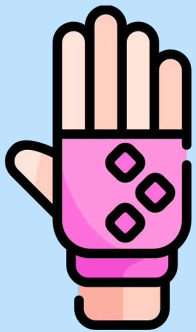
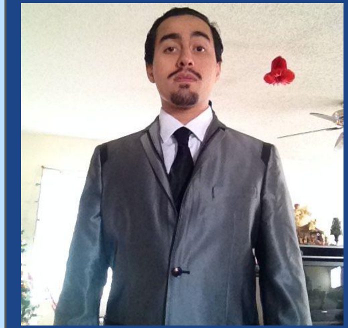
Project N.I.H.M.S. (Non-Invasive Health Monitoring System)



Group E

Nicole Fossenier *(Optics and Photonics)*
George Michael Ruiz *(Electrical Engineering)*
Gabriela Pinedo *(Computer Engineering)*
Schneider Maxime *(Computer Engineering)*

Meet the Group



George Ruiz
Electrical Engineering

Focuses:

- Power supply
- Temperature sensor
- PCB layout and design

Gabriela Pinedo
Computer Engineering

Focuses:

- Microcontroller
- Programming
- Mobile Application Backend

Nicole Fossenier
Photonics

Focuses:

- Solar Cells
- PPG

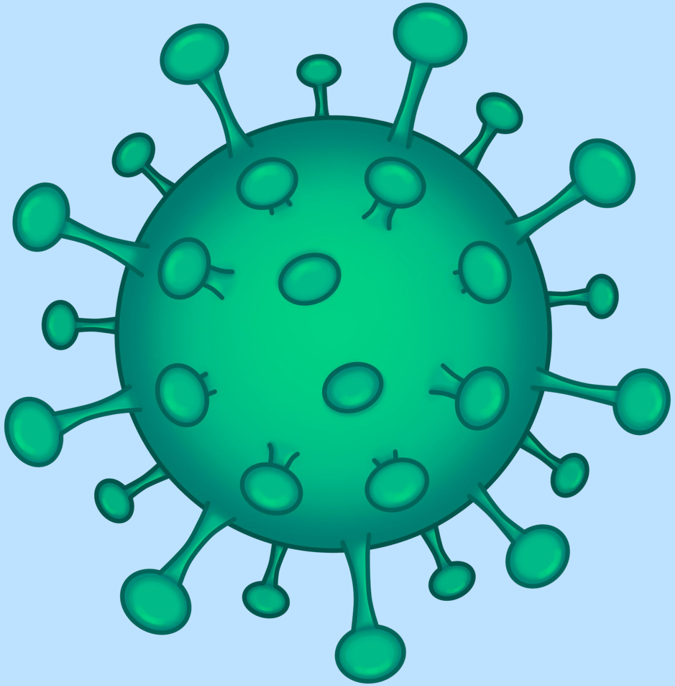
Schneider Maxime
Computer Engineering

Focuses:

- Bluetooth/Wi-Fi Connectivity
- Software Design
- Mobile Application Front End

Motivation

- The motivation for this project was to not only demonstrate our engineering abilities through a group project, but to also create a project that would be beneficial and potentially used in the medical field after it was built
- In the midst of a pandemic, we decided to create a device that would make it easier for those who are unable to reach a hospital or unable to check into the hospital with the staggering amount of hospital beds available.
- Our non- invasive wearable device is meant to be an alternative way to measure and track daily vitals and also be able to transmit them to a medical professional without needing to visit them in person.



Goals & Objectives

- The goal of our project is to design a fingerless glove with solar cell technology that will be able to check **heart rate/telemetry, blood pressure, pulse oxygenation, skin temperature**. The fingerless glove will also include an alert system built in to let the user know if an irregularity in vital signs is detected, and if said alert is triggered, the user will have the option to alert local authorities for any emergency help if they need to.

- **<u>Key Objectives:</u>**
  - Lightweight
  - Comfortable
  - Easy to use
  - E-diary that will hold a year of monitored readings
  - Ability to email e-diary readings

