Virtual Electronics Laboratory: A new tool to improve Industrial Electronics Learning

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Abstract - **This paper describes a new tool to improve the Industrial Electronics education process. The tool really constitute a virtual electronic laboratory because it is made up of a set of virtual experiments with a user-friendly graphic interface and interactive simulated electronic instruments relating practical concepts with theoretical ones.**

The virtual laboratory can be used with a traditional book as well as with a hypermedia learning system. The combination of the tutorial and the virtual electronic laboratory constitute a bridge between theoretical lessons and laboratory classes. The professor can use the experiments of the virtual laboratory in the classroom to improve student retention. Using this tool, undergraduate technical students improve their performance and increase their efficiency in the laboratory. A pilot experience has been implemented for Analog and Digital Electronics. The analog virtual laboratory includes a set of circuits using discrete electronic devices and operational amplifiers and four different simulated instruments: a signal generator, a power supply, a multimeter and an oscilloscope. The Digital Electronics virtual laboratory includes the different combinational and sequential digital circuits and a virtual logic analyzer to visualize the evolution of the different input and output signals.

Index Terms - Computer aided learning, Electronics learning, Learning tools, Virtual laboratory..

I- INTRODUCTION

Industrial Electronics is a very important area of Information Technologies because it contributes to increase industrial enterprises competitiveness.

At present, Industrial Electronics learning comprises two steps (Figure 1). First, the students learn theoretical concepts by attending lectures and studying a tutorial book and then they perform a set of tasks in a laboratory.

However, this process has several drawbacks [1] when applied to Electronics because:

- Tutorials included in a book do not give enough information about the dynamic behavior of the different devices and circuits [2] [3] [4].
- Students have insufficient knowledge about commercial electronic components, assembly techniques and measurement instruments. Design errors and component damage are common during laboratory classes.
- Students do not know if their knowledge on theoretical concepts is good enough.
- Students have no experience on testing electronic components behavior. Above all they do not have a good grasp of measurement instruments operation.
- It is not suitable for asynchronous distance learning.

Information technologies make the combination of a tutorial with a simulator possible. But available simulators are mainly system design oriented instead of system analysis oriented [5] [6] [7]. Due to this they are not useful for the first stages of the learning process because they do not relate theory and simulation, they do not have hypermedia capacity and they need many hard disk resources.
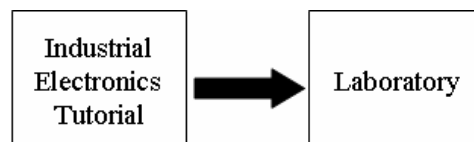

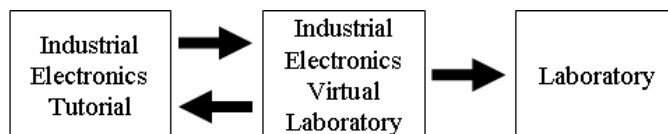Fig. 1.Learning process of Industrial Electronics at present

Fig. 2. Learning process of industrial electronics using a virtual laboratory

II- ELECTRONICS VIRTUAL LABORATORY

To overcome the above mentioned difficulties we developed a tool which is made up of a set of pedagogical simulations (Figure 2). We call this tool Electronics Virtual Laboratory because it has the following characteristics:

- A user-friendly graphic interface.

- Interactive simulated instruments with a functionality similar to the actual instruments.
- It is oriented to circuit analysis instead of to circuit design.
- It relates practical concepts with theoretical ones through a selected set of experiments.
- Each experiment is a pedagogical interactive simulation using just a few computer resources and can be included in any other software application.
- It contains destructive experiments which are not possible when using real electronic devices.
- It has self-test capacity.
- It is scalable to add new performances.

