SNS COLLEGE OF ENGINEERING

Kurumbapalayam (Po), Coimbatore – 641 107

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DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

COURSE NAME : 23EET206 CONTROL SYSTEMS AND INSTRUMENTATION

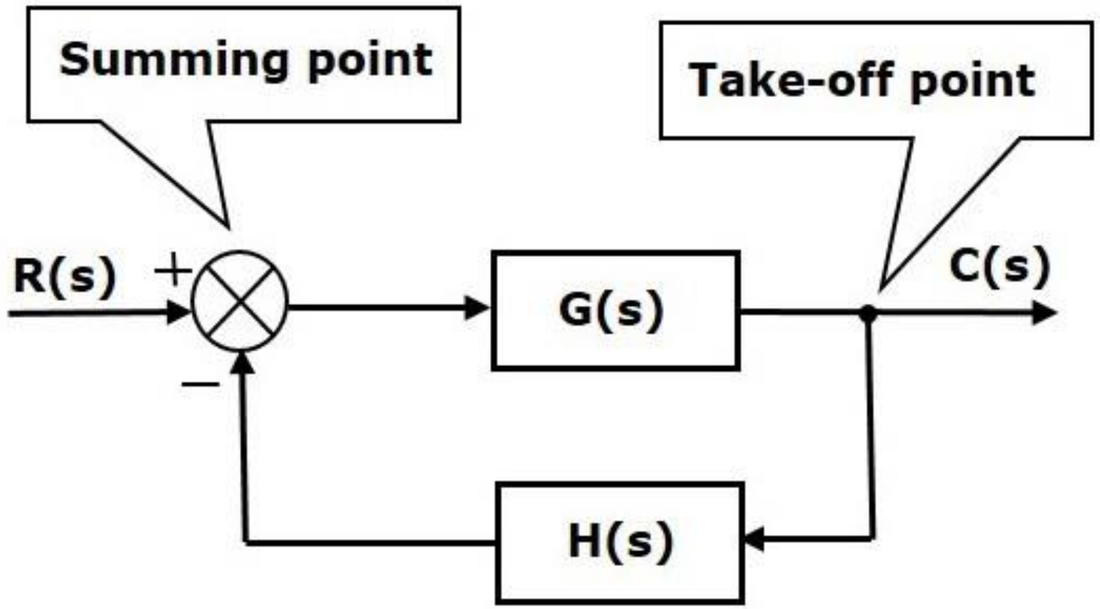
II YEAR ECE /III SEMESTER

Unit 1- Control System Modelling

Topic 6 : Block Diagram Reduction Technique

BLOCK DIAGRAM

- Block diagrams consist of a single block or a combination of blocks. These are used to represent the control systems in pictorial form.
- The basic elements of a block diagram are a block, the summing point and the take-off point.



BLOCK

The transfer function of a component is represented by a block. Block has single input and single output.

The following figure shows a block having input X(s), output Y(s) and the transfer function G(s).

Transfer Function, $G(s)=Y(s)X(s)$

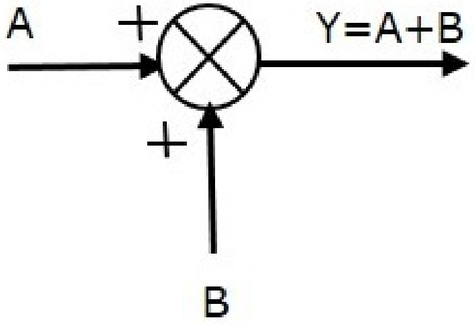
$$\Rightarrow Y(s)=G(s)X(s)$$

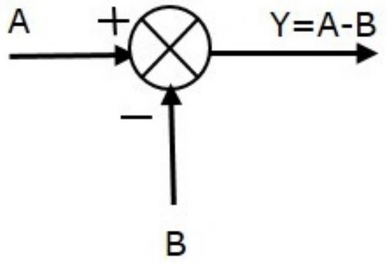
Output of the block is obtained by multiplying transfer function of the block with input.

SUMMING POINT

- The summing point is represented with a circle having cross (X) inside it. It has two or more inputs and single output.
- It produces the algebraic sum of the inputs.
- It also performs the summation or subtraction or combination of summation and subtraction of the inputs based on the polarity of the inputs. Let us see these three operations one by one. The inputs A and B have a positive sign.

So, the summing point produces the output, Y as sum of A and B.

