

Solar Powered Grass Cutter with Mobile Remote Control for Medium Outdoor Space

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Abstract- The increasing demand for eco-friendly and automated landscaping solutions has led to the development of a Solar-Powered Grass Cutter with Mobile Remote Control for medium outdoor spaces such as gardens, parks, and institutional campuses. The system harnesses solar energy via photovoltaic panels, which charge a 12V, 7Ah lead-acid battery through an MPPT charge controller. An ESP32 microcontroller receives Bluetooth commands from a mobile application to drive four Johnson DC gear motors (12V, 10 RPM) for mobility and a PMDC motor (12V, 5000 RPM) for blade actuation, interfaced via an L298N motor driver. Field testing demonstrated a cutting efficiency of 98.5% for grass heights of 15–25 mm and 78% for overgrown grass exceeding 60 mm, with operational runtime of 1.5–2 hours per full charge. The total fabrication cost is approximately Rs. 10,955, making it a cost-effective and environmentally sustainable alternative to conventional fuel-powered grass cutters.

Keywords: — Solar energy, ESP32, Grass cutter, L298N motor driver, PMDC motor, Johnson gear motor, Bluetooth control, Renewable energy, Eco-friendly automation.

I. INTRODUCTION

With the growing emphasis on sustainable technologies, the need for environmentally friendly solutions in everyday tasks has become prominent. Lawn maintenance in large outdoor spaces such as parks, sports fields, and institutional campuses requires significant labour, fuel, and electricity. Traditional grass-cutting equipment relies on fossil fuels or grid electricity, contributing to carbon emissions and increased operational costs.

This paper presents a Solar-Powered Grass Cutter with Mobile Remote Control — an eco-friendly alternative designed for effective lawn maintenance in medium outdoor areas. The system integrates renewable solar energy with a Bluetooth-based wireless control interface using an ESP32 microcontroller, enabling remote operation without manual effort or fossil fuel consumption.

The key contributions of this work are: (a) use of ESP32 with Bluetooth Classic for reliable mobile control; (b) integration of MPPT solar charge controller for improved energy harvesting; (c) a dual-motor architecture separating traction (Johnson gear motors) from cutting (PMDC motor); and (d) field validation with quantitative cutting efficiency results across four grass height categories.

II. PROBLEM STATEMENT & OBJECTIVES

Traditional grass cutting equipment presents several key challenges that must be addressed:

- High operational costs due to fuel consumption or grid electricity usage.
- Environmental pollution caused by emissions from gasoline engines.
- Physical strain on operators, including vibration-related health hazards.
- Limited accessibility in remote or uneven terrains.
- Dependency on power sources unavailable in off-grid locations.

To address these challenges, the following project objectives were defined:

- Design and develop a grass cutting machine powered entirely by solar energy.
- Eliminate dependency on petrol and grid electricity using renewable energy.
- Provide wireless remote control via mobile Bluetooth application using ESP32.
- Develop a low-cost (under Rs. 12,000), portable, and eco-friendly prototype.
- Validate cutting efficiency across varying grass heights through field testing.

III. LITERATURE SURVEY

[1] Udamale et al. (2023) — reported a prototype grass cutter powered by solar energy using Arduino UNO with smartphone-based control. The work focused on optimized blade positioning. However, it lacked advanced wireless communication capability and quantitative cutting efficiency results.

[2] Kupawat et al. (2019) — proposed a solar-based smart grass cutter with Bluetooth remote operation and obstacle detection for added safety. While user convenience and energy efficiency were highlighted, quantitative performance data was not reported.

[3] Jagdale & Rajput (2020) — presented an Android- controlled solar grass cutter robot using Arduino and HC- 06 Bluetooth module, powered by a 12V, 7.5Ah battery charged via 10W solar panel. It supported directional control and blade activation but was weather-dependent.

[4] Ramesh Babu et al. (2023) — introduced an autonomous solar grass cutter with obstacle and flame sensors and Android app-based remote control. While autonomous features were advanced, the system complexity and cost were higher compared to the present work.

The proposed system advances prior works by replacing Arduino with ESP32 (dual-core, integrated Wi-Fi and Bluetooth), employing an MPPT charge controller for superior solar energy harvesting, and providing field- validated cutting performance data.

IV. BLOCK DIAGRAM

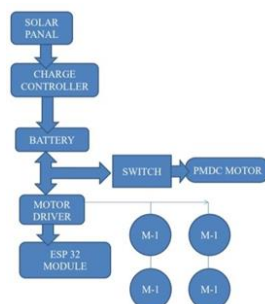


Fig. 1: Block Diagram of Solar Powered Grass Cutter

This block diagram represents the working of a solar powered grass cutter with ESP32 control. The system begins with the solar panel, which converts sunlight into electrical energy. This generated DC power is then sent to the charge controller, whose main function is to regulate the voltage and current so that the battery is charged safely without overcharging or deep discharging. The controlled power is stored in the battery, which acts as the main energy source and supplies power even when sunlight is not available.

