SDP21 - Let's Ride Demo Day

Team #23
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University of Massachusetts Amherst
BE REVOLUTIONARY™

Team #23

Advised by Professor Baird Soules

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Altium Lead

Xavier Farrell EE
Team Coordinator

Syed Ali CompE
Team Secretary

Ben Ledoux CompE
Team Treasurer

Problem Statement

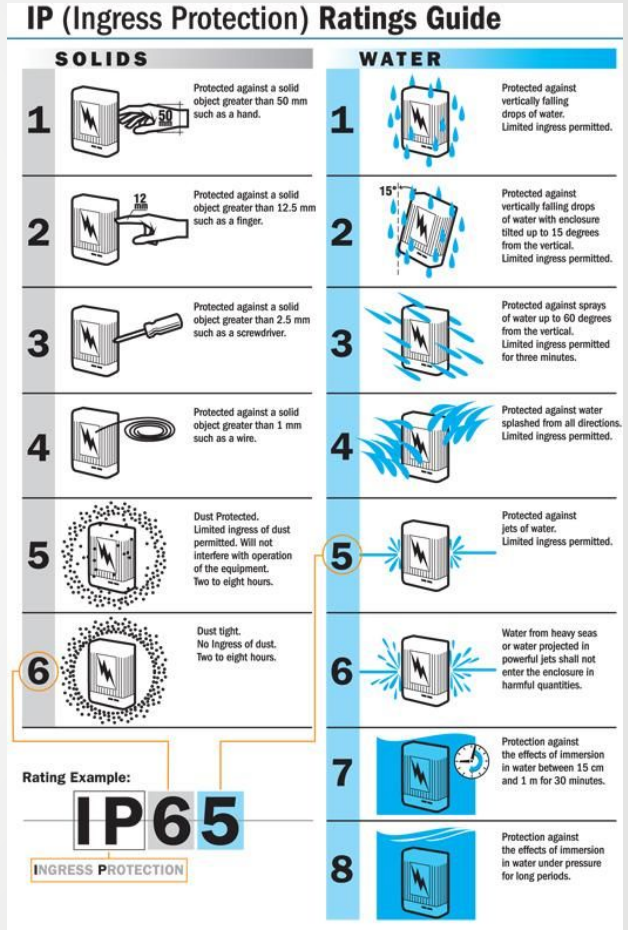
As Covid-19 continues to shutdown or limit gyms many workout enthusiasts are turning to working out at home. Peloton and other internet connected stationary bikes have seen huge success by allowing users to connect and workout with others virtually while tracking their workouts and progress. The problem with the currently available solutions is that they are expensive, difficult to move or transport, and cannot bring their experience to the outdoors. Our product Let's Ride solves these problems by providing a cheap system that can be easily installed on a user's own bike to communicate live ride data to an iOS app. Let's Ride allows users to workout with others virtually either inside on a stationary bike stand or outdoors on any terrain.

System Specifications: User Experience

- **Rider experience**
  - Passively receive real-time information on place via RGB light
  - Set up the physical system in <1 hour (one time installation on bike)
  - On bike system in water resistant enclosure that can be used in rain
  - Automatically connect via Bluetooth Low Energy >90% of the time
- **Application**
  - Store and track data in a user profile using Google Firebase Authentication and database
  - Opt into or create ride events matches based on skill level
  - Invite friends to created events or match with random players via Apple's GameKit

System Specifications: Power, Sensor, Computation

- **Power System**
  - Generates usable electric power at speeds > 3.2 m/s (~7 mph)
  - Meet the above specification in moderately rainy/wet conditions
  - Power system > 8 hrs
- **Sensor/Computation System**
  - Track distance travelled to error bar of ± 0.6m
  - Track amplitude change to error bar of ± 0.5m
  - Relay measurements to mobile devices in real-time
- **Physical Elements**
  - Max weight < 2lbs
  - Does not impair the natural cycling motion of the user
  - Removable and water resistant (IP34)



