UNIVERSITY OF ILLINOIS URBANA-CHAMPAIGN

Antweight Battlebot

Electrical & Computer Engineering

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TA: Michael Gamota

Professor: Viktor Gruev

May 6, 2025

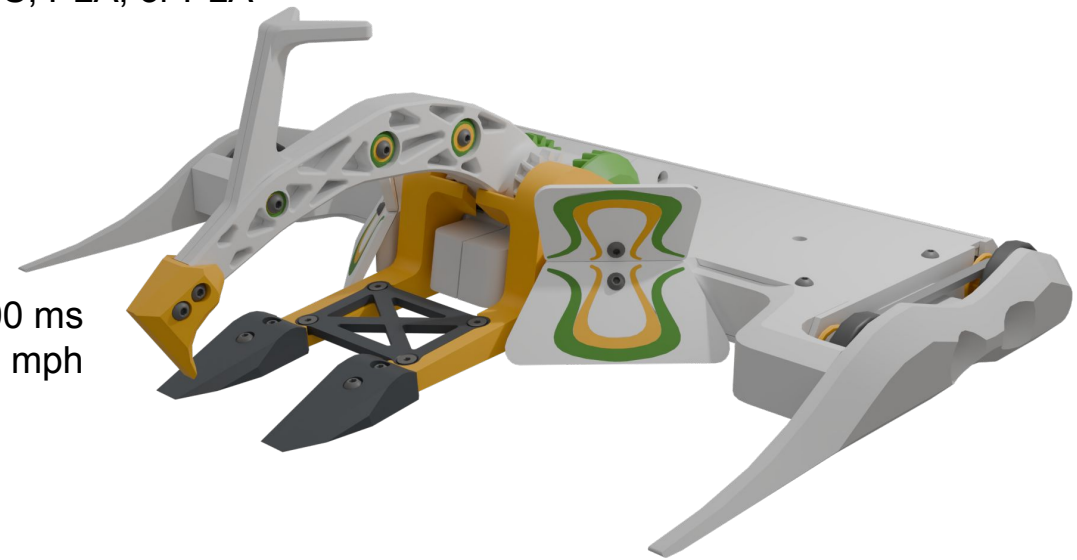
Professor Gruev's Antweight Battlebot Competition

Rules:

- Must be 3D printed with PET, PETG, ABS, PLA, or PLA+
- Less than 2 lbs
- Wirelessly controlled
- Have a "fighting tool"
- Safety shutdown switches

High Level Requirements

- Bluetooth latency must be less than 1000 ms
- Robot must have a minimum speed of 3 mph
- Weapon must be capable of lifting 2 lbs

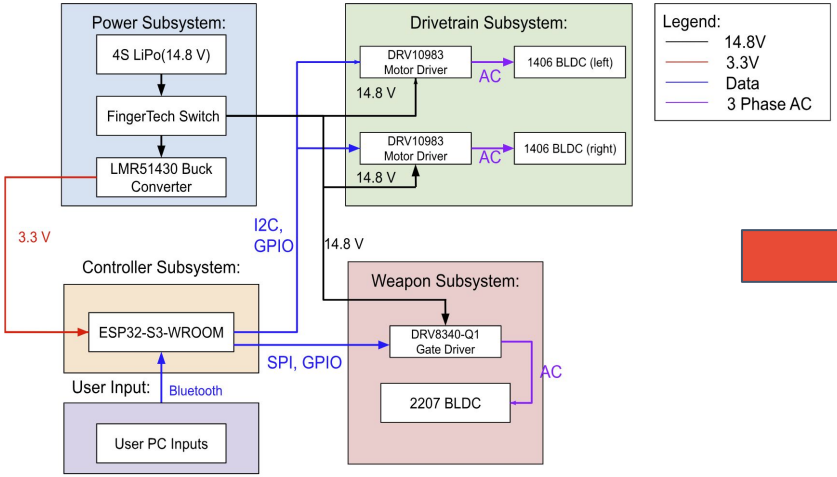


Design

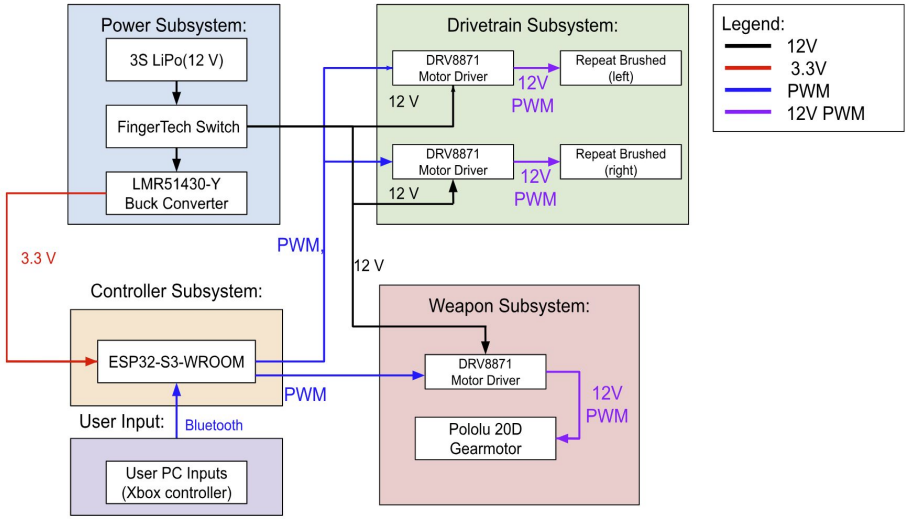
Electrical and Mechanical Design and Verification

