Sophomore Circuits Course Sequence Revision
An Integrated Laboratory/Lecture Approach

James A. Reising
University of Evansville

Abstract

This paper describes a major revision of the sophomore circuits sequence in electrical engineering at the University of Evansville. The revision was made in an effort to improve student learning. The former sequence of courses consisted of two three-hour lecture courses (EE 251 and EE 253) and two independent one-hour lab courses (EE 280 and EE 281). These courses were required of all engineering majors and were normally taken in the sophomore year. They served as the foundation courses for all of the upper-level electrical engineering courses. The former four courses for eight credit hours have been revised into just two courses (EE 210 and EE 211) for seven credit hours. The new courses feature an integrated lecture/lab format. EE 210 was first offered in the fall semester of 1998, and EE 211 was first offered in the spring semester of 1999. EE 210 was repeated in the spring semester of 1999. Both courses will be offered in the 1999-2000 academic year.

The first-year results indicate that the project was successful. The primary strategy involved combining a lecture course and its associated laboratory into an integrated lab/lecture session. Attitudinal surveys given to both students and faculty involved in the new courses indicated that both groups viewed this new strategy positively.

Combining lecture with short laboratory exercises reinforcing the lecture material is apparently the most effective aspect of the new courses. (The courses replaced by the new courses not only had separate lecture and laboratory sessions, but the lecture and lab were usually taught by different individuals and did not necessarily cover the same topic in the same week.) The new courses will be used as the sophomore circuits sequence in the 1999-2000 academic year. Current departmental plans are to retain the new courses as the standard sophomore circuits sequence replacing the former sophomore circuits sequence, so they will be offered regularly.

I. Introduction

The sophomore circuits course at the University of Evansville had been conducted in essentially the same format for a number of years. The course sequence was spread over the two semesters of the sophomore year and consisted of a lecture course and a laboratory section. The distribution of material between the two semesters had varied slightly through the years, although the lecture and the laboratory were separate courses. Faculty other than the faculty responsible for the lecture courses often conducted the laboratory sections, and the different laboratory sections were not always synchronized with the lecture or with each other. Many faculty members expressed the opinion that the students in the upper division courses did not all exhibit the knowledge of basic circuit theory that they expected. At the same time, an increased emphasis on team projects and collaborative learning was developing. Taken together, these factors indicated that a major revision in the sophomore circuits sequence was needed.

II. The Courses Prior to the Revision

The circuits sequence consisted of two three credit-hour lecture courses, EE 251 and EE 253, taken in the first and second semesters of the sophomore year, respectively, and two one credit-hour laboratory courses, EE 280 and EE 281. The lecture courses met for three fifty-minute sessions per week, and the laboratory sections met for one three-hour session per week. EE 280 was usually taken concurrently with EE 251, and EE 281 was usually taken concurrently with EE 253. The text for the lecture courses was the current edition of *Electric Circuits* by James W. Nilsson and Susan A. Riedel (Addison-Wesley, 1996), supplemented by lecture notes covering diodes and transistors, at least in most cases. The laboratory sections used experiment outlines provided by the instructor, and many instructors used laboratory manuals produced by the author. The laboratory course consisted of laboratory experiments performed by groups of two students. The experiments were chosen to illustrate essential topics in the lecture, although the laboratory experiments often covered topics different from the lecture topic in the same week. Students were typically asked to construct a circuit, make experimental measurements on the circuit, and compare the measured results to theory.

III. The Revised Courses

The philosophy behind the course revision was to include, ideally, a short laboratory exercise in each class period, with the laboratory material either introducing or reinforcing the material covered in the lecture. In addition, teams of four students were to work on a small number of out-of-class projects. Each project was to include some element of engineering design. In addition, two software packages were to be used in the course. MATLAB version 5, student edition (MathWorks, Inc.) was introduced as a computational tool, and MicroCapV (Spectrum Software, free demo version) was introduced as a circuit simulator.

The First Semester

There were two sections of EE 210 (the first semester course). One met twice per week with two hours, fifteen minutes per session, while the other met three times per week with one and one half hours per session. Consequently, the laboratory exercises were somewhat different for the two sections, although the same material and the same sections of the textbook were covered by both.
The author’s section was the one meeting three times per week. There were 20 laboratory experiments, three computer tools introductory exercises (one for MicroCap V and two for MATLAB), and three projects developed for the course. The first nine chapters of the text plus lecture notes on the basic operation of diodes and transistors were covered in lecture and in eleven homework assignments.

