

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

Ayush Shah

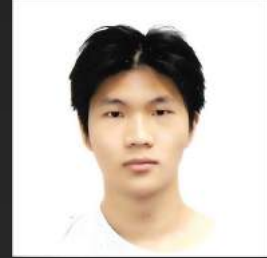


Torin Schlunk



Team Lead

Simon Lai



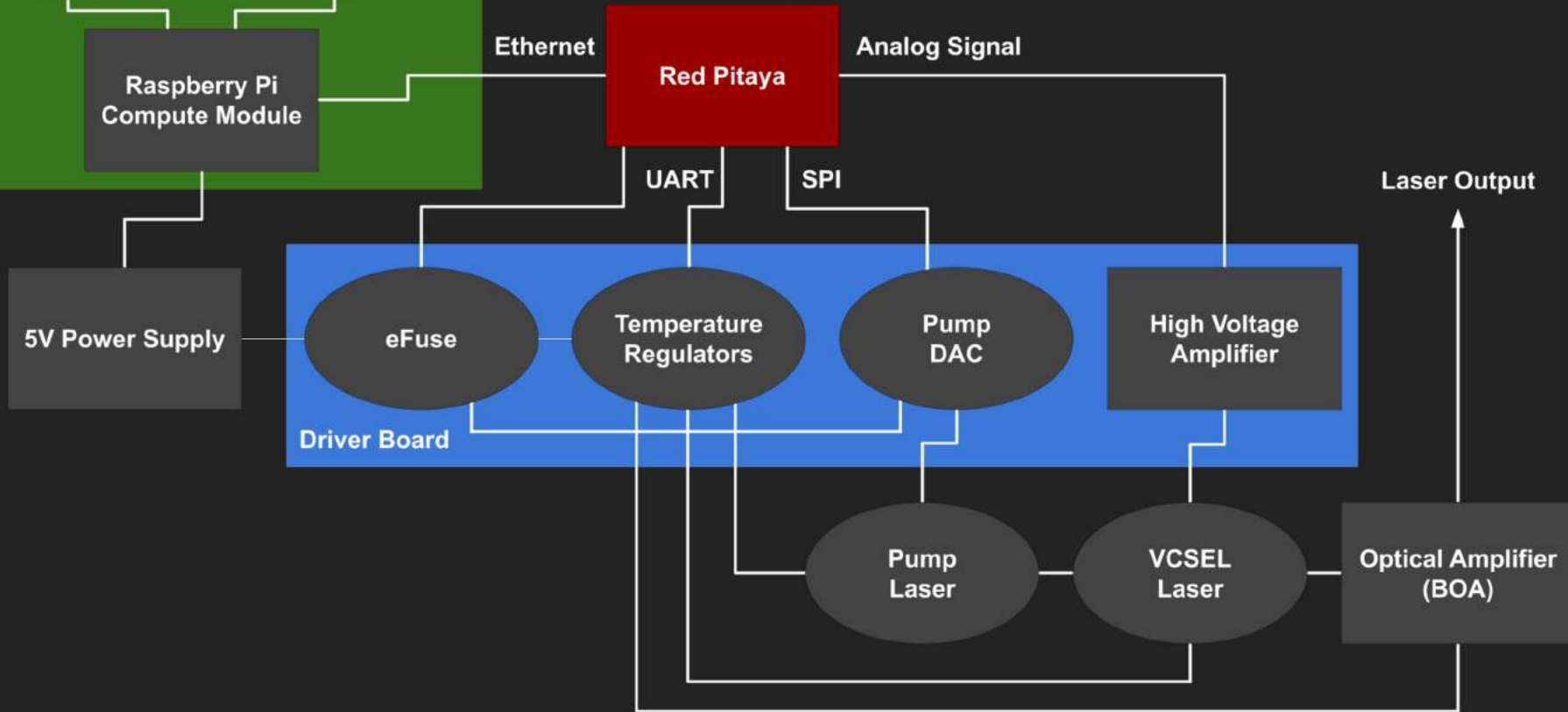
Rylan Pow



Rodney Li

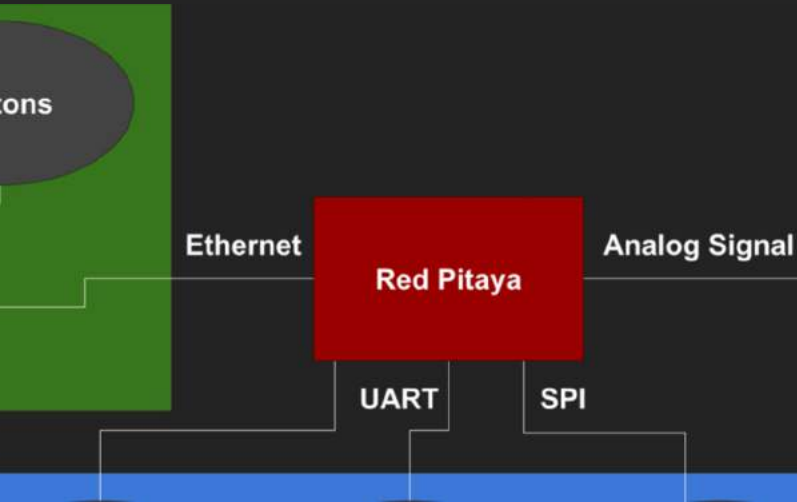
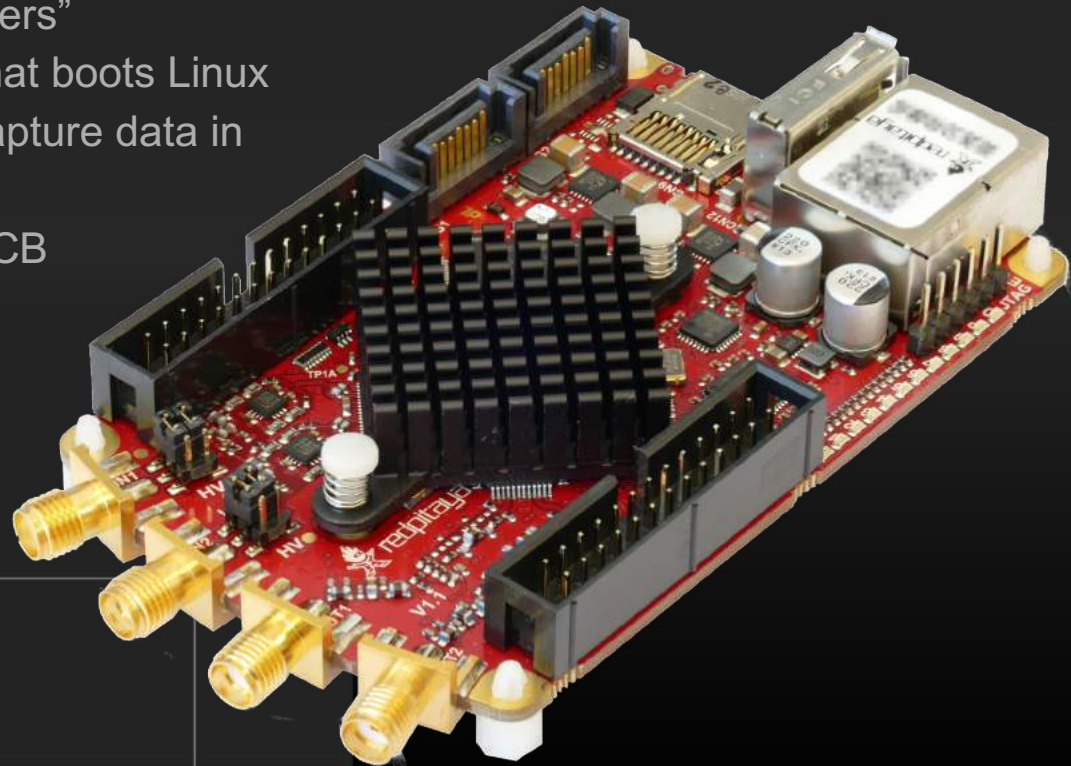


