[*Rana* *, Vol.2 (Iss.1): July, 2015]
ISSN: 2454-1907
DOI: https://doi.org/10.29121/ijetmr.v2.i1.2015.26

International Journal of Engineering Technologies and Management Research
A knowledge Repository
IJETMR

DEVELOPMENT OF PID LIKE FLC ALGORITHM FOR INDUSTRIAL APPLICATIONS

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Abstract:

Now a day, in many industries different types of controllers (PD, PID, PLC, FLC etc.) are used. One of them is fuzzy logic controller. Here we develop a PID like fuzzy logic controller for industrial application, such application is water purification plant. For developing the PID like FLC, first we have to design a PID algorithm than we develop an algorithm for fuzzy logic controller. By comparing this two of controller we will develop a PID like FLC. A simple PID controller is sum of three type of controller proportional, integral and derivative controller, after simulated on MATLAB. Same cases we can be develop a structure of FLC for water purification plant. In the water purification plant raw water or ground water is promptly purified by injecting chemical rates at rates, related to water quality [13][2]. The feed of chemical rate judged and determined by the skilled operator. Here we try to develop an FLC algorithm so that the feed rate of coagulant is can be judged automatically without any skilled operator, than compose a PID like FLC for water purification plant process.

Keywords:

PID controller, fuzzy logic controller, fuzzy PID controller, MATLAB Simulink.

Cite This Article: Sudesh Singh Rana, "Development of PID Like FLC Algorithm for Industrial Applications." *International Journal of Engineering Technologies and Management Research*, Vol. 2, No. 1(2015): 12-22. DOI: https://doi.org/10.29121/ijetmr.v2.i1.2015.26.

1. INTRODUCTION

- PID controller**:**

A propositional-integrated sensitive controller (PID) is a control loop feedback mechanism (controller) widely used in Industrial control systems. PID controller calculates an error difference value between measured process variable and desired set point [9] [10]. PID controller involves three separate terms proportional (P), integral (L) and derivative (D) for that reason sometimes it is called three term control [11]. These terms can be interrupted in time based on current rate of change. Output of a PID controller consists of following three terms:

1) One proportional to the error signal.
2) Another one proportional to integral error signal and
3) The other proportional to the derivative of error signal.

The gain is stabilized by the proportional controller and steady state error is produced, generating the gain of the proportional term increases the speed of the system response and reduces the steady state error. The steady state error is reduced or eliminated by the integral controller; integral term removes the steady state error. It tends to destabilize the system because of the extra phase lag it introduces. The rate of change of error is reduced by D controller, the derivative term speed up the transient response, it introduces a phase lead and that has a stabilizing effect.

- Fuzzy Logic Controller**:**

A scheme of systemic analysis that uses linguistic variables, such as hot, cold, very, little, large, small etc [3][7]. As opposed to Boolean or binary logics which is restricted to true or false states. Fuzzy control system based on algorithm composed of IF….THEN rules. A fuzzy logic may operation may be used in the construction of the rule IF…AND…THEN more than one rule may fine at the same time, each with its same strength [12][13]. Fuzzy logic control describes the algorithm for process control as a fuzzy relation between information on the condition of the process to be controlled and the control action [1][3]. There is an aspect of similarity between the system shown and other control system- a control action is produced based on measurement of the output. in conventional systems[6] ,control action is reached through an algorithm based on multiplication by a constant ,taking a derivative, integration, or a combination of all three(simple addition in PID) control and some more entangled combination in more complicated cases)[5].

2. DEVELOPMENT OF PID, FUZZY AND FUZZY PID CONTROLLER

- PID controller:

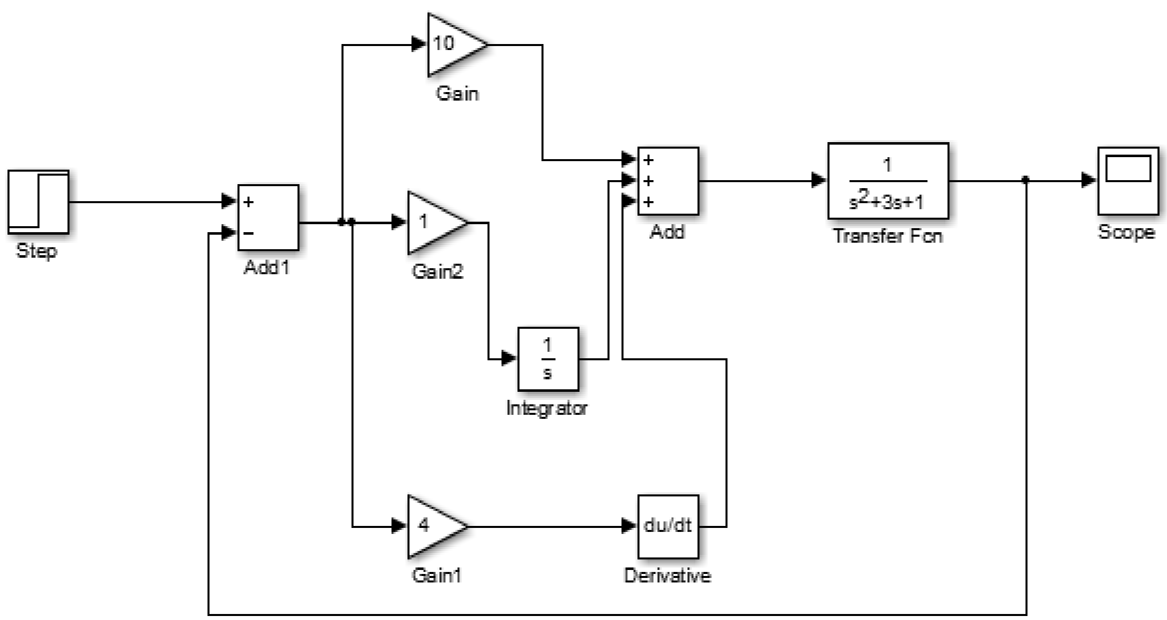

Fig. 1: Parallel architecture for PID controller.

