

# Implementation of a Remote Telecommunications Laboratory Using Emona-DATEx Trainer at Cantho University

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## ABSTRACT

*This paper presents a case study in the implementation of a remote telecommunications laboratory for teaching Telecommunication Systems courses at Cantho University. In this work, we present the use of the Emona-DATEx trainer and the NI-ELVIS platform to establish a telecommunications laboratory. To be assessed remotely, the system uses the LabVIEW Web Server tool for establishing a server and managing users. An Arduino Mega2560 kit is employed to control a switch matrix for setting up signal connections needed to perform experiments. Students can book time slots to carry out their remote experiments through the course websites.*

*The combination of hands-on laboratories and remote ones can be an effective approach for increasing students' technological knowledge and developing their self-learning ability. By using the microcontroller-based switch matrix, this work proposed a cost-effective and feasible approach to build a remote telecommunications laboratory for engineering universities with limited available resources of lab equipment. The remote laboratories can offer potential advantages for higher engineering education institutions in Vietnam and open opportunities for cooperation in training among engineering universities.*

**Keywords:** Telecommunications, Remote laboratory, Emona DATEx, ELVIS, Arduino.

## INTRODUCTION

Rapid development in the telecommunications sector has increased the demand for universities to provide electronics and communication engineering students with

up-to-date and relevant practical experiences. However, in Vietnam, the limited availability of laboratory equipment has reduced the breadth and depth of course objectives and lab assignments. One approach to mitigate this problem is to utilise online computer-based technology in expanding out-of-class learning activities.

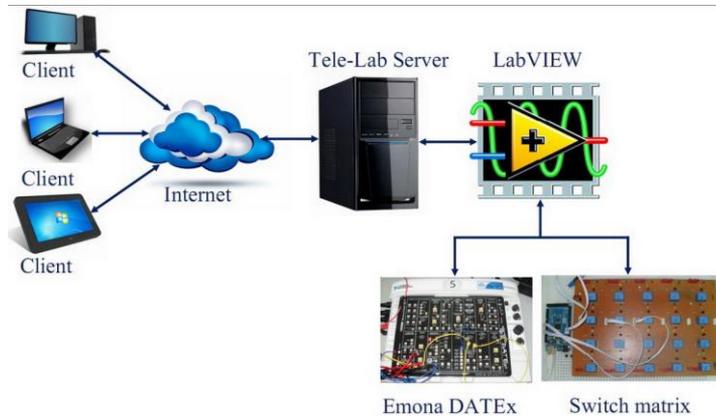
The remote labs have been developed throughout the world for over a decade. Firstly, in 1998, Jesus del Alamo started the iLab Project at MIT although it was several years before the project acquired its final name. Then, in 2001, Hal Abelson of MIT's Electrical Engineering and Computer Science Department and Dave Mitchell of Microsoft, who were both involved in the leadership of the iCampus Project, suggested that the various iLab researchers might progress more quickly if their online labs were built on a shared infrastructure (Achelangwa, 2011). As a result, MIT's Center for Educational Computing Initiatives joined the effort to lead the development of the resulting middleware known as the iLab Shared Architecture (ISA). Through an open source development kit and a public service broker, MIT encourages educators worldwide to develop their own iLabs and then share them with other academic institutions. Through these initiatives, MIT is delivering the educational benefits of hands-on experimentation to students anywhere, at any time (Oluwapelumi, et al. 2012). Besides, there are many forms of remote lab being developed at the same time such as the Netlab of the University of South Australia (Machotka, Nedic & Gol, 2007), the iLABRS of the Universitat Politècnica de Catalunya (Bragós, et al. 2010). However, these kinds of remote labs are developed with high-cost infrastructure, and this makes these models less feasible for applying to teaching engineering students in developing countries like Vietnam.

In the case study presented here, the remote instrumentation technology and the internet are merged to create a remote telecommunications lab, named the Tele-Lab. This system is based on the combination of the Emona Digital and Analog Telecommunications Experimenter (DATEX) trainer and the National Instruments Educational Laboratory Virtual Instrument Suite (NI ELVIS) platform. By using the Arduino microcontroller-based switch matrix, this work has proposed a low-cost and feasible solution to build a remote telecommunications lab. In addition, not using dedicated technology like service broker in the iLab system has made this system a cost-effective approach to be implemented. Besides, in order to assess the feasibility and usefulness of the Tele-Lab, a group of students have been asked to perform an experiment on the remote Lab and conduct a survey to collect their opinions about the use of this lab.

