# Remotely controlled electronics systems through the World Wide Web

A. ETXEBARRIA and R. BÁRCENA
Electronics and Telecommunications Department
University of Basque Country (UPV/EHU)
E. U. Ingeniería Técnica Industrial de Bilbao.
Plaza de La Casilla, 3. 48012 Bilbao
SPAIN
ainhoa.etxebarria@ehu.es, rafa.barcena@ehu.es, http://www.ehu.es/apes

*Abstract:* - In recent years, there has been a surge of interest in the development of Information and Communication Technologies (ICT), especially in the realm of education. A large portion of current ICT work focuses on remote control devices that use HTTP browsers. This paper presents the phases to develop a system that allows multiple users the access to a multiple real electronic circuits using any HTTP browser. With this aim, specific hardware and software have been designed and incorporated to a server-computer which includes a data acquisition card. The novel feature of this work is that the user has in a unique environment with the descriptions of the circuits to study, the possibility to work with real measurements and the necessary laboratory instruments to analyze the circuit signals. The prototype employed analyzes basic analog electronic circuits in order to check out the practical viability of this type of remote control system. Once functionality is demonstrated, the prototype can be used as an applicable model for remote controls in any type of real system.
The communication protocols, control programs and user interfaces that allow the data transmission and the hardware access have been programmed using Virtual Instruments (VI) designed with LabView® – Laboratory Virtual Instrument Engineering Workbench. LabView® is a graphical programming language widely adopted throughout industry, academia, and research laboratories as the standard for data acquisition and instrument control software. The front panel of the VIs that guides the user through the system is embebed in his or her web browser like an ActiveX Control. In addition, the user has the possibility to pass information from the HTML browser to the application in the Server in order to study the behaviour of the composed circuits.

*Key-Words:* - WWW, remote control, Internet, interface, Virtual Instrument, HTTP.

## 1 Introduction

The current evolution of Information and Communication Technologies allows us to use new types of technology supporting teaching and learning systems for engineering education like the distance learning [1]-[2]. Taking a deeper look at the e-learning offer, is obvious that the theoretical environments predominate, like [3]-[4]-[5], upon the practical environments. So, it may be interesting to develop more applied systems. In this way, some studies focused in remote control devices managed remotely via HTTP browsers have been described. In addition, the design of new systems as alternatives to improve the functionality of the HTTP remote controls is a very important goal. Some of the best known efforts in this area are: in 1995 the University of Oregon created a laboratory to control a robotic arm [7], and in 1997 the Institute of Automatica of Lausanne (EPFL) [8] published a remote application to control a motor by means of a PID and used LabView® to design their virtual instruments. Following this same line of work, the computer engineering department at the Siena University designed an automated tele-laboratroy [9]. The Norwegian University of Science and Technology developed a laboratory for the characterization of electronic semiconductor devices [10]. The University of Tennessee's Resource Center for Engineering Laboratories on the Web offers students six experiments on process dynamics and control systems. [11] The Engineering faculty at the National University of Singapore offers virtual experiments in a variety of subjects [12].

This article discusses an innovative system that allows for the study and analysis of specific topologies of electronic circuits using an HTTP browser and Virtual Instruments [6]. Through this system, users have remote access to real measures acquired through different electronic circuits. Such electronic circuits are specifically implemented on configurable hardware and designed for this application. The concept of configurable hardware referred to here is based on the distribution of different electronic components on a printed circuit board. These components automatically interconnect to form a circuit which the remote user can later study the behavior of. Compared to previously mentioned projects [7]-[12], this research largely focuses on minimizing the amount of time the user occupies the selected experiment, thereby reducing the amount of hardware resources consumed and increasing the number of students served. In prior prototypes developed by the author of this paper, the system controls are only allowed for one remote user at a time, as described in [13]. Additionally, the manipulation of virtual instruments was based on sending the image of the front panel of the instrument, overloading the broad band connection and making it very slow. This paper discusses the solutions adopted to solve these problems, one of which being the use of ActiveX controls to create dynamic HTML pages containing virtual instruments – this is described in detail in [14].

Additionally considered is the development of software designed to control multiple user access to the electronic configuration for each user while using only one data acquisition system. The prototype employed analyzes basic analog electronic circuits to check out the practical viability of this type of remote control device. Once functionality is demonstrated, the prototype can be used as an applicable model for remote controls in any type of real system.

The system is made up of the following phases which are discussed throughout this paper: reconfigurable hardware; communication interface between configurable hardware and the computer that houses the WWW server; interface for remote user; protocols that administers and controls hardware access and users access to the system; and the design of dynamic HTML pages.

The paper is organized as follows: section 2 gives an overview of the general design of a remote control laboratory. The hardware and software techniques for controlling the process from a local computer is described in section 3 and 4 and, finally, in section 5, the remote control through an HTTP network is introduced.

## 2 General design of a remote access laboratory

The purpose of the laboratory is to offer students in remote locations the opportunity to study a real process. From their computer they can take measurements, analyze results, and manipulate real data. The prototype is designed to be used through any web browser (Fig. 1) so that the users do not need to install on or download to their computer any specific software.

