The Phoenix Board

Group 8

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Simeon Richards	EE

Motivations

- We each wanted different ideas incorporated into a project
  - Solar energy/power management
  - Mobile communications (Wi-Fi or Bluetooth)
  - Computer vision
- We wanted something fun that would keep us all motivated throughout the duration of the project
- We wanted something that could be used regularly and reliably
- Quick travel within a college campus

Goals and Objectives

Core Features:

- Motor functions properly
- Battery receives charge
- PCB communicates with all peripherals
- Mobile communications are consistent and precise
- Weight-sensitive safety mechanism
- Efficient and reliable

Stretch Features:

- Computer vision is consistent, providing accurate danger assessment while minimizing false flags
- LEDs for Night Mode are responsive and allow for user customization

Specifications

Total Board Weight	< 25 lbs
Maximum Board Speed	> 15 mph
Battery	36V, 10Ah, < = 10A
Battery Charge Time	< 3 hours
Communication	< 0.5s response time between app and PCB
Motor Efficiency	> 70%
Battery Efficiency	> 80%
Cost	< $1000

Existing Projects

Halo Board - 2nd Edition

- 14 lbs
- 286 lb weight limit
- 14 miles of ride time
- Max speed: 26 mph
- Recharge time: 3 hrs
- Cost: $1,497.00 USD

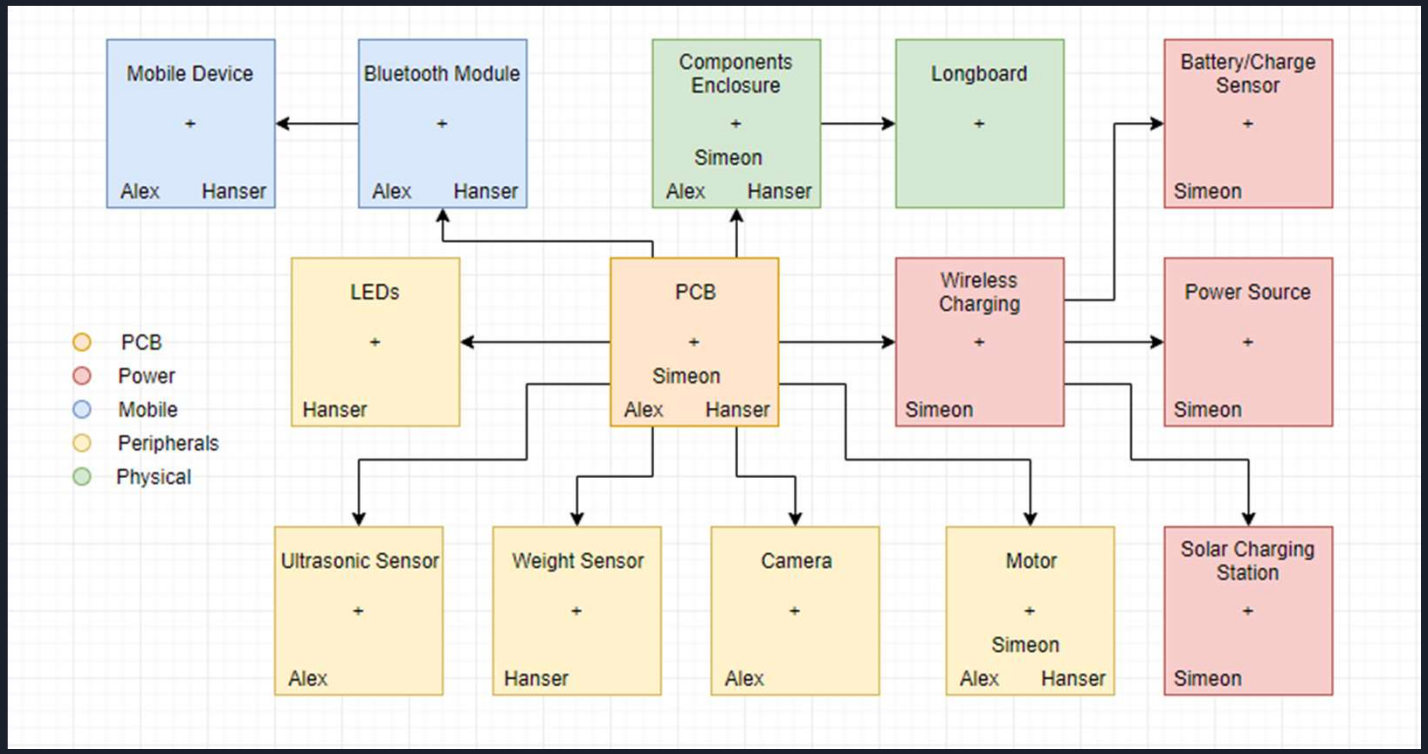
Evolve Boards - Bamboo GTX

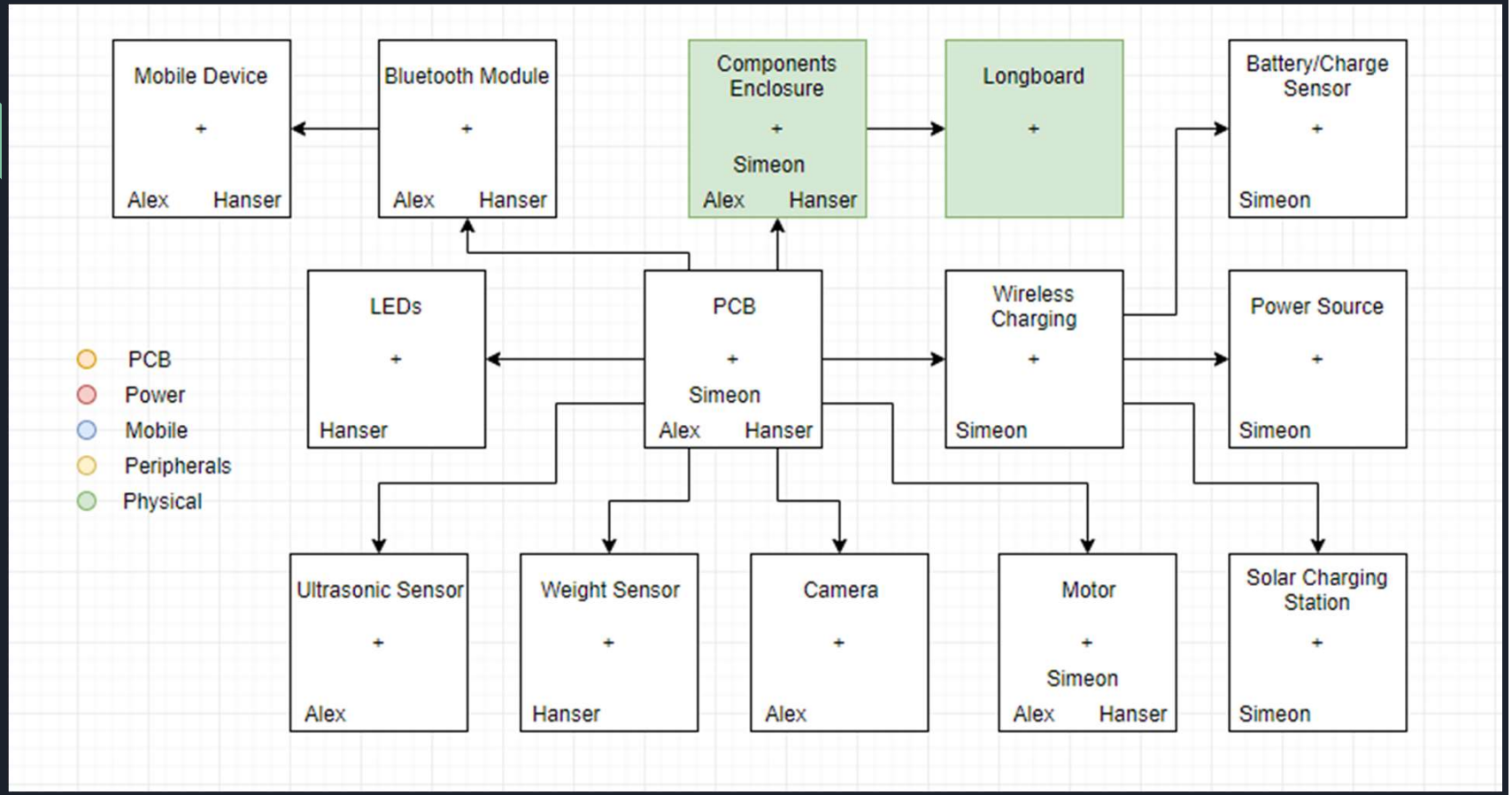
- 19.4 lbs
- 220 lb weight limit
- 19 miles of ride time
- Max speed: 26 mph
- Recharge time: 4-5 hrs
- Cost: $1,779.99 USD

Boosted Boards - Boosted Plus

- 17 lbs
- 250 lb weight limit
- 14 miles of ride time
- Max speed: 22 mph
- Recharge time: 1.75 hrs
- Cost: $1,399.00 USD

Block Diagram




Mobile Device
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Alex Hanser
Bluetooth Module
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Motor
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Solar Charging Station
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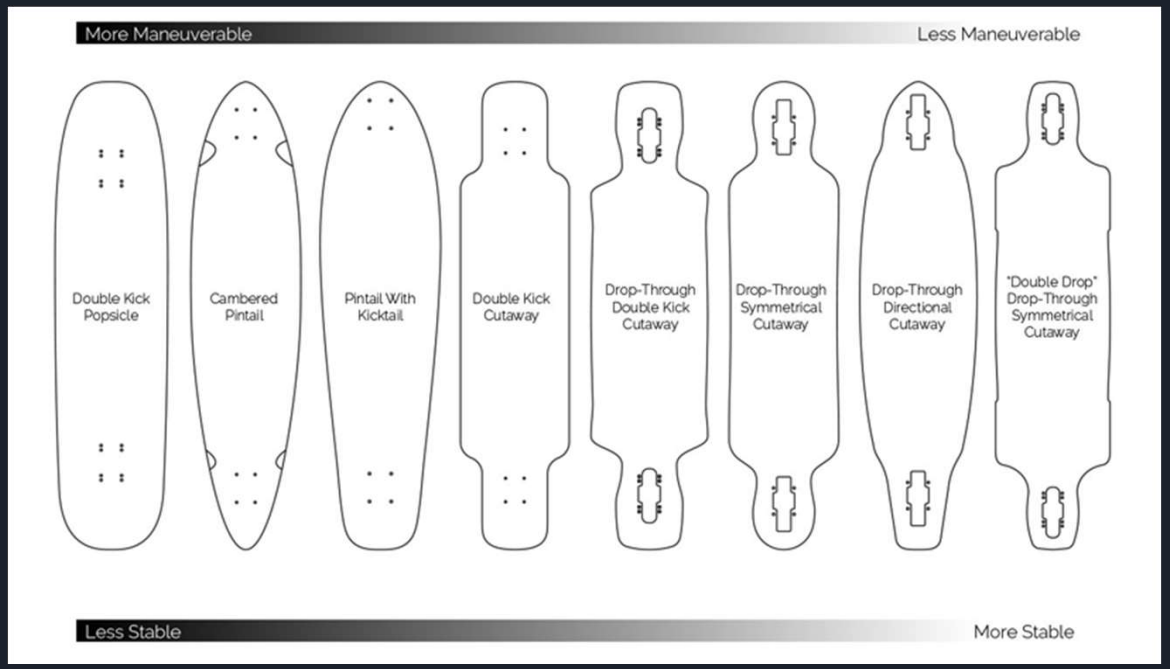
Longboard Selection

