Project Proposal

ECE 445 – Senior Design Laboratory

Combative Hardened Ultra Tumbler – Antweight Battlebot

Team #47

Abhinav Garg (ag90)
Rahul Krishnamoorthy (rahulr9)
Shobhit Sinha (ss194)

TA: Yu Xiaodong

February 14, 2026

Abstract

This proposal describes our plan to design and build a 2 lb antweight combat robot with a spinning drum weapon and a custom control system. The robot will run on a 4S LiPo battery and use a custom PCB that integrates motor drivers, voltage regulation, and current sensing. An ESP32 microcontroller will handle wireless communication and overall control. The drum will be belt-driven to reach high rotational speed while keeping the layout compact and mechanically simple. The system will be designed to meet competition limits on weight and safety while maintaining reliable drive and weapon performance under high current conditions. Separate 5 V and 3.3 V power rails will support logic and control electronics. We will evaluate the robot through testing of mobility, weapon spin-up, wireless responsiveness, and electrical stability under load.

1 Introduction

1.1 Problem

The antweight battlebot competition requires teams to design and build a combat robot under strict constraints on weight, materials, and electronics. The robot must weigh less than 2 lb, use approved 3D printed materials, and integrate control and motor driving onto a custom PCB rather than relying on commercial radio receivers. At the same time, the robot must survive repeated high energy impacts while operating a high speed rotating weapon and a lithium polymer battery. These constraints create a challenging systems problem that combines embedded control, high current power electronics, wireless communication, and mechanical shock resilience. Improper handling of rotating weapons or LiPo batteries can pose safety risks, so the system must include reliable communication and fail-safe shutdown behavior to protect operators and bystanders during testing and competition.

1.2 Solution

We propose to design and build a 2 lb antweight battlebot featuring a two-wheel drivetrain and a drum spinner weapon. The robot will be controlled wirelessly from a laptop using Bluetooth or Wi-Fi through an ESP32-C3 microcontroller mounted on a custom PCB. The PCB will integrate wireless communication, PWM motor control, motor driver circuitry, voltage regulation, and battery monitoring. Software on the microcontroller will interpret user commands and enforce safety logic, including immediate motor disable on communication loss. The weapon system will use a belt-driven drum spinner to help isolate the motor from direct impact shocks. Power will be supplied by a 14.8 V 4S LiPo battery with on-board regulation for logic-level electronics. The overall design prioritizes reliable wireless control, electrical stability under high current loads, and mechanical durability during repeated collisions.

1.3 Diagram

Figure 1 shows the proposed system blocks and their primary interfaces. A detailed version will be added once the electrical and mechanical architectures are finalized.

1.4 High-Level Requirements

1. The fully assembled robot shall have a total mass less than or equal to 2.00 lb and comply with all competition material and electrical constraints.

2. The robot shall achieve wireless control with an end-to-end command latency less than or equal to 75 ms and shall disable all motor outputs within 250 ms of communication loss.
3. The drum spinner shall achieve a steady-state rotational speed of at least 1000 rpm and operate continuously for at least 3 minutes without electrical brownout or thermal shutdown.

