Neuro-fuzzy controller used to control The speed of An Induction Motor.

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Abstract - Induction Motors are widely used in industrial applications. This is due to their high robustness, reliability and low cost. We have to note that they present a strong non-linear behaviour resulting of the magnetic saturation effects and strong temperature dependency of electrical motor parameters. Simplified models have been used in real applications. The introduction of field oriented control has increased their use in many applications where dynamic and precision are needed. It delivers the best dynamic behaviour and a high robustness under sudden changes but the optimization and parameterization of a field-oriented controller is laborious and must be performed specially for each drive. The separately control of the flux and the torque contributes to do that. Unfortunately, the introduction of the classical controllers introduces non-linearity. We propose in this paper a neuro-fuzzy speed controller to perform the system response in terms of dynamic and precision and to avoid the

control approach. It is based on a fuzzy controller using neural network properties, which is easy to build with good performances. Simulations have been performed in this way, at the first step using the fuzzy controller then using the neuro-fuzzy controller. The obtained results show that the second one is better and presents an improvement of the dynamic properties of the induction motor compared to the flux controller.

1. INTRODUCTION

Since the 1980
control and demonstration that the induction motor can be controlled like a separately excited dc motor, the use of ac motor is increasingly acceptable.

Vector control techniques can be classified as direct or feedback and indirect or feedforward methods

It can be shown that the rotor flux orientation gives true decoupling control between the torque and the flux. In our case we will use the simplified method of field-oriented Control considering the speed loop as principal.

PI regulator is calculated at the same classical way used with the dc separately exc ited motor.

Fuzzy control system will be used perform the response in term of dynamic and precision at the first step. The Neuro-fuzzy controller has to perform the dynamic of the system using the adaptive neuro-fuzzy inference system.

Different approaches are used. Zieger- Nicols method [1]. Another ones based upon the pattern recognition [2]and those upon the expert-system [3].

The Method of Mamdani [4] is included in the latter it can be realized in two different ways:

1. The realization of the regulator is given by the fuzzy logic.
2. The Fuzzy logic informs the expert tuning of regulator parameters.

In add to this we will use a simplified field-oriented method when the model is similar to a DC Motor the NFC interne structure is given in fig 2 .