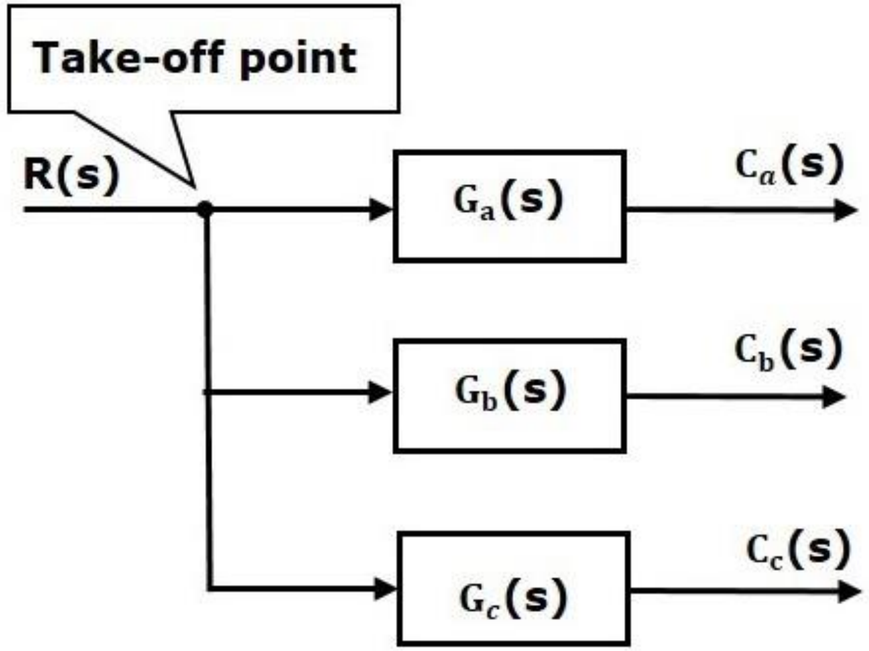


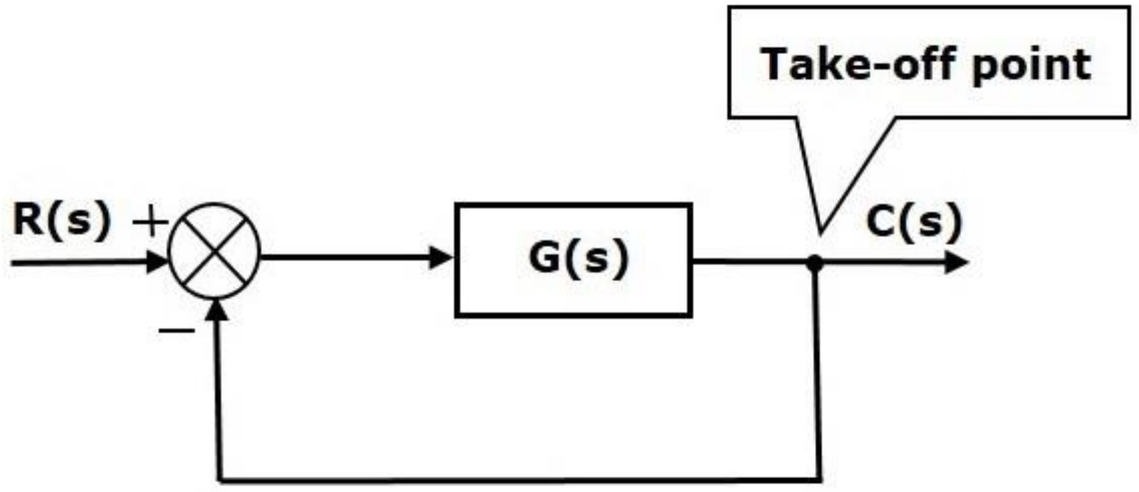


$$Y = A + (-B) = A - B$$

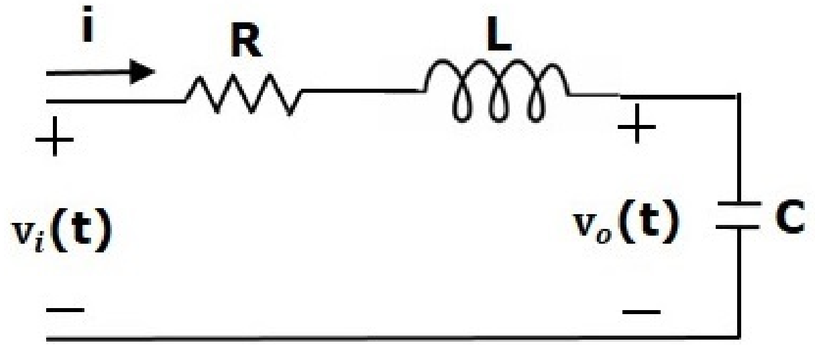
TAKE-OFF POINT

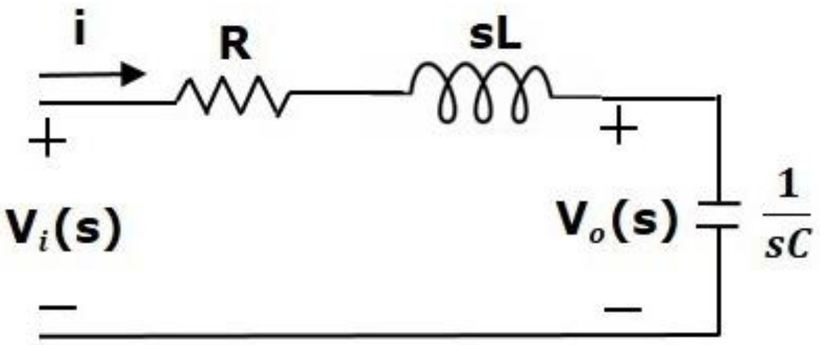
- The take-off point is a point from which the same input signal can be passed through more than one branch. That means with the help of take-off point, we can apply the same input to one or more blocks, summing points.
