ECE 445 - Spring 2025

Senior Design Project Proposal
Antweight Battlebot

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Table Of Contents:

1. Introduction

1.1. Problem

This project aims to create an antweight battlebot that would weigh less than 2 lbs to participate in the Antweight Battlebot Competition. The criteria given are that all robots must have visible and controlled mobility such as rolling, non-wheeled, shuffling, or other methods; must be controlled via either Bluetooth or WIFI using a microcontroller with a manual operation for disconnection; and mounted with an attacking mechanism which would contact the arena 5 inches above the ground level and could come to a complete stop within 60 seconds.

1.2. Solution

The battle bot will have a tombstone-style horizontal spinning weapon that disables opponents by striking with high-speed impacts. We will use the Emax RS2205 2600KV brushless motor for the weapon, utilizing its high RPM and strong striking force. The weapon will be controlled by an ESP32-C3 microcontroller and operated through user input via Wi-Fi or Bluetooth.

The battle bot will use Greartisan DC 3V 19RPM N20 High Torque Speed Reduction Motor, controlled by a DRV8833 motor driver, for smooth maneuvering. We will use a Thunder Power 325mAh 3S battery to provide efficient power while keeping the design lightweight. The microcontroller will control mobility and weapon activation to ensure precise control. The design will focus on precise control, durability, and optimized weapon operation while maintaining a lightweight frame within the 2-pound limit.

1.3. Visual Aid

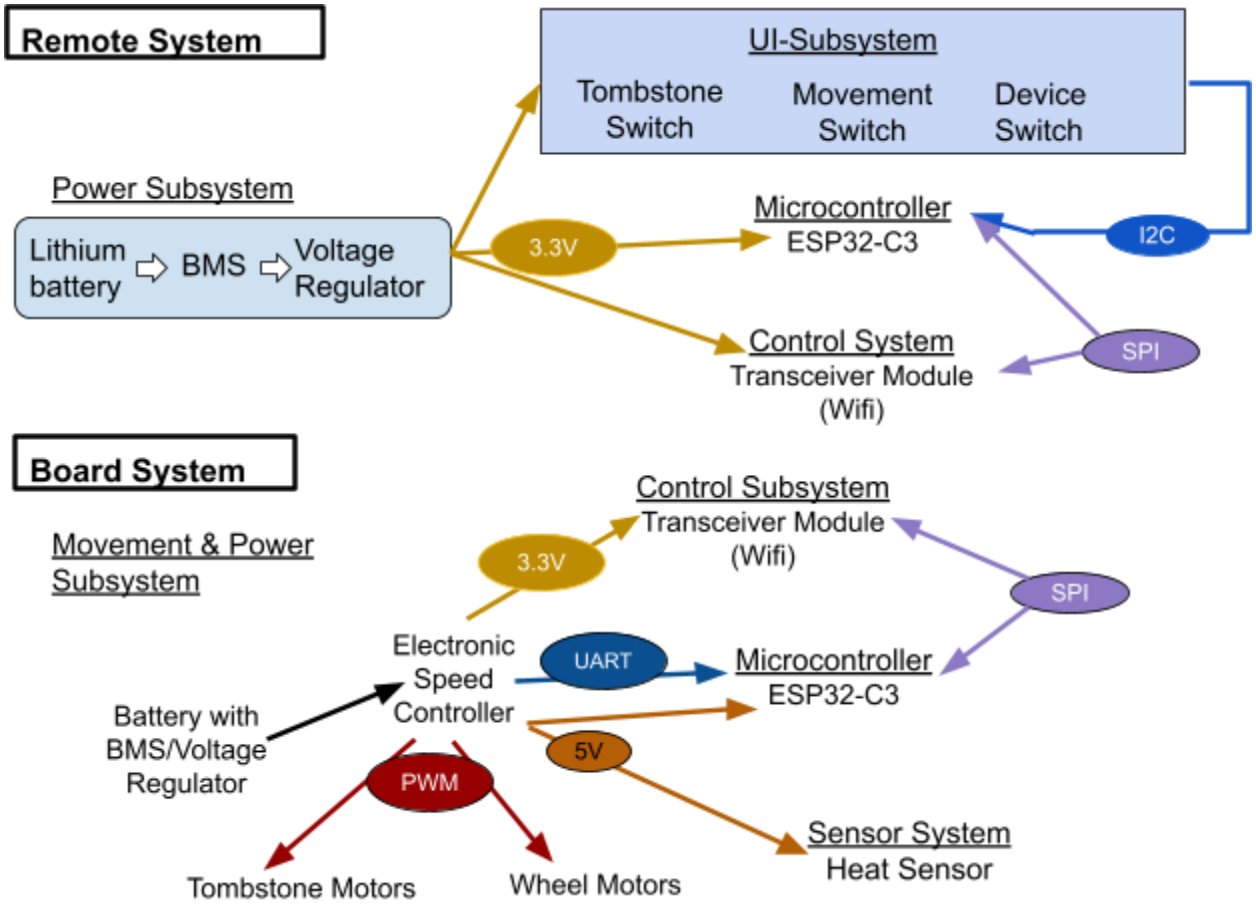
We plan to use a tombstone weapon mechanism like the visual aid above and the Nintendo GameCube Controller to control the battle bot through the ESP32 - C3.

