



RESEARCH ARTICLE

**TOWARDS VIRTUAL LABORATORIES: A SURVEY OF LABVIEW-BASED
CONDUCTION OF SCIENCE EXPERIMENTS VIA THE INTERNET WITH AN
ILLUSTRATIVE CONSIDERATION OF REMOTE CONTROL OF AN OSCILLOSCOPE**

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ABSTRACT

In this work, a Remotely Accessible and Configurable Digital Cathode Ray Oscilloscope experiment system is designed in LabVIEW graphical development platform. The LabVIEW application is used to perform several tasks that include user interface design, publishing and sharing measured data over the web, instrument control and remote access to a system in the campus Physics lab. This paper describes how to control a digital CRO existing in a laboratory via a PC running LabVIEW from National Instruments. In addition, how to turn any LabVIEW application into a remote application accessed via a Web browser without any additional development time is explained in detail. The other instrument used in the work is a non-programmable signal generator. Ensuring instrument control and publishing the front panel on the web, students are allowed to access and control the system variables such as adjusting the CRO timebase, running Autoseup, Reading the Waveforms and acquiring continuous signals from the signal generator by the CRO. A student accesses the website through a web-browser (Internet explorer) by using an URL provided. Once the website is located, the student is required to login by putting in the name and the admission number. Once these details are verified, the user is allowed to proceed with the experiment.

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INTRODUCTION

Nowadays Internet is widely used in many areas in daily life. The recent scope of the internet is not only ordinary communication skills but also remote measurement, monitoring and control. The usage of internet in such an application provides some advantages in education especially in distance type besides other areas. For example, it enables a distant user to access and operate a remote system, and to monitor the outputs of the system as well. (Arslan, 2006). Recently used new technologies such as Virtual experiments or distance education do not satisfy the two counterparts of the education (instructors and learners). By supporting those types of education with some real components as used in normal face to face in-lab and/or in-class education will help to minimize the disadvantages of virtual one. (Sapijaszko, C. and Sapijaszko, 2004, Cheng and Chan, 2002, Baccigalupi and De Capua, 2006). For example instrument control softwares allow the students to access a real instrument such as a dc power supply, functional generators among other programmable instruments from their home. With LabVIEW software, one can design a remote panel exactly the same as real one. Then students can learn how to use an instrument existing in the laboratory without attending

the lab session by accessing it remotely. In fact it is possible to learn how to use an instrument by using a simulator. But simulators do not support the real instrument control via internet. Remote Access can be defined as the ability to log onto a network from a distant location. Generally, this implies a computer, a modem, and some remote access software to connect to the network. Whereas remote control refers to taking control of another computer, remote access means that the remote computer actually becomes a full-fledged host on the network. An instrument driver is a set of software routines that control a programmable instrument. National Instruments provides instrument drivers for a wide variety of instruments. In LabVIEW, an instrument driver is a set of VIs that communicates with an instrument. Each VI corresponds to a programmatic operation, such as configuring, reading from, writing to and triggering an instrument. LabVIEW instrument drivers simplify instrument control and reduce test program development time by eliminating the need for designers to learn the complex, low-level programming commands for each instrument. Instrument drivers are available for more than 5,000 instruments from over 200 different vendors for LabVIEW (NI). With the built-in Web Server in LabVIEW, the front panel of the application can be published without adding any development time and programming skills to the project. After enabling the Web Server, LabVIEW generates front panel images that the distant user (clientele) can access

om any Web browser such as internet explorer, Mozilla Firefox, Google Chrome among others. With remote control, the execution of a system is controlled from another computer in a distant location. In LabVIEW, remote execution can be achieved for every application developed with just a few clicks of the mouse. LabVIEW remote front panels allows users to view and control VIs through a standard Web browser. Creating a remote front panel Web page is easy with the LabVIEW Web Publishing Tool. A few mouse clicks creates a Web page with the embedded VI front panel image that can be viewed through the client's Web browser. Remote front panels allow only one client to simultaneously view the front panel of the same VI in older version of LabVIEW. However, in new versions such as LabVIEW 8.20, multiple clients can control the VI's front panel at the same time. The main aim of the complete work is to design a new alternative educational environment for Electronics-Instrumentation Education and Computer-Control Education at Pwani University College. This will help to design a remotely accessible Electronics Laboratory which is the most real virtual application while controlling real instruments remotely. In addition this will support the student's lab-practice works without any time and place limitation. In this method, measured data from the experiment kits on the server side are transferred into internet by using LabVIEW Web Publishing Tool to enable the student access.

