

AMERICAN UNIVERSITY OF BEIRUT
FACULTY OF ENGINEERING AND ARCHITECTURE
EECE 460 Control Systems
Spring 2005-2006
Quiz II
Prof. Fouad Mrad
SOLUTION

Name :

1.5 hours.

May 13, 2006

Total of 100 points

Open Book Exam, 2 pages

YOU MUST RETURN THIS EXAM WITH YOUR ANSWER BOOKLET

Problem 1 (60 points):

For the system given by the following state model:

$$\dot{X}(t) = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ 1 & 2 & 3 \end{bmatrix} X(t) + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} U(t)$$

$Y(t) = [1 \ 0 \ 0]X(t)$ is output, $X(t)$ is state vector, $U(t)$ is input

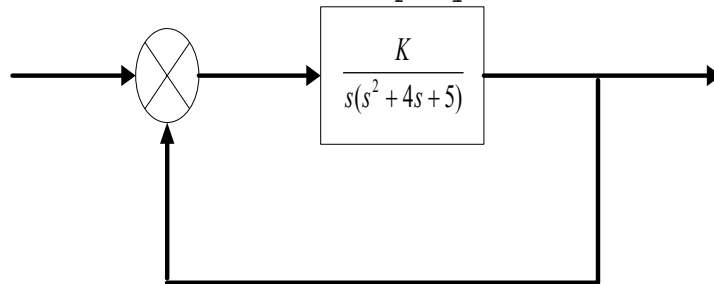
- Is the system fully controllable? Verify
CONTROLLABILITY MATRIX IS FULL RANK, YES
- Is the system fully observable? Verify
OBSERVABILITY MATRIX IS FULL RANK, YES
- Supply open loop system poles, is the system stable? Why.
3.6; -0.31+j0.42; -0.3-j0.42 (UNSTABLE SINCE ONE RHP POLE)
- Design if needed and possible a controller that assumes all states are available for feedback to force the closed loop system to have the following desired pole locations in the s-plane: -1+j; -1-j; -5
 $F = [11 \ 14 \ 10]$ $U(t) = -F X(t)$
- What are the achieved dominant transient step response specs of the closed loop system (Max overshoot, Settle time 2%)
 $M_p = 4.4\%$ and $T_s = 4$ sec

- f) If the only available measurement for feedback is the output, design if possible and needed an observer to estimate needed states by the controller of part (d) with desired observer pole locations at $(-10, -11, -12)$

Observer gain $K_e = [36 \ 472 \ 2810]$ Transpose

Problem 2 (40 points):

The following process transfer function represents a SISO LTI system. Assume that the closed loop system has unity feedback.



For one gain value K , supplied are open loop Bode plots and the system Phase and gain Margins.

- Compute the gain K of the supplied plots.
If you noticed plot vs Hz then K is 31 is not then K is 5 (I accepted both)
- Estimate (graphically) the G.M., P.M., and Bandwidth
GM = 12 dB and PM = 50 deg and $W_b = 1$ Hz
- Determine the static velocity error constant of the system
Related to K in part (a), 6.3 or 1
- While maintaining the same static error constant, what is the type of compensator you would recommend to improve the phase margin to 75 deg? Why?
LEAD since compensator needs to add only around 30 deg
LAG can do the job too, LAG-LEAD is an overkill.

