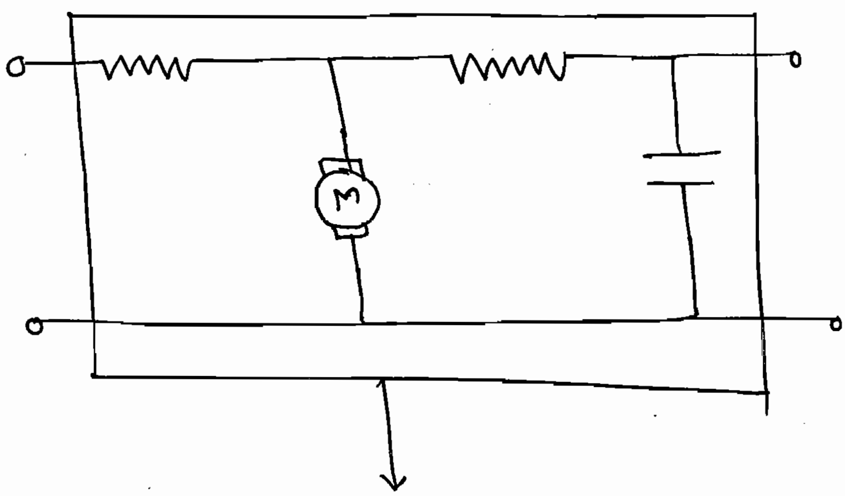
BLOCK DIAGRAM :-

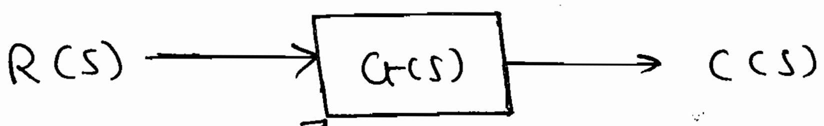
⇒ The purpose of the Block diagram is to find the overall TF of the system.

⇒ A Block Diagram is nothing but the Short hand pictorical representation of the system betn input and output.

⇒



⇒

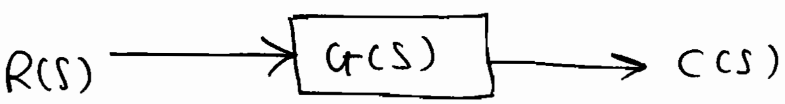


Short-hand pictorical representation of the sys.

⇒ The systems can be represented in a two ways ① open Loop form.

② Closed Loop form.

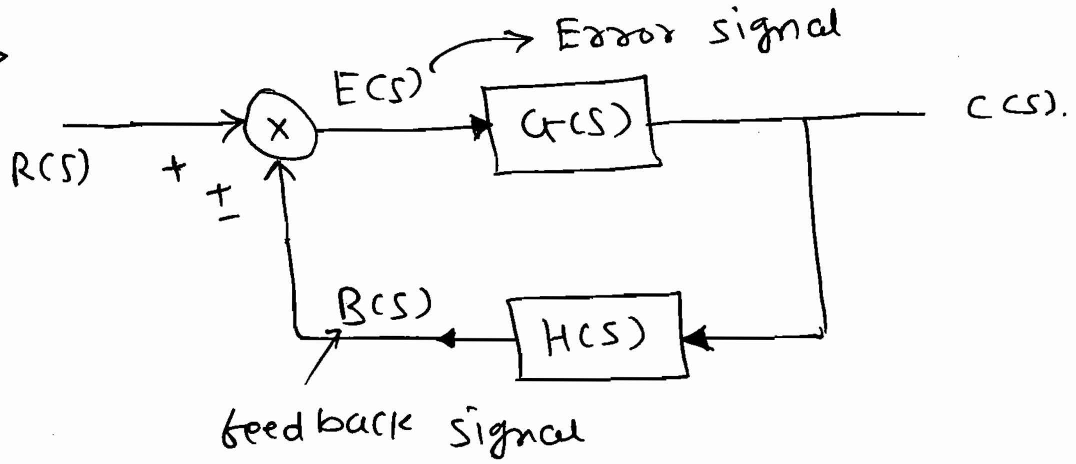
① Open Loop form:



$\therefore \dfrac{C(s)}{R(s)} = G(s).$

② Closed Loop form:

⇒

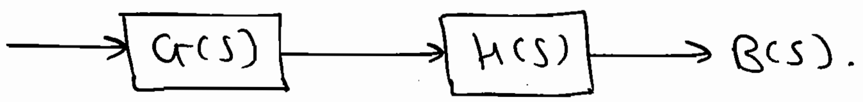


⇒ G(s): Forward Path gain $= \dfrac{C(s)}{E(s)}$.

⇒ H(s): Feedback path gain $= \dfrac{B(s)}{C(s)}$.

⇒ G(s)·H(s): Loop Gain (open loop gain).

⇒



G(s)·H(s) ⇒ OLTF of a Non-unity F/B system.

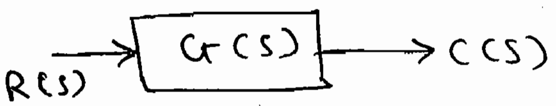
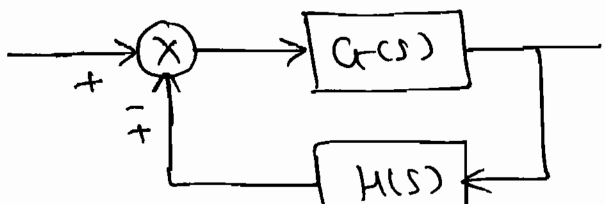
⇒ $\xrightarrow{H(s)=1}$ G(s) ⇒ OLTF of a Unity FB sys.

⇒ The factor G(s)·H(s) represent the actual closed loop system. It is also called as loop gain (open loop gain).

⇒ $$\boxed{\frac{C(s)}{R(s)} = \frac{G(s)}{1 \mp G(s)\cdot H(s)}} \rightarrow \text{CLTF}$$

⇒ In a Practical system the phase shift betⁿ feedback signal and input signal is 0° (or) ±360° whereas for -ve feedback the phase shift betⁿ i/p and feedback signal is ±180° (or) out of phase.

* Comparision b/w open Loop system & Closed Loop System.

⇒ Open Loop system	Closed Loop system.
* Gain:  $G(s) = \frac{C(s)}{R(s)}$.	 → The main disadvantage of F/B is the gain is reduced by the factor of $\frac{\cancel{G(s)}\ 1}{1+G(s)\cdot H(s)}$. $\frac{C(s)}{R(s)} = \frac{G(s)}{1+G(s)\cdot H(s)}$.

* Stability:

→ Stability is a notion that describes whether the system will be able to follow the input command.

⇒ The OL system is more stable.	→ The CL sys. stability depends on the loop gain.

→ If GH = -1 then the CL sys. stability affected.

→ If GH = 0 then CL sys stability = OL sys. stability.

→ If GH > 0 then the CL sys. more stable than the OL sys.

* Accuracy.

⇒ The OL sys. accuracy depends on the i/p and process.

⇒ The OL sys. is less accurate.

⇒ The CL sys. accuracy depends on the F/B N/w ratio.

⇒ If the F/B N/w gives the stable value then the CL sys. becomes highly more accurate than OL sys.

* Sensitivity:

⇒ The OL system is highly sensitive w.r.t. the disturbance, noise and environmental condn. because whenever changes occurs in the system it directly affect the o/p.

⇒ The closed loop sensitivity decreased by the factor of 1+ G(s). H(s). i.e. the changes in o/p due to the disturbance, noise and the environmental condn is very less.

BW:

→ For any Practical system the gain BW Product is Constant.

$$BW \propto \frac{1}{t_r} \approx \frac{0.35}{t_r}.$$

→ With feedback the gain is decreased by the factor of 1+GH. that means the BW increased by 1+GH.

→ The large BW gives the very quick response.

→ The CL sys. gives the very quick response compared to the OL sys.

* Reliability:

→ The realibility Completely depends on the no. of discrete components used in the system.

⇒ The open loop sys. is more reliable as it has less no. of Components.

⇒ It is less realiable than OL system.

⇒ In OL system it is not necessary to measure the output.

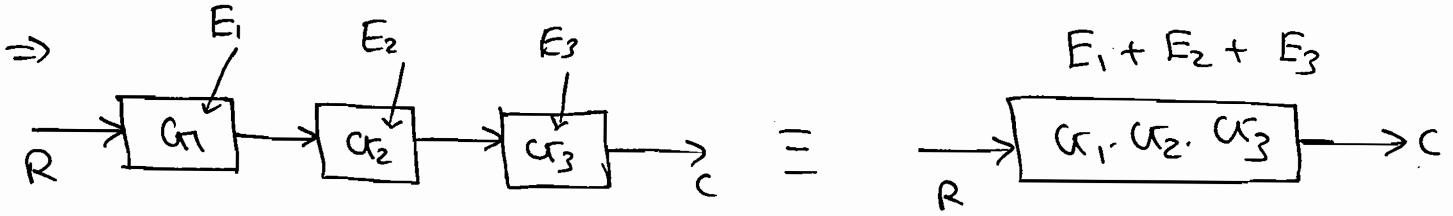
⇒ The output must be measured, error are generated, sensors are

errors are not generated. sensors are not essential design is very easy.	essential and design is complex.

☆ BLOCK DIAGRAM Reduction Techniques:

① BLOCKS are in series (or) Cascade:-

⇒

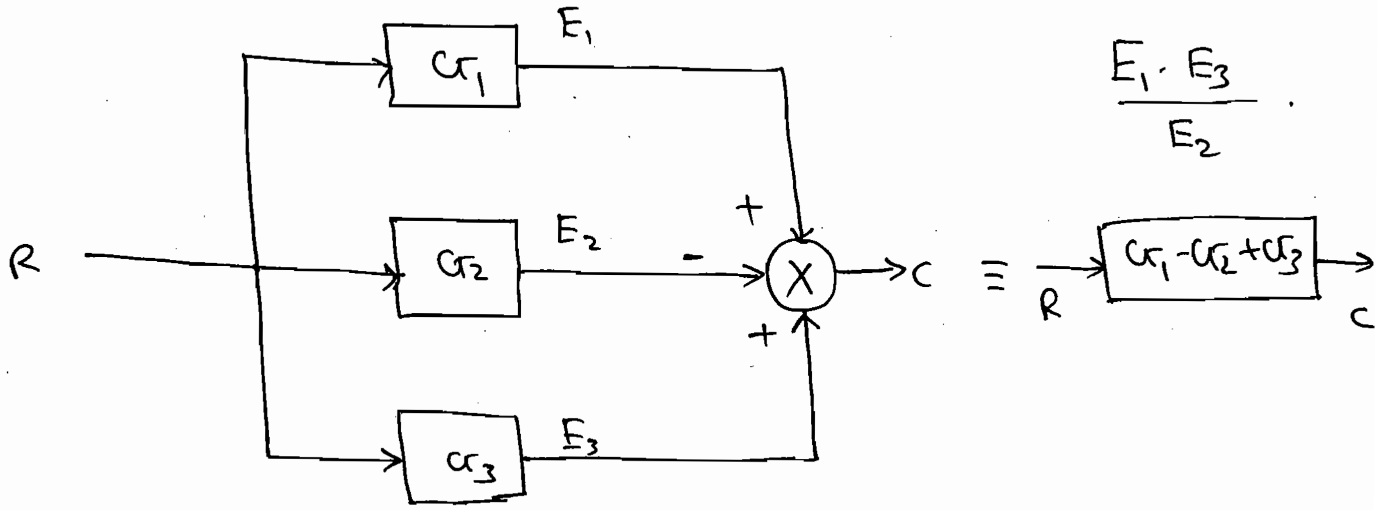


Log

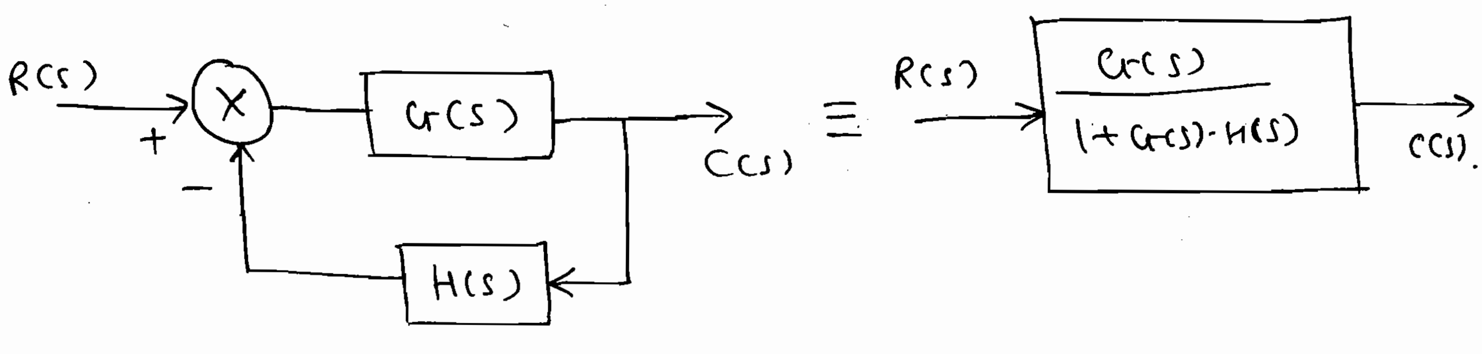
∴ $\times \leftrightarrow +$

$\div \leftrightarrow -$.