Block Diagram

Old Design

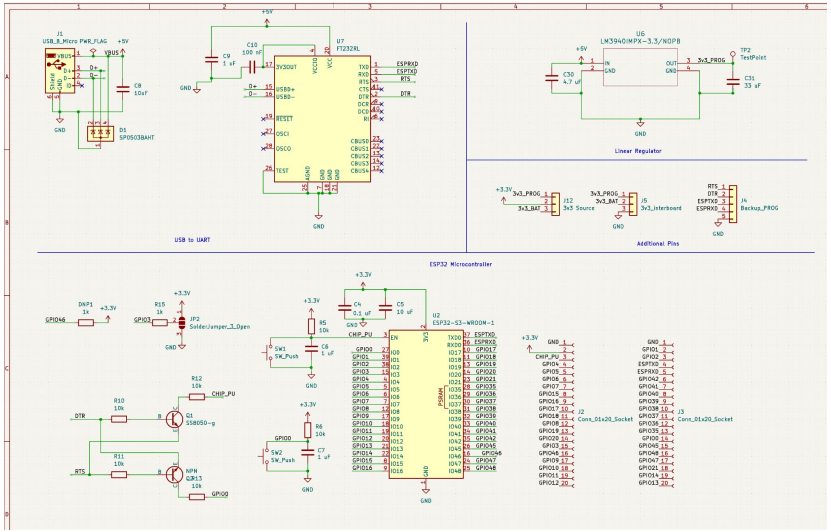


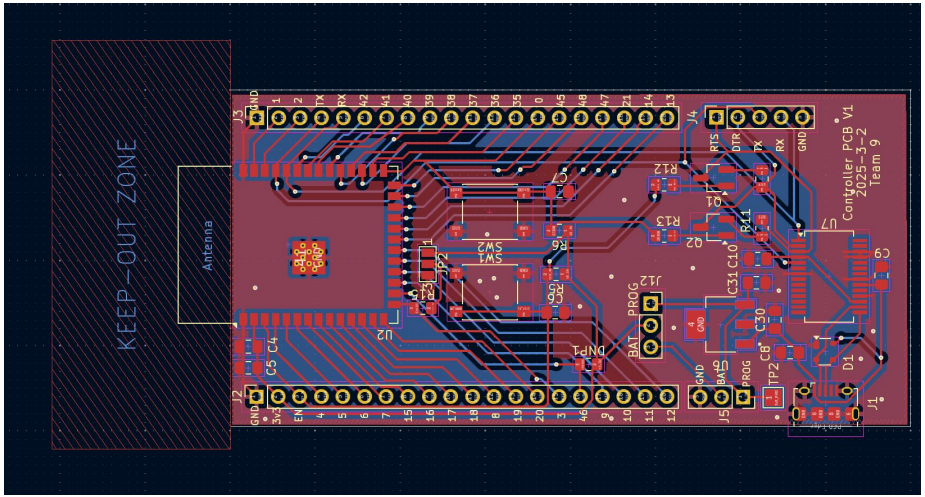
New Design



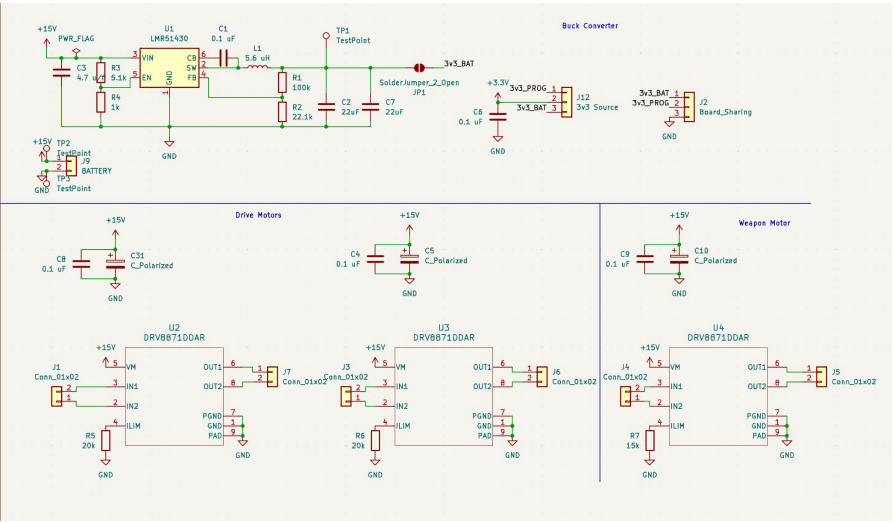
- Switched from brushless controllers and motors to brushed
- 4S to 3S LiPo battery

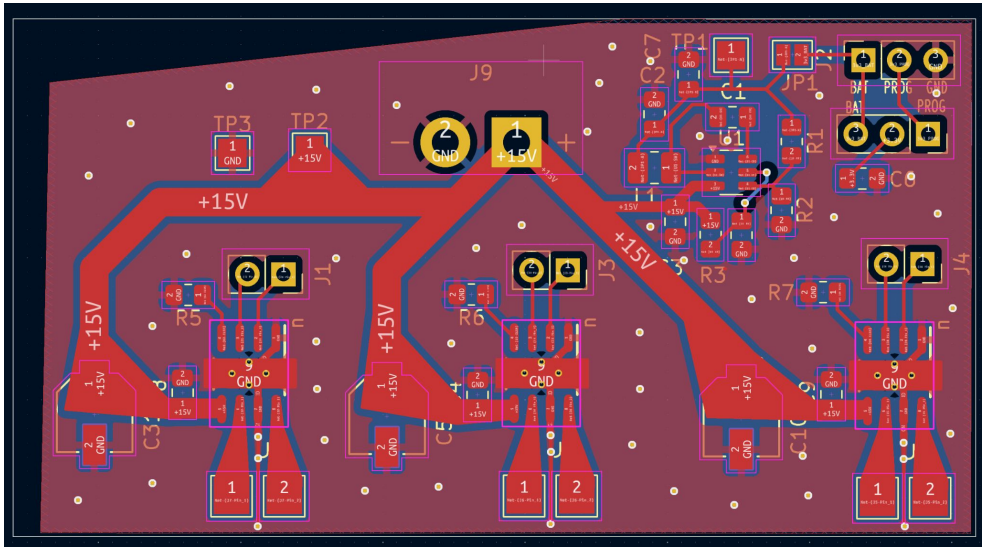
PCB Design - Controller PCB



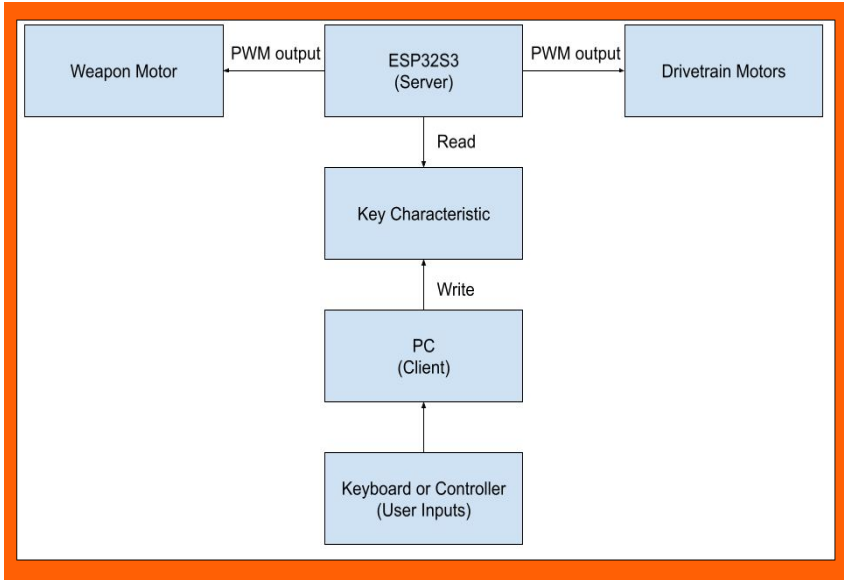


PCB Design - Motor PCB





Controller Subsystem



Bluetooth Low Energy Data Flow:

- Configures the BLE stack on ESP32-S3 using NimBLE and sets it as the server
- Establishes a connection using Bleak, with the PC acting as the client
- Writes joystick and button data to designated BLE characteristics
- Reads new characteristic data on ESP32-S3 and determines output PWM

Arcade Drive

- One axis controls speed and the other controls rotation

Requirement:

- ESP32 must connect to PC via Bluetooth Low Energy with a latency of less than 1000 milliseconds

Verification:

- Connect a PWM pin from the ESP32 to an oscilloscope and measure the time it takes to change when given an input from the controller

Result:

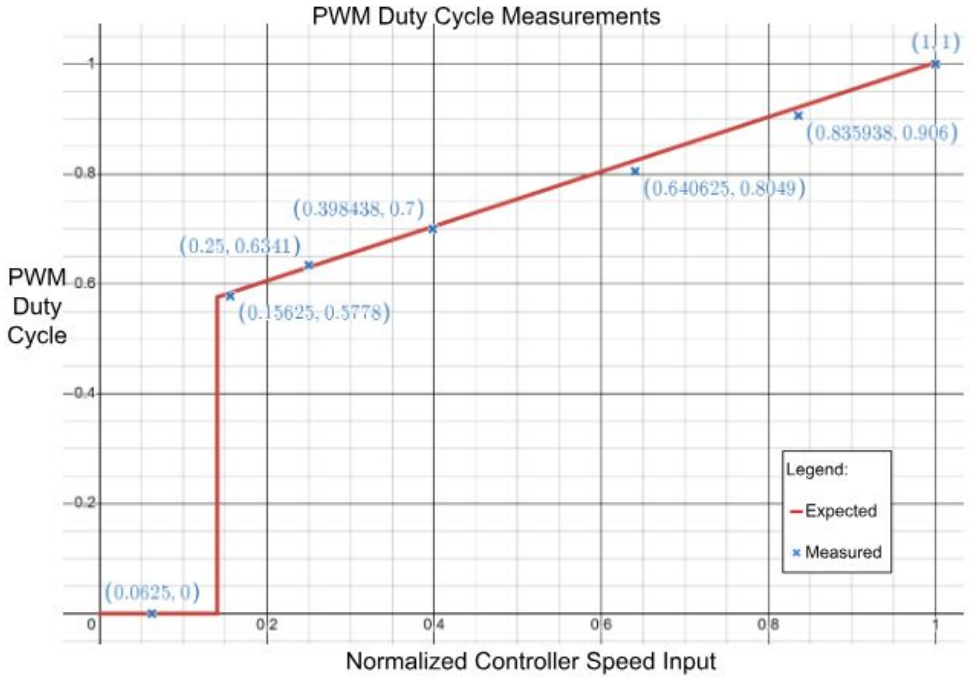
- After three trials, the average latency was 135 milliseconds

Requirement:

- Must send PWM signal with ± 10% accuracy corresponding to controller speed input

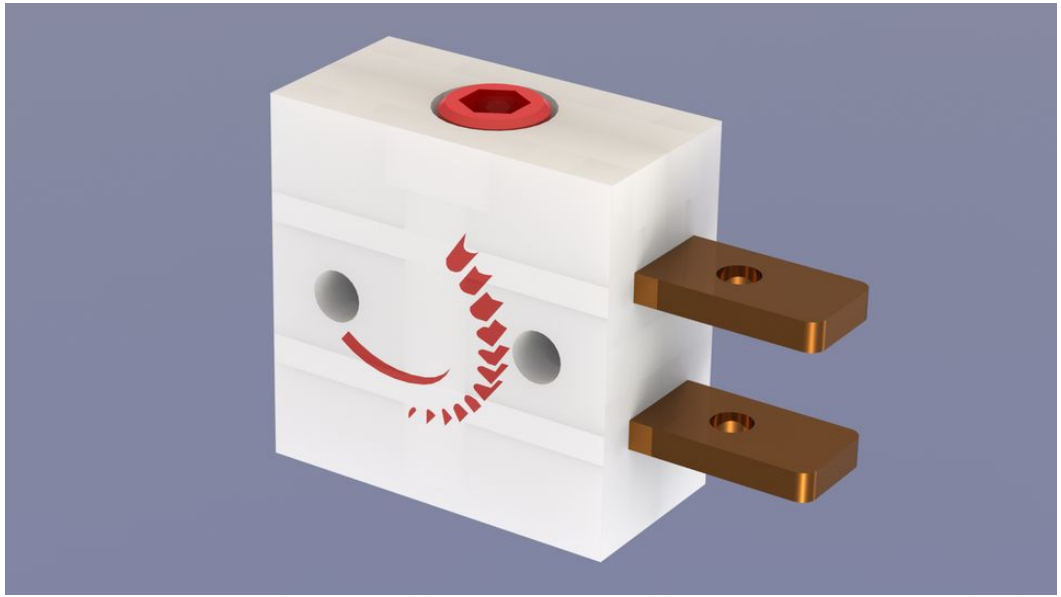
Verification Results:

- Average 0.88% error
- Maximum 2.35% error



Power Subsystem

Power Switch



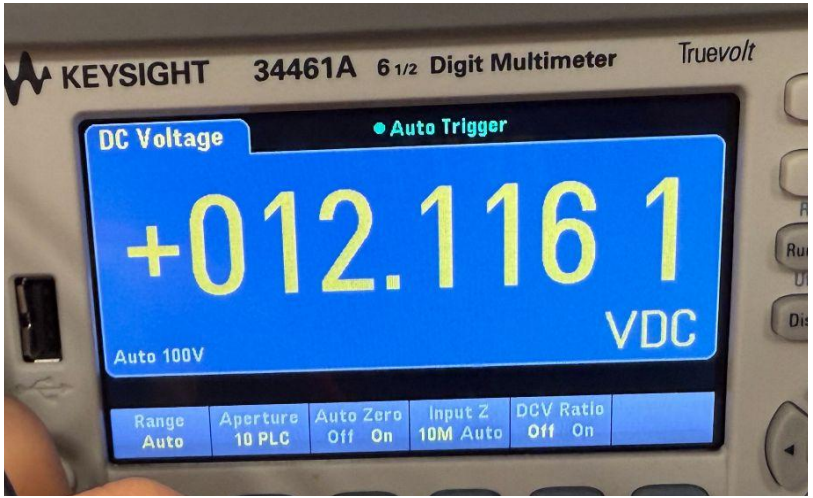
Fingertech Power Switch

- Easy manual shutdown

Battery

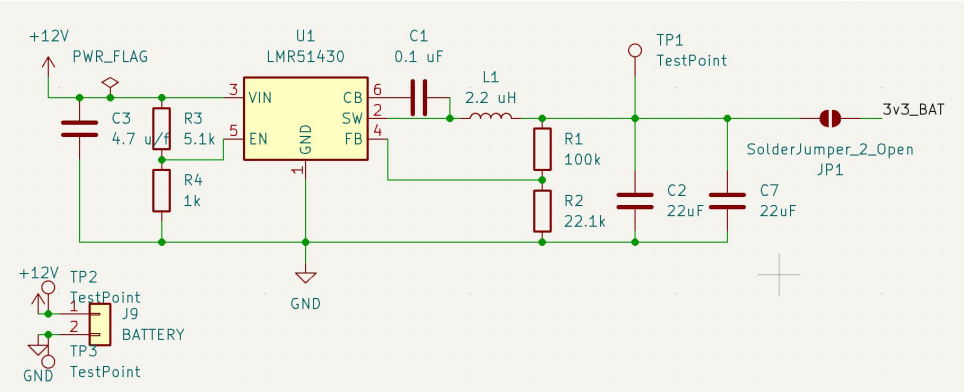
Requirement: Provide power for 2 entire 2 minute match duration and not drop below 9.6 V

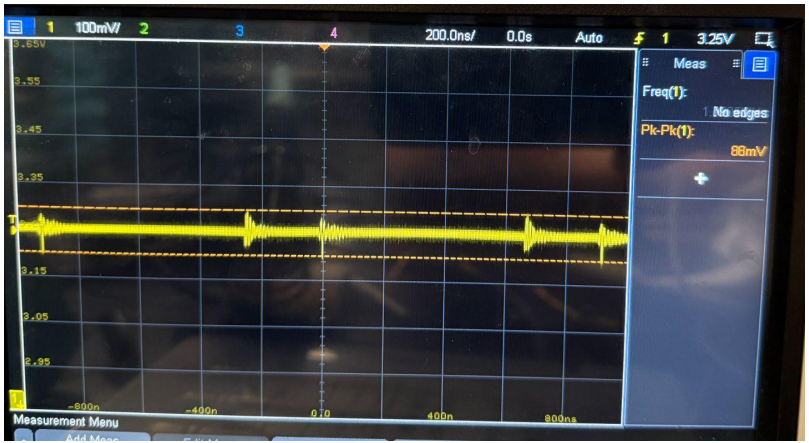
Before (Fully Charged)



After 2 minutes

Buck Converter





LMR51430

- Steps down 3S (11.1 V nominal) to 3.3 V
- Up to 3 A output

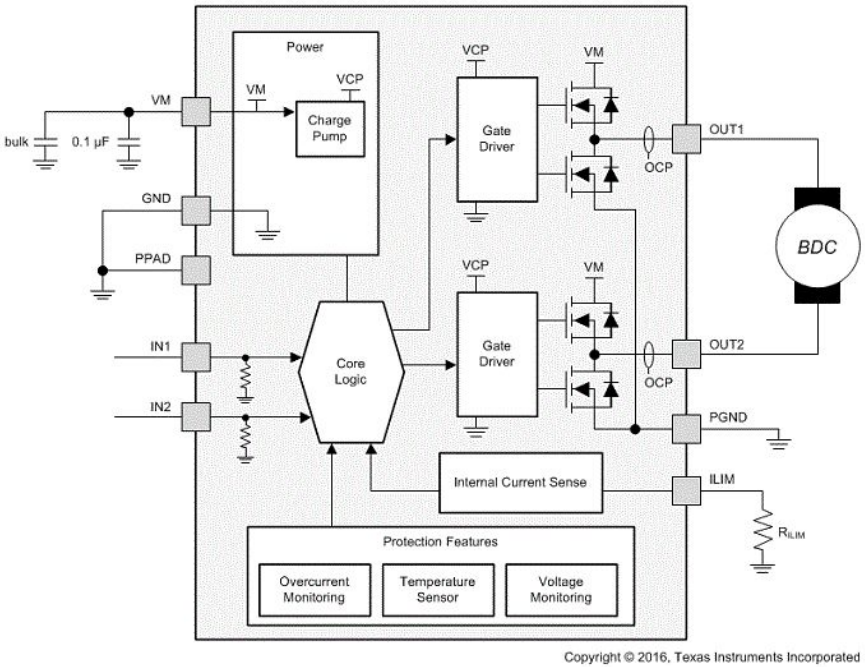
Requirement: Provide Stable 3.3 V ± 0.3V

Results:

- Average: 3.25 V
- Ripple: 88 mV

Drive Subsystem

Drive



DRV8871

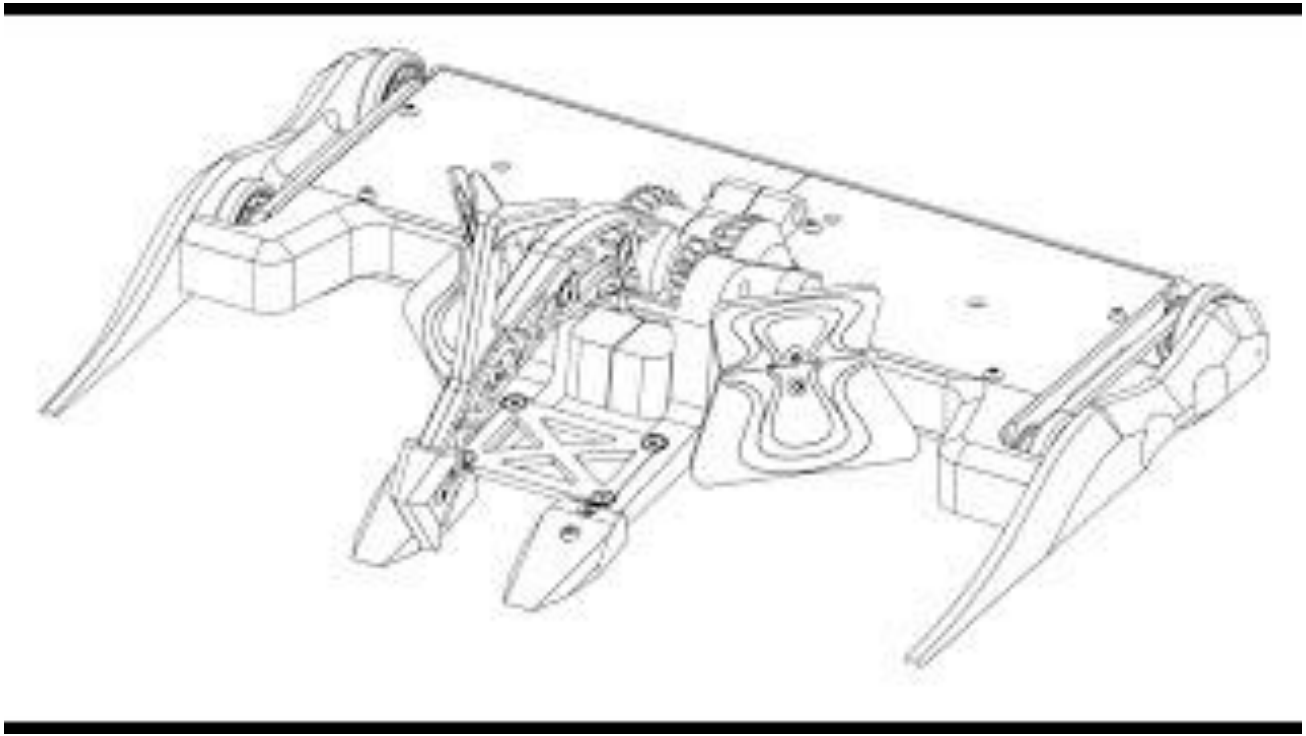
- 3.6 A output limit
- 2 PWM inputs

Requirement: Must be able to reach 3 mph

- Measured 3.24 mph at max speed

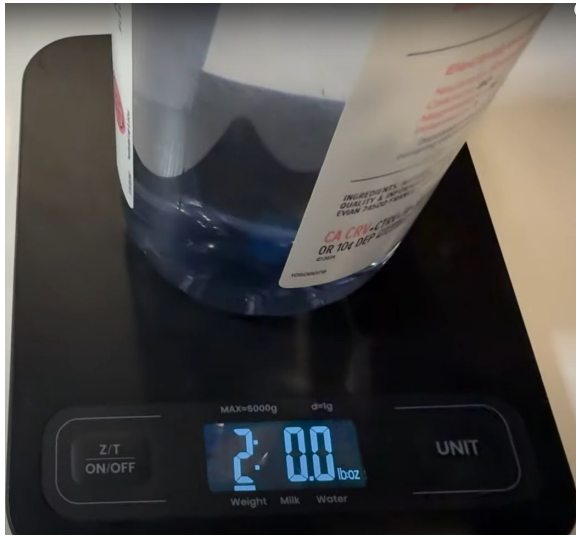
Requirement: Movement must stop within 3 seconds of Bluetooth disconnect

Requirement: Robot can drive or flip itself upright if knocked upside-down



Weapon Subsystem

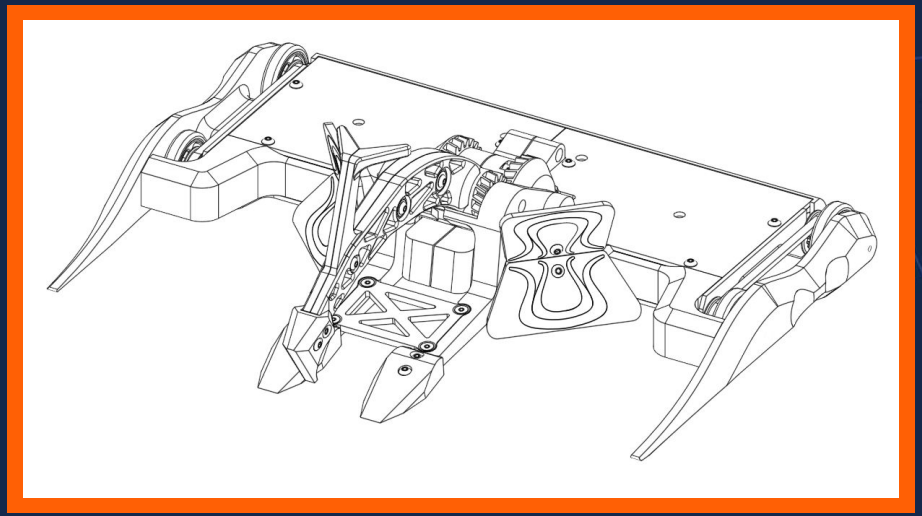
Weapon



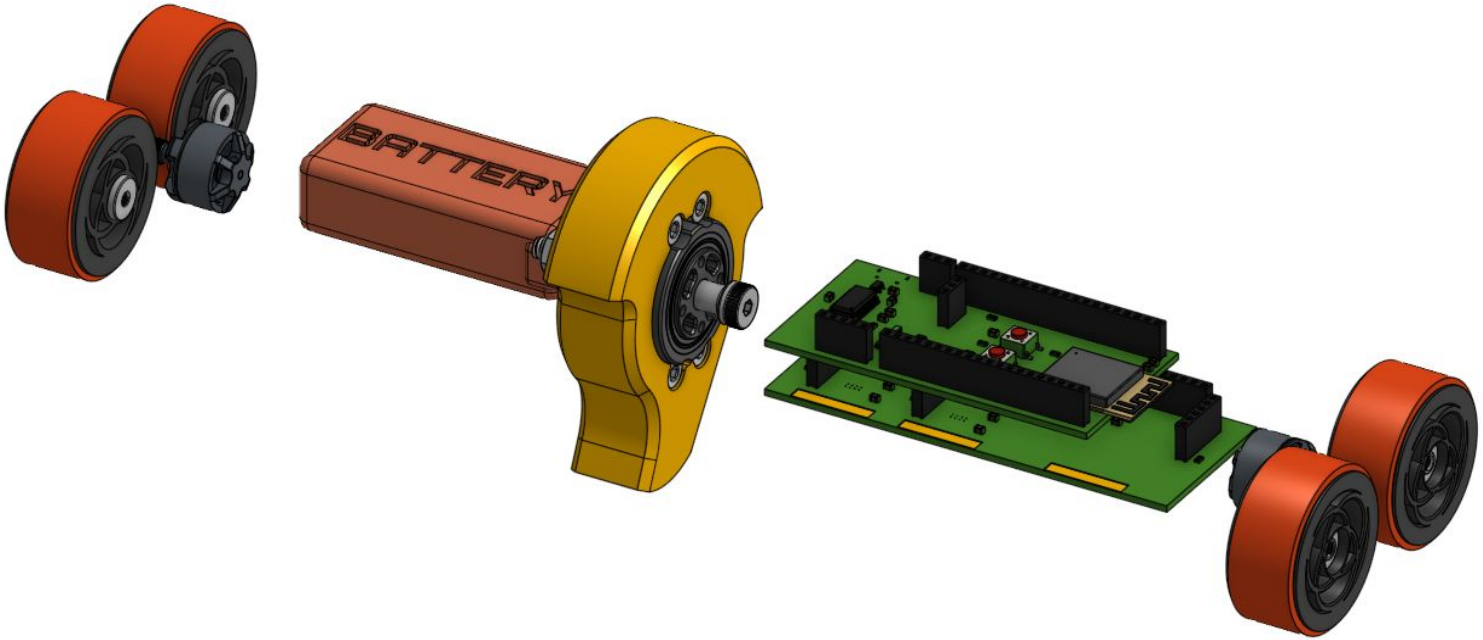
Requirement: Weapon must be able to lift 2 lbs

