Self-Contained Dye Laser Cavity for UV Sunscreen Absorbance Testing

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Introduction

- Absorption testing
- Measure optical power before and after the object in question
- Typically done with arc lamps or filament bulbs

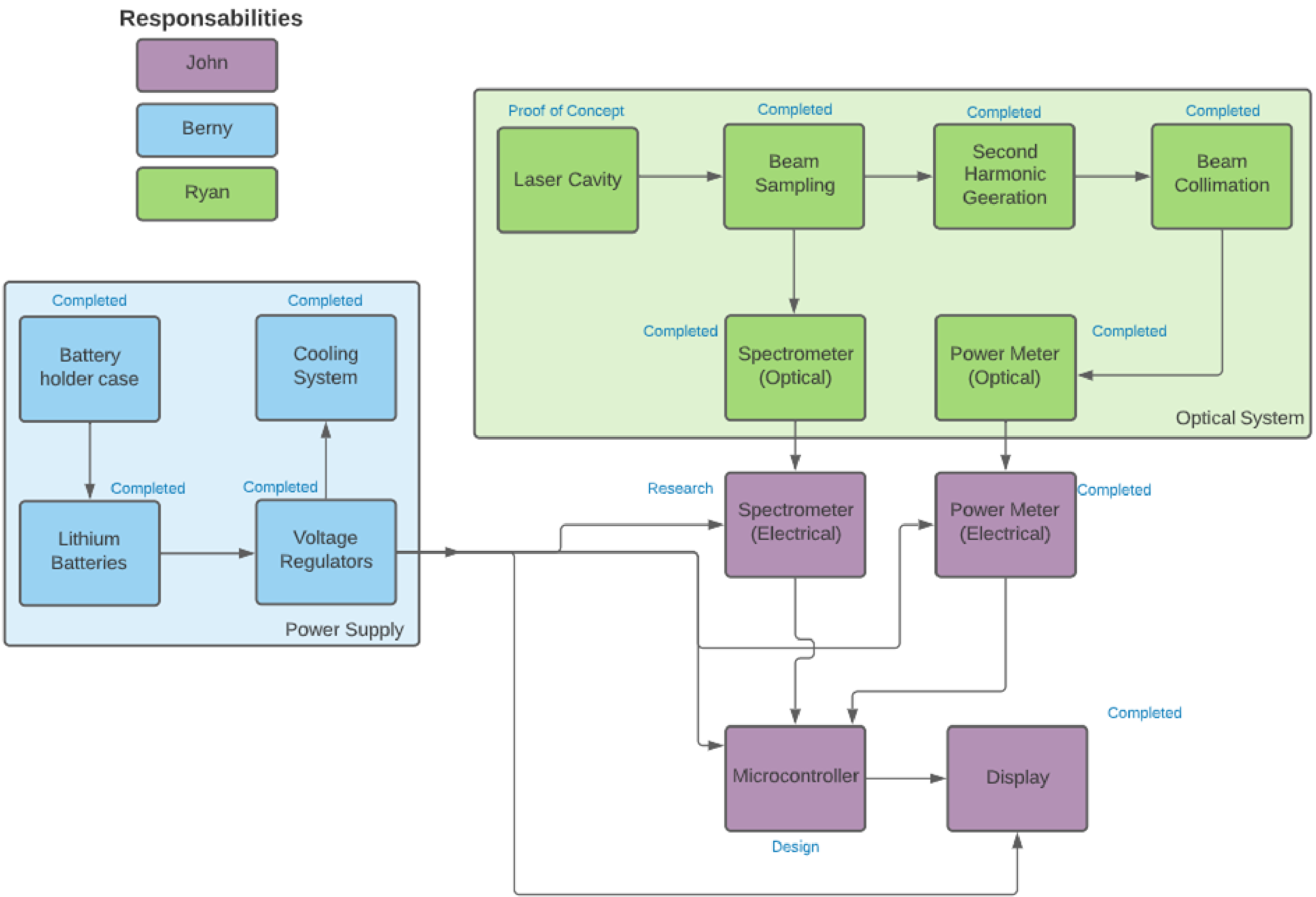
Goals/Objectives

