Battle of the Bikes

Group 20:
Adam Brower - EE
Allison Kovarik - EE
Nicolas Leocadio - EE
Bo Williams - CpE

Introduction

- Create an entertaining one-on-one racing game to encourage gym members to work out and compete together
- Generate energy from the players' efforts in order to power the system
- Monitor and display users' speed and power generation (Calories) to encourage competition
- Over course of the game, users will get "power-ups" that make pedaling harder for the other user to further stimulate competition

Motivation

- Promote cardiovascular health by encouraging gym goers to engage in cardiovascular exercise
- Make cardio fun through competition

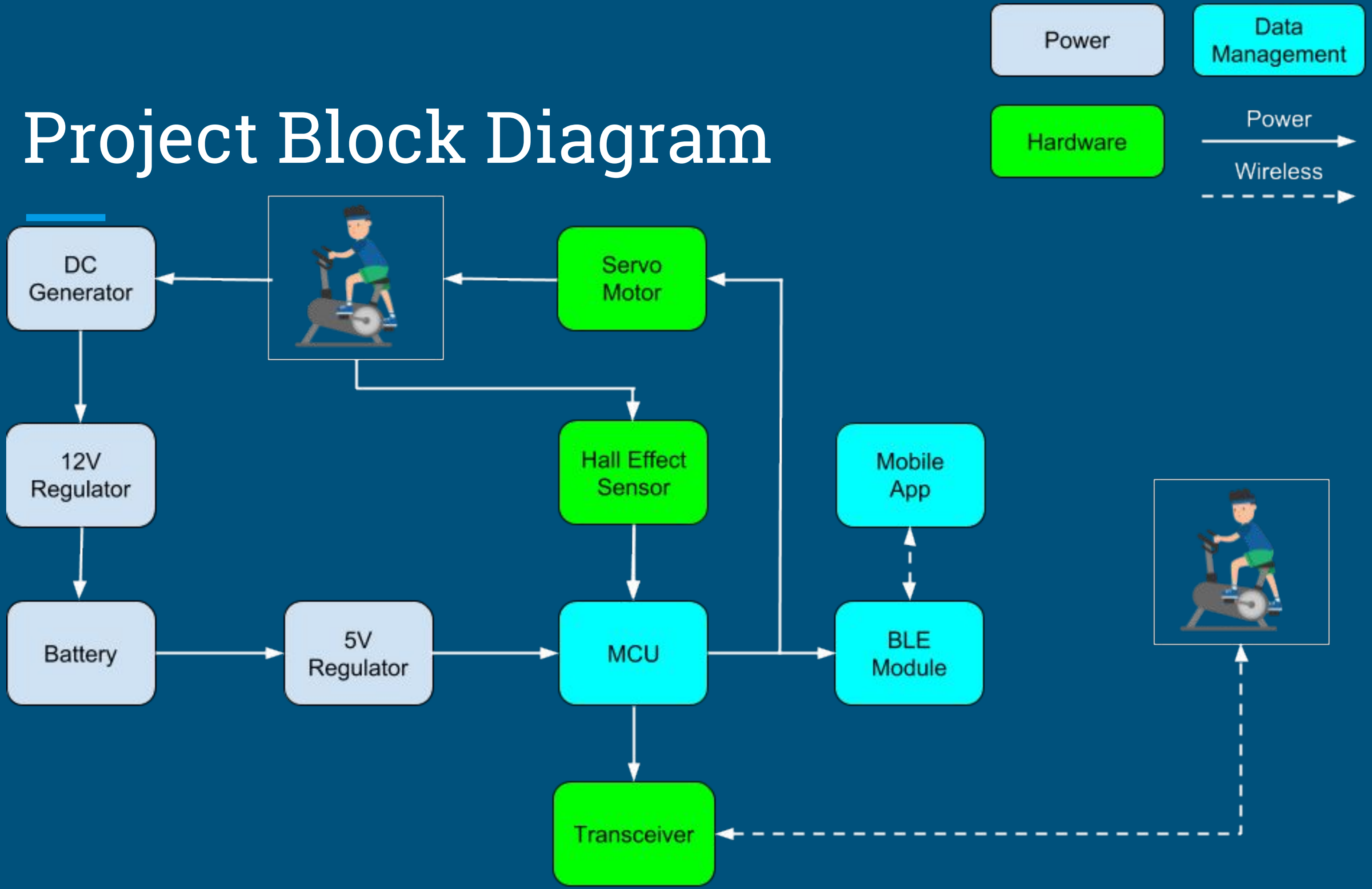
Project Goals and Objectives

- Entire system powered by human effort
- Wireless communication between two bikes and two phones
- Direct and automatic control of bicycle tension

Specifications and Requirements

Feature	Parameter	Design Specification
Wireless Connectivity	Minimum Range	6 feet
Distance Travelled	Accuracy	+/- 13 feet
Speed	Accuracy	< 2 mph
Electronics Box	Size	3 ft x 1 ft x 1 ft
Battery	Output Power	At least 30 W

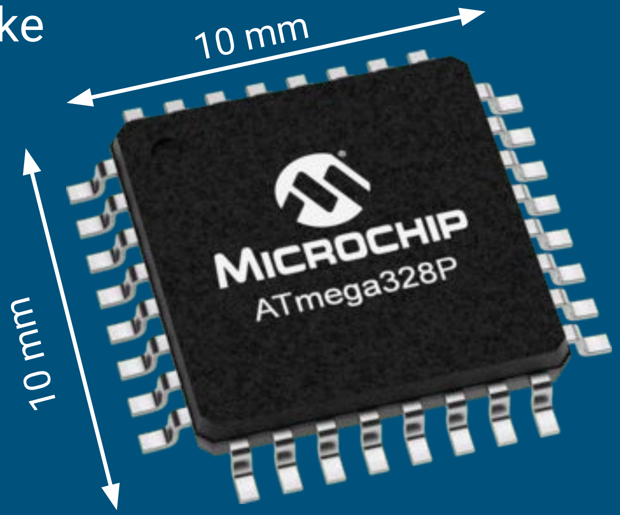
Project Block Diagram



ATmega328P

- Brain of the system
  - Hold information to send to app
  - Take signals to change tension on correct bike

Manufacturer	Atmel
Voltage	1.8 - 5.5 V
Processor Speed	20 MHz
Memory	32 KB



Arduino Uno R3

- Development environment
- Language based on C/C++
- Many libraries for hardware
- Open source
- Has IDE for ease of programming and is compatible with mcu

