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Fuzzy Logic Controller for DC motor using 80C51 microcontroller

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Abstract: This paper mainly focus on speed control of DC motor using Fuzzy logic control (FLC).In FLC the variables are linguistic in nature rather than numeric in the fuzzy set. The FLC making activates by following fuzzy logic rules. Among these linguistic variables. In fact, personal computer the flexible advantage of setting up the speed control by making use of the inbuilt fuzzy packages. The proposed controller system consists of multi-input Fuzzy logic controller (FLC) for Speed control. The system utilizes the FLC and AC to DC converter. The system has the characteristics of precise, fast and effective speed references tracking with minimum overshoot and minimal steady state error. The system consist of Fuzzy speed control loop in which the actual speed is send by IR sensor and the error signal is obtain by comparing with the reference speed. Chang of error (e) and change in error (Ce) are given as input to FLC. The software part aims to design logic speed controller to control the speed of the DC motor using MATLAB/Simulink. The present work also verified in real time thorough 80C51 microcontroller.

Keywords: DC motor, fuzzy logic controller, micro controller, regulated power supply, Simulink/Matlab.

I. INTRODUCTION

The development of high performance applications is very important in industrial as well as other applications. The DC motors are used in various applications such as defence, industries, Robotics etc. DC drives, because of its simplicity, ease of application, reliability and favourable cost. Which are the major facts and seems to be the back bone for industrial appilications. DC drives are less complex with a single power conversion from AC to DC. The DC drives are normally less expensive for most horsepower ratings. DC motors have a long tradition of use as adjustable speed machines and a wide range of options have evolved for this purpose. In these applications, the motor should be precisely controlled to give the desired performance. Many varieties of control schemes such as proportional (P), proportional integral (PI), proportional derivative integral (PID), adaptive and fuzzy logic controller (FLCs) have been developed for speed control of DC motors. The proposed controller system consists of multi-input fuzzy logic controller (FLC) for the speed control. The proposed system utilizes the fuzzy logic controller and AC to DC converter. The drive system has the characteristics of precise, fast and effective speed references tracking with minimum overshoot and minimal steady state error.
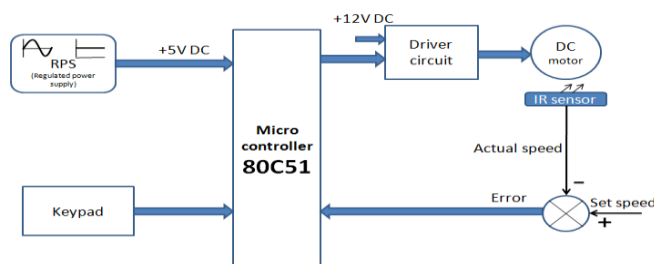

Fig.1 Block diagram of fuzzy speed control of DC motor using micro controller

The fuzzy logic speed command profile is followed even under load torque disturbances. The proposed system shown in Figure 1 consists of AC-DC converter to drive the DC motor. The IR sensor is used to sense the speed and to be used for speed feedback. A microcontroller is used to generate the PWM signal to switch the converter, during the implementation.

The system consists of fuzzy speed control loop in which the actual speed is sensed by IR sensor and the error signal is obtained by comparing with the reference speed. Change of error is calculated by considering the present and previous error in the proposed system two input fuzzy controller is used. The error (e) and change in error (ce) are given as inputs to the fuzzy controller. The output of fuzzy controller is denoted as duty cycle. The change in duty cycle for the converter can be calculated from the new duty cycle and previous duty cycle. The input and output gain of the fuzzy controller can be estimated by simulation. The fuzzy controller can reduce the error to zero by changing the duty cycle of the switching signal.

II. MATHEMATICAL MODELLING OF DC MOTORS

The simulation of the entire setup can be done using following DC motor Modelling equations.

