Senior Design Report for ECE 477 – Spring 2004

submitted by

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School of Electrical & Computer Engineering
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Contents

Overview

One of the unique features of ECE 477, *Digital Systems Senior Design Project*, is that each team gets to choose their own specific project (subject to some general constraints) and define specific success criteria germane to that project. In general, this approach to senior design provides students with a sense of project ownership as well as heightened motivation to achieve functionality. All project teams this semester successfully designed and built a printed circuit board, achieved at least basic functionality of their microcontroller-based hardware, and successfully integrated their application software. Some groups, in fact, continued to work on their projects *after* the semester was over ("just for fun"), to add features and/or obtain a higher degree of functionality. In short, students not only devoted a lot of time to this course, but they also learned a lot – in the words of several students, "more than in all their other ECE courses combined." The complete set of Senior Design Reports is included as Appendix A.

Self-Evaluation

The high degree of success achieved by each team was a direct result of the availability of the course staff (Profs. Meyer and Jones) to spend a significant amount of time consulting with each team. Another reason for the high degree of success attained was the incredible effort put forth by our outstanding teaching assistants, John Leimgruber and Gilbert Tseng.

The course staff is quite pleased with the rigorous, quantitative assessment of the course outcomes. There is always room for change, however, and one of our goals has always been to strive for continuous improvement. A problem inherent in all "open-ended" project courses is the tractability of the student-chosen design projects. This semester there was one project in particular that should not have been allowed based on its inherent complexity. The staff needs to be more "forceful" in rejecting project proposals that are too ambitious and in suggesting alternative ideas. (This semester, we posted a descriptive list of "alternate projects" on the course web site, but we were unable to convince students to abandon their "own" ideas.)

Also, the course and instructor evaluation forms used by the senior design courses (in particular, EE 402 and EE 477) need to be revamped. (The forms developed for EPICS were used by "default" until they no longer were made available to us – currently, there is no uniform evaluation mechanism for the senior design courses). I have developed an alternative form compatible with the University's PICES system, and used it on an experimental basis in ECE477 for several semesters. I will once again attempt to present the idea of a "universal senior design evaluation form" to the ECE Senior Design Advisory Committee next fall.

Finally, the ECE Administration is encouraged to remain cognizant of the fact that ECE477 is not a "standard 3-credit hour" load – the amount of evaluation and consultation required is *several times* that of a "normal" course. With 48 students scheduled for Fall 2004, it is important not only to have two faculty involved, but also at least 1.0 FTE T.A. as well (an enrollment of 48 students translates into 12 independent project teams).

Course Policies and Procedures

Course Description: A structured approach to the development and integration of embedded microcontroller hardware and software that provides senior-level students with significant design experience applying microcontrollers to a wide range of embedded systems (e.g., instrumentation, process control, telecommunication, intelligent devices, etc.).

Objective: To provide practical experience developing integrated hardware and software for an embedded microcontroller system in an environment that models one which students will most likely encounter in industry.

Instructors: Prof. D. G. Meyer, meyer@purdue.edu, Office: MSEE 238, Phone: 494-3476; and Prof. Andrew Jones, ajones@purdue.edu, Office: EE 176, Phone: 494-3454.

Course Teaching Assistants: John Leimgruber (leimgrub@purdue.edu) and Gilbert Tseng (gtseng@purdue.edu).

Course web site: http://shay.ecn.purdue.edu/~dsml/ece477

Course E-mail address: ece477@ecn.purdue.edu

Office Hours: Scheduled office hours will be posted on the course web site; other times may be arranged by E-mail appointment. Please make use of the "live" consultation hours available rather than E-mailing "long" or detailed questions specific to your project.

Open Shop Lab: Room EE 069 is the laboratory for this course; students enrolled in ECE 477 will be given a key code that will provide them with 24-hour access. This facility is equipped with expensive, state-of-the-art instrumentation; students are expected to treat the equipment and furnishings with respect. There will be a "zero tolerance" policy for abuse/misuse of this lab: anyone who does so will be unceremoniously dropped from the course, receive a failing grade, and be prohibited from re-registering for the course. Theft will be prosecuted.

Design Project: Of utmost importance in the "real world" is the ability to document and present technical information in a clear, organized, succinct, and well-illustrated fashion. In microprocessor-based designs, the ability to integrate hardware and software is a fundamental skill that should be possessed by all Computer Engineering graduates. The design project, formal written report, and videotaped presentation will give each student in this course the opportunity to develop these skills. Students will work on their design in teams of *four*.

Lab Notebook: Developing good design documentation skills is an important part of this course. A significant part of your grade (10%) will be based on the individual lab notebook you maintain throughout the design and development process.

Weekly Meetings: During a scheduled (10-minute) portion of the weekly lab period for this course (8:00-10:00 AM on Wednesdays), each team will meet with a course staff member to discuss progress on the design project. Each team member will be expected to post a completed weekly progress report on their team's project web site in advance of these meetings.

Group Account and Team Webpage: Each team will be assigned an ECN group account to use as a repository for all their project documentation and for hosting a password-protected team web page. The team web page should contain datasheets for all components utilized, the schematic, board layout, software listings, interim reports, presentation slides, etc. It should also contain the individual lab notebooks for each team member as well as the progress reports (prepared in advance of the weekly progress briefings) for each team member. At the end of the semester, each team must submit a CD-ROM archive of the group account.

Homework: Several "homeworks" will be assigned related to key stages of the design project. Some of the assignments will be completed as a team (1, 3, 12, 14), some will be completed individually (2, 13), and some will be completed by a selected team member (one from the set {5, 6, 7, 10} and one from the set {4, 8, 9, 11}).

1. Preliminary Design Project Proposal
2. OrCAD Exercise
3. Final Design Project Proposal
4. Design Constraint Analysis and Component Selection Rationale/Parts List
5. Packaging Specifications and Design
6. Schematic and Hardware Design Narrative/Theory of Operation
7. Board Layout
8. Patent Liability Analysis
9. Reliability and Safety Analysis
10. Firmware Listing and Software Narrative
11. Social/Political/Environmental Analysis
12. User Manual
13. Confidential Peer Review
14. Senior Design Report/Project Summary

Grade Determination

Your course grade will be based on both team effort (50%) and individual contributions (50%):

TEAM COMPONENTS		INDIVIDUAL COMPONENTS	
Project Proposal {1 and 3}	3%	Significance of Individual Contribution	10%
User Manual {12}	4%	Laboratory Notebook	10%
Senior Design Report {14}	3%	Design Component {5, 6, 7, or 10}	10%
Design Review	10%	Professional Component {4, 8, 9, or 11}	10%
Final Video Presentation	10%	OrCAD Exercise {2}	2%
Final Written Report & Archive CD	10%	Peer Review {DR + 13 + FP}	6%
Project Success Criteria Satisfaction	10%	Weekly Progress Briefings/Attendance	2%

Your **R**aw **W**eighted **P**ercentage (RWP) will be calculated based on the weights, above, and then "curved" (i.e., mean-shifted) with respect to the upper percentile of the class to obtain a **N**ormalized **W**eighted **P**ercentage (NWP). Equal-width cutoffs will then be applied based on the **W**indowed **S**tandard **D**eviation (WSD) of the raw class scores; the minimum **C**utoff **W**idth **F**actor (CWF) used will be 10 (i.e., the nominal cutoffs for A-B-C-D will be 90-80-70-60, respectively). Before final grades are assigned, the course instructor will carefully examine all "borderline" cases (i.e., NWP within 0.5% of cutoff). Once grades are assigned, they are **FINAL** and WILL NOT be changed. Note that **all** course outcomes (listed on page 7 of this document) must be demonstrated in order to receive a passing grade for the course.

Lecture Schedule:

Week 1	Tu – course and project overview, team formation
	Th – project proposal guidelines and documentation requirements
Week 2	Tu – PCB layout basics, OrCAD demo, packaging specifications
	Th – technical writing guidelines, real-world design constraints
Week 3	Tu – microcontroller survey - PIC
	Th – microcontroller survey - Rabbit
Week 4	Tu – microcontroller survey - Atmel
	Th – interfacing: D.C. and A.C. loads, optical isolation
Week 5	Tu – interfacing: keypad encoding, switch de-bouncing, RPGs
	Th – interfacing: PWM applications, position control, steppers, LCDs
Week 6	Tu – power supply design – basic considerations, linear regulators
	Th – power supply design – switching regulators, DC-DC converters
Week 7	Tu – capacitor and resistor selection guidelines
	Th – patent infringement liability
Week 8	Tu – (no class – Design Reviews individually scheduled this week)
	Th – (no class – Design Reviews individually scheduled this week)
Week 9	Tu – design for reliability, maintainability, and safety
	Th – FMECA worksheet
Week 10	Tu – soldering issues and techniques, board construction tips
	Th – embedded software organization and development tools
Week 11	Tu – interactive “broken board” debugging
	Th – interactive “broken board” debugging
Week 12	Tu – social/political/environmental considerations
	Th – user manual, final report, and final presentation guidelines
Week 13	Tu – current embedded system topics
	Th – current embedded system topics
Week 14	Tu – (no class)
	Th – (no class)
Week 15	Tu – (no class – Project Presentations individually scheduled this week)
	Th – (no class – Project Presentations individually scheduled this week)

Design Project Specifications

Work on the design project is to be completed in teams of four students. The design project topic is flexible, and each group is encouraged to pick a product that uses the strengths and interest areas of their group members. The design must have the following components:

- **Microprocessor:** To help make the project tractable, microprocessor choices will be limited to 68HC12, PIC, Rabbit, and Atmel variants. Development tools are readily available in lab to support these devices. Further, the devices themselves are relatively low cost and readily available.
- **Interface to Something:** Your embedded system must interface to some other device or devices. It could be a computer, or it could be some embedded device such as a Palm Pilot, telephone line, TV, etc. Some interface standards that could be used are: serial to a computer, parallel to a computer, Universal Serial Bus (USB), Firewire, Ethernet, Infrared (IR), Radio Frequency (RF), etc. This requirement has a large amount of freedom. To help with some of the more complex interfaces such as Ethernet, USB, or Firewire there are dedicated chips which encapsulate the lowest layers of the interface. This makes using these interfaces easier to handle but not necessarily trivial. Be sure to investigate the interface(s) you wish to utilize and make a reasonable choice. (NOTE: *Interfaces involving A.C. line current require special permission – see the instructor for details.*)
- **Custom printed circuit board:** Through the process of the design, each group will be required to draw a detailed schematic. From the schematic, a two-layer (maximum) printed circuit board will be created. Board etching will be processed by the ECE Department (the first one is "free", but any subsequent iterations are the team's responsibility). The team is then responsible for populating the board (solder the parts on the board), and for completing the final stages of debugging and testing on their custom board.
- **Be of personal interest to at least one team member:** It is very difficult to devote the time and energy required to successfully complete a major design project in which you and/or your team members have no personal interest. There are *lots* of possibilities, ranging from toys and games to "useful and socially redeeming" household items, like audio signal processors and security systems.
- **Be tractable:** You should have a "basic idea" of how to implement your project, and the relative hardware/software complexity involved. For example, you should not design an "internet appliance" if you have no idea how TCP/IP works. Also, plan to use parts that are reasonably priced, have reasonable footprints, and are *readily available*. Be cognizant of the prototyping limitations associated with surface mount components.
- **Be neatly packaged:** The finished project should be packaged in a reasonably neat, physical sound, environmentally safe fashion. Complete specification and CAD layout of the packaging represents one of the project design components.
- **Not involve a significant amount of "physical" construction:** The primary objective of the project is to learn more about *digital system* design, not mechanical engineering! Therefore, most of the design work for this project should involve digital hardware and software.

Project Proposal

Each group should submit a proposal outlining their design project idea. This proposal should not be wordy or lengthy. It should include your design objectives, design/functionality overview, and project success criteria. The five success criteria common to all projects include the following:

- Create a bill of materials and order/sample all parts needed for the design
- Develop a complete, accurate, readable schematic of the design
- Complete a layout and etch a printed circuit board
- Populate and debug the design on a custom printed circuit board
- Package the finished product and demonstrate its functionality

In addition to the success criteria listed above, a set of **five significant** *project-specific* success criteria should be specified. The degree to which these success criteria are achieved will constitute one component of your team's grade.

Forms for the preliminary and final versions of your team's project proposal are available on the course web site. Use these skeleton files to create your own proposal. Note that the proposal should also include assignment of each team member to one of the design components as well as to one of the professional components of the project.

Design Review

Part way through the design process, there will be a formal design review. This is a critical part of the design process. In industry, this phase of the design process can often make or break your project. A good design review is one where a design is actively discussed and engineers present concur with the current or amended design. The design review is in some cases the last chance to catch errors before the design is frozen, boards are etched, and hardware is purchased. *A friend is not someone who rubber-stamps a design, but rather one who actively challenges the design to confirm the design is correct.*

Approach the design review from a top-down, bottom-up perspective. First, present a block diagram of your design and explain the functional units. Then drop to the bottom level and explain your design at a schematic level. Be prepared to justify every piece of the design; a perfectly valid answer, however, is applying the recommended circuit from an application note. If you do use a circuit from an application note, have the documentation on hand and be able to produce it. *Your grade for the design review will not be based on the number of errors identified in your design.* The best engineers make mistakes, and the purpose of the design review is to *catch them* rather than spend *hours of debugging later* to find them. The design review will be graded primarily on how well the group understands their design and the professionalism with which they present it.

To facilitate the design review process, the class will be split into subgroups that will meet at individually scheduled times. Both the presenters and the assigned reviewers will be evaluated.

Milestones

Each group is responsible for setting and adhering to their own schedule; however, there are several important milestones, as listed in the table below. Always "expect the unexpected" and allow for some buffer in your schedule. *Budget your time.*

Week 1	Jan 12 – Jan 16	**Formulate Group and Project Ideas**
Week 2	Jan 19 – Jan 23	**Preliminary Project Proposal Due**
Week 3	Jan 26 – Jan 30	• Research Parts • Create Block Diagram
Week 4	Feb 2 – Feb 6	**Final Project Proposal Due**
Week 5	Feb 9 – Feb 13	• Draw Schematic • Construct Prototype • Begin Software Development • Create Bill of Materials • Begin Ordering/Sampling Parts
Week 6	Feb 16 – Feb 20	**Schematic and Parts List Due**
Week 7	Feb 23 – Feb 27	• Prepare for Design Review
Week 8	Mar 1 – Mar 5	**Design Reviews**
Week 9	Mar 8 – Mar 12	**Board Layout Due**
Week 10	Mar 22 – Mar 26	• Continue Software Development • Populate Circuit Board
Week 11	Mar 29 – Apr 2	
Week 12	Apr 5 – Apr 9	**Firmware Listing Due**
Week 13	Apr 12 – Apr 16	• Debug Hardware on Printed Circuit Board • Hardware/Software Integration and Testing • Write Report and Prepare Presentation
Week 14	Apr 19 – Apr 23	
Week 15	Apr 26 – Apr 30	**Project Demonstrations and Final Presentations**
Week 16	May 3 – May 7	**Archive CD, Peer Review, Final Report, and Senior Design Report due May 5 at 5:00 PM**

Outcome Assessment

In order to successfully fulfill the course requirements and receive a passing grade, each student is expected to demonstrate the following outcomes:

(i) an ability to apply knowledge obtained in earlier coursework and to obtain new knowledge necessary to design and test a microcontroller-based digital system [1, 2, 3, 4, 5; a, b, c, e, i, j, k]
(ii) an understanding of the engineering design process [4, 6, 7; b, c, e, f, h]
(iii) an ability to function on a multidisciplinary team [6, 7; d, h, j]
(iv) an awareness of professional and ethical responsibility [6, 7; f, h, j]
(v) an ability to communicate effectively, in both oral and written form [6; g]

The following instruments will be used to assess the extent to which these outcomes are demonstrated (the forms used to "score" each item are available on the course web site):

Outcome	*Evaluation Instruments Used*
(i)	Design Component Homework
(ii)	Individual Lab Notebooks (two separate evaluations)
(iii)	Success Criteria Satisfaction (general and project-specific)
(iv)	Professional Component Homework
(v)	Formal Design Review, Final Presentation, and Final Report

Students must demonstrate basic competency in ***all*** the course outcomes, listed above, in order to receive a passing grade. Demonstration of Outcome (i) will be based on the satisfaction of the design component homework, for which a minimum score of **60%** will be required to establish basic competency. Demonstration of Outcome (ii) will be based on the individual lab notebook, for which a minimum score (average of two separate evaluations) of **60%** will be required to establish basic competency. Demonstration of Outcome (iii) will be based on satisfaction of the general and project-specific success criteria, for which a minimum score of **80%** will be required to establish basic competency. Demonstration of Outcome (iv) will be based on the professional component homework, for which a minimum score of **60%** will be required to establish basic competency. Demonstration of Outcome (v) will be based on the Design Review, the Final Presentation, and the Final Report. A minimum score of **60%** on the Design Review and a minimum score of **60%** on the Final Report and a minimum score of **60%** on the Final Presentation will be required to establish basic competency.

Since *senior design* is essentially a "mastery" style course, students who fail to satisfy all outcomes but who are otherwise passing (based on their NWP) will be given a grade of "I" (incomplete). The grade of "I" may subsequently be improved upon successful satisfaction of all outcome deficiencies. If outcome deficiencies are not satisfied by the prescribed deadline, the grade of "I" will revert to a grade of "F".

Appendix A:

Senior Design Reports

Purdue ECE Senior Design Semester Report

Course Number and Title	ECE 477 *Digital Systems Senior Design Project*
Semester / Year	Spring 2004
Advisors	Prof. Meyer and Prof. Jones
Team Number	1
Project Title	Chateau De Nemo

Senior Design Students – Team Composition			
Name	**Major**	**Area(s) of Expertise Utilized in Project**	**Expected Graduation Date**
Ali Shareef	ECE	Circuits, Network Programming	5/15/04
Jason Lim	ECE	Embedded Programming	5/15/04
Sin Hoe Lim	ECE	Circuits	5/15/04
Niraj Balwani	ECE	Networking Programming	5/15/04

Project Description: Provide a brief (one or two page) technical description of the design project, as outlined below:

(a) Summary of the project, including customer, purpose, specifications, and a summary of the approach.

We designed an automated aquarium controller to help people who do not have enough time to maintain their aquarium. Our product would be suitable for people who travel a lot and aquariums that are in public places such as shopping malls, offices, and clinics. The aquarium controller must be able to maintain pH levels of water--since change of pH indicates excess waste in the water. It should also be able to monitor and control temperature, feed the fish on user specified schedules, simulate daylight, and allow user to access the system remotely over the internet.
We used a microprocessor that had built-in networking capability. We used sensors to monitor pH and temperature. The pH level was maintained by replacing the water in the tank and we used a heater to heat the water accordingly. Devices that required 120 VAC were connected to an external power module that uses relays to control when these devices are connected to power.

(b) Description of how the project built upon the knowledge and skills acquired in earlier ECE coursework.

The knowledge we gained in EE201 (Circuit Analysis), EE255 (Semiconductor Devices), EE270 (Digital Logic), EE264 (C programming), EE362 (Microprocessors), EE495R (Networking), and EE364 (Script Programming) enabled us to complete this project. These courses helped us to examine datasheets and be able to select components that were compatible with each other.

