Metal Detector Using Arduino

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Abstract:
Metal detection plays an important role in security systems, industrial inspection, and material separation. Conventional metal detectors are often expensive and complex, making them unsuitable for small-scale or educational applications. This project presents a low-cost and portable metal detector using an Arduino Uno microcontroller The system works on the principle of electromagnetic induction, where a search coil generates a magnetic field and detects disturbances caused by nearby metallic objects. Changes in inductance and oscillation frequency are processed by the Arduino to identify the presence of metal. Audible and visual indicators provide instant feedback. The proposed system is simple, cost-effective, and suitable for learning as well as practical applications such as security checking and metal identification.

Keywords: **Metal Detector, Arduino Uno, Electromagnetic Induction, Search Coil, Embedded System, Security System, Inductance Variations**

1. Introduction

Metal detectors are widely used in security screening, treasure hunting, industrial quality control, and landmine detection. They operate by generating an electromagnetic field and analyzing its interaction with metallic objects. When a metal object enters the magnetic field, it alters the field characteristics, which can be detected and processed electronically.

Traditional metal detectors are accurate but expensive and often require complex circuitry. With the advancement of microcontrollers like Arduino, it has become possible to design compact and affordable metal detection systems. Arduino-based systems are easy to program, flexible, and ideal for academic projects and prototypes.This project focuses on designing a simple metal detector using Arduino Uno and a coil-based sensing mechanism. The system detects metal presence and alerts the user through a buzzer and LED, making it suitable for basic security and educational use.t.LiteratureSurvey

Several researchers have explored low-cost metal detection techniques using microcontrollers. Studies show that LC oscillator-based metal detectors are effective for short-range detection. Variations in coil inductance due to metallic objects cause frequency shifts, which can be measured using digital controllers.

Previous work includes analog metal detectors using operational amplifiers and oscillators. Recent developments integrate Arduino and other microcontrollers to digitize detection, improve sensitivity, and provide user-friendly interfaces. Compared to conventional systems, Arduino-based detectors are simpler, programmable, and cost-efficient.

2.Problem Statement

Existing metal detectors are often costly, bulky, and difficult to customize. There is a need for a compact, affordable, and easy-to-build metal detector that can be used for basic detection tasks, educational purposes, and small-scale security applications.

3.Aim and Objectives

To design and implement a low-cost metal detector using Arduino Uno.
Objectives:

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- To detect metallic objects using electromagnetic induction.
- To interface a sensing coil with Arduino for signal processing.
- To provide audible and visual alerts upon metal detection.
- To develop a simple and portable embedded system.

1.System Architecture:

The proposed system consists of a search coil, oscillator circuit, Arduino Uno, buzzer, LED indicators, and power supply. The search coil generates an electromagnetic field. When a metal object comes near the coil, the inductance changes, affecting the oscillator frequencyThe Arduino measures this frequency variation and compares it with a reference value. If the variation exceeds a predefined threshold, the Arduino triggers the buzzer and LED, indicating metal detection. Arduino Uno The Arduino Uno is an open-source microcontroller board based on the ATmega328P. It provides digital and analog I/O pins, making it suitable for sensor-based embedded applications.

2. Search Coil

Block Diagram |
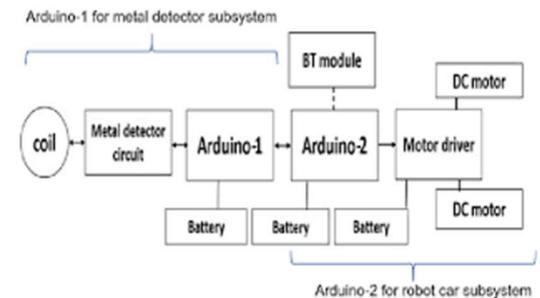
3. BUZZER

5.Component

1.Ardino Uno

Buzzer A piezo buzzer provides an audible alert when metalisdetected

Buzzer A piezo buzzer provides an audible alert when metalis detected.

Electrical conductivity. It provides an analog output proportional to the TDS level, which helps assess water or liquid purity. Commonly used in water quality monitoring, agriculture, and food industry, it's compatible with microcontrollers like Arduino and ESP32 for real-timemeasurement.
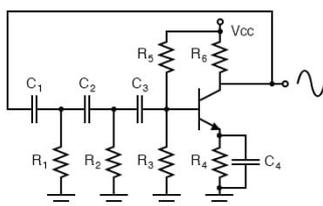
3. **LED**

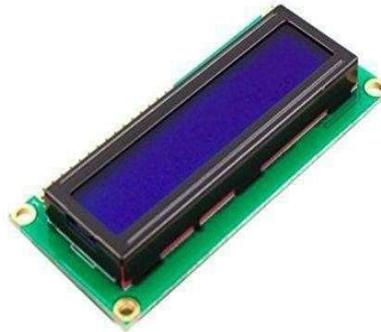4.LED Indicator LEDs are used for visual indication of metal presence
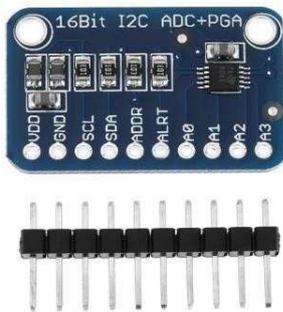
5.Osilator Circuit

Oscillator Circuit An LC oscillator circuit converts inductance changes into frequency variations that can be measured by the

Arduino.

A.   LCDDisplay16X2

The 16x2 LCD is a commonly used alphanumeric display module that can show 16 characters per line on 2 lines. It uses the HD44780 controller and communicates via parallel or I²C interface. It's widely used in microcontroller projects for displaying data such as sensor readings, status messages,and user prompts

6. Working

The search coil generates an alternating magnetic field. When a metallic object enters this field, eddy currents are induced in the metal, which oppose the original magnetic field. This interaction The oscillator circuit converts this inductance change into a frequency shift. The Arduino continuously monitors this frequency. When a significant change is detected, the system identifies the presence of metal and activates the buzzer and LED.

7.Results

The developed system successfully detects metallic objects such as iron, steel, and aluminum at short distances. The buzzer sound intensity increases as the metal approaches the coil, indicating proximity. The results confirm that the Arduino-based metal detector is effective for basic detection tasks.

8.Advantages & Applications Advantages

Low cost and easy to build

Educational demonstrations

Suitable for educational projects

Applications

9.Security checkin system

10.Treasure hunting (basic level)

11.Industrial metal detection

8.Future Scope

Future improvements may include increasing detection range, differentiating between metal types, adding LCD display, and integrating wireless communication for remote monitoring. Advanced signal processing techniques can further enhance sensitivity and accuracy.

9. CONCLUSION

The Arduino-based metal detector provides a simple and economical solution for metal detection. By using electromagnetic induction and microcontroller-based processing, the system achieves reliable detection with minimal hardware. This project demonstrates the potential of Arduino in developing practical embedded systems for real-world applications.

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