**Academic Year 2022-2023**

**Exam 2 – Part II - Maximum duration: 3 hours**

**Problem 1 [5 points]**

A linear dynamic system is described by the following internal description:

where as usual, is the input, is the output and and are the states.

1. Check whether the system is observable and design an estimator (closed-loop predictor) of the system states where the estimation error dynamics respond to critically damped behaviour with characteristic time constants of 0.1 seconds. Draw the block diagram resulting from the state estimation problem (using integrator blocks to represent the relationship between the states and their derivatives) and write the differential equation describing the dynamics of the predictor. **[0.5 points]**
2. Check whether the system is controllable and design a state vector feedback controller that allows a constant reference to be followed with dynamics 10 times slower than those specified in section 1. Draw the block diagram resulting from the closed-loop control (using integrator blocks to represent the relationship between the states and their derivatives) and write the differential equation describing the dynamics of the closed-loop system. **[0.5 points]**
3. Without performing any additional mathematical calculations (only the diagram is requested), draw the block diagram (using integrator blocks to represent the relationship between states and their derivatives) when implementing the state estimator calculated in section 1 and a state vector feedback controller that allows a disturbance at the system input to be rejected and references to be followed. Could any element be included to make the dynamics with respect to step changes in the reference less aggressive than those imposed by the disturbance rejection dynamics? **[0.75 points]**
4. Application of the root locus method (it is recommended to obtain the transfer function of the system beforehand using the appropriate formula, which you should write down and check that you have obtained correctly ):
   1. If the system is controlled by a proportional controller, plot the roots of that system when is varied between 0 and infinity (this is the range of variation considered throughout this section 4). **[0.25 points]**
   2. If a PD controller is used instead of a proportional controller, what value should have so that the closed-loop system behaves in a underdamped manner for all values of ? **[0.25 points]**
   3. If, instead of a PD, an ideal PI with integral time calculated in question 4b is used, from what value of of the controller are only real poles obtained in closed loop? Can the closed loop system become unstable for any range of values? If so, calculate that range. **[0.5 points]**
5. Analyse the stability of the system in section 4.a (system controlled with a proportional element with positive gain) using Nyquist's stability criterion. At what frequency does the sensitivity function of the closed-loop system become greater than or equal to 1? What implications does this have for the rejection of disturbances at the plant input? **[1 point]**
6. Design a controller so that the phase margin is equal to 45º, the steady-state error constant in acceleration and the closed loop is as fast as possible. Using the equivalence between the specifications in the time and frequency domains, indicate the approximate value of the overshoot and the expected rise time in the closed loop. **[0.5 points]**
7. Looking at the Bode diagram of shown below, indicate the name of the simplest controller that you think can meet the specifications listed below. Simply write the name of the proposed controller. No calculations are necessary (except for , at most). Just look at the Bode diagram and the specifications and think about which controller would be most appropriate. **[0.75 points]**

Gráfico, Gráfico de líneas

El contenido generado por IA puede ser incorrecto.

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| **Specifications** | **Controller** |
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| rad/s |  |
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