ELECOMP CAPSTONE SUMMIT

FRIDAY, MAY 12, 2017

Celebrating 10 Years of Excellence

2008 – 2017

THE UNIVERSITY OF RHODE ISLAND
COLLEGE OF ENGINEERING

DEPARTMENT OF ELECTRICAL, COMPUTER AND BIOMEDICAL ENGINEERING

SPONSORING COMPANIES

ELECOMP Capstone 2016–2017

HAYWARD

SIEMENS

TSR LED LIGHTING

BCA Bay Computer Associates

IGT

BoldCircuits

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Acumentrics Trusted Power Innovations

HEXAGON METROLOGY

"WE ALL express our sincere gratitude for your support"

Thanks Very Much Muito Obrigado Bahut Dhanyavaad

Asante Sana Muchas Gracias Vielen Dank

Merci Beaucoup Grazie Mille Shukraan Jazilaan

Fēicháng Gǎnxiè Nǐ Dōmo Arigatō Gozaimashita

Gratias Tibi Valde

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ELECOMP Capstone Design Program

SCHEDULE OF EVENTS

ELECOMP Capstone Design Program SUMMIT
Friday, May 12th, 2017

7:00 – 8:50 am	• **Breakfast** • **Registration** • **Viewing of Capstone Project Posters** *Location: 95 Club*
9:00 – 9:15 am	**Welcome** Professor Harish Sunak, Capstone Program Director *Location: Kirk Auditorium*
9:15 – 10:20 am	**Rocket Presentations I** (6 teams) *Location: Kirk Auditorium*
10:20 – 10:40 am	**Break**
10:40 – 11:56 am	**Rocket Presentations II** (7 Teams) *Location: Kirk Auditorium*
12:00 – 1:00 pm	**Lunch** *Location: 95 Club*
1:00 – 1:45 pm	**Poster Session & Demonstrations** *Location: 95 Club*
1:45 pm	**Announcement of Top 3 Teams** *Location: 95 Club*
1:45 – 2:30 pm	**Reception** *Location: 95 Club*

ROCKET PRESENTATIONS

ELECOMP Capstone Design Program
Schedule of "Rocket" Presentations
Kirk Auditorium

	Rocket Presentations I
9:15 – 9:25 am	Acumentrics
9:26 – 9:36 am	Bay Computer
9:37 – 9:47 am	Bold Circuits
9:48 – 9:58 am	Hayward Pool Products
9:59 – 10:09 am	Hexagon Manufacturing
10:10 – 10:20 am	IGT "Jackpot"
	BREAK
	Rocket Presentations II
10:40 – 10:50 am	IGT "Windfall"
10:51 – 11:01 am	Maxson Automatic
11:02 – 11:12 am	National Grid
11:13 – 11:23 am	Phoenix Electric
11:24 – 11:34 am	SARNET (ELECOMP Capstone)
11:35 – 11:45 am	Siemens
11:46 – 11:56 am	Thermal Solution

WELCOME BY PROFESSOR

ELECOMP Capstone Design Program Director

Welcome: It gives me great pleasure to welcome you all to our Annual Summit of the ELECOMP Capstone Design Program. This year we are celebrating 10 Years of Excellence in Capstone Design for Electrical (ELE) and Computer (COMP) engineers at the University of Rhode Island, in the Department of Electrical, Computer and Biomedical Engineering. The ELECOMP Capstone Design Program partners senior-level engineering students with industry sponsors to design, build, program and test solutions to real-world problems. We are excited to present 13 projects, covering a variety of problems in electrical and computer engineering. I have allocated 10 minutes per project for the oral "rocket" presentations, to allow more time for live/video demonstrations, poster session interactions and discussions. I hope you will have a stimulating day, especially if you would like to come on board with a new capstone project. The depth and breadth of work in these projects is outstanding and I hope it will inspire you to propose creative ideas for immense mutual benefits.

Capstone Bridge: The ELECOMP Capstone Bridge mirrors the well-known Wheatstone Bridge extremely well, as shown on the back cover. All facets of our Capstone Design Program *(page 34)* together with our talented seniors with diverse skills form the two known arms of the bridge. The third known arm is the sponsoring company, their Technical Director and the problem to be solved. Only when these three arms are in perfect balance and collaborate in excellent harmony, success is achieved in the unknown arm: The Best Outcome of the Sponsor's problem.

Together with my senior capstone designers, I would like to sincerely thank all the companies who became the third arms this year; they are listed on the inside of the front cover. Without their generous support, it would be impossible to execute on all the facets of the program. Special thanks to all the Technical Directors for their time and efforts in mentoring the teams.

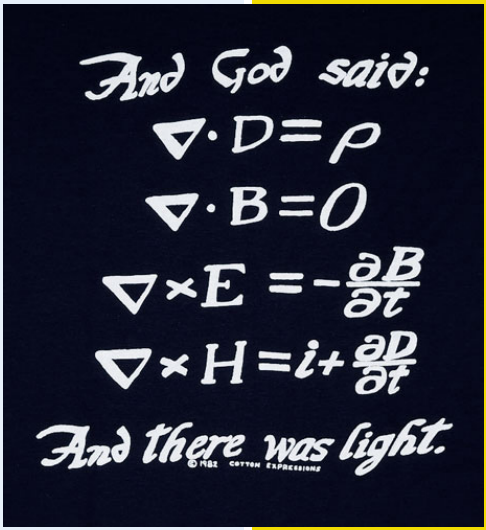
IGT Technical Directors' Quote: *By Bruce Parkes '96 and Raymond Leyland '93:* "The students' abilities to introduce new technologies, tools, processes, designs and academic rigor should not be overlooked. Additionally, they bring a naiveté that forces questions to be answered about a company's established products, processes and protocols."

Placement of Class of 2017: I am happy to report that 21 seniors have already accepted full-time positions in industry; 6 are going to graduate schools; 1 is spending his super-senior year abroad and another will be graduating in December this year. Hence 18 are still looking for suitable opportunities. If you have positions to fill in your company, I hope you will be able to make suitable connections today.

New Engineering Building: It will be very exciting to move into our new building in 2 years' time. The present freshmen class will be doing their capstone projects there. "It will be the finest Engineering Facility anywhere and will move URI to the absolute forefront of Engineering Research and Education." – URI President Dooley.

Graphic Designer: A BIG thank you to Kathie McKinstry, Graphic Designer in URI's Printing Services Department. Her ideas and creativity, to put this program together, have been outstanding. Thanks Kathie, and Happy Birthday today!

Favorite Gym T-Shirt: I would like to conclude by showing you my favorite gym T-shirt. I hope there is much light in your life. Congratulations to the Class of 2017 and today will be a day of celebration, before your pending graduation on May 21st, 2017.



