International Journal of Multidisciplinary Research and Development

Volume :2, Issue :4, 483-486
April 2015
www.allsubjectjournal.com
e-ISSN: 2349-4182
p-ISSN: 2349-5979
Impact Factor: 3.762

Dibya Jyotirmayee Sahu
Research Scholar, M.Tech, EEE,Centurian University of Technology & Management Bhubaneswar, Odisha, India

R.P. Dalai
Asst. Prof Electrical Engineering EEE,Centurian University of Te,chnology & Management, Bhubaneswar, Odisha, India

Correspondence:
Dibya Jyotirmayee Sahu
Research Scholar, M.Tech, EEE,Centurian University of Technology & Management Bhubaneswar, Odisha, India

A Comparative Analysis for Conventional PID controller with Fuzzy Logic Controller and Genetic Algorithm based Controller

Dibya Jyotirmayee Sahu, R.P. Dalai

Abstract
This project tries to explore the potential of using soft computing methodologies in controllers and their advantages over conventional methods. PID controller, being the most widely used Controller in industrial applications, needs efficient methods to control the different parameters of the plant. This thesis asserts that the conventional approach of PID tuning is not very efficient due to the presence of non-linearity in the system of the plant. The output of the conventional PID system has a quite high overshoot and settling time. The main focus of this project is to apply two specific soft-computing techniques viz. fuzzy logic and genetic algorithm to design and tuning of PID controller to get an output with better dynamic and static performance. The application of fuzzy logic to the PID controller imparts it the ability of tuning itself automatically in an on-line process while the application of genetic algorithm to the PID controller makes it give an optimum output by searching for the best set of solutions for the PID parameters. The project also discusses the benefits and the short-comings of both the methods. The simulation outputs are the MATLAB results obtained for a step input to a second-order plant.

Keywords: PID,FUZZY LOGIC,GA,MATLAB,Kp,Ki,Kd,Mutation,CrossOver

1. Introduction
PID controllers are the most widely-used type of controller for industrial applications. They are structurally simple and exhibit robust performance over a wide range of operating conditions. In the absence of the complete knowledge of the process these types of controllers are the most efficient of choices. The three main parameters involved are Proportional (P), Integral (I) and Derivative (D). The proportional part is responsible for following the desired set-point, while the integral and derivative part account for the accumulation of past errors and the rate of change of error in the process respectively.

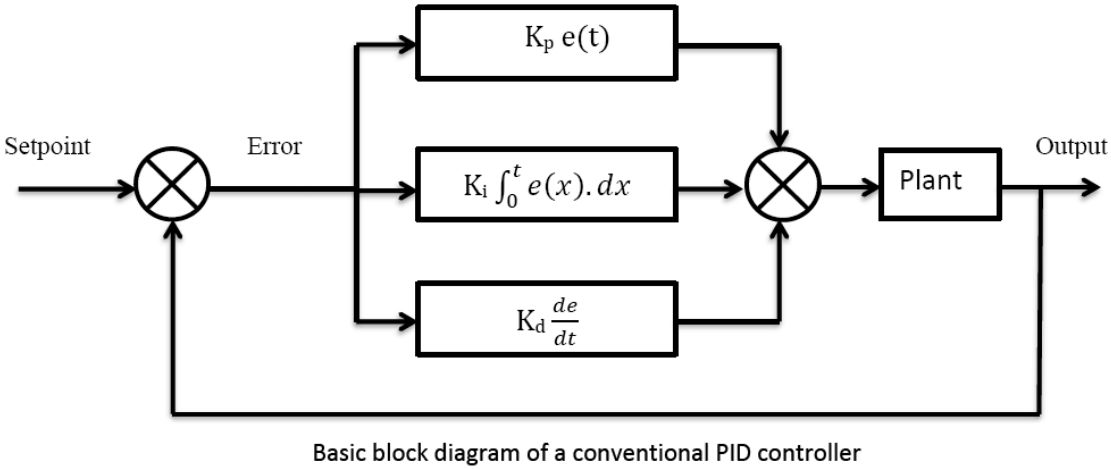


Fig. 1.1: Basic block diagram of a conventional PID controller

For the PID controller presented in Fig. 1.1,
Output of the PID controller,
$u(t) = Kpe(t) + Ki \int e(x)\, dx + Kd(de/dt)$……1.1
Where,