The material we gained from these courses was used extensively in designing our circuit board, connecting the board to the microprocessor and programming the microprocessor, and integrating the networking features with our design.

(c) Description of what new technical knowledge and skills, if any, were acquired in doing the project.

A new skill that we acquired was the ability to layout a circuit board and the details behind producing a successful PCB, such as selecting footprints, component placing, routing, size of traces, and generating Gerber files for the PCB fabrication. Another skill we acquired was deeper understanding of how the server/client paradigm worked in network communications. Another skill we acquired was the ability to search for and examine patents.

(d) Description of how the engineering design process was incorporated into the project. Reference must be made to the following fundamental steps of the design process: establishment of objectives and criteria, analysis, synthesis, construction, testing, and evaluation.

We selected project success criteria's that we were certain that we could accomplish during the semester. We also selected criteria's that we knew would be necessary to build a truly automated, low-maintenance aquarium controller. We took special considerations when we realized that we need to control peripheral devices such as heaters, lights, and water pumps that required 120 VAC. Since it was not safe for us to have this voltage on the board along with the microprocessor, on of the main decisions that we made was to separate the two. We built the peripheral power module and isolated it from the main controller module. The current design of the peripheral power module also has a 6 Amp fuse on it to protect the device in case of a short circuit. During the construction of the system we took careful measurement of the packaging material to ensure that the end product looked professional. We painted the device a blue color to coordinate it with the water in the aquarium. While testing our system, we were careful to take personal safety considerations. We tested the entire system separately outside of the aquarium until we were sure that the system worked safely. When testing the peripheral power module we used a 9 VAC power supply to check the functionality of the device before plugging it in to the wall. We performed extensive testing of the device to ensure that it worked properly. When evaluating the system, placed the device on an aquarium and connected all the peripheral devices and made sure the design worked as a whole in the intended manner.

(e) Summary of how realistic design constraints were incorporated into the project (consideration of <u>most</u> of the following is required: economic, environmental, ethical, health & safety, social, political, sustainability, and manufacturability constraints).

The economic considerations that we took in the development of this system was to select cheap parts. This will result in our being able to offer our design at a low cost to our consumers. We used Maxim temperature chip, interface our design to a pH meter rather than using more expensive parts that may increase the cost of the system. We also offered an external peripheral power module to connect the heater, water pumps, and lights if the user so desires—further reducing the cost and allowing us to offer the device at a lower cost. Environmental considerations were taken in the design by using non-toxic and bio-degradable components for our system. We used wood rather than plastic. Although we have an LCD and use lead in our PCB we have instructed the user to return the product to the manufacturer for proper disposal. Ethical considerations were taken to protect the user from harm. The peripheral power module contains a 6 Amp fuse. This module is also separate from the main control module which will be placed on the aquarium. This reduces the risk of hazards. The social considerations that we took were easy to use interface and remote access to allow user to monitor aquarium. Political consideration that we took was by using a 5 V regulator on the board. The user can buy the appropriate wall wart in another country using a different line voltage and use it for the system. This system features the automation of aquarium maintenance and hence we had to ensure the sustainability of the system. We did this by minimizing the use of components with mechanical parts. The water pumps can easily be replaced by the user since they only plug in to the peripheral power module. The only mechanical component is the auto-feeder motor for which we offer on-site service calls. Although the packaging for our prototype was made from wood, we intended to market our product using plastic which can be easily produced.

(f) Description of the multidisciplinary nature of the project.

Our system incorporated ideas found in electrical and computer engineering applied to maintaining a biological condition. This project required the integration of both hardware and software. The underlying foundation that our system was built on required both electrical and hardware knowledge. The monitoring of the temperature, pH, remote access, and determination of when to activate the different peripheral devices required software. We needed to gain the understanding that excess fish waste results in a change in the pH level of the water. We needed this understanding to satisfy the biological needs of fish in determining the ideal pH range for them and implementing this in our software.

Purdue ECE Senior Design Semester Report

Course Number and Title	ECE 477 *Digital Systems Senior Design Project*
Semester / Year	Spring 2004
Advisors	Prof. Meyer and Prof. Jones
Team Number	Group 2
Project Title	Parking Garage Monitoring System

Senior Design Students – Team Composition			
Name	**Major**	**Area(s) of Expertise Utilized in Project**	**Expected Graduation Date**
Matt Downes	BSCmpE	Embedded software design and hardware layout/construction	Fall 2004
Stephen Osborn	BsCmpE	Embedded software, hardware debugging	Fall 2004
Anup Rajan Daniel	BsCmpE	Schematic Layout, Design Prototyping	Spring 2004
Pawanjit Singh Chawla	BsCmpE	Emebedded software design and debugging	Summer 2004

Project Description: Provide a brief (one or two page) technical description of the design project, as outlined below:

(a) Summary of the project, including customer, purpose, specifications, and a summary of the approach.

The project was to create a parking garage monitoring system that used ultrasonic sensors to detect the presence or absence of a vehicle, transmit this information via cat5 cable to a transmitter module, which transmits the information via RF to a RF receiver module on each floor, which in turn passes the information via cat5 cable to a web server that displays the information. The purpose behind the project is to allow the user, the driver looking for a space to park, information about the status of a garage before entering a facility, thereby shortening the time spent searching for available spaces. The customer for the product is the owner of the garage, the one who wishes to ease their customer's frustration. The approach of the design was to get the sensing portion of the design and the web server portion working independently first, and then test the RF transmission with the two functional halves.

(b) Description of how the project built upon the knowledge and skills acquired in earlier ECE coursework.

The project required designing our own power supplies and various other small analog circuits, which built on our ECE201, 202, and 255 knowledge. We were required to interface with several multiplexers and other IC's which required understanding their datasheets, and this built on the knowledge that we acquired in ECE270. The Atmel microprocessor we used for the transmitter block was programmed in Assembly, which we learned in ECE362. Numerous other skills that were acquired in ECE362 were used, such as using the USART on the Atmel and SCI on the Rabbit, as well as the built in timers in the microprocessors. Coding of the Rabbit was done in dynamic C, and the C programming language was presented in CS152, ECE264 and ECE368.

(c) Description of what new technical knowledge and skills, if any, were acquired in doing the project.

During this project, the main skill we acquired are:

i. Learning to use Orcad: We used Orcad extensively during the designing of the each of the PCBs.
ii. Embedded Software Design and Testing: Developing software for the Atmel in assembly, and Rabbit routines in Dynamic C
iii. Interfacing with other devices using serial communication: Communication between Atmel-RF Transmitter and Rabbit-RD Receiver.
iv. RF transmission techniques: Using checksum and other measures to increase reliability of RF transmission.

(d) Description of how the engineering design process was incorporated into the project. Reference must be made to the following fundamental steps of the design process: establishment of objectives and criteria, analysis, synthesis, construction, testing, and evaluation.

The first phase of the project was involved in brainstorming ideas about different projects that we could implement. After debating on many project ideas, we decided to implement the parking garage monitoring system, which would be really useful in real life. Once the project was selected, project timelines were set to allot ample time for testing/debugging purposes. Milestones that were set for the project gave utmost priority in achieving the success criteria's chosen for the project. The next phase was to select appropriate components that would ideally suit our design. In order to avoid any mistakes in the PCB layouts for the three boards, we ensured that the schematic for the design should be close to perfect. If a mistake was made in the design process, there would be a second chance after our midterm evaluation to correct our schematic before outsourcing our PCB design for manufacturing.

Each component of the design was thoroughly tested on the breadboard to ensure that there were no manufacturing defects before implementing it on the PCB. New components were added incrementally onto the PCB after ensuring that the previous part of the design was working as desired before adding newer components. For example, we would first test the functionality of the sensors by measuring the ping and echo by means of an oscilloscope. Then we connected the Atmel to the sensors and tested it to see if we are able to receive an echo from the sensors. Once we were assured that the transmitter module was working, we concentrated on the RF transmission. After testing the RF transmission, we integrated the working part of the design with our web server end and tested it. Thus, we ensured that each of the modules was working before integrating a new module to the working design. These engineering practices helped us in designing, testing and finally implementing the project successfully.

(e) Summary of how realistic design constraints were incorporated into the project (consideration of most of the following is required: economic, environmental, ethical, health & safety, social, political, sustainability, and manufacturability constraints).

The choice of our project placed major constraints on us from the start. Each ultrasonic sensor was $35, and it was not economically viable to purchase a significant number. We bought two sensors to show the scalability of the project. The RF transmission power wattage is not FCC certified and is possible an environment hazard. We chose to use ultrasonic sensors and not inductive sensors to increase the safety of the design. The project aides the common man, in terms of reducing waste of time looking for parking spaces everyday and is hence a positive contributor to the society.

A real world working implementation of the project is a thousand fold bigger than the project implemented, and adds to it more complexity and lesser reliability. However modularity and scalability were some of the key criteria while developing this project, and it should not be extremely hard to expand this to a real world project. The project does not employ any exception part requirement or manufacturing and is relatively easy to build, however the installation of the project in an actual garage is challenging, specially if the system is not installed when the garage is built

(f) Description of the multidisciplinary nature of the project.

This project required knowledge in many different disciplines. We were required to write software for the web page, web server, Atmel microprocessor, and Rabbit microprocessor. We were required to work with hardware with the PCB's we created, as well as all of the power supplies which we designed. We were required to give two presentations, and write many documents regarding the project. This draws on the technical writing aspect of the design and communication.

