Team 1601: Circuit Breaker Calibration

Philip Simonin, Kyle Weber, Louis LeBlanc, Tyler Lyon

Sponsored by: Carling Technologies
Sponsor Advisors: John Lach and Marek Szafranski
Faculty Advisor: Dr. Ali Gokirmak

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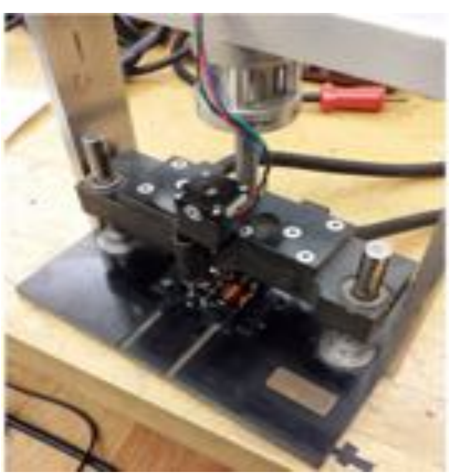
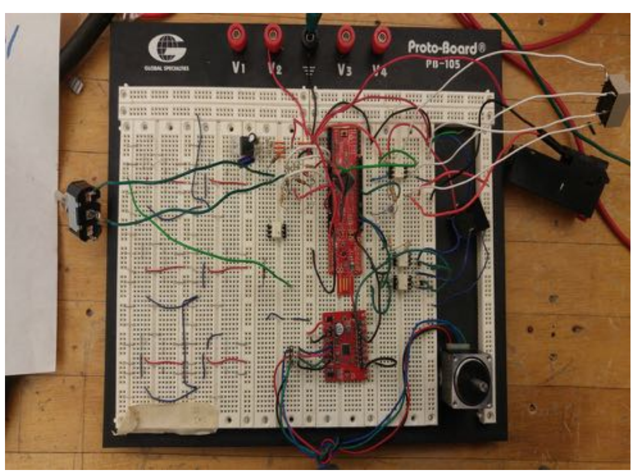
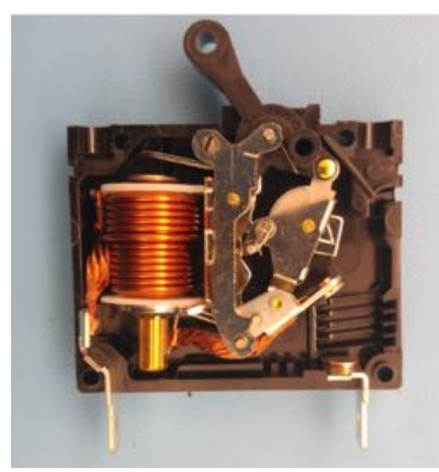
Magnetic circuit breaker calibration is traditionally achieved manually with a procedure that is implemented on the production line. The method currently involves the doubling of rated current to bring the iron core within the dashpot of the breaker to the trip-point required. This process may be repeated numerous times in order to come within a small window around the desired trip current value where adjustments can be made. Tripping the breaker at the necessary level requires slow adjustments around the point of tripping.

Carling has assigned this project in an effort to reduce the time required with manual calibration in both production and when needed in testing. A device capable of automating the process of calibration was created to increase the efficiency of the manufacturing plant. This device allows production line workers and technicians to remotely set or adjust circuit breakers. Ultimately, the device brings circuit breakers within their specified trip points more rapidly and with a certain repeatability that is time consuming with current methods.

The device is capable of being set to a specified current level and in approximately 20 seconds have adjusted a brand new breaker to its specified trip point. The calibration device operates using a programmable chip to read and detect current levels. Current levels are stepped down for the analysis of current with respect to time. Concurrently, adjustments are made with a stepper motor making adjustments to the circuit breaker. Minor adjustments are made until satisfactory levels have been met. The process is repeated to ensure proper adjustment of trip point and for accuracy purposes. The calibration device will create repeatable consistency among all breakers going through production so that each product is adjusted to specification.







Team 1602: Fiber Optic Control System for an Electric Motor

Edward Tash, Alison Hosey, Michael Barbieri

Sponsored by: Electric Boat
Sponsor Advisors: Chad Rice and Eric Hultgren
Faculty Advisor: Professor Eric Donkor

GENERAL DYNAMICS
Electric Boat

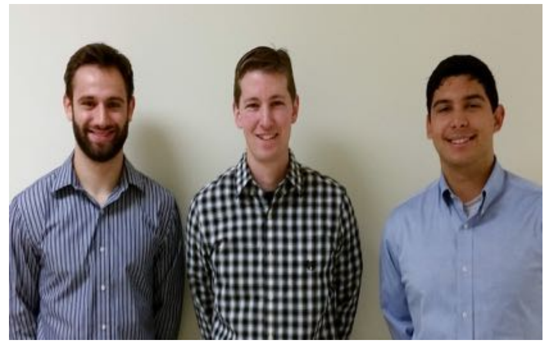
The purpose of this project is to develop a proof-of-concept system for remotely powering, controlling, and monitoring an electric motor entirely through fiber optics. Currently there are no fiber-based motors available in industry, so our system must be able to do the conversion between the fiber optics and the copper signals. There are a variety of benefits which can be derived from incorporating fiber optics into the system of an electric motor. Namely, fiber optic systems are resistant to electromagnetic interference (EMI) and operate more efficiently, in terms of both temperature and speed of transmission.

To ensure proper operation of the motor, a variety of sensory devices have been selected. These sensors will be powered through a commercially-available, power-over-fiber system and will provide remote feedback on the status of the motor's operating condition.

The power-over-fiber system takes an electric power supply, to modulate a laser system, and transmits over fiber optic cables. The light is converted back to electrical power, at the output end of the fiber optic cable, to drive the motor. The conversion from fiber optic light to standard electronic power uses photodetectors (or photovoltaic cells) and is based on a mechanism similar to solar energy conversion using solar panel.

The development of entirely fiber-based systems serves to increase the efficiency and speed of transmissions, particularly through noisy or insecure mediums, prevents electrostatic and electromagnetic interferences, and provides an alternative to copper in various applications.

Team 1603: Dynamometer for Testing Frequency Inverter Performance



Alexander Sawyer, Christian Ratliff, Andres CalleOtero

Sponsored by: Lenze
Sponsor Advisor: Christopher Johnson
Faculty Advisor: Prof. Ali Bazzi

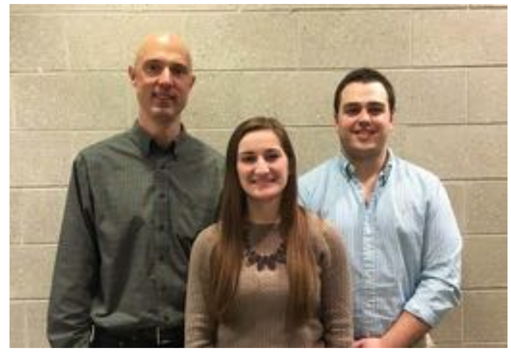
Lenze
www.Lenze.com

A frequency inverter, or frequency drive, is an essential device used to operate motors by manipulating the voltage magnitude, as well as, the frequency at the motors terminals. These controls allow the user to set a motor to a desired speed or torque level. The motivation for this project is drawn from the prevalence of electric motors in today's society and the importance of frequency drives in their operation for flexible control and high efficiency. Lenze is seeking a control solution that integrates two motor drives, which run in tandem and act as a test bench for their equipment. By utilizing Lenze control equipment, Team 1603 distilled their existing test setup into a single interface that not only allows the manipulation of all the elements involved but also the compilation of the performance data, including current, torque and speed, into easily interpreted graphs.

This project strives to improve Lenze's capability to test the performance of their drives' efficiency and reliability. Currently, Lenze tests drives using a test setup that is multi-platform and uncoordinated. The project utilizes two frequency inverters, one to run the dynamometer (dyne) which acts as a load, and a second "drive under test" (DUT) which controls the other motor. The motor and the dyne are mechanically coupled together with a torque transducer for torque measurements. Current is measured using external hardware, and speed readings come from the dyne. The entire control scheme takes the form of a graphical user interface implemented on a touch screen Human Machine Interface (HMI).

