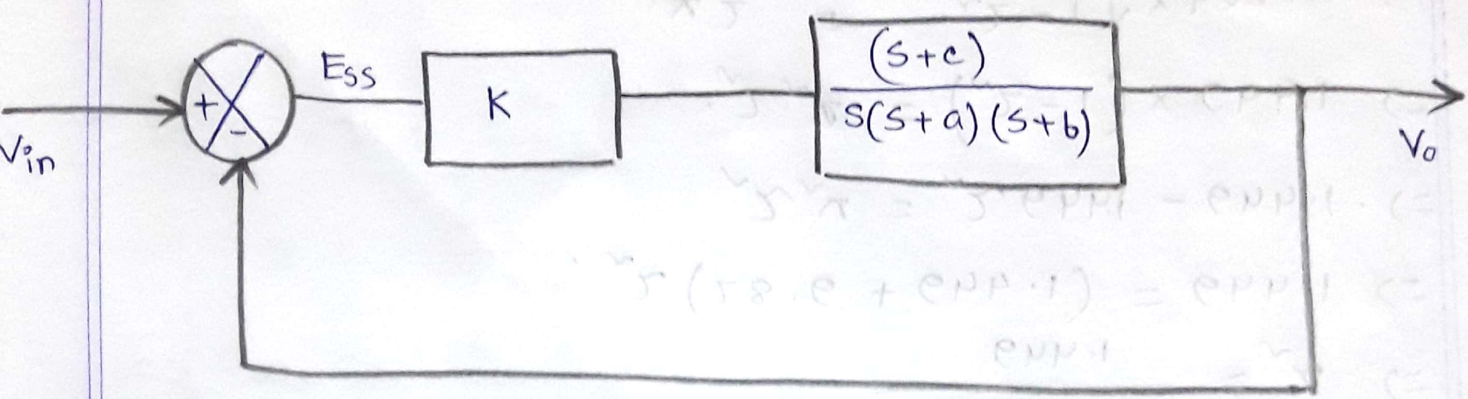
ID-16.02.05.095

1 (a)



According to the ques

$X = \frac{5}{2} = 2.5 \longrightarrow 3$

$Y = 3$

$Z = 2\%$

so percentage of overshoot $= 30\%$

setting Time $T_s(2\%) = 3$ sec.

Now;

$$P.O = e^{-\frac{\zeta\pi}{\sqrt{1-\zeta^2}}}$$

$$\Rightarrow \frac{30}{100} = e^{-\frac{\zeta\pi}{\sqrt{1-\zeta^2}}}$$

$$\Rightarrow \ln(0.30) = -\frac{\zeta\pi}{\sqrt{1-\zeta^2}}$$

$$\Rightarrow -1.204 = -\frac{\zeta\pi}{\sqrt{1-\zeta^2}}$$

$$\Rightarrow 1.204 \times \sqrt{1-\tau^2} = \tau\pi$$

$$\Rightarrow 1.449 \times (1-\tau^2) = \pi^2\tau^2$$

$$\Rightarrow 1.449 - 1.449\tau^2 = \pi^2\tau^2$$

$$\Rightarrow 1.449 = (1.449 + 9.87)\tau^2$$

$$\Rightarrow \tau^2 = \frac{1.449}{12.768}$$

$$\Rightarrow \tau = \sqrt{0.113}$$

$$= 0.34$$

$\boxed{\therefore \text{Damping ratio } \tau = 0.34}$

T3

Now;

$$T_s\ (2\%) = \frac{4}{\zeta \omega_n}$$

$$\boxed{\zeta = 0.34}$$

$$\Rightarrow \quad 3 = \frac{4}{\zeta \omega_n}$$

$$\Rightarrow \quad \omega_n = \frac{4}{3 \times 0.34}$$

$$= 3.92$$

$\boxed{\therefore \text{natural frequency } \omega_n = 3.92}$

Let, $C = 0$

$$\therefore G(s) = \frac{K}{(s+a)(s+b)}$$

$$\therefore T.F = \frac{G(s)}{1 + G(s)H(s)}$$

$$= \frac{K/(s+a)(s+b)}{1 + \frac{K}{(s+a)(s+b)} \times 1}.$$

$$= \frac{K}{(s+a)(s+b) + K}.$$

$$= \frac{K}{s^2 + sb + as + ab + K}.$$

$$\boxed{= \frac{K}{s^2 + s(a+b) + ab + K}.}$$

Compare with ;

$$\frac{\omega_n^2}{s^2 + 2\zeta\omega_n s + \omega_n^2}$$

$a+b = 2\zeta\omega_n$

$= 2 \times 0.34 \times 3.92$

$$\boxed{a+b = 2.67}$$

and ;

