

An Introductory Electrical Engineering Lesson on Operational Amplifiers.

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Abstract

This paper describes an introductory multimedia lesson on operational amplifiers developed using the ToolBook® authoring system. The lesson is designed to introduce students to operational amplifiers, their characteristics and several common circuits using operational amplifiers. The lesson is intended to be both theoretical and practical.

Introduction

Operational amplifiers are important electrical circuits. They are used in signal processing, control, and instrumentation circuits. Of all analog integrated devices, the operational amplifier is the most widely used electrical component in a vast variety of electronic circuits. Most electrical engineers will probably encounter more operational amplifiers than any other integrated device. We have developed this lesson to introduce first year electrical engineering students to operational amplifiers and their applications.

Electronic lessons become an effective learning tool for the beginning student when the following features included.

- A. The lessons are designed to take the student through the four stages of the Kolb learning cycle: 1) what topics will be learned, 2) why are the topics useful, 3) how can the topics be applied, and 4) asking students “What if?” questions^{1,2}.
- B. The lessons incorporate visual and animated material that show how to construct circuits. Also, the lessons include sound clips demonstrating the effects of clipping at the power supply limits.
- C. The lessons are interactive and evaluate student responses. The requested responses are varied and include numerical responses and checklists of possible answers.
- D. The lessons can be run individually and repeated by the student at any time.



Advantages of the Electronic Lessons

Electronic lessons can lead to a different style of student-instructor interaction. Although it would appear that the instructor is insulated from the students, the opposite occurs. The electronic lesson provides a structure with guidelines and definite goals for student progress. The lessons contain enough information and instruction for most students to proceed without much faculty assistance. The instructor can now focus on students who are having problems so that a greater number of the students will complete and understand the material presented.

Lesson Content

The lesson contains seven sections. The title page has hyperlinked hotwords that allow the student to navigate to the start of each section. The section titles are :

- 1. What does an operational amplifier look like, where are they found, and why do you want to learn about them ?*
- 2. Some details of a typical operational amplifier.*
- 3. The Inverting Amplifier - Analyzing A Simple Operational Amplifier Circuit.*
- 4. Connecting and Testing the Inverting Amplifier*
- 5. Some Practical Considerations*
- 6. Some Operational Amplifier Problems.*
- 7. Some Inverting Amplifier Problems*

Sample of a Lesson Section

Section 4 of the lesson guides the student through building and testing an inverting amplifier circuit. The lesson proceeds by showing the student sequentially presented photos of the circuit board and components in various stages of construction.

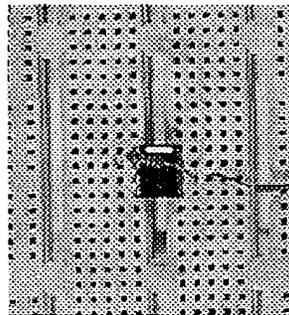


Figure 1
A Partial Circuit

One photo in the middle of the construction process is shown in Figure 1. At this point the student needs to insert a resistor at the inverting terminal of the operational amplifier, and after the insertion, the circuit looks like Figure 2.

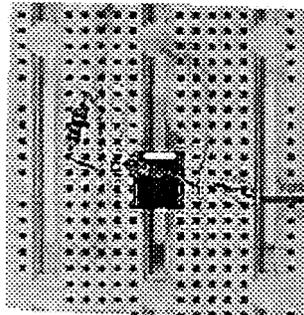


Figure 2
The Next Stage

An animation that shows a sequence of steps to build the circuit is included in Section 4 as well. Figure 3 shows a snapshot of the completed animation.

