Ant-weight 3D Printed Battlebot

Electrical & Computer Engineering

Group 1

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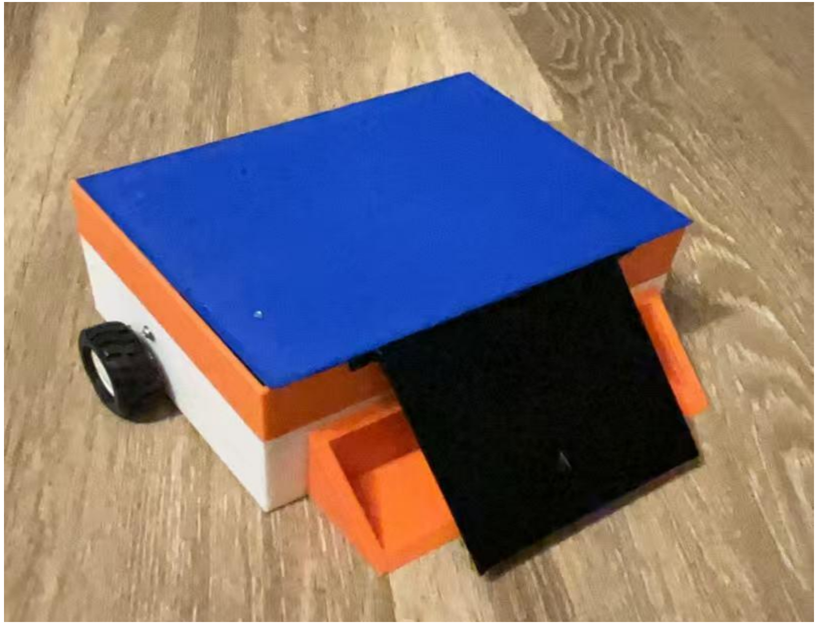
What problem are we solving?

A competition for Antweight 3D Printed Battlebots was proposed. The problem is that everyone wants to win while also following all design constraints. The constraints included a **weight limit** of 2lbs, **3D** printed structure, **2 minute** rounds, etc. To win, our goal was to **outlast/destroy** differently designed Battlebots.

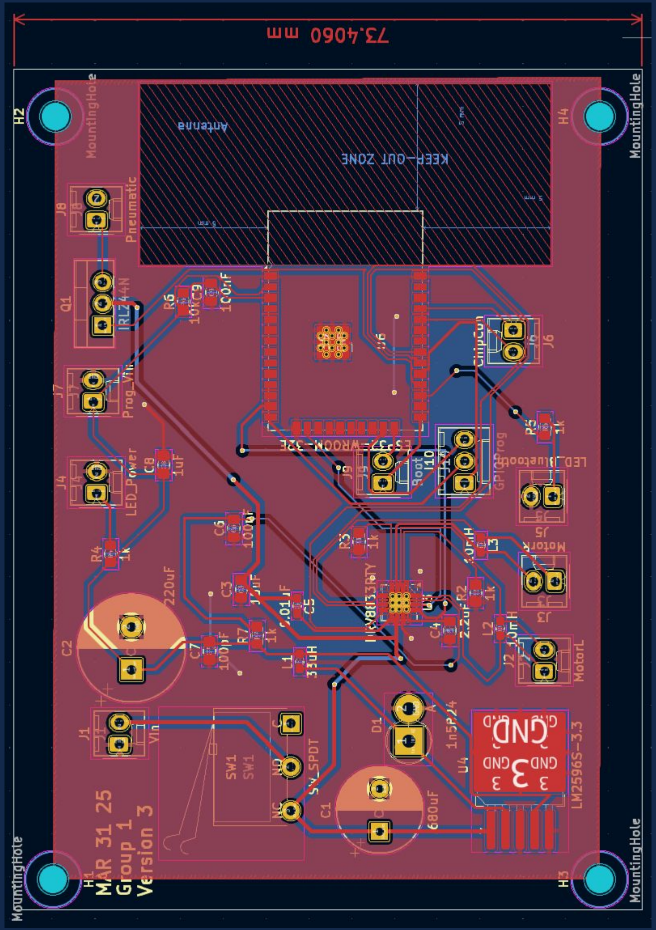
Factors to solve the problem!

- **Designing** an Ant-weight 3D-printed Battlebot for the Ant-weight Battlebot competition
- **Combines** PCB design, embedded systems, and wireless control
- **Goal:** Build a robot that is durable, responsive, and within weight limits
- Design a pneumatic weapon in order to scoop up competitors
- Focused on control, weapon function, and lightweight structure

Let’s see what is our battlebot looks like



The final design of our battlebot! Current score for this battlebot: 1 win - 1 loss.



