Implementation of a Remote Analog and Digital Communications Laboratory for E-Learning

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Abstract—**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. One approach that can be implemented to overcome this problem 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.**

Index Terms—**Remote, Analog, Digital, E-learning**

I. INTRODUCTION

Remote laboratories allow students around the world to log into 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. In this paper, we propose the use of a computer-controlled switch matrix with the Emona DATEx trainer and the ELVIS II platform in order to eliminate the need for user presence in the lab to perform the RF connections needed to perform Analog and RF communications experiments.

In this paper we are presenting a setup that was used to perform modern RF and Digital communications experiments in the lab, and it can be used remotely in a distance learning environment. For remote instrumentation control, a switch matrix is used to eliminate the need for students to be present in the lab. The remote use of 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.

Developing a remote RF and digital laboratory using National Instrument's ELVIS II and Emona Instrument's DATEx telecommunications trainer can be realized by incorporating a computer-controlled RF switch matrix into this setup to eliminate the need for in-lab RF connections.

The first component in the proposed remote lab setup is National Instrument's Educational Remote Instrumentation Suite (NI ELVIS) [1]. In addition to its built-in instruments, the NI ELVIS 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 second component in the proposed remote lab setup is Emona's DATEx trainer [2], which is a plug-in module for the ELVIS II platform. The DATEx-ELVIS II bundle, shown in Figure 1, enables the use of a hands-on approach in teaching engineering communications concepts. However, experiments can't be remotely performed using LabVIEW.

By using the DATEx-ELVIS II-based remote laboratory, as shown in Figure 1, students can log in and generate their own AM/FM/BPSK signals, set up a bandwidth limited signal and explore its spectral composition, and much more by controlling the RF switch matrix.

II. REMOTE LABORATORIES

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. Limitations on equipment access and funding reduce the availability of laboratory resources in many institutions. Remote labs help alleviate this problem by increasing access and simultaneously reducing cost. References [3-5] are examples of some of the early work in developing a remote lab capability. References [6-8] illustrate how the architectures and designs have improved. In the past five years, additional advances have been reported.

Over the past 10 years, two primary solutions have been implemented. Recently reported work continues to mirror this trend [9-12]. 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.

In order to perform communications experiments using the ELVIS II-DATEx setup given in Figure 1 in a remote laboratory environment, there is a need for eliminating the user interface needed to perform the required connections for the DATEx modules.

The user interface can be accomplished by using a LabView controlled switch matrix, and this makes the lab setup, shown in Figure 2, 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.
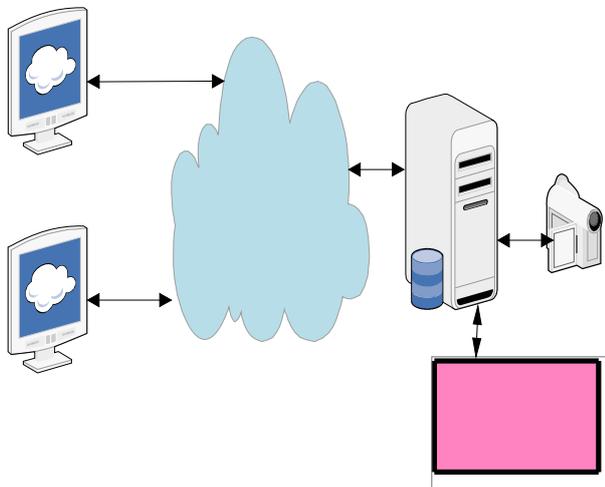
Figure 1.   Emona DATEX-ELVIS II communications bundle

Figure 2.   Remote Communications laboratory based on the DATEx-Elvis II setup

III.   INTRODUCTION TO NATIONAL INSTRUMENT'S ELVIS II EDUCATIONAL PLATFORM

NI ELVIS can be used in many electrical engineering laboratories. The features of ELVIS II set-up are:

- More than 30 modern digital and analog experiments in a single board.
- Hands-on experiential system featuring a widely accepted block diagram modeling approach.
- NI ELVIS II with USB plug-and-play interface for flexible setup.
- Operation in both local manual mode and under fully integrated LabVIEW software control.
- NI LabVIEW and LabVIEW Signal Express software

IV.   EMONA'S DATEX COMMUNICATIONS TRAINER NATIONAL INSTRUMENT'S ELVIS II EDUCATIONAL PLATFORM

The DATEx trainer is a plug-in module for the ELVIS platform. The DATEx- ELVIS II bundle enables us to use

hands-on approach in teaching engineering communications concepts remotely using LabVIEW. We will show that by using the DATEx- ELVIS II-based remote laboratory, as shown in Figure 1, students can log in and generate their own AM/FM/BPSK signals, set up a bandwidth limited signal and explore its spectral composition, and much more. In addition to providing online laboratories, this remote laboratory will be an ideal venue for on-line instrument evaluation.

