Final Presentation

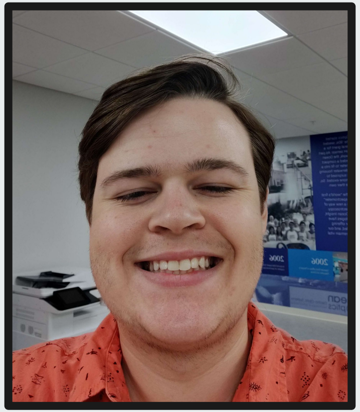
Semi-Automated Diffraction Grating Efficiency System

University of Central Florida

Sponsored by Ocean Insight

Ryan Goff	Carlos Irizarry	Christopher Robertson	Ecclezias Senat
CPE	PSE	CPE	EE

Meet the Team



Ryan Goff
CPE

Carlos Irizarry
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Motivation

- Diffraction gratings are the heart of spectroscopy
- Low efficiency gratings can result in poor output
- For commercial-use products should have a standard efficiency

Carlos Irizarry

Project Summary

- Optical system to determine diffraction grating efficiency as a function of wavelength
- Semi-automation with use of motor and motor controller
- Accurate grating efficiency and angle of diffraction and incidence
- 400 nm bandwidth for capturing efficiency values
- Display data in the form of a graph

Carlos Irizarry

Goals and Objectives

- Semi-automate diffraction efficiency measurement process
- Design a system with compatibility for a variety of gratings
- Have independent stage and arm movement
- Provide precise measurements to a computer for visualization

Carlos Irizarry

Sponsor: Ocean Insight

- Specialize in spectroscopy
- Diffraction gratings fundamental to spectrometers
- Aid in quality control for grating usage

Carlos Irizarry

Design Approach

- System had to be aligned consistently so a cage design was appropriate
- Dual rotation stages must be aligned vertically for accurate angle measurements
- Counterbalance added as to not damage motorized rotation stage
- Linear polarizer aids in polarization dependence concerns
- Fiber collimator ensures spot size is captured on photodetector

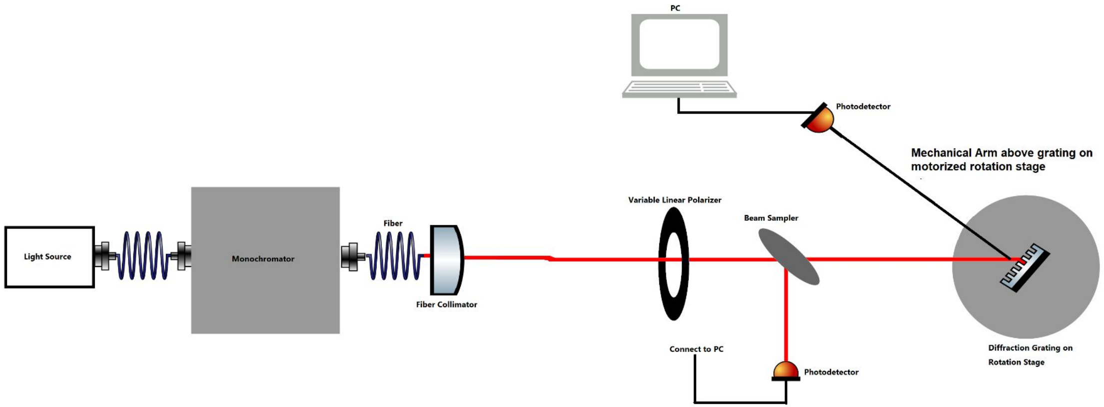
Carlos Irizarry

Engineering Specifications

- Functional for 300-700 nm wavelengths
- ±0.5 Diffraction Angle Accuracy
- Functional for a multitude of groove densities(300-1200 lines/mm)
- < 1 Sec Touch Screen Response Time
- ±0.1V for 5V Power Supply to PCB/MCU

Carlos Irizarry

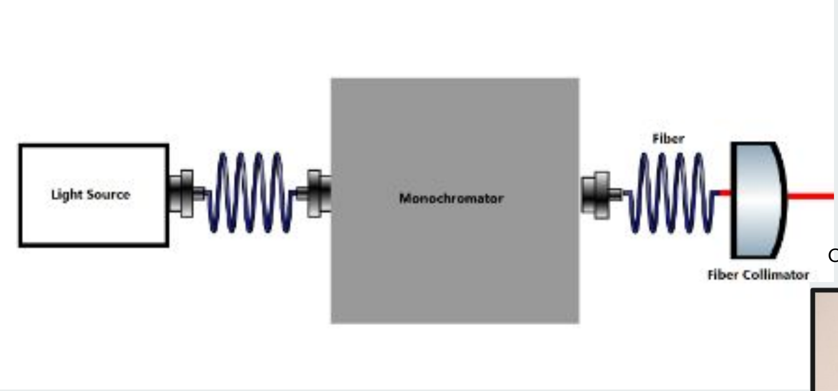
Schematics



Carlos Irizarry

Optical Design

- Broadband light source and monochromator allow for accurate efficiency plot
- Fiber collimator ensures light can travel



