M.E. First Semester (Electrical Engg. (Electrical Power System))
Advanced Control System : EP 2101

P. Pages : 4

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Time : Three Hours

0355

Max. Marks : 80

Notes : 1. Answer **three** question from Section A and **three** question from Section B.
2. Due credit will be given to neatness and adequate dimensions.
3. Assume suitable data wherever necessary.
4. Illustrate your answer necessary with the help of neat sketches.

SECTION – A

1. a) Explain the configuration of the basic digital control scheme. Also explain the operation of A/D converter and D/A converter in detail.   7

   b) Find the steady state value $y_1(k)$ and $y_2(k)$ for unit step and unit alternating sequence. The discrete time system is shown in fig. 1 (b). The state variable model equations of first order system are   6

   $$x(k+1) = 0.95\ x(k) + r(k);\ x(0) = 0$$
   and $$y(k) = 0.0475\,x(k) + 0.05\,r(k)$$
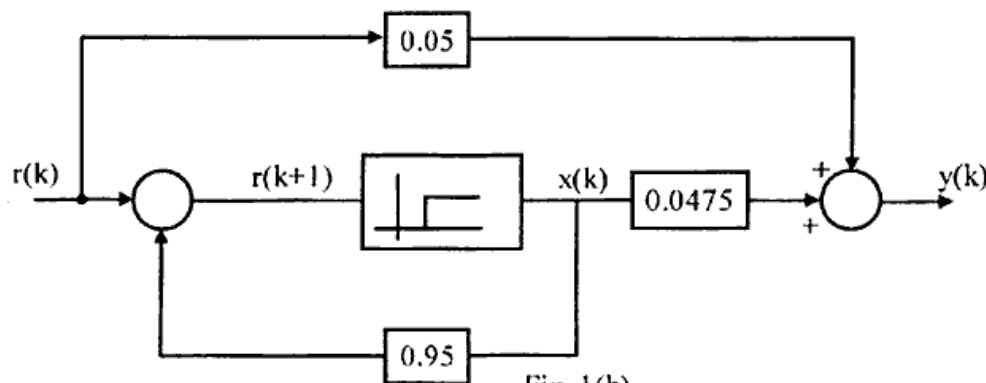

Fig. 1(b)

OR

2. a) State and explain   6
   i) Sampling theorem
   ii) Quantization effect
   iii) Aliasing effect

   b) For discrete time system   7

   $$y(k+2) + \frac{1}{4}y(k+1) - \frac{1}{8}y(k) = 3r(k+1) - r(k)$$

   with input $r(k) = (-1)^k\,u(k)$
   intial condition:
   $$y(-1) = 5;\ y(-2) = -6$$
   Find the output $y(k): k \geq 0$

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3. a) Explain the following methods of realizing digital controller. 7
      i) Direct
      ii) Cascade
      iii) Parallel

   b) i) A unity feedback system has the open loop transfer function 6

   $$G(s) = \frac{5}{s(s+1)(s+2)}$$

      using the Routh stability criterion, show that the closed loop system is stable.

      ii) The characteristic equation of a linear digital system is

   $$z^3 - 0.1z^2 + 0.2kz - 0.1k = 0$$

      Determine the value of $k > 0$ for which the system is stable.

<div align="center">OR</div>

4. a) Explain digital Position control system. 7

   b) i) Obtain the direct realization of 6

   $$D(z) = \frac{z^2 + 5z + 2}{z^3 + 6z^2 + 4z + 1}$$

      ii) Obtain the cascade realization of

   $$D(z) = \frac{z^3 + 3z^2 + 7z + 5}{z^3 + 3z^2 + 9z + 14}$$

5. a) State and explain different properties that describe the performance of feedback control system. 6

   b) Explain the types of compensators as referred to frequency response and also mention the need for compensation. 8

<div align="center">OR</div>

6. Feedback control system is shown in fig (6) below. The plant is described by 14

   $$G(s) = \frac{k}{s(s+2)}$$

   Design a digital control scheme for the system to meet the specifications
   i) $K_V = 6$
   ii) M_p to step input $\leq 15\%$
   iii) t_s for 2% tolerance band $\leq 5sec$.
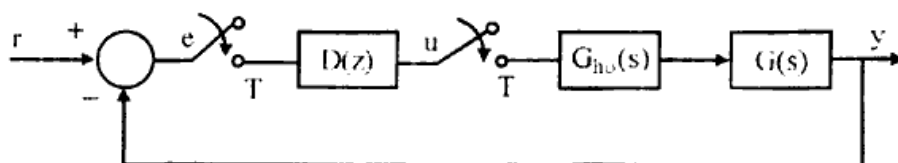

