YILDIZ TECHNICAL UNIVERSITY

FACULTY OF ELECTRICAL & ELECTRONICS ENGINEERING

DEPARTMENT OF CONTROL AND AUTOMATION ENGINEERING

KOM4221

CONTROL LABORATORY

Experiment 6

Emir OĞUZ

17016011

Group 2

Asst. Prof. Levent UCUN

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Summary of Experiment

The aim of this experiment is to design a PI+Feedforward controller for the Coupled-Tank system in order to satisfy design criteria.

Theory Implementation and Numerical Calculations

Question 2)

$$s^2 + \frac{\left(K_{p1}K_{dc_1} + 1\right)s}{\tau_1} + \frac{K_{\imath 1}K_{dc_1}}{\tau_1} = s^2 + 2\zeta\omega_n s + \omega_n^2$$

$$K_{p1} = \frac{2\zeta\omega_n\tau_1 - 1}{K_{dc_1}}$$

$$K_{\imath 1} = \frac{\omega_n^2\tau_1}{K_{dc_1}}$$

$$K_{dc\_1} = 3.2402, \tau_1 = 15.2368\ s$$

Design criteria:

- $PO_1 \leq 11\%$
- $T_s < 6$
- No steady-state error

To meet %OS criteria ζ should be 0.575 and for the T_s criteria ω_n should be as 1.16. Then, K_{p1} obtained as 5.9644 and $K_{\imath 1}$ obtained as 6.3276.

Question 4)

$$s^2 + \frac{\left(K_{p2}K_{dc_2} + 1\right)s}{\tau_2} + \frac{K_{\imath 2}K_{dc_2}}{\tau_2} = s^2 + 2\zeta\omega_n s + \omega_n^2$$

$$K_{p2} = \frac{2\zeta\omega_n\tau_2 - 1}{K_{dc_2}}$$

$$K_{\imath 2} = \frac{\omega_n^2\tau_2}{K_{dc_2}}$$

$$K_{dc\_2} = 1, \tau_2 = 15.2368\ s$$

Design criteria:

- $PO_1 \leq 11\%$
- $T_s < 21$
- No steady-state error

To meet %OS criteria ζ should be 0.575 and for the T_s criteria ω_n should be as 0.33. Then, K_{p2} obtained as 4.7824 and $K_{\imath 2}$ obtained as 1.6593.

Simulation Studies

Question 1)