Stability/Maneuverability Factors:

- Length
- Width
- Weight
- Flex
- Style (Truck height)
- Shape



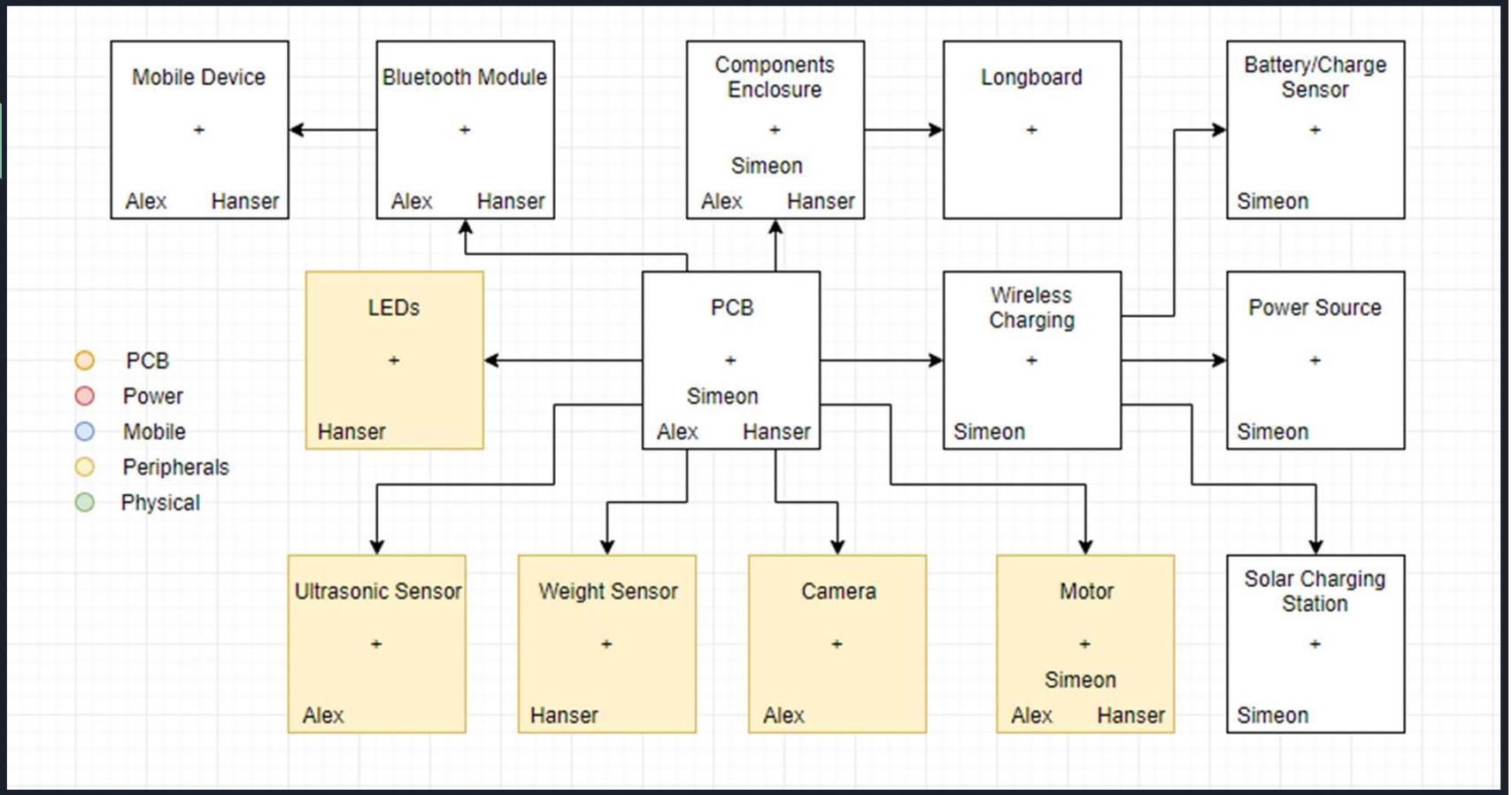
Battery/Component Enclosure

Pre-made enclosures

- Easier to acquire
- Puts constraints on how to layout components

Custom-made enclosures

- Multiple DIY tutorials online for fiberglass cases
- 3D-printed enclosures
  - Could lead to a better product but will cost significantly more
  - Acrylic Styrene Acrylonitrile (ASA) – $30-45 USD per Kg
  - Polyethylene Terephthalate (PET) – $45-70 USD per Kg
  - Nylon – $80-110 USD per Kg
  - Carbon Fiber Filled – $45-90 USD per Kg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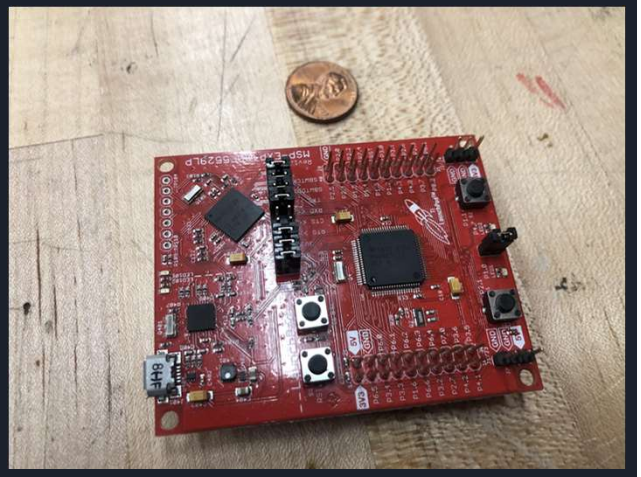
Microcontroller



MSP430F5529LP

- 16-bit RISC CPU, Up to 25 Mhz
- High Frequency Crystals up to 32 Mhz
- 128KB Flash and 8KB RAM
- 12 Bit Analog to Digital Converter
- Digitally Controlled Oscillator to wake up from Low-Power Modes
- Four 16-bit timers
- Two USCIs with UART, I2C, and Synchronous SPI support
- 63 I/O pins
- Low power/high efficiency

Embedded System IDE

Embedded IDE: Code Composer Studio (CCS)

- Used for developing applications for TI embedded processors
- Supports C/C++
- Programming for microcontroller will be done using C code
- CCS used due to wide availability of training materials and existing familiarity with the framework

Motors: Hub vs. Belt

Hub Motors

- Motor is integrated into wheel reducing the amount of noise made
- Less drag which provides a longer battery life
- Reduced resistance allows users to free roll
- Thinner urethane sleeving around motor as opposed to full-sized wheel reduces shock absorption
- Typically weigh less

Belt Motors

- Involve a belt/pulley system which can create significant amounts of noise
- Provide higher levels of torque
- Present a lot of resistance essentially barring free roll
- Can cause rider to feel a vibration when running
- Can use full-sized wheels for better shock absorption
- Typically weigh more

Motor Selection

- Weight: 9.57 lbs
- Motor size: 74.5 mm x 52 mm
- Wheel size: 90 mm
- Top Speed: 25 mph
- Operating voltage: 24V - 42V
- Simple integration
- Replaceable urethane sleeving

Dual 90mm Hub Motor Kit

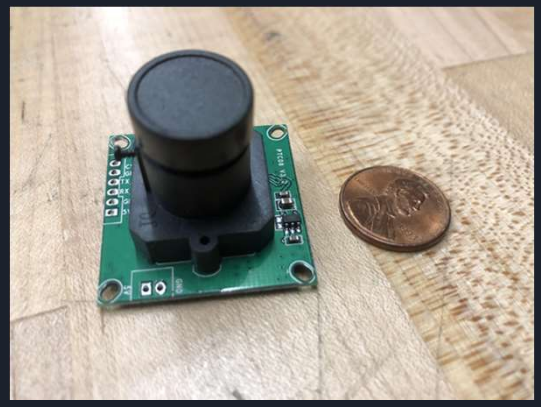
Ultrasonic Sensor

SMAKN Ultrasonic Module HY-SRF05 Distance Sensor

- Power Supply: +5V DC
- Idle Current: < 2mA
- Ranging Distance: 2 cm - 450 cm
- Resolution: 0.3 cm
- Full measuring angle: 30 degrees
- Effective angle: < 15 degrees
- Pins: VCC, GND, TRIG, ECHO, OUT
- Used for obstacle detection in front of the board and assist with engaging emergency slowdown to prevent/minimize rider injury

Camera

Adafruit TTL Serial JPEG Camera with NTSC Video



- Power Supply: +5V DC
- Current Draw: 75 mA
- Resolution: 640 x 480 (0.3 MP)
- FPS: 30
- Transmission baud rate: 38400
- Max transmission baud rate: 115200
- Image sensor: CMOS ¼ inch
- Viewing angle: 60 degrees
- Video will be sent to BLE radio via UART to app running OpenCV for Android obstacle detection algorithm, works in tandem with ultrasonic sensor

LCD Display

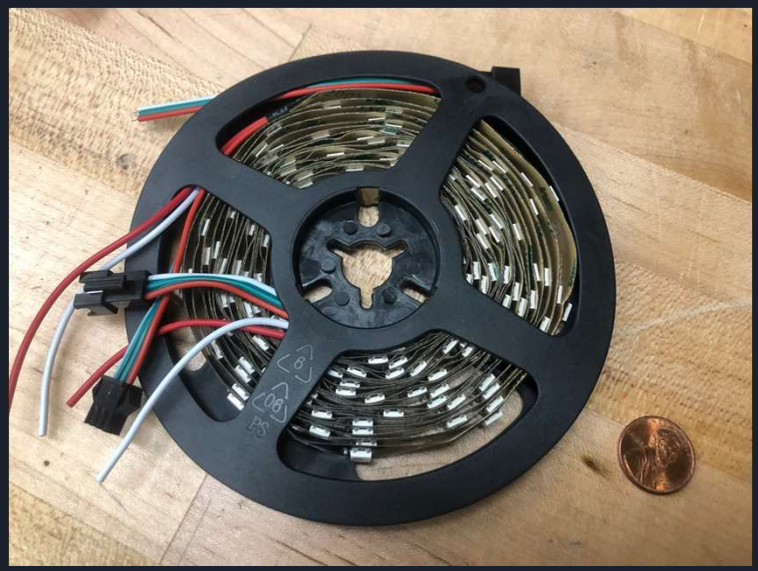
Jansane 16x2 1602 LCD Display

- 2 lines, 16 characters
- Operating Voltage: +5V DC
- I2C Serial Interface
- Capable of displaying almost any useful data, including time, temperature, etc.
- Used for displaying current battery on the board itself, without the app

Night Mode LEDs

WS2812B RGB LED Strip

- Power Supply: +5V DC
- 5050 RGB LEDs
- 24-bit color (8-bit red, green, and blue data)
- 120 degree view angle
- LED strip can be cut to desired length without damaging LEDs.



