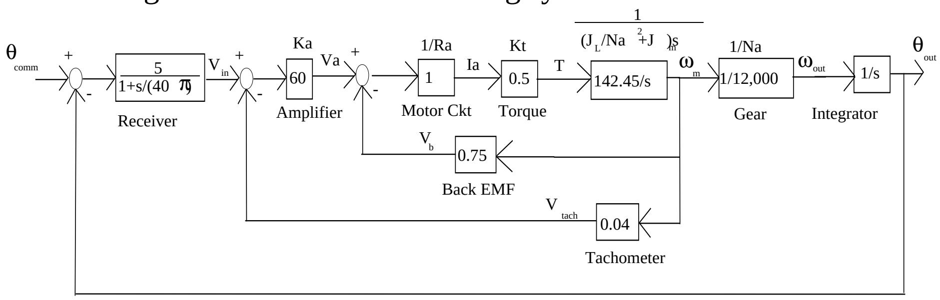
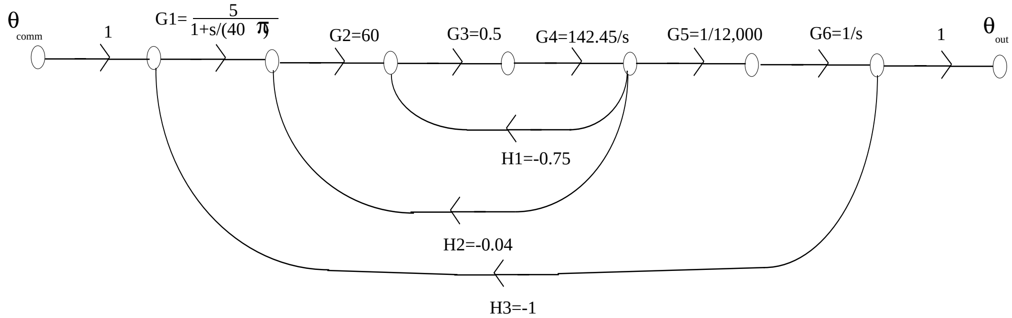
1a) The block diagram for the satellite tracking system is:



we can convert this to the following SFG:



By Mason's SFG Formula, the overall transfer function is:

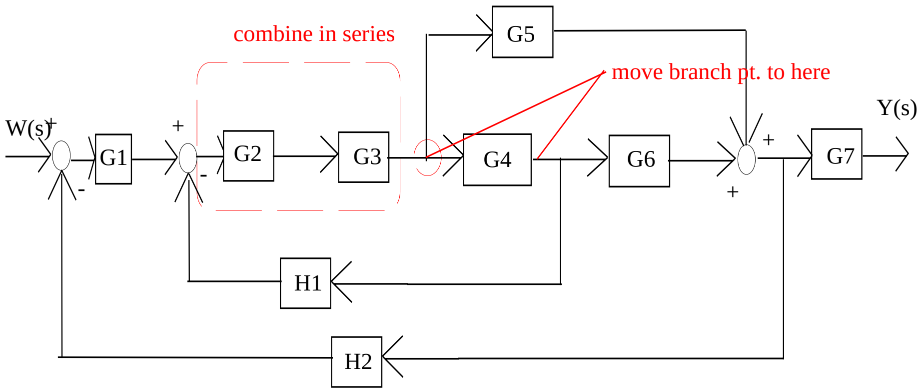
$$\frac{\theta_{out}}{\theta_{comm}} = \sum \frac{T_n \Delta_n}{\Delta} = \frac{T_1 \Delta_1}{\Delta}$$ where T_1=G1G2G3G4G5G6 and

