Remote Controlled Lawn Mower

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***Abstract* — This project presents a remote-controlled robotic lawnmower designed for safe and efficient operation. Built around an Arduino Uno with multiple motor controllers, drive motors, and ultrasonic sensors, the system supports manual multidirectional control and autonomous obstacle avoidance. When an obstacle is detected, the mower executes a navigation routine while continuously monitoring its environment. A user-accessible emergency stops overrides autonomous functions to ensure safety. The project highlights the integration of embedded control and sensor technologies to improve functionality and reliability in robotic lawnmower systems.**

***Index Terms* — Control systems, depth measurement, driver behavior, dynamic Response, electrical power distribution,**

I. INTRODUCTION

Lawn mowing is a repetitive and time-consuming task that many homeowners find physically demanding and inconvenient, particularly during peak growing seasons. For individuals with limited mobility or busy schedules, this routine chore can pose a significant burden. The Remote-Controlled Lawnmower was developed to address this challenge by introducing a solution that enhances both convenience and safety through remote-controlled automation and intelligent obstacle avoidance.

This project represents a comprehensive application of embedded systems, sensor integration, and motor control concepts to solve a practical engineering problem in residential lawn care. The system is built around an Arduino Uno microcontroller, supported by four motor controllers, power distribution boards, two motor controllers, and a drivetrain that together provide precise and reliable movement. Communication and user input are managed through a radio receiver and remote controller, while an ultrasonic sensor continuously monitors the environment to detect obstacles in real time.

The lawnmower operates in two distinct modes: manual mode, where the user directly controls movement in all directions, and an obstacle detection mode that activates when an object is sensed within range. During this mode, the mower executes a programmed routine to safely navigate around the obstacle. The system is designed to continually reassess its surroundings and restart the procedure if the obstacle shifts or a new one is encountered, ensuring consistent, safe operation. To maintain user control and safety, an emergency stop function is integrated, allowing the user to interrupt the obstacle detection behavior at any moment.

By addressing the common challenges of physical labor, time constraints, and safety risks, this project demonstrates how embedded technologies can be leveraged to create intelligent, efficient, and user-friendly robotic solutions for modern lawn care.

II. SPECIFICATIONS

Below is the specification table that demonstrates key technical and performance criteria for our Remote-Controlled Lawnmower.

TABLE 1 SPECIFICATION TABLE

Specification	Metric
Weight	≤ 200 lbs.
Distance Travelled	< 500 ft
Obstacle Detection Range	1ft to 2ft
Continuous Run Time	≥ 10 minutes
Obstacle Detection Accuracy	≥ 90%
Remote Control Range	≥ 50 ft
Remote Control Response Time	< 0.2 Seconds
Obstacle Avoidance Latency	≤ 0.3 Seconds
Degree of Rotation	≥ 90 Degrees
Power Consumption	< 250 Watts
Emergency Stop Response Time	< 0.5 Seconds

These specifications will be used as a reference to what our project must achieve on measure terms, within our live demonstration we'll have a focus on obstacle detection range, obstacle detection accuracy, remote control response time, and the emergency stop response time.

A. Obstacle Detection Range

An ultrasonic sensor is employed to measure the distance to the nearest object for obstacle detection. The system is configured to monitor a target range between 1 ft and 2 ft. When an object is detected within this range, the obstacle avoidance routine is initiated to ensure collision prevention and maintain navigation.

B. Obstacle Detection Accuracy

The obstacle detection system is designed to achieve a minimum accuracy of 90% within a target detection range of 1 ft to 2 ft. Again, an ultrasonic sensor is used to measure the distance to the nearest object, with measurements filtered through averaging techniques to mitigate noise and improve consistency. The accuracy threshold is defined as the percentage of correctly identified obstacles within the specified range during testing. Maintaining ≥90% accuracy is essential to ensure the reliable initiation of the obstacle avoidance routine and overall system safety.

