Building an Interface between Metal Detector and Jammer

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Abstract:

Metal detectors and jammers are restricted and unlawful devices, with usage limited to authorized government personnel and licensed civilians. The metal detector is employed for identifying both metals and explosive devices, contingent on its operational ranges, while the jammer is utilized to disrupt signal transmissions, depending on its frequency and coverage areas. These devices require an intermediary interface to enable automatic signal jamming the moment an explosive device is detected. The interface has been established between the detector and jammer, enabling the jammer to activate automatically upon bomb detection. Consequently, no signals or commands can be communicated to trigger the bomb, rendering it inert unless the jammer ceases operation. This automated jamming feature affords the team ample time to neutralize the threat and ensures certainty that no detonation will occur in the interim. This interface is relatively affordable and uncomplicated in comparison to the complexity of the detector and jammer systems. The setup serves as a safeguard, enhancing safety measures for the team's well-being.

Keywords: Bomb detection; Bomb diffuse; Jammer; Metal detector.

1. Introduction

Metal detectors and jammers are restricted and unlawful devices, reserved for government and licensed civilian use. These detectors are employed to identify metals and explosives, with their effectiveness determined by their respective ranges. On the other hand, jammers disrupt signal transmissions by emitting frequencies matching those of mobile devices, leading to signal interference and loss. Historically, bomb detection and jamming were distinct tasks; bomb detectors only identified explosives, leaving bomb squads responsible for their safe disposal. Unfortunately, instances of bombs detonating after detection occurred due to time delays and complications in defusing procedures. The functioning of metal detectors relies on electromagnetic induction principles, utilizing inductor coils to interact with metallic objects in the surrounding terrain.

Goyal [1] conducted an examination of the pin configuration and operational characteristics of each pin within the 555IC timer. Padhi [2] outlined an approach to ascertain current distribution in structurally uncomplicated coil or multi-turn loop antennas. The method involved determining input admittances for shielded and unshielded coils, considering their use as receiving components. Pakdaman et al. [3] provided an exposition on the design, execution, and evaluation of TABAR, a compact line-following robot devised for line-following competitions. This robot employs Infrared Ray (IR) sensors beneath it to detect and follow lines. The study delved into technical, as well as mechanical challenges, encountered during the TABAR's development. Louis [4] investigated the operational principles of Arduino, along with its software and hardware attributes, and explored its diverse applications. The guide demonstrated the process of creating sketches for Arduino using its integrated development environment (IDE). Onengiye and Chukwunazo [5] introduced a design and implementation for an RF-based wireless remote control generator system that interfaces seamlessly with an automated switch. Rigorous testing validated its accuracy before integration with the automatic switch.

Yamazaki et al [6] made an effort to theoretically analyze various properties of metal objects based on the output of a metal detector, including conductivity, size, and permeability. They developed an equation to estimate the vector voltage induced in the receiving coil by a metal object, using a simplified spherical sample for analysis. S. A. Makki et al. [7] introduced the application of advanced wireless technology for bomb detection, outlining fundamental approaches and techniques in wireless network technologies for this purpose. Sharawi and Sharawi [8] introduced a cost-effective, low-complexity handheld metal detector design utilizing very low frequency (VLF) technology, capable of distinguishing between different types of metals. Their experiments with iron, copper, and aluminum at various distances indicated that the metal detector could detect metals up to 16 cm beneath its coils. Choi [9] investigated the characteristics of two metal detection sensor channels and discussed potential interference effects during simultaneous operation. Omijeh et al. [10] presented a GSM-based metal detection system that sends SMS alerts to a designated security number upon detecting metallic objects, demonstrating potential for enhanced security in restricted areas. Alauddin et al. [11] described the design and implementation of a remote-controlled robot equipped with an electronic metal detector for detecting buried landmines. L.Junhui, C.Guorong [12] developed a metal detector utilizing a low-power microprocessor MSP430 for control, highlighting its wide-ranging applications in metal detection. R. Kumar, Khalkho [13] created a metal identifier using dual-tone multiple-frequency (DTMF) technology, where the metal sensor (Colpitts oscillator) detects nearby electrically conductive or metallic objects.