1.4. High-Level Requirements

- The total weight of the battlebot should not exceed 2 lbs. Therefore, the backbone of the battle bot will be obtained from a 3D printer using low-weight material PET-G, lowest weighing THP 325-3SR70J battery, and low-weight Emax RS2205 2600KV motor.
- The ESP32-C3 microcontroller processes input signals from buttons and controls the motor via DRV8833, which would be controlled by ESP32-C3-DevKitM-1. This supports stable operation for the ESP32-C3 microcontroller.
- The speed of the attacking mechanism, the tombstone, will have multiple speed options for blade rotation. Enough power from the battery as well as control of the voltage regulator and motor control would be essential for controlling the speed of the blade. We expect to have 3 options for the speed of blade rotation.k

2. Design

2.1. Block Diagram



2.2. Subsystem Overview

2.2.1. Power System

The Power System includes the Lithium-Ion battery and the voltage regulators which is a part of the development kit. The voltage regulators are necessary as they provide adequate voltage to various components in the system. ESP32-C requires 3.3V to operate correctly, the DRV8833 motor driver needs a maximum of 5 V, and the motors require at least 5 volts. Without the regulators, these components may be exposed to voltages that exceed requirements and may lead to damage. The Thunder Power 325 mAh 3S Battery is a 3-cell lithium polymer battery providing 11.1 nominal voltage. Its maximum continuous discharge is 70C, and its maximum continuous current is 22.75A (capacitance t325mAh times discharge). The ESP32-C3 requires 3.3 Volts, and the DevKit we are using has a voltage regulator that can take up to 5V input and step it down to 3.3V, however, the battery exceeds tha,t so we will require an additional voltage step-down converter to bring 11.1 V to 5 volts before connecting it to ESP32-C3. The 22.75 A max continuous current is more than enough for the microcontroller, motor driver, and hopefully another voltage regulator.

Thunder Power 325 mAh 3S Battery

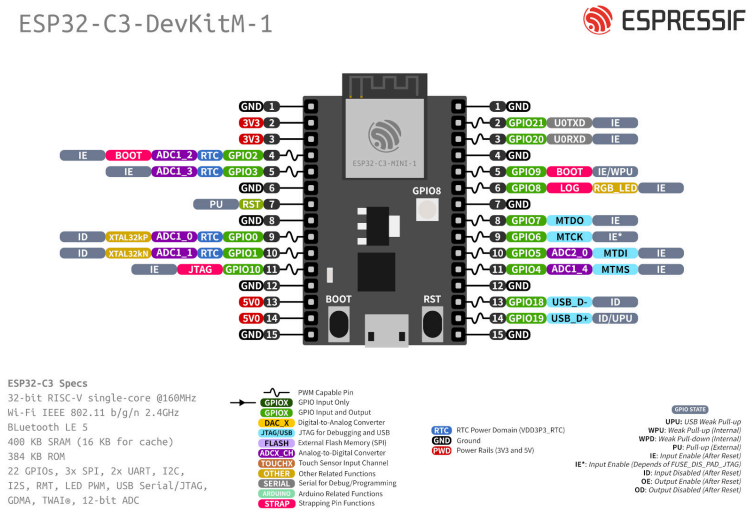
2.2.2. Communications Subsystem

The communication system would be in charge of handling communication between the microcontroller and motor drivers, as well as communication between the microcontroller of the remote controller and the microcontroller of the battlebot. The microcontroller has Bluetooth/WiFi feature, which would allow the two microcontrollers to communicate with each other. The battery and motors which are controlled by the electronic speed controller will communicate with the microcontroller on the board system using the UART cable and switches on the remote controller for the tombstone and movement as well as the power will communicate with the microcontroller on the remote system through I2C cable.

