

# Virtual Laboratory as a Tool to Improve the Effectiveness of Actual Laboratories\*

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*This article describes a virtual laboratory as a tool specially intended to improve the students skills before going to the actual laboratory. To accomplish this objective the system also provides a set of complementary resources, constituting a bridge between theory and practice. This new kind of virtual laboratory takes advantage of the information technologies (multimedia, simulation, etc.) and also facilitates the self-assessment of the students' knowledge.*

## STATE OF THE ART IN ELECTRONICS EDUCATION

AT PRESENT, electronics learning follows the process shown in Fig. 1. First, the students learn theoretical concepts by attending lectures and studying bibliography and finally they perform a set of laboratory works.

However, this process has several drawbacks when the students begin circuit mounting at the laboratory because:

- they have an insufficient knowledge about commercial electronic devices, assembly techniques, and measurement instruments: design errors and component damage are common during laboratory classes;
- they don't know if their knowledge on theoretical lessons is good enough to achieve a complete design;
- they have no experience on testing electronic circuit behavior; specially they do not have a good grasp of measurement instrument operation.

## VIRTUAL LABORATORY

To improve the traditional learning process we developed a set of hardware and software tools ranging from multimedia tutorials to educational modules [1–4]. Then we developed a virtual laboratory which is a hypermedia system [4–6] bridging the gap between theory learning and the actual laboratory (Fig. 2).

The main objectives of the virtual laboratory are:

- Teach the students electronic device mounting using protoboards (a widely used system) before they assemble electronic circuits in the laboratory.
- Teach the students how to find the most common electronic circuits fails such as:
  - protoboards with failed contacts;
  - short-circuited or open-circuit passive devices;
  - out-of-order solid-state devices;
  - incorrect values of resistors and/or capacitors.
- Allow students to come back to theoretical lessons using hypermedia links.
- Allow students to consult manufacturers' data sheets.

To put the idea into practice a virtual laboratory for improving analog electronic circuit learning has been developed covering the above aims. The system must be used between the theoretical studies [8, 9] and the practical work in the laboratory.

## ANALOG ELECTRONICS VIRTUAL LABORATORY

Figure 3 shows the block diagram of the developed system composed by three main blocks:

- workbench area;
- complementary resources;
- data module.

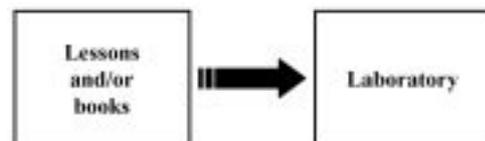


Fig. 1. Electronics learning process.

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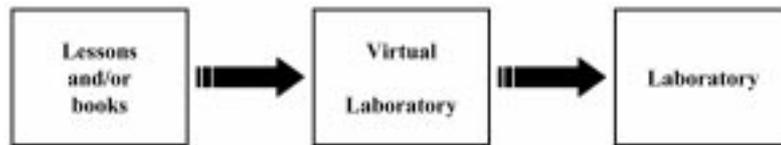


Fig. 2. Electronics learning process using the virtual laboratory.

hypermedia system.

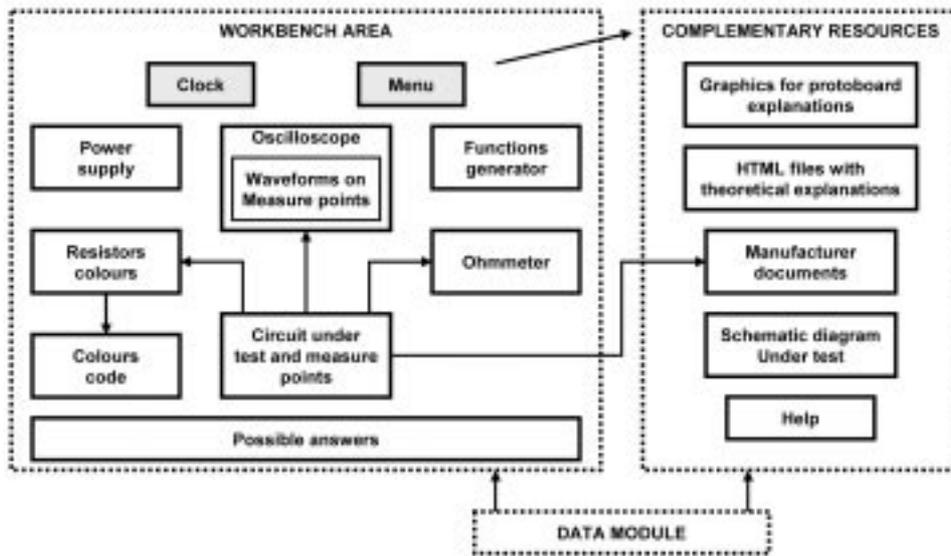


Fig. 3. Block diagram of the hypermedia system for analog circuit verification.

