CONTROL SYSTEM ENGINEERING

Block Diagram Reduction Techniques

Prepared by,

A.Parimala Gandhi,

AP(SS)/ECE Department,

KIT/CBE

Block diagram

A Block diagram is basically modelling of any simple or complex system.

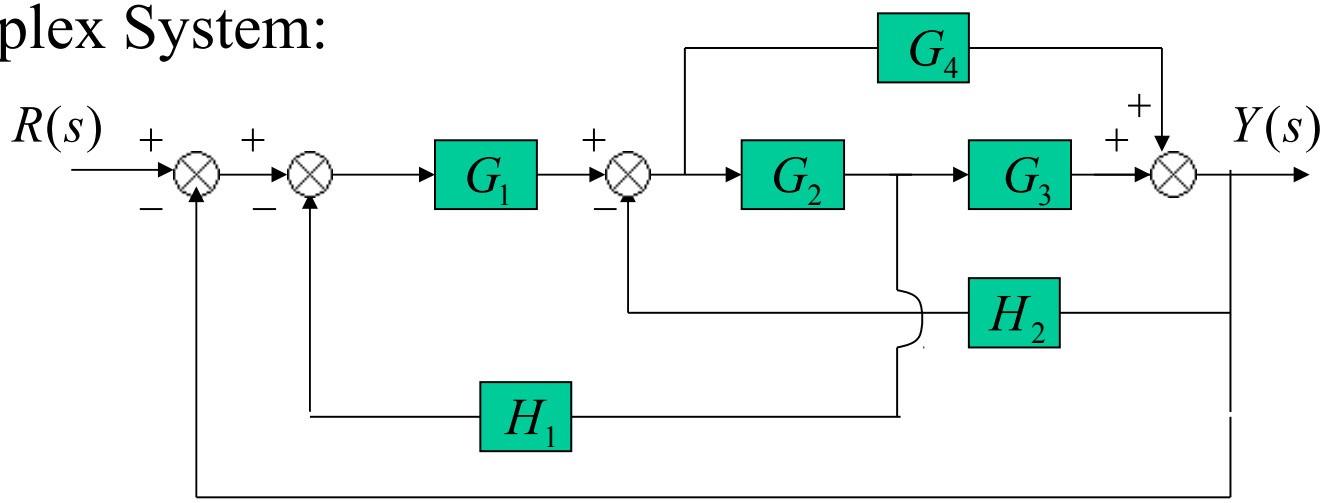
It Consists of multiple Blocks connected together to represent a system to explain how it is functioning

Transfer Function: Ratio between transformation of output to the transformation of input when all the initial conditions are zero.

Simple system:

G(s)=C(s)/R(s)

Complex System:

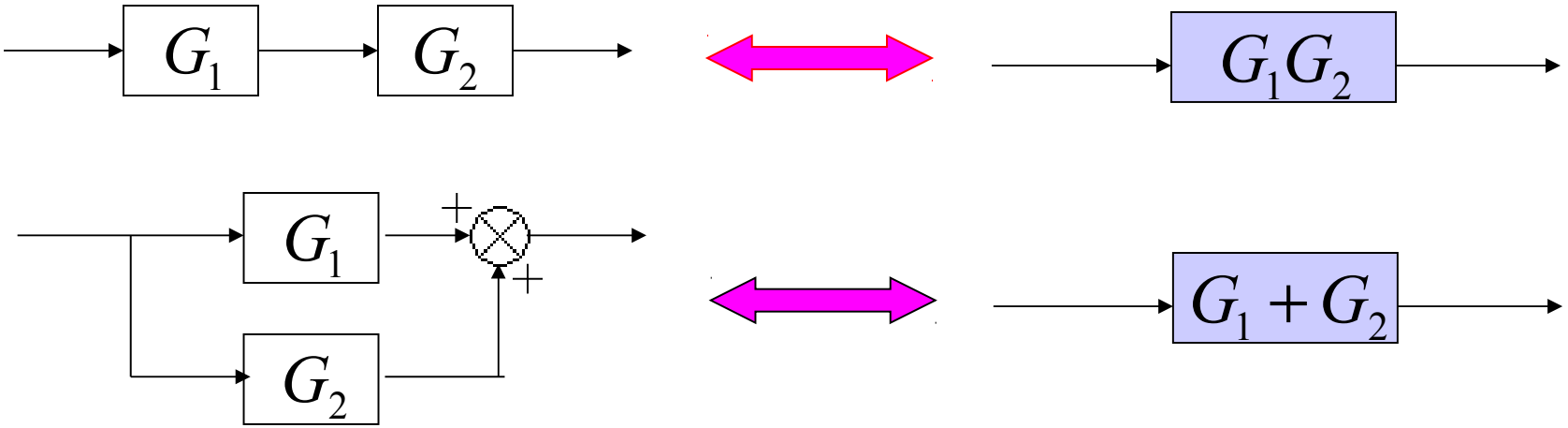


Need for block diagram reduction

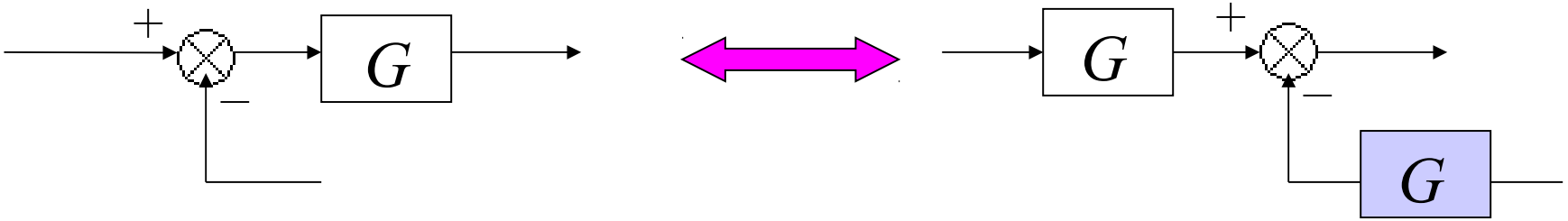
- It is normally required to reduce multiple blocks into single block or for convenient understanding it may sometimes required to rearrange the blocks from its original order.
- For the calculation of Transfer function its required to be reduced.

Block Diagram Reduction techniques

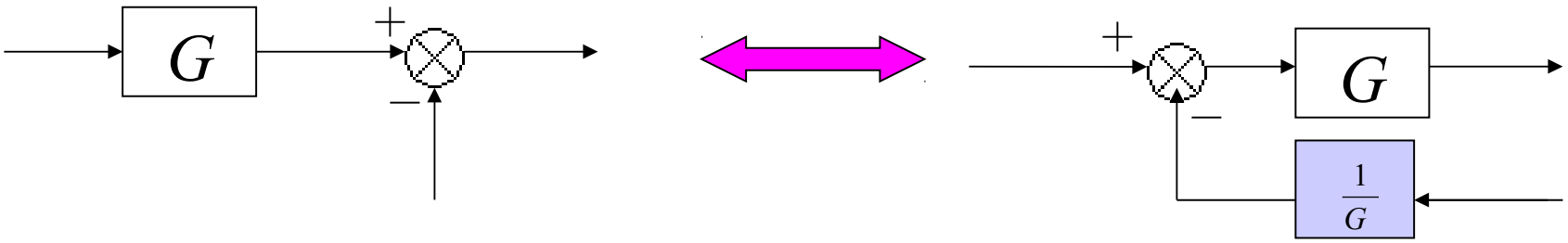
1. Combining blocks which are in cascade or in parallel



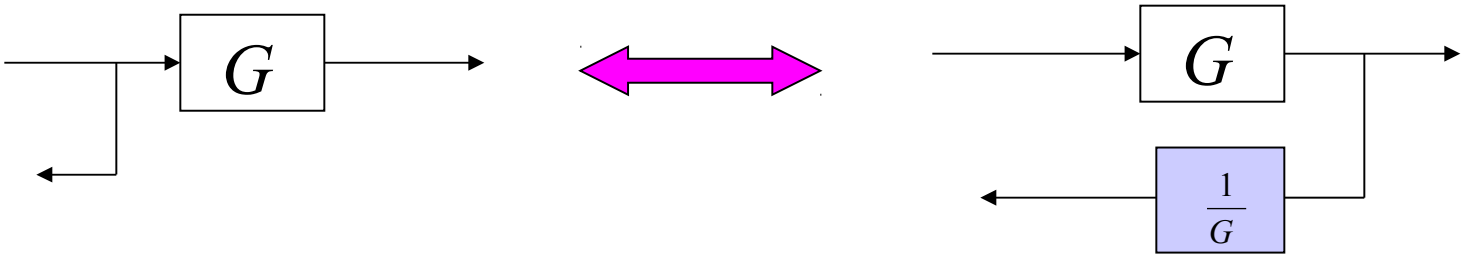
2. Moving a summing point behind a block



