COMPARSION BETWEEN NOMINAL AND FUZZY LOGIC CONTROL IN SPEED CONTROL OF D.C. MACHINE

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ABSTRACT

The project presents an insight into the speed control of D.C motor using a fuzzy logic controller to meet the desired speed. Fuzzy logic is one of the most successful applications of fuzzy set in which the variables are linguistic rather than numeric. A fuzzy logic controller (FLC) is based on a set of control rules (fuzzy rules) among linguistic variables. The personal computer provides the necessary flexibility in setting any speed profile with the use of fuzzy packages. The proposed fuzzy controller results in a better response compared to the normal response of D.C motor. The step response parameters can be closely controlled with the help of simple operations within the controller. The simulation of nominal and FLC control model is carried out and the simulation results present the flexibility of the motor speed control.

We have to design the separately excited dc motor system and to run the motor at rated speed and also control the armature current.

Keywords—fuzzy logic controller (FLC), Fuzzification, De- fuzzification

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I. INTRODUCTION

In recent years, Fuzzy logic met a growing interest in many motor control applications due to its non-linearities handling features and with a very wide range of operation. The fuzzy controller (FLC) operates in a knowledge-based way, and its knowledge relies on a set of linguistic if-then rules, like a human operator.

The wonderful world of fuzzy logic is a powerful new paradigm, helping us to analyze unknown and complicated systems. The importance of fuzzy logic various methods have been reported, that includes linear regression, exponential smoothing, stochastic process, ARMA models, etc.

Fuzzy logic controller also makes good performance in terms of stability, precision, reliability and rapidity achievable.

The advantages provided by a FLC are listed below:

- It is simple to design.
- It provides a hint of human intelligence to the controller.
- It is cost effective.

Disadvantages of the fuzzy logic controllers are the lack of systematic, effective and useful design methods.

The present work consists of the development and simulation of a controller for a closed loop speed control where the manipulated variable is the firing angle.

Speed of the DC motor is controlled by controlling the armature voltage. Armature voltage is controlled using different single phase AC/DC converter. Half converter, semi converter, full converter and dual converter are some of the thyristor based circuits which are used for speed control of DC motor. This paper studies Fuzzy Logic speed control technique of DC motor and makes a comparative study with Nominal Model (without controller).

II. MODELS USED

1. NOMINAL MODEL

The simulation model of the complete nominal system means system is an open loop system; no control strategy is applied on the motor. The system SIMULINK model is shown in figure5.

In this model armature voltage control strategy is followed, the voltage across the armature is varied by varying the firing angle. The following are the parameters of nominal model.

D.C. motor

D.C. motor input voltage = 150

Armature resistance and inductance [R_a (ohms) L_a (H)]: [0.5 0.01]

Field resistance and inductance [R_f (ohms) L_f (H)]: [84.91 13.39]

Field-armature mutual inductance L_{af} (H): 0.7096

Total inertia J (kg.m^2): 0.05

Viscous friction coefficient Bm (N.m.s): 0.02

Coulomb friction torque T_f (N.m): 1

Converter specifications:

Supplied voltage = 230 V, 3 – phase A.C.