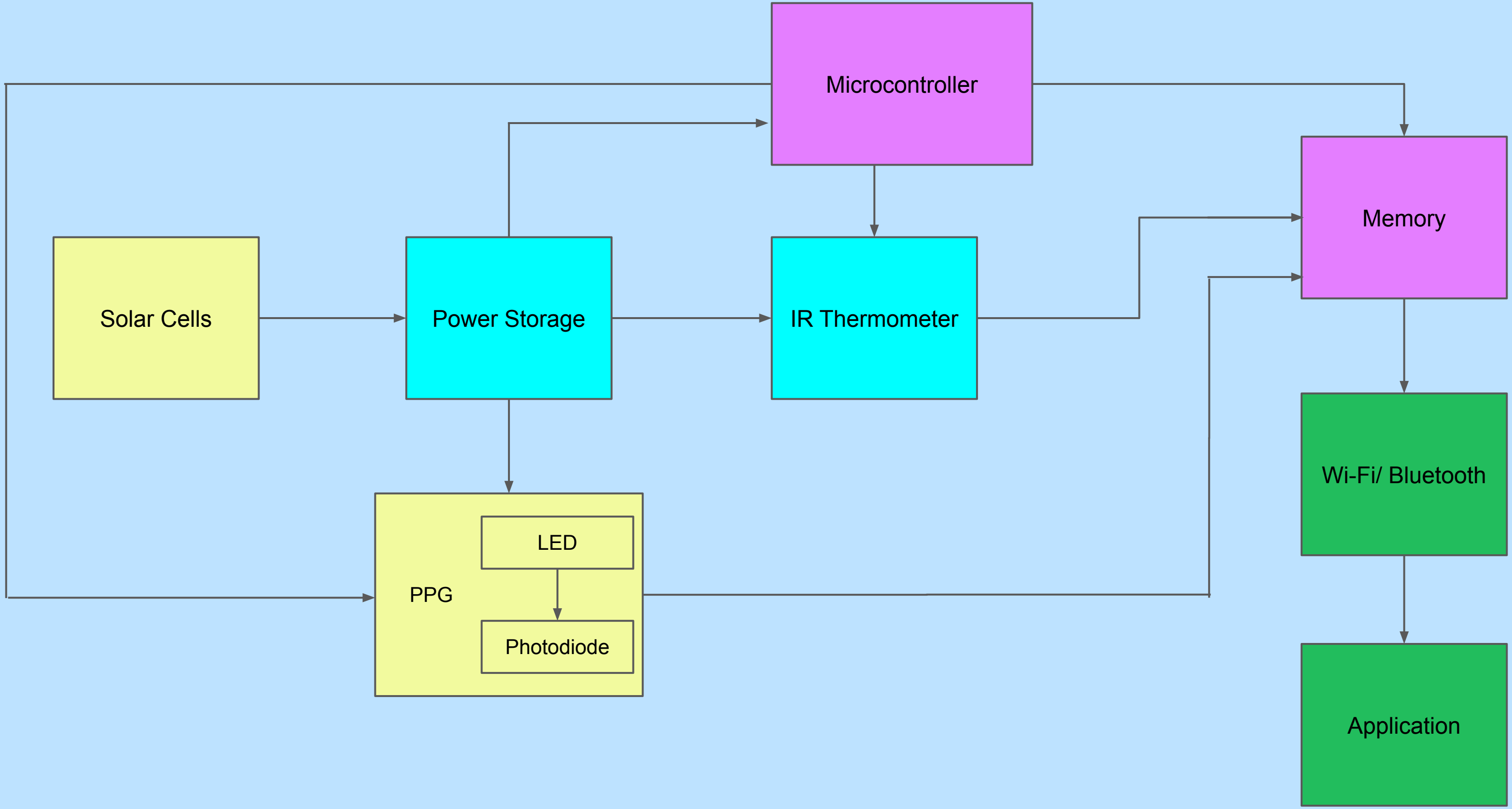
Requirements and Specification

Requirement	Specification
Wi-Fi Connectivity	Should reach 150 ft. indoors
Data Transfer	At least 2 Mb/s
Weight	Less than 1 lb.
Battery Life	Up to 8 hr. Battery life
Application Storage	1 yr. Worth of data on application
Wearability	Fit the average hand: approximately 7.6 in.
Product Storage	2 weeks worth of data stored on device
User Friendliness	User should be able to use it within 2 min.
Application Speed	Feedback from watch to phone in under 45 sec.
Emergency Detection	Notifies proper authorities within 60 sec.

