Industrial Automation and Robotics

Prof. Rocco

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NAME:

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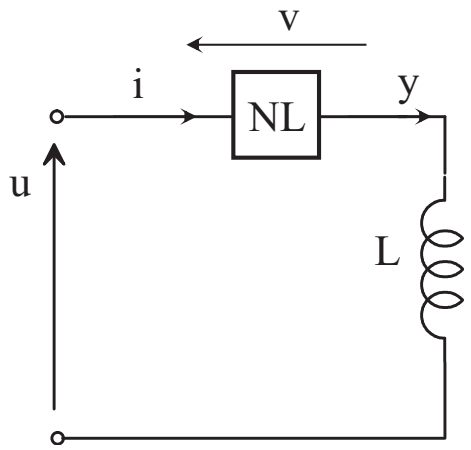
SIGNATURE: _____

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

Consider the electrical network sketched in the figure:



where the nonlinear element NL enforces the following relation between the current i passing through it and the corresponding voltage v across it:

$$v = i^3$$

1. Write the equations of the dynamic system that describes the electrical network.

2. Setting $L = 1$ compute the equilibrium state corresponding to the constant input $u = \bar{u} = 8$.

3. Write the equations of the linearized system around the equilibrium state previously obtained and derive the expression of the corresponding transfer functions.

4. Find the type, the dc gain, and the time constant, of the transfer function previously obtained.

EXERCISE 2

1. Explain precisely what is the meaning of the symbol `--|/|--` in a Ladder Diagram.

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

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

   Sketch a ladder diagram that implements this logical function.

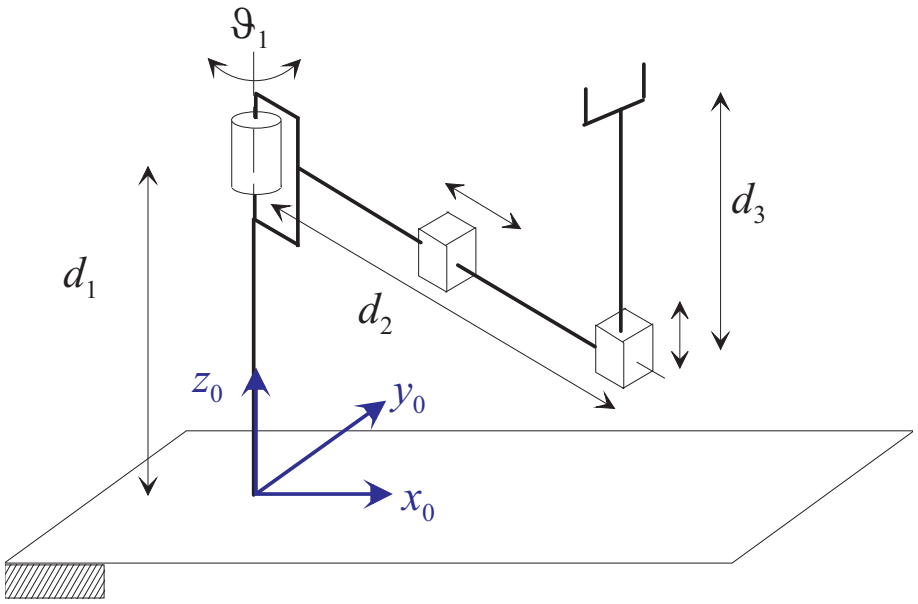
3. Sketch a Sequential Function Chart that implements an if-then-else programming structure and comment such sketch.

4. Explain what is a step in a Sequential Function Chart.

EXERCISE 3

1. Explain what is a homogeneous transformation matrix in the context of robot kinematics and what use can be done of such matrix.

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



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.

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

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