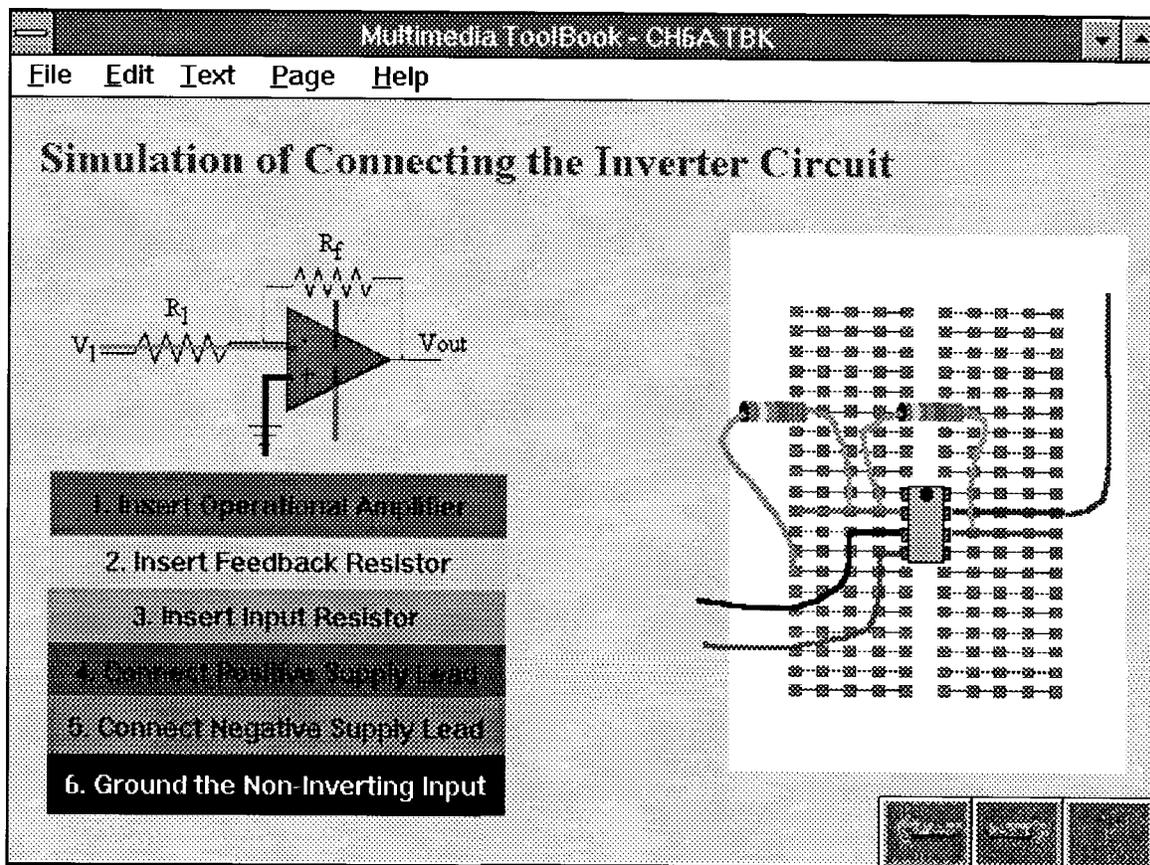


Figure 3
The Simulation Page

After building the circuit, the student is shown how to check the circuit to ensure that it works. The steps include checking the wiring, applying power to the circuit, and measuring voltages at various points in the circuit.

Hardware and Software Requirements

This lesson requires a WindowsTM based system with some multimedia capability. In particular, the electronic lesson requires video memory to display 16 bit colors, although it will run on systems that support only 8 bit color. The video memory is needed to display the photos quickly to keep a high level of student interest.

The lesson files are 3MB and the runtime version of ToolBook requires approximately 3MB of hard disk space.

For reasonable speed in playing the animations, a 486/50MHz system or better is desirable. The lesson uses standard Windows audio files (.WAV format), still image files (.BMP format) and digital video files (.AVI format). Playing any of these multimedia clips requires appropriate drivers and hardware. Sound is used to enhance the lesson, but a Soundlink+TM system which uses the built-in speaker, is adequate.

The lesson also contains embedded objects that are linked to other application programs. For example, a plot of output versus input showing saturation in an inverting amplifier is generated in MathCADTM and links are retained to the application program which generated the plot. If the user's computer has the generating application program in the appropriate directory, then the student can examine the computations that generated the plot.

Summary

We have described an electronic lesson on operational amplifiers used in introductory courses for first year electrical engineering students and for an instrumentation course for mechanical and chemical engineering students. The lesson is evolving and changes in response to student and faculty feedback. In particular, students have commented favorably about the animation and visual aspects of the lessons.

References

1. John N. Harb, S. Olani Durrant, Ronald E. Terry, "Use of the Kolb Learning Cycle and the 4MAT System in Engineering Education", Journal of Engineering Education, American Society for Engineering Education, Vol. 82, No. 2, April 1993, pp. 70-77.
2. E. J. Mastascusa, Maurice F. Aburdene, "Interactive Lessons for Instrumentation and Control" forthcoming in "Proceedings - ASCE Specialty Conference on Robotics for Challenging Environments".



Biography

E. J. MASTASCUSA Professor of Electrical Engineering at Bucknell University, also taught at the University of Wyoming. His interests include development of an interdisciplinary computer-assisted controls laboratory, modeling and simulation in control systems, and development of electronic modules for introductory EE material.

MAURICE F. ABURDENE, is the T. Jefferson Miers Professor of Electrical Engineering and Professor of Computer Science at Bucknell University. He was a project engineer and project manager at the Bristol Company, a visiting research scientist at MIT's Laboratory for Information and Decision Systems, and held various summer fellowships with NASA and the Naval Research Laboratory.

SIA YIU, born in Taipei, Taiwan in 1975. Sia received his high school education in Switzerland from 1990 to 1993. He now attends Bucknell University as a junior majoring in Electrical Engineering, and is expected to receive his Bachelor's degree in May of 1997.

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Acknowledgments

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