

Virtual Instrumentation as an Effective Enhancement to Laboratory Experiment

Yogendra B.Gandole

Dept. of Electronics

Adarsha Science J.B.Arts and Birla Commerce

Mahavidyalaya Dhamangaon Rly-444709 (India)

Abstract— This paper describes a tool to improve the electronics laboratory process. The tools really constitute a virtual electronic laboratory because it is made up of a set of virtual experiments with a user-friendly graphic interface and interactive simulated electronic instruments relating practical concepts with theoretical ones. The combination of the demonstration and the virtual electronic laboratory constitute a bridge between theoretical lessons and laboratory classes. The professor can use the experiments of the virtual laboratory in the classroom to improve student retention. Using this tool, undergraduate students improve their performance and increase their efficiency in the laboratory. A pilot experience has been implemented for Basic Electronics. This work demonstrates that instrumentation experience is greatly enhanced by integration Virtual Instrumentation into the Laboratory. The incorporation of computer data acquisitions into the undergraduate laboratory provides students with a valuable tool for data collection and analysis.

Keywords— Virtual Instrumentation, Laboratory Experiments, Learning Tool, Computer Technology.

I INTRODUCTION

The computer technology has the potential to provide a highly interactive and powerful learning environment for science and engineering disciplines. As Education and technology merge, the opportunities for teaching and learning expand even more. However, the very rapid rate of change in the fields of technology poses special problems for academic institutions, specifically for the science and engineering disciplines. There is of course a continual need to update and augment the content of curriculum to keep pace with this change, but it is in the area of science education and experimental work where major concerns arise. The central problem still remains the same; providing for students meaningful and relevant practical experiences while being limited by very finite resources in the provision of laboratory hardware and infrastructure. One solution to this problem is to use computer based techniques to interface the students with the physical world, with suitable front end design to provide increasing sophistication and increased flexibility. Although a

number of computer-based customized engineering courses and test systems [Pudlowski, (1995)] ,have been developed within the past ten years to replace conventional engineering courses, they have a number of limitations such as inflexible and unfriendly programming structure, excessive cost, hardware limitations, short and long-term incompatibility issues. However, due to recent technological advances in computer technology and software, it is now feasible to implement more advanced, more efficient, highly interactive and very user-friendly systems without using very costly custom-written software and tools. Virtual Instrumentation is an important technology that is making a significant impact in today's industry, education and research. Virtual instrument software can be used for simulation, and with appropriate interfacing, it can also be applied to data acquisition and control. Any instrument that has a GPIB capability includes in its manual a listing of GPIB commands. These commands can be used in LabVIEW environment to build a custom instrument driver whose functionality satisfies individual needs. As needs change, these drivers can be easily modified and expanded. An additional benefit of the custom tailored instrument driver is the inclusion in the same software package specific data processing tasks that a commercial package will not have. The VI that integrates instrument control and data processing can be modified and expanded with relative ease to include other instruments as well as additional processing tasks. For example, the waveform that an oscilloscope is displaying in process monitoring operation can be imported into a GPIB VI over the GPIB bus. The data can then be displayed on a waveform graph or stored to a file for future reference. The data can also be applied to immediate signal processing such as displaying its frequency spectrum in order to assess process performance in real time. This paper describes this type of instrument control for three different instruments with data processing.

The literature reviews indicate that LabVIEW is one of the primary choices in designing control and analysis solutions in the area of engineering technology and education. Some of the exceptional LabVIEW user solutions are reported, as 'user solutions' by the National Instruments Corp. (1999), which all are

multidisciplinary engineering solutions. The reference [Virtual Instrumentation in Education, Conference Proceedings, (June 1997)] contains many papers and covers: mechanical engineering, electrical and nuclear engineering, physics, biomedical engineering, chemistry and chemical engineering, and data acquisition and instrument control over the Internet. Lee (1996), integrated LabVIEW software into an instrumentation and experimental methods course for mechanical engineering students. Other researchers have developed LabVIEW applications for students in agricultural and biological engineering (Sumali, (2002)), mechanical and industrial engineering (Crist(2001)), and engineering technology (Bachnak(2002), Chen(1998), Chickamenahalli *et al*(1998), Krygowski (2001),). Some specific instances of LabVIEW-based experiments in introductory chemistry laboratory courses have been reported by others [Drew (1996), Muyskens *et al* (1996), Beasley *et al* (1999)].

An advanced teaching/learning laboratory can be developed by purchasing completely new equipment. However, this approach is the most expensive solution for academic institutions. An alternate cost-effective solution is to take the old laboratory, proven systems, and retrofit them with the computer data acquisition systems and develop custom-written software to suit the existing experimental modules.

