

Assignment # 2

NAME:-

M. NAEEM

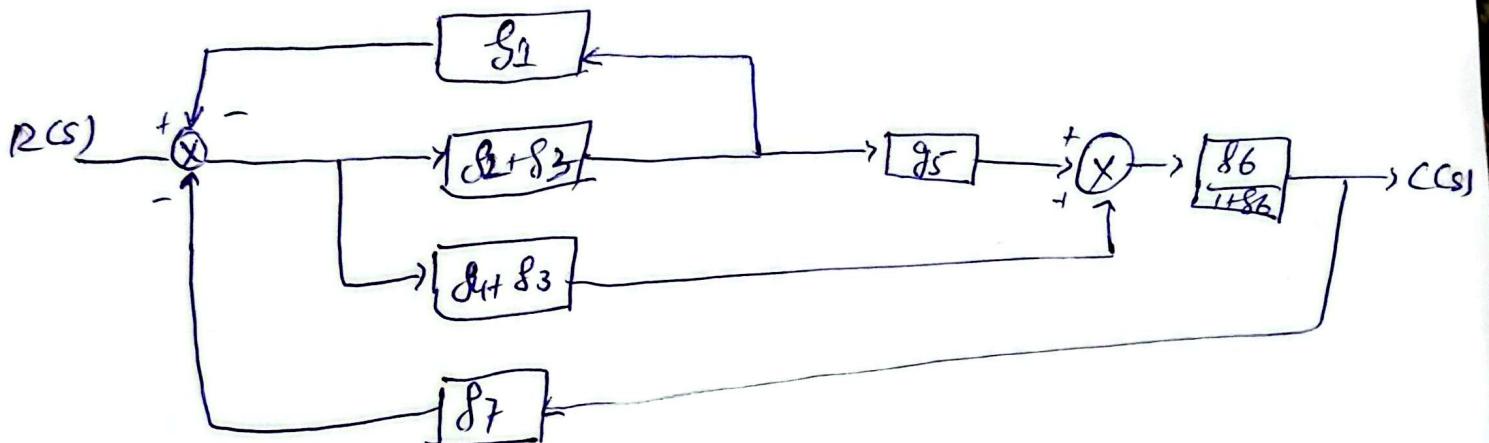
RegNo:-

RFA21-BCE-100

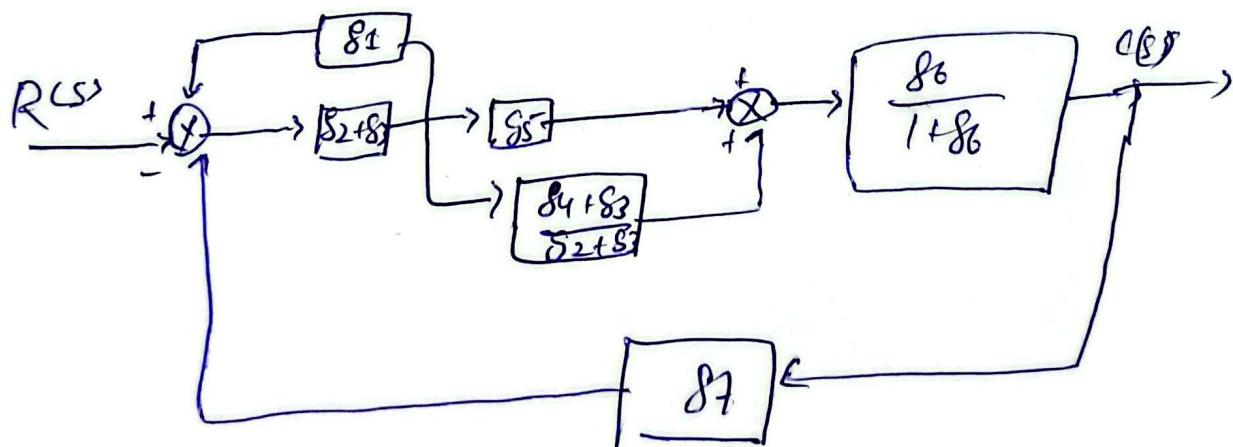
Question # 2

Solution:-

Step 1 :- split s_3 and combine s_2 and s_4
Also use s_6 and apply feedback formula :-

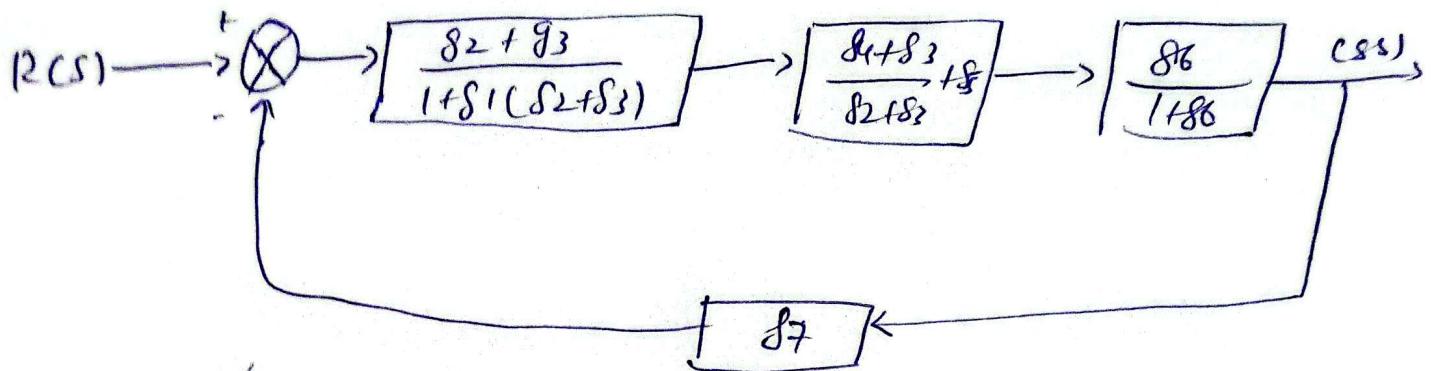


Step 2 :- push $s_2 + s_3$ to left past the
pickup point



Step 3:-

using the feedback formula of
combining parallel blocks.