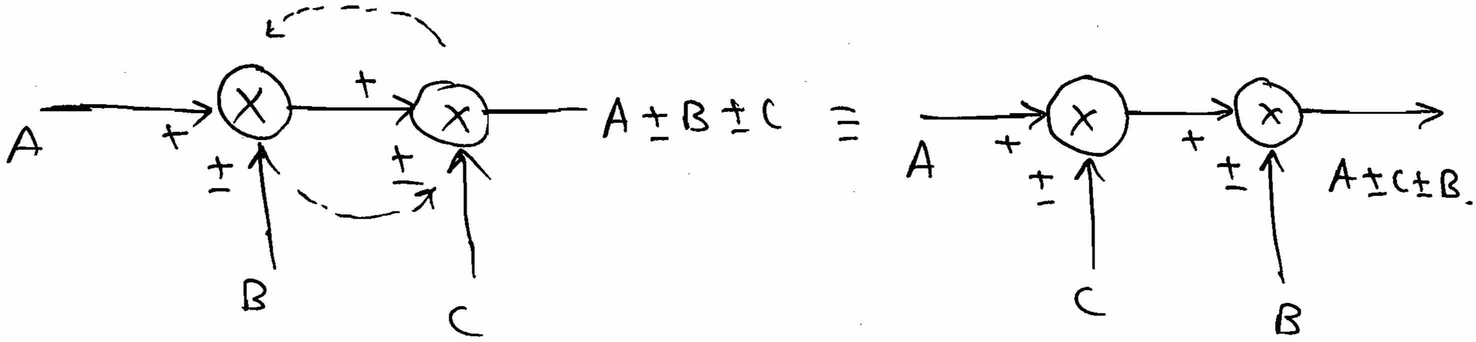
② BLOCKS are in Parallel:



③ Loop:

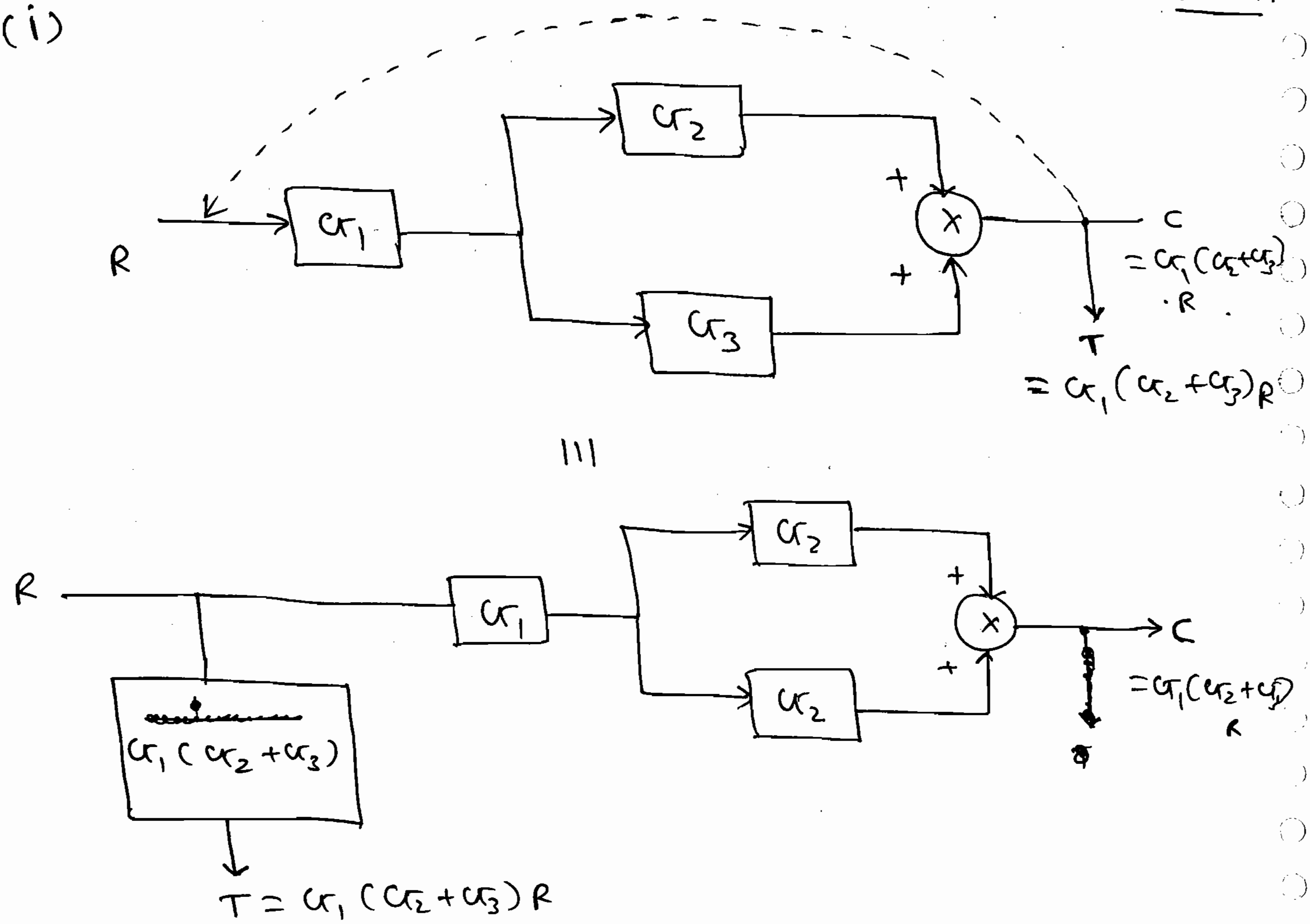


(4) Interchanging of Summing Points:

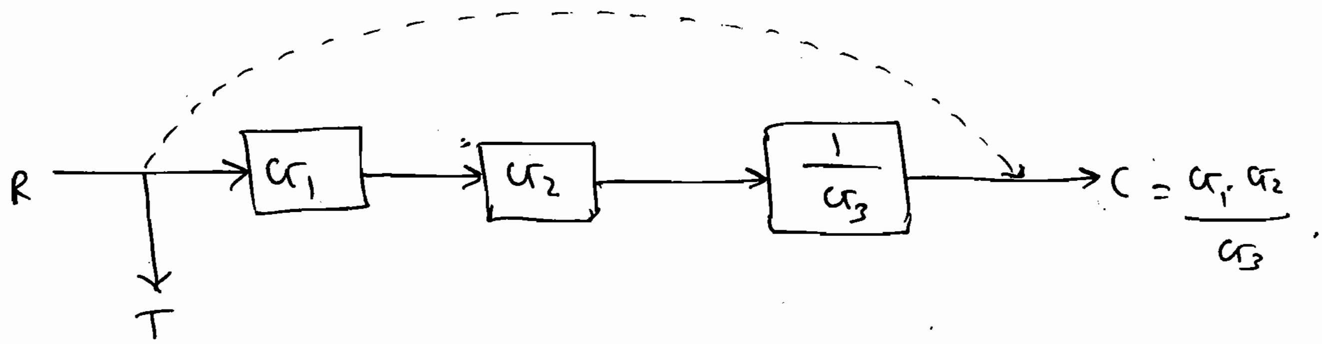


(5) Adjusting the Block Gain and Take OFF Point.

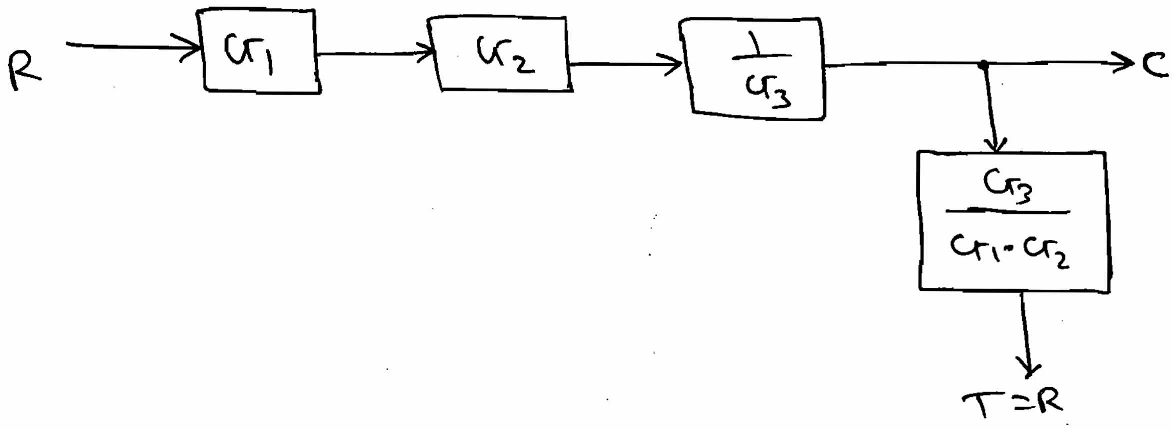
(i)



(ii)

