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Code : 031712

B.Tech 7th Semester Exam., 2018

LINEAR CONTROL THEORY

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. Choose the correct answer (any *seven*) : 2×7=14

(a) In a closed-loop control system

(i) control action is independent of output

(ii) output is independent of input

(iii) there is no feedback

(iv) control action is dependent on output

(b) The steady-state error due to a ramp input for a type two system is equal to

(i) zero

(ii) infinite

(iii) non-zero number

(iv) constant

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(f) The characteristic equation of a system is $3s^4 + 10s^3 + 5s^2 + 2 = 0$. The system is

(i) stable

(ii) marginally stable

(iii) unstable

(iv) None of the above

(g) The characteristic equation of a system is $2s^4 + s^3 + 3s^2 + 5s + 10 = 0$. How many roots does system have in the right half of *s*-plane?

(i) 1

(ii) 2

(iii) 3

(iv) 4

(h) The characteristic equation of a system is $s(s+4)(s^2+2s+s)+k(s+1)=0$. What are the angles of the asymptotes for the root loci for $k \geq 0$?

(i) 60°, 180°, 300°

(ii) 0°, 180°, 300°

(iii) 120°, 180°, 240°

(iv) 0°, 120°, 240°

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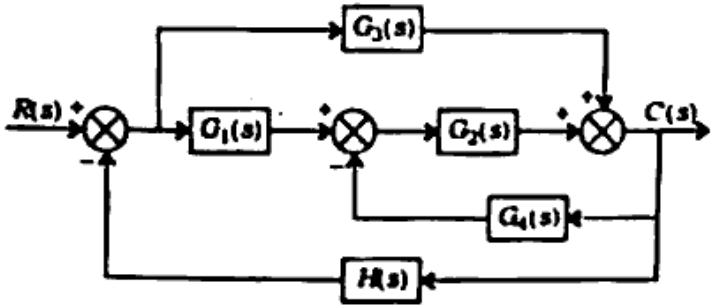
(c) Find out transfer function $C(s)/R(s)$ for diagram below using block diagram reduction technique : 5



3. (a) Find out $c(t)$ (i.e., the output) for the given second-order system subject to a unit step input. Also find out the rise time, peak time, damping ratio, settling time and % overshoot on 2% of tolerance band : 8

$$T(s) = \frac{C(s)}{R(s)} = \frac{16}{s^2 + 3s + 16}$$

(b) Derive the expression for the position error constant (K_p), velocity error constant (K_v) and acceleration error constant (K_a). 6

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4. (a) Given

$$G(s)H(s) = \frac{k(s + \frac{1}{3})}{s^2(s + 12)}$$

Sketch the root locus of the system. Find the value of k for which all roots are equal. What is the value of these roots? 10

(b) Using Routh-Hurwitz stability criteria, find out how many roots of characteristic equation lie on left-half of the s-plane : 4

$$s^6 + 3s^5 + 5s^4 + 9s^3 + 8s^2 + 6s + 4 = 0$$

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

$$G(s) = \frac{k(s + 1)}{s^3 + as^2 + 2s + 1}$$

Using Routh's criterion, determine value of k and a so that system oscillates at a frequency of 2 rad/s. 9

(b) For series R-L-C network, find out the transfer function. Output is taken across inductor L and input is

$$R(s) = A\sin(\omega t + \theta)$$ 5

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(i) What will be the gain margin dB of a system having following open-loop transfer function?

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

(i) 0

(ii) 2

(iii) 0·5

(iv) ∞

(j) A property of phase-lead compensation is that the

(i) overshoot is increased

(ii) bandwidth of closed-loop system is reduced

(iii) rise time of closed-loop system is reduced

(iv) gain margin is reduced

3. (a) What are the different standard test signals used in control system? Discuss them. 4

(b) What is compensation in control system and its type? Discuss lag-lead compensation. 5

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6. Obtain the polar plot for a system given below :

$$G(s) = \frac{(1+0\cdot2s)(1+0\cdot025s)}{s^3(1+0\cdot005s)(1+0\cdot001s)}$$

Determine whether plot cross the real axis. If so, determine frequency at which the plot cross the real axis and corresponding magnitude $|G(j\omega)|$. 14

7. A second-order system is described by the differential equation

$$\frac{d^2y(t)}{dt^2} + 0\cdot8\frac{dy(t)}{dt} + y(t) = x(t)$$

when $x(t)$ is the input and $y(t)$ is the output. Determine resonance frequency, peak resonance, cut-off frequency and bandwidth. Also find out the output for unit ramp input. 14

8. (a) State the Nyquist stability criterion. Define relative stability using Nyquist criterion. 7

(b) Draw the typical *R-C* lag network and derive transfer function. Why is it called a lag network? Comment on its effect on (i) gain cross-over frequency, (ii) bandwidth and (iii) signal to noise ratio. 7

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(c) What will be the type of the system, if the steady-state performance of control system yields a non-zero finite value of the velocity error constant?

(i) Type-0

(ii) Type-1

(iii) Type-2

(iv) Type-3

(d) A second-order system exhibits 100% overshoot. Its damping coefficient is

(i) equal to 0

(ii) greater than 1

(iii) less than 1

(iv) equal to 1

(e) For a unity feedback control system with

$$G(s) = \frac{9}{s(s+3)}$$

the damping ratio is

(i) 0·5

(ii) 1

(iii) 0·707

(iv) 0·33

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9. (a) Draw the schematic diagram of a 2-phase servomotor and draw the torque-speed characteristic. What care is taken to obtain linear characteristic? Derive the linearized transfer function under load condition. 10

(b) Explain the Mason's gain formula. 4

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