CONTROL System

- It is a system that is required in every type of applications in day to day Life for maintaining the input according to desired output.

- A control system is a system that compors the actual output with a referrine input and gives the desired output.

*. Advantage of control system.

- Quality of the system is improved.
- Productivity increase.
- Overall cost of energy production reduces.
- Control System is a mainly two types.
  - 1) open loop system.
  - 2) closed loop c. system.

→ automatic washing Machine.

closed loop - Ac
Fridge - Refrigeration.

*. Types of control System.

1) Linear and Non-Linear control system.
2) Time varient and Time varing system.
3) continuous time and discrete time system.
4) Pynomic and static system.
5) Single input and single output.
6) Deterministic and stochastic system.

Linear and Non Linear.

(2)

It is a system that posses homogenity and superposition properties.

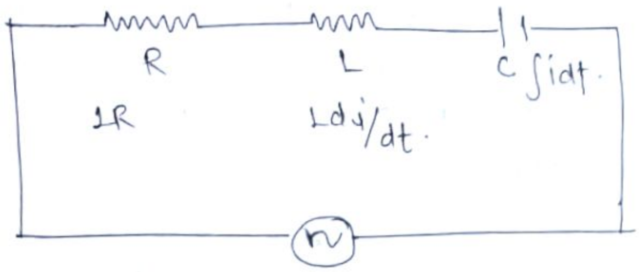
Superposition position:-

It state that It is a input $r_1(t) \rightarrow c_1(t)$ and another input $r_2(t) \longrightarrow c_2(t)$ then if we ambin the input the total system output will be sum of each output Homogenity.

When the behaviour of the system is same for different input is called as homogenity property.

→ Opposite of Linear System.
The system does not posses.

Time invariant and Time varient.

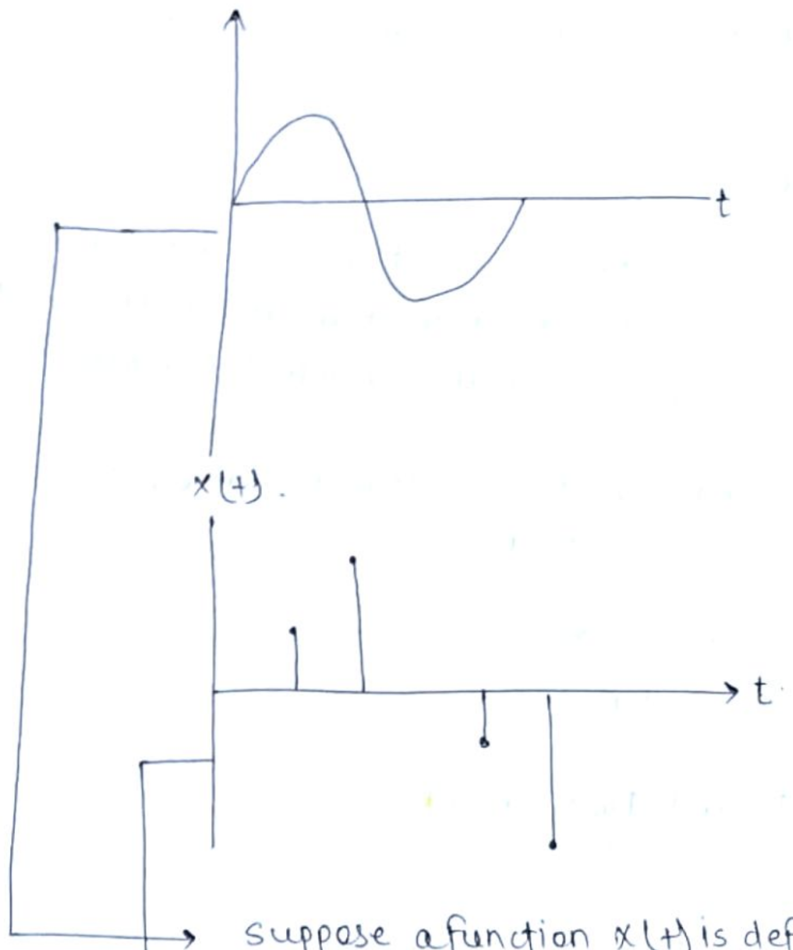


$$V = iR + L\frac{di}{dt} + C\int i\,dt.$$

- If the parameter of the system (RLC) does not vary with time the system is called as time invarient system.

- If any of the parameter (one or more) changes it behaviour with time it is called as the time varying system.

a. Continuous time :-



→ suppose a function x(t) is define for every instant of time and the value are changing at any instant is called as continuous time systm.

→ If the function x(t) is defined for a specific instant of time the system is called discrete time.

Static system.

In a system the input and output does not change with time.

e.g:- Dc electrical circuit with Resistant.

In a system is the output changes even when input is constant is called.

dy.s.

→ Ac circuits.

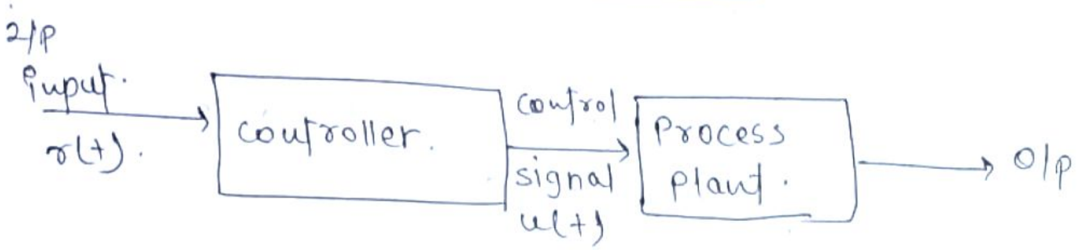
Deterministic and stochastic.

Deterministic :-

In a system for a given input if the system output one defined or can be calculated easily is called as deterministic.

for a given input if the output is uncertain and can be only preducted then the System.

Open loop control System.



It is type of controll system where the controll action body depends on the input signal and independent of output response.

Examples:-

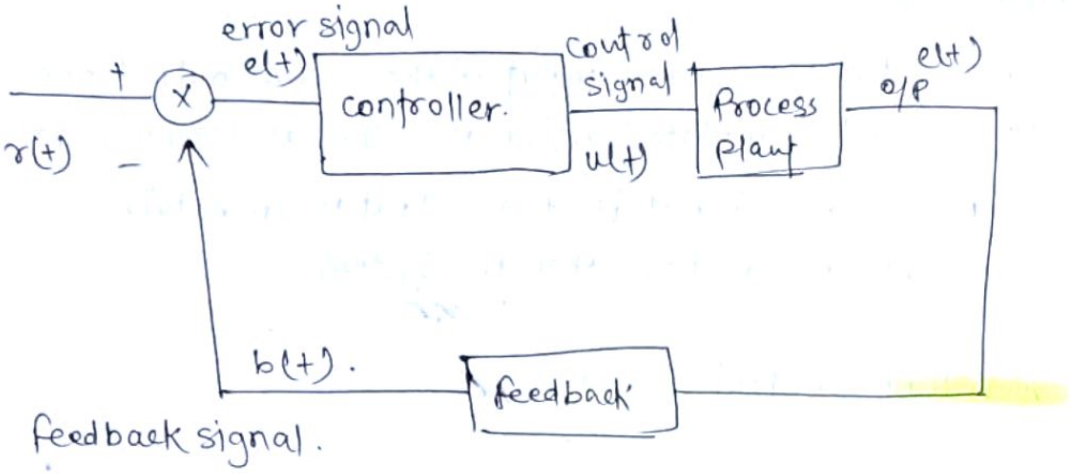
Advantages.

It is simple to design and construct
It is economically
The maintianence cost is very low.
It provides highly stable operation.

Cons.

It is not accurate when the system input or parameters are variable in nature that's way recallibiration of the parameters is required from time to time.

Closed loop control System.



- It is a type of controll system were the control action depends on input signal and output response.

  example :- automatic iron.

  The difference between the actual output of the system and the desired output.

Advantages :-

- It has more accurate operation as comparision to open loop system.
- It can operate efficient even the system inputs or parameter varying in nature.
- It is complex system and costly (disadvantage).
- Time to time re configuration of parameter is not required as theirr is a facility of automation.

Open loop	Closed loop
1.) No feedback is given to c.s	1) A feedback is applied.
2) It cannot be intelligent.	2) As automation is avaitable it is a intelligent controll system.
3) As the input is mostly constnt. their is no possibity of system oscillation.	3) As the system parameter or varying in nature it introduce system oscillation.

(6)

4.) The output will not vary for constant input.	4) The system output vary depends upon feedback loop.
5) Error detection is not present.	5) Error detection is present.
6.) It is mostly a stable system	6) It is prone to instability
7.) It is simple in design and economic	7) It has complex structure and costly.
8) It is effected by non linearity	8) its not affected by non linearity

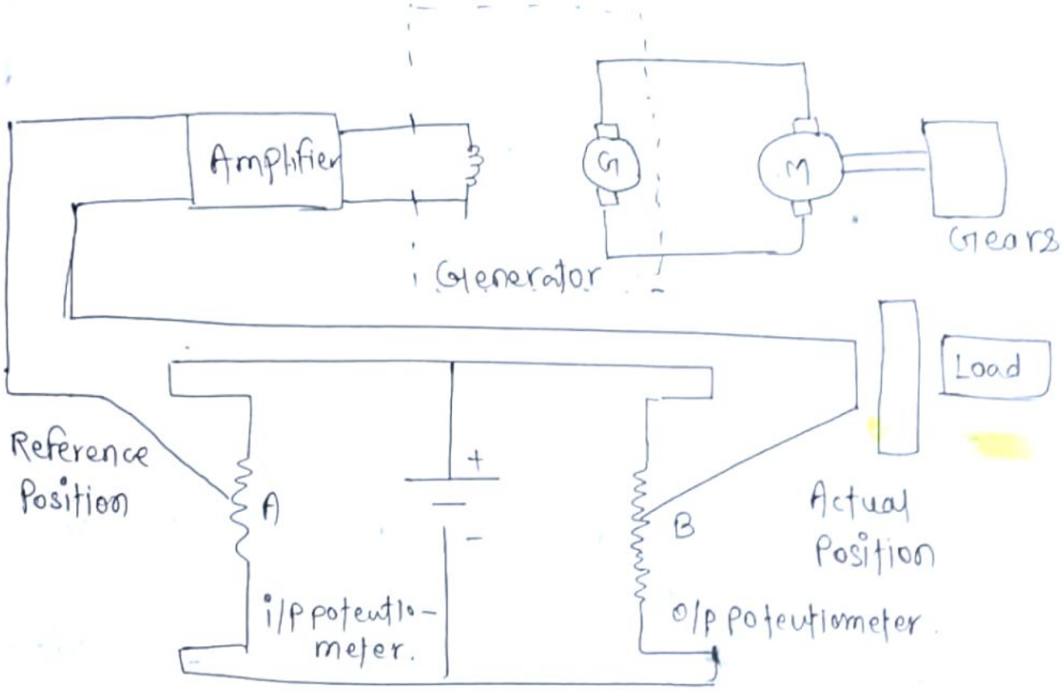
servo Mechanism.

