Implementation of Online Optoelectronic Devices Course and Remote Experiments in UC1 iLab

S. Rebiai, N. E. H. Touidjen, S. Mouissat
University Constantine 1 (UC1) Constantine, Algeria

Abstract—**This paper presents a remote experience on light emitting diodes programmed through the practical work of optoelectronic devices available in an online course from the electronic department of the University Constantine 1 (UC1). This course is one of three online courses proposed among the contributions by the UC1 in the e-Sience Tempus project.**

"Optoelectronic components" is an e-course dedicated to students from the "master electronic" training program. This e-course will be implemented in UC1's Moodle LMS (learning management system) platform. Its objective is to introduce and consolidate students' knowledge of optoelectronic devices used in optical transmissions.

The LED experiment is one of the practical works proposed to be implemented in UC1's remote laboratory. The remote e-courses and experiments are in progress and will be available online beginning October 2015.

Index Terms—**didalab-toolkit, e-course, LabVIEW, Moodle-platform, optoelectronic, remote laboratory, UC1-iLab.**

I. INTRODUCTION

For many years, the universities and technical colleges have made progress in the way of delivering education. Rising education costs, shrinking budgets and an increasing number of students have led universities to reconsider the way of offering education. Currently, universities are working on the development of online distance learning, also called an E-learning system [1, 2] or M-learning, which is e-Learning adapted to mobile usage by the learners. The latter is used to deliver distance learning via mobile media such as a smart phone, a media player, or a mobile tablet such as the iPad.

The use of remote laboratories is one of the future objectives for advanced teleworking; they are naturally suited to distance learning and flexible learning [3, 4].

The platform completes a system that provides continuous access to the same experiments remotely via the Internet and enables users to carry out experiments without being near the equipment [5, 6]. This allows the use of only one experimental setup by a great number of users, which reduces the practical work costs. In fact, this kind of experience is widely used for optoelectronic engineering [7, 8].

Optoelectronics is a multidisciplinary technology that requires knowledge from multiple areas: optics, electrical engineering, communication and physics. It is an emerging discipline that jointly uses electronics and optics. Progress in the fields of optoelectronics and photo-electricity has led to the marketing of components used extensively in industry, including Light-Emitting Diodes or LEDs. Practical work on light-emitting diodes is designed to familiarize students with the different characteristics of a light emitting diode and to allow them to see the links between the electrical, optical and physical parameters of LEDs.

The objective of this work is to present an "Optoelectronic devices" unit that includes theoretical and tutorial sessions starting with one remote experiment on light emitting diodes.

This course is one of three online courses in the field of electronic engineering proposed as part of UC1's contribution to the e-Sience Tempus project.

e-Sience Tempus is a Euro-Maghreb project that associates sixteen academic and industrial partners and is coordinated by the University of Bordeaux. Its purpose is to create three eLabs (laboratories of remote measurements) in the Maghreb region, allowing students of partner universities to perform real experimental work remotely and to implement an LMS (Learning Management System) that will host educational resources (courses, tutorials, quizzes and links through the eLab) [9].

The three e-courses will be implemented in the UC1 Moodle LMS platform. Using some remotely operated equipment, the practical work proposed by the UC1 as well as a light emitting diodes experiment are prepared and will be implemented through the first remote laboratory of University Constantine 1 (UC1-iLab). Thus, it will allow students to perform their real experiments at times and in spaces of their choice.

As the first step in light emitting diodes remote experiment, students will be able to measure point-to-point, volt-ampere characteristics of different LEDs. Thus, this paper will discuss the use of a didalab-toolkit PED037900 [10] for remote experiments. This toolkit is dedicated to face-to-face practical work on optoelectronic transducers and, with the use of some interfaces like LabVIEW, this practical work will be implemented in our remote laboratory. Many successful remote experiments have been developed in electrical engineering using a LabVIEW environment for hardware control and to respond to user commands. These remote experiments were developed to enable users to learn about the characteristics of different PV materials [3], optical fiber communication [7, 11] or electrical circuit experiments [12].

Compared to other online optoelectronic laboratories [13 and 14], didalab sets give students the opportunity to study the main optoelectric transducers as LEDs (static and dynamic specifications), photodiodes and photoresistors. They also give the option to illustrate applications such as the study of a transmission medium, the produc-

tion and detection of light pulses, and the transmission of a sound with an optical fiber [10].

This paper is organized in the following manner. An optoelectronic devices online course is presented in Section 2 and the remote experiment on LEDs in Section 3. Section 4 concludes the paper.