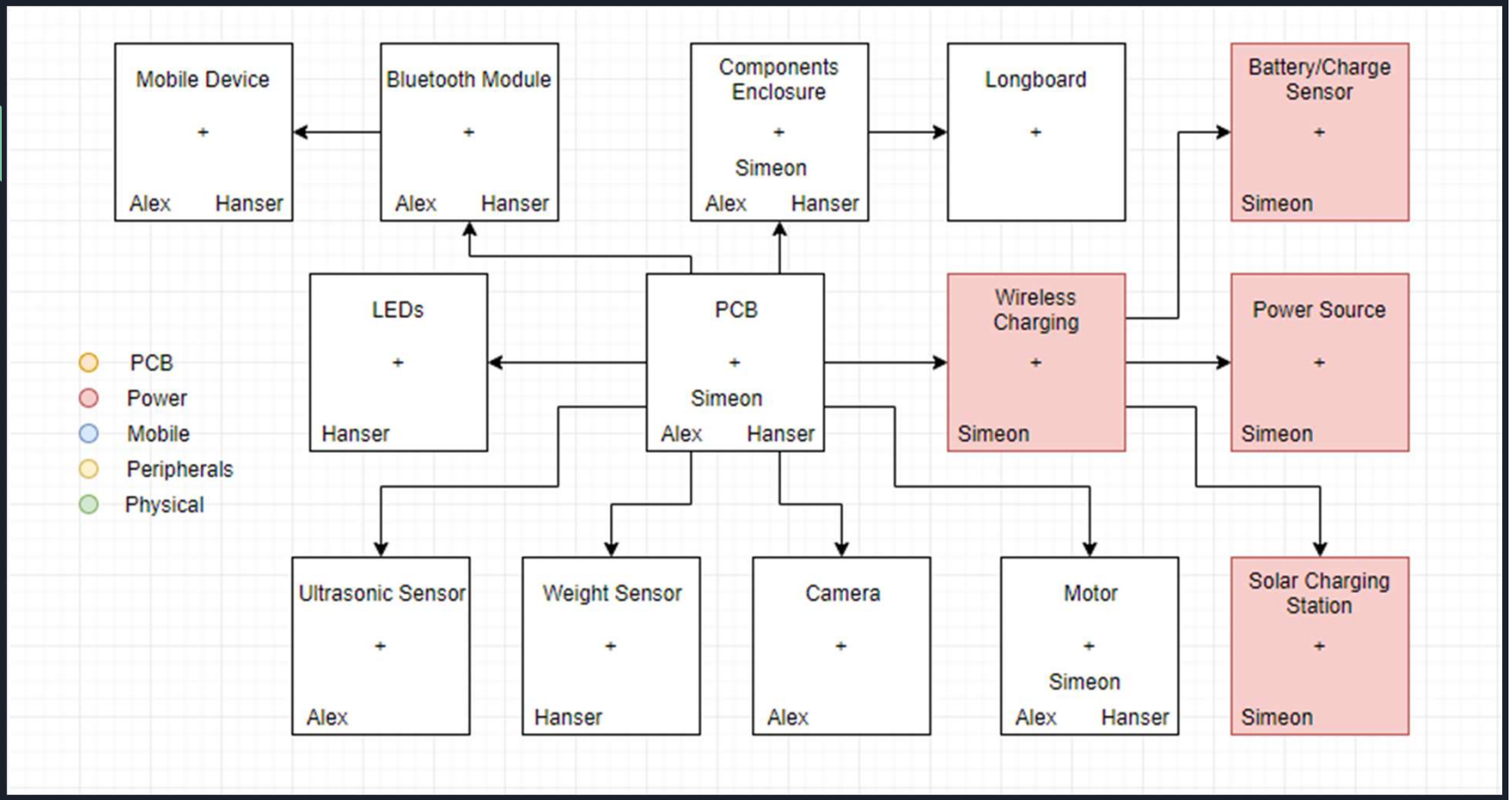
Load Cell and Load Cell Amplifier

Load Cell: TAS606 Load Cell - 200 kg

- 200 kg weight capacity
- Consists of 4 Strain gauges hooked up into a wheatstone bridge
- 20 mm x 11 mm, 2000 mm wire
- Operating Voltage: 5 - 15 V

Load Cell Amplifier: SparkFun Load Cell Amplifier - HX711

- ADC to convert analog Load Cell signal into a Digital signal
- Operating Voltage: 2.7 V - 5 V
- Operating Current: < 1.5 mA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Power Management

Solar Power

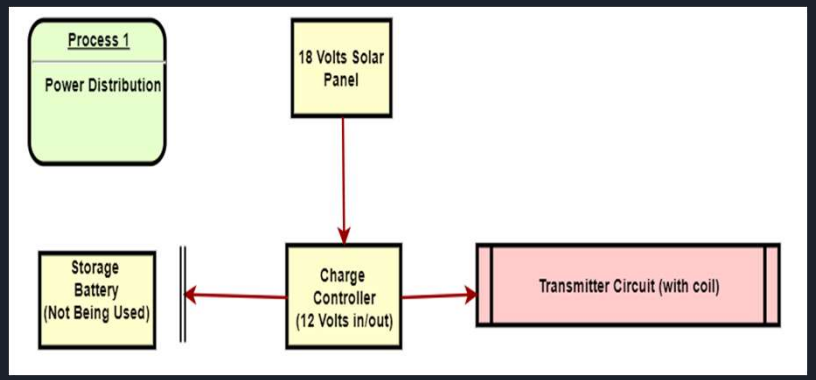
Monocrystalline Panel - Pros

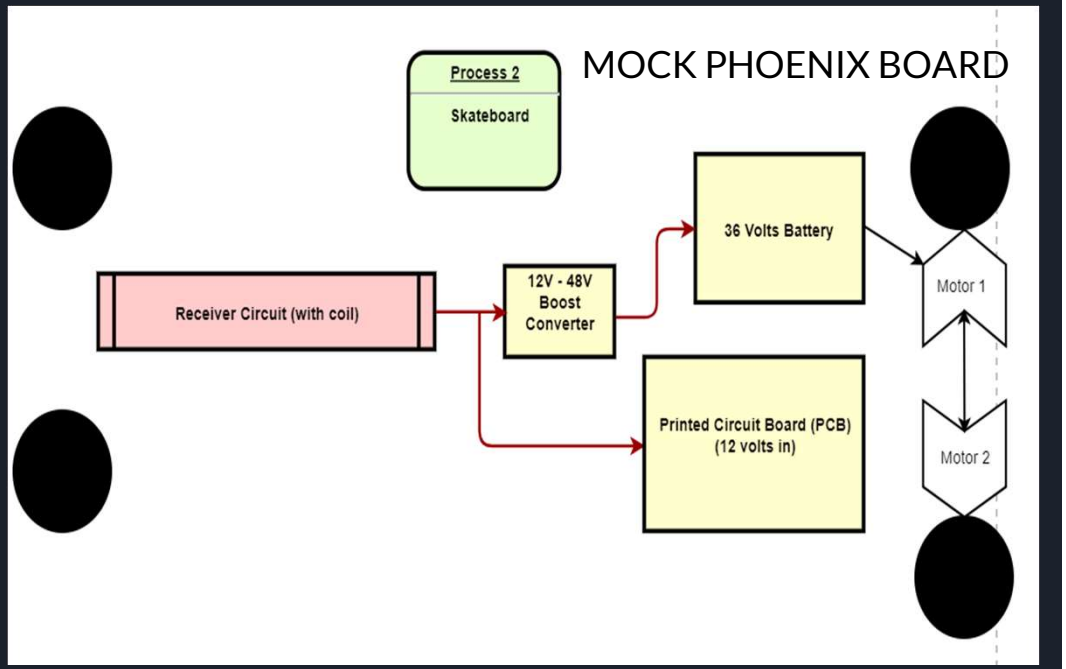
- First choice for highest efficiency
- Highest power output
- Requires least amount of space
- Longevity and long warranty from manufacturers (Usually 25 years)

Monocrystalline Panel - Cons

- More expensive
- Open circuit if covered by shade, dirt or snow (use of micro inverters required)
- More efficient in warmer weather

Power Management Flowchart





Power Management

Battery - 36V Lithium-Ion

Pros

- Greatest electrochemical potential
- Largest energy per weight
- High energy density
- Low internal resistance
- Low self discharge rate & low maintenance

Cons

- Fragile
- Requires protection circuit for safe operation (most)
- Expensive to manufacture
- Frequent upgrade

Battery Fuel Gauge

BQ34Z100-G1 Multi-Chemistry Impedance Track Standalone Fuel Gauge | Battery Gas Gauge

- Max Voltage Support: 65 V
- Max Capacity: 29 Ah
- Max Current: 32 A
- Impedance Track fuel gauge, works independently of battery series-cell configuration
- Internal Temperature Sensor
- Supports two-wire I2C and HDQ Single-wire communications

