Revista Sostenibilidad, Tecnología y Humanismo

8

https://doi.org/10.25213/2216-1872.42

Design and implementation of an EEG system as well as a physiographer for monitoring psychological treatments within the faculty of psychology of the Antonio Nariño University headquarters Cartagena

Diseño e implementación de un sistema de EEG y de un fisiólogo para el seguimiento de los tratamientos psicológicos en la Facultad de Psicología de la sede de la Universidad Antonio Nariño Cartagena

Juan Vicente Cajal-Barros

Ingeniero Mecánico, Juan.cajal@uan.edu.co,

Universidad Antonio Nariño, Cartagena de Indias, Colombia

*Autor de correspondencia: Juan.cajal@uan.edu.co

Recibido: Febrero 25 de 2018 Aceptado: Junio 5 de 2018

Cómo citar: J.V Cajal, "Design and implementation of an EEG system as well as a physiographer for monitoring psychological treatments within the faculty of psychology of the Antonio Nariño University headquarters Cartagena ", *Sostenibilidad, Tecnología y Humanismo,* vol. 9, no. 2, 8-16, 2018.

Abstract

The project designed and implemented was an EEG as the first part of a macro project, which allowed the integration between the different programs of ANTONIO NARIÑO University. This system is an integral part of the physiographer, conditioning circuits, filters, amplifiers, a data acquisition system and a virtual instrument were designed that capture the variables through a data acquisition card to be analyzed and visualized dynamically on a personal computer. Design and implementation process were divided into 5 modules. It will begin describing magnitudes to be measured, the sensors that will give us a better capture of our signals, the next two modules are the circuitry and the patient protection, to finish with data acquisition and the visualization in a personal computer.

Keywords: EEG system, Physiographer, Psychological.

Resumen

El proyecto diseñado e implementado fue un EEG como primera parte de un macroproyecto, que permitió la integración entre los diferentes programas de la Universidad ANTONIO NARIÑO. Este sistema es parte integral del fisiólogo, se diseñaron circuitos de acondicionamiento, filtros, amplificadores, un sistema de adquisición de datos y un instrumento virtual que capta las variables a través de una tarjeta de adquisición de datos para ser analizadas y visualizadas dinámicamente en una computadora personal. El proceso de diseño e implementación se dividió en 5 módulos. Se comenzará describiendo las magnitudes a medir, los sensores que nos darán una mejor captación de nuestras señales, los dos siguientes módulos son la circuitería y la protección del paciente, para terminar con la adquisición de datos y la visualización en una computadora personal.

Palabras clave: Sistema de electroencefalograma, Fisiólogo, Psicólogo.

Introduction

The design and development of a PC for the Acquisition and Visualization of EEG Electroencephalographic Signals on PC becomes highly relevant in studies aimed at diagnosing brain pathologies such as epilepsy and psychiatric disorders, and constitutes a fundamental piece in the development of a Neurofeedback.

Electroencephalography is a technique aimed at recording the potential variations produced by brain cells, while Neurofeedback is a procedure that presents the patient with information about their own brain electrical activity, in order to tune certain functions of the Central Nervous System and controlling them through learning [1].

An EEG team's main objective is to capture the potential oscillations that appear on the cranial surface by means of superficial or basal electrodes, which are subsequently amplified, filtered and digitized to be finally visualized.

The accessibility of electroencephalography equipment for learning purposes in an Electrophysiology or Biomedical Instrumentation Laboratory, or for research purposes for the implementation of techniques for digital signal processing, compression, encryption, transmission, among others, is a task that it is difficult, taking into account the acquisition costs associated with this type of technology.

Additionally, maintenance, repair and procurement of spare parts is a complex process due to the import formalities of said products or access to related technical services, so having the prototype of a biomedical device such as the one described would facilitate Ostensibly the work of teaching and research in the area of Bioengineering and Biomedical Engineering [2].

For these reasons, a low-cost equipment capable of acquiring and adapting four recording channels was designed in an efficient, reliable and secure manner, thus obtaining high-quality EEG signals. In addition, it has a graphical interface developed by means of an object-oriented programming software, highly practical and useful for the reconstruction, visualization and digital processing of said signals..

