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Booklets

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Title: Control through artificial neural networks of direct current motor

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Introduction

Introduction

Nowadays most of the processes are controlled automatically, due to the need to improve safety and reliability, as well as the quality control of the products, so day by day new control methods are sought, an alternative are the artificial neural networks (ANN), due to its characteristics are able to control different types of processes

Introduction

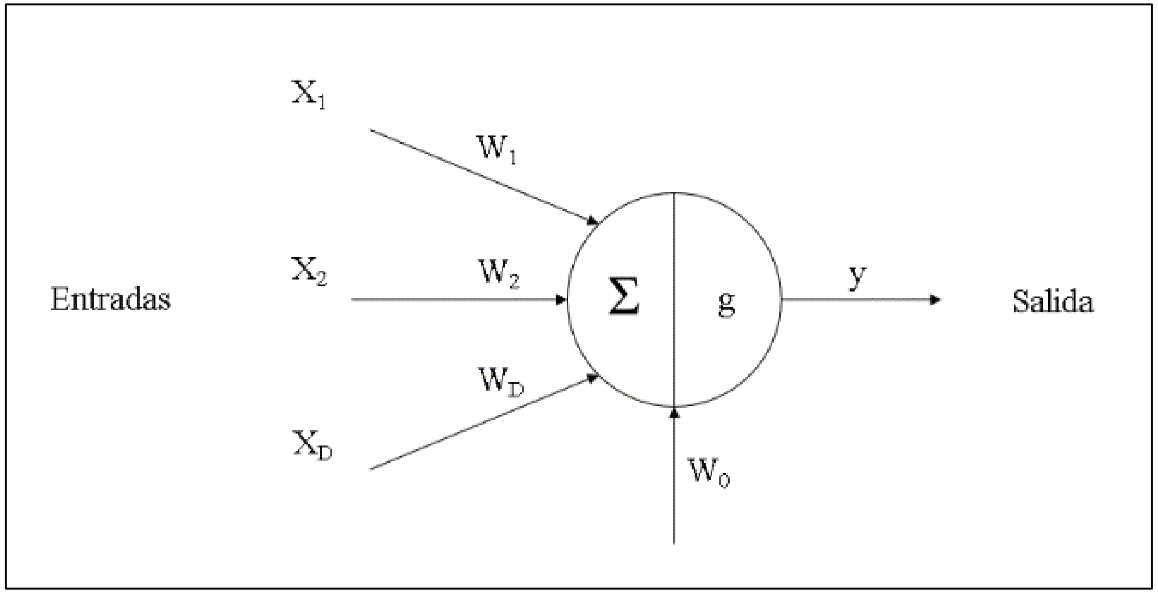

Figure 1: McCulloch-Pitts neural model.

An artificial neural network can be described as a massively parallel combination of simple processing units (neurons) that can acquire knowledge from the environment through a learning process and store the knowledge in their connections.. (Haykin,1999).

Introduction

On the other hand, DC motors are one of the most versatile machines in the industry, but with the advent of electronics their use has greatly decreased, despite this DC motors are still used in many power applications, which is why it is necessary to seek new alternatives for the control of these machines.

Figure 2: No-load direct current motor.

Introducción

During this presentation we will explain the process for controlling the speed of a DC motor experimentally through artificial neural networks of the NARX type (Nonlinear Autoregressive Neural Network with exogenous inputs).

Methodology

Methodology

Before starting the creation of the control, we must know that the structure of the control through artificial neural networks (ANN) has the form shown in Figure 3.

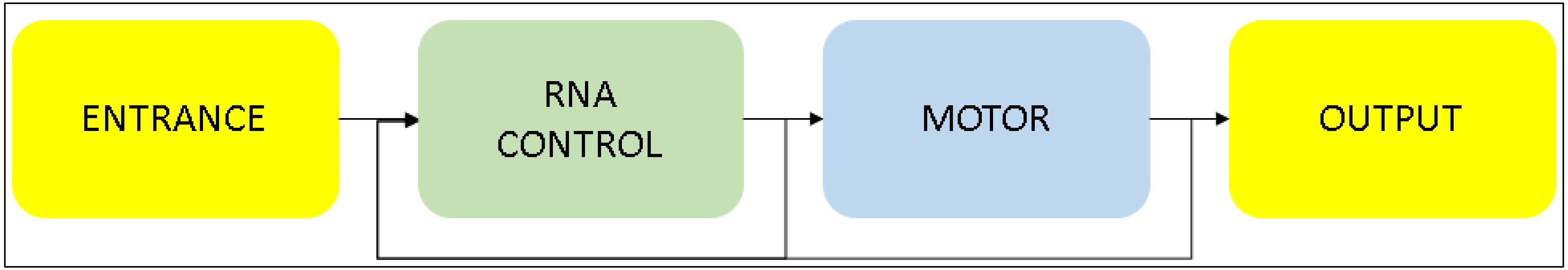

Figure 3: RNA control structure.

