Code No: RR220206 **Set No. 1**

II B.Tech II Semester Supplementary Examinations,
November/December 2005
CONTROL SYSTEMS
(Common to Electrical & Electronic Engineering, Electronics & Communication Engineering, Electronics & Instrumentation Engineering, Electronics & Control Engineering, Electronics & Telematics and Instrumentation & Control Engineering)

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks

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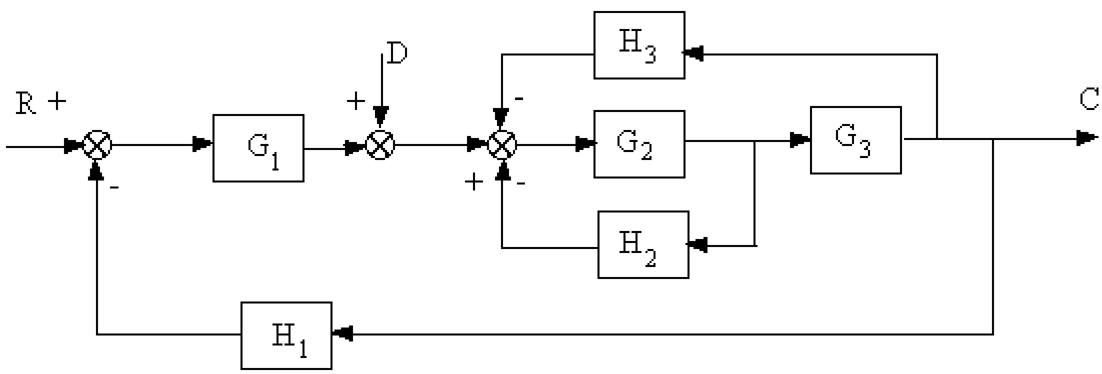

Figure 1:

1. (a) For the system in the above Figure 1, obtain transfer function
   i. C/R
   ii. C/D
   (b) Verify the above transfer function using signal flow graph. [8+8]
2. (a) Explain the effect of feedback on noise to signal ratio.
   (b) With the help of sketches, explain the construction and working principle of a Synchro transmitter. [8+8]
3. (a) Explain the important time response specification of a standard second ordered system to a unit step input.
   (b) Derive expressions for time domain specifications of a standard second ordered system to a step input. [8+8]
4. (a) The characteristic equation of a control system is given by $S^4 + 20S^3 + 15S^2$+2S+K=0 use Routh-Hurwitz criterion to find the value of K for which the system will be marginally stable and the frequency of the corresponding sustained Oscillations.
   (b) Explain :

i. Rise time
ii. Peak time
iii. Peak percent overshoot.
With regard to the unit step response of a prototype second order system. [10+6]

5. The block diagram of a control system is given in Figure2 Plot the root locus as a function of parameter K and comment on stability. [16]

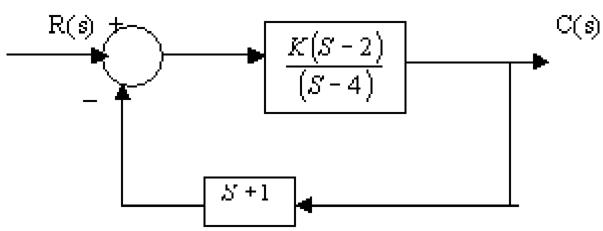

Figure 2:

6. Transient response of a 2^{nd} order underdamped system subjected to unit step i/p is found to have a peak overshoot of 16.2% at time $\pi/\ 5\sqrt{3}$. If the system is subjected to sinusoidal i/p. Find

   (a) The frequency of the i/p at which amplitude of steady state response will have Maximum value
   (b) Maximum value of steady state o/p. [8+4+4]

7. (a) Sketch the polar plot of a unity feed back system with open loop transfer function G(s) = $1/\mathrm{S}(1+S)^2$. Also find the frequency at which $|G(jW)|$ =1 and the corresponding phase angle $\underline{/G(jW)}$.
   (b) Determine the stability of the system whose open loop transfer function G(s)H(s)= $\frac{1}{s(1+2s)(1+s)}$. Also find gain and phase margin (using Nyquist plot). [8+8]