Purdue ECE Senior Design Semester Report

Course Number and Title	ECE 477 *Digital Systems Senior Design Project*
Semester / Year	Spring 2004
Advisors	Prof. Meyer and Prof. Jones
Team Number	3
Project Title	The MIDI Maestro

Senior Design Students – Team Composition			
Name	**Major**	**Area(s) of Expertise Utilized in Project**	**Expected Graduation Date**
Ben Johanek	CmpE	Software	May 2004
Matt Burgess	CmpE	Layout	May 2004
Christopher Coy	CmpE	Schematic	May 2004
Ryan Denison	CmpE	Packaging	May 2004

Project Description: Provide a brief (one or two page) technical description of the design project, as outlined below:

(a) Summary of the project, including customer, purpose, specifications, and a summary of the approach.

The project is a game for musicians, which interfaces with a MIDI keyboard to allow competition among the players. This device has two modes of operation. The first of these is a MIDI sequencing mode which allows 2 to 6 players to take turns building successively longer key sequences one note at a time. In this mode, a player is eliminated when he can no longer reproduce the sequence of the previous player. The second mode of operation is slightly more advanced. Each player must produce a melody, and then each opponent is given a chance to try and match the melody and timing of the player's melody. The game stores MIDI messages and their respective timing for the purpose of real-time comparison. Menu navigation is made possible with a control knob and LCD screen. In-game messages are played back to the users via a built-in speaker. To accomplish this, components were first selected for each functional block. Next, these separate functional blocks were prototyped. After the hardware was in place, software was written to send, receive, and compare MIDI messages.

(b) Description of how the project built upon the knowledge and skills acquired in earlier ECE coursework.

Knowledge from ECE270, ECE362, and all high-level programming courses was the foundation for this project. ECE270 helped with reading data sheets, prototyping with a breadboard, and using lab equipment (signal generators and oscilloscopes). The use of a microcontroller and interfacing with peripheral devices was learned in ECE362. The software for this project was written in embedded C, which is not very different from what was learned in ECE264. ECE201 and ECE255 supplied the circuitry background needed for the power supply design.

(c) Description of what new technical knowledge and skills, if any, were acquired in doing the project.

In completing the various stages of this project, new knowledge was gained in the areas of schematic designs, printed circuit board layout, embedded software, soldering techniques and integration of 3rd party hardware. Also, miscellaneous professional aspects of product development such as safety and reliability, patent liability, ethics, and environmental analysis were gained. This was also the first experience in taking an idea all the way from conception to completion of a finished product.

(d) Description of how the engineering design process was incorporated into the project. Reference must be made to the following fundamental steps of the design process: establishment of objectives and criteria, analysis, synthesis, construction, testing, and evaluation.

The first couple weeks were spent developing a feasible project idea, keeping in mind that it should be fairly inexpensive to produce and somewhat complex in nature. After the idea was developed, requirements were generated in the form of success criteria based on each functional block of the project. After the success criteria were defined, they were analyzed to determine the appropriate components necessary to realize the product. Prototyping work was done in order to synthesize a viable circuit, testing verified our prototypes, and eventually the final circuit was constructed and packaged. The original success criteria were re-evaluated to make sure all of them had been accomplished.

(e) Summary of how realistic design constraints were incorporated into the project (consideration of <u>most</u> of the following is required: economic, environmental, ethical, health & safety, social, political, sustainability, and manufacturability constraints).

Realistic design constraints were incorporated into nearly every aspect of the MIDI Maestro. During component selection a fairly strict budget was followed, in order to make the project economically feasible. The MIDI Maestro was also designed to have minimal power dissipation, thus making the device environmentally friendly. In order to ensure user safety and the satisfaction, much research was done on ethical, health and safety, and reliability concerns. This research led to the addition of many warning labels and cautions for the device.

(f) Description of the multidisciplinary nature of the project.

This project incorporated the knowledge from several engineering disciplines. Among these are Electrical Engineering, Computer Engineering, and Physics. Electrical Engineering aspects played a key role in the design of our power supply and selection of necessary capacitors. The majority of this project was related to Computer Engineering since a significant amount of work went into writing software and getting 3rd party digital devices to communicate with one another. Also, to minimize the EMI within the circuitry, past physics knowledge was utilized.

Purdue ECE Senior Design Semester Report

Course Number and Title	ECE 477 *Digital Systems Senior Design Project*
Semester / Year	Spring 2004
Advisors	Prof. Meyer and Prof. Jones
Team Number	Group 4
Project Title	DIGI-POD

Senior Design Students – Team Composition			
Name	**Major**	**Area(s) of Expertise Utilized in Project**	**Expected Graduation Date**
Christopher Carlevato	CmpE	C programming, software design	May 2004
Adam Goodson	EE	Circuit Analysis, hardware integration	May 2004
Brandon E. Wallace	EE	Circuit Analysis, C programming	May 2004
Rajeeve Subbiah	CmpE	C programming, hardware design	May 2004

Project Description: Provide a brief (one or two page) technical description of the design project, as outlined below:

(a) Summary of the project, including customer, purpose, specifications, and a summary of the approach.

The DIGI-POD is a scheduling device that will easily allow for several teams to share a single lab station (or lab pod) efficiently and without conflict. The DIGI-POD hosts a website on it's Rabbit 3000 Microcontroller, and it is on this website that the teams can sign up for the lab pod. Once signed up a team will check in at their appointment time by swiping one of their Purdue ID cards, and at this point the DIGI-POD will allow power to the pod (through use of X-10 devices). The DIGI-POD is efficient in that it does a lot of error checking, will remove appointments that are 15 minutes late, and will remove appointments that have not moved in the pod for more than 30 minutes. This product is specifically designed for the EE477 computer lab at Purdue University. For our purposed it is specified for use in one lab stations and for up to four teams of 4 people. The Rabbit microcontroller acts as the "brains" of DIGI-POD by hosting the website, communicating with X-10 devices, outputting to an LCD screen and receiving inputs from a card swipe and a motion sensor.

(b) Description of how the project built upon the knowledge and skills acquired in earlier ECE coursework.

Almost all of our prior ECE coursework was required in the completion of the DIGI-POD. Courses with C programming and assembly language instruction such as ECE362, ECE368, ECE468, and ECE264 proved to be very valuable in the software portion of the project. Our knowledge of C was essential to program the Rabbit microcontroller, and assembly language was also used in our design to read effectively from a card swipe reader. From a hardware perspective a look at prior coursework in ECE301, ECE255, ECE201 and ECE 202 were essential for our design. ECE301, ECE255 and higher-level courses provided an adequate background in power systems and supply that eventually led us to properly pick voltage regulators and corresponding parts. We utilized the knowledge learned in ECE201 and ECE202 in picking smaller components, debugging, and populating our printed circuit board.

(c) Description of what new technical knowledge and skills, if any, were acquired in doing the project.

Upon the completion of the DIGI-POD we were able to see what we had truly learned this semester. We learned to use OrCAD to do our layout and schematic. We also started learning technical skills like soldering, board populating, and coding in Dynamic C. Developing skills such as time management, team management, teamwork, designing, prototyping, debugging, and implementing were all a part of our experience this semester.

(d) Description of how the engineering design process was incorporated into the project. Reference must be made to the following fundamental steps of the design process: establishment of objectives and criteria, analysis, synthesis, construction, testing, and evaluation.

Our project began with our entire team brainstorming about ideas, and this gave us a general feel for our design. We established a design criteria and set landmarks for us to reach early on for Homework 3. After analysis and selection of components we made our PCB Board layout, and once it was completed we populated it with everything. Prototyping each component with the Rabbit was also done at the same time. Once the board was populated we built our packaging design and worked on putting our prototype on the actual PCB Board. The final stages of debugging and fly-wiring completed the project, and we evaluated ourselves based on our success criteria that were previously established.

(e) Summary of how realistic design constraints were incorporated into the project (consideration of most of the following is required: economic, environmental, ethical, health & safety, social, political, sustainability, and manufacturability constraints).

Many issues became project constraints, some technical and other not technical at all. We were constrained by issues of the Rabbit's capture rate, the motion sensor's rate, and the card swipe TTL logic rate. These constraints are reflected in our software design. We did have to watch ourselves on issues pertaining to ethics and environment. as we are members of EE477 too; and we needed to ensure the DIGI-POD was reliable as well. Our small packaging size and safety issues we faced with the product that became very realistic at the end of the project

(f) Description of the multidisciplinary nature of the project.

Our product concentrated heavily on computer and electrical engineering. This fact is reflected as we interfaced with TTL, and serial components, which our software could communicate with effectively. We needed several analog and digital components that involved multidisciplinary elements between Electrical and Computer disciplines. We did have non-engineering issues to concern about, such as environmental and ethical issues. We couldn't allow our system to be hacked into, and we wanted it to be environmentally friendly if at all possible.

Purdue ECE Senior Design Semester Report

Course Number and Title	ECE 477 *Digital Systems Senior Design Project*
Semester / Year	Spring 2004
Advisors	Prof. Meyer and Prof. Jones
Team Number	5
Project Title	Wireless Ordering Device

Senior Design Students – Team Composition			
Name	**Major**	**Area(s) of Expertise Utilized in Project**	**Expected Graduation Date**
Ed Sheriff	EE	Hardware Design System Integration Hardware Debugging	May 2004
Dan Sparks	ECE	Hardware Design Hardware Debugging C Programming	May 2004
Mike Klockow	ECE	System Programming Software Debugging	December 2004
Jon Hopp	ECE	Programming	August 2004

Project Description: Provide a brief (one or two page) technical description of the design project, as outlined below:

(a) Summary of the project, including customer, purpose, specifications, and a summary of the approach.

The wireless ordering device is a system that allows customers to view limited menus and possibly other information on a wireless remote device at a commercial establishment (e.g. a restaurant or bar). The aim of this project is to create a dining experience where a customer's drink and appetizer orders are waiting at their table when they are to be seated and the customer's perceived wait for that table is reduced.