Singh and colleagues [14] introduced a GSM jammer design with the goal of preventing the usage of mobile phones within specific areas, while ensuring that communication channels outside of these areas remain unaffected. The researchers noted that this approach offers a dependable means of obstructing mobile communication within designated restricted zones. Oke and co-workers [15] designed a mobile detection system that incorporates frequency jamming capabilities, utilizing techniques to assess a cell phone's electromagnetic properties, establish a distinct signature, analyze the RF spectrum, and satisfy jamming prerequisites. The team observed that their mobile detection system equipped with frequency jamming effectively identified and disrupted communication from all four major mobile operators.

The objective of this endeavor is to automatically disrupt signal transmission upon the detection of a bomb. The project necessitates components such as a metal detector, jamming device, Arduino, transmitter, receiver, defined frequency ranges, and security measures. The project involves establishing a connection between a basic metal detector and a low-frequency mobile jammer. This connection effectively hinders the bomb's functionality by interfering with incoming signals. Such integration finds potential applications in military and sensitive zones to enhance security.

2. Components, Assembly, Working

2.1 Components

The study considers the following components:

i) Metal detector - utilized for identifying metals or explosive devices based on their voltage characteristics.

ii) Jammer - disrupts incoming signals to the bomb; consists of a breadboard, jumper wires, capacitors, resistors, transistors, 555 IC timer, antenna, and battery.

iii) Tracking system - used to monitor the movement of individuals or objects and provide organized location data for further analysis.

A line tracking vehicle or line follower robot is a mobile robot capable of detecting and tracing a line marked on the floor. The route is typically predetermined and may be visible (e.g., a black line on a contrasting white surface) or invisible (e.g., a magnetic field). This robot relies on Infrared Ray (IR) sensors beneath it to detect the line. Figure 1 illustrates the employed line tracking vehicle.

iv) Infrared sensor - an electronic device that emits and senses aspects of its surroundings, measuring object heat and detecting motion.

v) Tracking path - The route followed by the line follower robot, offering a cost-effective and easily maintainable alternative to more expensive robotic devices.

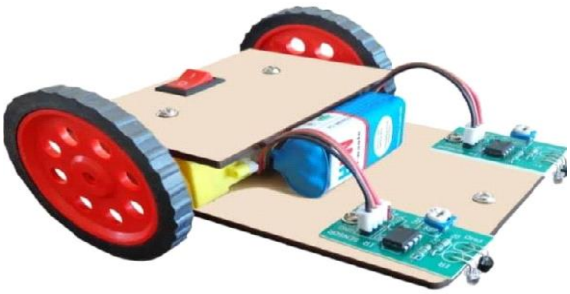


Figure 1: Line tracking Vehicle

2.2 Interfacing

In this project transmitter, receiver and Arduino have been used as interfacing components.

2.2.1. Receiver

A receiver functions as a hardware apparatus employed to capture various types of signals, contingent upon the specific application's context. Its role involves capturing and interpreting signals, subsequently converting them into a format comprehensible by another machine or computer system.

2.2.2. Transmitter

Transmitters function as devices designed to emit data as radio waves within a particular segment of the electromagnetic spectrum, serving specific communication requirements, whether for transmitting voice or general information. To achieve this, a transmitter draws power from a source and converts it into an alternating current of radio frequency that oscillates rapidly, varying direction countless times per second, depending on the desired transmission band. This swiftly changing energy is directed through a conductor, leading to the emission of electromagnetic or radio waves through an antenna. On the receiving end, a different antenna is linked to a receiver, which reverses this process to generate the original message or data.

2.2.3. Arduino

Arduino stands as an open-source platform for electronics, designed with user-friendly hardware and software to facilitate the creation of interactive projects. Its purpose encompasses individuals engaged in crafting projects that engage with their surroundings. By gathering input from various sensors, Arduino interprets its environment, subsequently exerting control over elements like light, motors, and other actuators. The Arduino development board comprises essential elements such as a microcontroller, external power source, internal programmer, reset button, analog and digital pins, as well as power and ground pins. On the software front, it features a text editor, message area, and text functionality. Images in Figures 2 through 4 depict the components utilized in this project: the receiver, transmitter, and Arduino.