- MATLAB Coding of PID:

```
clearall
clc
symss

% G= 1/ (s^2+3s+1)
num=1;
den=sym2poly(s^2+3*s+1);

G=tf(num,den);
H=1;
T=feedback(G,H);
step(T)
holdon
%%
Kp=1
Ki=0
Kd=0
Gc=pid(Kp,Ki,Kd)
Tc=feedback(G*Gc,H)
step(Tc)
gridon
```

- Fuzzy logic controller:

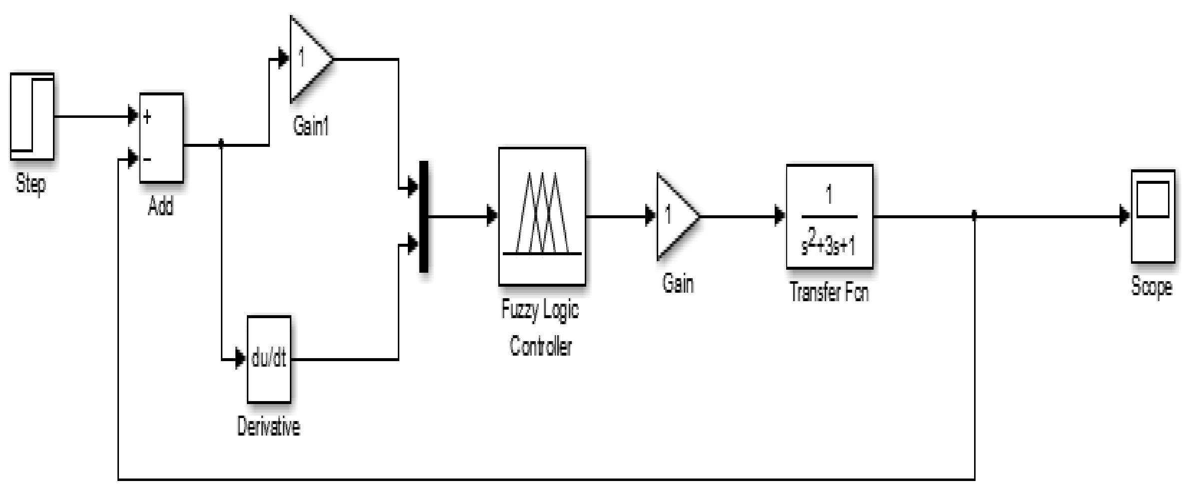

Fig. 2: Simulink diagram of fuzzy logic controller for water purification plant.

- PID like Fuzzy logic controller:

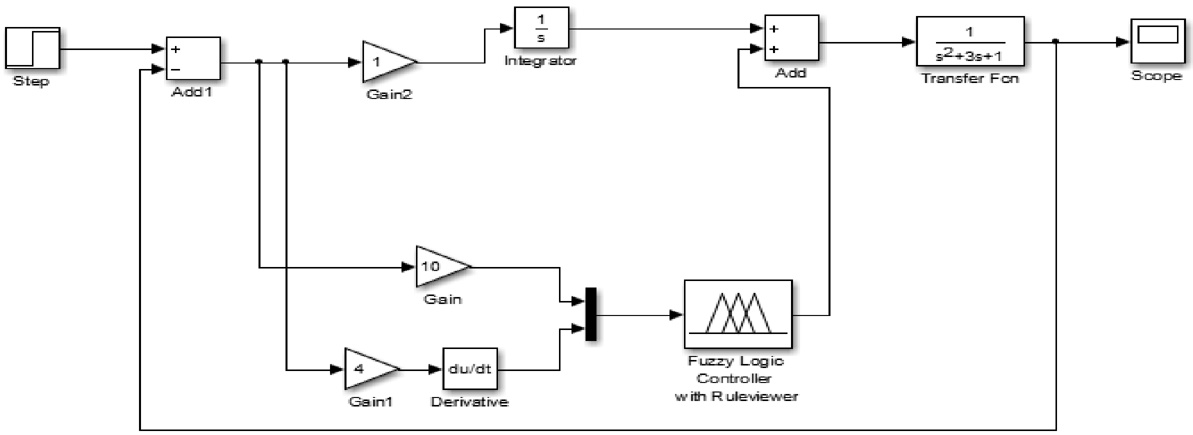

Fig. 3: PID Like fuzzy logic controller for water purification plant.

By applying ten control rules we can control the chemical rate of coagulant in water purification plant [2][12]. PID controller eliminate the value of overshoot but still present the steady state value, using fuzzy logic controller steady state value will be eliminate but overshoot value present. That's why we can use PID like fuzzy logic controller for water purification plant [12][10].

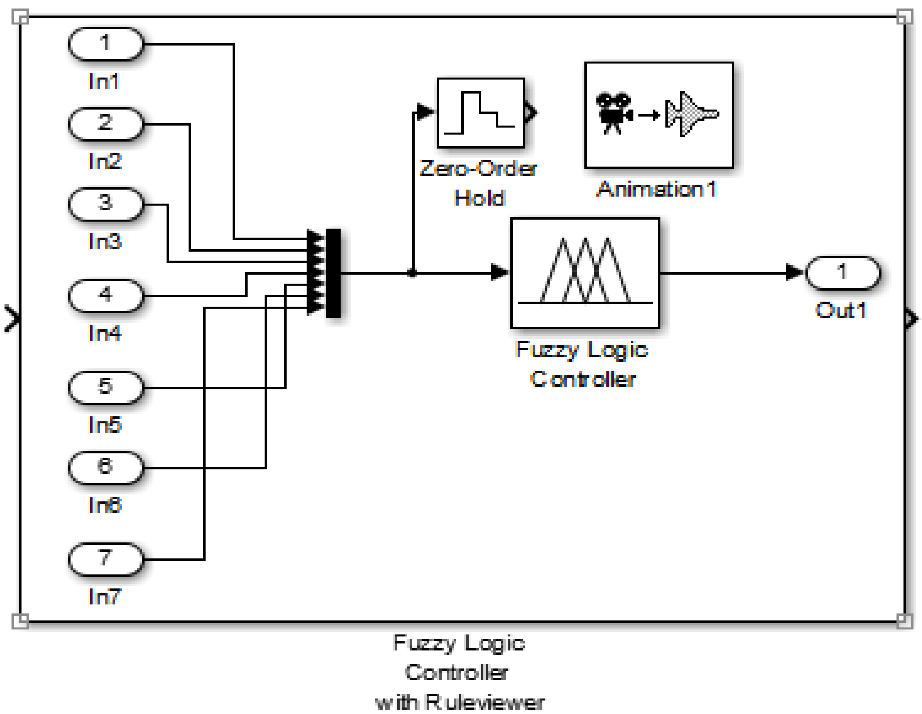

Fig 4: Fuzzy logic controller with rule viewer under masking [8].

