Name : ....

Roll No. : ....

Invigilator's Signature : ....

CS/M.TECH(EE)/SEM-1/PSM-101/2012-13

2012

ADVANCED CONTROL SYSTEM

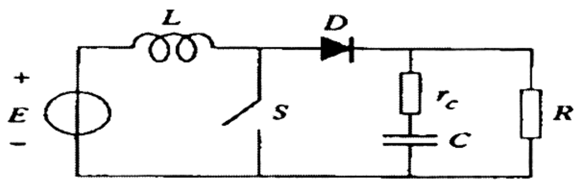
Time Allotted : 3 Hours *Full Marks* : 70

The figures in the margin indicate full marks.

Candidates are required to give their answers in their own words as far as practicable.

Answer any *five* questions. 5 × 14 = 70

1. a) For the system shown in following figure, write down state equations,



when switch S is closed and Diode D is open.

b) For the matrix given find (i) Eigenvalues, (ii) Eigenvector, (iii) Diagonalization matrix.

$$A = \begin{bmatrix} 3 & -2 \\ -1 & 2 \end{bmatrix}$$

c) Construct the state model for a system characterized by the differential equation,

$$\frac{d^3y}{dt^3}+6\frac{d^2y}{dt^2}+11\frac{dy}{dt}+6y=u$$

Hence obtain the block diagram of the system in canonical form. 4 + 5 + 5

2. a) Find the $f(A)=e^{At}$ using Cayley-Hamilton technique,

where $A=\begin{bmatrix} 0 & 1 \\ -1 & -2 \end{bmatrix}$

b) Consider the state equation

$$\begin{bmatrix} \dot{x}_{1(t)} \\ \dot{x}_{2(t)} \end{bmatrix}=\begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix}\begin{bmatrix} x_{1(t)} \\ x_{2(t)} \end{bmatrix}+\begin{bmatrix} 0 \\ 1 \end{bmatrix}u(t)$$

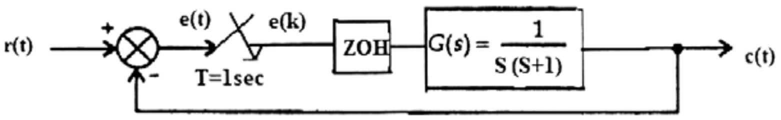
The problem is to determine the state-transition matrix $\Phi(t)$ and state vector $x(t)$ for $t\geq 0$, when the input is $u(t)=1$ for $t\geq 0$.

c) A continuous time plant is described by the state equation

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

The state equation is to be solved for $x(t)$ using digital computer. Obtain suitable recursive relations. Take sampling interval T = 1 sec. 4 + 5 + 5

3. a) Find out the overall transfer function of the system and also the output for k = 1, 2, 3.

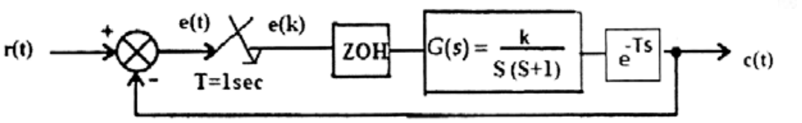


b) Solve the difference equation

$c(k+2)+3c(k+1)+2c(k)=u(k);\quad c(0)=1$

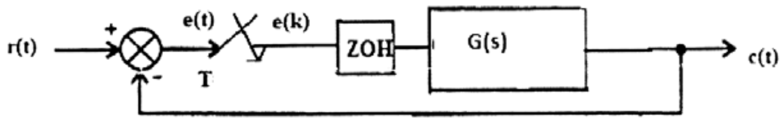
$c(k)=0$ for $k<0$.

c) Find the range of K for the system shown in the figure below to be stable.



5 + 4 + 5

4. a) A closed loop system shown in figure. The transfer function is $G(s) = \dfrac{k}{s(0 \cdot 5s+1)}$. Select a gain K and the sampling period T so that the overshoot is limited to 0·3 for a unit step input and the steady state error for a unit ramp input is less than 1·0.



b) What is Describing function ? Find out the describing function for Dead-zone with saturation. 7 + 7

5. a) Consider a plant $G(s) = \dfrac{1}{(s+1)(s+3)(s+5)}$ that is to be placed under PID control. Tune PID controller using *ZN* 2nd method.

b) Consider an LTI system with the following state-space coefficient matrices :

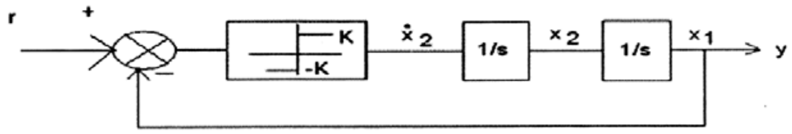
$$A = \begin{bmatrix} 0 & 50 \\ -200 & -200 \end{bmatrix}, B = \begin{bmatrix} 0 \\ 200 \end{bmatrix}, C = \begin{bmatrix} 1 & 0 \end{bmatrix} \text{ and } D = 0.$$

i) Design a State Feedback with Integral controller for the system such that the desired closed-loop poles are at $s_1 = -300, s_2 = -10 - 10i$ and $s_3 = -10 + 10i$.

ii) Draw state block diagram of the system with controller.

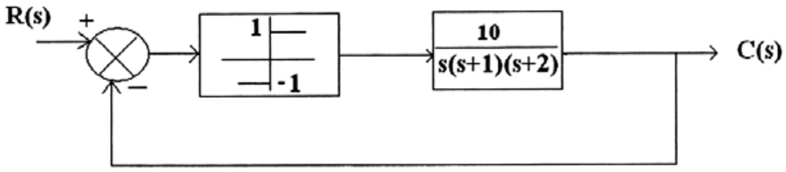
c) Show that the pole placement design and observer design are independent of each other. 5 + 5 + 4

6. a) Draw the phase plane trajectory of the following nonlinear system by Isocline method. Write a comment on stability.



b) Consider the system described by $x' = Ax$ where $A = \begin{bmatrix} -1 & -2 \\ 1 & -4 \end{bmatrix}$. Determine whether the system is stable or not. 8 + 6

7. a) Determine the stability of the non-linear system shown in figure.



Also determine the amplitude and frequency of the limit cycle.

b) A system is described by

$$x_1' = -x_1 + x_2 + x_1(x_1^2 + x_2^2)$$

$$x_2' = -x_1 - x_2 + x_1(x_1^2 + x_2^2)$$

Determine the asymptotic stability using Lyapunov's second method. 10 + 4

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