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2022

B.Tech. 4th Semester End-Term Examination

CONTROL SYSTEMS

(New Regulation & New Syllabus)

Full Marks – 70 Time – Three hours

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

Answer question No. 1 and any *four* from the rest.

1. Choose the appropriate answers from the following multiple choice questions: (10×1=10)

(i) The transfer function of a system is used to study its
- (a) steady-state behavior only
- (b) transient state behavior only
- (c) transient and steady state
- (d) none of the above

(ii) The "Type" of a transfer function denotes
- (a) the number of zeroes at the origin
- (b) the number of poles at the origin
- (c) the number of poles at infinity
- (d) the number of infinite poles

(iii) The open loop transfer function of a unity feedback control system is $G(s) = \frac{10}{s(s+10)}$. The closed loop system has
- (a) a pair of complex poles
- (b) a pair of real poles
- (c) a pair of complex zeroes
- (d) a pair of real zeroes.

[Turn over

(iv) The transient response of a control system with feedback compared to that of without feedback

(a) decays more quickly

(b) decays slowly

(c) rises at a slow rate

(d) rises at a faster rate.

(v) If the gain K of a control system increases, the steady state error of the system

(a) decreases

(b) increases

(c) may increase or decrease

(d) remains unaltered

(vi) Which of the following types of control systems generally preferred?

(a) critically damped system

(b) under-damped system

(c) over-damped system

(d) oscillatory system

(vii) The number of sign changes in the entries of the first column of Routh's array denotes

(a) the number of open loop poles in right half of s-plane

(b) the number of closed loop poles in the right half of s-plane

(c) the number of open loop zeroes in the right half of s-plane

(d) a pair of complex poles on the imaginary axis.

(viii) The characteristic equation of a feedback control system is $s^3 + 6s^2 + 8s + K = 0$. For the system to be marginally stable, the value of K should be

(a) 0

(b) K>48

(c) K<48

(d) K=48

(ix) The break-away points of a root locus occur at

(a) imaginary axis

(b) real axis

(c) multiple roots of characteristic equation

(d) either (a) or (b)

(x) The gain cross-over frequency is the frequency at which the decibel magnitude of $G(j\omega)H(j\omega)$ is

(a) 1
(b) 0
(c) >1
(d) <1

2. (a) How is a closed loop control system different from an open loop system? What is meant by negative feedback in control system? (5)

(b) Derive transfer function $\frac{E_0(s)}{E_i(s)}$ for the systems shown in Fig. 1. (5)

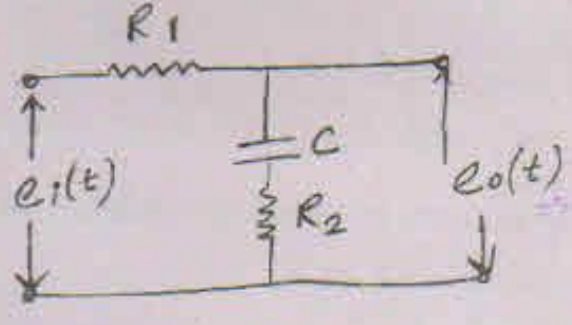

Fig.1

(c) The following differential equation represents a linear time invariant system, where $x(t)$ denotes the input, and y(t) the output. Determine the closed loop transfer function, characteristic equation and closed loop poles for the system. Also plot the pole-zero map. (5)

$$\frac{d^2y(t)}{dt^2} + 6\frac{dy(t)}{dt} + 10y(t) = 10x(t)$$

3. (a) Determine transfer function $\frac{C(s)}{R(s)}$ using reduction technique for the system whose block diagram is shown in Fig. 2. (8)

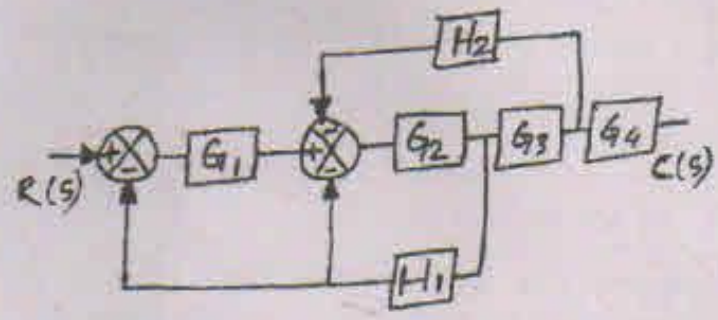

Fig.2

(b) Draw the equivalent signal flow graph for the block diagram shown in Fig. 2 and determine transfer function $\frac{C(s)}{R(s)}$ using gain formula. (7)

4. (a) What do you mean by transient response and steady state response of a control system? Explain with example. (5)

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

$$G(s) = \frac{20}{s(s+5)+25}$$

Determine un-damped natural frequency, damping ratio, peak time, maximum overshoot and settling time for the system. (5)

(c) Write short notes on anyone of the following:

(i) Error detector
(ii) Rotary Potentiometer
(iii) Tacho-generator (5)

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

$$G(s) = \frac{K(s+13)}{s(s+3)(s+7)}.$$

Determine static error constants (K_p, K_v and K_a) and steady-state errors as a function of K. (5)

(b) The open loop transfer function of a feedback control system is given by

$$GH(s) = \frac{K}{s(s+4)(s^2+2s+2)}.$$

Apply Routh's stability criterion to determine the range of K for the system to be stable. (5)

(c) What do you mean by analogous system? Explain 'force-voltage analogy'. (5)

6. (a) Calculate the following for the construction of root locus of open loop transfer function: $\frac{K}{s(s+4)(s+6)}$

(i) Angles of asymptotes
(ii) Centroid
(iii) Breakaway points (if any)
(iv) Intersecting points of root locus with imaginary axis and value of gain K at these points

Also plot the root locus. (7)

(b) A unity feedback system has open-loop transfer function $G(s) = \frac{200}{s(s+1)(s+10)}$. Draw the Bode magnitude and phase angle plot. Determine gain margin and phase margin from the plot. Give comment on the stability of the system. (8)

7. (a) What is Nyquist path and Nyquist plot? Sketch the Nyquist plot for the following open loop transfer function and examine the stability using Nyquist stability criterion. (8)

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

(b) What are the various types of compensation schemes used in control systems? Illustrate with the help of block diagrams. (7)
