PROJECT PORTFOLIO

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Summary

This document highlights some of the projects I have completed throughout my undergraduate degree.

Its purpose is to showcase my technical skills as well as provide insight into my level of experience working in this field.

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Rapid Response Satellite Earth Station

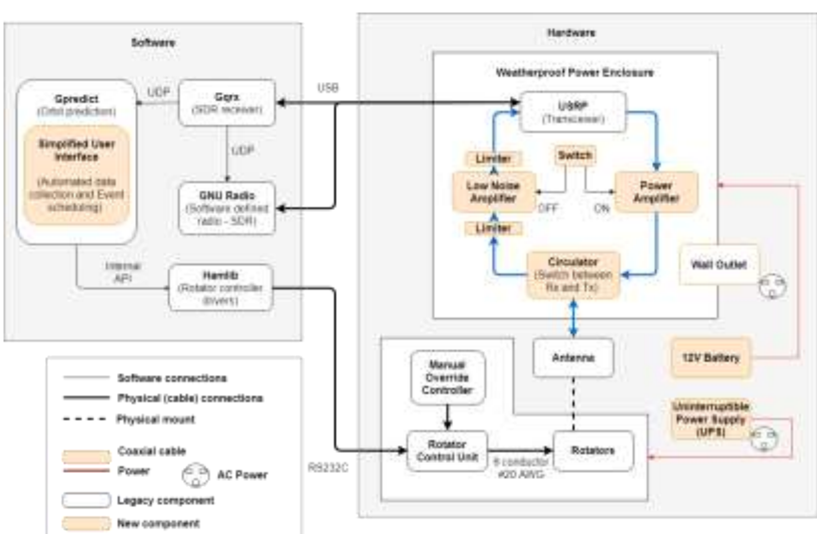
September 2019 – Present

Skills Gained

- Debugging antenna and RF components using RF analysis tools such as Network & Spectrum analyzers, impedance matching using Smith Chart, etc.
- Using Python HTML parsing libraries to pull data from online repositories and databases.
- Sourcing components within a specified budget.
- Amateur Radio License.
- Understanding of space and radiocommunication regulations within Canada.
- Power Enclosure Design

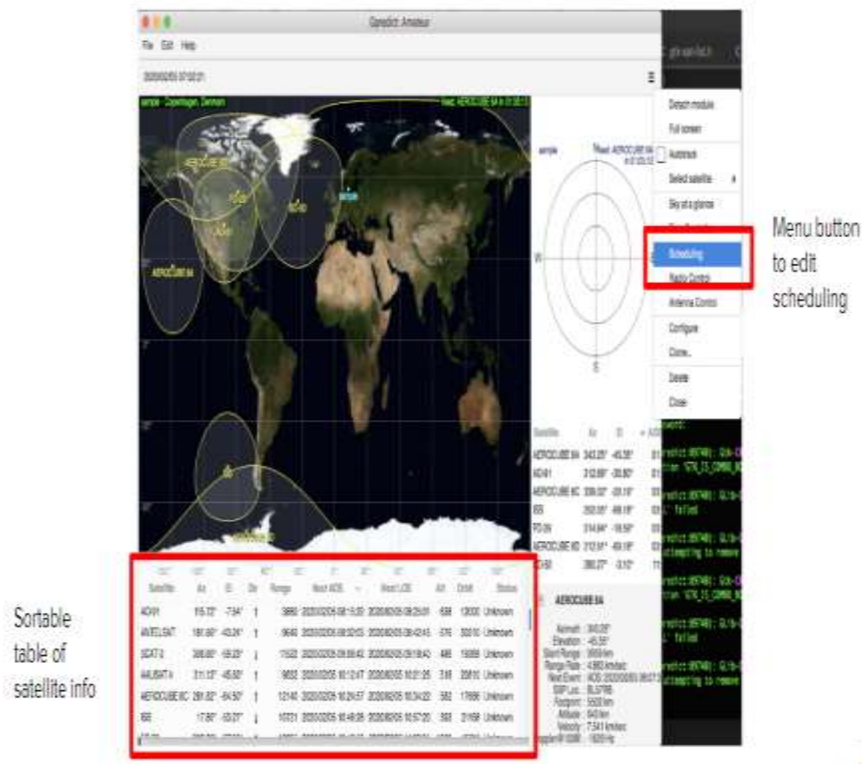
Description of Project

As part of the fourth-year capstone design course for Electrical Engineering students at UBC, I collaborated with 4 students and UBC's Radio Science Lab to design and create a portable, rapid response ground control station capable of communicating with amateur satellites in low earth orbit. This project had two purposes; the first was to increase public outreach of satellite communication technology through technical demonstrations of our system in public educational spaces (university campuses, libraries, schools, etc.). The second was to use our portable, rapidly deployable ground control station to communicate with ORCASAT, a CubeSat developed by UBC that is to be launched in 2021 in order to record satellite telemetry on the go.