• Block diagram represantation of Industerkal system. (7)

* Servomechanism :-

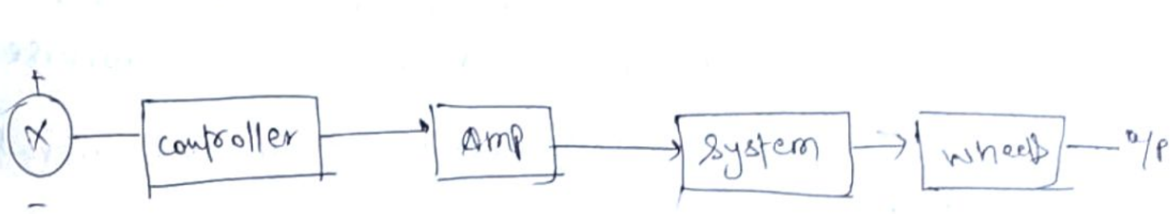
It is a type of controll system mainly used as feedback unit in Mechanical System where Both the input and output signal are Mechanical in nature.

• The output signal is diretely fat to the comparator
• The control variables are either position signal, velocity or acceleration (Mechanical signal).



Examples:-

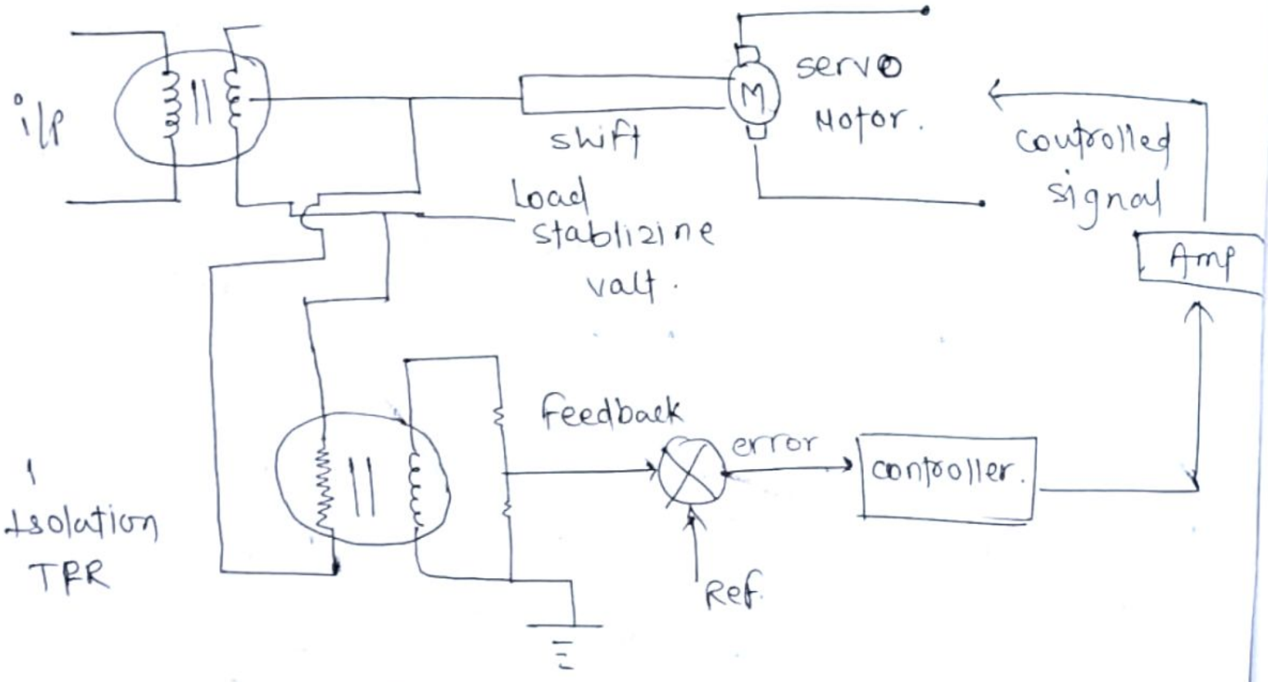
• used in missile launcher. ~~lancher~~
• Machine tool position control
• Power stearing of automobile vehicles



Regulator :-

(8)

It is a feedback unit that is used in electromechanical system where the output is ~~fop~~ constant w.r. of ~~constant~~ the output.



Servomotor :-

It is an Linear actuator that is used for the controll of linear position velocity and acceleration.

• Here the Motor is ~~coupt~~ ~~covered~~ coupled with sensor that is used in automated system

Isolation Transformer :-

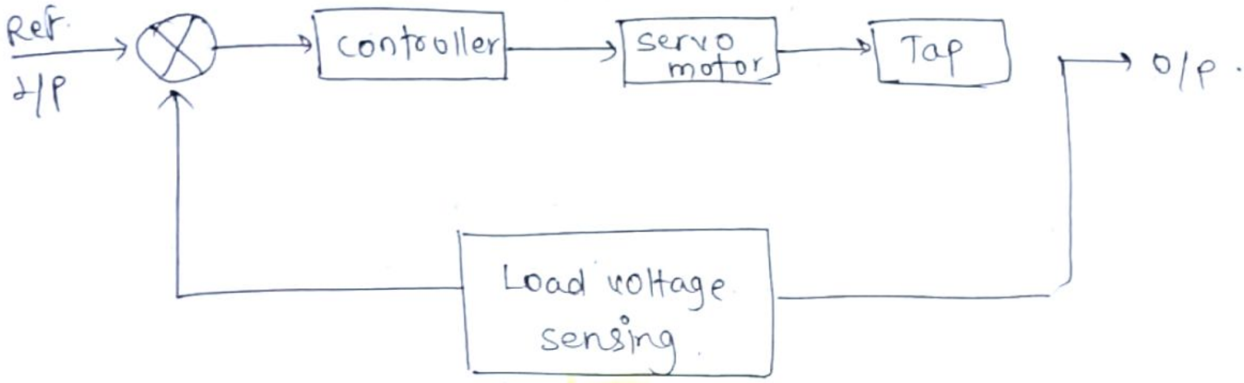
It is the transformer that transfer power from the main A.C source to the device while isolating the Power Device from the Main supply for protection purpose.

• It mainly protect againts voltage and current ~~against~~ surges.

• It transfer power between two circuit which are not connected electrical.

*. Regulator :-

(9)



Feedback.

Example of Regulating System

- speed governer
- Temperature Regulation
- Frequency Regulation.

Laplace Transform of a common function.

function	Time domain $x(t) = L\{(x(s)\}$	function domain.
Delay	$\sigma(t \cdot 2)$	$e^{-\lambda s}$
unit impulse	$\sigma(t)$.	
unit step	$u(t)$	$1/s$
Ramp		$1/s^2$
Exponential delay	$e^{-\alpha t}$	$1/s+\alpha$
Exp. approch	$1 - e^{-\alpha t}$	$\alpha/s+\alpha$
sine	$\sin \omega t$	$\omega/s^2 +$

cosine	$\cos\omega t$	$s/s^2+\omega^2$
hyperbolic sine	$\sinh\alpha t$	$\frac{\alpha^2}{s^2-\alpha^2}$
hyperbolic cosine	$\cosh\alpha t$	$\frac{s}{s^2-\alpha^2}$
Exp. delay sine	$e^{-\alpha t}\sin\omega t$	$\frac{\omega}{(s+\alpha)^2+\omega^2}$
cosine	$e^{-\alpha t}\cos\omega t$	$\frac{s+\alpha}{(s+\alpha)^2+\omega^2}$

Sol^n A L.T.

→ L.T can be

$$N(s) = \frac{A(s)}{B(s)}$$

The denomenaton canbe divided into 3 type.

a) unrepeated Factor.

b) Reapeated factor.

c) Unrepeated complex factor.

a) Unrepeated factor :-

$$\frac{N(s)}{(s+a)(s+b)} = \frac{A}{(s+a)} + \frac{B}{(s+b)}$$

b) Repeated factor :-

$$\frac{N(s)}{(s+a)^2} = \frac{A}{(s+a)^2} + \frac{B}{(s+a)}$$

c) Unrepeated complex factor.

$$\frac{N(s)}{(s+a)(s+\bar{a})} = \frac{As+B}{(s+a)^2+B^2}$$

TRASFER function :-

It Represent's the Ratio of L.T of the o/p is a system to the L.T of i/p of the system. to the L.T of i/p of the system.

$r(t) \rightarrow \boxed{g(t)} \rightarrow c(t)$

(Time domain)

$R(s) \rightarrow \boxed{G(s)} \rightarrow C(s)$.

(frequency domain).

$$\boxed{\text{L.T} \Rightarrow G(s) = \frac{C(s)}{R(s)}}$$

initial condition.

Property Transfer fun^c :-

- Zero Initial condition.
- It is same as L.T of its impulse Response.
- by $\frac{d}{dn}$ function in the transfer function the differential equ^n can be obtained.
-
- Stability can be none.
- It canbe only applicance in Linear system.
-

Advantage of T.F :-

1.) It is the mathematical Representation the gain of the system.

2) The impulse response can be found.

Disadvantage :-

1.) It is not applicance if the initial condition are reglected.

2) It give no information about actual structure physical system.

3) The poles of the transform function are those value of 's' which make the transfer function tend to ∞.

4) The 'zero's' of the transfer function are thus value of 's' which make the transfer function tend to zero.

5) If either 'Poles or zero' consider then such types of poles or zero are calculated Multiple pole or Multiple zero.

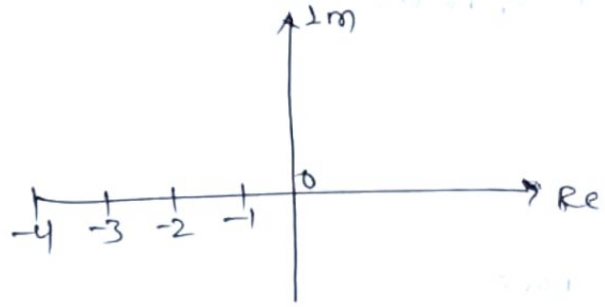
$$G(s) = \frac{50(s+3)}{s(s+2)(s+4)^2} \quad \begin{matrix} =0 \\ =0. \end{matrix}$$

Poles (x) on zeros (o).

$s=0$ $\qquad$ $s=-3$

$s=-2$

$s=-4.$



Signal flow graph (Page-17)."

The poles of the transfer function are those values of s which make the transfer function tend to infinity.

$$G(s) = \frac{50(s+3)}{s(s+2)(s+4)^2} \qquad \frac{(\text{Poles})}{\text{zero}}$$

The zero's of the transfer function are those value of s which make the transfer function tend to zero.

- If either poles or zero go inside then such type of poles or zero are called multiple pole and multiple zero.

$$G(s) = \frac{50(s+3)}{s(s+2)(s+4)^2} \quad \begin{matrix} = 0 \\ = 0 \end{matrix}$$

Poles(zero(o)

$s = 0$ $s = -3$

$s = 2$

$s = 4$

A system having input ($x(t)$) and output $y(t)$ is Represented by

$$\frac{dy(t)}{dt} + 4y(t) = \frac{dx(t)}{t} + 5x(t).$$

$$\frac{dy(t)}{dt} + 4y(t) = \frac{dx(t)}{dt} + 5x(t)$$

$y(t) \xrightarrow{Lap} y(s)$

$\frac{dy(t)}{dt} \xrightarrow{Lap} sy(s)$

$$\boxed{\cancel{y(t)\left[\frac{d}{dt} + 4\right]} = \cancel{x(t)\left[\frac{d}{dt} + 5\right]}}$$

$$sy(s) + 4y(s) = s\,x(s) + 5x(s).$$

$$y(s)[s+4] = x(s)[s+5]$$

$$\boxed{\frac{y(s)}{x(s)} = \frac{(s+5)}{(s+4)}}$$

Q:- The transfer function of the system is given by (15)

$$G(s) = \frac{4s+1}{s^2+2s+3}$$

Find the differential eqn of the system having input $x(t)$ and output $y(t)$.