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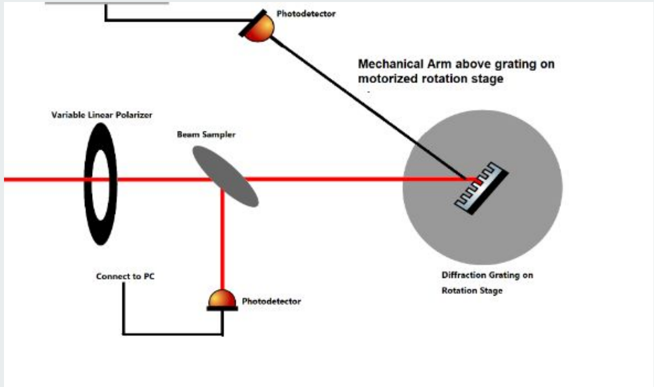
Optical Design (cont.)

- Linear polarizer ensures consistent polarization dependence
- 95/5 Beam sampler creates reference value with input light
- Diffraction grating/mechanical arm rotation provides automation to system

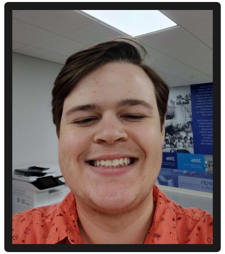


Carlos Irizarry

Motorized Rotation Stage

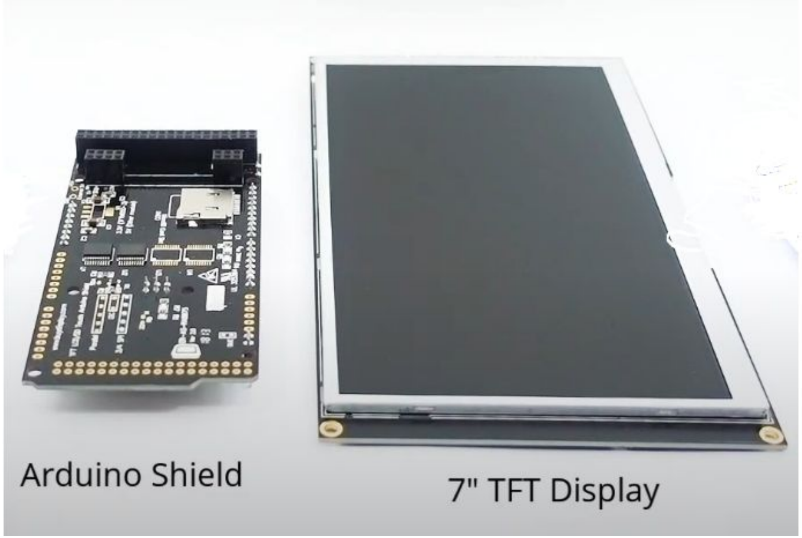
- PRMTZ8 - Motorized Precision Rotation Stage
- ±0.1° angle accuracy
- KDC101 Brushed DC Servo Motor Controller

Ryan Goff



Display

- Able to display all appropriate data, including an output graph
- A way of converting user inputs into visual changes
- Compatible with the Arduino Mega 2560 board



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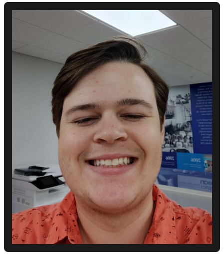
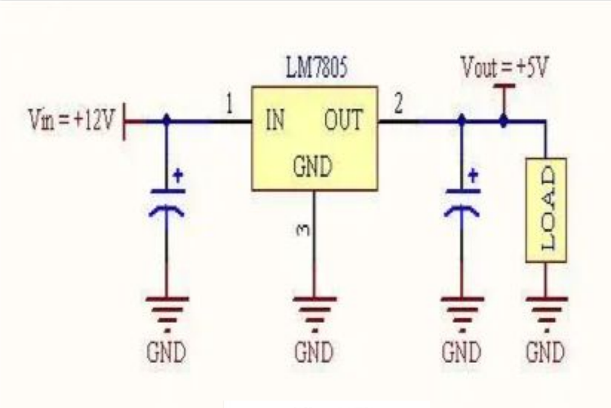


