Government College of Engineering, Amravati

(An Autonomous Institute of Government of Maharashtra)

Fourth Semester B. Tech. (Electronics and Telecommunication)

Summer – 2013

Course Code: ETU404

Course Name : Control System Engineering

Time : 2 hr.30min. **Max. Marks: 60**

Instructions to Candidate

1) All questions are compulsory.
2) Assume suitable data wherever necessary and clearly state the assumptions made.
3) Diagrams/sketches should be given wherever necessary.
4) Use of logarithmic table, drawing instruments and non-programmable calculators is permitted.
5) Figures to the right indicate full marks.

Q1 Solve the following

(a) What are the improvements occur in system's performance by using feedback? **04**

(b) Enlist the important properties of the signal flow graph. **04**

(c) Explain the effect of feedback on bandwidth using single loop feedback system. **04**

Q2 Solve any two

(a) The system closed-loop transfer function is **06**

$$\frac{C(s)}{R(s)} = \frac{w_n^2}{s^2+2\zeta w_n s+w_n^2}$$

where ζ=0.6 and ωn=5rad/s. Find rise time t_r, peak time

t_p ,maximum overshoot Mp and settling time t_s when the system is subjected to a unit-step input.

(b) A unity feedback position control system has a forward path transfer function G(s) $= \frac{K}{s}$. For unit step input, compute the value of K that minimizes ISE. 06

(c) Define delay time t_d, rise time t_r, peak time t_p, maximum overshoot Mp and settling time ts using transient response characteristics of a control system to a unit ramp input. 06

Q3 Solve the following

(a) Determine the stability of the system represented by the following characteristic equation and find the number of roots in right half of s-plane and on the imaginary axis using Routh's criterion. 04

$$s^6 + 2s^5 + 8s^4 + 12s^3 + 20s^2 + 16s + 16 = 0$$

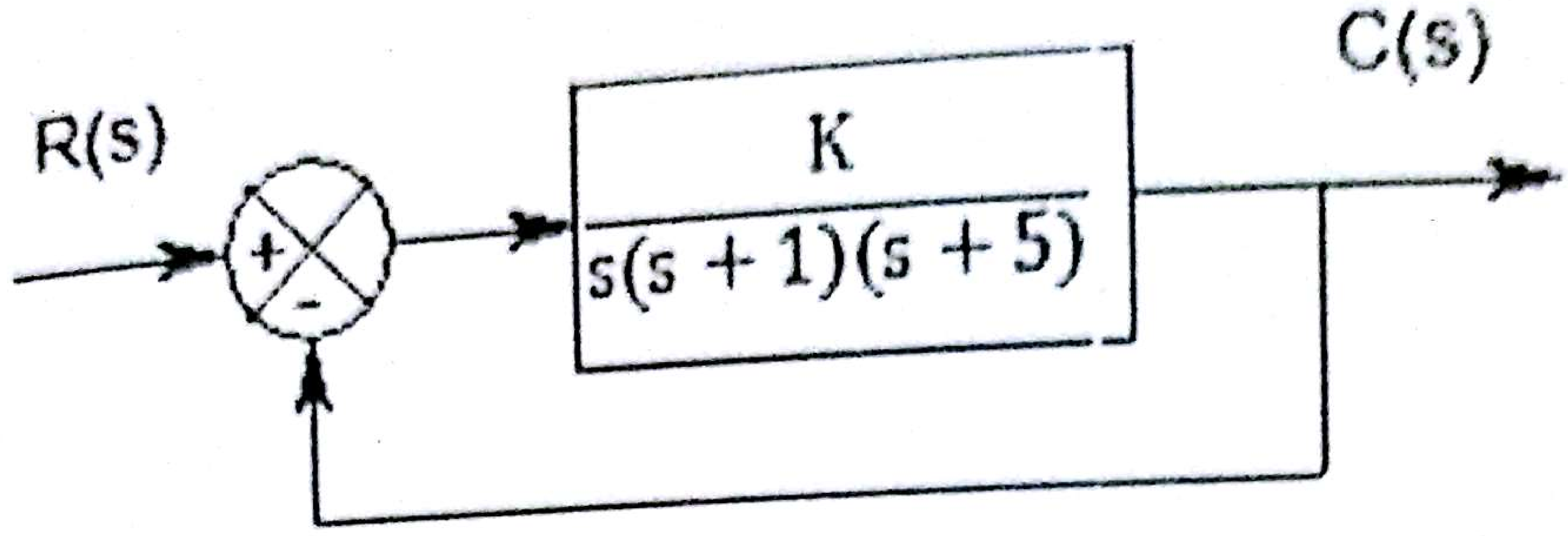
(b) Show that Routh's stability criterion and Hurwitz stability criterion are equivalent. 04