The laboratory experiments typically involved constructing a circuit similar to the circuit discussed in lecture, measuring the relevant circuit parameters, and comparing the results to either or both of the predictions of a theoretical calculation and a simulation of the circuit with the circuit simulator.

The first team project was assigned near the start of the term and will be used as an example. At that time the students had studied little more than basic definitions and Ohm's Law in the text, so a simple design project was used. The text did use a simple flashlight circuit as an example, so the first team project involved a design exercise involving the flashlight model.

Each group was given a flashlight and asked to measure the voltage of each battery separately, the voltage of the batteries in series, and the resistance of various parts of the battery circuit. Using their measurements, each group was to develop a preliminary circuit model for the flashlight and calculate the power dissipated in the bulb.

A table of manufacturer's data for 1.5 V alkaline batteries listing weight, capacity (hrs. to 0.9V/cell with 100Ω load), and rated current drain was given to each group, which was to design a flashlight that would provide at least 75% of the power dissipation in the bulb as the original flashlight using lighter weight batteries while having at least half the expected battery life of alkaline D cells. The number and connection (series, parallel, or series-parallel) of the batteries was left to the design team. Each team was asked to state clearly the assumptions made in arriving at their design.

The Second Semester

Each of two sections of EE 211 (the second semester course) met three times per week for two hours per session. There were twenty-two laboratory exercises and two group projects developed for EE 211. Chapter 9 in the text was reviewed and the remaining chapters through chapter eighteen were covered in lecture and in eleven homework assignments consisting primarily of end-of-chapter problems from the text. Some of the laboratory exercises required the students to construct their own circuit element.

The following experiment description is an example:

EE 211 Lab Exercise 7
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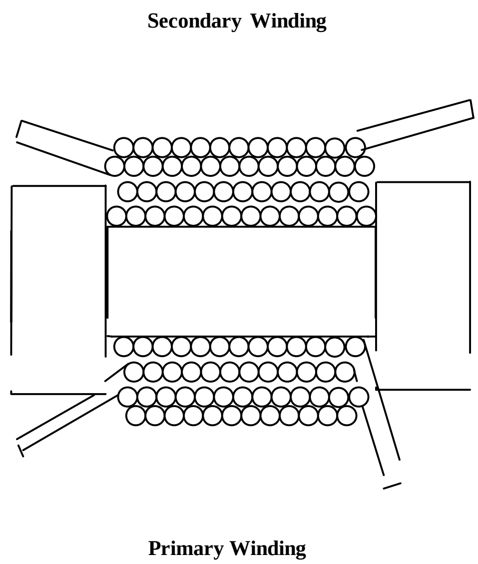
The sketch below shows a cross-sectional view of a simple transformer. In this lab you will construct a simple transformer from: 1) a two inch length of 1/2 inch plastic pipe; 2) two 1/2 inch plastic pipe unions for the ends; 3) 45 ft. of #28 AWG magnet wire; 4) 15 ft. of #28 AWG magnet wire; 5) a two inch length of steel rod. Superglue and sandpaper will be used in the construction process.

First, use superglue to glue the unions onto the ends of the plastic pipe. This will provide a form on which the coils can be wound. Use the 15-ft. length of wire for the primary winding. Try to wrap the windings as uniformly as possible. Use superglue to secure the windings. Then use the

45-ft. length of wire to wrap the secondary. Again, use superglue to secure the windings. Be sure to note the direction in which the windings are wrapped so you can determine the dot convention for your transformer.

Use sandpaper to remove the coating from the ends of the primary and secondary coils.



When your transformer is complete, do the following experiments:

1. Empirically determine the dot convention for your transformer. You can do this by connecting one coil to a DC power supply through a 1K resistor and noting the polarity of the pulse produced on the opposite winding. Verify that the dot convention you determine in this manner is the same as you thought it should be when you wound the core.

2. Observe the gain of your transformer over a wide frequency range. Use the signal generator for driving the primary, and use the oscilloscope to observe the voltage on the secondary and the primary. Explain why the gain of the transformer varies with frequency.

3. With the frequency set at about 5 to 10 KHz, observe what happens to the transformer gain when the steel rod is inserted into the pipe core. Explain your results.

