ECE496 Design Project
Preparing Your Project Proposal

Thursday, Sept. 11, 2014

All things are created twice. There’s a mental or first creation, and a physical or second creation.

Stephen Covey

Begin with a good plan …

- Maps
- Equipment
- Study terrain
- Plan path
.. to guide the rest of your journey

- Design
- Implementation
- Testing
- Presentations
- Teamwork

Outline

Tonight
- Draft A instructions and guidelines (Tallman)
- Panel Discussion: Some past project proposals
  - Digitally Configurable Lab Platform for Design-Oriented Teaching of Analog Electronics (Miad Fard, Richard Medal, 2013)
  - Modelling the Human Cardiovascular System (Nima Yasrebi, 2014)
- After the lecture
  - Q&A (Taglione)
  - Meeting with students not yet registered (Phang)
ECE496Y
Draft Proposal

Dr. K. Tallman
Engineering Communication Program

Draft Proposal Due Dates

- Two draft iterations of your proposal:
  - Draft Proposal A: Tuesday, Sept. 16, 3pm, SF B670
  - Draft Proposal B: Tuesday, Sept. 30, 3pm, Boxes SF B560
Draft A Sign-Up and Submission

- Tuesday, September 16, 9am-3pm:
  - Sign up for a Writing Instructor meeting on the sign-up sheet posted in SF B670. (Be sure whole group can attend.)
  - Write down Session Code, e.g., A28100, and Meeting Date, Time, and Place on the Draft A Feedback Form.
  - Note meeting details in your calendar.
  - Staple Draft A Feedback Form to front of your Draft A Proposal
  - Submit proposal in drop box.

Purpose of Draft A Meetings

- Writing Instructors will provide feedback to help the revision and editing process.
- Writing Instructors will ask questions to help you clarify your ideas.
## Proposal Deliverables

<table>
<thead>
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<th>Draft A</th>
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<tr>
<td>Executive Summary</td>
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<td>Table of Contents</td>
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<tr>
<td>Background and Motivation</td>
<td>x</td>
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<tr>
<td>Project Goal</td>
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<tr>
<td>Project Requirements</td>
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<td>Validation and Acceptance Tests</td>
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<tr>
<td>Technical Design</td>
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<tr>
<td>‣ Possible Solutions and Design Alternatives</td>
<td>x</td>
<td>x</td>
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<tr>
<td>‣ Assessment of Proposed Design</td>
<td>x</td>
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<tr>
<td>‣ System-level overview</td>
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<tr>
<td>‣ Module-level descriptions</td>
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<tr>
<td>Work Plan</td>
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<tr>
<td>‣ Gantt Chart (with work breakdown)</td>
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<td>‣ Financial Plan</td>
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<tr>
<td>‣ Feasibility Assessment (resources, risks)</td>
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**Draft B Additions**
Proposal Deliverables

<table>
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<tr>
<td>Conclusion</td>
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<tr>
<td>List of References</td>
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<tr>
<td>Appendix A: Student-supervisor agreement form</td>
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<tr>
<td>Appendix B: Draft B Evaluation Form</td>
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<tr>
<td>Appendix C: Report Attribution Table</td>
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<td>Appendix D, E, etc.: Authors’ appendices</td>
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ECE496Y Draft A Feedback Form

Please fill in your project title, session code, and meeting details, and staple this form to the front of your Draft A Proposal.

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<table>
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<tr>
<th>Component</th>
<th>Description</th>
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Specific Areas for Improvement:
ECE496Y Draft A Feedback Form

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Defines the scope of the project. Function and constraints are verifiable and objectives are measurable. Requirements are solution-independent and support the project goal. Comments:

Describes possible alternatives and discusses design trade-offs. Comments:

Reading Material

Identifies skills, knowledge, and resources required to complete the project. Acknowledges credible risks the project could face and a mitigation strategy for these risks. Comments:

References

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**Challenges Writing the Proposal**

- Describing how the project fits in the world: past, present and future
- Stating the project goal as a goal rather than an implementation strategy
- Choosing verifiable functions and constraints and measurable objectives by which the project will be realized
- Creating feasible tests for the project goals
Key points from discussion of sample proposals

Background and Motivation
- Situation-Problem-Solution
- Background
- make good use of references
- Concise
- The importance of getting it right
- Everything else (e.g. Requirements) follows from it
- For research-oriented projects
- distinguishing your project's goals from that of the larger research effort
- e.g. Conducting a successful experiment vs. finding a cure for Cancer
- Project 2 shows the evolution
- Points from Project 2
- Clear criteria for success that can be verified. If not, reframe the problem
- Is it feasible? If not, reduce the scope of the project.

Goal Statement
- Directly follows from the goal
- What category is it: function, requirements or constraint?
- Can it be verified and/or measured? If not, rethink or reframe it. Could it be a problem with the scope of the project?

Project Requirements
- checklist
- Ties back to the Goal Statement
- Shows you've achieved your goal
- Can it be verified and/or measured? If not, rethink or reframe it. Could it be a problem with the scope of the project?

