TeslaBot

A Bluetooth-Controlled Robot with Wireless Power Transmission

A project submitted to the Bharathidasan University

in partial fulfillment of the requirements

for the award of the Degree of

BACHELOR OF COMPUTER APPLICATIONS

Submitted by

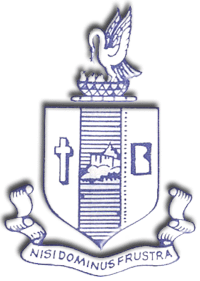
**R. Sasikumar**

Register Number: 235113714

Under the guidance of

**N. Geetha**,

Assistant Professor



DEPARTMENT OF COMPUTER APPLICATIONS

BISHOP HEBER COLLEGE (AUTONOMOUS)

“Nationally Reaccredited at A++ Grade with a CGPA of 3.69 out of 4 in NAAC IV Cycle”

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**TIRUCHIRAPPALLI-620 017**

OCTOBER – 2025

DECLARATION

I hereby declare that the project work presented is originally done by me under the guidance of  **Dr.M.Kavitha, M.Sc, M.Phil., Ph.D.,Assistant Professor, UG Department of Computer Applications, Bishop Heber College (Autonomous), Tiruchirappalli-620 017** and has not been included in any other thesis/project submitted for any other degree.

Name of the Candidate : R. Sasikumar

Register Number : 235113714

Batch : 2023-2026

Signature of the Candidate

**N. Geetha,**

**Assistant Professor,**

UG Department of Computer Applications,

Bishop Heber College (Autonomous),

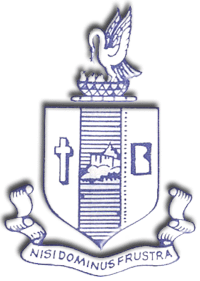
Tiruchirappalli – 620017

**Date:**

**CERTIFICATE**

This is to certify that the project work entitled **“TeslaBot: A Bluetooth-Controlled Robot with Wireless Power Transmission”** is a bonafide record work done by **R. Sasikumar, Register Number: 235113714** in partial fulfillment of the requirements for the award of the degree of **BACHELOR OF COMPUTER APPLICATIONS during** the period **2023 - 2026.**

**Place: Signature of the Guide**

**UG DEPARTMENT OF COMPUTER APPLICATIONS**

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TIRUCHIRAPPALLI – 620 017

Date:

Course Title: Course Code: U23CA5PJ

CERTIFICATE

The Viva-Voce examination for the candidate R. Sasikumar, Register Number:235113714 was held on \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

Signature of the Guide Signature of the HOD

Examiners:

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**ABSTRACT**

**CHAPTER – 1**

**ABSTRACT**

In the modern era of technological advancements, the demand for innovative solutions that combine mobility, automation, and energy efficiency is steadily increasing. The proposed project, TeslaBot, is a Bluetooth-controlled robotic car integrated with a Tesla coil for wireless power transmission. This system is designed to address the growing need for mobile, remotely operated machines capable of delivering power in emergency, medical, and defense scenarios.

The TeslaBot is engineered to perform two key functions: remote-controlled mobility and wireless energy delivery. Using a simple Bluetooth interface, the bot can be operated via a smartphone, enabling smooth navigation and maneuvering even in restricted or hazardous environments. Mounted on the bot is a Tesla coil, which generates a high-frequency electromagnetic field to transmit electrical energy wirelessly. This wireless power can be used to charge small electronic devices, light up equipment, or provide temporary power in critical situations where conventional wired supply is impractical.

The system combines hardware components such as Arduino microcontroller, Bluetooth module, motor driver, DC motors, and Tesla coil with software programming through the Arduino IDE for seamless operation. The use of wireless communication enhances user control, while the Tesla coil ensures contactless power delivery. The design is modular, cost-effective, and scalable, making it adaptable to a wide range of applications.

Practical applications of TeslaBot include deployment in military zones, where it can provide backup power to communication devices without human exposure to danger; in hospitals and emergency services, where it can supply temporary power during outages; and in remote or disaster-hit areas, where quick access to wireless charging can support critical rescue operations. Additionally, the project showcases the integration of robotics and energy transfer technologies, contributing to future research in sustainable and contactless power solutions.

By uniting robotic automation with wireless power transmission, TeslaBot represents a step forward in bridging mobility with energy innovation. It not only demonstrates technical feasibility but also highlights the potential of robotic systems in enhancing human safety, operational efficiency, and technological progress in real-world environments.

**Keywords:** TeslaBot, Bluetooth Control, Wireless Power Transmission, Tesla Coil, Robotics, Automation, Energy Innovation.