Torque equation of DC motor is

$$\varphi_m = K_f\, I_f \tag{1}$$

$$T = K'_m\, \varphi\, I_a \tag{2}$$

$$T = K'_m\, K_f\, I_f I_a \tag{3}$$

Speed equation of DC motor is

$$\omega_m = \frac{d\theta(t)}{dt} \tag{4}$$

$$e_a = E_b \overset{hu}{+} I_a(R_a) + L_a \frac{di_a}{dt} \tag{5}$$

Applying Laplace transform and solving

$$\frac{\theta_m(s)}{E_a(s)} = \frac{G(s)}{1+G(s)H(s)} \tag{6}$$

Where

$$\tau_a = \frac{L_a}{R_a} \tag{7}$$

$$K_m = K'_m\, K_f \tag{8}$$

$$G(S) = \frac{K_m}{sR_aB_m(1+s\tau_m)(1+s\tau_a)} \tag{9}$$

$$H(s) = s\, K_b \tag{10}$$

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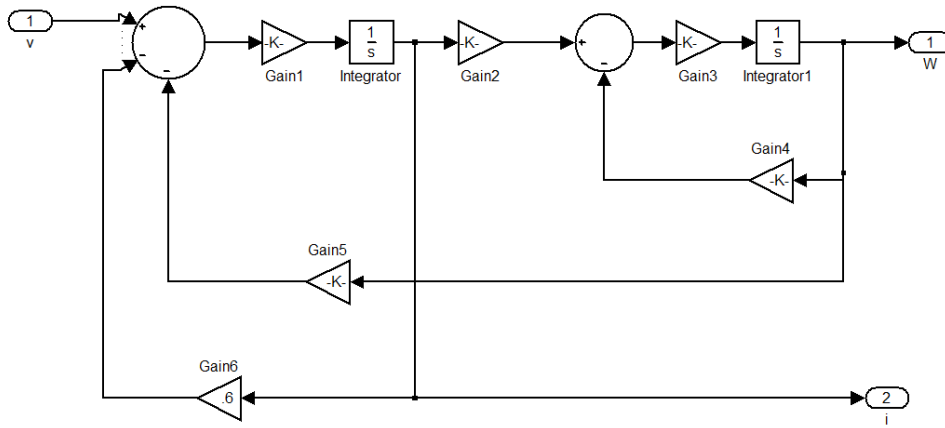*Volume 2, Issue 1, January 2014 pg. 578-584*

Fig.2 modeling of DC motor

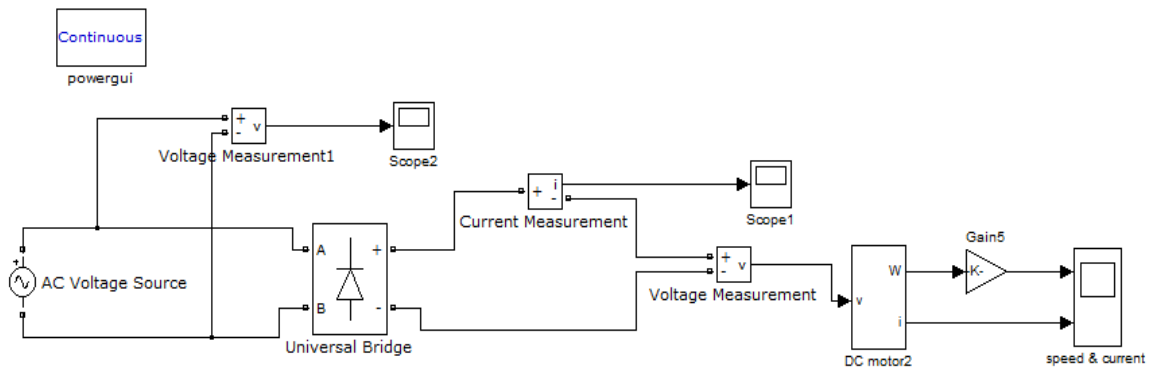### III. SIMULATION OF OPENLOOP AND CLOSEDLOOP CONTROL OF DC MOTOR

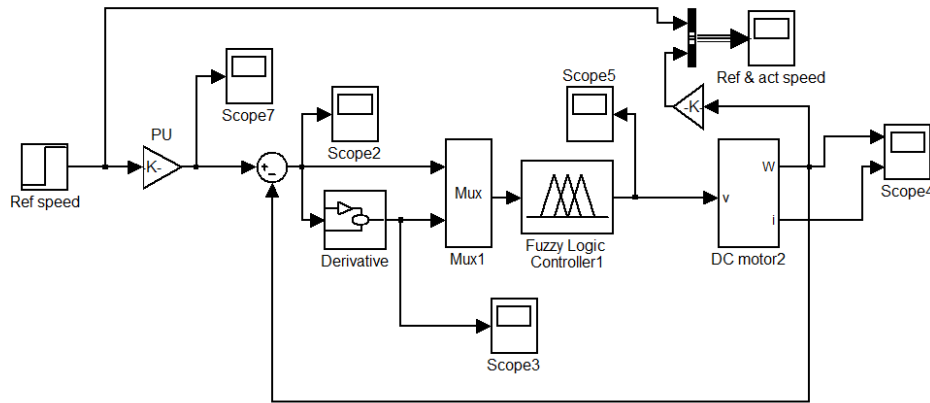Fig.3 Simulation of open loop speed control of DC motor