Acumentrics
Trusted Power Innovations

acumentrics.com

PROJECT TITLE

Development of AESA™

Acumentrics Easy Simple Network Management Protocol Application

TECHNICAL DIRECTORS

Peter Upczak
Ersson Zapata '84

TEAM MEMBERS

Brendan Smerbeck (C)
Nicholas Rommel (C)
Taylor Coogan (C)
Josiah Schaffer (E)

(L to R)
Taylor Coogan,
Josiah Schaffer,
Peter Upczak,
Nicholas Rommel,
Brenden Smerbeck

PROJECT MOTIVATION AND BEST OUTCOME

Acumentrics' Rugged Uninterruptable Power Supplies (RUPS) are trusted for reliable AC/DC power conditioning and providing battery backup in harsh and combat environments. However, the RUPS has no Graphical User Interface (GUI), requiring customers and developers to use a command-line interface (CLI) with complicated scripts to control the system. To monitor the system using the Simple Network Management Protocol (SNMP), users have to rely on third-party software; leaving much to be desired. Overall, the rigidity and high learning-curve of these alternatives leaves much to be desired.

The team was tasked with developing Acumentrics' first GUI application capable of communicating with, monitoring, and managing RUPS devices. The best outcome is a functional prototype capable of communicating using the SNMPv3 protocol, monitoring the devices, and supporting all commands and traps supported by the v3 protocol. It must be easy to use, and not require advanced technical knowledge. Ultimately, it must provide the users with all the controls originally provided by the CLI and third- party software.

PROJECT OUTCOME

SUMMARY

The application meets and exceeds the best outcome.

KEY ACCOMPLISHMENTS

Easy Scan: To simplify the user experience, the application can perform a scan of the local network and automatically discover Acumentrics devices.

SNMPv3: The application is capable of communication using all levels of the SNMP protocol (v1, v2, v2c, v3). The inclusion of all protocol levels provides Acumentrics a broad scope of compatibility for their current and future product line. Similarly, SNMPv3 provides the highest level of data security using multi-phase encryption.

Traps: Trap notifications are key to management; alarms and other events on the device can be programmed to send alert messages. Not only can the application configure where the RUPS send these alerts, but it can receive them and store them in a simple event log.

MVVM: Model-View-ViewModel architecture of the application ensures Acumentrics that they have a clean, well-structured application that can be easily tested and quickly integrated into their products and services.

Variable Resistive Load Bank: The development of a single unit that supports simultaneous AC and DC loads can be integrated into both testing and demonstrations of the Acumentrics product line.

Automatic Battery Shutoff Controller: When performing any tests on batteries, discharge past a safe level could result in venting; leaking toxic and possibly combustible gas. This controller ensures safety for engineers.

RECOMMENDED CONTINUATION

Further expansion of multi-device management to support N+1 master/slave configuration. Development of a mass-deployment system for network configuration and firmware updates. Web application implementation.

BROADER IMPLICATIONS

Having shown that UPS management can be a simple and intuitive experience, we imagine that this application can be expanded upon at a larger scale. Rather than manage local UPS devices, the system could be hosted on a web-server. UPS devices, regardless of location, could send their data to this central server and users could connect using any device with an internet connection. User of this system could monitor, configure, and control devices at multiple locations; receiving SMS or email messages when events occur. The system could also be easily ported to mobile devices.

PROJECT TITLE

Three Phase Motor Controller

TECHNICAL DIRECTOR

Dr. David Durfee

TEAM MEMBERS

Denise J Andreozzi (C)
Devin Pacheco (C)
Anibal Perez (C)

Above: Dr. David Durfee

Left: (L to R)
Anibal Perez
Denise Andreozzi
Devin Pacheco

PROJECT MOTIVATION AND BEST OUTCOME

Bay Computer Associates began this project as a Three Phase Motor Controller for a power assisted wheelchair. It was later implemented for an electric bicycle. The company would like to prepare for a redesign of the board, in the hopes of advancing the device to be used with a larger, four-wheeled vehicle, while also adding functionality to the firmware and software.

The ultimate goal of the Electronics Engineer is to increase efficiency and reduce the cost and footprint of each circuit, in order to eventually have the motor controller drive 80 amperes of current. Bay Computer Associates would also like a Firmware Engineer to implement a position control, which will add value to the product. A Software Engineer would be responsible for implementing tuning software to include an auto-tune feature.

PROJECT OUTCOME

SUMMARY

Redesigned 75% of regulated power supplies to reduce cost, increase efficiency, and maintain footprint. A position control feature with extrapolation and an auto tuning feature has been implemented and currently awaiting unit testing.

KEY ACCOMPLISHMENTS

Electronics: The Power-Up and Overcurrent Circuits have been corrected and the regulated power supplies (11V, 3.3V, 5V) have been redesigned.

Data Dumping: We have created a command in our serial terminal to dump specific data that is useful in the tuning software. This dumping feature gives us the ability to test and change the tuning algorithm to how we see fit.

Lagrange Function: This function within our firmware gives us the ability to predict the future by using Lagrange Polynomials. This is important in our position control function because it reduces the amount of oscillation that is forced upon the time versus distance graph.

Position Control: This position control implementation will get the motor from one point to another with ease. Our function uses the Lagrange polynomial which reduces the oscillation of our position curve.

Real Time Streaming: We implemented a graphing function for streaming real time data. We added an area of the application where this streaming data can be displayed graphically.

The Best Tuning Algorithm: We did extensive research for the best tuning algorithm given our application. Since we had to implement this algorithm using software, it was imperative we found one that can meet our requirements.

Tuning Options: We implemented an Auto-Tuning feature based on our research and added this function to our application. We also gave our users the ability to manually tune any Three Phase Motor Controller

RECOMMENDED CONTINUATION

Our recommendations for continuation are to redesign the overcurrent and overvoltage protection circuits; look into meters, feet, or other measurements for our position control; and implement the auto-tuning feature for both the velocity and the current feedback loop.

BROADER IMPLICATIONS

AC induction motors are very popular. The three-phase power system has a lot of benefits including better consistent delivery of power and better efficiency than other configurations. Creating a Three Phase Motor Controller that can adapt to any motor is something that can bring a lot of success to any engineering application. Our goal is to make the most optimal Three Phase Motor Controller that is also easy to use and configure.

PROJECT TITLE

ARM Based SD to FPGA Data Transfer Optimization

Advanced RISC Machine (ARM) Based Secure Digital (SD) to Field-Programmable Gate Array (FPGA) Data Transfer Optimization

TECHNICAL DIRECTOR

Mike D. Smith '01

TEAM MEMBERS

Ackara Or (E)
Jordan Volpe (C)
Virginia Alvarez (E)

(L to R)
Ackara Or
Virginia Alvarez
Jordan Volpe
Mike Smith

PROJECT MOTIVATION AND BEST OUTCOME

Many of today's applications where bulk storage or maximum write/read performance is desired call for the use of Secure Digital (SD) card memory capabilities. The uncertainties of the performance of SD cards include: advertised data transfer rates versus actual performance rates, and peak transfer rates versus sustained transfer rates. The goal of this project is to develop a system that uses an ARM processor to extract data from microSDs, the most common type of SD card, and transfer the data to an FPGA fabric to test and determine an optimal rate.