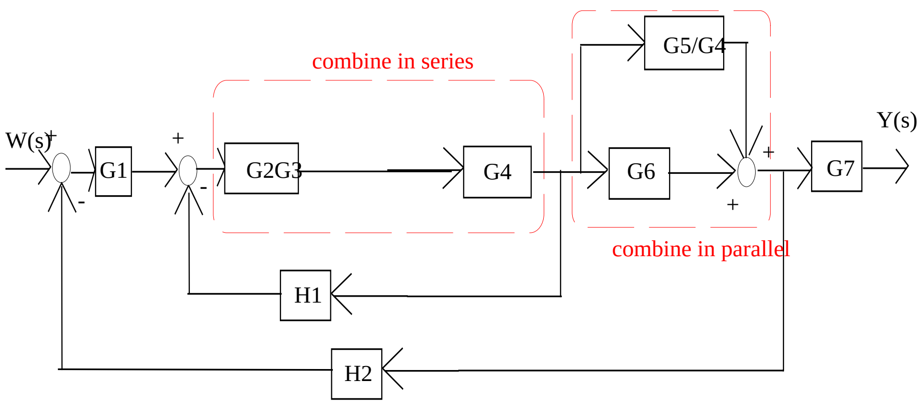
$$\Delta = 1 - \sum L_1's + \sum L_2's - \sum L_3's + \ldots$$
$$= 1 - [G1G2G3G4G5G6(H3) + G2G3G4(H2) + G3G4(H1)] + 0$$

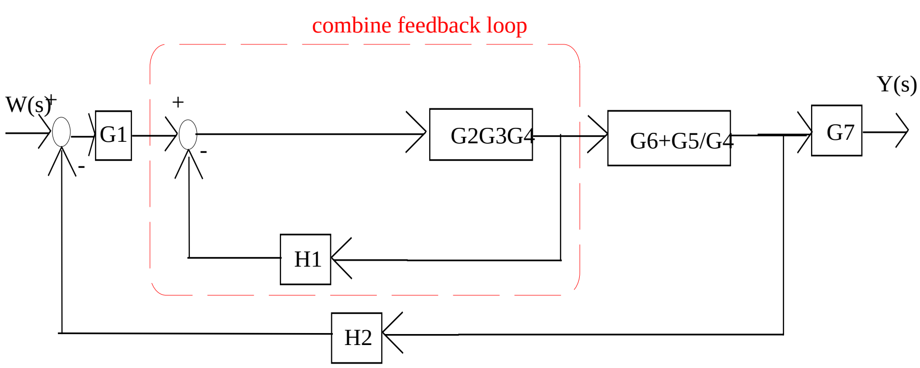
Thus, $\Delta_1 = 1$ and $\frac{\theta_{out}}{\theta_{comm}} = \frac{G1G2G3G4G5G6}{1 - G1G2G3G4G5G6H3 - G2G3G4H2 - G3G4H1}$

