A Windows Based Integrated Circuit Design Tool for Distance Education

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Abstract - A downloadable Windows NT/95/98 based integrated circuit (IC) design system has been developed. The need for such a system is introduced and discussed. The operation and use of this software is presented in this paper. The IC design system can be used for IC layout, schematic capture, design rule checking, design verification and SPICE netlist generation. Use of this tool in courses taught through distance education is discussed.

I. Introduction and Discussion

An important component of a contemporary course in integrated circuit design (IC) is the use of IC design tools. Unfortunately, all design tools that are available, without cost, from universities are implemented using the UNIX operating system and run on a workstation. Very few students, especially off-campus students taking a course through a video program, have a workstation at home. Students in IC courses are forced to either work in an on-campus computing facility (not an option for video students) or try to find a workstation, perhaps at their location of employment, to use for course assignments.

Commercial computer-aided-design companies also have UNIX based design software and have gladly offered their high powered tools for university use at a modest fee (normally a documentation fee of a few thousand dollars dependent on the number of licenses received.) The companies offer these "free" copies of their software in hopes that the university will "train" the students in its use and that the student will use the specific companies software when he/she makes the transition into industry. From this discussion we can make the following statements:

- Having IC design tools that can be used by the student at a time and a place of his or her liking fosters experimentation and learning. Since virtually all students have a PC the PC is the logical choice for a computer platform for IC design tools and courses in universities.

- While commercial software is powerful (and necessary in a production or industry environment), and thus more complicated, it also requires a large amount of systems level support. A typical IC company has a section of engineers and programmers whose job is to keep the software up and running and to solve problems with using the IC design software as the problems occur. This level of support is not practical for a university, in most situations, and the power of the commercial software is rarely used when introducing students to IC design.

- As many universities are using outreach programs as a means to increase enrollments the need for "easy to use, maintain and get" IC design software becomes obvious. The alternative, if the student doesn't have access to a workstation, is to NOT discuss layout, design rule checking, extraction and other fundamentally important topics.

- Training is a very important ingredient in an engineer's productivity at a company. However, training is of little importance at a university. As little time as possible should be spent training the students on how to use an IC design tool. Training students to run software uses valuable class time or requires time outside of class the students (and instructors) may not have. Classroom time should be devoted to the actual circuit design with the parasitics and matching considerations resulting from the IC layouts being discussed along with the IC design flow. Using simple IC design software which allows the students to learn the fundamentals of circuit design, layout and simulation should be the main concern of the instructor. Training students on commercial software should not concern the instructor. A student that understands the fundamentals will easily learn to use more advanced design tools when he/she makes the transition from academe.

Hopefully, this discussion has set the stage for why a windows based IC design system is needed. This paper presents and discusses the operation of a windows 95/98/NT IC design system that is easy to use, yet powerful, that can be downloaded from the web[1,2].

II. The LASI Layout System

The LAyout System for Individualists, LASI, (pronounced LAZY) program was written by Dr. David Boyce [3]. LASI has been setup for use with a textbook [2] so that both on-campus and video outreach students have access to a coherent textbook/software combination that can be used to learn analog and digital circuit design, layout and simulation. The system consists of a drawing program, used for layout and schematics, design rule checking, layout versus schematic, SPICE netlist generator and GDS or CIF to internal LASI TLC (Transportable LASI Cells) file converters.

Figure 1 shows the basic drawing window that comes up when LASI is started with an example layout. LASI contains a full on-line manual that can be accessed anytime while LASI is running by either pressing the F1 key or pressing the help button. In addition, tutorials covering the use of LASI exist online[1] and can be downloaded.

An important command accessible from the command menu on the top of the screen in Fig. 1 is the system menu screen (Sys). This screen is shown in Fig. 2. From this menu we can translate LASI TLC files into Calma Stream Format (GDS) or Cal-tech intermediate format (CIF) and vice-versa. We can also translate autocad (*.DXF) files into TLC files and then into GDS or CIF. Also, from this menu we can DRC cells, attach cells from a cell library, change the scale of a cell, copy a cell into another cell, kill or delete a cell, rename or resize a cell, rerank a cell or sort the cells according to rank and name. Figure 3 shows an example schematic drawn using LASI. Using the LasiCkt program we can extract a SPICE netlist from either layout or a schematic making a heuristic layout vs. schematic possible (the netlists and simulation results are compared.)

