Control Systems

Matlab Practical 5

State feedback control

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Learning objectives

By the end of this Matlab session, you should be able to

1. Simulate LTI systems described in a state-space form

2. Draw Bode plot for LTI systems described in a state-space form

3. Design a state feedback controller for pole placment

Task 1: Time responses

Consider a system described by

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} -0.5 & -0.8 \\ 0.8 & 0 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 1 \\ 0 \end{bmatrix} u \qquad y = \begin{bmatrix} 2 & 6 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + 0u$$

1. Define the system in Matlab using “sys = ss (*A, B, C, D*)” with the system matrices *A, B, C* and *D* given as above.
2. Check that the output of the ss call matches the system.
3. Use “initialplot(sys, x0)” to investigate system dynamics for different initial conditions $\boldsymbol{x}(0)$=x0. Start with x0=[0; 0] and then vary the values. Before plotting the dynamics, write down what you expect to see.
4. Plot the impulse response by using “impulse(sys) and identify the settling time using “lsiminfo”.

Task 2: Frequency responses

Consider the system as for Task 1 and an input u(t) that is a superposition of two sinusoidal signals

$$u(t) = \alpha \sin(5t) + (1-\alpha)\cos(0.5t)$$

1. Simulate the outputs of the system for a value of α between 0 and 1. Use “lsim(sys, u, t, x0)” by defining “t=0: delta_T: end_T” and different initial conditions x0. Describe your findings.

2. Repeat 1. for different values of α between 0 and 1. Describe your findings and explain why.

3. Draw the Bode plots of the system using “bodeplot(sys)”. What do you notice?

Task 3: Pole placement

Consider the system as for Tasks 1 and 2.

1. Calculate the poles of the system by “pole(sys)” and “eig(A)”, and evaluate the stability of the system.
2. Plot the poles and zeros on the complex plane by “pzmap(sys)”, to visualise how far the poles are from the unstable (positive real) region.
3. Consider a state-feedback u(t)= $[k_1 \; k_2]$ $\boldsymbol{x}$(t). Calculate the values for k_1 and k_2 that result in the closed-loop system to have the poles at -1 and -2.
4. Use “place(A, B, [-1 -2])” to check your calculation in 3.
5. Plot the poles and zeros of the closed-loop system on the complex plane, and compare the results in 2.
6. Plot the Bode plot and the impulse response of the closed-loop system and compare the results obtained in Tasks 1 and 2.