Our Design Approach

Use PLA+ 3D printing:

- Material is stronger and more solid than regular PLA, also lightweight

ESP32-WROOM-32E:

- fast Bluetooth control (low-latency response)

H-bridge driver converts control signals into PWM

- **output** for precise motor speed and direction control

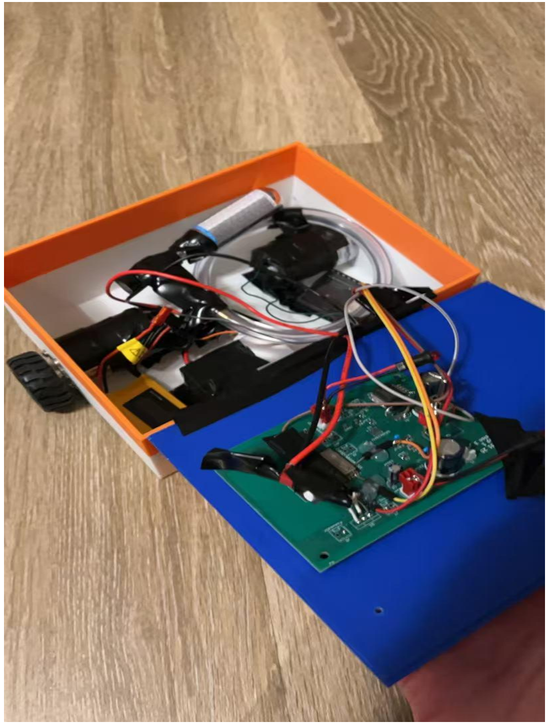
Pneumatic weapons

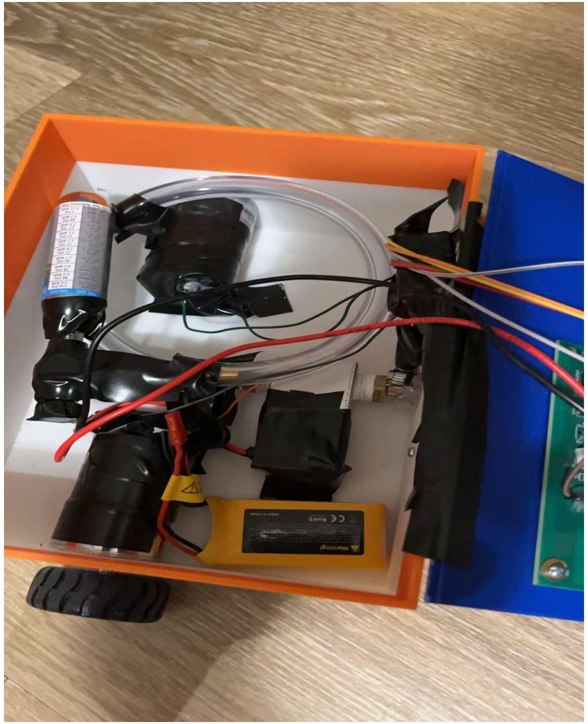
- for offense

Buck converter steps down 12V battery voltage to 3.3V

- safely power the ESP32 microcontroller

Let’s see what inside our battlebot

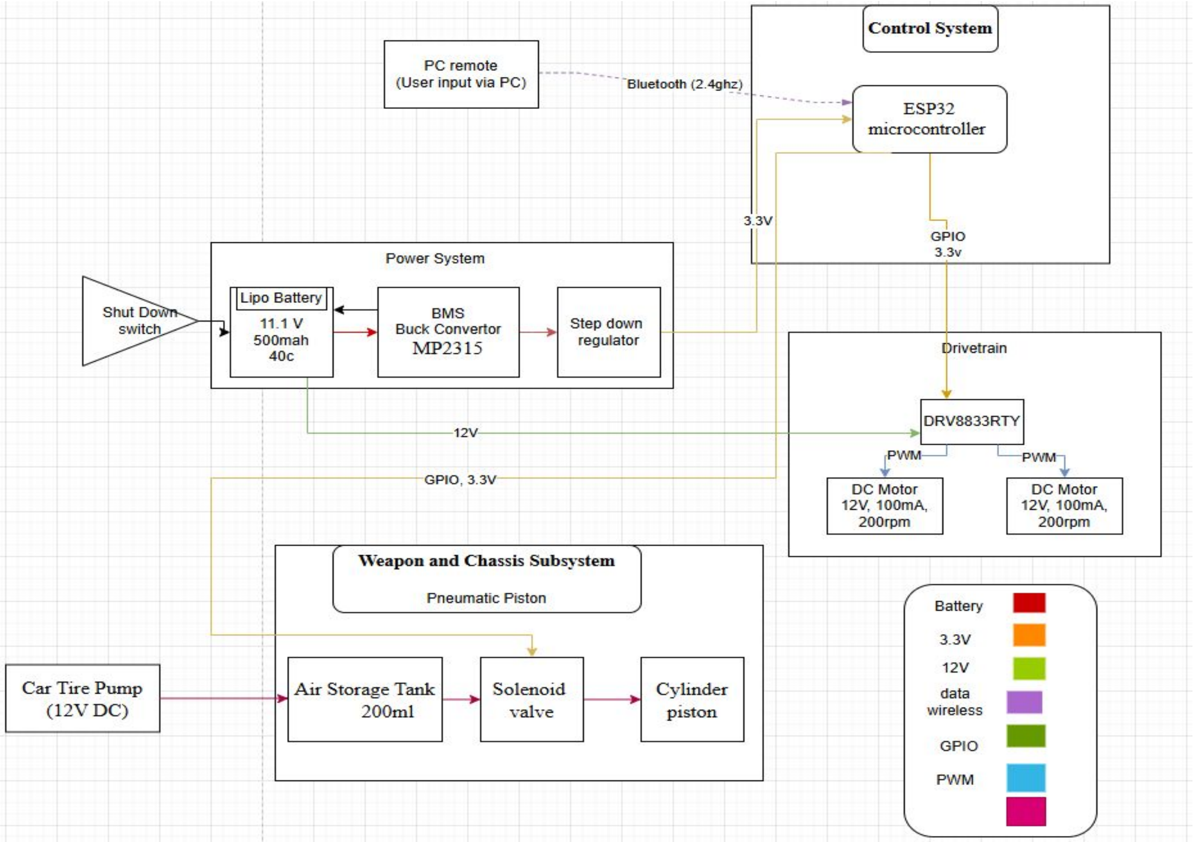




Left image shows the internals and how everything was **mounted**.
Right image shows the layout of our **heaviest** components (pneumatic, drivetrain, and battery).

