



Compact Unified Diagnostic Apparatus

Team

Noah Corona – Project lead, mobile app,
BLE

Moises Gutierrez – 3D Designer

Srikar Arani – RTC & sensor protocol

Jimmy Kraemer – PCB & LED system

Alex Lai – BLE & data processing



Project Specifications

Initial work by Aptitude

- Developed a rapid COVID test using a microcontroller that interfaces with a Raspberry Pi Zero W, as well as a case for the device

Our contributions

- Implemented a second type of test that monitors fibrinogen levels in a blood sample
- Modified the existing case to account for PCB changes
- Provided a platform to manage devices, patients, and test results
 - Simplifies management of large databases
 - Synchronizes patient info and test results across any number of devices
 - Any phone or tablet can monitor several reader devices concurrently

Project Motivation

Fibrinogen Measurement

- Can help indicate hypo- or hyper-coagulation
- Can be used to detect issues such as internal hemorrhaging

Speed

- Fibrinogen tests performed in a lab can take hours, and must physically travel from point of measurement to a lab
- External factors, such as heat, could degrade the sample quality while it travels to the lab
- Synchronized platform allows users to track patient results in real-time with minimal setup

Project Motivation

Data management

- Cloud implementation ensures data is never lost and that all users have the most current information available

Manufacturing cost

- CUDA reader monitoring via mobile device can reduce the cost of manufacturing by reducing the number of expensive components, like a display screen and an electrochemical sensor

Project Overview

CUDA Reader Device

Main device, adapted from the ACE Reader developed by Aptitude

Mobile App (Our contribution)

Device, user and patient management system

COVID Test (Developed by Aptitude)

COVID test from a nasal or saliva sample with results in 30 minutes

Fibrinogen Test (Our contribution)

Fibrinogen test from a blood sample with results in less than 1 minute

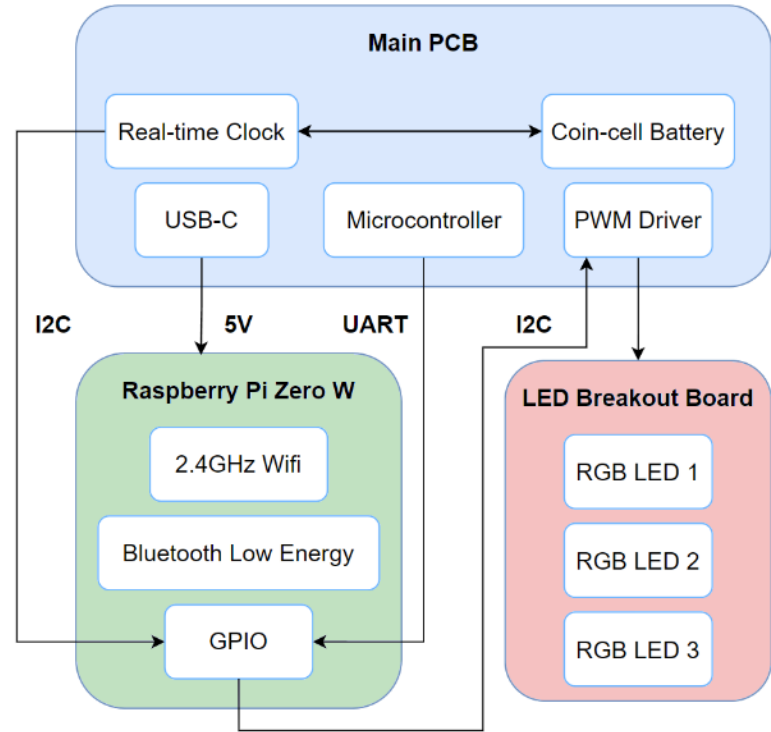
Block Diagram & Key Components

- **Main PCB**

- Adapted from Aptitude's original ACE reader
- Added PWM driver for improved LED control
- Added RTC for time synchronization