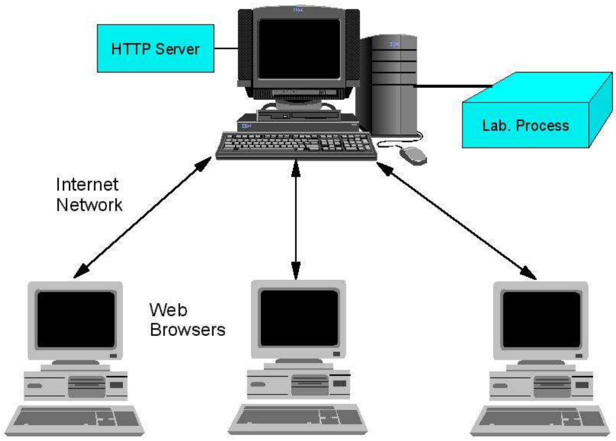


Fig. 1.- Access through the internet

To set up an automated laboratory the following interfaces are needed:

*Process/computer Interface* (Fig. 2) is based on a data acquisition card and specific programs and protocols necessary for signal sampling, to generate input signals into the process and to control for any other options available to the users from their computers.

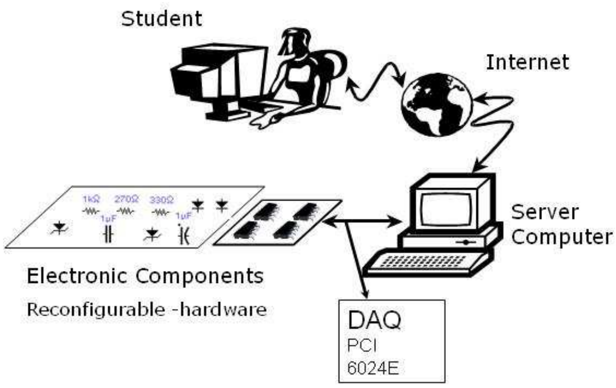


Fig. 2.- Process/computer interface

The card used here is National Instruments' PCI-6024E which uses two analog output channels (used to generate waves), 16 single ended input channels (used to gather answers from the circuits), and eight input/output digital lines (used for a communications protocol that allows users to choose a board as well as an experiment from that board). This data acquisition card was chosen because of its quality to price ratio. Its sampling frequency is sufficient for most experiments developed in the engineering field but if higher frequency is required, an interface with higher sampling frequency should be used and the budget subsequently increased.

*User/process interface* (Fig. 3), is based on VIs (Virtual Instruments) designed so that the user controls available circuits, studies the results and is able to compare them with theoretic results. These actions occur by means of specifically designed protocols that are completely transparent to the user.

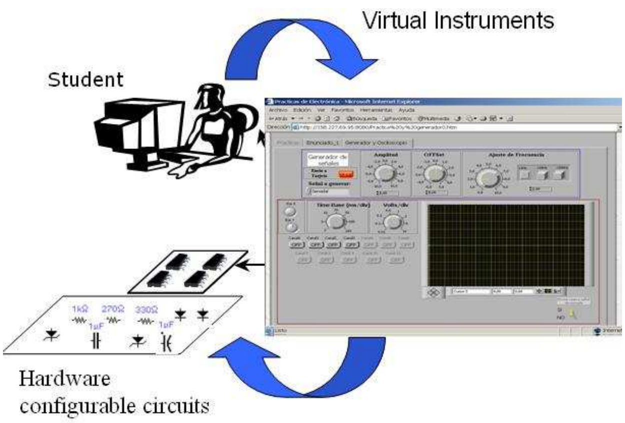


Fig. 3.- User/process interface

Both interfaces are houses in the Server machine together with the HTTP server and the programs that manager the laboratory access.

## 3 Design of programmable boards and communication protocol description

A remote laboratory is initially automated, monitored and tested using a local computer and then later can offer access from anywhere in the world. A detailed description of the programmable boards and the communication protocols developed follows below.

*Programmable board*: *reconfigurable hardware*. The system hardware, apart from a personal computer and the data acquisition card, is based on specifically designed configurable hardware circuits. The specific configuration of the hardware is selected using a computer via the digital outputs of the data acquisition card. The circuit is automatically configured.

The prototype discussed here is designed to offer an elevated amount of experiments, implying the need for different boards that contain configurable circuits.

The experiments that share a large number of common components are grouped together on the same board. The design followed for each of the boards allows for the interchanging of components that make up a whole circuit. Due to this design, components can be shared among experiments thus saving resources. Also, measurements are always taken from the same points thereby facilitating the process of automating the laboratory.

The interchange of components to form each circuit occurs by means of relays, which the user activates when selecting an experiment. This selection uses the same information needed to select a desired circuit.

One of the designed boards contains the next circuits or experiments: The behaviour of a basic diode, Diode like a "limiter", Diode to settle voltage level, Regulation with Zener diode. Different resistance values are available for each circuits and the whole design of this board is illustrated in Fig. 4. The relays that are necessary to be activate in order to make up each circuit with the different resistance values are presented in the next paragraphs:

Experiment 1: The behaviour of a basic diode.

A Option, 270Ω resistance: RL0 and RL15 have to be activated.

B Option, 1KΩ resistance: RL1 and RL15 have to be activated.

Experiment 2: Diode like a "limiter"

A Option, 270Ω resistance: RL0 and RL15 have to be activated.

B Option, 1KΩ resistance: RL1 and RL15 have to be activated.