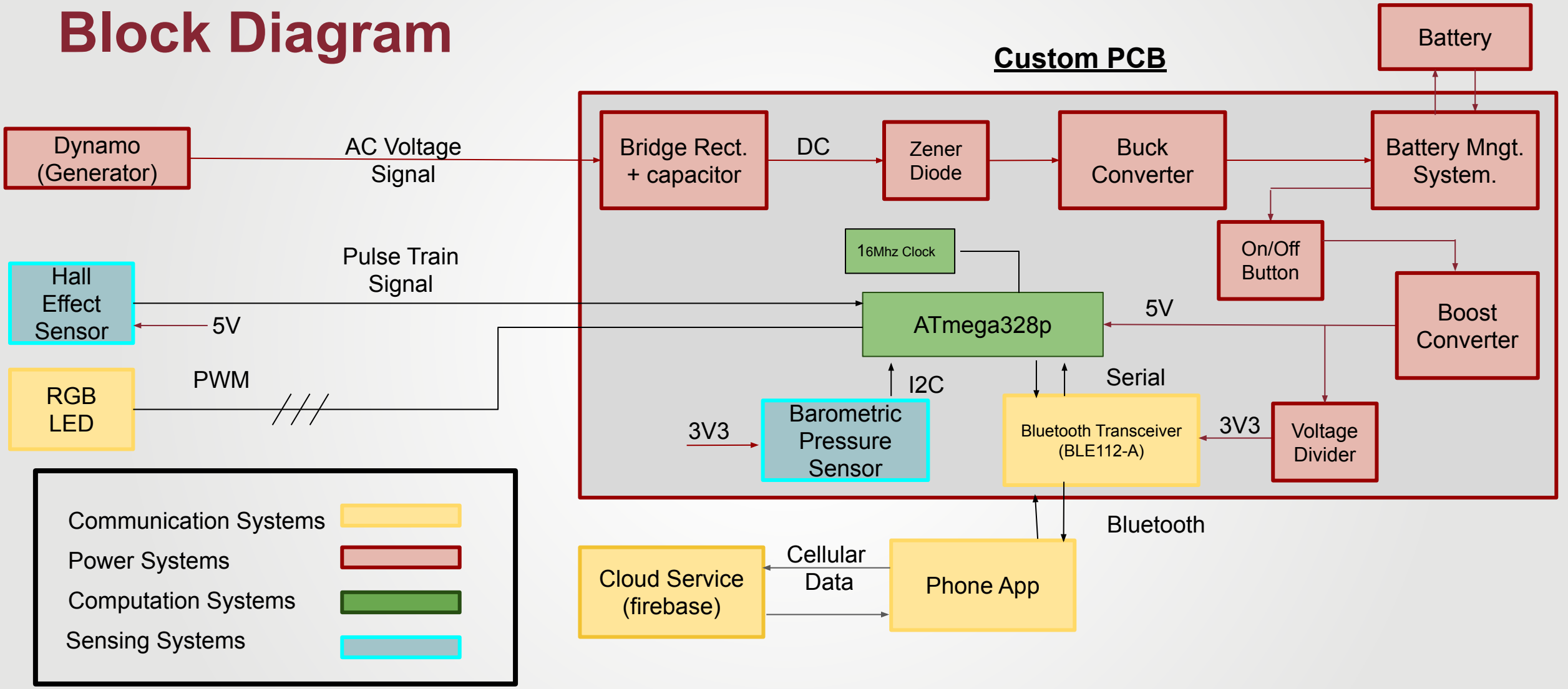
Normalized Unit of Measurement

- Required a way to measure “effort” comparatively
- Ranks by largest amount of ride points acquired
- Subjective solution to rewarding riders facing inclines.

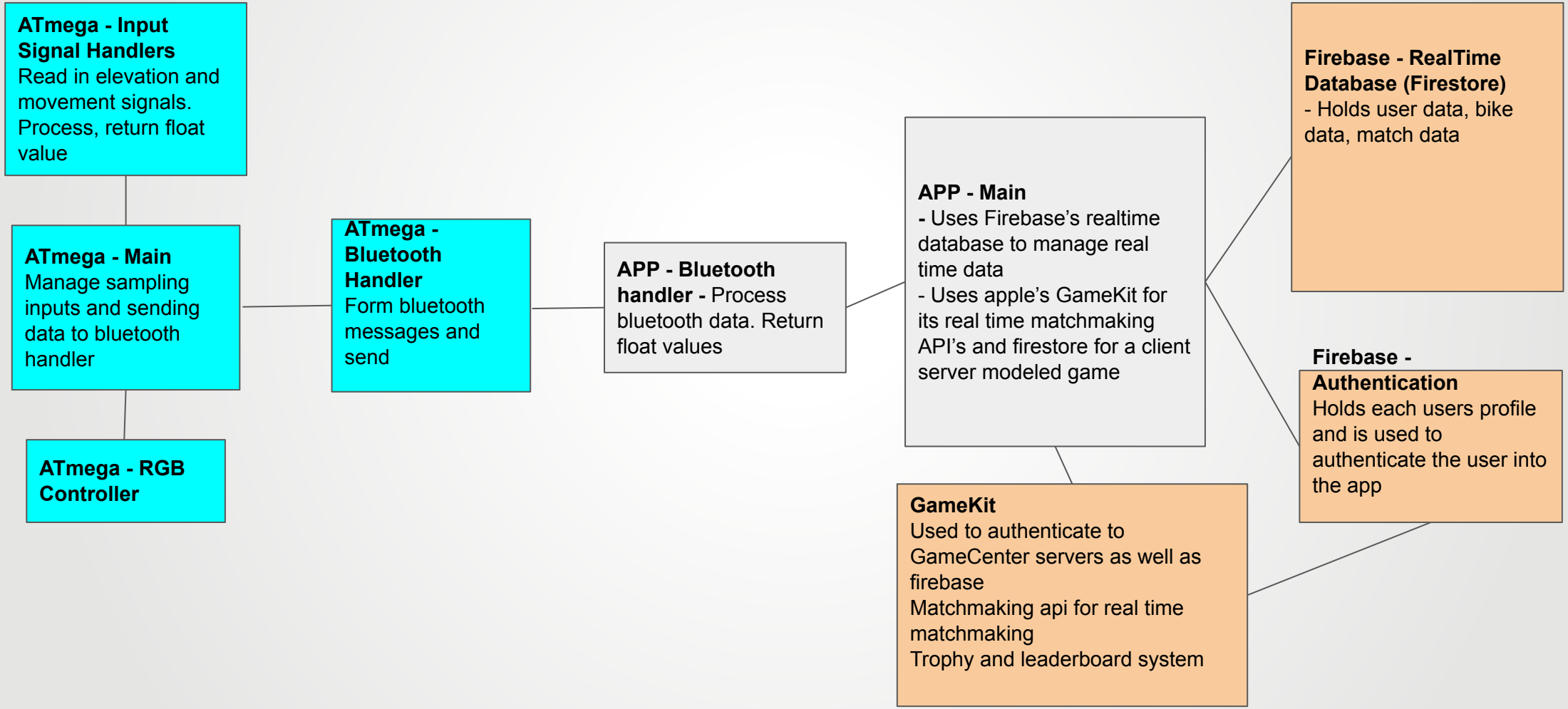
ΔD = change in distance, ΔA = change in altitude

