Roll No ....

MEPE-103

M.E/M.Tech., I Semester

Examination, December 2014

Advanced Control System

Time : Three Hours

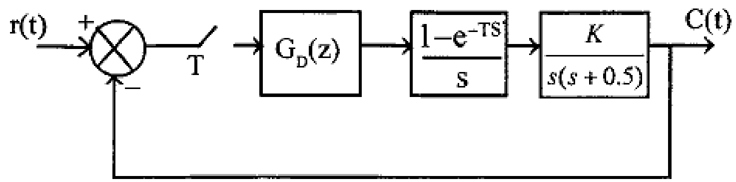
 Maximum Marks : 70

Note: i) Attempt any five questions.
ii) Each questions having equal marks.

1. a) Consider the following characteristic equation:
$P(z) = z^3 - 1.3z^2 - 0.08z + 0.24 = 0$
Determine whether or not any of the roots of the characteristics equation lie outside the unit circle in the z-plane. Use the bilinear transformations and the Routh Stability Criterion.

b) Show that geometrically the patterns of the poles near $z = 1$ in the z-plane are similar to the patterns of poles in the s-plane near the origin.

2. Using the Bode-diagram in the w-plane, design a digital controller for the system shown in fig. The design specification are that the Phase margin be 50°, the Gain margin be at least 10 dB, and the static velocity error constant kv, be 20 sec^{-1}. The sampling period is assumed to be 0.1 sec, or T = 0.1.



3. For the system defined by

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

$$y(k) = \begin{bmatrix} 1 & 0 \end{bmatrix} \begin{bmatrix} x_1(k) \\ x_2(k) \end{bmatrix}$$

Assume that the following outputs are observed:
$y(0) = 1$, $y(1) = 2$
The control signals given are $u(0) = 2$, $u(1) = -1$ Determine the initial state $x(0)$. Also, determine states $x(1)$ and $x(2)$.

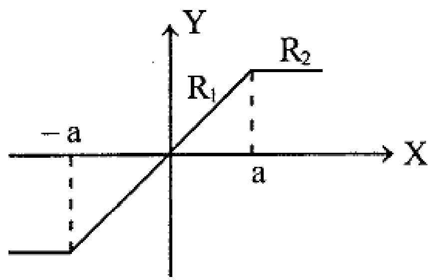
4. Explain with suitable example necessary and sufficient condition for arbitrary pole placement.

5. a) Give the application with necessary explanation of variable structure control.
   b) Explain variable structure control with suitable example.

6. a) Show that the following quadratic form is positive definite.

   $$Q(x_1, x_2) = 10x_1^2 + 4x_2^2 + x_3^3 + 2x_1x_2 - 2x_2x_3 - 4x_1x_3$$

   b) Derive the expression for describing function of the following non-linearity.



7. Consider the system

$$\begin{bmatrix} x_1(k+1) \\ x_2(k+1) \end{bmatrix} = \begin{bmatrix} 0 & 0 \\ 1 & 1 \end{bmatrix} \begin{bmatrix} x_1(k) \\ x_2(k) \end{bmatrix} + \begin{bmatrix} 1 \\ 0 \end{bmatrix} u(k),$$

$\begin{bmatrix} x_1(0) \\ x_2(0) \end{bmatrix} = \begin{bmatrix} 1 \\ 1 \end{bmatrix}$ and the performance index

$$J = \frac{1}{2} \sum_{k=0}^{\infty} \left[X^*(k) Q X(k) + u^*(k) R u(k) \right]$$

Where $Q = \begin{bmatrix} 1 & 0 \\ 0 & 0 \end{bmatrix}, R = 1$

Determine the optimal control law to minimize the performance index. Also determine the minimum value of J.

8. Write a short note on (any two)
   a) Transversal condition of optimal control.
   b) Euler-Lagrange equation
   c) Modeling through differential equation

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