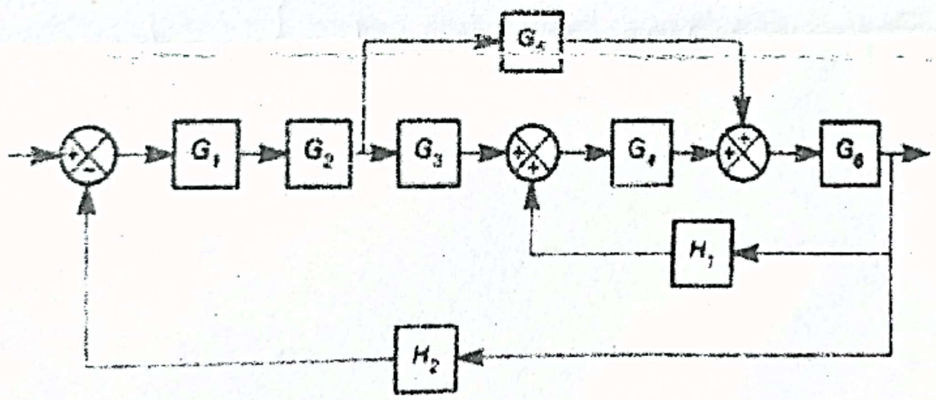
USN

CMRIT

Internal Assessment Test 2 – Dec. 2021

Sub:	Control Engineering					Sub Code:	18ME71/17ME73/15ME73	Branch	ME
Date:	16.12.21	Duration:	90 min's	Max Marks:	50	Sem/Sec:	VII/A&B		OBE

Answer All the Questions

		MARKS	CO	RBT
1	Define: i) Time Response ii) Steady State response iii) Transient Response iv) Steady State Error v) Impulse signal	[10]	CO3	L1
2	A unity feedback system has $G(s) = \frac{K}{s(s+2)(s^2+2s+5)}$ Determine: i) For a unit ramp input, it is desired that $e_{ss} \le 0.2$. Find K ii) Determine e_{ss} if input $r(t) = 2 + 4t + \frac{t^2}{2}$.	[10]	CO3	L3
3	Using Routh's method examine the stability of closed loop system with characteristic equation: $s^6 + 3s^5 + 4s^4 + 6s^3 + 5s^2 + 3s + 2 = 0$	[10]	CO4	L3
4.	Use RH criterion to determine the stability of a system with characteristic equation: $s^6 + 4s^5 + 3s^4 - 16s^2 - 64s - 48 = 0$ Calculate the number of roots with positive real part, negative real part and zero real part.	[10]	CO4	L3
5.	 Obtain the transfer function of the given system using block diagram reduction technique.	[10]	CO4	L3

Faculty Signature CCI Signature HOD Signature

1)

i)

Time response : *The response given by the system which is function of the time, to the applied excitation is called time response of a control system.*

ii)

- **Definition : Steady state response :**

  It is that part of the time response which remains after complete transient response vanishes from the system output.

- This also can be defined as **response of the system as time approaches infinity from the time at which transient response completely dies out.** The steady state response is generally the final value achieved by the system output. Its significance is that it tells us how far away the actual output is from its desired value.

iii)

Definition : Transient response :

The output variation during the time, it takes to achieve its final value is called as ***transient response.*** *The time required to achieve the final value is called* ***transient period.***

iv)

- *The difference between the desired output and the actual output of the system is called* ***steady state error*** *which is denoted as e_{ss}.* This error indicates the accuracy and plays an important role in designing the system.

v)

It is the input applied instantaneously (for short duration of time) of very high amplitude as shown in the Fig. 7.3.4.

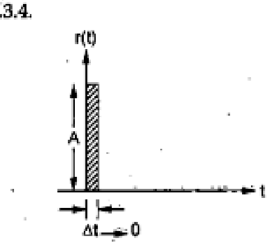


Fig. 7.3.4 Impulse

- Mathematically it can be expressed as,

$$\therefore \quad r(t) = A, \quad \text{for } t = 0$$
$$= 0, \quad \text{for } t \neq 0$$

2)

Sol. : For a given system,

$$G(s)H(s) = \frac{K}{s(s+2)\left(s^2+2s+5\right)}$$

i) For unit ramp input, K_v is required.