As the only electrical engineer in a team of software engineers, I took upon the task of designing the hardware and power electronics needed to accurately send and receive information between our ground station and amateur satellites in LEO. This involved calculating the specifications of certain electronic components necessary for the transmission and reception of signals to and from satellites and then sourcing these components. In this system architecture diagram, the items in yellow boxes under "hardware" indicate the components that I implemented into the system. The Low Noise Amplifier was needed in order to boost signal strength being received from satellites from hundreds of kilometers away in low earth orbit. I added the Power Amplifier in order to boost the signals being sent from our control station to select satellites. The circulator was used to automate switching between receiving and transmitting modes in our system. Finally, I wired the system up in such a way that all necessary electronics could be powered through either the grid or off the grid through an inverter in certain field use cases where the electric grid was inaccessible.

I have also assisted the software team in improving upon the existing open-source software used in amateur satellite communication through developing additional useful features to automate the process of communication. This included coding a scheduling function that would always task the software to initiate reception during selected satellite flyovers thus removing the need to have a user present at the station. The items in red indicate the new features implemented by my team to the existing software



Through Python, I was able to use various data gathering and processing libraries in order to pull various information such as flyover tracking, list of operating amateur satellites and their locations, etc. through online repositories.

VLSI – NAND3 Chip Design Using Cadence Software

November 2019

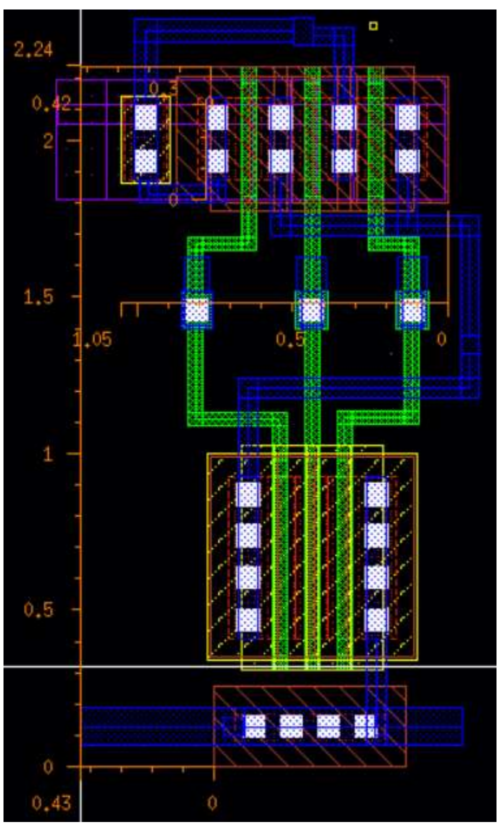
Skills Gained

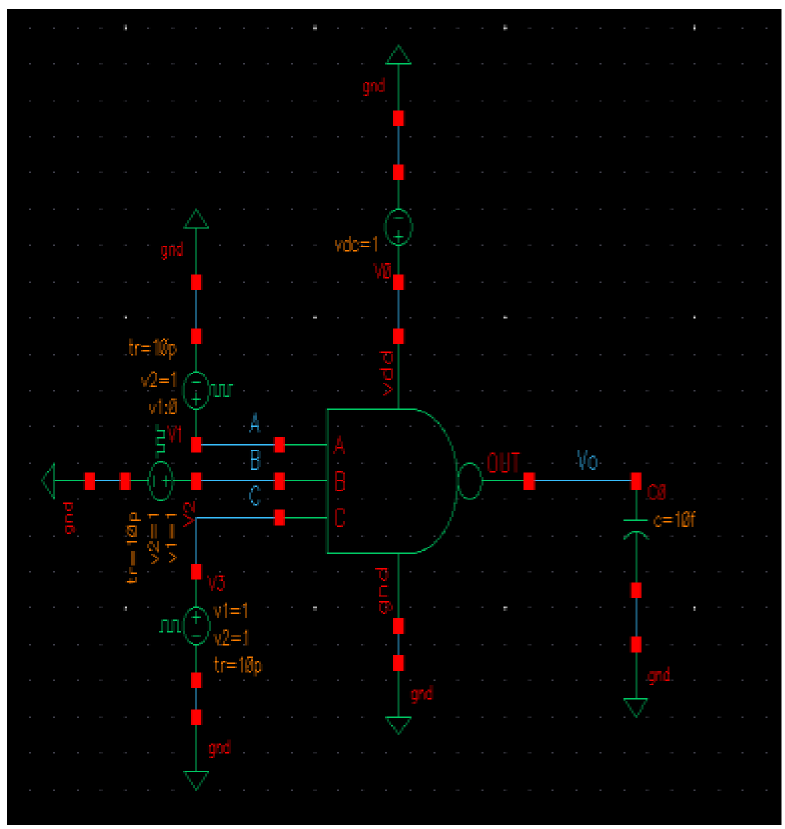
- Cadence Virtuoso and Encounter Software
- Static CMOS Logic
  - Sizing
  - Timing
- Simulation and Timing Analysis

Description of Project

As part of my coursework for a fourth-year VLSI design class, I used Cadence's Virtuoso Software to layout and characterize a simple 3 input NAND circuit. To do this, I first used this design tool to create a schematic of my circuit which I then was able to convert to a layout.

After performing the appropriate calculations for sizing and gate rise and fall times, I was able to characterize the delay of the layout in addition to simulating the propagation delay of the circuit.

