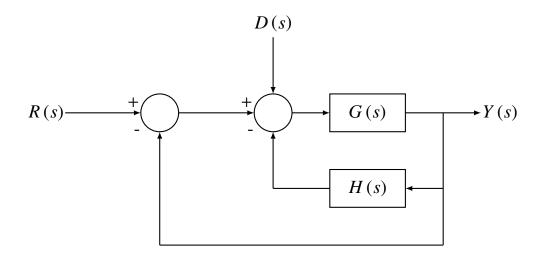
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GATE 2023 EC

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Question: 42 In the following block diagram, R(s) and D(s) are two inputs. The output Y(s) is expressed as $Y(s) = G_1(s)R(s) + G_2(s)D(s)$ $G_1(s)$ and $G_2(s)$ are given by



a)
$$G_1(s) = \frac{G(s)}{1 + G(s) + G(s)H(s)}$$
 and $G_2(s) = \frac{G(s)}{1 + G(s) + G(s)H(s)}$

b)
$$G_1(s) = \frac{G(s)}{1 + G(s) + H(s)}$$
 and $G_2(s) = \frac{G(s)}{1 + G(s) + H(s)}$

c)
$$G_1(s) = \frac{G(s)}{1 + G(s) + H(s)}$$
 and $G_2(s) = \frac{G(s)}{1 + G(s) + G(s)H(s)}$

d)
$$G_1(s) = \frac{G(s)}{1 + G(s) + G(s)H(s)}$$
 and $G_2(s) = \frac{G(s)}{1 + G(s) + H(s)}$

Solution:

By superposition principle, let

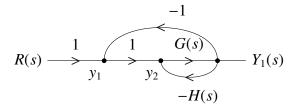
$$Y(s) = Y_1(s) + Y_2(s)$$

where $Y_1(s)$ = output considering only $R(s)$
 $Y_2(s)$ = Output considering only $D(s)$

When only R(s) is present:

By Mason's gain formula,

$$\frac{Y_1(s)}{R(s)} = \sum_{k=1}^n \frac{P_k \cdot \Delta_k}{\Delta} \tag{1}$$



Term	Description
n	Number of foward paths
Δ_k	Associated path factor
P_k	Path gain of the k^{th} forward path
Δ	Determinant of Signal flow graph

Mason's Gain formula parameters

Here,

$$n = 1$$
 (i.e path $R - y_1 - y_2 - y_3 - Y_1$) (2)

$$P_1 = G(s) \tag{3}$$

$$\Delta_1 = 1$$
 (As no isolated node is present) (4)

$$\Delta = 1 + G(s) + G(s)H(s) \tag{5}$$

Substituting in (1),

$$\frac{Y_1(s)}{R(s)} = \frac{G(s)}{1 + G(s) + G(s)H(s)} \tag{6}$$

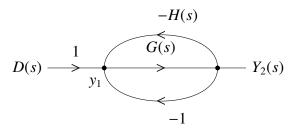
$$\frac{Y_1(s)}{R(s)} = \frac{G(s)}{1 + G(s) + G(s)H(s)}$$

$$Y_1(s) = \left[\frac{G(s)}{1 + G(s) + G(s)H(s)} \right] R(s)$$
(6)

Hence,

$$G_1(s) = \frac{G(s)}{1 + G(s) + G(s)H(s)}$$
(8)

When only D(s) is present:



Here,

$$n = 1$$
 (i.e path $D - y_1 - y_2 - Y_2$) (9)

$$P_1 = G(s) \tag{10}$$

$$\Delta_1 = 1 \tag{11}$$

$$\Delta = 1 + G(s) + G(s)H(s) \tag{12}$$

Substituting in (1),

$$\frac{Y_2(s)}{D(s)} = \frac{G(s)}{1 + G(s) + G(s)H(s)} \tag{13}$$

$$\frac{Y_2(s)}{D(s)} = \frac{G(s)}{1 + G(s) + G(s)H(s)}$$

$$Y_2(s) = \left[\frac{G(s)}{1 + G(s) + G(s)H(s)} \right] D(s)$$
(13)

Hence,

$$G_2(s) = \frac{G(s)}{1 + G(s) + G(s)H(s)}$$
 (15)

Option (a) is correct