

Sharing Laboratory Education through the WEB

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Abstract

Life long learning in high-tech professions brings more non-traditional students to colleges and universities. All institutions are engaged in developing distance-learning courses. Oregon Institute of Technology is engaged in a project for developing real laboratory courses taken by students over the web. Since the initial investment, development, and maintenance of such courses is very expensive, cooperation between colleges is very important. The paper will describe the beginning of common efforts by OIT and some community colleges in the state to develop and use in common laboratory experiments for courses in Electronics.

I. Introduction and Background

In the last two decades, distance education has been implemented at numerous colleges and universities. The internet is used more and more for its flexibility and versatility. As Plaisent stated, institutions of higher education will increasingly rely on various forms of web-based delivery in order to survive in the 21st century ². In Oregon, Oregon Institute of Technology (OIT) and Portland Community College(PCC) are no exceptions.

The Internet is widely used as a conduit for former lecture content-based courses. Many software tools are available for course development as WebCT, Blackboard, etc. Nevertheless, the availability of engineering laboratory courses remains moderate, and effective distance delivery of engineering laboratory courses remains a challenging problem to be solved ². Currently, there are very few engineering laboratory courses being offered online ²⁻¹². Two departments, Electronics Engineering Technology (EET) at OIT and Microelectronics Technology (MT) at PCC embarked on the road to solve the problem.

Oregon Institute of Technology (OIT) is the only institution in Oregon offering bachelor degrees in engineering technology. The main campus is situated in Klamath Falls, in Southern Oregon. In Portland, 300 miles north, OIT has two campuses providing education mainly to working adults, employed in Portland metropolitan area, in the so called "Silicon Forest". For these students, seeking degrees or professional development, availability of courses anytime, from anywhere, became more and more important.



Fig.1 The city of Portland seen from the Willamette River

Also in Portland, Portland Community College (PCC), the largest institution of higher learning in the state of Oregon, serves more than 1,000,000 residents in a five-county, 1,500-square-mile area in North West Oregon. PCC enrolls more than 83,000 full and part time students annually, or one in 13 residents. The college has three comprehensive campuses: Cascade, Rock Creek and Sylvania but classes are offered at approximately 200 other community locations throughout the district. Rock Creek campus is home for the PCC Microelectronics Technology (MT). PCC is considered one of the “feeder” schools for OIT, many of their graduates, holders of associate degrees, continuing on to OIT, where they may earn a Bachelor’s degree.

The cooperation of the two institutions in distance learning has already some history.

In 1998 PCC adopted the use of Web based teaching/learning in addition to the traditional classes, using WebCT. The program is powerful enough to cover the needs of a large variety of classes offered at PCC, including the engineering and technology classes. An example of such a course can be checked at:

<http://www.distance.pcc.edu/distancehq/DGDisplay.cfm?style=4&DispGroupID=13>

Because the majority of these classes have a lab component attached, the choice PCC made was to create the “hybrid classes”, meaning the lecture portion was offered on the Web with the laboratory offered as a traditional hand-on in class.

Encouraged by the success and rapid development of the distance learning (DL) classes at PCC, a year later OIT decided to adopt and use the same WebCT tool for teaching many of their classes, including courses in the Electronics Engineering Technology curriculum. Dorina Cornea, full time instructor at PCC developed and started to teach on the web for OIT a course called Topics in Network Analysis, EET 281 . This course is designed for students transferring from any community college into OIT program.

The EET department at OIT is also offering some other EET hybrid classes. The lecture courses are web courses. The students have to come to the campus for the associated laboratory course. This reduces much of the student commuting time, but still does not offer the possibility of completing the laboratory course while working abroad or during unexpected emergencies.

The EET department at OIT was not satisfied with the type of “hybrid classes” PCC adopted first, and when it came to teach on line electronics classes, took the initiative of designing the remotely controlled labs.

II. Major Steps of the Web-Based Laboratory Project

The administration of both colleges, OIT and PCC was receptive to EET department’s idea of designing and using remotely controlled labs for the electronics classes. Having the support of the administration, the EET department from OIT started to seek funds for the relatively costly project. We also found technical support and inspiration by visiting other universities with experience in the field as Washington State University in Vancouver, Washington. Finally OIT’s project was initially funded by a grant from Intel Corporation, a constant corporate supporter of both colleges.

