ELECOMP CAPSTONE SUMMIT

FRIDAY, MAY 11, 2018

Celebrating 11 Years of Excellence

2008 – 2018

THE UNIVERSITY OF RHODE ISLAND
COLLEGE OF ENGINEERING

DEPARTMENT OF ELECTRICAL, COMPUTER AND BIOMEDICAL ENGINEERING

SPONSORING COMPANIES

ELECOMP Capstone 2017–2018

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ON Semiconductor®

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BOSE® Better sound through research®

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Acumentrics Trusted Power Innovations

BOSCH Thermotechnology

Infineon technologies

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IRADION Ceramic Core CO_2 Lasers

"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 Gănxiè 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 11, 2018

7:00 – 8:40 am	• **Breakfast** • **Registration** • **Viewing of Capstone Project Posters** *Location: 95 Club*
8:50 – 9:00 am	**Welcome** Professor Harish Sunak, Capstone Program Director *Location: Pharmacy - Ernest Mario Auditorium*
9:00 – 10:15 am	**Rocket Presentations I** (8 teams) *Location: Pharmacy - Ernest Mario Auditorium*
10:15 – 10:40 am	**Break**
10:40 – 12:04 pm	**Rocket Presentations II** (9 Teams) *Location: Pharmacy - Ernest Mario Auditorium*
12:10 – 1:15 pm	**Lunch** *Location: 95 Club*
1:15 – 2:00 pm	**Poster Session & Demonstrations** *Location: 95 Club*
2:00 pm	**Announcement of Top 5 Teams** *Location: 95 Club*
2:00 – 2:45 pm	**Reception & Videos** *Location: 95 Club*

ROCKET PRESENTATIONS

ELECOMP Capstone Design Program
Schedule of "Rocket" Presentations
Pharmacy - Ernest Mario Auditorium

Rocket Presentations I

9:00 – 9:10 am	Acumentrics
9:11 – 9:19 am	AstroNova
9:20 – 9:28 am	Bay Computer
9:29 – 9:37 am	Bosch Thermotechnology
9:38 – 9:47 am	Bose Corporation
9:48 – 9:56 am	Hayward "Falcon"
9:57 – 10:06 am	Hayward "Rabbit"
10:07 – 10:15 am	Hexagon CMM

BREAK

Rocket Presentations II

10:40 – 10:48 am	Hexagon OCR
10:49 – 10:58 am	IGT Global Solutions
10:59 – 11:09 am	Infineon Technologies
11:10 – 11:18 am	Iradion Laser
11:19 – 11:27 am	ON Semiconductor
11:28 – 11:36 am	Phoenix Electric
11:37 – 11:45 am	Schneider Electric
11:46 – 11:54 am	SES America
11:55 am – 12:04 pm	TACO Comfort

WELCOME BY PROFESSOR

ELECOMP Capstone Design Program Director

Welcome: It gives me great pleasure to welcome you all to the Annual Summit of the ELECOMP Capstone Design Program. This year we are celebrating 11 Years of Excellence in Capstone Design for Electrical (ELE) & Computer (COMP) engineers in our Department. Our Program partners senior engineering students with industry sponsors to design, build, program and test solutions to real-world problems. We are excited to present 53 seniors on 17 projects, covering a variety of problems in electrical and computer engineering. I have allocated 8-10 minutes per project for the oral "rocket" presentations, to allow more time for live/video demonstrations and poster session interactions and discussions. I hope you will have a stimulating day, and I look forward for you to come on board with a new capstone project for the next year. The depth and breadth of work in these projects is outstanding and I hope it will inspire you to propose creative ideas.

"***If your actions inspire others to dream more, learn more, do more and become more, you are a leader.***"

– John Quincy Adams

The ELECOMP Capstone Program Director with the Class of 2018 after the announcement of teams on September 19th, 2017

HARISH R. D. SUNAK

Capstone Bridge: The ELECOMP Capstone Bridge mirrors the well-known Wheatstone Bridge extremely well, as shown on the back cover. All facets of our Program 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 Directors 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 Anticipated Best Outcome of the Sponsor's problem.

Together with all my capstone designers, I would like to sincerely thank the 15 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. I look forward to your continued support; 6 new sponsors have already made firm commitments: THANK YOU.

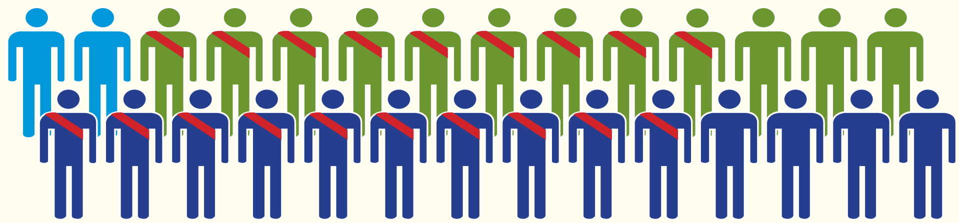
Hours Effort Summary: The total number of hours put in by the 53 seniors was 18,050, over 22 weeks. This is an average of 340 hours per capstone designer, and 15 hours per week. See Inside Back Cover.

New Engineering Building: It will be exciting to move into our new building; just 14 months away! The present sophomore 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. *(See Inside Back Cover.)*

TECHNICAL DIRECTORS

ELECOMP Capstone Design Program
Technical Directors (TDs) 2017-2018

Overview



Total number of TDs: 28 across the 17 Projects

- 14 TDs are graduates of our ECBE Department at URI: 50%
- 2 TDs are graduates of other departments at URI: 7%
- *10 out of these 16 are TDs for the First time!*
- 12 TDs are graduates of other Universities: 43%
- *9 out of these 12 are TDs for the First time!*

Major Achievements

Particularly proud to report a major achievement for our Program: **Brenden Smerbeck** and **Denise Androzzi**, who completed Capstone Projects with Acumentrics and Bay Computer Associates last year, graduated on May 20th, 2017, and are now Technical Directors on the projects sponsored by these Companies!

Also, very proud of **Mike Caneja**, who graduated in May 2015, and championed a capstone project sponsored by Bosch Thermotechnology, one month after being appointed Product Manager. Thanks Mike!

TDs from our Department of Electrical, Computer and Biomedical Engineering

Brenden Smerbeck (2017) *ELECOMP Capstone Graduate 2017*

Denise J Andreozzi (2017) *ELECOMP Capstone Graduate 2017*

Mike Caneja (2015) *ELECOMP Capstone Graduate 2015*

Mark Rodrigues (2010)

Sandro Silva (2002) *2nd Year TD*

Mike Guerra (2002) *2nd Year TD*

Mike Smith (2001) *2nd Year TD & Consulting TD on 4 Projects*

Robert Davis (1997)

Bruce Parkes (1996) *2nd Year TD*

David Kortick (1990)

Chris Tate (1989)

Denis Galipeau (1988)

Jamie Murdock (1984) *2nd Year TD*

Frank Kolanko (1981)

TECHNICAL DIRECTORS

ELECOMP Capstone Design Program
Technical Directors (TDs) 2017-2018

TD from our Department of Mechanical Engineering

Jonathan O'Hare (1994) *2nd Year TD*

TD from the College of Business Administration

Christopher Kyes (2016) *MBA*

TDs from other Universities

Peter Upczak *2nd Year TD*
David Durfee *2nd Year TD*
Joe Gundel *2nd Year TD*
Jeff August
David Connolly
Jerry Huson
Daniel Jaquez
Phillip Manning
Stephen McDonald
Frank Metayer
Robert Milkowski
Luka Petrovic

Team Bose and Team IGT will be presenting their work in Student Poster Session at:

Capstone Design
CONFERENCE 2018
JUNE 4-6, 2018 ▸ ROCHESTER, NY

CONGRATULATIONS!

Network Managed Power Distribution Unit for Military Application

acumentrics.com

TECHNICAL DIRECTORS:

Brendan Smerbeck
Peter Upczak

TEAM MEMBERS: (L to R)

Brenden Smerbeck
Peter Upczak
John King (E)
Jonathan Travelyn (E)
Michael Majdalani (C)
Nathan Mensah (E & C)
Jeremy Peacock (C & CS)

PROJECT MOTIVATION:

Power Distribution Units (PDU) are an integral component in providing power to a number of electrical appliances, which many entities rely on. With the explosion in interest of Internet of Things (IoT) devices utilizing embedded systems, companies are realizing the demand for these networked devices. With networking capabilities, products can have remote monitoring and management ensuring a higher amount of fault detection, safety tracking, and statistics accumulation to further develop better products and give notice for possible system failures. Currently, Power Distribution Units have seen some integration with networking capabilities in commercial markets. With regards to the market for Power Distribution Units that adhere to military quality and safety standards, there is a gap that is seeking to be filled. Having the capability to remotely monitor device statistics and manage the devices that provide power to their appliances can bring much needed security and safety to the military. This gap and need for safety is the project motivation for Acumentrics.

ANTICIPATED BEST OUTCOME:

The best outcome is to have a fully functioning Smart PDU prototype that can be presented and painlessly handed off to the Acumentrics engineering team. The prototype will provide sufficient power to connected appliances and will meet military quality and safety standards. Users will have the ability to remotely control the device via a web application's GUI, to switch outlets on and off; monitor statistics such as current, voltage, wattage, temperature and humidity; receive notifications when something goes wrong: overheating; view logs of monitored statistics; and generate reports from said logs.

IMPLICATIONS FOR COMPANY AND INDUSTRY:

With the Internet of Technology bubble growing fast, networked technologies are becoming a norm today, and it is up to companies such as Acumentrics to provide products that allow management and monitoring of devices in a protected and practical form, for both industry and military. A large implication is the usability and ease of use of said technology to guarantee a pleasant and stress-free user experience. To remain an industry leader, Acumentrics must take this into account when building its products. This will help expand Acumentrics' market offerings to satisfy growing customer demands for ruggedized network-capable PDUs.

PROJECT OUTCOME:

The Anticipated Best Outcome was achieved; the initial goals were surpassed with the product near market-readiness.

KEY ACCOMPLISHMENTS:

Component Selection: Researched and performed a cost-benefit analysis to select viable components. Components were required to meet “rugged” requirements including temperature, isolation (Hall Effect sensors, shown in Fig. 2), and performance (analog-to-digital converters).

Formal Schematic and PCB Fabrication: Designed a circuit with the selected components and fabricated PCBs from our circuit, shown in Fig. 1. They have been tested and fitted for parts on both the low and high power sides. Extra connectors are used for the extra Raspberry Pi GPIO’s as well as the open slots for the ADC that allow for expandability, including extra sensors.

Ruggedized Case: The chassis, shown in Fig. 3, is designed to meet the following certifications EMI/RFI - MIL-STD-461F, Blown Precipitation - MIL-STD-810G, Shock - MIL STD-810F, Vibration - MIL-STD-167-1, Shipboard - MIL-STD-1399, Vehicle Power - MIL STD-1275. It is currently pending certification testing.

Functionally Complete Web Application: All functional aspects from the best anticipated outcome have been met, explored in more detail below, along with many additional functional and non-functional aspects not originally asked for.

Live Data and Interaction: The user is able to see live data is a chart format, as well as select which data is shown. The user also has the ability to remotely toggle outlets on and off for their convenience.

Data History: The user is able to see historical data in tabular format. The table is sortable and can be filtered based on metrics the viewer wants to view.

Notifications: Users can receive email, SMS, and popup notifications at user-set intervals when metrics fall outside of user-set thresholds.

Report Generation: Users have the ability to export data to a CSV file so that they can manipulate data how they see fit.

UPS Communication: The system is able to communicate with an Uninterruptible Power Supply (UPS) that is connected to via the Simple Network Management Protocol (SNMPv3). The PDU is able to, once configured, receive SNMPv3 trap notifications from an Acumentrics UPS and respond by limiting power consumption, turning of outlets, etc.

Web Application Security: Prepared statements are used to prevent SQL injection; Anti-DDOS technology is implemented; HTTPS is forced and the user can upload their own certified SSL certificate; user authentication and authorization is required.

Error Handling: Development of client and server side error handling in addition to error-logging to make things easier for the transition to the Acumentrics team.

Responsive Web Design: The web application was written using responsive web design to allow the web application to function on a variety of screen sizes, allowing for mobile use.

Auto-Ranging Input: The schematic and simulation is complete. The prototype has been proven to work and shift between 120v and 240v. The circuit consists of an AC-DC transformer and comparators to use hysteresis to track previous voltage values and switch during a certain range.

Documentation: The project has sufficient documentation to facilitate a swift knowledge transfer. Acumentrics shall be continuing development upon the completion of the Capstone project.

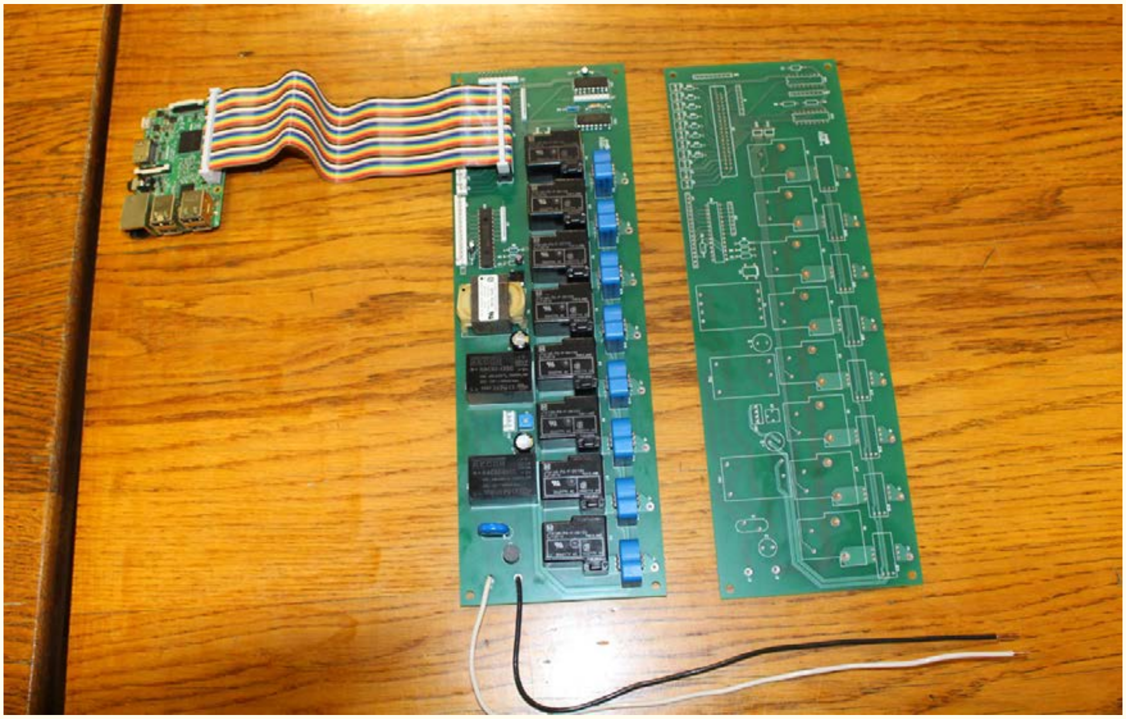


Fig 1: Empty PCB Board pictured next to the assembled circuit board with microcontroller.

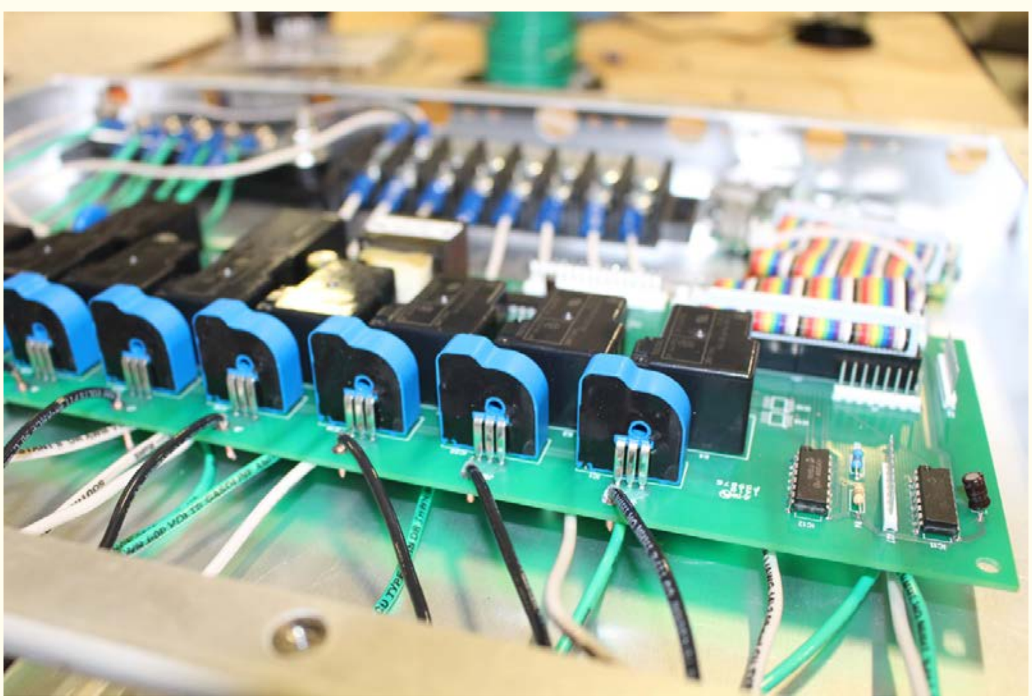


Fig 2: Hall-Effect Sensors were selected for their naturally isolating properties and simplicity when compared to alternative current-sensing systems.

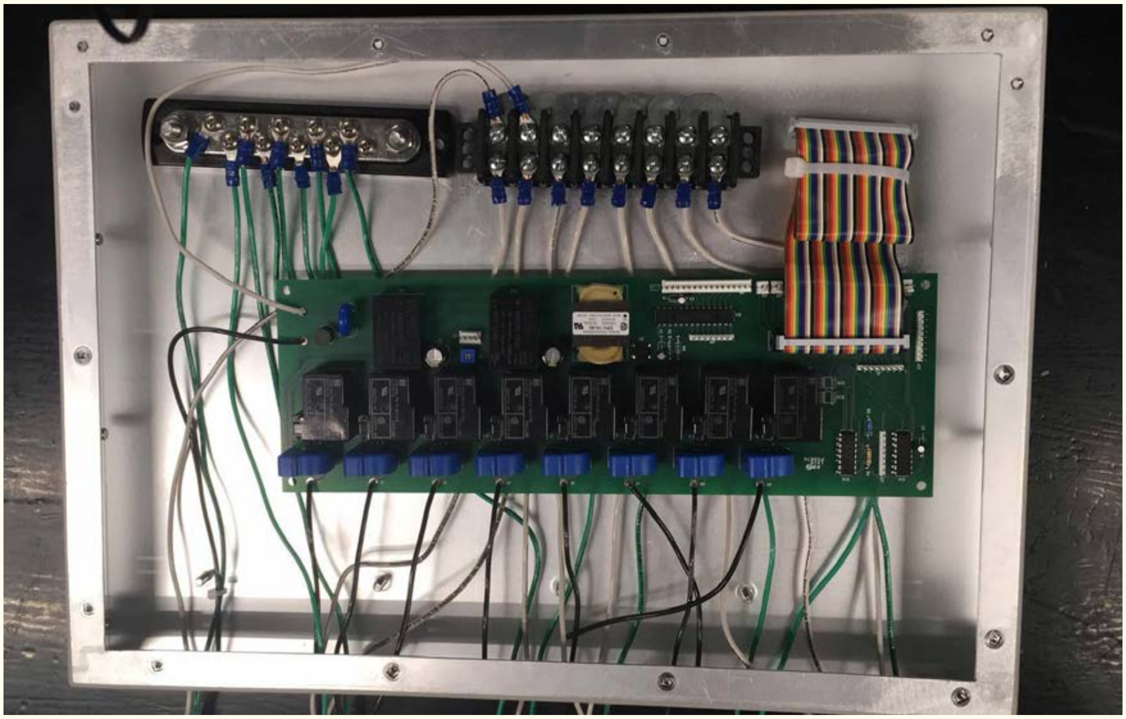


Fig 3: Top-down view of the initial prototype assembled within the half-depth aluminum chassis.

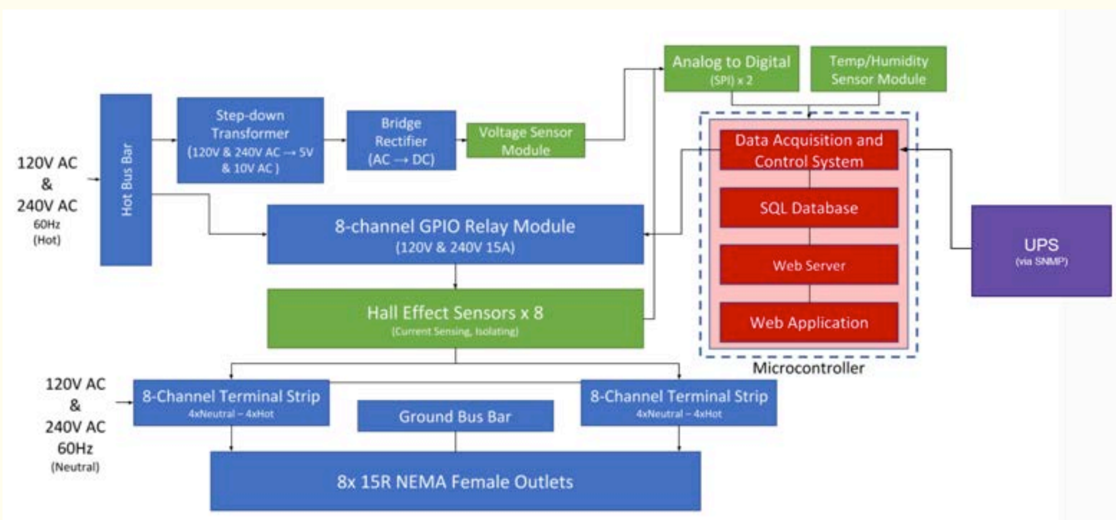


Fig 4: Updated block diagram for the product. Capabilities for UPS communication as well as 240v have been added.

Portable Waveform Generator

astronovainc.com

TECHNICAL DIRECTORS:

David Kortick
Chris Tate

TEAM MEMBERS: (L to R)

Chris Tate
Noah Johnson (C)
Nickolas Morello (E)
Thomas Mauldin (E)
David Kortick

PROJECT MOTIVATION:

AstroNova is committed to supplying their clients with the most innovative test and measurement equipment. To demonstrate the capability of such equipment, a handheld Waveform Generator was created; however recently the design has become obsolete due to rapid growth in the capabilities. Since there is no similar device on the market, AstroNova commissioned a Portable Waveform Generator to be designed. This waveform generator will be able to demonstrate the full capability of the data acquisition systems. In addition, this product will be of interest to future stakeholders due to its uniqueness. The design process was chosen to ease the transition from an in-house product, to a product sold on the market.

ANTICIPATED BEST OUTCOME:

Team AstroNova will develop a new portable waveform generator that can be used as a direct replacement for the older model. The last waveform generator was updated eleven years ago. Our new and improved WaveGen will feature a sleek updated design along with an easy to operate user interface. We plan to have a PC application that will allow the user to program arbitrary waveforms into onboard memory to be recalled later. In addition, the PC application will provide more control over the WaveGen. The updates and improvements to the product will offer new capabilities that will make it even more useful than the last.

IMPLICATIONS FOR COMPANY AND INDUSTRY:

The portable waveform generator will allow AstroNova to showcase their test and measurement equipment at trade shows in a way that was not previously envisioned. The key feature of the product is the ability to generate, store and output custom waveforms. This feature allows AstroNova associates to tailor the waveform output to suit the intended audience, maximizing relevancy and boosting sales potential. It is this versatility, as well as a low unit price that set the waveform generator apart as a possible innovative market product after some refinement. Furthermore, WaveGen will serve as a powerful hardware troubleshooting instrument for field technicians and engineering personnel alike due to its frequency range and resolution.

PROJECT OUTCOME:

The Anticipated Best Outcome was achieved: A replacement Portable Waveform Generator with an updated design and a PC Application.

KEY ACCOMPLISHMENTS:

Hardware: The major components of the WG800 were to provide the functional specifications previously outlined. These components consist of a display, an output connector, DACs, Op-Amps, a FPGA, a Serial Peripheral Interface (SPI) flash memory, push buttons, a power switch, a USB port, a power connector, a JTAG connector, a battery pack, a voltage reference, DC-DC converters, and LDO regulators. After the components were chosen, a schematic was generated. This schematic was reviewed by the team and was sent to a PCB fabrication house where revision A of the board was fabricated. All functionality of the PCB was tested and verified.

Internal Design and Implementation: The hardware to support pulse and arbitrary wave generation was added and modified for minimal size. The previous methodology put heavy emphasis on the use of large Xilinx IPs for both sinusoid and arbitrary waveforms. This was discovered to be an inefficient usage of device resources, so custom designs were written to generate user-specified waveforms. A channel-centric approach to the design was adopted to increase the speed of the design. On-chip memory was a concern, as we were unsure that all the predefined waveforms would fit on the limited space that we had. The bigger memory issue was the size of the Microblaze (MB), which grows proportionally to the complexity of the C code programmed onto it. This was necessary, but limits the set of usable header files for the code.

Embedded Software: Software development was completed for the MicroBlaze using C. The user interface consists of a startup screen, main menu, bank menu, options menu, host control, and low battery warning. The user can navigate through the menus and control the device. The software also includes the interpretation of host commands and queries from a PC. These commands include fine frequency adjustment, fine amplitude adjustment, bank control, waveform ID adjustment, phase control, voltage offset control, high voltage control, low voltage control and status requests. The MB software also creates triangle and sawtooth waveforms. The algorithms contain parameters to adjust the amplitude and voltage offset. Lastly, the MB uses the onboard memory that is used to configure the FPGA to store data. The MB software is a success.

PC Application: This application is based on a Windows Form Application, and is being completed using Microsoft Visual Studios using visual C#. The PC application is responsible for fine tuning of parameters. The front includes a master frequency and amplitude input. Beneath these inputs, each channel and current wave is listed. The “Restore Defaults” button will return all banks to default settings as specified in the documentation. The ‘Parameters’ button will only activate if Bank D is selected. This function opens up a table of all 8 channels with their parameters. This provides an easy way for the user to check and confirm all values. In order to connect, the user must specify the communication port. The PC App is near completion, with room for future development.