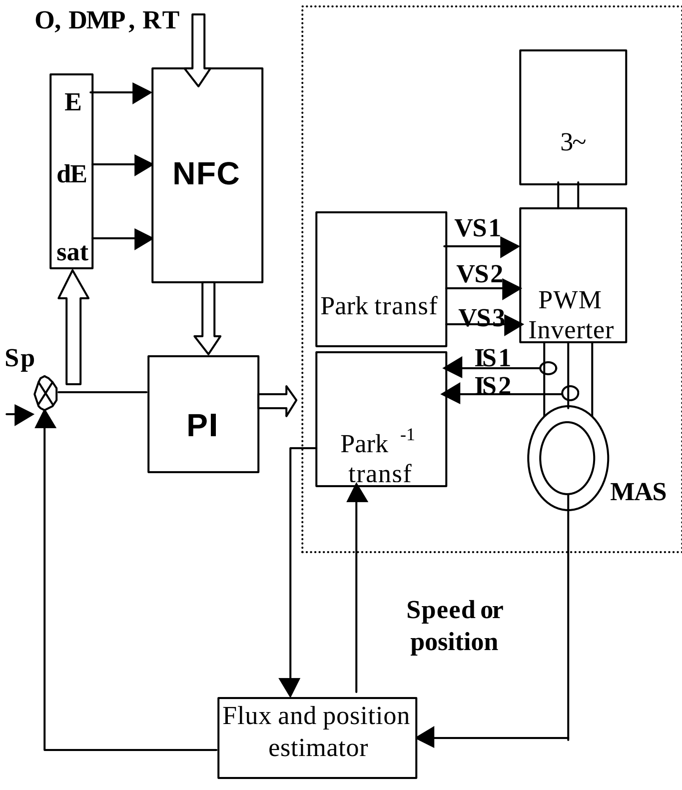

Fig1. Speed control Scheme of an Induction Motor Using Neuro-fuzzy controller

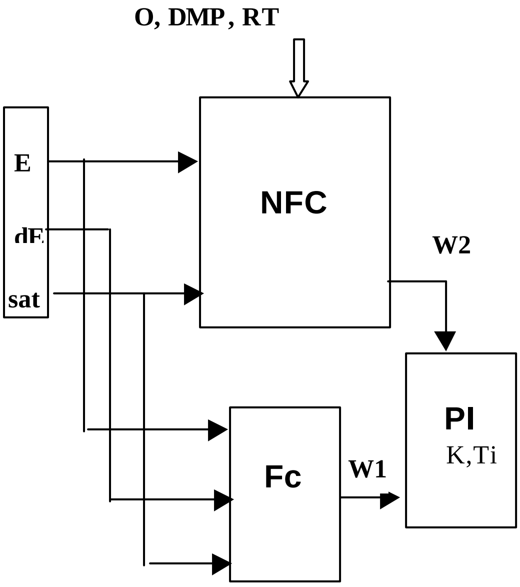

Fig 2. NFC intern structure

2. THE FUZZY CONTROLLER FC

The fuzzy controller has to operate over the PI parameters K and Ti.
The following heuristic considerations have been noted from the observation of the process behavior.
1. overshoot is mainly caused by integral term. Significant reduction of the overshoot cause system answer exceeds of the set point.
2. Increasing proportional term reduce the leading time but increase the oscillations.
The FS system inputs are the Error, the Error first derivative, the Sat variable for limitations due to the the saturation.
The FS system output is the weight W to give to the proportional and integral action of PI:
input variables fuzzy sets are: Negative: N. Positive: P. Zero: Z.
Output variable fuzzy sets: Zero: Z. Positive normal: PN. Positive Big: PB
From the expert controller, we use the following membership of fuzzy sets The rules supporting this system are expressed in the flowing table:

Table1: Rules of fuzzy system FS

Er	DEr	Sat	PI
N	/	N	Z
N	/	P	PB
P	/	N	PB
P	/	P	Z
Z	/	/	PN
/	/	Z	PN
/	Z	/	PN
N	N	Z	PB
P	P	Z	PB

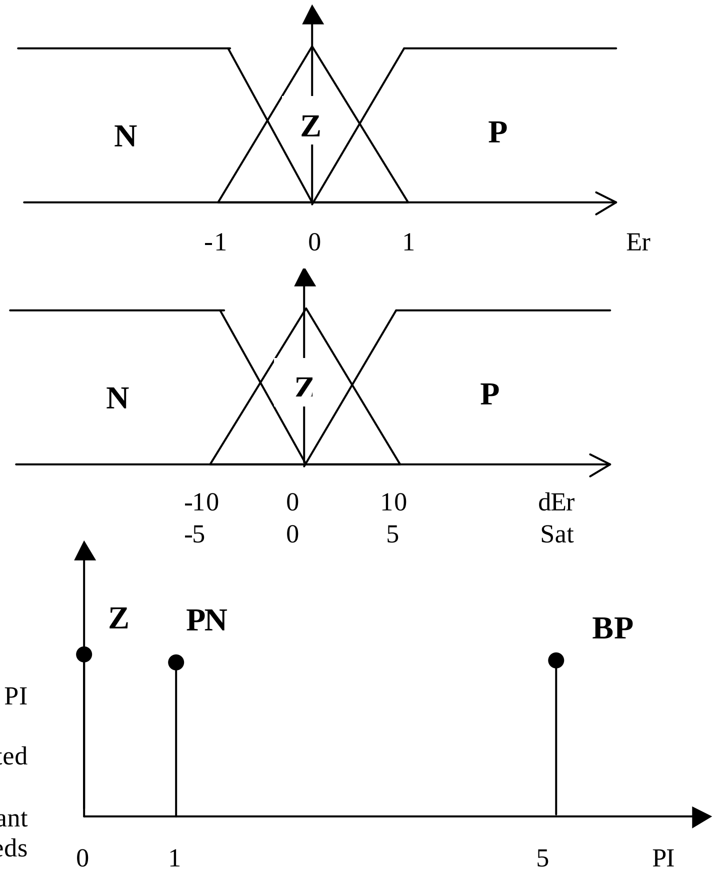

Fig 3 Input and Output Membership Functions of the FS.

THE TUNNING PROCESS

The system performance is evaluated by the overshoot Ov, the dumping DMP and the time response RT [7] .

$$Ov = E1 - Sp \qquad DMP = \frac{E3 - E2}{E1 - E2}$$

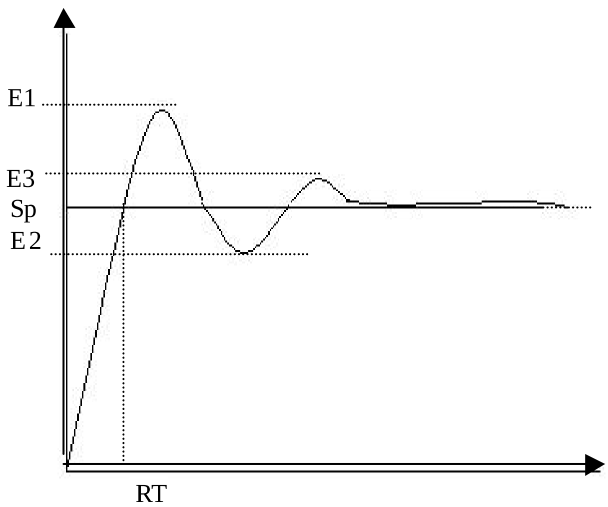

Fig 4 Performance measurement parame ters.

3. THE NEURO-FUZZY CONTROLLER NFC

Hybrid method combining both backpropagation and least square is used in the learning process.
The adaptive neuro-fuzzy inference system based on a given input/output data set has to generate a new fuzzy inference system. In our case we used (3 2 3 2 3) triangular membership function for the inputs then a network-type structure similar to that of a neural network, which maps inputs through input membership functions and associated parameters, and then through output membership functions and associated parameters to outputs, can be used to interpret the input/output map.

Based on the following fuzzy system which inputs are ÄOv, ÄDMP and ÄRT representing the difference between the estimated and the required parameters, the output W represents the weight which should be affected to the PI parameters