New opportunities arise from implementing a control scheme that can synchronize measurements precisely from multiple sources. Lenze will be able to try out new hardware, software, and techniques to enhance motor-drive performance and efficiency. All of the equipment including power supplies, cables, drives, motors, sensors, analog and digital PLC modules, connectors, and the HMI have been generously provided to UConn by Lenze for this project. The UConn team is integrating all of the hardware, and writing the HMI based program to control the system and extract performance data.

Team 1604: Implementation of a MIMO Transceiver Using GNU Radio



From the left: Michael Williams, Erica Wisniewski, Ethan Aebli

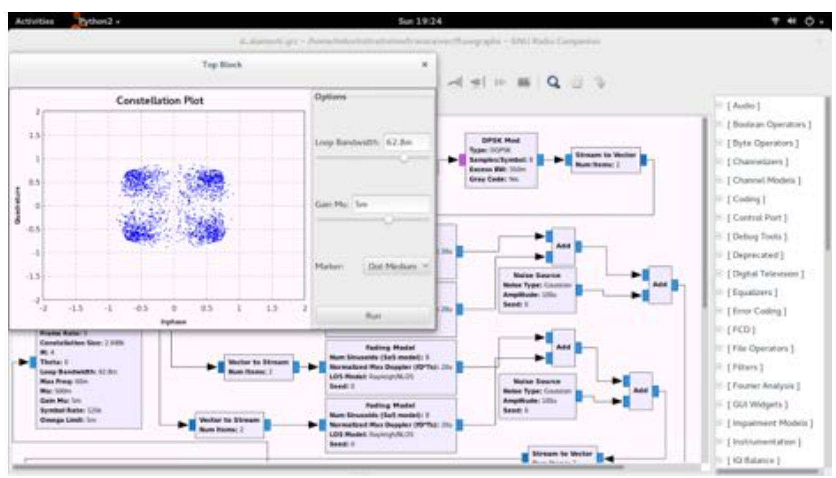
Sponsored by: The MITRE Corporation
Sponsor Advisor: Michael J. Wentz
Faculty Advisors: John Chandy and Peter Willett

Wireless communication is an essential component to life in the modern world. Advances in recent years has lead to a seamless integration of wireless technologies in our daily lives. The demand for greater bandwidth and faster speeds drives research and development. One such advancement is in the area known as multiple-input-multiple output (MIMO) systems. This system model is in contrast to the more traditional single-input-single-output system. By utilizing a MIMO architecture some of the most hostile communication environments can be operated in quite effectively. This is due to the fact that MIMO turns the apparent disadvantage of channel fading to its own advantage.

Since any communication system may possibly benefit from such an approach, being able to easily test such an augmented system for gains in bandwidth and reliability is an important capability for communication engineers. It is to this end that our project is focused. We employ the software-defined-radio (SDR) platform GNU Radio to design, build, and test such MIMO enhanced systems. Traditional radio signal processing is usually done in hardware; while reliable, this is not easily configurable. GNU Radio allows us to build a communication system in a modular manner at the software level and utilizes SDR hardware with modern field-programmable-gate-arrays (FPGAs), providing fast yet configurable implementations. Similarly, we can take pre-existing models and reconfigure them through many of the built-in capabilities of the GNU Radio platform.

The MITRE Corporation is a not-for-profit federally funded research and development center (FFRDC) that provides systems engineering and practical solutions for many of the critical challenges we face today. Currently, GNU Radio has no built-in MIMO functionality. The aim of our project is to design and build such MIMO capable software to be integrated into the GNU Radio platform and be able to run and verify our algorithm with the Ettus Research USRP hardware in order to provide our customer and project sponsor, MITRE, with a convenient tool for the purpose of design and testing. The long-term goal of the software-defined MIMO project is to develop new and more flexible communication systems for applications such as air-to-ground transmission for emergency service vehicles and drones.

This research was supported by The MITRE Corporation ® as an independent research project. The views, opinions, and findings are those of the authors and are not intended to convey or imply an official position of the The MITRE Corporation ®



Team 1605: Elevator Wire Rope Inspection Device using Resistance Measurement

Sponsored by: Otis

Sponsor Advisors: Rich Fargo, Peter Liaskas, Marty Hardesty

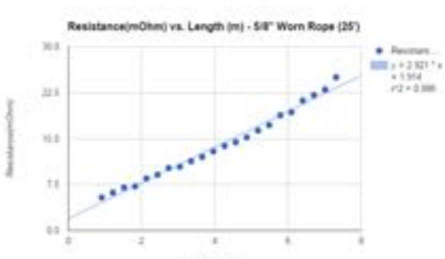
Faculty Advisors: Rajeev Bansal, Brice Cassenti

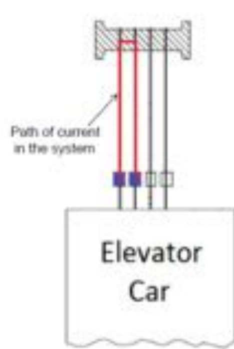
From left to right: Nancy Cheng, Amadeusz Nasuta, Lee Goglia
ME: Isak Bevan-Hrvacic, Anthony Mastroluca, Kyle Seniff

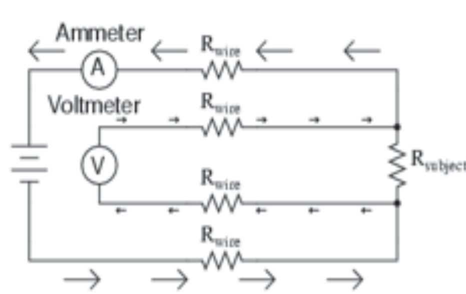
As Otis elevators run their course in service, the wire ropes that hoist the car degrade. Breaks and stretches can adversely affect the braided steel ropes as they repeatedly bend over the elevator sheave during motion. While all roped elevators have backup safety systems to support the elevator and protect passengers if the ropes were to fail, such a failure, or a failure to pass a manual rope inspection, could cause the elevator to be taken out of service until the ropes are replaced. It is a goal of this system to provide an advanced indication of rope wear, so that new ropes can be ordered, and the old ropes replaced, with minimal disruption to the customer.

Today, the primary method of inspection is a thorough visual inspection as stated in the American Society of Mechanical Engineers (A.S.M.E.) guidelines. This method, however, only accounts for what can be seen on the rope's exterior surfaces and does not take into account the interior conditions of the cable. Furthermore, a visual inspection is extremely time-consuming and costly which leads to an increase in the elevator's downtime as it cannot be in operation while maintenance personnel inspect the shaft. For these reasons, we need to develop an inspection method with higher accuracy, thoroughness, and efficiency.

Our approach is the resistance based inspection (R.B.I.) method which checks the condition of a steel rope by comparing the current electrical resistance of the cable to the resistance of the same cable when it was newly installed. Throughout a rope's lifetime, wire strands abrade and break causing the cross-sectional area to decrease. This in turn increases the resistance so it is useful to monitor this value over time. By using the Kelvin resistance measurement technique, the contact resistance for the measurement leads becomes negligible so the low resistance of the cable can be accurately determined. Then the measured rope resistance can be compared with the baseline value to provide a reasonable indication of cable wear. The device will sample on each floor to obtain a resistance profile of the rope since wear is not distributed evenly across the full length. From this data, we can monitor the cables over time to analyze the correlation between cable resistance and remaining strength.

