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A New Course for Freshmen: Introduction to Electrical and Computer Engineering (w/ Lab)

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Abstract

This paper describes a spring semester course, *Introduction to Electrical and Computer Engineering*, for freshmen EE and CpE majors as a sequel to the fall semester course, *Introduction to Engineering.* The primary purpose of the course is to provide students with more focused career guidance and to introduce them to certain fundamental concepts and skills relating to the practice and study of electrical and computer engineering. Particular focus is given in the paper to the laboratory element, which culminates in the students' assembly of their own microcontroller project boards.

Introduction

During their freshman year at Pacific, all engineering majors take ENGR 5, *Introduction to Engineering*. Among the objectives of the course is to "Describe the various branches of engineering (civil, computer, electrical, management, mechanical, biological and engineering physics), and various career paths available to you as an engineer."[1] Recently, a second freshman course was added for those students who have chosen to major in electrical or computer engineering. The new course, ECPE 5, *Introduction to Electrical and Computer Engineering*, seeks to provide additional career guidance for students through a variety of lecture presentations and laboratory experiences. Guest speakers provide presentations designed to enhance students' understanding of career options specific to electrical and computer engineering. In addition, a number of laboratory exercises are incorporated to introduce the students to certain fundamental concepts and skills relating to the practice and study of electrical and computer engineering.

Course Components

Offered as a one-unit course, and scheduled for only one two-hour meeting each week, there was a fairly tight limit to the amount of work that could be demanded of the students, not to mention to the number of things that could be done. Working under the standard semester format of 15 weeks of classes, the class periods had to be divided carefully between guest speakers and lab experiences. Typically, five or six periods the students meet in the laboratory for some hands-on experience, and the remaining nine or ten periods are filled with guest speakers. Homework assignments vary, but may include short research projects to enable the students to learn a little of the history of electrical and computer engineering, the many areas of specialty that are offered as career choices, typical companies and their products, and some of the many standards that they may touch as practicing engineers upon graduation.

During the spring 2003 semester, the titles of the in-class presentations were:

- Engineering Achievements in EE & CpE Fields
- History of the Internet
- Clean, Green and Renewable Energy
- Is a Robot in Your Future?
- A design Case Study
- Automatic Controls and Systems
- Bioengineering is for Everyone
- Network Security
- Microelectromechanical Systems (MEMS)
- Senior Project Presentations

The topics vary from year to year. Several objectives are achieved by the in class sessions, including introducing current Department faculty to the freshmen students and informing them of their areas of specialty; confirming for the students that theory is important to the practice of engineering, and that they must take seriously the math and science preparation of the first two years of any engineering curriculum; encouraging them to be familiar with the history of their chosen career field; and demonstrating the design process through the description of an actual product design experience, usually by an alumni and practicing engineer. The last class meeting, in addition to providing time for course "wrap up," is also given to senior design project oral presentations in order to provide the students with a glimpse of what their academic future holds. For each in-class meeting, the students are required to complete a summary assessment of the presentation. A single sheet assessment form is provided for this purpose, which is collected at the end of the corresponding class period. The sheets are designed to help the students focus their attention on the presentation. The sheets also provide feedback for the speakers, and serve as a record of attendance.

To encourage the students to learn a variety of things relating to both their academics and their career-of-choice, they are asked to do a little out-of-class work for which they submit a summary written on a standard 4x6 card. Source and reference information is required for each card. The topics assigned for the spring 2003 4x6 cards included:

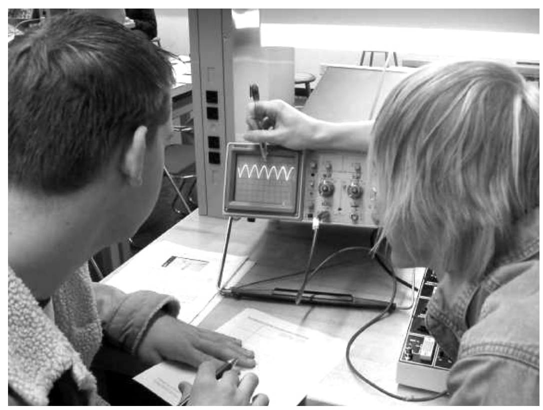
4x6 Card #	Topic
1	History (pre 1900): a person (name, achievement, field, connection to current company and products).
2	History (pre 1984): a product (description, related fields, technology employed, source/company, connection to current products/companies).
3	A present-day product: product name, company (companies) that manufactures it, technologies employed in product and/or its production, related engineering fields.
4	Sustainability: What does it mean? How can it be accomplished? How does/should it affect engineering design and manufacturing?
5	SOECS Instructor: name, areas of specialty, answer to survey question *(a special survey question to ask the instructor),* courses taught, office, signature.
6	Lab instrument: name, source (company that manufactures it), purpose, technology/application supported.
7	Software tool: name, source (company), purpose, technology/application supported.
8	Standard of concern to design engineer in your field: name, purpose, defining agency (e.g., IEEE or EIA), related technology.
9	UOP Co-op student: name, co-op employer, company location, survey questions *(a short list of questions to ask the contact).*
10	Graduate school: name, location, special field of study
11	Professional organization: name, student membership, fields supported.
12	Alumnus/Alumna: name, major, year of graduation, employment, current field of work.
13	Career Field Choice: name, related technologies, reason for interest.
14	Student defines it (must relate to chosen major).