C Option, 270Ω resistance: RL0 and RL14 have to be activate.

D Option, 1KΩ resistance: RL1 and RL14 have to be activated.

Experiment 3: Diode to settle voltage level

A Option, 10Ω resistance: RL2, RL11, RL14 have to be activated.

B Option, 4K7 resistance: RL2, RL8, RL14 have to be activated

C Option, 10Ω resistance: RL2, RL11, RL15 have to be activated.

D Option, 4K7 resistance: RL2, RL8, RL15 have to be activated

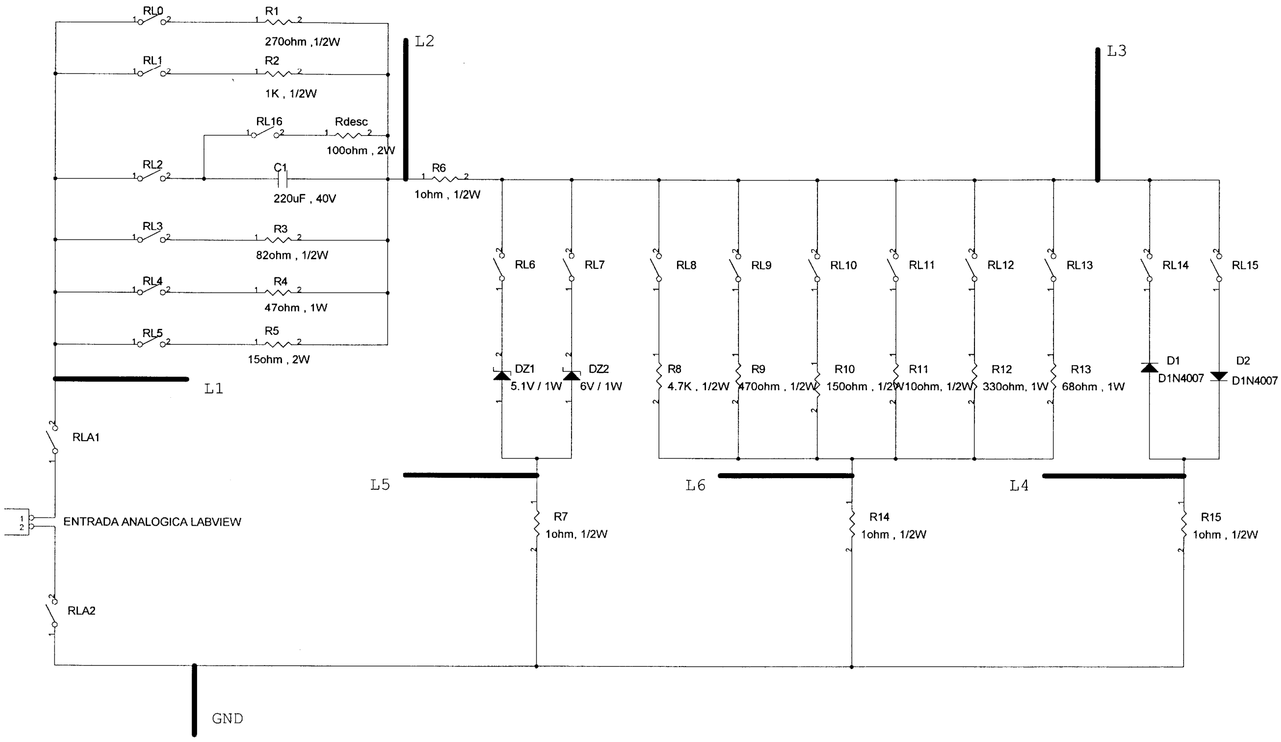


Fig. 4.- Configurable circuit by means of relays

Experiment 4: Regulation with Zener diode

A Option, 82Ω limiter resistance, 330Ω load resistance and 6V Zener diode: RL3, RL7, RL12 have to be activated.

B Option, 82Ω limiter resistance, 68Ω load resistance and 6V Zener diode: RL3, RL7, RL13 have to be activated.

C Option, 1KΩ limiter resistance, 330Ω load resistance and 6V Zener diode: RL1, RL7, RL12 have to be activated.

D Option, 1KΩ limiter resistance, 68Ω load resistance and 6V Zener diode: RL3, RL7, RL13 have to be activated.

A1 Option, 47Ω limiter resistance, 470Ω load resistance and 5.1V Zener diode: RL4, RL6, RL9 have to be activated.

B1 Option, 1KΩ limiter resistance, 470Ω load resistance and 5.1V Zener diode: RL1, RL6, RL9 have to be activated.

A2 Option, 15Ω limiter resistance, 150Ω load resistance and 6V Zener diode: RL5, RL7, RL10 have to be activated.

B2 Option, 15Ω limiter resistance, 10Ω load resistance and 6V Zener diode: RL5, RL7, RL11 have to be activated.

C2 Option, 1KΩ limiter resistance, 150Ω load resistance and 6V Zener diode: RL1, RL7, RL10 have to be activated.

D2 Option, 1KΩ limiter resistance, 10Ω load resistance and 6V Zener diode: RL1, RL7, RL11 have to be activated.