## **THE PRINCIPLE OF THE TELE-LAB**

Figure 1 shows the general structure of the Tele-Lab which, thanks to the LabVIEW Webserver tool, clients from anywhere can access the Lab Server via the internet to perform experiments merely by switching a software matrix-switch interface on or off to create/delete signal paths between components right on the real telecommunication circuits at the remote lab.

The hardware of the Tele-Lab mainly consists of NI ELVIS and the third-party add-on module, namely the Emona DATEx as shown in Figure 2.



**Figure 1: The general structure of the Tele-Lab**

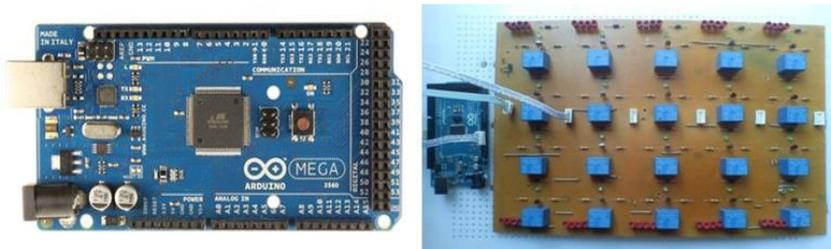


**Figure 2: Emona DATEx and NI ELVIS combination**

The NI ELVIS is a small-footprint, all-in-one electronics workstation that can be an alternative to almost all instruments that are basically equipped in an electronics engineering laboratory. It contains 12 virtual instruments (VIs) including Oscilloscope, Digital Multimeter, Variable Power Supply, Bode Analyzer, Dynamic Signal Analyzer and Arbitrary Waveform Generator. In addition, the NI ELVIS can be programmatically assessed and controlled within NI LabVIEW (Laboratory Virtual Instrumentation Engineering Workbench), a graphical development environment integrating innumerable hardware devices and libraries. The variety and mobility of NI ELVIS has made it very suitable for the development of a wide range of electronics experiments aiming to consolidate the solid knowledge of the electronics field.

Emona DATEx is a plug-in trainer module which is designed for telecommunications and signal processing courses. In particular, Emona DATEx actually includes more than 20 circuit blocks for basic telecommunications operations such as adder, multiplexer, mixer, signal generator and phase shifters, which can be used to perform dozens of telecommunication experiments merely by matching these block diagrams together. Moreover, Emona provides drivers that are compatible with the LabVIEW development environment, allowing this third-party add-on to be programmatically controlled in the same environment as the NI ELVIS. The NI ELVIS / Emona DATEx combination provides hands-on telecommunications experiments with real-world electrical signals.

To be accessed remotely, the Tele-Lab employs the LabVIEW Web Server function and the DATEx Soft Front Panel, where all knobs and switches are varied remotely under LabVIEW control. An Arduino Mega 2560 kit is used to control a 5 x 4 matrix switch, as shown in Figure 3, for setting up signal connections needed to perform experiments. The Arduino kit is connected to the lab server via a USB port. The status of each switch in the matrix board can be changed by using a software interface within the LabVIEW environment. The whole hardware set-up of the Tele-Lab can be seen in Figure 4.

