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On-line detection of voltage transient disturbances using ANNs

F. J. Alcántara, J. R. Vázquez, P. Salmerón, S. P. Litrán, M. I. Arteaga Orozco

Departamento de Ingeniería Eléctrica y Térmica
Escuela Politécnica Superior. Universidad de Huelva
Crta. Palos de la Frontera s/n., 21819, Palos de la Frontera, Huelva, Spain
Phone: +34-959217579, Fax: +34-959217304
e-mail: benju@uhu.es, vazquez@uhu.es, patricio@uhu.es, salvador@uhu.es, maria.arteaga@die.uhu.es

Abstract. The non-quality phenomena of the supply voltage in electrical power systems include transient disturbances as frequency variations, sags, swells, flicker or interruptions. In this work, a method to detect and measure some transient disturbances based on Artificial Neural networks (ANNs) will be presented. A Feedforward network has been trained to detect the initial time, the final time and the magnitude of a voltage disturbance. The design and training process of an ANN specialized in voltage sags detection will be presented. The performance of the designed measure method will be tested in a simulation platform designed in Matlab/Simulink through the analysis of a practical case.

Keywords
Electrical power quality, transient disturbances, measurement, artificial neural networks, feedforward.

1. Introduction

The artificial neural networks had been applied successfully in several topics of the Electrical Engineering, including the detection of some voltage disturbances. The speed and the parallelism of the calculations are the main advantages of these techniques.

In this work, a Feedforward ANN has been designed for transient disturbance measurements, specifically, for voltage sags detection. To probe the performance of designed measurement system, a network has been trained and simulated in a Matlab/Simulink platform. After an off-line training process using a Backpropagation algorithm, the network was connected to an electrical system for the on-line detection of supply voltage sags. The results of a practical case will verify the suitable performance of the designed network.

2. Neural network architecture

The Artificial Neural Networks includes a large number of strongly connected elements: the artificial neurons, a biological neuron abstraction. The model of an artificial neuron in a schematic configuration is shown in figure 1.

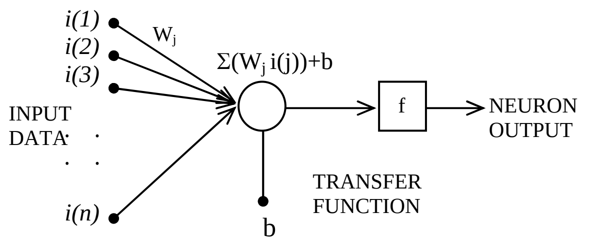

Fig. 1. Artificial Neuron Model

The input data *i(1)*, *i(2)*, *i(3)*, …, *i(n)* flow through the synapses weights W_j. These weights amplify or attenuate the inputs signals before the addition at the node represented by a circle. The summed data flows to the output through a transfer function, f.

The neurons are interconnected creating different layers. The feedforward architecture is the most commonly adopted. The scheme is shown in figure 2.

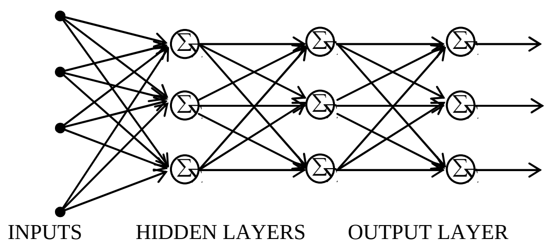

Fig. 2. Feedforward Neural Network Architecture

This network can be trained to give a desired pattern at the output, when the corresponding input data set is applied. This training process is carried out with a large number of input and output target data. These data can be obtained using a simulation platform or an experimental system. The training method most commonly used is the backpropagation algorithm. The initial output pattern is compared with the desired output pattern and the weights are adjusted by the algorithm to minimize the error. The iterative process finishes when the error becomes near null.

In this work, the neural network has been designed with three inputs, corresponding to the voltage at three consecutive time instants *v(t)*, *v(t-Δt)* and *v(t-2Δt)*, two hidden layers of 20 and 12 neurons with sigmoid transfer function, and an output layer with only one neuron with pure linear transfer function.

3. Simulation platform

To simulate the proposed measurement system, including the ANN training process and its on-line performance, a Matlab/Simulink platform has been designed.

To carry out the network training process, a set of input voltage waveforms with different length and depth sags was generated in Matlab/Simulink platform. The per unit voltage amplitude was considered as desired network output. The training process of the neural network was carried out helped by the Neural Network Matlab toolbox. The error evolution during the training process is presented in figure 3. The maximum error is 0.00032.