Photodiode

- Mounted Silicon Photodiode
- Can be placing at any angle
- 200- 1100 nm
- Cathode grounded

Initial Power Supply

- LM7805 Linear voltage regulator
- Three terminal regulator
- Internal overload protection
- Output current up to 2amps
- Powering Arduino mega, LCD display and rotation stage motor.
-
- Part not available & shipping could take 4 months



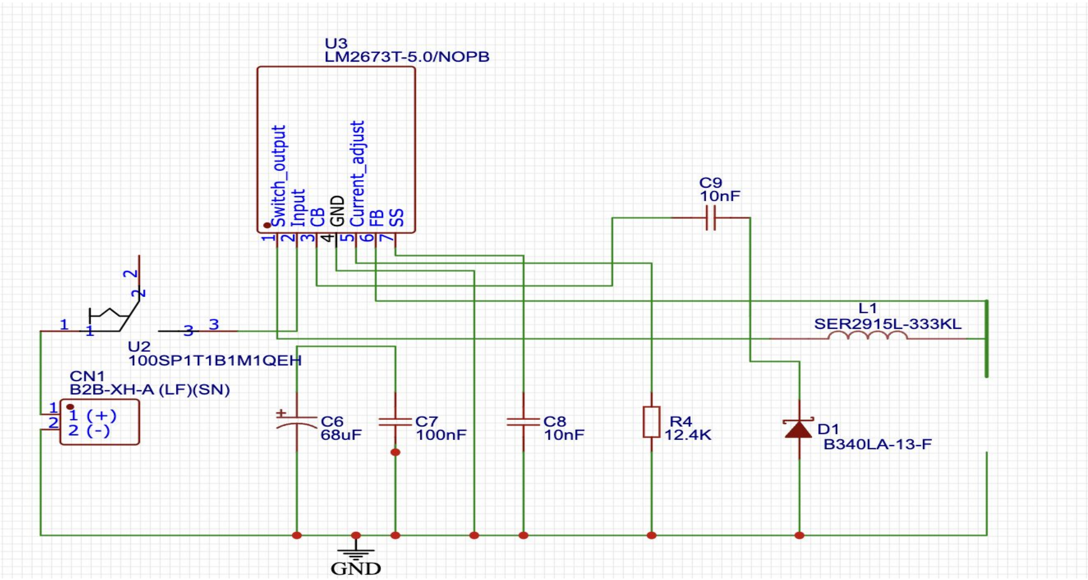
Power Supply Cont'd

- Simple switcher Buck Converter
- LM2973-5
- Input 12-40 volts
- Output 5 volts
- Thermal shutdown and current limiting protection
- High efficiency