Block Diagram



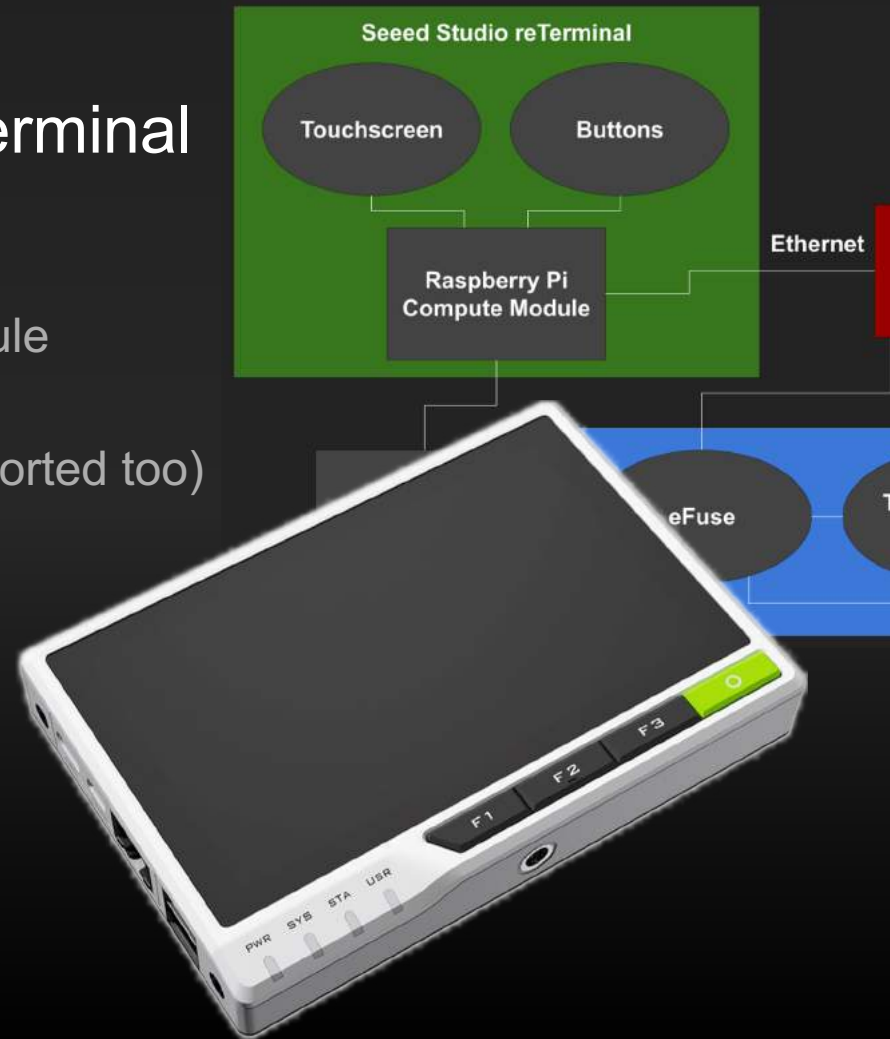
Components - Red Pitaya

- “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



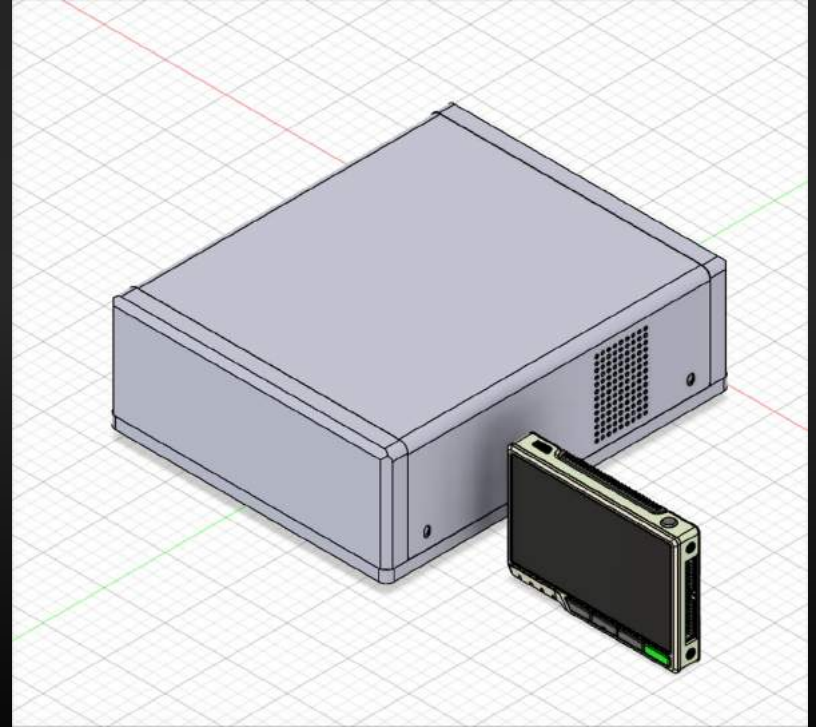
Components - Seed Studio reTerminal

