EE51 USN 2002 SCHEME EE52

Fifth Semester B.E. Degree Examination, Dec.08 / Jan.09
Modern Control Theory

Time: 3 hrs. Max. Marks:100

Note : *Answer any FIVE full questions.*

1 a. What is a controller? Discuss the performance features of P, PI and PID controllers used in control system. **(10 Marks)**

b. Figure Q1 (b) shows a position control system with PMDC motor. The motor moment of Inertia is J, kg m^2, friction coefficient is B, N-m/rad/sec. The motor inductance is L_a and resistance R_a respectively. Model the system in state space choosing appropriate state variables. Use ja(t), ω(t), sθ(t) as state variables with $x_1(t)$, $x_2(t)$, $x_3(t)$ respectively. **(10 Marks)**

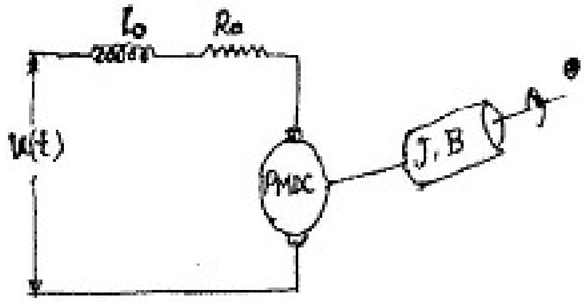

Fig. Q1 (b)

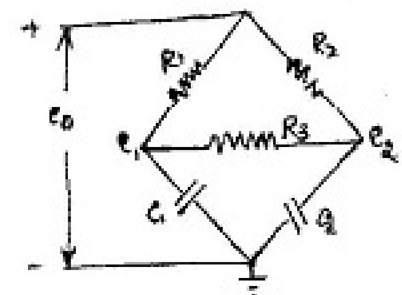

Fig. Q4 (a)

2 a. Obtain the state model in phase variable form, Given $\frac{Y(s)}{R(s)} = \frac{s(s+2)(s+3)}{(s+1)^2(s+4)}$. **(06 Marks)**

b. Obtain the state model in Jordan Canonical form, Given $\frac{Y(s)}{R(s)} = \frac{s(s+2)(s+3)}{(s+1)^2(s+4)}$. **(06 Marks)**

c. For a state model $\dot{x} = Ax$, show that $e^{At} = L^{-1}[SI - A]^{-1}$ and there by find the solution for a state equation $\dot{x} = Ax + Bu$. **(08 Marks)**

3 a. For the state model, $\dot{x} = \begin{bmatrix} 0 & 1 \\ -1 & 0 \end{bmatrix} x + \begin{bmatrix} 1 \\ 1 \end{bmatrix} u$, show that $e^{At} = \begin{bmatrix} \cos t & \sin t \\ -\sin t & \cos t \end{bmatrix}$, using Cayley Hamilton theorem. **(08 Marks)**

b. Given the state model, $\dot{x} = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix} x + \begin{bmatrix} 0 \\ 2 \end{bmatrix} u$, $y = \begin{bmatrix} 1 & 0 \end{bmatrix} x$, where u(t) is unit step occurring at t = 0 and $x^T(0) = \begin{bmatrix} 0 & 1 \end{bmatrix}$. Diagonalize A matrix and thereby find y(t). **(12 Marks)**

4 a. Circuit in Figure Q4 (a) shows an electrical bridge network. Determine the controllability of the bridge under balanced condition. Condition for balance is $R_1C_1 = R_2C_2$. **(10 Marks)**

b. Define observability of a system. Also prove that for a system $\left.\begin{matrix} \dot{x} = Ax \\ y = Cx \end{matrix}\right\}$ to be completely observable the rank of the matrix $\begin{bmatrix} C \\ CA \\ \cdot \\ CA^{n-1} \end{bmatrix}$ is n. **(10 Marks)**

5 a. A system has transfer function,

$$\frac{Y(s)}{U(s)} = \frac{1}{s(s+1)(s+2)}$$

Determine the feedback matrix such that the closed loop poles are moved to $s = -2 \pm j2\sqrt{3}$ and $s = -10$. Also write the block diagram of the feedback system. **(14 Marks)**

b. What is an observer? Mention the difference between full order observer and reduced order observer. Write the block diagram of full order observer. **(06 Marks)**

6 a. Obtain the observer gain matrix for the system,

$$\dot{x} = \begin{bmatrix} 0 & 0 & -6 \\ 1 & 0 & -11 \\ 0 & 1 & -6 \end{bmatrix} x + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} u$$

$y = \begin{bmatrix} 0 & 0 & 1 \end{bmatrix} x$, such that the observer closed loop poles are to be located at $-2 \pm j\sqrt{12}$ and -5. **(10 Marks)**

b. Explain about saturation, friction, backlash and relay non-linearities occurring in a physical system. **(10 Marks)**

7 a. Draw the phase plane trajectory using isocline method, given $\ddot{x} + \dot{x} + x = 0$ and $x(0) = 0$; $\dot{x}(0) = 6$ **(12 Marks)**

b. What are singular points in a system? Determine the singular points in the system.

i) $\ddot{x} + 0.5\dot{x} + 2x + x^2 = 0$

ii) $\dot{x} + 0.5\dot{x} + 2x = 0$ **(08 Marks)**

8 a. With reference to a non-linear system, explain jump resonance with a suitable example. **(06 Marks)**

b. Define i) stability ii) asymptotic stability iii) asymptotic stability in the large. **(06 Marks)**

c. Determine the energy function for the system and check the stability of the system given in figure Q8 (c). Assume linear spring at origin. **(08 Marks)**

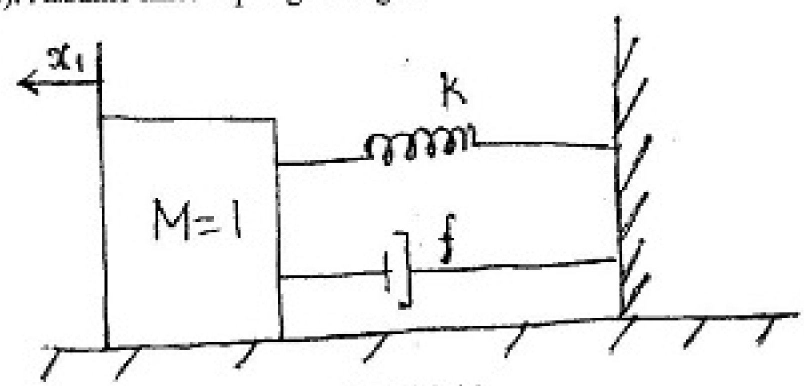

Fig. Q8 (c)