  Powering Arduino mega, LCD display

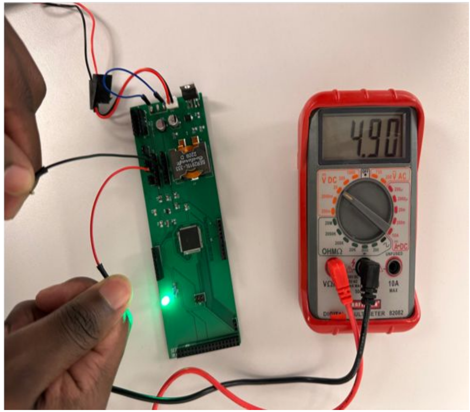
Buck Converter Schematic

- LM2973-5
- Input 12-40 volts
- Output 5 volts/2 amps

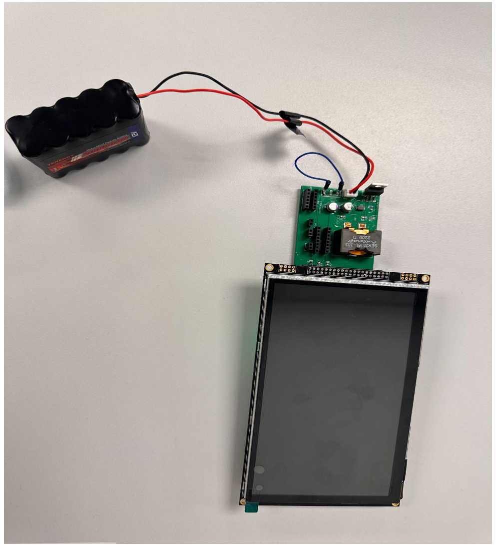


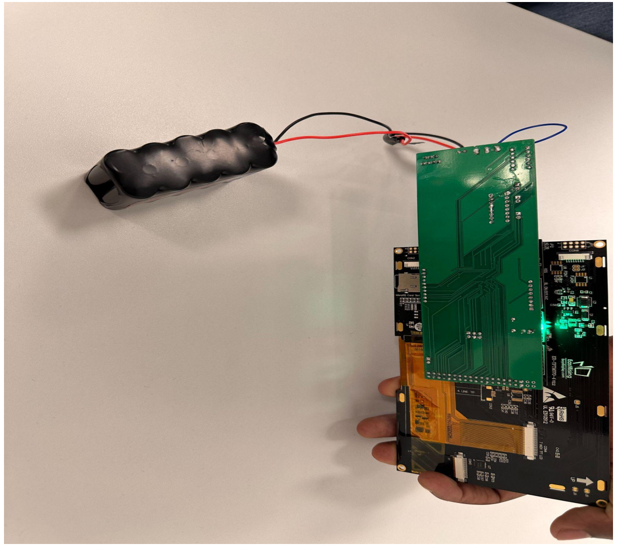
Final Power supply with battery

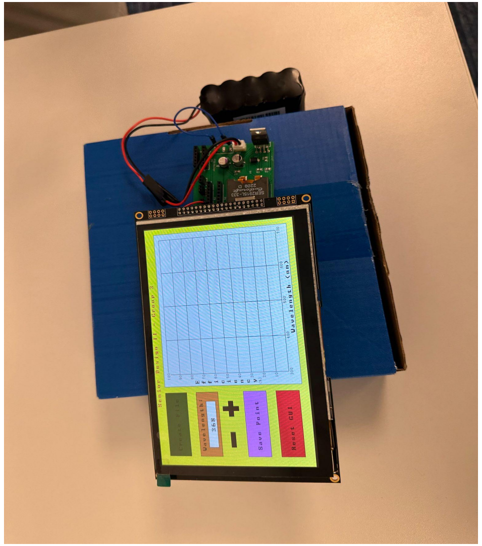
- 12 Volts Nickel - Metal Hydride Tenergy Battery
- 2000mah can power (24W/amps)
- Can power our electronics devices for long periods of time
- Rechargeable
- Fast charging