(c) Determine the range of K for stability using the Hurwitz stability criterion for characteristic equation. 04

$$s^4 + 2s^3 + (4 + K)s^2 + 9s + 25 = 0$$

Q4 Solve any two

(a) Obtain the phase and gain margins of the system shown in figure for the K=10 and K=100. 06



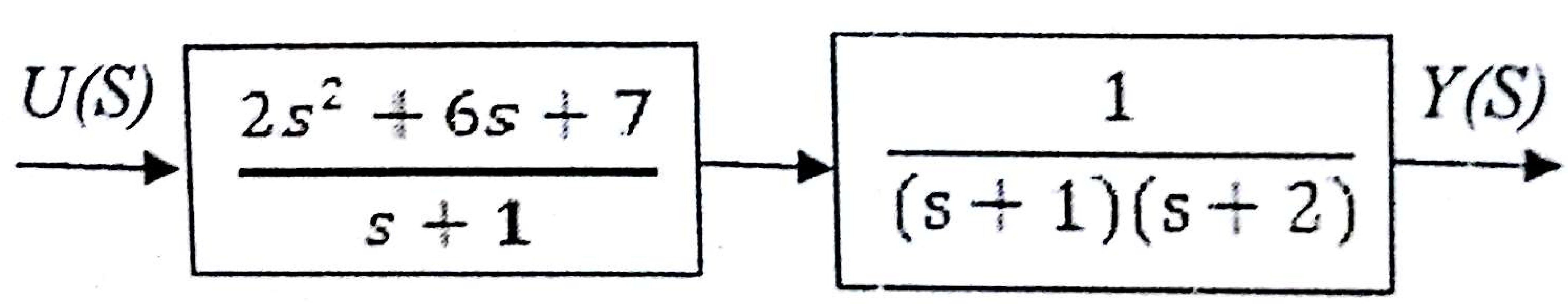
06

(b) Prove that the polar plot of the sinusoidal transfer function $G(j\omega)= \frac{j\omega T}{1+j\omega T}$, for $0\leq \omega\leq \infty$ is a semicircle. Find the center and radius of the circle. 06

(c) A unity feedback system whose open loop transfer function is $G(s)= \frac{Ke^{-0.2s}}{s+1}$ using the Nyquist plot, determine the critical value of K for stability.

Q5 Solve the following 06

(a) Write down the canonical state variable form for the complete system shown in figure and draw its block diagram in state variable form.



(b) Obtain the time response of the following system

$$\begin{bmatrix}\dot{x}_1\\ \dot{x}_2\end{bmatrix} = \begin{bmatrix}1 & 0\\ 1 & 1\end{bmatrix}\begin{bmatrix}x_1\\ x_2\end{bmatrix} + \begin{bmatrix}1\\ 1\end{bmatrix}[u]$$ 06

Where u(t) is a unit step occurring at t=0 and $x^T(0)=[1 \quad 0]$.

Government College of Engineering, Amravati

(An Autonomous Institute of Government of Maharashtra)

Fourth Semester B. Tech. (Electronics and Telecommunication)

Summer – 2014

Course Code: ETU404

Course Name: Control System Engineering

Time: 2 Hrs. 30 Min. **Max. Marks: 60**

Instructions to Candidate

1) All questions are compulsory.
2) Assume suitable data wherever necessary and clearly state the assumptions made.
3) Diagrams/sketches should be given wherever necessary.
4) Use of logarithmic table, drawing instruments and non-programmable calculators is permitted.
5) Figures to the right indicate full marks.