Wireless Charging

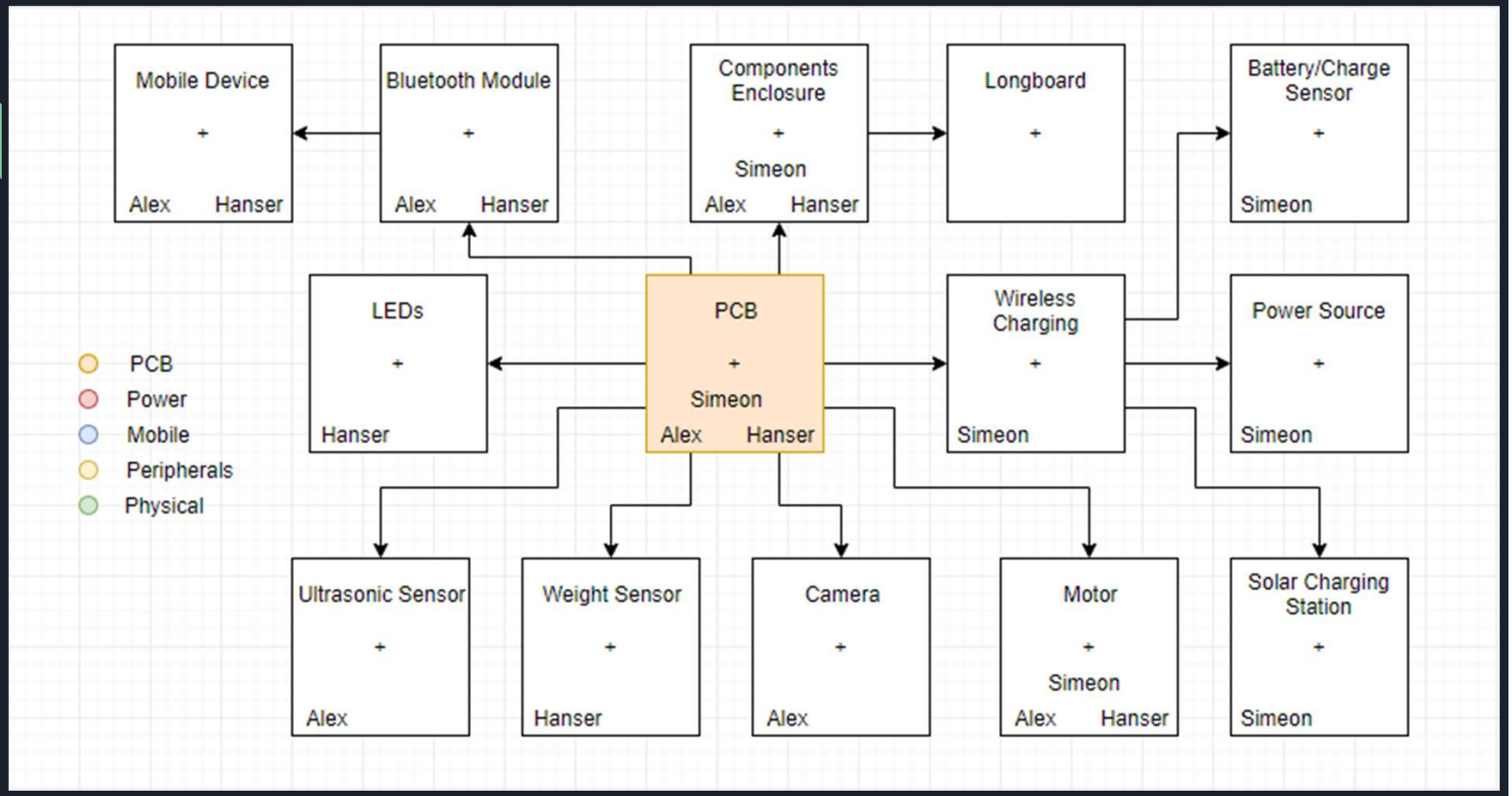
Magnetic Induction (Inductive)

Pros

- Simple and efficient
- Safe
- Scalable
- Mature
- Good coupling

Cons

- Single device operation
- Limited X/Y/Z space
- Close proximity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PCB Schematic Design

Initial Prototyping

Bluetooth module testing

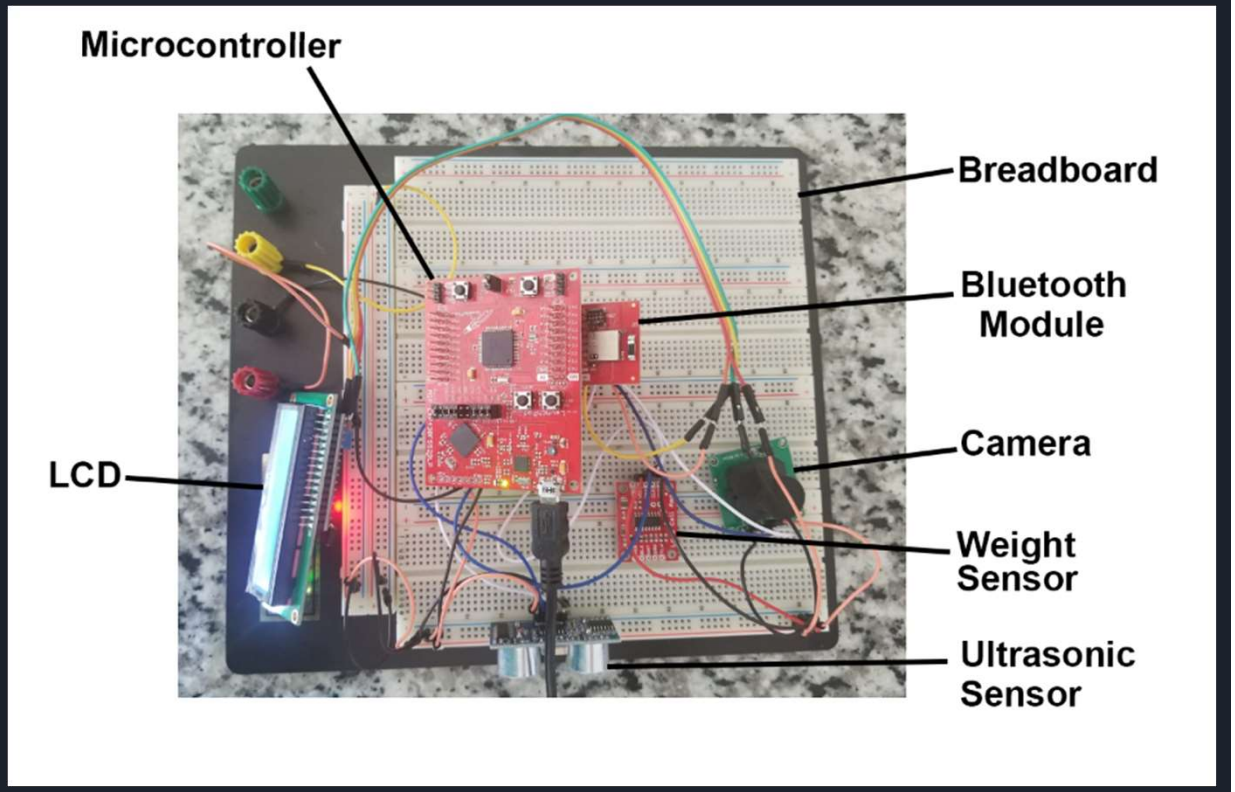
Ultrasonic Sensor testing

Camera testing

Load cell testing

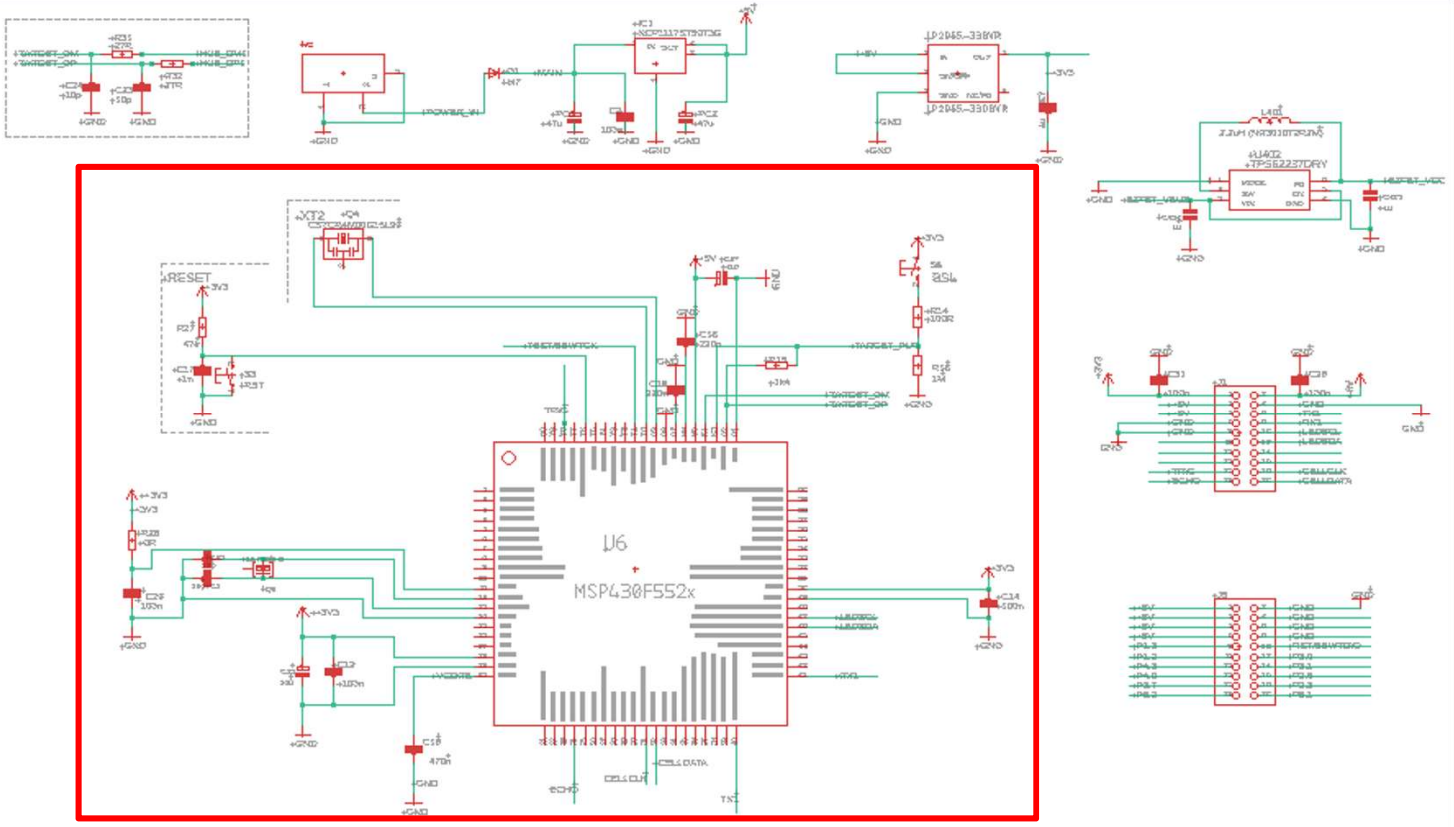
LCD testing

Fuel Gauge testing



PCB Schematic Design

MAIN PCB (target device)