Manufacturer	Arduino
Operating Voltage	5 V
IO Pins	14

Wireless Communication

Wireless Connectivity

- Bluetooth
  - Connect system to smartphones
  - Bi-directional
  - Easy to use with smartphones
- Transceivers
  - Send data between bikes
    - Other user’s speed
    - Power-up

Selection of Wireless Communication

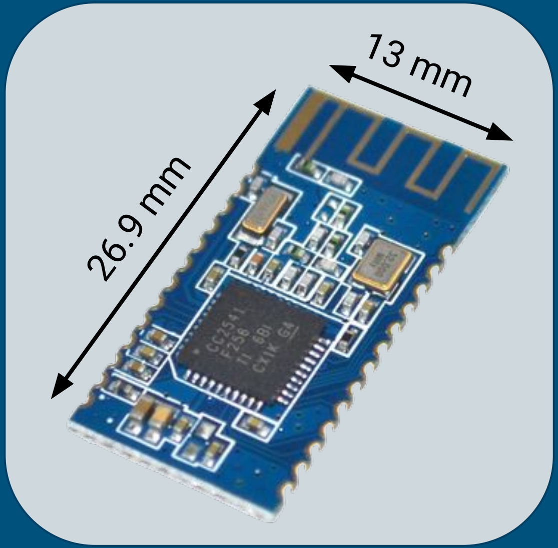
- Factors:
  - Low cost
  - Low power usage
  - Ease of implementation

	BLE	Wi-Fi
Transmit Power	2.5 mW	100 mW
Throughput	100 kb/s	900 Mb/s
Price	$10	$7

HM-10 BLE Module

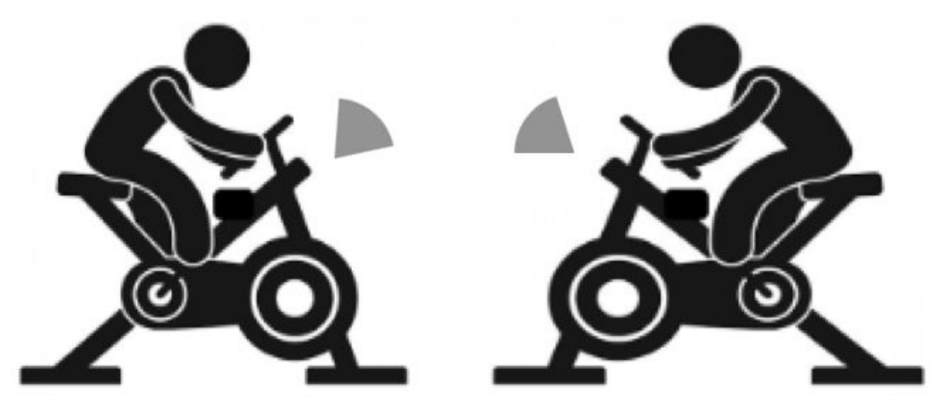
- Connect mobile device with microcontroller
- Allows back-and-forth communication to pass info

Manufacturer	DSD Tech
Power Supply	3.3 V
IO Lines	RX, TX, GND, VCC



Transceivers

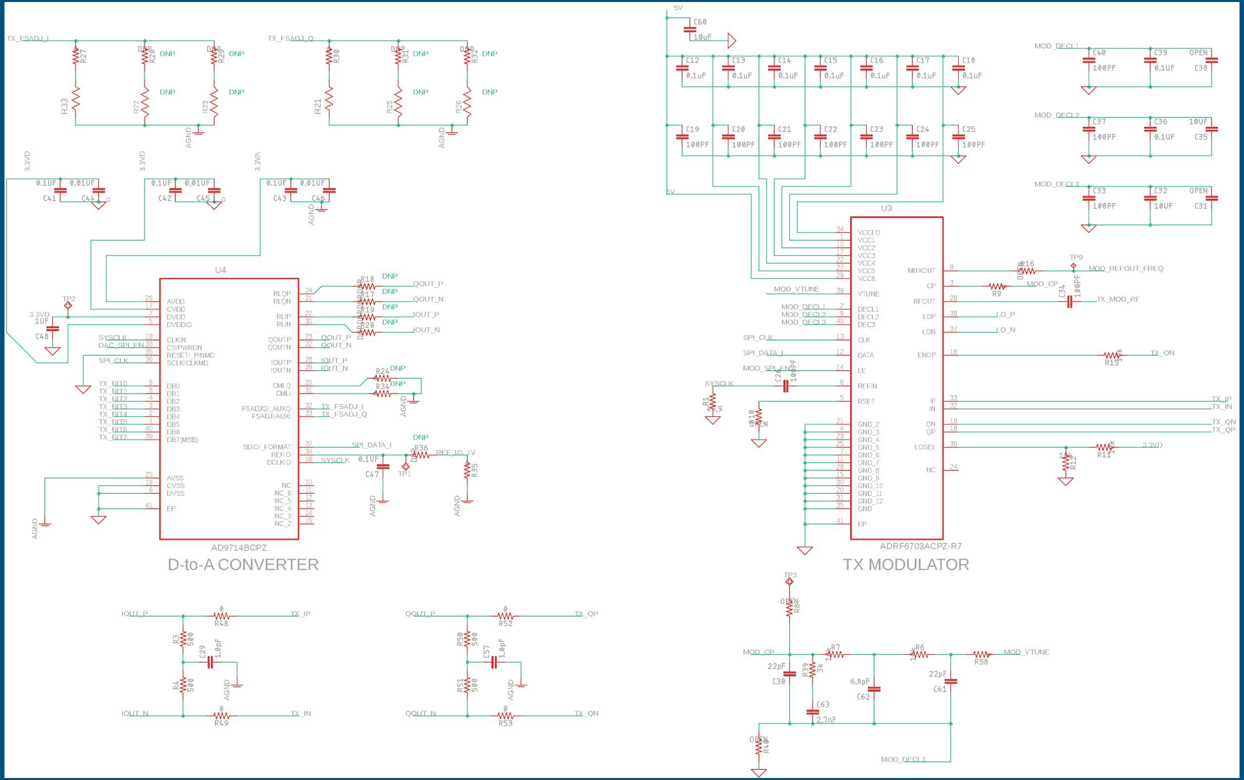
- QAM
  - I/Q Data
- Operating at 2.49GHz
  - Does not abide by any protocol
  - Transmitting under 1 Watt
- Transmit and Receive Paths
  - RF Switch controlled by firmware
- Design Focuses
  - Impedance matching
  - Phase conservation