II. DESCRIPTION OF OPTOELECTRONIC DEVICES ONLINE COURSE

Optoelectronics is an emerging discipline that jointly uses electronics and optics. It has a large span in various fields, especially in information technology, telecommunications and medical electronics.

Apart from optical fiber, which is an optical waveguide for propagating light confined by total reflections, the different devices considered in the course are made from semiconductors and particularly from PN junctions. These are electronic transducers to optical or optical to electronic whose operating principle is based on radiation interactions with electron-hole pairs that result in the emission or absorption of photons.

The course is structured in four parts. The first part of this course is devoted to the properties of semiconductor materials used in the field of optoelectronics. The second part deals successively with the two types of light sources used in today's communication: The LEDs and Laser Diodes. The third part of the course is dedicated to the study of optical fibers through general definitions of the fiber structure, the light transmission in this waveguide and the principle of wavelength division multiplexing (WDM). In the fourth and last part the student will become familiar with photo-detectors and their characteristics. The page for the course in the Moodle platform of UC1 is shown in Fig.1.

Exercises and assignments enable the implementation of these courses and deepen knowledge. Quizzes and collaborative work will be scheduled for the course evaluation. Moreover, the platform allows teachers to communicate with students via email, announcements, host online discussions and receive different planned homework assignments.

One activity added in the course is to use simulation of technological and electrical properties of optoelectronic devices to complete the remote experiment. This contribution uses the software TCAD (Technology Computer Aided Design)-SILVACO [15], which is widely used in the world of electronic components. For example, it will ask the students to create a structure of a green LED and simulate its characteristics with TCAD-ATLAS simulator tools. An example of expected result is shown in Fig.2.

A series of face-to-face practical work cover experiments on

1. Light-emitting diodes
2. Optical fibers
3. Photo-detectors

The first online experience is on light-emitting diodes. It is still under development. So the remote experience presented in this work will be focused on the static properties of LEDs.

At the end of this course, the student will be able to
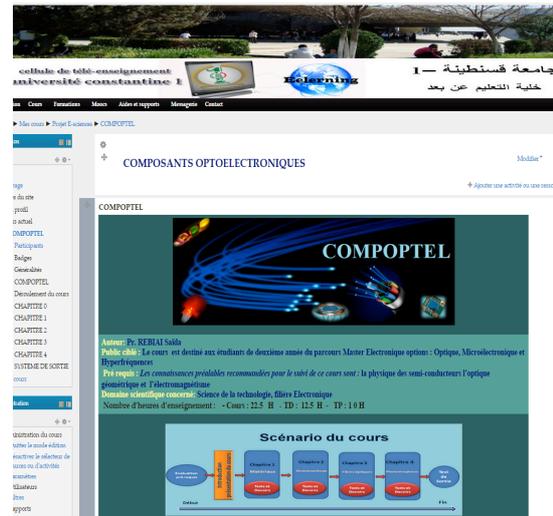
Figure 1.   Optoelectronic devices course page on Moodle Platform
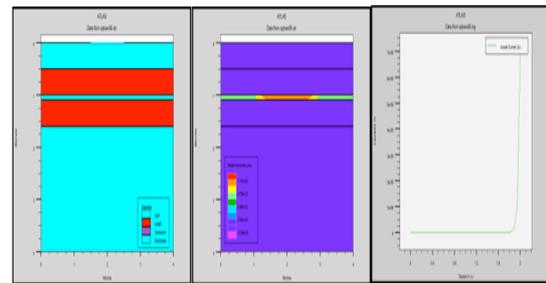
Figure 2.   Results of simulation: (a) The green LED structure, (b), radiative recombination rate in the device, (c) current- voltage characteristic

1. Know the operation principles of various optoelectronic elements in the optical fiber transmission chain through the study of components capable of emitting (Chapter 2), transmitting (Chapter 3) and receiving (Chapter 4) an optical signal.
2. Use devices characteristics to determine the energy balance of a fiber optic link.

III. DEVELOPPEMENT OF REMOTE EXPERIMENT ON LEDs

To develop a remote experiment on LED characteristics using real equipment, a face-to-face experiment is carried out with a didalab-toolkit [10]. Its implementation in a remote lab via the UC1iLab is actually in progress. The evolution of this work is presented in this section.

A. Traditional LED practical Work

Light emitting diodes, like laser diodes, are commonly used as light sources in communication via optical fibers. Knowledge of LED's characteristics is necessary to determine losses and signal dispersion in an optical fiber link. For this purpose, the main practical work in light emitting diodes is to characterize LEDs with different colors (red, green, yellow, blue and IR). To record different points of current-voltage characteristics, we used the didalab set illustrated in Fig.3. This toolkit allows the study of the main optoelectronic transducers through the combination of two modules, one for light sources and the other for detectors.

