UC Berkeley

# EE128 Homework #7

Due on 11/21/05

(1) In the class, 'observability' is loosely defined as the ability for an observer to see the effects of all dynamic modes in a system. It was also mentioned that, for some systems, one way to see if a system is observable is to diagonalize the system and see if all modes are connected to the output. Consider the following system:

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

$$y = \begin{bmatrix} 3 & 5 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$$

(1.a) Use the 'observability matrix' to show that the system is not observable.

(1.b) Sketch a block diagram of the system (using single integrator as the basic building block) and show that all modes are 'connected' to the output.

(1.c) Explain what part of the system is not observable.

(1.d) In the class, 'controllability is loosely defined as the ability to control all dynamic modes in a system via the input. It was also mentioned that, for some systems, one way to see if a system is controllable is to diagonalize the system and see if all modes are connected to the input. Explain what part of the system is not controllable.

(2) Consider the following system.

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

$$y = \begin{bmatrix} 3 & 5 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$$

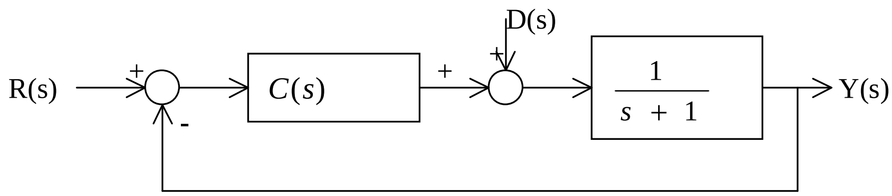
(2.1) Explain what makes this system observable while the system in problem (1) is not. You answer needs to be more than just saying that they have different A matrices.

(2.2) Explain what makes this system controllable while the system in problem (1) is not. You answer needs to be more than just saying that they have different A matrices.

(3) Textbook problem 7.43 (except part c.)

(4) Find the phase margin of the system you designed in (3) above. Hint: Plot the Bode plot of the loop transfer function first. Loop transfer function consists of the plant transfer function connected in series with the transfer function from y to u which include the estimator dynamics and the state feedback gains. You may use Matlab for the Bode plot of the loop transfer function.

(5) Consider the following system:




(5.a) Show that all of the following desirable properties can be achieved by simply using a very large constant 'k' for C(s).

- Reducing the effect of the disturbance D(s) on the output Y(s)
- Increasing the closed loop system response speed (i.e., bandwidth).
- Keeping the system stable.

(5.b) Give at least two reasons that the 'high gain' approach explained in (5.a) is not practical.

(5.c) Assume the disturbance term D(s) is a 60Hz sinusoidal function with an unknown magnitude and phase. Base on the concept introduced in section 7.9.3, design a C(s) that

- rejects this disturbance completely at steady state,
- achieves a closed loop bandwidth of 10Hz for input reference tracking, and
- renders a stable closed loop systems and gives the closed-loop system an unity DC gain.

(5.d) Compare the C(s) you derived in (5.c) to the one in textbook problem (4.18) and comment on any similarity and difference between the two.

(5.e) Use Simulink to verify your design. Use a 60Hz sinusoidal function with an arbitrary magnitude and phase in your plant model. (Show steady state disturbance rejection, tracking speed, and DC gain).