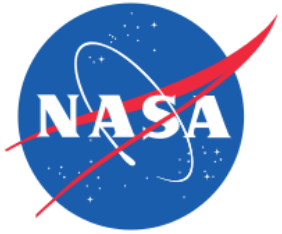


Development of Next Generation Fiber Optic Sensing System

SKYLER SZOT

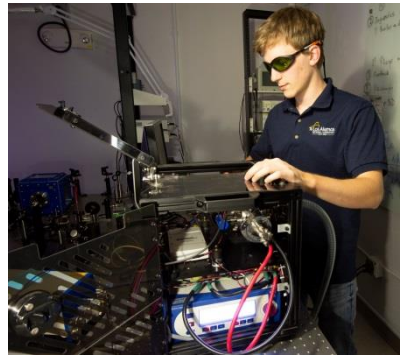
CODE 540: SENSORS AND SYSTEMS DEVELOPMENT

MENTOR: ALLEN PARKER

Skyler Szot

Trinity College
Electrical Engineering
Graduating May 2021

Previous Work:



Summer 2019 – Internship at Los Alamos National Laboratory

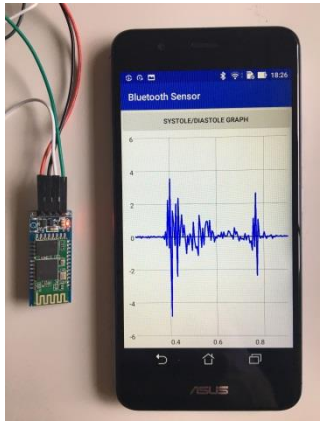
- **"Actinide Isotopic Analyzer"**

Fall 2018 – Spring 2019 – NASA Connecticut Space Grant

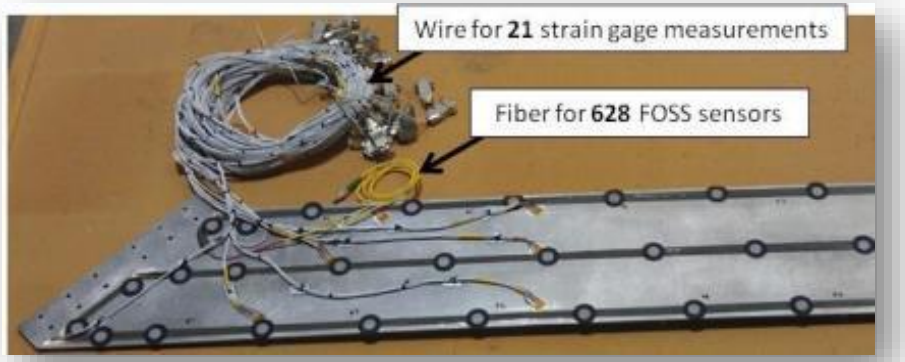
- **"Helicopter Vibration Analysis Through Spectral and Chaotic Methods"**

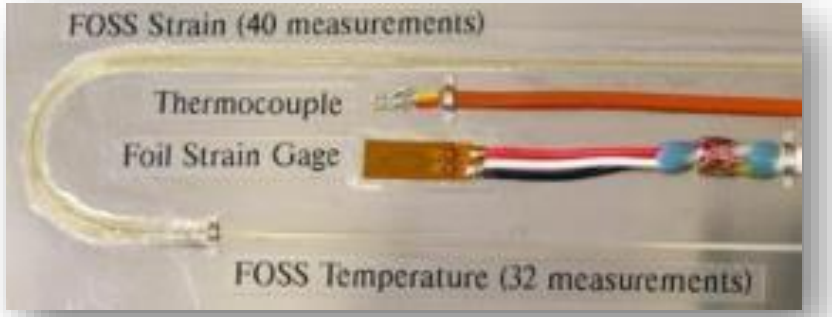
Summer 2018 – Published at the International Conference of Signal Processing (ICSP) in Beijing, China