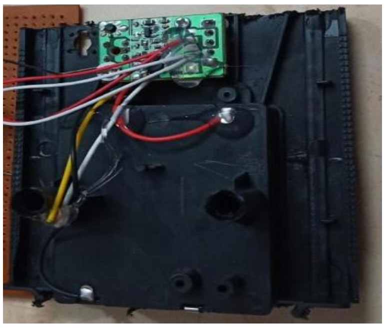


Fig 2. Receiver

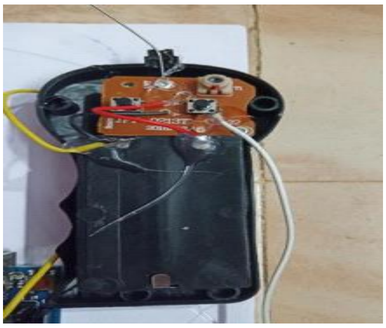


Fig 3. Transmitter

Fig 4. Arduino

2.3 Working

2.3.1 Working of a metal detector

The Metal Detector comprises four primary components: 1) a copper coil, 2) a circuit board, 3) a battery, and 4) a buzzer. The copper coil, battery, and buzzer are linked to the circuit board, which receives power from a 9V DC battery. Metal detection occurs as an object moves through the copper coil, triggering the buzzer to emit a buzzing sound.

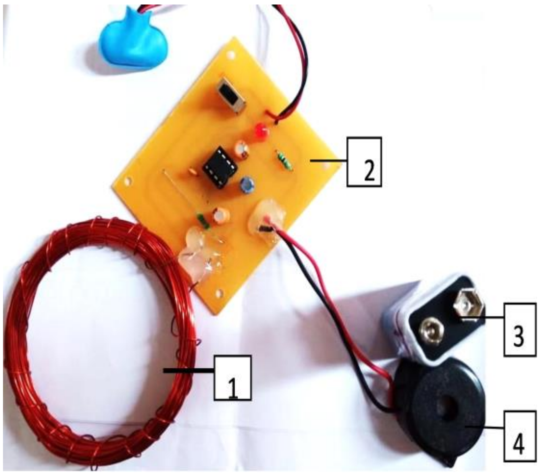


Fig 5. Metal Detector

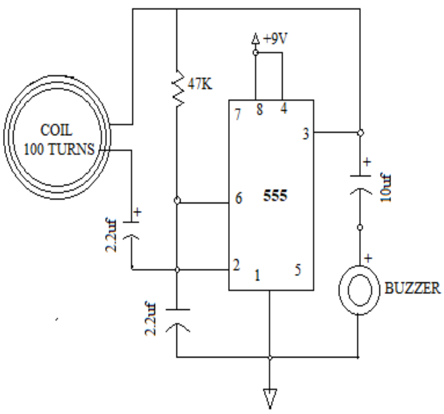


Fig 6. Metal detector circuit

2.3.2 Working of Jammer

When voltage is applied to the circuit board, an electric current flows through the copper coil, creating a magnetic field in its vicinity. When a piece of metal moves through this coil, it intersects the magnetic field, leading to the generation of electromagnetic force (emf). This emf alteration results in a shift in frequency, causing the buzzer to initiate its sound. This mechanism enables the metal detector to operate effectively. Diagram 6 depicts the metal detector circuit utilized in this undertaking.

2.3.3 Automatic Jammer

Blocking signals requires the activation of a jammer, either manually in conventional cases or automatically in the context of an automated jammer. In the automatic version, the jamming process is triggered upon the detection of metal, eliminating the need for manual intervention. The jammer operates by emitting specific frequencies according to its design. When these emitted frequencies intersect with incoming frequencies within the same range, they interfere with each other, resulting in the disruption of signals, effectively causing signal jamming. This phenomenon is depicted in Figure 7. To extend the frequency range of the jammer, an antenna is employed. By increasing the dimensions of the antenna, such as its length and diameter, along with the coils, the frequency range is expanded. Both Figure 7 and Figure 8 provide visual representations of the jammer and the corresponding circuit utilized in this project.

