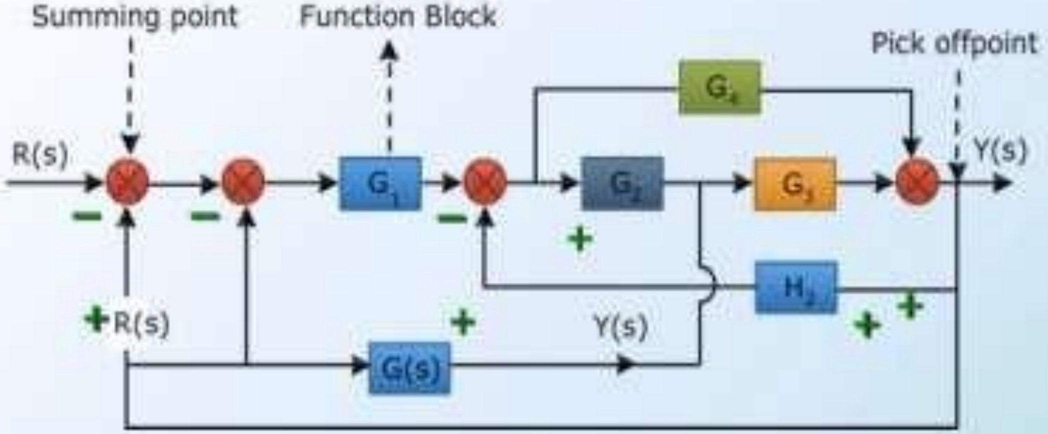
Block Diagram

- Block diagram (BD) is a diagram of a system in which the principal parts are represented by blocks connected by lines, that show the relation ships of blocks
- A block diagram comprises of following components
  - Summing point
  - Pick off point
  - Function block
- A block diagram has:
  - Rules for BD Reduction
  - Advantages
  - Limitations



Block Diagram Representation

Need of Block Diagram Algebra

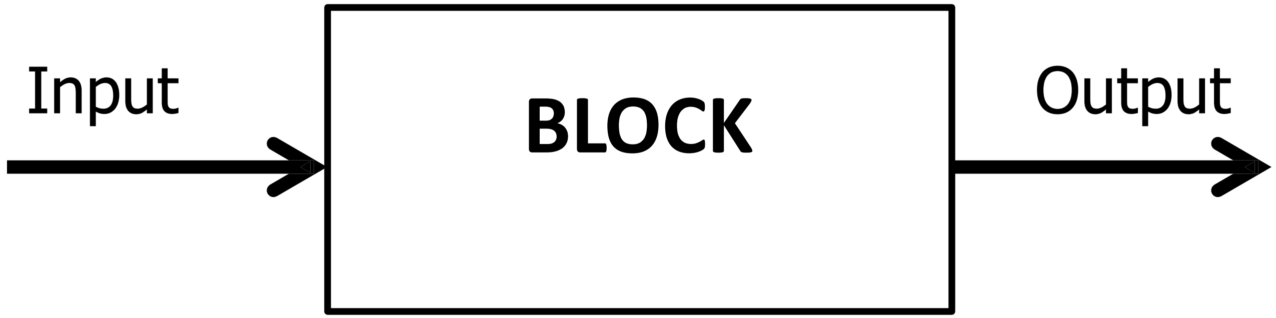
- If the system is simple & has limited parameters then it is easy to analyze such systems using the methods discussed earlier **i.e. transfer function**, if the system is complicated and also have number of parameters then it is very difficult to analyze it.

Need of Block Diagram Algebra

- To overcome this problem block diagram representation method is used.
- It is a simple way to represent any practically complicated system. In this each component of the system is represented by a separate block known as functional block.
- These blocks are interconnected in a proper sequence.

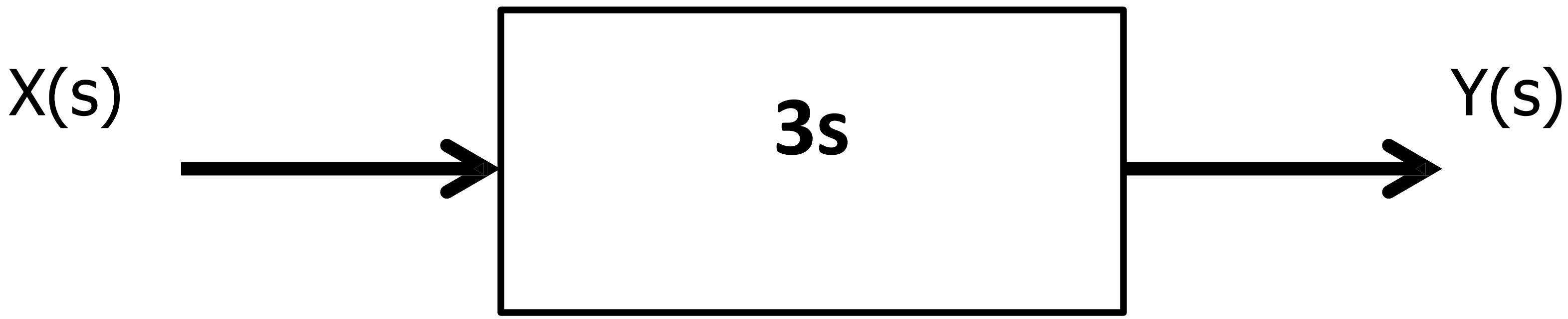
Block Diagram Fundamentals

- **<u>Block Diagram:</u>** It is shorthand, pictorial representation of the cause and effect relationship between input and output of a physical system.



Block Diagram Fundamentals

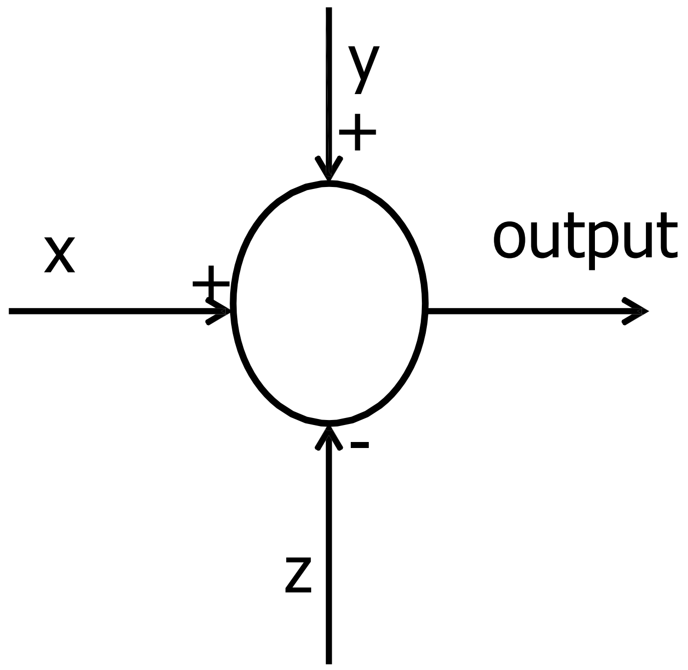
- **<u>Output:</u>** The value of the input is multiplied to the value of block gain to get the output.



Output $Y(s) = 3s.\,X(s)$

Block Diagram Fundamentals

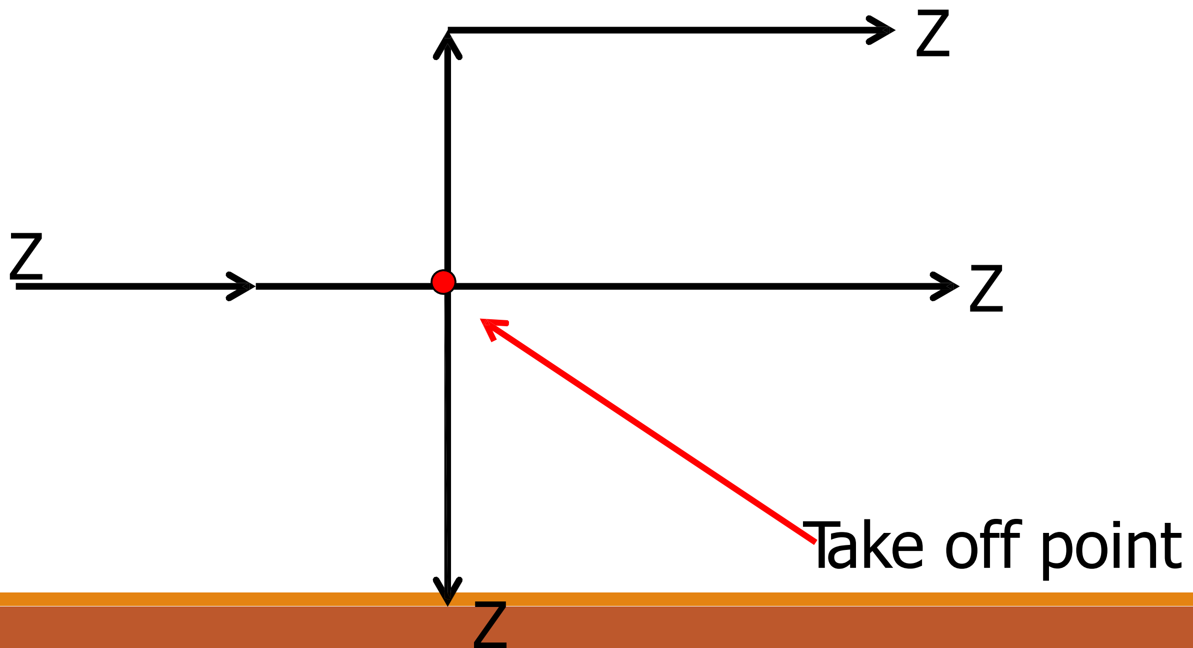
➢ **<u>Summing Point:</u>** Two or more signals can be added/ substracted at summing point.



Output =x+y-z

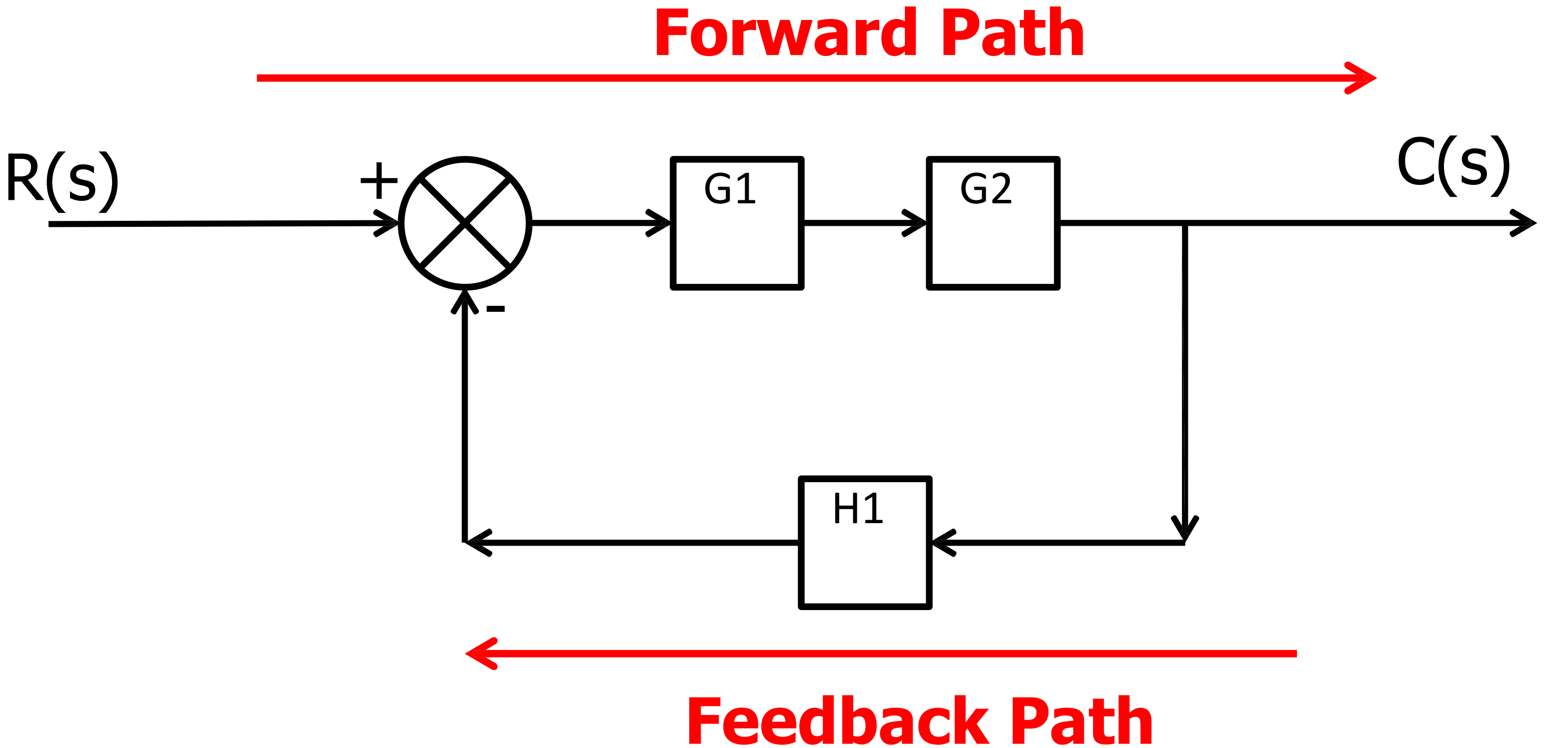
Block Diagram Fundamentals

- **Take off Point:** The output signal can be applied to two or more points from a take off point.



Block Diagram Fundamentals

- **Forward Path:** The direction of flow of signal is from input to output

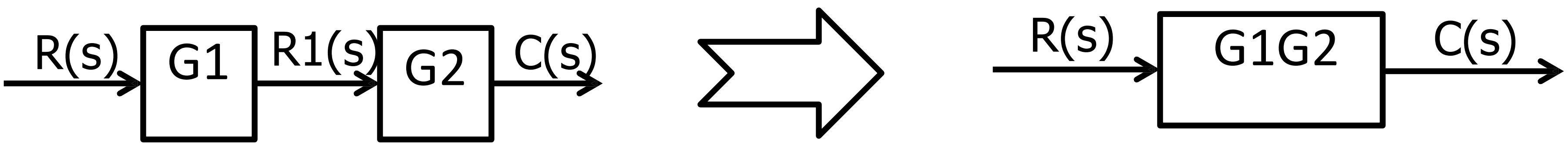


- **Feedback Path:** The direction of flow of signal is from output to input

Block Diagram Reduction Techniques

Rule 1: For blocks in cascade

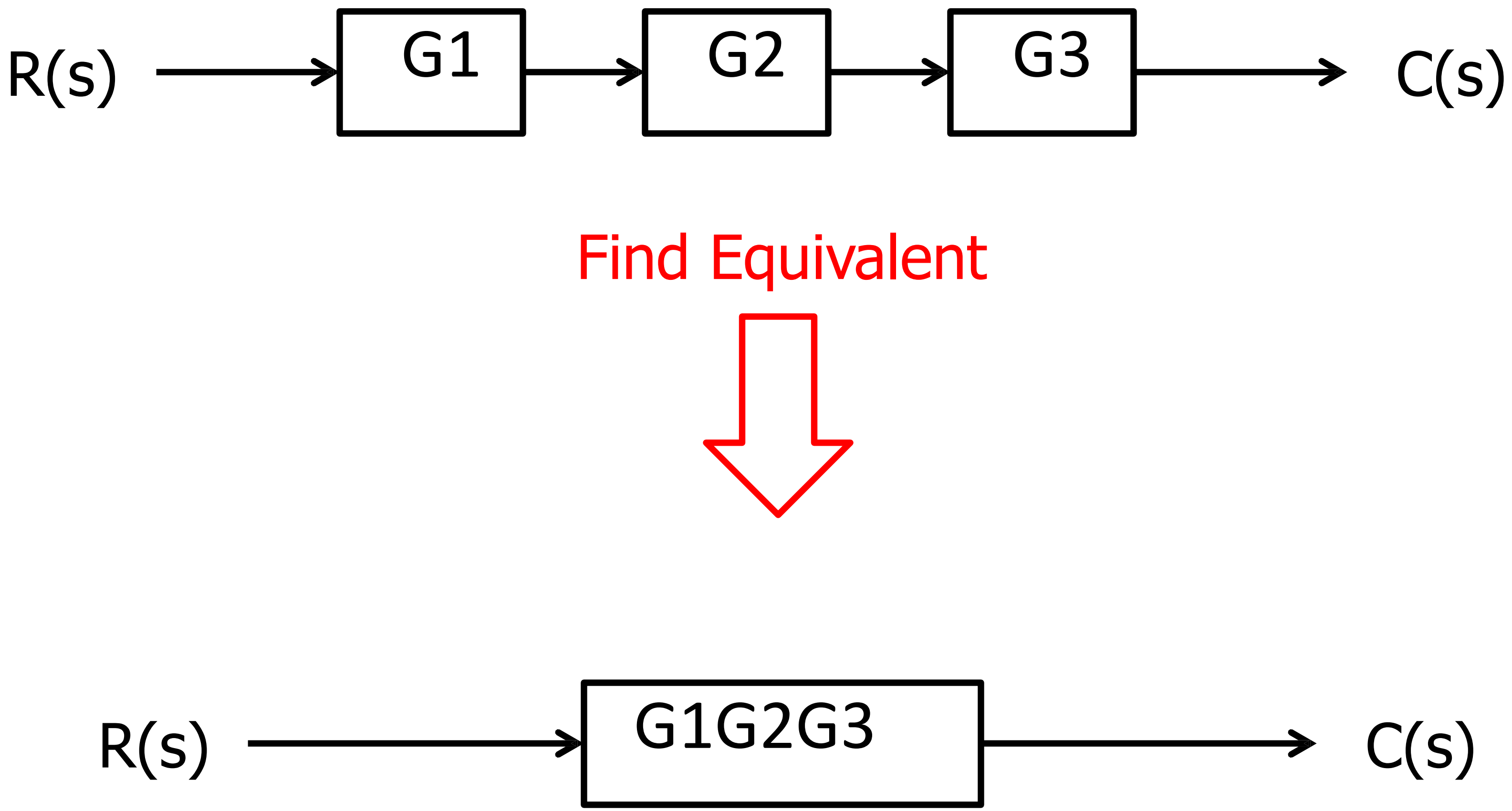
Gain of blocks connected in cascade gets multiplied with each other.

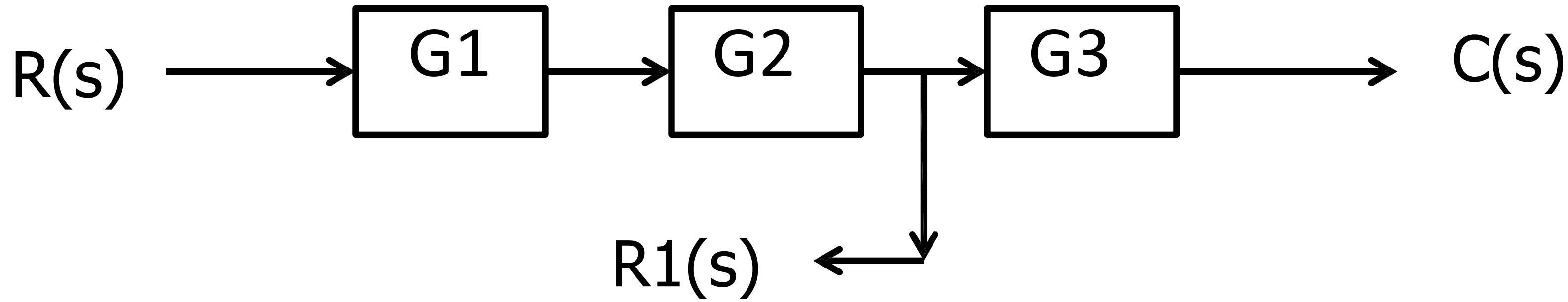


R1(s)=G1R(s)

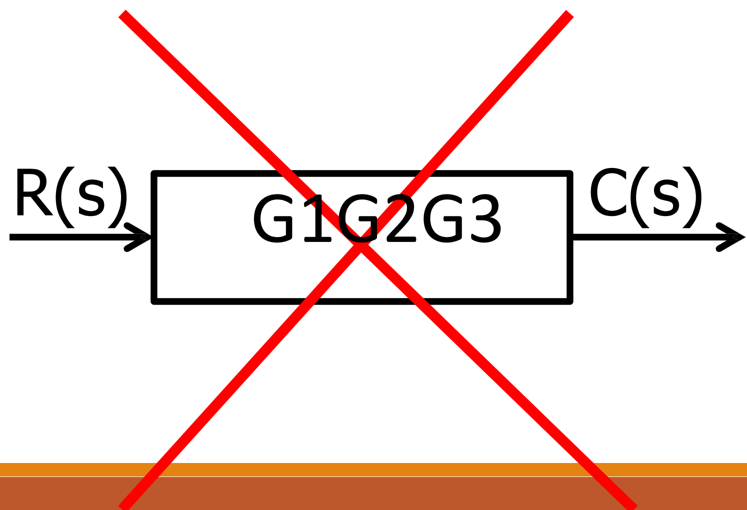
C(s) =G2R1(s)
=G1G2R(s)

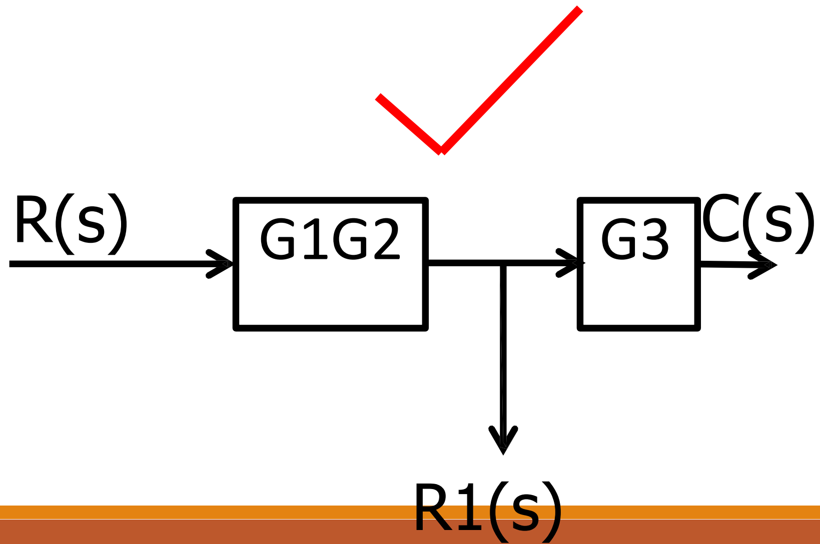
C(s)= G1G2R(s)


R(s)
G1
G2
G3
C(s)
Find Equivalent
R(s)
G1G2G3
C(s)



Find Equivalent

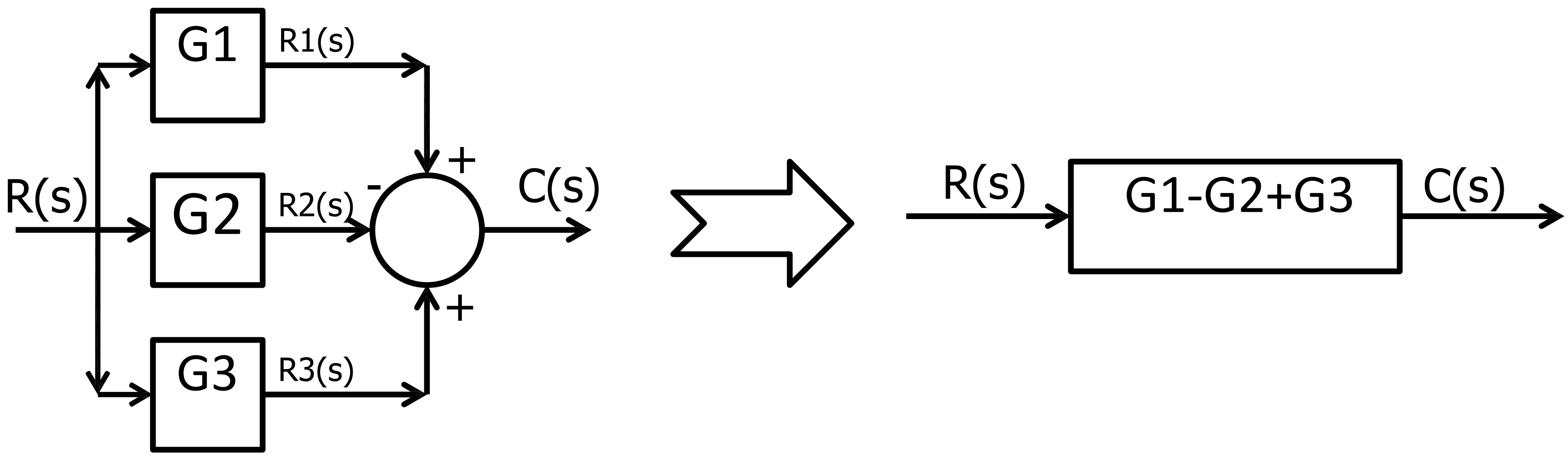




Block Diagram Reduction Techniques

Rule 2: For blocks in Parallel

Gain of blocks connected in parallel gets added algebraically.



C(s)= R1(s)-R2(s)+R3(s)

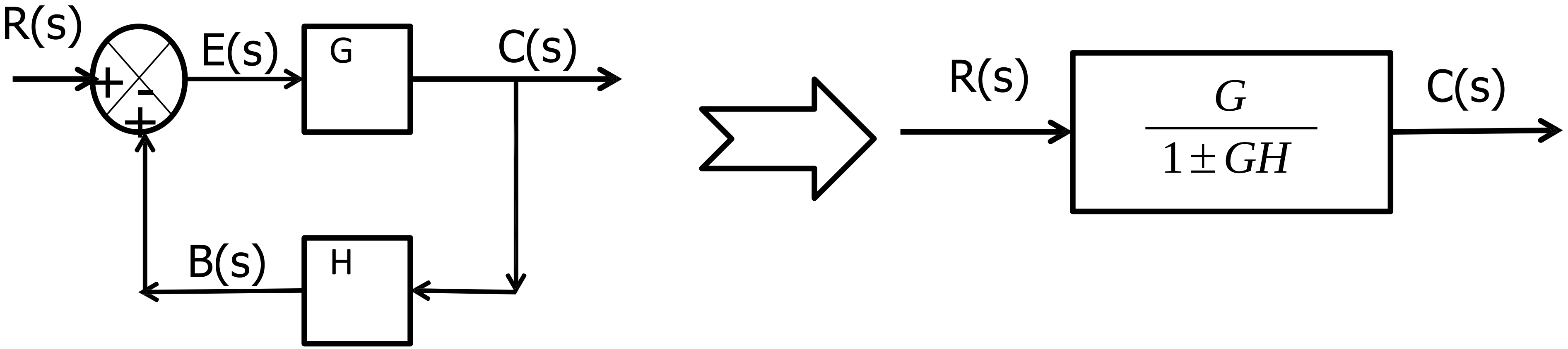
= G1R(s)-G2R(s)+G3R(s)

C(s)=(G1-G2+G3) R(s)

C(s)= (G1-G2+G3) R(s)

Block Diagram Reduction Techniques

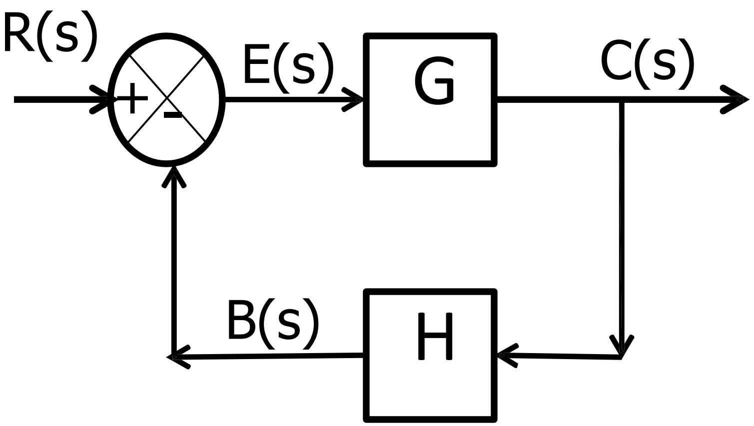
Rule 3: Eliminate Feedback Loop



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

In General

From Shown Figure,



$$E(s) = R(s) - \mathrm{B(s)}$$

and

$$C(s) = G.E(s)$$
$$= G[\mathrm{R(s)} - \mathrm{B(s)}]$$
$$= GR(\mathrm{s}) - \mathrm{GB(s)}$$

But

$$B(s) = H.C(s)$$

$$\therefore C(s) = G.R(s) - \mathrm{G.H.C(s)}$$

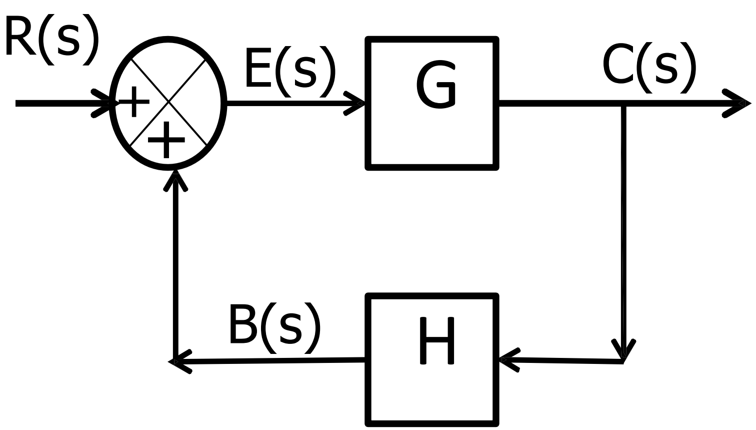
$$C(s) + \mathrm{G.H} = \mathrm{GR(s)}$$

$$\therefore C(s)\{1 + \mathrm{G.H}\} = \mathrm{G.R(s)}$$

For Negative Feedback

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

From Shown Figure,



$$E(s) = R(s) + B(s)$$

and

$$C(s) = G.E(s)$$
$$= G[R(s) + B(s)]$$
$$= GR(s) + GB(s)$$

But $B(s) = H.C(s)$

$$\therefore C(s) = G.R(s) + G.H.C(s)$$

$$C(s) - G.H = GR(s)$$

$$\therefore C(s)\{1 - G.H\} = G.R(s)$$

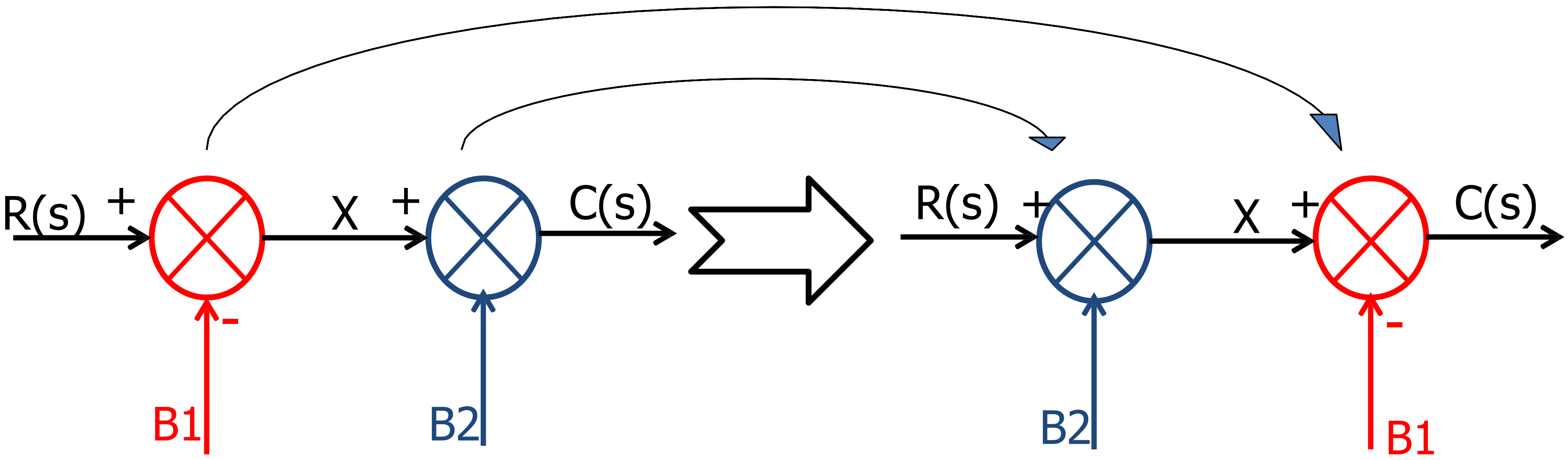
For Positive Feedback

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

Block Diagram Reduction Techniques

Rule 4: Associative Law for Summing Points

The order of summing points can be changed if two or more summing points are in series

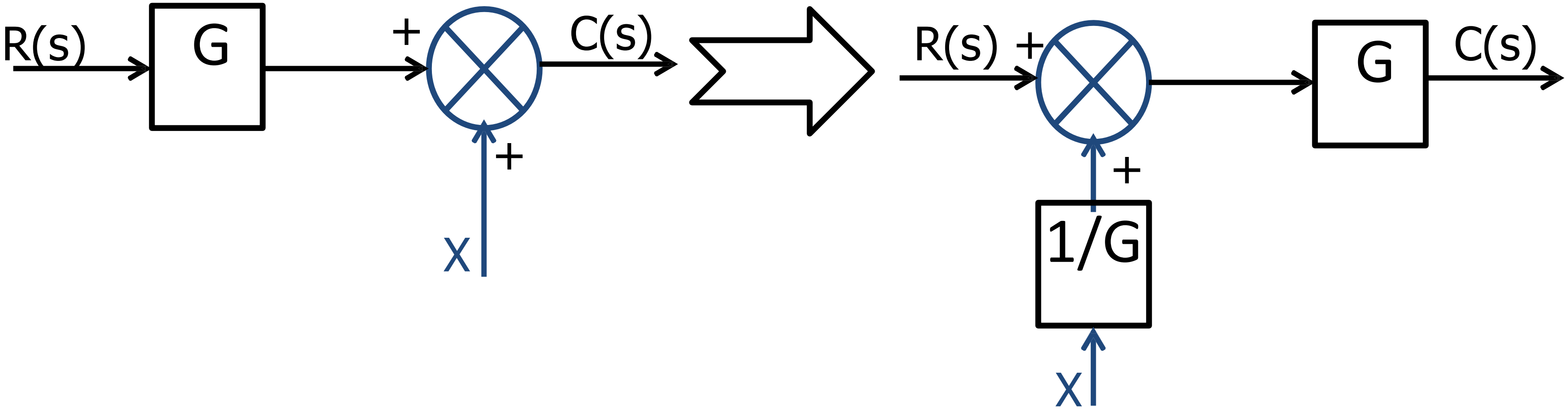


X=R(s)-B1
C(s)=X-B2
C(s)=R(s)-B1-B2

X=R(s)-B2
C(s)=X-B1
C(s)=R(s)-B2-B1

Block Diagram Reduction Techniques

Rule 5: Shift summing point before block

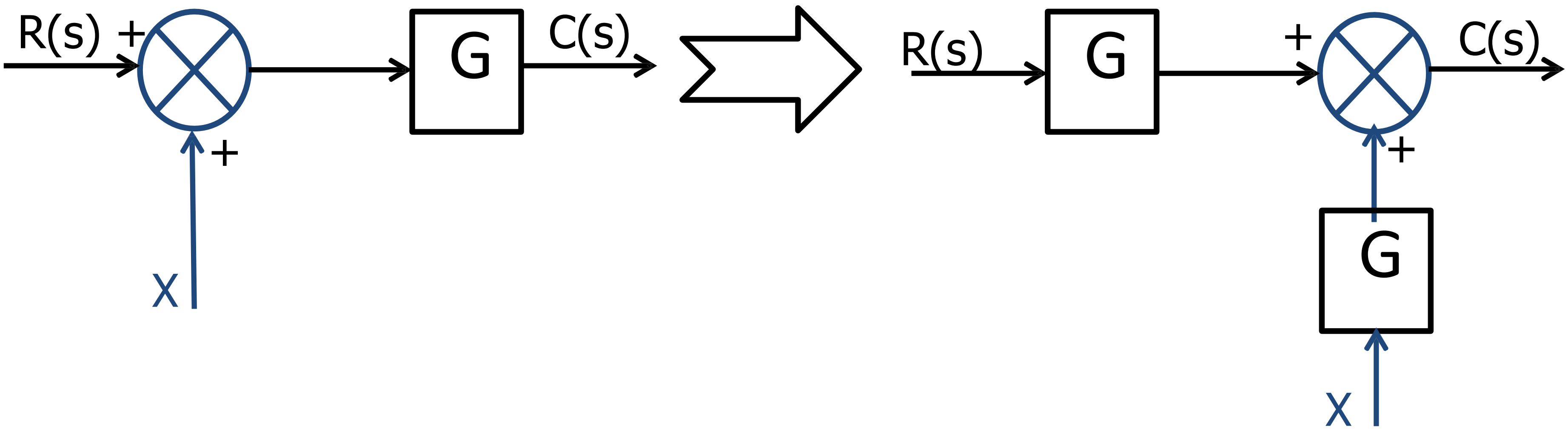


$C(s)=R(s)G+X$

$C(s)=G\{R(s)+X/G\}$
$=GR(s)+X$

Block Diagram Reduction Techniques

Rule 6: Shift summing point after block

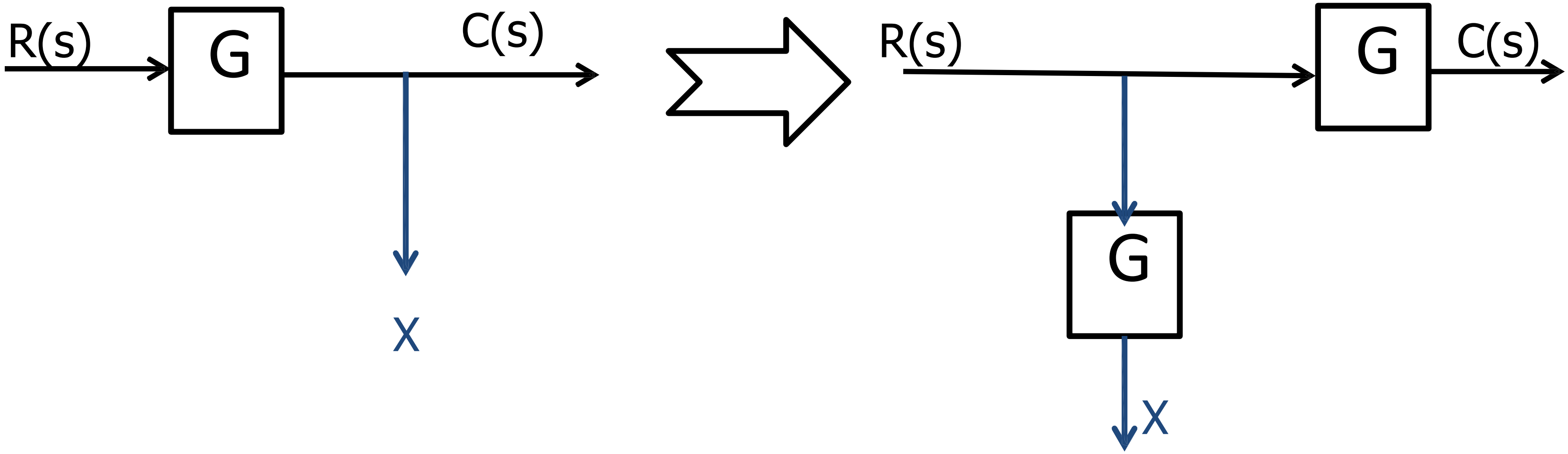


$$C(s) = G\{R(s) + X\}$$
$$= GR(s) + GX$$

$$C(s) = GR(s) + XG$$
$$= GR(s) + XG$$

Block Diagram Reduction Techniques

Rule 7: Shift a take off point before block

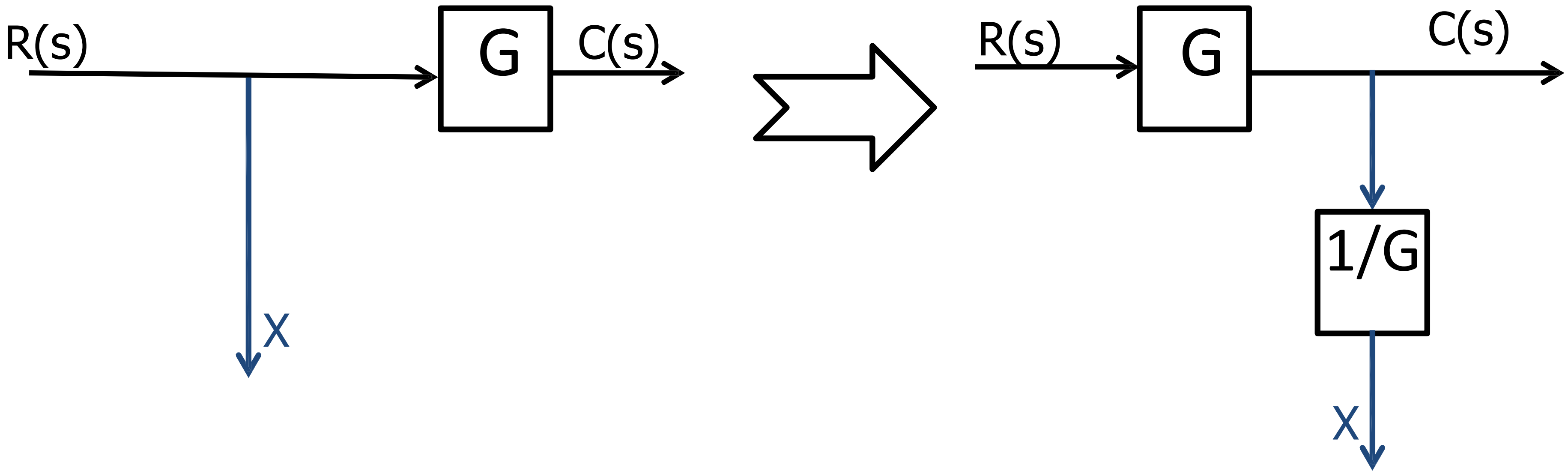


C(s)=GR(s)
and
X=C(s)=GR(s)

C(s)=GR(s)
and
X=GR(s)

Block Diagram Reduction Techniques

Rule 8: Shift a take off point after block



$C(s)=GR(s)$
and
$X=R(s)$

$C(s)=GR(s)$
and
$X=C(s).\{1/G\}$
$=GR(s).\{1/G\}$
$= R(s)$

Block Diagram Reduction Techniques

- While solving block diagram for getting single block equivalent, the said rules need to be applied. After each simplification a decision needs to be taken. For each decision we suggest preferences as

Block Diagram Reduction Techniques

First Choice

First Preference: Rule 1 (For series)

Second Preference: Rule 2 (For parallel)

Third Preference: Rule 3 (For FB loop)

Block Diagram Reduction Techniques

Second Choice

(Equal Preference)

Rule 4 Adjusting summing order

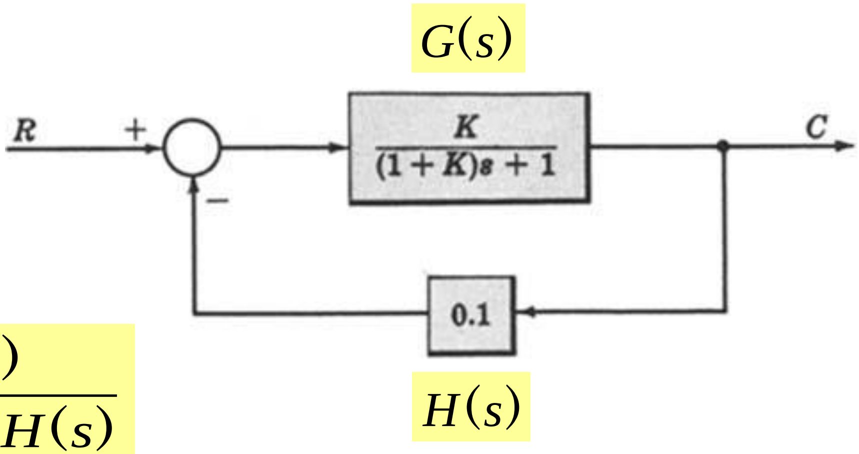
Rule 5/6 Shifting summing point before/after block

Rule7/8 Shifting take off point before/after block

1. Open loop transfer function $G(s)H(s)$

2. Feed Forward Transfer function $G(s)$

3. error ratio $\dfrac{E(s)}{R(s)} = \dfrac{1}{1+G(s)H(s)}$



4. closed loop transfer function

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

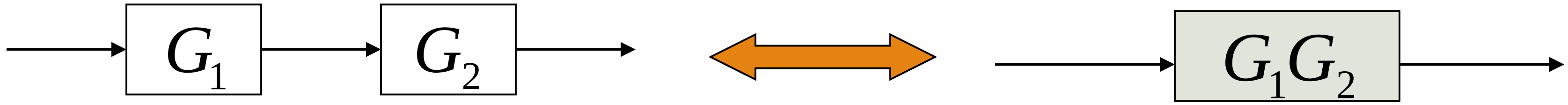
5. characteristic equation

$$1+G(s)H(s)=0$$

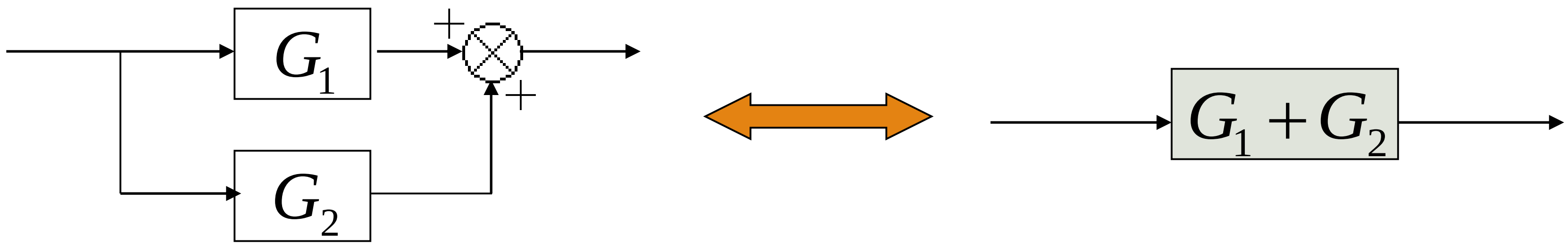
6. closed loop poles and zeros if K=10.

Reduction techniques

1. Combining blocks in cascade

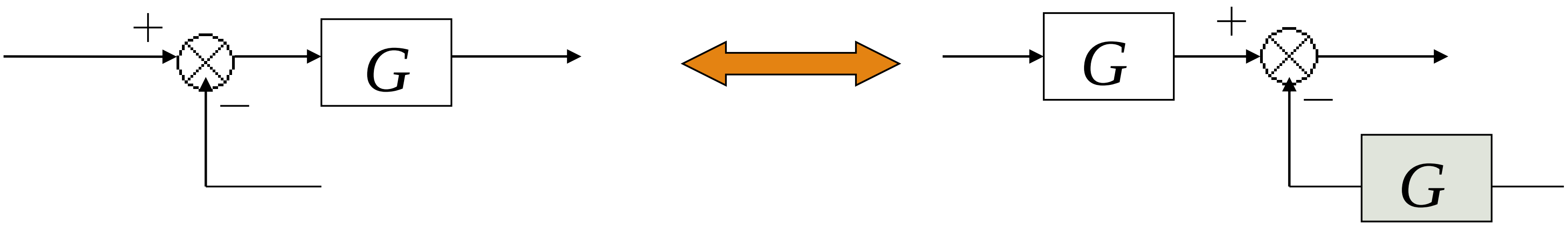


2. Combining blocks in parallel

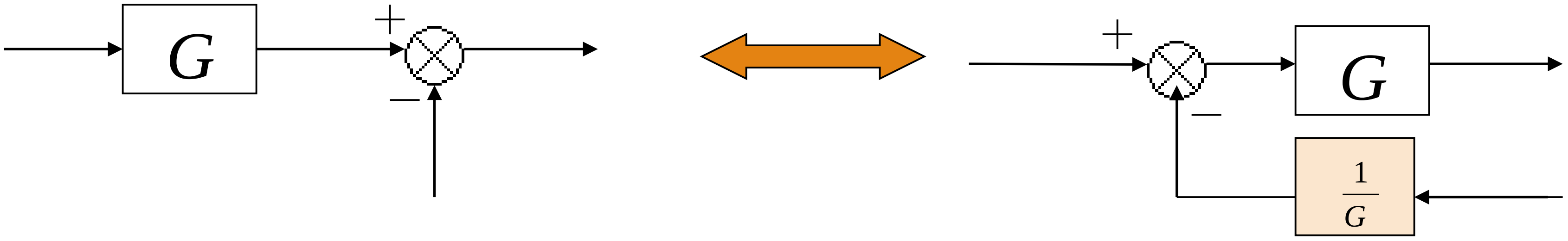


Reduction techniques

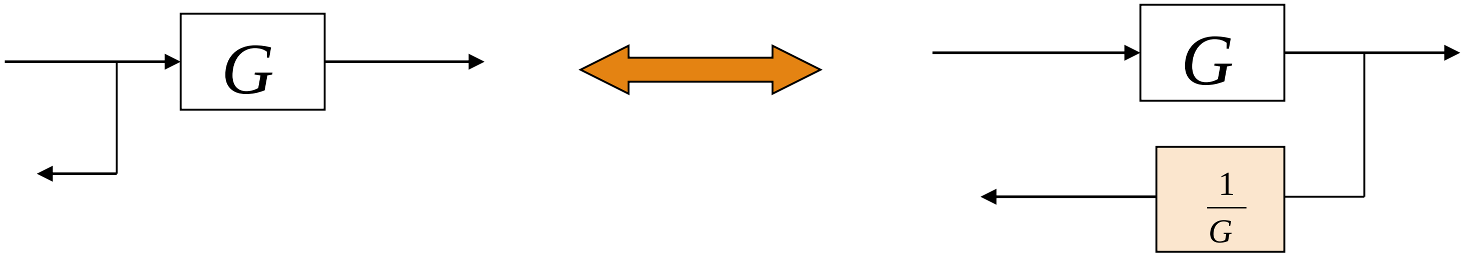
3. Moving a summing point behind a block



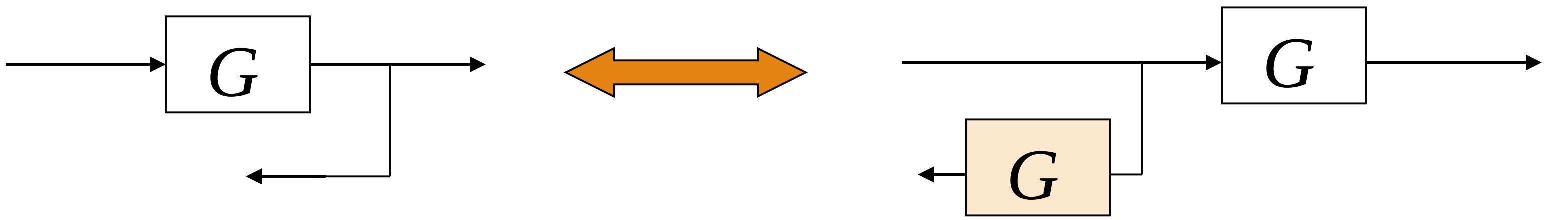
4. Moving a summing point ahead of a block



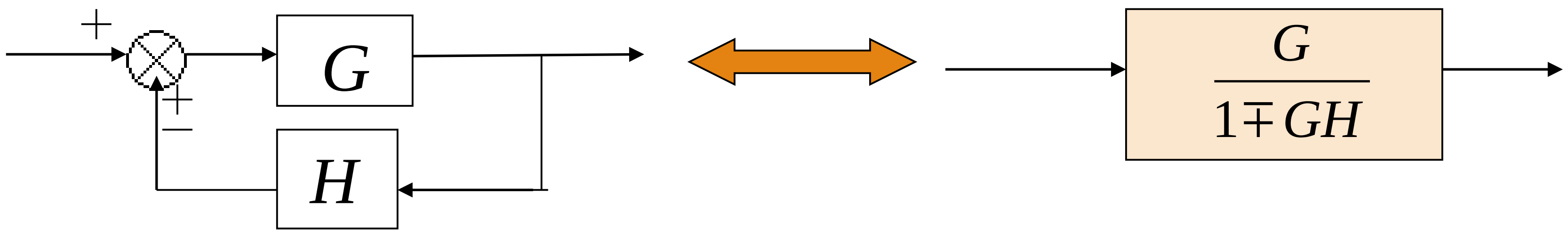
5. Moving a pickoff point behind a block

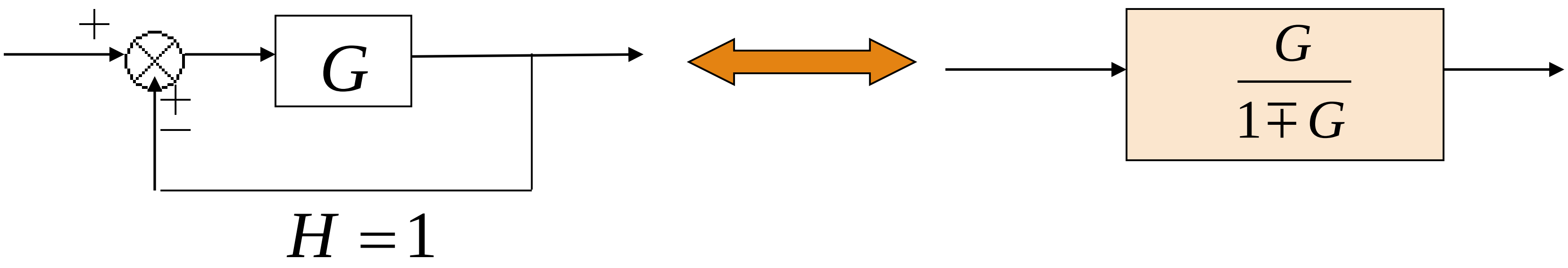


6. Moving a pickoff point ahead of a block

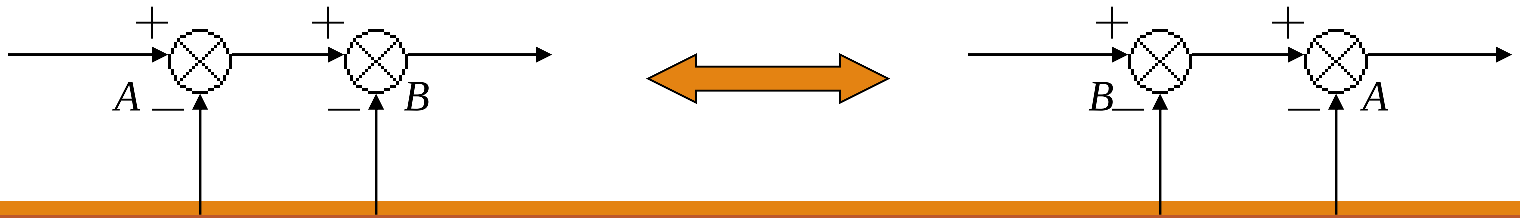


7. Eliminating a feedback loop

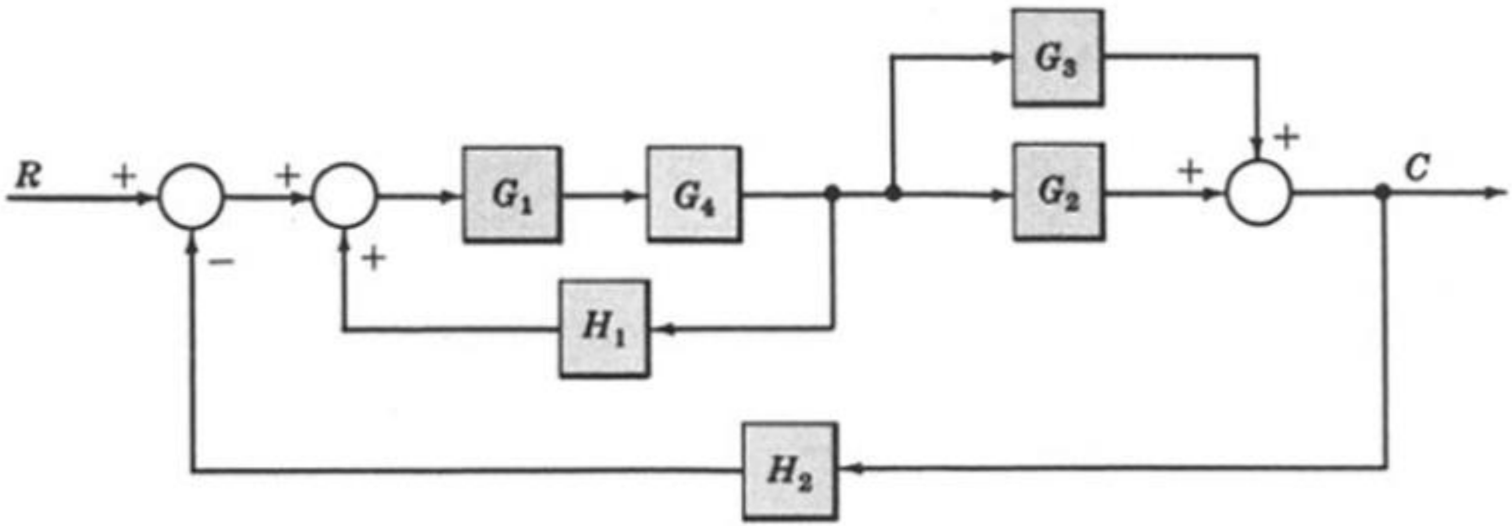




8. Swap with two neighboring summing points



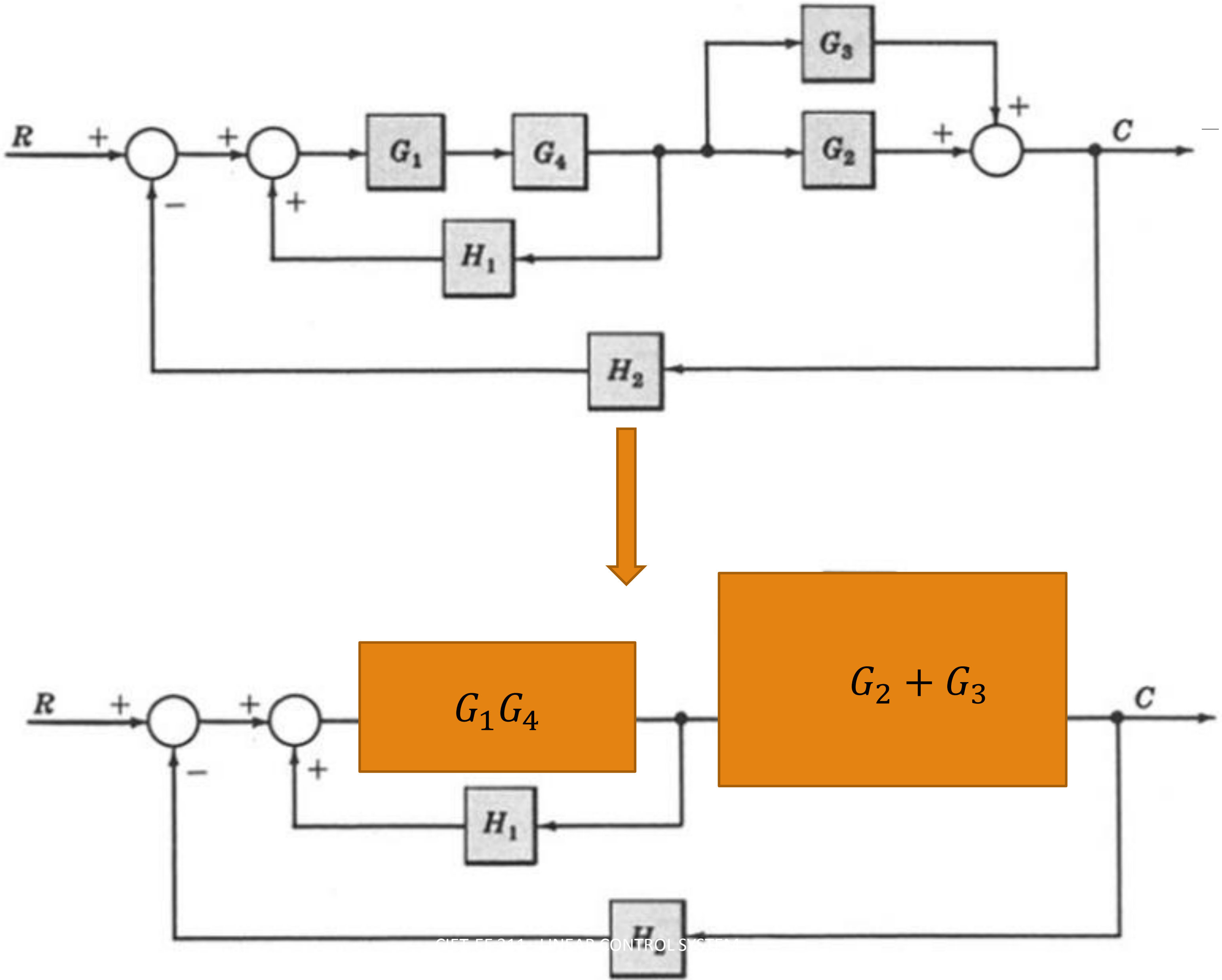
Example :Reduce the Block Diagram to Canonical Form.