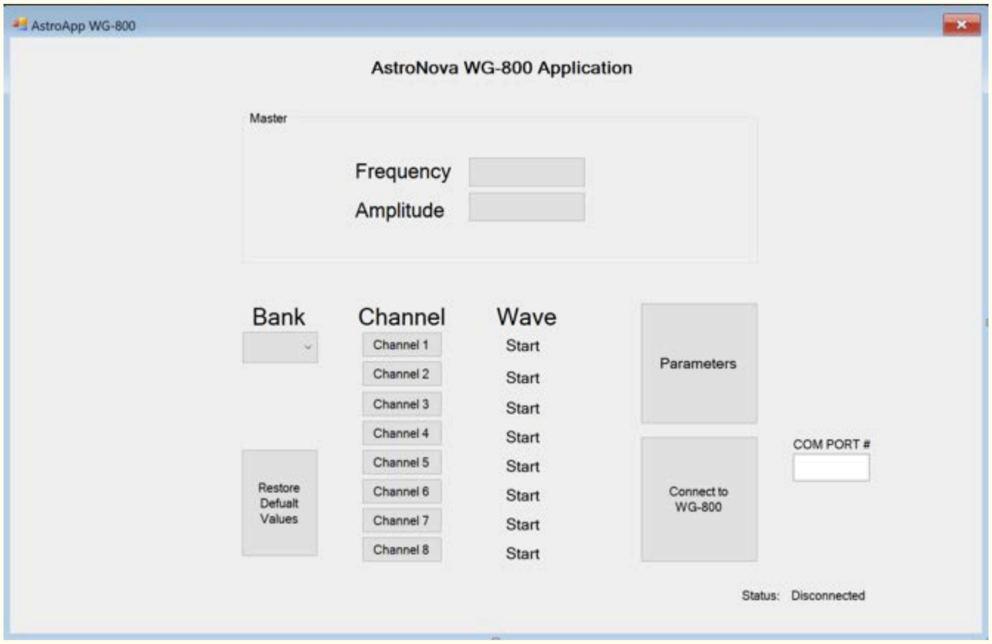


Fig.1: PC Application: Final User Interface

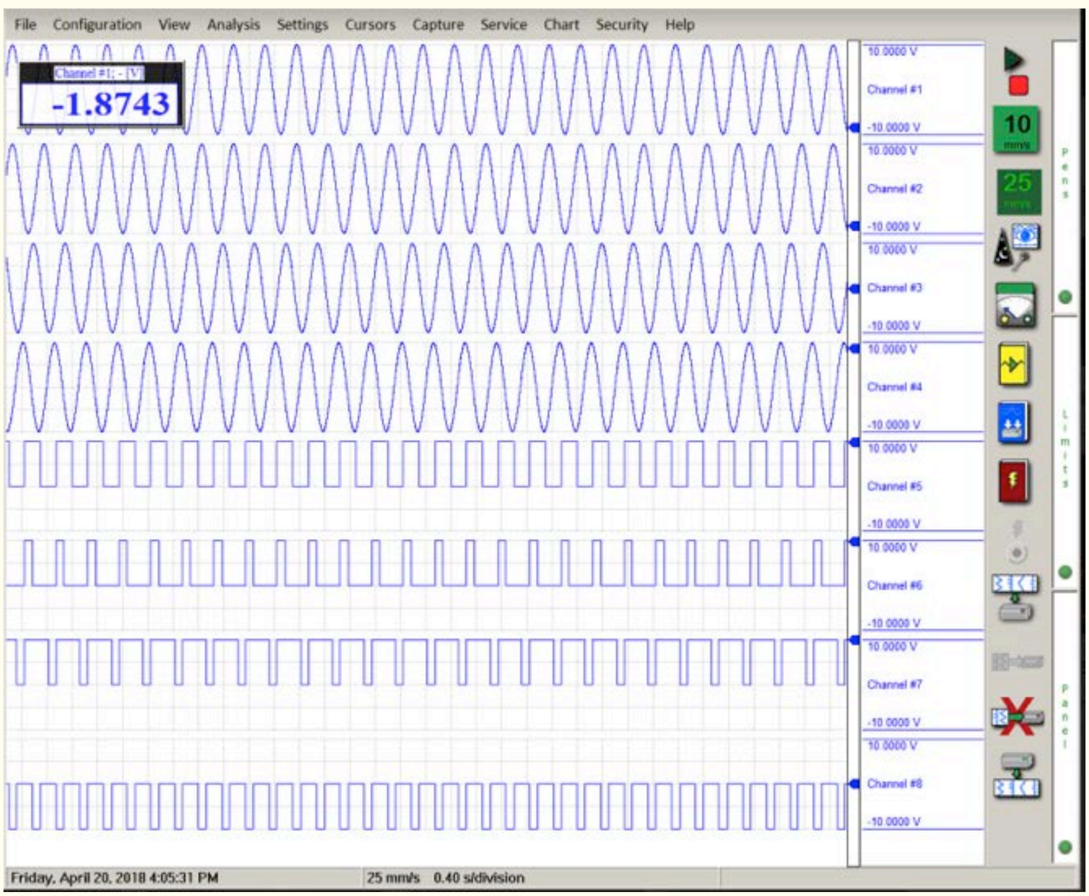


Fig. 2: Functional Output of the WG-800 (Sine and Square waveforms)

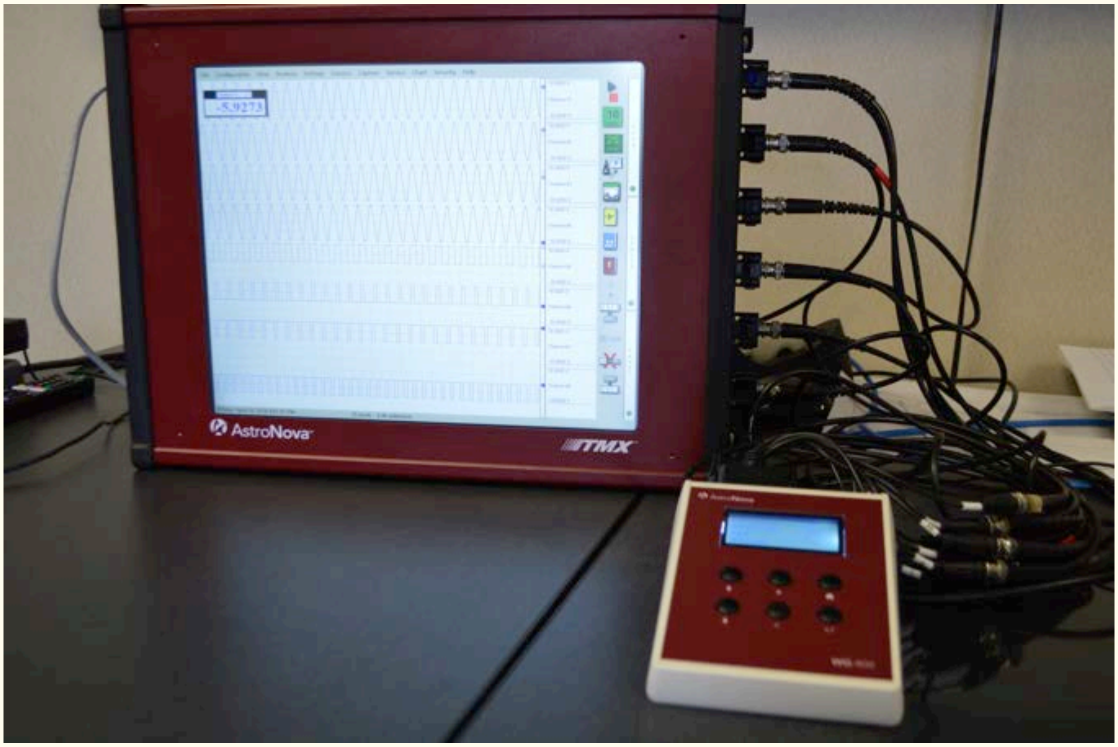


Fig.3: Practical application of WG-800 with capabilities of AstroNova's TMX

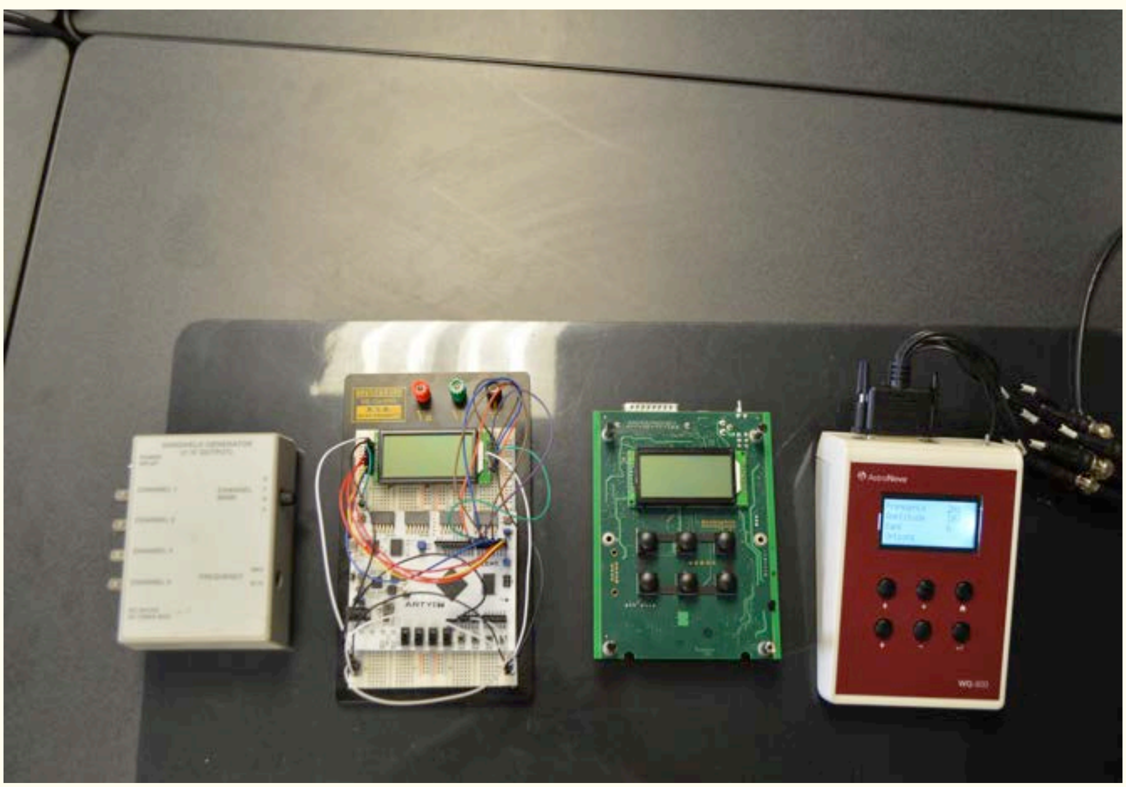


Fig.4: The progression of the Portable Waveform Generator

Three Phase Motor Controller

baycomp.com

TECHNICAL DIRECTORS:

David Durfee
Ben Ricci

TEAM MEMBERS: (L to R)

Daniel Finan (E)
Evan Magno (E)
Brandon Lian (C & E)
David Durfee

PROJECT MOTIVATION:

Originally, this project started as a motor controller for an electric wheelchair. This controller was later augmented for the operation of an electric bicycle, and is currently being redesigned for medical technologies that would require our motor controller. Many new design decisions have been made with the transition into the newest implementation, most notably, the control system in place for the position control algorithm; which left us with a lot of room for improvement. Second is the implementation of a parallel transistor setup that will allow higher current output while keeping the parasitic capacitance of the transistor configuration low. The goal of this project is to continue overcoming the obstacles that have yet to be solved and to further our designs. In the end we would like to have a motor controller that drives a larger range of currents, redesign the controller's board in order to maximize the use of space, and a more robust implementation of the position control.

ANTICIPATED BEST OUTCOME:

The best outcome of the project would be to have a completed market ready product with all updated and redesigned features that the current design does not have. These features include a redesigned MOSFET layout that can produce higher output currents, updated power supplies that can handle an increased range of input voltages, reliable current sensing, and the development of a robust position control algorithm. The outcome of this project will yield a product that is capable of controlling higher powered motors than the ones seen in previous designs, and can control the motor of a large scale medical device.

IMPLICATIONS FOR COMPANY AND INDUSTRY:

Reaching the project's best outcome would mean the product is very close to market readiness. When this product is released into the market it would mean a higher level of precision and safety for current motor controllers found in the medical industry. The product can be applied to an even wider range of technologies that need a reliable motor controller that may or may not even take advantage of our position control algorithm, like a human operated electric vehicle or appliance. With our best outcomes met we would be bringing a robust motor controller to a wide variety of markets.

PROJECT OUTCOME:

The Anticipated Best Outcome was not achieved; many goals we completed; board layout and some firmware tasks were not completed.

KEY ACCOMPLISHMENTS:

Implementation of the position control algorithm in C using floating point notation and a proof of concept and starting point for the fixed point representation. We can give the motor a distance to travel in either forward or backward directions and it will travel that distance. Modifications will have to be done to work with degrees rotated as opposed to distance traveled in the Matlab script since we won't know the exact conversion factors on a range of different applications and their gear ratios. The calculations are all done the same way, some constants may have to be redefined for this conversion

Development of the position control algorithm, this was done in Matlab as a proof of concept. We can give the motor a distance to travel in either forward or reverse and it will travel that distance. Modifications will have to be done to work with degrees rotated as opposed to distance traveled in the Matlab script since we won't know the exact conversion factors on a range of different applications and their gear ratios.

Research and Development of firmware functions to implement our position control algorithm in C; figuring out where we will be grabbing data from and the structure of other files that interact with the task scheduler to make sure we deal with race conditions properly and for code cleanliness and consistency.

Current design of the motor controller uses the H-Bridge design to output about 20 Amperes to the motor. To increase current output, we designed an H-Bridge with parallel MOSFETs. Added a simpler 5V power supply. The previous design used a switching mode power supply that dropped the unregulated supply down to 5V. We removed this because it was no longer necessary. A simple linear regulator that drops 11V to 5V is what we need.

Updated 3.3V power supply. The improvements made to the controller will require a 12-60V input voltage that the current 3.3V regulator is not equipped to handle. Combed through the schematics and removed features that are no longer necessary. One of the goals of this project was to make the motor controller more generic. This meant removing some miscellaneous circuitry such as the buzzer and the 5.5V drop down regulator for the CAN interface.

Added a quad 2-1 multiplexer for the current sensing circuit. The necessary updates to the current sensing requires there to be 8 outputs that must be monitored by the DSP rather than 4. We needed to add this multiplexer so the DSP has the capability to monitor all 8 signals. Finalized the new current sensing amplifier design. This design features two op-amps and two sensing resistors for each phase and for the total bus current. This will give us a higher resolution in being able to monitor currents that are less than 20 Amperes. A new op-amp was chosen for this design, as the previous op-amp was not fast enough.

Finalized all new schematics and began work on the new board layout.

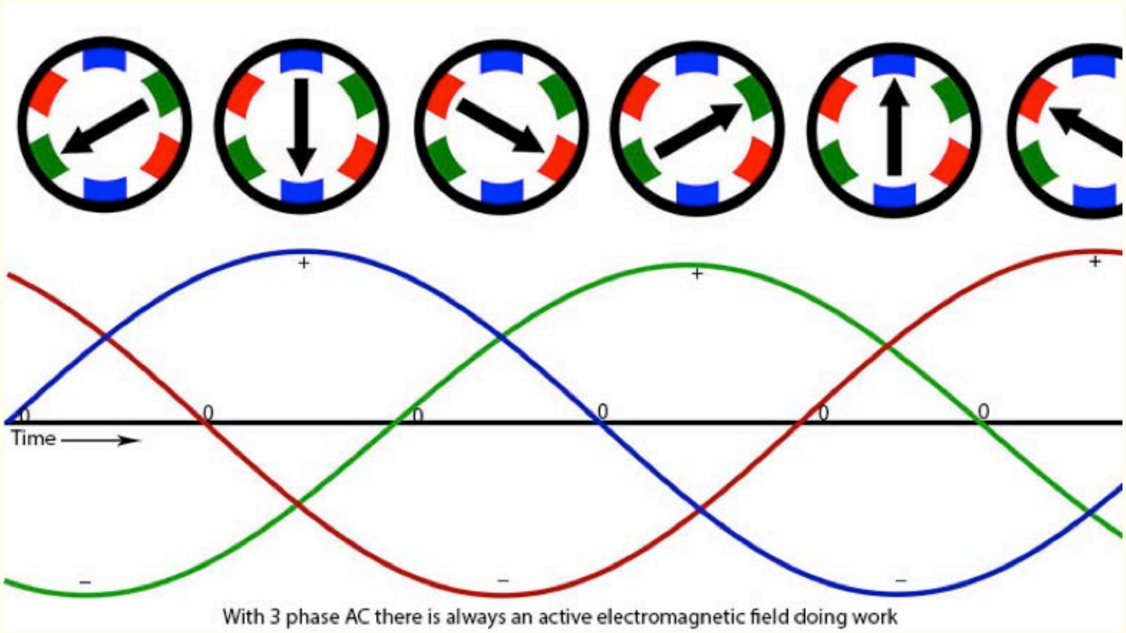


Fig 1: Representation of three phase induction.

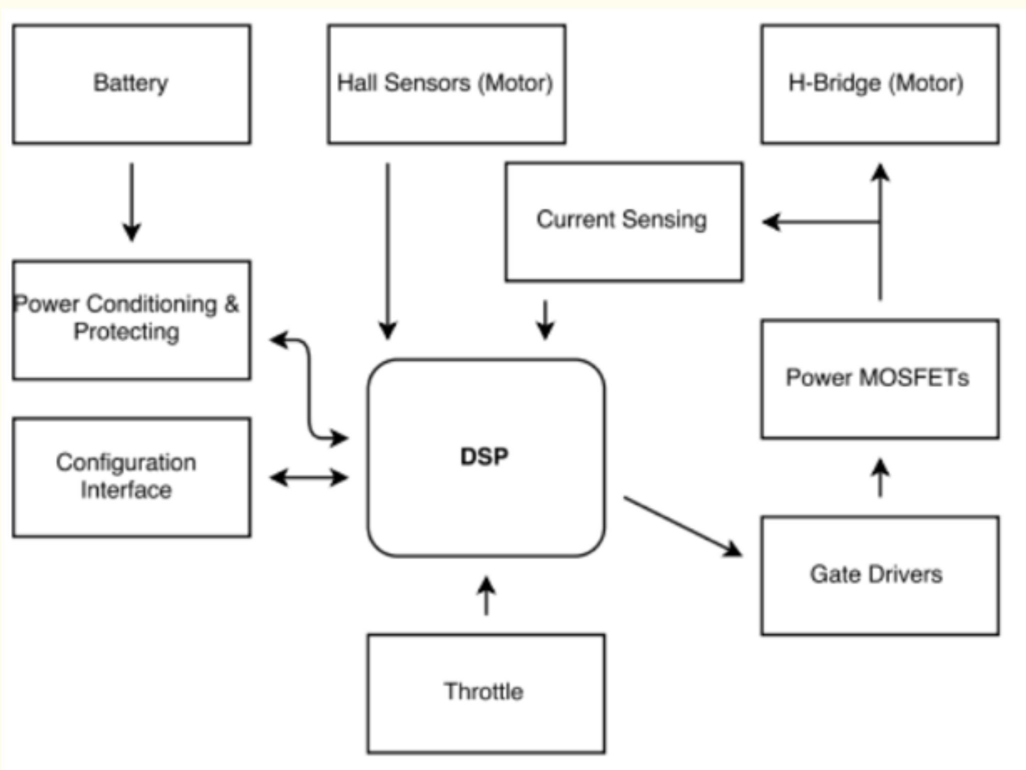


Fig 2: Block Diagram of the components in our Three Phase Motor Controller, describing which components communicate with each other

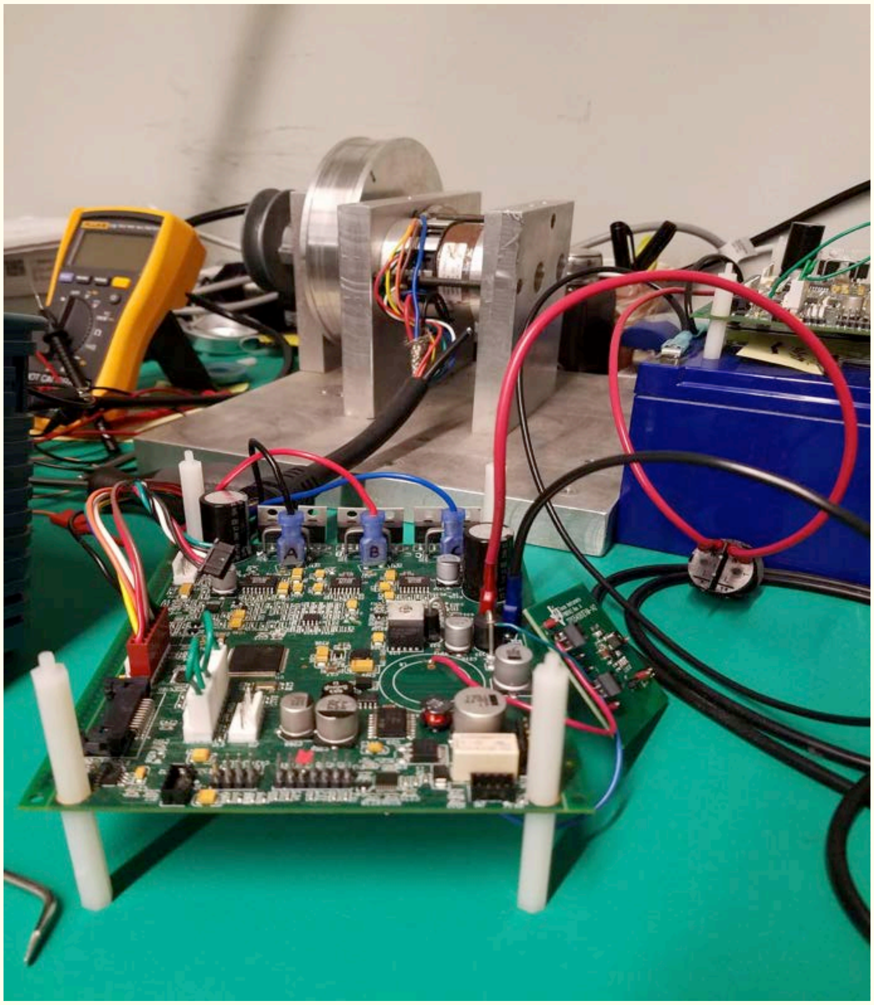


Fig 3: Our testing area, including a motor and our motor controller

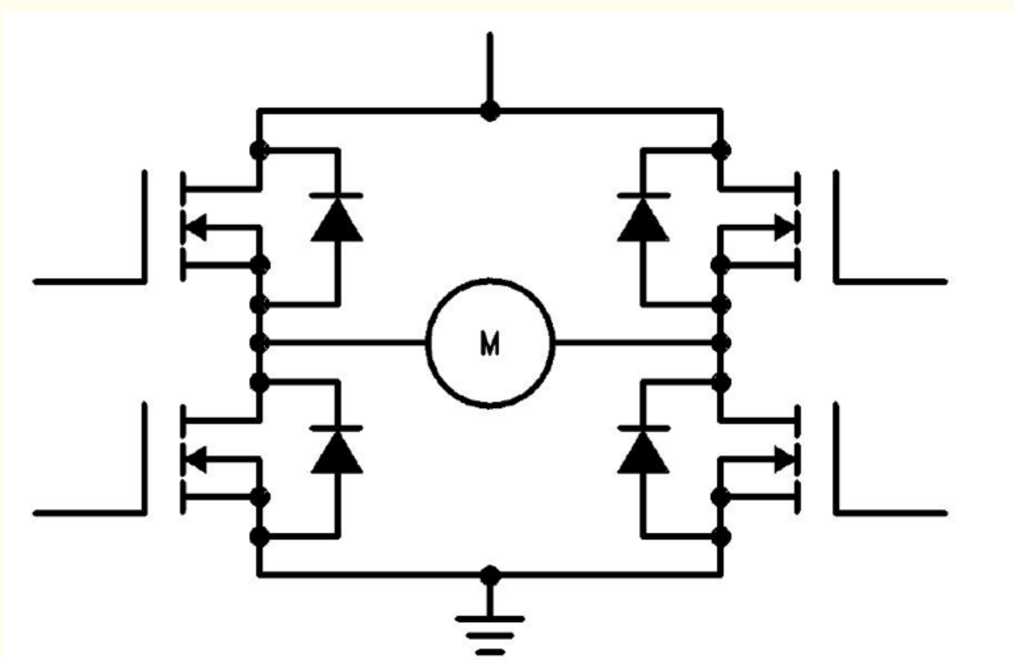


Fig 4: H-bridge MOSFET design that is used to drive the motor

Thermotechnology

HVAC Equipment Failure Modes and Potential Solutions

bosch-climate.us

TECHNICAL DIRECTORS:

Jerry Hudson
Mike Caneja
Mike Smith

TEAM MEMBERS: (L to R)

Mike Smith
Cole Wright (E)
Victoria Eno (E)
Alex DePetrillo (C)

PROJECT MOTIVATION:

The brand Bosch, **Invented for Life**; is committed to producing the highest quality products, Consumers buy their products and services because they offer quality and reliability. In the HVAC industry, Bosch offers comfort solutions in the form of Air Source Inverter Ducted Split Heat Pumps and Water Source Geothermal Heat Pumps. Beyond the mechanical components these systems require for good heat transfer, the systems have evolved to include more electrical and software based components. A result of increased components is an increase in vulnerability to failure. To maintain the company's reputation of quality and reliability during the manufacturing of these systems, Bosch utilizes low failure-rate components. The focus of this project is to help ensure such an equally satisfying result. Team Bosch is tasked with identifying component failures, and proposing solutions to extend the life of the components. The team devised a means of measuring component operation through both software and circuit design to monitor how various aspects of heating/cooling systems affect unit operation.

ANTICIPATED BEST OUTCOME:

Ideally, our group will build a hardware and software system which will be capable of field failure data for multiple types of HVAC system. This system will extract meaningful input such as temperature, run time, voltage, and current for various mechanisms within the unit. This data will be interpreted using a micro-controller to better understand failures of individual components in HVAC systems. The final deliverable will be a prototype which will incorporate these hardware and software systems.

IMPLICATIONS FOR COMPANY AND INDUSTRY:

The successful completion of this project will provide Bosch with a deeper understanding of how HVAC systems fail in the field. Moreover, this system will allow Bosch to see which components have higher failure rates, when components begin to fail, and how to improve their HVAC systems so that there are less failures and less warranty claims. This will help Bosch to cut both the costs and time taken to resolve claims, helping the industry to address issues faster and more effectively. Ultimately, the resulting information will aid Bosch to further develop higher quality products.

PROJECT OUTCOME:

The Anticipated Best Outcome was achieved.

KEY ACCOMPLISHMENTS:

Power Hardware Specifications: A hardware specification document was written so that once all the components arrived, the infrastructure was immediately known. A Bill of Materials listing all of the requirements to construct a prototype was also written early on. Moreover, circuit schematics were designed for purpose of implementing the electrical components of the HVAC system to the controller. For voltage and current, circuits were created for the 240 VAC motor components down to 5 VDC for purpose of real time continuous metering by the controller. All designs were simulated using software before physical implementation.

Software Specifications: A software specification report was written early on in the capstone process in order to effectively plan out the coding infrastructure before hardware implementation. After the software specification sheet was completed, snippets of code were used for syntax reference, and the overarching code was assembled with a clear vision in mind thanks to the specification guidelines.

Sensor implementation: Sensors were installed within the Inverter Ducted Split (IDS) (Figure 1) air handler and condenser. The needs and requirements were determined before sensor implementation. All required conductors were routed and installed in a clean and professional manner. The sensors were then placed onto the IDS unit, and all the sensor components for the circuits were installed onto breadboards (Figure 2) for purpose of Arduino integration. Once completed, all components were placed in a housing to preserve them from damage and provide a professional finish (Figure 3).

