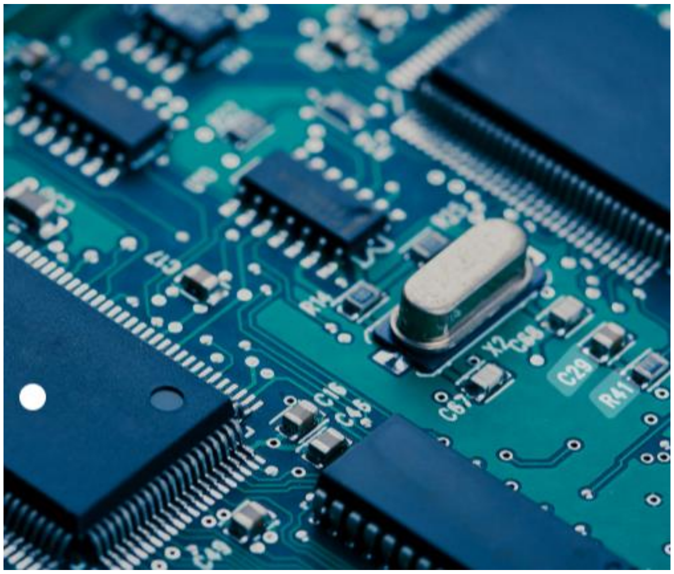


CONTROL SYSTEMS LAB REPORT

Group Number : 55

- Divyesh Jayswal (4021402)
- MD Mazidur Rehman (4020084)

LAB V1: Rapid Control Prototyping (RCP)with MATLAB & SIMULINK

Experiment performed on: 05.07.2022

Supervisor: **Prof. Dr. Tobia Kaupp**

1. Identification of System 3

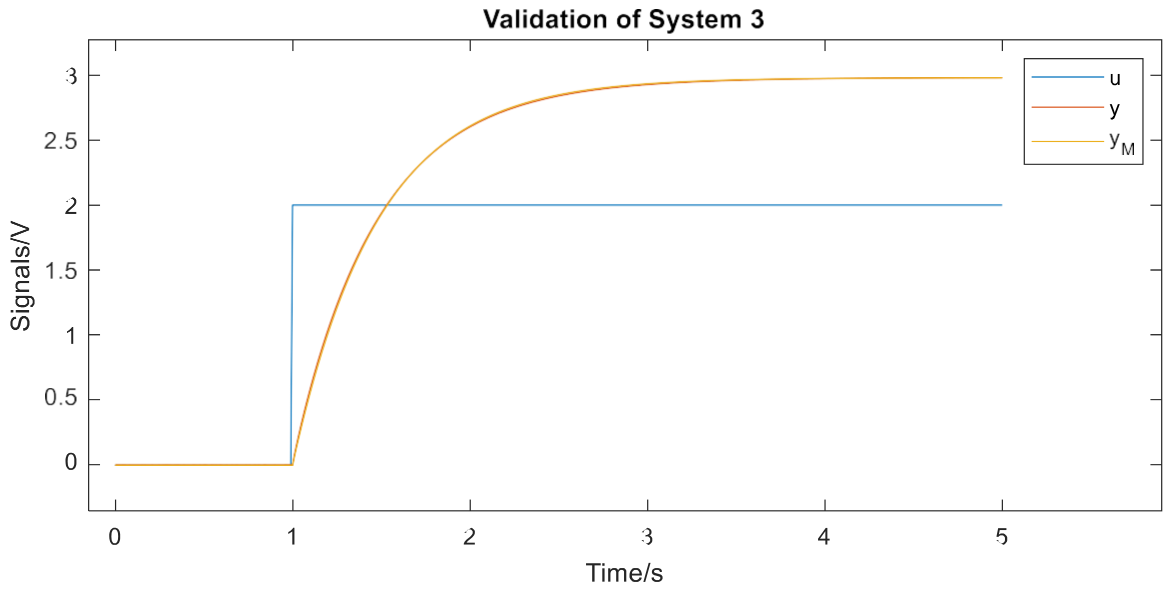


Figure 1. Step response of System 3

The step response of System 3 was recorded and was identified as a first order system (PT1). The estimated parameters of the first order system were:

- Steady-state gain K = 1.4898
- Time constant τ = 0.48

Calculations were made using the step response graph from the scope of the block diagram of the system in MATLAB Simulink and MATLAB commands in a MATLAB script as shown below.

```
t = MD1.time;                   %  time  vector
u = MD1.signals(1).values(:,1); % system input
y = MD1.signals(1).values(:,2); % system output

K = y(501,1) / u(501,1); % formula
T = 0.48;          % calculated from the graph, y(T) = 0.63*y_infinity
```

For a first order system the transfer function is given by

$$G(s) = \frac{K}{rs + 1}$$

Hence the suggested transfer function for the model system 3 is

$$G_{S3}(s) = \frac{1.4898}{0.48s + 1}$$

From Figure 1, it is visible that the output y_M of the suggested model is almost the same as the output y of the system. This means that the modelling error is very low and hence the suggested model is satisfactory.

2. Identification of System 2

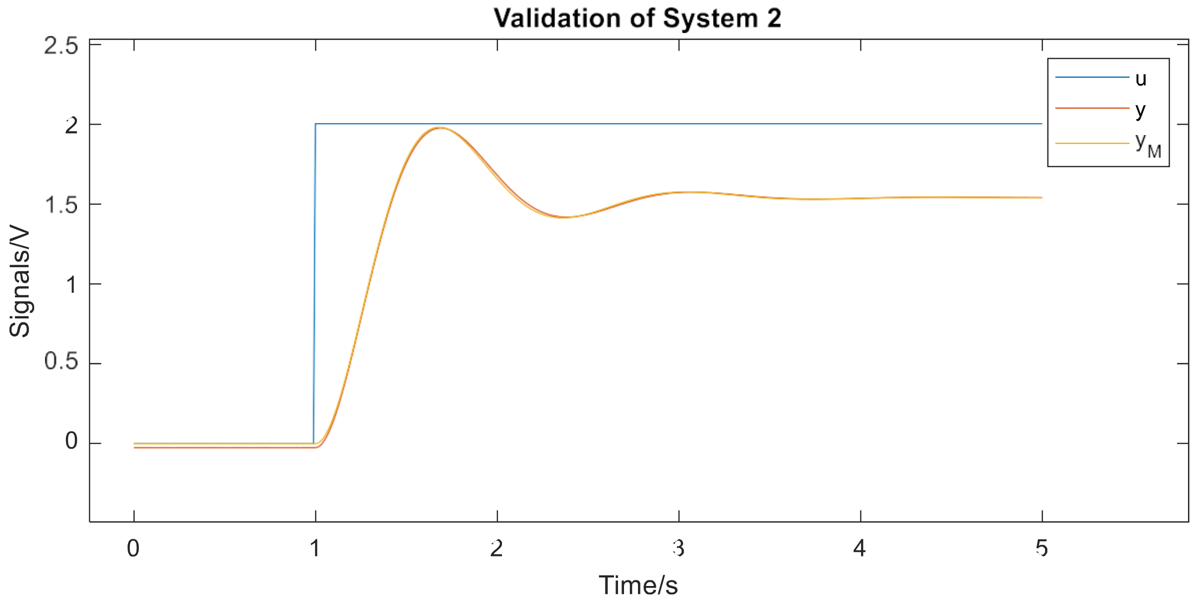


Figure 2. Step response of System 2

The step response of System 2 was recorded and was identified as a second order system (PT2). The estimated parameters of the second order system were:

- Steady-state gain K = 0.7688
- Overshoot M_P = 0.2833
- Damping coefficient D = 0.37
- Frequency of oscillation ω = 4.62
- Natural frequency ω_0 = 4.9729

Calculations were made using the step response graph from the scope of the block diagram of the system in MATLAB Simulink and MATLAB commands in a MATLAB script as shown below.

```
t = MD2.time;                      % time  vector
u = MD2.signals(1).values(:,1); % system input
y = MD2.signals(1).values(:,2); % system output
K = y(501,1) / u(501,1);                  % formula
y_inf = y(501,1);
y_max = max(y);
M_P = (y_max - y_inf)/y_inf;              % overshoot
T = 1.36                                  % time period calculated from the graph
Omega = (2*pi)/T;                         % frequency
```

```
D = 0.37                              % damping ratio, found from the graph in the
lab manual
Omega0  = Omega/sqrt(1 - D^2)         % Natural frequency of the system
```

controller parameters K_R, T_I and T_D were adjusted manually using trial and error method such that the controllers achieved the following performance:

- no steady-state error
- the new set-point is achieved as quickly as possible

For a second order system the transfer function is given by

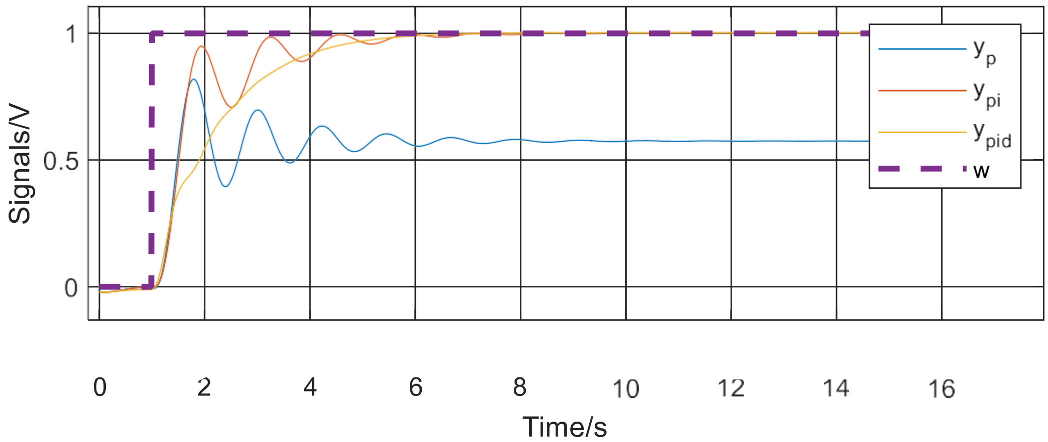
$$G(s) = \frac{K}{\left(\frac{s}{\omega_0}\right)^2 + 2D\left(\frac{s}{\omega_0}\right) + 1}$$

Hence the suggested transfer function is

$$G_{S2}(s) = \frac{0.7688}{\left(\frac{s}{4.9729}\right)^2 + 2 \times 0.37\left(\frac{s}{4.9729}\right) + 1}$$

From Figure 2, it is visible that the output y_M of the suggested model is almost the same as the output y of the system. This means that the modelling error is very low and hence the suggested model is satisfactory.

3. Implementation, Test and Tuning of P, PI and PID controllers



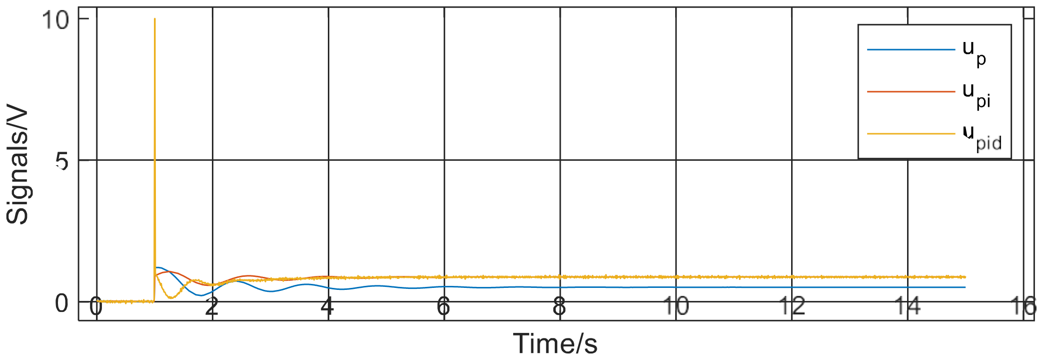


Figure 3. Step response of the linear system

- A linear system (series connection of System 3 and System 2) was to be controlled with the helpof P, PI and PID controllers. The controllers were implemented as Simulink block diagrams. The very small overshoot and negligibly small amplitude of oscillation.The estimated parameters of the optimized controller were:

CONTROLLER	K_R	T_I	T_D
P	1.2	-	-
PI	0.9	0.9	-
PID	1	1.4	0.8

Conclusion:

For the P controller K_R was chosen such that the oscillations decayed to a steady state as quickly as possible. The PI controller helped to achieve the set point. T_I was tuned to reduce the overshoot as much as possible. The PID controller helped to achieve the set point with minimum oscillations and as quickly as possible. The parameters were tuned to achieve optimum performance.