- The take-off point is used to connect the same input, R(s) to two more blocks.





BLOCK DIAGRAM REPRESENTATION OF ELECTRICAL SYSTEMS





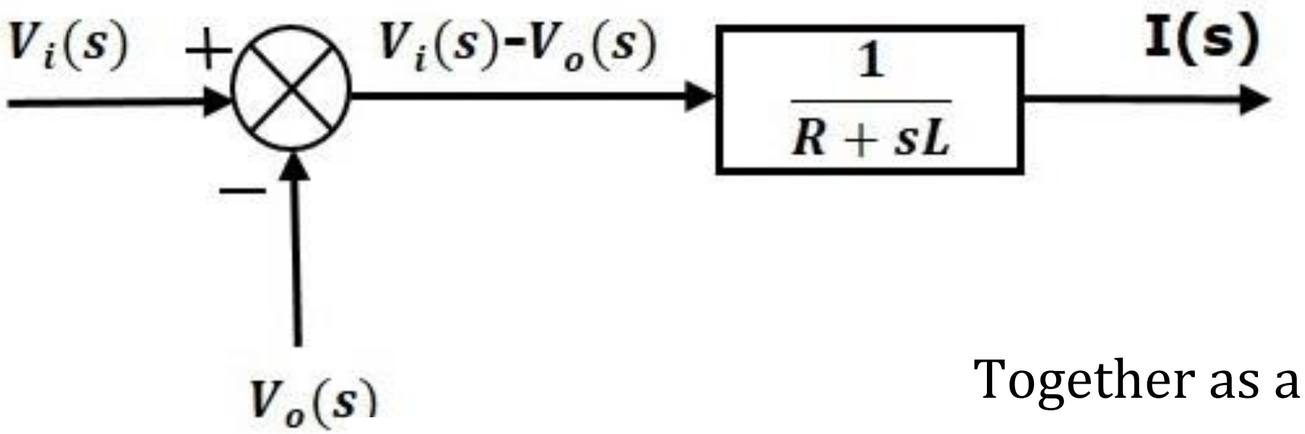
$$I(s) = \frac{V_i(s) - V_o(s)}{R + sL}$$

$$\Rightarrow I(s) = \left\{ \frac{1}{R+sL} \right\} \{V_i(s) - V_o(s)\} \qquad \textbf{(Equation 1)}$$

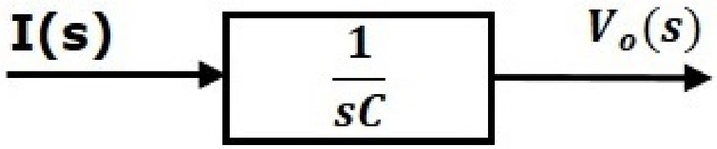
$$V_o(s) = \left(\frac{1}{sC} \right) I(s) \qquad \textbf{(Equation 2)}$$

