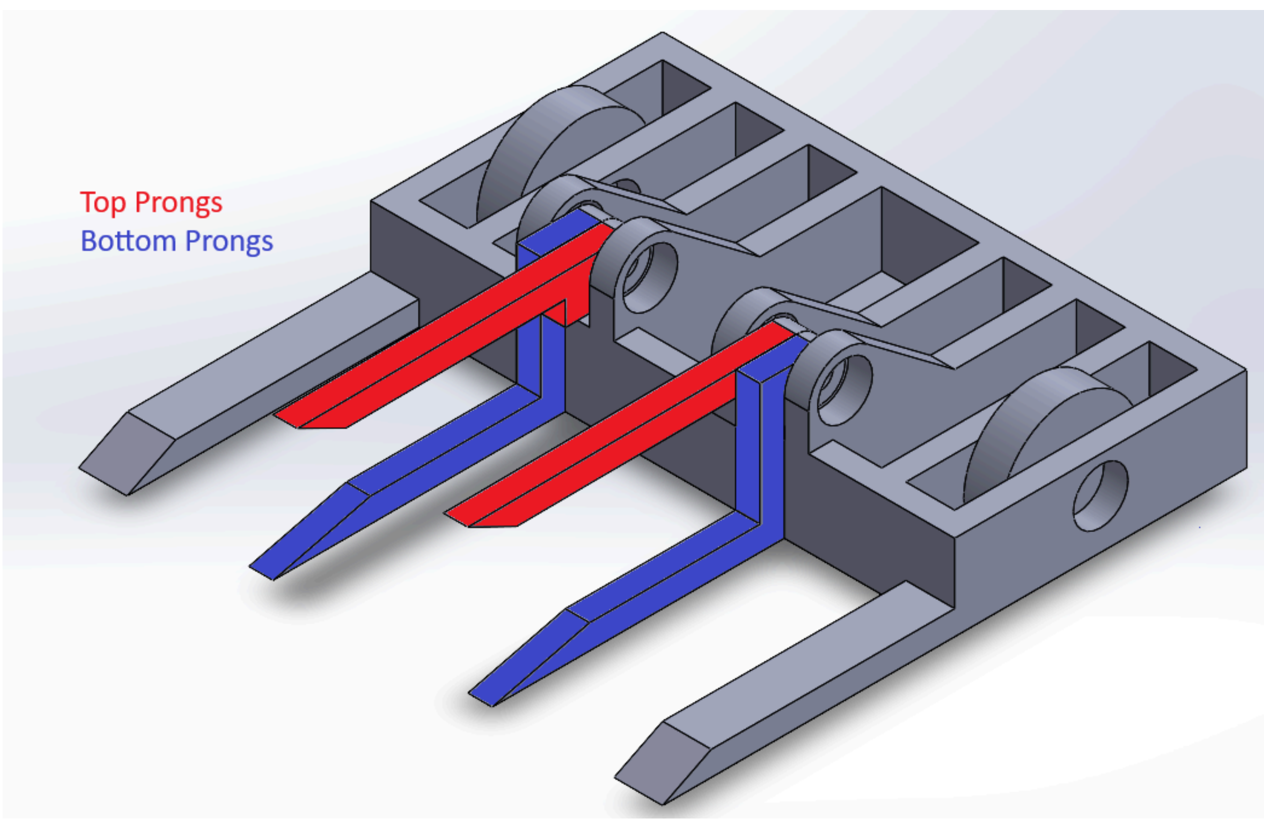