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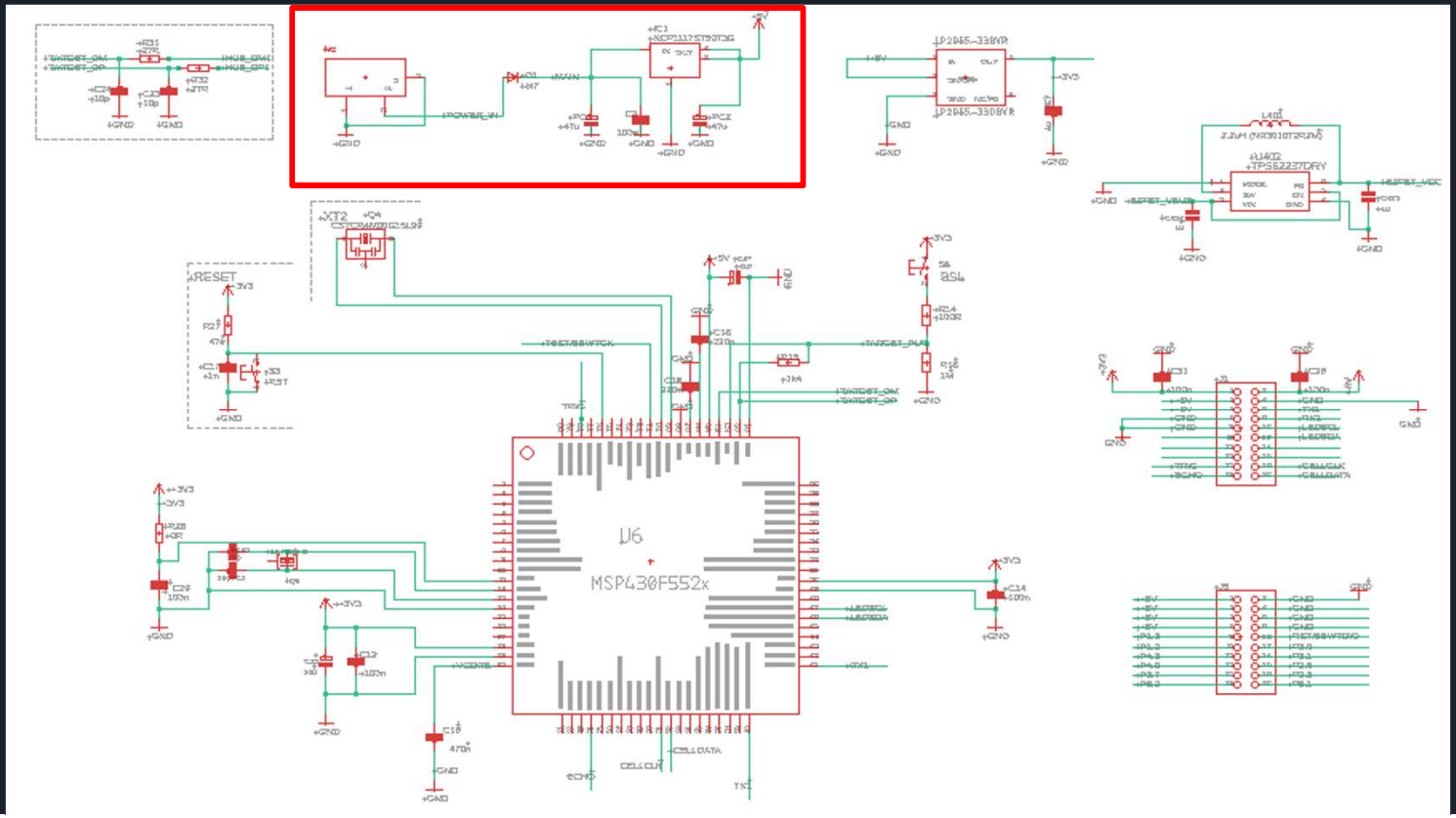

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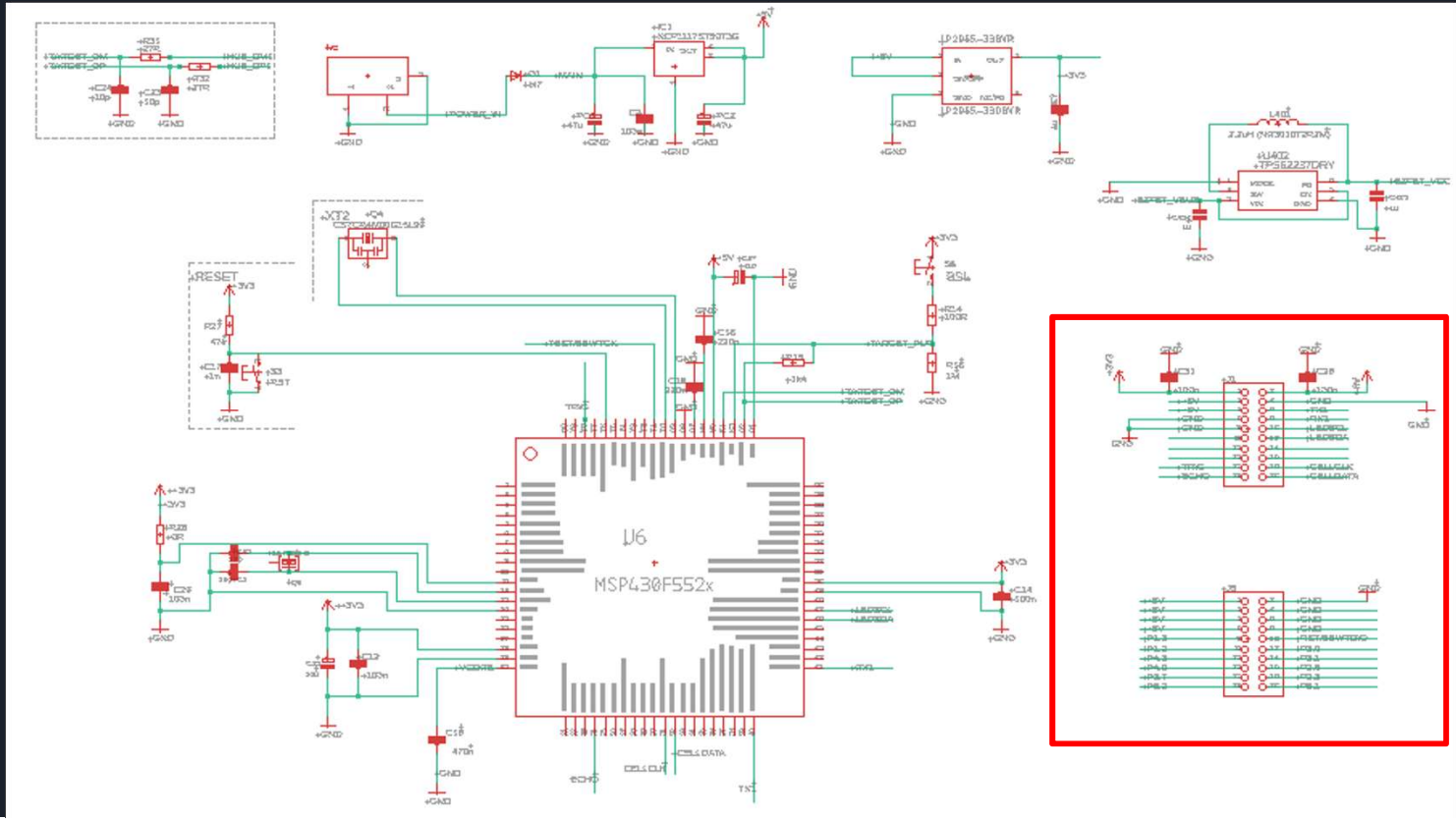

