Automatic Control A

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Name:...

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Warnings:

- This file consists of **8** pages (including cover). All the pages should be signed.
- During the exam you are not allowed to exit the room for any other reason than handing your work or withdrawing from the exam.
- You are not allowed to withdraw from the exam during the first 30 minutes.
- During the exam you are not allowed to consult books or any kind of notes.
- You are not allowed to use calculators with graphic display.
- Solutions and answers can be given **either in English or in Italian**.
- Solutions and answers must be given **exclusively in the reserved space**. Only in the case of corrections, or if the space is not sufficient, use the back of the front cover.
- The clarity and the order of the answers will be considered in the evaluation.
- At the end of the test you have to **hand this file only**. Every other sheet you may hand will not be taken into consideration.

Use this page ONLY in case of corrections or if the space reserved for some answers turned out to be insufficient

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Exercise 1

Consider the following dynamical system

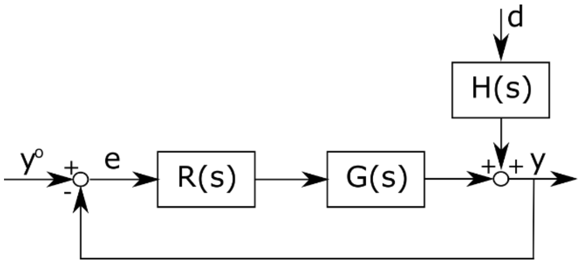
$$\begin{cases} \dot{x}_1 = -x_1 + 5x_2 + u \\ \dot{x}_2 = \alpha x_1 + u \\ \dot{x}_3 = x_1 + x_2 - 3x_3 \\ y = x_3 \end{cases}$$

1.1 Find the values of parameter $\alpha \in \mathbb{R}$ for which the system is asymptotically stable.

1.2 Find the values of parameter $\alpha \in \mathbb{R}$ for which the system is completely controllable and completely observable.

Exercise 2

Consider the following control system



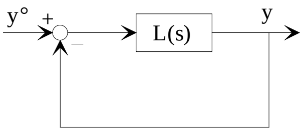
where $G(s)=10\frac{10-s}{s(10+s)}$ and $H(s)=\frac{10}{1+s}$.

Compute the transfer function $R(s)$ of a PD with filter on the derivative action in such a way that:

- $|e_\infty| = 0$ for $y°(t)$ = sca(t) and $d(t)$ = sca(t);
- the phase margin φ_m is greater or equal to 70°;
- the crossover frequency ω_c is greater or equal to 1 *rad/s*.

Exercise 3

Consider the following closed-loop system



where $L(s) = \rho \dfrac{s}{(s+1)^2(s-1)}$.

3.1 Sketch the direct and inverse root loci.

3.2 Using the previous root loci, find the values of ρ for which the closed-loop system is asymptotically stable.

Exercise 4

Consider the following discrete time dynamical system

$$G(z) = \frac{z-1}{(z+2)(z+0.5)}.$$

4.1 Compute the gain and type of the transfer function.

4.2 Is the discrete time system stable, unstable or asymptotically stable?

4.3 Compute the initial value and, if possible, the final value of the unit step response.

4.4 Compute the first four samples of the unit step response.

Exercise 5

5.1 Explain what is meant with kinematic and dynamic scaling of a trajectory, and write the general expression of a trajectory in normalized form that is used in such scaling.

5.2 The parametric form of a harmonic trajectory is given by

$$\sigma(\tau) = \frac{1}{2}(1 - \cos(\pi\tau))$$

Find the expressions of the maximum velocity and maximum acceleration for such trajectory in terms of the positioning time *T* and the total displacement *h*.

5.3 Consider the design of a harmonic trajectory from $q_i = 10^{\circ}$ to $q_f = 50^{\circ}$, with $\dot{q}_{max} = 30\ {}^{\circ}/s$ and $\ddot{q}_{max} = 80\ {}^{\circ}/s^2$. Find the minimum positioning time.

Exercise 6

6.1 What is a successive-approximation ADC? Sketch the functional diagram that shows how this converter works, and list and describe the steps of the conversion process.

6.2 Assuming that the full scale range of the ADC is *10 V* and the voltage resolution required by the application is *10 mV*, which is the minimum number of bits of the ADC in order to satisfy the requirement?

6.3 Assuming that the harmonics of the analog signal to be converted span the range *0-10 kHz* and the conversion interval is *1 μs*, is the sample-and-hold circuit required? Why?