PenGUI

VCSEL Development Kit

What is PenGUI?

- Working with Praevium Research, Inc., a Goleta-based company that researches and develops tunable lasers
- Task: redesign their developer kit user interface, replacing a previous web server approach
- Goal: make the developer kit as **user friendly, functional, and extensible** as possible, while keeping it **fully offline** (for practical and security reasons)
- The Product: a self contained kit used by researchers and developers to experiment with a tunable laser for their application

Applications

- Imaging
  - Non-invasive medical imaging without X-ray e.g. OCT
  - Non-destructive imaging in fragile parts e.g. batteries
- Raman Spectroscopy
  - Chemical detection (e.g. gas detection or mixture composition analysis)
  - Non-invasive glucose monitoring
- Fiber Optic Shape Sensing
  - Structural health monitoring
  - Aerospace
  - Surgical navigation
- LiDAR
- Optical data communication and storage

Development Team

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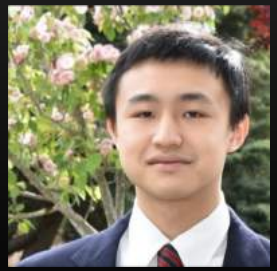
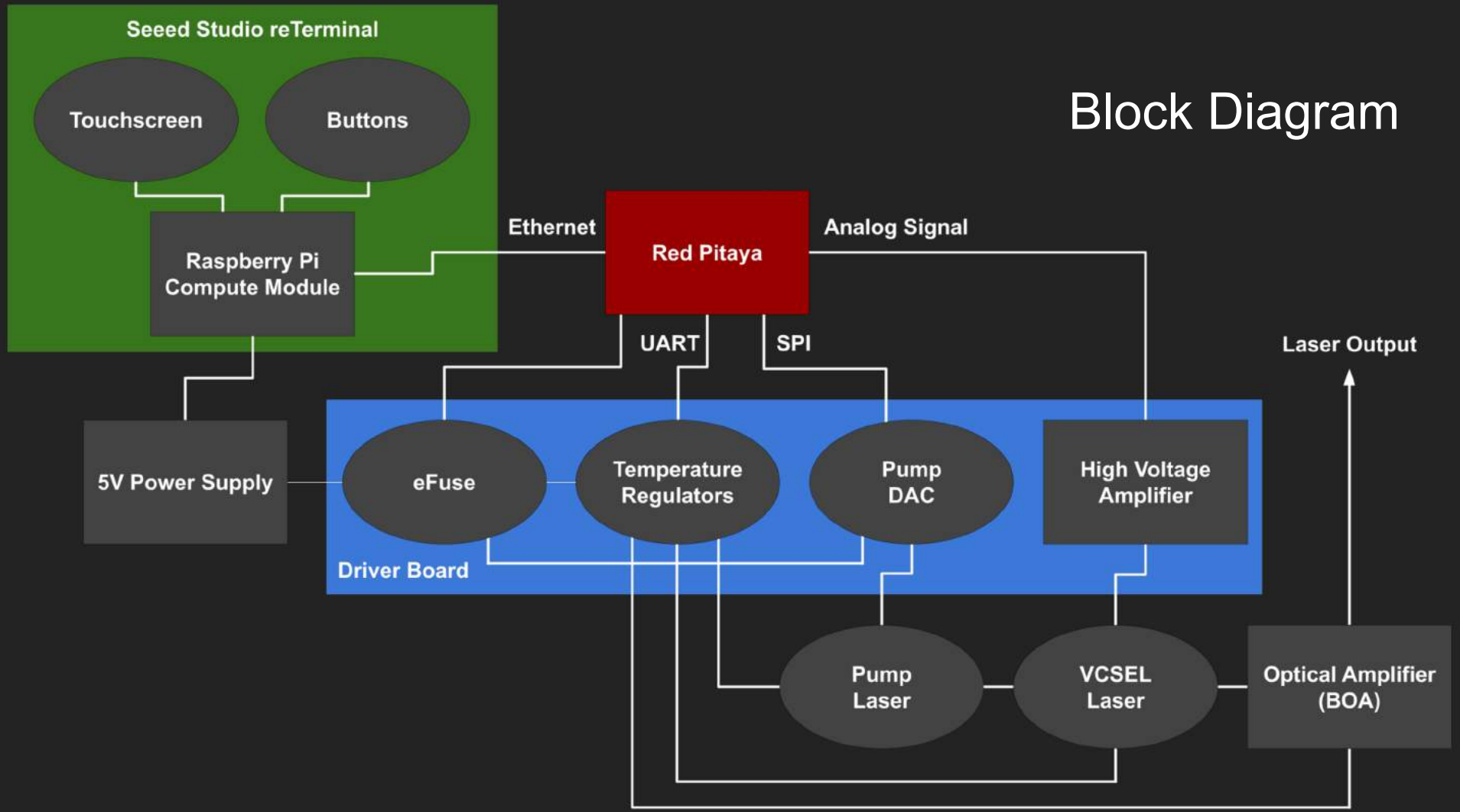