Ans:- Input $x(t) \xrightarrow{L.T} x(s)$

output $y(t) \xrightarrow{L.T} y(s)$.

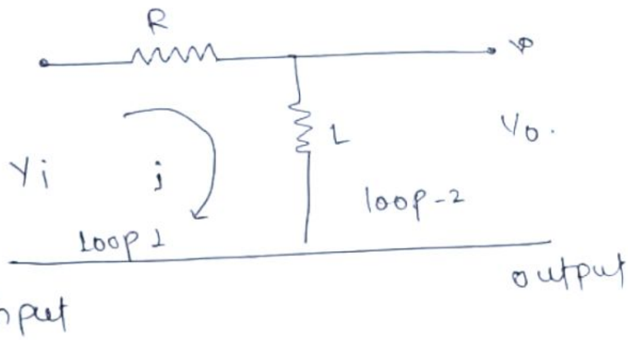
$$G(s) = \frac{y(s)}{x(s)} = \frac{4s+1}{s^2+2s+3}$$

$$= Y(s)(s^2+2s+3) = x(s)(4s+1)$$

$$= s^2 Y(s) + 2s(Y(s)) + 3Y(s) = 4s(x(s)) + x(s).$$

$$= \frac{d^2 y(t)}{dt^2} + \frac{2\, d\, y(t)}{dt} + 3y(t) = \frac{4\, d\, x(t)}{dt} + x(t).$$

Ques:- Find the transfer function of the given network



$$V_i(t) = Ri(t) + L \cdot \frac{di(t)}{dt}$$

$$V_o(t) = \frac{L\, di(t)}{dt}.$$

taking Lapalce transfer

$$V_i(s) = RI(s) + sLI(s).$$

$$V_o(s) = sLI(s)$$

$$T.F = \frac{V_o(s)}{V_i(s)} = \frac{LsI(s)}{\cancel{RI(s)+LsI(s)}\;(R+SL)(IS)} = \frac{SL}{(R+SL)}$$

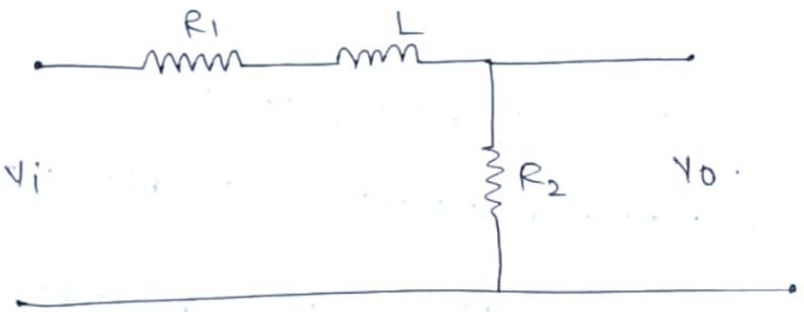
(1) for the given differential equn. find transfer function

(i) a) $\frac{d^2y}{dt^2} + 10\frac{dy}{dt} - 5y = 3x.$

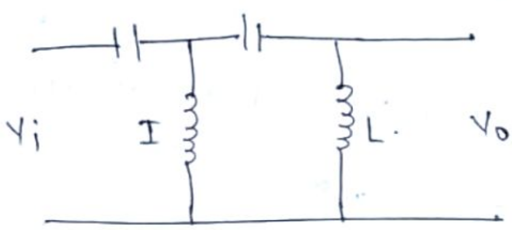
(ii) b) $\frac{d^2y}{dt^2} + 3y\,\cancel{(x)} = 5x.$

$y(t) \rightarrow$ output. $x(t) \rightarrow$ input.

(2) determine the transfer function of a given network.



(b)

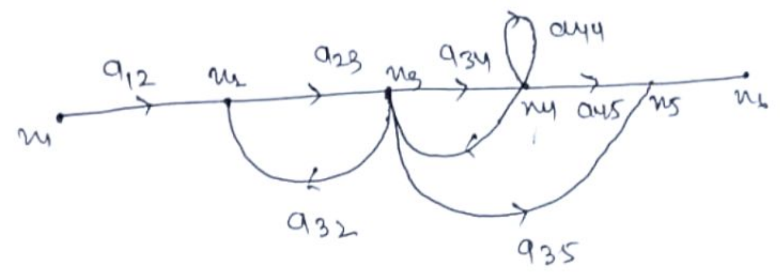


if L = 1H.

C = 1F.

Signal Flow Graph :-

- The process of block digram reduction was develop by S.J Mason.
- This Methode does not Required any reduction techique.
- It is a diagram which represent a set of simultaneous equation.
- It is ~~applicatic~~ applicable to Linear time invarient system.
- each variable is represented by a node. connected by a direct line called branches.
- every branch having an arrow represents the flow of signal.



1) Input Nodes / source Node :-
It has only outgoing Branches. → x_1

2) Output Node / Sink notes :-
It has only one or more incoming branches. → x_6

3.) Mixed Nodes :-
A node having incoming as well as outgoing branches. — x_2, x_3, x_4, x_5

4.) Transmittance :-

It is also known as transfer function which is normally written on the Branch near the ~~arro~~ arrow. - a_{12}, a_{23}, a_{32} etc

5.) forward path :-

It originates from the input nodes and terminates at the output node and along which no node is traversed more than one.

1.) $x_1 - x_2 - x_3 - x_4 - x_5 - x_6$.

2.) $x_1 - x_2 - x_3 - x_5 - x_6$.

6. Loop :- It is a path that originate and terminate on the same nodes and along which no other node is traversed more than one.

$x_2 - x_3 - x_2$

$x_3 - x_4 - x_3$

7.) self Loop :- It is a path which originate and terminate on the same node and does not Required other node to complete the loop.

8) Path Gain :- The product of the branch gains along the path is called path gain

for forward path 1

Gain :- $a_{12}, a_{23}, a_{34}, a_{45} \cdot 1$.

for forward path 2.

Gain :- $a_{12}, a_{23}, a_{35} \cdot 1$.

9) Loop Gain :-

Loop 1 :- a_{23}, a_{32}

Loop 2 :- a_{31}, a_{43}.

Loop 3 :- a_{44}.

10) Non touching Loop :- It has having no common nodes and Branches path.

x_2 to x_3 and $x_4 - x_4$.

The Gain of signal flow graph is given by Mason's Gain formula.

Mason's Gain formula →

$$T.(s) = \frac{\sum \cancel{g_k} \; g_K \Delta_K.}{\Delta}$$

$T.(s)$:- Transfer function / Gain of the overall system.

$\Delta = 1 -$ [sum of all individual loop gain]

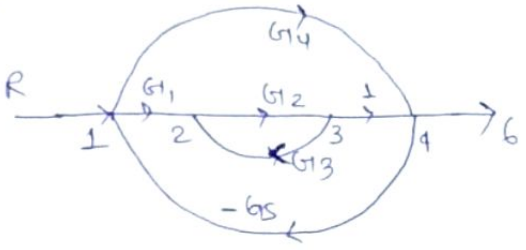
$+$ [Sum of all possible gain products of two non touching loops]

$-$ [sum of all possible gain products of three non-touching Loops]

ΔK = the part of Δ not touching the k^{th} forward path.

gK = Gain of the k^{th} forward path.

Q:- 7-Dec



No of forward path (k) = 2.

Path-I 1-2-3-4.

Path-II 1-4

Gain of forward path I $(g_1) = G_1G_2$

" " " " II $(g_2) = G_4$.

No. of Individual Loops = 3.

L_1 (2-3-2) $= G_2G_3$

L_2 (1-2-3-4-1) $= -G_1G_2G_5$

L_3 (1-4-1) $= \cancel{G_4 G_3} \cdot -G_4G_5$

Two non touching Loop $(L_1 \cdot L_3)$.

$$L_1L_3 = -G_2G_3G_4G_5$$

$$\Delta = 1 - [L_1 + L_2 + L_3] + L_1L_3.$$

$\Delta_1 = 1 - 0 = 1$ (forward path 1)

$\Delta_2 = 1 - G_2G_3$. (" " 2)

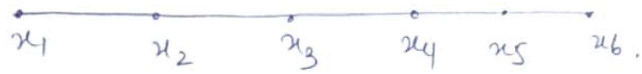
$$\text{T.F} = \frac{C}{R} = \frac{\Sigma g_K \Delta_K}{\Delta}$$

$$= \frac{g_1\Delta_1 + g_2\Delta_2}{\Delta}$$

$$= \frac{G_1G_2 - 1 + G_4(1 - G_2G_3)}{1 - (G_2G_3 + (-G_1G_2G_3) + (-G_4G_5) + (-G_2G_3G_4G_5))}$$

$$\boxed{\text{T.F.} = \frac{G_1G_2 + G_4 - G_2G_3G_4}{1 - G_2G_3 - G_1G_2G_3 - G_4G_5 - G_2G_3G_4G_5}}$$

e.g.



$x_2 = x_1 + a x_5$

$x_3 = b x_2 + c x_4$.

$x_4 = d x_2 + e x_3$.

$x_5 = f x_4 + g x_3$

$x_6 = x_5$.

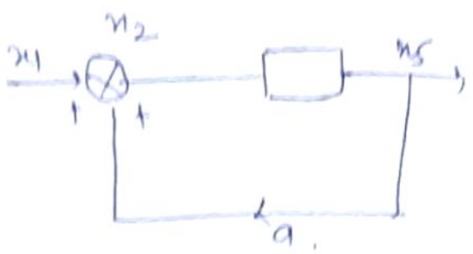
(2) $x_2 = x_1 + a x_5$

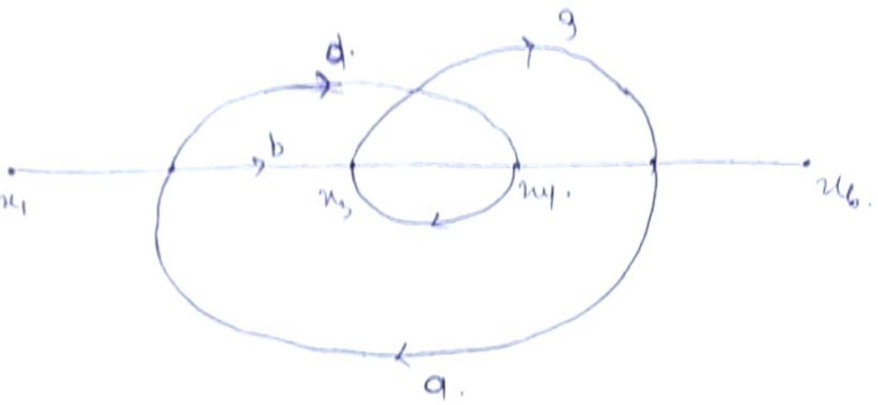
$x_3 = b x_2 + c x_4$

$x_4 = d x_2 + e x_3$

$x_5 = f x_4 + g x_3$

$x_6 = x_5$





(3) For the systems Represented by given equation. Find T.F $\frac{x_5}{x_1}$ by the help of sigle flow graph techique.

$x_2 = a_{12} x_1 + a_{32} x_3 + a_{42} x_4 + a_{52} x_5$.

