Design of a PD like Fuzzy Logic Controller for Precise Positioning of a Stepper Motor

Jyoti Kumar Barman, Pushpanjalee Konwar, Gitu Das

Don Bosco College of Engineering and Technology, Assam Don Bosco University
Guwahati - 781017, Assam. INDIA.
jyoti.barman@dbuniversity.ac.in, xika1205@yahoo.in, gitu.das@dbuniversity.ac.in

Abstract: ***Designing of controllers for control of various motors has been an exciting field for the researchers. Talking of controllers, PID controllers are the most popular among the various industries. Nowadays Fuzzy Logic Controllers (FLC) and PID like FLCs are very famous due to its robust design, faster response and accuracy. In this paper we have proposed a novel method to control a stepper motor with PD like FLC that can handle one sided errors like those in tracking problem such as tracking the Sun and maximum power point in PV array system. During simulation it is seen that the controller can easily handle different errors without much of oscillations. The speed of response mainly depends on the step size of the stepper motor.***

Keywords: Tracking problem, PD like Fuzzy Logic Controller, Stepper motor control. Matlab/Simulink, Fuzzy Logic toolbox.

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1. Introduction

Industrial motors are used to convert electrical energy into mechanical energy but they cannot be used for precise positioning of an object without using a closed-loop. Stepping motors are ideally suited for situations where either precise positioning or precise speed control or both are required in automation systems [1]. In our work we have chosen a hybrid stepper motor. One of the most important parameter of stepper motor is its step angle. Common step sizes are 1.8^0, 2.5^0, 7.5^0, 15^0. In our work we have chosen the step size of 1.8^0.

There are various methods offered in literature for controlling of stepper motors. Most common being PID controllers. However it is seen that PID like fuzzy controllers perform better than the conventional PID controllers. It is also shown that even without knowing the details of the control plant, we can construct a well performed fuzzy logic controller based on the experience about the position controller [2].Recently much more emphasis is given to the designing of PID like fuzzy controllers; however in our work we have chosen a simple scheme of PD like FLC to precisely position the stepper motor. C. Shanmei , W. Shuyun and D. Zhengeheng in their work Fuzzy speed controller of induction motor speed drive shown that PID controller is very simple to use, and very effective. However it needs tuning [3]. Although in 1965 Lofti Zadeh introduced the concept of Fuzzy logic [4], it was not used for any controlling purpose. Mamdani showed how to use fuzzy logic effectively in control applications in 1974[5]. In 1985 Takagei and Sugeno published the paper on Fuzzy systems known as T-S model in fuzzy system [6].

2. Overview of the System

Figure 1 shows the basic block diagram of the proposed system.

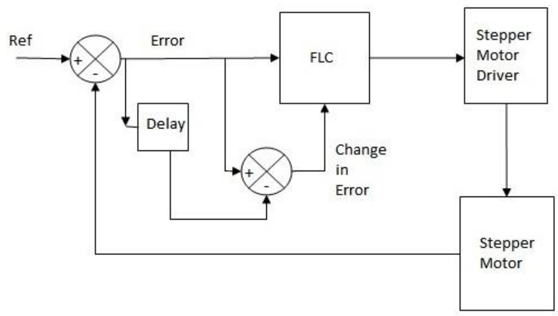

Figure 1: Basic block diagram of the proposed system.

In this system our aim is to keep the motor in its zero position irrespective of the initial position so that it can track its reference position. Here our reference point is 0^0. Instantaneous position of the motor in terms of angle (degree) is given to the comparator that compares it with the reference and produces the error signal. Error signal is given to the Fuzzy Logic Controller (FLC). To produce change in error we have utilised a memory block. Again the change in error is also given to the FLC so that a PD like FLC can be designed. Design of the FLC is discussed in the next section. Output from the FLC is given to the Stepper motor driver. The decision is taken by the FLC and implemented by the Stepper motor driver. And thus desired positioning of the motor is done.

3. Designing of the Fuzzy Logic Controller(FLC)

Designing of the FLC is entirely done on the fuzzy logic toolbox offered in Matlab 7.8.0(R2009a). Our aim is to design a PD like FLC, so 2 input functions will be required. We will consider one direct error and one change in error. Input 1 is considered for direct error. Figure 2 shows the membership functions for input 1.