**INTRODUCTION**

**CHAPTER – 2**

**INTRODUCTION**

Robotics and wireless power transmission are two rapidly advancing fields that are reshaping the way technology interacts with the world. In today’s era, automation plays a vital role in simplifying human efforts and enhancing operational efficiency across industries such as healthcare, defense, transportation, and energy. Alongside this, the concept of wireless power has emerged as a revolutionary solution to overcome the limitations of traditional wired charging systems. The integration of these two domains has led to the development of TeslaBot – a Bluetooth-controlled robot with wireless power transmission using a Tesla coil.

The main idea behind TeslaBot is to create a mobile robotic platform that can be operated remotely through a smartphone while simultaneously delivering power wirelessly to small devices and equipment. By combining the mobility of robotics with the capability of wireless energy transfer, this project aims to provide a versatile solution for emergency, medical, and military applications where wired power delivery is often challenging or risky.

The robotic car is designed using a microcontroller-based system that communicates with a smartphone via Bluetooth. Through this connection, the user can control the movement of the bot in different directions, enabling flexible navigation in various terrains and situations. The Tesla coil mounted on the bot generates a high-frequency electromagnetic field, allowing power to be transmitted without the need for direct contact. This enables the charging of electronic devices and operation of small loads within a limited range.

The problem addressed by TeslaBot lies in the difficulties of providing instant power in remote or hazardous areas. In military operations, soldiers often face communication failures due to lack of power supply in field zones. Similarly, in hospitals and emergency rescue missions, immediate power requirements arise where conventional wired methods are impractical. TeslaBot bridges this gap by offering a mobile, safe, and wireless power delivery system that reduces human effort and enhances efficiency.

Furthermore, TeslaBot demonstrates the potential of combining automation with energy innovation. Unlike conventional robots that focus solely on navigation or object handling, TeslaBot adds value by integrating energy transmission, making it a dual-purpose system. The project highlights the feasibility of applying Nikola Tesla’s principle of wireless energy transfer in modern robotics, presenting opportunities for future research in sustainable and contactless power solutions.

Thus, TeslaBot not only serves as a working prototype but also stands as a futuristic model for solving real-world challenges. It brings together the concepts of remote control, wireless communication, robotics, and Tesla coil-based energy transfer, showing how interdisciplinary technologies can work in synergy to deliver practical and innovative solutions for humanity.

**Existing and Proposed System**

**CHAPTER-3**

**Existing and Proposed System**

**3.1 Existing System**

Robotic vehicles and wireless power transmission technologies have been extensively explored, but most systems operate independently without integration. Traditional mobile robots are generally controlled via remote controllers or pre-programmed paths. While these systems allow basic navigation, they have limited range due to reliance on short-range wireless communication or wired connections. Wireless power transmission setups, such as stationary Tesla coils or inductive chargers, require devices to be placed in close proximity to the transmitter, making them impractical for dynamic or remote applications. Furthermore, most existing systems do not combine mobility and energy transfer, which necessitates manual intervention to position devices and increases operational complexity. High-voltage exposure in these systems also poses significant safety risks, limiting their real-world usability.

**Limitations of Existing Systems:**

1. **No integration of mobility and power transmission:** Existing systems are either robotic or wireless chargers, preventing simultaneous operation.
2. **Manual intervention required:** Devices must often be physically positioned for charging or operation, increasing human effort.
3. **Limited operational range:** Reliance on short-range communication or stationary setups restricts applicability in remote or dynamic environments.
4. **Safety concerns:** High-voltage exposure during wireless transmission poses risks in practical deployment scenarios.

These limitations highlight the need for a low-cost, mobile, and safe solution capable of combining autonomous navigation with wireless power delivery.

**3.2 Proposed System**

To overcome the limitations of conventional robotic and stationary wireless power systems, this project proposes the TeslaBot, a Bluetooth-controlled robotic car integrated with a Tesla coil for wireless power transmission. Unlike existing solutions, TeslaBot combines autonomous mobility and energy delivery in a single platform, enabling it to navigate dynamic environments and deliver power safely without human intervention. The system is designed to be modular, low-cost, and scalable, making it suitable for educational purposes, research, and practical deployment in emergency or industrial scenarios.