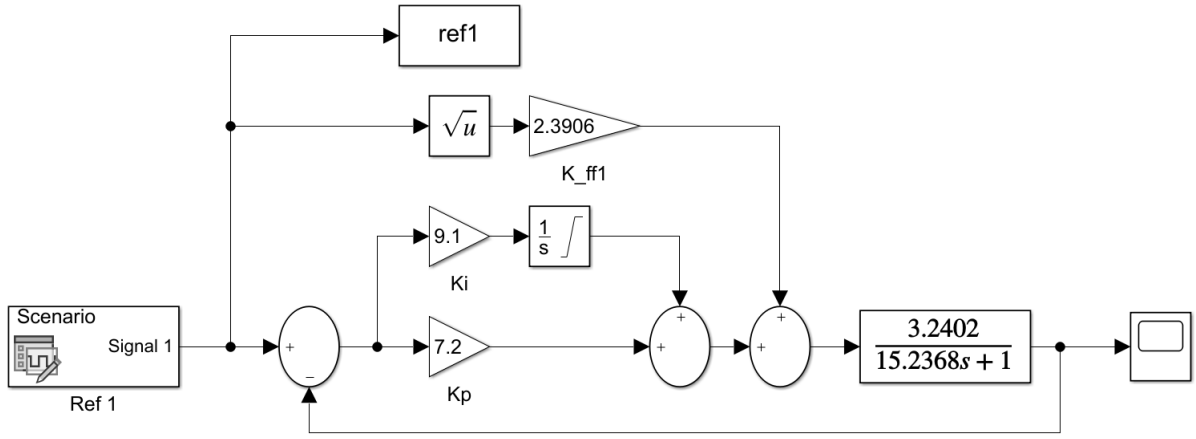

Figure 1: Block Diagram of Config. 1

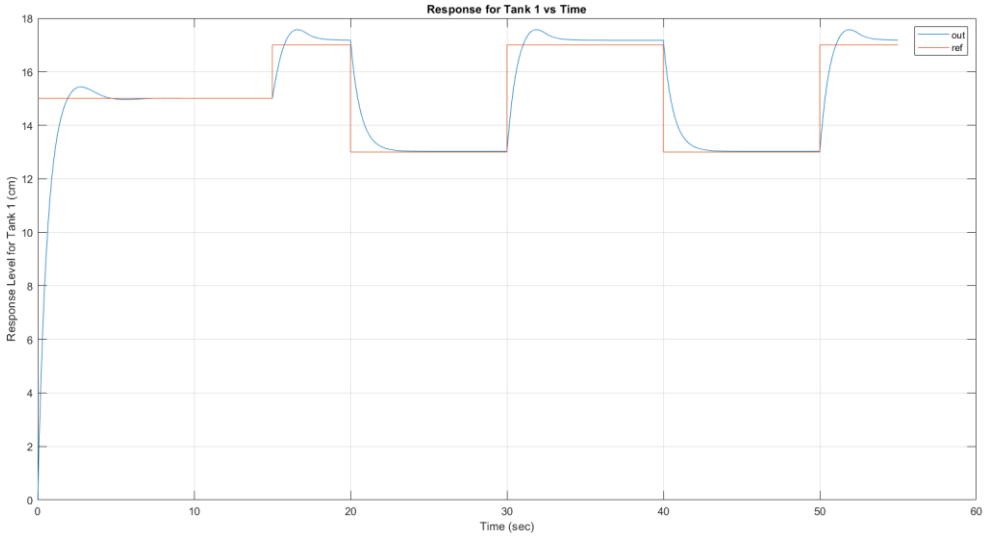

Figure 2: Response for Tank 1 vs Time

Question 2)

