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Project Report for Automotive Engineering

(22ME63)

on

DESIGN AND DEVELOPMENT OF RC CAR USING WIFI

Submitted by

NAME	Sem	USN
RISHABH KADKOL	6	1NT22ME049
SANJEEV T	6	1NT22ME053
MOHAMMAD UMRA AHMED	6	1NT22ME046

Under the guidance of

Dr. L. Harish Kumar

Associate Professor

Department of Mechanical Engineering

Date: 3rd June 2025

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This is to certify that the **"Design and Development of RC Car using WIFI"** a **Mini-project report** submitted for the subject ***Automotive and Engineering*** **(22ME63)** by RISHABH KADKOL(1NT22ME049**),** SANJEEV T(1NT22ME053**),** MOHAMMAD UMRA AHMED(1NT22ME046**),** Bonafide student(s) of **Nitte Meenakshi Institute of Technology**, **Bengaluru**, during the academic year **2024-25** is an authentic work carried out by them under my supervision and guidance**.**

It is certified that all corrections and suggestions indicated by me have been incorporated into the report submitted. The mini project work report has been approved as it satisfies the academic requirements prescribed for the subject Automotive Engineering.

Sl. No.	Name of the Evaluator	Signature with Date
1.	**Dr. L Harish Kumar** Associate Professor, Dept of Mechanical Engg, NMIT	

Abstract

This mini project presents the development of a Wi-Fi-based motor control system using the ESP32 microcontroller, specifically tailored for applications in automotive engineering. The system is designed to wirelessly operate two DC motors via a simple web interface hosted on the ESP32, simulating actuator control as used in modern vehicular systems such as electric windows, throttle control, and steering assistance. The motor control setup is built using an ESP32 board, an L298N motor driver, and N20 micro gear motors, all mounted on a custom 3D-printed chassis. The system connects to a Wi-Fi network (or mobile hotspot) and provides a user-friendly control interface accessible from any device on the same network. The project highlights the integration of embedded systems, web-based interfaces, and electromechanical components—skills essential in modern automotive mechatronics. Testing showed reliable and responsive motor control with stable wireless communication. This prototype lays the groundwork for more advanced automotive applications involving sensor feedback, automation, and vehicle-to-network (V2N) connectivity.

Acknowledgment

We take this opportunity to express our sincere gratitude to everyone who supported us in completing this mini-project report for the subject **Automotive Engineering(22ME63)**

First and foremost, we would like to thank our guide **Dr. Harish Kumar L**, Associate Professor, Department of Mechanical Engineering, Nitte Meenakshi Institute of Technology, Bengaluru, for his invaluable guidance, feedback, and constant encouragement throughout the course of this project. His expertise and insightful suggestions have been instrumental in shaping the outcome of this report.

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Declaration

We hereby declare that the mini-project titled "**DESIGN AND DEVELOPMENT OF RC CAR USING WIFI"**, submitted by us to the Department of Mechanical Engineering, Nitte Meenakshi Institute of Technology, Bengaluru, in partial fulfilment of the requirements of the course **Automotive Engineering (22ME63)**, is a record of our original work.

We have not copied from any other student's work or from any other source, except where due reference or acknowledgement is made in the report. We understand that any violation of this declaration may lead to disciplinary action as per the institute's academic policies.

Furthermore, we confirm that the plagiarism level of this document is below 10%, and the AI-generated content score is also below 10%, as evidenced in the enclosed reports.

Name	RISHABH KADKOL	SANJEEV T	MOHAMMAD UMRA AHMED
Signatures:	________________	____________________	____________________

Date: 3rd June 2025

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Chapter 1

INTRODUCTION

1.1 Background

The automotive industry is rapidly evolving with the integration of electronics, software, and embedded systems to enhance vehicle performance, safety, and automation. One key trend is the shift from mechanically actuated systems to electronically controlled systems — commonly referred to as *X-by-wire* technologies (e.g., steer-by-wire, brake-by-wire, drive-by-wire). These systems replace traditional mechanical linkages with electronically controlled actuators, increasing design flexibility, reducing weight, and enabling advanced features like remote control and automation.

Microcontrollers are central to these systems. The ESP32 is a powerful yet cost-effective microcontroller with built-in Wi-Fi and Bluetooth capabilities, multiple GPIOs, PWM outputs, and real-time task handling. These features make it suitable for prototyping and testing control systems in educational automotive applications.

In small-scale autonomous vehicle models and robotics, DC gear motors such as N20s are used to replicate real vehicular drive systems on a reduced scale. They allow controlled linear or rotational motion, which is critical for understanding vehicle dynamics, control algorithms, and system responses. The L298N motor driver serves as the interface between the ESP32 and the motors, allowing bidirectional control of voltage and current to drive the motors as required.