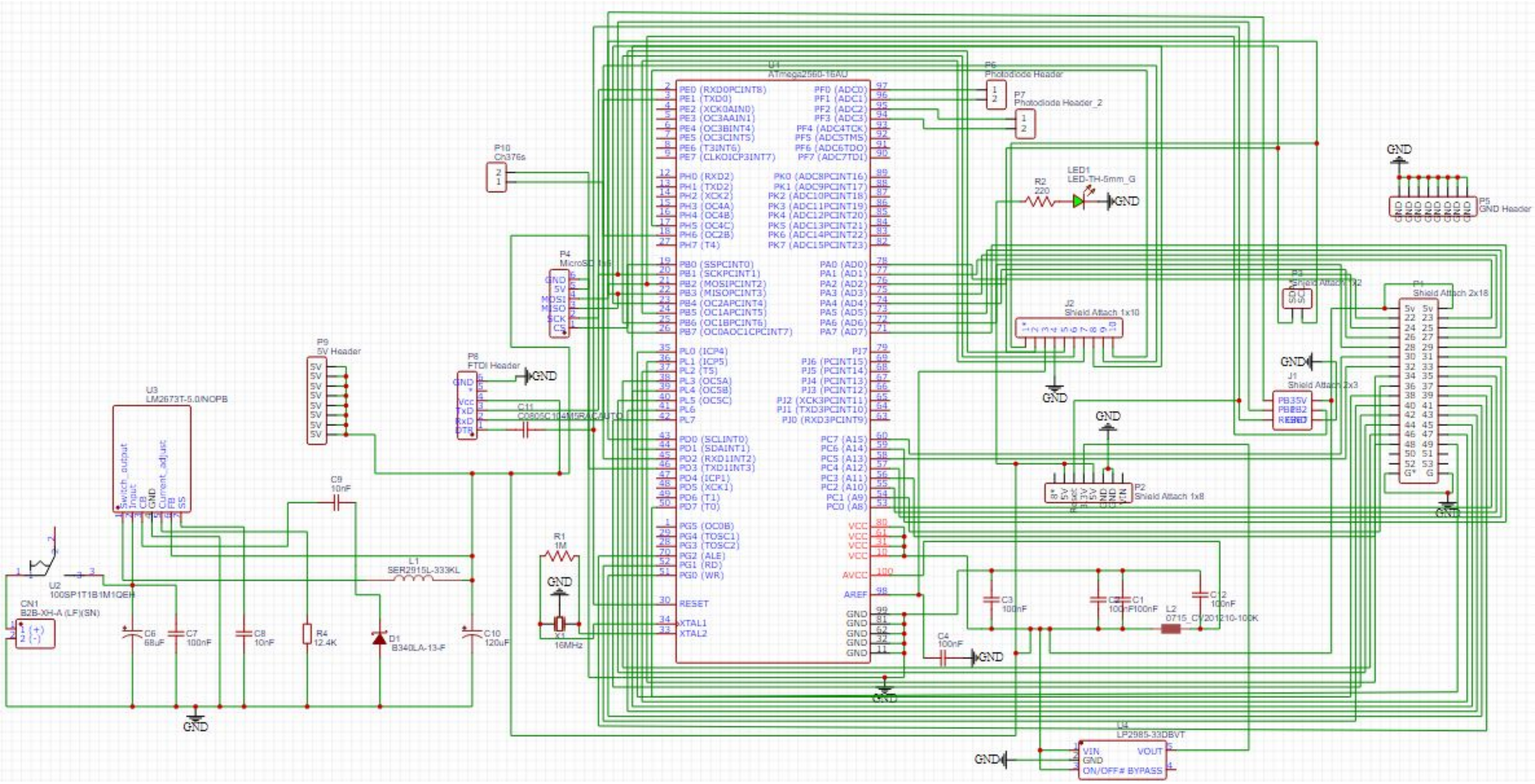
Final Power Supply Testing Result







Overall Schematic



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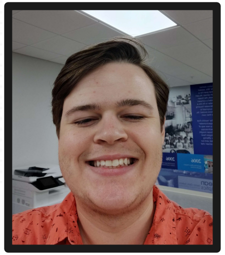
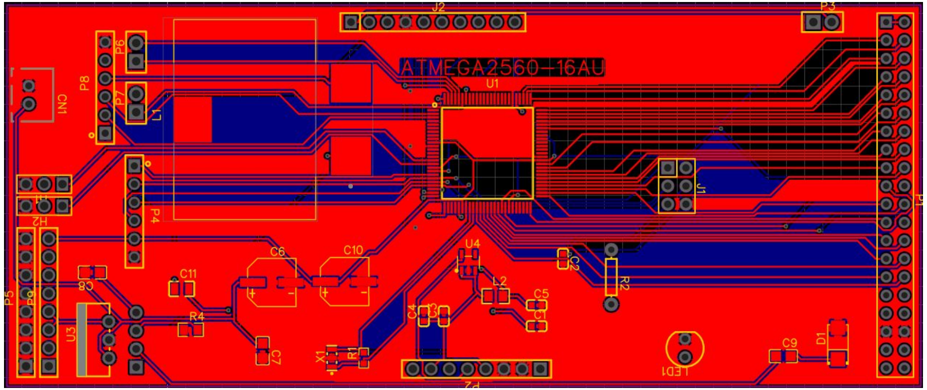


First PCB Design

Purpose:

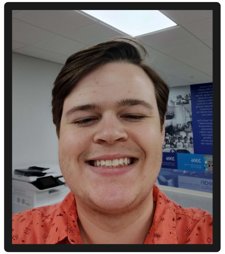
- To power all necessary components with 5V
- Send and receive signals from our LCD
- Mount directly to the included LCD shield
- Include the necessary headers for the USB module, servo motors, photodiodes, and FTDI programmer



Shortcomings:

- Inadequate power trace width
- Poor component layout
- Clearance issues with the inductor and LCD Shield

