UNIVERSITY OF ILLINOIS URBANA-CHAMPAIGN

Team 41 Antweight Battlebot

Electrical & Computer Engineering

5/6/2025

Battlebot Competition and Rules

Battlebot Competition and Rules

Battlebot Competition

- 6 teams compete in a bracket elimination tournament
- 2 battlebots will be placed in a 10 ft x 10 ft walled-off arena for 2 minutes
- Win by disabling the opposing enemy robot or controlling them throughout the match

Rules

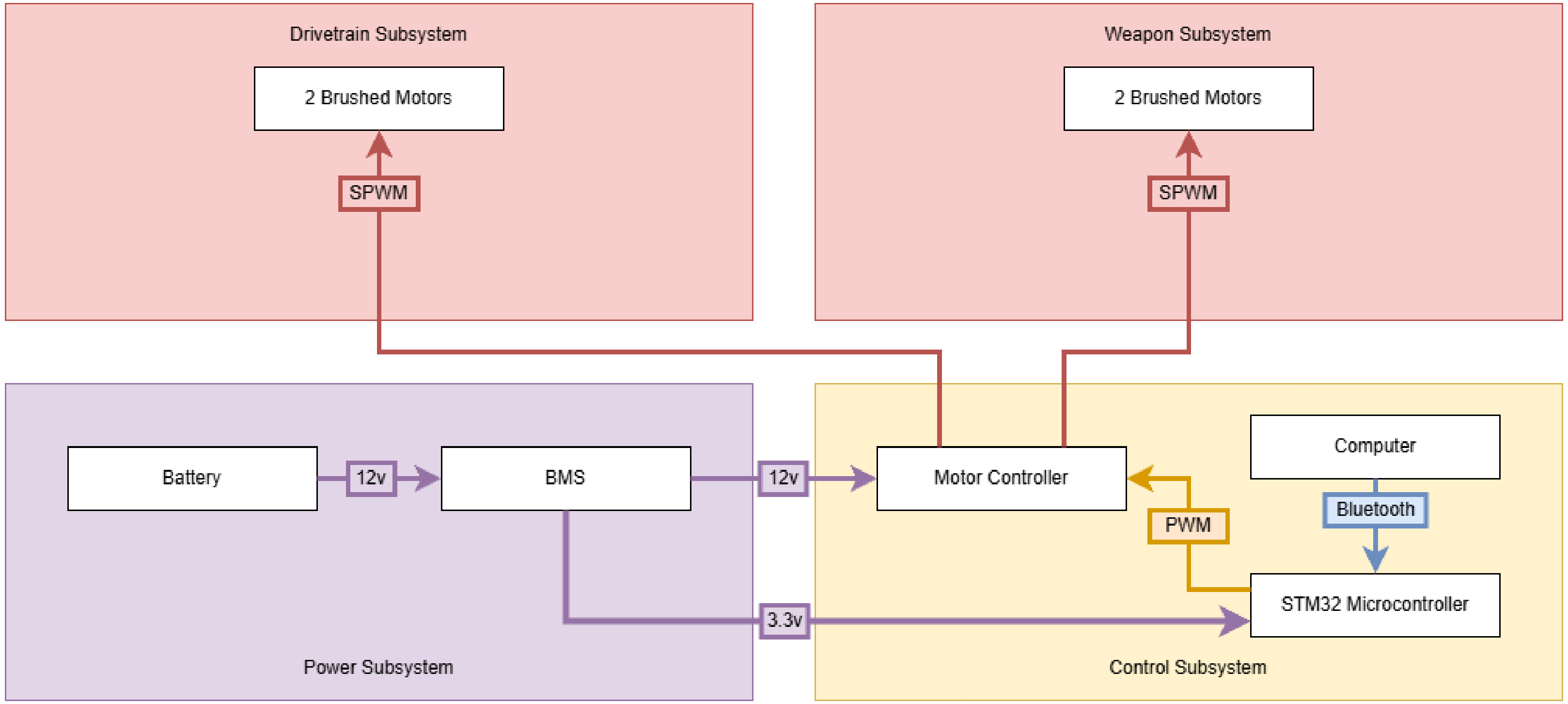
- Battlebot must be less than 2 lbs.
- Battlebot will be 3D printed using these materials: PET, PETG, ABS, or PLA, PLA+
- Battlebot will have a custom PCB
- Battlebot will be controlled from the PC via a Bluetooth or wifi
- Other rules and constraints are detailed in the National Robotics Challenge 2025 Contest Manual