Block Diagram & Subsystems

Original Block Diagram Design

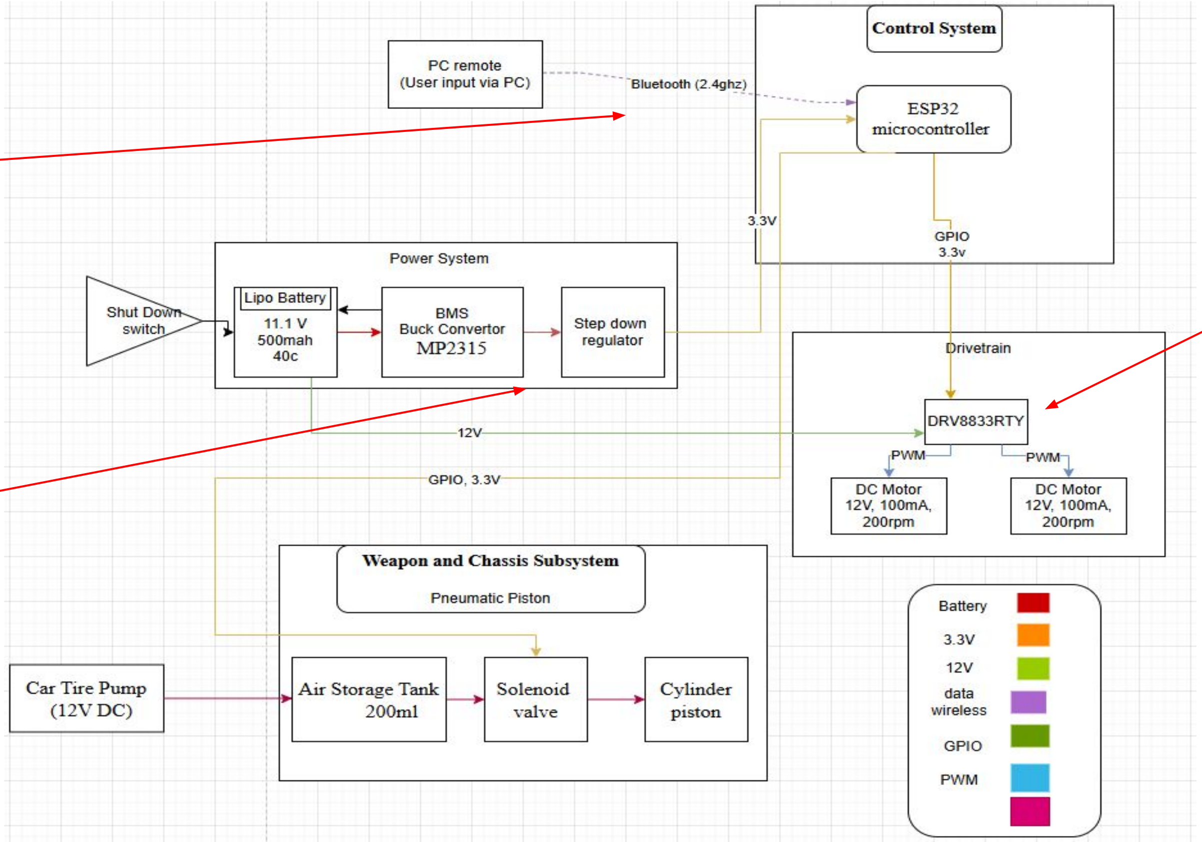


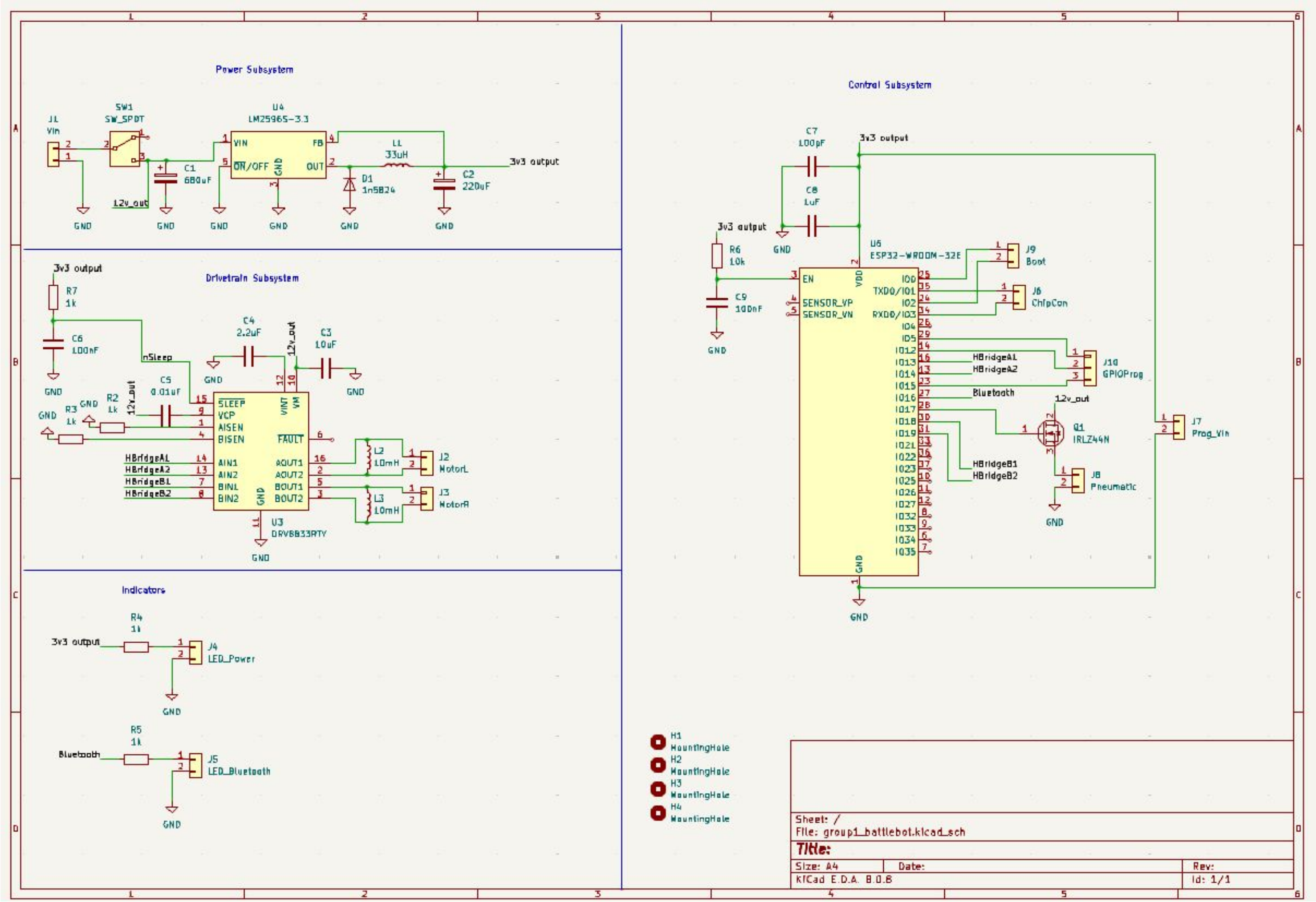
General Changes for Final Design

Change from BT to WiFi back to BT

Power system only uses Buck Converter (LMS2596s-3.3)

