

LOW -COST MODULES FOR REMOTE ENGINEERING EDUCATION: PERFORMING LABORATORY EXPERIMENTS OVER THE INTERNET

Hong Shen¹, Michael. S. Shur¹, Tor. A. Fjeldly^{1,2} and Kjetil Smith²

Abstract We report improvements on the AIM-Lab using low-cost computer boards for data acquisition.

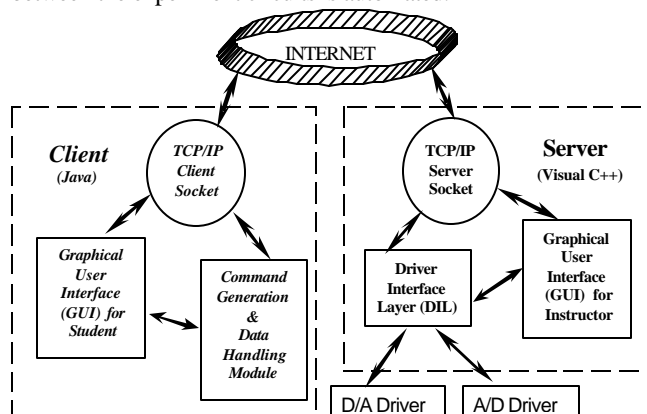
AIM-Lab (Automated Internet Measurement Laboratory), an Internet-based remote laboratory on semiconductor device characterization [1-3], is used in the distance learning programs at Rensselaer Polytechnic Institute and at the Norwegian University of Science and Technology. Specifically, we apply AIM-Lab in first year graduate/senior courses on semiconductor device modeling.

The latest implementation of AIM-Lab is shown in Fig. 1. The server includes two main components, a Transmission Control Protocol/ Internet Protocol (TCP/IP) server socket that receives commands sent over the Internet, and a Driver Interface Layer (DIL), which interfaces the higher levels of the server with the drivers for the data acquisition system.

In the previous configuration, we used an HP4142B Source/Monitor and an HPIB card to drive the circuits and collect experiment data. The HP instrument has a very high resolution and speed for both the source and the monitor, and it has an embedded processor that accepts high-level commands for a combination of actions such as, for example, a voltage scan and data collection. However, this equipment is too expensive to be owned by many schools and not portable enough for widespread use. In the new configuration, we replaced the HP instrumentation with a set of PCI/ISA cards that can be installed in the expansions slots of the host PC, including even laptops. We used one voltage output (D/A) card and one data collection (A/D) card. Controlled by the host PC via the communication buses, they have simple functionalities for outputting a single voltage and converting it into a digital signal that can be read by the host PC. They have low resolution and low speed, and do not have the ability to accept high-level commands. However, in addition to their low cost, they are very compact and hence can be easily distributed.

Since the PCI/ISA cards do not accept such high-level commands as a voltage scans, we augmented the previous driver interface layer with command interpreting functions

that convert the commands into simple low-level instructions for the cards. Each card has multiple channels to be connected to different circuits, and hence the switching between the experiment circuits is automated.



AIM-Lab provides a new and very useful dimension to remote courses, which cannot be replaced by simulation software packages. Based on the AIM-Lab concept, work is under way to develop laboratory courses and course modules within many disciplines of engineering and science that may be offered inexpensively to remote students any place in the world. Using our new implementation, the PCI/ISA cards, the software, the experiment circuit hardware, and specially designed course problems can be integrated into a complete package, and distributed to various schools. Each school will be able use the package to setup its own lab site, and add their own experiments.

[1] AIM-Lab URL: <http://nina.ecse.rpi.edu/shur/remote>, AIM-Spice URL: <http://www.aimspice.com/>

[2] H. Shen, Z. Xu, B. Dalager, V. Kristiansen, Ø. Strøm, M. S. Shur, T. A. Fjeldly, J. Lü, T. Ytterdal, "Conducting Laboratory Experiments over the Internet", *IEEE Trans. on Education*, Vol. 42, No. 3, pp. 180-185 (1999).

[3] T.A. Fjeldly, M.S. Shur, H. Shen, T. Ytterdal, "Automated Internet Measurement Laboratory (AIM-Lab) for Engineering Education", *Proc. 1999 Frontiers in Education Conference (FIE'99)*, San Juan, Puerto Rico, IEEE Catalog No. 99CH37011(C), 12a2 (1999).

¹Rensselaer Polytechnic Institute, Troy, NY

²Center for Technology, Norwegian University of Science and Technology, Kjeller, Norway