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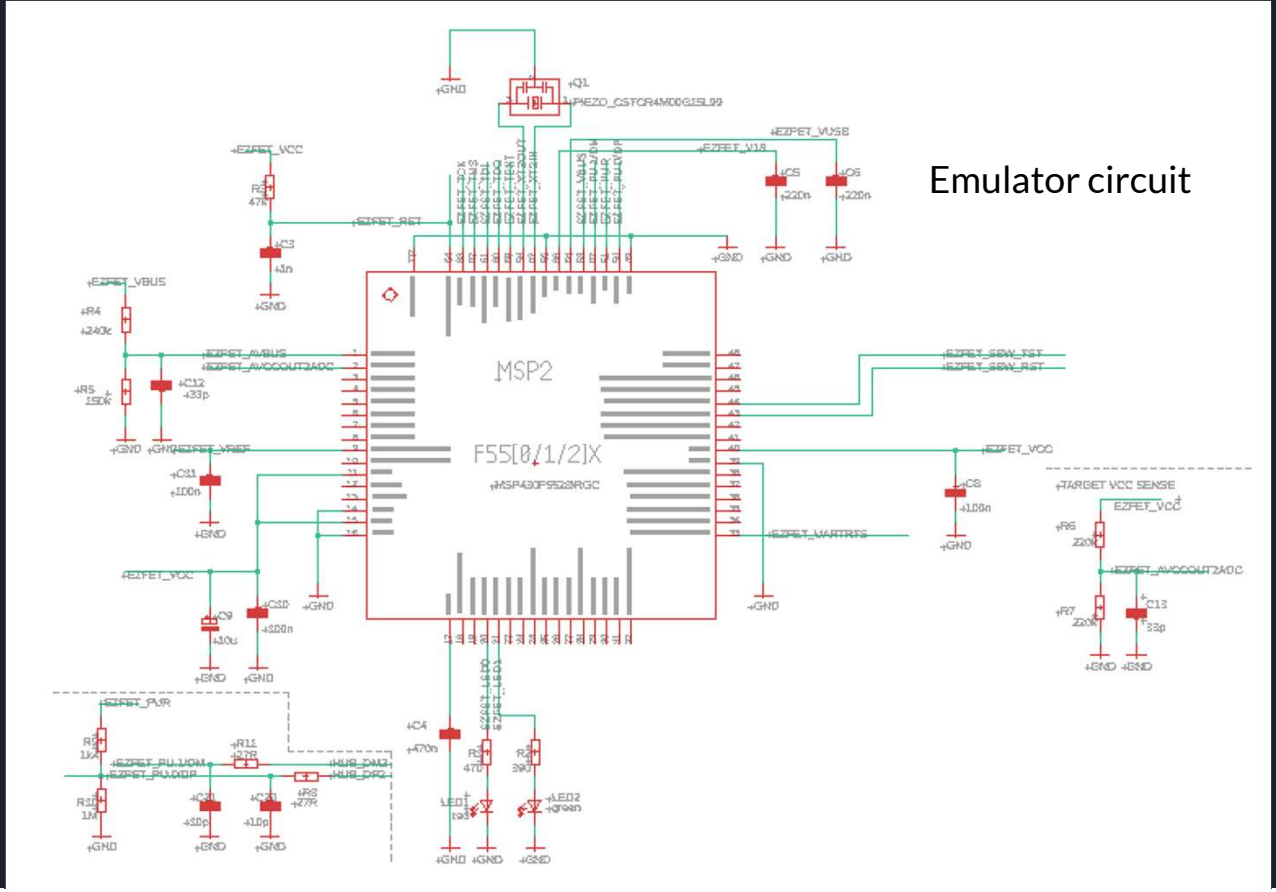
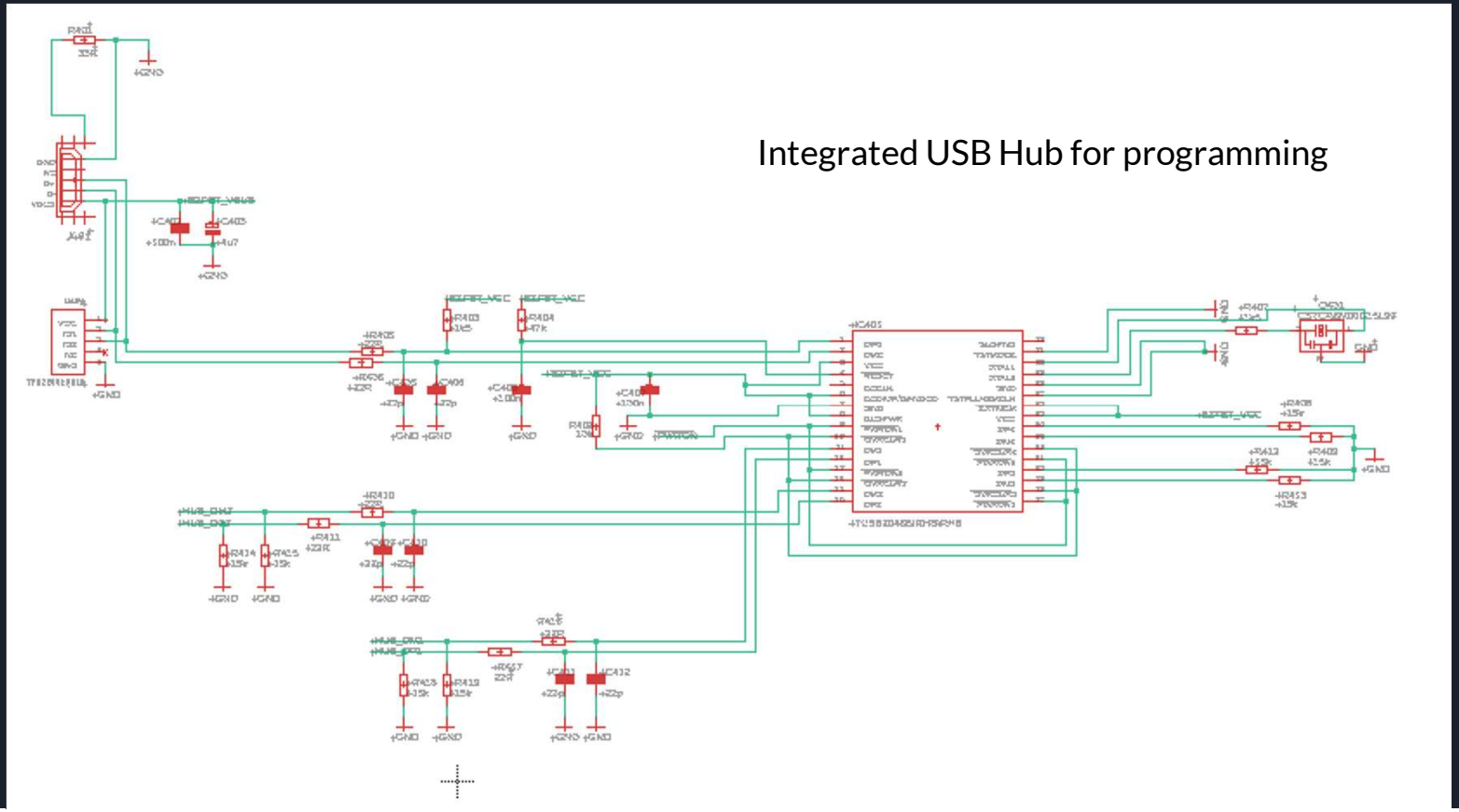
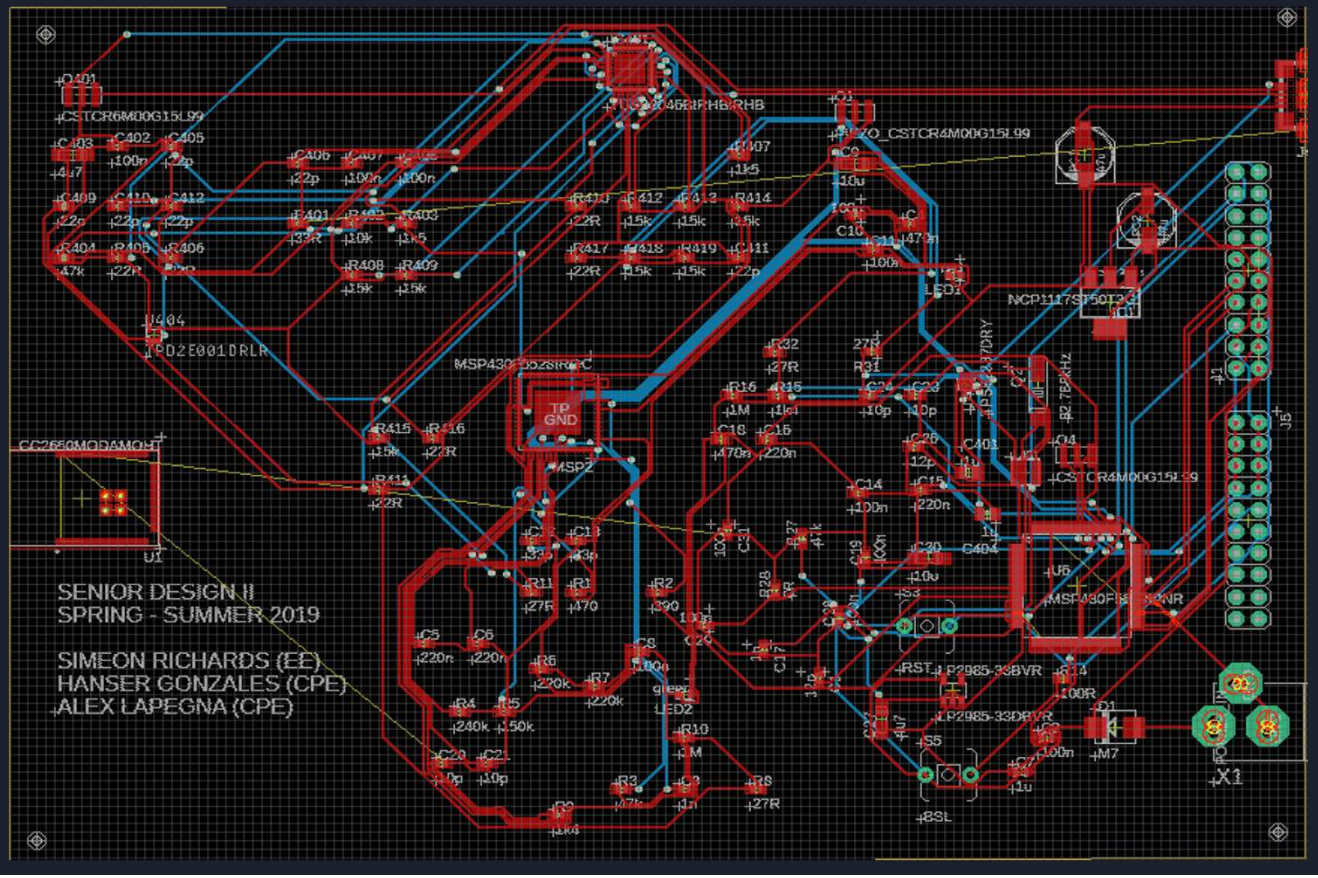