BLOCK DIAGRAM REPRESENTATION OF ELECTRICAL SYSTEMS

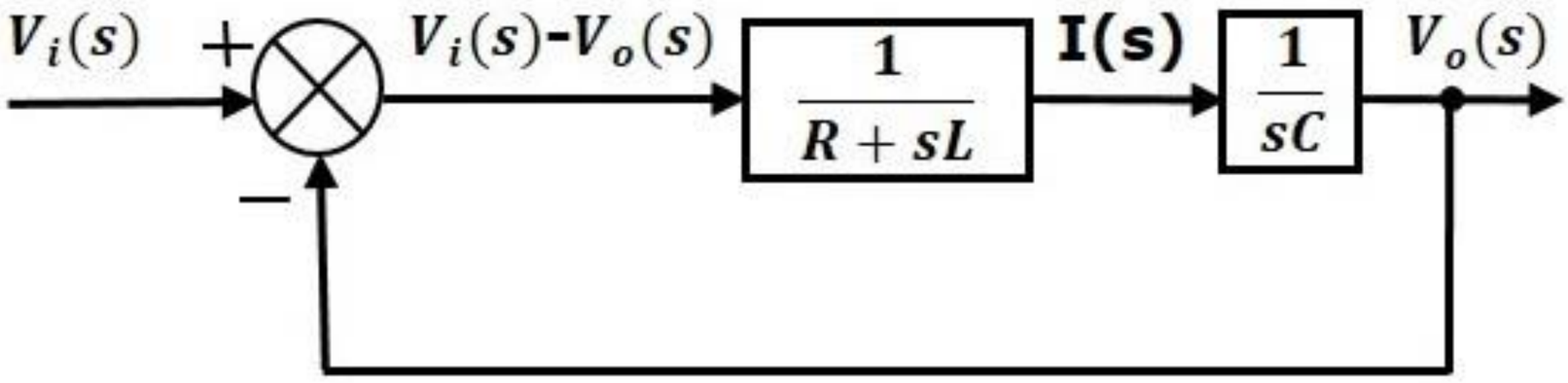
Equation 1



Equation 2

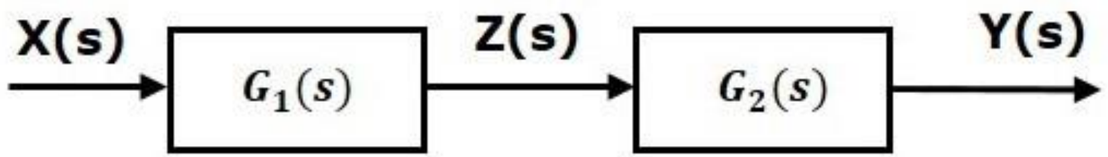


Together as a Block Diagram

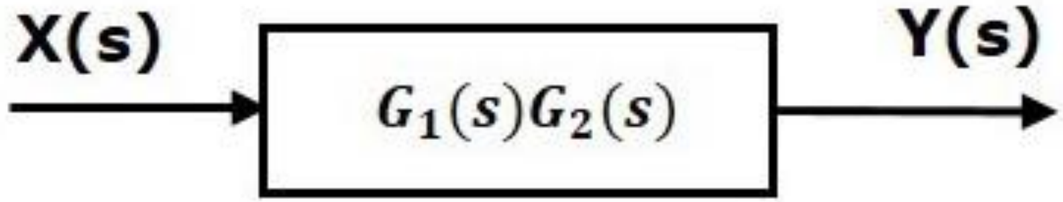


BASIC CONNECTIONS FOR BLOCKS

Series connection is also called cascade connection. In the following figure, two blocks having transfer functions G1(s) and G2(s) are connected in series.

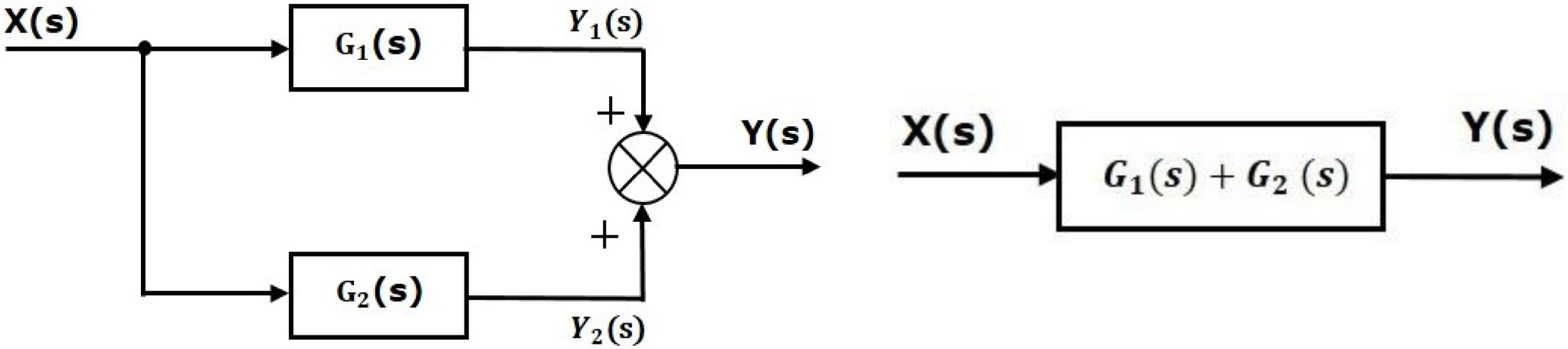


The series connection of two blocks with a single block. The transfer function of this single block is the product of the transfer functions of those two blocks.



