UNIVERSITY OF ILLINOIS URBANA-CHAMPAIGN

Electric Bicycle With Fully Electric Architecture

Electrical & Computer Engineering

Team 15

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Objectives and Intentions

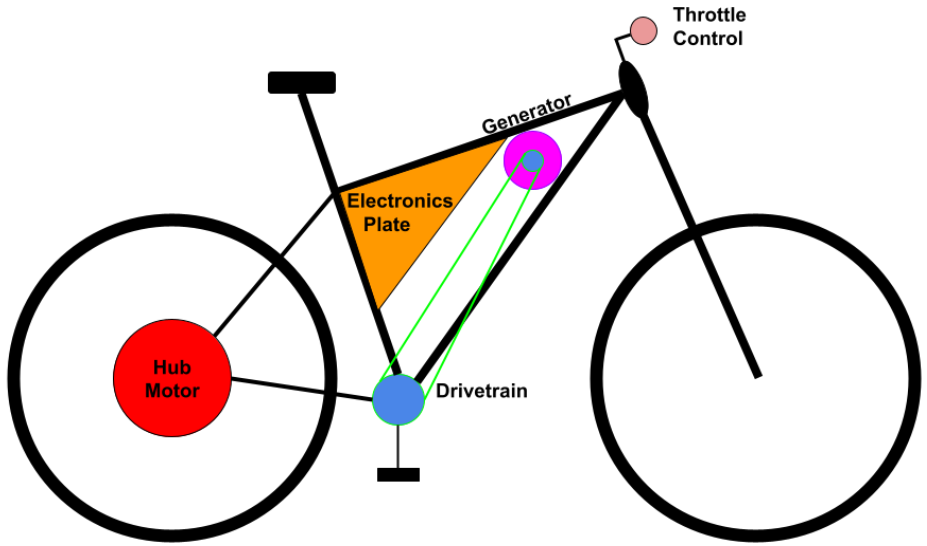
Project Objective, Block Diagram, High Level Requirements,

Motivation

- Most e-Bike designs still incorporate a pedal chain system.
- Exposed components can lead to durability issues in different environments.
- e-Bikes with ‘pedal-assist’ can still be difficult to pedal uphill and have fixed electric range.
- Large bike sharing companies like VeoRide need bikes that are durable and low maintenance.

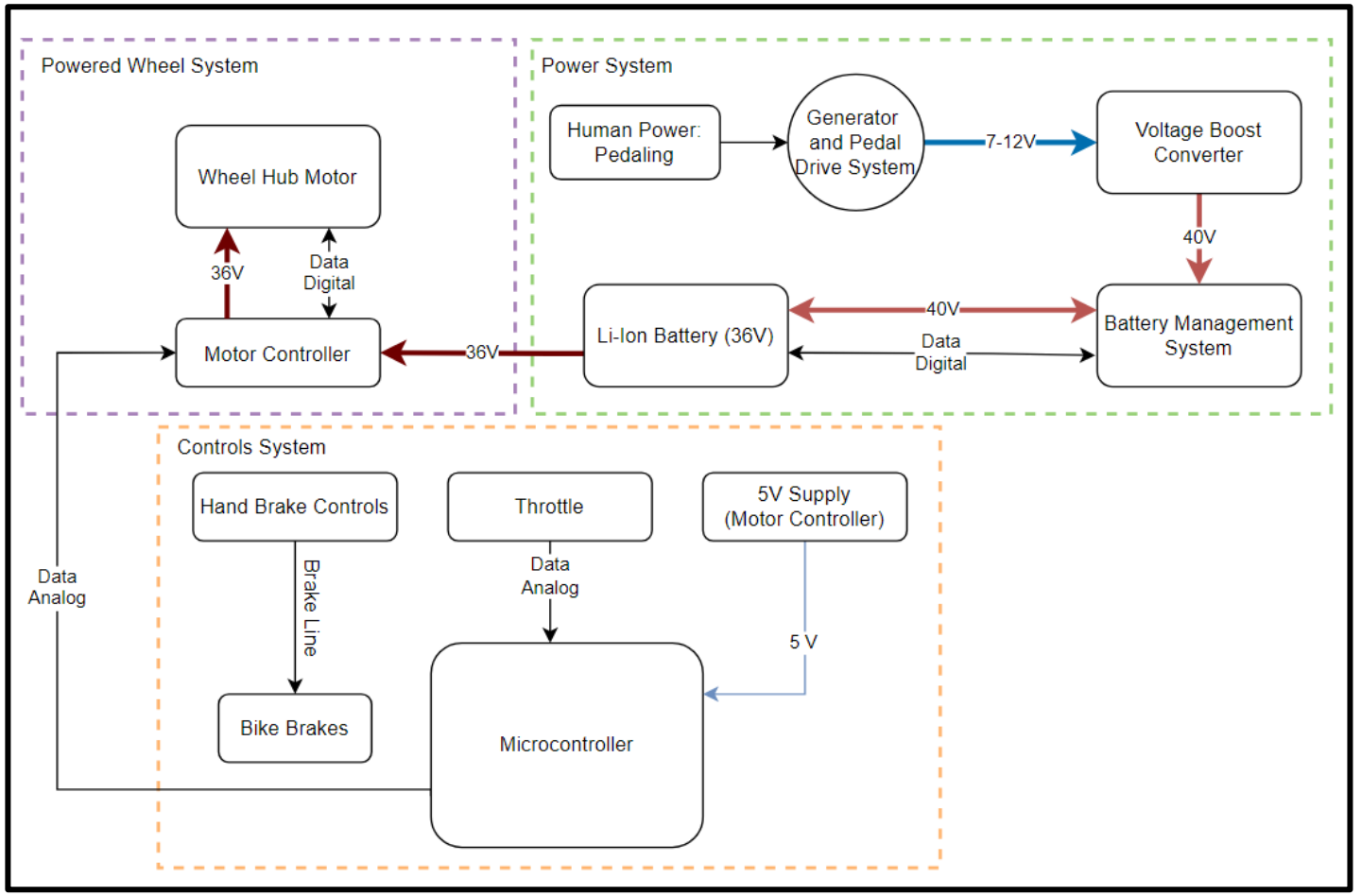
Objectives for our e-Bike Design

1. Capable of propelling the user forward with only battery power
2. Suitable range with battery power alone
3. Option to pedal/generator system as a range extender
4. Minimize exposed mechanical components to increase reliability and durability