1 (a) Find the system equation of the mechanical system shown in Fig (a). Also determine the force voltage and force current analogies. 6

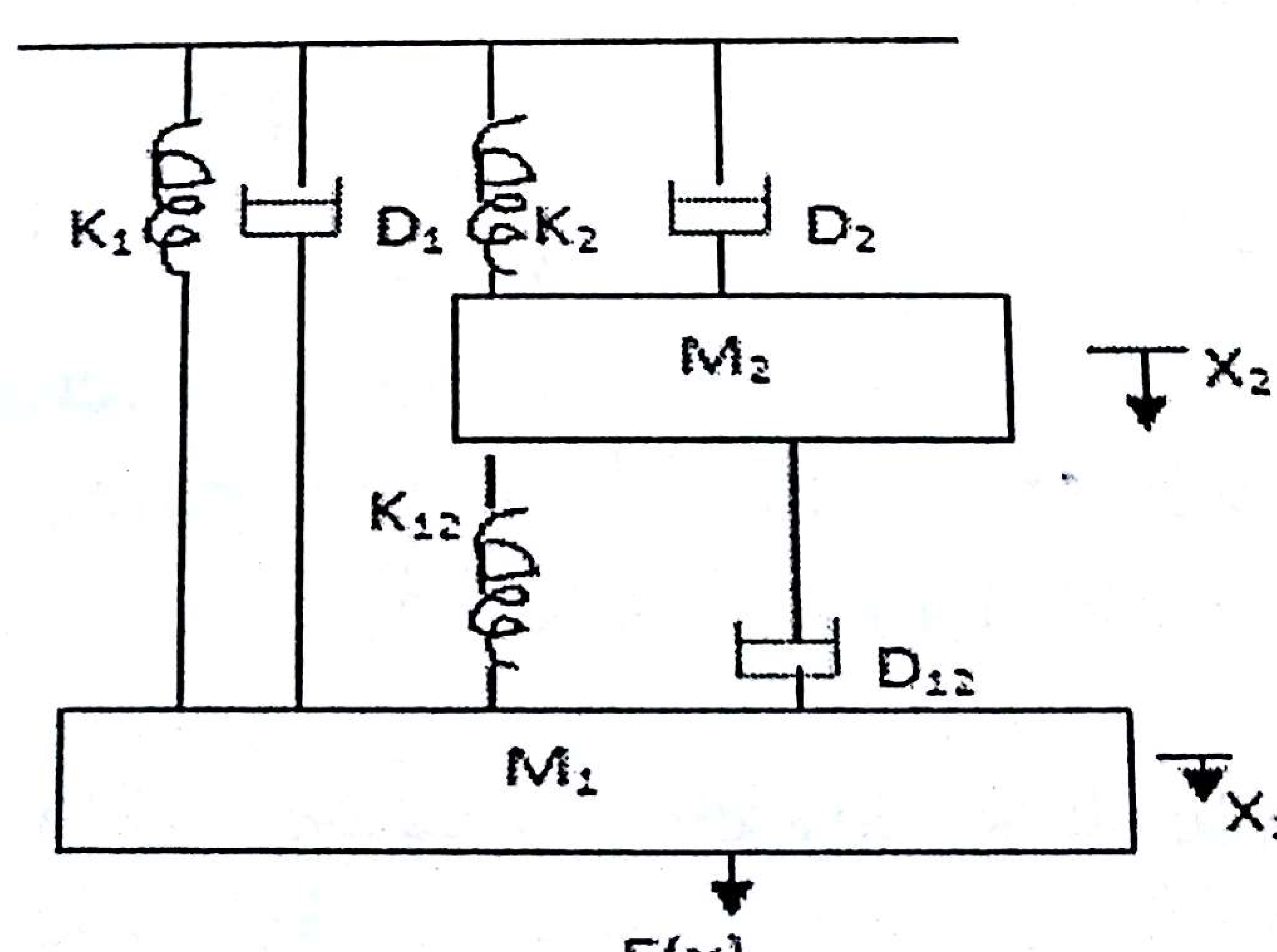


Fig (a)

(b) Find the gain of the system represented by the following equation. 6

$x_2 = t_{12}\, x_1 + t_{32}\, x_3$ $\quad$ $x_3 = t_{23} x_2 + t_{43}\, x_4$

$x_4 = t_{24}\, x_2 + t_{34}\, x_3 + t_{44}\, x_4$ $\quad$ $x_5 = t_{25}\, x_2 + t_{45}\, x_4$,

Here the input node is x_1 and output node is x_5.

2 **Solve any two** 12

(a) Write short on different types of stepper motor.

(b) The state equation of a linear time invariant system is given

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} -2 & 0 \\ 1 & -1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u$$

where u>0. Determine the following

(i) The state transition matrix.

(ii) $x_1(1)$ under zero initial conditions and a step input

(iii) Controlability and observability of the system.

