GATE CH-23 44

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Q: A cascade control strategy is shown in the figure below. The transfer function between the output (y) and the secondary disturbance (d_2) is defined as

$$G_{d2}(s) = \frac{y(s)}{d_2(s)}$$

.

Which one of the following is the CORRECT expression for the transfer function $G_{d2}(s)$?

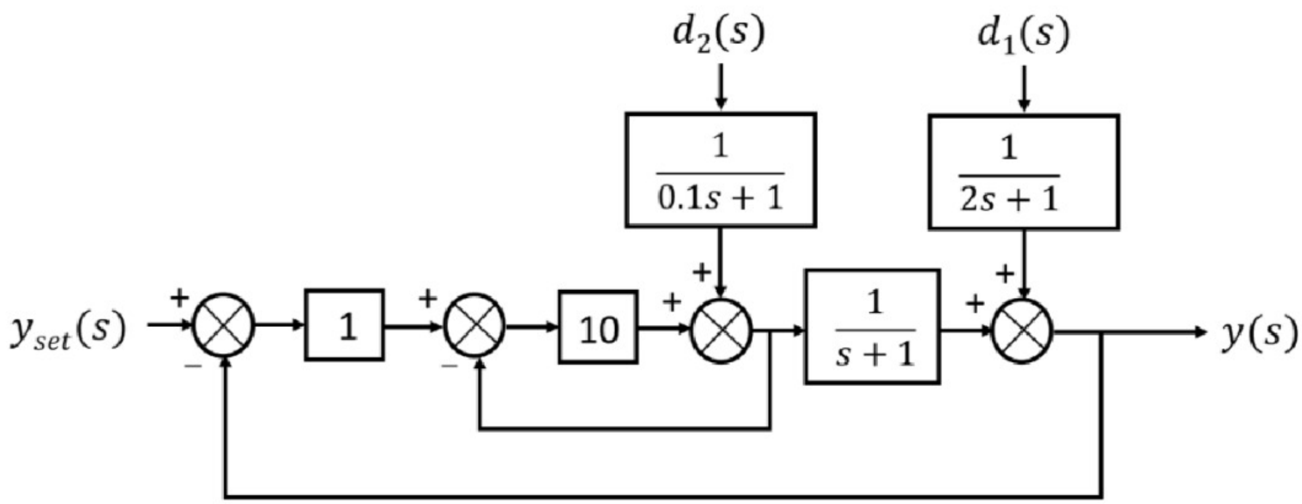

Fig. 0.

A. $\frac{1}{(11s+21)(0.1s+1)}$
B. $\frac{1}{(s+1)(0.1s+1)}$
C. $\frac{(s+1)}{(s+2)(0.1s+1)}$
D. $\frac{(s+1)}{(s+1)(0.1s+1)}$

Solution:

Variable	Description
$d_1(s)$	Primary disturbance
$d_2(s)$	Secondary disturbance
$G_{d2}(s)$	Transfer function between $y(s)$ and $d_2(s)$
$y_{set}(s)$	Set point for desired output
$y(s)$	Output

TABLE 4
Input Parameters

Variable	Description	value
P_1	Forward path gain e-c-d	$\frac{1}{(0.1s+1)(s+1)}$
Δ_1	Determinant of forward path e-c-d	1
Δ	Determinant of system	$1 + \frac{10}{s+1} + 10$
n	Number of forward path	1

TABLE 4
Defined Parameters

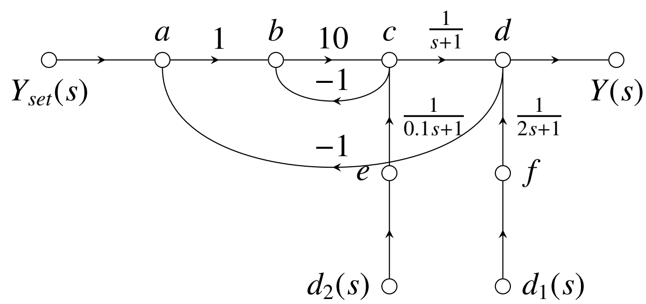

Fig. 4. signal flow graph

Using Mason's Gain formula for the above Signal flow graph,

$$G_{d2}(s) = \frac{y(s)}{d_2(s)} = \frac{\sum_{i=1}^{n} P_i \Delta_i}{\Delta} \tag{1}$$

