

Implementation of a Remote Analog and Digital Communications Lab for e-Learning

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Abstract-- A remote instrumentation model used to perform modern RF and digital communications experiments over the internet is presented. The setup allows for highly cost effective and pedagogically rigorous mechanism of instructions for students in situations where traditional laboratory equipment is either unavailable or at a premium cost. In the model, a switch matrix is used to eliminate the need for students to be present in the laboratory.

Index—Remote, Analog, Digital, E-learning

I. INTRODUCTION

Rapid changes in the field of engineering technology have increased the need for universities to provide engineering and engineering technology students with meaningful and relevant practical experiences. However, limited available resources in the provision of laboratory hardware and infrastructure have been the principal impediment in achieving this objective. Such hardware limitations have been increasingly marginalizing the quality of engineering and engineering technology education. E-learning can be used to help universities and technical colleges overcome this problem and one approach is to expand e-learning activities in programs with limited resources to take advantage of online computer-based technology. In this model, remote instrumentation technology and the internet are merged to interface students with the physical world. As such, remote laboratories allow students around the world to access a computer equipped with the suitable interface circuits, such as data acquisition systems connected to various sensors or communication modules, and perform real-time experiments. Each year, a growing body of work has appeared that has further validated both the technological viability of distance laboratories, and their effectiveness in delivering a worthwhile laboratory experience [1-4]. The quality of the architectures and designs has shown steady improvement, and there appears to be ample evidence that this form of experimentation delivers a valuable learning experience for students [5-9].

In this paper, a setup is proposed to perform modern RF and digital communications experiments remotely in a distance learning environment. The National Instrument

Educational Remote Instrumentation Suite (NI ELVIS) and Emona Instrument's DATEx telecommunications trainer [10-11] were utilized in this setup. An amplitude-shift keying (ASK) experiment was performed online to demonstrate how students can easily carry out many tedious tasks to perform the experiment; and hence focus on understanding the underlying principles of operation of the communication systems.

II. REMOTE LABORATORIES

Hands-on laboratories provide valuable experience in engineering and technology education. However, such trainers are not always necessarily available to students. Limitations on equipment access and funding further reduce the availability of laboratory resources in many institutions. Virtual laboratories are therefore a possible alternative to traditional laboratories, and they are already used in distance learning education in several universities. On the other hand, remote labs help alleviate these problem by increasing access and simultaneously reducing cost and a growing body of work has appeared that has validated both their technological viability and effectiveness in delivering a worthwhile laboratory experience. Over the past 10 years, two primary solutions have been implemented. Recently reported work continues to mirror this trend [12-17]. Some researchers have developed customized hardware and software that enables management and control of the process including data-based driven web pages with access scheduling. Others have chosen to employ commercial platforms, e.g. LabVIEW in combination with NI ELVIS. We decided on this latter approach since ongoing support, maintenance and design improvements would be readily available from the supplier network.

The NI ELVIS II can be used in many electrical engineering laboratories. In addition to its built-in instruments, it can be used to build LabVIEW-based remote instruments, a multifunction data acquisition device and a custom designed bench top workstation and prototyping board. The Main features on ELVIS II, shown in Fig. (1), are:

- Offering modern digital and analog experiments in a single board.

- Hands-on experiential system featuring a widely accepted block diagram modeling approach.
- Featuring a USB plug-and-play interface for flexible setup.
- Operation in both local manual mode and under fully integrated Lab VIEW software control.
- Out-of-the-box curriculum for telecommunications concepts.
- LabVIEW Programming and LabVIEW Signal Express software.

The Emona DATEx electronics training circuit board (ETCB) is a plug-in trainer board module that works in concert with a personal computer to provide a solution for students who need to perform laboratory experiments, whether at a distance or on campus. It plugs into the NI ELVIS II as shown in Fig. (1). All essential hardware devices/blocks in the laboratory are housed in



Fig. (1): Emona DATEX Set-up for Use in Communications Labs.

this single board which possesses the capabilities needed for implementing dozens of telecommunications operation such as adder, multiplier, mixer, signal generator and phase shifters, which can be effectively used in the construction of block diagrams by patching them together according to theoretical block diagrams. User management of this telecommunication bundle occurs in a PC-based control mode using LabVIEW and DATEx SFPs software to give the students the freedom to build communications systems hardware by joining together circuit blocks similar to those studied during the class.

