# Lab 8 Report
Coupled Tank System

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B20EE087

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# 1 Experiment 1

## 1.1 Objective:

To study the characteristics and a control action of PID on the tank 1.

## 1.2 Apparatus:

COUPLED TANK SYSTEM (VCTS-01) unit, Computer with software, Data acquisition system (VDAS –01), Power chord, Loop cable, USB cable.

## 1.3 Analysis:

To calculate pump constant Kp, We calculate the inflow rate due to the pump and outflow rate is calculated using the Bernoulli equation for small orifices. At equilibrium(steady state), we know that both inflow and outflow rates would be equal and thus their difference would be zero.

Vol. inflow $= K_p V_p$

$F_{i_1} = K_p V_p$

$V_p = 180\ V$

$L_1 = 5\ cm$

$a_{o1} = 0.78\ cm^2$

$a_{i1} = 3.14\ cm^2$

Vol. outflow rate

$F_{o1} = a_{o1}\sqrt{2gL_1}$

$\llcorner$ outlet area of tank 1

Flow rate through the tank

$$F_{i1} - F_{o1} = K_p V_p - a_{o1}\sqrt{2gL_1}$$

$$a_{i1}\frac{d(L_1)}{dt} = K_p V_p - a_{o1}\sqrt{2gL_1}$$

At steady state, rate $= 0$.

$$\therefore \frac{d(L_1)}{dt} = 0$$

$$\therefore K_p V_p - a_{o1}\sqrt{2gL_1} = 0$$

$$K_p = \frac{a_{o1}\sqrt{2gL_1}}{V_p}$$

$$= \frac{0.78\times10^{-4}\sqrt{2\times9.8\cancel{\times10}\times5\times10^{-2}}}{180}$$

$$\boxed{K_p = 4.32\times10^{-7}}$$

Figure 1: Calculations for Kp

## 1.4 Observations and Optimization:

The initial values of the PID controller and the corresponding graph is as follows: Here the desired level of the tank is 5 cm

