American University of Beirut
Department of Electrical and Computer Engineering

EECE 440 Signals and Systems

Homework 2: Due July 18, 2006

Part I

Problem 1

Consider a unity feedback linear time-invariant control system whose input is r(t) and output is c(t). The forward transfer function of this system is given by:

$$G(S) = \frac{20(S+1)}{S(S+2)(S+4)}$$

Represent this system in a state variable form by determining the state equation and the output equation.

Problem 2

The open-loop transfer function of a unity feedback control system is given by:

$$A(S) = \frac{(S+1)}{2S^4 + 4S^3 + 4S^2 + aS + 1}$$

Determine the stability of the system (state the reason) for the following two cases when a=0 and a=8.

Problem 3

The dynamic equations of a linear time-invariant system whose output is y(t) and input

$$\begin{bmatrix} X_1'(t) \\ X_2'(t) \end{bmatrix} = \begin{bmatrix} -1 & 2 \\ 2 & 0 \end{bmatrix} \begin{bmatrix} X_1(t) \\ X_2(t) \end{bmatrix} + \begin{bmatrix} 1 \\ 1 \end{bmatrix} r(t), \qquad y(t) = \begin{bmatrix} 1 & 1 \end{bmatrix} \begin{bmatrix} X_1(t) \\ X_2(t) \end{bmatrix}$$

r(t) are given by:

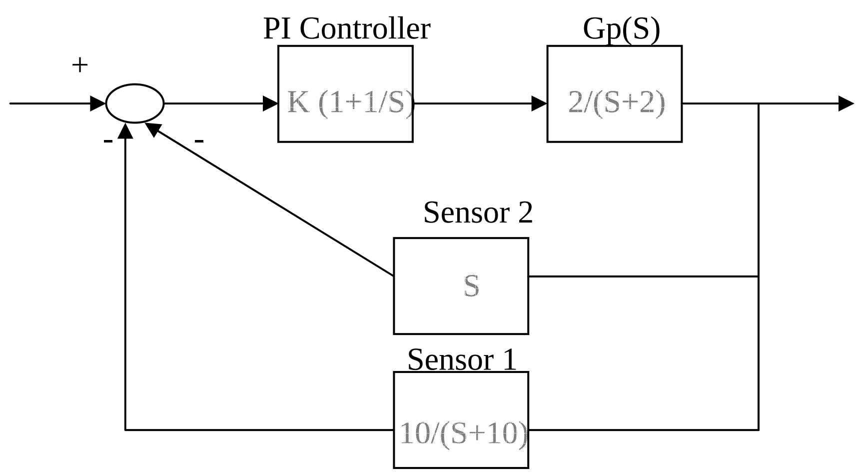
a. Determine the stability of the above system.
b. Determine the gains (f1, f2) of the input

$$r(t) = \begin{bmatrix} f1 & f2 \end{bmatrix} \begin{bmatrix} X_1(t) \\ X_2(t) \end{bmatrix}$$

in order to force the closed-loop system poles in the desired locations in the s-plane (-5 and –3).

Problem 4

A temperature control system is shown below. Sensor 1 measures the temperature, and this sensor is slow compared to the rate at which the temperature can change. Sensor 2 is called the rate sensor.



1. Find the values of K that will result in the system being oscillatory.
2. With K equal to the value found in (1), determine the period of oscillation.
3. Determine the range of K for stability.
4. Determine the steady-state error for a constant input provided that the system is stable.

Problem 5

Consider a linear control system whose system transfer function is given by:

$$\frac{C(s)}{R(s)} = \frac{K}{s+1}$$

a. For K=10, find the unit step response.
b. Find the time constant. **The time constant T is defined as the time T that satisfies the following equation:** $c(T) - c(\infty) = 0.368[c(o) - c(\infty)]$.
c. Can you have another definition or meaning of the time constant?
d. For K=10, close the loop with a constant feedback gain H. Design H so that the unit-step response reaches (and never decreases below) the 63% of its final value within the first 0.5 sec.

Problem 6

The open-loop transfer function of a unity feedback control system is given by:

$$G(s) = \frac{\frac{10}{z}(s+z)}{(s+1)(s+10)}$$

Determine z so that the step response percentage overshoot is 0.1.%

Problem 7

The open-loop transfer function of a unity feedback control system is given by:

$$G(s) = \frac{3s+10}{s^3 + 2s^2 + s}$$

Determine the steady-state value (final value) of the output signal for a unit-step input.

Problem 8

The closed-loop transfer function of a control system is given by:

$$\frac{C(s)}{R(s)} = \frac{s+1}{s^6 + s^5 + 5s^4 + 5s^3 + 7s^2 + 6s + 3}$$

1. Construct the RH table of the above system **<u>using the $\in$-method.</u>**
2. Choose $\in > 0$ and determine the number of poles of the closed-loop system in each half of the complex plane.
3. Choose $\in < 0$ and determine the number of poles of the closed-loop system in each half of the complex plane.
4. Comment on the results obtained in parts 2 and 3.
5. Using another procedure, determine the number of poles of the system in each half of the complex plane.

Part 2: Matlab Project

1. Stability using MATLAB.
   You are requested to determine a procedure to check on the stability of a LTI continuous using MATLAB. Give procedure and a minimum of two examples.

2. State Variable Analysis using MATLAB.

   Determine a MATLAB procedure for representing a system defined by its transfer function in a State-variable representation. Give a minimum of two examples.