High Level Requirements

1. Charge the 36V battery with the pedal-generator. Route ~36V from the battery to the hub motor
2. Rear wheel motor can propel the vehicle to 5 mph with ~180 pounds of load.
3. Motor speed can be controlled through a throttle system by the user.
4. 40% efficiency of power conversion from pedaling to electricity.



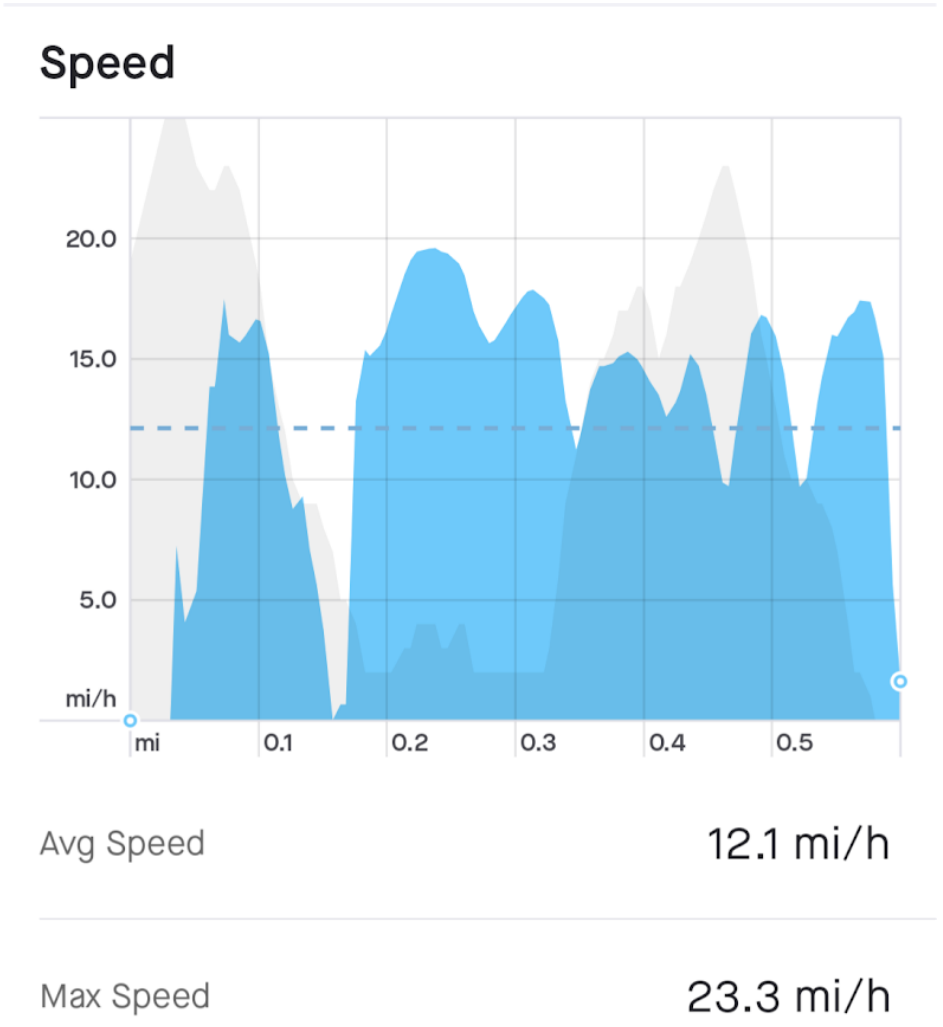
Results

Demonstrating a Functional e-Bike

Demonstrating a Functional e-Bike

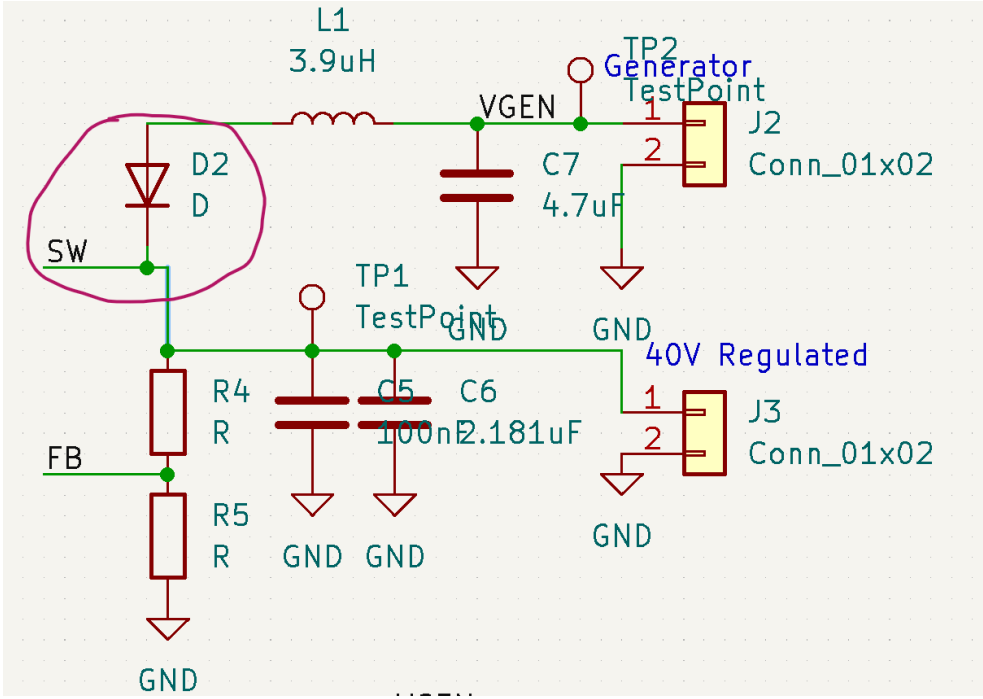
Demonstrating a Functional e-Bike

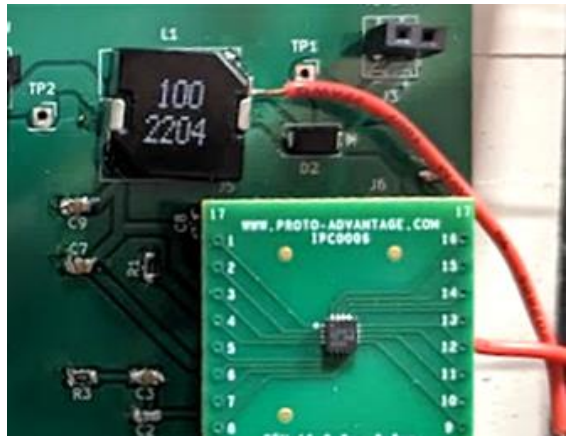
- Maximum measured speed of roughly 20 mph
