

Semi-Controlled Lawn Vacuum Cleaner and Grass Cutter

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ABSTRACT

This paper presents the design and development of a semi-controlled lawn vacuum cleaner and grass cutter that integrates mechanical cutting and vacuum suction in a single automated platform. The system employs an Arduino Uno microcontroller with an HC05 Bluetooth module to control movement through two 12 V DC gear motors driven by high-current motor drivers. A centrally mounted BLDC motor performs grass and leaf cutting, while a high-power vacuum motor collects the debris into a detachable bag. The system is powered using a 12 V, 30 A SMPS for all DC components and a direct AC line for the vacuum motor. The proposed design aims to minimize manual labour, enhance efficiency, and provide a low-cost smart solution for lawn maintenance.

Keywords: Arduino Uno, BLDC Motor, Bluetooth Control, BTS7960 Motor Driver, Lawn Vacuum, Semi-Controlled Grass Cutter, IoT-Based Robot.

I. INTRODUCTION

Modern urban and residential environments increasingly demand efficient and low maintenance solutions for lawn cleaning and grass cutting. Traditional manual grass cutters and blowers require significant physical effort and time. With the advancement of mechatronics and IoT-based wireless control, semiautomated lawn systems have become practical and affordable alternatives.

This study presents a semi-controlled lawn vacuum cleaner and grass cutter that integrates a BLDCbased cutting mechanism and a high-power suction system to simultaneously cut and collect debris. The robot's movement is controlled through an Arduino Uno interfaced with an HC05 Bluetooth module. The operator controls all directional movements using a mobile Bluetooth application.

The system uses two high torque 60 RPM DC geared motors driven through BTS7960 high current motor drivers to achieve differential motion. A BLDC motor connected via an ESC is centrally mounted to perform grass cutting. A detachable vacuum chamber collects shredded leaves and cuts grass. Power is supplied from a 12 V, 30 A SMPS for all DC subsystems, while the vacuum operates directly from AC mains.

This hybrid mechanical & electrical design reduces human effort while maintaining operator control, making it suitable for lawns in residential areas, institutions, and public gardens.

II. LITERATURE REVIEW

Several researchers have explored automation and smart control in lawn maintenance and cleaning systems, integrating mechanical design with electronic control for improved performance.

In [1], a low cost IoT-enabled smart lawn mower was developed using Arduino and Wi-Fi modules for remote operation, highlighting how embedded systems can simplify domestic automation. Similarly, [2] presented a semiautonomous grass cutting robot using ultrasonic sensors and Bluetooth for navigation, demonstrating how wireless control can reduce human involvement while maintaining precision.

Reference [3] proposed a hybrid solar electric grass cutter to improve energy efficiency, yet it lacked a high-capacity debris management system. Our design addresses this limitation by integrating a dedicated suction mechanism capable of removing heavier outdoor debris.

The study in [4] introduced an Arduino based vacuum cleaner using IR sensors to detect indoor obstacles. Although effective for small particles, the system was not suitable for outdoor grass clippings or uneven surfaces. In contrast, our design employs a BLDC cutter and high-power suction system engineered for outdoor lawn conditions.

In [5], researchers developed a Bluetooth controlled robot using an HC05 module and an L298N driver for motion control. Their communication structure aligns with our wireless movement control approach; however, our system advances this concept by using dual BTS7960 high current motor drivers and 12 V, 60 RPM high torque motors to handle outdoor terrain loads.

Studies [6] and [7] emphasized the advantages of BLDC motors in cutting applications due to their high torque, smooth operation, and energy efficiency. These principles directly support our use of a BLDC motor paired with an ESC for stable, highspeed cutting performance.

Differential drive locomotion was analysed in [8], where two DC motors provided both linear and angular movement. We employ the same kinematic concept but enhance it with high current BTS7960 drivers and SMPS based power delivery to improve torque stability on natural lawn surfaces.

In [9], an Arduino controlled suction robot demonstrated that microcontrollers can reliably coordinate high power actuators through careful electrical isolation. This idea influenced our power design, where a 12 V, 30 A SMPS supplies all DC subsystems and the ESC regulates power to the BLDC while maintaining a shared ground for control.

Reference [10] introduced a mobile app interface for real-time robotic teleoperation, emphasizing user-friendly command transmission. Our project builds on this by finetuning HC05 Bluetooth communication for semi-controlled navigation, where the user retains full directional control while the cutting and suction modules operate continuously.