Development.

The design and commissioning of an EEG Signal Acquisition and Visualization Kit requires an adequate knowledge of the characteristics of electroencephalographic signals [3]. The behavior of the EEG signal is random in nature, characterized by a voltage range between 1 μV and 100 μV, and a bandwidth ranging from 0.5 Hz to 100 Hz.

These considerations were taken into account when implementing the acquisition stage, in charge of capturing, amplifying and adapting the signals from the brain, which can be classified into four frequency bands that correspond to the different brain rhythms, as established in Table 1.

Table

Designación	Frecuencia [Hz]	Región Cerebral	Ocurrencia
Ondas Beta (β)	13 – 30	Parietal y frontal, normalmente.	Adultos en estado de vigilia.
Ondas Alfa (α)	8 - 13	Occipital, normalmente.	Relajación y concentración mental.
Ondas Teta (θ)	4 - 8	Regiones temporales.	Niños y adultos dormidos.
Ondas Delta (δ)	0.5 - 3	Varias regiones.	Bebés. Estados profundos de sueño.

Fuente: [3]

The project shows the engineering design and commissioning of the system for capturing and conditioning EEG waves; which was divided into 5 modules, as shown in figure 1.

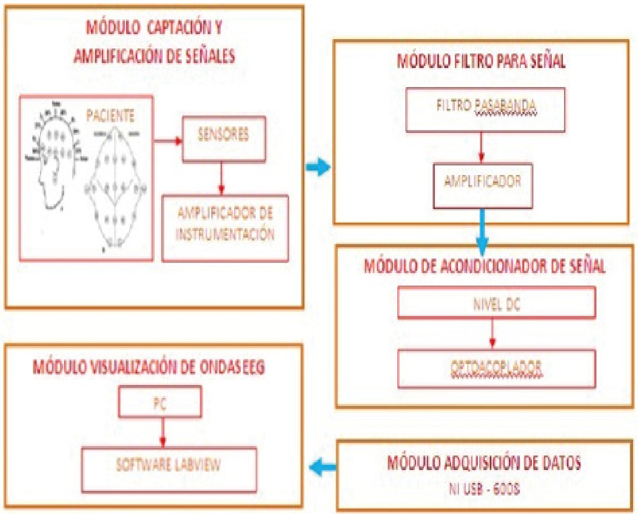

Figure 1.EGG waves modules

Fuente: [3]

Signal acquisition and amplification module

To capture the undulations of the electrical potentials of the brain, surface electrodes of Ag / AgCl have been used on the scalp, which are small 5mm diameter discs. These electrodes are located according to a technique called 10-20. In total, the system is made up of 17 electrodes and the ground, which are responsible for bringing brain waves over the surface of the scalp to the differential input of the instrumentation amplifier.

The function of the instrumentation amplifier is to amplify the EEG waves found on the scalp. To make the design of this amplifier, it was taken into account that when amplifying these signals, the noise that accompanies them can also be amplified, therefore the level of these signals is not brought to high levels of amplitudes since the noise that accompanies these signals would also be amplified.

Therefore, a low voltage gain was designed for this stage. The device selected as an instrumentation amplifier is the integrated AD620 [4].

Signal filter module

This module is in charge of taking the signals that were captured and amplified by the signal capture and amplification module and limiting them in a bandwidth that only EEG wave signals operate. For this, a bandpass filter figure 2 was designed, because it only allows signals to pass between the lower cutoff frequency f1 and the upper cutoff frequency f2. Frequencies that are not within this range will be attenuated [5].