- Combine all cascade block using rule-1

- Combine all parallel block using rule-2

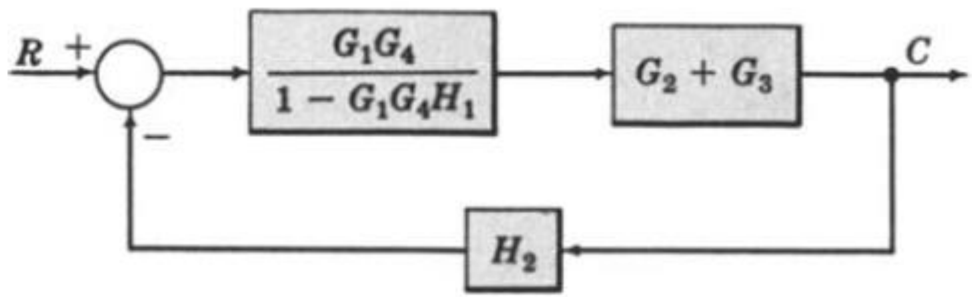
Example: Reduce the Block Diagram to Canonical Form.



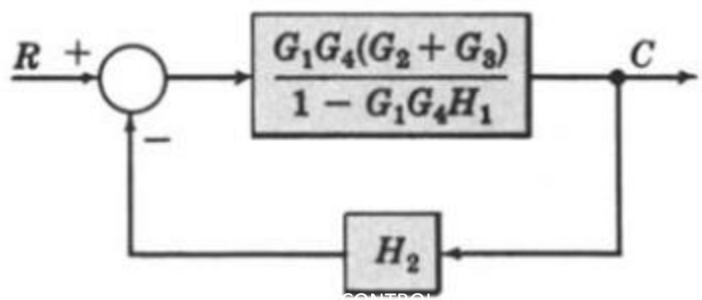
Example Continue.

- Eliminate all minor feedback loops using rule-7

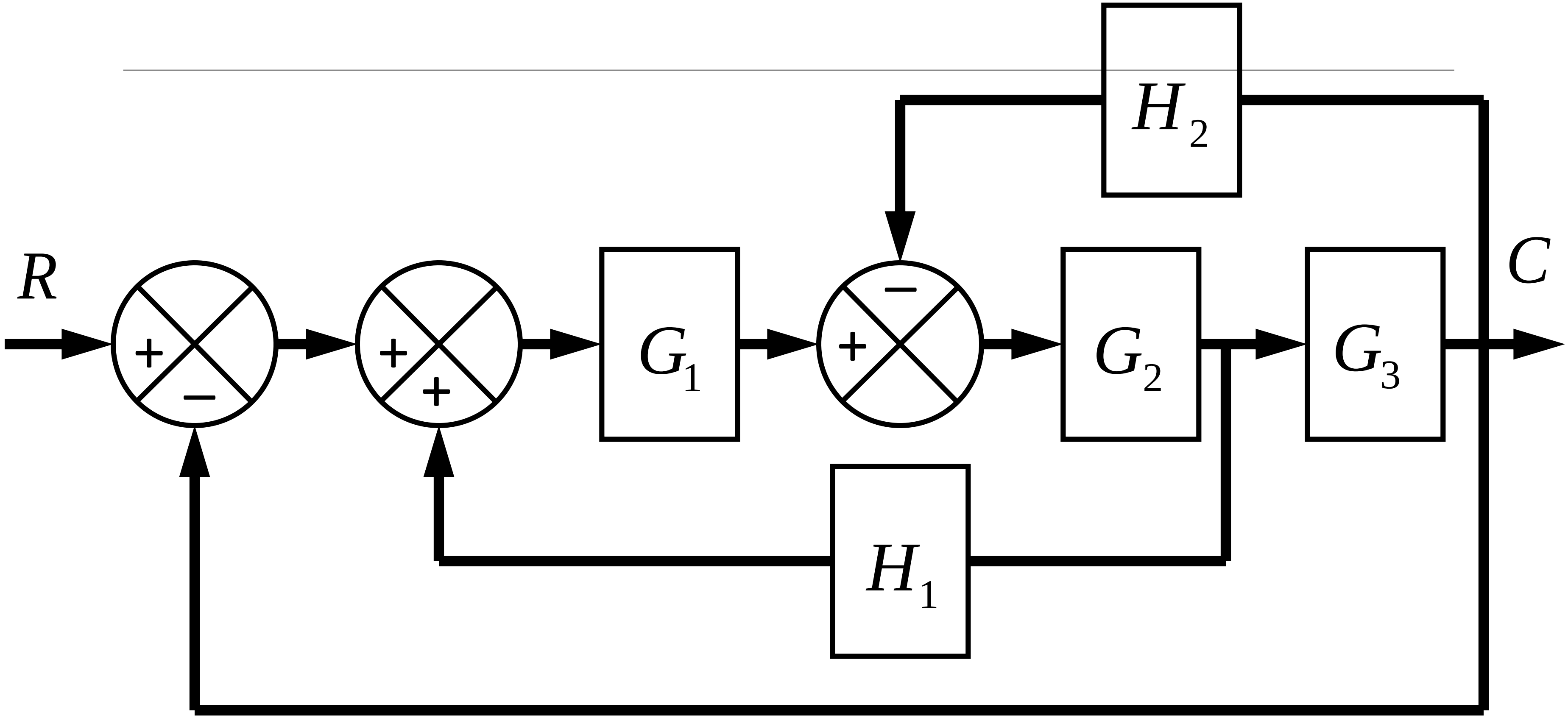
- After the elimination of minor feedback loop the block diagram is reduced to as shown below



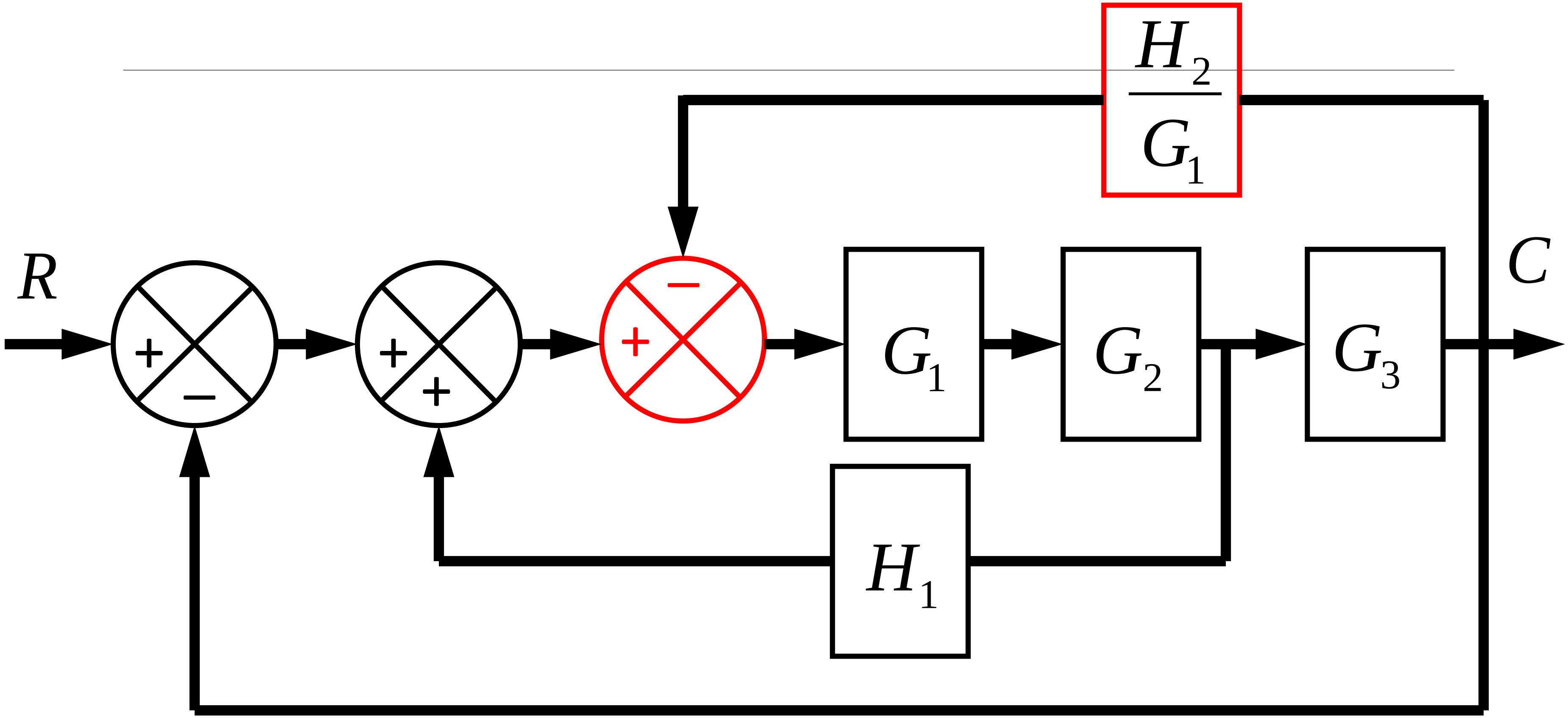
- Again blocks are in cascade are removed using rule-1



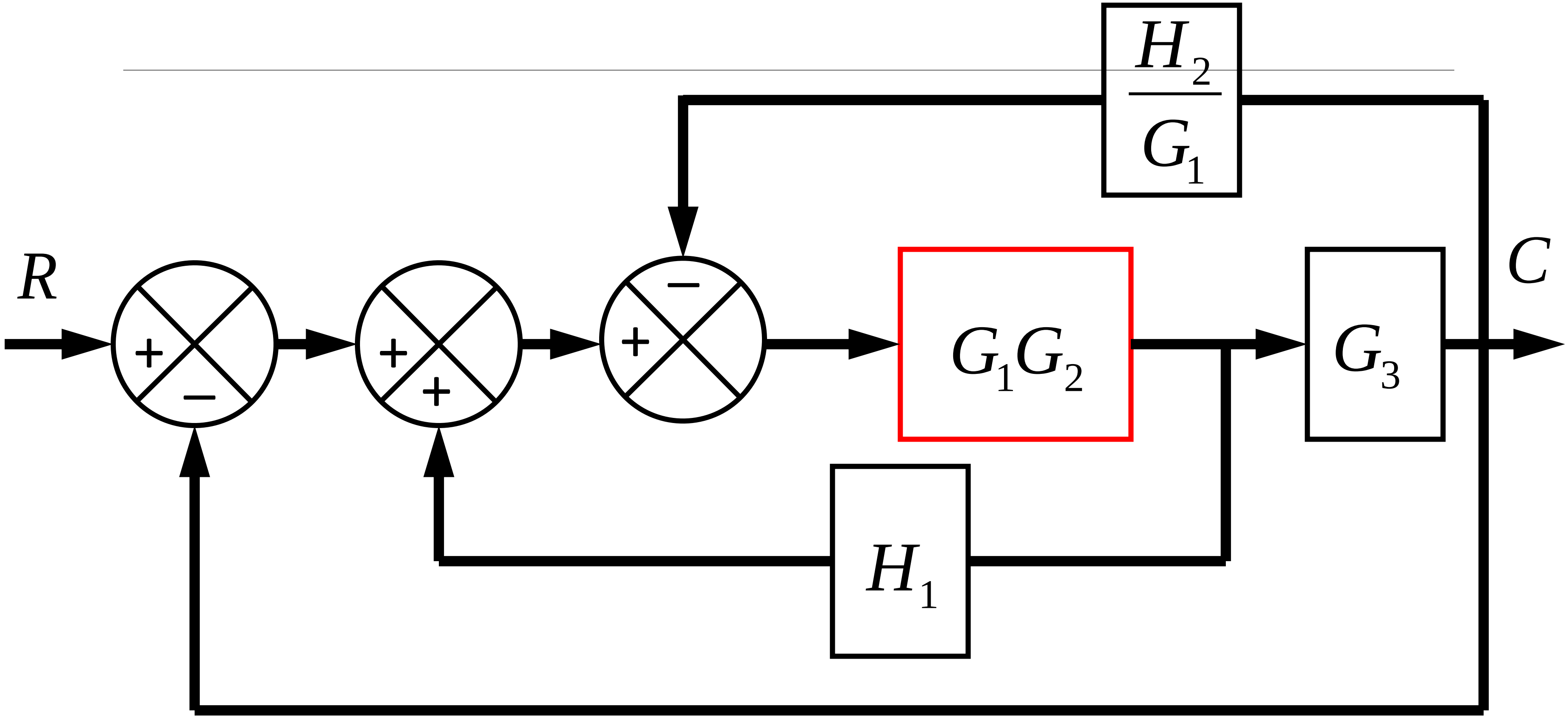
Example:



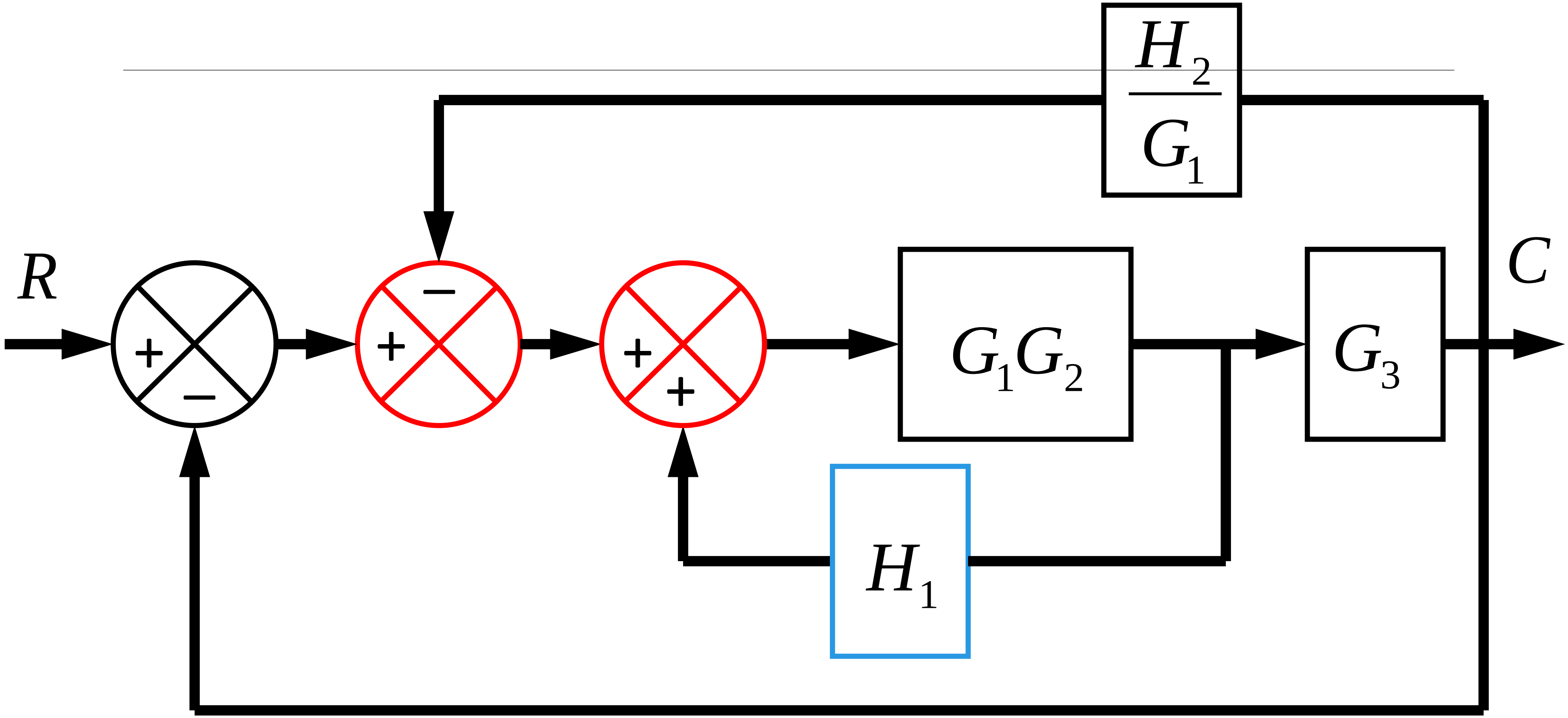
Example:



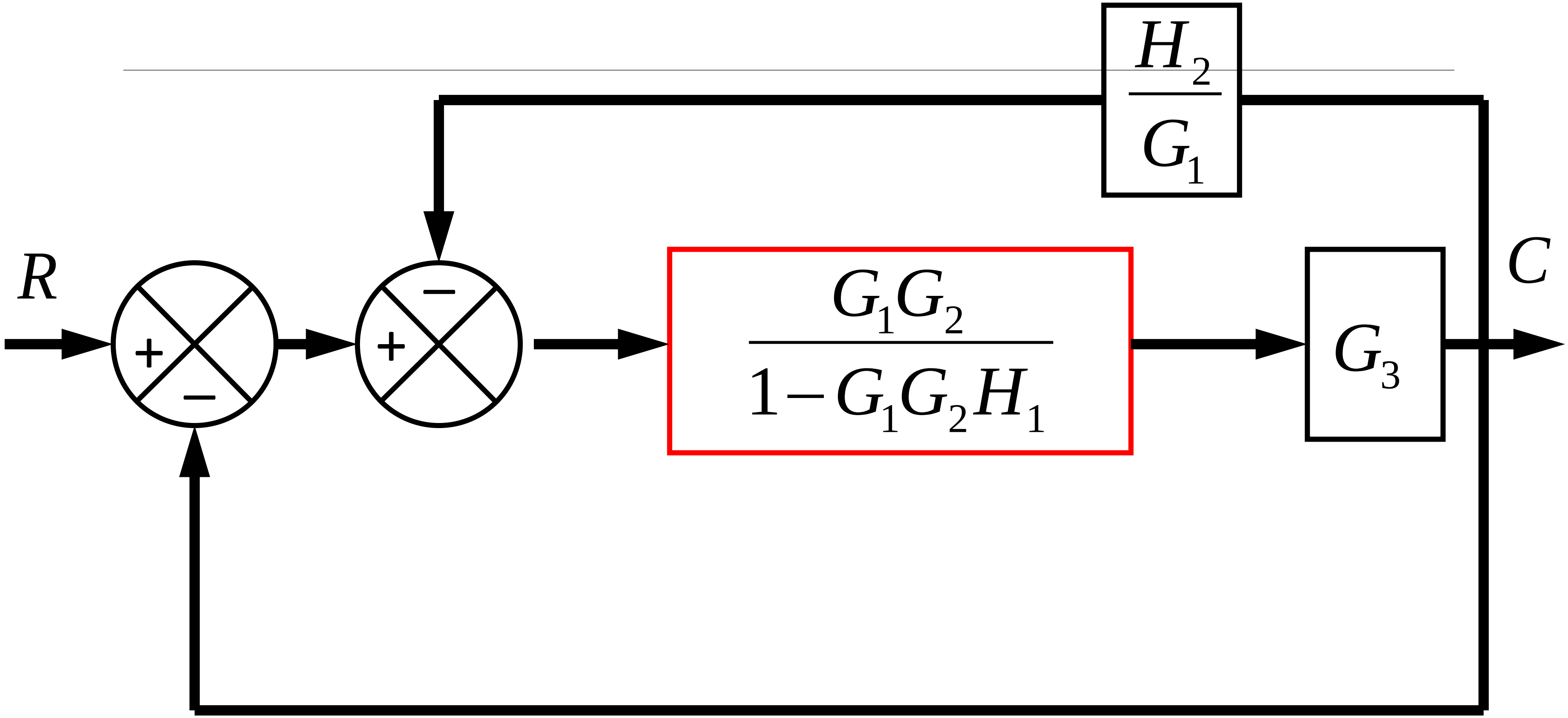
Example:



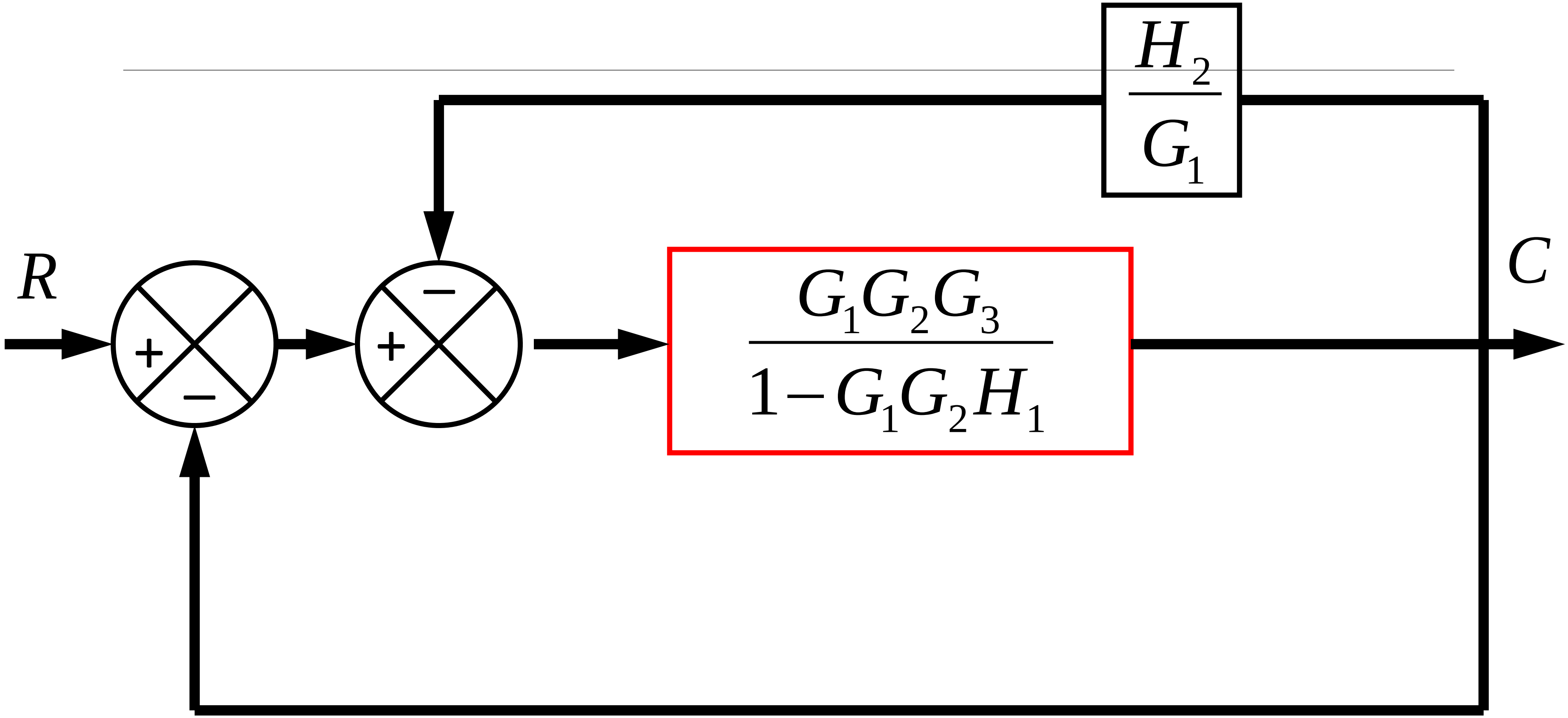
Example:



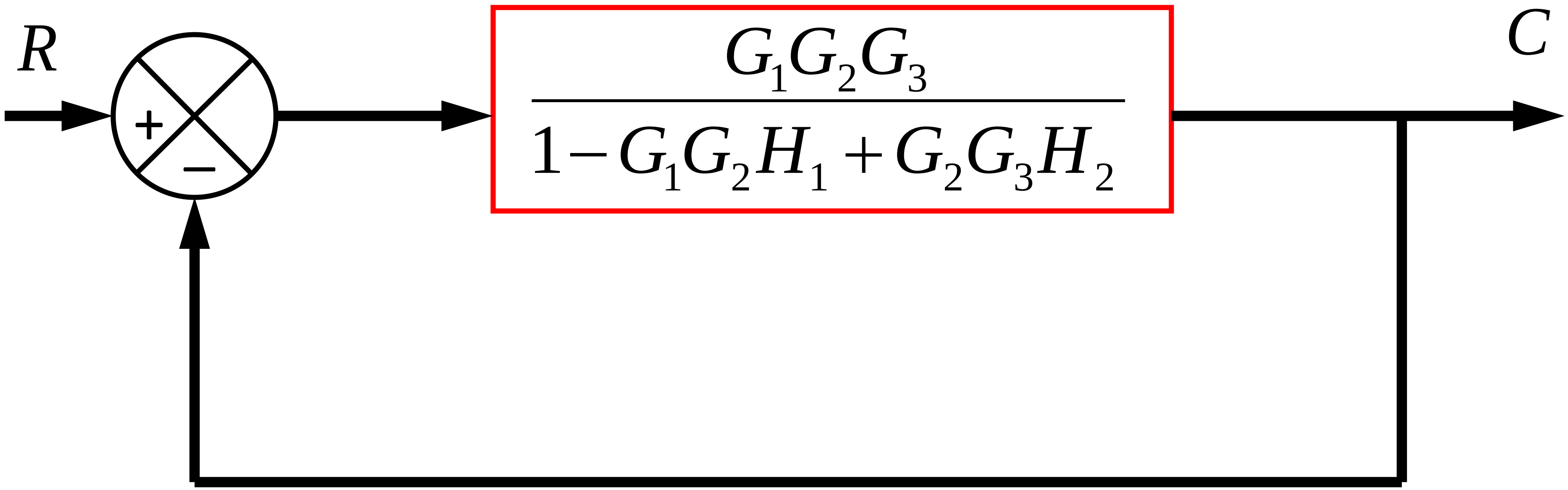
Example:



Example:

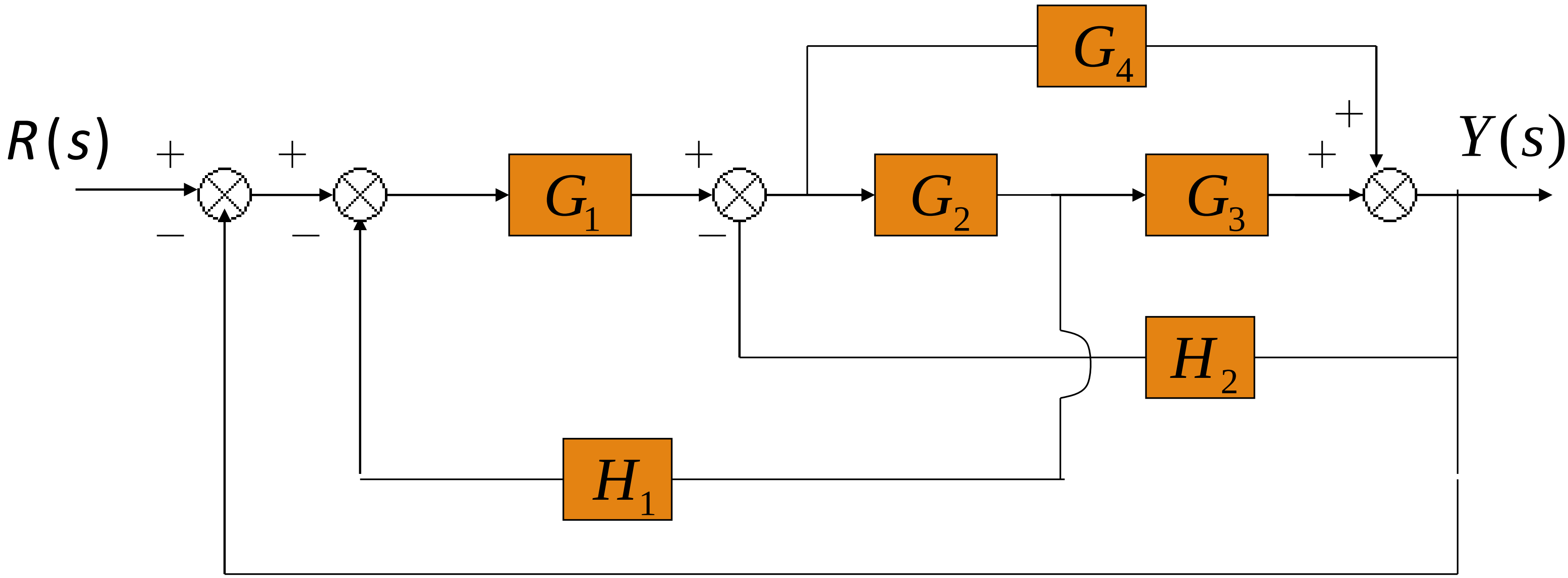


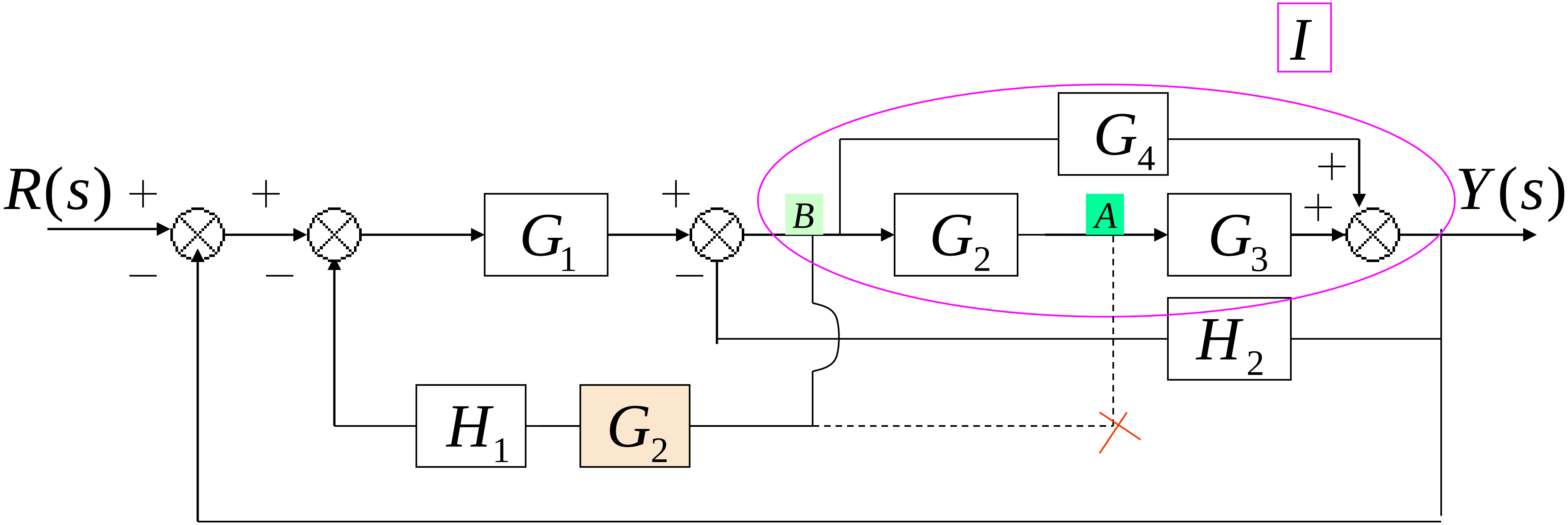
Example:



Example:

Find the transfer function of the following block diagram

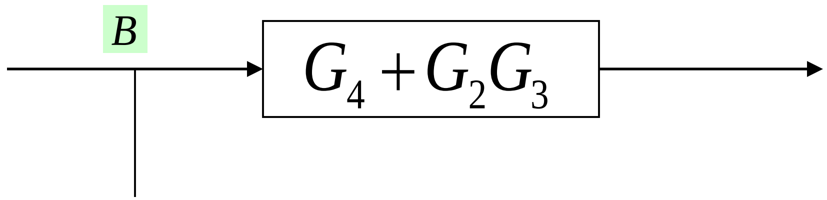


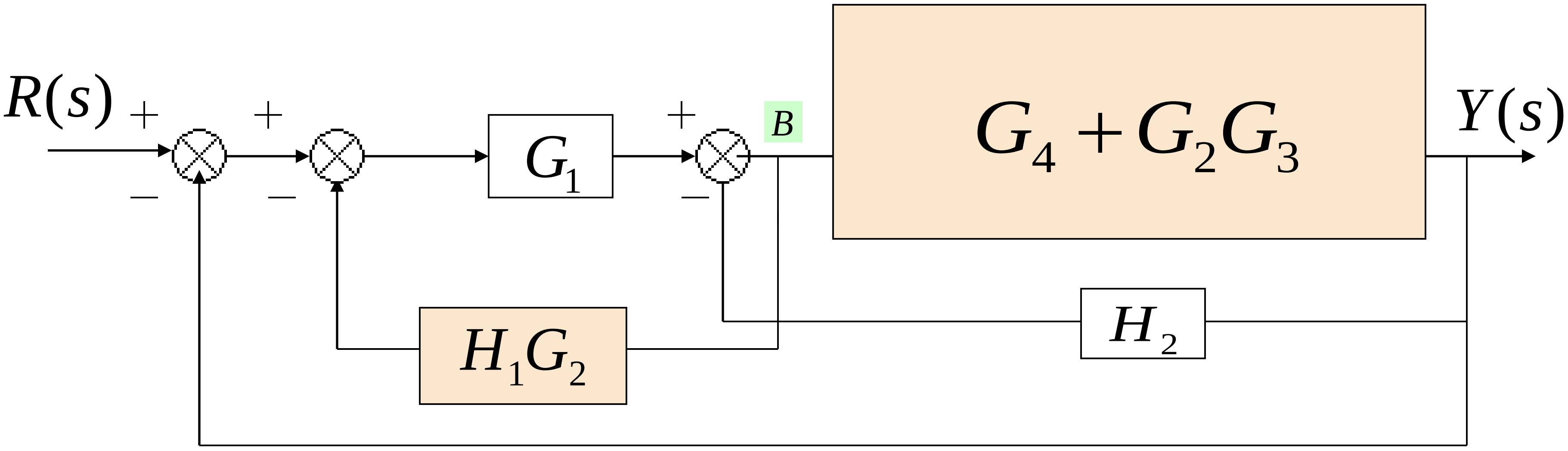


Solution:

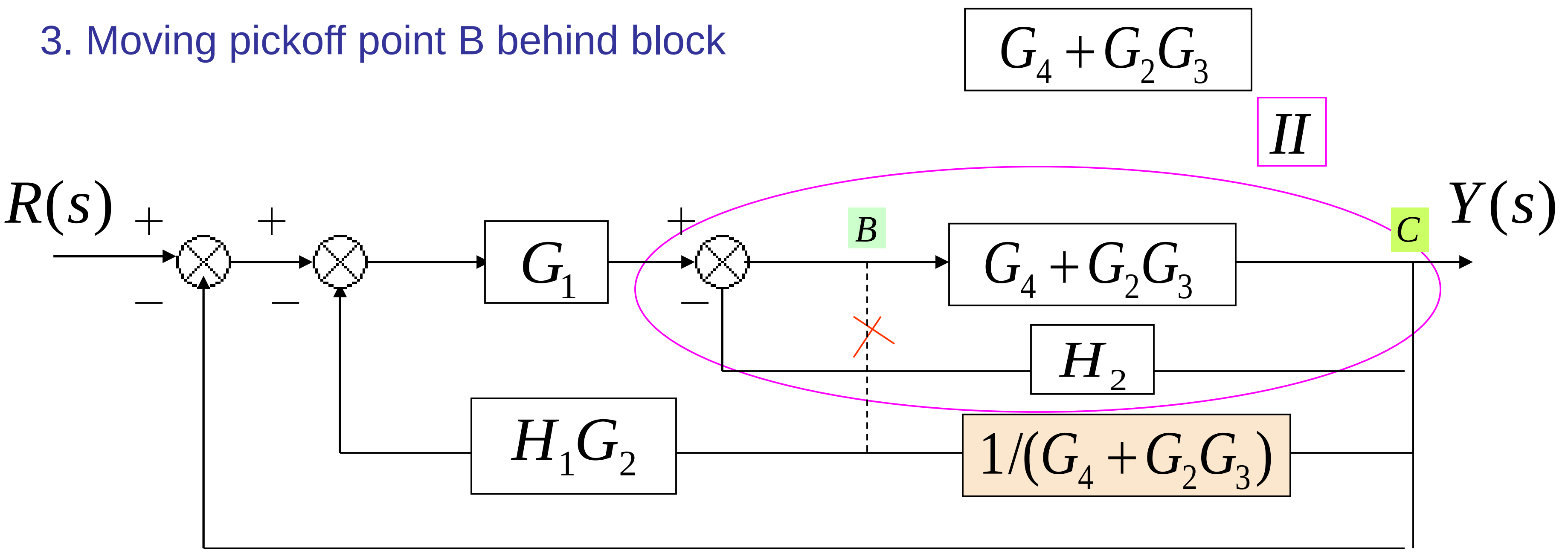
1. Moving pickoff point A ahead of block G_2

2. Eliminate loop I & simplify

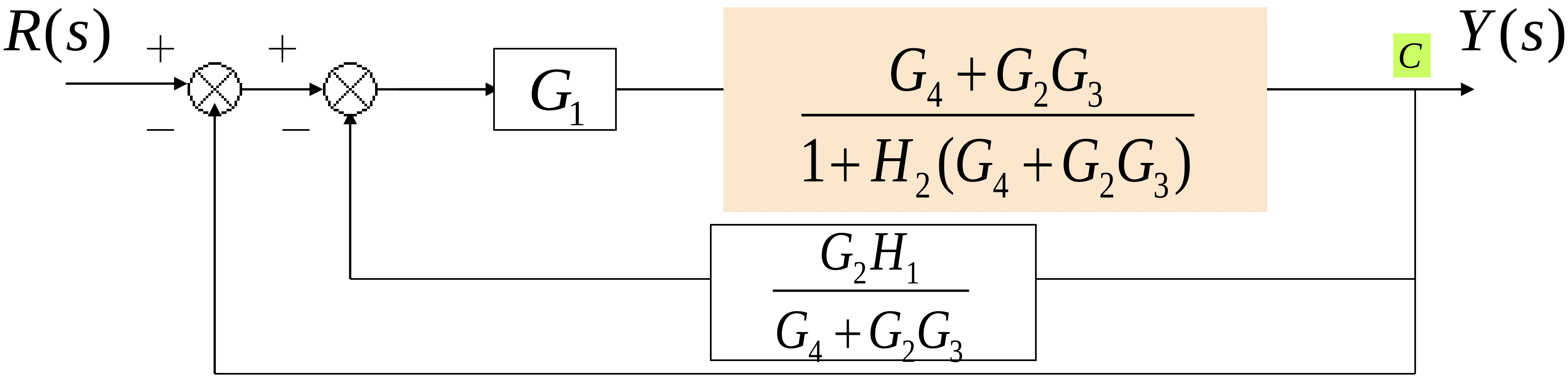


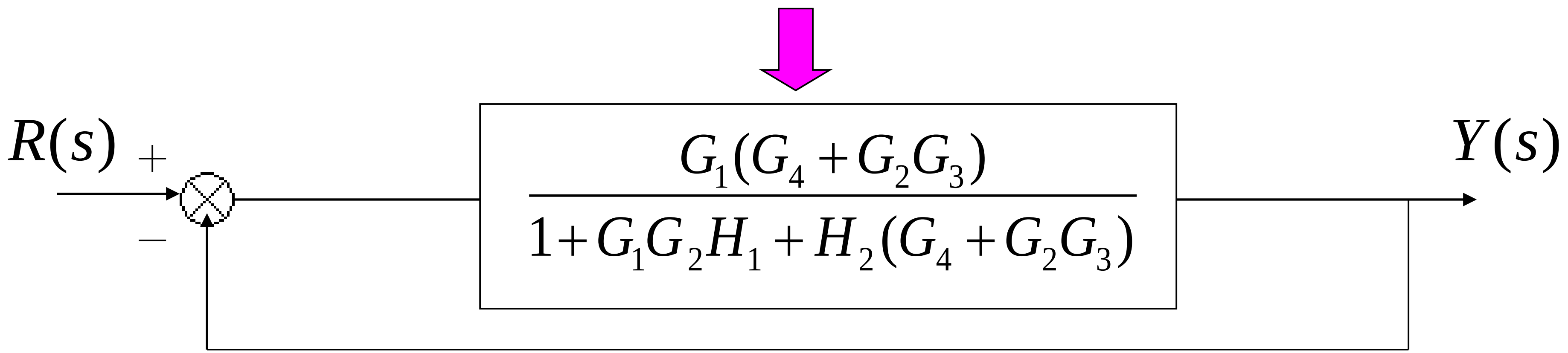


3. Moving pickoff point B behind block



4. Eliminate loop III

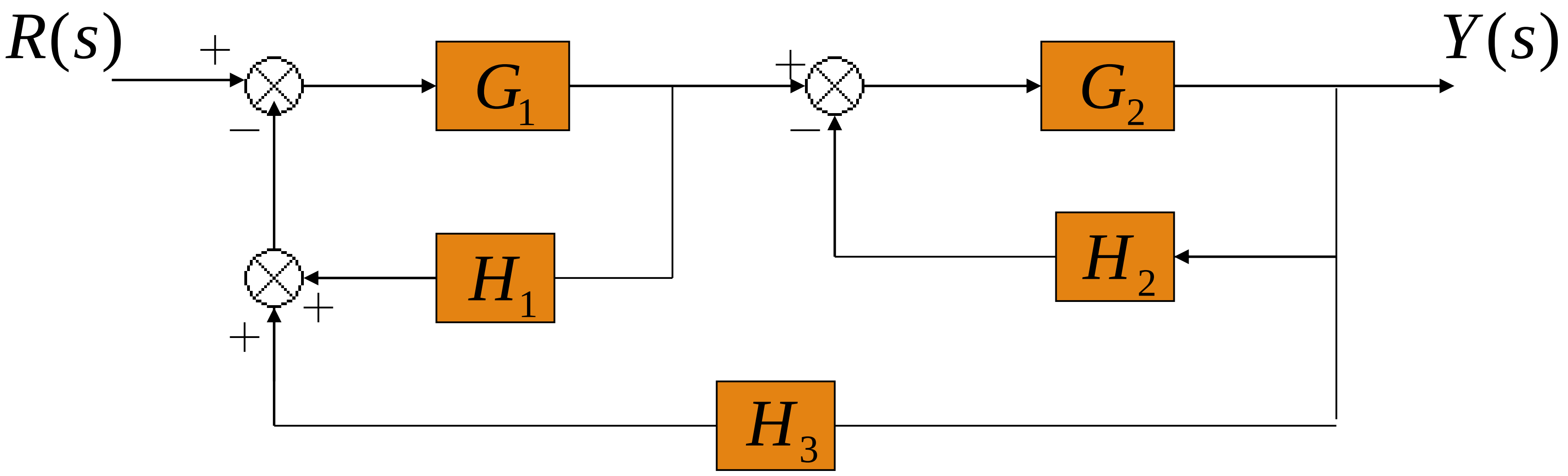




$$\frac{Y(s)}{R(s)}=\frac{G_1(G_4+G_2G_3)}{1+G_1G_2H_1+H_2(G_4+G_2G_3)+G_1(G_4+G_2G_3)}$$

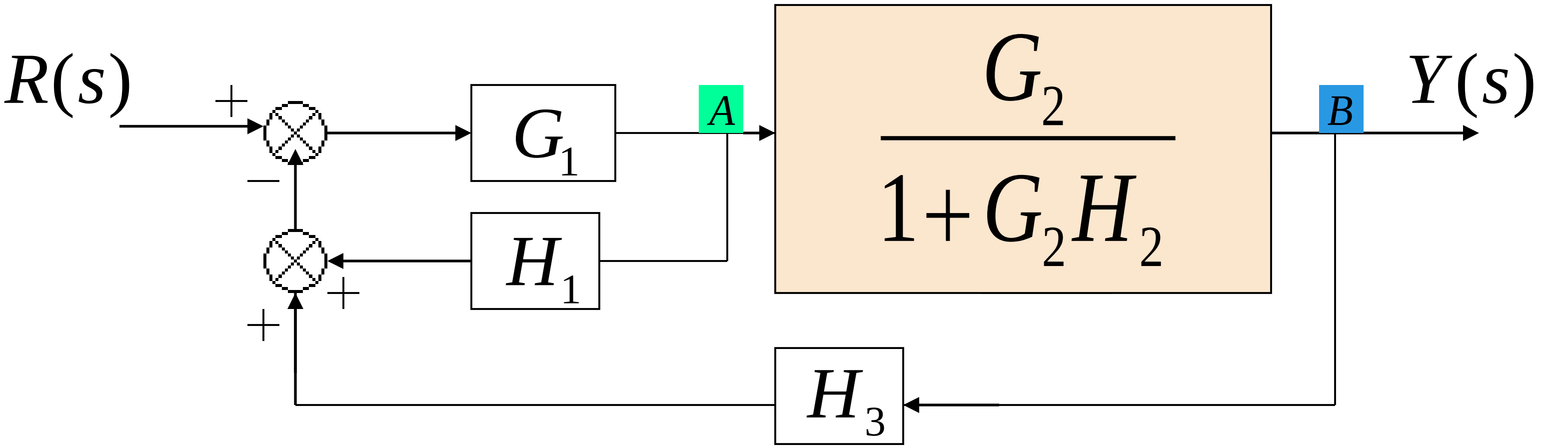
Example :

Find the transfer function of the following block diagrams

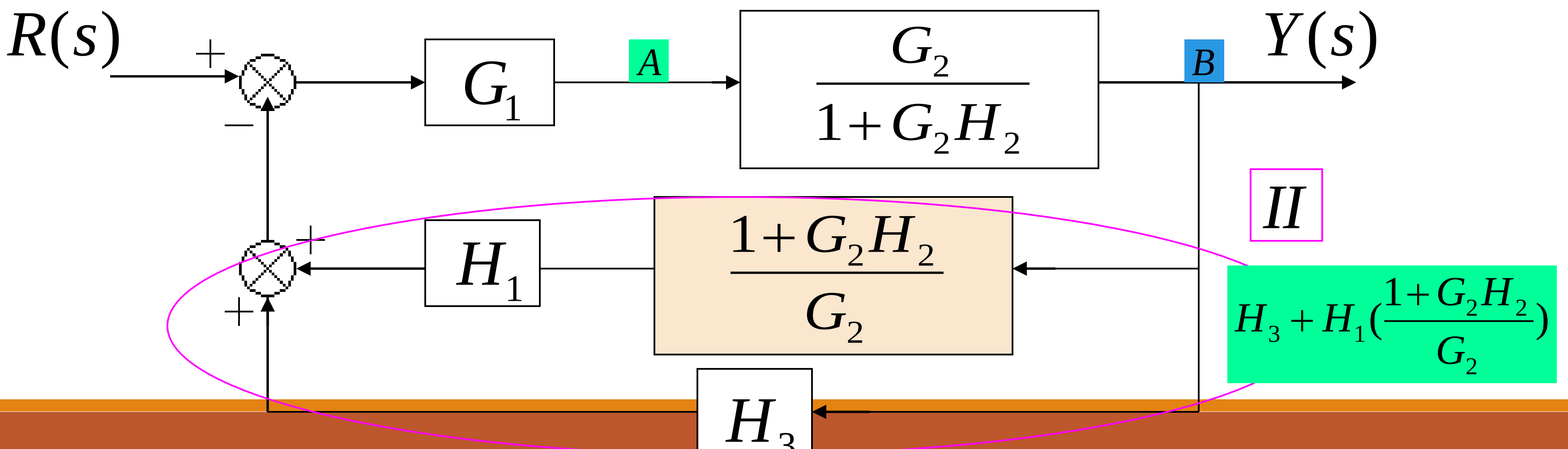


Solution:

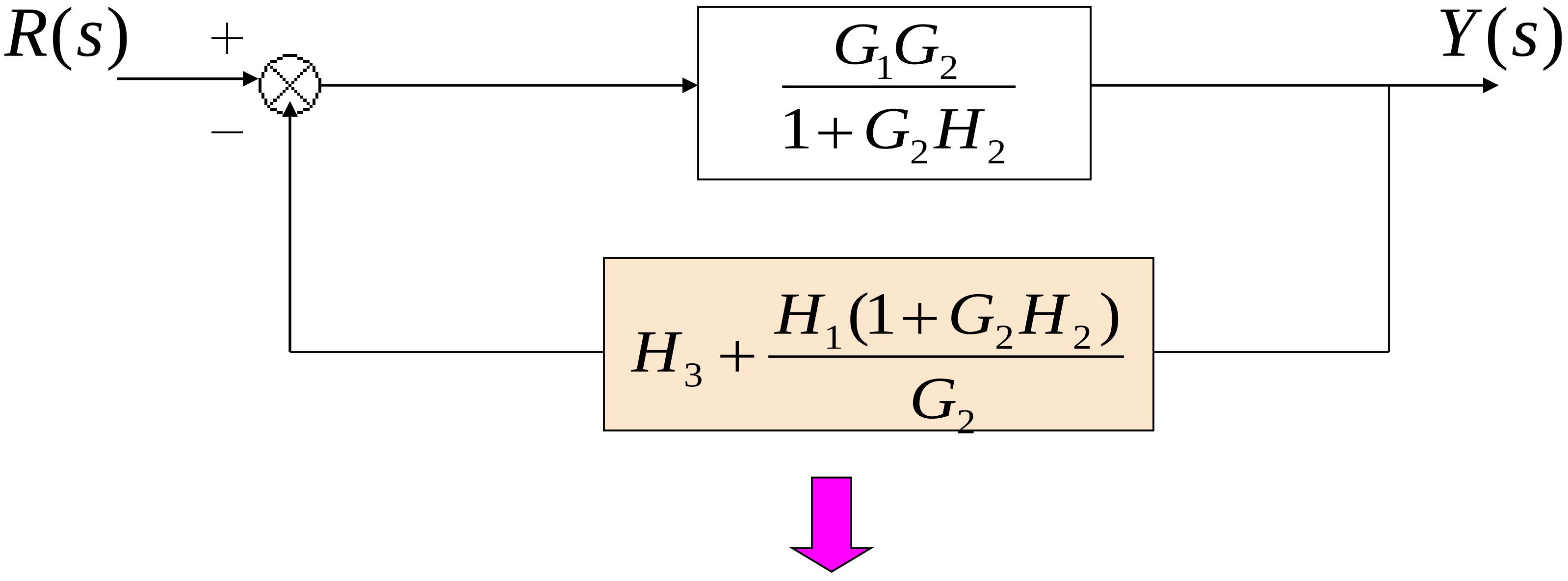
1. Eliminate loop I



2. Moving pickoff point A behind block $\boxed{\dfrac{G_2}{1+G_2H_2}}$



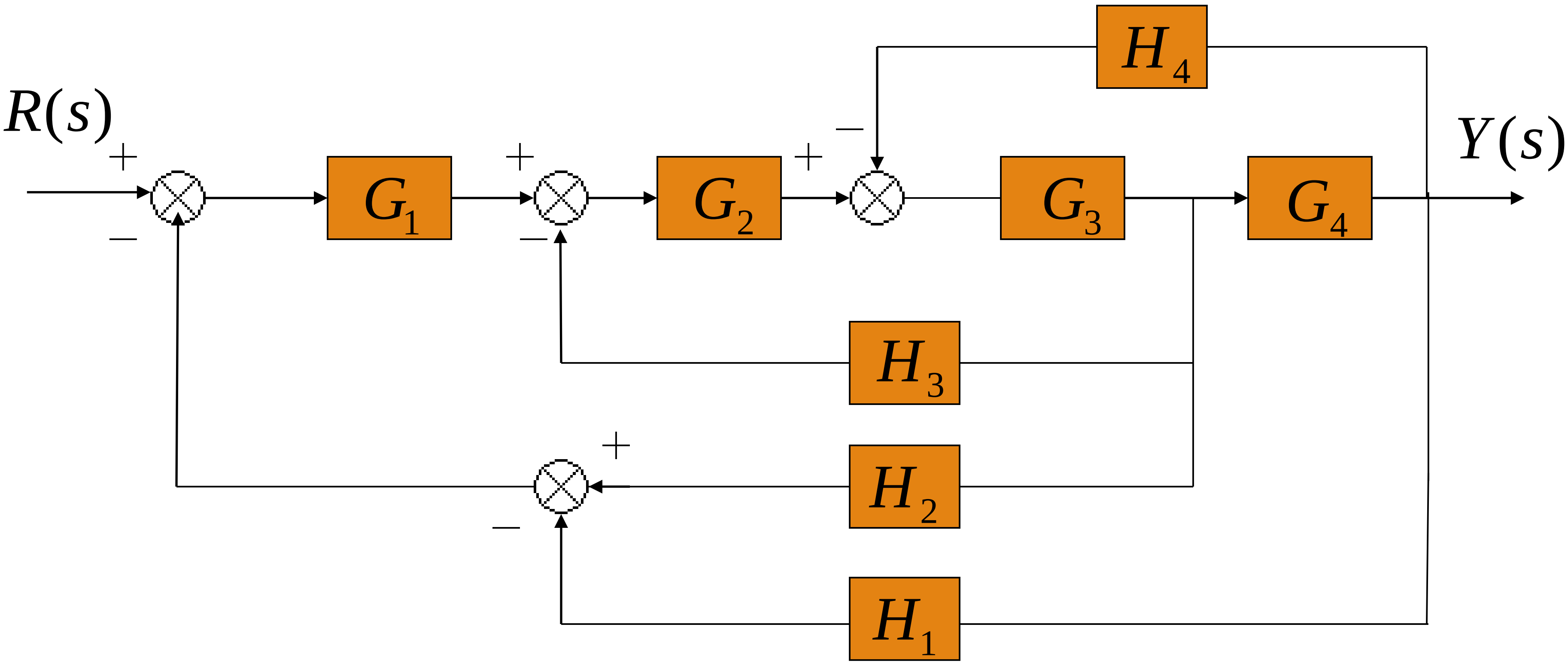
3. Eliminate loop II



$$\frac{Y(s)}{R(s)}=\frac{G_1G_2}{1+G_2H_2+G_1G_2H_3+G_1H_1+G_1G_2H_1H_2}$$

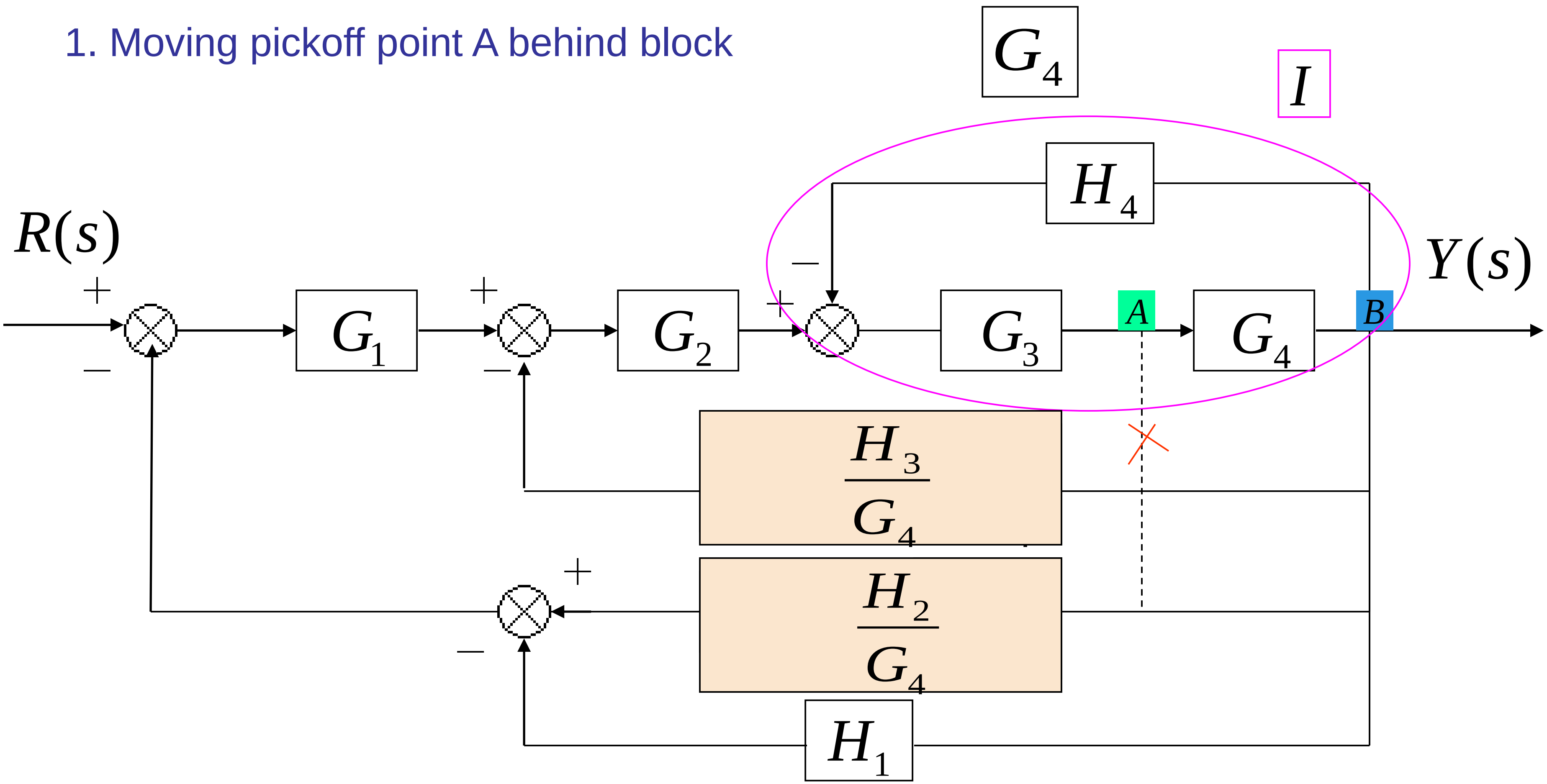
Example :

Find the transfer function of the following block diagrams

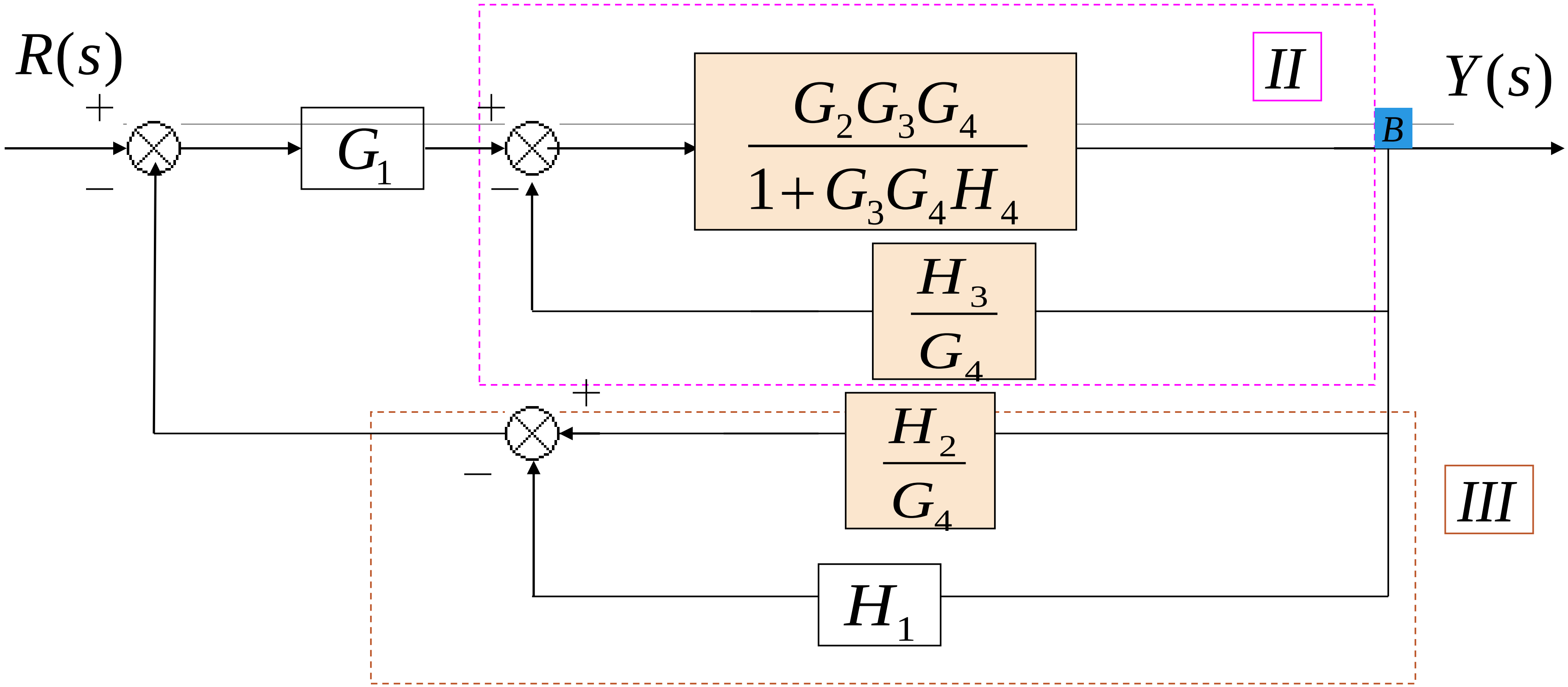


Solution:

1. Moving pickoff point A behind block



2. Eliminate loop I and Simplify



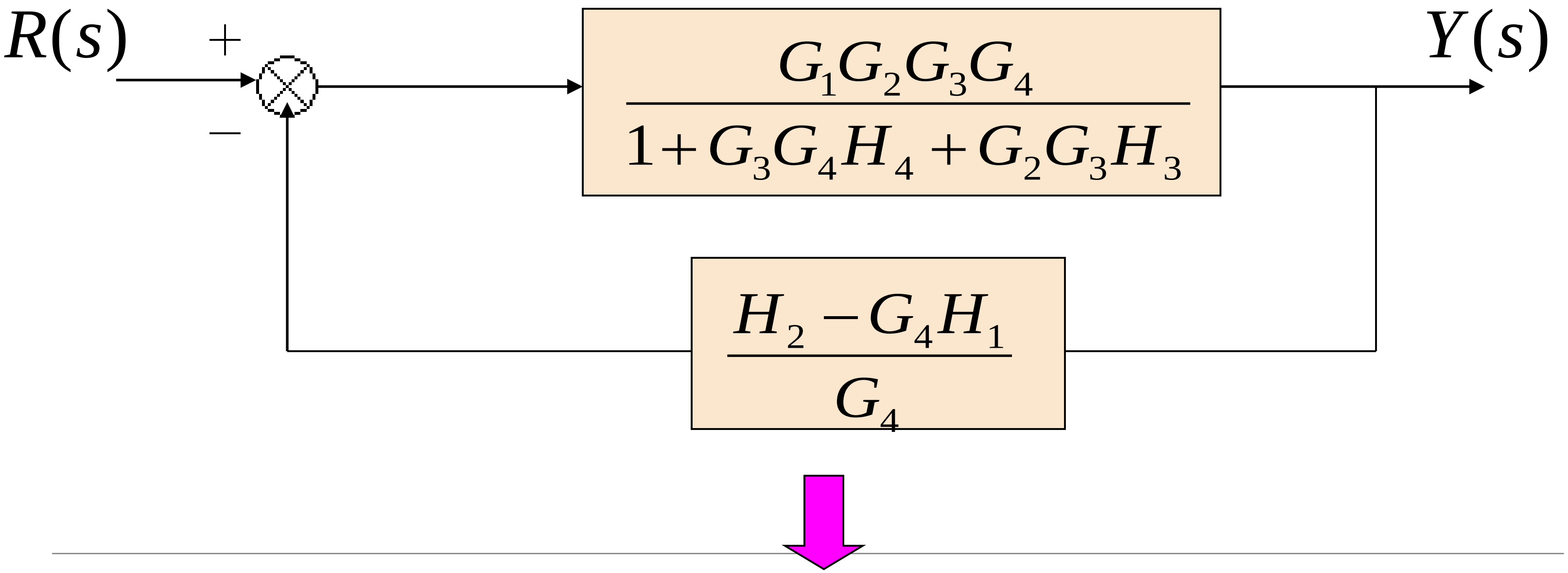
II feedback

$$\frac{G_2G_3G_4}{1+G_3G_4H_4+G_2G_3H_3}$$

III Not feedback

$$\frac{H_2-G_4H_1}{G_4}$$

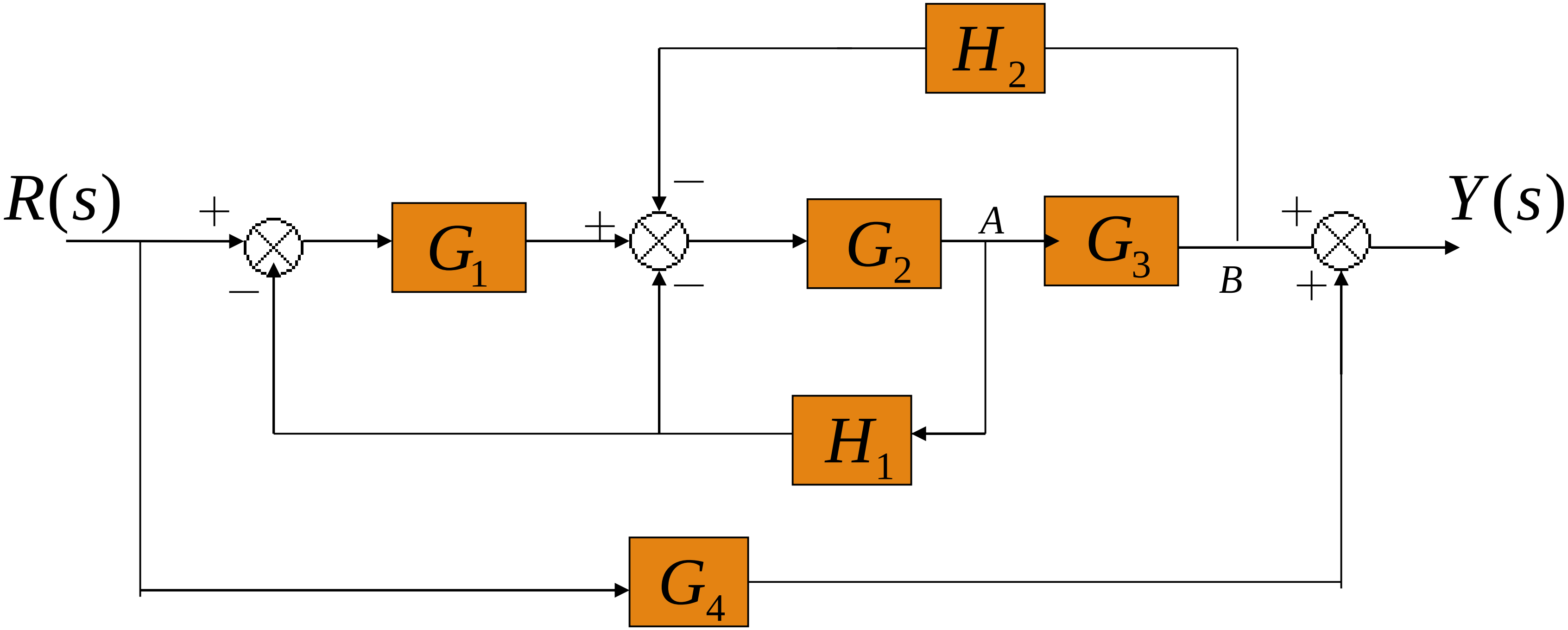
3. Eliminate loop II & IIII



$$\frac{Y(s)}{R(s)}=\frac{G_1G_2G_3G_4}{1+G_2G_3H_3+G_3G_4H_4+G_1G_2G_3H_2-G_1G_2G_3G_4H_1}$$

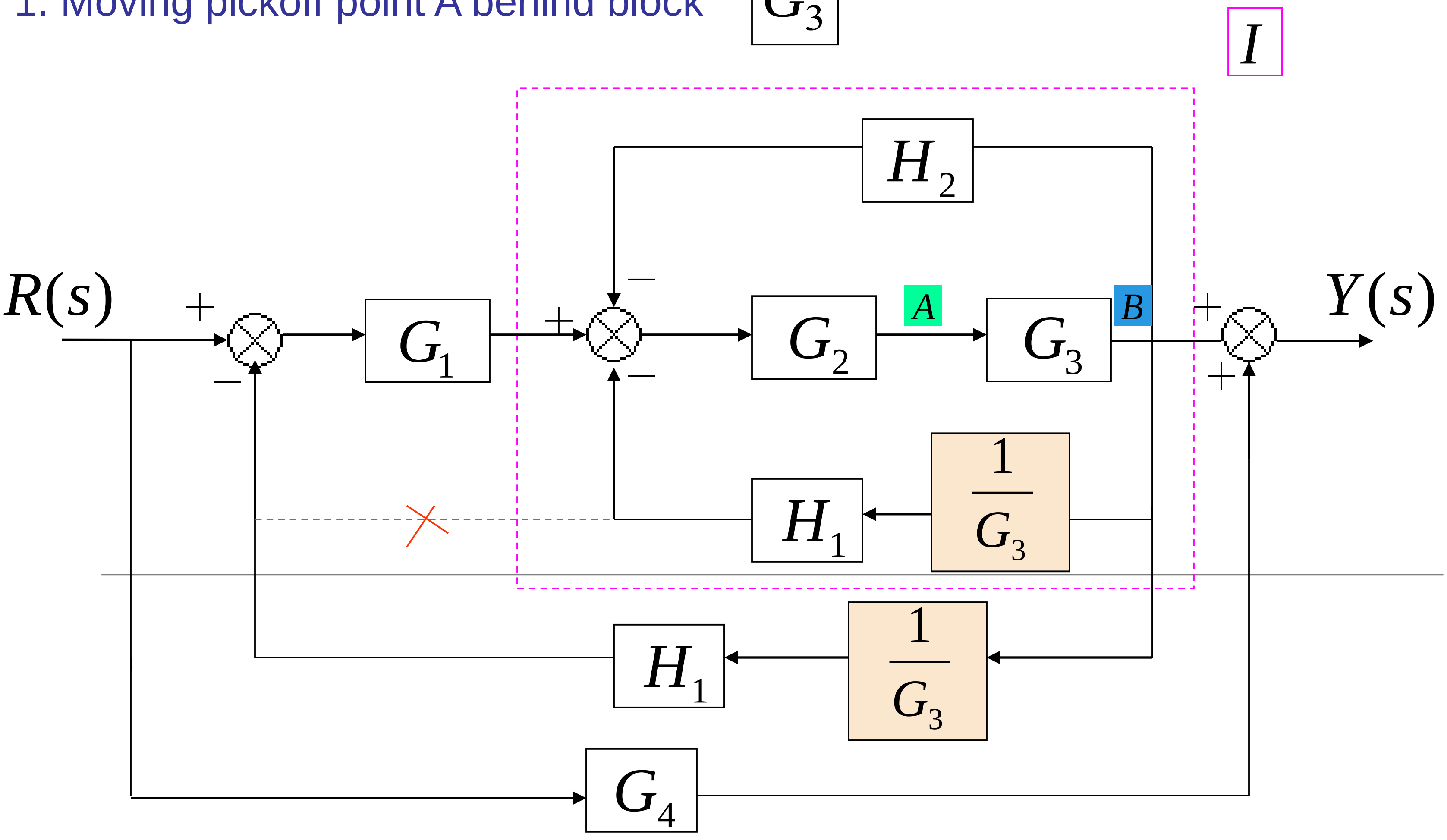
Example :

Find the transfer function of the following block diagrams

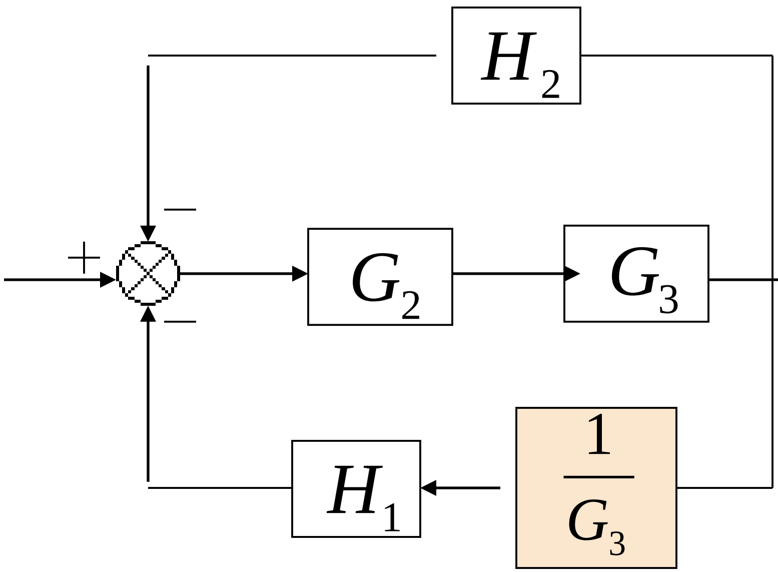


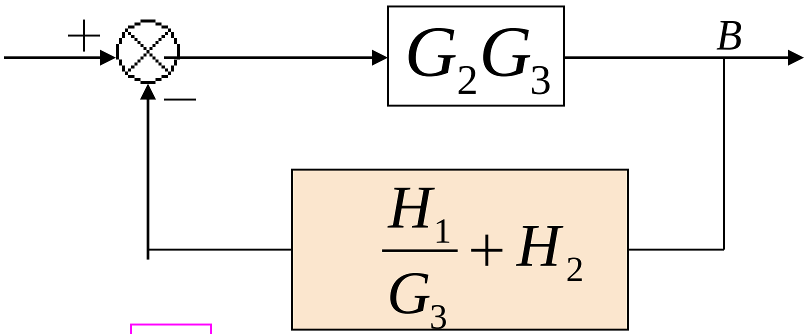
Solution:

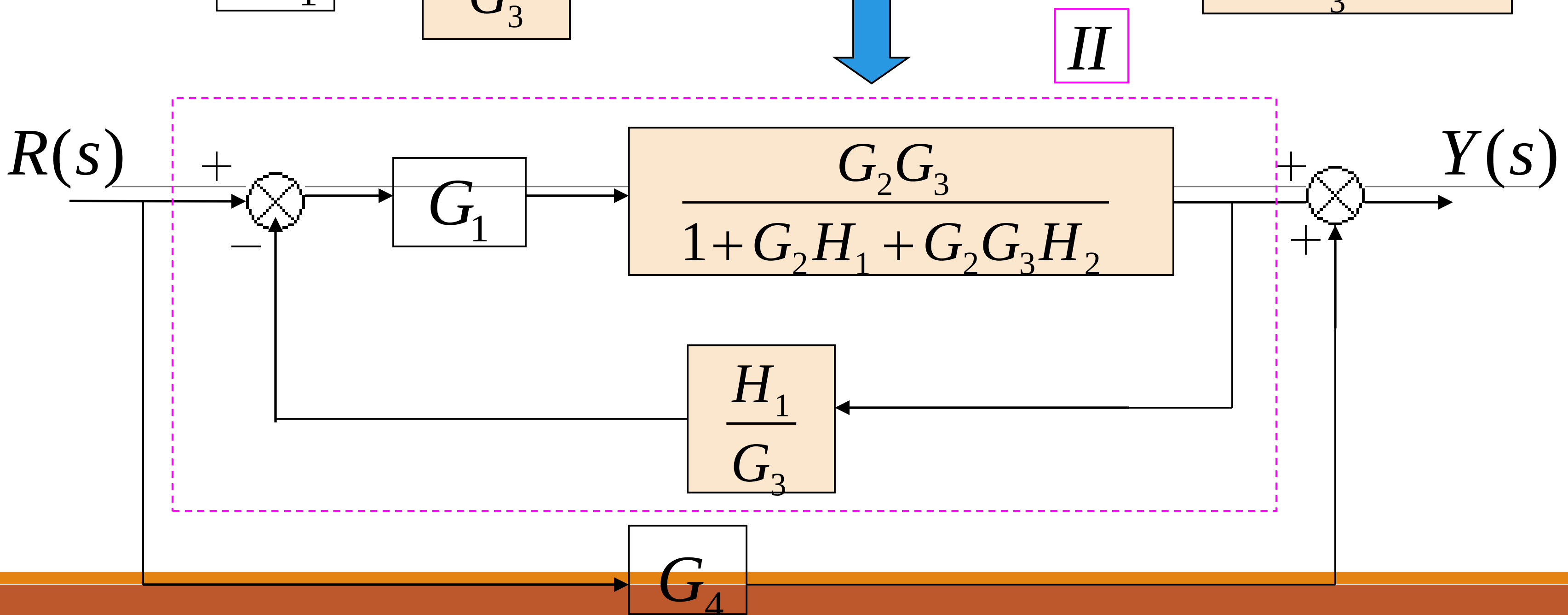
1. Moving pickoff point A behind block G_3



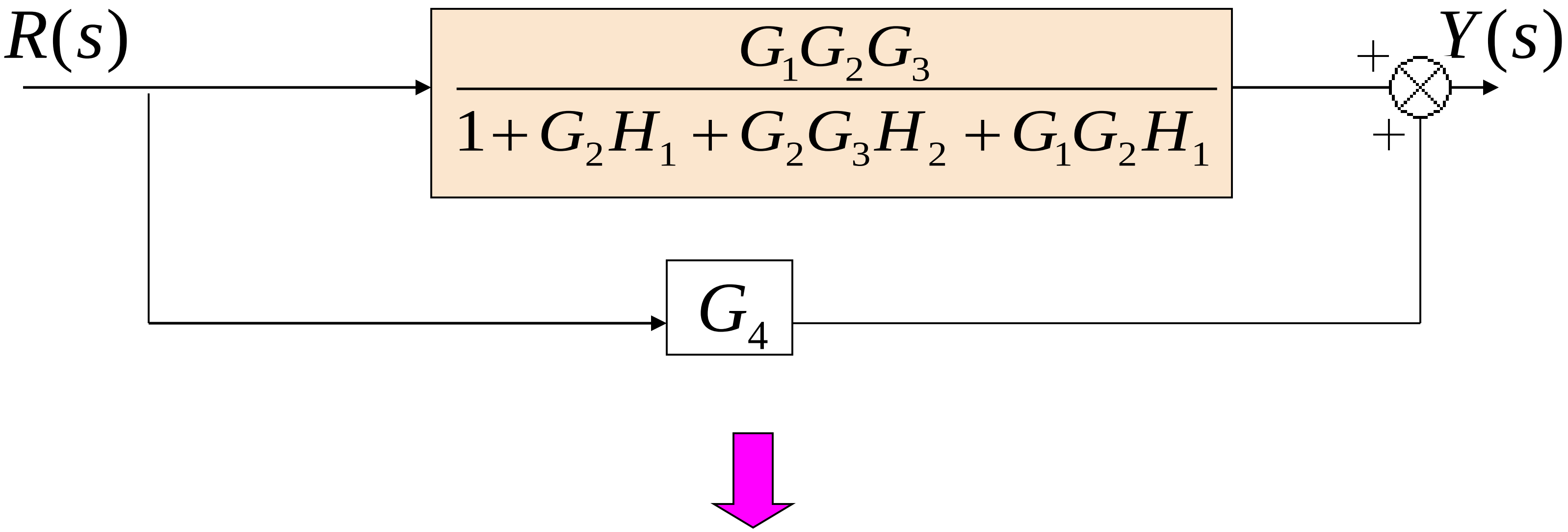
2. Eliminate loop I & Simplify





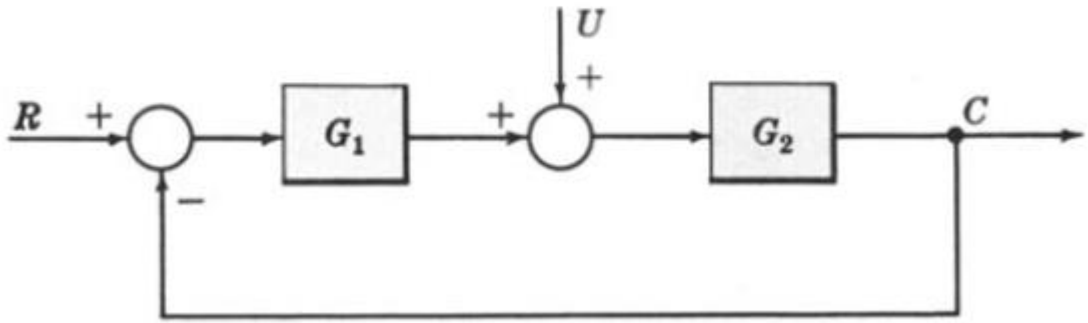


3. Eliminate loop II

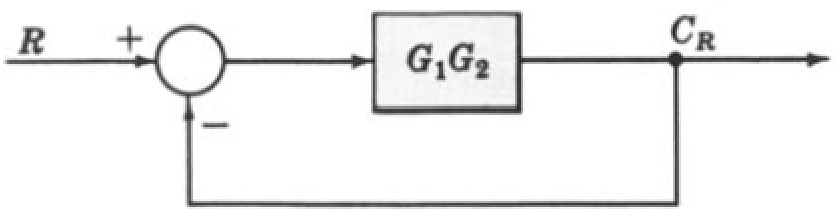


$$T(s) = \frac{Y(s)}{R(s)} = G_4 + \frac{G_1 G_2 G_3}{1 + G_2 H_1 + G_2 G_3 H_2 + G_1 G_2 H_1}$$

Example: Multiple Input System. Determine the output C due to inputs R and U using the Superposition Method.

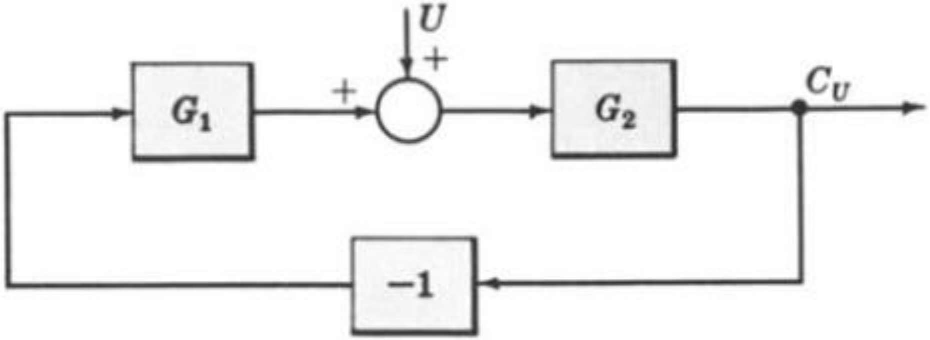


Step 1: Put $U \equiv 0$.
Step 2: The system reduces to



Step 3: the output C_R due to input R is $C_R = [G_1G_2/(1 + G_1G_2)]R$.

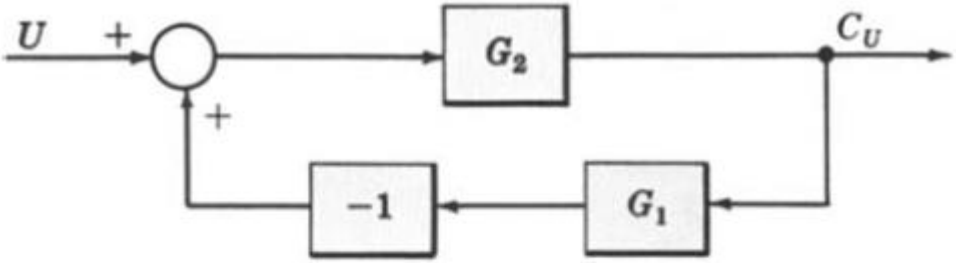
Example: Continue.



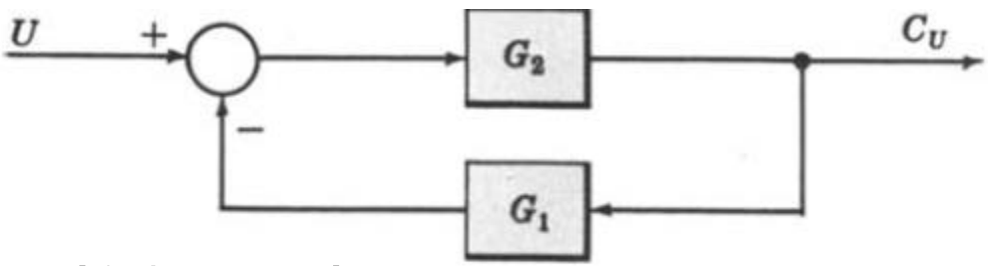
Step 4a: Put $R = 0$.

Step 4b: Put -1 into a block, representing the negative feedback effect:

Rearrange the block diagram:



Let the -1 block be absorbed into the summing point:



Step 4c: the output C_U due to input U is $C_U = [G_2/(1 + G_1G_2)]U$.

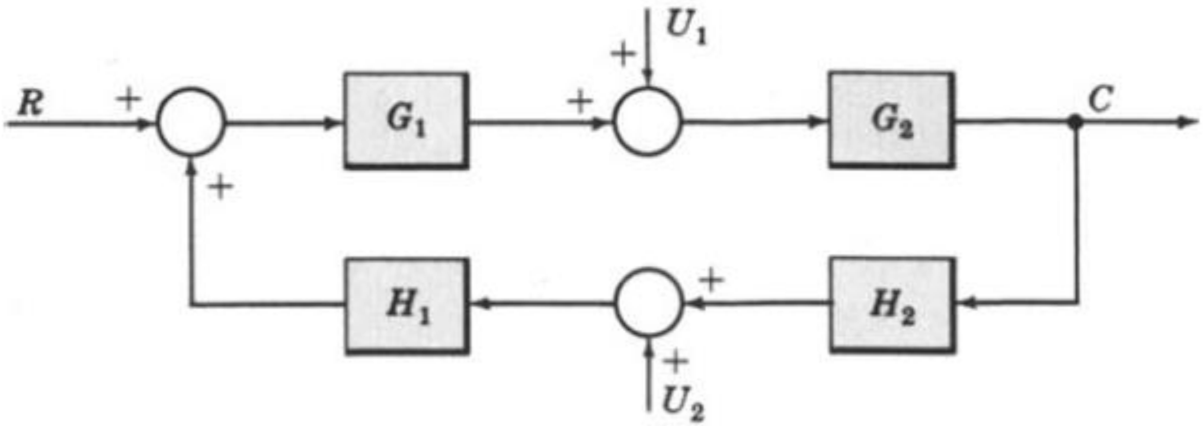
Example: Continue.

Step 5: The total output is $C = C_R + C_U$

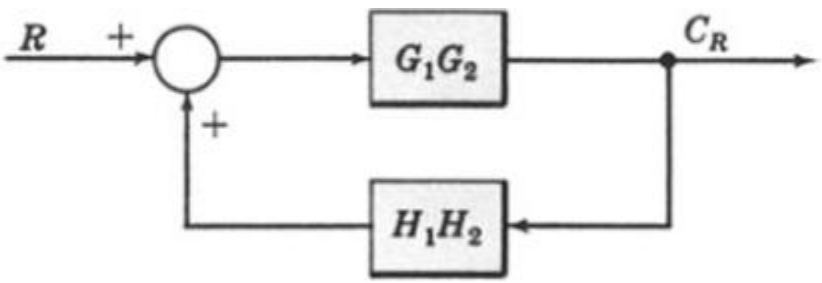
$$= \left[\frac{G_1G_2}{1+G_1G_2}\right]R + \left[\frac{G_2}{1+G_1G_2}\right]U$$

$$= \left[\frac{G_2}{1+G_1G_2}\right][G_1R + U]$$

Example: Multiple-Input System. Determine the output C due to inputs R, U1 and U2 using the Superposition Method.



Let $U_1 = U_2 = 0$.

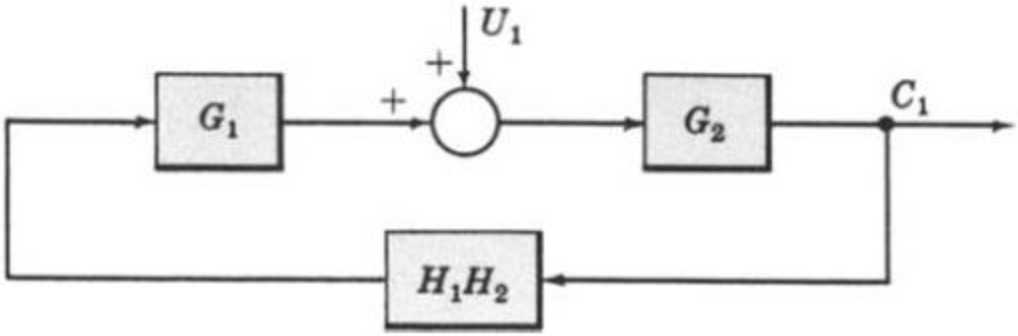


$$C_R = [G_1G_2/(1 - G_1G_2H_1H_2)]R$$

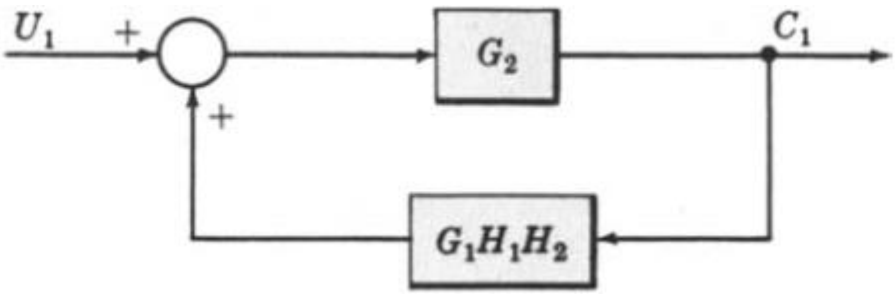
where C_R is the output due to R acting alone.

Example: Continue.

Now let $R = U_2 = 0$.



Rearranging the blocks, we get

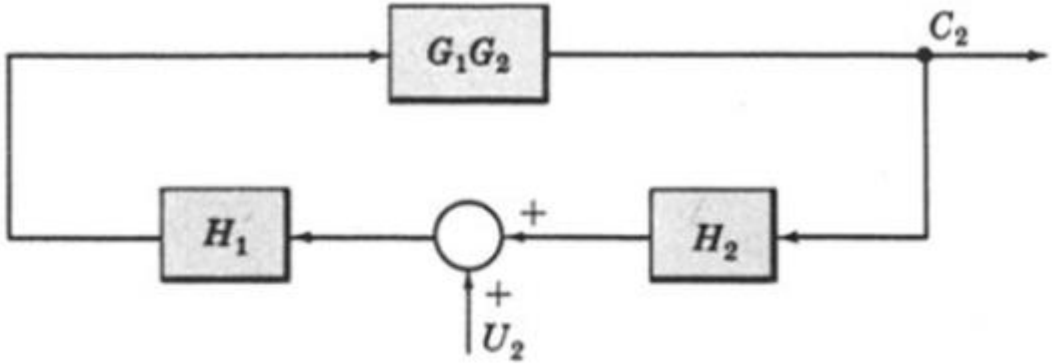


$$C_1 = [G_2/(1 - G_1G_2H_1H_2)]U_1$$

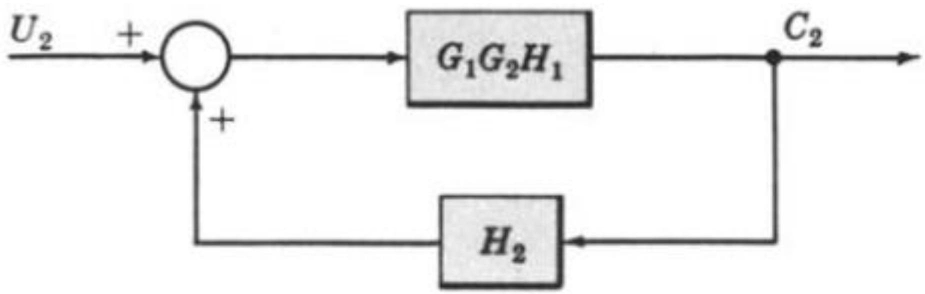
where C_1 is the response due to U_1 acting alone.

Example: Continue.

Finally, let $R = U_1 = 0$.



Rearranging the blocks, we get

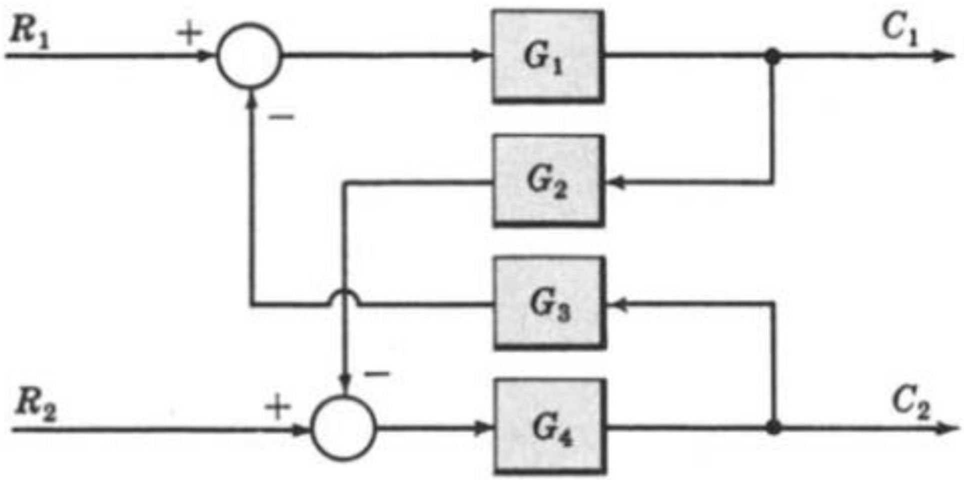


$$C_2 = [G_1G_2H_1/(1 - G_1G_2H_1H_2)]U_2$$

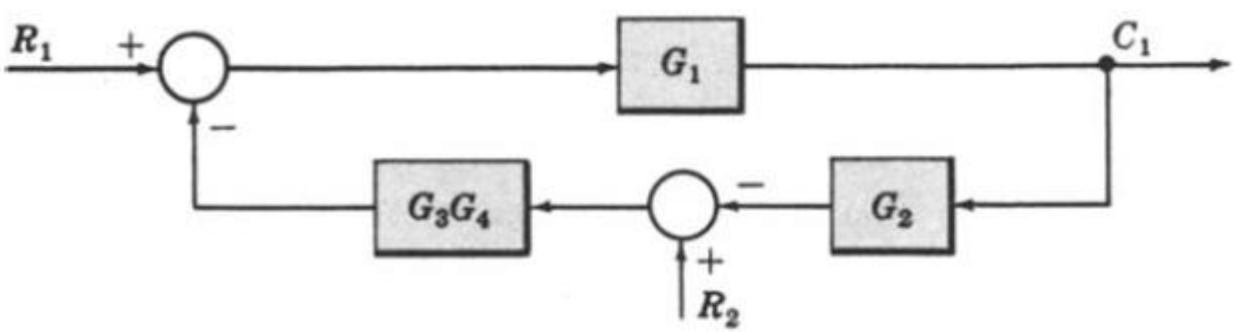
where C_2 is the response due to U_2 acting alone.

By superposition, the total output is $$C = C_R + C_1 + C_2 = \frac{G_1G_2R + G_2U_1 + G_1G_2H_1U_2}{1 - G_1G_2H_1H_2}$$

Example: Multi-Input Multi-Output System. Determine C1 and C2 due to R1 and R2.

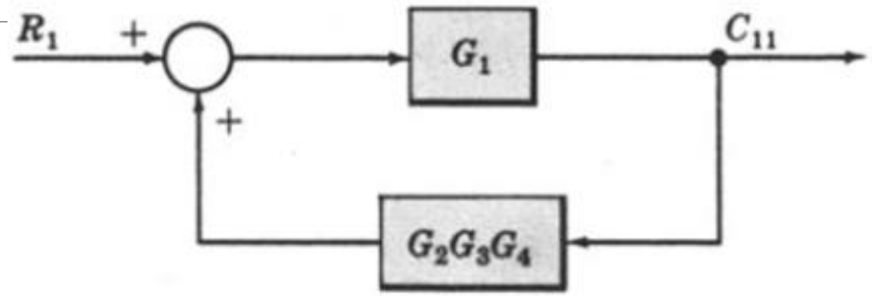


First ignoring the output C_2.



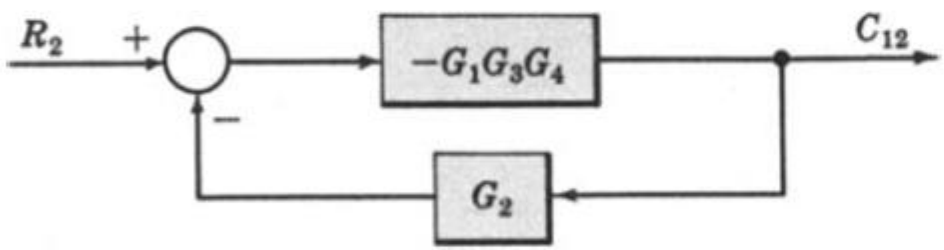
Example: Continue.

Letting $R_2 = 0$ and combining the summing points,



Hence C_{11}, the output at C_1 due to R_1 alone, is $C_{11} = G_1R_1/(1 - G_1G_2G_3G_4)$.

For $R_1 = 0$,

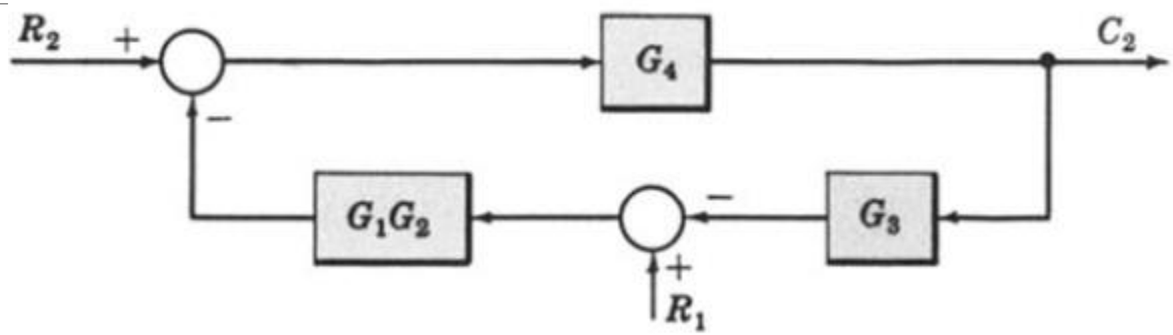


Hence $C_{12} = -G_1G_3G_4R_2/(1 - G_1G_2G_3G_4)$ is the output at C_1 due to R_2 alone.

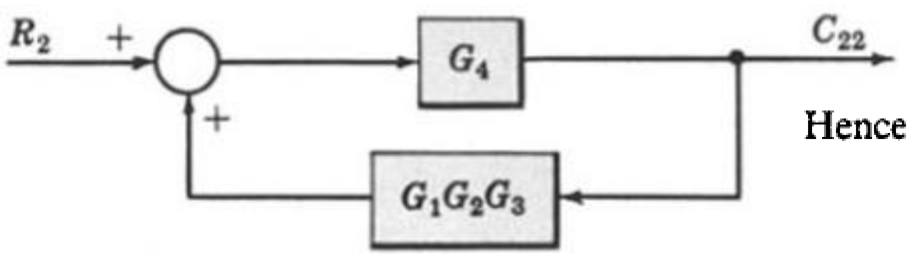
$$\text{Thus } C_1 = C_{11} + C_{12} = (G_1R_1 - G_1G_3G_4R_2)/(1 - G_1G_2G_3G_4)$$

Example: Continue.

Now we reduce the original block diagram, ignoring output C_1.