The best outcome of this project would be to have a working prototype designed, built, and functioning for proof of concept purposes. The prototype will be transferring data from a microSD card through an FPGA fabric, via an ARM processor, using two architectures, a separated architecture and an integrated architecture. The functioning data transfer rate should be a sustained rate, not a peak rate. We should also be able to analyze the performance of both architectures and highlight the strengths and weaknesses of each, via testing and results analysis.

PROJECT OUTCOME

SUMMARY

Our team is delivering a fully-functioning, but non-optimal, prototype for our integrated structure.

KEY ACCOMPLISHMENTS

Hardware Selection: The MicroZed System on Chip (SoC) and Cypress FX3S were selected for the ARM and FPGA fabrics. The MicroZed SoC was used for the integrated structure design, while the separated structure used the FX3S ARM in conjunction with the MicroZed FPGA. Additionally, different carrier cards were needed for communication between the Processing System (PS) and Programmable Logic (PL) to output data.

PS to PL Data Transfer: For the integrated structure, an AXI-lite interface was implemented in order to be able to send data between from the PS to the PL aboard the MicroZed. For the separated structure, code from examples was used to enable communication between the PL aboard the SoC on the MicroZed and the FX3, via the General Programmable Interface (GPIF) Slave FIFO.

Total End-to-End Data Transfer: For the integrated structure, a C program was used by the PS to extract data from an inserted microSD card to be stored in an internal buffer. The data was then written from the buffer across the AXI interface to the PL, which then transferred the data in parallel fashion to I/O ports. For the separated structure, it was not possible to create a functional end-to-end data transfer interface. However, an informative document was created in which all of the information about the functions and useful procedures that can be used in order to establish end-to-end communication between the microSD card on the FX3 and the PL in the MicroZed.

RECOMMENDED CONTINUATION

In the integrated structure, further work would consist of optimizing the established data transfer interface, and perhaps exploring the implementation of other data transfer interfaces. In the separated structure, further work would consist of further analysis of the GPIF interface.

BROADER IMPLICATIONS

While microSD and SD cards are the most common source of bulk storage, many devices do not feature I/O ports to read from these cards. Having a means to quickly stream or transfer the data on an SD card to a laptop or a cellphone for further use could result in SD cards becoming even more prevalent in the future and could potentially further expand their applications and capabilities.

HAYWARD®

hayward-pool.com

PROJECT TITLE

Smart Water Valve Actuator

TECHNICAL DIRECTOR

Jamie Murdock ’84

TEAM MEMBERS

Peter Jenkel (E)
Danielle Gonsalves (C)
Sean Deely (E)
Jimmy Nguyen (C)
Joseph Tudino (E)
Evan Lachance (E)

Above: Jamie Murdock

Left: (L to R)
Peter Jenkel, Danielle Gonsalves, Sean Deely, Jimmy Nguyen, Joseph Tudino, Evan Lachance

PROJECT MOTIVATION AND BEST OUTCOME

With Hayward’s current valve actuator, the customer must manually adjust the position of the valve and must only pick from two positions. Adjusting valve position changes flow rate to water features and thus changes the visual effect. The current actuators are only valid for one configuration, so when more features are added, all other water features are affected. This makes it very difficult, to near impossible, for the customer to get the look they want for all of their water features. A smart valve actuator will ensure the customer always gets the look they desire for every water feature.

Hayward tasked us with the goal of developing a commercially viable design of a prototype that consists of a Printed Circuit Board (PCB) Alpha design that fits in the housing of the previous version of actuator. In terms of hardware design, the PCB consists of a Kinetis K02 Processor, a motor driver circuit, integration with a flow sensing IC, and proper power management. For the software design of the prototype, the specifications called for software to control the motor, read position via the encoder, and read water flow via flow sensor.

PROJECT OUTCOME

SUMMARY

The application meets the best outcome.

KEY ACCOMPLISHMENTS

Schematic Design: Created a power management circuit integrating an automatic relay switching of two distinct power supplies. Created control circuits in Pulsonix implementing the Kinetis K02 Processor microcontroller, a motor control chip, and a one-hundred-and-twenty-eight absolute position Bourne's encoder.

Printed Circuit Board Layout Design: Successfully completed the routing for the PCB layout.

Migration from FRDM K22f to K02 Processor: Initially developed and tested firmware/software using the Kinetis FRDM-K22F development board. To fit the constraints of the prototype layout and the actuator housing, migration to the Kinetis K02 processor was necessary. The benefits of the K02 include but are not limited to, high performance processing efficiency for lower power applications, exceptional computation power for control algorithms, low dynamic power consumption.

Software Application: Used MQX Real Time Operating System (RTOS) to create a software application to control the smart valve actuator. Created two threads to move to user requested position or maintain user requested flow rate. Software supports multiple valve actuators.

Built Test Tank: With help from Hayward employees, a test tank was designed and created to implement two actuators for testing. The tank routes two actuators to independent flow sensors and jets as well as a return pipe for excess water flow.

RECOMMENDED CONTINUATION

API development to integrate the prototype with Hayward's OmniLogic mobile/desktop application for pool feature control. Additional components to improve power management safety. Revisions to current prototypes of PCB layout.

BROADER IMPLICATIONS

With the completion of a prototype, Hayward will be able to expand upon the capstone design. Hayward can interface the Smart Valve Actuator with their existing platform, Omni Logic. Omni Logic is a application customers use to control their Hayward products such as LED Lights in their pools. Once Hayward interfaces the Smart Valve Actuator with Omni Logic customers will be able to control flow rate to their water features from the convenience of their cell phones.

HEXAGON METROLOGY

hexagonmi.com/en-US

PROJECT TITLE

Workflow Optimization for Industrial Software Applications

TECHNICAL DIRECTOR

Jonathan O'Hare '94

TEAM MEMBERS

Paul Bally (C)
Jun Yu Lu (C)
Javier Restrepo (C)

(L to R)
Jon O'Hare
Javier Restrepo
Paul Bally
Jun Yu Lu

PROJECT MOTIVATION AND BEST OUTCOME

Among all the important aspects of engineering, one of the most important is making processes as efficient as possible. When we first opened PC-DMIS (Personal Computer-Dimensional Measurement Interface Specification) and began to learn how the software worked, we soon noted several things that could be improved to increase workflow and efficiency. We strived to implement these changes in our final product to substantially improve the software. We will also be introduced to new material during the course of the project to help broaden our array of technical skills.

The best outcome for this project was a redesigned example of a GUI, (Graphical User Interface), with the three segments of PC-DMIS we each chose, (Probe Qualification, Menu Bar, Refined Data Structure). This new GUI will be more efficient and easier to use. We will reduce the average learning time of 6-12 months per user by having the user complete fewer tasks to finish a process and to provide a visible workflow that can be followed step by step.

PROJECT OUTCOME

SUMMARY

Our program meets the best outcome for the project.