$$\therefore \quad K_v = \lim_{s \to 0} sG(s)H(s)$$

$$= \lim_{s \to 0} s\frac{K}{s(s+2)\left(s^2+2s+5\right)} = \frac{K}{10}$$

and $\quad A$ = Magnitude of ramp = 1

$$\therefore \quad e_{ss} = \frac{A}{K_v} = \frac{10}{K}$$

But $\quad e_{ss} \le 0.2 \quad$ i.e. $\quad \frac{10}{K} \le 0.2 \quad$ i.e. $\quad K \ge 50$

Thus for given condition $50 \le K < \infty$.

ii) r(t) is $A_1 = 2$ step, $A_2 = 4$ ramp, $A_3 = 1$ parabolic

And $\quad K_p = \lim_{s \to 0} sG(s)H(s) = \infty,$

$$K_a = \lim_{s \to 0} s^2G(s)H(s) = 0$$

$$\therefore \quad e_{ss} = e_{ss1} + e_{ss2} + e_{ss3} = \frac{A_1}{1+K_p} + \frac{A_2}{K_v} + \frac{A_3}{K_a}$$

$$= \frac{2}{1+\infty} + \frac{4}{\left(\frac{K}{10}\right)} + \frac{1}{0} = \infty$$

3)

s^6	1	4	5	2
s^5	3	6	3	0
s^4	2	4	2	0
s^3	0	0	0	0

⟸ Special case 2

Row of zeros

$$A(s) = 2s^4 + 4s^2 + 2 = 0 \quad \text{i.e.} \quad s^4 + 2s^2 + 1 = 0$$

$$\frac{dA(s)}{ds} = 4s^3 + 4s$$

s^6	1	4	5	2
s^5	3	6	3	0
s^4	2	4	2	0
s^3	4	4	0	0
s^2	2	2	0	0
s^1	0	0	0	0

⟸ Special case 2

Row of zeros again

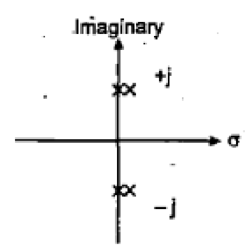
$$\therefore \quad A'(s) = 2s^2 + 2 = 0 \quad \text{i.e.} \quad \frac{dA'(s)}{ds} = 4s = 0$$

s^6	1	4	5	2
s^5	3	6	3	0
s^4	2	4	2	0
s^3	4	4	0	0
s^2	2	2	0	0
s^1	4	0	0	0
s^0	2	0	0	0

- No sign change, hence **no root is located in R.H.S. of s-plane.** As row of zeros occur, system may be marginally stable or unstable. To examine that find the roots of first auxiliary equation.

$$A(s) = s^4 + 2s^2 + 1 = 0 \qquad s^2 = \frac{-2 \pm \sqrt{4-4}}{2} = -1$$

$$s^2 = -1, \quad s^2 = -1, \quad s_{1,2} = \pm j, \quad s_{3,4} = \pm j$$



- The roots of $A'(s) = 0$ are the roots of $A(s) = 0$. So do not solve second auxiliary equation. Predict the stability from the nature of roots of first auxiliary equation.
- **As there are repeated roots on imaginary axis, system is unstable.**

4)

s^6	1	3	−16	−48
s^5	4	0	−64	0
s^4	3	0	−48	0
s^3	0	0	0	⟸ Special case 2

$$A(s) = 3s^4 - 48 = 0$$

$$\frac{dA}{ds} = 12s^3$$

s^6	1	3	−16	−48	
s^5	4	0	−64	0	
s^4	3	0	−48	0	
s^3	12	0	0	0	
s^2	[ε] 0	−48	0	0	
s^1	$\frac{576}{\varepsilon}$	0	0		⟸ Special case 1
s^0	−48				

$$\lim_{\varepsilon \to 0} \frac{576}{\varepsilon} = +\infty$$

∴ One sign change and system is unstable.