$$Ride\ Point = \Delta D(m) * (1 + |\Delta A(m)|)^{\left(\frac{\Delta A}{|\Delta A|}\right)}$$

Block Diagram



Software Design



Final System

- Final system implemented on soldered protoboard
- Sits inside weatherproof enclosure
- Wires come out of enclosure to handlebar mounted status LED, hall effect sensor, and bike dynamo to charge system
- PCB partially working

Hardware and Software - Final System

Power System

- 1 Tung Lin 4 pole Dynamo
- 1 Buck Converter (LM2596)
- 1 Chenbo Battery Charging Board (8205A)
- 1 Boost Converter (TPS63060)
- 1 Switch
- 1 Full Bridge Rectifier (KBP2005G)
- 1 Zener Diode 24V 5W (GA 5358B 1352)
- 1 Li-Ion Battery (EBL 18650)
- 1 Capacitor 50V 4700mF (1823)
- Assorted resistors to model system power demands

Sensor System

- 1 Hall effect sensor (US5881LUA)
- 1 Barometric pressure sensor (BMP 388)
- 6 Magnets (neodymium)

Hardware and Software - Final System

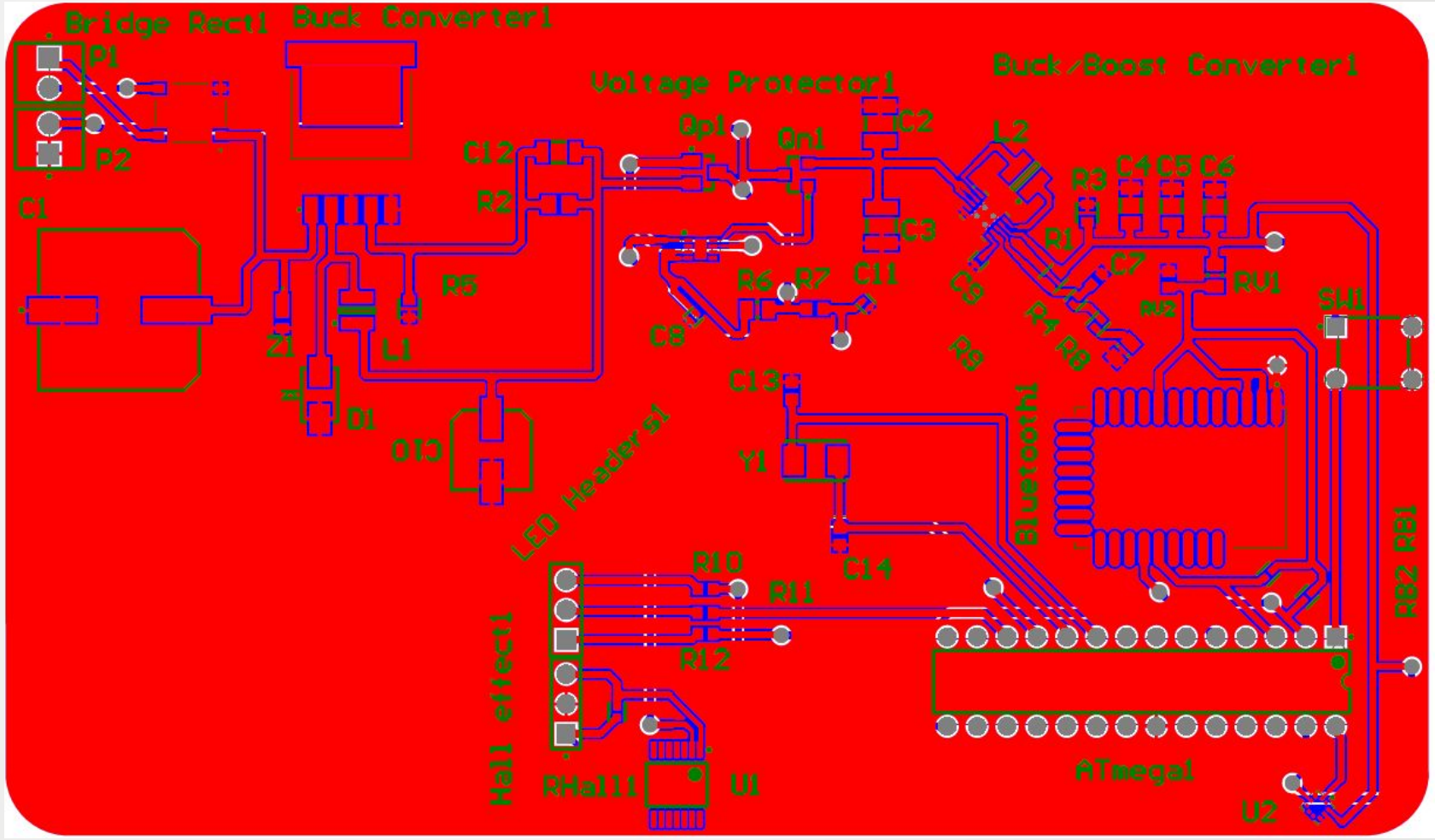
On Bike Microcontroller

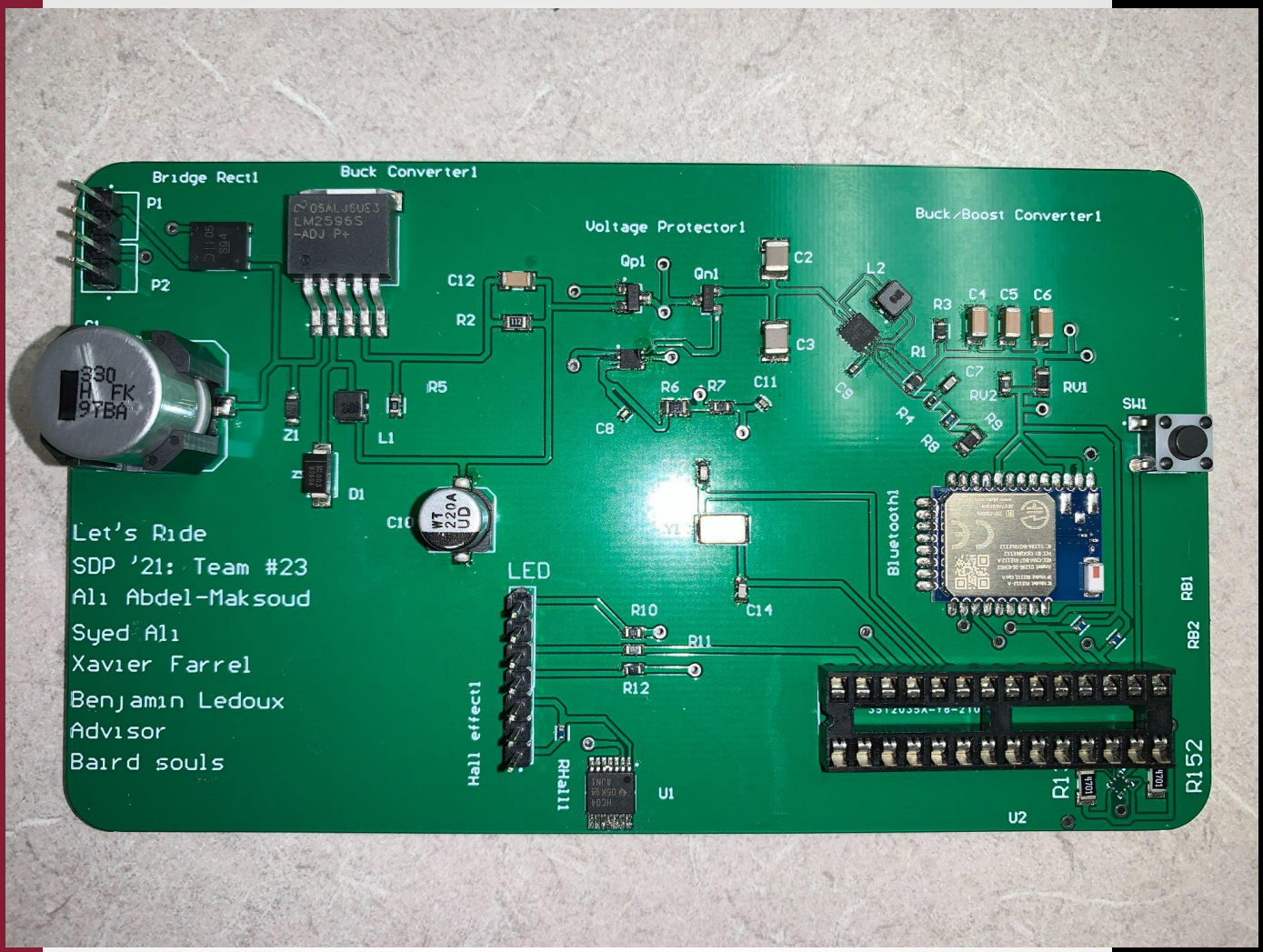
- Hardware
  - ATmega328p Microcontroller
  - BLE112A Bluetooth Low Energy module
- Software
  - IDE: Microchip Studio
  - Language: C++

iOS App

- Backend
  - Google Firebase
  - Apple GameKit
- Development
  - IDE: XCode
  - Language: Swift (Apple's development language based on Objective C)