**Key Features of the Proposed System:**

1. **Arduino Uno Microcontroller** – The Arduino Uno acts as the central processing unit of the TeslaBot. It manages all operations including motor control, reading sensor inputs, Bluetooth communication, and coordinating the Tesla coil for wireless power transmission. The Arduino ensures that the robot responds accurately to user commands and maintains safe operation of the high-voltage transmission system.
2. **Bluetooth HC-05 Module** – This module provides seamless wireless connectivity between the robot and a smartphone or tablet. Through a dedicated mobile application, the operator can send movement commands in real-time, monitor the robot’s status, and even control the Tesla coil activation. Bluetooth connectivity ensures a flexible range of operation without the need for physical wiring.
3. **DC and Servo Motors** – DC motors drive the wheels for forward, backward, and turning movements, while servo motors provide precise adjustments for steering or positioning of attachments. The combination allows the robot to navigate complex environments and reach target locations efficiently, even in tight or uneven terrains.
4. **Tesla Coil for Wireless Power Transmission** – The Tesla coil generates high-frequency alternating voltage capable of transmitting energy wirelessly to nearby devices. This feature eliminates the need for manually positioning devices near a charging source and allows the robot to perform power delivery in remote or hazardous areas. The coil is designed with safety limits to prevent electrical hazards.
5. **Integrated Chassis and Modular Design** – All components are mounted on a sturdy chassis that provides stability and protects the electronics. The modular design allows easy access for maintenance, upgrades, or integration of additional sensors such as temperature, obstacle detection, or IoT modules for advanced monitoring.
6. **User-Friendly Operation and Control** – TeslaBot can be operated via a simple mobile application, making it accessible even for users without technical expertise. The interface allows control over movement, activation of the Tesla coil, and real-time feedback on battery status and operational safety.
7. **Safety Features** – The system incorporates multiple safety measures, including voltage regulation for the Tesla coil, secure wiring, and automatic shutdown in case of overheating or fault detection. These features make TeslaBot safe to operate in laboratory, industrial, or experimental environments.

**Advantages over Existing Systems:**

* Integrated mobility and wireless power delivery, removing the need for manual device placement.
* Extended operational range through Bluetooth control, enabling deployment in larger or remote areas.
* Safe and modular design, reducing risks associated with high-voltage operations.
* Cost-effective solution, using widely available components like Arduino, DC motors, and Bluetooth modules.
* Scalable and upgradeable, allowing future integration of IoT connectivity, additional sensors, or AI-based navigation for autonomous operation.

**SOFTWARE AND HARDWARE REQUIREMENTS**

****CHAPTER-4****

## **Software and Hardware Requirements**

## To develop and operate the TeslaBot effectively, a specific set of hardware and software tools is required. This section outlines the components necessary for building, programming, and managing the robotic car integrated with wireless power transmission.

## **4.1 Hardware Requirements**

## The hardware components are the physical parts that make up the TeslaBot. These include the microcontroller, motors, power system, Tesla coil, and other essential modules that enable autonomous movement, wireless control, and energy transmission.

## **1. Arduino Uno Microcontroller**

## Acts as the main control unit of TeslaBot.

## Handles motor control, Bluetooth communication, and Tesla coil operation.

## Coordinates all actions to ensure safe navigation and wireless power delivery.

## **2. Bluetooth Module (HC-05)**

## Provides wireless connectivity between TeslaBot and a smartphone or tablet.

## Allows remote control of movement directions and activation of the Tesla coil.

## Supports real-time communication for responsive navigation.

## **3. DC Motors with Wheels**

## Provide locomotion for TeslaBot.

## Controlled by the motor driver module for forward, backward, and turning movements.

## Enable the robot to navigate complex or uneven terrain.

## Gebildet 4pcs DC3V-12V DC Geared Motor for Four-wheel Drive Toy Car/Robotic Body/Aircraft Toys+4pcs Plastic Tire Wheels : Amazon.in: Toys & Games

## **4. Servo Motors**

## Used for precise steering adjustments or for positioning attachments if required.

## Robodo SG 90 Tower Pro Micro Servo MotorEnsures accurate directional movement for better navigation.

## **5. Motor Driver Module (L298N)**

## Interfaces between Arduino and DC motors.

## Handles high-current requirements of the motors safely.

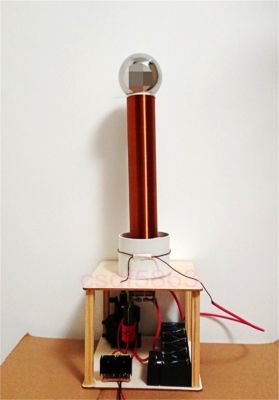
## Buy L298N Based Motor Driver Module – 2A Online at Robu.inAllows bidirectional movement and speed control.

## **6. Tesla Coil**

## Generates high-frequency voltage for wireless power transmission.

## Delivers energy to nearby devices without physical connections.

## Equipped with voltage limits and safety measures for controlled operation.



**7. Power Supply**

## A rechargeable Li-ion or Li-Po battery pack (7.4V–12V depending on motor specifications).

## Powers Arduino, motor driver, and Tesla coil simultaneously.

## How Lithium-ion Batteries Work - COE for EV Lab, AI Lab, IOT & Embedded Lab, Solar Lab and Drone LabVoltage regulators ensure stable and safe power distribution.