- **Raspberry Pi Zero W**

- **LED breakout board**

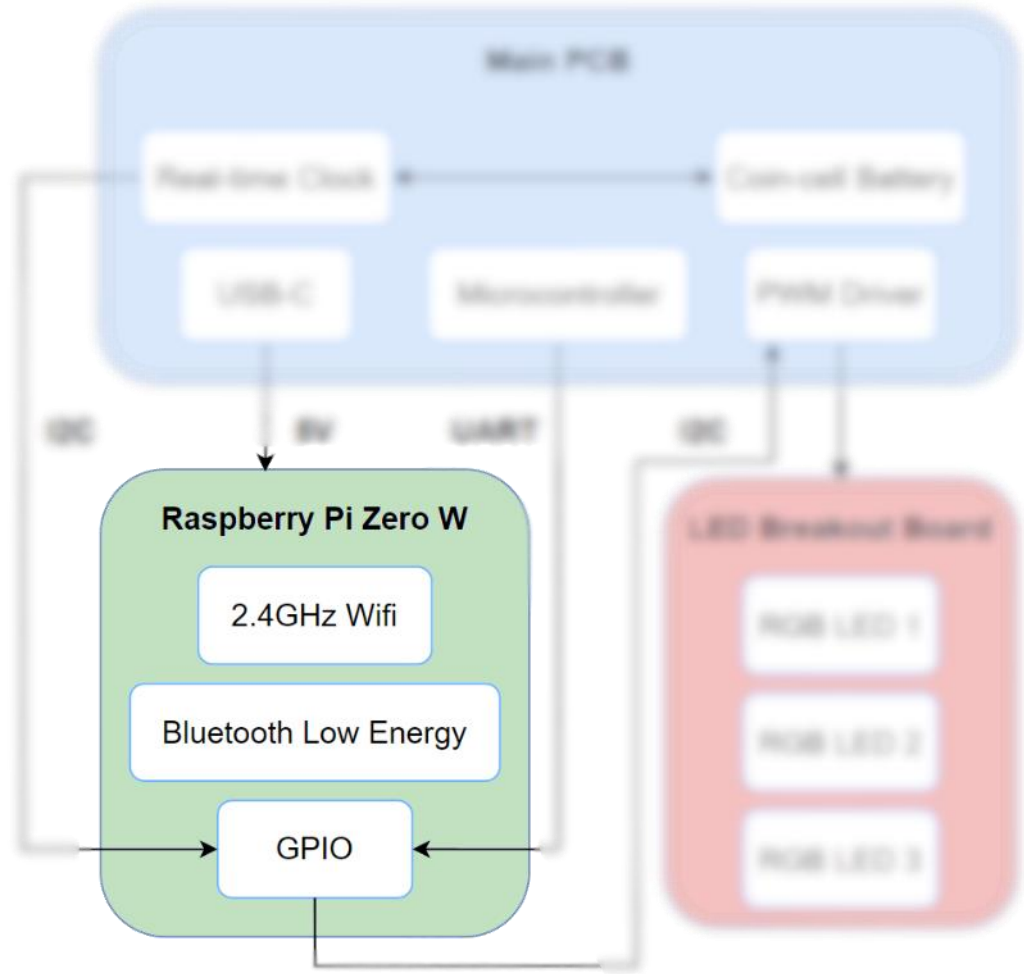


Raspberry Pi

Raspberry Pi Zero W



- Support for UART, I2C, and SPI protocols
- Analyzes sensor data to detect hypo/hyper-coagulopathy
- Runs Raspbian Lite OS

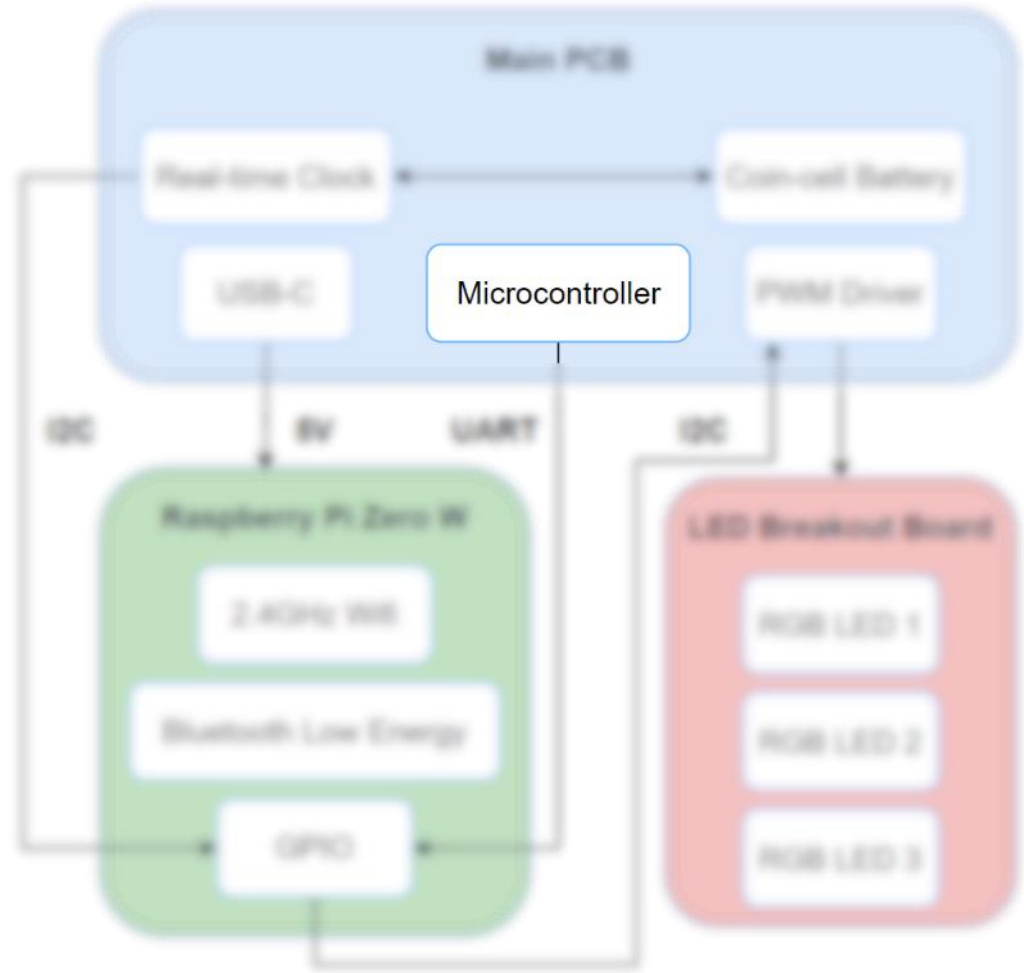


Microcontroller

M355 Microcontroller

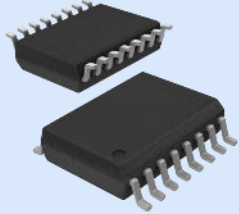


- Serial protocol: UART
- MCU used to emulate potentiostat
- Used to perform electrochemical measurements

