B.E. (EE) Part-III 5th Semester Final Examination, 2012
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) Determine the values of k>0 and a>0, so that the negative feedback system whose open loop transfer function is given below and oscillates at a frequency of 2 rad/sec.

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

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

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

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.
iii) Reduce the gain to half the value found in (ii) and study the relative stability of the system by shifting the axis and using the Routh stability criterion. **[5+6]**

2.a) What is Mason's gain formula?
b) Draw the equivalent signal flow graph for the system as shown in the following block diagram (Fig.-1) and calculate the over all gain by Mason's gain formula.

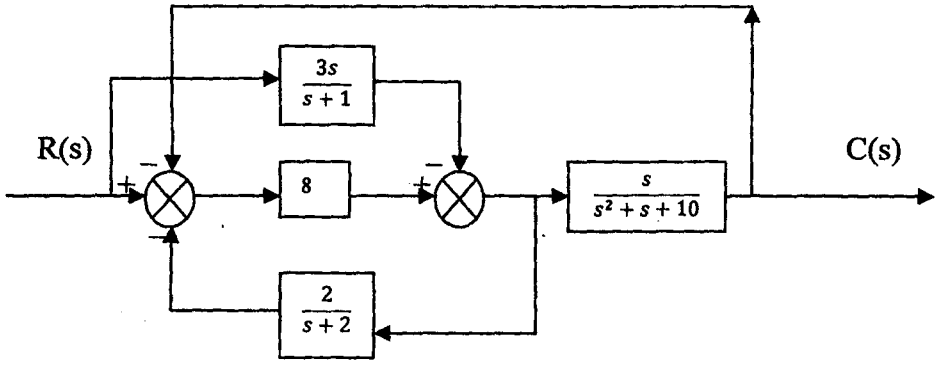

Fig.-1

c) What is **peak time** of an under damped second order system? Explain with diagram. **[2+5+4]**

3.a) Draw the block diagram of armature controlled dc servomotor. What are the Advantages of ac servomotor in comparison with its dc counter part?

b) An OP-AMP is connected with an input voltage v_i through an input impedance as the series combination of resistance R_1 and R_3 and a parallel combination of R_2 and C in the feedback path. If the output is v_0, find the transfer function of the circuit from fundamental equations. **[5+2+4]**

4. a) Comment on the steady state error of a **TYPE 2** system with ramp input superimposed on a unit step input.

b) What do you understand by the **electrical zero** of a Synchro transmitter and null position of Synchro control transformer?

c) Differentiate between Time varying and Time Invariant control system.

[3+6+2]

5.a) Find the open loop transfer function of a system with no finite zero and three finite poles at origin, s = -3 and s = -2. A **PID** controller is used to control the said system. Deduce one probable transfer function of the controller. How can you reduce the maximum overshoot of the above system? **[11]**

SECOND HALF

6. a) Define *stability* of dynamic systems. Sketch the unit step response of any *unstable* system.

b) Compare *open loop* and *closed loop* systems giving an example for each.

c) Explain how *gain margin* can be a measure of *relative stability.*

[3+4+4]

7. a) What is a *root locus*?

b) Draw the complete root locus for the unity feedback system with open loop transfer function (for $K \geq 0$):

$$G(s) = \frac{(s+4)}{(s+0.5)^2(s+2)}$$

$\frac{dK}{ds} = 0$, yields the solutions: -5.44, -1.56, -0.5.

c) Name a control system component which is used as: i) a *sensor*; ii) an *error detector.*

[2+7+2]

8. a) Sketch the *frequency response* curves of a standard second order system for varying damping ratio.

b) Draw the *Bode plots* of the open loop transfer function given by the system in 7 (b).

c) Find the *Gain Margin* and *Phase Margin* of the system in 8 (b). Hence comment on the stability of the closed loop system.

[2+6+3]

9. a) Define: i) *time delay* and ii) *non-minimum phase systems* giving examples of each.

b) Use *Nyquist's stability criterion* to find range of K for stability of the unity feedback system with open loop transfer function:

$$G(s) = \frac{K(s+1)}{(s^2 - 0.25)}$$

c) Why do we use a *logarithmic scale* for frequency in Bode Plots?

[2+7+2]

10. a) Which *compensator* is similar to a P. I. controller? Compare them.

b) For the unity feedback system with

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

Design a cascade *compensator* such that the *settling time*, $t_s \leq 4$ sec and *peak overshoot* for a unit step input ≤ 20 %. Can this be achieved by adding a forward path gain only?

[3+8]