Remote Laboratory Collaboration Plan in Communications Engineeering

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Abstract--Communications laboratories for electrical engineering undergraduates typically require that students perform practical experiments and document findings as part of their knowledge and skills development. Laboratory experiments are usally designed to support and reinforce theories presented in the classroom and foster independent thinking; however, the capital cost of equipment needed to sustain a viable laboratory environment is large and ongoing maintenance is an annual expense. Consequently, there is a need to identify and validate more economic solutions for engineering laboratories. This paper presents a remote laboratory collaboration plan for use in an elctrical engineering communications course.

Keywords; Remote, Virtual, E-learning environment

I. INTRODUCTION

Science and engineering courses typically involve students performing practical experiments and assignments in laboratories as part of their knowledge and skills development. This is essential in reinforcing theories learned in lectures and in providing means to foster independent thinking. Knowledge and skills development also bring the course theory alive so students can see how unexpected events and natural phenomena affect real-world measurements and control algorithms. However, equipping an upper-class electrical engineering laboratory is a major expense and its maintenance is expensive and can be difficult. Highly qualified teaching assistants are required to set up the laboratory experiments, instruct in the laboratory, and grade the laboratory reports, and the laboratories are available only when equipment and teaching assistants are both available. So, resources limitation in the provision of laboratory hardware is a principal impediment that has been increasingly marginalizing the quality of engineering and engineering technology education [1].

The use of remote laboratories has been shown to help in overcoming the problem of limited available laboratory equipment. Another sometimes overlooked advantage is promoting collaboration between programs from different institutions. In such cases, high quality experiments can be made available to more students. In addition, access to expensive, one-of-a-kind test and measurement equipment can be shared by a larger pool of users. This paper presents a remote laboratory collaboration plan for an electrical engineering communications course that increases access and fosters collaboration while reducing cost.

II. REMOTE AND VIRTUAL LABORATORIES AND DISTANCE LEARNING ENVIROMENTS

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 [2&3] are examples of some of the early work in developing a remote lab capability.

Distance learning, also referred to as e-learning, can be used to help universities and technical colleges overcome the limitation of available resources in the provision of laboratory hardware and infrastructure. 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 remote control technology.

This paper presents a plan for cooperation and resource sharing among universities in teaching in the areas of RF Communications, Data Communications, and Fiber Optic Communications using remote laboratories. The laboratory section in these courses has typically required expensive equipment that is out of reach for many institutions.

III. REMOTE LABORATORIES COLLABORATION PLAN

Sharing a remote laboratory platform between two institutions during the same timeframe requires detailed planning across several fronts. In our case, laboratory hardware is shared between onsite users at one institution with remote users at the other.

After some discussion, two main approaches were identified that allow as much flexibility as possible. Both approaches require a high degree of pre-planning of experiment details with minimal change during the semester. As given in Table I, the first approach called ‘synchronous’ presumes that both sites agree to assign the same experiments over the same timeframe. The advantage is that the set-up and take down for each experiment need only be performed once during a course. The main issue is how to avoid time conflicts between the two sets of users. This can be done by communicating available time blocks to each set of students and starting/stopping the LabVIEW remote VI browser.

Table I. Approaches to course collaboration

Approach	Advantage	Disadvantage
Synchronous	Minimal set up and take down required	Experiments & timing must overlap
Asynchronous	Experiments & timing are flexible	Resources needed for frequent coordination

The second approach called ‘asynchronous’ is the most flexible; however, it requires weekly coordination to ensure that the relevant experiments are ready to be performed especially for the remote users. Both require that an onsite technician be available in case there is a problem.

Another aspect that must be addressed is estimating how many remote students can be served by each ELVIS platform. Onsite users spend a predictable amount of time in the laboratory. The remainder can be devoted to the remote users. In our case, we started with 168 hours/week (7 days times 24 hours/day) and subtracted 10 hours for onsite use plus 5 hours for offline purposes. Thus, each lab station is available for 153 hours/week for remote users, and based on past experience, we estimate that one station can support 10 remote users. Assuming the average remote lab takes 4 hours to complete, the lab station utilization is 26%. Keeping this figure low ensures that students will not likely experience a queue when trying to use the system remotely. It also allows for intermittent networking problems, local or in the internet core, which may reduce availability.