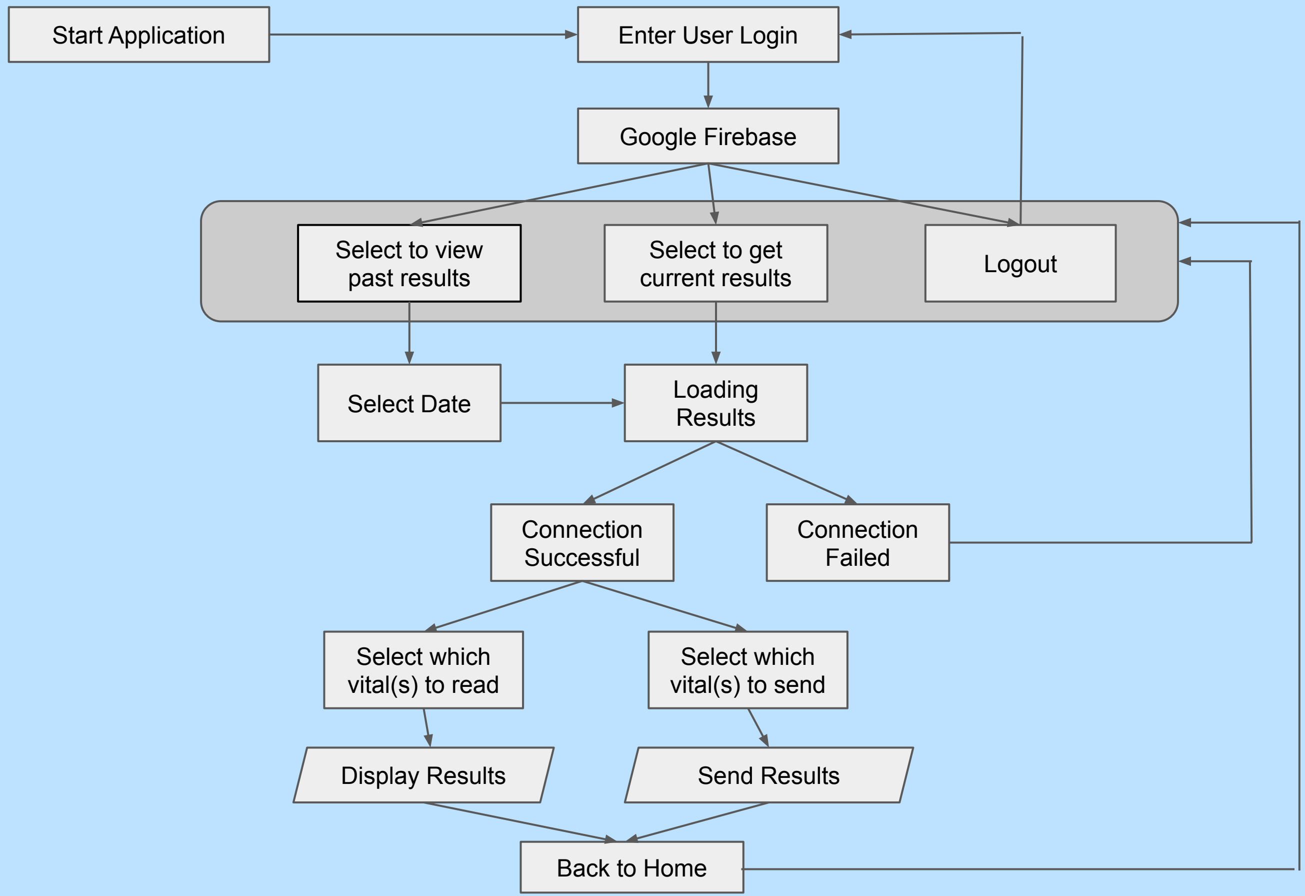
Block Diagram - Hardware

KEY

Gabriela George Schneider Nicole



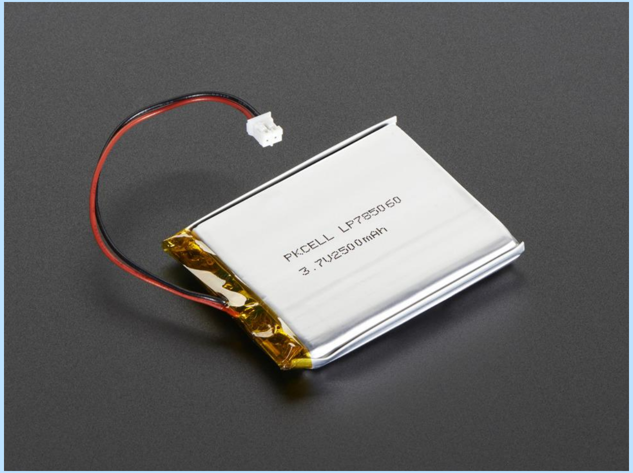
Block Diagram - Software

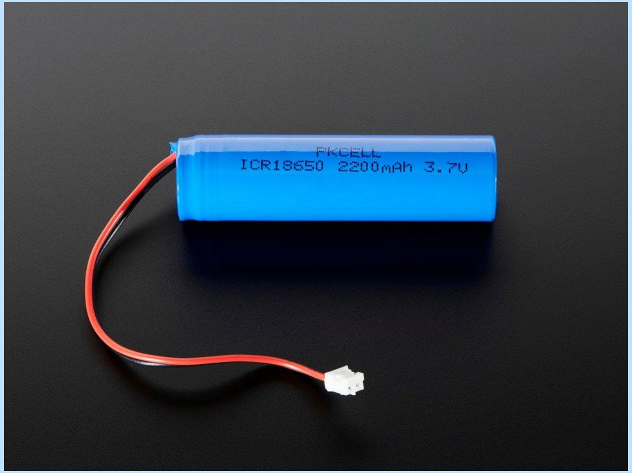


Solar Cells

- The initial plan for the project was to use solar cell fabric. However, due to high demand, we cannot use solar cell fabric so we either need to implement solar cells in a different way or rely solely on another form of power.
- The solar cells need to ensure they are outputting a sufficient amount of power as well as a sufficient conversion rate for our project device. Determining the evaluation of a solar cell performance primarily depends on finding the fill factor and the conversion efficiency.
- When there is no sunlight out for the solar cell cloth fabric, we will use the PV technology to keep the battery charged

Power Storage





<u>LP785060</u>

- Nominal Voltage: 3.7V
- Capacity: 2500 mAh
- Dimensions (mm): 47 x 61 x 6.7
- Cost: $14.95 (Adafruit)
- Our choice

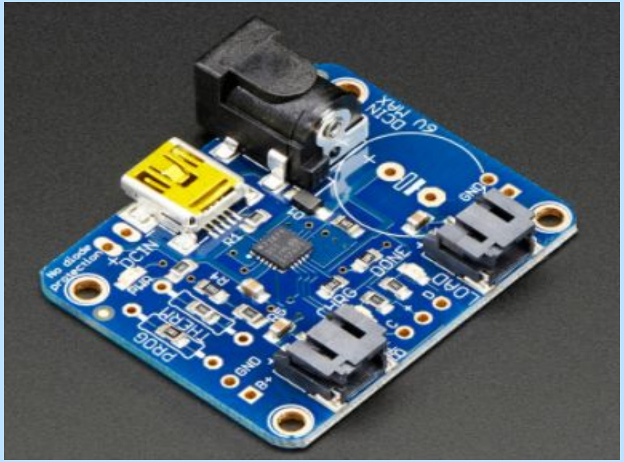
<u>ICR18650</u>

- Nominal Voltage: 3.7V
- Capacity: 2500 mAh
- Dimensions (mm): 69 x 18(diameter)
- Cost: $9.95 (Adafruit)

Solar Charger

BQ24074

- Solar Cell Input Voltage: 10V
- Max Charge Rate: 1.5A
- Cost: $10 (Adafruit)
- Our choice