- 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



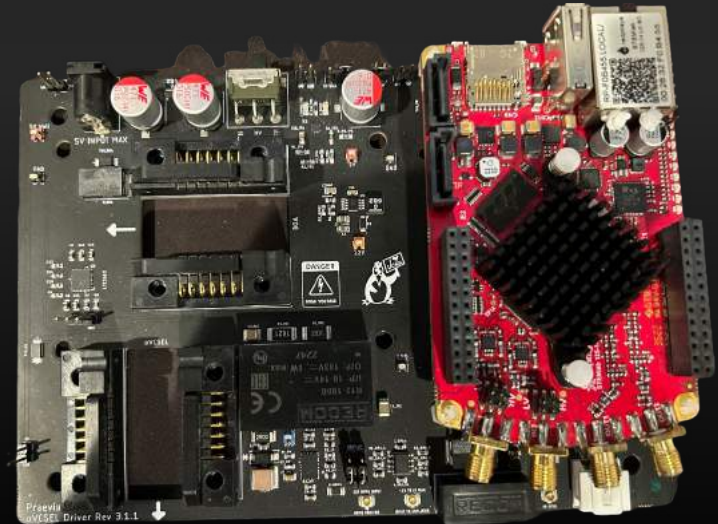
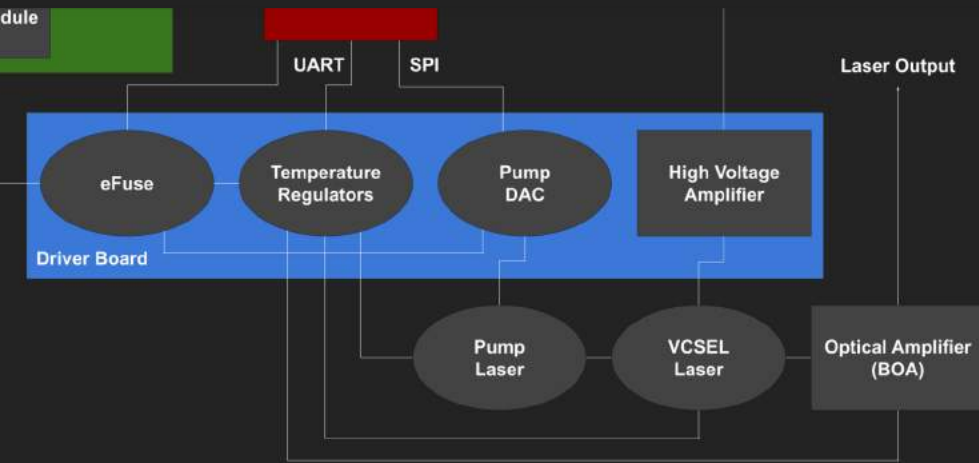
Components - Praevium Enclosure for DevKit