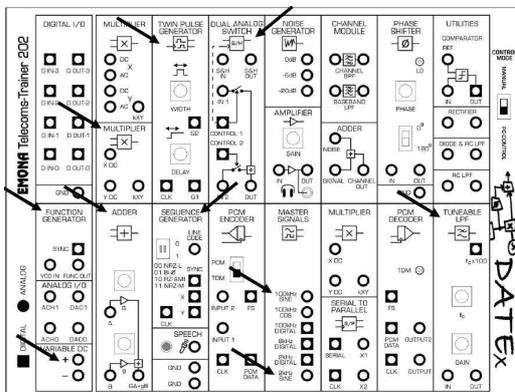


Fig. (2): Emona DATEx Front Panel.

The proposed architecture for this remote telecommunication lab is shown in Fig. (2). The main

part in the lab is the ELVIS II-DATEx set-up. Experiments can then be setup up and conducted using this flexible platform where all programmable devices are controlled by digital signals, originating from the experiment server, through a multifunction data acquisition (DAQ) card. The user interface for a given application can also be created quickly and simply by LabVIEW, as this graphical development environment does not require any line of traditional text-based code to create such applications. LabVIEW subroutines, called virtual instruments (VIs), are composed and programmed to control the experiments. These VIs are hosted on the VI server as shown in Fig. (3). The programmer can use readymade VIs or compile and customize new ones that achieve the desired requirements. The remote experiment can be run from anywhere inside a local area network (LAN) or globally via the internet. The application is usually published with a web publishing tool, which converts the VI front panel into HTML format that can then be hosted by the web server. The client students can actually access the experiments with simple internet web browser in the same way a conventional website is accessed.

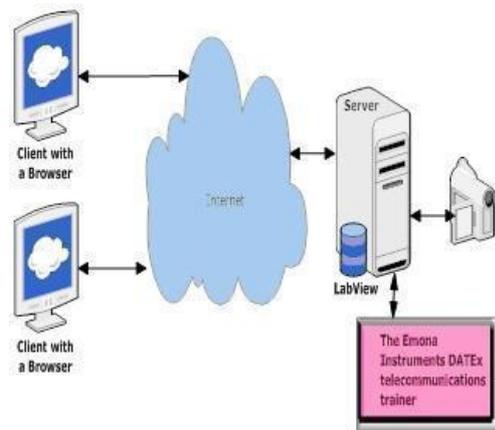


Fig. (3): Remote Communications Laboratory Based on the DATEx-ELVIS II Set-up.

In order to perform RF and digital communications experiments there is a need for eliminating the user interface needed to perform the required connections for modules. This setup has been prepared for students with only basic knowledge of mathematics and limited background in physics and electricity. The user interface can be controlled through a switch matrix that makes the lab setup accessible to the on-line community and obviates the necessity for physical presence of students in the lab to implement the necessary connection for the experiment being performed. Students can log in and generate their own AM/FM/BPSK signals, set up a bandwidth limited signal and explore its spectral composition. In addition to providing online laboratories, this remote laboratory may be a suitable way for on-line instrument evaluation.

III. SAMPLE ANALOG LAB: ADDING 2 SIGNALS

The Emona DATEX can model communications equations to bring them to life. This sample experiment will introduce you to modeling equations by using the Emona DATEX to implement two relatively simple equations. The steps needed to perform such an experiment using the standard ELVIS II-DATEX setup are as follows:

1. Launch the DATEX soft Front-panel and the NI ELVIS Oscilloscope Remote Instrument.
2. Locate the Adder module on the soft Front-panel and drag its G and g controls to about the middle of its travel.
3. The setup is implemented in the Front panel window by turning on the respective nodes.
4. The scopes time base control is tuned to view two or so cycles 2kHz sine output and measure the amplitude.
5. Now just disable the adder module's B input and activate the scope's channel B input by pressing the channel B controls on/off.
6. Adjust the Soft G control by using the tab key and arrow keys for fine adjustment.
7. Enable the B input then disable the A input and adjust the g control till the output voltage is same as the input voltage.
8. Enable the A input and you can implement:
9. Adder Module Output = Signal A + Signal B

This standard procedure may be followed by student in the lab in order to perform the experiment. This presence, however, can be eliminated when a computer-controlled RF switch matrix is used. These switch matrices are currently available from several manufacturers including National Instruments.

IV. SAMPLE DIGITAL LAB: AMPLITUDE SHIFT KEYING

Amplitude-shift keying (ASK) is a form of modulation that represents digital data as variations in the amplitude of a carrier wave. The amplitude of an analog carrier signal varies in accordance with the bit stream of the intelligence signal (modulating signal) keeping frequency and phase constant. The level of amplitude can be used to represent binary logic 0s and 1s. A carrier signal may be treated as an ON or OFF switch. In the modulated signal, logic 0 is represented by the absence of a carrier, thus giving OFF/ON keying operation. Fig. (4) shows the implementation of ASK modulation using the Emona 202 telecom trainer.