Frequency = 50 Hz

Synchronised 6 pulse generator

Frequency of synchronisation voltages (Hz): 50

Pulse width (degrees): 10

Thyristor Convertor

Number of bridge arms: 3

Snubber resistance Rs (Ohms):50

Snubber capacitance Cs (F):1e-7

Ron (Ohms):1e-3

Lon (H):0

Forward voltage Vf (V): 0.8

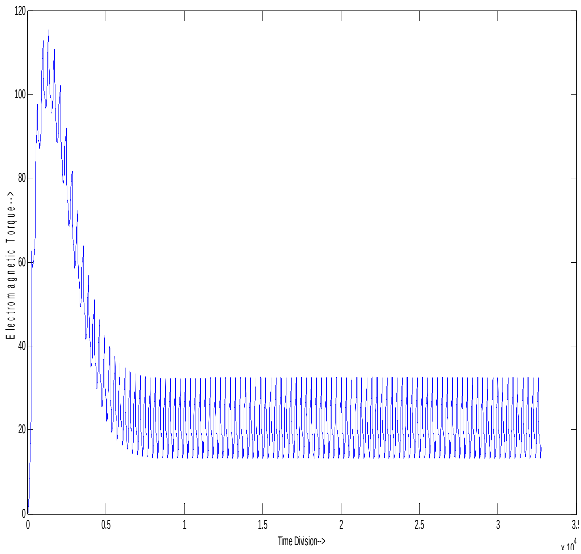


Fig 1: Electromagnetic Torque with nominal model

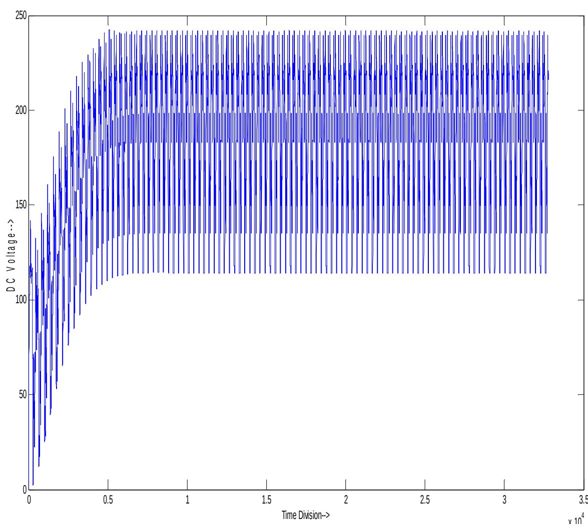


Fig 2: Response of DC voltage with nominal model

2. FUZZY LOGIC MODEL

In the last few years, fuzzy logic has met a growing interest in many motor control applications due to its non-linearities handling features and independence of the plant modeling. The fuzzy controller (FLC) operates in a knowledge-based way, and its knowledge relies on a set of linguistic if-then rules, like a human operator.

This paper makes use of simplified fuzzy inference in which the consequence of the fuzzy rule is expressed in crisp number. We can add new membership functions as per our convenience in fuzzy approach. To make a more accurate fuzzy expert system, regions are divided into intervals.

The interval for error (input 1) has been divided into seven triangular membership functions which are as follows:

- Large Negative(LN)
- Negative(N)
- Negative Zero(NZ)
- Zero(Z)
- Positive Zero(PZ)
- Positive(P)
- Large Positive(LP))

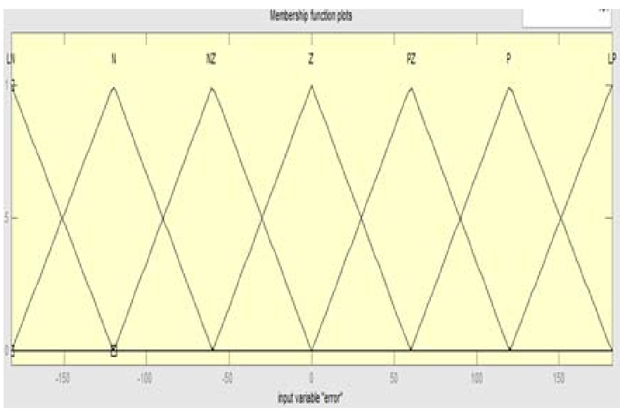


Fig 3: Triangular membership functions of error

The interval for firing angle (input 2) has been divided into seven triangular membership functions which are as follows:

- Large Negative(LN)
- Negative(N)
- Negative Zero(NZ)
- Zero(Z)
- Positive Zero(PZ)
- Positive(P)

- Large Positive(LP)

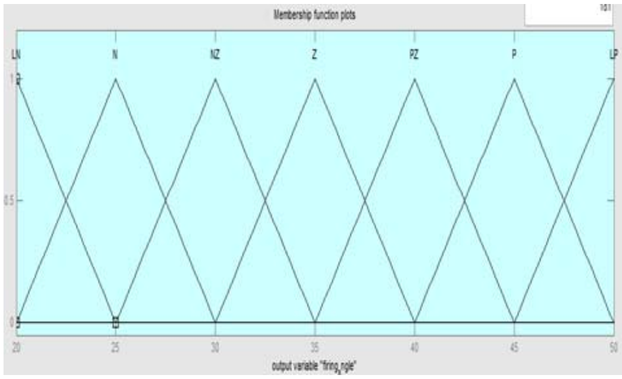


Fig 4: Triangular membership functions of firing angle

In the fuzzy logic approach, the calculations are based on the entire profile of the membership functions rather than based on the point values. This approach is much closer to people decision making process in real life.