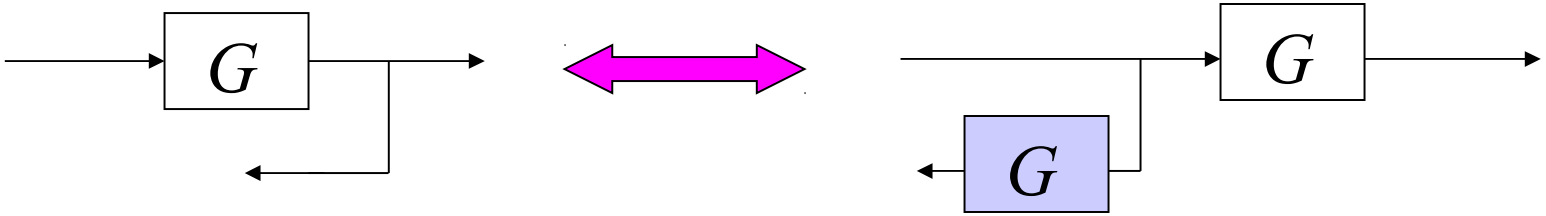
3. Moving a summing point ahead of a block



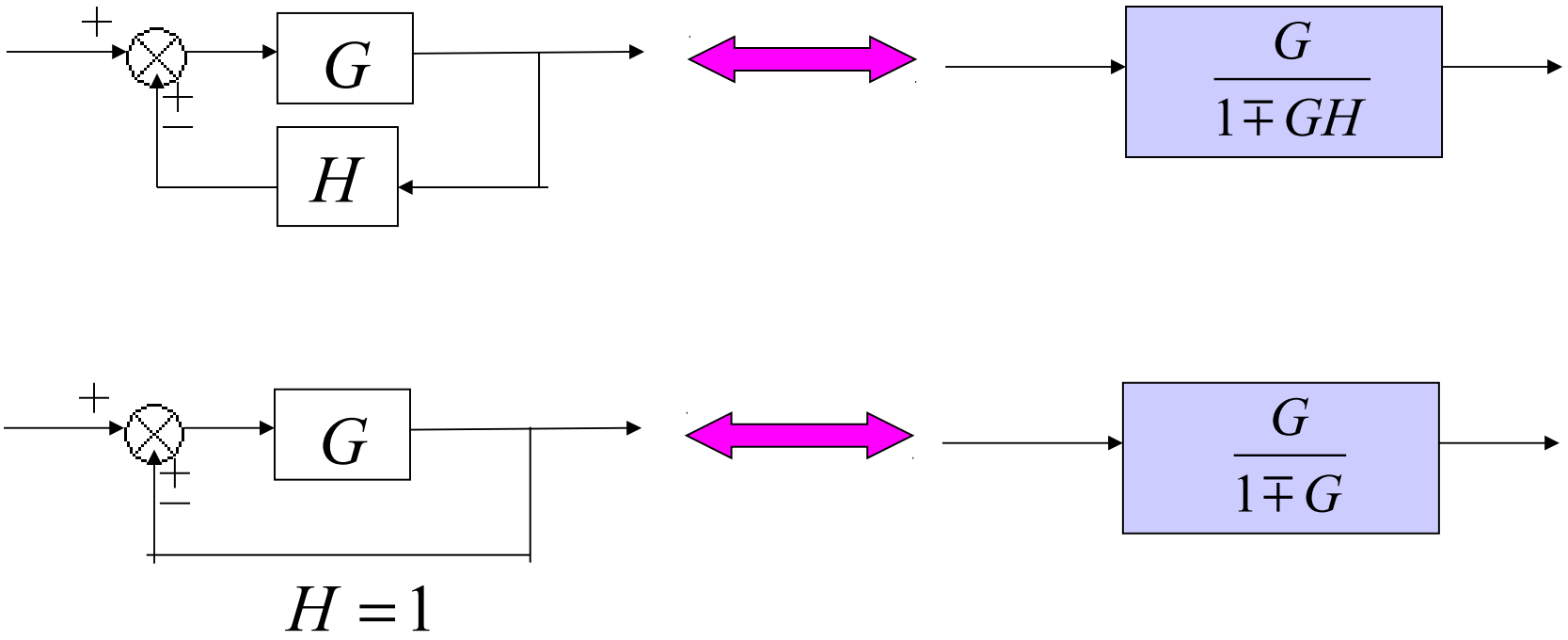
4. Moving a pickoff point behind a block



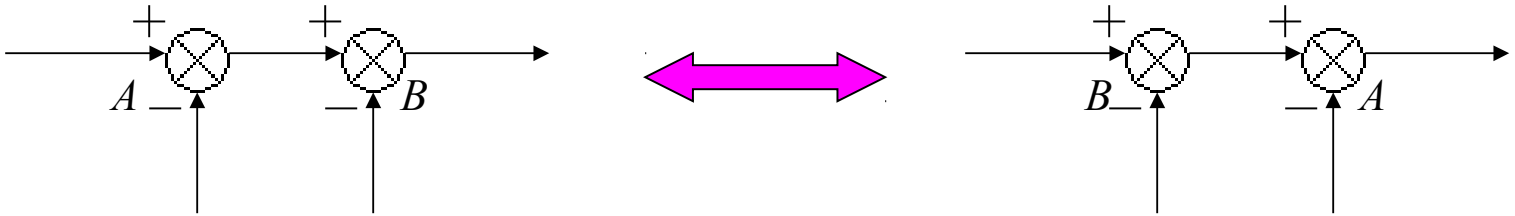
5. Moving a pickoff point ahead of a block



6. Eliminating a feedback loop



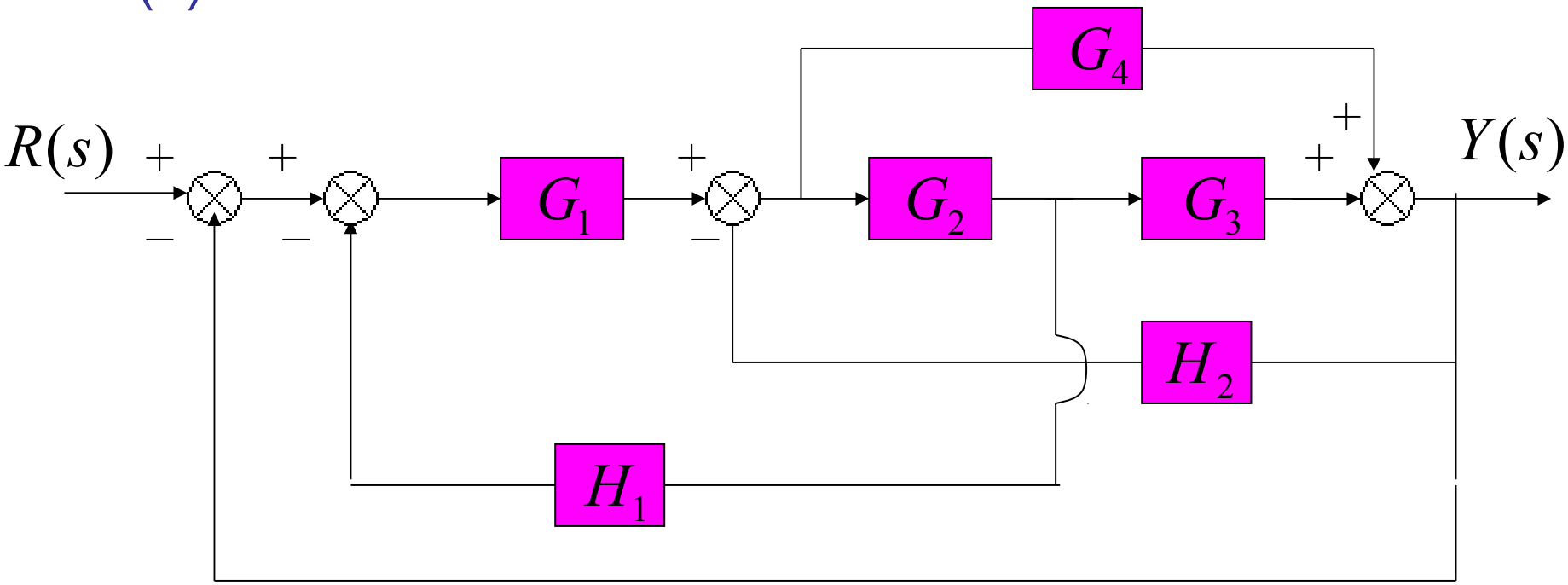
7. Swapping with two adjacent summing points

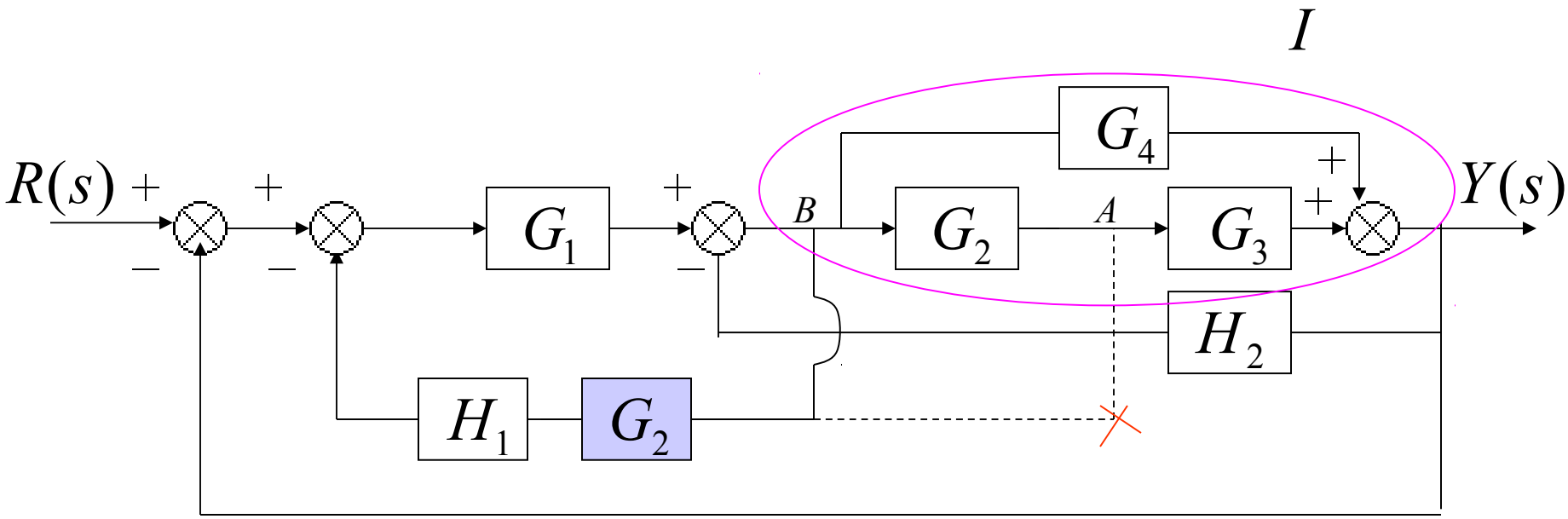


Example 1

Find the transfer function of the following block diagrams

(a)

