AC 2010-618: HANDS-ON DISTANCE-LEARNING LABORATORY COURSE USING INTERNET VIDEO TOOLS

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Hands-On Distance-Learning Laboratory Course Using Internet Video Conferencing Tools

Abstract

Since 2004, the Virginia Tech Department of Electrical and Computer Engineering has required a circuits laboratory course to accompany the circuits lecture course in its BSEE and BSCpE curricula. A unique feature of this course is that the students conduct much of their work using set of equipment, known as Lab-in-a-Box (LiaB), outside of a traditional classroom environment. To support the needs of the incoming transfer students and students engaged in co-op and internship programs, we decided to develop a distance learning hands-on laboratory course, an opportunity that is possible due to the flexible platform offered by LiaB. Lectures on each experiment and other supplemental learning materials have been developed, used in the on-campus course during Spring 2010, and converted to Powerpoint slides with embedded audio for use in the on-line course. A key component to the on-campus laboratory course is regular one-on-one interactions between each student and the course instructor or graduate teaching assistant (GTA). Hence, 'face-to-face' communication was immediately identified as a critical requirement for the success of the on-line laboratory course, where practical instructional support via real-time demonstrations of measurement techniques and methods to debug circuits is provided. In addition, we decided to maintain an element of the current on-campus course in which each student must demonstrate the circuit's operation to the GTA at the end of each laboratory experiment. Three software packages that would enable the needed video interaction were evaluated: Saba Centra, currently used at Virginia Tech for our distance learning courses; Adobe Connect Pro, a web conferencing and eLearning software package; and Skype, a voice- and video-over-internet program. While Adobe Connect Pro offered the most complete platform of the three programs evaluate, the quality of the video and voice transmission achieved using Skype was equal in performance and was the less expensive option. Two video capture devices were tested – the built-in webcam on an Apple Macbook Pro and the Logitech QuickCam Pro 9000. The external video camera allowed images of the circuit on the breadboard and video of the student performing measurements using the digital multimeter or oscilloscope to be easily collected. The distance learning hands-on circuits laboratory course using these tools will be offered in Summer 2010.

Introduction

The Virginia Tech Department of Electrical and Computer Engineering has offered a circuits laboratory course to accompany the circuits lecture course, which has generally been the first opportunity for most of our sophomore undergraduate students to design, construct, and characterize electrical circuits. A unique feature of this laboratory course is that the students conduct much of their work using set of equipment, known as Lab-in-a-Box (LiaB), outside of a traditional classroom environment.[1] The LiaB kit contains an analog/digital trainer (shown in Figure 1), a digital multimeter, various electrical components including a set of 5% resistors, a number of capacitors and light emitting diodes, an inductor, and several operational amplifiers. The laboratory course has been offered by the department since 2004.