Figure 3. Optoelectronic didalab toolkit and electronic component curve tracer
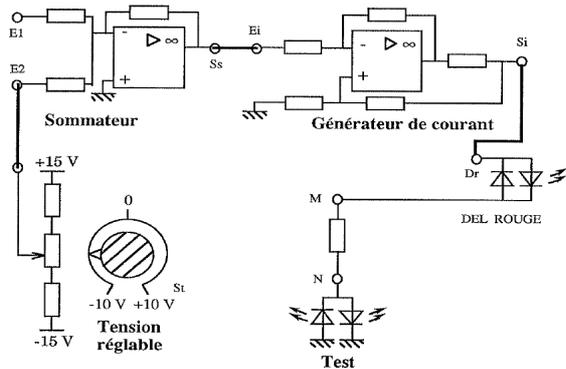

Figure 4. Basic circuit for measurement of LED's output characteristics
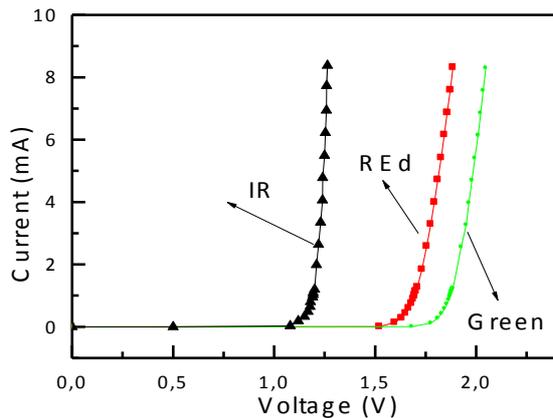
Figure 5. Current-voltage Characteristics of different LEDs

The electrical circuit used for LED alimentation is given in Fig.4 [10]. An electronic component curve tracer is also used to test the components.

The measured values of forward current I_D and voltage V_D are plotted, and the diode parameters of each LED are extracted from the basic exponential diode equation:

$$I_D = I_S . e^{V_D/_{n.U_T}} \quad (1)$$

Where U_T is the thermal voltage (equal $25mV$ at room temperature), I_S is the saturation current and n the ideality factor. An example of results is illustrated in Fig.5.

In addition, as in traditional face-to-face practical work, students plot the relative spectral characteristics of the LEDs. To obtain this curve, we used a standard set of instruments consisting of a monochromator (range 0.2 to 0.9 μm) and a photosensitive sensor with its photometer (Fig.6). For a given forward bias, light is emitted with a power proportional to current.

Figure 6. Instruments used to measure spectrum of LEDs
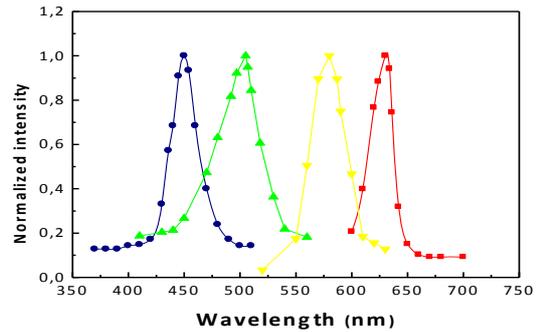
Figure 7. Emission spectra of LEDs of different colors (blue, green, yellow and red)
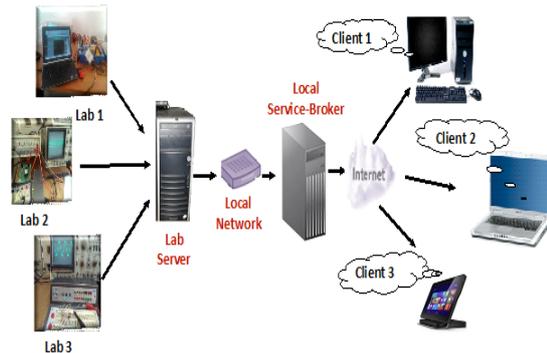
Figure 8. UC1 iLab architecture

An example of spectral curves for LEDs of different colors is illustrated in Fig.7. The center wavelength of an LED emission curve determines the band gap energy of the material forming the p-n junction.

B. UC1 online Lab architecture

To convert proposed practical work to remote experiments we will use modern computers, network technology and the UC1-iLab, which is under construction. The system architecture of the UC1 online Lab is shown in Fig.8.

