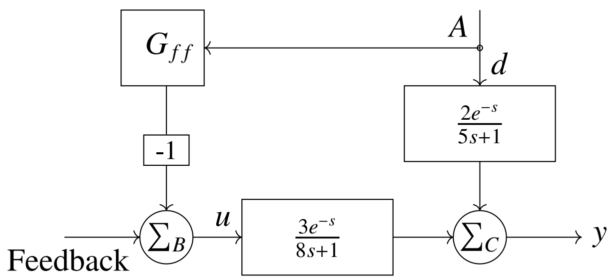
Question 23, CH Gate 2022

EE23BTECH11017 - Eachempati Mihir Divyansh*

Question: The appropriate feedforward compensator, G_{ff}, in the shown block diagram is



Solution:

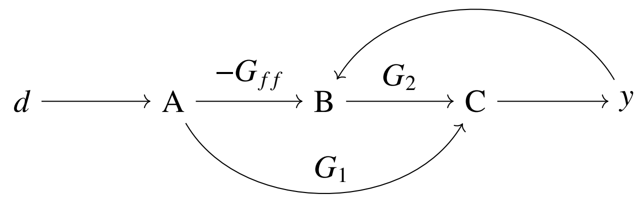
Symbol	Value	Description
y	-	Signal
d	-	Disturbance
H	?	Transfer function of the system
G_1	$\frac{2e^{-s}}{5s+1}$	Gains Given
G_2	$\frac{3e^{-s}}{8s+1}$	
P_1	$-G_2G_{ff}$	Gain of the 1st forward path
P_2	G_1	Gain of the 2nd forward path
Δ	1	Determinant of the graph
Δ_1	1	Determinant of the graph removing the 1st forward path
Δ_2	1	Determinant of the graph removing the 2nd forward path

TABLE 0
Input Parameters

In an ideal system, the output y must be independent of the disturbance d. This means, the transfer function

$$\frac{Y(s)}{D(s)} = 0$$

The signal flow graph for this system is given by



1) **Theory:** For such a system, Mason's Gain formula can be used. From Table 0
$$H = \sum_i \frac{\Delta_i P_i}{\Delta} \tag{1}$$
If L_i denotes the loop gain of ith Loop
$$\Delta = 1 - \sum_i L_i + \sum_i \sum_j L_i L_j - \ldots \tag{2}$$
Δ_i is the value of Δ without the nodes contained by the ith path.

2) Here, there are 2 forward paths
$$d \longrightarrow \text{A} \xrightarrow{-G_{ff}} \text{B} \xrightarrow{G_2} \text{C} \longrightarrow y$$
$$d \longrightarrow \text{A} \xrightarrow{G_1} \text{C} \longrightarrow y$$
For these paths,
$$P_1 = -G_2G_{ff} \tag{3}$$
$$P_2 = G_1 \tag{4}$$
$$\Delta_1 = \Delta_2 = 1 - (0) \tag{5}$$
$$\Delta = 1 - (0) = 1 \tag{6}$$
From (1) and Table 0
$$H = G_1 - G_2G_{ff} \tag{7}$$
Since $H = 0$,
$$G_1 - G_2G_{ff} = 0 \tag{8}$$
$$\implies G_{ff} = \frac{G_1}{G_2} = \frac{2}{3}\frac{8s+1}{5s+1} \tag{9}$$