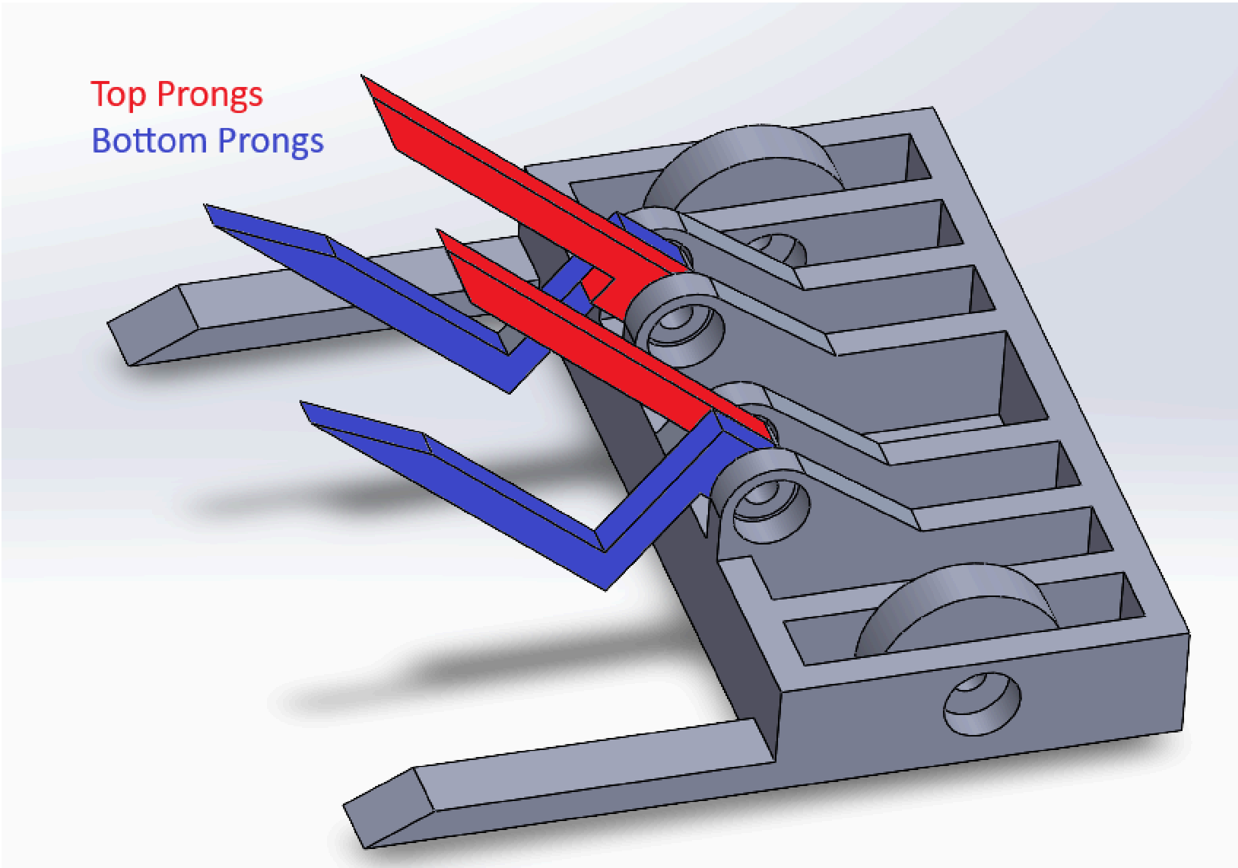
Project Proposal