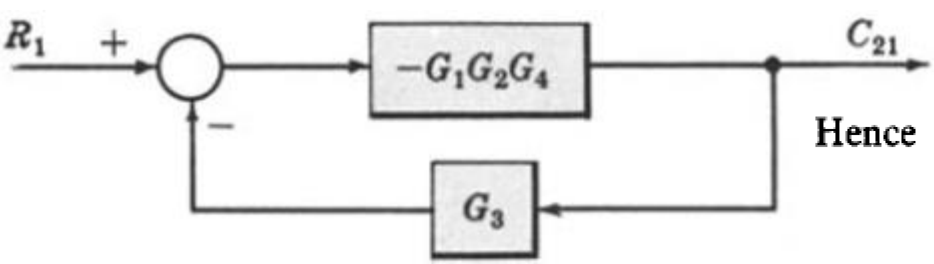


When R1 = 0,



Hence $C_{22} = G_4 R_2/(1 - G_1G_2G_3G_4)$

When R2 = 0,

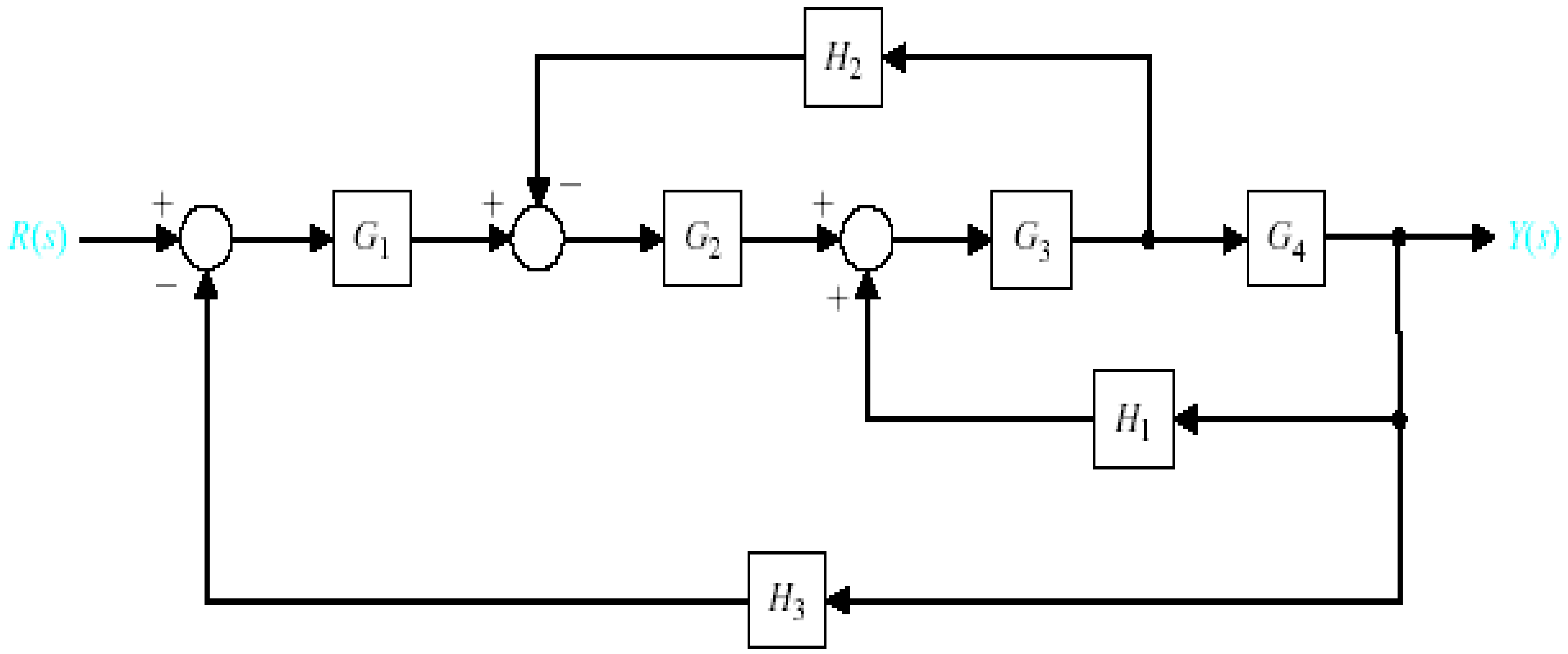


Hence $C_{21} = -G_1G_2G_4R_1/(1 - G_1G_2G_3G_4)$

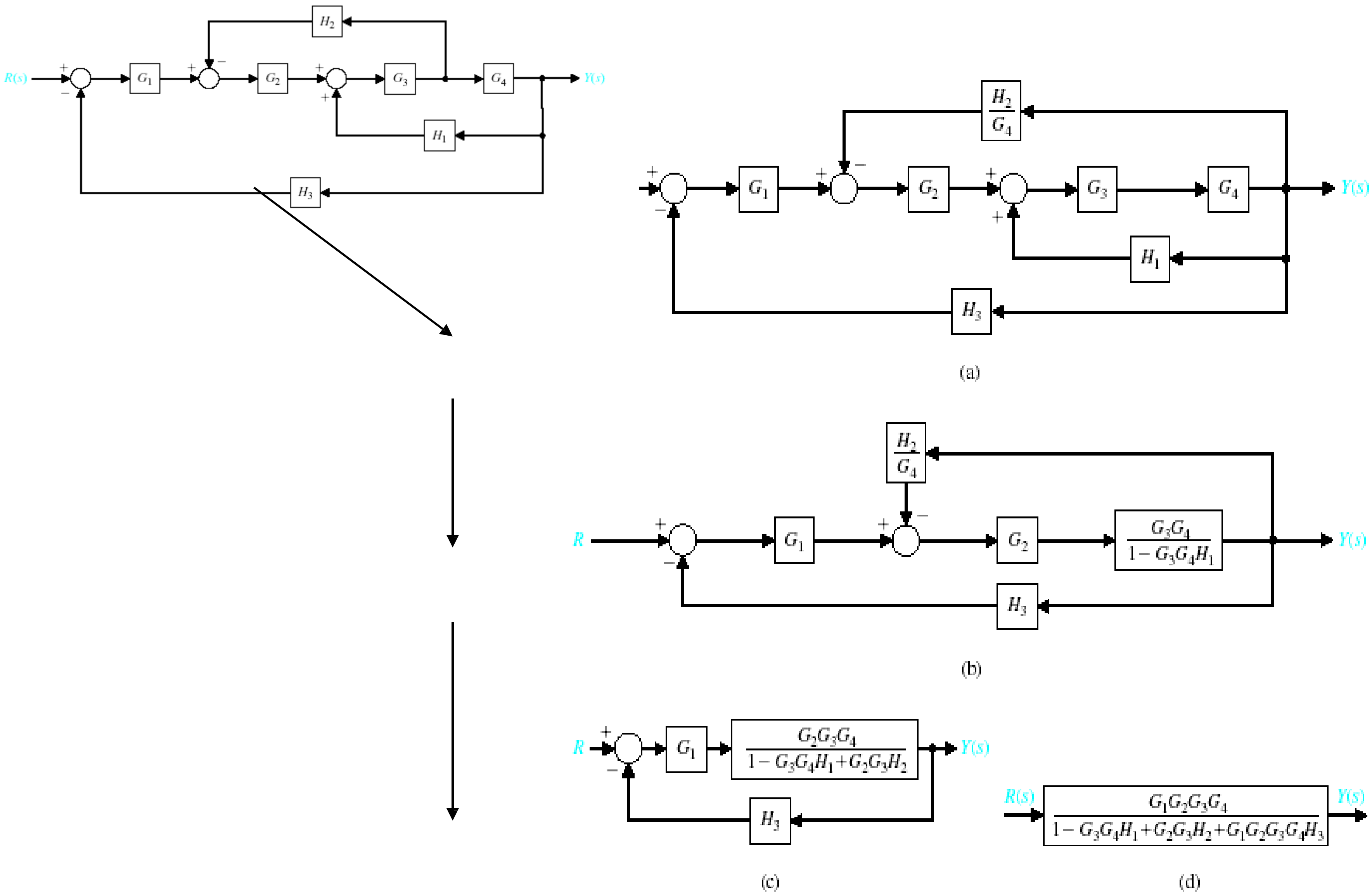
Finally, $C_2 = C_{22} + C_{21} = (G_4R_2 - G_1G_2G_4R_1)/(1 - G_1G_2G_3G_4)$

Block Diagram Models

Example

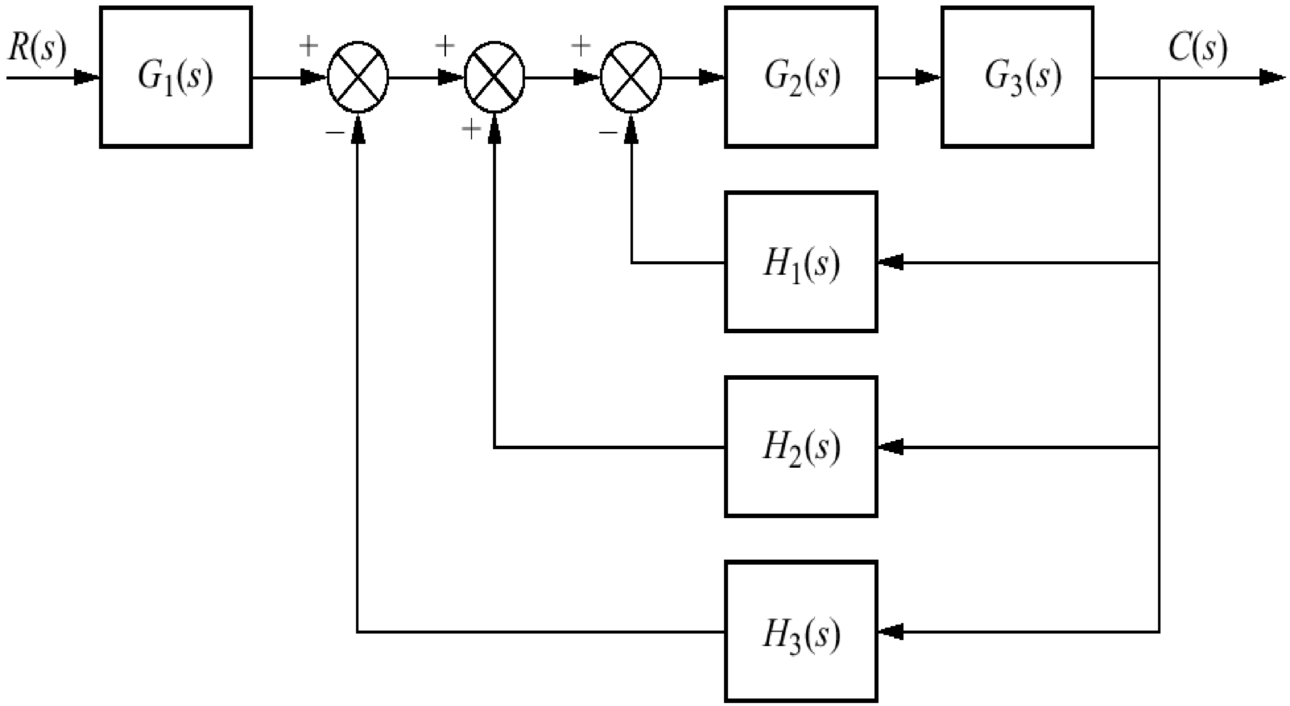


Block Diagram Models



Block diagram reduction via familiar forms for Example

Problem: Reduce the block diagram shown in figure to a single transfer function



Block diagram reduction via familiar forms for Example Cont.

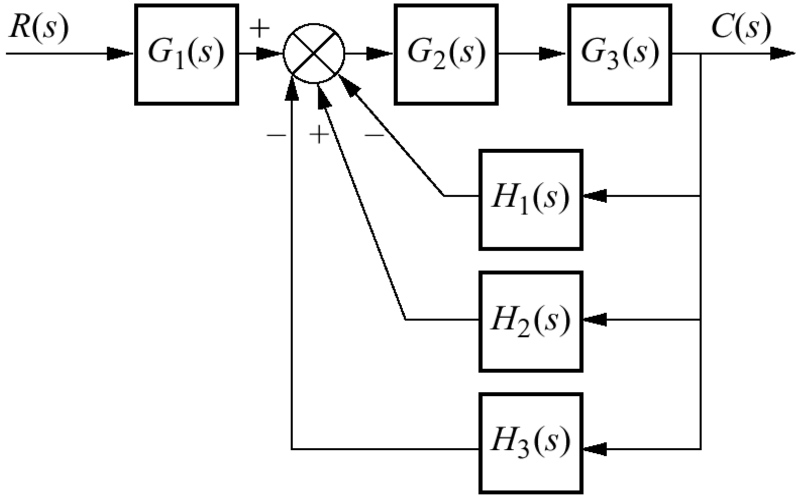
Steps in solving Example

a. collapse summing junctions; form

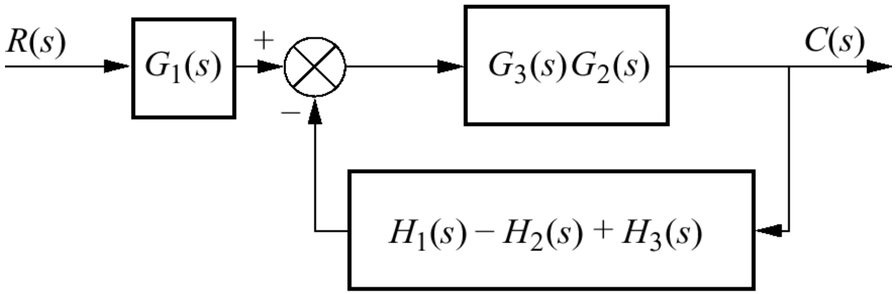
b. equivalent cascaded system in the forward path

c. form equivalent parallel system in the feedback path;

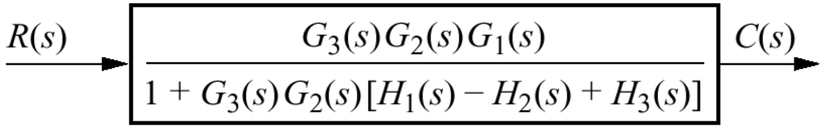
d. form equivalent feedback system and multiply by cascaded$G_1(s)$



(a)



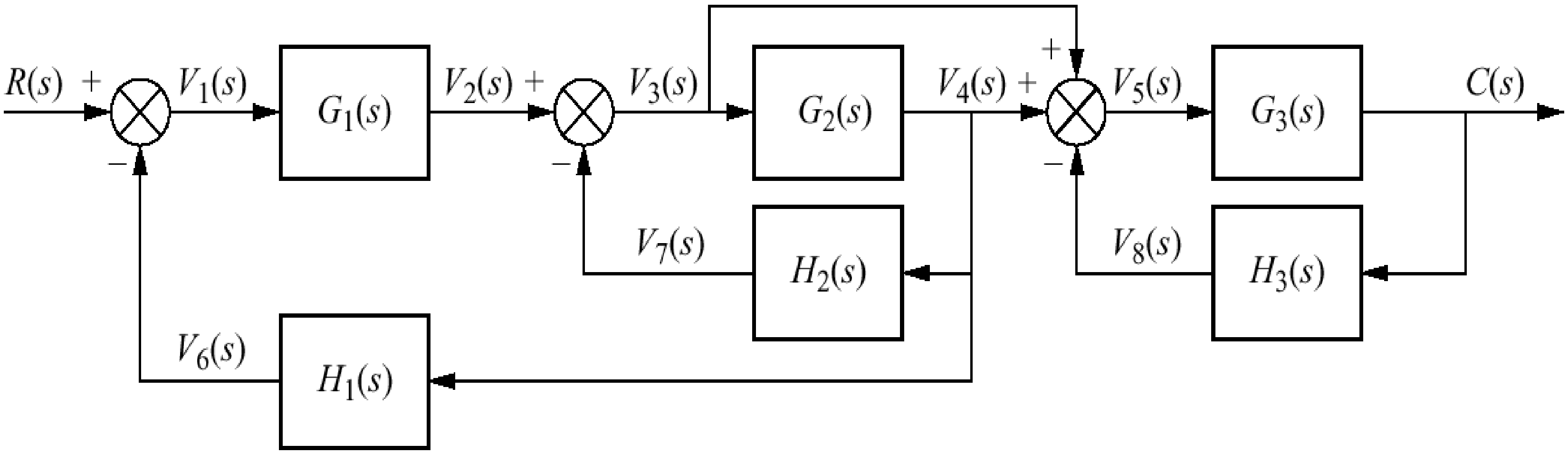
(b)



(c)

Block diagram reduction by moving blocks Example

Problem: Reduce the block diagram shown in figure to a single transfer function



Steps in the block diagram reduction for Example

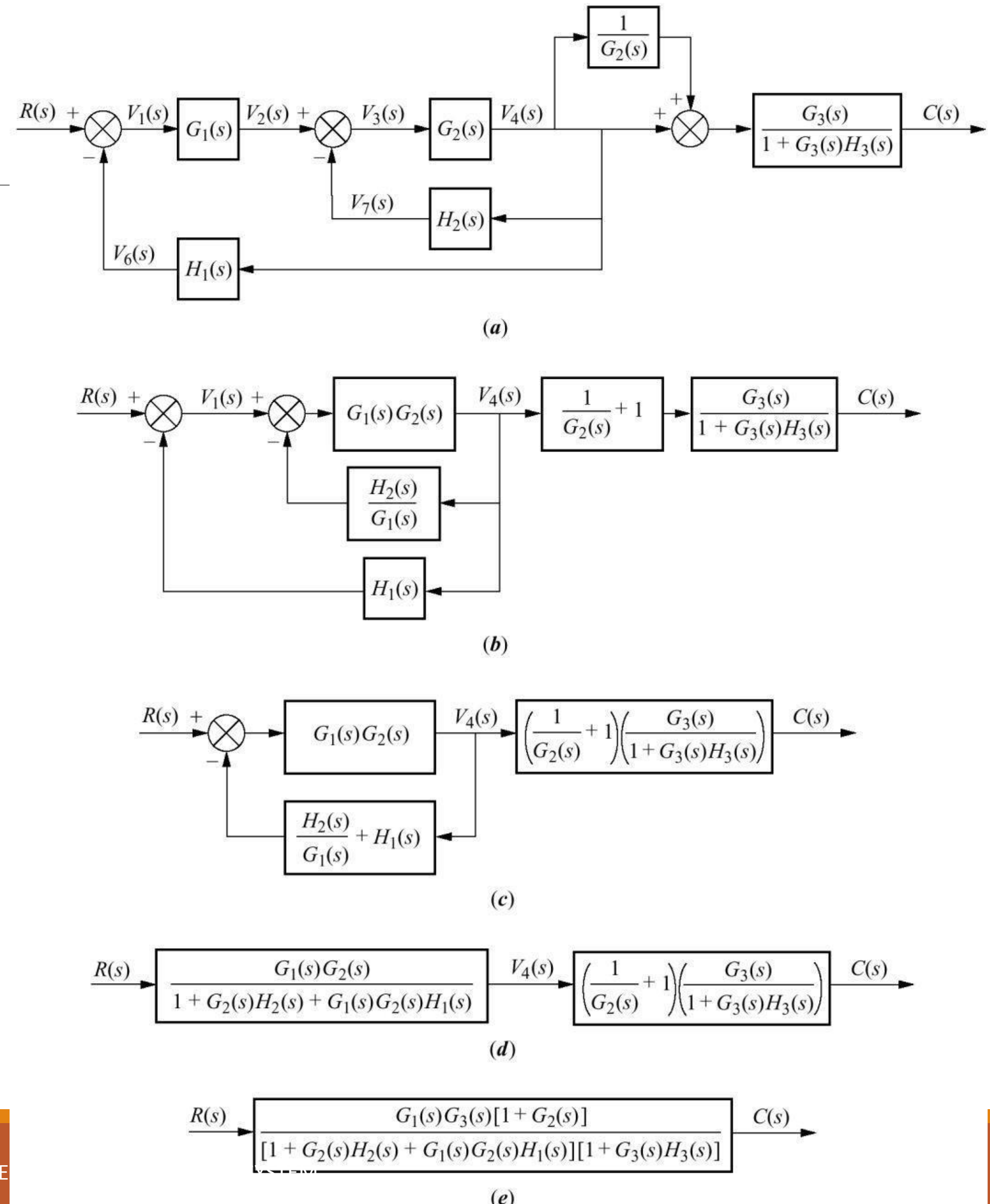
a)Move $G_2(s)$ to the left past of pickoff point to create parallel subsystems, and reduce the feedback system of $G_3(s)$ and $H_3(s)$

b)Reduce parallel pair of $1/G_2(s)$ and unity, and push $G_1(s)$ to the right past summing junction

c)Collapse the summing junctions, add the 2 feedback elements, and combine the last 2 cascade blocks

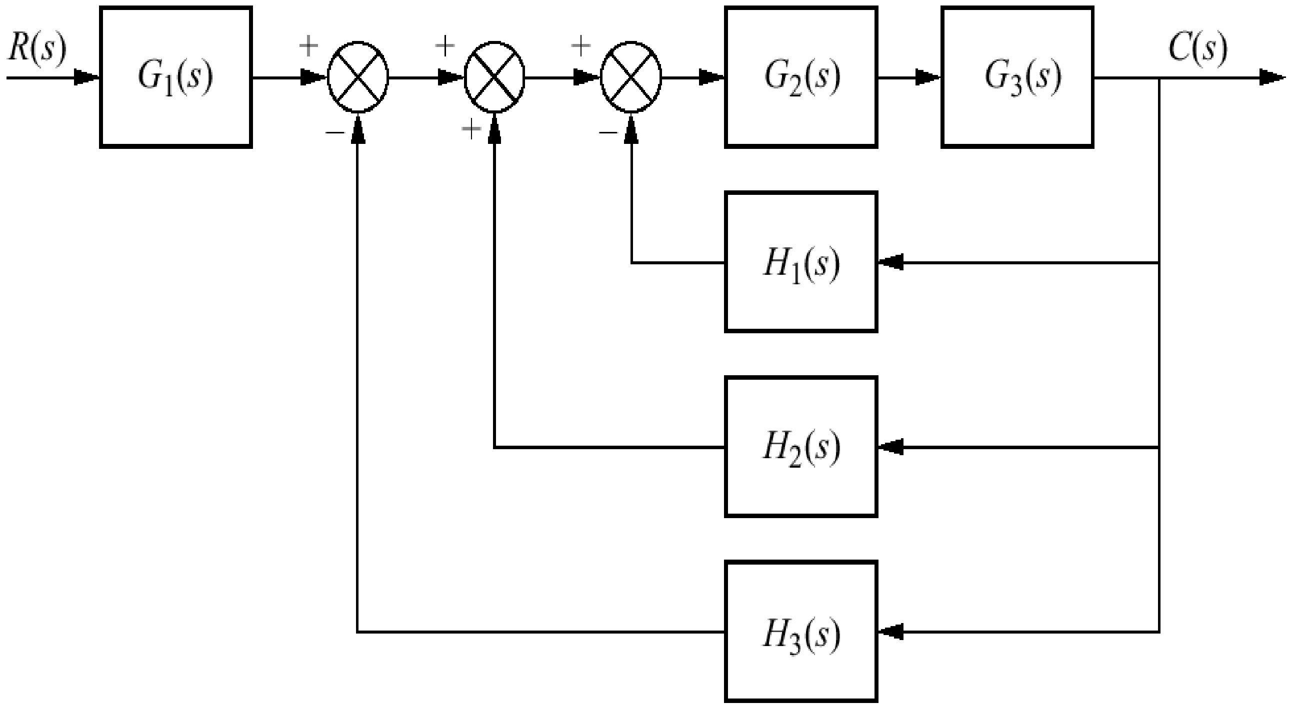
d)Reduce the feedback system to the left

e)finally, Multiple the 2 cascade blocks and obtain final result.



Block diagram reduction via familiar forms for Example

Problem: Reduce the block diagram shown in figure to a single transfer function



Block diagram reduction via familiar forms for Example Cont.

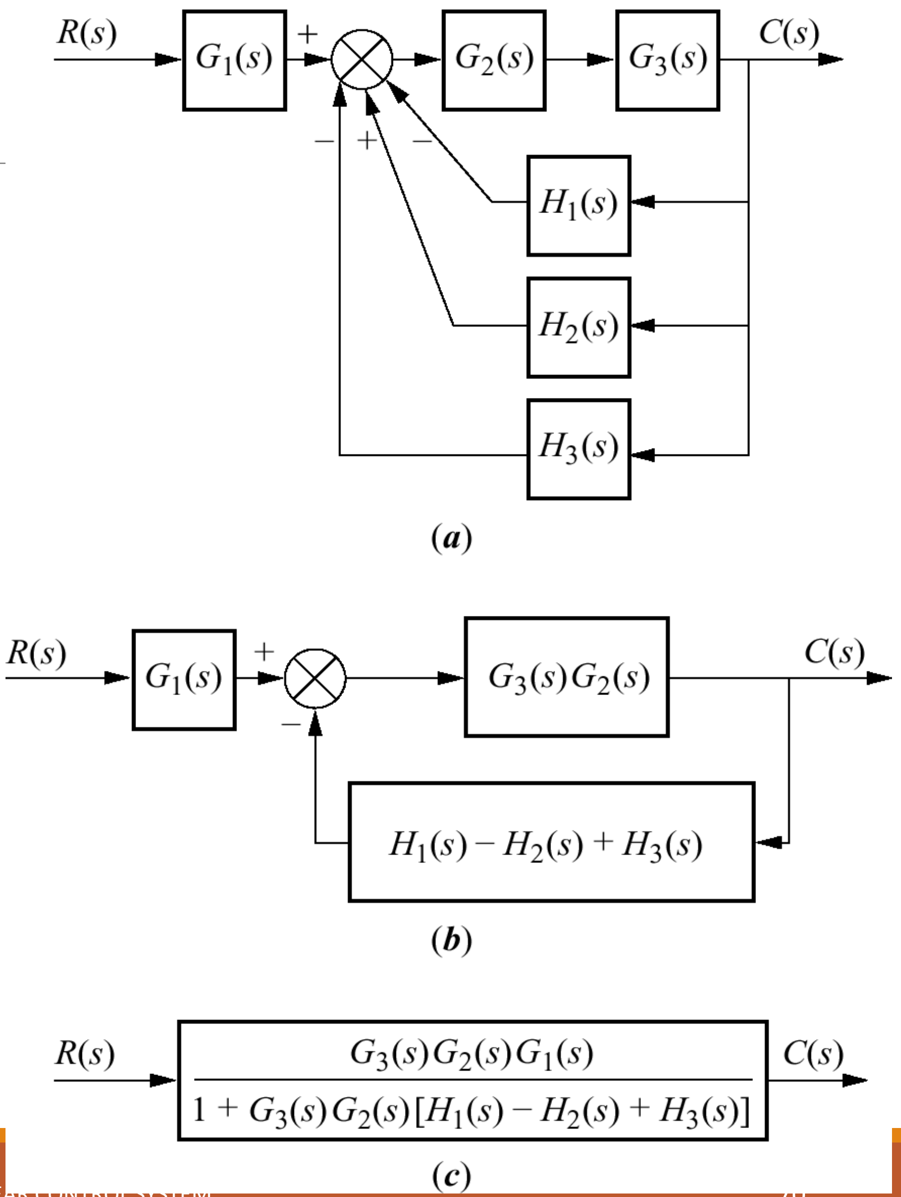
Steps in solving Example

a. collapse summing junctions;

b. form equivalent cascaded system in the forward path

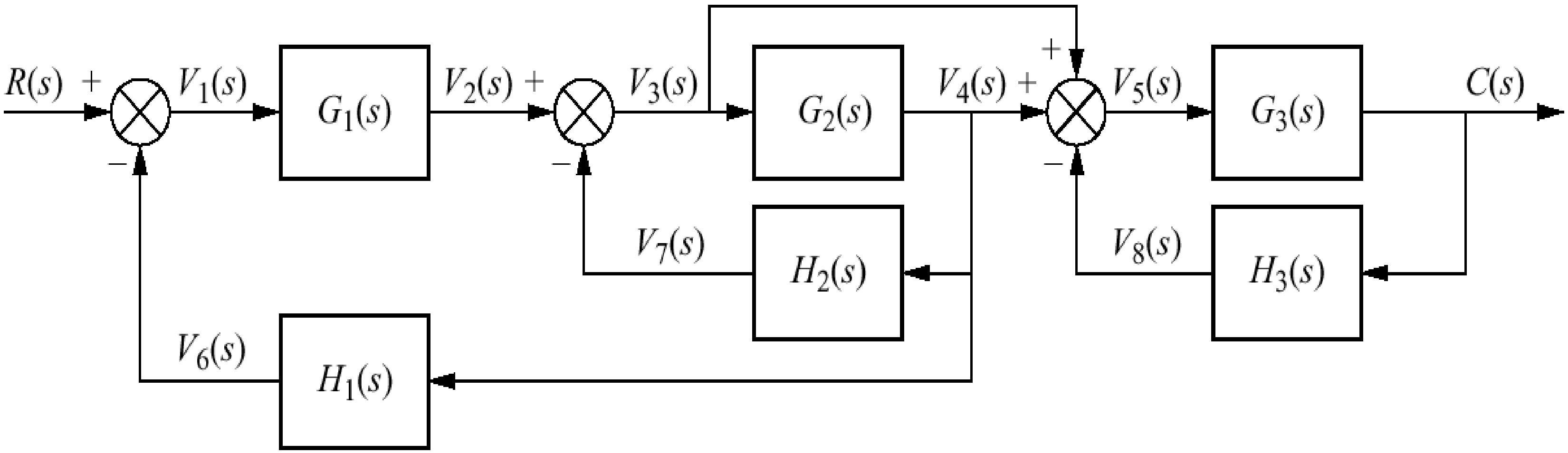
c. form equivalent parallel system in the feedback path;

d. form equivalent feedback system and multiply by cascaded$G_1(s)$



Block diagram reduction by moving blocks Example

Problem: Reduce the block diagram shown in figure to a single transfer function



Steps in the block diagram reduction for Example

a)Move $G_2(s)$ to the left past of pickoff point to create parallel subsystems, and reduce the feedback system of $G_3(s)$ and $H_3(s)$

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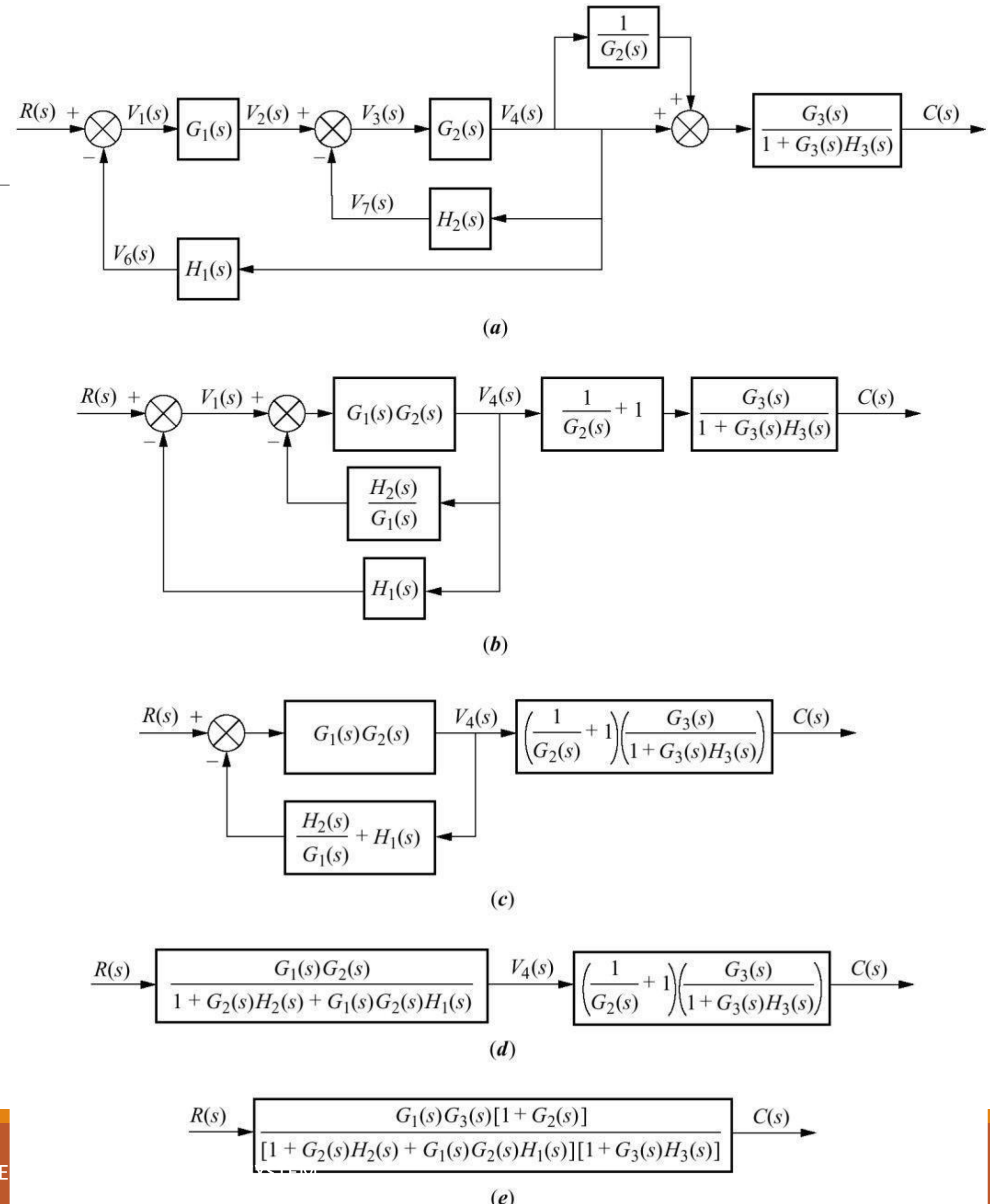
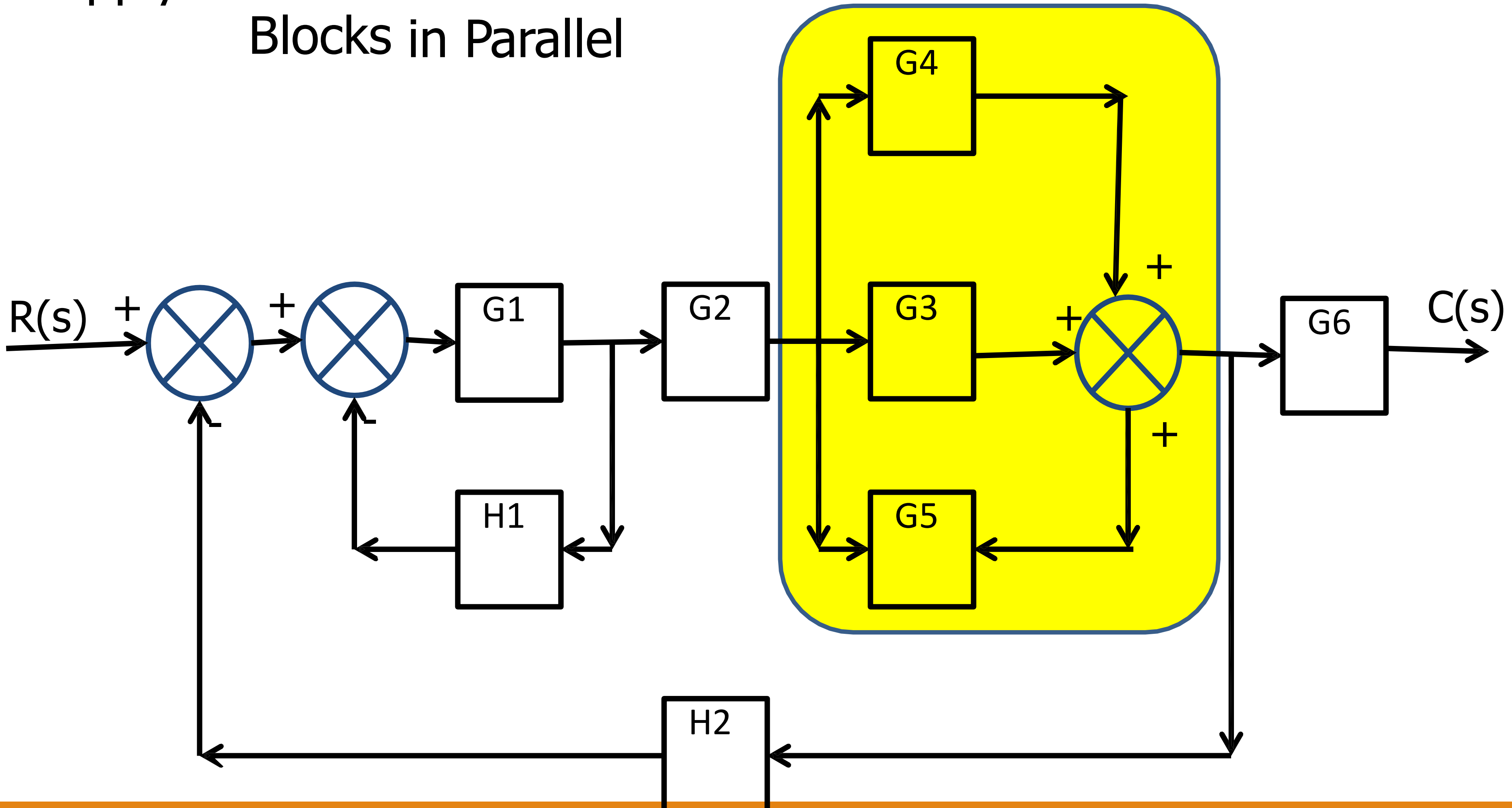


Example 1 cont….

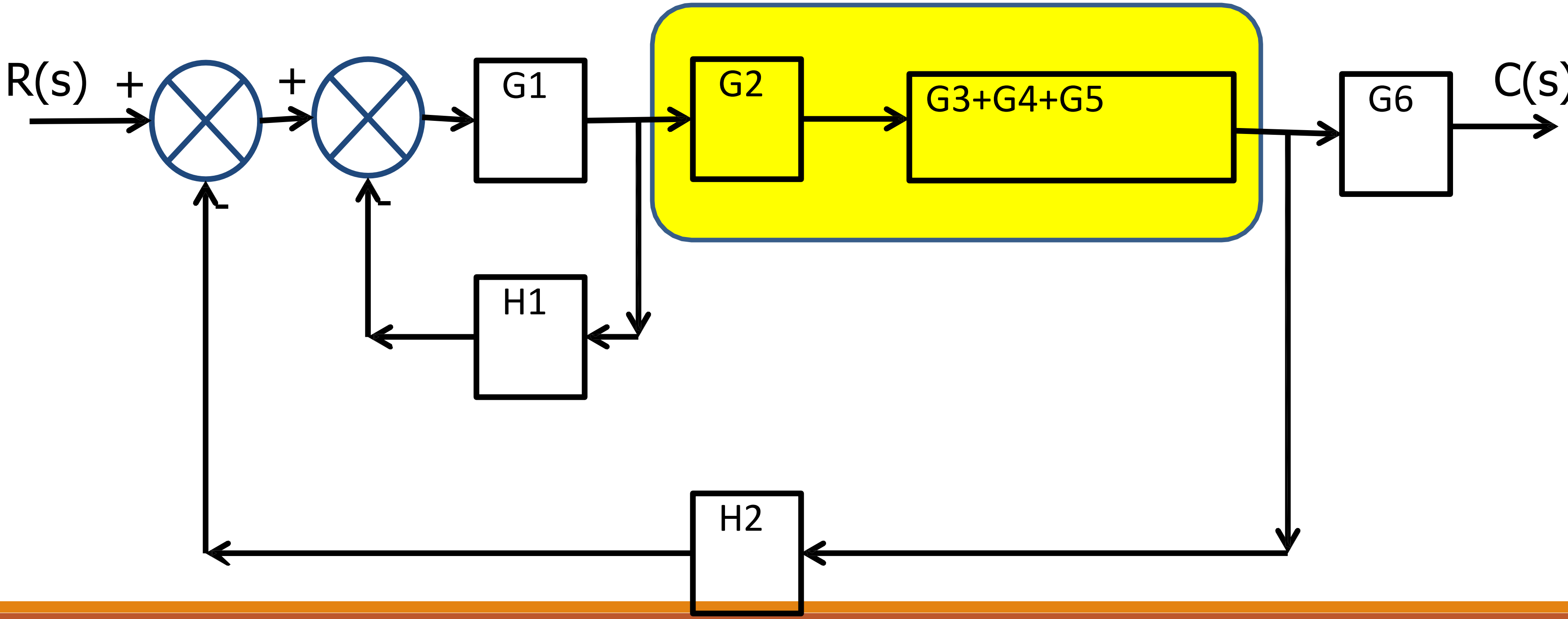
Apply Rule 2

Blocks in Parallel



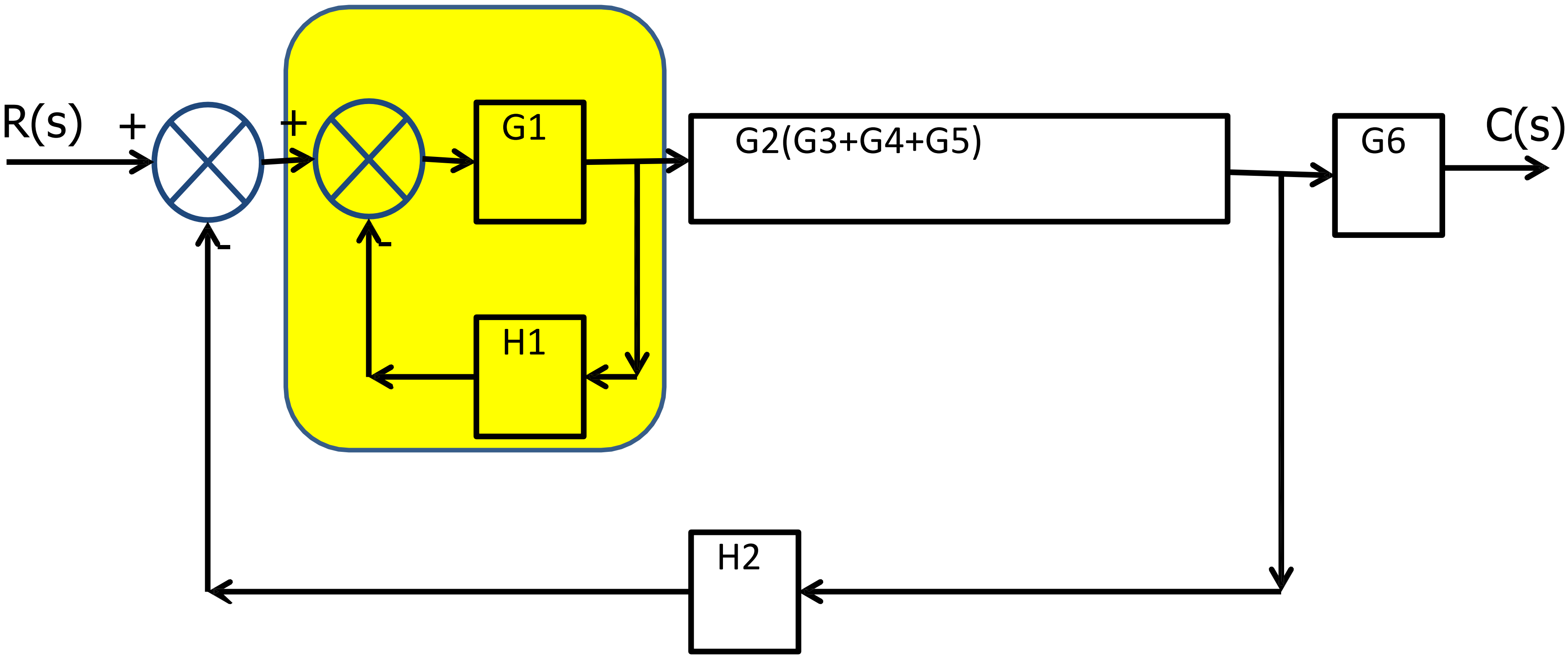
Example 1 cont….

Apply Rule 1 Blocks in series



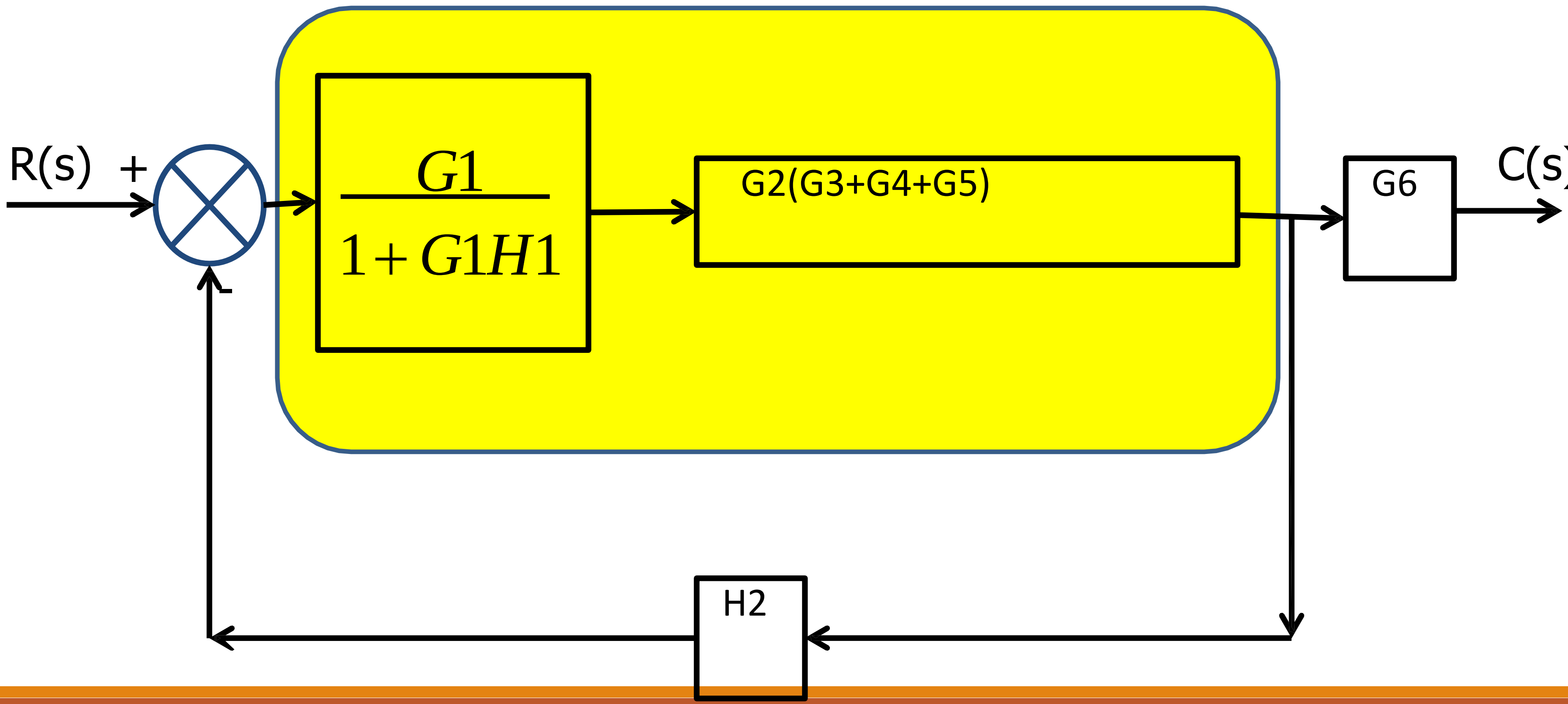
Example 1 cont….

Apply Rule 3 Elimination of feedback loop



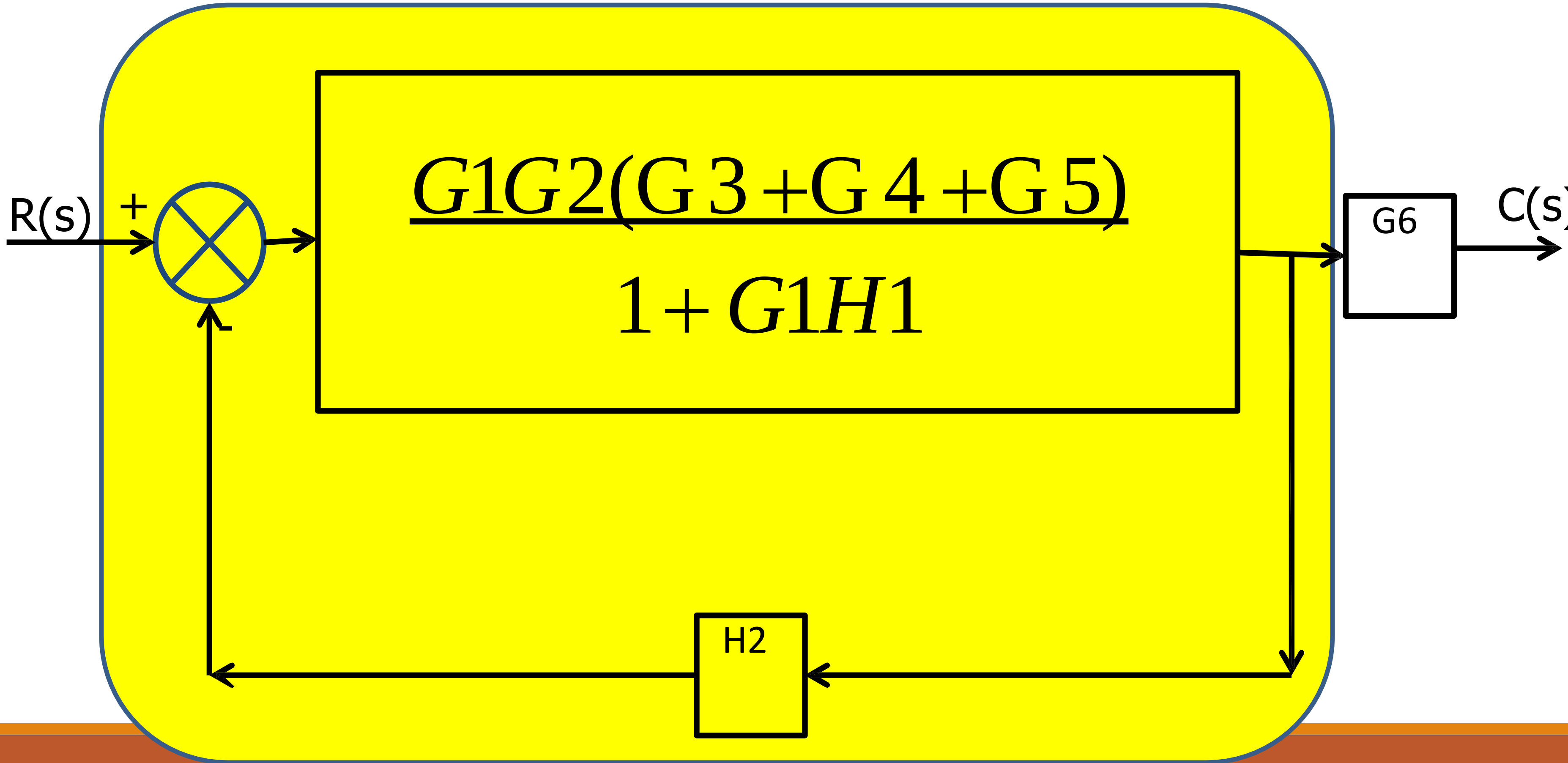
Example 1 cont….

Apply Rule 1 Blocks in series



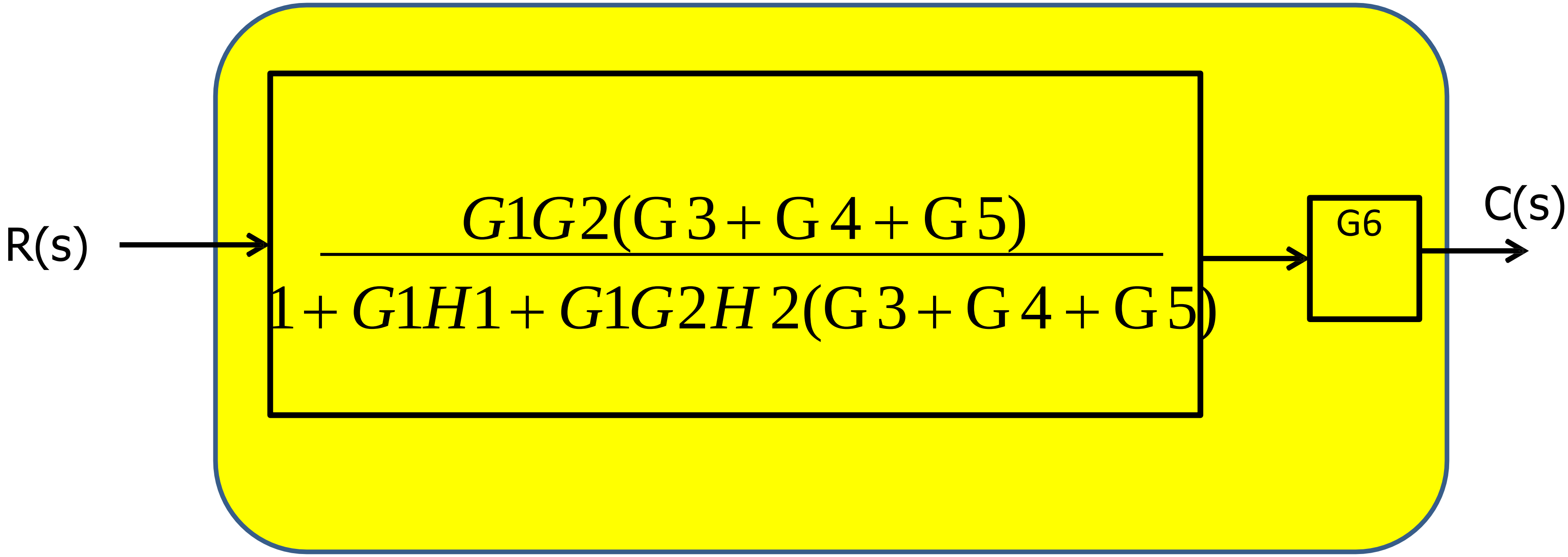
Example 1 cont….

Apply Rule 3 Elimination of feedback loop

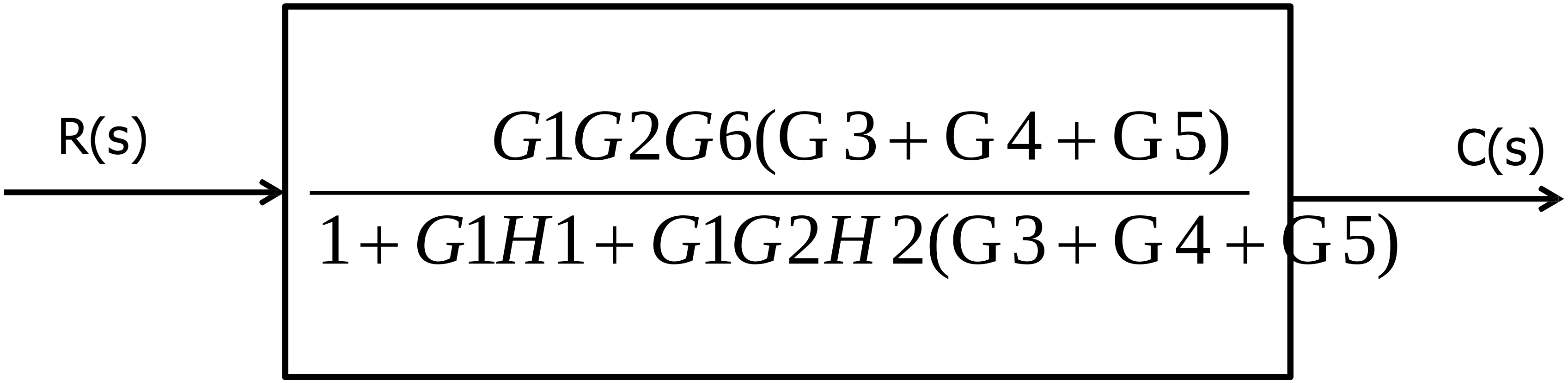


Example 1 cont….

Apply Rule 1 Blocks in series



Example 1 cont….

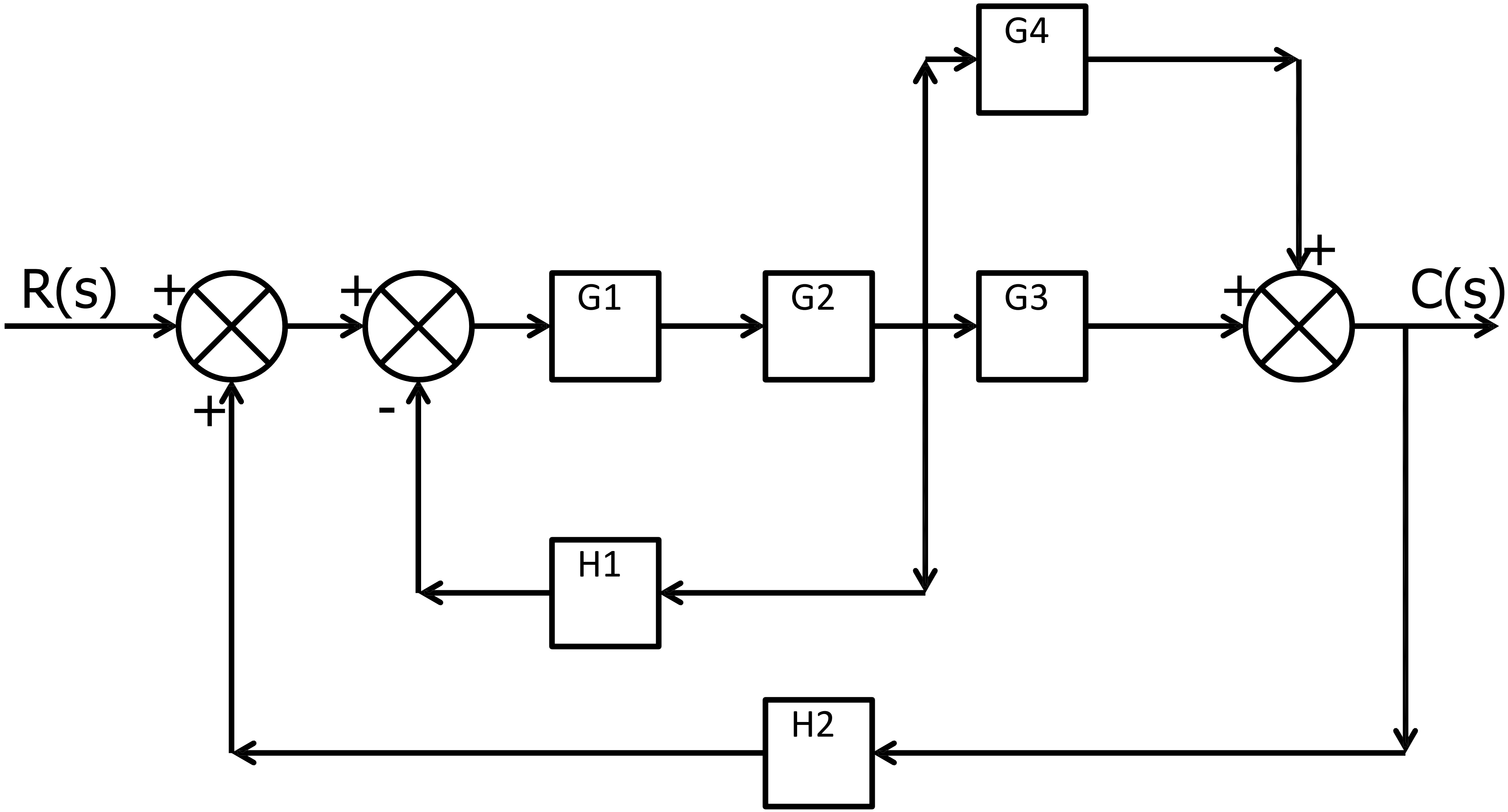


$$\frac{G1G2G6(G3+G4+G5)}{1+G1H1+G1G2H2(G3+G4+G5)}$$

Example 1 cont….