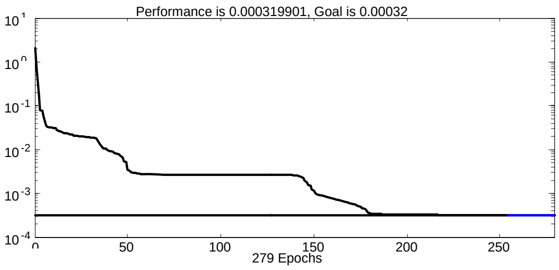

Fig. 3. Error evolution during the training process

4. Results of practical cases

After the network training process, the measurement system performance was tested in the presence of different ideal voltage sags which happen in different time instants. Figure 4 shows a voltage waveform with a 69% depth sag and the network output. It can be appreciated that the network works in a suitable form (s_{med} = 0,31), detecting the voltage sag, including the initial and final instant of the sag.

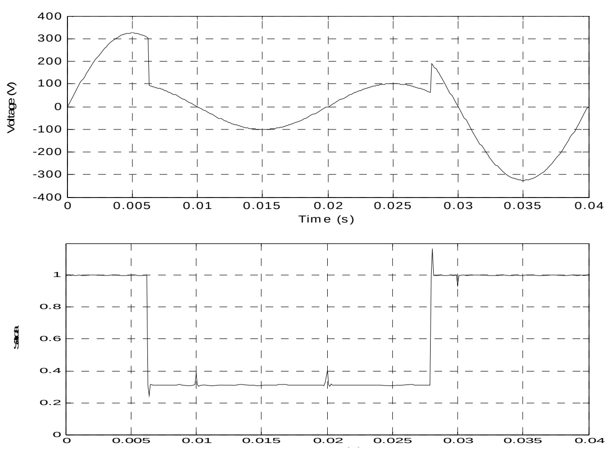

Fig. 4. Voltage waveform with a 69% depth sag and the network output

Finally, the designed ANN measurement block was applied to detect a sag in an electric power system with a three-phase fault. The figure 5 shows the Simulink block diagram simulated with a fault at point of connection of load 2 between 16,67 ms and 133,3 ms. The voltage has been measured at point of connection of a load 1, and the neural network output is presented in figure 6.

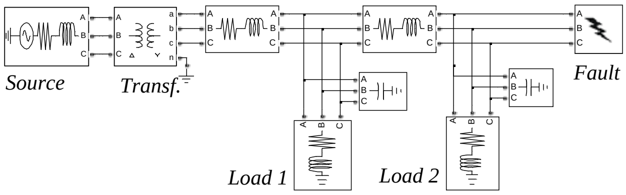

Fig. 5. Simulink block diagram of the electric power system

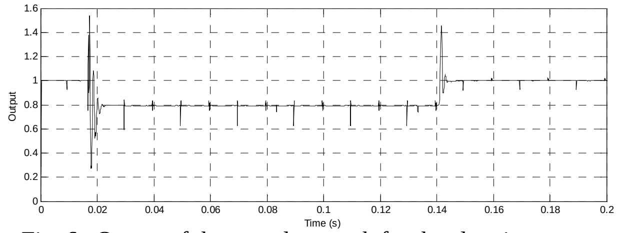

Fig. 6. Output of the neural network for the electric power system

The ANN answer is 0,79, and there are small oscillations of the network output caused by at the presence of transients. The network performance can be improved if it is trained to detect the transient periods too.

5. Conclusions

A procedure to measure on-line voltage disturbances based of using artificial neural networks has been presented. The feedforward neural networks designed have been trained by means the backpropagation method, using input/output data supplied with computer simulations. To have an adequate dynamic response of the disturbance detection system, three inputs were considered for the neural network, the voltage at instant t, and at two preceding instants, *t-Δt* and *t-2Δt.*

The neural network was satisfactorily tested for the detection and measurement of different voltage sags including sag caused by electrical system faults.

References

[1] "European Standard UNE-EN 50160: Voltage characteristics on public distribution grids". AENOR ,2001.

[2] "Estimating economic impact of voltage sags". Wang, J.; Chen, S.; Lie, T.T. International Conference on Power System Technology, 2004. Vol. 1, 21-24 Nov. Pp. 350-355.

[3] "Voltage sag vulnerability study in power system planning". Wang, A.C.; Teng, J.H.; Shen, C.C.; Lu, C.N.; Chen, Y.T.; Huang, C.Y.; Liu, E.. IEEE Power Engineering Society General Meeting, 2005. Pp. 383-388.

[4] "Fast Estimation of Voltage and Current Phasors in Power Networks Using an Adaptive Neural Network". P. K. Dash, S. K. Panda, D. P. Swain. IEEE Transactions on Power Systems, vol. 4, no. 12, 1997, pp. 1494-1499.

[5] "A new technique for unbalance current and voltage estimation with neural networks". F. J. Alcántara, P. Salmerón. IEEE Trans. On Power Systems, Vol. 20, No. 2, 2005, pp. 852-858.

[6] "Power quality disturbance data compression using wavelet transforms methods", S. Santoso, E.J. Powers, IEEE Trans. On Power delivery, Vol 12, No 3, July 1997.