(c) Consider the state matrix 'A' given by $A = \begin{bmatrix} 4 & 1 & -2 \\ 1 & 0 & 2 \\ 1 & -1 & 3 \end{bmatrix}$. If it is possible to diagonalise matrix 'A', determine matrix P so that $P^{-1}AP$ is in the Jordan canonical form.

3 (a) A system has $G(s) = \frac{K}{s(1+sT)}$ with unity feedback when K and T are constant . Determine the factor by which K should be multiplied to reduce the overshoot from 85% to 35% . 6

(b) (i)A feedback system is represented by the closed loop transfer given by $\frac{C(s)}{R(s)} = \frac{9(1+2s)}{s^2+0.6s+9}$ obtain the unit step response of the system. 6

(ii) Find K_p, K_v, and K_a for the system having the following closed loop transfer function;

$$\frac{C(s)}{R(s)} = \frac{9}{s^3 + 0.6s^2 + 9}$$ with unity feedback.

(iii) If $r(t) = 1 + t + \frac{t^2}{2}$, find the steady state error in the system.

4 (a) Sketch the complete root locus for the system having $G(s)\,H(s) = \frac{K}{s(s+3)(s^2+3s+4.5)}$. 6

(b) For the unity feedback system having forward transfer function $G(s) = \frac{K}{s(1+0.6s)(1+0.4s)}$ determine the range of values of K, marginal values of K and frequency of sustained oscillation. 6

5 **Solve any two** **12**

(a) Find K and 'a' for the unity feedback system with forward transfer function $G(s) = \frac{K}{s(s+a)}$ so that $M_r = 1.25$ and $\omega_r = 12.65$ rad/sec will be satisfied. Also determine the settling time and bandwidth.

(b) Sketch the Bode Plot for the transfer function $G(s)\ H(s) = \frac{2(s+0.25)}{s^2(s+1)(s^2+0.5)}$. Determine ω_{gc} and ω_{pc}, G.M, P.M. Comment on stability.

(c) Obtain the Polar plot for the given system

(i) $G(s)\,H(s) = \frac{1}{(Ts+1)s^2}$

(ii) $G(s)\,H(s) = \frac{1}{s(1+T_1 s)(1+T_2 s)}$

Government College of Engineering, Amravati
(An Autonomous Institute of Government of Maharashtra)

Fourth Semester B. Tech.
(Electronics and Telecommunication.)

Summer – 2016

Course Code: ETU404

Course Name: Control System Engineering

Time: 2 Hrs. 30 Min. **Max. Marks: 60**

Instructions to Candidate

1) All questions are compulsory.
2) Assume suitable data wherever necessary and clearly state the assumptions made.
3) Diagrams/sketches should be given wherever necessary.
4) Use of logarithmic table, drawing instruments and non-programmable calculators is permitted.
5) Figures to the right indicate full marks.

Attempt Any FIVE **(05X04)** **20**

a) A unity feedback system has 04

$$G(s) = \frac{40*(s+2)}{s(s+1)(s+4)}$$

Type of sys ~~transfer func~~

Determine i)
ii) All error coefficients

b) Define Proportional-Derivative (PD) controller with equation. State the effect of PD controller on system 04

c) Describe construction and working of AC Tachometer. State advantages of it. 04

d) The mechanical system shown in fig.1 has u1 and u2 as its inputs and y1 and y2 as its outputs. Obtain a state space representation of the system 04

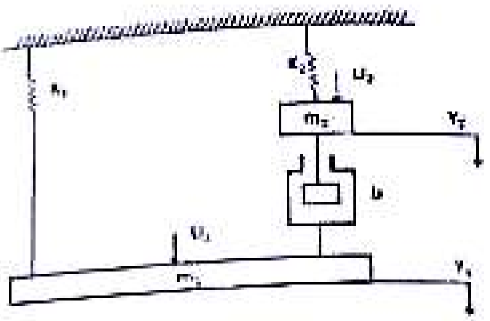


Fig.1

e) Construct the signal flow graph for the following set of system equations 04
$Y2 = G1Y1 + G3Y3$
$Y3 = G4Y1 + G2Y2 + G5Y3$
$Y4 = G6Y2 + G7Y3$

f) State Hurwitz's Criterion. Determine the stability of the given characteristic equation by Hurwitz's method. 04
$F(s) = S^3 + s^2 + s^1 + 4 = 0$ is the characteristic equation

