

REPORT
2006 IPFW SUMMER INSTRUCTIONAL DEVELOPMENT GRANT

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INTRODUCTION

I received an IPFW Summer Instructional Development Grant to transform the sequence of three foundational ECET courses which I am responsible for as course coordinator by adopting wireless communication as a common theme linking the three courses. I proposed to do this by incorporating one major project in each of the three courses. In the first course, each student builds a simple but very effective software-defined radio (SDR), capable of receiving Amateur Radio transmissions from any point in the world. In each of the two subsequent courses, each student will build modules which add capability to the SDR. At the end of the course sequence, each student will have three modules which will comprise a simple but very effective Amateur Radio transceiver capable of worldwide communication. As each of the courses progresses, the students are introduced to the concepts of electrical and electronic circuit analysis from the viewpoint of the first and most common application of electronics: wireless communication, or radio. It is expected that connecting the inherently abstract concepts of circuit analysis to an everyday application will improve the engagement and motivation of the students. After nearly completing one semester using this approach in the first of the three courses, the effort appears to be successful.

Objectives

The goal of this work is to transform a sequence of three courses: ECET 107 (cross-listed with CPET 101), ECET 157, and ECET 207. The transformation was broken down into the following objectives:

1. Identify three projects, one project to be built and tested in each of the three courses, and develop them into projects which can be successfully built by first-year and second-year students.
2. Develop instructional materials to integrate each of the projects into the course in which it would be built. These included lecture notes, laboratory exercises, and homework assignments.
3. To develop assessment methods for the transformed courses, primarily through the use of electronic student portfolios.
4. To publish at least one conference paper and one journal article as a result of this work..

All of these objectives have been accomplished to a degree. The overall objective is to transform a sequence of three courses, so the work will not be complete until each of them has been taught at least once using the new techniques.

Accomplishments

Project development: The three projects were identified during the spring semester. They are:

1. The basic software-defined radio receiver, to be built in ECET 107.
2. A “daughterboard”, or add-on module for the SDR which will include a bank of bandpass filters and a direct digital synthesizer (DDS) to replace the single filter and crystal oscillator included in the basic SDR. This will extend the SDR frequency coverage from a portion of the 20-meter Amateur Radio band to the entire shortwave spectrum. This will be built in ECET 157.
3. An add-on transmitter module, to be built in ECET 207. With the first two projects, this will comprise a fully functional shortwave transceiver, suitable for use in an Amateur Radio station.

During the summer a prototype of the first project was built, the basic SDR, was built and tested. Several minor design flaws were discovered and corrected. The design for the printed circuit boards (PCBs) on which the project is built, was finalized, and PCBs were ordered. Most of the cost of these was donated by the manufacturer, PCB Express.

At the beginning of the semester each student was supplied with a PCB and a kit of parts for the project. They were also given detailed assembly instructions and a great deal of guidance from the instructor and the teaching assistant, and the students did an outstanding job. Most practicing engineers fear the thought of assembling a surface-mount PCB by hand. Many of the parts are only .08 inch by .05 inch in size, and must be handled with jeweler’s tweezers (in full-scale production they are handled by “pick-and-place” robots). Furthermore, each part is attached to solder paste which the students applied by hand using a syringe with a 22-gauge square needle to copper “pads” on the PCB which are as small as .015 inch in width. Some of these pads are only .010 inch apart, but the solder must not “bridge” between pads. Some of this work had to be done under a microscope; a binocular magnifier was sufficient for the rest.

Most of the students have successfully completed their SDRs. Some are nearing completion, or are being debugged. When each student completes his or her project, it is taken to the new IPFW Amateur Radio Club station and connected to an antenna which was recently installed on the roof of the ET building and to a PC for operational testing. Each of the students who has done this has shown visible excitement and satisfaction when he or she hears Morse code from a transmitter hundreds or thousands of miles away coming from a radio he or she built. This seems to be the powerful motivating experience it was intended to be.

