AUTOMATIC CONTROL

Computer Engineering

Laboratory practice n. 3

Objectives: Design of control systems using state feedback. State feedback with observer. Output response of state feedback controlled systems.

Problem 1

Given the LTI system

$$\begin{cases} \dot{x}(t) = \begin{bmatrix} -0.2 & -1 \\ 1 & 0 \end{bmatrix} x(t) + \begin{bmatrix} 0.5 \\ 0 \end{bmatrix} u(t) \\ y(t) = \begin{bmatrix} 0 & 1 \end{bmatrix} x(t) \end{cases}, x(0) = \begin{bmatrix} 0 \\ 0 \end{bmatrix}$$

- Suppose that the system state can be measured. Design, if possible, a state feedback controller of the form

$$u(t) = -Kx(t) + Nr(t)$$

to meet the following requirements:

1. unitary dc-gain for the controlled system
2. $\hat{s} \leq 6\%$
3. $t_{s,2\%} \leq 2$ s

- Compute the analytical expression of the output response y(t) of the controlled system in the presence of a step reference input, i.e., r(t)=ε(t).

Problem 2

Given the LTI system

$$\begin{cases} \dot{x}(t) = \begin{bmatrix} -0.2 & -1 \\ 1 & 0 \end{bmatrix} x(t) + \begin{bmatrix} 0.5 \\ 0 \end{bmatrix} u(t) \\ y(t) = \begin{bmatrix} 0 & 1 \end{bmatrix} x(t) \end{cases}, x(0) = \begin{bmatrix} 0.1 \\ 0.1 \end{bmatrix}$$

- Suppose that the system state cannot be measured. Design, if possible, a state feedback controller of the form

$$u(t) = -K\hat{x}(t) + Nr(t)$$

to account for the following requirements:

1. unitary dc-gain for the controlled system
2. controlled system eigenvalues characterized by $\zeta = 0.66$ and $\omega_n = 2.93$ rad/s

- Evaluate the maximum overshoot of the output unitary step response in the presence of the given initial condition.

Problem 3

Consider the LTI system

$$\begin{cases} \dot{x}(t) = \begin{bmatrix} -1 & 0 \\ 0 & 10 \end{bmatrix} x(t) + \begin{bmatrix} 1 \\ 1 \end{bmatrix} u(t) \\ y(t) = \begin{bmatrix} 1 & 0 \end{bmatrix} x(t) \end{cases}$$

1. Study the stability properties of the given system.
2. Supposing that the system state can be measured, is it possible to compute a state feedback controller of the form $u(t) = -Kx(t) + Nr(t)$ to stabilize the given system? Motivate your answer.
3. Supposing that the system state cannot be measured, is it possible to compute a state feedback controller of the form $u(t) = -K\hat{x}(t) + Nr(t)$ to stabilize the given system? Motivate your answer.