This mini project, therefore, simulates the basic architecture of a wireless-controlled drive-by-wire system. It serves as an educational tool to demonstrate how such systems can be implemented, tested, and expanded in a controlled lab environment using embedded hardware.

1.2 Purpose of this work

The purpose of this mini project is to design and implement a simple, Wi-Fi-based motor control system using an ESP32 microcontroller, two N20 DC motors, and an L298N dual H-bridge motor driver. The system allows the user to control motor direction (forward and backward) wirelessly via a web interface accessible from a mobile phone or any device connected to the same Wi-Fi network.

This emulates the fundamental operation of a drive-by-wire system used in modern vehicles where control commands are issued electronically rather than through physical linkages. Although simplified, the project aims to develop insight into embedded systems integration, wireless communication protocols, motor actuation, and their relevance in automotive applications.

Through this project, students learn how microcontrollers interact with peripheral devices and how web-based control interfaces can be used to interact with physical hardware — all of which are key components in the development of intelligent transportation systems and automotive electronics.

1.3 Objectives

The specific objectives of this automotive-focused mini project are as follows:

1. **To design and construct a small-scale two-wheeled drive platform** driven by compact N20 DC gear motors, emulating the powertrain concept used in electric vehicles.
2. **To interface the ESP32 microcontroller with the L298N motor driver** to enable reliable and reversible control of both motors through GPIO pins and H-bridge logic.
3. **To program the ESP32 to host a local web server** that enables Wi-Fi-based control through an HTML user interface.
4. **To simulate basic vehicle maneuvers** (forward motion, reverse motion, stop) based on user input through the web interface.
5. **To analyze the effectiveness of wireless control in real-time actuation** and understand its practical implications in automotive systems such as remote diagnostics, remote parking, and autonomous vehicle navigation.
6. **To explore energy supply and stability considerations**, including powering the ESP32 and motors via USB and external battery systems — similar to automotive electrical subsystems.

1.4 Significance of the study

This project holds educational significance in the domain of automotive electronics and mechatronics. As vehicles evolve into intelligent and autonomous systems, the ability to control hardware components wirelessly and efficiently is becoming critical. Features such as autonomous parking, remote engine start, and connected vehicle platforms rely on embedded control units that process data and actuate components without human intervention.

The key contributions and significance of this study include:

- **Introduction to drive-by-wire concepts** through simplified prototypes that help visualize how electronic control units replace traditional mechanical systems.
- **Hands-on experience with microcontroller programming and motor control**, which is foundational for any automotive embedded system engineer.
- **Understanding wireless communication for in-vehicle and remote control**, reflecting the increasing importance of vehicle-to-driver and vehicle-to-infrastructure (V2X) systems.
- **Application of theoretical concepts in real hardware**, bridging the gap between classroom learning and practical implementation — a key goal in engineering education.
- **Scalability and future extension possibilities**, such as adding sensors for obstacle detection or using the system as a base for an autonomous path-following vehicle or smart parking assistant.

By completing this mini project, students gain practical knowledge and confidence in designing embedded systems, an essential skill set in the rapidly advancing field of automotive engineering.

Chapter 2

LITERATURE REVIEW

2.1 Embedded Systems in Automotive Applications

In recent decades, the role of embedded systems in automotive engineering has expanded significantly. Vehicles now commonly incorporate numerous microcontrollers and electronic control units (ECUs) for tasks such as engine control, braking systems (ABS), airbag deployment, and infotainment. According to Bosch (2019), a modern car may contain up to 100 ECUs. These systems rely on real-time data processing and actuator control, which are typically managed through dedicated microcontrollers.

The ESP32, although not automotive-grade, provides an excellent low-cost platform for prototyping such systems due to its integrated Wi-Fi, dual-core processing, and GPIO capabilities. Studies such as Ghosh et al. (2020) highlight the use of ESP32 in research and prototyping environments where wireless control and sensor integration are explored for automotive simulations and robotics.[1]

2.2 DC Motor Control in Vehicle Systems

In recent decades, the role of embedded systems in automotive engineering has expanded significantly. Vehicles now commonly incorporate numerous microcontrollers and electronic control units (ECUs) for tasks such as engine control, braking systems (ABS), airbag deployment, and infotainment. According to Bosch (2019), a modern car may contain up to 100 ECUs. These systems rely on real-time data processing and actuator control, which are typically managed through dedicated microcontrollers.