3. EXPERIMENTS AND RESULTS

EXPERIMENTAL RESULTS OF PID CONTROLLER:

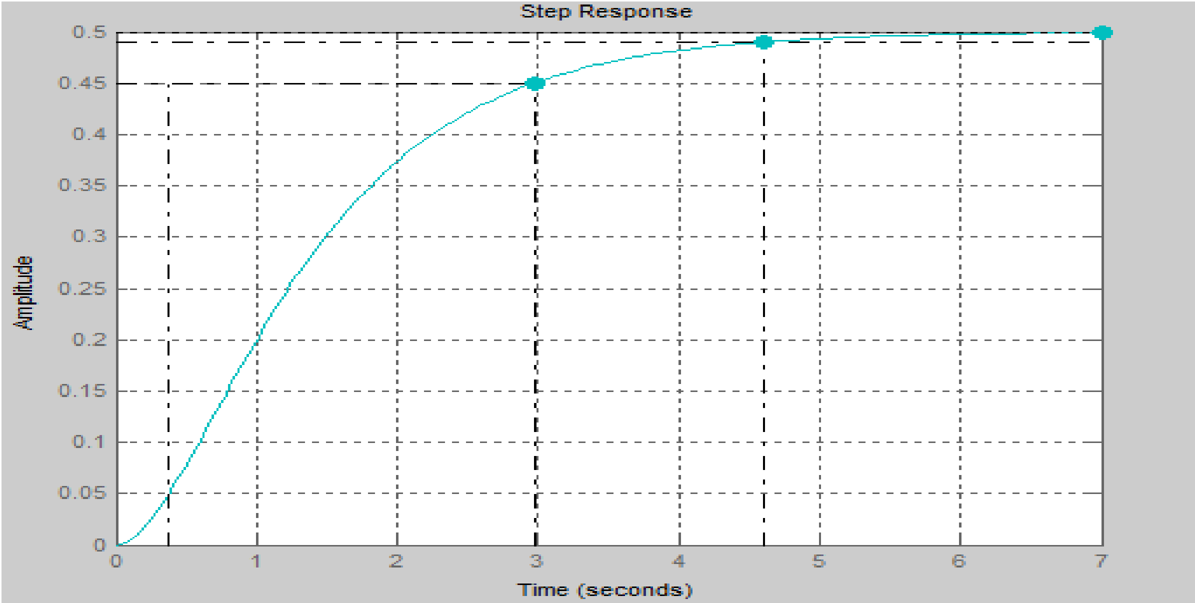

Fig 5(a): Step response of with or without PID controller

(Here step response is same for both cases because Kp=1,Ki,Kd=0)

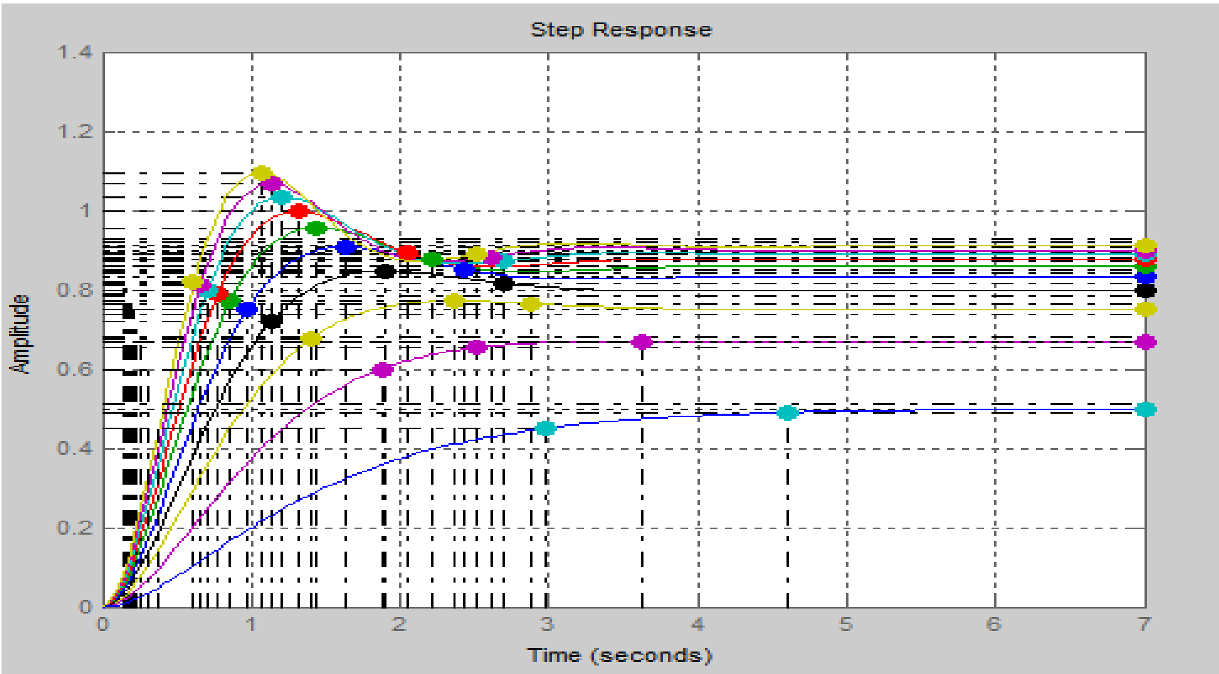

Fig 5(b): Step response of PID controller when Kp=1 to 10,Ki=0,Kd=0.

