LECTURE TWO
BLOCK DIAGRAM REDUCTION

Block diagram is a pictorial representation of a control system showing inter-relation between the transfer function of various components. The block diagram is obtained after obtaining the differential and transfer function of all components of a control system. Figure 2.1 shows an element of the block diagram. The arrowhead pointing toward the block indicates the input and the one pointing away from the block indicates the output.

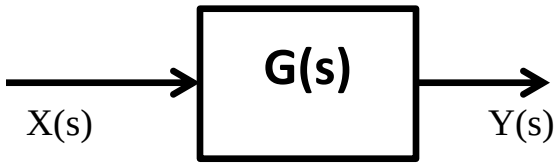


Figure 2.1 Single block diagram system

G(s) may be written as;

$$\boldsymbol{G(s) = \frac{Y(s)}{X(s)}}$$

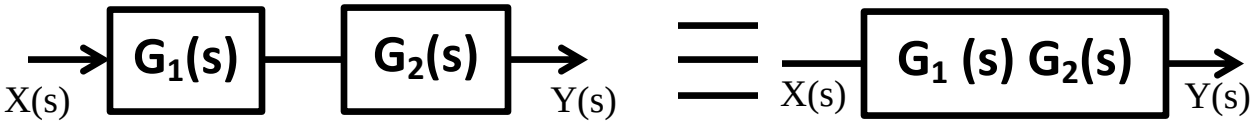
After obtaining the block diagram for each and every components, all blocks are combined to obtain a complete representation. It is then reduced using some rules to a more simple form with the help of block diagram algebra.

2.1 Rules for Block Diagram Reduction:

Now the following block diagram algebra is often used to describe rules for reduction:

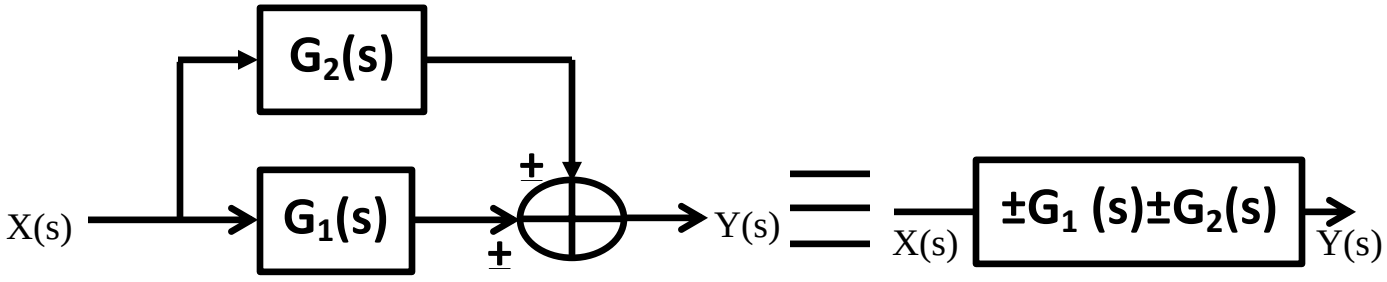
Rule 1: Blocks in cascade

Two or more blocks in cascade may be combined in one block.



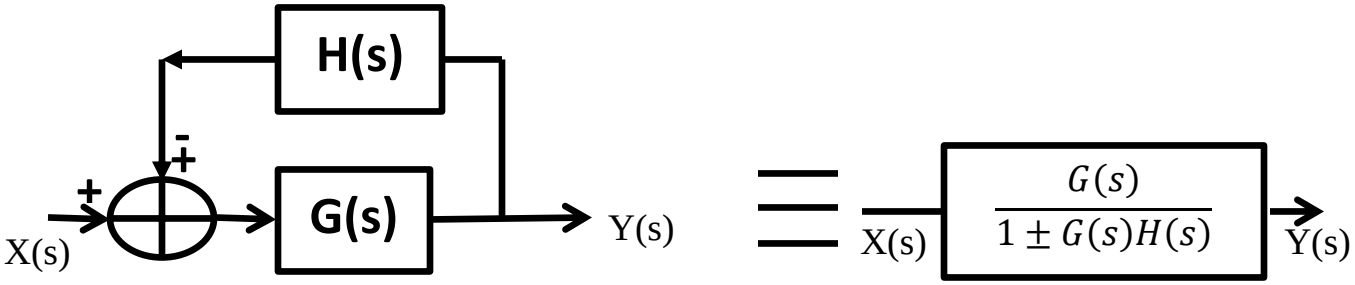
Rule 2: Combining Blocks in Parallel

Two blocks or more in parallel may be combined in one block as the algebraic sum.

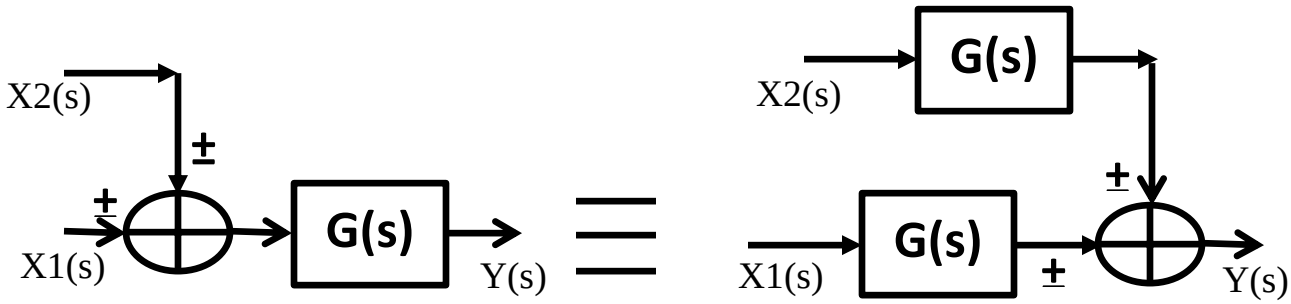


Rule 3: Eliminating a Feedback Loop

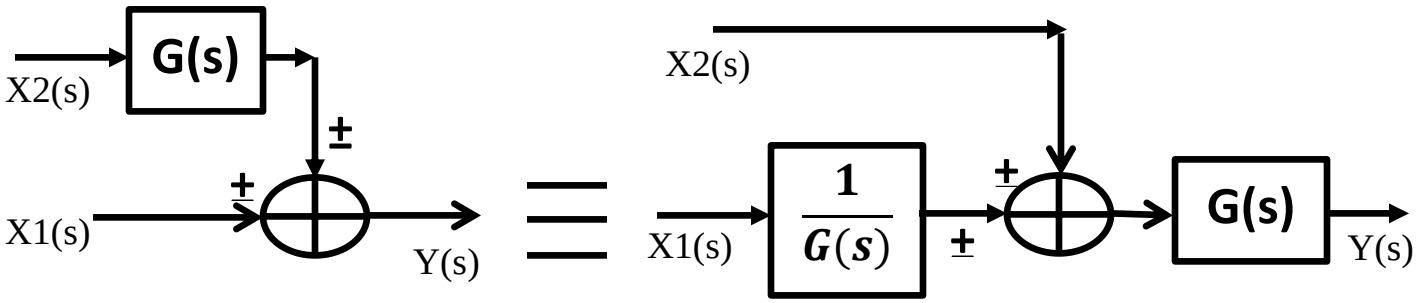
Each feedback combination may be replaced by one block with its corresponding beedback equation.