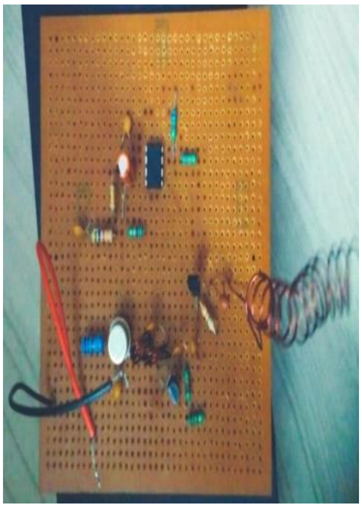


Fig 7. Jammer

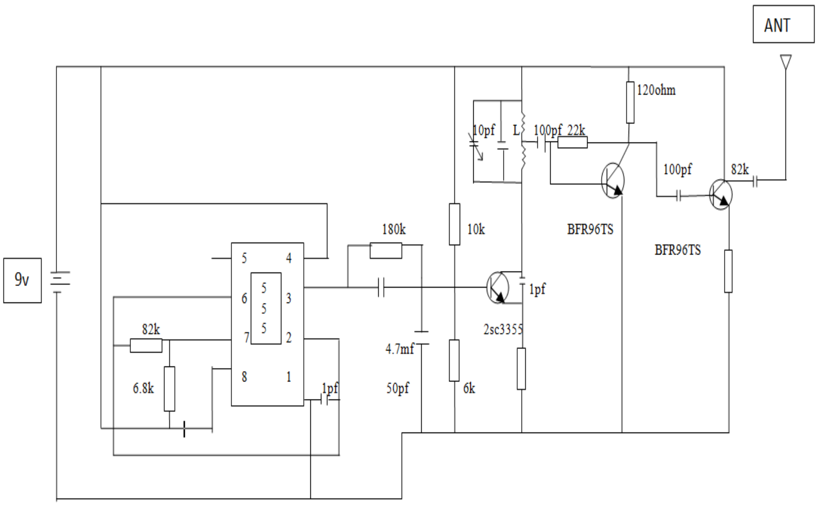


Fig 8. Jammer Circuit

2.3.3 Connectivity

The process of linking a metal detector with a jammer involves the utilization of a transmitter, a receiver, and an Arduino. Initially, the output from the metal detector is fed into the Arduino, which then forwards its output to the transmitter. These transmitted signals are subsequently received by a receiver that is connected to the jammer. As a result, the jammer initiates its operation. A specific Arduino program has been developed to gauge the voltage readings from the metal detector and determine the necessary adjustments. Once the program criteria are met, it triggers the transmitter input. Consequently, the metal detector is automatically switched, leading to the activation of the jamming process. The connectivity setup for this jamming procedure is illustrated in Figure 9.