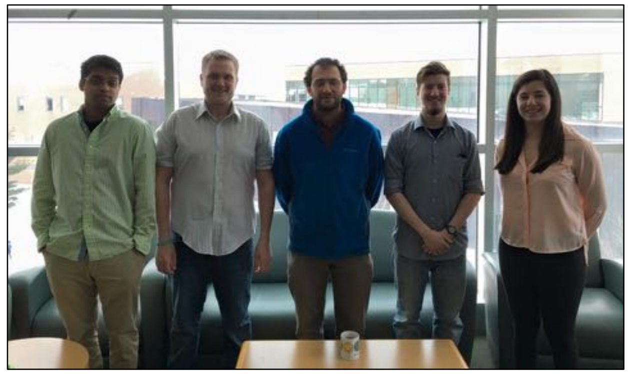






Team 1606: Current Monitor

Sponsored by: Phonon
Sponsor Advisor: Lam Dinh
Faculty Advisor: Prof. Ali Gokirmak

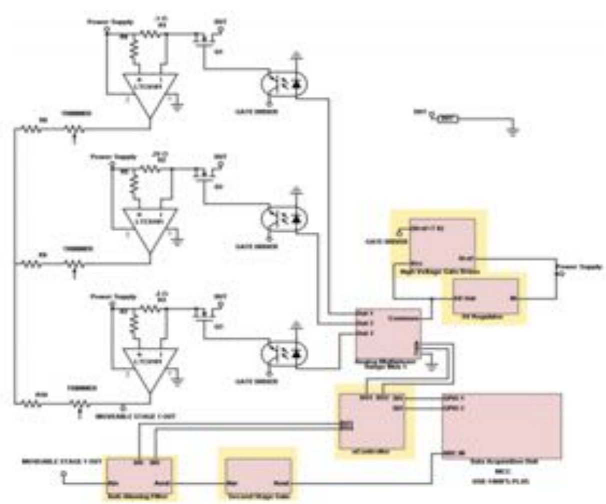


From Left to Right: Barath Parthasarathy, Andrew Pikul, Ali Gokirmak (Advisor), Jason Stock, Maya Dubrow

Phonon Corporation needs a specific type of calibrated AC/DC current measurement system to test their Surface Acoustic Wave (SAW) devices. The current measurement system can attach to any DC power supply to measure current, with low internal series impedance (<1 Ω), and output as much as 30 volts and 5 ampere. Furthermore, the current measurement system must integrate with existing data acquisition equipment already present in the lab, with software to drive and calibrate said equipment. The focus should be on developing a flexible device which can acquire, process, and track accurate data. The device is designed to allow easy expansion using a modular design principle.

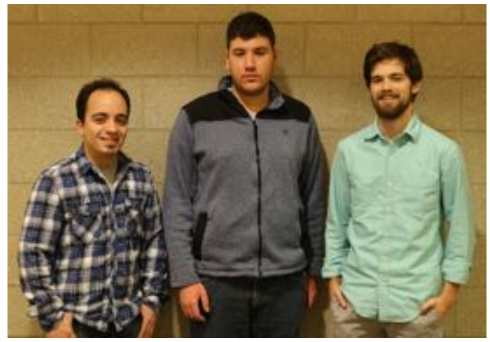
Besides the basic design, we are tasked with adding additional design features should time allow. These new features include transient current spike detection, voltage sensing, and a range selector to record data at different current ranges for increased accuracy. The project will encompass circuit building and a hardware component with a software component which will be used to gather data.

Our iteration of the Current Monitor benefits from a large supply voltage (5-30). Furthermore, the DAQ allows for easy switching between different ranges. The software developed is a complete solution which will interface with our current monitor as well as other equipment which use the same DAQ.



Team 1607: Sinusoidal Oscillator/Demodulator Design

Sponsored by: Trans-Tek
Sponsor Advisor: Mark Bennett and Jeff Gladu
Faculty Advisor: Sung-Yeul Park



Left to Right: Manuel Medeiros, Aaron Ciardullo, Connor Bailey

TRANS•TEK INCORPORATED

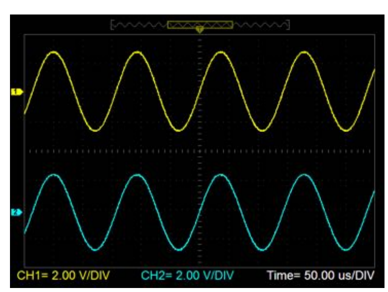
In today's modern world of advanced computational design, sensing technology has expanded into many different areas of applications. Linear Variable Differential Transformers (LVDTs) are at the forefront of position sensing technology. For close to half a century Trans-Tek has provided the best linear, angular, and linear velocity transducers in the industry. Each transducer is made and crafted with pride here in the USA, with LVDTs being Trans-Tek's main product.

An LVDT measures linear-displacement through the interaction of two excitable coil-forms and a ferromagnetic core. First, the primary coil, of the LVDT, is excited with a sinusoidal signal. Then, when the ferromagnetic coil experiences displacement, the secondary coil is excited, due to electromagnetic induction. The signal from the excited secondary coil is analyzed and utilized for a variety of applications. Trans-Tek offers a multitude of LVDT's, of different shapes, sizes, and design, in order to provide sensing technology for all possible applications.

The objective for this project is to re-design the control circuitry for a standalone unit that drives AC transducers. This system will provide a seamless interface between the LVDT and the user, which will make implementing a transducer in an existing design much easier. The design will generate sinusoidal signals, at adjustable amplitudes and frequencies, to excite the primary coil of the LVDT, and will also demodulate the output sinusoidal signals from the secondary coils, to a DC voltage that can then be easily read by a microcontroller or other circuitry.

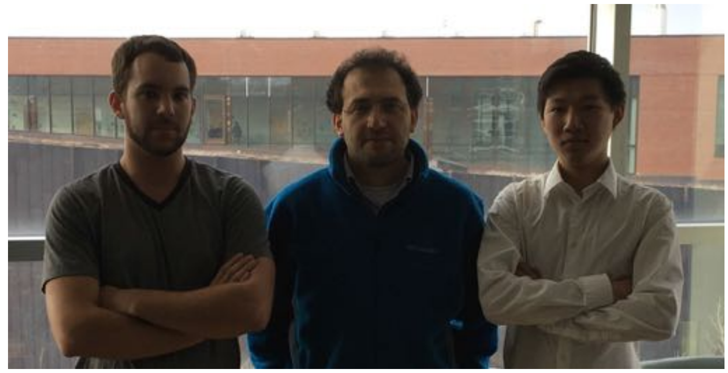
We have realized this functionality by implementing a microcontroller to generate the sinusoidal waveform via a Digital-to-Analog Converter (DAC). We have also employed a DAC and Analog-to-Digital Converter (ADC) to demodulate the secondary signal. Finally, we have designed amplification circuitry for both our primary-side and our secondary-side in order to condition the signals to meet specifications.

For further product information please visit http://www.transtekinc.com/



Team 1608: Next Generation Full Authority Digital Engine Control (FADEC) NVM

Sponsored by: Triumph Group Engine Controls
Sponsor Advisors: Mark Lillis and Lou Pannullo
Faculty Advisor: Prof. Ali Gokirmak



From left to right: Michael Cafaro, Ali Gokirmak, and Sam Wong

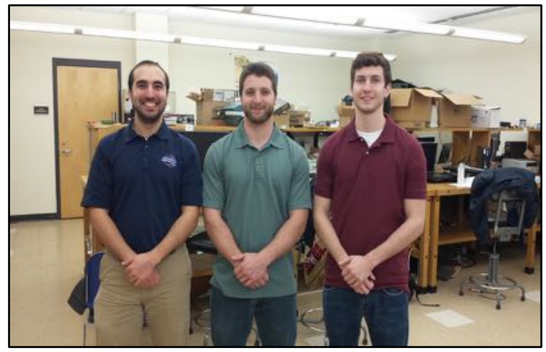
Triumph Engine Control Systems (TECS), based in West Hartford, CT, is a leading manufacturer of fuel pumps, metering units, and digital electronic control systems for aerospace gas turbine engines. The Full Authority Digital Engine Control (FADEC) is the controlling unit of the aircraft engine that converts the pilot's commands from the cockpit along with sensor data of the engine itself to decide the best response to the necessary effectors. The FADEC is also responsible for collecting large amounts of flight performance and fault data, which is used for engine maintenance and diagnostics. Despite its enormous importance to recording data, current FADEC technology utilizes rugged Flash Memory that is quite small, providing limited fault and crash data.

The goal of this project is to test possible Next Generation FADEC memory which would have an increased memory. Research into the most current non-volatile memory storage devices led us to choose industrial grade microSD cards for this application. MicroSD cards have a high memory density, are very lightweight, and are rated to operate in a temperature range of -40 to 85°C. FADEC's operate in high vibration and variable temperature environments which the memory device must be able to withstand. In order to verify that the microSD cards can function properly and reliably in an airborne environment a highly accelerated life testing (HALT), frequency response characterization and endurance testing will be performed in Triumph's Thermotron HALT chamber, which is a thermal chamber integrated with a six axis vibration table. A microcontroller was programed to communicate with the microSD card via SPI bus to ensure proper data transmission. The results of the test will demonstrate whether the microSD card, mounted at various points on the memory board, could survive under the vibrational and thermal environment the FADEC must endure.