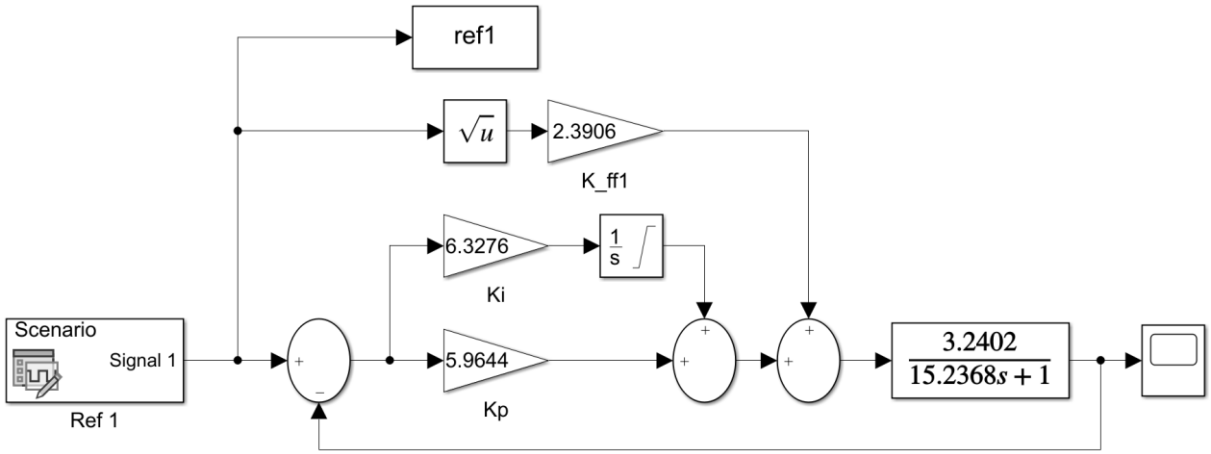

Figure 3: Block Diagram of Config. 1 for Desired New Criteria

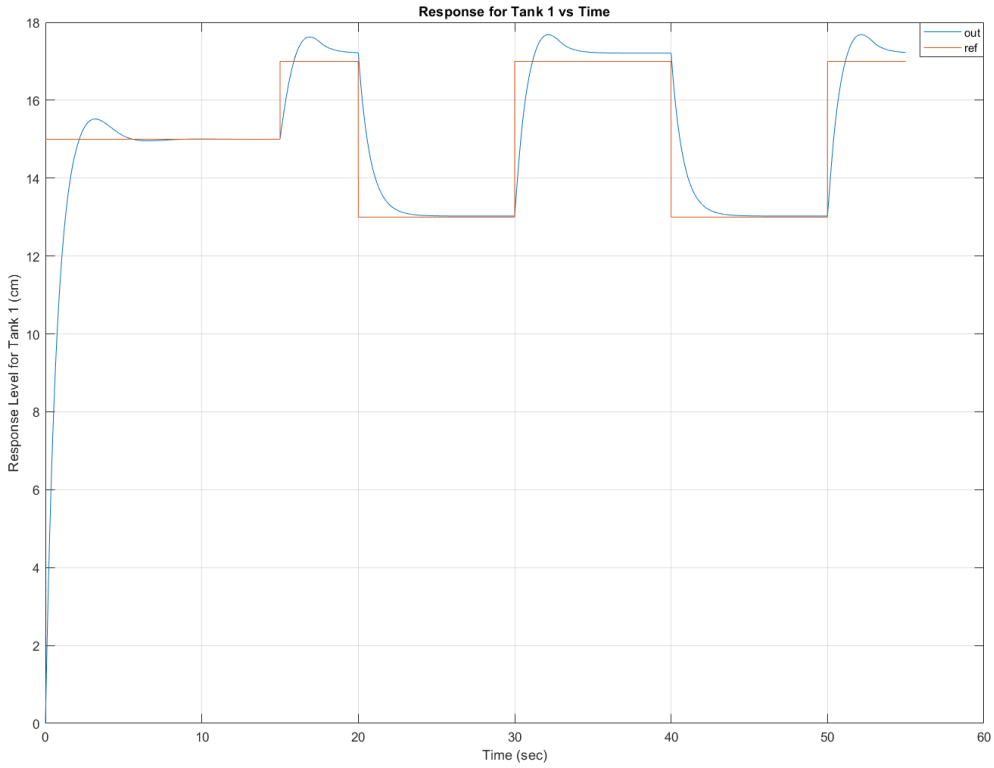

Figure 4: Response for Tank 1 vs Time for New Desired Criteria

Question 3)

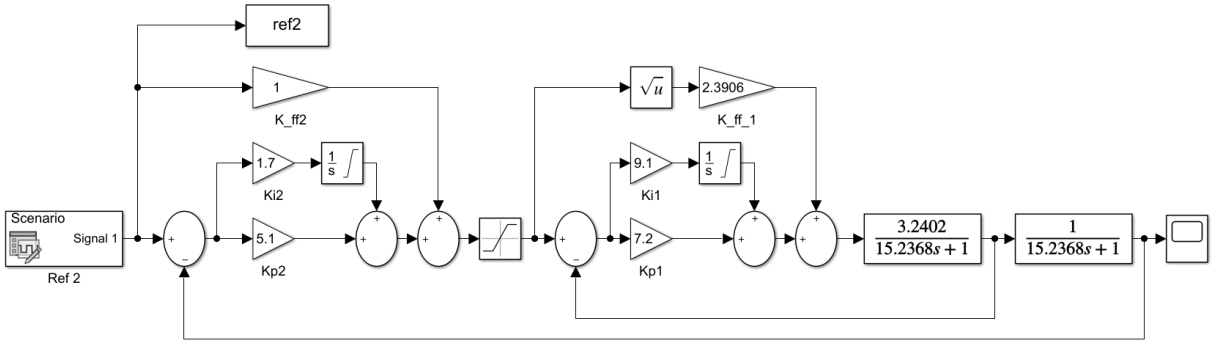

Figure 5: Block Diagram of Config. 2

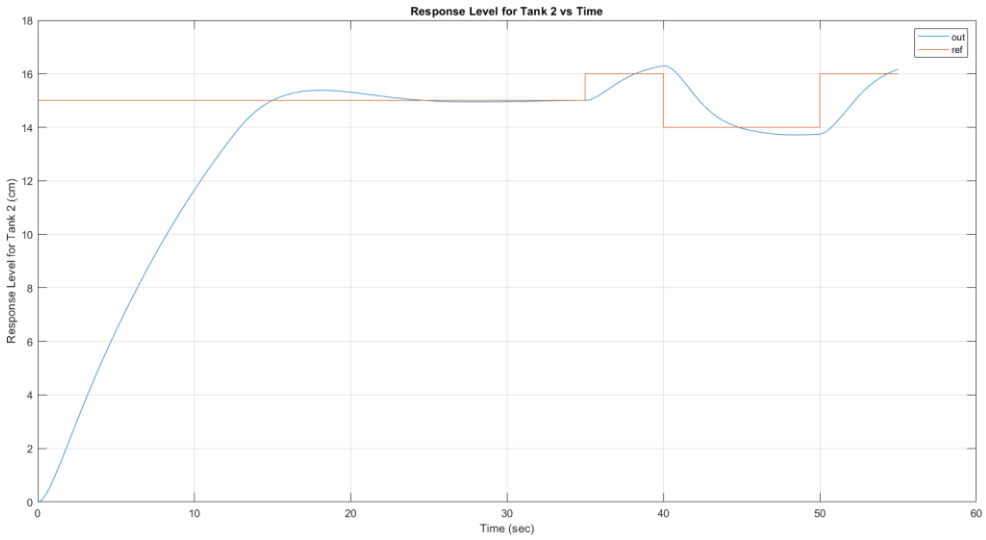

Figure 6: Response for Tank 2 vs Time

Question 4)