Initial High-Level Requirements

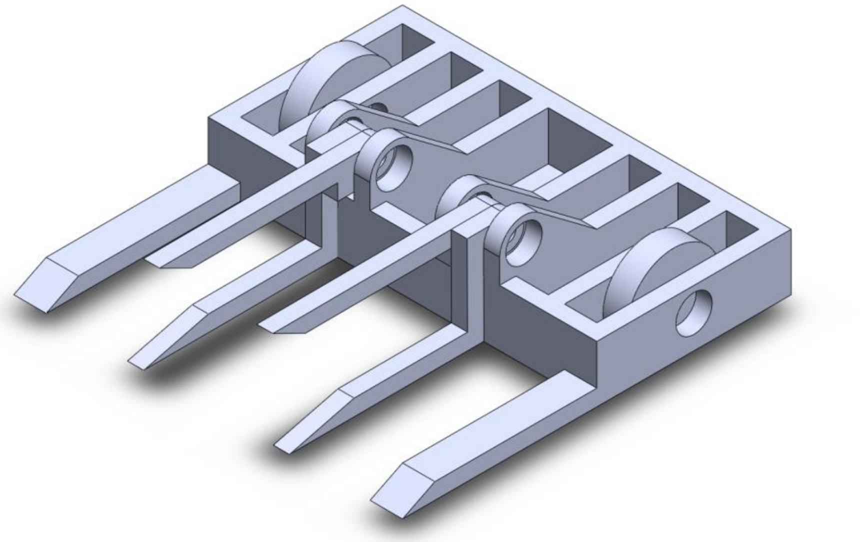
- The remote control of the robot is through bluetooth/Wi-Fi within a 10ft range.
- The robot should automatically disable within 500ms of the connection being lost.
- The robot should drive at a speed of at least 10 ft/s and operate a lifter weapon capable of lifting at least 2 lbs.