This project utilizes the serial port of a PC to communicate with a base station. This base station communicates to the remote devices via a RF connection. The remote unit decodes transmitted information and displays this on an LCD display. Menu navigation buttons allow a user to select and order items from the menu. The remote device transmits this information back to the base station. A bank of LEDs alerts a user when their table is ready. Software on the base station allows the employees of the establishment to view orders or update menu information through a graphical user interface.

(b) Description of how the project built upon the knowledge and skills acquired in earlier ECE coursework.

In order to complete this project we needed to utilize the skills learned during our time at Purdue. From our project specification we knew we'd need software to run on a PC that allowed a user to create menus and monitor orders submitted by remote devices. A graphical user interface was created using Visual Basic, with which Mike and Jon had experience. The wireless link we needed to allow the base station and remote devices to talk to each other had to be simple and easy to implement. Ed had gained experience with RF communication in previous classes. Both base station and remote device needed firmware to allow them to handle communication and decode incoming information as well as interface with the LCD module. Dan had experience in efficient firmware coding to minimize the memory usage on our microcontrollers.

(c) Description of what new technical knowledge and skills, if any, were acquired in doing the project.

Throughout this project the group was continually challenged and worked to overcome these obstacles. Not only did we gain experience in creating schematics from datasheets, we also learned how to integrate these schematics into a PCB layout. We came to understand timing diagrams more thoroughly in order to interface the LCD memory and microcontroller. Hardware was a source of constant frustration as previously working components would begin to behave strangely when new components were added to the board, leading to valuable debugging experience.

(d) Description of how the engineering design process was incorporated into the project.

Once we had established the idea for our project we sat down and brainstormed success criteria and milestones that would keep us on track and eventually lead to a finished product. We utilized a development board to program our microcontrollers in order to begin software development. We implemented an incremental build process; we built up only part of our design at a time, taking small steps towards a finished schematic. We used oscilloscopes and other test equipment to ensure that our data signals were correct and that our devices were communicating properly throughout the build process. Thorough testing and incremental development ensured a successful project.

(e) Summary of how realistic design constraints were incorporated into the project (consideration of most of the following is required: economic, environmental, ethical, health & safety, social, political, sustainability, and manufacturability constraints).

As this project is to be used continuously by many people ergonomics and health and safety were important issues. A well designed and waterproof package is a must. We are aware that PCBs and LCD modules pose an environmental hazard; environmentally friendly methods of manufacturing and disposal alleviate that risk. The RF link our system uses must conform to FCC guidelines. Proper precautions must be taken to ensure our project does not interfere with similar devices.

(f) Description of the multidisciplinary nature of the project.

The RF link, schematic design and board layout required the talents of an Electrical Engineer to reduce noise and ensure proper communication. The PC software and firmware needed to allow the microcontrollers to interface with the RF devices and LCD module was developed using skills acquired by a Computer Engineer. Industrial Engineering considerations were needed to develop packaging concerns and constraints. The large amount of paperwork required for the group to effectively communicate their goals and progress incorporated the school of Liberal Arts and Management.

Purdue ECE Senior Design Semester Report

Course Number and Title	ECE 477 *Digital Systems Senior Design Project*
Semester / Year	Spring 2004
Advisors	Prof. Meyer and Prof. Jones
Team Number	6
Project Title	Intelligent Refrigerator System

Senior Design Students – Team Composition			
Name	**Major**	**Area(s) of Expertise Utilized in Project**	**Expected Graduation Date**
Scott Mullins	CompE	Software	05/04
Brian Schrameck	CompE	Parts Coordinator	12/04
Rudy Ristich	CompE	HTTP, Software	05/04
Mike Beaudette	CompE	Debugging	05/04

Project Description: Provide a brief (one or two page) technical description of the design project, as outlined below:

(a) Summary of the project, including customer, purpose, specifications, and a summary of the approach.

The Intelligent Refrigerator System is future forward proof of concept project. The purpose was to design a high-tech refrigerator that uses a micro-controller based system that interfaces with an RFID reader, an Ethernet connection, and several sensors to simplify the user's daily life. By maintaining an inventory that is accurate and easily accessible by any computer on the internet, extra trips home can be saved and meals can be planned ahead of time based on knowledge of refrigerator contents. The completed project consists of a Rabbit 3000 micro-controller that interfaces with a Texas Instruments 2000 series RFID tag reader operating at 134.2kHZ, a Maxim DS1722 digital temperature sensor, and a Crystalfontz 634 RS232 LCD display. The approach taken to achieve the design is most closely defined as modular. Each component in the system was tested and debugged individually and once all individual modules were functional the system was pieced together through software control.

(b) Description of how the project built upon the knowledge and skills acquired in earlier ECE coursework.

Successful completion of this project would not have been possible with out the vast breadth of knowledge covered in earlier undergraduate coursework. Fundamental concepts such as Ohm's law and simple circuit analysis were used when designing a power supply. Micro-controller programming was an essential skill, as were knowledge of data structures and network programming. Other skills such as interpreting data sheets and keeping accurate note books were also built on.

(c) Description of what new technical knowledge and skills, if any, were acquired in doing the project.

The most important new technical skills acquired were that of PCB design and layout using the Cadence OrCad suite. This allowed us to create custom circuit boards for the project and have them fabricated. We also learned two serial protocols; RS232 and SPI. RS232 is an asynchronous protocol that is the standard for serial communications. SPI is a synchronous interface designed by Motorola that is mainly used in embedded systems with time critical applications. Development using Dynamic C, a C like development language for Z80 based micro-controllers (like the Rabbit 3000), was another new skill acquired. Much technical expertise in the field of RFID was gained.

(d) Description of how the engineering design process was incorporated into the project. Reference must be made to the following fundamental steps of the design process: establishment of objectives and criteria, analysis, synthesis, construction, testing, and evaluation.

The first step of the project was to define our objectives, which are stated above and then establish the criteria for our success. Through analysis of data sheets and power requirements we were able to design our power supply to meet our needs. We also needed to analyze different specifications for RFID readers to choose one suitable for our project. After designing our PCB that was synthesized and returned to us at which point we began to construct our completed circuit from our tested modules. After everything was pieced together the product was tested and debugged up to the time of the final presentation. Our self evaluation of the project was a success due to the fact that all success criteria were met. Evaluation was also made by course staff along the way.

(e) Summary of how realistic design constraints were incorporated into the project (consideration of most of the following is required: economic, environmental, ethical, health & safety, social, political, sustainability, and manufacturability constraints).

Real world constraints were a major focus of this project. The design was made to be as economic as possible while still retaining all the features that were originally intended. Help was received here by HKN because they sponsored the project up to $500, this gave us a goal to stay under. Environmental and ethical analysis was the topic of a course homework which is available for reference on the group website. Safety and reliability analysis was the topic of another homework, also available on the group website. In short, reasonable care was given to ensure that a product was design that was safe, reliable, and worked as advertised. The final product was intended to be economically reasonable in price and easily manufactured with out harmful waste.

(f) Description of the multidisciplinary nature of the project.

There were several aspects of the design that would make it classified as multidisciplinary. The final packaging was meant to be as aesthetically pleasing as possible and much thought was put into making sure the packaging was logical and looked good. Economic analysis was used in making critical decisions such as choosing parts and deciding to save time by purchasing more expensive parts that were easier to integrate into the design.

Purdue ECE Senior Design Semester Report

Course Number and Title	ECE 477 *Digital Systems Senior Design Project*
Semester / Year	Spring 2004
Advisors	Prof. Meyer and Prof. Jones
Team Number	7
Project Title	Breakthrough Electronic Audio Turntable System

Senior Design Students – Team Composition			
Name	**Major**	**Area(s) of Expertise Utilized in Project**	**Expected Graduation Date**
Clewin McPherson	CmpE	Software (RPG), Packaging, and Schematic	May 2004
Nick Schnettler	CmpE	Software (CF and RPG) and Soldering	May 2004
Jim Bauerle	CmpE	Software (MP3) and Layout	May 2004
Ruth Devlaeminck	EE	Software (LCD and ATD) and Packaging	May 2004

Project Description: Provide a brief (one or two page) technical description of the design project, as outlined below:

(a) Summary of the project, including customer, purpose, specifications, and a summary of the approach.

This project is an MP3 turntable. It is intended for use by Disc Jockeys who would manipulate music at parties, etc. It is not intended for use as a stand alone unit, it would be plugged into a mixer and external amplifier and used like a vinyl turntable is used today. The idea is to make the unit as similar in function to a vinyl record player as possible while allowing for the use of more compact forms of music. The unit will load MP3's via a compact flash card and then allow the user to manipulate the loaded file as though it was a record on a turntable using an RPG connected to a platter from a record player. An LCD display, various pushbuttons, a linear potentiometer, and a turntable platter will comprise the user interface.

(b) Description of how the project built upon the knowledge and skills acquired in earlier ECE coursework.

In the building of the power supply system, knowledge from *Introduction to Electronic Analysis Design* (ECE 255) was very useful in choosing values for capacitor values. Previous knowledge of microprocessors and the interfacing of peripherals to them from *Microprocessor Systems and Interfacing* (ECE 362) proved useful. One of the most important laws that we used was V = IR which was learned in *Linear Circuit Analysis I* (ECE 201). We also used RC time constants from that class in attempting to build our own oscillator. Some of our prototyped software was written in Python, a language taught in *Software Engineering Tools Lab* (ECE 364). Information on how to write the file system for the Compact Flash was taken from *Operating Systems Engineering* (ECE 469). A large portion of the logic design information was learned in *Introduction to Digital System Design* (ECE 270).

(c) Description of what new technical knowledge and skills, if any, were acquired in doing the project.

The major new skills learned include learning how to solder, how to better read data sheets, and how to use Orcad. We also learned how to make our code more compact so that it would fit in the microprocessor.

