2006-1901: TEACHING VLSI DESIGN AT THE KOREA UNIVERSITY OF TECHNOLOGY & EDUCATION

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Teaching VLSI Design at the Korea University of Technology and Education

Abstract

Human Resources Development Institute at the Korea University of Technology and Education has launched an International Invitation Lecture Program under which it has invited experts from universities around the world to offer one or two week intensive courses in several technologically advanced areas. In this paper, a course instructor and the course moderator have presented an overview of the HRDI activities and their experiences with one such course on VLSI Design.

Introduction

The Korea University of Technology and Education (KUT) believes that accelerated by the information-oriented and knowledge-based societies, the whole world in the 21st century is becoming one market and that survival in this limitless global competition requires a revolution in the education and development of its vocational and industrial work force. Human Resources Development Institute (HRDI) at KUT emphasizes growth in new technology education with the educational purpose of offering opportunities for up-to-date technology course aimed at the instructors of vocational ability development schools, special technicians, high school teachers, university professors and employees of technology colleges who are in charge of job education training. During the last few years, HRDI has launched an International Invitation Lecture Program under which it has invited experts from universities around the world and offered courses in several advanced fields such as computer-aided manufacturing, multimedia, computer-aided design, materials, manufacturing automation, industrial management, networks and electronics. These are 1 or 2 week long intensive courses offered during the summer and winter vacation periods. HRDI advertises these courses in the newspapers and through a daily web-site. In this paper, the course instructor (AG) and the course moderator (HC) list the HRDI programs at KUT and present their experiences with one such course on VLSI Design.

Human Resources Development Institute at KUT

Established by the support from the Ministry of Labor in January 1999 as part of the Government's new five-year economy plan, HRDI has played a unique role of providing specialized vocational training skills. Specifically, this institute has been set up in order to provide both teachers from vocational training schools and technicians from various industrial fields with opportunities to learn advanced teaching methodologies and new technologies. Historical development of HRDI is summarized in Table 1 and the various training programs

undertaken by HRDI from 1998 to 2003 and the number of participants in these activities are listed in Table 2. HRDI provides state-of-the-art classroom and laboratory facilities as shown in Figs 1 and 2.

Table 1

Historical Development of HRDI

Date	Activity
September, 1993	According to the government's New Five-Year Economy Plan, they established an educational plan to secure qualified teachers who could strengthen the nation's potential development.
January, 1994	Planning to establish a comprehensive vocational training institute by the Korea University of Technology and Education.
September, 1994	Government's approval for the investment in setting up the institute.
April, 1995	Foundation Execution Organization of General Training Institute
December, 1996	Establishment/operation of the Execution Organization of General Training Institute
March, 1998	Establishment of HRDI
September, 1998	Completion of Educational Hall A and Guesthouse
January, 1999	Completion of Educational Hall B

Description of the VLSI Design Course

At present, the CMOS technology is the most widely used technology for the fabrication of silicon-based VLSI circuits and systems. The principal purpose of this course was to familiarize the participants with the various aspects of the silicon CMOS technology and offer them an opportunity to actually design CMOS logic gates and circuits on a personal computer using the computer-aided design tool called L-Edit developed by the Tanner Research Corporation. This course consisted of a series of lectures, hands-on design projects and computer-based simulation projects outlined below.

Table 2

Number of Participants in the Various HRDI Programs from 1998 to 2003

HRDI Program		Term	1998	1999	2000	2001	2002	2003
Qualification Training	Teaching training for HRD Teachers	4 weeks	335	964	644	337	369	169
	Improvement training for HRD teachers	2 weeks	-	229	170	93	160	91
Vocational Improvement Educational Training								
	Vocational training manager program	1 week	144	203	179	590	345	307
	Role training for vocational abilities	1-4 weeks	-	157	78	189	323	101
	Vocational training teacher program	1-4 weeks	148	167	414	349	542	116
	Career counseling program for high school teachers	1 week	407	445	197	204	291	82
Technology Educational Training								
	Technology educational training	1-2 weeks	229	3,303	3,761	3,846	3,664	1,906
	Program for occupation transfer	1-2 weeks (2-8 weeks)	-	-	608 (146)	423 (72)	220 (170)	12 (-)
	Overseas experts invitation and seminar	1-2 days	-	940	294	65	62	50
Consignment Training								
	Government consignment training such as acceleration of employment	1-4 weeks	274	59	246	561	-	-
	Consignment training program for industrial organizations	1-2 weeks	61	810	854	1,273	1,035	873
	Employment insurance support	1-2weeks	-	-	-	61	36	23
Foreign Instructors Training		2 weeks	16	14	20	69	17	-
Professionals Training Overseas		1-2 months	-	-	-	-	8	-

