Industrial Automation and Robotics

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June 10, 2022

NAME:

UNIVERSITY ID NUMBER:

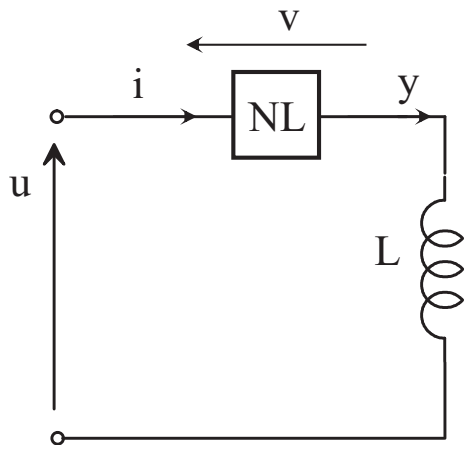
SIGNATURE: _____

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

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 $u = \bar{u} = 1$.

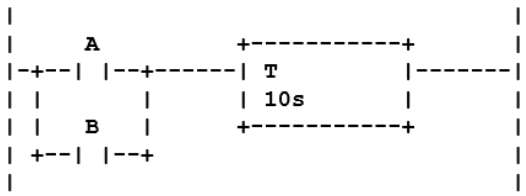
3. Write the equations of the linearized system around the equilibrium state previously obtained and derive the expression of the corresponding transfer functions.

4. Sketch the step response of the linearized system previously obtained.

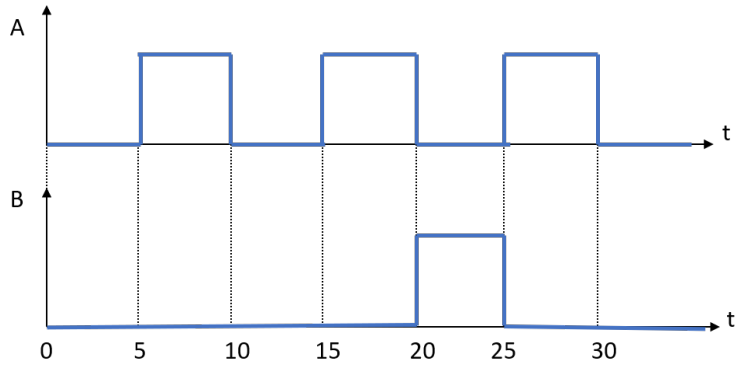
EXERCISE 2

1. Consider the Ladder Diagram programming language for PLCs. Explain what a "normally open contact" is.

2. Make reference now to the following Ladder Diagram code:

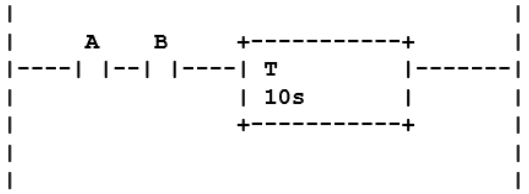


and assume that the Boolean inputs A and B have the time histories depicted in the following plots:



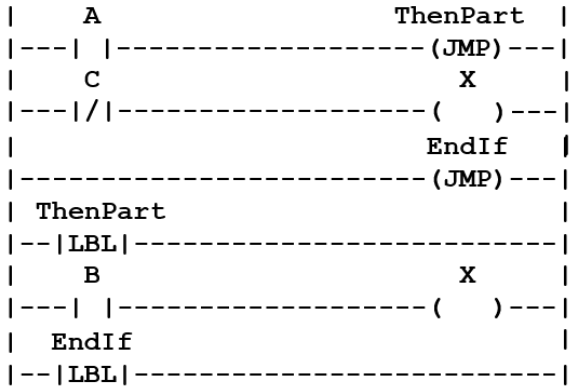
Sketch the plot of the Boolean variable T associated to the (simple) timer, commenting the answer.

3. Make reference now to the following Ladder Diagram code:



Assuming the same time histories of A and B as before, sketch again the plot of the Boolean variable T associated to the timer, commenting the answer

4. Consider the Ladder Diagram code represented below:



Write the corresponding piece of code in a high-level language (i.e. explain what is the meaning of this Ladder Diagram). Why is the Ladder Diagram still used in PLCs as a programming language?

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.