Control Systems

ELEC207

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Abstract

In this simulation lab feedback control system controller part is discussed. Integral control is able to take care of steady state error, while derivative control helps in reducing overshoot.

Plagiarism and collusion declaration

This is original work and collusion if any may occur due to use to commonly used technical words used in control system texts,

Introduction

The purpose of this simulation lab in feedback control lab is to explore plant modeling, closed loop control simulation using SIMULINK, introducing P and PI controller and see performance improvement by observing reduction in overshoot and steady state error.

Noise disturbance rejection is also need to be explored.

Material and methods

SIMULINK model building software of MATLAB is used to simulate the plant model and associated feedback blocks.

Typical Control System Model:

A control system is typically defined as shown in Figure no 1

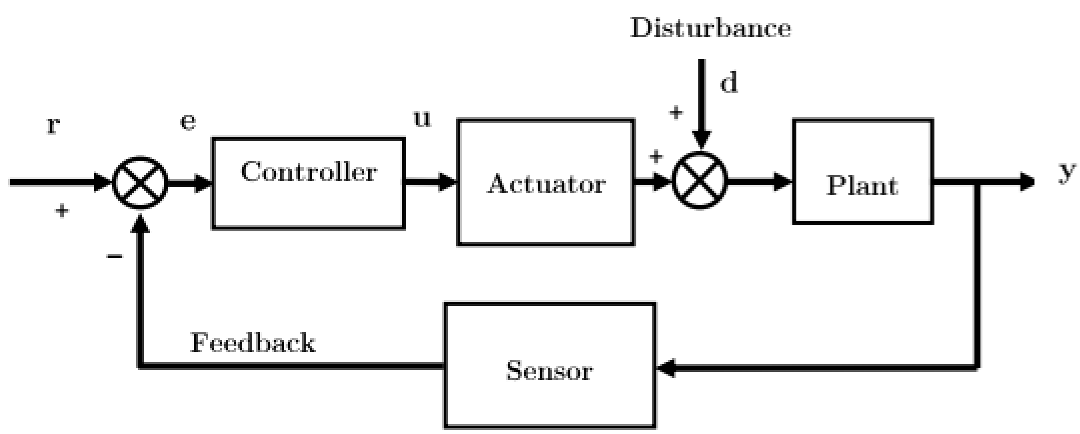


Figure 1 : A typical control system

A typical plant is represented in Laplace domain Can be given using Laplace Domain Transfer Function. Now let us study the plant.

Plant:

The given plant transfer functions is given below.