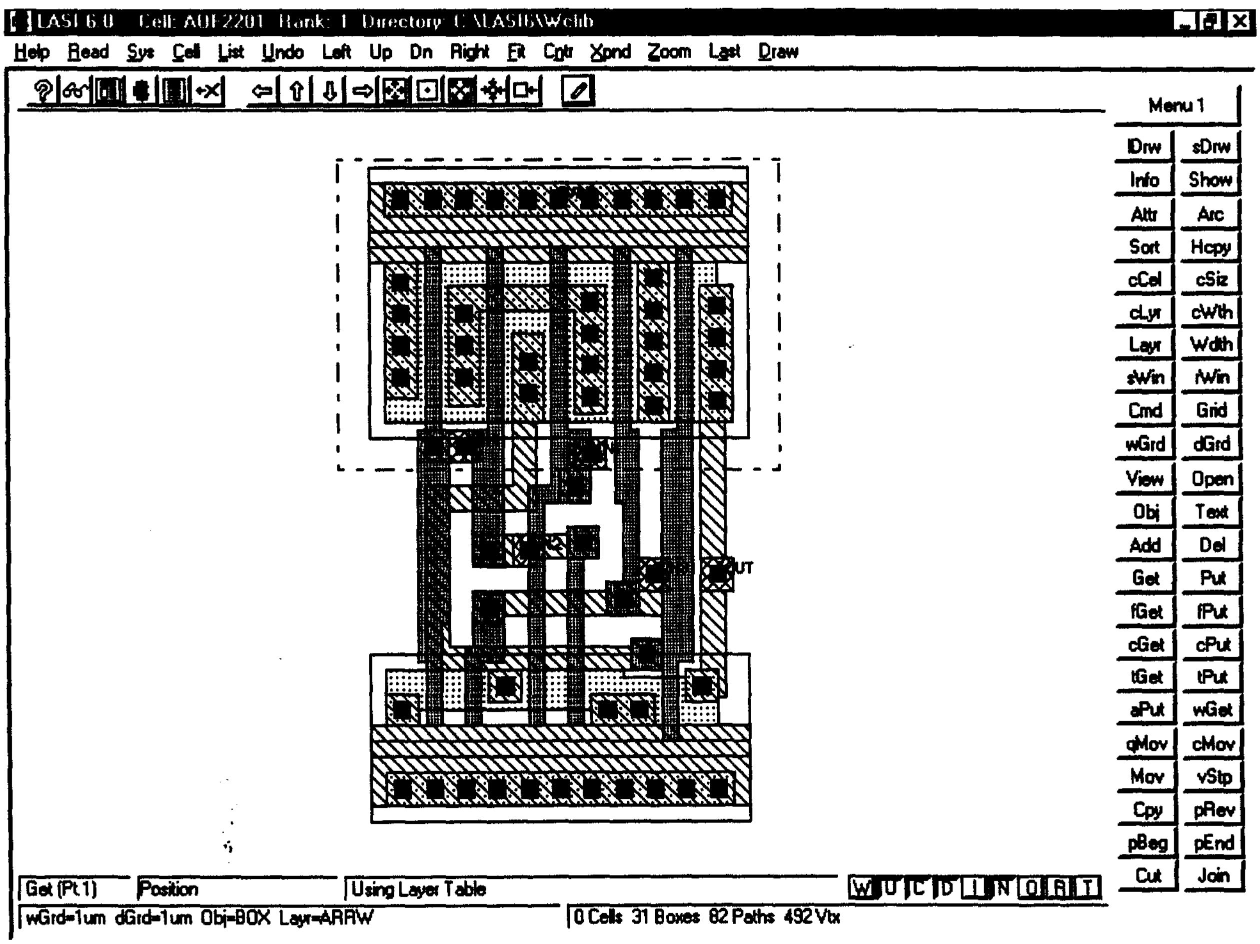

Figure 1 - LASI drawing screen.