The system includes a lab server that handles the management and storage of experiments measuring results. It is directly related to the hardware via acquisition interface and a Service Broker that ensures exchanges between the Lab Server and the Lab Client and provides storage and administrative services [5]. At first, three experiments will be connected to the lab server via a GPIB/USB acquisition interface and by the use of a remotely controlled switch matrix. Video cameras will be used to show real equipment in the laboratory.
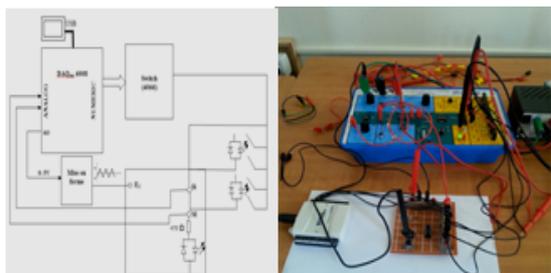
Figure 9. Measurement equipment and LabVIEW interface for LED remote experiment
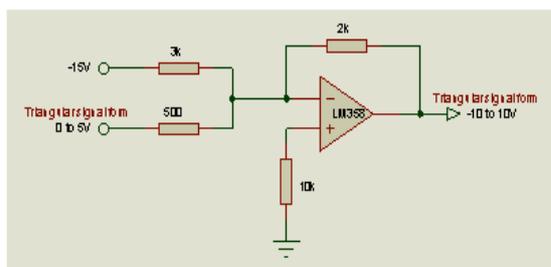
Figure 10. Electrical circuit for triangular signal generation
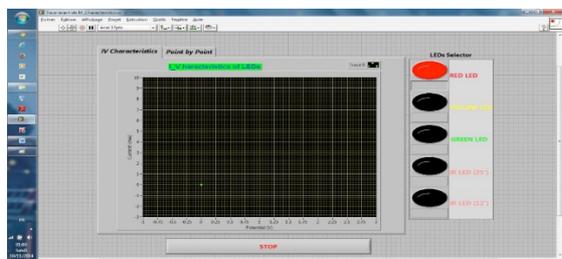

Figure 11. LabVIEW user interface

Figure 12. Drawn of I-V curve; L EDs VI block diagram and VI front panel
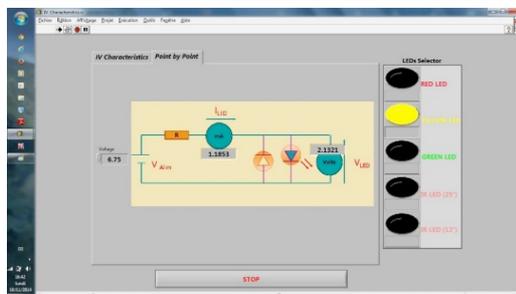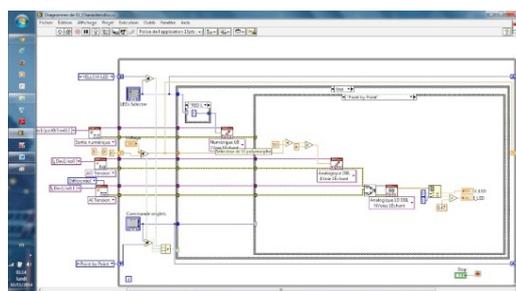
Figure 13. Point by point measurement; L EDs VI block diagram and VI front panel

C. Remote experiment with LabVIEW interface

To use a didalab toolkit in optoelectronic remote experiments we introduced some modification to the electrical circuit. We chose LabVIEW software to perform the instrumentation control and data acquisition, so we realized an interface of the data acquisition card DAQmx6008 with the experiment.

A circuit based on switch 4066 is also realized to select the LED to be characterized. The schematic interface between the PC and the experiment kit is illustrated in Fig.9.

Also, we have replaced the manual potential variation (with potentiometer) from -10 to +10V (see Fig.3 and Fig.4) by an electrical circuit based on a LM358 converter. The circuit designed to generate a triangular signal is represented in Fig.10.

A LabVIEW program was developed to enable the reading and automatic plot of the LED's characteristics. Using the remote panel technology of LabVIEW (Fig. 11), the student can select the LED to characterize and the measurement type.

The DAQmx 6008 measures the voltage across the LED and the current flowing through it. If an I-V curve is selected, the current-voltage characteristic map is drawn on the screen (Fig. 12) and the current-voltage characteristics of different LEDs can be saved on files with a spreadsheet format for later data analysis. If point-by-point measure is selected, students report current and voltage manually for a range of supply voltage (Fig. 13).