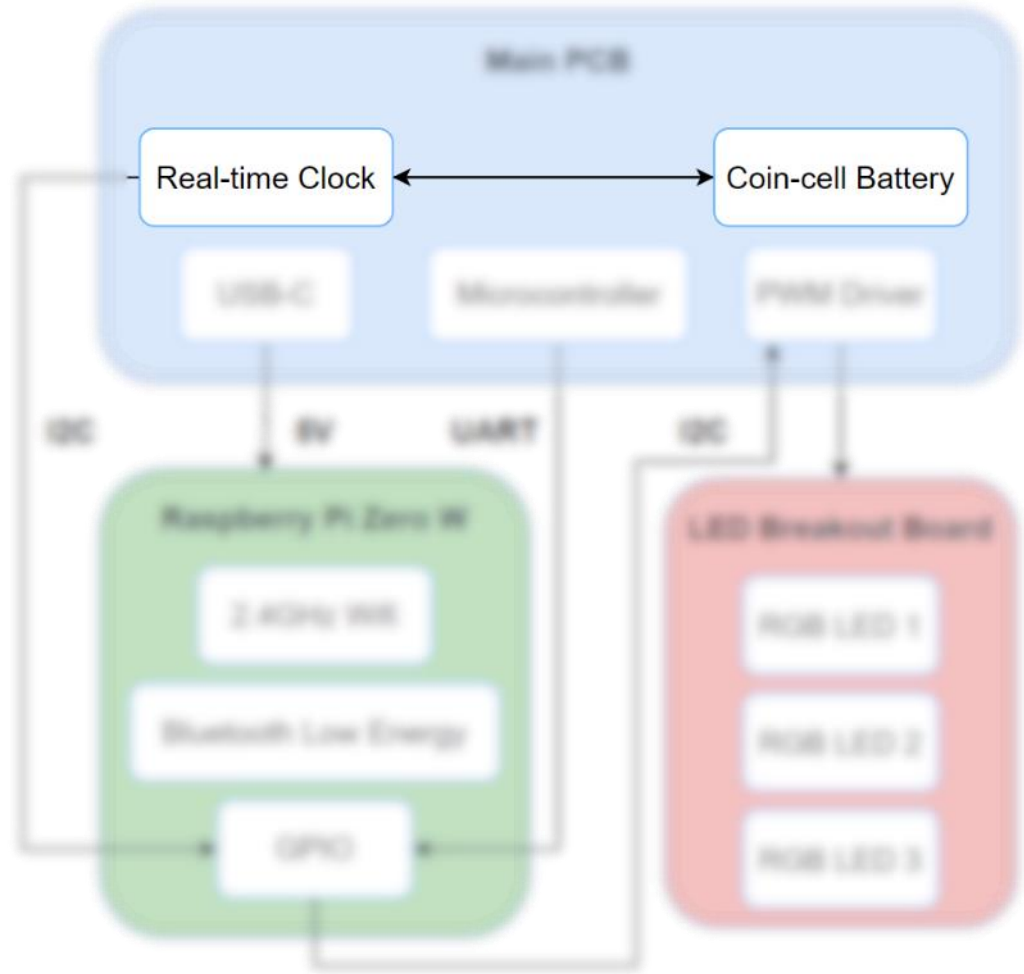


Modification #1

DS3231 Real-time Clock

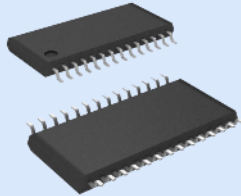


- Serial protocol: I2C
- Stores test time data
- Powered by a rechargeable coin-cell battery
- Charges the coin-cell battery while powered by 3V

