EE155/255 F17 Project Proposal

Assigned 10/23/17
Due 10/30/17

Summary

Starting November 6 you will be working on your EE155/255 project. The project is intended to give you hands-on experience with a Green Electronics system. Between now and November 6 you will develop your project proposal. The proposal will describe what you hope to accomplish with your project, what the deliverables will be at the end of the project, what the key issues are, and what intermediate milestones you will achieve. Pay particular attention to the weekly checkpoints. You need to plan appropriate amounts of work each week – and complete the checkpoints – or you won't have a working project at the end.

Specifically your proposal should have the following sections:

Team	Who is working together on this project. Submit just one proposal for the whole team.
Topic	What you plan to do in a sentence or two. For example: "implement a prototype GaN buck converter" or "build a 3-phase inverter and control for brushless PM motor drive" or "build a multi-level converter to drive a high-voltage DC transmission line".
Technical Approach	Explain your technical approach – draw a block diagram, describe key components, describe your control algorithm, etc…
Deliverable	What you will produce at the end of the project (December 16). For example, "working prototype" or "demonstrate a working SPICE simulation with all key parasitics modeled".
Issues	Explain what the key problems are and how you plan to solve them.
Checkpoint 1	What you plan to have accomplished by checkpoint 1 (Nov 13)
Checkpoint 2	What you plan to have accomplished by checkpoint 2 (Nov 20)
Checkpoint 3	What you plan to have accomplished by checkpoint 3 (Nov 29)
Checkpoint 4	What you plan to have accomplished by checkpoint 4 (Dec 6)

Process

Please start early on your proposal and come to office hours to discuss possible topics and plans with Professor Dally and the TAs. You can also bounce ideas off the course staff via e-mail or make an appointment to meet outside of office hours. A good proposal requires iteration. Your first proposal will almost certainly have some problems. It will be greatly improved by discussion and iteration. The goal of the proposal assignment is for you to complete these iterations before the clock starts on the project assignment.

Scope

You have only 39 days to complete the project and need to be realistic about what you can accomplish in one month (including Thanksgiving break). You can build a working prototype of something very simple (e.g., a buck converter) or you can investigate and simulate something very complex. It is unlikely that you can build a working prototype of something very complex in one month. If you want to take on a complex topic, plan an appropriate deliverable. You can always complete a working prototype as an independent study project in Winter quarter.

Suggested Topics

The following is a list of possible topics. You can choose one of these or come up with your own:

Efficient power converter	Pick a power conversion application (e.g., 12V to 1V computer supply, 120V to 20V charger, 480V to 1V computer supply, etc…) and design the most efficient converter you can for this application. You may want to characterize the Pareto-optimal tradeoff between cost and efficiency.
EMI Analysis and Measurement	Measure the EMI from a converter. Modify the design to reduce the EMI to specified limits.
Thermal Design	Design a system to remove a specified amount of heat from a particular component – (e.g., 50W from a TO220) with a minimum volume, mass, cost, and energy overhead. Build a prototype of your system and measure its performance.
3-Phase brushless motor drive	Develop a controller and power path to drive a 3-phase brushless permanent magnet motor. Explain how you will sense angle, what parameter you will control and what your control strategy will be.
Sensorless brushless motor drive	Like the above but with no explicit sensors (other than voltage and current sensors on the phases) to determine angle. Explain how you will sense angle from current and voltage – either actively or passively.
AC induction motor drive	Develop a controller and power path for an AC induction motor.
Efficient multi-level utility-scale PV inverter	Develop a simulation model of a PV inverter that uses multi-level techniques to eliminate the need for a final step-up transformer in utility-scale PV systems. You could either simulate the "module" that connects one

	1kV string to the three phase "stacks", or the overall system. Develop and evaluate a control strategy for the converter.
Module design for multi-level utility-scale PV inverter	Pick a module of the prototype multi-level PV converter. Characterize the module and design an improved module.
Intelligent PV module	Develop an intelligent PV module that supports one or more of: automated shutdown, arc-fault detection, V_{oc} limiting, per-module MPPT optimization.
Battery characterization	Characterize a particular battery (e.g., an 18650 LiFeP cell) collecting data on charge and discharge curves as a function of temperature and age. Also characterize mismatch between cells. Explain how your findings impact battery management.
Battery charger	Design a battery charger for a particular battery system.
Battery management system	Design a battery management system – includes charging, monitoring, cooling, etc… for a particular battery and application (e.g., electric vehicle.)
High-Voltage DC Converter	Design a converter that converts from moderate voltage (500V) AC or DC to/from high voltage DC (100kV) using the modular-multi-level concept.
Inverter	Design a grid-connected inverter. This inverter will need to track grid voltage and inject its current with unity power factor. Ideally it should have "anti-islanding" features.
Off-Grid Inverter and Battery Management	Design an off-grid inverter that connects PV modules and batteries to an off-grid 240V (center tapped) 60Hz electrical system. It should manage MPPT of the PV modules, charging and equalization of the batteries, and generating AC for the electrical system.
Transformerless Inverter	Design a grid-connected inverter using one of the newer "transformerless" inverter topologies.
Inverter with DC Link	Design a single-phase inverter that maximizes the efficiency of energy storage during the null of the AC cycle by using a topology with three ports that can transfer energy from the PV port to the storage port or AC line port and from the storage port to the AC line port.
Soft Switching	Design a converter with some form of soft switching: quasi-square wave, quasi-resonant, fully resonant, etc....
Photovoltaic controller/optimizer	Design a PV MPPT or optimizer.
Optimized gate drive	Study how to optimally drive the gate(s) of the FETs

	or IGBTs in a particular converter topology.
Teardown and analyze X	Teardown some existing piece of Green Electronics equipment and analyze its design.
Evaluate a novel component	Evaluate emerging component technologies such as SiC FETs and diodes and GaN FETs. Compare the cost effectiveness of these components to existing technologies.
Control Strategy	Develop and evaluate a new control strategy for a Green Electronics application – such as controlling a power converter or electric motor. For example, use model-based control to give very fast response to an output current transient – in one or two switching cycles.
Build Infrastructure	Build a piece of infrastructure that could be used in future EE155/255 offerings. Possibilities include developing a new compute board (and software library) using an Arduino Teensy or developing a brushless DC motor driver and lab.

Suggested Deliverables

Your end of project deliverable may be one of the following. In addition to these, all projects will need to produce a web page documenting their project. The requirements for this web page will be specified in the project assignment.

Working prototype	Fabricate, demonstrate, and evaluate a working prototype. This is feasible in the time available for only the simplest of projects. More complex projects can build prototypes as an independent study in later quarters.
SPICE Simulation	Develop a detailed SPICE model of your project including accurately estimated parasitics, detailed models of switching devices, models of magnetics losses, ESR and series inductance of capacitors, etc… Demonstrate and evaluate your design using SPICE.
Analysis	For some projects – e.g., battery characterization – the deliverable is a report reporting on the results of your analysis.