- **"A Wireless Digital Stethoscope Design"**



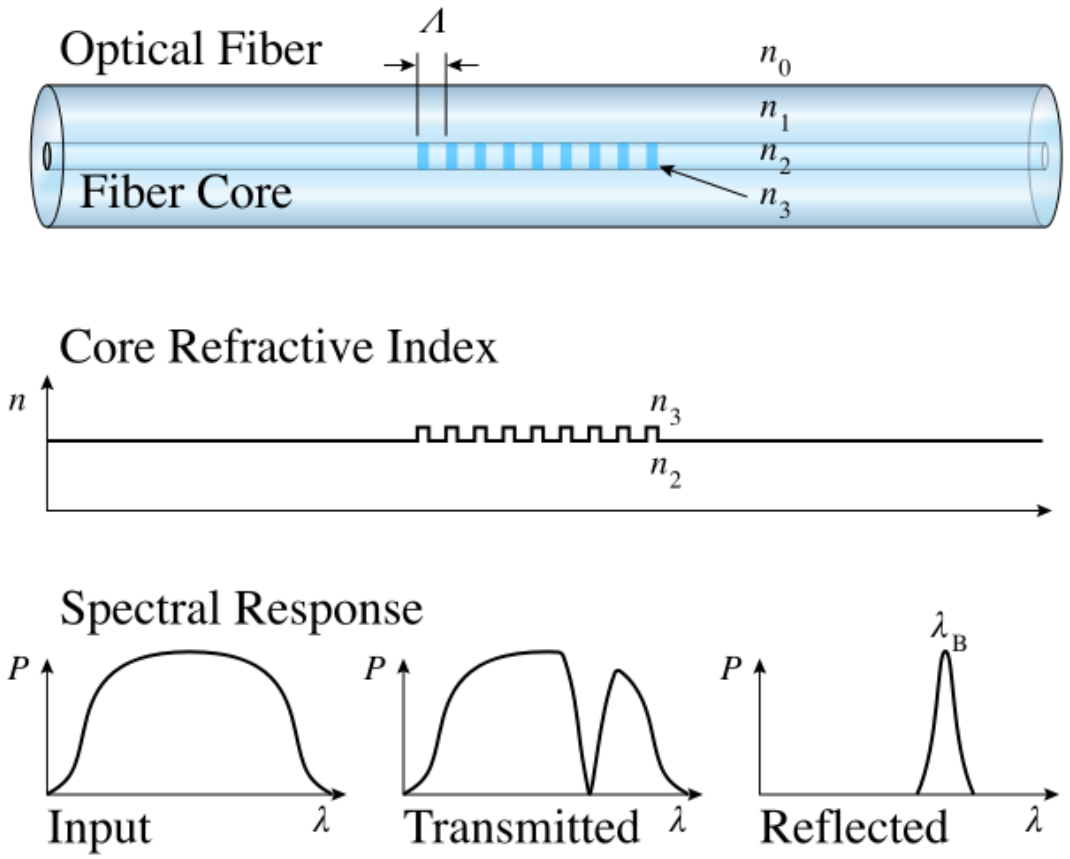
FOSS vs Resistive Gauges





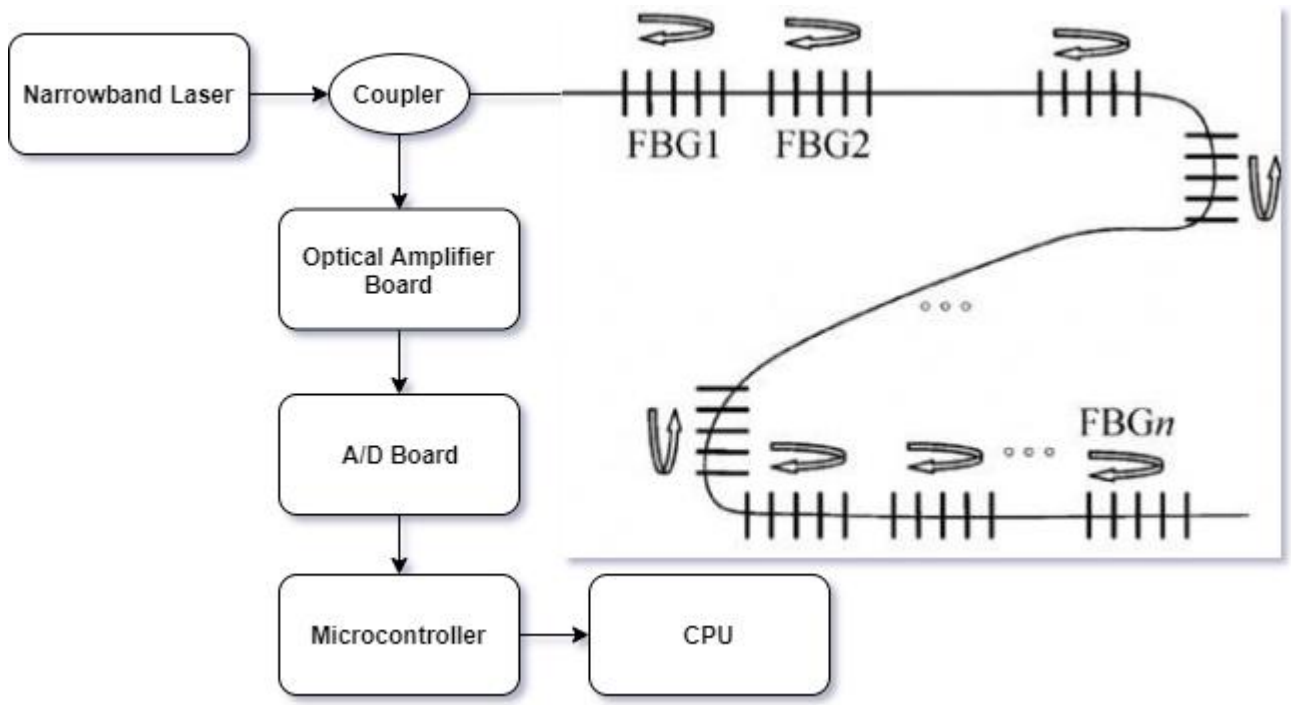
Fiber Bragg Grating (FBG)

