Industrial Automation and Robotics

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NAME:

UNIVERSITY ID NUMBER:

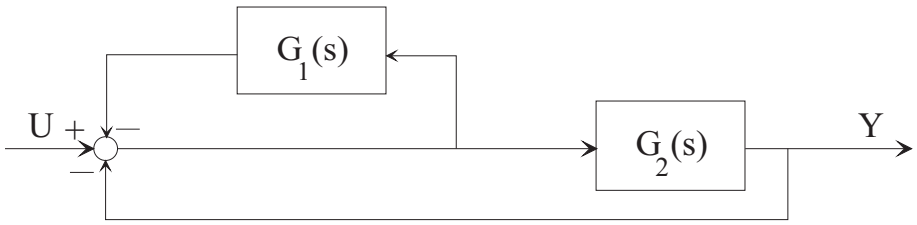
SIGNATURE: _____

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. Consider the dynamical system described by the following block diagram:



   Solve the block diagram by determining the transfer function from u to y.

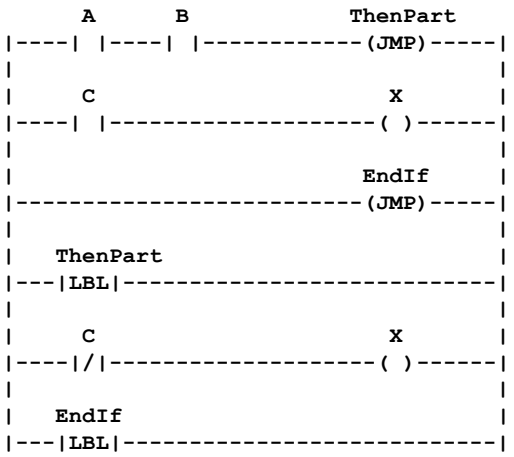
2. Setting $G_1(s) = k$, $G_2(s) = \dfrac{1}{s}$, assign the parameter k such that the overall system has a time constant $T = 10$.

3. Using the value of k found at the previous step, sketch the step response from input u to output y. What is the approximate duration of the transient?

4. Define what a frequency response is in general. Then for the transfer function discussed in the previous step, sketch the Bode diagram of the magnitude of the frequency response.

EXERCISE 2

1. Consider the following Ladder Diagram code for a PLC:



   Explain what this code stands for.

2. Consider now an automatic ventilation system. Pressing a button START the automatic ventilation system is activated for 3 hours. After such time interval, the ventilation system turns off and for 2 hours pressing the button START cannot activate the ventilation system. Program the system with a Ladder Diagram code.

3. Briefly explain what a hard real-time system is, providing an example.

4. A real-time operating system typically can enforce “pre-emption” of the processes. Explain what this stands for and why this feature can be beneficial for real-time purposes.

EXERCISE 3

1. Explain what is the difference between the trajectory generation for a robot in the joint space and in the operational space.

2. Consider now the design of a joint trajectory with a trapezoidal velocity profile. The total displacement is $h = 2$, the total positioning time is $T = 1s$ and the acceleration time is $T_a = 0.2s$. Compute the constant speed in the central part of the motion and the acceleration at the beginning of the trajectory

3. Consider now the generation of the trajectory in the operational space. Write the expression of a segment (linear Cartesian path) for the position of the end effector.

4. Suppose that you want to use the trapezoidal velocity profile previously computed for the generation of the operational space trajectory (the segment as previously discussed). Explain how this can be done. What would be the maximum linear velocity of the end-effector in this case?