Software implementation: Once the physical devices were installed and functional, the written code was physically linked to its respective sensors in order to be fully debugged in a practical setting. This involved large amounts of wiring and rewiring sensors in order to set up the system most efficiently. Once the Arduino was properly wired to the unit, the code was properly troubleshooted for any remaining issues.

Graphical User Interface: A Graphical User Interface (GUI) has been prototyped (Figure 4) for use on the web. GUI's were researched in depth to determine whether or not one should be written or simply downloaded for the purposes of the project. Ultimately a GUI writing program was found that directly coordinates with Arduino based code. This software was used to make a page of legible meters that ideally will take real time data from the respective sensor and display it both digitally and as an analog reading.

Fig 1: IDS unit – Air Handler (right) & Condenser (left)

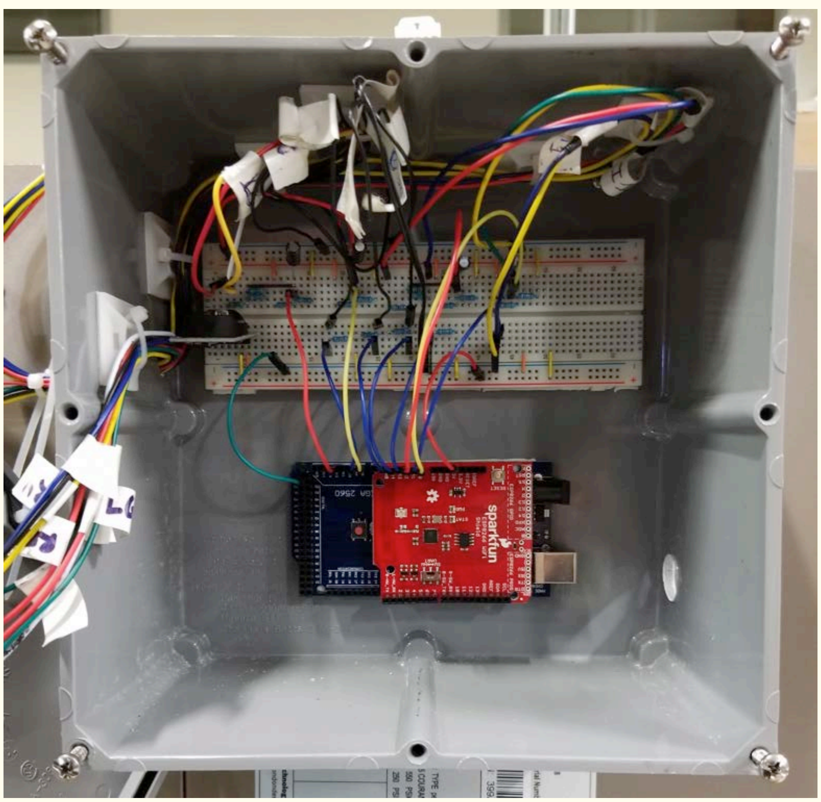


Fig 2: Sensor circuits with components integrated to Arduino

Fig 3: Housing with touchscreen IDS control

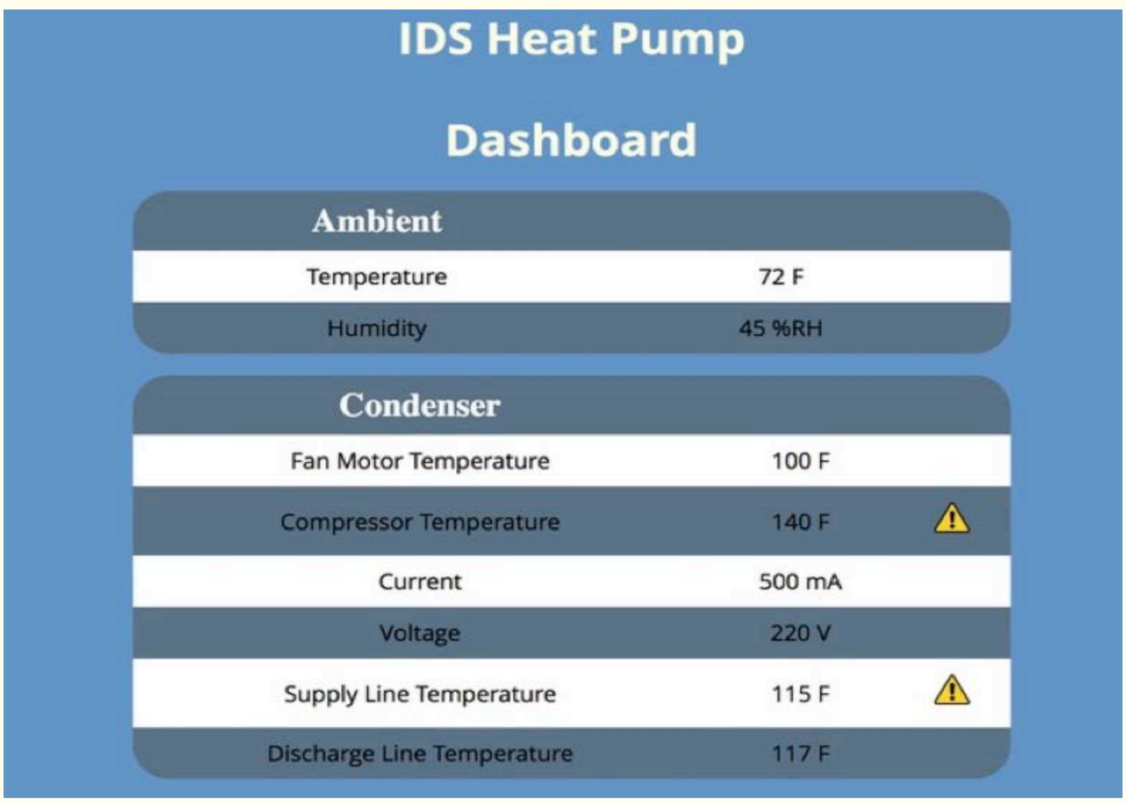


Fig 4: Graphical User Interface displaying real time values with alarms present

Better sound through research®

Personal Radar

bose.com

TECHNICAL DIRECTORS:

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Mike Smith

TEAM MEMBERS: (L to R)

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PROJECT MOTIVATION:

With an increase in technology, people have become more and more distracted by phones and other mobile devices. This can be dangerous when walking on the road due to cars, curbs and telephone poles. Recent advances in radar and its widespread use for automotive driver assistance have resulted in smaller, lower power, and cheaper systems. This project will investigate whether the technology has developed to the point where a personal, wearable radar is feasible. Using a compact radar board from Infineon Technologies, a personal collision detection system will be created which reads incoming radar signals, analyzes them using object detection algorithms and identifies potential dangers around the user. The personal radar system will be battery powered, self-contained, and able to warns users of potential dangers with a variety of methods. This device can be used by pedestrians who are constantly looking at their cellphone, or who are distracted by music. It could also be useful for people with visual impairment.

ANTICIPATED BEST OUTCOME:

The goal of the project is to have a wearable, battery powered, fully portable radar system with a functioning object recognition algorithm. Using Doppler and FMCW radar in conjunction with automotive radar equations, the wearable device should be able to detect and characterize objects in its range of vision. It should then track the object's location, speed, and acceleration and identify impending collisions. The device should alert the user, either through lights, noises, or vibrations. By the end of the project there should also be a quantifiable set of situations where the device works, and where it needs improvement.

IMPLICATIONS FOR COMPANY AND INDUSTRY:

This is a relatively unexplored field for Bose, and when the project is complete, Bose will have a better understanding how radar systems could be used in future projects. Possible products include a radar system for the blind, or headphones that have an integrated radar system that allow the user to continuously stay aware of their situations using auditory feedback. In the future, radar will be one of many types of wearable sensors that will help the user extend their awareness of the world, and in turn will improve the quality of life for everyone.

PROJECT OUTCOME:

The Anticipated Best Outcome was achieved: A portable radar device which warns users of impending collisions.

KEY ACCOMPLISHMENTS:

Power Object Tracking and Angle Measurement: In order to implement collision detection, it was necessary to be able to track objects over multiple frames. The algorithm is able to track multiple objects over any number of frames and pass this information to the collision detection algorithm. The algorithm additionally calculates the angles of movement of all objects in order to increase the accuracy of the collision detection algorithm as well reduce the amount of false alerts.

Collision Detection: Our algorithm compares objects over multiple time frames to predict whether the object will collide with the object. By comparing data frames over time, we are able to remove any background noise, and only alert users of valid objects. The object's position in relation to the user, its velocity, and its angular motion are all used to form a prediction of whether the object will collide, and how dangerous the object is with respect to the amount of time a user will have to react.

Data Visualization: To test the accuracy of the device as well as facilitate our testing, we developed a GUI in Matlab that plots the objects measured by the board in real-time. The GUI is also capable of only plotting objects tracked through multiple frames, logging experimental data for future use, and displaying an alert icon indicating the severity of impending collisions.

Audio Alert System: An audio alert system function was created to inform the user of the severity and location of an incoming object. The user would be alerted via a pair of headphones connected to the device. The alert consists of a beep that increases in frequency as the severity of impending collisions increases.

Radar Mount: A CAD design to reliably mount the radar device to a backpack was created, and then 3D printed. This positions the radar board at the correct angle as well as protecting the connections to the rest of the system.

Serial Communication: Serial communication was established with both the Infineon D2G and the TI IWR1642BOOST radar development kits. A script was created to extract relevant information from raw payloads obtained from the TI board in an infinite loop, and this information is passed to the object tracking and collision detection functions for further data processing.

Radar Testing: Testing was carried out on various implementations of the algorithm in order to allow the team to observe the various situations in which the system was not able to correctly interpret the objects, then to debug the algorithm to achieve the desired results. Real life situations were replicated to see how the board would process this data.

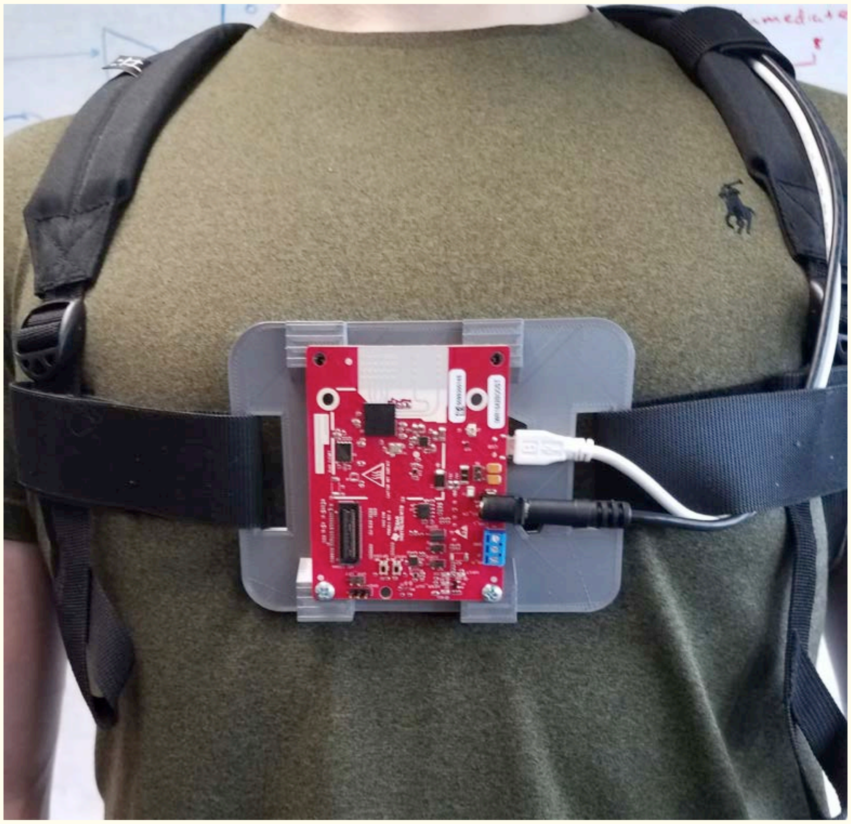

Fig. 1: Radar board & 3D printed standoff, mounted to a backpack.

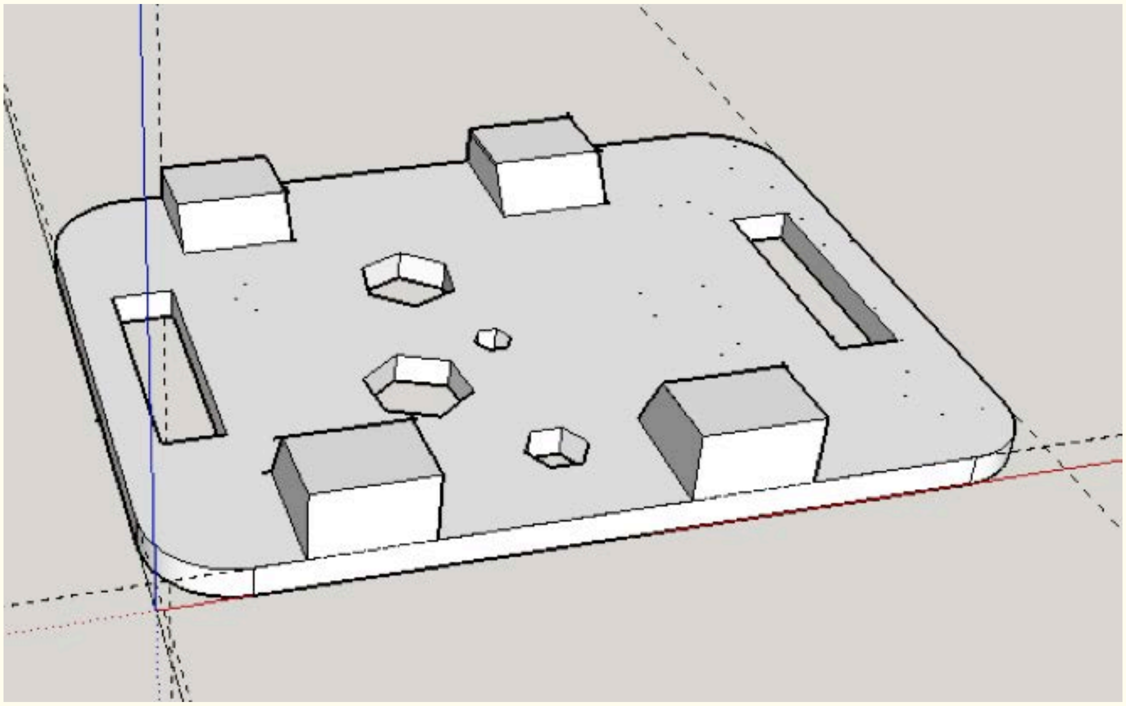

Fig. 2: Radar board standoff was lightweight; allows it to be properly positioned on user's body.

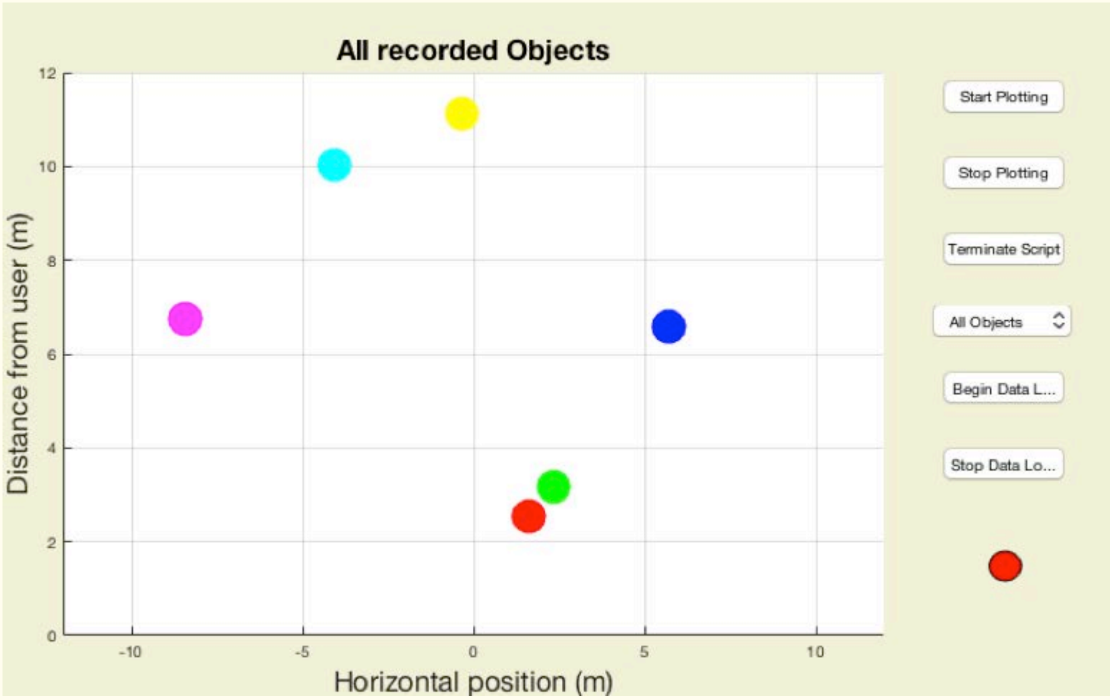

Fig. 3: The MATLAB GUI showing multiple objects at different X and Y positions.

Fig. 4: One of many testing experiments performed in various environments, wide open field.

Wireless Pool-Side Multi-Sensor System

hayward-pool.com

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PROJECT MOTIVATION:

In many facets of life, consumers are expecting more and more tasks to be automated. Thermostats, indoor and outdoor lights, and even garage doors are now easily and instantly automated through the use of mobile applications and timed schedules. Current pool automation technologies also offer remote control and schedules but require either wired sensing of remote parameters or require the pool filtration system to be turned on. They also sense only a subset of what is needed to automate lighting and water levels. Existing aftermarket solutions are insufficiently featured or are too costly to install, resulting in an unmet market need for a comprehensive solution.

A new wireless sensing system would provide a low cost upgrade to existing automation systems. This system would upgrade existing systems and provide an extended range of highly desirable features such as precise air and water temperature measurement, water level detection, automated landscape lighting control, and pool cover detection.

ANTICIPATED BEST OUTCOME:

An alpha level prototype of a two-unit system consisting of a poolside sensor hub unit and receiver unit which communicate via radio. The sensor unit should be battery operated and collect environmental data including air temperature, water temperature, pool cover position, water level, and ambient light level. This environmental data should be communicated to the receiver unit where it will be processed and sent to the existing automation units, which will control various pool features.

IMPLICATIONS FOR COMPANY AND INDUSTRY:

This new system will bring pool automation closer to current technology and fill a currently existing gap in the pool automation market for a comprehensive system. The poolside sensor system will give consumers the control expected of many home automation products today in a low cost package which will interface with existing Hayward pool automation products.

PROJECT OUTCOME:

The Anticipated Best Outcome was achieved.

KEY ACCOMPLISHMENTS:

Sensor Selection: Possible sensors were researched. The majority of the sensors needed to measure environmental factors were selected. These include ambient light and range detection for the pool cover, air and water temperature detection, and capacitive water level sensing

Radio and Microcontroller Selection: An integrated radio-microcontroller package (SAMR30G) was selected after substantial research.

Initial Sensor Testing: Sensor communication was achieved using an Arduino to explore I2C connection with project specific sensors. Testing was also completed using the ambient light sensor near sunset to establish a baseline level at which outdoor lighting should be turned on.

Radio Communication: Initial radio communication has been achieved using two MCU development boards. A private MiWi Star network is set up between the two devices, where one is the determined transmitter (poolside sensor unit) and the other the dedicated receiver (OmniLogic Receiver), or PAN coordinator.

I2C Protocol Communication: I2C Protocol was selected in order to reduce the amount of GPIO pins used by our multiple sensors, as it only requires two pins to create a data bus. Communication is accomplished via device addressing, which means that each I2C device is assigned an address that the MCU must use to communicate with it.

Thermistor Value Detection: Successfully capturing ADC value from thermistors in order to accurately determine temperature value, important for OmniLogic interfacing

Capacitive Sensing Layout Determined: Worked alongside contacts at Microchip to determine the ideal sensing layout and PCB layout for our water level sensing application. The large ground-coupling of the pool water allows the system to employ a small, thin measuring strip paired with a rectangular, floating reference pad of the same area in order to accurately measure the water level.

Pool Cover Detection Method and Sensor Determination: After researching pool coping measurements, pool cover reflectivity, and ideal water levels, an IR ranging / ambient light combination sensor was chosen in order to measure both the distance detection and light level.

Initial Schematic and PCB Design: Significant progress on the poolside sensor unit schematic and board layout has been completed. The MCU, external crystal oscillators, sensing devices, and battery holders have be chosen, laid out in the schematic, and placed on the PCB layout. Finalizations for the antenna must be completed before final traces and ground planes can be completed. All designs have been done using Pulsonix. See Figure 1

Initial Low Power Considerations Implemented: Our poolside sensor unit's processor has been programmed to go into a sleep mode between sensor reads which has significantly lowered the power consumption of the device. See Figure 3

Initial Enclosure Design: A basic prototype of the enclosure for the poolside sensor unit has been drawn up and is currently being designed. See Figure 4

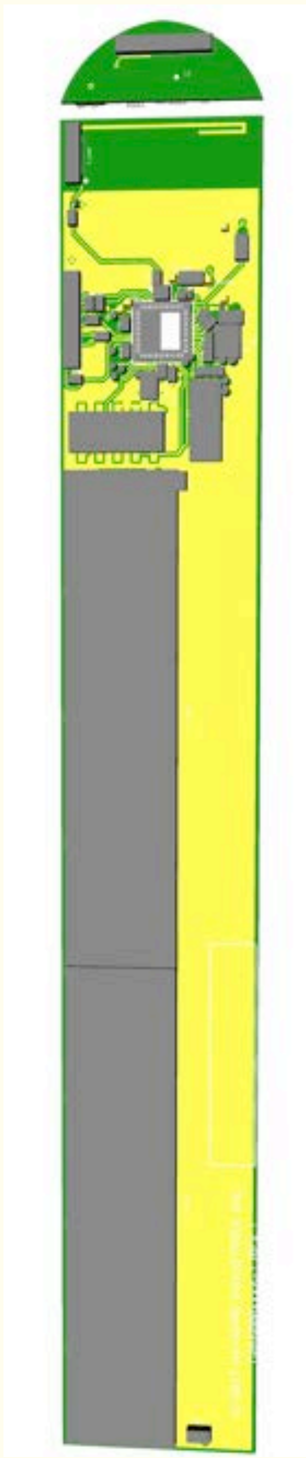

Fig 1: Printed Circuit Board Model of the Poolside Sensor Unit

Fig 4: SolidWorks Casing Prototype of the Poolside Sensor Unit's enclosure

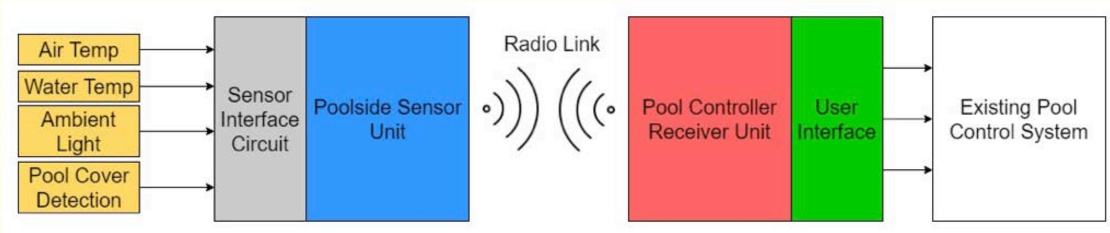

Fig 2: System Level Block Diagram showing the devices connected via wireless radio link.

Fig 3: Power Consumption Graphs of Poolside Sensor Unit in Awake Mode vs. Sleep Mode

HAYWARD

Fast, Portable Chlorine Generator Cell Tester

hayward-pool.com

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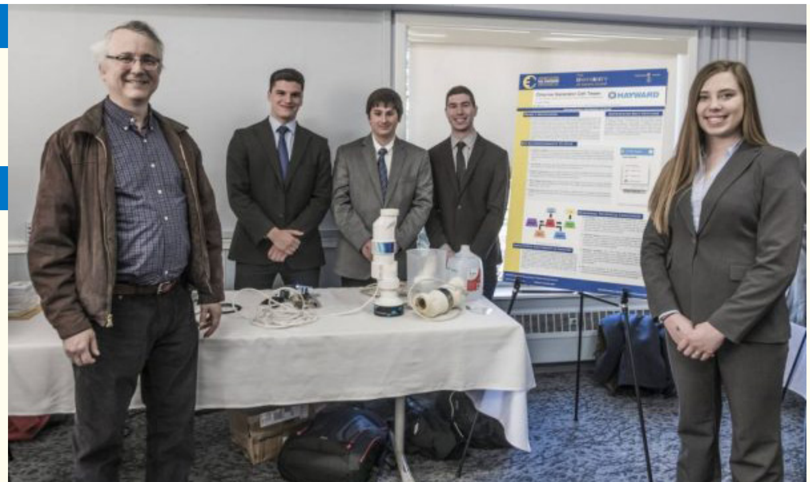

PROJECT MOTIVATION:

Currently, Hayward approved servicers of the AquaRite Salt Chlorine generation system use a storefront diagnostic tool to determine if the T-Cell chlorine generator has worn out. This involves connecting the warranty T-Cell to the tester's plumbing and generating measurable chlorine, the parts-per-million of which depend on the cell's age, as well as how dirty it is. The current tool is too expensive, too bulky, too easy to misinterpret, and thus is only used by a fraction of the servicers that diagnose and make warranty claims. As such, many cells are approved for warranty claims when they are in fact fully functional, or simply dirty.

Our capstone team will use water conductivity sensing, test signal generating circuits, impedance measurement, and software to produce a new testing method that is simple for any technician to comprehend, portable and less expensive. This innovation will allow Hayward to widely deploy thousands of T-Cell testers, saving possibly 15% of total warranty claims.

ANTICIPATED BEST OUTCOME:

Ideally, by the end of the project our team will have developed a fully functional T-Cell tester. The ideal test unit should be battery operated for portability, function at a wide range of temperatures and be compatible with all Hayward T-Cell models. The tester's interface will be simple and allow the user to initialize the test and clearly see if the cell passes or fails, as well as the cell's chlorine output and other parameters. Previous test results will be stored for ease of access, and be sent to a bluetooth-enabled app for simple warranty claims. Ideally, the total cost of the tester will be $30.

IMPLICATIONS FOR COMPANY AND INDUSTRY:

For Hayward this product will reduce illicit and costly warranty replacements of fully functional chlorine generator cells. Additionally, It could save Hayward up to $500k annually. From the end-user standpoint the new tester will assist Hayward technicians in troubleshooting faulty T-cell chlorine output, and simplify the warranty process for failed cells. By utilizing a simple yet comprehensive user interface there will be no confusion regarding whether or not a T-cell qualifies for a warranty replacement. If the cell qualifies, the warranty process will be streamlined via the tester's app. Overall, this will reduce bottom-line costs for Hayward and increase profits on T-Cell generators.

PROJECT OUTCOME:

The Anticipated Best Outcome was not achieved. The product schematic was successfully completed; the prototype remains to be produced.

