IJESRT

INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

Fuzzy PID Controllers Using Matlab GUI Based for Real Time DC Motor Speed Control

Suhas Yadav[*1], Prof.S.S.Patil[2]

[*1,2] Department of Electronics Engineering, Tatyasaheb Kore Institute of Engineering and Technology.(TKIET) - Warananagar, India

suhas_yadav99@rediffmail.com

Abstract

In this paper, an integrated electronic system has been designed, constructed and tested. Controlling DC (Direct current) Motor drive is design and development of real time MATLAB –GUI based using fuzzy logic controller. First, a controller is designed according to fuzzy rules such that the systems are fundamentally robust. To obtain the globally optimal values, parameters of the fuzzy controller are improved by MATLAB-GUI based FLC and IFLC algorithms optimization model. Computer MATLAB work space demonstrate that the fuzzy controller associated to integrated algorithms approach became very strong, gives a very good results and possess good robustness.

Keywords: Direct current motor drive; MATLAB-GUI; integrated Fuzzy logic controller.

Introduction

The development of high performance motor drives is very important in industrial as well as other purpose applications. Generally, a high performance motor drive system must have good dynamic speed command tracking and load regulating response. The dc motors are used in various applications such as defense, industries, Robotics etc. DC drives, because of their simplicity, ease of application, reliability and favorable cost have long been a backbone of industrial applications.

Many advanced model-based control methods such as variable-structure control [4] and model reference adaptive control [5] have been developed to reduce these effects. However, the performance of these methods depends on the accuracy of system models and parameters.

Generally, an accurate non-linear model of an actual DC motor is difficult to find, and parameter values obtained from system identification may be only approximated values.

Emerging intelligent techniques have been developed and extensively used to improve or to replace conventional control techniques because these techniques do not require a precise model. One of intelligent techniques, fuzzy logic developed by Zadeh [6, 7] is applied for controller design in many applications [8, 9].

Design and development of MATLAB based graphical user interface (GUI) for the DC motor speed control .This MATLAB-GUI is a program which acts as an interface tool between computer and user. MATLAB-GUI provides a user friendly interface to tune the fuzzy and integrated fuzzy logic controllers (IFLC) in real time environment.

The performance of the motor can be observed on the axes component of the GUI.An AD-DA converter has been designed and fabricated to acquire the speed and to generate control voltage to the DC motor.MATLAB-GUI is created for IFLC based DC motor speed control system using GUI component, that enable an user to perform interactive tasks by programming the callback function of each component on the GUI.This GUI is used to acquire the data and to send the control action to the motor .MATLAB –GUI displays all the required parameters of dc motor. Also this project deals with the performance of controller under different standard test signals such as step, square and set point variations. In this project, the performance of the GUI shows that tuning of variations controllers is made simple and user friendly. The pop menu on the GUI provides access to variations standard step inputs. This makes the selections of standard inputs easier.

The proposed MATLAB-GUI reduces the time which is consumed in tuning the controllers in other software the less effort. AS the other software are little complex and are not user friendly.

ISSN: 2277-9655
Impact Factor: 1.852

Fuzzy Logic Controller

Fuzzy Logic Controller (FLC) is based on fuzzy logic controller and constitutes a way of converting linguistic control strategy into an automatic by generating a rule base which controls the behavior of the system. Fuzzy control is control method based on fuzzy logic. Fuzzy provides a remarkably simple way to draw definite conclusions from vague ambiguous or imprecise information. It suitable for applications such as the speed control of dc motor which is has non linearities. [5] There are specific components characteristic of a fuzzy controller to support a design procedure. Figure 3 shows the controller between the preprocessing block and post processing block.[6]