C. Remote Control Response Time

The remote-control system is required to maintain a response time of less than 0.2 seconds to ensure timely and responsive user input handling. This specification defines the maximum allowable delay between an input command on the transmitter and the corresponding action executed by the receiver on the robotic system. Achieving this response time is essential for smooth manual operation and effective control during mode transitions. The system utilizes a 2.4 GHz RF communication module designed to minimize latency and provide reliable signal transmission within the specified threshold.

D. Emergency Response Time

The emergency stop function is designed to terminate the obstacle avoidance procedure within 0.5 seconds of activation. This response time ensures that the system promptly ceases obstacle avoidance maneuvers, allowing for immediate manual control or safe system shutdown. The control logic continuously monitors the emergency stop signal and overrides obstacle avoidance commands upon trigger, prioritizing safety and preventing unintended motion.

III. Component Overview

This section provides a detailed description of the primary hardware components integrated into the system. Each component was selected based on performance, compatibility, and suitability for the intended application. Key modules include the microcontroller, motor drivers, ultrasonic sensors, power regulation units, and the remote control interface. Together, these components enable both functionality and manual control, forming the foundation of the system's overall operation

A. Motor

The VEX 393 motor serves as the primary drive mechanism for the remote-controlled lawn mower, enabling precise and reliable movement of the platform. Operating in high-torque mode, the motor delivers sufficient power to support the mower's weight and traverse uneven terrain at controlled speeds. With a stall torque of approximately 1.67 Nm and an output of up to 100 RPM under load, the motor provides the necessary for consistent forward, reverse, and turning motions. Its integration with the drivetrain allows for responsive navigation, both in manual mode via remote control and during obstacle avoidance routines. The motor's compatibility with standard motor drivers and compact form factor makes it an efficient and practical solution for the mower's mobility system.

B. Microcontroller

The ATmega328P microcontroller, integrated on the Arduino Uno platform, serves as the central control unit for the system. Operating at 5 V with a 16 MHz clock frequency, it manages key functions such as sensor data acquisition, motor control logic, and mode switching between manual operation. The microcontroller features 32 KB of flash memory, 2 KB of SRAM, and 14 digital I/O pins, including six PWM outputs, which are utilized for precise motor control. Its compatibility with a wide range of peripheral libraries and ease of programming via the Arduino IDE make it an ideal choice for rapid prototyping and embedded control.

C. Receiver

The Radiolink ER8 receiver is used to enable manual remote control of the lawn mower via a paired transmitter. Operating on a 2.4 GHz frequency band, the ER8 offers low-latency, long-range communication with high resistance to interference, ensuring reliable control in outdoor environments. The receiver supports up to 8 channels, allowing for multi-function input handling such as throttle, steering, and mode switching. Its fast response time and signal stability are critical for maintaining real-time control during manual operation and for initiating emergency overrides during behavior. Compact and lightweight, the ER8 integrates easily with the system's microcontroller, providing a dependable interface between user commands and system actuation.

D. *Sensor*

The HC-SR04 ultrasonic sensor is used to detect obstacles and measure the distance between the mower and nearby objects. It operates by emitting a 40 kHz ultrasonic pulse and measuring the time interval between transmission and echo reception to calculate distance using time-of-flight principles. The sensor provides reliable measurements in the range of 2 cm to 400 cm, with an accuracy of approximately ±3 mm. In this system, the HC-SR04 is configured to monitor a forward detection zone of 1 to 2 feet, which is critical for initiating obstacle avoidance behavior. Its low cost, ease of integration with microcontrollers, and stable performance in short-range applications make it a practical choice for outdoor navigation.

E. *Power Supply*

The system is powered by a 24V 15A switching power supply, providing a maximum output power of 360 W to support high-current components such as DC motors, motor drivers, and onboard electronics. This power supply utilizes switch-mode regulations to deliver efficient voltage conversion with minimal heat generation and reduced power loss. The 24V output ensures sufficient headroom for voltage regulation and motor performance, while the 15A current capacity accommodates transient loads and peak power demands. Its compact form factor, integrated overvoltage and overcurrent protection, and high conversion efficiency make it well-suited for mobile robotics applications requiring both power stability and energy efficiency.