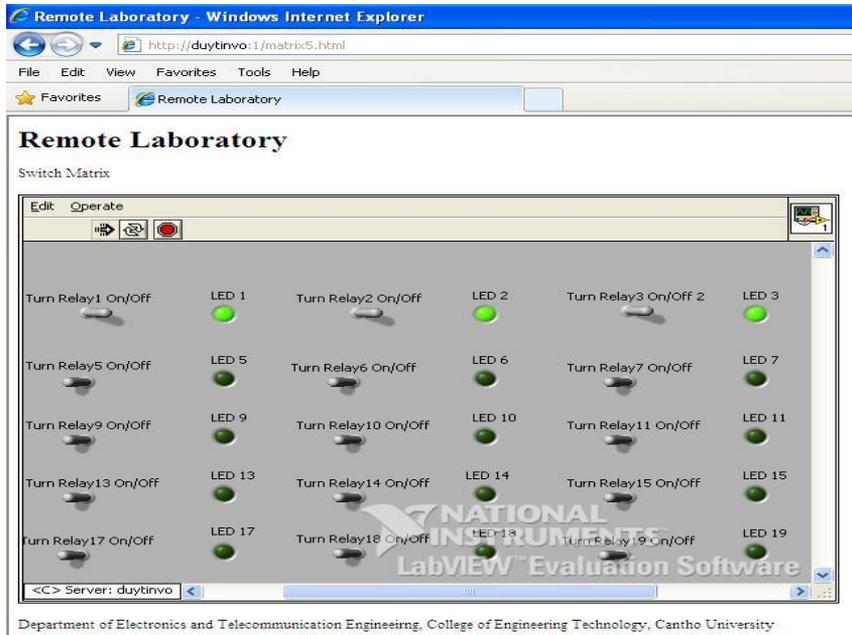


**Figure 3: Arduino 2560 kit and the 5 x 4 matrix switch**



**Figure 4: The hardware components of the Tele-Lab**

In order to control virtual instruments (VIs) remotely, LabVIEW Web Server function is used to publish these VIs on a web-based interface and manage both server and clients as well. With this tool of LabVIEW, the front panels of these VIs can be run on a machine that is separate from where the VIs reside and execute as shown in Figure 5.



**Figure 5: Software interface of the matrix switch**

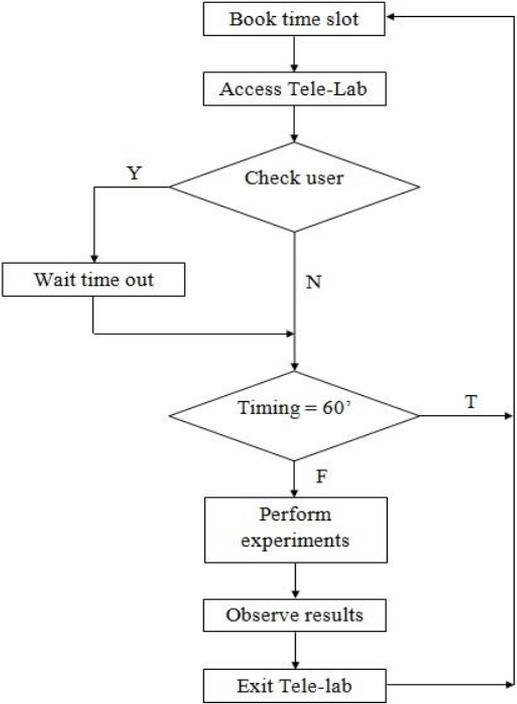
Moreover, the front panels can be embedded into a web page and operated within that page. On the client computer side, all that is required for executing in a web page is a web browser and the LabVIEW run-time engine installed on the computer. With the LabVIEW Web Server function enabled, the front panels can be connected and executed by remote clients. However, only one remote panel connection is allowed at one time. Therefore, a time division approach is employed to create experiment schedules for individual students. In our case study, students use Doodle's scheduling service to book suitable time slots for performing their lab assignments. By following this method, one student can only register with a fixed time slot to avoid simultaneous connections.

## **APPLICATION OF THE TELE-LAB**

Students attending lab courses can access the Tele-Lab to perform a broad range of telecommunications experiments offered by the combination of Emona DATEx trainer and the NI ELVIS platform. In this paper, the Amplitude Modulation experiment is presented as an example.

## Amplitude Modulation

In this experiment, a group of students have been asked to carry out the Amplitude Modulation (AM) experiment on the Tele-Lab. The procedure for registering and performing the experiment is summarised in Figure 6.