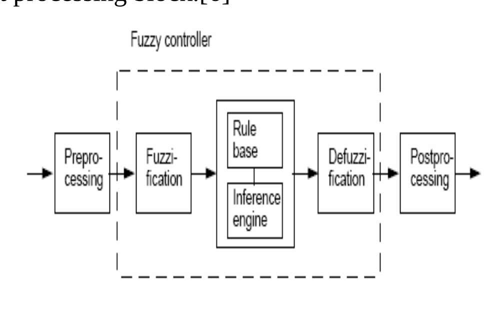
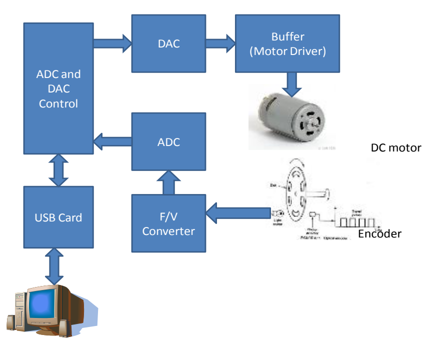


Figure 3: Structure of fuzzy logic controller

The structure of FLC consists of the following 3 major components which the first one is fuzzifier that used for measurement of the input or definition of the fuzzy sets that will applied. The second one is fuzzy control or rule base which provides the system with the necessary decision making logic based on the rule base that determine the control policy. The third method is defuzzifier which combines the actions that have been decided and produce single non-fuzzy output that is the control signal of the Systems.

Hardware Development for Fuzzy Logic based DC Motor Control using MATLAB- GUI



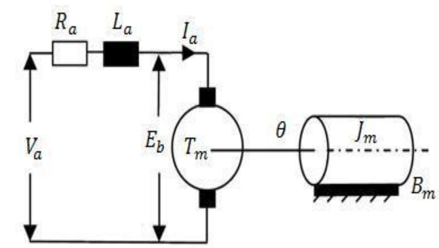
Block diagram of the proposed hardware system

This section deals with hardware development of dc motor control involving fuzzy implementation. It consists of PC interfacing card, power supply unit circuit, control circuit and driver circuit.

In control circuit, the driving pulses required for tachogenrator are obtained from FLC & IFLC Algorithm The overall hardware circuit is shown in figure 10.which is developing the hardware to interface with MATLAB. The other part is developing the programming for MATLAB and the IFLC Algorithm to control the speed of DC motor.

Model of DC Motor

The Permanent magnet DC Motors are light in weight and which are easy to install. We offer these motors as per the client's requirements and that exactly meets the desired output. We manufacture and export magnet DC motors to our clients at extensive range.



These DC motors have high torque and high density and also available in various sizes. These motors take less maintenance and power. The specifications of our range include

parameter	Units
Size	35.7mm outer diameter and 57.0mm length with 2.3mm shaft diameter.
Normal voltage	12V DC rated
Power	46.7W
No Load Speed	1500 rpm(Max)
No Load current	0.27A
Commutation	Carbon Brush
Weight	205gms
Torque	83.0gm-cm

Personal Computer

For the present work PC with the following is used OS Windows XP-SP3,Intel core2 Duo CPU E700@2.66GHz with MATLAB 7 version has been used.

Techo-generator

It consists of slotted aluminum disc and an optical encoder. When the slot comes in between the encoder, a high pulse is produced. The frequency of these pulses depends on the speed of DC motor. This frequency is converted into a voltage signal. Optical encoder is typically constructed using a slotted disk with a pair of light emitting diodes (LED's) which are aligned with a pair of photo-transistors (receivers) on the other side of the disk. The frequency of the output waveform is given by,

Fout=N*rpm/60

So, from above equation, The speed of the DC motor in rpm is given by

Rpm=Fout*60/N

F/V converter

The frequency of train of pulses from tachogenertor is converted into corresponding voltage by using LM2907 frequency to voltage converter. Frequency to voltage converter provides an output voltage proportional to the input frequency with zero input at zero frequency. The output voltage obtained is,

VO=VCC*fin*C1*R1*K.where Kis the gain constant.

Further the output of F/V converter is acquired through the A/D converter.

AD-DA board

Data acquisition is done through ADC-DAC. Speed of the dc motor connected is set with the help of a variable resistance of 10K which is connected to A0 pin which works as ADC port in the AVR Microcontroller (Atmega 16 bit). and DAC 7541 are proposed to be used. In practice, an ADC is usually in form of an integrated circuit (IC).