Requirement: Weapon must stop within 10 seconds of losing Bluetooth connection

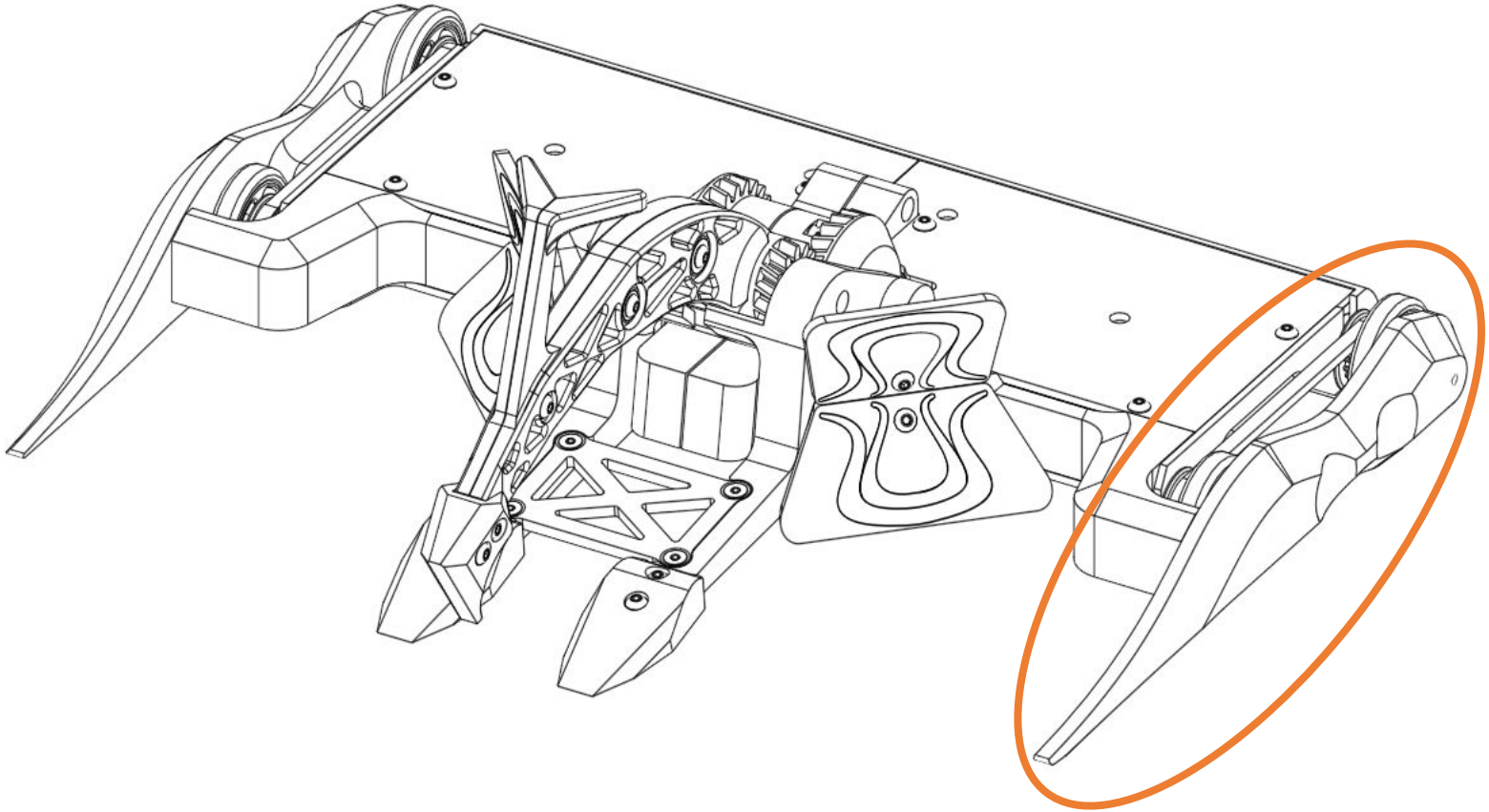
Mechanical Subsystem



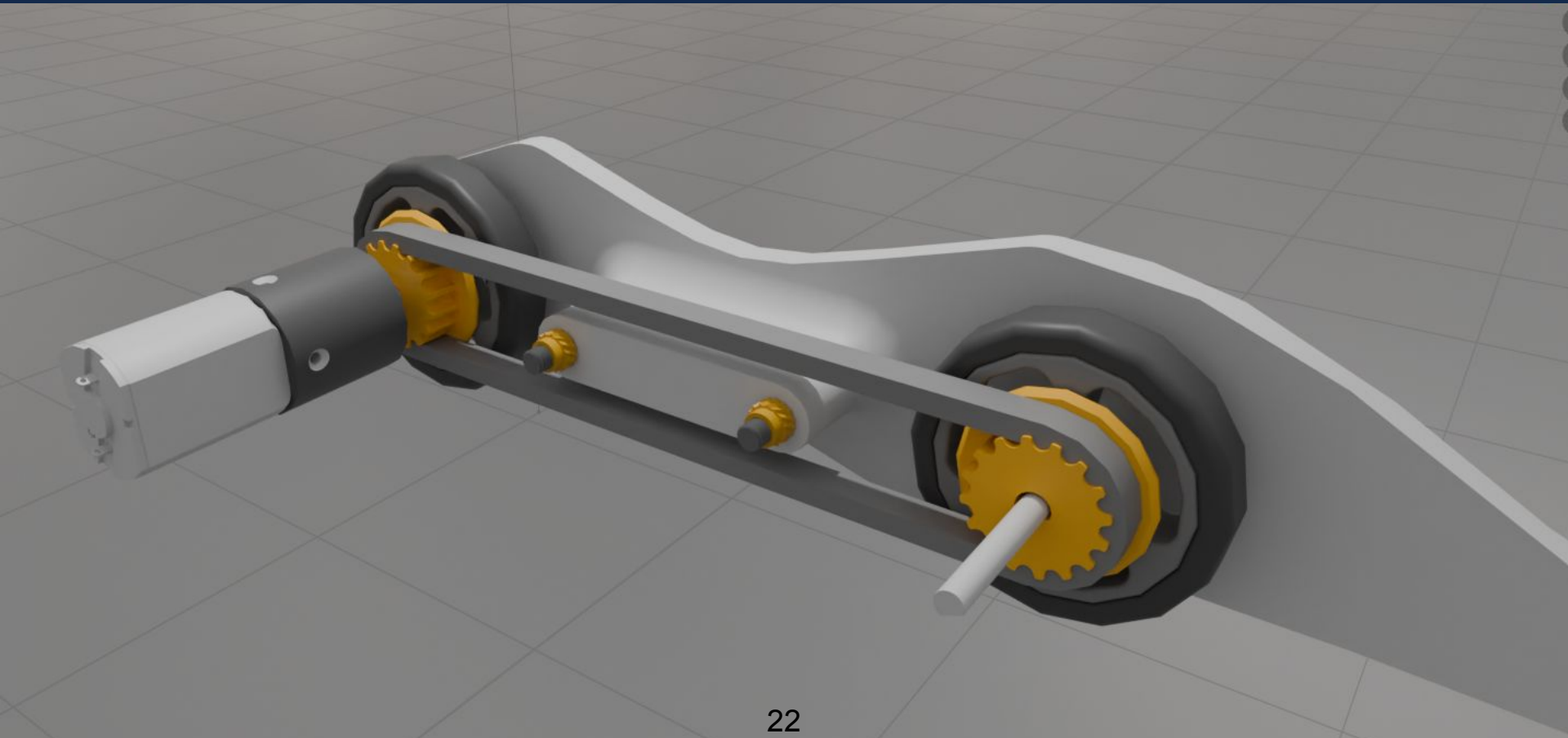
Previous Design



Final Design

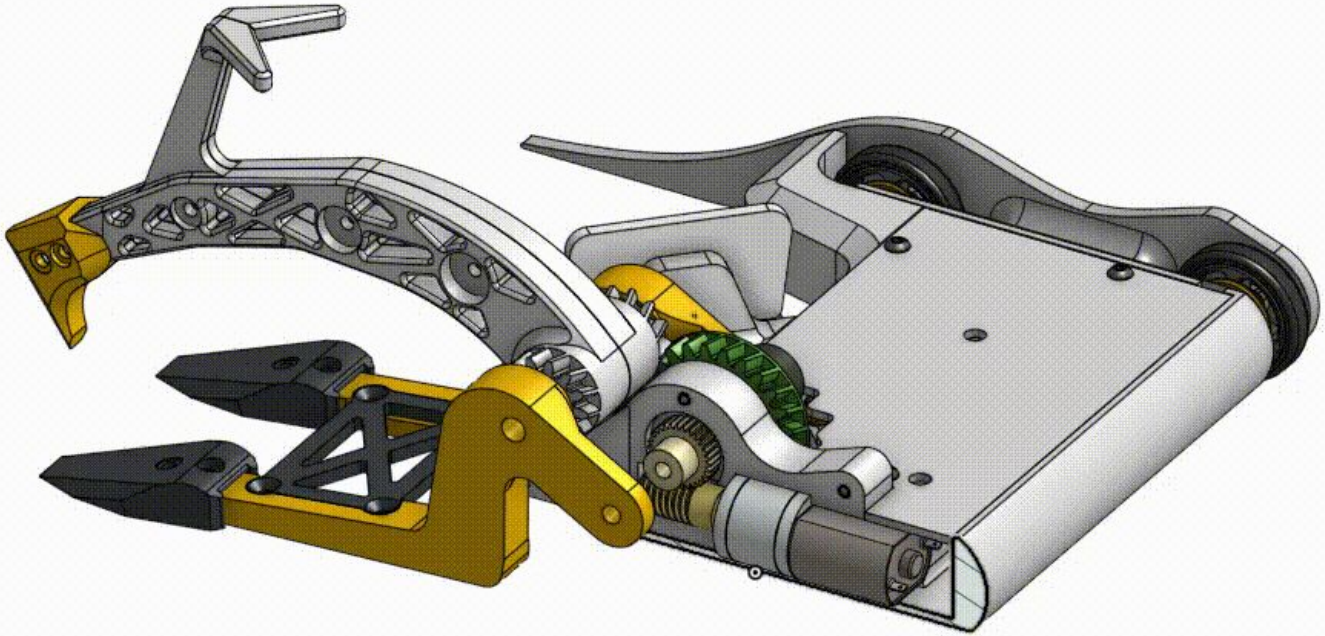


Drive Subsystem



Weapon Subsystem

Weapon Mechanism



Minimum Lifting Torque:

Given:

- Gear Reduction: **30:1** (Worm Gear to Green Gear 30:1)
- Lifting Mass: **0.907** kg (2 lbs)
- Arm Length: **15 cm** (150 mm)

We Find:

Torque ≥ M*L / Reduction

= 0.907 * 15 / 30

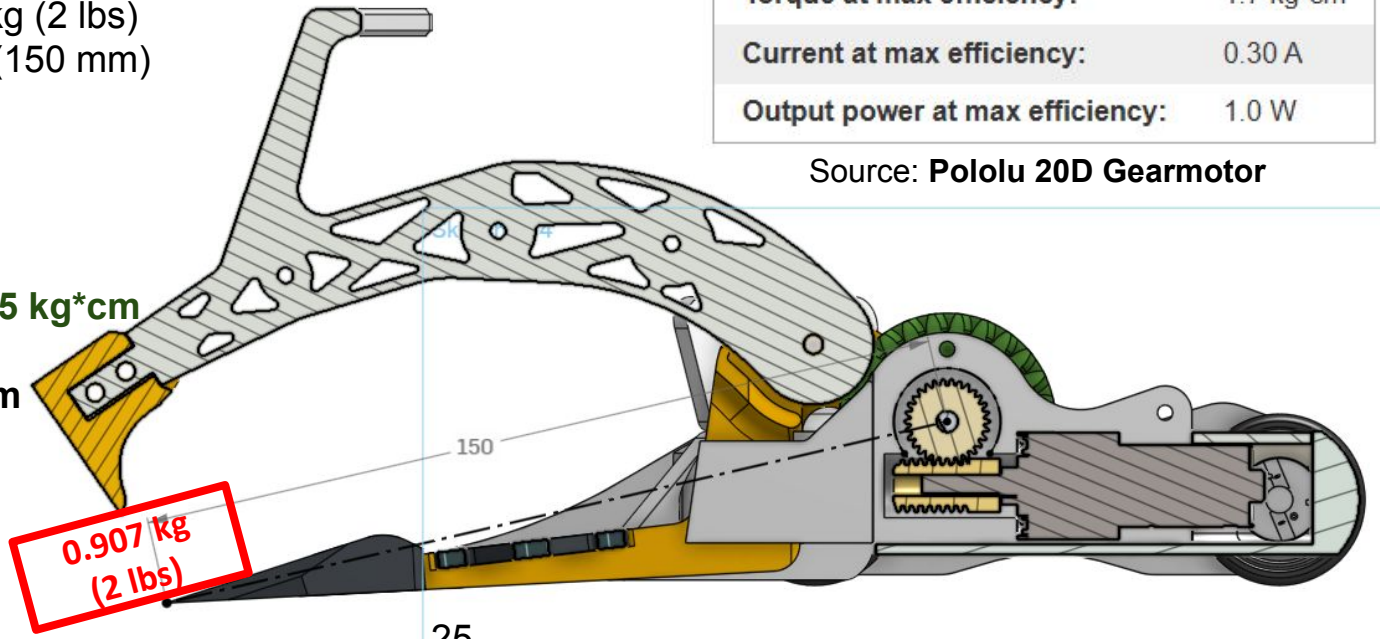
Minimum Torque ≥ 0.4535 kg*cm

Motor Provides 1.7 kg*cm of sustained torque.

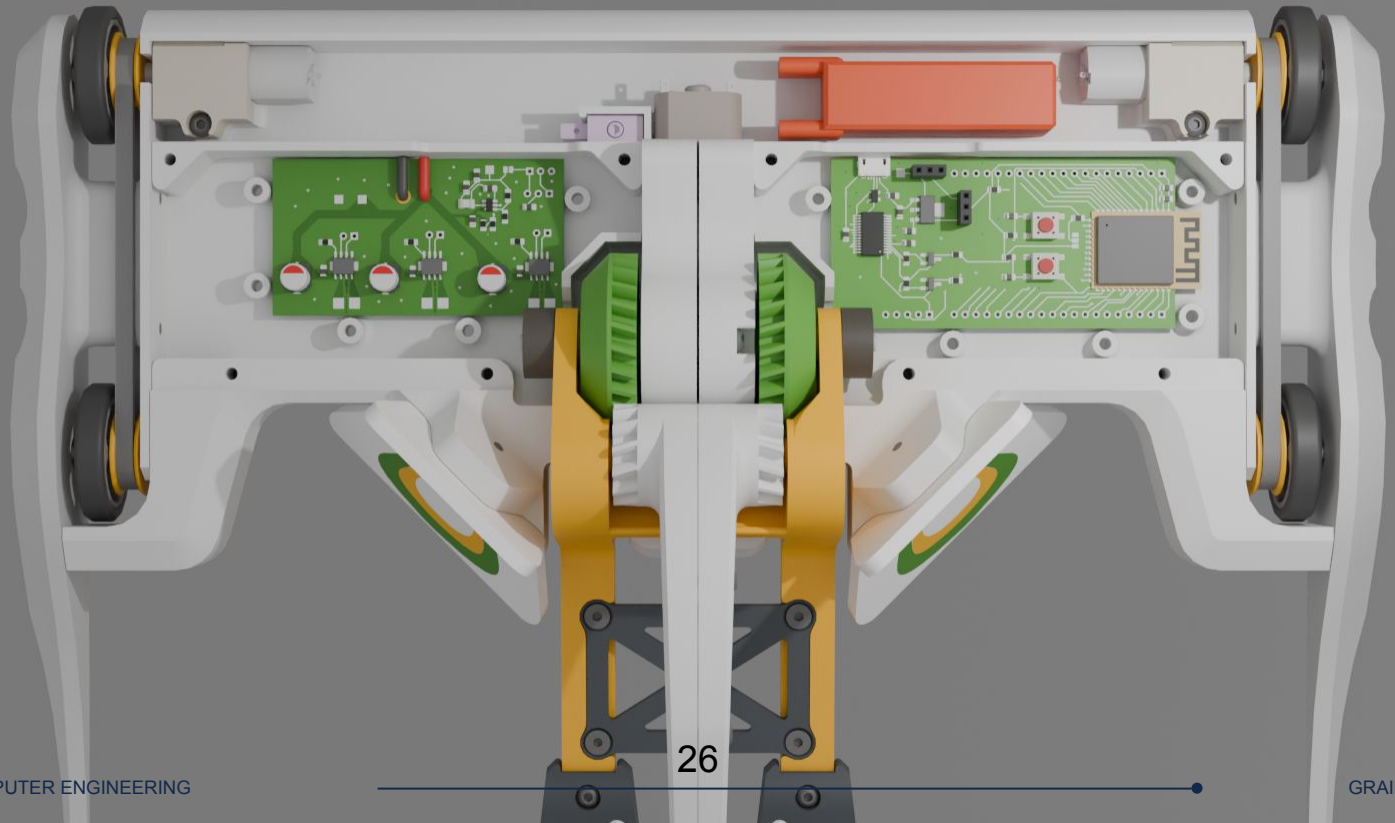
Performance at maximum efficiency

Max efficiency @ 12V:	29 %
Speed at max efficiency:	60 rpm
Torque at max efficiency:	1.7 kg·cm
Current at max efficiency:	0.30 A
Output power at max efficiency:	1.0 W

Source: **Pololu 20D Gearmotor**



Electronics Packaging



Requirements and Verifications

Requirement:
Chassis must be able to protect electronics and be capable of handling external impacts from opponents to a reasonable degree.

Result:
No electronics exposed. No wires or battery found to be hanging out of robot

Requirement:
Robot weighs no more than 2 pounds.

Result:
Weight registered of 1 lb and 11.6 oz.

Successes and Challenges

Challenges

- Could not connect to ESP32 even with MAC address
- Random BLE disconnects
- Joystick mapping
- Tuning brushless controllers
- Got destroyed by Roomba battlebot

Successes

- Stable and recoverable BLE connection
- Weapon is able to lift and maneuver objects up to 2 lbs
- Meets all requirements
- Beat another lifting robot in the competition

Project Conclusions

What did we learn:

- BLE stack and data transmission
- PCB design and layout

What would we do differently:

- Start out planning on using brushed DC motors

Recommendations for further work:

- Reduce latency by switching to ESP-NOW or tuning the delays
- Spend more time tuning motor drivers for brushless DC motors
- Fine tune arcade drive for driver preference

The Grainger College of Engineering

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