Signal Flow Graph

There are some basic terms connected to signal flow graph. These are

i. **Node:** The point at which branches meet is known as node. If a node has only outgoing branches, then it is known as input node. While if the same has only incoming branches, it is known as output node.

ii. **Forward Path:** The path from input to output without repeating any node.

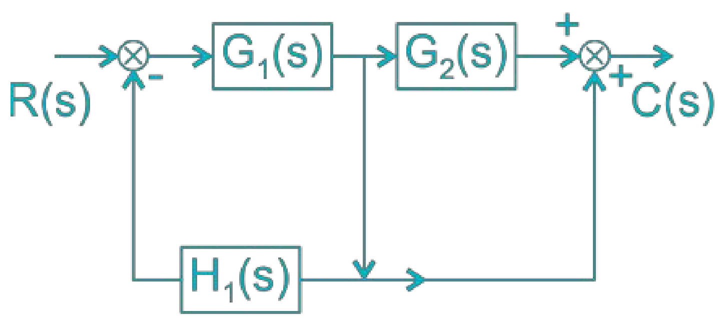
iii. **Loop:** The path which originates and terminates on the same node with no repetition of other nodes.

iv. **Path gain:** The product of the branch gains along the path.

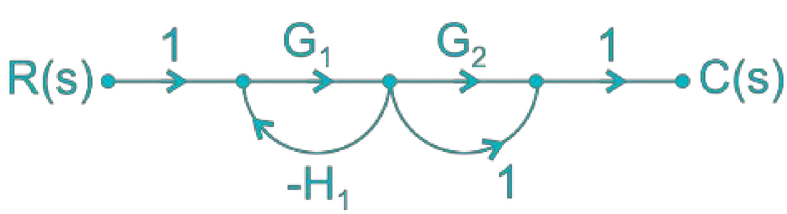
v. **Loop gain:** The product of the branch gain of the branches coming in the loop.

vi. **Non Touching Loop:** The loops which have no common nodes, branches and paths.

How a block diagram is changed to signal flow graph has been demonstrated below -



Block Diagram



Signal Flow Graph

In the given signal flow graph, we can see the summing points and junctions are converted into nodes. While the gains in the block diagram been converted into paths.

Now, we can calculate the gain from this signal flow graph using Mason's gain formula

It states that Gain, $T = \frac{\Sigma P_k \Delta_k}{\Delta}$

Here P_k = Gain of k^{th} forward path

Δ_k = 1 – (Sum of all individual loop gains not touching k^{th} forward path) + (Sum of product of gains of two non-touching loops not touching the k^{th} forward path) – …………

Δ = 1– (Sum of all individual loop gains) + (Sum of product of gains of two non-touching loops) – (Sum of product of gains of combinations of three non-touching loops) + ………….

Now, for the previously given signal flow graph,

There are two forward paths, G_1G_2 and G_1

There is only one loop, - G_1H_1

Also, this loop touches both forward paths.

Hence, $P_1 = G_1G_2$, $\Delta_1 = 1$

$P_2 = G_1$, $\Delta_2 = 1$

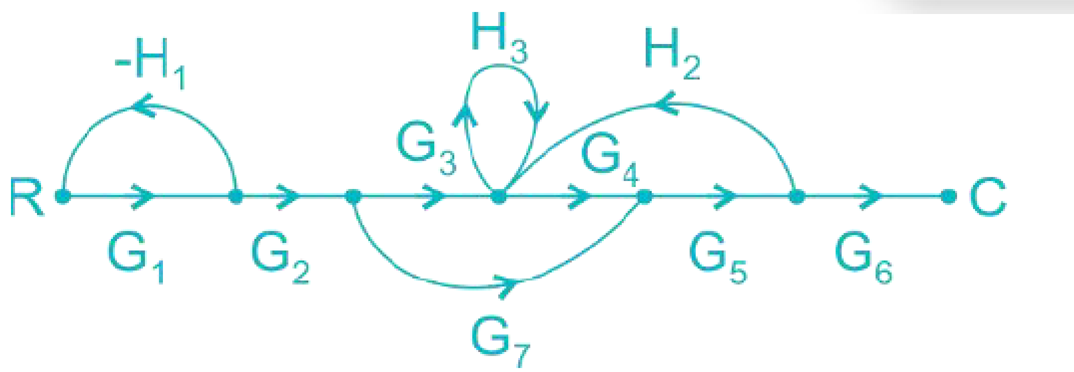
$\Delta = 1 - (-G_1H_1)$

$= 1 + G_1H_1$

Gain for the given system,

$$T = \frac{G1G2 + G1}{1 + G1H1}$$

Now, we will take the case for another signal flow graph given as below.



In the given graph, there are two forward paths.

$P_1 = G_1G_2G_3G_4G_5G_6$

$P2 = G_1G_2G_7G_5G_6$

There are three loops

$L_1 = -G_1H_1$

$L_2 = H_3$

$L_3 = G_4G_5H_2$

For P_1 path, all loops are touching it, hence $\Delta_1 = 1$.

For P_2 path, L_2 loop does not touch it, hence $\Delta_2 = 1 - H_3$

Now, L_1 & L_2 as well as L_1 & L_3 are non-touching loops

$\therefore \Delta = 1 - (L_1 + L_2 + L_3) + (L_1L_2 + L_1L_3)$

$= 1 - (-G_1H_1 + H_3 + G_4G_5H_2) + (-G_1H_1H_3 - G_1H_1G_4G_5H_2)$

$\Delta = 1 + G_1H_1 - H_3 - G_4G_5H_2 - G_1H_1H_3 - G_1G_4G_5H_1H_2$

Hence, gain $T = \frac{G_1G_2G_3G_4G_5G_6 + G_1G_2G_7G_5G_6(1-H_3)}{1+G_1H_1-H_3-G_4G_5H_2-G_1H_1H_3-G_1G_4G_5H_1H_2}$