06ES43

USN

Fourth Semester B.E. Degree Examination, December 2010
Control Systems

Time: 3 hrs. Max. Marks:100

Note: 1. *Answer any FIVE full questions, selecting at least TWO questions from each part.*
2. *Standard notations are used.*
3. *Missing data, if any, may be suitably assumed.*

PART – A

1 a. Define and compare open loop control systems with closed loop control systems, with examples. **(06 Marks)**

b. For the mechanical system shown in Fig.Q1(b), write the differential equation relating to the position y(t) and the force f(t). **(04 Marks)**

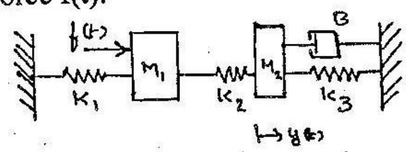

Fig.Q1(b)

c. Derive the electrical analogous quantities for the mechanical quantities using Force-voltage analogg. **(05 Marks)**

d. Derive the mathematical model for an armature controlled DC motor. **(05 Marks)**

2 a. Define the transfer function. Explain Mason's gain formula for determining the transfer function from signal flow graphs. **(06 Marks)**

b. For the block diagram shown in Fig. Q2(b), determine the transfer function $\frac{Q_2(s)}{Q(s)}$ using block diagram reduction algebra. **(08 Marks)**

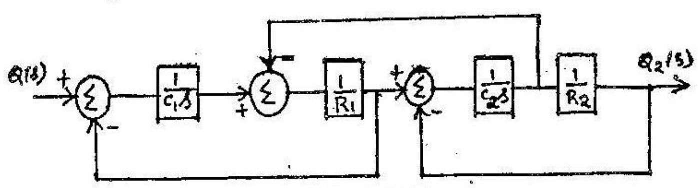

Fig.Q2(b)

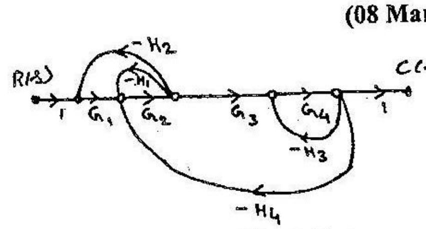

Fig.Q2(c)

c. For the system described by the signal flow graph shown in Fig.Q2(c), obtain the closed loop transfer function $\frac{C(s)}{R(s)}$, using Mason's gain formula. **(06 Marks)**

3 a. Define the following for an underdamped second order system :
i) Rise time ii) Peak overshoot iii) Settling time. **(06 Marks)**

b. Define the steady state error coefficients. Consider a unity feedback control system whose open loop transfer function is $G(s) = \frac{100}{s(0.1s+1)}$. Determine the steady state error, when the input is $r(t) = 1 + t + at^2$; $a \geq 0$. **(06 Marks)**

c. The forward path transfer function of a certain unity negative feedback control system is G(s). The system is subjected to unit step input. From the transient response curves, it is observed that the system peak overshoot is 15% and the time at which it occurs is 1.8 secs. Determine the closed loop transfer function of the system. **(08 Marks)**

4 a. Define absolute stability and marginal stability. **(04 Marks)**

b. The open loop transfer function of a unity negative feedback control system is given by :

$$G(s) = \frac{K(s+2)}{s(s+1)(s+3)(s+5)}.$$

Determine the value of K at which the system is just stable. **(08 Marks)**

c. A unity feedback control system has:

$$G(s) = \frac{20K}{s[(s+1)(s+5)+20]}, \qquad \text{where} \quad r(t) = 2t$$

It is desired that for ramp input $l(t)_{ss} \leq 1.5$. What minimum value must K have for this condition to be satisfied? With this K, is the system stable? **(08 Marks)**

PART – B

5 a. Define and explain the significance of angle and magnitude condition, as applied to the root locus method of stability analysis of linear system. **(06 Marks)**

b. Define brake away / in point on a root locus. Explain any one method of determining the same. **(06 Marks)**

c. For the following characteristic polynomial $s^2 + 2s + 2 + K(s+1) = 0$, draw the root locus for $0 \leq K \leq \infty$. **(08 Marks)**

6 a. Explain Nyquist's stability criterion. **(04 Marks)**

b. The open loop transfer function of a unity negative feedback system is given by:

$$G(s) = \frac{K(s+3)}{s(s^2+2s+2)}.$$

Using the Nyquist criteria, find the value of K for which the closed loop system is just stable. **(08 Marks)**

c. Derive an expression for the resonant frequency and resonant peak for a closed loop system having a second order transfer function. **(08 Marks)**

7 a. For the system having open loop transfer function given by :

$$G(s) = \frac{10(1+0.125s)}{s(1+0.5s)(1+0.25s)}$$

Draw the asymptotic Bode magnitude and phase plots. Also determine the phase and gain crossover frequencies and gain and phase margins. Comment on closed loop stability. **(12 Marks)**

b. For the Bode plot shown, evaluate the transfer function. Refer Fig.Q7(b). **(08 Marks)**

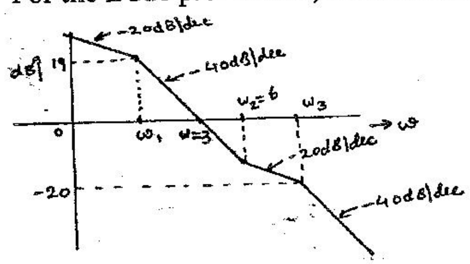

Fig.Q7(b)

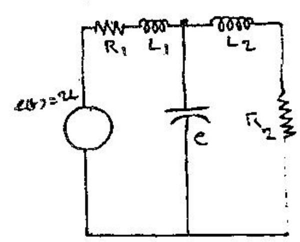

Fig.Q8(a)

8 a. Obtain the state and output equation for the electrical network shown in Fig.Q8(a). **(08 Marks)**

b. The state model of the system is given by :

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ -3 & -4 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u(t), \quad \begin{bmatrix} x_1(0) \\ x_2(2) \end{bmatrix} = \begin{bmatrix} 0 \\ 1 \end{bmatrix} \quad \text{where} \quad \begin{aligned} u(t) &= 0 \quad \text{for } t < 0 \\ &= e^{-t} \quad \text{for } t \geq 0 \end{aligned}$$

Obtain the response of the system. **(12 Marks)**

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