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**G 1230**

B.E./B.Tech. DEGREE EXAMINATION, MAY/JUNE 2009.

Fourth Semester

Electrical and Electronics Engineering

EE 235 — CONTROL SYSTEMS

(Common to B.E. Mechatronics Engineering)

Time : Three hours

Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. Why is negative feedback invariably preferred in a closed loop system?
2. State Mason's gain formula.
3. A second order system has a closed loop transfer function  $C(s)/R(s) = 200/(s^2 + 20s + 200)$ . Determine the damping ratio and natural frequency of oscillation.
4. What is meant by dominant poles?
5. Define gain margin and phase margin.
6. Draw the polar plot for a type 0, first order system.
7. What is minimum-phase system and all-pass system?
8. Examine the stability of  $s^3 + 5s^2 + 10s + 3 = 0$  using Routh's method.
9. To increase the damping of a heavily under damped system, what type of compensator must be used?
10. Draw the block diagram representation of a control system with compensators for (a) cascade compensation and (b) feedback compensation.

PART B — (5 × 16 = 80 marks)

11. (a) (i) Determine the closed-loop transfer function  $C/R$  of the block diagram shown in Fig. 1, using block diagram reduction techniques. (8)

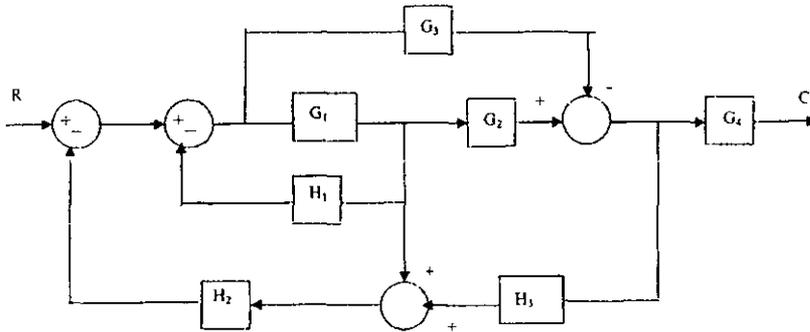


Fig. 1

- (ii) Obtain the state model of the electrical network shown in Fig. 2. (8)

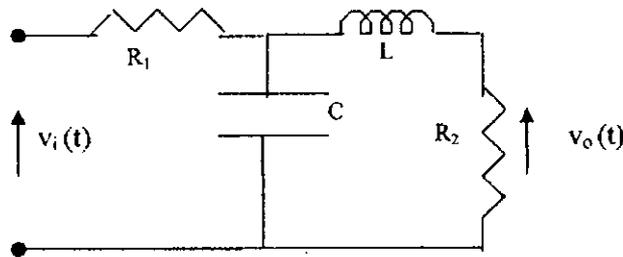


Fig. 2

Or

- (b) (i) Using Mason's gain formula, obtain the overall transfer function of the signal flow graph shown in Fig. 3. (8)

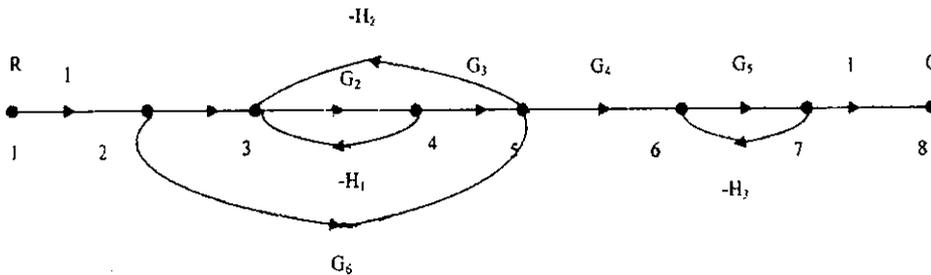


Fig. 3

- (ii) Derive the transfer function of a field controlled DC motor and comment on its stability. (8)

12. (a) (i) A unity feedback control system has an open-loop transfer function  $G(s) = 10/s(s + 2)$ . Find the rise time, peak overshoot, peak time, and settling time for a step input of 12 units. (8)
- (ii) A unity feedback system is characterized by the open-loop transfer function (8)

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

Find static error constants and steady-state error when the input is

$$R(s) = \frac{3}{s} - \frac{2}{s^2} + \frac{1}{3s^3}$$

Or

- (b) Sketch the root-locus of a unity feedback control system having an open-loop transfer function

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

Determine the value of K and the frequency at which the system exhibits sustained oscillations. (16)

13. (a) The open-loop transfer function of a unity feedback system is

$$G(s) = \frac{K}{s(0.02s+1)(0.04s+1)}$$

If the gain K produces a phase margin of  $45^\circ$ , find K and the corresponding gain margin. (16)

Or

- (b) (i) Derive an expression to relate the damping factor and the bandwidth of a second order system. (6)
- (ii) Explain how closed loop frequency response is determined from open loop frequency response using M and N circles. (10)
14. (a) (i) The characteristic equation of a feedback control system is given by

$$s^4 + s^3 + 3Ks^2 + (K+2)s + 4 = 0. \quad (8)$$

Determine the range of values of K, for which the system is stable.

- (ii) A feedback control system is shown in fig. 4. The process transfer function is (8)

$$G(s) = \frac{K(s+40)}{s(s+10)} \text{ and the sensor transfer function is}$$

$$H(s) = \frac{1}{(s+20)}$$

- (1) Find the gain  $K$  that result in marginal stability. Determine the frequency of oscillation.
- (2) Reduce the gain to half the value found in (1) and study the relative stability of the system.

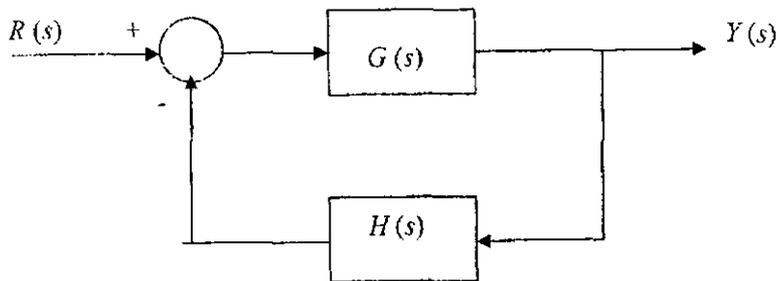


Fig. 4

Or

- (b) For  $G(s)H(s) = \frac{12}{s(s+1)(s+2)}$  draw the Nyquist plot and decide stability. (16)

15. (a) A unity feedback system is characterized by the open-loop transfer function. (16)

$$G(s) = \frac{K}{s(s+3)(s+4)}$$

- (i) Determine the value of  $K$  if 20% peak overshoot to unit step input is desired.
- (ii) For the above value of  $K$  determine the system  $K_v$  (velocity error constant) and settling time.
- (iii) Design a compensator that will give approximately 15 % overshoot to unit step input, while settling time is decreased by a factor of 2.5. What is the  $K_v$  of the compensated system?
- (iv) For the compensated system as in part (iii), it is desired to have  $K_v \geq 20$ . Design a compensator to meet both the specifications.

Or

- (b) A unity feedback system is characterized by the open-loop transfer function  $G(s) = \frac{1}{s^2}$ .

Design a suitable compensating network such that a phase margin of  $45^\circ$  is achieved without sacrificing system velocity error constant. Sketch the Bode plot of the uncompensated and compensated systems. (16)