KEY ACCOMPLISHMENTS

Identifying Areas of Potential Optimization in PC-DMIS: We analyzed PC-DMIS on our own personal computers and gained first-hand experience of problems which first time users were having with the program through attending Hexagon's PC-DMIS software classes.

Creating XML Files: Created XML files for each of our individual portions of this project gave us a database to store information that our programs would use. Stored data in XML files allowed dynamic interaction between the files and our programs, as we could add information to the XML file and that new information would be used in the program.

Completed Individual GUIs (Graphical User Interfaces): Each of us were assigned a particular portion of the project to work on separately. These three portions were the Menu Bar, the Probe Qualification process, and the Refined Data Structure, (including data trees). We successfully made GUI programs to redesign each portion in PC-DMIS to be more efficient and more appealing to the user.

Combining Individual Portions into a single Working Executable: After completion of our individual portions, we used the Menu Bar GUI as our base for adding the two other portions. The refined data structure portion was added beneath the menu bar left justified. The Probe Qualification process was added to open upon the press of a button in the Menu Bar.

RECOMMENDED CONTINUATION

Analyze more processes in PC-DMIS that could be redesigned so that the workflows would be more efficient. Then add those new processes to the current redesign and keep on building this program piece by piece.

BROADER IMPLICATIONS

PC-DMIS is a program with many features that not every user will need. To make PC-DMIS more flexible among a variety of users, we think it is possible to have different versions of the program. Much like many other software programs today, some versions have more features while some have just the basic features. A basic version of PC-DMIS would be more cost effective while there would be a more expensive version for users who wanted the additional features offered in PC-DMIS.

IGT "JACKPOT"

igt.com

PROJECT TITLE

Approaching Customer Sensing System

TECHNICAL DIRECTOR

Bruce Parkes '96

TEAM MEMBERS

Thomas Hamilton (E)
Ethan McClure (E)
Omose Ogala (C)

(L to R)
Ethan McClure
Bruce Parkes
Thomas Hamilton
Omose Ogala

PROJECT MOTIVATION AND BEST OUTCOME

IGT wishes to advance the technology of their lottery ticket terminals in order to advertise to a broader customer group and to give their players a better buying experience, meeting the needs of the modern consumer. The addition of proximity sensors that will cause the screen to react to customers will make the purchasing experience a more interactive and memorable experience. Adding more utility for customers as well as IGT. This project will help IGT remain progressive and lead the industry with the latest and greatest advertising technology.

We hoped to be able to achieve the best outcomes in three main areas. First, having a characterized and calibrated board in which we can have our board properly programed with our sensor processing data software. Second, sensing whether a person is moving within the proximity sensor's view using our sensing algorithm. Third, receiving data from our controller in which we can then send to the Linux computer. Essentially, this was a research project in hopes of understanding if this sensor is a good fit for IGT's gaming terminals.

PROJECT OUTCOME

SUMMARY

We are delivering a proof-of-concept model as well as extensive research on the sensor.

KEY ACCOMPLISHMENTS

Schematic and Bill of Materials: Developed circuit schematic for Time-of-Flight sensor printed circuit board. Compiled a complete bill of materials that includes vendors for all circuit board components.

Characterize Sensor: Properly calibrated sensor to environment as well as characterized the sensor data as it changed due to distance, temperature, field-of-view, and lighting.

Sensing Algorithm: Designed a sensing algorithm that took advantage of real-time distance and amplitude data coming from the proximity sensor, and fed it through a digital control system designed to sense approaching customers.

API: Created a system that organized data communication between hardware and software.

Terminal Application: Created C# application to test, calibrate and analyze the sensor data. In addition, this application graphs real-time information from the sensor in numerous ways.

RECOMMENDED CONTINUATION

Design an automated sensor calibration procedure designed for the final silicon, create a more robust multi-sensor system and implement a more advanced API structure. Additionally, revamp the schematic to compensate for changes to the final commercial silicon.

BROADER IMPLICATIONS

Through our research we have demonstrated that the proximity sensor has the capability to accurately sense approaching customers and send that information to a Linux computer. The technology behind this proximity sensing, Time-of Flight with included ambient light calibration, is at the forefront of proximity sensing technology. Going forward IGT could implement this type of sensing system in other lottery terminals. For instance, terminals could display different messages when possible customers are nearer or farther away, or the terminals could make different inviting noises to attract customers.

IGT "WINDFALL"

igt.com

PROJECT TITLE

Development of Bluetooth Dongle Manufacturing Package

TECHNICAL DIRECTOR

Raymond Leland '93

TEAM MEMBERS

Kevin Mathews (E)
Kyle Carvalho (E)
Sundaram Patel (C)

(L to R)
Sundaram Patel
Kevin Matthews
Kyle Carvalho
Ray Leland

PROJECT MOTIVATION AND BEST OUTCOME

IGT's modern line of Altura lottery terminals offer wireless connectivity, allowing lottery ticket purchases through IGT's PlaySpot application on Android and iPhone. However, hundreds of older Legacy Altura series terminals are still in operation, and cannot support modern Bluetooth connectivity. These machines have no internal antennas, and their Linux kernels do not support Bluetooth software stacks. Project Windfall's motivation is to develop Bluetooth connectivity for US legacy Altura terminals, allowing lottery players to purchase tickets wirelessly from modern smartphones.

Our team was tasked to develop a USB Bluetooth dongle with a full internal Bluetooth software stack. This would allow unsupported wireless functions to run on hardware separate from the lottery terminal, bypassing the older Linux kernel. The best outcome for this project would be to develop the full PCB manufacturing layout and schematic, and write source code for a full Bluetooth software support package, including multiple Bluetooth types (Classic, LE, etc.). In addition we would write an API for host side debugging.

PROJECT OUTCOME

SUMMARY

The board manufacturing package meets the design expectations. The software package must be finished and customized by IGT.

KEY ACCOMPLISHMENTS

Board Manufacturing Package: Full copies of the PCB schematic and layout now exist in IGT's system along with a full bill of materials with IGT part numbers and prices. The board has been designed to satisfy IPC manufacturing standards for RF.

Proximity Sensor Support: The board is designed with headers to allow the connection of a Texas Instruments OPT3101 Proximity Sensor. This allows the board to be used for sensing applications as well as Bluetooth, saving on cost and development time for other projects at IGT. Board components can be populated and depopulated depending on whether a terminal needs proximity sensing or Bluetooth.

Board Support Package Framework: The source code framework for the dongle hardware has been laid out. The software commands needed for USB and Bluetooth communication are implemented. The package can be modified by IGT to function with Altura lottery terminals. Supported Bluetooth profiles are GATT and GAP, needed for smartphone connection.

Host-Side Software: TCP socket connection established between the daemon and client (the lottery application). The USB connection is established between the daemon and the controller. Run time errors have also been discovered and fixed.

RECOMMENDED CONTINUATION

Proprietary IGT code will be added to the host side daemon and API in order for the dongle to run on IGT terminals. A housing will be developed by IGT's mechanical engineering and marketing teams. The USB and Bluetooth framework still need to be connected properly in order for full intended operation.

