iJRASET
International Journal For Research in Applied Science and Engineering Technology



INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 14 **Issue:** III **Month of publication:** March 2026

DOI: https://doi.org/10.22214/ijraset.2026.78428

www.ijraset.com

Call: 08813907089 | E-mail ID: ijraset@gmail.com

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 14 Issue III Mar 2026- Available at www.ijraset.com

Comparative Analysis on ANN based Fuzzy and PI Controller based Speed Control of DC Motor

Prashant Nayak[1], Ankit Tiwari[2], Ankit Kumar Sharma[3], Devansh Tiwari[4], Suneel Patel[5], MD Asif[6]
[1, 2, 3, 4, 5, 6]*Department of Electrical & Electronics, OIST, (RGPV), Bhopal, India*

Abstract: ***It concerns the study of intelligent control techniques and its application to speed control of DC motors fed by DC-DC converters, which can be implemented in an embedded system. The intelligent techniques include Fuzzy Logic Control (FLC) and Artificial Neural Network (ANN).***
Implementation of closed loop control for power converters and drives requires efficient controllers and in turn requires high computation rate and so embedded system implementation is advantageous. The ease of design of intelligent controllers can be well understood only if the complexities in the conventional controller design are explained. Initially, conventional PT controller design based on the small signal model of the motor with buck type DC-to-DC power converter is designed. This controller implementation on a PC using data acquisition card is presented.
Then a fuzzy controller was designed with the embedded systems implementation in mind and the analysis of response of the motor speed is compared with conventional Proportional and Integration (P1) controller. Fuzzy controller gives a better performance compared to P1 controller. The simulated fuzzy controller was implemented experimentally in an 8051-based embedded system. A buck type DC-to-DC power converter fed DC drive was constructed and the fuzzy controller performance was studied experimentally. The entire system is found to be cost effective and has more advantages in terms of steady state error and rise time.
Keywords: DC Motor, PWM, ANN,Fuzzy logic, Speed Control, Astable Mode, Variable Speed Drive.

I. INTRODUCTION

The conventional methods that control electric motors in the past were very inefficient, expensive and gave very poor performance. In recent years, the demand for greater performance and precision in electric motors, combined with the development of better solid state electronic devices and cheap microprocessors has led to the creation of modern intelligent adjustable-speed drives using power converters.

The power electronic converter provides the interface between the power supply and the motor. The main advantage of using power converters is the savings.

Controller is a circuit responsible for controlling the motor output. This is accomplished by manipulating the operation of the power electronic converter. The closed loop control of motors is essential in many industrial applications. The evolution of power electronic converters and their control has generated new trends and potential in multidisciplinary directions. In this context, DC-DC power converter systems with motor load are more appropriate for modern intelligent control techniques, which are considered in this work.

The system designed has two loops with an inner ON/OFF current controller and an outer fuzzy speed controller. In outer speed control loop, the speed is fed back and is compared with set speed. After comparison, error signal and the change in error are calculated and are given as input to fuzzy controller. The fuzzy controller attempts to reduce the error to zero by changing the duty cycle of switching signal and thereby, the voltage fed to the armature of the separately excited motor to regulate the speed. The quadrant of operation is decided by comparing the reference speed and the actual speed of the motor. The Four-quadrant converter is designed to have switching frequency of more than 20 KHz. The use of high switching frequency reduces torque ripples on the motor 43 II Q2 D4 - ON D1,D4 - ON -G Q3Q2-ON D4,Q2 - ON III I Q1 Q4 - ON +Vdc D2,Q4 - ON Jo Idc -Vdc Q4 D2 - ON D3,D2 - ON Iv S shaft. Such a converter requires both current and voltage reversing capability to match rapidly changing speed references and to compensate for step load disturbances.

