

# ECE 4890 Spring 2012: Design Project RFPs

*Revised 4/06/2012*

## Introduction

This document contains inputs received from the outside sponsors, faculty members, and other interested parties, with regard to senior design project ideas. The names of the submitters is available by request. When you have formed a possible design team, request project contact information from Dr. Wickert, and proceed to interview the submitter/customer for more details, and perhaps the formation of a preliminary requirements specification.

As more RFPs are submitted to me, they will be integrated into this document. Check back for additions and changes.

## RFPs

### Project 1: Medium-Voltage Distribution Automation

#### *Introduction*

Colorado Springs Utilities (CSU) seeks the assistance of a contractor in proving a concept as part of its initiative to develop a Smart Grid program.

Remotely-controllable devices are desired by CSU for the purpose of automatically restoring power to electric customers following an interruption in service (i.e., an outage) on its distribution system. Existing equipment that is currently installed is manually operated by sending a person out in the field to troubleshoot, isolate, and restore power. This equipment was not designed for remote sensing and control, and it has no onboard intelligence.

As equipment in the field comes due for replacement, or an increase in reliability is necessary on a circuit, CSU desires to investigate upgrading, replacing, and/or updating it to provide for additional functionality and possibilities for future Smart Grid integration. Experience gained by CSU in the sub-transmission use of remotely-controlled switches should be generalized to the distribution system.

#### *Product*

The outcome desired by CSU for this project is a prototype switching apparatus with remote control, fault sensing, automatic fault isolation, automatic outage restoration of non faulted segments, and measurement capability. Additional automatic features such as generator synchronizing will be explored, to provide future capabilities in the implementation of Micro Grids.

#### *Requirements*

The project team will need to:

- assess the capabilities and condition of equipment presently in service in the CSU distribution system

- research existing equipment that is available commercially
- determine how to integrate the intelligence into the distribution system for the desired results
- work with CSU employees to develop a list of necessary features and design criteria
- work with CSU employees to evaluate design ideas
- test control systems for functionality

### Constraints

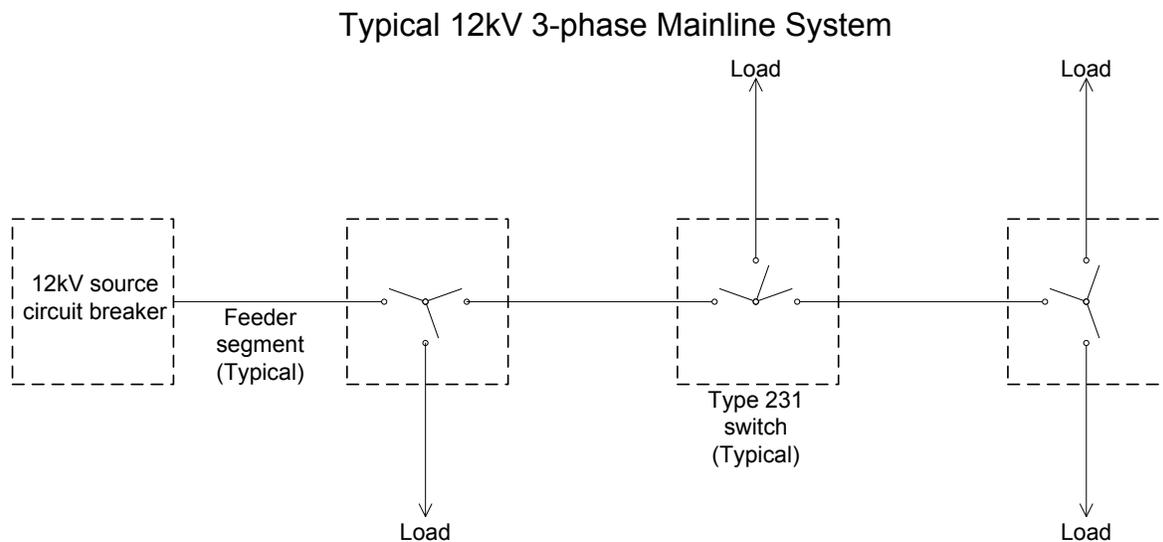
High-voltage equipment will be part of the product. It is anticipated that CSU will make work space available in a laboratory on CSU property in order that the project team may test the product.

Any product developed in the course of this project shall be suitable for installation and operation outdoors in all kinds of Colorado Springs weather.

Communications, processing, and control equipment shall be battery-powered, with charging power taken from the medium-voltage distribution system. A 30-year service life is expected. CSU has a budget for this project, including research and development.

### Application

CSU desires a device to replace or modify the existing padmounted, metal-enclosed equipment that is known internally as the Type 231 Interrupter Switch. The device shall have intelligence to be able to detect faults at any of the segments of a 12.47-kV, 600-Amp feeder as shown in the one line schematic diagram below:



The automated devices need to communicate with each other, and with the source circuit breaker, to automatically determine the location of a short circuit, isolate the shorted segment between automated devices, and restore as much of the feeder as possible and as quickly as possible.