g) State the co-relation between time domain and frequency domain. 04

2. **Attempt Any TWO (06X02)** 12

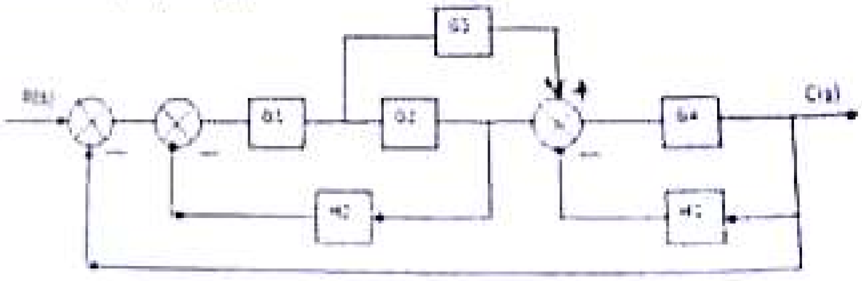
a) What is Syncros? Describe construction and working of Synchro Transmitter in brief 06

b) A second order system is given by 06

$$\frac{C(S)}{R(S)} = \frac{25}{S^2 + 6S + 25}$$

Find its rise time, peak time, peak overshoot and settling time if subject to unit step input. Also calculate expression for its output response.

c) Reduce the block diagram to its simple form and obtain C(S)/R(S) 06



3. **Attempt any TWO (02X02)**

a) Draw block diagram for AC position control system 04

b) State Nyquist stability criterion 02

c) What is controllability and observability of the system 02

d) State applications of stepper motor. 02

4. a) A unity feedback control system has 02

$$G(s) = \frac{80}{s(s+2)(s+20)}$$ 06

Draw the Bode Plot. Determine gain margin, phase margin ω_{gc} and ω_{pc}. Comment on stability

b) For $G(s)H(s) = \frac{K}{(s+1)(s+2+j2)(s+2-j2}$, calculate angle of asymptotes and the centroid. 06

5. a) Using the Routh-Hurwitz stability criterion, ascertain stability for each of the following characteristics equations of the system 06

a) $s^6 + 2s^5 + 8s^4 + 12s^3 + 20s^2 + 16s + 16 = 0$

b) $s^6 + s^5 - 2s^4 - 3s^3 - 7s^2 - 4s - 4 = 0$

b) **Solve following objective type questions:** 06

i. In an AC servomotor

a) one phase winding is supplied from a constant AC reference voltage and the other from the output of a servo amplifier which acts as a controlling field

b) one phase winding is supplied from a constant DC reference voltage and the other from the output of a servo amplifier which acts as a controlling field

c) both the windings are supplied from two-phase AC so as to create a rotating magnetic field effect

d) one phase winding is supplied from a constant DC voltage as reference voltage and the other from a sinusoidal AC voltage

ii. A closed-loop control system can be defined as

a) System that directly generates the output in response to an input signal

a) System with a measurement of the output signal and a comparison with the desired output to generate an error signal that is applied to the actuator

b) An interconnection of components forming a system configuration that will provide a desired response, the output having no effect upon the signal to the process

d) A system that utilizes a device to control the process without using feedback

iii. The steady-state error for the first order system is shown below

unit step & unit ramp.

Unit-ste $R(s) \longrightarrow \boxed{\dfrac{1}{1+Ts}} \longrightarrow C(s)$ t respectively are

a) T and I b) 0 and 0 c) I and 0 d) 0 and T

iv. If any root of the characteristic equation has a positive real part, the system is.....

a) Stable b) Unstable c) Oscillatory Conditionally stable

v. State variable method of modeling, analysis and design is applicable to

a) Linear, time-varying, multi-input multi-output system

b) Linear and non linear, time-invariant or time varying, multi-input multi-output system

c) Linear, time-invariant, single-input single-output system

d) Linear, time-invariant, multi-input multi-output system

vi. The two important performance indices for a second order system are

a) Band width and break frequency

b) Resonant peak, Mr and resonant frequency, ω_r

c) Error coefficient and resonant frequency, ω_r

d) Resonant peak, Mr and angular velocity, ω

Government College of Engineering, Amravati

(An Autonomous Institute of Government of Maharashtra)

Fourth Semester B. Tech.
(Electronics and Telecommunication)
Summer-2017

1 5004056

April 12.

