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B.Tech IV Year II Semester (R09) Advanced Supplementary Examinations, July 2013 MODERN CONTROL THEORY

(Electrical and Electronics Engineering)

Time: 3 hours

Max. Marks: 70

## Answer any FIVE questions All questions carry equal marks

1 (a) Construct state model and state diagram for the differential equation:

$$\frac{d^3y}{dt^3} + 6\frac{d^2y}{dt^2} + 11\frac{dy}{dt} + 6y + u = 0.$$

- (b) State and prove that the state model is non-unique.
- 2 For the state model:  $\dot{X} = \begin{bmatrix} 0 & 0 & 1 \\ -2 & -3 & 0 \\ 0 & 2 & -3 \end{bmatrix} X + \begin{bmatrix} 0 \\ 2 \\ 0 \end{bmatrix} U$ ;  $Y = \begin{bmatrix} 1 & 0 & 0 \end{bmatrix} X$ , find Jordan canonical form and hence deduce the controllability of the model.
- 3 For the system:  $\dot{X} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 2 & 0 \\ 0 & 0 & 3 \end{bmatrix} X + \begin{bmatrix} 1 & 0 \\ 0 & 1 \\ 1 & 1 \end{bmatrix} U$ , design a linear state variable feedback such that the closed loop poles are located at -1, -2 and -3.
- 4 (a) What is meant by describing function? Explain.
  - (b) Derive the describing function for saturation non-linearity.
- 5 Draw the phase trajectory of the system described by the equation  $\ddot{X} + \dot{X} + X^2 = 0$ . Comment on the stability of the system.
- 6 State and prove the Lyapunov's stability and instability theorems.
- 7 Discuss the following in detail with suitable examples:
  - (a) Minimum energy problem.
  - (b) Minimum time problem.
- 8 For the system  $\dot{x}_1 = x_2 + u_1$ ,  $\dot{x}_2 = u_2$ , find the optimal control u\*(t) for the functional  $J = \frac{1}{2} \int_0^4 (u_1^2 + u_2^2) dt$ . Given  $x_1(0) = x_2(0) = 1$ ;  $x_1(4) = 0$ .

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