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TO CONTROL THE CHARACTERISTICS OF AC MOTOR USING FUZZY LOGIC CONTROLLER

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ABSTRACT

This paper presents a hybrid Fuzzy Logic Controller (FLC) with vector-control method for induction motors. The vector-control method has been improved by using FLC instead of a simple PD controller. In this hybrid controller high quality regulation is achieved through utilization of the FLC, while stability of the system during transient and around wide range of operating points are assured through application of the vector-control. The hybrid controller has been validated by applying it to a nonlinear model of the motor.

Keywords: Fuzzy Logic, Vector-Control, Speed Control, Torque Control, Induction Motor

I INTRODUCTION

The induction motor is an important class of electric machines which finds wide applicability in industry and in its single phase form in several domestic applications. More than 85% of industrial motors in use today are in fact induction motors that is basically a constant speed motor with a shunt characteristic [1,2]. Various methods have been developed for this purpose including direct torque control, PD/vector control, etc. But due to their peculiar limitations none of them has been found failure-proof [3,4]. Here speed of induction motor is successfully controlled over a wide range of operating points with improved accuracy using Fuzzy Logic Controller (FLC) as a block of vector-control method. In the last few years, fuzzy logic has attracted a growing interest in many motor control applications due to its abilities to handle non-linearity’s and its independency of the plant's model. The FLC operates in a knowledge-based manner, and its knowledge relies on a set of linguistic if-then rules, similar to a human operator. This paper will focus on a hybrid FLC based vector-control and study its effect on the performance of the overall controller.

II DESIGN OF THE FLC

In recent years, Fuzzy Logic Control (FLC) techniques have also been applied to the control of motor drives. The mathematical tool for the FLC is the fuzzy set theory introduced by Dr. Zadeh. In FLC, the linguistic description of human expertise in controlling a process is represented as fuzzy rules or relations. This knowledge base is used by an inference mechanism, in conjunction with some knowledge of the states of the process (say, of measured response variables) in order to determine control actions [5]. The main advantages of FLC are: (a) There is no need for an exact mathematical model of the system, (b) It can handle nonlinearities of arbitrary complexity, and (c) It is based on linguistic rules with an IF-THEN general structure, which is the basis of human logic. However, standard FLC can not react to changes in operating conditions. The FLCs need more information to compensate nonlinearities when the operation conditions change. When the number of the fuzzy logic inputs is increased, the dimension of the rule based increases as well, thus, maintenance of the rule base becomes more time-consuming. Another disadvantage of the FLCs is the lack of systematic, effective and useful design methods and adequate analysis, which can use a priori knowledge of the plant dynamics. Moreover, the application of FLC has faced some disadvantages during hardware and software implementation due to its high-computational burden.

III ARCHITECTURE

The controller architecture includes some rules which describe the casual relationship between the two normalized input voltages and an output.

These are: -Error (e), that is the rotor angular velocity error, -Change-of-error (e Δ), that is the derivative ofe, and –Output rotor angular velocity (ω Δ). These error inputs are processed by linguistic variables, which require to be defined by membership functions. The FLC includes four major blocks: a fuzzification block, a Rule Base, an inference mechanism, and the last step is defuzzification [6].

IV PROPOSED KNOWLEDGE BASE

Fig.1 and Fig.2 shows the triangular-shaped membership functions of error (e) and change-of-error (e Δ). The fuzzy sets are designated by the labels: NL (negative large), NM (negative medium), NS (negative small), ZE (zero), PS (positive small), PM (positive medium), PL (positive large)