- 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



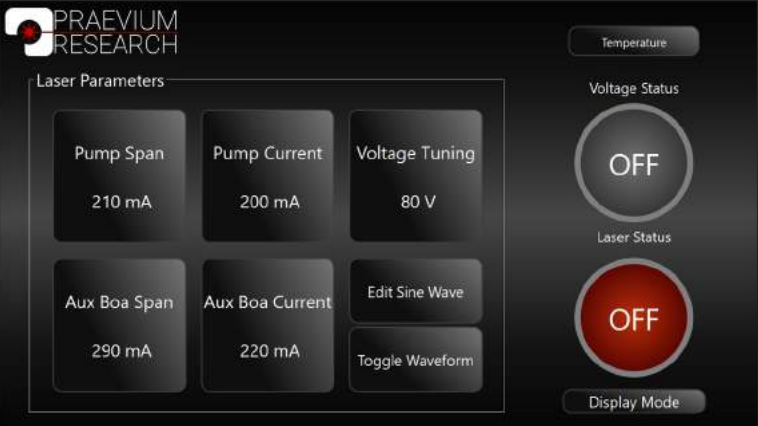
Components - Praevium Devkit/VCSEL

- “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

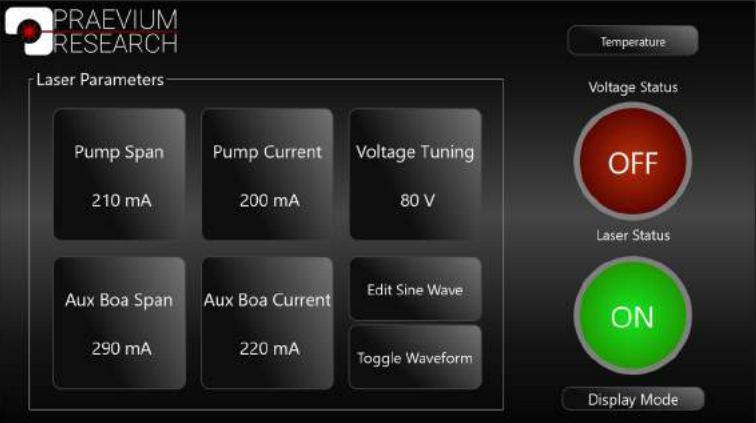


Idle Screen



Graphical User Interface

Touchscreen Friendly Layout



Intuitive Counter Design



Waveform Editing

- Allows for Sine Waves and Arbitrary Waveforms

The image displays two screenshots of a waveform editing interface. The left screenshot shows a configuration screen with the following parameters:

- Peak to Peak Voltage: 0.9
- DC Offset: 0.78
- Number of Points: 100
- Frequency: 10000.0

A 'Waveform Preview' section shows a yellow sine wave on a black background with axes. The right screenshot shows a similar screen with a 'Frequency' slider and a 'Load Waveform' button. Both screens feature a numeric keypad (1-9, 0, ., Del) and 'OK' and 'Cancel' buttons.

Temperature Editing

- And temperature manipulation!

The image shows a dark-themed user interface for temperature editing. It features three rows of controls, each for a different component: Pump, BOA, and VCSEL. Each row includes a label for the current temperature, a text input field for the set temperature, and a small 'OK' button. To the right of these inputs is a numeric keypad with buttons for digits 1-9, 0, and a decimal point. A 'Del' button is located at the bottom left of the keypad area. A large 'OK' button is positioned to the right of the Pump and BOA sections, and a 'Cancel' button is to the right of the VCSEL section. A 'Refresh' button is located at the bottom left of the entire interface.