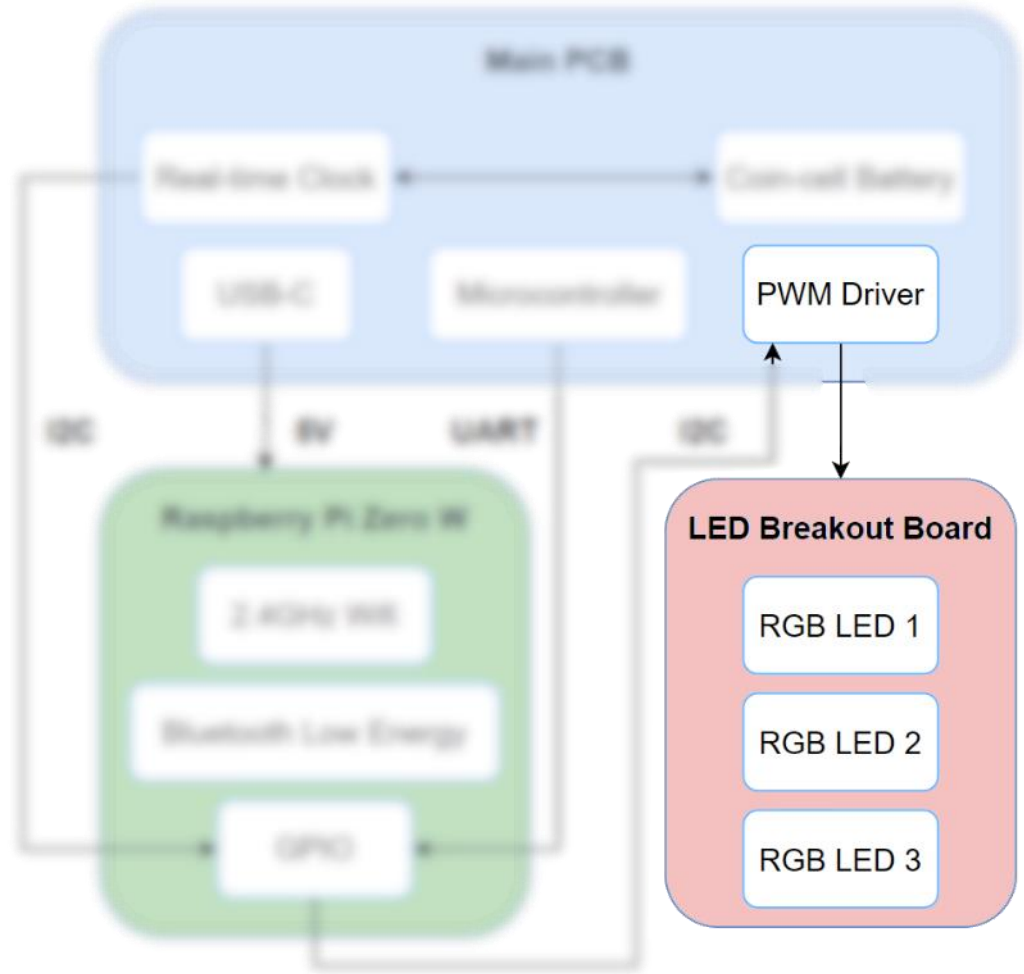


Modification #2

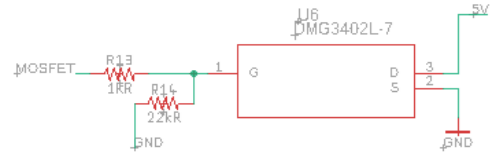
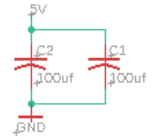
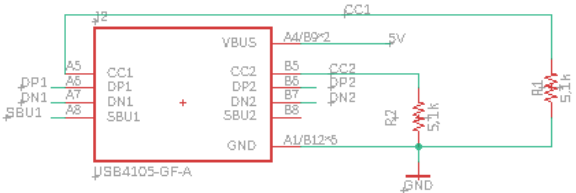
PCA9685 PWM Driver



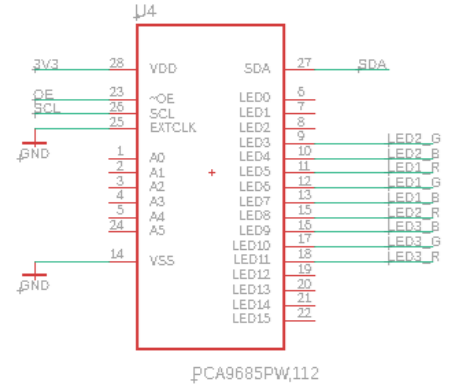
- Serial protocol: I2C
- 12-Channel PWM LED driver
- Used to control 3 RGB LEDs that indicate device status and test results



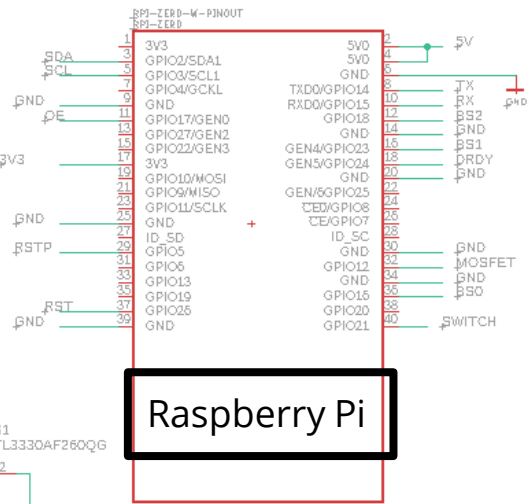
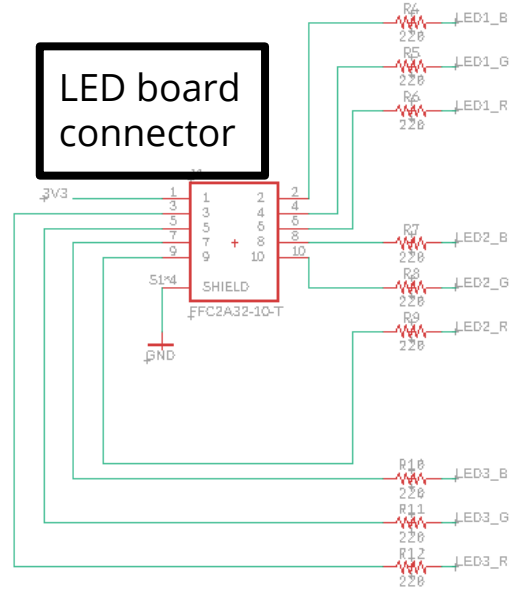
Schematic