IV. CONCLUSION

In this article, we have presented a learning environment for an optoelectronic e-course developed at UC1 as a contribution to the eSience Tempus project. We focused our work on the implementation of practical remote work on light emitting diodes. We have used a didalab toolkit and LabVIEW interface to conduct experiments online via the Internet using the UC1-iLab, which is under construction. An example of current-voltage characteristics plotted through a LabVIEW interface has been presented

The use of a LabVIEW interface for characterizing LEDs shows that it is possible to conduct several experiments using didalab tools with the developed online lab. This will allow students to perform other experiments with UC1's remote optoelectronic laboratory.

REFERENCES

[1] S. M. Zvacek, "Creating Engaging Online Courses", iJOE – Volume 5, Special Issue 2: "IRF'09", November 2009: http://www.i-joe.org

[2] N. Wagner, K. Hassanein, and M. Head, "Who is responsible for E-Learning Success in Higher Education? A Stakeholders' Analysis", Educational Technology & Society, Vol.11, N°3, pp. 26-36, 2008.

[3] S.R. Williams, R. Blanchard, A. Mohammed, M. Bliss, R. Pancholi, M. Clowes, " THE DEVELOPMENT OF A REMOTE LABORATORY FOR DISTANCE LEARNING AT LOUGHBOROUGH UNIVERSITY", Proceedings of EDULEARN13 Conference 1st-3rd July 2013, Barcelona, Spain, pp. 4342-4349.

[4] J. L.Moore, C. Dickson-Deane, K. Galyen, "e-Learning, online learning, and distance learning environnements: Are they the same?", Internet and Higher Education, Vol. 14, pp. 129–135, 2011. http://dx.doi.org/10.1016/j.iheduc.2010.10.001

[5] V. Judson et al, "The ilab shared architecture: a web services infrastructure to build communities of internet accessible laboratories," Proceeding of IEEE, Vol. 96, No. 6, pp. 930-951, June 2008.

[6] C. Gravier, J. Fayolle, B. Bayard , M. Ates, "State of the art about remote laboratories paradigms - foundations of ongoing mutations", iJOE 4, 1, 2008: http://www.online-journals.org

[7] Akram A. Abu-aisheh and T. E. Eppes, "Remote Laboratory Collaboration Plan in Communications Engineering", iJOE – Volume 8, Issue 4, November 2012: http://www.i-joe.org

[8] N. I. binti Mohd Rawi M. Z.i Jamaludin, F. Abdulla, "OPTISYSTEM: AN ALTERNATIVE TO OPTOELECTRONICS AND FIBER OPTICS TEACHING E-LABORATORY", International Journal of Asian Social Science, 2014, 4(2), pp. 307-313.

[9] E-Sience Tempus :http://www.esience.org/

[10] M.Demonchy, R.Legoff "Etudes des transducteurs optoélectroniques," didalab enseignement supérieur, 2009: http://www.didalab.fr

[11] Akram Abu-aisheh, Sameer Khader, and Omar Hasan, "Implementation of Dual Use Fiber Optic Communications Laboratories", iJOE – Volume 7, Issue 2, May 2011

[12] I. Gustavsson, "A Remote Access Laboratory for Electrical Circuit Experiments", Int. J. Engng Ed. Vol. 19, No. 3, pp. 409-419, 2003.

[13] Ryan A. Sherry and Susan M. Lord, "LabVIEW as an Effective Enhancement to an Optoelectronics Laboratory Experiment", (Volume: 2)

[14] M.G. Guvench , "Optoelectronic Device and Fiber Link Characterization in Computer Integrated Electronics Laboratory", Proceedings of the American Society for Engineering Education Annual Conference , 2007.

[15] Atlas user's Manual: Device Simulation Software. Santa Clara, 2013.http://www.silvaco.com

AUTHORS

S. Rebiaï is with the Microsystem and Instrumentation Laboratory, Electronic Department, Faculty of Science Technology, Constantine 1 University (UC1), Constantine, Algeria, (e-mail: saidarebiai@gmail.com).

N. E. H. Touidjen is with the Electronic Department, Faculty of Science Technology, University of Constantine 1 (UC1), Constantine, Algeria, (e-mail: houdatouidjen@yahoo.fr).

S. Mouissat is with the Microsystem and Instrumentation Laboratory, Electronic Department, Faculty of Science Technology, Constantine 1 University (UC1), Constantine, Algeria, (e-mail: sm_mouissat@hotmail.com).