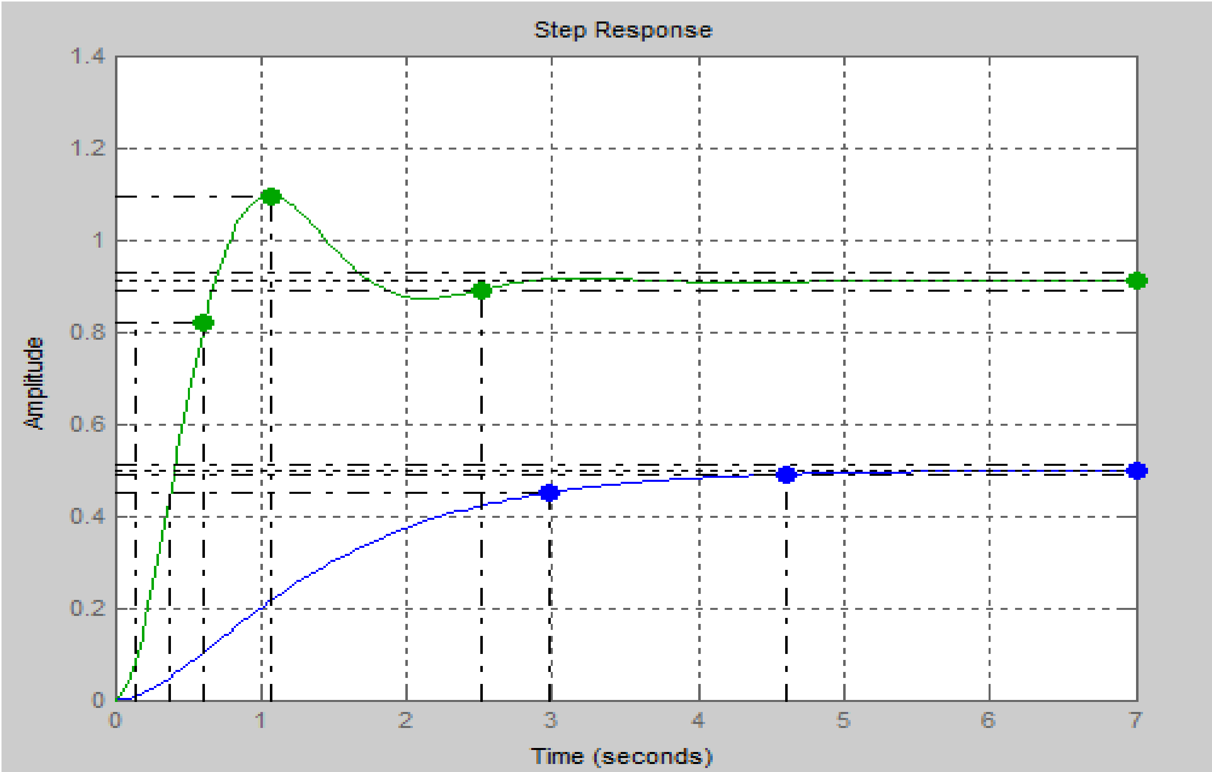

Fig 5(c): Step response of PID controller when Kp=10,Ki=0,Kd=0.

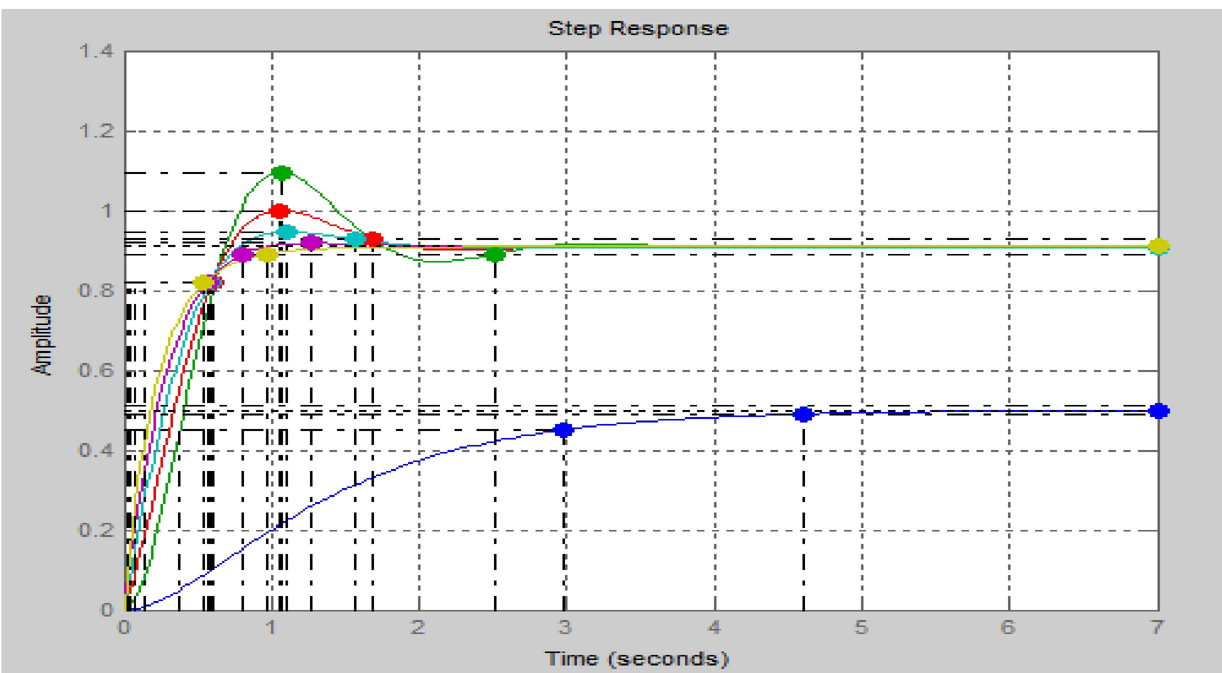

Fig 5(d): Step response of PID controller when Kp=10,Ki=0,Kd=1 to 4.

