Code : 100502

B.Tech 5th Semester Exam., 2020
(New Course)

CONTROL SYSTEMS

Time : 3 hours *Full Marks* : 70

Instructions :

(i) The marks are indicated in the right-hand margin.

(ii) There are ***NINE*** *questions in this paper.*

(iii) Attempt ***FIVE*** *questions in all.*

(iv) Question No. 1 is compulsory.

1. Answer any *seven* of the following questions : 2×7=14

   (a) Define tracking control using an example.

   (b) Define transfer function and relate impulse response with transfer function.

   (c) Define underdamped, overdamped and critically damped systems.

   (d) Find sensitivity of overall transfer function with respect to forward path transfer function.

   (e) Define and find the slope of Bode plot in case of complex poles.

(Turn Over)

   (f) Find sensitivity of overall transfer function with respect to feedback path transfer function.

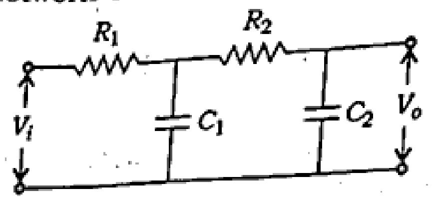
   (g) Explain absolute and relative stability and name two methods for each.

   (h) Define similarity transformation. Why is it used?

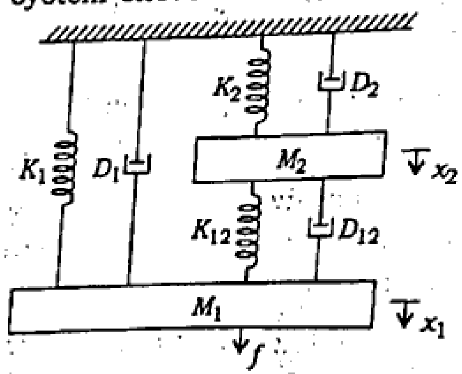
   (i) What is state transition matrix? Explain its significance.

   (j) Define phase-plane technique.

2. *(a)* Derive the transfer function of the network shown below :



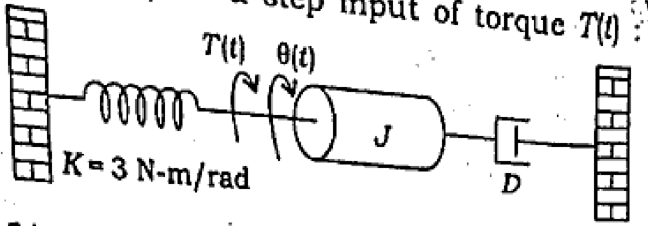
   (b) Find the modelling equations of the system shown below :



   (c) Explain Mason's gain formula. 5+5+4=14

(Continued)

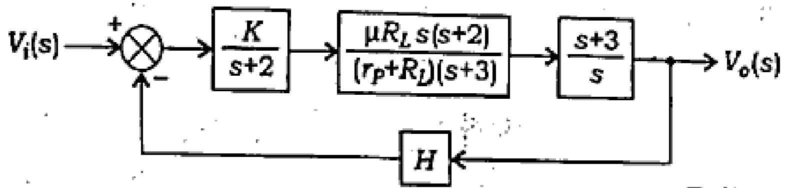
3. (a) Derive peak-time. Find J and D for the system shown in the figure given below to yield 25% peak overshoot and a settling time of 2·2 seconds (for 2% error band) for a step input of torque $T(t)$:



(b) Consider the figure given below with $R_L = 10\ k\Omega$, $r_p = 4\ k\Omega$ and find—

(i) the value of K for 4% overall system sensitivity due to variation of μ with $H = 0 \cdot 3$, $\mu = 12$;

(ii) the value of K for 3% overall system sensitivity due to variation of H with $H = 0 \cdot 25$, $\mu = 18$.



7+7=14

4. (a) A unity feedback servo driven instrument has open-loop transfer function $G(s) = \frac{10}{s(s+2)}$, find the following :

(i) The time domain response for a unit step input

(ii) The natural frequency of oscillation

(iii) Maximum overshoot and peak time

(iv) Steady-state error to an input $1 + 4t$

(b) Using generalized error series, calculate the steady-state error of a unity feedback system having $G(s) = \frac{15}{s(s+5)}$ for the following excitations :

(i) $r(t) = 4$

(ii) $r(t) = 4t + 5$

(iii) $r(t) = t^2/3 + 9$

(iv) $r(t) = 1 + 8t + 5t^2/2$ 7+7=14

5. (a) Consider a unity feedback system with forward path transfer function

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

having the oscillation of 2·5 rad/sec. Determine the values of $K_{marginal}$ and p. There are no poles in RHP.

(b) Draw root locus for the system having $G(s) = \frac{K}{s(s+2)(s+3)}$ and find the gain K for damping ratio $\xi = 0 \cdot 341$. 7+7=14

6. (a) For

$$G(s)H(s) = \frac{K}{s(s+1)(s+5)}$$

draw the Nyquist plot and hence calculate the range of values of K for stability.

(b) Draw Bode plot for the transfer function

$$G(s) = \frac{49(1+0\cdot 8s)}{s^2(1+0\cdot 05s)(1+0\cdot 01s)}$$

and from Bode plot, determine—

(i) phase crossover frequency;

(ii) gain crossover frequency;

(iii) gain margin;

(iv) phase margin. 7+7=14

7. (a) The open-loop transfer function with unity feedback is given by $G(s) = \frac{K}{s(1+s)(4+s)}$. Design a suitable lead-lag compensator to achieve the following :

Static velocity error constant $= 20\,s^{-1}$, phase margin = 50°, gain margin ≥ 15 dB.

(b) Find K and a for a feedback system with forward path transfer function $G(s) = \frac{K}{s(s+a)}$ so that resonant peak is 2·8 and resonant frequency is 25 rad/s. Also determine the settling time and bandwidth of the system. 7+7=14

8. (a) Find the transfer function of the given state-space model

$$\dot{x} = \begin{bmatrix} -2 & 0 & 1 \\ 1 & -2 & 0 \\ 1 & 1 & -1 \end{bmatrix} x + \begin{bmatrix} 1 & 0 \\ 0 & 1 \\ 1 & 0 \end{bmatrix} u, \quad y = \begin{bmatrix} 2 & 1 & -1 \\ 0 & 1 & 0 \end{bmatrix} x$$

(b) Consider the state-space model of an LTI system with matrices

$$A = \begin{bmatrix} 0 & 1 \\ -6 & -5 \end{bmatrix}, \quad B = \begin{bmatrix} 0 \\ 8 \end{bmatrix}$$

Find the state transition matrix.

(c) Consider the LTI system

$$\dot{x} = \begin{bmatrix} 0 & 1 \\ -5 & -9 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u$$

Find the non-homogeneous solution if $x_1(0) = 4$, $x_2(0) = 0$ and u is a unit step function. 5+5+4=14

9. (a) Define an optimal control problem. Describe performance index for each case.

(b) Explain the concept of absolute stability in non-linear system. Also state and explain the Popov criterion of stability.

(c) Derive the describing function of saturation non-linearity. 5+5+4=14

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