The timeline of the project is presented in Table 1.

TABLE 1. TIME OUTLINE OF COLLABORATION PROJECT

Major steps of the project:	OIT	PCC
Initial idea and initial research.	<i>May 2003</i>	-
Collaboration between the two colleges started	September 2003, Discussions, making a common plan.	
Writing a grant proposal	<i>November 2003</i>	<i>May 2004</i>
Funds approved	<i>January 2004</i> , grant from Intel Co. for 5 stations	<i>June 2004</i> , grant from\ Intel Co. for one station.
Starting the implementation	<i>February 2004</i>	<i>June 2005</i>
Purchasing the components from NI	<i>March 2004</i>	<i>January 2005</i>
Hardware installed and verified	June 2004	<i>July 2005</i>
Design of first two experiments	<i>August 2004</i>	
Evaluation of the system	<i>Fall term 2005</i>	<i>July-August 2005</i> while teaching on line MT 113 class and using OIT projects
Design of 9 experiments for a complete semiconductor course	<i>September 2005</i> – development grant from Intel Co.	<i>2005-2006 school year</i> Use of selected OIT experiments

III. System Description ¹

III. A. Hardware Description

The following criteria were used in the design of the web-based laboratories:

1. The circuits must use the same real devices as in the classroom laboratories.
2. Students are required to select and interconnect components to form a correctly wired electronic circuit.
3. Virtual instruments corresponding with those used in the classroom laboratories are used (e.g. virtual function generator, oscilloscope, DMM, and curve tracers).
4. All DC power supplies are hard-wired and not under the control of the students.
5. Any student regardless of location has access to any one of the five systems.

Because of its extensive use in industry, both colleges decided to use National Instruments hardware for the web-based labs. The major components of one such system are listed in Table 2, and a photograph of one set of the hardware is shown in Figure 2. The total cost of the National Instruments hardware for the five systems was a little over \$47,000.00 paid for by the grant from Intel Corporation.

TABLE 2. WEB-BASED LAB HARDWARE PER STATION

QUANTITY	NI PART #	FUNCTION	COMMENTS
2	SCXI-1130	High-density multi-configuration switch matrix	256 micro-switches each configurable in a row x column matrix.
2	SCXI-1378	Terminal block to configure switch matrix as a 4 x 64	Provides for a total of 512 micro-switches configured in an 8 row x 64-column matrix.
1	PCI-4070E	Digital multimeter, isolated digitizer, and matrix controller	Used to control switches in switch matrix. Plugs into PCI slot on PC.
1	PCI-6070	Data Acquisition (DAQ) card	Used to generate the function generator, oscilloscope, and curve-tracer virtual instruments. Plugs into PCI slot on PC.
1	BNC-2120	Input/Output connector block	Used to patch inputs and outputs between the DAQ card and the DUT via BNC cables.
1	SCXI-1000	4-slot chassis	Used to house, power, and control the switch matrixes and terminal blocks.
1		Dedicated PC with keyboard and monitor.	Contains LabVIEW software to control hardware.
1		DUT experiment printed circuit board.	Custom PCB used to mount DUT and other electronic components