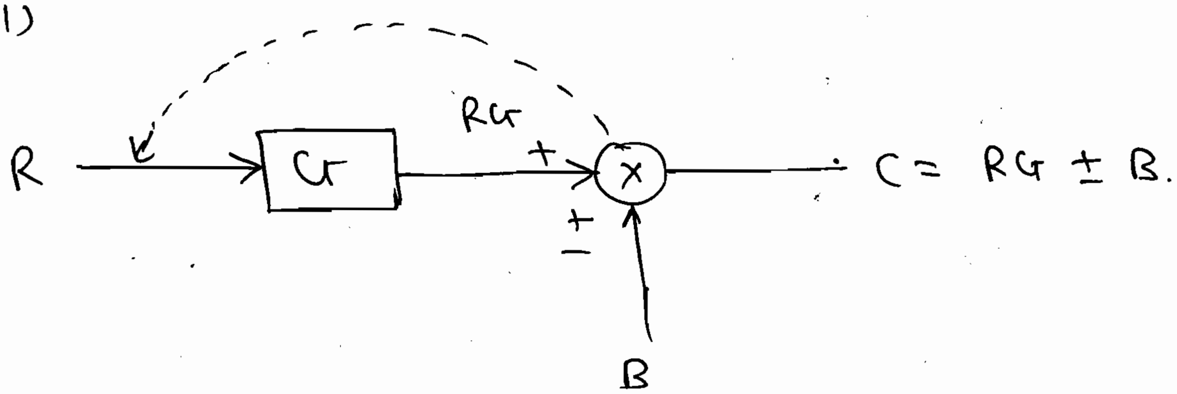


|||



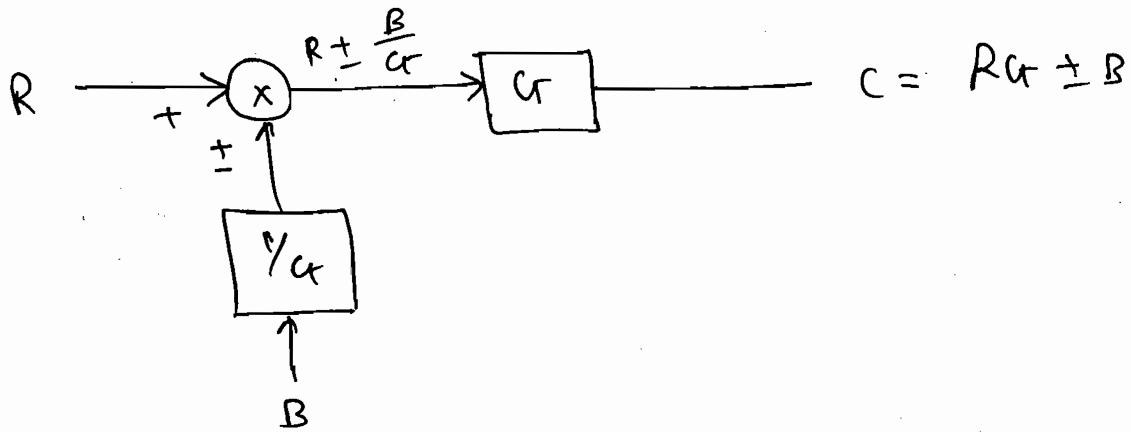
⑥ Adjusting Block Gain & Summing Point.

⇒ (i)

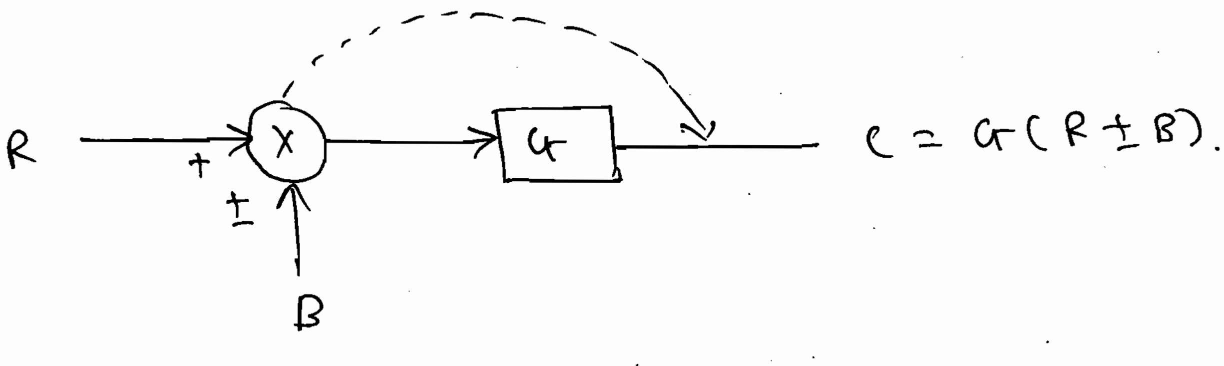


|||

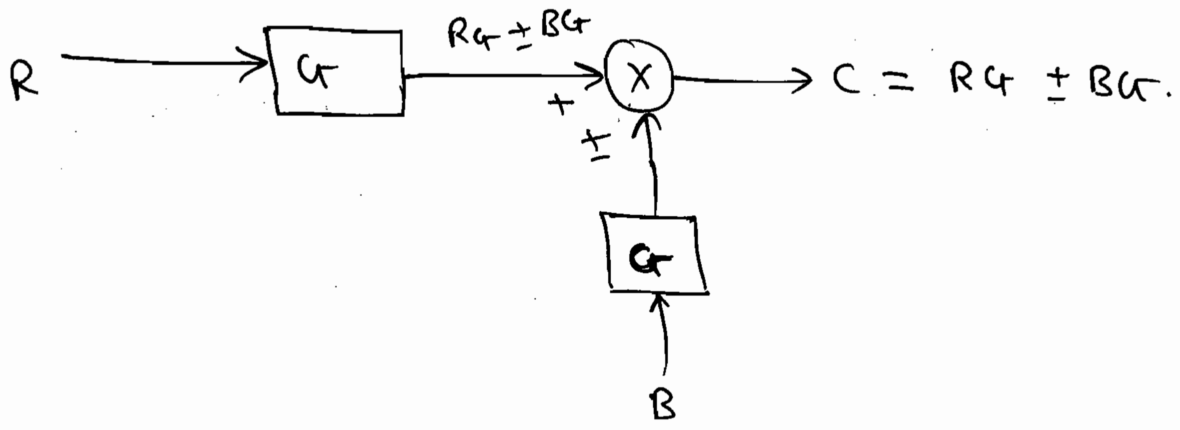
⇒



⇒ (ii)

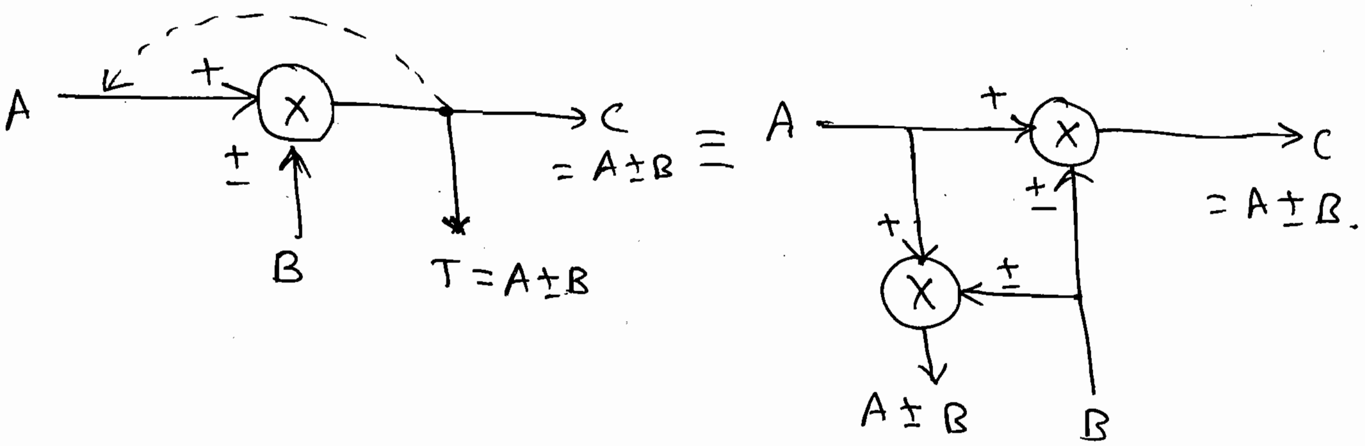


⇒

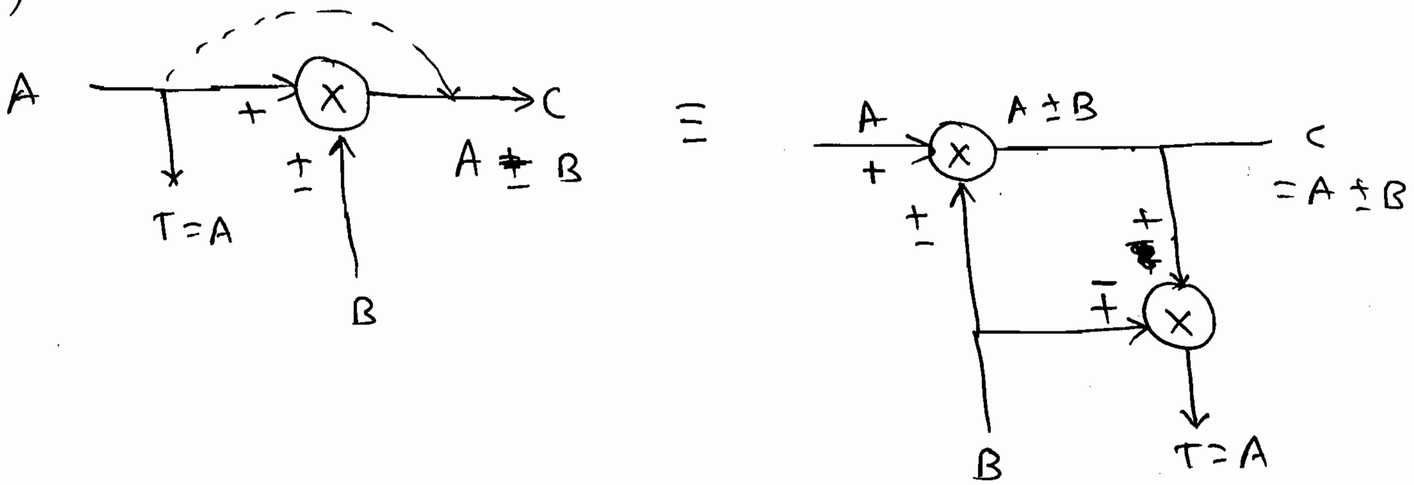


(7) Adjusting the Summing Point & Take OFF point.

(i)



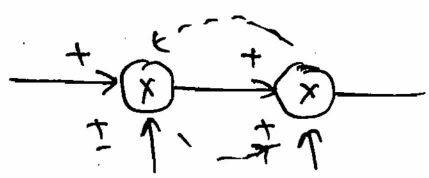
(ii)



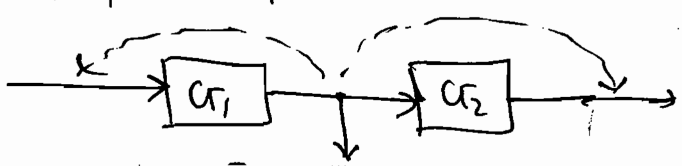
Steps:

S_1 :-> series || llel || Loop.