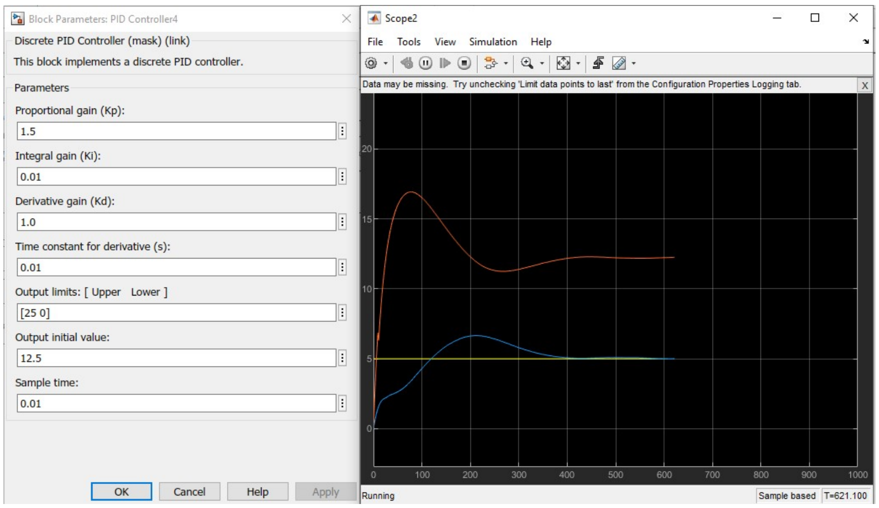


Figure 2: Initial values of the PID controller

### 1.4.1 Variation with Ki:

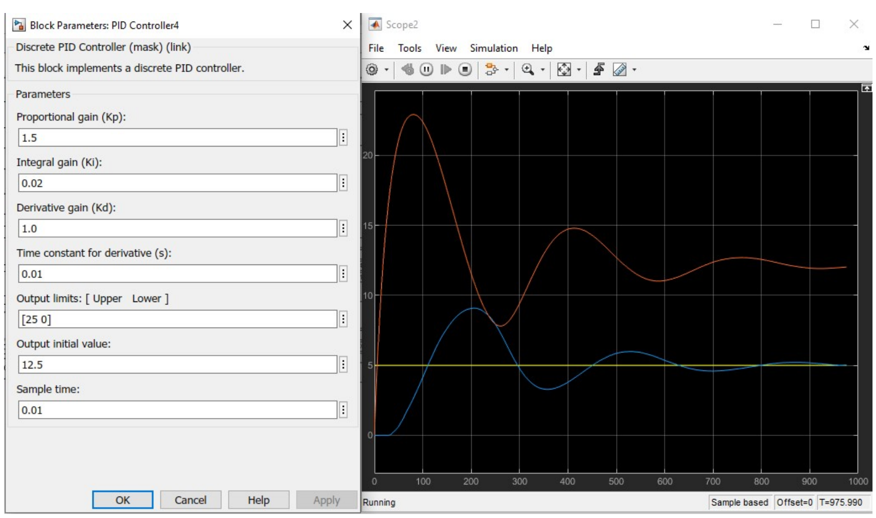


Figure 3: Increasing Ki

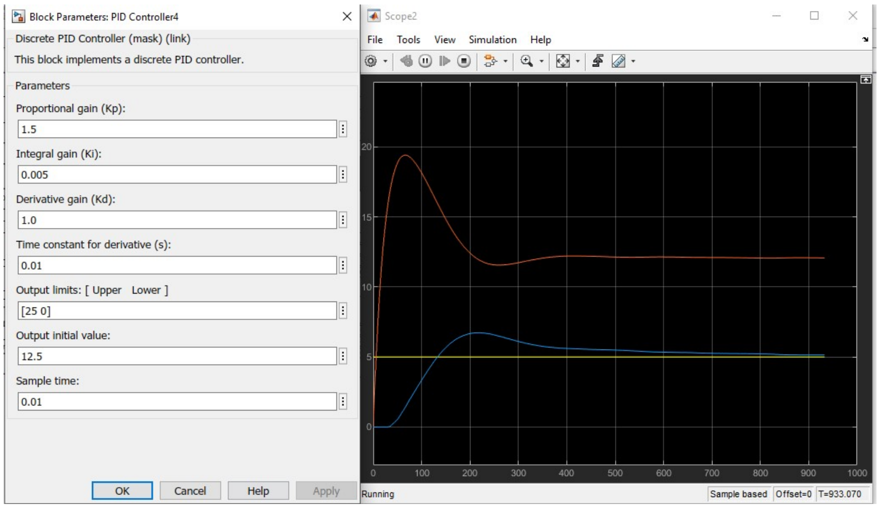


Figure 4: Decreasing Ki

By increasing the value of Ki, the rise time decreases but the overshoot and setting time increases to a great extent. We also observe that the oscillations are decreasing at a high rate, implying that the steady state error can be eliminated. The current also follows similar trend to that of the water level.

By decreasing the value of Ki, the rise time is higher but it leads to less overshoot and settling time, but the steady state error does not reduce to zero. The current also becomes steady after the settling time.