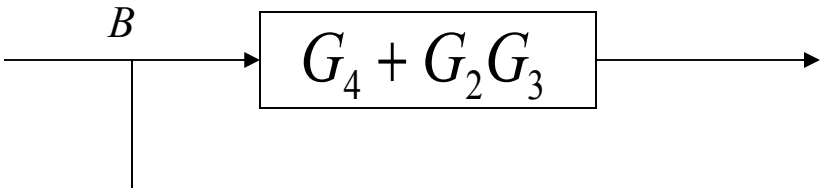


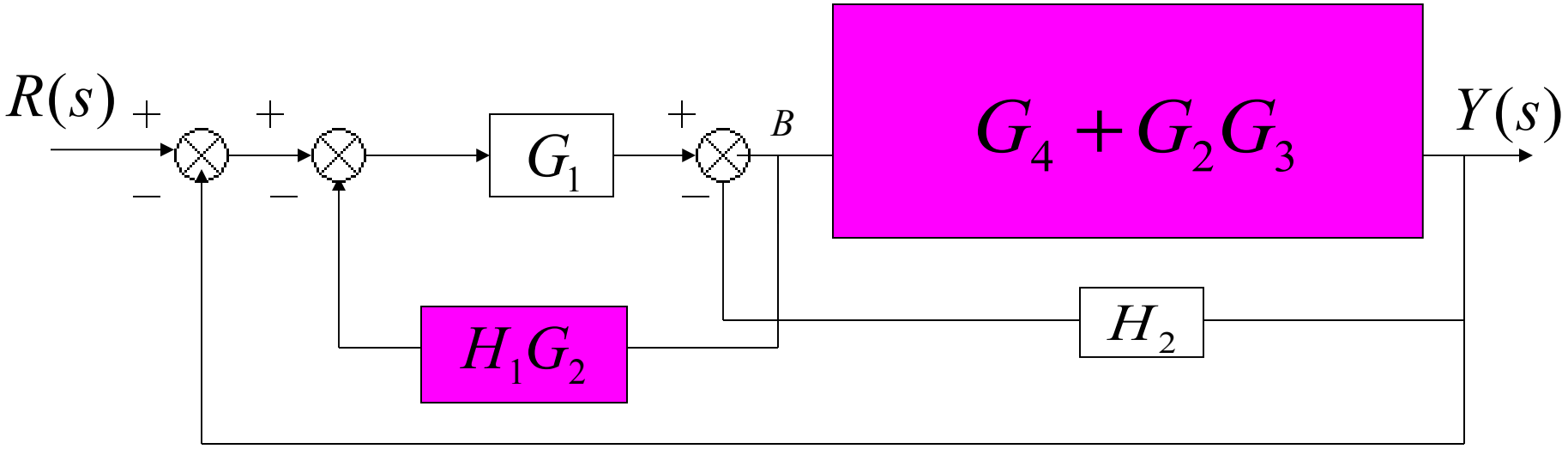


Solution:

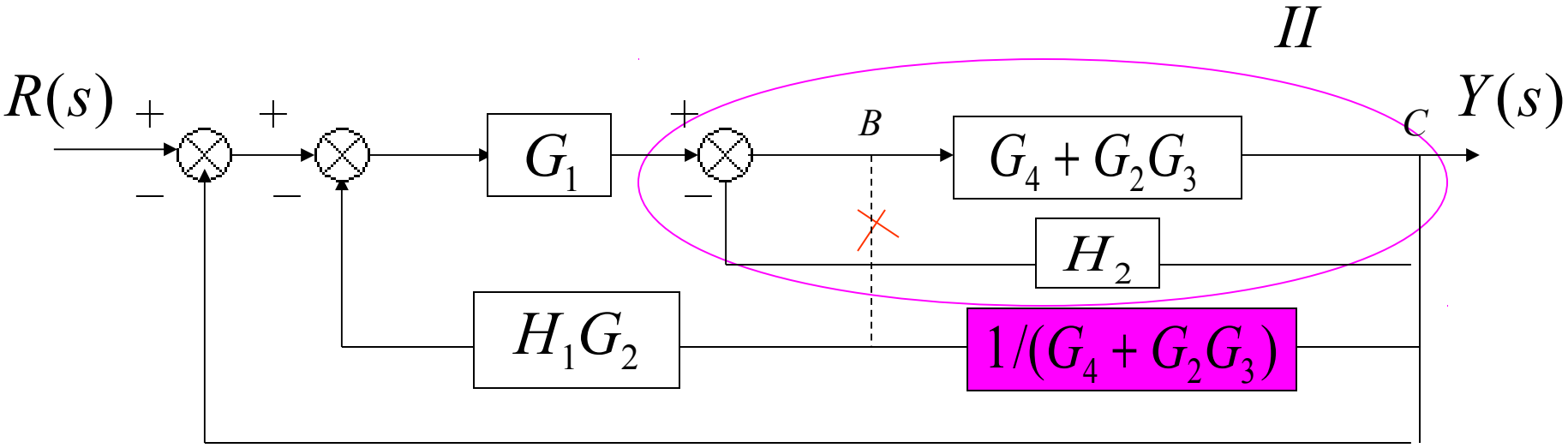
1. Apply the rule that Moving pickoff/takeoff point ahead of block G_2

2. Eliminate loop I & simplify as

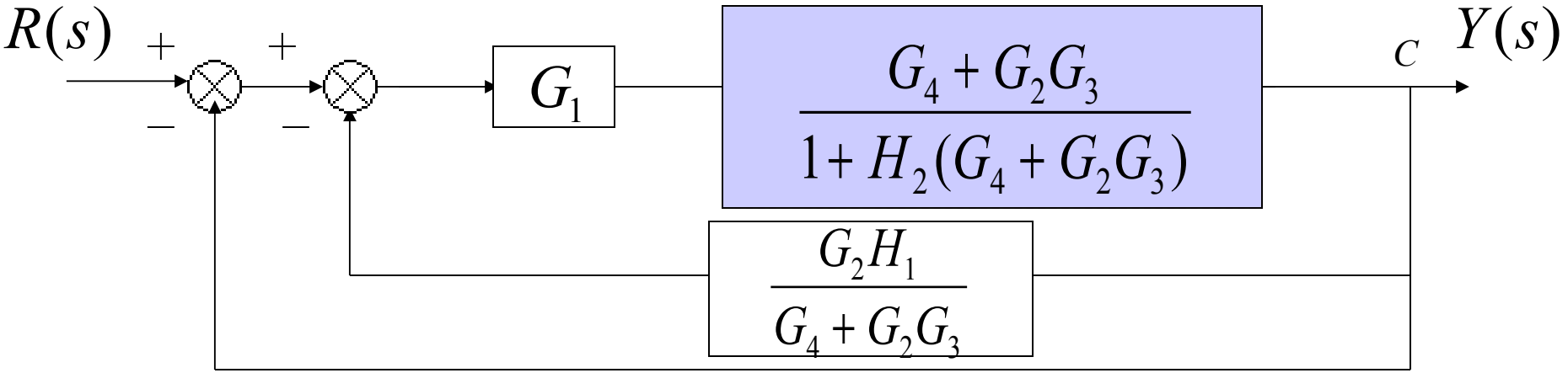




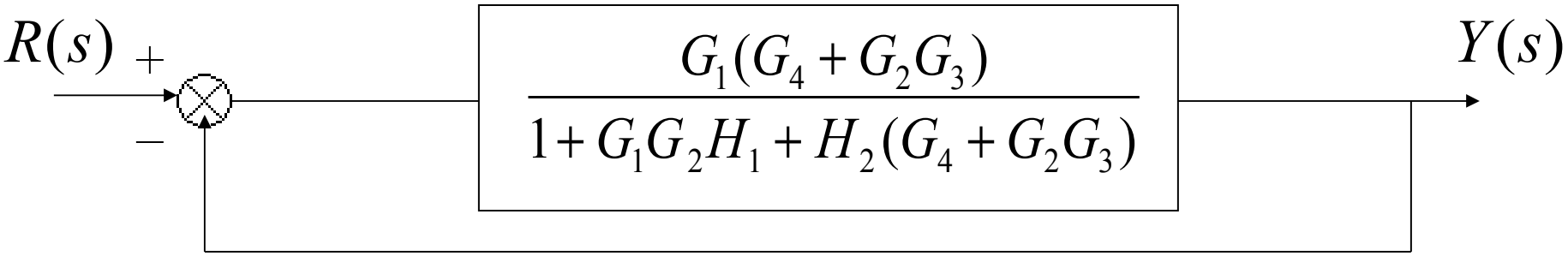
3. Moving pickoff point B behind block $G_4 + G_2G_3$