GENERAL STRUCTURE

As shown in Figure 1, the user who will control the system (student) and the system which will be controlled by (experiments) are separated by a distance. The connection between them is only internet. The realized Remotely Accessible and Configurable Electronics Laboratory system mainly consists of two parts (Azaklar, 2007):

- Hardware
- Software

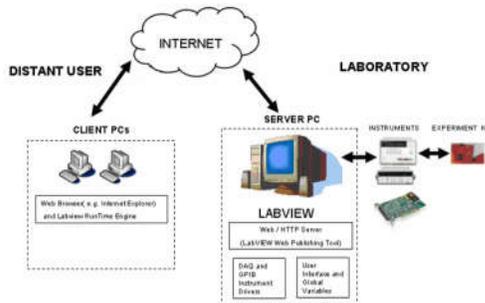
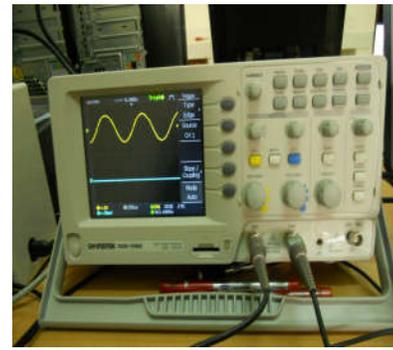


Fig. 1. General overview of the Remotely Accessible and Configurable Electronics Laboratory

Hardware

Hardware requirements of the system are as listed below

- *J2465-2 Signal Generator*- Non-programmable. The control was done through its front panel
- *GW Instek GDS-1022 Digital storage oscilloscope-25MHz* with a SUG interface
- *Control/ServerClient*
- *Client PC*



(a)



(b)

Fig. 2. Programmable Instruments (a) HP34970A Data Acquisition/Switch Unit (b) HP 3632A DC Power Supply Control

Software

In this paper, mainly software part of the complete system will be focused. Required softwares are listed below:

- Instrument drivers (Server PC)
- National Instruments LABVIEW 9.0 Evaluation edition and Web Publishing Tool
- LabView Runtime Engine and a Web Browser (Client PC)

Instrument Drivers

Software support is the most extensive of any instrument, including comprehensive drivers and ActiveX/COM-based programming tools for nearly every programming environment under any operating system. That's why instrument drivers are very important for communication between programmable instruments and a PC having a test and measurement software such as Lab view. One of the most important components in test systems today is instrument driver software. Instrument drivers perform the communication and control of the instruments in the system. Instrument drivers are the key to rapid development of test and measurement applications. By providing high-level and modular VIs, libraries, and classes for easy programming, they eliminate the need for users to learn complex programming protocols. An instrument driver is a set of software routines that correspond to a programmatic operation such as configuring, reading from, writing to, and triggering the instrument. Those drivers can be downloaded from NI Instrument Driver Network web page ("<http://sine.ni.com/idnetwork/>") freely. The programmer must choose the appropriate manufacturer or model number from this site.

Instrument Test

Measurement and Automation Explorer (MAX) provides access to all NI DAQ, GPIB, IMAQ, IVI, Motion, VISA, and VXI devices. With MAX, NI hardware can be configured, new channels, interfaces, and virtual instruments can be added, system diagnostics can be executed, and the devices and instruments connected to the system can be viewed. (MAX) In the set up shown in Figure 3, MAX shows a GPIB system with a HP34970A *Data Acquisition/Switch Unit* and a HP 3632A *DC Power Supply*.

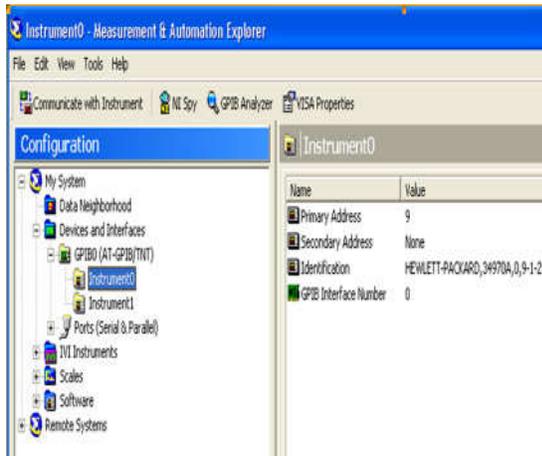


Fig. 3. NI-MAX Interface

If the Devices and Interfaces folder is expanded by clicking on the plus (+) sign next to it, all instruments and interfaces can be viewed. By right-clicking on the GPIB interface and selecting “Scan for Instruments”, MAX automatically detects two instruments. To be able to be sure that the devices are working properly, the user should right click on the desired instrument and then select the “Communicate with Instrument”.

Access to Instruments in LabVIEW Platform

Once a driver has been installed, the user can access the instrument driver from the Instrument I/O palette by clicking on the Window menu and selecting “Show Functions Palette” in Block Diagram as shown in Figure 4.

