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FUZZY SELFTUNING SYSTEM FOR INDUCTION MOTOR CONTROLLERS

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Abstract: Conventional fuzzy controllers have been recently proposed to implement vector control methods in induction motors. One of the most interesting problems in making fuzzy control a reality, is designing and adjusting the control rules. In this paper a new fuzzy–logic based method for the automatic tuning of the controller parameters is proposed. It changes the scaling factors of the inputs of the main fuzzy controller to achieve a good transient response. This system can be used not only for the initial tuning of the controller parameters, but during the on–line process as well. In this way, it can cope with changes in the plant parameters and load disturbances.

Keywords: Induction Motor, Fuzzy Control.

I. INTRODUCTION

The induction motor is a complex, non–linear system, with time–varying parameters. Different control strategies have been proposed to simplify the control of induction motors, such as Vector Control methods. Unfortunately, a set of time–varying parameters, such as inertia, torque and rotor resistance, can severely affect the dynamic performances, so that some kind of robustness or adaptativity is required [2].

Many applications of adaptive systems to the control of induction motors can be found in the literature [3]–[8]. Most of them are based on the Rotor time constant T_r estimation. With a proper estimation of these parameters, the Induction Motor can be considered to behave as a D.C motor.

Another kind of problems which appear in Vector Control of Induction Motors are due to the inadequate rejection of external disturbances and load variations. To face these problems adaptive systems with variable–structure control approach, such as sliding–mode control and fuzzy logic, have been successfully applied for controlling electric drive systems ([9]–[15]).

In a recent paper [14], we proposed a robust speed control of induction motors based on Fuzzy reasoning. The inherent non–linear characteristic of the fuzzy controllers make them to behave similary to an adaptive linear controller. This paper presents a method for the automatic tuning of the parameters of the fuzzy controller. The proposed method performs iteratively until an acceptable value of the motor time response is achieved. Note that no information about the motor characteristics are required.

Although this method is mainly intended for the initial tuning of the controller, it can be used on–line in those cases where the induction motor is continously in an start–up process, e.g., in elevators.

II. A FUZZY EXPERT SYSTEM FOR AUTOMATIC TUNING

Figure 1 depicts the block diagram of the fuzzy control proposed in [14]. In this figure, the Indirect Vector Control method (IVC) is used, which is described elsewhere [1]. The flux component of the stator current i_d^e is maintained constant, while the output of the fuzzy controller is the desired torque component of the stator current i_q^e. The error between the desired speed w_{ref} and the measured rotor speed w_r and the error integral, are the input to the proportional-integral fuzzy controller. The control action is obtained by means of the rules and membership functions depicted in figure 2. The upper part of figure 1 shows the fuzzy expert system which is the objective of this paper. The expert system is able to automatically tune the parameters of the main fuzzy controller. Different schemes for tuning can be devised [10], [12]. In our case, the system adaptation is carried–out by altering the scaling factors of the input variables of the main fuzzy system. A change in the scaling factor of the error (integral) input, produces an effect on the system response, which is similar to a change in the proportional (integral) constant of a PI–type contro-

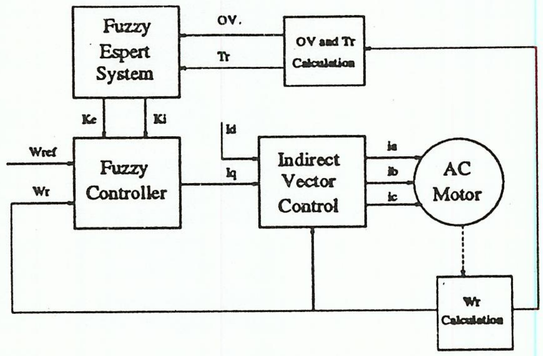

Figure 1: Fuzzy Control block diagram.

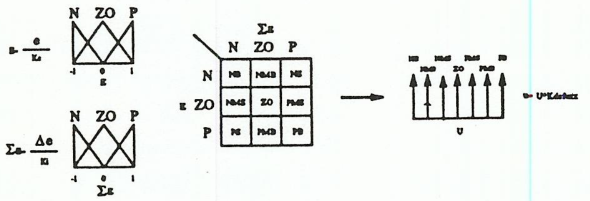

Figure 2: Rules and membership functions of the controler.

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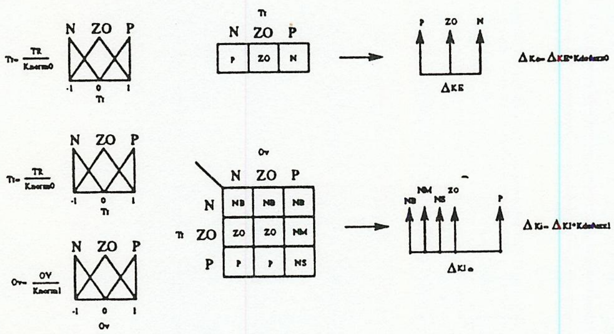
The expert system is implemented by means of a fuzzy controller whose rules are depicted in figure 3. Its inputs are the rotor speed overshoot (ov) and the rise time (t_r), which are computed in a pre-processing block. The scaling factors of the input variables of the main fuzzy controller (K_e and K_i) are the outputs of the expert fuzzy system.



system.

