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FRIDAY, MAY 12, 2017

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Development of AESA™

Acumentrics Easy Simple Network Management Protocol Application

Acumentrics TRUSTED POWER INNOVATIONS®

Team Members: Brenden Smerbeck (CPE), Nicholas Rommel (CPE), Taylor Coogan (CPE), Josiah Shaffer (ELE)

Technical Directors: Peter Upczak, Ersson Zapata

Project Motivation

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

The team was tasked with **developing Acumentrics' first GUI application capable of communicating with, monitoring, and managing RUPS devices.**

Best Outcome

The best outcome is a functional prototype able to:

- Communicate with devices using the SNMPv3 protocol
- Support all UPS-specific commands and controls
- Configure destinations for automatic alerts and notifications
- Display all information in a simple, easy-to-use format
- Replace all functionality of both the command-line interface and third-party software currently used by both staff and clients

Key Accomplishments

Easy Scan

With the majority of RUPS users being in the US military, we wanted to ensure the application functioned with as little assistance as possible. To streamline the configuration process, we developed a tool able to scan the local network and automatically detect Acumentrics devices and reduce the system's learning curve.

SNMPv3

The SNMPv3 protocol is required to securely communicate with SNMP devices. Not only were we able to support SNMPv3, we extended functionality to SNMPv1, v2, and v1c; maximizing compatibility and opening possibilities for further implementation.

Traps

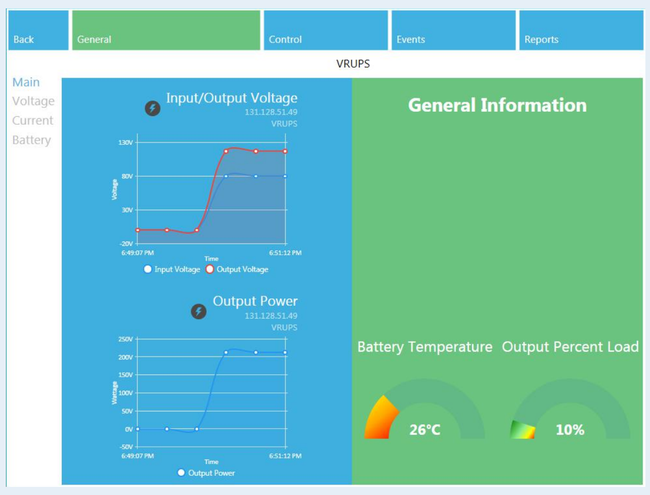
To be a viable product, AESA needed to be able to configure alert destinations for notifications. Expanding on this idea, we also included the ability for the system to act as a receiver for alerts. This further enabled users to not only configure devices, but monitor them.

MVVM

By design the application following Model-View-ViewModel architecture, we ensured that our sponsor's development team could easily expand upon our project and modify it as needed.

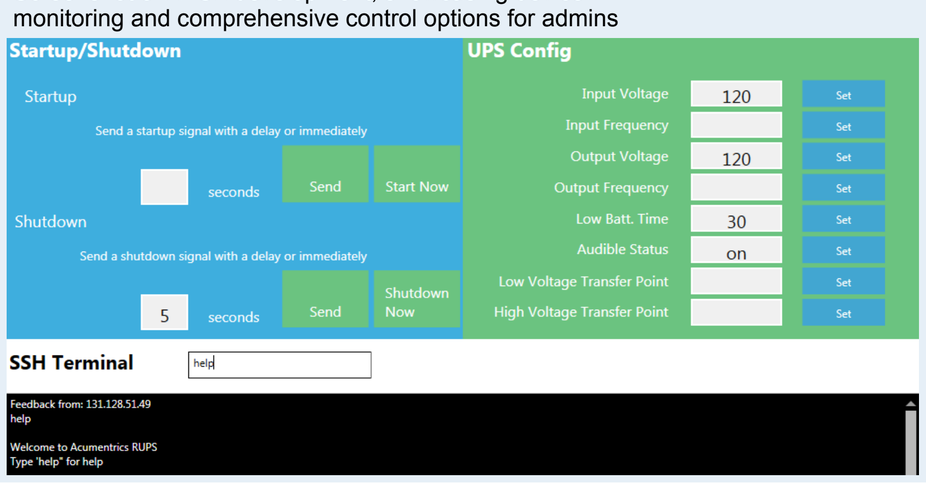
SSH

Much of the RUPS' functionality is found using serial communication as opposed to SNMP. Meeting our expected goals far in advance, we expanded upon AESA to support SSH communication. This will be integral in future development of the application.



The Acumentrics 1U "RUPS"
Rugged Uninterruptible Power Supply

Screenshot of AESA development, showcasing device monitoring and comprehensive control options for admins



Screen of the AESA control window. From this page, users can power their device on and off, set nominal values for various settings of the UPS, and even communicate using SSH.

Future Work

One feature left untouched is the ability to link up to eight RUPS devices. This "N+1" configuration would be an excellent task for future development and would complete the management suite for currently available Acumentrics devices. Additionally, the system could be further improved to allow administrators to configure and update both network configurations and firmware on a group of units at once.

Broader Implications

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

Electrical Components

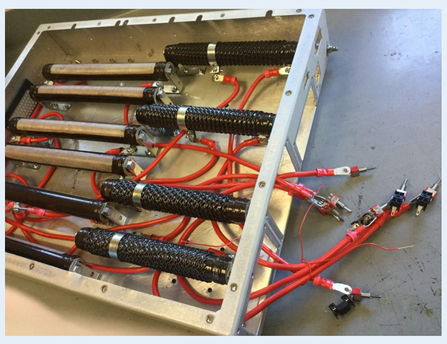
Josiah, our electrical engineer, focused on the creation of components to assist in design, testing, and demonstration of Acumentrics UPS devices both internally and externally.

Resistive Variable Load Bank

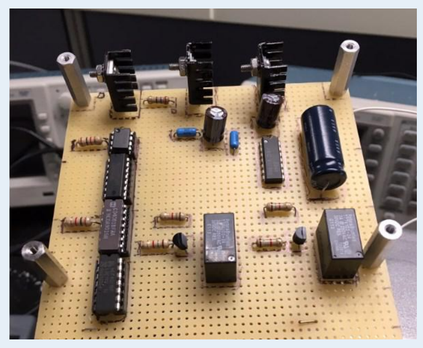
The purpose of this test equipment is to give a user with a RUPS device the ability to hook up and dissipate simultaneous AC and DC power as well as change the amount of dissipated power for both AC and DC. This device can be used as a flexible tool with RUPS devices for presentations, testing, characterization, and functionality testing. This device is different from the standard resistive load banks available because the power dissipation can be easily changed and it can handle simultaneous AC and DC power dissipation within its single container.

Automatic Battery Disconnect

When a lithium ion battery is discharging, the battery voltage slowly decreases to a critical point after which the voltage rapidly falls over only a few seconds and permanently damages the battery. The ABD will catch the battery just before the critical voltage point and prevent the battery from harm. In addition, a voltage to time integrator is added to the circuit that will tell the user how long the battery was discharging before reaching the critical point. This will allow the user to concentrate on other tasks without worrying about battery safety.



Resistive Variable Load Bank



Automatic Battery Disconnect

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Three Phase Motor Controller

Redesigned PCB Board with Additional Firmware and Software Features

BCA Bay Computer Associates

Team Members: Denise J Andreozzi (CPE), Devin Pacheco (CPE), Anibal Perez (CPE)

Technical Director: Dr. David Durfee

Project Motivation

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

Best Outcome

- Increase efficiency and reduce the cost and footprint of the circuit board.
- Eventually have the motor controller drive 80 Amperes of current to the motor.
- Implementation of a position control with an extrapolation method to reduce the oscillation.
- Implementation of an automatic tuning feature.

Key Accomplishments

Electronics

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

Data Dumping

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

Lagrange Function

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

Position Control

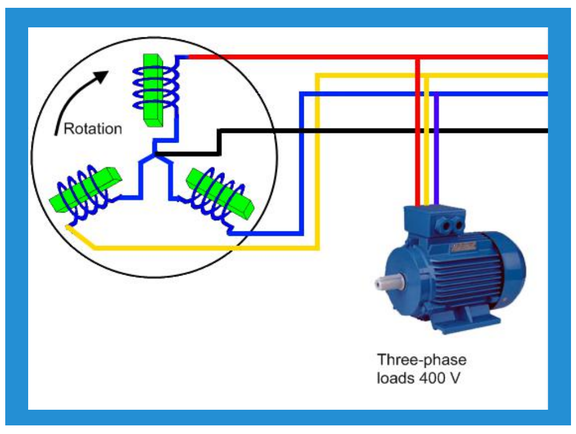
This position control implementation will get the motor from one point to another with ease. Our function uses the Lagrange polynomial which reduces the oscillation of our position curve.

Real Time Streaming

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

Tuning Options

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



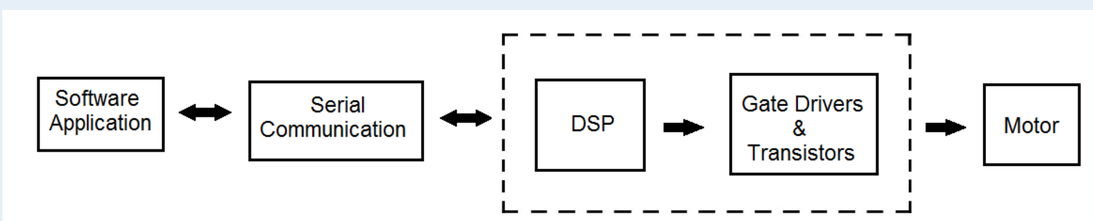
Three Phases

Current Design

Future Work

- **Electronics:** Redesign the overcurrent and overvoltage protection circuits and add additional MOSFET's to output stage.
- **Firmware:** Look into meters, feet or other measurements for the position control, and
- **Software:** Implement the auto-tuning feature for both the velocity and the current feedback loop.