From L1 to L6 are defined as the points to take the measurements. These points are connected to the "measurements relays" and these relays, in his turn, to the analog inputs of the data acquisition card (Fig. 5)

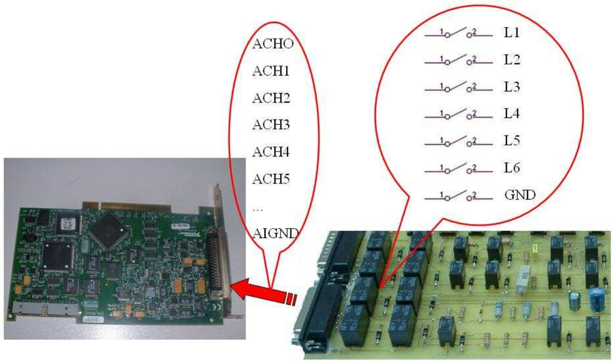


Fig. 5.- Measurements relays

| Experiment | Output | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| P1A | 000000 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 |
| P1B | 000001 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 |
| P2A | 000000 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 |
| P2B | 000001 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 |
| P2C | 000010 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 |
| P2D | 000011 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 |
| P3A | 000100 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 |
| P3B | 000101 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 |
| P3C | 000110 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 1 |
| P3D | 000111 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 1 |
| P4A | 001000 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 |
| P4B | 001001 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 |
| P4C | 001010 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 |
| P4D | 001011 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 |
| P4A1 | 001100 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| P4B1 | 001101 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| P4A2 | 001110 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 |
| P4B2 | 001111 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 |
| P4C2 | 010000 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 |
| P4D2 | 010001 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 |
| OFF | 010010 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 |

Table 1. True table for the combinational circuit

The design of this board includes 17 relays to select the components to form the circuit (RLi, i=0,..,16), 7 relays to acquire the signals to analyze from the selected circuit ("measurements relays") and 2 relays (RLA1, RLA2) to send the stimulus signal into the circuit.

The boards are interconnected through a series topology where information travels from the computer to the first board, then to a separate new connector located on the first board, then from the new connector to a second board, and so on (Fig. 6).

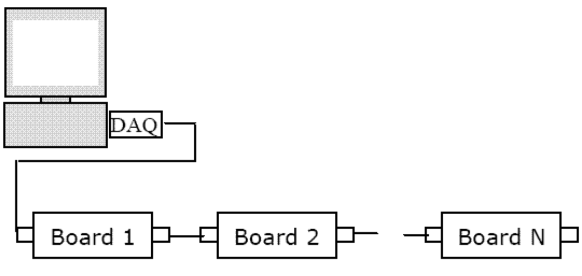


Fig. 6.- Connection between boards

The response route is the same, but in the opposite direction.

A diagram for the system described can be observed in Fig. 7.

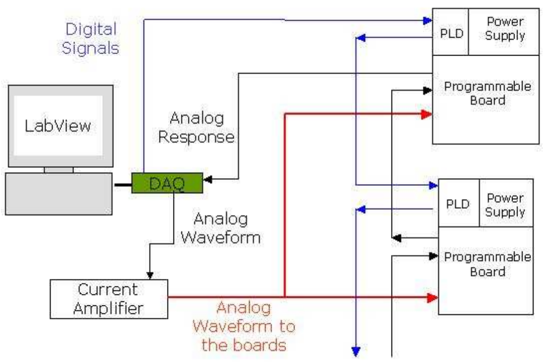


**Fig. 7.-** Generic design of an automated laboratory

*Communication Protocol*: The communication between server computer and the configurable hardware will be achieved through the digital lines of the data acquisition card. The selected algorithm uses all the eight digital lines to send two different information in two times: in the first time, the information is about the code of the board that contains the selected circuit and, in the second time, the digital lines carry the code to make up the circuit. A sequential digital circuit is needed to achieve this behaviour and the state diagram can be checked in Fig. 8.

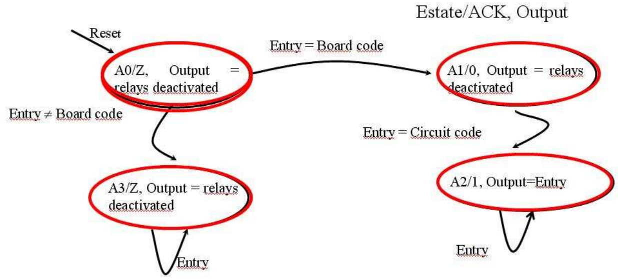


Fig. 8.- State diagram for the sequential circuit

Once the correct board is selected and the circuit code saved in sequential circuit's memory, a combinational digital circuit came into play. This circuit, based on the circuit code, activates the necessary relays. The true table of this combinational circuit for the board presented in this section is available in Table 1.

The logic programmable circuits that have been used to complete the described circuits are a PALCE22V10, for the sequential circuit and a EPM7032LC44-15, for the combinational circuit.

A schematic description of the board with the digital circuits is shown in Fig. 9.

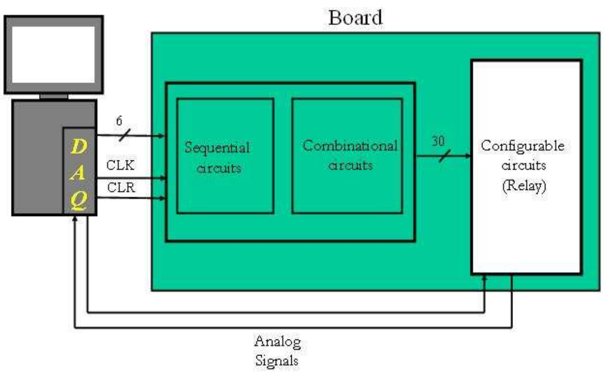


Fig. 9.- Board and digital circuits

The information to send through the digital lines to the digital circuits is loaded in memory thanks to the software design explained in the next section.