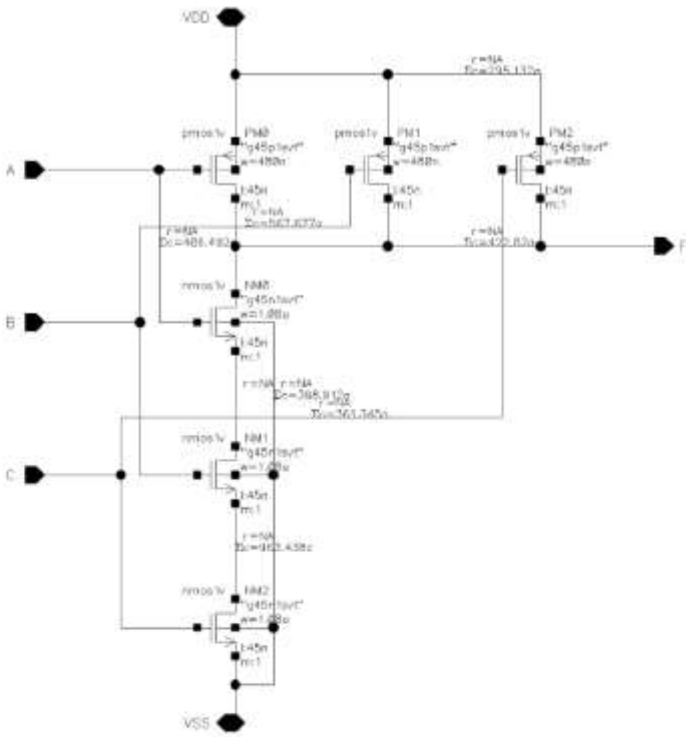


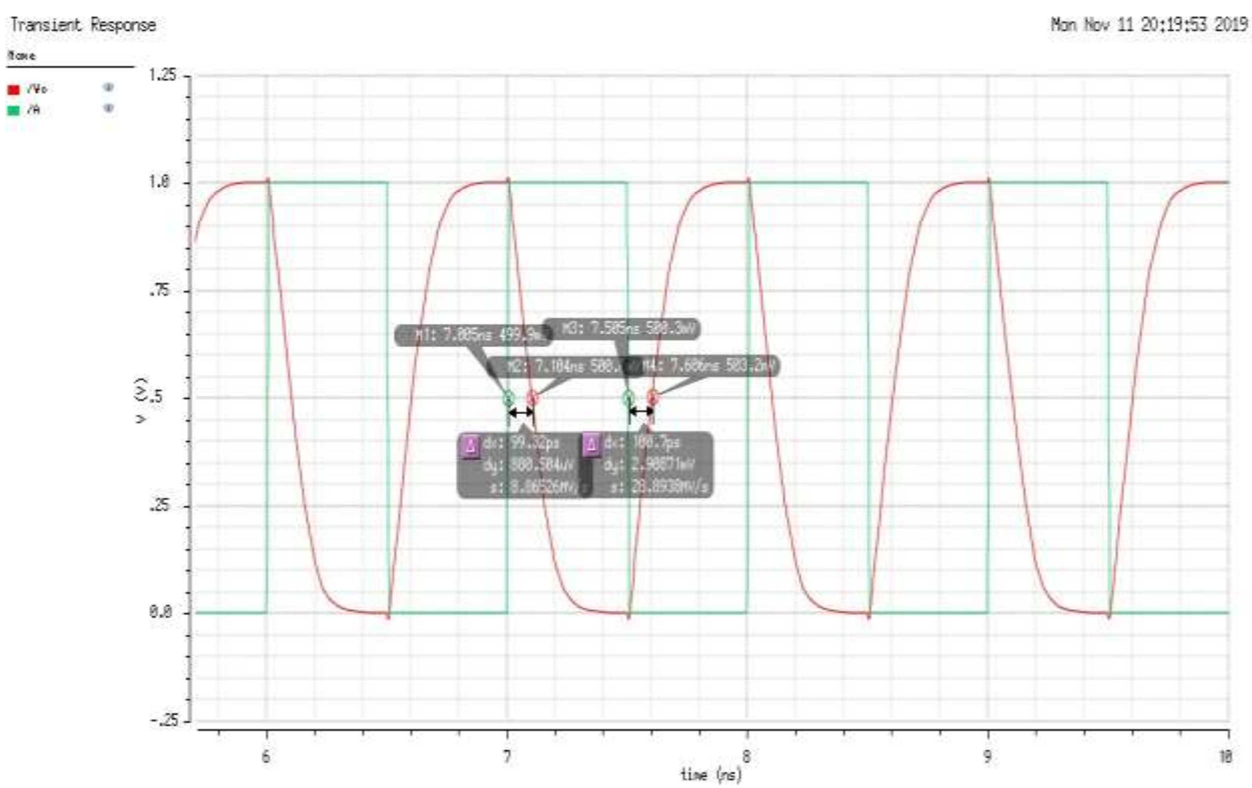


NAND3 Layout

NAND3 Testbench

NAND3 Schematic





NAND3 Worst Case Delay Simulation

Automatic Fire Detection & Extinguishing System

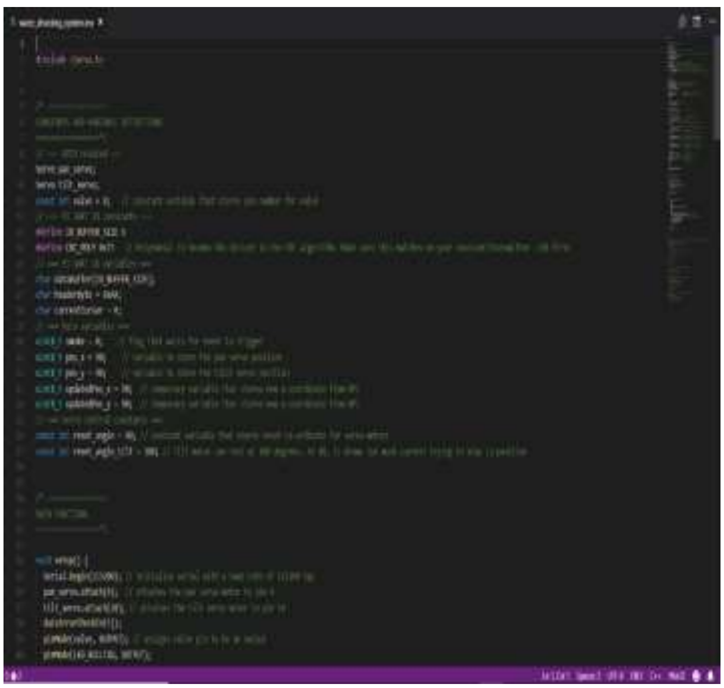
June 2019

Skills Gained

- Arduino Programming in C
- Firmware Programming in Python
- SolidWorks Component & Assembly Design
- Circuit Design

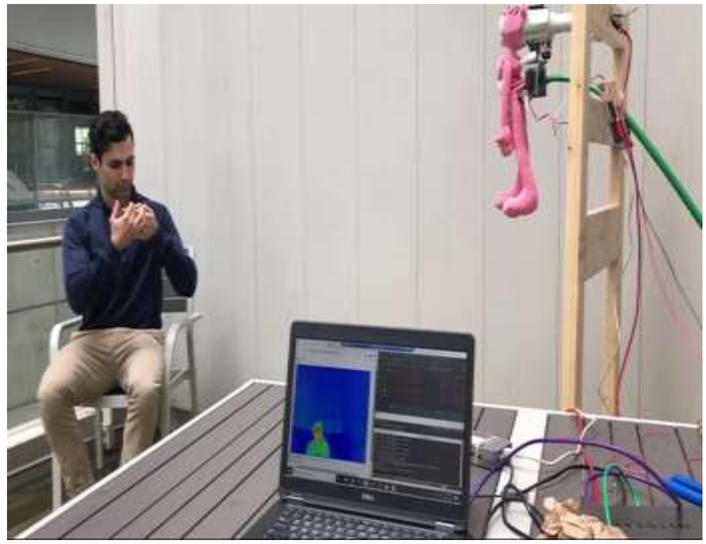
Description of Project

Working as an Electrical Designer Co-op at Avigilon provided me with the unique opportunity in competing at the company’s annual hackathon. I worked in a team of my coworkers to design an automated fire detection and extinguishing system.