Each student was also required to update his/her student portfolio, which had been begun during the fall *Introduction to Engineering* course. Suggested entries seek to encourage students to reflect on and plan for their personal and professional development.

For the spring 2003 offering of the course, the laboratory experiences were integrated in such a way as to enhance the motivation level of the students toward their chosen majors. Six laboratory exercises were designed centered on the microcontroller, a component that promised high student motivation, while at the same time affording a platform from which a breadth of skills and information could be presented. The following set of laboratory exercises was defined: 1) Power Supply Fundamentals, 2) Schematic Capture and PCB Layout, 3) Circuit Assembly, 4) Microcontroller Project Board, 5) Microcontroller Software, and 6) Embedded System Software Development. As a part of the lab activities, each student assembled a microcontroller experimenter board, which was theirs to keep. At the end of the semester they had sufficient information to enable them to "play" with the board to continue learning.

Among the ideas that motivated the ECPE 5 lab project for spring '03 was to have the students build a BCD LED clock that would be theirs to keep and show off to their roommates. It would be a clock from which they could read the time but their roommates could not. Because the students would keep their "product," one key to the project definition was to keep costs low. A survey of microcontrollers and related software and hardware support options led to the selection of the PIC processor by MicroChip Technology. An alumnus and practicing embedded systems engineer was invited to assist with the project. Discussions began just as the semester started, and the basic clock idea quickly blossomed into a full-fledged PIC microcontroller development board with much more extensive capability than a simple BCD clock.

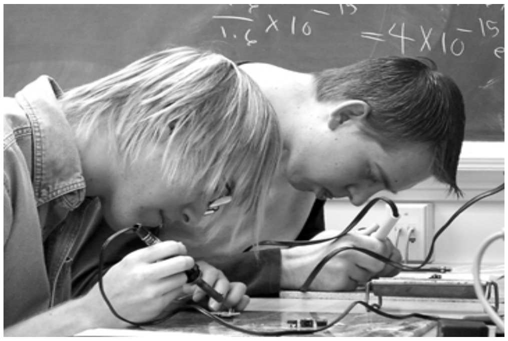
The Lab Project



The first laboratory of the six lab sequence was designed to introduce the students to the basic concepts behind simple power supplies, with the fundamental idea being that the high-voltage AC power obtained at a standard wall outlet must be converted to a DC power source at a voltage level appropriate to power the microcontroller project board. The students encountered a transformer, full wave rectifier and integrated circuit regulator as basic electrical components, and employed an oscilloscope to perform typical laboratory measurements.

During the second lab meeting, the students performed two of the lab exercises: Lab 2, *Schematic Capture and PCB Layout*, and Lab 3, *Circuit Assembly*. Each lab was designed to fit a one-hour time slot. In Lab 2, they used two freeware software packages, ExpressSCH and ExpressPCB,[2] to define a schematic for the power supply that would later be used to power their microcontroller project boards, then lay out a printed circuit board that would be similar to the one they would actually assemble in Lab 3. Keeping in mind the idea of low cost for the project as a whole, these software packages were selected both for their simplicity and short learning curve and because the students could obtain free copies for themselves should they want to play with the software on their own following the lab period.

In Lab 3, the students assembled the 5-volt power supplies that they had "designed" in Lab 2, most of them experiencing the task of soldering for the first time. As a part of this lab, in addition to soldering skills, they learned a little about component packaging (for example, DIP and TO-220), that some components are "polarized," and how to use a digital voltmeter for measuring voltage in testing the final circuit function with load.



Finally, in Lab 4, *Microcontroller Project Board*, the students reached the point where they were introduced to the microcontroller (a PIC 16F877). In this lab, they each assembled (soldered) and tested the ECPE 5 project board.[3] Construction was divided into four steps: 1) CPU unit, 2) serial unit, 3) power supply unit, and 4) I/O unit. Only the first two steps had to be completed to have a working, programmable board. A pre-programmed CPU provided a quick and easy test to confirm proper operation of the board following step 1. In step 2, the students tested the serial interface by reprogramming the chip. On-board LEDs served as outputs for both tests. Almost all students completed the first two steps, others were able to complete step three (which added an onboard power supply), and a few were able to complete the entire four-step process during the lab period. Those who did not complete the board in class were able to do so later that week. It was clear throughout the lab period that all of the students were pleased with the task and with the opportunity to assemble their very own microcontroller boards.

It was not until Lab 5, a few weeks later, that the students were shown how to edit and compile application programs and download the programs to their project boards. Then in Lab 6 the basic I/O devices were explained and the students were given time, working in teams, to invent and test their own applications. No matter what the level of success with this final project, they all seemed quite pleased with themselves and with their personal PIC project boards.