4. Eliminate loop III

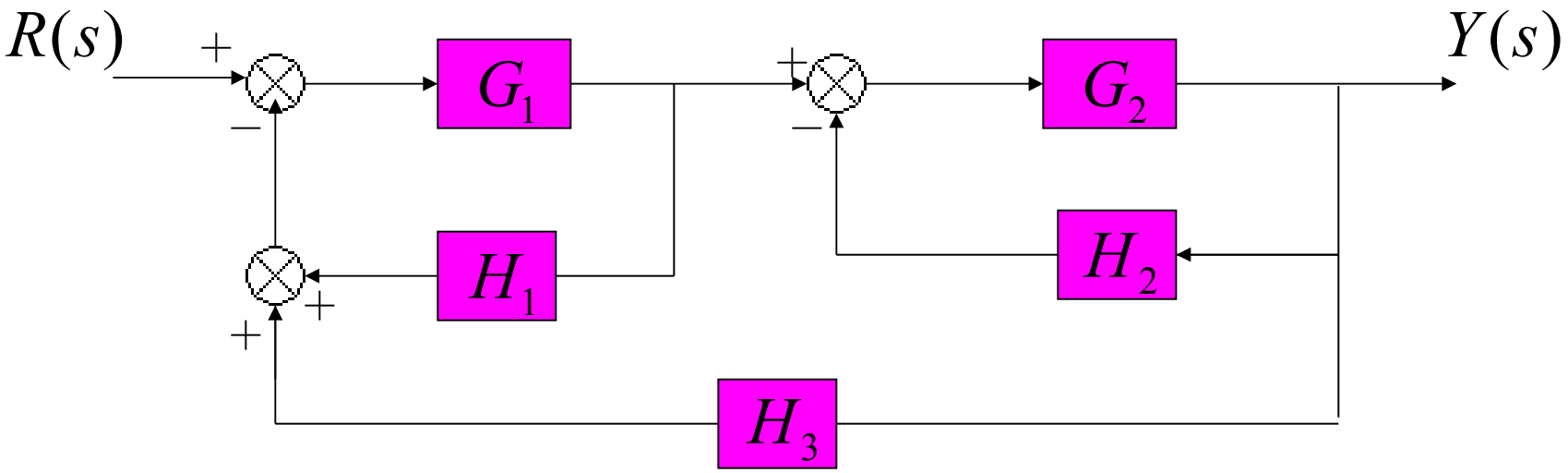


Using rule 6



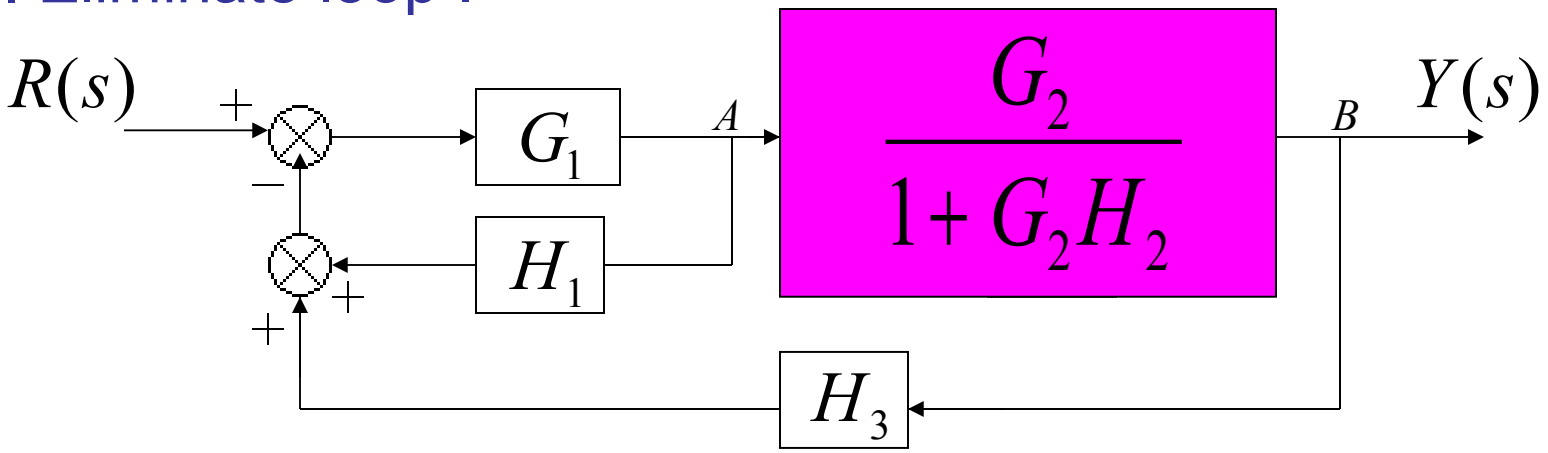
$$T(s) = \frac{Y(s)}{R(s)} = \frac{G_1(G_4 + G_2G_3)}{1 + G_1G_2H_1 + H_2(G_4 + G_2G_3) + G_1(G_4 + G_2G_3)}$$

(b)

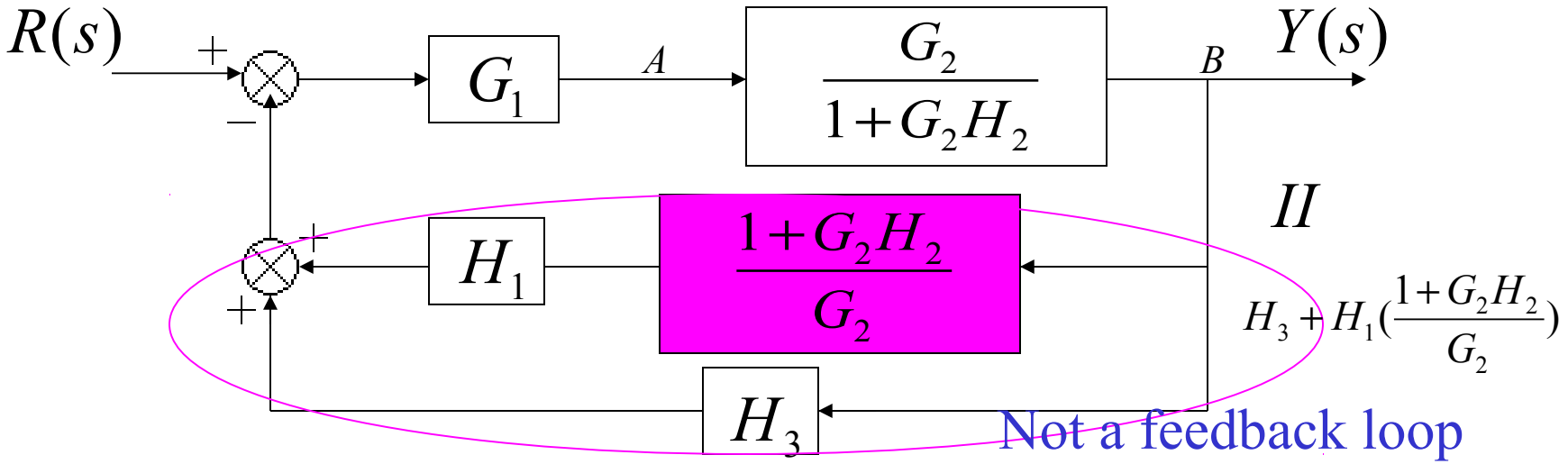


Solution:

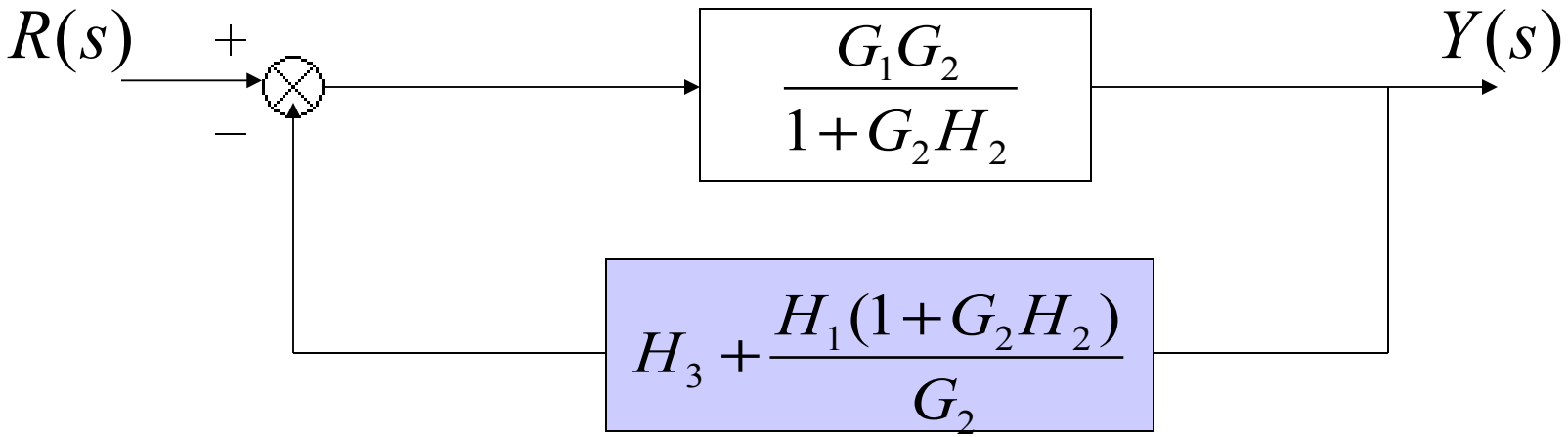
1. Eliminate loop I



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



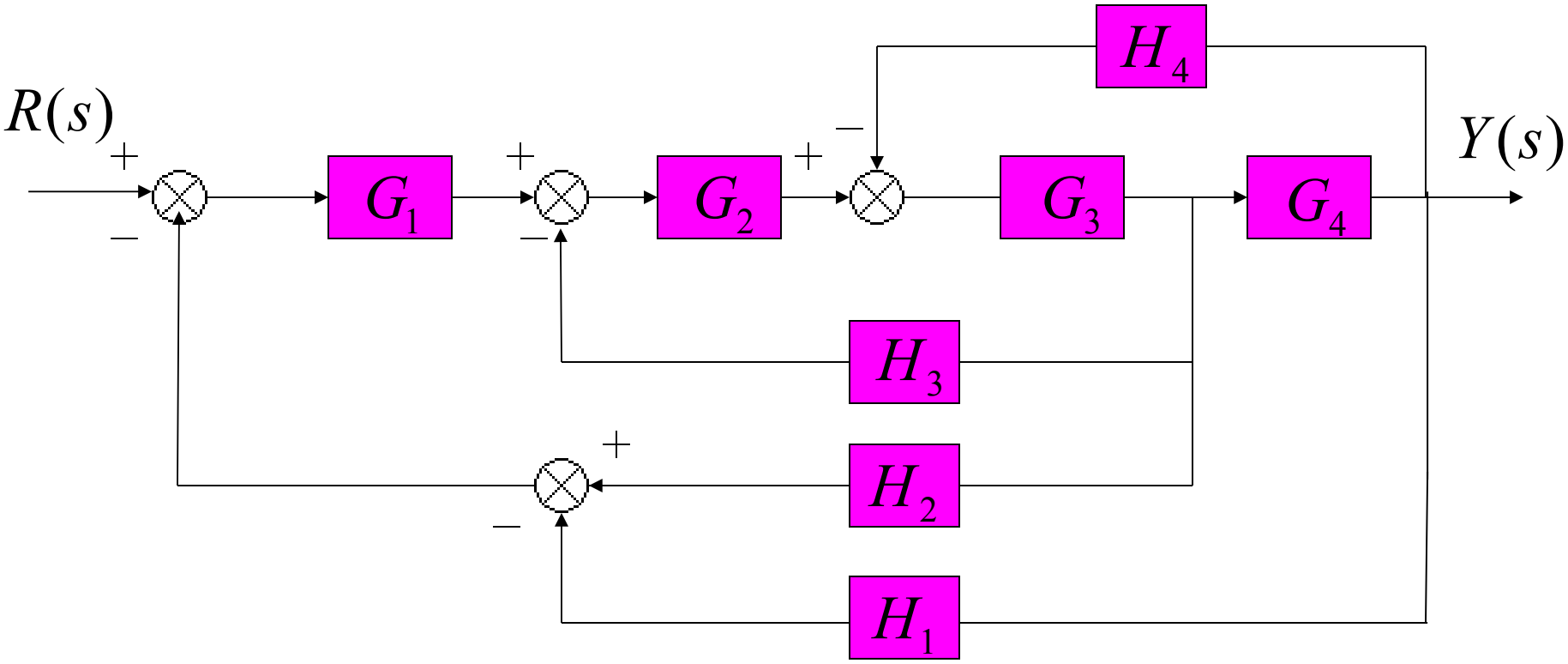
3. Eliminate loop II



Using rule 6

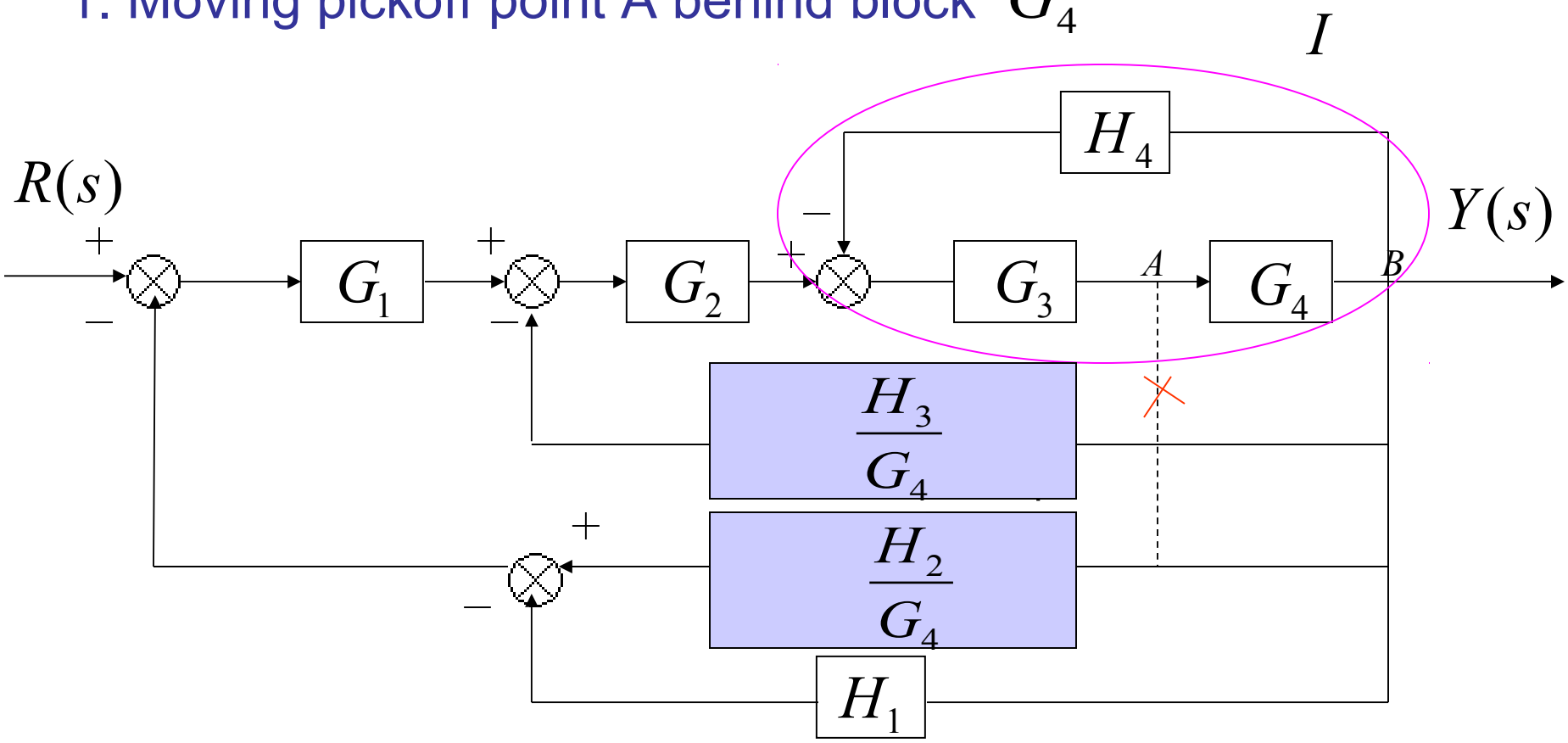
$$T(s)=\frac{Y(s)}{R(s)}=\frac{G_1G_2}{1+G_2H_2+G_1G_2H_3+G_1H_1+G_1G_2H_1H_2}$$

(c)