F. *Battery*

The EcoFlow River 2 Pro is utilized as the main portable power supply for the remote-controlled lawn mower, providing a reliable and consistent energy source for all onboard systems. With a capacity of 768 Wh and a continuous output of up to 800 W, it is capable of powering motors, control electronics, and sensors without the need for an external power connection. Its $LiFePO_4$ battery chemistry ensures long operational life and stable voltage output under load. The portability and high-power availability of the River 2 Pro make it an ideal solution for outdoor, untethered operation of the mower.

G. *Remote Controller*

The BetaFPV LiteRadio 2 SE serves as the handheld transmitter for manual operation of the robotic lawn mower. Operating in the 2.4 GHz ISM band, the controller transmits control signals wirelessly to the onboard Radiolink ER8 receiver, which converts the RF commands into standard PWM signals for the Arduino Uno. This setup enables real-time control of throttle, steering, mode switching, and emergency stop functionality. The LiteRadio 2 SE supports up to eight independent channels, and in this project, channels are mapped specifically to motor speed (CH1, CH4) and mode control (CH5), allowing seamless integration with both manual operation modes.

IV. System Design and Architecture

The system is designed as a compact, mobile platform capable of operating in both manual and obstacle avoidance modes. Core components include two VEX 393 DC motors for drivetrain actuation, an ATmega328P-based microcontroller for control logic, an HC-SR04 ultrasonic sensor for obstacle detection, and a Radiolink ER8 receiver for manual input.

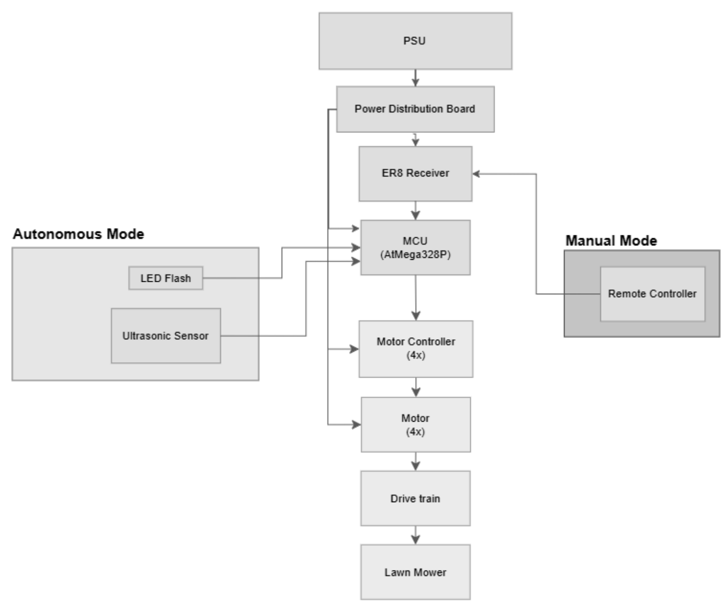

Fig. 1 Hardware Block Diagram

The mower operates in two distinct modes: manual and obstacle avoidance. In manual mode, the user controls the mower via the Radiolink ER8 remote, sending throttle and directional inputs directly to the microcontroller. Obstacle avoidance mode is activated when an obstacle is detected within a predefined range, causing the system to override manual input and execute an avoidance maneuver. Mode switching is handled by the microcontroller and follows a priority system that favors safety-critical operations such as emergency stops or sensor-triggered navigation events.

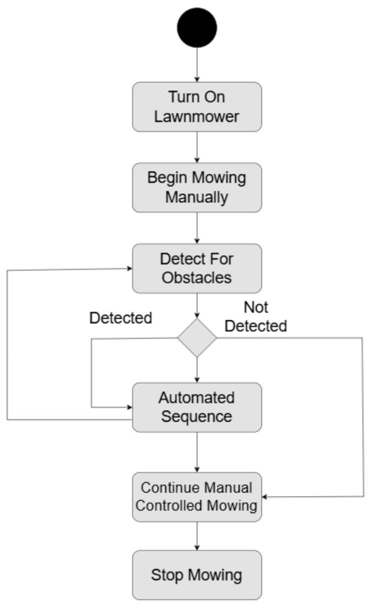

Fig. 2 Activity Diagram

Obstacle detection is performed using a single front-facing HC-SR04 ultrasonic sensor, which continuously measures the distance to nearby objects. When an object is detected within 1 to 2 feet, the system triggers an avoidance sequence: the mower halts, executes a right turn, advances forward briefly, and then performs a left turn to re-align with its original path. The sensor readings are filtered using a basic moving average to improve accuracy and reduce false triggers caused by noise or environmental interference.