Initial Solution

Initial Solution: Block Diagram



Initial Solution Block Diagram

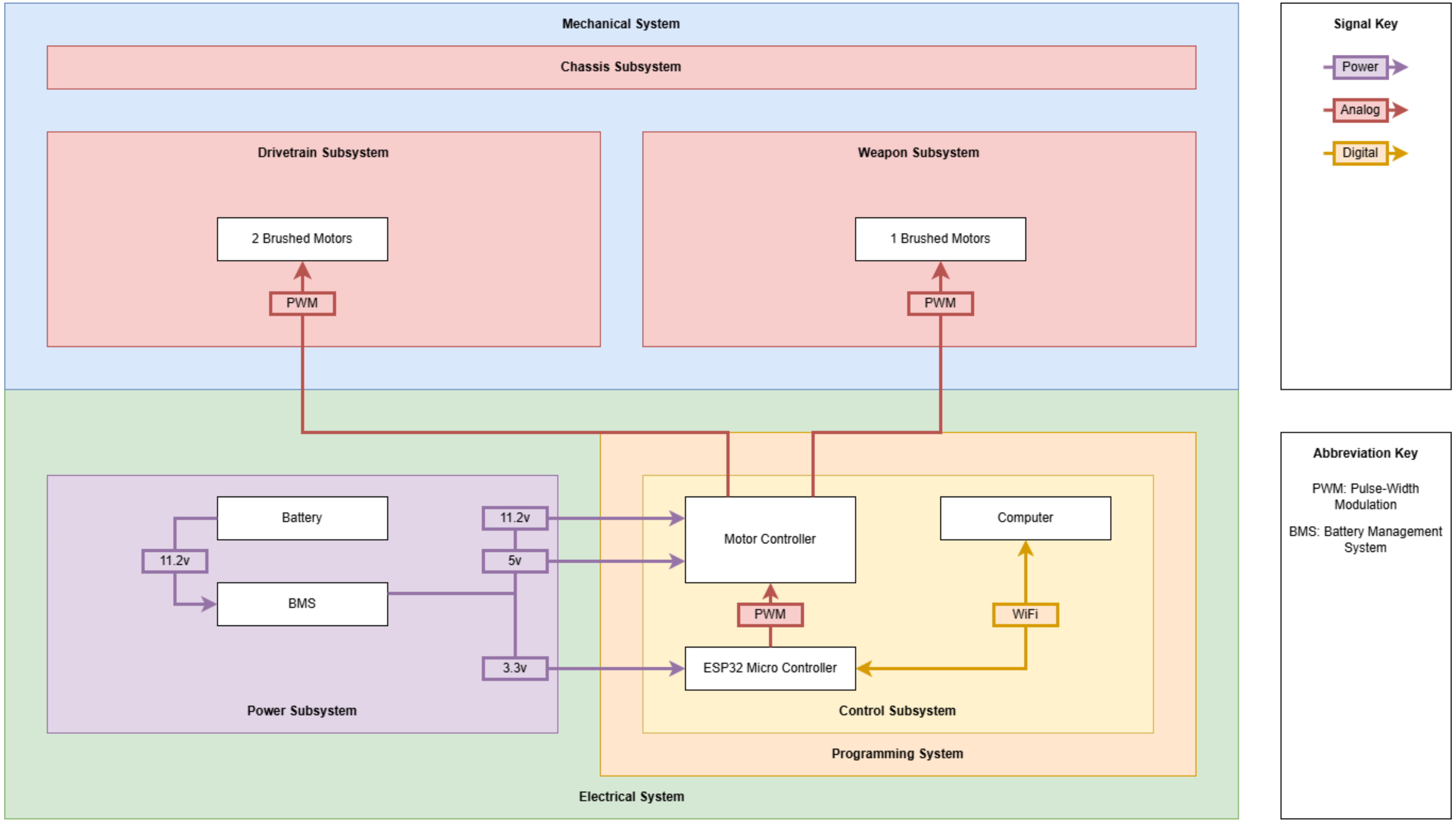


High Level Design Decisions

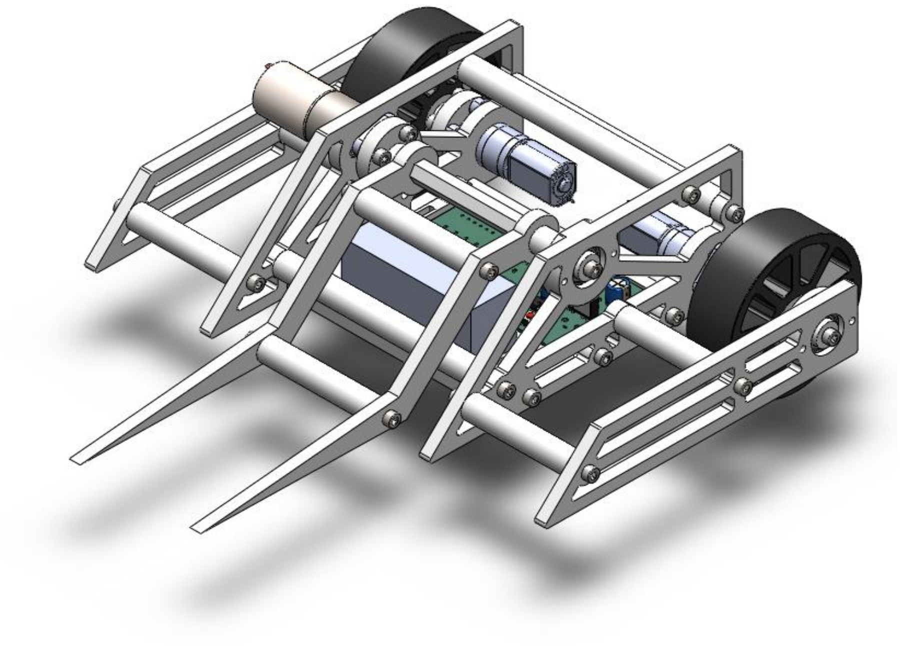
- 2 Wheeled Drivetrain
  - Front rests on the ground, allows robot to get underneath opponent more easily
- 2 Arm Lifter Weapon
  - At weight class and material restriction, control robot more effective