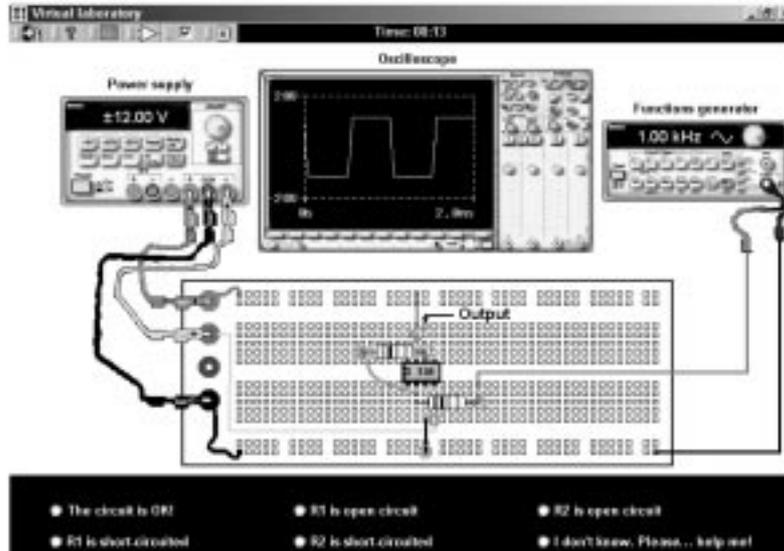


Fig. 4. Workbench area of the virtual laboratory.

#### Workbench area

Workbench area (Fig. 4) contains:

- a power supply;
- an oscilloscope, where the waveforms may be displayed;
- a function generator;
- a protoboard where the circuits are mounted

showing the way to optimize the device placement and interconnections;

- red circles signaling test points—for the oscilloscope to show the waveform at the selected point;
- the resistor color code, and an ohmmeter (Fig. 5);
- an area where possible circuit failures are indicated.

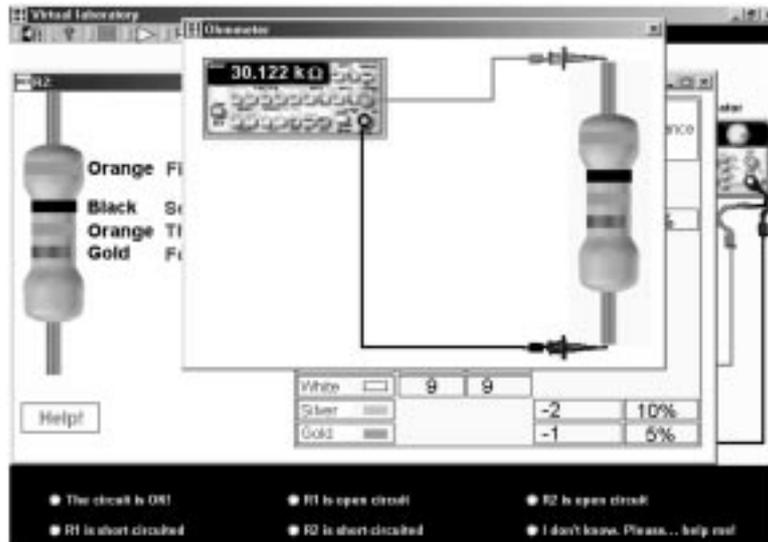


Fig. 5. Colors code and ohmmeter.

