MULTIMEDIA TEACHING TOOLS FOR AN INTRODUCTORY CIRCUIT ANALYSIS COURSE

Jean-Pierre R.Bayard and Steven de Haas
Electrical & Electronic Engineering Department
California State University, Sacramento
6000 J Street
Sacramento, CA 95819-6019

Abstract

This paper discusses the use of computer technology as a tool for increasing access to and quality of our electrical engineering program at the California State University, Sacramento. Using readily available software andinternet access, a comprehensive set of lecture materials, student exercises and basic laboratory demonstrations are produced in electronic format in order to promote learning, reinforcement and consistency. While the central focus of this work is on learning, the convenience aspect of this method of delivery has proven to be effective tool for increasing performance as well as enrollment.

Introduction

Multimedia teaching tools are a valuable resource for improving the quality of education. Providing these for an introductory circuits course is particularly important given the growing need for a very skillful workforce in the technical areas. In order to be competitive in this world market, technical personnel with four-year degrees or less will need to have broader knowledge base of computers and a better understanding of the fundamentals of electrical engineering. There are two emphases at the industry level: 1) A focus on new technologies at the technician level, i.e., better manufacturing / assembly technologies - All too often ideas and prototypes developed by research scientists in the United States are better produced by engineers and technicians abroad. 2) A stronger collaboration between research scientists and technicians in the development of new technologies. This implies a higher degree of understanding of fundamental concepts on the part of technicians. Also involving all segments of technical personnel at the earliest stages of development gives everyone the necessary time to come up with innovative ways of connecting theory to a customer-oriented product.

To best serve this changing economy, educational institutions need to develop curriculum materials with a focus on technicians and four-year degree candidates, while promoting strong analytical and technical content. The materials should provide the means to be virtually self-taught with easy access through multimedia technology such as CD ROM and the internet. To that goal a comprehensive electronic version of a basic circuit analysis course is proposed. The material covers a one-semester, lower-division course typically taught at community colleges or as a sophomore-level course at four-year institutions. This paper will include examples of concepts as well as circuit problem solutions. Ongoing work to add voice content, laboratory demonstrations, andinternet access/upgrade will be discussed.

Rationale

In order to appreciate the need for educational materials in such format, the state and mechanics of our electrical and electronic engineering (E&EE) program at the California State University, Sacramento (CSUS) is considered. CSUS is a comprehensive university with programs at the bachelor and masters levels. The university and more specifically the E&EE program receive the majority of their incoming students from the California community college system. More than 70% of E&EE students entering CSUS have completed their lower divisioncoursework elsewhere including the introductory course on circuit analysis. Yet it is widely accepted by faculty here and at other institutions that the basic course on circuits is the most important course in an electrical engineering curriculum. The basic circuit course provides the fundamentals from which all concentrations emerge. The lack of full-time instructors at some community colleges leads unfortunately to inconsistent preparation in the area of circuits. It is not uncommon for an engineering student to receive an A score at these colleges, yet not be able to develop a mesh or nodal procedure for a circuit with a dependent current

or voltage source. One should point out that this inconsistency is not unique to community colleges given that it can also be found at four-year colleges and universities including our own. Quality learning through consistency and an avenue for remediation when necessary are some of the challenges addressed by this work.

Electronic Materials and Method of Delivery

Using MicrosoftPowerpoint, a set of computer notes comprising of an introduction and six "chapters" are developed in the form of slides. The lecture portion of the notes are complemented by student exercises and basic laboratory demonstrations. The package covers every detail of a typical classroom instruction. Unlike most textbooks, these notes are tutorial in nature, modeled as closely as possible after classroom discussion. Learners remain active and involved.

In developing the material the following objectives are met:

- *Reinforcement, tailored to learners*: The notes provide a means for reinforcing difficult engineering concepts presented in the classroom. Students are able to review the notes whenever they choose, as often as needed, and at a pace suitable to their learning styles.
- *Leaner focus*: Because the notes are produced and distributed in hard copy, as well as available through the worldwide web, students can focus their undivided attention on understanding and learning the material instead of on the tedious, conventional note-taking process. At CSUS, the course is also offered through cable television, and videotapes of the lectures are placed on reserve in the library. With both the videotaped lectures and the notes accessible, students are strongly encouraged to engage in discussion among themselves and with the instructor in person, through the phone, or via electronic mail. Doing so, class participation in the virtual sense is greatly enhanced, an important feature of this approach given than the majority of our students work twenty or more hours per week.
- *Flexible, current teaching material*: Faculty use the material via an overhead projection system saving the time and effort of inscribing notes on a blackboard; moreover, they can access any segment of material at the push of a button. Faculty can easily update and add to the diskette format.
- *Lifelong learning*: Ongoing work includes adding optional voice content to selected portions of the material. In particular the sections on sinusoidal analysis can be a valuable training tool for technicians in the field. With this material, they can have access to lifelong learning and career advancement opportunities in industry, even when unaffiliated with an academic institution.