This paper builds on the authors’ prior work [1] on using a DATEX trainer to perform RF and digital communications experiments that can also be made available in a distance learning environment. The first component in the proposed remote lab set-up is the National Instrument’s Educational Remote Instrumentation Suite (NI ELVIS) [4]. The second component is Emona’s FOTEX and DATEx trainers [5] that are designed as compatible plug-in modules for the ELVIS II platform.

The FOTEx and DATEx trainers are plug-in modules for the ELVIS platform. This experimental set-ups enables students to perform hands-on experiments that re-enforce engineering communications concepts and do so remotely with LABVIEW. The FOTEx - ELVIS II-based remote laboratory set-up is shown in Figure 1 while the DATEx - ELVIS II-based remote laboratory set-up is shown in Figure 2. Students log-in via the internet and access a virtual instrument panel for use in acquiring data. Both optical and RF communications experiments such as bandwidth-limited signals and frequency spectra may be completed by student without them being present in the laboratory.

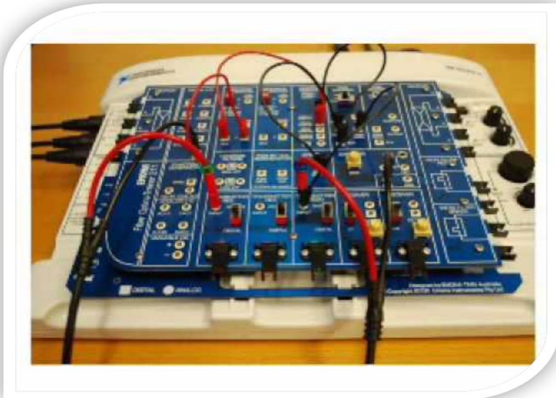


Figure 1: FOTEx-ELVIS II Communications Bundle.

Figure 2: DATEx-ELVIS II Communications Bundle.

IV. COLLABORATION SOFTWARE PLATFORM

There are many educational software tools and packages available for instructors to expend their course delivery beyond traditional face-to-face classrooms. Centra system (http://www.saba.com/products/centra/), Blackboard, and WebCT are examples of such tools; However, high cost and lack of adequate IT support prohibit utilizing and incorporating these tools in the discipline-based classes.

Since both communication setups presented here use LabVIEW, there is a need for a platform that is designed using LabVIEW software. A major advantage of LabVIEW is that it provides a convenient way to setup a PC as a server and establish server/client environment. Hence, an instructor with limited IT support, and networking and programming knowledge, can easily setup LabVIEW-based laboratory modules as needed for the FOTEx and DATEx Communications Trainers-ELVIS II educational platforms.

One possible platform that can be used for remote laboratory collaboration is Integrated Virtual Learning Platform (IVLP) given in [6]. IVLP is entirely based on LabVIEW, providing a user-friendly and configurable distance learning development environment, and it offers remote access laboratory experiments while allowing remote students to chat in real-time and participate.

V. SAMPLE EXPEREMINT USING THE FOTEX-ELVIS II TEST SET-UP: WAVELENGTH DIVISION MULTIPLEXING

This experiment demonstrates the use of the Emona FOTEx board to transmit two discrete message signals along an optical fiber in the same direction using WDM. At the receiver end we do filtering in order to recover just one of the messages. Figure 3 presents a block diagram for the WDM experiment while figure 4 presents the actual connections on the FOTEx board.