The user interface includes the different instruments used in the actual laboratory. These instruments are connected to the suitable test points. Figure 3 shows the general user interface of the Electronics Virtual Laboratory, including generating instruments, measurement instruments, input and output elements, and the electronic circuit under test.
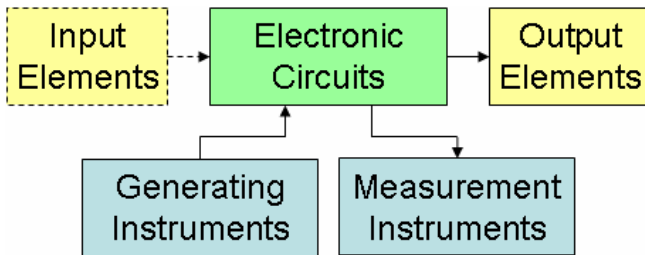

Fig. 3. Block diagram of the virtual laboratory for industrial electronics learning

The main parts of Industrial Electronics are Analog Electronics, Digital Electronics, Electronic Instrumentation (including sensors) and Power Electronics. A Virtual Electronic Laboratory can be developed for each one, but the principal line of our work includes an Analog and a Digital Electronics Virtual Laboratories.
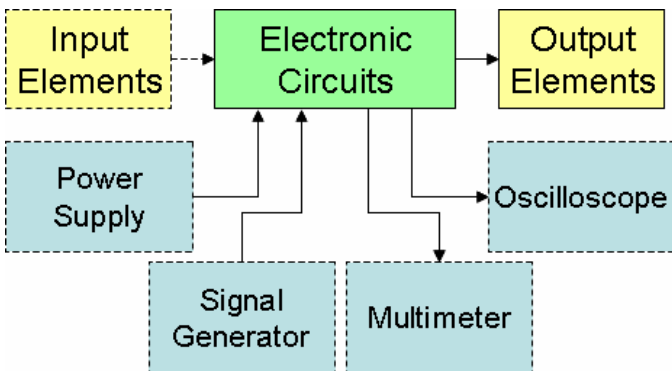

Fig. 4. Block diagram of the Analog Electronic Virtual Laboratory

III- ANALOG ELECTRONICS VIRTUAL LABORATORY

Figure 4 shows the block diagram of the Analog Electronics Virtual Laboratory including a signal generator, a power supply, a multimeter and an oscilloscope. All the experiments uses a power supply, and depending of the characteristics of the experiments, one or more of the other three instruments.
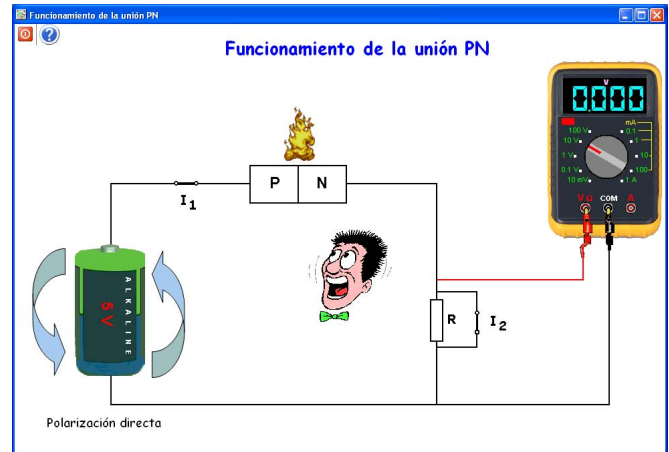

Fig. 5. PN behaviour destructive experiment using a multimeter

The multimeter is used in the experiments where just DC signals are involved. As an example, in figure 5 we can see the experiment to analyze the behaviour of the PN junction. This is a destructive experiment where the user can verify what happens when the PN junction is directly biased without a current limiting resistor.

