Using Virtual Instruments in a Measurements Laboratory

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Abstract--- implemented for Basic Electronics. This work demonstrates that instrumentation experience is greatly enhanced by integration Virtual 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 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 professors 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 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

VIRTUAL instrumentation is the use of customizable software and modular measurement hardware to create user defined measurement systems, called virtual instrumentation.

Traditional hardware instrumentation systems are made up of pre-defined hardware components, such as digital multimeters and oscilloscopes that are completely specific to their stimulus, analysis, or measurement function. Because of their hard-coded function, these systems are more limited in their versatility than virtual instrumentation systems. The primary difference between hardware instrumentation is that software is used to replace a large amount of hardware. The software enables and expensive hardware to be replaced by already purchased computer hardware; e.g. analog-to-digital convertor can acts as a hardware compliment of a virtual oscilloscope, a potentiostat enables frequency response acquisition and analysis in electrochemical impedance spectroscopy with virtual instrumentation. The concept of a synthetic is a subset of the virtual instrument concept. A synthetic instrument is a kind of virtual instrument that is purely software defined. A synthetic instrument performs a specific synthesis, analysis, or measurement function on completely generic, measurement agnostic hardware. Virtual instruments can still have measurement specific hardware, and tend to emphasize modular hardware approaches that facilities this specificity, virtual instrumentation has grown significantly since its inception in the late 1970s. Additionally, software package like National instruments’ Lab VIEW and other graphical programming languages helped grow adoption by making it easier for non-programmers to develop systems. The newly updated technology called "HARDWARE INSTRUMENTATION” is developed by some companies. It is said that with this technology the execution of the software is done by the hardware itself which can help in fast real time processing.

II. PROJECT LABORATORIES

The project lab structure has continued to evolve over the past 40 years. I-9 Students take 5, 3-hour credit laboratories not directly associated with any lecture course. Although the laboratories have no directly associated lecture course, they do have pre and co-requisites. In addition, the first 3 labs have general areas of specialization. The objectives of the ECE laboratories, which closely follow some of the ABET suggested “outcomes” 10, include the ability to:

1) Identify, formulate, and solve practical electrical engineering problems. This includes the planning, specification, design, implementation, and operation of
2) systems, components, and/or processes that meet performance, cost, time, safety, and quality requirements.
3) Communicate effectively through oral presentations and group discussions.
4) Communicate effectively through written reports and other documents.
5) Design and conduct scientific and engineering experiments, and to analyze and interpret the resulting data.
6) Function and communicate effectively within multidisciplinary teams.
7) Interact with other students, faculty and practicing professionals on professional and ethical responsibility issues.
8) Recognize the need for, and develop an ability to engage in, perpetual learning by working both individually and within multidisciplinary teams on projects for which they have no prior experience.
9) Use statistical techniques to represent, analyze, and interpret data.
III. PROJECT LABORATORY STRUCTURE

In all of the ECE labs, the student will be provided with the following information:

1) A basic statement of the project objective.
2) The faculty advisor (technical advisor and evaluator)
3) The team members

The faculty advisor for the project is the Product Engineering manager and, as such, is the primary technical evaluator for the project. The ECE labs operate in a matrix style of management. The lab instructor, as the Development Engineering manager, is the primary supervisor and project director. The ECE undergraduate labs director and staff (including Teaching Assistants) are the resource and quality control managers. Whenever possible, at least two members of the management team will attend the lab sessions.

To properly manage a project it is necessary to develop a clear and thorough plan and carefully monitor the execution of the plan. In cooperation with the Product Engineering manager (faculty advisor), the Development Engineering manager (lab instructor), and the resource/quality manager (lab director or staff) and within one week after receiving the project, the project team must develop a detailed project plan. Although all projects and project plans are dynamic, it is imperative that a detailed plan be developed initially and continually examined to properly execute the project within time and budget constraints.

For all ECE laboratory projects, activities on a Gantt chart must be broken down into time intervals no longer than one week in duration. Each task must have a specific deliverable (physical evidence) to indicate the task completion. Completion of the project within the given time and budget constraints is critical. Agreement between all parties (students, faculty advisors, lab instructors, and lab director's staff) on acceptable deliverables is required. The project Gantt chart must indicate these weekly deliverables.

Most of the projects in the ECE labs are team projects. Although each team member will be assigned specific actions by the team, all team members are equally responsible for successful completion of the project. Team members will be measured for their contribution to the team by their advisor, lab instructor, lab director's staff, and the team itself.

IV. PROJECT REQUIREMENTS

Throughout the semester, each ECE lab student must provide oral progress reports. All oral presentations must be well organized and include visual aids. Each member of the project team is required to speak during each oral presentation. These presentations must be organized so that each student has approximately the same amount of presentation time. These presentations are mini-design reviews and must contain enough technical information for the other students, the lab instructor, and the lab director's staff to fully understand the direction of the project. The presenter should be prepared to answer any questions concerning the project. Although each team member will have specific deliverables, all team members are equally responsible for successful completion of the project and all team members should be prepared to answer questions on the whole project.