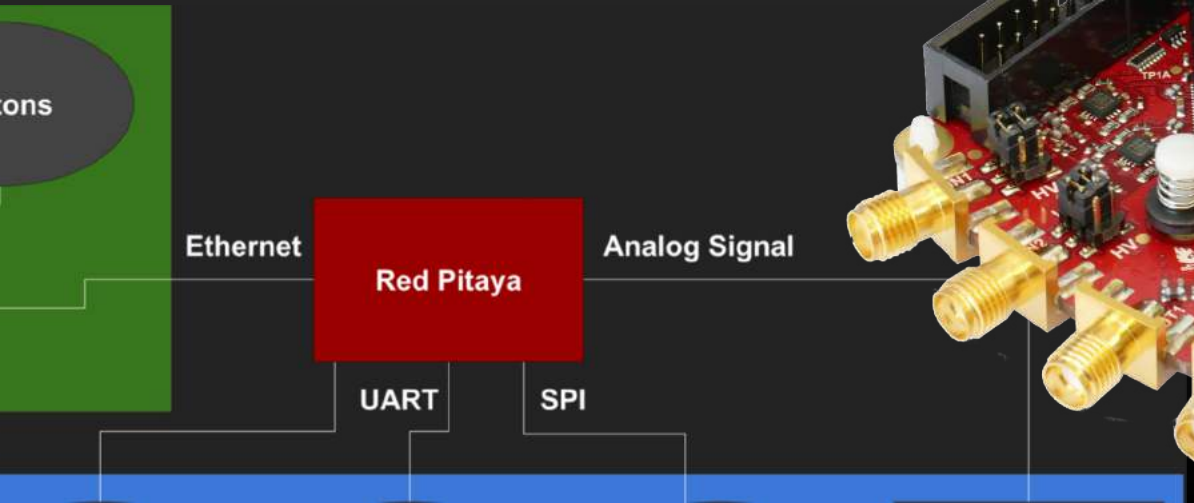
Rodney Li

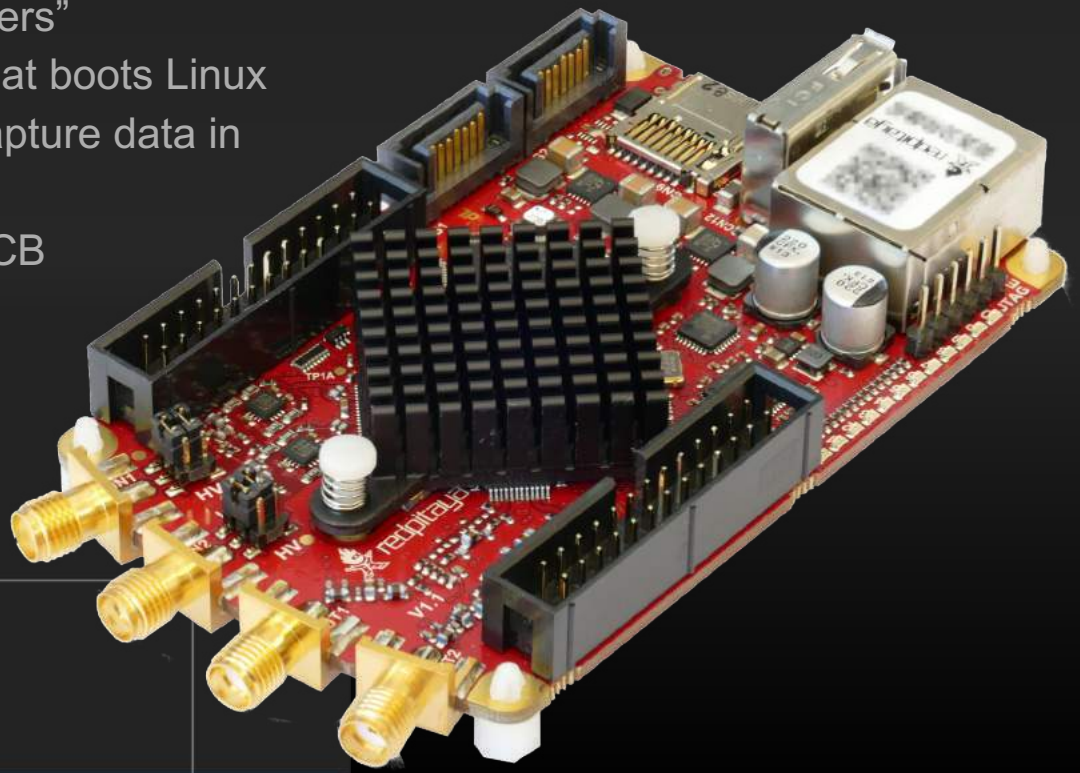
Block Diagram



Components - Red Pitaya

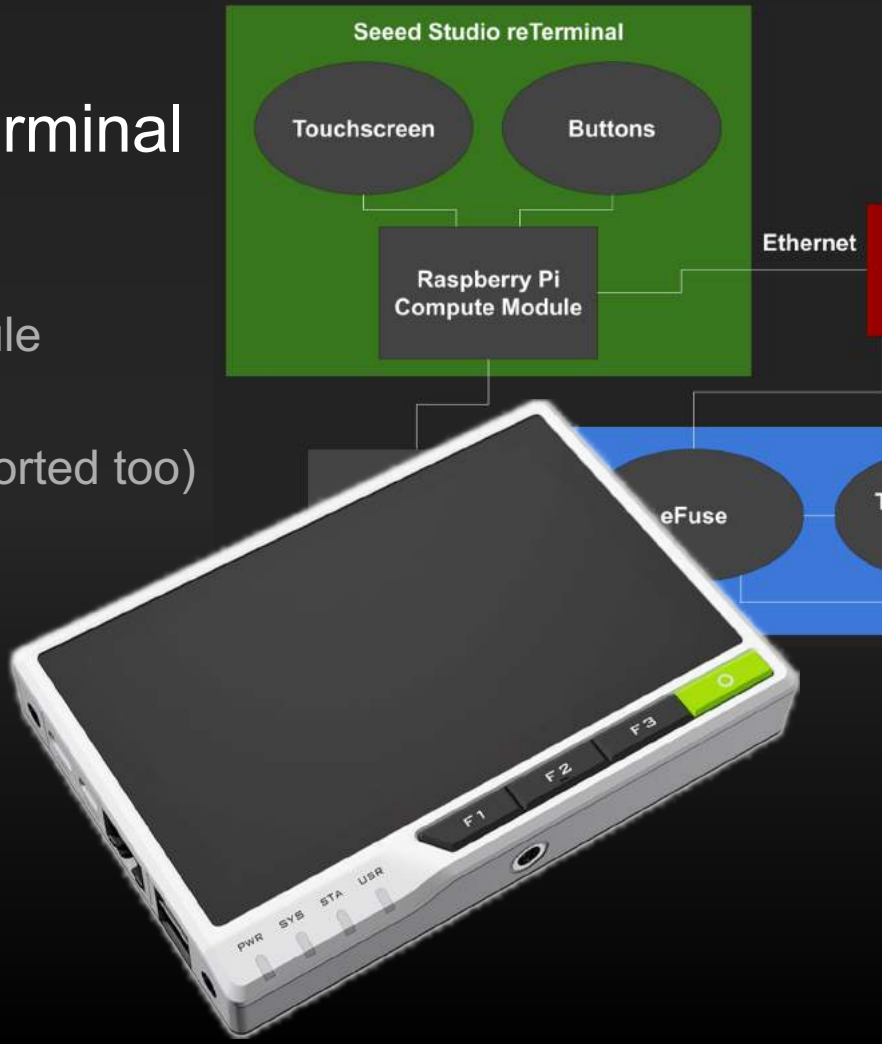
- “The Swiss Army Knife For Engineers”
- On-board FPGA as well as CPU that boots Linux
- Used to control the VCSEL, can capture data in applications
- Optionally replaced with custom PCB