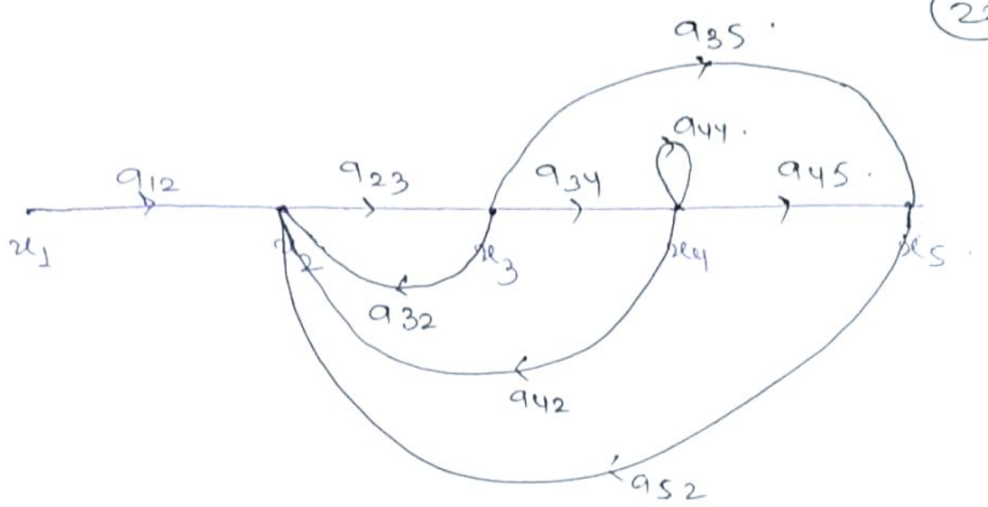
$x_3 = a_{23} x_2$

$x_4 = a_{34} x_3 + a_{44} x_4$.

$x_5 = a_{35} x_3 + a_{45} x_4$.

$x_1 \rightarrow$ Input.

$x_5 \rightarrow$ output.



No. of Forward path (K) = 2

Path I = $x_1 - x_2 - x_3 - x_4 - x_5$

Path-II = $\cancel{x_3 - x_5}$ $x_1 - x_2 - x_3 - x_5$

Gain of forward path I (g_1) = $a_{12}\, a_{23} \cdot a_{34}\, a_{45}$.

Gain of forward path II (g_2) = $\cancel{a_{..}}$ $a_{12} a_{23} a_{35}$.

No. of Individual Loop = 5.

$L_1 (x_2 - x_3 - x_2) = a_{23}\, a_{32}$

$L_2 (x_2 - x_3 - x_4 - x_2) = a_{23}\, a_{34} \cdot a_{42}$

$L_3 (x_2 - x_3 - x_4 - x_5 - x_2) = a_{23}\, a_{34}\, a_{45} a_{52}$

$L_4 (x_2 - x_3 - x_5 - x_2) = \cancel{a_{35} a_{45} a_{34}} \cdot a_{23} a_{35} a_{52}$

$L_5 (x_4) = a_{44}$.

Two non touching Loop

$(L_1 L_5)$ and $(L_4 \cdot L_5)$

$L_1 L_5 = a_{23} a_{32} a_{44}$.

$L_4 \cdot L_5 = a_{23}\, a_{35} a_{52} a_{44}$.

$$\Delta = 1 - [L_1 + L_2 + L_3 + L_4 + L_5] + (L_1 L_5 + L_4 \cdot L_5)$$

$$= 1 - [a_{23}a_{32} + a_{23}a_{34}a_{42} + a_{23}a_{34}a_{45}a_{52} + a_{23}a_{35}a_{52} + a_{44})$$

$$+ (a_{23}a_{32}a_{44} + a_{23}a_{35}a_{52}\,a_{44})$$

$\Delta_1 = 1 - 0 = 1$ (all nodes are involved.) (23)

$\Delta_2 = 1 - L_5 = 1 - a_{44}$.

$$T.F = \frac{C}{R} = \frac{g_K \Delta_K}{\Delta}$$

$$= \frac{g_1 \Delta_1 + g_2 \Delta_2}{\Delta}$$

$$= \frac{a_{12}a_{23}a_{34}a_{45} \cdot 1 + a_{12}a_{23}a_{35}(1 - a_{44})}{\Delta}$$

$$= \frac{a_{12}a_{23}a_{34}a_{45} + a_{12}a_{23}a_{35}(1-a_{44})}{1 - [a_{23}a_{32} + a_{23}a_{34}a_{42} + a_{23}a_{34}a_{45}a_{52} + a_{23}a_{35}a_{52} + a_{44}) + (a_{23}a_{32}a_{44} + a_{23}a_{35}a_{52}a_{44})}.$$

Assigment Question.

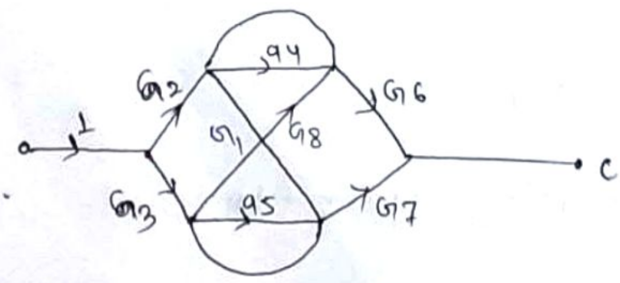
1.) ~~Do~~ Optain the signal flow graph of T.F througu following equn.

$x_2 = 9x_1 + 2x_3 + 2x_2$

$x_3 = 6x_1 + 5x_2 + 2x_3$

$x_4 = 2x_2 + 2x_3$

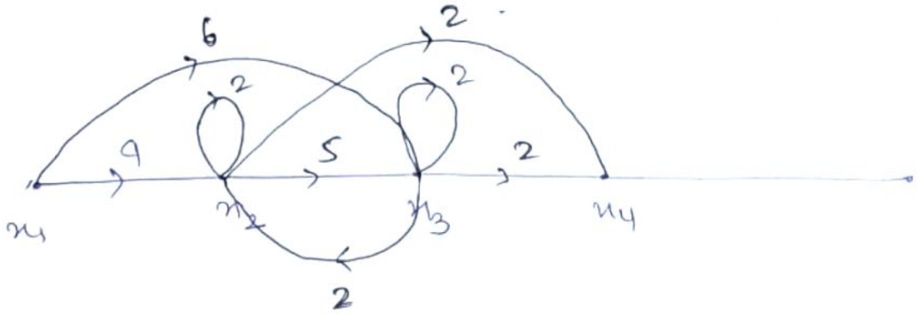
(2) Optain the T.F from the signal flow graph.



Answer

(1) Given eqn.

$$x_2 = 4x_1 + 2x_3 + 2x_2$$
$$x_3 = 6x_1 + 5x_2 + 2x_3$$
$$x_4 = 2x_2 + 2x_3.$$



No. of forward path. (K) = 3.

Path 1 = $x_1 - x_2 - x_3 - x_4$.

Path 2 = $x_1 - x_3$

Path 3 = $x_1 - x_2 - x_4$.

Gain of forward path (1) (g_1) = $4 \times 5 \times 2$

$= 40.$

Gain of forward path 11 (g_2) = 6.

Gain of forward path 3 (g_3) = $4 \times 2 = 8$.

No. of Individual Loop. = 5.

$L_1 (x_1 - x_3 - x_2 - x_4) = 6 \times 2 \times 4 = 48$

$L_2 (x_4 - x_2 - x_4 - x_2 - x_4) = 4 \times 2 \times 2 \times 5 \times 4 = 320$

$L_3 (x_2 - x_3 - x_2) = 5 \times 2 = 10$

$L_4 (x_2 - x_2) = 2$

$L_5 (x_3 - x_3) = 2$

Two non touching loop.

$(L_2 \cdot L_5)$ & $(L_4 \cdot L_5)$.

$L_2 \cdot L_5 = 320 \times 2 = 640.$

$L_4 \cdot L_5 = 2 \times 2 = 4.$

(25)

$$\Delta = 1 - [L_1 + L_2 + L_3 + L_4 + L_5] + [L_2 \cdot L_5 + L_4 \cdot L_5]$$

$$= 1 - [48 + 320 + 10 + 2 + 2] + [640 + 4]$$

$$= 1 - [382] + [644]$$

$$= 1 - 1026$$

$$= -1025.$$

$$\Delta_1 = 1 - 0 = 1$$

$$\Delta_2 = 1 - L_4 = 1 - 2 = -1.$$

$$\Delta_3 = 1 - L_5 = 1 - 2 = -1.$$

$$T.f = \frac{C}{R} = \frac{g_K \Delta_K}{\Delta}.$$

$$= \frac{g_1\Delta_1 + g_2\Delta_2 + g_3\Delta_3}{\Delta}.$$

$$= \frac{40 \times 1 + 6 \times -1 + 8 \times -1}{-1025}$$

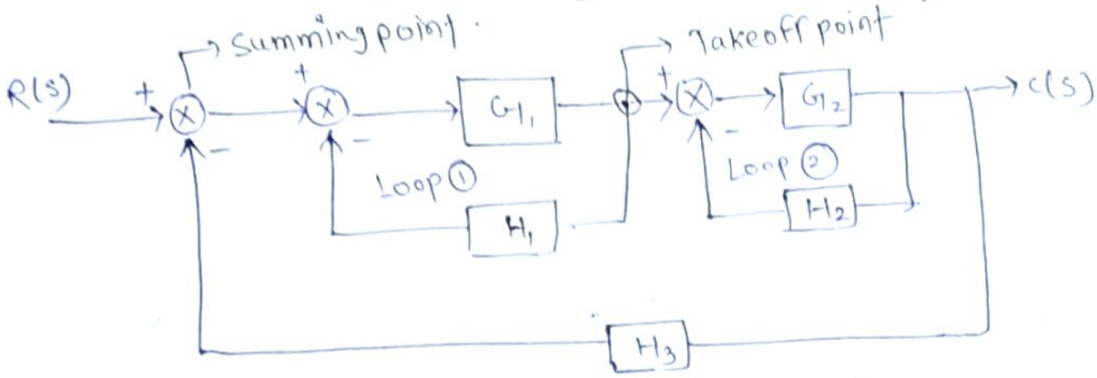
$$= \frac{40 - 6 - 8}{1025} = \frac{40 - 14}{-1025} = \frac{26}{-1025} = \frac{-26}{1025}$$

$$\boxed{T.f. = \frac{-26}{1025}}$$

Block Diagram Reduction Techique. (26)

- Block diagram is a pictorical Representation of the complecated control system. It can be Reduced by the Reduction Rule.
- When A No blocks are connected the overall T.f obtained by Block diagram Reduction Techique.

1.) Drive the T.f using Blockdiagram Reduction Techique



close loop → O/p depend on I/p.
There is a Relation between O/p and I/p.

Open Loop → O/p d not depend on I/p.
This is ano any Relation between O/p and I/p.

