The Alpha Experiments

and

Omega Explorations

Contents

Welcome

Overview

First-Year students will be introduced to core concepts in ECSE through the hands-on laboratory experience. Each lab has an option to build and explore designs that use the core concepts learned in the class. Alpha Design Experiments are a guided approach to design, while Omega Explorations allow a student to make choices about their path to design based on their personal interests within the discipline.

You will not be graded only on the overall functionality of your design. Instead, *your grade will be based on how well you document your Proof of Concepts which requires mathematical analysis, simulation, and experiment and discussion/comparisons*. Omega Explorations will require a 5-minute video presentation AND an Exploration Document that tells us 1. The skills you learned along the way 2. Any failures and troubleshooting you had to do 3. DETAILS on the deeper depths of knowledge you need to overcome that failure 4. The future course or courses that might help you understand!

How Do Alpha Experiments and Omega Explorations Work?

Each student group will be required to decide what type of Design approach they will approach for each of the three Labs on Alpha/Omega Lab Design Ideation and Planning Day. On this day, each group will submit a course plan and decide their path throughout the course.

Switching Between Alpha and Omega Labs

You don't have to do Omega-Labs for the entire semester, in fact, you can go in and out of Omega-labs. Because both Alpha- and Omega-labs are based on the Course Concepts, it's easy to apply some concepts in your Omega-lab design and use alpha labs to 'fill-out' the others as needed. This can mean doing Omega-Labs for only part of the semester. For example, you may do Alpha-Labs for the first Lab, and Omega-Labs for Labs 2 and 3. **In Intro to ECSE you will most likely do multiple small design projects instead of one big design project. If you do have a plan to connect 2 or 3 concepts, that is above and beyond the requirements for this First Year course.**

Alpha Experiment and Omega Explorations Differences

Highlighted Differences	Alpha Experiments	Omega Explorations
Learning Approach	Bottom-up Step by Step, Guided Design	Open-Ended Explorations of Design Ideas
Relationship to Concepts in Class	Automatically written to be directly related	Student must create and show how the design is directly related
Documents/Assessment Required	Proof of Concepts	1. Proof of Concepts 2. 5-minute or less Demonstration Video (Presentation) 3. Exploration Map
Planning Need	Just keep up with class schedule	Be sure to look ahead and plan for the work over the semester
Benefits	Learn how to design after step-by-step experiments, some iteration required	• Learn to design with high risk, failure, more iteration • Get out of final IF all requirements are met.
Portfolio Content?	Yes! Your design belongs in your portfolio. Don't forget to add it!	Yes! Your design belongs in your portfolio. Don't forget to add it!

Are Omega Explorations Right for You?

Unlike Alpha Experiments, Omega Explorations are not consistent, straightforward, and predictable in terms of difficulty and time. Omega Explorations are potentially unpredictable and require you to be more involved. However, Omega Explorations provide many things Alpha-Labs do not: **the freedom to build whatever you want and the chance to practice what engineers really do: *design***. To decide which lab is best for you, think about your time constraints for the rest of the semester and what classes you're taking. Consider too that you could use your Omega Exploration project in another class like Intro to Engineering Design or independent study. Think about how you learn best as well - do you need a structured assignment to learn, or do you do best by diving in and creatively applying the concepts?

Grading

You will <u>not be graded only on the overall functionality of your entire circuit</u>; If your whole interconnect designed simulation, circuit, or project does not work, you may not lose any points from your lab grade. One purpose of the Omega Design Exploration is to give you a safe space to try new things and fail. In addition, we are requiring you to dig as deep into a failure/lack of understanding as possible by figuring out the knowledge you may need to help you complete the work AND the courses that might get you there in ECSE or at RPI! By not grading you on the functionality of the whole circuit, we hope to encourage exploration and to allow you to experience and learn from failed designs.

You will be graded based on your progress, documentation, iteration, and your Proof of Concepts. The grade distribution is meant to distribute the grade evenly between mathematical analysis, design, and progress.

Omega Exploration Requirements for Opting out of the Final and Grade calculation

TO OPT OUT OF THE FINAL, YOU MUST:

1. Complete all lab assessments with a grade of 80% or above (combined average for each lab)
    a. Proof of Concepts
    b. 5-minute or less Demonstration Video (Presentation)
    c. Exploration Map
2. The complete 100% of your individual Proof of Skills
3. Complete 2 out of 3 Omega Lab explorations (meaning you can switch to Alpha one time!)

If you don't meet the grade requirement, there will be an opportunity during the semester to optimize your system for each lab and earn some points back.

Lab Documentation Grade (30% of overall grade)

Assignment	Grade Percent
Proof of Concepts	33.3%
5-minute or less Demonstration Video (Presentation)	33.3%
Exploration Map	33.3%
Course Plan for Labs	Check off

Individual Grade (15% of overall grade)

Assignment	Grade Percent
Proof of Skills	100%

Lab Requirements

The following is a short description of the assignments you must complete at the end of each Lab for Omega Explorations. Make sure you use the corresponding assignment template to find more detailed information and to complete each assignment.