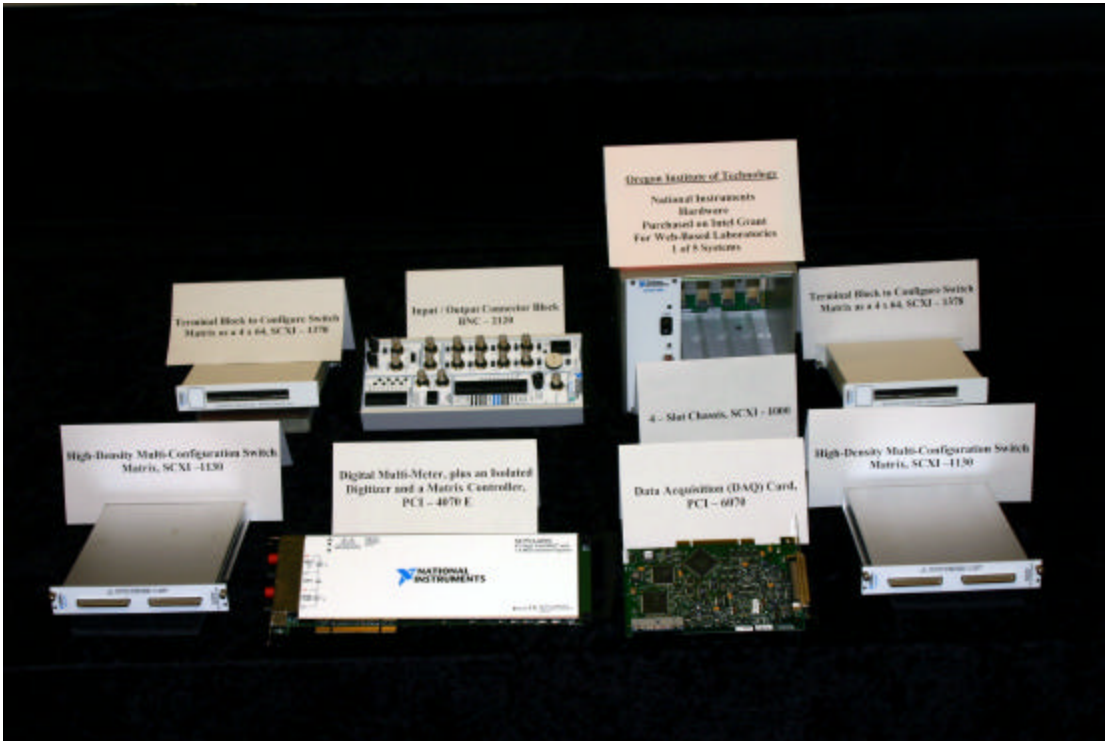


Figure 2. Hardware Components for Web-Based Labs. (Desktop PC and DUT printed circuit board not shown.)

The core of each system is the switch matrix and the terminal block that configures the 512 micro-switches into an 8 row by 64-column format. The opening and closing of these switches is triggered by the matrix controller, which is controlled by the LabVIEW software running on the dedicated personal computer. All 64 columns of the switch matrix are connected through ribbon cables to a custom PCB containing the DUT and electronic components such as resistors and capacitors required for a particular experiment.

III.B Software Development

We found that LabVIEW, as a graphical development software tool, is ideal for this project. Specifically, LabVIEW enables efficient development of interfaces for student control of virtual instruments because of the built-in web-publishing capabilities.

IV. Web-Based Labs ¹

Currently, two sophomore-level laboratory experiments are available to OIT electronics majors to be run remotely over the web - an operational amplifier (op-amp) lab, and a MOSFET lab. The rest of seven labs are under development to be completed this summer.

The op-amp lab is an introductory experiment, treating an integrated circuit operational amplifier such as the $\mu\text{A}741$ or LF411 as an “ideal” op-amp. The student is expected to choose appropriate resistor values and wire the circuit to provide inverting and non-inverting voltage amplifiers with a wide range of voltage gains. The resultant closed-loop gains and input impedances are predicted using hand calculations, measured using the web-based lab, and computer simulated using PSPICE. The student will connect to the system via web and will remotely control the switch matrix to make the appropriate connections. The results of the measurements will be displayed on his screen. The data could be also used in a spreadsheet.

Fig. 3 shows the front panel seen by the student after correctly connecting the parts, and Fig. 4 the panel with the results.