### 1.4.2 Variation with Kp:

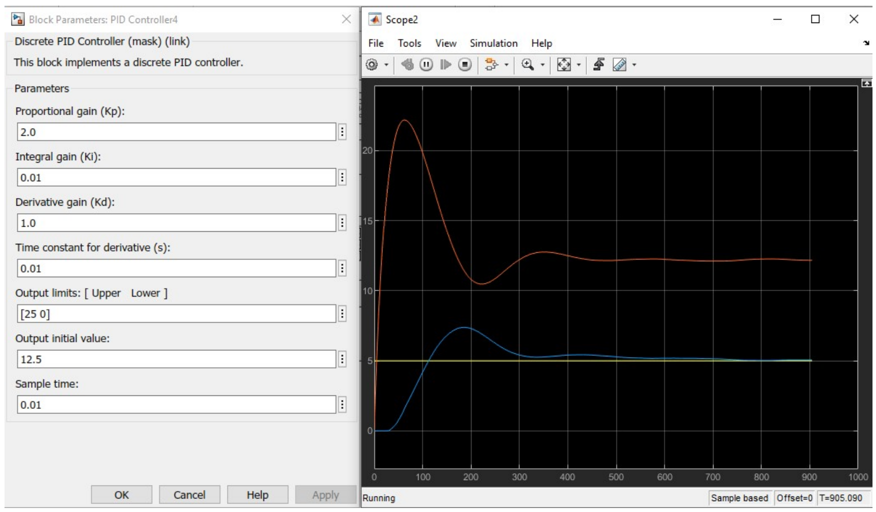


Figure 5: Increasing Kp

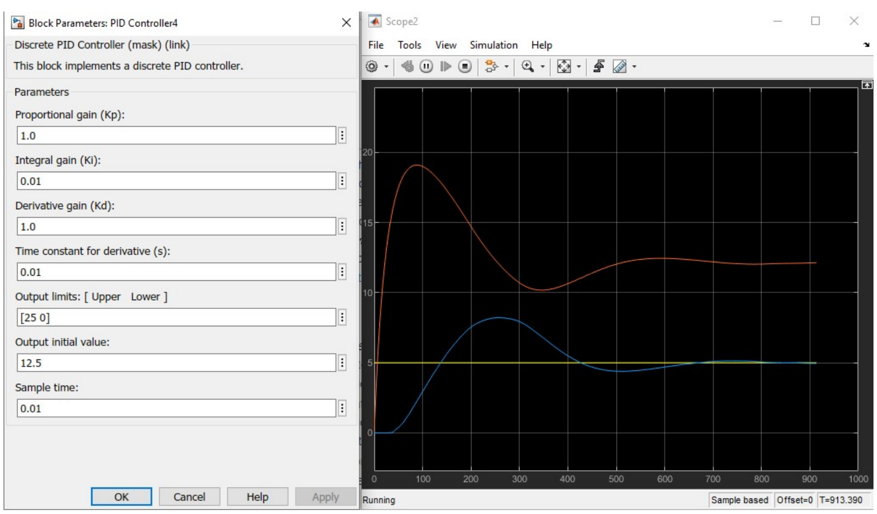


Figure 6: Decreasing Kp

By increasing the value of Kp, the rise time decreases at the cost of increasing peak overshoot. We observe that there is not much change in the settling time and steady state error.

By decreasing the value of Kp, the rise time as well as the peak overshoot is observed to be slightly higher. The current variation is steady compared to higher fluctuations observed when the value of Kp was increased.