## **8. Chassis and Mounting Components**

## Provides structural support for all electronic and mechanical components.

## Lightweight design allows smooth movement and easy maintenance.

## Modular framework enables future upgrades or sensor additions.

## **9. Jumper Wires, Breadboard/PCB**

## Jumper wires interconnect all components.

## ApTechDeals Breadboard 840 point with jumper wires Set(10+10+10)Breadboard or custom PCB ensures neat and stable connections.

## **4.2 Software Requirements**

## Software tools are essential for programming the Arduino, integrating sensor data, controlling the motors, and managing wireless power transmission.

## **1. Arduino IDE**

## Used for writing, compiling, and uploading code to the Arduino Uno.

## Supports C/C++ programming for embedded applications.

## Allows inclusion of libraries for motor control, Bluetooth communication, and Tesla coil operation.

## **2. Required Libraries**

## Servo.h – Controls servo motor rotations.

## SoftwareSerial.h – Enables serial communication with the HC-05 Bluetooth module.

## Wire.h / Adafruit Libraries (optional) – For additional sensors or modules in future upgrades.

## **3. Mobile Application (Bluetooth Controller)**

## Sends commands to TeslaBot via HC-05 module.

## Provides user-friendly interface for movement control and Tesla coil activation.

## Real-time operation ensures responsive navigation.

## **4. Serial Monitor / Debugging Tools**

## Arduino IDE Serial Monitor is used during development for debugging.

## Checks motor control signals, Bluetooth communication, and Tesla coil activation.

## Ensures correct calibration and safe operation.

## **5. Optional Tools**

## Fritzing / Proteus / Tinkercad – For circuit simulation and diagram creation.

## Version Control (GitHub) – To manage source code and track updates.

## 

**Review of Literature**

**CHAPTER-5**

**5.1 Review of Literature**

The development of robotic systems with wireless power transmission and remote navigation has been an active area of research in recent years. Scholars and engineers have consistently emphasized the importance of integrating robotics with emerging technologies like wireless energy transfer, IoT, and artificial intelligence to improve autonomy, efficiency, and real-world applicability. Over time, research has shifted from simple remote-controlled systems to intelligent, self-powered platforms capable of addressing critical challenges in defense, healthcare, and industrial sectors.

One of the earlier works in this domain was by William C. Brown (1969), who pioneered the concept of wireless power transmission using microwaves. His experiments laid the groundwork for future research into safe and efficient energy transfer methods. Although his work was more theoretical at the time, it highlighted the potential of powering remote devices without physical connections, which directly inspires projects like TeslaBot. Later, Kurs et al. (2007) demonstrated efficient mid-range wireless power transfer using resonant inductive coupling. Their study proved that it was possible to transmit power wirelessly with practical efficiency levels while maintaining safety. This advancement was critical because it showed that wireless power could be integrated into moving systems such as robots, drones, and autonomous vehicles.

In the robotics field, Rajesh Mothe et al. (2020) introduced an IoT-based obstacle-avoidance robot using Arduino and ultrasonic sensors. Their work demonstrated how low-cost microcontrollers could be integrated with IoT platforms for navigation and monitoring. Although the system was limited to basic movement control and collision prevention, it represented a step toward combining automation with remote connectivity.

Recent works, such as by Patil and Jadhav (2021), have focused on Bluetooth and Wi-Fi-based robotic control systems. Their study explored how wireless modules like HC-05 and ESP8266 can be used for real-time control of mobile robots, eliminating the need for wired connections. This approach is closely aligned with TeslaBot, which also employs Bluetooth for remote navigation and wireless modules for flexible communication.

Another significant development comes from energy research where Singh and Kumar (2022) examined compact Tesla coil designs for wireless charging applications. Their findings indicated that Tesla coils could provide sufficient energy transfer for small devices, particularly in emergency situations where physical charging is not feasible. TeslaBot builds upon this principle by integrating a Tesla coil on a robotic platform, making it possible to deliver power wirelessly to external systems in field operations.

From these studies, it is evident that robotics, wireless power transmission, and IoT technologies have been advancing in parallel. TeslaBot draws inspiration from these works by combining remote-controlled navigation, Bluetooth communication, and Tesla coil-based wireless energy transfer into a single integrated system. Unlike earlier approaches that focused on either navigation or energy transfer separately, TeslaBot merges both, making it a practical prototype for future applications in military, healthcare, and emergency services.