From the battery, power is distributed to two sections. First, through a switch, power is supplied to the PMDC motor that drives the cutting blade used for grass cutting. The switch allows the user to turn the cutter ON and OFF easily. Second, the battery supplies power to the motor driver, which acts as an interface between the motors and the ESP32 module. The ESP32 is the main controller that receives commands (such as from mobile Bluetooth control) and sends signals to the motor driver. The motor driver then controls the movement of the four DC motors (M1–M4) that move the wheels of the grass cutter in forward, backward, left, and right directions. Thus, the system efficiently uses solar energy to operate both the cutting mechanism and the movement of the machine in an eco-friendly and automated way.

V. CIRCUIT CONNECTIONS

A. Circuit Description

The complete electrical circuit of the solar grass cutter is described below. The solar panel (output ~14.7V from 3 panels in series) connects to the MPPT charge controller input. The charge controller output connects to the 12V battery terminals. The battery positive terminal is connected to: (i) the VS pin of the L298N motor driver module; and (ii) via a manual switch to the PMDC cutter motor. The ESP32 GPIO pins are connected to L298N control pins for motor direction and speed. The L298N output pins drive the four Johnson gear motors, and the 5V output of L298N powers the ESP32 module.

The L298N motor driver acts as a power bridge between the ESP32 and the motors. Since the ESP32 provides only low-current logic signals, the L298N amplifies these using its internal H-Bridge circuit to drive high-current motors from the 12V battery supply. GPIO pin 13 of ESP32 controls a relay that

switches the PMDC cutter motor ON and OFF independently of the wheel motors.

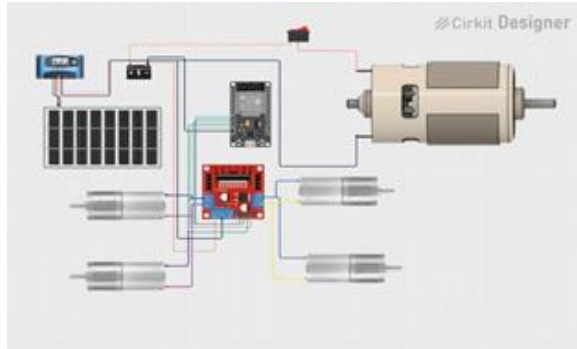


Fig. 2: Circuit Diagram of Solar Powered Grass Cutter

VI. HARDWARE COMPONENTS

A. ESP32 Microcontroller (ESP-WROOM-32)

The ESP32 serves as the central controller with a Tensilica Xtensa Dual-Core 32-bit LX6 processor at 240 MHz, 520 KB SRAM, 4 MB Flash memory, integrated Wi-Fi (802.11 b/g/n) and Bluetooth v4.2 BR/EDR + BLE. It was programmed using Arduino IDE with the BluetoothSerial library to receive single-character commands from a mobile device: 'F' = Forward, 'B' = Backward, 'L' = Left, 'R' = Right, 'S' = Stop, 'C' = Cutter ON, 'c' = Cutter OFF.

B. L298N Motor Driver

The L298N dual H-Bridge motor driver interfaces the ESP32 with DC motors. Key specifications: driver voltage 5–35V, maximum motor supply 46V, driver current 2A per channel, maximum power 25W, logic voltage 5V. It drives four wheel motors in pairs and manages both direction and PWM speed control. An internal 78M05 voltage regulator supplies 5V to the ESP32 when input is 12V.

C. Solar Panel (3 × 4.9V, 2.5W)

Three photovoltaic panels (4.9V, 2.5W each) are connected in series providing approximately 14.7V open-circuit voltage with 7.5W total rated power. The panels use crystalline silicon cells and generate DC electricity through the photovoltaic effect. They charge the battery during daylight hours and supplement runtime during operation.

D. MPPT Charge Controller

An MPPT (Maximum Power Point Tracking) controller continuously adjusts its input to match the

solar panel's optimal operating point and converts excess voltage into additional charging current, improving efficiency by up to 30% compared to conventional PWM controllers. It protects the battery from overcharging and deep discharge, extending battery life.

E. Lead-Acid Battery (12V, 7Ah)

A sealed valve-regulated lead-acid (VRLA/SLA) battery (12V, 7Ah) provides energy storage. It is maintenance-free, operates in any orientation, and delivers high surge currents suitable for motor loads. With a total estimated load of approximately 10A, the battery provides a theoretical runtime of ~42 minutes, extended to 1.5–2 hours due to solar supplementation and variable load conditions.

F. PMDC Motor (Cutter)

A 12V, high-speed PMDC (Permanent Magnet DC) motor rated at approximately 80–100W and 5000 RPM drives the 12-inch steel cutting blade. PMDC motors use permanent magnets instead of field windings, offering compact design, high starting torque, and suitability for battery-powered applications. At 5000 RPM, the blade angular velocity is approximately 523.6 rad/s, providing sufficient kinetic energy to shear grass cleanly.