Furthermore, when technology-intensive teaching tools become widely available, the traditional roles of the university lecturers will change from pure classroom-based teaching to one of consultation, advice and direction giving. However, it is believed that the technology-based course will not eliminate the educators; instead it will change the type of activities the educators carry out. In the technology-based teaching/learning practice, the major activities of the lecturers may include preparation of the software packages, adopting new concepts and new teaching practices, modifying existing materials to suit the changes introduced in the latest version of the multimedia tools, and above all these they can spend time to continuously evaluating the teaching/learning outcomes.

This paper is a result of my development effort to include virtual instrumentation experiments in the electronics laboratory of the undergraduate programme of B.Sc. Electronics

II EXPERIMENTAL SETUP

In the laboratory applications, from the technical point of view, all the science problems deal with some physical quantities such as temperature, speed, position, current, voltage, pressure, force, torque, etc. A computer equipped with the suitable interface circuits, data acquisition systems and software, can give a visual look to these quantities, and can process the acquired data. Figure 1 illustrates the common features of a computer-assisted real-time experimental module.

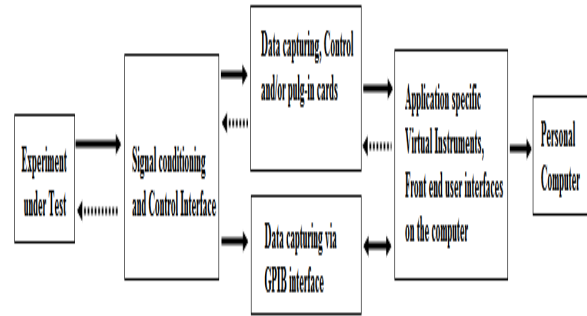


Fig. 1: The general block diagram of a Virtual Instrumentation-based laboratory system.

III DEVELOPMENT OF SOFTWARE

A number of interactive computer-delivered simulation, control, and scientific visualization software solutions are available in the market, and many application-specific tools have already been reported in the literature [Pudlowski, (1995)], which use diverse software, such as Hypertext, Authorware, Director, Labtech, Visual C., Visual Basic, Matlab/Simulink, and LabVIEW. It is found that the following criteria may be contemplated [Dehne, (1995)] for selecting application software to build virtual instrumentation used in Science and engineering education:

- Modularity, allows to test individual modules easily and to develop applications quickly.. Multi-platform portability enables designers to work on separate parts and compile them on one platform.
- Compatibility with existing code, allows incorporating with previous applications, and also with the previous versions of the software.
- Compatibility with hardware, to be able to gather data from different interface hardware.
- Extendable libraries, to let the designer build libraries of low-level routines to link them in higher level systems.
- Advanced debugging features, to optimize product design and to determine a defect in the code.
- Executables, to avoid alteration, to hide the code or to create standalone applications.
- Add-on packages, which indicate the market acceptance of the product and speed the development.
- Performance, to ensure that the end product meets the required performance.
- Intuitive Graphical User Interface (GUI), enables a user to look at it and see what needs to be done.
- Multimedia capabilities, for future developments.

However, due to the diverse nature of the lectures and the laboratory courses in every institution, custom-built software and hardware development is required most of the time. In addition, due to the fast developments in technology, the choice of the software and hardware should be considered carefully along with the cost. The ideal software tool should have all the features listed above. However, the commercial packages available in the market for the science and engineering courses are either very complex to use or do not provide all the necessary functions to achieve the certain tasks, or are too expensive. The LabVIEW software allows for the creating of application-specific templates (sub-virtual instruments) to reduce the production time for the identical subjects. Many useful functions can be incorporated with the LabVIEW programs to perform very useful tasks in a laboratory virtual instrumentation system design. Some of these useful functions [National Instruments, (May 1999)] are listed below:

- adding warning/message sounds or voices;
- providing instructions, pre-practical tutorials and/or interactive short-tests [Ertugrul, (1998)];
- generating a test report or a data file in a common text format;
- printing a specific chart or a part of the user front panel;
- linking to other currently available systems and software;
- inclusion of passwords to limit the access;
- animating the system or subsystem operation for easy understanding;
- providing GUI that mimics the real instruments;
- playing a video.