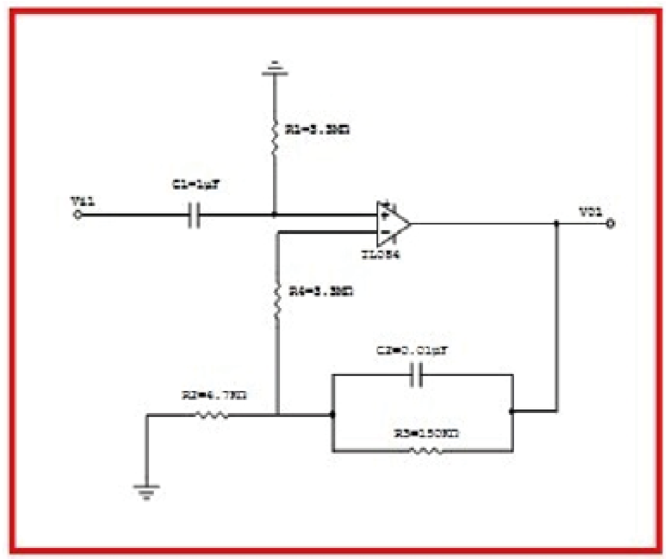

Figure 2. Filter without signal

Fuente: [5]

Signal conditioning module

This module is divided into two parts, one part is in charge of patient protection, for this an optical coupling circuit was designed, with an integrated reference MCT6, and its function is to provide greater protection to the patient. The other part is the design of a circuit whose function is to mount the waves at a level of direct voltage, to avoid the negative peaks of the signal being cut when it passes through the optical coupling circuit. Figure 3 shows the complete circuit of the signal conditioner module. The design of each of these circuits is explained below.

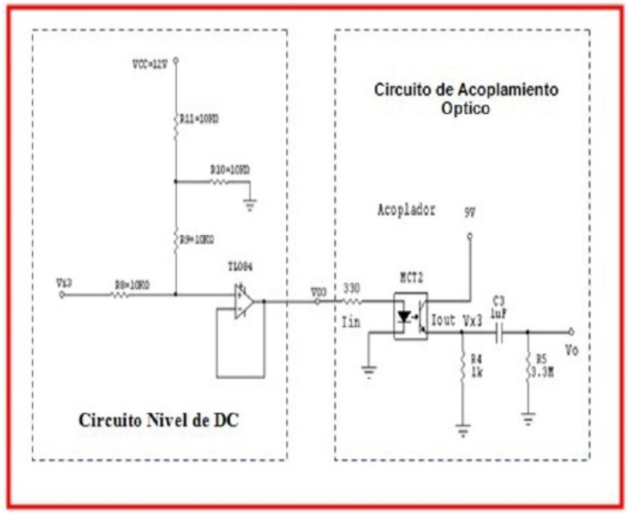

Figure 3.No signal conditioner, [5]

Data acquisition module. This module serves as an interface between the captured signals and the computer, to then be taken to the EEG wave display module. For this module, an NI USB - 6008 card was selected. This card must reject the digital noise present inside the computer and that may contaminate the analog signals it is trying to analyze. The card is shown in figure 4.

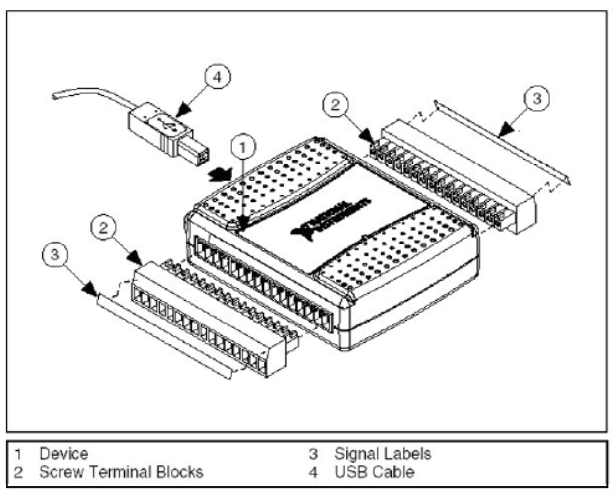

Figure 4.Connectors EEG wave display module, [6]

Card NI USB – 6008. The program designed in LabView, Graphs the electroencephalogram signals captured and amplified by the project's analog stage and digitized with the DAQ card, see figure 5. EEG program block diagram of the 8-channel program [7].

EEG wave display module. The program designed in LabView, Graphs the electroencephalogram signals captured and amplified by the analog stage of the project and digitized with the DAQ card, see figure 5 [8].