Step-I :- There are 2 internal Loop. Remove this Loop By using the equation

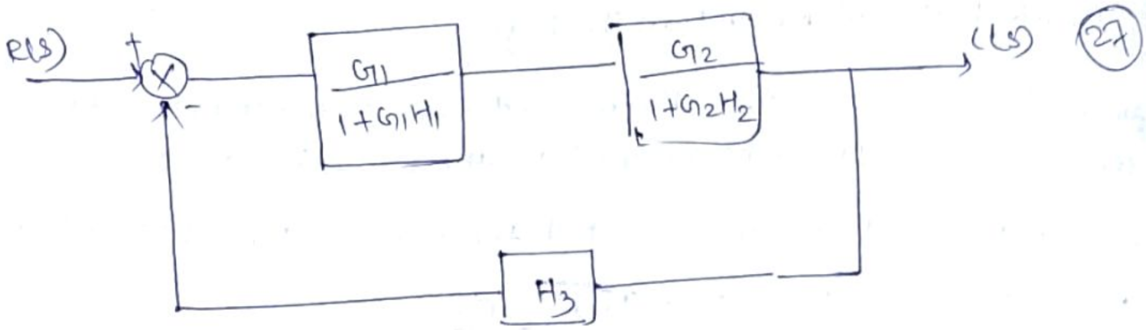
$$\frac{C(S)}{R(S)} = \frac{G(S)}{1+G(S)H(S)}$$

Internal Loop-1.

$$\frac{C(S)}{R(S)} = \frac{G_1(S)}{1+G_1(S)H_1(S)} = \frac{G_1(S)}{1+G_1H_1}$$ for -ve feedback

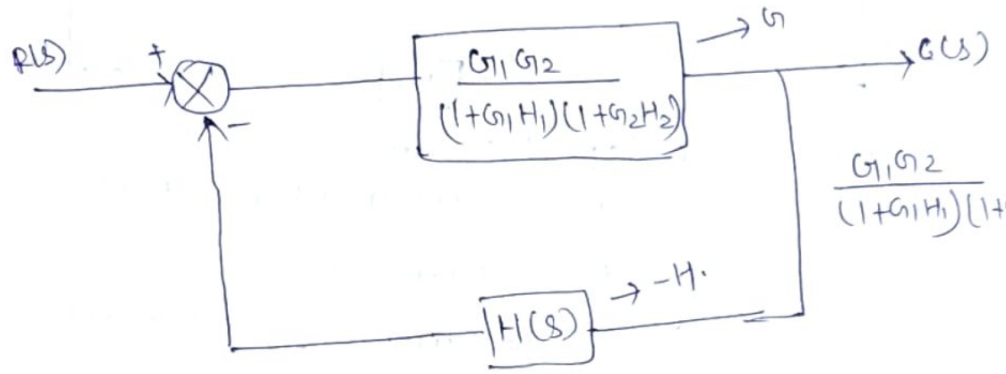
Internal Loop-2

$$\frac{C(S)}{R(S)} = \frac{G_2(S)}{1+G_2H_2}.$$



Step 2 :- The 2 Blocks are in casacade after that

Rule 1 :- When 2 or more block are in casacade (series) The Resultant Block is a product of Individual Block Transfer function.



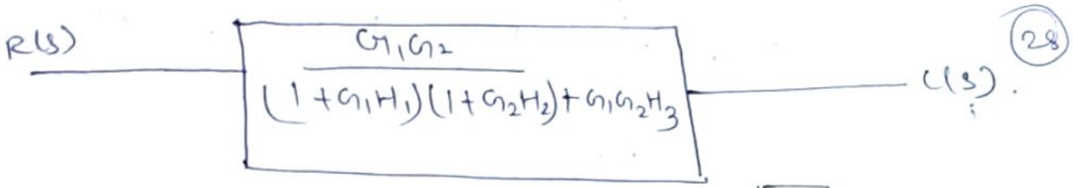
$\frac{G_1 G_2}{(1+G_1H_1)(1+G_2H_2)}$ Represt by

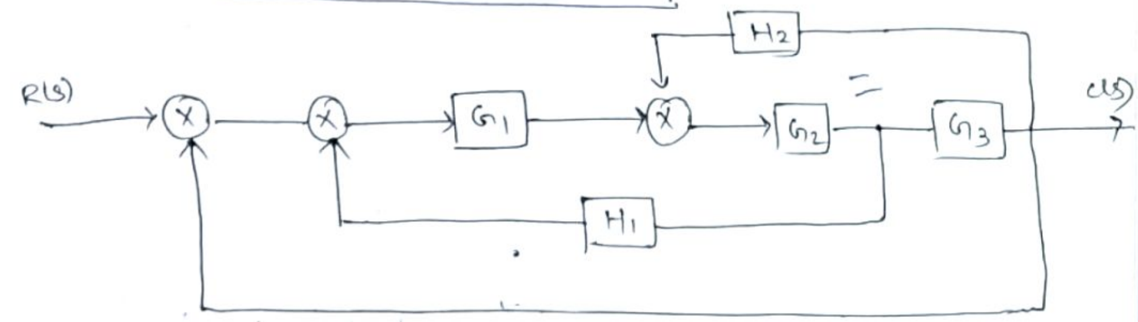
step 3:- Use the close loop equation to Reduce the Block.

$$\frac{C(s)}{R(s)} = \frac{G}{1+GH} = \frac{\frac{G_1 G_2}{(1+G_1H_1)(1+G_2H_2)}}{1+\frac{G_1 G_2}{(1+G_1H_1)(1+G_2H_2)} \cdot H_3}$$

$$= \frac{\frac{G_1 G_2}{(1+G_1H_1)(1+G_2H_2)}}{\frac{(1+G_1H_1)(1+G_2H_2)+G_1G_2H_3}{(1+G_1H_1)(1+G_2H_2)}}.$$

$$= \frac{G_1 G_2}{(1+G_1H_1)(1+G_2H_2)+G_1G_2H_3}$$



② 

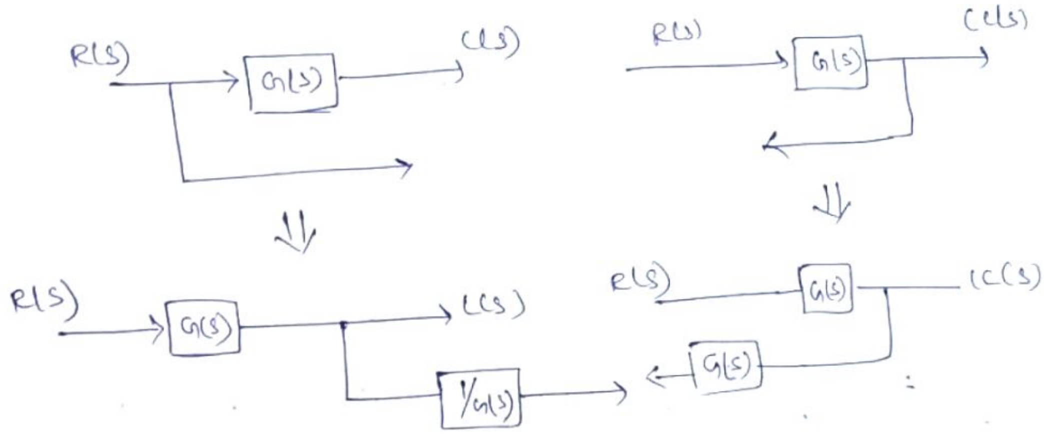
<u>Solution</u>

step 1 :- shift the take of point beyond the Block G_3.

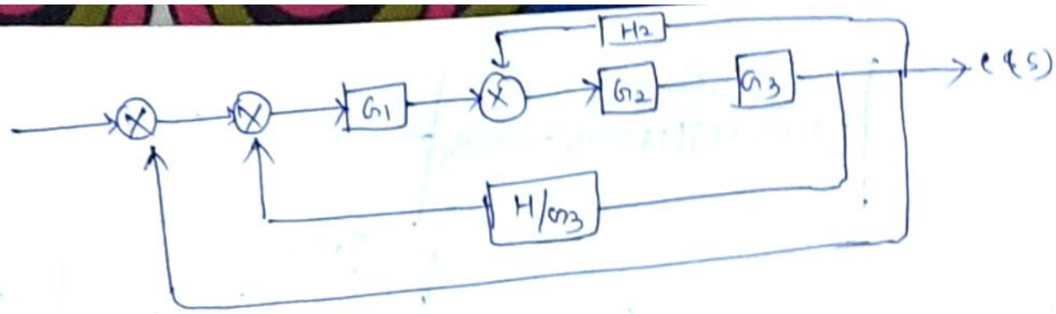
$$\frac{C(s)}{R(s)} = \frac{G(s)}{1+G(s)H(s)}$$

Rule 4 :- Moving a take of point after the block

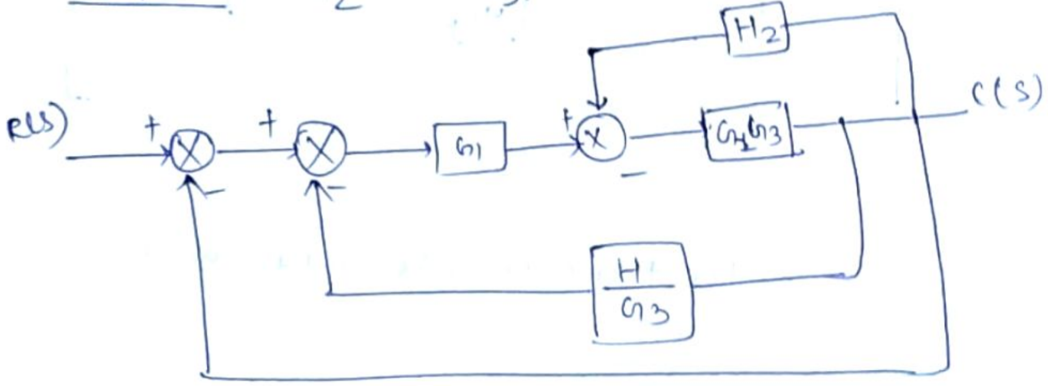
If the take off point is move after a block. A block with the Reciprocal with the T.F is introduce in the Branch of a take off point as shown fig :—



If the take off point is move before a block. A block with the same with the T.F is introduce in the branch of a take off point.



step 2 :- G_2 and G_3 cascade

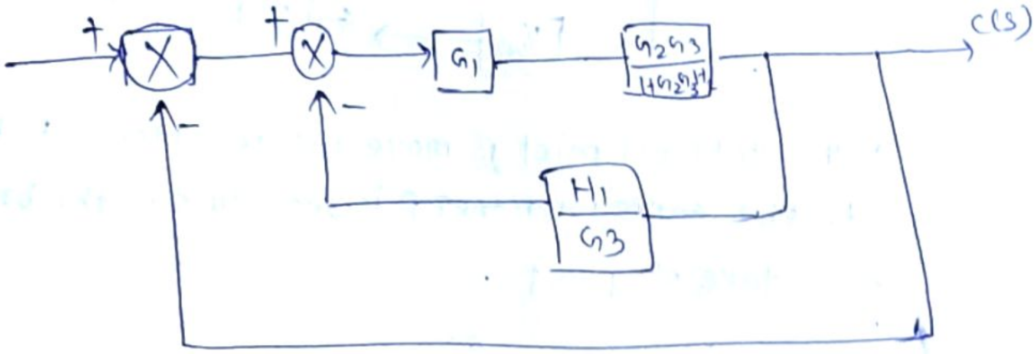


step 3 :- Reduce the close loop system
where $G = G_2 G_3$ and $H = H_2$.

