# ANALYSIS OF CONTROL STRUCTURE FOR ELECTRIC DRIVE SYSTEM USING A DIRECT CURRENT MOTOR

Thao T.P. Do[1]

[1] *Thai Nguyen University of Technology, Thai Nguyen City, Vietnam*

## ABSTRACT

*The controlling speed for DC motors, especially in industry, is always associated with the production technology process and it greatly determines the quality of the products. Depending on the nature and requirements of the process, it requires appropriate control methods. This paper given a designs of speed controlling for a DC servo system based on a newly developed fuzzy system, which is very powerful and has brought about many unexpected achievements in the field of fuzzy logic control.*

**Keywords:** *DC servo motors, Fuzzy controller, Fuzzy PID.*

---

## 1. INTRODUCTION

The DC servo motors are popularly used as prime movers in computers, numerically controlled machinery, or other applications where starts and stops are made quickly and accurately. Servo motors have lightweight, low-inertia armatures that respond quickly to excitation-voltage changes. The speed of DC motor can be adjusted to a great extent so as to provide easy control and high performance. There are several conventional and numeric controller types intended for controlling the DC motor speed at its executing various tasks: PID Controller, Fuzzy Logic Controller (FLC) [1]; or the combination between them: PID-Particle Swarm Optimization, PID-Neural Networks, PID-Genetic Algorithm. One of the problems which might cause unsuccessful attempts for designing a proper controller would be the time-varying nature of parameters [2-6], unknown the parameters of the plants and variables which might be changed while working with the speed systems. Thus, the hybrid fuzzy PID controller is adopted in this paper which is very flexibility to control the speed of the DC servo motor.

## 2. FLC AS A FUZZY KEY SWITCH

Fuzzy hybrid system abbreviated as Fuzzy-PID is a control system in which the control device consists of two components: classical control component and fuzzy control component.

FLC as a fuzzy key switch

To perform fuzzy conversion between the FLC levels and the PID converter, one can set up multiple PID regulators i (i = 1,2 ... n) each of which is selected to optimize the quality according to a specific method. somehow to produce a good feature in a limited region of the input variable as shown in the Figure 2. These regulators share the same input information and their effect depends on the input value. In this case, the transformation rule can be written in the fuzzy system as follows:

If (state of the system) is Ei then (control signal) = ui

Where i = 1, 2,..., n; Ei is the language variable of the input signal, ui is the function with the parameters of the control action. If at each tuning region, the control action is due to the PID regulator with:

$$u_i = K_{Pi}e + K_{Ii}\int_0^t e(t)dt + K_{Di}\frac{de}{dt} \quad (i = 1, 2, ... n) \tag{1}$$

Thus, the coefficients of the PIDi regulator depend on the input signals, more generally on the state of the system. If we consider the coefficients $K_{Pi}$, $K_{Di}$, and $K_{Ii}$ as the defuzzification results according to the center-average method from three functional fuzzy systems:

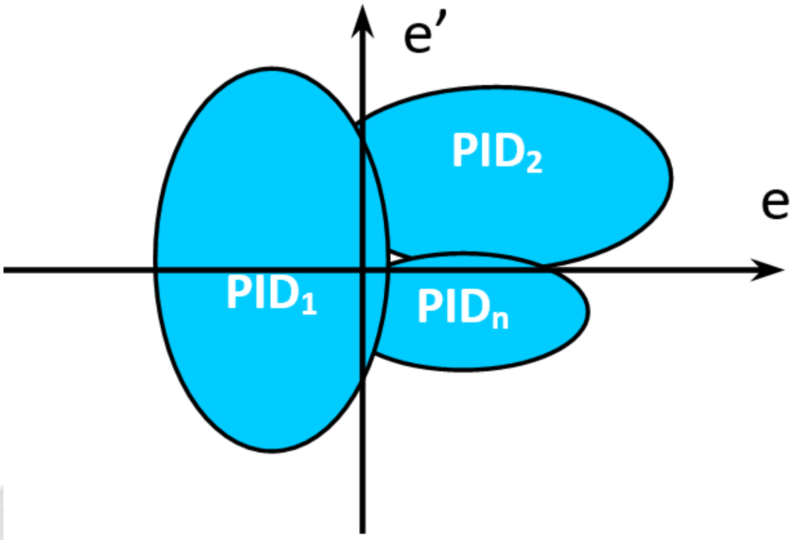

**Figure 1.** Active area of the controller

Functional fuzzy system calculates the coefficient KP with the rule system:

Ru(i): if E is Eiand DE is DEithen $K_P = K_{Pi}$ (2)

Functional fuzzy system calculates coefficient KD with the rule system:

Ru(i): if E is Eiand DE is DEithen $K_D = K_{Di}$ (3)

Functional fuzzy system to calculate coefficient KI with the rule system:

Ru(i): if E is Eiand DE is DEithen $K_I = K_{Ii}$ (4)

The theory research on hybrid fuzzy control system is mentioned above. A proposal of a hybrid fuzzy control structure for the problem of motor speed stability, based on the distribution of the working area between the fuzzy controller and the classic PID controller through the switching as shown in the Figure 2.

