Classical Control (M1 CORO/JEMARO)

Exercises 1 (Lab1) for Group 1

Wednesday 4 October 2022 - 1:45 pm

Deliverables	**Type :** group of 2 students	
Format : Printed Document	**Due date :** 22 October 2023	**One double-sided A4 paper (2 pages)**

For this laboratory (or here "exercises in class") the report concerns only section 3.

1 First order systems, $G(s) = \frac{k}{1+sT}$, $(T > 0)$

1.1 Time constant, pole location, step response

1. Plot the step response of the systems characterized by the transfer function $\frac{1}{1+sT}$ for different values of time constant $T > 0$ to illustrate the property that the smaller T is, the faster is the response of the system (the faster the response converges to its final value). For example, choose $T = 1, 5, 10, 50$.
   Matlab function : step.
2. On the same figure, but on an other axis (*Matlab function : subplot)* plot in the complex plane the pole location of the system for each of the chosen values of T.
   Matlab function : pzmap.
3. Give the value of the 5% settling time for each case.
   Matlab function : stepinfo.

1.2 dcgain, settling time, slope at origin

1. Illustrate that the time response (5% settling time for example) is independent of k, the dcgain of the system. Plot the step response of $G(s) = \frac{k}{1+sT}$ with $T = 10\,s$ and $k = 1, 2, 5, 10$.
   Matlab function : step.
2. For each of this system plot the slope at the origin.
   Matlab function : plot.

1.3 Frequency response, step response

1. Plot the frequency response of the systems characterized by the transfer function $\frac{1}{1+sT}$ for different values of $T > 0$ to illustrate the property that the smaller T is, the higher is the bandwidth of the system (the $-3\,db$ cut-off frequency. For example, choose $T = 1, 5, 10, 50$.
   Matlab function : bode (or bodemag) and bandwidth.
2. On the same figure, but on an other axis (*Matlab function : subplot)* plot the step response of the corresponding systems.
3. Check that the higher is the bandwidth the smaller is the time constant so the faster is the step response.

2 Second order system, $G(s) = \frac{k\omega_n^2}{s^2+2\xi\omega_n s+\omega_n^2}$, $(\xi > 0)$

2.1 Natural frequency, pole location, step response

1. Plot the step response of the systems characterized by the transfer function $G(s) = \frac{k\omega_n^2}{s^2+2\xi\omega_n s+\omega_n^2}$ for different values of the natural frequency ω_n, but a constant value of the damping coefficient ξ, in order to illustrate the property that the higher ω_n is, the faster is the response of the system (the response converge faster to its final value). For example, choose $\omega_n = 1, 2, 5, 10$ and $\xi = 0.4237$, $k = 1$. *Matlab function : step.*
2. On the same figure, but on an other axis (*Matlab function: subplot)* plot the pole location of the system for each of the previous chosen values of ω_n and ξ. Check that the poles with positive imaginary part (resp. negative) are all on the same straight line. *Matlab function: pzmap.*
3. Give the value of the 5% settling time, the time of the first overshoot and the percent overshoot for each case.
   Matlab function : stepinfo.

2.2 Damping coefficient, pole location, step response

1. Plot the step response of the systems characterized by the transfer function $G(s) = \frac{k\omega_n^2}{s^2+2\xi\omega_n s+\omega_n^2}$ for different values of damping coefficient ξ, but a constant value of the natural frequency ω_n, in order to illustrate the property that the higher ξ is, the less oscillation the step response exhibits. For example, choose $\xi = 0.2, 0.4237, 0.707, 1$ and $\omega_n = 1$, $k = 1$. *Matlab function : step.*

2. On the same figure, but on an other axis (*Matlab function: subplot)* plot in the complex plane the pole location of the system for each of the previous chosen values of ω_n and ξ. Check that all the poles are on a semi-circle of radius ω_n and center 0. *Matlab function: pzmap*

3. Give the value of the 5% settling time and the time of the first overshoot and the percent overshoot for each case. *Matlab function: stepinfo.*

2.3 dcgain, settling time, slope at origin

1. Illustrate that the time responses (Peak time response or 5% settling time) and that the percent overshoot ($M_p\,(\%)$) are independent of k, the dcgain of the system.
   Plot the step response of the systems characterized by the transfer function $G(s) = \frac{k\omega_n^2}{s^2+2\xi\omega_n s+\omega_n^2}$ for $\omega_n = 1$ and $\xi = 0.4237$ and $k = 1, 2, 5, 10$. *Matlab function: step.*

2. For each of this system check that the slope at the origin is equal to zero.

2.4 Frequency response, step response

1. Plot the frequency response of the systems characterized by the transfer function $G(s) = \frac{k\omega_n^2}{s^2+2\xi\omega_n s+\omega_n^2}$ for $\omega_n = 1, 2, 5, 10$ and $\xi = 0.4237$, $k = 1$ to illustrate the property that the higher ω_n is, the higher is the bandwidth of the system (the $-3\,db$ cut-off frequency). *Matlab function: bode (or bodemag) and bandwidth.*

2. On the same figure, but on an other axis, plot the step response of the corresponding systems.

3. Check that the higher is the bandwidth the faster is the step response.

3 The influence of the zeros on the step or frequency responses

The influence of the presence and location of a zero is considered here for the following transfer functions
$G(s) = \frac{1}{(s+1)(0.5s+1)}$ and $G_c(s) = \frac{-s+c}{c(s+1)(0.5s+1)}$ for $c = -10$, -0.25, -0.1, $+0.1$, $+0.25$, $+10$.

3.1 Step response

1. Plot the step response of these seven transfer functions (duration of the simulation 6 seconds).

2. Evaluate the undershoot or the overshoot when they exist. Give the relation between the location of the zero and the existence and the magnitude of an overshoot or an undershoot.

3.2 Frequency response

1. Plot the frequency response (bode plot) of these 7 transfer functions. Use "Adjust Phase Offset" (right clic of the mouse on the phase axis, and then use the menu "Properties ...") to be able to compare the 7 plots.

2. Compare the gain and the phase of a triple $G_{c=-\alpha}(s)$, $G(s)$ and $G_{c=\alpha}(s)$ for $\alpha = +10$, $\alpha = +0.25$ or $\alpha = +0.1$. Explain the name "non minimum phase system".

3.3 Report

One double-sided A4 paper.
On the first page : response to subsection 3.1. On the second page : response to subsection 3.2.
Don't forget the name of the two students of the group. Don't forget the date of the Lab.