Fig.4 Simulation of closed loop speed control of DC motor

 Fig.3 shows the Matlab model of simulation of open loop control of DC motor. Output of universal bridge rectifier is connected to DC motor. Fig.4 shows the simulation of closed loop speed control of DC motor. Actual speed of the DC motor is compared with the set speed or reference speed to generate the error. The error and change in errors are given as inputs to the Fuzzy logic controller. Output of the Fuzzy logic controller is given as input to the DC motor.

IV. FUZZY RULE BASE FOR SPEED CONTROL OF DC MOTOR

Design of fuzzy controller

The goal of designed FLC in this study is to minimize speed error. The bigger speed error the bigger controller input is expected. In addition, the change of error plays an important role to define controller input. Consequently, three linguistic variables are used for FLC:

1. Error (e) = reference-actual speed

2. Change of error (cherror) = de/dt

1. IF (Error is PM) THEN (Control is PM)

2. IF (Error is NM) THEN (Control is NM)

3. IF (Error is Z) AND (CE is N) THEN (Control is NS).

4. IF (Error is Z) AND (CE is P) THEN (Control is PS)

5. IF (Error is NS) THEN (Control is NS)

6. IF (Error is PS) THEN (Control is PS)
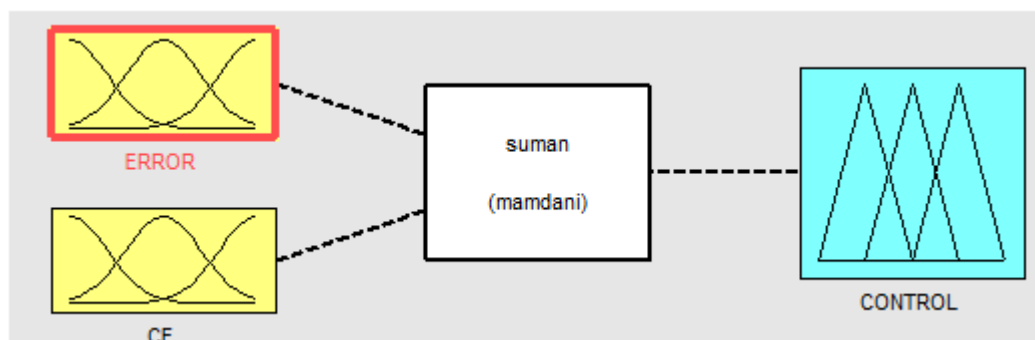
7. IF (Error is Z) THEN (Control is Z)

Fig.5 Mamdani Fuzzy Inference system Developed For Fuzzy Controller
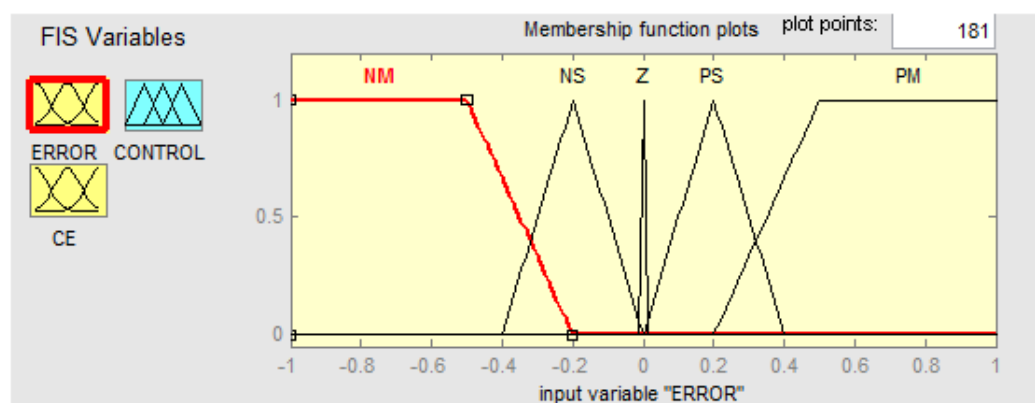

Fig.6 Membership for Input (error)