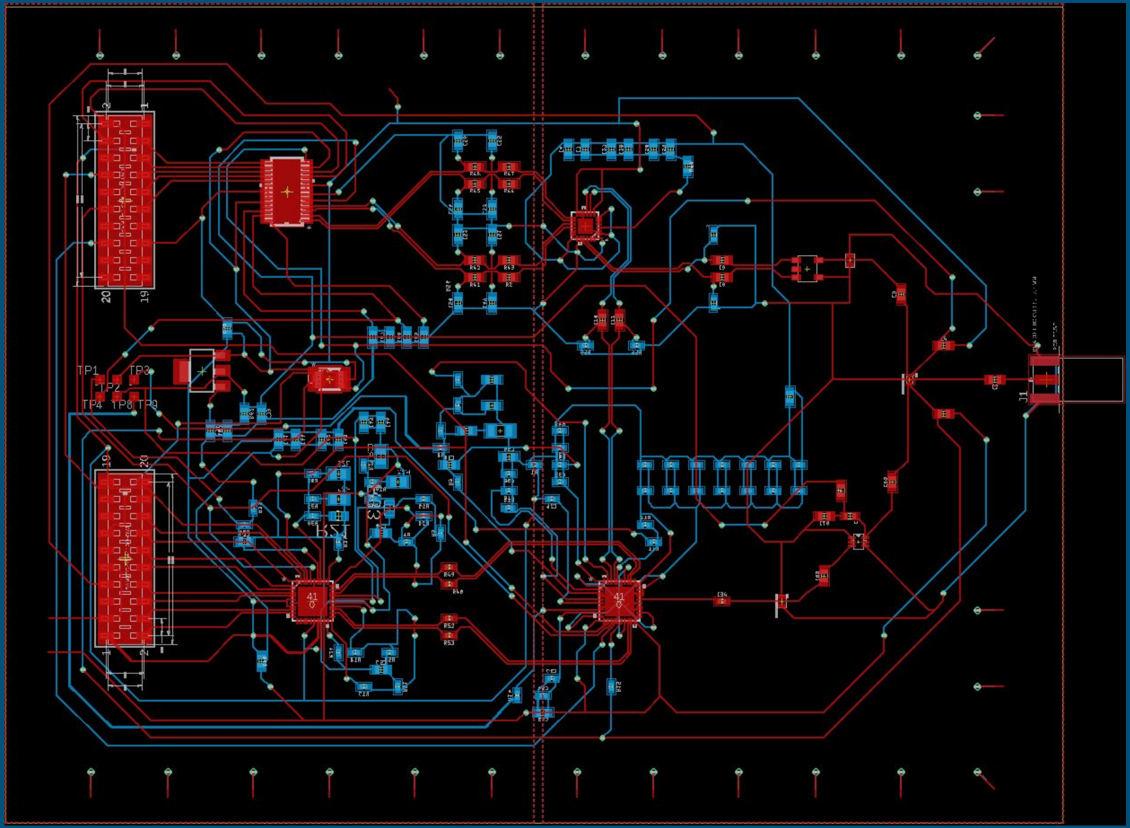
Main Modules

- DAC
  - AD9714 - Analog Devices, TxDAC family, 8-bit resolution
- Modulator
  - ADRF7603- Analog Devices, on-chip LO generator, wide LO range
- Demodulator
  - ADL5382- Analog Devices, no calibration file necessary
- ADC
  - AD7729- Analog Devices, Dual Sigma Delta ADC, 15-bit resolution

Transceiver Schematic Excerpt



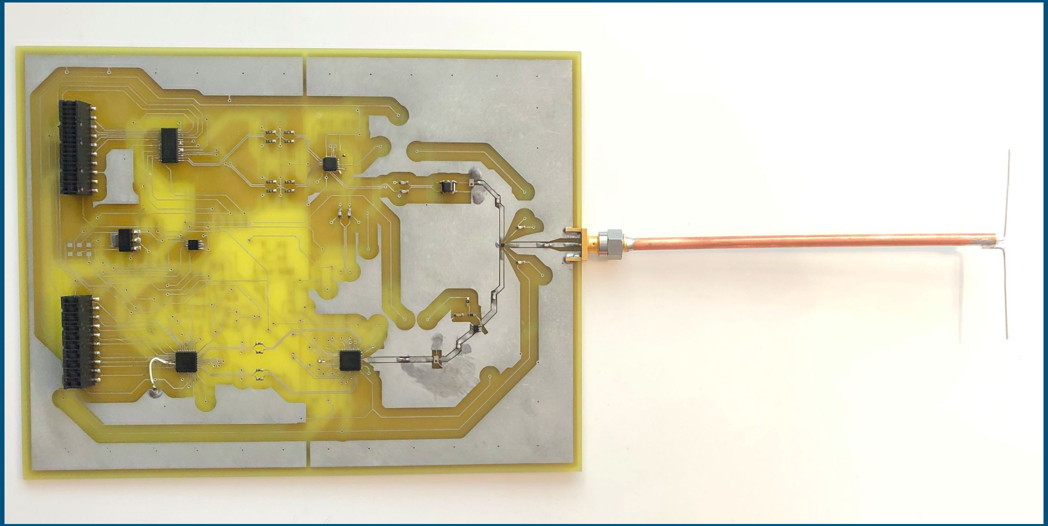
Transceiver Board Layout



Transceiver Populated PCB

Other Components:

- Band Pass Filters
- Amplifier (15.3 dBm)
- TX/RX Switch
- RF Switch
- Balun
- Coplanar Waveguide
- Dipole Antenna



Bike Hardware

Resistance Control

- Adds competition to the game
- Controlled by the game
- Gear on a servo used to move a rod up and down to change resistance of the wheel
- Precise control over resistance
- Keeps tension on wheel by keeping servo locked in position

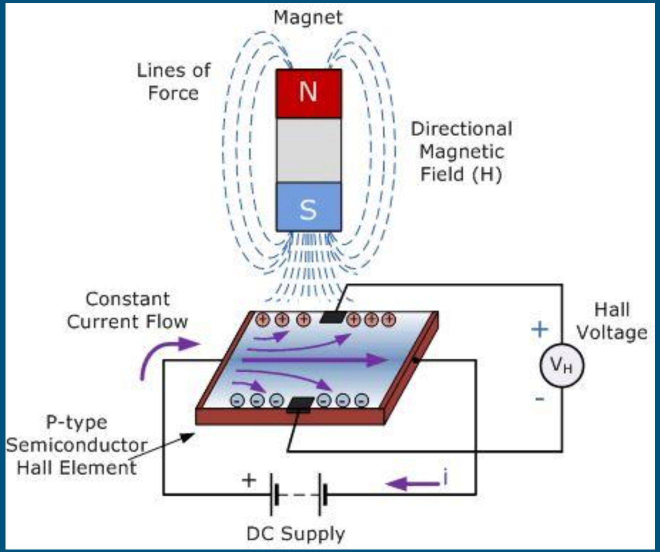
Servo Motor

- Adjusts bike tension
- Controlled by MCU and opposite bike

Specification	Rating
Torque	20 kg*cm
Working Voltage	6-7.4V

Wheel Rotation Monitoring

- Hall Effect Switch Sensor
- Magnet + sensor
- Measures each revolution
- Calculate speed and distance of bicycle