From the expert controller, the following membership of fuzzy sets are used

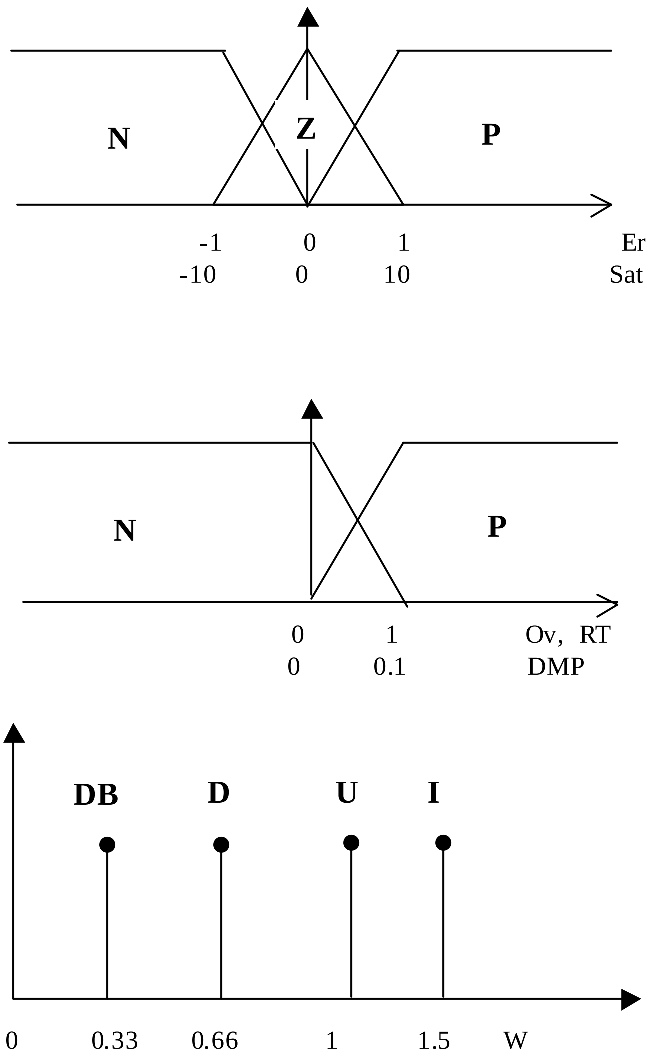

Fig 5 Input and Output Membership Functions of the FS used to learn the neuro-fuzzy controller.

The rules supporting this system are expressed in the flowing table:

Table2

E	Sat	ÄOv	ÄDMP	ÄRT	W
/	/	N	N	N	U
Z	Z	N	N	P	I
Z	N	N	N	P	U
Z	P	N	N	P	U
Z	/	N	P	/	U
N	/	N	P	/	D
P	/	N	P	/	D
Z	/	P	N	/	D
N	/	P	N	/	U
P	/	P	N	/	U
Z	/	P	P	/	DB
N	/	P	P	/	U
P	/	P	P	/	U

The neural network structure used for the learning process is giving as follow:

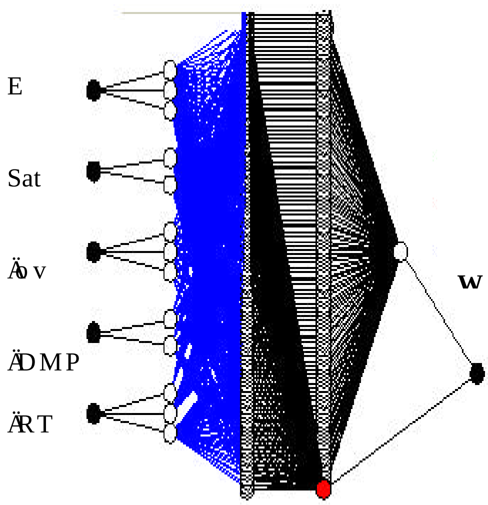

Fig 6 The neural network structure used in the learning process.

4. RESULTS

The simulation results are represented in figure 7 to 12. At the first step PI parameters are constant then the Weight W1 from the fuzzy controller is used finally the NFC's output representedby W2 weight is taken.
We have to note that using the fuzzy controller the system response is nearly the same to the classical one. When the time response is better for the neuro-fuzzy controller.

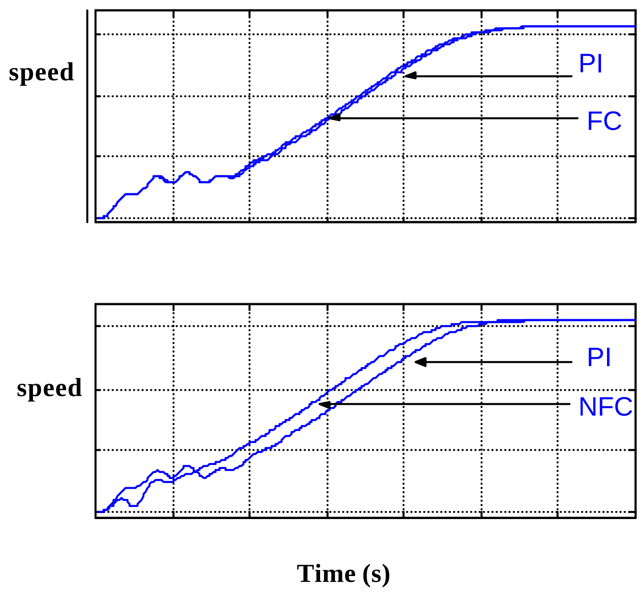

Fig 7 system response
With the reference Load.