Methodology

Once we know the shape of the control, the first step is to obtain data on the dynamic behavior of the motor (in RPM) when different voltages are applied, in this case 50 different voltage values were used..

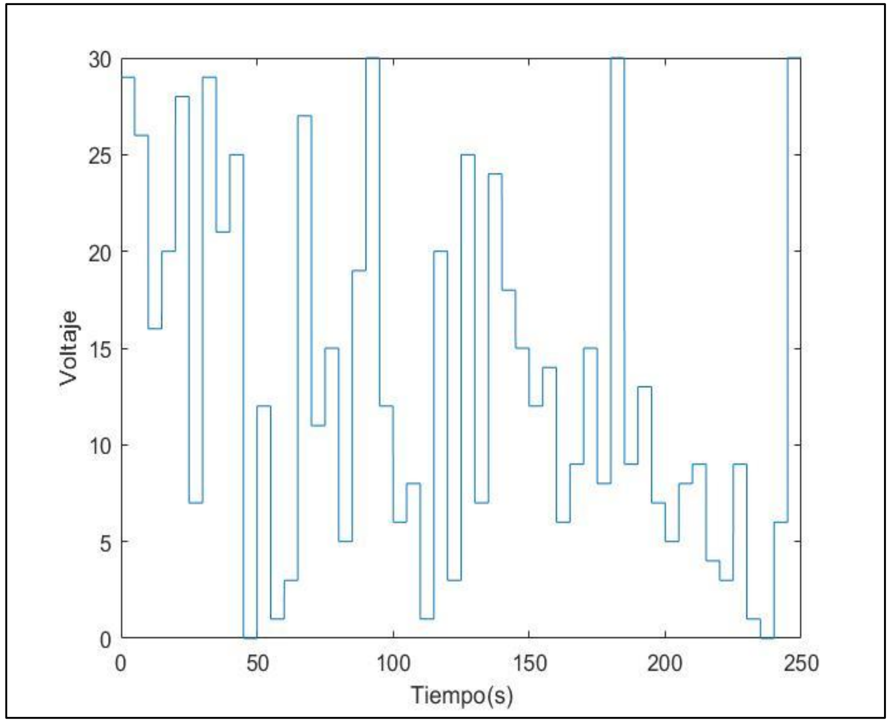

Figure 4: Voltage versus time data

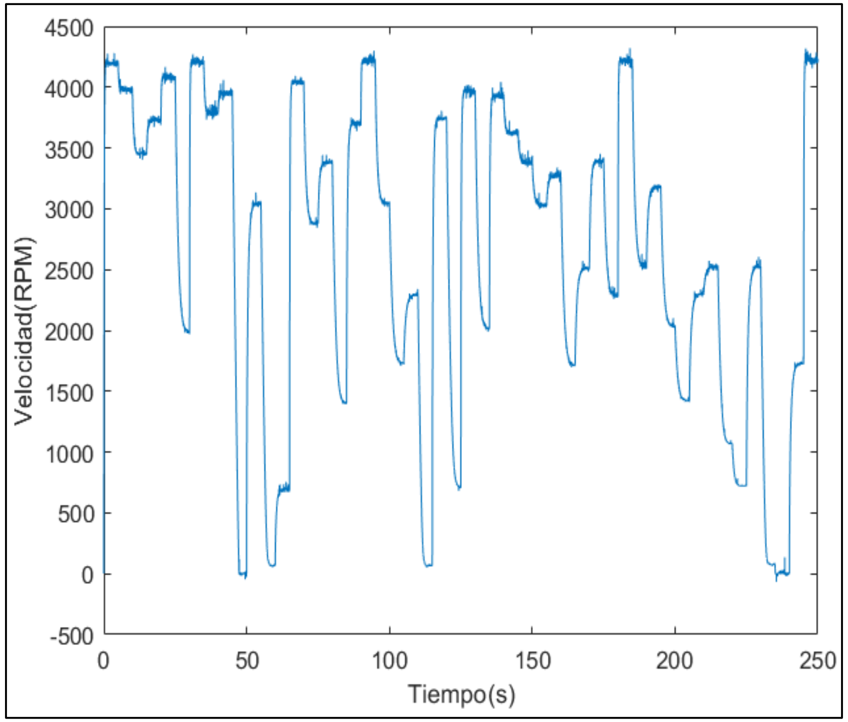

Figure 5: Engine performance (RPM)