$ab + k = \omega_n^2$

$\Rightarrow ab = (3.92)^2 - k$

$$\boxed{ab = 15.37 - k}$$

Here ;

$E_{ss} = 0.045$;

Now;

$$E_{ss} = \lim_{s \to 0} \frac{sR(s)}{1 + G(s)}$$

$$\Rightarrow 0.045 = \lim_{s \to 0} \frac{s \times 1/s}{1 + \frac{K}{(s+a)(s+b)}}.$$

$$\Rightarrow 0.045 = \frac{1}{1 + \frac{K}{ab}}$$

$$\Rightarrow 0.045 \left(1 + \frac{K}{ab}\right) = 1.$$

$$\Rightarrow 1 + \frac{K}{ab} = \frac{1}{0.045} = 22.22.$$

$$\Rightarrow \frac{K}{ab} = 22.22 - 1. = 21.22.$$

$$\Rightarrow \frac{K}{15.37 - K} = 21.22$$

$$\Rightarrow K = 21.22(15.37 - K)$$

$$= 326.1514 - \cancel{22}\ 21.22K$$

$$\Rightarrow K = \frac{326.1514}{22.22}$$

$$= 14.678$$

$$\boxed{\therefore K = 14.678}$$

Now;

$$ab = 15.37 - 14.678$$

$$= 0.692$$

$$a = \frac{0.692}{b}$$

Now;

$a + b = 2.67$

$\Rightarrow \dfrac{0.692}{b} + b = 2.67$

$\Rightarrow 0.692 + b^2 = 2.67b$

$\Rightarrow b^2 - 2.67b + 0.692 = 0.$

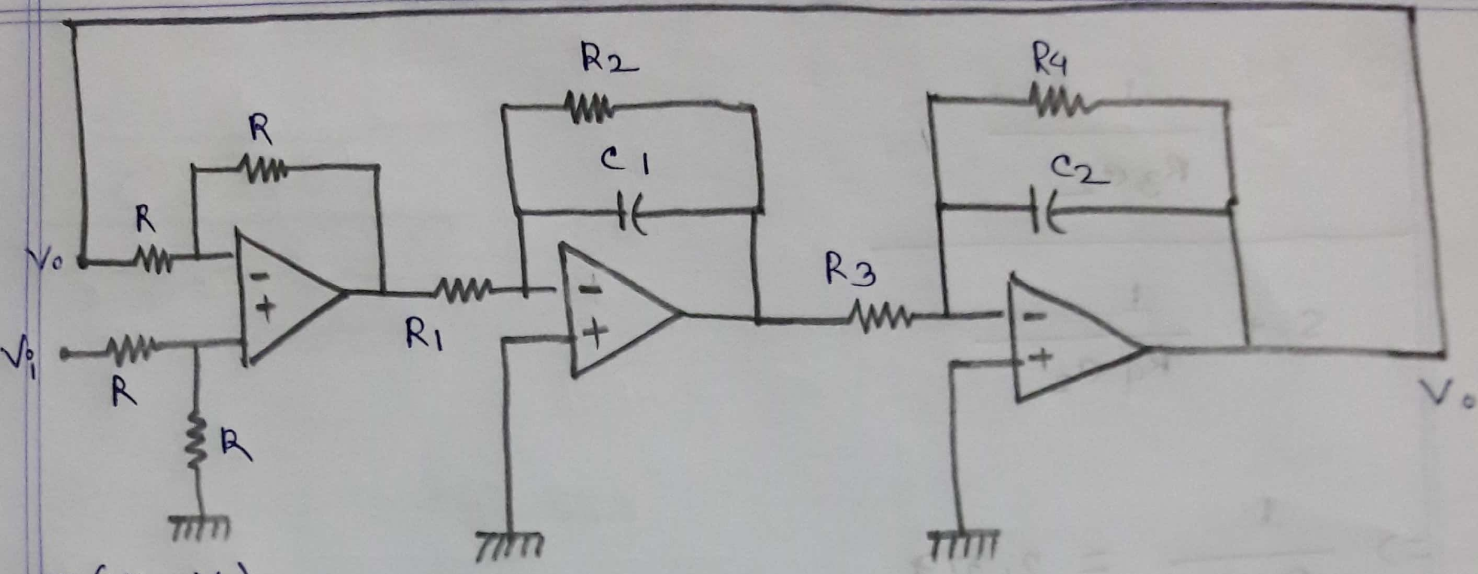
$\boxed{\therefore b = 2.379\ ,\ 0.29}$

$\therefore a = \dfrac{0.692}{\cancel{0.29}\ 2.379}$

$\boxed{a = 0.291}$

$\boxed{c = 0}$

$\boxed{k = 14.678}$



$m(V_i - V_o)$

Differential Amplifier circuit.