If the microSD proves to be a viable alternative to the current rugged Flash Memory, TECS will be able to integrate it into the Next Generation FADEC and utilize the increased memory to provide enhanced data analysis potential to their customers.

Team 1609: Integrated Grid Study

Sponsored by: The United Illuminating Company
Sponsor Advisor: James Mader
Faculty Advisor: Prof. Peng Zhang



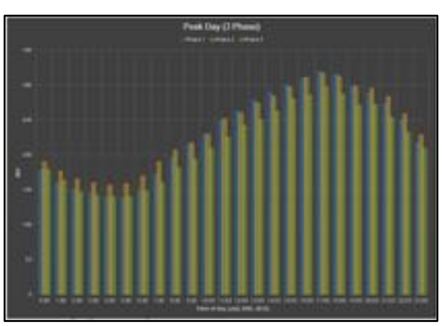
Group 1609 members Elia D'Onofrio (Left), Frank Corso (Center), and Daniel O'Rourke (Right) standing in front of design work station.

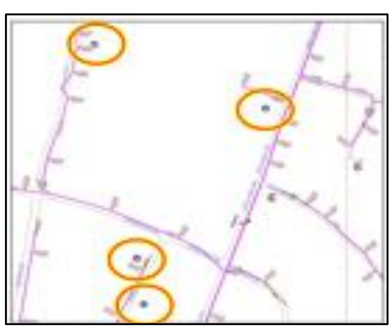
The United Illuminating Company

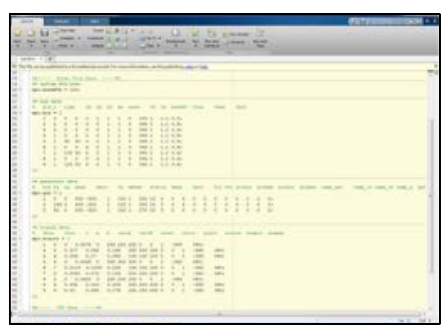
UI is an electric transmission and distribution company that delivers power from centralized generating facilities to its customers. Everyone in a certain geographical area receives power that is supplied by the same circuit. In any given neighborhood a customer might install a small rooftop photovoltaic (PV) system and start a chain reaction where all of their neighbors do the same. A situation like this will eventually cause problems since there will be a large amount of uncertainty as to when and how much power the PV systems will be injecting into the grid.

By injecting intermittent PV power into the grid, the grid supply changes from being predictable and constant to unpredictable and periodic. This will cause issues for the distribution network since there will now be the potential for bidirectional power flow and islanding. By artificially creating these issues through modeling we hope to understand the impacts and provide a solution as to how to mitigate them.

A simulated experiment will be conducted on a distribution feeder with moderate solar photovoltaic (PV) penetration within UI's territory. The feeder circuit will be manipulated to investigate the potential impacts on the distribution network. The study will include a power-flow analysis in MATLAB Simulink of the current circuit as well as various potential problem scenarios. The result of the study will be a report documenting the findings of network power quality and stability problems and a recommendation for how to alleviate or mitigate the hazards caused by high penetration of distributed PV generation if and when they arise.







Team 1610: Command and Control of Unmanned Autonomous Vehicles

Sponsored by: LINKS Lab
Sponsor Advisor: Professor Shalabh Gupta

Ramon Rivera, James Boivie, Raman Singh

LINKS
Laboratory of Intelligent Networks and Knowledge-Perception Systems

A quadcopter is a very simple machine, meriting it as the most common aerial platform used for research and recreation. In accord, the base of UAV (Unmanned Autonomous Vehicle) is a quadcopter. The primary application for our UAVs is to have them operate in areas too dangerous for humans. One potential area, for example, is a collapsed mine. It is much safer for a quadcopter to assess damages and locate survivors in the mine than to send in a traditional rescue team for the job. The advantages are limitless. Suppose there is a fire in a tall building. UAV sensors are useful for not just navigation, but for three-dimensional map generation and target detection as well. The ability to identify human whereabouts and visualize the layout of the building will prove invaluable to fire-rescue missions.

In order for the UAVs to be successful in these missions, it is critical that they function accurately in GPS-denied environments. The device must not depend on circumstance. Rather, it must be reliable in any environment. From the tallest buildings to the deepest tunnels, wifi accessibility may range from inconsistent to entirely absent. Hence, the capability of our UAVs must operate invariably.

The three-dimensional maps are generated through an algorithm called SLAM (simultaneous localization and mapping). As the UAV is flying, the algorithm compares adjacent frames to estimate the change in position. Using the estimated changes in positions and the corresponding frames at those positions, a 3D map of the environment can be constructed.

The generated three-dimensional maps are only useful if they are correct. At present, techniques of validating a map's accuracy independent of GPS, wifi, or expensive sensor networks does not exist. We have developed and extensively tested an inexpensive technique to verify the accuracy of the generated maps.

Team 1611: Design and Implementation of an Intelligent Sensor Network

Sponsored by: Laboratory of Intelligent Networks and Knowledge-Perception Systems
Faculty Advisor: Dr. Shalabh Gupta

(From Left) Michael Budarz, Andrew Finelli, David Paquette

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Laboratory of Intelligent Networks and Knowledge-Perception Systems

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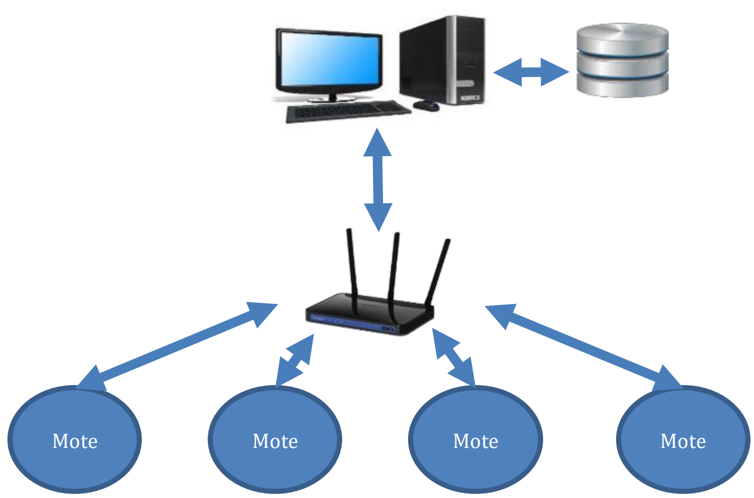
This goal of this project was to design an sensors for data collection and algorithm
implementation. This consists of creating tes that will report information back to a
database. These motes also have the abil ata from the database in order to operate
intelligently. The final goal of this project is d software platform for this sensor network
so that it may be appropriated by other uses sting and verification. Possible applications
for this project include border surveillance, spitals, urban environment target tracking,
and general situation awareness.

A mote is defined as a single node in a s ed of multiple different sensors of varying
degree of power consumption. These senso ensors at low power, and a SONY camera,
Microsoft Kinect, and a laser range finder g. One project goal was to redesign and
replicate multiple motes and connect them ork. The network of motes is designed to
record data to a database for access by lab sign also allows for the access of data from
one mote by other motes on the network. I hese sensor's work and interact with each
other, we designed a software environmer mplement their algorithm. Specifically, we
designed the software to allow each sensor d independently of the other sensor/motes.
The network hardware was also designed to be modular (sensors can readily be changed for others) and to be both durable and easily deployed in a lab environment.