**DEFINITION OF THE PROBLEM AND SCOPE OF THE RESEARCH WORK**

**CHAPTER-6**

**Definition of the Problem and Scope of the Research Work**

## **6.1.Definition of the Problem**

With the increasing demand for mobile robotics in defense, healthcare, and emergency applications, the challenge of integrating both mobility and wireless power transmission has become evident. Most existing robots either focus on navigation alone or on stationary wireless charging systems, but very few attempt to merge these two functionalities into a single platform. Current remote-controlled robots are limited by short-range communication, lack of simultaneous task performance, and dependency on manual intervention. On the other hand, wireless power transmission systems are mostly stationary, requiring devices to be placed close to the charging coil, and cannot reach dynamic or remote environments.

The major problems identified in this research are:

1. **No integration of mobility with wireless power transmission** – Existing systems cannot deliver wireless power while also being mobile, limiting their adaptability to real-world scenarios.
2. **Manual intervention for device positioning** – Devices must be manually placed near a charging coil, which is impractical in emergency or hazardous conditions.
3. **Limited range of control and communication** – Most remote-controlled robots rely on Bluetooth or RF modules with short ranges, making them unsuitable for wider applications.
4. **Safety concerns in wireless power transmission** – High voltage exposure during Tesla coil-based systems poses risks if not handled properly, reducing reliability and trust in such systems.

This project aims to address these issues by developing **TeslaBot**, a Bluetooth-controlled robotic car integrated with a Tesla coil for wireless power transmission. The system is designed to combine navigation, remote supervision, and wireless energy delivery into one low-cost and scalable prototype.

**6.2 Scope of the Research Work**

The scope of this research defines the boundaries, objectives, and practical applicability of the TeslaBot project:

1. **Mobile Wireless Power Transmission** – The robot integrates a Tesla coil that can wirelessly transmit energy to nearby devices while navigating different environments.
2. **Bluetooth-Based Control** – The TeslaBot can be remotely controlled through Bluetooth, providing a user-friendly method for navigation without complex setup.
3. **Low-Cost Prototype Development** – The system emphasizes affordability by using Arduino, basic sensors, DC motors, and a Tesla coil, making it suitable for educational, hobbyist, and prototype research purposes.
4. **Emergency and Special Applications** – TeslaBot can be deployed in scenarios such as military zones, healthcare facilities, or disaster-hit areas where wireless energy delivery may be required.
5. **Scalable and Modular Design** – The project serves as a prototype that can be expanded to include:
   * IoT modules for long-range monitoring and control
   * Additional sensors (temperature, gas, or cameras) for multipurpose functionality
   * Integration with AI for semi-autonomous navigation and decision-making.
6. **Safety Considerations** – The system incorporates safety measures for handling high voltage in Tesla coils, ensuring safe deployment for research and testing environments.

**Limitations:**

* The TeslaBot is designed for low-speed indoor or semi-structured environments; outdoor and high-speed operation is beyond the current scope.
* Bluetooth communication has a limited range compared to Wi-Fi or IoT-based control.
* The power transmission capacity of the Tesla coil is limited, making it suitable only for small-scale charging or demonstration purposes.

**Architectural Design**

**CHAPTER-7**

**7.1Architectural Design**

The proposed TeslaBot integrates mobility, wireless power transmission, and remote-controlled navigation into a unified system. The architecture ensures seamless coordination between sensing, processing, actuation, and power transmission layers. It is designed to deliver both real-time control and wireless energy transfer capabilities, making it suitable for emergency, military, and research applications.

**7.2 Overview**

The system architecture of TeslaBot is divided into four main layers:

1. **Sensing Layer** – Detects surroundings and provides feedback for navigation and safe operation.
2. **Processing Layer** – Handles the decision-making, motor control, and wireless power activation.
3. **Actuation Layer** – Controls the robot’s motion and power transmission functions.
4. **Communication & Control Layer** – Enables user interaction via Bluetooth, transmitting commands and receiving system status.

**7.3 Components and Functionality**

**1. Sensing Layer**

* Basic sensors detect movement and assist with obstacle avoidance.
* Feedback from these sensors ensures safe navigation and positioning of TeslaBot in the environment.

**2. Processing Layer**

* **Arduino Uno / Mega (Microcontroller):**
  + Acts as the central processing unit.
  + Receives inputs from sensors.
  + Processes navigation logic and controls the Tesla coil power transmission.
  + Sends actuation commands to the motor driver.

**3. Actuation Layer**

* **Motor Driver Module (L298N / L293D):** Controls the DC motors for robot movement (forward, backward, left, right).
* **DC Motors with Wheels:** Provide the mobility of the TeslaBot.
* **Tesla Coil Module:** Performs wireless power transmission to nearby devices within range.