2.2.3. Control Subsystem

The ESP32-C3 is the central control unit for the battlebot. It provides wireless communication between the robot and the user controller. It will receive commands via

Wifi or Bluetooth and translate them into control signals for the robot's function. It will send the control signals to the DRV8833 motor driver which is the drive control and the Emax RS2205 which is the motor used as the attacking mechanism.



ESP32-C3

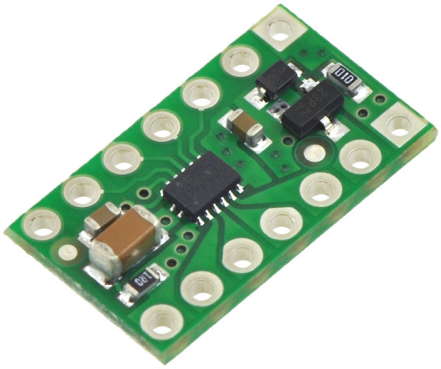
2.2.4. Attacking Mechanism

For our attacking mechanism, we plan to use the Emax RS2205 2600KV brushless motor, which is known for its high-speed rpm. This motor is usually used for drones, but we plan to repurpose it as a spinning weapon for the battle bot. It will receive power from a battery and be controlled by the ESP32 to determine when and at what speed to spin.

Emax RS2205 2600KV brushless motor

2.2.5. Robot Mobility

We will use the Greartisan DC 3V 19RPM N20 High Torque Speed Reduction Motor controlled by the DRV8833 motor driver. The DRV8833 dual H-bridge configuration enables independent control between the motors to provide forward, backward, and turning movements. The ESP32-C3 microcontroller sends control signals to the DRV8833 motor driver, enabling precise speed and direction adjustments. The battery ensures a sustained energy supply for efficient movement.



DRV8833 motor driver.

Greartisan DC 3V 19RPM N20 High Torque Speed Reduction Motor

2.2.6. PCB Design

The custom PCB will integrate key components of the battlebot to minimize wiring complexity, improve reliability, and optimize space efficiency. The PCB will include:

- **ESP32-C3 microcontroller footprint:** To directly mount the ESP32-C3 and handle signal processing.
- **Voltage regulation circuit:** A step-down DC-DC converter to provide 5V for the motor driver and a 3.3V regulator for the microcontroller.
- **Motor driver integration:** Connections for the DRV8833 motor driver to control the Greartisan DC 3V 19RPM N20 High Torque Speed Reduction Motor.

- **Weapon motor control:** A dedicated circuit to manage the high-speed brushless motor using an ESC (Electronic Speed Controller).
- **I2C and UART interfaces:** To facilitate communication between sensors, motor controllers, and remote input signals.

2.3. Subsystem Requirements

2.3.1. Power Subsystem

The power subsystem must be able to supply at least 500mA to the rest of the system continuously at 5V +/- 0.1V considering the 5V voltage required for electronic speed control, ESP-32 microcontroller, and the sensor subsystem. The battery provides 11.1 V with a continuous discharge of 22.75 A.

2.3.2. UI-Subsystem

The UI subsystem will consist of a tombstone switch, movement controller, and device power switch, which will all be powered by the 3.3V voltage which is regulated by the voltage controller originating from the battery. It will be controlled by the ESP-32 microcontroller via an I2C connection.

2.3.3. Control Subsystem

The microcontroller ESP32-C3 operates at 3.3 volts so the voltage must be stepped down icing a DC-DC buck converter to 5V (for the motor driver, etc) and also 3.3V for the microcontroller. The ESP32-C3 devkit regulates the 5V to 3.3V for proper microcontroller operation. It must have 3.3 V at all times as it handles communication.

2.3.4. Movement Subsystem

The movement subsystem is controlled by the Greartisan DC 3V 19RPM N20 High Torque Speed Reduction Motor consumes up to 1A at stall, and is operated at 100 RPM at no load with a torque of 3.5 kg*cm. When converting the power supply from the battery to the motor, a step-down converter would be needed to convert the 11.1 V from the battery to 5 V to power the DRV8833 motor driver. These motors are powered directly by the DRV8833 and require a minimum of 5 V to operate, the battery must be at least 5V at all times for the motor driver to operate but the driver can handle 10.8V.

Speed Calculation:
RPM = (Rated RPM × Operating Voltage) / Rated Voltage = (100 × 7.4) / 12 = 61.67 RPM
Angular Velocity:
$\omega = (2\pi \times RPM) / 60 = (2\pi \times 61.67) / 60 = 6.46$ rad/s

Linear Velocity:
$v = \omega \times r = 6.46 \times 0.05 = 0.323$ m/s ≈ 1.16 km/hr

This movement speed provides precise control and agility in the arena while ensuring efficient power usage. The 7.4V step-down regulation balances performance with motor driver safety, preventing voltage overload and excessive current draw.

