

Name : .....

Roll No. : .....

Invigilator's Signature : .....

**CS/B.Tech(EE-NEW)/SEM-6/EE-603/2010  
2010**

**CONTROL SYSTEM - II**

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.*

**GROUP – A**

**( Multiple Choice Type Questions )**

1. Choose the correct alternatives for any *ten* of the following :

10 × 1 = 10

- i) Liapunov function must be
  - a) a scalar and negative definite function
  - b) a scalar and positive definite function
  - c) a positive semi-definite function
  - d) all of these.
- ii) If both the eigenvalues of a second order system are real and negative, then it is termed as
  - a) the saddle point
  - b) the nodal point
  - c) the focus point
  - d) the unstable focus point.



- iii) Hysteresis in a mechanical transmission is termed as
- damping
  - backlash
  - dead zone
  - drift.
- iv) For SISO :  $Y(s) = G(s)U(s)$
- $G(s)$  is a scalar
  - $G(s)$  is a transfer function
  - $G(s)$  is  $m \times r$  dimensional matrix
  - both (a) and (b).
- v) The transfer function for the state variable representation is given by
- $D + C(SI - A)^{-1}B$
  - $B + C(SI - A)^{-1}D$
  - $C + B(SI - A)^{-1}D$
  - $A + C(SI - B)^{-1}D$ .
- vi) The inverse Z transform of the function  $\frac{TZ}{(Z-1)^2}$  is
- $kT$
  - $(kT)^2$
  - $e^{-kT}$
  - 1.
- vii) For the difference equation  $x(k+2) + 4x(k+1) + 5x(k) = 0$ , the initial conditions are  $x(0) = 0$  and  $x(1) = 1$ . The value of  $x(2)$  is
- 4
  - 4
  - 9
  - 0.
- viii) For analysis of non-linear system by describing function
- the structure of non-linear system must be reduced to linear  $[G_L(jW)]$  and non-linear  $[N(R)]$  parts
  - the structure of non-linear system must be reduced to non-linear  $[N(R)]$  part only
  - the structure of whole system must be reduced to linear  $[G_L(jW)]$  part only
  - the linear part must have characteristics of a high-pass filter.

- GROUP – B**

Answer any *three* of the following.

$$3 \times 5 = 15$$

- Dia.



3. Give  $A = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix}$ , determine  $\phi(k) = A^k$  using Cayley-Hamilton method.

4. Solve the difference equation

$x(n+2) = 3x(n+1) + 2x(n) = u(n)$ . The initial conditions are  $x(0) = 0$  and  $x(1) = 1$ .

5. Use the second method of Liapunov to show that the following system is stable for all positive values of  $k$ .

$$\dot{X} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & -1 & 1 \\ -k & (-1 - k/2) & -k/2 \end{bmatrix} X$$

6. For the discrete time system.

$x(k+2) + 5x(k+1) + 6x(k) = u(k)$ ,

$x(0) = x(1) = 0$ .

Find the state transition matrix.

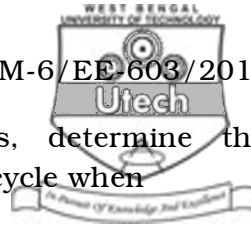
### GROUP – C

( Long Answer Type Questions )

Answer any *three* of the following.  $3 \times 15 = 45$

7. a) Determine the describing function of the non-linear element shown in the figure having a dead zone followed by linear characteristics.

Dia.



- b) Using describing function analysis, determine the amplitude and frequency of the limit cycle when  $k = 4$ .

Dia.

8 + 7

8. a) Define phase plane, phase trajectory and phase portrait.  
b) Plot the phase trajectory of the system shown with initial conditions  $e(0) = 2$  and  $\dot{e}(0) = 0$ .

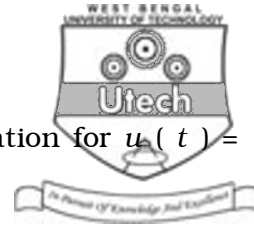
Dia.

3 + 12

9. a) Determine the controllability and observability of the system

$$\dot{X} = \begin{bmatrix} -1 & 0 & 0 \\ 0 & -2 & 0 \\ 0 & 0 & -3 \end{bmatrix} X + \begin{bmatrix} 1 & 0 \\ 0 & 2 \\ 2 & 1 \end{bmatrix} u$$

$$Y = \begin{bmatrix} 1 & 1 & 2 \\ 3 & 1 & 0 \end{bmatrix} X$$



- b) Obtain the solution of the state equation for  $u(t) = 1$  for  $t \geq 0$

$$\dot{X} = \begin{bmatrix} 0 & 1 \\ -3 & -4 \end{bmatrix} X + \begin{bmatrix} 0 \\ 2 \end{bmatrix} u$$

$$X(0) = \begin{bmatrix} 0 \\ 1 \end{bmatrix}, Y(t) = [1 \ 1] X(t). \quad 8 + 7$$

10. a) State Shanon's sampling theorem.
- b) For the sampled data control system shown below, find the output  $(k)$  for  $r(t) = \text{unit step}$ .

Dia.

3 + 12

11. a) Show that the arbitrary pole placement of a liner state feedback system is possible if the system is completely controllable.



- b) Determine the state feedback gain matrix so that the closed loop poles of the following system are located at  $(-2 + j4)$ ,  $(-2 - j4)$ ,  $-10$

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 0 \\ -1 & -5 & -6 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} u$$

7 + 8

12. Write short notes on any *three* of the following :

3 × 5

- a) Harmonic linearization
- b) Global asymptotic stability
- c) Digital compensator
- d) Anti-aliasing filters.

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