The oscilloscope is used when the experiment includes timing variable signals. As an example, in figure 6 the experiment analyzing the behaviour of an inverting amplifier can be seen.
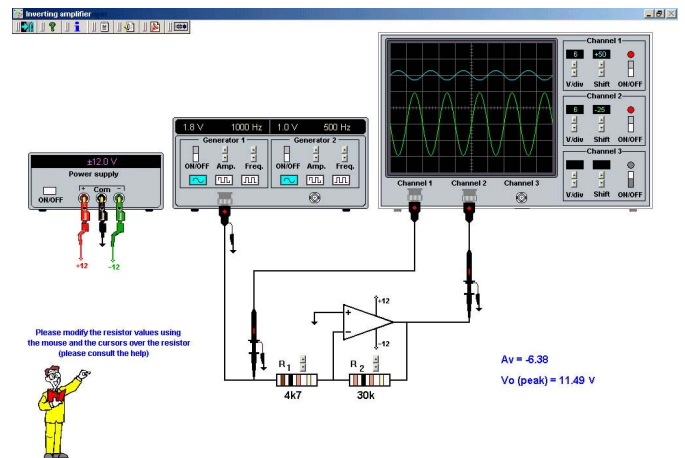

Fig. 6. Inverting amplifier experiment of an analog Virtual Laboratoy using a signal generator and an oscilloscope

The student can change the value of the resistors and the type of the waveform of the signal generator, including its

amplitude and frequency. The resistor values can be only standard ones and the colour code is used.

IV- DIGITAL ELECTRONICS VIRTUAL LABORATORY

The Digital Electronics Virtual Laboratory (figure 7) has an interactive graphic user interface including a digital circuit and a virtual logic analyzer to visualize the evolution of the different input and output signals.
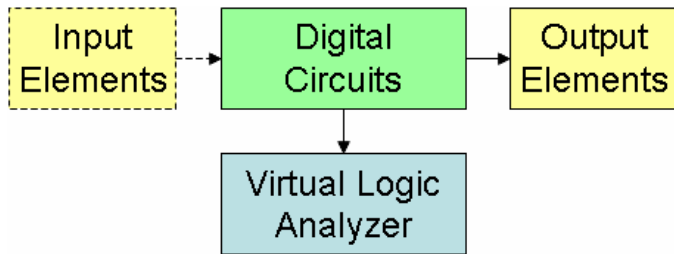

Fig. 7. Block diagram of the digital virtual laboratory

The virtual logic analyzer (figure 8) has 8 channels. It works like the real equipment, including user programmable signal display speed. Signal display can be stopped at any time. In this situation, clicking on the magnifying glass a cursor facilitates signal level reading on any point of the virtual logic analyzer screen.
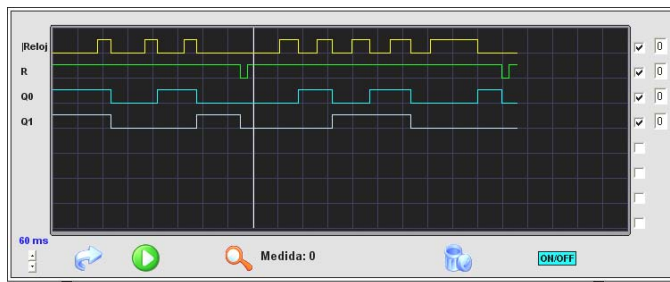

Fig. 8. Virtual Logic Analyzer Interface

The simulation of the different logic gates is shown in figure 9. The student can select the type of gate and the logic level of the inputs.

The virtual logic analyzer is a suitable tool to understand the behavior of the different sequential circuits. Figure 10 shows the experiment describing an asynchronous counter behavior.

V- INDUSTRIAL ELECTRONICS TUTORIAL

The analog and digital virtual laboratories can be used by the professor in the classroom. But to become a useful tool achieving self-learning capacity, they must be combined with a tutorial document.