Final Solution: Overview

Final Solution: Block Diagram



Final Solution Block Diagram



High Level Design Changes

- 1 Arm Lifter Weapon
  - Similar level of effectiveness
- Plate and Spacer Contruction
  - Allows for stronger sidewalls
  - Modularity

High Level Requirements

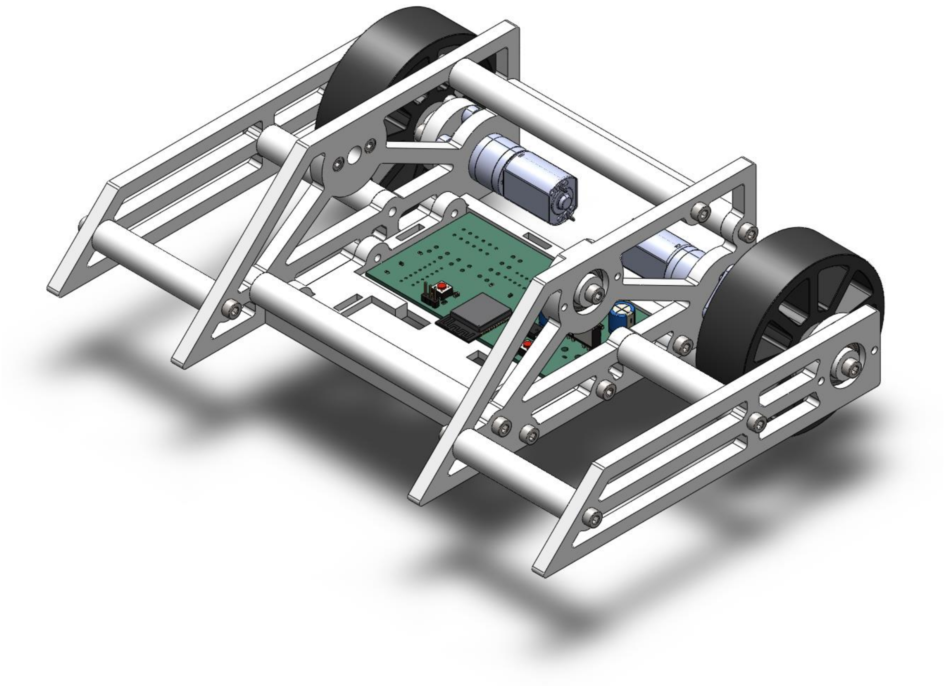
- Remote Control of the robot within at least a 15ft range
  - Reasonable distance between operator outside the arena and robot in arena
- The robot should automatically disable within 500ms of the connection being lost
  - Safety in the event the robot loses connection
- The robot should drive at a speed of at least 5 ft/s and operate a lifter weapon capable of lifting at least 2 lbs.
  - Reasonable speed for an arena size of 10 ft x 10 ft
  - Capable of lifting max enemy robot weight

Mechanical Design Considerations

Considerations

- ABS
  - Lightweight
  - Durable
  - Difficulty in printing remedied by Bambu X1C
- Brushed Motor
  - Implementation Simplicity
  - Instant Torque

