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 $G_{d2}(s)$?

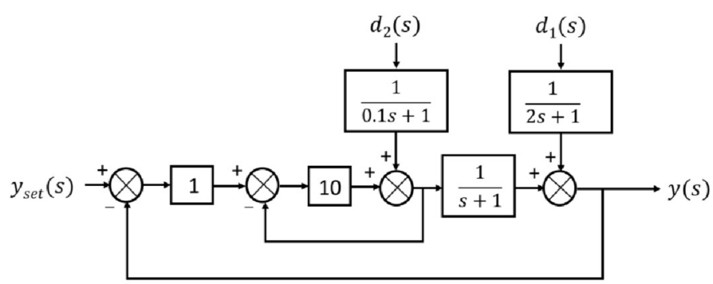

Fig. 0.

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
a	Error signal

TABLE 4
DEFINED PARAMETERS

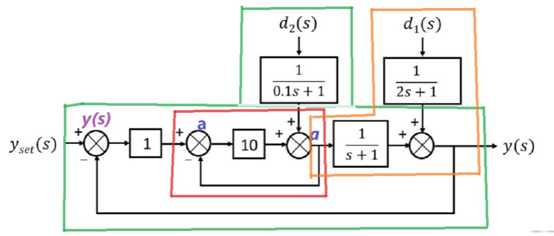

Fig. 4.

$$\left[\left(y_{sp}-y(s)\right)(1)-a\right]10+d_2(s)\frac{1}{0.1s+1}=a \tag{1}$$

$$a\left(\frac{1}{s+1}\right)+d_1(s)\frac{1}{(2s+1)}=y(s) \tag{2}$$

From (1)

$$\left(y_{sp}-y(s)\right)10-10a+d_2(s)\frac{1}{0.1s+1}=a \tag{3}$$

$$\left(y_{sp}-y(s)\right)10+\frac{d_2(s)}{0.1s+1}=11a \tag{4}$$

$$\left(y_{sp}-y(s)\right)\frac{10}{11}+\frac{d_2(s)}{11\,(0.1s+1)}=a \tag{5}$$

Substituting (5) in (2)

$$\left[\left(y_{sp}-y(s)\right)\frac{10}{11}+\frac{d_2(s)}{11\,(0.1s+1)}\right]\frac{1}{(s+1)}+d_1(s)\frac{1}{(2s+1)}=y(s) \tag{6}$$

$$\left(y_{sp}-y(s)\right)\frac{10}{11}\frac{1}{(s+1)}+\frac{d_2(s)}{11\,(0.1s+1)\,(s+1)}+d_1(s)\frac{1}{(2s+1)}=y(s) \tag{7}$$

$$(0-y(s))\,\frac{10}{11}\frac{1}{(s+1)}+\frac{d_2(s)}{11\,(0.1s+1)\,(s+1)}=y(s) \tag{8}$$

$$\frac{d_2(s)}{11\,(0.1s+1)\,(s+1)}=y(s)+\frac{10}{11}y(s)\frac{1}{(s+1)} \tag{9}$$

$$\frac{d_2(s)}{11\,(0.1s+1)\,(s+1)}=y(s)\left(1+\frac{10}{11}\frac{1}{(s+1)}\right) \tag{10}$$

$$\frac{d_2(s)}{11\,(0.1s+1)\,(s+1)}=y(s)\left(\frac{11\,(s+1)+10}{11\,(s+1)}\right) \tag{11}$$

$$\frac{d_2s}{(0.1s+1)}=y(s)\,[11s+11+10] \tag{12}$$

$$\frac{d_2s}{(0.1s+1)}=y(s)\,[11s+21] \tag{13}$$

$$\frac{y(s)}{d_2s}=\frac{1}{(0.1s+1)\,(11s+21)} \tag{14}$$

$$\implies G_{d2}(s)=\frac{1}{(0.1s+1)\,(11s+21)} \tag{15}$$

Now taking the inverse laplace transform we have,

$$G_{d2}(t) = \mathcal{L}^{-1}\left(\frac{10}{(s+10)(11s+21)}\right) \tag{16}$$

$$= \mathcal{L}^{-1}\left(\frac{-10}{89(x+10)} + \frac{110}{89(11x+21)}\right) \tag{17}$$