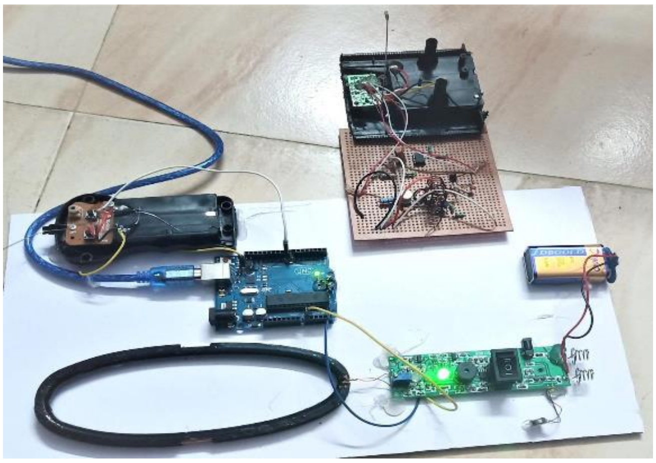
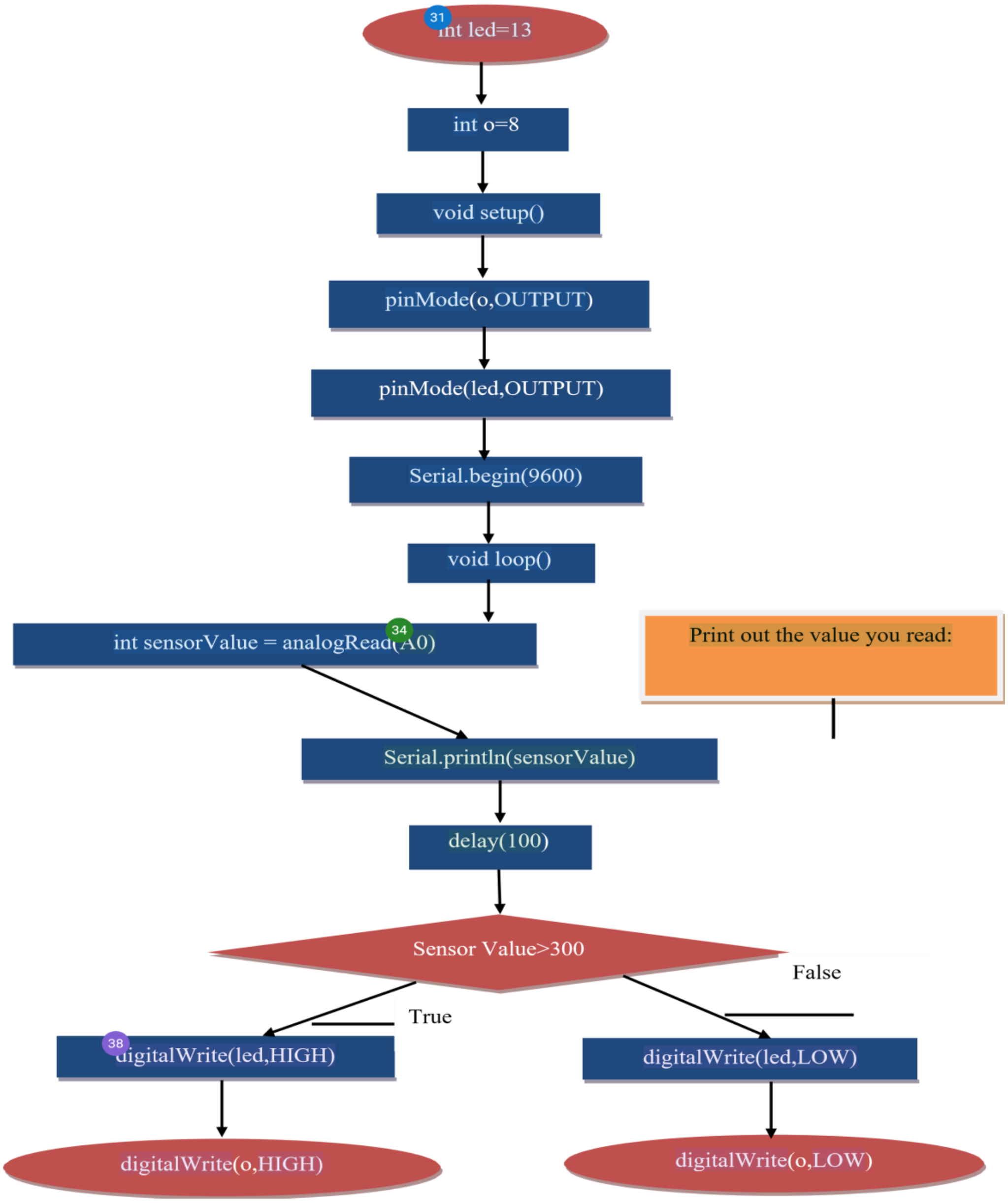


Fig 9. Connectivity for the jamming

2.3.4 Arduino Flow Chart

Arduino flow chart



2.3.5 Working Of Line Tracking Vehicle

The line-following vehicle utilizes a pair of IR sensors: one white sensor emits IR rays, which are then directed onto a black surface. These rays are subsequently reflected and detected by the black sensor. This detection triggers the vehicle to initiate movement. In cases where the rays aren't reflected back to the receiver, no commands are issued to the vehicle, resulting in no movement. Additionally, the black track on which the line-following vehicle operates must span the distance between its two wheels. Figure 10 illustrates the pathway along which the line-following vehicle operates.

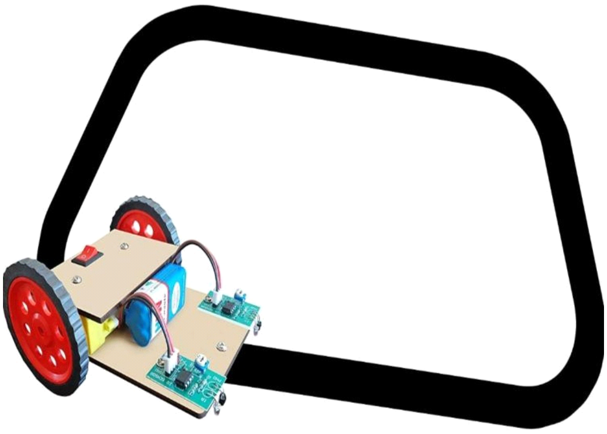


Fig.10 Working Path of Line Tracking Vehicle

2.4 Assembly

The setup involves incorporating various elements such as a metal detector, Arduino, transmitter, receiver, and jammer onto a line-tracking vehicle. Once placed on a predetermined path, the vehicle travels along it. The metal detector remains active, capable of identifying any metal objects within its range as the vehicle moves. Upon detection, the programmed Arduino triggers the automatic operation of the transmitter, receiver, and jammer. As a result, any communication signals directed towards a potential explosive device are intercepted, preventing the device from detonating. The arrangement of the project components for signal jamming is illustrated in Figure 11.

