VIRTUAL LABORATORY OF DIGITAL SYSTEMS

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ABSTRACT

The subject of this work is the set up of a Virtual Laboratory of Digital Systems, an environment for Computer Assisted Learning - CAL, where the student can immerge into virtual experiences. In the virtual laboratory the student can interact with the instruments and electronic components when carrying out his experiments. The interaction happens through equipment of VR, mask and gloves, where the student operates the equipment as if he were in front of a bench with shelves with components and all the necessary equipment to set up a discreet digital system and evaluate it. One of the first tools is a visual simulation one, which works like a virtual color electron beam microscope.

INTRODUCTION

Equipment like the oscilloscope, signal generator, DC source and multimeter, is operated in the same way as the real equipment (with the advantage that the virtual doesn't burn!), leading the student to learn how it works as if he were in a real laboratory. Besides, the equipment includes help keys that activate a virtual instructor that shows how to operate the instruments instead of simply showing manuals on the screen. This virtual instructor can also make demonstrations and tutorials. So the student can be instructed on the correct use of equipment by operating in the virtual laboratory. In an example of use of the laboratory there may be a series of components available to the student which are common in experiments of this nature, such as connection threads, integrated circuits (family 74xx, for example), LED, among others, presented in their real form.

VIRTUAL PROTOBOARD

Experiments proposed to the students, such as exercises or class works, will be the set up of circuits using these components and a virtual protoboard, simulating the reality of a laboratory of digital systems (figure 1). As the circuit is being set up, a schematic description of the circuit is generated automatically and it can to be evaluated with the use of circuit simulators.

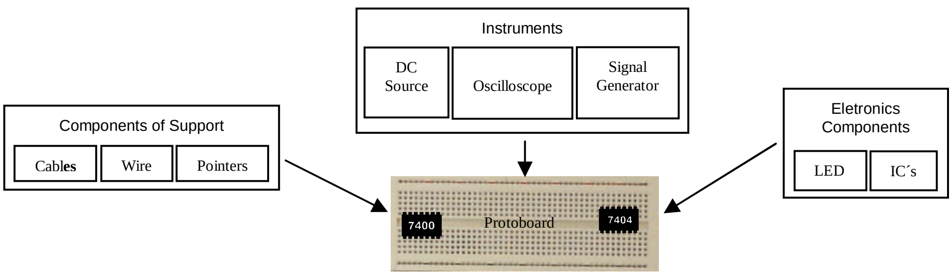

Figure 1 Interaction between components

VISUAL SIMULATION

The virtual nature of this laboratory will make it possible to use resources that will never be available in a real laboratory. The first of these resources is the possibility that connections among the components change colors dynamically according to the variation of their electric level, at the level of schematic as well as of layout (figure 2).

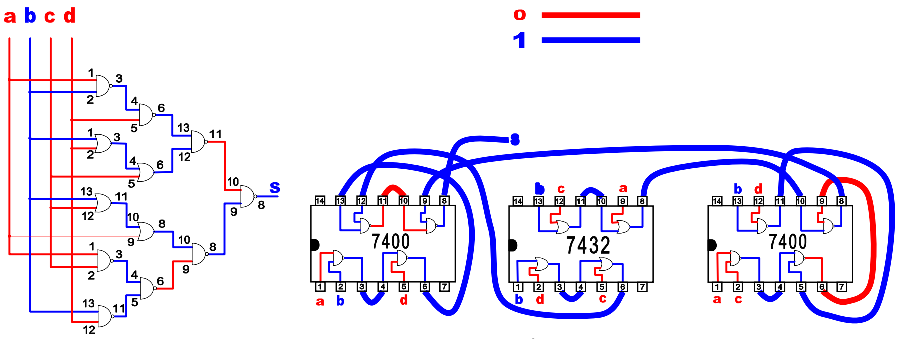

Figure 2 Color simulation of circuit

In layout level, for example, the user can control the speed of propagation of the changes in the circuit input by defining a standard delay of propagation of one change from one block to another. This provides to the user a simulated view of a circuit at work. If the user selects a color view of the layout, it is defined by the user or by default two levels of colors for each layer. For example, a metal layer represented in blue will have the dark blue as logic level 1 and the light blue as logic level zero (or vice-versa). In figure 3 we can see one of the possible modes of visualization, where only the inputs and outputs of a cell have dark color or light color indicating the values of voltage in these lines (in these case black is zero and white is logic 1). But, several visualization modes will be available. For example, the user can define colors; the parts of a layout that he wants to "see" the voltage (only the transistors e connections between them, or he wants also to see the power lines colored in relation to their voltage).