Block Diagram & Applications



Broader Implications

An efficient Three Phase Motor Controller that implements a position control feature in firmware and an auto-tuning feature in software offers an Engineering firm many options for various applications. While the device can easily supply power to a vehicle, a position control feature would allow the device to be integrated into applications that require precise and accurate movement, such as an X-Ray Machine. An auto-tuning feature would also allow the device to easily sync with any motor during integration.

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ARM Based SD to FPGA Data Transfer Optimization

BoldCircuits

Team Members: Jordan Volpe (CPE), Virginia Cebollada (CPE/ELE), Ackara Or (ELE)

Technical Director: Mike Smith '01

Project Motivation

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

Best Outcome

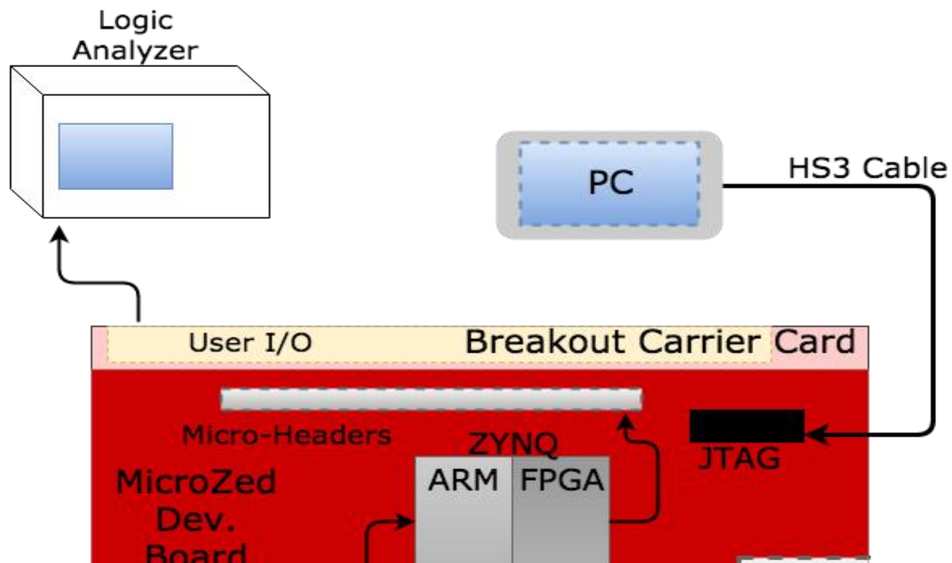
- Working prototype designed, built, and functioning for proof of concept purposes
- Transferring data from a SD card through an FPGA fabric, via an ARM processor
- Achieve a sustained rate, not a peak rate, during normal operating conditions

Key Accomplishments

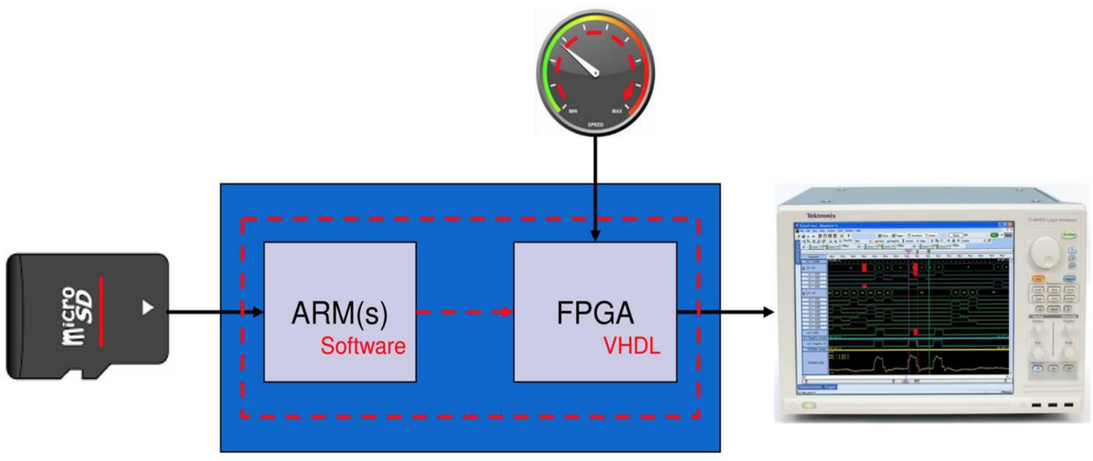
Hardware Selection: The MicroZed System on Chip (SoC) and Cypress FX3S were selected for the ARM and FPGA fabrics. The MicroZed SoC was used for the integrated structure design, while the separated structure used the FX3S ARM in conjunction with the MicroZed FPGA. Additionally, different carrier cards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

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

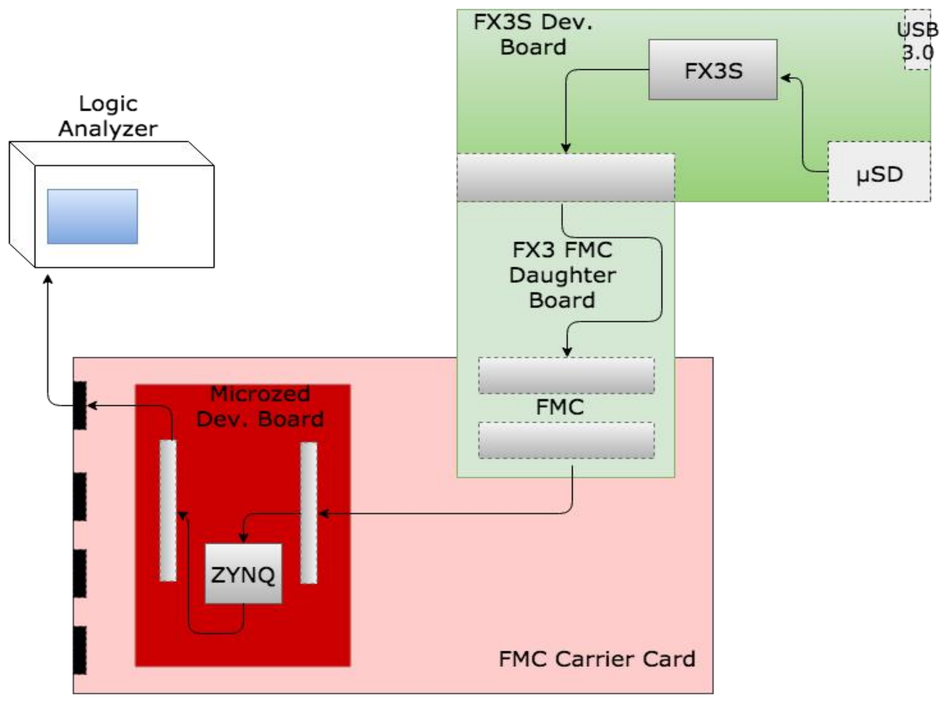
Total End-to-End Data Transfer: For the integrated structure, a C program was used by the PS to extract data from an inserted microSD card to be stored in an internal buffer. The data was then written from the buffer across the AXI interface to the PL, which then transferred the data in parallel fashion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



Integrated Structure



High Level Block Diagram



Separated Structure

Future Work

In the integrated structure, further work would consist of optimizing the established data transfer interface, and exploring the implementation of other data transfer interfaces. Similarly for the separated structure, work will consist of optimizing the data transfer rate. Once the FPGA on the MicroZed board is configured as a Stream Out device and on the FX3 device, different interfaces should be examined and combined. The purpose of combining is to create software to transfer the data from the micro-SD card to the GPIF Slave FIFO.

Broader Implications

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

Further Discussion

In our project, there are two different design approaches for this problem: an integrated structure and a separated structure. The integrated structure will use an ARM processor and an FPGA System on Chip (SoC) to transfer the data from an SD card. The separated structure will use an ARM processor to pull data from an SD card and use a generic interface to send the data to an FPGA fabric for further processing. Software was written for the ARM processor data extraction, FPGA interfacing, and to output the processed data. Finally, end-to-end testing from the SD card to a logic analyzer connected to the FPGA was performed to ensure read data is being transferred correctly and to verify the transfer rate.

