Department of Electrical Engineering
Islamic University of Science & Technology

Tutorial-II	Advanced Control Systems	5^{th} Sem. EE
Marks 05	Autumn-2018	

Questions can be discussed in class if required. Solved submissions would be accepted on 1^{st} January 2019 till 11:00 AM only. Clarity and neatness of submission is important.

1. A regulator system having the plant model given by $\dot{x} = Ax + bu;\ y = cx$ with

$$A = \begin{bmatrix} 0 & 0 & -6 \\ 1 & 0 & -11 \\ 0 & 1 & -6 \end{bmatrix};\ b = \begin{bmatrix} 1 \\ 0 \\ 0 \end{bmatrix};\ c = \begin{bmatrix} 0 & 0 & 1 \end{bmatrix}$$

   (a) Compute k so that the control law $u = -kx$ places the closed loop poles at $-2 \pm j3.464, -5$. Give the state variable model of the closed loop system. Give a block diagram of the control configuration.

   (b) For the estimation of the state vector x, use an observer defined by $\dot{\hat{x}} = (A - mc)\hat{x} + bu + my$. Compute m so that the eigenvalues of $A - mc$ are located at $-2 \pm 3.464, -5$. Give a block diagram of the observer structure.

2. Consider a system with the transfer function $\frac{9}{s^2-9}$. Find the system model in observable canonical form.

   (a) Compute k so that the control law $u = -kx$ places the closed loop poles at $-3 \pm j3$.

   (b) Design a full order observer such that the observer error poles are located at -6 ± 6.

   (c) Find the transfer function of the compensator by combining (a) and (b).

   (d) Find the state variable model of the complete observer based state feedback system. Draw the overall block diagram of the system.

3. A servo system having the plant model given by $\dot{x} = Ax + bu;\ y = cx$ with

$$A = \begin{bmatrix} 0 & 1 & 0 \\ 0 & -1 & 1 \\ 0 & 0 & 2 \end{bmatrix};\ b = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix};\ c = \begin{bmatrix} 1 & 0 & 0 \end{bmatrix}$$

   (a) Compute k and N so that the control law $u = -kx + Nr$ places the closed loop poles at $-1 \pm j1, -2$ and $y(\infty) = r$, a constant reference input.

   (b) For the estimation of the state vector x, use an observer defined by $\dot{\hat{x}} = (A - mc)\hat{x} + bu + my$. Compute m so that the observer error poles are located at $-2 \pm j2, -4$.

   (c) Replace the control law in (a) by $u = -k\hat{x} + Nr$ and give a block diagram of the observer based servo system.

4. Determine the z-transform and the region of convergence for the following sequences:

   (a) $x(k) = \begin{cases} \alpha^m; & m \geq 0 \\ 0; & m \leq -1 \end{cases}$

   (b) $x(k) = \begin{cases} \alpha^m; & m \geq 0 \\ \beta^m; & m \leq -1 \end{cases}$

5. Find $x(k)$ by direct division when $X(z) = \frac{z(z+2)}{(z-1)^2}$

6. Find a closed form expression for $x(k)$ given that $X(z) = \frac{z^{-2}}{(1-z^{-1})^3}$

7. Solve the following difference equations:

   (a) $y(k+2) + 3y(k+1) + 2y(k) = 0;\ y(-1) = \frac{-1}{2},\ y(-2) = \frac{3}{4}$

   (b) $2y(k) - 2y(k-1) + y(k-2) = r(k);\ y(k) = 0$ for $k \leq -1$ and $r(k) = u(k)$ where $u(k)$ is standard discrete-time unit step function.

8. For the transfer function models and inputs given below find the response $y(k)$

   (a) $\frac{Y(z)}{R(z)} = \frac{2z-3}{(z-0.5)(z+0.3)}$, $r(k) = \delta(k-1)$ where $\delta(k)$ is the standard discrete-time impulse.

   (b) $\frac{Y(z)}{R(z)} = \frac{1}{(z-0.5)^2(z-0.1)}$, $r(k) = u(k)$, where $u(k)$ is standard discrete-time unit step function.

9. Examine the stability of the following characteristic equations:

   (a) $z^4 - 1.2z^3 + 0.07z^2 + 0.3z - 0.08 = 0$

   (b) $z^3 - 1.1z^2 - 0.1z + 0.2 = 0$

10. Consider the discrete-time unity-feedback control system whose open loop transfer function is given by $G(z) = \frac{K(0.3679z+0.2642)}{(z-0.3679)(z-1)}$. Determine the range of K for stability by use of the Jury stability test.