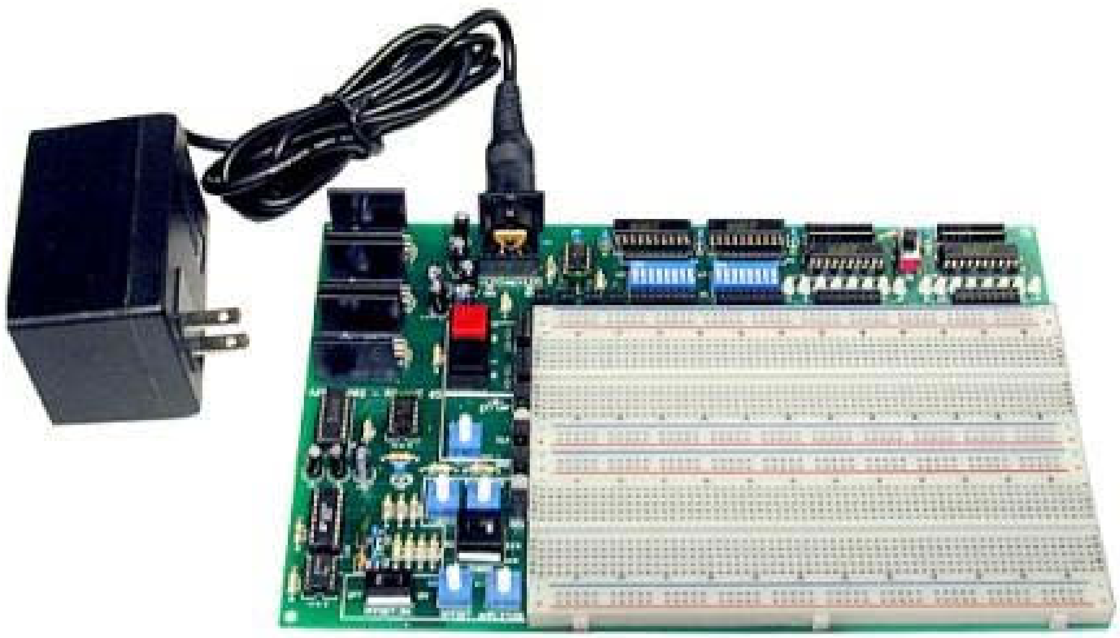


Figure 1: The RSR/VT A and D trainer.

Rationale for On-Line Laboratory Course

As a public institution of higher education, the Virginia Tech Department of Electrical and Computer Engineering accepts 20-30 transfer students per year from community colleges within the Virginia Community College System. Several of the community colleges offer a lecture-based circuits course, but have not instituted a circuits laboratory course. Given that the lecture and laboratory course are prerequisites for subsequent circuits and electronics courses at Virginia Tech, the plans of study for in-coming transfer students from these colleges have to carefully crafted so that the circuits laboratory course is taken in their first semester on campus and that the shift in the sequence of the remaining circuits and electronics courses does not negatively impact their graduation date. A number of the transfer students (~25%) decide to enroll in the circuits laboratory course at Virginia Tech during the summer semester to insure that they can take the recommended set of courses identified in the Virginia Tech BSEE or BSCpE checksheet in their first full semester in the fall. This places a large financial burden on many of the transfer students as most have to move from home to Virginia Tech at the beginning of the summer session to take the on-campus circuits laboratory course.

Another issue that we have recently noticed is a decrease in the number of Virginia Tech students who are enrolling in the ECE courses offered during the summer semesters, a likely result of the recent economic downturn. The lower enrollment has placed in jeopardy our ability to offer the courses during the summer semester, which in turn affects not only those in-coming transfer students who decide to take the laboratory course during the summer but also the Virginia Tech students who participate in the engineering co-op program and take courses offered during the summer so that they can graduate in four years.

Pedagogical Approach

We have realized that our circuits laboratory course does not need to be constrained to on-campus students because of the flexible platform offered by LiaB. Therefore, we have developed a hands-on circuits laboratory course that can be offered via distance learning to address the needs of the in-coming transfer students as well as the students currently enrolled in our program. We have recognized that a significant portion of the sophomore electrical and computer engineering students in our program are not familiar with simple electrical measurements, circuit construction techniques, and debugging methodologies. Hence, we have developed a series of lectures to instruct students on these topics as well as to provide information on the specific simulation and measurement techniques that will be used in each of the assigned experiments. These learning materials have been converted to Powerpoint slides with embedded audio for use in the on-line course. As we reviewed the requirements for the on-line course, the need for 'face-to-face' communication for office hours was identified as a critical component for instruction as well as to verify the student depth of learning achieved at the end of each experiment. An evaluation of three software packages was conducted, which will be used when the on-line course is offered in Summer 2010, to enable real-time interactions between the students and the course instructor and graduate teaching assistants (GTAs).

On-line Learning Materials

In each lecture, the goals of each experiment are reviewed, an explanation of how to apply the design criteria to determine component values in the early experiments and, later, to determine the circuits to be implemented is supplied, an example of the PSpice simulations to be performed is provided with instructions on the modifications to be made to the part attributes or device models, and measurement techniques are demonstrated when new features on the digital multimeter or oscilloscope are integrated into the laboratory procedure. The connection between the results obtained from the analysis of the circuit, the PSpice simulation, and the experimental measurements is made to help the students identify when their circuit is performing as expected and how to determine the errors in their circuit design, construction, and/or measurement procedures. Audio recordings have been embedded in each lecture presentation using Adobe Presenter. Additional supplemental materials are posted as PowerPoint slides on the course website to provide instructions on how to use the various tools. The instructions include a step-by-step guide on the installation of PSpice and the software for the USB-powered oscilloscope, explanations on the measurement functions available on the digital multimeter and oscilloscope with a description about the voltage and frequency limits and the accuracy of the measurements for each instrument, and tutorials on MatLAB, which the students used in certain experiments to analyze the circuits and perform calculations on the measured data. The learning materials have been used in the circuits laboratory course on-campus during the Spring 2010 semester and feedback from the students has been used to refine the lecture presentations and supplemental materials. As each experiment is assigned, the corresponding lecture will be posted on the course website while the supplemental materials are posted on-line at the beginning of the course.