Error, e(t) =Set point- Plant output
Kp= proportional gain, Ki = integral gain, Kd= derivative gain

2. Proposed Method

This project explores the potential of using soft computing methodologies. The advantages of soft computing over conventional methods
Application of specific soft-computing techniques are given below

- ✓ fuzzy logic
- ✓ genetic algorithm .

The project emphasizes on the tuning of its various control parameters (P, I and D) and for this requirements are Stability, desired rise time, peak time and overshoot.

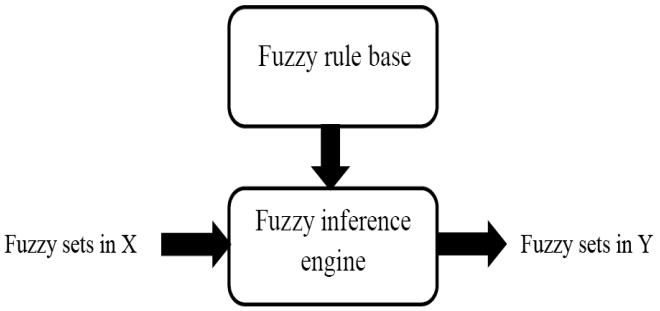
- ✓ Types of tuning –
  - Good gain method.
  - Ziegler – Nichole's method.

The transfer function describing the plant for our example is as follows:

$$G(S) = \frac{4}{s^2+2s+4}$$

3. Fuzzy Logic

A soft computing technique conceived by Lotfi Zadeh .In this work Mamdani fuzzification technique is used .FL is a problem-solving control system methodology.It is rule-based **IF X AND Y THEN Z** approach .It requires some numerical parameters in order to operate .Fuzzy logic is a logic having many values.



A pure fuzzy system

Design of A Fuzzy PID Controller
It uses the fuzzy reasoning and variable universe of discourse to regulate the PID parameters.Also called, a self-tuning fuzzy PID controller .It can tune the parameters Kp, Ki, and Kd .It makes the precision of overall control higher .It takes error "e" and rate of change-in-error "ec" as the input.
The fuzzy relationship between the three parameters of PID Kp, Ki, Kd and "e" , "ec .
The language variables of "e" ,"ec", Kp, Ki, and Kd is chosen in seven fuzzy values -
(NB, NM, NS, ZO, PS, PM, PB) .
The region of these variables, in this case, is taken to be {-3,-2,-1,0,1,2,3} .
"If e is A and ec is B, then Kp is C, Ki is D and Kd is E." are used to create the fuzzy rule table .

Fuzzy rules for ΔKp, Δki, ΔKd

e \ ec	NB	NM	NS	ZO	PS	PM	PB
NB	PB	PB	PM	PM	PS	ZO	ZO
NM	PB	PB	PM	PS	PS	ZO	NS
NS	PM	PM	PM	PS	ZO	NS	NS
ZO	PM	PM	PS	ZO	NS	NM	NM
PS	PS	PS	ZO	NS	NS	NM	NM
PM	PS	ZO	NS	NM	NM	NM	NB
PB	ZO	ZO	NM	NM	NM	NB	NB

e \ ec	NB	NM	NS	ZO	PS	PM	PB
NB	NB	NB	NM	NM	NS	ZO	ZO
NM	NB	NB	NM	NS	NS	ZO	ZO
NS	NB	NM	NS	NS	ZO	PS	PS
ZO	NM	NM	NS	ZO	PS	PM	PM
PS	NM	NS	ZO	PS	PS	PM	PB
PM	ZO	ZO	PS	PS	PM	PB	PB
PB	ZO	ZO	PS	PM	PM	PB	PB

