NEW SCHEME

USN

Fifth Semester B.E. Degree Examination, July/August 2005

Electrical & Electronics Engineering

Modern Control Theory

Time: 3 hrs.] [Max.Marks : 100

Note: ***Answer any FIVE full questions.***

1. (a) Explain effects of a PI controller on the static and dynamic response of a system. (5 Marks)

   (b) Consider a typical second order, type one system with unity feedback, being controlled by a PD controller and show that

   i) Damping increases with PD control

   ii) Steady state error to a ramp input remains unchanged if proportional gain $k_p = 1$. (8 Marks)

   (c) Obtain the state model of the electrical network shown in fig.1(c) selecting $v_1(t)$ and $v_2(t)$ as state variables. (7 Marks)

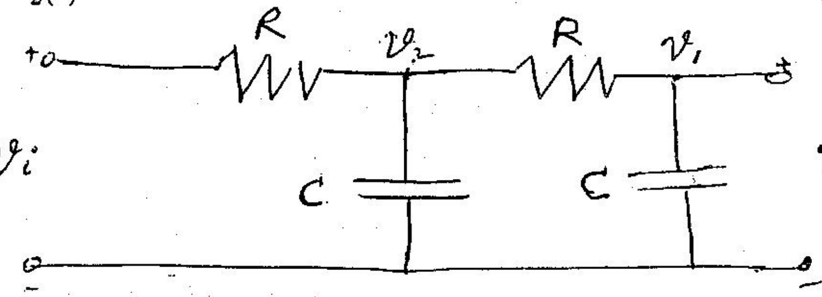

Fig. 1(c)

2. (a) Obtain the state model of the system represonsed by the following differential equation

   $\dddot{y} + 6\ddot{y} + 5\dot{y} + y = u.$ (5 Marks)

   (b) Obtain two different state models for a system represented by the following transfer function. Write suitable state diagram in each case.

   $\frac{y(s)}{u(s)} = \frac{8s^2+17s+8}{(s+1)\ (s^2+8s+15)}$ (8 Marks)

   (c) Obtain the state model of the system represented by the following transfer function in Jordan canonical form. Write the state diagram.

   $\frac{y(s)}{u(s)} = \frac{2s^2+6s+5}{(s^2+2s+1)\ (s+2)}$ (7 Marks)

3. (a) What are generalised eigen vectors? How are they determined? (5 Marks)

(b) Convert the following state model into canonical form

$$\overset{\circ}{x} = \begin{bmatrix} 1 & -4 \\ 3 & -6 \end{bmatrix} x + \begin{bmatrix} 0 \\ -1 \end{bmatrix} u$$
$$y = [1 \;\; 0]x.$$
(8 Marks)

(c) Convert the following square matrix A into Jordan canonical form using a suitable non singular transformation matrix P.

$$A = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -4 & -9 & -6 \end{bmatrix}$$
(7 Marks)

4. (a) What is a state transition matrix? List the properties of state transition matrix. (6 Marks)

(b) Given the state model of a system.

$$\overset{\circ}{x} = \begin{bmatrix} 0 & 1 \\ -4 & -5 \end{bmatrix} x + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u$$
$$y = [1 \;\; 0]x.$$

with initial conditions $x(0) = \begin{bmatrix} 1 \\ 1 \end{bmatrix}$

Determine :

i) The state transition matrix

ii) The state transition equation $x(t)$ and output $y(t)$ for an unit step input

iii) Inverse state transition matrix. (14 Marks)

5. (a) Explain the concept of controllability and observability. (6 Marks)

(b) Determine the controllability and observability of the following state model

$$\overset{\circ}{x} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -6 & -11 & -6 \end{bmatrix} x + \begin{bmatrix} 1 \\ 0 \\ 1 \end{bmatrix} u$$
$$y = [10 \;\; 5 \;\; 1]x$$
(8 Marks)

(c) A system represented by following state model is controllable but not observable. Show that the non-observability is due to a pole-zero cancellation in $C[sI - A]^{-1}$. (6 Marks)

$$\overset{\circ}{x} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -6 & -11 & -6 \end{bmatrix} x + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} u$$
$$y = [1 \;\; 1 \;\; 0]x$$

6. (a) Write the block diagram of a system with observer based state feedback controller. (5 Marks)

(b) It is desired to place the closed loop poles of the following system at $s = -3$ and $s = -4$ by a state feedback controller with the control law $u = -Kx$. Determine the state feedback gain matrix K and the control signal.

$$\mathring{x} = \begin{bmatrix} 0 & 1 \\ -1 & -3 \end{bmatrix} x + \begin{bmatrix} 0 \\ 2 \end{bmatrix} u$$
$$y = [1 \quad 0]x$$

(7 Marks)

(c) Consider the system represented by

$$\mathring{x} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -6 & -11 & -6 \end{bmatrix} x + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} u$$
$$y = [1 \quad 0 \quad 0]x$$

Design a full order observer such that the observer eigen values are at $-2 \pm \rho 2\sqrt{3}$ and -5. **(8 Marks)**

7. (a) With reference to non-linear system explain :

i) Jump resonance ii) Limit cycles. **(6 Marks)**

(b) What are singular points? Explain the classification of singular points based on the location of eigen values of the system. **(8 Marks)**

(c) Explain the construction of a phase trajectory either by isocline method or by delta method. **(6 Marks)**

8. (a) Define :

i) Stability

ii) Asymptotic stability

iii) Asymptotic stability in the large. **(5 Marks)**

(b) Investigate the stability of the following nonlinear system using direct method of Liapunov.

$$\mathring{x}_1 = x_2$$
$$\mathring{x}_2 = -x_1 - x_1^2 x_2$$

(5 Marks)

(c) A second order system is represented by

$$\mathring{x} = Ax \text{ where } A = \begin{bmatrix} 0 & 1 \\ -1 & -1 \end{bmatrix}.$$

Assuming matrix Q to be identity matrix, solve for matrix P in the equation $A^T P + PA = -Q$. Use Liapunov theorem and determine the stability of the origin of the system. Write the Liapunov function $V(x)$. **(10 Marks)**

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