**Figure 6: Procedure for undertaking the remote experiments**

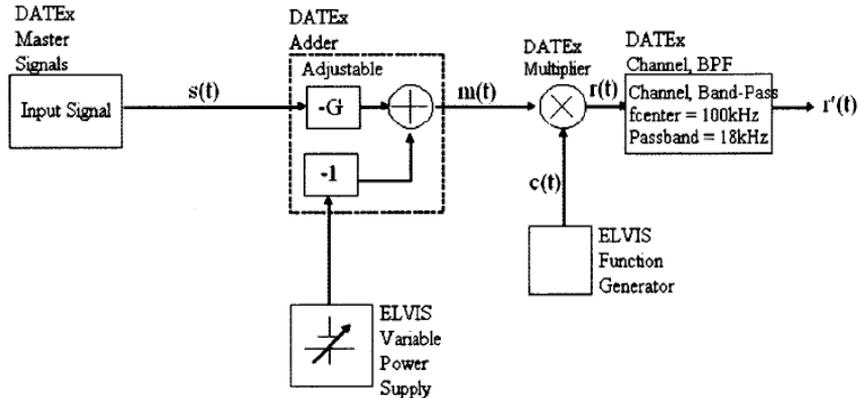
Firstly, students must book a 60-minute time slot via Doodle scheduling service by clicking on the Doodle link in an email sent by the lecturer. Each student can only check up to two time slots per week. Figure 7 shows a typical interface for registering the lab course using Doodle.

Poll "Fundamental Telecommunication Experiments"

	April 2013											
	Mon 22						Tue 23					
	7:00 AM - 8:30 AM	8:30 AM - 10:00 AM	10:00 AM - 11:30 AM	1:30 PM - 3:00 PM	3:00 PM - 4:30 PM	4:30 PM - 6:00 PM	7:00 AM - 8:30 AM	8:30 AM - 10:00 AM	10:00 AM - 11:30 AM	1:30 PM - 3:00 PM	3:00 PM - 4:30 PM	4:30 PM - 6:00 PM
Vo Duy Tin 002432	OK						OK					
duytinvo						OK						OK
Count	1	0	0	0	0	1	1	0	0	0	0	1

**Figure 7: Registered time slots in Doodle service interface**

Then, at the pre-registered time, students can access all VIs of the Tele-Lab by using a web browser. If there are any users currently using the Lab, the student must request to take control and then wait for the current user to release his/her control.



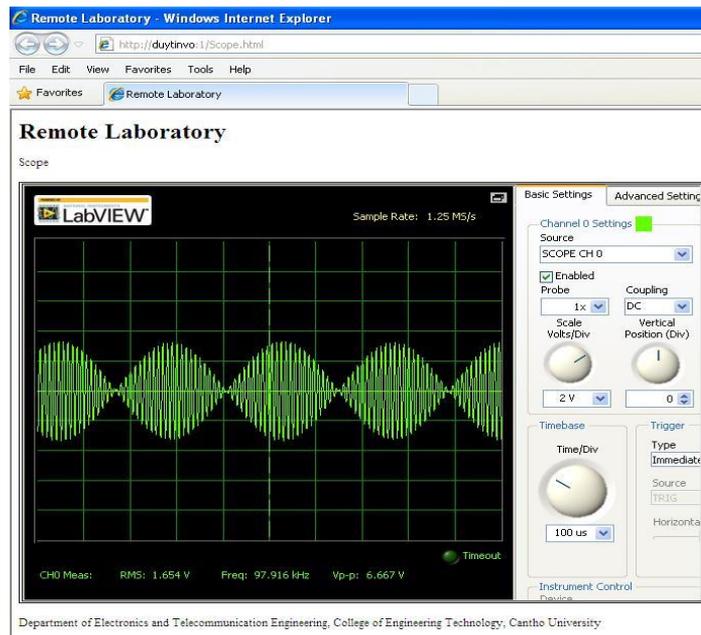
**Figure 8: DATEx block diagram of Amplitude Modulation**

After gaining control, the student performs the experiment and observes the results by establishing connections between each part of the Emona DATEx-ELVIS communications bundle as shown in Figure 8 and running these VIs via a browser as displayed in Figure 9.

Finally, at the end of the 60-minute time slot, students must release their control and log off the Tele-Lab.

