SDP21 - Let’s Ride MDR

Team #23
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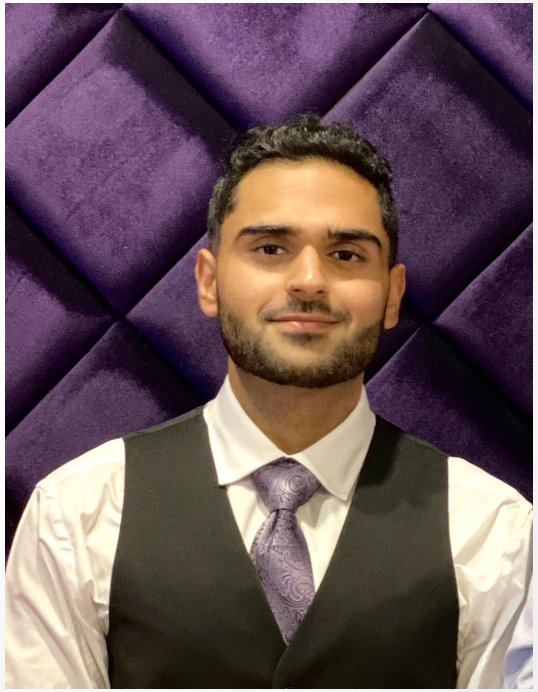
University of Massachusetts Amherst BE REVOLUTIONARY™

Team #23

Ali Abdel-Maksoud EE
Altium Lead

Xavier Farrell EE
Team Coordinator



Syed Ali CompE
Team Secretary

Ben Ledoux CompE
Team Treasurer

Problem Statement

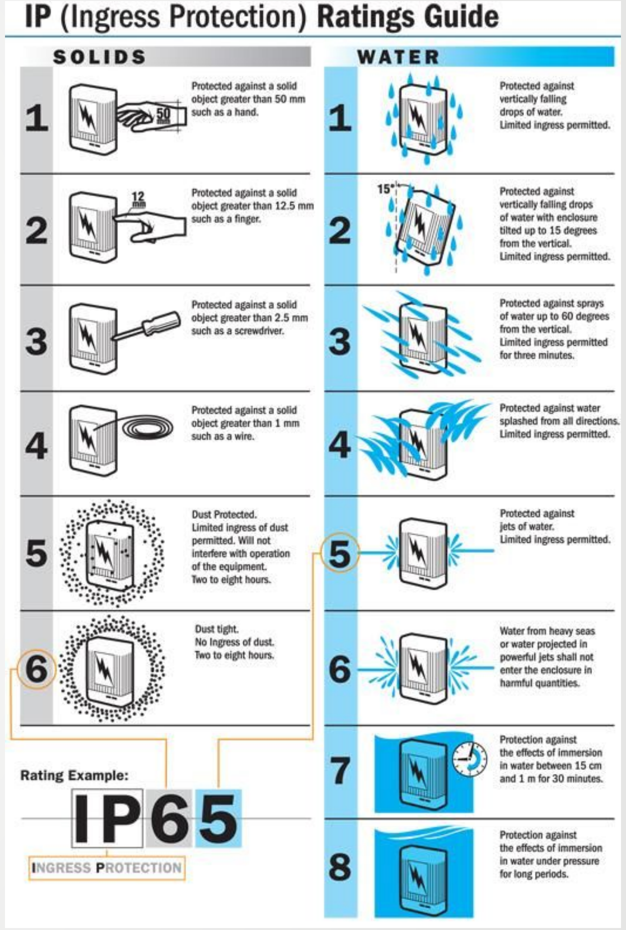
- Covid-19 has created an environment in which staying connected is more challenging than ever. Even crossing state lines to bike with friends has become a hurdle or altogether prohibited. Our product “Let’s Ride”, allows users to embark on coordinated leisurely or fun competitive rides with other cyclists at a distance. Our product captures the user’s and their fellow cyclist’s travelled distance very accurately and through wireless communication provides real-time information on their partner’s/competitor’s progress.