### 1.4.3 Variation with Kd:

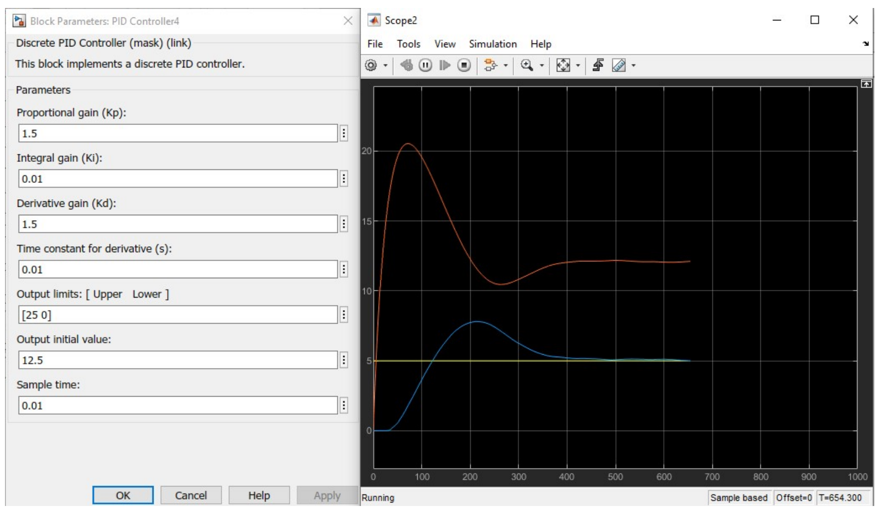


Figure 7: Increasing Kd

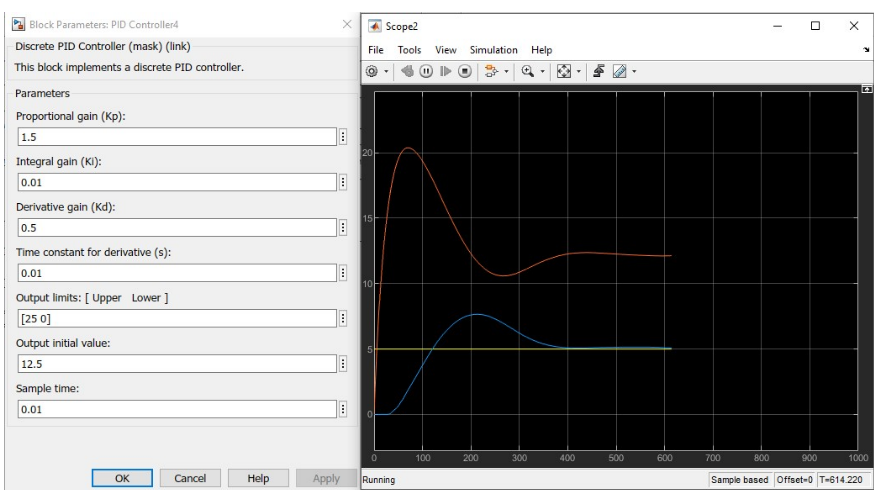


Figure 8: Decreasing Kd

By increasing the value of Kd, peak overshoot and settling time values decrease slightly. No visible effect is observed on the steady state error.

By decreasing the value of Kd, peak overshoot and settling time values increase slightly. No visible effect is observed on the steady state error. The current profile also does not change much.

# 2 Experiment 2

## 2.1 Objective:

To study the characteristics of coupled tank system in interaction.

## 2.2 Apparatus:

COUPLED TANK SYSTEM (VCTS-01) unit, Computer with software, Data acquisition system (VDAS –01), Power chord, Loop cable, USB cable.

## 2.3 Observations and Analysis:

The initial values of the PID controllers are as follows: Here the desired level of the tank1 is 5 cm and that of tank2 is 10 cm. The water can only flow from tank1 to tank2.

