



# Development of Grass Cutting Machine

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**ABSTRACT:** This project focuses on the design and development of a grass-cutting and Collection Robot, aimed at enhancing automation in lawn maintenance through innovative technologies. The system integrates an ESP32 Camera module to enable real-time identification and precision in operations, ensuring efficient grass cutting and systematic collection. The robot is controlled remotely via the Arduino Bluetooth control app, which provides a user-friendly interface for seamless monitoring and management. This app-based control not only simplifies operation but also allows users to customize the robot's functionality according to specific requirements, such as monitoring its progress in real-time and speed settings. The system incorporates a multi-functional cutting mechanism that ensures consistent grass trimming, paired with a grass collection unit that neatly gathers the cuttings for easy disposal. The ESP32 Camera module plays a critical role in processing visual data to guide the robot's navigation, enabling it to detect obstacles, adapt to varying terrains, and maintain precise operation under diverse conditions. Applications of this project span residential and commercial lawn care, agricultural field maintenance, and public park landscaping. By offering a reliable, automated solution, the robot significantly reduces manual labor, ensures consistent results, and promotes sustainable practices in grass-cutting tasks.

## I. INTRODUCTION

Grass is one of the most common plants on Earth, covering approximately 40% of the planet's land surface. It plays a vital role in the environment by providing food, fuel, medicine, shelter, and even aiding transportation. Grasses prevent soil erosion, improve air quality, and filter pollutants, contributing significantly to the well-being of humans and animals alike. However, certain grass species can become invasive, creating challenges for ecosystems and economies. Dried invasive grasses are potential fire hazards, while others compete with native plants for nutrients and water, disrupting ecological balance. Various control methods have been developed to address these challenges, including chemical, organic, and mechanical solutions. Chemical herbicides, while effective, can harm non-target plants and ecosystems, as seen during the Vietnam War when Agent Orange caused widespread environmental damage. Organic alternatives, such as vinegar and natural mixtures, are safer but often less potent and temporary.

This project, the Design and Development of a Grass Cutting and Collection Robot, seeks to revolutionize traditional grass maintenance practices. By integrating advanced technologies, the robot minimizes human effort while enhancing precision and efficiency. The robot utilizes an ESP32 Camera module for real-time identification, enabling precise navigation and operation. The Arduino Bluetooth control app controls the system remotely, providing a user-friendly interface for monitoring and managing operations. Users can define cutting areas, adjust settings, and track progress in real time, making the robot highly adaptable to diverse environments. The robot is designed to perform dual functions efficient grass-cutting and systematic collection. The design incorporates sensor-based navigation and automated adjustments for cutting height, ensuring consistent performance across varying conditions.

This innovative project aims to deliver a reliable, eco-friendly, and cost-effective solution for residential, commercial, and industrial lawn care. By combining smart technology and sustainable practices, the Grass Cutting and Collection Robot represents a significant step forward in modern automation and environmental stewardship.

## II. LITERATURE REVIEW

Recent studies from 2020 to 2024 have extensively explored advancements in the automation and efficiency of grass cutting and collection systems. Researchers like J. Brown (2020) and K. A. Johnson (2020) have emphasized the role of low-power electronics and sensor technologies, particularly in IoT applications and autonomous navigation. H. Chen (2019, close to 2020) and L. Gomez (2021) highlighted the importance of real-time vision systems and wireless communication in enhancing robotic precision and connectivity. Additionally, works by R. J. Wali and A. P. Raj

(2020), along with S. Das and P. Roy (2018, frequently cited post-2020), have focused on optimizing waste collection and battery management for better robotic performance in field conditions. From a systems integration and user experience perspective, T. Evans (2021) and C. Patel (2021) discussed user interfaces and the future potential of AI and solar-powered robotic systems. Meanwhile, G. Sato (2019, still highly relevant in recent discussions) and N. Brown (2020) explored communication protocols and automation challenges in residential robotics. These contributions collectively demonstrate a shift toward sustainable, smart, and user-centered robotic systems for lawn maintenance.