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Smart Water Valve Actuator

HAYWARD®

Smart Actuator with Flow and Angle Position Sensing

Team Members: Sean Deely (ELE), Danielle Gonsalves (CPE), Peter Jenkel (ELE), Evan Lachance (ELE), Jimmy Nguyen (CPE), Joseph Tudino (ELE)

Technical Director: James Murdock '84

Project Motivation

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

Best Outcome

- Water flow sensing and a control loop in a valve actuator
- Method is developed to sense valve shaft angle
- An infinitely variable actuator is demonstrated
- 12 V DC motor and drive is demonstrated and can replace 24 V AC actuator motors
- A commercially viable design
- The prototype is in final form with a PCBA developed in the right shape using components Hayward would take to market

Key Accomplishments

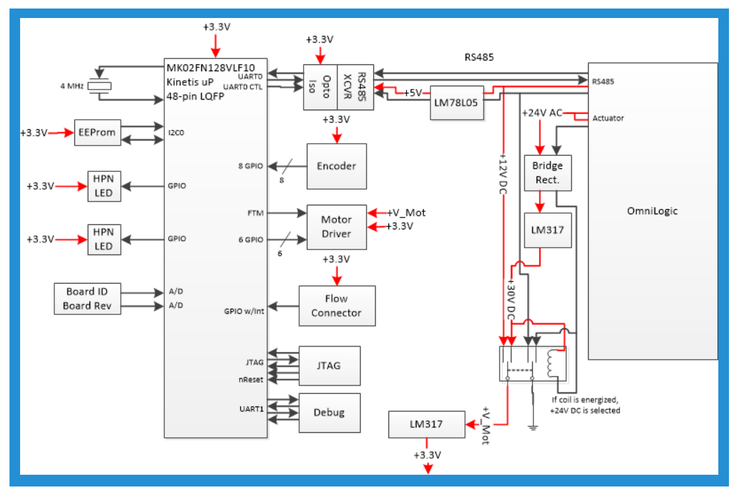
Schematic Design: Created a power management circuit integrating an automatic relay switching of two distinct power supplies. Created control circuits in Pulsonix implementing the Kinetis K02 Processor microcontroller, a motor control chip, and a one-hundred-and-twenty-eight absolute position Bourne's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

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

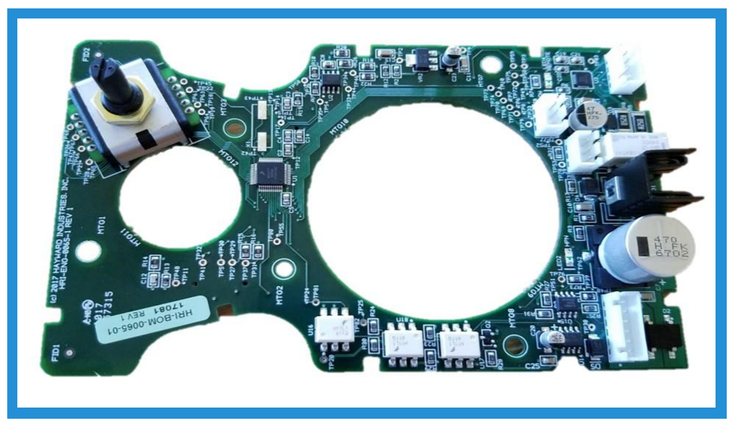
Migration from FRDM K22f to K02 Processor: Initially developed and tested firmware/software using the Kinetis FRDM-K22F development board. To fit the constraints of the prototype layout and the actuator housing, migration to the Kinetis K02 processor was necessary. The benefits of the K02 include but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

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

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



Block Diagram



Printed Circuit Board (Alpha Design)

Future Work

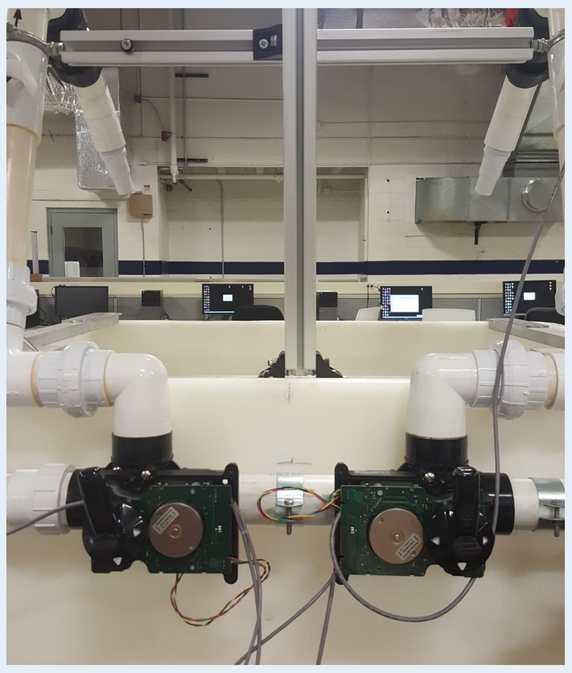
Future work that would build on top of our prototype and work towards the end goal of a working product that is liable on the market would include API development and eventually full integration with Hayward's OmniLogic application. This is allow a consumer to be able to control their water feature in a mobile and user friendly environment. This removes the hassle of any manual adjustments after the initial setup of the actuator in a pool system. Of course, alongside API development and connecting with OmniLogic, more testing should also be done with the actuator on a test tank.

Broader Implications

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

Experimental Results

Test Tank



The test bed design for our demo reused an older tank that is accessible onsite at Hayward. We restored this tank with an engineering tech at Hayward to make sure there are no leaks and to add two test jets inside the tank. A variable speed pool pump allowed various flow rates to be tested, and the two valves allowed interactions to be tested.

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Workflow Optimization for Industrial Software Applications

HEXAGON MANUFACTURING INTELLIGENCE

Team Members: Paul Bally (CPE), Jun Yu Lu (CPE) and Javier Restrepo (CPE)

Technical Director: Jonathan O'Hare '94, Program Manager

Project Motivation

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

Best Outcome

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

Key Accomplishments

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

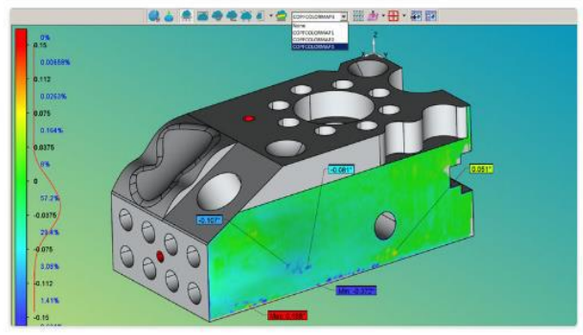
Creating XML Files: Created XML files for each of our individual portions of this project gave us a database to store information that our programs would use. Stored data in XML files allowed dynamic interaction between the files and our programs, as we could add information to the XML file and that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

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

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

Modular Design: Separated the PC-DMIS GUI that we created so it could be used together or separate from the main version of PC-DMIS.

Coordinate Measuring Machine(CMM)



Part in PC-DMIS being checked for Tolerance.

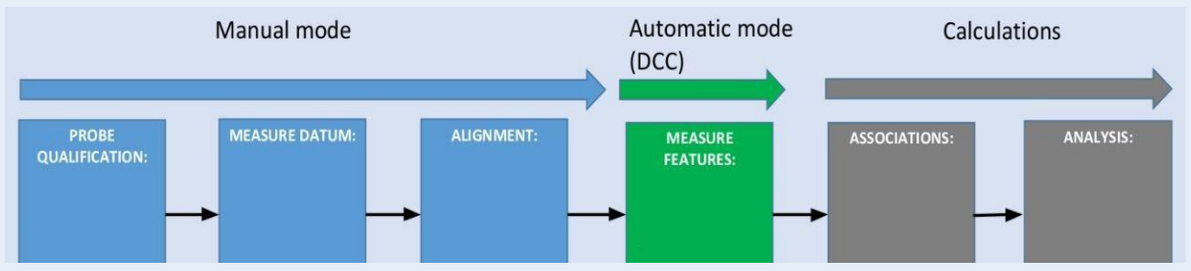
Future Work

Analyze more processes in PC-DMIS that could be redesigned so that there workflows would be more efficient such as the report mode. Then add those new processes to the current redesign and keep on building this program piece by piece. A good place to start would be implementing the menu icons so that they function properly. The status bar and the menu may also be improved by transforming it from a static implementation to a dynamic implementation.

Broader Implications

PC-DMIS is a program with many features that not every user will need. To make PC-DMIS more flexible among a variety of users, we think it is possible to have different versions of the program. Much like many other software's today, some versions have more features while some have just the basic features. A basic version of PC-DMIS would be more cost effective while there would be a more expensive version for users who wanted the additional features offered in PC-DMIS. This creates a more modular design that allows flexibility in both a technical and business perspective since every customer will only receive the features that they require.

Block Diagram



Probe Qualification: Determine the probe setup. These are the tooltips required to measure the part.

Measure Datum: measure features on part necessary for alignment.

Alignment: align part with the nominal part reference system based on the measured reference features.

Measure Features: Measure all other features in DCC mode. This is the automatic measure path for the machine.

Associations: Create relationships between measures geometry features

Analysis: Geometric dimensioning and tolerancing

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Team Jackpot

Approaching Customer Sensing System

Team Members: Thomas Hamilton (ELE), Ethan McClure (ELE), Omose Ogala (CPE)

Technical Directors: Bruce Parkes

Project Motivation

International Game Technology is one of the world's largest lottery and gaming companies, operating in over 100 countries. IGT provides government-sponsored and commercial gaming across the spectrum of retail, web and mobile. In wishing to advance the technology of their lottery ticket terminals, by advertising to a broader customer group and giving their players a better buying experience, IGT plans to include motion detectors that cause the screens to change. The addition of proximity sensors will make the purchasing experience a more interactive and memorable experience for customers. Adding more utility for customers as well as IGT. This project will help IGT remain progressive and lead the industry with the latest and greatest advertising technology.

Best Outcome

We hoped to achieve best outcomes in three main areas. First, having a characterized and calibrated board in which we can have our board properly programed with our sensor processing data software. Second, sensing whether a person is moving within the proximity sensor's view using our sensing algorithm. Third, receiving data from our controller in which we can then send to the Linux computer for software purposes. Essentially, the project focused on researching if this sensor was a good fit for IGT's gaming terminals. We were aiming to create a proof-of-concept design that demonstrated our insight into the technology.

