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Code No: A4903, A4303

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
M.TECH I SEMESTER EXAMINATIONS, APRIL/MAY-2012
MODERN CONTROL THEORY
(COMMON TO ELECTRICAL POWER ENGINEERING, POWER ELECTRONICS)

Time: 3hours **Max.Marks:60**

Answer any five questions
All questions carry equal marks

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1. (a) Explain the advantages and disadvantages of
   (i) physical variables
   (ii) phase variables
   (iii) Canonical variables for state –space formulation of control systems.
   (b) Differential equation of dynamic system is given by

$$\ddot{c}_1 + \dot{c}_1 + 3c_1 - 5c_2 = r_1$$
$$\ddot{c}_2 + 2c_1 + c_2 = r_2$$

   write state equation and output equation.

2. (a) Derive the solution of Non-homogeneous state equations.
   (b) Obtain the time response of the system where u(t) is the unit step function occurring at t=0.

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u$$

3. (a) Explain with an example the concept of observability in continuous time invariant system.
   (b) Consider the system given by

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -2 & -4 & -3 \end{bmatrix} \begin{bmatrix} x_1(t) \\ x_2(t) \\ x_3(t) \end{bmatrix} + \begin{bmatrix} 1 & 0 \\ 0 & 1 \\ -1 & 1 \end{bmatrix} u(t); \qquad z(t) = \begin{bmatrix} 0 & 1 & -1 \\ 1 & 2 & 1 \end{bmatrix} \begin{bmatrix} x_1(t) \\ x_2(t) \\ x_3(t) \end{bmatrix}$$

   Check for controllability and observability of the above system.

4. For the system represented by state equation $\dot{X}(t) = AX(t)$ the response is

$X(t) = \begin{bmatrix} e^{-2t} \\ -2e^{-2t} \end{bmatrix}$ when $X(0) = \begin{bmatrix} 1 \\ -2 \end{bmatrix}$; and $X(t) = \begin{bmatrix} e^{-t} \\ -e^{-t} \end{bmatrix}$ when $x(0) = \begin{bmatrix} 1 \\ -1 \end{bmatrix}$

   determine the System matrix A and the state transition matrix.

5. (a) State the Lyapunov theorems?
   (b) Consider a non-linear system described by the equations:

$$\dot{x}_1 = -2x_1 + x_1x_2$$
$$\dot{x}_2 = -x_2 + x_1x_2$$

   Investigate the stability about the equilibrium point $X = \begin{bmatrix} 1 \\ 2 \end{bmatrix}$

Contd…2

6. A linear time invariant system is described by the state equation

$\dot{X}(t) = AX(t) + bu(t)$ where

$A = \begin{bmatrix} 1 & 0 \\ 0 & 0 \end{bmatrix}$; $b = \begin{bmatrix} 1 \\ 1 \end{bmatrix}$ $y(t) = \begin{bmatrix} 2 & -1 \end{bmatrix} X(t)$

Design a state observer that makes the estimation error to decay at least as fast as e^{-10t}.

7. Find the optimal control $u^*(t)$ for the system $\dot{X} = \begin{bmatrix} 0 & 1 \\ -10 & 0 \end{bmatrix} X + \begin{bmatrix} 0 \\ 10 \end{bmatrix} u$ which minimizes the performance index $J = \frac{1}{2}\int_0^2 u^2 dt$ Given $X(0) = \begin{bmatrix} 1 \\ 1 \end{bmatrix}, X(2) = \begin{bmatrix} 0 \\ 0 \end{bmatrix}$

8. (a) What is the variable end point problem? Discuss the generalized boundary condition.

   b) Explain the term-Linear quadratic regulator.

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