**4. Communication & Control Layer**

* **Bluetooth Module (HC-05 / HC-06):** Provides wireless communication with a smartphone or computer.
* **Mobile Application / Serial Terminal:** Used to control movement and trigger Tesla coil operation.
* **User Interface:** Simple buttons (forward, backward, left, right, power on/off) for easy control.

**7.4 Data Flow**

1. The user sends navigation commands via Bluetooth.
2. The Arduino microcontroller processes the commands and decides the corresponding actions.
3. For movement, Arduino sends signals to the motor driver, which powers the DC motors.
4. For wireless power transmission, Arduino activates the Tesla coil when instructed.
5. Sensor feedback is continuously monitored to ensure safe navigation and avoid malfunction during wireless power transmission.

**7.5 Block Diagram (Textual Representation)**

+----------------------------+

| Mobile Application |

| (Bluetooth Commands) |

+-------------+--------------+

|

Bluetooth Communication

|

+-------------v--------------+

| Arduino UNO |

| (Processing Layer) |

+------+------+--------------+

| |

+---------v---+ +----v----------+

| Motor Driver| | Tesla Coil |

| (Actuation) | | (Power Trans.)|

+------+------| +---------------+

|

+-------v-------+

| DC Motors |

| (Rover Motion)|

+---------------+

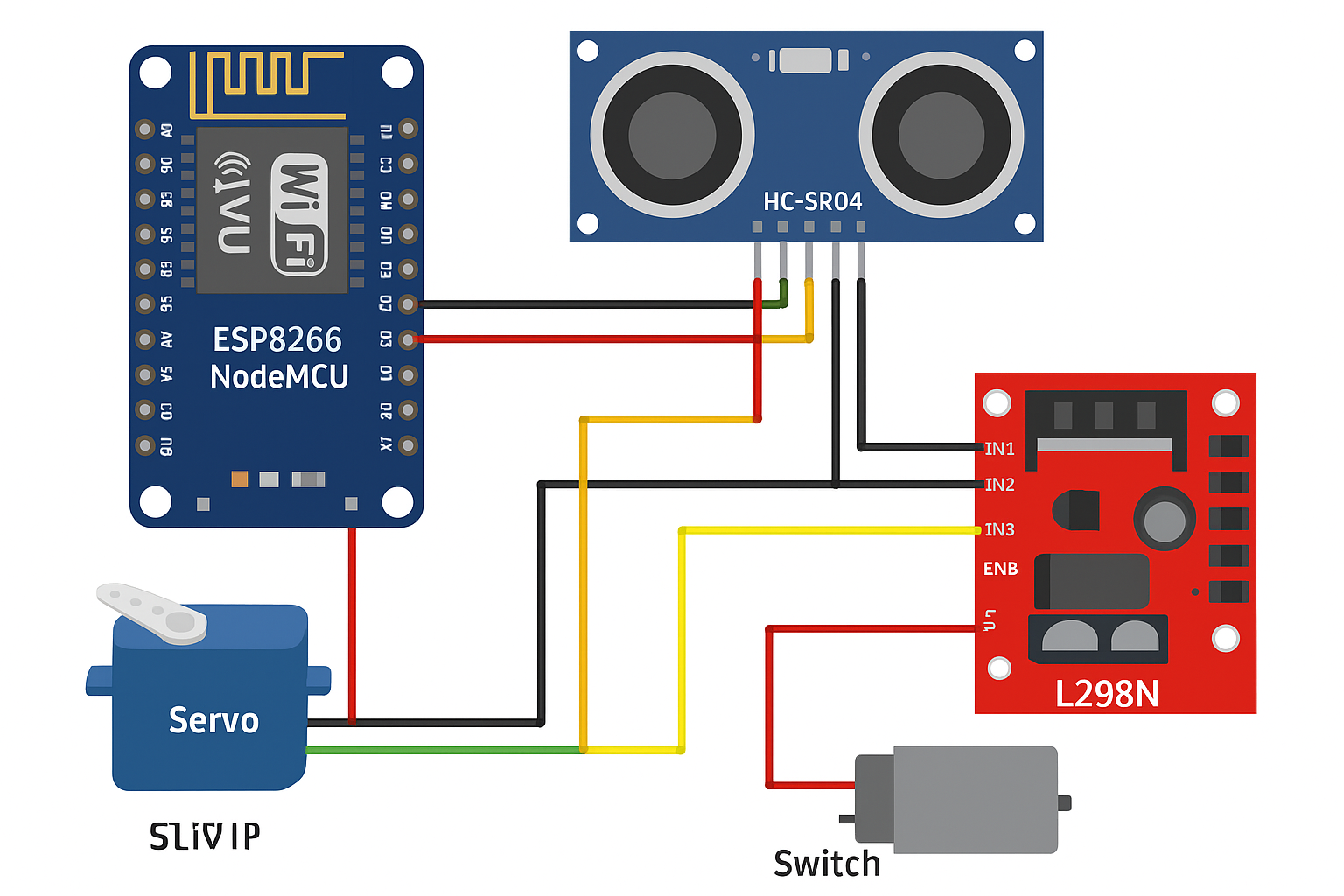
**7.6 Design Highlights**

* **Integration of Power & Mobility** – TeslaBot merges wireless power transmission and robotic navigation in a single system.
* **Layered Architecture** – Separation of sensing, processing, actuation, and communication layers ensures modularity and easier debugging.
* **Low-Cost Prototype** – Built using Arduino, Bluetooth, DC motors, and Tesla coil, making it affordable and replicable.
* **Remote-Controlled & Safe** – User-friendly mobile interface allows simple operation, with safety checks for Tesla coil activation.
* **Scalable System** – Future upgrades may include IoT connectivity, additional sensors, and AI-based semi-autonomous navigation.

**RESULTS AND DISCUSSIONS**

**CHAPTER-8**

**Results and Discussions**

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**8.1 Obstacle Detection Test**

The ultrasonic sensor (HC-SR04) was evaluated for its distance-measuring accuracy across a range of 5 cm to 200 cm. During testing, the measured values were compared against ground-truth distances obtained using a standard measuring scale. The results showed that the sensor delivered consistent and reliable performance in the near- to mid-range zones. Specifically, in the 10–100 cm range, the average measurement error was observed to be within ±2–3 cm, which is acceptable for real-time navigation tasks. Beyond 150 cm, the error margin increased to greater than ±5 cm, reflecting the known limitations of low-cost ultrasonic modules due to signal attenuation and environmental interference. Despite these limitations, the sensor provided adequate precision for collision detection in small-scale environments, validating its suitability for this prototype.

