ISSN: 2278 – 909X
International Journal of Advanced Research in Electronics and Communication Engineering (IJARECE)
Volume 4, Issue 11, November 2015

Hybrid PID-Fuzzy Controlling Approach

Shalini Jain, Dr. N. S. Beniwal

Abstract- **This paper deals with a new controlling mechanism that uses the classical PID and the latest Fuzzy control techniques in harmony to increase the efficiency of the existing methods. The proposed method is better than the previous pre-established methods in literatures in terms of various parameters like the rise time and overshoots values of the response. Basically, here in this design the three parameters of the PID controller are varied continuously as per the pre-defined fuzzy rulebase making this control technique intelligent and robust in comparison to other methods. The results are observed using various simulations and the proposed method is found to possess better transient response when compared to individual PID or pure Fuzzy controllers.The hybrid controller shown and simulated here under this paper is having a rise time of only 0.7ms which is minimum of all the other control mechanisms for the given process.**

Index Terms- **Fuzzy System, PID controller, Simulation.**

I. INTRODUCTION

A proportional-integral-derivative controller (PID controller) is a controlled feedback mechanism (controller) widely used in industrial control systems. Being simple, reliable, and easy to implement techniques; this control mechanism is one of the oldest and commonly used techniques used at different levels. A PID controller calculates an error value which is the difference between a measured process value and a desired set point [4]. The controller attempts to minimize the error by altering the process through use of number ofoperated variables. The PID controller algorithm involves three discrete constant parameters, and hence also called three-term control. These three control parameters are the proportional, integral and derivative parametersgenerally denoted as P, I, and D. These values can simply be understood in terms of time; P depends on the present error, I on the accumulation of past errors, and D is a prediction of future errors, as per the current rate of change. The weighted sum of these above discussed parameters is used to adjust the process using a control element such as control valve position, value of damper, or the power supplied to a heating element. Conventional PID controllers are based on mathematical models that have assured stability, reliability and controllability [5].

A standard PID controller as known the “three-term” controller is having a transfer function of the form

$$G_{PID}(s) = K(1 + \frac{1}{T_i s} + T_d s)$$

Here, K_p is the proportional gain, K_i the integral gain, K_d the derivative gain, Ti the integral time constant and, Td the derivative time constant. The PID controllers provides assured stability of the system as they are based on pure mathematical models but it also increases the level of complexity which further increases in case of non-linear systems.

Apart from the classical PID controlling techniques, Fuzzy logic is always been usage as controller in many of the applications. The fuzzy logic has an advantage of having solution of the problem which can be cast in simple linguistic terms that human operators can easily understand and interpret. This makes it quite easier to automate the given tasks that were already successfully performed by humans. In a fuzzy logic controller, the control action is determined from the evaluation of a set of simple linguistic

Shalini Jain, Department of Electronics & Communication, B.I.E.T, Jhansi, U.P., India.
Dr. N. S. Beniwal, Assistant Professor, Department of Electronics & Communication, B.I.E.T, Jhansi, U.P., India.

rules. They are very effectively used in digital system. FLCs can be classified into two major categories: the Mamdani type FLC that uses fuzzy numbers to make decisions and a Takagi– Sugeno (TS) type FLC that generates control actions by linear functions of the input variables [2].

Fuzzy controllers show outstanding performance in several applications including the most complex industrial processes to the most basic processes used in day to day works. The fuzzy systems are based on the approximate rather than the exact or fixed reasoning. Unlike "two valued" logic in case of binary systems, fuzzy set theory sanctions the degree of truth value of any variable to lie in between the range [0,1]. For example, if cost is a linguistic variable or a fuzzy input, then the terms less, medium, high and expensive describe the fuzzy set for this cost variable. If the universe of discourse used for cost is [0, 100], then “low” could be defined as “values less than 10”, “medium” is “around 40”, and so on [6]. This division of the entire range is completely dependent on the designer and his preferences and purposes of the usage. So, clearly the fuzzy systems are highly user friendly and simple in comparison to the other mathematical systems. Here, for controlling the output of a Plant, linguistic variables are the control inputs for converter itself and several fuzzy rules are used to rules define the relationships between the inputs. Thus, in case of a fuzzy controller detailed information of a plant's transfer function is not mandatory for implementation of the controller. The other advantage with fuzzy system is that designing and defining the rules in the linguistic form is quite simple in comparison to the complex mathematical models. But the drawback of the fuzzy controllers is that they are implemented based on the designer’s experiences, not on rigorous theoretical methods. This raises the concern about reliability, controllability and stability of these fuzzy controllers.