Finally, studies [11]– [13] integrated suction and cutting mechanisms for agricultural residue management, proving that combining both actions reduces postprocessing time. We advance this concept by implementing simultaneous cutting and vacuuming in a compact, Bluetooth controlled outdoor robot powered entirely from a single SMPS source.

Despite significant progress in smart lawn maintenance systems, there remains a research gap in low-cost, semi controlled outdoor robots combining BLDC cutting, high power suction, and SMPS driven high current motor control. The proposed system fills this gap by merging robust mechanical design with efficient power electronics and user directed Bluetooth control.

III. SYSTEM DESIGN AND METHODOLOGY

The semi-controlled lawn vacuum cleaner and grass cutter consists of three major subsystems:

- (1) the control unit,
- (2) the cutting and suction unit, and
- (3) the motion drive unit.

All components operate together to enable Bluetooth based navigation, continuous cutting, and simultaneous debris collection.

A. System Overview:

The system architecture is centred around an Arduino Uno microcontroller acting as the command processing unit. The operator sends directional inputs through a smartphone using an HC-05 Bluetooth module. Arduino interprets these commands and controls two 12 V, 60 RPM high torque geared motors through dual BTS7960 motor drivers to achieve differential steering.

A BLDC motor connected through an electronic speed controller (ESC) performs highspeed grass cutting. Simultaneously, a suction unit collects cut grass and debris into a detachable chamber. All DC components—including the geared motors, ESC, and BLDC—are powered through a 12 V, 30 A SMPS, ensuring stable current distribution even under load fluctuations.

B. Hardware Components:

1. Arduino Uno

Serves as the main controller, receiving Bluetooth commands and generating logical outputs for movement.

2. HC05 Bluetooth Module

Provides wireless communication with the user's smartphone. Supports simple UART serial protocol for directional commands.

3. Dual BTS7960 Motor Drivers

Each BTS7960 driver controls one high torque DC motor. Their current handling capacity (up to 43 A) ensures reliable performance on grass terrains with frequent load variations.

4. 12 V, 60 RPM High Torque Geared Motors

These motors provide sufficient torque to move the robot through uneven lawn surfaces. Used in a differential drive configuration.

5. BLDC Motor with ESC

The BLDC motor performs grass cutting. The ESC supplies regulated power and receives control signals from Arduino.

6. 12 V, 30 A SMPS

Provides all DC power required for motors and electronics. Ensures stable current without voltage sag during simultaneous motor operation.

7. Vacuum Suction Motor & Detachable Collection Bag

Draws grass clippings and leaves into a storage bag. Positioned behind the blade mechanism to ensure efficient collection.

8. Chassis Assembly

A rigid metal frame supports all components, maintaining a balanced centre of gravity and minimizing vibration.

C. Software Implementation

The software for the robot is developed using the Arduino IDE. Directional commands such as "F" (forward), "B" (backward), "L" (left), "R" (right), and "S" (stop) are decoded through serial communication.

The program uses:

Digital Write () for switching movement states

PWM signals to control the BLDC motor speed through the ESC

Safety routines including motor off timeout and command validation

The code is designed to ensure immediate motor response and smooth turning transitions.