BROADER IMPLICATIONS

With the recent release of Bluetooth 5, newer iterations of dongles can be created to further increase the lifespan of older lottery terminals in establishments across the country. Bluetooth 5 offers increased range, power and data transfer rates, which would be ideal for large establishments like sports bars and grocery stores. More Bluetooth profiles can be added for supporting devices like wireless barcode scanners, ticket printers, and wireless repeaters. This would help consolidate many common devices for terminal owners.

maxson automatic machinery company

maxsonautomatic.com

PROJECT TITLE

Dual Knife Rotary Sheeter

TECHNICAL DIRECTORS

Joseph Matthews '80
Michael Terranova

TEAM MEMBERS

Timothy Gennari (C)
Michael Reinhart (E)

(L to R)
Seated:
Joseph Matthews
Michael Terranova

Standing:
Timothy Gennari
Michael Reinhart

PROJECT MOTIVATION AND BEST OUTCOME

Our project motivation is to develop an alternative, lower cost sheeter that can deliver higher speeds while maintaining sheet length accuracy. Ideally, the goal is to provide a more marketable sheeter with a smaller foot print and an attractive and user friendly HMI. Ultimately, the goal is to take a fresh look at Maxson's sheeter and to find areas of improvement. Our goal is to find a better value package for the sheeter or see if Maxson currently has the best deal.

The best possible outcome for this project is to provide Maxson with a more visually appealing and intuitive interface for the sheeter's Human Machine Interface. This new interface will also include a screen keeping track of past and future orders. Multiple vendors must have been consulted regarding our application and provided us with quotes on needed materials. Maxson must be provided a recommendation regarding whether to switch from their current vendor with a goal to obtain a cheaper package.

PROJECT OUTCOME

SUMMARY

The savings found were not worth a switch in vendors. The HMI's new interface has functional and visual improvements.

KEY ACCOMPLISHMENTS

HMI Visual Improvements: The home screen features an interactive and realistic visual of the side of the sheeter that is used to navigate to the different screens. Each screen has a modern look to it with intuitive user interaction.

HMI Functional Improvements: A new screen features a table that will help the user keep track of and update important information for past, present, and future orders. Another screen is dedicated to providing help to the user through instructional videos. This will provide quick and simple assistance and information without needing to leave the sheeter. Saving and loading orders is also possible with the new program.

Vendor Selection: After meeting with a spectrum of different vendors and comparing their competing sheeter solutions, it was discovered that Bosch Rexroth provided the most competitive and valuable sheeter package. This will give Maxson the confidence that their existing relationship with Bosch Rexroth is valuable and competitive, allowing for following capstone teams to work more closely with this vendor in future projects.

Hardware Components: During our research into the existing electronic hardware used in the sheeter, we discovered an unexplored piece of equipment. The Industrial PC is a piece of control hardware that uses soft PLCs and interacts with HMIs. IPCs promise to offer a more centralized solution with potential marginal monetary savings.

RECOMMENDED CONTINUATION

Maxson may want a team of computer and electrical engineers to pilot an IPC solution for the sheeter design. It would be wise to develop an IPC option to see if there is any potential advantage.

BROADER IMPLICATIONS

This project focused on the dual knife rotary sheeter, but the user interface can be expanded past that. While designing the new screens, we kept in mind the option of using them for various other HMIs. The screens are spacious and the buttons are large. This allows them to be more easily used on a smaller screen. This could be useful if they are used on different sheeter models with different HMIs or even if Maxson wanted small portable HMIs.

nationalgrid nationalgridus.com

PROJECT TITLE

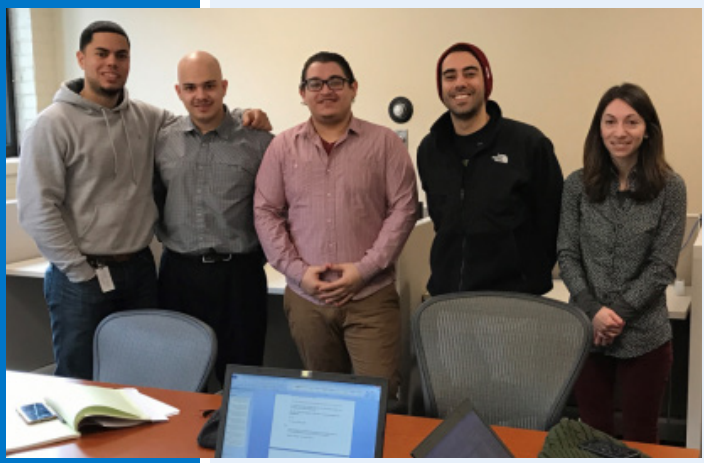
Distributed Generation Direct Transfer Trip (DTT)

TECHNICAL DIRECTORS

Erica Russell Salk
Luis Rodriguez '15

TEAM MEMBERS

Miguel Angel Vega (E)
Eder Borgas (E)
Omar Perez (E)



(L to R)
Luis Rodriguez
Miguel Vega
Omar Perez
Eder Borgas
Erica Russell Salk

PROJECT MOTIVATION AND BEST OUTCOME

The main task the team aims to address is a replacement for Teleprotection products and introduce a wireless Telecommunication method to the DTT process, eliminating the need for a third party such as Verizon. Our focus is on improving costs and lead-time by providing less costly, yet reliable solutions attained through rigorous research and evaluation from experienced engineers. National Grid's work ethic is "Ensuring the safety and well-being of our employees, customers, and communities." Safety is one of the key elements driving our project; as the very nature of a DTT is to provide system level, fault-tolerant electrical protection to a portion of the power grid.

The best outcome for our project was met. The new implementation of the DTT will reduce equipment cost and lead time. National Grid requires this project to support IEEE 1547 and FCC licensing regulations. The DTT itself provides a range from 1 to 20 miles; security and support National Grid's 5-9 (99.999%) reliability rule for Fresnel Zone clearance. Our design has been successfully tested in a laboratory setting and has been shown to exceed the best outcomes and requirements.

PROJECT OUTCOME

SUMMARY

The team has developed a new implementation of a direct transfer trip (DTT) scheme that reduces equipment cost and lead time.

KEY ACCOMPLISHMENTS

DTT Design scheme – The direct transfer trip (DTT) system will use line-of-sight (LOS) microwave communication to transmit the DTT signal wirelessly between two points. The SEL-2506 protection unit is a viable replacement for the RFL-9745 protection unit.

Product selection and Financial Projections – The microwave unit selected was the ExploreAir by Exalt. The protection unit selected was the SEL-2506 by Schweitzer Engineering Laboratories (SEL). Equipment total cost estimate is $ 17,633.12.

Bench Test (EX-5i) – The EX-5i microwave unit by Exalt was provide by National Grid for laboratory testing and documentation. During the experiment the EX-5i unit supported the transmission of a T1 signal and provided reliability and secure DTT signal.

Bench Test (SEL-2506) – The SEL-2506 by SEL was provided by National Grid for laboratory testing and documentation of the DTT signal transmission. During the experiment our team was able to demo a DTT signal being transmitted from one unit to another.