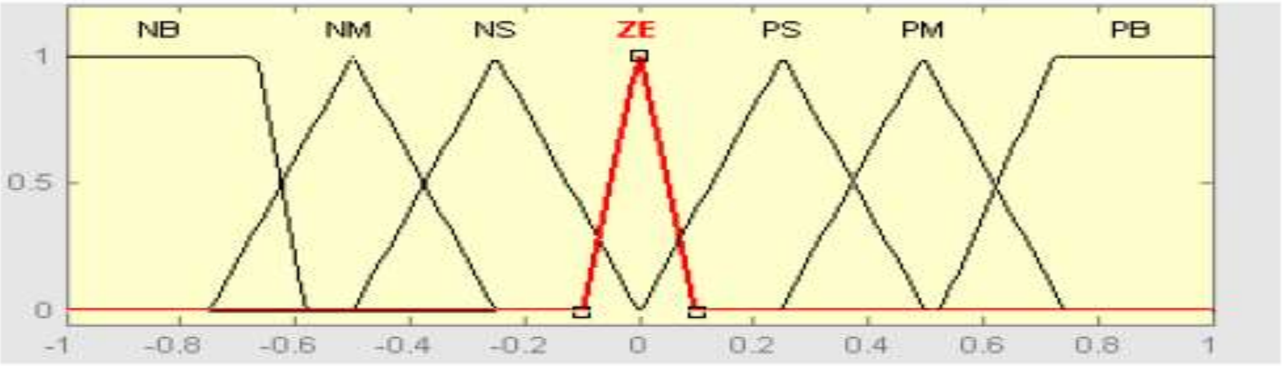


Fig.1 Input Error(e)

Fig.3 show the proposed member-ship functions for output variable and the control rules. The inference strategy used in this system is the Mamdani algorithm, and the center -of-area/gravity method is used as the defuzzification method.

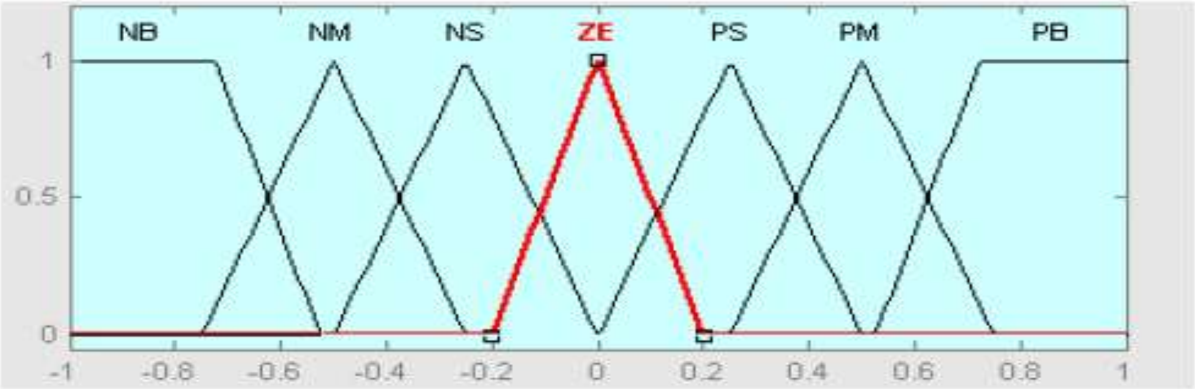
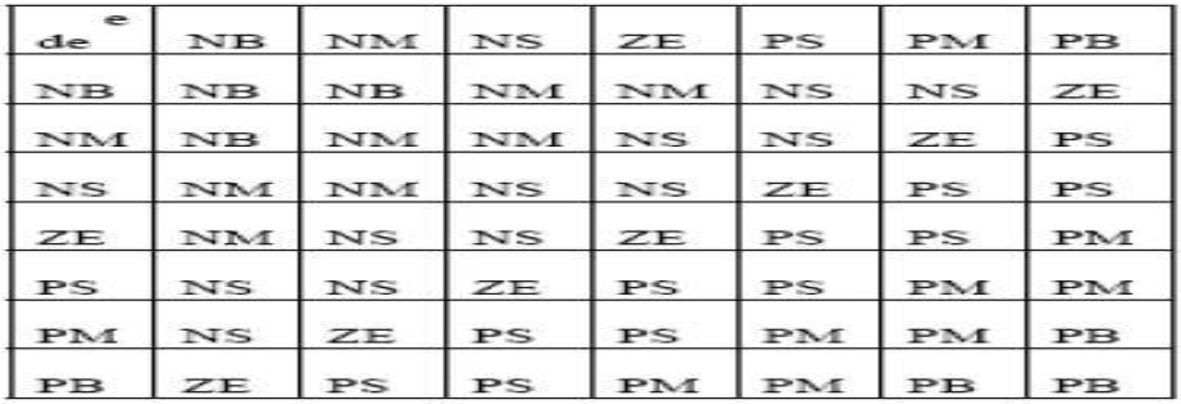