- Fiber Reflector that reflects a particular wavelength and transmit all others
- Bragg Wavelength: $\lambda_B = 2n_e\Lambda$
- ρ = strain-optics coefficient
- Strain (ε) = $\frac{\Delta\lambda_B}{\rho \cdot \lambda_B}$



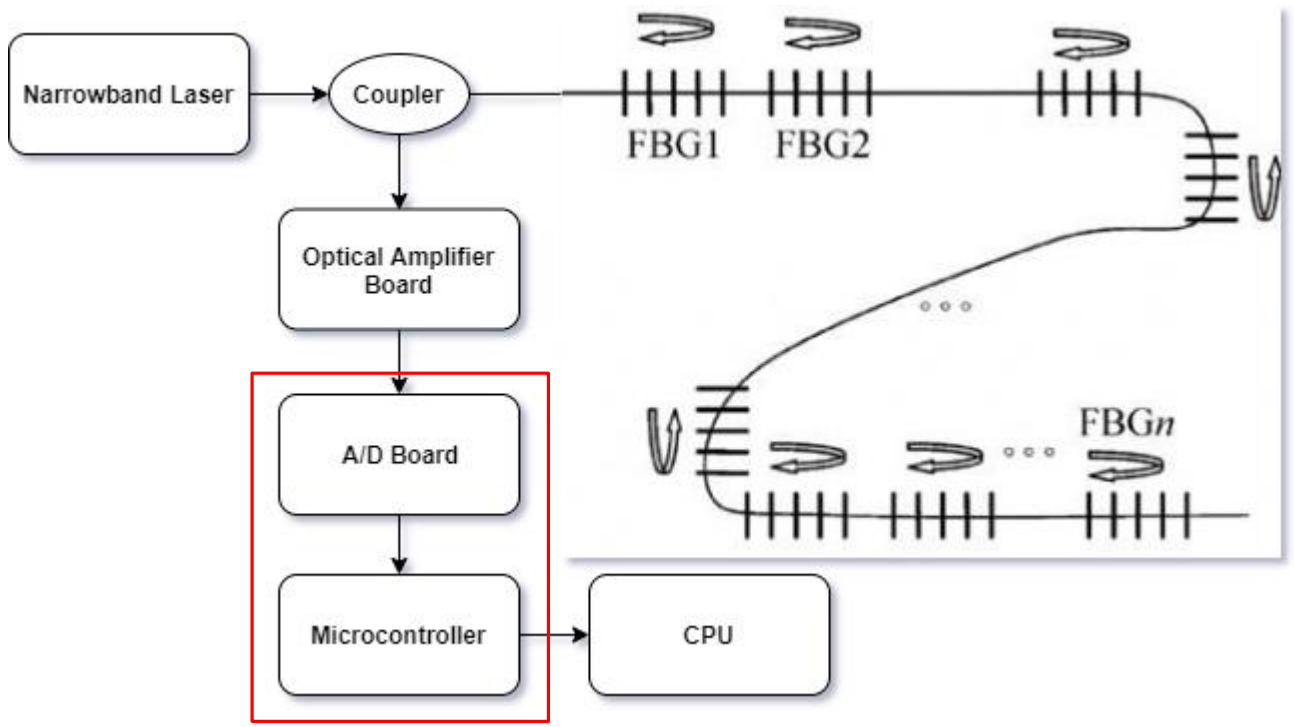
Temperature Tuned FOSS

- Temperature tuned laser
- Slower scan rate
- Lower cost
- Useful for applications like liquid level monitoring, temperature measurements, and static strains
- Cryogenic fuel management



Temperature Tuned FOSS

- Temperature tuned laser
- Slower scan rate
- Lower cost
- Useful for applications like liquid level monitoring, temperature measurements, and static strains
- Cryogenic fuel management