D. System Workflow

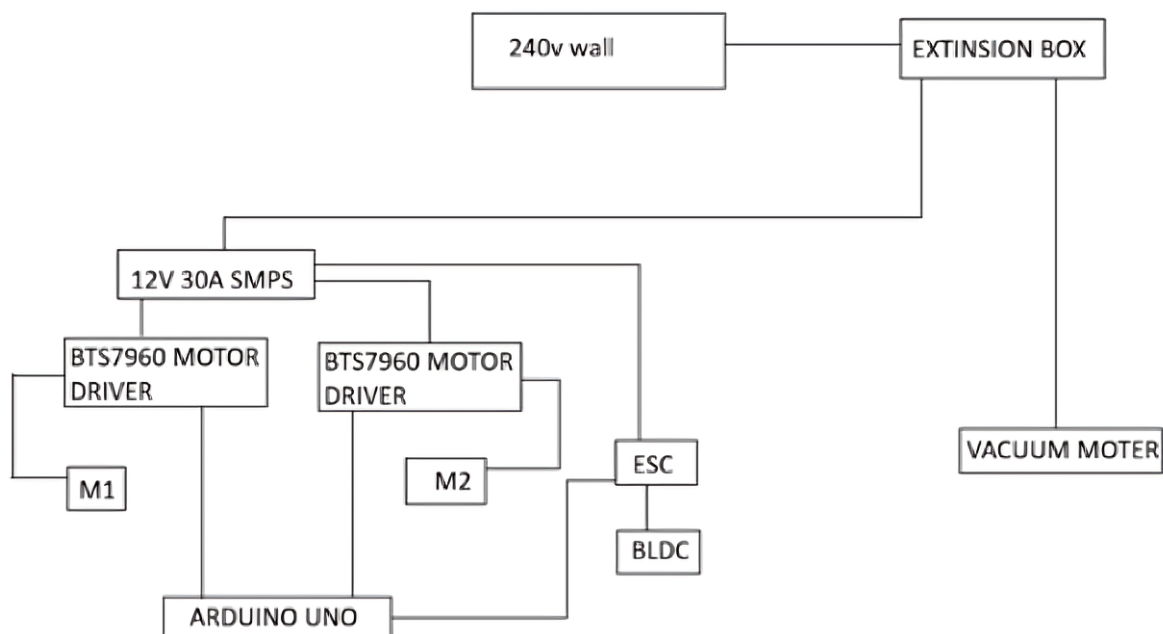
The complete working sequence is summarized below:

1. Power ON? SMPS energizes DC components
2. Bluetooth module pairs with smartphone
3. Arduino via HC-05 receives movement commands
4. BTS7960 motor drivers actuate geared motors
5. BLDC motor cuts grass
6. Vacuum motor collects debris

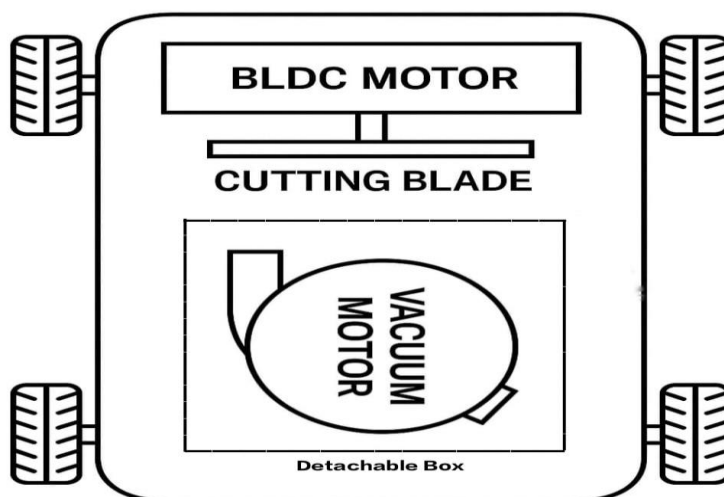
7. Waste is stored in detachable bag

8. System stops on command or when power is switched off

Complete Block Diagram of Component Connections



Mechanical Assembly Diagram: BLDC Motor, Cutting Blade & Vacuum Box



IV. CONCLUSION:

The development of the semi-controlled lawn vacuum cleaner and grass cutter successfully demonstrates an efficient integration of mechanical cutting, suction-based debris collection, and wireless user-controlled navigation. By utilizing high-torque 12 V, 60 RPM geared motors driven through BTS7960 high-current motor drivers, the system achieves stable movement on outdoor lawn surfaces. The BLDC motor, powered via an ESC, delivers consistent cutting performance, while the vacuum module effectively collects grass clippings and leaves, significantly reducing the manual effort required for post-cutting cleanup.

The implementation of a 12 V, 30 A SMPS ensured reliable and uninterrupted power delivery to all DC components, maintaining voltage stability even under high load conditions. Bluetooth control via the HC-05 module provided smooth, low-latency directional operation, enabling precise human-in-loop control without the complexity of autonomous navigation algorithms.

Overall, the prototype validates that a low-cost, semi-controlled robotic platform can perform lawn cutting and cleaning tasks efficiently while remaining simple to operate and maintain. The system offers a practical and accessible alternative to fully autonomous lawn-care robots, making it suitable for residential, institutional, and small-scale outdoor environments.

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