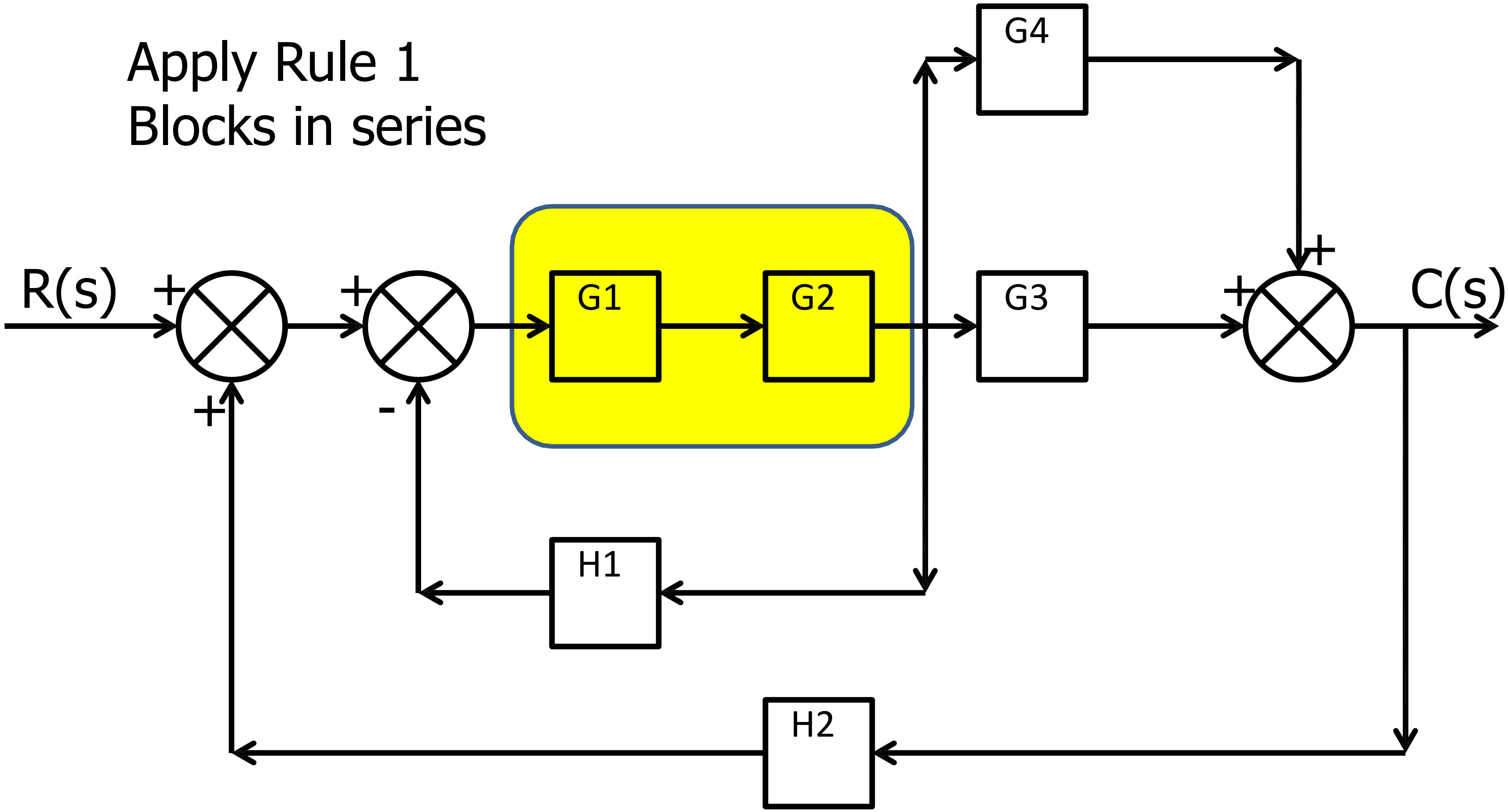
$$\frac{C(s)}{R(s)} = \frac{G1G2G6(G3+G4+G5)}{1+G1H1+G1G2H2(G3+G4+G5)}$$

Example 2



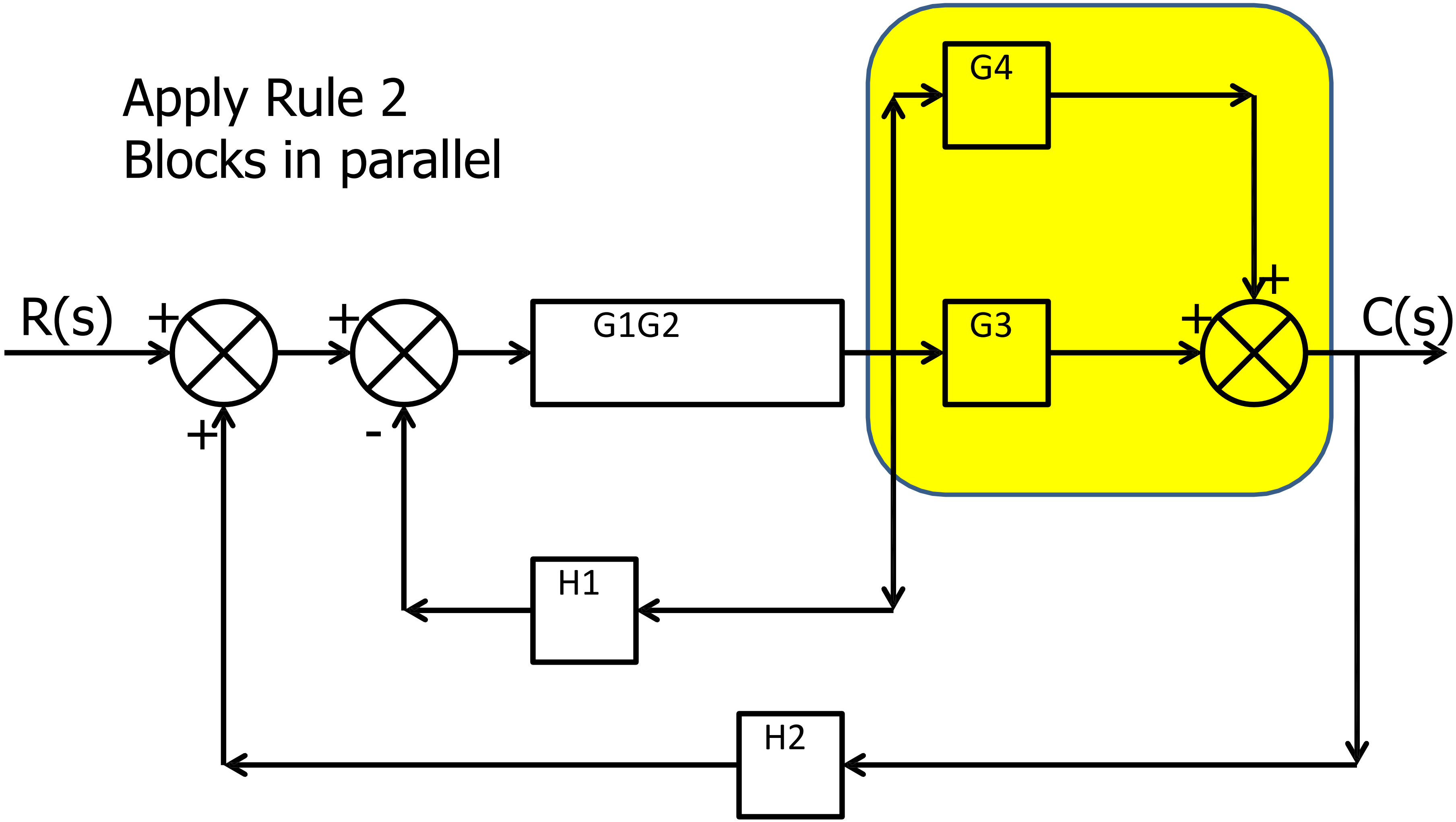
Example 2 cont….

Apply Rule 1
Blocks in series



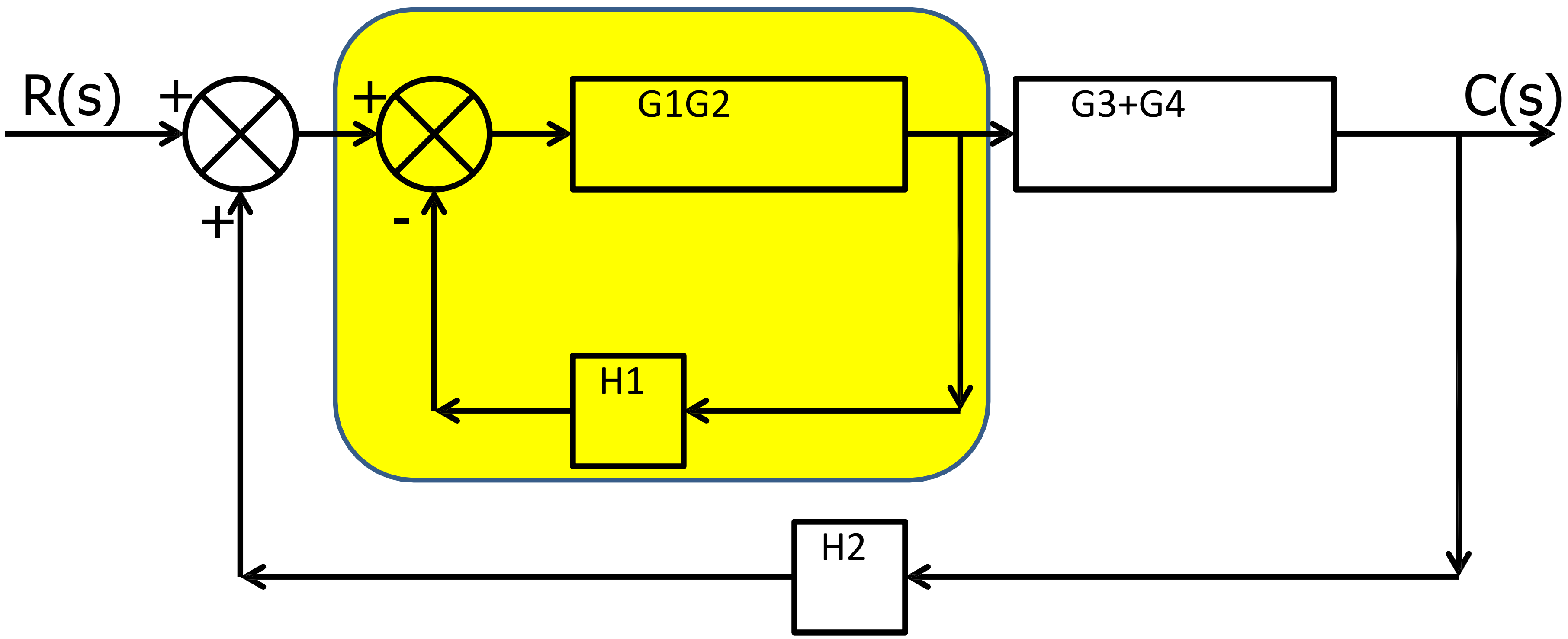
Example 2 cont….

Apply Rule 2
Blocks in parallel



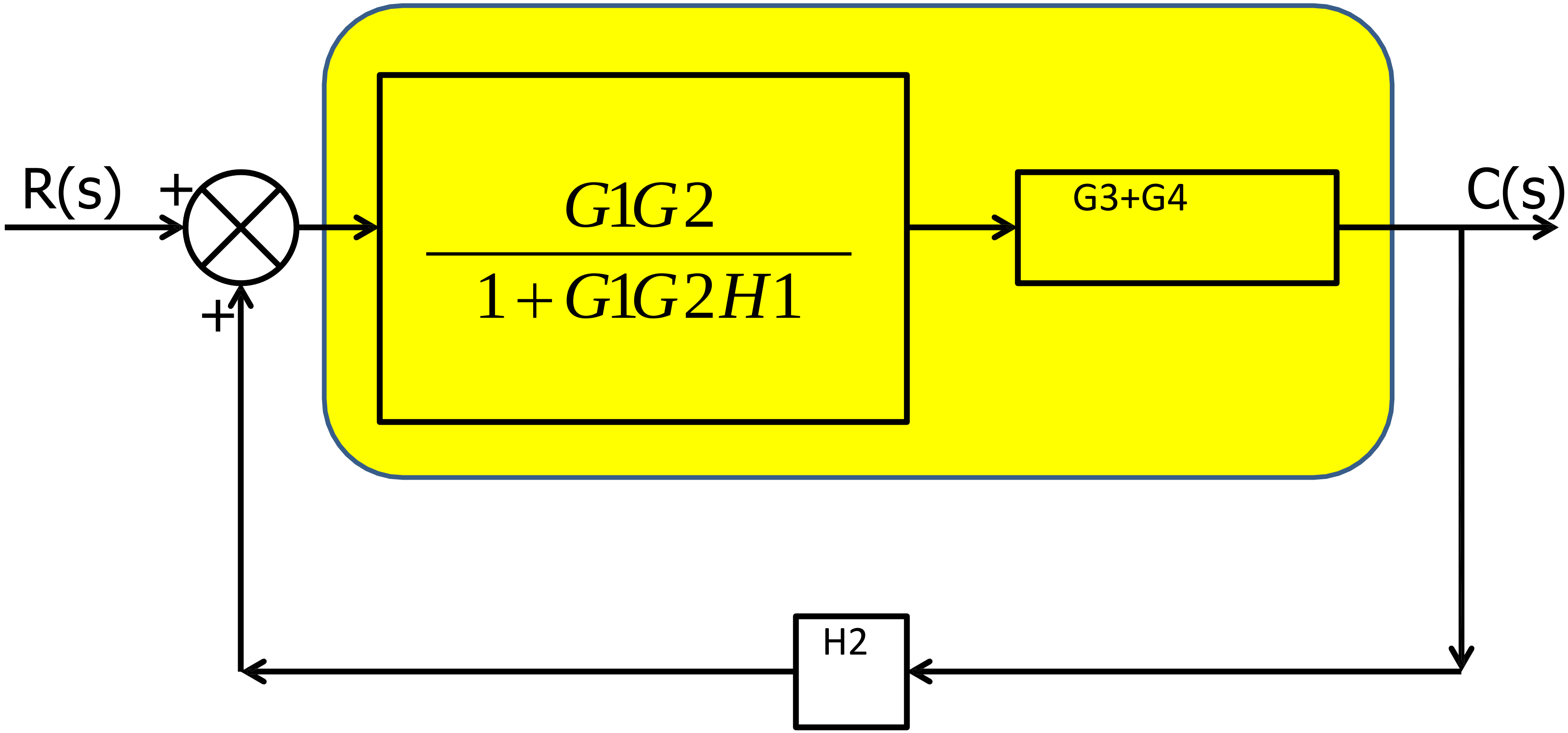
Example 2 cont….

Apply Rule 3
Elimination of feedback loop



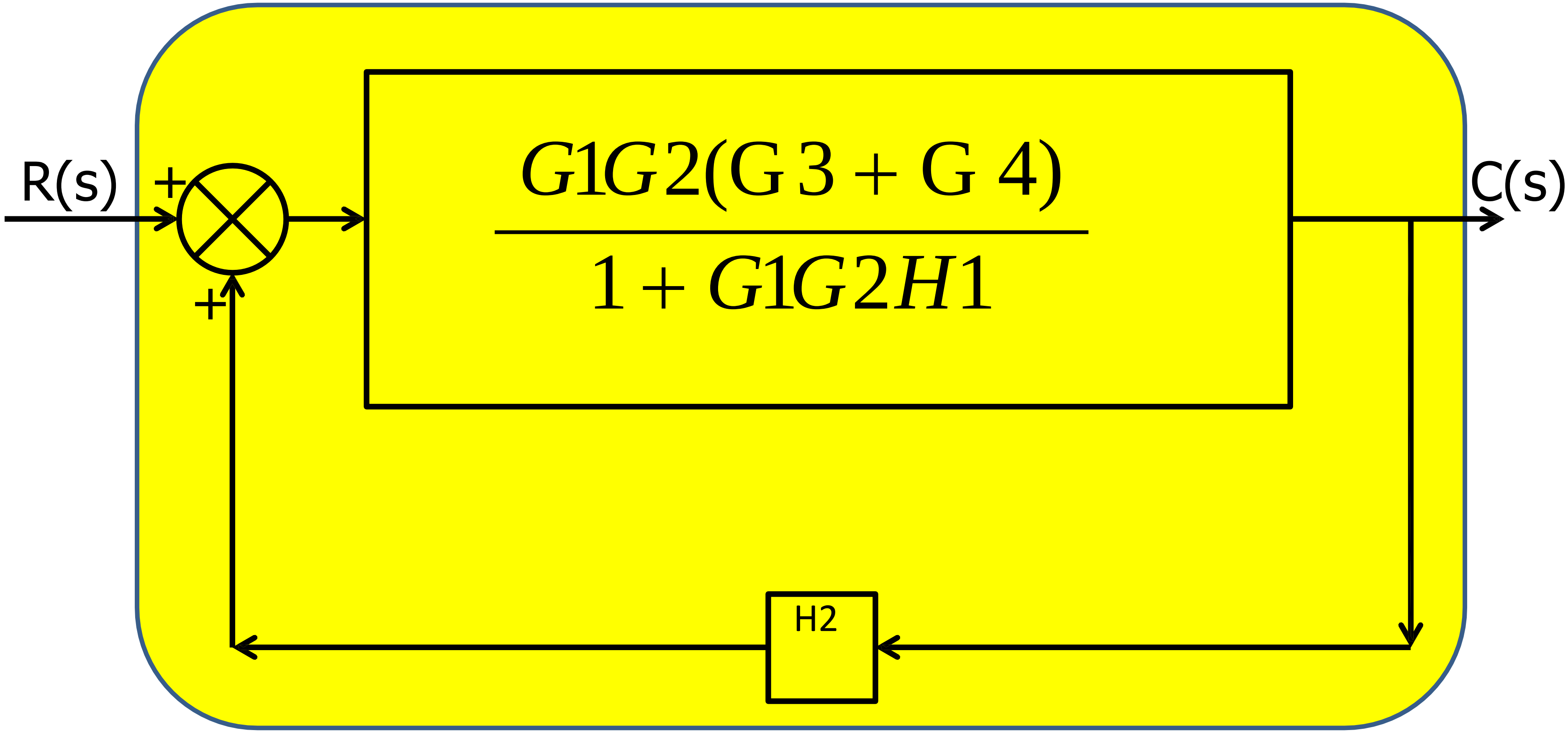
Example 2 cont….

Apply Rule 2 Blocks in series



Example 2 cont….

Apply Rule 3 Elimination of feedback loop



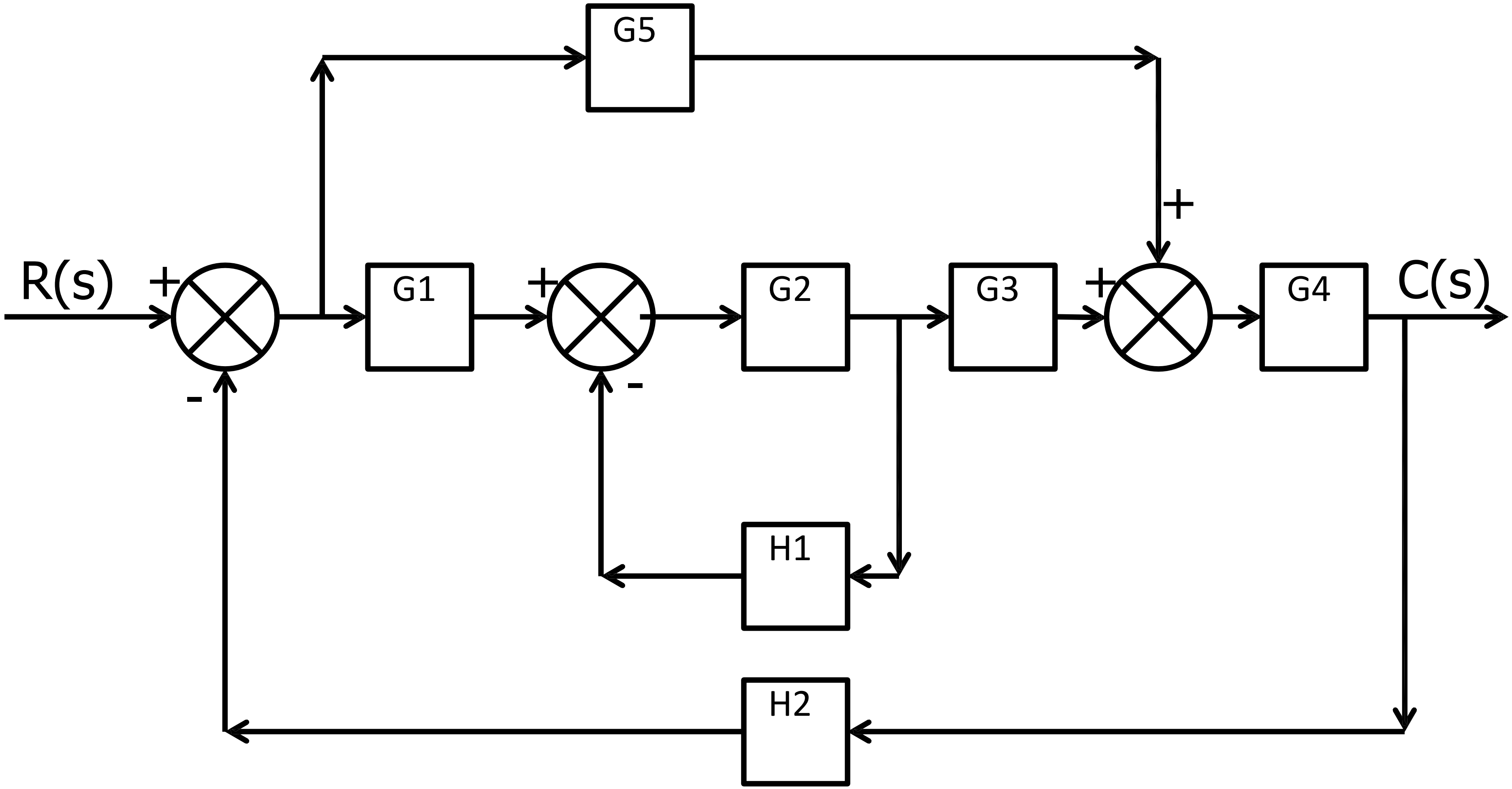
Example 2 cont….

$$R(s) \longrightarrow \boxed{\dfrac{G1G2(G3+G4)}{1+G1G2H1-G1G2G3H2-G1G2G4H2}} \longrightarrow C(s)$$

Example 2 cont....

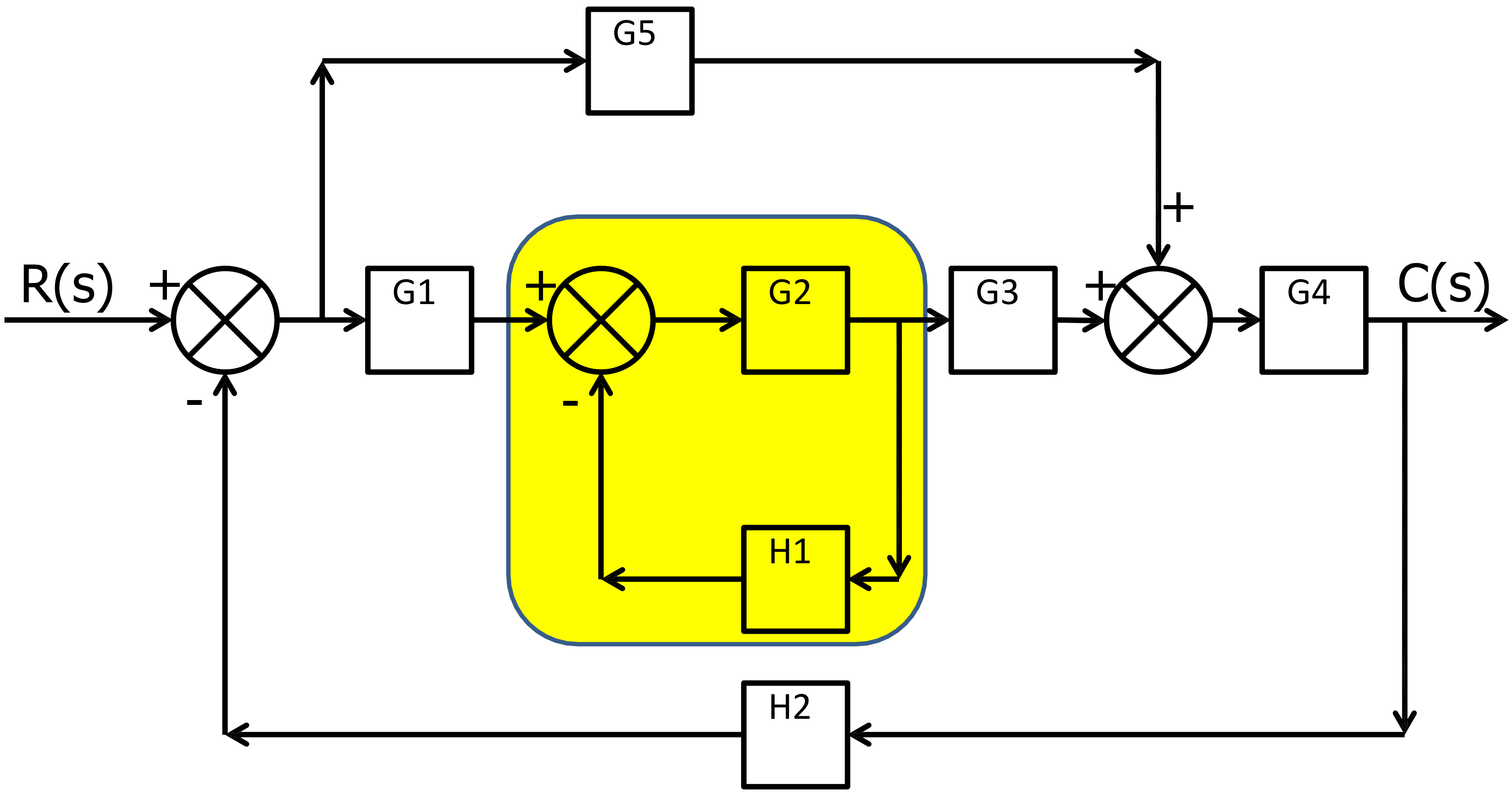
$$\frac{C(s)}{R(s)} = \frac{G1G2(G3+G4)}{1+G1G2H1-G1G2G3H2-G1G2G4H2}$$

Example 3



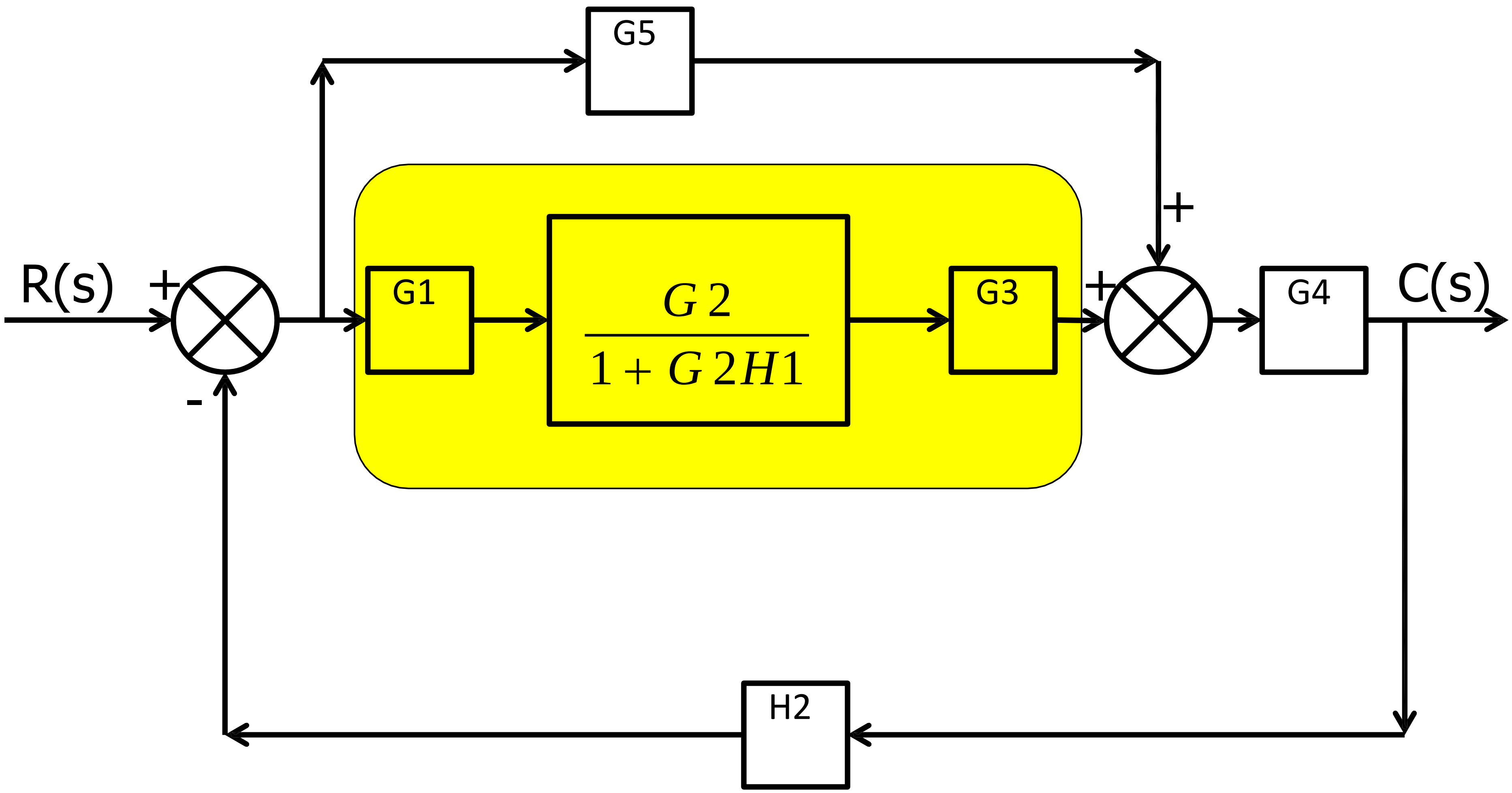
Example 3 cont….

Apply Rule 3 Elimination of feedback loop



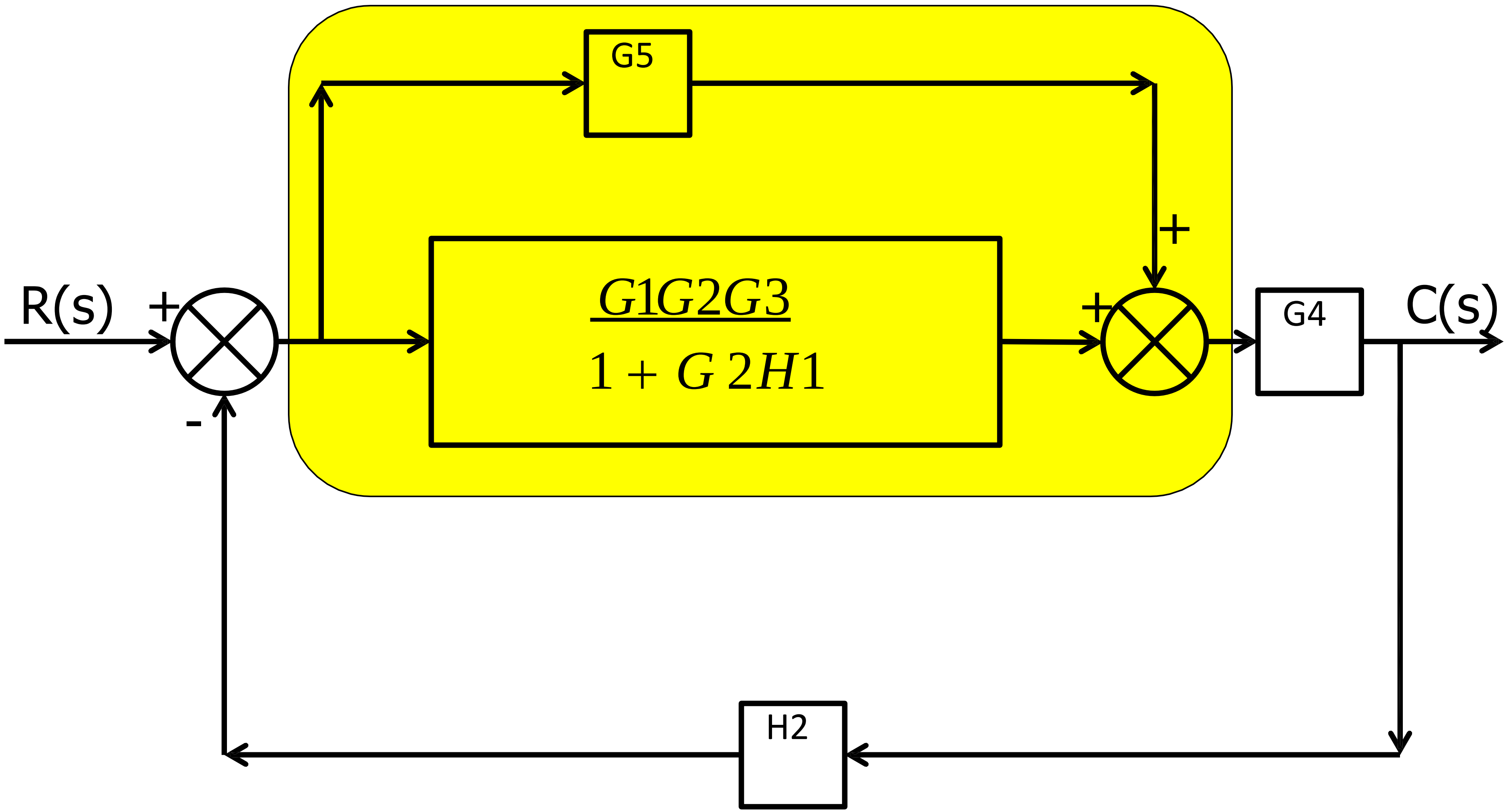
Example 3 cont….

Apply Rule 1 Blocks in series



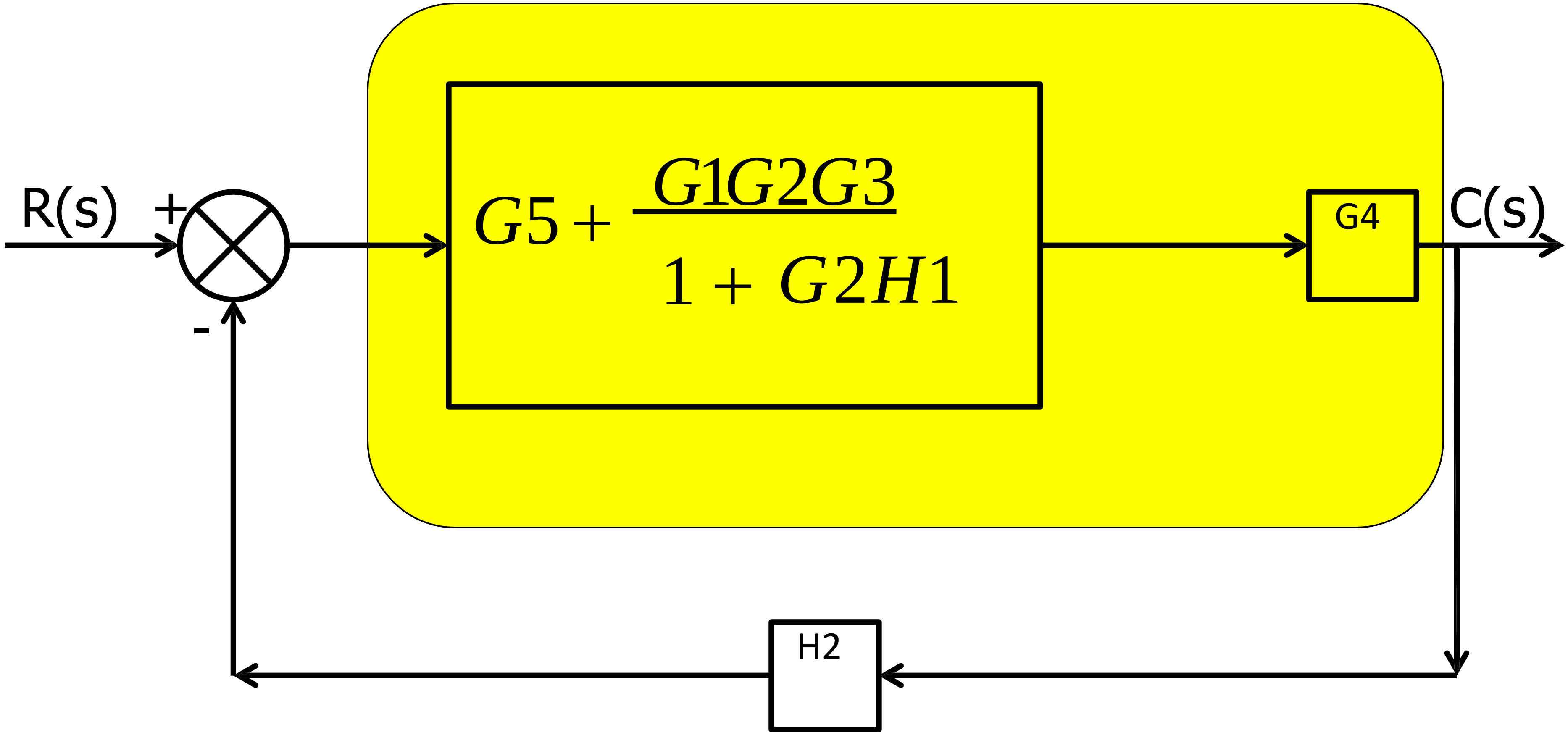
Example 3 cont….

Apply Rule 2 Blocks in parallel



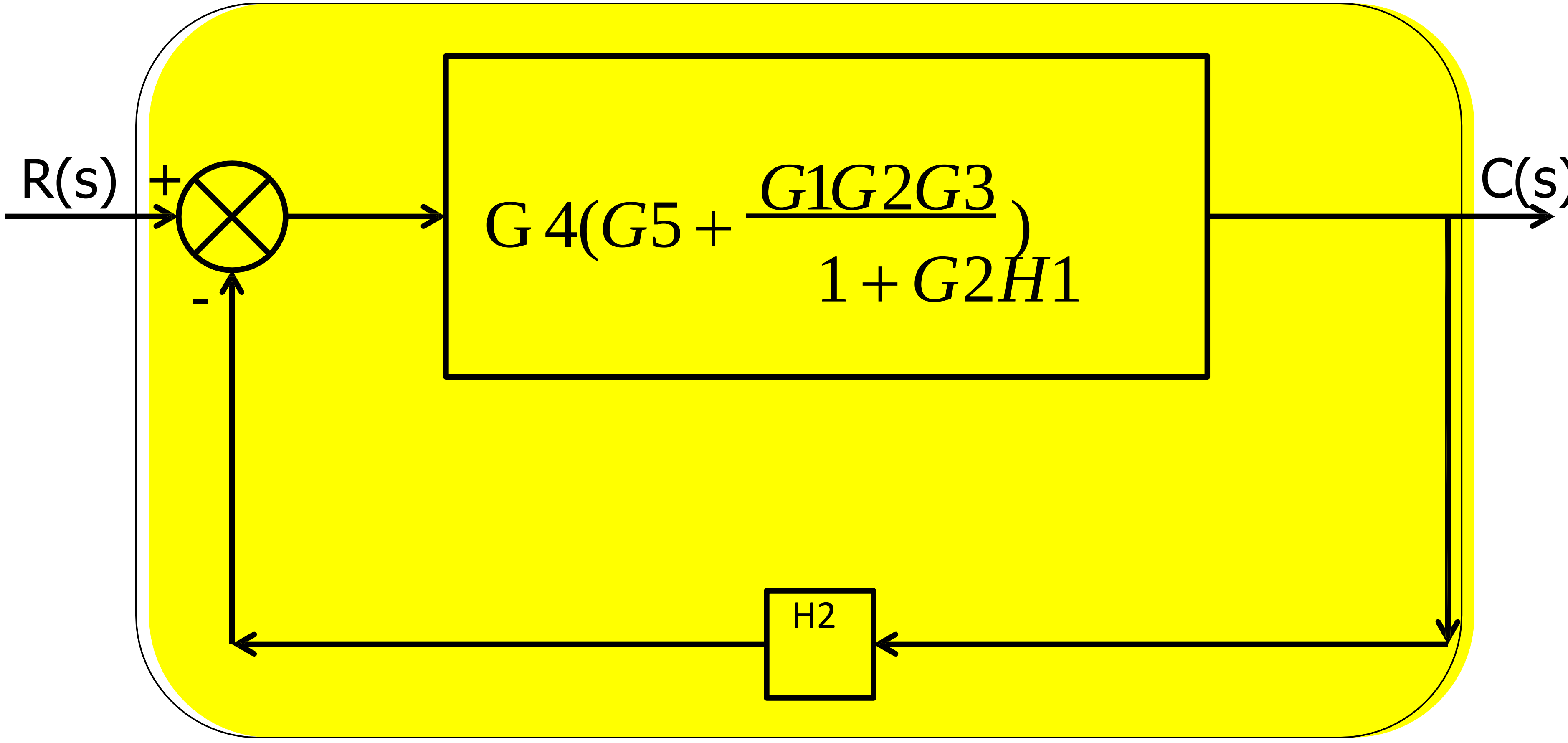
Example 3 cont….

Apply Rule 1 Blocks in series



Example 3 cont….

Apply Rule 3 Elimination of feedback loop



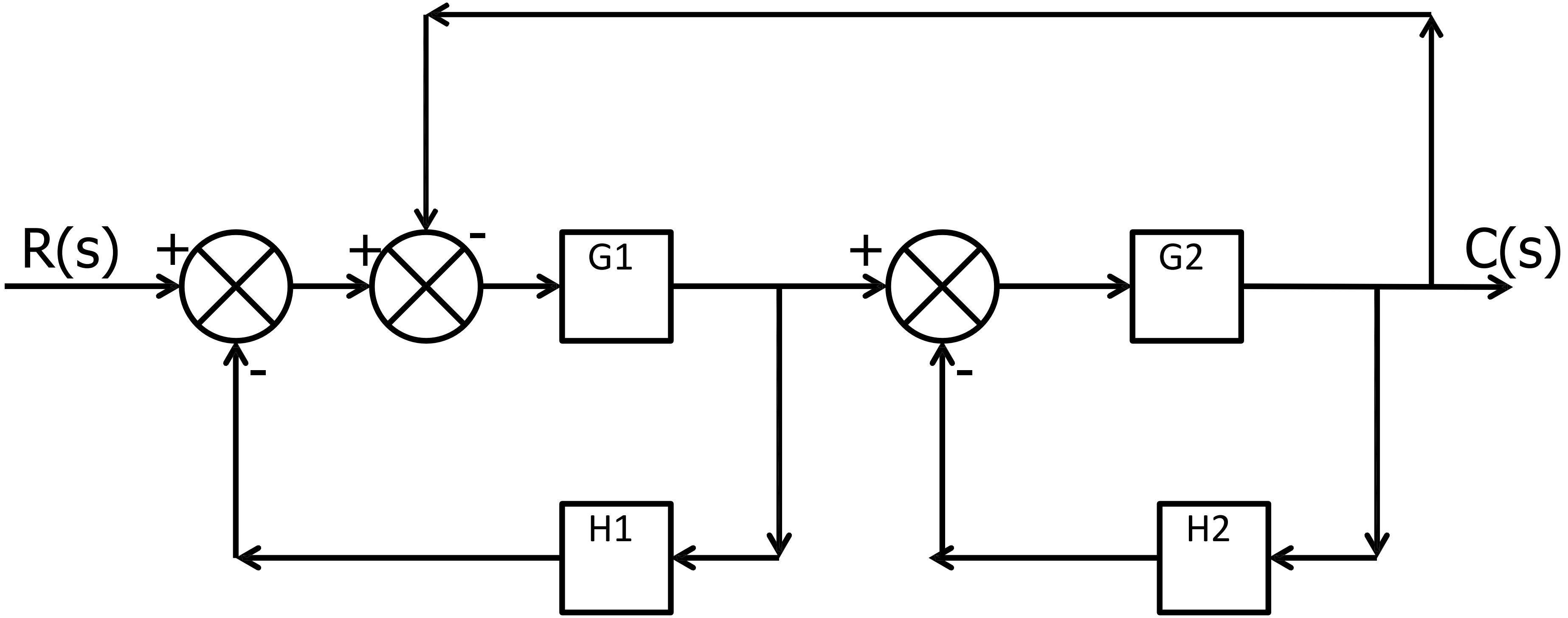
Example 3 cont….

R(s)

$$\frac{G4G5 + G2G4G5H1 + G1G2G3G4}{1 + G2H1 + G4G5H2 + G2G4G5H1H2 + G1G2G3G4H2}$$

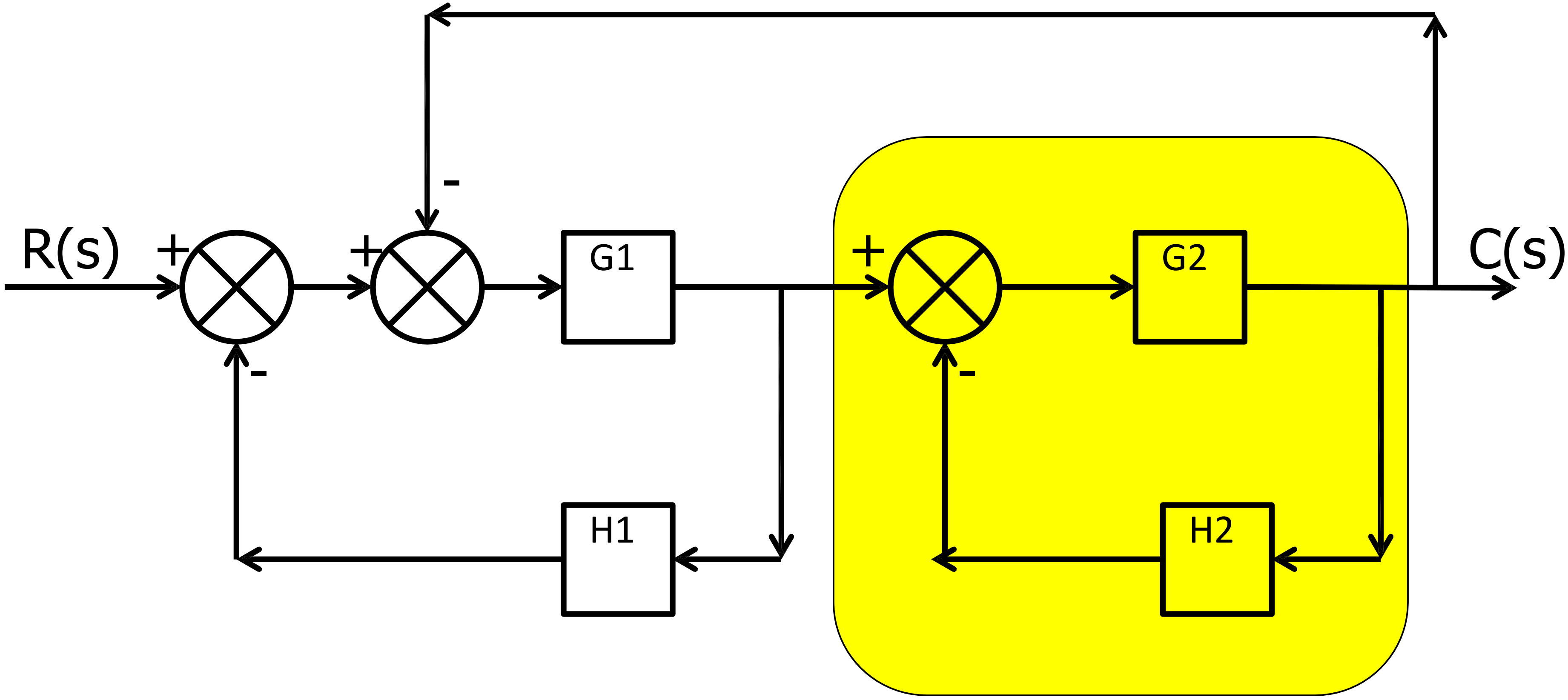
C(s)

Example 4

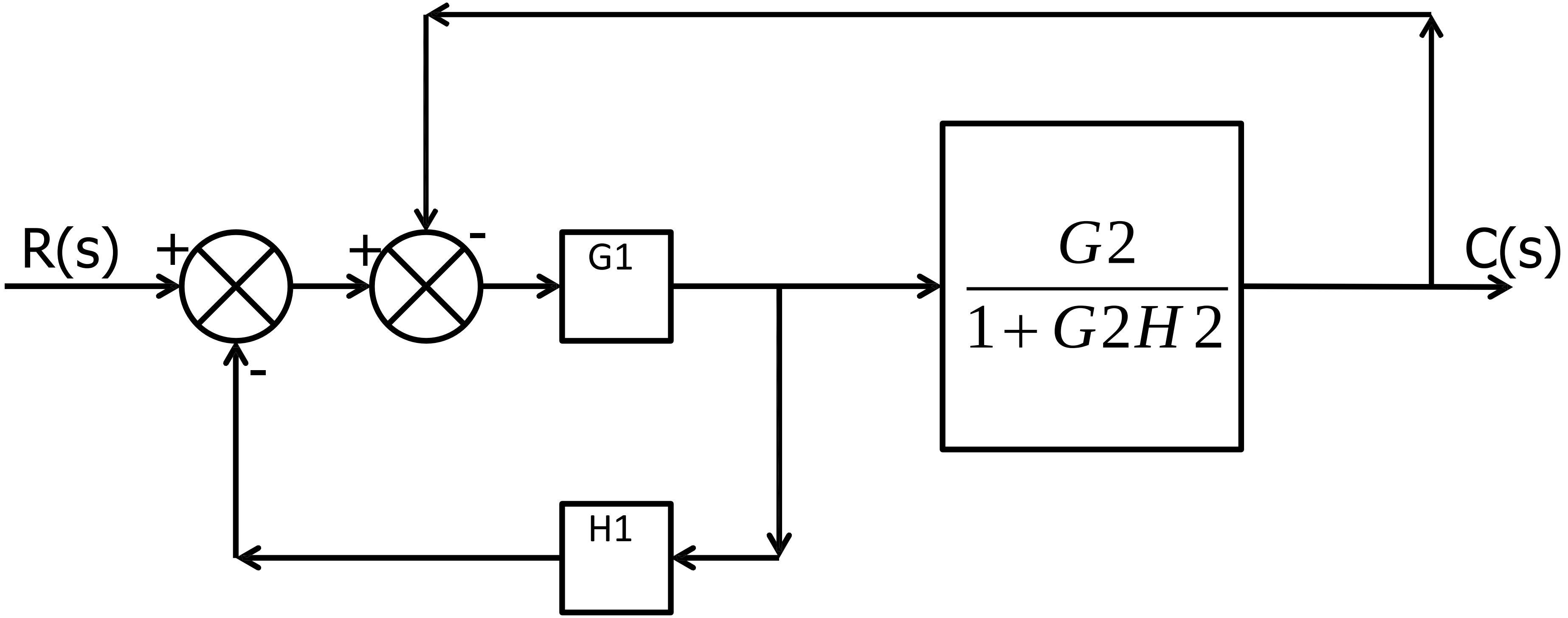


Example 4 cont….

Apply Rule 3 Elimination of feedback loop



Example 4 cont….

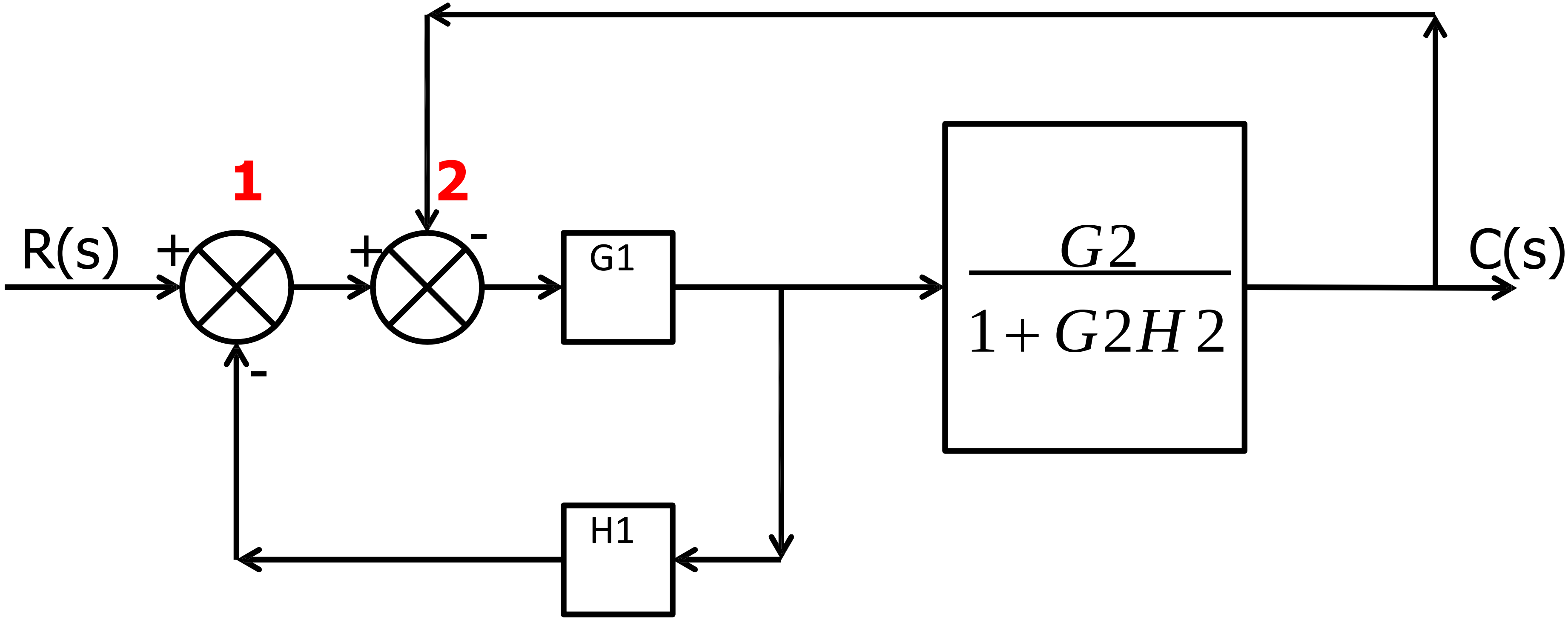


- Now Rule 1, 2 or 3 cannot be used directly.
- There are possible ways of going ahead.
  a. Use Rule 4 & interchange order of summing so that Rule 3 can be used on G.H1 loop.
  b. Shift take off point after $\frac{G2}{1+G2H2}$ block reduce by Rule 1, followed by Rule 3.

Which option we have to use????