The online instrumentation can be evaluated by first having some basic knowledge about the NI ELVIS equipment. The bulk of measurements needed to test and repair electronics systems can be performed with just these devices. Similarly, the DC power supply and function generator are used in wide range to power the equipment and to provide a variety of AC signals. All these essential hardware devices/blocks in the laboratory are now in a single unit called the Emona DATEx, which possesses the capabilities needed for implementing dozens of telecommunications experiments.

RF and digital communications remote Experiments make use of the Emona DATEx telecommunications trainer kit together with the NI ELVIS platform, and the RF switch matrix, and LabVIEW running on a PC. Thus, for e-learning, it is sufficient to take advantage of this infrastructure by simply logging on to a computer equipped with suitable interface circuits.

RF and digital communications Experiments related to this setup have been prepared for students with only basic knowledge of mathematics and limited background in physics and electricity. Thus, the RF and digital communication experiments that can be performed using the proposed setup are ideal for implementation in a remote RF and digital communication laboratory environment.

The ETCB (electronics training circuit board) is a custom-built trainer board that works in concert with National Instruments NI ELVIS (Electronics Laboratory Remote Instrumentation Suite) and a personal computer, and it is a solution for students who need to perform laboratory experiments, whether at a distance or on campus. This board offers students the convenience of purchasing a laboratory manual and a custom-built eTCB, which are designed to offer a complete set of laboratory experiments in DC and AC circuit analysis courses.

V.   SAMPLE ANALOG COMMUNICATIONS EXPERIMENT: ADDING 2 SIGNALS USING EMONA'S DATEX COMMUNICATIONS TRAINER

Mathematics is an important part of electronics, and especially for communications and telecommunications. The output of all communication systems can be described mathematically with an equation [13].

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 scope's 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:

Adder Module Output = Signal A + Signal B

We can see from this standard procedure that a student needs to be present in the lab next to the instruments 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.

VI. SAMPLE DIGITAL COMMUNICATIONS EXPERIMENT: 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.

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 seuence 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.

VII. 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, 09 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. Were the Emona-ELVIS setup experiments clearly written?

3. Were 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 figure 3. 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.
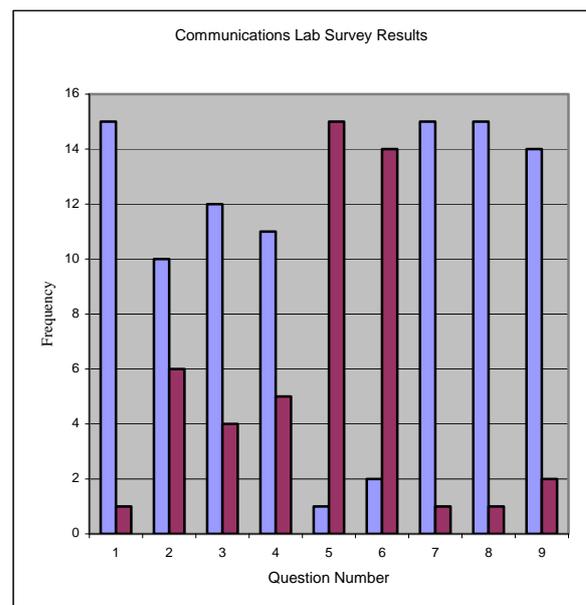

Figure 3. Communications Lab Survey Results

From the results we see that there is 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.

VIII. CONCLUSION

In this work, we presented a setup that can be used to perform modern RF and Digital communications experiments remotely in a distance learning environment. In this model, a switch matrix is used to eliminate the need for students to be present in the lab. This setup, combined with the remote nature of the process, 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.

The results of the survey conducted about the use of the communications set-up in the lab were very positive, and it shows that the set-up is a great one to use. The next step is to implement the use of a switch matrix and use the set-up in a distance learning communications lab.

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