Methodology

This first NARX type ANN will learn the behavior of the motor when voltage values are introduced to it.

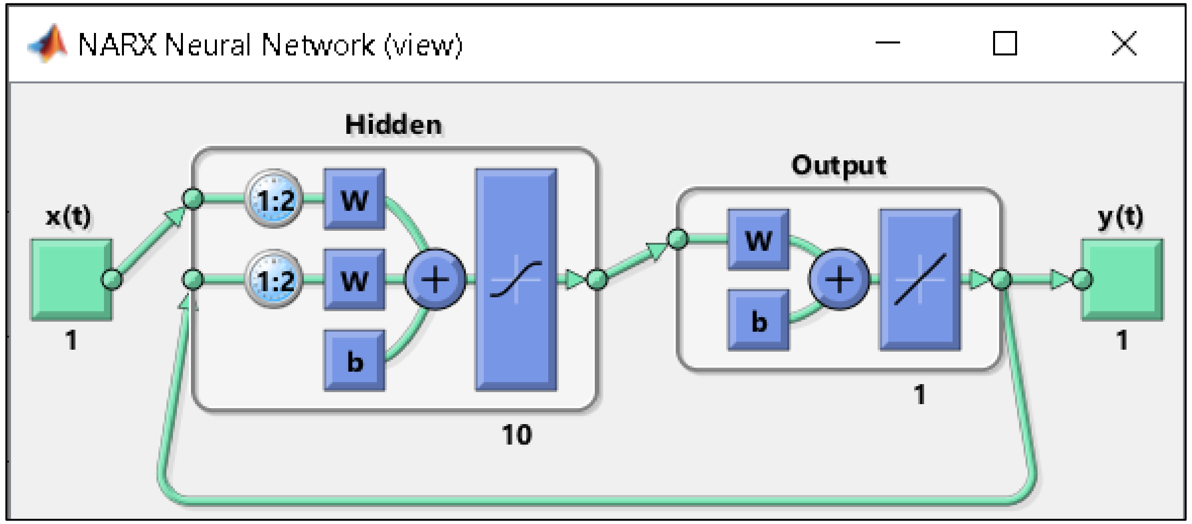

Figure 6: NARX-like ANN structure that learned the behavior of the DC motor.

