

Design and Implementation of Fuzzy Logic Controllers for DC Motor Speed Control using MATLAB-GUI Application.

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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.

1. INTRODUCTION:

Almost every industry and household has motors used in their equipment or appliances. Motors that are often controlled by computers have also become an essential part of many motion control systems. Major problems in applying a conventional control algorithm in a speed controller are the effects of nonlinearity in a DC motor.

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.

2. 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]

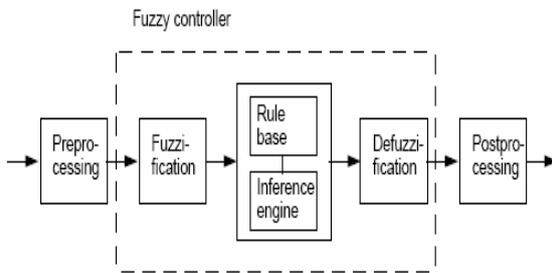
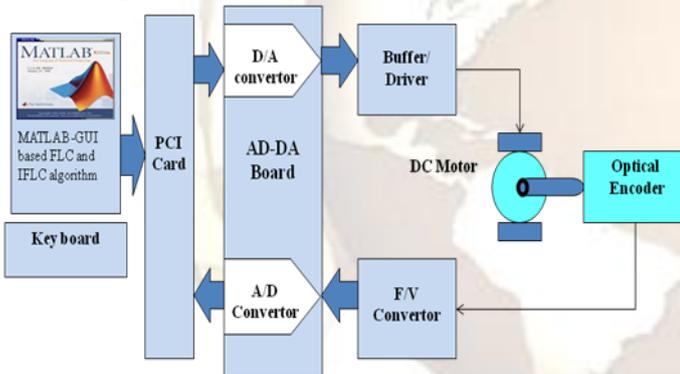


Figure 3: Structure of fuzzy logic controller

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.

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



Block diagram of the proposed hardware system

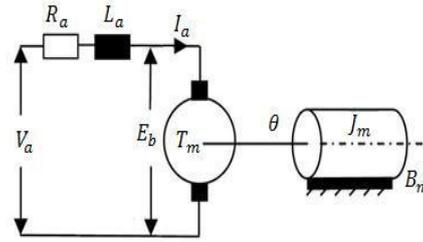
This section deals with hardware development of dc motor control involving fuzzy implementation. It consists of PC interfacing card, power supply unit circuit, control circuit and driver circuit.

In control circuit, the driving pulses required for tachogenerator 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.

3.1 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	10500rpm(Max)
No Load current	0.27A
Commutation	Carbon Brush
Weight	205gms
Torque	83.0gm-cm

3.2 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.

3.3 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,

$$F_{out} = N * \text{rpm} / 60$$

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

$$\text{Rpm} = F_{out} * 60 / N$$

3.4 F/V converter:

The frequency of train of pulses from tachogenerator 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,

$$V_O = V_{CC} * f_{in} * C_1 * R_1 * K, \text{ where } K \text{ is the gain constant.}$$

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

3.5 AD-DA board:

Data acquisition is done through AD-DA board. Standard devices ADC 1674 and DAC 7541 are proposed to be used. In practice, an ADC is usually in form of an integrated circuit (IC). AD1674 ADC and DA 7541DAC are two typical device of 12-bit converter.

3.5 PCI Card:

PCI 1751 card is proposed to be used. This card uses high density small computer system interface for easy and reliable connection to field devices.

The PCI-1751 is a 48-bit digital I/O card based on a PCI bus. Its 48 bits are divided into six 8-bit I/O ports and users can configure each port as input or output via software. The PCI-1751 also provides one event counter and two 16-bit timers, which can be cascaded to become a 32-bit timer.

3.6 Buffer/ Driver:

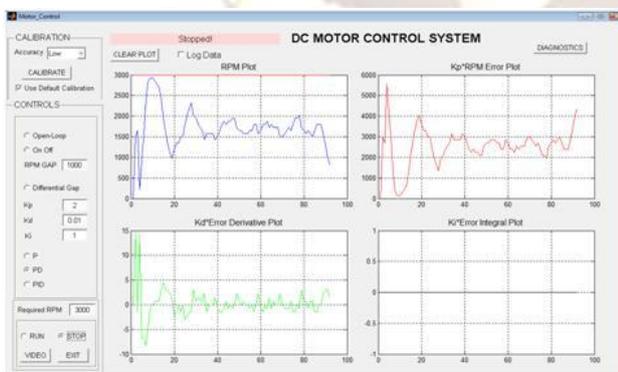
A driver circuits with transistor will be built, to provide enough current to drive the motor.

4. SOFTWARE DETAILS

4.1. Design of MATLAB GUI:

GUIDE, the MATLAB® Graphical User 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 MATLAB 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.

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.

4.2. 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.

3. 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.

5. EXPERIMENTAL RESULTS:



In the present study ,speed of the given Dc motor is controlled at 5000 rpm. from the experimental results it is observed that IFLC gives the better performance over the FLC controller in terms of early rise time and settling time ,less overshoot and undershoot. The values are tabulated as shown in table 3.

The standard square input of 5000-4000 rpm is applied to the FLC and IFLC shows overshoot and undershoot at 4000 rpm and no overshoot and undershoot at 5000 rpm. But IFLC shows neither overshoot nor undershoot for both 5000 rpm and 4000 rpm.

The performance of controllers for step variation is carried out at 1000 rpm up to 5000 rpm. from the experimental results it is concluded 1000 rpm gives considerable overshoot and undershoot but it gives better performance from 2000 rpm onwards.

6. Conclusion

Recent developments in science and technology provide a wide range scope of applications of high performance DC motor drives in area such as rolling mills, chemical process, electric trains, robotic manipulators and the home electric appliances. They require speed controllers to perform tasks. Hence, a fuzzy based DC motor speed control

system was designed using MATLAB-GUI. In this paper, a comprehensive analysis of DC drive system has been performed by using fuzzy logic controller. The model is implemented in MATLAB-GUI environment. From the output speed wave form, we can see that the speed becomes constant at 0.6 sec for an open loop system while it becomes constant at 0.1 sec for a fuzzy PI. Also in Fuzzy PI we have a smooth speed control with less overshoot and no oscillations.

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