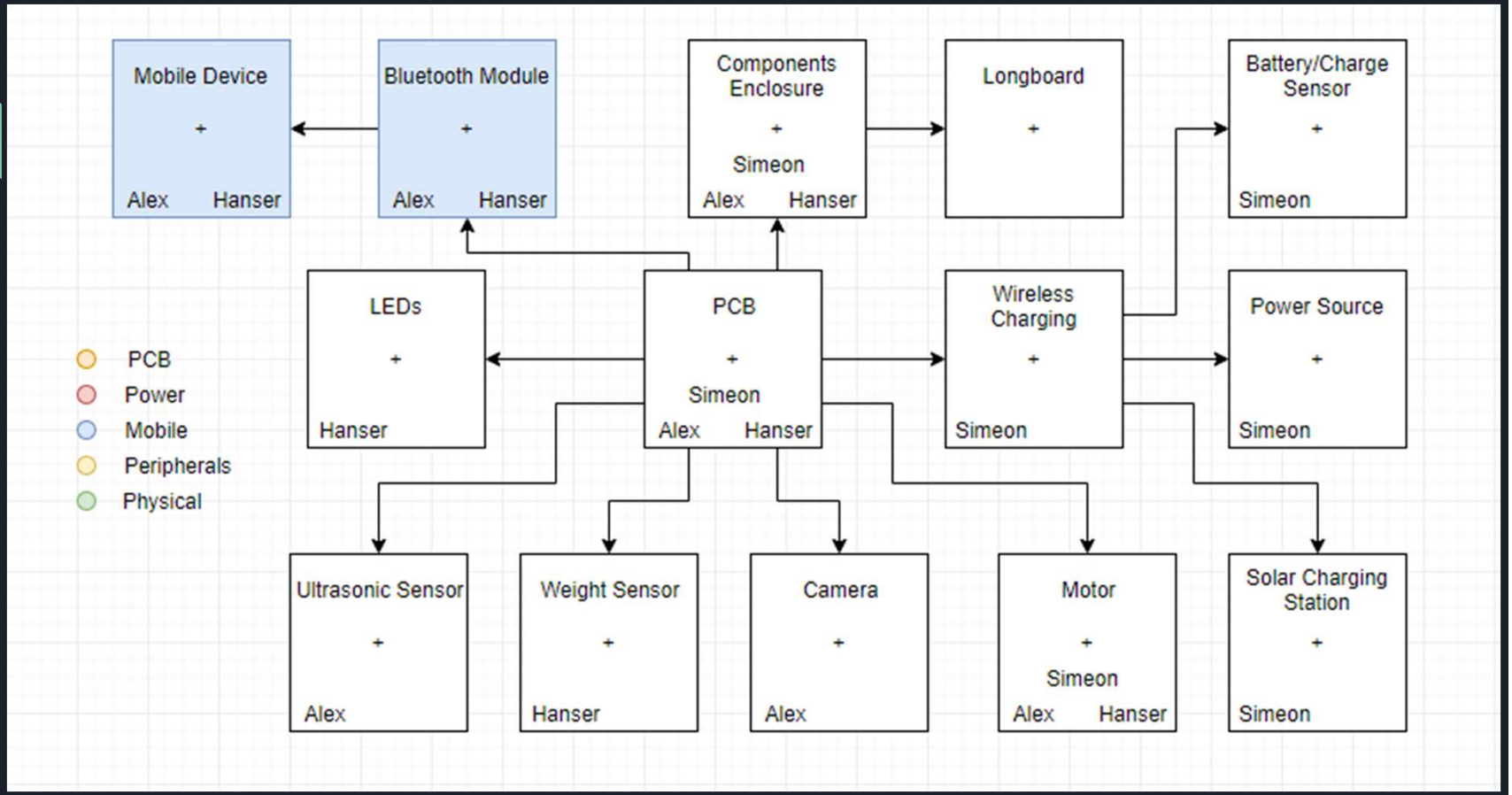
PCB Schematic Design



Integrated USB Hub for programming

PCB Schematic Design

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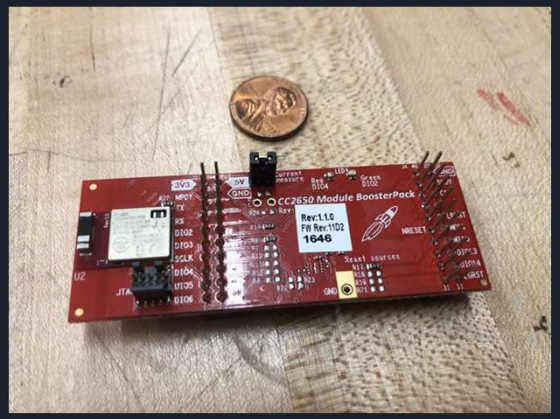
Bluetooth Module

TI SimpleLink Bluetooth Low Energy CC2650 Module BoosterPack Plug-in Module



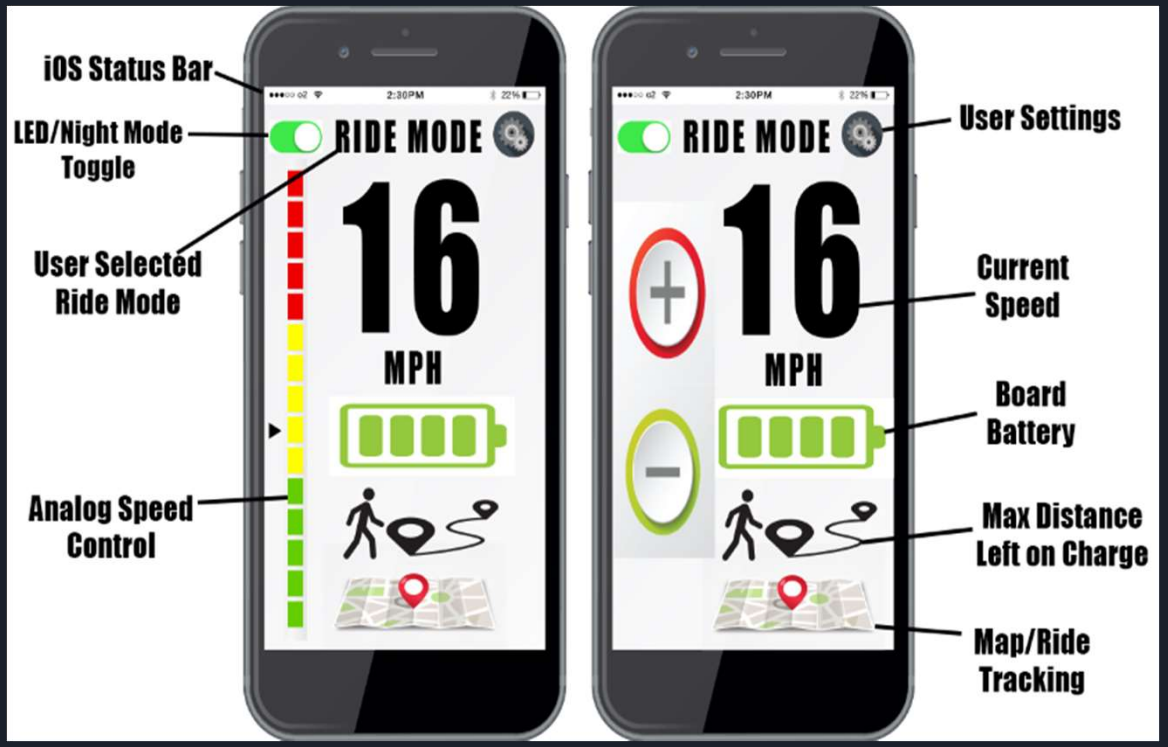
- Utilizes TI's CC2650 wireless MCU for Bluetooth applications
- Voltage Operating Range: 1.8 to 3.8V
- ARM Cortex M3
- Up to 48-MHz Clock Speed
- 128KB of System Programmable Flash
- 8KB of SRAM for Cache
- 20KB of Ultralow-Leakage SRAM
- 2-Pin cJTAG and JTAG Debugging
- 2.4-Ghz RF Transceiver Compatible with Bluetooth Low Energy (BLE) 4.2 Specification

Mobile Application IDE

Mobile IDE: React Native

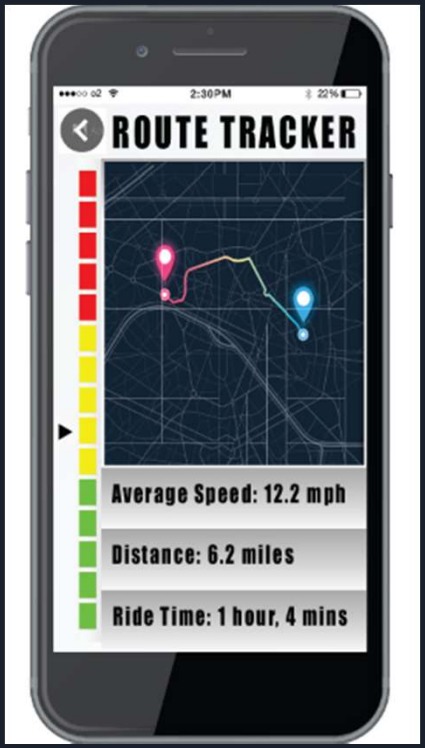
- React Native selected for ability to natively develop for both Android and iOS
- Utilizes Node.js, Python2, and Java SE Development Kit 8
- Development done in Android Studio
- Current goal is developing Android version only, future goal can expand to iOS version
- Testing done on Samsung Galaxy S5 and Android Virtual Device