Validation and Acceptance Tests
- System-level validation for now, module-level validation comes later
- Think about what you show at the Design Fair
- Ties back to the Goal Statement
- System-level validation for now, module-level validation comes later
- The evolution of the proposal
- Figuring out what it is that you are truly trying to accomplish takes time and effort.

The clearer you make the proposal, the better the map you have to navigate with for the rest of the year.

Even successful projects encounter this challenge
Even research-oriented projects need a plan.

Project 1 Background and Motivation

**Background and Motivation**

Electrical and Computer Engineering (ECE) students at the University of Toronto (U of T) are required to take a set of core courses during their first two years of study. There are three introductory level electronics courses (ECE110, ECE212 and ECE231), all of which have a laboratory component where students are introduced to simple electronic circuits in a hands-on environment. The experiments are performed using 1970’s era breadboards[^1] and they allow students to explore fundamental electrical principles and gain familiarity with basic circuit components.

At present, the labs provide an excellent introduction to modern electronics, but breadboard technology is quickly becoming obsolete. The students spend too much time selecting components, wiring, and debugging the circuits. This leaves little or no time for students to gain deep insight into the circuit operation by varying voltages, resistances, and circuit configurations. This is especially noticeable with the more complex transistor circuits taught in ECE231. Additionally, the breadboard based labs do not expose students to real-world, industry-standard technology. Modern electronic systems are built using Printed Circuit Boards (PCBs), which incorporate surface-mount devices (SMDs) and integrated circuits (ICs). For these reasons, we believe that a more state-of-the-art approach would be highly beneficial to introduce students to modern electronic circuits.

In this project we will realize a PCB centric platform as a complete lab package designed to replace the current system used in ECE231.

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Project 1 Goal Statement

Our project goal is to develop a flexible hardware platform that utilizes industry-standard PCBs and SMD components to be used by students to perform analog circuit experiments based on the popular Sedra/Smith *Microelectronic Circuits* textbook used for ECE231.
Project 1 Project Requirements

Functional Requirements
- The design shall be capable of demonstrating experiments that are based on the material presented in the *Microelectronic Circuits* textbook by Sedra/Smith.
- The design shall allow students to change certain experimental circuit parameters such as resistance values, input signals, and circuit configurations.
- The experimental circuits shall be printed on PCBs and use only SMD components to introduce students to modern circuit design.

Constraints
- The design must be small enough to fit on a single lab station/workbench.
- The design must be compatible with current lab equipment such as power supplies, function generators, and oscilloscopes.

Objectives
- The design should be completed by January 2013 in time for ECE231 offered in the spring term.
- The design should be modular and open source to allow expandability to additional experiments, different courses, and/or unforeseen future applications.

Project 1 Validation & Acceptance Test vs Goal

Project Goal
Our project goal is to develop a flexible hardware platform that utilizes industry-standard PCBs and SMD components to be used by students to perform analog circuit experiments based on the popular Sedra/Smith *Microelectronic Circuits* textbook used for ECE231.

Validation and Acceptance Test
To verify the functionality of our project ... The final product will eventually be distributed to each of the lab stations used in ECE231... <description of a sample op amp lab experiment> ... the new platform will only be given to a select number of volunteer students in the spring semester. This sample group can provide feedback on how effective the new platform is from a student’s point of view. Feedback can be obtained from student surveys, Teaching Assistant (TA) interviews, and by comparing practical understanding of lab content between students who used the current breadboard system versus those who used the new PCB platform.
Validation & Acceptance Test

To verify the functionality of our project ... The final product will eventually be distributed to each of the lab stations used in ECE231... <description of a sample op amp lab experiment > ... the new platform will only be given to a select number of volunteer students in the spring semester. This sample group can provide feedback on how effective the new platform is from a student’s point of view. Feedback can be obtained from student surveys, Teaching Assistant (TA) interviews, and by comparing practical understanding of lab content between students who used the current breadboard system versus those who used the new PCB platform.

All PCB boards will go through testing procedures to ensure full compatibility with the lab equipment and experiments used with the breadboard system. These procedures are presented in the table below.

Table 1. A list of components to be tested along with procedures and validations

<table>
<thead>
<tr>
<th>Component</th>
<th>Procedure</th>
<th>Validation</th>
</tr>
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<tbody>
<tr>
<td>Circuit Design</td>
<td>Before the design of the PCB the circuit must be simulated using all the parasitic (capacitance, resistance, etc.) of the SMD components found in their respective datasheets</td>
<td>The simulations will be compared to ideal circuit models to ensure proper functionality. Sample results can be found in Appendix D</td>
</tr>
<tr>
<td>Firmware Code</td>
<td>The software used to operate the PCB will have to be tested before being applied to the actual board to avoid damages. The code will instead be tested in a virtual environment</td>
<td>The code will be tested for correct compilation and functionality in a virtual environment</td>
</tr>
<tr>
<td>PCB Design</td>
<td>Once the circuit is designed and a firmware coded, the PCB will be designed, assembled and tested. The boards will go through experiments performed in the lab</td>
<td>The results must match the simulations performed on the ideal circuits and also what is expected from a theoretical stand point of the circuit being experimented on</td>
</tr>
</tbody>
</table>

