

BTTL Bot

ECE 445 Project Proposal

Team Number: 51

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1. Introduction

1.1 Objective and Background

Our project's objective is to build a combat bot, under 2 pounds, for the FA26 ECE 445 battlebots competition. The robot must remain responsive throughout a match, survive impacts from opposing robots, and provide the driver with reliable control and situational awareness while remaining within the competition's weight constraint.

We want to use two independently controlled side-mounted hammer arms. Each hammer can be activated separately, allowing the driver to attack from either, also performing a push OR strike. We can also activate both of them together to come together in the front, calling it a "Dual Smash".

The robot will include an onboard camera and time-of-flight sensors to provide live visual and distance information during the match. To reduce the effectiveness of opposing wedge or lifting robots, the chassis will incorporate low-clearance front and side wedgelets designed to make it more difficult for an opponent to get underneath the robot. Heavier components will also be mounted low in the chassis to maintain a low center of gravity and improve stability.

1.2 High-Level Requirements

- Completed Robot Design that must weigh less than 2 pounds and must contain the following: sensors, camera, hammer mechanisms, defensive wedgelets, PCB and a drivetrain.
- The robot must be remotely controlled and be active for the 2 minute match. It must receive movement inputs from the laptop only, and also transmit a live feed through a camera that is protected from damage.
- The robot must support independent left- and right-hammer activation and simultaneous Dual Smash operation, with both hammer movements beginning within **100 ms** of each other,

while the drivetrain and weapon system must disable within **500 ms** of losing the WiFi control connection.

2. Design and Requirements

2.1 Block Diagram

The system will be divided into three different subsystems: the sensing and driver-interface subsystem, the drivetrain & weapon subsystem, and the power system. The ESP32-S3 will be the central controller, which will receive commands through our custom driver over WiFi, and also take in inputs from the camera, time-of-flight sensors and motor drivers [1]. The block diagram below shows the power flow, control signals, and communication protocols between these subsystems.

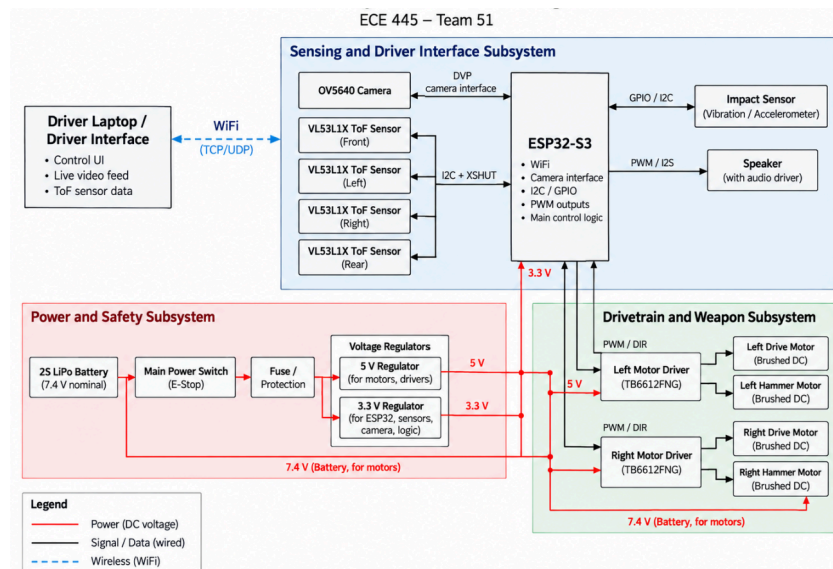


Image 1: Block Diagram of Subsystems

2.2 Sensing & Driver Interface Subsystem

This subsystem provides the driver with live information about the robot's surroundings including distance between the bots. We will mount an OV5640 camera in a protected chamber, providing a live video feed after processing it [2]. On the other hand, four VL53L1X

time-of-flight sensors positioned around the robot will measure nearby distances as a supplementary feature [3]. The ESP32-S3 will collect camera and sensor data and transmit it over WiFi to the driver laptop.