Methodology

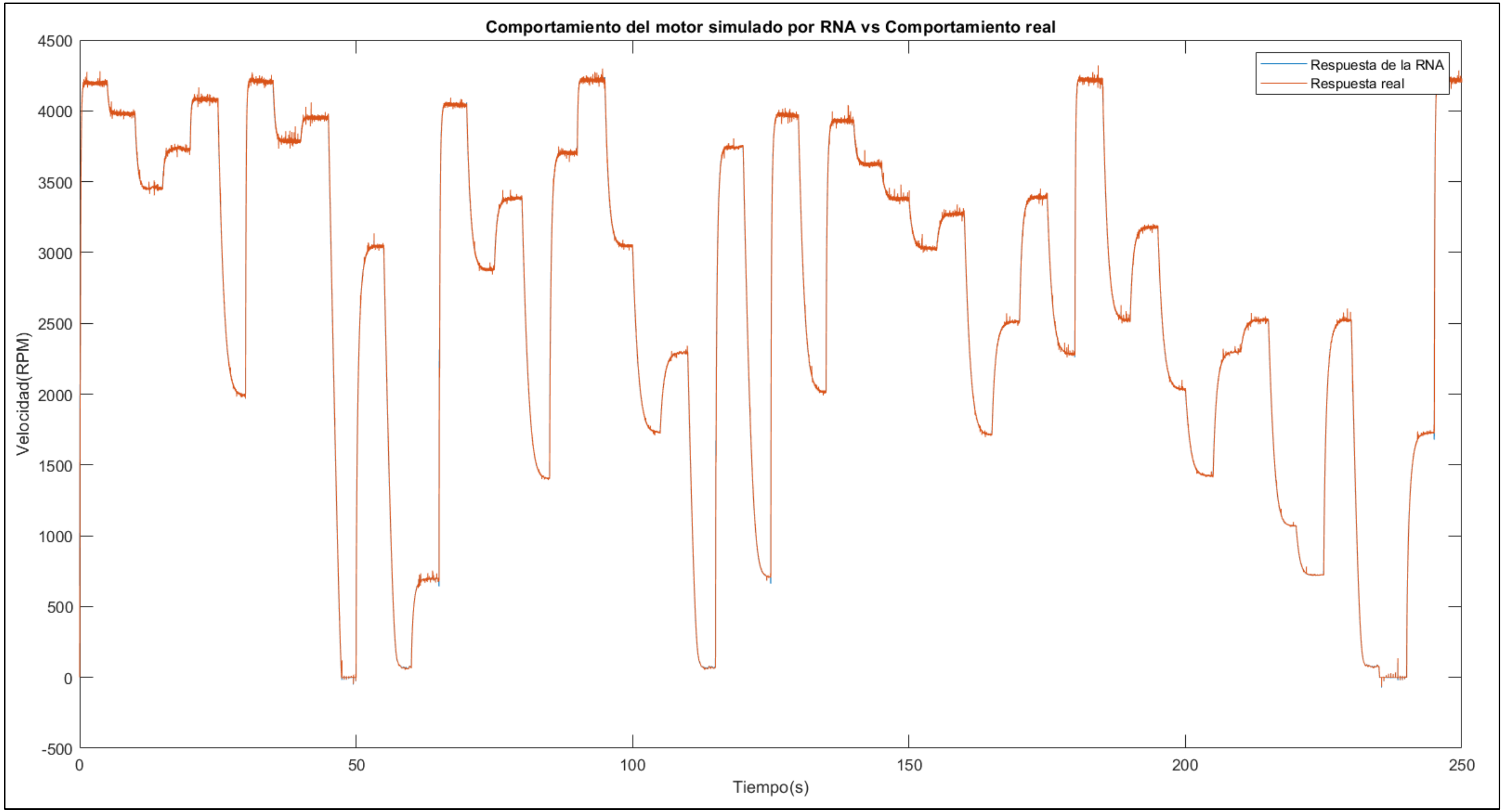

Figure 7: Engine behavior simulated by the artificial neural network (blue) and real engine behavior (orange).