©IJRASET: All Rights are Reserved

ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 14 Issue III Mar 2026- Available at www.ijraset.com

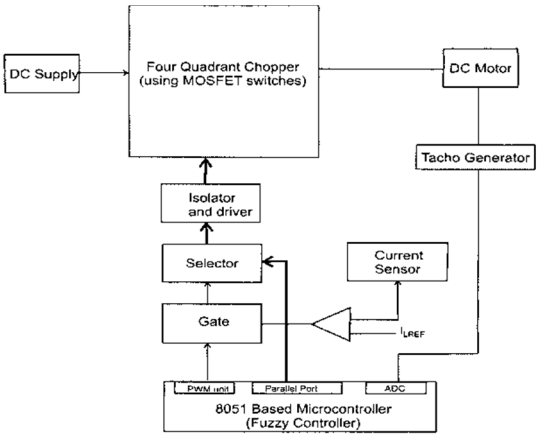


Fig-1. Block diagram of proposed model

II. METHODOLOGY

Neural networks and fuzzy set theory have been the object of intense study and application, especially in the last decade. Neural networks and fuzzy control were developed to deal with problems that were hard or impossible to solve using traditional techniques. Implementation of closed loop control for power converters and drives requires 1 efficient controller and in turn requires high computation rate. So embedded system implementation becomes essential

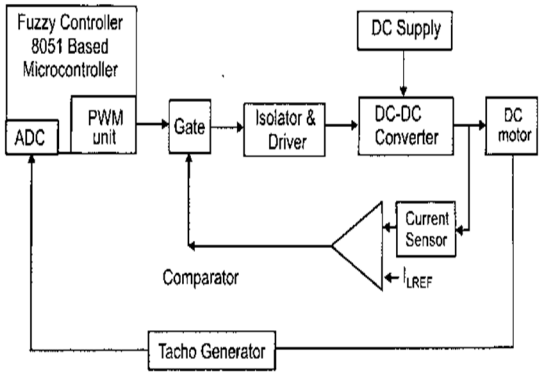


Fig. Fuzzy logic Controller for DC motor

Table 1. Comparative analysis for steady state error of ANN based Fuzzy and PI Controller

Speed	Load	PI	Fuzzy	ANN trained with Fuzzy controller data	ANN trained with PI controller data
60% of rated value	0% of rated torque	1.2	0.55	0.44	0.29
	100% of rated torque	1.0	0.75	0.6	0.56
100% of rated value	0% of rated torque	2.0	1.67	1.0	0.05
	100% of rated torque	8.7	1.86	1.0	0.625

©IJRASET: All Rights are Reserved

Table 2. Comparative analysis for Rise time of ANN based Fuzzy and PI Controller

Speed	Load	PI	Fuzzy	ANN trained with Fuzzy controller data	ANN trained with PI controller data
60% of rated value	0% of rated torque	1.057	0.8313	0.83	0.814
	100% of rated torque	11.4	5.45	4.89	4.6
100% of rated value	0% of rated torque	1.9	1.417	1.42	1.417
	100% of rated torque	23.5	10.5	9.95	9.95

III. EXPERIMENTAL IMPLEMENTATION

The designed controllers were implemented using Cygnal 8051 based processor (C805 1 F005) and programming it. A buck converter was built and the controllers were 93 tested on the 220V DC motor. A tacho-generator was used to sense the speed and to feedback the speed signal. A LEM make current sensor LTS25NP is used to sense the armature current and it is compared with the reference current using a comparator. The AND gate is used to allow the PWM waveform when the actual current is less than the reference current. This PWM waveform is then level amplified and fed to the DC -DC power converter through an isolator and driver chip. The Buck converter output is used as supply to the armature of the DC motor, whose speed is to be controlled. The tacho generator connected to the motor shaft gives a DC voltage proportional to the speed and this DC voltage is fed to the ADC available in the micro-controller. The Figures 6.7 to 6.9 show the experimental graph of response of DC motor for a step change in reference speed applied to a prototype motor. Figure 6.7 shows the response of the Conventional PT controller. While Figures 6.8 shows the response of the Fuzzy controller, Figure 6.9 shows the response of the ANN controller trained using P1 controller data. These results confirm the simulation results that the ANN controller reduces the rise time in the response.