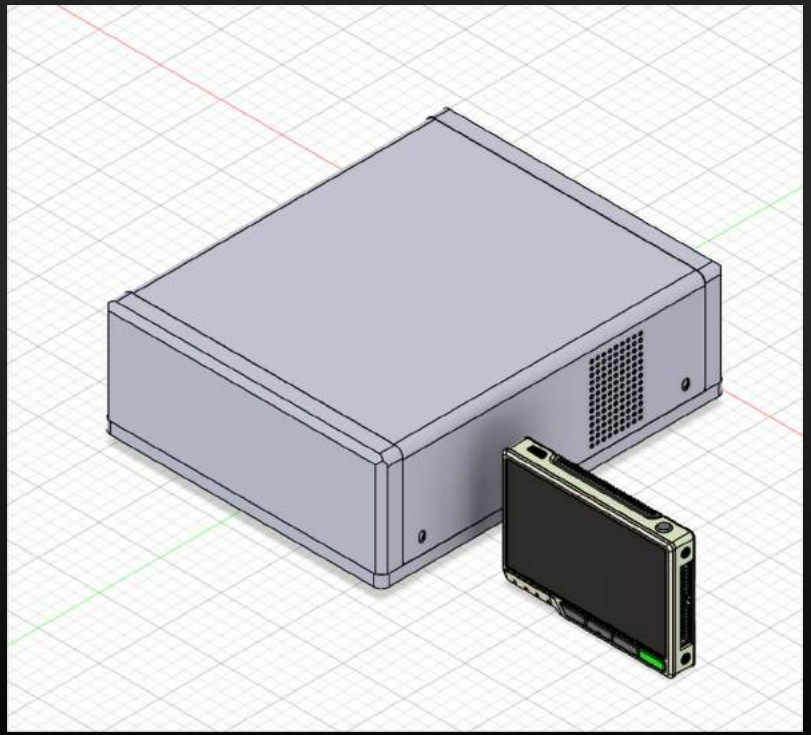
Components - Seed Studio reTerminal

- Off-the-shelf component
- Contains a Raspberry Pi Compute Module
- Touchscreen support
- Ethernet Port (wireless connection supported too)
- USB Ports
- Serves as the interface between user and the Red Pitaya/Laser



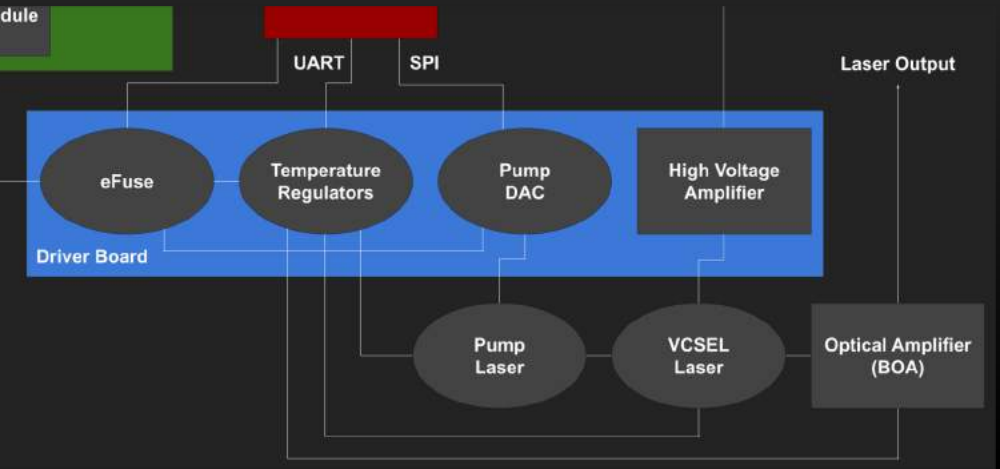
Components - Praevium Enclosure for DevKit

