**Academic Year 2025-2026**

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

**Problem 1 [2.5 points]** [Estimated maximum completion time: 20 minutes]

Given the block diagram in the figure.

**Diagrama

El contenido generado por IA puede ser incorrecto.**

1. Obtain its transfer function **[0.5 points]**
2. Calculate the values of and from the unit step response in shown in the figure below. **[0.75 points]**

Gráfico, Gráfico de líneas

El contenido generado por IA puede ser incorrecto.

1. Obtain a linear internal description in state space from the block diagram. **[0.5 points]**
2. Draw the Bode diagram of the system, indicating gains, phases, and most significant frequencies. **[0.75 points]**

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**Problem 2 [2.5 points]** [Estimated maximum completion time: 40 minutes]

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 the transfer functions from the linearisation of the non-linear model around the operating point and study the stability of the linearised systems as a function of the parameter . Note that there may be more than one equilibrium. **[1 point]**
2. For and choosing only one of the two transfer functions obtained in the previous question (whichever you prefer), calculate the time response of the system starting from the initial conditions and if a unit impulse is also introduced at the input at time s. **[1 point]**
3. Draw the Simulink diagram of the non-linear model and compare it with the linearised model around the operating point given by . **[0.5 points]**

**Problem 3 [2 points]** [Estimated maximum completion time: 45 minutes]

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 range of values of for which the closed loop is stable and the range for which it is unstable **[0.25 points]**
2. Draw the root locus for , indicating the range of values of for which the closed loop is stable and the range for which it is unstable. **[0.5 points]**
3. Analyse the stability of the closed loop using Nyquist's stability criterion with**[0.5 points]**
4. For calculate an state-space 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 the system to be regulated to the origin by imposing a closed-loop dynamics characterised by two equal real poles at () 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). A**fter obtaining the internal description, no calculations need to be performed in the control section; the equations indicated are left unsolved (calculation of and ).**

**Problem 4 [1 point]** [Estimated maximum completion time: 15 minutes]

Consider the system whose transfer function is given by:

Design a control scheme that allows a step disturbance at the plant input to be rejected without steady-state error and with dynamics dictated by two real poles at , and that manages to follow a step reference without steady-state error with dynamics dictated by the same dominant poles as in the case of disturbance rejection.

**Problem 5 [2 points]** [Estimated maximum completion time: 45 minutes]

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

Gráfico

El contenido generado por IA puede ser incorrecto.

1. Design a controller that allows for a steady-state error at step input in the reference equal to 0.1 and a phase margin equal to or greater than 90 degrees. What is the gain cutoff frequency? What is the closed-loop time constant? **[0.5 points]**
2. A delay time of 1 second is added to the transfer function Would the specifications in the previous section still be met with the designed controller? If not, propose a controller that would allow them to be met by selecting, for example, a gain crossover frequency rad/s. **[0.75 points]**
3. For the transfer function used in question 1, design a controller that allows for a steady-state error with a ramp input at a reference equal to 0.1 and a phase margin equal to or greater than 60 degrees, seeking a fast closed-loop response. What is the gain crossover frequency? Draw a schematic diagram of the root locus of the compensated system. What is the approximate rise time of the closed loop? Is there any overshoot? **[0.75 points]**

Imagen que contiene biombo, edificio, jaula

Descripción generada automáticamente