  - Demonstrated by calculation and with Strava
  - Safety vs Unlimited Power Modes
- Easily controllable
  - Throttle control
  - Cabled front brake



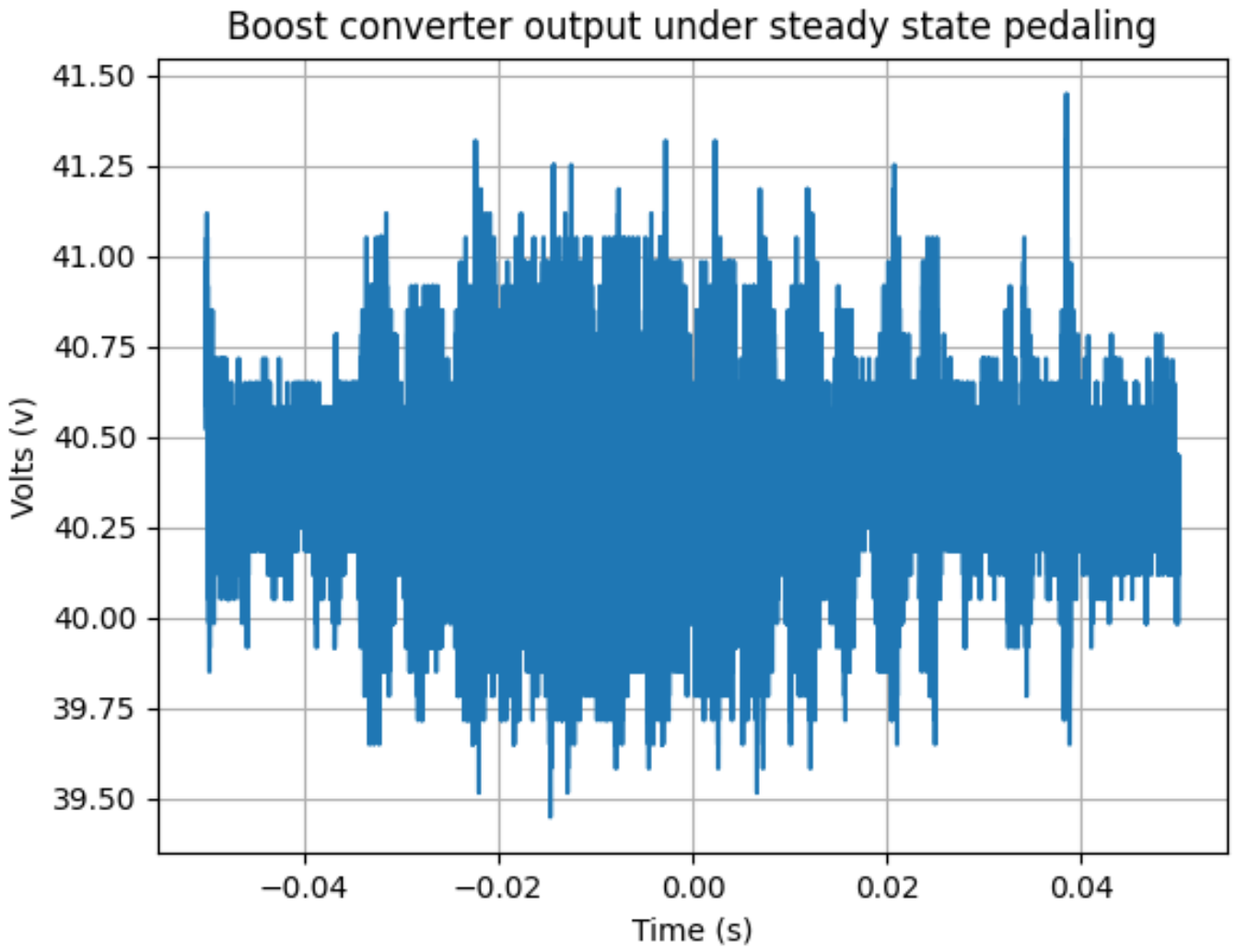
Testing the Boost Converter

- Purpose of Boost Converter:
  - Regulate unstable 5-15V input from generator to a steady 40V output
- Results
  - Expected output voltage under no load
  - Output voltage ‘sags’ under higher loads as the output current increases
  - Oscilloscope traces on next slide
- Bugs
  - Initially were getting barely any boosting, from 8V to about 11V at most. We had an issue in our PCB, shown to the right, that we had to quickly fix

