AMERICAN UINVERSITY OF BEIRUT
FACULTY OF ENGINEERING AND ARCHITECTURE
EECE 460 Control Systems
Spring 2003-2004
Quiz II
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Name:

1.5 hours.
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Total of 100 points
Open Book Exam, 2 pages
YOU MUST RETURN THIS EXAM WITH YOUR ANSWER BOOKLET

Problem 1 (30 points):

The space station attitude control dynamics has the plant transfer function given by G(s). Design a digital controller to have desired closed loop natural frequency around 0.3 rad/sec and damping ratio of 0.7 using emulation.

Assume that the supplied Continuous controller is D(s) and the sampling frequency is 6 rad/sec.

$$G(s) = \frac{1}{s^2} \quad \text{and} \quad D(s) = \frac{0.81(s+0.2)}{(s+2)}$$

+3 1. Is the sampling frequency fast enough for emulation? Justify. OK $T_s = 1sec$ $\omega_s \cong 20\omega_n$ $\left(\frac{4.6}{\zeta\omega_n}\right)$

+8 2. What are the desired transient specifications of the system? M_p, t_r

+8 3. What are the corresponding s-plane desired poles? $s_{1,2} = -0.21 \pm j0.214$

+8 4. Design D*(z) using Zero Pole Matching discretization. $0.389\left(\frac{z-0.82}{z-0.125}\right)$

+8 5. Derive the equivalent algorithm (difference equation) for microprocessor coding. $u(k) = 0.135\,u(k-1) + 0.389\,e(k) - 0.319\,e(k-1)$

+3 6. Is your derived routine implementable? Justify, if not suggest a practical solution. yes

Problem 2 (35 points):

The discrete equivalent linear time invariant state model of a second order system is given by the following:

$$X(k+1) = A\,X(k) + B\,U(k)$$
$$Y(k) = C\,X(k)$$

The matrices are:

$$A = \begin{bmatrix} 0 & 1 \\ -1 & 1 \end{bmatrix} \qquad B^T = [0\ 1 \qquad ; \ C = [2\ 0]$$

+10 a) What are the poles of the system in the z-plane? $\frac{1}{2} \pm j0.86$

+10 b) Is the given system fully observable? Justify. yes R^{-1} exists

+15 c) Design a predictor estimator to have desired poles in the Z-plane located at 0. (Supply needed gain vector). $L_p = [.5\ \ 0]$

Difference Equation Model of estimator

Problem 3 (35 points):

The discrete equivalent (T is 0.1 sec) linear time invariant state model of a continuous second order system is given by the following:

$$X(k+1) = A\,X(k) + B\,U(k)$$
$$Y(k) = C\,X(k)$$

The matrices are:

$$A = \begin{bmatrix} 1 & -1 \\ 0 & 1 \end{bmatrix} \qquad B^T = [1\ 1 \qquad ; \ C = [1\ 2$$

The desired given reference state vector is given by Xd(k) different from zero and corresponds to a given command input signal Uc(k). Define the state error by e(k)= X(k)-Xd(k).

+5 a) Is the given system fully controllable? Justify yes Q^{-1} exists

b) Design a feedback gain matrix G such that U(k)=Uc(k) - Ge(k) will force the closed loop system error to go to zero with desired poles in the Z-plane located at 0.4 and 0.6. $G = [-0.25,\ 1.24]$

+15

+15 c) What are the obtained transient step response specifications of the closed loop system in the continuous domain?

$s = \frac{1}{T}\ln(z) = \begin{cases} -9.16 \\ -5.1 \end{cases} \Rightarrow \cancel{t_p} = 0.27$

$\zeta > 1 \quad \Rightarrow \omega_n\,\zeta \Rightarrow \quad t_s = 2 \quad 0.67$