PWM Driver

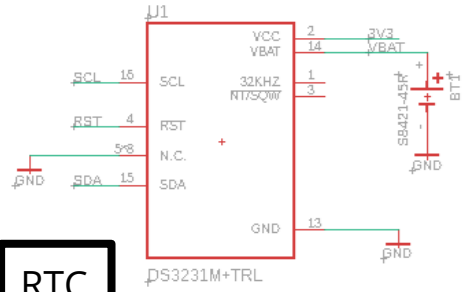


LED board connector



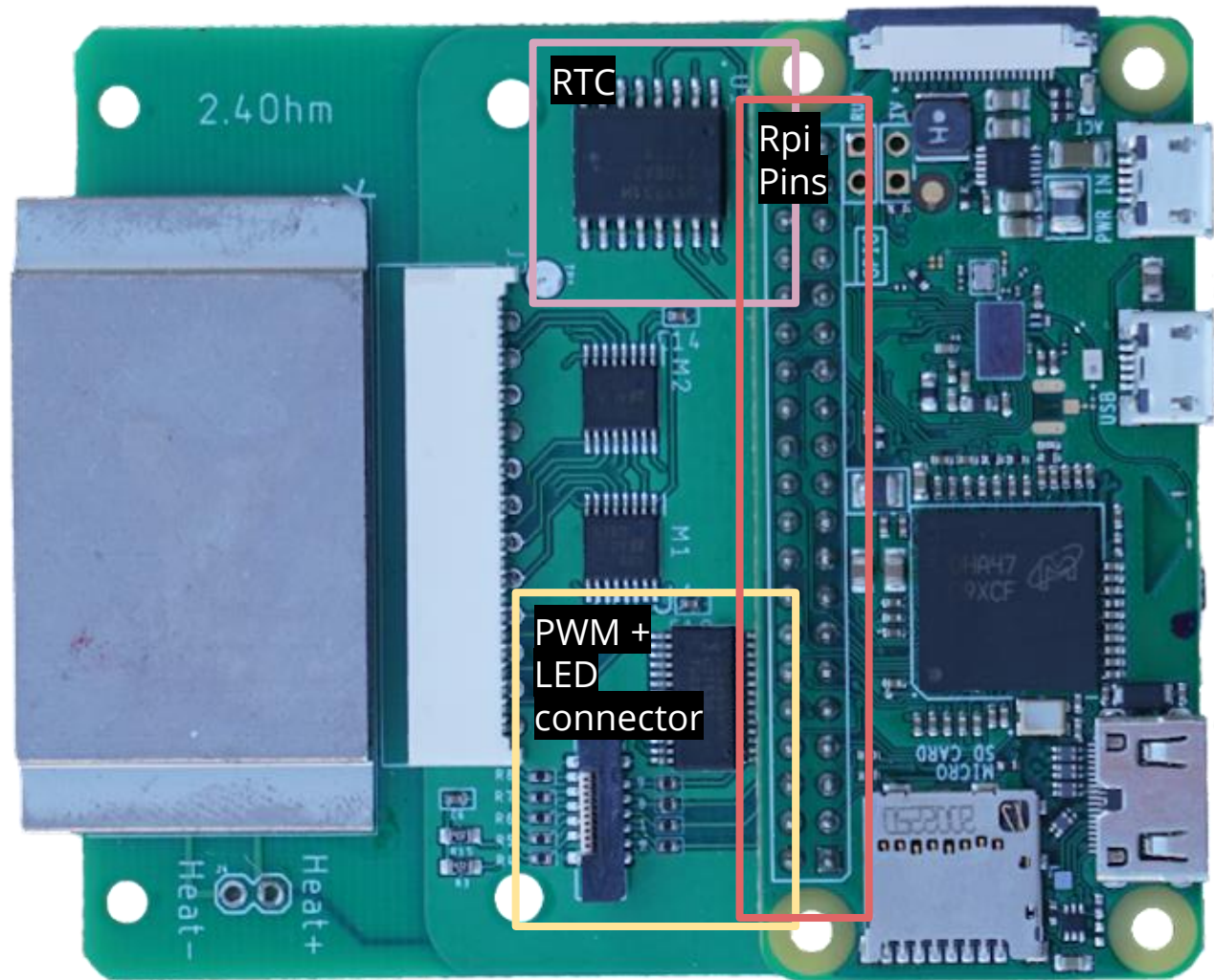
Raspberry Pi

RTC



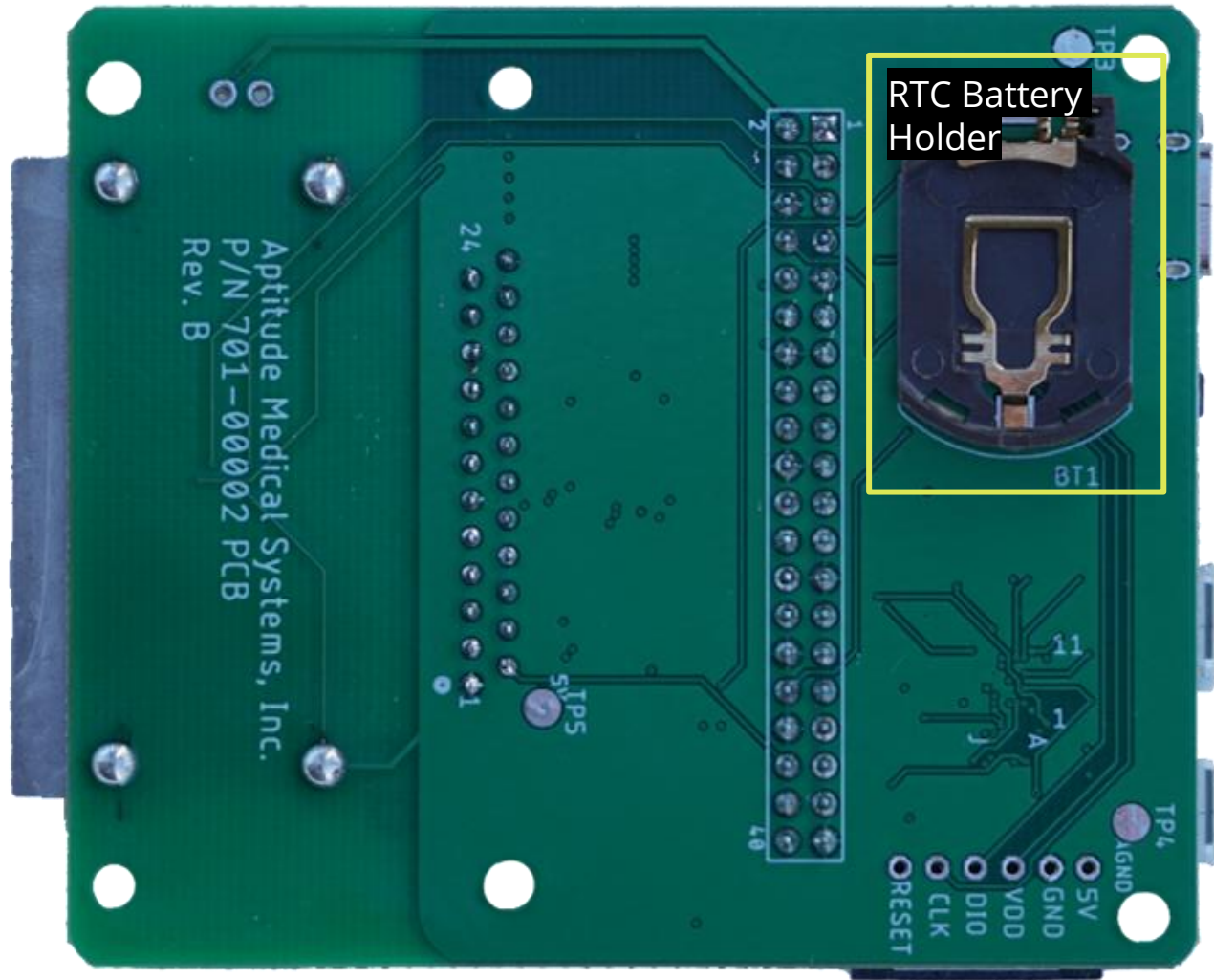
PCB

- Adapted from Aptitude's PCB
- 76.2 by 65.05 mm
- 4 Layer
 - Top - GND
 - 2nd - 3V3
 - 3rd - 5V
 - Bottom - GND
- 31 unique SMD parts



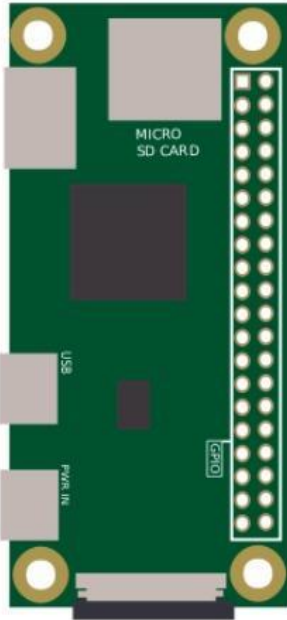
PCB

- Adapted from Aptitude's PCB
- 76.2 by 65.05 mm
- 4 Layer
 - Top - GND
 - 2nd - 3V3
 - 3rd - 5V
 - Bottom - GND
- 31 unique SMD parts



Embedded Software Design Bluetooth Protocol

BLE Server



Sends status and results of tests



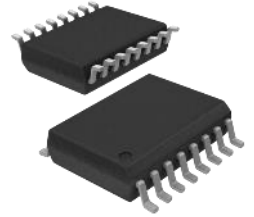
BLE Client



Real Time Clock and PWM Changes

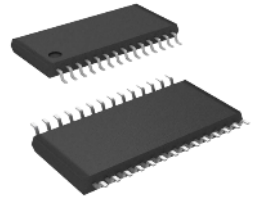
RTC

- Accurate timestamps for testing device between boots
- Time is pulled from RTC between boots