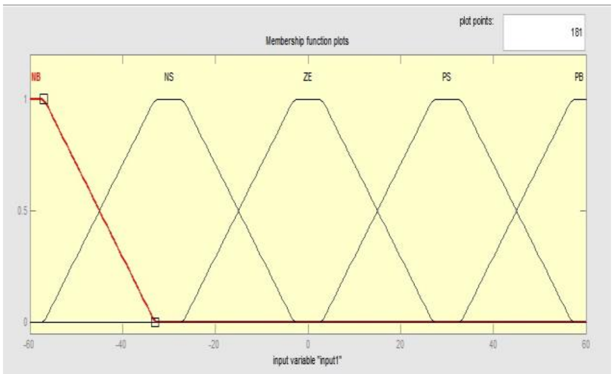

Figure 2: Membership functions for input 1

Membership functions are considered as follows:
Five membership functions are considered and all are trapezoidal functions. They are NB (negative big), NS (negative small), ZE (zero), PS (positive small), PB (positive big). Range considered is -60^0 to 60^0 .
For change in error we have considered input 2. Figure 3 shows the membership functions for input 2.

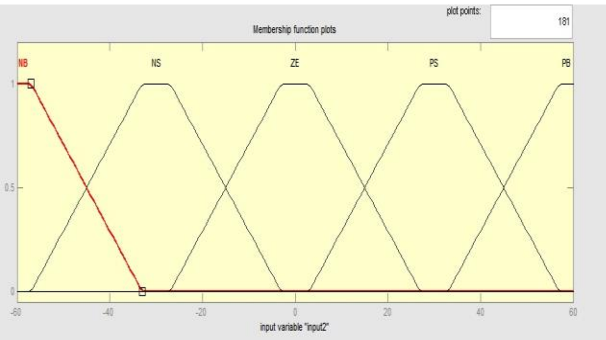

Figure 3: Membership functions for input 2

Membership functions are considered as follows:
Five membership functions are considered and all are trapezoidal functions. They are NB (negative big), NS (negative small), ZE (zero), PS (positive small), PB (positive big). Range considered is -60^0 to 60^0 .
Figure 4 shows the membership functions for output.

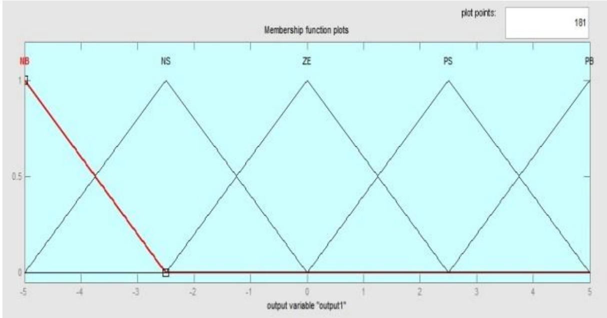

Figure 4: Membership functions for output

Membership functions are considered as follows:
Five membership functions are considered and all are triangular functions. They are NB (negative big), NS (negative small), ZE (zero), PS (positive small), and PB (positive big). Range considered is -5^0 to 5^0 .
Designing of the rule base is based on table 1 as shown below:

I. **Table 1:** RULE BASE FOR PD LIKE FUZZY LOGIC CONTROLLER

ER\CE	**NB**	**NS**	**ZE**	**PS**	**PB**
NB	NB	NB	NB	NS	ZE
NS	NB	NB	NS	ZE	PS
ZE	NB	NS	ZE	PS	PB
S	NS	ZE	PS	PB	PB
PB	ZE	PS	PB	PB	PB

ER represents the error and CE represents the change in error.
Defuzzification is done using centre of gravity method.

4. Simulation

Simulation is done in the Simulink environment of Matlab 7.8.0(R2009a). Fig 5 shows the set up that was simulated in Simulink.

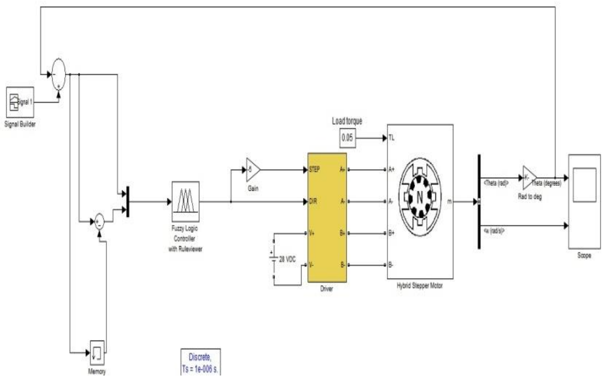

Figure 5: Set up of the system that was simulated.

