ARTIFICIAL INTELLIGENCE TECHNIQUE BASED ON ARTIFICIAL NEURONAL NETWORKS APPLY TO A VECTOR CONTROLLED INDUCTION MOTOR

TECNICA DE INTELIGENCIA ARTIFICIAL BASADA EN REDES NEURONALES APLICADA AL CONTROL VECTORIAL DE MOTOR DE INDUCCION

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Abstract: One of the main things needed in electrical conventional drive controllers is the capacity to capture the unknown load characteristics around a wide range of the operation point; this hinders the controller's parameters' selection and tuning. In this work we used an Artificial Neural Network (ANN) for the identification of a field oriented controlled (FOC) induction motor. The neural network training results and the system identification simulation, both, are exposed in this paper.

Resumen: Una de las principales deficiencias de los controladores convencionales de los accionamientos eléctricos es la incapacidad de capturar las características desconocidas de una carga alrededor de un amplio rango del punto de operación, lo cual dificulta la selección y ajuste de los parámetros del controlador. En este trabajo se propone la utilización de las Redes Neuronales Artificiales (RNA) para la identificación de un motor de inducción por campo orientado. También se exponen los resultados obtenidos luego de realizar el entrenamiento de la red y la simulación de la identificación del sistema.

Keywords*:* Induction motor, field oriented control, artificial neural networks, identification.

1. INTRODUCTION

In order to design a motion control system with a good tracking response it is necessary to use a complex adaptive control algorithm due, fundamentally, to the non-linear characteristic of both, the electromechanical converter and the driven mechanism.

This is particularly true when an induction motor with field oriented control driven a non-linear mechanical load is being utilized.

In the past, a classical algorithm like a proportional integral (PI) with variable parameters was employed. This choice brings about a complication of the software development. Recently another modern control techniques like the variable structure, the model reference adaptive control and the sliding mode control has been applied successfully. Nevertheless, these solutions are very complicated too.

Some years ago, Narendra and Parthasarathy, [3] demonstrated that the neural network parallel processing characteristic could be utilized to identify and control dynamic systems allowing capturing it as a whole, the nonlinear properties of the electromechanical motion systems.

Since then, some investigators have been engaged in the development of neural network control systems of direct and alternating current electrical drives.

2. THE FIELD ORIENTED CONTROLLER

In this paper, we choose Simulink® as simulation language due to the experiences of the authors concerning the use this program for induction motor (IM) control. The field oriented controlled IM with simulation is the plant to be identified with artificial neural networks.

The indirect method of field oriented control for induction motor was used. A three phase current controlled inverter with pulse width modulation (PWM) in stationary control feeding an induction motor was simulated. This system is shown in figure 1.

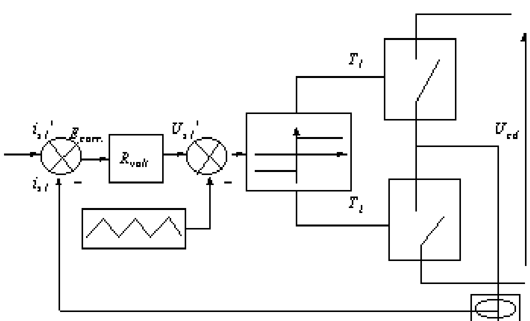

Fig. 1. Three phase current controlled inverter with pulse width modulation and stationary control

3. NEURAL NETWORK TOPOLOGY AND TRAINING

An open loop field oriented induction motor control like the one shown in figure 2 was simulated as the plant to be identified considering the torque producing current $i_{sq}(k)$ as the input and the motor speed $w(k)$ as the output.

The training pattern was obtained "exciting" the plant with a waveform very much alike to the corresponding to the motor starting. One composed by an initial increasing ramp and a final decreasing ramp was the choice.

The slopes and relative times of the two ramps were varied in order to generate different training patterns. The inputs to the Artificial Neural Network (ANN) were $w(k)$, $w(k\text{-}1)$ and $i_{sq}(k\text{-}2)$ and $i_{sq}(k\text{-}1)$ was the output.

A three layer back propagation neural network (351) with 0.2 as learning rate and 0.9 as the bias was selected. The maximum quadratic error was 0.3.

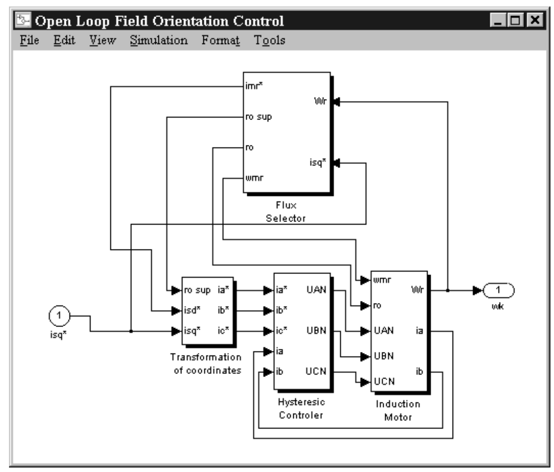

Fig. 2. Open loop field oriented control simulation

In figure 3 the simulation scheme implemented in order to training the neural network is shown. The identification of the induction motor using the trained ANN is shown in figure 4.