The robotic platform moves using two VEX 393 motors arranged in a differential drive configuration. PWM signals from the microcontroller control motor speed, while directional changes are managed through an H-bridge driver integrated into the custom PCB. By adjusting the speed of each motor independently, the system achieves forward, reverse, and turning motions. In obstacle avoidance mode, motor behavior is governed by control logic, whereas in manual mode, it responds to real-time inputs from the remote controller. The ATmega328P microcontroller serves as the central processor, coordinating inputs from the ultrasonic sensor and receiver while issuing control commands to the motor driver. Digital and analog I/O pins are mapped to specific system tasks, such as PWM generation, sensor triggering, and signal reading. The control loop is implemented using interrupt-driven programming, allowing timely responses to sensor data and emergency stop signals. Software routines are structured to prioritize real-time responsiveness and deterministic behavior.

Timely response is critical for both user control and obstacle avoidance functions. The system is configured to react to manual inputs within 0.2 seconds and to emergency stop commands within 0.5 seconds. The emergency stop routine immediately disables motor outputs and overrides all control modes. This feature is embedded into both software and hardware layers to ensure redundancy and reliability. The system also includes basic timeout monitoring to prevent unexpected behavior due to communication loss or sensor failure.

V. Control Logic and Software Implementation

The control logic of the robotic lawn mower is executed on the Arduino Uno microcontroller, which orchestrates sensor inputs, user commands, and motor actuation in real time. The system operates in two primary modes: manual and obstacle avoidance. In manual mode, the Arduino continuously reads PWM signals from the Radiolink ER8 receiver. Channel inputs for throttle and steering are mapped directly to the left and right drive motors using PWM outputs, enabling smooth and responsive control. Any invalid or missing signals are neutralized to prevent erratic behavior, ensuring consistent motion within a response time of less than 0.2 seconds.

Table 2 Pin Configuration for ER8 Receiver

Channel	Function	Measurement
CH1	Forward/Backward (Left)	>1500 µs backwards < 1500 µs forwards
CH4	Forward/Backward (Right)	
CH5	Emergency Stop	Halts all signals

When an obstacle is detected within one to two feet by the onboard ultrasonic sensor, the system switches into obstacle avoidance mode, temporarily overriding manual inputs. A predefined avoidance routine is executed through a state machine that controls a sequence of actions: reversing, braking, turning right, moving forward, turning left, and redetecting obstacles as needed. Each maneuver is precisely timed using millisecond counters, and PWM signals are adjusted to control motor speed and direction smoothly. If a new obstacle is detected mid-sequence, the routine resets and reinitiates from the beginning.

Mode switching is embedded in the main control loop, with priority given to safety. A manual override or emergency stop command delivered through a designated PWM channel or a physical switch immediately halts all motor activity and resets the control logic. Interrupt-driven programming ensures these emergency signals are serviced with minimal delay, meeting the system's safety requirement of a response time under 0.5 seconds.