MCP73871

- Solar Cell Input Voltage: 6V
- Max Charge Rate: 500 mA
- Cost: $18 (Adafruit)

Solar Charger & Battery Testing

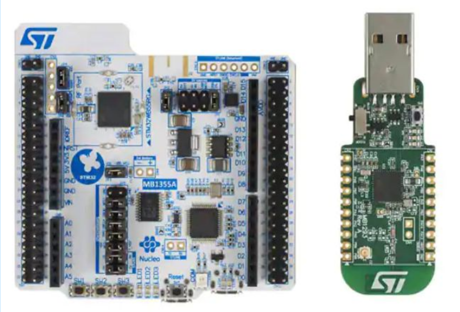
Microcontroller

Options we considered:

Our Choice:

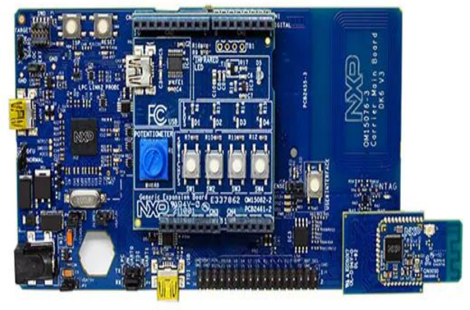
MAX32666

Storage	1MB
Memory	560KB Flash
Speed	Up to 96 MHz
Data Bus	32 bit
Cost	$176 (Digikey)



STM32WB55

Storage	256 KB
Memory	1MB Flash
Speed	Up to 48MHz
Data Bus	32 bit
Cost	$56 (Digikey)



QN9090THN

Storage	152KB
Memory	640KB Flash
Speed	Up to 48MHz
Data Bus	16 bit
Cost	$40 (Mouser)

Microcontroller

- Storing Data that is gathered from device
- Using I2C for Data Transmission between application and device
- Best for our project as we are requiring use of several parts to be working all at once (PPG Sensor, Battery, Bluetooth, etc)

IR Thermometer

- High accuracy
- Small size
- Wide temperature range
- Low cost

Thermometer Purchased:
MLX90632SLD-DCB-000-SP

- Accuracy of ±0.2℃
- 3 mm^2
- Temperature range from -20°C to 85°C
- Cost without shipping and handling: $18.32

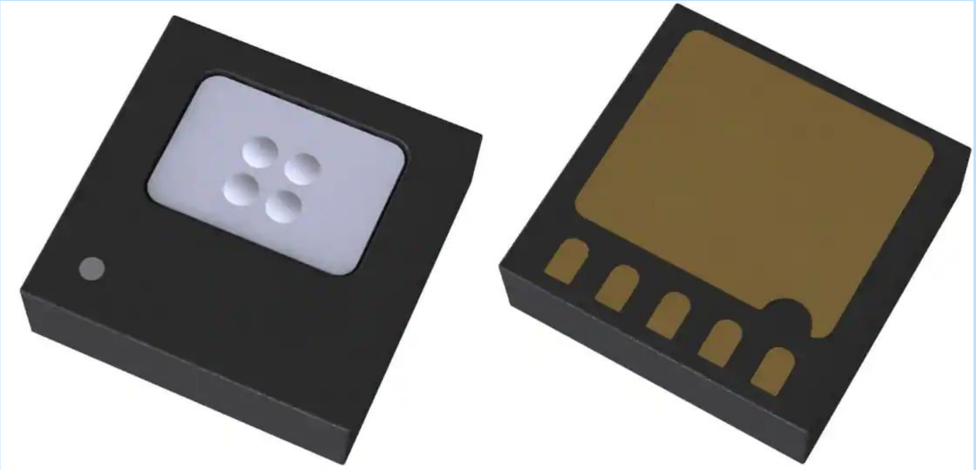


Fig. #. The digital temperature sensor purchased from Digi-Key Electronics.

Photoplethysmography

The user's heart rate is measured using reflective mode photoplethysmography (PPG). The main components of the PPG are the IR LED and photodiode. The LED illuminates the skin and the photodiode detects changes in the reflected light; the intensity varies due to the change in blood volume.

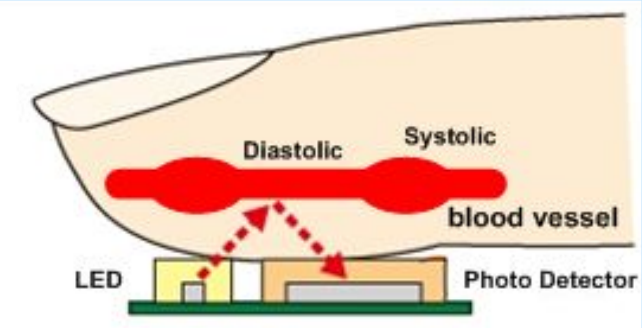
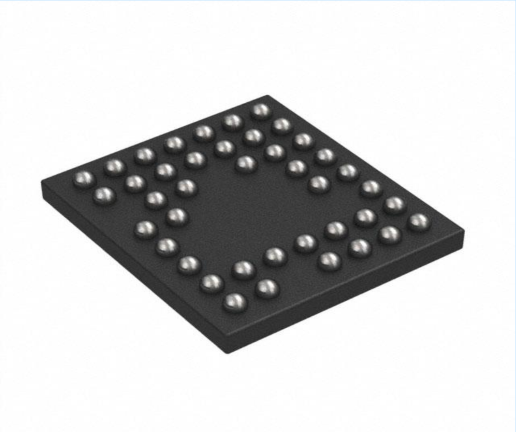


Figure #. Representation of how the module works and what is being measured.