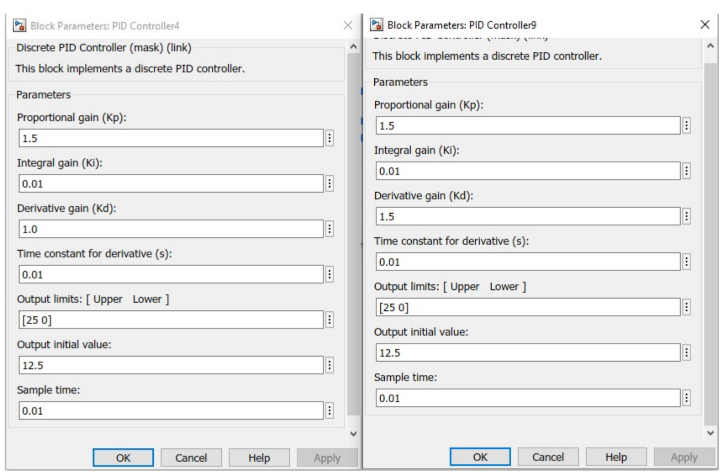


Figure 9: Initial values of the PID controller

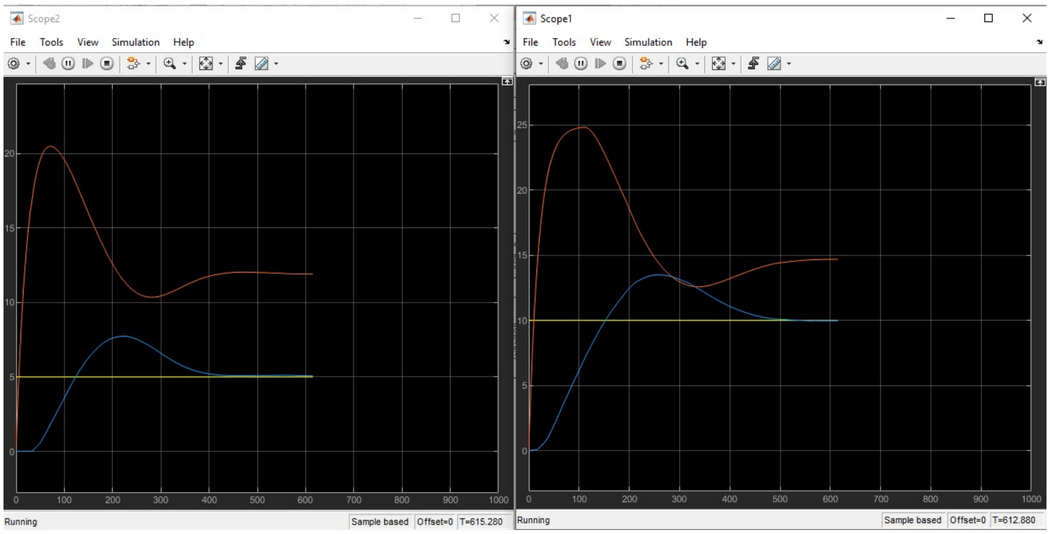


Figure 10: Initial variation between desired and observed levels.

### 2.3.1 Increasing the value of Kp for tank1:

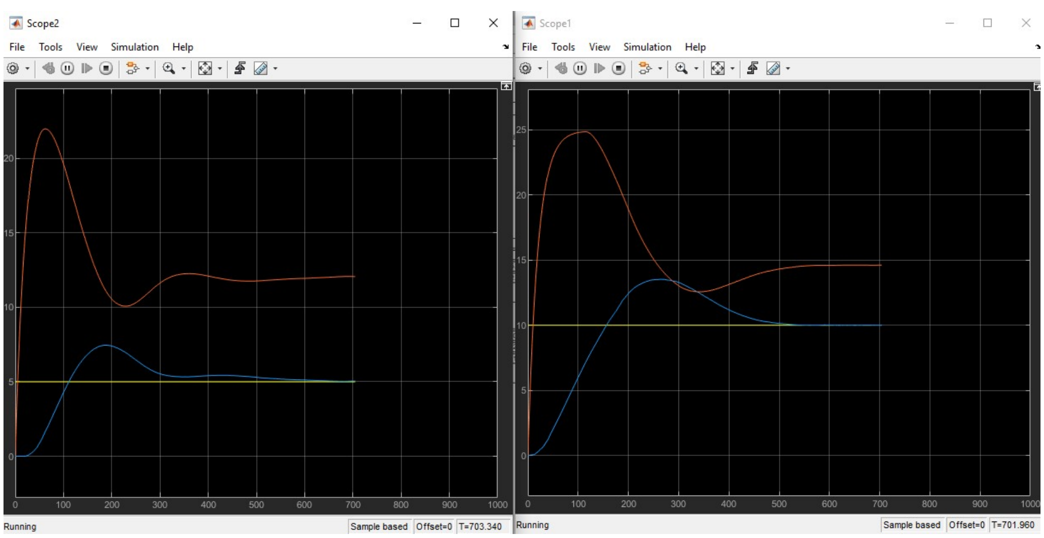


Figure 11: Increasing Kp for tank1

By increasing the value of Kp, the rise time decreases at the cost of increasing peak overshoot. We observe that there is not much change in the settling time. The steady state error is observed to reduced slightly from the graphs.