Updated 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
  - After initial pairing, automatically connect via BLE >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

Updated System Specifications: Power, Sensor, Computation

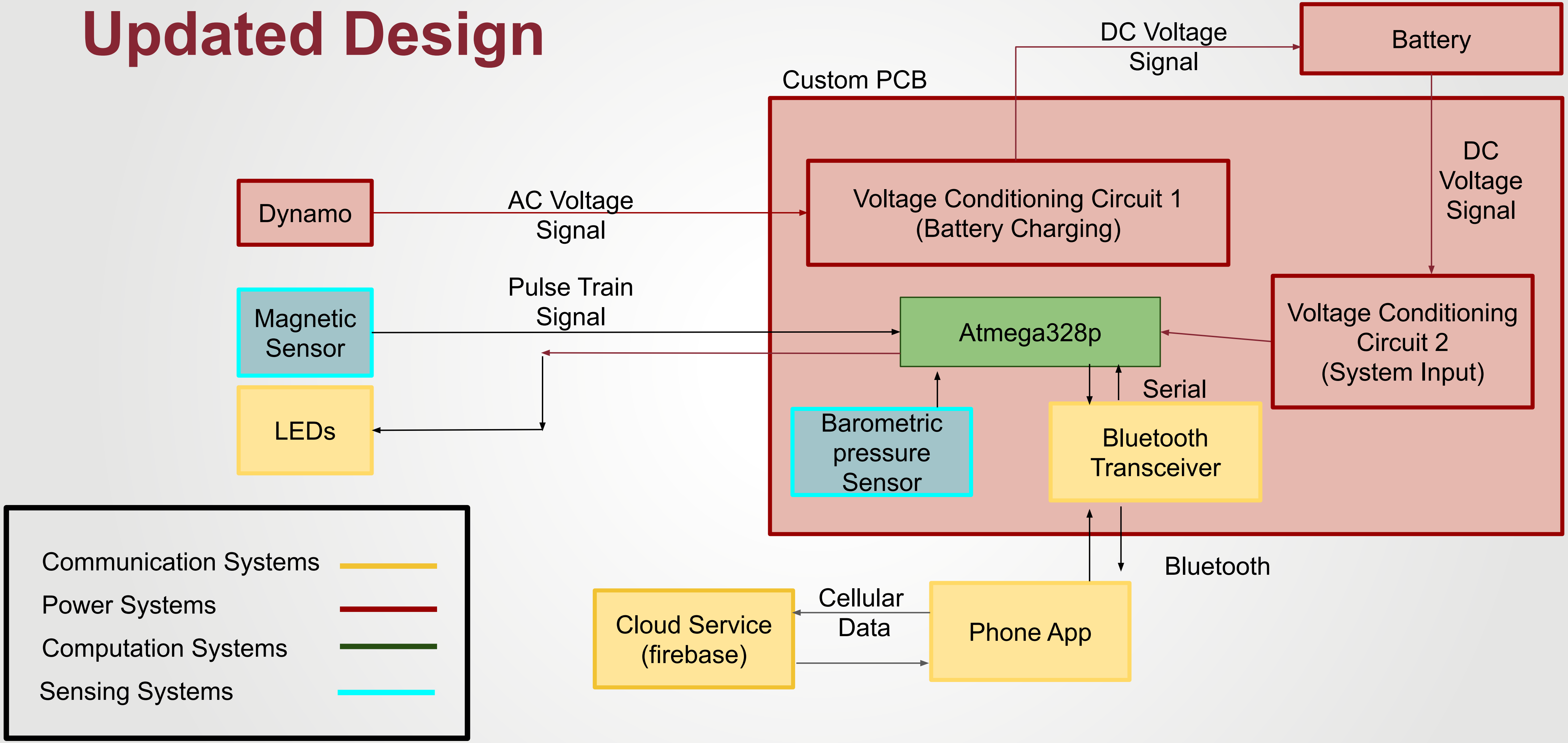
- **Power System**
  - Generates usable electric power at speeds > 6 mph (~2.7 m/s)
  - Continuous generation > 9 hours without heat failure
  - Power system 10 hrs without generation (speed < 6 mph)
- **Sensor/Computation System**
  - Track distance travelled to error bar of ± 0.6m
  - Track amplitude 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)