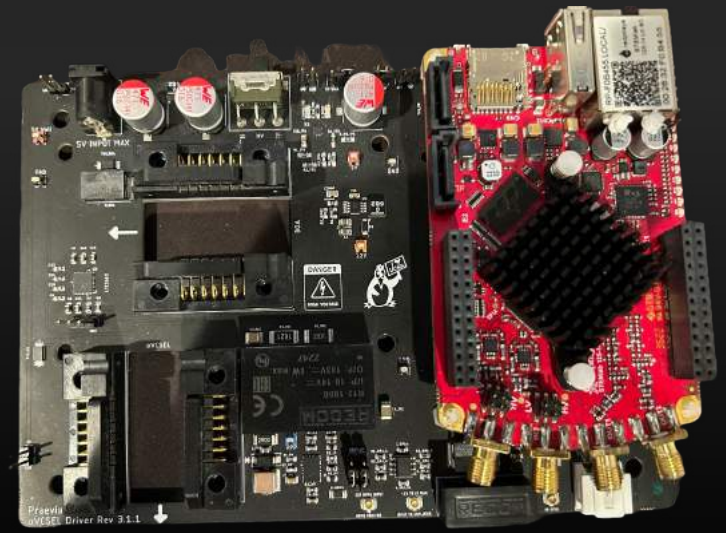
- Houses the entire Devkit that controls the VCSEL
  - Devkit: laser, Red Pitaya, Praevium's PCB
- Designed by Praevium team
- Originally not designed for reTerminal integration



Components - Praevium Devkit/VCSEL

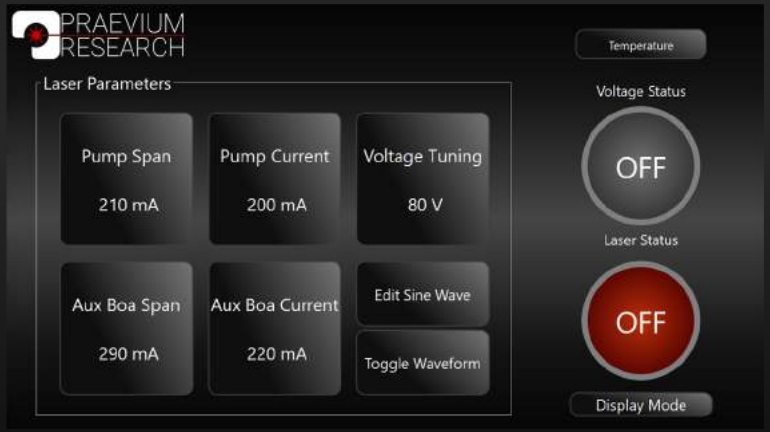
- “Vertical Cavity Surface Emitting Laser”
  - Gas, Solid-State, Fiber, Semiconductor/”Diode” Lasers(Edge emitting and VCSELs)
- Uses as listed earlier
  - imaging, spectroscopy, LiDAR, etc
- Designed by Praevium