PPG Sensor



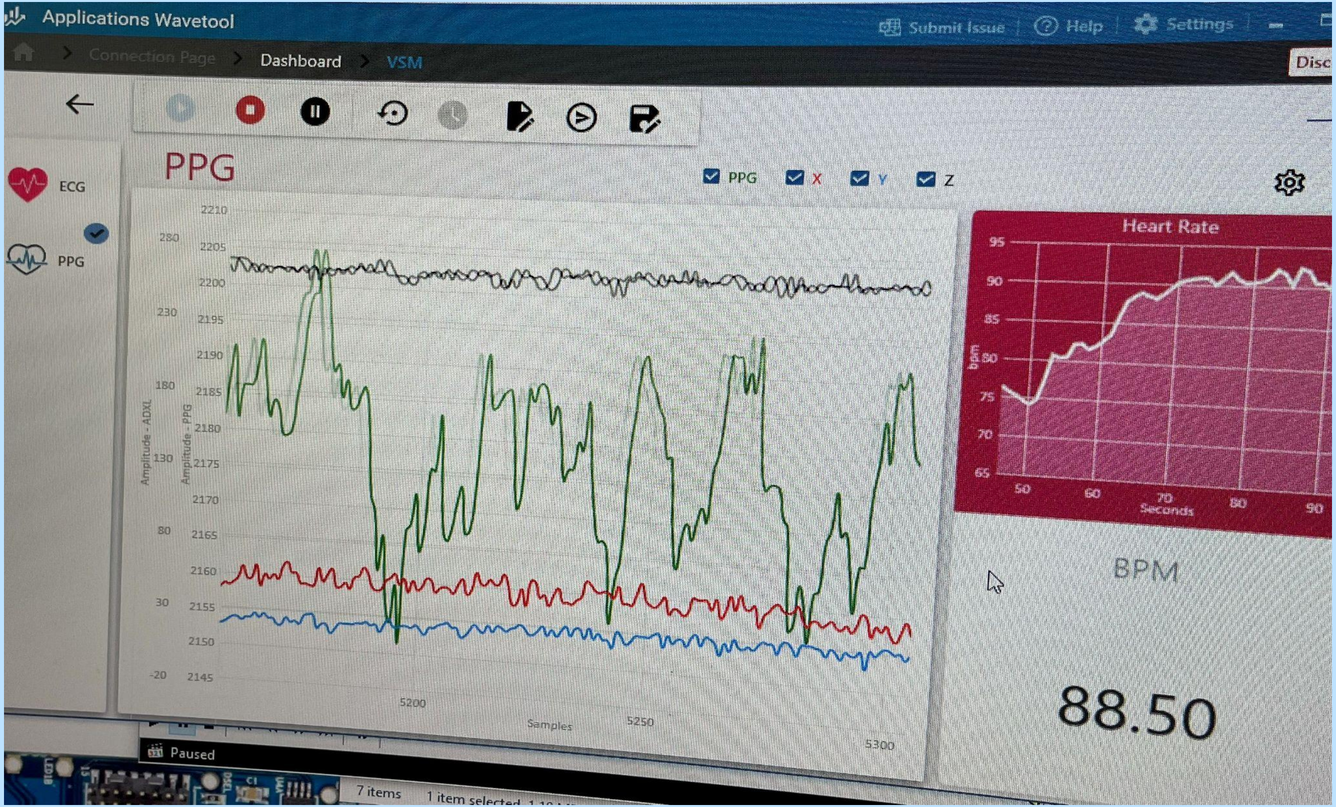
RT1025

ADPD4100

- Interface Used: I²C
- Voltage Supply: 1.62V-3.3V
- Power: 2.18 mW
- Cost: $15 (Digikey)

- Interface used: I²C or SPI
- Voltage Supply: 1.7V-3.6V
- Power: 30 μW
- Cost: $11.95 (Mouser)
- Our choice

PPG Sensor Testing



Photodiode Requirements

- Detects NIR light
- Size within range:
  - Large enough to get an accurate reading
  - Small enough to comfortably fit on device

Photodiode Purchased: *FDS025*

- Wavelength range of 400 to 1100 nm
- Active area of 0.049 mm^2
- Typical dark current of 35 pA at 5 V

Figure #. Photodiode purchased from Thorlabs

Near Infrared Light Emitting Diode Requirements

Figure #. Single-color IR LED purchased from Thorlabs

- Strong signal
- Safe for user; will not burn user
- Wavelength is easily absorbed by blood: 600 nm - 800 nm
- Size within range:
  - Large enough to emit a strong signal
  - Small enough to comfortably fit on device

LED Purchased: *LED750L*

- 750 nm wavelength
- 18 mW optical power at 50 mA
- 23 nm spectral full width half max

Bluetooth Requirements

- Low power consumption
- High data transfer rate
- Lightweight
- Large memory

For our project we used a Adafruit Flora BlueFruit 802.15.1

- 3.3 V power supply input
- 0.09 oz (2.5 g)

