ENGINEERING & MANAGEMENT EXAMINATIONS, DECEMBER - 2008

CONTROL THEORY

SEMESTER - 5

Time : 3 Hours] [Full Marks : 70

GROUP - A

(Multiple Choice Type Questions)

1. Choose the correct alternatives for any *ten* of the following : $10 \times 1 = 10$

i) The characteristic equation of a second order system is $s^2 + 6s + 25 = 0$. The system is

a) underdamped b) overdamped

c) undamped d) critically damped. ☐

ii) Addition of a zero to the closed loop transfer function

a) increase rise time b) decrease rise time

c) increase overshort d) no effect. ☐

iii) For a Type - I system, the steady state error due to step input is

a) $\frac{1}{1 + K_p}$ b) $\frac{1}{K_v}$

c) 0 d) α. ☐

iv) The root loci of a system have three asymptotes. The system can have

a) five poles and two zeros b) three poles and one zero

c) four poles and two zeros d) six poles and two zeros. ☐

v) The lag compensator

a) decreases the bandwidth b) increases the bandwidth

c) does not affect the bandwidth d) increases steady state error. ☐

vi) Gain margin is a measure of

a) relative stability b) controllability

c) observability d) absolute stability. ☐

vii) The open loop transfer function of a unity feedback system in given below :

$$G(S) = \frac{SK}{(0{\cdot}5\,S + 1)}$$

The initial slope of Bode plot intersecting 0 db axis at

a) $w = k$ b) $w = \frac{1}{k}$

c) $w = \sqrt{k}$ d) $w = \frac{1}{\sqrt{k}}$. ☐

viii) A system has a single pole of origin. Its impulse response will be

a) constant b) ramp

c) decaying exponentially d) oscillatory. ☐

ix) In force-voltage analogy, mass is analogous to

a) change b) current

c) inductance d) resistance. ☐

x) A is an $n \times n$ matrix. For the system to be controllable, the rank of the controllability matrix should be

a) n b) $> n$

c) $\geq n$ d) $\leq n$. ☐

xi) The settling time of a second order system on 2% basis is given by

a) $\frac{4}{\xi \omega_n}$ b) $\frac{3}{\xi \omega_n}$

c) $\frac{4\xi}{\omega_n}$ d) $\frac{2}{\xi \omega_n}$. ☐

xii) In a signal flow graph, loops are said to be non-touching, if they

a) do not touch alternate nodes

b) do not touch any node

c) do not posses any common node

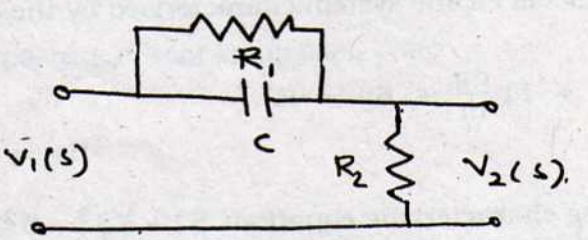
d) posses at least one common node. ☐

GROUP – B

(Short Answer Type Questions)

Answer any *three* of the following. $3 \times 5 = 15$

2. Obtain the transfer function of the circuit shown :



3. Find the steady state error for a unity feedback system having tranfer function

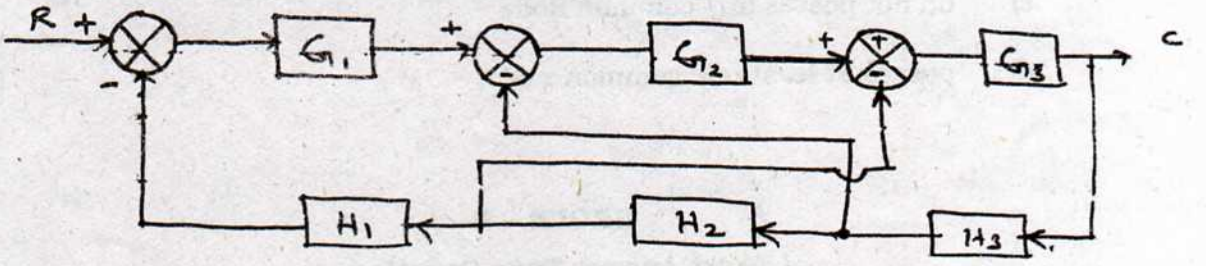
$$\frac{20}{S(S+2)(S^2+2S+2)}$$ subjected to

a) Unit step,

b) Unit ramp and

c) Parabolic input $\frac{t^2}{2}$.

4. Using block diagram reduction techniques, find the closed loop transfer function of the system whose block diagram is given below :



5. Construct the state model for the system characterised by the differential equation

$$\frac{d^3y}{dt^3} + 6\frac{d^2y}{dt^2} + 11\frac{dy}{dt} + 6y = u.$$

6. Consider the following characteristic equation $S^4 + KS^3 + S^2 + S + 1 = 0$.

Using Routh's stability criterion, determine the range of K for stability.

GROUP – C

(Long Answer Type Questions)

Answer any *three* of the following. $3 \times 15 = 45$

7. The open loop transfer function of a unity feedback system is given by

$$G(S) = \frac{K(20 + S)}{(S+1)(S+2)(S+10)}$$. Construct Bode plot for $K = 10$.

Determine :

a) Gain crossover frequency

b) Phase crossover frequency

c) Gain margin

d) Phase margin.

Determine whether the closed loop system is stable. 15

8. A unity feedback control system has an open loop transfer function

$$G(S) = \frac{K}{S(S+4)(S^2 + 4S + 20)}$$

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

a) Centroid, number and angle of asymptotes.

b) Angle of departure of root locus from poles

c) Breakaway point

d) The value of K and the frequency at which the root locus crosses the JW axes.

Hence find the value of K so that the system has a damping factor of 0·707. 15

9. a) State and explain Nyquist criterion.

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

$$G(S)H(S) = \frac{4S+1}{S^v(S+1)(2S+1)}.$$

Draw the Nyauist plot and determine closed loop stability. Calculate gain margin also. 5 + 10

10. a) The state model of the following system is given below :

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -6 & -11 & -6 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} u, \quad Y = [10 \ 5 \ 1] \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}$$

Test the controllability and observability for the system.

b) Prove that the polar plot of the high-pass *RC* circuit is a semi-circle. 8 + 7

11. Write short notes on any *three* of the following : 3 × 5 = 15

a) DC tacho-generators

b) Minimum phase and non-minimum phase systems

c) Basic compensators

d) Performance indices.

END