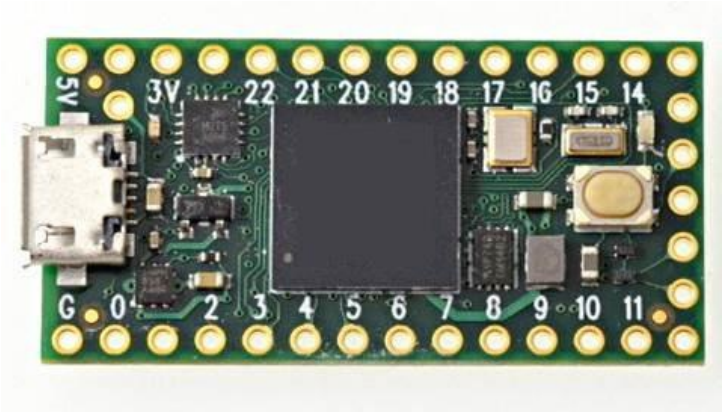
Analog to Digital Converter (ADC)

ADC Requirements:

- >50 kHz sample rate
- 8 channels simultaneously sampled
- 16 bit resolution

Microcontroller:

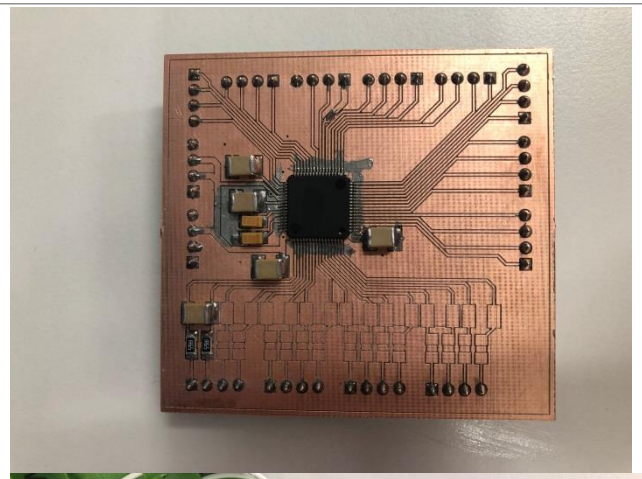
- 600 MHz clock
- 40 digital / 14 analog pins
- 3 SPI ports
- 1 USB port

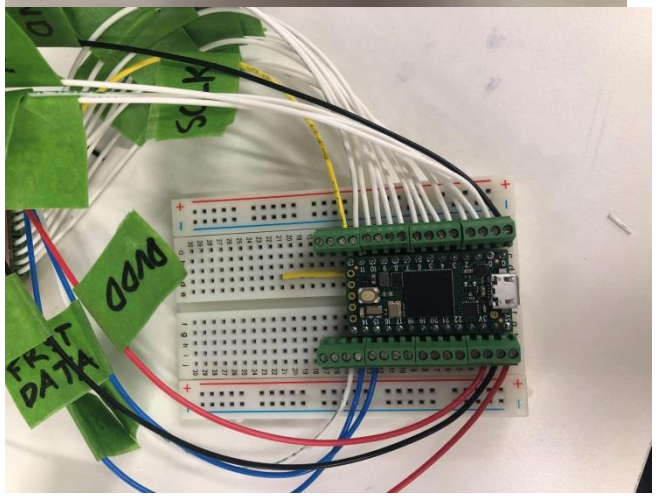


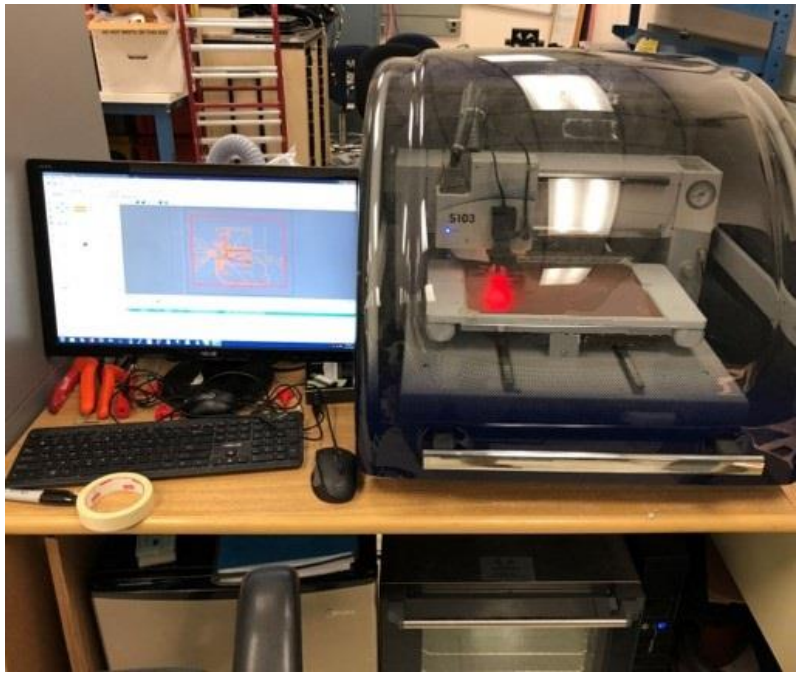
PCB Prototyping

PCB Version 1:

- Separate ADC and microcontroller
- Designed with CAD software
- Worked intermittently, suspected bad connections
- Learned I had to use the SPI interface, and serial data read operation



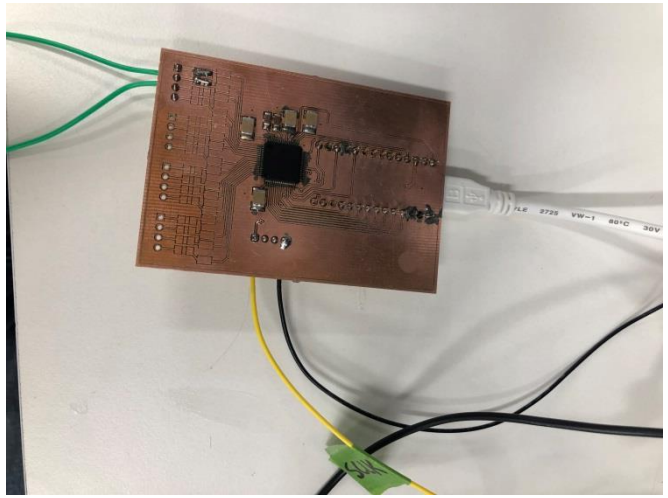


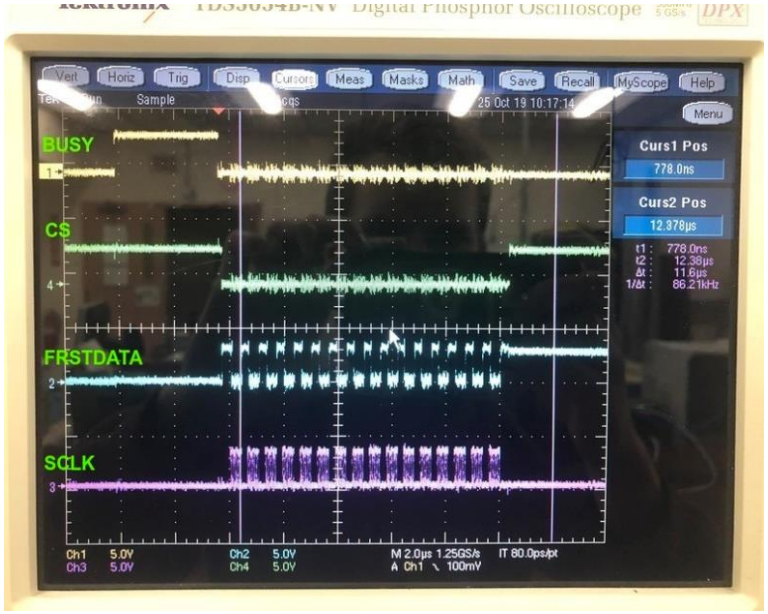


PCB Prototyping

PCB Version 2:

- Integrated ADC and microcontroller on one board
- Still working intermittently, suspected grounding problem
- Learned connections were not the issue