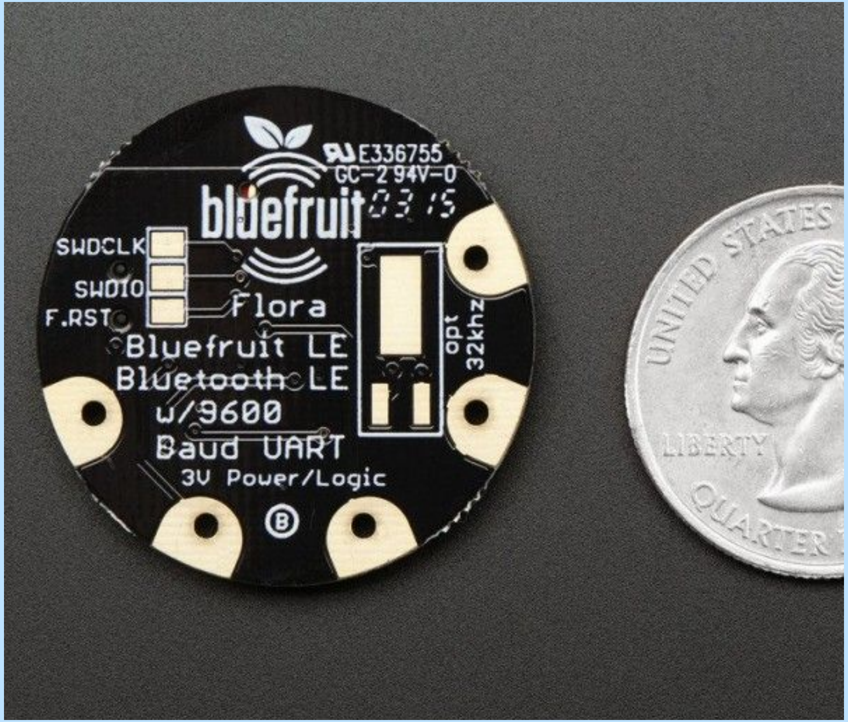
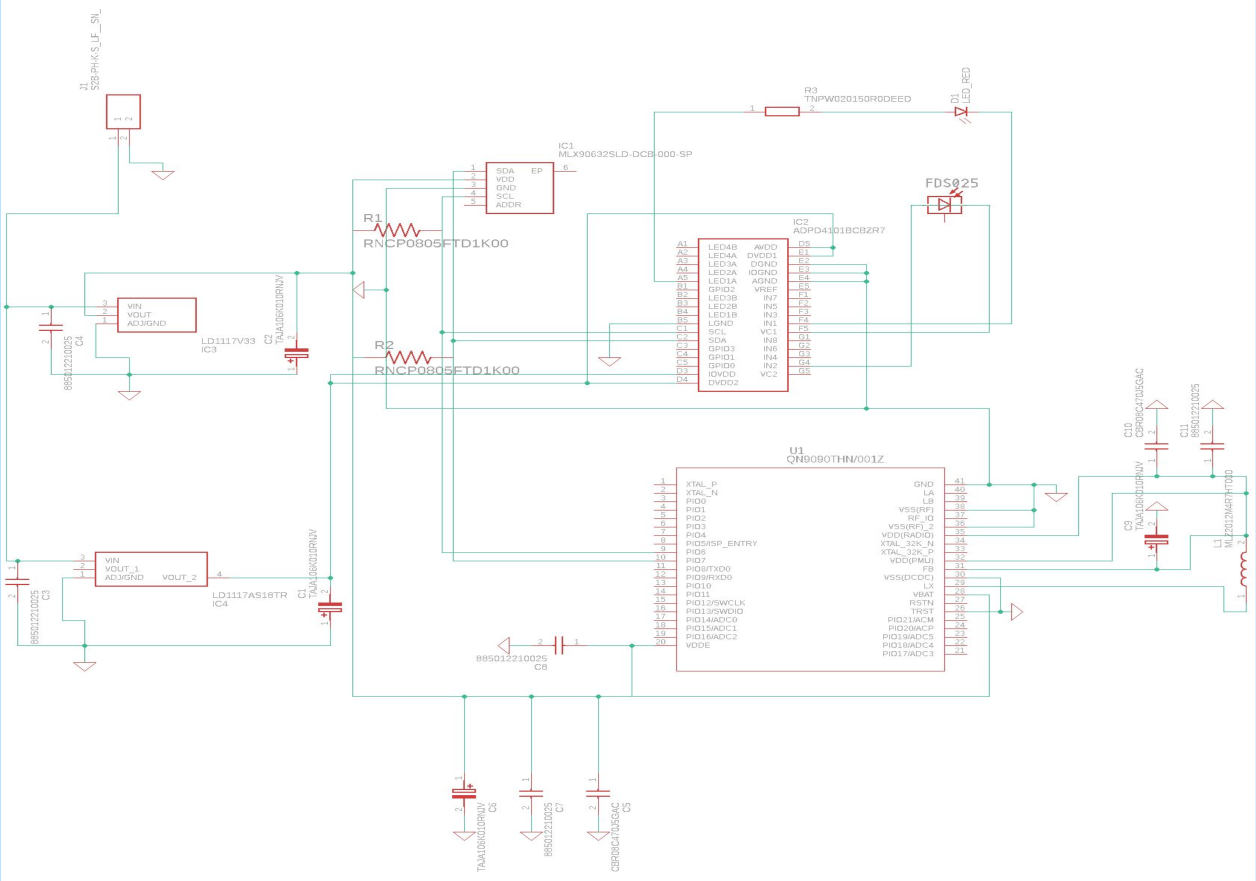


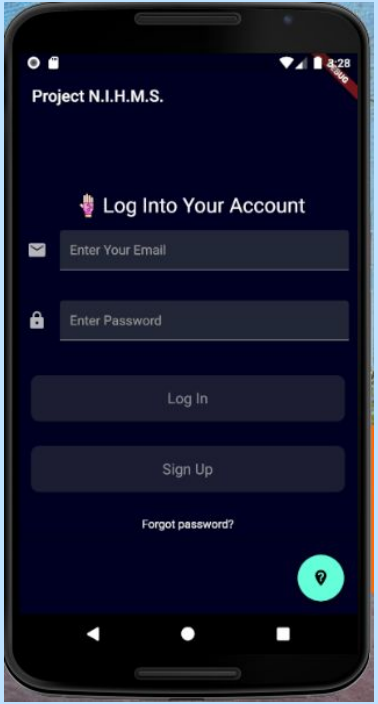
Fig. #. Bluetooth module size comparison with a quarter.