KEY ACCOMPLISHMENTS:

Confirmed New Testing Method - After several rounds of testing on various T-Cells, we confirmed the initial assumption made by Hayward that we could determine the health of a T-Cell based solely on the voltage and current it generated when a square wave is applied.

Finalized Schematic - Using the Pulsonix platform, the final schematic of Cell tester was created. Such schematic included all aspects of the tester including sensing circuitry, user interface circuitry, MCU connections and power circuitry for each component.

Finalized Board Layout - From schematic we created in Pulsonix, Hayward completed board layout, a custom printed circuit board (PCB). This PCB (shown in figs 1 and 2), would be based on an existing board designed to fit inside the pre-made Hayward enclosure.

LTSpice Simulation of T-Cell Tester - Throughout the design of the sensing circuit, LTSpice simulations were utilized to verify certain outputs and improve upon the specifications of the designed circuit.

Designed "Sensing Circuit" - To verify if a cell is functional, "sensing" circuitry was required to test the impedance of cells. Good cells have low impedance, bad cells have high impedance. Updates and modifications were made to improve upon the circuit designed previously.

Wrote Firmware for "Sensing Circuit" - Wrote code to read from and control the sensing circuit that was designed by our team. This including outputting a 1kHz square wave and other control signals, as well as reading from the circuit at certain nodes using the onboard analog to digital converter.

Wrote Firmware for 2x20 Character Display - Wrote code to output content onto the character display given to us by Hayward (shown in fig 3). This included writing code to initialize the display, change the data memory address to write to, and write characters to the display.

Wrote Firmware for MSP430 - Wrote code to take advantage of the features made available by the microcontroller we decided to use for this project, the MSP430FR5994. This included utilizing the general purpose input/output (GPIO) pins, the various independent timers, the analog to digital converters (ADCs), and others. (Block diagram shown in fig. 4).

Designed Scheduler to Execute Tasks - Based on the design provided by our Technical Directors, we implemented a simple scheduler which allowed us to execute tasks on a given time interval. Since we are working with a microcontroller with no operating system, this involved setting up a timer to increment a count every 1 milliseconds so that there was a way to keep track of the amount of time passed.

Wrote Tasks in Software - Break our flowchart into separate tasks to be executed independently. This, along with a state machine created from flowchart as well, we identified several different tasks. Among the tasks implemented were reading the battery level, testing the T-Cell and reading from and writing to the user interface (UI).

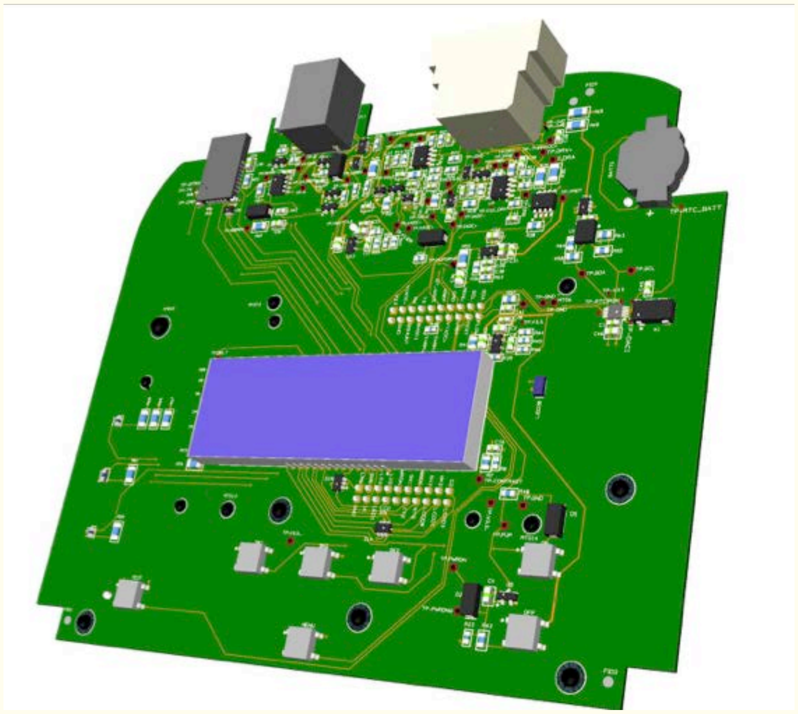

Fig 1: Shown above is the front of the custom printed circuit board (PCB).

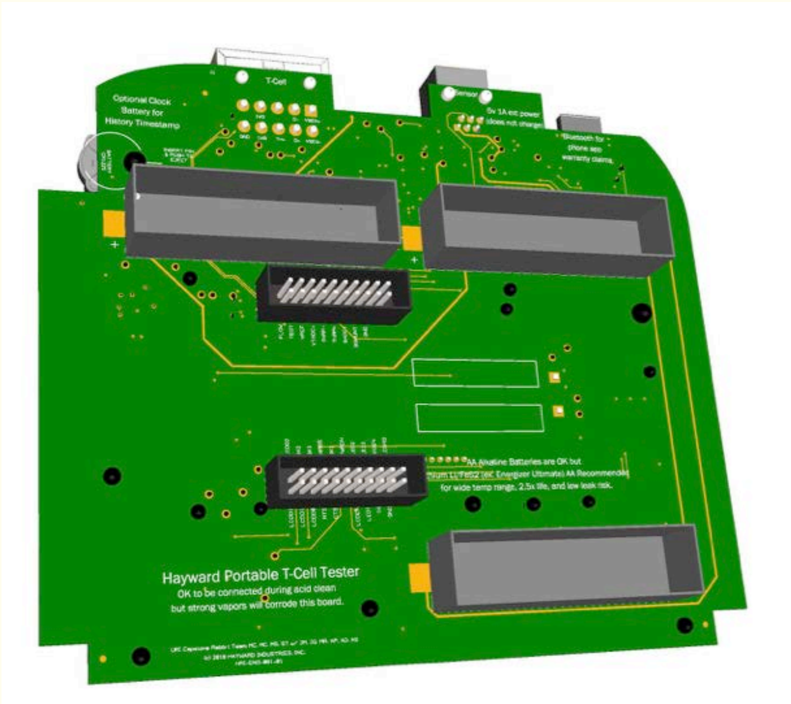

Fig 2: Shown above is the back of the custom printed circuit board (PCB).

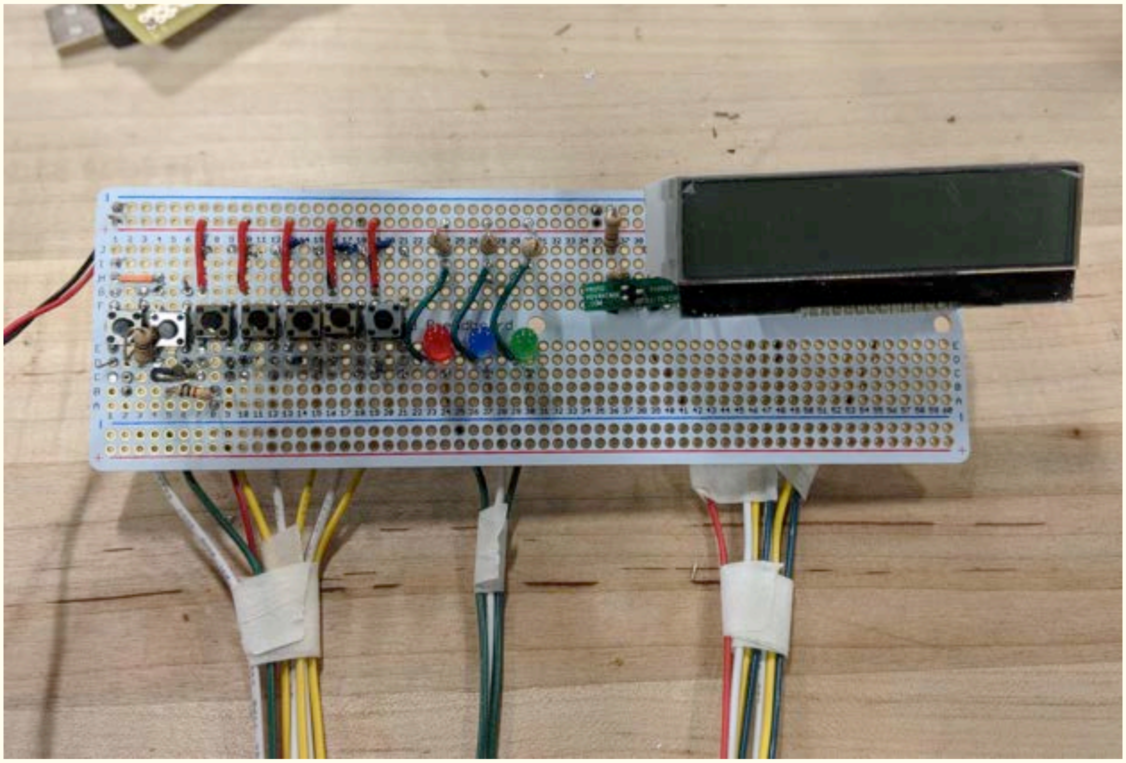

Fig 3: Current layout of our 2x20 character display, LEDs and buttons.

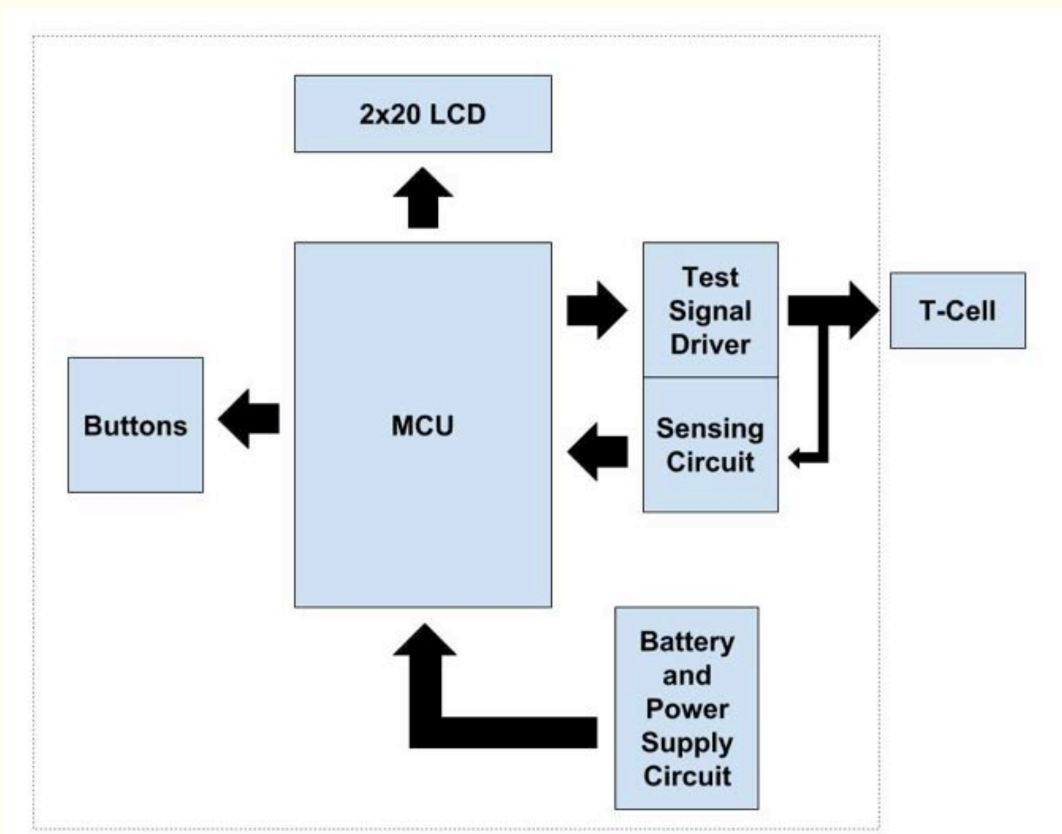

Fig 4: Shown above is the current block diagram for the design.

HEXAGON METROLOGY

3D Printing Retrofit Package for a Coordinate Measuring Machine

hexagonmi.com/en-US

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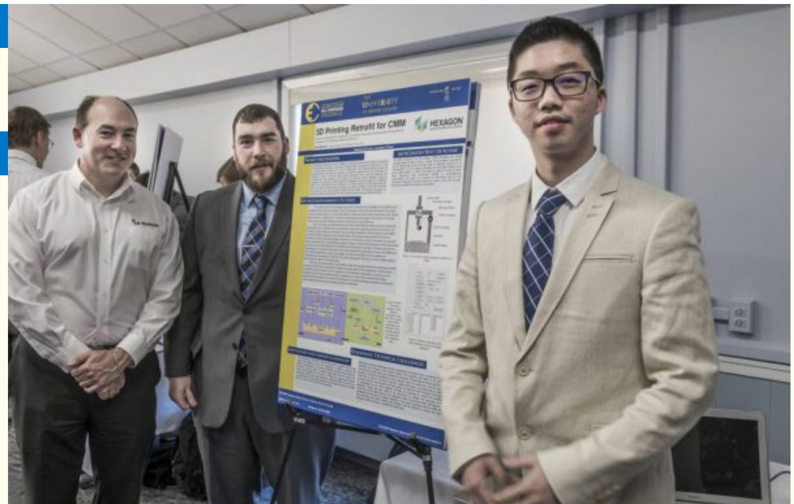

PROJECT MOTIVATION:

A time demanding factor of ensuring that a product is created to exact design specifications is the designing, engineering, and manufacturing of the fixtures that will hold it in place during the measurement process. The motivation of this project is to provide a retrofit package to add the capability of 3D printing to a Coordinate Measuring Machine (CMM). Adding the capability to 3D print an object on a CMM will allow users to leverage the size and precision of a CMM to design and print large format 3D prints. The intent of developing this package is to provide the means to 3D print the fixtures that will secure the product being measured by the CMM. This project will begin as exploratory research and expand into proof of concept design, testing, and demonstration.

ANTICIPATED BEST OUTCOME:

The anticipated best outcome for this project is a fully functional proof of concept 3D printing retrofit package for the CMM that provides an interface and a 3D print head assembly. The interface shall have the capability of using a 3D drawing file as a selectable input, slicing the 3D drawing into layers, translates the layers into movement commands for the print head and the CMM, and sends them to their respective devices. The 3D print head assembly shall be mountable to the existing CMM design. When installed the output shall be a usable 3D printed object.

IMPLICATIONS FOR COMPANY AND INDUSTRY:

The implications of the BEST outcome will result in a patent and a niche market that utilizes the size and capabilities of CMMs to perform 3D printing. Additionally, by leveraging the capability to create the required fixtures for measuring a product will provide a cost saving method to owners of the system. Most CMM functions require an operator, however, 3D printing does not and as such it can be performed during the natural downtime of the system increasing productivity. On a broader spectrum, this package will help set Hexagon equipment apart from their competitors, more than it already is.

PROJECT OUTCOME:

The Anticipated Best Outcome was achieved: We successfully designed and tested a proof of concept as required.

KEY ACCOMPLISHMENTS:

Power User Interface: A user interface allows the user to interact with the respective parts of the retrofit package. This interface provides the means to connect to and control the CMM.

Hardware Components: The hardware components for the 3D printer retrofit package were ordered, assembled, wired, and tested to ensure they met the minimum requirements for the scope of this project. These components included the printer assembly, the Arduino controller, the PCB heat bed, and the power supply.

Machine Mounting: A mounting assembly was fabricated that allows for the print head assembly to utilize the existing probe head mounting system. This allows for simple installation and removal of the printer retrofit package and does not require any modifications to the CMM machine, which is one of the marketing requirements. A diagram of the installed retrofit package can be seen in Figure 1 and an image of the installed print head can be seen in Figure 4.

G-Code Translation: A method has been developed that allows the created g-code translator to parse out the required information as it relates to the extrusion process and the movement path and create files designed to be read by the interface during operation, as seen in Figure 3.

Communication Methods: A serial connection was configured for communication between the Arduino and the user interface to allow for control of the print head assembly while reading the extrusion file. A TCP/IP connection was configured for communication between the interface and the CMM to allow for control of the CMM while reading the movement file.

Optimization: The Arduino and the interface codes have both gone through an optimization process to help reduce the impact of delay during operation which would cause a loss of synchronization during the print job.

Printing: Prints were made to demonstrate the viability of future development of this project. The prints were successful in showing progress, promise, and future development hurdles.

Testing was performed on the various aspects of the retrofit package. Some of these tests include object printing, timing evaluation, path evaluation, and translation accuracy.

DELIVERABLES:

Software Documentation were created to describe the operation, purpose, and potential modifications to the existing software. The documentation also provides a high level description of each function in the software for the purposes of understanding for future developers.

Operating Instructions provided directions for installing and operating the retrofit package.

Wiring Diagrams were created to provide a functional schematic for the retrofit package to aid in future development of product, a simplified version of the system wiring diagram in Figure 2.

Testing results have been collected and analyzed. The test results will be used to identify future development needs.

B**ill of Materials** have been created and provided to Hexagon listing all of the materials and resources that went into the development of this proof of concept design.

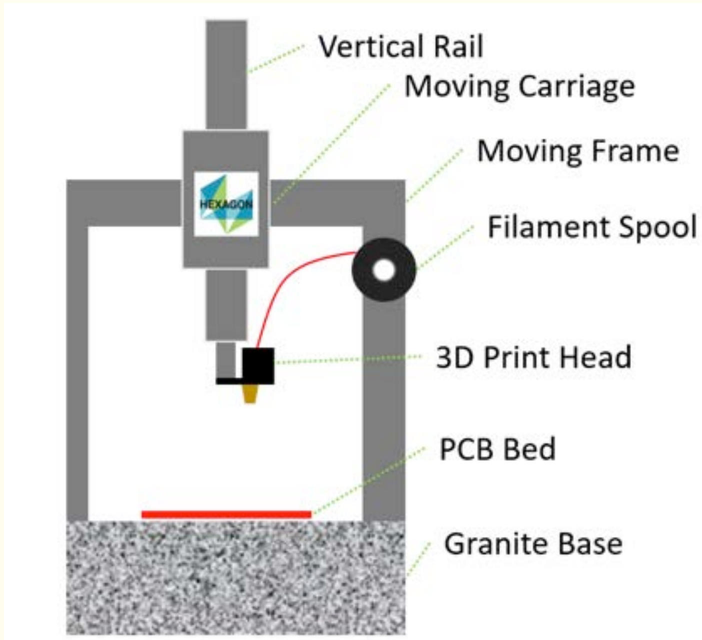

Fig 1: The CMM with the BEST outcome deliverable 3D printing retrofit package.

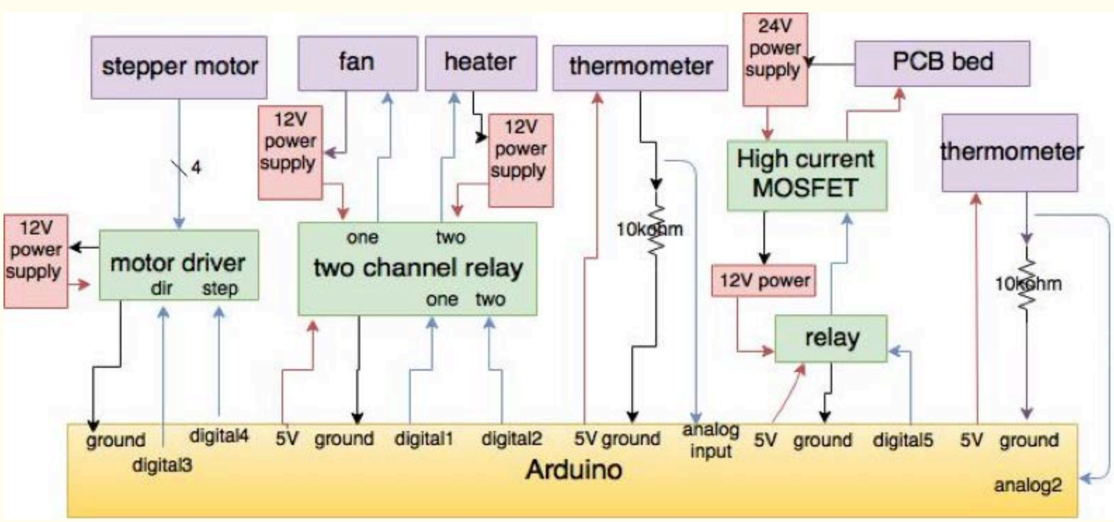

Fig 2: Wiring diagram for the 3D printer retrofit package.

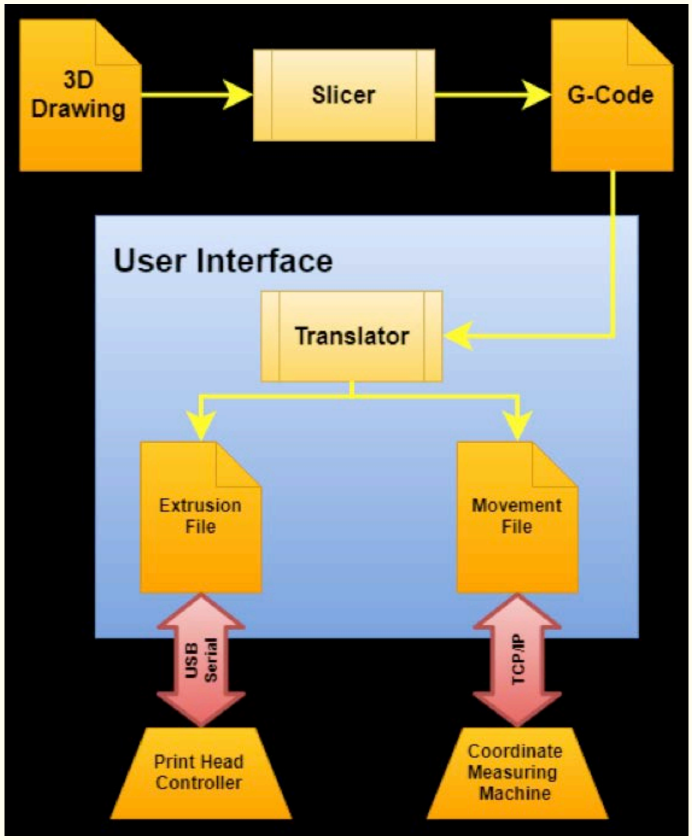

Fig 3: Program flowchart for user interface.

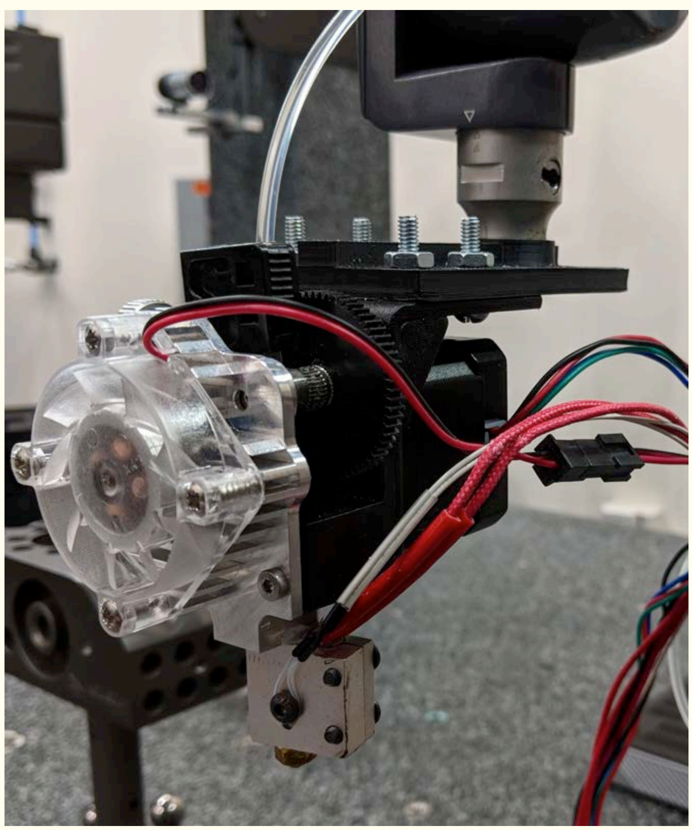

Fig 4: Picture of 3D printer retrofit package installed on the CMM.

Optical Character Recognition Reader for Manufactured Drawings

hexagonmi.com/en-US

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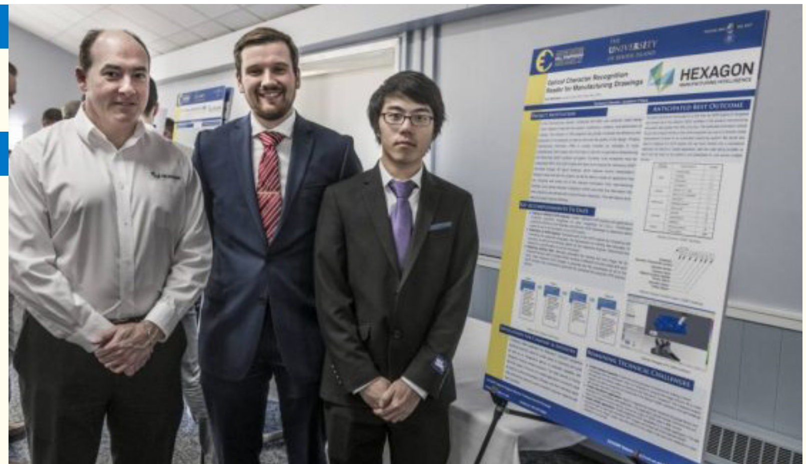

PROJECT MOTIVATION:

In the manufacturing industry, companies use computer aided design (CAD) software to create, modify, analyze and optimize a design. CAD programs have increased the efficiency and productivity of the designer and improved the quality of the design. Product manufacturing information (PMI) is included as metadata in more comprehensive CAD models, with information such as geometric dimensioning and tolerancing (GD&T) symbols and glyphs. Currently, companies have not incorporated PMI in their CAD models and resort to conveying the necessary GD&T information through 2D layout drawings, requiring human interpretation. The information from manufacturing drawings is extracted manually and logged into other programs. This process is time-consuming, is prone to errors, and results in massive losses for companies. Hexagon hopes that we will create an application that can recognize and extract PMI from manufacturing drawings using optical character recognition (OCR); enter the information into other programs automatically with minimal human interaction, thus reducing error rates with improved efficiency.

ANTICIPATED BEST OUTCOME:

The best outcome for this project is to first train an OCR engine to recognize and extract all of the relevant GD&T symbols in the product manufacturing information with greater than 90% accuracy. The extracted information should be put into a logical format so that other programs can use it to directly create measurement routines for an automated measuring system. We would also need to integrate the OCR engine that we have trained into a standalone application as well as a mobile application, with the code being portable so that it can be used on any platform and distributed for use across multiple devices.

IMPLICATIONS FOR COMPANY AND INDUSTRY:

A working mobile application for GD&T character recognition would be very useful to many customers and could be sold as an inexpensive add-on to extended capability with Hexagon's existing software products. The other benefit of having the OCR engine as a mobile application is that it could be used as a direct link between Hexagon and their individual users and could also be used as a tool to maintain customer relations with their customers.

PROJECT OUTCOME:

The Anticipated Best Outcome was not achieved: the mobile application was not developed.