Project 2 Background and Motivation

According to Canadian Heart and Stroke foundation, cardiovascular diseases are causing 29% of deaths in Canada[1]. One of the novel ways is to use numeric solvers or modeling to simulate the behavior of the vessels to increase our understanding of the underlying processes[2]. Currently there are two different approaches for approximating the solution. One is the use of non-linear numerical solvers to directly calculate their behavior, without any simplifications to the governing differential equations. However, this approach is very time consuming, as it requires three days of computation time for modeling only five artery system[2]. Thus, it is not feasible to use this in real time processing operations.

Another existing solution is to linearize the equations governing the flow before modeling. This simplification allows for much faster calculations, while having only small deviations from the actual results [2]. Additionally, because of the similarities between the physics the fluid mechanics and electrical transmission lines, it is possible to turn the linearized equations governing blood flow into circuits. This is done because of the overwhelming ability of modern circuit simulators. That is, it is easier to model the blood vessels in circuitry rather than trying to directly understand the behavior of the vessels.

In this project, we build on the previous progress done in electric simulation of the cardiovascular system, by accounting for nonlinear effects and streamlining the calculation process to gain faster runtime speed than the aforementioned numerical nonlinear modeling. To achieve this, we will be modeling the Navier-Stokes equations which are the underlying governing equations for the physics of cardiovascular systems[3]. We will be removing the linearizing constraints one by one, and hope to build a circuit system which is not limited by the simplifications of linearizations, but still has the speed due to the use of circuit stimulation.
Project 2 Goal Statement and Requirements (initially)

Goal
This design is intended to a cardiovascular system to predict the future state of the system to assist the surgeons during surgery and alarming heart diseased patients of upcoming threats.

Project Requirements
There are several factors which have to be considered during the design process and some would be used as guidelines for helping during decision making processes. Some of which are as follows:

Functions:
The design intends to address following factors:
- Receive each Heart pumping pattern for modelling the source behaviour
- Predict the stabilized pressure state of the body.
- Predict the future state of the body.
- Visually graphs the current and future states of the system.

Project 2 Evolving the Goal Statement …

Project Goal (initial)
This design is intended to a cardiovascular system to predict the future state of the system to assist the surgeons during surgery and alarming heart diseased patients of upcoming threats.

Project Goal (final)
The goal of this project is to create an accurate circuit model of the cardiovascular system so that we can obtain information about the pressure and flow rate at various junctions of the system. This will be compared with work done by the previous group and by the work done by graduate students.[1]
Project 2 Goal Statement and Requirements (final)

Project Goal (final)
The goal of this project is to create an accurate circuit model of the cardiovascular system so that we can obtain information about the pressure and flow rate at various junctions of the system. This will be compared with work done by the previous group and by the work done by graduate students.[1]

Project Requirements (final)

Functions:
- The design shall simulate the cardiovascular system using a circuit model
- It shall produce a visual representation of the flow rate and pressure at each artery

Objectives:
- Its runtime time shall be within seconds to minutes for it to be comparable with the fastest existing solution [1]
- Its accuracy should be at least 95% matching with results from numerical solvers of the graduate students, and its error should be less than the circuit with linear lumped elements [1]

Constraints:
- The design shall use the PSpice circuit simulation program.
- The solution shall be in the form of circuit diagram.

Project 2 Validation & Acceptance Test vs Goal

Project Goal
The goal of this project is to create an accurate circuit model of the cardiovascular system so that we can obtain information about the pressure and flow rate at various junctions of the system. This will be compared with work done by the previous group and by the work done by graduate students.[1]

Validation and Acceptance Tests
To verify that our design, we will compare the output from our new preprocessor with the output from the linear case and with the graduate students work [1] with the following requirements:
- Our output shall have at least 95% correspondence with the output of the graduate student's. This can be verified by extracting the data output from LTSpice to MATLAB and using numerical analysis to compare each of the values. A graph of the relative percentage error will be shown and the average error will be calculated.
- We shall test the speed of simulation of our nonlinear circuit by running it 3 times with a single artery in our model for both the linear and nonlinear case. We expect the speed for modelling a single artery in the linear case to be under 1 second, the speed for the nonlinear case to be under 3 seconds.
Some comments

- Tutorials held next semester and teams attend only two nights (1 practise, 1 grading)
- Online submission done through the registration website [https://ece496.ece.toronto.edu](https://ece496.ece.toronto.edu)

<table>
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<tr>
<td>Proposal Draft B</td>
<td>2014-09-30 15:00:00</td>
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<td>2014-10-16 15:00:00</td>
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<td>Individual Progress Report</td>
<td>2015-01-15 15:00:00</td>
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<td>Group Final Report</td>
<td>2015-03-19 15:00:00</td>
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