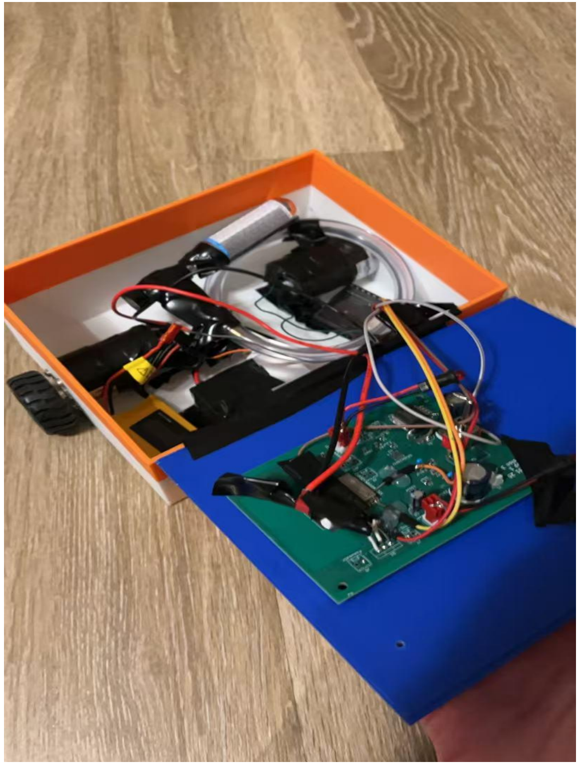
Had to use a different H-Bridge module





Latest schematic version used for our PCB (individual sections shown later)

High Level Requirement Table



- Uses **Bluetooth** with a response time of under **100ms**.
- Drivetrain uses **two high-torque DC** motors powered by an **H-bridge** circuit for precise movement and speed control.
- **Skid Bucket** weapon controlled via a **pneumatic** actuator, capable of flipping or **destabilizing 2 lb** opponents.
- **3D-printed** chassis using **PLA+** plastic, ensuring durability and stability.
- Utilize a 3S **11.1V** 500mAh **LiPo** battery with proper protections

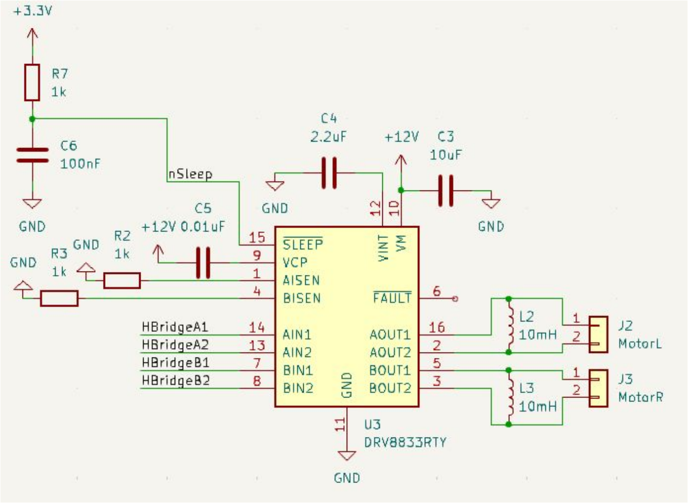
A short clip of our functioning robot!

Functional Video

Round 1 Fight!

Subsystem: Drivetrain

- Utilized **two high torque** DC motors from Greartisan
- Each provides **2.2kg*cm** of torque with no-load speed of **200 rpm**
- **Note**: Originally, utilized an H-bridge from Texas Instruments, the DRV8833RTY
  - However, due to how we wired original circuit, we **fried 3** of these chips since we were giving **12V** to an H-bridge with **maximum 10.8V**
  - Ended up using a **L9110s** DC motor driver module
- **"Sticky tires"** – most amount of grip to complement the high torque DC motors
- Side Note: Peak current draw is 1A with an average of 0.3A



Subsystem: Drivetrain, Requirements & Verification

Requirements	Verification
Can produce a maximum of **2.2kg*cm of torque** under no load	● Tested by pushing something of 2.2kg for approx. 1cm ● Ended up using the battlebot to **push** something of roughly **4lbs** (close to **2.2kg**) with our final battlebot
Can reach a **maximum of 210 rpm** under no load	● We did not have a tachometer, counted revolutions and approximated the rpm ● Roughly 210 rpm (**3.5 revolutions per second**)