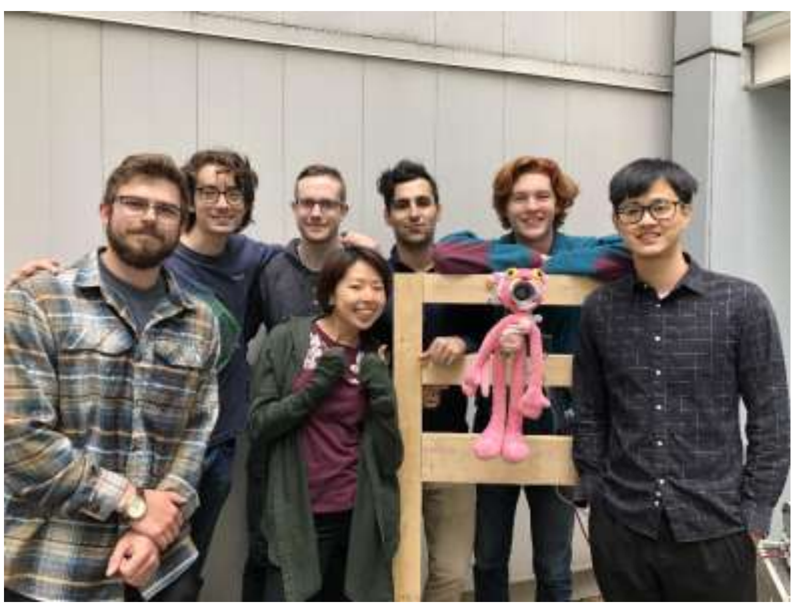
Using one of Avigilon’s proprietary thermal imaging cameras, I created a python script to trigger an alert in case of an appearance of an on-screen fire. This was easy as the introduction of a fire highlighted the flame to be the brightest object on display while lowering the brightness of all surrounding objects. Once this event was triggered, pixel coordinates of the flame would be sent to an Arduino microcontroller which would translate the information to real-life co-ordinates and point the water hose in that general direction.