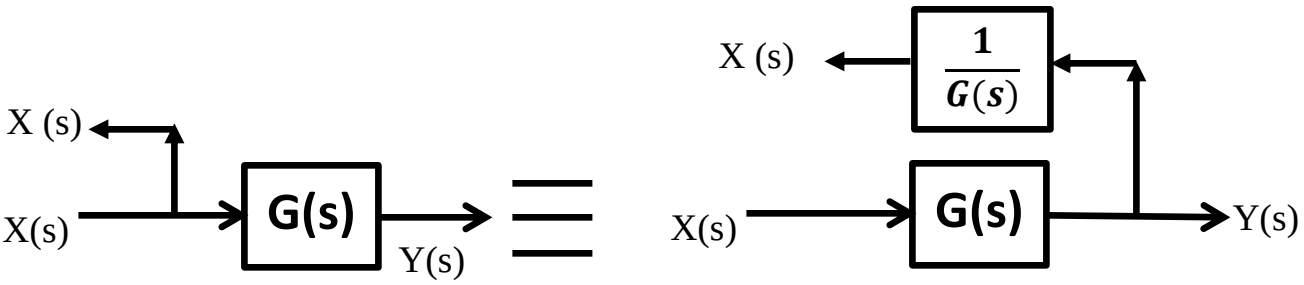
Rule 4: Moving a Summing Point Beyond a Block



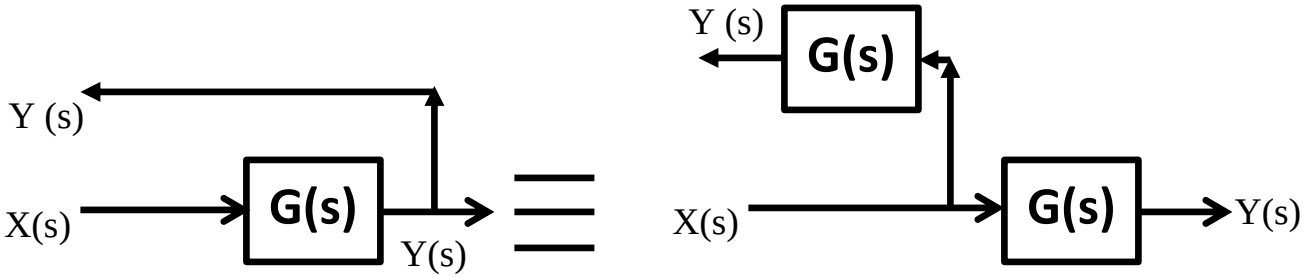
Rule 5: Moving a Summing Point Ahead of a Block



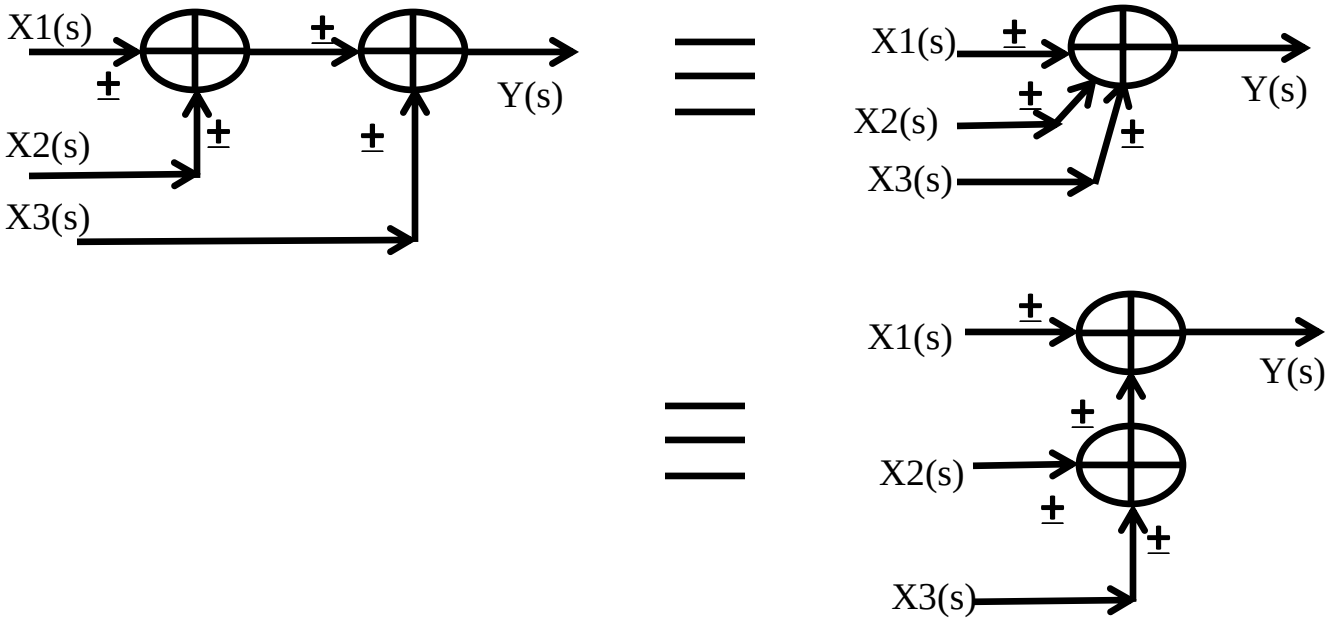
Rule 6: Moving a Take off Point Beyond a Block