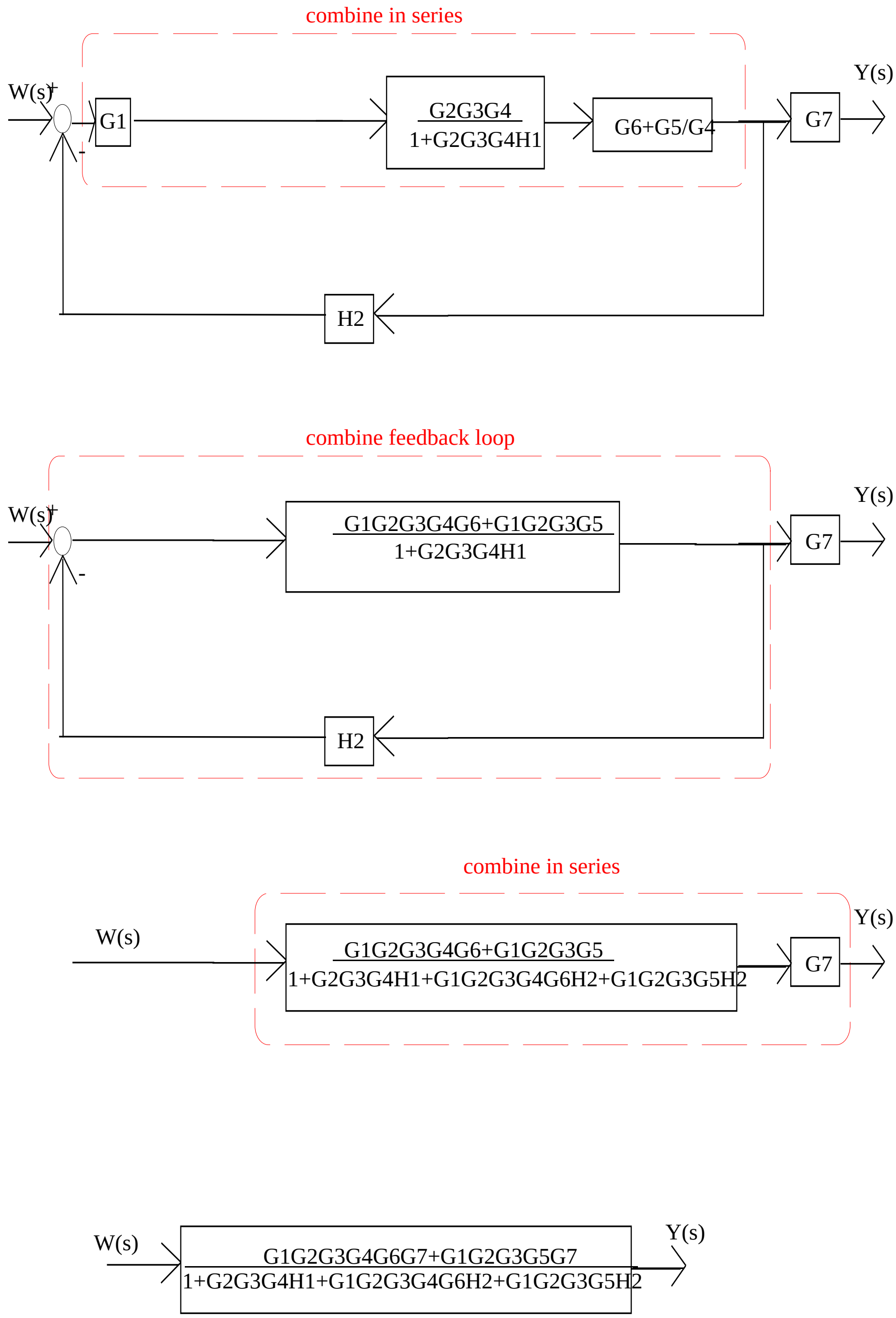
or $\frac{\theta_{out}}{\theta_{comm}} = \frac{223.9}{s^3 + 125.79s^2 + 30461.0s + 223.9}$

2a) i)

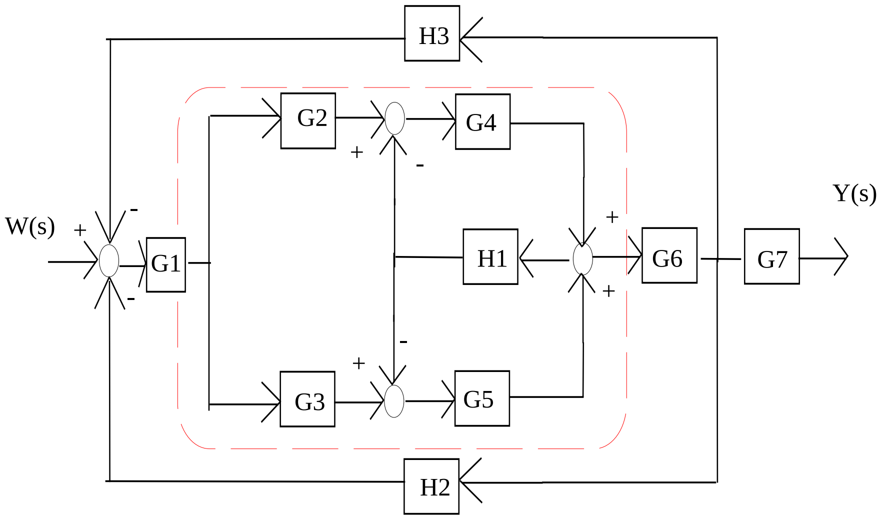

combine in series
G5
move branch pt. to here
Y(s)
W(s)
+
G1
+
-
-
G2
G3
G4
G6
+
+
G7
H1
H2