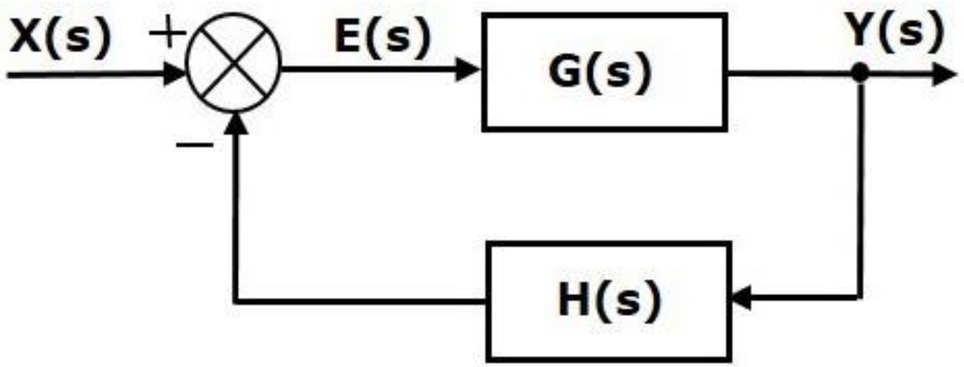
BASIC CONNECTIONS FOR BLOCKS

The blocks which are connected in parallel will have the same input. In the following figure, two blocks having transfer functions G1(s) and G2(s) are connected in parallel. The outputs of these two blocks are connected to the summing point.



BASIC CONNECTIONS FOR BLOCKS

There are two types of feedback — positive feedback and negative feedback. The following figure shows negative feedback control system. Here, two blocks having transfer functions G(s) and H(s) form a closed loop.



The output of the summing point is -

$$E(s) = X(s) - H(s)Y(s)$$

The output $Y(s)$ is -

$$Y(s) = E(s)G(s)$$

Substitute $E(s)$ value in the above equation.

$$Y(s) = \{X(s) - H(s)Y(s)\}G(s)\}$$

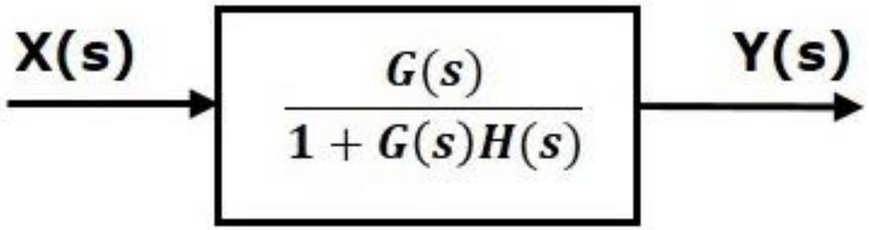
$$Y(s)\{1 + G(s)H(s)\} = X(s)G(s)\}$$

$$\Rightarrow \frac{Y(s)}{X(s)} = \frac{G(s)}{1 + G(s)H(s)}$$

Therefore, the negative feedback closed loop transfer function is $\frac{G(s)}{1+G(s)H(s)}$

BASIC CONNECTIONS FOR BLOCKS

This means we can represent the negative feedback connection of two blocks with a single block. The transfer function of this single block is the closed loop transfer function of the negative feedback. The equivalent block diagram is