Buffer/ Driver:

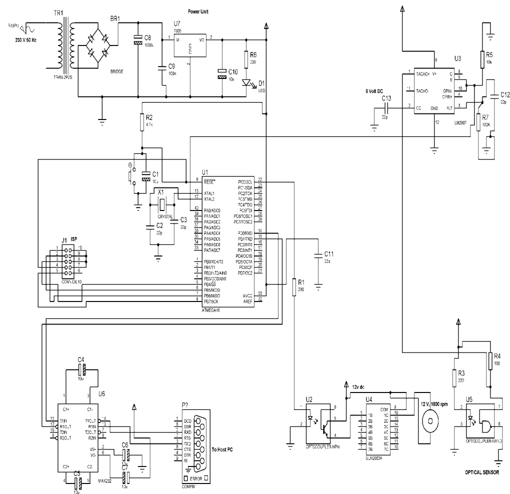
A driver circuits with transistor will be built, to provide enough current to drive the motor. ICs ULN2003 *and MAX232 were used to* drive *the* motor *and to do serial.*

MAX232

It is an IC, that converts signals from an RS-232 serial port to signals suitable for use in TTL compatible digital logic circuits. The MAX232 is a dual driver/receiver and typically converts the RX, TX, CTS and RTS signals. The drivers provide RS-232 voltage level outputs (approx. ± 7.5 V) from a single + 5 V supply via on-chip charge pumps and external capacitors. This makes it useful for implementing RS-232 in devices that otherwise do not need any voltages outside the 0 V to + 5 V range, as power supply design does not need to be made more complicated just for driving the RS-232 in this case.

The receivers reduce RS-232 inputs (which may be as high as ± 25 V), to standard 5 V TTL levels. These receivers have a typical threshold of 1.3 V, and a typical hysteresis of 0.5 V.

Schematic circuit Diagram



Software Details

Design of MATLAB GUI:

GUIDE, the MATLAB® Graphical Use Interface development environment provides a Set of tools for creating graphical user interfaces (GUIs). These tools greatly simplify the process of designing and building GUIs. User can use the GUIDE tools to lay out the GUI MATLA Provides a facility to design a GUI.

It allows user to set the desired set points for DC motor speed through the edit box. It may also help to find other parameters such as fuzzy values.

This GUI is used to tune the FLC ,IFLC controllers .While tuning these values the results are observed on the axes provided on the MAT_GUI.By this GUI ,User can test the performance of designed controllers under different standard test input commands such as step, sine ,triangular, ramp, and set point variations etc.one of the standard test inputs commands are chosen through this GUI from combo box provided on the GUI.each standard test commands programmed in MATLAB_GUI facilitates the easy access to the different inputs. The FLC and IFLC are tuned through this GUI by clicking on “tune IFLC” pushbutton. The previously tuned values of controller are retrieved by clicking on ‘get tuned’ pushbutton .the new values can also be saved for future reference by clicking on ‘save’ pushbutton .when all the required parameters are entered by the user; by clicking on ‘start’ pushbutton the performance of the controller can be studied and DC motor speed is controlled at desired set point.

ISSN: 2277-9655
Impact Factor: 1.852

By clicking on 'start' pushbutton, GUI initializes the DIOT card and AD-DA card.GUI acquires the current speed of the DC motor and displays on the GUI. This GUI provides communication between DC motor and PC (hosts the GUI).MATLAB_GUI provides some user defined menu options such as file, analysis and help. Analysis menu option helps in storing the values for further analysis of the performance of the controller i.e.to get hard copy of plot or data .help menu provides help about the GUI.

Matlab Guide

GUIDE, the MATLAB graphical user interface development environment, provides a set of tools for creating graphical user interfaces (GUIs). These tools simplify the process of laying out and programming GUIs [13].

- GUIDE is primarily a set of layout tools
- GUIDE also generates an M-file that contains code to handle the initialization and launching of the GUI.