Electronics Enclosure

- Dimensions: 3 ft x 1 ft x 1 ft
- Allow heat to escape enclosure
- Used to hide and protect electronics as well as to keep tension on generating equipment
- Material: wood
  - Don’t want to disrupt wireless communication
  - Easy to work with


XSPEC
XSPEC THE BEST
www.crosslinksmart.com
Item Number: CRS804811
Description: MAX Indoor Cycling Bike - Blue
Qty/CTN: 1 PCS
N.W.: 29 kgs / 63.8 lbs
G.W.: 32kgs / 70.4 lbs
Carton size: 99X21X91.5 cm
Carton size: 39X8.3X36 inch
Carton No: 57 of
Keep Box For Returns
RMA#:
Customer Service (626) 965-2600
Monday-Friday 9am-5pm PST
B104
/CrosslinksEn

Power

Power Generation

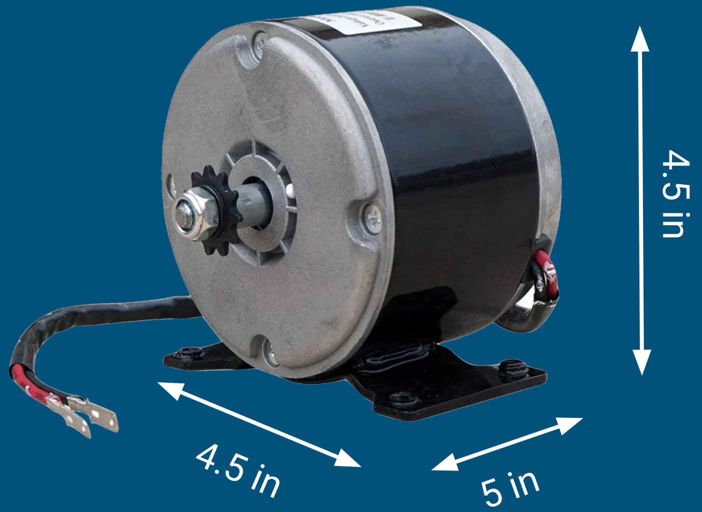
- Rubber belt on axle of stationary bicycle connected to the shaft of motor
- Typical use generates about 60W of power
- Peak generation of 12.5V at 5A
- Using the motor shaft for highest possible voltage due to our battery charger

Generator Selection

- Alternator
  - Produces alternating current
  - Only used for powering external devices
- DC Motor
  - Produces a direct current
  - More ideal as no DC converter will be required for internal systems
  - Voltage can be more easily controlled

DC Permanent Magnet Motor Generator

- 12V/24V Generator
- Rated current: 16 A
- Rated speed: 2750 RPM
- Outputs DC
- Output power: 300 W



Lead Acid Battery

- 12 Volt
- 20 Ah
    - Charges at up to 14.9V
    - Max recommended charge rate of 4A for battery longevity

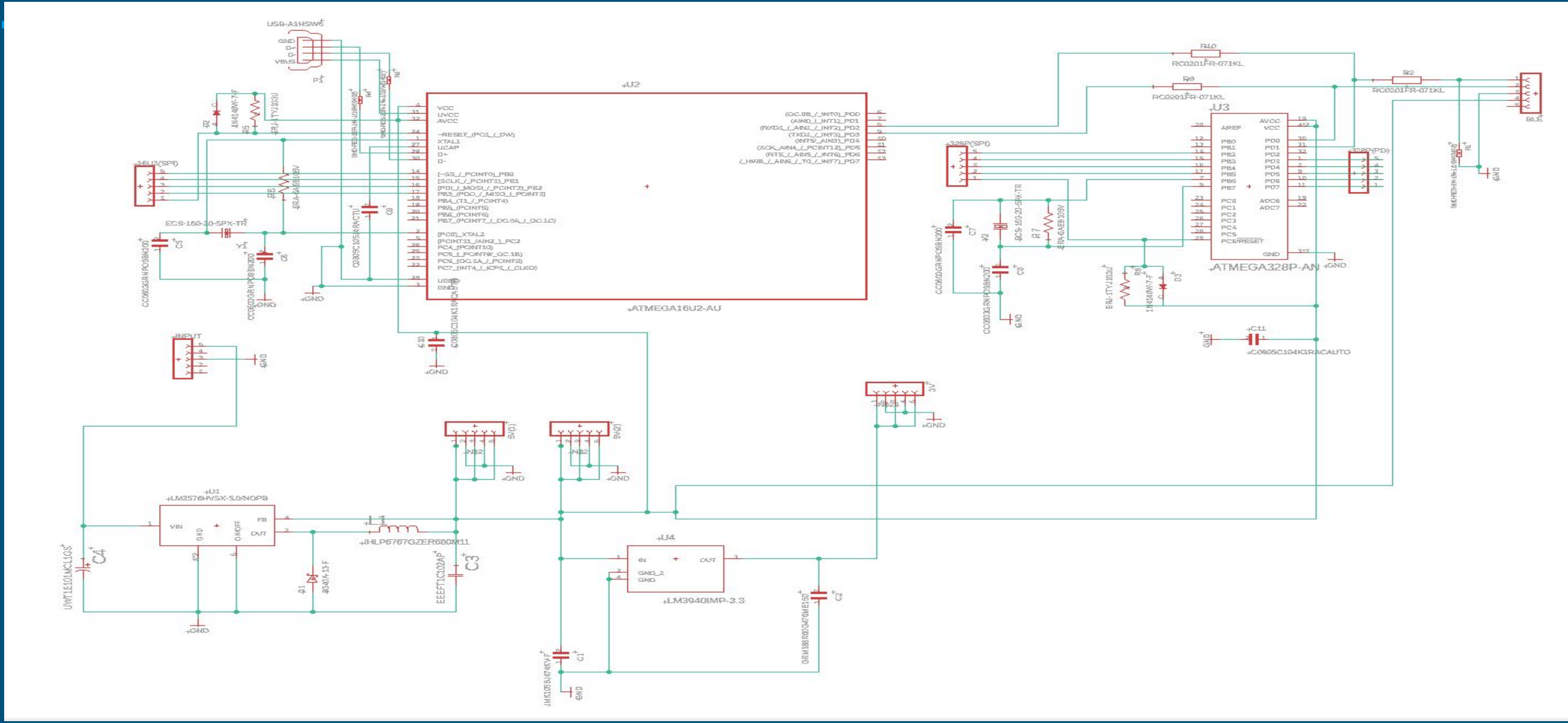
Battery Charger

- Thunder 0620 300W
- Multiple selectable modes
- Charges our battery at max of 4A up to 14V (6-cell capacity)
- Requires 10V to operate
- Hackable - we are able to begin battery charging via a microcontroller connection