Real-Time Video Technologies for Instruction

We have noted that a critical component of the success of the laboratory course offered on-campus is one-on-one communication with course instructor or GTA. Discussions with the students who have their LiaB kit with them has been needed to provide real-time support through concrete demonstrations on live circuits to some of the students as they learn the skills needed to perform the laboratory exercises. Furthermore, we decided to maintain an element of the current on-campus course in which each student must demonstrate some aspect of the circuit's operation to the course instructor or graduate teaching assistant as part of the grade for the laboratory exercise. A portion of the circuit validation includes a brief question-and-answer section on select topics covered in the laboratory lecture and in the written background material from the lab manual.[2] The validation process insures that the students have learned how to make the required measurements and that the GTAs can provide feedback to correct improper construction and measurement techniques. In addition, it also encourages students to develop a better understanding of the circuits that they have constructed by thoroughly reading the experimental procedure and reviewing the lecture materials. Lastly, the circuit validation process also serves as a means to determine whether each student is designing and characterizing his or her own circuit as opposed to rebuilding another student's circuit. To keep these critical components in the on-line version of the laboratory course, we determined that we had to provide a means to have visual and audio communication between students and the course instructor and GTAs during office hours to assist students as they work on the assigned experiments and to perform the circuit validations as part of the on-line laboratory course.

We evaluated three software packages and associated hardware that can be used to facilitate interactions between the instructor and/or graduate teaching assistant at Virginia Tech and students in remote locations. The software programs that were tested were Saba Centra, a virtual classroom, e-meeting, and Web seminar platform that is currently in use at Virginia Tech for our distance learning courses; Skype, a voice- and video-over-internet program; and Adobe Connect Pro, a web conferencing and eLearning software package. We also tested two video capture devices – the built-in webcam on an Apple Macbook Pro and the Logitech QuickCam Pro 9000.

Centra is very classroom-oriented with the ability to have multiple users logged in concurrently. A capability in the program also allows the creation of breakout rooms, which permit the student and instructor or graduate teaching assistant to have private discussions. Unfortunately, we found that Centra has several drawbacks that limited its usefulness for our application. While there was very little lag time associated with the voice and video transmission, the video had very low resolution (Figure 2). Moreover, the program is designed such that a video connection can only be made in the main room and not the breakout rooms, eliminating the possibility of a one-on-one session in which a student could demonstrate the operation of his or her circuit to the instructor or graduate teaching assistant for a grade. A significant disadvantage is the requirement to establish a bridge between transmission and receive sites, which translates to a need to have a scheduled time for the video interaction between specific fixed transmission and receive sites. Thus, impromptu video help sessions are not possible.