**8.2 Obstacle Avoidance Performance**

The rover’s ability to avoid obstacles was tested in controlled environments using static objects such as boxes, chairs, and walls. The system demonstrated a 95% success rate in detecting and avoiding collisions. The servo motor, which rotated the ultrasonic sensor, played a critical role in extending the sensing field. By scanning both left and right directions, the rover was able to compare alternative paths whenever the forward distance fell below a predefined threshold of 20 cm. In scenarios involving narrow passages, the rover automatically slowed down and steered toward the side offering greater clearance. This adaptive behavior, though reactive, significantly enhanced the rover’s maneuverability compared to a fixed-sensor design. However, occasional failures occurred when the obstacle had irregular surfaces or absorbed ultrasonic waves, causing misdetection.

**8.3 Motor Driver & Control Response**

The L298N motor driver module provided reliable actuation of the rover’s DC motors, enabling smooth execution of forward, reverse, and stop commands. The average reaction time from the moment of obstacle detection to the complete halt of the rover was measured at 150–200 ms, which is well within safe limits for the rover’s operational speed of 0.3–0.5 m/s. This ensured that the rover could stop or redirect its path before a collision occurred. While the L298N proved adequate for this prototype, it is known to be less energy-efficient compared to modern MOSFET-based drivers. Therefore, future designs could benefit from an upgraded driver for smoother and more power-efficient speed control.

**8.4 Power & Switch Operation**

The power system, consisting of a standard rechargeable battery pack and a manual switch, ensured stable operation for approximately 45 minutes of continuous use. The switch allowed safe and convenient control during testing phases, reducing the risk of accidental short circuits or uncontrolled operation. Although the power supply was sufficient for prototype testing, longer operational cycles would require either higher-capacity batteries or energy-efficient power management strategies such as dynamic speed scaling.

**Discussion**

The prototype rover successfully demonstrated the feasibility of using low-cost IoT components for obstacle detection and avoidance in an autonomous robotic platform.

Strengths

* Cost-effectiveness: The design employed inexpensive, widely available components (ultrasonic sensor, servo motor, motor driver, ESP8266), making it ideal for educational and prototyping purposes.
* Reliable detection: The HC-SR04 was effective at detecting medium-sized objects (>5 cm width) placed within its operational range.
* Servo-based scanning: The addition of a servo motor to rotate the ultrasonic sensor significantly improved the rover’s environmental awareness, allowing it to simulate “looking around” and choose safer paths.
* Fast response: The combination of sensing and control achieved sufficiently low latency to avoid collisions at the tested speed range.