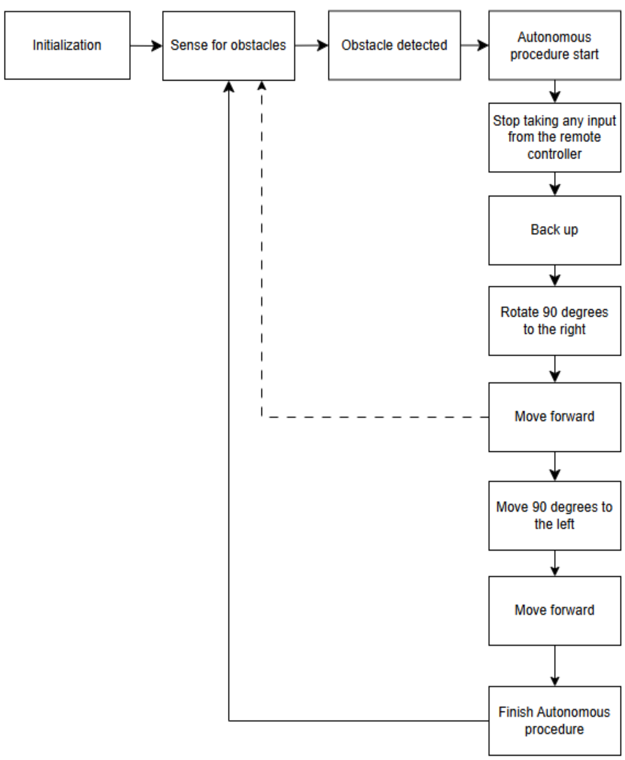

Fig. 3 Obstacle Avoidance Procedure

To increase reliability, the ultrasonic sensor readings are filtered using a moving average algorithm, reducing false positives due to signal noise or reflection artifacts. The control software avoids blocking operations and leverages time-based logic using the millis() function, maintaining a deterministic and non-blocking control loop. This ensures that sensor data, mode arbitration, and motor commands are updated consistently and predictably, even under complex conditions.

VI . Hardware System Design

The hardware subsystem of the remote-controlled lawn mower was designed to achieve robust wireless operation, real-time environmental sensing, and efficient motor control while maintaining high electrical reliability and low power consumption. The design is modular, separating the control logic, power electronics, and sensing interfaces, which enhances system maintainability and scalability for future upgrades or feature expansion.

A. Embedded Control Unit and Peripheral Interfaces

The central processing element of the system is the ATmega328P microcontroller, as shown in Fig. 4, is an 8-bit, low-power microcontroller, widely utilized in embedded control applications due to its balance of computational capability, low power requirements, and extensive peripheral support. Operating at 16 MHz, the microcontroller provides sufficient processing bandwidth to handle concurrent tasks, including wireless command decoding, PWM signal generation for motor control, and ultrasonic distance measurement.

The microcontroller is clocked using a 16 MHz external crystal oscillator, supported by a pair of 22 pF ceramic capacitors to ensure stable frequency operation, critical for accurate PWM timing and reliable communication protocols. A hardware reset circuit, composed of a tactile push-button and a 10 kΩ pull-up resistor, enables system restarts during development or in the event of software faults.

Peripheral connectivity is facilitated through multiple standardized headers, simplifying integration with key subsystems. The ultrasonic distance sensor interfaces through header J6, providing real-time obstacle detection via echo-pulse timing. This sensor data is processed through interrupt-driven routines, allowing the microcontroller to react to environmental changes with minimal processing overhead. The wireless remote control system utilizes an ER8 radio receiver, connected through dedicated I/O lines. The receiver converts operator joystick inputs into digital or PWM signals, which are directly processed by the microcontroller to command motor speed, direction, and navigation behaviors.