Instructional Material Development

Six lab exercises using the SDR were developed during the fall semester. Each of these required the students to make simple measurements of voltage and resistance on portions of the SDR in order to demonstrate principles of series and parallel DC circuits, and to gain experiments using the lab instruments. Each student also performed a series of measurements on the radio before powering it up for the first time in order to detect faults

(e.g., short circuits) which might cause damage. This is a good engineering practice, introduced at least three semesters earlier than it has been in the traditional course sequence. Another series of tests confirmed that the local oscillator and phase-shift network were working correctly before connection to the antenna. An exercise in which each student tested the voltage regulator portion of the radio under load to estimate its Thevenin resistance proved to be impractical because the Thevenin resistance was too low to measure without damaging the regulator. However, this was turned in to an opportunity by adding an exercise in which a simulated regulator was tested in a way that would have destroyed the real regulator. The simulation exercise demonstrated to the students that circuit simulation can be a valuable tool with which to investigate circuit operation under conditions that cannot be imposed on actual hardware.

Most incoming students know absolutely nothing about wireless communications or radio. Some don't realize that a cell phone is a radio transceiver. Therefore, to integrate a radio project into the first course in the sequence it was necessary to give the students a quick introduction to the basics of radio technology. A set of notes, divided into five sections and titled "Introduction to Wireless Communication" was developed during the summer of 2006. These notes were "tested" on a person who, like many students, had no prior knowledge of the subject. Unlike the students, the test subject had no particular interest in radio technology, but kindly volunteered in order to be helpful. After reading all five sections she was still uninterested, but said she understood how radio transmitters and receivers work. The students were assigned to read these notes early in the semester, while they were building their SDR projects.

Instructional materials were also developed to introduce the students to the assembly techniques they needed to successfully complete their projects, including solder paste application and placement of the various parts on the PCB.

Assessment

For assessment, a framework for electronic student portfolios was developed using existing tools: Microsoft Word, Microsoft Excel, and WebCT Vista. The course material was analyzed to identify major topics, of which thirteen were found. Each student was required to submit three "examples of evidence" of learning for each topic. These could include solutions to homework or exam problems, material taken from the student's electronic lab notebook, or they could be short papers written specifically to demonstrate that the student had learned a topic. Each example of evidence was placed in a discrete Word document (one example of evidence per document), which was then placed in the portfolio folder. These were indexed by an Excel spreadsheet file, which was also included in the portfolio folder. The index file contained hyperlinks to each example file, a hyperlink to the student's reflective journal (another Word document, also placed in the portfolio file), and a hyperlink to the student's lab notebook (similar to the reflective journal, but strictly focused on lab activities). Places were also provided in the spreadsheet for the student's self-evaluation of each example of evidence, and for the instructor's evaluations. Each student was given a portfolio folder with a blank reflective journal document, a blank laboratory notebook, and an index file with places for all the required evaluations and hyperlinks. The process of keeping this portfolio is not as

complicated as it appears, but few students haven even thought of keeping a detailed record of their learning activities. Therefore, a set of notes was developed to teach the students in detail exactly how to begin keeping their portfolios.

Publications

This work has resulted in the acceptance of three conference paper abstracts accepted for the American Society for Engineering Education Annual Conference and Exposition: “A Software-Defined Radio Project for First-Year ECET Students”, Teaching Circuit Analysis Using a Theme-Based Approach”, and “Electronic Student Portfolios Made Easy.” An article entitled “A Software-Defined Radio Project for Freshmen” for the journal Computer Applications in Engineering Education is nearing completion, and will be submitted within the next two weeks. Additional papers and article will be written as the work progresses.

Conclusion

To date, most of the effort has focused on ECET 107, the first course in the sequence. However, most of this effort will transfer directly to ECET 157 and ECET 207. Over the next several weeks a prototype of the second project will be built and tested, and instructional materials for ECET 157 will be developed. The project and instructional materials for ECET 207 will be prepared during the coming spring and summer for use in the fall of 2007.

The other ECET faculty are very supportive of this work, and there is every indication that the other instructors who teach these courses will adopt the theme-based, project-oriented approach. .