The modularity of LabVIEW programming allows the designer to simplify the programming structure by using sub-virtual instruments (sub-VIs), which may require thousands of lines of codes in other programming software tools. All LabVIEW graphical programs, called Virtual Instruments or simply VIs, consist of a Front Panel and a Block Diagram. Front Panel contains various controls and indicators while the Block Diagram includes a variety of functions. The functions (icons) are wired inside the Block Diagram where the wires represent the flow of data. The execution of a VI is data dependant which means that a node inside the Block Diagram will execute only if the data is available at each input terminal of that node. By contrast, the execution of a traditional program, such as the C language program, follows the order in which the instructions are written. LabVIEW incorporates data acquisition, analysis and presentation into one system. For acquiring data and controlling instruments, LabVIEW supports IEEE-488 (GPIB) and RS-232 protocols as well as other D/A and A/D and digital I/O

interface boards. The Analysis Library offers the user a comprehensive array of resources for signal processing, filtering, statistical analysis, linear algebra operations and many others. LabVIEW also supports the TCP/IP protocol for exchanging data between the server and the client. LabVIEW v.5 also supports Active X Control allowing the user to control a Web Browser object.

IV STUDENT LAB EXPERIMENTS

A very important part of Electronics education is student lab experiments, where students carry out their own experiments. The experience to make an experiment and to observe, measure and acquire data is essential for a deep and thorough understanding of physical processes. Doing lab experiments, the students are learning experimental techniques and begin to understand the inherent limitations of precision in measuring relevant parameters. Different types of sensors are used to track and measure variables during a student lab experiment. We use LabVIEW and E-LAB-080 in this domain for the following main reasons:

- The appropriate use of E-LAB-080 and LabVIEW-based instrumentation to acquire signals gives the student more time for observation and investigation of physical and electrical processes.
- The possibility to modify and adapt, as well as the versatility of virtual instrumentation, saves time and funds, and allows maintaining a large number of dedicated to individual experiments

The investigator developed the software using “mixed” design methodology. The programme modules were developed using Visual Basic 6.0, Visual C++, Multisim-8, LAB-VIEW-9 and SPICE programming language in Window 2007 environment. It provides multimedia presentation platform to attract the sense of learner for easy and happy learning. The investigator had seen that the frames were unambiguous, brief, simple and straightforward. An associated instrumentation, have been piloted with over 100 undergraduate Electronics science students affiliated to Sant Gadge Baba Amravati University, Amravati.. The design of the Computer Software for each of these experiments was divided along pedagogical lines into three sections which are presented consecutively to the students:

1. Introduction

In this section, the students were given an overview of the experiment to be undertaken, an animation showing how it worked, what was being measured and how it related to real applications.

2. Procedure and Data logging

In this part of the experiment students perform the experiment and see the data logged and

graphed on the PC as they progress through the experiment.

3. Theory and Calculations

In this section, the students work through their calculations manually and calculate the result being sought from the experiment. They then enter their own values into the computer and receive immediate feedback of how these compare to the automatically calculated values from the Virtual Instrumentation and simulation techniques.

Figure 2 (a-b) shows the sample block diagram and front panel for the experiment, study of piezoelectric transducer.

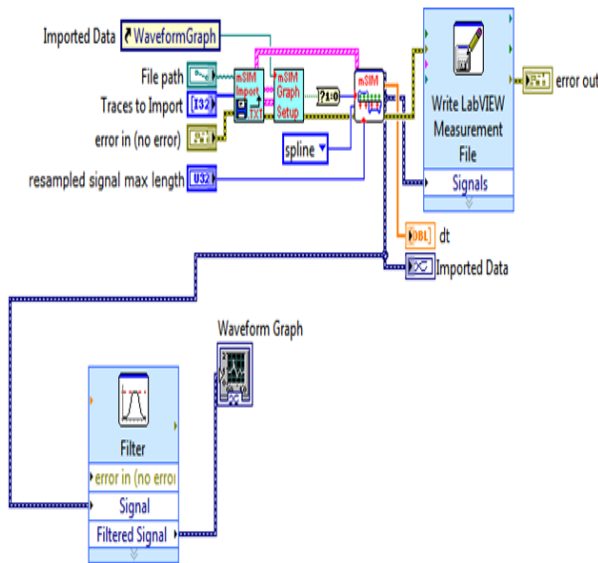


Fig.2- (a)