Current Pump Temperature:
Set Pump Temp OK

Current BOA Temperature:
Set BOA Temp OK

Current VCSEL Temperature:
Set VCSEL Temp OK

Refresh Del 0 . OK Cancel

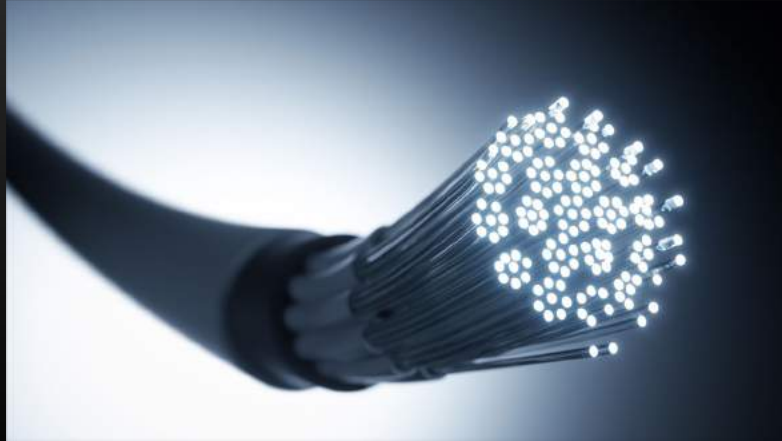
Communication

- Parameter changes and waveforms are correctly generated

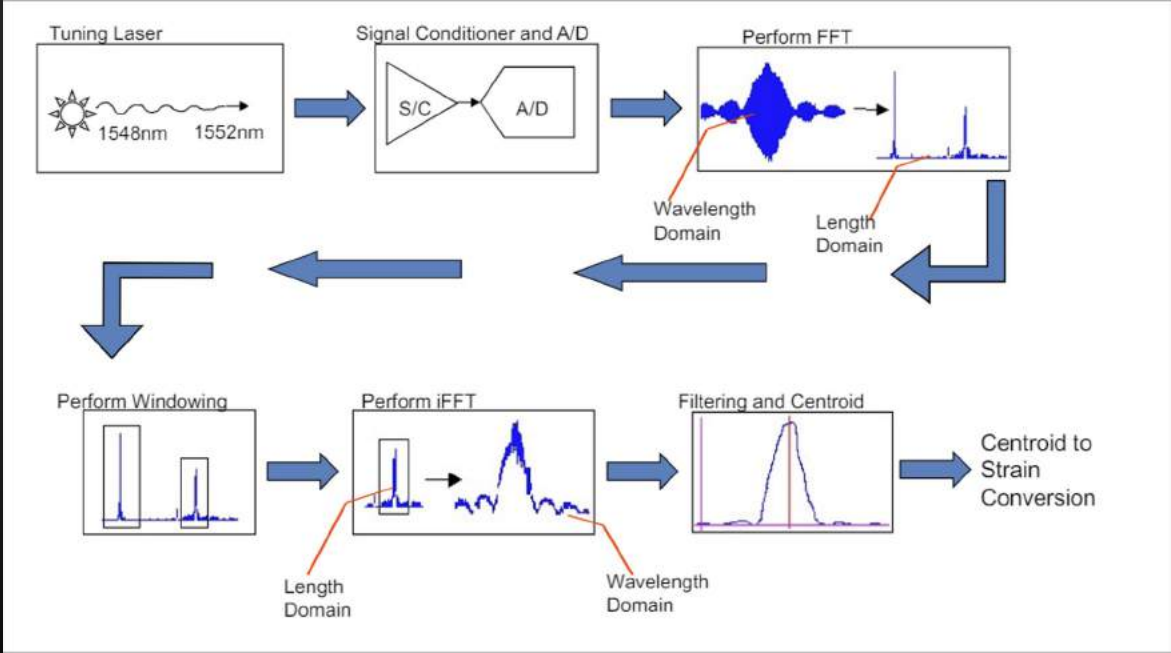