G5/G4
combine in series
Y(s)
W(s)
+
G1
+
-
-
G2G3
G4
G6
+
+
G7
combine in parallel
H1
H2

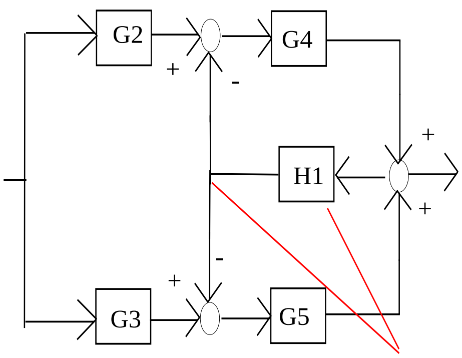

combine feedback loop
Y(s)
W(s)
+
G1
+
-
-
G2G3G4
G6+G5/G4
G7
H1
H2


combine in series
W(s)
+
-
G1
G2G3G4
1+G2G3G4H1
G6+G5/G4
G7
Y(s)
H2
combine feedback loop
W(s)
+
-
G1G2G3G4G6+G1G2G3G5
1+G2G3G4H1
G7
Y(s)
H2
combine in series
W(s)
G1G2G3G4G6+G1G2G3G5
1+G2G3G4H1+G1G2G3G4G6H2+G1G2G3G5H2
G7
Y(s)
W(s)
G1G2G3G4G6G7+G1G2G3G5G7
1+G2G3G4H1+G1G2G3G4G6H2+G1G2G3G5H2
Y(s)

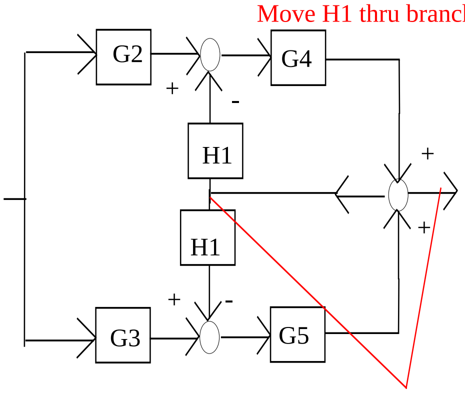
2aii)



