

Analog Electronics Basic Simulator and Virtual Laboratory

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Abstract. This paper describes a basic electronics learning system combining a hypermedia system explaining theoretical concepts with a basic simulator and a virtual laboratory to improve the engineering education process on electronics and 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 hypermedia tools takes advantage of the information technologies (multimedia, simulation, etc.) and also facilitates the self assessment of the students knowledge.

1 Introduction

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.

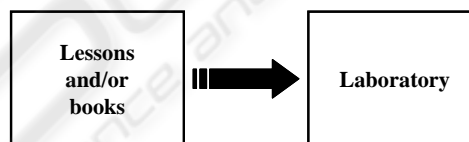


Fig. 1. Electronic learning process

However, this process has several drawbacks because:

- The tutorial included in a book does not give enough information about de dynamic behaviour of electronic circuits [1] [2] [3].
- The students have an insufficient knowledge about commercial electronics devices, assembly techniques, and measurement instruments. Design errors and components damages are common during laboratory classes.

- The students don't know if their knowledge on theoretical concepts is good enough.
- The students have no experience on testing electronic circuit behaviour. Specially they do not have a good grasp of measurement instrument operation.

By these reasons, we developed a basic simulator and a virtual laboratory to improve the previously described learning process.

2 General Description

Fig. 2 shows the proposed learning process. The tutorial is a hypermedia system explaining theoretical concepts [4] [5]. When explaining the concepts the students use the basic simulator to consolidate his knowledge.

Before going to the actual laboratory, they use the virtual lab including a workbench area with a power supply, an oscilloscope, a function generator and a proto-board. Using the interface the student can select the points whose waveforms are shown on the scope. The virtual lab also includes an area where questions about the possible circuit fails are indicated.

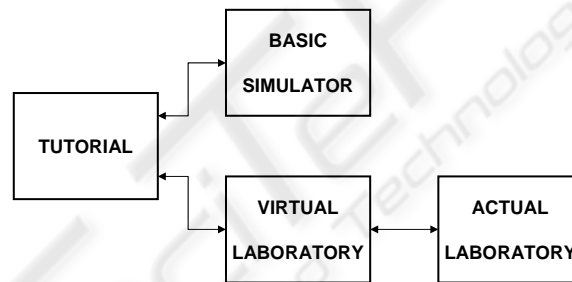


Fig. 2. Block diagram of the proposed learning process

3 Basic Simulator

Available simulators are mainly oriented to circuit design instead of to circuit analysis. Due to that they are not useful for the first stages of the learning process by the following reasons:

- They use actual models of the components, when just a simplified model is needed.
- They do not relate theory and simulation.
- They do not have hypermedia capacity nevertheless they need many hard disk resources.

A basic simulator of analog electronics is just developed achieving the following characteristics:

- It has a graphic user interface including a power supply, two independent function generators and a three channels oscilloscope.
- It shows the circuit scheme with the function generators connected to the inputs and the scope channels connected to the adequate circuit points.
- It has links to manufacturer data sheets.

Fig. 3 shows the graphic user interface of the basic simulator.

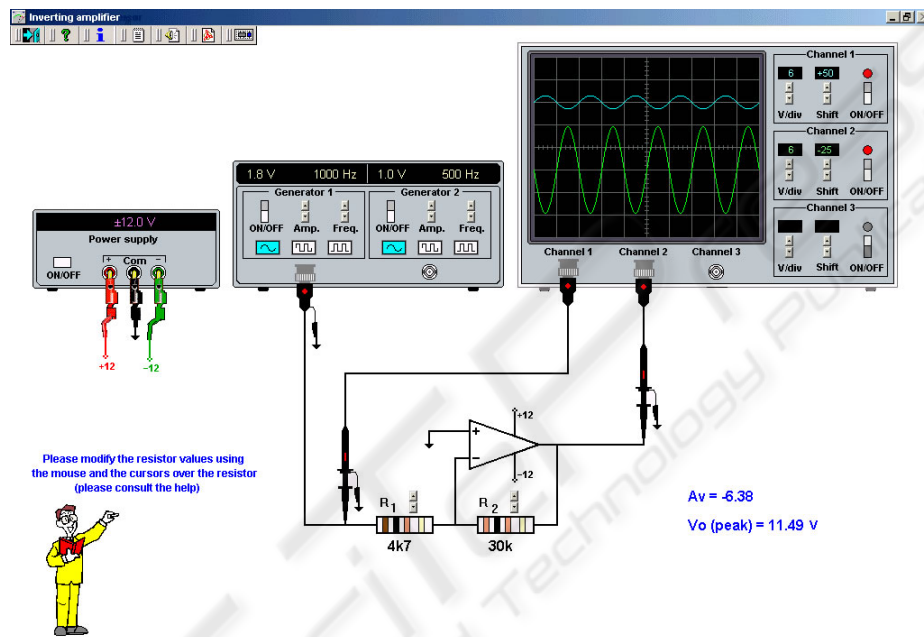


Fig. 3. Graphic user interface of the basic simulator

The students can change the resistors values clicking with the mouse just over the component (Fig. 4).