Fig. 10 shows a prototype with three interconnected boards and the necessary circuits and connections. The description of its numerated parts can be summed up:

1.- Current amplifier and power supply.

2.- CB-68LP connector to access to the inputs and outputs ports of the data acquisition card.

3.- Analog and digital buses interconnections .

4.- Boards that contains the electronic components to make up the selected circuit.

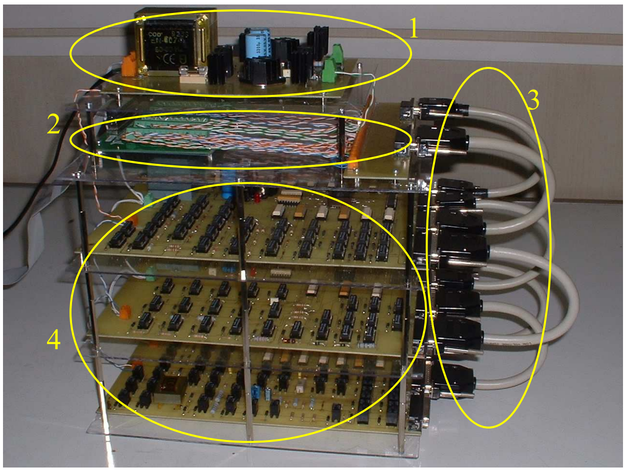


Fig. 10.- Prototype with tree board

## 4 Developed software to access to the selected circuit in the programmable boards

The protocols, control programs and user interfaces that allow the data transmission and the hardware access have been programmed with LabView®, a National Instruments product. All these programs can be grouped into two blocks: user/process interface and process/computer interface. The first one allows the user to select the experiment and the second one conducts the communication protocol described in the previous section.

The user/process interface includes the panels to select the experiment and to work with the virtual instruments. The process/computer interface is transparent for the user seeing that is executed under the user/process interface. Its task focuses on the communication between the server computer and the configurable hardware.

The user/process interface is designed with panels to guide the user through the laboratory and introduce VIs needed to conduct the experiments. The interface is compacted to fit into a single VI that is both simple and practical to use. The user only operates in one window from which they can choose the experiment and circuit, send a stimulus waveform, and study the response. The interface shows three tabs, as shown in Fig. 11. The first tab (Experiments) shows a list of all of available experiments and the user should select one.

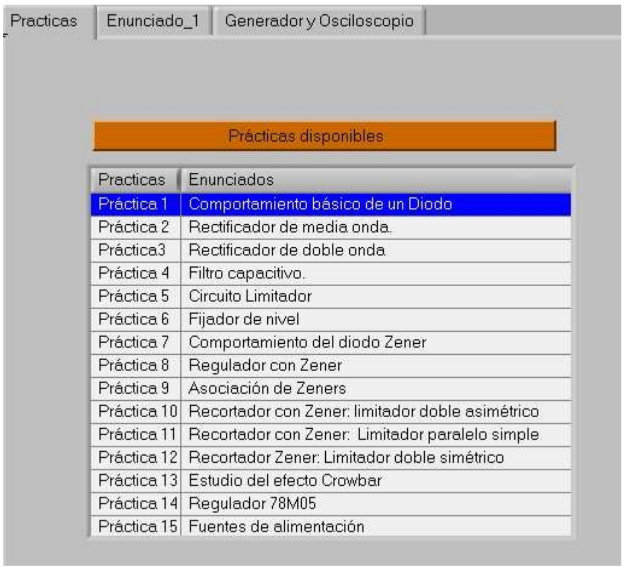


Fig. 11.- User interface: selection of experiments

Depending on the selection made, the second tab (Statement_nº) will show the corresponding statement for the experiment. (Fig. 12). The user must select one circuit (1 in Fig. 12) in order to study it behaviour.

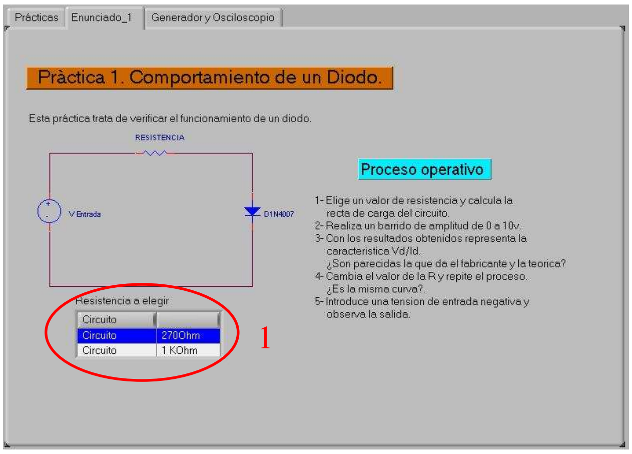


Fig. 12.- Statement from experiment 1

In the third tab of the interface, the necessary instruments to study any electronic circuit are at the user's disposal - such as a virtual signal generator and a virtual oscilloscope (Fig. 13).