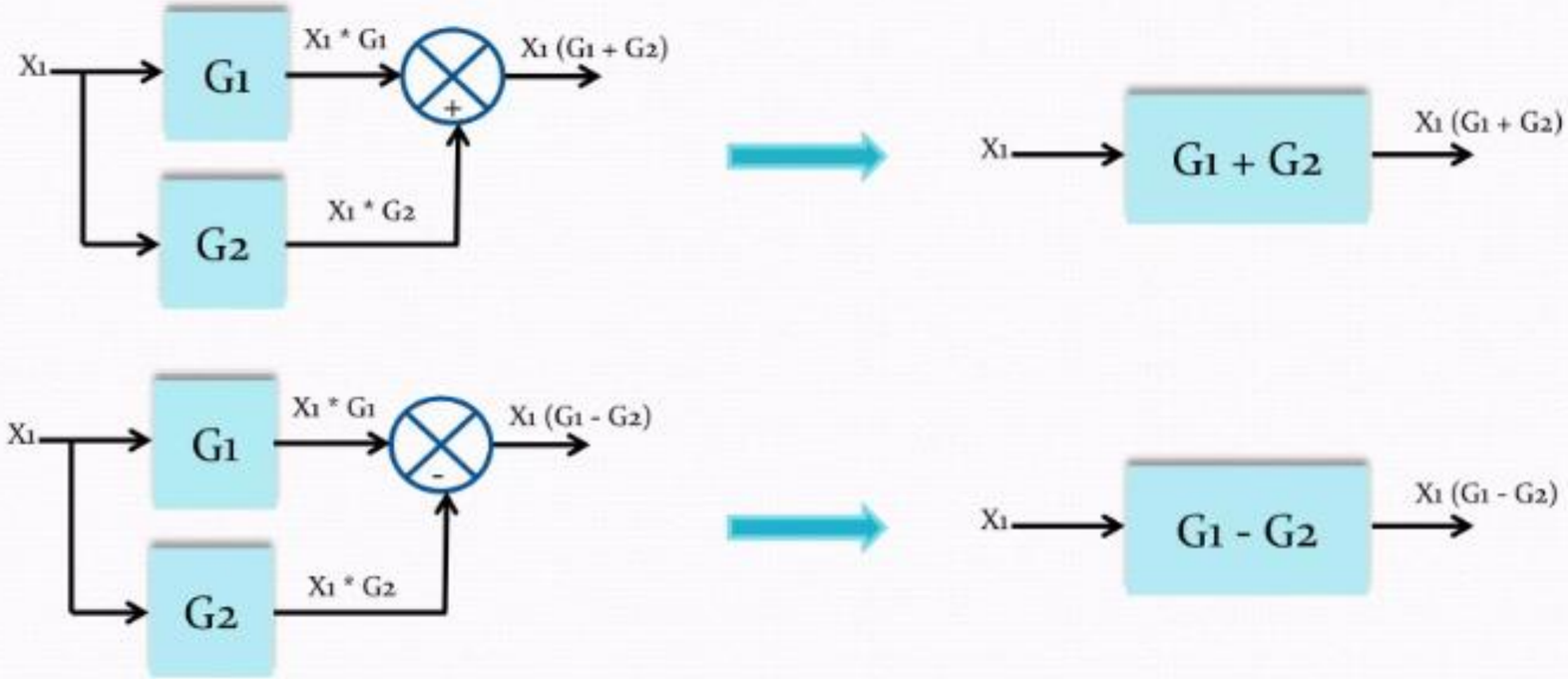


Similarly, you can represent the positive feedback connection of two blocks with a single block. The transfer function of this single block is the closed loop transfer function of the positive feedback, i.e., G(s)1−G(s)H(s)

BLOCK DIAGRAM REDUCTION TECHNIQUE

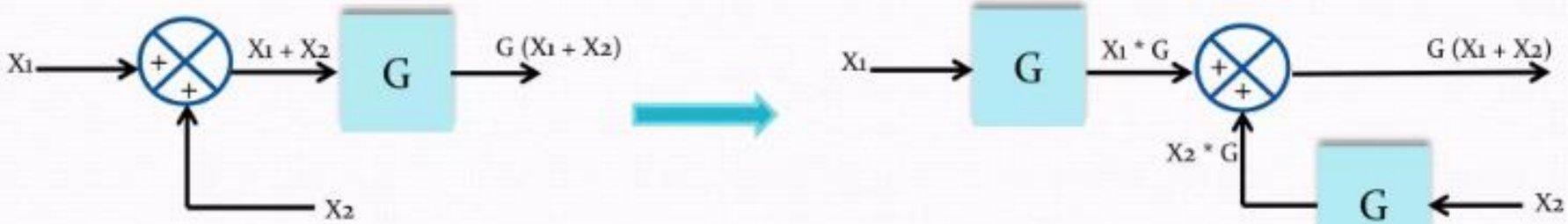
- **COMBINING BLOCKS IN CASCADE (SERIES)**

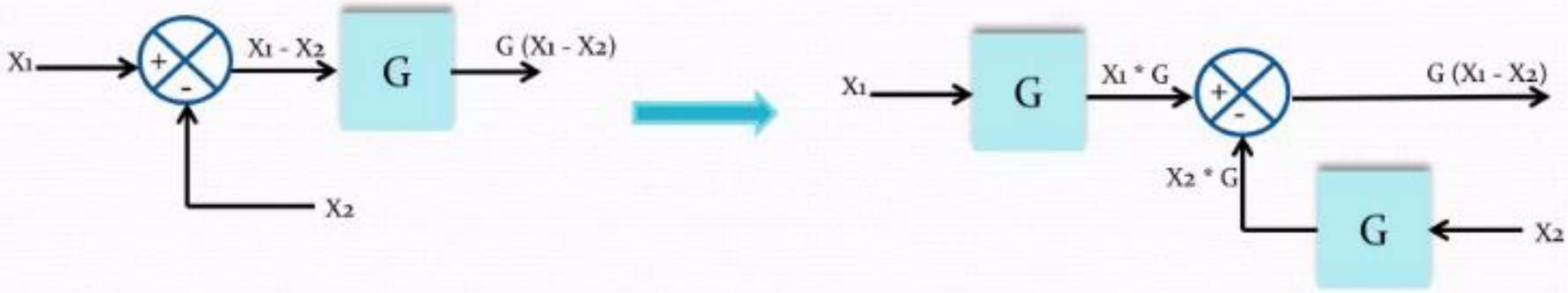
- **COMBINING BLOCKS IN CASCADE (PARALLEL)**