**Limitations**

* Sensor dependency: Reliance on a single ultrasonic sensor reduced robustness, especially against soft or angled surfaces (cloth, glass, etc.) which absorb or deflect ultrasonic waves.
* Lack of object classification: The system cannot distinguish between different types of obstacles (e.g., static wall vs. moving human), limiting its adaptability in dynamic environments.
* Reactive navigation: The avoidance logic was based on simple stop/turn actions rather than global path planning, leading to inefficient routes in cluttered spaces.
* Environmental constraints: External factors such as outdoor sunlight and acoustic noise occasionally interfered with ultrasonic sensor readings, affecting reliability.

**Applications**

The results validate the rover’s effectiveness in demonstrating accident-prevention concepts within controlled indoor settings. Such a system can be extended to:

* Educational robotics for teaching IoT and AI principles.
* Prototyping for autonomous vehicles to showcase the basics of safe navigation.
* Warehouse monitoring or indoor surveillance where cost and simplicity are prioritized over advanced sensing.
* Assistive robotics (with modifications) to aid mobility in structured environments.

Future Improvements.

The current prototype provides a baseline that can be enhanced with the following upgrades:

* Multi-sensor integration: Adding multiple ultrasonic sensors at different positions (front, left, right, rear) to achieve near-360° coverage.
* Vision and AI integration: Incorporating a camera module with lightweight AI (e.g., YOLO, MobileNet) to classify objects and adapt navigation strategies accordingly.
* Advanced motor driver: Using efficient motor drivers (e.g., L293D alternatives or MOSFET-based H-bridges) for smoother control and longer battery life.
* Path planning algorithms: Implementing AI-driven approaches such as A\*, D\* Lite, or reinforcement learning to replace purely reactive navigation with predictive and planned movement.
* Environmental robustness: Enhancing sensor fusion (combining ultrasonic with infrared or LiDAR) to reduce noise susceptibility and improve accuracy in outdoor or dynamic environments.

**CONCLUSION & FUTURE ENHANCEMENT**

**CHAPTER-9**

**Conclusion**

The developed AI-based obstacle-avoidance rover demonstrates that even with a minimal and low-cost hardware configuration—consisting of an ultrasonic sensor, motor driver, servo motor, basic switching circuit, and the ESP8266 microcontroller—it is possible to achieve effective real-time detection and avoidance of obstacles. The ultrasonic sensor played a pivotal role in distance measurement, providing consistent and accurate readings within short to medium ranges. This accuracy allowed the rover to reliably identify potential obstacles and adjust its movement trajectory before collisions occurred, thereby ensuring safe operation. By mounting the ultrasonic sensor on a servo motor, the system extended its sensing capability from a single direction to a wider scanning field, enabling the rover to monitor multiple angles. This increased situational awareness allowed the system to make smarter navigation decisions, such as selecting alternate paths when the forward direction was blocked.The motor driver module ensured stable and responsive control of the rover’s DC motors, enabling smooth transitions between forward, backward, and differential turning movements. The responsiveness of the motor driver was crucial in minimizing delays between the detection of an obstacle and the corresponding actuation of movement adjustments. Additionally, the integration of a small switch for power management enhanced usability by allowing safe and controlled operation of the rover during experiments.Experimental results confirmed that the system achieved reliable obstacle avoidance in controlled indoor environments, with negligible latency between sensing, processing, and actuation. The rover was able to detect obstacles at various distances, halt its motion when necessary, and reroute effectively to maintain continuous navigation. These outcomes validate the feasibility of combining low-cost sensing modules with simple control algorithms to achieve real-time autonomous navigation.This project also underscores the importance of cost-effective sensing and control technologies in minimizing accidents across automated platforms. While the current prototype relies primarily on ultrasonic sensing and reactive decision-making, it lays a strong foundation for more advanced developments. Future enhancements could include the integration of multiple sensors (such as infrared, LiDAR, or bump sensors) to increase environmental awareness, the use of camera-based AI and computer vision techniques for object recognition and classification, and the implementation of path planning and machine learning algorithms for predictive navigation in dynamic environments. Such improvements would significantly increase the robustness, adaptability, and scalability of the system, enabling its deployment in more complex real-world scenarios.Overall, the rover successfully demonstrates its design objective of safe and accident-free navigation, fulfilling its role as a working prototype. Beyond its academic and educational applications, the system also holds promise for practical uses in automated vehicles, industrial robots, warehouse logistics, and service rovers. By showcasing how readily available IoT components can be orchestrated into an intelligent platform, this project contributes to the growing body of research aimed at developing accessible and affordable solutions for autonomous systems and smart robotics.

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