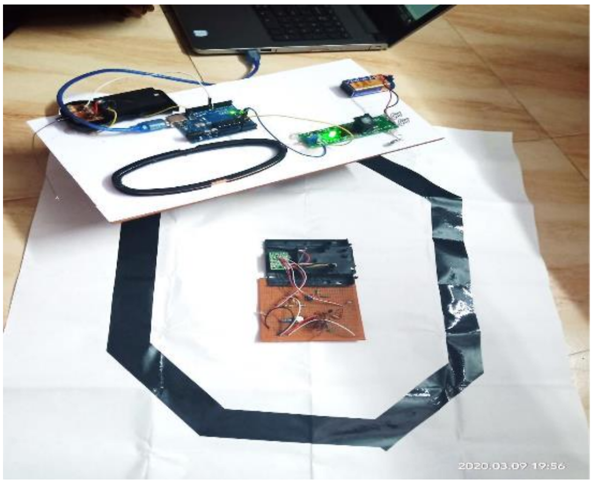


Fig.11 Assembly

3. Results

3.1 Metal Detector Voltage Values

In the process of metal detection, different types of metals and alloys are identified using a metal detector. To determine the specific metal being detected, it's essential to record the average voltage readings produced by the metal detector for various metals and alloys. By analyzing these voltage values, the type of metal can be identified.

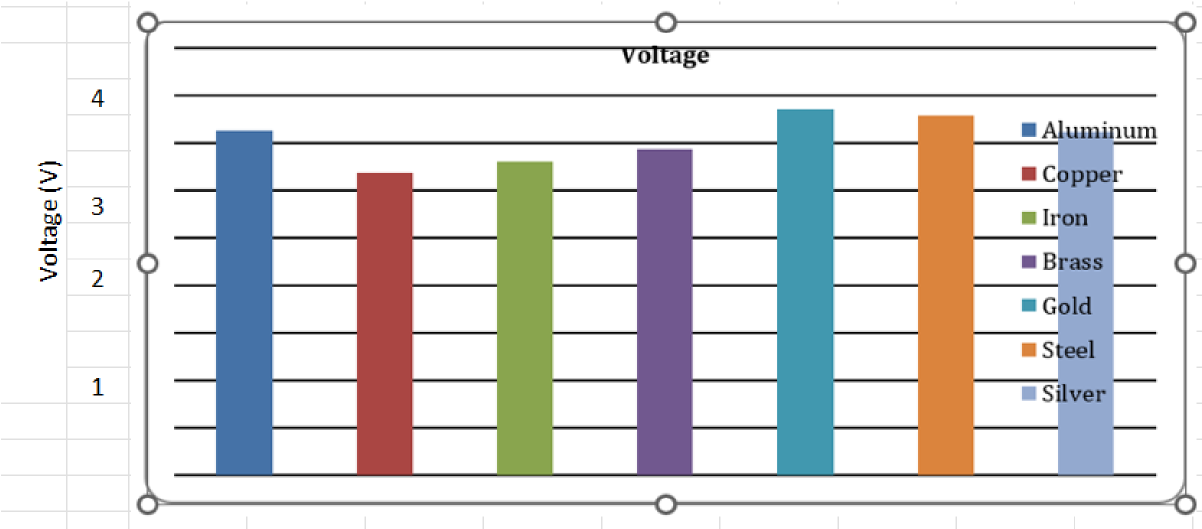
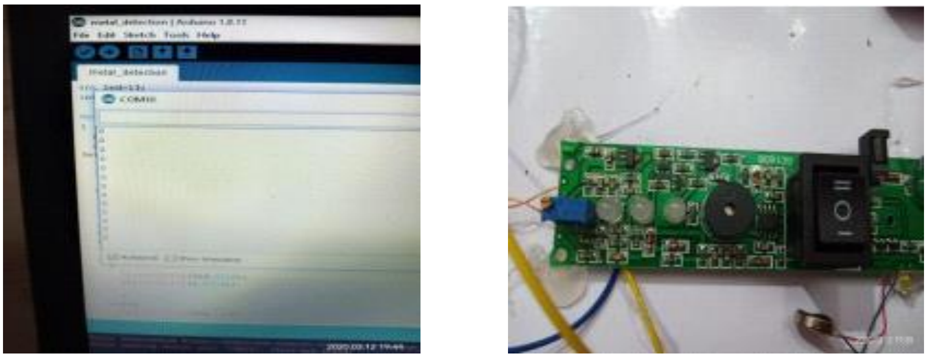