Methodology

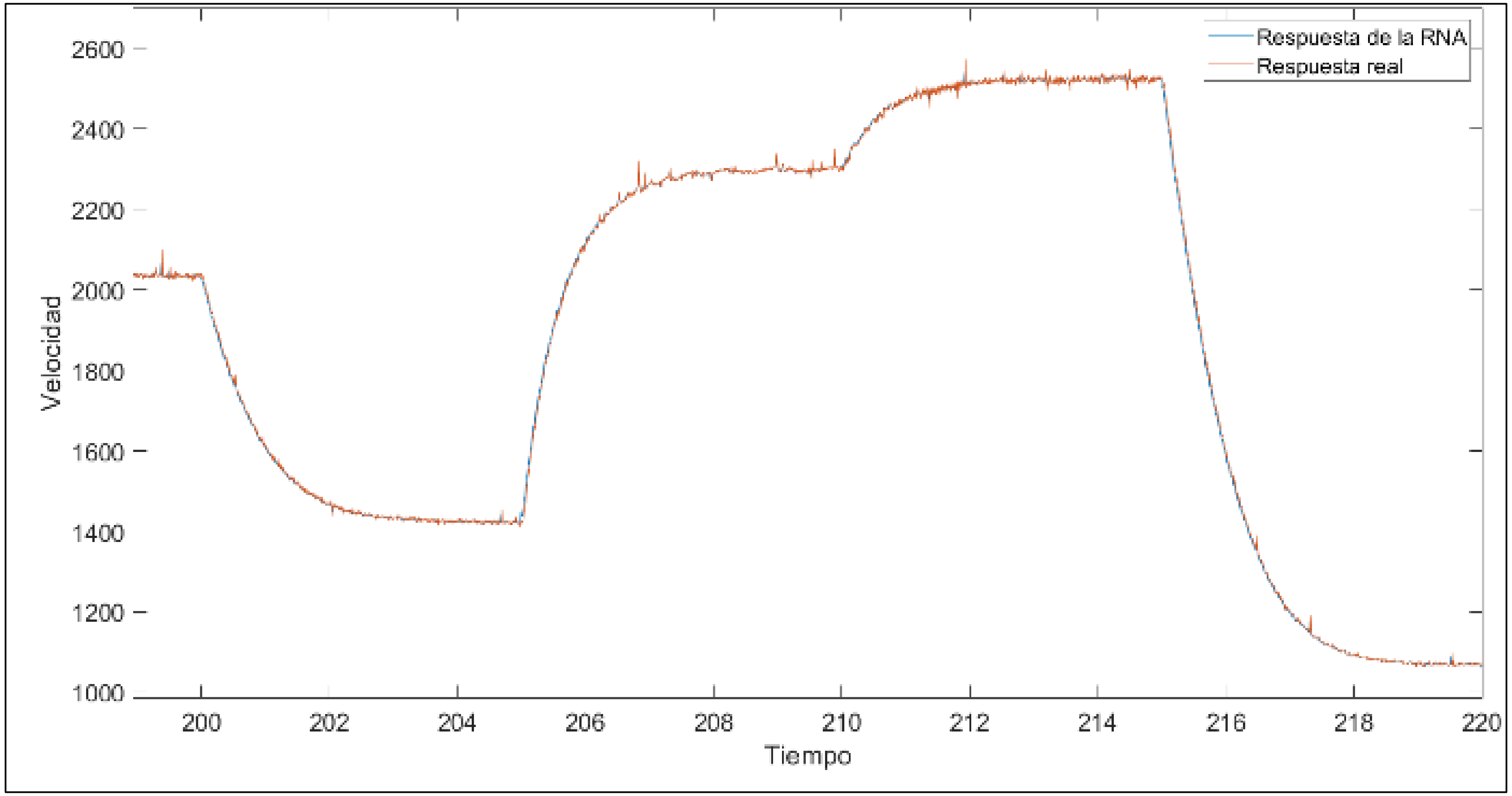

Figure 8: Close-up of the engine behavior simulated by the artificial neural network (blue) and the real engine behavior (orange).

Methodology

Since we have the network that learned the behavior of the engine, a second NARX type artificial neural network was created, which will be divided into two parts, the control (hidden layer 1 and 2) and the engine (hidden layer 3 and output layer) as shown in Figure 9.