Path Profiler – A computer simulation tool provided by Exalt was used to detect terrain variations and line-of-sight obstructions for our DTT system. For the locations given to our team, the software proves that the DTT system will function properly when installed in a particular way.

Small Scale Model – This model will simulate the entire DTT system functioning by using Arduinos, relays, and IR sensors.

RECOMMENDED CONTINUATION

This project's design for the DTT system is focused on point-to-point communication. This can be improved to incorporate multi-point transmission of a DTT signal. A network of DTT systems can communicate with each other to enlarge scope of DTT protection.

BROADER IMPLICATIONS

The DTT design can be used for different applications, such as communicating signals aside from DTT. Transmission of data is supported as by the design. The LOS microwave transmission method can be replaced with a satellite method to communicate a DTT signal from any location, regardless of the environment. The design can be altered to allow cross communication between multiple DTT systems, which can potentially reduce cost and installation lead time of a DTT system.

PROJECT TITLE

Fiber Optic Design High Voltage Equipment Control System Interface

TECHNICAL DIRECTORS

Sandro Silva '02
Mike Guerra '02

TEAM MEMBERS

Edgar Braley (E)
Basim Anabtawi (E)
Michael O'Hara (E)

(L to R) Edgar Braley, Basim Anabtawi, Michael O'Hara, Mike Guerra, Sandro Silva

PROJECT MOTIVATION AND BEST OUTCOME

Conducted electromagnetic interference is caused by the physical contact of the conductors as opposed to radiated EMI, which is caused by induction (without physical contact of the conductors). This persists in all conductors and mutual inductance between two radiated electromagnetic fields will result in EMI. For lower frequencies, EMI is caused by conduction and, for higher frequencies, by radiation. EMI through the ground wire is also very common in an electrical facility.

The best outcome for this project is to have a circuit that encodes the level of a wire either higher than the threshold or below the threshold, on or off respectively. This threshold is the industry standard of 125 VDC. That voltage is then going to be stepped down to a manageable voltage for the digital circuit we designed. Also, to lower the effects of EMI, we designed the circuit to use fiber cable as the medium. Fiber optic cable is immune to electromagnetic interference and electromagnetic pulses.

PROJECT OUTCOME

SUMMARY

We successfully designed a system as defined in the best outcome. The system can transmit data signals over an optical fiber cable medium.

KEY ACCOMPLISHMENTS

Parallel to Serial Circuit: First, we were able to take the incoming parallel signals and transform them into a serial signal. This was done with a tri-state buffer and shift register. The final word is created by the shift register and is then sent to fiber optic transceiver to be turned to an optical signal.

Fiber Optics: We want to integrate this new technology into the power industry. The use of fiber components allows for increased safety and space management so it would be very helpful for utilities. Our use of a transceiver allows the count of the components to be halved. We were able to install fiber optic cable in our system successfully.

Serial to Parallel Circuit: After the serial signal is transmitted through the fiber optic cable, we need to return the serial data to parallel data. Using another shift register, with a large delay circuit, we were able to regain the original parallel values from the tri-state buffer. After passing these values through a gate decoding system, we were able to achieve proper output signal leveling.

Floating Pins: The largest obstacle we came to was floating pins on the input of our chips. This was giving us many different outcome for the chips because the inputs were not what we had theoretically. We were finally able to overcome this issue by placing resistors at every input of the different IC chips.

RECOMMENDED CONTINUATION

Development of error detection and correction, hand shaking between transmitter and receiver, and proper user notification of system error. Research and creation of an asynchronous serial to parallel conversion would eliminate the need for clock synchronization between circuits.

BROADER IMPLICATIONS

With proper development and expansion of our circuits, we can see that this would be the power control system of the future. With fiber optics replacing copper wiring for power control lines, we would see an increase in grid safety and even municipal safety. With further progress, we could even see this system in our own homes to control lighting. This would create a central control box for any digital controlled system for efficient wiring methods.

"SARNET"

web.uri.edu/elecomp-capstone

PROJECT TITLE

SARNET (Search And Rescue Network)

TECHNICAL DIRECTOR

Mike D. Smith '01
Consulting Technical Director

TEAM MEMBERS

Camilo Giraldo (E)
Teresa Blanco (E)
Dan Goff (E)
John Navilliat (C)

(L to R)
Camilo Giraldo
John Navilliat
Dan Goff
Mike Smith
Teresa Blanco

PROJECT MOTIVATION AND BEST OUTCOME

This project represents our future work as engineers. We will have to be able to detect the needs of the consumer or to identify where a lack of technology exists, then develop and transform them into engineering projects. By the end of these projects, We will notice remarkable improvement in society since our project will offer essential products to the consumers.

During the 2017 ELECOMP capstone session we consider the following to be a best outcome: A functioning GPS module that is being processed by a python application, a completely functioning web server with PHP capability, a video camera that is visible from our private network, an image processing application used to check for positive thermal hit, an image processing application that will update the server with positive thermal images and GPS coordinates, a functioning searching application that surveys an area based on GPS coordinates, a WiFi network that is scale ready, a basic GUI to be refined as the project progresses.

PROJECT OUTCOME

SUMMARY

SARNET has been focused on the intelligence of the system. Consequently, the SARNET project is a success for have accomplishing all the tasks promised and being able to demonstrate it.

KEY ACCOMPLISHMENTS

GPS: Team SARNET count with a functioning GPS module that is correctly being processed by a python application GPSD, in addition to latitude and longitude, we calculated other useful information such as heading or speed. Moreover, a functioning searching application that surveys an area based on GPS coordinates has been implemented.

Wi-Fi network: To send images and GPS coordinates over the network, team SARNET is using a completely functioning web server with PHP capability. In addition, to ensure communication between the Raspberry Pi and the user, a WiFi network is scale ready.

Visual and Thermal images processing: Firstly, the visual images are generated by a video camera that is visible from our private network. Regarding the thermal images, an image processing application used to check for positive thermal hit. This application is fed a variable that sets the range of thermally hot pixel clusters. Any thermal hit that falls outside of this range should be considered a false positive. Finally, SARNET has developed an image processing application that will update server with positive thermal images and GPS coordinates.

GUI - Integration of the components: A basic GUI that displays information in four quadrants: a live video-feed, a thermal video-feed, an information console that displays GPS and alerts the user to a positive thermal hit, and a map windows that lets the user set the initial search area and tracks the drones flight in real time.

RECOMMENDED CONTINUATION

Considering the initial objective of our project, the first feature to consider for future work would be to include a drone in our system. The importance of testing our system in a real-life situation will help us to ensure the correct functioning of our system.

BROADER IMPLICATIONS

Search and Rescue missions are time consuming, expensive and extremely time sensitive. Our goal was to develop a proof of concept communication network between a number of drones and a human operator that would provide an inexpensive and efficient alternative to current search and rescue methods.