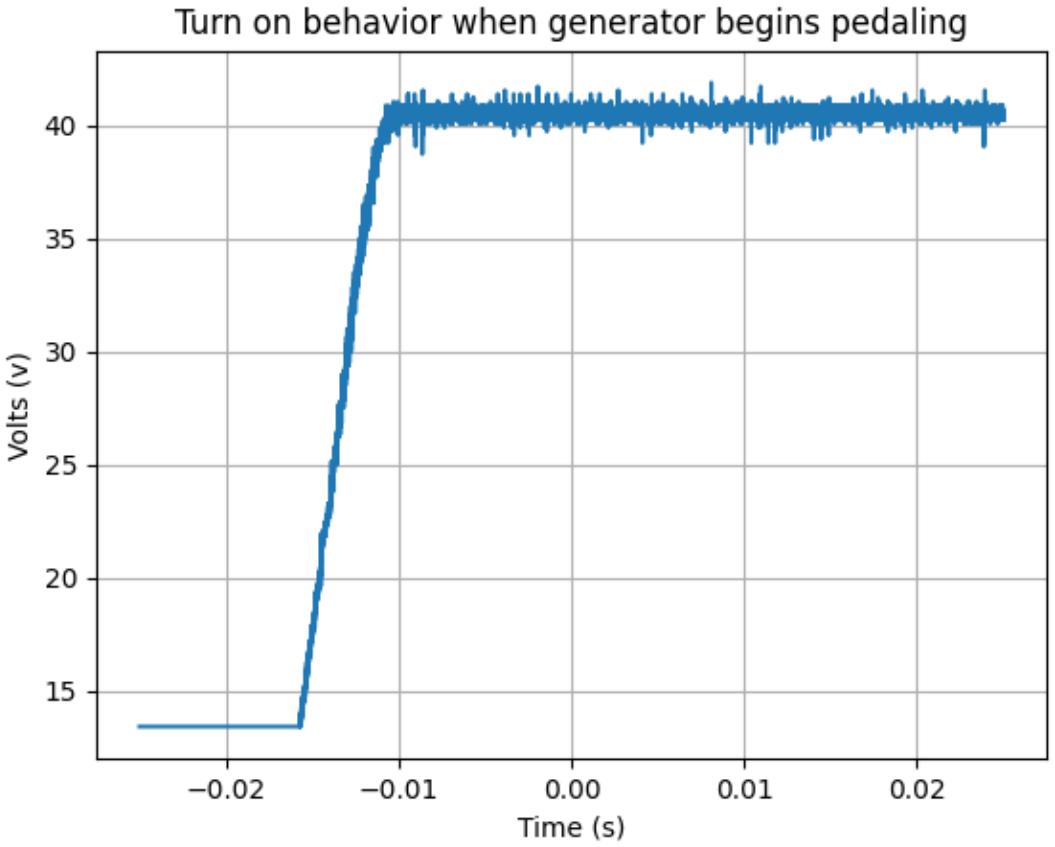


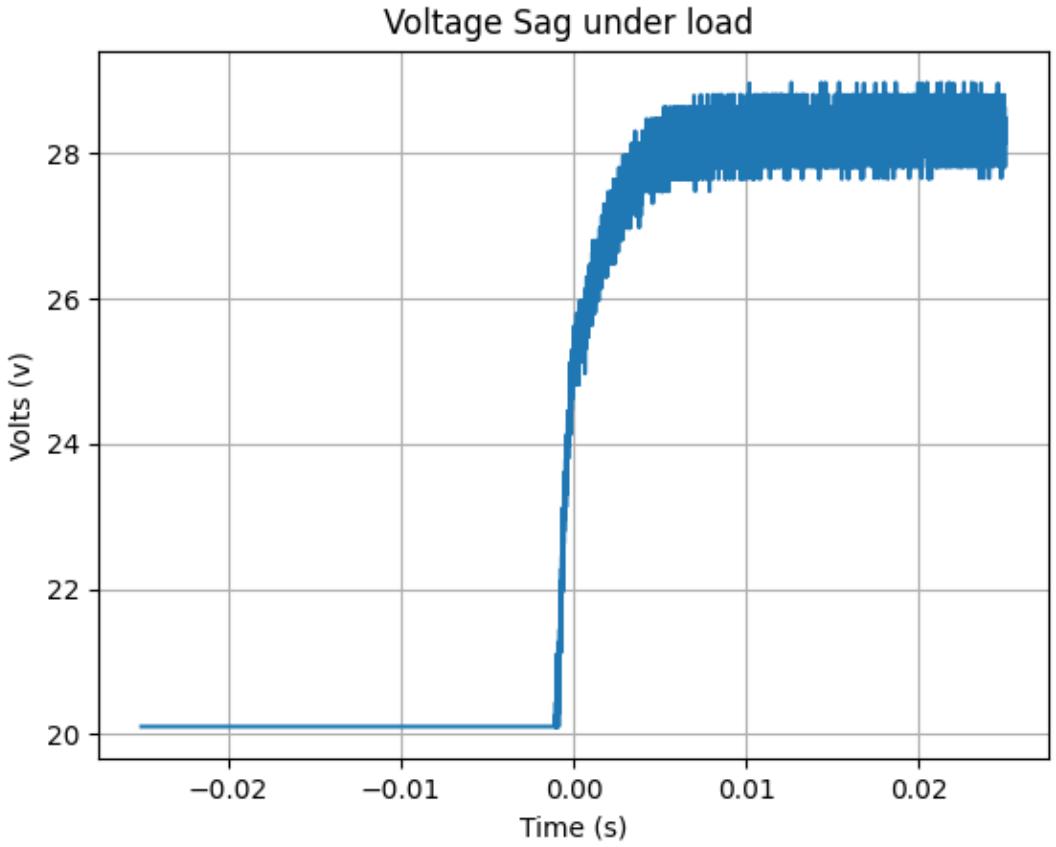


Power System Testing



Power System Testing





Efficiency of the Power System

- We developed two resistor networks to measure the output power of, then compared to the input power from the generator.
  - 330 Ohms - 70% Efficient
  - 10,000 Ohms – 20% Efficient

- With larger power loads, the output voltage dropped to account for the current jump.