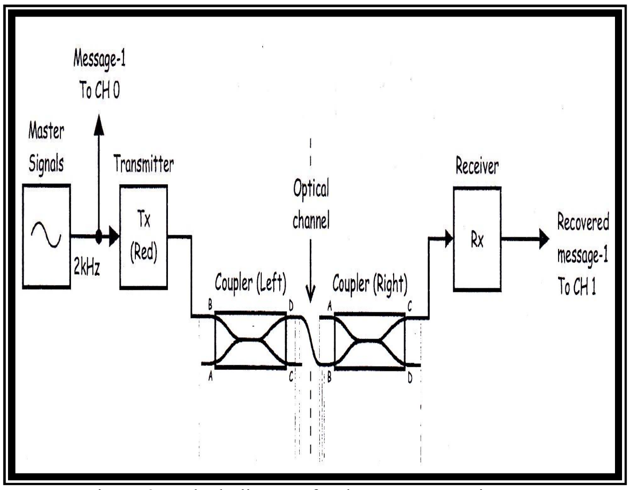


Figure 3 – Block diagram for the WDM experiment

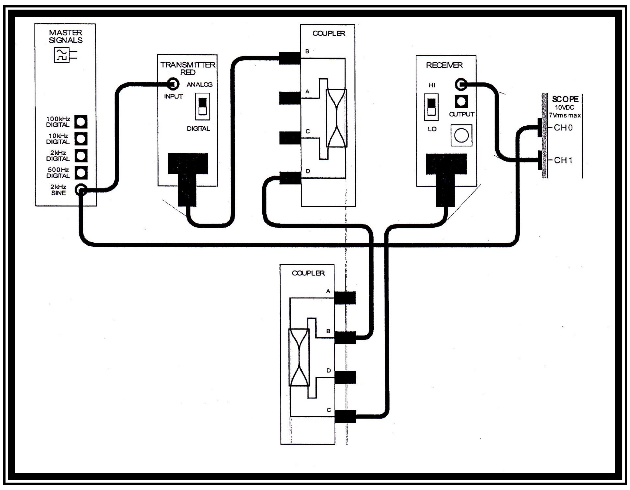
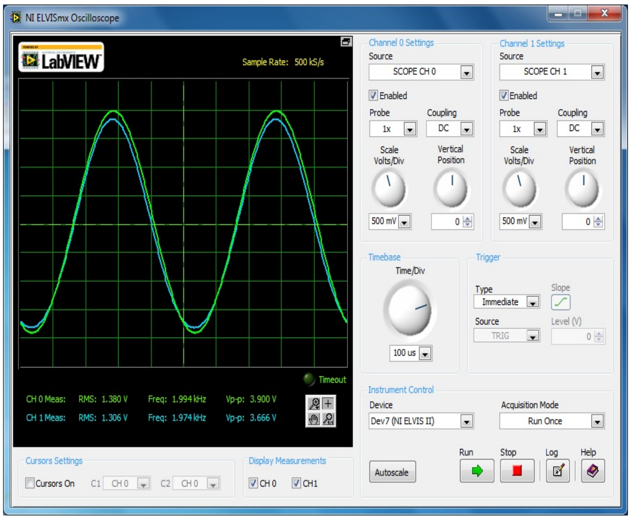


Figure 4 - WDM experiment set-up

The setup is a single channel transmission system. The master signals module's 2 kHz sin output is used to model an analog message. Coupler modules are used to facilitate the remainder of the experiment. Then set the NI ELVIS II osciloscope VI as follow:

- Timebase control is made 100us/div.
- Channel 1 is activated. Recovered message observed is given in figure 5.

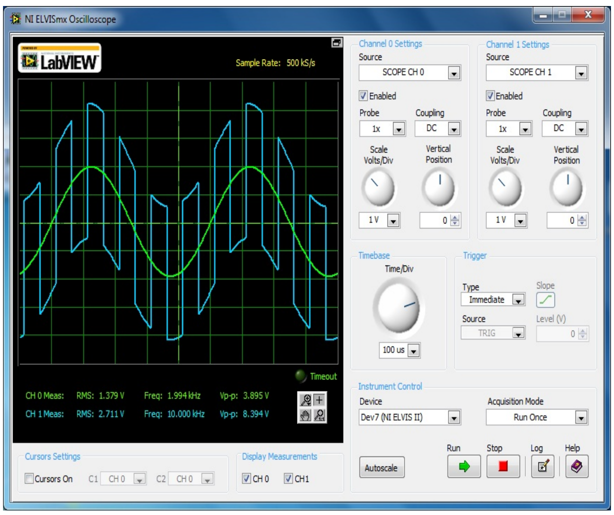
Figure 5: The output is the same as the input.