The lecture notes are in the form of 700 slides stored in several Powepoint files. The table below lists the names of the files and gives a brief description of the subject matter:

File Names	*Description*
Intro.ppt	Introduction and outline
Chap1.ppt	Electrical concepts and sources
Chap2.ppt	Resistors, Ohm's law, KCL and KVL
Chap3a.ppt	Nodal analysis for circuits with no voltage sources
Chap3b.ppt	Nodal analysis for general circuits - Mesh analysis for circuits with no current sources
Chap3c.ppt	Mesh analysis for general circuits - Choosing between mesh and nodal
Chap3d.ppt	Linearity - Superposition
Chap3e.ppt	Practical Sources - Maximum power transfer
Chap3f.ppt	Thevenin's & Norton's circuits
Chap3g.ppt	Operational amplifiers
Chap4.ppt	Voltage-current relation for L and C
Chap5a.ppt	RC and RL circuit with no sources
Chap5b.ppt	Step responses of RC and RL circuits
Chap5c.ppt	RLC circuits
Chap6a.ppt	Introducing phasors
Chap6b.ppt	Nodal, mesh, Thevenin and Norton's circuits using phasors
Chap6c.ppt	Sinusoidal power

Figure 1 shows an example of lecture material introducing the voltage-current relationship for a capacitor. With this technology, concepts can easily be illustrated using drawings or digitized pictures of circuits and elements.

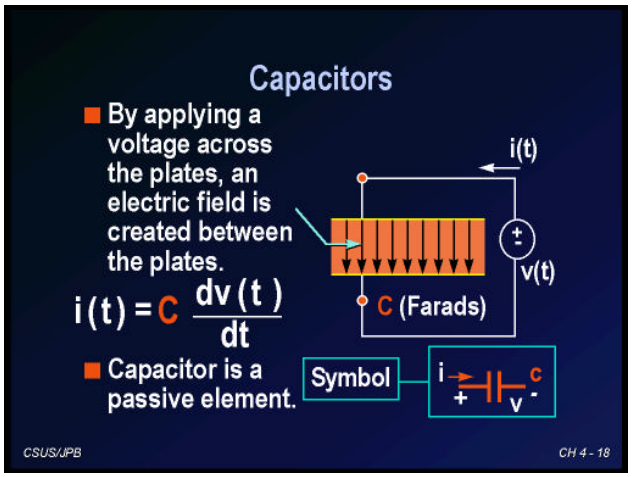

Figure 1. Example of lecture notes.

A series of exercises covering every segment of material listed in the above table are developed to supplement the lecture slides. In a classroom environment, it is paramount that students be actively involved in the learning process, not just idly watching a slide show. After working through examples in the lecture slides that demonstrate the concepts, an instructor can allow ten to fifteen minutes for students to outline the solutions to a particular problem; instructors at CSUS use that time to provide one-on-one help to students, particularly those who might be too intimidated to ask questions in public settings. Institutions with larger class sizes may find this an opportune time for teaching assistants to provide that personal attention. At the end of the allotted time, the instructor goes over the solution emphasizing the areas of difficulty. Figure 2 shows a segment of a mesh analysis exercise including the formation of a supermesh.

