**Academic Year 2024-2025**

**Exam 1 – Part I - Maximum duration: 3 hours**

**Problem 1 [1.5 points]**

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

where is the controllable input andthe output of the system

1. Obtain a linear model around the operating point given by both in transfer function and state space form. Draw the Simulink diagram of the non-linear model and compare it with the linearised models. **[0.5 points]**
2. Analyse the local stability and transient behaviour of the linearised system as a function of the parameter in the range (. **[0.5 points]**
3. For a value of the parameter that yields a critically damped response, calculate the expression for when a unit step is introduced at the input at time s, assuming zero initial conditions. **[0.25 points]**
4. For , calculate the time response of the system starting from initial conditions and . **[0.25 points]**

**Problem 2 [1.5 points]**

1. Can a first-order transfer function be obtained from a second-order internal description? Justify your answer. **[0.25 points]**
2. Calculate the transfer function associated with the following internal description and draw the step response **[0.5 points]**:

;

with

1. For the same system, if the input but the initial conditions are different from zero , justify whether or not the system response coincides with the step response obtained using the transfer function. Obtain the expression fo and . **[0.75 points]**

**Problem 3 [1.5 points]**

* Calculate the impulse and step responses of the system represented by the transfer function **[0.5 points]**
* Draw the Bode diagram (use the semi-logarithmic sheet on the following page) and the Nyquist diagram of the system represented by , indicating the characteristic low-frequency, high-frequency and some intermediate frequency points on both the magnitude and phase axes and on the frequency axes. **[1 point]**

**Problem 4 [0.5 points]**

Calculate the transfer function of a minimum phase system whose Bode diagram is shown in the following figure.

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