- After applying the first changes now the mode control of the green transmitter is turned into DIGITAL.
- Then the setup is modified into;

Then, send two signals over the channel – an analog and a digital message (modeled by the master signals moduls 10kHz Digital Output). The result of the WDM operation can be observed on the oscilloscope and it is given if figure 6. The set-up used for this experiment enables students to use LABVIEW capabilities for data calculations.

Figure 6: WDM output



VI. STUDENTS EXPERIENCE USING THE FOTEX TRAINER IN A HANDS ON ENVIROMENT

Two surveys were conducted to get students feedback about the use of the FOTEx and DATEx communication trainers' set-ups in the lab. The survey results for using the DATEx trainer set-up are given in [1]. The following questions about students experience in using the FOTEx-ELVIS II set up in a fiber Optic Communications course were used for the survey:

1- Do you feel comfortable using the FOTEx-ELVIS setup?
2- Where the FOTEx -ELVIS setup experiments clearly written?
3- Where the FOTEx -ELVIS setup experiments procedures easy to follow?
4- Did the use of the FOTEx -ELVIS setup increase your interest in the labs?
5- Did you have difficulties in configuring the FOTEx -ELVIS setup software?
6- Did you have difficulties in configuring the FOTEx -ELVIS setup hardware?
7- Did you experience difficulties in performing any Fiber Optic Communications experiment?
8- Was the FOTEx -ELVIS lab setup very valuable in terms of learning?
9- Overall, do you support the use of the FOTEx -ELVIS setup in this course?

The survey included 15 students enrolled in a graduate fiber optic communications engineering course, and the results of the survey are illustrated in Figure 7 where 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. As given in the graph, there is a total agreement among all students that they feel comfortable using the FOTEx-ELVIS setup an that FOTEx -ELVIS setup experiments clearly written.

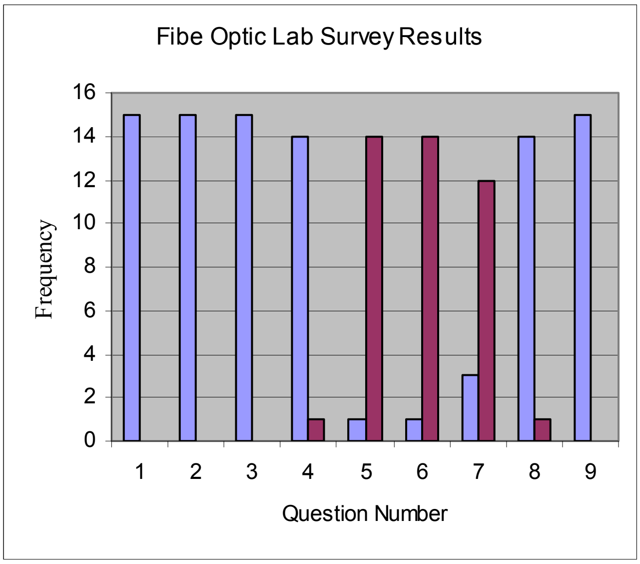


Figure 7: Fiber Optic Communications Survey Results

The results given in figure 3 shows that there is a total agreement among all students that they feel comfortable using the FOTEx-ELVIS setup an that FOTEx -ELVIS setup experiments clearly written. Also, all students surveyed support the use of the FOTEx -ELVIS setup.

CONCLUSION

In this work, we presented a plan for remote laboratory collaboration in engineering communications courses. This plan has presented strategies that can be followed and sample set-ups that can be used when implementing remote communications laboratories.

The results of the survey conducted about the use of the fiber optic communications set-up in the lab were very positive, and it shows that the FOTEx-ELVIS II set-up is a user friendly that has a fast learning curve. The next step is to implement the use of this set up with an optical switch matrix and use the set-up in a collaborative distance learning environment.

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