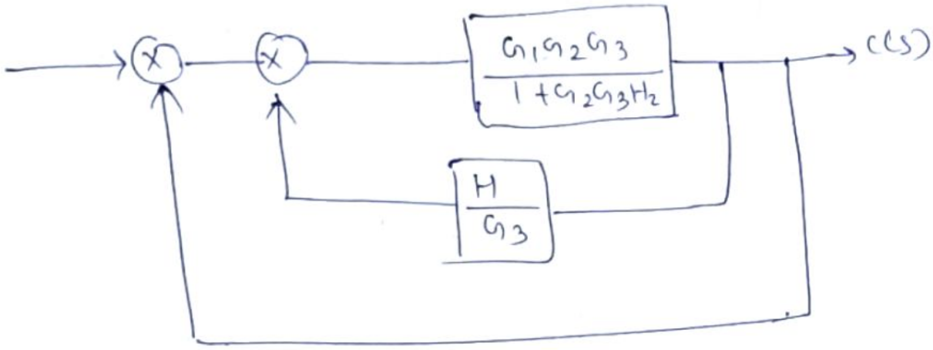
$$\frac{C(s)}{R(s)} = \frac{G}{1+GH}$$

$$= \frac{G_2 G_3}{1+G_2 G_3 \cdot H_2}$$

$$= \frac{G_2 G_3}{1+G_2 G_3 H_2}$$



step-4:- G_1 and $\frac{G_2G_3}{1+G_2G_3H_2}$ are cascade. (30)



Step 5:- Reduce the closed Loop

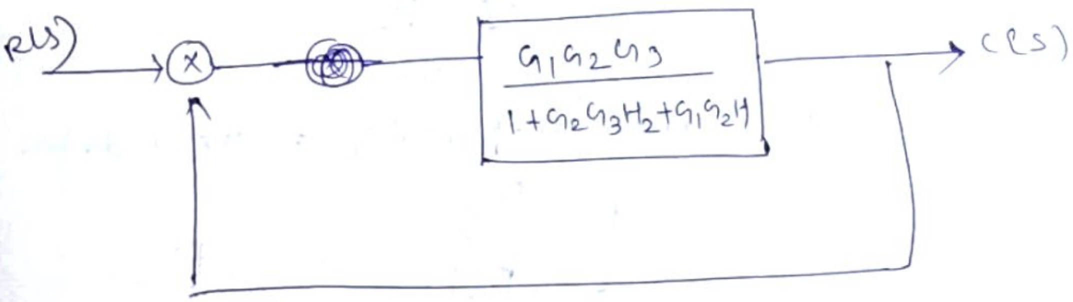
where $G = \frac{G_1G_2G_3}{1+G_2G_3H_2}$

and $H = H/G_3$.

$$\frac{C(s)}{R(s)} = \frac{G}{1+GH} = \frac{\frac{G_1G_2G_3}{1+G_2G_3H_2}}{1+\frac{G_1G_2\cancel{G_3}}{1+G_2G_3H_2}\cdot\frac{H}{\cancel{G_3}}}$$

$$= \frac{\frac{G_1G_2G_3}{1+G_2G_3H_2}}{\frac{1+G_2G_3H_2+G_1G_2H}{1+G_2G_3H_2}}$$

$$= \frac{G_1G_2G_3}{1+G_2G_3H_2+G_1G_2H}.$$



Step 6 :- Find the final Transfer function.

When No given value of H then $H = 1$

If $H = 0$ no path.

$$\frac{C(s)}{R(s)} = \frac{G(s)}{1+GH} = \frac{\dfrac{G_1 G_2 G_3}{1+G_2G_3H_2+G_1G_2H_1}}{1+\dfrac{G_1G_2G_3}{1+G_2G_3H_2+G_1G_2H_1}\cdot 1}$$

$$= \frac{\dfrac{G_1 G_2 G_3}{\cancel{1+G_2G_3H_2+G_1G_2H_1}}}{\dfrac{1+G_2G_3H_2+G_1G_2H_1+G_1G_2G_3}{\cancel{1+G_2G_3H_2+G_1G_2H_1}}}$$

$$= \frac{G_1G_2G_3}{1+G_2G_3H_2+G_1G_2H_1+G_1G_2G_3}.$$

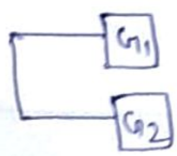
$$R(s) \longrightarrow \boxed{\frac{G_1G_2G_3}{1+G_2G_3H_2+G_1G_2H_1+G_2G_2G_3}} \longrightarrow C(s)$$

Note :- When block in cascade (series) = Multiply

eg:-

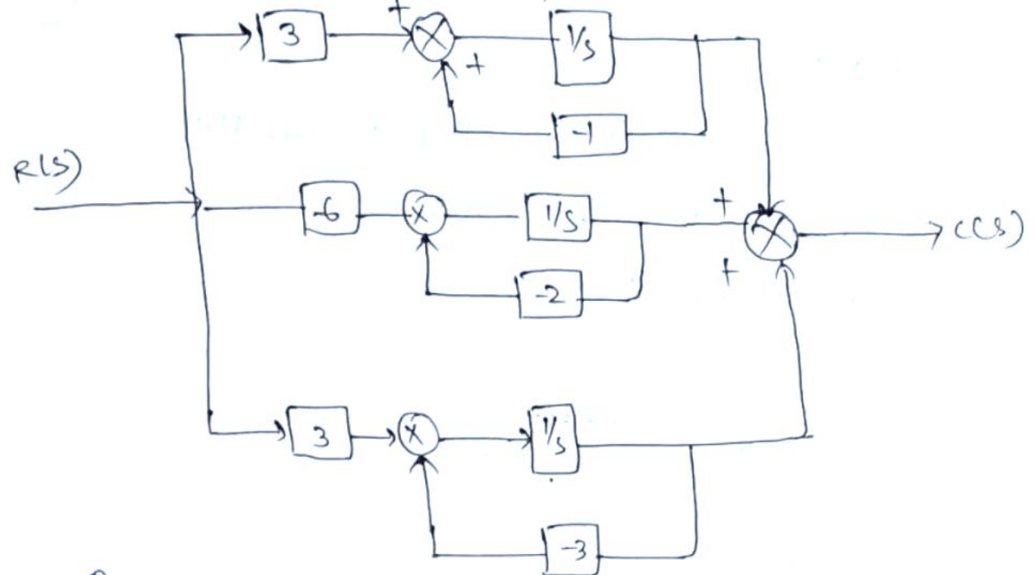
$G_1 G_2$

When block in parallel = ~~div~~ add.



$= G_1 + G_2$.

(3) Find the T.F of the system



Soln :-

Reduce close Loop system

Loop1 :- $\frac{C(s)}{R(s)} = \frac{G}{1-GH}$ (+ve feeback)

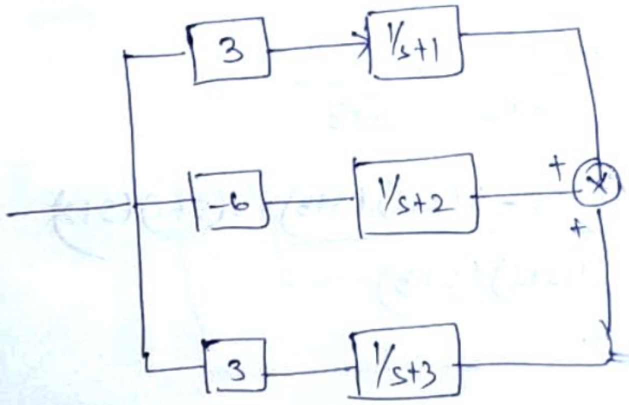
$$= \frac{1/s}{1-\left[1/s \cdot -1\right]}$$

$$= \frac{1/s}{1+1/s} = \frac{1/s}{\frac{s+1}{s}} = \frac{1}{s+1}$$

simillary

Lopp 2 :- $\frac{C(s)}{R(s)} = \frac{G}{1-GH} = \frac{1}{s+2}$

Loop 3 :- $\frac{C(s)}{R(s)} = \frac{G}{1-GH} = \frac{1}{s+3}$



~~Case -II~~

Rule 2. Rules

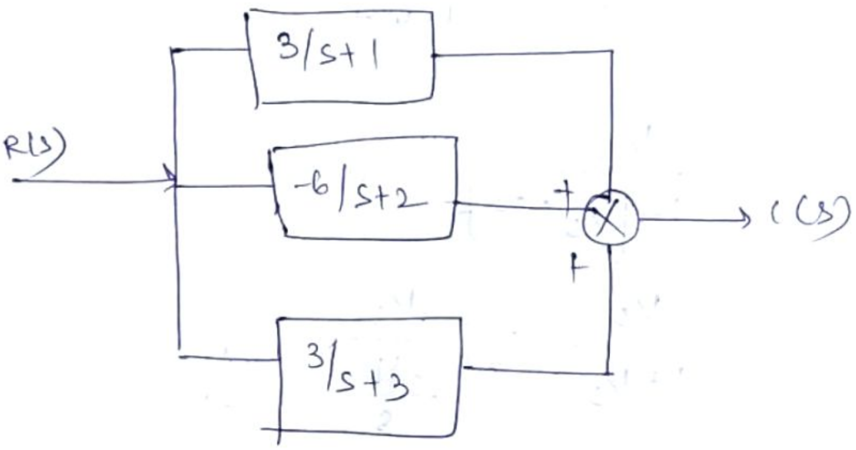
when 2 or more Block parallel is parallel the Resultant Block is the sum of Individual Block T.F.

step :- 2

3 and $\frac{1}{s+1}$ cascade

-6 and $\frac{1}{s+2}$ "

3 and $\frac{1}{s+3}$ "



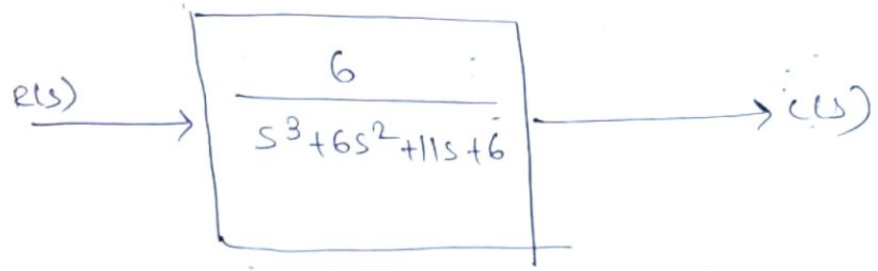
$\frac{3}{s+1}$ and $\frac{-6}{s+2}$ and $\frac{3}{s+3}$ are in parallel

then $\frac{C(s)}{R(s)} = \frac{3}{(s+1)} + \left(\frac{-6}{s+2}\right) + \frac{3}{s+3}$