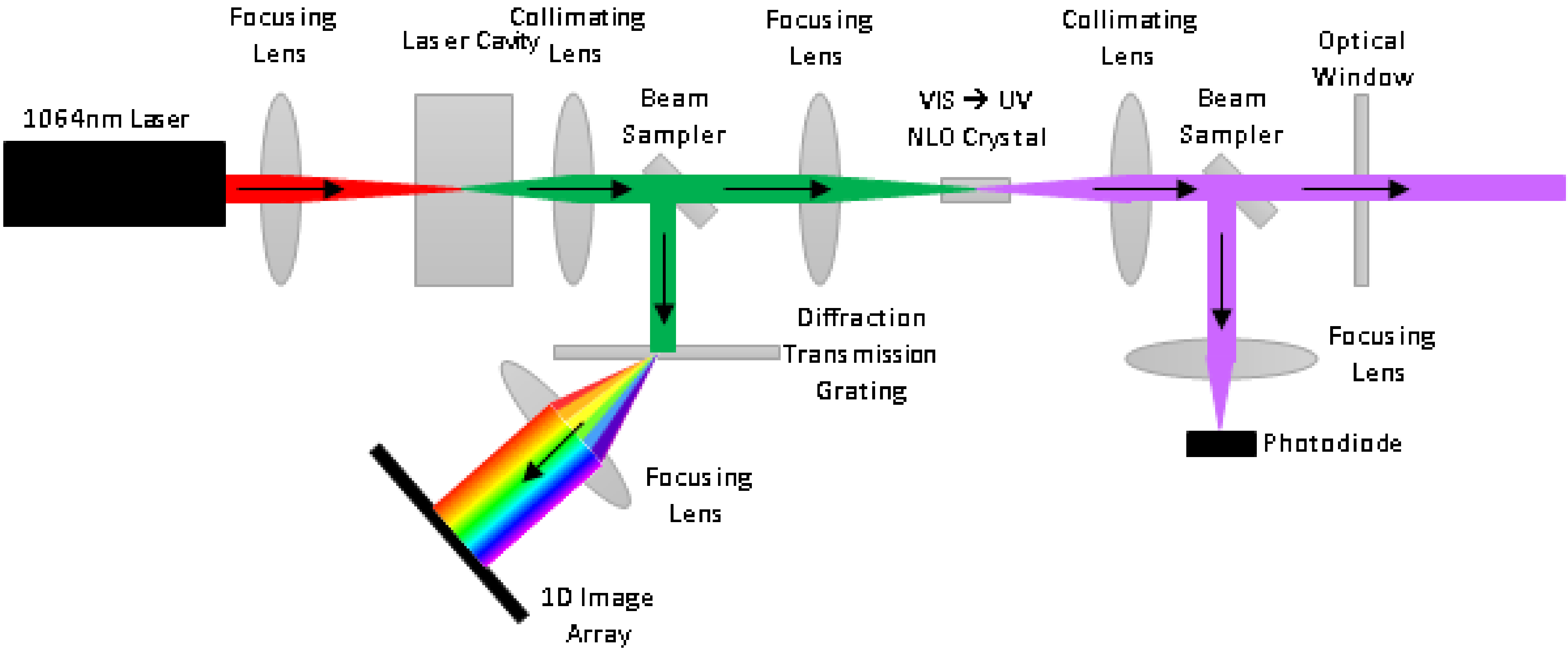
- Swappable, refillable, VIS laser dye cavity
- NLO conversion from VIS to UV
- Built-in VIS spectrometer and UV optical power meter
- Laser and battery information displayed to user
  - Wavelength
  - Optical power
  - Battery percentage
- Rechargeable battery
- Easy to use