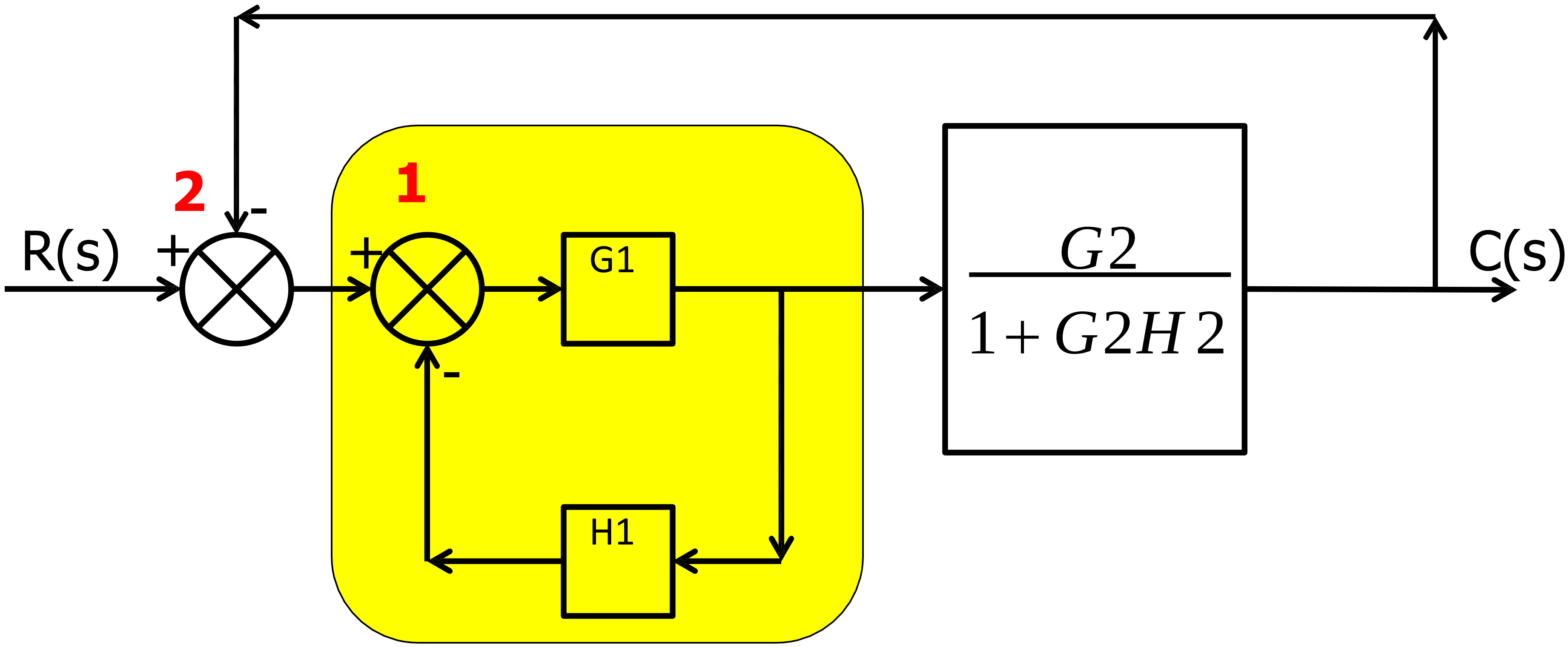
Example 4 cont….

Apply Rule 4 Exchange summing order



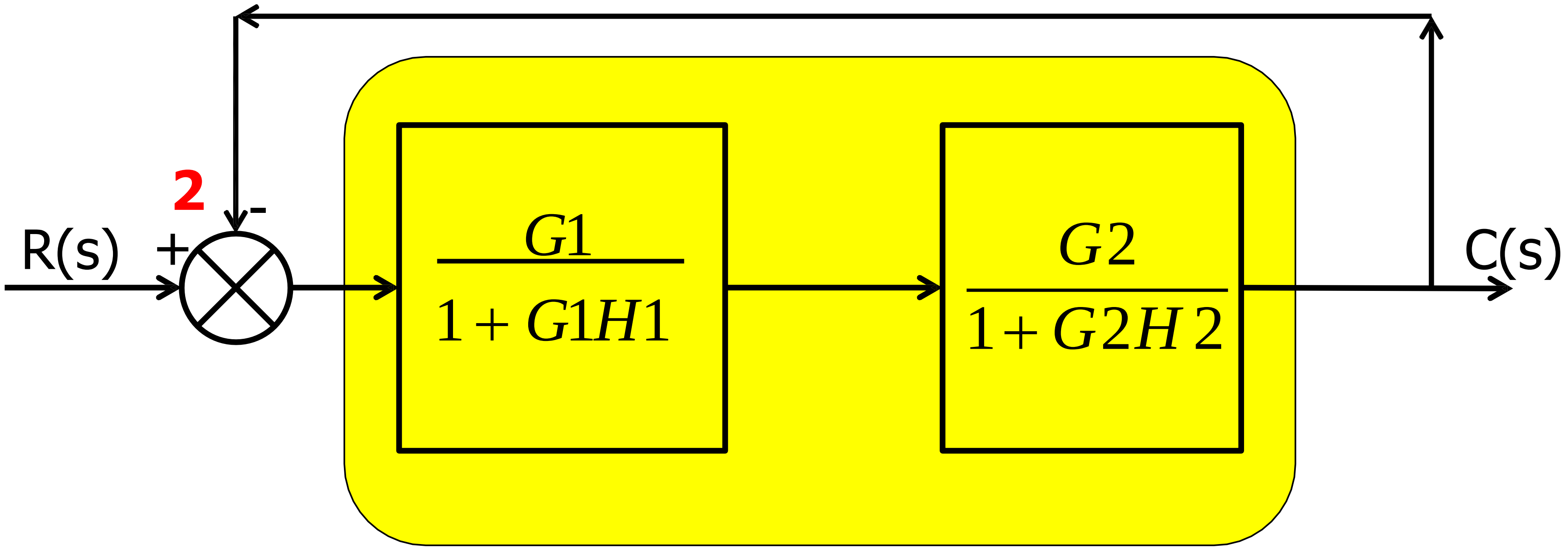
Example 4 cont….

Apply Rule 3 Elimination feedback loop

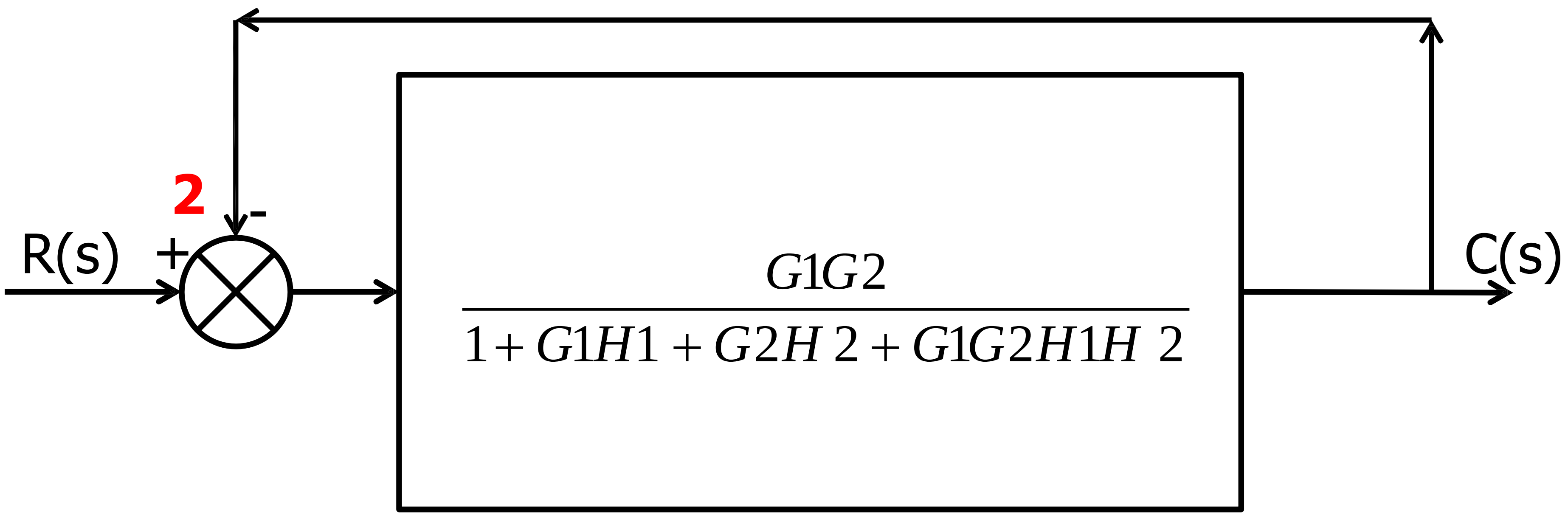


Example 4 cont….

Apply Rule 1 Bocks in series



Example 4 cont….



Now which Rule will be applied

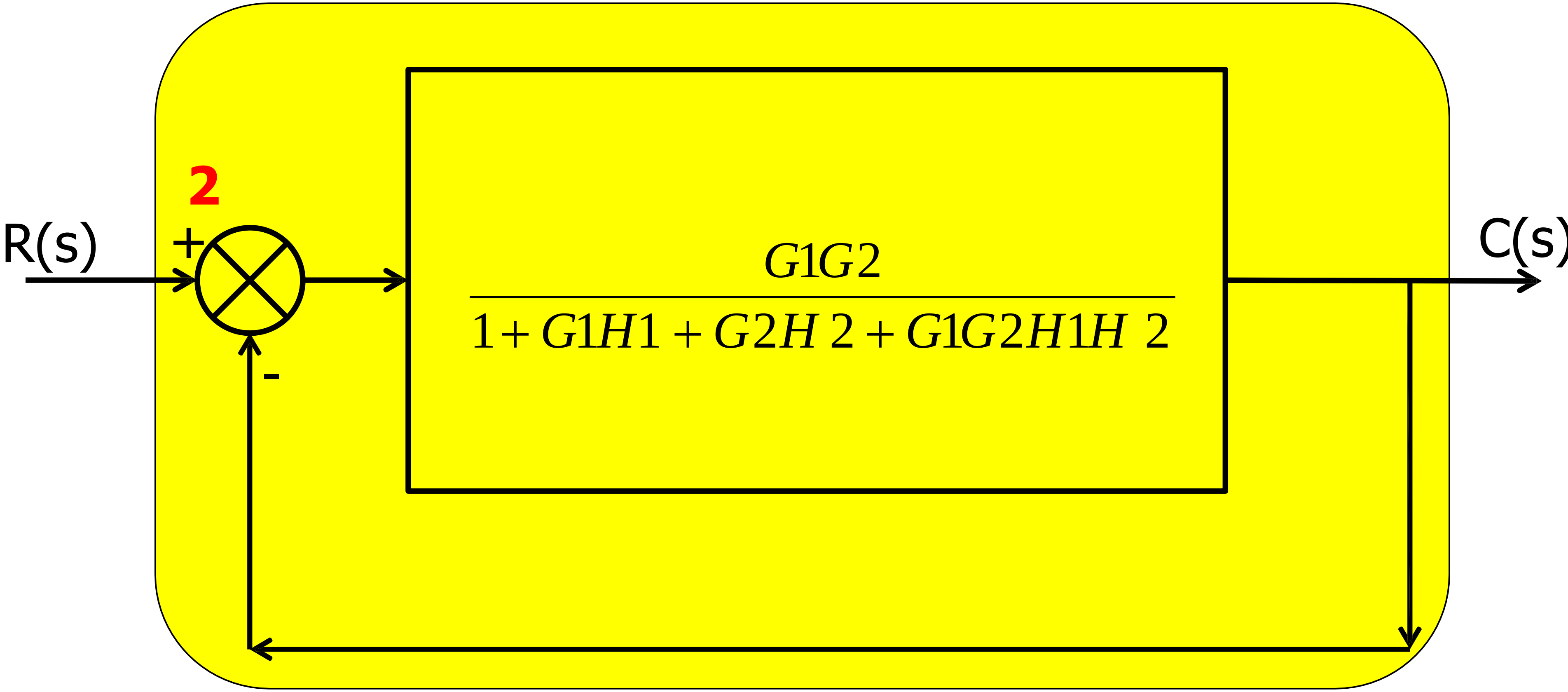
-------It is blocks in parallel **OR**

-------It is feed back loop

Example 4 cont….

Let us rearrange the block diagram to understand

Apply Rule 3 Elimination of feed back loop



Example 4 cont….

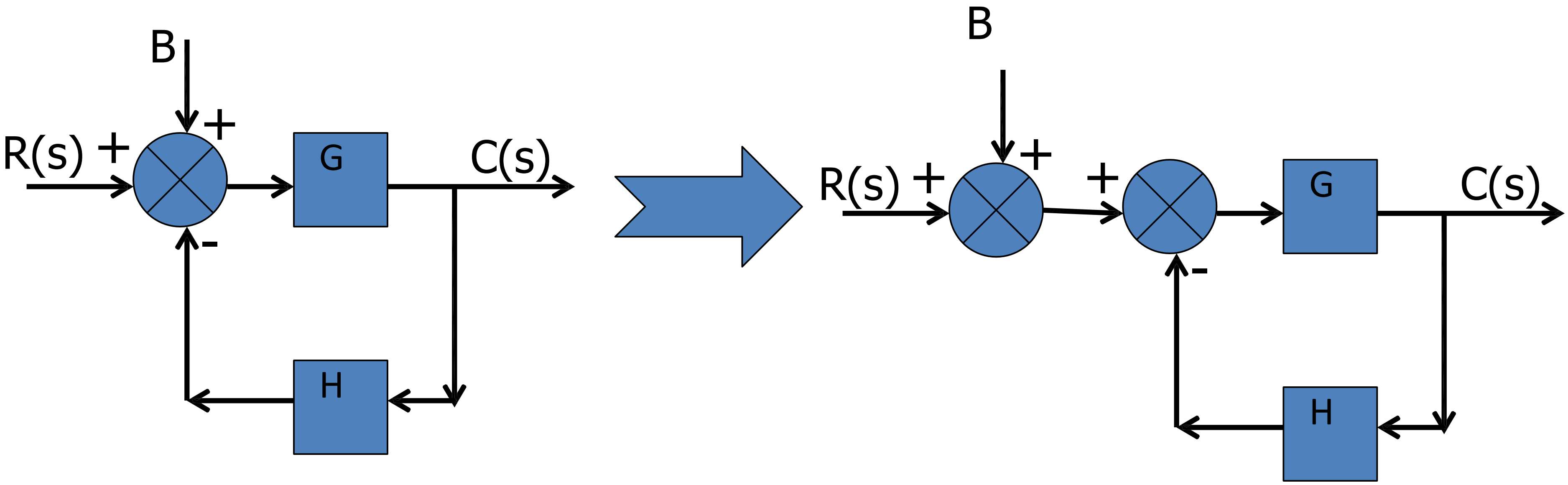
$$R(s) \longrightarrow \boxed{\dfrac{G1G2}{1+G1H1+G2H2+G1G2H1H2+G1G2}} \longrightarrow C(s)$$

Example 4 cont....

$$\frac{C(s)}{R(s)} = \frac{G1G2}{1 + G1H1 + G2H2 + G1G2H1H2 + G1G2}$$

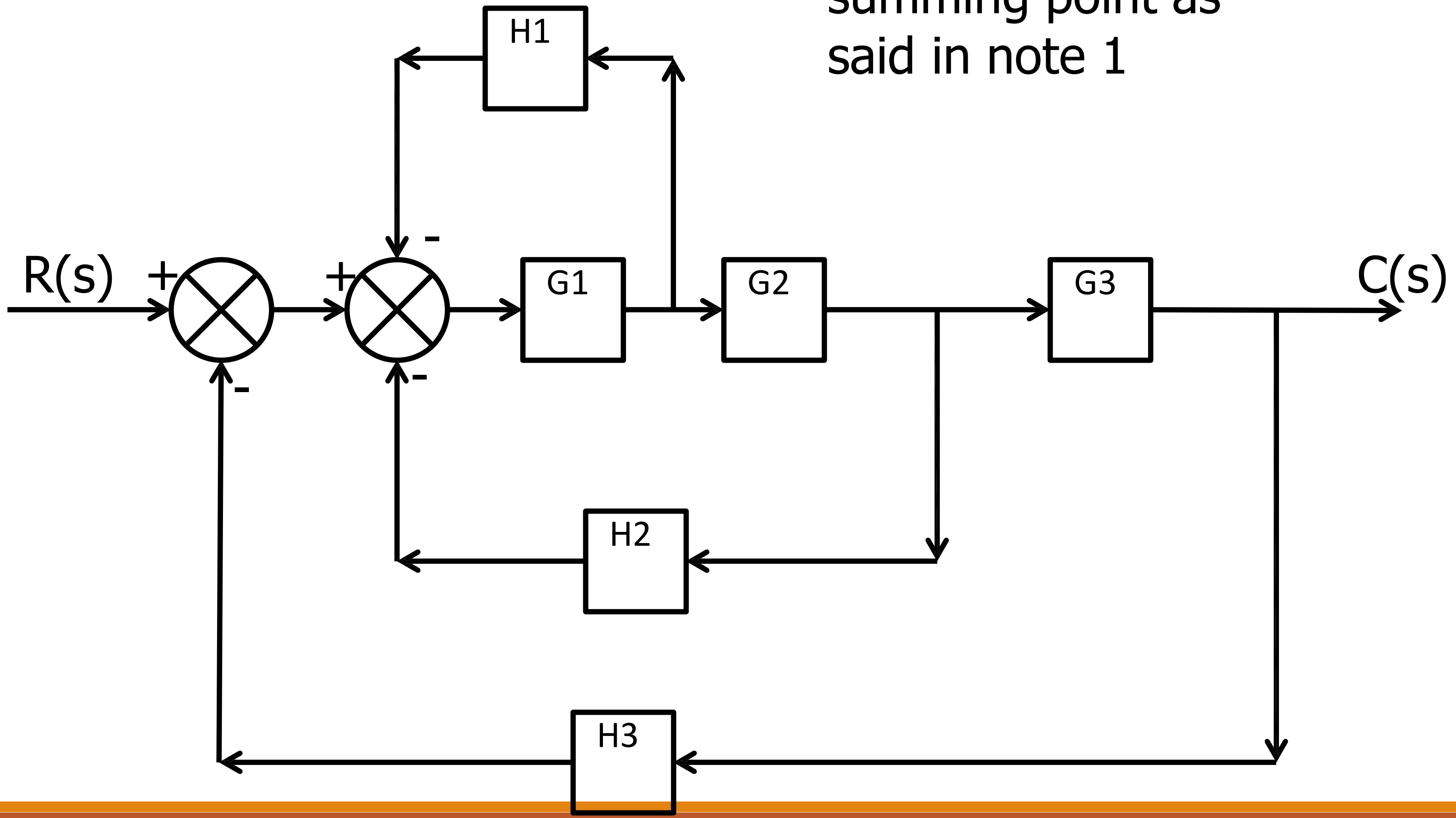
Note 1: According to Rule 4

- By corollary, one can split a summing point to two summing point and sum in any order



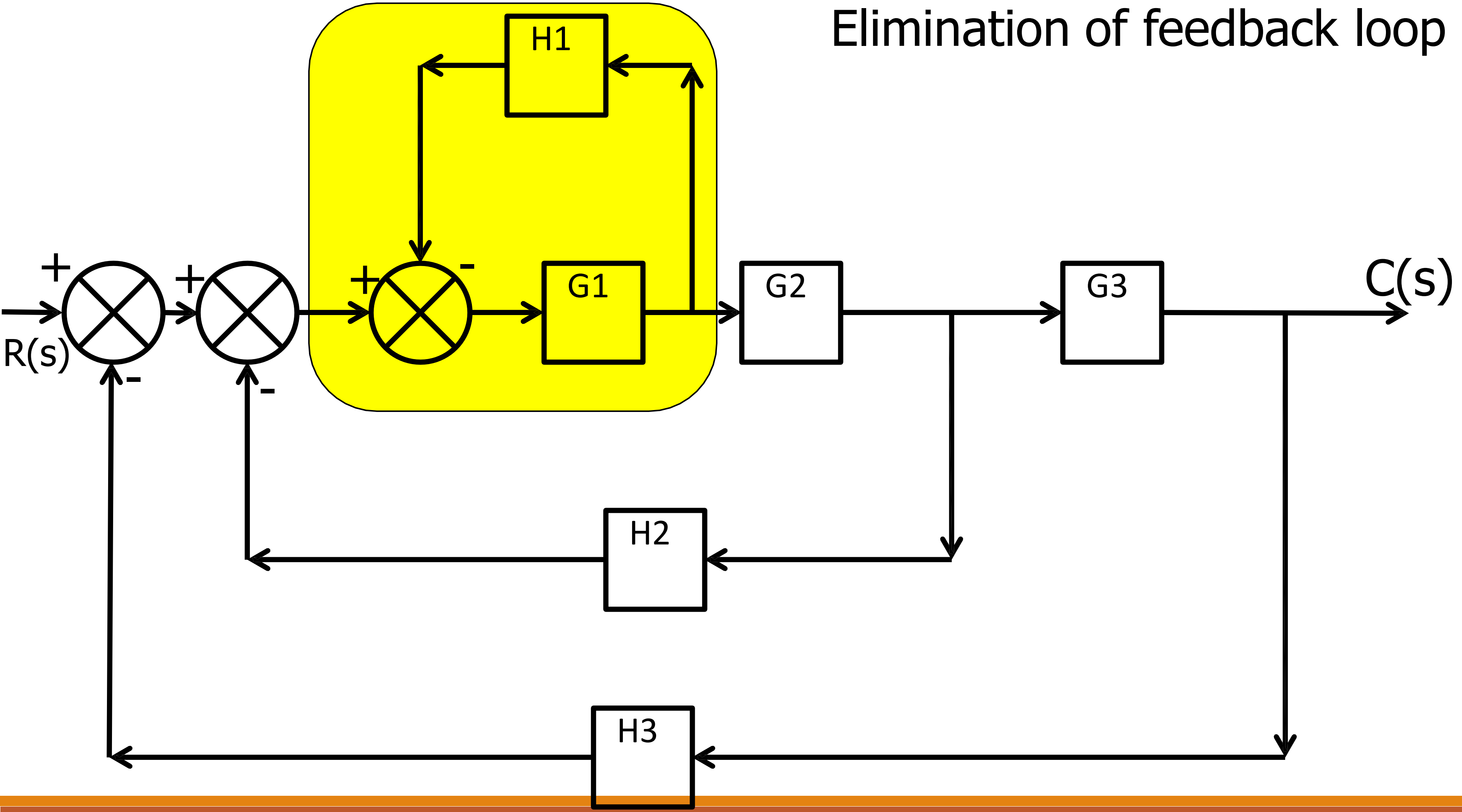
Example 5

Simplify, by splitting second summing point as said in note 1



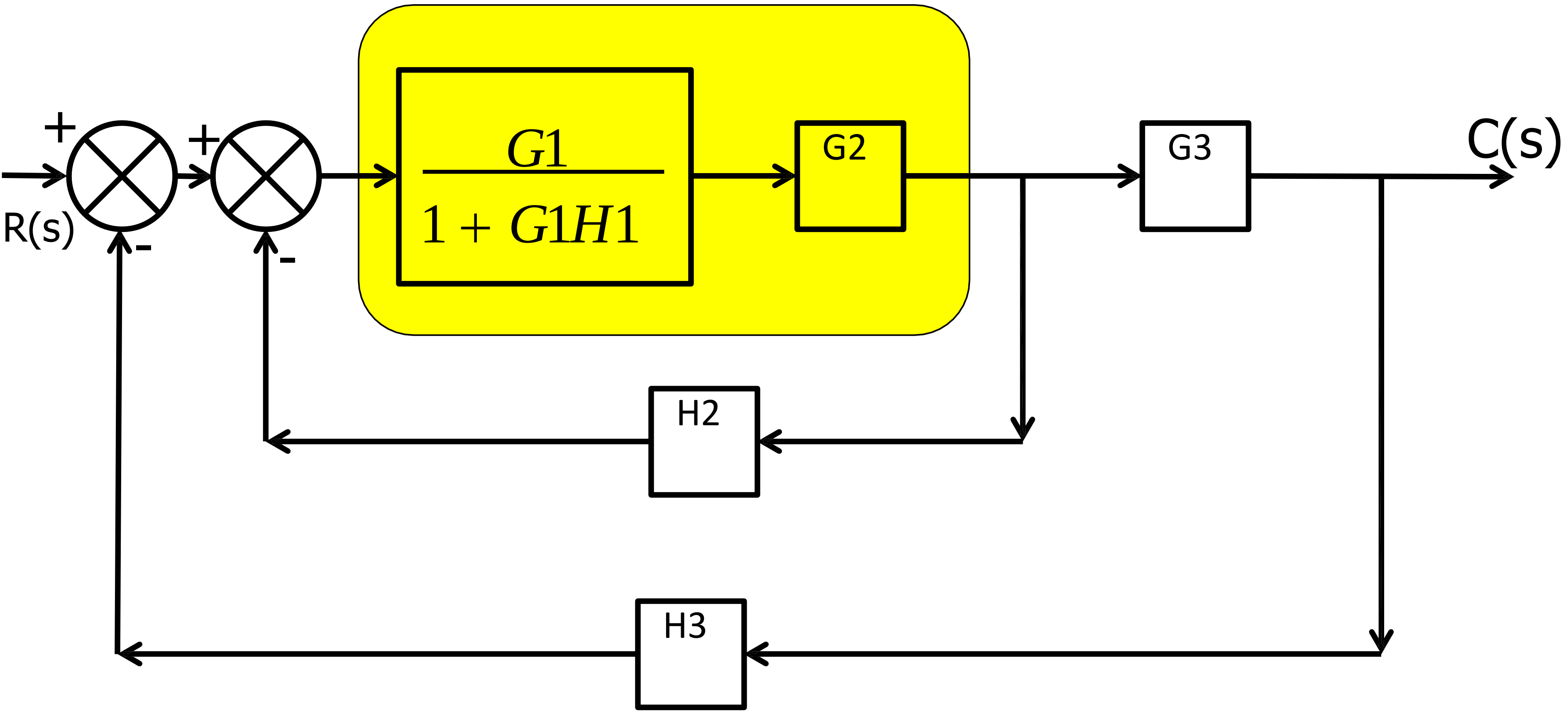
Example 5 cont….

Apply rule 3
Elimination of feedback loop



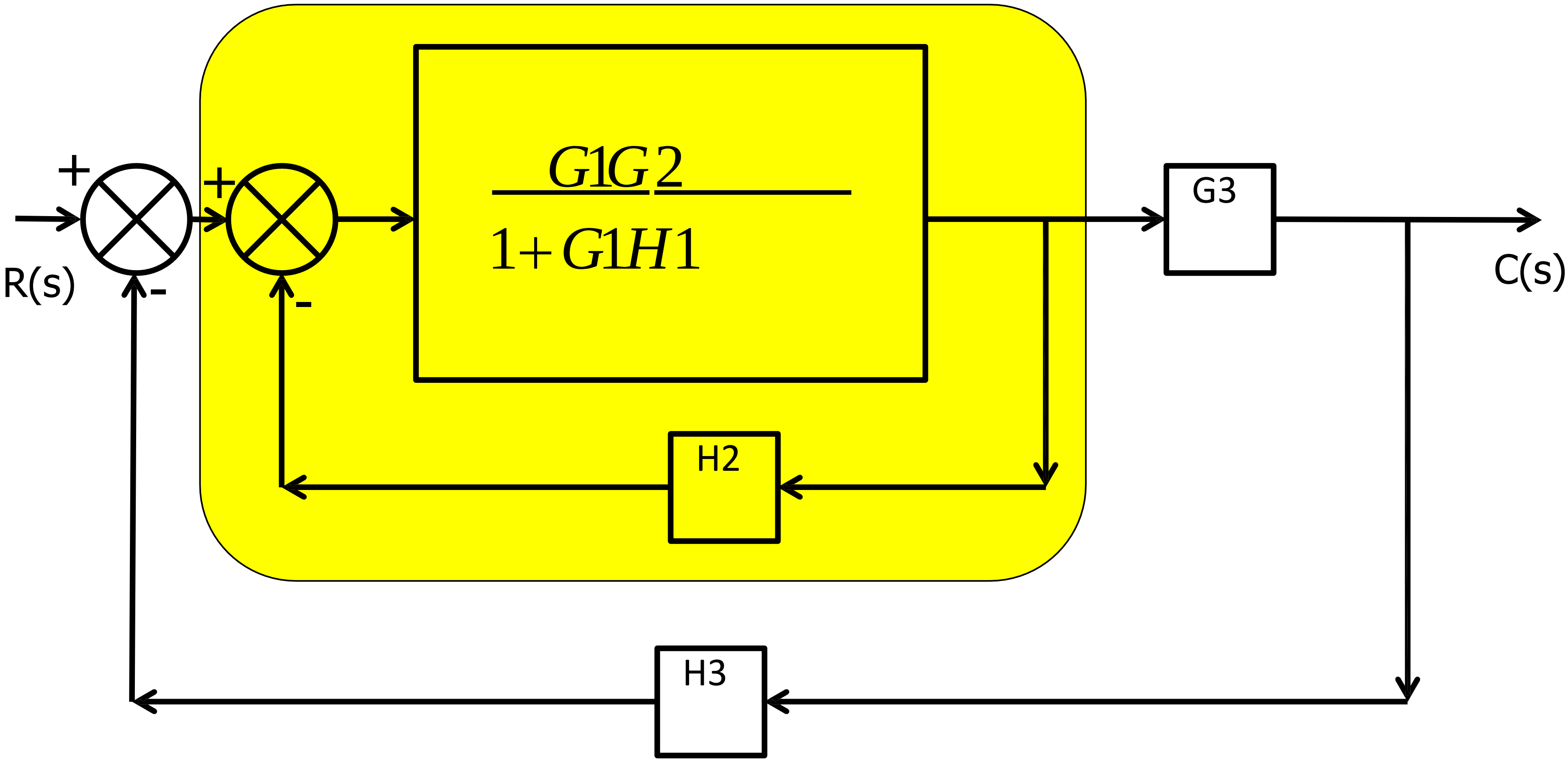
Example 5 cont....

Apply rule 1 Blocks in series



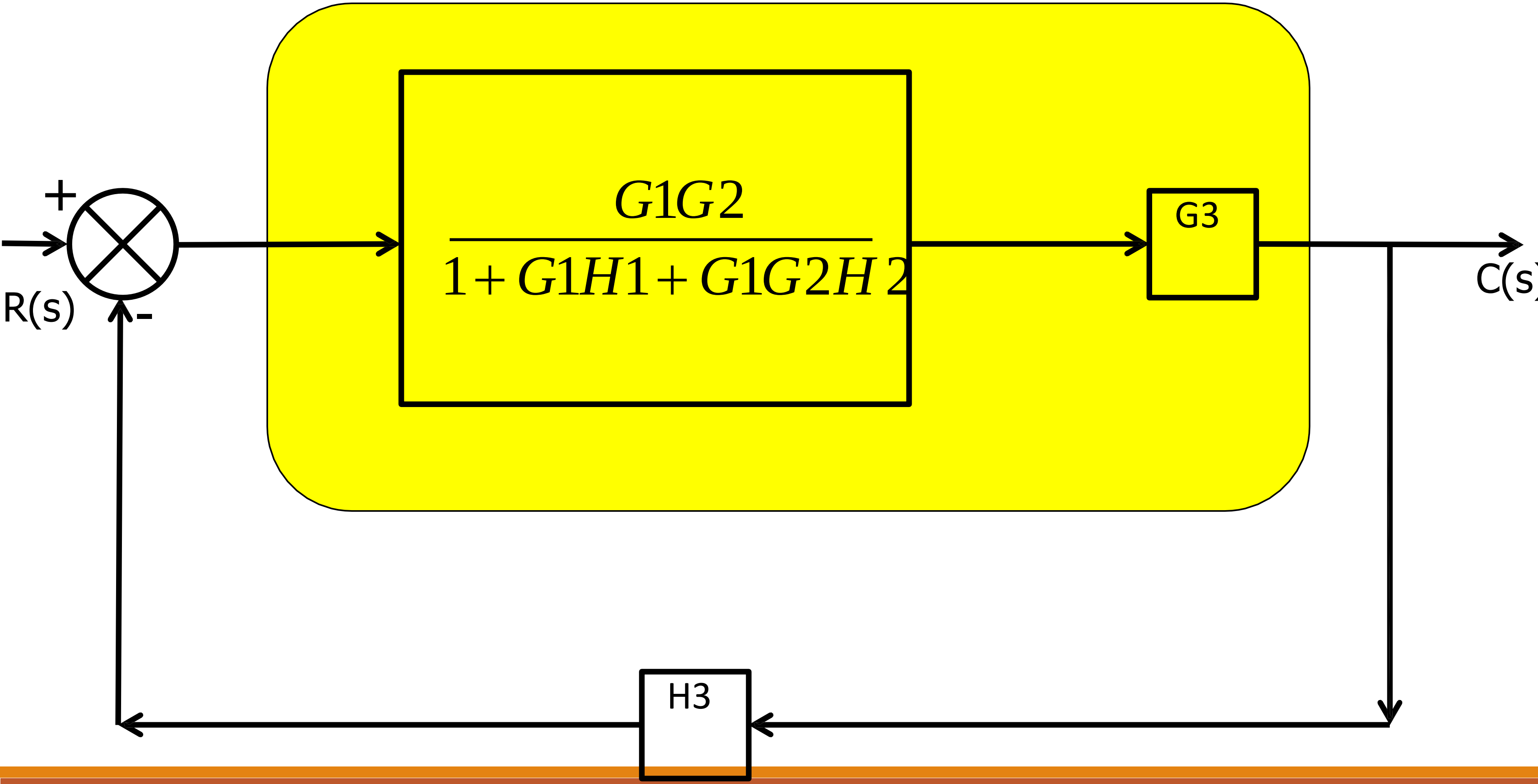
Example 5 cont….

Apply rule 3 Elimination of feedback loop



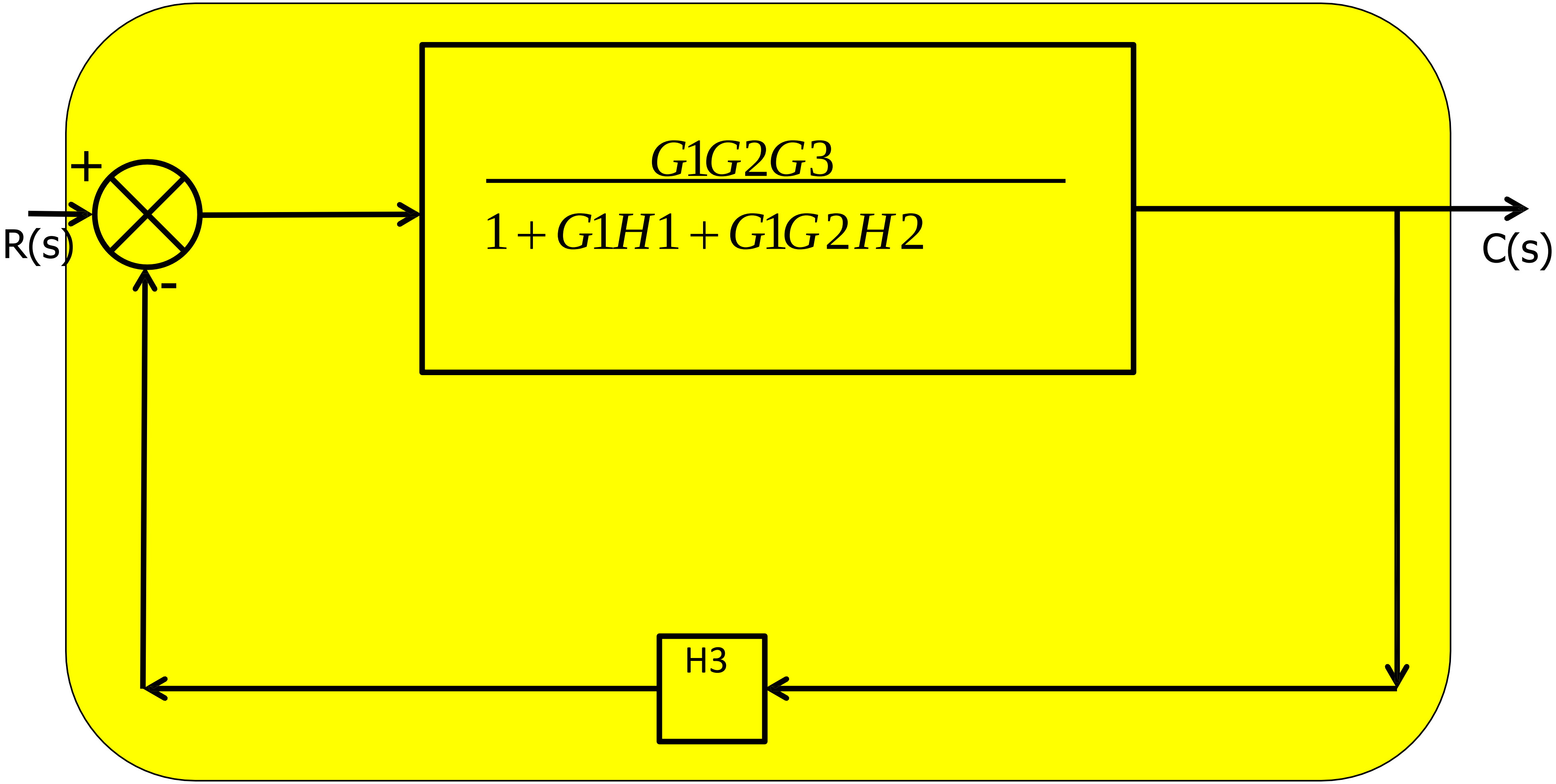
Example 5 cont....

Apply rule 1 Blocks in series



Example 5 cont….

Apply rule 3 Elimination of feedback loop



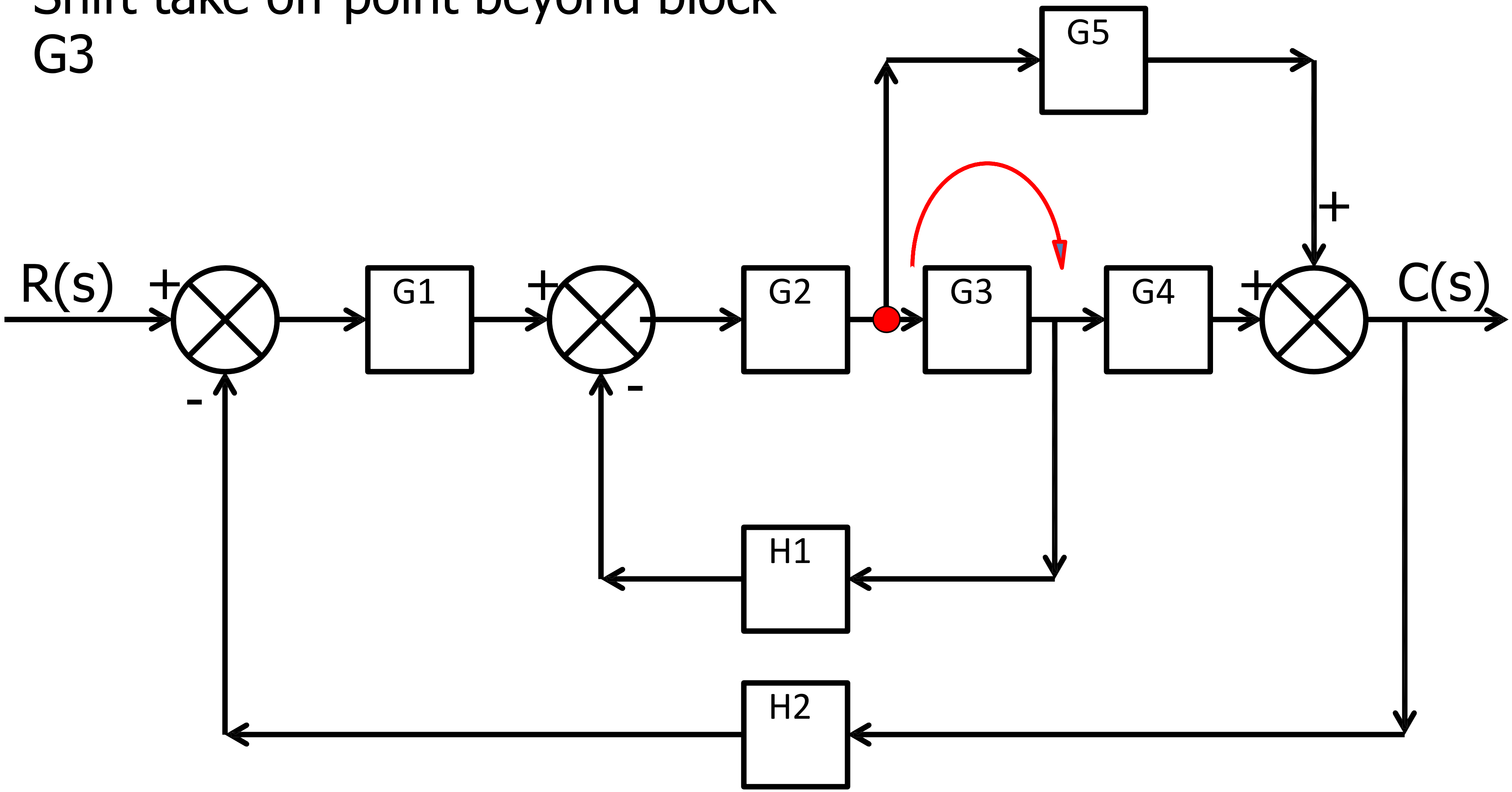
Example 5 cont....

Example 5 cont....

$$\frac{C(s)}{R(s)} = \frac{G1G2G3}{1 + G1H1 + G1G2H2 + G1G2G3H3}$$

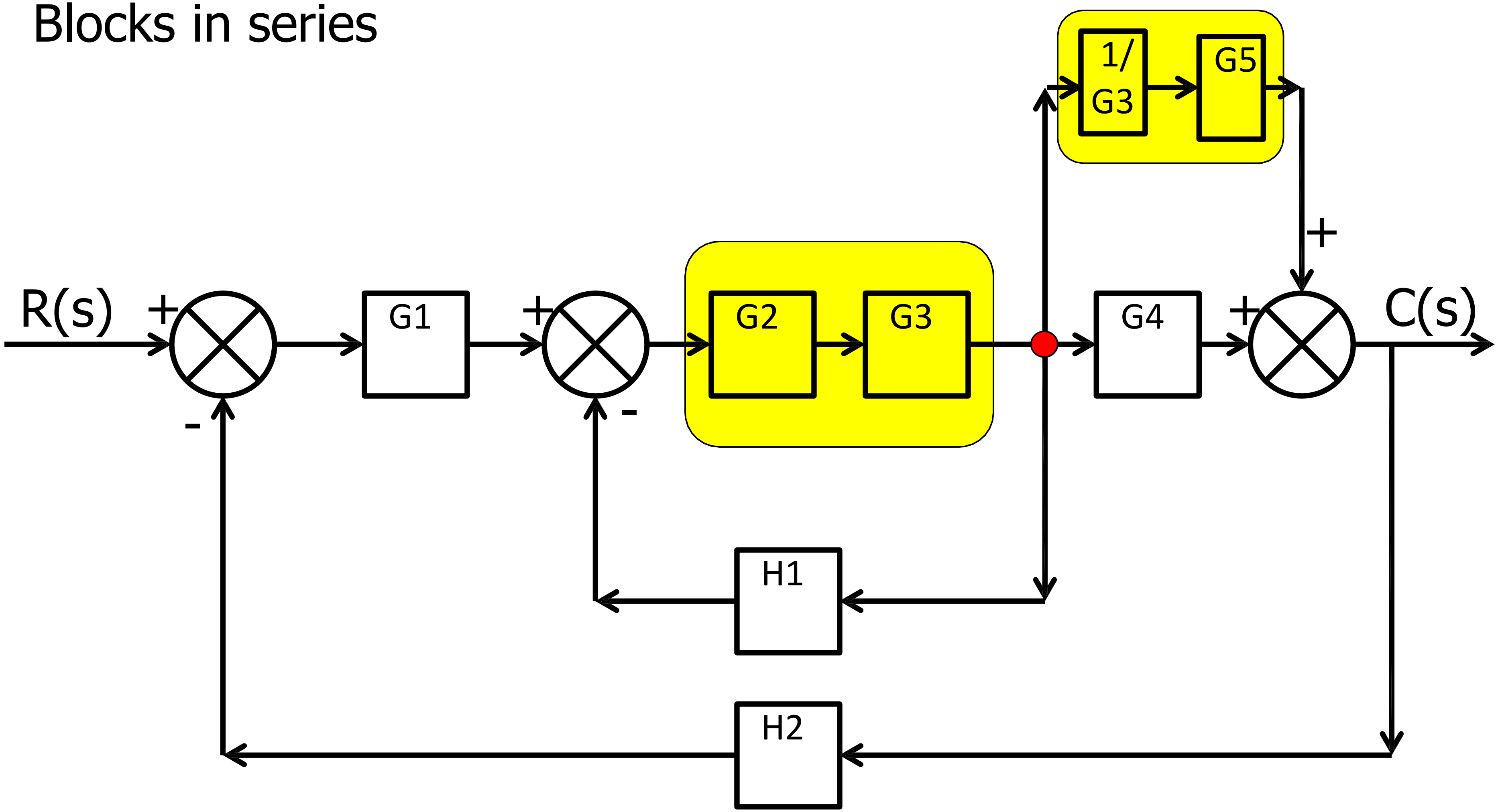
Example 6

Apply rule 8
Shift take off point beyond block G3



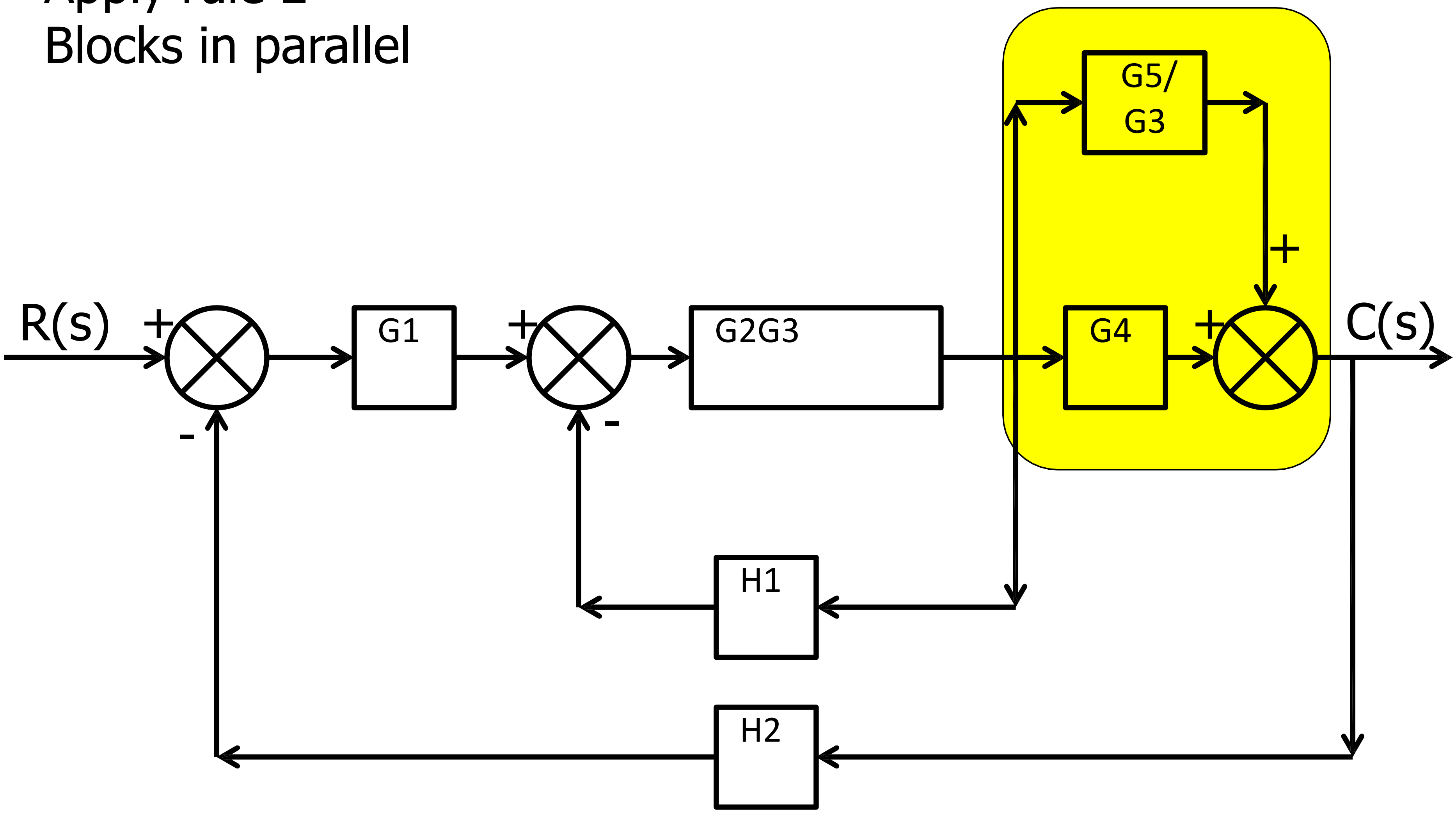
Example 6 cont….

Apply rule 1
Blocks in series



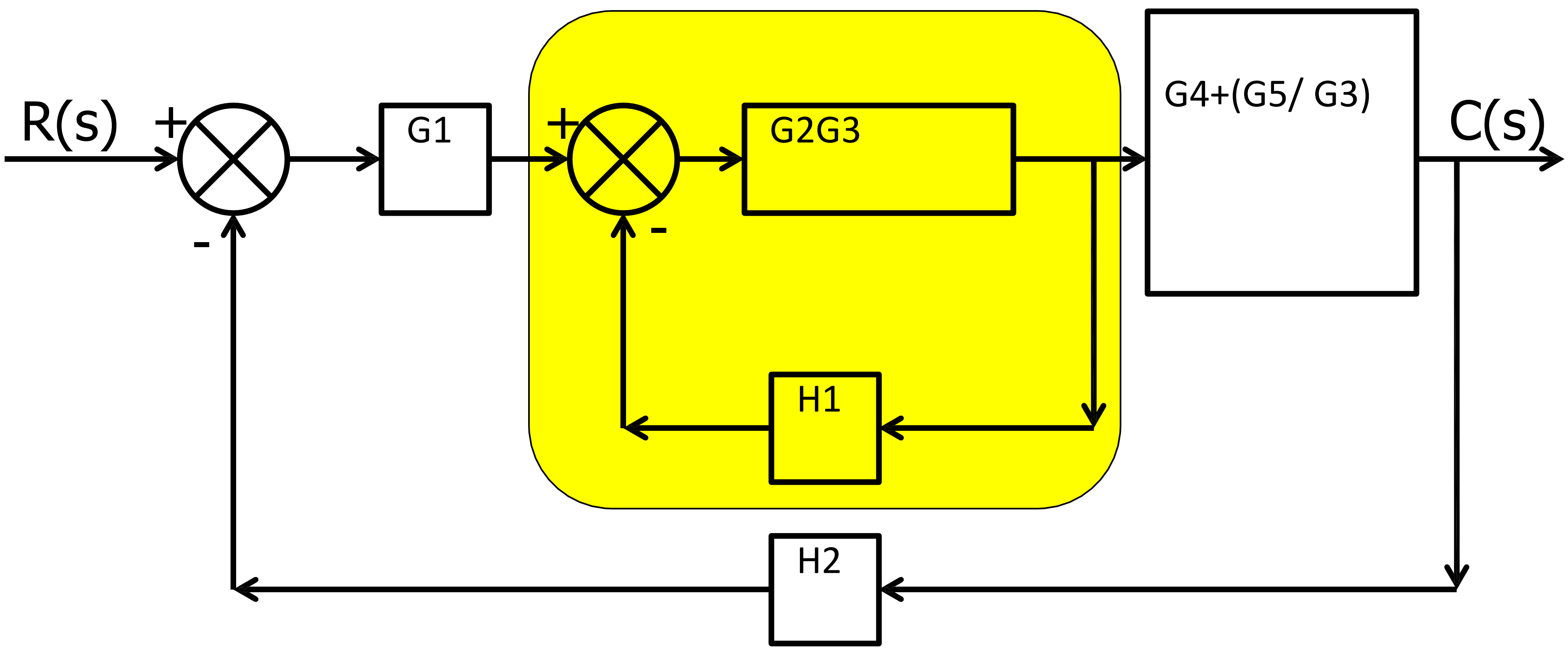
Example 6 cont….

Apply rule 2
Blocks in parallel



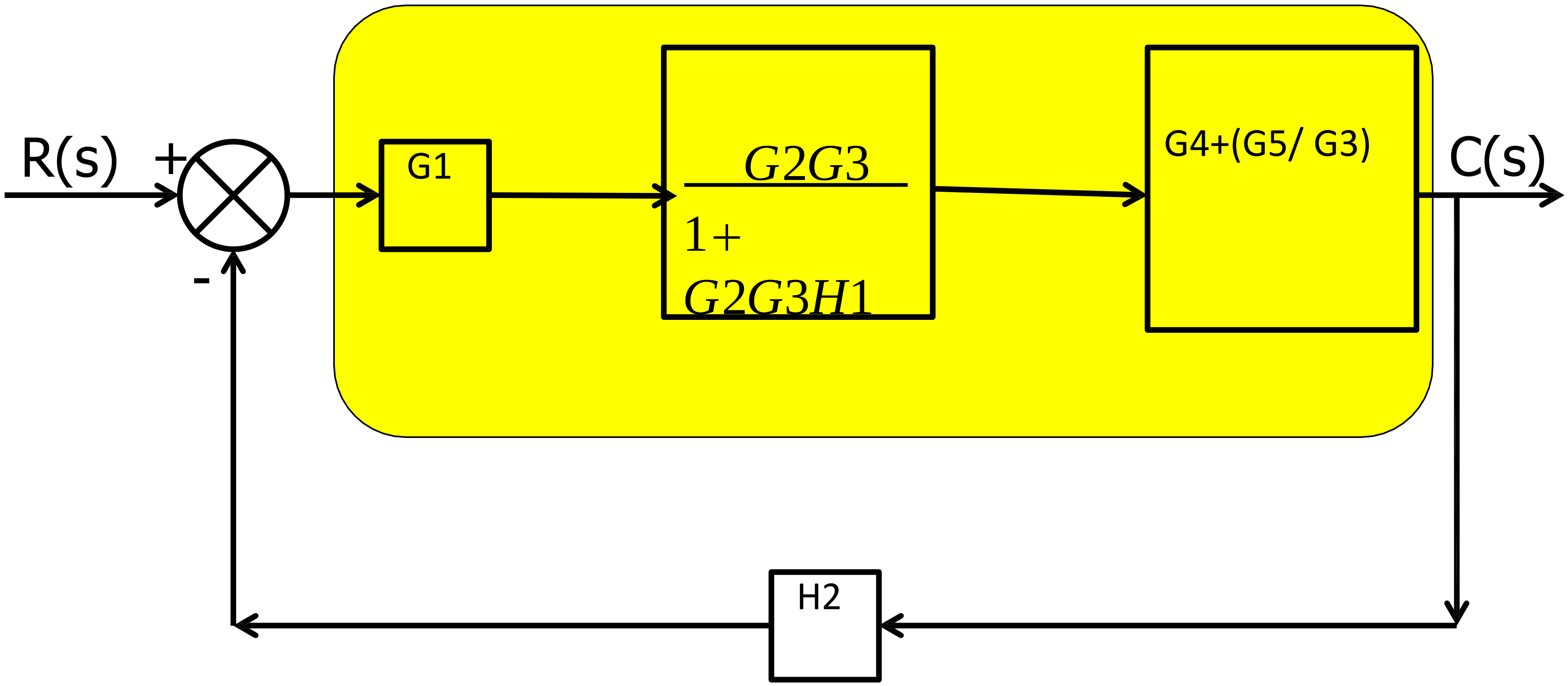
Example 6 cont....