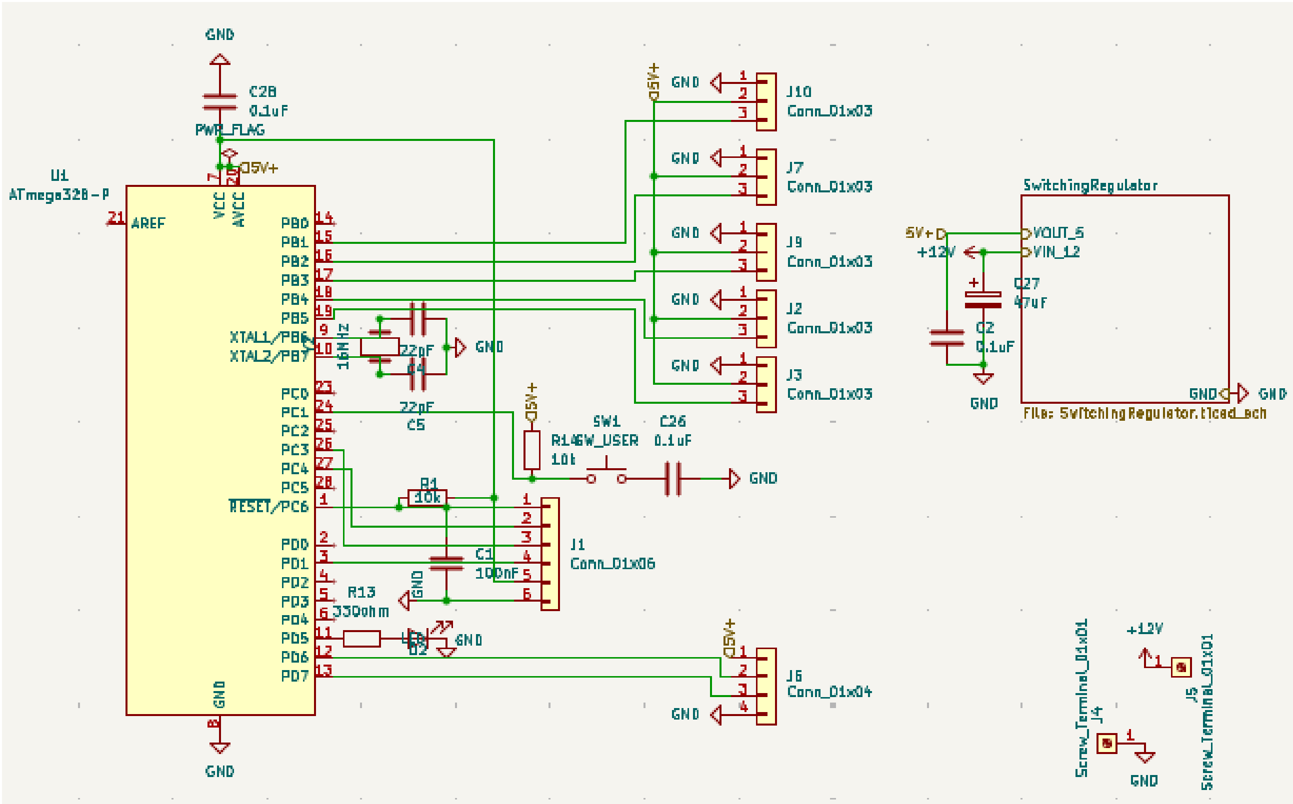

Fig. 4 ATmega328P microcontroller circuit for system control, wireless receiver interface, and ultrasonic sensing

Four additional headers route pulse-width modulation signals from the microcontroller to the motor driver circuitry, providing fine-grained control over each motor channel. The modular design of these connections allows for straightforward replacement or modification of sensors, actuators, or auxiliary electronics without significant redesign of the main control board.

The ATmega328P microcontroller functions as the decision-making center, coordinating wireless inputs, real-time sensor data, and actuator outputs. This integrated approach enables responsive, reliable operation of the lawn mower across diverse environmental conditions.

B. High-Power Motor Driver Architecture

The propulsion system of the lawn mower requires a motor driver capable of efficiently switching high-current loads while maintaining electrical isolation between sensitive control electronics and the noisy power stage. The complete motor driver architecture is depicted in Fig. 5.

At the heart of the driver circuit is the A9494DKLPT-R gate driver integrated circuit, which provides the necessary current and voltage levels to rapidly switch the gates of the power MOSFETs. Fast, reliable switching is essential for minimizing energy losses and achieving smooth motor operation, particularly in dynamic load environments such as outdoor terrain.

The motor power stage utilizes four AO4401E N-channel MOSFETs configured in an H-bridge topology. This arrangement enables full bidirectional control of the DC motors, allowing the lawn mower to move forward, reverse, and perform differential steering maneuvers. The MOSFETs' low on-resistance reduces conduction losses, enhancing efficiency and minimizing thermal stress on the components.

Electrical isolation between the microcontroller and motor driver is provided by a TLP118E opto-isolator, which transmits control signals via optical coupling. This isolation is critical for protecting low-voltage logic circuits from voltage spikes, inductive kickback, and ground potential differences commonly present in high-current motor circuits. Opto-isolated designs significantly enhance system robustness, especially in electrically noisy outdoor environments.