e \ ec	NB	NM	NS	ZO	PS	PM	PB
NB	PS	NS	NB	NB	NB	NM	PS
NM	PS	NS	NB	NM	NM	NS	ZO
NS	ZO	NS	NM	NM	NS	NS	ZO
ZO	ZO	NS	NS	NS	NS	NS	ZO
PS	ZO	ZO	ZO	ZO	ZO	ZO	ZO
PM	PB	NS	PS	PS	PS	PS	PB
PB	PB	PM	PM	PM	PS	PS	PB

Advantages of fuzzy self-tuning PID controller
Fuzzy PID controller has a better dynamic response curve.
It can be modified and tweaked easily to improve or drastically alter system performance
Any reasonable number of inputs can be processed (1-8 or more).
FL can control nonlinear systems.
It is inherently robust since it does not require precise, noise-free inputs.

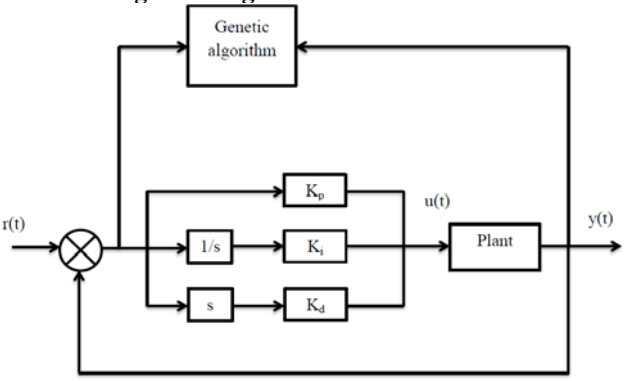
4. General Introduction to Genetic Algorithm

GA's are a subclass of Evolutionary Computing.GA's were created by John Holland in the mid-70's.Evolutionary computing evolved in the 1960's.

Genetic Algorithm – Basic algorithm

0. START : Create random population of n chromosomes
1. FITNESS : Evaluate fitness f(x) of each chromosome in the population
2. NEW POPULATION
   SELECTION : Based on f(x)
   RECOMBINATION : Cross-over chromosomes
   MUTATION : Mutate chromosomes
   ACCEPTATION : Reject or accept new one
3. REPLACE : Replace old with new population: the new generation
4. TEST : Test problem criterium
5. LOOP : Continue step 1 – 4 until criterium is satisfied