PCB Schematic

- 3.3V and 1.8V Buck Converters
- JST-PH Connector
- PPG Sensor
- Microcontroller
- Temperature Sensor



Application



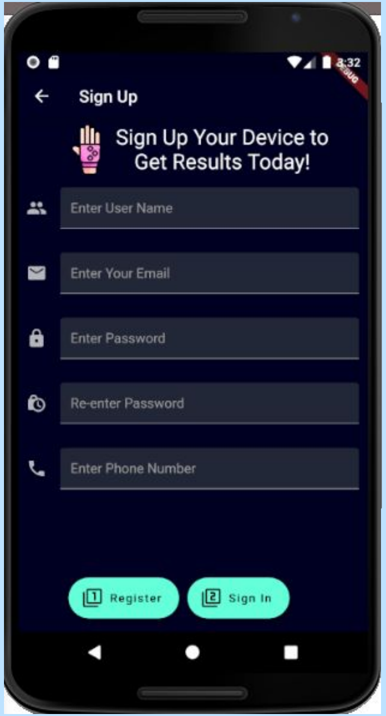
Login Screen

Purpose

To allow user to sign in to their account to utilize device and get past or present vitals.

Test Cases:

- Incorrect Username or Password
- Attempt of use of Username of Password that does not exist
- Clicking on the help button or sign up link and not getting the proper screen



Register Screen

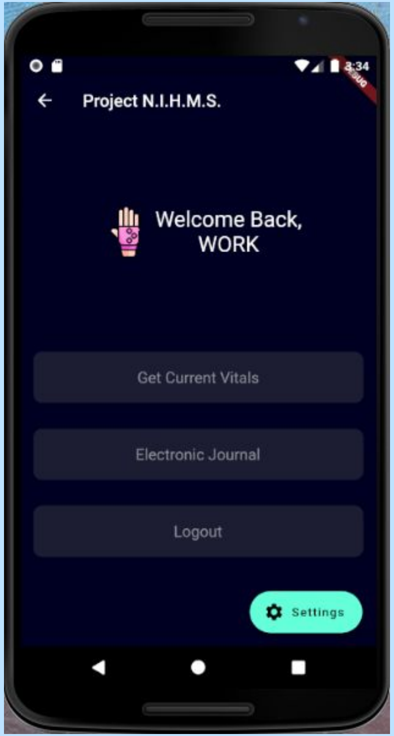
Purpose

To allow user to provide their personal information in order to register with an account if they are using the device for the first time.

Test Cases:

- Password and reentry of password do not match
- Username has already been taken by another account
- Missing entry on one of the required boxes
- Password not meeting the required character amount

Application



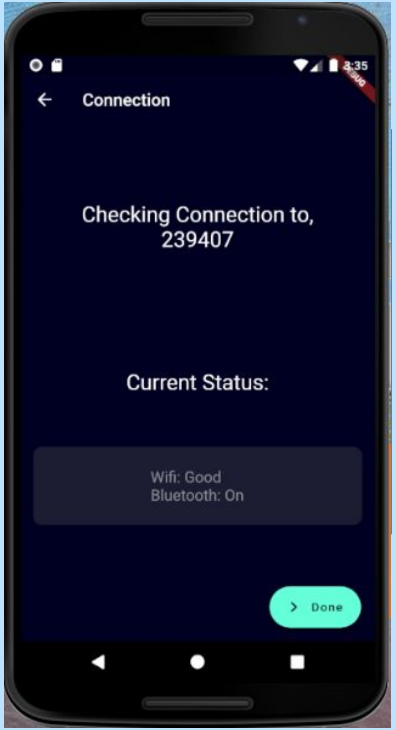
Home Screen

Purpose

To allow user to choose to check current vitals or check for past vitals

Test Cases:

- Correctly display username
- Clicking on either vitals or electronic journal routes you to the correct page
- Logout button logs the current user out and back to the login page



Check Connection Screen

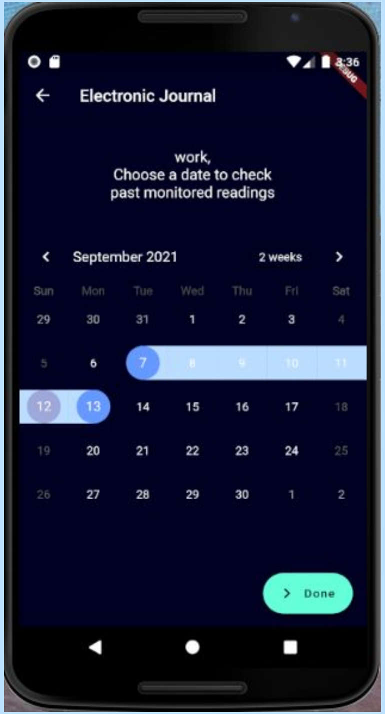
Purpose

To allow user to check their connection between their phone and our device

Test Cases:

- Checks if the user phone has wifi
- Checks if their bluetooth is on
- Displays our device bluetooth name

Application



Purpose

To allow user to check their past monitored vitals up to a year

Test Cases:

- Correctly display username
- Ability to check a range of selected dates
- Correctly display monitored readings

Electronic Journal Screen

Purpose

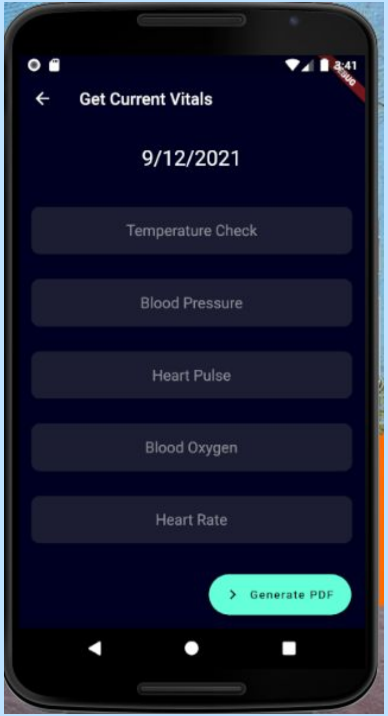
Visual aid to let the user know that the device is currently on and gathering their vitals

Test Cases:

- Correctly displays a progress bar that signifies how much time is left until the device has completed the vital readings

Loading Screen

Application



Vitals Options Screen

Purpose

To allow user to view their current vitals

Test Cases:

- Correctly display username and today's date
- Correctly displays all vitals recorded from device

Generate PDF Screen

Purpose

To allow user to view a pdf version of any range of dates of vital readings

Test Cases:

- Correctly display user selected date ranges
- Correctly displays all vitals recorded from device

Design Constraints

Economic & Time:

1. Seeking a sponsor
2. Working with each other's schedules
3. Short period of time in semester to finish a working project
4. Shortage in supplies causing delays

Health & Safety:

1. Working throughout the COVID-19 pandemic
2. Getting knowledge in how to use equipment to build design and be safe while doing so

Design Constraints

Ethical:

1. Develop our own original work
2. Communicate ideas and give proper credit where it's due
3. To not cause harm to any user that uses our device
4. Our design will read accurate results and not display any false information

Environmental:

1. PV Solar Cells
2. LEDs
3. Battery

Design Constraints

Manufacturability:

1. Set weight desired to provide comfortable experience with our product
2. No exposure to any wiring/unnecessary sensors that may discomfort user

Sustainability:

1. Securing parts to not allow any pieces to fall off product when user is putting on, using, or taking off device
2. Using parts that are already eligible to purchase off websites like Digikey and Mouser

Standards - Dart

- Flutter is used for our mobile and web application. Flutter uses Dart language which is an user interface that wraps the C++ code in Dart classes and libraries.
- Dart follows the Ecma-408 (European Computer Manufacturers Association).
- Just like other languages, Dart comes with object-oriented, class-based, garbage-collected language combined with C-style syntax.

Standards - W3C

- W3C is the standard that defines the open web platform of project N.I.H.M.S. phone application development
- The mission of W3C is “to lead the World Wide Web to its full potential by developing protocols and guidelines that ensure the long-term growth of the Web”
- W3C standard includes HTML and CSS to create our mobile web application. HTML and CSS are used to build the web pages for our project
- W3C also includes information on how our phone application can be made for the accessibility to people with disabilities

Project Successes and Difficulties

Successes	Difficulties
Creating the frontend of the app with flutter/dart	Powering the device using solar cells
Setting up the user sign-in with email verification and authentication through Google Firebase	Integrating PPG and ECG Waveforms on application
Designing PCB and sending it off for it to be built	Testing Photodiode and LEDs due to inadequate access to proper technology

Budget

Item	Estimated Cost	Actual Cost
IR Thermometer	$20.00	$25.00
Solar Cell Cloth	$30.00	TBD
PCB	$50.00	$55.00
Bluetooth Device	$50.00	$25.45
PPG/ECG Sensor	$30.00	$30.00
Microcontroller	$25.00	$15.75
Fingerless Glove	$20.00	$12.00
Photodiode	$35.00	$45.41
LED	$15.00	$12.77
Solar Cell Charger	$10.00	$22.45
Battery	$15.00	$15.00

Estimated Total Cost
$300.00

Actual Total Cost ***(including shipping and tax)***
$258.83

Cost per team member
$64.70

Current Progress – Hardware

Task	Progress	Percentage of Completion
Research	Complete	100%
Acquiring Parts	In Progress	90%
Testing of parts	In Progress	70%
PCB Build	In Progress	50%
Assembly and Soldering	Incomplete	10%
Testing Completed Project	Incomplete	0%

Current Progress – Software

Task	Progress	Percentage of Completion
Generate PDF	In Progress	50%
Emergency Services	In Progress	20%
Microcontroller Storage to Application	In Progress	10%
PPG Sensor to Application	In Progress	10%

Project Planning and Outlook

Next Steps: Hardware

1. Testing individual pieces
2. Assembling device once PCB order is received
3. Testing assembled device
4. Adjustments and reassembly

Next Steps: Software

1. Application testing on a physical mobile device
2. Microcontroller data displayed on application
3. Debugging any issues between application and device

THANKS FOR LISTENING!

Questions?