Fig.12 Metals Vs Voltage

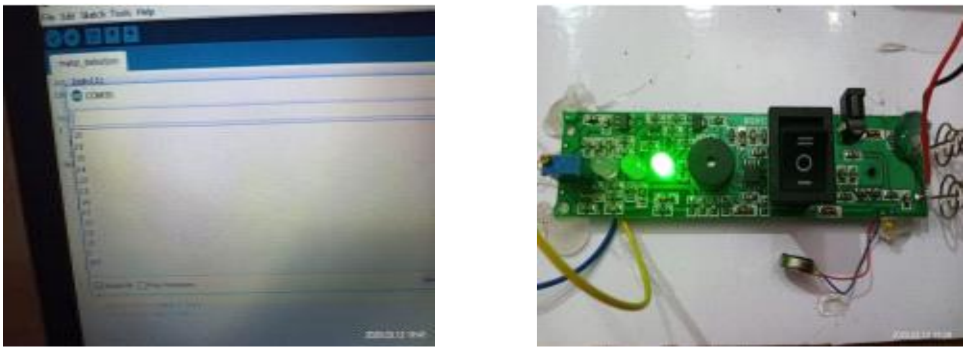
The information conveyed in Figure 12 illustrates a graph plotting metal versus voltage relationships. The graph indicates that metals and alloys exhibit voltage values ranging from 3V to 4V, while mobile phones display voltage values around 1V to 2V. As a result, this particular metal detector exclusively identifies metals that emit electromagnetic radiation (EMR), offering the advantage of effectively detecting potentially hazardous objects such as bombs.

Figures 13 through Figure 15 illustrate different states of the metal detector, namely the OFF condition, the absence of detected metal, and the presence of detec ted metal.



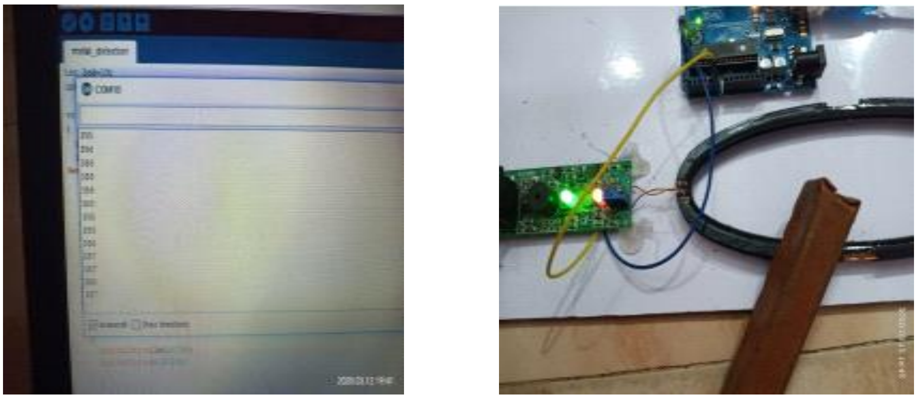
(a) (b)

Figure.13 Metal Detector OFF condition



(a) (b)

Figure.14 Metal Detector ON condition (no metal detected)



(a) (b)

Figure.15 Metal Detector ON condition (metal detected)

3.2 Jammer Frequency

The frequency range of the Jammer utilized in this project is limited to 450MHz, which proves inadequate for disrupting the frequencies of modern mobile phones that operate above 800MHz. Table 1 provides an overview of the frequency ranges for different generations of mobile phones. Additionally, Fig. 16 visually depicts the operational status of the jammer.

Table 1 Frequency range of various generation mobile phones

Sl. No	Mobiles	Frequency Ranges
1	1G Mobiles	800MHz
2	2G Mobiles	900 – 1800MHz
3	3G Mobiles	2100MHz
4	4G Mobiles	850 – 1800MHz

(a) (b)

Figure. 16 Jammer OFF and ON condition

4. Conclusion

In this project, a metal detector is linked to both a transmitter and an Arduino, where a programmed code is implemented. The receiver is then connected to a jammer. Various metals like aluminium, copper, iron, brass, gold, steel, and silver are examined for their respective voltage values as detected by the metal detector. These voltage values are used to generate a graph. Because each metal has a distinct voltage value, it becomes possible to determine the detected metal based on the observed voltage readings.