### 2.3.2 Increasing the value of Kd for tank2:

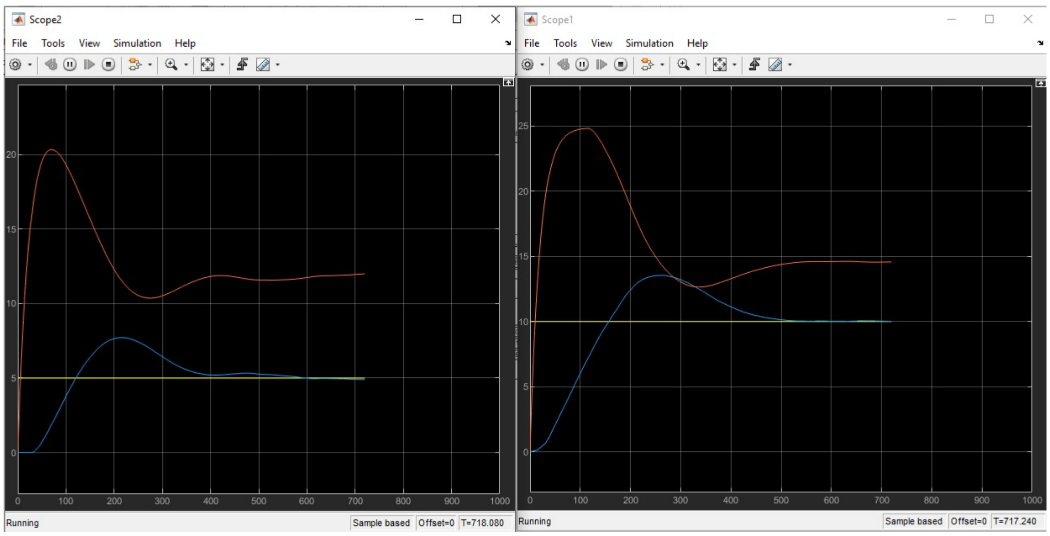


Figure 12: Increasing Kd for tank2

By increasing the value of Kd, peak overshoot and settling time values decrease slightly. No visible effect is observed on the steady state error.

### 2.3.3 Increasing the value of Ki for tank1:

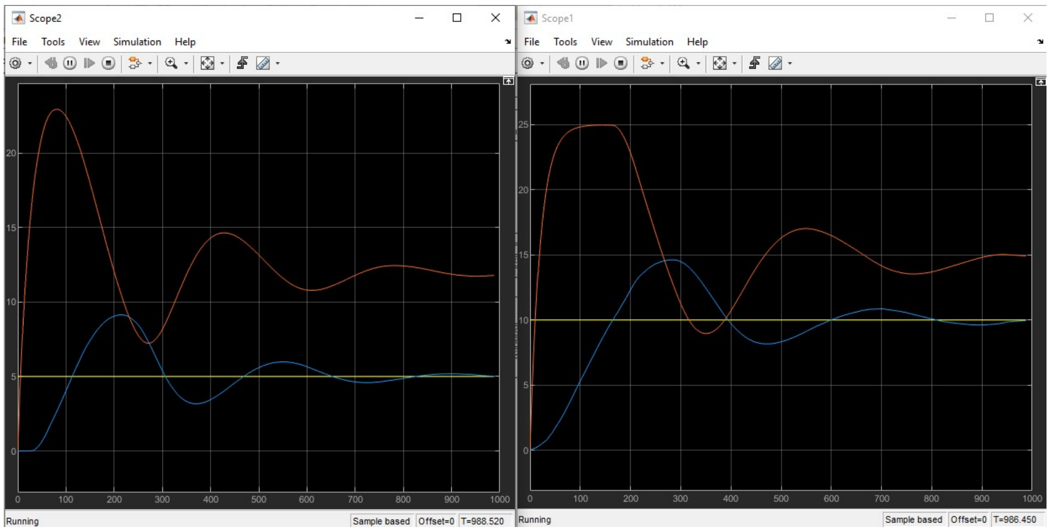


Figure 13: Increasing Ki for tank1

Increasing the value of Ki, there is a decrease in rise time, but it increases the overshoot as well as the settling time. The rapidly decreasing value of error implies that increasing Ki helps to eliminate the steady state error.

# 3 Conclusion:

In the above experiments, the most optimal behaviour is observed at the initial values of the PID controllers. We can also conlcude that in the hit and trial process of determining the values of the PID controller, we can use Kp to decrease the rise time, Ki to reduce or eliminate steady state error and Kd to reduce overshoot and settling time.