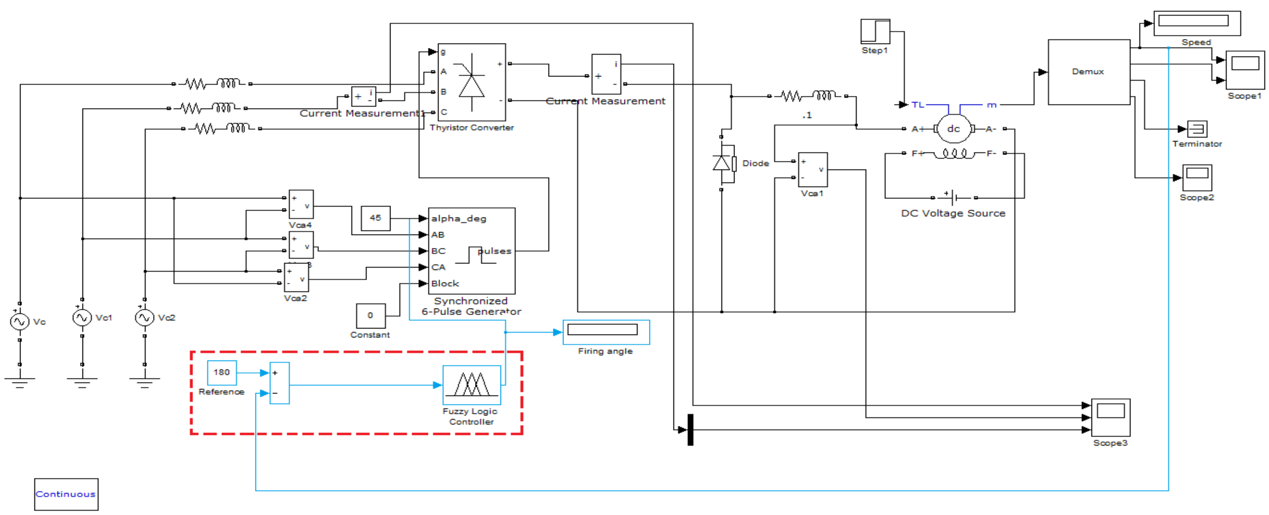
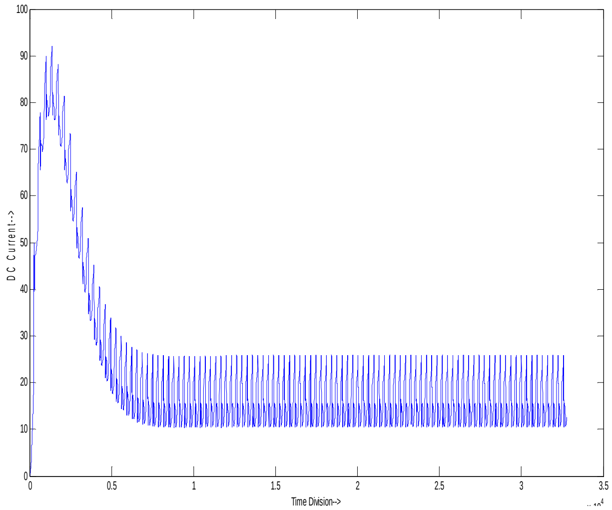


Fig 5:



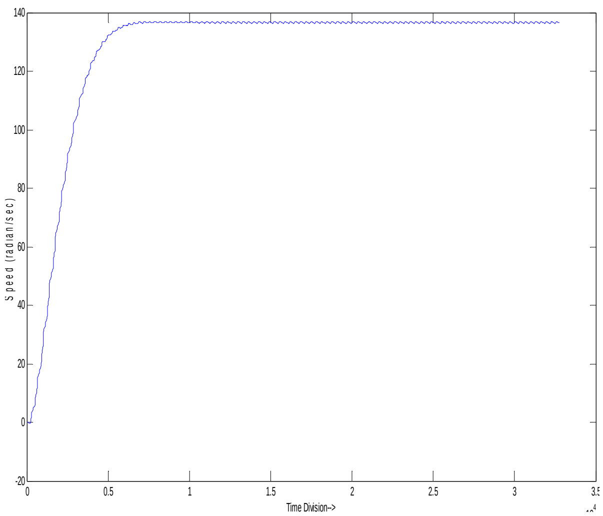
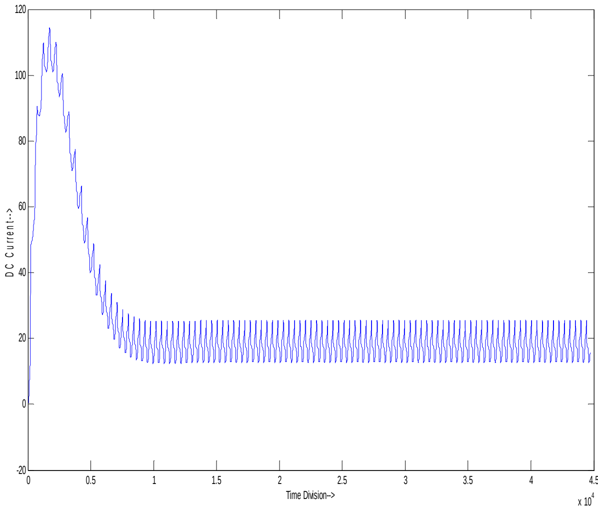


Fig 6(a): Armature current with nominal model

Fig 6(b): Motor speed with nominal model



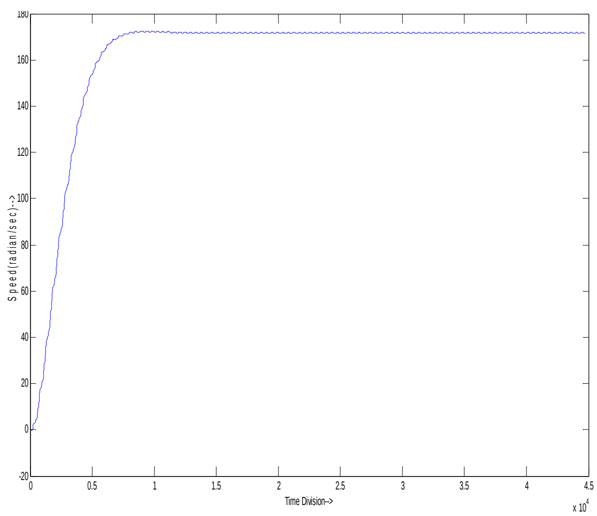


Fig7(a): Armature current with fuzzy model Fig7(b):Motor speed with fuzzy model

III. DEFUZZIFICATION

Defuzzification means the fuzzy to crisp conversions. The fuzzy results generated cannot be used as such to the applications, hence it is necessary to convert the fuzzy quantities into crisp quantities for further processing. This can be achieved by using defuzzification process [2, 6].

Defuzzification can also be called as "rounding off" method. Defuzzification reduces the collection of membership function values in to a single sealer quantity.

There are seven methods used for defuzzifying the fuzzy output functions.

They are:

(1) Max-membership principle,

(2) Centroid method,

(3) Weighted average method,

(4) Mean–max membership,

(5) Centre of sums,

(6) Centre of largest area, and

(7) First of maxima or last of maxima

In this paper we have used the 'CENTROID Method' for defuzzification. This is the most widely used method. This can be called as centre of gravity or centre of area method.

It can be defined by the algebraic expression:

$$z^{*}= \{ \int \mu_{c}(z).z\,dz\}/\{ \int \mu_{c}(z)dz\}$$

$\int$ is used for algebraic integration.

IV. RESULT

After running the two models viz. Nominal model and Fuzzy logic model successfully on Simulink the following results were obtained:

PARAMETERS	NOMINAL	FUZZY
Firing Angle	45^{o}	Output of Fuzzy Controller
Motor Speed	137 radian/sec	175 radian/sec
Settling Time	0.9 sec	0.25 sec

V. CONCLUSION

Two separate models were developed for determining the response of DC motor. The result of nominal model shows oscillation in response of motor armature current and speed response of motor with less speed of motor**.**

On the contrary the precision of the fuzzy logic model was found to be adequate enough to discriminate between the two models used. It is concluded that the oscillations in current response is die out and speed response becomes smoother as compared to nominal model. Also, the settling time is reduced to 0.25 sec.

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