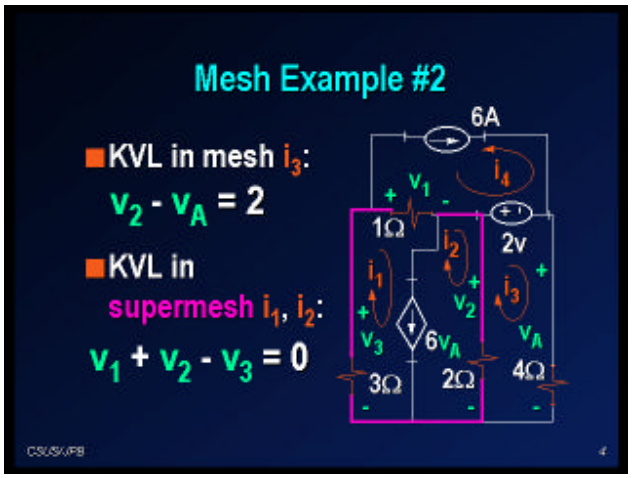

Figure 2. Example of student exercises

The exercises also contain some limited animation that stimulates class participation as will be demonstrated.

The laboratory demonstrations are not intended to be a substitute for real laboratory time and experience. We hope that they will however provide lower division students some familiarity with basic electrical measurements and devices. Figure 3, shows a basic setup for measuring current through and voltage across resistors in a divider circuit.

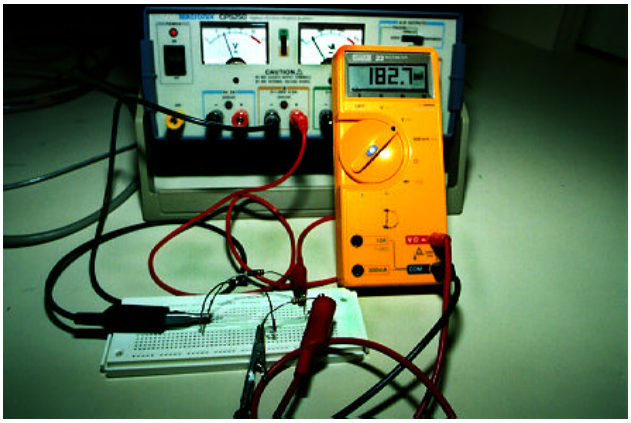

Figure 3. Experimental setup

In Figure 4, a close-up is shown for the measurement of voltage across a resistor. Students will be reminded by voice or in writing that in a real circuit, nodes do not appear as "dots", but simply as a region of the circuit with a constant potential. Practical notions such as voltage ranges in sources and meters are discussed.

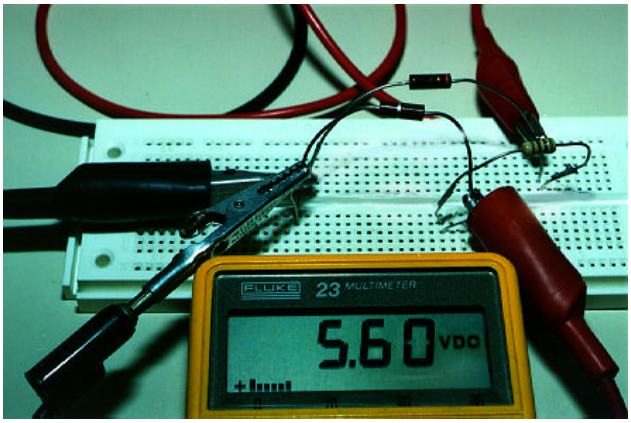

Figure 4. Voltage measurement

Benefits/Population Served

While the notes are primarily intended for use in engineering programs at colleges and universities throughout the U.S., their format and content make them

ideal for lifelong learning opportunities for technicians in industries where an understanding of circuit design and applications are important. In particular, the portions of the notes (sinusoidal analysis) which do not involve applications of differential equations can be taught to technicians with no formal calculus or differential equation training.

The electronic materials offer several advantages over both videotaped coursework or educational programs offered on cable television:

- The diskette format permits updating/adding content by faculty users.
- Students viewing the slides on the internet, on diskettes or via CDROMs have complete autonomy over both speed and frequency.
- At the click of a button, students can review material, promoting new insights, deeper understanding and reinforcement of material learned earlier.
- The laboratory demonstrations will serve to connect concepts to practice, particularly for nontraditional students, i.e., technicians not enrolled in an engineering program.
- CSUS and transfer students with poor electrical engineering foundation can access the materials at any time, and strengthen their knowledge of circuits without having to retake the course.

Link:

- Set of computer notes comprising of an introduction and six "chapters"

Acknowledgment

We wish to thank Jerry Olup and Svetlana Tikhomirov for reviewing the notes. Thanks also to the CSUS media services for their work on the CD ROM.