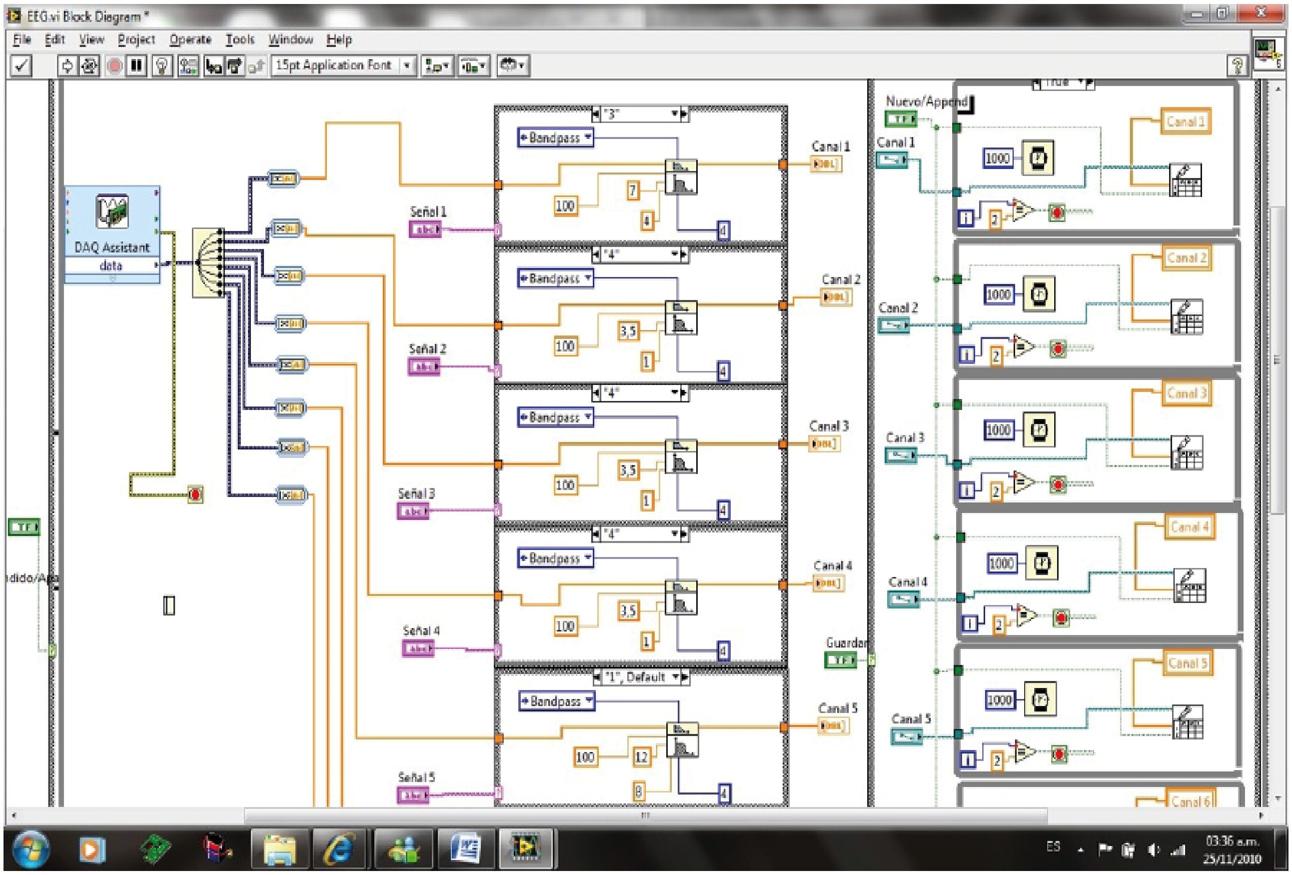

Figure 5.EEG program block diagram of the 8-channel program, [9]

The entire program is contained within a case structure, the input terminal is wired to a Boolean control, located on the front panel as an on / off button.