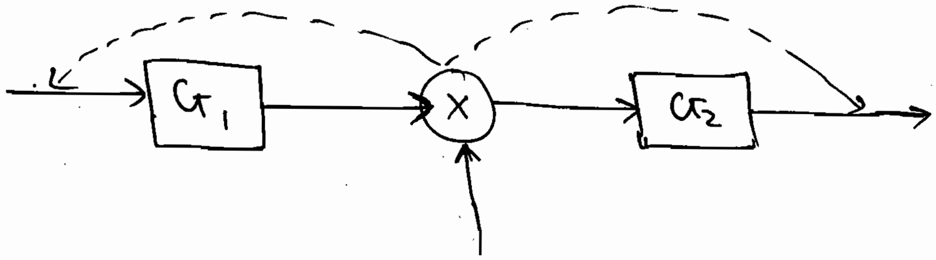
S_2 :->



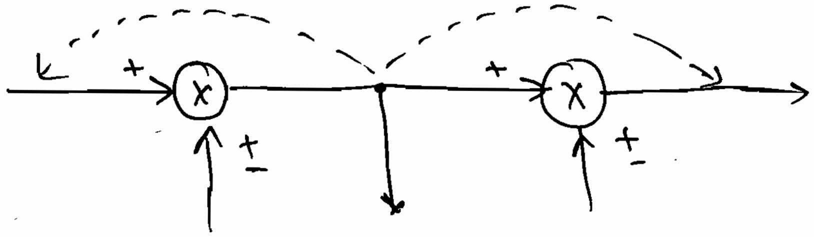
S_3 :->



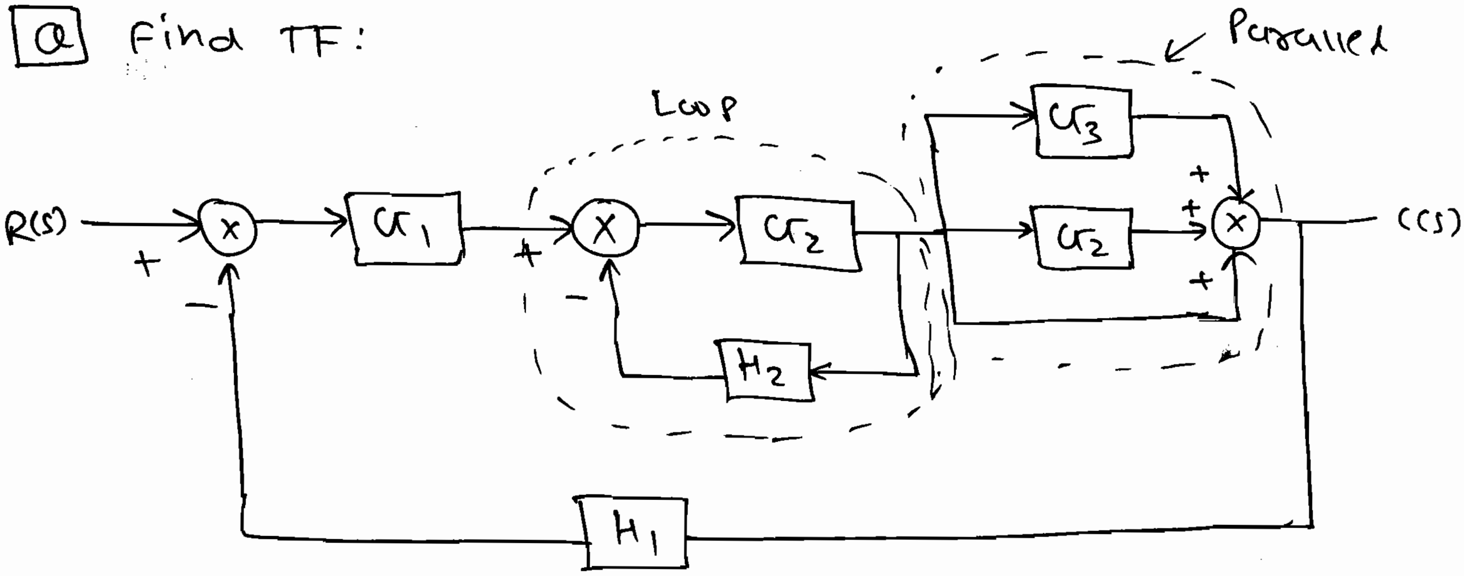
S_4:



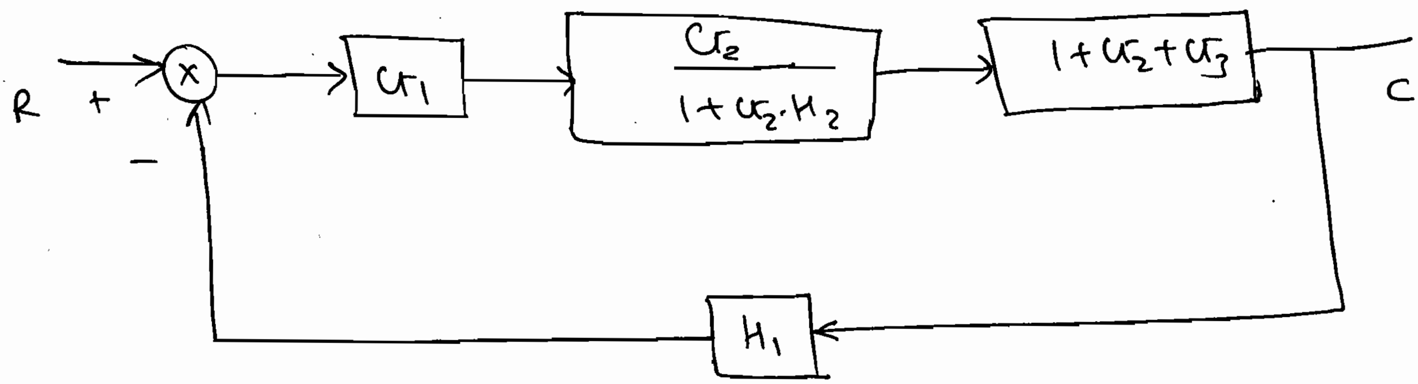
S_5:

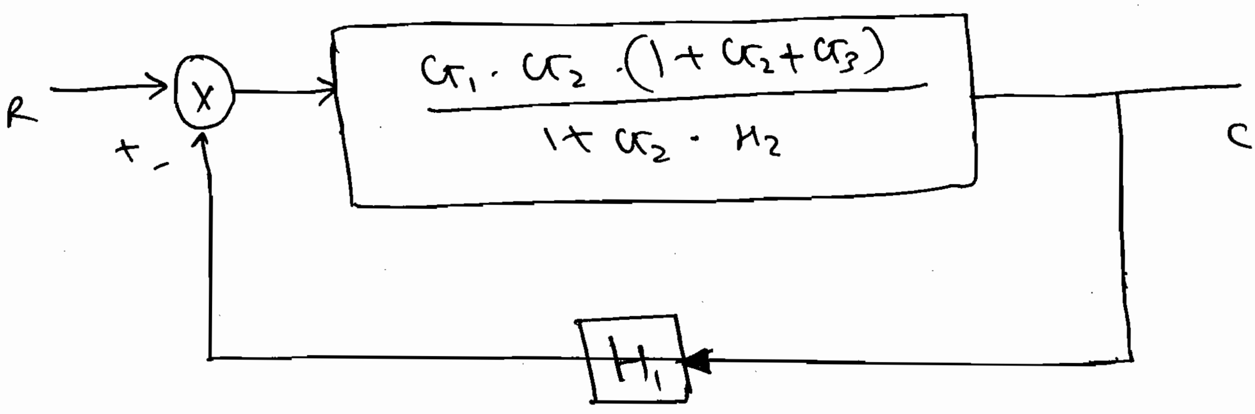


Q Find TF:



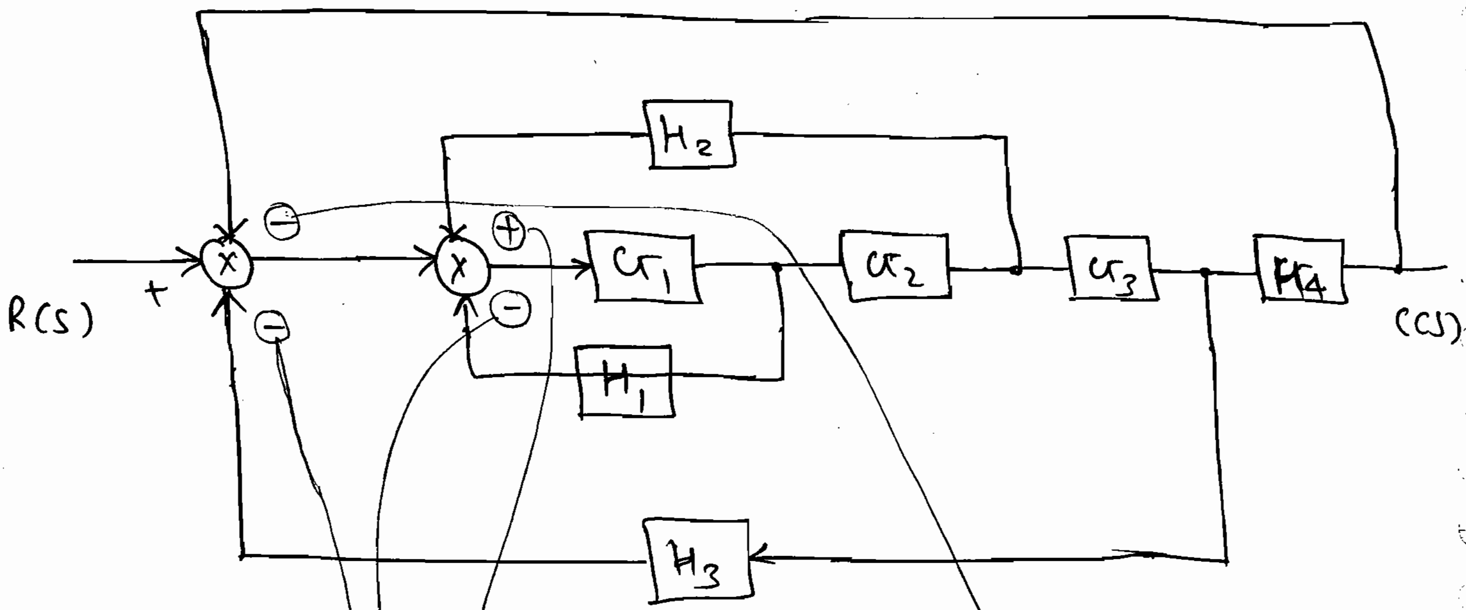
Soln:





$$\Rightarrow \quad \frac{C(s)}{R(s)} = \frac{G_1 \cdot G_2 \,(1 + G_3 + G_4)}{1 + G_2 H_2 + H_1 \cdot G_1 \cdot G_2 \,(1 + G_3 + G_4)}$$

$\boxed{Q}$ Find TF.

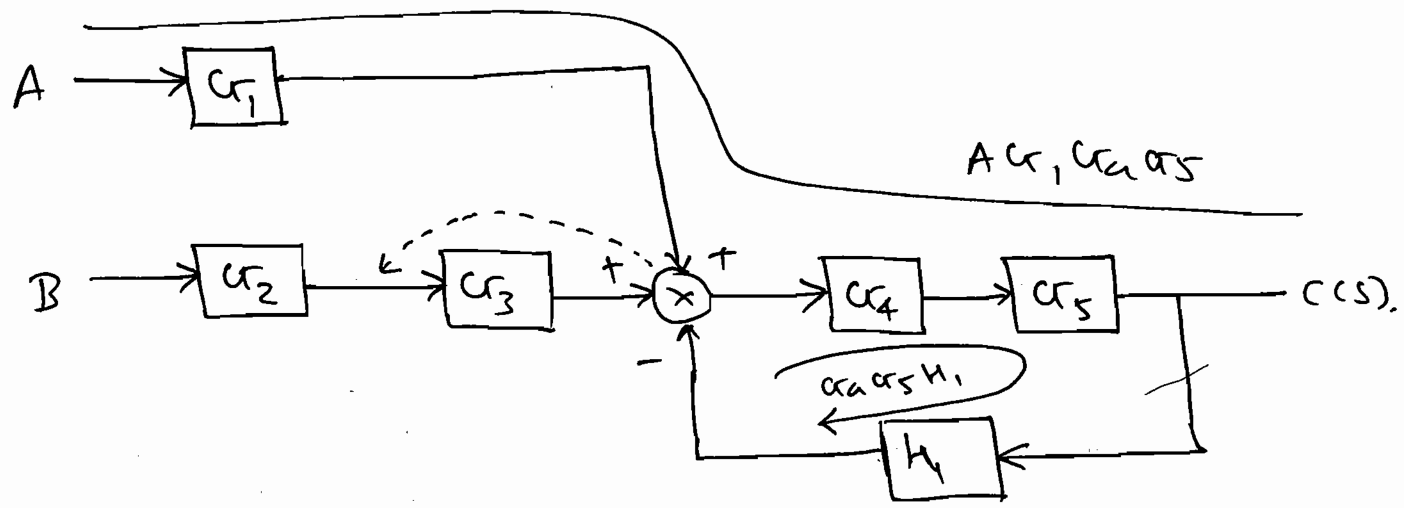


Solⁿ:

$$\frac{C(s)}{R(s)} = \frac{G_1 \cdot G_2 \cdot G_3 \cdot G_4}{1 + G_1 \underline{\underline{H_1}} - G_1 \cdot G_2 \cdot \underline{\underline{H_2}} + G_1 \cdot G_2 \cdot G_3 \, \underline{\underline{H_4}} - G_1 \cdot G_2 \cdot G_3 \cdot G_4 \, \underline{\underline{1}}}$$