Fig. 1: A picture showing the state-of-the-art classroom facilities at HRDI, KUT

Fig. 2: A picture showing the state-of-the-art laboratory facilities at HRDI, KUT

Lectures

To be able to design CMOS logic gates and circuits, it is important to understand the switching characteristics and physics of the n- and p-type MOS field effect transistors, modeling of the CMOS devices and circuits and on the basic layout principles of transistors and circuits including the various design rules. Several issues related to the design and fabrication of CMOS integrated circuit chips were also addressed. It is widely understood that more than 50% of the propagation delays on an IC chip result from the interconnection lines used to connect the several devices on the chip. In this course, the relevant interconnection issues such as the interconnect parasitics, interconnect delays, crosstalk and electromigration-induced failure were also discussed. During the last few years, gallium arsenide (GaAs) has emerged as a preferred material for the development of the very high speed integrated circuits and the participants were familiarized with the relative advantages of GaAs over silicon. As an additional bonus, the participants were

introduced to a popular computer language called VHDL which stands for VHSIC Hardware Description Language. Specifically, lectures were delivered on the following topics:

- Review of Basic Concepts
- Introduction to L-Edit
- Circuit Layout Using L-Edit
- Designing CMOS Logic Circuits
- Modeling of CMOS Circuits
- Chip Design Issues
- VHDL - An Introduction
- VLSI Interconnects - Issues and Modeling

Design Projects Using L-Edit

In this course students used a popular PC-based layout tool called L-Edit (developed by Tanner Research Corporation) for hands-on designing of several CMOS gates. First, they learnt how to design an n-FET and a p-FET followed by a CMOS inverter and then used L-Edit to design more complex logic gates. Participants were able to verify the functionality of the logic gates designed by them by simulating their performances including their input-output characteristics using a widely accepted circuit simulator called P-Spice. They were encouraged to do space saving designs that would result in lower usage of the chip area and would result in lower gate propagation delays. Specifically, the following design projects were planned:

- n-MOSFET
- p-MOSFET
- CMOS Inverter
- CMOS 2-Input NAND Gate
- CMOS 2-Input NOR Gate
- CMOS 3-Input NOR Gate
- CMOS XOR and XNOR Gates
- CMOS 16 Bit Parallel Adder

Simulation Projects

In this course, the participants were able to use the software modules developed earlier by the course instructor and run the following computer-based simulation projects:

- Performance of Silicon-Based IC Chips
- Performance of GaAs-Based IC Chips
- Electromigration-Induced Failure Analysis

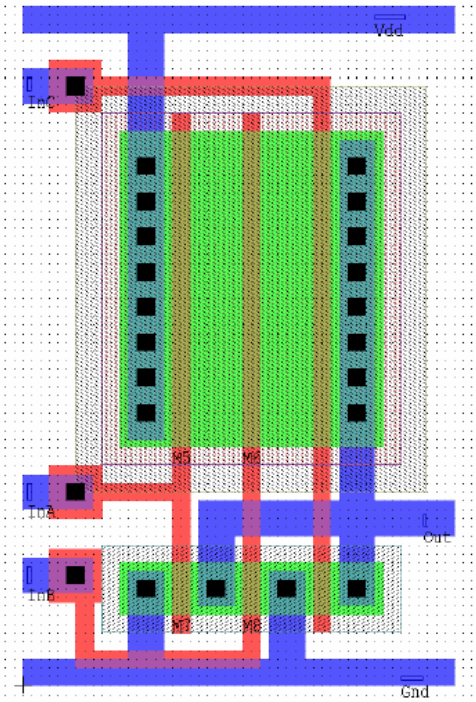

Fig. 3: Layout of a 3-input NOR gate using L-Edit

The programs NCHIPSIM and CCHIPSIM have been developed to predict the performances of silicon-based integrated circuit chips using the NMOS and CMOS technologies, respectively. For given values of chip, gate and interconnect parameters, the each program computes the following performance indicators for the chip: size, area, fabrication yield, clock frequency, power consumption, computational capacity, power efficiency and its functional throughput rate. Students were able to study the dependence of chip's performance characteristics on the resistivity of the interconnect material, number of interconnect layers, number of logic gates on the chip and scaling of the transistor and interconnect parameters. On the same lines, another program called GCHIPSIM was used to study the relative performance of a GaAs-based integrated circuit chip.