Basic block diagram discussed in figure 1 is translated into Simulink model as shown in figure 5 with an additional scope to record the results. System is simulated for three different initial conditions. Three different initial angles considered are 5^0, 15^0, 20^0 .

5. Results and Discussions

Figure 6, 7 and 8 shows simulation results for 5^0, 15^0 and 20^0 respectively.

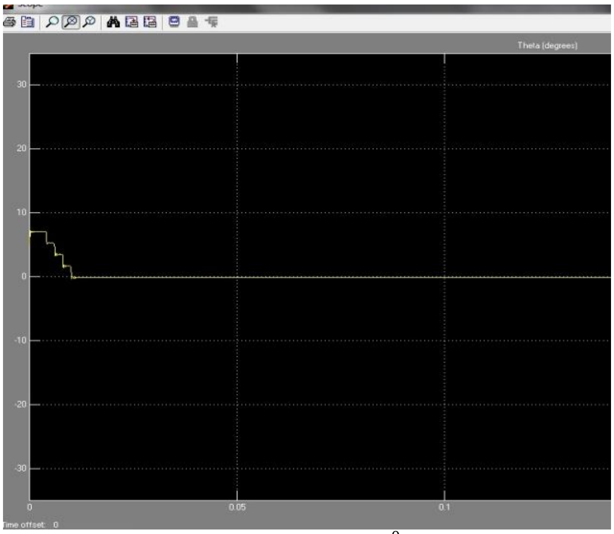

Figure 6: Simulation result for 5^0 initial condition

Figure 6 shows the simulation result for 5^0 initial condition. Response reaches its reference value in just 8 mS.

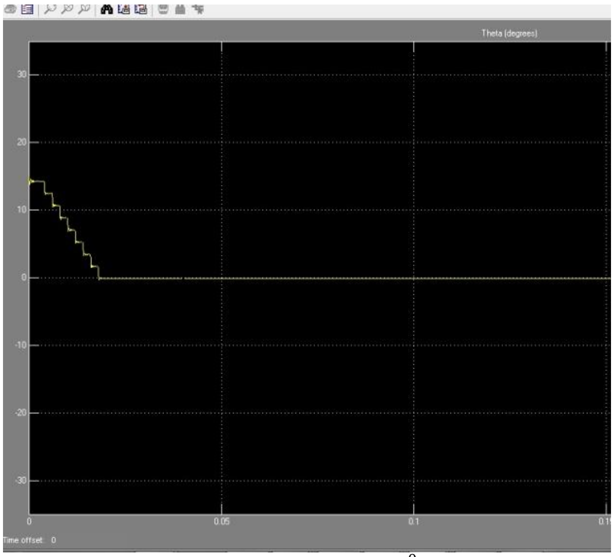

Figure 7: Simulation result for 15^0 initial condition

Figure 7 shows the simulation result for 15^0 initial condition. Response reaches its reference value in just 17 mS.

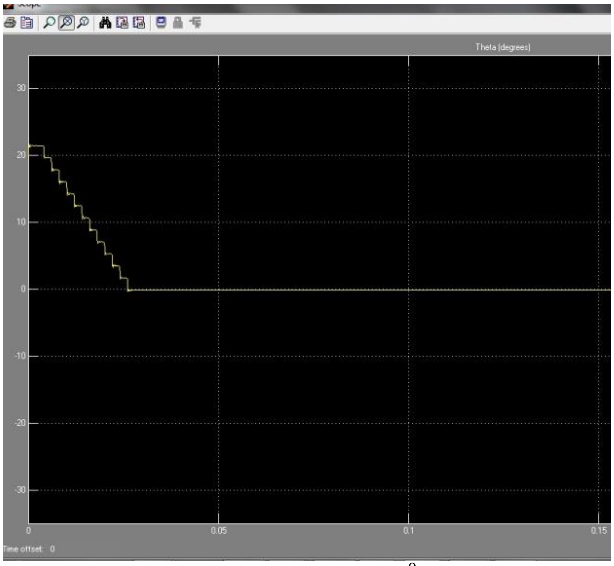

Figure 8: Simulation result for 20^0 initial condition

Figure 8 shows the simulation result for 20^0 initial condition. Response reaches its reference value in just 25 mS.