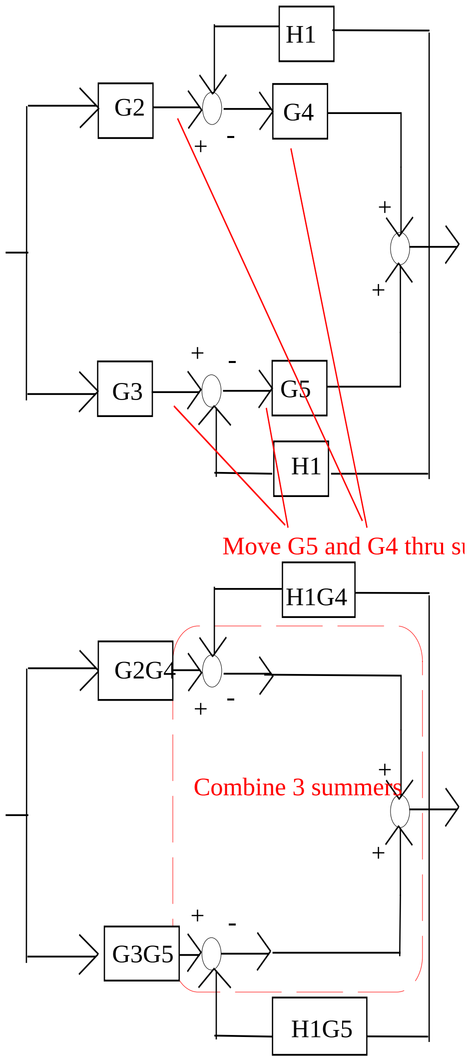
Reduce middle part first

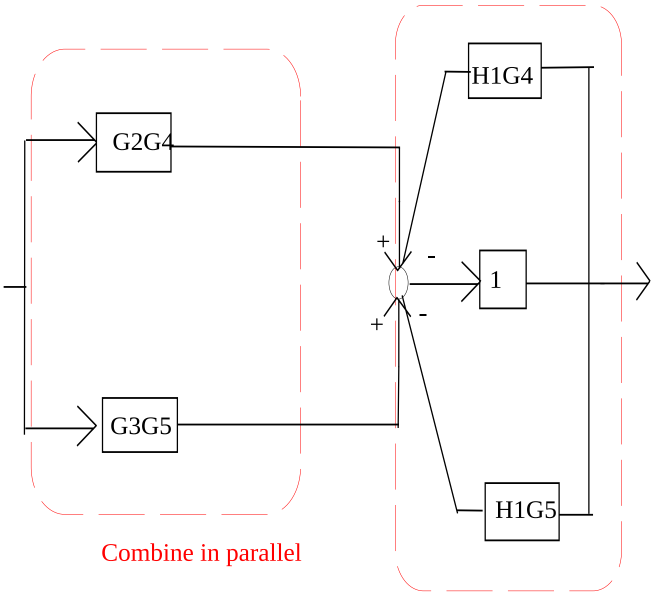


Move H1 thru brancl



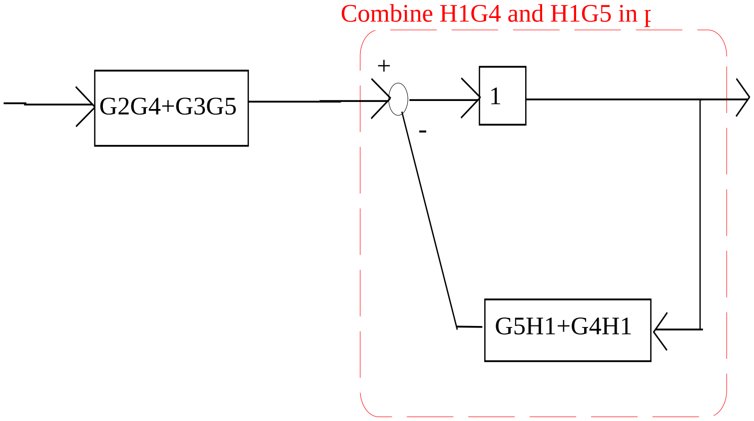
Attach branch pt. here anc


H1
G2
G4
G3
G5
H1
Move G5 and G4 thru su
H1G4
G2G4
Combine 3 summers
G3G5
H1G5

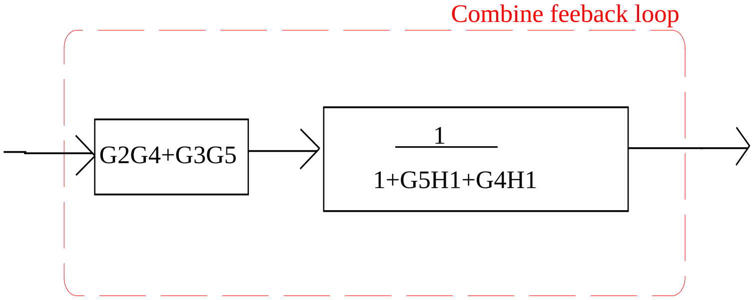


Combine in parallel

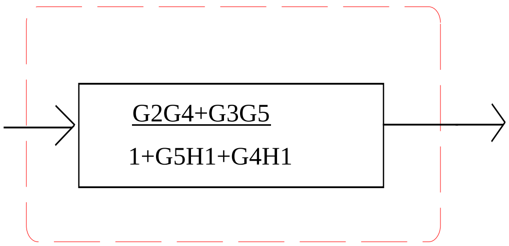
Combine H1G4 and H1G5 in p



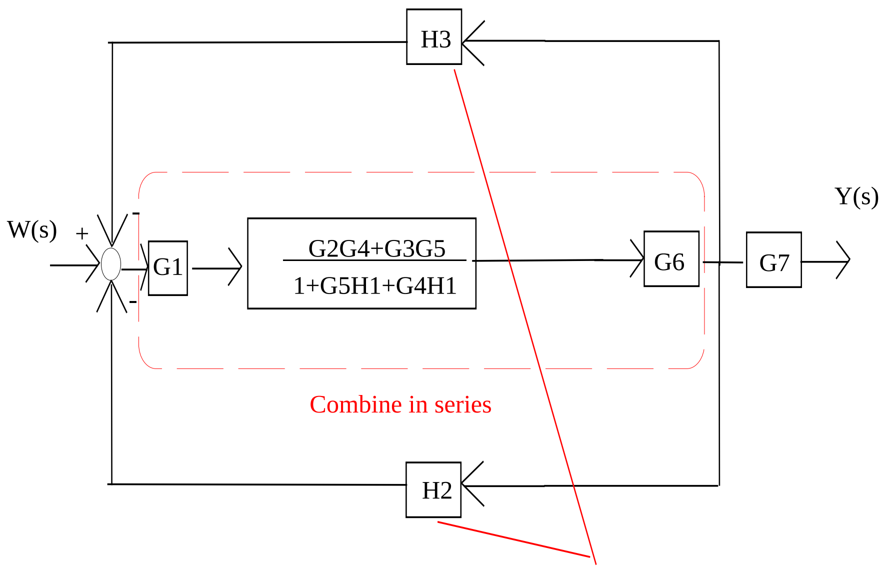
Combine feeback loop



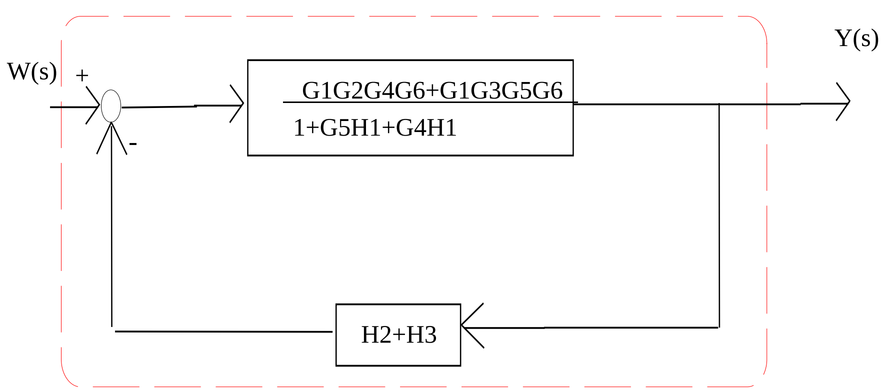
Combine in series



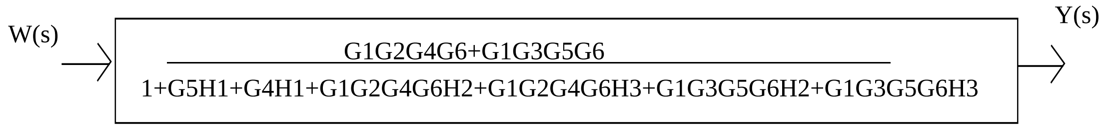