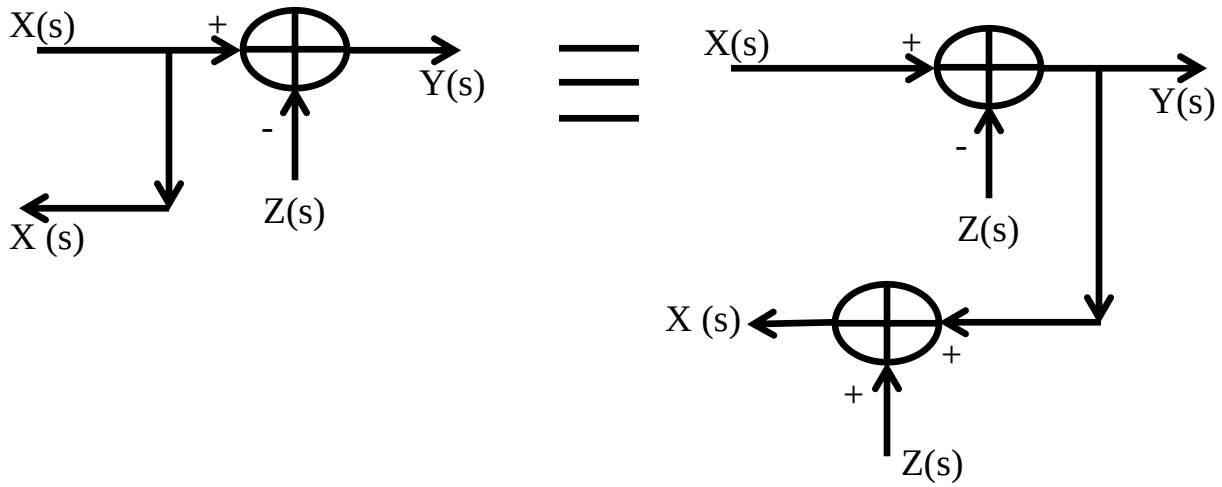
Rule 7: Moving a Take off Point Ahead of a Block



Rule 8: Rearranging Summing point

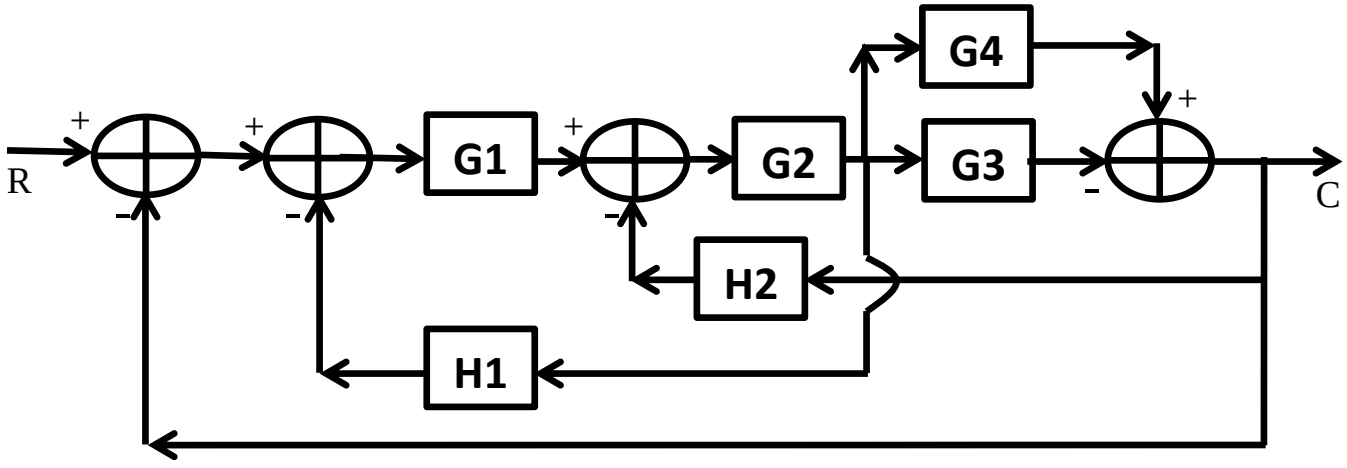


Rule 9: Moving a Take-off point beyond a Summing point

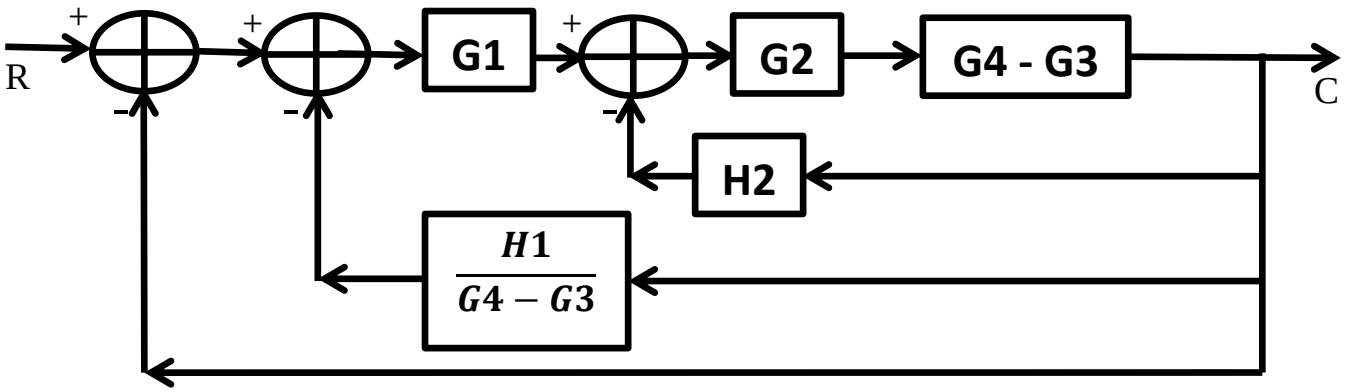


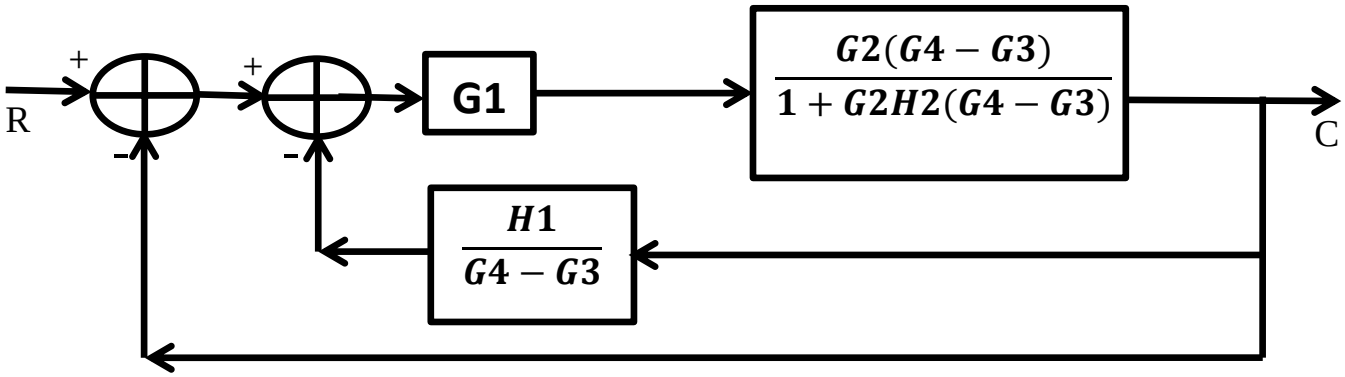
Example 2.1:

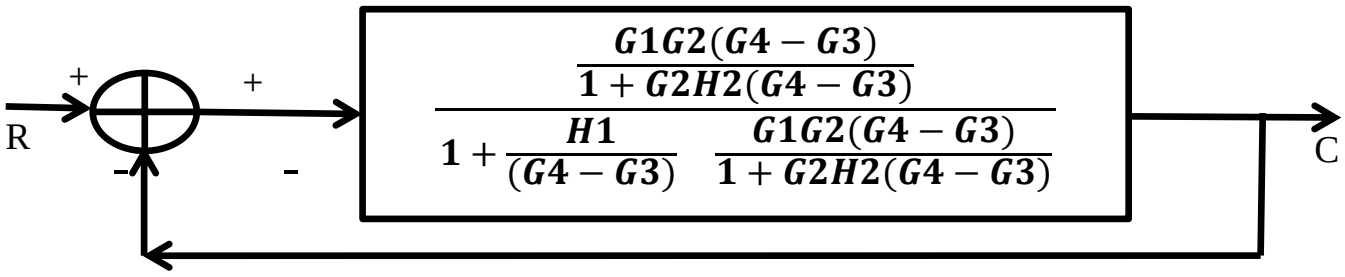
Obtain the transfer function of the block diagram control system using block diagram reduction method.

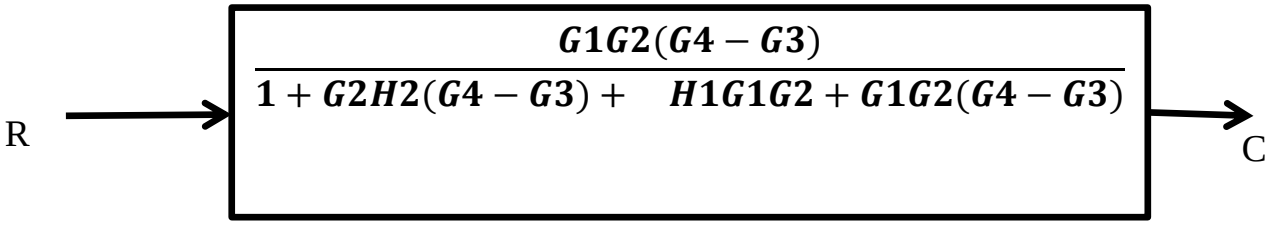


The solution of this type of problems will be based on detecting the combinations that match one or more of the rules previously explained.



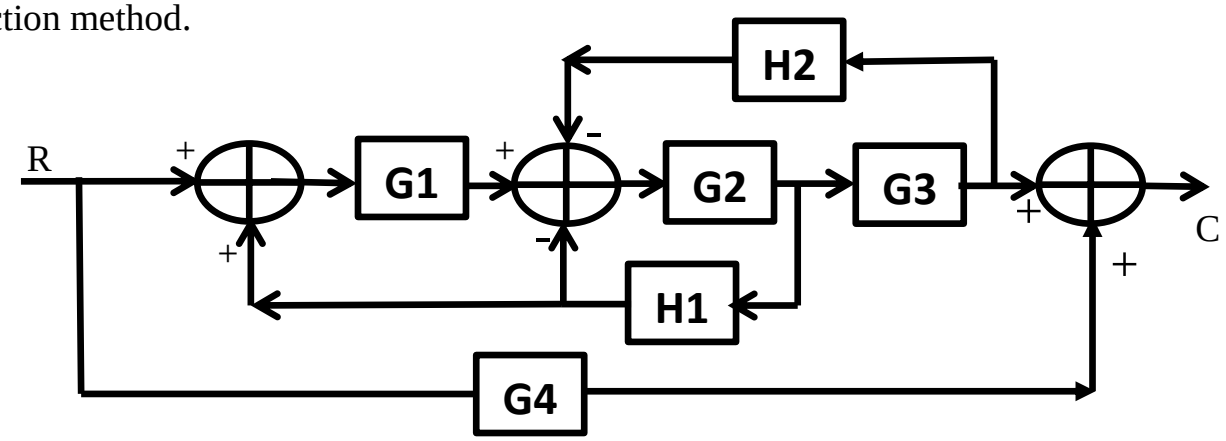




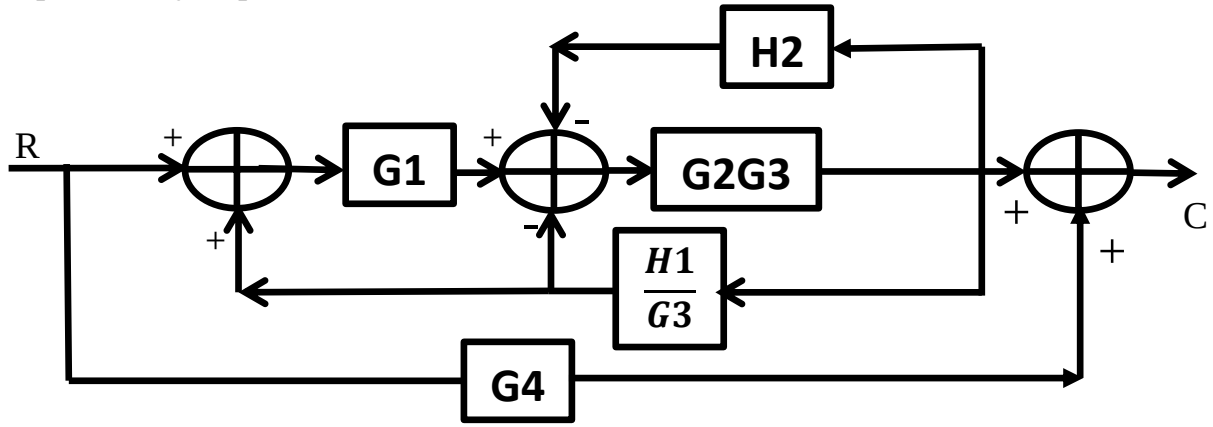


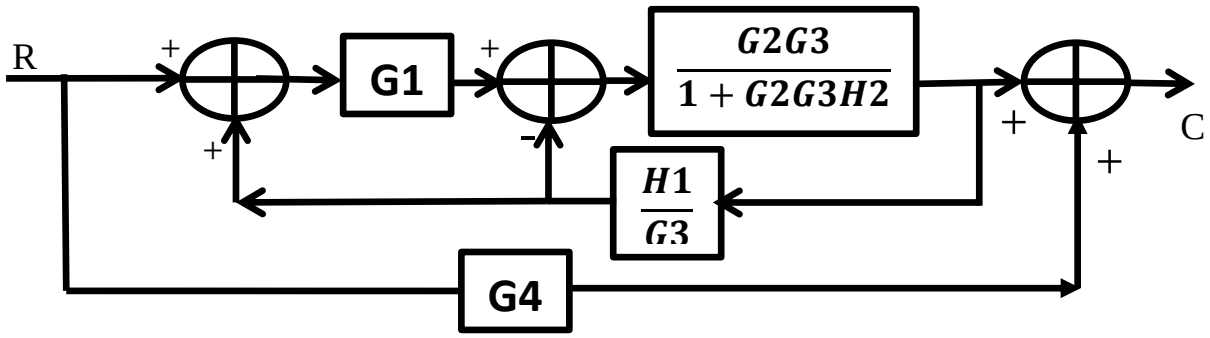
Example 2.2:

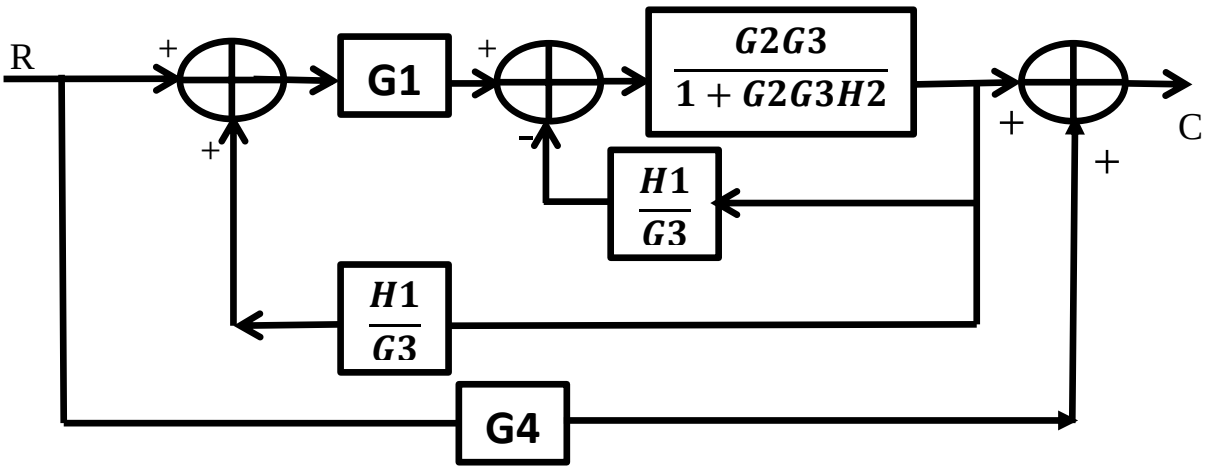
Obtain the transfer function of the block diagram control system using block diagram reduction method.

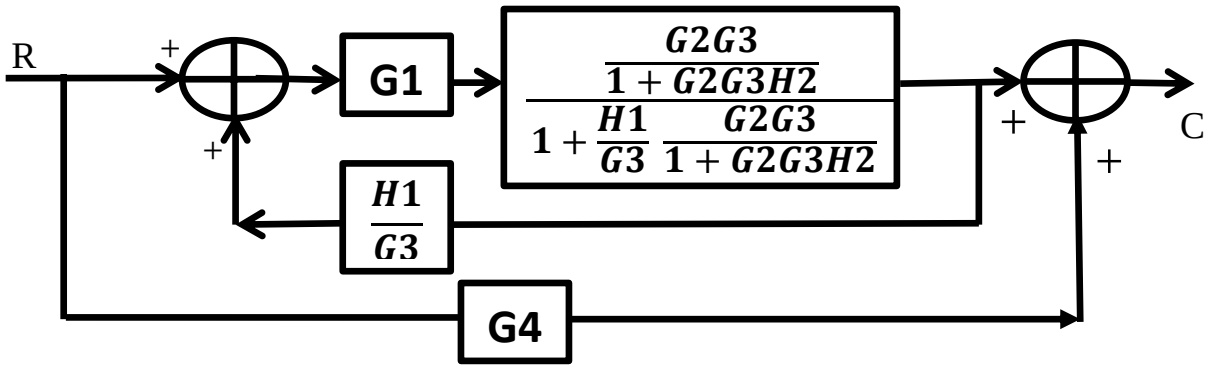


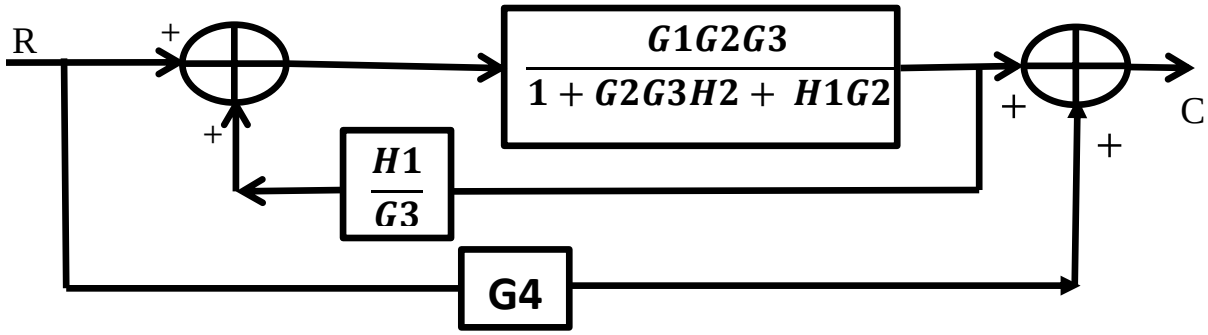
Using the previously explained rules:

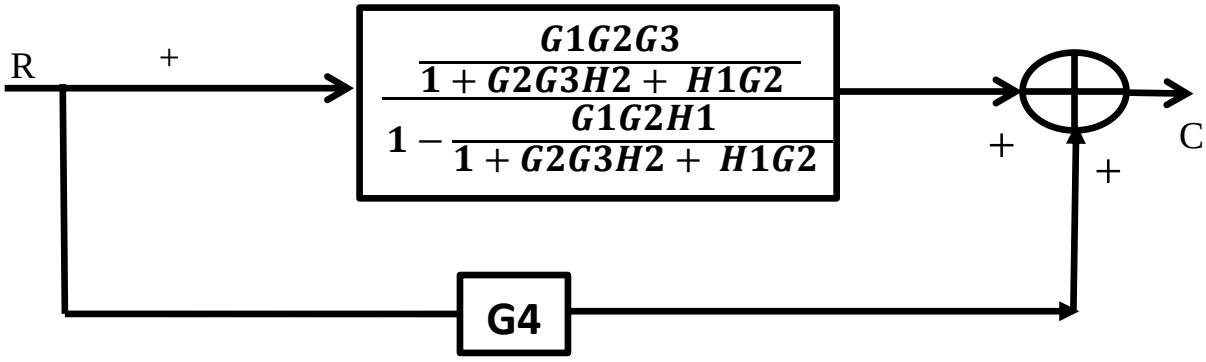


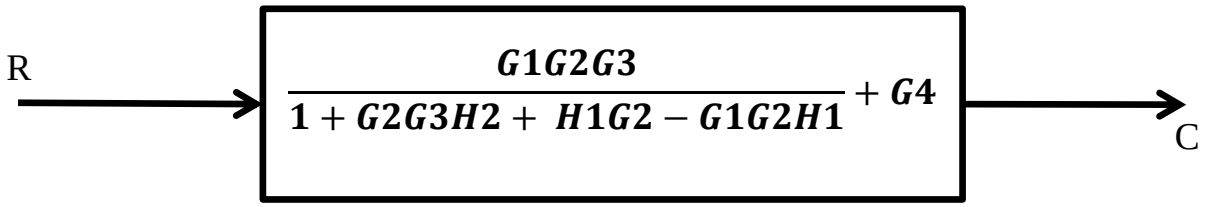



R
+
G1
+
$\frac{G2G3}{1+G2G3H2}$
+
C
+
+
$\frac{H1}{G3}$
$\frac{H1}{G3}$
G4


R
+
G1
$\frac{\frac{G2G3}{1+G2G3H2}}{1+\frac{H1}{G3}\frac{G2G3}{1+G2G3H2}}$
+
C
+
+
$\frac{H1}{G3}$
G4