Ryan Goff



Second PCB Design

Improvements

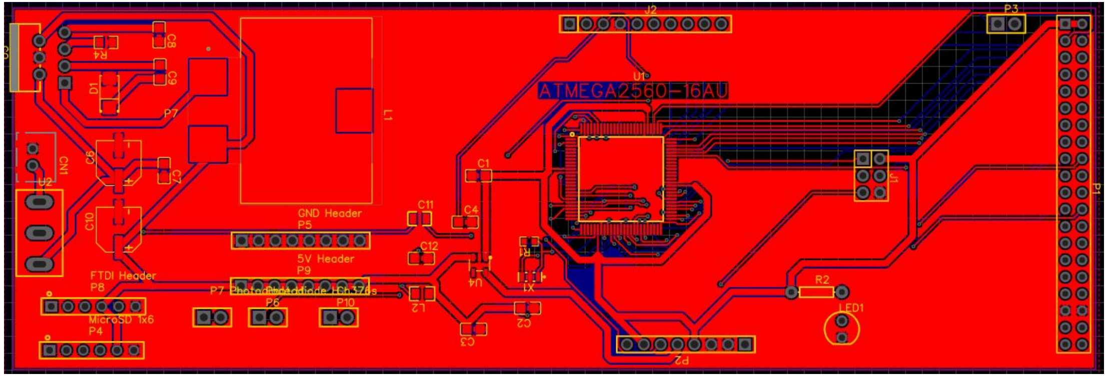
- Increased trace width of all 5V traces
- Moved the inductor over so that the LCD shield could mount properly
- Localized all power components to one area on the PCB to reduce noise

Major Design Changes:

- Removed the two servo headers
- Added a switch to the power supply

Complications:

- Incorrect footprint for switch



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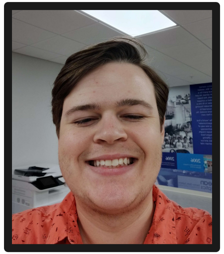
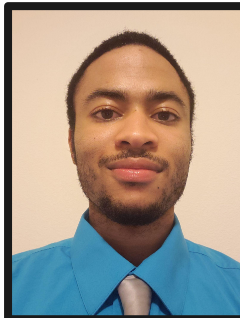


Initial MCU Usage Requirements

- In the Initial design of the project, the microcontroller would be used to control a dual servo motor setup that would move the rotation stage that the diffraction grating was placed on in conjunction with a motor to adjust the position of the second photodiode which would be measuring the lights intensity after the light was diffracted.
- In addition to these motor controls, the analog voltage measurements from both photodiodes would be used to determine the efficiency of the grating and then output to the display.
- The display was going to be used as a motor controller as well as a data point plotter for the efficiency ratings at specific wavelengths.

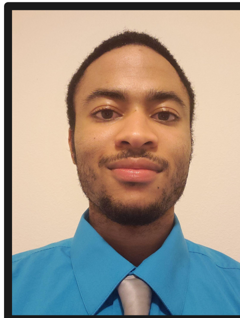
Christopher Robertson



Current MCU Usage Conditions

- Instead of a dual motor configuration, the system was set up with a single motor that would still be moving the photodiode based on the diffraction angle of the grating at a given wavelength.
- The Photodiode analog measurements would still be collected from both photodiodes in order to provide an efficiency rating of the diffraction grating.
- The rotation stage's motor was no longer being controlled via the display, but the display would still be used to plot points at the specified wavelengths on top of the other touch screen features that were still being implemented.

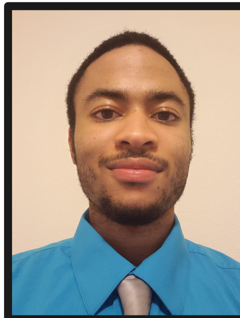
Christopher Robertson



Exporting Data

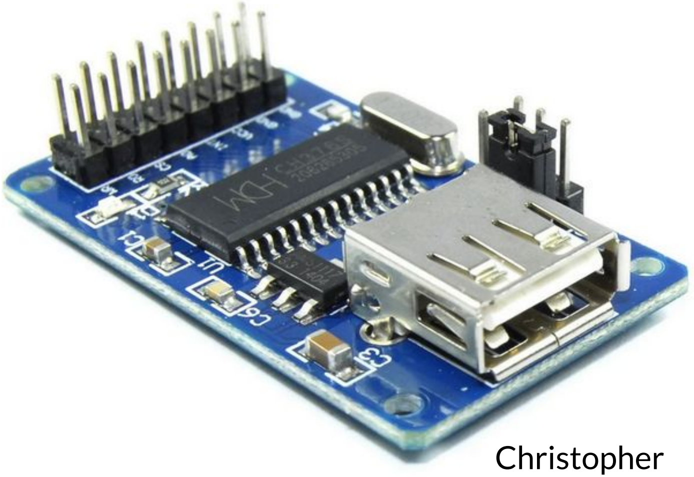
- A feature that was added to the initial design was a method to export the data collected by the system to external devices, as the microcontroller couldn't be used to store the data for long term usage.
- Initial plan was to write the information to a SD Card and use that as an external memory device for data collection.
- A USB Flash Drive was the alternative solution as the hardware compatibility with external devices was more common.