Fig.2 Input Error (De)

According to the equation giving a PD-like fuzzy knowledge based controller (FKBC) is



e de	NB	NM	NS	ZE	PS	PM	PB
NB	NB	NB	NM	NM	NS	NS	ZE
NM	NB	NM	NM	NS	NS	ZE	PS
NS	NM	NM	NS	NS	ZE	PS	PS
ZE	NM	NS	NS	ZE	PS	PS	PM
PS	NS	NS	ZE	PS	PS	PM	PM
PM	NS	ZE	PS	PS	PM	PM	PB
PB	ZE	PS	PS	PM	PM	PB	PB

Fig.3 Rule base

The fuzzy if-then statements are symbolically expressed with the form If e is (e) and e Δ is (de) then ω Δ is (e+de) The command signal is obtained from fourty-nine rules witch all have the same weight. To tune the FLC, it is possible to change the two values pk and D k . Fig.4 shows the control surface of our FLC. The surface can take any shape based on our design of membership functions and rules that eventually this nonlinear surface can cope with nonlinearities of the system.

V SIMULATION RESULTS

The response of the controller will be investigated with the Matlab/Simulink simulation program, the FLC, and Sim Power Systems (SPS) tool-boxes. The induction motor is fed by a current-controlled IGBT inverter which is built using a Universal Bridge block as presented in Fig.5.

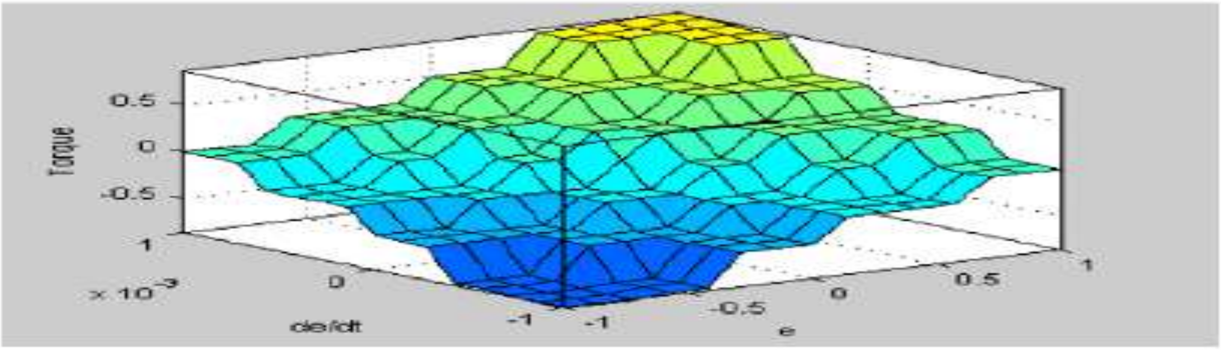


Fig 4 Rule Base Surface

Several tests were performed to evaluate the performance of the proposed FLC based vector- control of the IM drive system in MATLAB/SIMULINK. The speed-control loop of the drive was also designed and simulated with the PD controller in order to compare the performances to those obtained from the respective FLC based vector-control. The speed responses are observed under different operating conditions such as a sudden change in command speed, step change in load etc. some sample results are presented in following section [7].