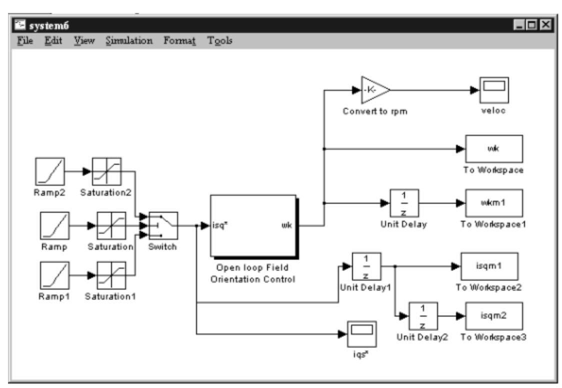

Fig. 3. Simulation scheme for neural network training

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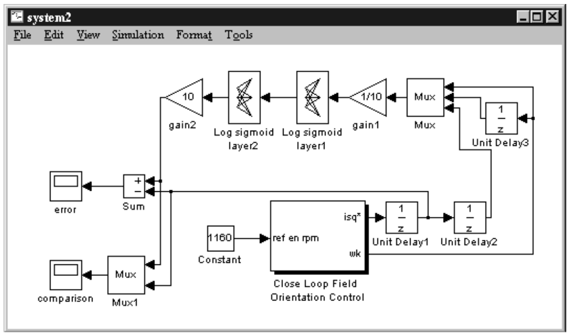

Fig. 4. Identification process using the selected Artificial Neural Network

As final training result the closed loop system identification error was obtained, it can be observed for figure 5, it is below the preset level and in steady state it ends up being very small, in the order of 0.04, which demonstrates that successful network training was carried out, and the training patterns emulate the real system dynamics.

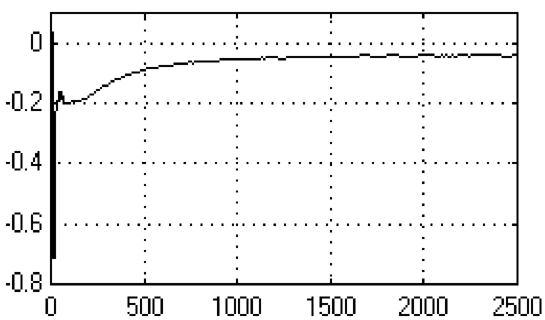

Fig. 5. Identification error (step reference change)

Comparison between the torque producing current i^{*}_{sq} obtained by closed loop system simulation and the one obtained using ANN is shown in figure 6. The error is shown in figure 6. Its value was never grater than 0.1.

The network behavior before random sudden reference variations can be examine in figures 7 and 8 where can observe that the network and the system outputs are very similar each other and that the actual error between these signals is below the allow maximum error.

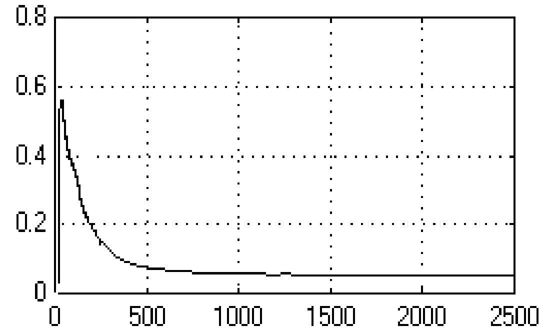

Fig. 6. Motor current and network output (step reference change)

Some instantaneous picks can be occurred due to that the network has one input that comes from the output signal, unit delayed, then, the network take a time instant to give the right answer.

This time instant is similar to the one used as integration interval and very inferior to the smallest time constant of the system, that is way; the identification behaviour is not affected at all.

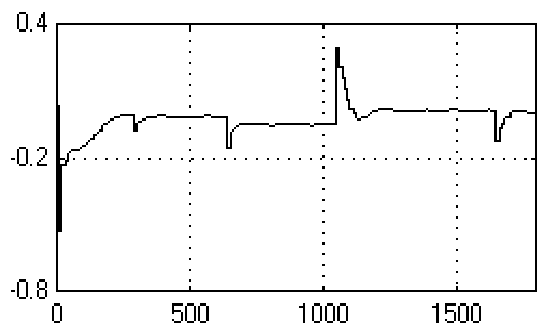

Fig. 7. Identification error (random reference change)

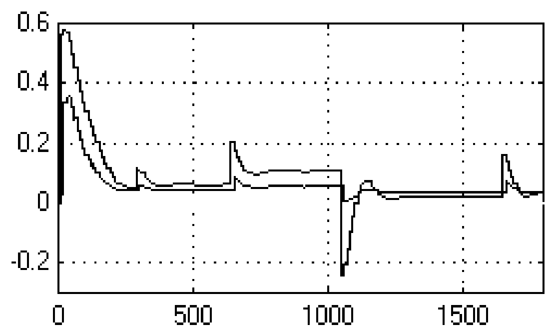

Fig. 8. Motor current and network output (random reference change)

4. CONCLUSIONS

The training patterns selection is very important in order to obtain successful neural network learning. The better selection of the neurons number of each layer is a matter of experience.

The training patterns selection also influences the successful learning of the network in a decisive way when the dynamic processes of the system are considered. It could also be established that the learning process accelerates during the training if the network output signal is feedback.

With the simulation results is demonstrated that the trained network identified the system in open and closed loop with errors inferior to 0.1, when the system was stimulated with random input reference signals.

Finally, we can also conclude, that this neural network representing the non-linear system can be use in the future as the control algorithm of the speed loop of the field oriented controlled induction motor system.

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