Voltage Regulators

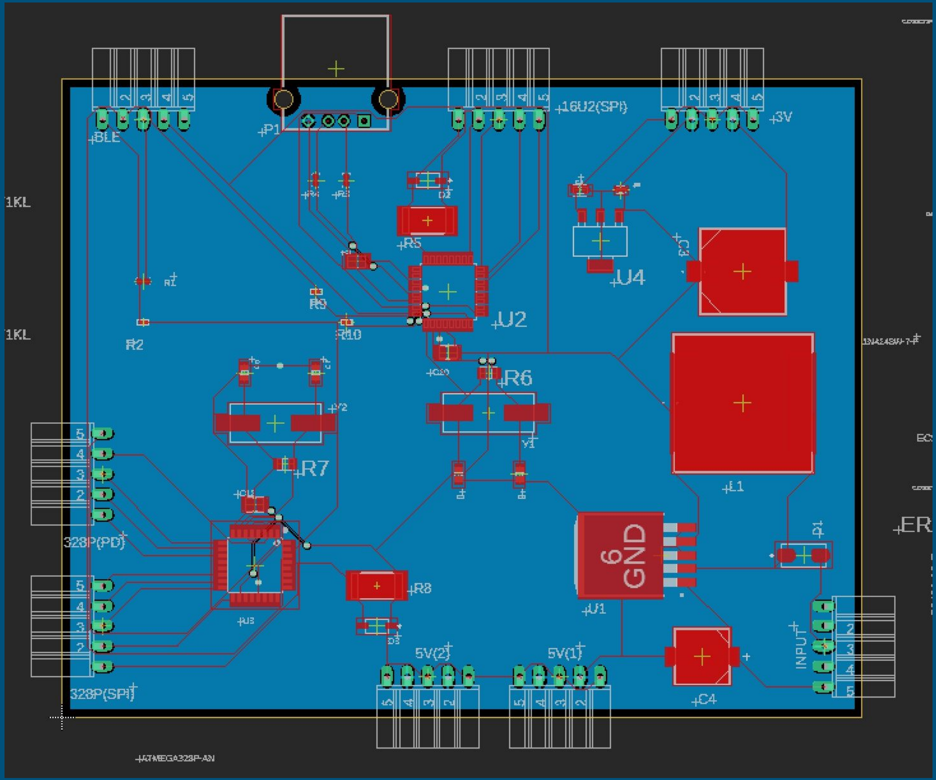
- To obtain specific voltage requirements throughout the system two types of regulators will be required.
- Switching Regulator
  - 12V to 5V
    - TI LT8608 Synchronous Regulator
- Linear Regulator
  - 5V to 3.3V
    - LM3940

Main_PCB Schematic



Main PCB Layout

- 3rd Revision
- Notable Changes from REV 2
  - Additional control pins from Atmega328p
  - Additional 5V output voltage pins
  - Adjusted 5V regulator circuit due to previously missed connection in schematic



