USN

NEW SCHEME

Fifth Semester B.E. Degree Examination, July 2006
Electrical and Electronics Engineering
Modern Control Theory

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

Note: *1. Answer any FIVE full questions.*

1 a. Define the concept of i) State ii) State variables iii) State space **(06 Marks)**

b. A temperature control system has the block diagram given in fig.1(b). The input signal is a voltage and represents the desired temperature θ_r. Find the steady-state error of the system when θ_r is a unit step function and i) $D(s)=1$ ii) $D(s)=1+\frac{0.1}{s}$ iii) $D(s)=1+0.3s$. What is the effect of the integral term in the PI controller and the derivative term in PD controller on the steady state error? **(08 Marks)**

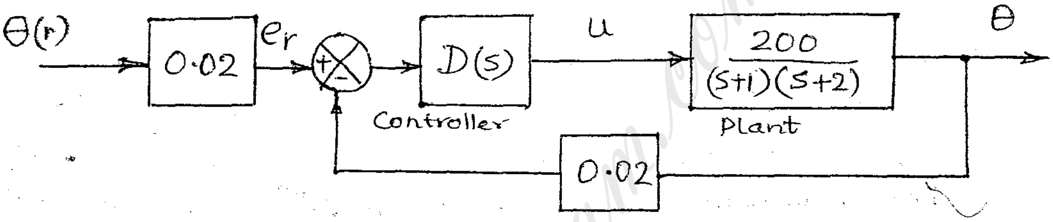

Fig.1(b)

c. Fig.1(c) shows the block diagram of a speed control system with state variable feedback. The drive motor is an armature controlled dc motor with armature resistance R_a, armature inductance L_a, motor torque constant K_T, inertia referred to motor shaft J, viscous friction coefficient referred to the motor shaft B, back emf constant K_b, and tachometer K_t. The applied armature voltage is controlled by a three phase full-converter. e_c is control voltage, e_a is armature voltage, e_r is the reference voltage corresponding to the desired speed. Taking $X_1 = \omega$ (speed) and $X_2 = i_a$ (armature current) as the state variables, $u = e_r$ as the input, and $y = \omega$ as the output, derive a state variable model for the feed back system. **(06 Marks)**

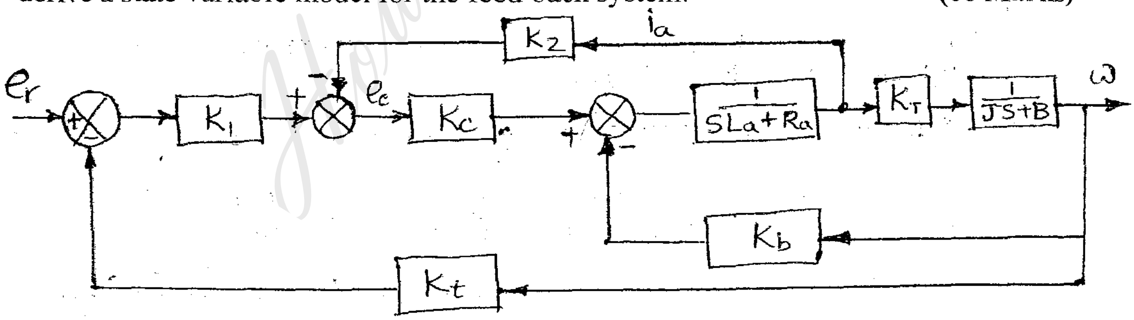

Fig.1(c)

2 a. For the RLC network shown in fig.2(a) write the state model in matrix notation choosing $X_1(t) = V_c(t) + R_i(t)$ and $X_2(t) = V_c(t)$ where $X_1(t)$ and $X_2(t)$ are state variables, $V_c(t)$ is output, V(t) is input. **(08 Marks)**