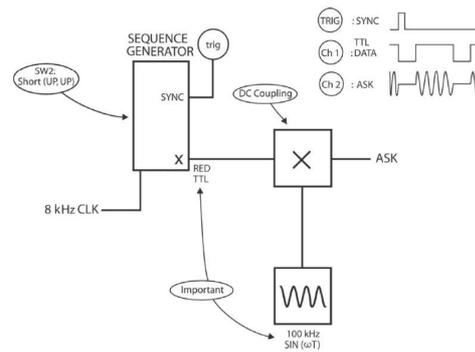


Fig. (4): Amplitude Shift Keying Set-up.

ASK modulation can be performed in a very easy way. The modules Sequence generator, Masters signals, Dual analog switch and oscilloscope are used for connections. The connections will be as follows:

1. Oscilloscope Ch 0->sequence generator X->Dual switch control2.
2. Oscilloscope Ch1->Dual switch out,trigger-> sequence generator sync,
3. Masters signals 2 KHz digital and 2 KHz sine -> sequence generator clk and dual switch IN2.
4. ASK signal's carrier and the sequence generator module's clock are the same frequency.

This experiment has been designed to make the ASK signal easy to monitor on the scope. Ideally, the frequency of the carrier signal should be much higher than the bit-rate of the digital signal supplied by the sequence generator module's clock frequency. The seence generator module is used to model a digital signal and its sync. output is used to trigger the scope to provide a stable output, and the dual analog switch is used to generate the ASK signal.

Students do not have to perform many tedeous connnection tasks to perform the experiment; rather, they can focus on understanding the communication system and its components.

V. STUDENTS FEEDBACK ABOUT THE USE OF THE DATEX TRAINER / ELVIS II SET-UP

A survey was conducted to get students feedback about the use of the ELVIS II-DATEX communication trainer set-up in the lab. 20 students who used the set-up in their RF communications lab in the spring 2009 semester, and who are currently taking a data communication class and using the same set-up for the second semester.

The following questions about students experience in using the Emona-ELVIS set up in ECT352: Analog Communications (COMI) and ECT 361: Digital Communications (COMII) laboratories were used for the survey:

- 1- Do you feel comfortable using the Emona-ELVIS setup?

- 2- Where the Emona-ELVIS setup experiments clearly written?
- 3- Where the Emona-ELVIS setup experiments procedures easy to follow?
- 4- Does the use of the Emona-ELVIS setup increase your interest in the labs?
- 5- Did you have difficulties in configuring the Emona-ELVIS setup software?
- 6- Did you have difficulties in configuring the Emona-ELVIS setup hardware?
- 7- Was the Emona-ELVIS setup very valuable in terms of teaching and learning?
- 8- Overall, do you support the use of the Emona-ELVIS setup in the Communications labs?
- 9- Would you like to see test set-ups similar to the Emona-ELVIS setup integrated into other labs?

The survey was conducted for 16 students enrolled in two different lab sections, and the results of the survey are illustrated in Fig. (5). In this figure, the blue (light) bar represents a “YES” answer and the red (dark) bar represent a “NO” answer. The X-axis represents the question number, and the Y-axis represents the frequency of each answer.

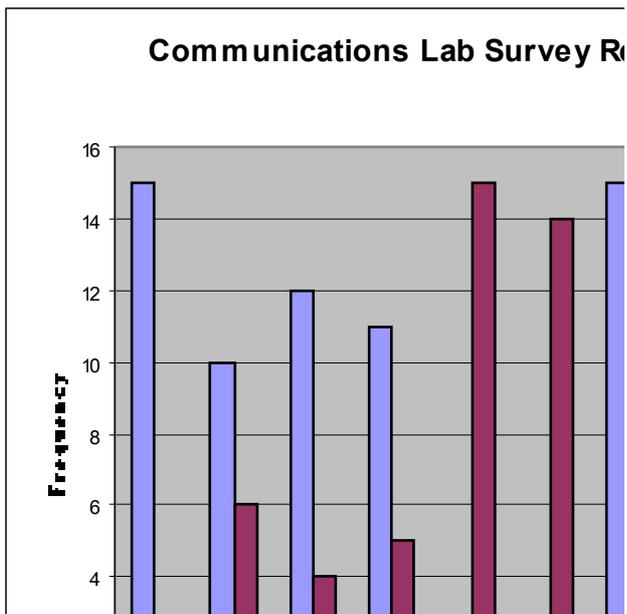


Fig. (5): Communications Lab Survey Results

From the results we see that there is a total agreement among students that they feel comfortable using the presented set-up. Only few students were not comfortable with the clarity of the experimental procedure for the labs. Students were comfortable using the LabVIEW software and the Emona-ELVIS II hardware set-up, and they overwhelmingly support the use of similar set-ups in other technical laboratories.