Team 1612: Sit-to-Stand Rehabilitation Device for Cerebral Palsy Patients

Sponsored by: University of Connecticut
Department of Electrical Engineering
Department of Biomedical Engineering
Sponsors Advisor: Dr. Shalabh Gupta,
Dr. Krystyna Gielo-Perczak
Graduate Assistant: Shaniel Bowen

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Laboratory of Intelligent Networks
and Knowledge-Perception Systems

(Top)From left to right: John Hodorowski, Sean Kivney Charles Fayal
(Bottom)From left to right: Tylur Craddock, Keval Vyas, Tapan Dalal

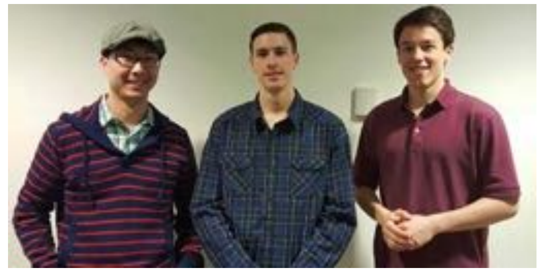
This project involved the development of a motorized Sit-to-Stand platform. The finished device will be able to assist the rehabilitation of patients with neuromuscular disorders like cerebral palsy and other patients with injured, or weakened, lower limbs, such as the elderly. The device implements a linear actuator, sensors, microcontrollers, and measuring devices as well as springs to assist in vertical force while the device is at low angles. These components were used for real-time data acquisition and mechanical output, such as force applied to the seat platform and velocity of vertical lift. The models chosen were determined by musculoskeletal modeling and simulations, and computer-aided design (CAD) using the AnyBody Modeling System and SolidWorks respectively. Working Model 2D was also used to simulate the design and help choose variables.

To determine the best base design of the device, current devices on the market were analyzed, with close attention paid to improvements that can be made. The best improvement that was made, and what sets this device apart from others, is the joint translational and rotational movement of the platform. In order to choose and validate the optimal design, force platform testing was performed with people of differing heights and weights. A control system is made using the sensors, microcontroller, and measuring devices mentioned above to linearize vertical velocity by controller input velocity.

A SolidWorks model was constructed to test the overall device after the implementation of actuator and springs. AnyBody software was used to determine the angle of the seat platform that corresponded to minimum activity in the knee. The goal is to allow the user to still use part of the knee in conjunction with the device to prevent any type of muscle atrophy from occurring.

Upon completion of the project, further modifications will be made to the device in the future to establish a product that will be patented and put into publication.The ultimate goals of this device is for it to be eventually used in a home or clinical setting and that it will be able to give patients a means of gaining greater mobility, more independence, and a better quality of life.

Team 1613: Sinusoidal Battery Charger



From left: Alec Surprenant, Andrew Brooks, and Peter Darinzo

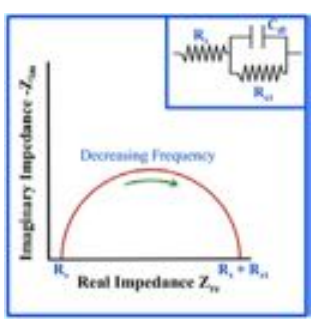
Sponsored by: UConn ECE Department
Faculty Advisor: Professor Sung Yeul Park

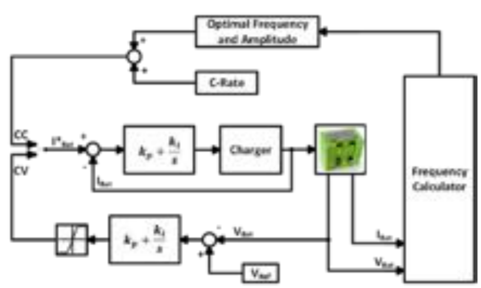
UCONN
SCHOOL OF ENGINEERING

With the growing popularity and quantity of rechargeable battery devices and systems, such as personal electronics and electric vehicles, there is a growing need for more efficient ways to recharge these batteries. Current, conventional battery charging algorithms do not consider the time-varying electrochemical properties of these batteries. The ever-changing electrochemical properties make for very complex and computationally demanding algorithms. By utilizing an adaptive algorithm, the potential benefits include increased cycle life, energy savings, faster charging times, and reduced costs.

Our goal is to design a sinusoidal ripple current algorithm and battery charger that takes into account time varying electrochemical properties of rechargeable lithium-ion batteries. By understanding the processes of lithium plating, the formation of solid electrolyte interphase (SEI), and limited exchange current, we can create an algorithm that minimizes these negative effects. The foundation of the charging algorithm and battery charger design is in electrochemical impedance spectroscopy (EIS). This process allows us to use a frequency sweep to experimentally determine the frequency with the lowest impedance through the battery. This gives us the critical charging parameters such the optimal charging frequency and ripple current amplitude.

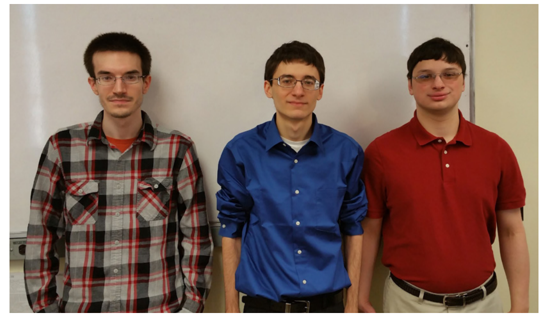
We developed a synchronized buck converter to supply and adjust the current and voltages to a battery array consisting of, 14.6V LiFeMgPO4 batteries in a 1x4 or 4x1 arrangement. The monitoring and control of the battery charger was done with dSpace. The development of the PCB components were done via Altium.





Team 1614: High Power Density AC-DC Converter

Sponsored by: ECE department
Faculty Advisor: Prof. Sung-Yeul Park



From left to right: Kevin Bisson (EE), Jason Morin (EE), and Daniel Wohlmuth (CMPE/EE)

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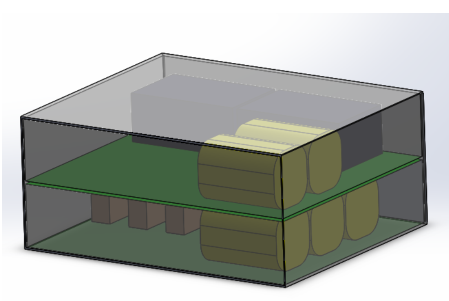
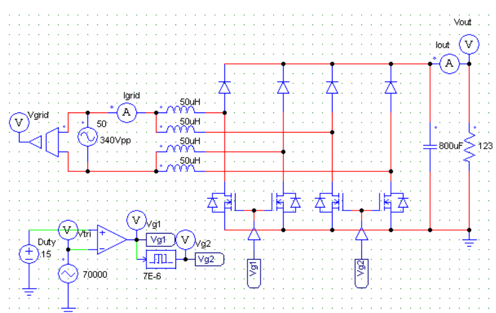
IEEE IFEC'16

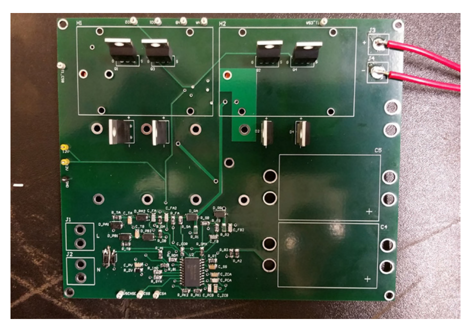
The IEEE International Future Energy Challenge (IFEC) is an international undergraduate students competition in the power electronics societies. It will provide members of the team with invaluable experience in the design, testing, and critical thinking necessary to meet and exceed the goals set by the challenge. For this year's upcoming IFEC 2016 our objective is to design an Ultra-High Power Density AC-DC Power Converter. AC-DC power converter is to convert ac outlet input to regulated dc voltage in order to supply constant dc voltage to either dc load or motor drive. The usages of the AC-DC converter has a wide range from a few Watts ~ a few kilo Watts.

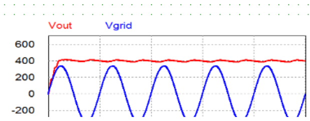
Designing for the IFEC involves a significant amount of work and desire to engineer solutions to everyday problems. We have done our schematic, simulation testing, printed circuit board (PCB) design, 3D model, and have started assembly. During these design activities, we learned the software we are using such as Altium, Power Simulation (PSIM), and SolidWorks. A second revision of the PCB will be necessary after our first pass of testing. This is because the volume requirement is crucial even if our first board's testing fulfills the converter goals.