8. (a) For the given system $\dot{X}$ = AX + BU, Y = CX.
$$A = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -1 & -2 & -3 \end{bmatrix} \quad B = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} \quad C = \begin{bmatrix} 1 & 0 & 0 \end{bmatrix}$$
   Obtain Jordan form representation of state equation of A. Also find the transfer function.
   (b) Derive the expression for the transfer function G(s) = Y(s) / U(s) .Given the state model
   $\dot{X}$ = A X + B U
   Y = C X + D U [8+8]

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1. (a) Derive the transfer function of the following network given below. Figure 1

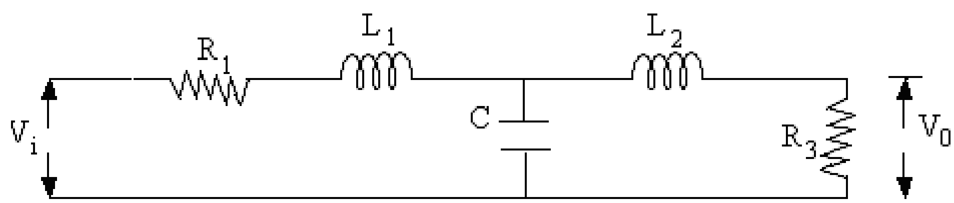

Figure 1:

(b) A signal flow graph Figure 2 is given below. Use mason's formula to find the transfer function [8+8]

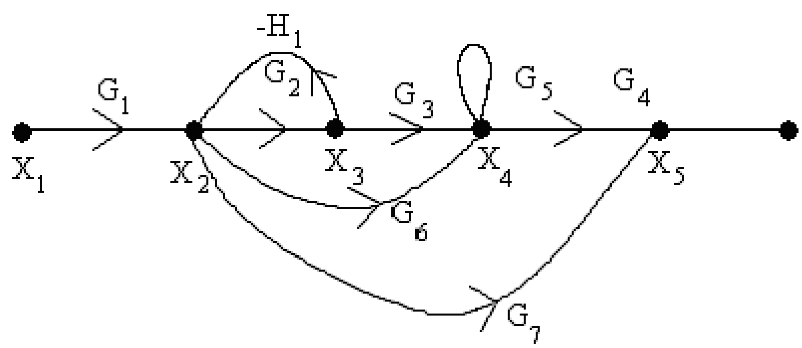

Figure 2:

2. (a) Derive the transfer function of an a.c. servomotor and draw its characteristics.
   (b) Explain the Synchro error detector with circuit diagram. [8+8]

3. (a) Define transient response specifications.
   i. Delay time
   ii. Rise time

iii. Peak time

iv. Maximum overshoot

v. Settling time of second order system.

(b) A unity feedback system is characterised by an open loop transfer function.

$$G(s) = \frac{K}{s(s+10)}$$

Determine gain 'K' so that system will have a damping ratio of 0.5. For this value of 'K' determine settling time, peak overshoot and time to peak over shoot for a unit step input. [10+6]

4. (a) The open-loop transfer function of a servo system with unity feedback isG(s)= $\frac{10}{s(0.1s+1)}$. Evaluate the static error constants (K_p, K_v, K_a) for the system. Obtain the steady-state error of the system when subjected to an input given by the polynomial r(t)=a_0+a_1t +$\frac{a_2}{2}$ t^2

(b) The open-loop transfer function of a unity feedback control system is given by G(s)=$\frac{K}{(s+2)(s+4)(s^2+6s+25)}$. By applying the Routh criterion, discuss the stability of the closed-loop system as a function of K. Determine the values of K, which will cause sustained oscillations in the closed-loop system. What are the corresponding oscillation frequencies? [8+8]

5. (a) Show that the breakaway and break-in points, if any, on the real axis for the root locus for G(s)H(s)= $\frac{KN(s)}{D(s)}$, where N(s) and D(s) are rational polynomials in s, can be obtained by solving the equation $\frac{dK}{ds}$ =0.

(b) By a step by step procedure draw the root locus diagram for a unity negative feedback system with open loop transfer function G(s)=$\frac{K(s+1)}{s^2(s+9)}$. Mark all the salient points on the diagram. Is the system stable for all the values of K? [8+8]

6. (a) Explain the concept of phase margin and gain margin. [4]

(b) Draw the Bode Plot for a system having G(s) =$\frac{100}{s(1+0.5s)(1+0.1s)}$,
H(s) = 1.
Determine:

i. Gain cross over frequency and corresponding phase margin.

ii. Phase cross over frequency and corresponding gain margin.

iii. Stability of the closed loop system.

