Senior Project Design Course Sequence

Electrical Engineering

Spring 2007

ECE401, ECE402, ECE403

Introduction

Welcome to the Senior Project Capstone design course sequence. This course sequence will take three semesters to complete and will culminate in a working piece of hardware of your own design and of your own conception. This document will describe all three semesters so keep it in a safe place for future reference. Once a project is chosen in the first semester during ECE401, that project must be the project presented in the final semester during ECE403. The specifications of your project established in ECE401 cannot be changed as the course continues, so spend time and take care in choosing your project. We recommend that you join another classmate and form a team of two for the duration of this course sequence. Teams are generally more efficient at solving problems and are better at detecting trouble spots and mistakes. ECE401 and ECE402 can be taken in the fall, spring, or summer semesters, however, ECE403 can be taken only in the fall or spring; it is never offered in the summer. Only one course may be taken in each semester, in other words, this course sequence cannot be completed in two semesters.

Before describing the 3-semester sequence you're just beginning, a word is in order about what is meant by design in the context of this academic setting. In the manufacturing environment where many of you will be heading, new products are created everyday by large teams of people from many diverse disciplines. The full scale design of a product requires the development of marketing, economic, and sales plans as well as the concerns of manufacturing, testing, and packaging the device itself. The product may also affect the environment or be a safety risk just to mention a few of the many other considerations that go into a complete design. At best, the work done in this course sequence must be considered a partial design because it does not consider in depth many of the aspects of a complete design.

It's instructive and interesting to speculate on how the missing pieces of a complete design might affect the project you eventually choose to build. There are numerous standards and policies that have been developed by commercial (IEEE, Underwriters Lab) and governmental (FCC) agencies that regulate products and methods of manufacture. You will be asked to investigate the standards and policies that apply to your project and to include this information in your final report.

This course is called a capstone course because it puts the finishing touch on your education in engineering by allowing you to design and build something. You are expected to demonstrate that you are able to contribute to a design effort by using the skills you've learned over the last two and a half years to create electronics and perhaps software that could be part of the complete design of a product. You have had formal training and practice in designing, analyzing, and testing electronic circuits and circuits that use microprocessors. It is here that you will be

expected to make informed choices and use good judgment in choosing a project to build and in making the project meet the specifications you have determined. You will be judged and graded for the next 3 semesters on how well you can bring together all the pieces of design, analysis, trouble-shooting, and communication that you have learned in the preceding courses to conceive and build a working project in your field. Good luck, it's a big challenge but it's also an opportunity to design something of your own choosing.

The following pages of this document are divided into 4 sections. The first section is a description of what constitutes a project and what documents will describe the project. Following that description will be one section for each of the three semesters of the sequence. Each semester section will discuss the objectives and the criteria for grading.

1. Project Description

An Electrical Engineering design project is a small-scale system, device, or instrument, involving hardware design and construction. Hardware in this context means electronic components of the sort studied and used in the undergraduate curriculum. Examples of these components would include resistors, capacitors, inductors, transformers, transistors, op-amps, logic elements and other integrated circuit devices. Purchasing and using pre-made circuit cards with these components on them will not count as part of the design. The project can include but not consist solely of software development. Computer engineering students are encouraged to include low-level software development (assembly language) as part of their project. A PC can be included as part of the project, but high-level software developed on the PC will not be considered as part of the overall design effort upon which you are graded.

The project will be proposed, designed, constructed, debugged, tested and evaluated by a single student or a project team of two students. Teams may collaborate with students from other disciplines to develop larger design projects. The completed project will be presented to the class and a final report on the project will be submitted. The project concept does not have to be unique or original.

Not acceptable as total projects are;

- Pure research work
- System integration using off-the-shelf hardware
- Library research
- Market surveys
- Software evaluation
- Software development

Three documents will be used to describe the specifications of your project and to keep a running record of its progress. All these documents will also be used as a basis for grading the results of your work. These documents are a Project Proposal, a Project Description, and a Project Notebook. A definition of these documents follows.