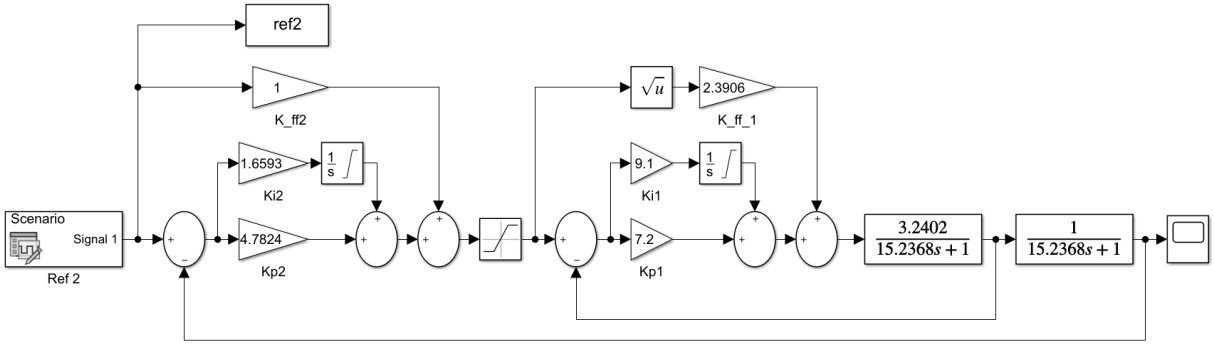

Figure 7: Block Diagram of Config. 2 for Desired New Criteria

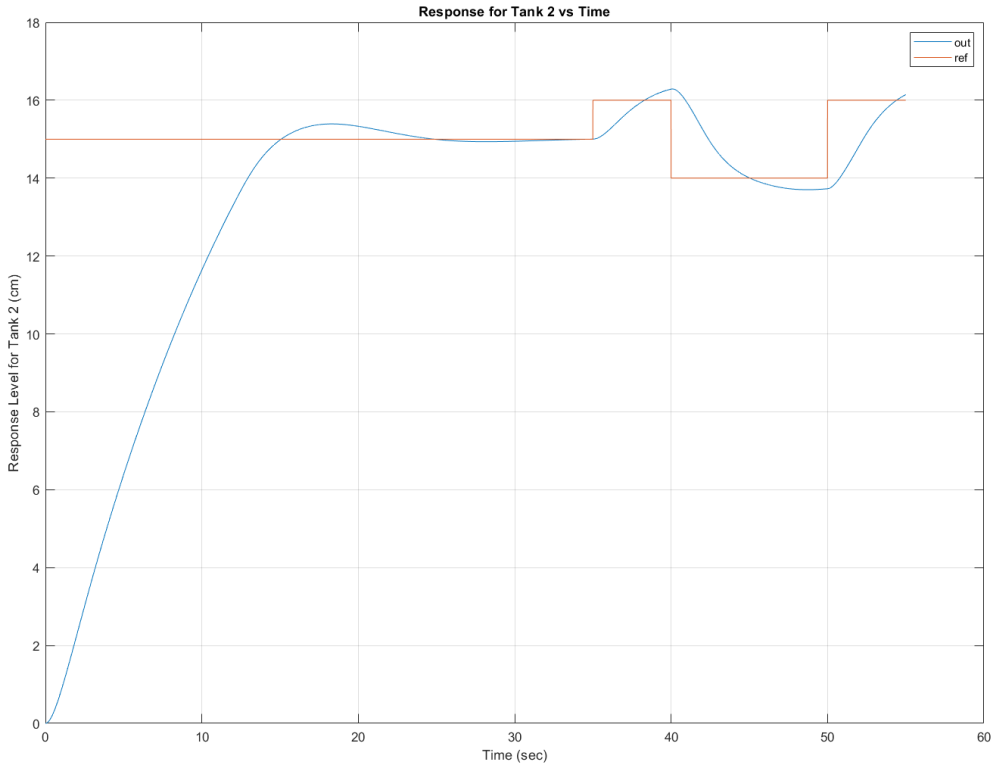

Figure 8: Response for Tank 2 vs Time for New Desired Criteria

Analysis and Interpretation of Results

Question 1)

From figure 2 we can conclude that %OS and settling time criteria meet exactly but there is a steady-state error when reference input bigger than last input. If I change the saturation limit PI controller's integral term +3 and -3 to much wider area, steady-state error goes to zero but %OS increases.

Question 2)

As we can seen from figure 4 %OS and settling time criteria meet exactly but there is a steady-state error when reference input bigger than last input. When reference input smaller than last input steady-state error goes zero.

Question 3)

Due to high settling time criterion system cannot catch the rapidly changing reference input. From figure 6, %OS criterion meet exactly but it seems there is a small steady state error. This can be occur because of saturation limit of PI controller's integral term and liquid level of other tank.

Question 4)

Can be seen from figure 8 system cannot catch the quickly changing reference input due to high settling time criterion and there is a steady-state error but %OS criterion satisfied.