Abstract

This paper describes a project-based educational system recently implemented at the Electronics laboratory of our department. This system utilizes a combination of hardware implementation and a specific type of computer simulation assistance, which is initially customized to the particular experiments of the few first laboratory sessions, and becomes progressively modifiable by the student throughout the remaining sessions. Preliminary system performance results are discussed.

1. Introduction

Since the eruption of network-integrated personal computers, the idea of implementing computer assisted Electronics Laboratories has been extremely appealing in the academic environment. Many powerful commercial programs (simulators) exist, such as SPICE, MICROCAP, etc., which are normally used for this purpose. However, the academic challenge still remains of how to optimally utilize simulators in the delicate process of transferring knowledge to students.

In order to discuss the optimization of a computer assisted Electronics laboratory, we define our teaching objectives in priority order.

1. The student must be able to obtain experimental results that agree with deterministic predictions obtained from theoretical design.
2. To become a competitive engineer, the student must learn the use of powerful computer simulators as part of the undergraduate curriculum.

In pursuing the above objectives, it must be taken into account the realistic fact that the amount of time available per laboratory session is limited to usually a maximum of three hours.

The two main educational strategies are as follows. On the one hand, is the modern “software approach” of simulating the whole Electronics laboratory, which defeats our main teaching objective. A not-so-extreme alternative includes experimental verification, but prioritizes software over hardware by requiring students to write the complete needed simulation programs as part of the laboratory sessions. This approach fails in practice, not only because of the time constraint, but mainly because of the student’s involvement in software subtleties, such as name and location of circuit component libraries, adequate selection of integration time, etc., which will inevitably draw his/her attention from the fundamental laboratory objective, regardless of the simulator’s degree of sophistication or the student’s programming skills. On the other hand, the older “hardware approach”, that is, the exclusion of any computer simulation, would simply handicap the student in today’s most powerful tool for analysis and design used in the industrial world. Of course the alternative of teaching computer simulators independently of circuit applications would be highly inefficient, mainly due to the student’s lack of motivation.

Our idea is to implement a project oriented laboratory as in [2], but trying to optimize the teaching efficiency of computer assistance by reaching an appropriate equilibrium in the utilization of software and hardware. With this objective in mind, we created a system based on Initially Customized - Progressively Modifiable (ICPM) programs written inside the environment of a powerful computer simulator, such as SPICE.

2. The ICPM System

This system is best explained with the aid of Figure 1. For all laboratory sessions, the input to the system is a desired circuit action with an associated performance. The complexity of the student’s task is progressively increased from the early to the later sessions.

On the first laboratory session, an appropriate circuit schematics is provided to the student, who need only calculate the component values. These values are then
input into a customized computer program previously written in SPICE, which provides a simulation of the circuit input and output on the computer screen. Calculation of component values is corrected as needed until a good match between the circuit desired and simulated performances is achieved. The next step is the hardware implementation of the circuit on a breadboard, during which the circuit is troubleshooting until its output matches the one provided by the computer simulator.

On the next few following laboratory sessions, the student faces the challenge of designing both a basic and a slightly modified circuit performance; however, only a circuit schematics for the basic performance is provided. First, the student deals with the basic part, by repeating all of the steps previously described. Afterwards, he/she tackles the modification part by doing three things: (i) incorporating appropriate changes into the circuit schematics, (ii) programming these changes into the user-interactive ICPM program (of course back-up copies of the original ICPM programs remain unaltered, ready to be used by a new student class), and (iii) performing the corresponding changes on the experimental breadboard.

By the last laboratory sessions, the student should be able to design a circuit adequate to the given specifications, write most of the simulator code, and perform the experimental verification.

There are many didactic advantages to the ICPM system. (i) In the first sessions, the student learns what SPICE can do, and through “peeking” at the source code, he/she can figure out how the simulation is done. This is probably one of the most efficient approaches to learning any new computer program. Very often, students lose motivation to learn a new program simply because they do not know what they should be trying to accomplish! (ii) The easy first laboratory sessions will surely lead to a successful experimental verification of both theoretical design and simulation. This fact will strongly motivate the need for mastering the utilized powerful simulator. (iii) As a matter of fact, it is impossible to obtain profit from a given simulator without having an excellent grasp of the corresponding theory. In the ICPM system, the demand for programming knowledge is increased sequentially, at a pace compatible with the student’s assimilation of Electronics circuit theory.

3. Discussion

The ICPM educational system was implemented at New Paltz for the first time in the Fall of 96 for the Electronics I course. Although the initial response was satisfactory, there is still room for improvement.

On the first laboratory sessions, students were excited by success. However, with the progression of sessions, the appearing mismatch between theoretical and simulated performances began to demand more time than available from the average students, who had to face the “real life” dilemma of whether their proposed circuit was inadequate, their calculated values incorrect, or their ICPM code modifications wrong. This situation necessitated a strong (more than desired!) tutorial participation by the laboratory instructor. It is expected that his problem will be alleviated in the near future, by spreading the progression of complexity into both the Electronics I and II courses.

Perhaps the most important and challenging aspect of the ICPM system is the creation of an adequate sequence of laboratory experiments of progressively increased complexity. Although highly demanding, this work might become extremely rewarding, as it might lead to the future creation of an internet ICPM library, where ICPM programs could be interchanged by electronic departments of several universities.

References