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2.3 Wireless Control of Motors Using Microcontrollers

Wireless communication in automotive control systems enables features such as remote start, keyless entry, and over-the-air (OTA) updates. In educational and prototyping contexts, researchers have used microcontrollers like the ESP8266 and ESP32 to simulate wireless control of mechanical systems.

For example, Raut and Kale (2021) demonstrated a remote-controlled robotic car using the ESP8266 module and a motor driver, controlled via a smartphone interface. Their findings indicated that Wi-Fi-based control is a reliable, low-latency solution for short-range motor actuation. Building upon such work, this project uses the ESP32 to implement a self-hosted web server to eliminate the need for an external server or app — an approach supported by Sharma et al. (2022), who developed smart IoT devices using similar methods.[2]

2.4 Drive-by-Wire and Mechatronic Subsystems

Drive-by-wire systems are an emerging standard in electric and autonomous vehicles. These systems replace mechanical connections with electronic sensors and actuators. According to SAE International, drive-by-wire technologies can reduce vehicle weight and improve performance and safety by enabling rapid system diagnostics and predictive maintenance.

Prototypes and scaled-down models are widely used to simulate these systems in academic settings. The current project falls into this category by implementing a simplified drive-by-wire concept where motor control commands are sent over Wi-Fi instead of through a physical input device. This offers an early insight into how mechatronic subsystems function in modern intelligent vehicles.

2.5 Gaps in Existing Studies and Project Contribution

While many academic studies have explored wireless motor control and embedded systems, few focus on integrating these technologies specifically for educational models that emulate automotive principles. Most available works use either Bluetooth or prebuilt apps for control. This project differs by developing a custom, self-contained Wi-Fi server hosted on the ESP32, accessible via any web browser — reflecting real-world connectivity trends in automotive electronics.

Furthermore, this project contributes by:

- Reinforcing the concept of actuator control via web-based commands.
- Emphasizing power management in microcontroller-based systems.
- Providing a scalable foundation for future automation or autonomous vehicle projects.

Chapter 3

METHODOLOGY

3.1 Methodology Flowchart

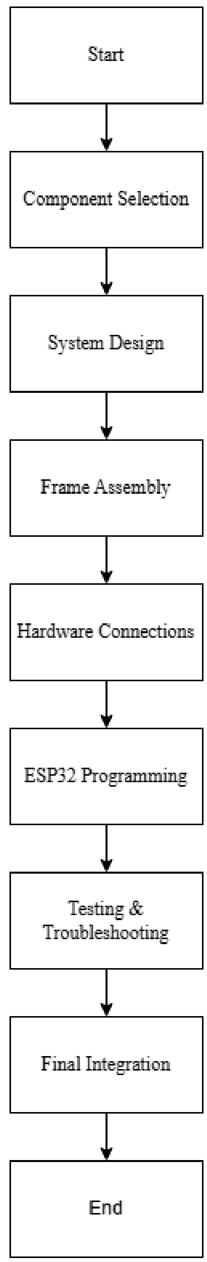

Figure 1 : Methodology Flowchart

3.2

3.3 Different parts, its use/working and its specifications.

This section describes the key components used in the design and implementation of the RC Car using WIFI.

ESP32 Microcontroller

Function:

Acts as the central control unit for the system. It receives user input over Wi-Fi, processes the commands, and sends control signals to the motor driver to operate the motors.

Specifications:

- Dual-core Tensilica Xtensa LX6 processor (up to 240 MHz)
- 520 KB SRAM
- Built-in Wi-Fi (802.11 b/g/n)
- Bluetooth 4.2 and BLE
- Up to 34 programmable GPIOs
- 3.3V logic level
- USB programming support

Figure 2: ESP32

L298N Dual H-Bridge Motor Driver

Function:

Serves as an interface between the ESP32 and the DC motors. It controls the direction and enables or disables power delivery to the motors.

Specifications:

- Operating voltage: 5V–35V
- Output current: 2A (max) per channel
- Dual H-bridge motor driver
- Logic voltage: 5V
- Onboard 5V regulator

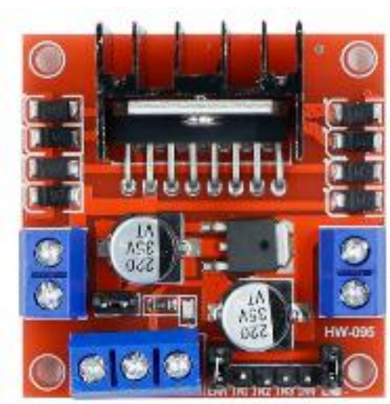

Figure 3 L298N Motor Driver

N20 DC Gear Motors

Function:

Used to simulate drive motors in an automotive application. These motors drive the wheels of the prototype vehicle and mimic the function of an electric powertrain.