	Goal	Outcome
Output Optical Power	1+ mW	Unknown
Laser Profile	Gaussian	N/A
Operating Time	>8 hr	20.5 hr
Total Drawn Current	<2.8 A	>.3105 A*
Recharge Time	<12 hr	Unknown
Charge Cycles	>500	>300
Weight	<16.5 lb	<1 lb
Volume	<6000 cm^3	15.905 cm^3**
Price	~$1,500	~$1,022.36

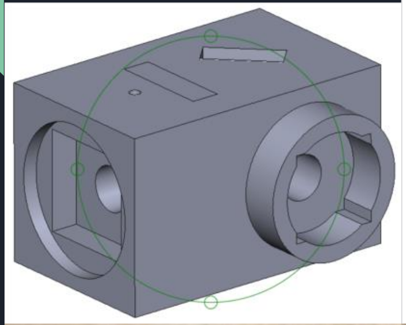
*from design without photodiode circuit
**optical only

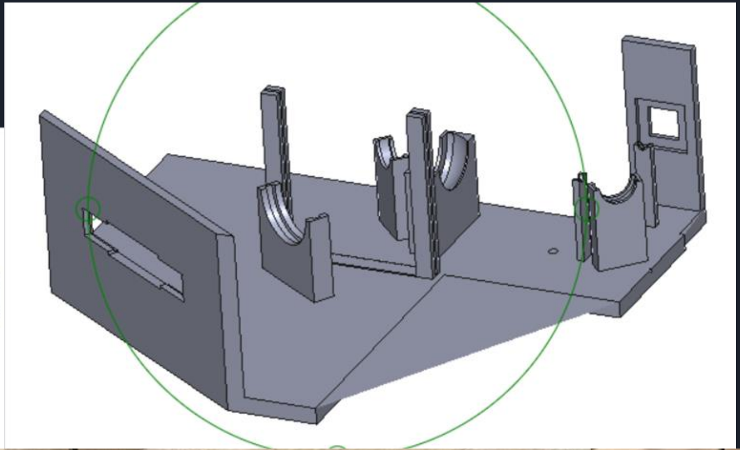
Hardware Block Diagram

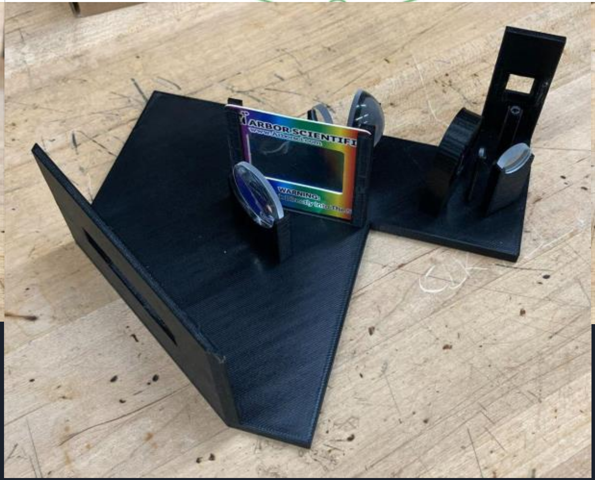




Focusing Lens
Laser Cavity
Collimating Lens
Focusing Lens
Collimating Lens
Optical Window
1064nm Laser
Beam Sampler
VIS → UV NLO Crystal
Beam Sampler
Diffraction Transmission Grating
Focusing Lens
Photodiode
Focusing Lens
1D Image Array



