B.E. (EE) Part-III 5th Semester Final Examination, 2013

Control System – I

(EE - 504)

Time: 3 hrs **Full Marks:70**

i) Use separate answer script for each half.
ii) Answer six questions taking three from each half.
iii) Two marks are reserved for neatness in each half.
iv) Use semi log or ordinary graph paper if required.

FIRST HALF

1. a) Let the open loop transfer function of a system is

$$G(s) = \frac{2}{s+0.5}$$

If the input, r(t) =3cos0.4t is applied at t=0,

i) Find the steady state response of the system
ii) Find the range of t where the system will be in steady state?
iii) What is the change in steady state response if the input changes to r(t)=3cos4t ?
iv) Compare the amplitude of response in (i) and (iii) with the amplitude of input signal equal.

b) Determine the values of k>0 and a>0, so that the negative feedback system whose open loop transfer function is given below oscillates at a frequency 4 rad/sec.

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

[6+5]

2. a) A feedback control system has forward path transfer function and feedback transfer function given by the following expression

$$G(s) = \frac{k}{s(0.1s+1)}, \quad H(s) = \frac{1}{(0.2s+1)}$$

i) Determine the limiting value of gain k>0 for a stable system.
ii) For the gain that results a marginal stability, determine the oscillation frequency.

b) What is Mason's gain formula?

c) What is **rise time** of an under damped second order system? Explain with diagram.

[5+2+4]

3. a) When 2 lb of force is applied to a mechanical vibratory system, the mass oscillates. Determine m, b, k of the system from following data:

i) $x(\infty) = 0.1$ ft.
ii) $M_p = 9.5\%$.
iii) $t_p = 2$sec.

b) Draw the block diagram of field controlled dc servomotor. [6+5]

4. a) Determine the values of k1 and k2 of the closed loop system

$$\frac{C(s)}{R(s)} = \frac{k1}{Js^2+k1k2s+k1}$$

so that the maximum overshoot in unit step response is 25% and the peak time is 2sec. Assume that J=1 kg-m^2.

b) Comment on the steady state error of a **TYPE 3** system with ramp input.

c) Give the OP-AMP based electronic circuit of a PID controller. How can we change the gain parameter of the said circuit? [4+3+4]

5. a) Write the relative advantages and disadvantages of DC and AC motor applicable to the control system.
b) Write the principle of operation of an ac motor when applicable to a servo system.
[5+6]

SECOND HALF

6. a) What do you mean by *Zero Input Stability* of a system? Can we judge it from the transfer function of the system?
b) Give the block diagram of a *sampled data system/discrete time* system.
c) Write the differential equation of a *third order* system which is i) linear time invariant and ii) nonlinear and time varying. Indicate the terms responsible for the particular nature.
d) What information can we obtain from *frequency response* of systems?
[2+2+4+3]

7. a) State the *angle criterion* in the theory of Root Locus.
b) Draw the complete *root locus* for the unity feedback system with an open loop transfer function (for $K \geq 0$):

$$G(s) = \frac{(s+2)}{(s^2+2s+17)(s+3)(s+4)}$$

c) Sketch the Bode magnitude and phase plot of any first order type zero *non-minimum phase* transfer function. **[2+7+2]**

8. a) Sketch the *phase* curves of a standard second order system with varying damping ratio.
b) Draw the *Bode plots* of the open loop transfer function given by the system:

$$G(s) = \frac{200(s+2)}{s(s^2+2s+2)}$$

c) Find the Phase Margin, Cut-off frequency and the Band Width from the Bode plot in 8.
[2+6+3]

9. a) How is *phase margin* related to stability of a system? Explain in brief from a polar plot.
b) Use *Nyquist's stability criterion* to find range of K for stability of the unity feedback system with open loop transfer function:

$$G(s) = \frac{K(s+3)}{s(s-1)}$$

c) Show how a lead compensator may be implemented using analog components. What is its transfer function in terms of the passive components?
[2+7+2]

10. a) What type of *compensator* may be used to improve the *steady state error* to a step input? Why is it so called?

b) For the unity feedback system with

$$G(s) = \frac{K}{(s+2)(s+4)(s+6)},$$

is operating with 10 % overshoot. Design a cascade *compensator* such that the position error constant equals 20 without appreciably changing the dominant poles of the uncompensated system. Can this be achieved by adding a forward path gain only?

c) What is a Gyro? What is it used for?

[2+7+2]