Final Solution: Drivetrain



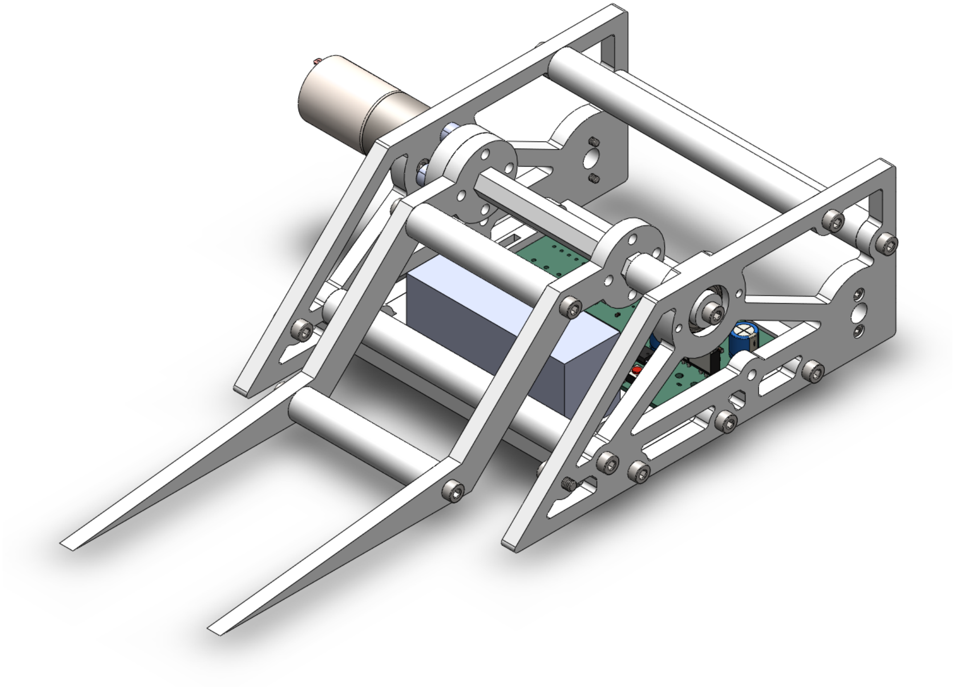
Drivetrain Design

- 3" 50 A Durometer Wheels
  - Balance between hardness and compliance to provide good traction
- 508 RPM Motor
  - Provides enough rotational speed to reach at least 5 ft/s for good maneuverability
  - Provides at least 0.1 ft-lbs for good pushing power

Drivetrain: Requirements and Verification

Drivetrain Subsystem	
Requirements	Test and Results
Minimum top speed of 5 ft/s	Used timer and tape measure to compute v = d/t Average Speed: 5.32 ft/s
Minimum 0.1 ft-lbs. torque per wheel	Used jig to press motor output to scale Stall Torque: 0.168 ft-lbs.

Final Solution: Weapon



Weapon Design

- Configurable Prongs
  - Different prong designs to adapt to enemy opponent
- Self-righting Capable
  - Allows the robot to self-right in the event it is flipped over
- 56 RPM Motor
  - Provides enough torque to lift 2 lbs.
  - Provides enough rotational speed to lift enemy in less than 1 second

Weapon: Requirements and Verification Pt. 1

Weapon Subsystem	
Requirements	Test and Results
Minimum 1.333 ft-lbs. torque at the lifting points	Used jig to press motor output to scale Stall Torque: 4.48 ft-lbs.
Fully extended arm length and chassis length must be within 13” size limit	Measured with Tape measure Passed
Lifting mechanism must raise opponents a minimum 2 inches from ground	Passed, lift height depends on arm configuration

Weapon: Requirements and Verification Pt. 12

Weapon Subsystem	
Requirements	Test and Results
Must complete full deployment motion within 1 second	Tested with Timer Average Deployment Time: 0.86 seconds
Self-righting capability must function when robot is flipped over	Passed
Arms must withstand impact force of 20 N without structural failure	Passed

Challenges

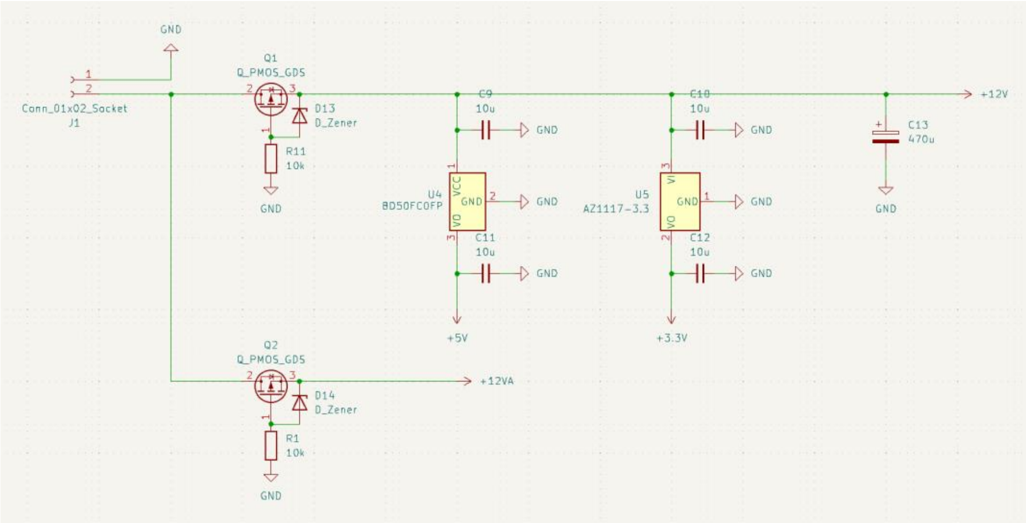
- High Torque Sheared the 3D Printed Axle Under Load
  - Directly attached prong to the hub
  - Axle now serves to stabilize the lifting motion
- Gearbox Gears Sheared During Control Subsystem Test
  - Gearbox is still within specifications to lift 2 lbs.