Q Draw the eqn Block Diagram to the following. 65

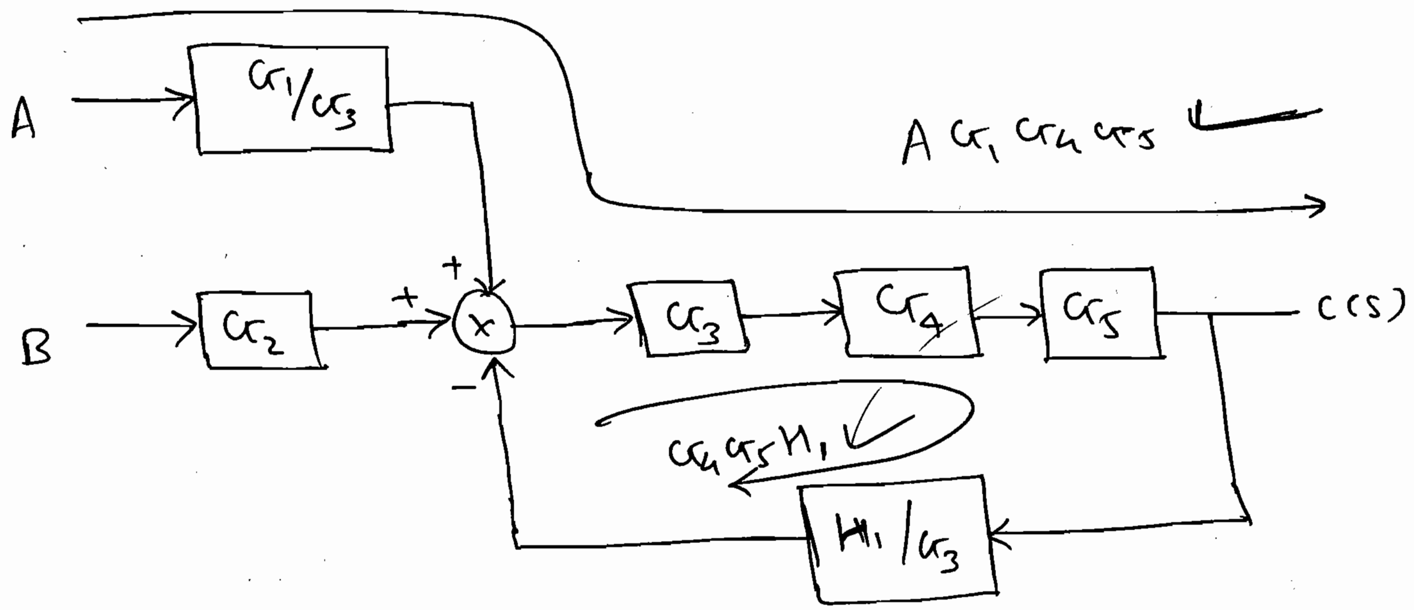
=>



Soln:

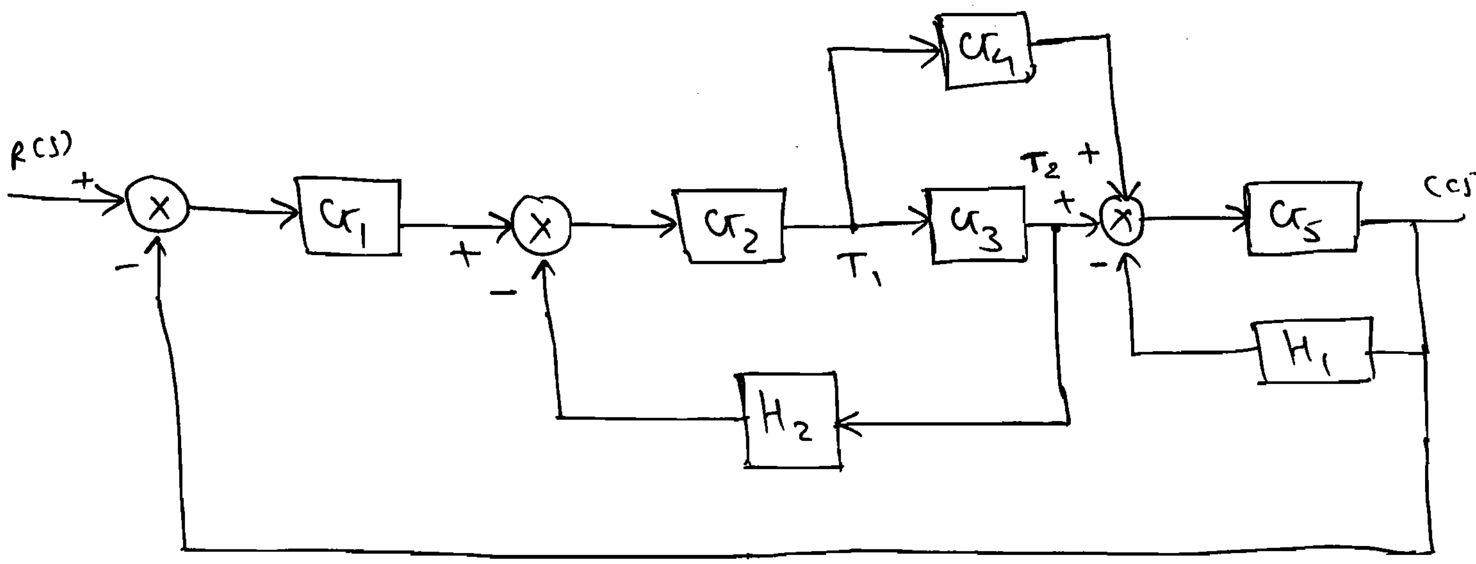
Note: While doing the shifting operation, the changes are occurs only in additional forward path and feedback path connected to that point only. (H.B)

=>



=> Before shifting and after shifting, forward path gain should be remain same. We dont want to loose and we dont want to/any extra gain. So, if it is extra gain after shifting then divide and if it is we loose any gain, we should multiply.

Q Find the TF.



Sol^n: We have 2 option:

(i) Shifting T_1 after G_3.

→ Before shifting there are three block G_1, G_2 & H_2.

→ After shifting there are four block G_1, G_2, G_3, & H_2. So, we should divide G_4 by G_3.

(ii) Shifting T_2 before G_3.

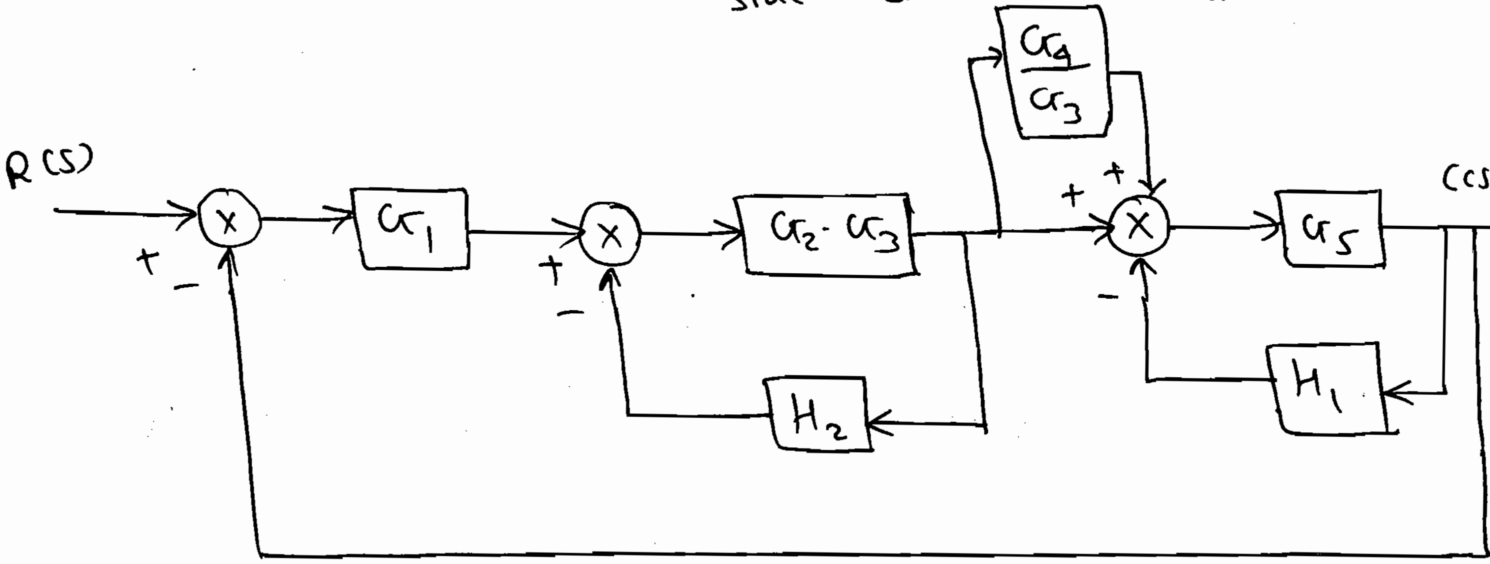
→ Before shifting there are ~~three~~ four blocks G_1, G_2, G_3 & H_2.

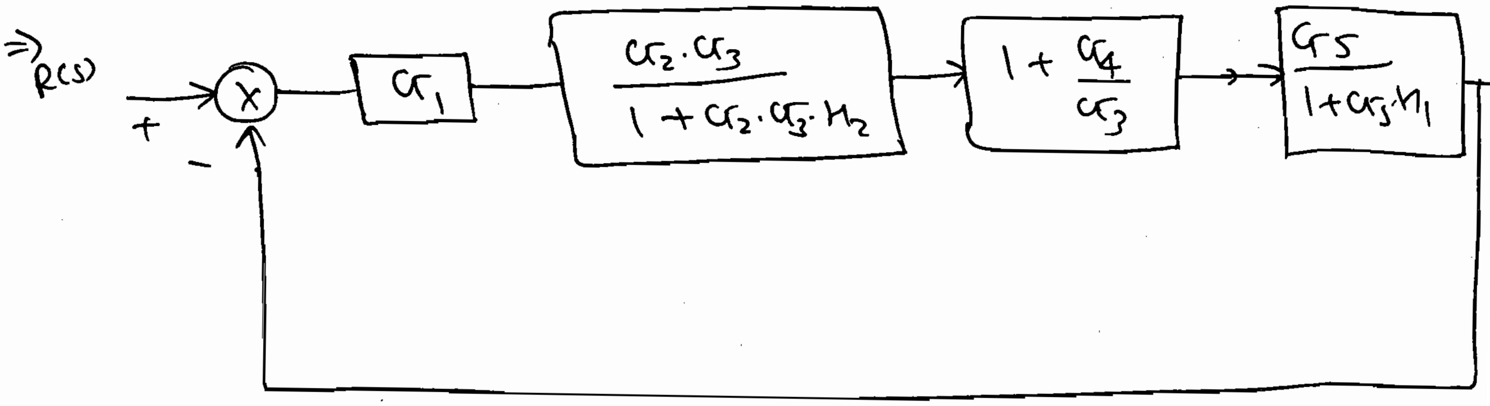
→ After shifting they becomes 3 blocks. i.e. G_1, G_2 & H_2. So, we should mutiply

H_2 by G_3.