The hose was controlled by 2 servo motors: one controlling the hose's vertical positioning and the other controlling it's horizontal positioning. Furthermore, the event trigger was also programmed to turn on a valve, allowing water to only be ejected in case of a fire.



Due to the time constraints that came with participating in a hackathon, there were some pitfalls the team and I found ourselves in during the initial design of the product. To start, the servo motors we used initially were incapable of precisely moving the hose as the load's weight was too large for the motor. The reason we chose these motors was simply because they were most readily available to us during the project. Another aspect we would have loved to improve upon was the underlying algorithm within the software that detected the presence of a flame on screen. In certain corner cases where multiple flames would be recorded on screen, the motor did not have a clear idea of where to point the hose and thus ended up splattering water in all directions. These bugs could have easily been accounted for in other situations but for hackathon purposes, our proof of concept for this device was a success.

Avigilon Hackathon 2019 – Team "GTFO - Get That Fire Out"



2-DOF Motorized Laser Controller

January 2018 – April 2018

Skills Gained

- Schematic Capture & PCB Layout using Altium Designer
- DC Motor Design
- SolidWorks Component & Assembly Design
- Microcontroller programming (PIC32)
- Circuit Design
- Machine Shop License

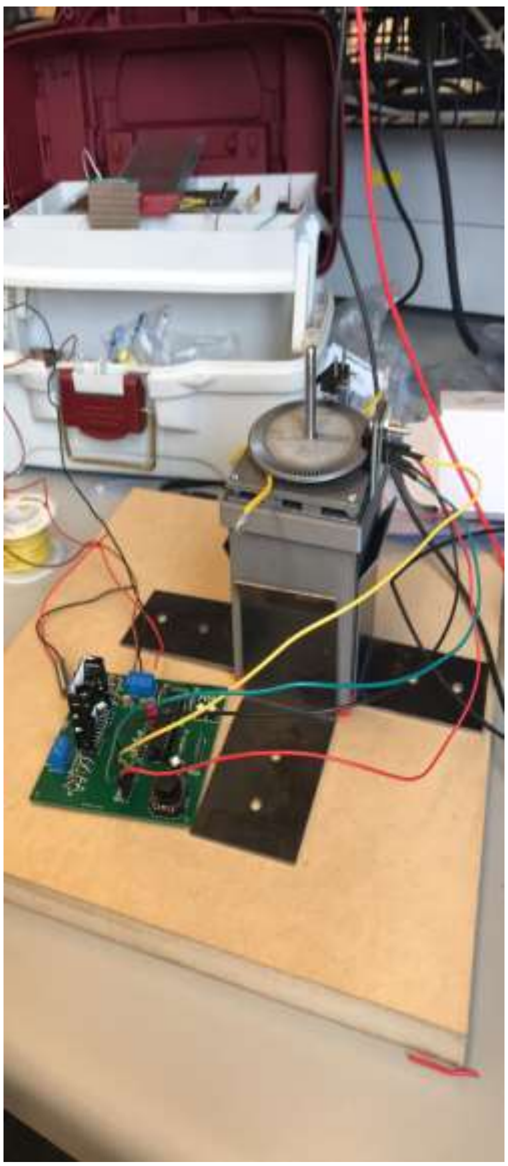
Description of Project

For my third-year electrical engineering design course, I worked in a team of 4 students to design and create a 2 degree-of-freedom spherical wrist that could rotate a laser pointer to create a 2D shape on a surface when rotated rapidly. Our final product was able to create circles, squares, and sine wave shapes on any given surface.

Since this was meant to be a learning experiment, certain electronic components could not be bought of the shelf but rather made in-house. This included two Permanent Magnet Brushed DC Motors; one to control the horizontal movement of the laser pointer and one to control its vertical motion. To do this, I had to design a metal core and stator using SolidWorks, waterjet cut the iron core pieces and glue them together, hand-wire magnetic wire around the core, and create a commutator and brush for each motor.

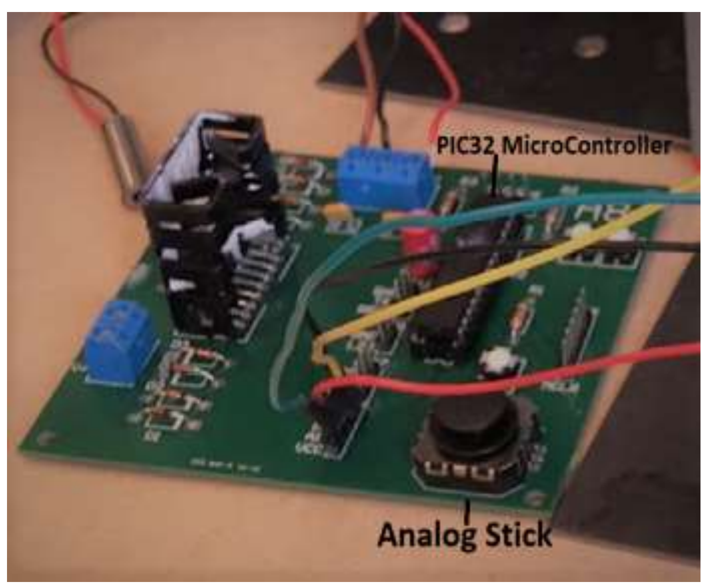
The enclosures for the core, rotor and commutator were designed and 3D printed using Tinkerine FDM 3D Printers. It was designed to accommodate the brushes to be held in place in order to make consistent contact with the commutator so that the motor could turn efficiently. I also designed the enclosure to contain slots to house the neodymium permanent magnets within the stator.