The tutorials describe the theoretical concepts about the different circuits, linking to the appropriate experiment. Each experiment includes the description of the activities to be accomplished by the student, as shown in figure 11.
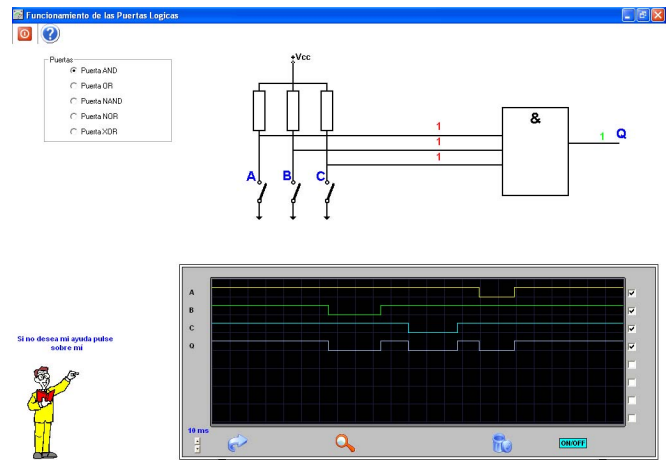

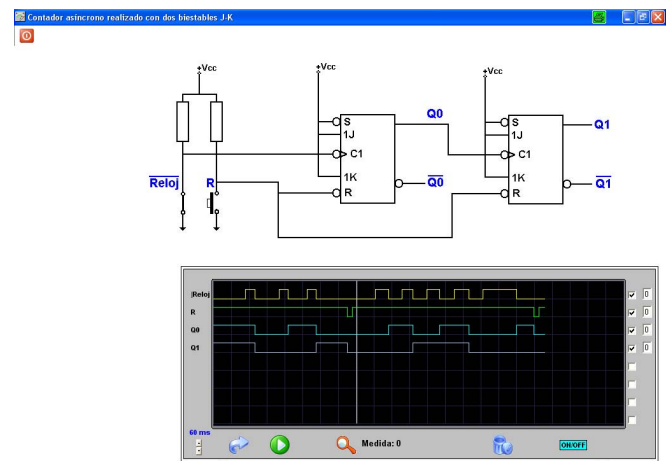Fig. 9. Experiment of the different logic gates

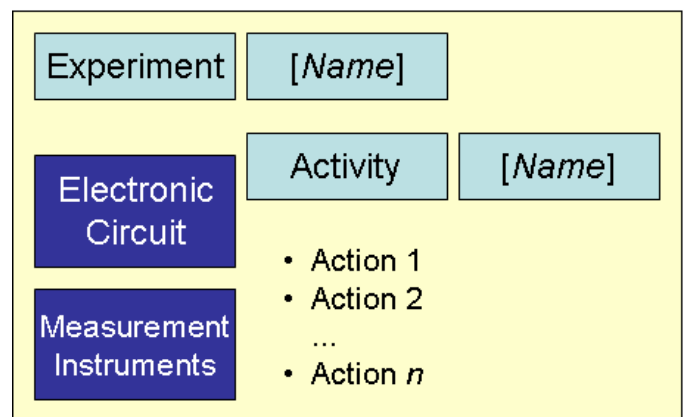Fig. 10. Experiment of an asynchronous Counter

Fig. 11. Block diagram of the experiment

In figure 12, the reader can see the experiment "R-S latch with set priority".