Graphical User Interface

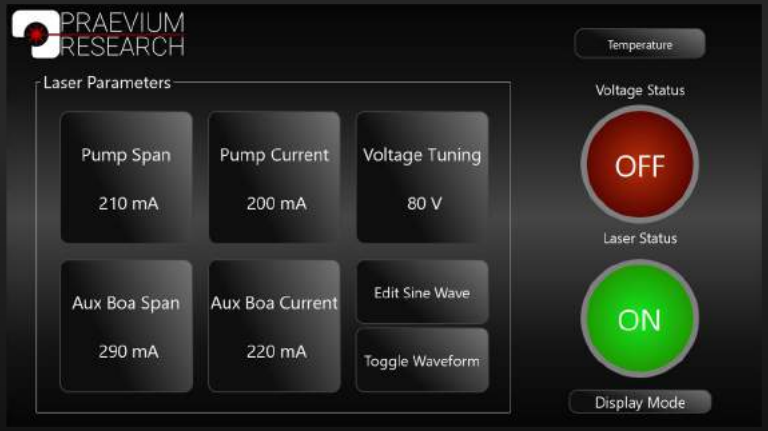
Main Menu Layout



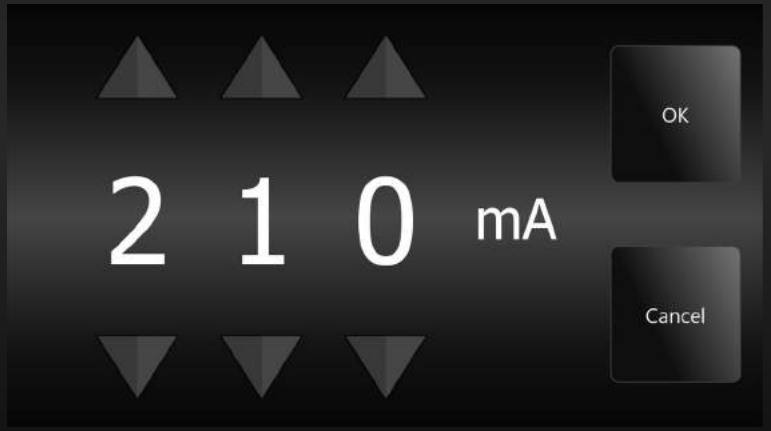
Idle Screen

Graphical User Interface

Touchscreen Friendly Layout

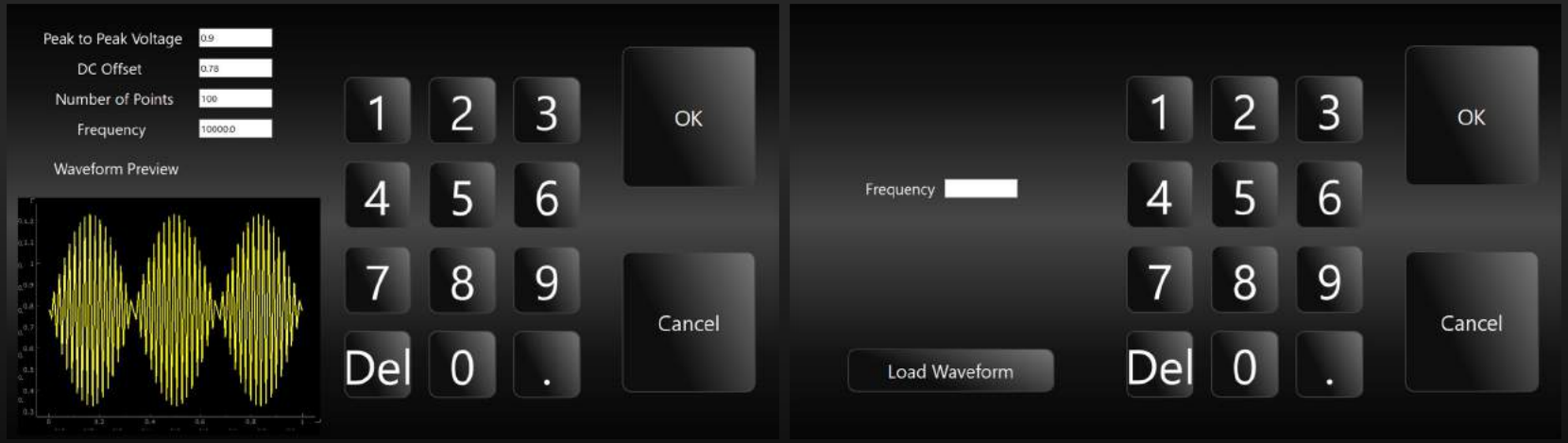


Intuitive Counter Design



Waveform Editing

- Allows for Sine Waves and Arbitrary Waveforms



Temperature Editing

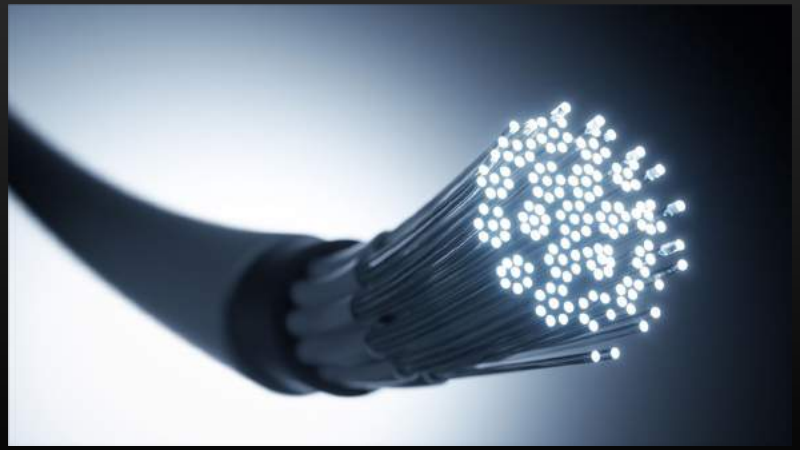
- And temperature manipulation!

Communication

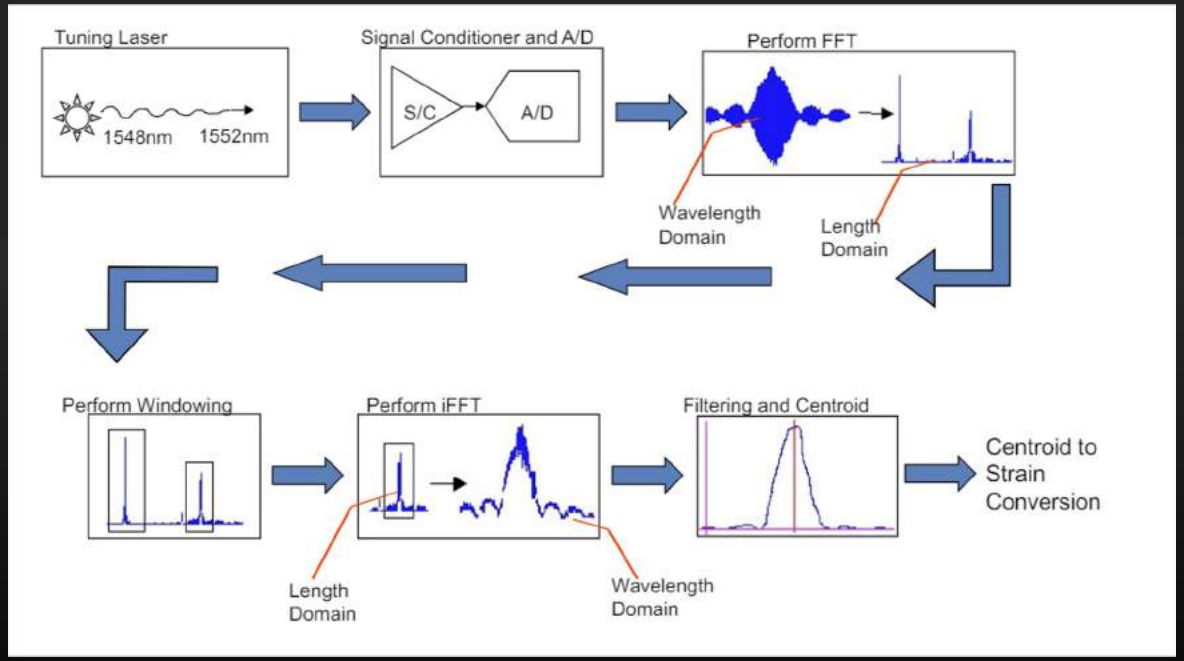
- Parameter changes and waveforms are correctly generated

Demo - Fiber Optic Shape Sensing

- Goal: visualize shape of an object dynamically and in real time
- Equipment: fiber optic cables, Fiber Bragg Gratings(strain sensors), ATS9373 waveform digitizer, NVIDIA RTX 4090 GPU