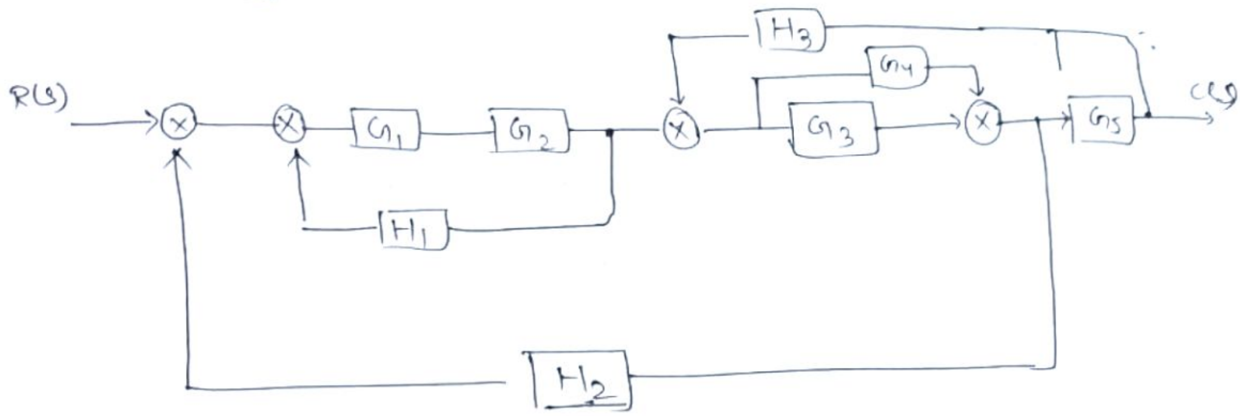
$$= \frac{3}{s+1} - \frac{6}{s+2} + \frac{3}{s+3}$$

$$= \frac{3(s+2)(s+3) - 6(s+1)(s+3) + 3(s+1)(s+2)}{(s+1)(s+2)(s+3)}$$

$$= \frac{6}{s^3+6s^2+11s+6}$$

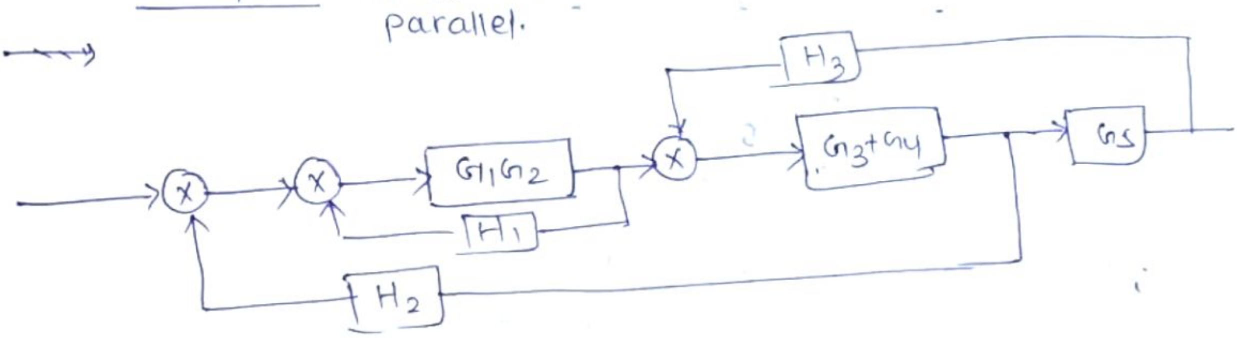


Question.



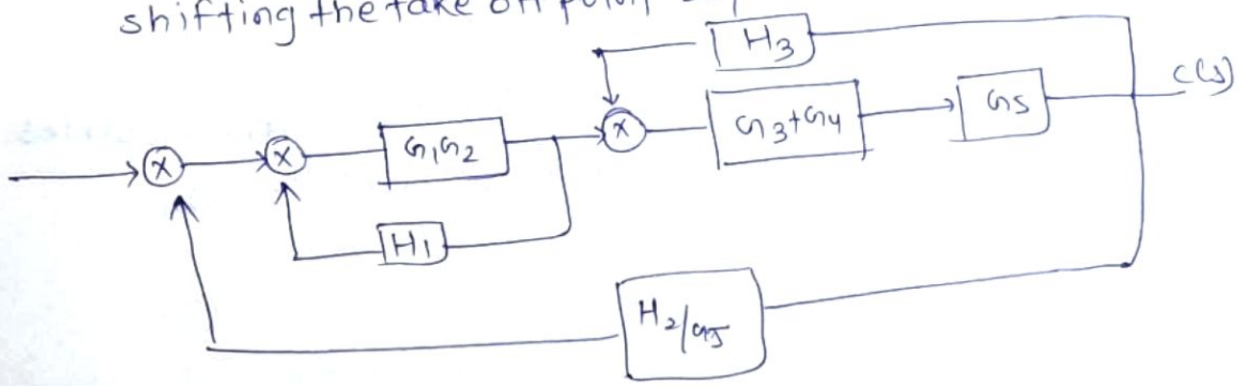
Solve:-

step 1: $G_1 G_2$ are in series and G_3 and G_4 are parallel.



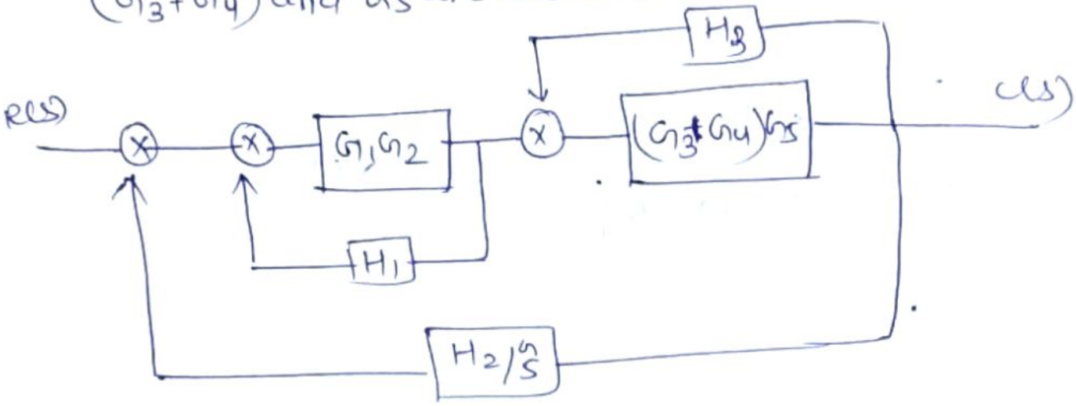
step ②

shifting the take off point beyond the block G_5.



step 3.

(G_3+G_4) and G_5 are cascode.



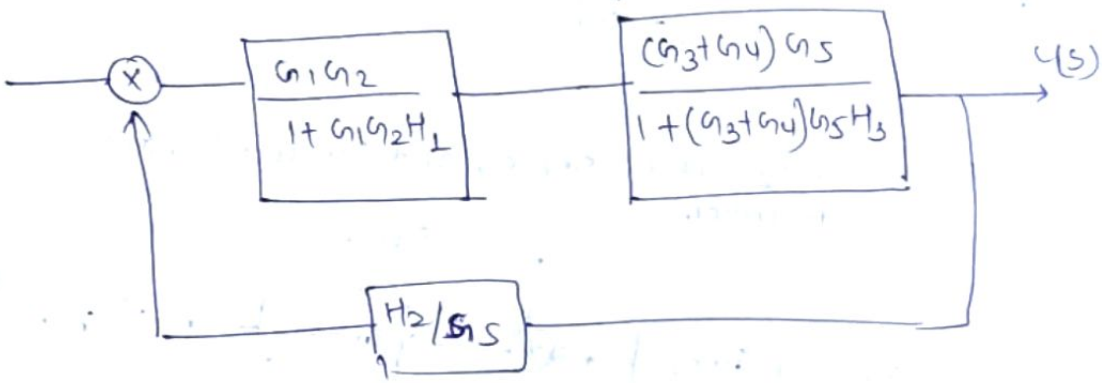
Step 4.

Resolve the closed Loop

where -

$G = G_1G_2$ and $G = (G_3+G_4)G_5$

$H = H_1$ $H = H_3$.



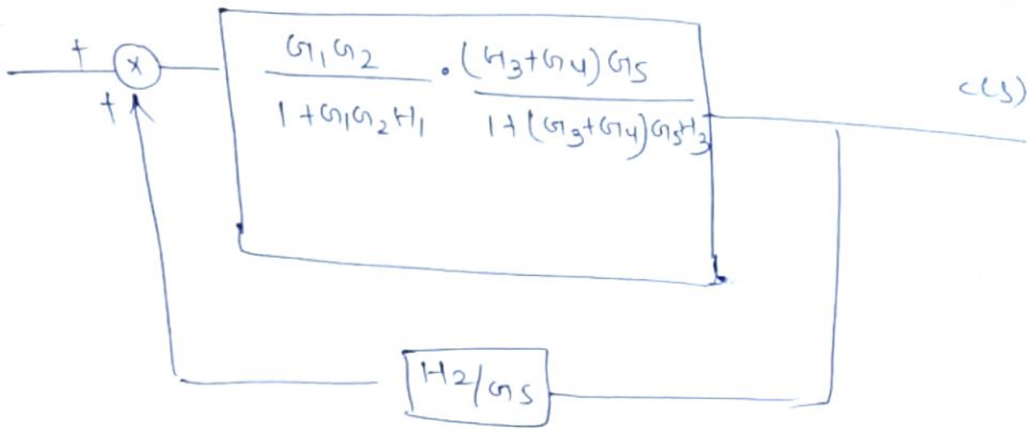
case I.

$$\frac{G(s)}{R(s)} = \frac{G}{1+GH} = \frac{G_1G_2}{1+G_2G_2H}$$

case II

$$\frac{G}{1+GH} = \frac{(G_3+G_4)\,5}{1+(G_3+G_4)G_5H_3}.$$

step 5. $\frac{G_1G_2}{1+G_2G_2H_1}$ and $\frac{(G_3+G_4)G_5}{1+(G_3+G_4)G_5H_3}$ are in series.



Step-6. Find Transfer function

$$\frac{C(s)}{R(s)} = \frac{G}{1-GH}$$

$$= \frac{\frac{G_1G_2}{1+G_1G_2H_1} \cdot \frac{(G_3+G_4)G_5}{1+(G_3+G_4)G_5H_3}}{1-\frac{G_1G_2(G_3+G_4)G_5}{(1+G_1G_2H)[1+(G_3+G_4)G_5H_3]} \cdot \frac{H_2}{G_5}}$$

$$= \frac{G_1G_2G_5(G_3+G_4)}{(1+G_1G_2H)(1+(G_3+G_4)G_5H_3) - G_1G_2(G_3+G_4)H_2}$$

*. Signal flow Graph from Block diagram:-

Method to obtain signal flow graph from the system equation.

Step-1.

Represent each variable by a saperate note.

Step-2.

Use the property that value of the variable represented by your note is an algebric sum of all the signal enterigate that node to simulate the equation

Step-3.

Co-efficient of the variables in the equation are to be Represented as the Branch gain joining the node in signal flow Graph.

Step-4.

Show the input and output variable saperately to complete the signal flow Graph.

Method to obtain signal flow Graph from the given Block diagram.

Step-1

Name all the summing point and take off point in the Block diagram.

Step-2.

Represent each summing point and take off point by a seperate node in signal flow graph (SFG).

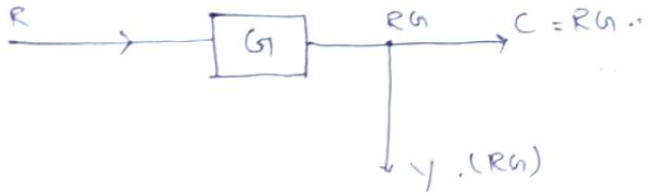
Step-3.

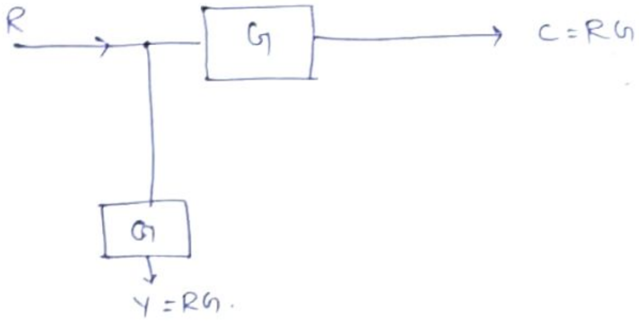
connect them by the Branches instant of Block indicating Block transfer function as the gain of corresponding Branches.

Step 4. Show the I/p and o/p nodes saperately If Required to complete the signal flow graph.

* shifting a take off point behind a block.

While shifting a take off point behind the Block. add a Block having transfer function same as that of the Block Behind which take off point is to be shifted in series with all the signals taking of from that point.