Waveform generator: The student can monitor and generate different wave types (triangular, sine, sawtooth, pulse, square and continuous) and change the parameters (amplitude and frequency). Due to card limitations, parameters are limited to a range of between 0 to 10 V and from 0 to 100 Hz.

Oscilloscope: The student can view multiple channels or one at a time and establish various parameters such as time scale, amplitude and vertical and horizontal shift.

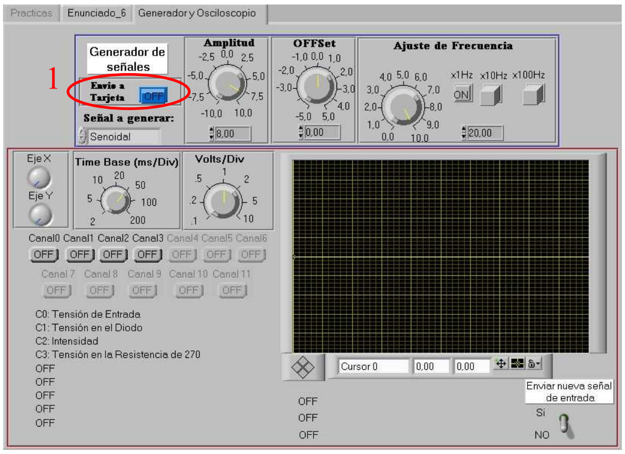


Fig. 13.- Virtual instruments : waveform generator and oscilloscope

Other advantages of these VIs are: storage ability and recovery of signals on a disk, possibility to display multiple channels, cursors for precise reading of values and the possibility to do mathematical operations among signals and to compare real values with simulated theoretic values.

The amount of storage capacity on a disk allows each student to create a personalized file containing their experiment results, so they can analyze the data without having to be connected to an experiment.

The corresponding algorithm for this area is summed up in the following steps: (including programming execution described in the hardware section -communication protocol and the generation and acquisition of signals).

Step 1: Expose the different experiments offered.

Step 2: Activate the screen that corresponds with the selected experiment.

Step 3: Select components of the experiment to be done $\Rightarrow$ assign a corresponding code to the following variables: the board that contains the experiment and the binary combination that activates relays on that board.

Step 4: Select the input signal using the virtual signals generator.

Step 5: Push "Envio Tarjeta" (1 in Fig. 13) bottom and then execute communication protocol thereby configuring the selected circuit.

Step 6: Generate the input signal.

Step 7: Receive circuit responses from different components of the experiment and store them in a text file.

Step 8: Study the signals saved in the text file using the virtual oscilloscope.

## 5 Server dedicated to remotely control the electronics experiments

The main objective for the automated experiments is none other than to gain remote access to real experiments. This section discusses the software and developments needed to set up a laboratory with remote access experiments, data transmission, and access to real applications using VIs designed with LabView®.

With this aim in view, in the server computer have been installed two web servers in two different ports. Obviously, we need LabView® package installed and continually running on the server machine, because the HTTP server programs are installed through this program.

One of the servers (G Web Server, Fig. 14), executes CGIs (Common Gateway Interfaces) and the other one (HTTP Server), publishes the HTML pages with designed user/process interface like ActiveX controls.

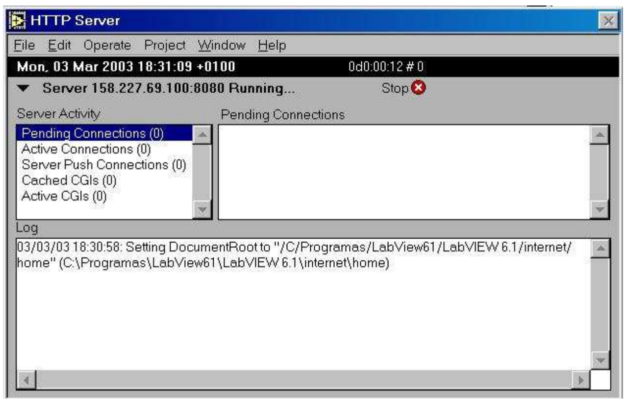


Fig. 14.- G Web Server panel control

In addition to these servers, a VI designed with LabView® stores relative data on resources and user access. Such information is constantly required by different interfaces in order to work accurately. One of the more important VI is the VI that saves Global Variables (Fig. 15), that is to say, variables that contain the necessary information for VIs executing in different instants.

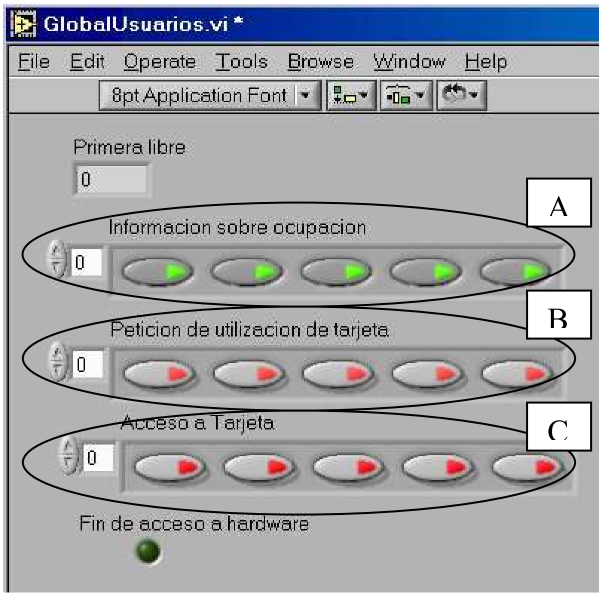


Fig. 15.- Virtual instrument panel saving the global variables

The number of users that have access to the system is limited by the server computer capacity to load in memory and run different VIs at the same time.