Mobile App Prototype



Mobile App Prototype

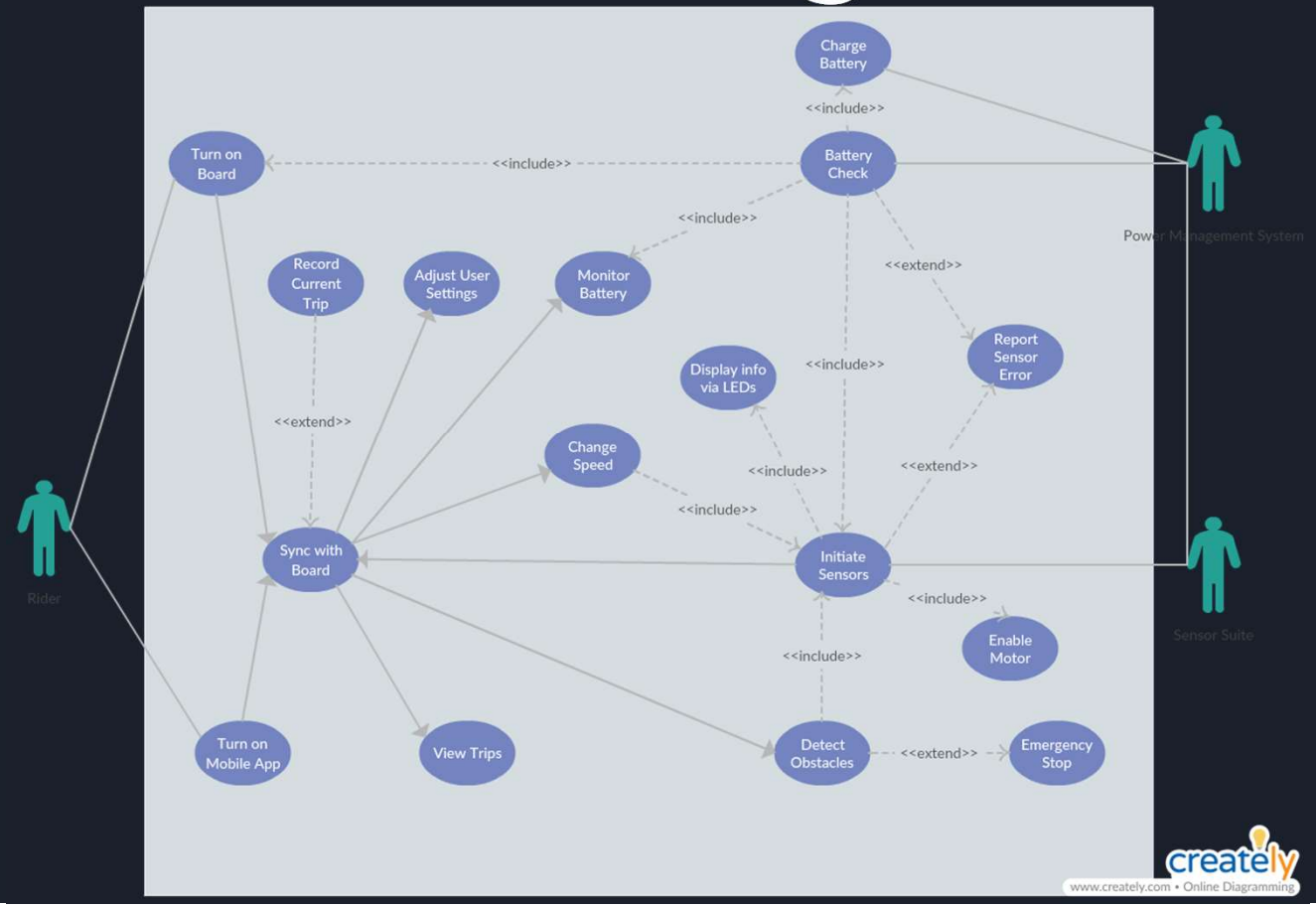
- Integrated map
  - Using the phone's internal GPS in order to get this information
- Tracking Ride Data
  - Can be used in various ways in order to maximize ride efficiency
  - Metrics can be used to compare different routes



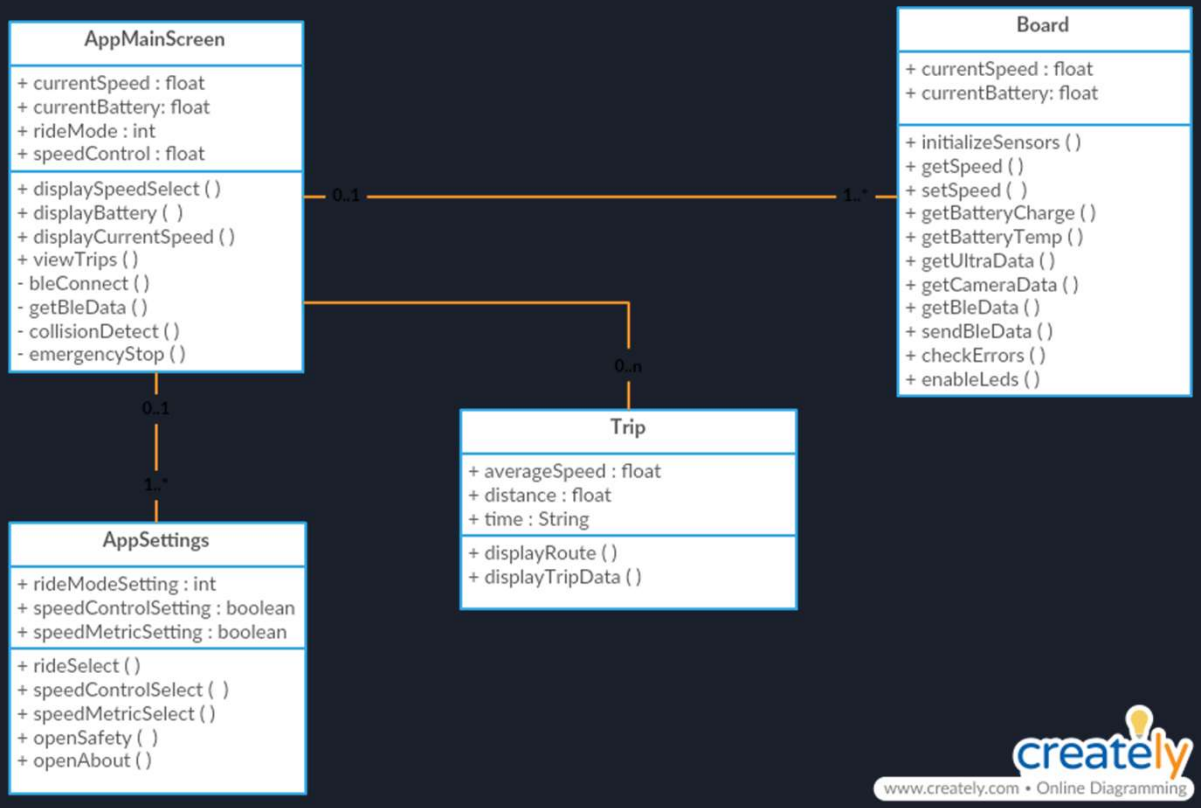
Mobile App Prototype

- Ride Modes
  - Beginner
  - Intermediate
  - Advanced
  - ECO
- Customization

Use Case Diagram



Class Diagram



Constraints

- Economic
  - Rapidly approaching project budget
- Camera
  - Camera may be transmitting too much data
- Size and weight
- User experience
  - Accessible for any level of rider
  - Customizable and easy-to-use app
- Ensuring safety of user without compromising experience

Current Issues

- Missing libraries for PCB design
- PCB clutter and wiring layout
- Finding sample code for components with TI processor
- Sample code for app development
- Time

Distribution of Responsibilities

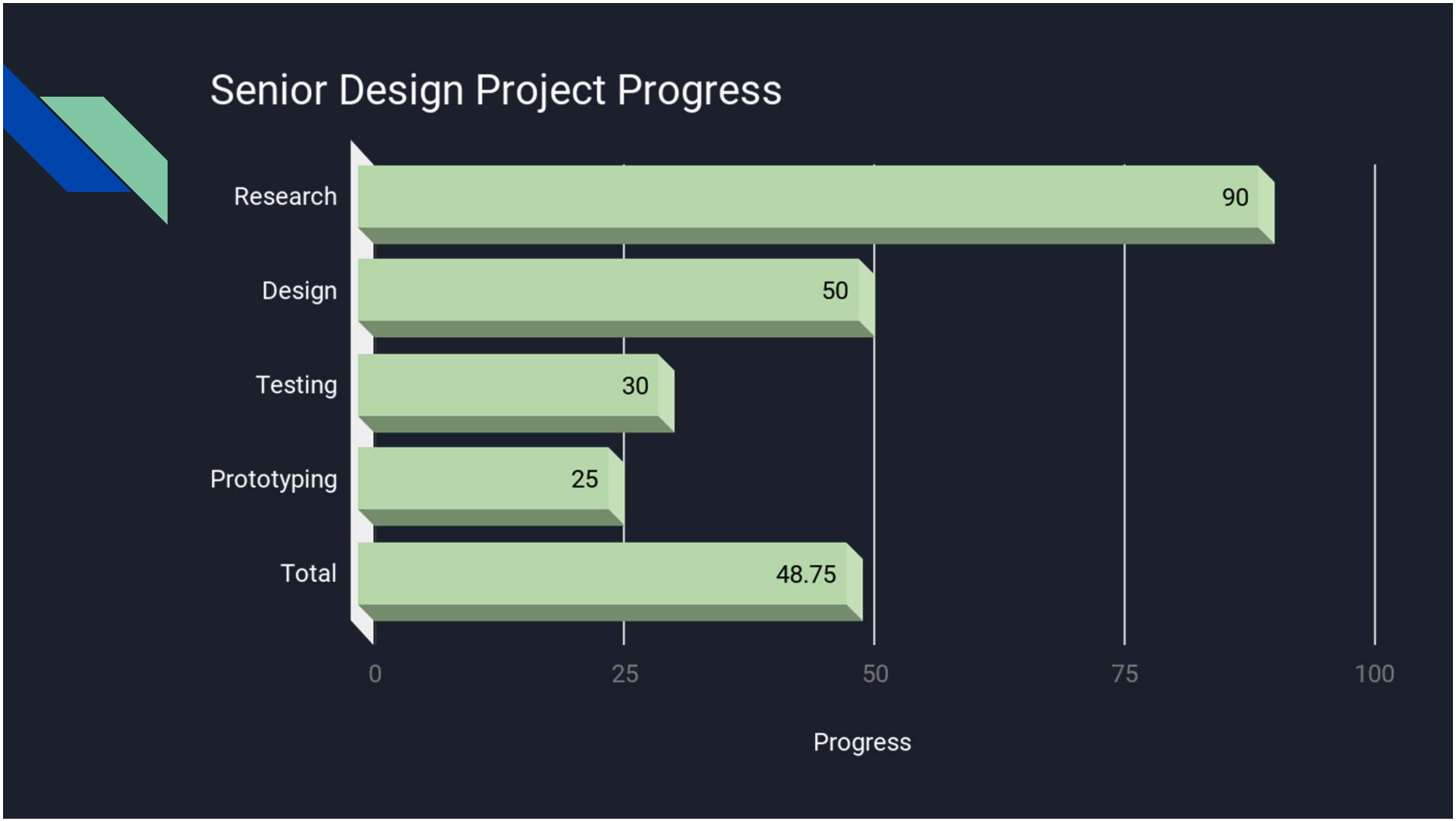
Name	Mobile App	PCB	Sensor Suite	Battery / Power Management	Motor	Components Enclosure
Alex	*	*	X		X	X
Hanser	X	*	*		X	X
Simeon		X		X	X	X

X = Primary

* = Secondary

Budget

Part	Estimated Price (USD)	Part	Estimated Price (USD)
Longboard	$60	Ultrasonic Sensor	$6
Load Cell	$60	PCB Fabrication	$50
Load Cell Amp	$10	Voltage Regulator	$7
Battery	$146	RGB LED Strip	$20
Battery Fuel Gauge	$4	Launchpad	$13
Hub Motor	$220	MPPT Charge Cont.	$47
Solar Panel	$87	Boost Converter	$34
Bluetooth Module	$30		
Camera	$40	Total	$834.00


Senior Design Project Progress
Research
Design
Testing
Prototyping
Total
90
50
30
25
48.75
0
25
50
75
100
Progress

Any Questions?