The case structure has two possible cases (true / false), for the false case the program does not perform any operations, for the true case the program starts the data acquisition sequence importing the data from the acquisition card to LabView with the block DAQ Assistant, this part of the program is contained within a while loop (stop if true) structure, so that the program is in an indefinite cycle of interactions in which the analog signals will be read, digitized, it gives them due processing and they are repeatedly graphed as long as the "TRUE" condition is not given in the "STOP" terminal of said structure [9].

When inserting the DAQ Assist block in the block diagram, it automatically starts its configuration wizard, then we prepare the block in the acquire signal mode, choose an analog signal and in the unit or type of signal choose voltage. After this configuration, the wizard automatically detects any data acquisition card connected to the equipment and displays the analog inputs available on it [10].

The wizard immediately displays the following box in which the parameters of the signal to be digitized are selected. The following are configured in this table:

- Signal voltage range (maximum and minimum + 9V and -9V)
- Signal voltage range (maximum and minimum + 9V and -9V)
- Units (Volts)
- Terminal configuration. (simple or with land reference)
- Acquisition mode, (continuous samples)
- Number of samples to read (3K)
- And the sampling rate (1K) [11].

Each channel of the DAQ card is selected and names are assigned according to the order of the channels (channel 1, channel 2, ……. Channel 8). The 8 signals collected by the acquisition card come out of the DAQ assistant through the same terminal in the form of dynamic data, to separate these signals and give them the treatment that each individually requires, using the Spit Signals function, which separates and each delivers them separately at their different terminals. After separating the signals, the dynamic data is converted to numerical arrangements with the from DDT function, this step is necessary to be able to give each signal the appropriate treatment according to the type of wave to be displayed [12].

With one Combo Box function per channel, we configure a text string control with the names of the signals that are generated in the reading of the encephalogram, (Alpha, Theta, Beta and Delta) and it is configured so that each text string throws me a numerical value from 1 to 4 like this: Alpha 1, Beta

2, Theta 3, Delta 4, The output of the combo box is wired to the input terminal of a case structure, in each case a fourth order butterworth filter is placed whose upper and lower cut-off frequencies are configured according to the signal that is going To be displayed.The waveform plotters are located on the front panel, in which the electroencephalogram signals for each channel will be displayed. See figure 6.