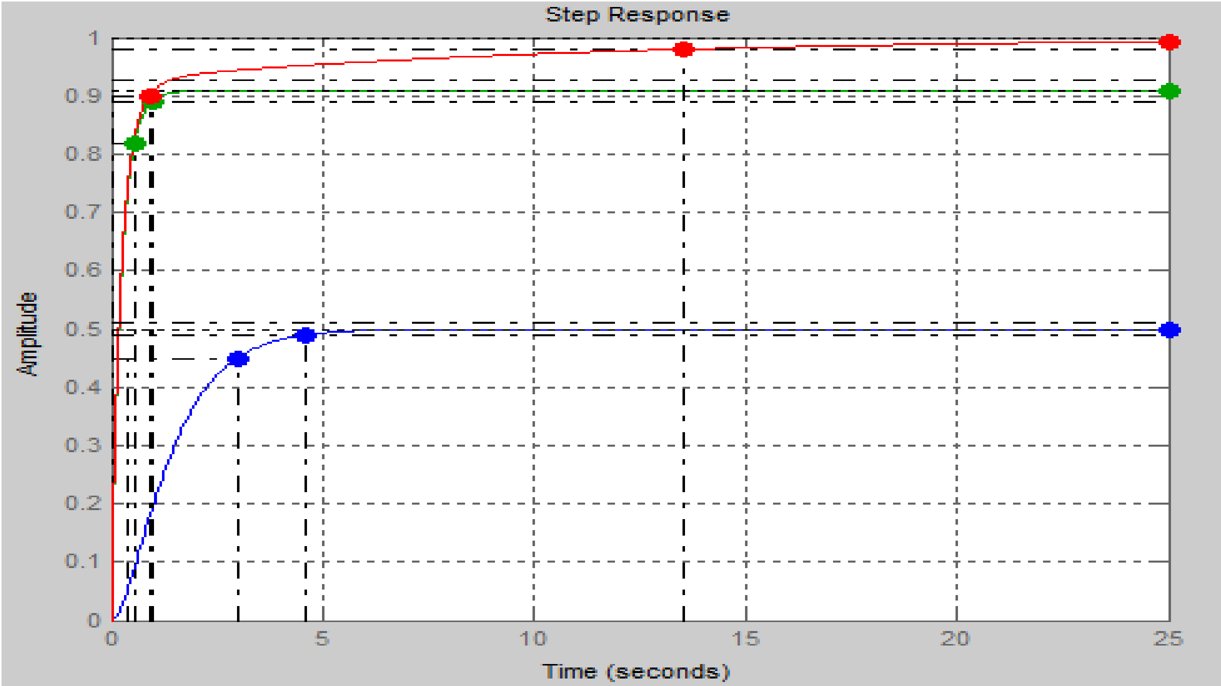

Fig 5(e): Step response of PID when Kp=10, Ki=1, Kd=4.

Here in the fig 5 (a) characteristics of with or without controller is same.

Rise time = 2.59 sec
Setting time = 4.6 sec
Steady state value = 0.5

Now, first we increase the value of proportional gain by 1, and observe that the characteristics of with or without controller will change. Further as we increased the value of Kp overshoot also increases proportionally, now we increased the Kp value at 1 to 10 and observe the effect on overshoot as shown in fig 5(b) and fig 5(c). When we increase the value of Kd from 0 to 1 (red curve) the overshoot decreases.

Rise time = 0.522
Setting time = 1.68
Steady state value= 0.909
Overshoot = 9.98% at time 1.06 sec
Peak amplitude = 1

Now, again as we increase the value of Kd 1 to 4 the overshoot will be decreases s shown in fig 5(d). Here , as we shown in fig as we increase the value of Ki by one the overshoot becomes zero as shown in fig5(e).

Here overshoot value becomes zero but the steady state value is still one, that's why by using PID like fuzzy controller we can eliminate or reduces the steady state value.

EXPERIMENTAL RESULTS OF FUZZY LOGIC CONTROLLER:

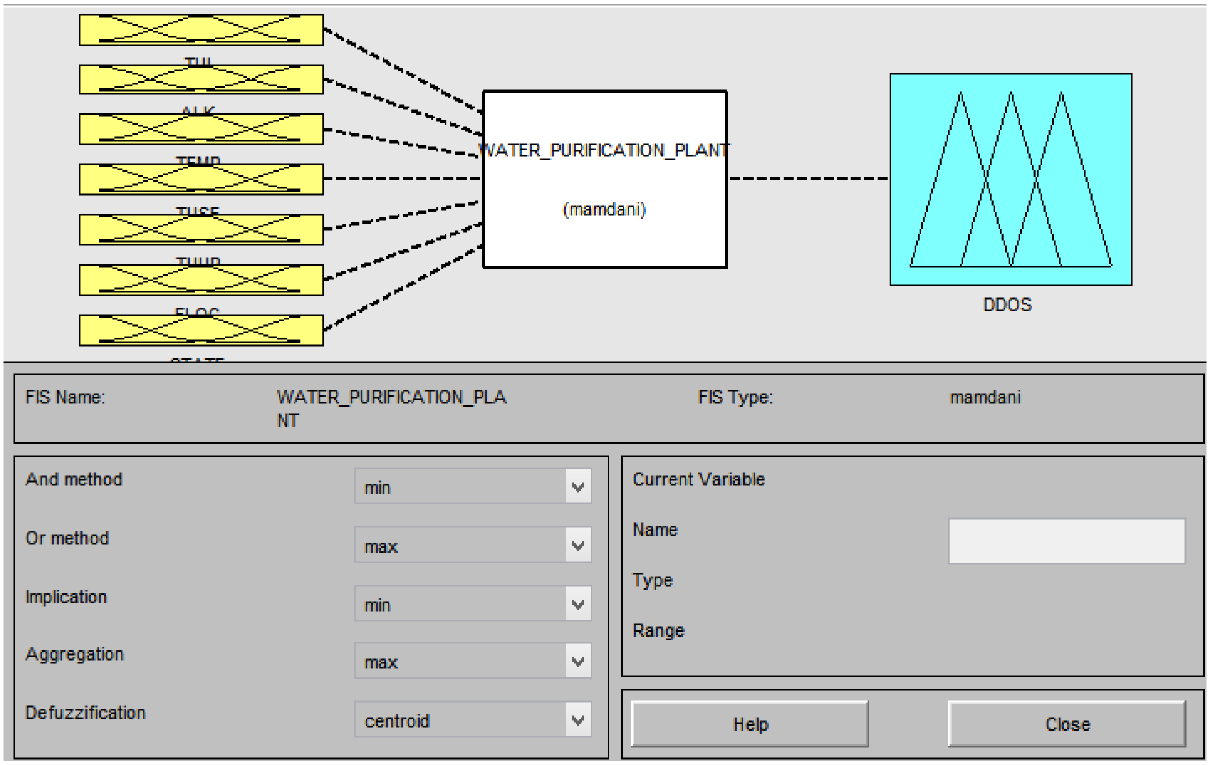

Fig 5(f): Mamdani fuzzy inference

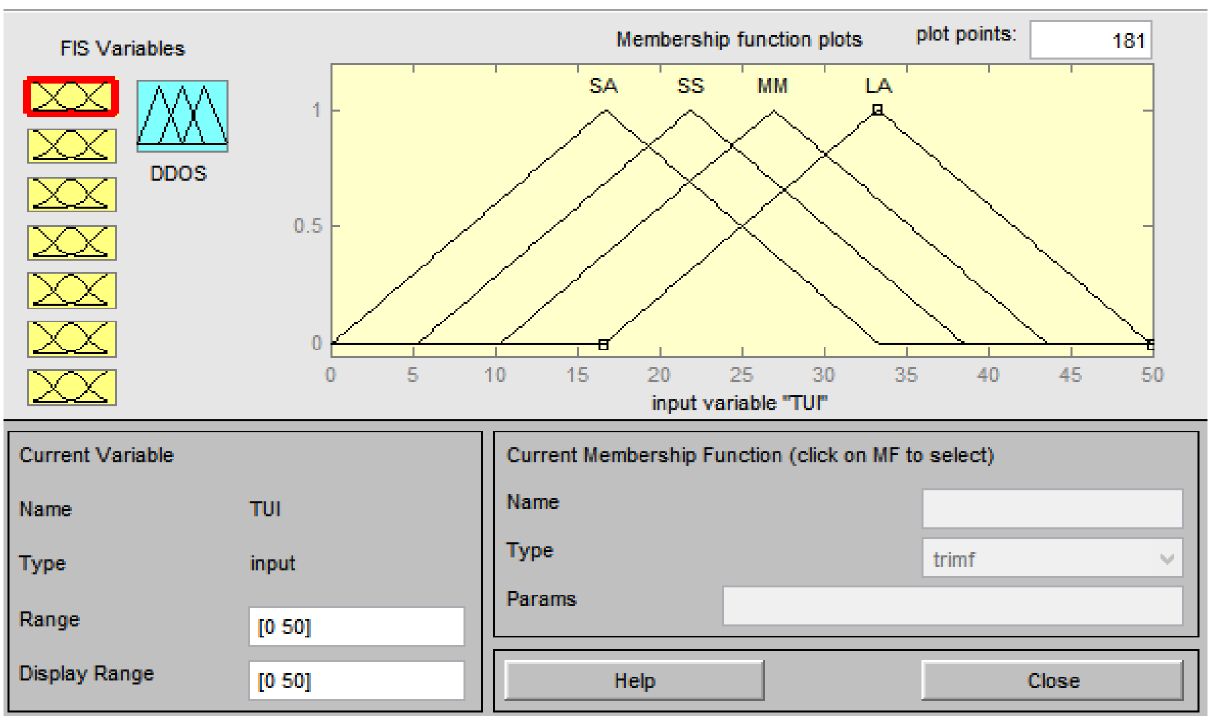

Fig 5(g): Membership function of TUI input.