Apply rule 3
Feedback loop

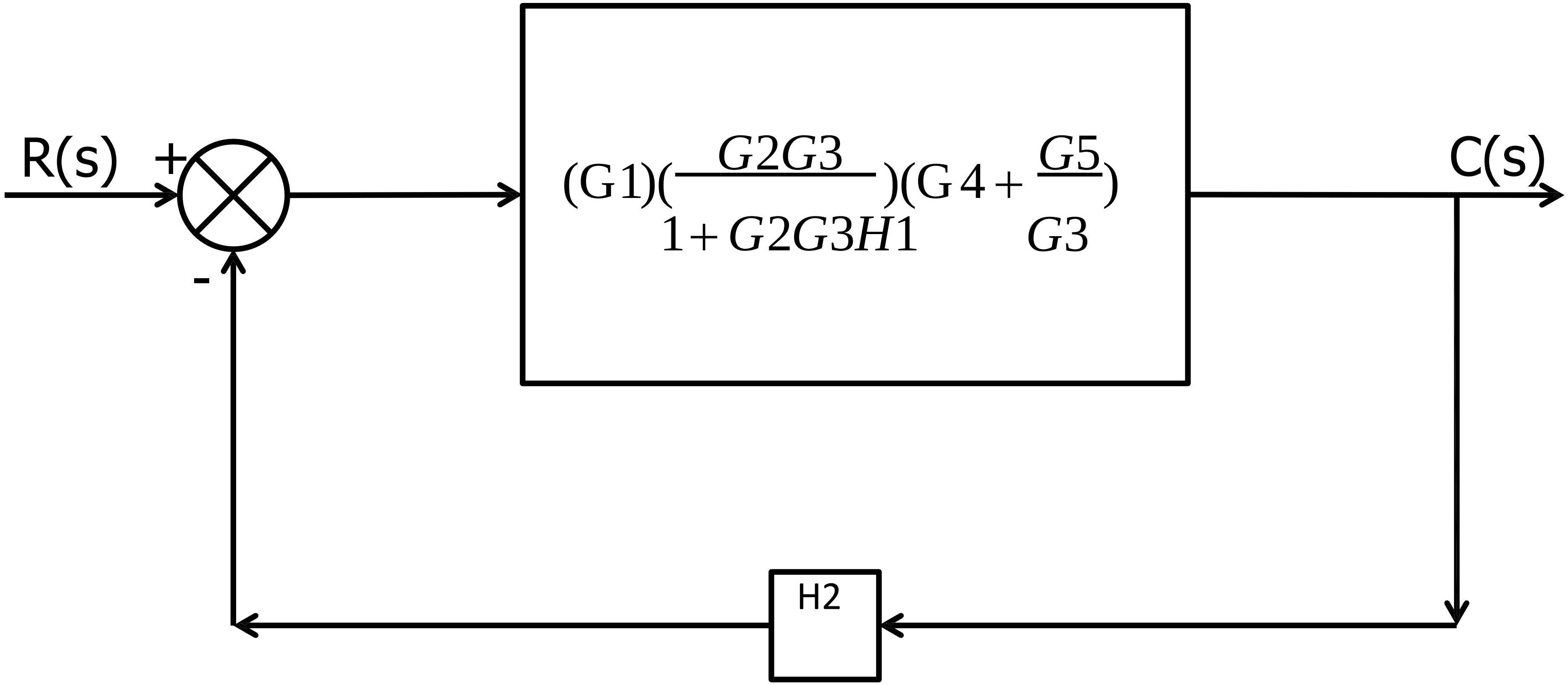


Example 6 cont….

Apply rule 1
Blocks in series

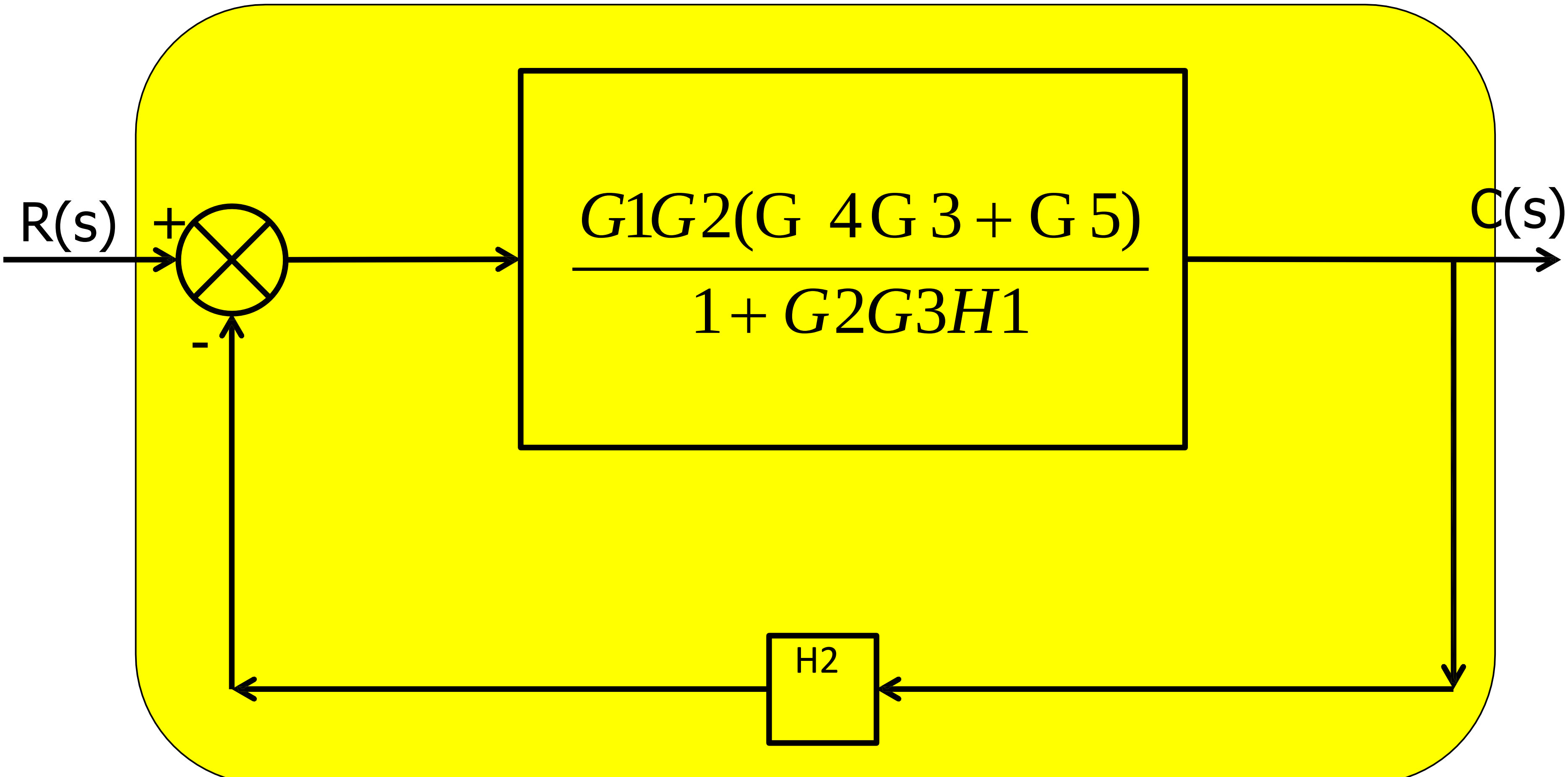


Example 6 cont....



Example 6 cont….

Apply rule 3 Feedback loop



Example 6 cont….

R(s)

$$\frac{G1G2(G4G3+G5)}{1+G2G3H1+G1G2H2(G3G4+G5)}$$

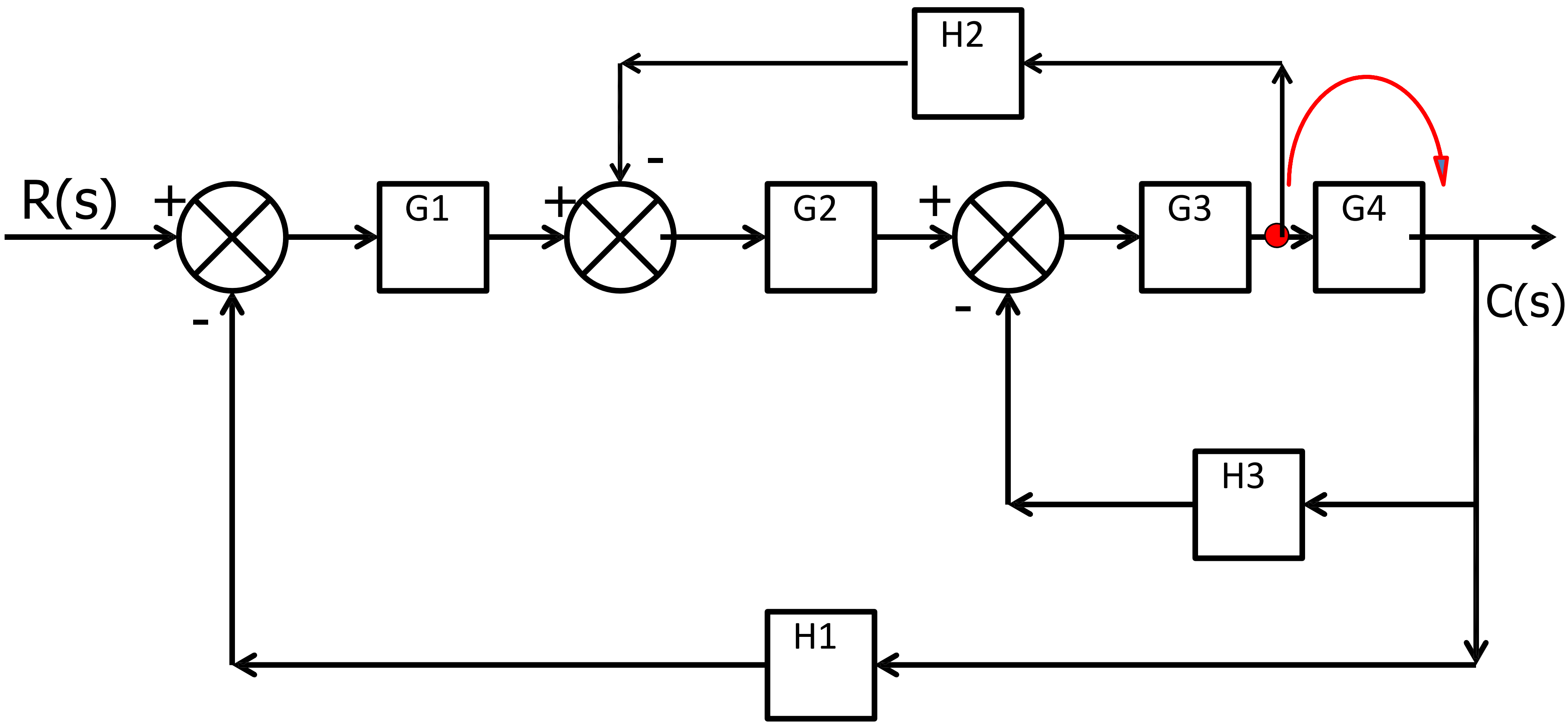
C(s)

Example 6 cont….

$$\frac{C(S)}{R(S)} = \frac{G1G2(G4G3+G5)}{1+G2G3H1+G1G2H2(G3G4+G5)}$$

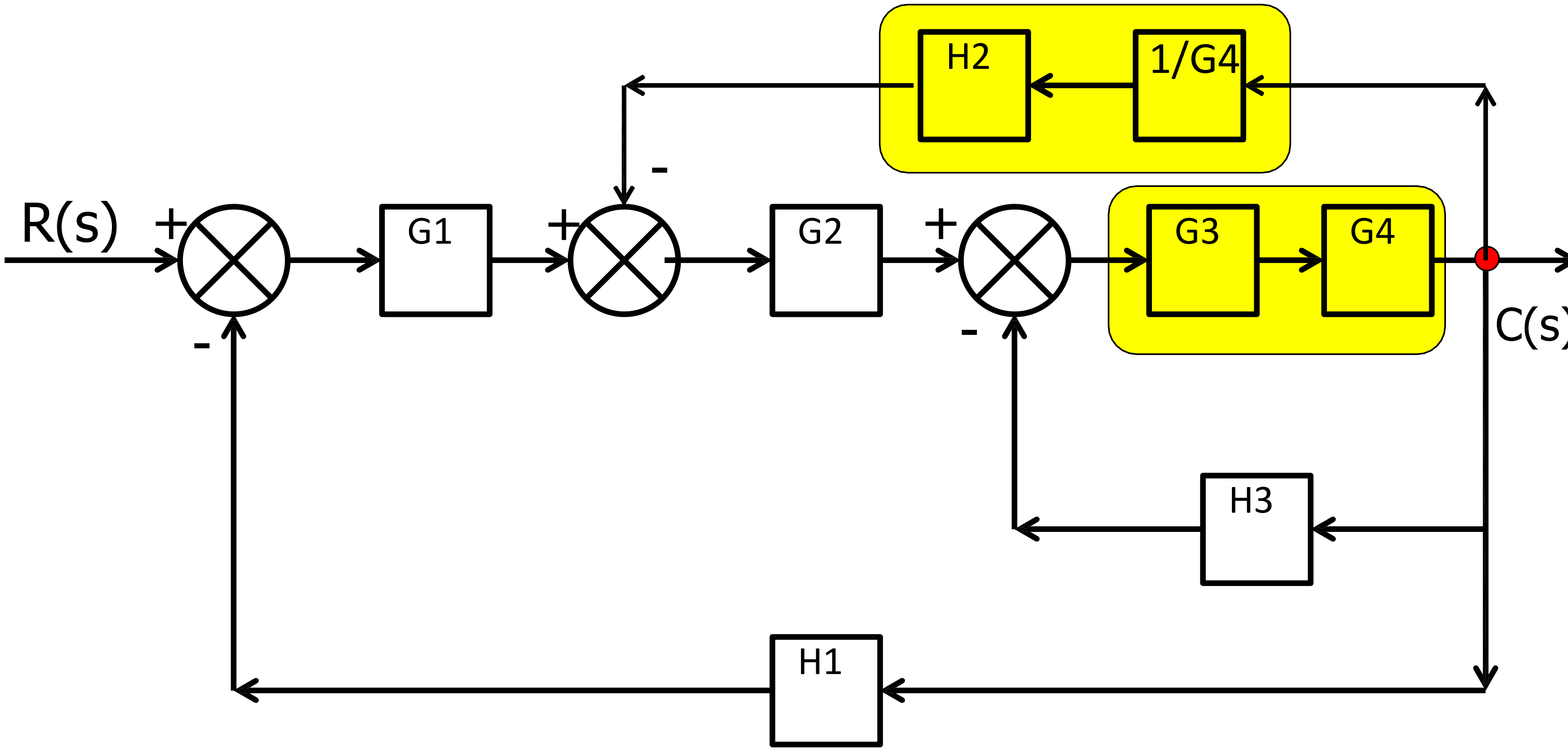
Example 7

Apply rule 8 Shift take off point after block G4



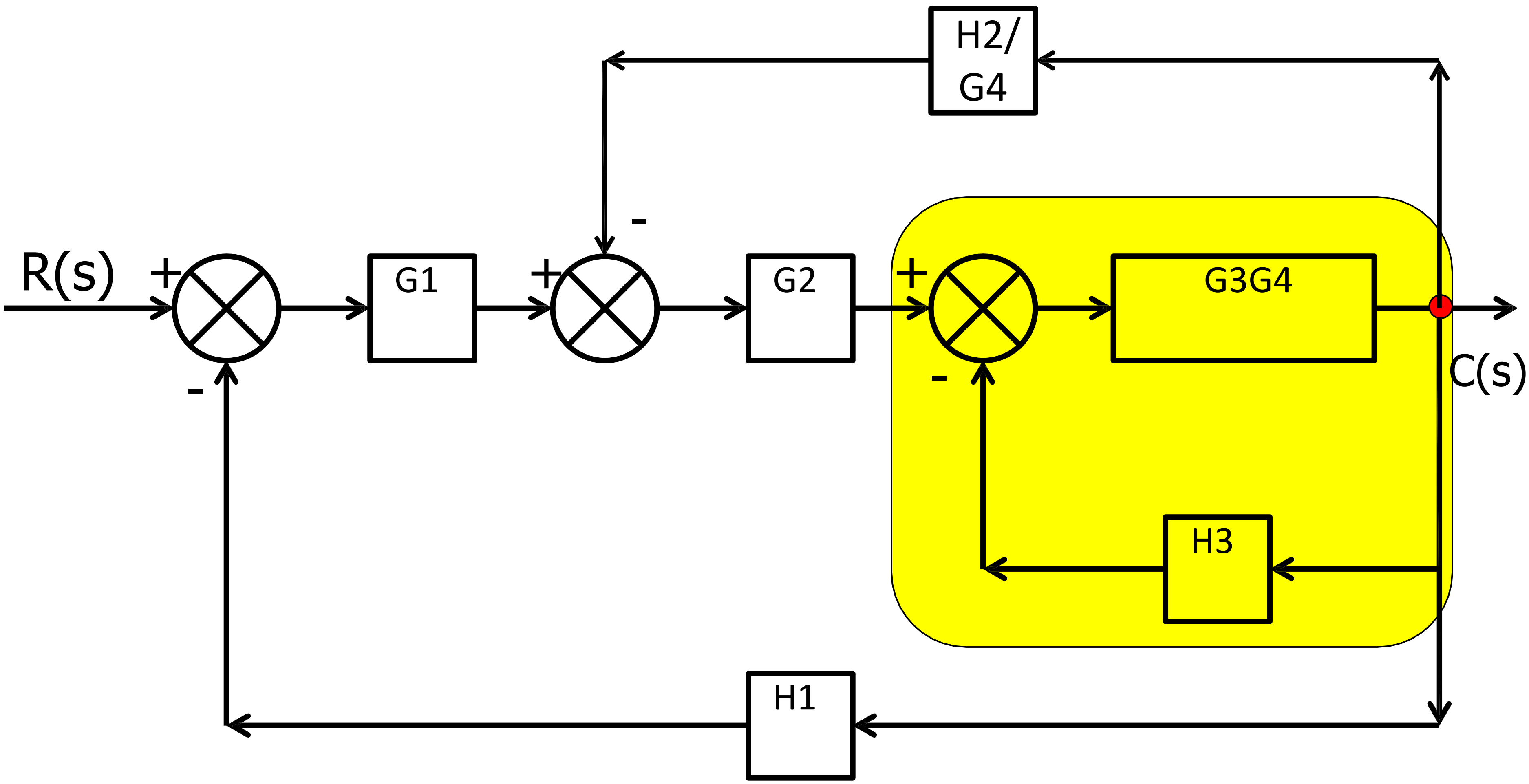
Example 7 cont….

Apply rule 1 Blocks in series



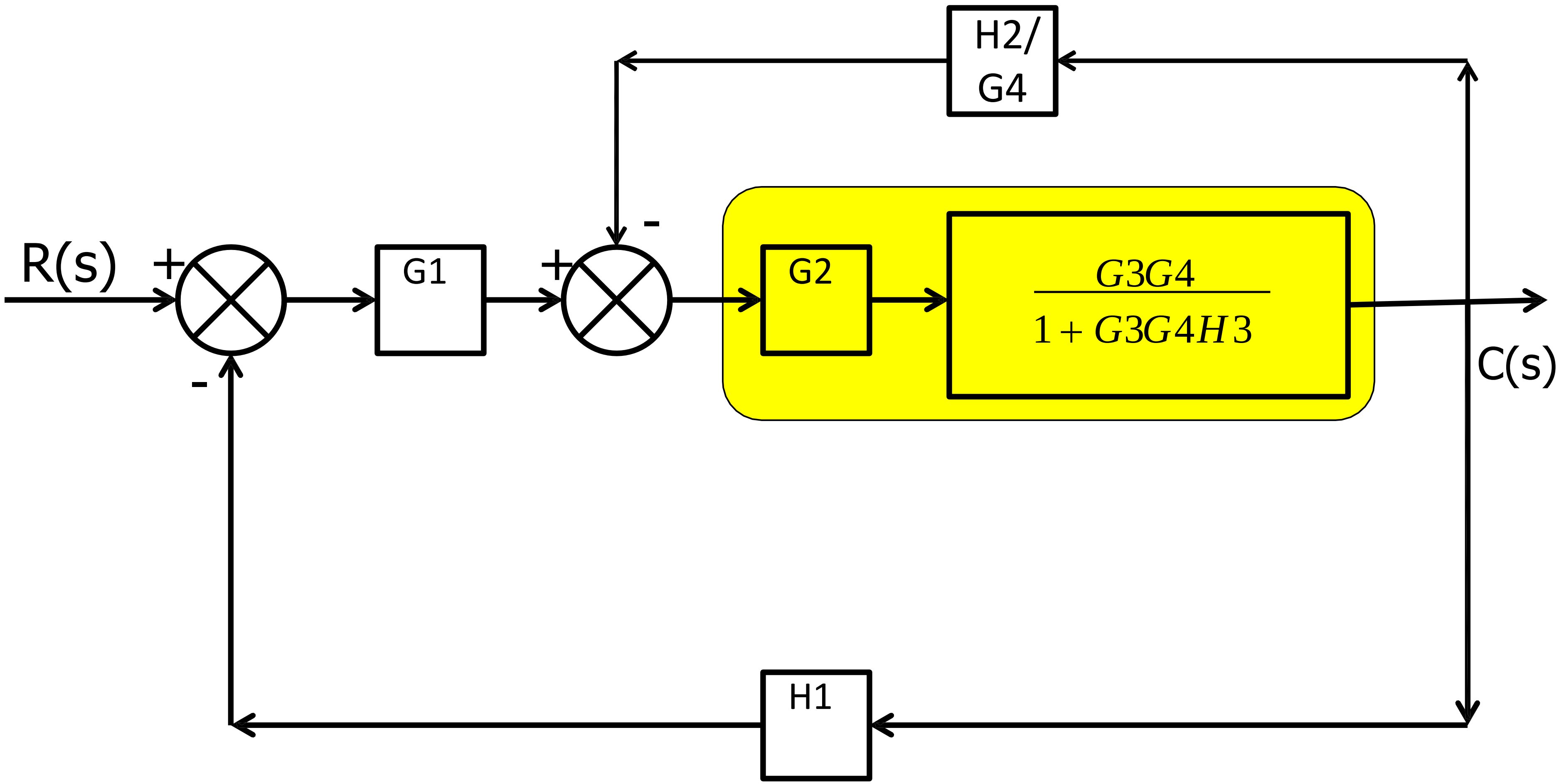
Example 7 cont….

Apply rule 3 Feedback loop



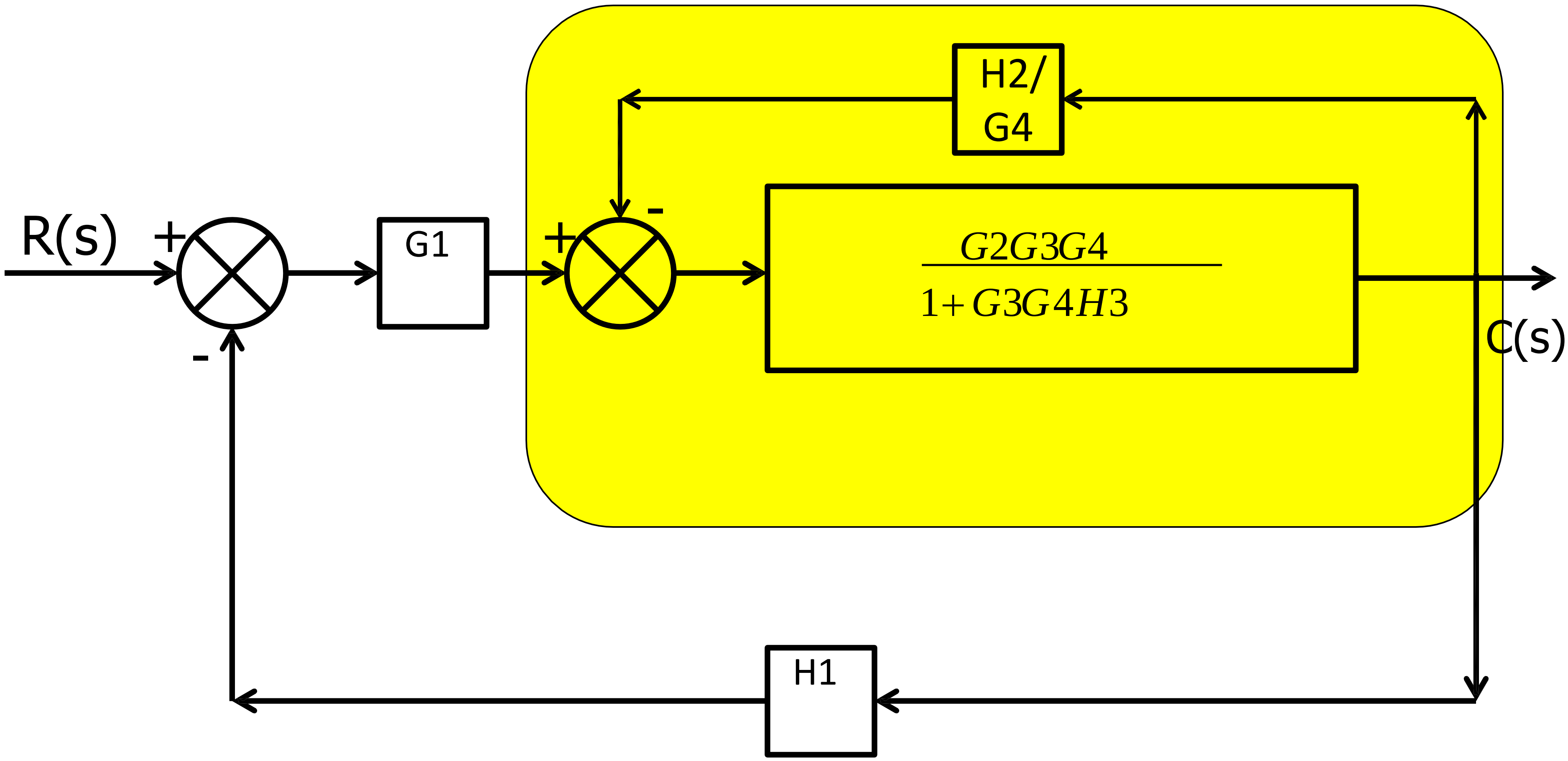
Example 7 cont….

Apply rule 1 Blocks in series



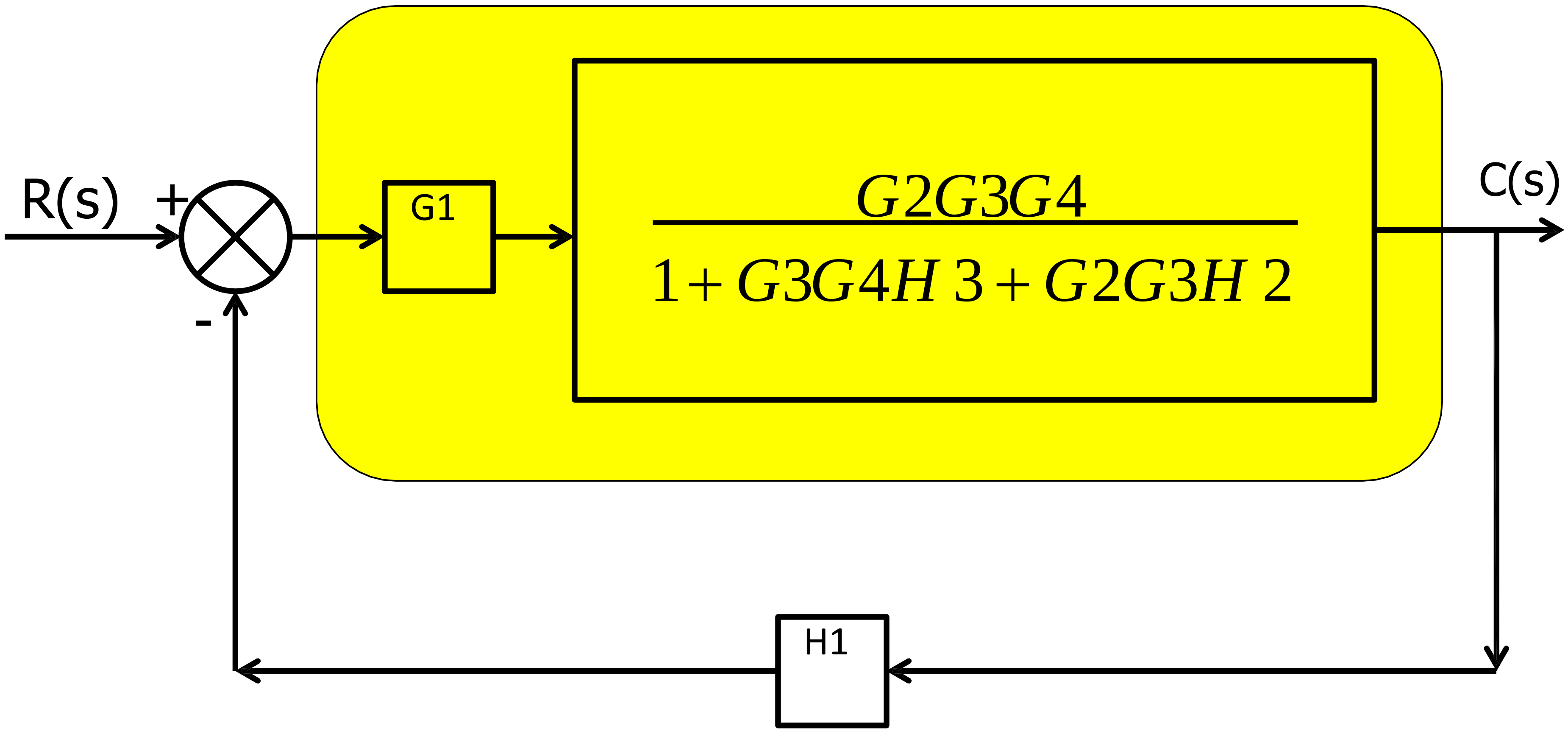
Example 7 cont….

Apply rule 3 Feedback loop



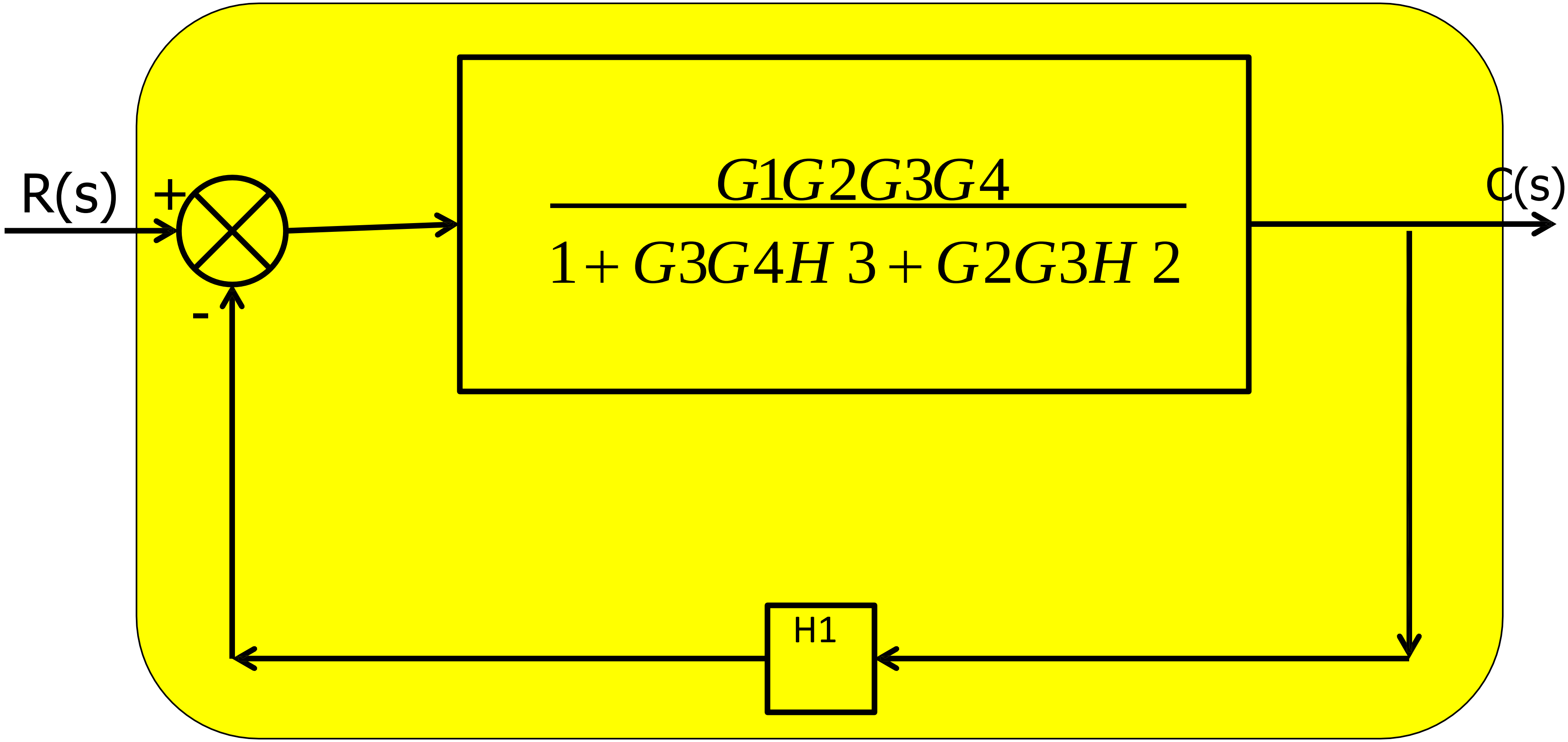
Example 7 cont….

Apply rule 1 Blocks in series



Example 7 cont….

Apply rule 3 Feedback loop



Example 7 cont….

R(s)

$$\frac{G1G2G3G4}{1 + G3G4H3 + G2G3H2 + G1G2G3G4H1}$$

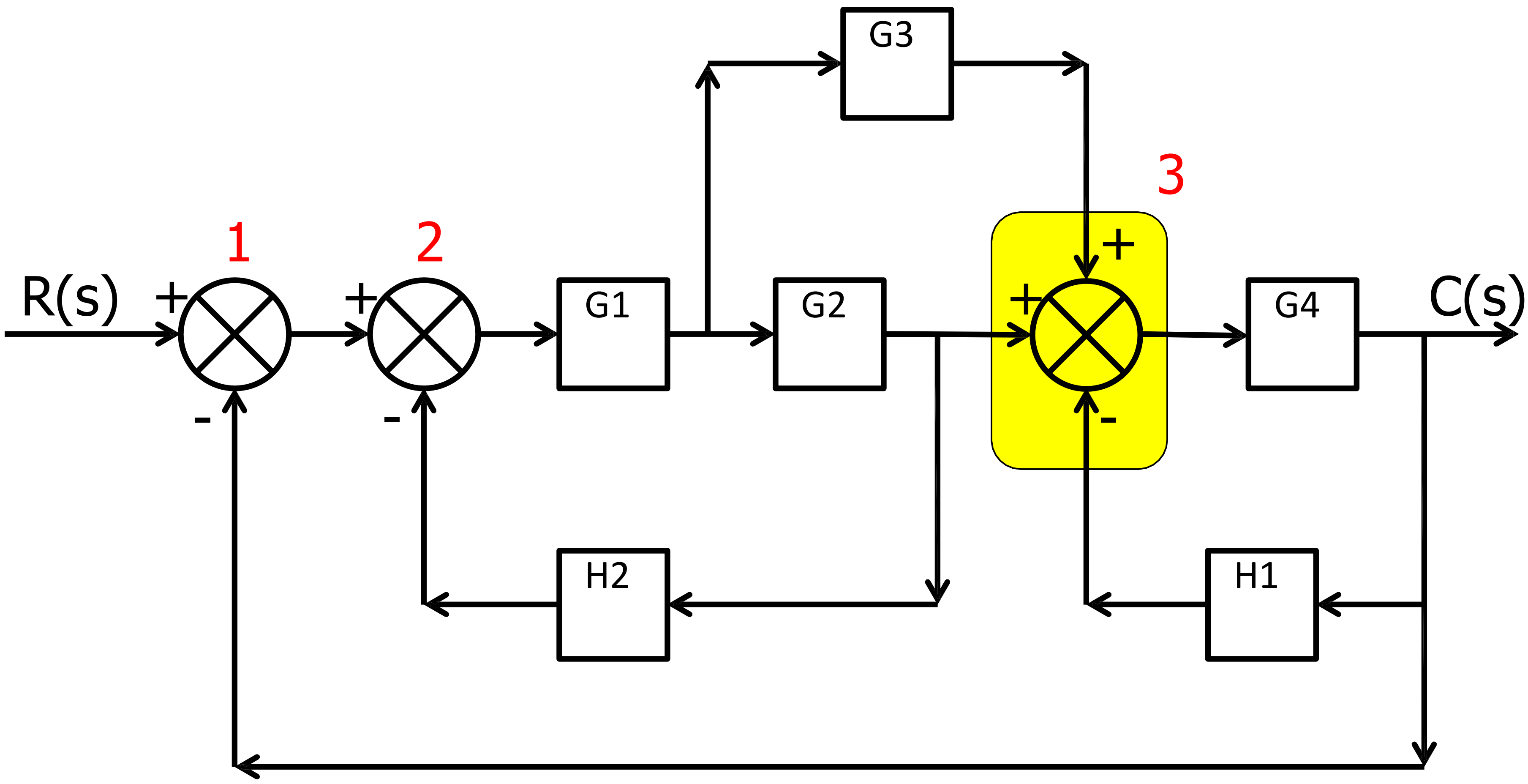
C(s)

Example 7 cont....

$$\frac{C(S)}{R(S)} = \frac{G1G2G3G4}{1 + G3G4H3 + G2G3H2 + G1G2G3G4H1}$$

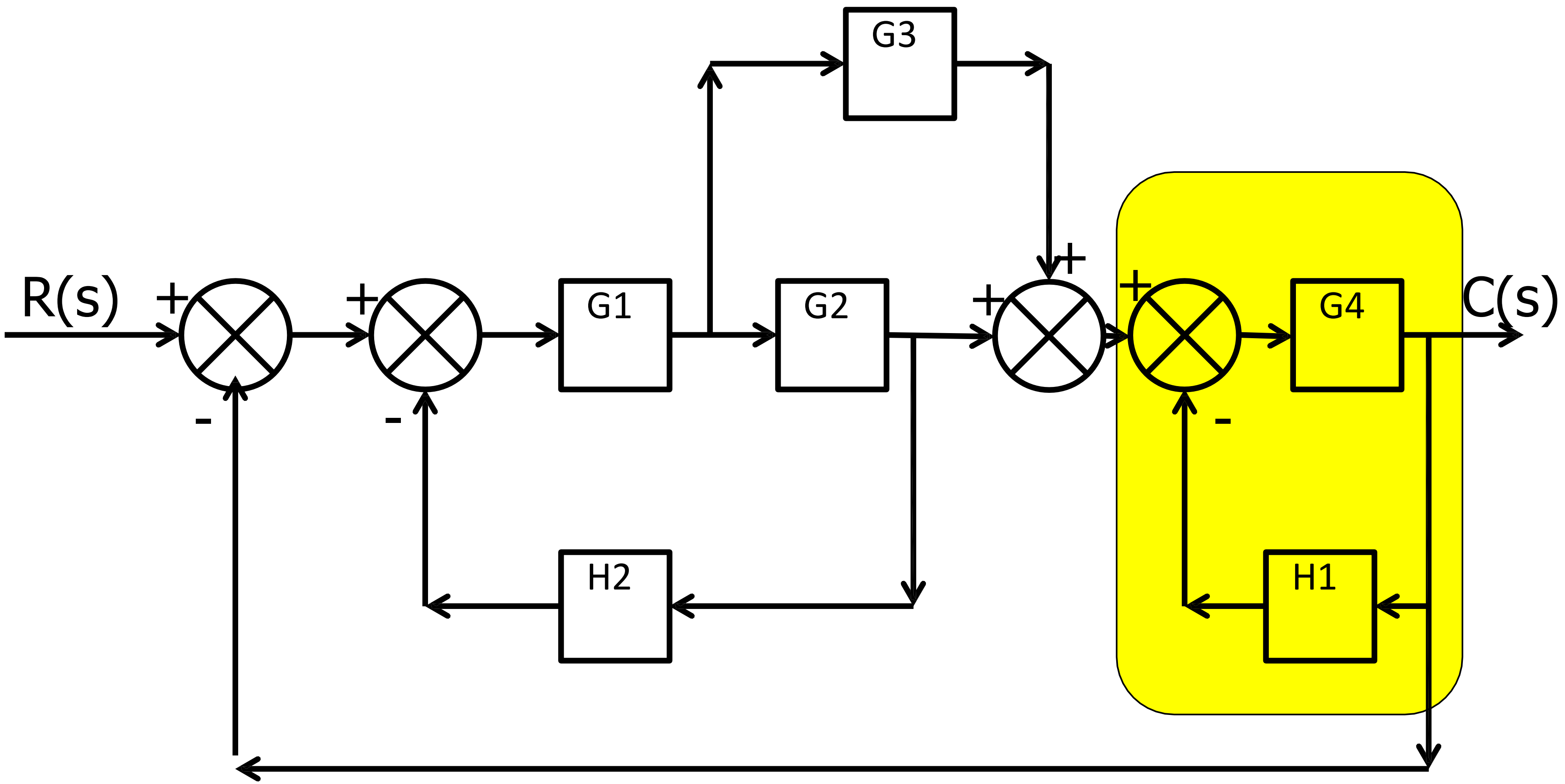
Example 8

Simplify, by splitting 3rd summing point as given in Note 1



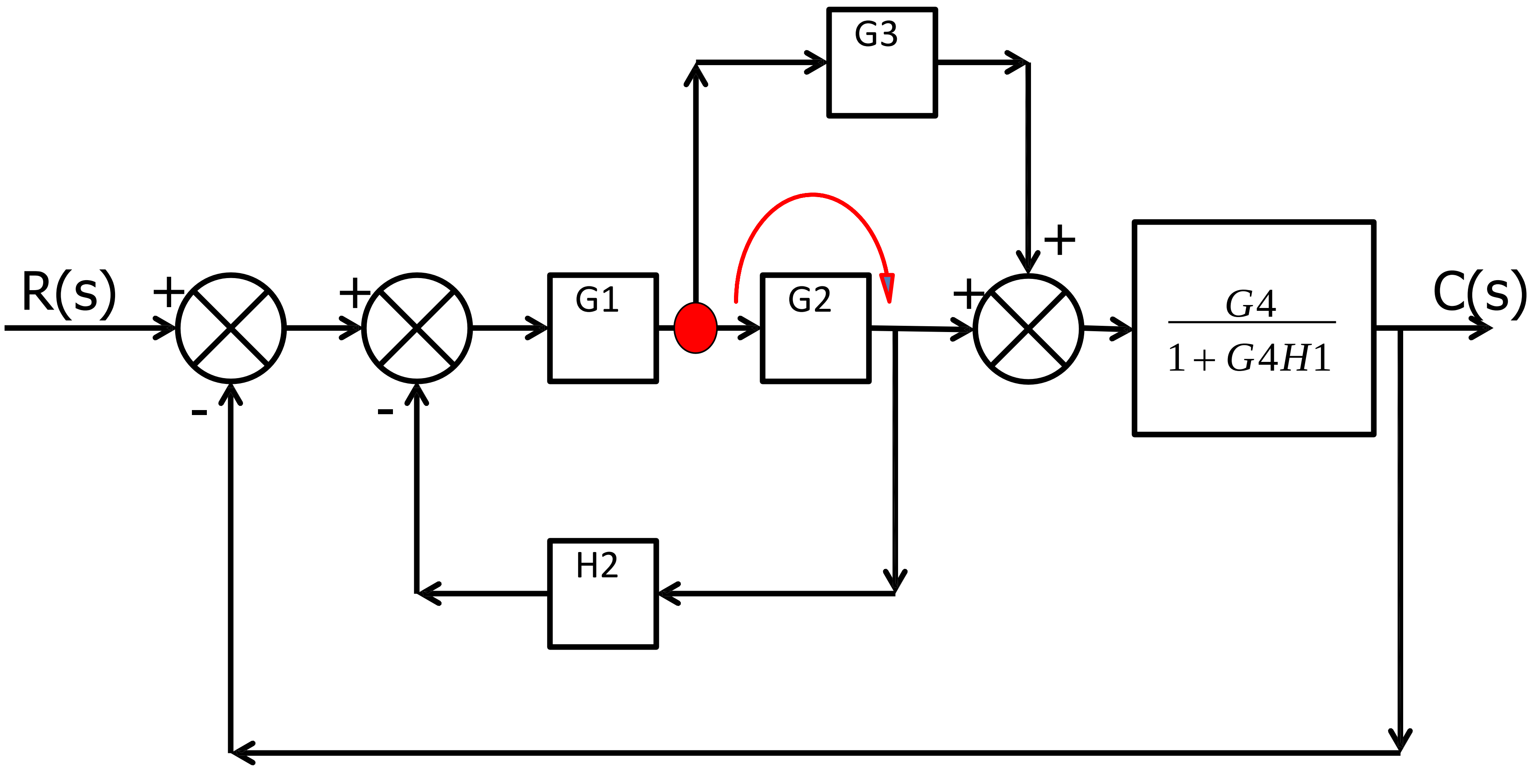
Example 8 cont….

Apply Rule 3 Elimination of Feedback loop



Example 8 cont….

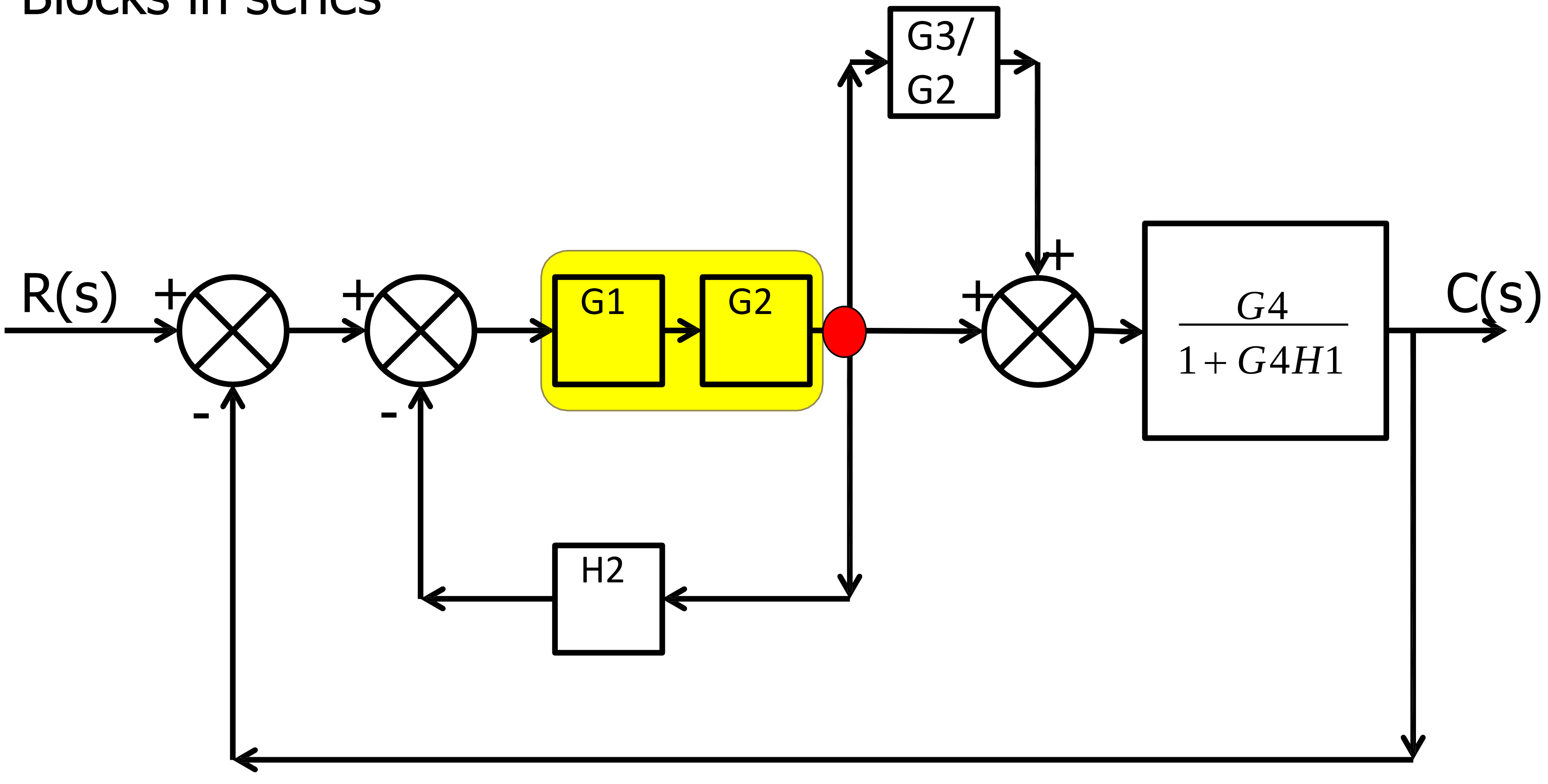
Apply Rule 8 Shift take off point after block



Example 8 cont….

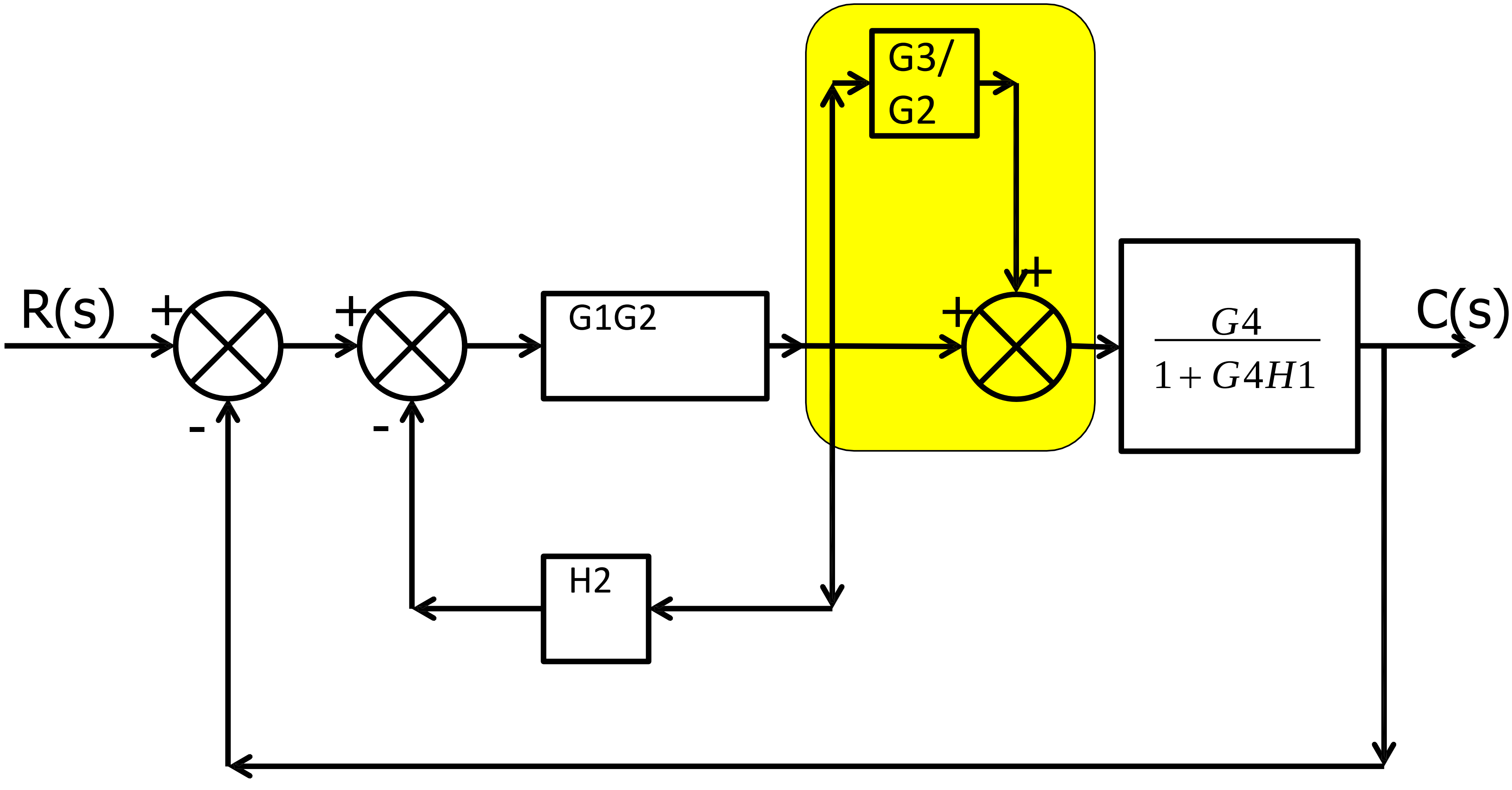
Apply Rule 1

Blocks in series



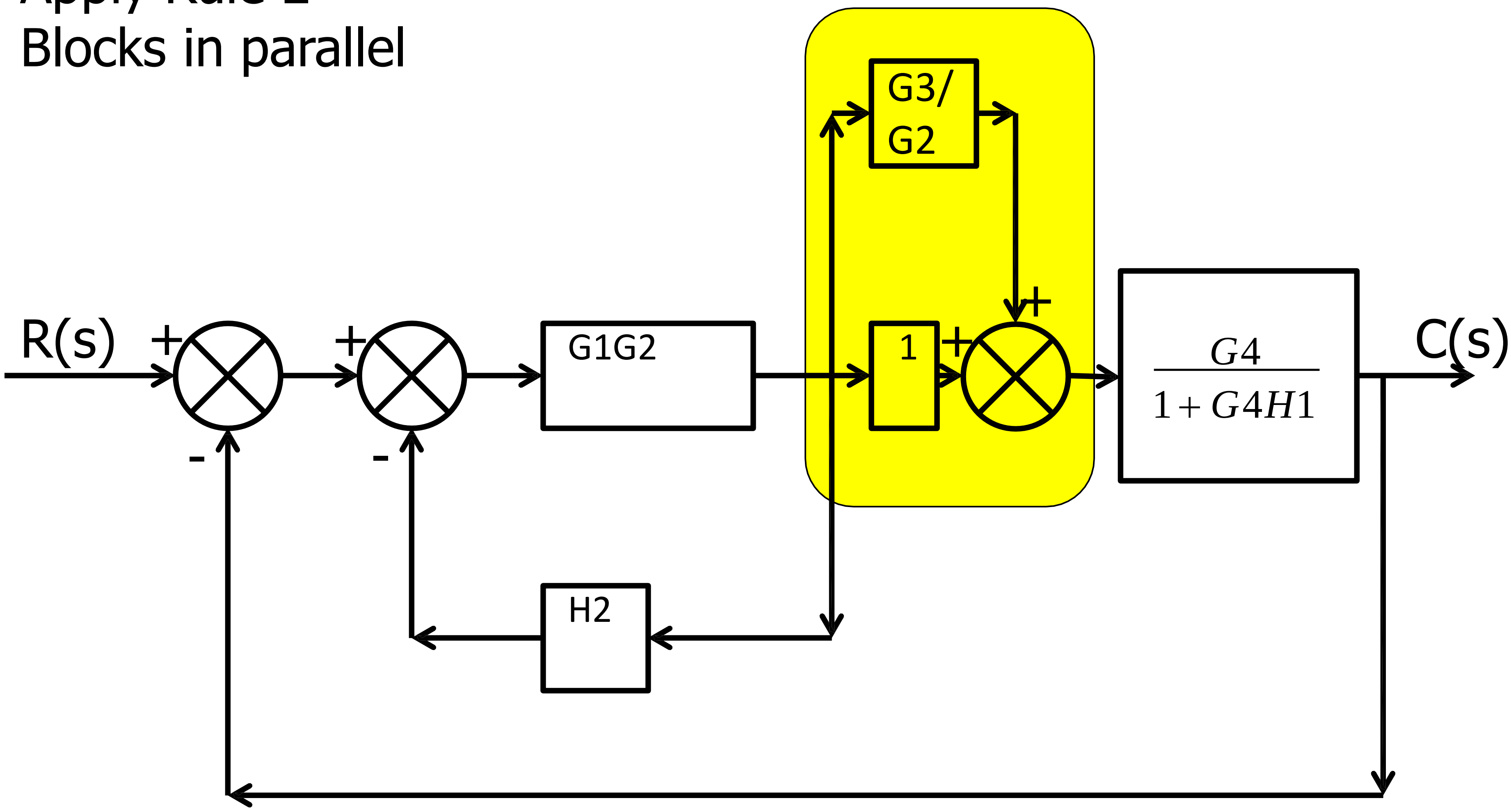
Example 8 cont….