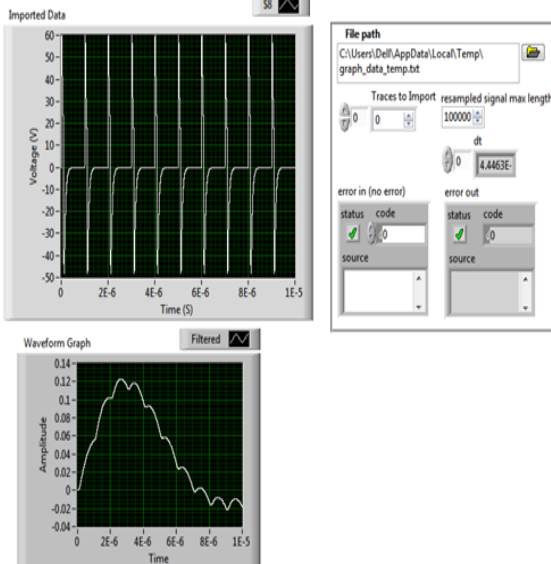


Fig.2 (b) GUI for Characteristics of Piezoelectric transducer using LABVIEW.

E-Lab 080 (Dynon Instrument) is another alternative for data acquisition. It consists of Digital storage oscilloscope, Logic analyzer, arbitrary waveform

generator, clock generator and Programmable Power supply. The E-Lab 080 model and GUI front panel is shown in figure 3 (a-b) respectively.



Fig. 3 (a) Model of ELAB-080

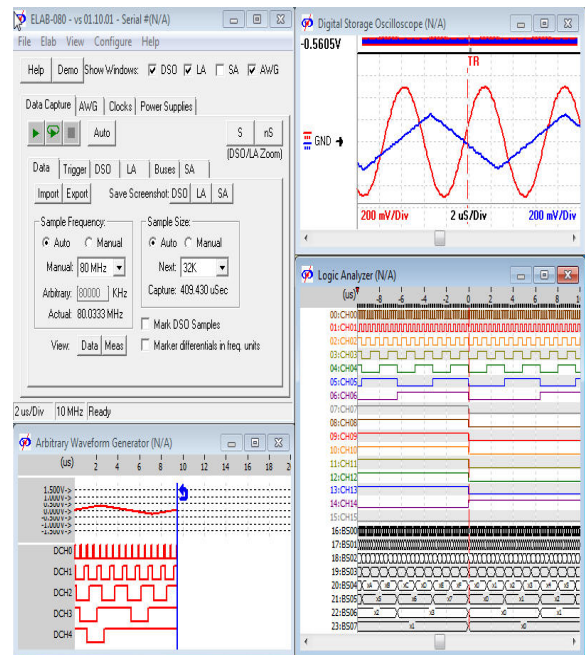


Fig 3 (b) GUI front panel for ELAB-080

V SIMULATION MODULE

Multisim is a comprehensive circuit analysis program that permits the modeling and simulation of electrical and electronic circuits. It provides a large component database, schematic entry, analog/digital circuit simulation, and many other features, including seamless transfer to printed circuit board (PCB) layout packages. Multisim is interactive and offers a number of user-friendly features. A major feature of Multisim is that the schematic diagram is created on the screen using a mouse and various windows options. The type of analysis desired is then applied to the circuit, and the results can be observed in a number of ways

One of the most valuable features of Multisim is that the source excitation and instrumentation functions closely parallel those of a basic electronics laboratory, and the procedures that are used in obtaining data are very similar to those of the "real world." Hence, it

closely approaches the concept of an ideal “virtual laboratory.” For example, the test and measurement models contain voltmeters, ammeters, a multimeter, a function generator with several output waveforms, a two channel oscilloscope, a frequency counter, a distortion analyzer, and other instruments. These instruments must be wired into the circuit in essentially the same fashion as in an actual laboratory. Thus, good laboratory skills can be taught very easily using a computer and the software.

NI ELVIS, an integral part of the NI electronics education platform, combines simulation and measurements from NI ELVIS inside the NI Multisim capture and SPICE simulation environment. Students transfer concepts taught in a textbook to Multisim, where they can learn through modelling circuit behaviour and interactive circuits. They can compare simulation and real measurements with a single mouse click using NI ELVIS instruments inside the Multisim environment and achieve more complex analysis using LabVIEW or LabVIEW Signal Express.

With the NI-ELVISmx driver, students can access their suite of 12 instruments through the NI-ELVISmx instrument launcher. These virtual instruments with their soft front panels provide an interactive interface to configure instruments.

NI ELVIS virtual instruments are open-sourced and customizable in LabVIEW. With the installation of the driver, students can use LabVIEW Express VIs and LabVIEW Signal Express steps to program their devices.

This provides point-and-click configuration capabilities for the individual instruments, so they can achieve customized and more complex analysis of acquired data in LabVIEW. Those who are familiar with the DAQmx API can program general analog input, analog output, and timing functionality on NI ELVIS using NI-DAQmx.

