI SISO systems with and without feedback is the scope of the laboratory exercise.

Determine individual parameters of the system depend on your name and student ID (e.g. Jan Nowak, ID 50789)

k=length of the first name (3)
T=length of the last name (5)
a=fifth digit of the ID (9)
b= fourth digit of the ID (8)

2. Stability of the LTI SISO systems

Define the following transfer functions (with command *tf(num,den)*):

$$G_A(s)=\frac{1}{1s+1},G_B(s)=\frac{1}{1s-1},G_c(s)=\frac{1}{0.1s+1},G_D(s)=\frac{1}{3s+1}$$

e.g.: *G_A=tf([1],[1 1]);*

From components G_A, G_B, G_C and G_D define following systems:

1. $G_1(s)=G_A(s)$
2. $G_2(s)=G_B(s)$
3. $G_3(s)=G_A(s)\cdot G_B(s)$
4. $G_4(s)=G_A(s)\cdot G_C(s)\cdot G_D(s)$

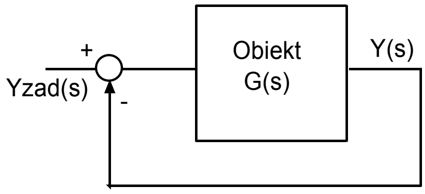
5. $G_5(s)=\dfrac{k}{Ts^3+as^2+bs+1}$ - *A, B,C* - Your choice of constant in range (1-10).

a. Find location of the poles (roots of $M_i(s)$) for system described as $G_i(s)=\dfrac{L_i(s)}{M_i(s)}$ using Matlab instruction *pzmap(G_i)* .G_i means G_1..G_5. (i=1,2,3,4,5)

b. Plot the step response 1(t) - use command *step(G_i).*

Repeat steps a and b for each system G_1..G_5. Save all results in report. Comment results.

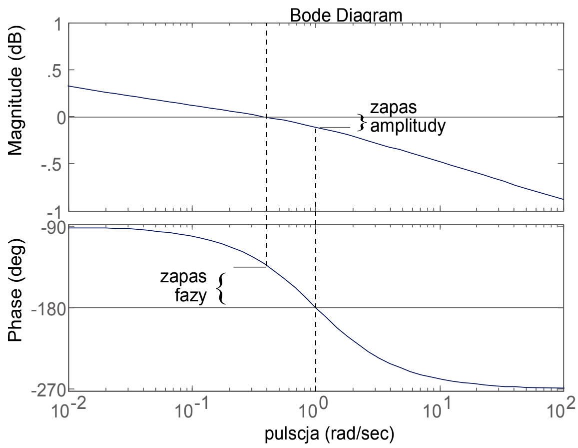
3. Stability of the closed loop SISO systems



Check stability of the closed loop systems using Nyquist criterion, which are based on the logarithmic characteristics (amplitude, phase) of the **open systems**.

- Define set of transfer functions $G_{6i}(s) = K_i G_4(s)$ where K_1=10, K_2=30, K_3=70, (i=1,2,3).

- Plot amplitude and phase margin eg. using command *margin(*G_{61}*)* for each defined system. Read results and fill two columns (Amplitude margin and phase margin) in the Table 1. Find critical value of gain K_{kr} (from range 10 to 70) where stability margin is closed to 0 and system becomes unstable. Define system $G_{64}(s)=K_{kr}G_4(s)$.



- Define close loop system (with full negative feedback) $G_{Zi}(s)$ for each $G_{6i}(s)$ from following equation:

$$G_{zi}(s) = \frac{G_{6i}(s)}{1 + G_{6i}(s)}$$

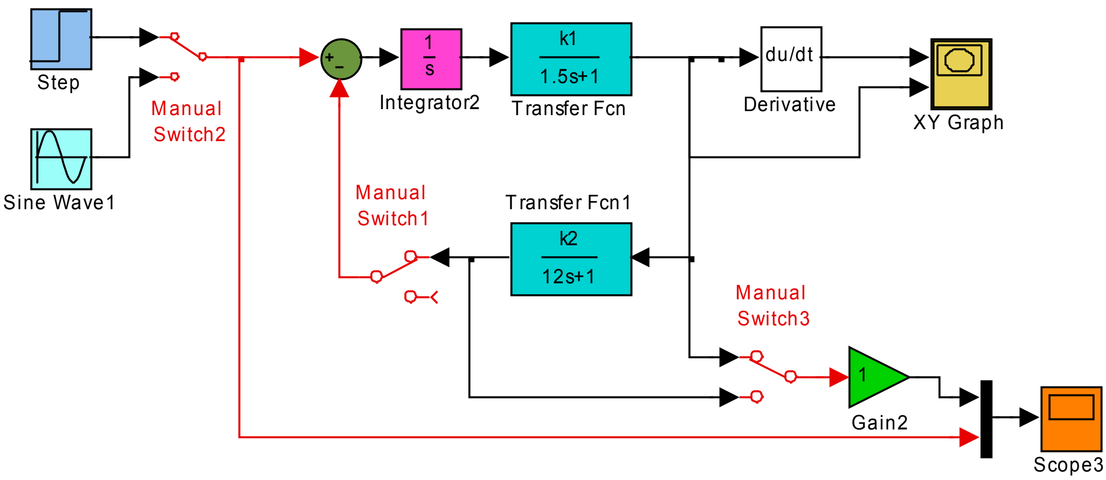
- Plot step response and poles locations for each $G_{Zi}(s)$.
- Plot the Nyquist characteristic for $G_{6i}(s)$ with *nyquist(*$G_{6i}(s)$*)* and compare results with poles location for $G_{Zi}(s)$.
- Fill the table with your results:

Table. 1.

$G_6(s)$	**Amplitude margin**	**Phase margin**	**Step 1(t) response**	**Poles location**
K_1=10				
K_2=30				
K_3=70				
K_{kr}= *(critical)*				

4. Simulink

1. Create following diagram in Simulink.



2. Try several values of *k1* in first order inertia and find the critical value when the system is on the stability boundary with k2=2. Do math calculation in order to find the critical value of k1 and compare results with simulation. Attach calculation to the reprt.

5. Report

- Describe the influence of the poles location in view of the stability issue.
- For parameters k2 = 2 check stability of the closed loop system in view of Nyquist criterion. (Find analytic solution)
- Conclusion