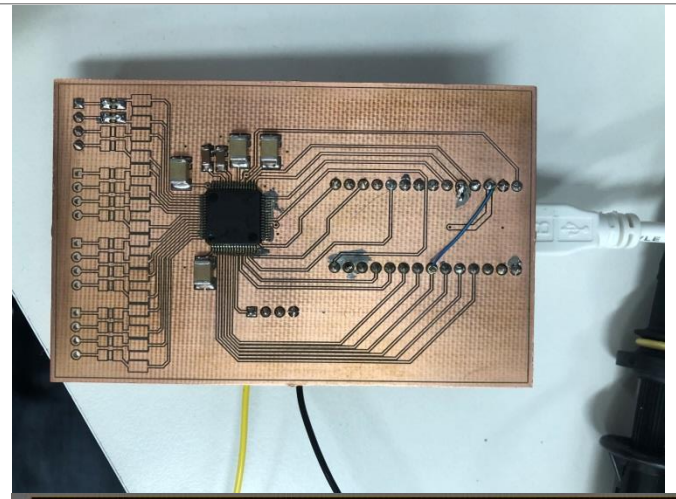


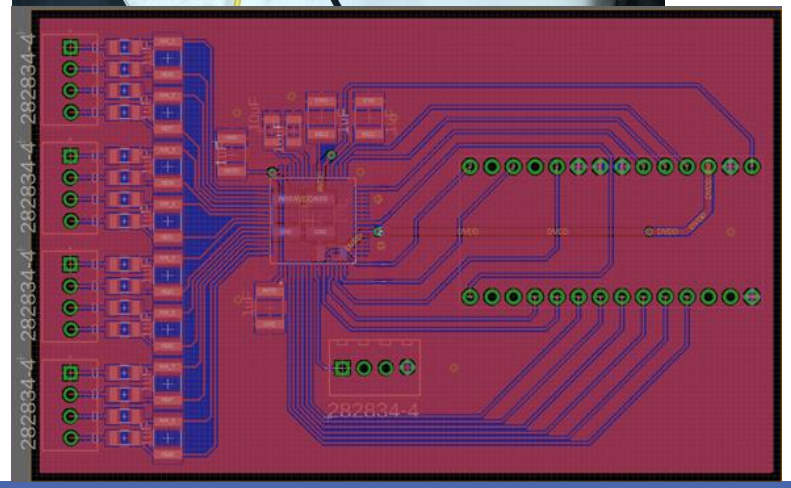


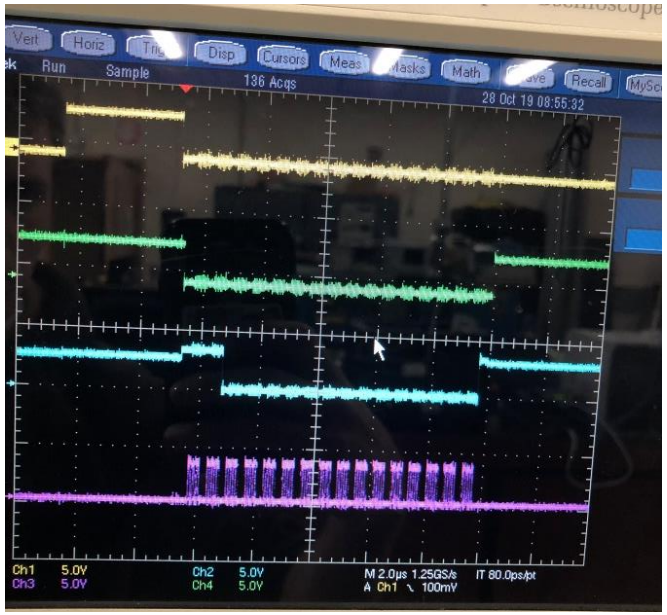
PCB Prototyping

PCB Version 3:

- Refined board, minimized path length, avoid vias, maximize trace spacing
- Inspected digital pins with scope
- Needed to tie digital pins directly to 3.3V or GND