Solve, $A(s) = 3s^4 - 48 = 0$

Put $s^2 = y$

∴ $3y^2 = 48$ ∴ $y^2 = 16$, ∴ $y = \pm\sqrt{16}$

∴ $s^2 = +\sqrt{16} = 4$ $s^2 = -\sqrt{16} = -4$

$s = \pm 2$ $s = \pm 2j$

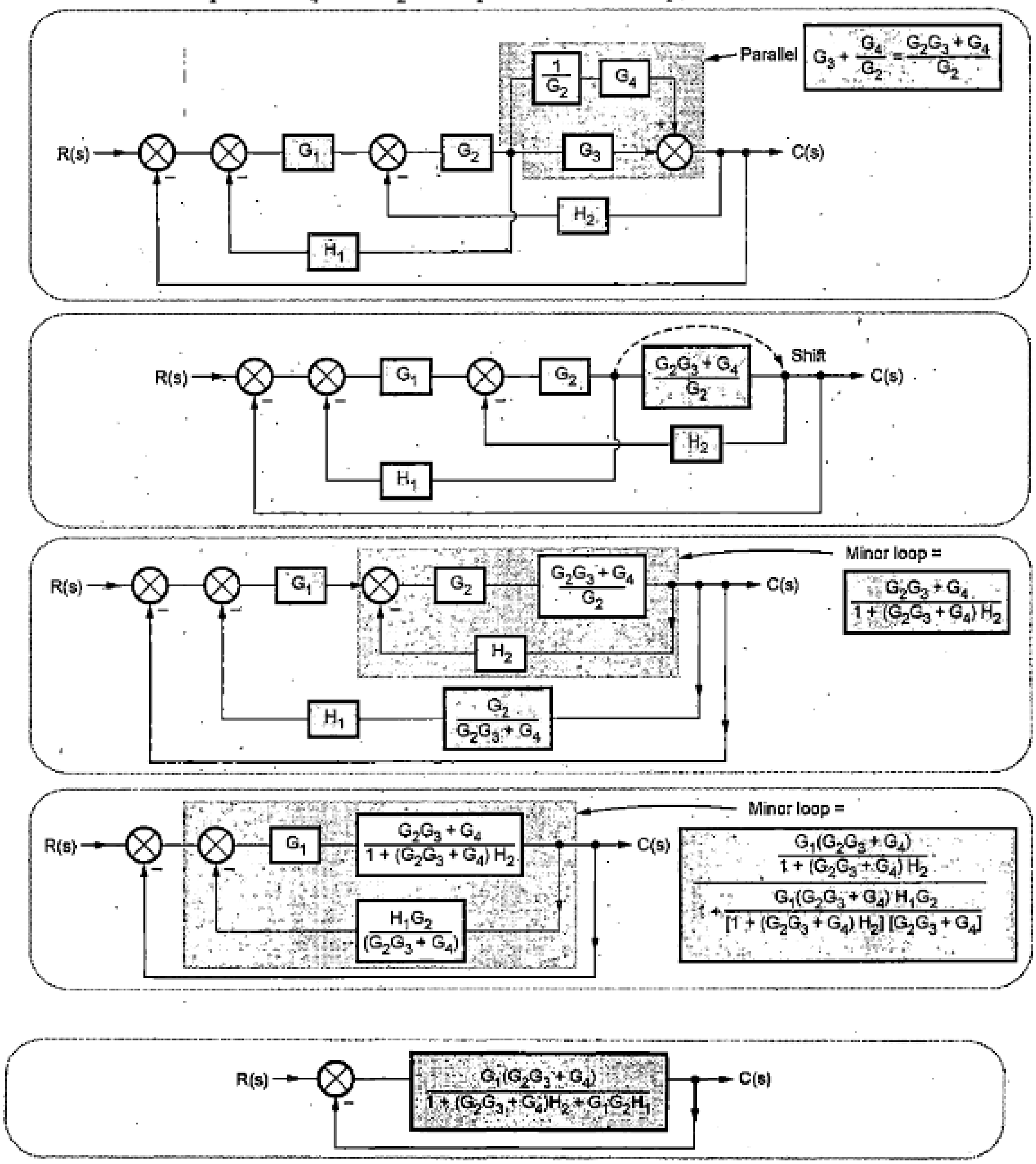
Roots with positive real part → **One**

Roots with zero real part → **Two**

Roots with negative real part → **Three**

5)

Sol. : Shift the take off point of G_4 after G_2 and separate the feedback paths.



$$\therefore \frac{C(s)}{R(s)} = \frac{\dfrac{G_1(G_2G_3+G_4)}{1+(G_2G_3+G_4)H_2+G_1G_2H_1}}{1+\dfrac{G_1(G_2G_3+G_4)}{1+(G_2G_3+G_4)H_2+G_1G_2H_1}} = \boxed{\frac{G_1G_2G_3+G_1G_4}{1+G_2G_3H_2+G_4H_2+G_1G_2H_1+G_1G_2G_3+G_1G_4}}$$