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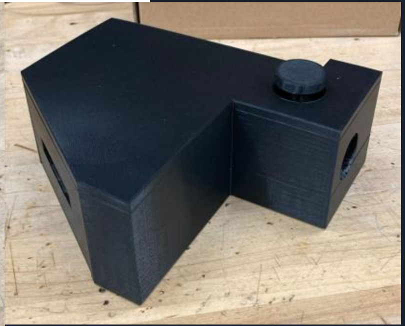
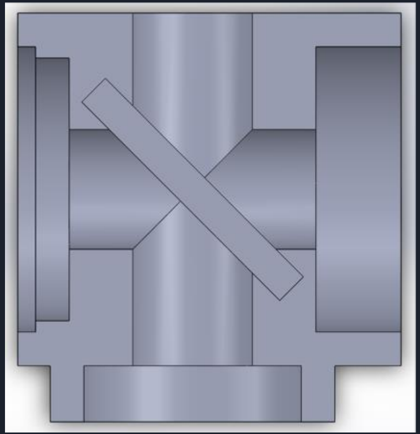
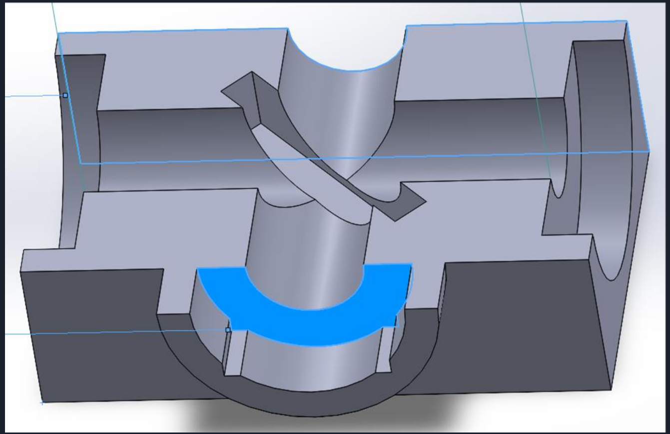
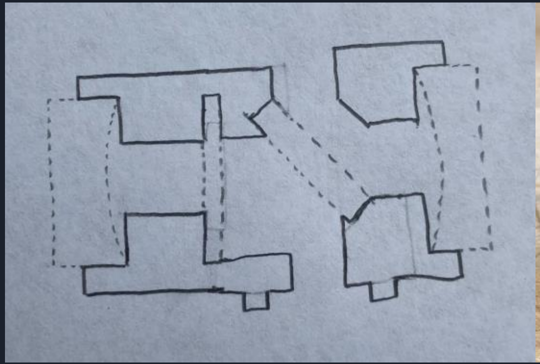


Cavity







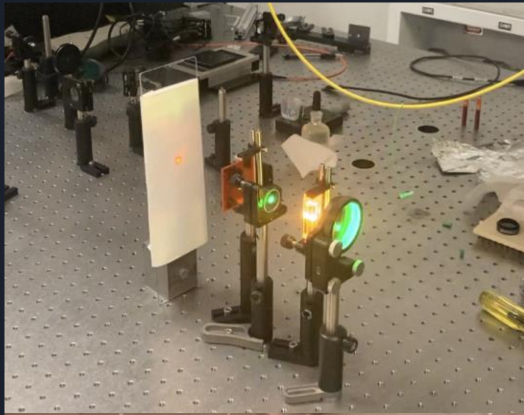
Cavity cont.

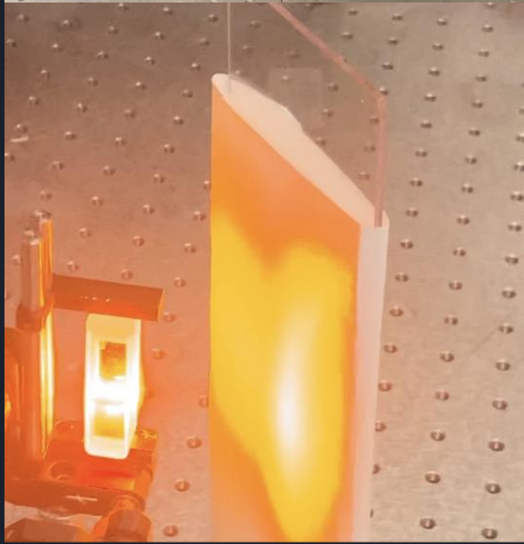
Issues

- Not enough pump power
- Not fast enough pulsing
- At high concentration: lasing in cuvette would come out the side
- At low concentration: cavity optics not strong enough

