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Metal Detector Car Using ESP32

Ajay Kumar , Chandrashekara B H
Amruta Institute of Engineering and Management Sciences, Bidadi, Bangalore, India

Guide: **Vasanth Kumar Reddy**

Abstract

This project presents the design and development of a metal detector car using the ESP32 microcontroller for remote metal detection and monitoring. The system integrates a metal detection coil, motor driver module, and robotic chassis with the ESP32, which provides wireless control through Wi-Fi or Bluetooth. The metal detector circuit identifies metallic objects based on changes in electromagnetic fields, while the ESP32 processes the signal and alerts the user. This mobile platform allows safe inspection of areas without human involvement and offers improved flexibility compared to traditional handheld detectors. The proposed system is low-cost, easy to operate, and suitable for applications in security, industrial inspection, and educational robotics. Future enhancements may include autonomous navigation, advanced sensing, and IoT-based data monitoring.

Keywords

Metal Detector, ESP32, IoT, Electromagnetic Induction, Wireless Control, BFO Method, Robotic Car, Metal Detection System, Motor Driver, Remote Monitoring, Embedded Systems, Automation.

I. Introduction

Metal detection plays a major role in security, safety, and industrial applications. Traditionally, handheld metal detectors are used, but they require human involvement and expose users to risk in dangerous areas. To address this, a mobile metal detector car offers a safer and more flexible solution.

The ESP32 microcontroller is widely used in IoT projects because it supports Wi-Fi, Bluetooth, and has good processing capabilities. When combined with a metal detector coil and motorized chassis, it becomes a powerful tool for remote monitoring and object detection.

This review focuses on the concept, operation, and significance of an ESP32-based metal detector car.

II. Working Principle

Metal detectors work on the principle of electromagnetic induction. When an AC current passes through a coil, it generates a magnetic field. If a metal object comes near the coil, the magnetic field changes due to induced eddy currents. This disturbance is detected by the circuit and passed to the ESP32.

A. Beat Frequency Oscillation (BFO)

- Uses two oscillators: one fixed and one variable.
- When metal is detected, the frequency difference changes..

B. Very Low Frequency (VLF)

- Uses two coils: transmitter and receiver.
- Gives improved accuracy and noise performance.

C. Pulse Induction (PI)

- Sends short bursts of current through the coil.
- Used for deeper underground detection.

III. System Design And Components

A. ESP32 Microcontroller

ESP32 controls the vehicle, reads sensor data, and provides wireless communication. Key features include:

- Wi-Fi and Bluetooth
- Dual-core processor
- Multiple ADC/GPIO pins
- Low power consumption

B. Motor Driver (L298N / L293D)

Controls the movement of the DC motors by providing direction and speed control.

C. Metal Detector Module

- Copper coil
- Oscillator circuit
- Output signal for detection

D. Robotic Chassis

- Wheels
- DC motors
- Acrylic or plastic base

E. Power Supply

- 9V battery
- 7.4V Li-ion battery pack
- USB power bank for ESP32

IV. Working of the System

1. The ESP32 is powered on and connects to a mobile app or web interface.

2. The user controls the movement of the car through Wi-Fi/Bluetooth.

3. The metal detection coil continuously scans the ground.

4. If metal is present, the coil's frequency shifts.

5. ESP32 reads the signal and triggers:

- LED indicator
- Buzzer alert
- Wireless notification

6. The user can move the car to new areas for scanning.

V. Advantages

- Wireless operation using Wi-Fi/Bluetooth
- Low cost microcontroller
- Easy integration of sensors
- Real-time data transmission
- Higher processing speed compared to Arduino
- Compact and portable design

VI. Limitations

- Metal detection depth is limited (especially in BFO systems).
- Motor noise can interfere with the coil's magnetic field.
- Cannot identify the type of metal.
- Battery life reduces with continuous scanning.
- ESP32 requires stable regulated power to avoid resets.

VII. Conclusion and Future Work

The metal detector car using ESP32 provides an easy and effective method for detecting metal objects from a safe distance. By combining a metal detector coil with a mobile car and wireless control, the system allows users to scan areas without direct contact. The ESP32 makes the project more flexible by offering Wi-Fi/Bluetooth control and fast processing. Overall, the project works well for basic metal detection and shows how IoT and robotics can be used for simple automation tasks.

The project can be improved by adding features like autonomous navigation, GPS tracking, and cloud- based monitoring. Better coil designs or advanced detection methods can increase accuracy and depth. Adding a camera, solar charging, or AI-based metal identification can make the system more powerful and suitable for real-world applications.

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