BLOCK DIAGRAM REDUCTION TECHNIQUE

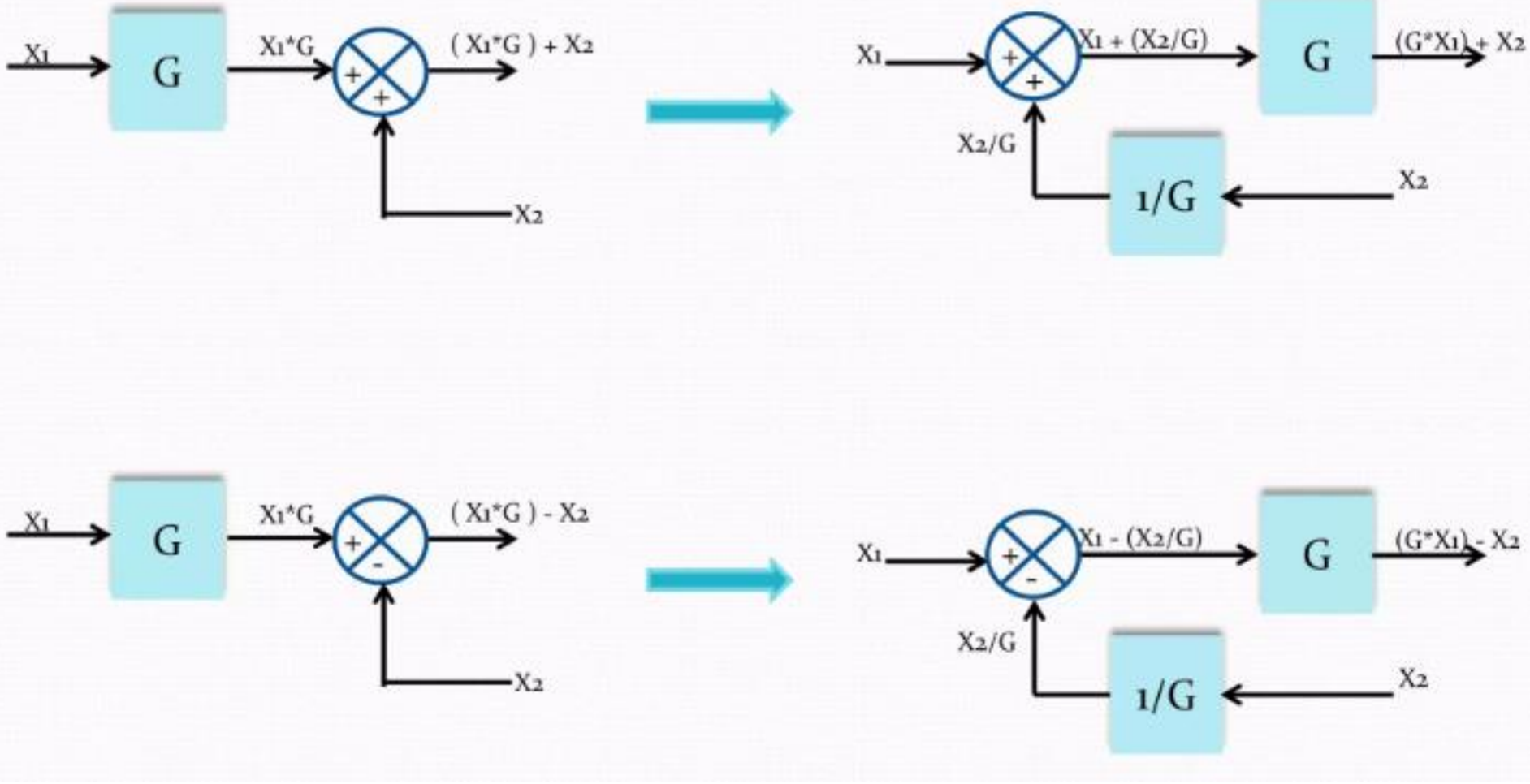
- **MOVING SUMMING POINT AFTER A BLOCK**