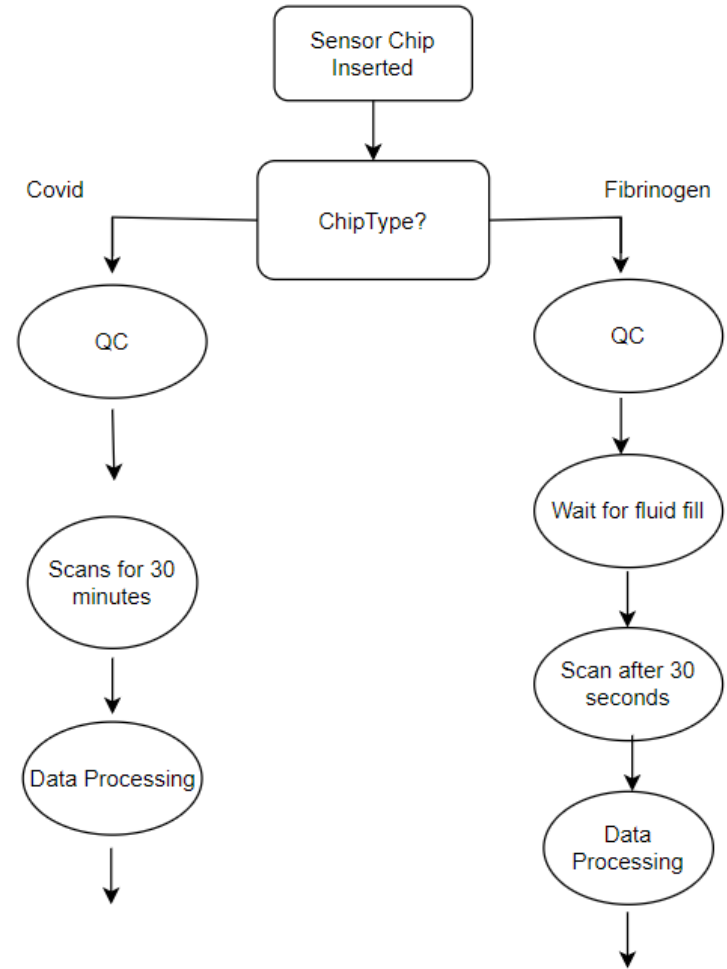
PWM Driver

- Allows greater control of led for indicating status/result of tests
- PWM Driver powers the 3 LED status lights instead of 3 GPIO pins



CUDA Device Workflow

- Test begins when chip is inserted
- Chip Type is automatically detected
- Different procedures for each test
- Mobile app receives error messages and final result through BLE

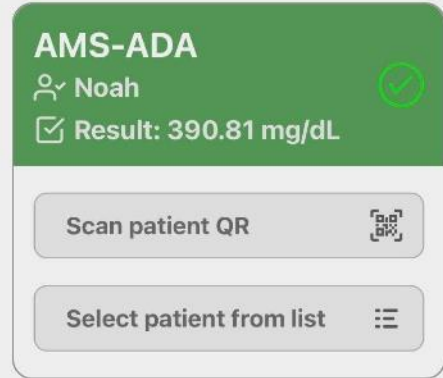


Mobile App: Key Features

- **Monitors reader devices**
 - Uses Bluetooth Low Energy to reduce power consumption
 - Can manage several connections to reader devices
- **Authentication and storage**
 - Sign in with Apple, Google, or an email and password
 - Implemented with OAuth and Firebase Authentication
 - User and patient information backed up in the Cloud
 - Implemented with Firebase Real-time Database
 - Supports online and offline use

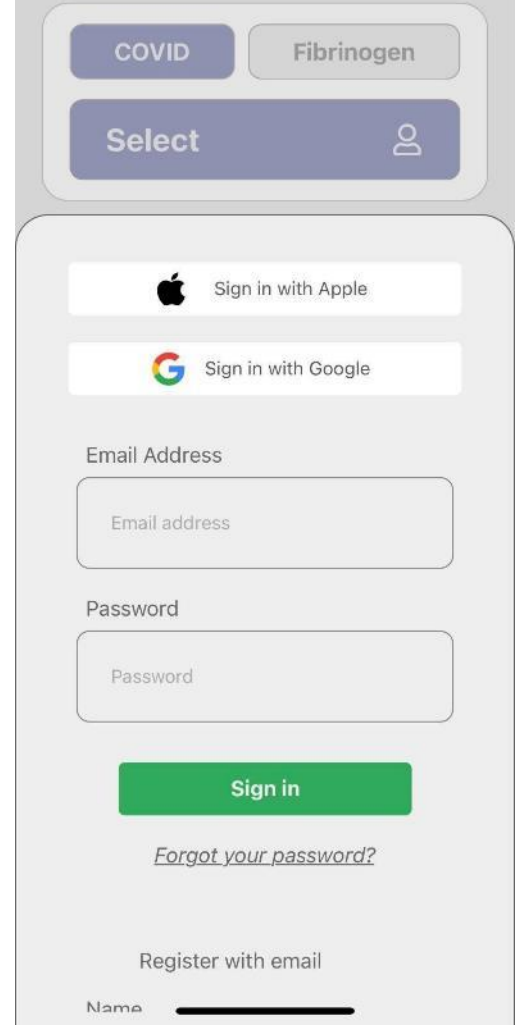
Monitoring

- Nearby CUDA Readers appear as cards
 - Card color indicates the device status
- Results from connected devices automatically uploaded
 - Ability to choose a patient from the database for device the results to upload to, or guest
- A notification is generated when a test completes or an error occurs