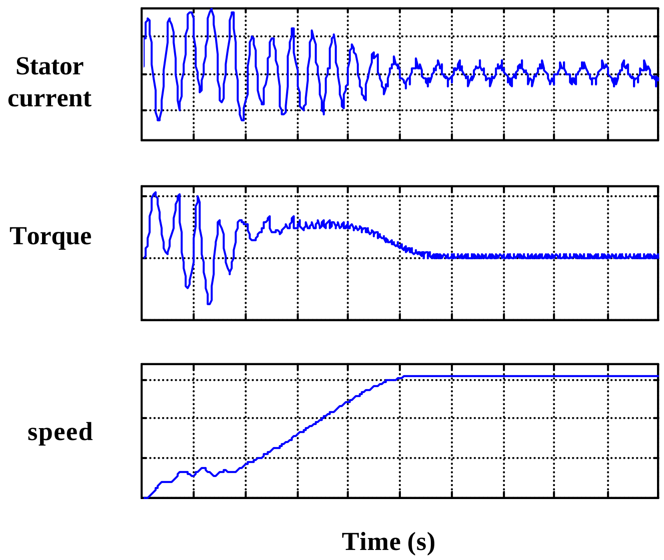

Fig 8. Response of the System
With a PI regulator.

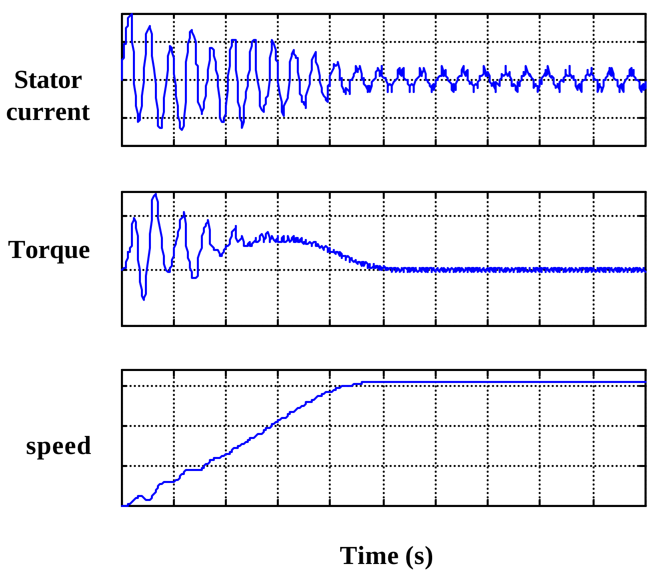

Fig 9. Response of the System
With the NFC regulator.

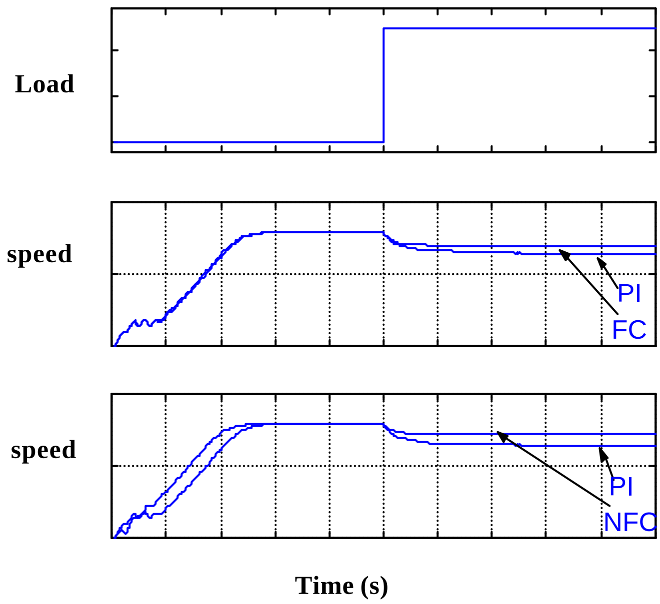

Fig 10 Step Response of the System
With a Step Varying Load.