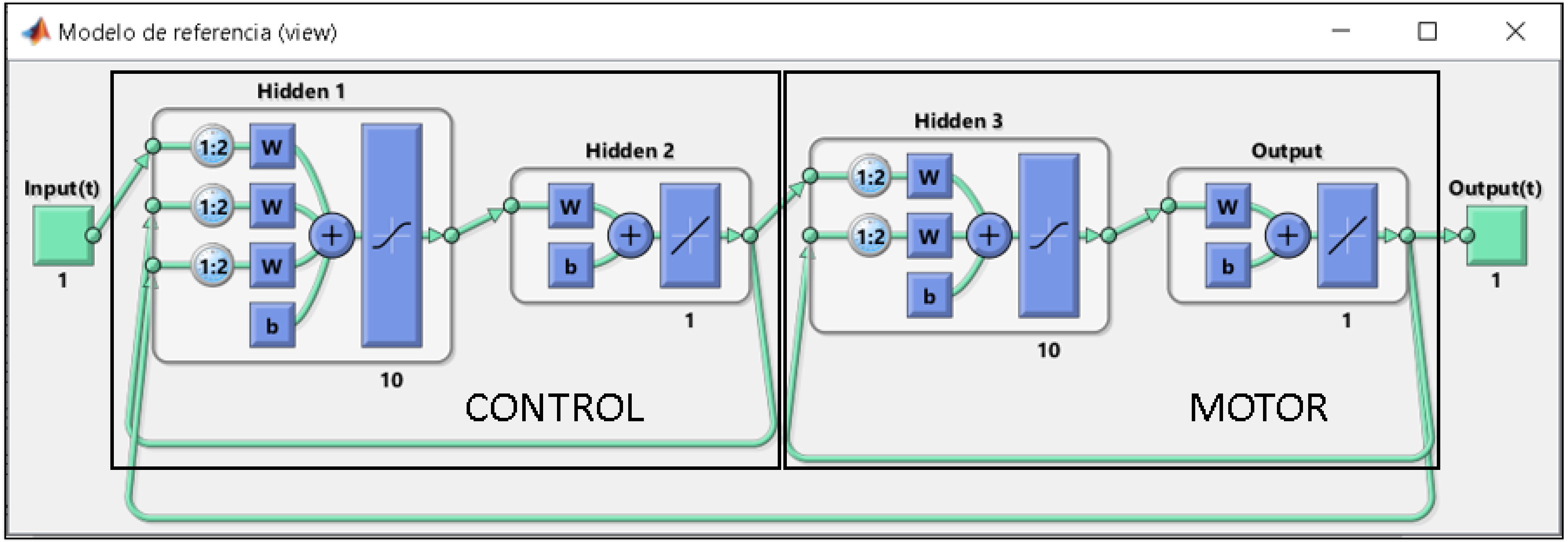

Figure 9: Artificial neural network control for a DC motor

Methodology

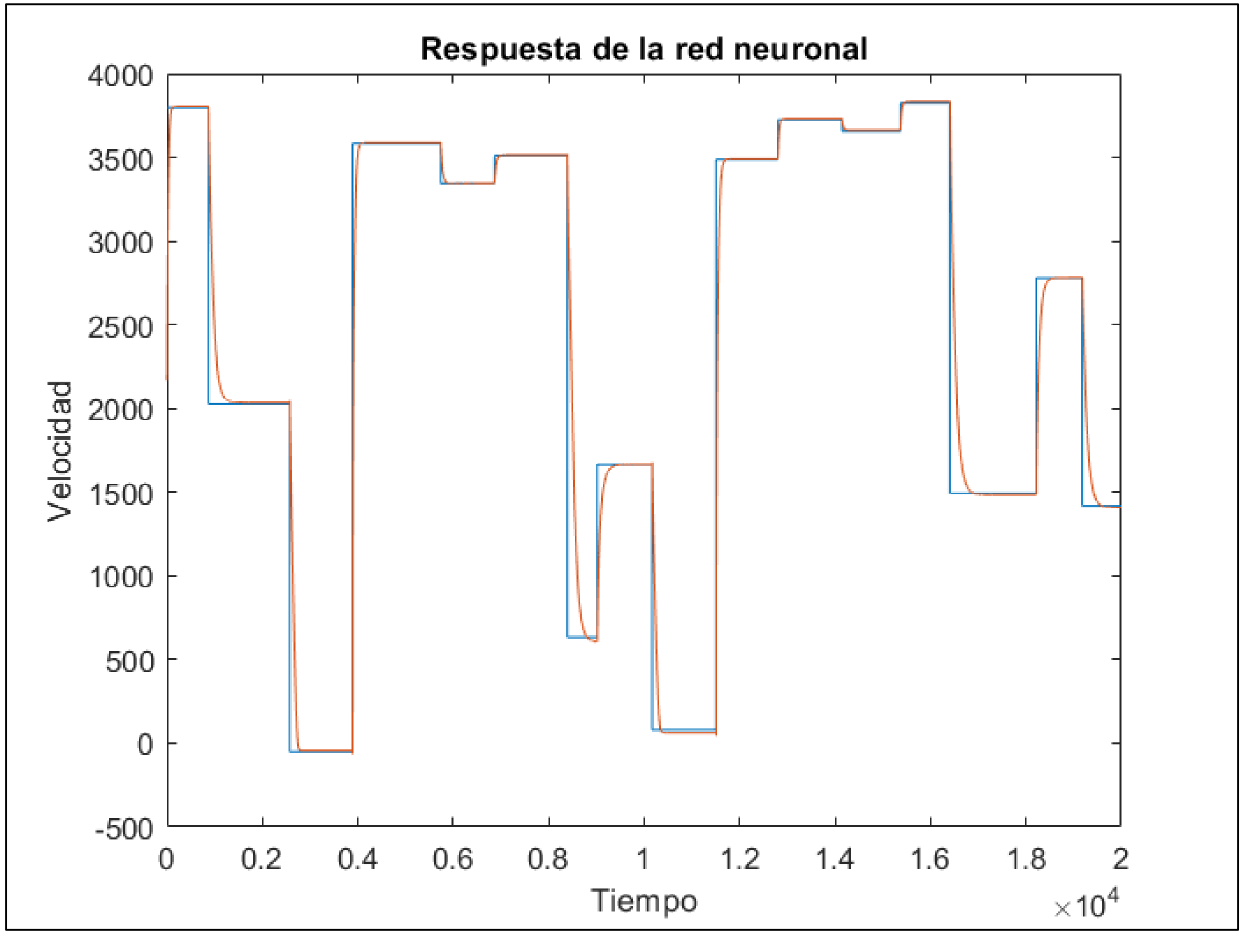

Figure 10: Simulator behavior by controlling an artificial neural network with different step inputs.