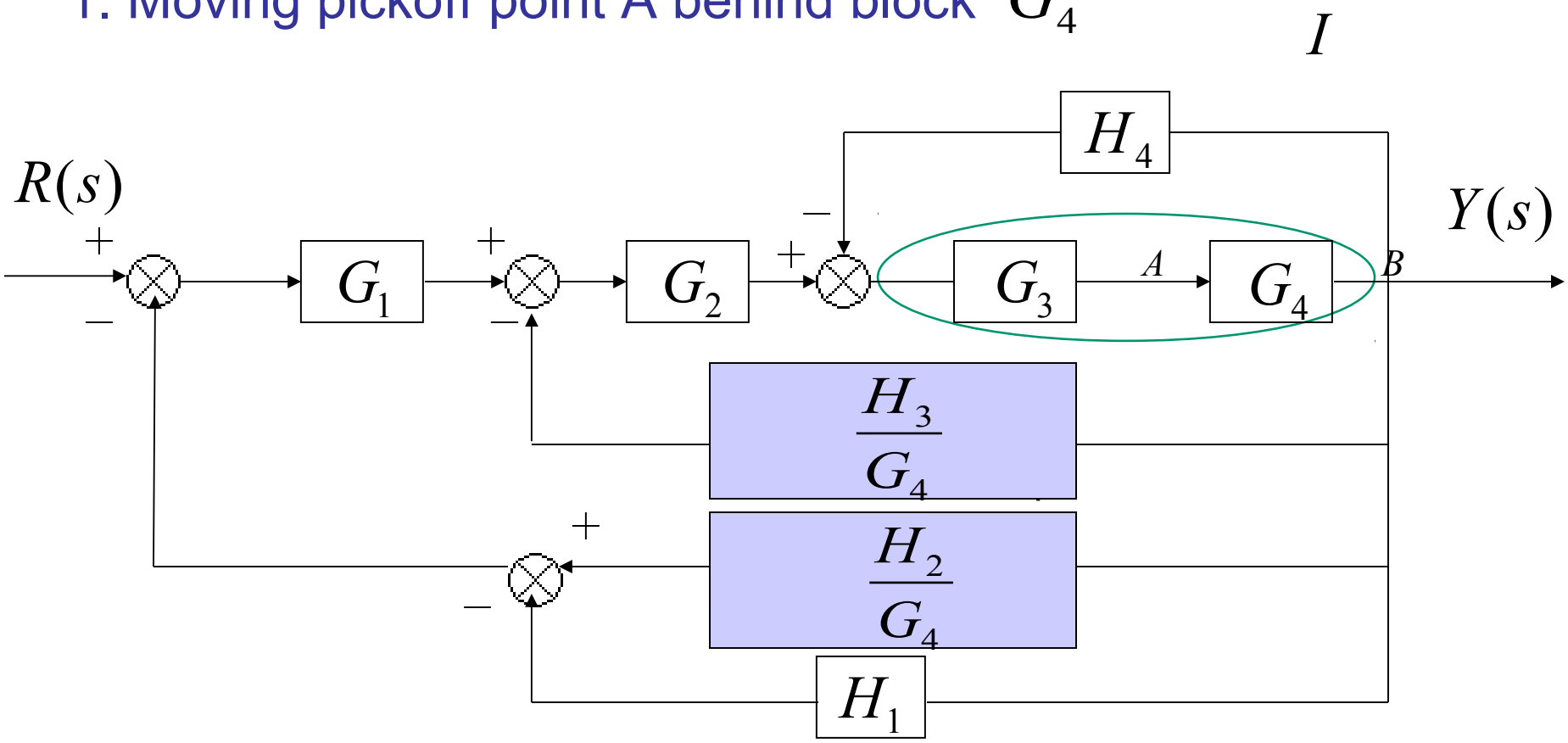
Solution:

1. Moving pickoff point A behind block G_4



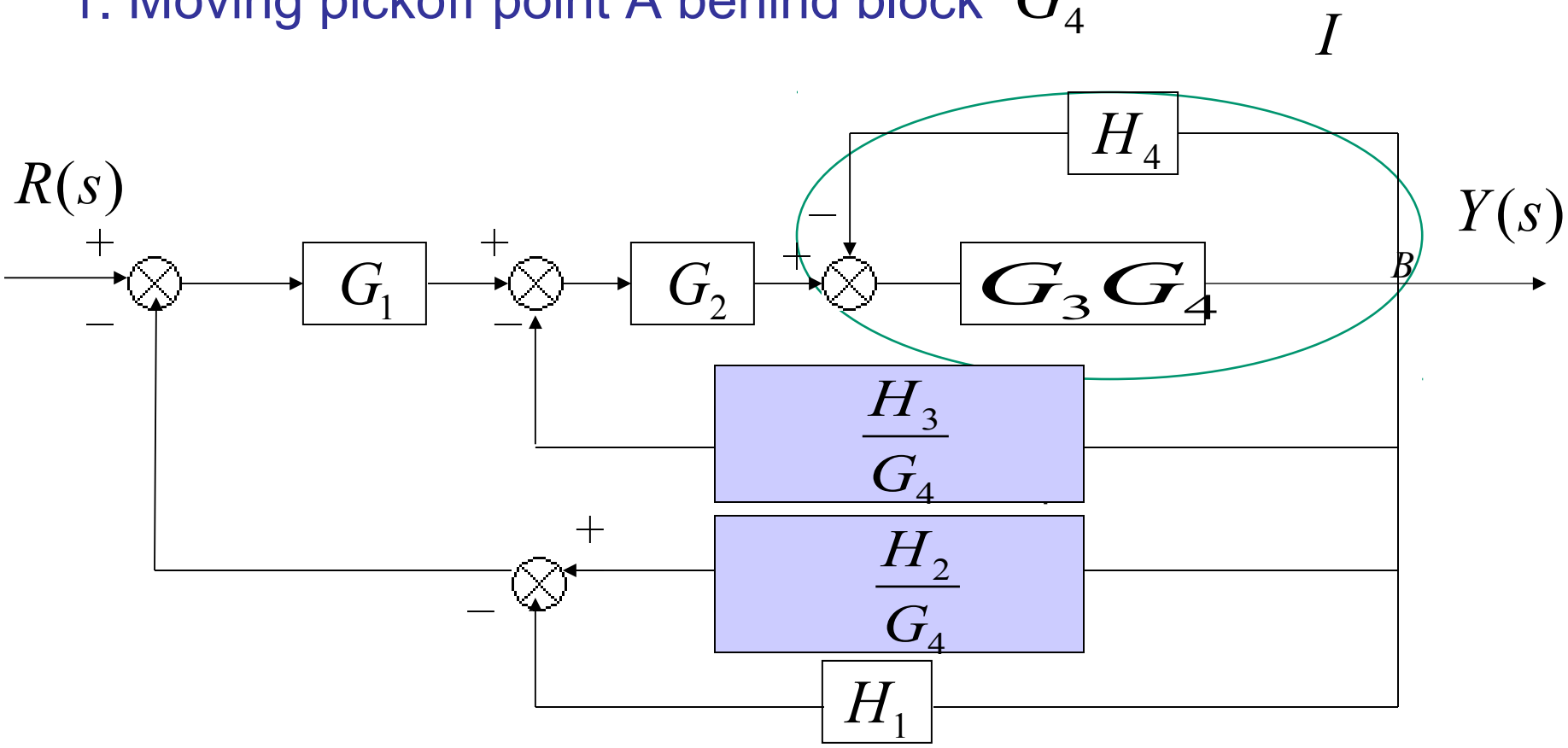
Solution:

1. Moving pickoff point A behind block G_4



Solution:

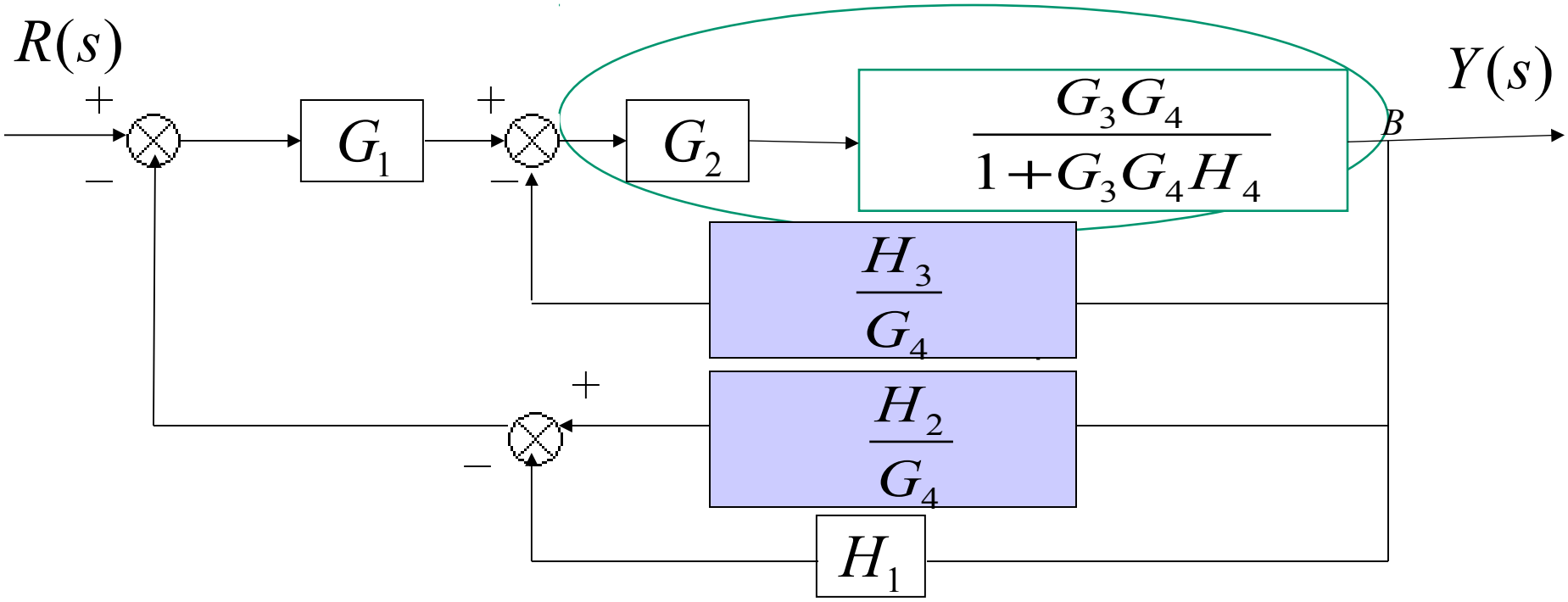
1. Moving pickoff point A behind block G_4