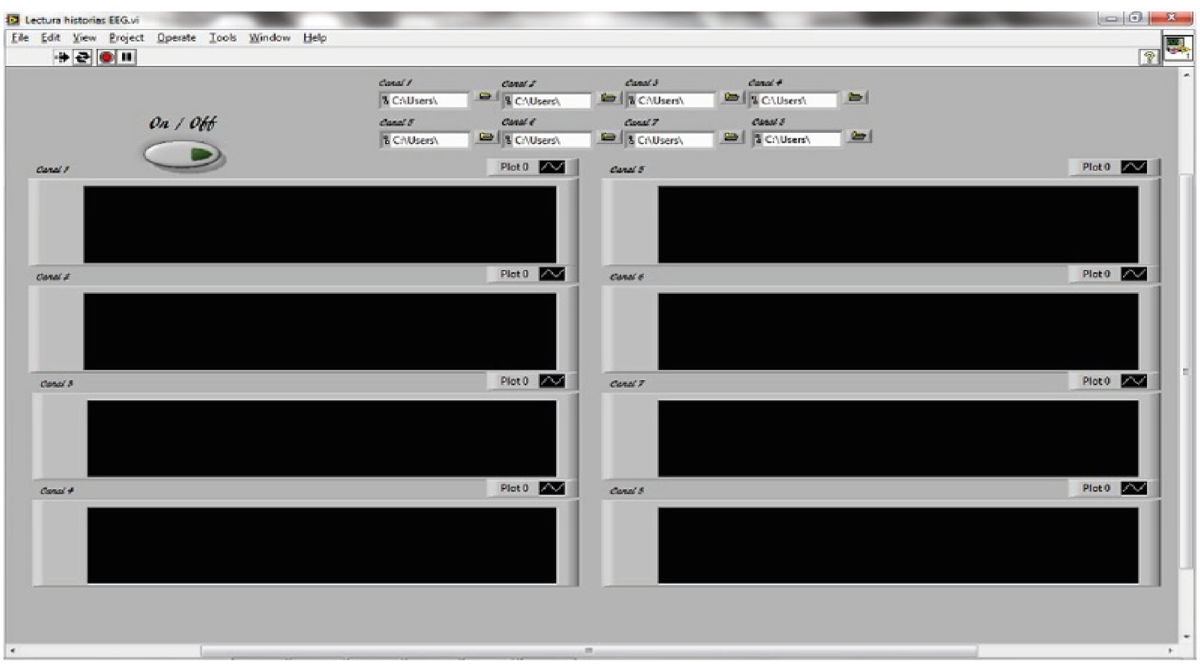

Figure 6. Electroencephalogram, [12]

EEG results

During the process of d Figure 6.To save the data in a file, in case it is required to make histories of the signals captured in the patients, a file creation and writing cycle is implemented, through a writing block of files, this block is configured through a dialog box and a Boolean control on the front panel the file path and choose whether to write data to a new file or to write continuous data to an existing file. See figure 7, design and development of the measurement system for EEG signals, the gain test of the conditioning circuit of this physiological signal was performed, with an input voltage level of 5.6mV, to establish the existing margin of error [13].