The most challenging aspect about this project was controlling the two hand-made DC motors. As they were built from scratch, they were not as reliable as commercially available DC motors and were hard to characterize. It was also difficult to make DC motors with enough torque and reliability to be controlled effectively. The motors had undergone many design iterations to ensure that they could produce the necessary torque and rpm needed to be controlled as efficiently as possible. The horizontal-control motor was particularly difficult to design as it needed to rotate the vertical-control motor and was thus carrying a much heavier load.



Another item to design was a PCB that could effectively drive the two DC motors in order to create the required shapes. Using Altium Designer, I was able to create schematic captures and a PCB layout of the first iteration of the board. For an additional bonus feature, we implemented the use of an analog stick onto our PCB which allowed us to manually control the laser pointer. Optical encoders were designed to create a closed-loop system, allowing us to keep track of the rotor's position at all times.

The design was then sent off to be manufactured and the components were sourced through the generated BOM.



Simple iPod

October 2017

Skills Gained

- FPGA Programming using SystemVerilog
- PicoBlaze (Embedded Microcontroller Core) Programming in Assembly

Description of Project

As part of my third year Digital Systems Design course, I used an FPGA to mimic the functionality of a iPod. By interfacing the FPGA with a keyboard, I was able to send instructions to forward, rewind, pause, reset, and speed up or slow down audio.

To do this, I had to create a glitch free finite state machine that could read from the flash memory programmed on the board. This flash contained sound samples of a song that I had to move to the audio DAC converter in order to listen to them.

To read a new value from the flash memory and send it to the audio, I had to reproduce at the sampling rate of the song (every 0.045 milliseconds) or 22,000 Hz. To do this, I implemented a frequency divider that divided the 50MHz clock to a frequency of 22kHz but also made sure to synchronize this clock with the 50MHz using edge detection.

I created another FSM to control the address being sent to the flash as well as an interface between my FSM and ASCII code received from the keyboard to control the music with instructions such as pause, play, rewind and fast forward.

To build upon this project, I was also able to add an LED strength meter using the LEDs on-board the FPGA to show the strength of the audio signal of playable songs within the flash memory of the development board. This was done using the embedded PicoBlaze processor on the Altera DE1-SoC FPGA. To get this feature to work, I had to implement different operations using Assembly language such as an averaging filter to perform real-time signal averaging.

UBC Solar – Battery Design

September 2017 – May 2018

Skills Gained

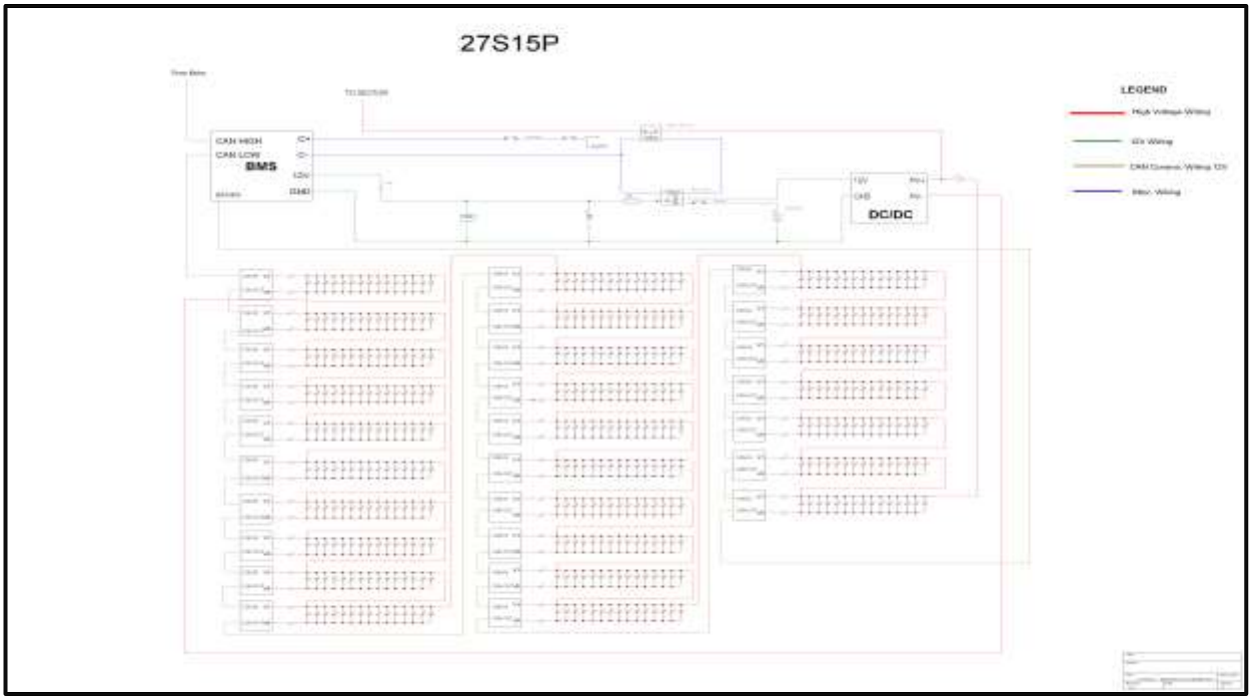
- Understanding of different battery technologies and cooling techniques
- CAD tools to create electrical schematics
- Interpersonal skills when working in large teams
- Sourcing components from suppliers