Course Code: ETU 404

Course Name: Control System Engineering

Time: 2 hrs. 30min. **Max. Marks: 60**

Instructions to Candidate

1) All questions are compulsory.
2) Assume suitable data wherever necessary and clearly state the assumptions made.
3) Diagrams/sketches should be given wherever necessary.
4) Use of logarithmic table, drawing instruments and non-programmable calculators is permitted.
5) Figures to the right indicate full marks.

1. **Solve any two from the following.**

(a) Find the transfer function of the system shown in Figure-1 using Mason's gain formula. **6**

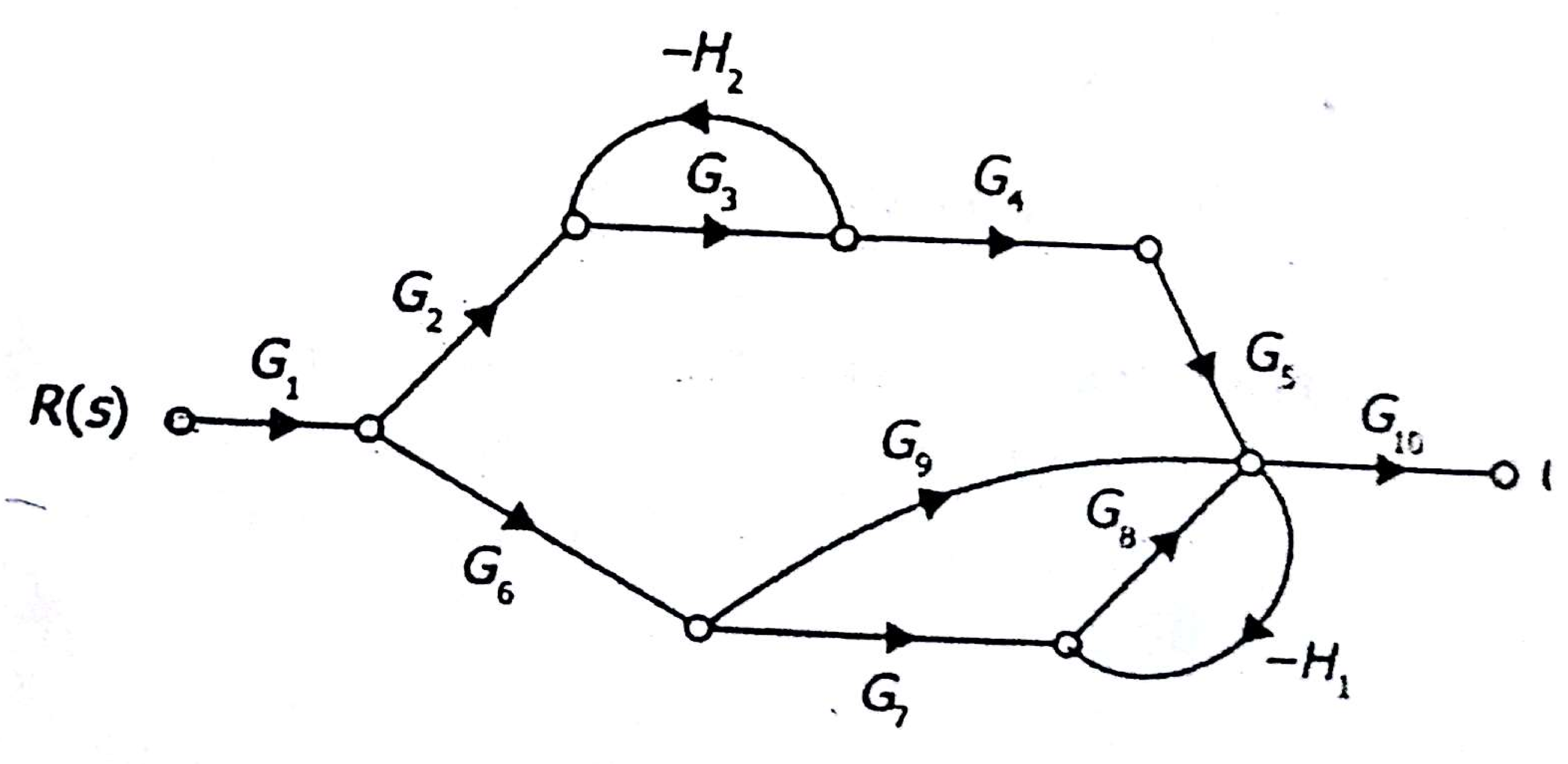


Figure-1

(b) Reduce the block diagram of the multi-loop system shown in Figure-2 to obtain the transfer function. **6**