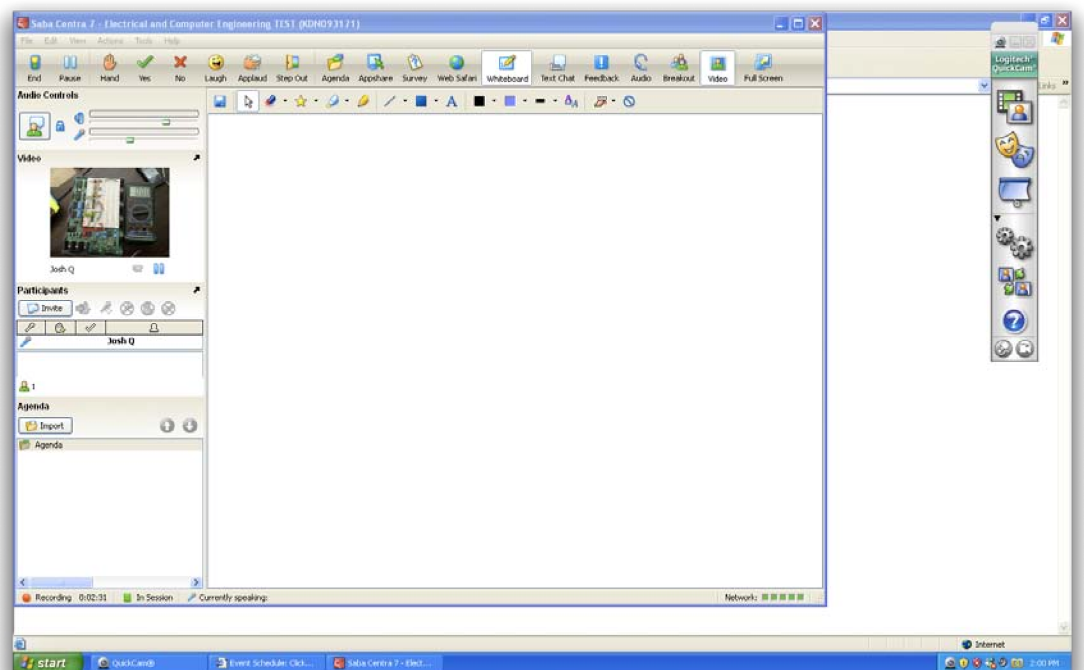
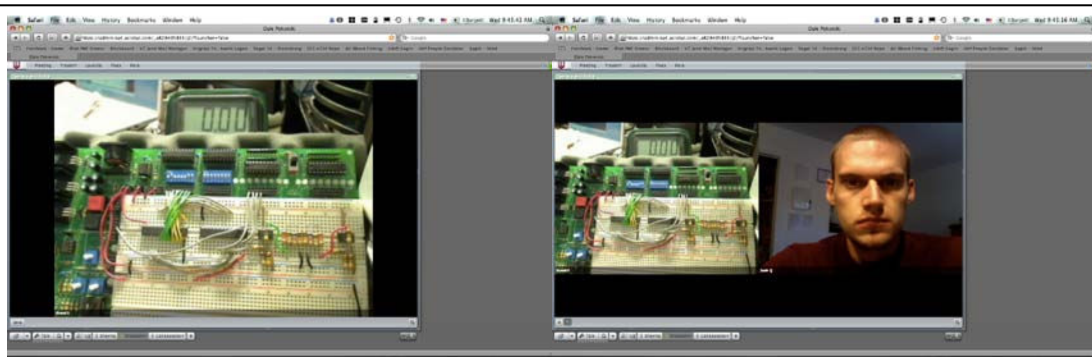


Figure 2: Image of the screen displayed to the participants using Saba Centra software. The video image of the circuit is located in the upper left of the screen.

The second software package evaluated was Adobe Connect Pro. The Virginia Tech College of Engineering has recently obtained a short-term license to evaluate this software package. Adobe Connect Pro offered an exceptional classroom-style setup and had great video capabilities, including the ability to have video in breakout rooms. Video of the circuits or split screen images of the participant and the circuit can be displayed on screen in a large format (Figure 3a and 3b, respectively). It was determined that Adobe Connect Pro was the best software solution for use in our distance learning circuits laboratory course. Unfortunately, the Virginia Tech administration has not made a commitment as of yet to purchase the software license. Although monthly and pay-for-use plans are available for individual users, it was not clear if there exists a means within the Electrical and Computer Engineering Department to fund the necessary licenses long-term and, therefore, there was a substantial risk that the investment of the faculty's and staff's time and effort to incorporate Adobe Connect Pro into the distance learning circuits laboratory course would only be of value for a few semesters.



a) b)

Figure 3: Examples of the large format video images transmitted using Adobe Connect Pro, where a) is a single frame of the circuit constructed by the student where the display of the digital multimeter is clearly readable and b) is a split screen image of the circuit and the student.

The last software package evaluated was Skype, which, as one would expect, lacked the classroom environment. However, Skype has a very capable video interface, which was comparable to that of Abode Connect Pro and was far superior to that offered by Centra. Skype also has the advantage that it is free of cost to the University user and the student once registered at the Skype website or for a cost if the student dials in from a land-line or cell phone number. A minor disadvantage of Skype over Centra is the inability to connect a large number of people together as the maximum number of participants on a conference call is presently twenty five. Conference calls may be made between individuals at any location at any time. As we determined that our primary goals were to engage the student in one-on-one discussions with the instructor or GTA and to transmit high quality images of the student's circuit board and video of their measurement techniques, we did not evaluate the quality of the video or voice connection during a conference call using Skype. Thus, the decision was made to adopt Skype in the design the one-on-one instructional modules for the distance learning circuits laboratory course.