Figure 3: Rules and membership functions of the expert system.

III. EXPERIMENTAL RESULTS

To test the abilities of the proposed method, the controller of figure 1 has been implemented on a PC 386. The nominal characteristics of the Induction Motor used in the experiment (figure 6) are shown in table 1. Figure 4 shows the evolution of the system response during the tuning process. Note that a good time response is achieved in a short number of cycles. The lower part of the figure shows the system responses at the first and 24th cycles. Figures 5(a) and 5(b) show the evolution of the rise time and the overshoot

$L_m(H)$	2.0642	$R_s(\Omega)$	24.45
$L_s(H)$	2.0888	$R_r(\Omega)$	41.774
$L_r(H)$	2.0887	p	2

Table 1: Induction Motor nominal parameters.

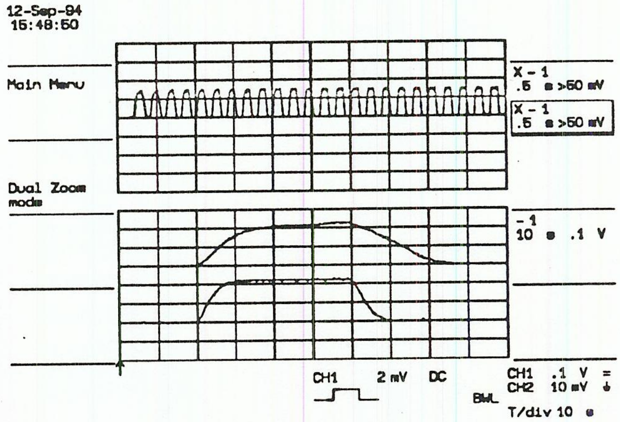


Figure 4: System response during the tuning process.

for the same example of figure 4. The low precision in the overshoot measured is due to a poor encoder resolution. Figure 5(c) shows the adaptation of the scaling factors. Note that the scaling factors tend to a steady state value to satisfy the specifications of the experiment: no overshoot and 0.18s rise time.

IV. CONCLUSIONS

A fuzzy expert system for the automatic tuning of an Induction Motor Fuzzy Controller has been presented. Experimental results show that the required specifications are attained in a short number of cycles. This expert system can be used both for the initial tuning of the main fuzzy controller parameters as well as during on-line process to deal with good performances of the system.

Acknowledgment

This work has been partially supported by the spanish *Comisión Interministerial de Ciencia y Tecnología* under project TAP-0608-C03-03.

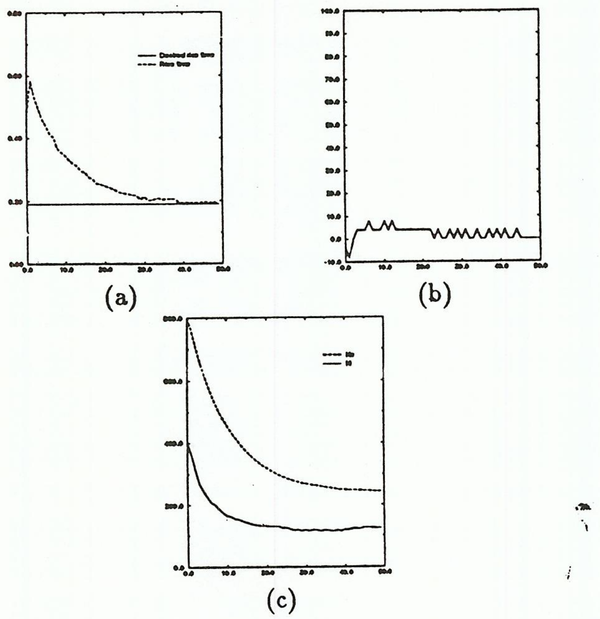


Figure 5: (a) Rise time evolution during the adaptation sequence. (b) Overshoot evolution during the adaptation sequence. (c) Adaptation of the scaling factors.

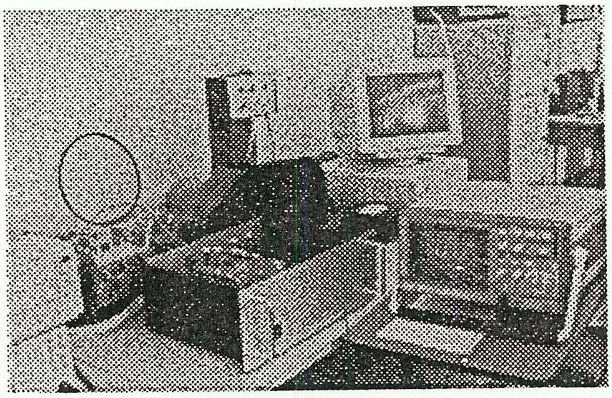


Figure 6: Photograph of the controlled system.

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