Error input variable has five membership functions i.e. Negative medium (NM), Negative small (NS), Zero (Z), Positive small (PS), Positive medium (PM).
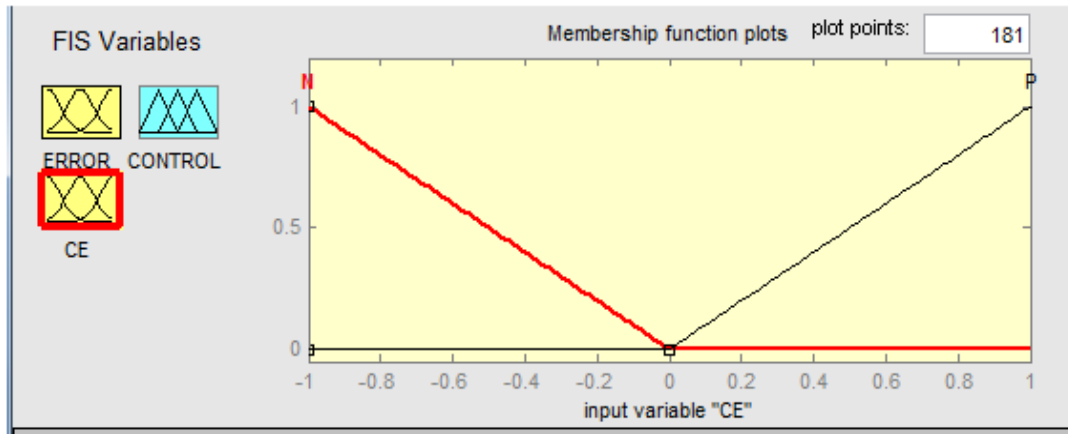
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Fig.7 Membership Function for Input (Change of error)

Change of error input variable has two membership functions i.e. Negative (N), Positive (P).

V. Hardware Implementation

Implementation of Speed Control of DC Motor using Fuzzy Logic

The 230V AC supply is stepped down to 12V AC using a step down transformer. The output of the transformer is given to the uncontrolled bridge rectifier which converts given AC supply to pulsating DC. The ripples in the pulsating DC can be eliminated with the help of filters (here capacitors are used) to obtain pure DC. This obtain DC output may vary due to load fluctuations.

In order to protect the circuit from these fluctuations, the voltage needs to be maintained constant for which voltage regulator is placed at the output of filter. 7812 voltage regulator maintains a constant voltage of 12V DC, which is necessary for the operation of driver (L293D) used in the project. The micro controller used in the project requires 5V DC. Hence the output of 7812V regulator is stepped down to 5V DC using 7805 voltage regulator. Speed is sensed through the infrared sensor (IR) and compared with the set speed to generate the error. The error is given to the micro controller.
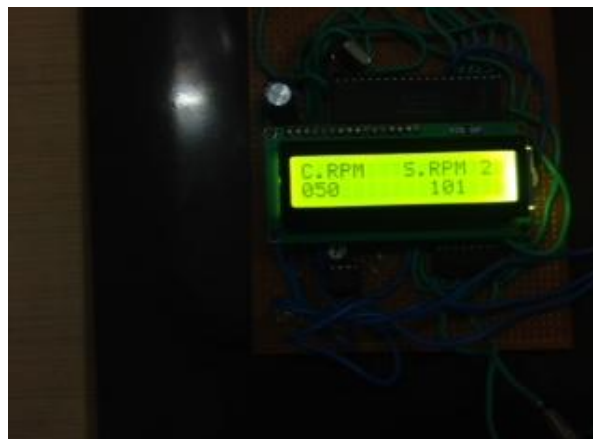