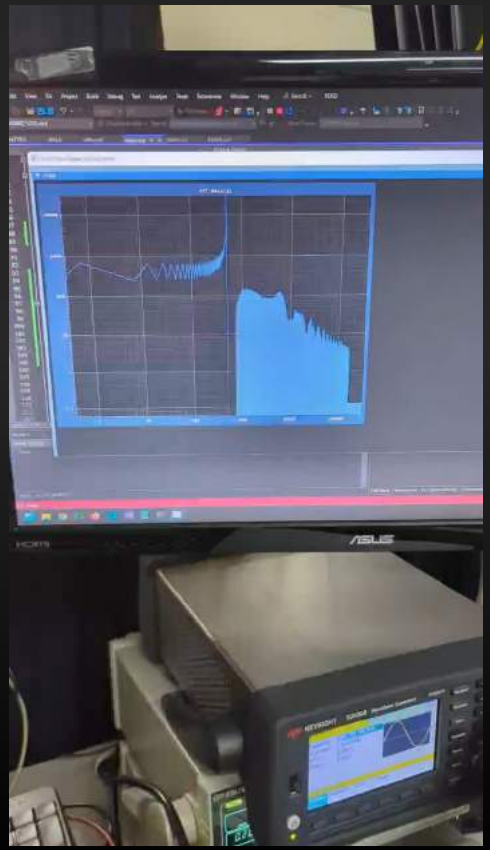


Demo - Fiber Optic Shape Sensing



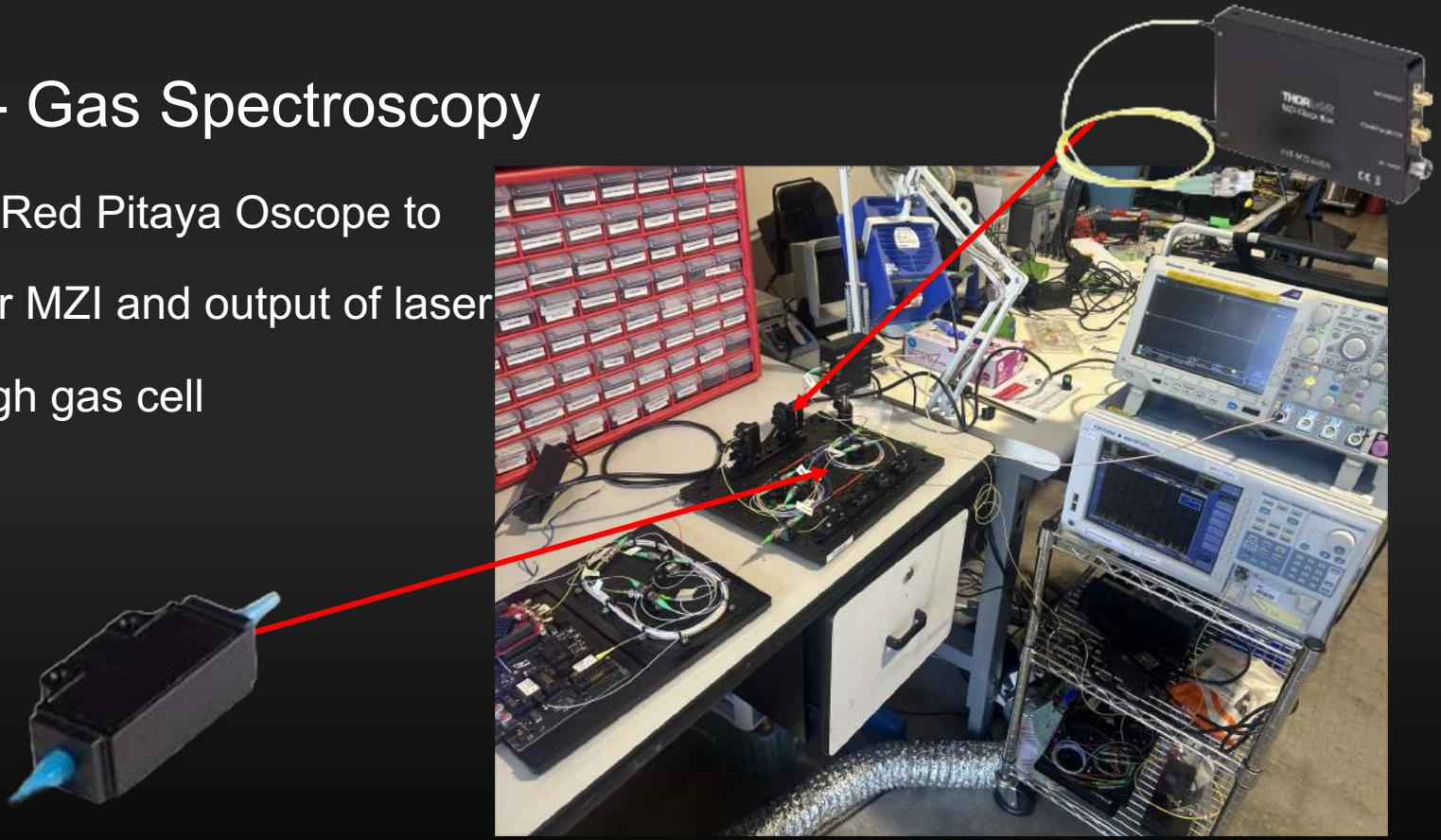
Whole Procedure

Demo - Fiber Optic Shape Sensing

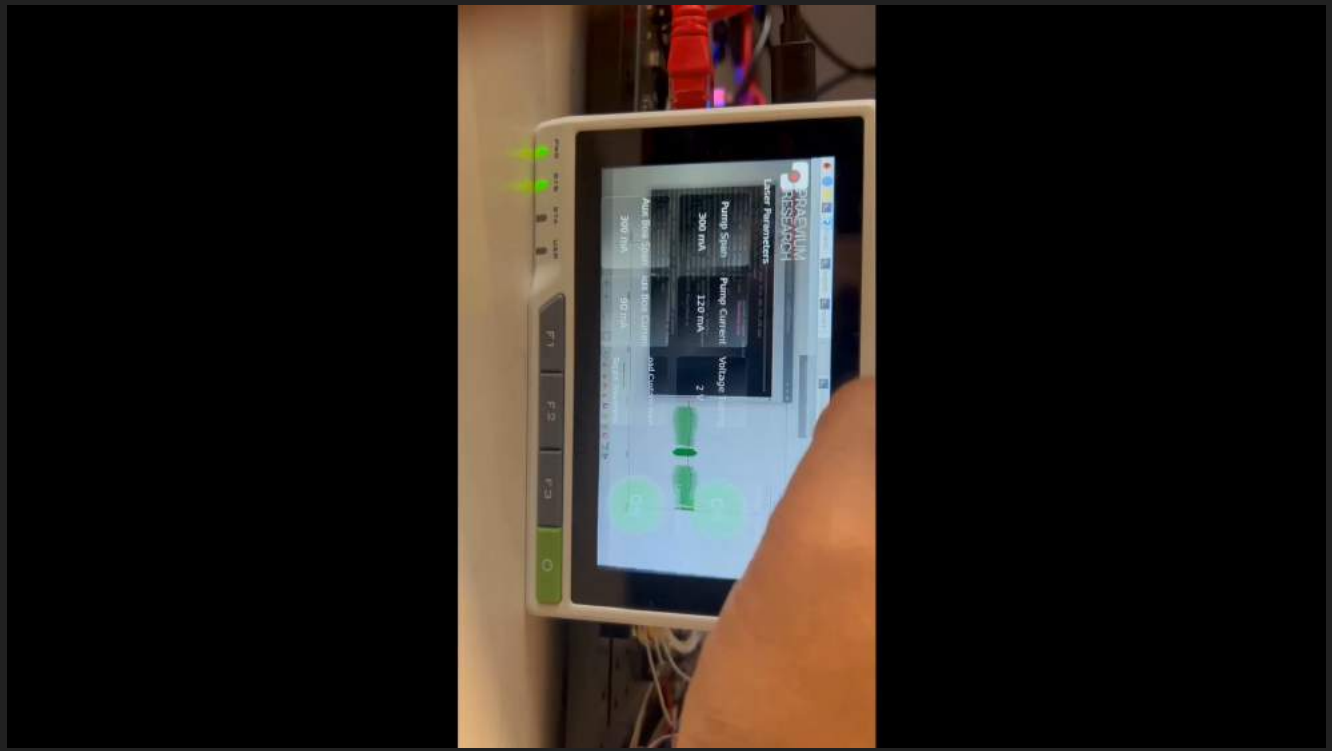


Demo - Gas Spectroscopy

