Name: ... Id No.: ...

Eskişehir Osmangazi University - Electrical Engineering Department Fundamentals of Control Systems – Final Examination - Spring 2013

For each question, put the answer just below it. Correct answers are sufficient for full credits. 1. [25 pts.] Consider following single input single output system:

$$\dot{x}_1 = x_2$$

 $\dot{x}_2 = -2x_1 + u$
 $y = x_1 + x_2$

(a) Draw a block diagram of this system. The blocks you can use are integrators, gains and summers.(b) Write the plant transfer function.



2. [25 pts.] Plot the root locus for the system below. For which K values is the system unstable?



3. [25 pts.] Consider following single input single output system with sampling time T = 2 seconds.

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

Assume that zero order hold is used for the input signal (i.e., the input is sampled at every sampling instant and is kept unchanged until the following sampling instant).

(a) Calculate e^{AT}

(b) Use part (a) in writing the discrete time model in the form

$$x(k+1) = Ax(k) + Bu(k); \ y = Cx(k) + D(u(k))$$

Ans. (a) $e^{AT} = \begin{bmatrix} e^2 & 0 \\ 0 & e^{-4} \end{bmatrix}$ (b) $x(k+1) = \begin{bmatrix} e^2 & 0 \\ 0 & e^{-4} \end{bmatrix} x(k) + \begin{bmatrix} 0 \\ \frac{e^{-4}}{-2} + \frac{1}{2} \end{bmatrix} u(k); \ y(k) = \begin{bmatrix} 1 & 1 \end{bmatrix} x(k)$ or $x(k+1) = \begin{bmatrix} 7.389 & 0 \\ 0 & 0.0183 \end{bmatrix} x(k) + \begin{bmatrix} 0 \\ 0.490 \end{bmatrix} u(k); \ y(k) = \begin{bmatrix} 1 & 1 \end{bmatrix} x(k)$

4. [25 pts.]For the configuration below, write the transfer function $\frac{Y(s)}{U(s)}$



Ans. $\frac{Y(s)}{U(s)} = \frac{\frac{4}{s^3} + \frac{8}{s^2} + \frac{2}{s^2}}{1 - (\frac{-6}{s} - \frac{11}{s^2} - \frac{6}{s^3})} = \frac{4 + 10s}{s^3 + 6s^2 + 11s + 6}$ Good Luck, A. Karamancıoğlu