(d) Description of how the engineering design process was incorporated into the project. Reference must be made to the following fundamental steps of the design process: establishment of objectives and criteria, analysis, synthesis, construction, testing, and evaluation.

Following a decision regarding a project, five objectives were decided on. Parts were chosen based upon analysis of the requirements, both packaging for the user and technical requirements. For example the LCD needed to be large enough to be viewed from a standing position while the unit is placed on a table. The different components of the design were tested as stand alone items before being combined into a final design. The actual construction of the unit was accomplished quickly. The packaging had been designed to closely mimic a vinyl record player with such adaptations as necessary, for example the LCD and CF card reader. The testing of the project following construction was limited by the fact that not all of the components were fully functional on their own. The final evaluation of the project concluded that some major design changes were required in order to make the project a success.

(e) Summary of how realistic design constraints were incorporated into the project (consideration of <u>most</u> of the following is required: economic, environmental, ethical, health & safety, social, political, sustainability, and manufacturability constraints).

Many different constraints must be taken into consideration when designing a project. Perhaps the most important for this project would be the economic constraints. Due to cost of manufacturing, purchasing rights for using a patent, design costs, etc., this project is not very feasible. Other units which have similar functions exist on the marketplace today. Environmental constraints were basically limited to the constraints placed on it by using a PCB board. The manufacturer of the PCB board would be responsible for the environmental issues created in its' manufacture, however this group would still be responsible for dealing with its' disposal. There were limited social, political, or ethical constraints which needed to be addressed.

(f) Description of the multidisciplinary nature of the project.

This project required the use of hardware, software, and construction. It used different forms of software, the integration of different pieces of hardware, and the combination of all of the pieces into an attractive package.

Purdue ECE Senior Design Semester Report

Course Number and Title	ECE 477 *Digital Systems Senior Design Project*
Semester / Year	Spring 2004
Advisors	Prof. Meyer and Prof. Jones
Team Number	8
Project Title	Sparky

Senior Design Students – Team Composition			
Name	**Major**	**Area(s) of Expertise Utilized in Project**	**Expected Graduation Date**
Rich Capone	CmpE	Schematic/Game	May 15 2004
Hong Jin Cho	CmpE	Flash/CF/Packaging	May 15 2004
David Elliott	CmpE	PCB/HW debugging	May 15 2004
Ryan Gates	CmpE	Video/Controller	May 15 2004

Project Description: Provide a brief (one or two page) technical description of the design project, as outlined below:

(a) Summary of the project, including customer, purpose, specifications, and a summary of the approach.

This project is a simple video game console. Interfaces include a handheld NES controller and CompactFlash card (the game cartridge). The output is NTSC video directly to a television input jack. The console is powered by a standard 6V wall-wart power plug. This is a product marketed towards anyone who enjoys gaming because it will be expandable and have a wide array of games. The design was approached in a following manner. First the project was chosen, and the success criteria were set. Then studies regarding the components necessary and many analyses were done. The schematic and PCB layout were done. The PCB board was populated, tested, and debugged while software was developed in parallel.

(b) Description of how the project built upon the knowledge and skills acquired in earlier ECE coursework.

This project was largely based upon the knowledge we have gained in many of our classes. We used our analog devices skills (ECE201, 202) for the speaker and the video out. We used a large amount of our digital design courses from the past. This is evident in the amount of Assembly (ECE362) and ABLE (ECE270) code used for the design. HCS12 processor used in the project was a family of HC12 used in ECE362. Usage of data bus and latches were learned in ECE270.

(c) Description of what new technical knowledge and skills, if any, were acquired in doing the project.

New technical knowledge we gained included generating schematics and creating PCB layouts. Additionally we learned about how to use a memory bus and how NTSC video works. We learned how to code in embedded C and improved our Assembly skills. Finally, we learned some very key skills for working in a group on a technical project.

(d) Description of how the engineering design process was incorporated into the project. Reference must be made to the following fundamental steps of the design process: establishment of objectives and criteria, analysis, synthesis, construction, testing, and evaluation.

Many of the engineering design process were incorporated into our project via many professional papers. Establishment of objectives were done by proposal and setting our own success criteria. Much of the analysis was done regarding to constraints, patent liability, reliability and safety, ethical and environmental. Synthesis was done by schematic and PCB layout design. Constructions include population of the PCB board, packaging, and software development. Hardware and software debugging were done multiple times while we tested functionality. Finally our design was evaluated by our advisors and classmates on presentation with the live demonstration.

(e) Summary of how realistic design constraints were incorporated into the project (consideration of <u>most</u> of the following is required: economic, environmental, ethical, health & safety, social, political, sustainability, and manufacturability constraints).

During the constraint analysis, our goal was to create a gaming system that has lower development cost than existing system. Our system should cost less then $50 to produce one in volume. According to ethical and environmental considerations document, our system was designed to use minimal power while in operation, and when it needs to be disposed of, the user will be advised to dispose it to the approved facilities for recycling. Our design follows the IEEE code of ethics according to the Ethics document. We tested multiple times to verify proper operation and to avoid misuse. Many health risks were studied and the warning labels will be placed on the console. According to reliability and safety analysis, our system was designed reliably that it should operate over 35 years continuously powered. Potential dangers that can be caused by our system were identified and many solutions were found in FMECA document. Our design does not infringe on any patents available in the United States according to our patent liability analysis. Our PCB layout was done efficiently with no extraneously hard malfunctions. The board should be easily populated by the machine or hand.

(f) Description of the multidisciplinary nature of the project.

The project primarily consists of three disciplines include electrical, computer, and mechanical engineering. The video system and power supply are both examples of the Electrical aspect of the design. Building the wood enclosure are aspects of mechanical engineering. Finally programming and interfacing with the microcontroller and Xilinx are examples of computer engineering.

Purdue ECE Senior Design Semester Report

Course Number and Title	ECE 477 *Digital Systems Senior Design Project*
Semester / Year	Spring 2004
Advisors	Prof. Meyer and Prof. Jones
Team Number	9
Project Title	InfraRed based Interactive Laser Tag (IRILT)

Senior Design Students – Team Composition			
Name	**Major**	**Area(s) of Expertise Utilized in Project**	**Expected Graduation Date**
Jason Kazmar	EE	Optics	5/15/2004
Chad Lau	EE	Signals and Systems	5/15/2004
Jonathan Stoffer	CompE	Software Design	5/15/2004
Ali Zaheeruddin	CompE	Layout and Schematic	5/15/2004

Project Description: Provide a brief (one or two page) technical description of the design project, as outlined below:

(a) Summary of the project, including customer, purpose, specifications, and a summary of the approach.

Project IRILT (InfraRed based Interactive Laser Tag)is a reliable embedded system which provides digitally managed laser tag equipment, allowing the user to create his/her own game rules. The IRILT system includes two complete units; each unit is comprised of a sensor vest (with headband) and a gun. Each vest comes complete with four infrared (IR) sensors (two on the front and two on the back), while the headband has two (front and back). Next to each sensor are a red LED and a vibrating motor. Once the sensors pick up an IR shot from another gun, the LED will light up and the motor will vibrate, indicating a hit. The gun is an IR emitting rifle, and it is connected to an LCD display mounted on an arm band. The LCD displays important information, such as the ammunition level, health meter status, and important messages. The target market for IRILT is the military. IRILT was designed to be a combat simulator which the military could use for battlefield training. The gun was designed to be sturdy and reliable, as well as provide the weight that actual weapons provide. The project required knowledge in optics, signal processing, computer programming, and circuit theory.

(b) Description of how the project built upon the knowledge and skills acquired in earlier ECE coursework.

The knowledge of component operation is the main skill we applied to this project. Being able to understand the data sheets was a direct application of previously acquired skills. The microcontroller required C programming which would have been acquired in EE156 and EE264. The interrupt operations as well as time sheet operations were gleaned from EE362. The RF operation was understood through the EE307 lab course. The IR operation and frequency modulation was explored in EE301 and EE306. An understanding of the vibrator motor operation was gained in EE321. The debouncing switches which were necessary to our design draw roots from EE202. As a whole our project represented many EE classes through our Purdue careers from the very first back Sophomore year.

(c) Description of what new technical knowledge and skills, if any, were acquired in doing the project.

There was a plethora of new experience gained throughout this course. To do something on paper is far different from doing something in hardware. There are numerous problems which emerge as a result of unforeseen circumstances. Simple tasks such as soldering were a mystery to us at the beginning and now we are nothing short of slightly above average solderers. How to trouble shoot a circuit is another skill with which until now as been unknown. Testing voltage at every point and monitoring voltage through the oscilloscope have proven to be important processes. The microcontroller was a new experience. It varied in operation from the development board to implementation. There were problems with floating pins and unexplained errors. Through careful organization and examination we were able to eliminate the errors and conclude with a fully operational product.

(d) Description of how the engineering design process was incorporated into the project. Reference must be made to the following fundamental steps of the design process: establishment of objectives and criteria, analysis, synthesis, construction, testing, and evaluation.

The project began with the drafting of a design proposal, in which we outlined the project objectives and success criteria. After the proposal was approved, each group member analyzed the data sheets of the components which we were considering. After this analysis, we chose the components to use in the project, and tested each one individually before placing each component in the final circuit. Once each component was placed on the board and the microcontroller programmed, we placed the PCB inside the rifle casing (PVC pipe) and attached all wires to the wires in the vest. We then evaluated the project by testing all success criteria (i.e. shooting and ensuring that the ammunition counter decremented).

(e) Summary of how realistic design constraints were incorporated into the project (consideration of <u>most</u> of the following is required: economic, environmental, ethical, health & safety, social, political, sustainability, and manufacturability constraints).