Solutions

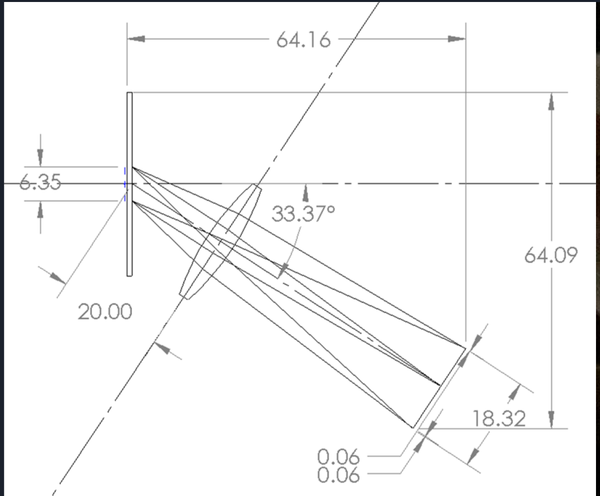
- High concentration
  - Use lasing output from side of cuvette
  - Very messy beam
- Dropping dye cavity entirely
  - Project turns into a modular system to attach to a VIS laser

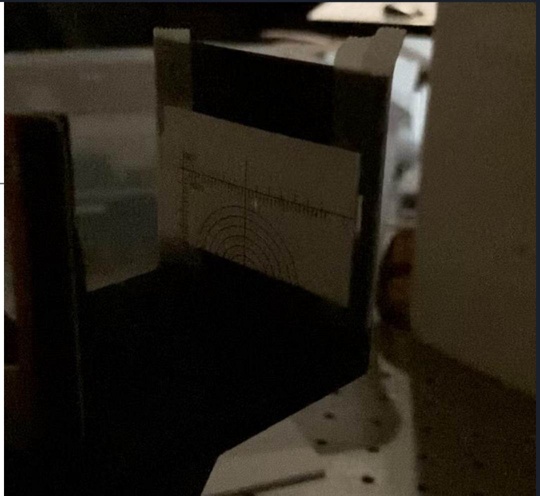




Spectrometer

- Has been working optically since midterm demo for SD1
- Unable to test resolution due to incomplete sensor circuit
  - Predicted .1150nm/pix at center and 1.035nm/pix at edges
- It is predicted that some changes would be made during testing to the sensor’s longitudinal location to even out blurring from spherical aberrations



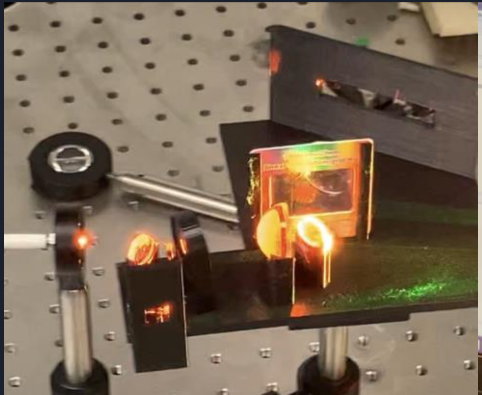


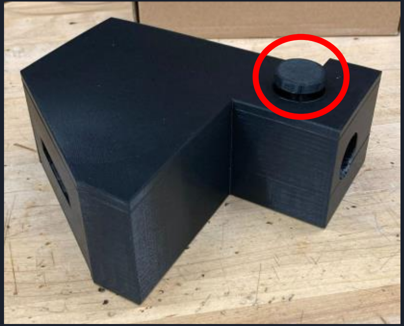
VIS -> UV

- Tested successfully with powerful input source
- Theoretically, lower input sources would still successfully produce UV light, though at lower powers

Issues

- Conversion efficiency could not be tested due to limited access to pump source and oversaturation of measuring devices when reading both VIS and UV through the BBO
- It is possible that some wavelengths nearing the bottom of this project’s attempted spectrum (nearing 400nm) would not work due to the BBO housing limiting accepted incident angles