We have seen the results obtained for three different initial conditions viz. 5^0, 15^0 and 20^0. In all the three cases we get very good results. The motor goes to its reference position i.e. zero position well within 0.05 seconds. The step size for the motor was 1.8^0 . Number of steps that should have taken for 5^0 is around 3 but in the simulation result we can see that first it goes to around 7^0 and comes to 0^0 in 4 steps. Similar effects can be seen for the 15^0 and 20^0 simulations also. We can neglect this minor oscillation as the system is very fast if we consider tracking problem such as tracking the Sun and maximum power point in PV array system.

6. Conclusion

A novel method for precise positioning of a stepper motor is proposed. In the design process only one sided errors are considered as the system is designed for simple tracking problem such as tracking the Sun. The system designed is PD like Fuzzy Logic controller. The system is designed and tested in Matlab/Simulink/Fuzzy Logic toolbox platform. In the result a minor oscillation is observed which is about 1mS.We can neglect this minor oscillation as it is very small and the system is very fast for most of the real life applications.

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References

[1] B. L Theraja, A.K. Theraja, A textbook of electrical technology in S.I units, volume II. S. Chand, 2006

[2] Essam Natsheh, Khalid A. Buragga, “Comparison between conventional and Fuzzy Logic PID Controllers for controlling DC Motors”, IJCSI International Journal of Computer Science Issues, Vol 7, Issue 5, September 2010. url:http://www.ijcsi.org

[3] C. Shanmei , W. Shuyun and D. Zhengeheng “Fuzzy speed controller of induction motor speed drive ” IEEE, Vol .113, No.13, 1997, 1071-1076.

[4] L.A. Zadeh, “Fuzzy sets” Information and Control 8, 338-353(1965)

[5] E.H. Mamdani, “Application of Fuzzy Logic To Approximate Reasoning Using Linguistic Synthesis.”

[6] T. Takagi and M. Sugneo, “Derivation of fuzzy control rules for human operator’s control actions, Proc. of the IFAC Symp. On Fuzzy Information, Knowledge Representation and Decision Analysis” 55-60, July 1983

[7] K. Eugineraj, Dr. G.Uma, “T-S Fuzzy Maximum Power Point Tracking Modelling And Control Of Solar Power Generation”, International Journal of Engineering Research and Applications, Vol. 3, Issue 1, January - February 2013, pp.1887-1892

[8] Basil M. Hamed, Mohammed S. El-Moghany, “Fuzzy Controller Design Using FPGA for Sun and Maximum Power Point Tracking in Solar Array System”, International Journal of Modeling and Optimization, Vol. 3, No. 2, April 2013

[9] M. Gopal, “Digital Control and State Variable Methods Conventional and Intelligent Control Systems” McGraw Hill Education (India) private limited, 4th edition, 2013.

[10] J. Jantzen, "Design of Fuzzy Controllers", Technical University of Denmark: Department of Automation, Technical report number 98-E 864, 19 Aug 1998, URL: http://www.iau.dtu.dk/

[11] C. C. Lee, "Fuzzy Logic in Control Systems: Fuzzy Logic Controller-Part I", IEEE Transactions on Systems, Man, and Cybernetics, Vol. 20, No. 2, pp. 404-418, 1990.

[12] K. Ogata, "Modern Control Engineering", Prentice-Hall,1970.

Brief about the Authors

Jyoti Kumar Barman, is working as an assistant professor in Don Bosco College of Engineering and Technology, Guwahati, Assam, India. He is pursuing his master degree in Electronics and communication with specialization in digital signal processing from Don Bosco College of Engineering and Technology, Guwahati, Assam, India. His research interest includes study of different sensors, data acquisition system, wireless sensor network, soft computing.

Puspanjalee Konwar, is working as an assistant professor in Don Bosco College of Engineering and Technology, Guwahati, Assam, India. She has completed her master degree in Electronics and communication with specialization in opto-electronics from Don Bosco College of Engineering and Technology, Guwahati, Assam, India. Her research interest includes biomedical instrumentation and soft computing.

Gitu Das, is working as an assistant professor in Don Bosco College of Engineering and Technology, Guwahati, Assam, India. He is pursuing his master degree in Electronics and communication with specialization in embedded systems from Don Bosco College of Engineering and Technology, Guwahati, Assam, India. His research interest includes Real time embedded systems, robotics, soft computing.