We were required to write a report considering each of the design constraints listed above. A patent liability analysis was performed to ensure that, if marketed, project IRILT would not infringe on any patents; infringement would require the payment of royalty fees. The limited ability to recycle PVC and PCB was noted in the environmental analysis, considering the fact that neither are bio-degradable and could have adverse effects on the environment. As far as ethics are concerned, we made a product that was both safe and reliable. The gun is safe to the end user because it does not look like a real gun. Because of this it will not be misconstrued as a real gun thereby endangering the end user. We also went through a number of testing cycles to make sure that the gun and vest could actually stand up to regular use. This showed that the project was reliable.

(f) Description of the multidisciplinary nature of the project.

As a laser tag project, it was necessary to be able transmit coded information from one unit to another. We accomplished this goal by using On-Off-Keying (OOK) binary transmission on an infrared (IR) beam. Optics played a major role in the project, as the IR had to be focused properly so that the beam width was restrained to appropriate parameters. The binary transmission required knowledge in signals and systems. Skill in computer programming was necessary to implement the binary transmission in an embedded system. The PCB layout and circuit construction required a thorough understanding of circuit theory. In the layout, it was necessary to properly distance all components away from RF transmitters and receivers to prevent electromagnetic interference. RC circuits were used in the final system to debounce various switches, such as the trigger.

Purdue ECE Senior Design Semester Report

Course Number and Title	ECE 477 *Digital Systems Senior Design Project*
Semester / Year	Spring 2004
Advisors	Prof. Meyer and Prof. Jones
Team Number	10
Project Title	Wyld Stallyns Site Management System

Senior Design Students – Team Composition			
Name	**Major**	**Area(s) of Expertise Utilized in Project**	**Expected Graduation Date**
Jeff Groom	CompE	Hardware	May 2004
Mike Newman	CompE	Software	May 2004
Loulwa Salem	CompE	Hardware	May 2004
Mike Wagner	CompE	Software	May 2004

Project Description: Provide a brief (one or two page) technical description of the design project, as outlined below:

(a) Summary of the project, including customer, purpose, specifications, and a summary of the approach.

The project was to provide a solution for the problem of physical space allocation to competing parties. Our customer is any organization that shares common workspaces such as offices, labs, and cubicles. The purpose of the project is to solve the aforementioned problem by creating an electronic and autonomous system that can be used efficiently and easily.

The specifications set forth during the proposal phase of the project included a web-enabled reservations system, authentication of users in order to activate electrically powered site equipment, and clear indications of remaining time. Other specifications included interfacing to and using readings from a motion sensor for the purpose of canceling reservations when parties are not present.

To approach the project, the team met to discuss alternative strategies for meeting the specifications in practical manners. Research into similar products was done in order to frame our expectations into something that was realistic and possible to do in one semester. After developing a basic proposal of the project, the team began meeting the milestones set by the ECE477 course outline.

(b) Description of how the project built upon the knowledge and skills acquired in earlier ECE coursework.

ECE 477 built on the material taught in ECE 201, ECE 270, and ECE 362. Basic circuit knowledge derived from 201 was useful most when reading data sheets and creating simple circuits. Simple digital logic such as encoding and decoding was useful from ECE 270. Microcontroller programming and interfacing was done with new tools but the same underlying concepts from ECE 362 were used. Overall the material from ECE 201 and ECE362 were most useful in completing the semester project.

(c) Description of what new technical knowledge and skills, if any, were acquired in doing the project.

Various valuable technical experiences and skills were gained through ECE477. While other courses like EE255 gave students initial understanding of OrCAD Schematic software, ECE477 allowed the team to learn more about the software and its features, and utilize the new found knowledge in the design process. A new technical knowledge was gained by learning to use OrCAD Layout; the software was a new addition that was not covered in any course in the past.

A major advantage of ECE477 is that it allowed the team to work on circuit design. The projects gave the team an opportunity to investigate various circuit implementations and decide the option most efficient to use. The course also allowed for hands on experience, mainly soldering parts to a PCB. Working immediately with the hardware gave everyone a good trouble shooting and problem solving experience. The project experience also extended to software in terms of programming and interfacing microcontrollers. The team learned Dynamic C in order to program the microcontrollers and achieve the final product functionality.

(d) Description of how the engineering design process was incorporated into the project. Reference must be made to the following fundamental steps of the design process: establishment of objectives and criteria, analysis, synthesis, construction, testing, and evaluation.

The project started with the establishment of objectives. These were manifested as success criteria and were used to determine whether or not our goals had been met. After goals had been established, a substantial amount of analysis was performed. This occurred when making special considerations during parts selection, schematic design, PCB layout design, and software design. We often had to do cost-benefit analysis to come up with cost/environmentally effective solutions as well as electrical circuit analysis to come up with efficient solutions. We took a bottom-up approach and tested all sub-components before bringing everything together. This was shown through the prototyping of sub-circuits on bread boards and the testing of software on development boards. When sufficient testing had been done we synthesized the entire system by bringing all sub-circuits together on designated PCBs and loading software onto the microcontrollers that were at the heart of these circuits. We constructed all external circuitry and boxes to house the circuitry as well as user interfaces to make the design useable. We then performed testing again on the fully synthesized and constructed design. Finally, in order to evaluate the success or failure of the project we demonstrated the functionality of the design and thus the fulfillment of the initial success criteria.

(e) Summary of how realistic design constraints were incorporated into the project (consideration of <u>most</u> of the following is required: economic, environmental, ethical, health & safety, social, political, sustainability, and manufacturability constraints).

Realistic design constraints were incorporated into the project through homework. There was homework assigned weekly to investigate the constraints. Each homework had a theme and was expected to relate our project to that theme. Examples of homework assignments include Ethical and Environmental Impact Analysis, Patent Liability Analysis, Reliability and Safety Analysis, and Component Selection and Rationale. Each of the homework assignments discuss in depth the realistic design constraints of our project.

(f) Description of the multidisciplinary nature of the project.

Any project taken from concept to realization is going to be multidisciplinary in nature. First a definition of what the project is supposed to do is necessary. Next the actual design must be laid out. Details such as how something will be encoded or programmed must also be worked out. The whole project must then come together as a work of both hardware and software. Functionality can be achieved through this synergy of hardware and software but other factors must still be considered. What customers will want this product, how should the product be packaged, are there any ethical or environmental issues to consider, et cetera. Each one of these questions must be answered and no one person is an expert in all these issues. Large projects require a team of people to cover every aspect of a good and successful design.

Purdue ECE Senior Design Semester Report

Course Number and Title	ECE 477 *Digital Systems Senior Design Project*
Semester / Year	Spring 2004
Advisors	Prof. Meyer and Prof. Jones
Team Number	11
Project Title	GPS Personal Trainer

Senior Design Students – Team Composition			
Name	**Major**	**Area(s) of Expertise Utilized in Project**	**Expected Graduation Date**
Tyler Olsen	CmpE	EE264, EE270, EE362, EE202	May 2004
Phil Vorsilak	CmpE	EE264, EE270, EE362, EE437	May 2004
Nick McCarroll	EE	EE202, EE270, EE362, EE457	May 2004
Gennady Vayl	EE	EE201, EE270, EE362, EE264	May 2004

Project Description: Provide a brief (one or two page) technical description of the design project, as outlined below:

(a) Summary of the project, including customer, purpose, specifications, and a summary of the approach.

The GPS Personal Trainer is an electronic device which measures distance, time, speed, and heart rate of a user during exercise. The device is designed for athletes who need a means of monitoring real-time statistics during their workout. Our specifications include a 16x2 line LCD screen, piezo speaker, rotary pulse generator, 5KHz heart rate receiver, and 4 AA batteries (8 hour life expectancy). Our approach was to design a three part device which would minimize weight (since the user will wear the device) and minimize area and power consumption since it is a portable device.

(b) Description of how the project built upon the knowledge and skills acquired in earlier ECE coursework.

The foundation for the project was built on the microprocessor programming and interfacing techniques learned in ECE362. We used the assembly language skills learned in ECE362 and improved upon in ECE437 to aid in the programming of the ATmega8L microcontroller. We also used the knowledge learned about interrupts and polling, as well as timers, PWMs, and serial transmission. From ECE270 we used knowledge about truth tables, NAND gates, switch debouncing, and IC interfacing. We used filter knowledge gained from ECE202 and ECE457.

(c) Description of what new technical knowledge and skills, if any, were acquired in doing the project.

Some new technical knowledge and skills acquired during the design of the GPS Personal Trainer include: design of schematics, PCB layouts, embedded C programming, soldering and packaging techniques, and design integration.

(d) Description of how the engineering design process was incorporated into the project. Reference must be made to the following fundamental steps of the design process: establishment of objectives and criteria, analysis, synthesis, construction, testing, and evaluation.

Establishment of objectives and criteria was done before any initial design took place. Once these were known, analysis of the necessary parts was performed. Synthesis was then performed with the heart rate receiver and the LCD screen, as well some software modules. The hardware was constructed and tested block by block. The main software module was implemented using a bottom-up technique. Basic routines and functions were created and tested before adding them to the main code itself. Using this method the main code module required less debugging. The success criteria were demonstrated and evaluated in simulation.

(e) Summary of how realistic design constraints were incorporated into the project (consideration of <u>most</u> of the following is required: economic, environmental, ethical, health & safety, social, political, sustainability, and manufacturability constraints).

Economic constraints were displayed by buying all of the parts ourselves and realizing just how much the device would cost. The velcro straps on both the wrist and shoulder units were tested to make sure the unit wouldn't become disconnected from the user during a workout. Political constraints were demonstrated through the research of literal and doctrine of equivalents infringement. Sustainability of the device is contingent upon the expected battery life (8 hrs.) as well as the estimated lifetime of such parts as the power supplies and regulator. Manufacturability was taken into account by the use of customizable packaging.