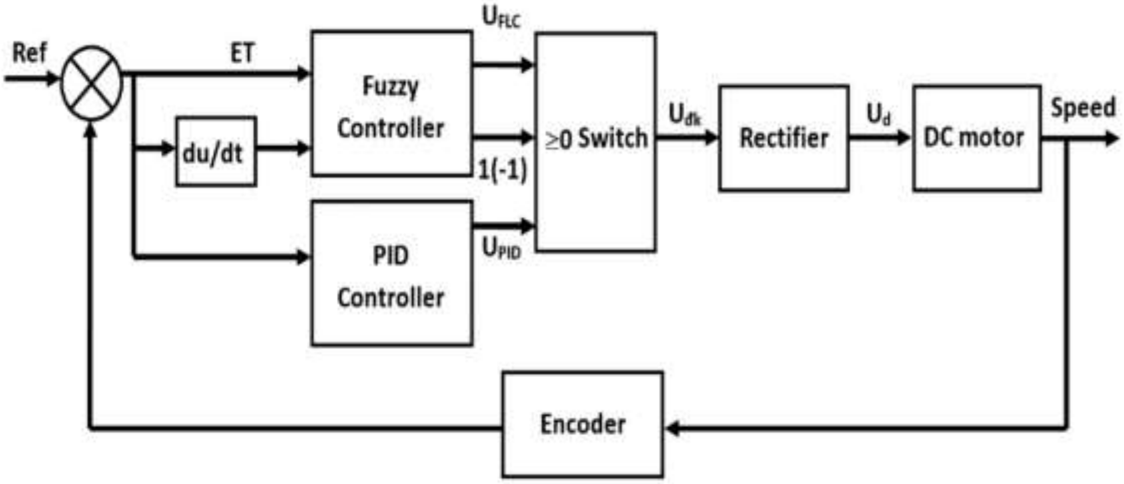

**Figure 2.** The Hybrid fuzzy controller structure

## 3. CONCLUSIONS

In this paper, the author presented an overview of the hybrid fuzzy control system, the design method of the hybrid fuzzy controller and proposed a hybrid fuzzy control structure for the problem of stabilizing the DC motor speed as described which proposed in this paper, in the next study will discuss about the hybrid fuzzy control system for DC motors.

## 4. ACKNOWLEDGEMENT

This work was supported by Thai Nguyen University of Technology, Vietnam.

## 5. REFERENCES

[1]. Yesil, E., Guzelkaya, M., & Eksin, I. (2003). Fuzzy PID controllers: An overview. In The Third Triennial ETAI International Conference on Applied Automatic Systems, Skopje, Macedonia (pp. 105-112). ETAI Society of Macedonia.

[2]. Bhushan, B., Jha, N., Devra, S., & Pillai, S. S. (2014, February). Performance analysis of PID and Fuzzy PD+ I controller on nonlinear systems. In 2014 IEEE International Advance Computing Conference (IACC) (pp. 1195-1200). IEEE.

[3]. Iqbal, S., & Ayyub, M. (2018, September). Improved Performance of Fuzzy Logic Controller to Control Dynamical Systems: A Comparative Study. In 2018 International Conference on Computational and Characterization Techniques in Engineering & Sciences (CCTES) (pp. 122-126). IEEE.

[4]. Mondal, S., Mitra, A., Chowdhury, D., & Chattopadhyay, M. (2015, February). A new approach of sensorless control methodology for achieving ideal characteristics of brushless DC motor using MATLAB/Simulink. In Proceedings of the 2015 Third International Conference on Computer, Communication, Control and Information Technology (C3IT) (pp. 1-4). IEEE.

[5]. Sun, Y. L., & Er, M. J. (2001, September). Hybrid fuzzy control of linear and nonlinear systems. In Proceeding of the 2001 IEEE International Symposium on Intelligent Control (ISIC'01)(Cat. No. 01CH37206) (pp. 303-307). IEEE.

[6]. Bouras, S., Kotronakis, M., Suyama, K., & Tsividis, Y. (1998). Mixed analog-digital fuzzy logic controller with continuous-amplitude fuzzy inferences and defuzzification. IEEE transactions on Fuzzy Systems, 6(2), 205-215.

[6]. Sun, Y. L., & Er, M. J. (2001, September). Hybrid fuzzy control of linear and nonlinear systems. In Proceeding of the 2001 IEEE International Symposium on Intelligent Control (ISIC'01)(Cat. No. 01CH37206) (pp. 303-307). IEEE.

[7]. Jian, L., Yong, K., & Jian, C. (2002, October). A novel fuzzy-repetitive control scheme for inverters. In *Proceedings of the IEEE Internatinal Symposium on Intelligent Control* (pp. 104-109). IEEE.

[8]. Santana Blanco, J. Hybrid Self-Learning Fuzzy PD+ I Control of Unknown SISO Linear and Nonlinear Systems.

[9]. Song, S., Park, J. H., Zhang, B., & Song, X. (2020). Adaptive hybrid fuzzy output feedback control for fractional-order nonlinear systems with time-varying delays and input saturation. *Applied Mathematics and Computation*, *364*, 124662.

[10]. Song, S., Park, J. H., Zhang, B., & Song, X. (2019). Observer-based adaptive hybrid fuzzy resilient control for fractional-order nonlinear systems with time-varying delays and actuator failures. *IEEE Transactions on Fuzzy Systems*, *29*(3), 471-485.

[11]. Lee, H. J., Park, J. B., & Chen, G. (2001). Robust fuzzy control of nonlinear systems with parametric uncertainties. *IEEE Transactions on fuzzy systems*, *9*(2), 369-379.

[12]. Tong, S., Liu, C., Li, Y., & Zhang, H. (2010). Adaptive fuzzy decentralized control for large-scale nonlinear systems with time-varying delays and unknown high-frequency gain sign. *IEEE Transactions on Systems, Man, and Cybernetics, Part B (Cybernetics)*, *41*(2), 474-485.

[13]. Mohd Basri, M. A., Husain, A. R., & Danapalasingam, K. A. (2015). A hybrid optimal backstepping and adaptive fuzzy control for autonomous quadrotor helicopter with time-varying disturbance. *Proceedings of the Institution of Mechanical Engineers, Part G: Journal of Aerospace Engineering*, *229*(12), 2178-2195.