- The battlebot weapon is a **ramp-based** flipping mechanism powered by a **13mm pneumatic piston** actuated by **compressed CO_2**.
    - Circuit driven by **bjt** transistor (tip120)
    - **12V** trigger solenoid
    - Using a **flyback diode** to gives inductive load spike a safe path to circulate
    - **10kΩ** is our choice to minimize current draw from the microcontroller.
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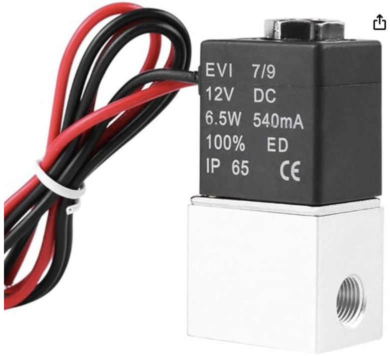
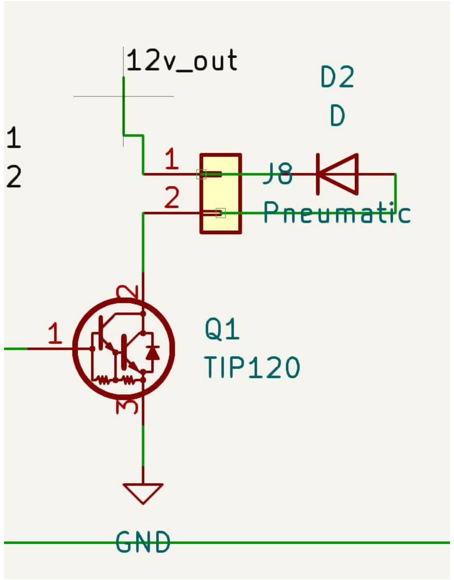
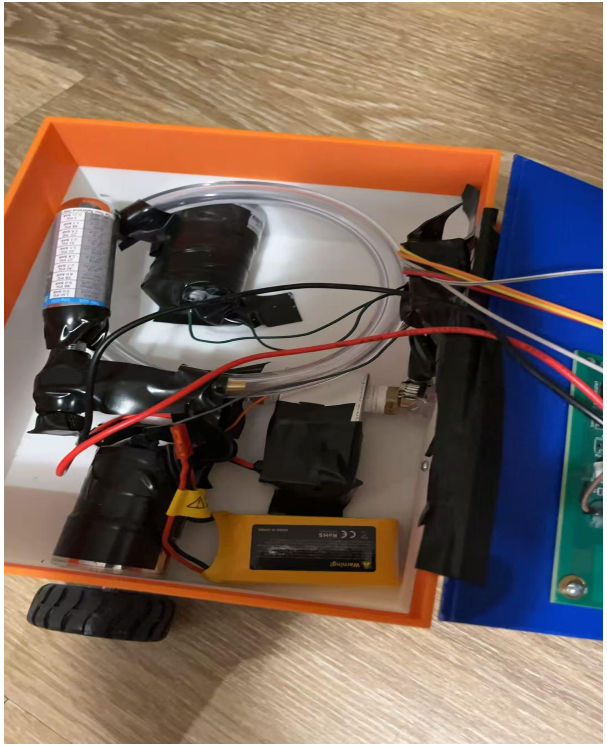




Subsystem: Chassis (of Weapon/Chassis)

- 3D prints utilizing **PLA+ plastic** served as the main chassis of our Ant-weight battlebot
  - PLA+ offers a balance between **durability** and **weight efficiency**
  - **Less brittleness** than PLA, also has increased impact resistance
- Mounted most of the **heavy components at bottom** of chassis
  - Lower center of gravity
- **Two layers of Ramp and scooper** will allow us to slide under the chassis of opponents
  - And be able to scoop and ramp under; or use backside of battlebot to ram

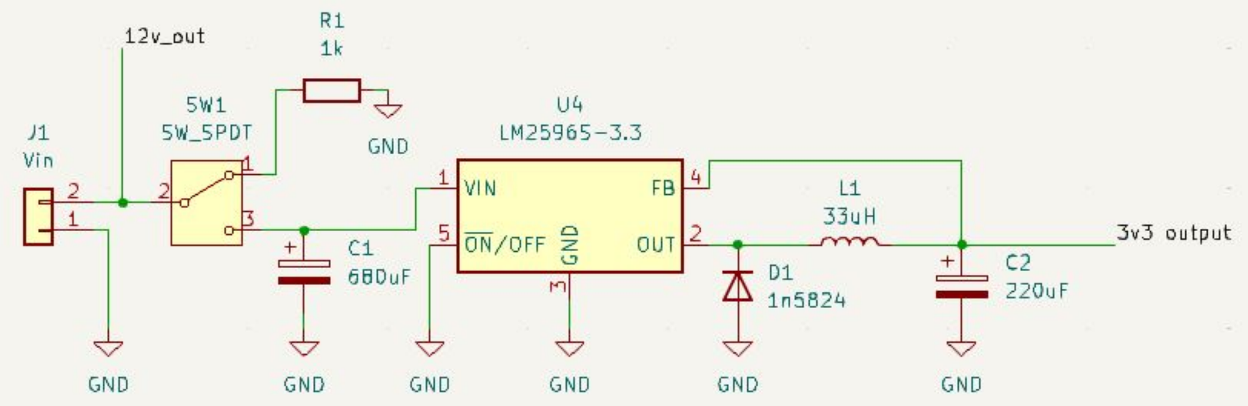


Subsystem: Weapon and Chassis, Requirements & Verification

Requirements	Verification
1.5A battery current draw requirement	• Current draw with the solenoid trigger is **0.5A**
Solid build structure using **PLA+** plastic • Able to **move 2 lbs**	• Our robot can **move over 4 lbs** of weight
Gas tank that can withhold **120 psi** for pneumatic weapon	• We utilized pre-filled **CO_2 cartridge** that holds **over 120psi** • Amount of carbon dioxide able to be used on weapon was predetermined • Able to launch over **7 times** with fully power flip.