Demo - Fiber Optic Shape Sensing

- 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

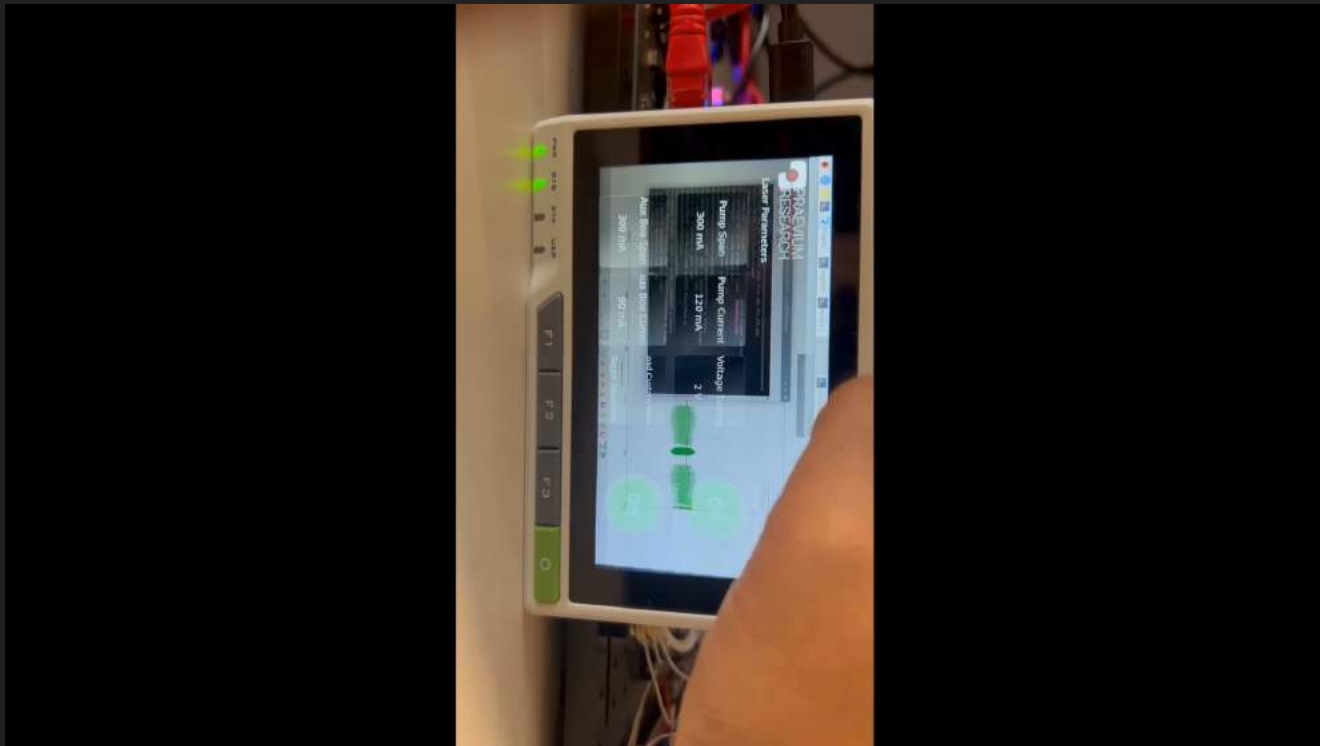


Demo - Gas Spectroscopy

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



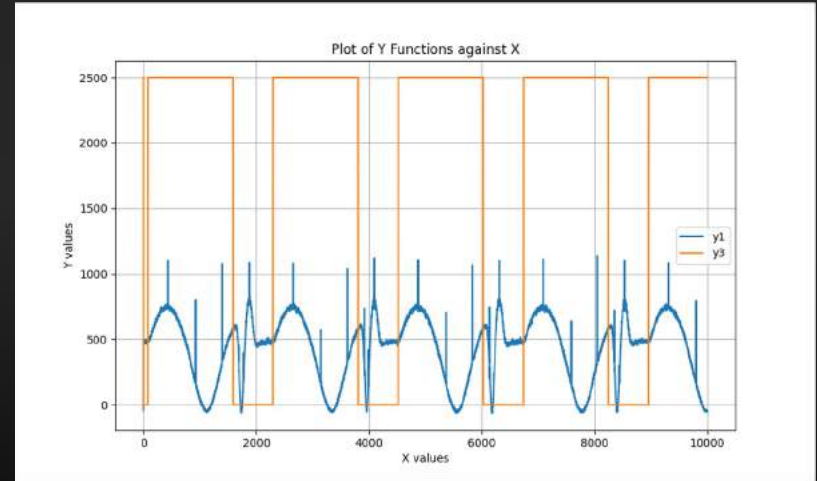
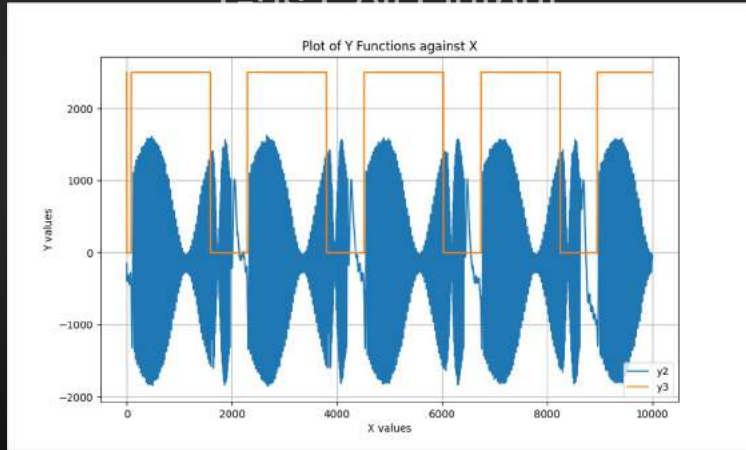
Video



