

Total number of printed pages-7

53 (IE 503) CNSY-I

2014

CONTROL SYSTEM-I

Paper : IE 503

Full Marks : 100

Time : Three hours

The figures in the margin indicate full marks for the questions.

Answer any five questions out of seven.

1. (a) Obtain the differential equations governing the behaviour of the mechanical system shown in Fig.(1.a). Also obtain the analogous electrical circuits based on :
- (i) force - current analogy
 - (ii) force - voltage analogy 2+2+2

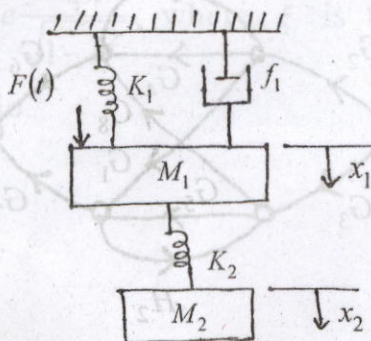


Fig.(1.a)

Contd.

- (b) Simplify the block diagram shown in Fig.(1.b). Obtain the closed-loop transfer function $C(S)/R(S)$ using block diagram algebra. 7

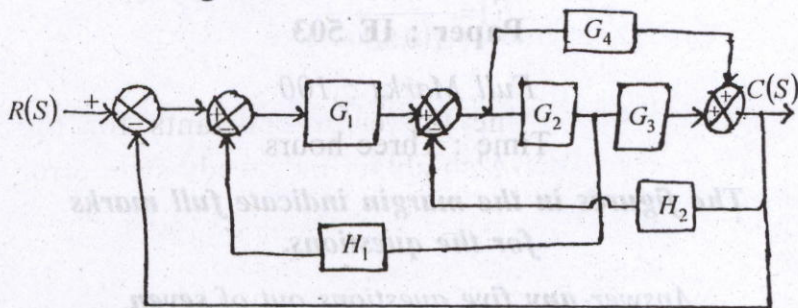


Fig.(1.b)

- (c) Obtain the overall transfer function C/R from the signal flow graph shown in Fig. (1.c). 7

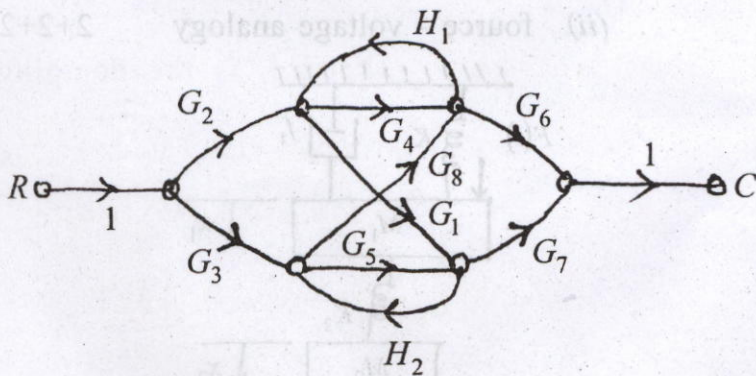


Fig.(1.c)

2. (a) A unity feedback system is characterised by an open loop transfer function

$$G(S) = \frac{40}{S(0.5S + 1)}$$

Determine the error constants for the system. Also obtain the steady-state error when the input is $r(t) = 1 + 5t + 10t^2$. 5

- (b) Derive the unit step response to a typical second order feedback control system. 5

- (c) Prove the maximum overshoot for the unit step response for the second order system

is $e^{-\frac{\xi\pi}{\sqrt{1-\xi^2}}}$, where ξ is the damping ratio. 5

- (d) The open loop transfer function of a unity feedback control system is given by

$$\frac{K}{S(S+3)(S^2+S+1)}$$

By applying Routh criterion, discuss the stability of the closed loop system as a function of K . Determine the value of K which will cause sustained oscillations in the closed loop system. What are the corresponding oscillation frequency ? 5

3. (a) The open-loop transfer function of a unity feedback system is given by

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

where K and T are positive constant. By what factor should the amplifier gain be reduced so that the peak overshoot of unit-step response of the system is reduced from 75% to 25% ? 5

- (b) A unity feedback control system has an open-loop transfer function

$$G(S) = \frac{K}{S(S^2 + 4S + 13)}$$

Sketch the root locus plot of the system by determining the following :

- (i) Centroid, number and angle of asymptotes.
- (ii) Angle of departure of root loci from the poles.
- (iii) Break away point if any.
- (iv) The value of K and the frequency at which the root loci cross the $j\omega$ -axis.

15

4. Sketch the Bode plot showing the magnitude (dB) and phase angle (degree) as a function of log frequency for the transfer function

$$G(S) = \frac{10}{S(1 + 0.5S)(1 + 0.01S)}$$

Determine the gain crossover frequency, phase crossover frequency, gain margin and phase margin.

20

5. Sketch the Nyquist plot having the open loop transfer function of a unity feedback control system as

$$G(s) = \frac{K}{s(s+1)^2} \text{ and determine} \quad 20$$

- (i) The limiting value of K for closed loop stability.
(ii) The gain and phase margin for $K=0.5$.

6. (a) What is the difference between the polar plot and Nyquist plot ?

With an example explain which technique is best for stability checking. 5

- (b) Sketch the polar plot of the system

$$G(s) = \frac{1}{s(1+s)(1+2s)} \quad 10$$

- (c) State and prove the Nyquist stability criterion. 5

7. Write short notes on : *(any four)*

4×5

- (a) The P-I-D control effect
- (b) Armature control PMDC motor
- (c) Synchro error detector
- (d) Brushless DC motor
- (e) BIBO stability.

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