Description of Project

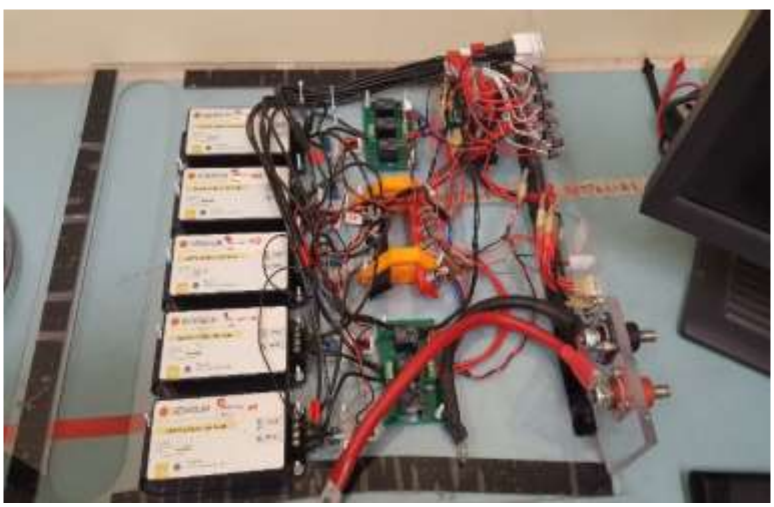
During my third year at UBC, I joined UBC Solar, an engineering, student-led design team at UBC dedicated to designing and racing solar-powered vehicles. I joined the battery team and was responsible for designing a rechargeable battery pack and a battery management system capable of powering the vehicle motor and peripherals.

Through researching the numerous amounts of cell types available to us, we were able to choose the Panasonic 18650B: a lithium-ion cell that provided a nominal voltage of 3.6V and had a capacity of 3400 mAh. This particular cell also had a high temperature tolerance and was therefore a favorite among amateur solar car developers and even large manufacturers such as Tesla.

After calculating the power requirements of the largest consumer of power within the car: the motor, I was able to start designing an initial draft of our battery schematic, primarily utilizing a cell configuration of 27S15P.



Once sample cells arrived from multiple suppliers, we began running characteristic tests to check whether they functioned up to datasheet specifications. After two months of testing and communicating with suppliers, we placed an order for approximately 600 cells, x1.5 the amount we needed for the actual battery pack.



Since the battery pack was designed from scratch, the previous Battery Management System we had in store could not work with our new system. For that reason, the battery team and myself also researched a new BMS capable of managing our battery bank by monitoring its state, calculating secondary data, reporting that data, etc.

Although I helped in the initial prototyping and development of the Battery Management System, I was unable to continue doing so due to my commitments to my full-time co-op position. For that reason, I had to end my work at UBC Solar from the summer of 2018 onwards.

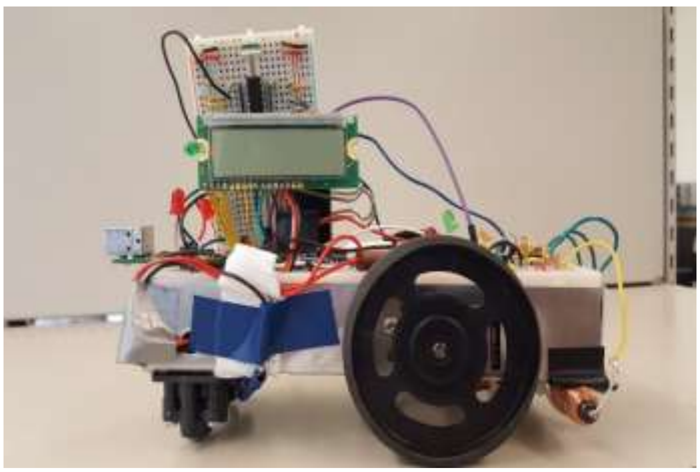
Magnetic Field Tracking Robot

April 2017

Skills Gained

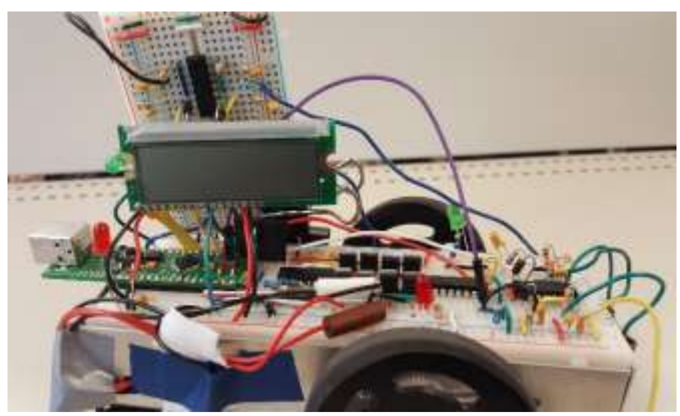
- Rapid prototyping of electronic circuits
- Troubleshooting electronics using lab equipment such as oscilloscopes, multimeters, etc.
- Reading and understanding complex electrical schematics
- Firmware programming in C