What to do in a Lab Session

1. Choose your general design path or idea as it relates to the core concepts being taught in the lab.
2. Determine what equation governs your design and which Concept it corresponds to.
3. Create a block diagram of your system to document the main functional blocks and their inputs and outputs.
4. Decide how you want the circuit or simulation to function and mathematically analyze it using that Concept.
5. Create it in LTSpice or MATLAB Simulink and confirm that calculated values allow the circuit or system to operate the way you intended. If not, check your simulation or go back to step 3.
6. Implement a physical version of the circuit or system if possible and confirm that it operates as predicted by your calculations and simulation. If not, check your wiring or research non-idealities that may cause the circuit to operate differently.
7. Use the prior steps to fill out your Proof of Concept.
8. Document any new skills or knowledge gaps as you proceed through your exploration of the design.
9. Use the phrases from your knowledge gaps to search for RPI courses that might help you accomplish your design goals in the future.
10. Write down any questions you have for the instructors or course staff that came up during your Omega Exploration.

This workflow is intended to help you through the design process for creating your building blocks. The Proofs of Concept and the process you went through to create them will then be highlighted in your Exploration Map.

Project Plan

The Project Plan (document can be found here) is a sheet that is meant to help you plan out your project, and it helps both you and the TA make sure that project scope is reasonable. The Plan asks you to outline what your project is, why you want to do it, what circuits you will need to build, and what goals you want to achieve in each Milestone period. We'll do this as a class on Alpha/Omega Lab Design Ideation and Planning Day.

Proof of Concepts

See the Proof of Concepts assignment for more details, an assignment template, and examples.

The Proof of Concepts (document can be found here) demonstrates that you can apply the mathematical concepts you are learning in the course to your circuit. The Proof of Concepts should represent the analysis you've done to design your circuit, program, or system. For each concept, you should include:

- Header with concept name
- The name of the building block to which it corresponds
- A labelled circuit diagram
- A 1-2 sentence description of how you are applying the concept and what circuit variables you are analyzing to demonstrate it
- A mathematical analysis
- A simulation and plot
- A measurement and plot
- A brief discussion of the results
- An explanation of how this analysis helped in circuit design

See the example entries on the course website. Keep in mind that these entries do not need to be long - in fact, keep them as brief as possible! **You can apply multiple concepts to the same circuit.** Additionally, you can apply concepts to a circuit not in your final project, say a discarded design, so long as you support that the analysis of that circuit helped you to arrive at your final design.

Concept List (Proof of Concepts)

Concepts in Blue are Explorations beyond Intro to ECSE basics to consider depending on your interests

Lab 01: Basic Analysis and Engineering Practices

1. Ohm's Law
2. Polarity
3. KVL
4. KCL
5. Circuit Reduction of Parallel and Series Resistors
6. Voltage Divider (their applications)
7. Bridge Circuits
8. R-2R Ladder Resistor Networks

Lab 02: Linear Systems and Beyond

1. I-V Characteristic of a Resistor
2. Non-Linear I-V Characteristic of an LED
3. Differential Resistance of a Diode
4. Nodal Analysis
5. Design with Nodal Analysis
6. Operational Amplifier as a Comparator
7. Operational Amplifier as an Amplifier
8. Sensor Decision Circuit (Alpha)
9. Transfer Functions (Omega)
10. Linear Algebra (Omega)
11. Non-Linear Diodes (Fabrication, Microelectronic/Photonics Device Physics)
12. Eigenvalues and Eigenvectors (Imaging)
13. Principal Component Analysis (Imaging)
14. PID Control (Control Systems)

Lab 03: The Signals and the Noise

1. Adding Signals
2. Deconstructing Signals (Fourier Analysis)

3. Reconstructing Signals (Fourier Synthesis)
4. Analog First Order Passive Filter
    a. Must Analyze:
        i. Transfer Function
        ii. Bode Plot
        iii. Cutoff Frequency
        iv. Roll-Off in dB
5. A) Associate Audible Features of Signal with Frequency Spectrum

   B) Design of Audio Signals
6. Removing or Isolating Frequency Ranges with a Filter
7. Pulse Width Modulation
8. Amplitude Modulation
9. Phase Modulation
10. FFT and Spectrum Analysis
11. Schmitt Triggers vs. Comparators for Noise Reduction
12. DSP Filter implementation for audio sample in Simulink

Presentation

This is an informal presentation to the TAs and Professor to demonstrate the functionality of your circuit and discuss progress. In this presentation, you should check this document for full details.

You can include anything else you deem *necessary*. The presentation is a good opportunity to get feedback and ask for advice. Plan for this to take ~5-10 minutes.

Exploration Map

The purpose of the exercise (document can be found here) is for you to explore ideas and concepts beyond your knowledge and beyond the concepts in this course. It is important as an engineer and lifelong learner to define what you don't know and find paths to explore what you don't know! By doing so, you may find interesting connections to future courses and real motivations to develop the appropriate background (math courses, core ECSE courses, ECSE electives, courses in Physics etc.) to achieve your overall goals!