$$G(s) = \frac{K}{(T * s + 1)^2}$$

Here the plant is cascaded two first order system

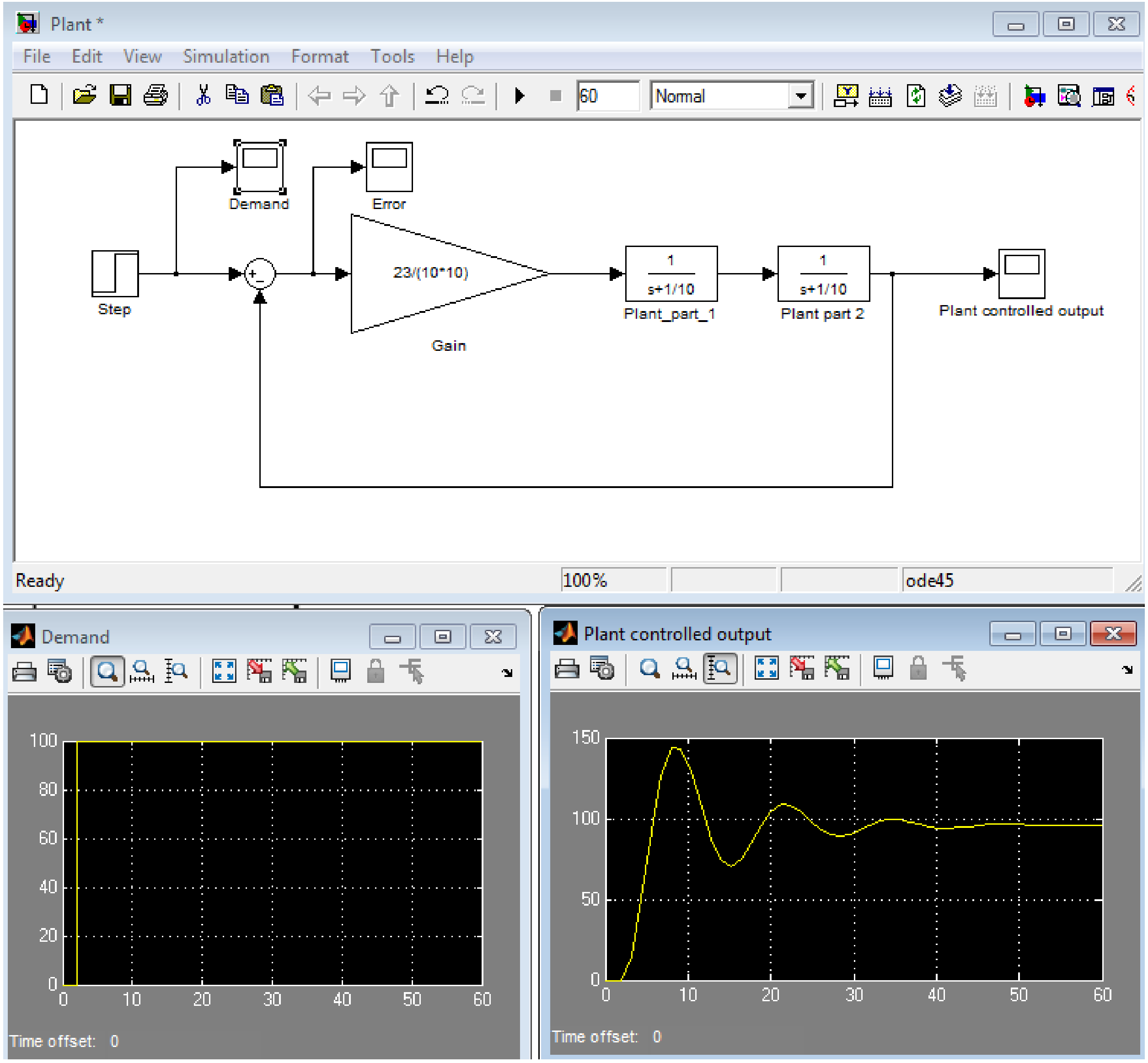
Since my date of birth 23/10/1993

K= day of birth = 23

T= month of birth= 10

Part 1

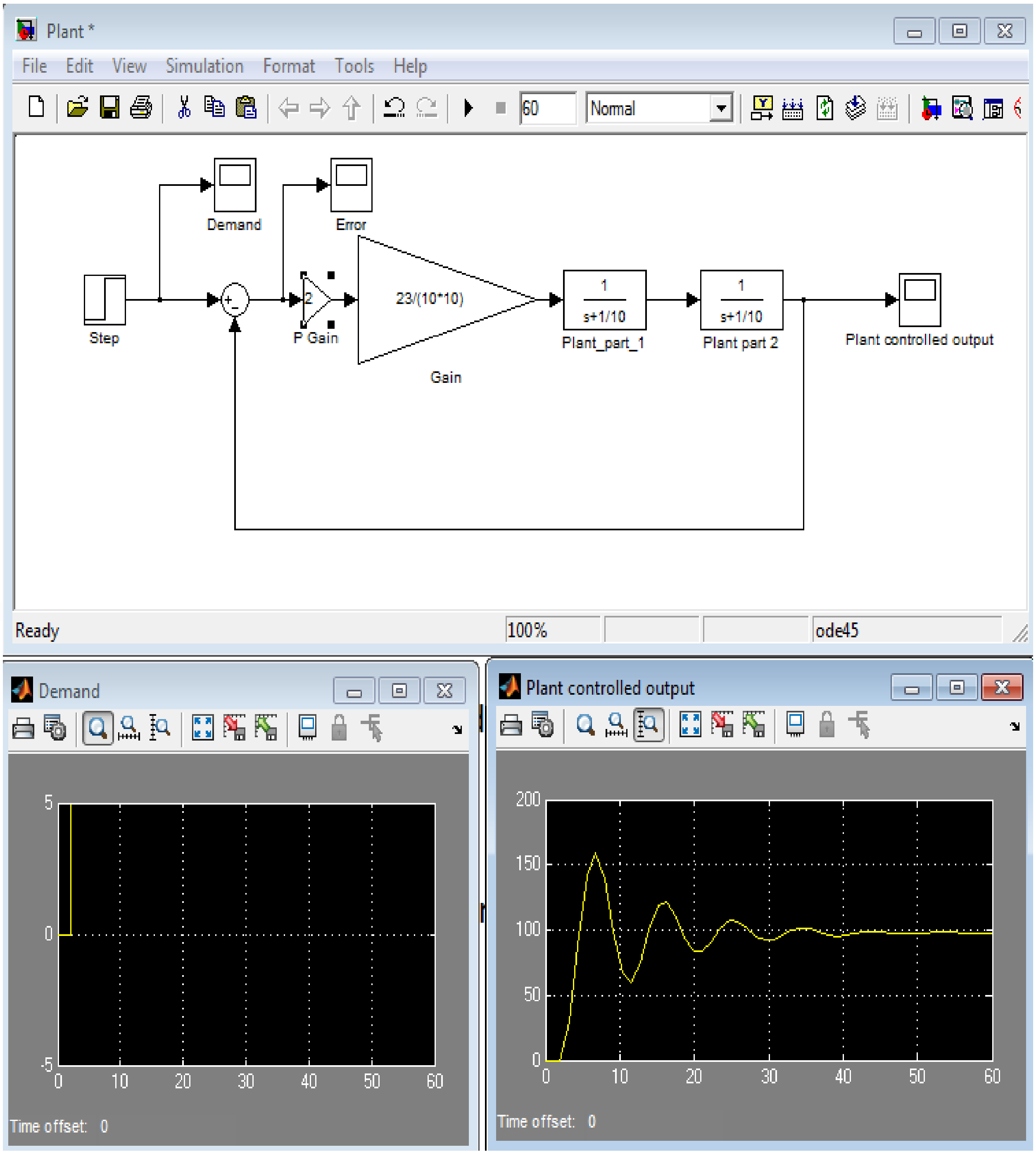
The simulated plant with its output is shown below