Authentication and Storage

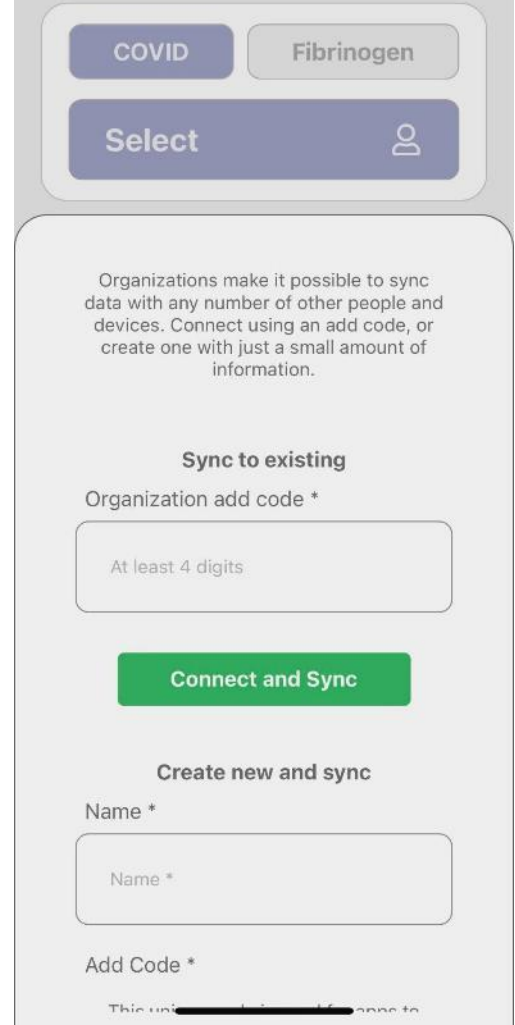
- Sign in with existing accounts from other providers
- Register an email/password, with recovery
- Users can back up data in the cloud without signing in



The image shows a mobile application interface for authentication. At the top, there are two buttons: 'COVID' and 'Fibrinogen'. Below them is a 'Select' button with a user icon. The main section contains two social login options: 'Sign in with Apple' and 'Sign in with Google'. Below these are input fields for 'Email Address' and 'Password'. A green 'Sign in' button is positioned below the password field. A link for '[Forgot your password?](#)' is located below the 'Sign in' button. At the bottom, there is a section for 'Register with email' with a 'Name' input field.

Authentication and Storage

- Users have the option of creating or joining an organization
- A code is chosen for other users to use to connect to the organization
- All devices in the same organization have a synchronized patients database



The image shows a mobile application interface for organization synchronization. At the top, there are two buttons: "COVID" (highlighted in blue) and "Fibrinogen" (grey). Below these is a "Select" button with a person icon. The main content area contains a text block explaining that organizations allow syncing data with other people and devices. Below this, there are two sections: "Sync to existing" and "Create new and sync". The "Sync to existing" section has a label "Organization add code *" and a text input field with the placeholder "At least 4 digits". Below this is a green "Connect and Sync" button. The "Create new and sync" section has a label "Name *" and a text input field with the placeholder "Name *". Below that is a label "Add Code *" and a partially visible text input field with the placeholder "This uni...".

COVID Fibrinogen

Select

Organizations make it possible to sync data with any number of other people and devices. Connect using an add code, or create one with just a small amount of information.

Sync to existing

Organization add code *

At least 4 digits

Connect and Sync

Create new and sync

Name *

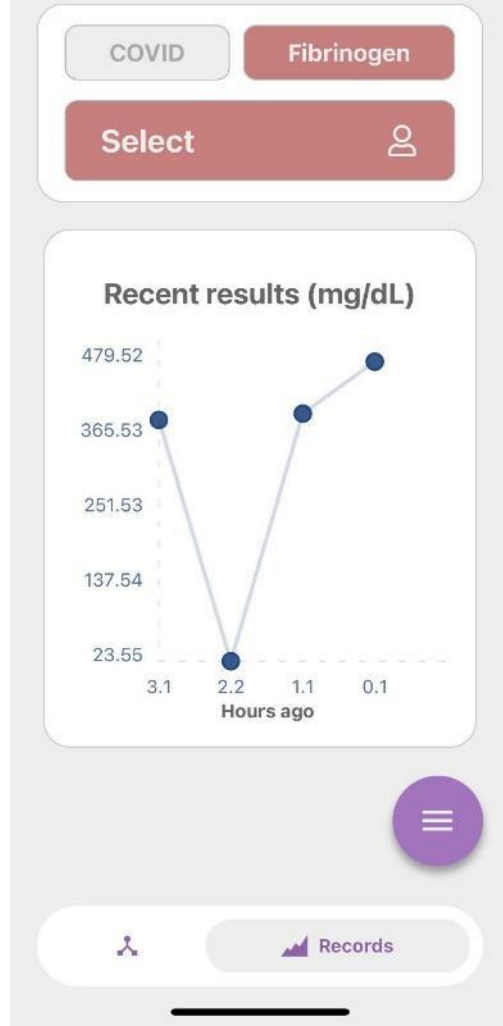
Name *

Add Code *

This uni... of apps to

Patient Portal

- Store patient information
- View and export patient results for COVID or fibrinogen tests
- For fibrinogen measurements, a graph is displayed to make it easy to track results over time



Acknowledgements

- Thank You to Tyler Chozinski, Wentao Shi, Zachary Rengert, Hui Kang, and the rest of the Aptitude Team
- Special Thanks as well to Professor Yoga and the wonderful TAs Brycen Westgarth and Chris Cheney



CACI

Lead sponsor of CE Program

UC SANTA BARBARA
College of Engineering

Questions?