ECE 4890 Spring 2009: Design Project RFPs

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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: Satellite Simulator for Education & Research

Space technology serves as an effective focus for many multidisciplinary research and education initiatives. It's further been shown to be a highly effective motivational topic for students of engineering. A growing number of university engineering programs now include involvement with small satellite research (at both payload and system level); some have successfully placed satellites on-orbit and interact with their payloads via command and control stations located on-campus.

The intent of this project is to take the first step toward small satellite research at UCCS through the design and development of a highly adaptable, small-scale satellite simulator that can be used for both educational demonstrations and as a test bed for research. Although this project will not use space-qualified hardware, the simulator will reasonably represent the operation and dynamics of an orbiting satellite within the constraints of the laboratory/classroom environment and surface gravitational field.

Examples of cross-disciplinary technologies than may be integrated into a small satellite research program include: microwaves and lasers for energy transmission and communications, global positioning system applications, advanced nanosat propulsion concepts, materials and fabrication methods, power handling and electronics, and many more. The initial phase of this project will focus on integration of microwave technology for space-based power transmission.

Product

- Small-scale satellite simulator (nanosat: 1-10 kg or microsat: 10-100 kg) featuring:
  - On-board power
  - Single axis rotational freedom
  - Means of (single axis) attitude determination (e.g., gyroscopes, accelerometers, etc.)

- Means of (single axis) programmable attitude control (e.g., reaction wheel, reaction thrusters, magnetic torque rods, etc.)
- Means of command/control and telemetry 'downlink'
- Extensible design and architecture (i.e., students are laying groundwork for future development)
- Integration of microwave source for targeted transmission of power over a specified distance

Application

The simulator would be used for classroom demonstration (e.g., dynamics, feedback control, Kalman filtering, satellite attitude determination, etc.) and as a test-bed for research (e.g., feedback control algorithms, satellite pointing and tracking, etc.)

Senior Project End Solution

A stand-alone single-axis satellite simulator achieving the requirement set listed above.

Possible Areas of Engineering Required

- Understand materials and specifications required for small satellite design and fabrication
- Explore and select components for sensors and actuators
- Design, develop and implement feedback control system for single-axis attitude control
- Design, develop and implement communications system for two-way data link
- Design, develop and implement microwave source and antenna for power transmission

Project 2: Project 7: 16-bit ADC Simulation and Characterization

Product

One problem faced in analog and mixed signal ASIC design is the simulation of complex mixed signal blocks such as ADCs. This senior project will focus on simulating and characterizing a 16-bit silicon proven sigma delta ADC designed in either TSMCs 0.18μm or ON Semiconductors 0.5μm process. The students will use well known industry standard mixed simulation tools such as Mentor ADMS and Cadence AMS to simulate INL, DNL, noise, and offset and compare the results of the two simulators. The student will ultimately define a mixed signal simulation strategy for complex ADC's consisting of both digital and analog blocks. After simulation, the students will then design an automated bench characterization program using National Semiconductor's LabVIEW to characterize the aforementioned ADC specifications. The simulation results will be compared to the actual silicon characterization results for a comprehensive top to bottom analysis of a complex mixed signal ADC found in industry leading semiconductor design centers worldwide such as ON Semiconductor.

Application

Complex mixed signal system-on-a-chip ASICs used in medical, industrial, automotive, commercial electronics and other fields.

Senior Project End Solution

A simulated and characterized 16-bit sigma delta ADC.

Possible Areas of Engineering

- Electrical Engineering:
  - Analog/Mixed-Signal ASIC/ASSP design
  - ADC signal delta algorithm understanding
  - Mixed Signal Simulation
- Computer Engineering:
  - LabVIEW program and GUI design
  - Ocean script creation to automate corner simulations

What the Students Gain

Practical and relevant industry knowledge that will help the student get a job as an analog/mixed-signal ASIC/ASSP design engineer. The student will gain experience using bench equipment and simulation programs ASIC designer use on the job every day.

Project 3: Cemetery Security System

Product

This senior project involves creating a security system to put in a mausoleum to minimize and prevent vandalism. The system would involve creating a trigger element (must not damage the stone) that would be put in the mausoleum that would register any movement of the doors, send a signal to a control element in one of the offices that would be able to call or email management or security. This project involves hardware and programming elements. Because no wireless internet is available in the cemetery, other alternatives will need to be found.

Senior Project End Solution

The goal of this project is to build the entire security system and be able to implement it in the cemetery. The final product will be used in the cemetery as is when completed.

What the Students Gain

The students are able to apply their hardware and software skills to a real world application. The students will gain experience with having to be aware of environmental and safety concerns, due to the area in which the product will be implemented.

Project 4: Amateur Rocketry Flight Data Logging Device

Product

Amateur rocketry is enjoyed by enthusiasts worldwide. Individuals can invest as little as $20.00 to achieve flights in excess of 800-meters or many thousands of dollars to achieve impressive heights while carrying payloads. In all cases, individuals build the rocket and can optimize its performance. Unfortunately, there appears to be no inexpensive, robust, light-weight payload that could be attached to these rockets which could record critical flight data. The goal of this project is to build an Amateur Rocketry Flight Data Logging Device.

Application

Amateur rocketry enthusiasts are interested in recording key metrics on their flight, including total time of flight, height of the rocket above earth with respect to time, maximum height of flight, acceleration, velocity, and position. A recorder could be placed inside the rocket during its entire flight and record this critical information. Once recorded, the information would need to be transmitted to a computer for further analysis and logging. The recorder needs to be robust enough to record data reliably during flight and re-usable for later launches.

Senior Project End Solution

The ultimate goal of this Senior Design Project is to produce a recorder that profiles key rocket performance data during flight and downloads this data to a computer for analysis. A custom rocket will likely need to be built for holding this payload, and multiple test flights using different rockets with different performance will have to take place. The team will work with the advisor to balance keeping costs of the recorder low while maximizing features.