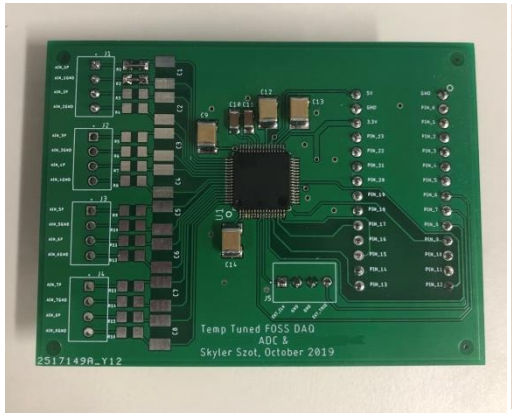


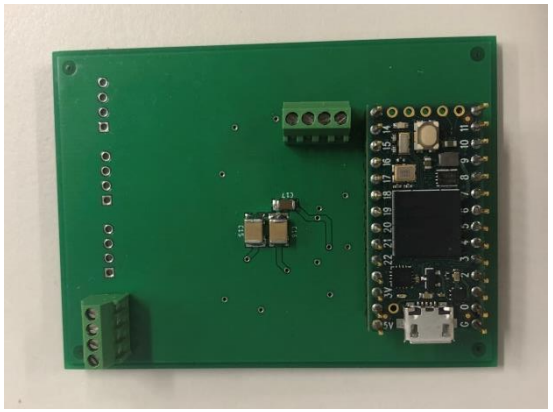


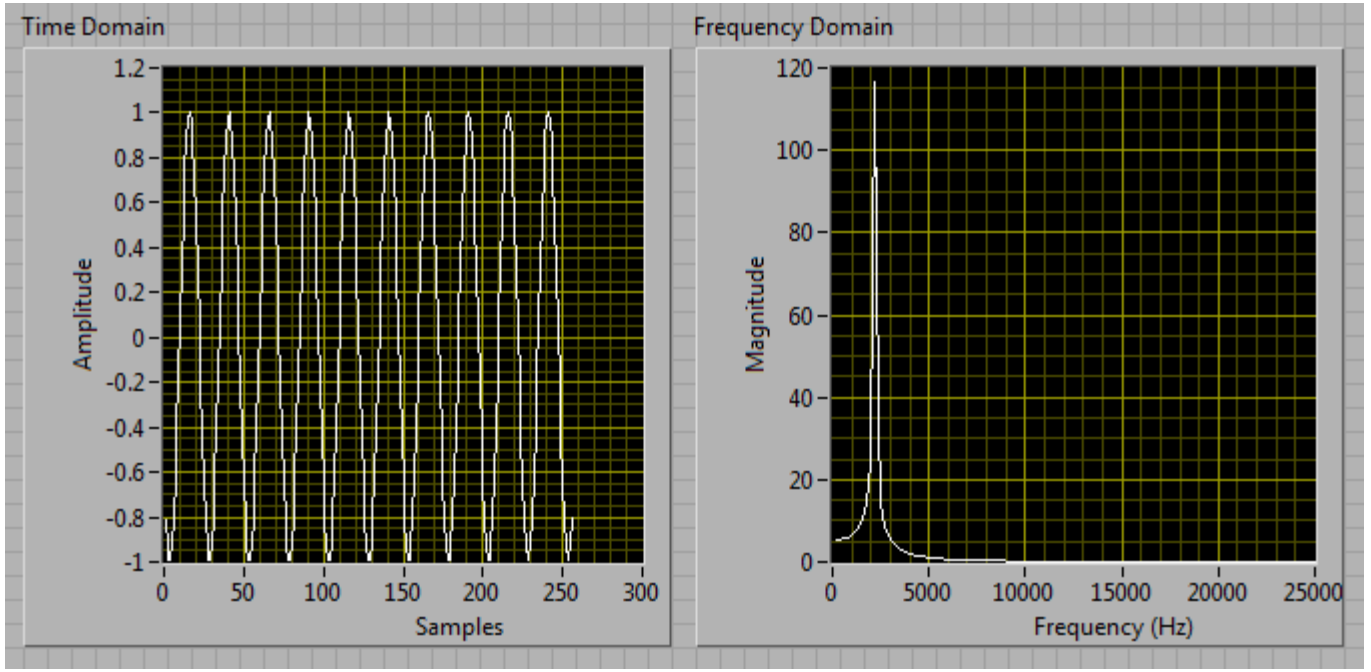
PCB Prototyping

PCB Version 4:

- Ordered boards online
- User interface
- User requests amount of data
- Plots data in time and frequency domain







Left: 256 samples of a -1V to 1V, 2kHz sine wave, sampled at 50kHz
Right: Fast Fourier Transform (FFT) of the time domain data

PCB Prototyping

PCB Version 5:

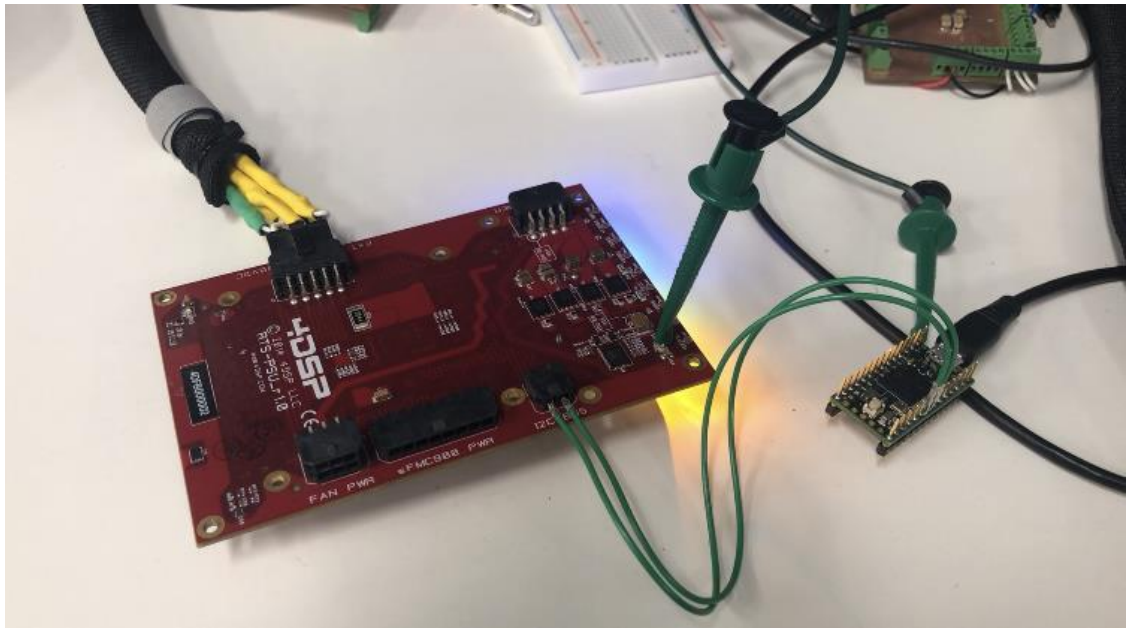
- Put chips on component side of board
- Added LED indicators and extra digital ports
- Designed analog filters for input channels