$$= \frac{P_1 \Delta_1}{\Delta} \tag{2}$$

$$= \frac{\frac{1}{(0.1s+1)(s+1)}}{1 + \frac{10}{s+1} + 10} \tag{3}$$

$$= \frac{\frac{1}{(0.1s+1)(s+1)}}{\frac{11s+21}{s+1}} \tag{4}$$

$$\implies G_{d2}(s) = \frac{1}{(11s+21)(0.1s+1)} \tag{5}$$

Now taking the inverse laplace transform we have,

$$G_{d2}(t) = \mathcal{L}^{-1}\left(\frac{10}{(s+10)\,(11s+21)}\right) \tag{6}$$

$$= \mathcal{L}^{-1}\left(\frac{-10}{89\,(x+10)} + \frac{110}{89\,(11x+21)}\right) \tag{7}$$

$$= \frac{-10e^{-10t}}{89} + \frac{10e^{\frac{-21t}{11}}}{89} \tag{8}$$

$$= \frac{10\left(e^{\frac{-21t}{11}} - e^{-10t}\right)}{89} \tag{9}$$

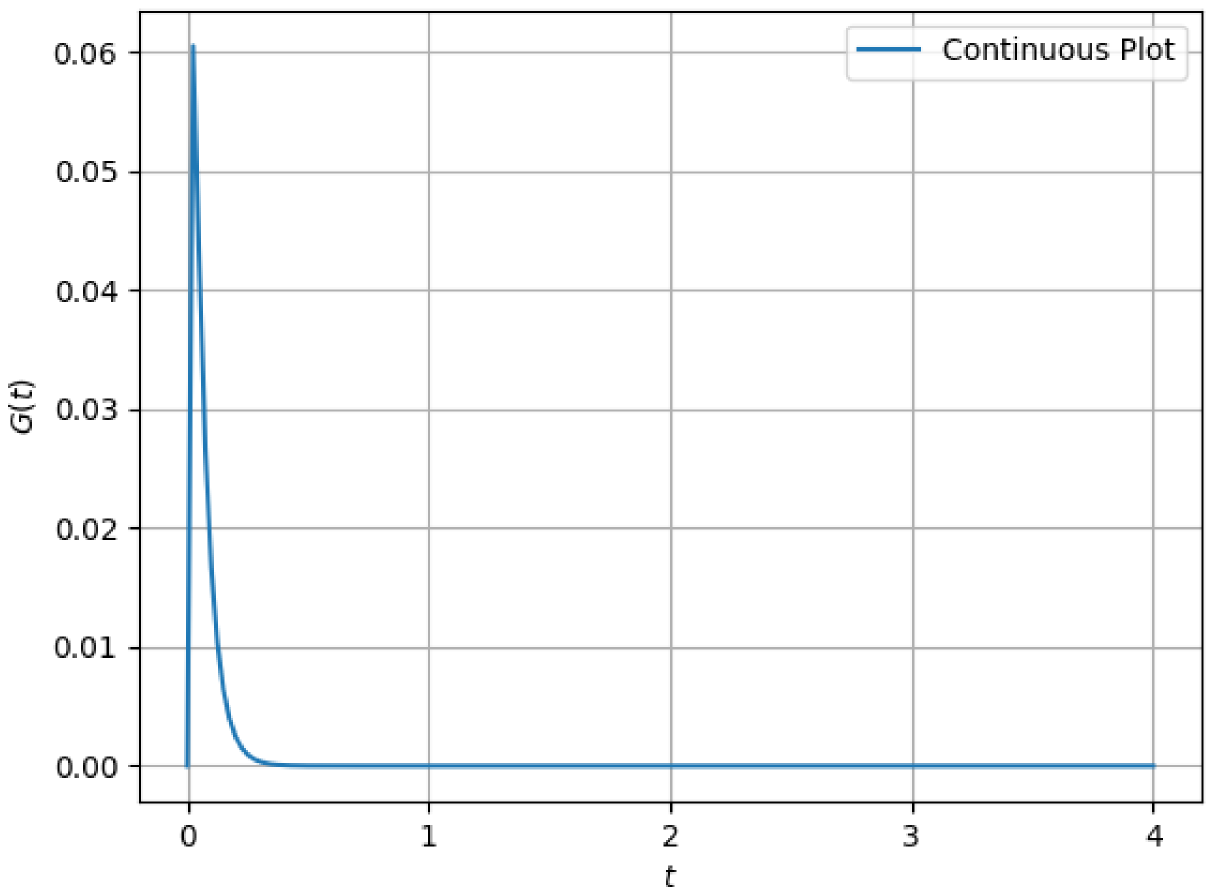

Fig. 4.