As a part of the School of Engineering, the team representing UCONN will need to step up and take on this engineering challenge in order to display what we have learned both through instruction and through personal endeavors of design. UCONN have been finalists at IFEC in 2011 and 2015. Winning the grand prize would be a great accomplishment for the team and the university.









Team 1615: Constant Wireless Power Transfer with Underwater Applications

Sponsored by: University of Connecticut Electrical Engineering Department
Faculty Advisor: Dr. Lei Wang

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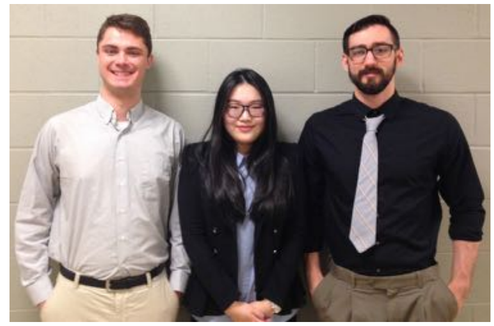
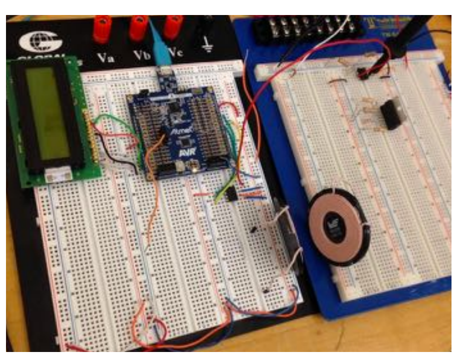


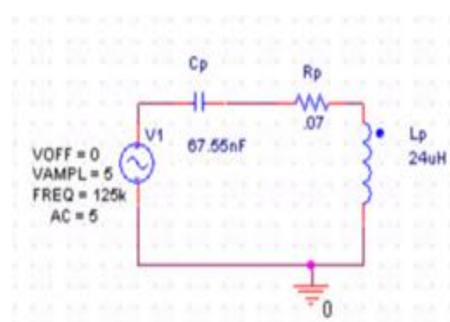
From left to right: Michael Donohue, Weichen Zhang, Ryan Andrews

Wireless power transfer (WPT) is the transmission of energy from a power source to an external device or system with the absence of a direct connection. Inductive charging is the most popular method used. Induction systems operate similarly to a transformer where current is sent through a primary coil creating a magnetic field which induces a current in a secondary coil. This current is then used to charge the target device. The goal of this project is to design a closed loop WPT that will deliver a constant supply of electricity under changing conditions such as distance or orientation of the receiver.

The advantage of wireless power transfer is the ability to keep the system fully enclosed and protected. One of the most common places a consumer would interact with a WPT device would be in an electric tooth brush. This allows the device to be changed without the danger of damage from water. The technology is also used in charging pads for smart phones and tablets. Mobile devices on these pads can positioned in different orientations relative to the source coils. The source will change the amplitude of the signal delivered to account for any loss due to non-ideal orientation. This project aims to combine these two principles to create an inductive charging system that could be applied to a device such as an embedded sensor underwater where pitch and orientation could fluctuate consistently. The prototype consists of two Atmega328p microcontrollers connected using SPI communication, and transmitting using two copper plated coils. The transmitter generates a sinusoid which changes dynamically with feedback from the receiver to provide a constant level of power within the transmission range of the coils. This allows a device to charge uninterrupted under the non-ideal conditions that could be experienced in an underwater environment.

```
void SPI_Master_Transceiver(uint16_t cData)
{
    PORTB &= ~(1<<SPI_SS); // Pull Slave_Sel
    upper = cData >> 8;
    lower = cData & 0xFF;
    SPDR = upper;
    while(!(SPSR & (1<<SPIF))); // Wait for
    SPDR = lower;
    while(!(SPSR & (1<<SPIF)));
    PORTB |= (1<<SPI_SS); // Pull Slave Sele
}
```





Team 1616A: Smart Ocean Wave Energy Converter

Andrew Budd, Nana Ahiabli, John Jacquinet

Sponsored by: UCONN School of Engineering
Faculty Advisor: Peng Zhang

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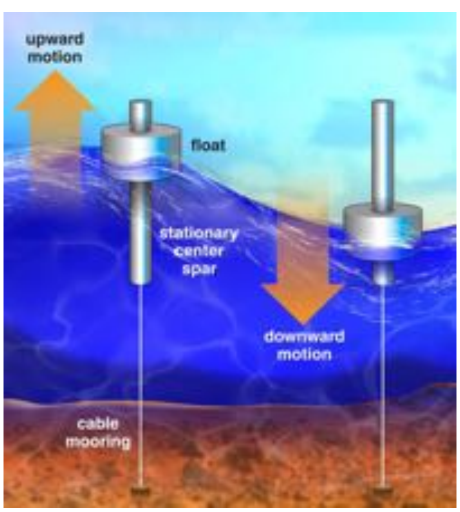
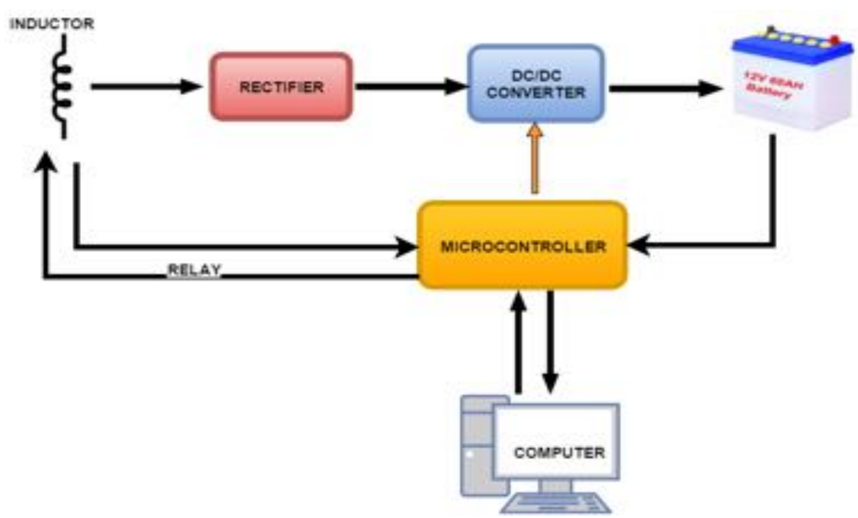
The University of Connecticut plans to utilize autonomous underwater vehicles (AUVs) in order to monitor the aquatic environment on Long Island Sound. These vehicles are battery powered and require frequent charging which is unavailable when in use underwater. The goal of the Wave Energy Converter (WEC) is to generate power for the AUVs to use. The WEC stores the electrical energy that it generates in its own battery and wirelessly transmits the power to the AUVs. This allows the AUVs to continuously operate without needing to stop and charge, as well as removing the need for undersea cables to charge them.

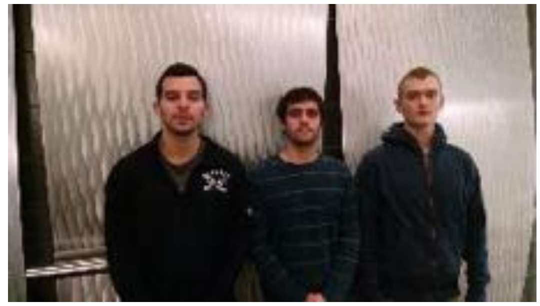
The Wave Energy Converter was initially designed with a direct-drive linear generator consisting of one coil attached to a buoy, and three permanent magnets in a spar. The Spar's vertical movement is dampened by a heave plate which keeps it relatively stationary. This allows the system to generate electricity using the relative motion of the buoy to the Spar. This year, the coil was replaced by a set of three coils and a power conditioning circuit was added. Electricity from the three phases (coils) is rectified, then passed through a PI (Proportional-Integral) controlled Buck-Boost Converter. The Buck-Boost Converter is set to output 13.8 volts in order to charge the 12 volt Lead Acid batteries. Our system is designed to output 100 Watts continuously with peaks of 300 Watts.