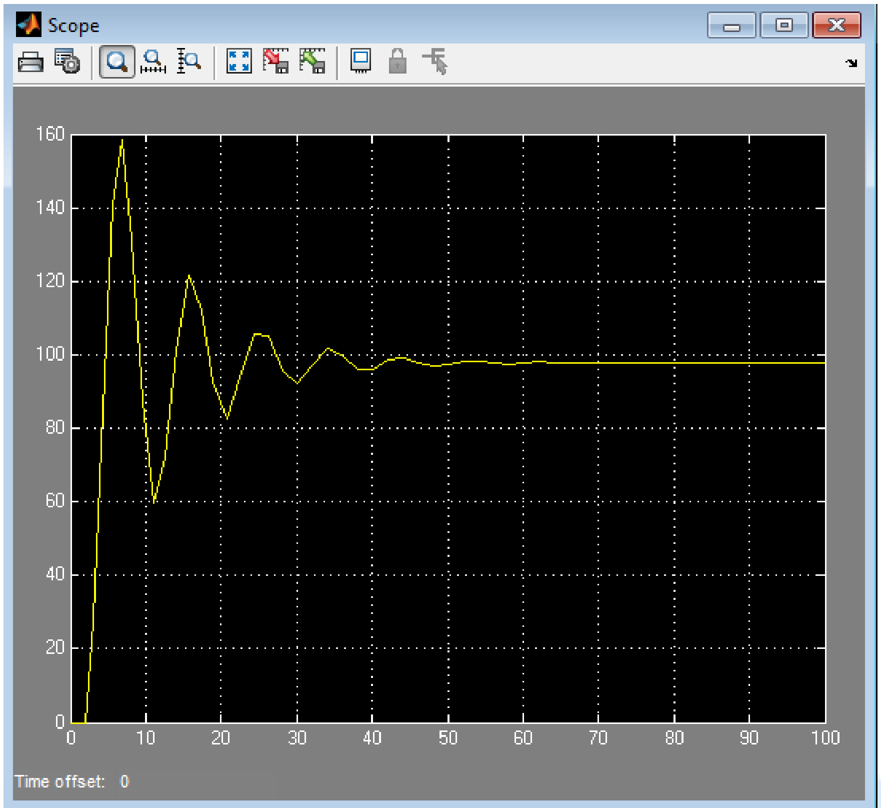
For demand of 100 at time = 2 sec , we get a peak of 140 at around 9 sec , and the response settles down to 95 giving an steady state error of 5 %

Part 2:

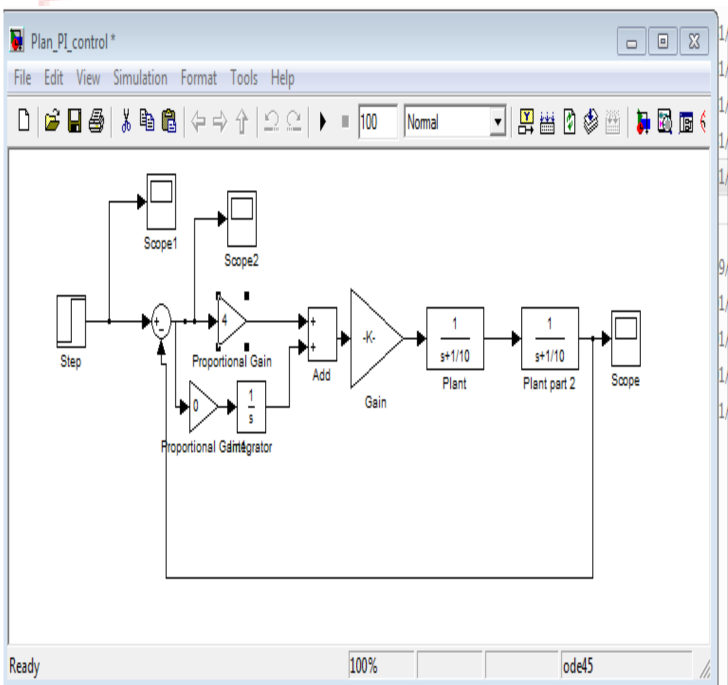
When we introduce proportional gain and set gain to 2