To use any one of the three software packages, the student and the instructor or GTA must have a digital camera interfaced with their personal computer. As all Virginia Tech engineering students are required to own a Tablet PC and all of the Tablet PC models that meet the Virginia Tech College of Engineering's specification come equipped with an integrated 1.3 megapixel webcam, the first camera evaluated was the webcam integrated in an Apple Macbook Pro owned by one of the authors. The second camera evaluated was a Logitech QuickCam Pro 9000, a stand-alone camera with 2 megapixel imager. Using Skype, the images received from both cameras were of more than sufficient quality to resolve the components on the analog/digital trainer and the readout of the digital multimeter (Figure 4). While the images obtained from the Logitech QuickCam Pro 9000 were of higher quality, its major advantage over the integrated webcam was the fact that it could be easily maneuvered by the user to collect whatever images were requested during the one-on-one discussions.

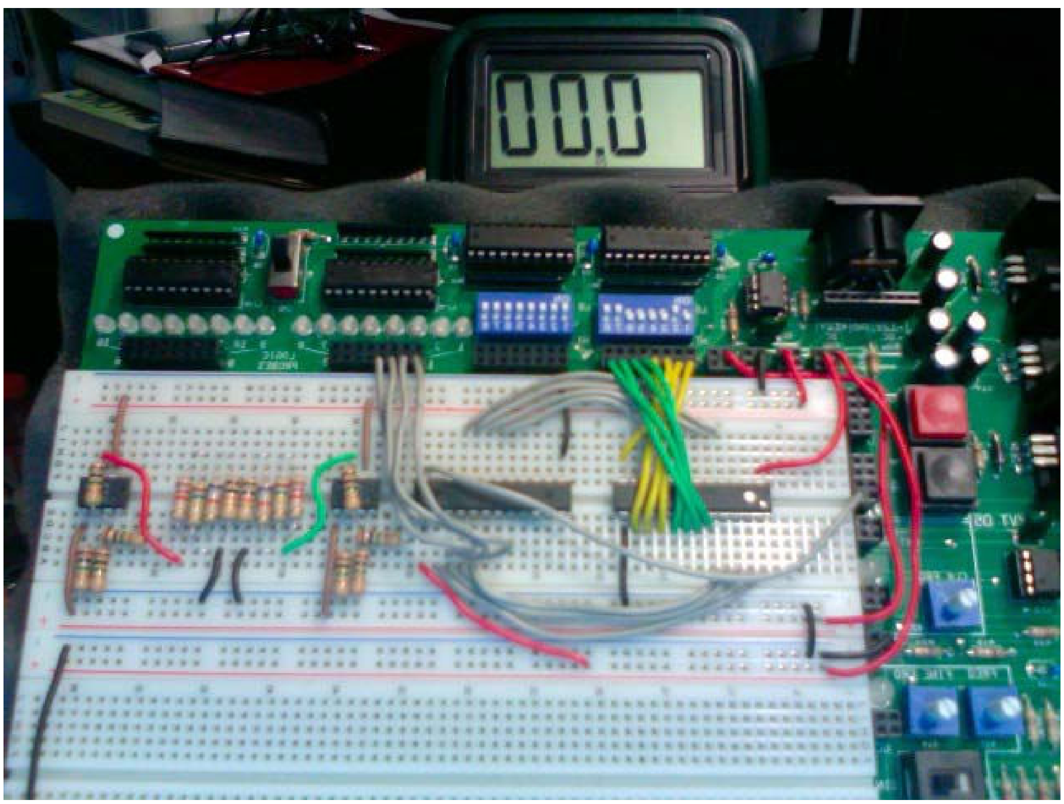


Figure 4: Screen shot of the video transmitted using Skype and collected using the webcam integrated in an Apple Macbook Pro.

Conclusion

A set of instructional materials have been developed to support the on-line offering of a circuit laboratory course. The topics covered in the instructional materials include information on the circuit to be designed and constructed, analysis and simulations to be performed, and the measurements to be carried out on the circuit. Additional material on the simulation and measurement techniques and information on the digital multimeter and oscilloscope as well as step-by-step instructions on how to perform specific measurements have also been developed and refined, incorporating feedback from students enrolled in the on-campus course during Spring 2010. It was determined that real-time video is required to address the need for 'face-to-face' interactions between the students enrolled in the on-line course and the course instructor and GTAs. Based upon our software evaluation, we have selected Skype as the internet video software package that will be used for one-on-one communications between students enrolled at remote sites and the course instructor or GTA. We also determined that it is highly desirable for the students enrolled in the distance learning circuits laboratory course to use a stand-alone camera with a resolution of at least 1.3 megapixels during the video connections with the course instructor or GTA. The distance learning hands-on circuits laboratory course using these tools will be offered in Summer 2010.

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