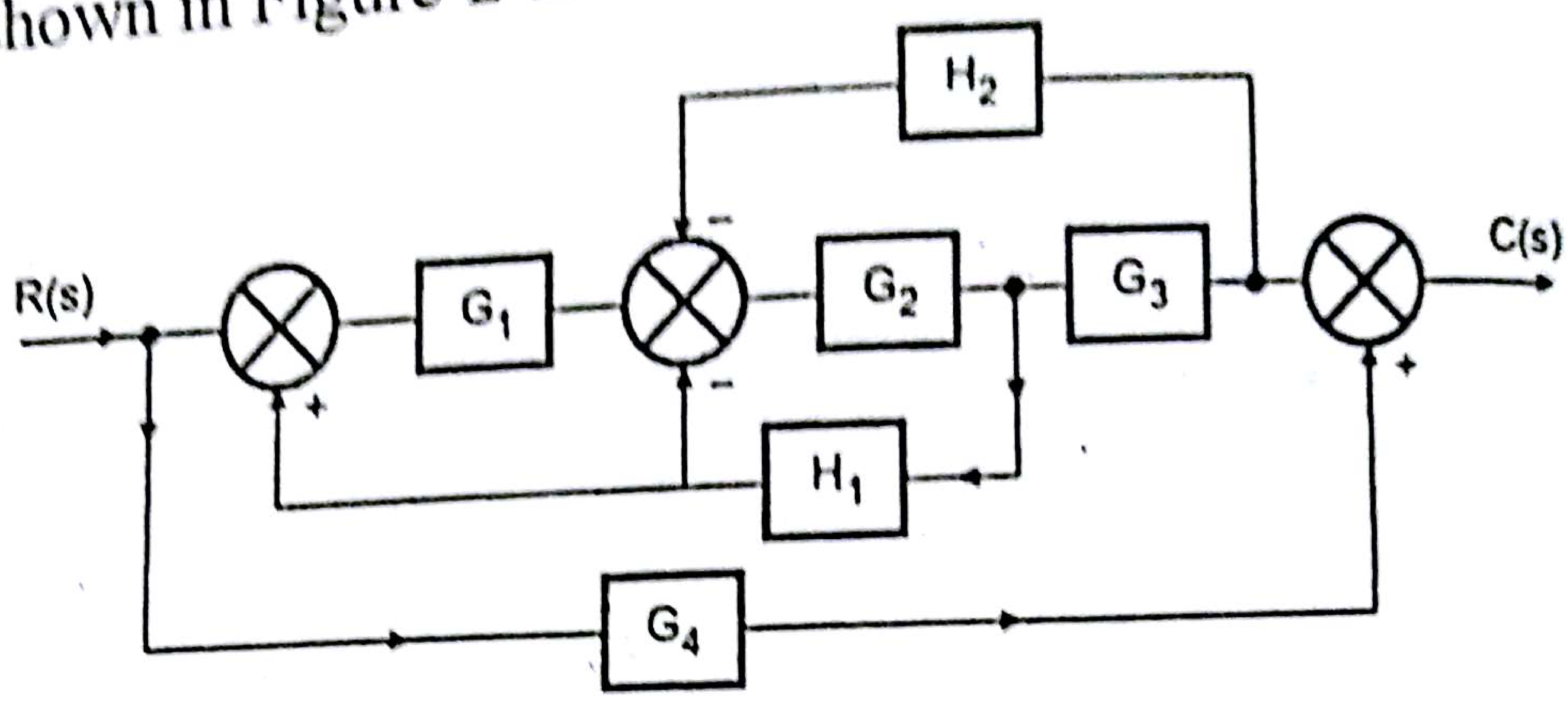


Figure-2

(c) Define sensitivity of the control system. Derive the expression for sensitivity of the closed loop system with respect to feed forward gain G(s) and feedback gain H(s). Hence find the sensitivity of the overall transfer function of the system shown in Figure-3 w.r.t i) forward path transfer function and ii) feedback path transfer function. The value of ω is 1.2 rad/sec. **6**