An auxiliary PIC16F1829 microcontroller is integrated within the motor driver subsystem. This secondary microcontroller provides additional safety, diagnostics, and visual feedback functions. It monitors motor driver status and communicates fault conditions to the main control unit. Additionally, it controls RGB LED indicators, providing visual cues for system status, including idle, active, and fault states. This layered approach improves fault detection and simplifies system monitoring during operation and maintenance.

The motor driver PCB includes onboard test points, screw terminal connectors for power and motor wiring, and decoupling capacitors for noise suppression. These features improve system serviceability, allowing technicians to perform in-field diagnostics, voltage measurements, and rapid hardware replacement.

C. Power Regulation and Distribution

Reliable power delivery is fundamental to the stable operation of both control and actuation circuits. The system employs a high-efficiency, synchronous DC-DC buck converter to step down the main battery voltage to a regulated 5V supply, as shown in Fig. 6.

The regulation stage is based on the LMR51265YFDDCR, a compact switching regulator that supports input voltages up to 17V and provides up to 2A of output current. The converter steps down the 12V battery voltage, delivering a stable 5V rail necessary for the ATmega328P microcontroller, the PIC16F1829 subsystem, and other logic-level devices.

Input filtering is implemented with a 47 µF electrolytic capacitor and a 100 nF ceramic capacitor, mitigating voltage ripple and suppressing transient spikes originating from the battery, especially under high motor load conditions. The output stage comprises a 10 µH power inductor and additional ceramic capacitors to ensure low ripple voltage at the 5V output. Proper filtering and regulation prevent noise coupling into sensitive control signals, thereby enhancing system stability.

Voltage feedback regulation is achieved through a resistive divider, composed of 100 kΩ and 200 kΩ precision resistors, setting the output voltage to the desired 5V level. The circuit's compact footprint and high conversion efficiency are advantageous in mobile, battery-powered applications, reducing thermal dissipation and prolonging