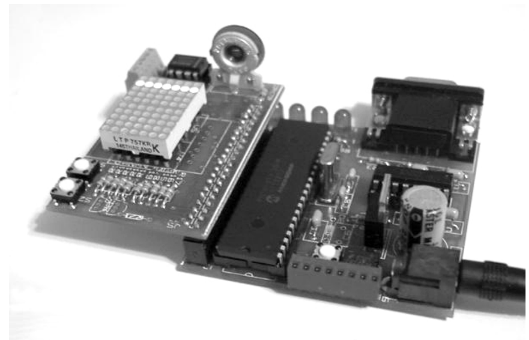
"What about the BCD LED clock?" the students asked. They had not forgotten the announcement at the beginning of the semester months earlier that they would build a BCD LED clock to show their friends. In response, software was provided that implemented the BCD clock using the two SPST switches and a 5x7 matrix LED on the I/O portion of the project board. But, of course, the students had learned by that point that their project boards have many other application possibilities, and their interest in the clock had diminished a bit. Their vision of the world of computers, in particular embedded systems, had been expanded considerably.

The ECPE 5 Project Board … A Summary Description

One key requirement for the ECPE 5 project board was that the full kit, including parts and PC board, should cost $25 or less. The students were informed at the beginning of the semester that they would be expected to pay a lab fee of $25, and in return they would take home their own microcontroller project board. The intention was that the students would have minimal, preferably zero, additional cost to continue the use of their boards following the end of the semester should they choose to study embedded systems programming and applications on their own.

The project board has the following hardware specifications:

- Processor: PIC 16F877-20/P
- Power source: 9 VAC (or DC) transformer, full wave rectifier, LM7805 5 volt regulator
- I/O:
  RS-232C serial
  Four discrete LEDs (active low)
  Two SPST switches (normally open)
  10K Ohm potentiometer (ADC input)
  DS1821 temperature sensor
  (1-Wire interface)
  MAX522 dual DAC
  (SPI interface)
  One 1.2 inch 5x7 matrix LED or
  Two 0.7 inch 5x7 matrix LED (10x7 matrix)
  (time multiplexed display)



- Physical Dimensions: 2.5" x 4.25"
  (The board can be cut into 2.5" x 2.5" CPU board with CPU, RS-232 serial interface, power supply and discrete LEDs, and a separate 2.5" x 1.75" I/O board with matrix LEDs, SPST switches, POT, DAC, temperature sensor. The I/O "daughter" board can be plugged piggyback style onto the CPU board, as shown in the photo to the right.)

Software support for the project came from two sources, both offering free products. Microchip provides Microlab IDE, which incorporates both assembler and simulator for execution on a PC. Assembly language programming was not covered in the course, so little use was made of this package except by the faculty. To enable the students to program the project board with their limited programming background (most had taken an introductory programming course, taught using C++, but some had not), a simple and free high level language compiler was sought. The primary programming language employed for this first implementation of the project was JAL, offered by Wouter Olaf van Ooijen.[4] Although suitable for this freshman project, a C compiler is preferred, and efforts will be made to provide a C compiler for the next offering of the course (Spring 2004). Again, one of the primary considerations was the identification of software to which students would have free (or very inexpensive) access. The hope was to create a system that would encourage them to continue studying on their own.

To enable the students to program their project boards with no additional outlay of funds for special software or programming hardware, the self-programming feature of the PIC 16F877 was utilized, along with Wloader, a free bootloader offered by Wouter van Ooijen.[5] For editing and also to provide support for downloading application code (hex files), we employed Programmer's File Editor, pfe32.[6] Xwisp,[7] another freeware software product offered by van Ooijen, supported the PC-to-PIC communication over the serial link.

Student Response and Future Plans

The students seemed to enjoy and appreciate the microcontroller project a great deal. In a survey administered at the end of the semester, most of the students indicated that this was their favorite part of the course. A typical comment on the surveys was "The PIC project was great." Several expressed interest in continuing discussions of the project board and its applications, and a web link was set up for that purpose. Several students suggested that more time and support should be provided during the semester. Interestingly, numerous seniors, when they learned about the experience the freshmen were having with the PIC project, soldering, etc., expressed frustration that they had missed out on the fun.

Over 2/3's of the students indicated that the course, through the influence of both the lectures and the labs, increased their "level of interest and excitement" regarding today's technologies. However, some expressed concern that their career choices were not as clearly described as they might have been.

Acknowledgements

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References

1. http://www1.uop.edu/eng/courses/engr/engr5/F03_Syllabus_gml.html (freshman engineering course syllabus)
2. http://www.expresspcb.com/ (schematic capture and PCB layout software)
3. http://www.dunmire.org/projects/picProjectBoard/ECPE5_Project_Board.html (information on project board)
4. http://www.voti.nl/jal/n_index.html (JAL)
5. http://www.voti.nl/wloader/n_index.html (WLoader)
6. http://www.geocities.com/thestarman3/tool/pfe/PFE32.htm (PFE32)
7. http://www.voti.nl/xwisp/n_index.html (XWisp)

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