(i) Method - 1:

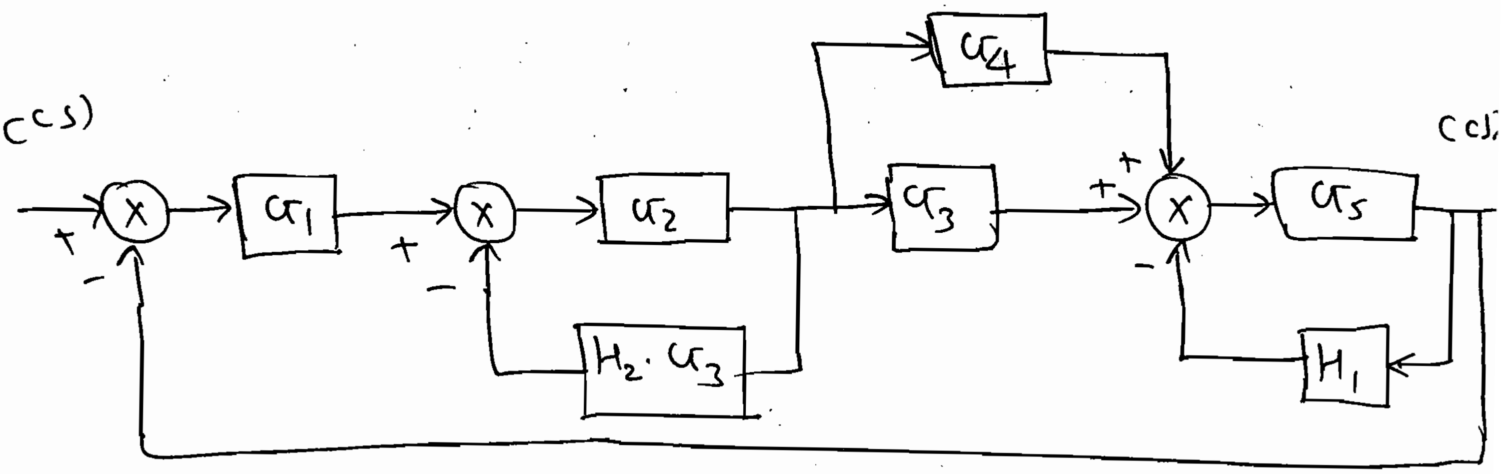
Note: For Take off point see left side block changes. & 67 for summing point see Right side block changes.



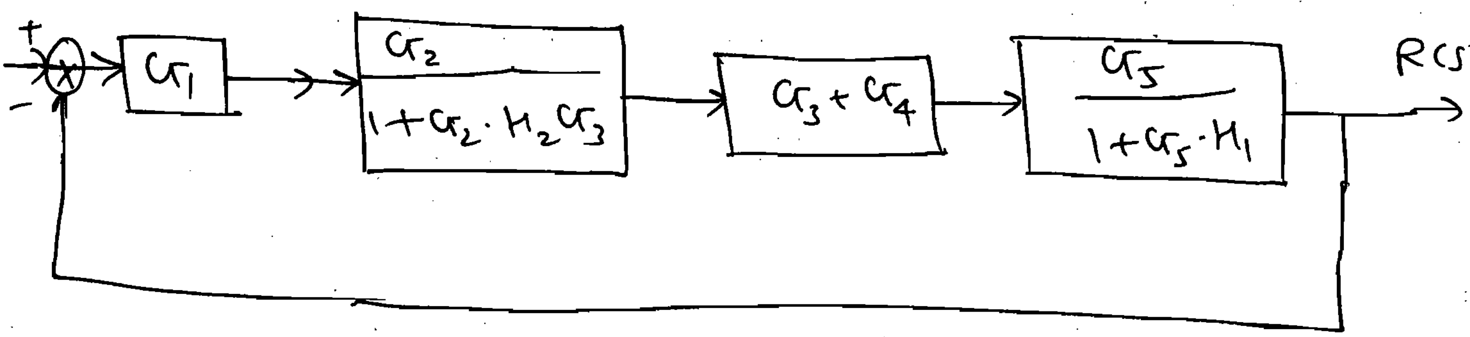


$$\therefore \frac{C(s)}{R(s)} = \frac{G_1 \cdot G_2 \cdot (G_3 + G_4) \cdot G_5}{1 + G_2 \cdot G_3 \cdot H_2 + G_5 \cdot H_1 + G_1 \cdot G_2 \cdot (G_3 + G_4) \cdot G_5}$$

(ii) Method - 2

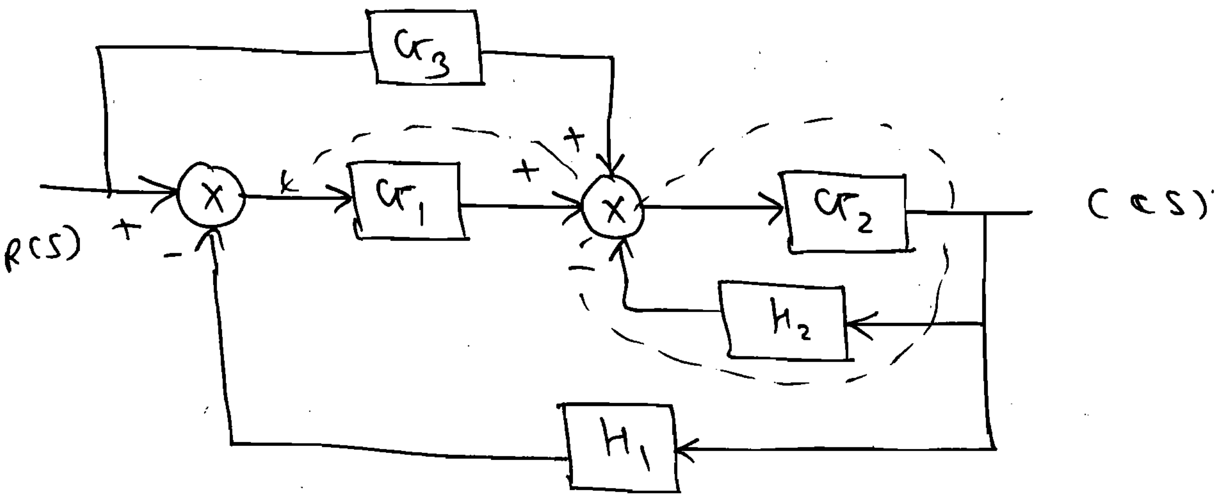


⇒

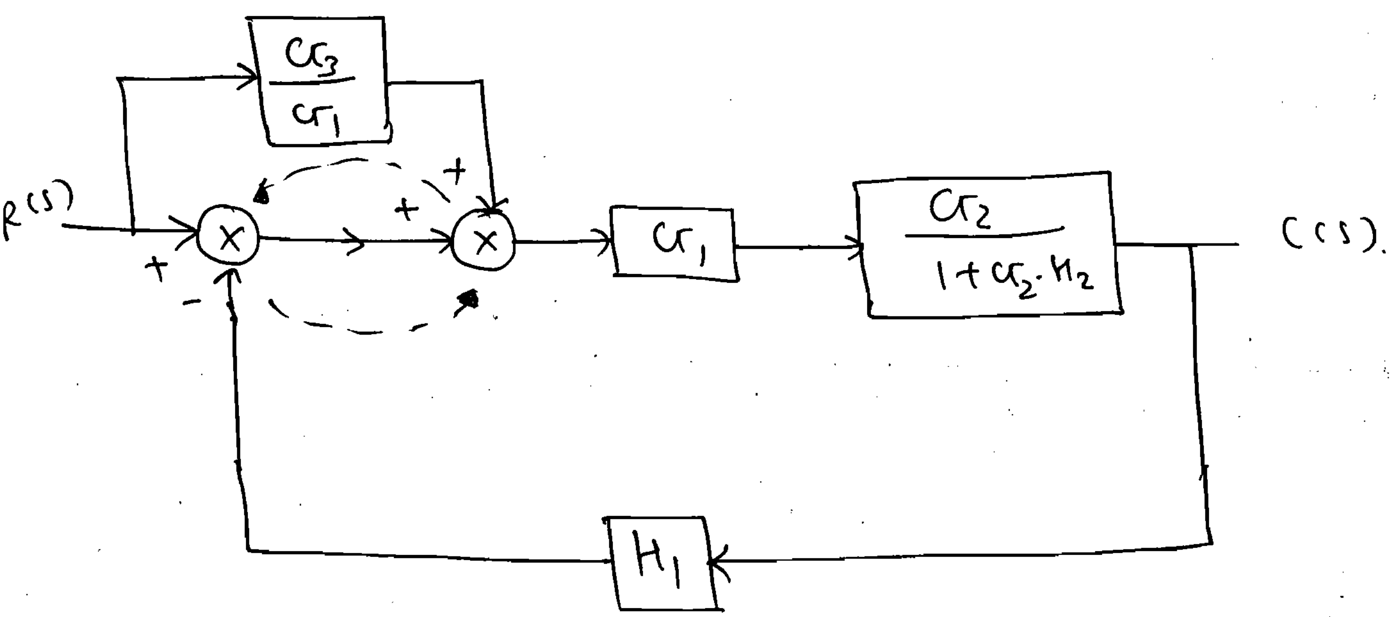


$$\therefore \frac{C(s)}{R(s)} = \frac{G_1 \cdot G_2 \, (G_3+G_4) \, G_5}{1+ G_2 \cdot H_2 \cdot G_3 + G_5 \cdot H_1 + G_1 \cdot G_2 \, (G_3+G_4) \cdot G_5}$$

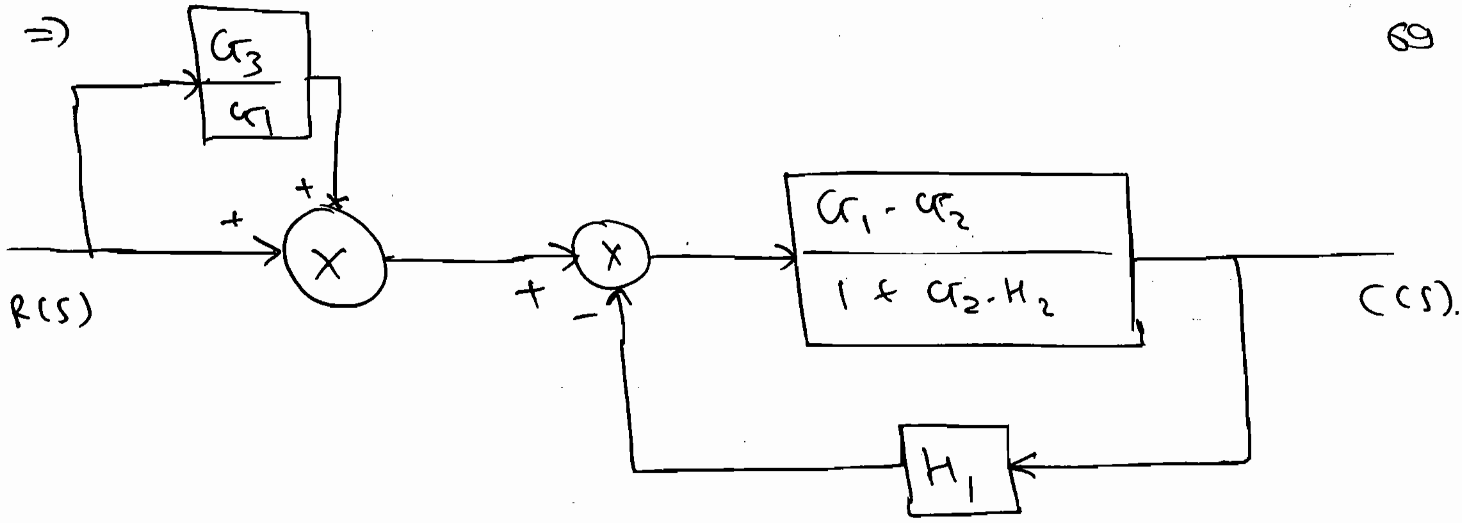
Q Find the TF.