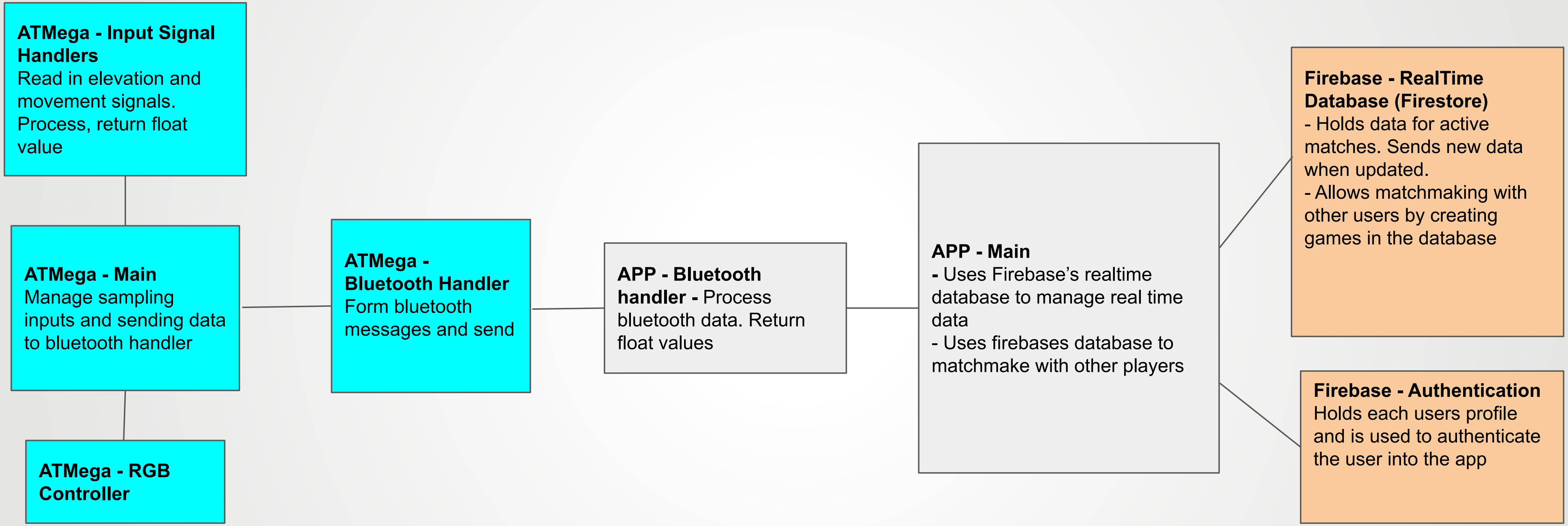
Normalized Unit of Measurement

- Required a way to measure “effort” comparatively
- Effort = distance (m) [H] + positive distance (m) [B]
- Sums contributions by everyone
- Magnitude of contribution of whole / Magnitude of individual contributions
- Ranks by percentage of contribution
- Keeps rankings purely competitive

Updated Design



Software Design



MDR Accomplishments - sensor system (Ali)

- **Proposed MDR Deliverables**
  - Capture output of sensor in response to magnetic excitation ✓
  - Optimize resolution ✓
    - 0.66m diameter wheel
    - circumference = 2.07m
    - 6 magnets $\longrightarrow \simeq$ 0.4m
- **Notables**
  - Barometric pressure sensor
  - Normalized unit of measurement

MDR Accomplishments - Power System (Xavier)

- **Proposed MDR Deliverables**
  - Produce a steady DC output signal from the voltage conditioning circuit using a signal generator: **Achieved**
  - Charge a battery from 0% to 100% using a voltage conditioning system and a signal generator: **Achieved**
  - Produce a Speed vs Output Power plot for Bike Dynamo: **Partially Achieved**

- **Accomplishments**
  - Total System Power Demands: ~300mW
    - Power System Produced ~1.7W @ 13mph (simulated)
  - System Current Demands: ~60mA
    - Power System Produced ~ 400mA @ 13mph (simulated)
  - System Voltage Demands: ~6V
    - Power System Produced ~ 24V Open Circuit @ 13mph (simulated)

Application MDR Deliverables (Syed)

- Matchmaking with a friend or random person
  - partially completed
- Supports skill levels and matchmakes based on the skill level the users have selected
  - Completed