KEY ACCOMPLISHMENTS:

Testing of different OCR engines: Tested 7 different OCR engines and applications, Tesseract, JavaOCR, ImageGear for Java, ImageGear for C/C++, FineReader, LeadTools Winforms OCR Modules and Winform OCR Advantage to determine which engine to use for the foundation of our OCR engine.

Evaluation of OCR engines: Evaluated each of the OCR engines by comparing and contrasting the supported languages, the requirements for training new language, its accuracy, as well as the licensing options for the respective engines. Determined that Tesseract is a good engine to use for this project.

Preparing training files: Manually generated the training text and image file for Tesseract training, which includes GD&T symbols of different font size mixed with each other. Used Tesseract OCR Chopper to generate box file coordinates for all of the GD&T symbols. Ran commands to generate the unicharset file using the TIFF and box file pair.

Training Tesseract: Finished the training process of Tesseract by making a starter traineddata from the unicharset and using this as a base to build upon. We iterated through this process to push accuracy of character recognition close to the desired level of 90%.

Integrating Tesseract into Hexagon's PC-DMIS: Integrated Tesseract with GD&T recognition into a test harness Hexagon provided with the help of Hexagon developer Robert Jurca. Through this we were able to integrate Tesseract into PC-DMIS without having to gain access to the program.

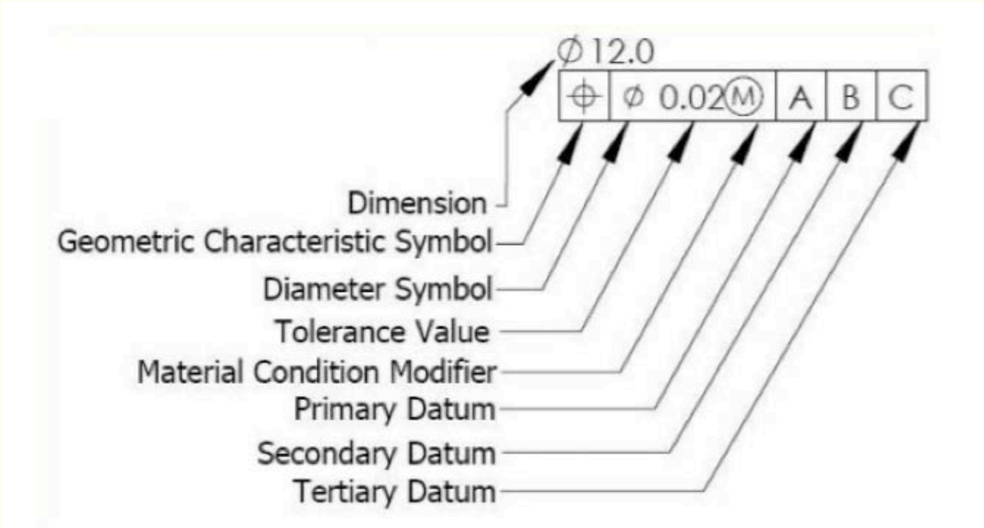

Fig 1: Example of a feature control frame used in CAD (Computer-aided Design) blueprints to describe the conditions and tolerances of a geometric control.

TYPE OF TOLERANCE	CHARACTERISTIC	SYMBOL
FORM	STRAIGHTNESS	⏤
	FLATNESS	⏥
	CIRCULARITY	○
	CYLINDRICITY	⌭
PROFILE	PROFILE OF A LINE	⌒
	PROFILE OF A SURFACE	⌓
ORIENTATION	ANGULARITY	∠
	PERPENDICULARITY	⊥
	PARALLELISM	∥
LOCATION	POSITION	⌖
	CONCENTRICITY	◎
	SYMMETRY	⌯
RUNOUT	CIRCULAR RUNOUT	↗
	TOTAL RUNOUT	⌰

Fig 2: Some of the common GD&T (Geometric Dimensioning and Tolerancing) symbols seen in feature control frames. These are the symbols we need to train Tesseract to recognize.

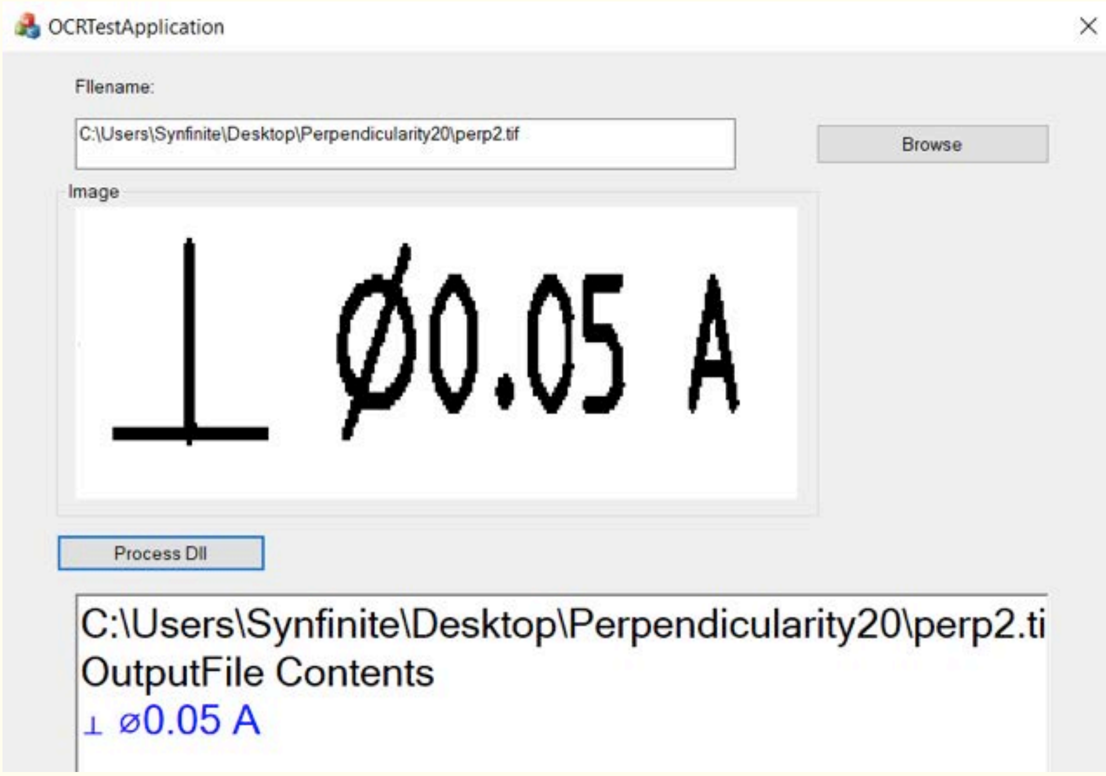

Fig 3: Screenshot example using the test application developed by Hexagon. This is used to integrate Tesseract with GD&T recognition into the company's software, PC-DMIS.

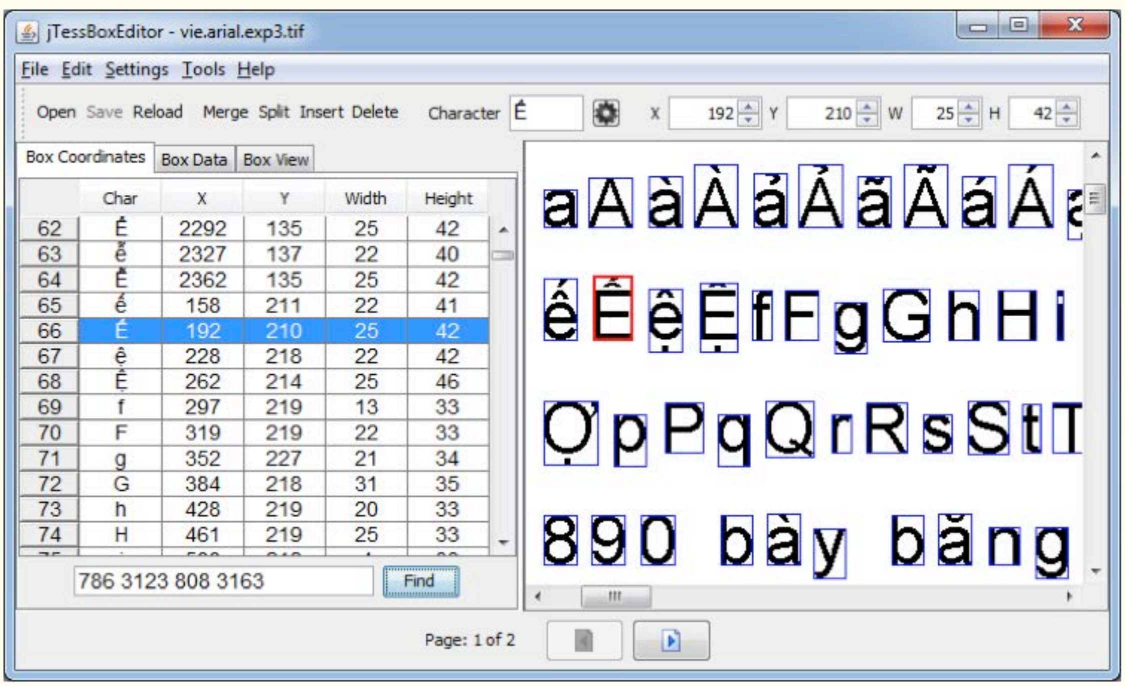

Fig 4: Example of a box editor needed for the training process. It reads common image formats such as PNG or TIFF create boxes around the characters that Tesseract needs to recognize. Data includes the box coordinates, the font, as well as the font size of the character.

Image Processing from a Camera Type Device

igt.com

TECHNICAL DIRECTOR:

Frank Metayer

TEAM MEMBERS: (L to R)

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Catherine Cronin (E)
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PROJECT MOTIVATION:

The motivation for this project is to improve upon the current lottery terminal playslip reading technology. The current readers have done tasks at the same level of quality and efficiency for several years. IGT's camera readers can have trouble when sunlight is overexposing a portion of the playslip or when playslips are crinkled and bent. IGT would like a camera reader that can scan playslips in more varied lighting, using High Dynamic Range technology. IGT would also like to upgrade the scanner's ability to process uneven and obstructed images, possibly by stitching together several partial images. Image processing software using the Java programming language will be implemented to demonstrate the effectiveness of developed algorithms. Data will be received from the camera through raw image files, allowing for more control over the raw sensor data being collected by the camera. These raw image files will be processed and the image's pixel data will be extracted through the application.

ANTICIPATED BEST OUTCOME:

The best outcome of this capstone Design Project is to produce an image of significant to support the reading of numbers and text from IGT lottery slips. The playslip scanned can be of varied quality, whether wrinkled, shadowed, or angled. The code designed will use the High Dynamic Range (HDR) technique, taking multiple photos of a playslip and combining the images for the highest quality processed result. In addition to this, the process of Illumination Normalization will be used to help clearly define and remove any unintentional lighting, shadows, and blurs.

IMPLICATIONS FOR COMPANY AND INDUSTRY:

Currently, camera-based playslip reading technology is greatly hindered by factors such as topography asymmetries and lighting aberrations. If we are successful at developing an HDR algorithm, the algorithm can be integrated into a new image processing library currently under development at IGT to combat the aforementioned obstacles. This breakthrough will grant new image processing capabilities to IGT and revolutionizes the way images are processed in the lottery industry. The data and experience gained from the project will get IGT closer to using improved image taking in unstable lighting, and processing data from combining multiple partial images.

PROJECT OUTCOME:

The Anticipated Best Outcome was achieved: The ability to use High Dynamic Range technology to produce high quality readable images.

KEY ACCOMPLISHMENTS:

Power Hardware Setup: inverted tripod, two 12-W LED strips, Flashair wireless photo transfer SD card, Canon Powershot S110 digital camera, 11 inches above a 6x9 inch platen. (Fig. 1)

Software Tool was developed in Java; allows to test team IGT's algorithms. Images are loaded from the user's local file system, for further image processing applications such as HDR. Additionally, software communicates with the hardware with a WiFi chip. any pictures taken from the hardware can be transferred directly into software for image processing. All the components of our software are fully proprietary; developed from scratch by the team; all the software is developed using Java's native library, without the usage of any third-party libraries.

User Interface: Software contains a GUI: user can select a raw image file to be processed by algorithms developed by the team. The user is able to save any processed images to their local file system. Image data such as RGB values are displayed as histograms inside the interface. The graphics are made to look modern to allow a clean and intuitive user experience.

Raw Data Extraction: Raw image data extracted from raw image files or from a custom bayer image format and displayed as the images bayer pattern output. These patterns can then be interpolated using a bilinear interpolation algorithm developed by the team to emulate how the image is perceived by the human eye.

High Dynamic Range (HDR) Imaging: Solutions implemented for producing HDR images, which reduces shadows and light glares from the input images while retaining all relevant information. Given raw underexposed and overexposed images of the same subject, various HDR algorithms were developed from scratch that combine aspects from both exposures to create an output image with better details and greater range of luminance. (Fig. 4)

Color Balance Algorithm was developed with the function of removing the colored tint that can appear in images under various lighting setups. Assuming all tickets would have a white background, each pixel in a given image is color balanced so that its local region has a white background. This color balancing technique results in images that are primarily white. Pixels in the image that stand out from their local background, such as ticket boxes, are emphasized and stand out more. (Fig. 3)

Image Stitching Algorithm: Often times, it may require two or three shots to capture the entirety of one lottery play slip. This is tedious and could lead to errors in processing. To solve this problem, we implemented a very basic stitching algorithm that takes these images as inputs and stitches them together either vertically or horizontally to create one single image.

Presenting Project at Student Poster Session at:

Capstone Design
CONFERENCE 2018
JUNE 4-6, 2018 ▸ ROCHESTER, NY

http://www.capstoneconf.org

Fig 1: Inverted Tripod Camera Display used to collect RAW images.

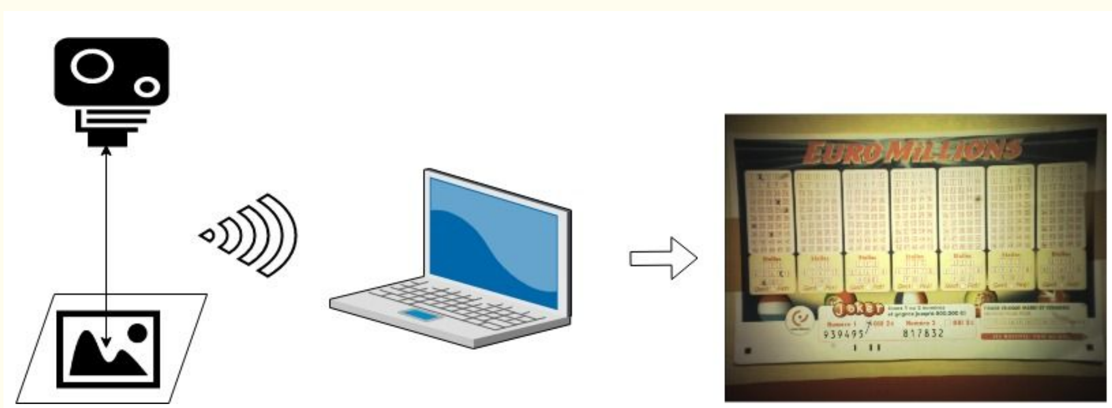

Fig 2: The process of producing HDR images: one or more over- and under- exposed photos are taken from the camera, and transferred wirelessly to the laptop for image processing applications; hence one high quality HDR image is produced.

Fig 3: A color balancing technique is used to alter the original coloring of an image so that the image has a consistent white background. Outliers in the coloring of the image, such as the ticket boxes, then stand out.

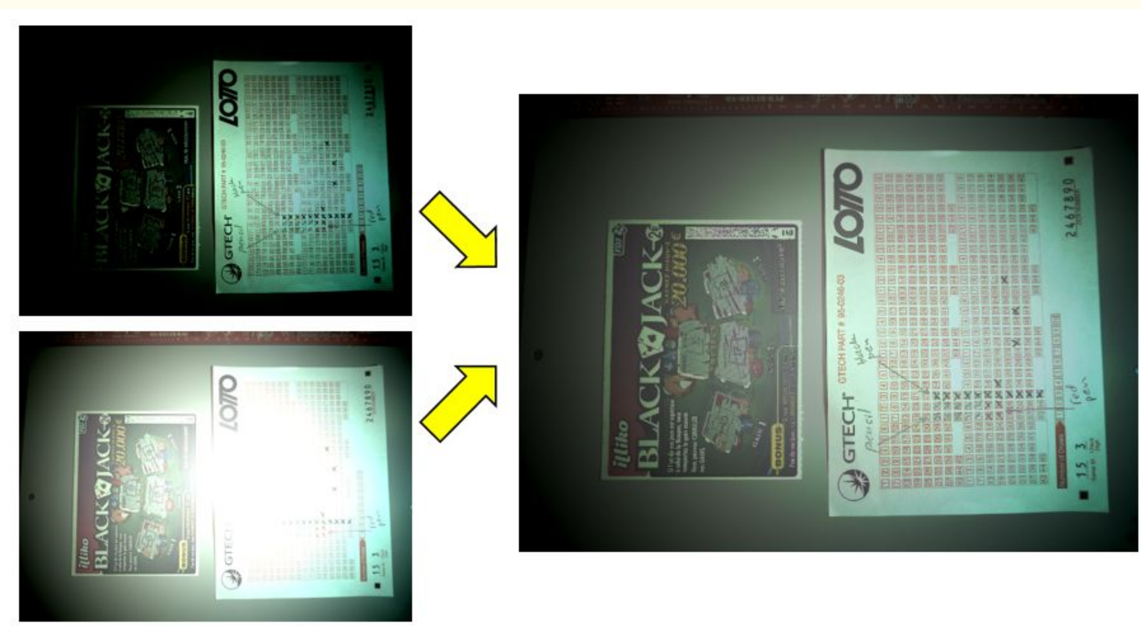

Fig 4: Underexposed(top left) and overexposed(bottom left) images combined using a contrast based HDR algorithm to produce an optimal quality HDR output image(right).

Gen-2 SPEC Tester (System Power Extended Cycling)

infineon.com

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PROJECT MOTIVATION:

DC-DC converters must provide steady power to large processing units and as power demands are increasing, competition to make the most effective and efficient devices pushes innovation forward. Once many of the logistics of a design have been determined, minor modifications can be made in order to further optimize the performance of the design. These could be changes in the layout of MOSFETs on the chip, supporting hardware, or changes in semiconductor structure or doping levels. Testing racks are used to test sets of these chips, each divided into groups. These IC's are placed under heavy demands and held under identical conditions in order to maintain a controlled testing environment. The results of these tests can further the development of these chips. This project is motivated by the need for an efficient, compact, testing rack that can both control the conditions between chips and accurately report data. This will allow Infineon engineers to properly interpret the results and to work towards the best outcome for their DC-DC converters.

ANTICIPATED BEST OUTCOME:

By April 13th, 2018 we anticipate to have implemented a complete system capable of monitoring and managing the entire SPEC (System Power Extended Cycling) testing platform. The features/functions of this system will include the following: Telemetry data consolidation and management for 60+ I2C devices, thermal management and monitoring of local cooling fans, load control, support for different cycling modes for input power and channel enabling/disabling, and fault management through use of text/email alerts along with channel isolation and E-Fuse control. All of these features/functions will be controlled using a graphical user interface specifically designed and programmed for this system.

IMPLICATIONS FOR COMPANY AND INDUSTRY:

The successful completion of this project has the potential to give Infineon a significant advantage in the switch-mode power electronics industry. Using the SPEC testing platform, Infineon engineers will be able to precisely test multiple design configurations of their DC-DC converters both quickly and effectively. By monitoring the individual performance of each device, the team at Infineon will be able to determine the optimal characteristics for their devices performance and efficiency. With this system, Infineon will be able to actively stay ahead of their competition in the power electronics industry.

PROJECT OUTCOME:

The Anticipated Best Outcome was not achieved. VHDL designs created to communicate with SPEC platform using FPGA; also developed PC-based GUI to display telemetry data; developed backend software for communication between GUI and FPGA.

KEY ACCOMPLISHMENTS:

Waveform Generator Board: The circuit schematic for the DAC board was implemented on a standalone waveform generation card. This separate Printed Circuit Board is sized to plug directly on top of the Cyclone V DE10-Nano into its GPIO headers. While the design was initially intended to be implemented as a revision to the main system board, Infineon engineers felt a dedicated card would allow for more customization in the system. Rather than using the ATX power net of the mainboard, this card now runs of the 5V supply provided by the FPGA as it has low power requirements. Waveform generation will be customized via the SPI controller on the FPGA. Waveforms will generally be trapezoidal, with customizable rise/fall times and duty cycle for the duration of extended stress testing. However, this board is extremely modular, and any wave pattern can be programmed into its local SRAM.

I2C Controller: In order to communicate with the SPEC testing platform a VHDL design built to run on the FPGA was created. The primary purpose of the I2C controller was to communicate with the load board controller and obtain telemetry data on a regular interval from multiple built-in registers. The primary architecture of the controller was based around a finite-state machine so that users can easily debug the controller by examining individual states to observe each phase of communication. After finalizing the initial design, multiple additional versions were created to communicate with several registers simultaneously as well as take commands directly from our PC GUI.

SPI Controller: Sending commands to the waveform generator board required communication over an SPI bus therefore an SPI controller design was also created in VHDL to run in parallel with the I2C controller. The SPI controller followed the same methodology of the I2C controller by using a finite-state machine as the primary backbone of its underlying architecture. While the I2C controller communicates directly with onboard registers to obtain telemetry data, the SPI controller communicates directly with the DAC on the waveform generator board in order to define the specifics about the current transients to send to the load board. Establishing this communication with the waveform generator board over SPI using the FPGA will allow users to easily send customizable current transients to the load board using our PC GUI.

GUI Development: The GUI provides the end user with a simple way to control the testing boards and to view the data collected from each of the boards in real-time. Clicking on one of the boards displays its data, including, but not limited to, its voltage, current, power consumption and temperature. The GUI also offers the user a selection of tests to run on the boards. The user can choose to run tests on individual boards, on ten board testing neighborhoods, or on the entire rack of sixty boards.

System Overview/Flowchart of final deliverable product

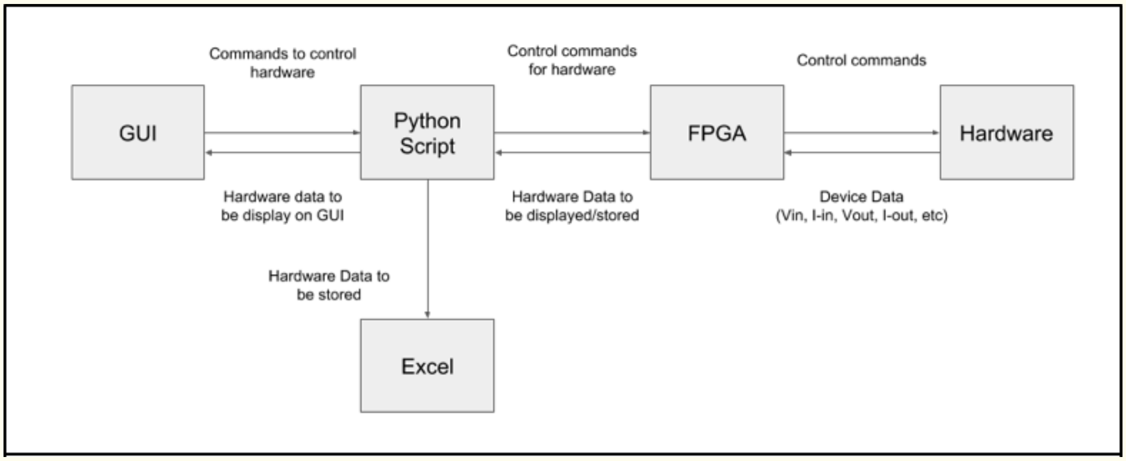

Fig 1: System flowchart of final deliverable product

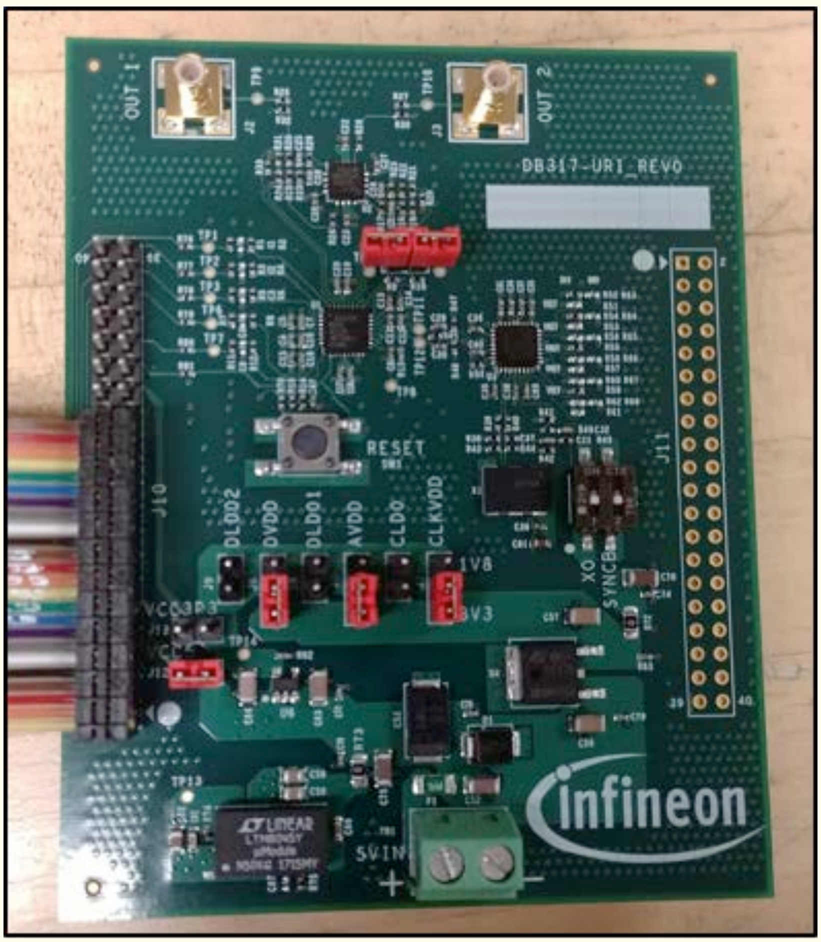

Fig 2: Waveform Generator Board

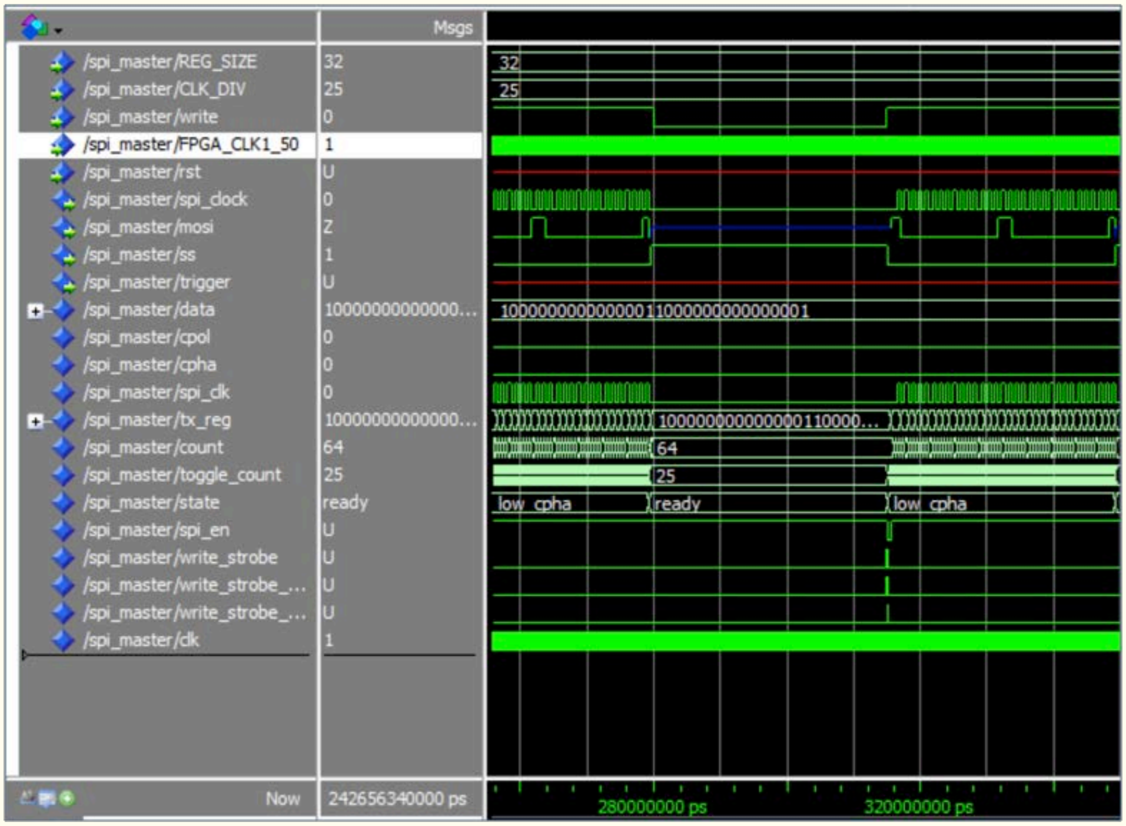

Fig 3: ModelSim Simulation of SPI Controller

Fig 4: GUI to control and monitor 60 devices

IRADiON
Ceramic Core CO_2 Lasers

Automatic Laser Optimization

iradionlaser.com/en

TECHNICAL DIRECTORS:

Robert Milkowski
Michael Mielke

TEAM MEMBERS: (L to R)

Domenic Ferri (C & E)
Tyler Creighton (C)

PROJECT MOTIVATION:

As Iradion further grows its product line and customer base, the ability to deliver the highest quality lasers in the allocated time becomes more and more challenging with traditional laser tuning methods. These methods consist of entering the laser with long screw drivers, making inaccurate manual adjustments, and using the laser beam to calculate complicated attributes. This process is very inconsistent, time-consuming, and dangerous.