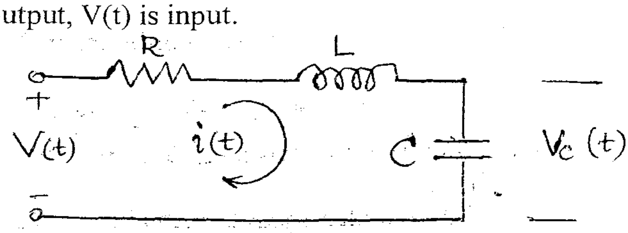

Fig.2(a)

b. For a transfer function given by $G(s) = \dfrac{2}{s^2 + 3s + 2}$ write the state model in
i) Phase variable form ii) Diagonal form. **(08 Marks)**

c. Compare classical control theory against modern control theory. **(04 Marks)**

3 a. State the properties of transition matrix. **(05 Marks)**

b. Given the system $\dot{X} = \begin{bmatrix} -3 & 0 \\ 2 & -1 \end{bmatrix} X + \begin{bmatrix} 3 & 0 \\ 3 & 2 \end{bmatrix} U$. Find the input vector U(t) to give the following time response:

$X_1(t) = 6(1 - e^{-t})$

$X_2(t) = 3e^{-3t} - 2e^{-4t} + 6(1 - e^{-t})$ **(10 Marks)**

c. The vector $\begin{bmatrix} 1 \\ 2 \\ -1 \end{bmatrix}$ is an eigen vector of $A = \begin{bmatrix} -2 & 2 & -3 \\ 2 & 1 & -6 \\ -1 & -2 & 0 \end{bmatrix}$. Find the eigen value of A corresponding to the vector given. **(05 Marks)**

4 a. The following is the state space representation of a linear system whose eigen values are -3, -2, -1.

$$\dot{X} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -6 & -11 & -6 \end{bmatrix} [X] + \begin{bmatrix} 0 \\ 0 \\ 2 \end{bmatrix} u$$

Given that u=0, $X(0) = [001]^T$. Find X(t) **(10 Marks)**

b. Find the transition matrix $\phi(t)$ for a system whose system matrix is given by $A = \begin{bmatrix} -5 & -1 \\ 3 & -1 \end{bmatrix}$ by the following techniques:
i) Laplace transform ii) Infinite series iii) Cayley-Hamliton. **(10 Marks)**

5 a. Define controllability and observability. **(06 Marks)**

b. Show that the characteristic equation and eigen values of a system matrix are invariant under linear transformation. **(08 Marks)**

c. State the properties of Jordan matrix. **(06 Marks)**

6 a. What are inherent nonlinearities? Explain any three of them. **(06 Marks)**

b. Sketch the following nonlinearities :
i) ideal relay ii) relay with dead zone iii) relay with dead zone and hysterisis
iv) relay with hysterisis v) dead zone. **(04 Marks)**

c. A linear second order servo is described by the equation $\ddot{C} + 2\zeta\omega_n \dot{C} + \omega_n^2 C = 0$ where ζ = 0.15, ω_n = 1 rad/sec, C(0) = 1.5 and $\dot{C} = 0$. Determine the singular point. Construct the phase trajectory, using the method of isoclines. **(10 Marks)**

7 a. Consider a linear system described by the transfer function $\dfrac{Y(S)}{U(S)} = \dfrac{10}{S(S+1)(S+2)}$.
Design a feedback controller with a state feedback so that closed loop poles are placed at -2,-1±j1. **(10 Marks)**

b. Consider the system described by the state model $\dot{X} = AX$; Y = CX where $A = \begin{bmatrix} -1 & 1 \\ 1 & -2 \end{bmatrix}$; C = [1 0]. Design a full – order state observer. The desired eigen values for the observer matrix are $\mu_1 = -5$; $\mu_2 = -5$. **(10 Marks)**

8 a. State and explain Liapunov theorems on i) asymptotic stability ii) global asymptotic stability iii) instability. **(10 Marks)**

b. Define singular point on a phase plane. Explain different types of singular points. **(10 Marks)**

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