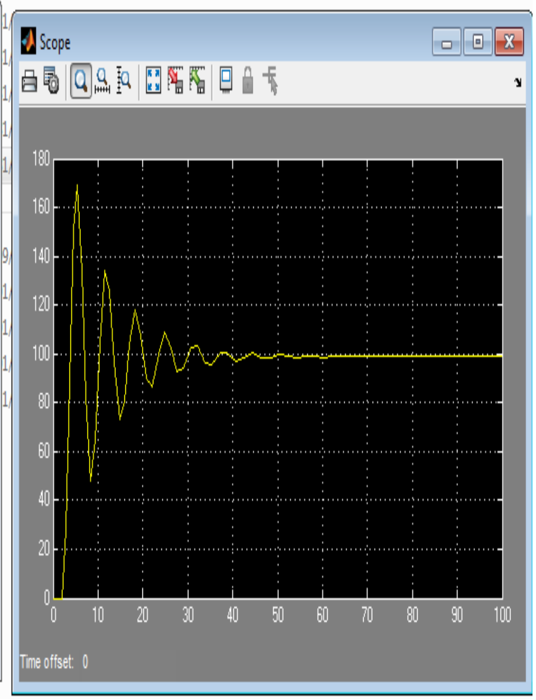


With PI gain 2

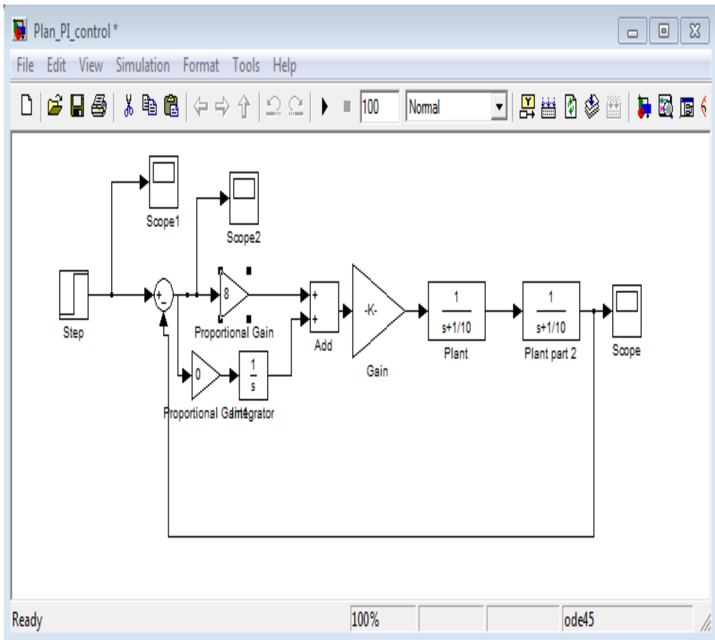


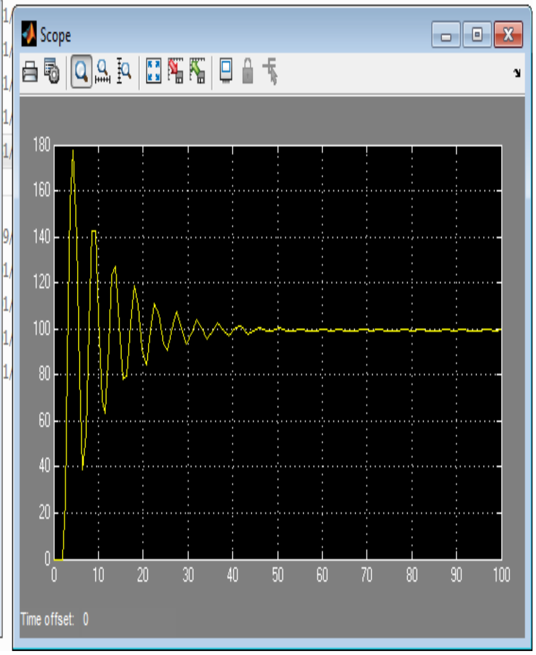
With Gain 4





With PI gain 8





Obseravtions:

P Gain	% Overshoot	Steady state error
2	60%	2%
4	70%	1%
8	80%	0.5%

We find reduction in steady state error, from 5% to just 2%, but overshoot rises to 160

As PI gain values are increased % overshoot rises and steady state error decreases.

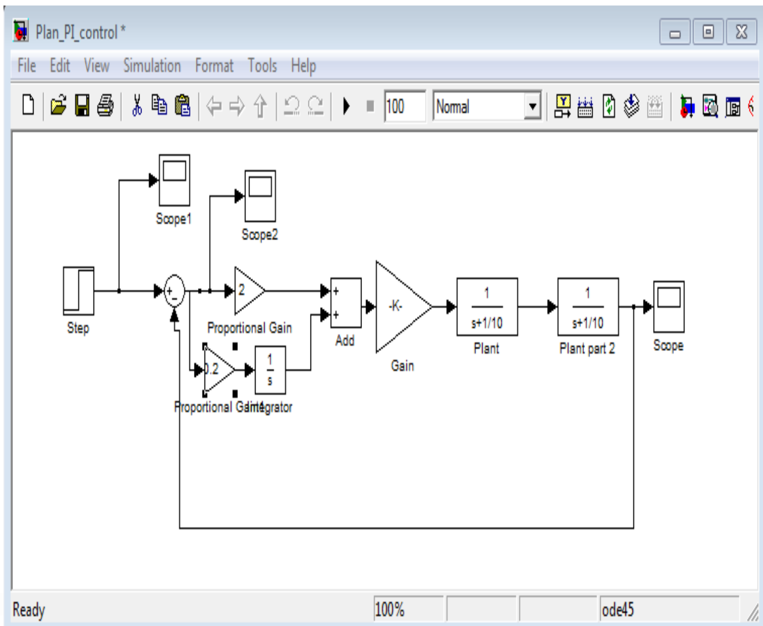
Thus we see that to reduce steady state error to acceptable value of 1 % we have live with 80% overshoot.

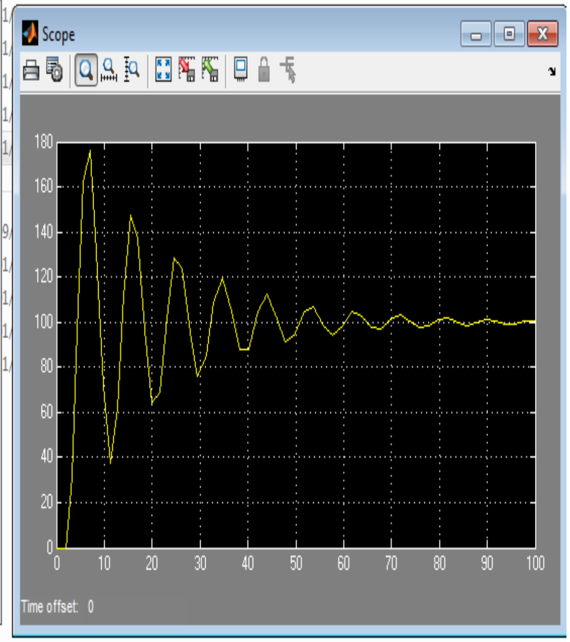
Part 3:

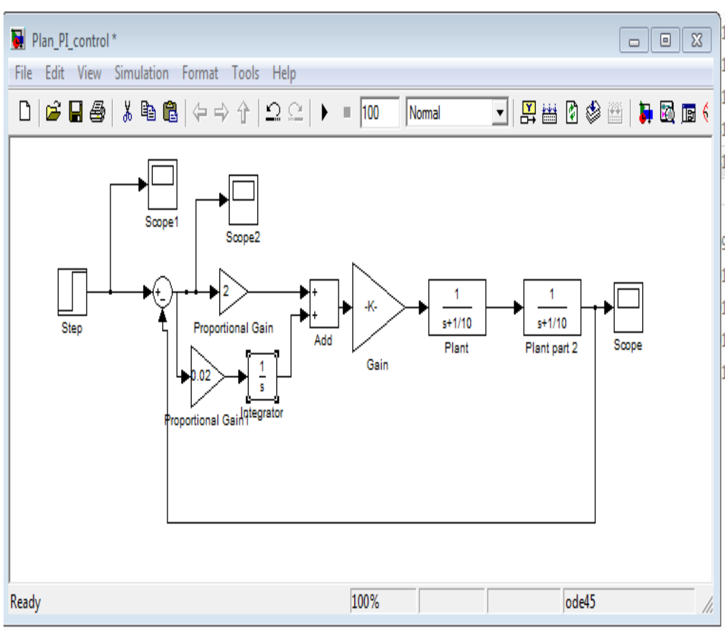
PI controller

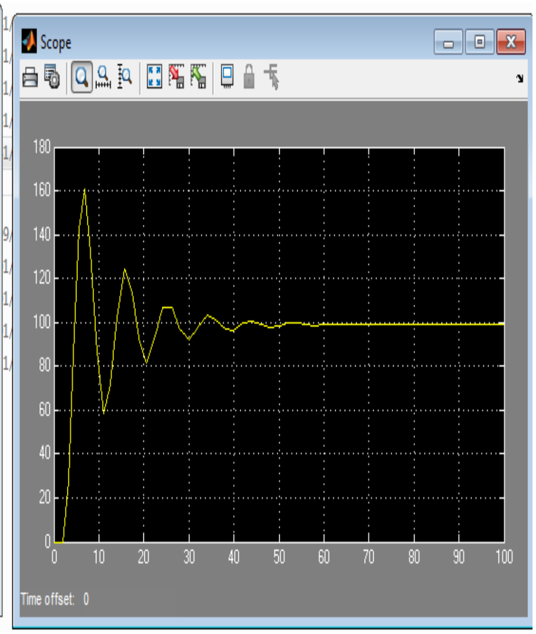
Using PI control Simulink model is worked out.

We try Proportional gain of 2 and integral gain of 12.









Obseravtions:

PGain	IGain	% Overshoot	Steady state error
2	0.2	70%	0%
2	0.02	60%	0%

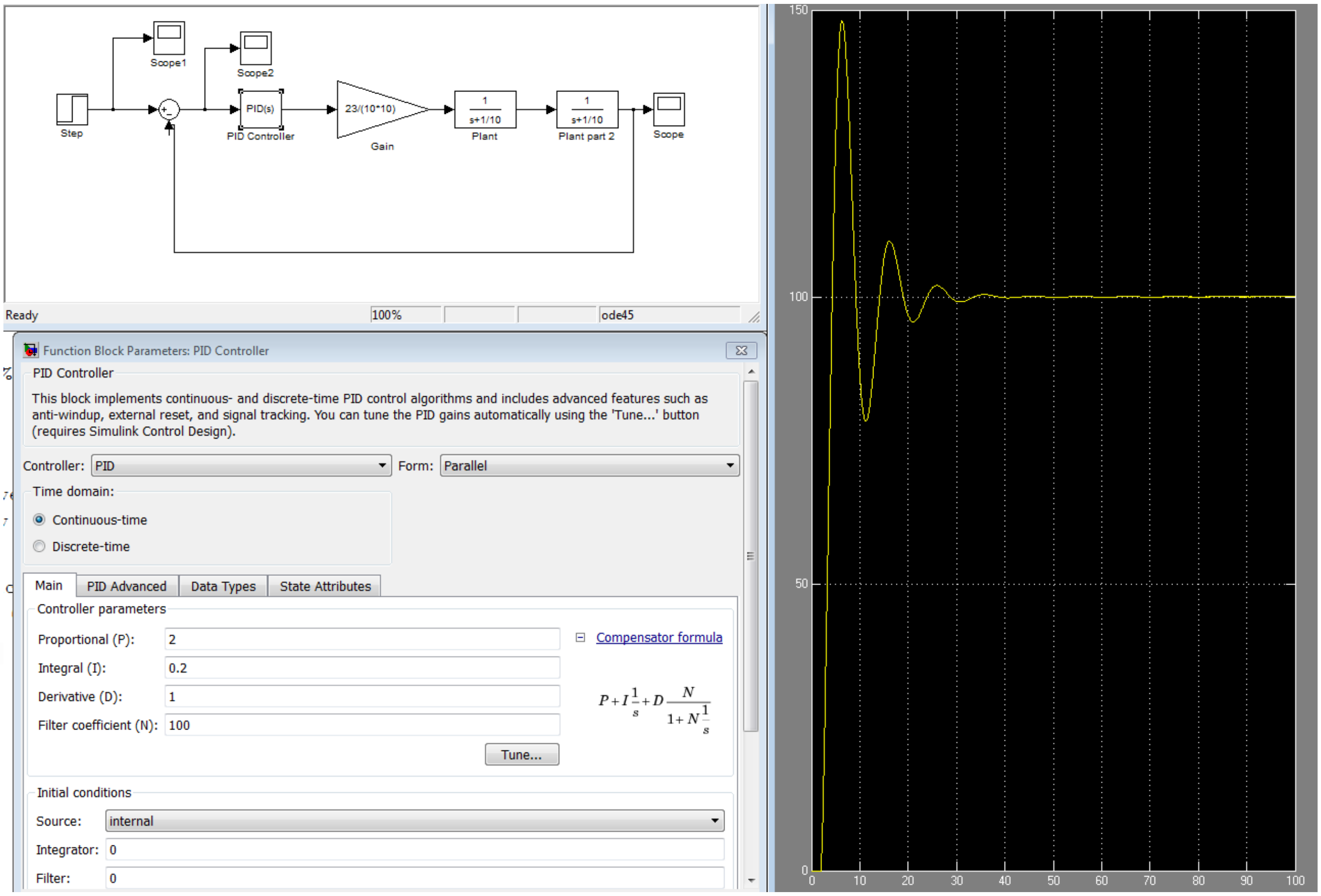
The output is given in figures. We see that by using PI controller steady state error can be eliminated but peak further rises to 170.