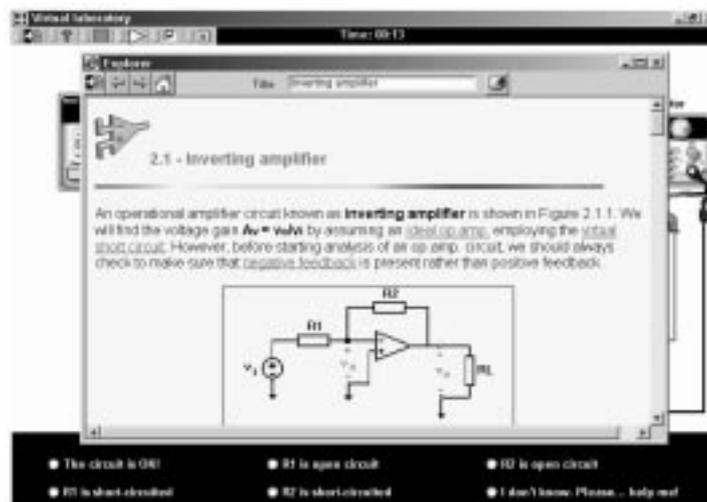


Fig. 6. Theoretical lesson including hyperlinks.

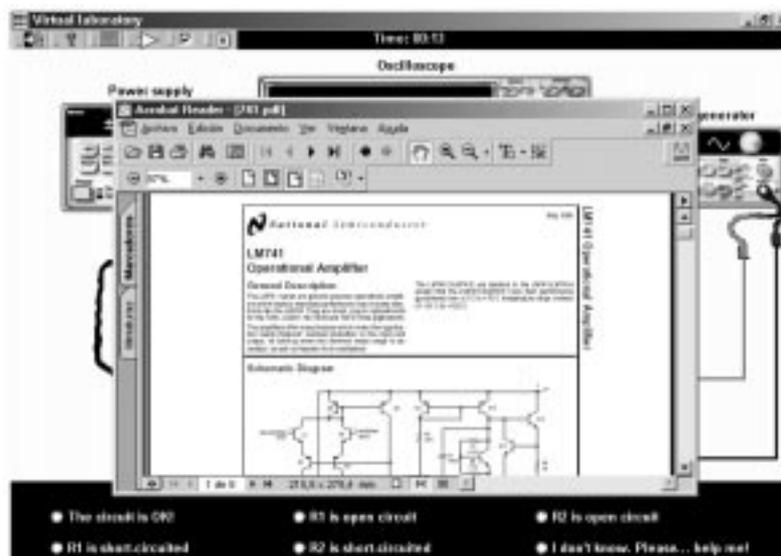


Fig. 7. Hyperlink to manufacturers' documents.

*Complementary resources*

Among others, complementary resources are composed of:

- Hyperlinks to theoretical lessons (Fig. 6) in such a way that the student relates theoretical explanations and practical work. From the theoretical lessons, the students can access a glossary containing 800 words of common use in electronics, to the biographies of 68 scientist and engineers that have participated in electronics development, and can navigate through the history of electronics in the last century. Also, students can listen to, among others, J. J. Thompson speaking about the electron or they can watch 21 videos explaining electronics concepts.
- Hyperlinks to manufacturer's documents so that students learn how to interpret them (Fig. 7).

*Data module*

The information (graphics, device values, links, questions and answers) associated with every practice is included in a small file called 'data module'. It is about 95Kb long and it may be downloaded from the Internet giving a great flexibility to the system. Data are compressed using a special format to prevent the students from searching inside the solutions.

### ASSESSMENT OF THE VIRTUAL LABORATORY

The system has been tested with 12 students as follows: two groups were formed, group A and group B, each one with six students. Each group was divided in 3 subgroups of two students. While

the students of group A went to the laboratory using only the practice manual in use over several years, those of group B used the virtual laboratory previously. All of them mounted the same circuit with a device (a resistor) out of order. The three subgroups constituting group A mounted the practical circuit in a different way while the three subgroups constituting group B mounted in an identical way. Students of Group A spent 4.10, 5.30 and 6.35 minutes to find the fault (mean time: 5'25"). By the contrary group B students only spent 1.15, 1.46 and 2.03 minutes to find the fail (mean time: 1'55", 65% shorter than group A).

### CONCLUSIONS

This article describes a virtual laboratory of analog electronics based on hypermedia resources. It has been demonstrated that the virtual laboratory increases the students' skills to detect the most common analog circuit faults. Using this system as a bridge between theoretical lessons and laboratory classes, students improve their performance and increase their efficiency in the laboratory. Besides this, using the system students can learn how the most common measurement instruments work, interpret manufacturers' documents and access theoretical lessons using hypermedia links.

The system is modular supporting the addition of new exercises. All the students will use the system during the next academic year 2003–2004.

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