The purpose of the AutoLase project is to offer a faster, safer, and hands-off approach to laser tuning and alignment. The adjustment process will fully computer automated by using customized actuators driven by customized hardware and software algorithms capable of reading specific laser attributes and making the necessary adjustments. Adjustments will now be far more accurate thus increasing the overall consistency of products being sold. No longer will production workers spend a large sum of their valuable time with the current trial and error process, or be required to enter the laser and place their hands next to powerful laser beams.

ANTICIPATED BEST OUTCOME:

The best outcome for this project would be to create the hardware and software required to completely automate and optimize the laser tuning and alignment process. The system will make adjustments to the laser in order to achieve the desired laser attributes. This will be achieved with a feedback loop that will take in measurements of the current attributes, and simultaneously adjust the laser in order to produce the desired output. A user friendly GUI will be used to interact with the system. The system will be portable, hands-off, meet accuracy and safety standards, and fit the required dimensions.

IMPLICATIONS FOR COMPANY AND INDUSTRY:

Computer controlled automation of the laser adjustment process will significantly speed up production and increase worker efficiency. With the rapid optimization of desired laser attributes, Iradion will significantly increase throughput thus greatly increasing profitability of the company. The system can be applied to build a variety of laser products with greater consistency and better performance, thus keeping customers happy. The introduction of automation in the laser adjustment procedure will create an opening for increased specialization of workers within the industry. Such specialization will drive innovation and produce higher quality products at a significantly lower cost.

PROJECT OUTCOME:

The Anticipated Best Outcome was achieved.

KEY ACCOMPLISHMENTS:

Mathematical: We have discovered and tested the relationship between the position of the mirror adjustment screws and the position of the reflected beam. Using this relationship, we were able to create algorithms that allow us to move the reflection to any point within the mechanical bounds of the mirror structure. This correlates to being able to perfectly center the mirror using the three screws in a timely and efficient manner. The algorithm was derived from regulating the X and Y outputs from the autocollimator to zero. The built-in angle for the mirror mount allows one of the mirrors to reach the desired non-zero angle by emulating a perfectly horizontal mirror.

Mechanical: We have designed in Solidworks and realized using 3D printing technology a functional actuator that couples onto the adjustment screws and uses stepper motors to turn them (IMG 1). The system and motors are offset from mirror to accommodate the extremely limited space between screws (IMG 2-3). Therefore, we use MXL timing belts and pulleys to transfer rotary power from the motors to the couplers. The system is fully adjustable for different sized components. The current design used all available space to create the most optimal gear ratio between the couplers and motors to maximize the torque of the design. This allows the motors full control of the screws such that the desired output is always accessible. The final design is assembled on an optical bread board to allow for a precise connection of components (IMG 4).

Hardware: An FPGA is used to send the required signals to a series of stepper motor drivers to control the speed, direction, and number of steps. This allows our program full control of turning multiple motors in parallel for increased efficiency. An autocollimator was also used in the design, which outputs light toward the mirror which is reflected into the device. This reflection is sent into a camera that identifies its distance from the center. The light takes the shape of a crosshair, making it easy to align with the included optical axis (IMG 5). The device outputs X and Y distances from the center point in the form of micro radians to the C# program. Both the FPGA and the autocollimator communicate to the program over UART serial communication.

Software: The user can interact with the system through a simple application written in C#. The program shows the distance the reflection is from the center point. Once the user hits the start button, the *find* algorithm will start. The resolution on the autocollimator is extremely precise, and most mirrors won't show the crosshair of light at the start of the centering process. This algorithm turns all the screws in a specified pattern searching for the crosshair to appear within the area of influence. Once the crosshair is visible, the *adjustment* algorithm takes several runs of turning various screws to reach the regulated point. Once completed, the program waits for the user to signal a new mirror is ready.

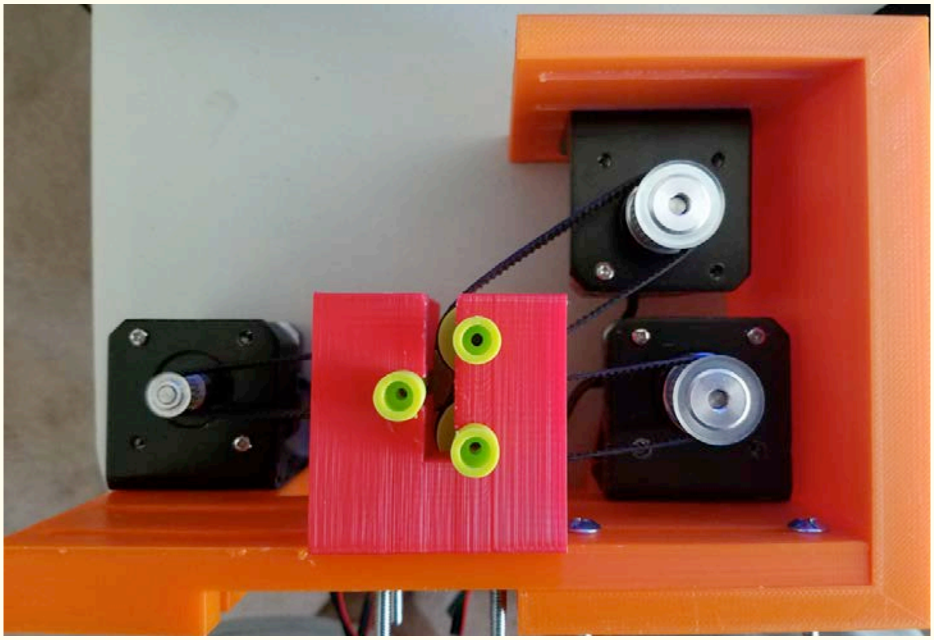

Fig 1: 3D printed hardware that turns the screws.

Fig 2: Z mirror frontal view

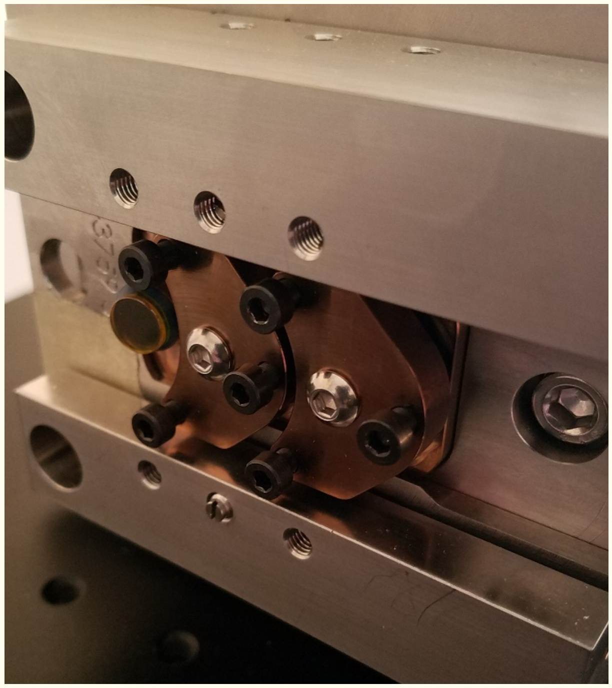

Fig 3: Z mirror rear view

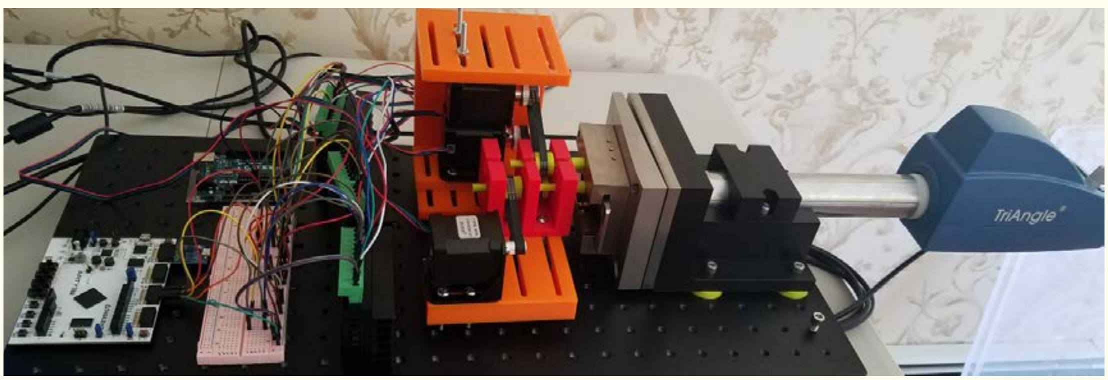

Fig 4: Complete hardware design including the Triangle autocollimator, mirror mount, actuator, and hardware drivers.

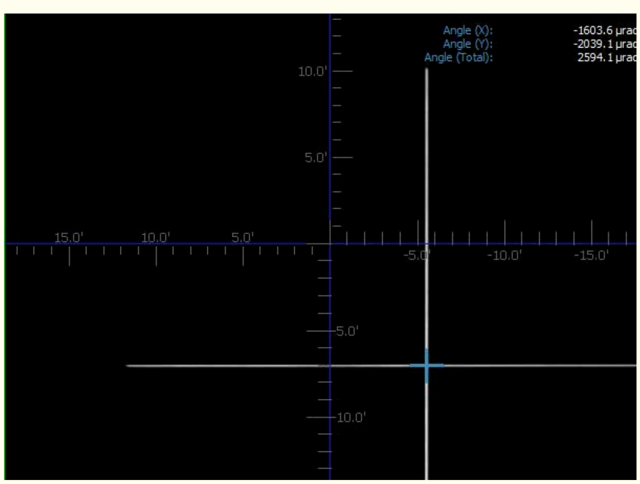

Fig 5: Autocollimator output; White crosshair is the reflection from the mirror, scale marks the center point.

Web Based ON Semiconductor Integrated Circuit Simulation Development

onsemi.com

TECHNICAL DIRECTORS:

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TEAM MEMBERS: (L to R)

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PROJECT MOTIVATION:

In the field of integrated semiconductors, a plethora of SPICE simulators exist to design and troubleshoot products before production. Unfortunately, due to the limitation of some of these simulators, issues with convergence and unacceptable simulation times often occur. Therefore, people waste a significant amount of time in the development phase downloading various simulators, designing on those simulators, and then coordinating between the buyer and the manufacturer. Any questions that arise throughout this procedure also prolong the overall development process as customers clarify their intent. At the moment, no integrated circuit manufacturer has fully implemented an online simulator to reduce the time needed for ordering semiconductor products. SystemVision, a product of Mentor Graphics, provides a cloud-based platform that can solve the aforementioned interfacing problems by providing an online schematic simulator platform capable of accurately reproducing and simulating integrated circuits. With its VHDL-AMS modeling language and its graphical user interface, the design process becomes broadly accessible to customers, designers, and manufacturers.

ANTICIPATED BEST OUTCOME:

For this capstone project, each capstone member will provide extensive support by creating fully working schematic design simulations on SystemVision. At ON Semiconductor, the baseline of the products includes: switching regulators, drivers, SMART drivers, LED drivers, and low dropout linear voltage regulators. Phase one of this project focuses on developing the simulation of a buck converter product family within the SystemVision website. In phase two, if time permits, the capstone team will provide demo boards of these products with their respective manuals for use in recruiting and promotional events.

IMPLICATIONS FOR COMPANY AND INDUSTRY:

With SystemVision's powerful simulator, ON Semiconductor could gain a significant advantage by enhancing the product design-in experience. In fact, ON Semiconductor stands to transform the way people shop for integrated circuits by streamlining the design process, saving a significant amount of time in the purchasing phase. Using cloud-based simulations, a customer will be able to remotely design products and interact with ON Semiconductor representatives instead of running simulation in two different locations. Specifically, this company will have a set of web-based buck converter models and simulation benches as a part of their pilot program with the help of this capstone team.

PROJECT OUTCOME:

The Anticipated Best Outcome was achieved.

KEY ACCOMPLISHMENTS:

Component Implementation: Mentor Graphics SystemVision provides an online platform for circuit simulation that addresses the needs of professionals, enthusiasts, and students. As a website that continues to grow and promote shared designs, our capstone team designed a mixture of digital and analog components to serve as foundational components of the final integrated circuit. Our capstone team sequentially implemented sub-circuits of the buck converter to ensure that each of them worked as expected. On a weekly basis, our team created components for a soft-start ramp, an oscillator, an error amplifier, a voltage mode regulator, and a current-mode regulator.

Design Within Specification: After verifying the performance of each subcircuit of the buck converter chip, alterations were made so that outputs better matched the ideal performance according to each respective spec sheet. Additional circuits such as a bootstrap, a saw tooth oscillator, and a gate driver were added to the buck converter simulation draft. Finally, circuit protection features such as overvoltage, and undervoltage were added to the schematics.

Supplemental Pin Simulations: Each member of the NCV8901xx buck converter family contains pins for input voltage, ground, enable, drive, bootstrap, feedback and compensation. For added functionality, the NCV890104 model has the ability to add resistors to set the modulation and depth of the switching frequency. Additional features on some models include pins that set a reset delay for regulation mode, and other models which contain pins for synchronization. Each of these additional pins were simulated for later use.

Buck Converter Simulation: Upon testing and combining each of the sub-circuits, this capstone team created top-level designs of each respective buck converter in the NCV8901xx product family with their corresponding pins and specifications.

Printed Circuit Board Schematics and Layout: Once each NCV8901xx buck converter was successfully simulated in the SystemVision environment, individual schematics were created using Orcad. A demo board was defined to highlight five members of the NCV8901xx family. The board is divided into 3 sections to highlight 3 different application features. Then, a netlist was imported to PADS were the PCB design layout began.

- Cascaded buck converters demonstrate ability to synchronize with other timers.
- Digital meters at inputs and output provide current and voltage readouts to demonstrate efficiency.
- Three device family members (each with different current capabilities) are used to supply power to 3 isolated USB ports for cell phones or other devices.

Then, a netlist was imported to PADS and PCB layout began.

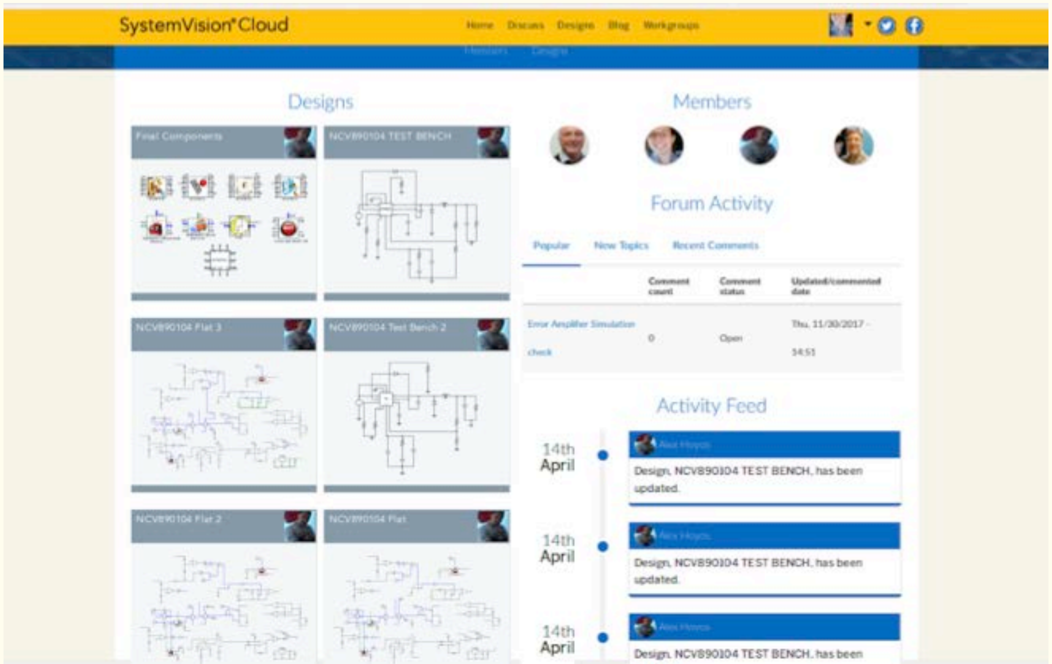

Fig 1: Screenshot of the SystemVision Development Tool; provides user with a schematic simulation environment for customers to see accurate simulations.

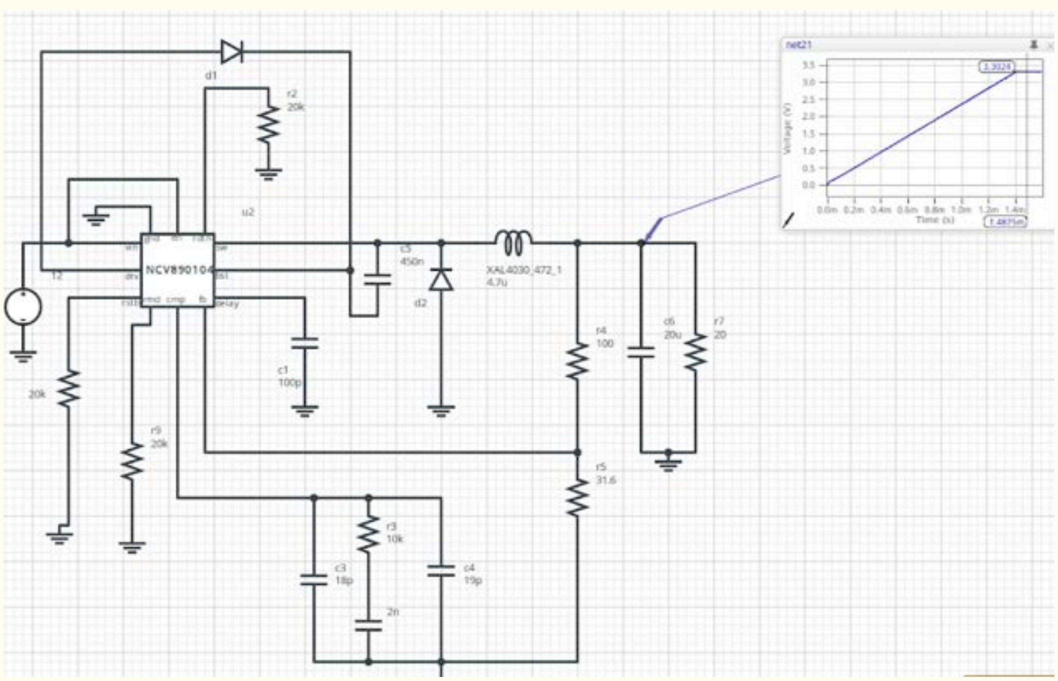

Fig 2: SystemVision online simulation implementation of NCV890104 device. The probe indicates that the simulation works as expected.

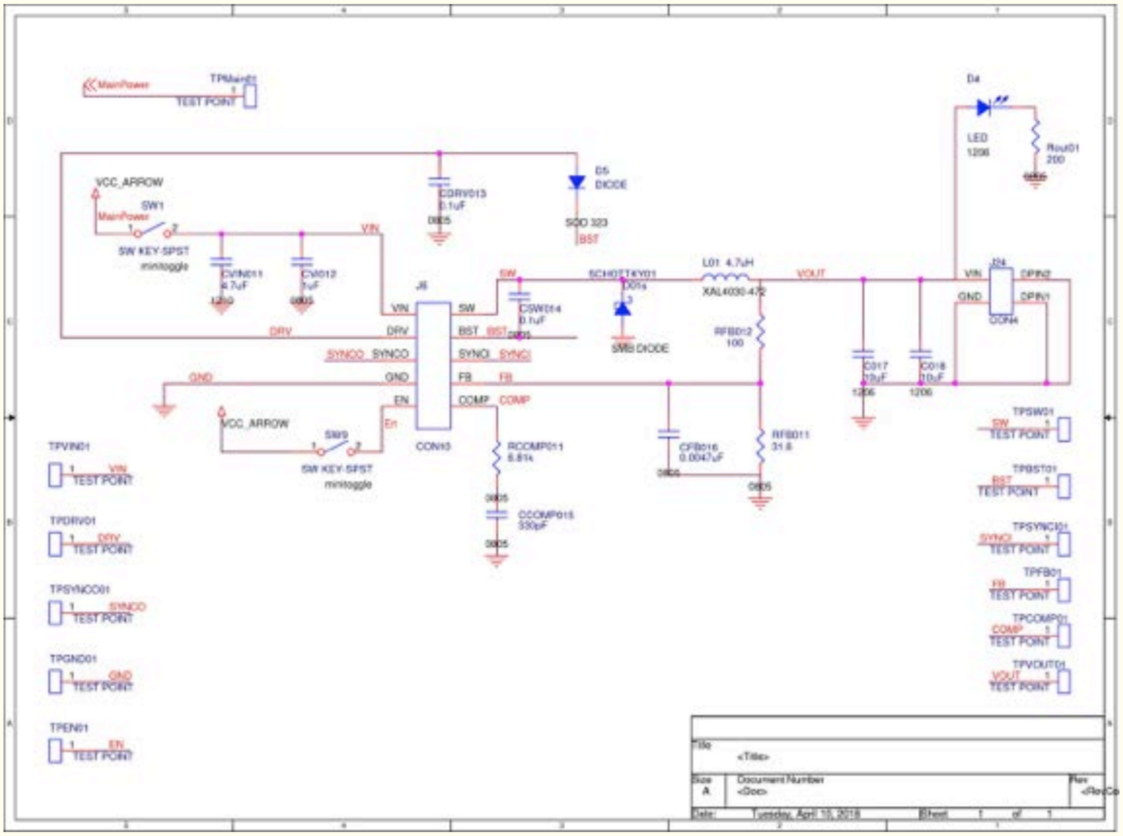

Fig 3: Orcad schematic of for PCB layout of NCV890101 board

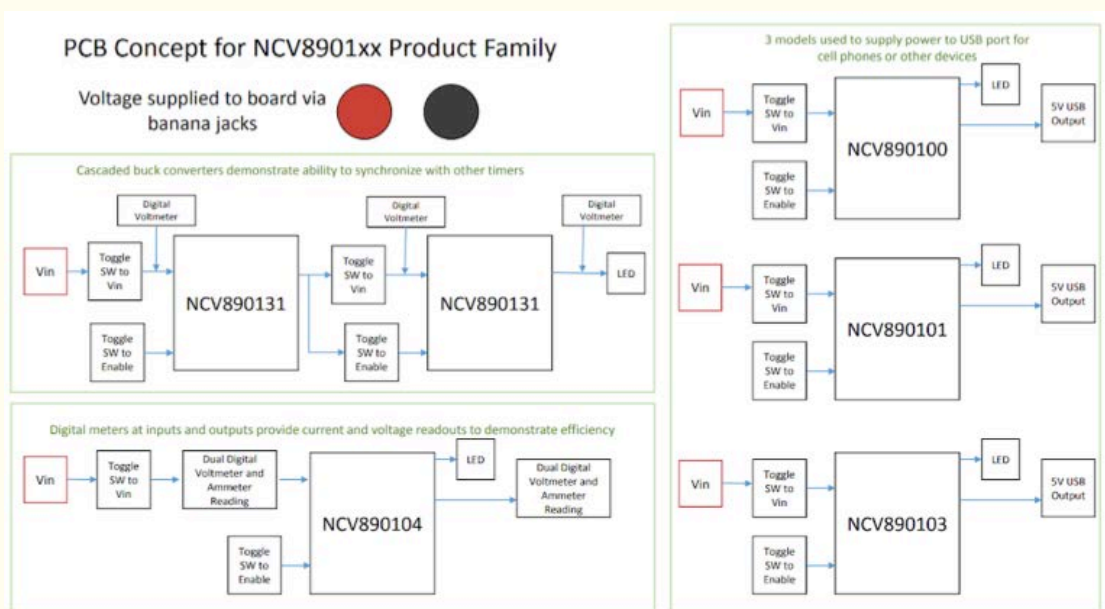

Fig 4: Block diagram of PCB functionality: This layout includes all NCV8901xx chips where three models provide a 5V supply to a handheld device. The left layouts present voltage and current readings as well as abilities to sync with another timing device.