On further reduction in Integral gain over shoot can be brought back to 60%.

Part 4 and part 5:

To improve further we use a PID control

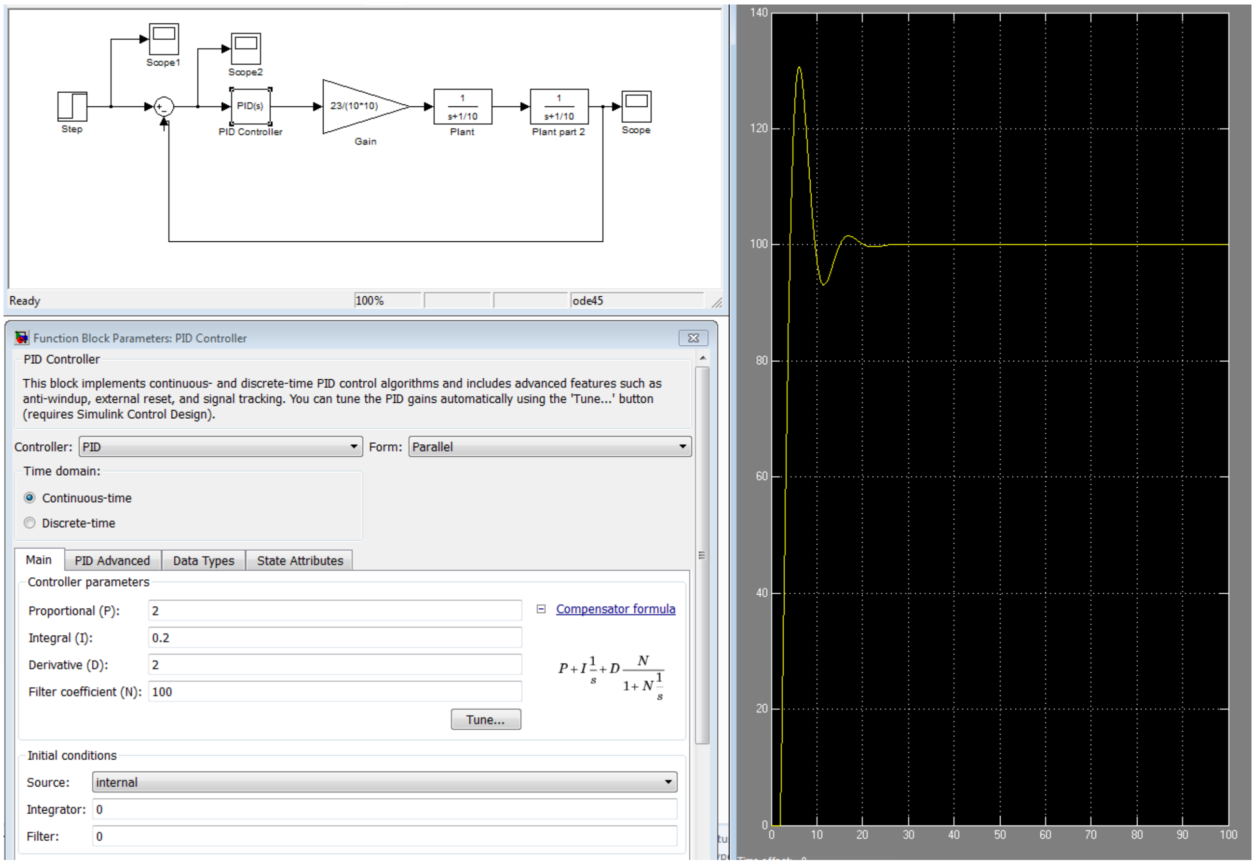
Here we have introduced derivative gain of 1 , P=2 and integral gain as 0.2