MDR Deliverables on Bike Microcontroller (Ben)

Promised at PDR	**Delivered at MDR**
Run from arduino for MDR, eventually transition to AVR ✓	Runs from Arduino Uno board, utilizes Arduino libraries, programed with Arduino IDE
Feed arduino simulated rider data via signal generator, and simulated opponent data via python script and laptop bluetooth ✓	Python script generates pulses train to send from Raspberry Pi GPIO pin to Arduino digital input pin.
Process simulated input and store in hardware counter ✓	16-bit hardware counter updated automatically on rising edge without use of interrupts
The app will use data transmitted from the atmega to the bluetooth receiver to compute how far the bike has travelled **Not complete**	Some setbacks in being able to launch the app to test Bluetooth on real device (Bluetooth not available on simulator)

Demos

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Hardware and Software Used up to MDR

On Bike Microcontroller

Arduino UNO

HC - 08 BLE Module

Raspberry Pi as signal generator

pigpio library for generating signals

iOS App

Google Firebase

- Authentication, Firestore(real time db)
- xcode - language: Swift

Hardware and Software Used up to MDR

Power System

- 1Tung Lin 4 pole Dynamo
- 1 Buck Converter (LM2596)
- 1 Full Bridge Rectifier (KBP2005G)
- 1 Zener Diode 27V 5W (GA 5358B 1352)
- 1 Li-ion Batteries (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)
- Arduino Uno

Custom PCB - Hardware Plan for FPR

Sensors

- Barometric pressure (BMP 388)

