# Senior Design Project Suggestions from ECE Faculty
# Spring, 2010

**J. Robert Boston**
Office: 438 BENDM
Email: boston@engr.pitt.edu

**Real-time Signal Processing Systems (with Mark Murawski, Vocollect)**

The goal of this project is to gain experience with hardware for real-time speech processing applications. The project is being conducted in collaboration with Vocollect, a global company based in Pittsburgh whose product, Vocollect Voice, talks workers with mobile jobs through their daily tasks, replacing traditional lists and traditional data capture methods with personal voice dialogues. They are interested in evaluating alternative hardware systems for potential use in their products. Groups interested in this project should include both EE's and CoE's.

One hardware option to investigate is Beagle Board, a low cost, high performance, low power embedded system platform designed by BeagleBoard.org community members and intended for open-source use. It features a OMAP3530 processor to provide laptop-like performance at handheld power levels, OpenGL© ES 2.0 capable 2D/3D graphics accelerator capable of rendering 10 million polygons per second, HD video capable TMS320C64x+™ DSP for versatile signal processing at up to 430MHz, and USB power, as well as ports and drivers for a variety of peripherals. A previous senior design group has put together a development system for the Beagle Board based on open source Linux-based software.

Other hardware options may also be available.

The specific application to be implemented is open. One possibility is to investigate porting a program (such as automatic gain control or a digital filter) from MATLAB to the board. Another is to implement a simple game controller. Groups interested in this project are welcome to suggest their own applications, and they should contact Dr. Boston.

**Steve Jacobs**
Office: 332 BENDM
Email: spj1@pitt.edu

**Automatic Identification and Localization of Focal Brain Lesions**

The Western Pennsylvania Patient Registry contains a large set of 3-D MRI images of the brains of patients who have suffered some form of focal injury. The goal of this project is to morph these image sets to a common coordinate space, and then search them for images which show statistically significant contrast in a specified anatomical region. The students who work on this project will produce a software tool that will take as input the brain coordinates of interest, and produce as output a list of patients who are likely to have a lesion near these coordinates.

**Alex Jones**
Office: 334 BENDM
Email: akjones@ece.pitt.edu

**Project 1: Build a digital radio!**

There is a lot of recent interest in the new HD Radio standard that many radio stations in Pittsburgh and across the country. In this project you will construct an HD radio receiver and attempt to tap into this new layer of radio.

**Project 2: Build a digital iTrip (not for the faint of heart)**

The problem with HD Radio is that it is a closed standard and to build something requires that you purchase a pre-fabricated decoder chip for your receiver. However, there are competing standards such as the european standard called DRM for digital radio. In this project you will build a digital transmitter and receiver to approximate the functionality of a high fidelity digital iTrip.

**Marlin Mickle**
OFFICE: 432 BENDM
Email: mickle@ee.pitt.edu

**Title: Message Generation in Space - Not Message Transmission**

Classical Communications deals with sending a message from point A to point B where the message itself travels the distance between point A and point B. In some instances in wireless (radio frequency) communications, it is desired to transmit the energy that will eventually form the message from A to B, although the message itself is not formed until it reaches B. If point C is beyond B, the message will not be there, i.e., the message only appears at point B.

Communications of this type are important in certain clandestine applications and are accomplished with theory that is taught in courses such as ECE 31 and ECE 41.

The project can actually be done using MatLab or an equivalent type of software. Preliminary work has been done with published results for a set of fixed frequencies determined by legal restrictions. The project involves using a set of frequencies with no restrictions to produce the best result.

**Mingui Sun**
**(**Departments of Neurosurgery, Electrical and Computer Engineering and Bioengineering)
*NOTE: For any of the following projects, please contact Steve Hackworth, Head, Neuroelectronics Lab , Laboratory for Computational Neuroscience, Departments of Neurosurgery; Phone: 412-802-6478*; *email: stevenahackworth@gmail.com ; please also cc. to: drsun@pitt.edu*

**Project 1: Real-Time Heart Monitoring for Early Detection of Heart Disease**

Heart disease is the No. 1 killer in the United States. Sudden and severe heart attack has claimed numerous lives. In this project, we will develop an inexpensive device that allows people to record the Laplacian (second-order derivatives) of the ECG in times where the risk of heart attack is high, e.g., when an individual experiences unusual physical or emotional events. The specific tasks to be accomplished are to design a wireless adhesive pad with multi-ring electrodes and a low-power, low-noise amplifier. Future developments will include digital storage or transmission of the ECG, which will not be part of this senior design project.