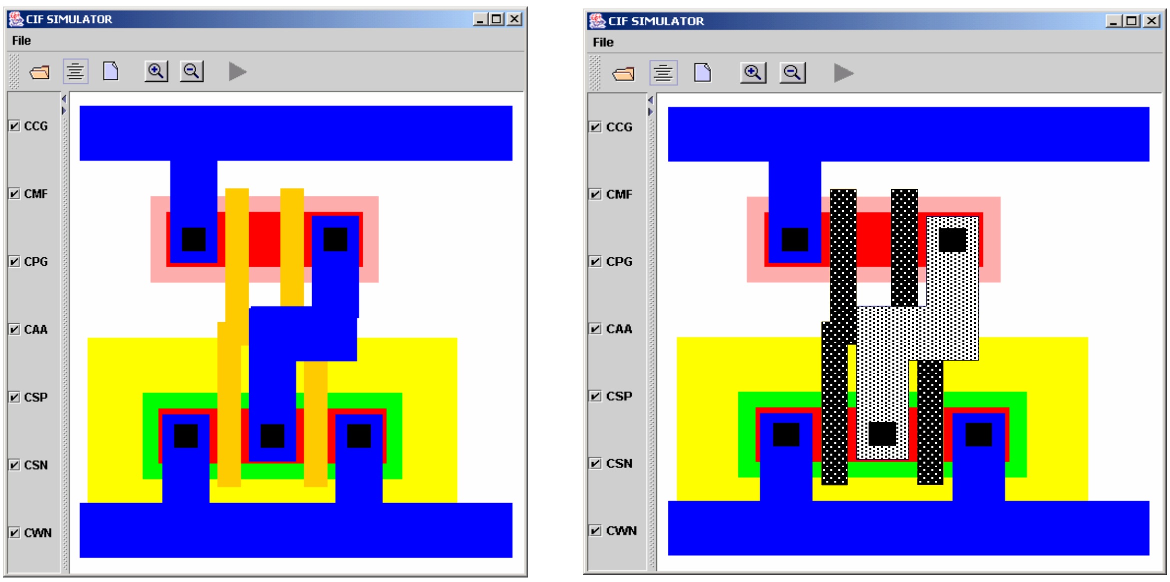

Fig. 3 Visual Simulation Tool at Layout Level

The tool provides a vision that is in some way similar to the view of a circuit that we can have with an electron beam microscopy, but in color.

CIRCUIT 3D VIEW

Another resource is the possibility of making a "three-dimensional zoom" that lets 'to go inside' the experiment (figure 4) in a scenery of VR and to visualize the *intern logical gates* of the integrated circuits and their connections that can also show the variation of their electric levels through colors. This immersion can continue, going from the layout of transistors through to visualization of the electric currents and to see, for example, how a transistor MOS works with the voltage variation on its gate (figure 5). All this can give to the virtual laboratory a didactic capacity never seen before.