2.3.6. Sensor Subsystem

The board system will include a heat sensor to prevent overheating of the tombstone blade rotation. Powered by a 5V battery, the sensor will trigger a warning on the display if temperatures exceed 80°C, as most 3D-printed backbone materials of the battlebot have a long-term heat deflection temperature of 100-120°C. We plan to use the LM335AH temperature sensor to ensure the safety of the attacking mechanism.

LM335AH Temperature Sensor

2.4. Tolerance Analysis

2.4.1. Weight Analysis

One aspect that could pose a huge risk to the completion of the project is the battery we decided to use. We are using the THP 325-3SR70J, which is 35g. As the key problem is to make the battle bot under 2 lbs, this battery could be a huge problem as it takes a significant portion of the allotted 2 lbs. With this as a major criterion, we would have to make changes to the power system if needed as well. To ensure sufficient power for the system, we have decided to use two THP 325-3SR70J batteries in parallel. This will provide additional power capacity, ensuring stable voltage levels during peak loads. Another consideration would be the weight of the motors. The Greartisan DC 3V 19RPM N20 High Torque Speed Reduction Motor has significantly higher torque despite its heavier weight. This would result in a more powerful and faster battlebot, which leads to cutting weight on frame weight or elsewhere. Using this motor would also allow more precise speed control as well as controlling the speed of the tombstone attacking mechanism.

Mathematical analysis:

- Emax RS2205 2600KV: 29 grams
- ESP-32 Dev kit: 28.34952 grams
- THP 325-3SR70J Battery (x2): 70 grams
- Greartisan DC 3V 19RPM N20 High Torque Speed Reduction Motor: 9 grams
- DRV8833 Motor Driver Board: 1.5 grams
- 3 wheels: 210 grams
- LM335AH: 0.3 grams
- Estimation for 3D printed parts: 200 grams

Total Weight: 583.15 grams
Weight Limit: 907.185 grams

Our estimated total weight is 583.15 grams, well within the 907.185g limit, providing flexibility for minor design adjustments.

2.4.2 Power Consumption Analysis

To ensure efficient operation, we analyzed the power needs of each subsystem.

- **Weapon System:** The Emax RS2205 motor requires 11.1V and draws up to 25A, consuming a maximum of 277.5W, but typically around 150W.
- **Mobility System:** The Greartisan DC 3V 19RPM N20 High Torque Speed Reduction Motor operates at 3V, consuming from 0.09W to 0.3W under normal use and 3W at peak stall conditions.
- **Control System (ESP32-C3 & Peripherals):** Runs on 3.3V, drawing 0.25A, consuming 0.825W.
- **Motor Driver (DRV8833):** Requires 5V and consumes up to 5W.
- **Sensor System (LM335AH Temperature Sensor):** Negligible power consumption (0.0005W).

Total Estimated Power Consumption:

- **Normal Operation:** 178W
- **Peak Load:** 357W

Power Supply Feasibility with Two Batteries

- **Batteries Used:** Two THP 325-3SR70J (3S LiPo, 11.1V, 22.75A each)
- **Total Available Power: 504.4W**

- **Conclusion:** Both normal and peak power requirements are met, ensuring stable operation without voltage drops.

3. Ethics and Safety

3.1. IEEE Code of Ethics #1: Safety

We will prioritize the safety of the surrounding environment, operators, and spectators to ensure that the battle bot operates in a controlled environment. The bot will be tested in safe conditions and follow the necessary steps to handle the high-speed motors, batteries, and wireless communications.

A few components we will need to watch out for safety are the LiPo Battery which we will make sure not to overcharge, or improperly handle, and use safe charging and discharging procedures. Another component would be the motors for which we will make sure to use a cover to ensure the motor doesn't rotate when not in use and has a guard to prevent it from injuring anyone.

3.2. IEEE Code of Ethics #9: Privacy and Security Concerns

We will be using Wi-Fi or Bluetooth, so we will ensure secure connectivity to prevent unauthorized access and hacking of the bot. We will ensure this by using a secure authentication mechanism for the ESP32-C3 so that the operator can only use it to control the bot.

3.3. ACM Code of Ethics 2.2: Fair Competition

Our bot will comply with the competition rules and regulations to ensure fair play and participation. We will not use unauthorized material or unfair advantages

4. References

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