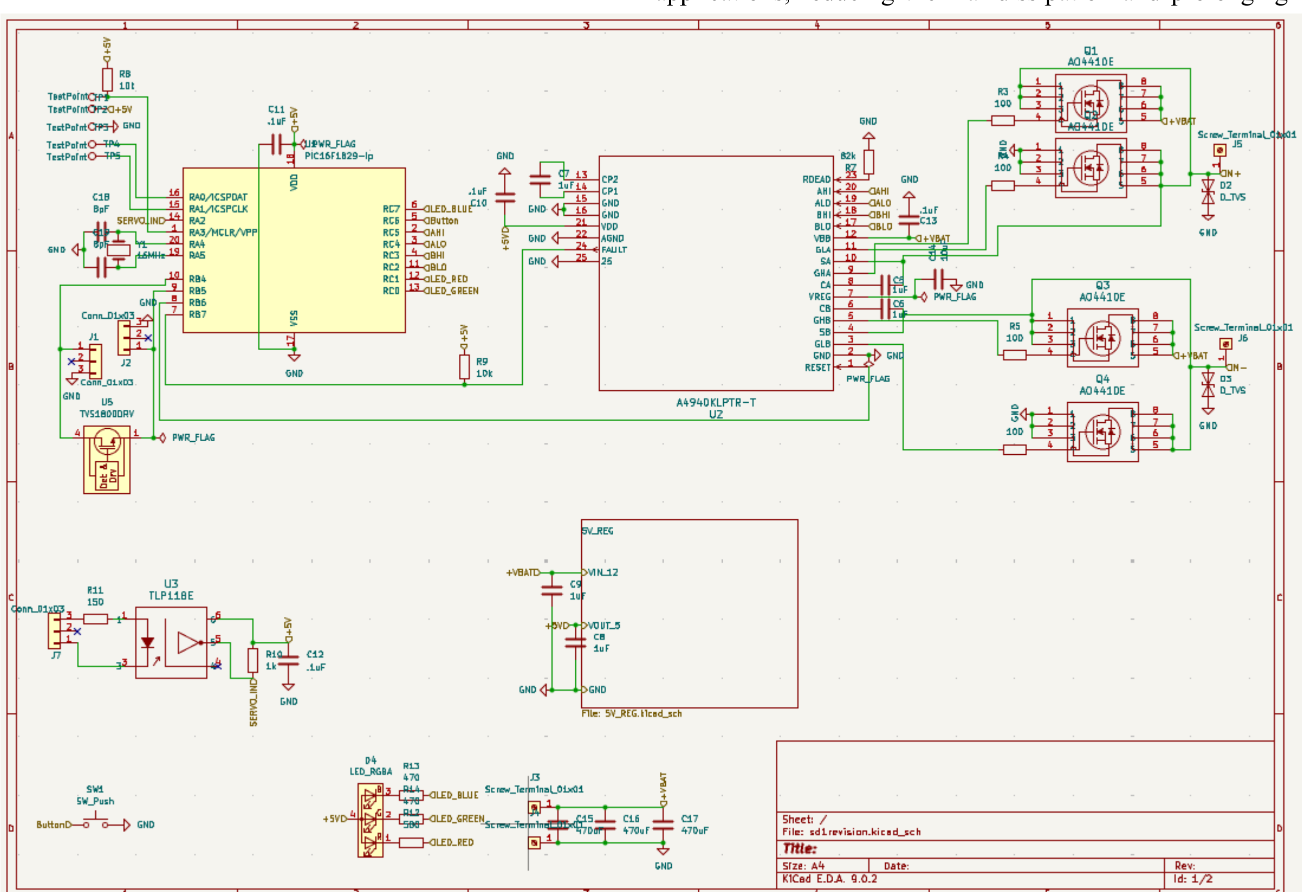

Fig. 5 High-power motor driver circuit with H-bridge MOSFET configuration, opto-isolation, and integrated status monitoring.

system runtime. The modular power design simplifies future expansion, allowing higher-capacity power supplies to be integrated as system demands grow.

Overall, the power regulation subsystem ensures clean, stable voltage delivery, forming the electrical backbone of the lawn mower's control and actuation systems

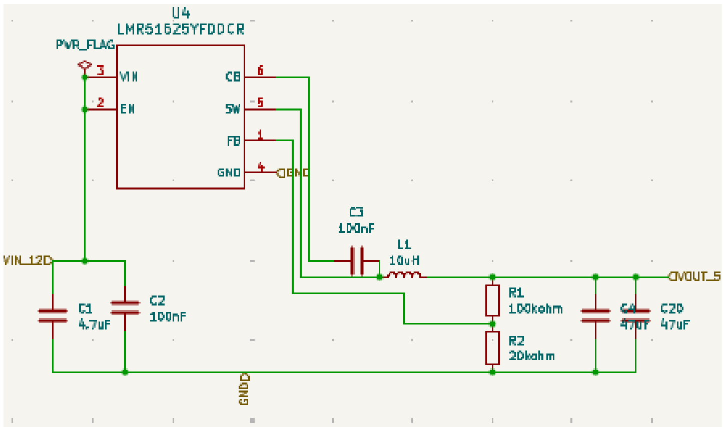

Fig. 6 Switching voltage regulator providing 5V stabilized output from 12V battery source.

Conclusion

This project successfully demonstrates the design and implementation of a remote-controlled robotic lawn mower equipped with obstacle avoidance. By integrating low-cost hardware components including the Arduino Uno, ultrasonic sensing, custom PCB, and portable power supply the system balances manual control with automated navigation in a compact and modular platform. The control logic prioritizes safety, responsiveness, and expandability, making the mower both functional for real-world use and adaptable for future development. This work lays the foundation for more advanced outdoor systems through scalable hardware and software integration.

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Biography

Brayden Anderson is currently a senior at the University of Central Florida graduating with a Bachelors of Science in Electrical Engineering in August of 2025. He currently works at L3 Harris as an engineer.

Steven Huynh is currently a senior at the University of Central Florida and will graduate with a Bachelor's of Science in Computer Engineering in August of 2025. He currently works at Unilumin, an audio/visual company focusing in manufacturing LED's .

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