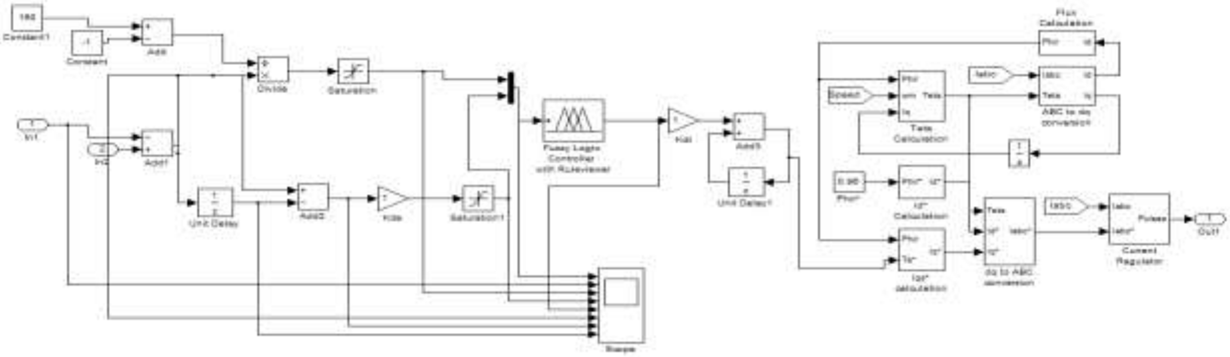


Fig.5 Fuzzy Logic Controller

In this work, we proposed a hybrid FLC based vector-control in order to overcome the disadvantages of PI in vector-control.Fig.5 shows a circuit diagram for this hybrid controller. Furthermore, compared with the experimental results of the PD with fixed parameters control system shown in Fig.6,Fig.7 and Fig.8 the responses are improved using the proposed FLC based vector-control.