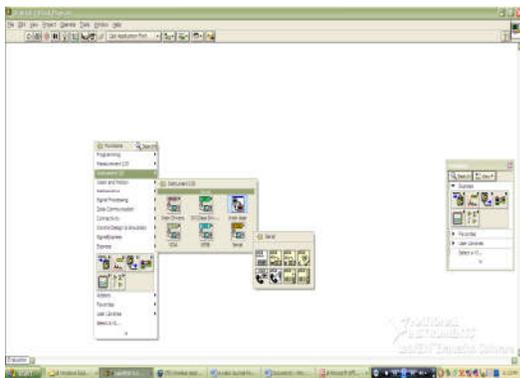


Fig. 4. Function palette view in LabVIEW showing Instrument I/O

Web Interface (Web Publishing Tool)

In this study, Web Publishing Tool of the LabVIEW application has been utilized. First of all, Web Publishing Tool under the Tools menu on the Front Panel is selected in order to access to the realized laboratory environment. Once the Web Publishing Tool option is clicked, the dialog box shown in the Figure 5 is displayed (NI).

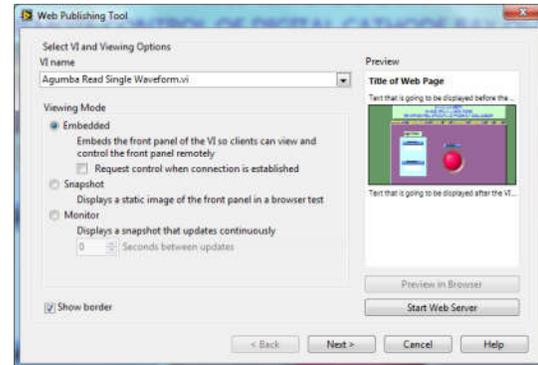


Fig. 5. Web Publishing Tool Window

The Document Title and VI Name fields in the displayed window are loaded automatically. The Document Title option indicates under which title the VI to be published shall be displayed. The Header option enables you to enter notes to be displayed above the VI and the Footer option enables you to enter notes to be displayed below the VI. All these fields can be modified as you desire. There are 3 different viewing options of VI over the internet. In case you want to grant control rights to the users, the embedded option shall be selected. Also the Request Control option shall be selected too. In case the Snapshot option is selected, the front panel of the VI will be displayed as an image. The Monitor option will only grant rights to monitor the VI's. There is no control right at this point. After applying these settings, one may use the “Preview in Browser” option to preview the web site to be published. In the second step, the web server shall be started. In order to do this, the “Start Web Server” option is selected shown on the same page. By selecting this option, the PC functions as a web server. In the last step, the html file which will be published over the internet is created using the “Save to Disk” option. This file will be saved under the www folder in the Lab view application as default (C:\Program Files\National Instruments\Lab view 7.0\www\). After saving the file, the URL address dialog box, which will enable the access over the internet, will be displayed. After OK is clicked, the created laboratory environment is ready to be published over the internet.

Web Server: Configuration

Fist of all, the settings in this option shall be done. By selecting “Enable Web Server” option, the Web Server functionality of the PC is defined. The location of the address to be published over the internet is entered in the “Root Directory” field. The default “HTTP Port” is 80 as shown in Figure 6. The location of the user access information file is entered in the “Use Log File” field.

Web Server: Browser Access

It is easy to publish over the web using the NI LabVIEW and there is also a powerful security option. In order to enable this, the option Tools-Web Publishing Tool- Options- Web Server: Browser Access is selected. There are three selections under this option as shown in Figure 7.

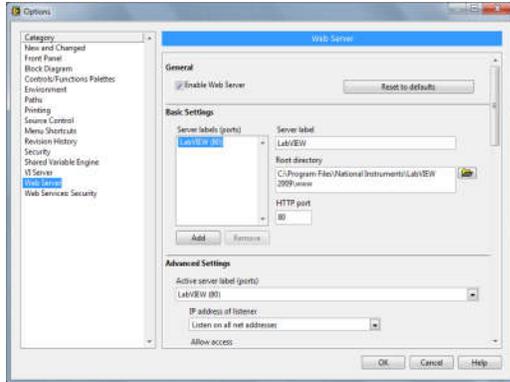


Fig. 6. Web Server: Configuration Window

Allow viewing and Controlling

User IP addresses with both viewing and control rights are defined.

Allow Viewing

User IP addresses with only viewing rights are defined.

Deny Access

Banned user IP addresses are defined. In case you want to grant access rights to all the users, then (*) is defined.