Requirement 1: Camera system must pre-process and provide continuous live video feed to the driver laptop for the full 2-minute duration without requiring a controller reset. We can record this and store it as well.

Requirement 2: All 4 VL53L1X sensors must initialize successfully and report distance measurements to the driver interface using a unique I2C address through the control pins.

2.3 Drivetrain, Weapon, Defense Subsystem

Two brushed DC gearmotors controlled through a dual H-bridge [4] will allow the bot to move forward, backward, and turn in place. Two independently controlled side-mounted hammer arms will serve as the primary attacking mechanism. For our defense criterion, we will have low-clearance front and side wedgelets / skids built into the chassis.

The Robot will also include an impact-detection sensor (vibration sensor) that checks whether both the hammer arms had an impact. If detected within a short window, we will program the ESP32-S3 to trigger a custom pre-recorded variety of audios through a small speaker.

Requirement 1: drivetrain obeys forward, backward, left-turn, right-turn commands from the driver laptop.

Requirement 2: Each hammer can deliver consecutive strike-and-reset cycles without mechanical / electrical failure.

Requirement 3: upon sensing impact only when both hammers were used, the bot is able to output sound through the speaker.

2.4 Power & Safety

To power our battlebot, we'll be using a 2S LiPo battery. Voltage regulation on the custom PCB will generate the required voltage rails for the low-voltage electronics. Power distribution, decoupling, and protection components will be integrated into the subsystem, alongside a manual emergency stop and a MOSFET-based motor cutoff [5].

Requirement 1: the subsystem must continuously operate the complete robot for the entire match, supporting all the spikes when the hammers will be swung, sensors will relay data etc.

Requirement 2: if the WiFi control connection is lost, the drivetrain and hammer actuators will disable within 500 ms, and all motor commands must default to zero during setup.

2.5 Tolerance / Risk Analysis

The Risk in this project is whether the dual-hammer mechanism can produce enough torque and speed to meaningfully strike another robot, which obeying the 2lb weight limit. We will have to design the hammer-arm length, hammer mass, and desired angular acceleration.

Using our initial designs, for a preliminary hammer mass of 0.08 kg and arm length of 0.10 m, the rotational inertia is on the order of 10^{-4} to 10^{-3} kgm² depending on how the mass is distributed. This shows that a compact geared actuator in the approximate 0.1–0.5 Nm torque range can produce significant angular acceleration while keeping each hammer assembly within a practical mass range. Final torque and speed will be verified using the selected actuator's torque-speed curve before fabrication.

3. Ethics and Safety

The project will follow the necessary ethical expectations of ECE 445 as well as the IEEE code of ethics [6]. The main point of focus is to ensure that the robot does not create unnecessary risk to team members and operators. We will also ensure that our design will prioritize safe operation and compliance with competition rules.

The robot will include a manual emergency-stop mechanism and a motor cutoff so that drivetrain and weapon power can be disabled almost instantaneously. Lastly, the robot functionality will be thoroughly tested in a safe environment. All these precautions align with the ECE 445 safety requirements for laboratory work and project testing [5].

4. References

- [1] Espressif Systems, “ESP32-S3 Datasheet,” 2026.
<https://www.espressif.com/support/documents/technical-documents>
- [2] OmniVision Technologies, “OV5640 CMOS Image Sensor Datasheet.”
- [3] STMicroelectronics, “VL53L1X Time-of-Flight Ranging Sensor.”
<https://www.st.com/en/imaging-and-photonics-solutions/vl53l1x>
- [4] Toshiba Electronic Devices and Storage Corp, “TB6612FNG Brush Motor Driver IC.”
<https://toshiba.semicon-storage.com/eu/semiconductor/product/general-purpose-logic-ics/detail.TB6612FNG.html>
- [5] University of Illinois Urbana-Champaign, ECE 445 Senior Design Laboratory, “Safety Guidelines.” <https://courses.grainger.illinois.edu/ece445/guidelines/safety.asp>
- [6] IEEE Code of Ethics, <https://www.ieee.org/about/corporate/governance/p7-8.html>