C 61456 (Pages : 4) Name..........................

Reg. No.........................

SIXTH SEMESTER B.TECH. (ENGINEERING) DEGREE EXAMINATION

APRIL 2014

(2009 Scheme)

EE/PTEE 09 603—MODERN CONTROL THEORY

(Regular/Supplementary/Improvement)

Time : Three Hours Maximum : 70 Marks

Part A

Answer **all** *the questions.*
Each question carries 2 *marks.*

1. Write the MATLAB commands to enter a transfer function, given the location of poles, zeros and the gain.
2. Write the describing function of a ON-OFF non linearity.
3. How the state controllability differs from the output controllability ?
4. Explain the physical concept behind Lyapunov stability Analysis.
5. Write the reduced Riccatii Equation and explain the tips for the solution of such equations.

($5 \times 2 = 10$ marks)

Part B

Answer any **four** *questions.*
Each question carries 5 *marks.*

6. Explain how the state model can be derived from the transfer function model of a system.
7. Explain how the magnitude and frequency of oscillation of the limit cycle exhibited by a linear system can be determined using Describing function analysis.
8. Explain how the quadratic from can be obtained from the given scalar function. What is the condition for the quadratic form to be positive definite, negative definite and indefinite.
9. Describe the procedure for obtaining a Lyapunov function for a system which describes the stability of the system.
10. What is a minimum time problem. State it and write the mathematical representation explaining the parameters involved in performance index.

11. A system is described by $\dot{X}(t) = \begin{pmatrix} -8 & 6 \\ -6 & 4 \end{pmatrix} X(t) + \begin{pmatrix} 4 \\ -6 \end{pmatrix} u(t),\ y(t) = (1-1)\,X(t)$, check whether the system is observable.

(4 × 5 = 20 marks)

Part C

Answer **four** *full questions.*
Each question carries 10 *marks.*

12. (a) Obtain the state model of the circuit shown in Fig. 1 and represent it using a block diagram.

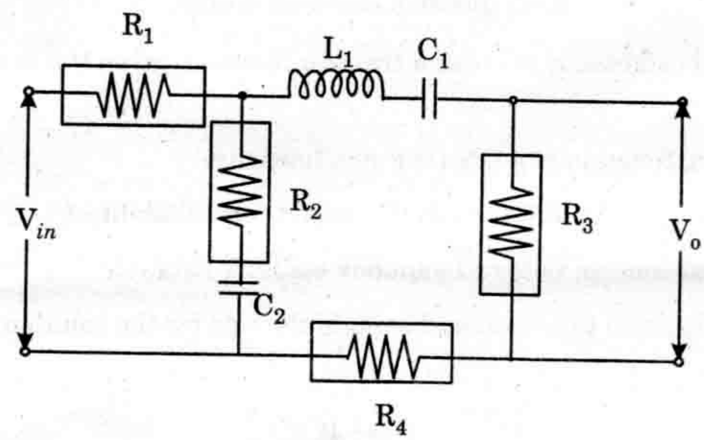

Fig. 1

(10 marks)

Or

(b) Write the Transfer function and state space representation in phase variable form for the system described by $\frac{d^3y}{dt^3} + 9\frac{d^2y}{dt^2} + 23\frac{dy}{dt} + 15\,y = 3u\,(t)$. Find the transformation matrix and get the canonical form of state model.

(10 marks)

13. (a) Investigate the stability of the system shown in Fig. 2 for a input of zero value using phase plane diagram.

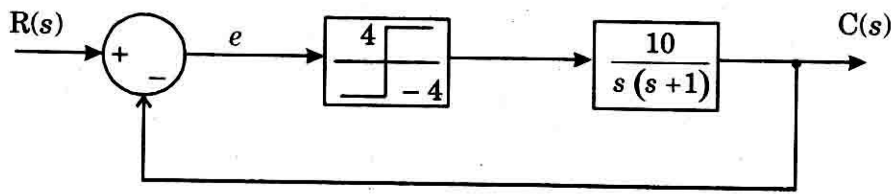

Fig. 2

(10 marks)

Or

(b) Determine the nature of the singular points $x = 0$ with $\dot{x} = 0$ and $x = -2$ with $\dot{x} = 0$ of the system $\ddot{x} + \frac{\dot{x}}{2} - 2x + x^2 = 0$.

(c) A non-linear system with unity feedback has a variable gain having describing function N and $G(s) = \frac{10}{s(s+1)(s+4)}$. If a limit cycle exists for the system, find the frequency of oscillations.

(5 + 5 = 10 marks)

14. (a) Using Lyapunov method or any other method, investigate the stability of the system $\dot{x}_1 = x_2, \dot{x}_2 = -(x_1) - x_1^2 x_2$.

(b) With sketches, explain (i) Stability in the sense of Lyapunov ; (ii) Asymptotic stability ; (iii) Asymptotic stability in the large ; and (iv) Instability of a system.

(6 + 4 = 10 marks)

Or

(c) Investigate the sign definiteness of the matrix, $\begin{pmatrix} 0 & 0 \\ 0 & -1 \end{pmatrix}$.

(d) A linear autonomous system is described by the state equation, $\dot{x} = Ax$ where $A = \begin{pmatrix} -4K & 4K \\ 2K & -6K \end{pmatrix}$. Find the value of K which ensures stability of the system.

(3 + 7 = 10 marks)

15. (a) A linear time-invariant system is represented by the state equation $\dot{x} = \begin{pmatrix} 0 & -1 \\ 1 & 0 \end{pmatrix}\begin{pmatrix} x_1(t) \\ x_2(t) \end{pmatrix} + + \begin{pmatrix} 1 \\ 0 \end{pmatrix} u(t)$. The performance index to be minimized is

$J = \frac{1}{2}\int_0^{\infty}\left[x^T(t)\,Qx(t) + u^T(t)\,Ru(t)\right]dt$ where $Q = \begin{pmatrix} 2 & 0 \\ 0 & 2 \end{pmatrix}$ and R = 1. Determine the optimal control law $u^*(t) = -kx(t)$.

(10 marks)

Or

(b) A first order system is represented by $\dot{x}(t) = x(t) + u(t)$. A feedback controller is to be designed such that $u(t) = -kx(t)$. The desired equilibrium condition is $x(t) = 0$ at $t \to \infty$. The performance index to be minimized is $J = \int_0^{\infty} x^2(t)\,dt$. The initial value of the state variable is $x(0) = \sqrt{2}$. Obtain k.

(10 marks)

[4 × 10 = 40 marks]