The basic simulations are linked to audio theoretical explanations (Fig. 5).

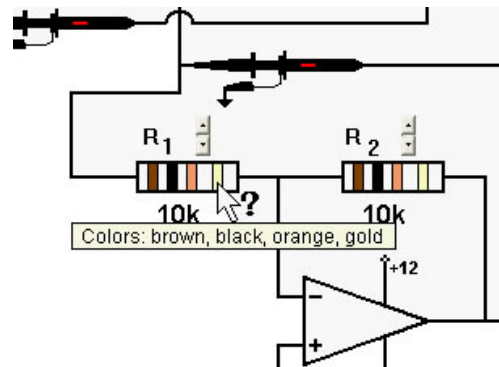


Fig. 4. Using the mouse to change the resistor values

If due to the change of the component values or the amplitude of the input signals the circuit fails, the interface give an easy identifying signal (Fig. 6).

4 Virtual Laboratory

The basic simulator is a good tool for theoretical concepts learning but it does not relates theory and practical activities. That is why we also developed a virtual laboratory. This computer tool constitutes a bridge to the real laboratory because:

- Teaches the students electronic devices mounting using protoboards (a widely used system) before they assemble electronic circuits in the laboratory.

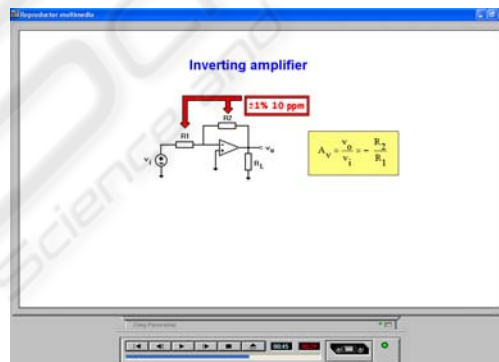


Fig. 5. Audio theoretical explanation

- Teaches 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.
 - Non-correct values of resistors and/or capacitors.
- Allows students come back to theoretical lessons using hypermedia links.
- Allows students to consult manufacturers' data sheets.

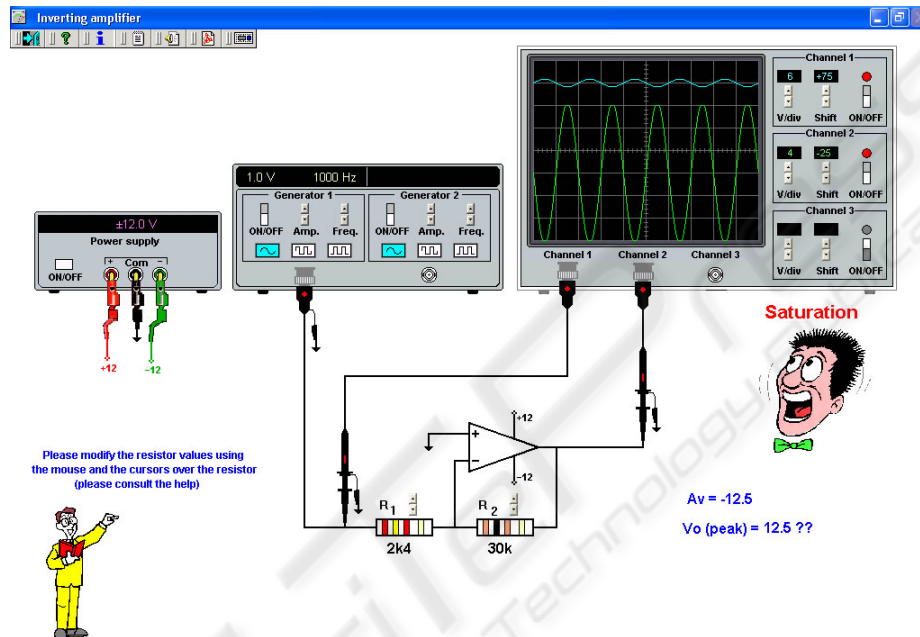


Fig. 6. Identification of a failing circuit

The system must be used between the theoretical studies and the practical work in the laboratory. Fig. 7 shows the block diagram of the developed system composed by three main blocks:

- Workbench area
- Complementary resources
- Data module

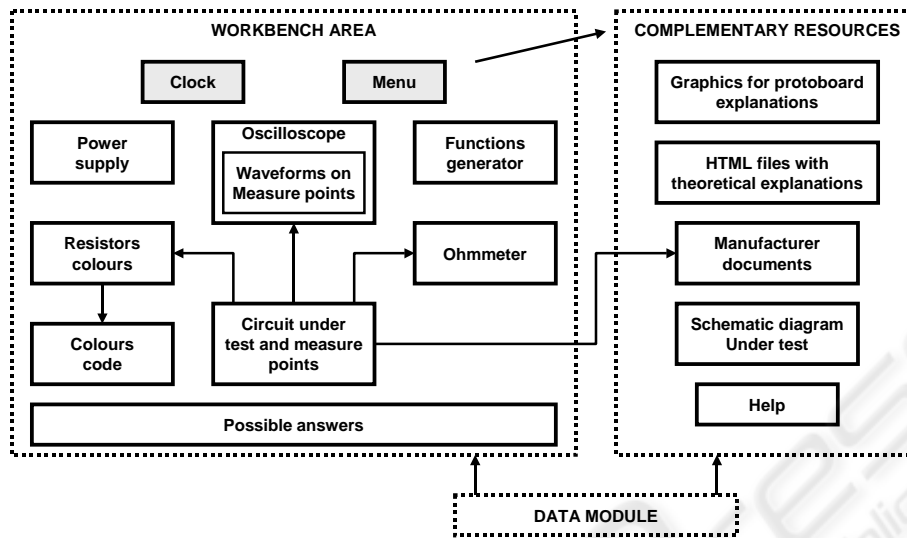


Fig. 7. Block diagram of the virtual laboratory

4.1 Workbench Area

Workbench area (Fig. 8) contains:

- A power supply.
- An oscilloscope, where the waveforms may be shown.
- A function generator.
- A protoboard where the circuits are mounted showing the way to optimize the devices placement and interconnections.
- Red circles signaling test points. Clicking on them the oscilloscope shows the waveform at the selected point.
- The resistor color code, and an ohmmeter.
- An area where possible circuit failures are indicated.

5 Assessment of the System

The system has been tested with 12 students with basic knowledge of circuits theory and electronic devices fundamentals. The test has been done as follows: two groups were done, 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 being used during several years, those of group B used the basic simulator and 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 each one while the three subgroups constituting group B did it almost equal. Students of Group A spent 4.10, 5.30 and 6.35 minutes to find the fail (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% less than A group).

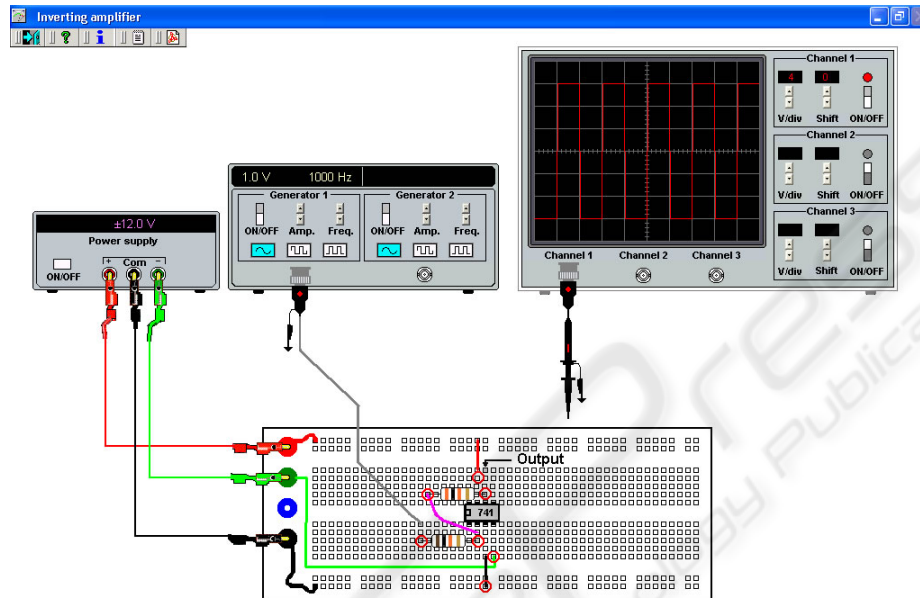


Fig. 8. Workbench area of the virtual laboratory

6 Conclusions

This article describes an analog electronics basic simulator and a virtual laboratory based on hypermedia resources. Using this system as a bridge between theoretical lessons and laboratory classes, students improve their performance and increase their efficiency in the laboratory. The system is modular supporting the addition of new exercises.

The combination of the basic simulator and the virtual laboratory constitutes a self-checking system providing students with a tool for testing their level of knowledge.

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