G. Johnson DC Gear Motor (Wheel Drive)

Four Johnson 12V, 10 RPM DC gear motors drive the wheels. The internal metal gearbox reduces speed while multiplying torque — suitable for moving the 10 kg chassis across varied terrain. Each motor produces approximately 4.77 Nm torque (rated 5W). The 100mm diameter, 40mm width rubber wheels provide adequate ground clearance and traction on soft or uneven surfaces.

VII. RESULTS & PERFORMANCE ANALYSIS

A. Grass Cutting Efficiency

Field tests were conducted across four grass height categories to evaluate cutting performance. The cutting efficiency was calculated as the ratio of cleanly cut grass area to total area traversed by the machine. Results are presented in Table I below:

As observed from Table II, cutting efficiency is highest (98.5%) for short, thin grass (15–25 mm) and decreases progressively with increasing grass height due to higher blade motor load. Even for overgrown

grass exceeding 60 mm, the system maintains 78% cutting efficiency, demonstrating robust performance across typical lawn maintenance conditions. The PMDC motor at 5000 RPM provides sufficient torque to handle medium-density grass without stalling.

Cutting Height (mm)	Grass Density	Efficiency (%)	Power Consumption
15 – 25 mm	Low / Thin	98.5%	Lowest
26 – 45 mm	Medium	92.0%	Moderate
46 – 60 mm	High / Thick	85.0%	High
> 60 mm	Overgrown	78.0%	Maximum (Peak)

Table I: Grass Cutting Performance by Height

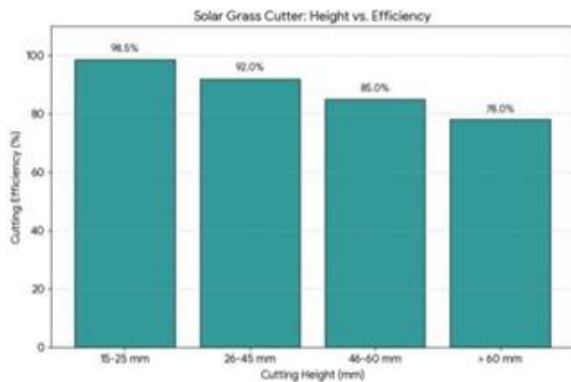


Fig. 3: Bar Graph of Cutting Height vs. Efficiency

B. Overall System Performance

- Solar powered grass cutter successfully developed and field-tested.
- Wireless Bluetooth control via mobile application — responsive with latency < 100 ms within 10 m range.
- Directional movement: forward, reverse, left, and right — smooth and reliable.
- Cutting blade rotates at 5000 RPM and effectively cuts medium height grass.
- Operational runtime: 1.5–2 hours per full charge (solar panel supplements during daylight).
- Battery recharge time: 4–5 hours under full sunlight conditions.
- Adjustable blade height enables uniform cutting across uneven ground surfaces.

VIII. ADVANTAGES & LIMITATIONS

Advantages

- Emission-free operation — powered by solar energy, no fossil fuel combustion.
- Low operational cost — eliminates fuel expenses and minimizes maintenance requirements.
- Enhanced operator safety — remote control keeps user away from blades and debris.
- Low noise — DC motors generate significantly less noise than gasoline engines.
- Portable and lightweight — easy to transport and deploy across various locations.
- Scalable design — can be enhanced with obstacle sensors, GPS, and AI navigation.

Limitations

- Weather dependency — performance is reduced on cloudy or rainy days due to lower solar energy generation.
- Limited runtime — 7Ah battery provides approximately 1.5–2 hours of continuous operation per charge cycle.
- Bluetooth range — effective remote control is limited to approximately 10–15 metres.
- Higher initial investment — compared to basic manual grass cutters, upfront fabrication cost is higher.

IX. FUTURE SCOPE

- AI & Machine Learning: Intelligent path planning, obstacle detection, and automatic grass-type identification for fully autonomous operation.
- GPS Integration: Boundary mapping and geofencing for precise navigation in large outdoor areas.
- Auto-Charging Dock: Autonomous return to charging station when battery level is low.
- Weather Sensing: Automatic pause and shelter during rain or adverse weather conditions.
- Larger Solar Array: Higher-wattage panels for extended operational runtime and faster charging.
- Voice Control: Integration with Google Assistant or Amazon Alexa for hands-free operation.

X. CONCLUSION

This paper presented the successful design, fabrication, and field validation of a solar-powered grass cutter with mobile remote control for medium

outdoor spaces. The system integrates a 12V, 7Ah lead-acid battery charged via an MPPT controller from three series-connected solar panels, an ESP32 microcontroller for Bluetooth-based mobile control, an L298N dual H-Bridge motor driver for four-wheel DC gear motor drive, and a high-speed PMDC motor for blade actuation. Field tests demonstrated cutting efficiency ranging from 98.5% for short grass (15–25 mm) to 78% for overgrown grass (>60 mm), with an operational runtime of 1.5–2 hours per charge. The system is eco-friendly, low-cost, low-maintenance, and practically viable for home lawns, gardens, sports grounds, and institutional campuses. Future enhancements including AI navigation, GPS integration, and auto-charging docks can evolve this prototype into a fully autonomous smart lawn management system.

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