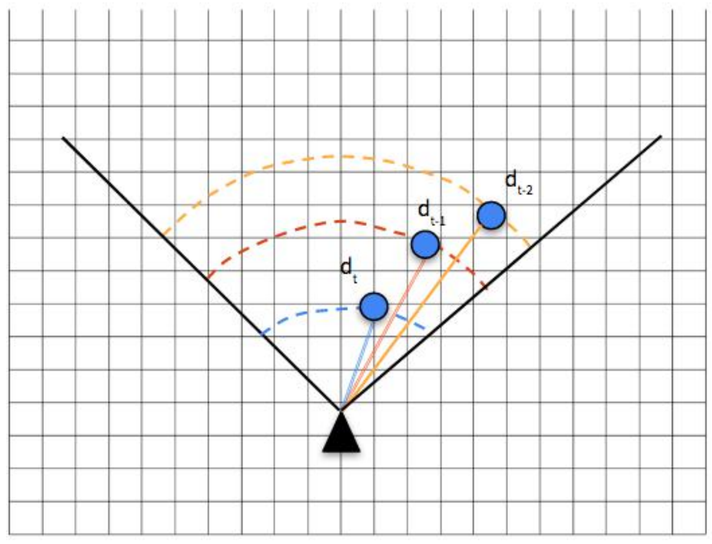
Key Accomplishments

Sensor Schematic and Bill of Materials: Initially our goal was to design a working prototype which incorporate the Time-of-Flight and the embedded microprocessor on one dedicated circuit board. After testing a evaluation module designed by TI we designed a schematic and bill of materials to produce our own sensor board. However due to the fact that the sensor is still under development, we determined it would be best to wait to produce our sensor board until all developments have been finalized by TI.

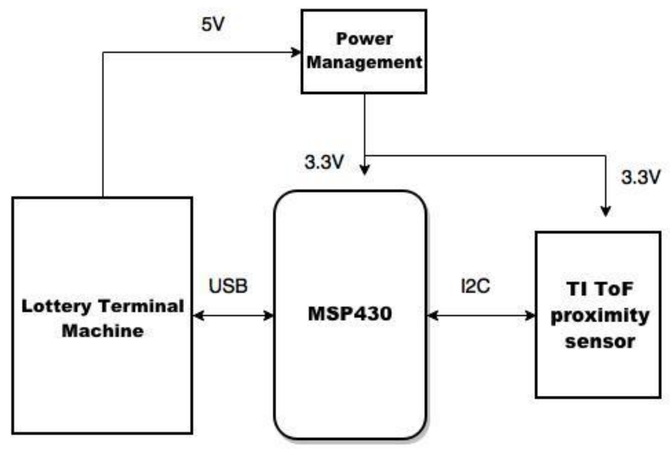
Sensor Characterization: After scope of our project was changed from product development to research, much of our time was dedicated to determining the characteristics and limitations of the Time-of-Flight sensor. Through our testing and concurrent meetings with TI we were able to characterize the sensor data. Sensor features such as; accuracy of data, field of view of sensor optics and the effect that ambient lighting and temperature has on the sensor was observed. Through these realizations we were able to determine this Time-of-flight sensor is suitable for this sensing application.

Sensing Algorithm: Not only is the Time-of-Flight sensor capable of determining distance, it can also report back a value known as amplitude, which is used to help verify the distance data. The sensing algorithm that was designed takes advantage of both the distance and amplitude data. These values are used to calculate velocity as well as a parameter known as kai, which compares the predicted amplitude based on distance to the measured amplitude. We used these calculated values and a basic digital control system to design our customer approaching system.

Application Programming Interface and Terminal Application: After enabling the microprocessor to perform as a USB device, an application programing interface(API) was developed to work with the lottery terminal. This API was configured to transfer specific sensor information between the hardware and software. Next a terminal application was written C# to control the API. This application is capable of controlling the sensor calibration, reading and writing to the sensor and plotting live data points for visual analysis.



Proximity Sensing in the Field of View



High-level block diagram

Obstacles Overcome

The heart of this program is an Optical Time of Flight solution from Texas Instruments that offers high performance under varied lighting condition and over longer distances. The device is not yet publicly available and we had early access to NDA material. Due to the timing of our project certain features could not be fully integrated in our demonstration

Future Work

Among our many accomplishments, perhaps the most important is providing IGT with the knowledge that we have obtained about time of flight technology, software APIs and sensing algorithms. With this information, future URI students or IGT personnel can build on our findings by designing an automated sensor calibration procedure designed for the final silicon, creating a more robust multi-sensor system and implementing a more advanced API structure. Additionally, in the future the schematic should be revamped to compensate for changes to the final commercial silicon.

Broader Implications

Through our research we have demonstrated that the proximity sensor has the capability to accurately sense approaching customers and send that information to a Linux computer. The technology behind this proximity sensing, long-range Time-of Flight that compensates for ambient light, is at the forefront of proximity sensing technology. Going forward IGT could implement this type of sensing system in other lottery terminals. For instance, terminals could display different messages when possible customers are nearer or farther away, or the terminals could make different inviting noises to attract customers. Furthermore, in the future IGT could add additional sensors to their terminals that continuously gather information. Currently we are living in the age of Big Data – by adding more sensing capabilities to their terminals IGT will be better equipped to understand and serve customers.

Customer Approaching a Terminal

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IGT Project Windfall

Dual Mode USB Bluetooth Controller

Team Members: Sundaram Patel (CPE), Kevin Mathews (ELE), Kyle Carvalho (ELE)

Technical Director(s): Raymond Leland '93, Technology Manager II

Project Motivation

IGT's lottery contracts often span 5-10 years, with extensions sometimes putting them at 15 years. Lengthy contracts mean that there are IGT point of service lottery terminals in US sports bars and grocery stores currently operating with legacy hardware & software. The onboard Linux kernel in legacy IGT Altura terminals specifically, cannot support modern Bluetooth connectivity for smartphones, wireless barcode scanners, or wireless ticket printers. **Project Windfall's motivation is to develop a way to extend the lifespan of in-field Altura legacy terminals.**

Best Outcome

Our team's goal is to create a USB Bluetooth dongle with a full internal Bluetooth software stack. This dongle would be designed to attach to an IGT legacy Altura terminal, circumventing the older Linux kernel which is unable to support Bluetooth natively. The best outcome for this project would be to develop a full PCB manufacturing package, a full Bluetooth software support package, and an API for the host side operations. Typical venues include large areas like bowling alleys, sports bars, and grocery stores, so a 100m transmission range is desired for the Bluetooth signal.

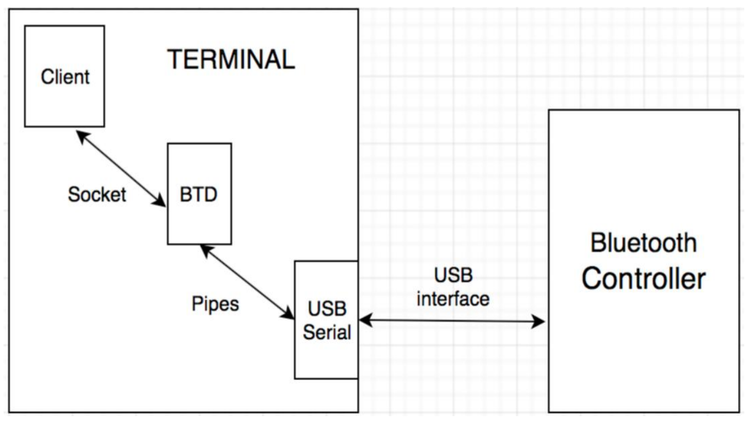
Key Accomplishments

Board Manufacturing Package:
Full copies of the PCB schematic and layout now exist in IGT's system along with a full bill of materials with IGT part numbers and prices. The board has been designed to satisfy IPC manufacturing standards for RF. The board also includes headers to support proximity sensing applications. The estimated selling price is $30.

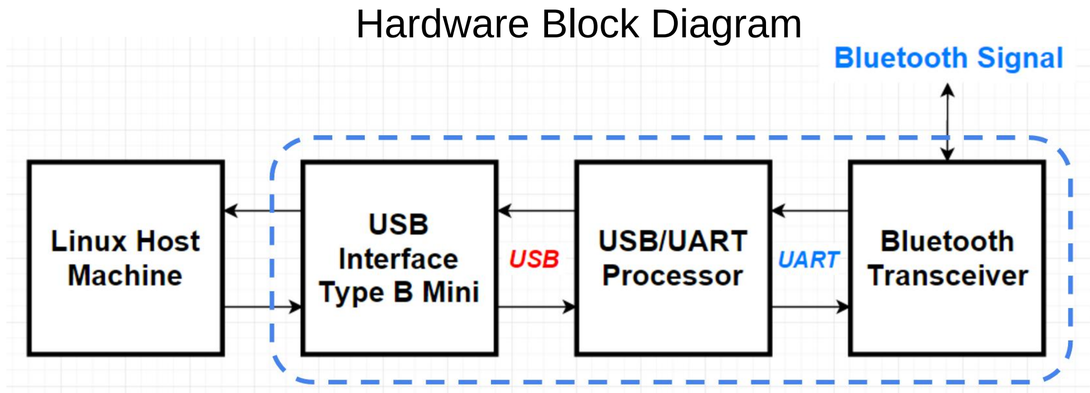
Board Support Package Framework:
The source code framework for the for the dongle has been laid out. This framework implements the software commands needed for the USB side as well as the Bluetooth Low Energy side. This package can be modified by IGT's software team to function with specific models of Altura lottery terminals. Current supported Bluetooth profiles are GATT and GAP, used for smartphone connection.