ECE 400

Document Definitions

Project Proposal

The project proposal is a one-page document, which briefly describes what you are going to build. Your project must meet the specifications in this document to obtain a C grade in the second semester (ECE 402) of this course. Your project must meet or exceed the specifications presented in this document to pass the final semester (ECE403) of the course. The proposal must include the following sections:

1) A name for the project.
2) Description and function of the proposed project.
A one-paragraph description of what the project will do.
3) Inputs - Outputs
A listing and brief description of the input and output signals or conditions required for your project.
4) Specifications
A list of specific objectives that your project will achieve. Some of these objectives must be quantitative. You must be able to test and measure these objectives on your final project to prove that your project is in conformance with these specifications. For guidelines, see the grading section of ECE402.

Project Description

This (3-5 page double-spaced) document will be an expanded description of your project. Unlike the details and specifications in your proposal, which must be achieved to pass the third semester, the details and specifications contained in this description are considered goals to be accomplished if possible. Think of this as the description of a project that would merit an A or B grade in ECE402. See grade descriptions under ECE402 for guidelines.

The details to be included in this document should concern what your project does and what its inputs and outputs are. It will be an expansion of topics 2, 3 and 4 of the project proposal. This document should not detail how the project will accomplish the specifications presented in the proposal so avoid details that tie you to a single approach or piece of hardware. Do not choose specific components or families of components, exact voltages for internal power supplies or specific devices unless they are crucial to the operation of your project. For example, if your project has a display, be clear about what will be displayed under all conditions of operation but do not specify that you will use 7-segment LED displays. You may decide later that liquid crystal displays are a better choice for your project

To earn an A or B grade for ECE402 your project will need to include a challenging piece of design work. Work that requires testing and development beyond that which is encountered in

laboratory exercises. Review the grading section for ECE402 so that you understand what will constitute an A or B grade.

Notebooks

All students must keep a personal engineering notebook that documents the effort and progress made on the project. The notebook must be started as soon as you have established what your project will be and it should be used for the three-semester span of this course. Each student must keep an individual notebook even when working closely with a partner. The book should document your own contribution to the effort as well as the progress of the overall project. The notebooks must have bound pages (no 3-ring binders).

2. First Semester ECE401

Course objectives (one credit)

- Project selection.
- Project team organization and faculty advisor assignment.
- Resource location.
- Parts assessment.
- Project cost analysis.
- Other Concerns –safety, economic, environmental, and manufacturing issues may be considered.
- Practical advice - Project planning, Scheduling, etc.
- Publication of Project Proposal on an Internet website.
- Final Project Proposal signed.

Grading ECE401:

For a C grade:

Preliminary Project Proposals and an acceptable final Project Proposal must be turned in when indicated on the detailed first semester schedule. Notebooks must be available for review.

For a B grade:

In addition to the C grade requirements, an acceptable Project Description must be handed in with the Project Proposal.

For an A grade:

In addition to the B grade requirements, the Project Description must include specifications that would constitute an A grade for ECE402 if they were accomplished. See grading section under ECE402 for suggestions. The project must have the depth to include A grade design work.

3. Second Semester ECE402

Second Semester (four credits)

- Design
- Construction
- Debugging
- Written progress reports
- Oral progress report
- Hardware show (during finals week)

Grading ECE402:

For a C grade:

An acceptable oral progress report, written progress reports that accurately reflect the work done, and finally, demonstrated proof (during finals week) that the project performs as indicated in the Project Proposal. Students must demonstrate a full understanding of their design. It is acceptable to borrow and combine schematics from many sources, but you must understand the circuitry and show circuit analysis work in your notebook to back up your understanding. Typical expectations for quantitative measurements in C grade work should be at or above the following guidelines.

- Digital measurements of voltage and current that are made at low frequency intervals (less than 10,000 sps) should have at least 8 bits of resolution.
- Measurements of time intervals should be accurate to 5 microseconds .
- Measurements of temperature should be accurate to 1 degree centigrade.
- Amplified audio signals should be flat to within 3 dB in the passband and total harmonic distortion (THD) for audio amplifiers should be less than 1% (typical linear IC amplifier).
- Wireless communication channels (IR, RF, ultrasonic) should function at distances of 10 ft or greater.
- The guidelines above are based on using integrated circuit components in the design, projects that use discrete transistors to accomplish these specifications will be judged differently.