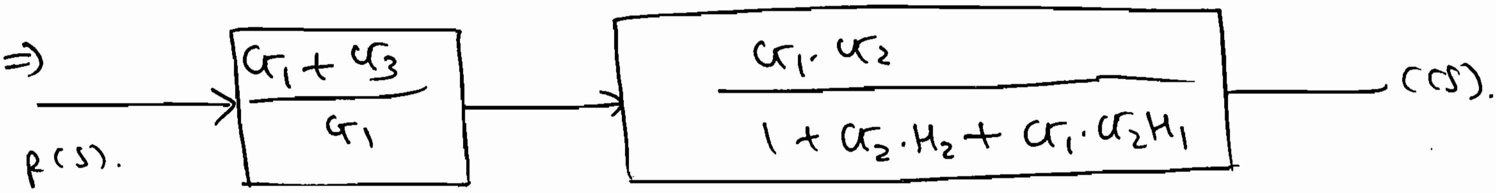
Sol^n:



$\Rightarrow$

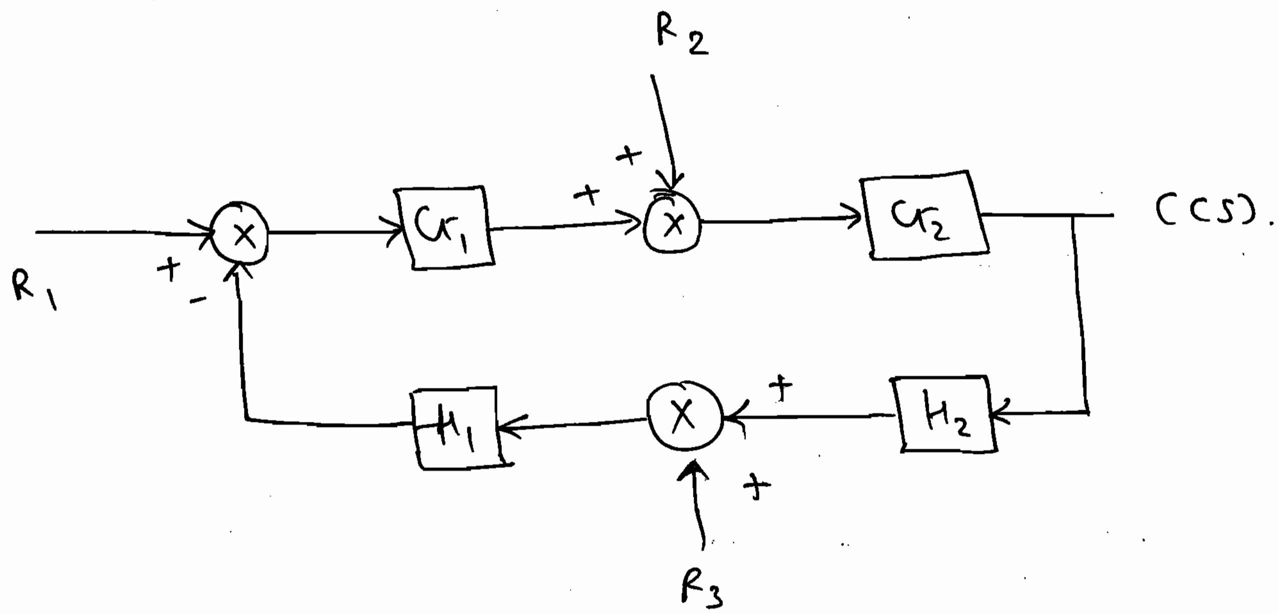


$\Rightarrow$



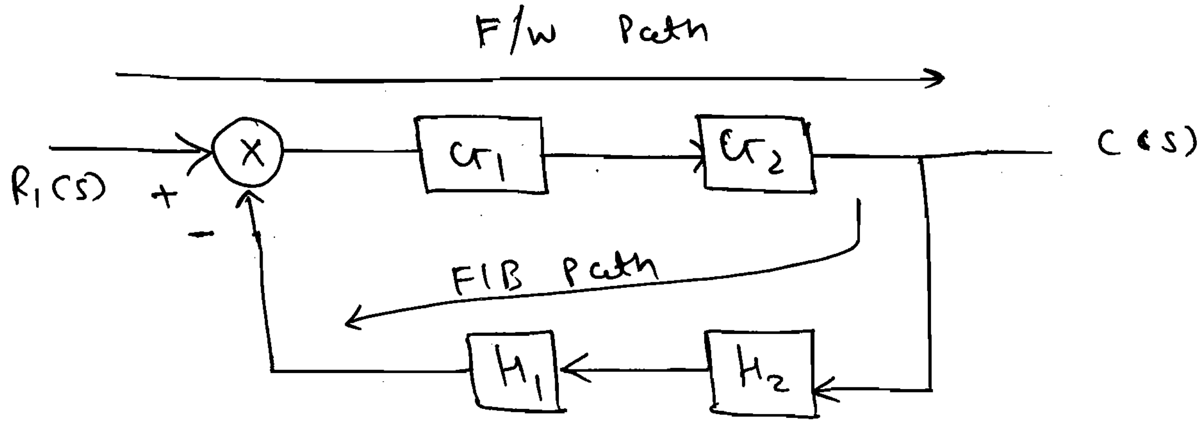
$$\Rightarrow \frac{C(s)}{R(s)} = \frac{G_2 \cdot (G_1 + G_3)}{1 + G_2 \cdot H_2 + G_1 \cdot G_2 H_1}.$$

$\boxed{Q}$ Find the o/p due to the multi i/p.



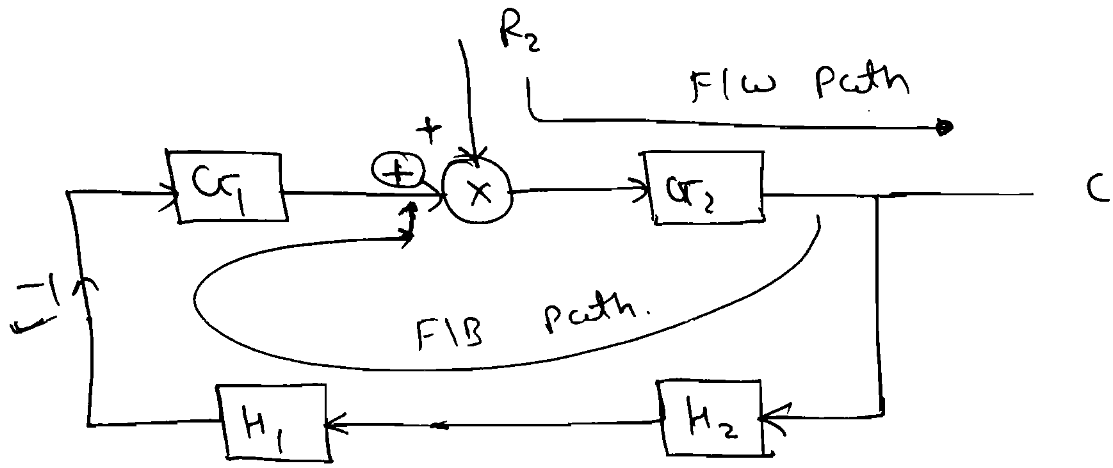
Solⁿ: By super possition theorm it can be solved. i.e. take only one input at a time keeping all other zero.

(i) R_1, $R_2 = 0$, $R_3 = 0$.



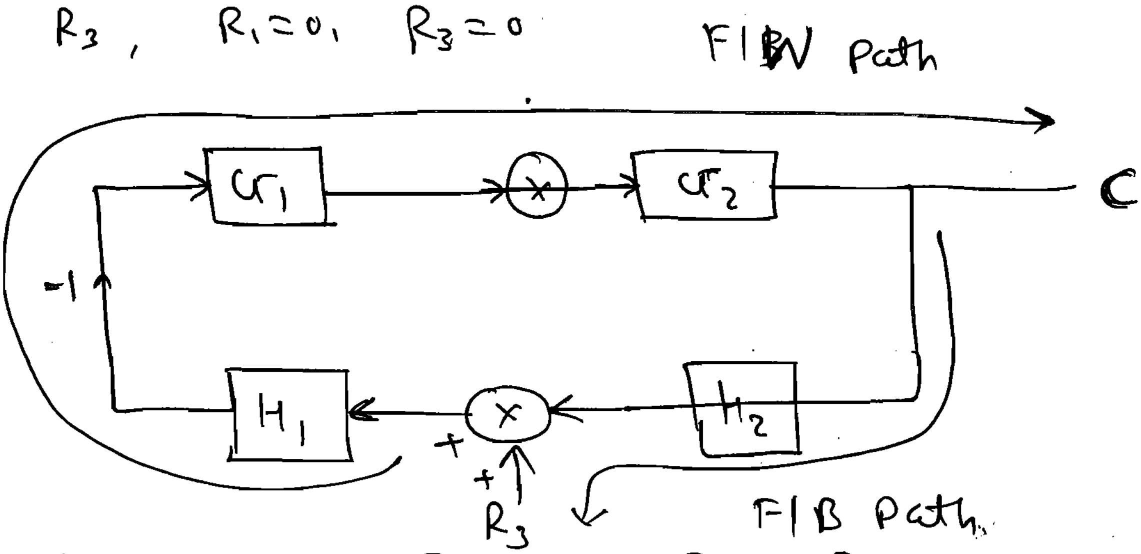
$$\therefore \quad C = \frac{G_1 \cdot G_2}{1 + G_1 \cdot G_2 \cdot H_1 \cdot H_2}.$$

(ii) R_2, $R_1 = 0$, $R_3 = 0$.



$$\Rightarrow \quad \frac{C}{R_2} = \frac{G_2}{1 - (G_1 \cdot -H_1 \cdot G_2 \cdot H_2)} = \frac{G_2}{1 + G_1 G_2 H_1 H_2}$$

(iii) R_3, $R_1 = 0$, $R_3 = 0$

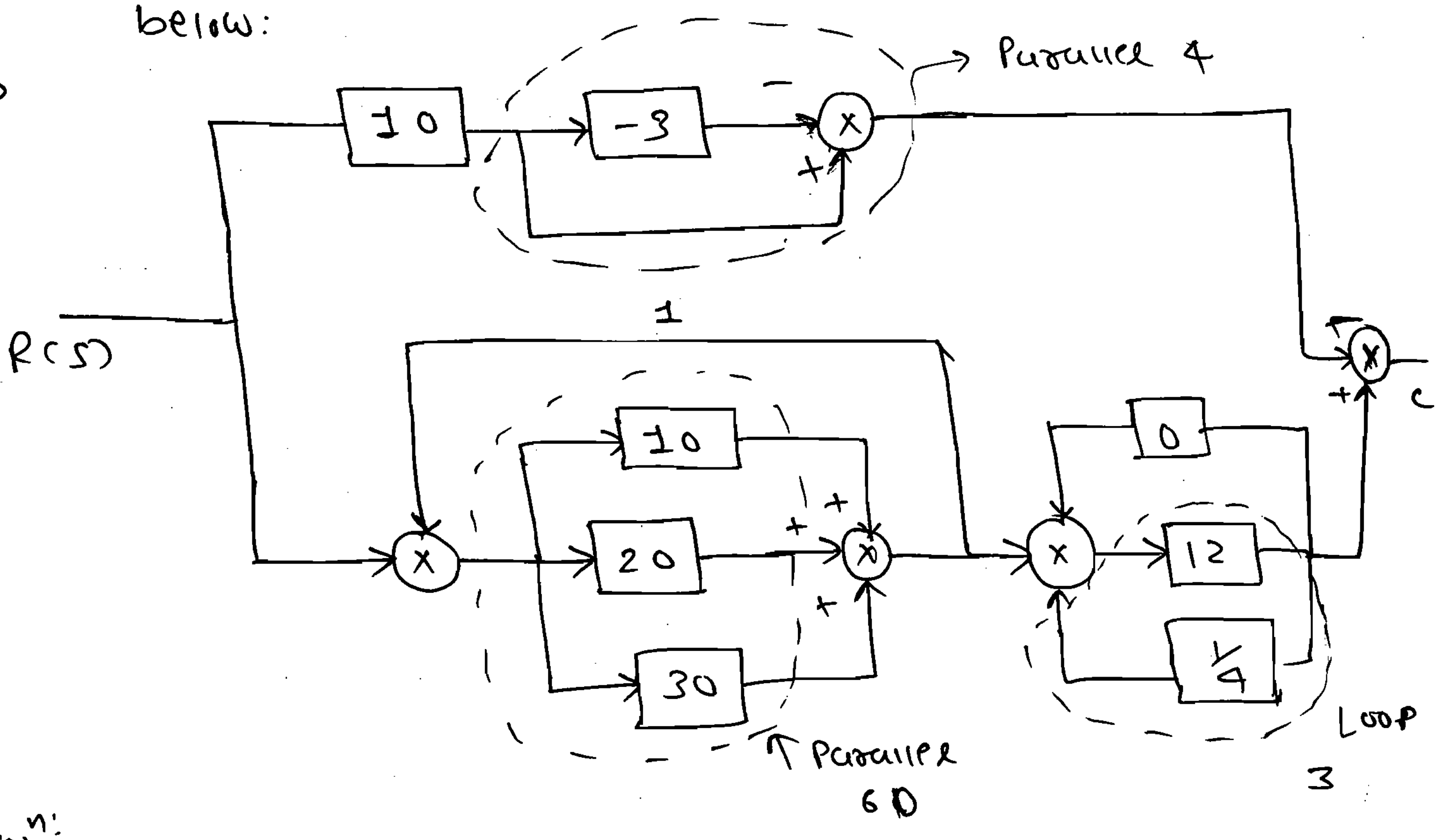


$$\therefore \quad \frac{C}{R_3} = \frac{-H_1 \cdot G_1 \cdot G_2}{1 + G_1 \cdot G_2 \cdot H_1 \cdot H_2},$$