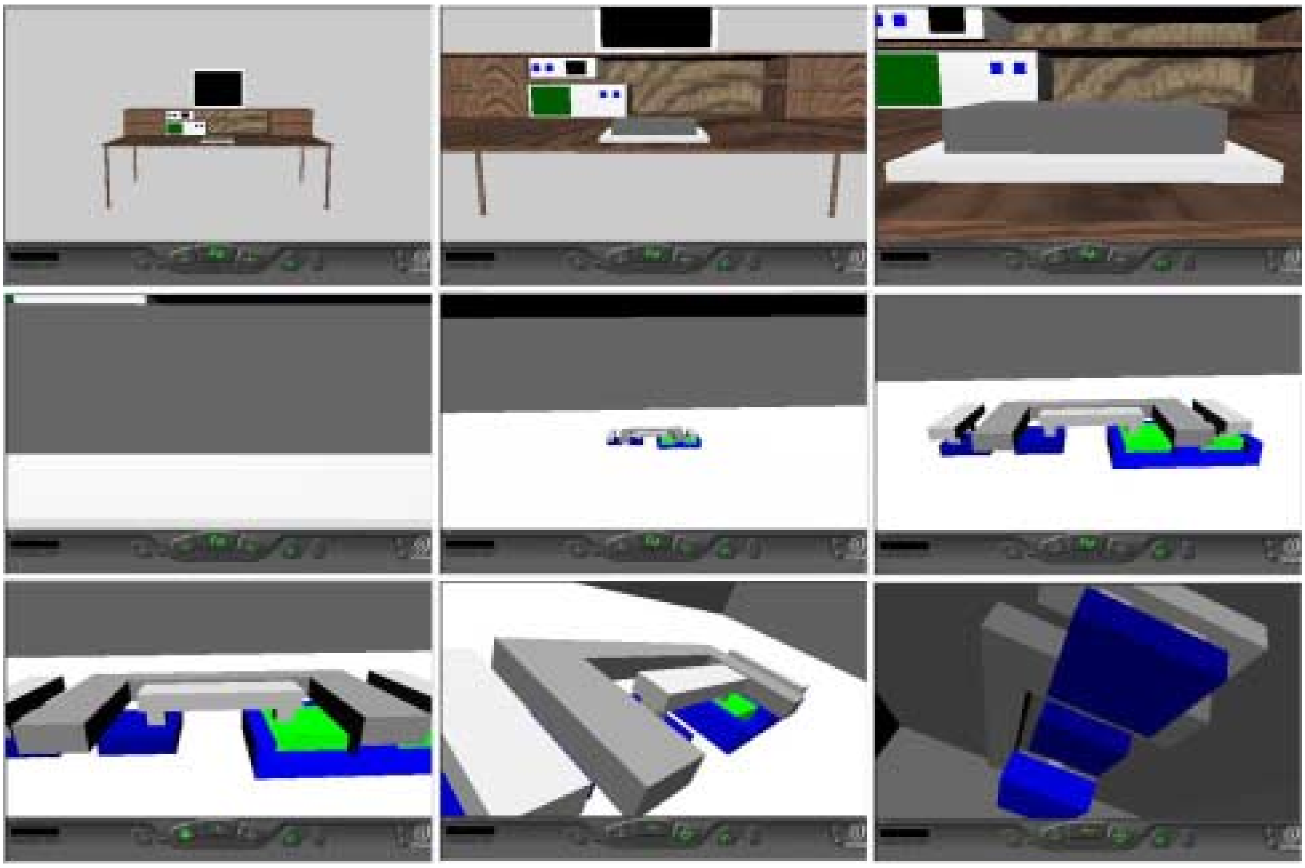

Figure 4: Immersion in the Virtual Laboratory

CONCLUSIONS

The importance of a laboratory of this nature lies not only on its innovative but also on its economical aspect. The cost of setting up a real laboratory and maintaining it is quite high. The necessary instruments for the accomplishment of an experiment are also expensive. In a virtual laboratory by WEB, each instrument can be simulated, for example, by an applet in JAVA and the multiplication of the laboratories would just depend on the distribution of these applets. This laboratory is based on a framework, which allows the inclusion of new equipment and instruments according to the needs. The virtual laboratory will be the interface, which will integrate the project tools of the CAVE[1] framework and the teaching-learning environment. This integration will be possible through the virtual computer inserted in the virtual laboratory. As a result the user won't need to change environments, which give him a homogeneous view of all resources.