V. PROJECT LABORATORY I

The first project laboratory has 2 projects. The first project is an instrumentation project and the second project is a microprocessor based robotics project. This paper discusses the first project. The objectives of the first project are: to develop measurement abilities within the project lab frame work; to develop understanding of the internal structure of basic instruments, to cover a variety of different instruments, and to cover a variety of different measurement applications.

Specific Instruments

1) Voltmeter - DC, AC; Ohmmeter; Ammeter – DC, AC
2) 2. Oscilloscope – Triggering techniques; Dual Trace; etc.
3) 3. Spectrum Analyzer
4) 4. Special Displays – Frequency Response; X-Y plots

Circuit

5) 5. Active filters
6) 6. Oscillators
7) 7. Tuned Amplifiers
8) 8. Power Amplifiers
9) 9. Switching Regulators
10) 10. Amplitude Modulation and Demodulation
11) 11. Phased Lock Loop
12) 12. Noise Reduction Circuit

VI. PROJECT DETAILS

A virtual instrument is actually a PC that uses plug-in cards and software to create a variety of instruments. Graphical software packages allow the design of the instrument at the block diagram level, which enables the student to see the structure of the instrument without having to actually build it. The characteristics of the instrument can be easily seen and studied at a number of different levels. The virtual instrument can then be compared to actual instruments to show similarities and differences. Instrumentation clusters can also be easily configured on the same system. Since the instrumentation is on a PC, data collection and analysis can be integrated into the same environment. Figure 1 shows a block diagram of the system used in the lab. It is a National Instruments Electronic Laboratory Virtual Instrument System, or NI ELVIS, plus a Data Acquisition Board, or DAQ. The NI ELVIS uses Lab VIEW-based software instruments, a multifunction DAQ device, and a custom-designed bench top workstation and prototyping board to provide the functionality of a suite of common laboratory instruments. Figure 2 is a picture of NI ELVIS.
A virtual Function Generator, shown in Figure 4, provides a choice of waveforms (sine, square, or triangle) with amplitude and frequency variability. The Generator also has DC offset, frequency sweep, and modulation capabilities.

The control panel of the NI ELVIS built-in virtual 2 Channel Oscilloscope is shown in Figure 6. The scale and position for each channel is adjustable as is the time base. The trigger source and mode can also be set. All of the functions are similar to a standard laboratory oscilloscope.

A virtual Digital Multimeter (DMM) is shown in Figure 5. This instrument can measure AC and DC voltages, resistance, and capacitance. It can also perform continuity checks and test diodes.

One of the major advantages of a virtual instrument is the ability to see inside the instrument and to understand how it works. The functional diagram of each of the instruments is available in the form of a graphical programming language. The program for the 2 channel oscilloscope is shown in Figure 7. It is beyond the scope of this paper to discuss the details of the graphical program. The point is that the internal structure of the instrument is readily available. This is analogous to examining the block diagram of a standard laboratory oscilloscope in a technical manual. As with many block diagrams, there are numerous other blocks that can be examined in more detail, down to the circuit schematic level for a standard instrument. The process can be carried out with virtual instruments by examining the sub-virtual instruments (Sub-VIs). This allows the students to fully understand the operation of the instrument along with what it can and cannot do. By comparing these virtual instruments with more classical hard instruments in both their structure and capabilities the students are able to have a better understanding of instrumentation and measurement capability.
Another advantage of the Virtual Instrument is that the data is already available within the PC. This allows for additional data manipulation and analysis with ease. Figure 8, for example, shows a sample log file from the 2 channel oscilloscope. The sample time and value of each channel at that time are recorded for further analysis, if desired.

Virtual Instruments also have the capability of instrument configurations that are difficult to obtain in direct hardware systems. The Bode analyzer in the ELVIS systems is a good example of that capability. Figure 9 shows the output of the Bode analyzer, which behaves as a simple instrument in the ELVIS system.

VII. PROJECT RESULTS

The following are comments from the final student presentations on describing NI ELVIS as compared to standalone physical instruments.

Advantages:
1) The entire Lab VIEW/ELVIS System costs much less than a complimentary set of physical laboratory tools.
2) The Visual Based nature of the Lab VIEW software allows for a shallow learning curve with the ease of customization.
3) Lab VIEW allows for testing of the “ideas” of a circuit even before actual construction.
4) Ease of Use for:
   a) Oscilloscope
   b) Digital Multimeter
   c) Variable power supply
   d) Prototype Board
5) Side connections are easy to find
6) Breadboard on the system is a plus

Disadvantages
1) Limited Operational Range
2) Limited accuracy
3) Oscilloscope is Digital ONLY
4) Frequencies higher than 40kHz are difficult to process
5) Only 9 time division settings on Oscilloscope
6) Entire Lab VIEW system is vulnerable to PC system speed (Slow Computer=Slow Signal Processing)
7) Only a few Lab VIEW or ELVIS resources can be used simultaneously without suffering from errors or decreased performance (PC dependence)
8) While the relatively inexpensive Lab VIEW/ELVIS system can simulate an entire workbench of tools, it does not simulate any one task as well as a physical tool.

VIII. CONCLUSION

Of course, there are many advantages and disadvantages to virtual instruments available today. By having the students go through the analysis of the instruments and compare the capability of the instruments, they can learn instrumentation and measurement techniques while doing a meaningful project.

REFERENCES