2 Design

2.1 Block Diagram

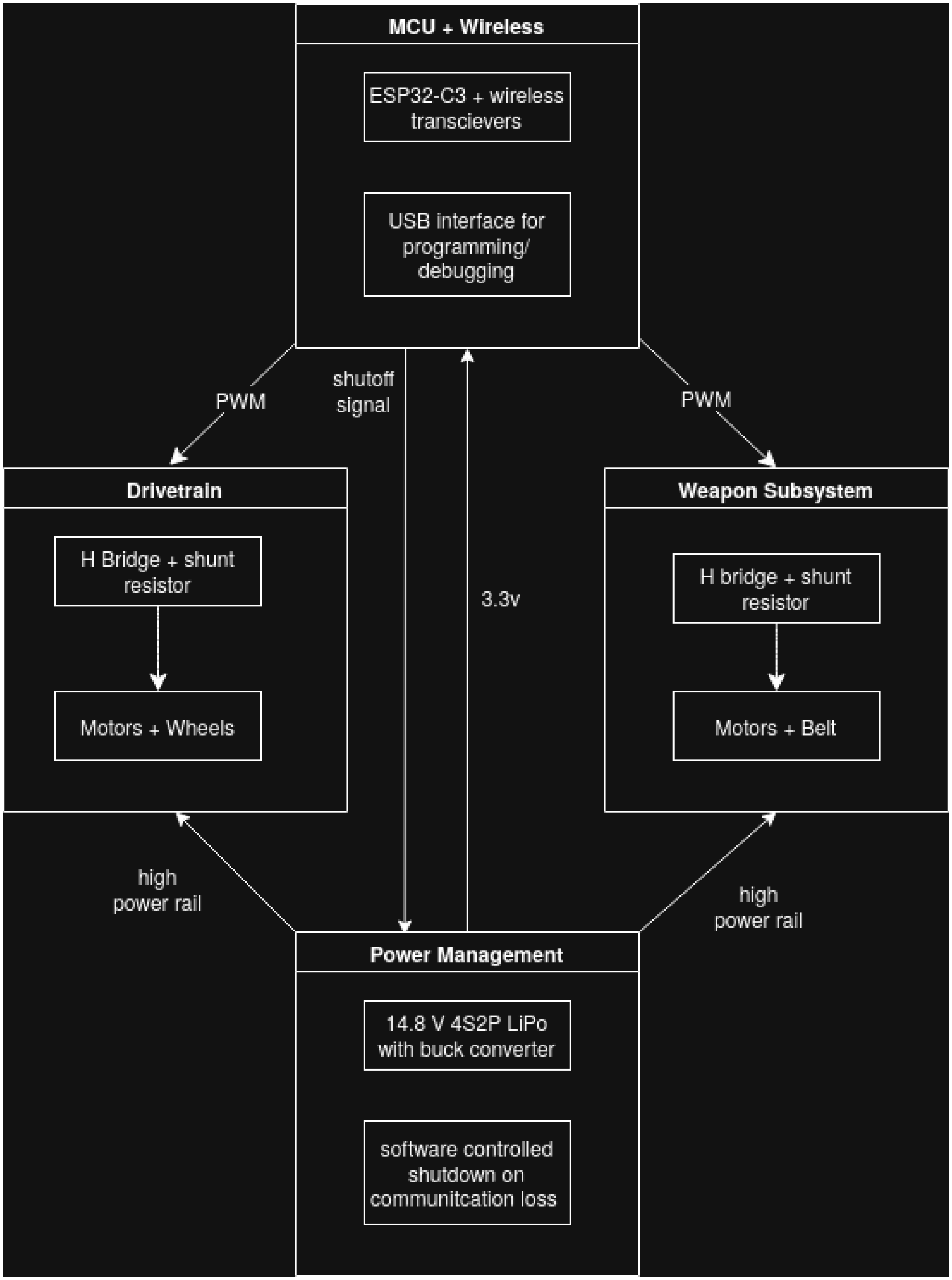

Figure 1: High-level block diagram of the proposed antweight battlebot.

2.2 Block Descriptions

2.2.1 Control and Communication System

Functionality. An ESP32-C3 microcontroller manages wireless communication and command parsing, generates PWM signals for motor control, and handles system coordination. The subsystem includes a USB interface for programming and debugging.[2]

Requirements.

- Support Bluetooth and Wi-Fi control links with command update rates of at least 50 Hz.
- Provide three PWM outputs with at least 10-bit resolution for two drivetrain motors and one weapon motor.
- Maintain operation across 3.0–3.6 V logic supply and recover to a safe state after brownout.

2.2.2 Motor Control System

Functionality. Two motors provide a centered two-wheel drivetrain while a third motor drives the spinning drum weapon. Motor drivers are controlled by PWM outputs from the ESP32-C3 and provide bidirectional drive and current handling for combat loads.[3]

Requirements.

- Drive two drivetrain motors with independent forward/reverse control and a minimum combined continuous current capability of 20 A.
- Drive the weapon motor with a continuous current capability of at least 15 A and a peak current capability of at least 25 A for 3 s.
- Provide electrical isolation or adequate filtering to prevent weapon motor noise from resetting the controller.

2.2.3 Power Management and Safety

Functionality. A 14.8 V 4S2P LiPo battery supplies power to the drivetrain and weapon motors. On-board regulation provides logic power, and a voltage divider monitors battery voltage. The system includes a software-controlled shutdown that disables motion on communication loss.

Requirements.

- Regulate battery voltage to a stable 3.3 V logic rail with at least 500 mA available current.
- Sense battery voltage with at least 1% accuracy over the 12.0–16.8 V operating range.
- Enforce a software kill condition that disables all motor outputs within 250 ms of loss-of-link.

2.2.4 Mechanical Structure and Weapon

Functionality. The mechanical subsystem houses electronics, provides protection, and delivers offensive capability via a spinning drum weapon. The weapon is belt-driven from the weapon motor and the chassis is 3D-printed using approved plastics (e.g., PLA or ABS).

Requirements.

- Maintain total robot mass under 2.0 lb with a center of mass within 10 mm of the drivetrain axis.

- Withstand repeated impacts without structural failure of the chassis or weapon mount during a 3-minute match.
- Provide mechanical guards and standoffs that prevent electrical shorts and protect the PCB from impacts.

2.2.5 Optional: Inertial Measurement and Weapon Optimization

Functionality. An optional IMU may measure vibration and angular velocity to characterize weapon balance and inform software-based tuning.

Requirements.

- Measure angular rate up to at least 2000 deg/s with sampling at 200 Hz or higher.
- Provide vibration metrics that can be logged over USB for offline analysis.