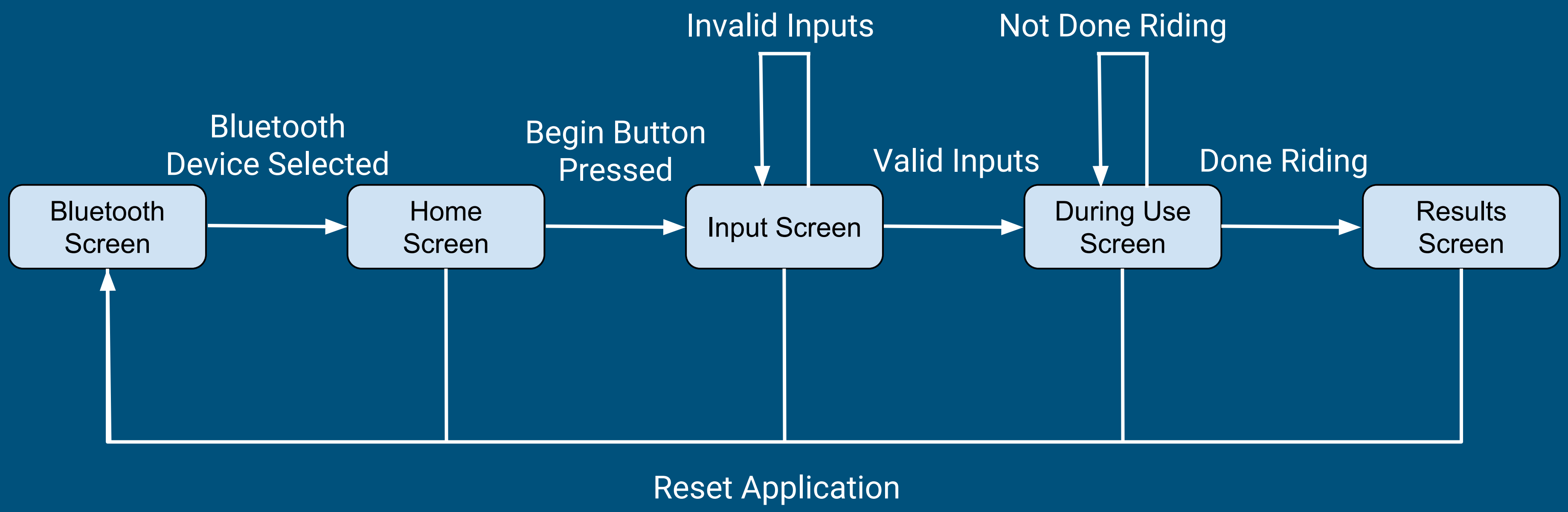
Mobile App

Android vs iOS

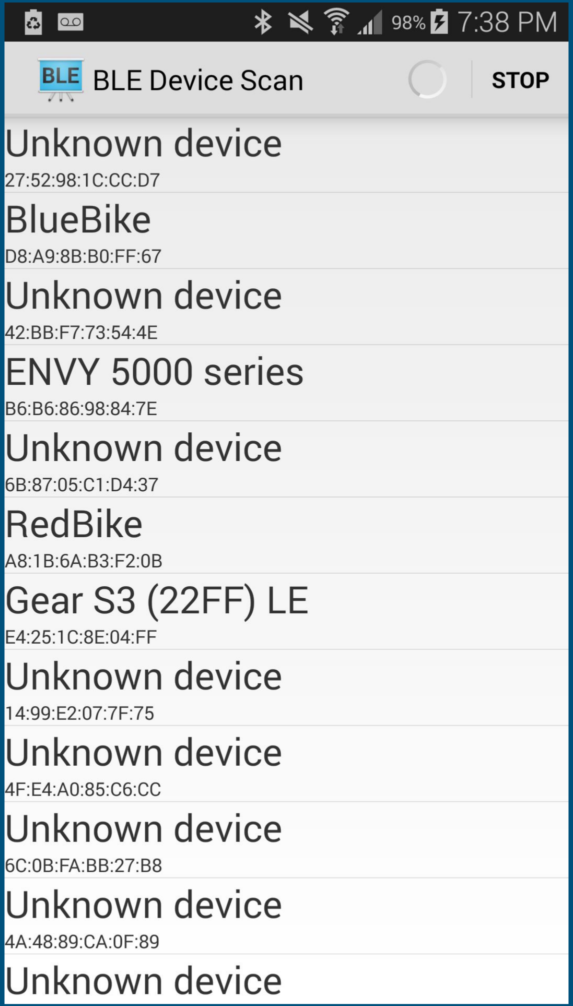
- Programmable on any operating system
- Java
- Open Source
- More users worldwide
- Cheap development and fast publishing
  - One time $25 fee vs yearly $100 fee for iOS
  - App on Google Play store in a few hours

- Devices are standardized
- More security
- More iOS users in North America

Application Flow Diagram

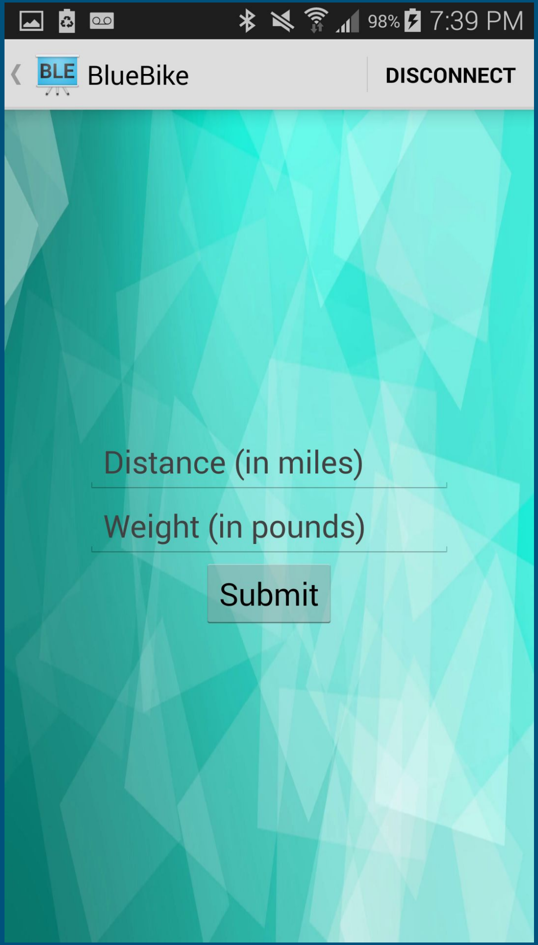


Bluetooth Selection Screen

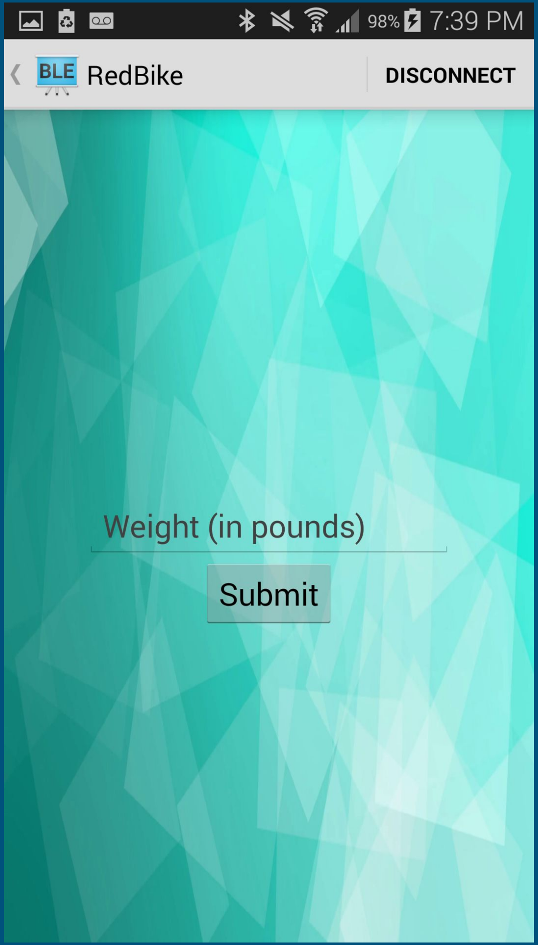


Startup Screen

Input Screens



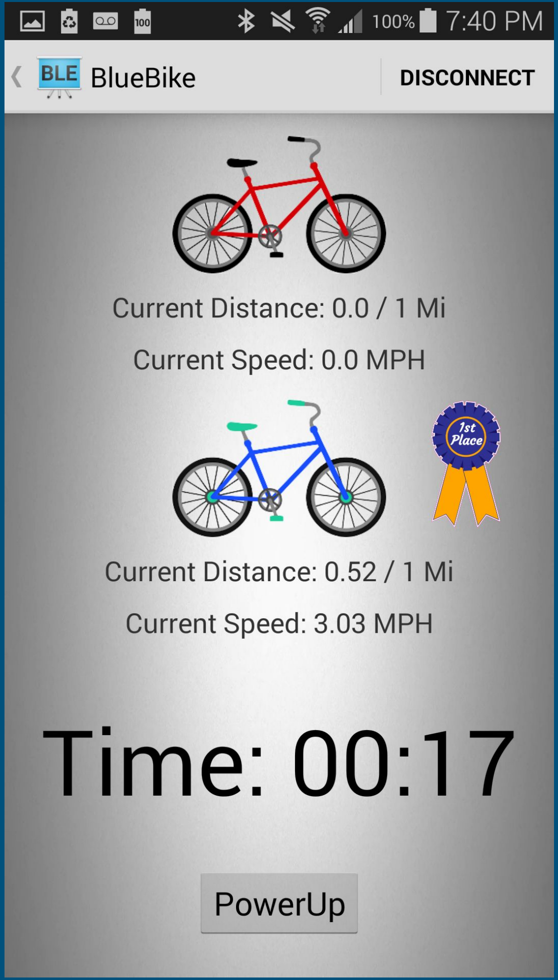
Master Bike



Slave Bike

Mobile App Features

- Easy to read displays during use
  - Current speed
  - Distance travelled
  - Competitor’s speed
  - Competitor’s distance
  - Time that user has been riding
  - Power-up
- Power-up button