Insert back into diagram



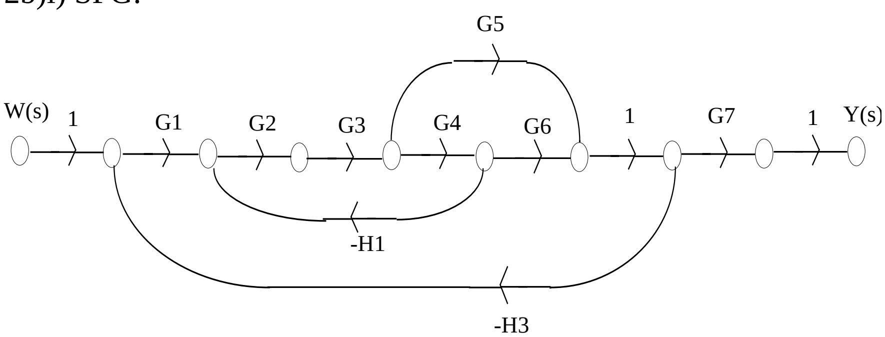
Combine H2 and H3 in parallel



Combine Feedback Loop



2b)i) SFG:



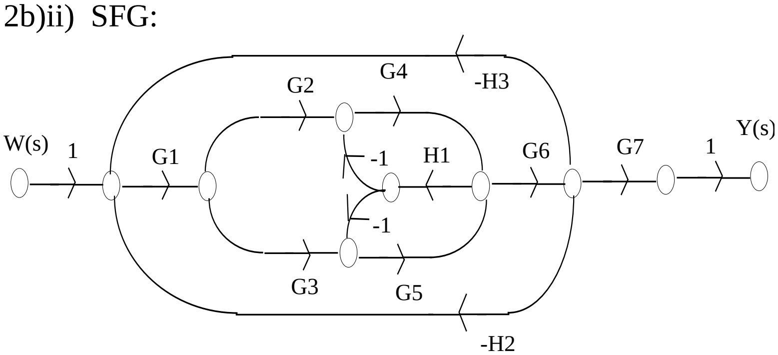
By Mason's SFG Formula, the overall transfer function is:

$$\frac{Y(s)}{W(s)} = \sum \frac{T_n \Delta_n}{\Delta} = \frac{T_1\Delta_1 + T_2\Delta_2}{\Delta}$$ where T_1=G1G2G3G4G6G7 and T_2=G1G2G3G5G7

$$\Delta = 1 - \sum L_1's + \sum L_2's - \sum L_3's + \ldots$$
$$= 1 - [G2G3G4(-H1) + G1G2G3G4G6(-H3) + G1G2G3G5(-H3)] + 0$$

Thus, $\Delta_1 = 1$ and $\Delta_2 = 1$ and $\frac{Y(s)}{W(s)} = \frac{G1G2G3G4G6G7 + G1G2G3G5G7}{1 + G2G3G4H1 + G1G2G3G4G6H3 + G1G2G3G5H3}$

2b)ii) SFG:



By Mason's SFG Formula, the overall transfer function is:

$$\frac{Y(s)}{W(s)} = \sum \frac{T_n \Delta_n}{\Delta} = \frac{T_1\Delta_1 + T_2\Delta_2}{\Delta}$$ where T_1=G1G2G4G6G7 and T_2=G1G3G5G6G7

$$\Delta = 1 - \sum L_1's + \sum L_2's - \sum L_3's + \ldots$$
$$= 1 - [G1G2G4G6(-H3) + G1G3G5G6(-H3) + G1G2G4G6(-H2) + G1G3G5G6(-H2) + G4(-H1) + G5(-H1)] + 0$$

Thus, $\Delta_1 = 1$ and $\Delta_2 = 1$ and

$$\frac{Y(s)}{W(s)} = \frac{G1G2G4G6G7 + G1G2G3G5G6G7}{1 + G1G2G4G6H3 + G1G3G5G6H3 + G1G3G5G6H2 + G1G2G4G6H2 + G4H1 + G5H1}$$