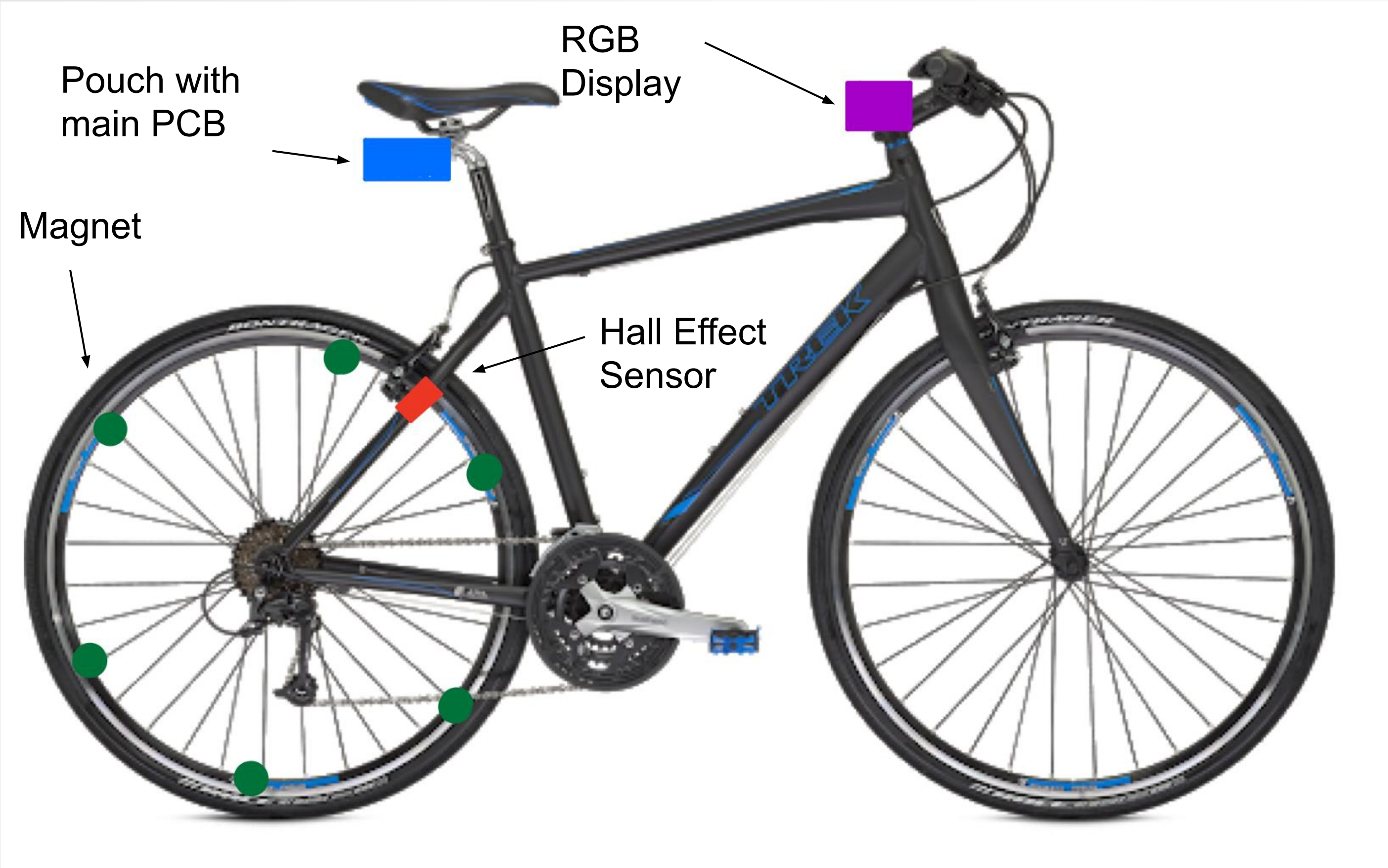
Microcontroller

- Atmega328p
- Bluetooth receiver (RN4020)

Power Systems

- Buck Converter (LM2596)
- Buck Boost Converter (tp63060)
- AC to DC converter (RDBF310-13)
- Zener diode 27V 5W (BZX84B10VLYFHT116)
- Zener diode 5V 1W (MM5Z5V1T5G)

Mounting Plan



PCB in plastic enclosure which will be placed inside of cycling pouch

Wires to RGB display and hall effect sensor secured with velcro straps

CDR Deliverables - Xavier

- Combine both power system stages to produce stable 5V DC output from dynamo
- Complete power system PCB layout design
- Supply power to the entire system in operation

CDR Deliverables - Ben

- Send data from microcontroller to iOS app via BLE (unfinished MDR deliverable)
- Control RGB lights based on opponent data
- Transition to AVR
- Transition from solderless breadboard to PCB

CDR Deliverables - Ali

- Seamless integration of hall effect and magnets
- Completed PCB layout
- First design of enclosure ready for testing

CDR Deliverables - Syed

- inviting and joining games with friends
- Display players stats along with leaderboard
- Ability to specify the type of game they're looking to play
- Display live game details (Partial Deliverable)

Project Expenditure

So Far

Item	Quantity	Item Price	Total Price
SC-HC-08 BLE	2	$6.50	$13.00
Schmitt Trigger 74HC04	1	$6.70	$6.70
Baromtric Sensor BMP388	3	$9.95	$29.85
Hall Effect Sensor US5881LUA	5	$2	$10
10 pcs Neodyium Magnets	5	$2.15	$10.75
Buck Boost Cnvtr.	2	$9.95	$19.90
Bike Dynamo	1	$33.75	$33.75
		Total	**$123.95**

Next Semester

Item	Quantity	Item Price	Total Price
BLE HC-08 Surface Mount	3	$7.75	$23.25
ATmega328p surface mount	3	$1.90	$5.70
BMP 388 Surface Mount	3	$3.47	$10.41
74HC04 Surface Mount	3	$0.40	$1.20
Full Bridge Rectifier (RDBF310-13 smd)	5	0.6	3
Zener Diode 27V (MM5Z5V1T5G)	3	0.23	0.69
Zener Diode 5V (BZX84B10VLYFHT116)	10	0.37	3.7
Cycling pouch	1	$11	$11
Buck Converter (LM2596)	2	5.73	11.46
tp63060	2	2.34	4.68
Blank PCB	10	$2.00	$20.00
		Total	**$95.09**