Description of Project



One of the projects I worked on during my second-year electrical engineering design course involved designing, building, programming and testing an autonomous robot which could be controlled using a magnetic field generated by a guide wire track. This robot used two inductors placed on its undercarriage to detect the magnetic field emanating from the wire track.

The robot was powered by a 9V battery and was able to precisely navigate its way around a wire track capable of producing a magnetic field. The ATMega328P microcontroller on board the car was able to use the magnetic fields picked up by the inductors in order to accurately turn the robot's wheels during a curve or sharp turn.



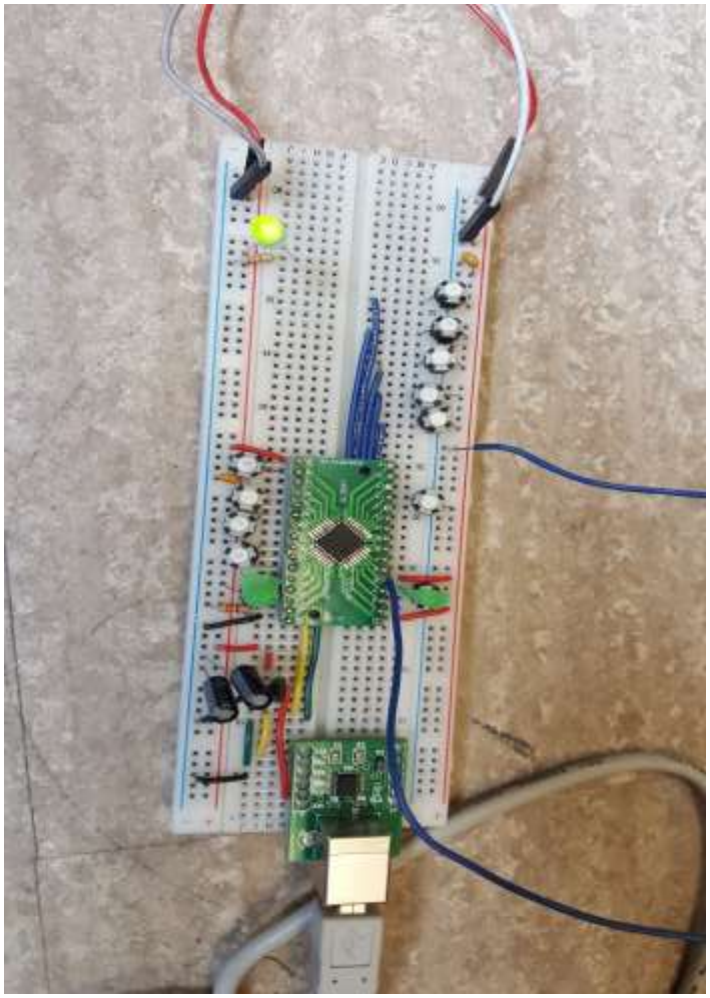
Two large circuits were created in this project. The **receiver** circuit was placed on-board the robot which did the following tasks:

- Implemented multiple H-Bridges to drive the 2 motors allowing for movement of the wheels
- Use the inductors to find the amplified peak voltage of each inductor
- Data transmission comparison

- Microcontroller with PWM capabilities to speed up and slow down the car upon appropriate instructions received from the transmitter circuit
- Green and red LED's blinked upon left turn, right turn or stop instruction.
- The on-board LCD was used to display information such as car velocity and log of instructions received.

A **transmitter** circuit was designed to transmit instructions to the robot by varying pulses within the guidewire. Through this encoding method, the receiver circuit on board the robot was able to perform multiple functions. The transmitter circuit used a variety of pushbuttons connected to an STM32 microcontroller to send the following instructions to the robot:

- Forward
- Reverse
- Stop
- Intersection – Left
- Intersection – Right
- Intersection – Stop
- Rotate 180 degrees
- Speed up
- Slow Down



The challenging aspect about this project was learning to encode different pulses that could allow the transmitter circuit to wirelessly communicate with the receiver circuit. Using the UART protocol allowed us to configure the code to match the baud rate of data being transmitted.

Additional Certifications

Amateur Radio License

Innovation, Science and Economic Development Canada | Innovation, Sciences et Développement économique Canada

Certificate of Proficiency in Amateur Radio

This is to certify that

Hamza Ahmed

has obtained the following qualifications:

Basic with Honours

The certificate holder is authorized to operate amateur radio apparatus in accordance with the regulations made pursuant to the ***Radiocommunication Act***, and to use the following call signs:

VA7HMZ

Certificate Number: 20200000385
Issue date: 25 February 2020

Issued by Jacques Filiatrault

Canada