$With\ R_{load} = 9.73k\ Ohms$
$V_{in} = 8\ V$
$I_{in} = 0.1\ A$
$P_{in} = .8\ W$
$V_{out} = 40.2\ V$
$P_{out} = 0.166\ W$

Efficiency = 20.75%

$With\ R_{load} = 333\ Ohms$
$V_{in} = 7.7\ V$
$I_{in} = 0.35\ A$
$P_{in} = 2.695\ W$
$V_{out} = 25.7\ V$
$P_{out} = 1.98\ W$

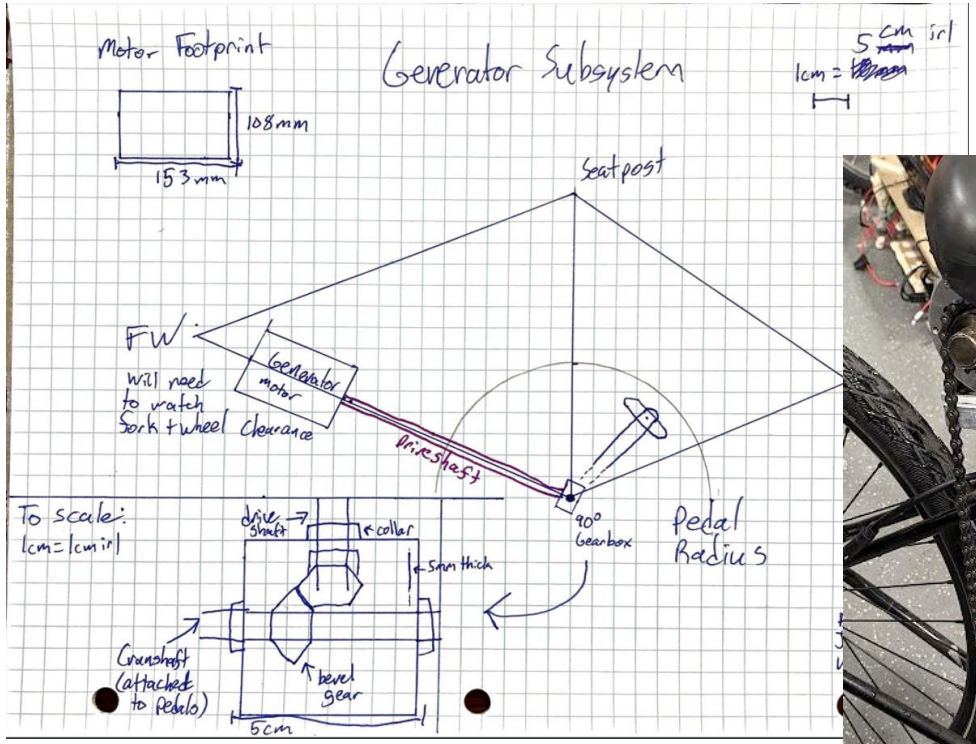
Efficiency = 73.5%

Project Development

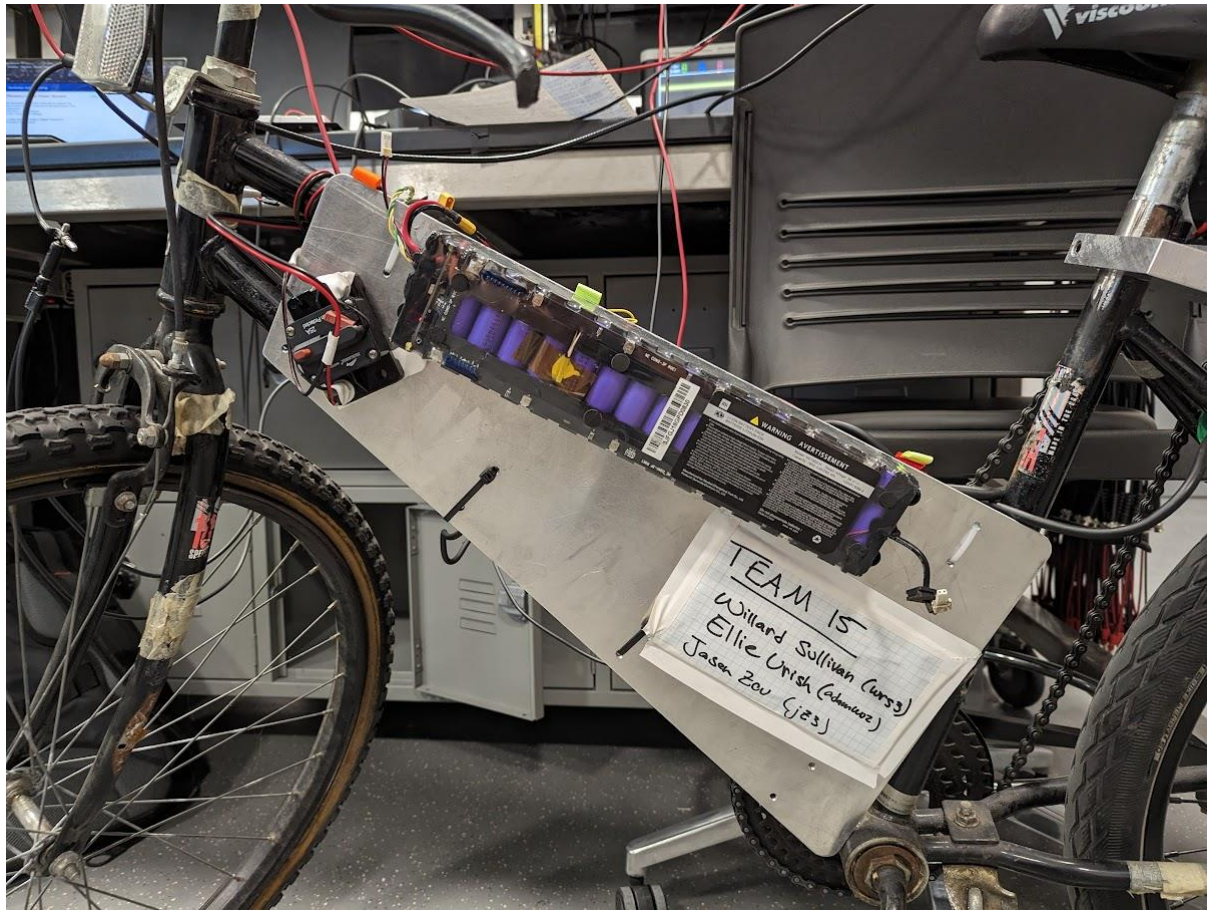
Building and Designing Processes, Implementation