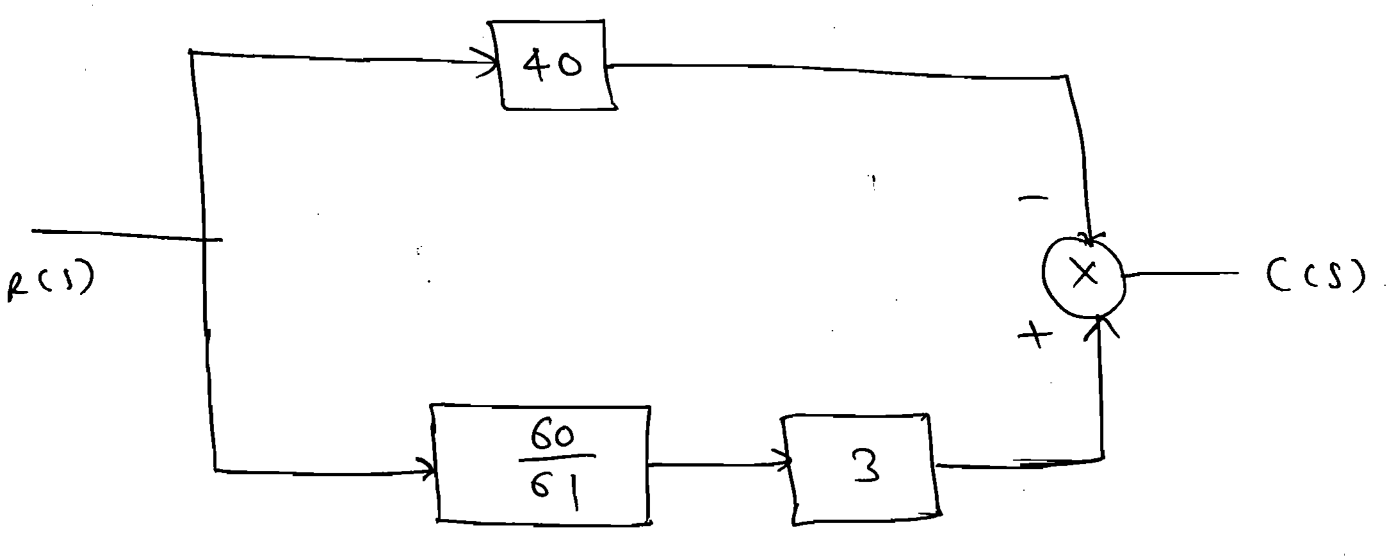
$$\therefore \quad C = \frac{R_1 \cdot G_1 \cdot G_2 + R_2 \cdot G_2 - R_3 \cdot G_1 \cdot G_2 \cdot H_1}{1 + G_1 \cdot G_2 \cdot H_1 \cdot H_2}.$$

$\boxed{Q}$ Find the Gain of the system given below:

=>

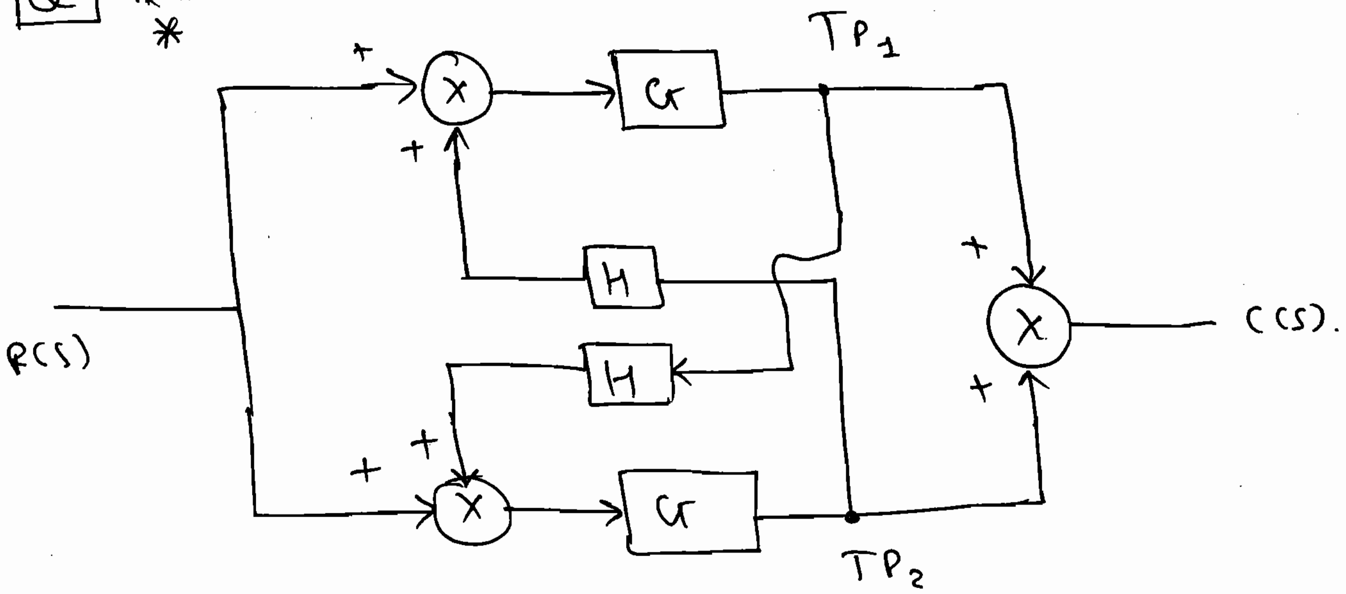


Soln:

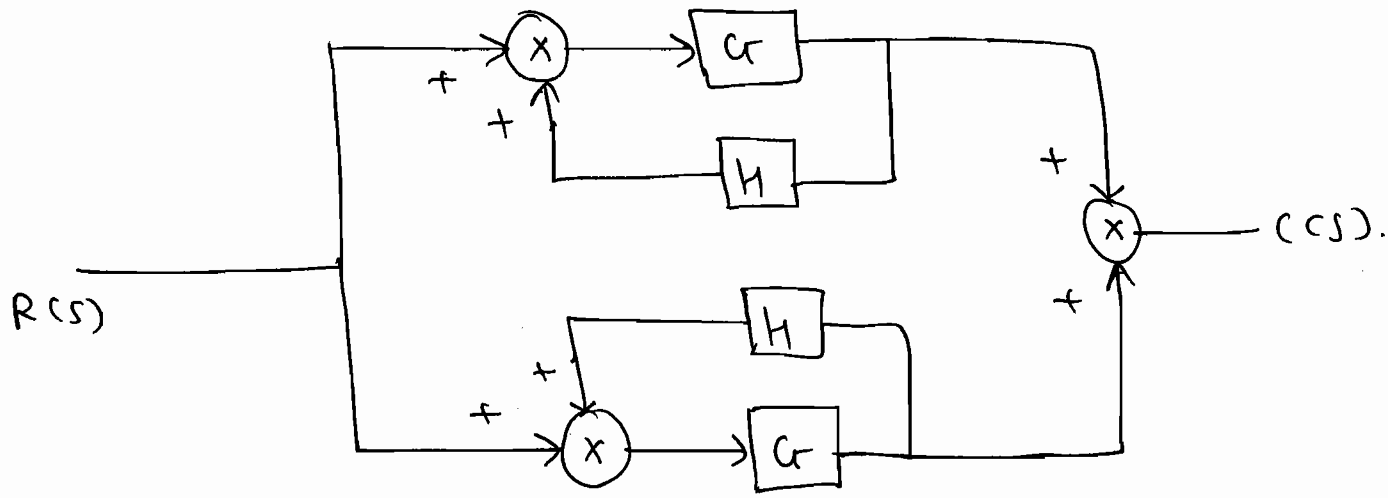


$$\therefore \quad \frac{C(s)}{R(s)} = -40 + 2.95 \simeq -37.$$

Q ***



Soln: In the above example the o/p at TP_1 is equal to the o/p at at TP_2 at any instant for any i/p. so, they can be interchanged as follow.



So, $$\frac{C(S)}{R(S)} = \frac{G}{1-GH} + \frac{G}{1 - GH}.$$

$$\Rightarrow \boxed{\frac{C(S)}{R(S)} = \frac{2G}{1-GH}}$$ //

Q The impulse response of the unity feedback system is

$c(t) = \left(-t \cdot e^{-t} + 2e^{-t}\right)$. The open loop TF equal to?

Sol^n: Mention F/B is a CLTF.

$$\therefore \frac{C(s)}{R(s)} = \frac{-1}{(s+1)^2} + \frac{2}{(s+1)}.$$

$R(s) = 1$ ($\because$ impulse).

$$\therefore \frac{C(s)}{R(s)} = \cancel{+\ s+1+1/s^2+2s+1}$$

$$= \frac{-1 + 2s+2}{s^2+2s+1}$$

$$\therefore \frac{G(s)}{1+GH} = \frac{2s+1}{s^2+2s+1}$$

$$\therefore \boxed{G(s) = \frac{2s+1}{s^2}} \leftarrow \text{OLTF.}$$

Q Find the OL DC gain of a unity F/B system of closed loop TF.

$$\frac{C(s)}{R(s)} = \frac{2s+4}{s^2+6s+13}.$$

Sol^n:

$$G(s) = \frac{2s+4}{s^2+4s+9} \quad \swarrow \text{OLTF}$$

for D.C. $\Rightarrow s = 0$.

$\Rightarrow$ OL. gain $= 4/9$.

Q The impulse response of a system is $5e^{-2t}$. To produced the responsed of $t \cdot e^{-2t}$. The i/p must be equal to _?

Soln:

$$g(t) = 5 \cdot e^{-2t},$$

$$c(t) = t \cdot e^{-2t}.$$

$$\therefore \quad G(s) = \frac{C(s)}{R(s)}.$$

$$\therefore \quad R(s) = \frac{C(s)}{G(s)}.$$

$$\therefore \quad R(s) = \frac{\frac{1}{(s+2)^2}}{5 \frac{1}{(s+2)}} = \frac{1}{5(s+2)}.$$

$$\therefore \quad \boxed{r(t) = \frac{1}{5} \cdot e^{-2t}}$$

$$\Rightarrow \quad \boxed{r(t) = 0.2 \cdot e^{-2t}.}$$