PCB Design Considerations

Considerations

- Trace Width Considerations
  - 4 A Peak Current
  - 2 oz copper
- Heat Dissipation
  - Spread significant heat generating components across PCB

Final Solution: Power



Power Design

- 50C 2.2Ah 3s LiPo
  - Peak 110 A output
  - Power for whole competition
- Reverse Polarity Protection
- 3.3v Output
  - Stable 3.3v for microcontroller
- 5v Output
  - Stable 5v for motor controller
- 12v Output
  - 12v for motor controller
- Individual Fuses For Each 12v Output
  - Overcurrent protection does not disable other systems

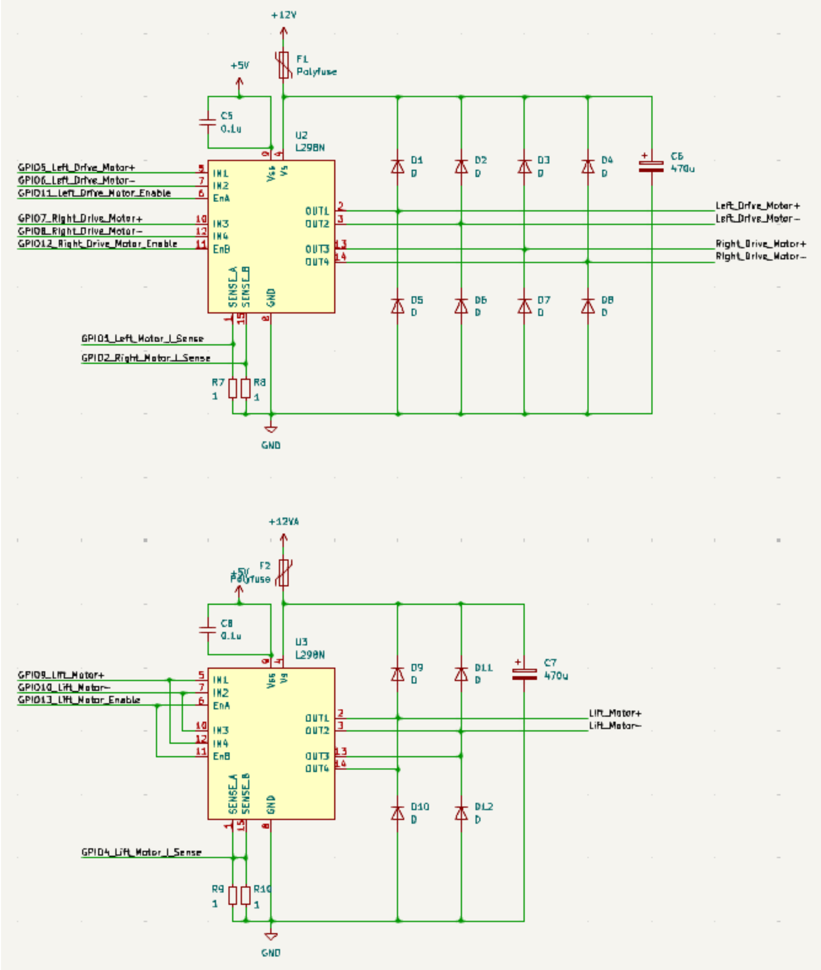
Power: Requirements and Verification

Power Subsystem	
Requirements	Test and Results
Voltage regulation must maintain 3.3V ±5% for microcontroller under all load conditions	Tested with Multimeter Maintains 3.3V±0.2%
Battery management system (BMS) must supply sufficient current to the robot for 2 mins	Determined by battery specs Passed