Results Screen

Calorie Calculations

- Use METs (Metabolic Equivalent of a Task) to keep track of Calories burned during use

MET	Description
4	Less than 10 mph on average
6	10 - 11.9 mph on average
8	12 - 13.9 mph on average
10	14 - 15.9 mph on average
12	16 - 19.9 mph on average
16	More than 20 mph on average

Calories Burned = 0.0175 * MET * Weight(kg) * Minutes

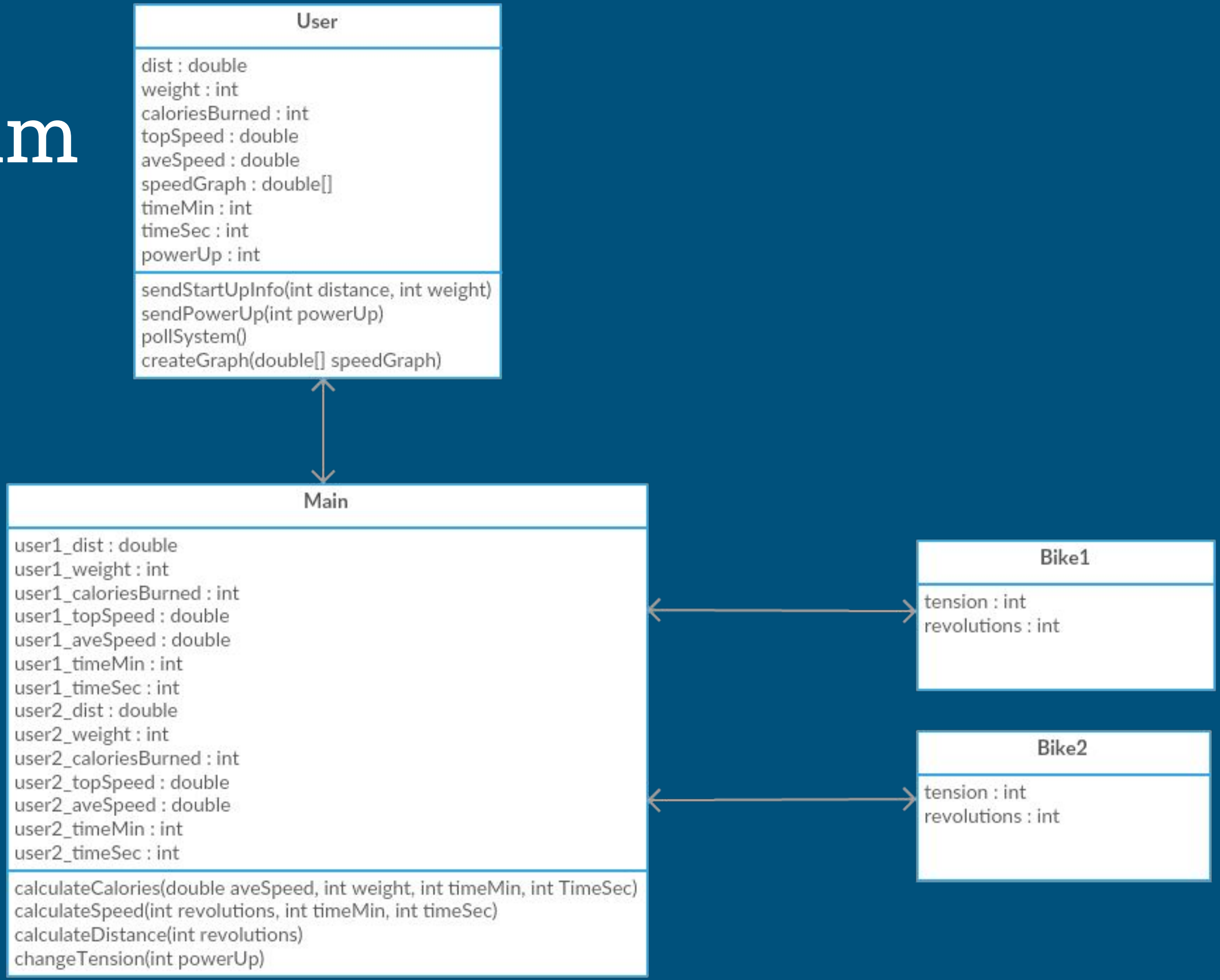
User Interaction with System

- Provide distance and weight for initialization of system
- Send power-up signal to change tension on other user’s bike

System Interaction with User

- Tension constantly changes throughout ride
  - Based off distance user has ridden
    - Checkpoints
  - Gives feeling of riding on different terrain
- Constant updating of speed and distance to app