Fiber Optics Design High Voltage Equipment Control System Interface

pec-usa.biz

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PROJECT MOTIVATION:

Electromagnetic interference threatens signal transmission and reception in copper wires. The current power grid is rarely shielded from electromagnetic interference (EMI), which makes it particularly vulnerable to terrorist attacks and other serious equipment failures that could leave entire cities or counties without power for weeks. In modern times, people are extremely dependent on electricity; no power for a week could prove fatal. Fiber optic cables are immune to EMI and provide a reliable and effective solution. Fiber provides pronounced signal quality while also not conducting electricity. Fiber is also resistant to fluctuations in temperature and can be directly placed in water without affecting the signal that it's carrying. The glass core makes tampering with fiber optic cables impossible therefore offering a higher level of security. Fiber optics are a safer, more rugged alternative to copper cabling especially in electrical facilities. Utilizing fiber optics is the next step to revolutionizing and modernizing the power transmission and distribution industry.

ANTICIPATED BEST OUTCOME:

The best outcome of this project by the end of the spring semester will be to have a functional prototype interface control system. The control system will operate with two distinct control cards. First, the master control card will interface with the previous control power hub to drive indications and relay state changes to its counterpart. The other distinct card will detect changes in connectivity, adjust relays states, and report back to the master card via the fiber. This design will have additional connections for future signals and enough extra memory for any future programming.

IMPLICATIONS FOR COMPANY AND INDUSTRY:

The prototype will begin the push for American power companies to add additional security measures to protect power transmission and distribution facilities from EMI and terrorist threats. Phoenix Electric Corporation (PEC) will add to their marketability by adding this unique product not offered in most American markets. The product may also encourage PEC suppliers to make products to assist PEC in this new market once the control system is deployed. The Fiber Optic interface system will give PEC an exclusive edge against their competitors while providing heightened security and safer installation at a reasonable cost.

PROJECT OUTCOME:

The Anticipated Best Outcome was not achieved. The PCBs still need to be fabricated and VHDL tested.

KEY ACCOMPLISHMENTS:

Simulate Major Circuits: Vital circuits in our design have been simulated to ensure proper functionality. An electric rule check has been performed to make sure there are no open or short circuits within the design.

Generate Schematic for High Voltage Equipment Board: The team has created a schematic for the board that will be used on the High Voltage side of the system. We used Diptrace as our computer software tool to design the schematic. This is the schematic that will be used to generate the PCB that will be placed where the High Voltage switching equipment is located.

Generate Schematic for Local Control Cabinet Board: The team also created a schematic for the board that will be used inside of the Local Control Cabinet. Just as with the High Voltage Equipment board, Diptrace was used in its creation. This is the schematic that will be used with the creation of the other PCB for the Local Control Cabinet.

Design High Voltage Equipment PCB: With the schematics for the High Voltage Equipment complete, the team has fully designed the printed circuit board. Although the board hasn't yet been physically fabricated, the design has been reviewed and cleared for manufacturing. The VHDL can be loaded onto the board when it has been made to test for "real life" functionality.

Design VHDL Communication Protocol: In order for the boards to perform their desired functions, much coding had to be done. The communications system was written in VHDL with SerDes (Serializer/Deserializer) as the protocol. This is going to control how the boards "talk" to each other and receive/transmit data.

Fig 1: Local control cabinet and high voltage equipment

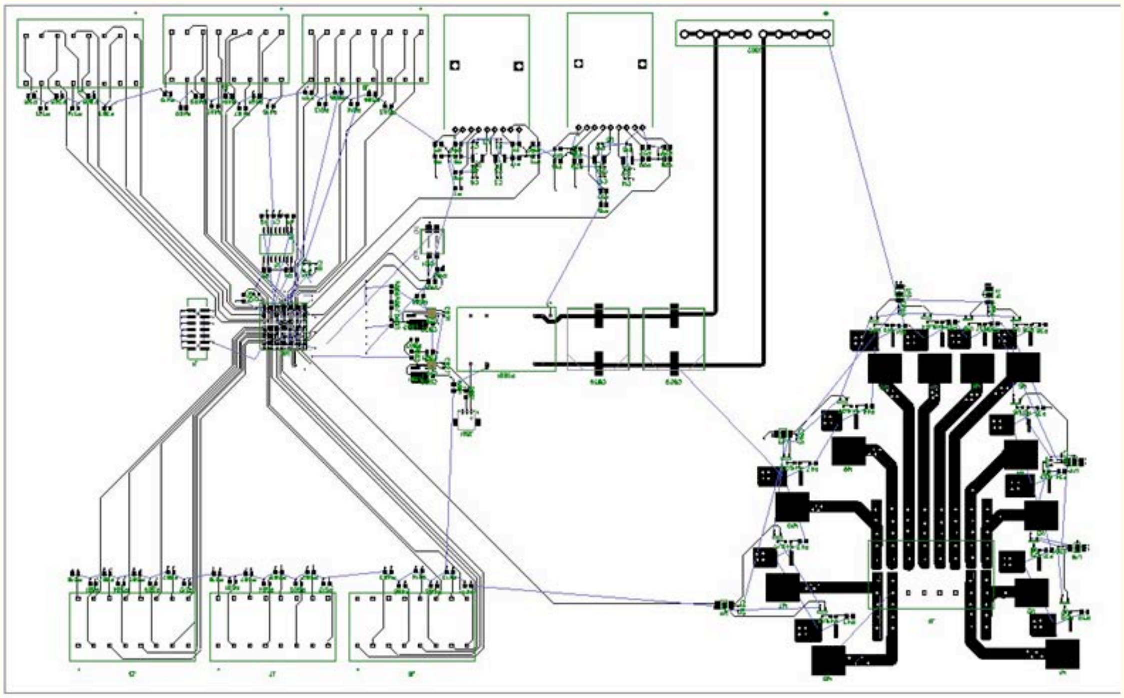


Fig 2: PCB top layer

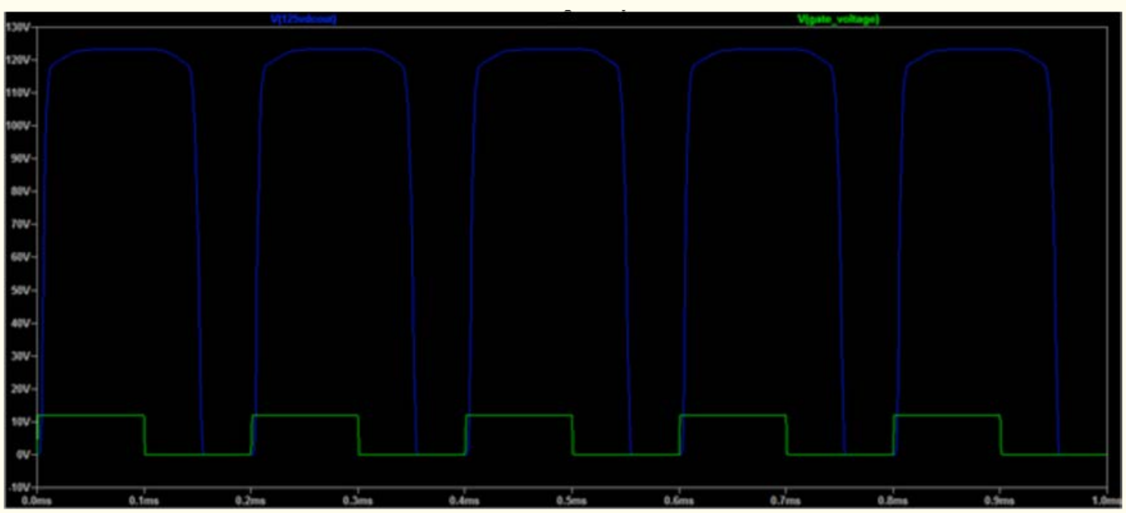


Fig 3: N-Channel MOSFET Gate Voltage and P-Channel MOSFET Gate Voltage vs. Time

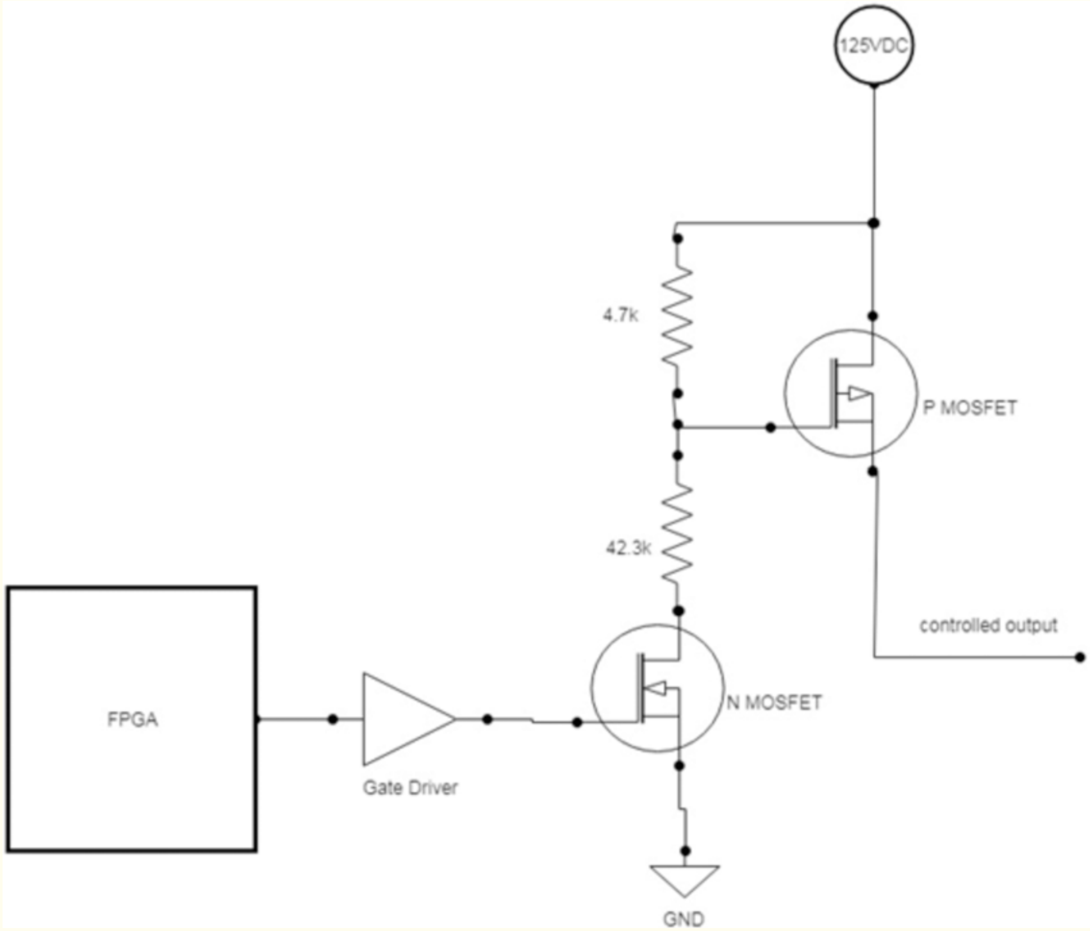
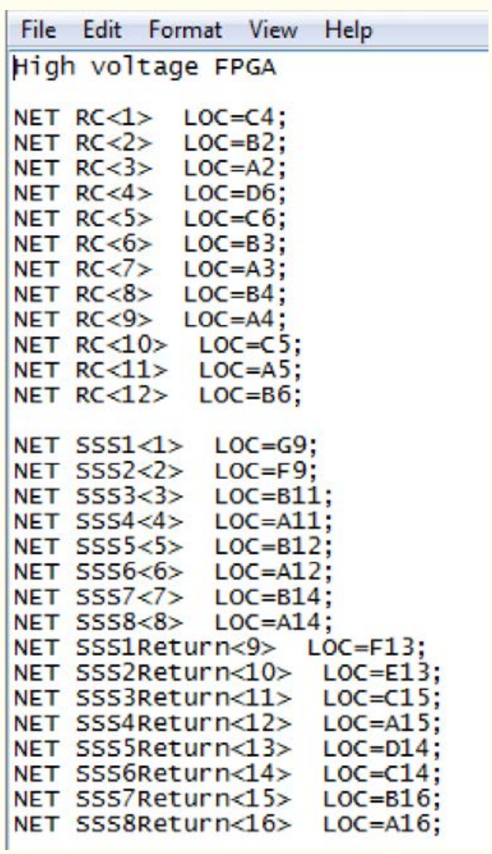


Fig 4: Driving Circuit



```
File  Edit  Format  View  Help
High voltage FPGA

NET RC<1>  LOC=C4;
NET RC<2>  LOC=B2;
NET RC<3>  LOC=A2;
NET RC<4>  LOC=D6;
NET RC<5>  LOC=C6;
NET RC<6>  LOC=B3;
NET RC<7>  LOC=A3;
NET RC<8>  LOC=B4;
NET RC<9>  LOC=A4;
NET RC<10>  LOC=C5;
NET RC<11>  LOC=A5;
NET RC<12>  LOC=B6;

NET SSS1<1>  LOC=G9;
NET SSS2<2>  LOC=F9;
NET SSS3<3>  LOC=B11;
NET SSS4<4>  LOC=A11;
NET SSS5<5>  LOC=B12;
NET SSS6<6>  LOC=A12;
NET SSS7<7>  LOC=B14;
NET SSS8<8>  LOC=A14;
NET SSS1Return<9>  LOC=F13;
NET SSS2Return<10>  LOC=E13;
NET SSS3Return<11>  LOC=C15;
NET SSS4Return<12>  LOC=A15;
NET SSS5Return<13>  LOC=D14;
NET SSS6Return<14>  LOC=C14;
NET SSS7Return<15>  LOC=B16;
NET SSS8Return<16>  LOC=A16;
```

Fig 5: User Constraints File Sample for High Voltage Card

Schneider Electric

UPS Compliant with Department of Energy Efficiency Requirements

schneider-electric.us

TECHNICAL DIRECTORS:

Jeff August
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TEAM MEMBERS: (L to R)

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Nicholas Raptakis (C)

PROJECT MOTIVATION:

APC by Schneider Electric Uninterruptible Power Supplies (UPS) are known for their efficiency in power conditioning, and providing power backup in case of a grid power outage. The Energy Star® program for UPS products provides information so consumers can easily select more efficient models to save energy and operating costs. The Department of Energy (DoE) plans to release new efficiency regulations for these types of products. The efficiency requirements the DoE intends to release are more stringent than the current Energy Star® program. If the regulation is approved, products that are sold in the United States must comply or be removed from the market. With new Department of Energy efficiency regulations being placed into effect, Schneider Electric must revise and improve their already efficient UPS systems. To achieve this new level of efficiency, it means the redesign of several different sub-systems within the UPS.

ANTICIPATED BEST OUTCOME:

The team will have to identify several sub-circuits can be redesigned to lower power consumption. Once identified, the team will analyze the circuits and improve them without affecting the interaction with the overall system. The goal is to reduce power consumption of the UPS by several watts. In addition, the team will work on software that provides analytical data on the UPS operation. This includes analysis of cloud data as well as analysis of data from direct communication with the UPS. The analysis of the UPS data will result in dashboards to show statistics on loading, self-test results, and customer configurations.

IMPLICATIONS FOR COMPANY AND INDUSTRY:

If the team is successful in this project, Schneider Electric could apply the changes to improve the efficiency of the UPS product. The changes could be applied to several different models. This will help Schneider Electric meet the new DoE requirements when they come into effect. The combination of the data analysis and improved efficiency could put Schneider Electric at a competitive advantage, potentially gaining market-share from key competitors in a multibillion-dollar market.

PROJECT OUTCOME:

The Anticipated Best Outcome was not achieved: A few sub-circuits were designed to reduce power consumption by a couple of hundred milliwatts.

KEY ACCOMPLISHMENTS:

Modification of IC 412 Comparator Circuit: For this particular circuit a mathematical derivation of a transfer function was performed to understand the frequency response of the circuit. A simulation and frequency sweep were performed for comparison with transfer function's Bode Plot. This was done using PSPICE. Using the mathematical transfer function, resistor and capacitor values were maximized for minimal power consumption. For this circuit, there was a limitation in one resistor value. As a result of this limitation, the ratio between resistor increase and capacitor decrease could not be maintained equal. Adjustments were made to maximize values and retain the circuits response as close as possible to the original response. This result can be seen in fig. 4.

Vout Error Amplifier: For this circuit, a simulation was performed to understand circuit parameters and operational purpose. A frequency sweep was done in PSPICE in order to visualize the circuits response. A mathematical transfer function was derived using circuit components. The transfer function was then plotted in MATLAB and compared with the simulated PSPICE frequency response. This was done to ensure that the mathematical transfer function was correct. Using the transfer function, resistor and capacitor values were adjusted and determined to minimize circuit power consumption and retain original circuit functionality. Since there was no limitation on resistor values, all resistors were increased to 4 times their original value, and capacitors were reduced accordingly. The response can be seen in fig. 3.

Charger Disconnect Switch: High power consumption was identified in the battery charging circuit. A way to turn off the circuit when the battery charging cycle was completed was devised. A MOSFET driven Optocoupler switch that was powered from AC conditioned input was implemented. Leakage current protection was built into the circuit as well as overvoltage protection for MOSFET. Resistor Values were maximized for optimal power conservation. The designed circuit can be seen in fig. 1.

Updating firmware: Used Eclipse to update firmware files in collaboration with firmware engineer. The team also used programs such as BitBucket and SourceTree to share files in collaboration with the firmware engineer.

Data Analysis: Created repositories and exchanged information with the firmware engineer regarding data analysis. This included obtaining telemetry data that was logged to Schneider's digital service platform and doing analysis on the collected data.

QR Generator: The team created a QR code generator that can be used to test error messages that occur in each device. When scanning the QR code, the user is sent to a web page with relevant information regarding the error and the device. This includes the device serial number, the MAC address of the device, the error code, and a description of the error. A sample of the webpage can be seen in fig. 2.

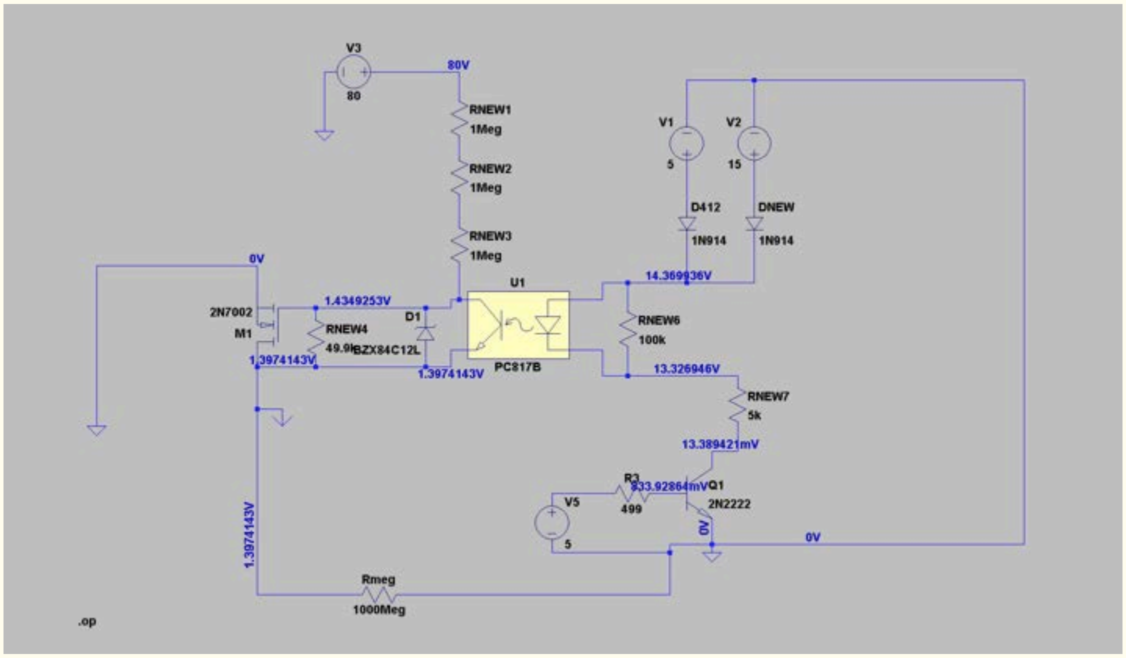

Fig 1: Charger Disconnect Switch

Fig 2: Example QR-Redirected Error Page

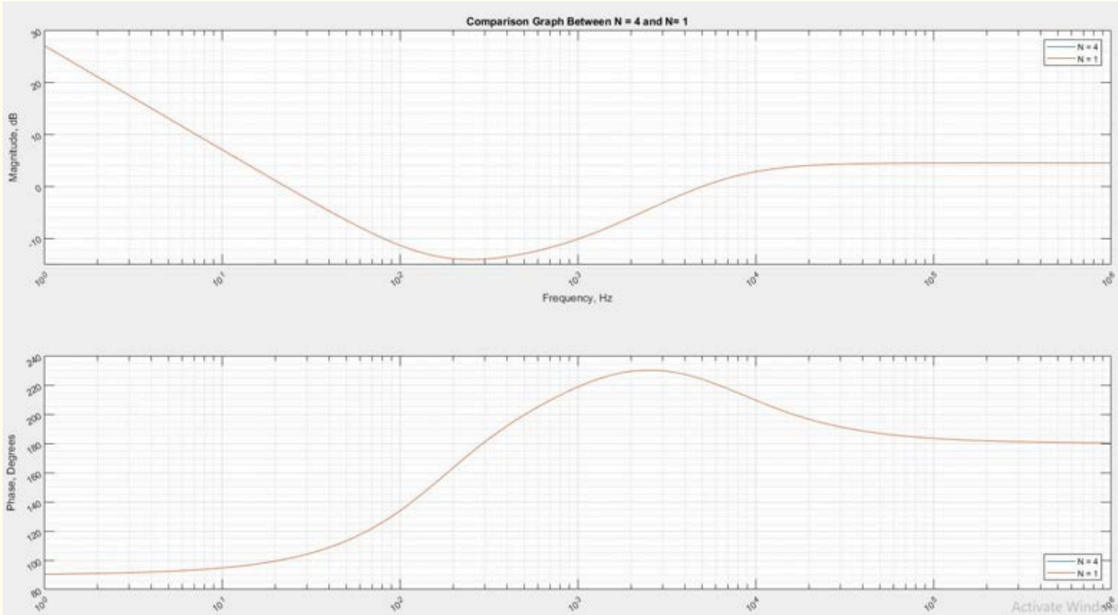

Fig 3: Adjusted Frequency Response Comparing Different Circuit Scale Parameters

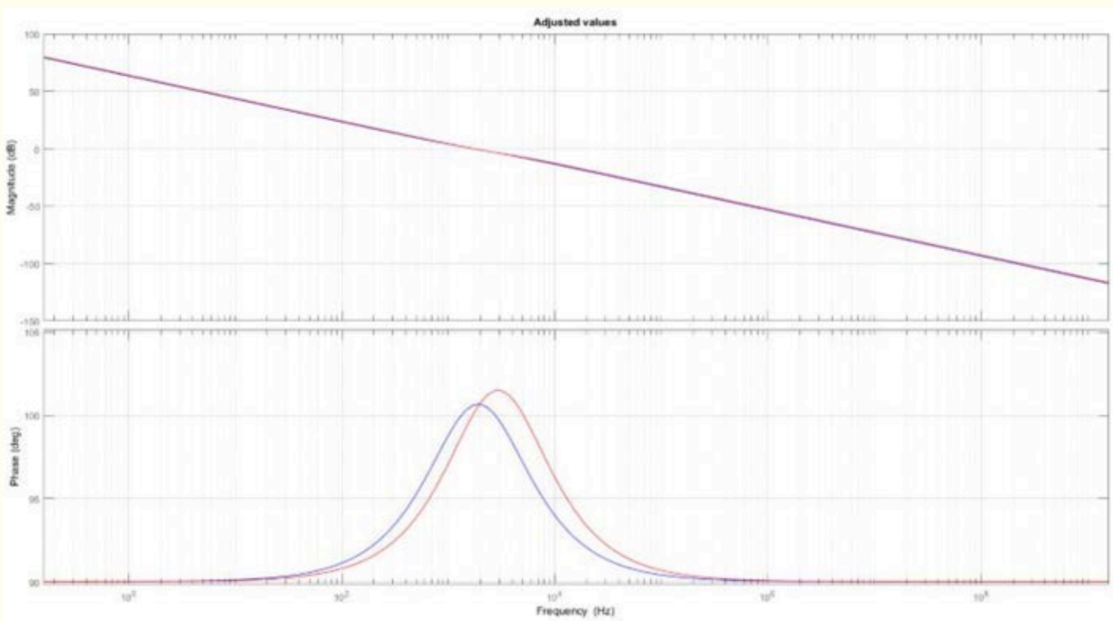

Fig 4: IC 412 Adjusted Frequency Response

Blank Out Sign Connectivity Over Cellular Network

sesamerica.com

TECHNICAL DIRECTOR:

David Connolly

TEAM MEMBERS: (L to R)

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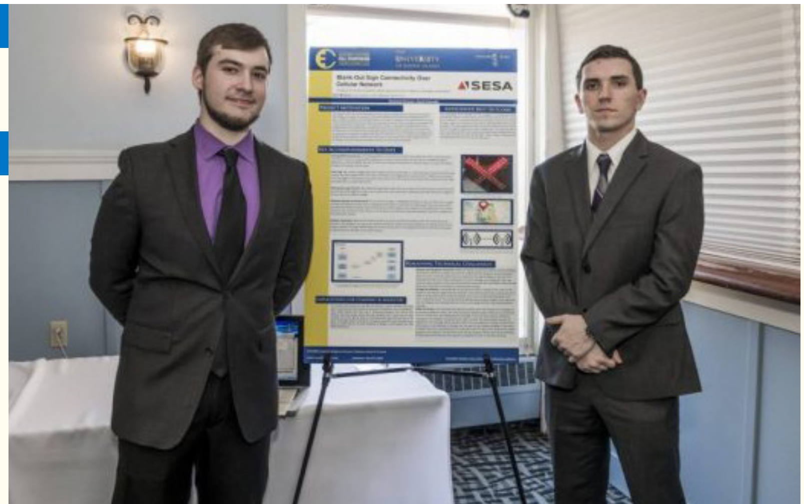

PROJECT MOTIVATION:

This project is all centered around Blank-Out Signs, which are signs that are used on the roads that offer different messages to motorists. This works by lighting up LEDs that are implemented in the signs in different sections such that they display a message. An example of this would be the LED signs show in toll booths that represent which lanes are open or closed. These messages are predefined so a sophisticated control apparatus is not necessary in order to change the message shown. SESA designed the BOS to operate with a simple dry-contact closure driven by a low-cost microcontroller. This alternative to full-featured DMS makes BOS lack the means for communication. This means that the only way to change the message on the sign or to check for an error. The expensive installation of hardwired communications infrastructure necessary to control and monitor signs negates the cost advantages of of the BS products and renders remote use economically untenable.

ANTICIPATED BEST OUTCOME:

The anticipated best outcome for the projects is a production-ready, modularized cellular communication system interface able with the current BOS architecture. The module will allow asynchronous transmission of both the sign's status to a remote server as well as control operations from a web application. The web application will be secure and mobile friendly as well as be able to support multiple users with multiple signs. The end user will be able to manage their BOS, relay commands to other signs and allow the user to be able to check the status of their signs. When a fault is detected, the web application will send email alerts to the users.

IMPLICATIONS FOR COMPANY AND INDUSTRY:

This product will change the way that SES America's clients interface with their signs. Currently, if the client wants to see which message their sign is displaying or even simply making sure their sign is functioning properly. This will be cost effective and time saving, which will save company cost if they have to send someone out to the sign to verify. It could potentially save full work days if the sign is far enough away. In the future a response-based BOS sign interfaced with speed or traffic sensors can alert motorists of danger so this project has road safety implications.