Structure of genetic algorithm based PID controller



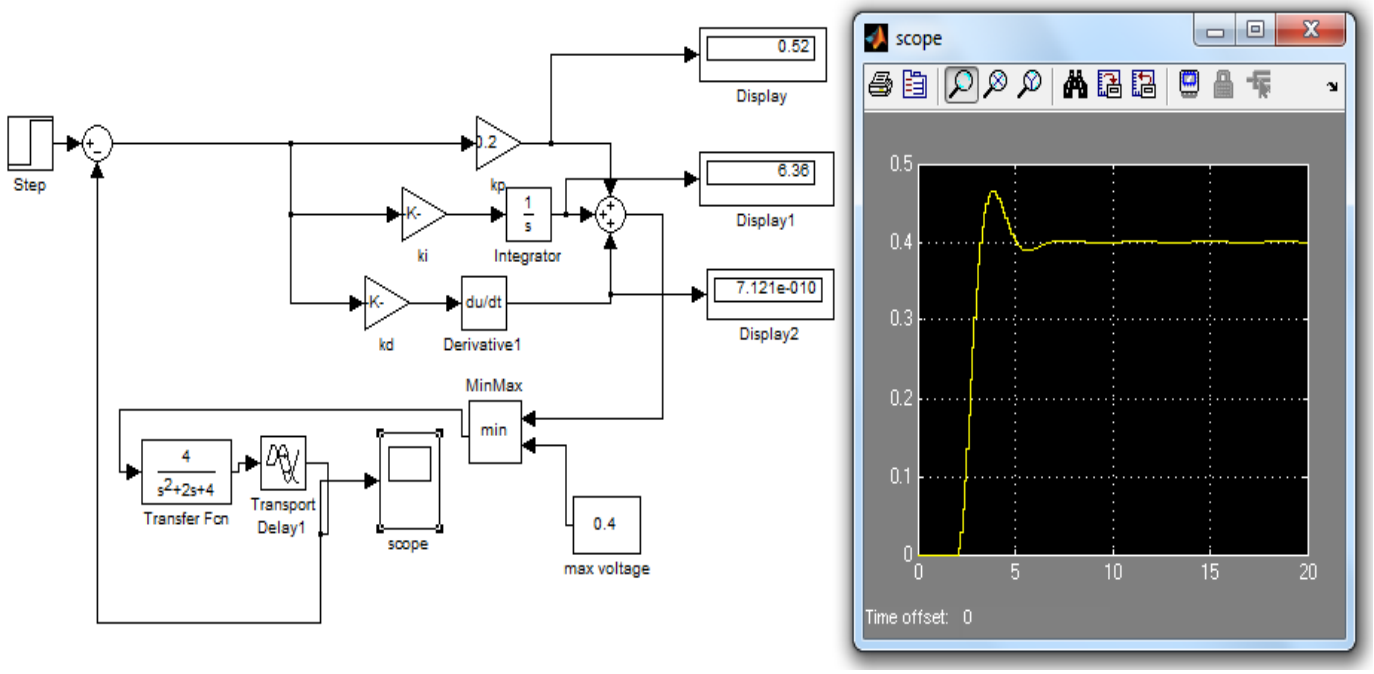
Advantage of GA-PID cantroller

- Simple algorithm that can be easily understood and implemented.
- Robust
- It searches a population of points instead of single solution.
- It is a non linear process.
- Ga does not need information about the system.