$$= \frac{-10e^{-10t}}{89} + \frac{10e^{\frac{-21t}{11}}}{89} \tag{18}$$

$$= \frac{10\left(e^{\frac{-21t}{11}} - e^{-10t}\right)}{89} \tag{19}$$

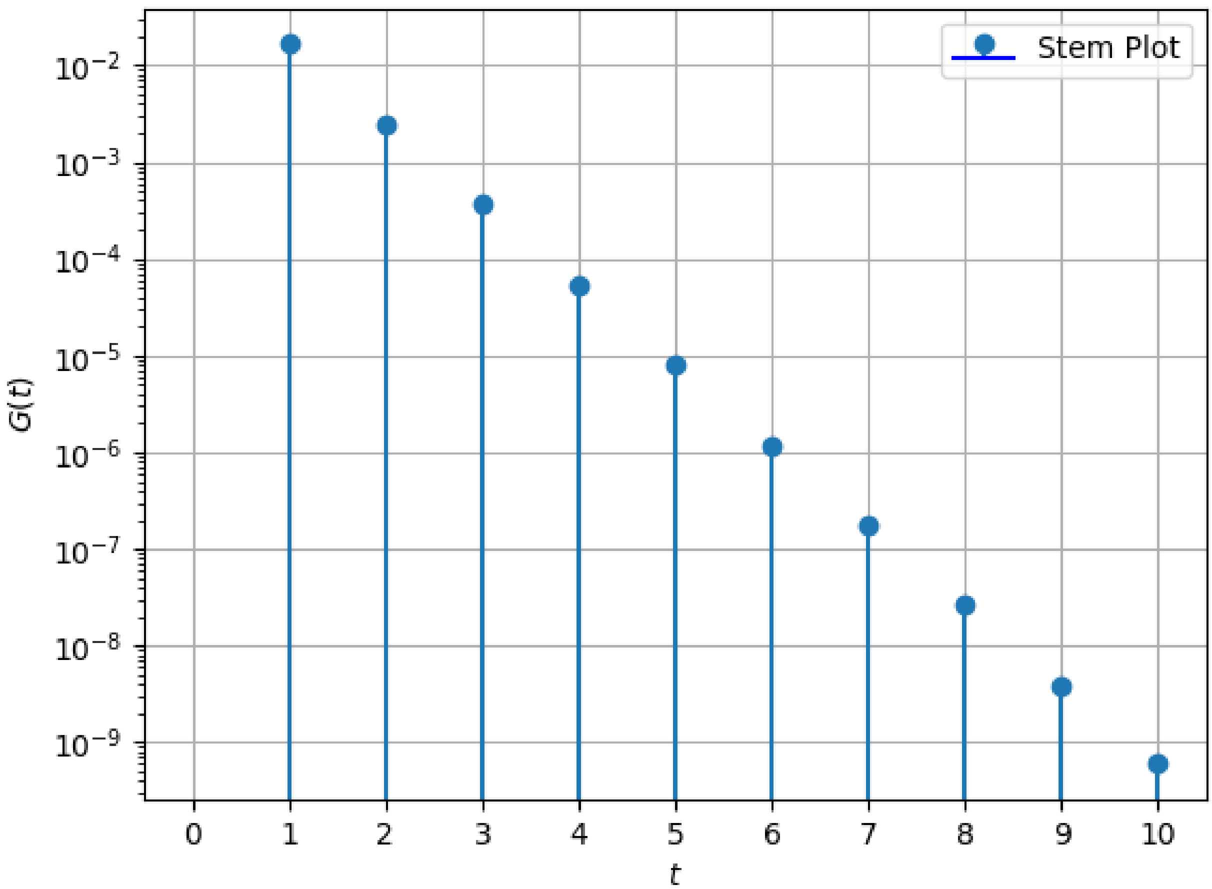

Fig. 4.