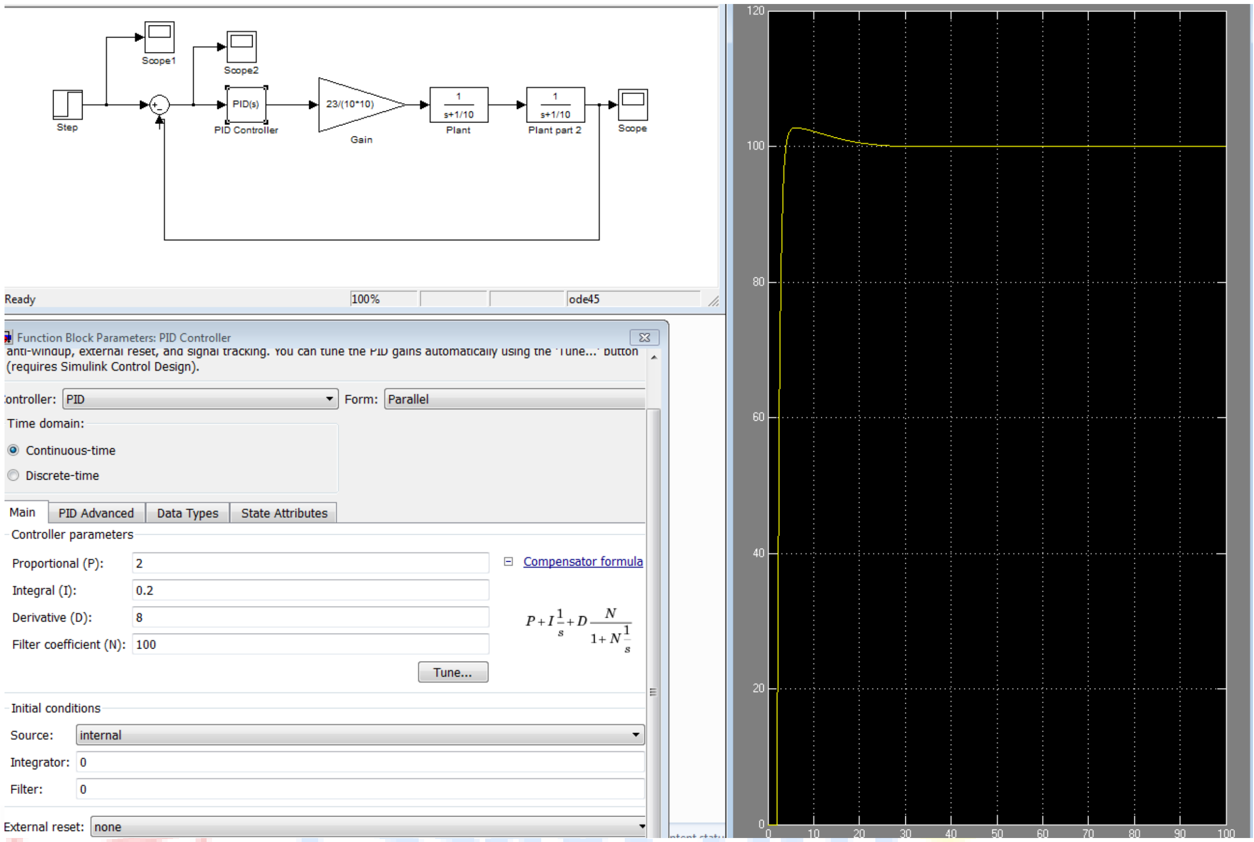
We can see that there is no steady state error and overshoot is also reduced less than 48%

With increase in derivative gain further

We can see further fall in peak overshoot to 30%

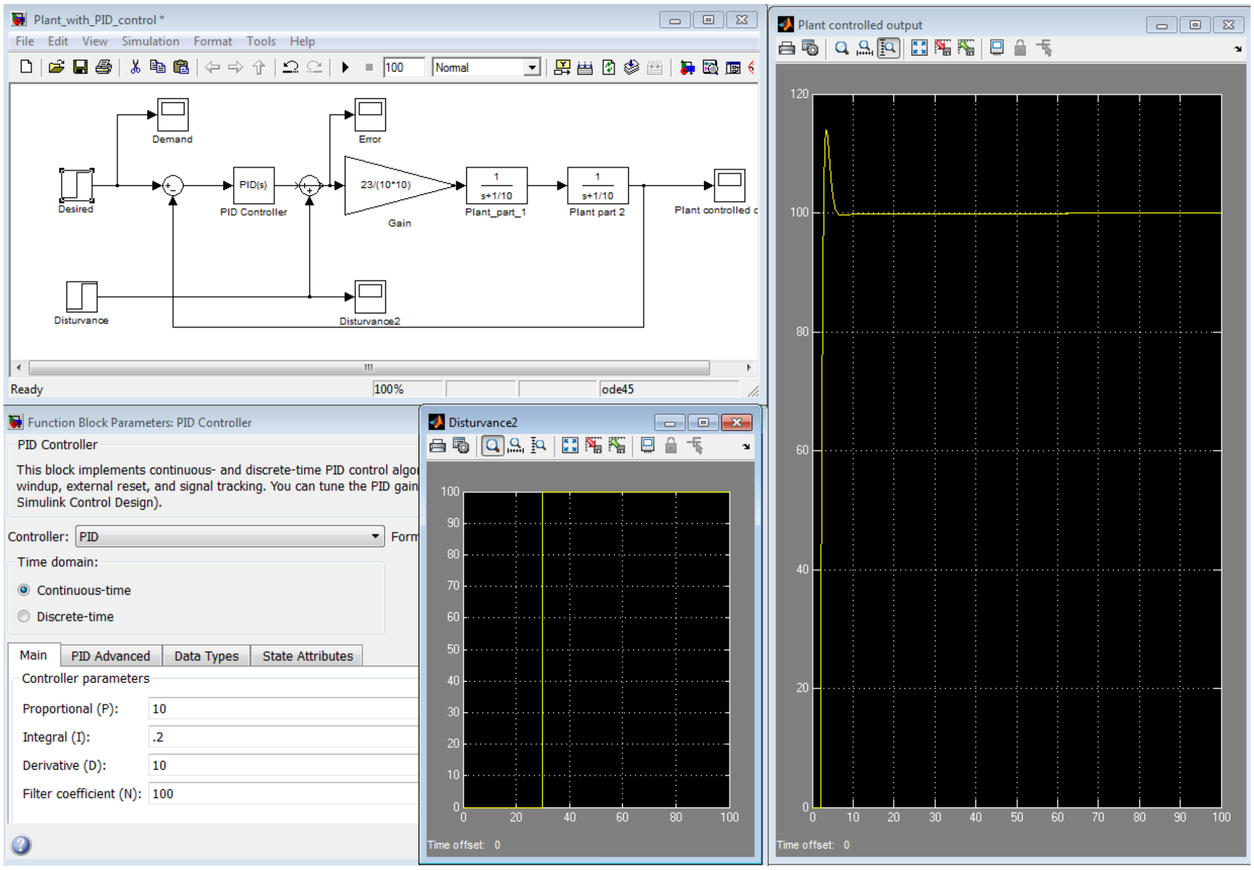


Finally with Derivative gain incrweased to 8 we get ideal vehavior with just 5% overshoot.