The G Web Server (Fig. 14) was configured to allow remote user interaction via CGIs. The designed CGIs have two functions when the users access to the system. The first one is devoted to administer remote user access to any open work space at a particular moment, so that once all work spaces are occupied, no other remote user can gain access. To carry out this action, the user select “Consultar ocupación” in Fig. 16 and the browser calls a GCI that check out the occupancy. In case that there should be a free work place, the user access to the system and the CGI marks in A in Fig. 15. a new occupied place.

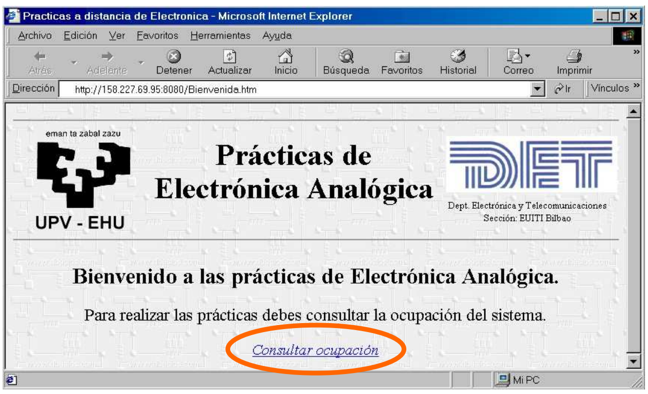


Fig. 16.- Main page of the WWW server

The second CGI function is to load in memory the VI associated with the front panel to embed like ActiveX control in the remote user HTTP browse. Once the VI is loaded in memory, the other server, the HTTP Server, come into play (Fig. 17).

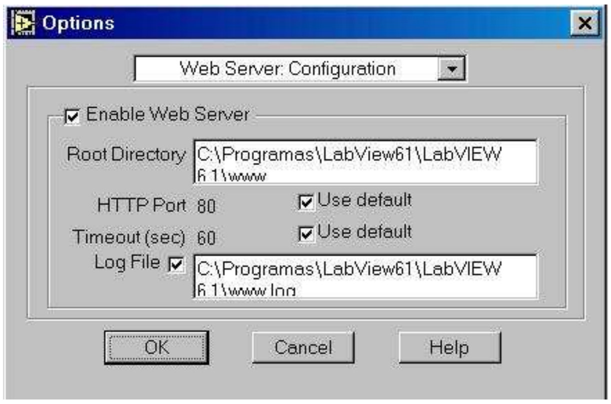


Fig. 17.- HTTP Server panel control

A specific CGI opens a new HTTP page, located in this server, with a front panel embebed on this page like an ActiveX control. By using these controls, the front panel that appears on the browser and the associated VI running in the system computer can interact. From this moment, the front panel presented in the section 4 (Fig. 11) is accessible through the user web browser (Fig. 18).

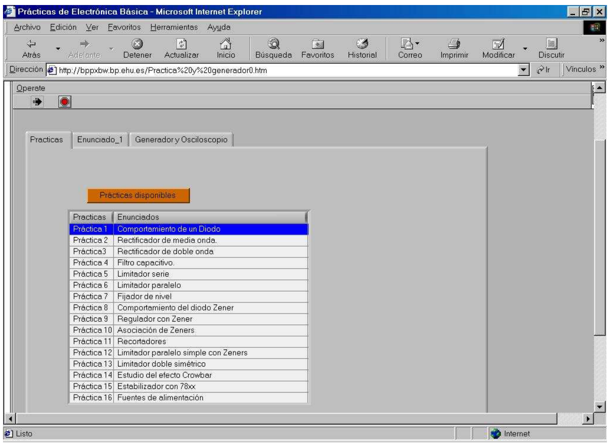


Fig. 18.- User interface via an HTML browser

Additionally, an application was implemented that administers the sequential user access to the data acquisition card. The user requests for data acquisition access are implemented after the selection of both the circuit to be studied and the analog input signal. At this moment the "data acquisition access" request is added to a waiting list (B in Fig. 15). Then, when the users turn comes up (C in Fig. 15), the chosen circuit is configured in the hardware described in the second section, the input signal is generated and the response signals from the circuit are acquired. The data acquisition card use by each user begins when the user pushes the "Envio Tarjeta" (1 in Fig. 13) bottom and finish with the acquisition of the response signals. In this interval, the communication protocol is executed. The whole time to make up all the tasks is about 1,5 seconds, but the design reserves 5 seconds for each user in order to create a security margin. This small time is possible because the signals are saved in a text file and, therefore, the data acquisition card utilization is not necessary anymore.

Everything described in this section occurs with complete transparency to the remote user. He or she only has to connect to the main page and request a free work space. If there is a space free, a Web page will open and the remote student can choose a circuit, stimulus signal and interactively study the response.