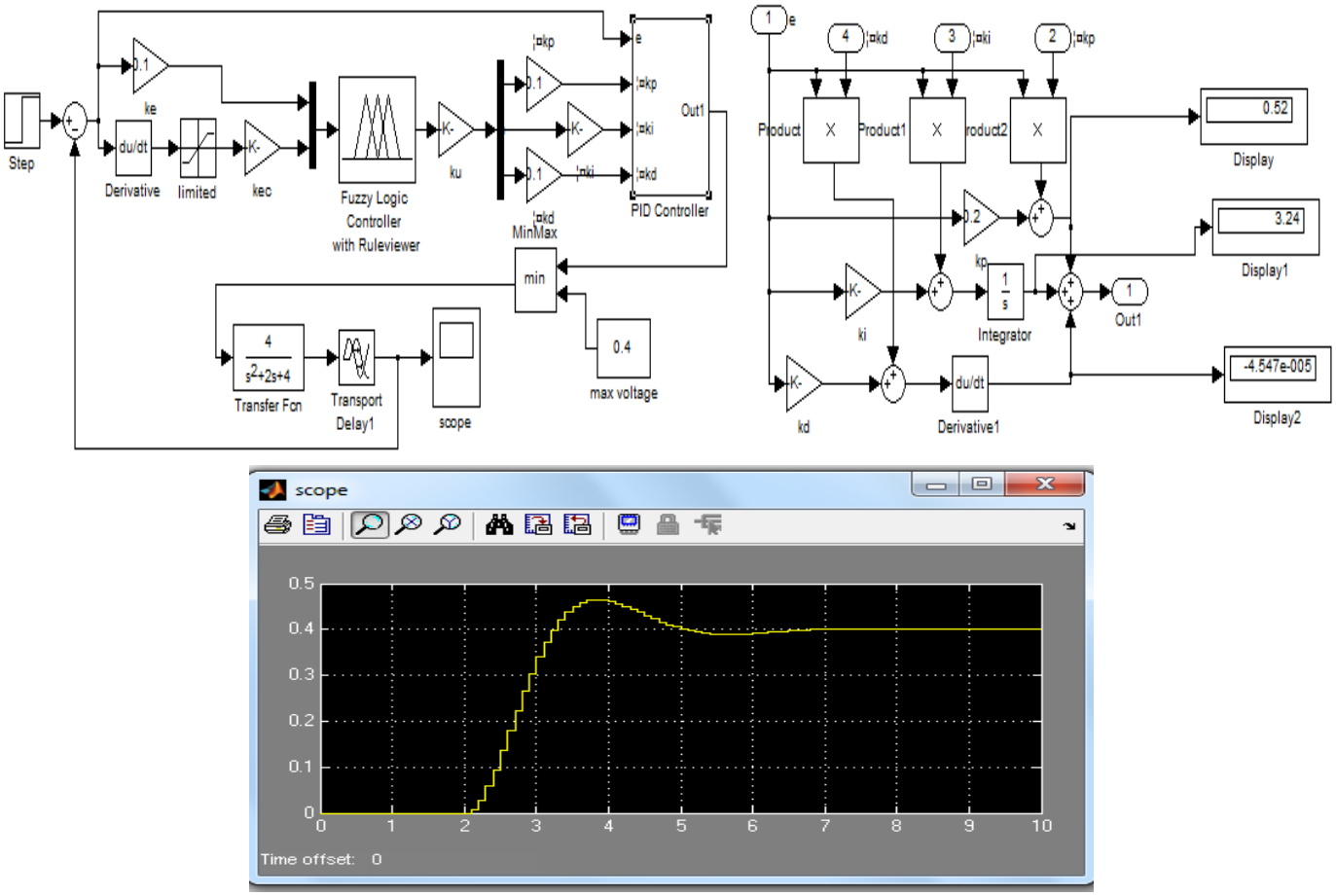
5. Results & Discussion

In this paper,we have proposed the method of designing PID controller using various optimized techniques.We have designed PID controller using fuzzy logic based controller and Genetic algorithm based controller and finally made a comparative analysis for Kp,Ki and Kd values.Also the transfer function output has been shown for the conventional PID as well as FLC based PID and GA based PID.

