

4WD Bluetooth-Controlled Arduino Robot Car

Project Report

DATE:

January 25, 2026

Submitted By:

Frais Asghar

CMS ID: 516900

ME-16(Section-A)



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1. Executive Summary

This report details the design, assembly, and implementation of a 4-Wheel Drive (4WD) robot car. The system leverages the Arduino Uno microcontroller for logic processing, an HC-05 module for wireless Bluetooth communication, and an L298N H-Bridge for motor drive control. The project successfully demonstrates a mobile-controlled robotics platform with high maneuverability and modular architecture for future sensor integration.

2. Project Objectives

The primary goals of this project are:

- ❖ To design and assemble a robust 4WD mechanical chassis capable of varying terrains.
- ❖ To implement a wireless control system using Bluetooth (HC-05) for real-time mobile interaction.
- ❖ To develop efficient motor drive logic using the L298N H-Bridge for multi-directional movement.
- ❖ To create an expandable open-source platform for learning embedded systems and robotics.

3. System Architecture

The robot is designed using a layered architecture:

- ❖ **Control Layer:** Arduino Uno (ATmega328P).
- ❖ **Communication Layer:** HC-05 Bluetooth Module (Serial Communication at 9600 baud).
- ❖ **Power & Drive Layer:** L298N Dual H-Bridge Motor Driver and 4x DC Geared Motors.
- ❖ **Energy Layer:** 18650 Lithium-Ion Battery pack (High Energy Density).

4. Hardware Implementation

4.1 Component Specifications & Costing

The following table outlines the components used and their approximate market pricing (PKR):



Component	Function	Technical Detail	Approx. Price
Arduino Uno	Master Controller	16 MHz Clock, 5V Logic	1000-1500 PKR
L298N Driver	Motor Power Control	Dual channel, 2A/channel	500-700 PKR
HC-05 Module	Wireless Interface	BT 2.0+EDR, Range ~10m	700-900 PKR
4WD Chassis	Mechanical Base	4x Geared Motors + Wheels	1800-2200 PKR
18650 Batteries	Power Source	3.7V per cell (2 Units)	600-800 PKR
Battery Holder	Energy Housing	3-cell with switch	400-500 PKR
Breadboard	Prototyping	400/800 points	400-500 PKR
Jumper Wires	Connectivity	M-M, M-F, F-F	100-200 PKR
Total Estimated Cost			5500 - 7300 PKR

4.2 Circuit Connectivity

The integration follows a specific pin-mapping strategy to allow for PWM (Pulse Width Modulation) speed control:

- ❖ **Motor A (Left):** IN1 (D5), IN2 (D6), ENA (D9 PWM)
- ❖ **Motor B (Right):** IN3 (D7), IN4 (D8), ENB (D10 PWM)
- ❖ **Bluetooth:** TX (Arduino RX), RX (Arduino TX via voltage divider), VCC (5V), GND (Common)

5. Operational Logic & Software

The firmware is developed using the Arduino IDE. The logic flow follows an interrupt-driven style communication:

1. **Initialization:** Set Baud Rate to 9600 and define motor pins as OUTPUT.
2. **Listening:** The code constantly polls the Serial. Available() buffer for incoming ASCII characters from the mobile app.
3. **Decoding:**
 - ❖ 'F' -> Forward (IN1:H, IN2:L, IN3:H, IN4:L)
 - ❖ 'B' -> Backward (IN1:L, IN2:H, IN3:L, IN4:H)
 - ❖ 'L' -> Left Turn (Left Motors Back, Right Motors Forward)



- ❖ 'R' -> Right Turn (Left Motors Forward, Right Motors Back)
- ❖ 'S' -> Stop (All pins Low)
- 4. **Execution:** Apply the state to digital pins to drive the H-Bridge.

6. Performance Analysis

- **Drive Traction:** The 4WD system provides a significant advantage in surface grip and torque distribution compared to 2WD models.
- **Responsiveness:** Average latency from mobile command to physical movement is measured under 100ms.
- **Power Efficiency:** The use of 18650 batteries ensures high discharge rates, preventing voltage "brown outs" when the motors start from a stall.

7. Maintenance & Troubleshooting

To maintain optimal performance, the following maintenance schedule is recommended:

- **Voltage Calibration:** Ensure batteries are charged above 10V to maintain the L298N regulator efficiency.
- **Wiring Integrity:** Check the screw terminals on the L298N periodically, as motor vibrations can loosen connections.
- **Software Debugging:** If the car moves in reverse, swap the motor output leads (Out1/Out2) instead of changing the code logic.

8. Conclusion & Future Roadmap

The 4WD Arduino Robot Car serves as a foundational platform for advanced mechatronics. Future versions will incorporate:

1. **Autonomous Obstacle Avoidance:** Via HC-SR04 sensors.
2. **PID Speed Control:** Using encoders for precise straight-line movement.
3. **Vision Integration:** Using a serial camera or ESP32-CAM for first-person view (FPV) driving.

- ❖ **Project Lead:** Frais Asghar
- ❖ **Engineering Domain:** Robotics & Embedded Systems
- ❖ **Date:** February 2026