**Project 2: Solar Ease**

The proposed project focuses on developing a solar panel system that utilizes novel wireless energy transfer technology (WiTricity) to transmit solar power into homes and buildings without any wires through the wall. Reducing cost, complexity, and long term investment risk normally associated with solar installation will encourage adoption of this "green" source of energy, coinciding with government initiatives and energy efficiency programs. A prototype system will be built to validate the concepts of this system. Constructions of special RF coils and electronic circuits will be performed.

**Project 3: Wireless Power Transfer by WiTricity**

WiTricity (Wireless electricity) transfers power without wires between a central station to a group of devices within a certain distance (e.g., within a room). The aim of this project is to design and implement a new "router" which not only transmits data, but also provides power to remote devices. This project will involve considerable hands-on tasks and experimental studies within our electronics laboratory, including resonant coil design, evaluation, and testing.

**Project 4: Body Sensor Network Using WiTricity**

This project aims to construct a sensor network for the human body. It involves implementing an array of microsensors in the form of low-profile sticker pads which are easily pasted on clothes. Both power supply and communication functions will be implemented using the WiTricity concept. Hands-on construction and evaluation of resonant coils and sensor interfaces will be the main tasks of this project.

**Project 5: Stress Detection and Evaluation**

Traumatic brain injury (TBI) and post-traumatic stress disorder (PTSD) are major causes of mental and physical disabilities among return soldiers wounded in Afghanistan and Iraq. There is a need to develop convenient computational tools for the remote evaluation of stress level at low cost. The team will investigate the use of historical recordings of telephone or cell phone conversation for quantitative stress level assessment. Computer algorithms will be developed to process speech data automatically. Good mathematical background and high interest in signal processing are preferred. For legal purpose, only mock recording data will be used in this research.

**Project 6: Finger-Tip Keyboard**

As the mobile computer and the smart cell phone integrate and miniaturize, data input to a mobile device becomes a critical problem. This project investigates new hardware that can record relative

positions of fingers. A finger position code will be developed to represent all or a subset of keyboard characters. The result will be tested and the feasibility of finger position coding for computer input will be accessed. This project will be jointly directed by Professor Zhi-Hong Mao (zhm4@pitt.edu).

**Project 7: Finite Element Simulation**

Using powerful computers and software packages, many physical phenomena can now be simulated accurately by implementing finite element methods (FEM). The main tasks of this project are high-level computer programming using commercial FEM packages, physical system analysis, and explanation of simulation results. Candidates of this project should have taken college level courses in physics and differential equations.

**Project 8: Micro and Nano Structured Skin Electrode**

Many insects have the extraordinary ability to grasp and walk on the surface of difficult objects, such as a vertically positioned glass panel. Scientific studies revealed that their legs have special micro and nano structures that enable them to perform these tasks. This project will investigate the leg structures of insects and use the knowledge to design a new skin grabbing electrode. Research tasks include biological study, structural design, material selection, micro/nano fabrication, and evaluation.

**Project 9: Wireless Data Communication Using Zigbee for Biological Signals**

ZigBee is a powerful wireless data communication standard from the IEEE. It supports high data rates and consumes relatively little power. This project consists of a study of this standard, construction of miniature Zigbee transmitters integrated into small electrodes, construction of a base receiver, and performance evaluation for wireless transmission of biomedical data such as EEG and ECG. This project requires knowledge of wireless system and antennae design.

**Project 10: Mathematical Study and Algorithm Development for Signal Processing**

This project is designed for candidates who are good at mathematics and are interested in theoretical studies in signal processing. The aim of this project is to study sparse representation and compressive sensing. A moderate amount of programming using Matlab will be required. The candidates of this project must have taken advanced calculus and linear algebra.

**Minhee Yun**
OFFICE: 542 BENDM
Email: yunmh@engr.pitt.edu

**Title: Single Nanowire Electronics**

Nanowires, which have a diameter less than 100 nanometers (1000 times thinner than human hair), are considered important building blocks for various electronic, mechanic and biomedical applications. A cheap and effective way of fabricating nanowires is under pursue and presents as one of the hottest topics in nanotechnology development. Our lab discovered the growth of single nanowires using electrochemical deposition and we successfully fabricated sub-50 nm nanowires made of Palladium and Polypyrrole. In this project, the fabrication process of single nanowires will be improved so that

thinner and longer nanowires can be synthesized more reliably. Also, nanowires made with other materials, such as semiconductors, will be investigated.