The occurrences of nonlinear effects in case of PID controllers sometimes limit their performances while most of the FLCs are designed using trial and error approach which increases its complexity exponentially when it is be used to control complex systems [1]. So, hybridization of these two controller structures to utilize the favorable points of both categories is the new modern approach to increase the efficiency of the system to a greater extent. Designing a fuzzy logic type of PID controller is quite simple by modifying the conventional system, via using some important fuzzy logic IF- THEN rules into the given control system or process. But, this method of designing will complicate the overall process and do not satisfy the requirements of the new fuzzy PID controllers [3]. Besides, they usually do not have critical formulas to be used for control specification as well as for stability analysis. So, basically these hybrid fuzzy PID controllers are designed by using fuzzy logic controlling techniques, to achieve a new controlling mechanism that retain analytical formulas very similar to those of that a conventional PID controller.

II. IMPLEMENTATION OF HYBRID CONTROLLER

The simple and robust structure of the PID controlled system makes it quite suitable and most commonly used controllers for most of the industrial processes. The operation of PID controllers completely depends on the selection of the variables or the three control parameters. So, here in case of the hybrid controller the tuning of a PID controller is done using a Fuzzy interface [13]. The block diagram showing the actual operating principle is shown below

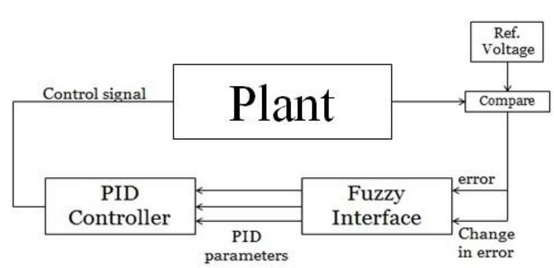

Fig.3.14. Block diagram for hybrid controller

Here, the observed output of the Plant is compared with the desired set point so as to generate an error signal which needs to be minimized using the controlling mechanism. The error signal and change in error with time are used as inputs for the fuzzy system whose output will be varied as per the rule base. The fuzzy interface is used to calculate the values of the PID control parameters (K_P, K_D and K_I) in such a way that settles the output to its desired value as fast as possible. The fuzzy interface used here works as an automatic tuner for the PID controller on the basis of the values of error coefficients.

The Self-tuning fuzzy PID controller, which takes error "e" and rate of change-in-error “ce" as the input to the controller makes use of the fuzzy control rules to modify PID parameters on-line. The self-tuning of the PID controller refers to finding the fuzzy relationship between the three parameters of PID, Kp, Ki, and Kd and "e" and "ce", and according to the principle of fuzzy control modifying the three parameters in order to meet different requirements for control parameters when "e" and "ce" are different and making the control object produce a good dynamic and static performance. Selecting the language variables of “e”,”ce”, Kp, Ki, and Kd is choosing seven fuzzy values (NB, NM, NS, ZO, PS, PM, PB). Here (NB, NM, NS, ZO, PS, PM, PB) is the set of linguistic values which respectively represent “negative big”, ”negative medium”, ”negative small”, ”zero”, ”positive small”, ”positive medium” and “positive big”.

III. SIMULATION & RESULTS OF HYBRID CONTROLLER

A. Simulink model of controller

The Simulink model for the hybrid controller that will be using a fuzzy system to automatically tune the PID controller is shown here. The entire circuit contains two sub-sections: first being the power stage and other is the controller stage. The power stage is nothing but the actual network whose output need to be controlled, denoted here by plant or process. The controller stage is a hybrid structure as mentioned before using the PID and Fuzzy system.

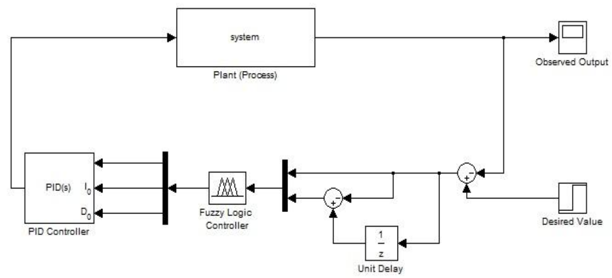

Fig.1. Simulink Model for the Hybrid Controller

B. Response of the Hybrid Controller

The response of the DC-DC buck converter using a hybrid type of controller shown above demonstrates the best results having the minimum settling time of only 0.7ms. It simply means that if a PID-Fuzzy Hybrid controller is used with the given plant, the output voltage will take only 0.7ms to reach the desired voltage level which is 5V in this case.