Introduction

Problem:
Eight teams will compete with their own battlebots in a tournament with the goal to dominate the robot by controlling or destroying the opponent. In this version of battlebot, the robot must be less than 2 lbs, 3D printed from plastics, contain a custom PCB that connects the microcontroller to a remote control system, use a motor or pneumatic fighting tool, and have easy manual/automatic shutdown.

Solution:
Our solution is to control and prevent the opposing robot from moving. By controlling the whole match we plan to win by decision. Controlling the opposing robot is an effective yet simple way to earn points in this weight class. We plan on having 2 independent prongs that grab and lift the opposing battlebot, preventing it from moving.

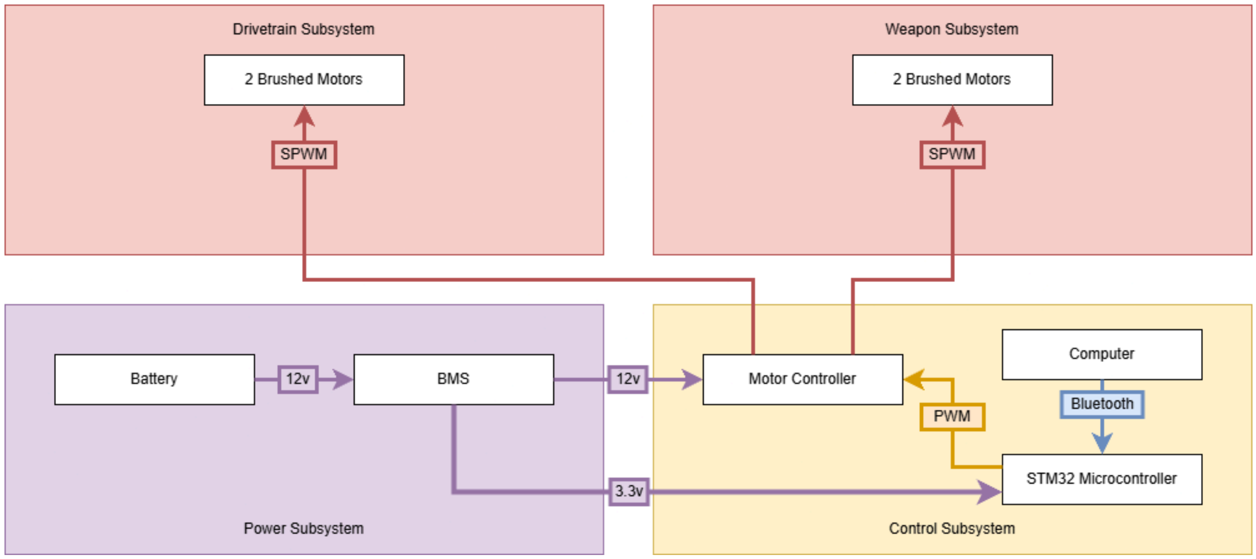




High-level requirements list:

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

Top Level Design:



Subsystem Overview

Drivetrain:
The drivetrain consists of 2 brushed motors that will be appropriately geared in conjunction with the wheels to give a top speed of at least 10 ft/s. They will also take up a sizable portion of the weight allocation so that we may get stronger motors to push other robots. This subsystem is critical to completing the drive portion of task 3 in the high-level requirements.

Lifter Weapon:
The weapon consists of 2 independent forks (top and bottom) that will be used to sandwich and lift the enemy robot. It should be able to comfortably lift at least 2 lbs (maximum weight in this tournament). Because of the lifting application, we will use the same motors as the drivetrain but geared down further for higher torque. The top prong of the weapon will also serve to self flip the robot in the event that we are flipped over. This subsystem is critical to completing the weapon portion of task 3 in the high-level requirements.

Power:
The power subsystem will distribute the 12V from the 3S LiPo battery to the motor controller and microcontroller. It will step down the voltage from 12v to 3.3v to be used in our microcontroller. While this subsystem is not directly responsible for completing any high-level requirement, it is critical for all the other subsystems to complete their tasks.

Control:
The microcontroller onboard the robot will interface with the computer through bluetooth to allow for wireless control. It will also provide the appropriate signals to the motor controller that will drive the 4 motors on the robot (2 for drivetrain and 2 for weapon). In the event that the microcontroller disconnects with the computer or when a manual shut down button is pressed, the robot will turn off within 500ms. This subsystem is critical to completing task 1 and 2 in the high-level requirements.

Subsystem Requirements

Drivetrain Subsystem:
- Must achieve a minimum top speed of 10 ft/s using two brushed DC motors
- Motors must provide minimum 0.5 N·m torque per wheel for effective pushing power
- Wheel traction must provide sufficient grip to push a 2-pound load without slipping

Lifter Weapon Subsystem:
- Must generate minimum 1.5 N·m combined torque at the lifting points
- Fully extended arm length + chassis length must be within 13” size limit
- Lifting mechanism must raise opponents minimum 2 inches from ground
- Must complete full deployment motion within 1 second
- Self-righting capability must function when robot is inverted
- Arms must withstand impact force of 20N without structural failure