Class Diagram



Administrative

Standards and Benefits of Our System

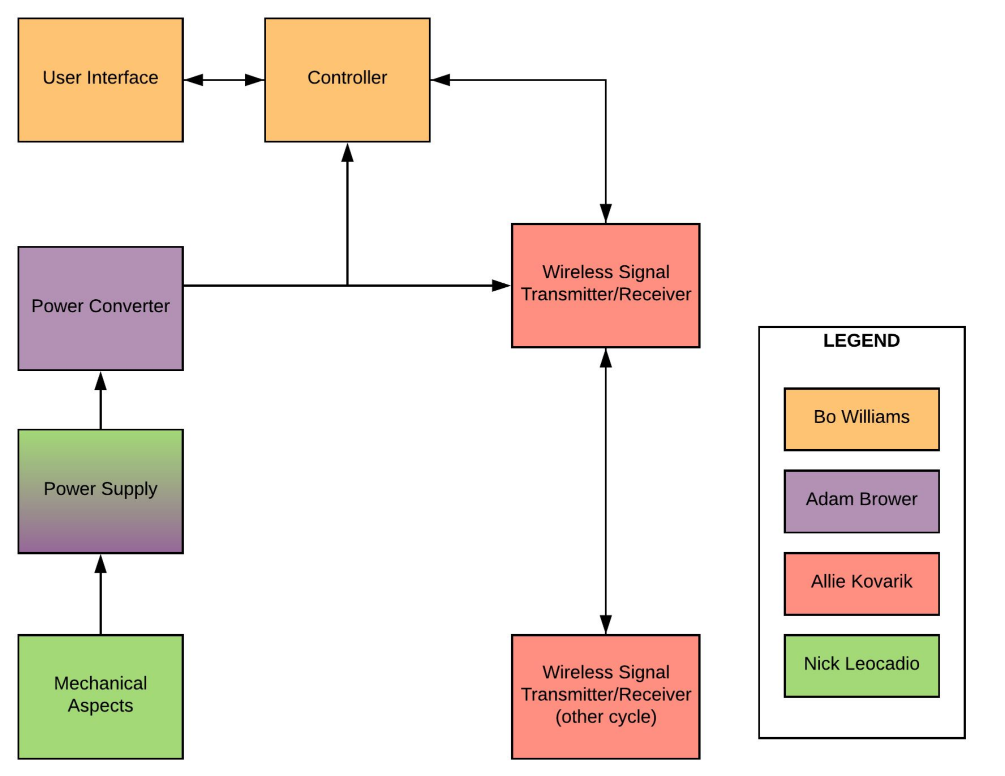
- IEEE 802.15.1
  - Bluetooth Standard
- ASTM F1250
  - Stationary Bike Safety Standard
- System is self reliant
  - Save on power bills
  - Reduce carbon footprint on our environment
- Promotes self health

Project Budget and Financing

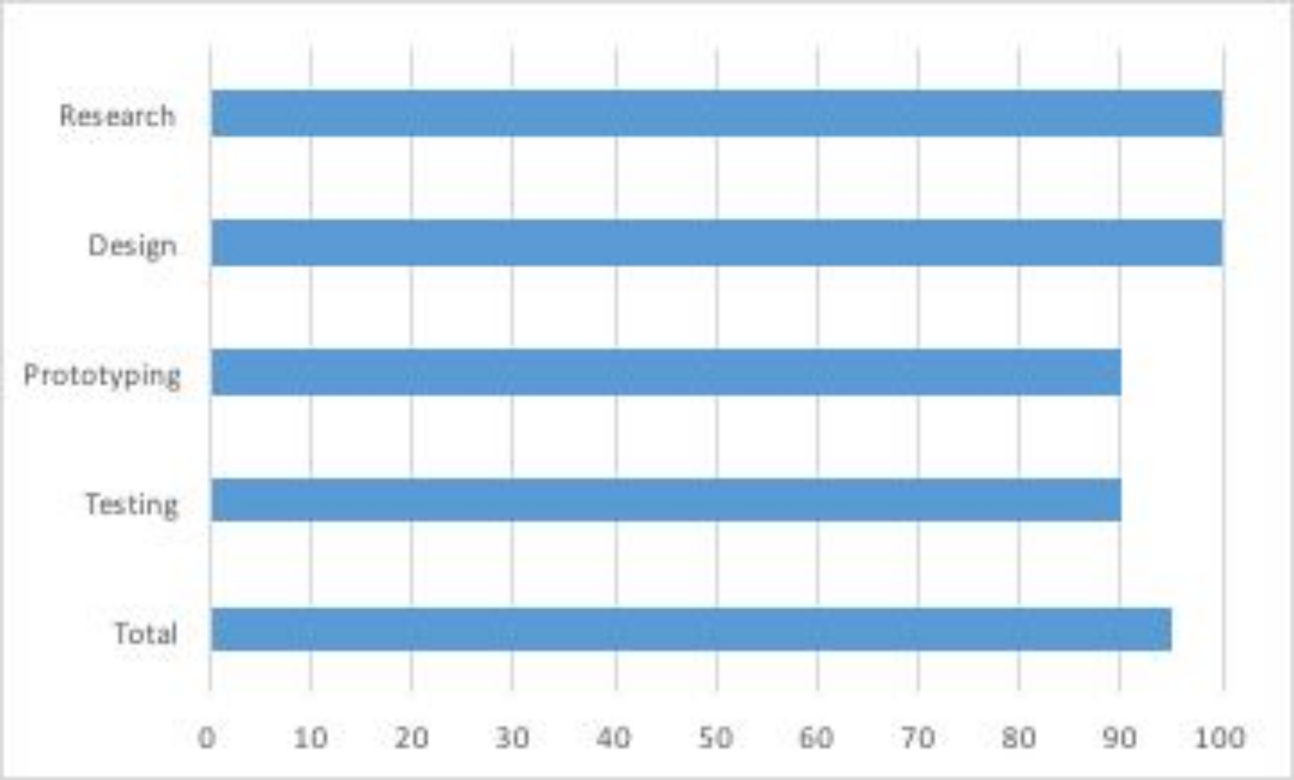
Part	Item Count	Price/Unit	Total Cost
DC Motor	2	$65	$130
HM-10 BLE Module	2	$9.99	$19.98
Stationary Bike	2	$149.99	$299.98
12 V Battery	1	$42.95	$42.95
Servo Motor	2	$17.49	$34.98
Development Board	1	$24.37	$24.37
Magnetic Sensor	20	$0.50	$10
PCB	4	-	$20
Miscellaneous	-	-	$86.23
Total	**-**	**-**	**$668.49**

Part	Item Count	Price/Unit	Total Cost
DC Motor	2	$65	$130
HM-10 BLE Module	2	$9.99	$19.98
Stationary Bike	2	$149.99	$299.98
12 V Battery	1	$42.95	$42.95
Servo Motor	2	$17.49	$34.98
Development Board	1	$24.37	$24.37
Magnetic Sensor	20	$0.50	$10
PCB	13	Varies	$80
Miscellaneous (Parts)	-	-	$250
Electronics Housing	1		$35
Battery Charger	1	$83.95	$83.95
Projected Total	**-**	**-**	**$1011.21**

Project Workload Responsibilities



Progress Completion



Project Difficulties

- First time developing a mobile app
- Staying within a reasonable budget
- Creating necessary mechanical components of system
- Transceiver module cal file loading
- ATmega bootloading

Immediate plans for completion

- Load cal files into DAC and modulator
    - Access if transceiver PCB is viable
- Once main PCB is fully functional, integrate all components together

Questions?