Industrial Automation and Robotics

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NAME:

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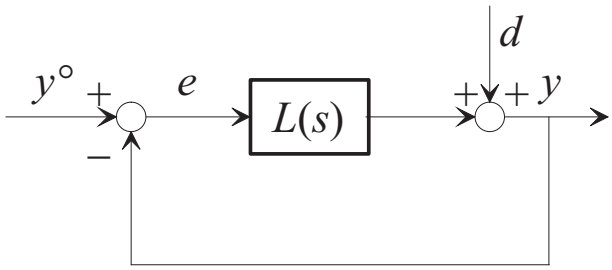
SIGNATURE: _____

Warnings

- This file consists of **8** pages (including cover).
- 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.

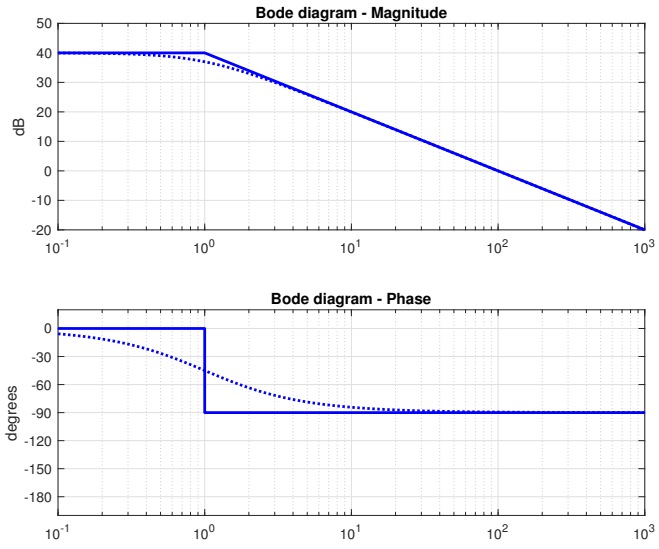
EXERCISE 1

1. With reference to a generic control system



Give the definition of sensitivity function of the system, explaining its use.

2. Suppose that the loop transfer function L has the Bode plots of the magnitude and of the phase as shown in this picture:



Discuss the stability of the closed loop system.

3. Still making reference to the picture of this exercise, sketch the asymptotic Bode plot of the magnitude of the sensitivity function. Specify the bandwidth where a disturbance $d(t)$ can be rejected.

4. Consider a disturbance $d(t) = sin(10t)$. Compute the factor by which this disturbance is attenuated.

EXERCISE 2

1. Consider the Ladder Diagram programming language for PLCs. List the types of timers that can be included in a Ladder Diagram, briefly explaining how they work.

2. Consider now the following process: pressing a button **START** a light turns on for one minute. After such time interval, the light turns off and for 10 minutes pressing the button **START** cannot turn on the light. Program the system with a Ladder Diagram code.

3. Explain the difference between a soft real time system and a hard real time system, citing one example for both.

4. Consider now the Ethernet protocol for the digital communication on a bus: briefly describe how the access to the bus among the various agents is handled.

EXERCISE 3

Consider the planning of a cubic polynomial trajectory $q(t)$, starting at $t = 0$ from $q = 0$, and with initial and final zero values of the speed.

1. Find the expressions of the position, the speed and the acceleration as a function of the total displacement h and the total positioning time T.

2. Find the expressions of the maximum values of the speed $\dot{q}_{\max}$ and of the acceleration $\ddot{q}_{\max}$ as a function of h and T.

3. Assume that the displacement is $h = 10$ and the maximum value of the speed $\dot{q}_{\max}$ is 20. Find the corresponding minimum positioning time T and the corresponding maximum value of the acceleration $\ddot{q}_{\max}$.

4. Write the expression of a segment in space parameterized by the natural coordinate s.