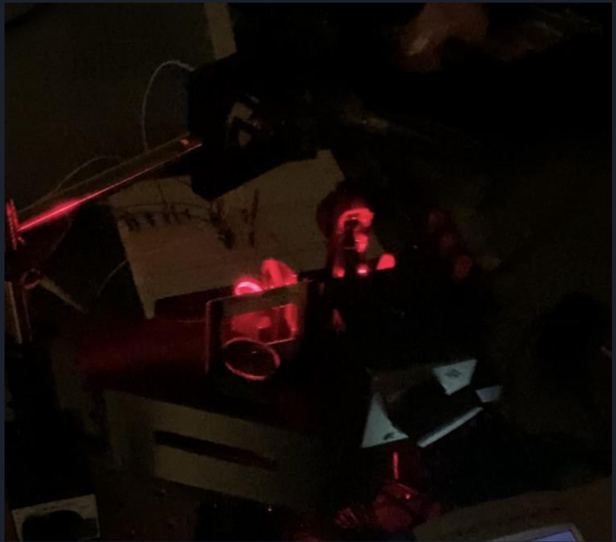


Optical Power Meter

- Light properly focused to sensor
- Sensor successfully tested for response that is directly correlated to incident power

Issues

- Due in part to communication errors, the part needed to mount the sensor was not acquired, and so this piece was not mountable by our system alone



Power delivery

The power supply will deliver power to:

- Cooling system (Two fans)
- Spectrometer (1-D array sensor)
- Power meter (transimpedance circuit)
- Microcontroller
- The display.

Power Supply Design

Battery powered with rechargeable Li-ion batteries

Battery holder case

Voltage Regulators

Cooling System

Microcontroller power connection circuit

Power supply setup

- Two batteries connected in parallel
- Switch to turn on and off microcontroller, sensors and display.
- Voltage regulators feed each component which requires power
- Connection from regulators to microcontroller power circuit connection

Voltage regulators

- The 3.3V step-down regulator using the XCL210C331GR-G IC
- Connected to the 5V regulator output
- Powers the MSP430FR6989 microcontroller DVCC and AVCC pins.
- The IC was found through a parts supplier and the regulator was design with the aid of the datasheet directions and specifications

Voltage regulators

- The 5V step-down/step-up regulator using the LM2698MM-ADJ/NOPB IC
- Connected directly from the 3.7V batteries
- Powers two fans in the cooling system and the LCD display
- Designed using TI Webench Power Designer

Voltage regulators

- The 12V step-up regulator using the XC9143B10DER-G IC
- Connected directly from the 3.7V batteries
- Supplies power to the transimpedance circuit for the photodiode used as the power meter as well as the 1-D array spectrometer.
- The IC was found through a parts supplier and the regulator was design with the aid of the datasheet directions and specifications

Transimpedance circuit

- Consists of photodiode connected connected to op amp with a feedback capacitor and bypass capacitors.
- It was tested with 650 nm light. The optical power and voltage were directly proportional.
- The transimpedance circuit was completely built but was not soldered and could not record the video in time for the demo

Image sensor

- The image sensor included 5340 elements across each line
- Each line has a different sensitivity to light of uniform color temperature
- The typical output signal frequency is 1 MHz and most pins required this frequency
- Could be in bit clamp mode or line clamp mode

Code for Image Sensor

- Repetitively samples voltage and converts it to integer
- Repetitively converts ADC value to float and then multiplies it by the gain
- Highest value is left after loop
- Position in the array determines the position along the x-axis to find wavelength
- Display as integer on the LCD

Code for Transimpedance Circuit

- Converts ADC converted value to float and then multiplies it by the gain.
- The gain is dependent on the frequency
- Using laser with known frequency and the responsivity provided by the manufacturer
- Display as float on the LCD

Issues interfacing with the image sensor

- The timing of the pulse signals were too small and the microcontroller could not reliably create those signals
- Large sinusoidal signals produced by the PWM could damage the component
- Op amp would amplify those signals. Level Shifter may have helped but was not working by presentation

Display

- The display only used 4 pins for data to reduce the number of output pins
- The display is always left in read mode
- 0.5 V on the contrast pin was the optimal voltage for reading characters.