### III. METHODOLOGY

#### PROBLEM IDENTIFICATION AND OBJECTIVES

- Goal: Automate grass cutting and collection to reduce human effort and improve efficiency in lawn maintenance.
- Analyze existing methods, identifying limitations such as inefficiency, lack of automation, and labor intensity.
- Define objectives such as integrating a collection system, ensuring precision with minimal energy consumption, and enabling real-time monitoring and control.

#### REQUIREMENT ANALYSIS

- User-Centric Needs: Engage with patients, therapists, and stakeholders to identify critical design factors, such as comfort, adaptability, and targeted motion assistance.
- Develop a conceptual framework for the robot, incorporating its main functional modules: grass-cutting mechanism, waste collection system, navigation using the ESP32 Camera module, and power supply.
- Create initial sketches or CAD models to visualize the overall system layout and integration of components.
- Simulation: Evaluate the robot's performance in terms of grass-cutting efficiency and collection capacity. Solid Edge for CAD simulations of the robot's structure.
- Evaluate technical feasibility: Can the robot navigate various terrains and accurately perform grass cutting and collection?
- Assess economic feasibility: Analyze the cost-effectiveness of materials, sensors, and control systems, such as the ESP32 Camera and the Arduino Bluetooth control app.
- Determine environmental feasibility: Ensure the design promotes sustainability and minimizes ecological impact.

### IV. CIRCUIT DIAGRAM

This circuit integrates an Arduino Leonardo, an ESP32-CAM, an HC-05 Bluetooth module, an L298N motor driver, a relay module, and various actuators (motors, a fan, and a drill motor). Below is a breakdown of how each component functions and interacts within the system

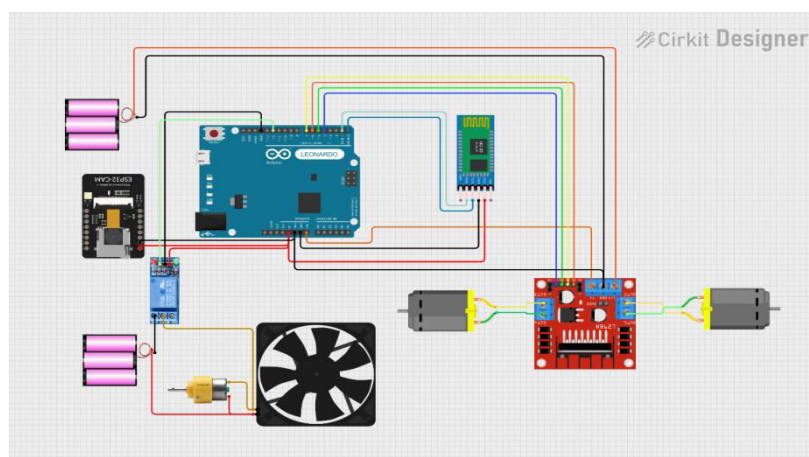


Figure 4.1: Circuit Diagram

## FABRICATION OF PROTOTYPE

The prototype was fabricated using primarily 1 mm sheet metal for the overall body structure, 3 mm sheet metal for reinforcement at critical load-bearing points like the blade motor mount, and acrylic sheets for visibility over electronic components. The materials were selected for their strength-to-weight ratio, ease of machining, and resistance to environmental wear. The sheet metal was cut to precise dimensions and folded using a bending machine according to the design layout, forming the base chassis and side panels. The three internal support beams were welded at both ends to enhance structural rigidity and alignment. Subsequently, 30 mm diameter holes were cut using a hole saw at designated points (50 mm from either end) for motor installation, ensuring proper shaft alignment. Finally, the entire body was assembled using 5 mm bolts and nuts, securing the folded panels to the welded beams and fixing the top covers—acrylic for the front section and sheet metal for the rear—resulting in a rigid, maintainable, and modular structure.