Uses Red Pitaya Oscope to gather MZI and output of laser through gas cell



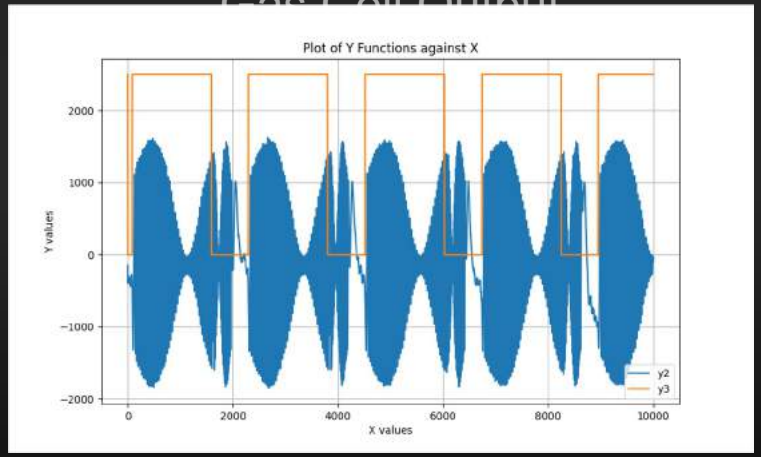
Video

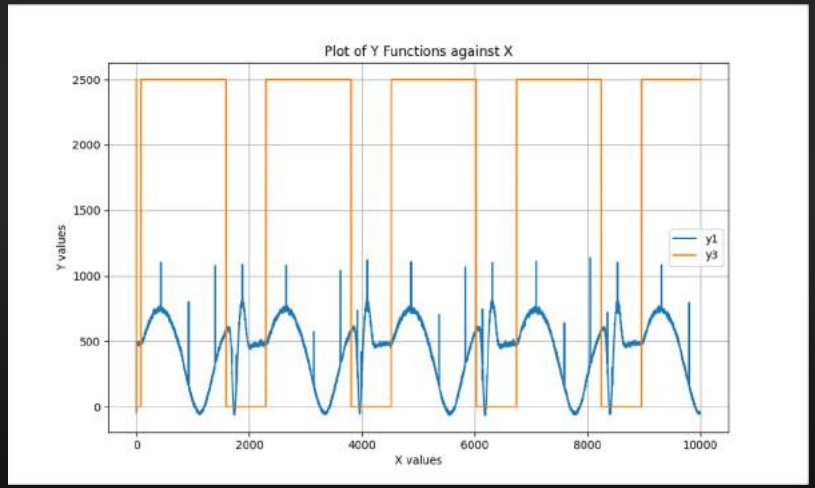

GRABLUM
RESEARCH
Laser Parameters
Pump Spot
300 mA
Pump Current
120 mA
Voltage
F1
F2
F3
O