Subsystem: Power System

- Relied upon a **11.1V** 500mAh **LiPo** battery
  - Max output of approximately **12.6V**; used this voltage range of **6-12V** for our motors
- Used a buck converter (LM2596S-3.3) to convert **12V to 3.3V**
  - Allows for use in circuit (Control System)
- **Shut off safety**: Switch and battery connector to shut off system

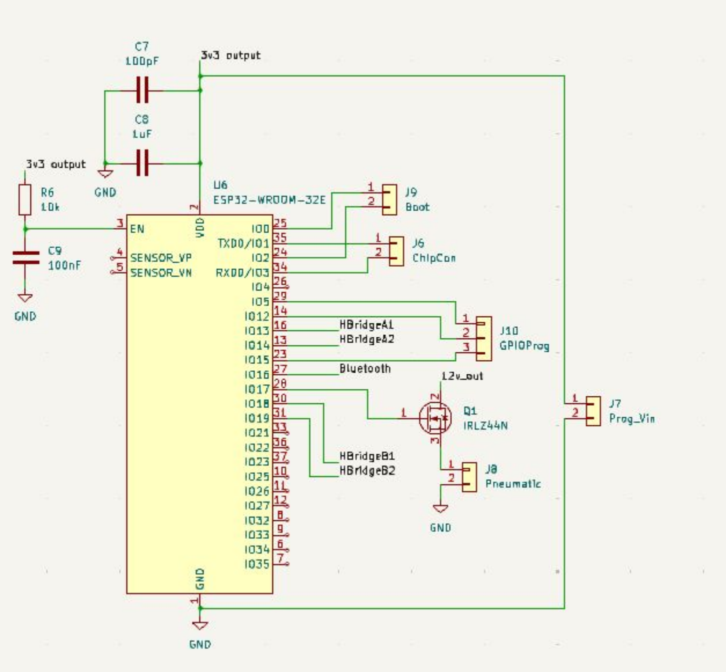


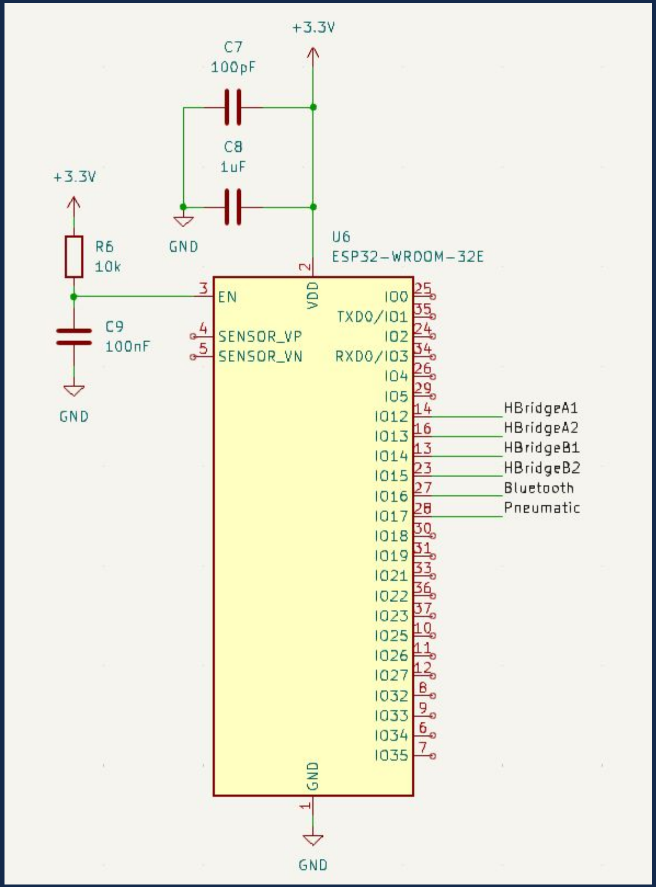
Subsystem: Power System, Requirements & Verification

Requirements	Verification
Can supply **continuous 3A** of current to all subsystems when underload	● Actual current amounts vary from **0.3A to 1.5A** when all subsystems are underload, meaning our design works very **efficiently** compared to our planned maximum current
Has enough capacity to **last 2 minutes** of continuous usage	● Our full design under load lasts a lot longer than 2 minutes ○ Roughly **~9 minutes** under load

Subsystem: Control System

- Relies on an **ESP32-WROOM-32E** as our central processing unit
- Uses **Bluetooth** connectivity
    - (Originally wanted WiFi)
- Can leverage PWM and GPIO for control of motors (drivetrain) and Pneumatic (weapon) systems





Original design of our Control System!