Board Layout




Bridge Rect1
Buck Converter1
Voltage Protector1
Buck/Boost Converter1
P1
P2
LM2596S
-ADJ P+
Qp1
Qn1
C2
C3
L2
R3
C4
C5
C6
C12
R2
R5
L1
Z1
D1
C10
R6
R7
C11
C8
C9
R1
C7
RV2
RV1
R4
R8
R9
SW1
Bluetooth1
RB1
RB2
Y1
C14
LED
R10
R11
R12
Hall effect1
RHall1
U1
U2
R1
R152
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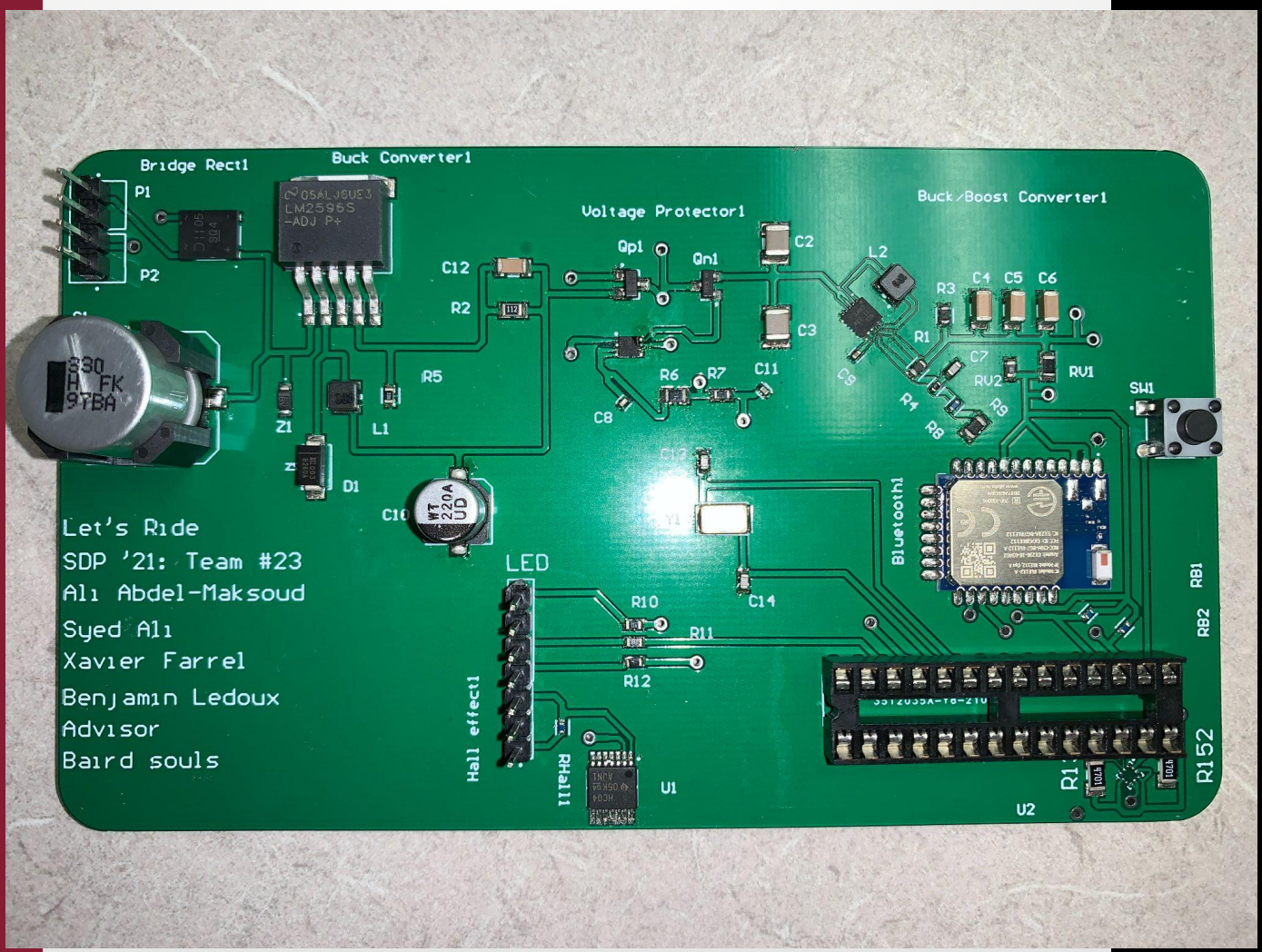
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R6
R7
C11
C8
C9
R1
C7
RV2