Step 4:-

multiplying the blocks
of forward path and applying
feedback formula

$$Q(s) = \frac{s_6 s_4 + s_6 s_3 + s_6 s_5 s_3 + s_6 s_5 s_2}{1 + s_6 + s_3 s_1 + s_2 s_4 + s_7 s_6 s_4 + s_7 s_6 s_3 + s_7 s_5 s_6 s_3 + s_7 s_6 s_5 s_2 + s_6 s_3 s_1 + s_6 s_2 s_4}$$

A15

Rise time -

$$T_r = \frac{\pi - \phi}{\omega_d}$$

$$\therefore \omega_d = \omega_n \sqrt{1 - \frac{\Sigma^2}{s}} = 64.64 \text{ rad/s}$$

$$\therefore \phi = \tan^{-1} \sqrt{\frac{1 - \frac{\Sigma^2}{s}}{s}} = 0.848 \text{ rad}$$

$$T_r = 0.03180 \text{ s}$$

Settling Time -

$$T_s = \frac{4}{\omega_n} = \frac{4}{(0.58)(85.73)}$$

$$T_s = 0.0804 \text{ s}$$

Question #13 :-

Solution :-

Step #01 :-

Identify the forward path :-

$$PI = \delta_2 g_2 g_3 \delta_4$$

Step #02 :-

Identify all individual loops

$$La = -1 ; \quad Lb = -g_2 g_3 g_4 ; \quad LC = -\delta_3 \delta_4$$

$$LD = -g_4$$

Step #03 :-

Non-touching loops :-

$$LaLc ; LaLd$$

Step #04 :-

compute Δ

$$\Delta = 1 - (-1 - g_2 g_3 g_4 - g_3 g_4 - g_4) + (g_3 g_4 + g_4)$$

$$\Delta = 2 + 2g_4 + 2g_3 g_4 + g_2 g_3 g_4$$

Step #05 :-

compute Δ_I

$$\frac{\Delta - I}{I}$$

$$\zeta = ?$$

Let $M = \frac{40s}{100}$ then

$$\ln M = -\frac{\zeta \pi}{\sqrt{1-\zeta^2}}$$

$$\zeta = -\frac{\ln M}{\sqrt{\delta^2 + (\ln M)^2}}$$

(B)

$$OS = 10\% \quad R \quad TP = 5s$$

1) overshoot $\rightarrow M \Rightarrow M = 0.10$

2) damping ratio $\zeta = \frac{-\ln(0.10)}{\delta^2 + (\ln 0.10)^2} = 0.59115$

3) damped natural frequency $\omega_d = \frac{\pi}{TP} = \frac{\pi}{5} = 0.628 \text{ rad/sec}$

4) natural frequency $\omega_n = \frac{\omega_d}{\sqrt{1-\zeta^2}} = 0.7790 \text{ rad/sec}$

5) poles $s_1 s_2 = -\zeta \omega_n \pm j\omega_d = -0.6605 \pm j0.628(\text{rad/sec})$

6) $TP = 5; Tr = 3.507s; Ts = 8.686s$

7) The system is stable, underdamped with $10\%, 0\%$, moderate oscillation of slow settling response.

Step II :-

mason's Gain formula :-

$$T(s) = \frac{CCS}{RCS} = \frac{P \cdot D_1}{D} = \frac{g_1 g_2 g_3 g_4}{2 + 2g_4 + 2g_3 g_4 + g_2 g_3 g_4}$$

Step 7 :-

loop Instructions

In this system each feedback loop effects the overall transfer function by changing D is mason gain formula

- i) Touching loop directly influences the poles, damping and stability of system
- ii) Non-touching loops add positive product terms to parameters changing.
- iii) Local loops adjust local gains & improve damping.

Question ~~II~~ 4

Solution ~~II~~

(A)

Relationship :-

$$f(s) = \frac{\omega^2 n}{s^2 + 2\zeta\omega_n s + \omega^2 n} \quad (\text{amplifying ratio})$$

percent overshoot $\rightarrow \% OS = 100e^{-\frac{\zeta\pi}{\sqrt{1-\zeta^2}}}$



(B)

$$T_p = 5s$$

Step 2:- finding damping ratio

$$\% OS = 100e^{-\frac{2\zeta\pi}{\sqrt{1-\zeta^2}}}$$

$$0.10 = e^{-\frac{2\zeta\pi}{\sqrt{1-\zeta^2}}} = \boxed{\zeta = 0.591}$$

Step 2 :-

find the normalized frequencies -

$$TP = \frac{\omega_n}{\omega_n(1-\zeta^2)} = \frac{\tau}{TP, 1-\zeta^2}$$

$\omega_n = 0.779 \text{ rad/sec}$

$$\omega_1 = \omega_n \sqrt{1-\zeta^2} = 0.628 \text{ rad/sec}$$

Step 3 :- find pole location

$$s_{1,2} = -\zeta \omega_n \pm j\omega_1$$

$$s_{1,2} = -0.46 \pm j0.63$$

Step 4 :-

→ poles lie in the left ~~SC~~ half-plane
stable system

→ Real part (-0.46) → rate of decay

→ Imaginary part (0.63) → oscillation frequency.

→ results in $\times 10^{-4}$ overshoot, $TP = 5.5$ smooth

settling (8s)