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BT–6 / M–15

CONTROL SYSTEM ENGINEERING

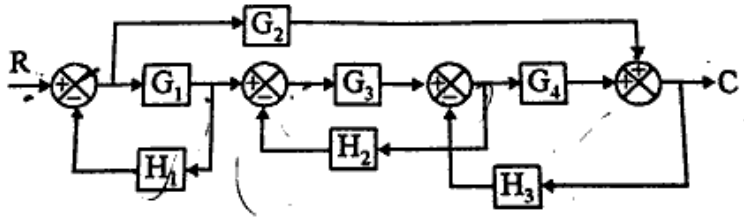
Paper–ECE–302E, Opt. (I)

Time allowed : 3 hours] *[Maximum marks : 100*

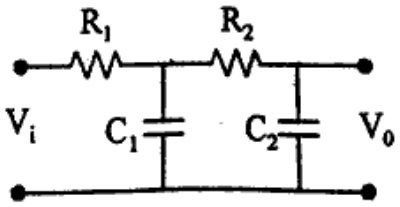
Note : Attempt five questions in all by selecting at least one question from each section.

Section–I

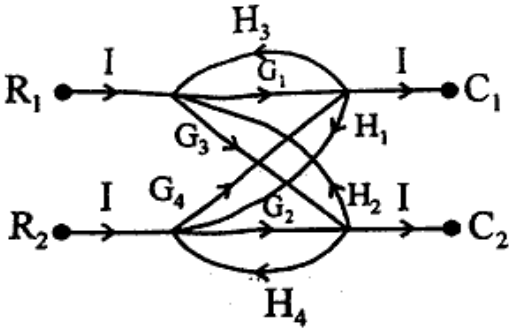
1. (a) Obtain the overall transfer function for the block diagram given below by using block diagram reduction techniques. 10



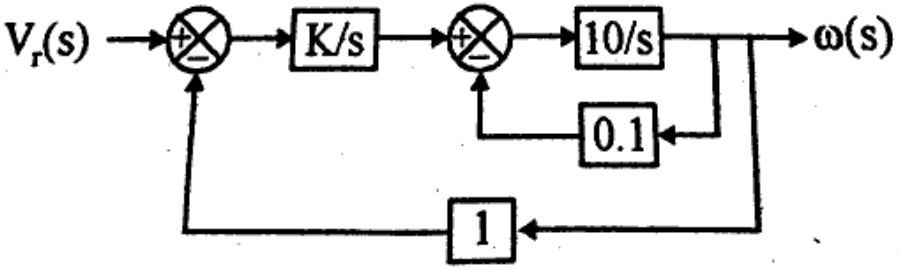
(b) Draw the block diagram and signal flow graph and find out the transfer function of the circuit shown below ? 10



2. (a) For the signal flow graph of a system given below find expressions for outputs C_1 and C_2. Also determine the condition that makes C_1 independent of R_2 and C_2 independent of R_1 ? 10



(b) Consider the speed control system shown below wherein the inner loop corresponds to motor back emf. The controller is an integrator with gain K observe that the load is inertia only ? 10



(i) Determine the value of K for which steady state error to unit ramp input is less than 0.01 rad/sec.

(ii) For the value of K found in part (i) determine the sensitivity $\left(S_K^T\right)$ w.r.t. K and what will be the limiting value of $\left(S_K^T\right)$ w.r.t. K at low frequencies ?

Section–II

3. (a) The open loop transfer function of a system is $G(s) = \dfrac{50}{s^2(s^2+4s+200)}$ and its feedback with a transfer function of $H(s) = 0.6s$. Determine (i) Position, velocity and acceleration coefficient and (ii) steady state error for the system when system is subjected to an input $r(t) = 1 + t + t^2/2$ using generalized error series ? 10

(b) The open loop transfer function of a unity feedback control system is given by $G(s) = \dfrac{25}{s(s+2)}$.

Calculate :

(i) The natural frequency of oscillations, damped frequency, damping factor, and maximum overshoot of unit step input. 4+2+4=10

(ii) The steady state error for a unit ramp input.

(iii) Maximum overshoot and tachometer constant if damping ratio is to be made 0.75 using tachometer feedback.

4. (a) For the following characteristic equation, find the number of roots which lie in the right half and left half of s-plane : $s^6 + s^5 - 2s^4 - 3s^3 - 7s^2 - 4s - 4 = 0$ using Routh array and comment on the stability of the system. 10

(b) Sketch the root locus from the open loop transfer function of a unity feedback system given below and determine the value of K for which all the roots are equal. What is the value of these roots ?

$$G(s) = \frac{K(s+4/3)}{s^2(s+12)}$$ 10

Section–III

5. (a) Derive expression for correlation between time and frequency response for a second order system. 10

(b) The open loop transfer function of a unity feedback control system is given as :

$$G(s) = \frac{K(s+10)(s+40)}{s(s+1)(s+4)}$$

Apply **Nyquist Plot** method to examine the closed loop stability for (i) K = 0.1 and (ii) K = 1. 10

6. (a) The open loop transfer function of a system is given by $G(s)\,H(s) = \frac{0.75(1+0.2s)}{s(1+0.5s)(1+0.1s)}$. Draw the **Bode Plot** for the system and determine the frequency domain specifications and hence the stability. 10

(b) The open loop transfer function of a unity feedback system is given by $G(s)\,H(s) = \frac{1}{s(s+1)^2}$. Sketch the **Polar Plot** for the system and determine the gain and phase margin of the system. 10

Section–IV

7. Consider a unity feedback uncompensated system with the open loop transfer function as

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

Design a lag-lead compensator for the system such that the compensated system has static velocity error constant $K_v = 10\ sec^{-1}$, gain margin $(g_m) \geq 10$ dB and phase margin = 50°. 20

8. (a) Write the properties of State Transition Matrix and Derive solution for Non-homogeneous type state equation for continuous time systems. 10

(b) Find the state equation and output equation for the system given by $\frac{S^3+5S^2+6S+1}{S^3+4S^2+3S+3}$? 5

(7)

(c) Obtain the transfer function of the system defined by the following state space equations : 5

$$\begin{bmatrix} x(t)_1 \\ x(t)_2 \\ x(t)_3 \end{bmatrix} = \begin{bmatrix} -1 & 1 & -1 \\ 0 & -2 & 1 \\ 0 & 0 & -3 \end{bmatrix} \begin{bmatrix} x(t)_1 \\ x(t)_2 \\ x(t)_3 \end{bmatrix} + \begin{bmatrix} 1 & 0 \\ 0 & 1 \\ 1 & 0 \end{bmatrix} \begin{bmatrix} u(t)_1 \\ u(t)_2 \end{bmatrix}$$