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BT6/M11 8614

Control System Engineering

Paper : ECE-302E, Option : I

Time : Three Hours] [Maximum Marks : 100

Note :— Answer any FIVE questions, selecting at least ONE question from each section.

SECTION—I

1. (a) Explain in brief working of a stepper motor and derive a suitable mathematical model for it. 6

   (b) Define parameter sensitivity and exp ain effect of feedback on it. 4

   (c) For the mechanical system shown in Fig. 1, write equations of motion. Determine $X_1(s)/F(s)$ and $X_2(s)/F(s)$ and draw electrical analog circuit. 10

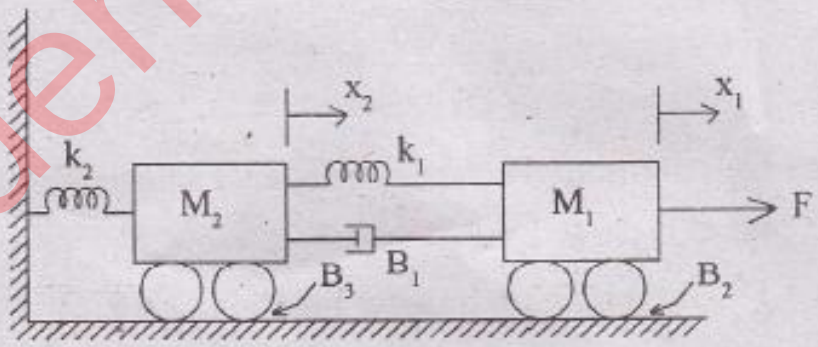

Fig. 1

2. (a) Explain the following terms with reference to signal flow graph : (i) Node, (ii) Path, (iii) Loop, (iv) Transmitter. 8

(b) Fig. 2 is a signal flow graph of a closed loop control system :

(i) Determine C(s)/R(s).

(ii) If the branch K were made zero, the same transfer function could be still obtained by appropriately modifying G(s) branch. Determine the required modified G(s). 12

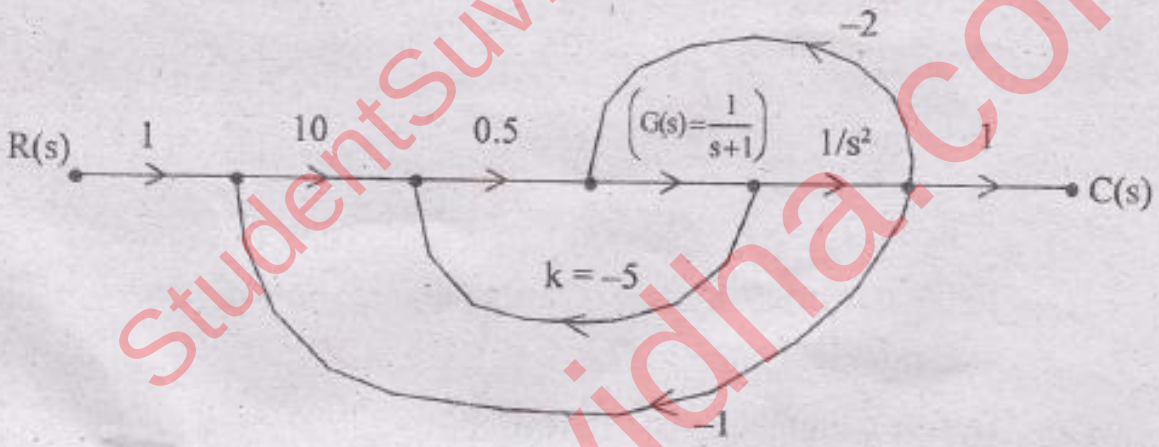

Fig. 2

SECTION—II

3. (a) Distinguish between 'order' and 'type' of the system. 4

(b) The loop transfer function of a closed loop system is given by :

$$G(s)\,H(s)=\frac{20}{s(1+2s)}.$$

Determine static error coefficients and steady state error when input is r(t) = 1 + 3t. 8

(c) The forward path transfer function of a unity feedback control system is :

$$G(s)=\left(100+\frac{k}{s}\right)\left(\frac{1}{2s(2s+1)}\right).$$

Determine the range of values k over which the system will remain stable. 8

4. (a) Explain time domain specifications of a second order system. Determine these quantities for a second order system characterized by transfer function :

$$\frac{C(s)}{R(s)} = \frac{40,000}{s^2 + 48.5s + 40,000}.$$ 10

(b) Sketch root locus of the system having $G(s) = \frac{k}{s(s+1)}$ and

$H(s) = \frac{s+3}{s+2}$ for $k \geq 0$. 10

SECTION—III

5. The open loop transfer function of a unity feedback control system is :

$$G(s) = \frac{k}{s(1+0.2s)(1+0.02s)}.$$

Sketch Bode plot for $k = 1$ and determine the gain margin, gain cross over frequency, phase margin and phase cross over frequency. Comment on effect of increasing k on the stability of the system. 20

6. (a) Explain correlation between time domain and frequency domain responses. 8

(b) The open loop transfer function of a unity feedback system is given by $G(s) = \frac{k}{s(s+a)}$. Discuss stability of the system for $k = 10$ and $a = 2$ using Nyquist plot. Comment on stability as k and a are varied. 12

SECTION—IV

7. (a) Explain the concept of 'state' and 'state variables'. 4

(b) Given the state equation :

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u$$

determine the state transition matrix. 8

(c) The transfer function of a control system is given by :

$$\frac{Y(s)}{U(s)} = \frac{4s+3}{s^2+5s+10}$$

Find a state model for the system using decomposition technique. 8