Final Specifications:

- 83kHz max sampling rate
- 8 channels simultaneously sampled
- 16 bit resolution
- USB serial interface
- Approximate cost: $50
- Savings of $400 per unit vs industrial DAQ system

Rocket Box

- Power Board for Rocket Box
- First FOSS application for space, ULA Vulcan
- Used a microcontroller and I2C serial interface to power ON/OFF the laser
- Will be integrated into software to disable laser when overheating



Key Takeaways

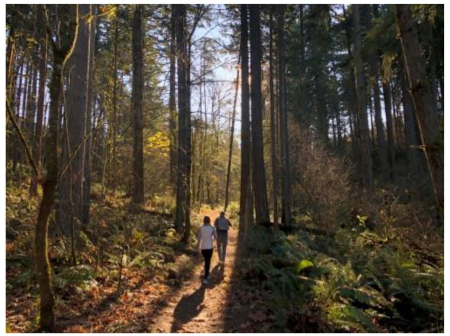
- Use the scope properly
- Government can be slow
- NASA is super cool
- California is awesome

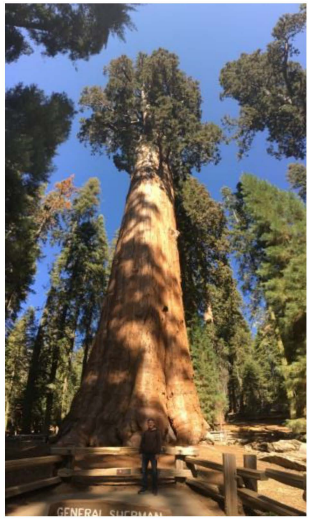
Next Steps:

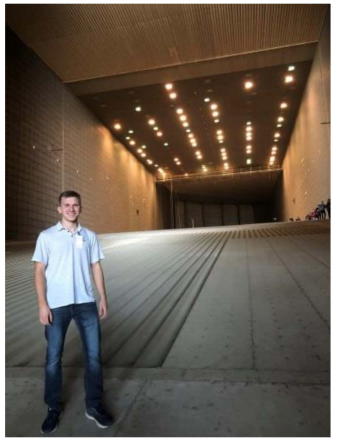
- Integrate and test entire system
- Populate more boards
- Combine ADC board, CPU, and optical amplifier into single board

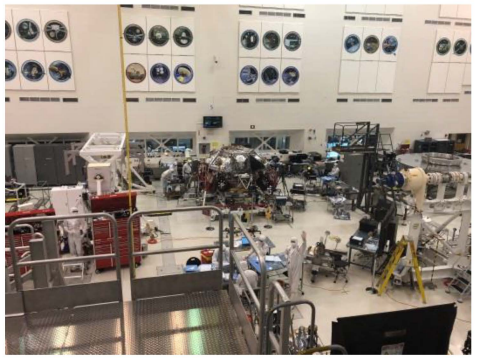
Knowledge gained:

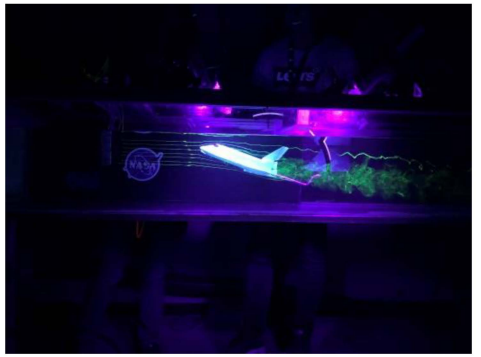
- General knowledge of space and aerospace
- NASA soldering certification
- PCB design and manufacturing
- Integrated circuits and microcontrollers
- LabVIEW, Arduino, C, Python
- Serial communication











Future Work

- Study abroad Spring 2020 at KU Leuven in Belgium
- Researching with Marc Moonen, a professor of signal processing
- IEEE fellow, president of the European Association for Signal Processing, previously worked with Bell Labs

Acknowledgements

Allen Parker
Lisa Illowsky
Richard Hang
Paul Bean
Patrick Chan
Frank Pena
Shideh Naderi
Phil Hamory
John Rudy
Jonathan Lopez
John Strenio
Jody White

Questions?