[8+4]

7. (a) Explain gain margin and phase margin.

(b) The open loop transfer function of a feed back system is G(s)H(s)= $\frac{K(1+s)}{(1-s)}$. Comment on stability. [6+10]

8. (a) Define the terms

i. State variable

ii. State transition matrix. [4+4]

(b) Obtain the state equation and output equation of the electric network show in Figure3 [8]

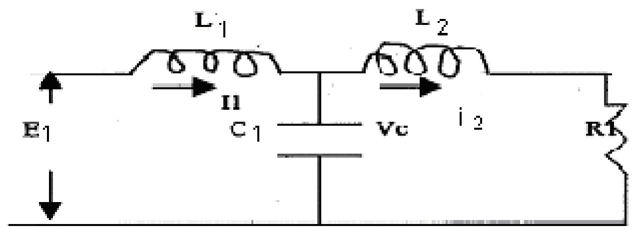

Figure 3:

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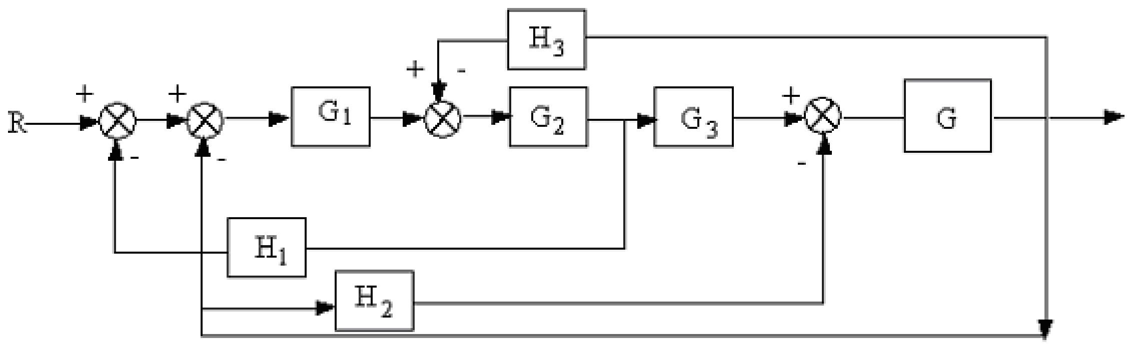

Figure 1:

1. Using block diagram reduction technique find the transfer function for the system shown in Figure 1 above and verify the transfer function by mason's gain formula. [8+8]

2. Derive the Transfer Function for a.c. servomotor. Explain about torque-speed characteristics. [8+8]

3. The open loop transfer function of a unity feedback control system is

$$G(S) = \frac{K}{s(1+Ts)}$$

   (a) By what factor should the amplifier gain "K" be multiplied in order to increase the damping ratio from 0.2 to 0.8?
   (b) By what factor should 'K' be multiplied so that the maximum overshoot for a step input decreases from 60% to 10%? [8+8]

4. (a) The characteristic equation of a control system is given by $S^4 + 20S^3 + 15S^2$+2S+K=0 use Routh-Hurwitz criterion to find the value of K for which the system will be marginally stable and the frequency of the corresponding sustained Oscillations.

(b) Explain :

i. Rise time

ii. Peak time

iii. Peak percent overshoot.
With regard to the unit step response of a prototype second order system.

[10+6]

5. The block diagram of a control system is given in Figure2 Plot the root locus as a function of parameter K and comment on stability. [16]

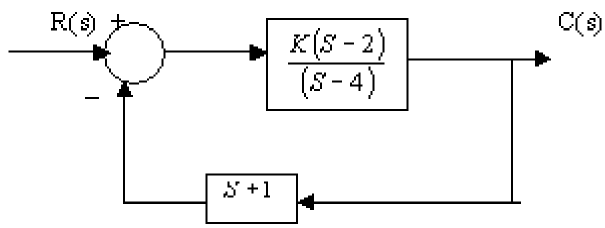

Figure 2:

6. Draw the exact Bode Plots and find the gain margin and phase margin of a system represented by G(s)H(s)=$\frac{10(s+1)}{s(s+0.05)(s+3)(s+5)}$. [8+4+4]

7. (a) Explain how polar plots are useful in finding the stability of a system

(b) Sketch the Nyquist plot and find the stability of the following system.
G(s)H(s)=$\frac{100}{(s+2)(s+4)(s+8)}$ [8+8]

8. (a) Obtain the solution of a system whose state model is given by X = A X(t) + B U(t) ; X(0) =X_0 and hence define state Transition matrix.