CONCLUSIONS

A laboratory design concept to perform RF and digital telecommunications experiments remotely in a distance learning environment is proposed based on an ELVIS II/DATEX trainer. In this model, a switch matrix is used to eliminate the need for students to be present in the lab. This setup allows for a highly cost effective and pedagogically rigorous mechanism of instructions for students in situations where traditional laboratory equipment is either unavailable or at a premium cost.

Assessments of the system show a strong interest of students on remote experimentation especially for those who cannot physically attend lab sessions to obtain hands-on experience. In addition, most of the class opined that it helped them to better understand syllabus topics and gain more applied knowledge. And the majority of students would certainly like to use remote labs in the future.

REFERENCES

- [1] Eppes, T. and Schuyler, P., “Pilot Test Results of a New Distance Laboratory Platform” *Proceedings of the 2005 Annual Conference & Exposition*, Session 2550.
- [2] Eppes, T. and Schuyler, P., “A Robust and Scalable Distance Laboratory Platform” *Proceedings of the 2004 Annual Conference & Exposition*, Session 2426.
- [3] Cooney, E. & Shriver, A. “Remote Control of a Robot Using LabVIEW and the World Wide Web”, *Proceedings of the 2001 ASEE Conference & Exposition*, Session 2526.
- [4] Gurocak, H. & Ash, I. & Wiley, J. “Assessment of Effectiveness of an Electronic Book to Deliver Robotics Lab Experience Over the Internet”, *ASME 2002 Proceedings of the DETC*, Montreal Canada, CIE-34413.
- [5] Gustavsson, Ingvar. “A Remote Laboratory for Electrical Experiments”, *Proceedings of the 2002 ASEE Annual Conference*, Montreal, Quebec Canada, June 2002.
- [6] Gerdin, G. “Remote Instruments for Distance Learning”, *Proceedings of the 2002 ASEE Annual Conference*, Montreal, Quebec Canada, June 2002.
- [7] Plummer, Mitty et al. “A Circuits II Laboratory Accessible by Internet”, *Proceedings of the 2002 ASEE Annual Conference*, Montreal, Quebec Canada, June 2002.
- [8] Malki, Heidar et al. “Web-based Control Systems Laboratories”, *Proceedings of the 2003 ASEE Annual Conference*, Nashville, Tennessee, June 2003.
- [9] Kolla, Sri et al. “Internet-Based ON/OFF Controller Using LabVIEW”, *Proceedings of the 2003 ASEE Annual Conference*, Nashville, Tennessee, June 2003.
- [10] Multi-experiment Single Board Telecoms Trainer for the popular NI ELVIS™ platform, Emona Telecoms Trainer ETT-202 [HTTP://WWW.TIMS.COM](http://www.tims.com)
- [11] 2007, Barry Duncan, Emona Instruments, “Emona DATEX Lab Manual for Electronic Instrumentation Laboratories”, 2/e.
- [12] Dunlap, D. et al. “A Database and User Interface Design for a Remote Accessible Laboratory,” *2007 ASEE Annual Conference*, Honolulu, Hawaii, June 2007.

- [13] Nafalski, A. et al. "A Remote Laboratory for Collaborative Experiments," *2009 ASEE Annual Conference*, Austin, Texas, June 2009.
- [14] Mickelson, A. et al. "A Two Credit Hour Stand-alone Remote Optics Laboratory," *2007 ASEE Annual Conference*, Honolulu, Hawaii, June 2007.
- [15] Chassapis, C. et al. "An Architecture for Real-time Remote Laboratories," *2007 ASEE Annual Conference*, Honolulu, Hawaii, June 2007.
- [16] Melkonyan, A. et al. "Real-Time Remote Internet-Based Communication Laboratory," *39th ASEE/IEEE Frontiers in Education Conference*, San Antonio, Texas, October 2009.
- [17] Arsen Melkonyan, David Akopian, and C. L. Philip Chen, "Real-Time Remote Internet-Based Communication Laboratory", , 39th ASEE/IEEE Frontiers in Education Conference, Session M2E-1, October 18-21, 2009, San Antonio, TX, USA.