R
+
$\frac{G1G2G3}{1+G2G3H2+H1G2}$
+
C
+
+
$\frac{H1}{G3}$
G4

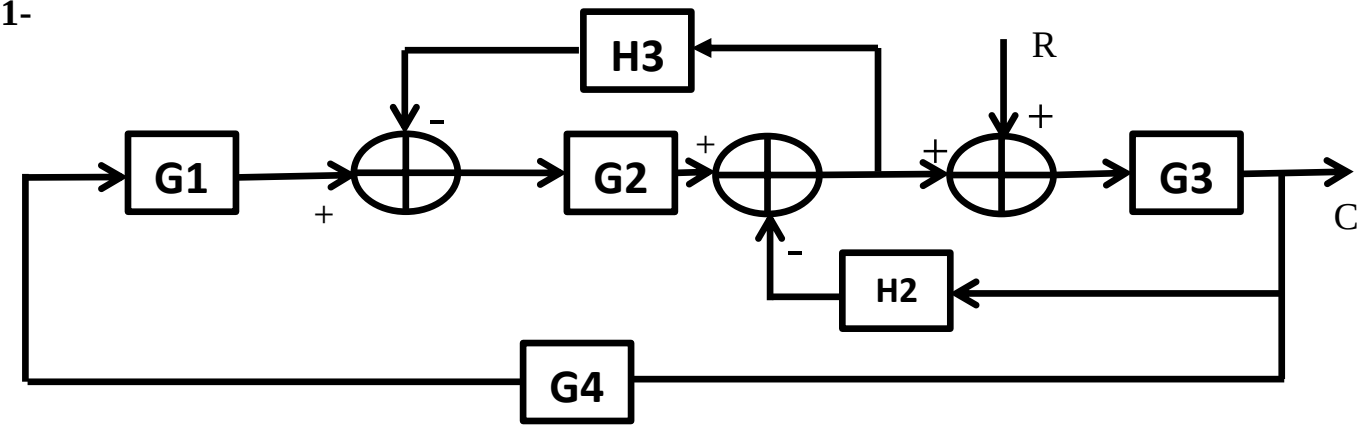

R
+
$\frac{\frac{G1G2G3}{1+G2G3H2+H1G2}}{1-\frac{G1G2H1}{1+G2G3H2+H1G2}}$
+
C
+
+
G4



Exercises:

Obtain the transfer function of the following block diagram control systems using block diagram reduction method.

1-



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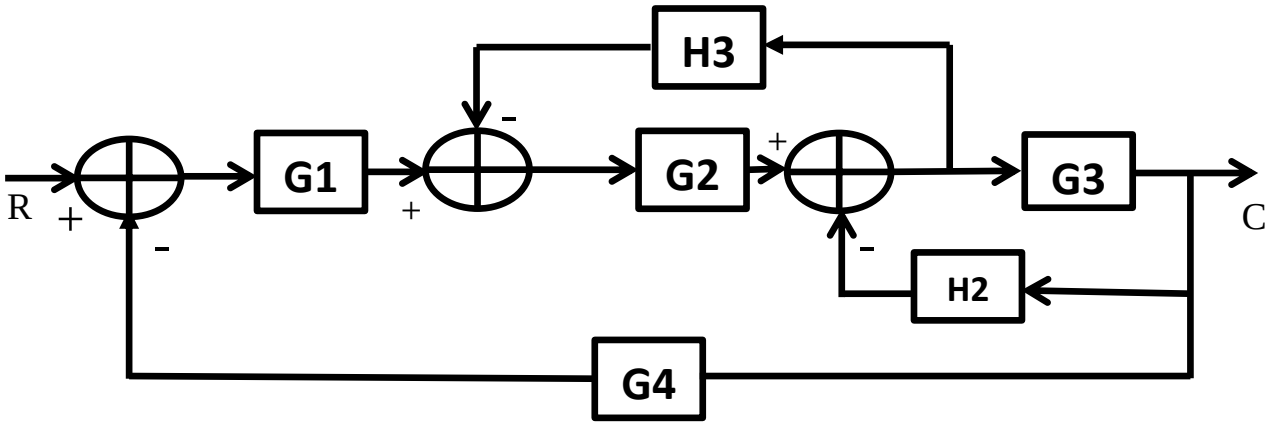

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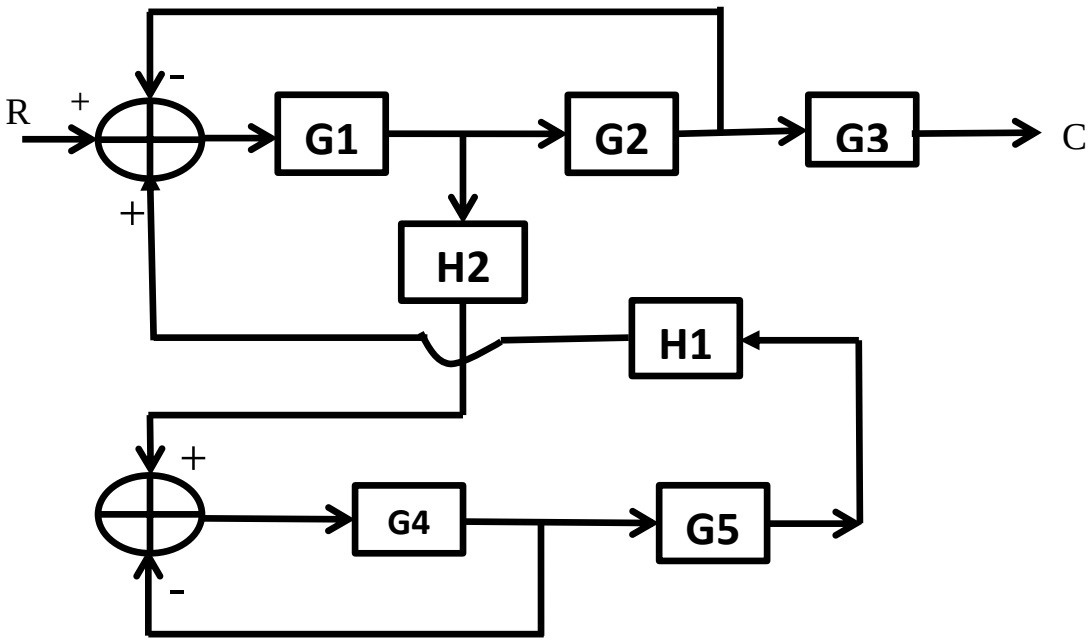