The automated devices will report remotely, “pre-outage” and “post-outage” conditions to the CSU control center via the existing Supervisory Control And Data Acquisition (SCADA) system.

Project scope will include comparison of at least three devices before a preferred option is chosen. The devices compared can be any combination of a complete replacement, an upgrade, or modification.

### Areas of Engineering

- Electric Power Systems – three-phase power
- Communications – relatively low-bandwidth data with small latency
- Control Systems or Robotics – control of a motorized medium-voltage switch

### What the Student Gains

The student participating in this project will gain experience in combining integrating different specialties within the Electrical Engineering curriculum to produce a useful device, apparatus, or system. The student will learn to communicate interpersonally with people in various trades and disciplines to learn their expectations and to address their concerns.

## **Project 2: Solder Reflow Oven**

### Problem Statement

The EE/CE programs at UCCS currently require all students to complete a Senior Design project, as a way of demonstrating that the knowledge gained over a student’s academic career can be applied to the “real-world” problem of creating a product capable of meeting a customer’s demands and solving complex engineering problems. Many of these projects require students to design custom printed circuit boards as part of the implementation of their final design. Currently, the University does not have any capability to perform printed circuit board population on site, requiring all student boards using surface mount technology to be sent out for reflow to local industry sponsors or painstakingly hand-soldered. By bringing a small solder reflow oven onsite, the university would be able to accommodate the vast majority of board population work required for Senior Design, as well as offer students invaluable hands-on experience with the skills needed for creating a populated board - from stencil work to device placement and reflow profile design.

### Specifications

- The proposed design must be able to replicate the reflow profiles specified by IPC Test Method 650 (see section 5.2, IPC-TM-650 Test Methods Manual, attached)
- Additionally, the design must be able to accept and store up to ten student-designed reflow profiles up to three steps long (presoak, heating to solder liquidus and hold, cooling); a “step” is defined by a stored temperature set point and length of time
- The design must have a display and user interface for selecting and designing reflow processes. This user interface should be able to display a profile number, step number, temperature setpoint, and time setpoint, with simple pushbuttons for adjusting each of the aforementioned parameters.
- The design must have a feedback loop monitoring reflow chamber temperature, so that temperature set points can be properly maintained

- The design must have datalogging capability, to store the actual temperature and time values a project is exposed to during the reflow process
- The device must interface with a Windows PC so that the datalog may be imported into spreadsheet software (such as Excel) for analysis and generation of temperature/time graphs
- As a stretch goal, a PC-based user interface will be designed that will integrate all features listed so far - profile design and storage, datalogging, and data analysis - into a single application which will be used to create a reflow profile, initiate reflow, automatically generate a temperature/time plot, and flag any anomalies in the performed reflow (e.g. time above liquidus point too long).

### Verification

Verification of the design shall be accomplished through a final acceptance test, in which a sample circuit board will undergo a reflow profile as outlined in IPC-TM-650. The circuit board will be examined for solder joint quality - e.g. no cold solder joints or other wetting anomalies - and the temperature/time datalog will be examined to ensure that the specified profile was properly executed, with times and temperatures within the specifications outlined by the IPC specification.

## **Project 3: Real-Time Audio Pitch Shifting**

### Introduction

This project involves performing DSP functions on an FPGA development board and implementing frequency scaling (pitch shifting) on streamed audio (real-time). A DSP algorithm needs to be designed that will scale down the frequencies between 4k – 20k to the 20 – 4k range. The algorithm needs to minimize harmonic distortion and aliasing. The algorithm needs to be designed such that it can be implemented on a general purpose FPGA.

### Project Description

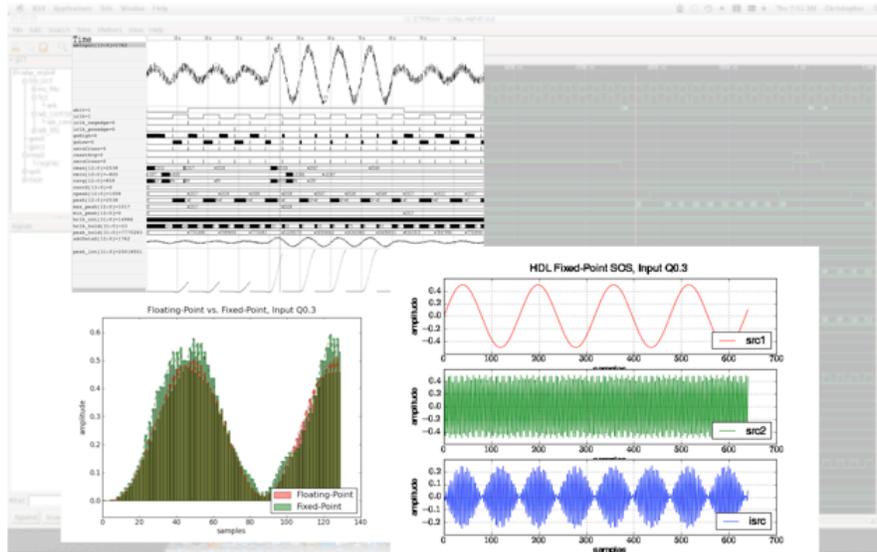
1. DSP frequency scaling (pitch shifting) algorithm that minimizes harmonic distortion and aliasing and is also suitable for FPGA implementation.
2. FPGA implementation of the frequency scaling algorithm. A framework will be provided to interface to the hardware.
3. PC application to stream audio data to the FPGA board (framework provided). Also integrated into the application should be algorithm analysis to quantify the real-time algorithm [optional].