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

Software Block Diagram



Hardware Block Diagram



Future Work

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

Bluetooth Classic
Profiles: SPP / HID
Use Case: POS Hardware

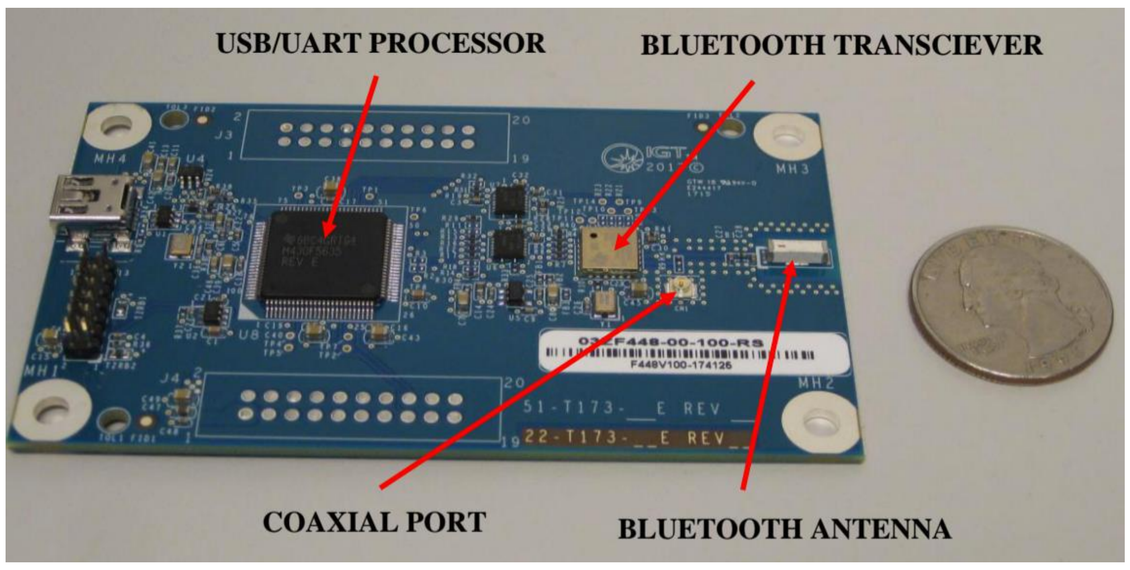
Bluetooth Low Energy
Profiles: GATT / GAP
Use Case: Personal Mobile Devices

USB Serial
Use Case: Wired Connection to IGT Terminals

Broader Implications

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

Prototype PCB



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Dual Knife Rotary Sheeter

maxson automatic machinery company

Team Members: Timothy Gennari (CPE), Michael Reinhart (ELE)

Technical Directors: Joseph Matthews '80, Michael Terranova

Project Motivation

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

Best Outcome

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

Key Accomplishments

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

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

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

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

Maxson's Dual Knife Rotary Sheeter

Bosch Rexroth Industrial PC

Future Work

Going forward Maxson might have their next capstone project use a team of computer and electrical engineers to pilot an IPC solution for the sheeter design. Bosch Rexroth currently has a MLD and an MLC solution developed, it would be wise to develop a third option to see if there is any potential reward.

Broader Implications

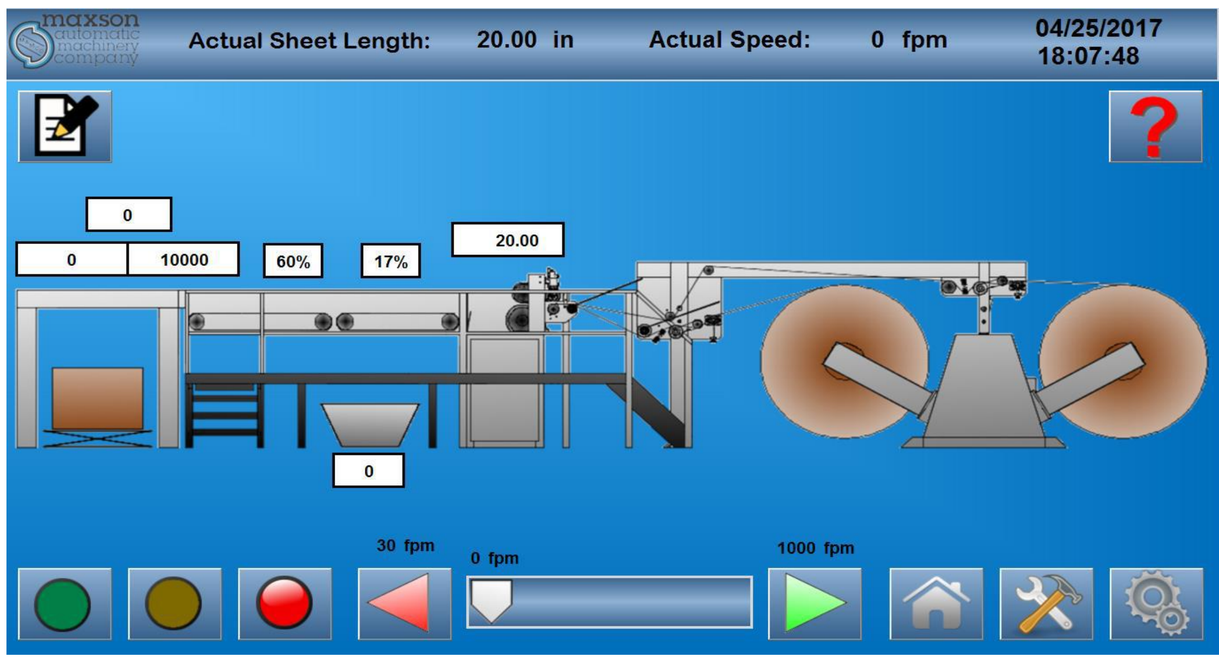
This project focused on the dual knife rotary sheeter, but the user interface can be expanded past that. While designing the new screens, we kept in mind the option of using them for various other HMIs. The screens are spacious and the buttons are large. This allows them to be more easily used on a smaller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

The old mono-chromatic, pushbutton HMI would give the sheeter an archaic feel due to the technology we have today. By using a large, colored, touchscreen HMI, potential customers may get a good initial impression towards the quality and modern-ness of the sheeter.

Further Discussion

HMI Background: The background colors and buttons were changed from mono-colored to gradients to provide a more modern look. A colored and edited CAD drawing of the sheeter is now the main image and retains the same functionality as before. The error status bar was removed.

HMI Error Messages: Errors are now constantly checked by a script on each page. When the status changes, a popup will appear displaying the error and offering retry and cancel options. Retry will clear the message if the status is cleared or stay if it isn't. Cancel will let you close the dialog box, but not start until it is solved.



Human Machine Interface Home Screen

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Distributed Generation

Direct Transfer Trip (DTT)

nationalgrid

Team Members: Miguel Angel Vega (ELE), Omar Perez (ELE), Eder Borgas (ELE)

Technical Director(s): Erica Russell Salk, Luis Rodriguez

Project Motivation

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

Best Outcome

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

Key Accomplishments

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

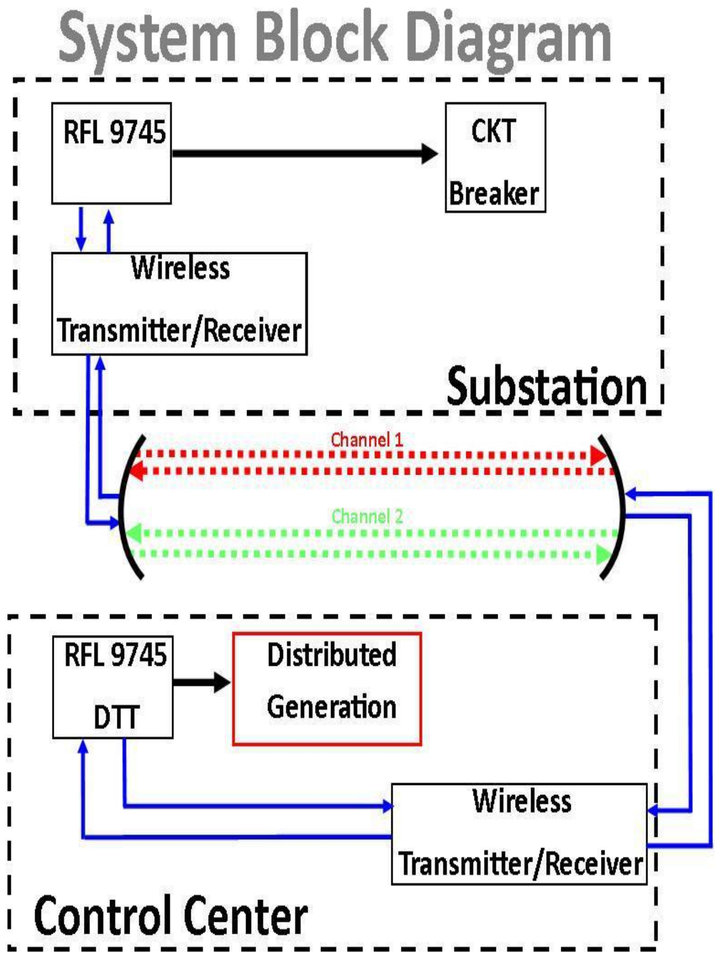
Product selection and Financial Projections – The microwave unit selected was the ExploreAir by Exalt. The protection unit selected was the SEL-2506 by Schweitzer Engineering Laboratories (SEL). Equipment total cost estimate is $ 17,633.12.