Methodology

With the control network trained and tested in a simulated way, it is necessary to be able to control the DC motor in real time, it was necessary to extract the data of the weights and biases of the hidden layer 1 and 2, that is, the part of the artificial neural network that corresponds to the control, these data will be used to program the controller using the LabVIEW software.

Results

Results

To obtain the results in this work, a DC motor connected to a CompactRIO (CRIO) data acquisition device was used, as shown in Figure 11.

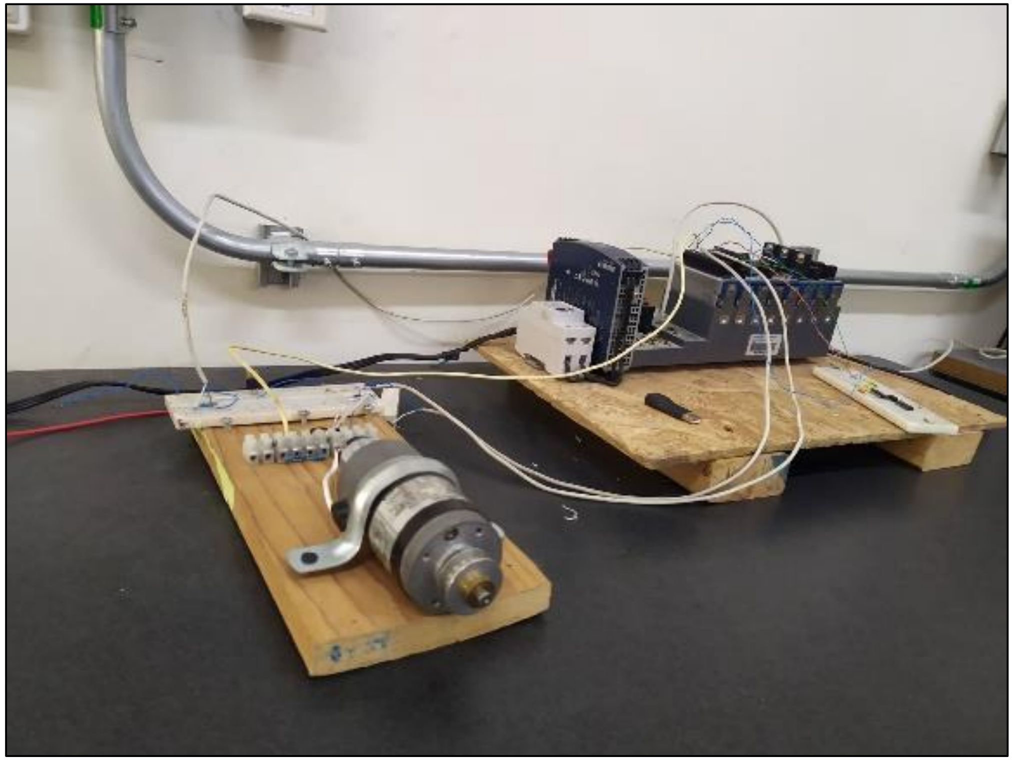

Figure 11: DC motor and its connections to CompactRIO

Results

The motor used has the following characteristics:

Parameters	Value
DC Voltage	30.8 V
Current	3 A
Nominal Speed	4200 RPM
Torque	1.6 N/m