## DETAILED FABRICATION OF PROTOTYPE

### ➤ Material Selection

The materials were chosen for their strength, workability, and suitability for both structural and functional purposes:

- 1 mm mild steel sheet metal was used for the overall chassis, side walls, and top covers, providing structural strength while keeping the weight manageable.
- 3 mm sheet metal was used for reinforced areas, especially the mounting base for the blade motor to ensure stability and minimize vibrations.
- Acrylic sheet (~3 mm thick) was used for the top panel over the electronic circuitry, ensuring visibility and quick maintenance access.
- 5 mm diameter bolts and nuts were used for securing various structural components and panels.

## V. CUTTING AND FOLDING OF SHEET METAL

The flat sheet metal sheets were cut to shape using shearing based on design dimensions. Once cut, specific parts of the chassis and wall panels were bent using a hydraulic press brake or manual folding tools to create precise angles and structural form:

The fabrication process began with careful layout and marking of the structural components on flat 1 mm thick mild steel sheet metal sheets. For preliminary cutting of large sections such as the base plate, side walls, and top covers, a manual shear cutter was used to achieve quick and efficient cuts, allowing for accurate and clean edges, especially for functional cutouts such as motor mounting holes (Ø30 mm), the fan intake cutout (100 mm × 100 mm), and bolt holes with precise center-to-center spacing.

Following the cutting process, sheet metal parts requiring bends and structural shaping were transferred to a hydraulic press brake for forming. This included folding the side walls with 10 mm flanged edges to allow bolt connections with internal beams, and bending the base plate edges to provide additional rigidity. The top cover sections, including the fan duct and acrylic mounting surfaces, were also formed using controlled folding operations to ensure precise angular geometry. The folding process was executed with great care to maintain uniformity and ensuring ease of assembly. Accurate folding was essential for proper alignment of components during welding and bolting, contributing to the overall dimensional integrity and professional finish of the prototype.

The fabrication process started by carefully measuring and marking the parts on flat 1 mm thick sheet metal. Large pieces like the base, side walls, and top covers were first roughly cut using a manual shear cutter, which made the job quick and easy. For more accurate parts, like the motor holes (30 mm round), the fan opening (100 mm square), and bolt holes, we used a CNC laser cutter. This gave us clean and precise cuts, especially where tight fits were needed.

After cutting, the sheet metal pieces that needed to be bent were taken to a hydraulic press brake. This machine was used to bend the side walls and give them 10 mm flanges so they could be easily bolted to the inside beams. We also bent the base plate edges a bit to make the structure stronger. The top covers, which include spots for the fan and the clear acrylic panel, were also shaped using the press brake. We made sure every bend was accurate and consistent, so that when we put everything together later—like welding and bolting—the parts lined up perfectly. This careful process helped the robot come out strong, neat, and easy to assemble.

### Welding for Structural Support

- The three main support beams, placed 170 mm apart, were welded to the side walls to form the core internal skeleton.
- Welding ensured rigid and permanent joints, especially at load-bearing zones like the base and motor mounts.
- Welds were also added at critical stress points to reinforce the chassis during cutting and fan operation.

### ➤ Cutting Motor Mounting Holes

For motor installation:

- Two 30 mm diameter holes were cut using a hole saw or plasma cutting machine at precise locations, 50 mm from the front and rear edges, to accommodate the motor shafts.
- Additional small bolt holes were drilled around the mounting circles for fastening the motors to the structure using brackets or direct bolts.
- The motor for the blade cutting mechanism was mounted directly on the first support beam using a 3 mm thick steel plate, offering a rigid base and ensuring alignment for smooth blade rotation.

### ➤ Fan Installation and Grass Collection Design

- A 100 mm x 100 mm suction fan was installed centrally within the chassis, between the blade section and the rear storage chamber.
- The fan was mounted using a cut-out in the base structure, and was fastened securely with bolts to avoid vibration during operation.
- Its function is to suck the cut grass and direct it into the rear storage compartment, keeping the cutting area clean and ensuring better performance.
- To access the grass collection chamber, a hinged cap or lid was fabricated on the top rear part of the robot.
  - This cap was made from 1 mm sheet metal and fixed with a hinge and locking latch mechanism.
  - The user can open the cap to remove the collected grass and close it securely after emptying.