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R4
R8
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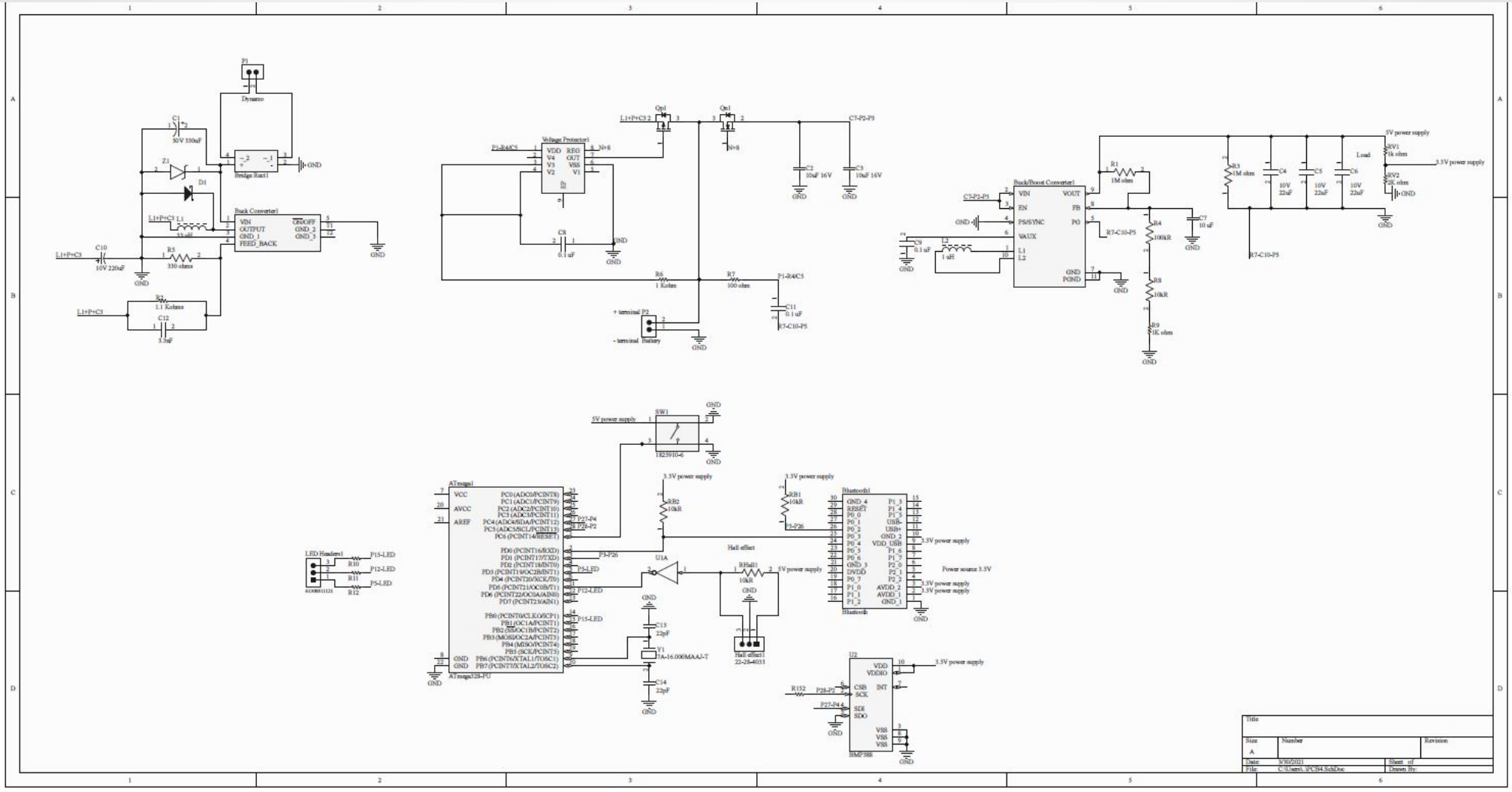
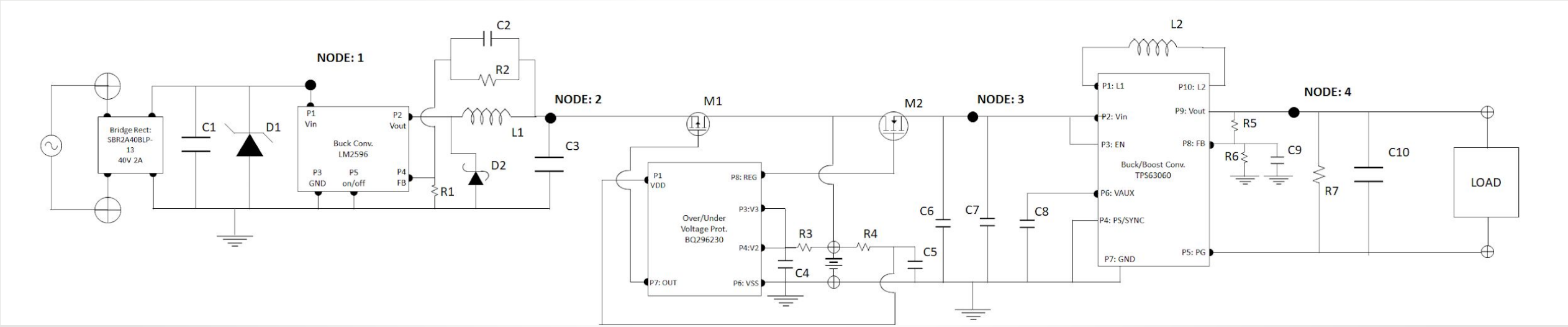
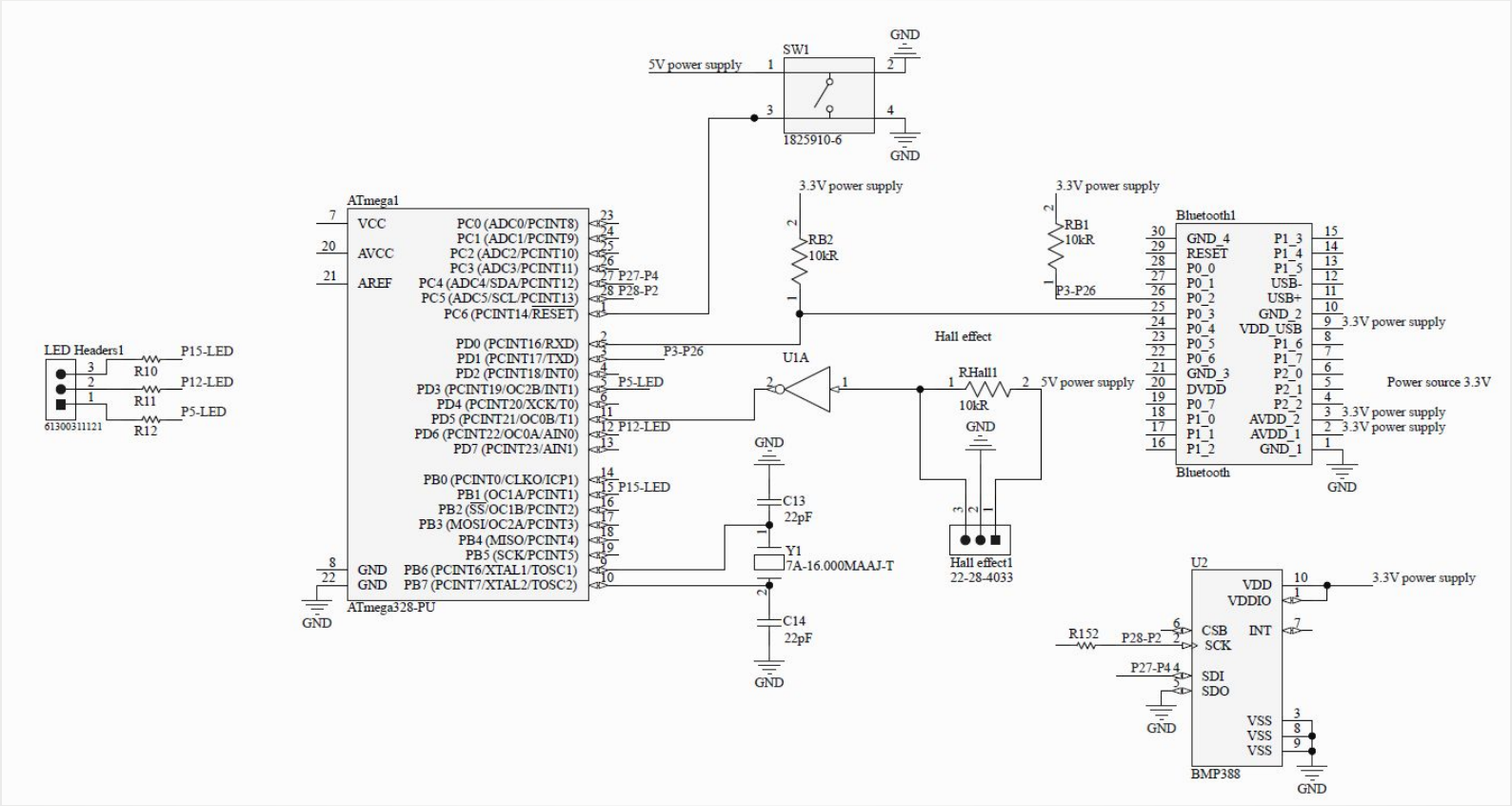
PCB Schematic



