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)**

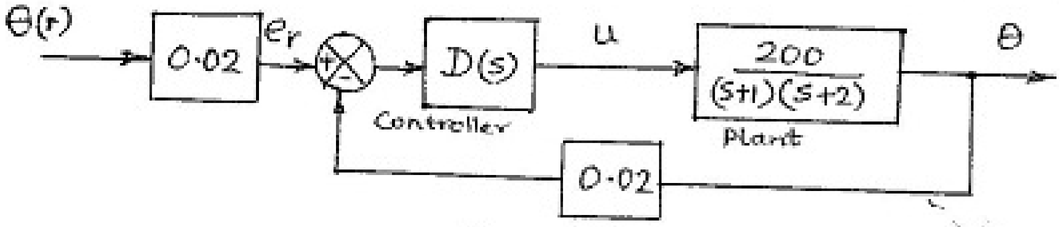

Fig.1(b)

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)**

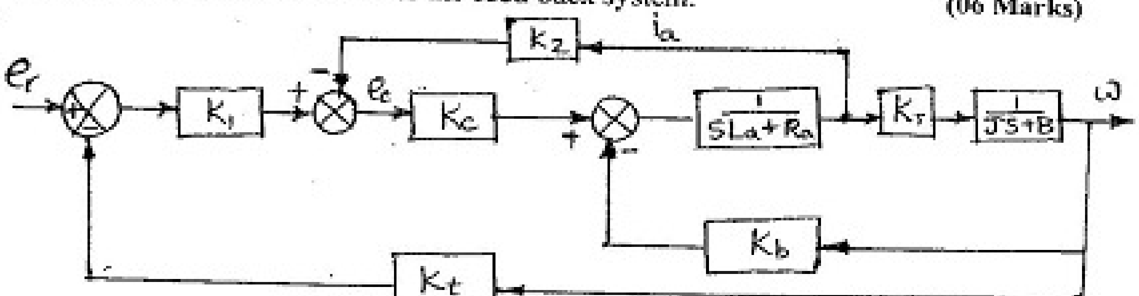

Fig.1(c)

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)**

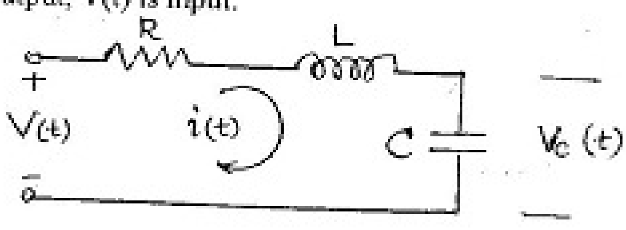

Fig.2(a)

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b. For a transfer function given by $G(s)=\frac{2}{s^2+3s+2}$ 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:

$X_1(t)=6(1-e^{-t})$ (10 Marks)

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

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 $\ddot{C}+2\zeta\omega_n\dot{C}+\omega_n^2C=0$ 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 $\frac{Y(S)}{U(S)}=\frac{10}{S(S+1)(S+2)}$.

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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