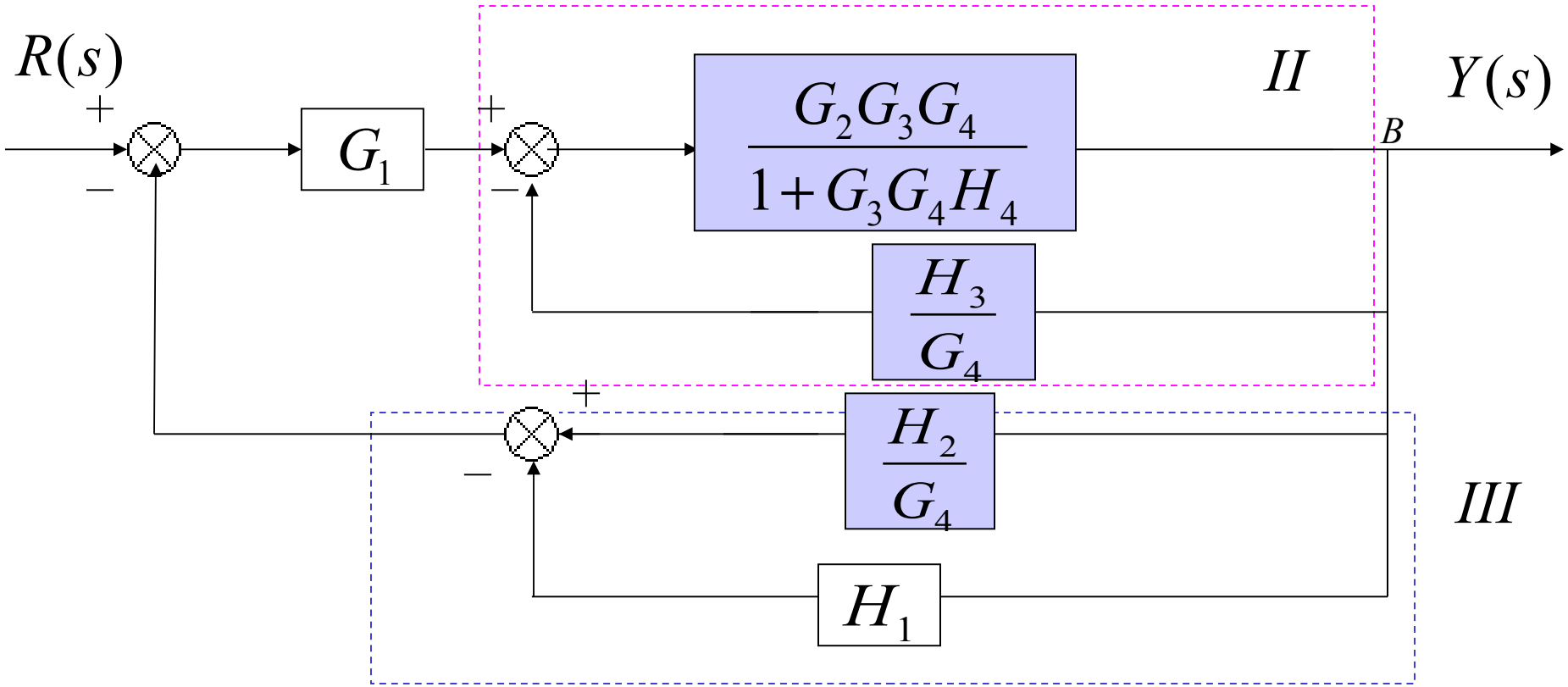
Solution:

1. Moving pickoff point A behind block G_4

I



2. Eliminate loop I and Simplify



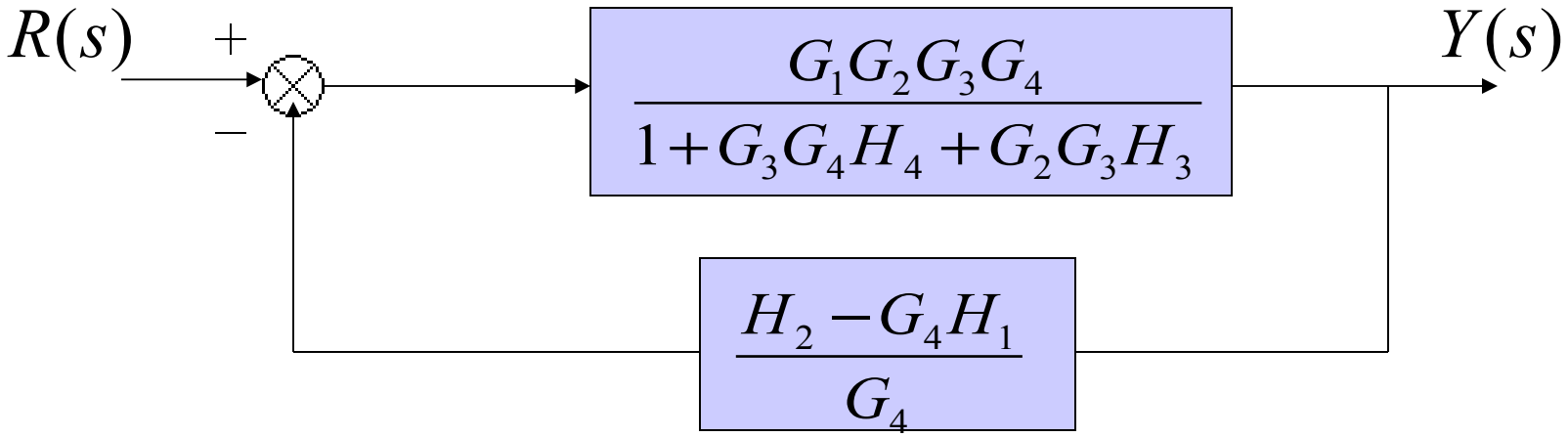
II feedback

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

III Not feedback

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

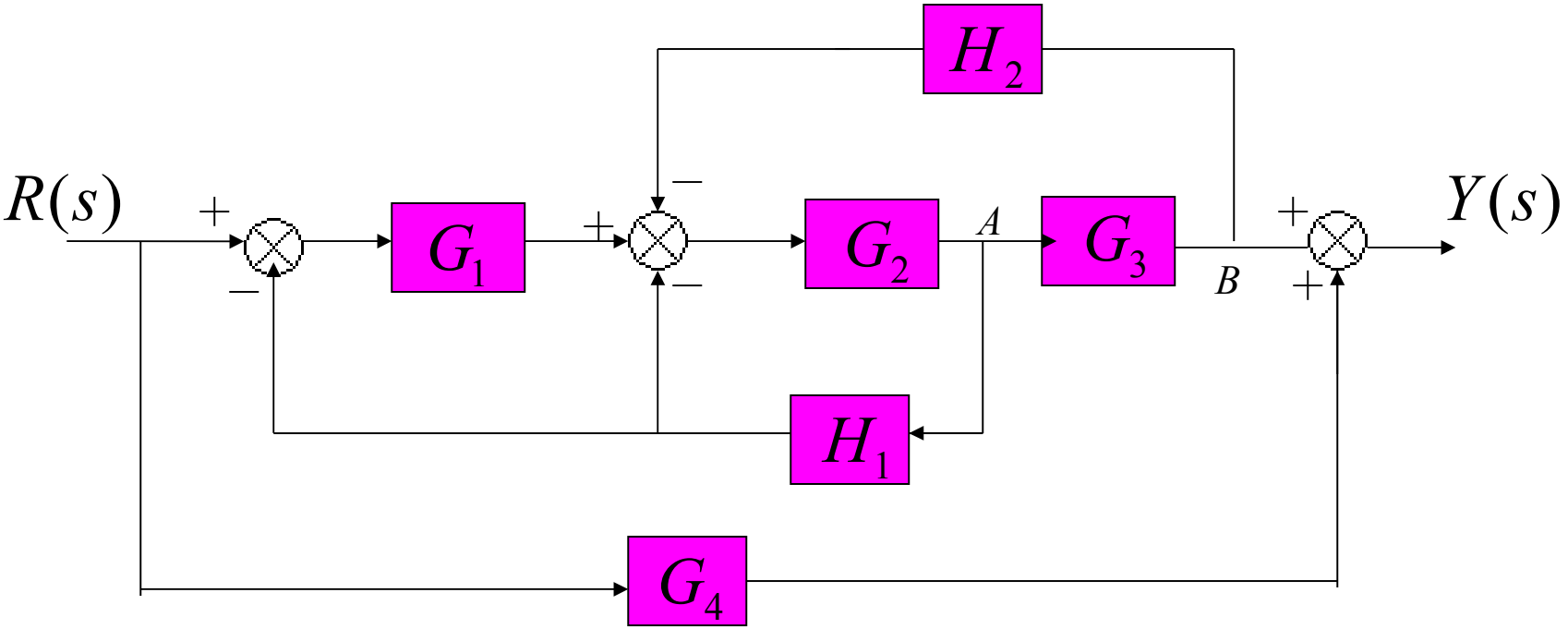
3. Eliminate loop II & III



Using rule 6

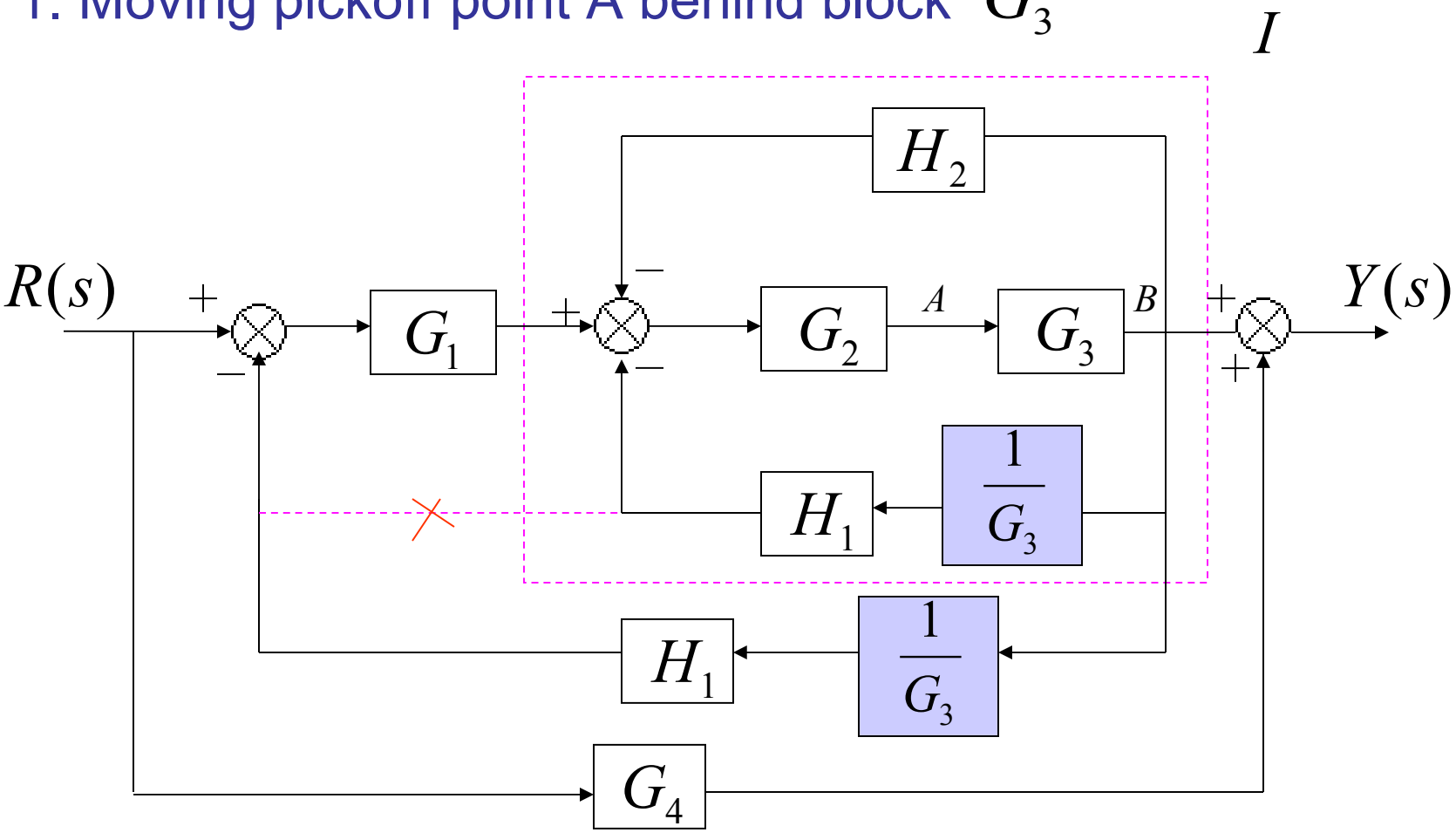
$$T(s)=\frac{Y(s)}{R(s)}=\frac{G_1G_2G_3G_4}{1+G_2G_3H_3+G_3G_4H_4+G_1G_2G_3H_2-G_1G_2G_3G_4H_1}$$

(d)

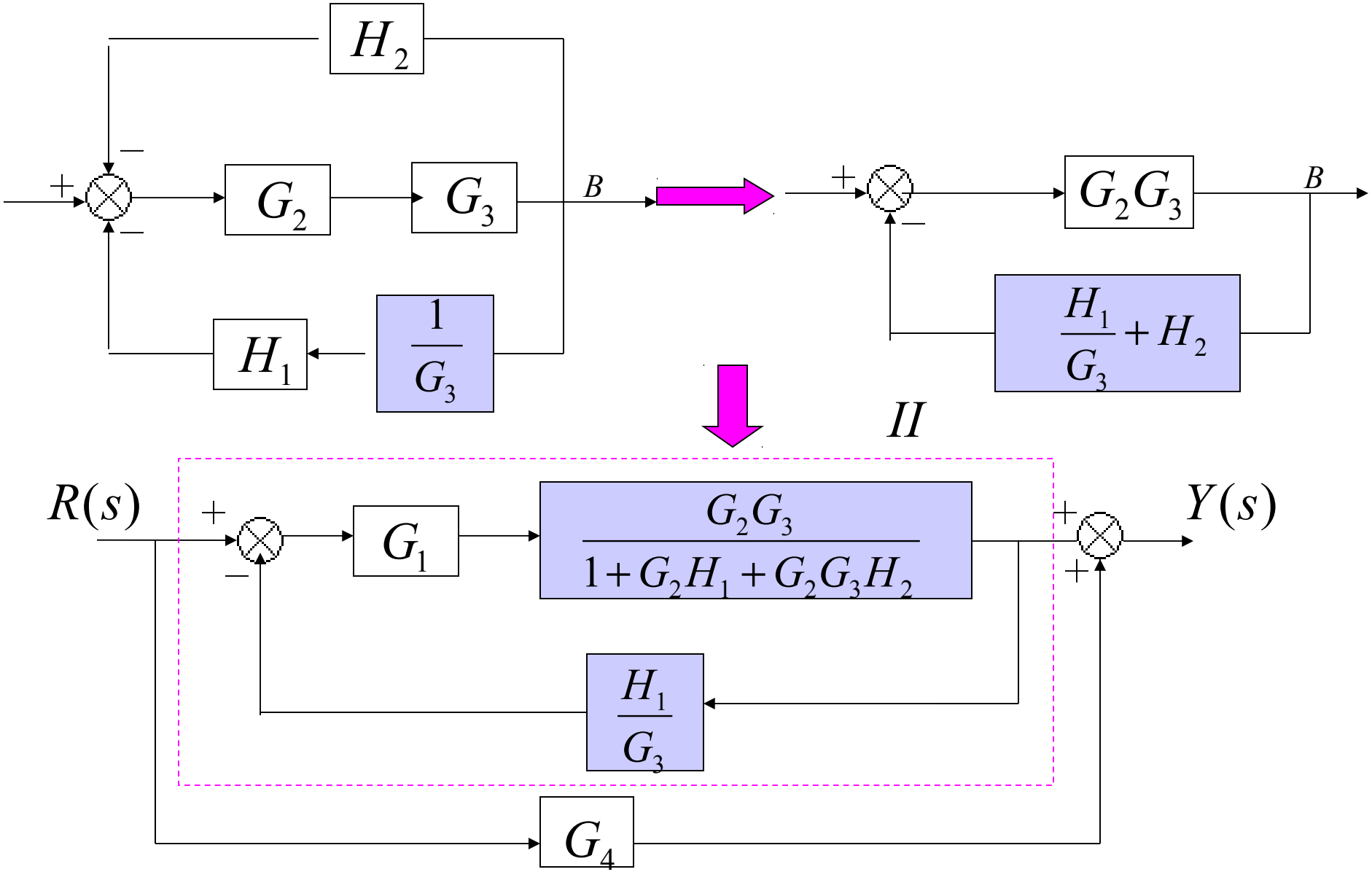


Solution:

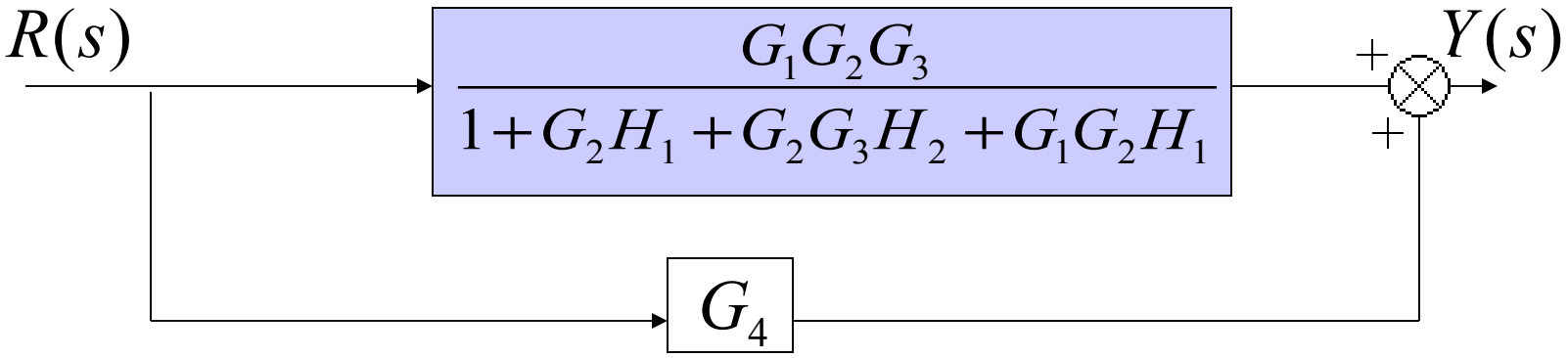
1. Moving pickoff point A behind block G_3



2. Eliminate loop I & Simplify



3. Eliminate loop II



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

End