Now which rule we have to use?



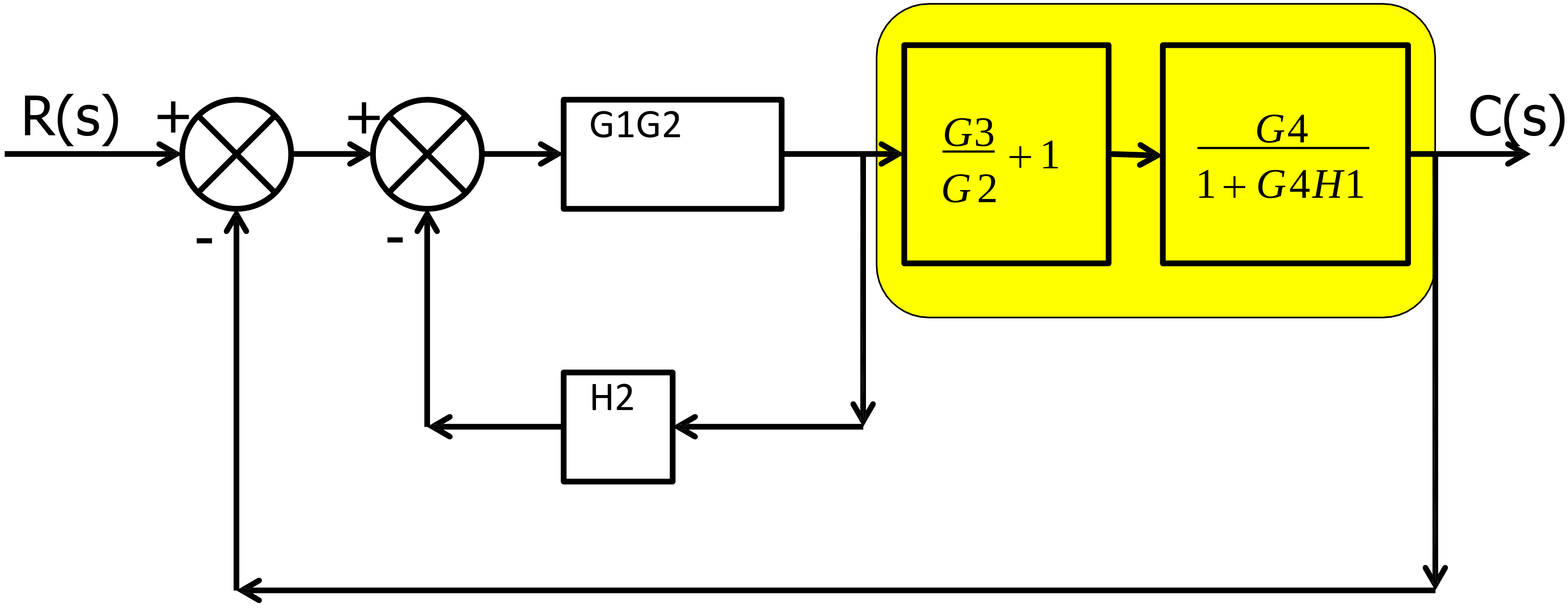
Example 8 cont….

Apply Rule 2
Blocks in parallel



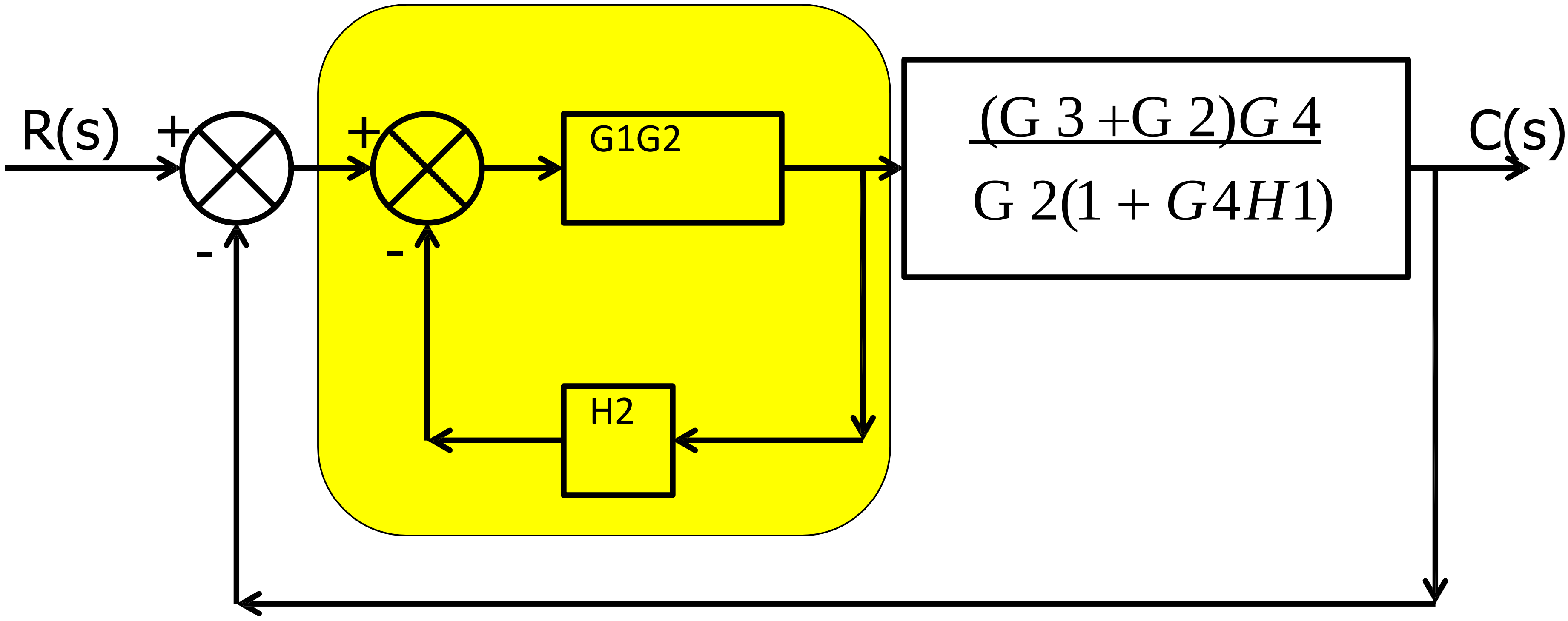
Example 8 cont….

Apply Rule 1 Blocks in series



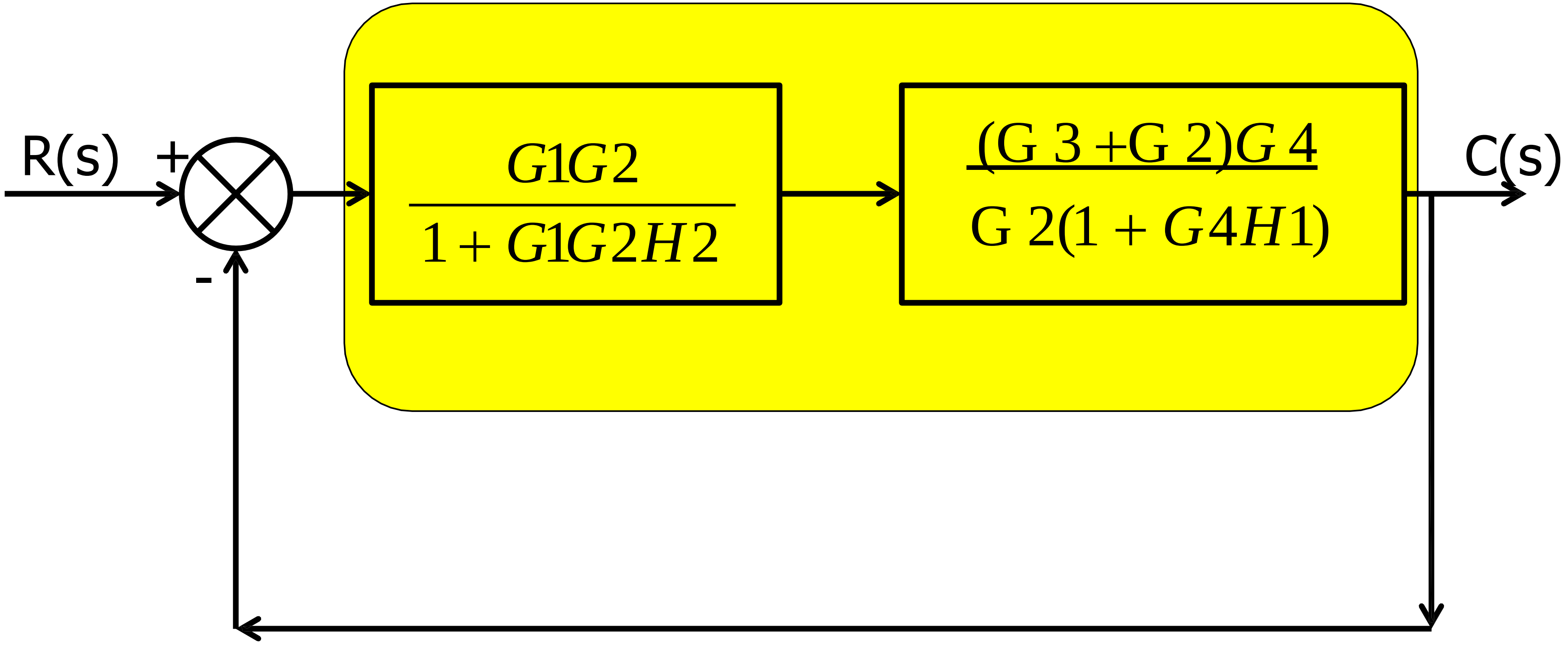
Example 8 cont….

Apply Rule 3 Elimination of Feedback Loop



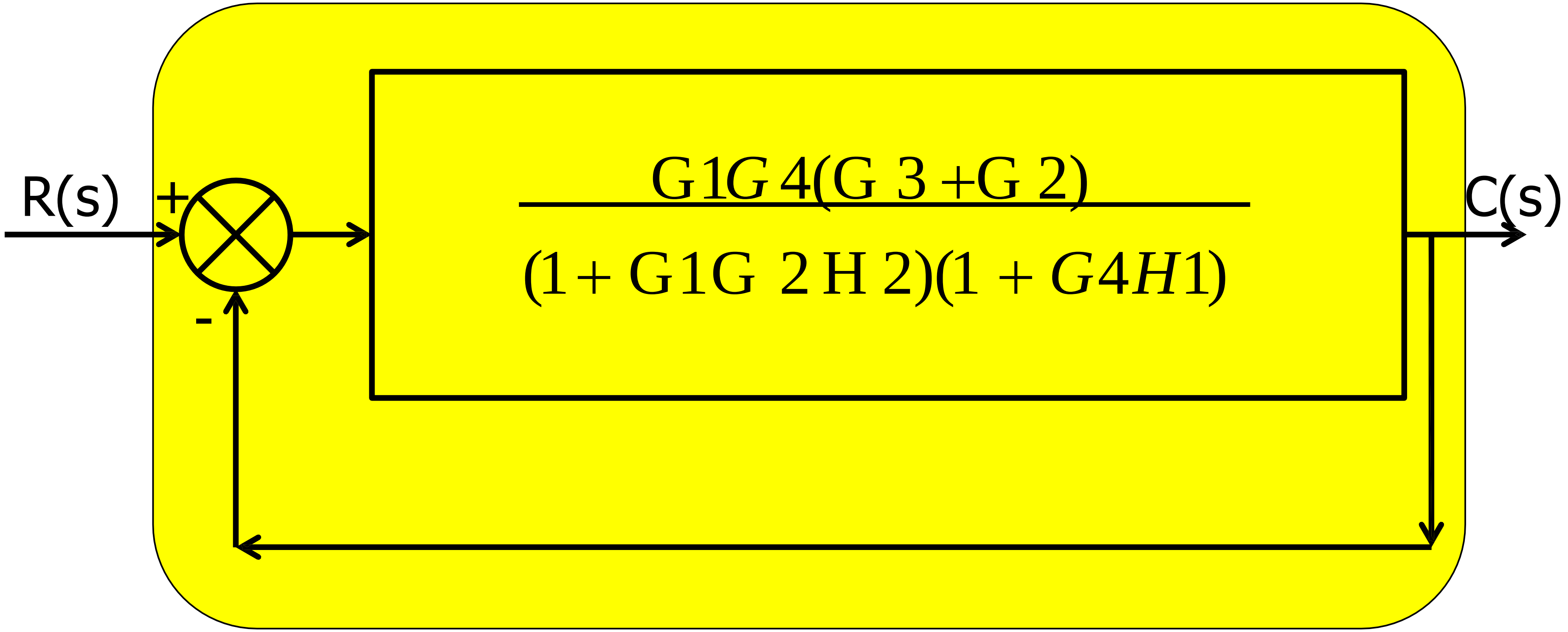
Example 8 cont….

Apply Rule 1 Blocks in series



Example 8 cont….

Apply Rule 3 Elimination of Feedback loop



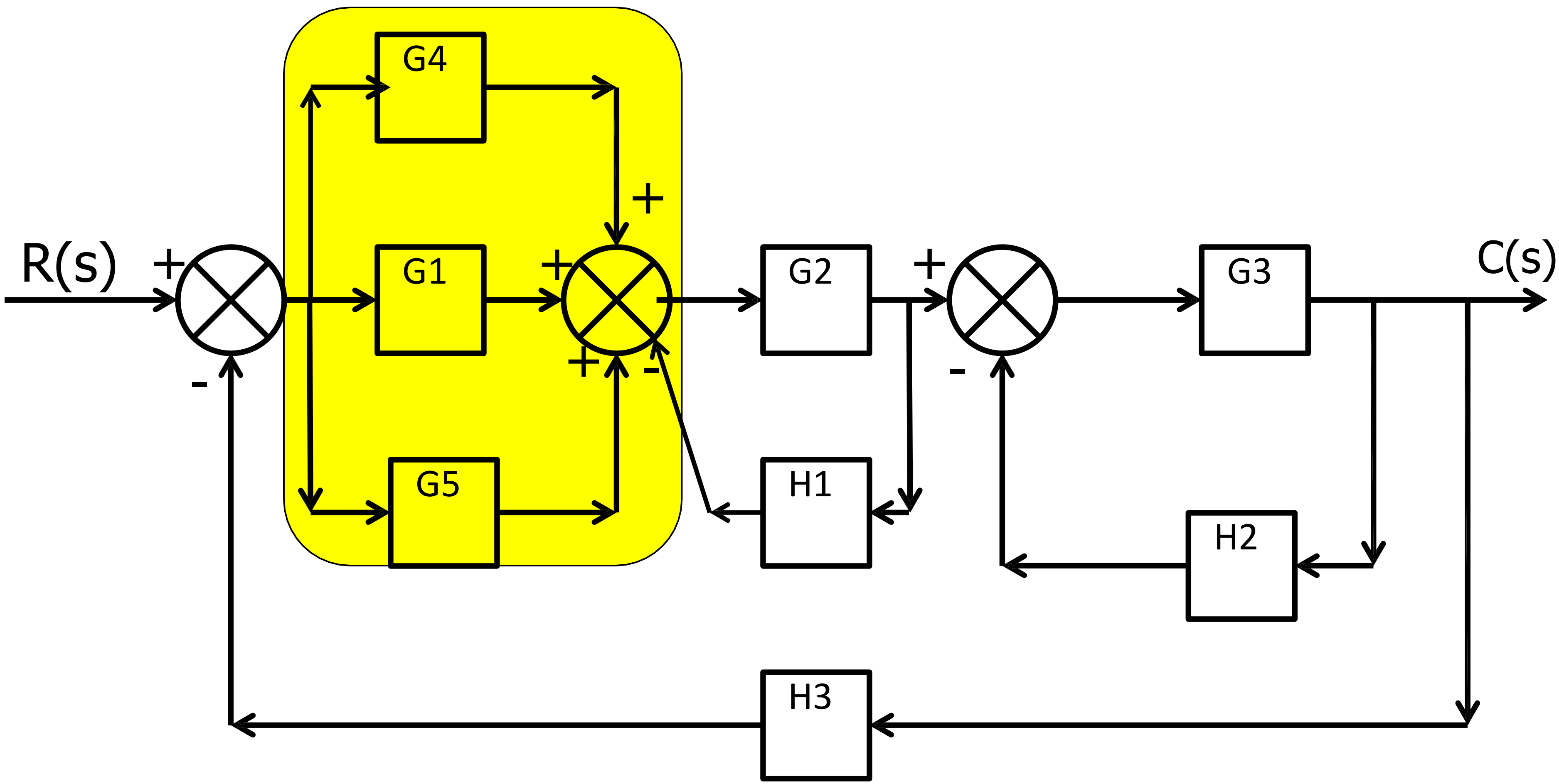
Example 8 cont….

R(s) → C(s)

$$\frac{G1G4(G3+G2)}{1+G4H1+G1G2H2+G1G2G4H1H2+G1G4(G2+G3)}$$

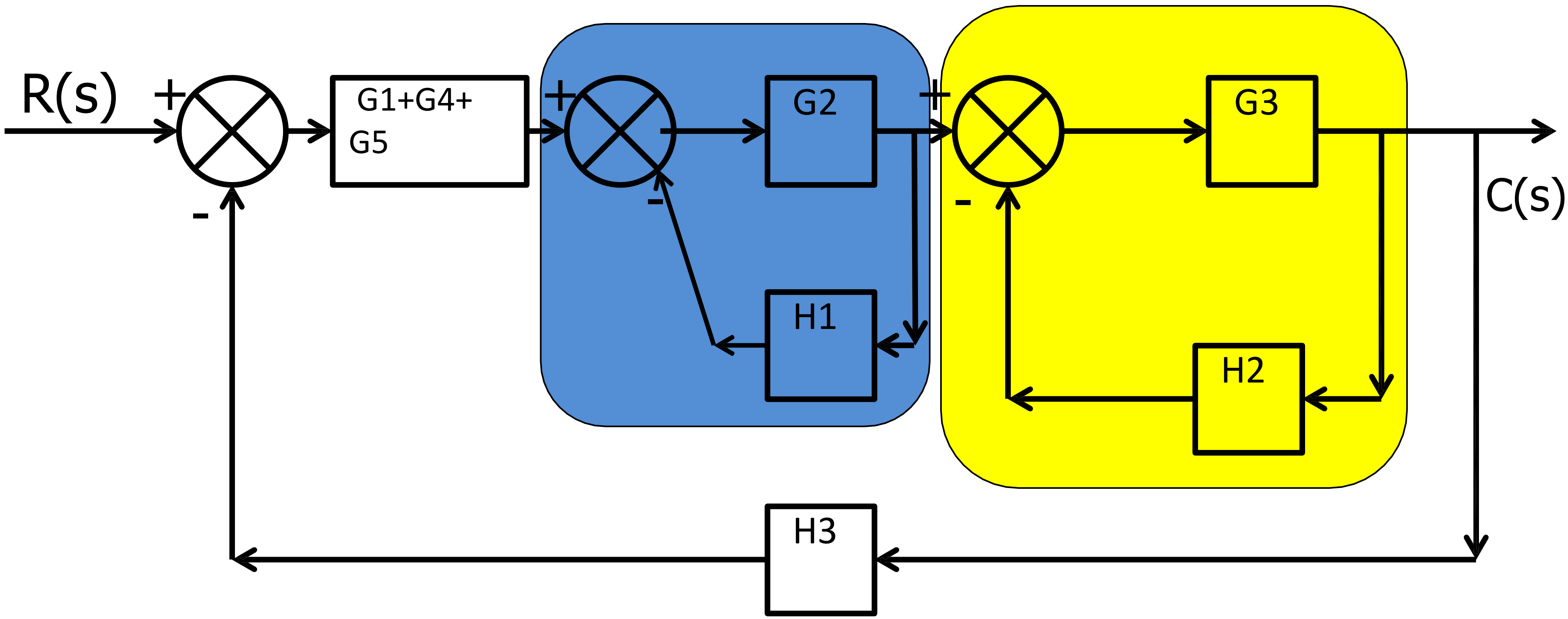
Example 9

Apply rule 2 Blocks in Parallel



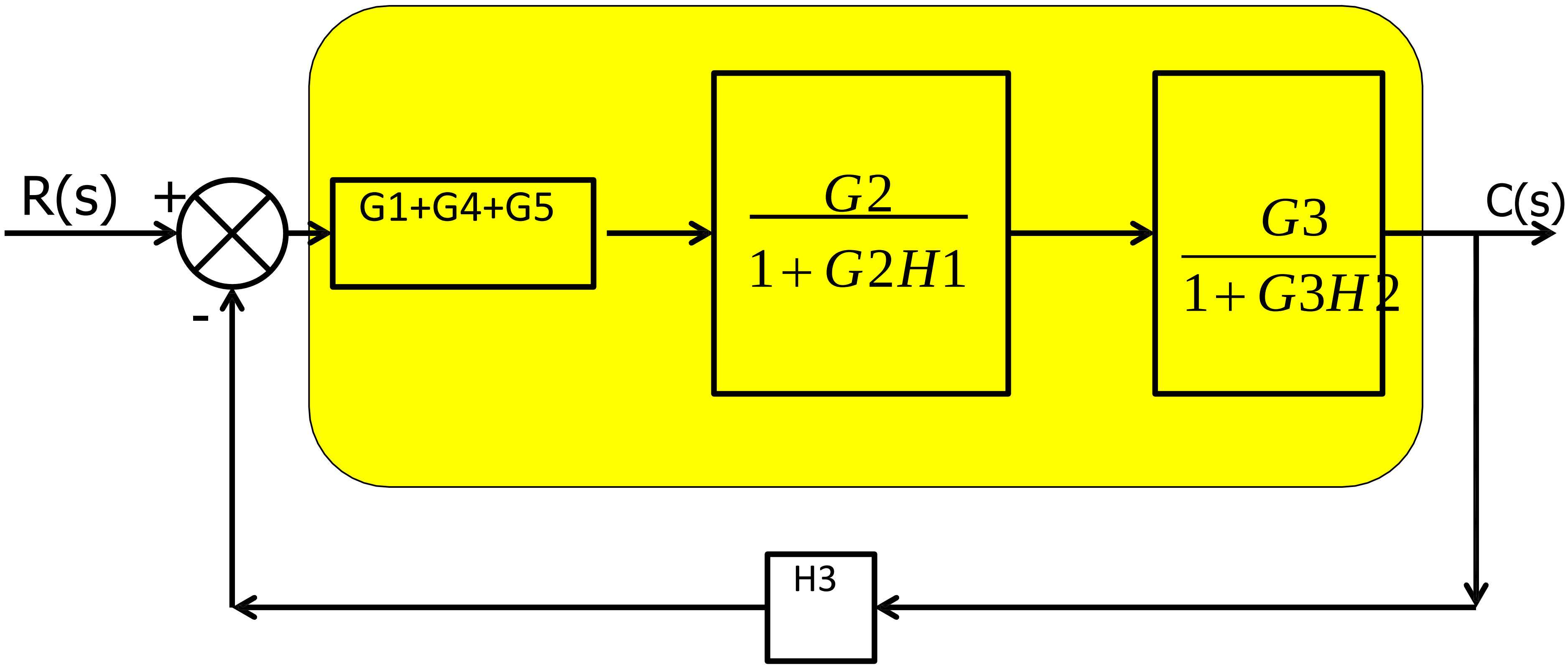
Example 9 cont....

Apply rule 3 Elimination of Feedback Loop



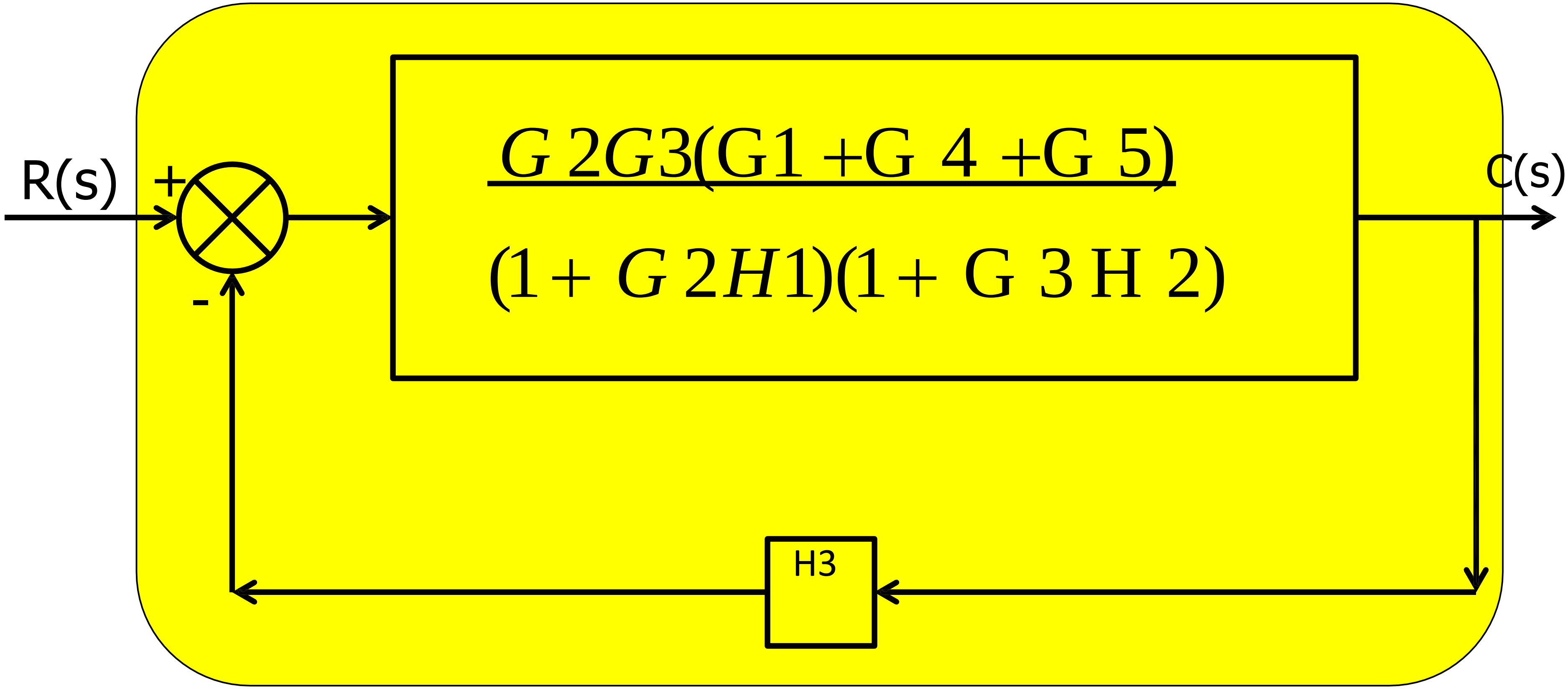
Example 9 cont....

Apply rule 1 Blocks in Series



Example 9 cont….

Apply rule 3 Elimination of Feedback loop



Example 9 cont….

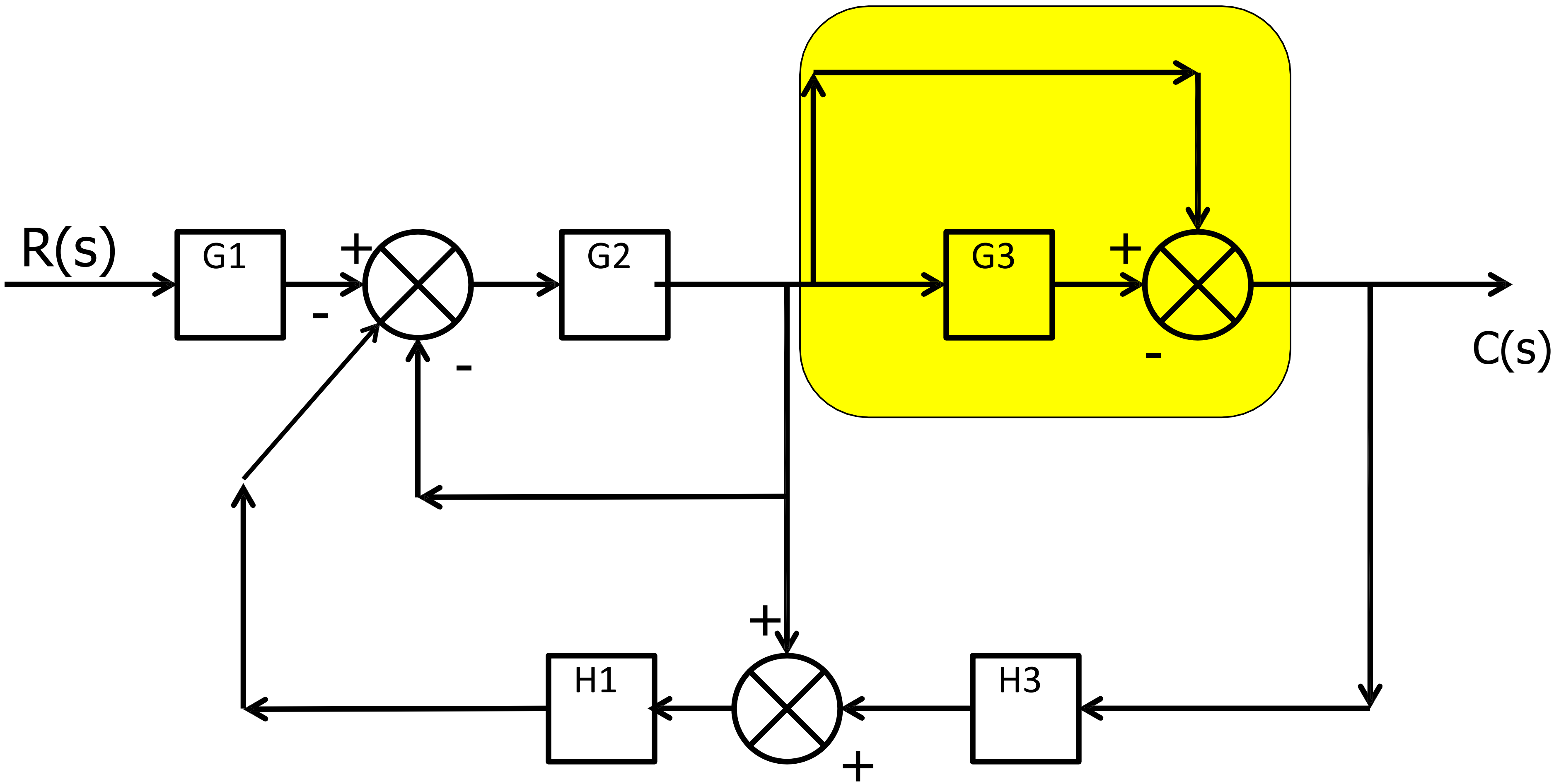
R(s)

$$\frac{G2G3(G1+G4+G5)}{1+G2H1+G3H2+G2G3H1H2+G2G3H3(G1+G4+G5)}$$

C(s)

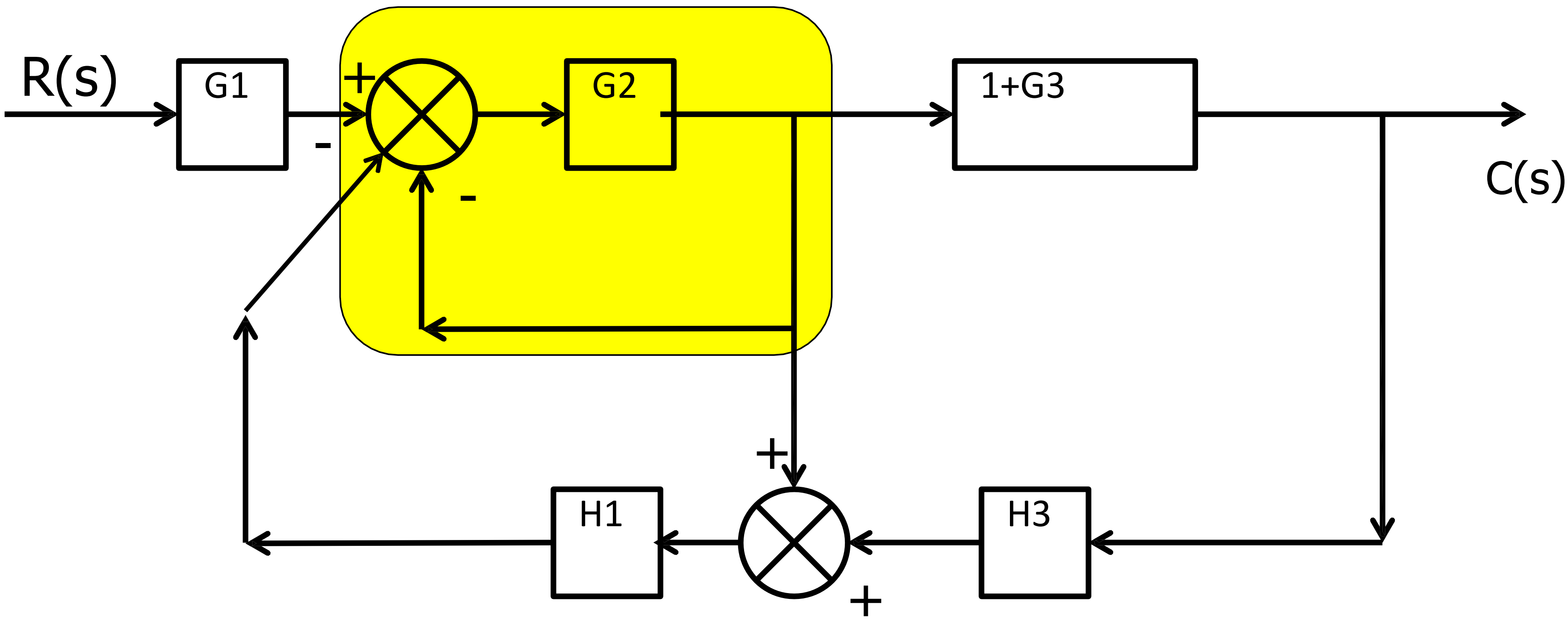
Example 10

Apply rule 2 Blocks in Parallel



Example 10 cont….

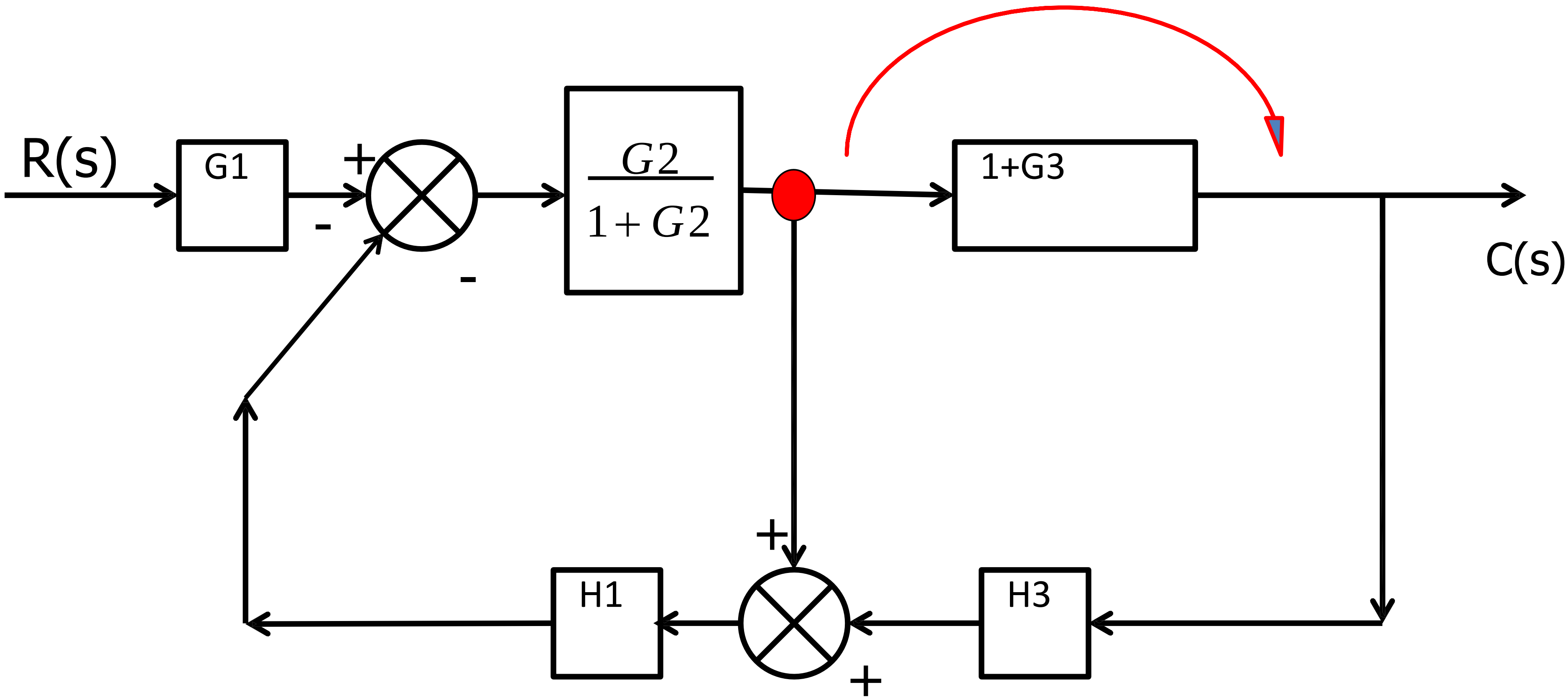
Apply rule 3 Elimination of Feedback Loop



Example 10 cont....

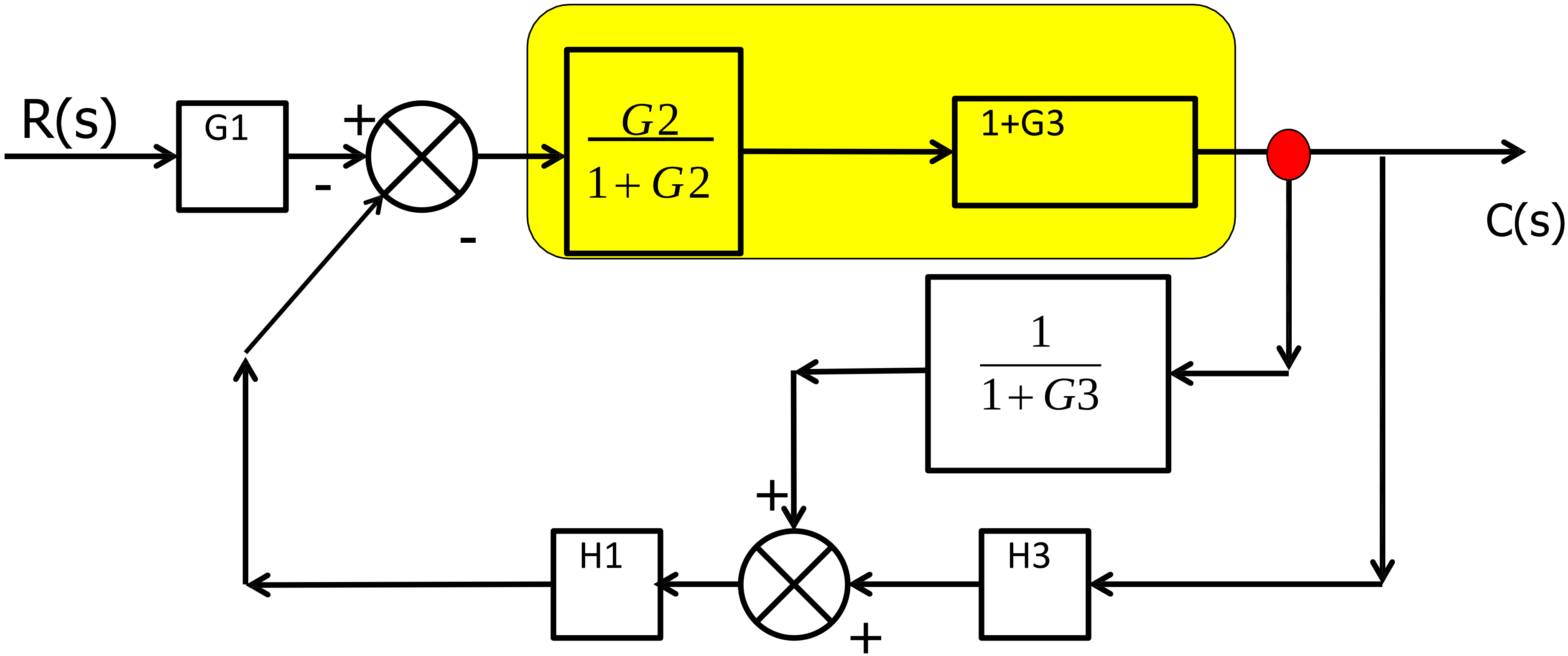
Apply rule 8

Shift take off point after block



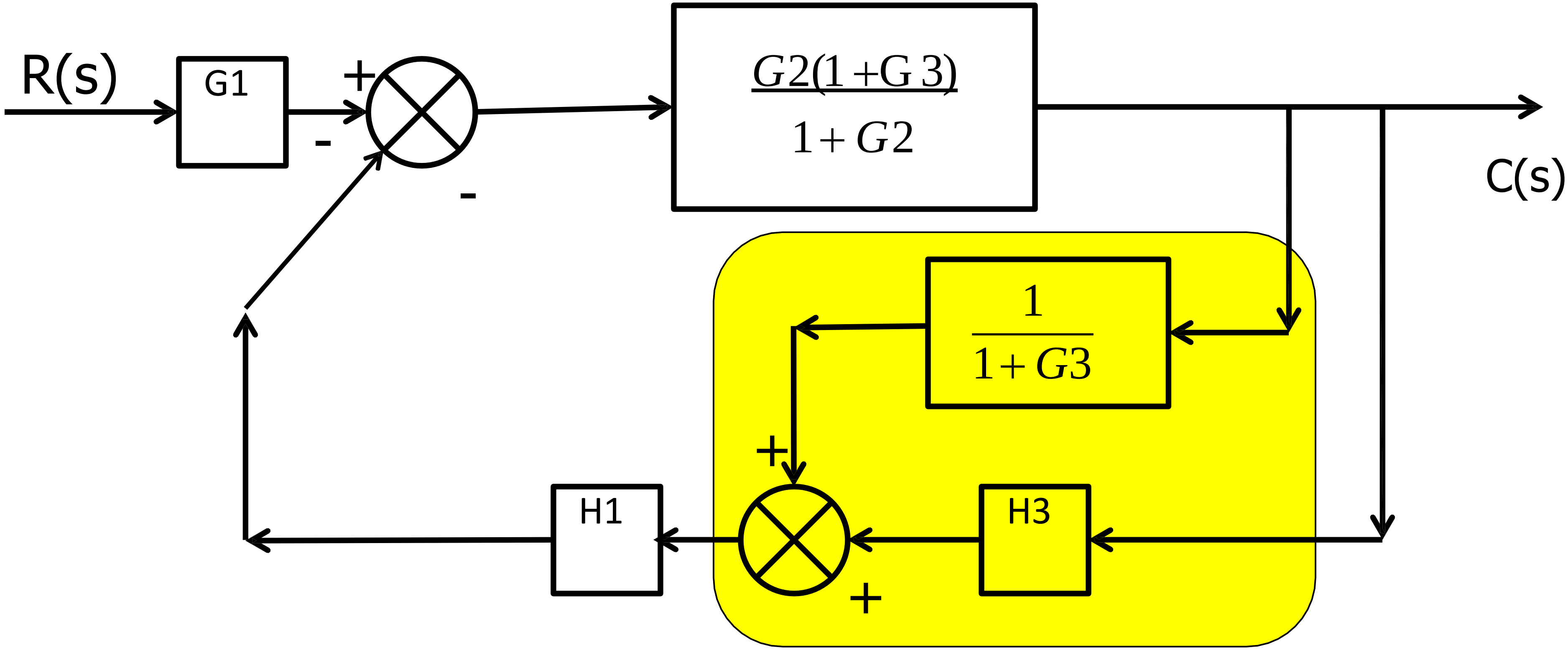
Example 10 cont….

Apply rule 1 Blocks in series



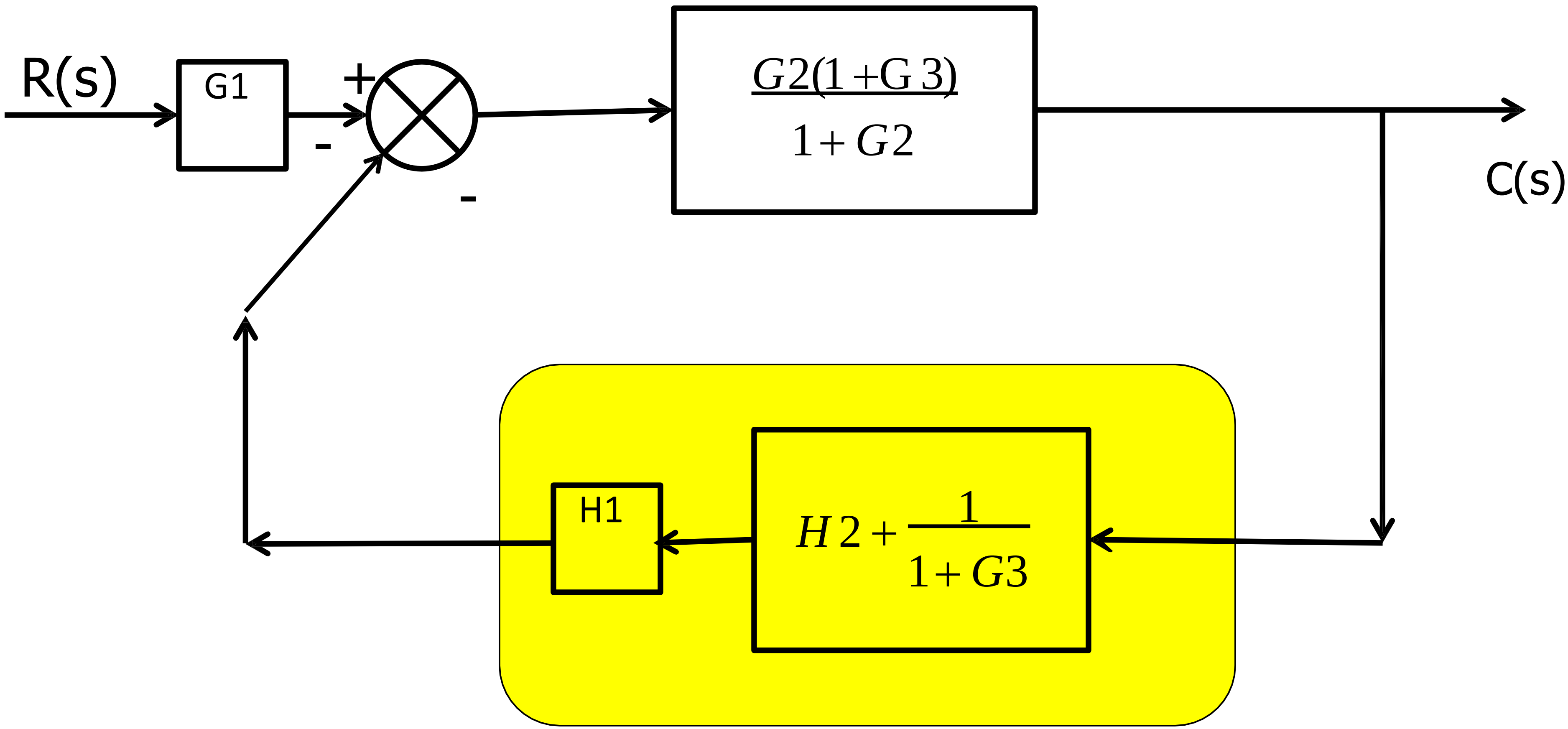
Example 10 cont....

Apply rule 2 Blocks in Parallel



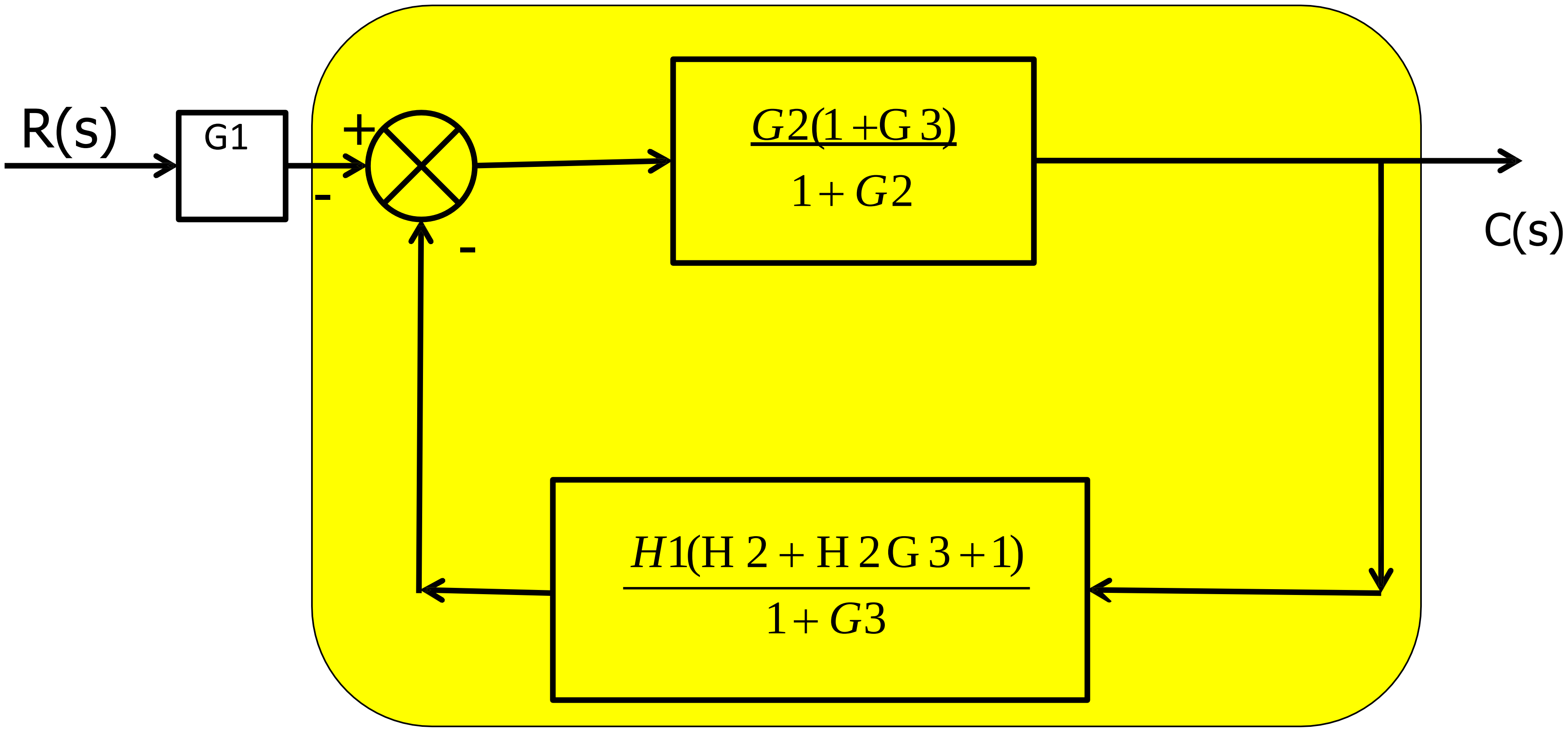
Example 10 cont….

Apply rule 1 Blocks in Series



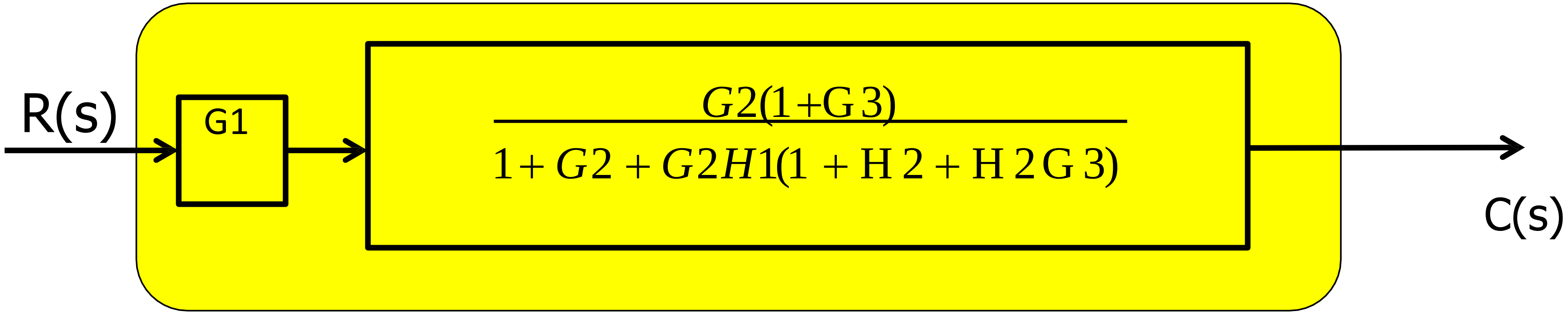
Example 10 cont….

Apply rule 3 Elimination of Feedback loop

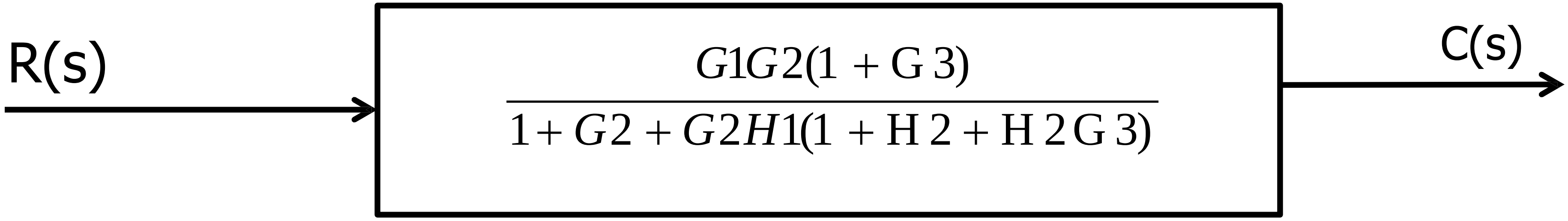


Example 10 cont….

Apply rule 1 Blocks in series



Example 10 cont….



Example 10 cont….

$$\frac{C(s)}{R(s)} = \frac{G1G2(1+G3)}{1+G2+G2H1(1+H2+H2G3)}$$