**Greg Reed**
OFFICE: 343 BENDM
Email: reed5@pitt.edu

## *Industry sponsored projects:*

**University of Pittsburgh Swanson School of Engineering**

**In Collaboration with Eaton Corp**

**Spring 2010 Senior Design Project**

**Title of Project:** EDR3000 Self-powered Protective Relay

**Background:**

The Protective Relay product line has an existing product that is powered either by fault currents or by way of the AC Control Power in the power system. This product concept must be carried over into Eaton's new current only "E"-Series relay. We call this the EDR3000 Dual- Source, and / or EDR3000 Self-Powered unit. During a power system short circuit, the line voltage may dip, causing the protective relay to loose power and in turn miss seeing the short circuit event. The EDR3000 Self-powered will use this fault current to develop an additional power source to keep the protective relay energized.

**Assumptions:**

- An electronic design exists and is the basis of the new product.
- 50% of the project involves redesigning the enclosure. Some AutoCAD experience is required. The other 50% is defining the PC board real-estate, and laying out the circuit board using newer components. The product must pass EMI testing.
- Preliminary tests indicate that the existing circuit should work.
- The old design will be updated to newer components were possible.
- One seat of PADS and AutoCAD are available to student.

**Expected Deliverables:**

- PCB data base and drawing package.
- Working prototype PC boards.
- Prototype of the complete assembly.
- Test plan, and test data that demonstrate comparable operating to the existing design.
- EMI/EMC testing should be completed, and should be considered in the design.
- Suggestions for a beta revision.

**Period of Performance:**

- One to two terms

**Budget:**

- $1500-$2,000

**Point Of Contact:** Jim Wise- 412-893-3261

jamesiwise@eaton.com

Eaton Corporation

Jim Lagree

1000 Cherrington Pkwy
Moon Twp, PA 15108
Tel: 412-893-2840

**Title of project:** Investigate Digital Signal Processing Techniques for Metering and Trip Unit Functions

**Background:**

Presently, our meters and trip units use analog techniques to perform noise filtering when extracting the current and voltage signals from Current Transformers. Additionally, we are migrating toward the use of Rogowski Coils instead of CTs, due to their performance and cost advantages. The output of a Rogowski Coil must be integrated over time, as it is proportional to the rate of change of the current or voltage. This integration is also performed using analog techniques.

We are beginning to use low-cost Digital Signal Processors in certain designs due to their high performance. However, we are using them primarily as general-purpose microprocessors.

This project would involve the investigation of adding the integration and filtering functions into the digital signal processor. This would allow us to remove the passive filters and integrators from the circuit board, reducing the cost, power, and PC board space from existing designs. In

addition, we would have a standard circuit and software suite which could be used in multiple meter and trip unit designs with little changes.

**Assumptions:**

The students would require an evaluation DSP board, emulator, compiler, and editor. They would also perhaps need a test board for the CT and Rogowski coil interface – this would not be difficult to provide. We are presently designing a product using the TI TMS320F2812 DSP.

They would be required to write code and investigate DSP techniques for filtering and integration, with the goal of providing as accurate a system as possible for measuring current, voltage, and power.

As part of the project, the students would become proficient with the TI 2812 DSP and associated compiler, emulator, and simulator. They would also become proficient in digital signal processing techniques for low-pass and band-pass filters, and for integration. They would also become familiar with Current Transformers, and Rogowski Coils, and metering voltages, currents, power, and energy.

Eaton would provide the following items:

- C2000 Code Composer Studio – editor, assembler, compiler, and Integrated Development Environment for C code development - $500
- XDS510 USB Plus JTAG Enulator – emulator to test code - $1500
- EzDSP Evaluation Kit – evaluation board for DSP Processor - $469
- Hardware prototype board with Rogowski Coil Interface – Internally developed

**Expected Deliverables:**

- A working prototype that:
    - reads 60Hz AC current inputs via Rogowski coils
    - samples the waveforms
    - converts the samples to digital
    - filters the signals to eliminate noise
    - performs a digital integration on the signal
    - scales and converts the signal to engineering units
- A report detailing different DSP filtering techniques, including response time and effectiveness in eliminating noise.

**Period of Performance:**

One term

**Budget:** None anticipated – materials will be provided by Eaton.

**Point of contact**

Jim Lagree

JamesLLagree@eaton.com

Tel: 412-893-2840