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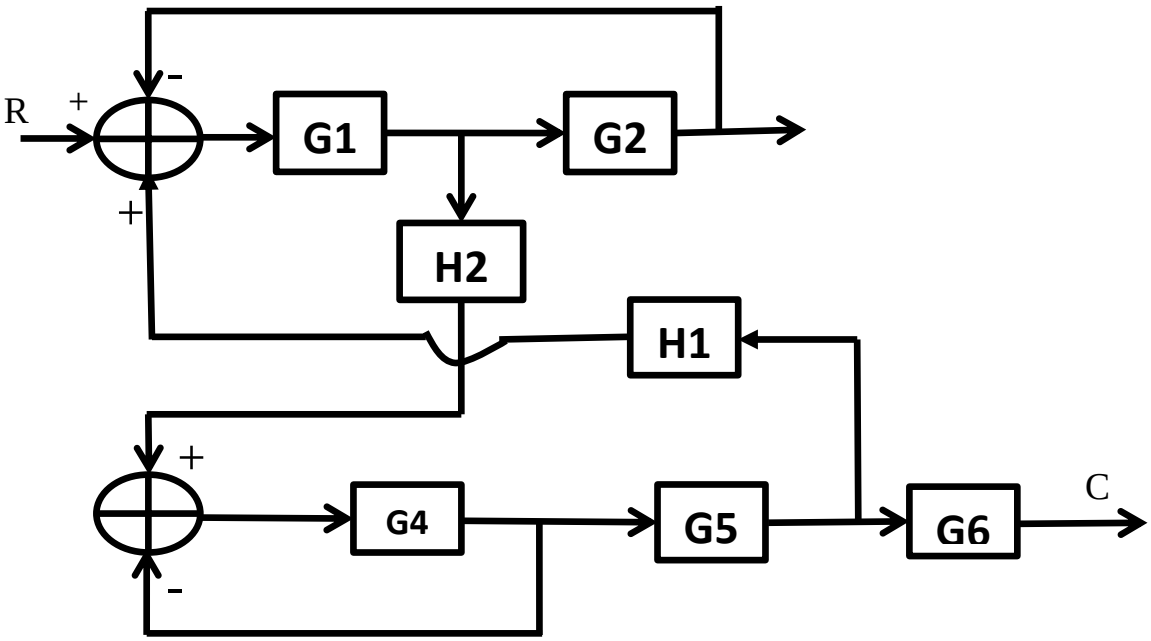

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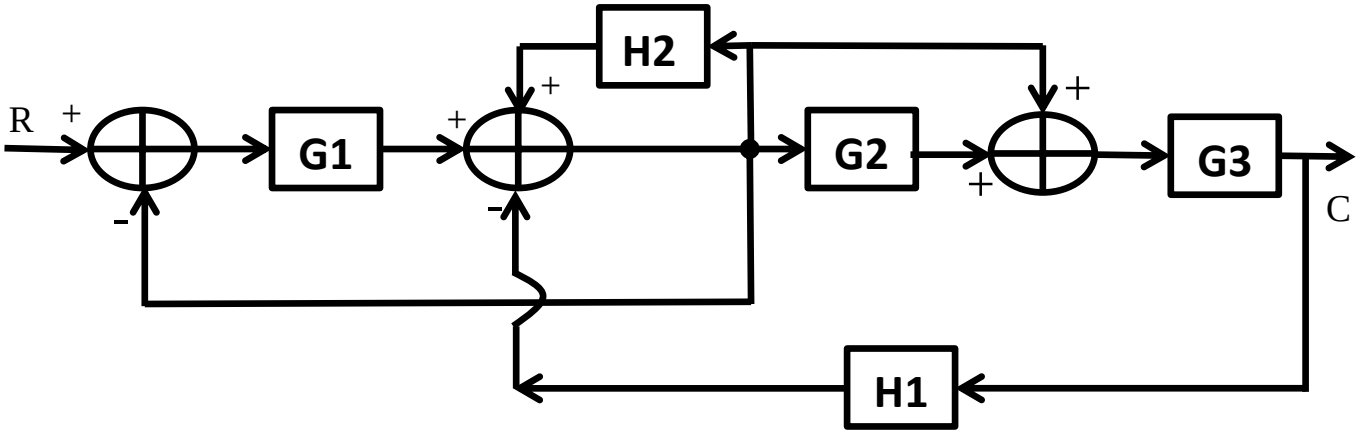

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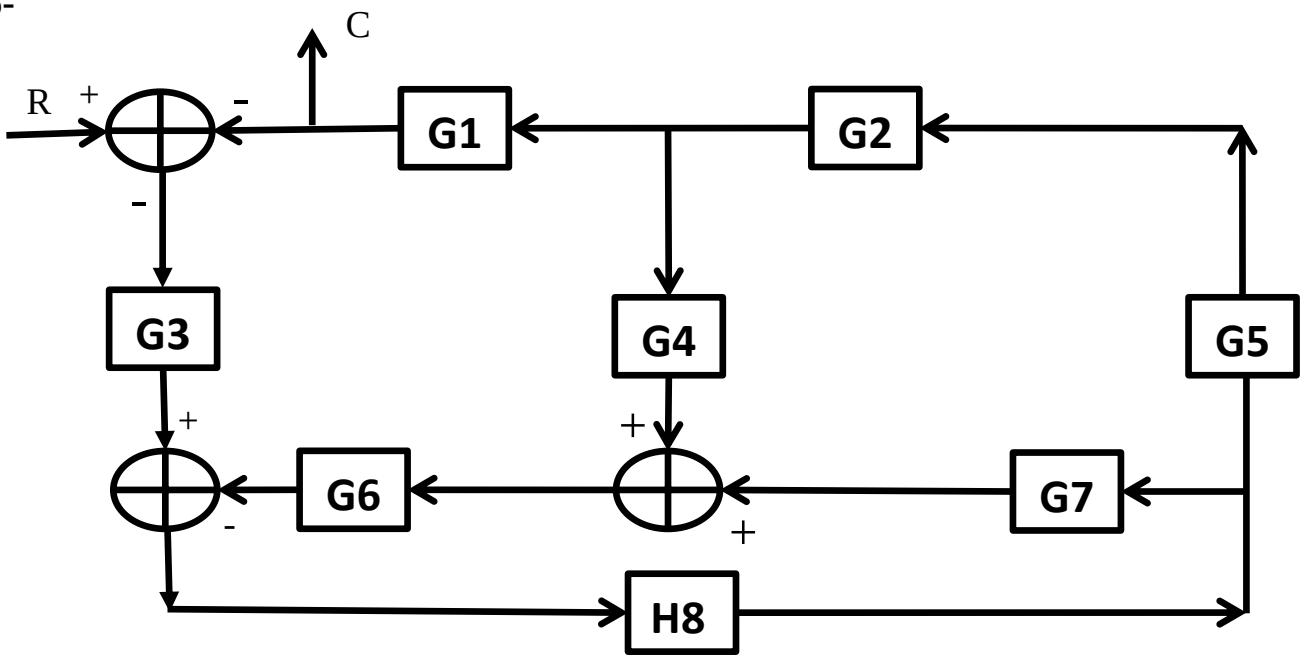