Gantt Chart

Task	Feb				March	CDR				April		FPR
On-Bike Controller	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Week 11	Week 12
Control led to alert user of position			Ben									
Transition to AVR				Ben								
Design controller PCB portion						Ben, Ali						
Test and finalize mounting position								Ben				
iOS App												
Invite friends to races			Syed									
Display player stats and leaderboards					Syed							
Allow specific race details							Syed					
Display game details live											Syed, Ben	
Power System												
Analyze buck converter PCB schemetic				Xavier								
Altium Training		Xavier										
Design power system PCB in Altium							Xavier, Ali					
Integrate into first basic system						Xavier						
Real tests on bike ride								Xavier				
Final PCB design												Xavier
Sensor System												
Design sensor system PCB in Altium				Ali								
Test hall effect mounting design							Ali					
Final ride, IP, druability testing												Ali, Ben

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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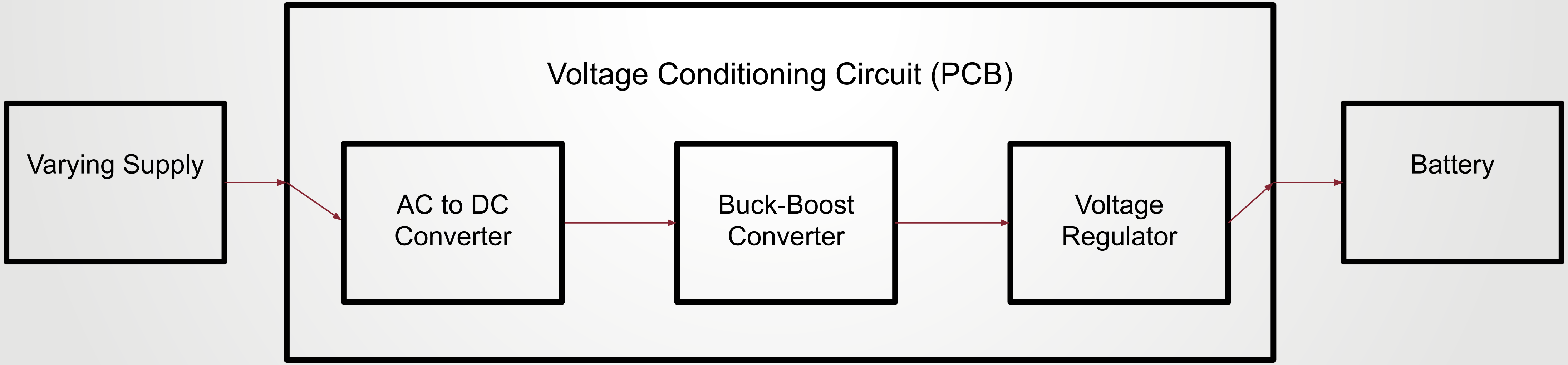
Backup

Custom Hardware

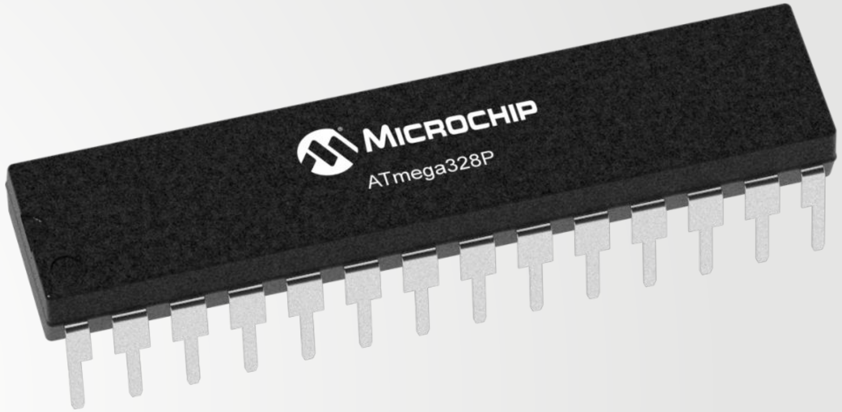
Voltage Conditioning Circuit

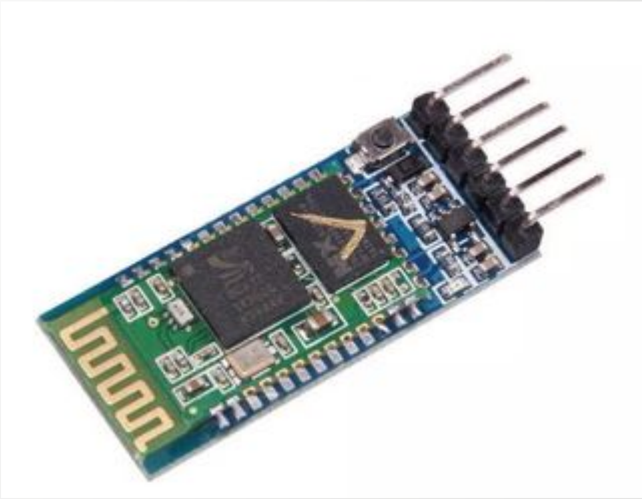
- Similar products exist in solar power to battery power conversion electronics
- General Layout:



On-Bike Microcontroller

- **ATMega328**
  - Low power
  - Computes distance travelled
  - Receives and transmits information via bluetooth
  - Encodes race placement and programs LEDs
- **HC-05 Bluetooth Module**
  - Low cost
  - Reliable
  - Serial Port Protocol Profile
  - Bluetooth V2.0+Enhanced Data Rate (3Mbps), 30m range
- **Schmitt Trigger**
  - Convert analog signal to digital





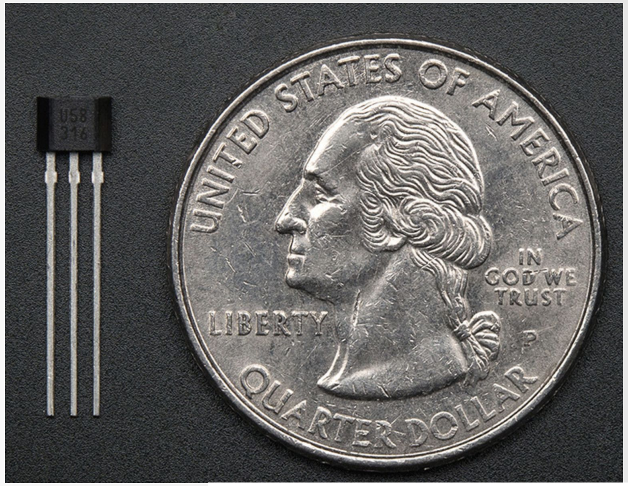
MDR Deliverables

- **Power System**
  - Produce a Speed vs Output Power plot for Bike Dynamo
  - Produce a steady DC output signal from the voltage conditioning circuit using a signal generator
  - Charge a battery from 0% to 100% using a voltage conditioning system and a signal generator
- **Magnetic Sensor**
  - Capture output of sensor in response to magnetic excitation
  - Optimize resolution

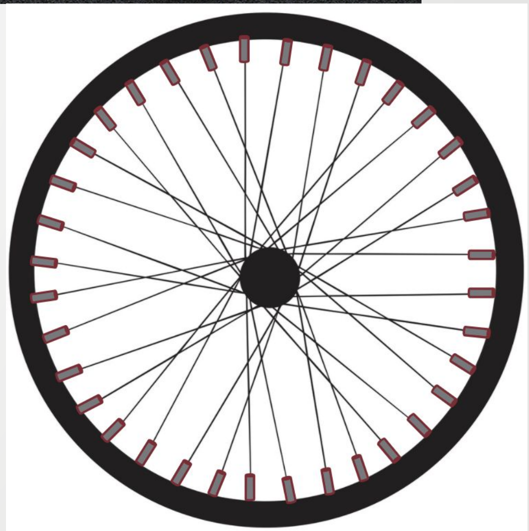
Power System

- **Layout**
  - Power Supply: Bike Dynamo (generator)
  - Voltage Conditioning Circuit
  - Rechargeable Battery
- **Bike Dynamo Specs**
  - Outputs an AC signal
  - Max Voltage Rating = 6V
  - Max Power Rating = 3W
- **Voltage Conditioning Circuit**
  - AC to DC converter
  - Buck-Booster Design
  - Voltage Regulator
- **Battery**
  - Natural waste heat management
  - Meet voltage demands for sensor, microcontroller, LED, and bluetooth system

Sensor System - Magnetic Sensor



- **Spokes**
  - All spokes evenly spaced
  - Magnetic material placed on spokes
- **Bike Fork**
  - Hall effect sensor
  - Sensed change will indicate certain passage of distance



Power Sy