The program EMVIC has been developed to simulate the electromigration-induced failure of the various interconnection components including a straight segment, bend, step, plug, via and a power/ground bus. Participants were able to use EMVIC to study the dependences of the median-time-to-failure (MTF) for each interconnect component on the various component parameters such as its length, width, temperature and current density for a straight interconnect segment; on the gate current and the number of gates served for a power/ground bus, etc. Participants were encouraged to draw and discuss their conclusions from these projects.

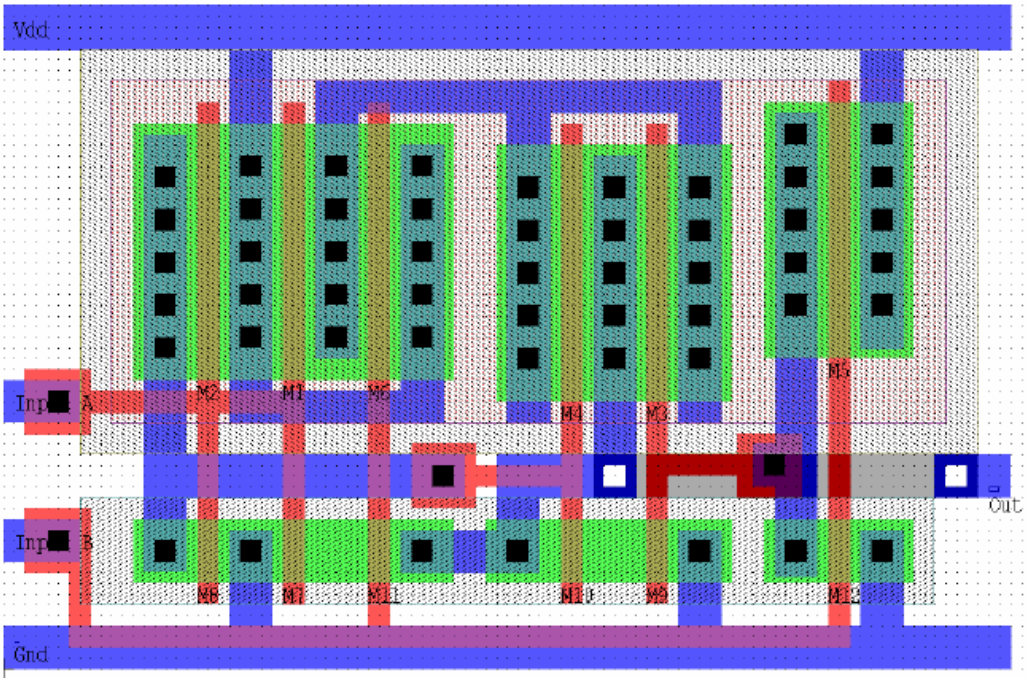

Fig. 4: Layout of a 2-input XOR gate using L-Edit

Course Management

A course based on the outline presented above has been offered at KUT five times between 2001 and 2005. Each course consisted of nearly 15 participants who were invited to participate from all over South Korea by the standard advertisement methods used by HRDI. Most of the participants worked as teachers in vocational schools and in other technical colleges. Medium of instruction was English. Speaking English and understanding spoken English was somewhat difficult for a many participants and the course moderator served as an effective medium between the students and the course instructor. Students were encouraged to work on the design projects and the simulation projects in groups of two each which was quite effective.

Conclusions

Since the purpose of this KUT program is to train the school and college teachers about the state-of-the-art technologies who will ultimately transfer that knowledge to their students in their classrooms, it is too early to measure the overall success of the program. However, in the post-course oral and written evaluations, the participants expressed satisfaction about their participation in this course. They felt that it will help them in their personal development as well as help their students become aware of the latest technological developments. Since a similar course has been taught at KUT five times so far, the course instructor and the course moderator have fine-tuned the course contents and the pace of their presentation to match the participants' preparation and expectations.