PROJECT OUTCOME:

The Anticipated Best Outcome was not achieved; the radio communication units between signs were not purchased and tested.

KEY ACCOMPLISHMENTS:

Arduino Mega2560 Development - The Arduino Mega2560 is a small microcontroller that allows the user to send and store information. It uses the ATmega2560 processor and has an available 8192 addresses of internal static random access memory (SRAM) and 56832 addresses of external SRAM. We had to find a way to power this processor and use its pins to relay information between the website and the signs while using a connected modem.

Daily Logs - We created a logger.php with multiple functions to be able to create daily logs and echo back the logs created. We then updated the server files to be able to use logger.php to log processes in addition to creating a JavaScript logger to log client-side events, thus ensuring all events (both client-side and server-side) are captured in one daily log text file. Server system errors that are not application-specific are logged in separate files.

Refining the Login Process - Edited logout.php, login.php, home.php, & session.php to successfully work together to log a user in (given that they know their credentials) and then keep them logged in as they redirect to different pages. A method for registering completely new users was also added.

Register Signs to a User - A registration page was added for users who are logged in so that they have the ability to register new signs. This registration includes adding the id of the new sign to the correct row in the customer database as well as adding a new row in the sign database.

Server Set Up - Switching from GoDaddy.com to AWS meant the server and databases had to be set up once again and the web application needed to be re-uploaded to the server. The AWS server now has all necessary installations and uploaded files and can perform the needed tasks, such as running a socket to receive and transmit data.

Module Connection - None of this project works if we can't connect the module to the TCP socket and send queries to the database. Our group successfully tested the socket connection between the server and the sign module. The server can receive HTTP requests sent by the sign module and send back a response according to the database values for that sign.

Setting I/O Pins - The Arduino continuously queries the server for new database information. When a customer uses the user interface to change database values, the socket will push out these new values to the corresponding sign module the next time it asks for updated information. The sign module uses the received information to set I/O pins accordingly; ensuring only one pin is set high at one time.

BOS Integration - Sign module has been successfully integrated into a blank-out sign for testing the final product. Proven that the front and back end of the server work together to send updated information to the Arduino and consequently change the message displayed on the sign to the desired message.

Fig 1: Blank Out-Signs that are to be retrofitted with the cellular module to allow connection to the server for receiving a new message.

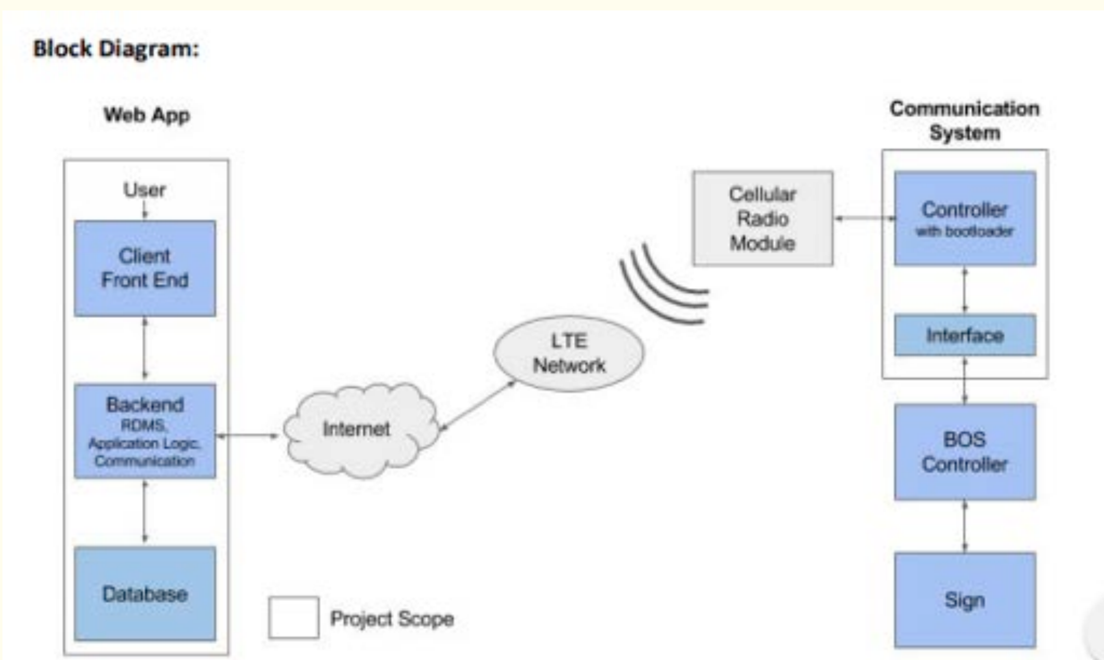

Fig 2: Block Diagram of the system. This shows the step by step process of how the signs interact with the users, allowing them control over the messages that the sign displays.

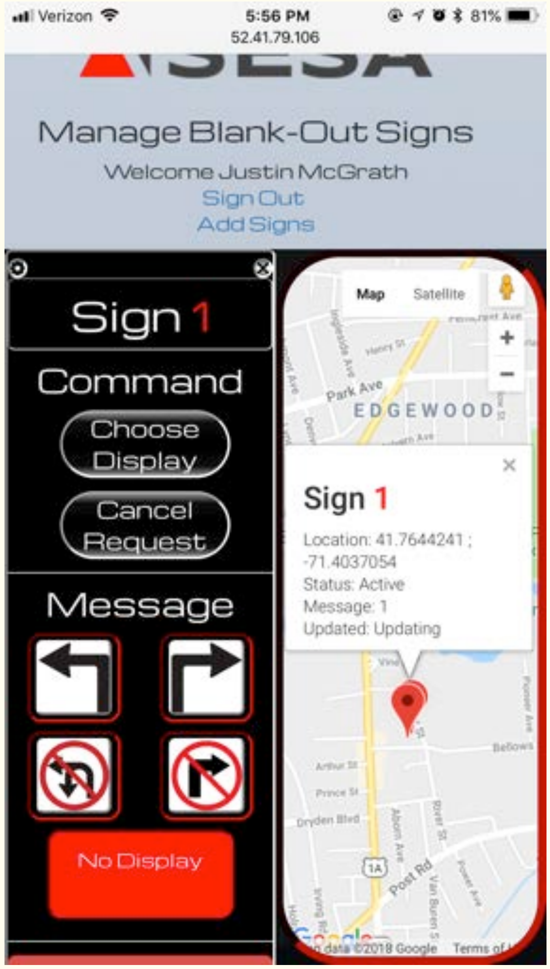

Fig 3: Photo shows user's ability to connect with a sign on their mobile device; allowing them to manipulate their sign on the go.

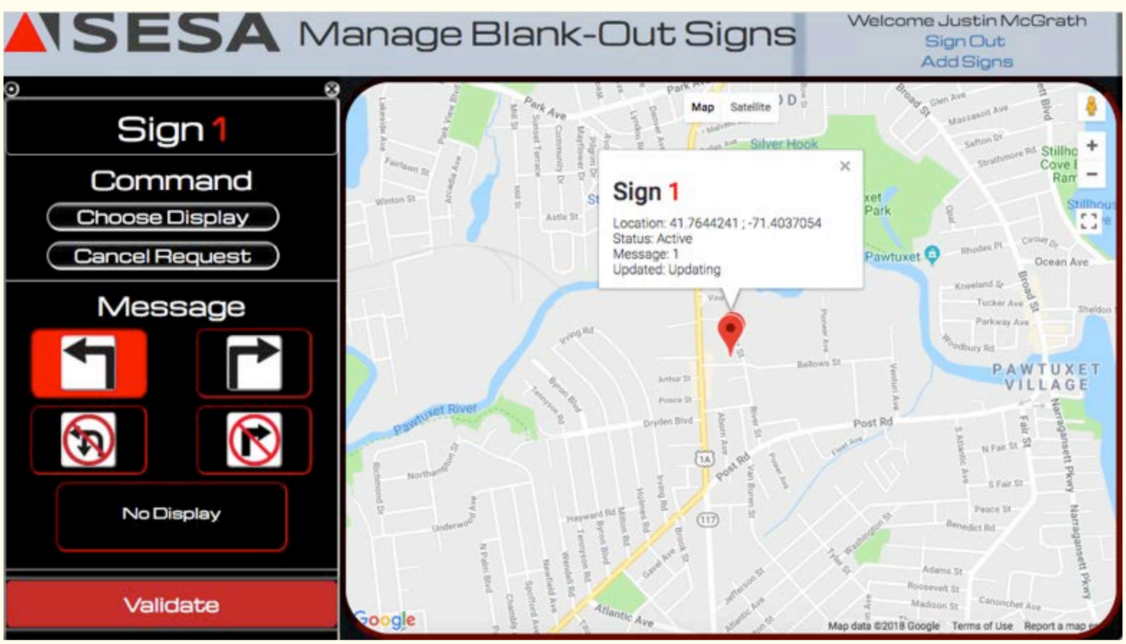

Fig 4: Image displays the user interface of the web application after logging into the web application on a desktop, clicking on a marker, and setting a new message for the sign.

Cellular Pump Control

tacocomfort.com

TECHNICAL DIRECTORS:

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Phillip Manning

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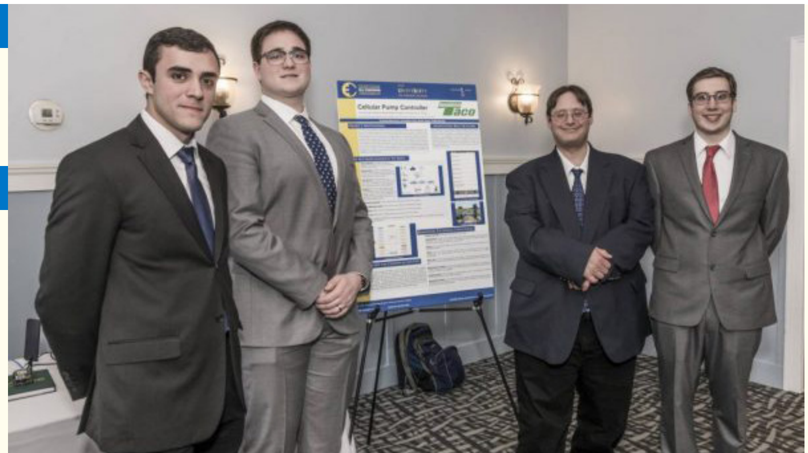
Steven Marques (E)
Gregory Soito (E)



PROJECT MOTIVATION:

The mining and agricultural industries use pumps for irrigation and water removal respectively. Easy access is not always possible since the pumps are often located far from the base of operations. The operators have to either drive out into a field or travel deep into a mine to switch the pumps on and off and sometimes just to check if the pump is operating properly. If a pump was to malfunction then fields could flood destroying a farmer's crops. In the case of mining it is very important that water levels are monitored and controlled since flooded mines can result in loss of life. To better ensure the safety of their employees and to protect their operations, customers want a solution that will allow them to control and monitor their pumps remotely. There is currently no solution on the market that allows wireless long-range communication to an industrial grade water pump. Taco Comfort Solutions, Inc. hopes to be the first to put a product on the market that will satisfy their customer's requests and hopefully their competitor's customers as well.

ANTICIPATED BEST OUTCOME:

We are expecting to have a working prototype of our design soon. Minimally, we hope to have a functional proof of concept for Taco to develop and to produce. Our goal is to exceed our minimal goal. We are aiming to lay the foundation for a marketable product that the company can continue developing and begin selling by summer 2018. A large portion of this project involves the building of infrastructure which lies outside of the scope of this project. We plan to have a final design for this infrastructure. These are the best possible outcomes. Our team has the skills and passion required to complete this daunting task.

IMPLICATIONS FOR COMPANY AND INDUSTRY:

Upon the successful completion of this project, Taco will be the first company to provide an industrial grade internet of things device that is capable of controlling pumps used for agriculture and mining. Taco aims to provide a platform that will provide their clients with detailed information about their pumps. With this system, customers will be notified of any potential problems with their pump. Detecting potential issues and preemptively shipping replacement parts to the owner to eliminate costly down time. This will push the mining industry forward and save time for farmers that would be wasted managing their pumps manually.

PROJECT OUTCOME:

The Anticipated Best Outcome was achieved: remote and wireless long-range communication to monitor and control industrial grade water pumps.

KEY ACCOMPLISHMENTS:

Power Creation of Prototype: We were successful in creating a prototype pump controller which could be powered by 480, 277, 240, 208, or 120 Volts AC which is present with most standard TACO pumps, communicate remotely via Verizon cellular modem through a web app with any pump with a variable frequency drive through our controller.

UL Listed: We sourced exclusively UL listed components. The process to obtain UL Listing is costly and time consuming. By using only previously UL Listed components, we have negated the time and cost in favor of a design that is inherently UL Listed.

FCC Compliant: All of our communications components were prefabricated and meet FCC requirements as designed. By only using components which already meet FCC Guidelines we have created a design that meets FCC requirements without the need to test compliance.

Safety: All major metallic parts are grounded through the attached power cord and plug. There are three individual fuses integrated into the design. One for each voltage level: 120 V AC. 24 Volts AC, and 24 volts DC are each separately protected by a dedicated fuse. This provides safety at each of the voltage levels present within our design.

Mobile Application: The parameters for the mobile application were changed several times, underwent many iterations and were not fully finished. We were successful in creating a prototype which can connect to the controller and has basic functionality.

Communication: We implemented a cellular connection to allow the controller to access the internet from any location where a Verizon signal can be received.

Interface: We created an interface through our mobile app to allow user interaction with the pump controller anywhere their device is connected to the internet.

IP66 Rating: We used a polycarbonate watertight enclosure as well as a watertight cellular antenna. Both of these components give our design an IP66 rating. An IP66 Rating means that our design, in addition to being protected from dust and environmental contaminants, is protected from *“Powerful water jets: Water projected in powerful jets (12.5 mm nozzle) against the enclosure from any direction shall have no harmful effects.”*

Ease of Access: Our “Consumer First” design was created with easy access, installation and maintenance in mind.

Sensors: Our sensor connections are adaptable so that the user can modify it to only the sensors desired. Sensor data is fed from the controller to the user.

App Functionality: Our app provides a *Remote Power Control and Status of the Pump* from the mobile app.

AWS Backend: We used AWS to provide all the backend tools necessary to keep these devices connected.

Bill of Materials: We created a complete bill of materials listing quantity, cost, supplier, and vendor contact information for all of the components which we selected to be used in our project.

Fig 1: The mobile app displaying a sensor reading and button to turn the pump on/off.

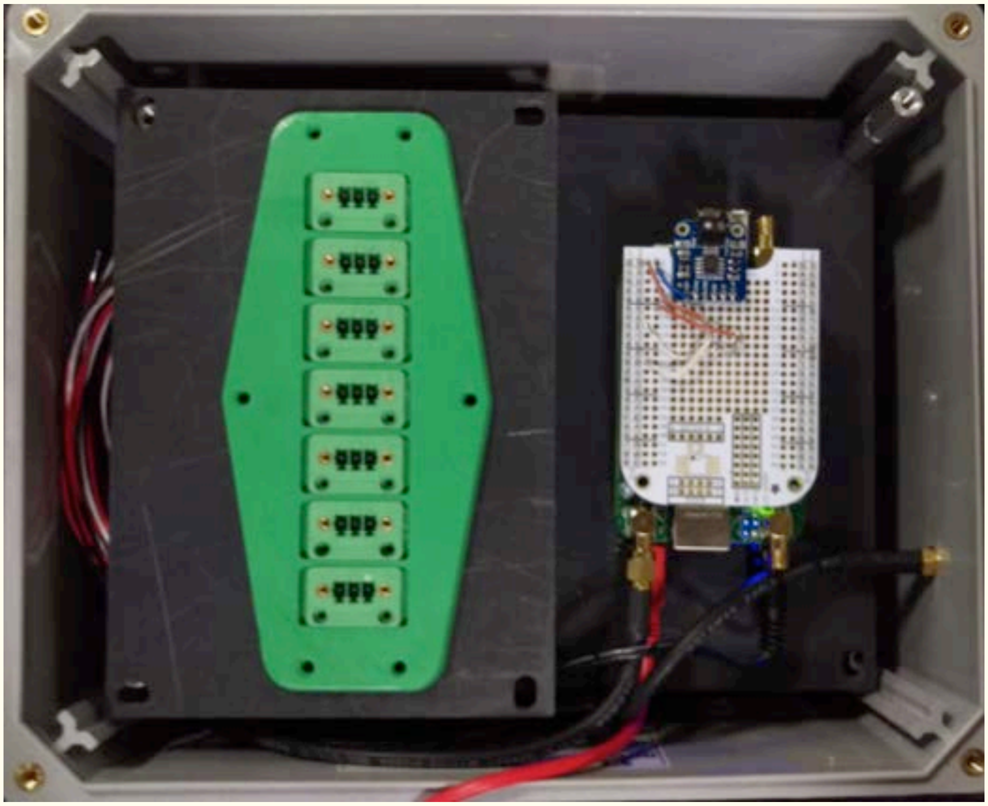


Fig 2: The top level of our enclosure, including microcontroller and terminal blocks for sensors to be mounted.

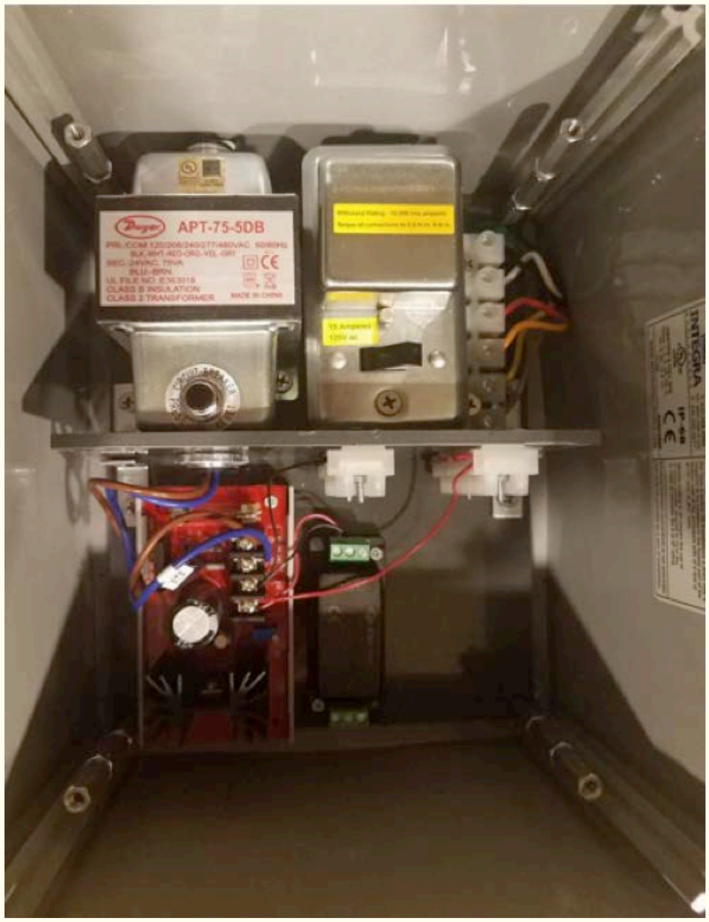


Fig 3: The lower level of our enclosure where the voltage conversion and power supply circuitry is located.

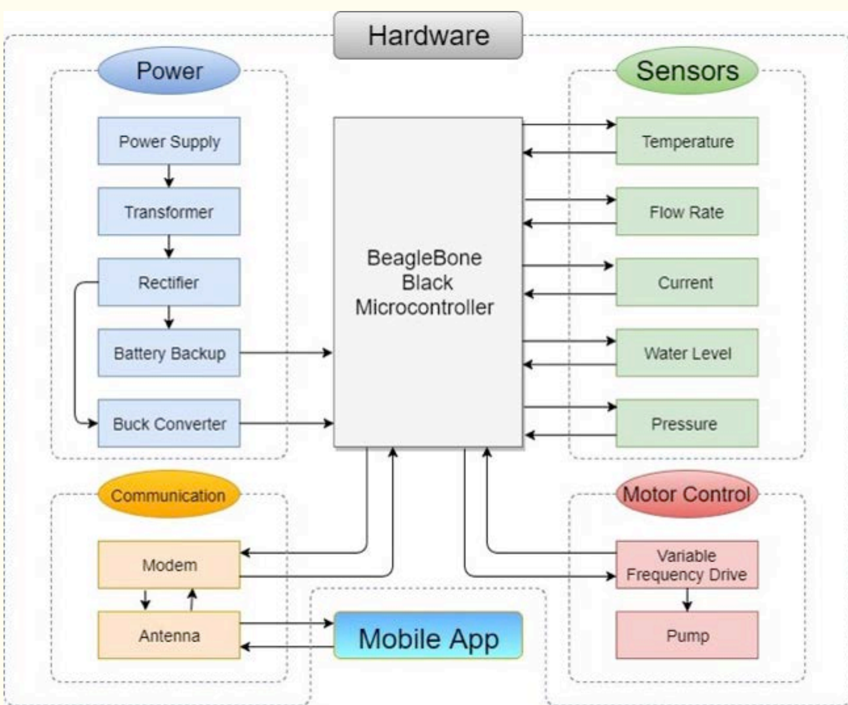
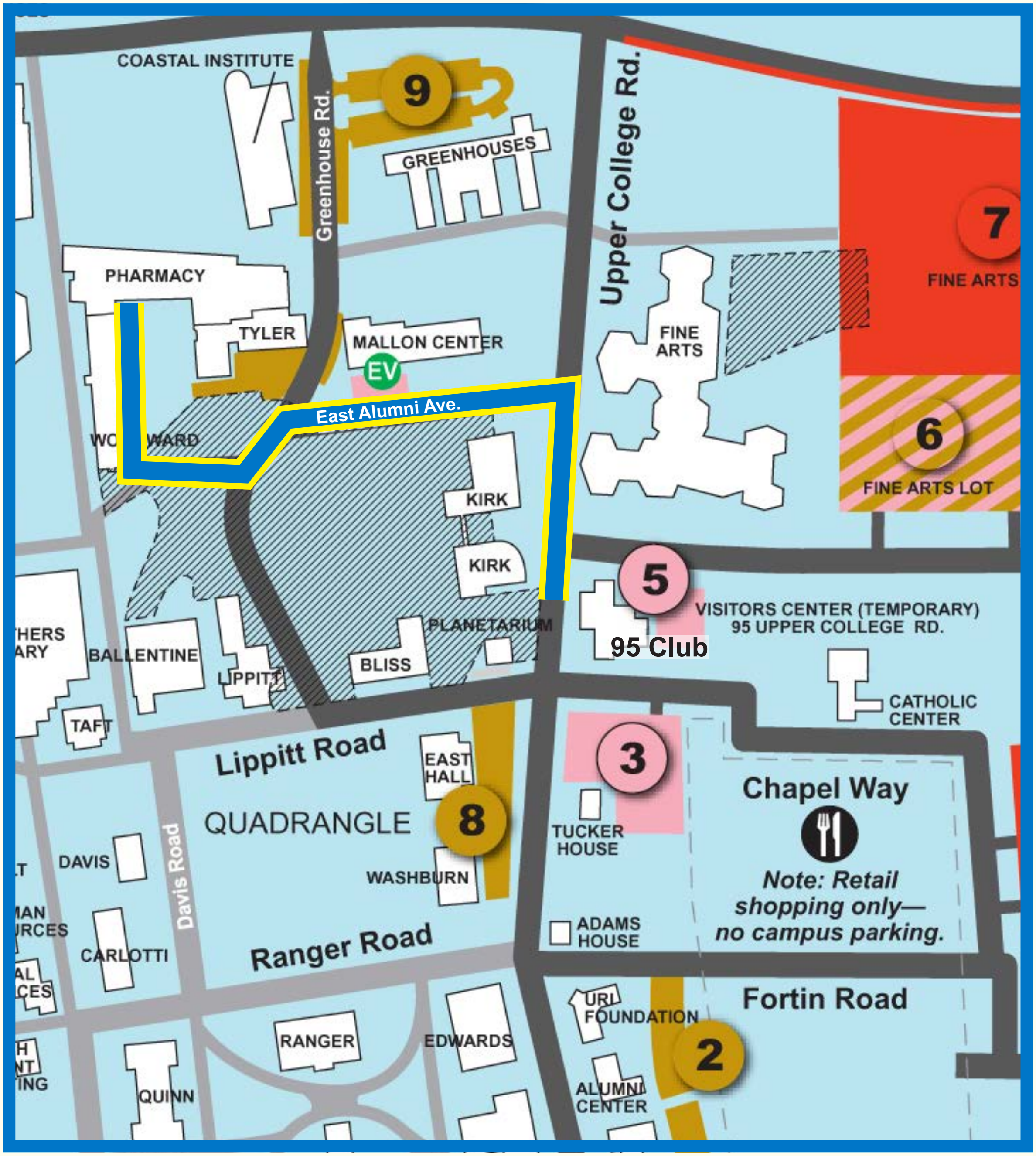


Fig 4: Our block diagram showing how each of the different components are interconnected.

WALKING MAP

Walking directions from the 95 Club to Pharmacy - Ernest Mario Auditorium



Follow the highlighted route to walk from the 95 Club to the Pharmacy Auditorium.

NEW COE BUILDING
ELECOMP CAPSTONE WEBSITE

New College of Engineering Building

EFFORT SUMMARY 2017-2018

18,050
Total of all hours worked. (T)

11
Number of Designers with hours >1.1A

21
Number of Designers in range: 0.9A & 1.1A

340
Average hours worked among 53 ELECOMP Designers (A)

13
Number of Designers in range: 0.9A & 0.8A

8
Number of Designers below 0.8A

15
Average hours/week over 22 weeks

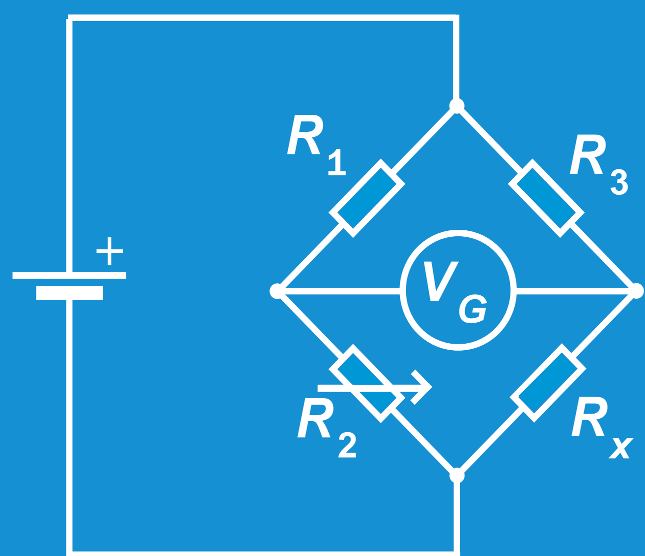
MOST HOURS WORKED

661	Jeremy Peacock - Acumentrics
567	Jonathan Trevlyn - Acumentrics
563	Noah Johnson - Astro Nova
507	Tyler Creighton - Iradion
507	Dominic Ferri - Iradion

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