[Total No. of Questions - 8] [Total No. of Printed Pages - 3]
(2125)

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M. Tech 1st Semester Examination

Digital Control Systems (NS)

EE1-514

Time : 3 Hours **Max. Marks : 100**

The candidates shall limit their answers precisely within the answer-book (40 pages) issued to them and no supplementary/continuation sheet will be issued.

Note : Total number of questions listed in the question paper is eight. Attempt any five questions. All questions carry equal marks.

1. (a) Draw a block diagram of digital control system. Explain (S/H) (Sample and Hold) and transducer blocks in detail with more theoretical justifications.

   (b) Compare digital and analog controllers as well as explain the superiority of digital control methods over the analog. (20)

2. (a) Define z transform beginning from the notion of Laplace transform of the continuous-time signals. Write the relation between the z transform and discrete-time Fourier transform.

   (b) Explain sampling Theorem for the discrete-time control systems and state its limitations. Discuss the signal processing methods for sampled data control systems. (20)

3. (a) Explain linear time-varying continuous and discrete-time systems by using the state space interpretations and output equations.

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   (b) Find the pulse transfer functions of zero-order hold and nth order hold circuits. Write the usefulness of the both circuits in detail in the context of signal constructions. (20)

4. (a) Determine the inverse of the matrix (zI-G), where

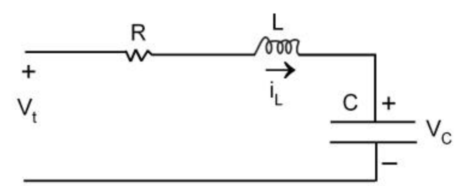
$$G = \begin{pmatrix} 0.1 & 0.1 & 0 \\ 0.3 & -0.1 & -0.2 \\ 0 & 0 & -0.3 \end{pmatrix},$$

   Compute the following: (i) State transition matrix (ii) the characteristic polynomials of the matrix G (iii) State the location of the eigen values of the matrix G, where the matrix G is associated with the discrete-time linear time-variant system.

   (b) Find the solution of linear time-invariant discrete-time state equation coupled with the out equation.
   $x(k+1)=Gx(k)+Hu(k)$,
   $y(k)=Cx(k)+Du(k)$,
   where u(k) is the control signal and y(k) is the output signal and x(k) is n dimensional state vector. (20)

5. (a) Explain pulse-transfer function matrix for the multi-input multi-out systems. Develop the pulse transfer function of the PID control actions as well as explain the physical interpretations of the control actions of the controller.

   (b) Write down the state equation of the following electrical circuits in the continuous-time and discrete time settings.



(20)

6. (a) Explain controllability and observability of state equations and measurement equations in the discrete-time setting by stating their necessary and sufficient conditions.

(b) Consider the system defined by

$$\begin{pmatrix} x_1(k+1) \\ x_2(k+1) \end{pmatrix} = \begin{pmatrix} a & b \\ c & d \end{pmatrix} \begin{pmatrix} x_1(k) \\ x_2(k) \end{pmatrix} + \begin{pmatrix} 1 \\ 1 \end{pmatrix} u(k),$$

$$y(k) = (1 \ \ 0) \begin{pmatrix} x_1(k) \\ x_2(k) \end{pmatrix},$$

determine the conditions on a,b,c and d for complete state controllability and complete observability. (20)

7. (a) The control system defined by

$$\begin{pmatrix} x_1(k+1) \\ x_2(k+1) \end{pmatrix} = \begin{pmatrix} 0 & -1 \\ -0.16 & -1 \end{pmatrix} \begin{pmatrix} x_1(k) \\ x_2(k) \end{pmatrix} + \begin{pmatrix} 1 \\ 0.5 \end{pmatrix} u(k), \begin{pmatrix} x_1(0) \\ x_2(0) \end{pmatrix} = \begin{pmatrix} 1 \\ -1 \end{pmatrix},$$

examine whether the system is completely state controllable. If the system is controllable, determine a sequence of control signals u(0), u(1),u(2) such that the x(3) becomes

$$\begin{pmatrix} x_1(2) \\ x_2(2) \end{pmatrix} = \begin{pmatrix} -1 \\ 2 \end{pmatrix}$$ (20)

8. (a) Obtain the state transition matrix of the following discrete-time system:

$$x(k+1)=Gx(k)+Hu(k),$$

$$y(k) = C^T x(k), x(0) = \begin{pmatrix} x_1(0) \\ x_2(0) \end{pmatrix} = \begin{pmatrix} 1 \\ -1 \end{pmatrix}$$

where $G = \begin{pmatrix} 0 & 1 \\ -0.16 & -1 \end{pmatrix}$, $H = \begin{pmatrix} 1 \\ 1 \end{pmatrix}$, $C = \begin{pmatrix} 1 \\ 0 \end{pmatrix}$, then obtain the state x(k) and the output y(k) for the instants k=1,2,3, where the input u(k)=1 for k=0,1,2. (20)