2.3 Risk Analysis

The highest risk is the motor control and power subsystem because of high current draw, electrical noise, and the need for reliable operation under mechanical shock. Failure in this block can cause brownouts or loss of control, directly violating the high-level requirements. Acceptable tolerances include maintaining logic supply within 3.0–3.6 V during worst-case motor transients and ensuring the motor drivers remain below their thermal limits. Risk mitigation includes careful PCB layout, bulk capacitance near drivers, separate power and logic grounds with a single-point connection, and staged testing with current-limited supplies before full battery integration.

3 Design Verification

We will verify performance through a staged test plan. Mobility tests will confirm drivetrain response and command latency, weapon spin-up tests will measure time to reach steady-state and sustained operation at target RPM, and wireless tests will confirm loss-of-link detection and shutoff within 250 ms. Electrical stability will be validated by monitoring logic rail droop and current draw during combined drive and weapon loads.

4 Costs

Table 1 summarizes expected parts costs. The gearmotor line item is pending final selection and will be updated once the drivetrain motor choice is locked.

4.1 Parts

4.2 Labor

Labor estimates will be added after the initial prototyping and integration schedule is finalized.

5 Ethics

This project will follow the IEEE Code of Ethics and will be conducted to avoid harm to others, including opponents, spectators, and team members. The robot is designed for competition within controlled environments, and the team will be transparent about system capabilities and limitations. Wireless control software

Table 1: Parts costs

Part	Manufacturer	Count	Retail Cost ($)	Actual Cost ($)
Gearmotor	TBD	3	TBD	TBD
DRV8874 Motor Driver	Texas Instruments	1	11.94	5.50
2.25” Foam Wheels	Pololu	2	7.95	15.90
Motor Mount Bracket	Pololu	2	5.95	11.90
4S 850mAh 75C LiPo	Tattu	1	32.00	32.00
XT30 Connector Pair	Amass	1	3.50	3.50
Mini Toggle Switch 20A	NKK	1	8.50	8.50
MP1584EN Buck Converter	Monolithic Power	1	3.00	3.00
AMS1117 3.3V Regulator	Advanced Monolithic	1	0.80	0.80
ESP32 DevKitC	Espressif	1	12.00	12.00
2207 2450KV Brushless Motor	Generic RC	1	18.00	18.00
35A Brushless ESC	Generic RC	1	22.00	22.00
GT2 Belt + Pulley Set	Generic	1	10.00	10.00
Bearings MR115 2RS	Generic	2	3.00	6.00
IRLZ44N MOSFET	Infineon	1	1.50	1.50
Total (excluding gearmotor)				150.60

will include a failsafe to reduce the risk of unintended motion. Ethical considerations include ensuring safe handling of the weapon system during testing and demonstrating respect for rules and fair competition.[1]

6 Safety

Primary safety concerns include the spinning drum weapon, high-current motor drivers, and LiPo battery handling. Safety measures include a physical arming switch, software kill functionality, insulated power distribution, guarded weapon exposure during test runs, and the use of appropriate PPE. Battery charging and storage will follow manufacturer and laboratory safety guidance, and all testing will be performed in a controlled area with a clear safety perimeter and a spotter ready to cut power.[5]

7 Conclusion

7.1 Accomplishments

This proposal defines the system architecture, safety plan, and quantitative requirements for a 2 lb antweight drum spinner with custom control electronics.

7.2 Uncertainties

Final drivetrain motor selection, detailed weapon balancing, and thermal margins under sustained load remain open items to be resolved during prototyping.

7.3 Ethical Considerations

The team will prioritize safe testing procedures and competition compliance to reduce risk to people and property.

7.4 Future Work

Next steps include completing the schematic and PCB layout, fabricating the chassis and weapon components, and executing the verification plan.

A Requirement and Verification Table

Table 2: System requirements and verifications

Requirement	Verification	Verified (Y/N)
Robot mass $\leq$ 2.00 lb and compliant materials	Weigh assembled robot and inspect materials list	
Wireless latency $\leq$ 75 ms and loss-of-link shut-off $\leq$ 250 ms	Measure command RTT and log motor disable timing	
Drum speed $\geq$ 1000 rpm for 3 minutes without brownout	Tachometer test under load with rail voltage logging	

References

References

[1] IEEE, "IEEE Code of Ethics," https://www.ieee.org/about/corporate/governance/p7-8.html.

[2] Espressif Systems, "ESP32-C3 Series Datasheet," https://documentation.espressif.com/esp32-c3_datasheet_en.html.

[3] Texas Instruments, "DRV8874 H-Bridge Motor Driver With Integrated Current Sense and Regulation Datasheet," https://www.ti.com/product/DRV8874.

[4] Pololu, "70:1 Metal Gearmotor 37Dx54L mm 12V (Helical Pinion)," https://www.pololu.com/product/4744.

[5] University of Washington Environmental Health & Safety, "Safety Measures for Lithium-Ion Batteries," https://www.ehs.washington.edu/about/latest-news/safety-measures-lithium-ion-batteries.