Hardware Lab at Home Possible with Ultra Low Cost Boards

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Abstract

This paper describes the new Logic Design course implementation in 2004. In the new course the labs and the evaluation methods were changed. In the old course the labs were developed in a traditional manner in the school lab rooms; and in the present system the lab assignments were done in the student's home with a new designed PLD board, and then presented and evaluated by the teachers. The boards were successfully designed, and a great number of these hardware kits were assembled and distributed to the groups of students for the whole semester. The goals were fulfilled with good acceptance from the students and many advantages from an educational point of view.

1. Introduction

The increasing number of students in the Logic Design course at the School of Engineering of the Universidad de la República (UR) (Montevideo, Uruguay) and the low budget assigned, made it difficult to perform traditional laboratory practices. This problem was detected and present during the past few years and this project proposed a solution. One of the main objectives was that the students did not lose the hardware contact instead of making only simulations.

Logic Design is a core undergraduate course, the traditional topics of information digital representation, combinatory systems, sequential systems and RTL descriptions are studied in it [1]. For some years now, in this course, programmable logic circuits were used in labs instead of discrete integrated circuits [2], [3].

The use of programmable logic has been very effective, since technological and cabling problems are avoided, enabling a fast passage from paper to circuit.

The number of students owning a PC was high, and the School of Engineering also had computer rooms available for the students. Besides, free student versions of software tools are available from Altera [4] and Xilinx.

The idea of developing the lab at home came up based on these facts. The problem that remained was that the commercial boards cost wasn't affordable for Latin-American students, neither could the University buy an important number of them.

Thus the objective was:

- To design and build a significant number of ultra low cost boards with PLD's that could be given out to the students for the whole semester
- New laboratory assignments adapted to the new boards.
- New knowledge evaluation procedures

In the following sections we describe the different steps of the project.

2. The Boards

The goal was to design a board with a programmable chip and some input and output elements, in order to be able to implement a wide set of designs, but at the same time keeping the overall board cost low, so that a significant number of boards could be manufactured with the budget assigned.

The designed boards have a programmable chip with 64 macrocells, a power regulator, an oscillator,

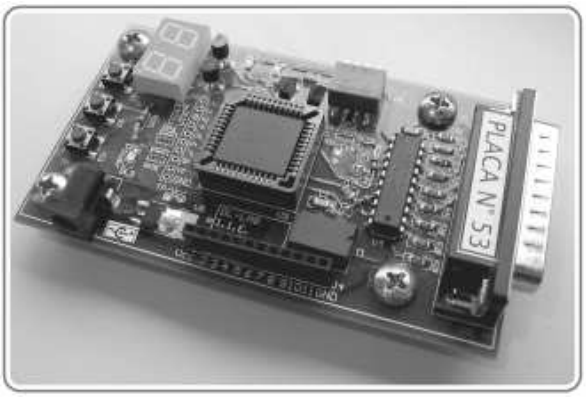

Figure 1. The designed lab board

seven-segment displays and leds to observe outputs, button and dip switches to input signals, and expansion connectors connected to the chip pins. The

configuration of the PLD is made directly (without a cable) via PC parallel port using the DB25 connector [5].

The printed circuit boards were manufactured in the USA, but the whole design, building and testing of the boards were made in the Instituto de Ingenieria Electrica, UR. Every kit, besides having the board, has a power supply and a user manual. The final cost of each kit is around U$S 28.

3. Laboratory Assignments

Three lab assignments were created so that the designs of the first ones were reused in the following labs. In this way, larger and more complex designs can be built since the students are already familiar with basic blocks that they designed in the previous labs. As an example, in the 2004 course edition, the assignment consisted in the design of a Discman keyboard controller [6]. The first assignment was to design several combinatory modules such as a seven-segment controller and adders. The second one was a sequential design; the circuit had to distinguish when the user pressed a switch to change the song or to fast forward it. The third design was an RTL module that had to integrate all the blocks previously designed to implement the controller, receiving as inputs the three buttons: play/pause, rewind/skip_previous, fast_forward/skip_next functions.

4. Methodology

The students formed groups of three members at the beginning of the course, and each group was given a kit for the whole semester. They worked at their homes or in the school's computer room, having a deadline to defend their work. Teachers in fixed office hours and an e-mail list were available for them to answer questions and evacuate doubts.

The defense consisted on presenting the designs, answering the teacher's questions and showing the hardware working as specified in the assignment. In these evaluation instances they were graded to up to 25 points, adding them to the final exam grade (75 points).

5. Conclusions

The new course was successful, the objectives were fulfilled, the kits were designed and built, and the first edition of the Logic Design course was implemented.

Good student receptivity to this new course modality was observed and then confirmed by a study from the School Teaching Unit. In general, they worked very well and very independently, showing real grasp of the software tool and the technology involved. They exposed and defended their designs, this being one of the first times they had to deal with such a situation.

Another important result is that after finishing the course all the boards were in perfect condition, which shows the responsibility that our students can have. The average grade obtained in the labs was 22.5 points out of 25.

The new modality:

- Requires less professors' hours
- Doesn't need three professors at the same time
- Doesn't need a big lab room
- Relaxes the schedule constraints of professors and students
- Allows to have more assignments in less time.

These properties make the new system more scalable, since in order to embrace more students, it suffices to scale the teaching staff hours and the hardware kits; but it is not necessary to have lab rooms and lab equipment.

The multiple lab evaluation instances also enabled a better feedback, emphasizing the most difficult topics in the lectures and exercise classes.

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7. References

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