Power Subsystem:
- Voltage regulation must maintain 3.3V ±5% for microcontroller under all load conditions
- Battery management system (BMS) must cut power if cell voltage drops below 3.0V
- All power connections must handle peak current draws of 25A
- Must include reverse polarity and over-current protection
- Total power system weight must not exceed 0.5 pounds

Control Subsystem:
- STM32 microcontroller must process control inputs at minimum 100Hz
- Bluetooth communication must maintain stable connection at 10 foot range
- Control latency must not exceed 100ms from input to motor response
- Emergency stop must trigger within 500ms of signal loss
- Monitor battery voltage and temperature with ±5% accuracy

Tolerance Analysis

A critical aspect of our design is ensuring the power system can handle peak loads while maintaining stable voltage for the control system. This analysis focuses on the worst-case scenario when all motors are under maximum load.

System Parameters:
- Battery: 12V 3S LiPo (nominal voltage)
- Drive Motors: 2 × 12V, 5A peak each
- Weapon Motors: 2 × 12V, 5A peak each
- Control System: 3.3V, 200mA
- Internal resistance of battery: 20mΩ (typical for quality 3S LiPo)
- Voltage regulator efficiency: 85%

Peak Current Analysis:

1. Maximum total current draw:
   - Drive motors: 2 × 5A = 10A
   - Weapon motors: 2 × 5A = 10A
   - Total peak current: 20A

2. Voltage drop calculation:
   - V_drop = I_total × R_internal
   - V_drop = 20A × 0.02Ω = 0.4V
   - Minimum battery voltage under load = 12V - 0.4V = 11.6V

3. Voltage Regulator Analysis:
   - Input voltage range: 11.6V - 12.6V
   - Required output: 3.3V ±5% (3.135V - 3.465V)
   - Power dissipation = (Vin - Vout) × I_control
   - Maximum dissipation = (12.6V - 3.3V) × 0.2A = 1.86W

Results:
- The voltage drop under peak load (0.4V) is within acceptable limits
- The voltage regulator maintains 3.3V regulation with input variation of 11.6V-12.6V
- Power dissipation in regulator (1.86W max) requires minimal heatsinking
- System maintains required voltage levels with 20% safety margin

This analysis demonstrates that our power system design can handle worst-case loads while maintaining stable operation, with sufficient margins for unexpected peak demands.

ETHICS

Lab Safety:
To make our battlebot, we will need to 3D print and solder. To stay safe while soldering, we will use proper soldering lab procedures. These safety precautions include PPE, safety glasses, maintaining a clean/organized environment, checking equipment before use, and working with a lab partner. We will also follow proper procedures when 3D printing. Although 3D printers aren't necessarily dangerous, they can be fragile. By following standard operating procedure, we can ensure safety for ourselves and the 3D printer. Our goals to maintain lab safety reflect the ACM Code of Ethics. (ACM Code of Ethics 1.2)

Operational Safety:
Safety is essential and a serious concern when it comes to battlebots. These battlebots are designed to damage each other. In most cases, these battlebots can just as easily hurt people. We will equip our battlebot with manual and automatic disable. This will allow us to shut off the battlebot if we lose control of it or if we lose connection to it. We will also ensure safe operation of the 12V 3s LiPo battery. If shorted or damaged, these batteries can catch on fire. We will undergo examination of our circuit to ensure that we abide by the tolerance analysis detailed earlier in this report. We will also undergo thorough testing of our battlebot in a controlled environment before the competition to make sure everything is operating properly. Our goals to maintain a safe environment reflect the IEEE Code of Ethics. (IEEE Code of Ethics I.1)

Integrity:
In other battlebot competitions, there have been lots of cheating scandals. We will follow all the rules for the competition. If we are unsure of a rule, we will contact a TA or a professor for clarification. After finishing our battlebot, we will go back to the rulebook and make sure that we are abiding by all of the rules. Our goals to honor integrity reflect the ACM Code of Ethics. (ACM Code of Ethics 1.3, 2.2, and 2.3)