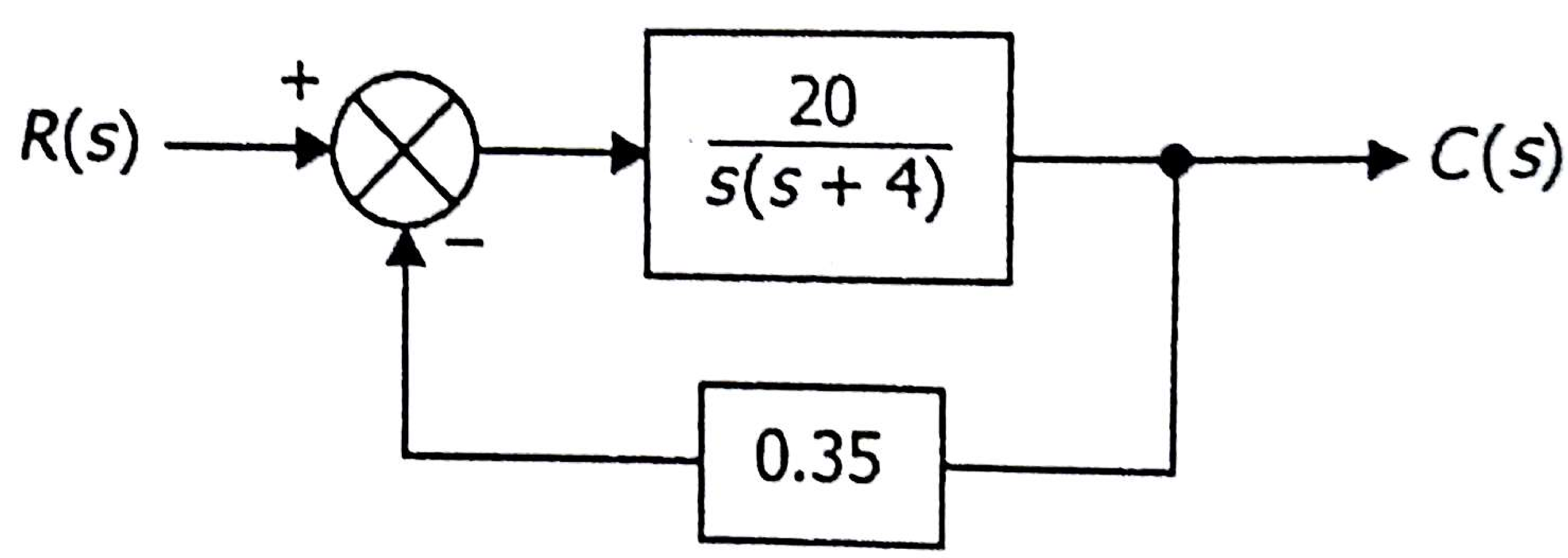


Figure-3

2. **Solve any two from the following.**

(a) What important role does control system components plays while designing any system. Hence explain importance of DC and AC servo motor. **6**

(b) Using generalized error series calculate the steady- **6**

state error of a unity feedback system having $G(s) = 10/(s+2)$ for the following excitation.
i) $r(t) = 3$, ii) $r(t) = 2t$, iii) $r(t) = t^2/2$, iv) $r(t) = 1+2t+t^2/2$

(c) Open loop transfer function of unity feedback system is $G(s) = [K/ (1+Ts).s]$ where K and T are constants. Determine factor by which gain K should be multiplied so that overshoot of unit step response be reduced from 75% to 25%. 6

3. **Solve any two from the following.**

(a) For a unity feedback control system, system is marginally stable and oscillates with frequency 4 rad/sec. Find K_{mar} and 'q'. $G(s) = [4/ (s^2+qs+2K).s]$ 6

(b) The open loop transfer function of a unity feedback control system is $G(s) = [K/s (s+4) (s+6)]$. Draw the root locus of the system. 6

(c) Write short note on: i) PI controller ii) PD controller 6

12

4. (a) A unity feedback control system has $G(s) = [400 (s+2)/ s^2 (s+5) (s+10)]$. Draw the Bode plot. 6

(b) Consider a system with open loop transfer function as $G(s).H(s) = [10/s]$, obtain its polar plot. 6

~~5.~~ (a) The state equation of a linear time invariant system is given below, where u> 0. Determine the following: 6

12

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} -2 & 0 \\ 1 & -1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u$$

i) The state transition matrix

ii) Controllability and observability of the system

(b) Derive the state equation of a system having transfer function as follows: [Y(s)/U(s) = 8/s (s+2) (s+3)] Use i) cascade and ii) parallel decomposition. 6