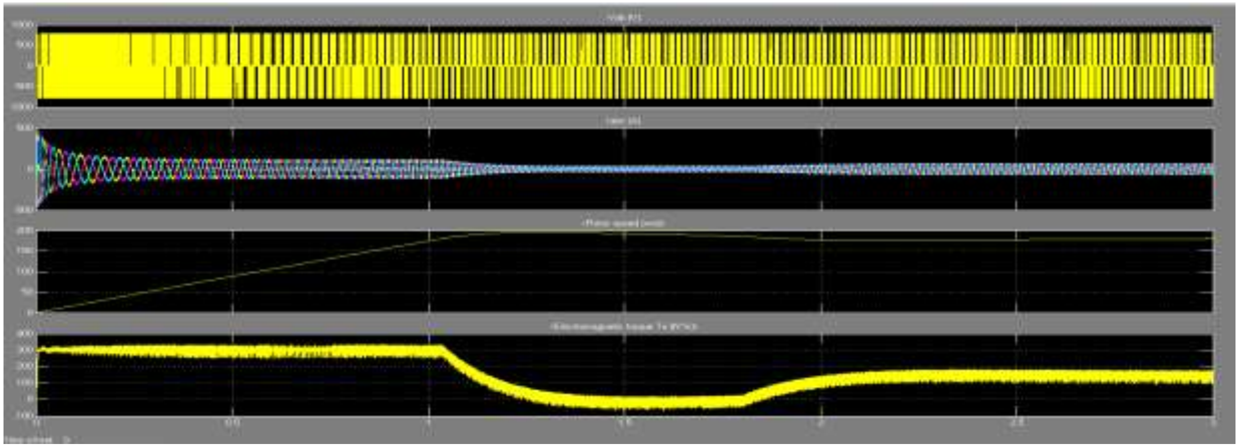


Fig.6 Result Iab, Vabc, Speed, Torque

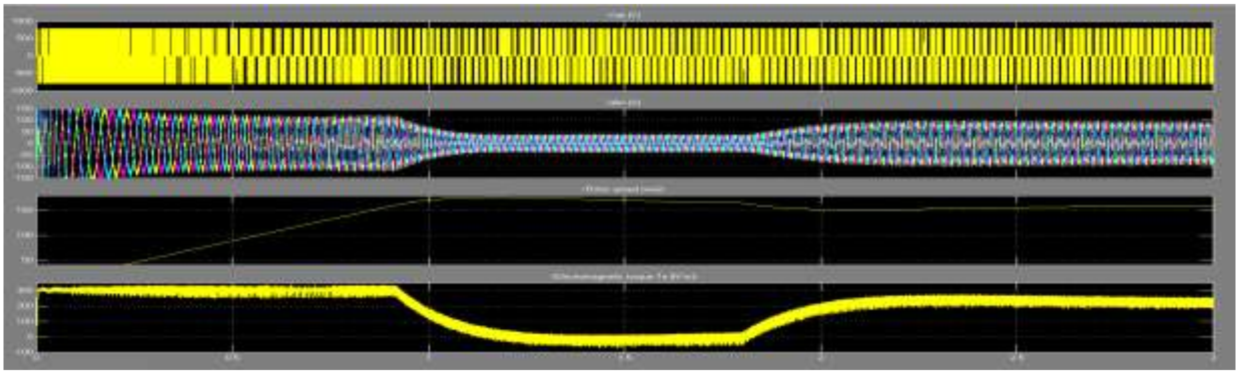


Fig.7 Result Iab, Vabc, Speed, Torque

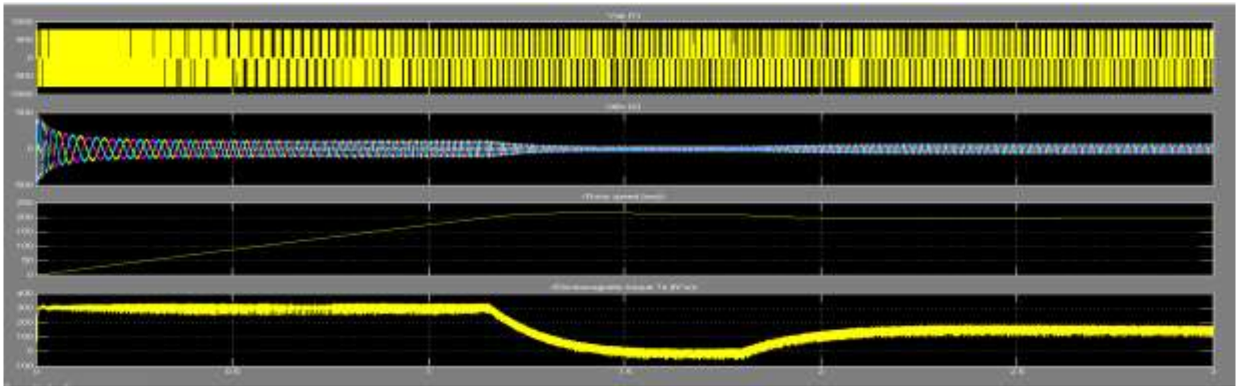


Fig.8 Result Iab,Vabc,speed,Torque

The motor speed follows its reference with zero steady-state error. On the other hand, the PD/vector-control shows steady-state error with a high starting current. It is to be noted that the speed response is affected by the load conditions. This is the drawback of a PD/vector-control with varying operating conditions. The FLC based vector-control gives better responses in terms of over-shoot, steady-state error, and fast response. These results also show that the FLC based Vector-control can handle the sudden increase in command speed quickly without overshoot, under-shoot, and steady-state error, whereas the PD/ vector-control has steady-state error, Thus, the proposed FLC-based drive has found superior to the conventional PD/vector-control.

VI CONCLUSION

The results section show that the performance of FLC based vector-control is superior to that with PD/vector-control. Thus, by using FLC the transient and steady state response of the induction motor has been improved noticeably. The robustness of the response is evident from the results. Since exact system parameters are not required in the implementation of the proposed controller, the performance of the drive system could be claimed to be robust, stable, and insensitive to parameters and operating condition variations. The performance has been investigated at different dynamic operating conditions. It is there for concluded that the proposed FLC based vector-control has shown better performance over the PD/vector-control.

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