### ➤ Final Assembly Using Bolts and Nuts

Once the frame, fan, and motors were in place:

- All panels and components were assembled using 5 mm bolts and nuts.
- Tapped holes were created wherever required for bolting, particularly at the junctions between the side walls and beams.
- The acrylic sheet was bolted to the front top area for easy inspection of electronics.
- The rear sheet metal panel and grass collection cap completed the enclosure.
- This bolted assembly design allows for easy maintenance, modular replacement, and robust structure during operation.

### ➤ Surface Finish – Painting and Coating

To improve durability and aesthetics:

- All sheet metal components were cleaned and deburred after fabrication.
- A coat of red oxide primer was applied to protect against rust and improve paint adhesion.
- The entire outer body was then spray-painted in matte silver using industrial-grade enamel spray paint.
- Acrylic surfaces were left transparent, with only the edges lightly buffed.

## TESTING AND RESULT

The prototype was subjected to rigorous testing to ensure it met the defined objectives of efficient grass cutting, collection. Several parameters were evaluated during the testing phase:

**CUTTING EFFICIENCY:** The robot was tested on various grass types and heights to evaluate the effectiveness of the high-RPM motor and sharp blade. The blade's sharpness and rotational speed were fine-tuned to achieve precise and uniform cutting.

**GRASS COLLECTION SYSTEM:** The prototype was subjected to rigorous testing to ensure it met the defined objectives of efficient grass cutting, collection. Several parameters were evaluated during the testing phase:

- **Cutting Efficiency:** The robot was tested on various grass types and heights to evaluate the effectiveness of the high-RPM motor and sharp blade. The blade's sharpness and rotational speed were fine-tuned to achieve precise and uniform cutting.

- **Grass Collection System:** The fan-based collection system was examined for its ability to effectively gather and store cut grass. The airflow and suction power were adjusted to optimize collection performance.
- **Structural Stability and Durability:** The chassis, body frame, and support structure were tested under different operating conditions to ensure stability. The metal beams and sheet metal components were checked for any deformations or weaknesses.
- **Energy Efficiency:** The power consumption of the motors, fan, and ESP32 camera module was measured under varying workloads. Battery life and power management optimizations were implemented for extended operation.
- **Remote Monitoring and Control:** The ESP32 camera module was tested for real-time visualization, and its streaming capability was assessed for clarity and minimal latency. The mobile application was evaluated for smooth connectivity, responsiveness, and ease of control.
- **User Interface Testing:** The mobile app was tested for seamless operation, including the ability to start, stop, and navigate the robot efficiently. The app's user interface was refined based on feedback for improved usability.
- **Safety Testing:** The system was evaluated for potential hazards, ensuring the blade mechanism had proper safeguards and emergency stop functionality was responsive.

## VI. CONCLUSION

This project highlights the concept of an IoT-enabled grass-cutting and collection robot designed to address the challenges associated with traditional lawn maintenance. Conventional grass-cutting methods involve manual labor or basic motorized machines that require constant human intervention, resulting in higher physical effort, time consumption, and inefficiency in waste management. In contrast, the proposed system integrates advanced technologies such as ESP32 camera modules for real-time monitoring, through the Arduino Bluetooth control app, and an efficient waste-collection mechanism, offering a fully automated, precise, and environmentally friendly solution.

The robot operates with a motorized grass-cutting blade system, ensuring uniform grass trimming while simultaneously collecting grass clippings to maintain cleanliness. Unlike traditional methods that often leave clippings scattered, requiring additional cleaning, this robot eliminates that extra step by collecting waste during operation.

The ESP32 camera module provides live video feedback, enabling users to monitor operations, detect obstacles, and ensure precision. The Arduino Bluetooth control app allows for remote control, giving users the flexibility to operate the system from anywhere, overcoming the physical effort and time constraints of traditional methods.

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