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

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

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

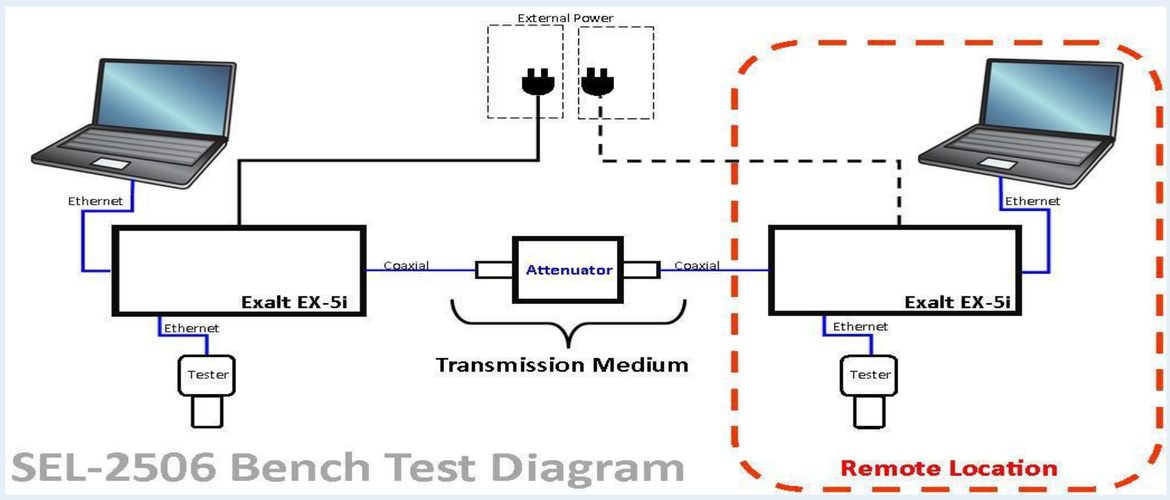
Small Scale Model – This model will simulate the entire DTT system functioning by using Arduinos, relays, and IR sensors.



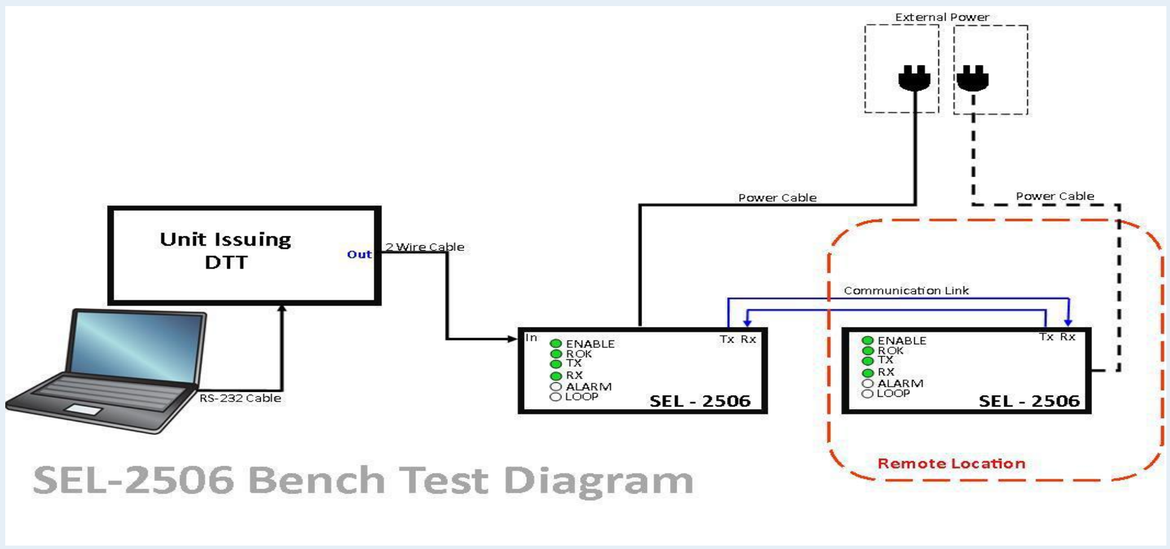
Future Work

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

Laboratory Results



SEL-2506 Bench Test Diagram



SEL-2506 Bench Test Diagram

Broader Implications

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

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Fiber Optic Design High Voltage Equipment Control System Interface

Team Members: Edgar Braley(ELE), Basim Anabtawi (ELE), Michael O'Hara (ELE)

Technical Directors: Sandro Silva '02, Michael Guerra '02

Project Motivation

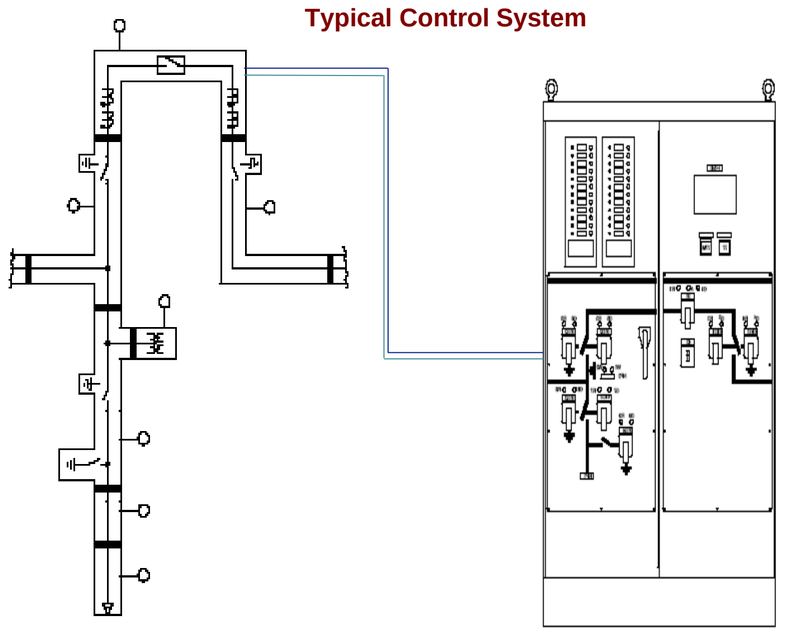
Conducted electromagnetic interference is caused by the physical contact of the conductors as opposed to radiated EMI, which is caused by induction (without physical contact of the conductors). This persists in all conductors and mutual inductance between two radiated electromagnetic fields will result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

Typical Gas Insulated Substation

Best Outcome

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

Typical Control System



High Voltage Equipment Gas Insulated Switchgear (GIS)

Local Control Cabinet (LCC)

Key Accomplishments

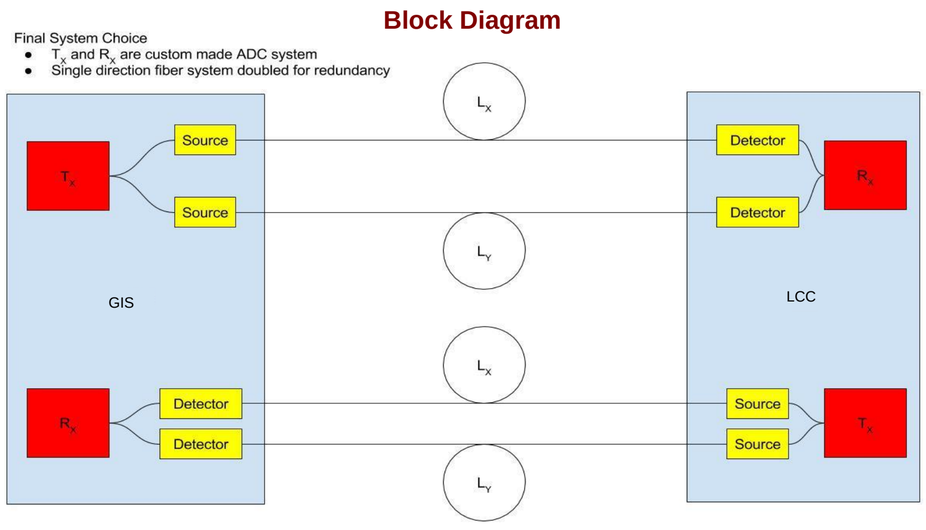
Parallel to Serial Circuit: First, we were able to take the incoming parallel signals and transform them into a serial signal. This was done with a tri-state buffer and shift register. The final word is created by the shift register and is then sent to the fiber optic transceiver to be turned into an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

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

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

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

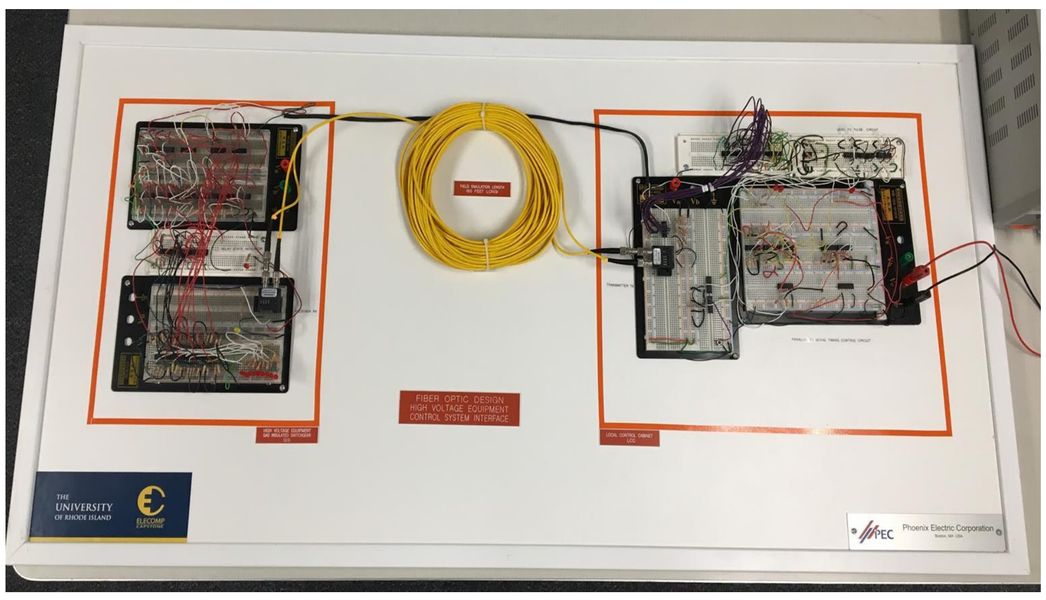
Block Diagram



Broader Implications

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

Completed Design



Further Study

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

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SARNET

Search and Rescue Network

Team Members: Teresa Blanco (ELE), Camilo Giraldo (ELE), John Navilliat (CPE), Dan Goff (ELE)

Consulting Technical Director: Mike Smith '01

Project Motivation

This project represents our future work as Engineers. We will have to be able to detect the needs of the consumer, or to localize where there exists a lack of technology development and transform them into Engineering Projects. By the end of these projects, we will notice remarkable improvement in society, since our project will offer essential products to the consumers.