$$\frac{-\frac{1}{R_1C_1}}{s+\frac{1}{R_2C_1}}$$

(Shifted pole)

$$\frac{-\frac{1}{R_3C_2}}{s+\frac{1}{R_4C_2}}$$

(Shifted pole).

$$\frac{-1}{s+\frac{1}{R_2C_1}}$$

$$\Rightarrow \frac{1}{R_2C_1} = 0.291$$

$$\Rightarrow R_2 = \frac{1}{0.291 \times 10 \times 10^{-6}}$$

$$\boxed{R_2 = 343.64\,k\Omega}$$

$$\frac{-\frac{1}{R_3 C_2}}{S + \frac{1}{R_4 C_2}}$$

$$\Rightarrow \frac{1}{R_4 C_2} = 2.379$$

$$\Rightarrow R_4 = \frac{1}{2.379 \times 10 \times 10^{-6}}$$

$$\boxed{R_4 = 42.034\,k\Omega.}$$

$$-\frac{1}{R_3 C_2}$$

$$s + \frac{1}{R_4 C_2}$$

$$\Rightarrow \frac{1}{R_3 C_2} = 14.678$$

$$\Rightarrow R_3 = \frac{1}{14.678 \times 10 \times 10^{-6}}$$

$$\boxed{R_3 = 6.81 \text{ k}\Omega}$$

So;

$R_1 = 100 \text{ k}\Omega$

$R_2 = 343.64 \text{ k}\Omega$

$R_3 = 6.81 \text{ k}\Omega$

$R_4 = 42.034 \text{ k}\Omega$

$C_1 = C_2 = 10 \mu F.$

ⓒ $M = X + 1 = 3 + 1$

$= 4$

$N = Y + 1 = 3 + 1$

$= 4$

$\therefore$ % ~~..~~ OS = 40%

Ts (2%) = 4 sec

Critically damp $= 1$.

overdamp > 1.

(c)

given;

$M = X + 1$	$N = Y + 1$	$\% OS = 40\%$
$= 3 + 1$	$= 3 + 1$	$T_s\ (2\%) = 4$ sec.
$= 4$	$= 4$	

Now;

overshoot $= 40\%$.

$\Rightarrow 0.4 = e^{-\pi\zeta / \sqrt{1-\zeta^2}}$

$\Rightarrow \ln 0.4 = -\pi\zeta / \sqrt{1-\zeta^2}$

$\Rightarrow -0.916 = -\pi\zeta / \sqrt{1-\zeta^2}$

$\Rightarrow 0.916 = \pi\zeta / \sqrt{1-\zeta^2}$

$\Rightarrow 0.916 (\sqrt{1-\zeta^2}) = \pi\zeta$

$\Rightarrow 0.839 (1-\zeta^2) = \pi^2\zeta^2$

$\Rightarrow 0.839 - 0.839\zeta^2 = \pi^2\zeta^2$

$\Rightarrow 0.839 = (\pi^2 + 0.839)\zeta^2$

$\Rightarrow 0.839 = 10.7086\zeta^2$

$\Rightarrow \zeta = \sqrt{\dfrac{0.839}{10.709}} = 0.28$

$\boxed{\therefore \text{Damping ratio } \zeta = 0.28}$

underdamp response.

Now;

~~F(s)~~ $T_s(2\%) = \frac{4}{\zeta\omega_n}$

$\Rightarrow \quad 4 = \frac{4}{\zeta\omega_n}$

$\Rightarrow \quad \omega_n = \frac{1}{\zeta} = \frac{1}{0.28} = 3.571$

$$\boxed{\therefore \text{natural frequency } \omega_n = 3.571}$$

$$\boxed{\therefore \omega_n^2 = (3.571)^2 = 12.755 = K}$$

now;

$\zeta\omega_n = 3.571 \times 0.28$

$= 0.999$

$\therefore$ new pole $= 2 \times \zeta\omega_n = 2 \times 0.999$

$= 1.9998$

~~From Sisotool we get~~;