VI CONCLUSIONS

The roles of teachers and students are changing, and there are undoubtedly ways of learning not yet discovered. However, the computer and software technology may provide a significant role to identify the problems, to present solutions and life-long learning. It is clear that the computer based educational technology has reached the point where many major improvements can be made, and significant cost reductions can be achieved, specifically in the area of science and engineering education. The full-course (lecture . laboratory component) may replace the existing lecture-based courses, and the virtual instruments may provide a highly interactive user interface and advanced analysis facilities that were not deliverable in the conventional methods. From the educational point of view, it is expected that the new teaching/learning technology tools available in the market may provide common experiences to cater for students who are

coming from increasingly diverse backgrounds, and whose learning is best achieved in a contextual setting. However, more designing, teaching and organizational skills are now required to establish a good course material utilising computer interaction and multimedia capabilities in engineering disciplines. Therefore, the selection criteria of a suitable software is the major issue, which should have a long life-cycle, easy interface with the hardware products, and be compatible with the existing development tools. However, it should be emphasised here that having proper equipment and technique will not ensure a problem-free system. The proper use of techniques and methodologies are also critical in any technology intensive teaching/learning development system. In addition, it should be ensured that the designed work keeps up with the curriculum review and update, and the laboratory work should be relevant to the material taught in lectures. These may require continuous update of the material, which may change the role of the educator.

REFERENCES

- [1] Bachnak, R. (2002). Design and Implementation of a Three Course Sequence in Control Systems, ASEE Annual Conference Proceedings. (http://www.asee.org/conferences/caps/document/2002-29_Paper.pdf)
- [2] Beasley, C. A.; Vitz, E. (1999), Toolbutton Data Acquisition into Spreadsheets for Educational Laboratories. *Abstracts of Papers*, 218th National Meeting of the American Chemical Society, New Orleans, LA, Aug. 22-26, American Chemical Society: Washington, DC, CHED122.
- [3] Chen, C. (1998). Using LabVIEW in Instrumentation and Control Course. ASEE Annual Conference Proceedings. Available: <http://www.asee.org/conferences/search/00612.pdf>
- [4] Chickamenahalli, S. A., Nallaperumal, V., and Waheed, V. (1998). Labview based electric machines laboratory instrumentation. ASEE Annual Conference Proceedings. Available: <http://www.asee.org/conferences/search/00355.pdf>
- [5] Crist, S. C. (2001). A Laboratory-Based Instrumentation Course for Non-EE Majors. ASEE Annual Conference Proceedings. Available: <http://www.asee.org/conferences/search/20385.pdf>
- [6] Dehne T., (1995), “Putting Virtual Instruments to Work, Product Design and Development”, Feature Report, No.360795A-01, National Instruments Corp.
- [7] Drew, S. M. (1996), Integration of National Instruments. LabVIEW Software into the Chemistry Curriculum. *J. Chem. Educ.* , 73,1107-1111.
- [8] Ertugrul N. , (1998) ,”New era in engineering experiments: an integrated interactive teaching/ learning approach and real time visualizations”, *Int. J. Eng. Educ.*, 14, 5 pp. 344-355
- [9] Krygowski, F. R. (2001). Modernizing a Physical Measurements Laboratory in Engineering Technology. ASEE Annual Conference Proceedings. Available: http://www.asee.org/conferences/search/00695_2001.PDF

- [10] Lee, C. (1996). An active learning mode for laboratory education. ASEE Annual Conference Proceedings. Available: <http://www.asee.org/conferences/search/01138.pdf>
- [11] Muyskens, M. A.; Glass, S. V.; Wietsma, T. W.; Gray, (1996), T. M. Data Acquisition in the Chemistry Laboratory Using LabVIEW Software. *J. Chem. Educ.*, 73, 1112.1114.
- [12] National Instruments, (May 1999), Computer-Based Measurement and Automation, (<http://www.natinst.com>).
- [13] Pudlowski Z. J., (1995), (Ed.) Computers in Electrical Engineering Education-Research, Development and Application, Monash Engineering Education Series, Monash University, Melbourne, Australia.
- [14] Sumali, H. (2002). An Instrumentation and Data Acquisition Course at Purdue University. ASEE Annual Conference Proceedings. (http://www.asee.org/conferences/caps/document/2002-1855_Paper.pdf)
- [15] Virtual Instrumentation in Education, Conference Proceedings, (June 1997), Massachusetts Institute of Technology and University of California at Berkley, National Instruments Corporation, Part Number 350357A-01.