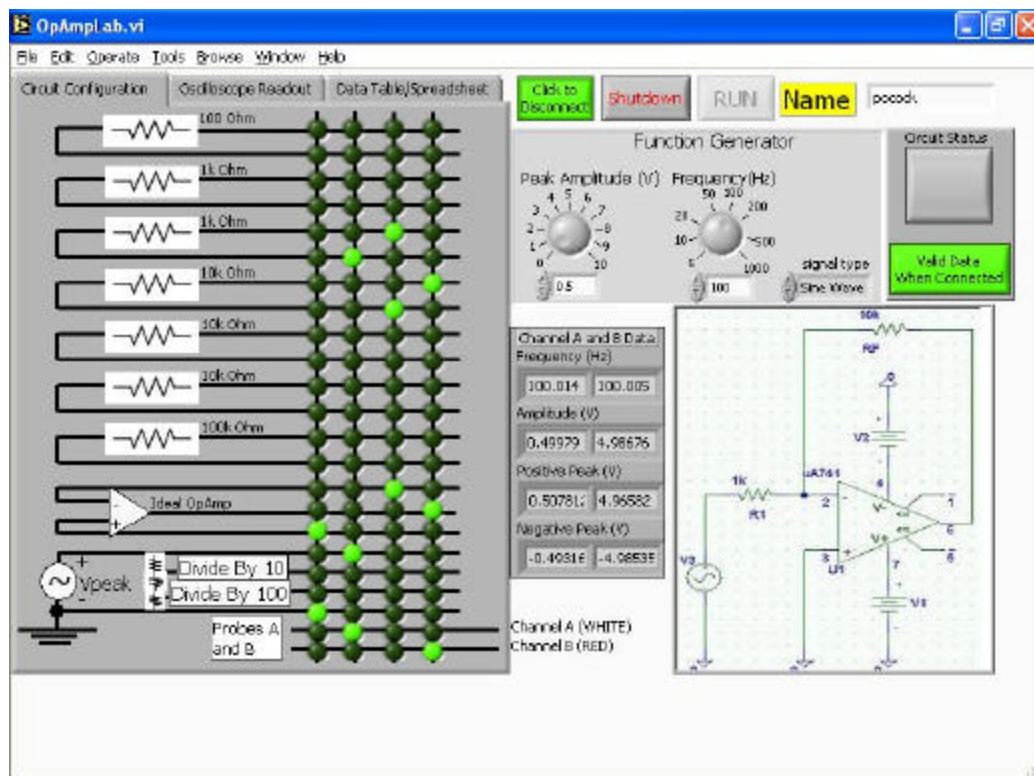


Figure 3. Front panel of OpAmp Lab showing correctly wired circuit. Highlighted “LED’s” indicate student-selected closed