$$\cancel{G(s)} =$$

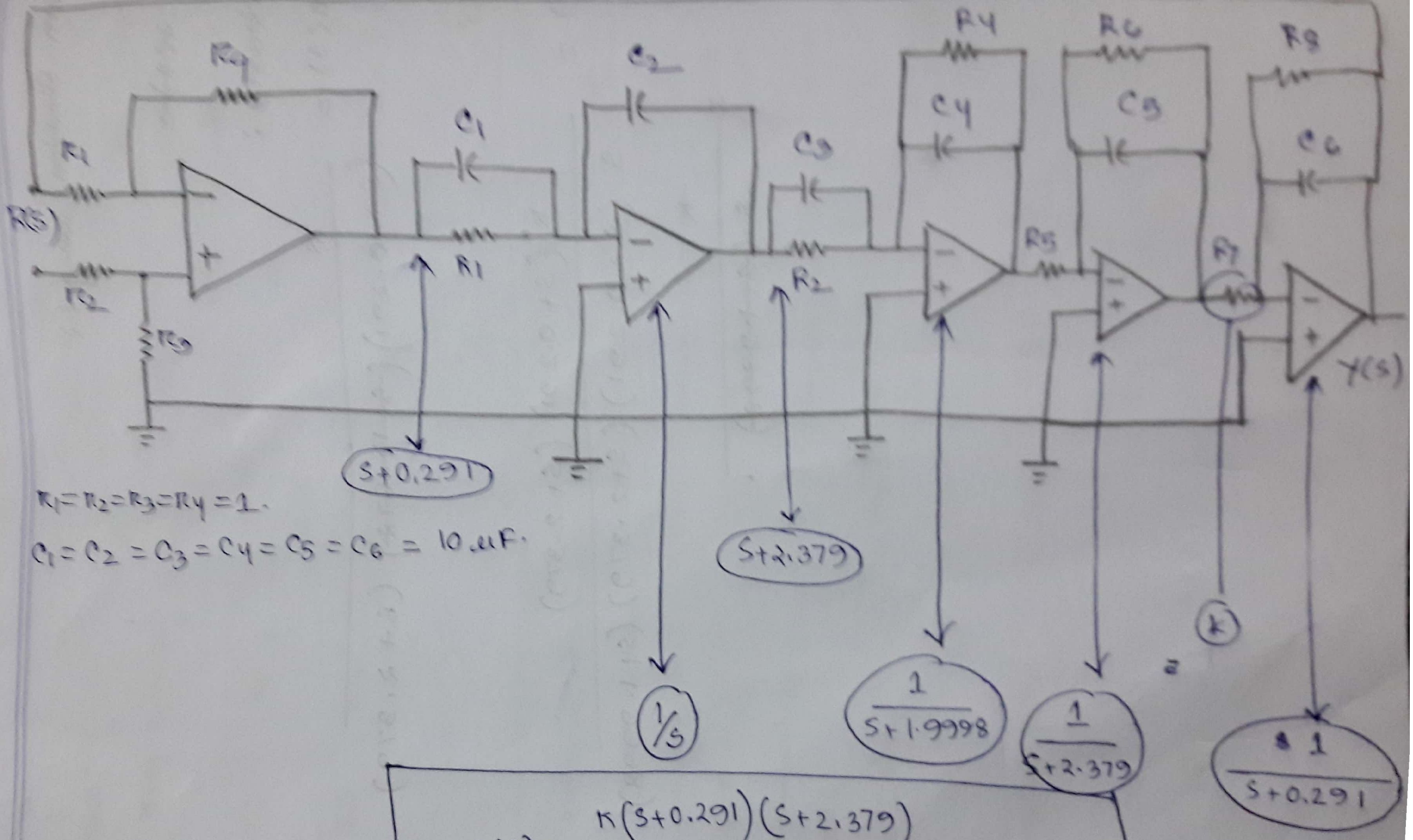
Previously;

$$G(s) = \frac{K}{(s+0.291)(\cancel{s+14.678})(s+2.379)}$$

Now;

$$G(s) = \frac{K(s+0.291)(s+2.379)}{s(s+0.291)(s+2.379)(s+1.9998)}$$

$$= \frac{\cancel{K}}{\cancel{s(s+1.9998)}}.$$



$R_1 = R_2 = R_3 = R_4 = 1.$

$C_1 = C_2 = C_3 = C_4 = C_5 = C_6 = 10\,\mu F.$

$$G(S) = \boxed{\frac{K(S+0.291)(S+2.379)}{S(S+0.291)(S+2.379)(S+1.9998)}}$$

Now ;

$$\frac{1}{R_4 C_8} = 1.9998$$

$$\therefore \frac{1}{R_4} = 1.9998 \times 10^{-6} \times 10$$

$$\therefore R_4 = \frac{1}{1.9998 \times 10^{-6} \times 10}$$

$$= 50\,k\Omega$$

$$\boxed{\therefore R_4 = 50\,k\Omega}$$

$$\frac{1}{R_7 C} = 12.755$$

$$\Rightarrow R_7 = \frac{1}{12.755 \times 10 \times 10^{-6}}$$

$$= 7.84\,k\Omega$$

$$\boxed{\therefore R_7 = 7.84\,k\Omega}$$

$R_1 = 343.64\,k\Omega$

$R_2 = 42.034\,k\Omega$

$R_4 = 50\,k\Omega$

$R_5 = 100\,k\Omega$

$R_6 = 42.034$

$R_7 = 7.84\,k\Omega$

$R_8 = 343.64\,k\Omega$