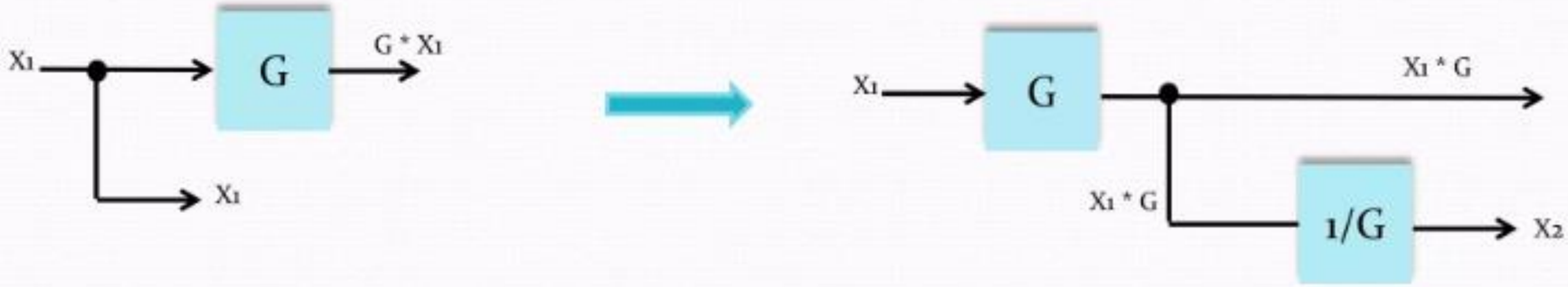
BLOCK DIAGRAM REDUCTION TECHNIQUE

- MOVING SUMMING POINT BEFORE A BLOCK



BLOCK DIAGRAM REDUCTION TECHNIQUE

- **MOVING A TAKE OFF POINT AFTER A BLOCK**

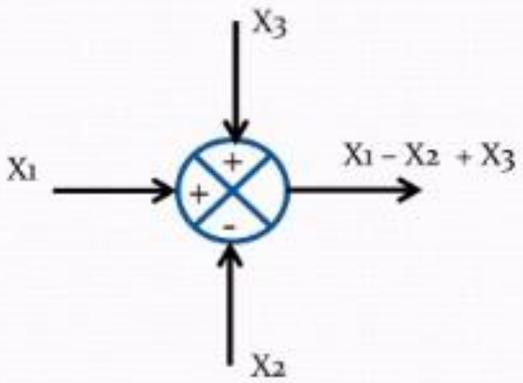


- **MOVING A TAKE OFF POINT BEFORE A BLOCK**

BLOCK DIAGRAM REDUCTION TECHNIQUE

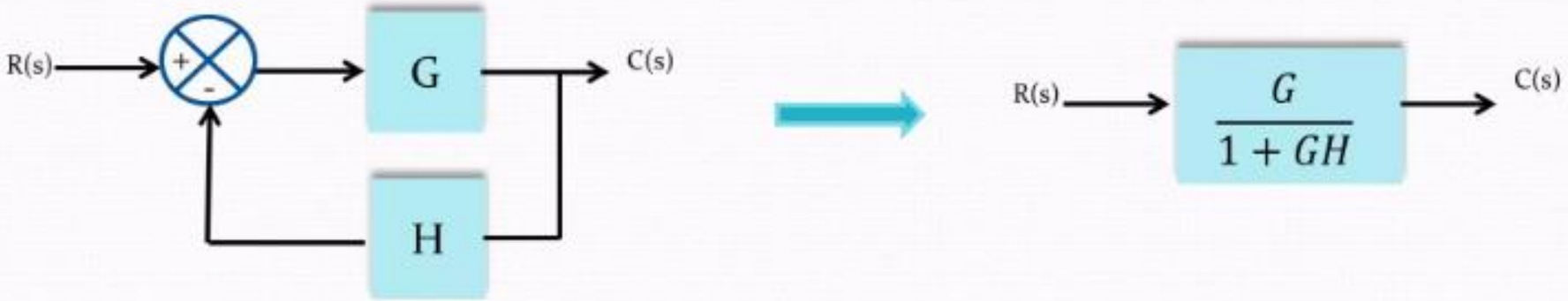
- **SWAP WITH TWO NEIGHBOURING SUMMING POINT**

- **WHEN TWO OR MORE SIGNALS ENTERING A SUMMING POINT**



BLOCK DIAGRAM REDUCTION TECHNIQUE

ELIMINATING A FEEDBACK LOOP



BLOCK DIAGRAM REDUCTION TECHNIQUE

- **SHIFTING TAKE OFF POINT AFTER SUMMING POINT**

- **SHIFTING TAKE OFF POINT AFTER SUMMING POINT**

References

1. Nagrath, J., Gopal, M., “Control System Engineering”, New Age International Publishers, 7th Edition, 2021 (Unit I-III).
2. Benjamin.C.Kuo.,“Automatic Control Systems”, Prentice Hall of India, New Delhi, 9th Edition,2007 (Unit I-III).
3. Richard C. Dorf and Robert H. Bishop, “Modern Control Systems”, Addison, 12th Edition, 2010. (Unit I-III).
4. Katsuhiko Ogata, “Modern Control Engineering”, Prentice Hall of India, New Delhi, 5th Edition, 2009(Unit I-III).

Thank You