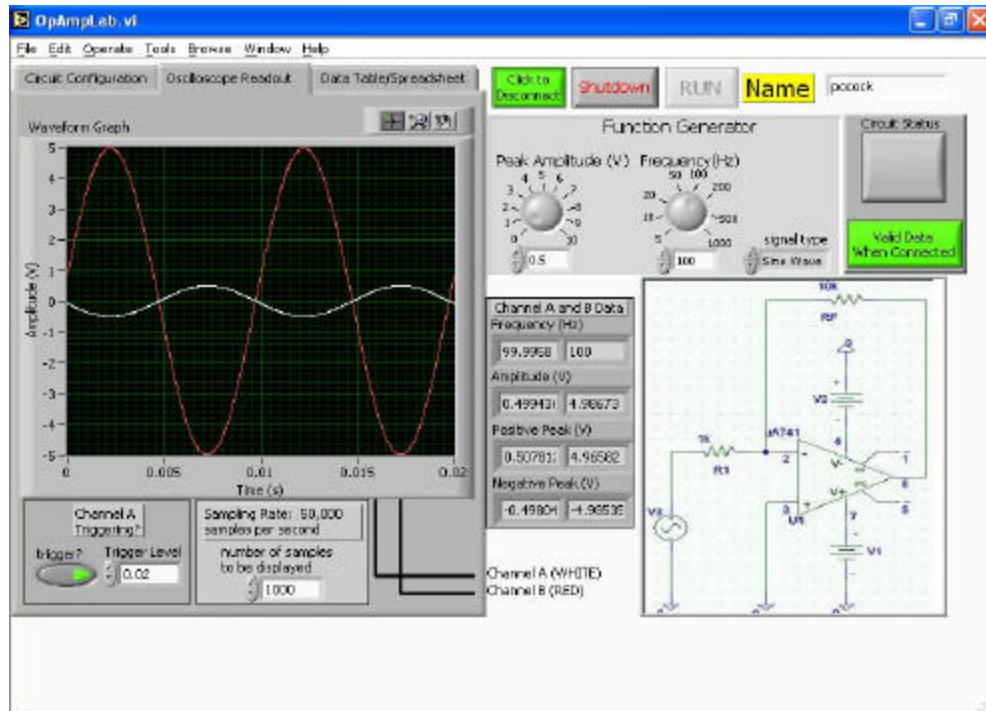


Figure 4. Front panel showing virtual oscilloscope waveforms of actual input and output voltages.

The MOSFET lab is an introductory experiment where the student is expected to measure the common-source output characteristics (drain current, I_D , versus drain-to-source voltage, V_{DS}) as a function of the input voltage, V_{GS} , with the body-to-source equal to zero. The DUT is a CD4007 CMOS transistor array that contains three n-channel and three p-channel devices. In this lab the students are required to determine values for PSPICE parameters V_{TO} (threshold voltage), K_P (transconductance parameter) and $LAMBDA$ (channel shortening parameter) from the real device. To implement this “curve tracer” function, the custom PCB for this experiment contains two DUT and a “virtual ground” using a transresistance amplifier with a gain of 1 volt/mA to convert the drain current of the MOSFET into a voltage that is then input to the DAQ card for the vertical axis (i.e. I_D) of the virtual curve tracer. This transresistance amplifier is transparent to the student.

