Industrial Automation and Robotics

Prof. Rocco

January 17, 2023

NAME:

UNIVERSITY ID NUMBER:

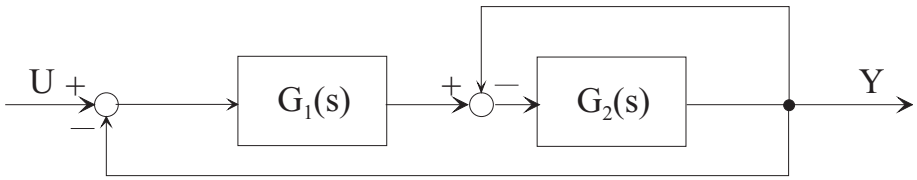
SIGNATURE: _____

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. Discuss whether it is necessary and/or sufficient that one or more of the transfer functions be asymptotically stable in order for the overall system to be asymptotically stable

3. Setting $G_1(s) = k$, $G_2(s) = \dfrac{1}{1+s}$, assign the parameter k such that the dc gain of the overall transfer function is $\mu = 0.5$.

4. Using the value of k found at the previous step, write the equations of the dynamic system in state form that has the transfer function of the overall system obtained in the previous step.

EXERCISE 2

1. Explain what a discrete events system is and what is the importance of discrete events systems in the context of an industrial automation system.

2. Consider now a logical system that has to implement the function:

   if (A and B)
   X = (C and D); Y = not(X);
   else
   X = (C or D); Y = X;

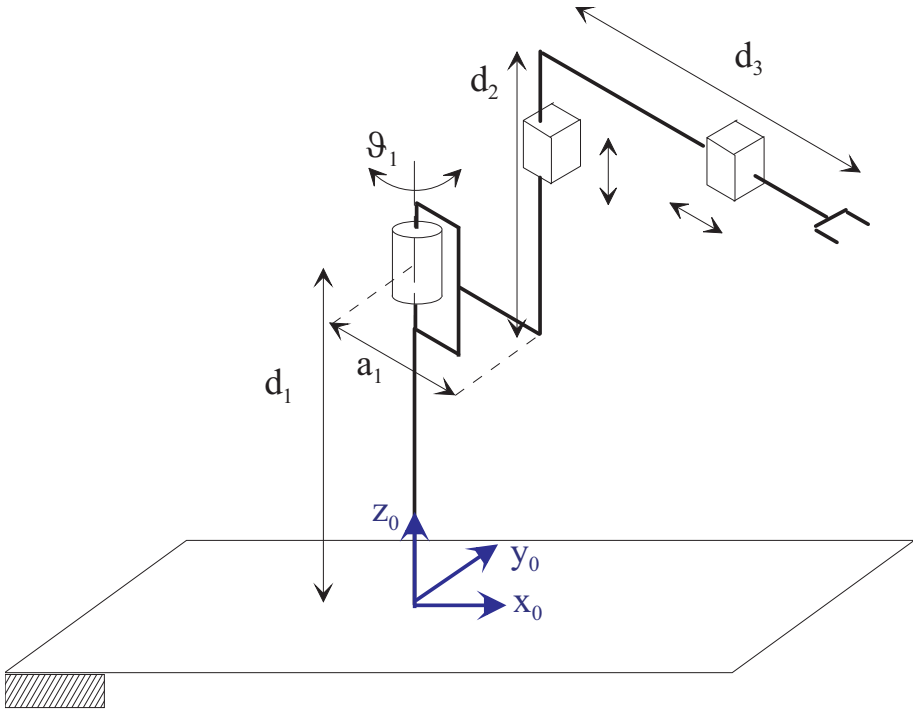
   Sketch a ladder diagram that implements this logical function.

3. Sketch a Sequential Function Chart that implements an if-then-else programming structure and comment such sketch.

4. Consider now the interconnection of digital systems. Explain what are the advantages of a bus architecture compared to a centralized architecture. What do we mean with physical layer of a bus?

EXERCISE 3

Consider the following robot manipulator with 3 joints (rotational, prismatic and prismatic):



1. Find the expression of the direct kinematics of the robot, in terms of the position coordinates of the end effector with respect to the joint variables ϑ_1, d_2, and d_3.

2. Write the expression of the Jacobian of the manipulator of this exercise.

3. Characterize the singularities of the manipulator of this exercise.

4. Consider now the safe interaction between a robot and a human. Explain what is the speed and separation monitoring safe interaction mode, writing down the inequality that characterizes such interaction mode.