Best Outcome

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

Key Accomplishments

GPS Module

Using a GPS module actively processed by the GPSD python application, it is possible to capture not only standard information like latitude and longitude, but also other useful information such as heading and speed.

Web Server

The ideal implementation of the project is platform independent. To allow universal compatibility, the drones report back to a fully-functional web server with PHP capability.

Thermal Image Processing

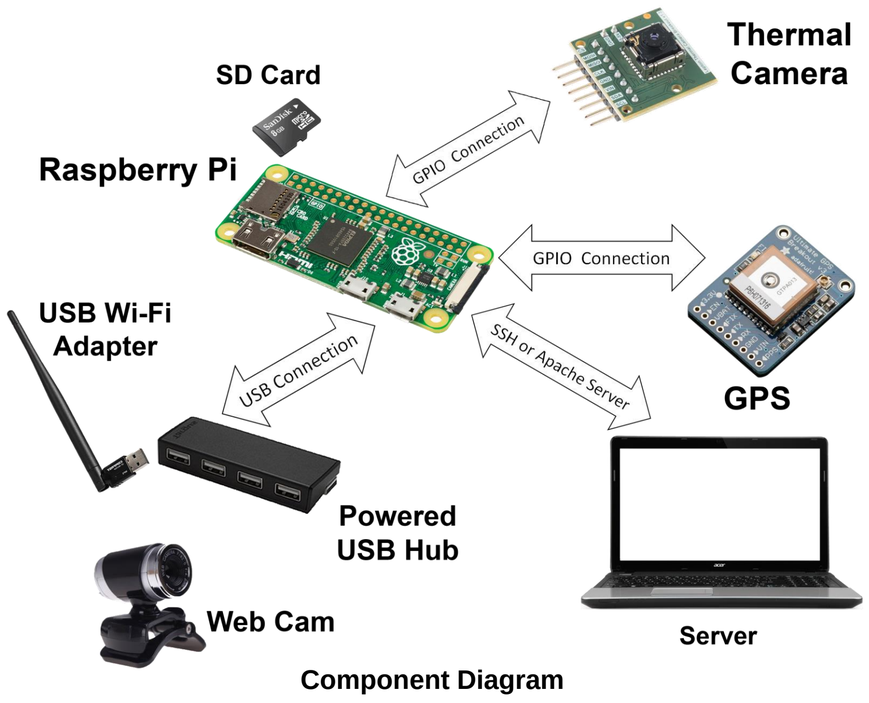
Using a thermal camera visible from a private wireless network, images are taken and transmitted to the server. The server then uses an image processing application to analyze each image for positive thermal hits. This application is fed a variable that sets the range of thermally hot pixel clusters. Any thermal hit that falls outside of this range are considered a false positive.

WiFi

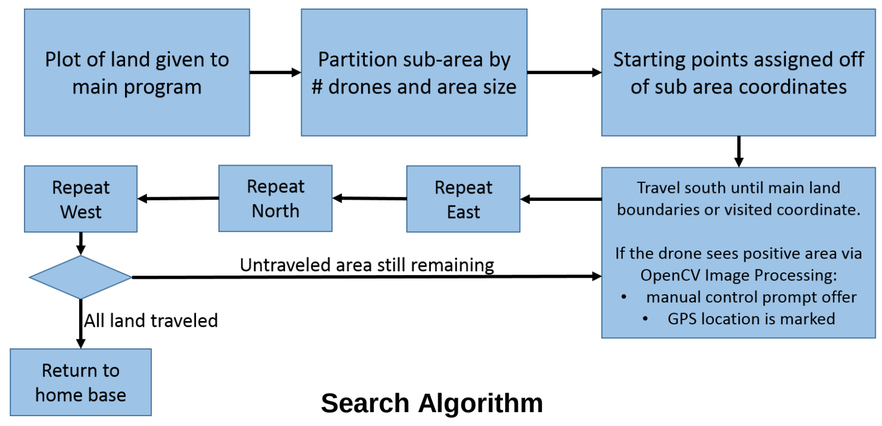
With the intention of this project to expand beyond single-device implementation, a scale-ready wireless communication network between drones and the server is necessary.

Graphical User Interface

Information gathered is presented in four quadrants: a live video-feed, a thermal video-feed, an information console that displays GPS data and alerts the user to a positive thermal hit, and a configurable map window that lets the user set the initial search area and tracks the drones flight in real time.



Component Diagram

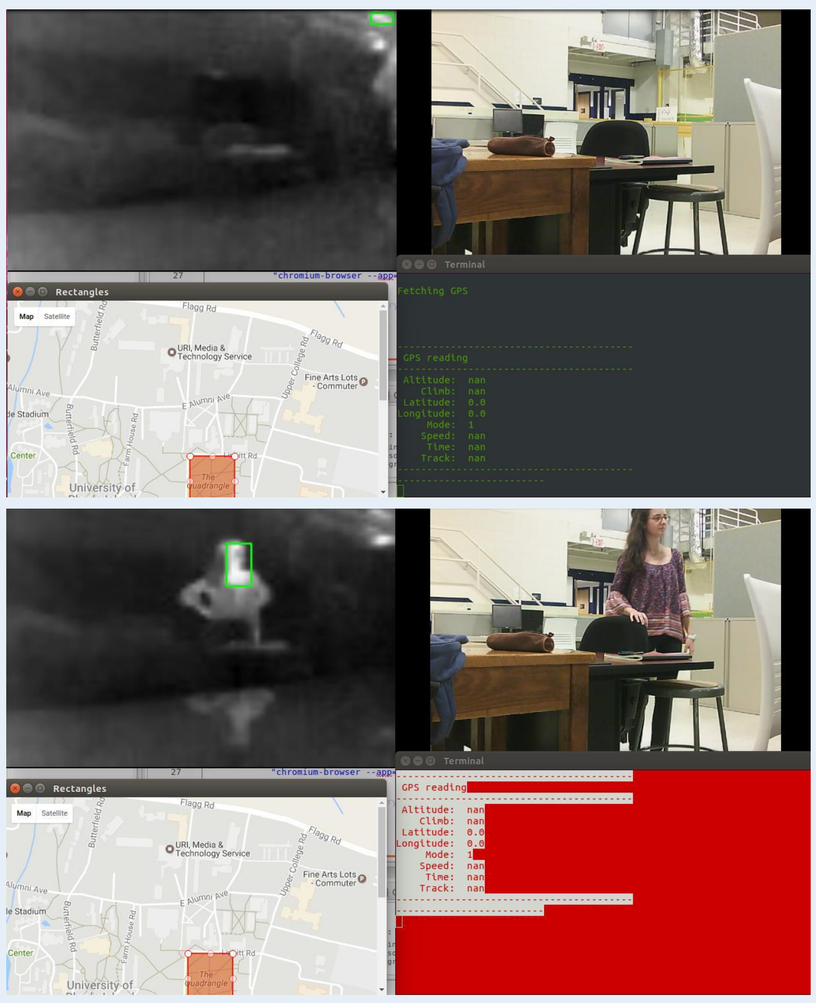


Search Algorithm

Obstacles Overcome

Future Work

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



Screenshots of the four-quadrant graphical user interface both with and without positive thermal hits.

Broader Implications

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

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

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Low Cost Human Machine Interface

SIEMENS

Design a Low Cost HMI that meets budget and specifications

Team Members: Cody Desoto (ELE), Rassoul Diouf (ELE), Damon Georgiou (ELE), Faith Akinbo (CPE), Wasim Rasheed (CPE), Matt Haley (CPE)

Technical Directors: Thomas Lennon '15, William Thorpe

Project Motivation

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

Best Outcome

Create a low-cost open-frame Human Machine Interface for less than $100. Assemble the handpicked hardware components onto connected circuit boards and load our software/operating system that provides the tablet with the functionality desired by Siemens.