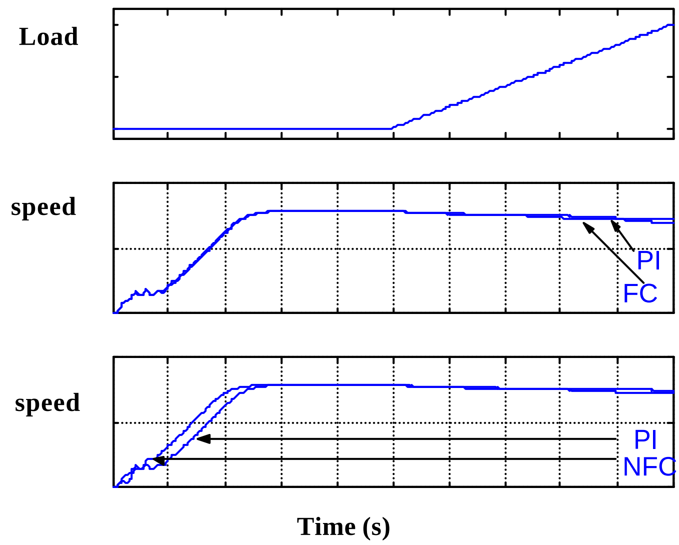

Fig 11 Step Response of the System
With a ramp Varying Load.

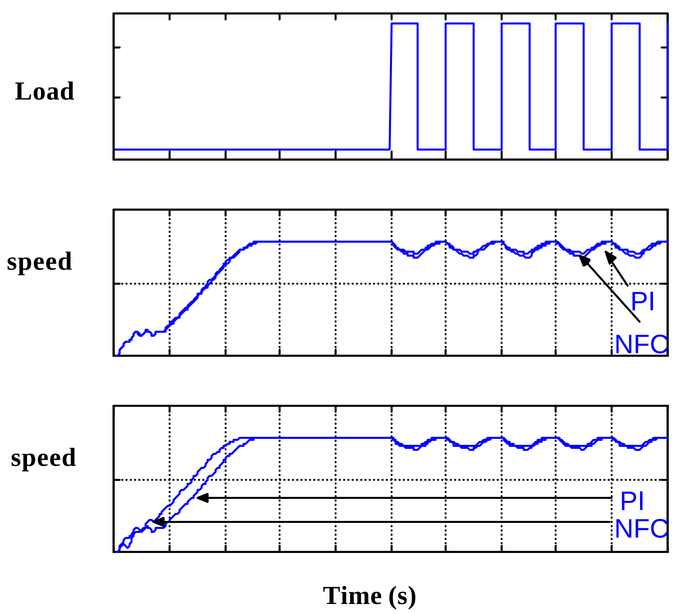

Fig 12 Step Response of the System
With a periodic square Varying Load.

Motor parameters

P=1500 W
U=220 V
F= 50 Hz
Rs = 4.85 Ù
Rr = 3.805 Ù
Ls = 0.274 H
Lr =0.274 H
Lm= 0.258 H
P=2

Load

B= 0.08NMs/rad
J= 0.09 .

PI parameters

K=0.3264
Ti=103.89

5. CONCLUSION

- The simplified field-oriented control method can be easily realized and gives acceptable results. The use of Fuzzy and neuro-fuzzy controller rich this use.
- The advantages offered by the fuzzy control and neural learning process can be used with systems handling more complex parameters.

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