The reality is that we live in one of the most exciting periods of technological development. The systems and tools that we will be developing during the course of our career will have an impact on peoples lives like never before

SIEMENS

siemens.com

PROJECT TITLE

Design of a Low Cost Human Machine Interface

TECHNICAL DIRECTORS

William Thorpe
Thomas Lennon ’15

TEAM MEMBERS

Cody DeSoto (E)
Matt Haley (C)
Rassoul Diouf (E)
Wasim Rashid (C)
Damon Georgiou (E)
Faith Akinbo (C)

(L to R)
Cody DeSoto
Matthew Haley
Bill Thrope
Faith Akinbo
Damon Georgiou
Rassoul Diouf
Wasim Rashid

PROJECT MOTIVATION AND BEST OUTCOME

Siemens is exploring the feasibility of entering into the market of low-cost tech devices. Traditional HMIs (Human Machine Interface) can be costly. By creating a low-cost system, Siemens can invest their resources in the development of new technologies. Our team is responsible for creating such a system. Once it has been designed and manufactured, the device will be used to run an Android-based application used by Siemens. Because they are a leading global company, their systems need to be continuously updated and improved.

We have chosen the OpenRex development board as a means to test and implement the components of our project and to display the outcome of it on Android OS. The plan from there was to write the software necessary to get those parts to boot Android using UBoot, but we were unable to get Android on the OpenRex due to image compatibility issues. We have however made some valuable progress, and believe that the project can be overtaken and completed with one or two semesters worth of work.

PROJECT OUTCOME

SUMMARY

A foundation was built with all the research done, which will enable either Siemens or another team to continue working on the project in the future.

KEY ACCOMPLISHMENTS

Research Parts and Compile B.O.M.: We have researched all the parts for our device and come up with a B.O.M. of $63.92, without accounting for the screen, since we have not been able to find a low-cost touchscreen that met Siemens' specifications. Our B.O.M. also does not include manufacturing costs, but looking into the Nexus 7, it was found that the production cost was $8.00 for the 8GB version, and $7.50 for the 16GB one (pcmag.com). If the VLSI work is done in-house then there will be no cost for designing PCB layout.

Implement and Test Parts: Most of the parts being surface-mount devices, we have decided to avoid going the PCB design route, as it would take too long to complete. We have rather decided to work with the OpenRex, which has a processor similar to ours, and SMT to DIP adapters for the rest of the chips.

We have however run into problems when it came to install Android on the OpenRex. Currently, there is no compatible Android image to work with the OpenRex. So we have chosen to work with the DragonBoard 410c to add peripherals. The Android operating system is being developed for the OpenRex and will be completed within two months. When complete, Android and its updated version of Uboot should be installed.

RECOMMENDED CONTINUATION

The team recommends to use the foundation that we've accomplished these two past semesters as a basis to complete the project. A possible route to follow would be to buy breakout boards, if available, to implement and test other parts. For the others, websites such as *protoadvantage* provide SMT to DIP adapters to allow the use of chips on breadboards. The OpenRex will be compatible with Android by next year, so all the hardware could be added the board with Android running.

BROADER IMPLICATIONS

By producing a BOM that is under budget, while leaving room for the unknown manufacturing costs, we believe a low-cost Human Machine Interface, meeting the majority of Siemens specifications and budget is possible. With future work on the VLSI aspect of the project, a HMI including all the advanced features desired could be produced within a reasonable range of the budget. By using the research we completed for the HMI, Siemens will be able to introduce the device to the market as both an affordable and powerful device.

TSR LED LIGHTING

tsrledlighting.com

PROJECT TITLE

Wireless Relay Module

TECHNICAL DIRECTORS

Mikhail Sagal
Gary Arnold

TEAM MEMBERS

Kensey Auguste (C)
Daniel Correia (C)
Christopher Marshall (E)
Oliver Tully (E)

L to R)
Ken Auguste
Chris Marshall
Mikhail Sagal
Daniel Correia
Gary Arnold
Oliver Tully

PROJECT MOTIVATION AND BEST OUTCOME

TSR is developing a wireless relay module for existing LED light fixtures to connect them to the Internet of Things (IoT). This module will have several benefits, such as full 0-10V dimming capabilities and an energy-measuring feature, which gives the user the ability to monitor their energy use. Our team was responsible for designing and building this device from scratch. This involved constructing a fully functional PCB as well as choosing a microcontroller and writing all the firmware for the application.

Our initial best outcome was to have a prototype of the module that would be able to control up to 10 LED fixtures and turn them into ‘smart’ fixtures. The prototype would be able to, by use of the microcontroller and radio, send power to attached lighting fixtures and dim the lights between 0-10V wirelessly. The lights would be connected to a ZigBee mesh network and conform to all ZigBee standards.

PROJECT OUTCOME

SUMMARY

We have met our best outcome as we have a functioning device that is close to being a production-ready module.

KEY ACCOMPLISHMENTS

PCB Design: Using a program, called Autodesk Eagle, a schematic was designed for the Wireless Relay Module. The layout of the circuit was also designed using this program to minimize the size of the PCB.

Construction and Testing: The PCB schematic was exported to a gerber file and boards were ordered. Once the boards arrived, components were soldered onto the boards to make a working circuit. Using LEDs on the board, the circuit was tested to assure that it functioned properly before attaching an LED down light to test the power and dimming functions.

Microcontroller: Researched dozens of MCU's manufactured by several different companies and came to the decision that an, produced by Silicon Labs, was the right choice. This is due to the MCU having all the necessary features and because Silicon Labs provided a great development environment and a solid online resource base.

Firmware: Built a ZigBee HA dimmable light application that incorporated all the needed clusters. These clusters were then manipulated to produce the required behaviors, such as: on/off, dimming via PWM signal, full network functionality, over the air updating, and power cycle resetting.

3D Printed Enclosure: A case for the circuit was 3D printed using the URI Maker's Space. Using the program Autodesk Tinkercad, the case was designed to hold the PCB in place to avoid damage to the board and make the device safer to handle during testing.

RECOMMENDED CONTINUATION

Finalize calibration requirements for the Energy IC on the PCB. Updates to the software stack that can be implemented to existing modules via "over the air" (OTA) secure data updates.

BROADER IMPLICATIONS

One of the broader implications of this project is the ability to save energy. By adding energy reading to this device, we have not only given the consumer the ability to monitor and evaluate their energy usage, but we have built a product that encourages industries to switch to LED light fixtures from incandescent fixtures which will save even more in energy costs and consumption. This wireless relay module will usher in a new generation of smart lighting that can be integrated into IoT networks for commercial business and cities.