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IV. Evaluation and Conclusion

Since the major reason for revising the course sequence was to improve student learning, students were asked to answer a series of questions in an attitudinal survey near the end of each semester. The students taking the new course EE 210 had a positive attitude toward the course as a group. Students taking the second of the two courses, EE 211, indicated a positive attitude on the attitudinal survey, although for the most part, their answers were slightly less positive than those given in response to the survey for the first course, even most of the students took both courses. There was a uniformly positive response to the question asking if the hands-on experience was more beneficial than a traditional course. A number of respondents indicated that the pace of the course and the amount of material covered made the course more challenging than other courses at the 200 level. This is a matter, which should be addressed, in future offerings of the course.

The project was successful. The primary strategy involved combining a lecture course and its associated laboratory into an integrated lab/lecture session. The attitudinal surveys given in the new courses indicated that students in the course positively viewed this strategy.

Combining lecture with short laboratory exercises reinforcing the lecture material is apparently the most effective aspect of the new courses.

A summary of the results of the attitudinal surveys given appears below:

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Sophomore Circuits Survey Summary EE 210
36 respondents

Answer each question by circling one of the numbers 1 – 5 where

1 = strongly agree, 2 = agree, 3 = neutral, 4 = disagree, and 5 = strongly disagree

1. Overall I like the idea of having the lecture and lab in the same course. 1 2 3 4 5

All respondents Avg 2.2 Std Dev 1.4

2. I feel that the projects aided my understanding difficult concepts. 1 2 3 4 5

All respondents Avg 2.3 Std Dev 1.1

3. I enjoyed working with others on projects. 1 2 3 4 5

All respondents Avg 1.8 Std Dev 0.9

4. I learned more by working in teams on projects. 1 2 3 4 5

All respondents Avg 2.3 Std Dev 1.2

5. Working on small projects frequently with short lectures helped me learn. 1 2 3 4 5

All respondents Avg 2.1 Std Dev 0.9

6. Having a separate laboratory course would be a better arrangement. 1 2 3 4 5

All respondents Avg 3.7 Std Dev 1.3

7. Use of the computer to aid in design and problem solving helped me learn. 1 2 3 4 5

All respondents Avg 2.6 Std Dev 1.1

8. The hands-on experience in the course was more beneficial than a traditional lecture. 1 2 3 4 5

All respondents: Avg 2.0 Std Dev 1.0

9. At what stage (frosh, soph, junior or senior) do you feel you would most benefit from hands-on experience in your respective field?

Circle one answer:	freshman	sophomore	junior	senior
All respondents:	9	16	8	2

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Sophomore Circuits Survey Summary EE 211
25 respondents

Answer each question by circling one of the numbers 1 – 5 where

1 = strongly agree, 2 = agree, 3 = neutral, 4 = disagree, and 5 = strongly disagree

1. Overall I like the idea of having the lecture and lab in the same course. 1 2 3 4 5

Average 2.8 Std. Dev. 1.3

2. I feel that the projects aided my understanding difficult concepts. 1 2 3 4 5

Average 2.7 Std. Dev. 1.0

3. I enjoyed working with others on projects. 1 2 3 4 5

Average 2.2 Std. Dev. 1.0

4. I learned more by working in teams on projects. 1 2 3 4 5

Average 2.4 Std. Dev. 1.1

5. Working on small projects frequently with short lectures helped me learn. 1 2 3 4 5

Average 2.6 Std. Dev. 0.9

6. Having a separate laboratory course would be a better arrangement. 1 2 3 4 5

Average 3.0 Std. Dev. 1.5

7. Use of the computer to aid in design and problem solving helped me learn. 1 2 3 4 5

Average 2.2 Std. Dev. 0.9

8. The hands-on experience in the course was more beneficial than a traditional lecture. 1 2 3 4 5

Average 2.0 Std. Dev. 1.0

9. At what stage (frosh, soph, junior or senior) do you feel you would most benefit from hands-on experience in your respective field?

Circle one answer:	freshman	sophomore	junior	senior
No. of responses	7	10	6	2

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Other questions appearing on each survey were:

List at least one thing you think is good about the course.

List at least one thing you think could be improved about the course.

Comments:

As might be expected, answers to these questions varied considerably.

V. Acknowledgement

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JAMES A. REISING
James Reising is an Associate Professor of Electrical Engineering at the University of Evansville. Professor Reising is a registered Professional Engineer in Indiana. Prior to coming to the university, he was employed by Eagle-Picher Industries at the Miami Research Laboratories and at the Electro-Optic Materials Department, Specialty Materials Division.