Specifications:

- Voltage: 3V–12V DC (typically 6V for best efficiency)
- No-load speed: ~100–500 RPM (depends on model)
- Gear ratio: 1:10 to 1:300 (varies)
- Current: ~100 mA (no load), up to 1 A (stall)
- Output shaft: 3 mm D-shaft

Figure 4 N20 DC Gear Motor

12V Li-ion Battery Pack

Function:

Powers the motors through the L298N motor driver and, optionally, powers the ESP32 via a voltage regulator.

Specifications:

- **Voltage: 12V**
- **Rechargeable**

Figure 5 12V Li-ion Battery

Table 1: List of Components

Quantity	Component
1	ESP32 Microcontroller
1	L298N Dual H-Bridge Motor Driver
2	N20 DC Gear Motors
1	12V Li-ion Battery Pack
4	42mm wheels
1	3D Printed Chassis

3.4 Working procedure

The system is designed to control the forward and backward motion of two DC motors using a web interface over Wi-Fi. Below is the sequence of steps involved in setting up and operating the system:

Hardware Setup

1. **ESP32 Connection:**
    - The ESP32 microcontroller is connected to the L298N motor driver using four GPIO pins (two per motor).
    - The ESP32 is powered via USB during programming and can later be powered using a voltage-regulated supply (e.g., from the L298N's 5V pin if appropriate).
2. **Motor Driver (L298N):**
    - Two N20 gear motors are connected to the L298N's motor output terminals.
    - A 12V lithium-ion battery is connected to the L298N's power input to drive the motors.
3. **Power Distribution:**
    - The 12V battery powers the motors via the motor driver.
    - ESP32 receives 3.3V or 5V from the motor driver or an external regulator.

Programming the ESP32

- The ESP32 is connected to a computer via USB.
- A program is uploaded using the Arduino IDE, which:
    - Connects the ESP32 to a Wi-Fi network.
    - Creates a simple web server.
    - Allows the user to send commands ("Forward", "Backward", "Stop") through a web browser.

Wi-Fi Connection and Web Interface

- Once powered and booted, the ESP32 connects to the specified Wi-Fi network.
- The IP address assigned to the ESP32 is displayed on the serial monitor.
- The user types this IP address into a web browser (smartphone or PC) to access the control interface.

Motor Control via Web Commands

- The web interface displays buttons for controlling the motors:
  - **Forward**: Both motors rotate in the same direction to simulate forward vehicle motion.
  - **Backward**: Motors reverse direction to move backward.
  - **Stop**: Halts both motors by setting all control pins LOW.
- Clicking any button sends a request to the ESP32, which executes the corresponding motor control logic using the L298N driver.

Chapter 4

RESULTS AND CONCLUSION

4.1 Results

The Wi-Fi-controlled DC motor system was successfully designed, assembled, and tested as a scaled-down prototype representing an automotive actuator control mechanism. The results of the project are summarized below:

- **Successful Motor Control:**
  The system was able to control two DC motors wirelessly using a smartphone or computer connected to the same Wi-Fi network as the ESP32. Forward, backward, and stop operations were reliably executed.
- **Stable Web Interface:**
  The ESP32 hosted a responsive and stable web server that allowed real-time control of the motors via buttons on a simple HTML interface. This mimicked how modern vehicles might use electronic control units to respond to user inputs.
- **Wireless Operation via Hotspot:**
  The system operated successfully even when the ESP32 was connected to a mobile hotspot, demonstrating flexibility in network connectivity, which is crucial in automotive telematics and IoT integration.
- **Compact Hardware Integration:**
  All components (ESP32, L298N, motors, battery) were securely mounted on a 3D printed frame using hot glue. The final assembly was compact, stable, and lightweight — factors important for modular design in automotive systems.
- **Real-Time Response:**
  The motors responded to web commands with negligible delay, simulating a responsive actuator control system similar to those used in automatic transmission selectors, smart doors, or throttle-by-wire systems.

4.2 Conclusion

This mini project successfully demonstrated the implementation of a Wi-Fi-based motor control system using the ESP32 microcontroller, aligning with the core principles of automotive engineering such as system integration, actuator control, and wireless communication.

The prototype serves as a simplified model of electronic actuator systems commonly used in modern vehicles, such as power windows, electric seat adjusters, or drive-by-wire systems. The use of the ESP32 reflects how embedded controllers interface with motor drivers to manage motion control based on user input.

From an educational standpoint, the project enhanced understanding of:

- Microcontroller programming and interfacing,
- Embedded system design,
- Wireless communication in vehicular applications, and
- Control of electro-mechanical actuators.

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