VI- DIGITAL VIRTUAL LABORATORY EXPERIENCES

The Digital Electronics Virtual Laboratory has been tested with a group of forty digital electronic students. Two groups were created, group A and group B, each one with twenty students. Students of group A went to a classroom where the professor did not use the digital virtual laboratory to explain the behaviour of the different digital functional blocks. On the contrary, students of group B went to a classroom where the professor used the digital virtual laboratory.
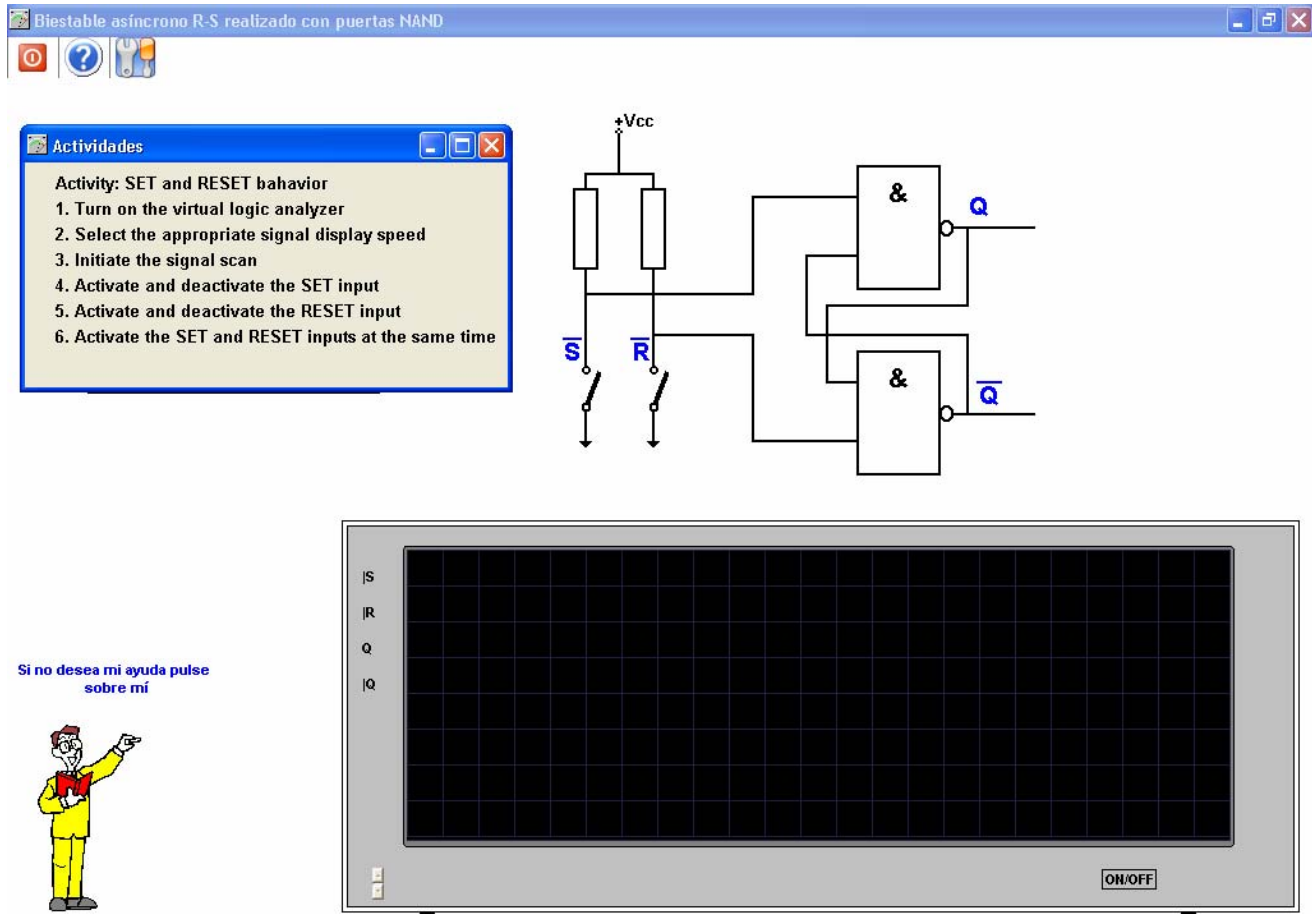

Fig. 12. Student interface of the experiment "R-S latch with set priority"

At the end of the group B classes, a poll was taken to verify the satisfaction of the students. 81% of the students considered the virtual laboratory to be a good tool to learn the subject and 19 % considered it to be "useless". In the final examination, just 64% of group B students and only 31 % of group A passed.
At present the virtual laboratory is being used on continuous education courses for mechanical and electrical engineers with very good results. Educators find the system very useful.

VII- REFERENCES

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