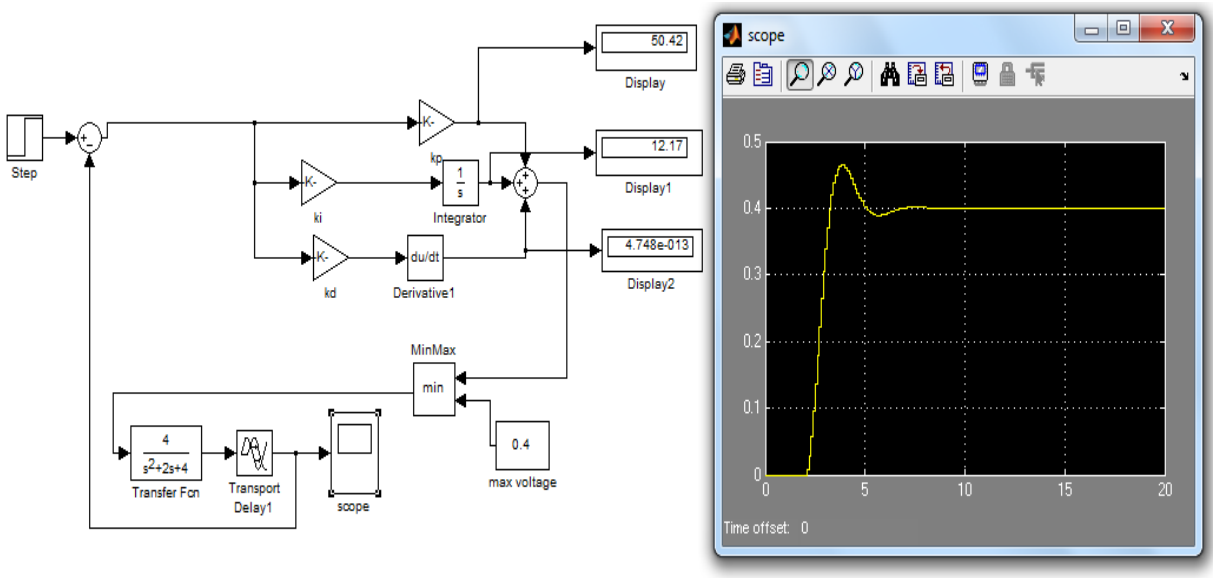
Results for Conventional PID Controller



Results for Fuzzy based PID Controller



Results for GA based PID Controller



6. Tables and Figures

The below table shows the comparative analysis for the three different proposed techniques of the PID controller design.

CONTROLLER TYPES	CONVENSTIONAL PID	FUZZY LOGIC BASED PID	GENETIC ALGORITHM BASED PID
Kp Value	0.52	0.52	50.42
Ki Value	6.36	3.24	12.17
Kd Value	7.12 e-10	4.5 e-5	4.7 e-13

7. Conclusions

In this project, we studied the design and tuning methods for PID controller using fuzzy logic and Genetic algorithm.Fuzzy logic to the PID controller imparted it's the ability to tune itself while operating on-line.Genetic algorithm enabled the PID controller to get an output which is robust and has faster response.In the future works our work can be tested for Artificial neural networks and other optimization techniques for getting more reliable output.

8. References

1. J.-S.R. Jang, C.-T. Sun, E. Mizutani. *Neuro-fuzzy and soft computing.*
2. S. N. Sivanandam, S. Sumathi , S. N. Deepa. *Introduction to fuzzy logic using Matlab.*
3. Wang-Xiao Kan, Sun Zhong-Liang, Wnglei, Feng Dong-qing. "*Design and research*
4. *based on fuzzy self-tuning PID using Matlab*". Proceedings of International Conference
5. on Advanced Computing theory and Engineering (2008).
6. Liu Fan, ErMengJoo. "*Design for Auto-tuning PID Controller Based on Genetic*
7. *Algorithms*". IEEE Conference on Industrial Electronics and Applications (ICIEA 2009)
8. B. Nagaraj, S. Subha, B.Rampriya. "*Tuning Algorithms for PID Controller Using Soft*
9. *Computing Techniques*".
10. Melanie Mitchell."An introduction to genetic algorithms".MIT Press.
11. K. J. Astrom & H. Hagglund, PID controllers: theory, design, and tuning. (Research Triangle Park, NC: Instrument Society of America, 2nd ed., 1995).
12. J. G. Ziegler & N. B. Nichols, Optimum settings for automatic controllers, Trans. A.S.M.E.,62(3), 1942, 759–768.
13. G. H. Cohen & G. A. Coon, Theoretical consideration of retarded control, Trans. A.S.M.E.,75(4), 1953, 827–834.
14. K. J. Astrom & T. Hagglund, Automatic tuning of simple regulators with specifications on phase and amplitude margins, Automatica, 20(5), 1984, 645–651.
15. M. Morari & E. Zafiriou, Robust process control. (Englewood Cliffs NJ.: Prentice-Hall,
16. 1989).
17. C. C. Hang, K. J. Astrom, & W. K. Ho, Refinements of the Ziegler-Nichols tuning formula,IEE Proc. Contol Theory and Applications, 138(2), 1991, 111–118.
18. M. Zhuang & D. P. Atherton, Automatic tuning of optimum PID controllers, IEE Proc.
19. Control Theory and Applications, 140(3) 1993, 216–224.