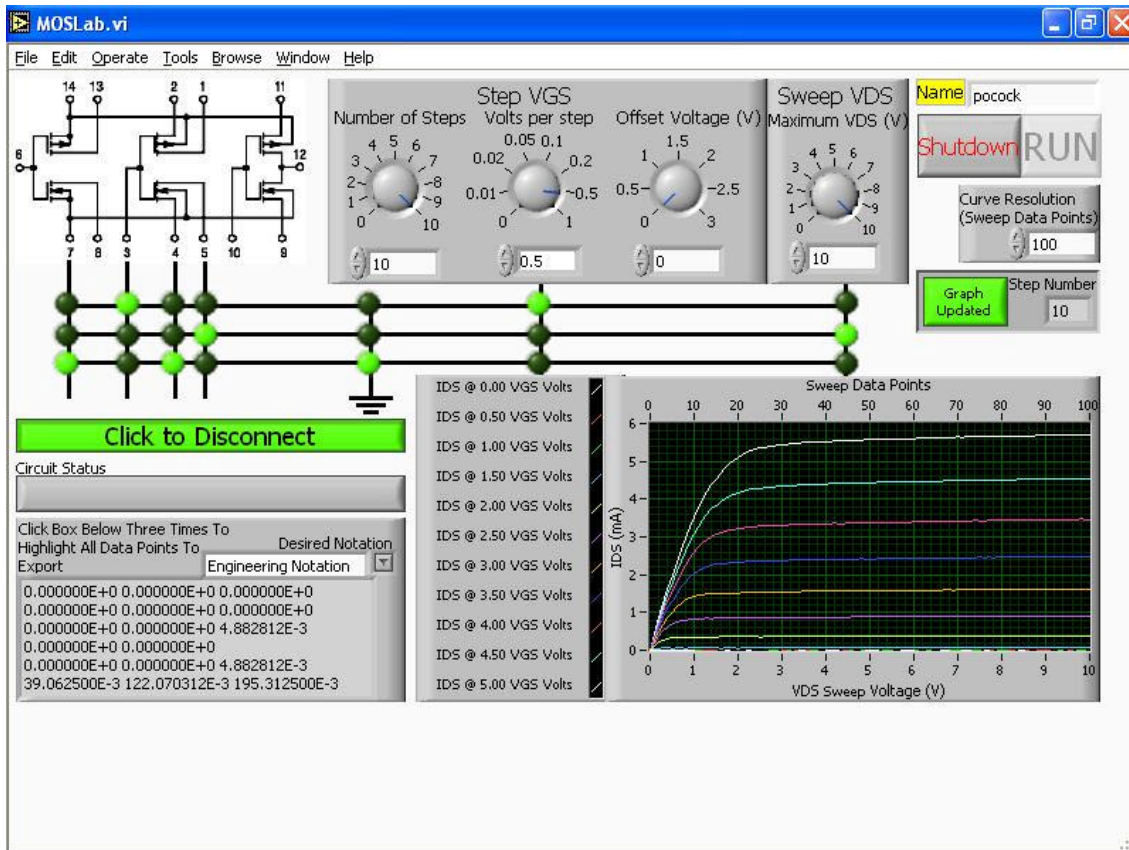


Fig.5. Results for the MOSFET Lab

V. Student Satisfaction

During Fall term 2004, the two completed laboratories were run with students on both OIT campuses, in Portland and Klamath Falls. The students performed the lab experiments, both remote, using the new systems, and with the traditional equipment.

In spite of the new paradigm of doing “hands-on “ measurements remote, and not even seeing the real devices, the results were satisfactory. The results are presented in Table 3.

TABLE 3.
SUMMARY OF RESULTS FROM STUDENT SURVEY ¹

	Op-Amp Lab		MOSFET Lab	
	Number of Students	Percent	Number of Students	Percent
1. Taking survey	20		15	
2. Considered web-based lab at least as good a learning experience.	9	45%	4	27%
3. Considered web-based lab at least as pleasurable to run.	12	60%	9	60%
4. Preferred web-based lab.	8	40%	8	53%
5. Considered web-based lab an acceptable alternative if they lived a long way from campus.	17	85%	13	87%

VI. Future Plans of Cooperation between OIT and PCC

A. Sharing the hardware

OIT and PCC plan on sharing all the hardware necessary for performing the remotely controlled labs. OIT and PCC students will have access to both college's systems. This may alleviate with some careful planning, the loading of the systems at peak of enrollment. Students from all campuses, will have access to any of the systems.

B. Sharing of Development

The laboratory projects already developed by OIT professors will be shared with PCC to the extent that the content could apply to PCC classes. Although the hardware and Virtual Instruments(VI) developed will be the same, the laboratory guides will be different, since the content and the level of instruction is in many instances, different.

PCC will develop some laboratory projects primarily for their AC course and those will be shared with OIT with modified lab guides.

For the web-delivered bridge class in network analysis, EET 281, a laboratory will be associated.

Same instructors could teach for both colleges, making the flow of ideas continuous between the two departments and colleges.

VII. Advantages and Disadvantages of the System

VII A. Advantages

By permitting the implementation of complete distance education courses and programs, the approach widens the access to technical education in the state of Oregon and beyond.

Using the systems described, students at both colleges are trained at the newest industry level of advanced technology. The graduates of both institutions will be more employable, since the National Instruments standards and similar technologies are widely used in industry.

In addition, PCC students will have an easier transition to the four year degree if they choose to transfer to OIT, since the labs will use the same technology.

Despite the fact that these labs can be performed remotely only due to a sophisticated software that comes with each particular experiment, the amount of programming that the student should do is minimal, which is attractive for the EET or MT students.

Last but not least, the big advantage is the flexibility of these classes/labs. Using the same equipment and the virtual instruments developed, new experiments can be easily created. They will use different boards and experiment guides. Furthermore, the same boards could be used in different experiments by both programs.

VII . Disadvantages

The initial cost of the investment is high. With approx. \$70,000, six complete systems were purchased with deep discounts from national Instruments. Also, the initial development cost is very high, especially since none of the professors involved had any prior experience in LabView development. Many man-hours were used for training of professors and students involved in the project. The programming of VI in LabView is quite involved and often time consuming. Nevertheless, after the steep learning curve, the development becomes more efficient.

Another disadvantage is the fact that the students do not touch the devices and equipment. Cameras could be used, but they are more useful for mechanical or control system experiments, where students could see moving parts.

VIII. Conclusion

With all the difficulties of implementing a new technology, the cooperation between OIT and PCC in delivering laboratories over the web marks the beginning of a new improved level of accessibility to technical education for the people of Oregon.

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Biographies

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