LAB ON THE WEB

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Running Real Electronics Experiments via the Internet

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PREFACE

The ubiquity of the Internet as a communication medium has opened up a wide range of possibilities for extending its use into new areas. Remote education, a rapidly growing part of the university curricula, is one such area that can benefit greatly from the use of the Internet. Utilizing the Internet and the World Wide Web technology, courses can be offered to students anywhere in the world, without any other technical requirements than a personal computer and a telephone line. Although laboratory courses are an essential part of education, especially in engineering, such courses have until recently been considered impractical for remote students. Instead, these students often have to make time-consuming and expensive travel in order to complete laboratory courses. Also, with the tight budget at many educational institutions, lots of students are prevented from having local access to state-of-the-art equipment. However, the advances over the last decade in the Internet, World Wide Web technologies, and computer-controlled instrumentation presently allow net-based techniques to be utilized for setting up remote laboratory access, permitting remote education to be enhanced by experimental modules.

User-friendly, computer-controlled instrumentation and data analysis techniques are revolutionizing the way measurements are being made, allowing nearly instantaneous comparison between theoretical predictions, simulations, and actual experimental results. An ever-increasing array of industry-standard design and simulation tools now provides the opportunity to fully integrate the use of computers directly in the laboratory. Once this integration happens, it will no longer be crucial to have a piece of equipment physically located next to an engineer or scientist, thus opening the door for remote access via the Internet.

The remote, web-based experimentation augments the laboratory experience of the students by offering access to sophisticated instrumentation. It provides a natural and valuable extension of the traditional laboratory component, which normally uses relatively simple equipment. For limited periods of time, direct physical access to the Internet laboratory stations might be allowed in order to further acquaint the students with the equipment. However, remotely, the access might be 24 hours a day, and it might be further enhanced by live video showing the laboratory equipment and devices under the test. Remote laboratories have an enormous throughput, since, in many cases, the equipment is accessed by the user only for the very short time required for the actual measurement. All data processing occurs at the server and/or at the user's personal computer, so that he or she has the feeling of using the equipment alone. Another big advantage is safe and foolproof operation of expensive laboratory equipment, with safeguards built into the software.

These important advantages make remote-distance, interactive experimentation an important emerging educational trend. The Internet is an ideal medium for remote instruction purposes, offering interesting possibilities for disseminating many kinds of educational material to students, both locally and as part of remote education. Its ubiquity and protocol standards make data communication and front-end graphical user interfaces easy to implement.

Rensselaer Polytechnic Institute (RPI) and the Norwegian University of Science and Technology (NTNU) jointly developed a remote characterization laboratory for measurements of electronic devices over the Internet called AIM-Lab (Automated Internet Measurement Laboratory) in 1997. The time was apparently ripe for this development, since, at about the same time, several other groups independently started similar activities. Some of the remote laboratory systems and applications emerging from those pioneering activities are reviewed in this book. In fact, the independent nucleation of such activities has resulted in an interesting diversity of system solutions. In Chapter 1, the remote laboratory installations AIM-Lab (RPI) and LAB-on-WEB (NTNU) are presented, both resulting from the U.S.–Norway collaboration. Chapter 2 deals with WebLab developed at MIT Microelectronics. These two chapters deal with efficient systems for semiconductor device and circuit characterization. Chapter 3 describes the Retwine project, a collaboration between the University of Bordeaux I (France), the University of Applied Sciences of Münster (Germany), and the Autonomous University of Madrid (Spain). This project emphasizes training in the use of advanced instruments for controlling real remote experiments by means of virtual instruments with realistic images and functions. Chapter 4 presents the Next Generation Laboratory (NGL) at NTNU. Also emerging from the initial U.S.–Norway collaboration, NGL applies the .NET technology in remote characterizing of analog integrated circuits. The Remote Laboratory at the Blekinge Institute of Technology (Sweden), presented in Chapter 5, is applied to basic circuit characterization and to transducer experiments. Finally, the I-Lab system at Chalmers University of Technology (Sweden), which is discussed in Chapter 6, is used for the precise characterization of two-terminal devices. From the material presented in these chapters, the reader can compare different technologies involved in existing Web-based laboratories and review the rich variety of accompanying experiments.

The above remote laboratory installations are presently used to provide access to state-of-the-art laboratory instrumentation and experiments for both local and remote students. Presently, both national and international collaboration on remote laboratory development between universities is taking place, and international educational conferences have started to hold special sessions on this technology. This way, a broad range of sophisticated experiments is being made accessible to students on a global scale at a relatively modest investment for each institution. As remote laboratories have become operational at several sites, novel pedagogical uses have also emerged, including experimental demonstrations to enhance traditional classroom lectures, adding laboratory modules as homework exercises in regular courses, and establishing studio classrooms where students do supervised laboratory exercises on individual terminals. This remote experimentation greatly improves the learning process and encourages individual student discovery. All of this fits well into a strategy for distance learning.

No doubt, this technology should and will be applied to other areas of engineering and science, well beyond electrical circuits or device applications. Eventually, Internet laboratory courses covering many disciplines of engineering and science may be offered to students worldwide, removing a major obstacle for establishing a boundless and nearly complete remote education engineering curriculum and making engineering and science education attractive and available to segments of the population that otherwise would be disadvantaged by distance and lack of resources. This will be nothing less than a true revolution in distance education.

We hope that this book will be useful for students, teachers, and professors interested in remote instruction as well as for university and educational administrators who are interested in the development of efficient and economical educational technologies serving both their local student population and also students worldwide, including underprivileged communities. We would like to inspire teachers and professors to use the remote laboratory technology for applications in education and beyond, including many applications we have not even imagined.

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