Fig.8 Display for setting set speed

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Fig.9 (a) Output of the driver circuit (12v)   9(b) Hardware set up
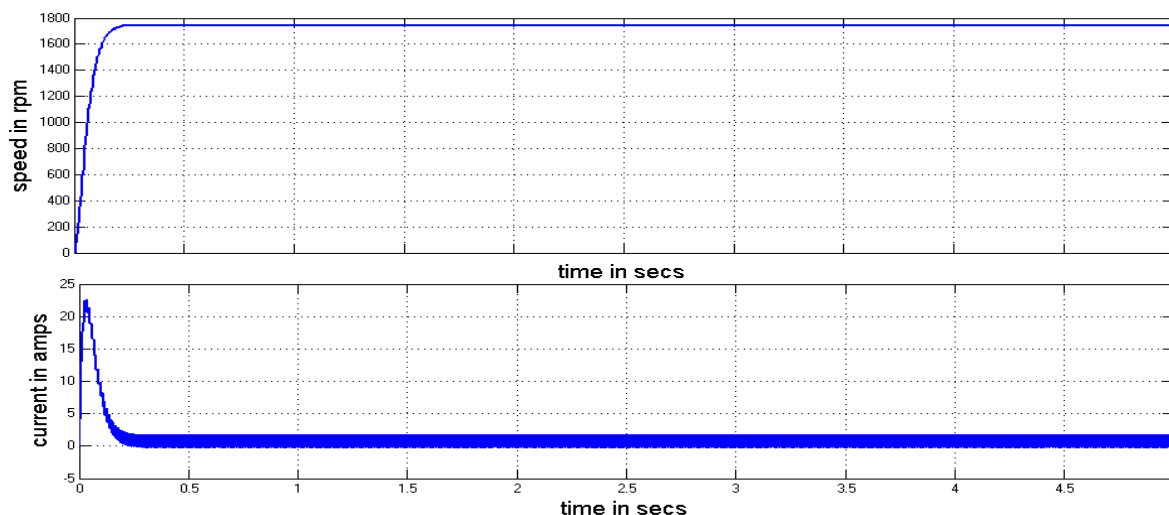
VI. SIMULATION AND HARDWARE RESULTS

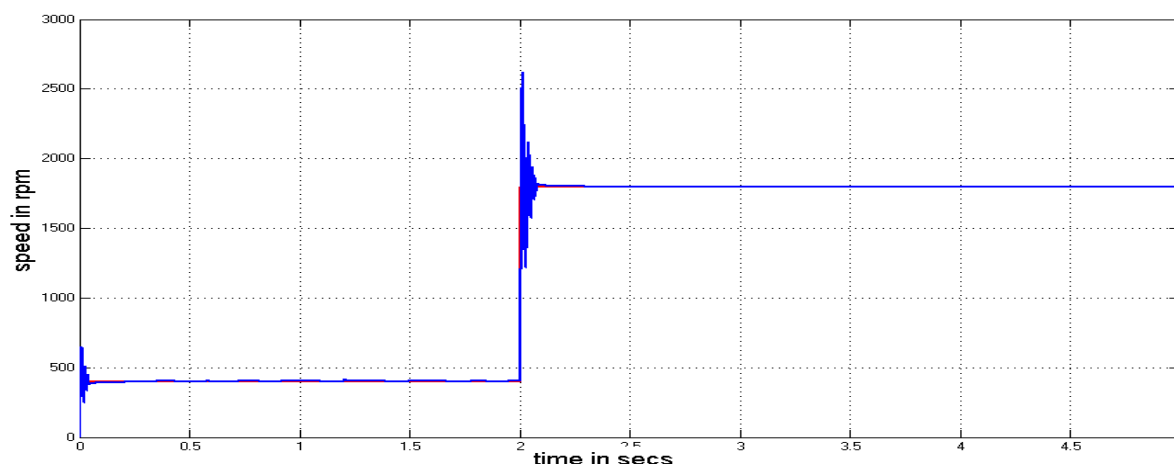Fig.10 Open loop results of DC motor a) speed b) current

Fig.11 Simulation result of Speed control of DC motor using fuzzy controller with step input

VII. MOTOR PARAMETERS

Parameters of DC motor for simulation

Motor rating	=	3HP
DC supply voltage	=	220V
Motor rated current	=	4.3A
Armature resistance R_a	=	0.6
Armature inductance L_a	=	0.008H
Inertia constant J	=	$0.011 Nm^2$
Damping constant B	=	0.004 Nm /rad /s
Torque constant parameter K_t	=	0.556
Back emf constant K_b	=	0.556
Speed	=	1800 rpm

VIII. 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 PIC microcontroller. It is a closed loop real time control system, which maintains the desired speed even when there is a variation of load. In this paper, a comprehensive analysis of DC drive system has been performed by using fuzzy logic controller. The simulation model is implemented in MATLAB/Simulink environment. From the output speed wave form, we can see that the

speed becomes constant at 0.2 sec for an open loop system while it becomes constant at 0.1 sec for a fuzzy. Also in Fuzzy we have a smooth speed control with less overshoot and no oscillations. In the hardware part, the fuzzy logic control algorithm was developed using C, a high level programming language for programming a microcontroller.

Acknowledgement

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4. SIMULATION STUDIES ON HYBRID FUZZY-PI CONTROLLERS FOR DC MOTOR CONTROL,major.pdf

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