Mechanical Design

- Mechanical design mostly entails the Generator/Power System.
  - We have had several design iterations.
- Our system uses a chain drive system to the generator, despite going against our original intentions.
- A metal mounting plate houses our battery and electronics.

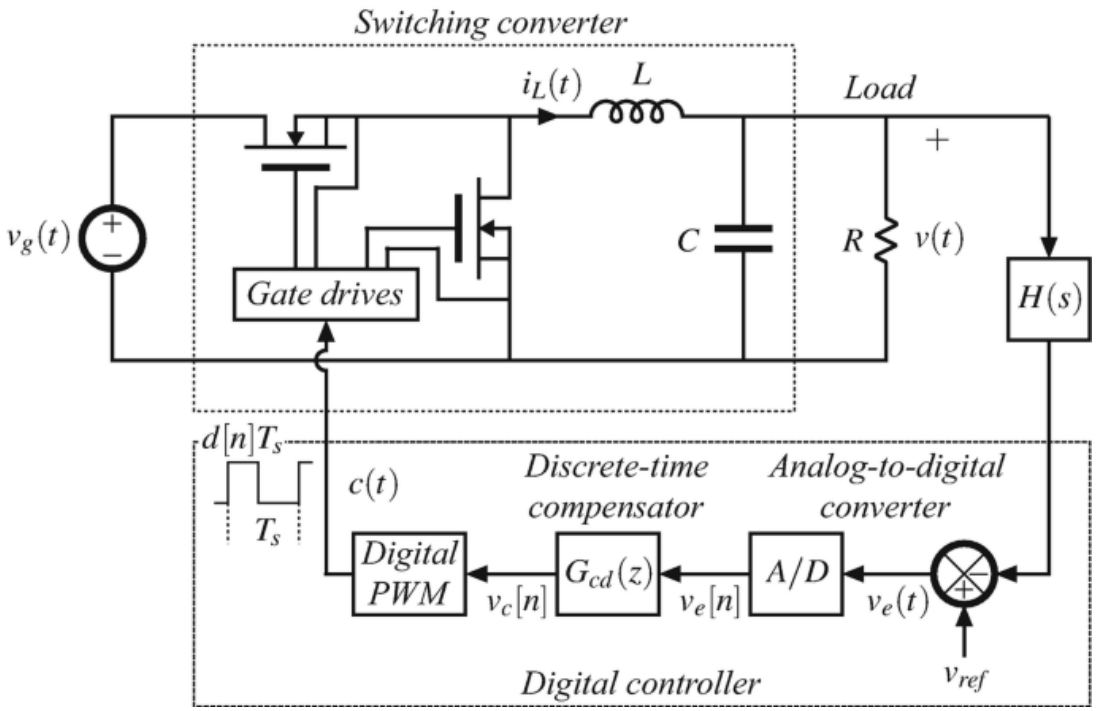


Mechanical Design Implementation