Subsystem: Control System, Requirements & Verification

Requirements	Verification
Connect via **Bluetooth**	● Able to use **phone** to **connect** to Battlebot ● Utilize **Dabble** library to connect ● **LED** to display bluetooth is in use
Be able to control all **4 directional movements** of battlebot with given signals - left, right, forward, backwards	● Able to move in the **4 directions** properly ● H Bridge A1,A2,B1,B2

Original Tolerance Analysis Calculations

Average and Peak Current Draw of both motors:
$I_{motors} = N_{motors} * I_{motor} = 2 * 0.1A = 0.2A$
$I_{peakM} = N_{motors} * I_{motor\_peak} = 2 * 2A = 4A$

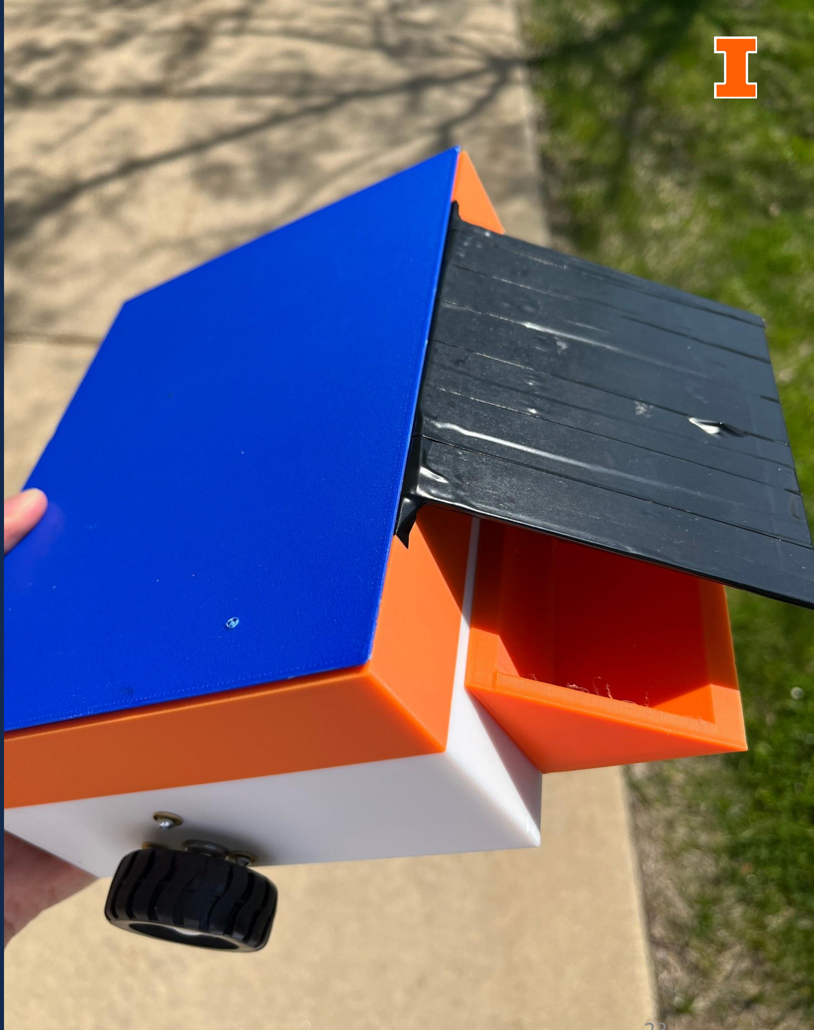
Total and Peak Current Draws:
$I_{total} = I_{motors} + I_{pneumatic} + I_{IC} = 0.2A + 3A + 0.15A = 3.35A$
$I_{peak} = I_{motors\_peak} + I_{pneumatic\_peak} + I_{IC\_peak} = 4A + 5A + 0.2A = 9.2A$

Capacity of Battery Wanted = I_{total} * Total Time = 3.35A * 2min = 3.35 * 2/60 h = **0.1116 Ah**
Peak current of battery = **9.2A**

(3.35A/500mAh = 6.7C and 9.2A/500mAh = 18.4C), both of which are **within discharge rate limits** of our battery: **6.7C < 35C** and **18.4C < 70C**

Conclusion

- We Successfully built a Bluetooth-controlled Antweight Battlebot with a scooper, pneumatic weapon, and sticky wheels.
- We successfully combined the drivetrain, power, pneumatic weapon, chassis, and control system into a cohesive unit to create a fully functional battle bot
- The battlebot meets competition goals: durable, responsive, and combat-ready
- In the future, we would need to buy a lighter motor so that it could satisfy our light weight requirements



Thank You!
Any questions for us?