Christopher Robertson



USB Module

- Used to transmit data to external devices via Flash Drive or SD Card.
- Can utilize both UART and SPI at different Baud rates.
- UART protocol will use pins on the Ch376 USB Module and Microcontroller that are designated as Transmit/Receive pins to transmit Data to and from the devices.



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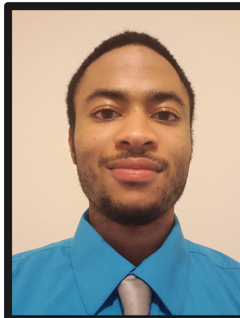
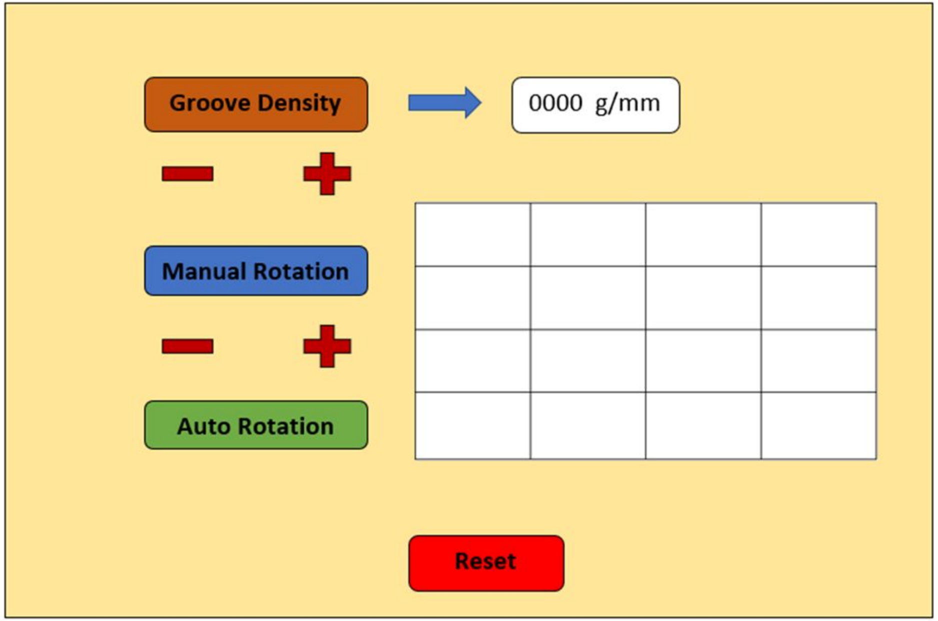


LCD GUI First Iteration



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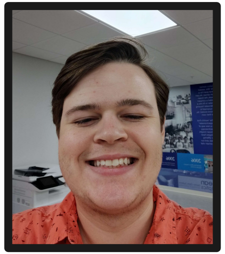
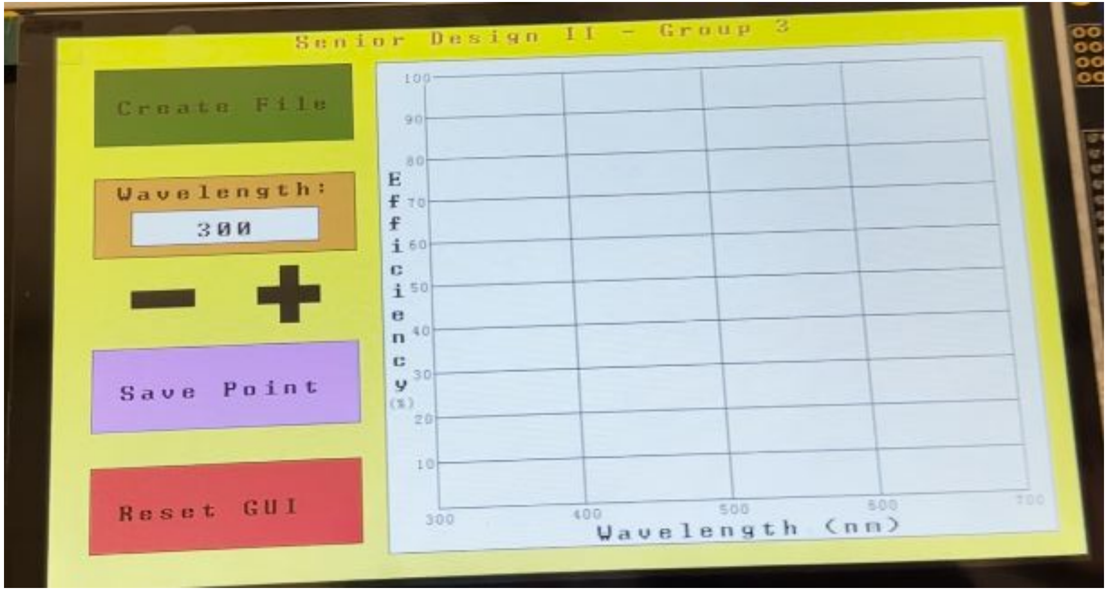