(b) Obtain the transfer function of a control system whose state model is [8+8]

$\dot{X}$ (t) - A X(t) + B U(t) Y(t) = CX(t)

Where A= $\begin{bmatrix} 0 & 1 & 0 \\ 0 & -1 & 1 \\ 0 & -1 & -10 \end{bmatrix}$

B= $\begin{bmatrix} 0 \\ 0 \\ 10 \end{bmatrix}$ C = $\begin{bmatrix} 1 & 0 & 0 \end{bmatrix}$

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1. (a) What is a mathematical model of a physical system? Explain briefly.
   (b) Write the differential equations for the system shown in Figure 1 below : [6+10]

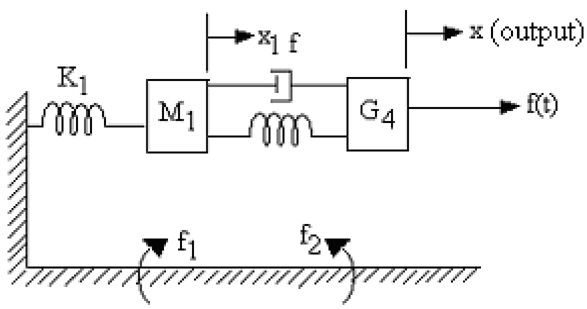

Figure 1:

2. (a) Explain the effect of feedback on noise to signal ratio.
   (b) With the help of sketches, explain the construction and working principle of a Synchro transmitter. [8+8]

3. (a) A unity feedback system has a forward path transfer function G(s)=$\frac{9}{s(s+1)}$. Find the value of damping ratio, undamped natural frequency of the system, percentage overshoot, peak time and settling time.
   (b) Measurements conducted on servomechanism show the system response to be c(t) = 1 + 0.2e^{-60t} - 1.2e^{-10t} when subjected to a unit-step unit. Obtain the expression for the closed-loop transfer function. [10+6]

4. (a) For the system shown in Figure 2 , find the value of the steady state output when an input $\theta_i(t) = (2t+5e^{-3t})$ is applied. Determine the steady state error of the system. What is the type and order of the system?
   (b) Explain the Hurwitz criterion to determine the stability of dynamical system. [10+6]

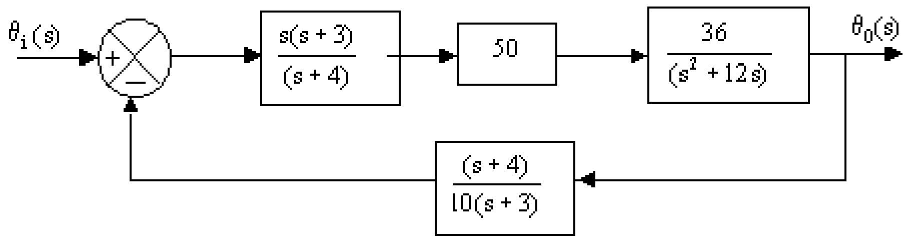

Figure 2:

5. (a) Show that the breakaway and break-in points, if any, on the real axis for the root locus for G(s)H(s)= $\frac{KN(s)}{D(s)}$, where N(s) and D(s) are rational polynomials in s, can be obtained by solving the equation $\frac{dK}{ds}$ =0.

   (b) By a step by step procedure draw the root locus diagram for a unity negative feedback system with open loop transfer function G(s)=$\frac{K(s+1)}{s^2(s+9)}$. Mark all the salient points on the diagram. Is the system stable for all the values of K? [8+8]

6. (a) Explain the frequency response specifications.

   (b) Draw the Bode Plot for the system having G(s)H(s) = $\frac{100(0.02s+1)}{(s+1)(0.1s)(0.01s+1)}$. Find gain and phase cross over frequency. [8+8]

7. (a) Explain how polar plots are useful in finding the stability of a system

   (b) Sketch the Nyquist plot and find the stability of the following system. G(s)H(s)=$\frac{100}{(s+2)(s+4)(s+8)}$ [8+8]

8. (a) Construct the state variable model for the system characterized by the differential equation
   $\dddot{Y} + 6\ddot{Y} + 11\dot{Y} + 2y = 41 + 1$

   Also give the block diagram of the model.

   (b) Explain properties and significance of state transition matrix. [10+6]

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