The project must be constructed with care and planning. Proper prototyping techniques should be used to ensure that the project can be handled, tested and inspected without jeopardizing its operation. Wirewrapping is the recommended method for interconnecting electronic devices so make sure you do not use the white breadboards used in lab work to construct your project. Use connectors between separate parts of the project and use wire that is appropriate for the job (no solid wire interconnecting different segments of the project). The best final package for these projects is a flat piece of plywood with circuit boards attached. Don't try to package projects in a fancy box, your time would be better spent improving your electronic design.

Notebooks detailing the work on the project must be available during the hardware show.

For a B grade:
To receive a B grade, you must demonstrate the working C grade part of the project during or before the C Grade Week indicated in the semester schedule. The project does not have to be in its final form at this time, but it must meet the C grade specifications. In addition, you must also demonstrate (during finals week) your completed project and at this time it must meet the following criteria to qualify for a B grade.

The oral and written progress reports must be above average in content and presentation. The project must be in final presentable form with input switches and signals labeled and outputs clearly described where appropriate. The project does not need to be in a box as its final package, it is better to be neatly arranged on a board with all components exposed, that is an excellent final package. Full schematics must be available and they should conform to standard schematic conventions. The project must also include some part of the hardware that represents an above average design component. The following examples represent some of the possibilities.

- Make your own microprocessor board (don't use the EVBU or Axiom board), and use the data and address buss along with the control lines of a microprocessor to make available additional memory or I/O. Using data registers to access additional I/O doesn't count.
- Write assembly language code that takes advantage of multiple interrupt schemes to accomplish some goal.
- Build a sequencer with at least 5 states to control part of the project.
- Develop a wireless communication channel that can transmit at 300 baud or better.
- Incorporate into your project one of the complex analog integrated circuits that are not discussed in your course work, for example; Phase Locked Loop (LM565), Digitally-Controlled Tone and Volume control (LMC1982), Digital Potentiometer (LM1973), Active Filter (LMF40), and there are many more.
- Build a switching power supply.
- Use only transistors to build an amplifier or control system.
- Create a hi-side driver for an N-channel CMOS H-Bridge or half H-Bridge.
- Use Triacs in a control system.
- Create an electro-mechanical position control system that uses linear feedback.

For an A grade:
The A grade is given when B grade work demonstrates one of the following characteristics.
- A project that solves a problem or performs a task in a unique way. A clever solution showing high creativity (as judged by the faculty).
- A project that controls large amounts of power (>100watts for DC power) in a continuous or PWM manner (not just switched on and off).

- A project that controls large amounts of current (>20 amps DC, or >30 amps AC) in a continuous or PWM manner (not just switched on and off).
- A project that senses and makes use of very low level signals (<100*10E-6 volts).
- A project that transmits information at high speeds (1 mega-bits/sec) without using an existing chip-set or standard.
- Any other feature that you can think of that will push the capability of the project into areas that require deep understanding, extensive testing, and repeated tries to get it right. These features are open to debate and you will need to convince the faculty that your ideas merit consideration.

4. Third Semester ECE403

Third Semester (two credits)

- Preparation of a written report
- Oral presentation and demonstration

Grading ECE403:

To pass this semester your project must be operational and meet the Project Proposal specifications before the last day of classes. If the project works on the day of your presentation, the grade you receive will be based on the presentation (50%) and the grade you received for your report (50%). The report is graded twice. The grade received on the first reading will form the base grade for the report. The report will be read again after revisions are made and the base grade may move up or down by one third of a grade level. Any improvements made in the operation of the project since the hardware show (ECE402) will be of secondary value in determining the grade for this semester.

If the project fails to meet specifications on your presentation day, your grade will be reduced. You will still, however, be required to make your presentation on the day assigned to you. If the project fails to meet specifications before the end of the last day of classes, you will receive an F grade for the third semester and you will have to register for the third semester again. To obtain a passing grade you must fix your project and demonstrate that it meets specifications.