Team 1616: WEC - Underwater Wireless Power Transfer

Sponsored by: University of Connecticut
Sponsor Advisor: Peng Zhang, Taofeek Orekan



From left to right: Juan Carlos Lluberes, Brandon Colon, Tyler Hayslett

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Senior Design Team 1616 is focused on the design of a generator buoy that can capture wave energy for use in Autonomous Underwater Vehicles(AUVs). Currently, AUVs are powered by batteries that are changed out by expensive on-site teams. In the marine environment mechanical connections are rigid, and also prone to corrosion. Wireless power transfer allows two electrically isolated systems to transfer energy. This will allow untethered AUVs to be charged as they station near the generator, or even as they carry out assigned tasks. Our subgroup of team 1616 is focused on the testing and design of a wireless power transfer system capable of functioning in a marine environment. It will be coupled with wave energy generation to simplify AUV deployment, removing the need for repeated human interaction.

The marine environment is not friendly to any form of EM power transfer. This is the reason that sonar is used in place of cameras for seabed mapping, and submarines are so difficult to talk to by radio. Even in waters with low turbidity, directed beam or other far field transmission methods perform poorly. However, a new type of near field transfer may be much more effective. Resonant inductive coupling allows two intermediary coils with the same resonant frequency to couple strongly to each-other at longer ranges, extending the near-field effect. While immersed in salt water the efficiency and power transfer rate is affected by the distance the coils are separated. This is due to the natural attenuation by the salt water, and the decrease in coupling efficiency. With adequate source and load control, power transfer rate and efficiency can be controlled even as distance changes. Our testing has focused on fully describing the effect salt water has on transfer efficiency at different frequencies, and includes digital source and load control to improve efficiency over a range of distances.

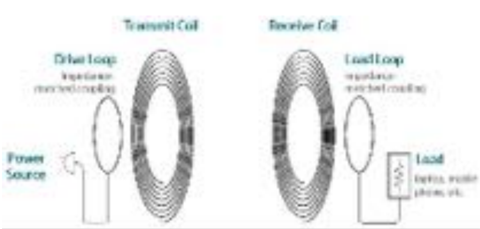
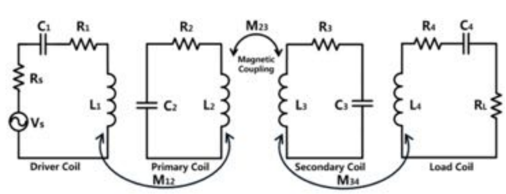
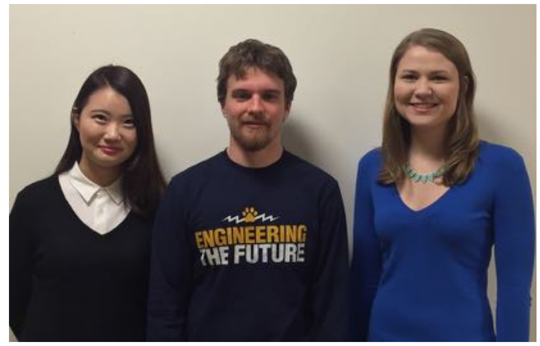


Figure 1. Resonant circuits connected to transmitting and recieving coils.



Team 1617: Autonomous Firefighting Robot



Team members: Chutian Zhang (EGPHYS), Zachariah Sutton (EE), and Katherine Drogalis (EE)

Sponsored by: University of Connecticut
Sponsor Advisor: Professor John Ayers

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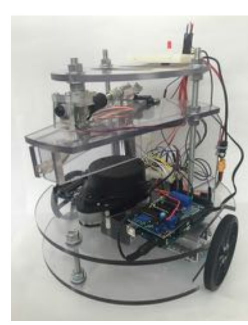
The Autonomous Firefighting Robot was in conjunction with the Trinity College International Robot Contest, which took place April 2-3, 2016 and is an annual, not-for-profit event that promotes innovation and creativity in the STEM field. The main requirement of this project was to design and create a fully autonomous robot, meaning that once initiated by the user, the robot can navigate, search for, and extinguish a fire on its own, with no external input or assistance from the user. The principles used in the design of this robot were implemented with the intent to be extendable to a more robust system used to combat actual fires in residential or commercial settings. In order to meet this criteria, many critical decisions were made involving part selection, mechanical and electrical design, and control for the robot. The ultimate goal was to not only accomplish all of the above listed criteria, but also to create a robot that works quickly and accurately.

This is a complex system with many different parts that must function in unison. The main operations are broken up into navigation, which involves finding where the robot is relative to its surroundings and deciding where to go next, movement, which involves robot actuation, and flame extinguishing. The flame extinguishing is ultimately the main goal of the robot, but the other operations are essential to accomplishing this task.

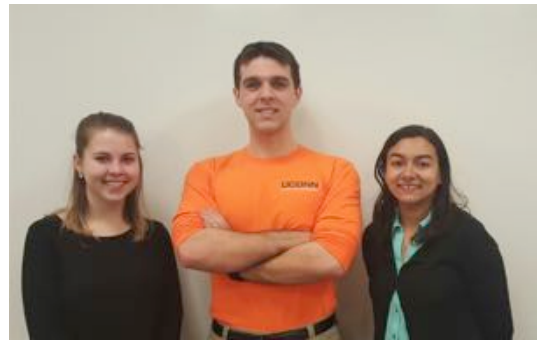
The navigation sensor used is a 360^{o} laser scanner that records and sends data to a Raspberry Pi, running ROS (Robot Operating System), to process and perform localization and path planning calculations. A secondary Arduino board was used with a motor control shield to receive velocity commands from the Pi and transfer them into pulse-width modulation signals to drive the motors. A thermal array sensor was used to monitor for the flame and if a significant heat difference is detected, it overrides the path planning to navigate toward the fire. A small tire inflator with compressed CO_2 was used with an extended nozzle to extinguish the flame. Once in position, the robot initializes a servomotor used to press the button of the inflator to release the gas and extinguish the flame. The images below show the robot body, the model contest arena, and the fully equipped robot, respectively.





Team 1618: Device to Measure Bite Strength of a Military Working Dog

Sponsored by: United States Army
Sponsor Advisor: Capt. Sean McPeck
Faculty Advisors: Rajeev Bansal and David Pierce



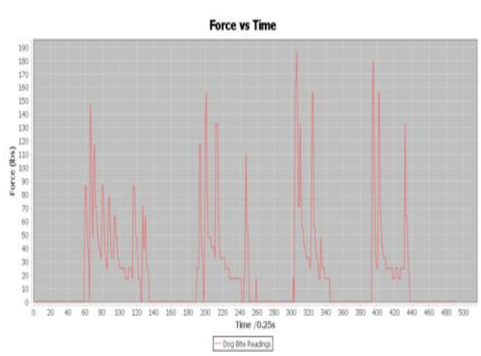
From left to right: Sarah Durno, David Stamper, Jacquelyn Khadijah-Hajdu

Working dogs are commonly used to aid military and police units. Part of their training involves bite strength conditioning. To condition a working dog's bite, trainers will use a bite sleeve or sometimes a large tug, which is held with two hands by the trainer. There are currently many varieties of bite sleeves and tugs which vary in toughness; however, there are none that can measure the pressure of the dog's bite. Thus, the U.S. Army tasked UConn to create a device that is able to measure and display the bite force of the Military Working Dog (MWD). Our device will ultimately help with validating training methods used for conditioning bite strength, enable trainers to keep record of health issues, and help with identifying muscular problems. The ECE team was paired with a Mechanical Engineering team to create a non-intrusive product that will fit inside a standard bite tug.

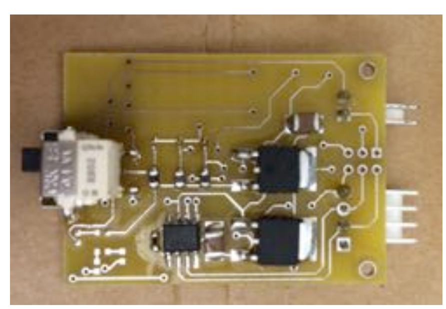
To achieve the above goal, the team is constructing a tug with an air bladder containing a pressure sensor, which connects to a microcontroller-contained PCB with Bluetooth capability. During training, when the dog bites the tug the pressure measurements travel from the microcontroller to a Bluetooth dongle connected to a computer. Using software created for our device the measurements are saved and displayed in a graphical format so that the dog bite data is easily readable. Additionally, because multiple dogs will be biting the tug in one training session, configurable profiles within our software are available. Trainers can store the graph of bite force over time, raw sensor data, and webcam footage of each dog's bite. In addition to storing the data, the trainer can review the dog's performance by playing back the video footage with a synchronized graph of the bite force over time. This will allow trainers to determine how different stimuli affect the dog's bite.