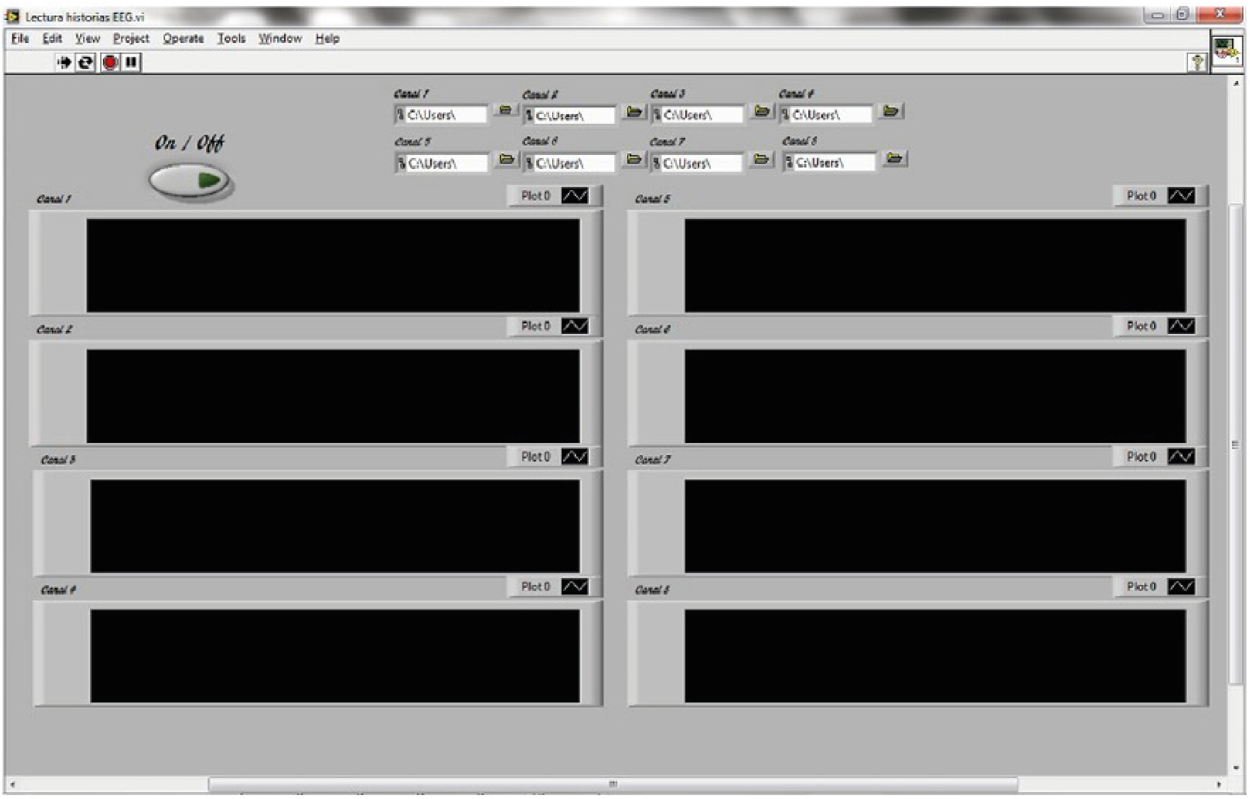

Figure 7. Design and development of EEG measurement

Additionally, a frequency response test of the conditioning circuit was carried out, using a signal generator and as a result a bandwidth of 113 Hz was obtained, which, compared to the theoretical value of 106 Hz, gives an absolute error of 7 Hz and Relative Error (%) of 6.6%, say the designed filter is working with an effectiveness of approximately 90%. This value of the bandwidth deviation of the filter will be compensated with the filtering by digital processing carried out in Labview [14].

After the above, it is concluded that the design of the conditioning stage of the EEG signal capture system is capable of taking the electrical signals generated by the brain for monitoring and processing through Labview.

To determine the functionality of the EEG signal measurement system, three patients aged 27 years, 28 years, and 30 years were chosen for the acquisition, acquisition, and visualization of electrical signals from the brain. Following the recommended procedure for this activity, the system was tested.

References

[1] K. Astrom y J. Bjorn, ***Wittenmark, Computer-controlled systems:*** theory and design, third edition, Capítulo I. México. Prentice Hall. 1997

[2] A. Creus ***Instrumentación industrial,*** 7 ed. México: Alfaomega grupo editor S.A. 2005.

[3] T.L. Floyd, ***Dispositivos Electrónicos,*** 3 ed. México: Linusa 2000

[4] Instituto Colombiano de Normas Técnicas, ***Normas Colombianas para la presentación de trabajos de investigación***. Santa fe de Bogotá D.C: 2008

[5] K. Ogata, ***Ingeniería de Control Moderno***, 3 ed. México: Prentice Hall- Pearson. 2001

[6] R. Pallas Areny, ***Sensores y Acondicionadores de Señal***, 3 ed. México: Alfaomega Marcombo. 1998

[7] A.P. Porras Monanero, ***Autómatas Programables,*** 5 ed. México: Mc Graw Hill. 1993

[8] Wonderware Factorysuite Intouch USER'S Guide. Version C. Invensys Systems, Inc. 2005

[9] L.E. Márquez, Y. Abdo y J.F. Ángulo, "Prototipo de control de acceso a aulas y registro automático de asistencia", ***Revista Colombiana de Tecnologías de Avanzada***, vol. 2, no. 26, 2015

[10] F.E. Moreno-García, J. J. Ramírez-Matheus, y O. D. Ortiz-Ramírez, "Sistema de supervisión y control para un banco experimental de refrigeración por compresión", *Respuestas*, vol. 21, no. 1, pp. 97-107, ene. 2016.

[11] J.R. Hechavarría-Hernández, A. Cordovés-García, y M. García-Pérez, "Sistema para el cálculo de redes de acueducto", ***Respuestas,*** vol. 6, no. 1, pp. 3-11, 2016

[12] M.L. Estrada-Estrada, F.J. Arias-Aragonés, y J.J. Jurado-Coronell, "Análisis del sistema integral de recuperación del servicio en el sector hotelero de la ciudad de Cartagena", *Respuestas*, vol. 21, no. 2, pp. 112-123, 2016.

[13] I. M. Ascanio y S. A. Ariza Quiñonez, "Diseño de sistema de control automatizado para horno de tratamientos térmicos de Aceros Cúcuta–Colombia", *Aibi revista investig. adm. ing.*, vol. 6, no. 2, pp. 27-32, 2018

[14] J. V. Sánchez Frank, "Diseño de un sistema con base en las nuevas tecnologías de la información y la comunicación para la medición de la calidad y productividad de la docencia universitaria", *Aibi revista investig. adm. ing.*, vol. 2, no. 2, pp. 2-12, jul. 2014