Challenges

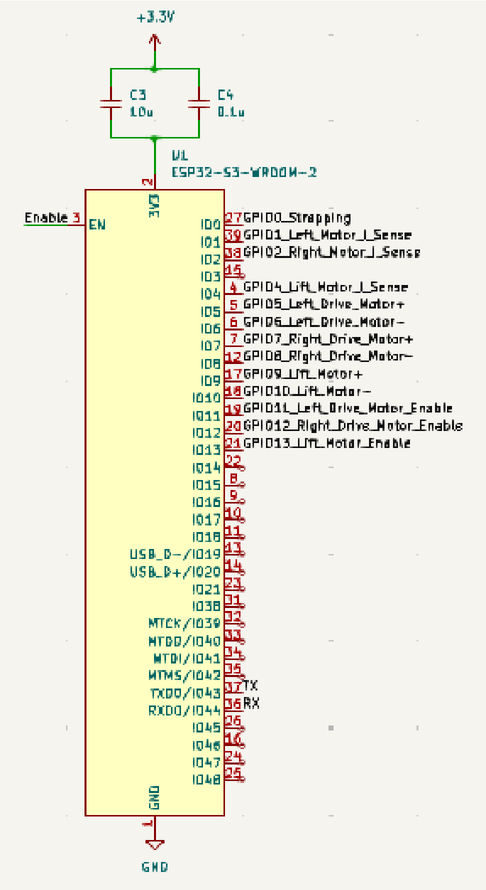
- Original 3.3v LDO For STM 32 Not Rates For ESP 32
  - Did not account for additional current draw from onboard wifi of the ESP 32
  - New LDO provides sufficient current
- 12v to 3.3v LDO High Power Loss as Heat
  - Possible reason for loss of first PCB
  - Added heat sinks to help dissipate heat

Final Solution: Control



Motor Controller Design

- Drivetrain
  - 2 A Continuous Current
- Weapon
  - 4 A Continuous Current
- Flyback Diode Network
  - Prevent flyback events from the inductive effects of the motors



Micro Controller Design

- Wifi Remote Control
  - Use the ESP 32 as an access point for low latency
  - Creation of customizable UI through HTML to control the robot
- ADC Current Sensing
  - Setup, Not Implemented

Control: Requirements and Verification

Control Subsystem	
Requirement	Test and Results
Wifi communication must maintain stable connection at 15-foot range	Inherent properties of 2.4 GHz Passed
Emergency stop must trigger within 500 ms of signal loss	Timer created within code Average Emergency Stop Time: 138 ms
Motor controller can temporarily supply max stall current to the motors	Passed

Challenges

- Difficulties With STM 32 Serial Bluetooth Controller
  - Not able to setup a heartbeat mechanism to check for user connection
  - Ultimately lead to the switch to the ESP 32

Final Solution: Conclusion and Further Work

Skills Learned

- Mechanical
  - SolidWorks
  - Manufacturing Tolerance
- Electrical
  - KiCad
  - Soldering and Baking
  - Debugging and Testing
- Software
  - Arduino IDE
  - HTML

Changes

- Planetary Gearboxes
  - Broken gearbox during stall test
  - Allow robot to handle stall torque
- Buck Converter Before LDO
  - 12v to 3.3v LDO high power loss in form of heat
  - Possible damage from heat
- Modular Side Plates

Future Work

- Joystick Control
  - Prototype implemented
  - More precise control of robot
- Current Sense
  - Act as limit switch to prevent damage to arm when at extension limits
- Brushless Motor

Ethics

Ethics

- Safety Risks to Participants & Spectators
  - Strict arena safety standards
  - Emergency stop in the event of a disconnection
- Fair Competition & Cheating
  - Inspection of robot to strict adherence of rulebook
- Promotion of Responsible Engineering
  - Balance destruction with innovation

Performance

Performance

Thank You!