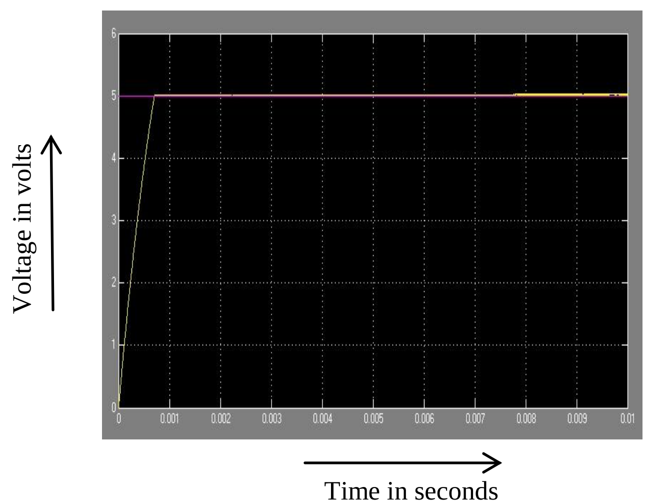

Fig.2. open loop response of the hybrid controller

IV. CONCLUSION

On the basis of the simulated results shown here in this paper, it can be clearly concluded that the proposed hybrid controller designed using the automatic tuning of the PID controller for the given process is more efficient in comparison to the individual PID controller or Fuzzy controller for the same system. The automatic tuning of the controller is done with the help of a fuzzy system and hence the entire mechanism has been called as a hybrid controller. The response of this PID-Fuzzy Hybrid type controller has shown the best result in terms of its lowest settling time and peak overshoot in comparison to both the classical PID as well as the Fuzzy controller.

ACKNOWLEDGMENT

I would like to express my sincere gratitude to Dr. N. S. Beniwal, Assistant Professor, Electronics & Communication department, B.I.E.T., Jhansi (U.P.) for helping me at every step in making of this research paper. Apart from this I also want to thank my family for their motivation and support while studying this subject.

REFERENCES

[1] Brehm, Thomas, and Kuldip S. Rattan. "Hybrid fuzzy logic PID controller." in Aerospace and Electronics Conference, 1993. NAECON 1993., Proceedings of the IEEE 1993 National, pp. 807-813. IEEE, 1993.

[2] Mattavelli, P. "General-purpose fuzzy controller for DC-DC converters "Power Electronics, IEEE Transactions on (Volume:12 , Issue: 1) in 2002

[3] Erenoglu, Isin, Ibrahim Eksin, EnginYesil, and MujdeGuzelkaya. "An intelligent hybrid fuzzy PID controller." In European Conference on Modelling and Simulation, pp. 62-67. 2006.

[4] Seongmin Lee "A DC-DC buck converter with using a digital PID regulator based on a simple control algorithm", Signals, Circuits and Systems (ISSCS), 2011 10th International Symposium in 2011.

[5] Qiang Tonga*, DongLaiZhangb, NaiTongZhangc in 2012 International Workshop on Information and Electronics Engineering (IWIEE).

[6] Prasad, KV Hari, CH Uma MaheswarRao, and A. Sri Hari. "Design and simulation of a fuzzy logic controller for buck & boost converters." International Journal of Advanced Technology & Engineering Research (IJATER) 2, no. 3 (2012).

[7] AugustiLindiya, Dr. S. Palani, "Performance Comparison of various controllers for DC-DC converter", published in International Conference on Modelling, Optimization and Computing, 2012.

[8] Verma, Sujata, S. K. Singh, and A. G. Rao. "Overview of control Techniques for DC-DC converters." Research Journal of Engineering Sciences ISSN 2278 (2013): 9472.

[9] Siew-Chong Tan Y. M. Lai Martin K. H. Cheung Chi K. Tse, "On the Practical Design of a Sliding Mode Voltage Controlled Buck Converter", IEEE Transactions on Power Electronics, Vol. 20, No. 2, March 2005.

[10] C. Edwards and S. K. Spurgeon, "Sliding Mode Control: Theory and Applications", Taylor and Francis, London, U.K., 1998.