Possible Areas of Engineering

- Electrical Engineering: Custom PCB Design, Firmware Development, Data Transmission, System Design, Sensor Integration, Component Selection
- Computer Engineering: Communication with the device, data logging, data storage, data analysis tools
- Rocket Construction and Modification
- Feature vs. Cost Analysis
- Comparing Solution vs. Existing Products

What The Student Gains

The students on this design team will gain practical experience in taking a full product from concept to reality. They will engage in everything from component selection to testing, from analog design to software design. The sponsor may choose to post information about the student team, the design process, and recorder performance to a website later for other amateur rocketry enthusiasts to construct for themselves.

Project 5: Vehicle Diagnostic Logging Device

Product

Microcontrollers have revolutionized the amount of data that exists on a modern automobile's performance. Key metrics, such as vehicle diagnostic error codes, engine idle time, engine settings, and the data necessary to calculate fuel efficiency all exist as possible outputs to be quantified in today's ECU-based vehicle. The goal of this project is to build a system to capture and transmit this information to a remote receiver for processing and evaluation.

Application

Most modern commercial vehicles provide a standard OBD-2 diagnostic port. An ELM327 chip, coupled with a microcontroller, a Bluetooth module, and a modern smartphone may be combined to record and communicate key vehicle diagnostic data from the car directly to an interface understandable by the average consumer. All power for such a system could be drawn directly from the OBD-2 diagnostic port.

Senior Project End Solution

The ultimate goal of this project is to build the entire vehicle diagnostic logging system, demonstrating the ability to pull data off the OBD-2 diagnostic port at regular intervals, store the data in memory, process the data using the ELM327, transmit the data via Bluetooth to a smartphone, and display the data on the smartphone using a custom user interface.

Possible Areas of Engineering

- Electrical Engineering: Custom PCB Design, Firmware Development, Bluetooth Module Selection, System Design, RF Communications
- Computer Engineering: Smartphone Bluetooth Communications, Embedded Software Design on a Mobile Device, User Interface Design, Data Structures and Management

What The Student Gains

The students on this design team will gain practical experience in taking a full product from concept to reality. They will engage in everything from component selection to testing, from analog design to software design. The sponsor company may choose to use this as a prototype for launching a commercially viable product.

Project 6: Project: Underground Cable Ampacity Calculations

The Pueblo Chemical Agent Pilot Plant (PCAPP) project is currently under construction East of Pueblo, Colorado at the Pueblo Chemical Depot (PCD). The PCAPP project engineering design team working for Bechtel National Inc. (BNI) has a need to determine the amperage of 90 degree centigrade rated power cable installed in underground conduit and duct banks. It is known that temperature can adversely affect the amperage capability of a power cable system, and the PCAPP team wants to ensure design amperage requirements to installed equipment are achieved upon installation of the cable.

This senior design project involves collecting data from cable manufacturers (BNI to assist in identifying appropriate suppliers) and using the cable derating ampacity calculations found in the National Electric Code (NEC) to determine the effects of temperature, ground depth and duct bank configuration and loading on the cable's ampacity rating. Calculations will be performed on various cable types and sizes to be specified by BNI. Calculations to be electronically documented in a tabular form to allow for ease in reference when designing power system circuits and checking power cable installations in the field. Automating the process would enhance the results of the project.

Upon establishing this cable ampacity information, the UCCS team should attempt to contact EPRI (Electric Power Research Institute) and or an NRTL (Nationally Recognized Testing Laboratory) to obtain test data representative of the data and analysis done by the project team.

Project 7: Atmospheric Pressure Plasma Surface Processing of Solar Cells and Semiconductors

Atmospheric pressure plasmas are of considerable interest for material processing applications including surface coating, semiconductor etching, plasma cleaning, surface modification, and plasma polymerization. Processing materials at atmospheric pressure provides clear advantages over traditional, vacuum-based plasma processing. In addition to reducing the capital cost of equipment and eliminating constraints imposed by vacuum-compatibility, high-pressure and low-temperature plasma processes offer unprecedented improvements for the generation of active chemical species, high chemical selectivity, minimal ion densities that result in low surface damage, and surface-treatment methods unattainable by other means.

Senior design tasks

- Investigate the effects of plasma parameters (voltage, gas flow rate, and gap distance) on solar cell and semiconductor surface processing
- Obtain optimum condition for plasma cleaning of semiconductors and surface modification of solar cells

Application

Semiconductor and solar cell industry.

Possible areas of engineering required

- Electromagnetics,
- Material Science,
- Physics,
- Chemistry.

What students gain

Material surface analysis technique including operation of XRD (X-ray diffractometer) and various equipment, plasma surface treatment technique, knowledge of atmospheric plasma generation, solar cell and semiconductor surface processing.

Project 8: Multi-node 802.15.4 Radio Based Network with Network/DC Performance Characteristics Based on SOS Embedded Operating System

- Participate/drive the porting of SOS to Atmel based (RF230) hardware
  - Develop build tools for ATmega1281 + ATRF230 systems
  - Realize the implementation of SOS on these systems
  - Develop a sample application on SOS and Atmel hardware
- Performance characteristics
  - Publish network related metrics
    - » Network latency > 50 node network
    - » Network collisions, re-try, failure…
  - Power saving techniques
    - » Sleep techniques and associated power consumption
  - Geographical/geometric coverage per node

The SOS OS is managed by UCLA and is an alternative to TinyOS. It is completely C based and my serve to bring low power wireless networks to realization.

Required hardware will be provided by Atmel, Colorado Springs. Additionally, appropriate software tools and consultation with Atmel engineers will be made available.