Table 1: Motor nameplate data

Results

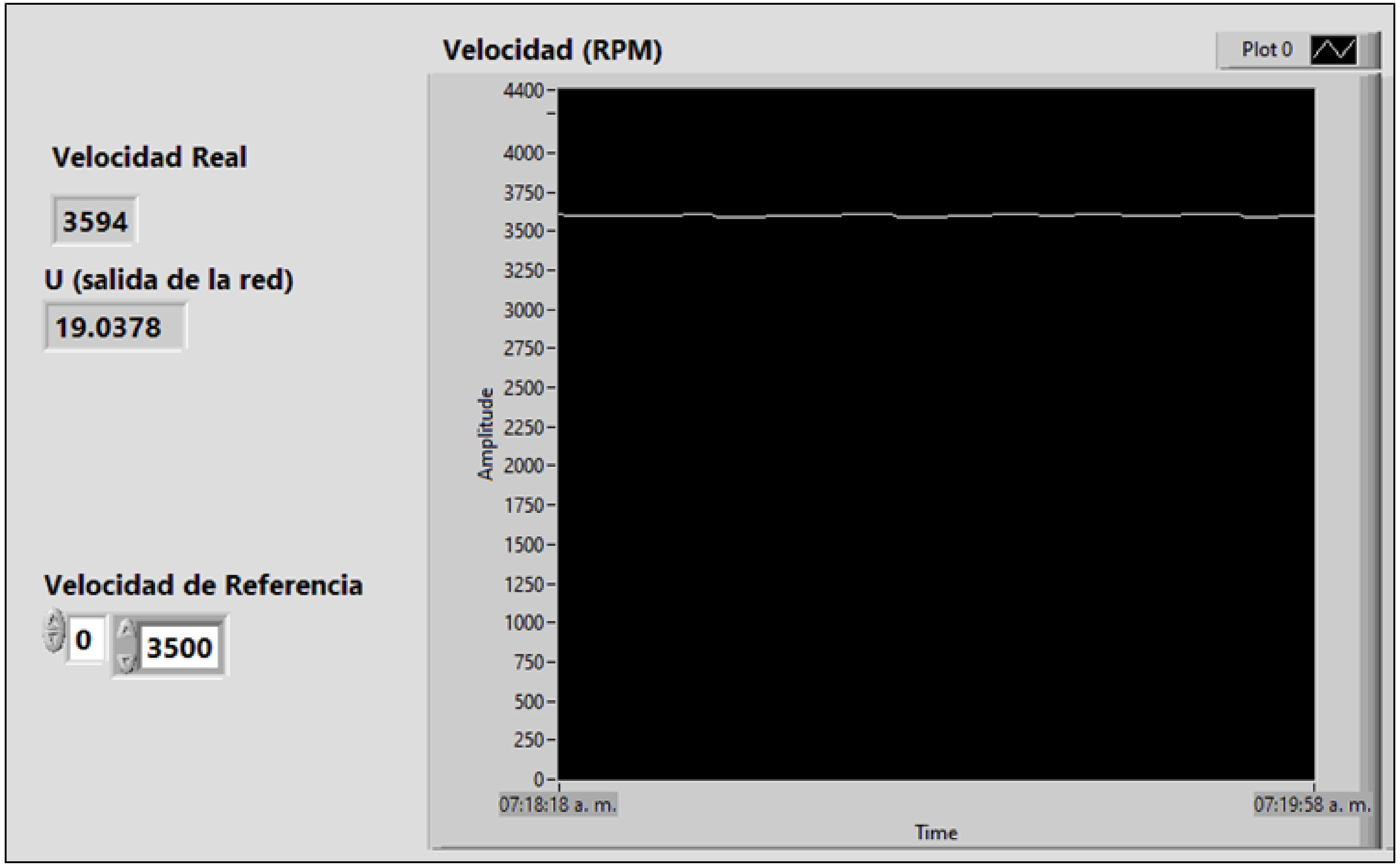

Figure 12: Human Machine Interface (HMI) for speed control of a DC motor at 3500 RPM.

Resultados

Value of reference (RPM)	Measured value (RPM)	Difference in RPM	Percentage error
2500	2491	9 RPM	0.4%
3000	3094	94 RPM	3%
3500	3594	94 RPM	3%

Table 2: Experimental results of the artificial neural network controlling the motor.

Conclusions

Conclusiones

The objective of controlling the speed of a DC motor through NARX-type artificial neural networks was achieved since the motor is able to reach the reference value over the entire range of motor working speeds with an error below 3%.

Conclusiones

One of the main advantages of this type of control using an ANN, is that only one database is needed to train the ANN consisting of: the voltage applied to the motor and motor speed in RPM, it is important to note that for the control to work properly, the range of data must change from minimum to maximum motor supply voltage, ie throughout the operating range of the motor, also the more accurate and precise the data is better performance in controlling the motor speed.

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