Design of FLC Controller:

Fuzzy logic controller has been used to provide solutions to control system, which are ill defined; too complex to model etc.FLC is used to compute value of action variables from the observations of state variable of the process under control. A general fuzzy logic controller consists of four models, a fuzzifications model, a fuzzy rule base, a fuzzy interface engine and a defuzzification model. in this study because triangular membership functions are the best suitable for the process parameters and with center of gravity are formed and is as shown in table2.i.e.IF error (e) is PM THEN change in control action (ca) is PL[10]

In present work, the fuzzy logic controller is designed in MATLAB by using fuzzy logic tool kit. This toolbox provides ease of designing FLC as it provides various GUI's.the membership functions of error change in error and control action.

Fuzzy Rule Matrix

The control rules that relate the fuzzy output to the fuzzy inputs which are derived from general knowledge of the system behavior is shown in table 4. Some of the control rules are developed using trial and error method.

Table 4: Rule Matrix Table

e \ Ce	NM	NS	Z	PS	PM
NM	NM	NM	NM	PS	Z
NS	NM	NM	NS	Z	PS
Z	NM	NS	Z	PS	PM
PS	NS	Z	PS	PM	PM
PM	Z	PS	PM	PM	PM

To illustrate the control of motor by the fuzzy rule matrix, 4 valid rules from the rule matrix table are identified for Zero & Positive small of error and change in error

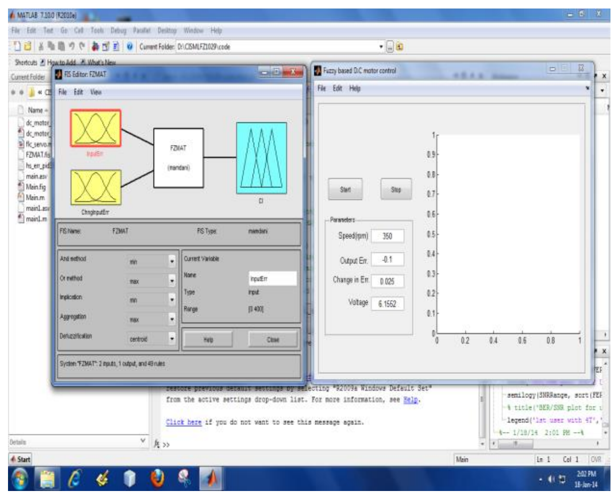


Figure 4: Mamdani fuzzy inference system developed for fuzzy controller

Experimental Results

The performance of PID controller and IFLC is evaluated for the speed control of PMDC motor during different operating conditions. The performance specifications such as settling time, peak over shoot, steady state error, time taken to reach the set speed in the reverse direction and dip in speed when rated load torque applied are shown in Table.3 from the observations of transient and steady state response of the PMBLDC motor for the set speeds of 3500 rpm, 3000 rpm, 2500 rpm, 2000 rpm, 1500 rpm and 1000 rpm for both the PID controller and IFLC. It is found that the steady state error for PID controller is 14 rpm whereas for IFLC, it is only 0.5 rpm which is very less as compared to PID controller.

It is observed that IFLC starting response is good for all the speeds and for most of the speeds overshoot is less. The improved performance of BLDC motor is obtained by minimizing the overshoot present in the transient response and settling time using the IFLC as compared with PID controller by obtaining the step response. The transient deviation of the response from the set reference following variation in load torque is found to be negligibly small along with a desirable reduction in settling time for the IFLC. The response is smooth and no oscillation in the case of IFLC. This is due to robust and accurate control structure of the IFLC. The results show significant improvement in the response of PMBLDC motor with the IFLC.

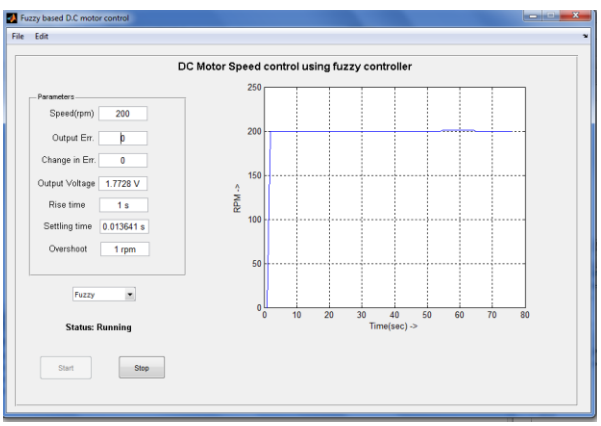


Figure 5:Speed response with Pid Fuzzy Logic Controller (IFLC).