To calibrate the pressure sensor data, the team placed different weights on the device noting the corresponding values that were output. The bite force was determined by creating equations from the known weight applied to the sensor. We were able to work with local K-9 units to perform initial testing of our device.

Device Testing



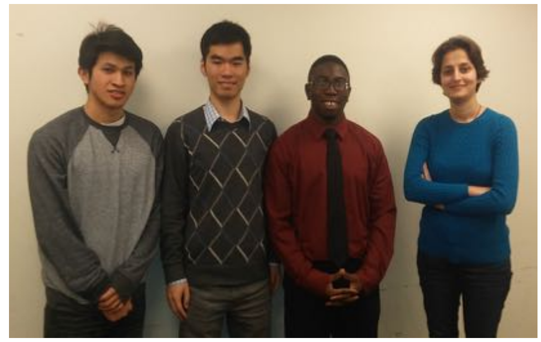
Data from Dog Bite



Device Out-of-Sleeve

Team 1619: Debugging Probe for Hardware Security Testing

Sponsored by: UConn ECE Department
Faculty Advisor: Dr. John Chandy



From left to right: Austin Funes, Cheng Guo, Somtochukwu (Sommy) Okwuosah, Fatemeh Tehranipoor

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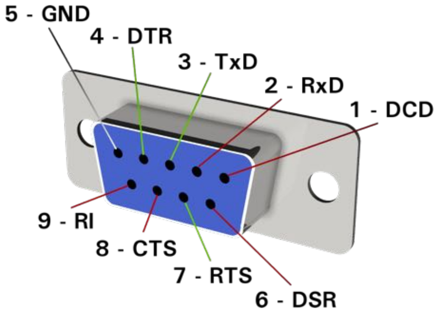
Embedded devices are not always manufactured with security in mind. As a result, many of commercial devices today have vulnerabilities that provide attackers with a means to maliciously exploit them. This presents an even larger problem because of the phenomenon commonly referred to as the Internet of Things (IoT). IoT describes a scenario in the near future where interconnection between devices will be a very common occurrence. Information being leaked by any one of the devices within a system of interconnected devices could be dangerous if it gets into the wrong hands.

Today, some devices still retain their test ports and communication headers even after manufacturing and testing. This is unsafe because it gives attackers a backdoor into sensitive parts of device such as the memory and firmware. Access to these could ultimately alter a device's functionality and compromise the users of the device.

Our project is to design a probe capable of interacting with embedded devices, identify what type of communication protocol is being used (RS232, JTAG, SPI, I2C, etc.) and analyze the data being sent and received from the device. Our probe should work effectively as a debugger without any prior knowledge of the pinout or protocols utilized by the device. This probe will be very useful for debugging and testing devices with greater ease. With this accomplished, signals can be further analyzed in order to improve the way these devices allow information to be accessed and thus, make them safer from malicious exploitation. Our probe will be able to identify the two communication protocols; RS232 and JTAG. We expect this to eventually grow to encompass more protocols.



Team 1620: FPGA Mapping

From Left to Right: Katharine Neils, Caleb Garrett, Miolgens Almezy,

Sponsored by: UTC Aerospace Systems
Sponsor Advisor: Kim Sendlein
Faculty Advisor: John Chandy

UTC Aerospace Systems

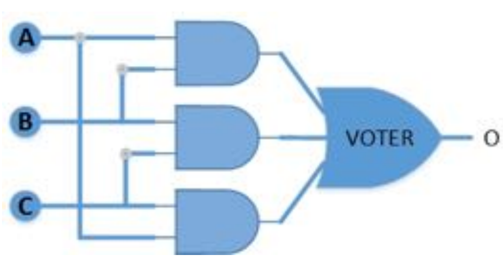
In the aerospace industry, Field Programmable Gate Arrays (FPGA) are employed extensively to provide hardware that allow complex systems that perform critical to mission tasks in environments of high energy radiation. Flash-based FPGA’s are one technology that have shown concrete evidence in their ability to provide hardened hardware to high energy radiation and lower the single events upsets (SEU) in these embedded systems. SEUs occur due to a high energy particle passing through the depletion region of a transistor. This causes an error due to a state change in that transistor, thus triggering a system failure on the rest of the design. However, the trade-off using Flash-based FPGA for protection against SEUs is the high performance offered by other memory types, such as RAM-Based FPGAs. Although RAM-based FPGAs have higher performance, they also have higher susceptibility to SEU’s.

Investigated were ways to reduce RAM-based FPGA’s susceptibility to SEU’s. One way was with Triple Modular Redundancy (TMR). TMR works by triplicating design logic whose 3 outputs are passed to a majority voter. This method allows the system to continue running because error in from one output is masked by the two agreeing outputs. Along with the TMR, a single error mitigation module (SEM) was investigated to repair the masked errors in the design. This module works by scanning through the design for any errors and corrects them. This SEM module operates in the background while the FPGA operates, further increasing the uptime of the system.

Existing design was migrated from a Flash-Based Microsemi FPGA to a RAM-based Xilinx FPGA. A number of changes had to be done such as replacing proprietary code from Microsemi with Xilinx IP cores. Once the code migration was complete, a series of test-cases provide by our sponsor, UTC Aerospace Systems (UTAS), were done to validate the design at pre- and post-implementation.

Microsemi SmartFusion2 Start Kit Board

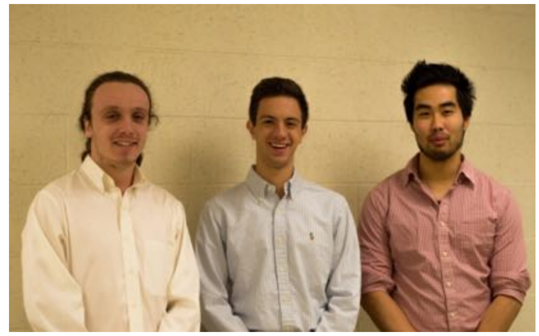
Image Credit: Microsemi



Zedboard Zynq-7000 Evaluation Board

Image Credit: Zedboard

Team 1621 Smart Fuel Metering Unit



Ian MacGregor, Thomas Blackburn, Solomon Lin.

Sponsored by: UTC Aerospace Systems
Sponsor Advisor: William Rhoden
Faculty Advisor: Prof. Lei Wang

UTC Aerospace Systems

Modern commercial aircraft contain a Fuel Metering Unit (FMU) that is responsible for metering fuel to the engine. In order to calculate the burn flow (how much fuel is required by the engine in order to operate at peak efficiency), the FMU uses a generic performance map that may not be perfectly calibrated to the engine's parameters. This map is generally created by averaging the performance data of many different FMU's of the same make and model. As this generic map is based on the performance data of many different units, it will never perfectly model the performance of any individual unit. Therefore, any burn flows calculated using this generic map will fall short of achieving the best possible burn flow given the current environmental conditions. UTC Aerospace Systems (UTAS) is looking to improve the efficiency of their burn flows. To do this, UTAS will map the performance data of each individual FMU rather than an average of multiple FMU's.

In order to accomplish this, a memory chip will be permanently attached to each FMU, storing its own performance parameters to be recalled later by the Electronic Engine Control (EEC). Our solution is 3 fold: acquisition of performance data, extracting good data, and determining how to meaningfully store that data on the memory chip. The acquisition involves operation of a test rig to capture 5 key parameters, FMU temp, pump speed, pressure out, resolver position and metered flow. Extraction of good data requires removing unstable data and the use of data which exhibits the most steady state. In order to store the data on the memory chip, a combination of mapped values using a lookup table and coefficients which produce a regression fit. Both of these tools must be used to achieve the desire 0.1% accuracy and have the data read by the EEC in less than 0.5 seconds.