ELECOMP Capstone Design Program Labs Opening Ceremony and Ribbon Cutting

Labs

The labs are temporarily housed in an expansive space provided by Schnieder Electric (SE) to URI and located at 132 Fairgrounds Road, West Kingston, RI 02892. A New Engineering Building is being built on the Kingston campus, with a projected completion in the summer of 2019. *(see Inside Back Cover)*

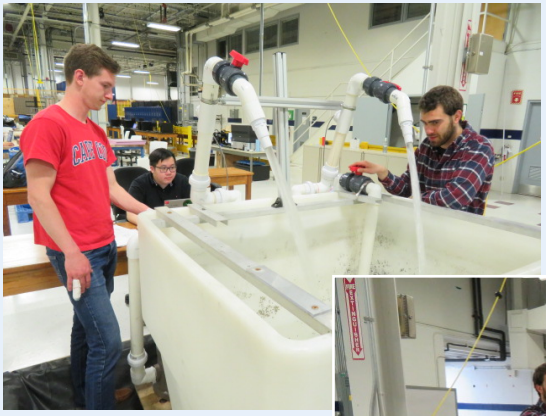
Opening Ceremony and Ribbon Cutting

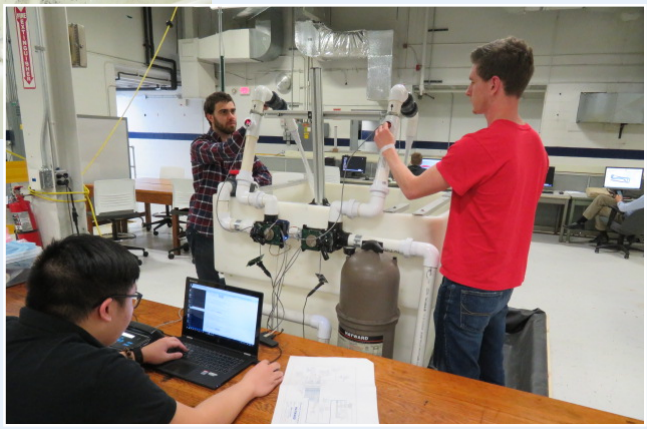
The Opening and Ribbon Cutting Ceremony at SE was held on February 3rd, 2017. The photograph above shows the Ribbon Cutting Ceremony. The photo below, taken after the ceremony, shows from left to right, David Dooley (URI President), Stefan Pryor (RI Secretary of Commerce), Ray Wright (Dean of Engneering) and Harish Sunak (Capstone Program Director).

CAPSTONE DESIGN LABS

ELECOMP Capstone Labs at Schneider Electric

The ELECOMP Capstone Design Labs at Schneider Electric





Testing Hayward's Smart Water Valve Actuator; *see pages 12-13*

PROGRAM WEBSITE

ELECOMP Capstone Design Program

web.uri.edu/elecomp-capstone

Menu

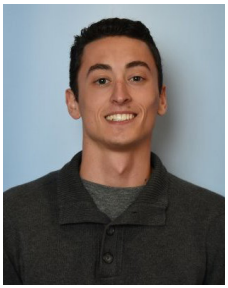
Students

ELECOMP Logo Design Competiton

The competition was set up by the Program Director in October 2017. Many designs were submitted; the Winner was Paul Bally, a member of the Hexagon Metrology Team. *(pages 14-15)*

The Idea Behind the Logo

In Paul's own words: "I wanted to incorporate both aspects of the Capstone Program, the Electrical Engineers (ELE), and the Computer Engineers (COMP) in the logo. To do this I decided to design a logo based around an E and a C. The way the E and C are placed also provide the shape of an electrical plug, which can be seen by focusing on the inner space of the C."



Paul Bally

Paul Bally

A native Rhode Islander, Paul Bally is from Middletown, RI where he grew up and graduated from Middletown High School in 2013. At Middletown, he was a student athlete who played baseball in the Spring and swam competitively in the winter on the high school swim team where he led the Men's Team to win their first division championship his senior year. In college, he continued to be a student athlete and joined the ultimate frisbee team his freshman year. Along with his major in Computer Engineering he also is minoring in Cyber Security and is the Vice President of the Eta Kappa Nu chapter at URI. After graduation, Paul will be working at the Naval Undersea Warfare Center, (NUWC), as a software engineer.

Effort by ELECOMP Capstone Design Class of 2017

Number of Weeks worked: 25 over 2 semesters.

Average number of hours/student, for each of the 13 teams, was in the range 250-400.

Average number of hours, for all teams: 322 hours/student. This works out to an average of 13 hours/week/student.

The total number of average hours worked by all students was calculated by (322 x 47) = 15,120 hours. (This would translate to an expenditure of about one million dollars, if employed in the corporate world)

The highest individual number recorded was 437 hours, by Edgar Braley, from Team PEC *(pages 24-25)*. Congratulations, Edgar, the check is in the mail!

NEW URI COLLEGE OF

New URI Engineering Facility plans

Ground Breaking Ceremony of the New Engineering Building
April 24, 2017

(L to R) Kalvin Cho (Class of 2020), Michael Brandmeier (President and CEO of Toray Plastics), David Dooley (URI President), Gina Raimondo (Governor of RI) and Ray Wright (Dean of Engineering)

ENGINEERING BUILDING

Take a tour: egr.uri.edu/tourvr

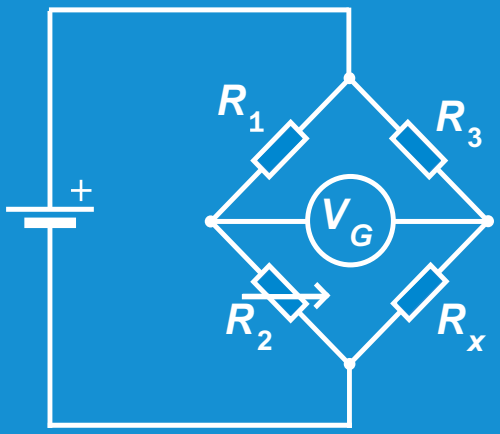
Experience the new facility through 360 degrees panoramic tours.

"This is a **critical moment** in the transformation of URI. When this project is complete in 2019, it will be the **finest Engineering facility** anywhere and will move URI to the **absolute forefront** of Engineering Research and Education. This facility will be the one that every university in America, whether it's one of my alma maters, CALTECH, or MIT or anybody else, will be pleased to have. It will immediately position URI as having facilities that are equivalent to the quality of its faculty and students; and they are **among the best in the world**."

– *David Dooley*
URI President, at the Groundbreaking Ceremony

ELECOMP
CAPSTONE BRIDGE

The Capstone Bridge mirrors the well known Wheatstone Bridge, shown in the diagram below.



The unknown resistance Rx is to be measured; resistances R1, R2 and R3 are known and R2 is adjustable. Only when the bridge is adjusted to be in PERFECT BALANCE, the measured voltage VG is zero, and the unknown Rx is determined.

Now we can see the parallel with the 3 important aspects of the Capstone Bridge:

R1: ELECOMP Capstone Design Program

R2: ELE & COMP Seniors with diverse talents

R3: Sponsor's Technical Director & Problem to be solved

When these aspects are in perfect balance and collaborate in excellent harmony, SUCCESS is achieved in the UNKNOWN (Rx): The Best Outcome of the Sponsor's Problem

THINK BIG WE DO℠

web.uri.edu/elecomp-capstone