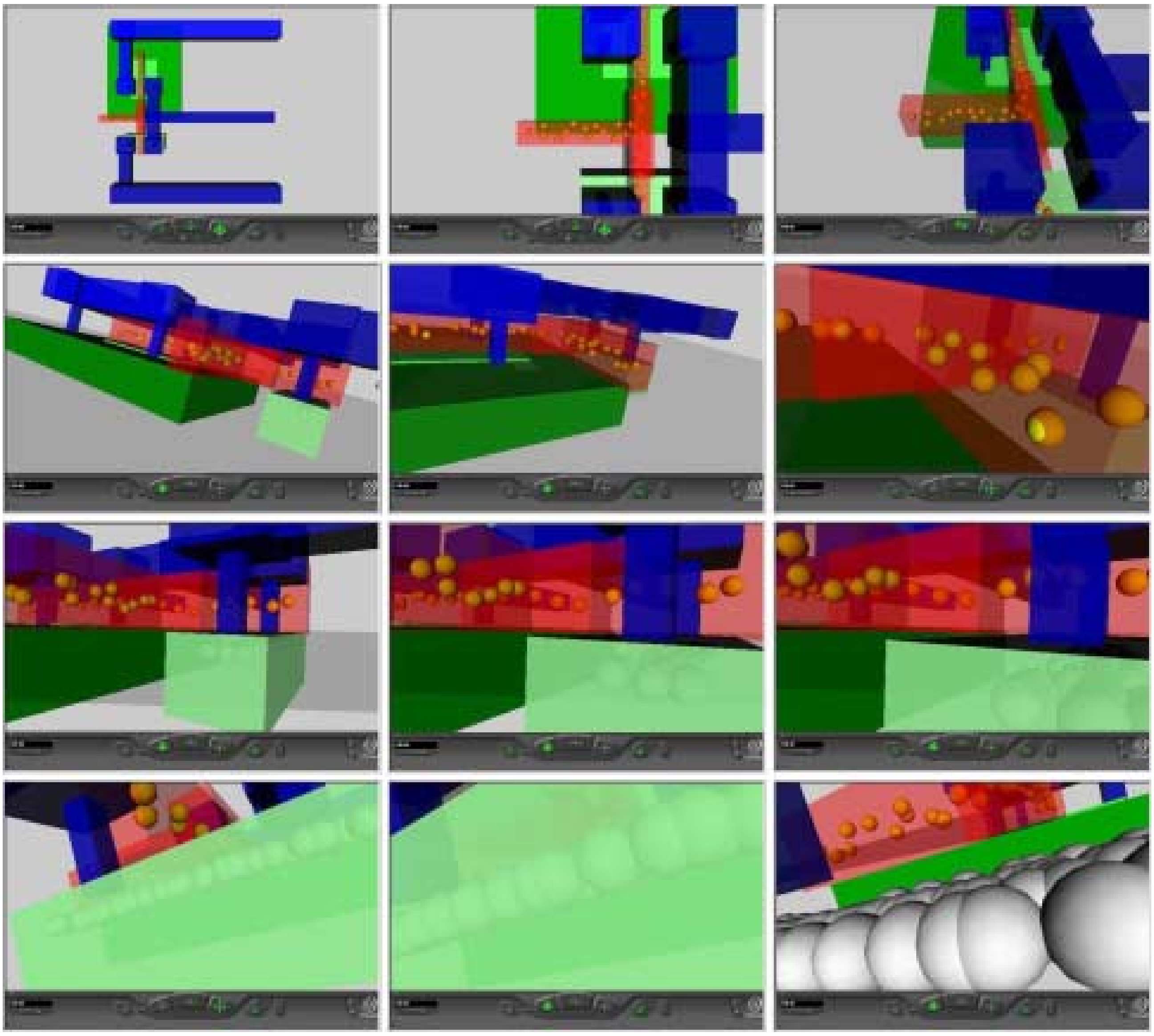

Figure 5 Visualization of electric flow in a transistor

[1] REIS, Ricardo Augusto da Luz; INDRUSIAK, Leandro. "**Project Management and Design Methodology Support for the CAVE Project: A Hyperdocument-Centric Approach**" In: Symposium on Integrated Circuits and Systems Design, 12, Natal, RN, 28 setembro a 2 outubro 1999. Anais. IEEE Computer Society, 1999.