FPGA Oscilloscope Output

MZI Output

Gas Cell Output



Wavelength Outputs

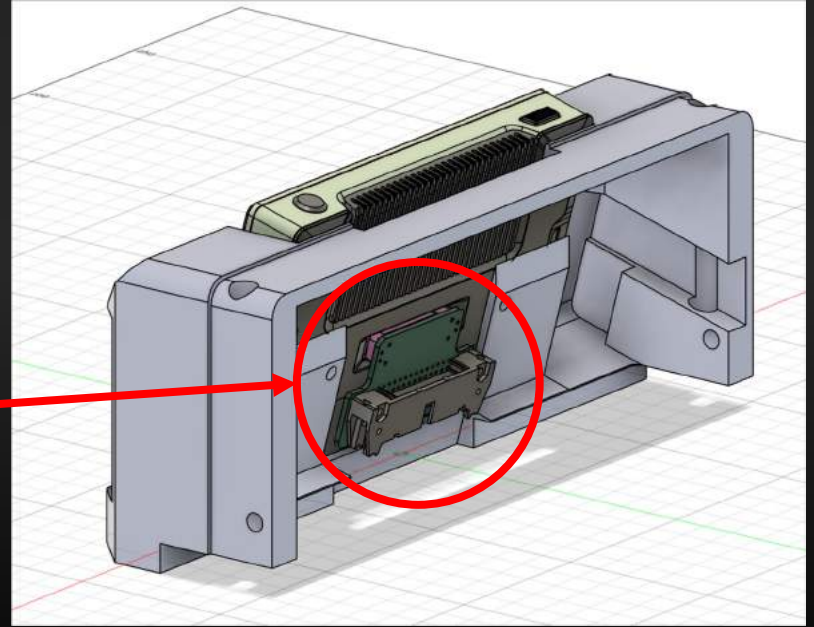
Error of +/- 1nm

	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

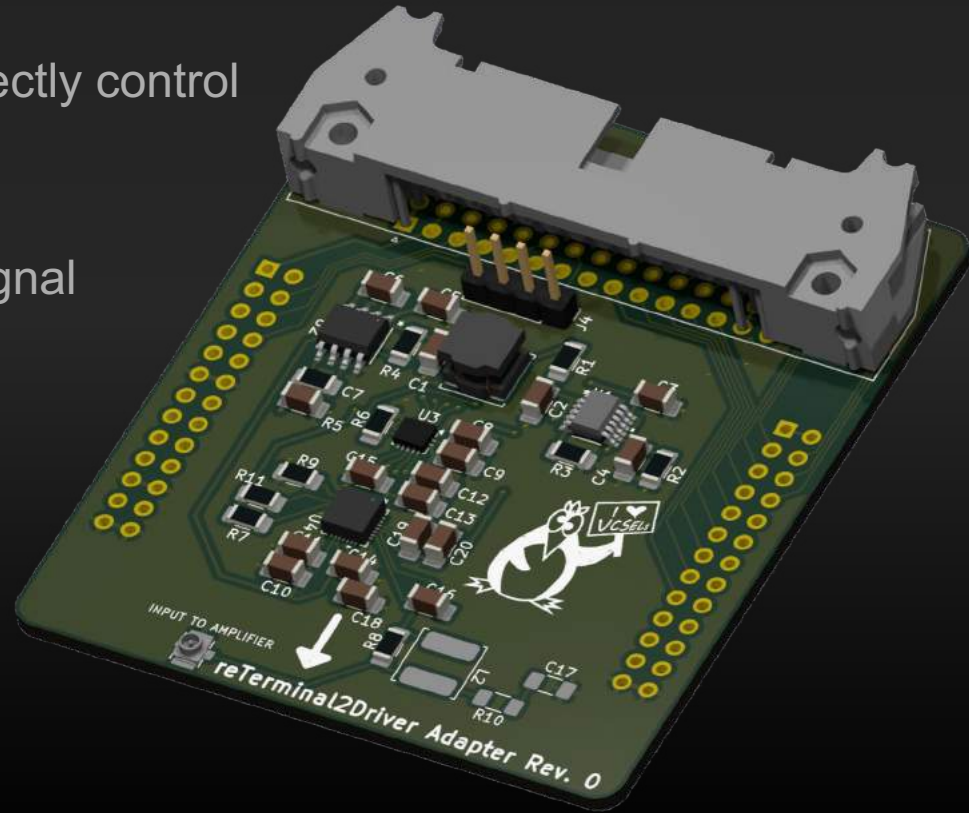


Red Pitaya Replacement PCB

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