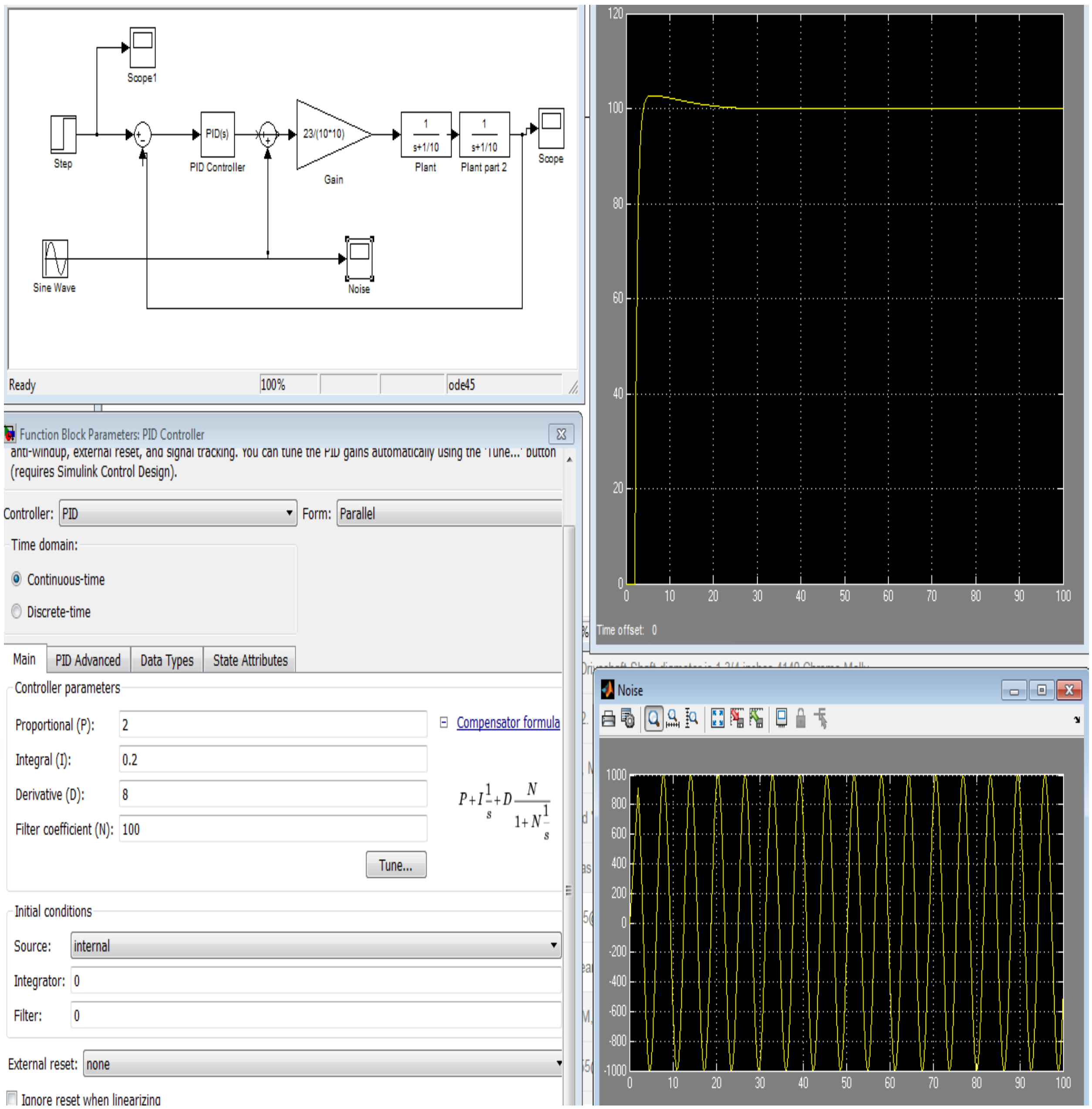
Let us now introduce a disturbance in the form of stem input, of 100 at time = 30 sec is introduced.

From the output we can see that plant has good disturbance removal property.



We see that a step noise is totally taken care of.

Let us now try Sinusoidal noise input of 1000 amplitude



Again we see system response is totally immune to 1000 unit sinusoidal noise.

Results

Original plant without ant controller had the following performance," peak of 140 at around 9 sec , and the response settles down to 95 giving an steady state error of 5 %"

With introduction of proportional control of gain 2. We find reduction in steady state error, from 5% to just 2%, but overshoot rises to 160"

Addition of integral control in part 3, the steady state error get fully eliminated but peak further rises to 170.

We have tried further reduced integral gain from 0.2 to 0.02 which is adequate to remove steady state error

Final with PID control we achieve the best performance, which is elaborated in part 4,

We can increase derivative gain to 8 to achieve less than 5% overshoot with no steady state error.

In addition to reduced overshoot, we have good disturbance reduction performance.

Discussion and Conclusions:

I have learnt that by introducing Integral control steady state error gets removed and further by adding derivative part we get a PID controller, and we are able to reduce the overshoot to desired level of just 5% and at the same time steady state error is also zero.

With PID controller we see noise immune system.

We have tried to introduce step noise and also sinusoidal noise of very high amplitude, 1000 units, and output follows the signal demanded which is 100 unit of step response.

Thus in the lab we have learnt all three elements of control. The proportional part, the integral part and the derivative part.

We have seen how increase in gain of all these three elements of classical PID control works.

References:

Potluri, R., & Gunasekaran, M. (2016). Lab Manual for EE380 (Control Lab). Department Electrical Engineering, IIT Kanpur. Retrieved from http://www.iitk.ac.in/ee/data/Teaching_labs/Control_System/EE380_labmanual.pdf

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