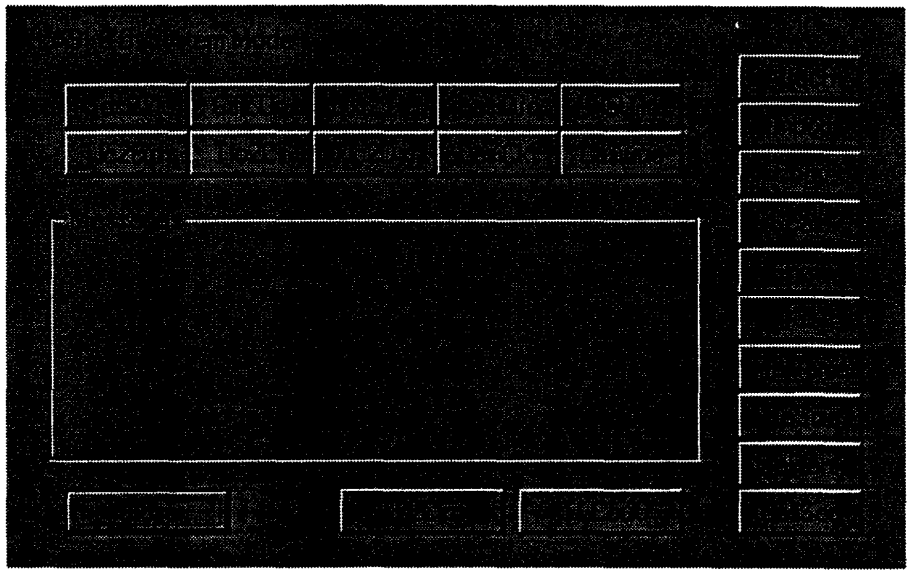

Figure 2 - LASI system screen.

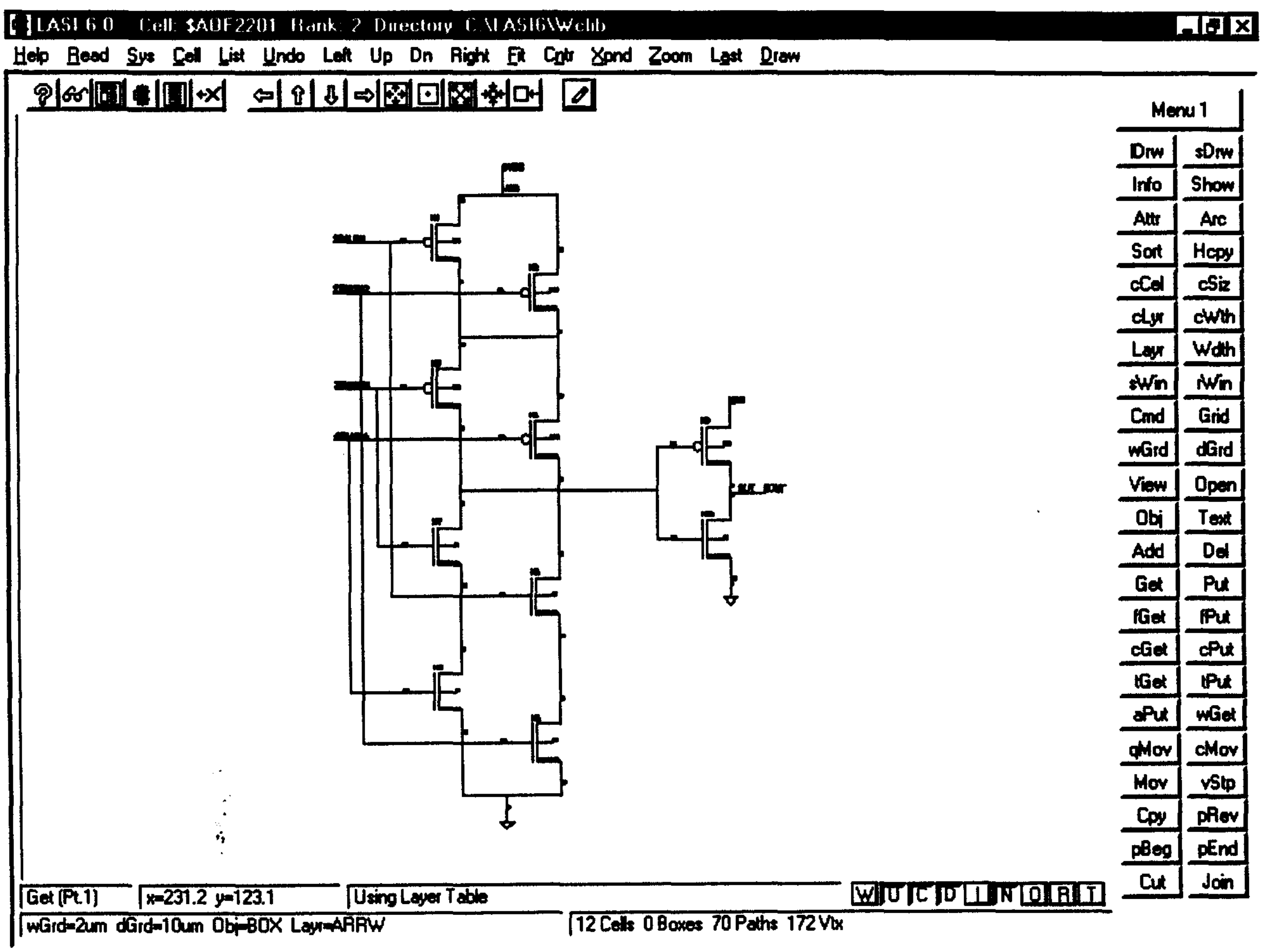

Figure 3 - Schematic drawn using LASI.