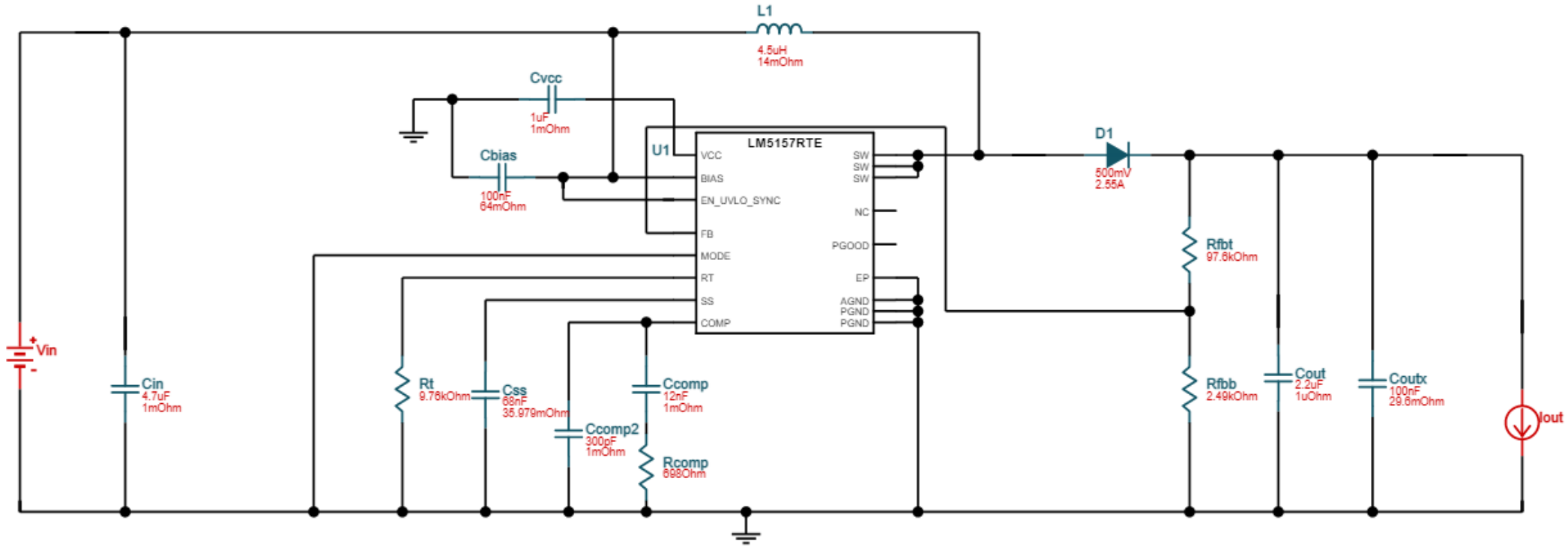


Electrical Design - PCB

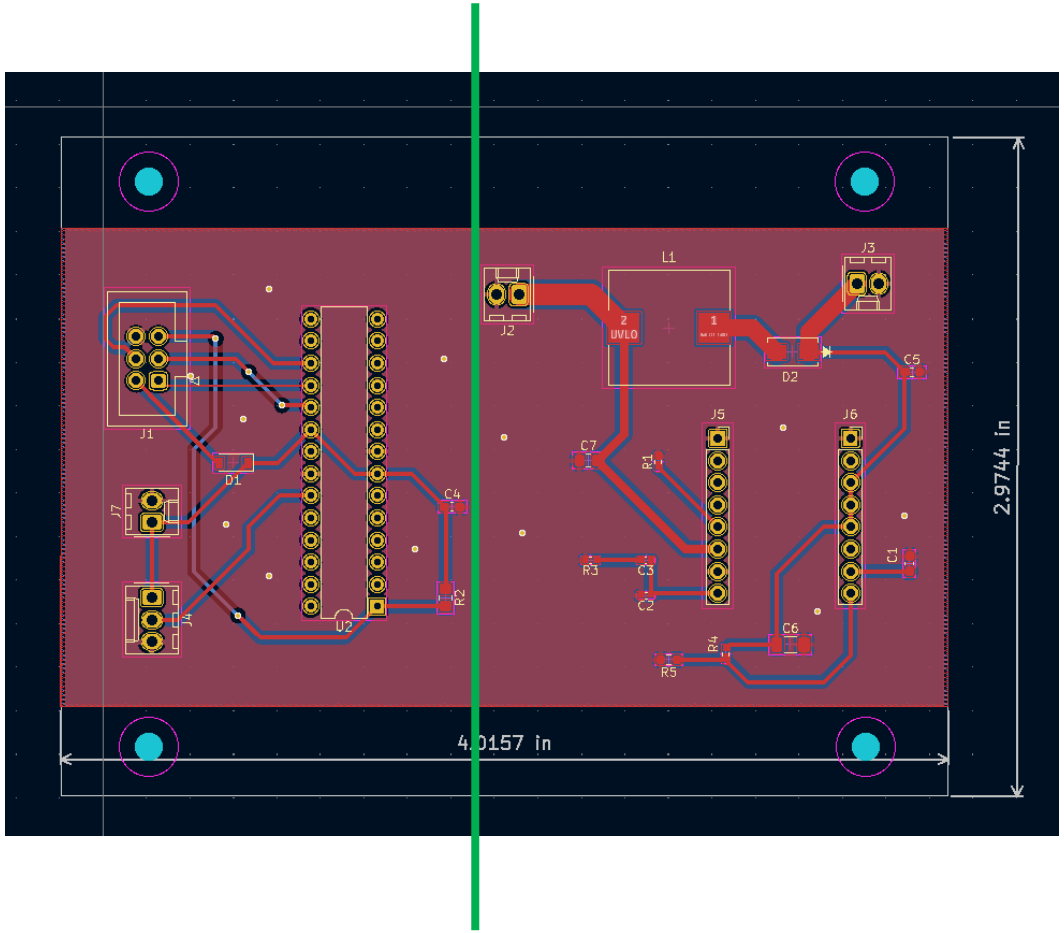
- Boost converter increases the pedaling voltage of between 5-15V into a useable 40V output for charging the battery.
- The Controls Subsystem regulates the maximum speed of the bike and limits the throttle to a safe range.
  - An Atmega328 microcontroller is used.