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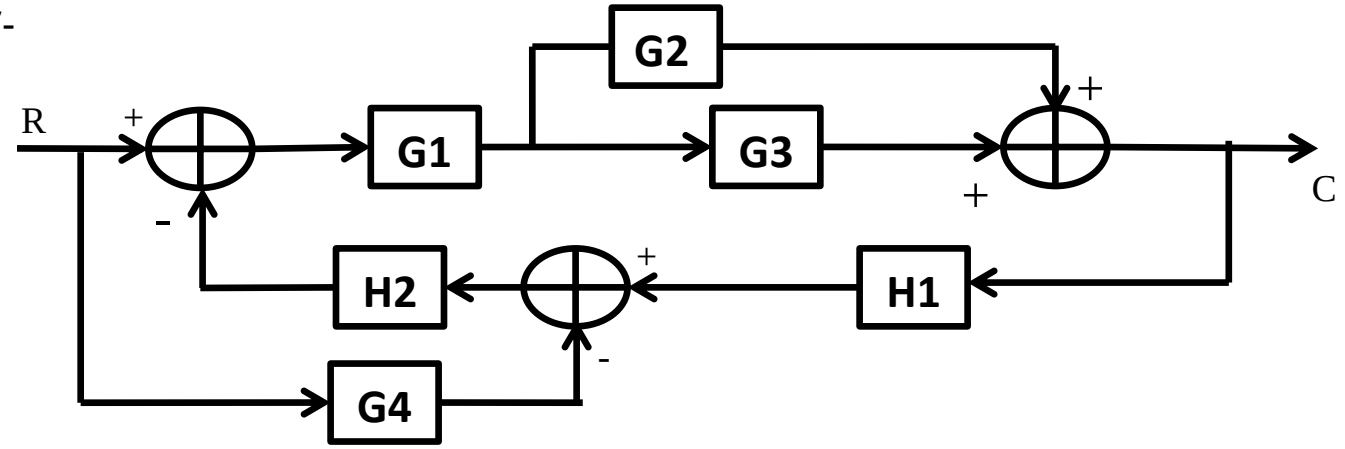

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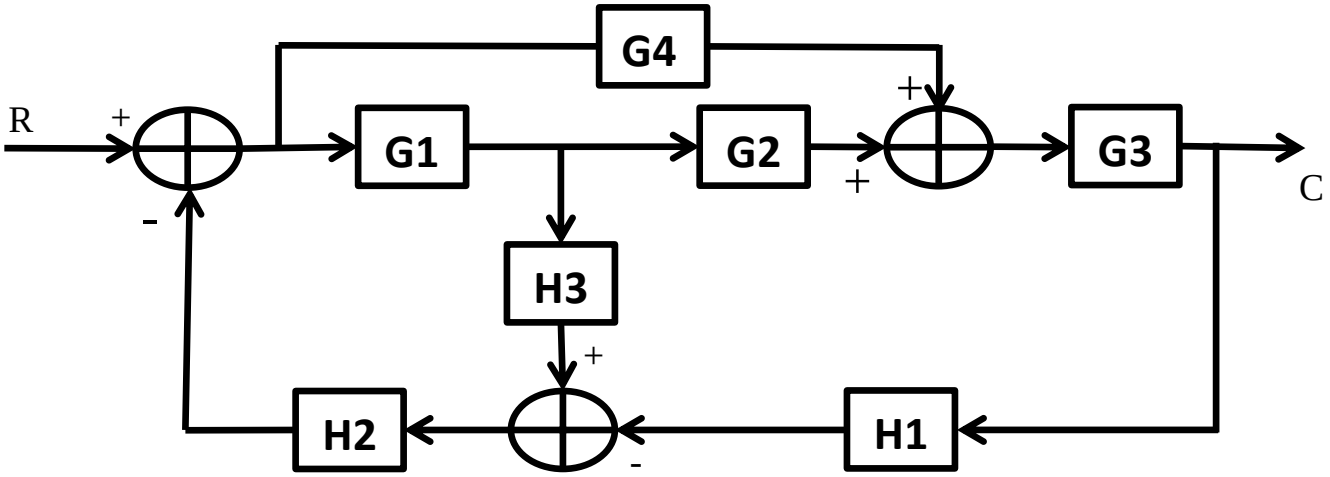

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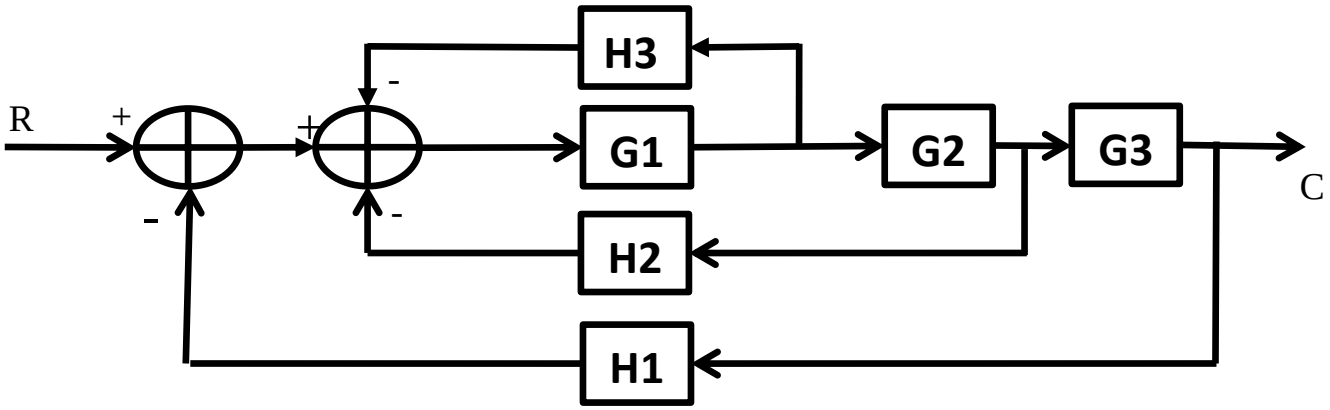

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