Seat No.: ________ *Enrolment No.___________*

GUJARAT TECHNOLOGICAL UNIVERSITY

M. E. - SEMESTER – I • EXAMINATION – WINTER • 2013

Subject code: 714702N **Date: 26-12-2013**

Subject Name: Advance Control Systems

Time: 10.30 am – 01.00 pm **Total Marks: 70**

Instructions:

1. **Attempt all questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**

Q.1 **(a)** Do as directed. **07**

(1) Why compensation is necessary in feedback control system?

(2) State advantages of state-space method over the conventional transfer function method.

(3) Discuss the advantages and disadvantages of sampled data control systems.

(b) What is the relation between *s* and *z* domain? Discuss the stability criterion for each of them. **07**

Q.2 **(a)** Draw the frequency domain characteristic of phase-lag network used for control system compensations. Discuss the importance when lag compensation is employed. **07**

(b) Design suitable lag compensator for a system with unity feedback and having open-loop transfer function **07**

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

to meet the following specifications:

(i) Phase Margin is 40°.

(ii) the steady state error for ramp input is less than or equal to 0.2.

OR

(b) Design a lead compensator for a unity feedback control system with open-loop transfer function is given by **07**

$$G(s) = \frac{\mathrm{K}}{s(s+4)(s+7)}$$

to meet the following specifications:

(i) Percentage peak overshoot = 12.63%

(ii) Natural frequency of oscillation (w_n) = 8 rad/sec

(iii) Velocity error constant (K_v)≥ 2.5

Q.3 **(a)** Derive the describing function of the element whose input – output characteristic is shown in Figure 1. **07**

(b) For the system shown in Figure 2 having a saturating amplifier with gain K. Determine the maximum value of K for the system to stay stable. **07**

OR

Q.3 **(a)** Derive the describing function of the element whose input – output characteristic is shown in Figure 3. **07**

(b) Using Delta method construct a phase trajectory for a nonlinear system represented by the differential equation, **07**

$$\ddot{x} + 4|\dot{x}|\dot{x} + 4x = 0 \text{ with initial condition } \begin{matrix} x(0) = 1 \\ \dot{x}(0) = 0 \end{matrix}$$

Q.4 **(a)** Determine z-transform of the function $f(t) = \sin \omega t$. **07**

(b) Determine the unit step time response for the pulse transfer function **07**

$$\frac{C(z)}{R(z)} = \frac{z}{z^2 - z + 0.5}$$

OR

Q.4 **(a)** With suitable example explain pulse transfer function. **07**

(b) Find out inverse z – transform, using partial expansion method **07**

$$F(z) = \frac{z^2}{z^2 - 1.5z + 0.5}$$

Q.5 **(a)** For the given differential equation **07**

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

(a) Represent in state variable form.

(b) Find out state transition matrix.

(b) A system is described by the following equations **07**

$$\dot{x}(t) = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -1 & -2 & -4 \end{bmatrix} x(t) + \begin{bmatrix} 0 \\ 0 \\ 10 \end{bmatrix} u(t) \; ; \qquad y(t) = \begin{bmatrix} 1 & 0 & 0 \end{bmatrix} x(t)$$

Find the transfer function of the system.

OR

Q.5 **(a)** Obtain the state model for a system whose transfer function is given as, **07**

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

(b) A linear-time-invariant system is characterized by the homogeneous state equation **07**

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ 1 & 1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} \text{; Assume the initial state vector } \begin{bmatrix} x_1(0) \\ x_2(0) \end{bmatrix} = \begin{bmatrix} 1 \\ 0 \end{bmatrix}$$

Compute the solution of homogeneous state equation.

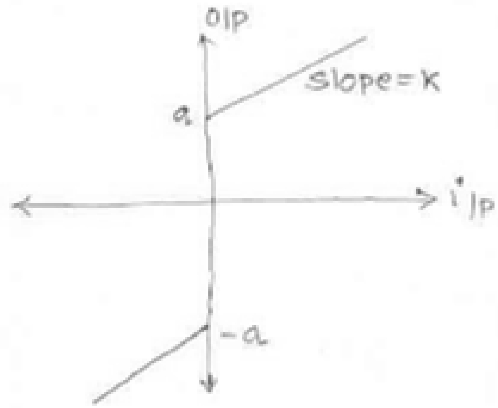

Figure. 1

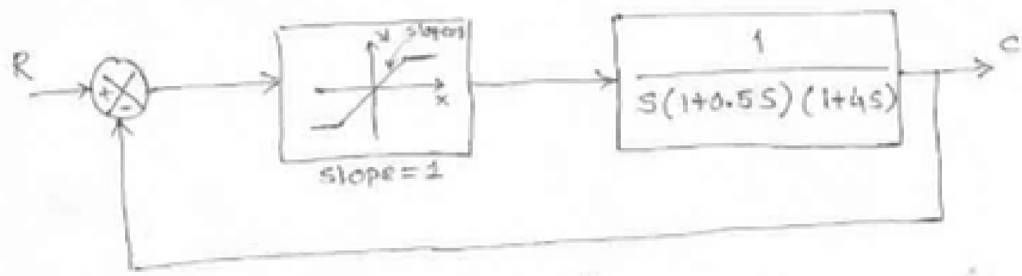

Figure. 2

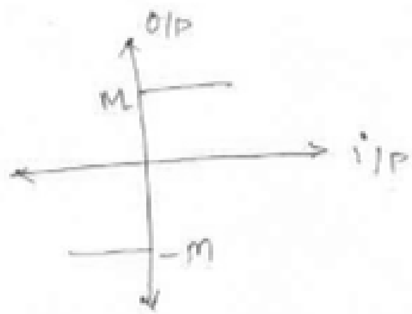

Figure. 3

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