Key Accomplishments

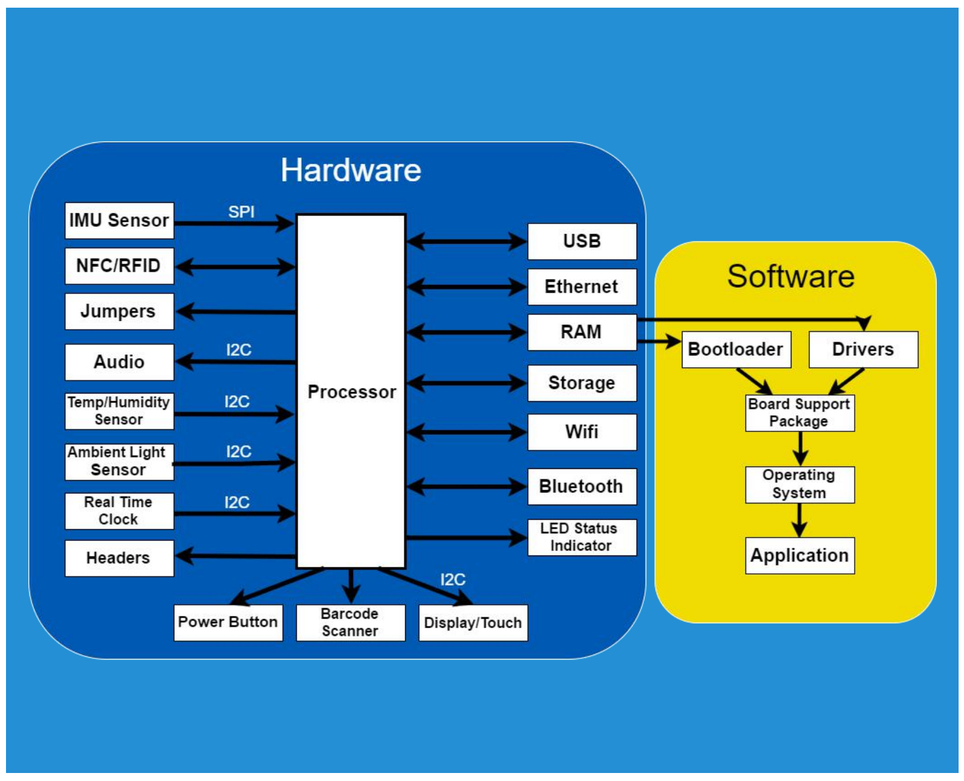
Research Parts and Compile B.O.M.:

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

Implement and Test Parts:

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

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



Block Diagram

Future Work

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

Broader Implications

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

Bill of Materials

Component	Cost (Estimated)	Budget before	Budget After
Processor	15.95	100	84.05
RAM	7.53	84.05	76.52
Storage	5.35	76.52	71.17
Ethernet	0.756	71.17	70.414
USB interface	0.268	70.414	70.146
WiFi / Bluetooth	20.03	70.146	50.116
Accelerometer/Gyro IMU	1.81	50.116	48.306
NFC/RFID	0.68	48.306	47.626
Jumpers	0.25	47.626	47.376
Audio	2.83	47.376	44.546
Power Button	0.06	44.546	44.486
Barcode Scanner	0	44.486	44.486
Display/Touch	0	44.486	44.486
Real Time Clock	4.72	44.486	39.766
Ambient Light Sensor	0	39.766	39.766
Temperature/Humidity Sensor	1.5	39.766	38.266
LED Status Indication	0.34	38.266	37.926
Power	1.83	37.926	36.096
External Temp sensor	2.9	36.096	33.196
$# = estimated price left	33.196		
$# = estimated price used	66.804		

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THE UNIVERSITY OF RHODE ISLAND

THINK BIG WE DO℠

Wireless Relay Module

Connecting existing light fixtures to the Internet of Things

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Technical Directors: Mikail Sagal, Gary Arnold

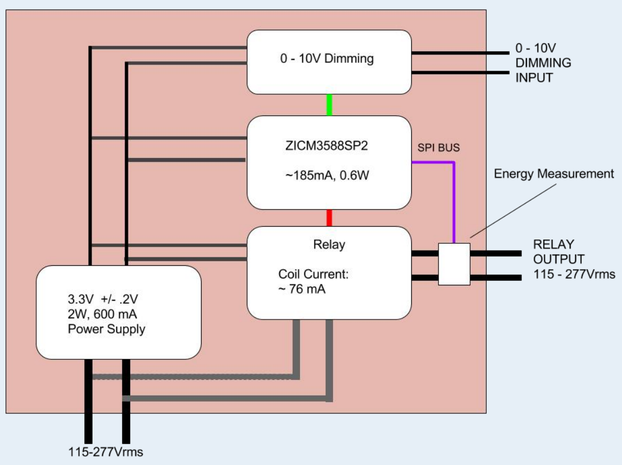
Project Motivation

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

Best Outcome

- Build a device that connects up to 10 LED fixtures wirelessly to a ZigBee network
- Build functional PCB that interacts with the MCU and all other components
- Write firmware application that defines TSR's desired dimming behavior and conforms to all ZigBee standards
- Provide energy consumption information to user so they can evaluate their energy usage patterns

Key Accomplishments



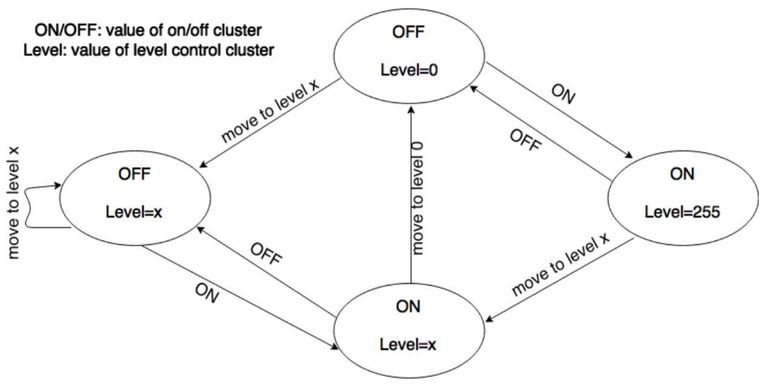
Our block diagram (pictured left) shows the key components that make up the wireless relay module. The module consists of a microcontroller unit, 0-10V dimming circuit, switching relay, power metering IC and power supply.

With a finalized block diagram our team was able to select the proper components to design and build our first PCB. After debugging, we ended up with a working PCB with all the desired functions.

The microcontroller was programmed by the computer engineers. It allows for wireless communication with a ZigBee network and can be controlled via a ZigBee gateway.

The MCU application was designed to provide on/off capabilities as well as full dimming behavior (pictured right). The chip has been programmed to abide by all standard ZigBee practices in terms of configuration, and will automatically look to connect to an available ZigBee network, has over the air updating capabilities implemented, and a power cycle reset feature.

Fully constructed PCB



State diagram for light behavior

Future Work

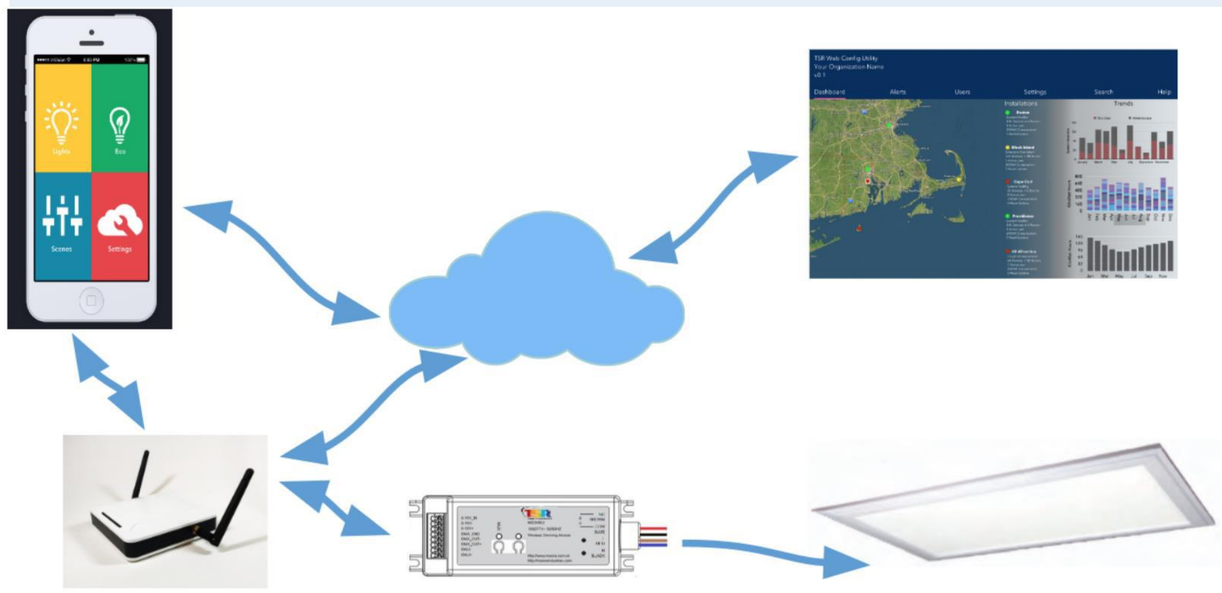
For future work, the main focus would be energy reading capabilities. While the PCB is set up to interact with the energy IC, this functionality is not fully implemented. After the device is successfully communicating with the MCU, the energy usage information will need to be relayed to TSR's online database.

Also, while TSR has an existing mobile app, they would like to make changes to the app to incorporate our wireless relay module specifically.

Broader Implications

This project has very big implications. First of all, the IoT is among the fastest growing areas in the engineering field, so we can see many companies utilizing this module. Capable of Over The Air updates, the module can download updates to continue to be compatible with available sensors and other IoT devices.
Using data about the surrounding environment from sensors, the module can dim lighting in the building and reduce the power used by lighting. This is a step forward in reducing a company's electric bill and also reducing the carbon footprint. Another step in reducing energy is the aforementioned energy measuring functionality which will send energy usage information to the consumer so they can review their usage patterns.

Further Discussion



Pictured above is the high level architecture for the module. The module (labeled TSR) transmits a signal to the light. The module knows which signal to send based on the information received from the ZigBee gateway. The gateway connects to the network so that commands can be sent via the TSR mobile app.

The dashboard printed in the top right hand corner is for energy consumption information. The gateway receives this information from the module and transmits it to the cloud, making it available for the consumer.

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