IV. RESULTS

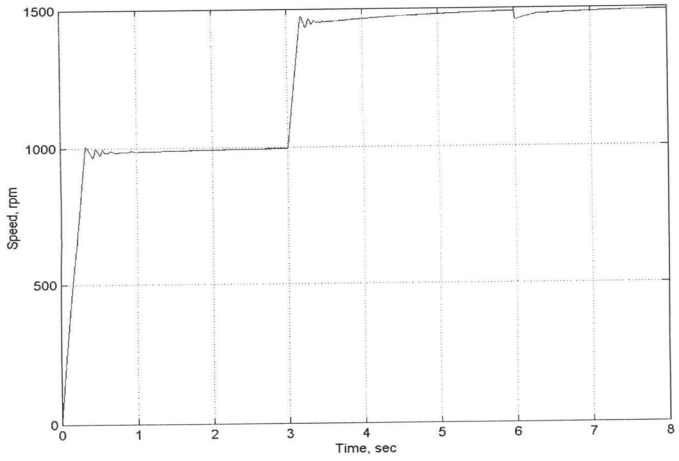


Fig. Simulated Speed variation for the step change in reference speed 1000 rpm to 1500 rpm and for change in load torque from zero to rated value at t=6 secs with PI controller

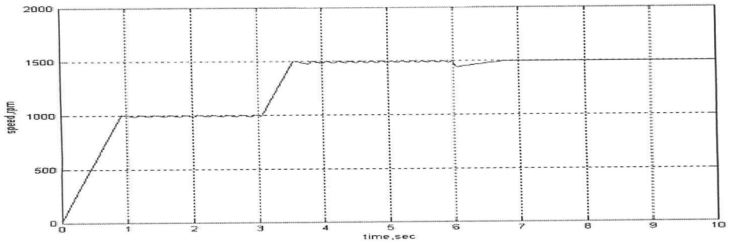


Fig. Simulated Speed variation for the step change in reference speed 1000 rpm to 1500 rpm and for change in load torque from zero to rated value at t=6 secs with Fuzzy controller