Fig.6

SECTION – B

7. A feedback system has a C. L. T. F.   **14**

$$\frac{Y(s)}{R(s)} = \frac{10(s+4)}{s(s+1)(s+3)}$$

Derive three different state modes for given system.
a) one where the system A is a diagonal matrix
b) one where A is in first companion form
c) one where A is in second companion form

OR

8. A Linear time invariant system is characterized by the homogeneous state equation.   **14**

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

a) Compute the solution assuming initial state vector $x(0) = \begin{bmatrix} 1 \\ 0 \end{bmatrix}$ using Laplace transform method

b) For L. T. I. system $\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ 0 & -2 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u$

Compute the solution assuming intial condition $x(0) = \begin{bmatrix} 1 \\ 0 \end{bmatrix}$ where u is unit step input.

9. a) Investigate the controllability and observability of the following system.   **6**

a) $x(k+1) = \begin{bmatrix} 1 & -2 \\ 1 & -1 \end{bmatrix} x(k) + \begin{bmatrix} 1 & -1 \\ 0 & 0 \end{bmatrix} u(k)$

       $y(k) = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} x(k)$

b) $x(k+1) = \begin{bmatrix} -1 & 1 \\ 0 & -1 \end{bmatrix} x(k) + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u(k)$

       $y(k) = \begin{bmatrix} 1 & 1 \end{bmatrix} x(k)$

b) The block diagram of sampled data system is shown in fig. 9 (b). Obtain the discrete time   **7**
state model of the system.

$$A = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix}; \quad b = \begin{bmatrix} 0 \\ 1 \end{bmatrix}; \quad c = \begin{bmatrix} 1 & 0 \end{bmatrix}$$
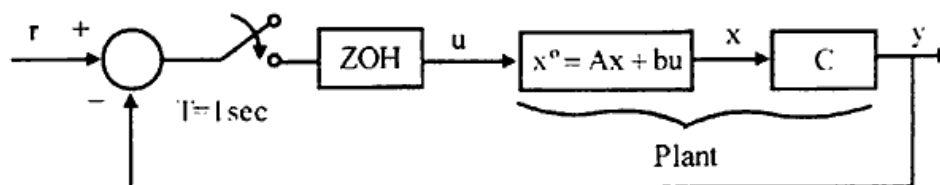

Fig.9 (b)

OR

10. a) For the system

$$\begin{bmatrix} x_1(k+1) \\ x_2(k+1) \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix} \begin{bmatrix} x_1(k) \\ x_2(k) \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \end{bmatrix} (-1)^k$$

$$x_1(0) = 1 = x_2(0)$$

$$y(k) = x_1(k)$$

Find $y(k)$ for $k \geq 1$ 6

b) Given

$$n \hat{x} n = \begin{bmatrix} \lambda_1 & 1 & 0 \cdots\cdots 0 \\ 0 & \lambda_1 & 1 \text{------} 0 \\ \vdots & \vdots & \vdots & \vdots \\ 0 & 0 & 0 \text{-----} 1 \\ 0 & 0 & 0 \cdots\cdots \lambda_1 \end{bmatrix}$$

Compute $\wedge^k$ using the Cayley Hamilton technique.   7

11.
$$\dot{x} = \begin{bmatrix} 0 & 1 \\ 20.6 & 0 \end{bmatrix} x + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u$$

$$y = [1 \quad 0] x$$

a) Design a full order state observer to estimate the state vector. The observer matrix is required to have eigen value at $-8, -8$.

b) Design control law $u = -kx$, so that the closed loop system has eigen values at $-1.8 \pm j2.4$ 13

OR

12.
$$x(k+1) = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -0.5 & -0.2 & 1.1 \end{bmatrix} x(k) + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} u(k)$$

Determine state feedback gain matrix 'K' such that $u(k) = -kx(k)$; $X(0)$ is initial state. Give state variable model of closed loop system.   13

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