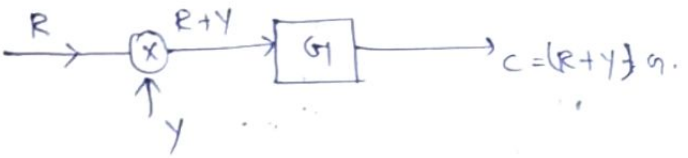


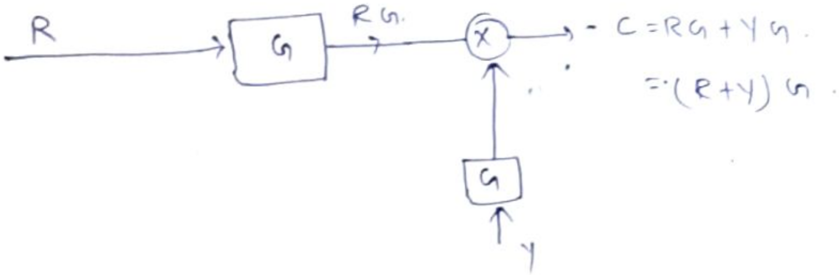


Q:- Determine the T.F. from the Block diagram shown.

- shifting a summing point Beyond the Block.

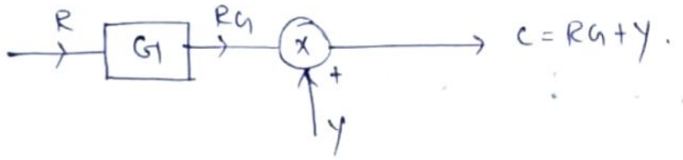
While shifting a summing point after a Block add a Block having Transfer function same as that of the Block after which summing point is to be shifted in series with all the signal at that summing point.

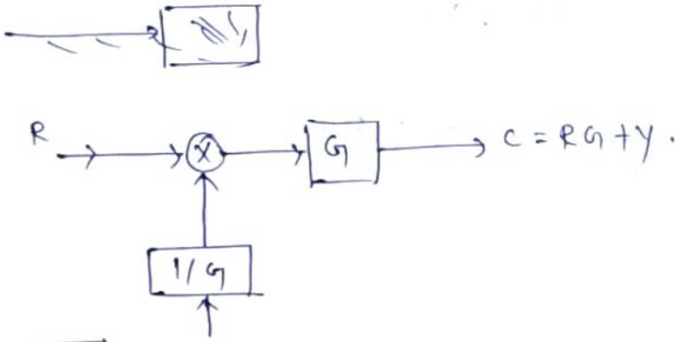


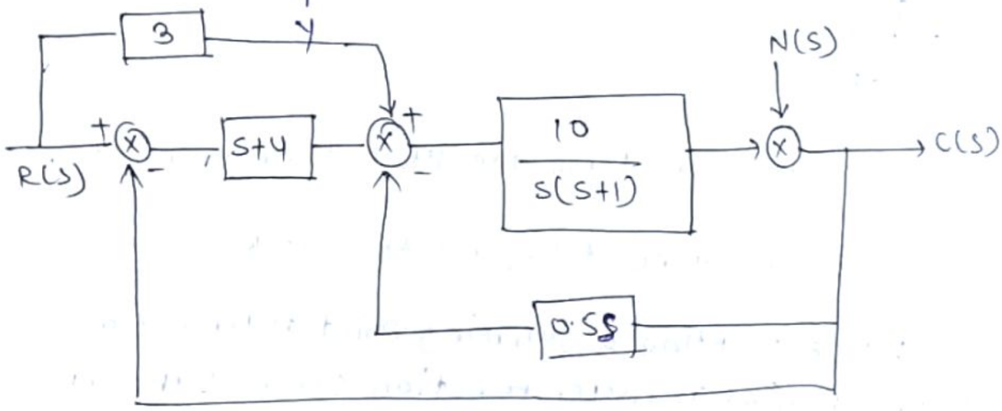


* shifting a summing point behind the block.

While shifting a summing point behind a block add a block having Transfer function add as Reciprocal of the T.F of the block Before which summing point is to be shifted in series with all the signal at that summing point

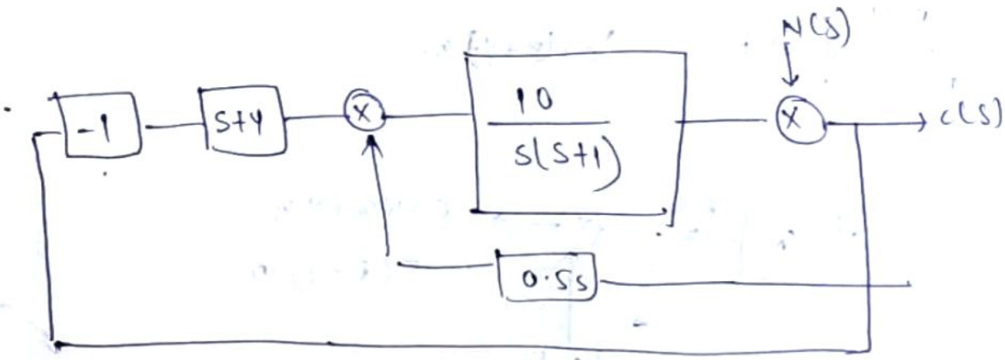






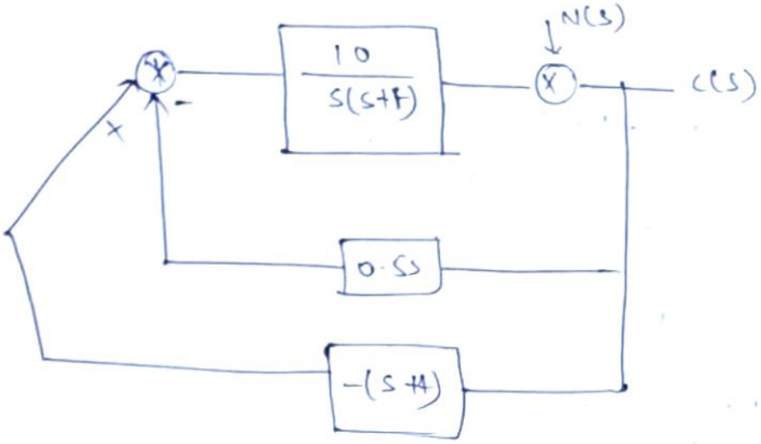
Find $\frac{C(S)}{N(S)}$ if $R(S)=0$.

When Given $R(S)=0$



−1 and s+4 are cascode.

$\therefore -(s+4)$.

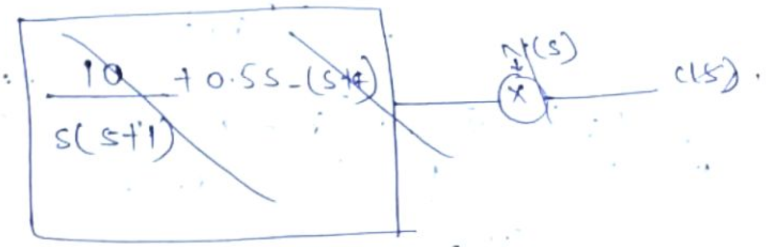


$\frac{10}{s(s+1)} + 0.5s - (s+4)$

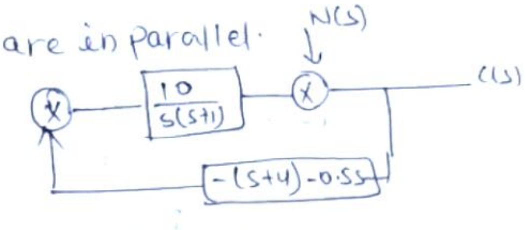
$-(s+4) + 0.5s$

$0.5s - s - 4$.

$\underline{-(0.5s+4)}$.



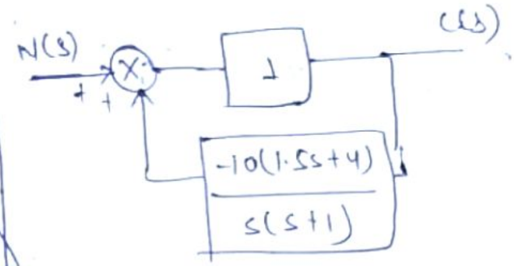
0.5s and −(s+4) are in parallel.

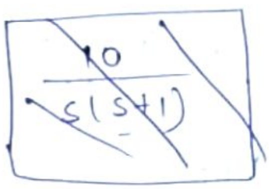


$-0.5s - (s+4)$

$-0.5s - s - 4$.

$-(1.5s+4)$





$\frac{10}{s(s+1)}$ and $(-1.5s+4)$ are cascade.
because summing point not existing.

then $\frac{-10(1.5s+4)}{s(s+1)}$

$$\frac{C(s)}{N(s)} = \frac{G}{1-GH}$$

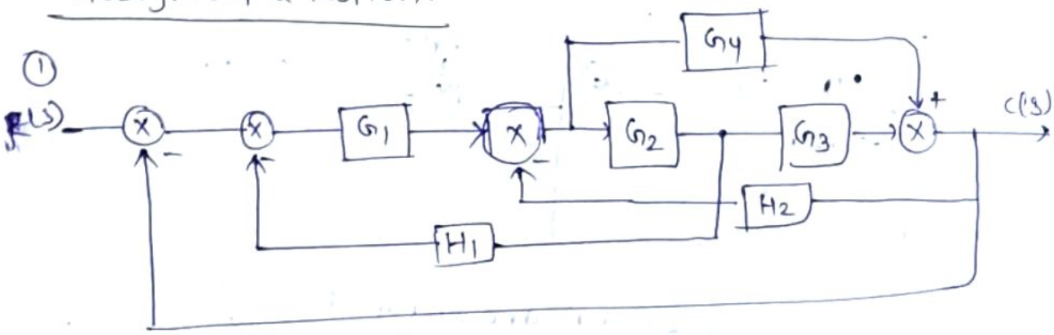
$$= \frac{1}{1 - 1.\left[\frac{-10(1.5s+4)}{s(s+1)}\right]}$$

$$= \frac{1}{1 + \frac{10(1.5s+4)}{s(s+1)}}$$

$$= \frac{s(s+1)}{s(s+1)+10(1.5s+4)}$$

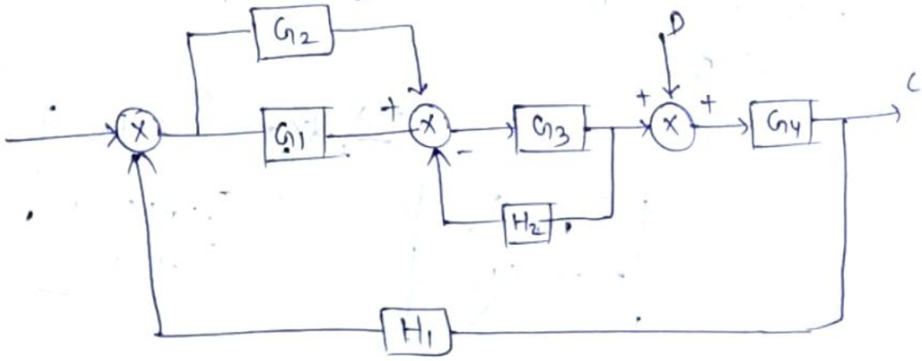
Assigment Question.

(1)



determine $\frac{C(s)}{R(s)}$.

(2)



determine $\frac{C}{R}$, $\frac{C}{D}$ and total output.