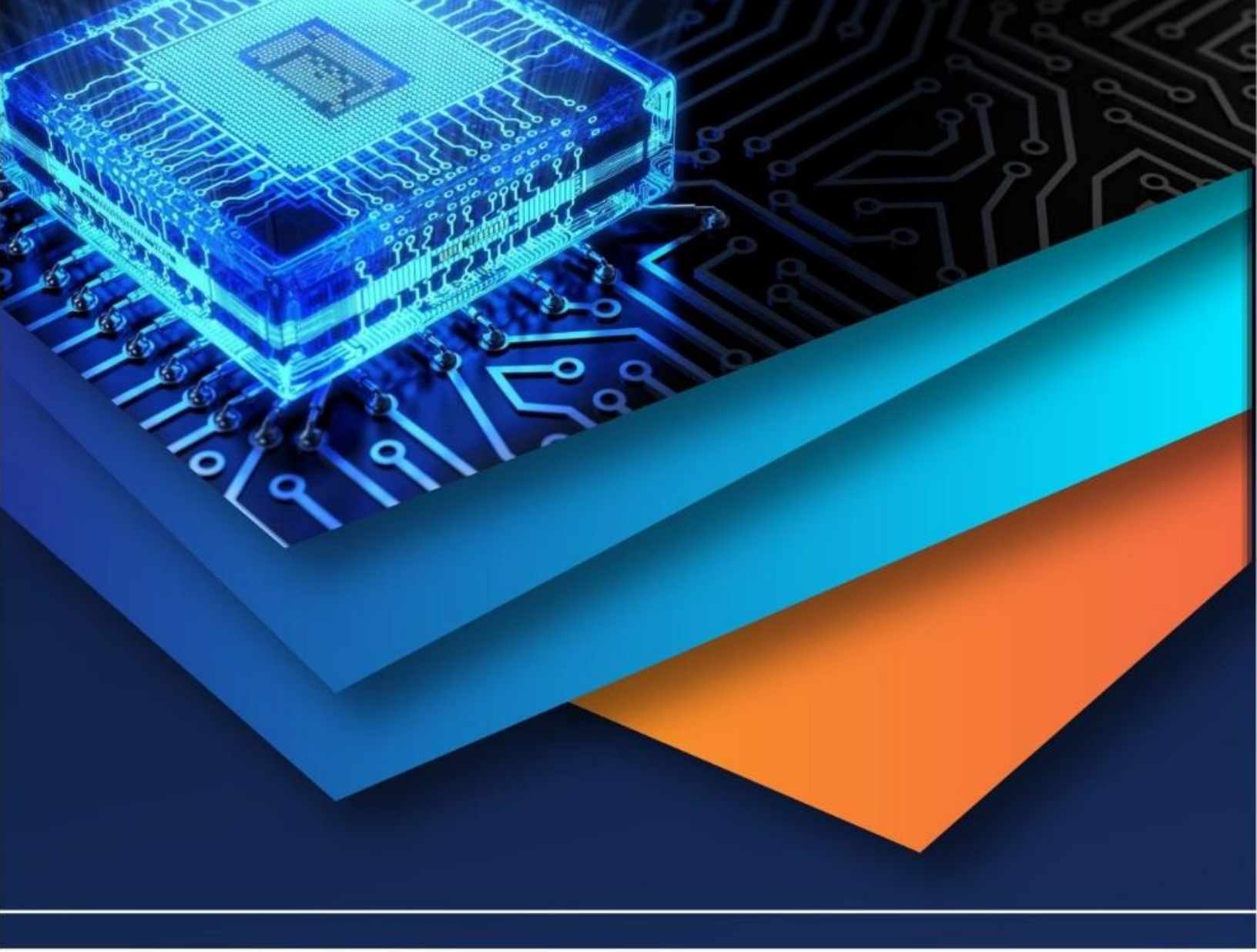
V. CONCLUSION

The study of Fuzzy and ANN control techniques and its application to control the speed of separately exc motors has been taken up in this thesis. The DC motor drive system uses Buck type DC-DC converters and microcontroller based embedded system for intelligent control algorithm implementation. Initially, the conventional controller design starting from mathematical modeling of the DC motor and the related power electronic converters were discussed. Instead of the general time averaged model, the small signal model was developed and based on the small signal model; the conventional P1 controller was designed. The small signal model is advantageous as it takes care of the dynamics of the system under study.