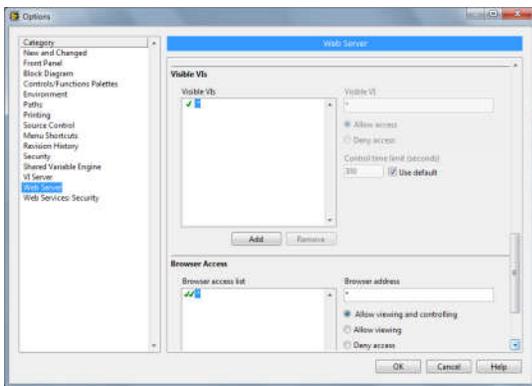


Fig. 7. Web Server: Browser Access

Web Server: Visible VIs

The programmer may grant access to only the selected VI's created in LabVIEW. You may grant access individually and if you desire to grant access to all VI's, then you must define as (*). Also the access time to these VI's is defined by using this option. In this way, the VI access is granted within the defined time. This option, granting multiple user access, is highly important for this application. In case a time is not

defined in the "Control Time Limit" option, then the user has unlimited control access. In this situation, other users are blocked from accessing as shown in Figure 8.

RESULTS AND DISCUSSION

First, the student must login by inserting the correct name and admission number for authentication. This is to make sure that only learners registered for the lab session are allowed to perform the remote experiments. The details are entered in the GUI below.



Fig. 8. Login window

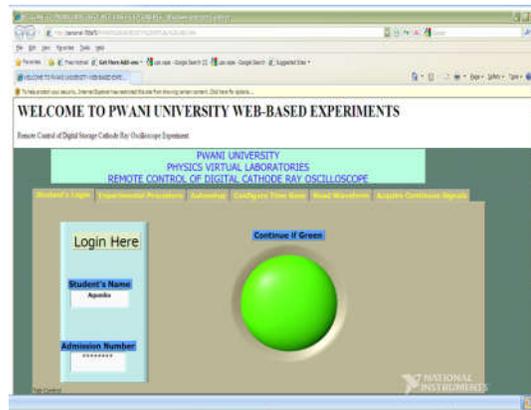


Fig. 9. Login window showing authenticated user

Once the student is logged in, the indicator turns green as shown in the figure below and he/she will be able to continue with the experiment. After successful login the student shall now proceed by reading the experimental procedure as shown in the user interface below.



Fig. 10. Window showing experimental procedure

The user shall now start conducting the experiment by first performing autoseup of the digital storage CRO, configure the CRO time base, read waveforms and acquire continuous waveforms. Figure 11 shows a GUI that is used by users/clientele to configure the CRO time base.

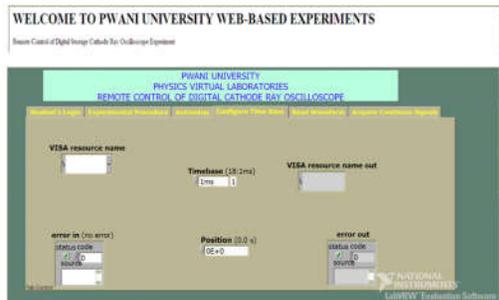


Fig. 11. GUI showing timebase configuration

The user shall be able to continuously monitor the signals generated by the signal generator and displayed in the CRO screen. Figure 12 shows a photo of the whole system with the generated signal displayed on the screen of the client computer.

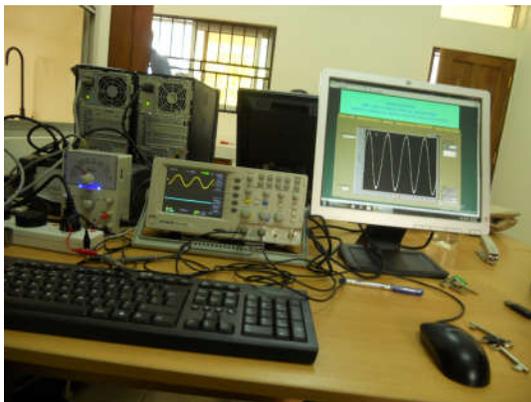


Fig. 12. A Photograph of the virtual laboratory server

EVALUATION AND CONCLUSION

In this study, a remote access real-time environment has been developed in order to support the laboratory studies of the students in Pwani University. It is possible to monitor the changes in the output parameters by changing the input parameters of the experiments by using PC-controlled instruments and an appropriate software.

LabVIEW seems the easiest one among the other solutions. It is easy to learn and use for instructors and also students. Additionally, it provides web applications rapidly. Anyone who has experience about LabVIEW in lower-intermediate level can publish his/her own project including real instrument control to the internet. With the realized laboratory environment, it is thought that the problems occurring in the applications such as time limitations, group study etc. may be solved at certain level and also contribute to the success of the students.

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