FPGA Oscilloscope Output

MZI Output

Gas Cell Output





Wavelength Outputs

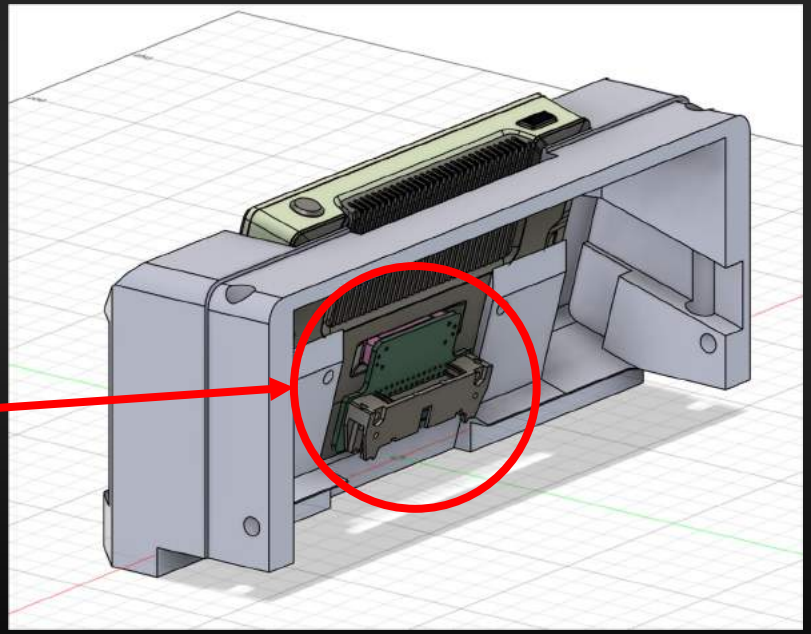
Error of +- 1nm

	derivative	zero_crossings_before_derivative
1288	196.0	20
1782	524.0	51
2247	527.0	76
3507	255.0	20
4000	394.0	51
4464	626.0	76
5726	227.0	20
6218	383.0	51
6682	646.0	74
7942	248.0	20
8435	514.0	51
8897	471.0	74

[1312.92, 1322.096, 1329.496, 1312.92, 1322.096, 1329.496, 1312.92, 1322.096, 1328.904, 1312.92, 1322.096, 1328.904]

Dev Kit Frame

- New prototype modeled dev kit frame to support the replacement PCB for Red Pitaya
  - Reverted back to using old Aluminum shroud dimensions, requiring previously designed frames to be reworked/scrapped
  - Pictured; breakout connector on back of reTerminal device, connects to PCB Red Pitaya replacement

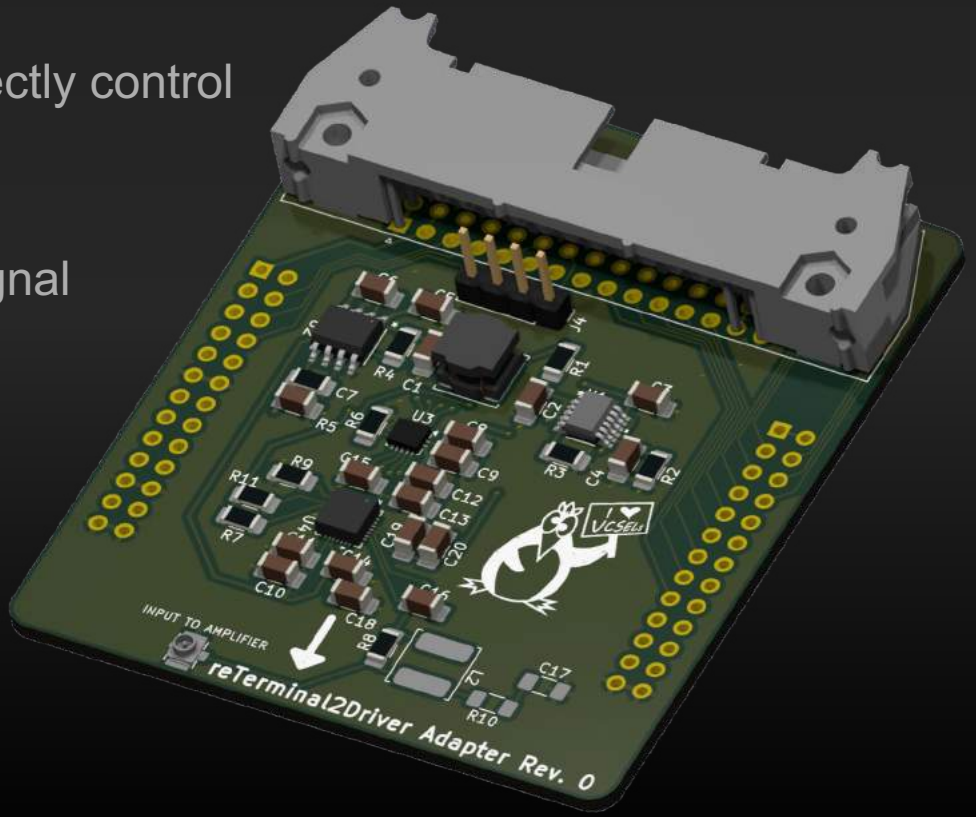


Red Pitaya Replacement PCB

Custom PCB to allow reTerminal to directly control the driver board

AD3541R DAC allows for low-speed signal generation or constant output

Reduces DevKit costs and complexity while not impacting many possible use cases



Special Thanks

Chris, Bernie, Calisto, Anthony, Colin, and all the staff at Praevium Research

Professor Yogananda

TA Alex