Automatic Control A

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September 21, 2016

Name:..

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Warnings:

- This file consists of **8** pages (including cover). All the pages should be signed.
- 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.

Use this page ONLY in case of corrections or if the space reserved for some answers turned out to be insufficient

Exercise 1

Consider the following dynamical system

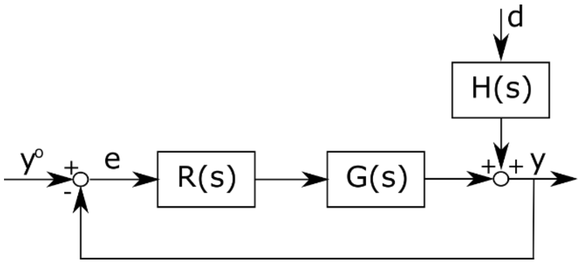
$$\begin{cases} \dot{x}_1 = x_2 + u \\ \dot{x}_2 = x_1 \\ y = x_2 \end{cases}$$

1.1 Assuming that all the state variables are available for feedback (full-state feedback problem), design a control law that places the poles of the closed-loop system at -1 and -2.

1.2 Assuming now that only the system output is available, design a state observer. The dynamic of the state estimation error is characterized by two real poles 10 time faster than the poles of the closed-loop system.

Exercise 2

Consider the following control system



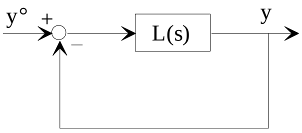
where $G(s) = 10\dfrac{10 - s}{s(10+s)}$ and $H(s) = \dfrac{10}{1+s}$.

Compute the transfer function $R(s)$ of a PD with filter on the derivative action in such a way that:

- $|e_\infty| = 0$ for $y°(t)$ = sca(t) and $d(t)$ = sca(t);
- the phase margin φ_m is greater or equal to 70°;
- the crossover frequency ω_c is greater or equal to 1 *rad/s*.

Exercise 3

Consider the following closed-loop system



where $L(s) = \rho \frac{1}{(s^2 - 1)}$.

3.1 Sketch the direct and inverse root loci.

3.2 Using the previous root loci, find the values of ρ for which the closed-loop system is asymptotically stable. Compare this result with the one of Exercise 1.

Exercise 4

Consider the following discrete time dynamical system

$$G(z)=\frac{z+2}{(z+0.2)(z^2+1.5z-1)}.$$

4.1 Compute the gain and type of the transfer function.

4.2 Is the discrete time system stable, unstable or asymptotically stable?

4.3 Compute the initial value and, if possible, the final value of the unit step response.

4.4 Compute the analytic expression of the unit step response.

Exercise 5

Consider a servomechanism with rigid transmission characterized by the following parameters:

- motor moment of inertia $J_m = 1.5 \cdot 10^{-4}\ Kg\ m^2$
- motor viscous friction $D_m = 0.0034\ Kg\ m^2/s$

5.1 Compute the parameters of a torque disturbance observer, justifying the selection of T_f, and show the block diagram of the system including the disturbance observer.

5.2 Explain, analyzing the transfer functions of the system including the torque disturbance observer, what happens when the servomechanism has a flexible transmission.

Exercise 6

6.1 List and describe the main steps executed by a PLC at every cycle.

6.2 Write the code implemented by the following ladder diagram.

```
    a                      then
|---| |---+--------------(JMP)---|
|   d     |                      |
|---| |---+                      |
|   d                      x     |
|---| |---+--------------(   )---|
|   c     |                      |
|---| |---+                      |
|   x                      y     |
|---|/|------------------(   )---|
|                         endif  |
|------------------------(JMP)---|
|   then                         |
|---|LBL|------------------------|
|   b                      x     |
|---| |------------------(   )---|
|   a                      y     |
|---| |------------------(   )---|
|   endif                        |
|---|LBL|------------------------|
```

6.3 Assume that a motor is started by an operator pushing a “start” button, and the motor moves until the operator pushes the “stop” button or a failure signal is received. Write the ladder diagram that allows to implement this behavior on a PLC.