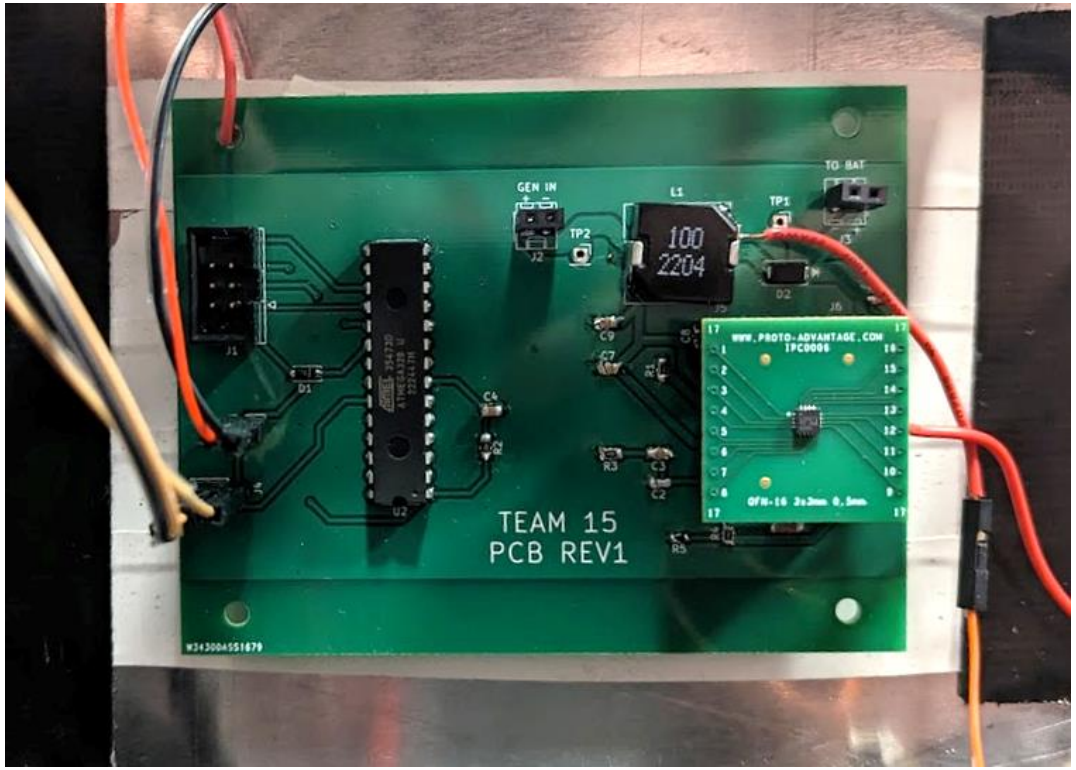


Boost Converter



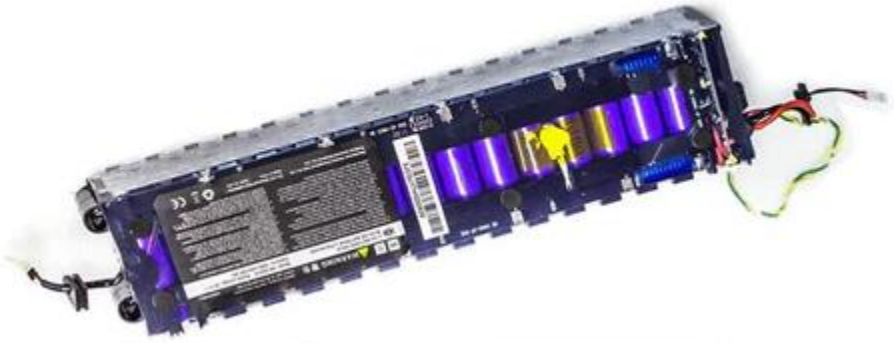
PCB Design


L1
J3
J2
UVLO
D2
C5
J5
J6
C7
R1
J1
D1
C4
J7
R3
C3
C2
C1
R2
J4
U2
C6
R4
R5
2.9744 in
4.0157 in


GEN IN
TO BAT
TP1
TP2
L1
100
2204
TEAM 15
PCB REV1

Electrical Design – Powered Wheel

- Four main components for the Powered Wheel System, which are common on other e-Bikes:
  - Battery: 36V/8A
  - Hub Motor: 36V/350W
  - Motor Controller
  - Throttle
- The Motor Controller serves as the “nucleus” of this system as it manages input/output data and power.



Review

Our Successes and Challenges, Final Thoughts

Successes:

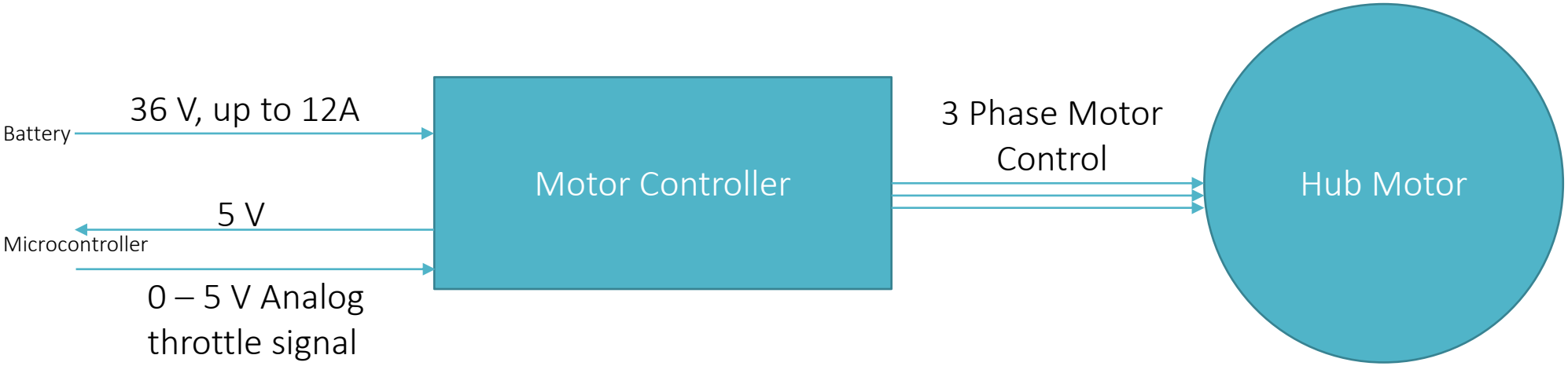
- e-Bike has enough power to propel user to high speeds – up to 20 mph
- Throttle limiter through microcontroller works as expected
- Mechanical implementation works well, generates 40V

Challenges:

- Boost converter voltage currently sags under larger current draw, causing issues with battery charging
- Issues with lack of documentation for powered wheel subsystem, prevented implementation of encoder speed control

Future Endeavors

- Design needs additional versions to get closer to the original envisioned goal
- Integration of the power generation subsystem with the rest of the bike
- Refining design to be more polished, user friendly, and weather ready


36 V, up to 12A
Battery
Motor Controller
3 Phase Motor Control
Hub Motor
5 V
Microcontroller
0 – 5 V Analog throttle signal

Thank You

Are there any questions?

The Grainger College of Engineering

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