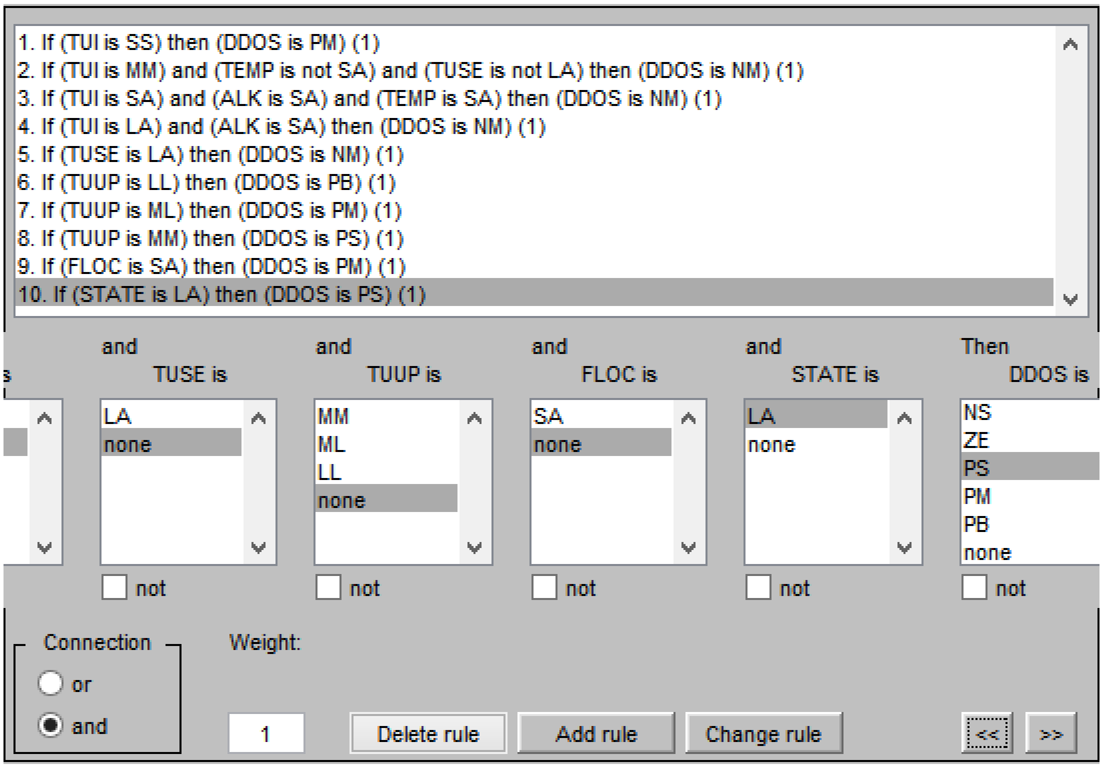

Fig 5(h): Implication rule

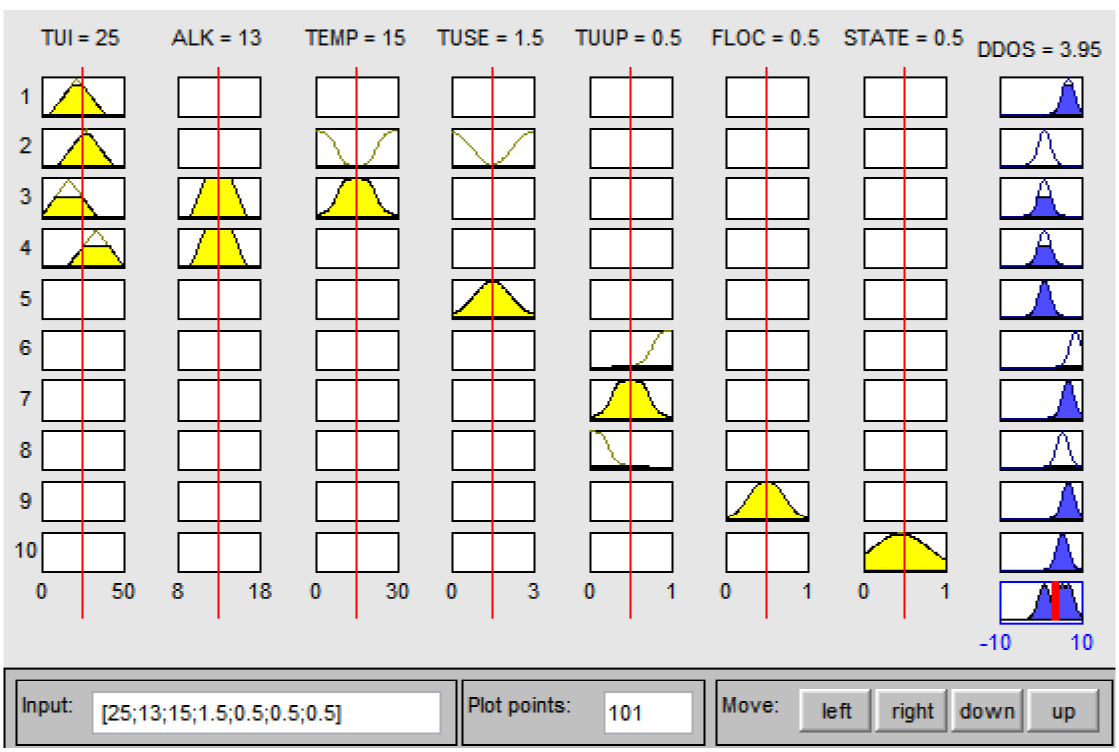

Fig 5(i): Rule viewer

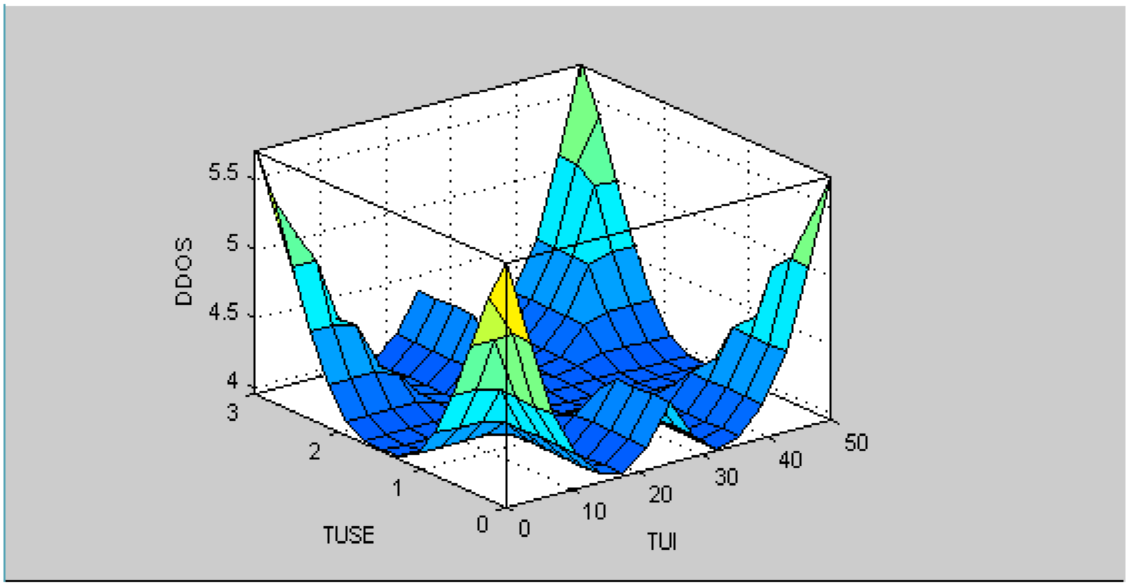

Fig 5(j): Surface view

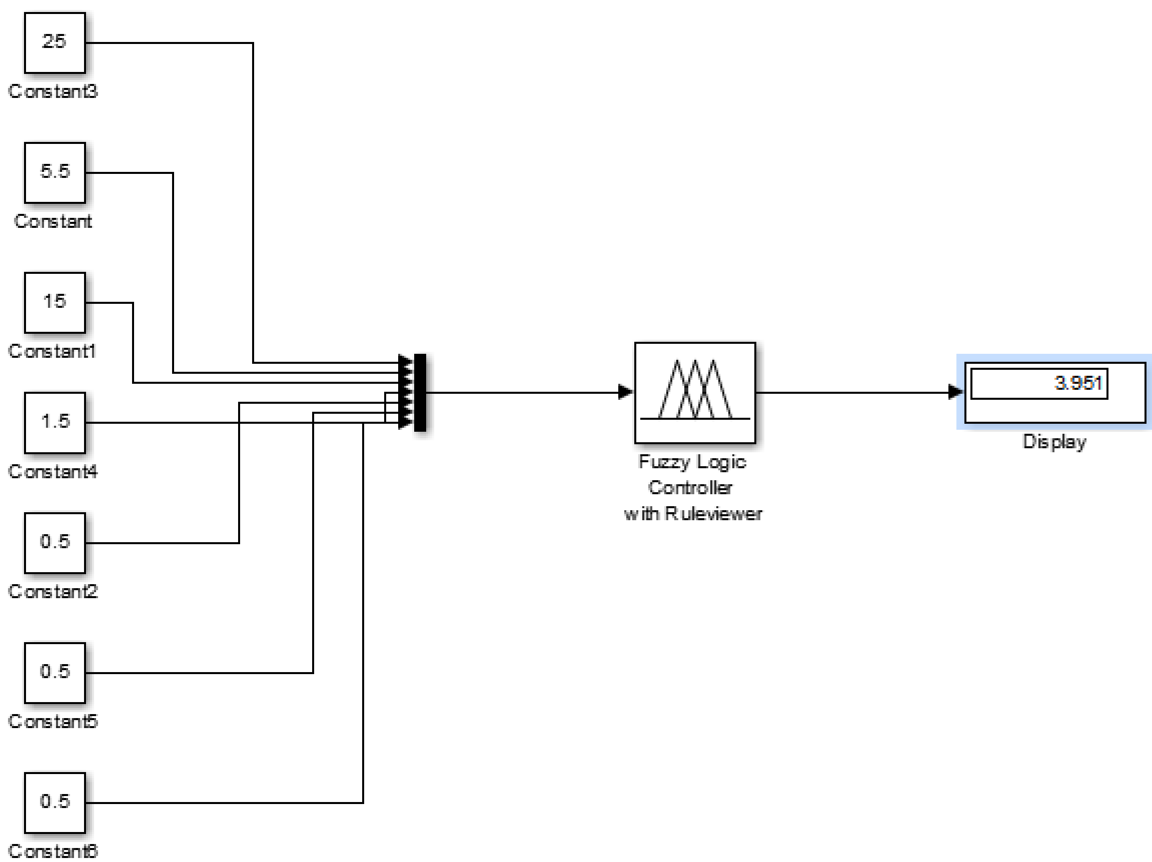

Fig 5(k): Simulink diagram of fuzzy logic controller of water purification plant.

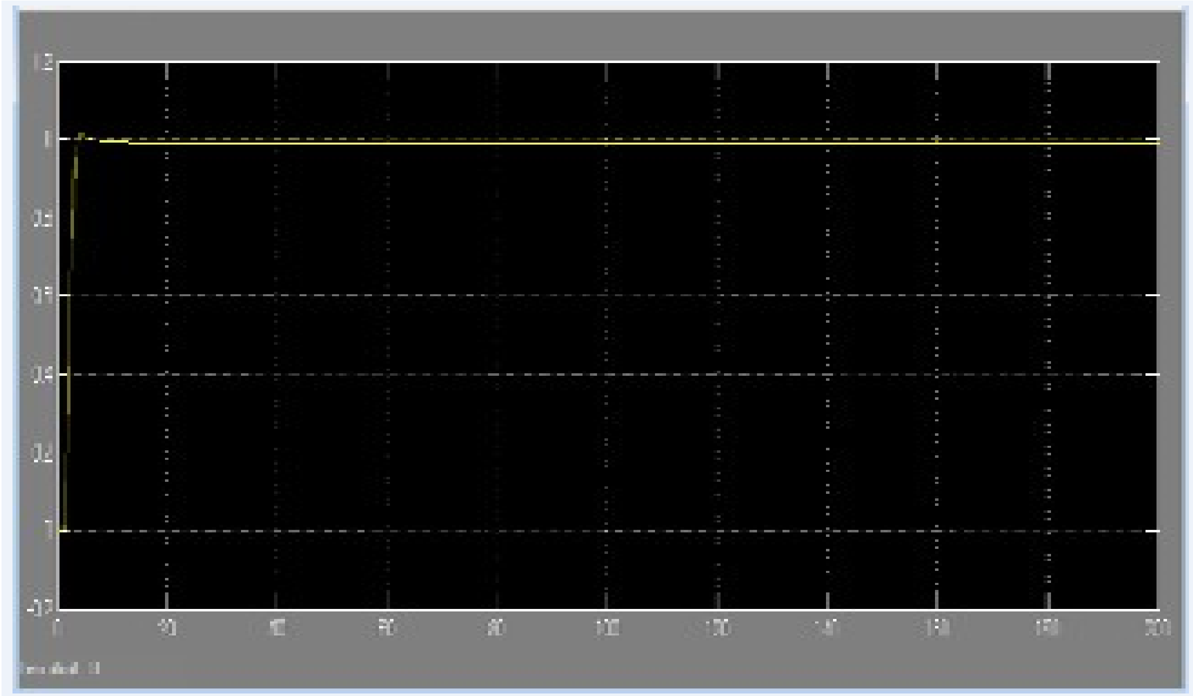

Fig 5 (l): Step response of fuzzy logic controller.

4. CONCLUSION

Here we observe that in the PID controller, as we increases the value of proportional gain controller overshoot was occur. To reduce these overshoot we use derivative controller, but at fix limit of increases derivative control gain, the value of overshoot becomes constant at some value, by using integral controller we eliminate the overshoot, it becomes to zero. From the figure, results show that the response of PID Controller is oscillatory which can damage the system. But the response of FLC is free from these dangerous oscillations in the transient period. Hence the proposed FLC is better than PID controller.

For better efficiency the above observation can also be performed on PID like fuzzy controller.

5. ACKNOWLEDGMENT

This research paper is supported by Department of ECE at Sir Padampat Singhania University, Udaipur.

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