Comparison of PID controller and IFLC controller step response specifications are tabulated in Table III.

Specifications	PID	IFLC
Rise time	0.0028	0.0027
Settling time	0.499	0.55
Steady state error	2	0.3
Peak overshoot	100	100

Conclusion

In this paper IFLC system is designed to control the speed of any DC motor and implemented. The design dramatically reduced the hardware to the least possible and on the other hand made the system software rather a complex one. The software combined the hardware simulation of all types of control (i.e. conventional types of control as well as FC). By using this software, the user can find out the correct values of the control parameters for all control types in the conventional and IFLC. Moreover there is a capability to enhance the system performance by altering the MFs and the Fuzzy rules in order to obtain the optimal result (by monitoring the motor speed response).

The FLC is implemented to evaluate the proposed system, and to display the speed response drawing for all control types used in this paper. In IFLC the corresponding values of all parameters (over shot, settling time, rise time, steady state) are very small in comparison with the parameters of the conventional control. That means the IFC has higher stability, gains optimal performance.

References

[1] *Maiers J. and Sherif Y. S., 1985, Applications of Fuzzy Set Theory, IEEE Trans. Systems, Man, and Cybernetics, Vol. SMC-15, No. 1, pp.175-189.*

[2] *Zadeh L. A., 1973, Outline of a New Approach to the Analysis of Complex Systems and Decision Processes, IEEE Trans. Systems, man, and Cybernetics, Vol. SMC-3, No. 1, pp.28-44.*

[3] *Lee C. C., 1990, Fuzzy logic in control systems: fuzzy logic controller, IEEE Trans. Systems, man, and Cybernetics, Volume: 20 Issue:2, pp. 404 –418.*

[4] *Lee C. C., 1990, Fuzzy logic in control systems: fuzzy logic controller II, IEEE Trans. Systems, man, and Cybernetics, Volume: 20, Issue:2, pp. 419-435.*

[5] *Zadeh L. A., 1965, Fuzzy Sets, Information and Control 8, pp.338- 353.*

[6] *Mamdani E. H. and Assilian S., 1975, An experiment in Linguistic Synthesis With a Fuzzy Logic Controller, Int. J. Man-Machine Studies 7, pp.1-13.*

[7] *Eminoglu I.and Altas I. H., 1996, A Method To Form Fuzzy Logic Control Rules For A*

 ISSN: 2277-9655
Impact Factor: 1.852

pmdc Motor Drive System, Electric Power Systems Research, 39 (1996), pp. 81-87.

[8] Altas I. H, 1998, The Effects of Fuzziness in Fuzzy Logic Controllers, 2nd International Symposium on Intelligent Manufacturing Systems, August 6-7, Sakarya University, Sakarya, Turkey, pp.211-220..

[9] Klawonn F. and Keller A., 1997, Fuzzy lustering and Fuzzy Rules. Proc. 7th Intern. Fuzzy Systems Association World Congress (IFSA'97) Vol. I, Academia, Prague, pp.193-198

[10] [Online]. Available: www.ni.com/.

[11] J.-H. Kim, K.-C. Kim, and E. K. P. Chong, "Fuzzy precompensated PID controllers," LEEE Trans. Contr. Sys. Tech., vol. 2, no. 4, pp. 406-411, 1994.

[12] J. T. Teeter, M. Chow, and J. J. Brickley Jr., "A novel fuzzy friction compensation approach to improve the performance of a DC motor control system," IEEE Trans. Ind. Electron., vol. 43, no. 1, pp. 113-120, 1996.

[13] Y. Tipsuwan and M.Y. Chow "Fuzzy logic microcontroller implementation for DC motor speed control" IEEE Trans. pp. 1271-1276, 1999.