Power System PCB Design



Microcontroller PCB Design



Demos

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Final System Performance - User Experience

Receive real time information on place in race via LED RGB light on handlebar	Tested users continuously passing each other. LED would change within 2 seconds (at max) of change in place when comparing local score
One time installation of system in <1hr	We were able to install the system in 22 minutes, and 31 minutes for the second system. When given to a roommate to install it took them 47 minutes.
Weather resistant enclosure allows system to be used in rain	System and enclosure was left out in rainstorm for 30 minutes, system still functioned afterwards
Automatically connect to iOS app to Bluetooth module via BLE >90% of time	Tested both prototypes 25 times each (total of 50 tests) by force quitting app to close Bluetooth connection and reconnecting. 3 total failed connections out of 50 for 94% automatic connection.

IOS App Test Plan

Thing to test	Spec/Requirement	Test Plan
Sustained Connection/Use	8 hrs	Leave app connected to bluetooth on bike for 8 hrs in an indoor ride. Grep log file for disconnection. Do 3 times. Do multiple 30min outdoor rides. Grep log files for disconnections
Connection over Cellular data	System can sustain rides over cellular without disconnecting	Do outdoor rides with connection over cellular data. Scout areas with poor reception and try riding through them. See how the app recovers from dropped connection.
Test that data sent over Game Center is accurate.	Data being sent is the same as data being received	Do rides with measured stops, check scores and the scores appearing on opponents screens at those stops to make sure they match.
Test LED position	Displays position data	Do rides and purposefully change positions in race. Make sure LED changes with position.
Automatic Connection	>90%	Test that the app connects via bluetooth to the board immediately when starting a race. Toggle board power to reset and reset app then start new race. Test starting 100 races.

FPR Deliverables - IOS App

Promised at CDR:	Delivered for FPR:
• Adding more achievements and trophies	• Capability for adding achievements completed
• Support for multiple friends	• can play with up to 4 other people in a game
• Adding a game starting countdown timer which gets triggered once all players have hit ready to ride button.	• counter counts down from 5 once all players hit ready

FPR Deliverables - Microcontroller and Bluetooth

Promised at CDR:	Delivered for FPR:
• Add error checking for messages sent between iOS app and microcontroller	• Microcontroller counts number of binary 1s in count and altitude values, sends that as part of message. App checks these for consistency and throws out bad messages

FPR Deliverables - Power System

Feature	Description	Spec	Result
Portable	Weight	< 2lbs	System < 0.9lbs
	Size	< 6 cubed inches	System < 4.5 cubed-inches
	Mountable	Cannot cause significant immediate damage to bike	Clamps and zip-ties
Safe	Electrically	Short circuit and/or overvoltage protection Off/ON Button	Achieved: Voltage protection board limits battery voltage to 4.18V and Zener limits input voltage to 24V
	Physically	No direct contact with electronics while in use No sharp or pointed edges	Achieved: Physical Enclosure
	Functionally	Cannot induce a sudden stopping event	Achieved: Robust mounting and detachment scheme
Ride Condition Insensitive	Output power in varied weather	5V 300mW for speeds > 7mph in dry and moderately wet conditions	Achieved: Battery powered the system from with IP34 rated box
Durable	Physical Strength	Withstand 2 drops from mounting height	Untested: IP34 rating and metal dynamo encasing suggests achievable
Reusable	Can supply power at multiple separate and distinct times of use	Estimate product life expectancy	Achieved: 20,000 workouts over more than a year

Calculating Product Lifespan

Main Wear Item: Lithium Ion Battery

$$Hours\ of\ Operation = \frac{Battery\ Rating}{Load\ Current}$$

$$Number\ of\ Workouts = \frac{2\ Workouts}{Hour} * Hours\ of\ Operation$$

$$Total\ Number\ of\ Workouts = \frac{Number\ of\ Workouts}{Charge\ Cycle} * Number\ of\ Charge\ Cycles$$

$$Total\ Operable\ Hours = \frac{Hours\ of\ Operation}{Charge\ Cycle} * Number\ of\ Charge\ Cycles$$

$$Total\ Number\ of\ Days = \frac{Hours}{Day} * Total\ Operable\ Hours$$

FPR Deliverables - Sensor System

Promised at CDR:	Delivered for FPR:

• Test the stationary capabilities of the magnet mounting system
  • vary speeds
  • take it on an actual ride and see if any of them get knocked out of place
	• bike was taken for a full ride and magnets stayed in place with varying speeds and bumps

• Insuring consistent and real time data readout of the hall effect over many different durations of activity • cycling characterization	• we stationed the wheel and spun it a set amount of rotations • Counted the expected count of magnets coming out • spun it 10 times got a count of 50-55 out of 60
• Test the effectiveness of the BMP in inducing intended reward using the Ride points formula.	• The barometric pressure starting acting weird when we got it in the box and gave us repeatedly inconsistent data. did not have the time to fully troubleshoot

Project Management

Team Responsibilities:

- **Budget Leader - Ben**
- **Team Secretary - Syed**
- **Team Coordinator - Xavier**
- **Altium Lead - Ali**

Technical Responsibilities:

- **Power System - Xavier**
- **Sensing System - Ali**
- **Cloud Infrastructure - Syed**
- **Embedded System - Ben**
- **iOS App - Syed/Ben**

QUESTIONS?

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Backup

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