III. Experience in Distance Education

At the present time the microelectronics field is exploding[4]. The demand for an education in the integrated circuit design field is present on-campus and off campus. Outreach programs target companies not located near a university and provide flexibility by supplying lectures on video tape, so that the student can view the lectures on her/his schedule, and course materials, in many cases, on the Internet. This section will present some of the author's experiences in teaching IC design through an outreach program over the last five years.

A Discussion

Some have argued that simulation and layout are not fundamental topics and that they shouldn't be included, in any detail, in a course on integrated circuit design. Instead the course should concentrate on derivations and mathematical rigor to enhance the problem solving capabilities of the student. While it is very important the student be exposed to derivations and mathematical rigor early in their undergraduate education, perhaps as part of a freshman or sophomore physics, calculus or circuits courses, it is equally important that the student, at some point later in their education (especially after the student has started working), gain some marketable skills. *Conclusion*: if a course is taught through an outreach program to a working engineer and doesn't contain practical and useful information the course will not be well received.

A good circuit designer thinks of their work as an artful craft that requires creative solutions and not rigorous mathematical derivations. Because of the need for creative solutions it is important that the designer be exposed to the design tradeoffs and the decision-making process rather than be provided a set of numbers taken as absolutely unchanging when designing an integrated circuit. Adding the ability to simulate a circuit helps to develop and enhance the understanding and operation of a circuit (and the tradeoffs). In other words, the student can gain an understanding of a circuit using simulation tools such as SPICE that wouldn't be possible even if the student were to build the circuit! Learning how to simulate a circuit and the limitations of the simulator is not knowledge that is learned overnight. It is important to start the simulation learning process as soon as possible. *Conclusion*: simulation tools are an important part of a course in IC design.

Some have argued that layout (the process of physically defining how an integrated circuit is assembled) is not something that an engineer, or an engineering student should be concerned with. Layout, as they would argue, is the task of the draftsmen not the engineer. Unfortunately these thoughts couldn't be farther from the truth.

High-performance analog, digital or mixed-signal circuits are almost always designed with matching or parasitics at the front of the engineers design concerns. The engineer must know how to do layout, how the layout affects the circuit design and how to direct the layout draftsman. Layout is an important circuit design concern and should be taught together with simulation in an IC design course. *Conclusion*: layout knowledge is an important part of a circuit designer's skills and should be presented together with circuit design and simulation in an IC design course.

On the other hand, although these topics (simulation and layout) are important their inclusion shouldn't take up too much of the class time. As discussed in Section I because of the complexity of modern layout and design software the learning curve can be steep. The result is that the instructor may spend more time talking about a computer operating system and layout software then talking about circuit design. One solution to the lack of time is to setup labs so the students can spend additional time (provided they have the time) outside of the classroom learning the software. This, of course, is not a solution for off-campus students since they will not have access to the labs. Also, if not careful, the instructor can create major differences between the education received on- and off-campus. Conclusion: (borrowing information from Section I) using the PC-based LASI program, with its ease of use, for an IC design course with both on- and off-campus students will provide the needed exposure to layout (and DRC, LVS, schematic capture, etc.) while not requiring a major investment in course time.

V. References

[1] http://www.engboi.uidaho.edu/lan-group/jbaker/wwwbook/book.htm

[2] Baker, R.J, Li, H.W. and Boyce, D.W. "CMOS: Circuit Design, Layout and Simulation," IEEE Press, 1998.

[3] Dr. David E. Boyce, 68 Bergdorf Rd. Parish, NY 13131, USA Fax/Phone: 315-625-7291.

[4] 1998 Semiconductor Roadmap available at http://www.sematech.org

About the Author R. Jacob (Jake) Baker is an Associate Professor of Electrical Engineering at the University of Idaho. His teaching and research interests are in the area of CMOS mixed-signal circuit design. He is the co-author of *CMOS: Circuit Design, Layout and Simulation* published by the IEEE Press, 1998. Jake holds several patents and has over ten years of industry experience in the integrated circuit design field. He received the BS and MS degrees in electrical engineering from the University of Nevada, Las Vegas and the Ph.D. degree in electrical engineering from the University of Nevada, Reno.