Final GUI (Software)



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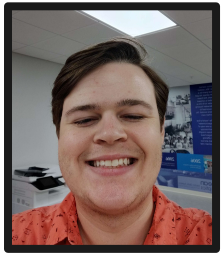
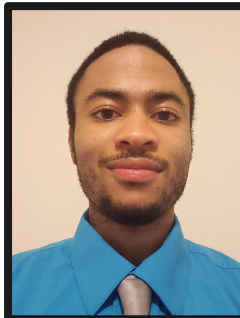


USB Module (software)

Writing to the USB requires a communication protocol to be used between the Microcontroller and USB module. A UART communication channel was set up between the two devices using the Communication pins specified on the Microcontroller.

After setting up the pin connections and setting the Baud rate, the communication channel is open and data transmission between the connected devices is ready. Using read and write commands from a Ch376 library that can be found in the Arduino IDE software then lets the microcontroller write to the Flash Drive which can later be viewed on an external PC, Laptop; etc.

Christopher Robertson



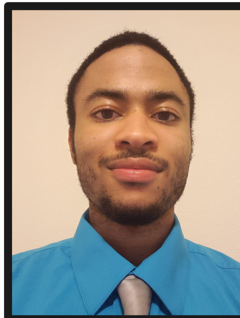
Photodiode (Software)

When a light hits the photodiode, a voltage reading is produced. This voltage reading can be measured on the Microcontroller by using the analog pins that are available. These measurements will then be used to calculate overall efficiency of the diffraction grating, with the reference voltage being the light before it reaches the grating, and output voltage being the measurements of the diffracted light.

To collect analog measurements in the Arduino Software, the Analog pin(s) would need to be initialized as a variable before the setup code. A second variable would be used to hold the pin's numerical value. Either an "int" variable or a "float" variable if it is desired for decimal values to be considered.

After the setup code is made, the analog values can be read from the specified pin(s) into the selected int/float variable that was made.

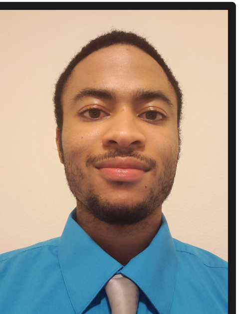
Christopher Robertson



Budget

- Sponsored Group
- Total project cost: $2903.52
- Total Cost for parts not bought through sponsor: $252.20

Christopher Robertson



Senior Design Project - Semi Automated Diffraction Grating Efficiency Station		
Item	**Quantity**	**Cost**
HL-3P	1	$0
600μm VIS-NIR Fiber	2	$0
MonoScan 2000	1	$0
Variable Linear Polarizer	1	$269.06
1" Beam Sampler	1	$73.09
Achromatic Doublet	1	$53.88
30mm Cage Rod	4	$54.92
1/2" Optical Post	5	$26.52
1/2" Lens Mount 1/2"	1	$42.18
30mm Cage Mounting Bracket	2	$32.16
1/2" Post Component Clamp	1	$28.53
1/2" Post Holder	2	$17.90
Small Adjustable Clamping Arm	1	$21.43
Motorized Rotation Stage (DC Servo Motor)	1	$1,017.33
K-Cube Brushed DC Servo Motor Controller	1	$757.51
Mounted Photodiode	2	$79.36
Fiber Collimator	1	$177.45
Arduino Mega R3 Board	1	$35.12
SMA Male to BNC Female Cable	2	$17.98
BNC Male Connector (10 Pack)	1	$6.76
7" Arduino Touch Screen Display	1	$57.35
PCB 1st Iteration	1	$22.00
PCB Components	1	$18.00
PCB 2nd Iteration	1	$25.00
PCB Components	1	$21.00
Power Supply	1	$42.00
Ch376 USB Module	1	$6.99
Total		$2,903.52
Total (Self Bought)		$252.20

Conclusion

- Project meet our goal and specification
- Our sponsor pleased with the final result