The Arduino is configured to ensure that the transmitter exclusively emits signals when the metal detector identifies a metal, as indicated by the specific voltage thresholds. Upon signal transmission, the receiver catches these signals, consequently triggering the jammer attached to the receiver. Consequently, the jammer disrupts the signals. The metal detector utilized in this setup can identify metals at distances of up to 4.72 inches. Meanwhile, the jammer operates at a frequency of 450 MHz and is capable of obstructing signals within a range of roughly 5 meters.

A functional interface has been developed to automatically disrupt signal transmission upon detection of explosive devices. This technology finds applications in military and classified environments to enhance security measures.

REFERENCES

[1] H. Goyal, understanding of IC 555 timer tester and IC 555 timer tester, International Journal of Inventive Engineering and Sciences, 2015.

[2] T. Padhi, Theory of Coil Antennas, RADIO SCIENCE, Journal of Research NBS/USNC- URSI, 1965, vol.69D(7), pp.997-1001.

[3] M. Pakdaman, M.M. Sannatiyan and M.R. Ghahroudi, A line follower robot from design to implementation: Technical issues and problems, The 2nd International Conference on Computer and Automation Engineering (ICCAE), Singapore, 2010, pp.5-9, doi: 10.1109/ ICCAE.2010.5451881.

[4] Leo louis, Working Principle of Arduino and using it as a tool for study and Research, International Journal of Control, Automation, Communication and Systems (IJCACS),2016, Vol.1(2),pp.21-29, DOI: 10.5121/ IJCACS.2016.1203.

[5] G.M. Onengiye, E.J. Chukwunazo, Design and Implementation of RF based Wireless Remote Control Generator System, International Journal of Engineering and Advanced Technology (IJEAT), 2016, Vol.5(4),pp.139-143.

[6] S. Yamazaki A. Tanaka, Basic analysis of a metal detector, IEEE Transactions on Instrumentation and Measurement,2002, Vol.51(4),pp.810-814.

[7] S.A. Makki, M.S.A.J.Hashim, Explosives Detection Techniques using Wireless based Technologies: A Review, IOSR Journal of Computer Engineering, 2016, vol.18(6),pp.132-143.

[8] M.S. Sharawi and M.I. Sharawi, Design and Implementation of a Low cost VLF Metal Detector with Metal-type Discrimination Capabilities, IEEE International Conference on Signal Processing and Communications, 2007, pp.480-483.

[9] K.N. [9] K.N. Choi, Two-Channel Metal Detector using Two Perpendicular Antennas, Journal of Sensors, 2014.

[10] B.O. Omijeh, G.O. Ajabugo, L.T. Osikibo, Microcontroller-Based Metal Detection System with GSM Technology, IOSR Journal of Electrical and Electronics Engineering (IOSR-JEEE), 2015, Vol.10(1), pp.80-87.

[11] T. Alauddin, T. Islam, H.U. Zaman, Efficient design of a metal detector equipped remote-controlled robotic vehicle, International Conference on Microelectronics, Computing and Communications, 2016, pp.1-5, DOI: 10.1109/MicroCom.2016.7522508.

[12] L.Junhui, C.Guorong, Design of metal detector based on single chip microcomputer, 2016 IEEE International Conference of Online Analysis and Computing Science (ICOACS), pp. 389-392, doi: 10.1109/ICOACS.2016.7563122.

[13] R. Kumar , Khalkho, Design and implementation of metal detector using DTMF technology, 2016 International Conference on Signal Processing, Communication, Power and Embedded System (SCOPES), Paralakhemundi, 2016, pp. 368-371, doi: 10.1109/SCOPES.2016.7955853.

[14] S. Singh, K.Yadav, R. singh, A. Soni, H. Matharuf, P. Rao, Blocking Of Signal Using Signal Jammer, International Journal of Current Research, 2017, Vol. 9(12), pp.62344-62347.

[15] A. O. Oke, A. S. Falohun, A. A. Adigun, The Design and Implementation of a Mobile Phone Detector Device with a Frequency Jamming Feature, International Journal of Computer Applications, 2016, Vol. 143(1), 15-19.