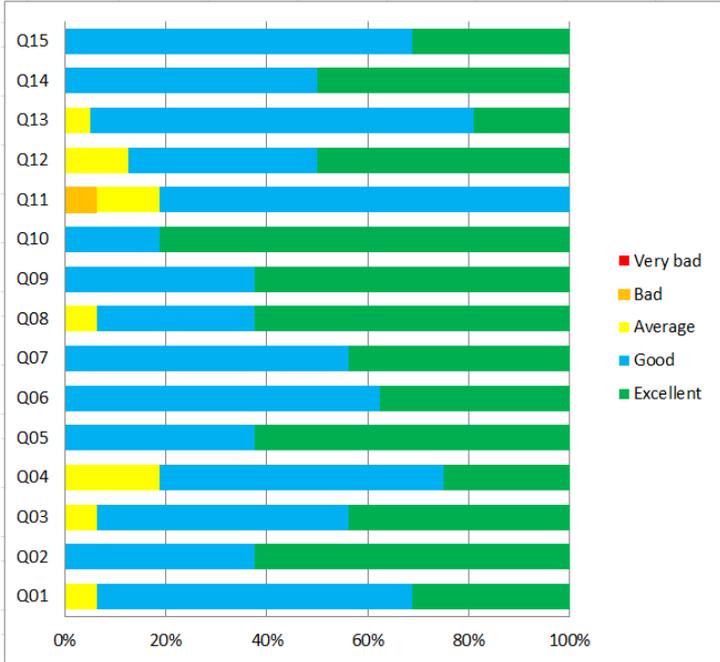
## Students' Feedback

The Tele-Lab is a work in progress and has not been officially used in Telecommunications lab courses at the Department of Electronics and Telecommunication Engineering, Cantho University. However, some initial evaluations have been conducted to discover whether the Tele-Lab is feasible in practical conditions, and whether the use of the Lab motivates students' self-study ability. A group of 16 students volunteered to participate in the pilot course. All students were provided with lab manuals, asked to perform the AM experiment on the Tele-Lab, and undertake a survey about the advantages and disadvantages of the Lab. Google Docs application was employed to collect students' opinions using the survey questions listed below:



**Figure 9: AM signals shown on the screen of remote clients**

- Q1. Ease of use?
- Q2. Are you provided with complete lab manuals of the remote lab?
- Q3. Are lab manuals and related documents helpful to you?
- Q4. Is the remote lab useful for you in studying practical courses?
- Q5. Is the remote lab an innovative method of teaching?
- Q6. Perspectives of remote lab?
- Q7. Are you satisfied with doing experiments remotely?
- Q8. Do you feel comfortable using the Tele-Lab?
- Q9. Were the lab manuals clearly written?
- Q10. Does the use of the Tele-Lab increase your interest in the lab?
- Q11. Did you have difficulties in configuring the software and hardware?
- Q12. Are the Tele-Lab assignments related to your class topics?
- Q13. Do you think the Tele-Lab helped you to better understand the class topics?
- Q14. It is easy to connect to the Tele-Lab?
- Q15. Give a general evaluation about remote lab.



**Figure 10: Students' survey results**

Through these questions, initial results reflected a positive signal for the use of the Tele-Lab at Cantho University. In particular, the survey result, shown in Figure 10, states that all students recognised the Tele-Lab as an advanced lab to help them review what they have studied (Q05). Almost all of students agreed that performing experiments remotely is an attractive method of self-study due to its mobility and flexibility (Q10), while only one student responded that he encountered a little bit of difficulty in manipulating the remote lab (Q11). Generally, the students appreciate applying the Tele-Lab (Q15) in teaching and suggest expanding the model of this remote lab to other lab courses in the Electronics and Telecommunication Engineering program at Cantho University.

### CONCLUSION

The remote use of this system can reduce the need for students to be present in the lab to carry out experiments. By using the microcontroller-based switch matrix, this work has presented a low-cost and feasible solution to build a remote telecommunications lab. The combination of hands-on laboratories and remote ones can be a cost-effective approach for higher engineering education in Vietnamese universities where limited available resources in the provision of laboratory equipment have been the main obstacle. This can also open opportunities for cooperation among engineering education institutions in sharing lab facilities.

## ACKNOWLEDGEMENT

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