Remark that the remote access to experiments through an internet browser does not require installation of LabView® on the remote user's computer.

## 6 Conclusion

This area of integrated work leads to rapid progress and efficiency in the study of electronic circuits without losing the sensation of doing real experiments for the remote student. The VIs are designed in such a way as to demonstrate the same operating characteristics as real experiments, given that the circuit response obtained with the data acquisition card is from a real circuit, not from a numeric simulator. The technology used for controlling the VIs and to control the data information transferred through Internet is based on the use of CGIs and ActiveX controls. It is important to point out that a real time sensation is achieved thanks to the design of signal generators and virtual oscilloscopes, developed considering the similarities of use between these virtual instruments and those of a traditional laboratory. Because of this, a user experimenting with these virtual tools will not experience any problems adapting to use of a traditional analog instruments, keeping in mind that traditional here refers to non virtual (analogical or digital). Virtual instruments can be used seamlessly in any laboratory as an alternative or complement to traditional instruments. In fact, these virtual instruments offer possibilities that traditional tools can not, for example, the flexible storage of information. Virtual instruments also have an advantage, in respect to digital instrumentation, of being able to program any necessary operative for prompt development of an experiment.

One of the most noteworthy characteristics of this research is that it offers a low cost alternative from two points of view: one is that it eliminates the need to purchase a large quantity of software for electronic circuit simulation in teaching laboratories; and the other is that the proposed system does not require a large investment in hardware. All that is needed is a data acquisition card, a PC server, and one National Instrument's LabView® Software licence.

In conclusion, it is worth pointing out that a system based on an HTTP server and used to administer access to operations of a computerized data acquisition system, functions independently of the type of application executing on the server. This means that it is possible to modify and amplify the experiments without changing the access control system. All that would have to be done is to develop the hardware and add it to the series described in section 3.

*References:*


[1] S. Campanella, G. Dimauro, A. Ferrante, D. Impedovo, S. Impedovo , M. G. Lucchese, R. Modugno, G. Pirlo, L. Sarcinella, E. Stasolla, C. A. Trullo, "E-learning platforms in the Italian Universities: the technological solutions at the University of Bari", *WSEAS Transactions on Advances in Engineering Education*, Volume 5, January 2008, pp 12-19

[2] Tingsheng Weng, "The Study of Using e-Learning Platform to Analyst Learning Process. Curriculum in Higher Education", *WSEAS Transactions on Advances in Engineering Education*, Volume 5, June 2008, pp 447-456

[3] L. Seidel, R. Mª Benito, Mª E. CÁMARA, J. C. Losada, F. J. Arranz "Development of an Interactive Learning Environment for Introductory Physics in Engineering", *WSEAS Transactions on Advances in Engineering Education*, Volume 5, May 2008, pp 306-315

[4] S. Ivanov, D. Grenier, F. Labrique, M.J. Resende, B. Robyns, "Online Interactive Lessons on the Principle of the Direct Torque Control of the Induction Machine", *WSEAS Transactions on Advances in Engineering Education*, Volume 4, November 2007, pp 238-241.

[5] S. Enache, A. Campeanu, M.A. Enache, S. Ivanov, "E-learning Tools for Education in Asynchronous Machines",

[6] A. Etxebarria, I. Oleagordia, M. Sánchez; "Telelaboratory: Real-time Remote Access in Internet", *Computers and Computational Engineering in Control,* World Scientific and Engineering Society Press, pp 375-379, 1999.

[7] B.Aktan, C.A Bohus, L.A.Crowl, "Distance learning applied to control engineering laboratories", *IEEE Transactions on Education*, Vol. 39, No 3, 1996, pp 320-326.

[8] D.Gillet, C. Salzmann, R. Longchamp, D. Bonvin, "Telepresence: an opportunity to develop real-world experimentation in education", *European Control Conference*; Belgium 1997.

[9] M. Casini, D. Prattichizzo, A. Vicino, "The Automatic Control Telelab: a Remote Control Engineering Laboratory", *40th IEEE Conference on Decision and Control*, Florida USA, December 2001.

[10] T.A. Fjeldly, M.S. Shur, H. Shen, T. Ytterdal, "Aim-Lab: A System For Remote Characterization Of Electronic Devices And Circuits Over The Internet", *Int. Caracas Conference on Devices, Circuits and Systems ICCDCS-2000*, Cancun, Mexico

[11] J. Henry, "Controls Laboratory Teaching via the World Wide Web", *ASEE Paper*, Washington, DC, June 1996.

[12] C.C. Ko, B.M. Chen, J. Chen, Y. Zhuang, K.C. Tan, "Development of a Web-based Laboratory for Control Experiments on a Coupled Tank Apparatus", *IEEE Transactions on Education*, Vol 44, No 1., February 2001, pp 76-86.

[13] A. Etxebarria, I. Oleagordia, M. Sánchez, "Laboratorio de Electrónica Analógica controlado por Instrumentos Virtuales local o remotamente", *SAAEI´01*, Septiembre 2001, Matanzas Cuba.

[14] J. Travis, "Using LabView for Remote Virtual Instrumentation Via the Internet: An Overview", http://www.ni.com/academic/distance_learning.html

[15] J. Travis, "Internet Applications in LabView", Prentice Hall, 2000