**Academic Year 2024-2025**

**Exam 1 – Overall assessment - Maximum duration: 3 hours**

**Problem 1 [2 points]**

The figure on the right shows the response of the system in the figure on the left (mass-spring-damper assembly) to a step input of N. The differential equation modelling the system is as follows:

1. Obtain its transfer function and a linear internal description in state space in which the states have physical meaning. The equilibrium position, with respect to which is considered in the figure on the right, is influenced by gravity and is obtained with . **[0.75 points]**
2. Identify the values of , and , indicating their units. **[0.75 points]**
3. Considering the values calculated in the previous section, draw the Bode diagram of the system, indicating the most significant gains, phases, and frequencies. **[0.5 points]**

|  |  |
| --- | --- |
|  |  |

**Problem 2 [2 points]**

The following equation represents the dynamic model of a circuit that includes a coil, a capacitor, and a tunnel diode:

where is the manipulable input andis the system output.

1. Obtain a linear model in both transfer function and state space form, bearing in mind that the operating point given by will be chosen so that at that equilibrium the response of the linearised system does not depend on **[0.75 points]**
2. For the above case, calculate the time response of the system starting from initial conditions and if a unit step is also introduced at the input at time s. **[0.75 points]**
3. Draw the Simulink diagram of the non-linear model and compare it with the models linearised around the operating point given by . **[0.5 points]**

**Problem 3 [4.5 points]**

For the dynamic system described by the transfer function:

considering unit feedback and controlled with a gain :

1. Draw the root locus for , indicating the value of at which the closed-loop system changes its stability condition, determining in which range of that gain it is stable and in which range it is unstable. **[0.25 points]**
2. Draw the root locus for , indicating the value of at which the closed-loop system changes its stability condition, determining in which range of that gain it is stable and in which range it is unstable. **[0.5 points]**
3. Analyse the stability of the closed-loop system using Nyquist's stability criterion as a function of the gain value only for the case **[0.75 points]**
4. Only for the case analyse and represent the phase margin and gain margin as a function of the gain K in the Bode diagram, indicating the values at which the closed-loop system changes its stability condition. **[0.5 points]**
5. Calculate an internal description of the system represented by . Assuming that no sensors are available to measure the states (only the values of the system input and output are known), design a control system that allows any reference to be reached in the presence of disturbances at the plant input, imposing a closed-loop dynamics characterised by two equal real poles a () and an observation error dynamics characterised by two equal real poles at . Verify that the system is controllable and observable and draw the complete block diagram including the control and state observer with the highest possible degree of definition (using integrator blocks to represent the relationship between each of the states and their derivatives). You must also indicate the equations that provide the evolution of the estimated states and the control signal (write the equation that describes the dynamic evolution of each estimated state). After obtaining the internal description, no calculations need to be performed in the control part; the equations indicated are left unsolved (calculation of H and L). **[2.5 points]**

**Problem 4 [1.5 points]**

Consider the minimum phase time-invariant linear system whose transfer function is described by the following Bode diagram:



Design a control scheme that allows a step disturbance at the plant input to be rejected without steady-state error and with dynamics such that the gain cutoff frequency of the controlled system is 10 rad/s. When choosing the appropriate controller, it is recommended to first use root locus (to select the controller structure) and secondly the Bode diagram, as there are many solutions to the problem. What would need to be added so that, given a step in the reference, the closed-loop system has a dominant time constant of 0.1 seconds?

Imagen que contiene biombo, edificio, jaula

Descripción generada automáticamente