### Project Support

A USB FPGA Audio board will be provided and the students need to design and implement the previously described system. The basic framework for interfacing to the hardware and USB will also be provided. This project can be used in a real-world applications that includes but not limited to, accessibility, audio effects, etc.

In addition, a design contest will be held in the Fall of 2011. The above project will also be the design topic for the contest. Students can submit their designs for a chance to win a development board and a \$100 Amazon gift card. The contest will be announced in late September. More infor-

mation and a framework will be provided to get started. See the last design contest for an example. See [www.dsptronics.com](http://www.dsptronics.com) for previous contest information.



## Project 4: Verilog Linting Tool

A linting tool is a tool that checks that a verilog design can be synthesized, simulated, tested, and adheres to company specified coding guidelines. A verilog design that is synthesizable can be translated to gates and implemented in an ASIC or FPGA. Testbenches are typically not synthesizable.

An example of a commercial linting tool is Synopsys's Leda RTL Checker. Details on Leda can be found at <http://www.synopsys.com/tools/verification/functionalverification/pages/leda.aspx>. UCCS has Leda installed on the Linux server LATS2.

### Project Need

Students in the ECE 4242/5242 Advanced Digital Design Methodology course often find that their coding style is not synthesizable and does not adhere to coding guidelines like number of comments, usage of the compiler directive. ``default_nettype none`, etc. When they take a follow on course to ECE 4242/5242 like 4200 Advanced Digital Design Methodology lab or 4211/5211 Rapid Prototyping with FPGA's they often find that their designs have to be completely rewritten to be synthesizable. It is desired to provide this feedback earlier in the ECE 4242/5242 class.

### Project Description

This project involves creating a linting tool to check for synthesizability and adherence to coding guidelines. The tool should be able to be used on a windows based PC using only a minimum of freely available software. Portability to a Linux based OS would be a plus. The tool is intended to be installed on any machine that students create their design on. This could be a personal PC, RATS, or the machines in EN229 or EN233. A web-based tool might be a good solution.

There are 3 main tasks to this project:

1. Create the linting tool

2. Create test cases for the linting tool. These test cases will be written in verilog and will contain code that should pass or fail when the linting tool is run on them as well as expected output.
3. Create a testing environment that will run the test cases created in 2 and compare the output (i.e. warnings/errors) of the linting tool against expected output.

### Team Makeup

The team should be made up of at least 1 computer engineer with strong software skills. A team of size 2 is appropriate. The team members need to have earned a B or better in ECE 4242 and should preferably be taking or have taken 4200 and/or 4211/5211.

## **Project 5: A Club-Mounted Golfer's Swing Analyzer with Wireless Display**

### Introduction

Golfer's who take the game seriously are always looking for ways to improve their game. Golfer's who are on top of their game, want to stay there. A club-mounted swing analyzer has been developed, but is in need of product enhancement. The objective of this project is add a wireless data link to the existing product so that swing velocity profiles can be displayed on a PC graphical user interface, in near real-time. The golfer can then see if his or her swing is *up to par* (pun intended).

*Personal best* profiles and selected pro-golfer profiles will also be available for comparison. In this way the golfer can keep track of their swing history and experiment with different techniques to hopefully improve on their game.

### Product

The end result of this project will be a proof of concept demo system which utilizes the Texas Instruments (TI) eZ430-Chronos Quick Start to wirelessly transfer golf swing velocity profiles to a PC graphical display. The existing product will also need to be ported to the CC430 family, which is the microcontroller + radio chip combination utilized in the eZ430 Chronos kit. On the PC host a software application will be written which post processes the club swing acceleration data into a velocity profile, plots the data, and allows for further analysis of the data

### Application

Provide amateur and pro-golfers with a reliable tool for perfecting their swing. In a future, beyond this project development, the wireless graphical display and software application will be posted to one or more popular smart phones. The solution will then be truly portable, allowing the golfer to compare their swing velocity profile to a database, anywhere on the course.

### Areas of Engineering

- Embedded systems design
- Graphical user interface software application development
- PCB design involving RF, analog, and digital circuit component layout
- Communications protocols at various levels and on more than one platform

*What the Student Gains*

Experience with embedded systems and wireless development tools, experience with PCB design, practical GUI design and software application development.