REFERENCES

[1] Bimal K. Bose, "Power Electronics and Motion Control-Technology Status and Recent Trends", IEEE Transactions On Industry Applications, Vol. 29, No. 5, September! October, 2023, pp 902-909.
[2] Bimal K. Bose, "Intelligent Control and estimation in Power electronics and drives", Invited Paper, IEEE International Electric Machines and Drives Conference (IEMDC97), Milwaukee, Wisconsin, May 18-21, 2022
[3] Bimal K. Bose, "Power electronics and motor drives-recent technology advances", Proceedings of the IEEE International Symposium on Industrial Electronics, L'Aquila, Italy, July 8-11, 2022, pp. 22- 25.
[4] Ming-Yuan Shieh, Tzuu-Hseng S.Li, "Integrated fuzzy logic controller design," Proceedings of IEEE, IECON'93, Maui HW, USA, pp.279-284.
[5] Sousa, G.C.D., Bose, B.K., "A fuzzy set theory based control of a phase-controlled converter DC machine drive" IEEE Transactions on Industry Applications, Vol. 30, No. 1, January !February, 2021, pp 34-44.
[6] Richard W. Wall, Herbert L.Hess, "Design and Microcontroller Implementation of a Three Phase SCR Power Converter", Journal of Circuits, Systems, and Computers, Vol. 6, No. 6, December, 1996, pp.;619-633.
[7] Krzysztof Zawirski, Konrad Urbanski, "Application of fuzzy control technique to thyristor DC drive" Proceedings of the IEEE International Symposium on Industrial Electronics, ISlE, Guimares, Portugal, July 1997, vol.3, pp 1173-1178.
[8] G.Uma, C.Chellamuthu, "Design and Implementation of Fuzzy logic control Speed control system for a converter fed DC drive using 8097 micro controller" 101 Proceedings of the IEEE International Symposium on Industrial Electronics, ISlE Cholula, Puebla, Mexico, December, 2000, pp 735-740.
[9] J.L.Castro, "Fuzzy Logic Controllers Are Universal Approximators", IEEE Transactions On Systems, Man, And Cybernetics, Vol. 25, No. 4, April, 1995, pp 629-635.
[10] Chen Weitian, "Sufficient Conditions on Fuzzy Logic Controllers as Universal Approximators", IEEE Transactions on Systems, Man, and Cybernetics - Part B: Cybernetics, Vol. 31, No. 2, April 2001, pp 270-274.
[11] Wing-Chi So, Chi K.Tse Yim-Shu Lee, "Development of Fuzzy logic Controller for DC/DC converters: Design, Computer Simulation, and Experimental Evaluation", IEEE transactions on Power Electronics, Vol. 11, No. 1, January, 1996, pp 24-32.
[12] Paolo Mattavelli, Leopoldo Rossetto, Giorgio Spiazzi, Paolo Tenti, "General Purpose Fuzzy Controller For DC-DC converters", IEEE Transactions on Power electronics, Vol. 12, No. 1, January 1997, pp 79-86.
[13] V.S.C.Raviraj and P.C.Sen, "Comparative Study Of Proportional-Integral, Sliding Mode, and Fuzzy Logic Controllers For Power Converters", IEEE Transactions on Industry Applications, Vol.33, No.2, March/April, 1997, pp 5 18-524.
[14] Tarun.Gupta, R.R.Boudreax, R.M.Nelms, John Y.Hung, "Implementation of a Fuzzy Controller for DC-DC Converters Using an Inexpensive 8-Bit micro controller", IEEE Transactions on Industrial Electronics, Vol. 44, No. 5, October, 1997, pp 661-667.
[15] Dake He and R. M. Nelms, "Fuzzy Logic Average Current-Mode Control for DC— DC Converters Using an Inexpensive 8-Bit Microcontroller", IEEE Transactions On Industry Applications, Vol. 41, No. 6, November! December, 2005, pp 1531- 1538.
[16] .Pierre Guillemin, "Fuzzy logic applied to Motor control", IEEE Transactions on Industry applications, Vol.32, No. 1, January/February, 1996, pp 51-56
[17] .O.Montero, J.Fonseca, S.Bautista, R.Castellanos, R.Alejos, "Experimental Results of speed control in Electrical machines using fuzzy logic controllers" IEEE International Power Electronics Congress Cuernavaca, Mexico, 1996, pp 59-62.
[18] .A.Khoei, Kh.Hadidi, "Microprocessor based closed loop speed control system for DC motor using Power MOSFET", ICECS, 1996, pp 1247-1250.
[19] Hung-Ching Lu, "Design and implementation of a digitized Fuzzy controller for DC servo drives", IEEE International Conference on Intelligent Processing Systems, 1997, pp 242- 246.
[20] Zakharov Alexei, Halasz Sandor, "Robust Speed Fuzzy Logic Controller for DC drive", IEEE International conference on Intelligent Engineering System, 1997, pp. 379-383.
[21] M.K.Miahra, A.G.Kothari, D.P.Kothari, Arindam Ghosh, "Development of a fuzzy logic controller for Servo systems" IEEE Region 10 International Conf. on Global Connectivity, Communication and Control, December, 17-19, 1998, New Delhi, pp 204-207.

©IJRASET: All Rights are Reserved | SJ Impact Factor 7.538 | ISRA Journal Impact Factor 7.894 |



10.22214/IJRASET

45.98

IMPACT FACTOR: 7.129

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Call : 08813907089 (24*7 Support on Whatsapp)