(f) Description of the multidisciplinary nature of the project.

The project had to be designed from two viewpoints. The constraint analysis was done from an electrical engineering perspective, while an exercise science perspective was needed to determine what features to include and how the overall operation of the device should function.

Purdue ECE Senior Design Semester Report

Course Number and Title	ECE 477 *Digital Systems Senior Design Project*
Semester / Year	Spring 2004
Advisors	Prof. Meyer and Prof. Jones
Team Number	12
Project Title	Digital Picture Frame Interface

Senior Design Students – Team Composition			
Name	**Major**	**Area(s) of Expertise Utilized in Project**	**Expected Graduation Date**
Jeff Turkstra	CmpE	C Prog., Interfacing, Schematic, Layout	May 2004
Bill Kreider	EE	IR, Web design, Schematic	May 2004
Phillip Boone	CmpE	Software/Debugging, Design Constraints	May 2004
Egomaron Jegede	CmpE	C Prog./Debugging, Network Prog.	May 2004

Project Description:

(a) Summary of the project, including customer, purpose, specifications, and a summary of the approach.

The project is a digital picture interface between a VGA display and a remote picture database. This device enables a user to access pictures stored on a remote computer via the internet and display those pictures on a monitor without any additional equipment. The device is intended for use by anyone who takes digital pictures, but is geared towards users with little computer knowledge. For instance, an elderly couple's children could setup the entire device, and send pictures to their parents. The device consists of a black box with pushbuttons, an IR sensor, VGA connector, RJ-45 connector, and an AC power adapter.

The two major phases of our approach were a top-down design followed by a bottom-up implementation. We started by drafting an initial block diagram, and determined what major functional blocks were necessary. We then examined each functional block and ultimately achieved the design at a component level. From these constraints, components were selected. We then proceeded to implement the design block by block, and then interconnected them using OrCAD schematic. A layout was generated from the schematic and the board was manufactured from the layout. The board was populated with components, tested, and software was developed to interface with the board. After testing the final packaging was completed.

(b) Description of how the project built upon the knowledge and skills acquired in earlier ECE coursework.

This design built upon many prerequisite courses. EE201 knowledge was used in component selection. EE207 and EE208 knowledge was used in board testing and debugging. EE255 was used to design the current reference input to the digital to analog converter. EE270 knowledge was used to configure the PLDs as latches, work with binary and hexadecimal numbers, and read data sheets. EE362 was used for timing analysis, microcontroller programming, operating a logic analyzer, and working with bit-wise operations. EE264, EE495R and EE462 programming knowledge was applied to the software development.

(c) Description of what new technical knowledge and skills, if any, were acquired in doing the project.

Several new skills were learned in the span of the project. We learned to solder, select components, design a schematic, produce a layout, project management, division of responsibility, ability to work on a target deadline, techniques of debugging, and C microcontroller programming.

(d) Description of how the engineering design process was incorporated into the project. Reference must be made to the following fundamental steps of the design process: establishment of objectives and criteria, analysis, synthesis, construction, testing, and evaluation.

Weekly homeworks focused on important aspects of the engineering design process were completed individually and as a team. The preliminary project proposal and final project proposal established the team objectives and project specific success criteria. We performed detailed analysis of design constraints, packaging, circuit design and the theory of operation. We created a layout with a successful design rules check that was then submitted for a production check and subsequently for manufacturing. We then developed software, populated the circuit board, and tested each aspect of software and hardware. We documented the final working project and gave professional presentations while in progress and at completion of the project.

(e) Summary of how realistic design constraints were incorporated into the project (consideration of most of the following is required: economic, environmental, ethical, health & safety, social, political, sustainability, and manufacturability constraints).

We originally wanted to incorporate an LCD display into our project. However, due to economic constraints we could not obtain an affordable display and eliminated that aspect of the design. We performed an ethical and environmental analysis of the product, reliability and safety analysis of the electrical components, a patent and liability analysis to avoid infringement on existing products, and a design constraint analysis investigating power supply, packaging, computation and cost constraints involved in component selection.

(f) Description of the multidisciplinary nature of the project.

Software engineering was used in programming the microcontroller and PC client. Electrical engineering knowledge was applied in powering and testing components and most board related issues. Systems engineering was incorporated in designing the circuit board. Process engineering was used to make the board more efficient, reliable, and safe.

Appendix B:

Proposed Evaluation Form

ECE Senior Design Course/Instructor/Lab/TA Evaluation

Directions: Circle the response that best represents your assessment of each criterion.

Major (SA = CmpE, A = EE, U = other)	SA A U D SD
Hours/week outside class (SA = 1-2, A = 3-4, U = 5-6, D = 7-9, SD = 10 or more)	SA A U D SD
Your current GPA (SA=3.50-4.00, A=3.00-3.49, U=2.50-2.99, D=2.00-2.49, SD=<1.99)	SA A U D SD
COURSE (SA=excellent, A=good, U=average, D=marginal, SD=poor)	
Significance of design experience	SA A U D SD
Specification and clarity of design project requirements	SA A U D SD
Relevance of design experience to your personal career goals and objectives	SA A U D SD
Relevance of lecture topics to course objectives and outcomes	SA A U D SD
Quality and clarity of course documents	SA A U D SD
Clarity of grading standards and methodology	SA A U D SD
Usefulness of feedback provided on graded materials and peer evaluations	SA A U D SD
Effectiveness of homework assignments in pacing the design project	SA A U D SD
Clarity and awareness of course outcomes	SA A U D SD
Course outcome assessment procedures	SA A U D SD
INSTRUCTOR (SA=excellent, A=good, U=average, D=marginal, SD=poor)	
Qualifications of instructor	SA A U D SD
Effort put forth by instructor	SA A U D SD
Instructional techniques used in classroom presentations	SA A U D SD
Effectiveness in answering questions	SA A U D SD
Rapport with students	SA A U D SD
Availability during scheduled office hours	SA A U D SD
Dedication of instructor to helping students learn and grow as professionals	SA A U D SD
LAB (SA=excellent, A=good, U=average, D=marginal, SD=poor)	
Quality of lab facility (space, room, furnishings)	SA A U D SD
Availability of lab facility	SA A U D SD
Quality of lab equipment	SA A U D SD
Maintenance of lab equipment	SA A U D SD
Adequacy of lab space and equipment for current enrollment	SA A U D SD
Overall, I would rate this lab as:	SA A U D SD
T.A. (SA=excellent, A=good, U=average, D=marginal, SD=poor)	
Qualifications of T.A.	SA A U D SD
Effort put forth by T.A.	SA A U D SD
Quality of assistance provided	SA A U D SD
Rapport with students	SA A U D SD
Availability during scheduled office hours	SA A U D SD
Overall, I would rate this T.A. as:	SA A U D SD

UNIVERSITY CORE:

Overall, I would rate this instructor as: ___ Excellent ___ Good ___ Fair ___ Poor ___ Very Poor

Overall, I would rate this course as: ___ Excellent ___ Good ___ Fair ___ Poor ___ Very Poor

Appendix C:

ECE Course Assessment Report

ECE Course Assessment Report

Course: ECE 477 **Submitted by:** D. G . Meyer
Term: Spring 2004 **Course PIC:** D. G. Meyer

1. *Were all course outcomes addressed during the administration of the course? If not, why not and what actions do you recommend to remedy this problem in future offerings of this* course?

   The following outcomes must be demonstrated to receive a passing grade in ECE 477:
   (i) an ability to apply knowledge obtained in earlier coursework and to obtain new knowledge necessary to design, build, and test a microcontroller-based digital system
   (ii) an understanding of the engineering design process
   (iii) an ability to function on a multidisciplinary team
   (iv) an awareness of professional and ethical responsibility
   (v) an ability to communicate effectively, in both oral and written form

   All of these outcomes were addressed and, as indicated below, all students enrolled during the Spring 2004 offering of ECE 477 successfully demonstrated each outcome.

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Average Outcome Scores and Outcome Demonstration Statistics for ECE 477 - Spring 2004

Outcome # 1 Avg Score:   81.7%    Passed:  48/ 48 = 100.00%    Failed:   0/ 48 =   0.00%

Outcome # 2 Avg Score:   74.9%    Passed:  48/ 48 = 100.00%    Failed:   0/ 48 =   0.00%

Outcome # 3 Avg Score:   85.0%    Passed:  48/ 48 = 100.00%    Failed:   0/ 48 =   0.00%

Outcome # 4 Avg Score:   80.2%    Passed:  48/ 48 = 100.00%    Failed:   0/ 48 =   0.00%

Outcome # 5 Avg Score:   85.0%    Passed:  48/ 48 = 100.00%    Failed:   0/ 48 =   0.00%

Demonstrated all five outcomes based on primary assessment:  48/ 48 = 100.00%

Note: Remediation on Outcome #4 was required for 6 students.
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2. *Are the course outcomes appropriate?* Yes.

3. *Are the students adequately prepared for this course and are the course prerequisites and co-requisites appropriate? If not, explain.*

   For the most part, yes, especially as the "pipeline" from the old ECE 266/267 has emptied.

4. *Do you have any suggestions for improving this course? If so, explain.*

   The course staff members (Prof. Meyer, Prof. Jones, John Leimgruber, and Gilbert Tseng) are very satisfied with the very thorough outcome assessment strategy currently in place.

   The primary improvement that could be realized is better preparation of students in prerequisite courses, which has been addressed by reinstituting the "Mini-Project" in ECE 362 and by introducing students to OrCAD (the primary schematic capture/PCB layout tool used) in ECE 270.

   We are still looking for ways to continue to improve the lab notebooks as well as team dynamics. One change we will institute effective Fall 2004 is to add a midterm peer evaluation (currently we only have an end-of-semester peer evaluation).