1. Introduction

A Metal Detector is an instrument that detects the presence of metal in the nearby area. The project has been made a very sensitive, but simple device, to build "Induction Balance" type of metal detector made up with the help of Arduino microcontroller and several other components.

The Induction Balance principle uses two coils arranged in such a way that there is virtually no inductive pick-up between them. A modulated signal is fed in to one of the coils. When metal is brought in the range, the electromagnetic field gets disturbed and the other coil picks-up an appreciably higher signal. The construction becomes simple due to the microcontroller. Also, the module for weak signal amplification with LM358 IC.

2. BLOCK DIAGRAM

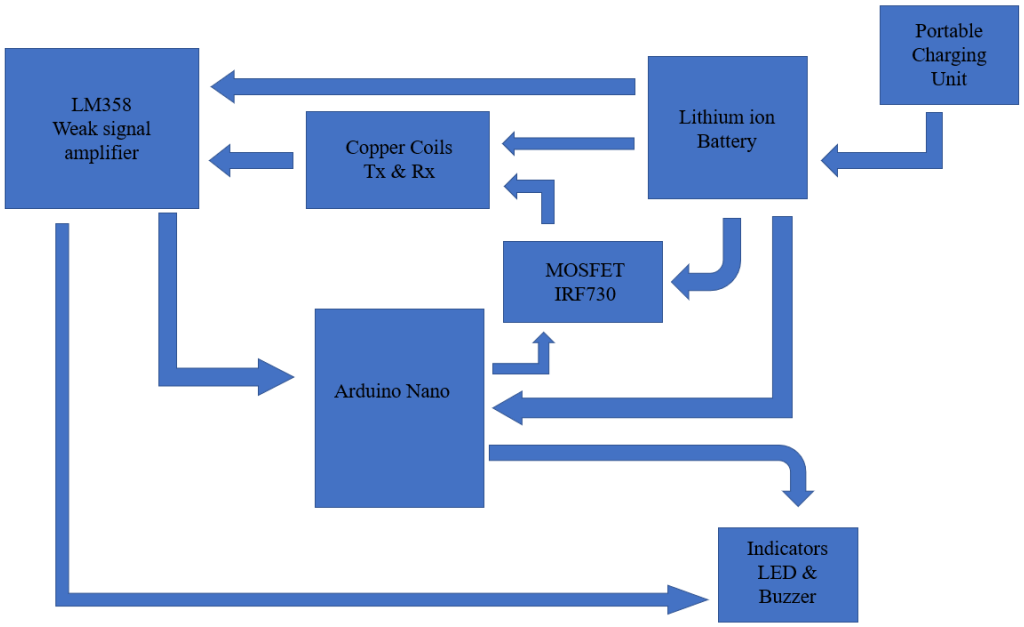


Fig. No. 2. Block Diagram of Sensitive Metal Detector Using Arduino NANO

2.1 BLOCK DIAGRAM DISCRIPTION/ WORKING

The system consists of the following components:

- Lithium-ion Battery
- Arduino Nano
- Copper Coils
- LM358 Amplifier unit
- IRF730 MOSFET
- LED
- Buzzer
- Charging unit

Working:

Lithium-ion Battery: A lithium-ion or Li-ion battery is a type of rechargeable battery which uses the reversible reduction of lithium ions to store energy. The anode (negative electrode) of a conventional lithium-ion cell is typically graphite made from carbon. The cathode (positive electrode) is typically a metal oxide. The electrolyte is typically a lithium salt in an organic solvent.

Arduino: The Arduino is a single chip 8-bit microcontroller which is having five software selectable power saving modes. It operates between 1.8-5.5 volts. ATmega328 is chosen mainly because of its reduced weight which helps in reducing the overall weight of the board. Its small size, low powered and low cost makes it more appropriate.

Copper Coils: Copper is the electrical conductor in many categories of electrical wiring. Copper wire is used in power generation, power transmission, power distribution, telecommunications, electronics circuitry, and countless types of electrical equipment. Copper and its alloys are also used to make electrical contacts. Electrical wiring in buildings is the most important market for the copper industry. Roughly half of all copper mined is used to manufacture electrical wire and cable conductors.

LM358: The LM358 is a low-power dual operational amplifier integrated circuit, originally introduced by National Semiconductor.
It supports an operating voltage of +3 to +32 volts (single power supply) or ±1.5 to ±16 volts (dual power supplies).
Input voltage can range from −0.3 to +32 volts with single power supply. Small negative input voltages below ground are acceptable because the bipolar junction transistors at the input stage are configured such that their base-emitter junction voltage provides just enough voltage differential between the collector and base for the transistors to function.

IRF730 MOSFET: Third generation power MOSFETs from Vishay provide the designer with the best combination of fast switching, ruggedized device design, low on-resistance, and cost-effectiveness.
The TO-220AB package is universally preferred for all commercial-industrial applications at power dissipation levels to approximately 50 W. The low thermal resistance and low package cost of the TO-220AB contribute to its wide acceptance throughout the industry.

LED: A light-emitting diode (LED) is a semiconductor device that emits light when current flows through it. Electrons in the semiconductor recombine with electron holes, releasing energy in the form of photons. The colour of the light (corresponding to the energy of the photons) is determined by the energy required for electrons to cross the band gap of the semiconductor. White light is obtained by using multiple semiconductors or a layer of light-emitting phosphor on the semiconductor device.

Buzzer: Early devices were based on an electromechanical system identical to an electric bell without the metal gong. Similarly, a relay may be connected to interrupt its own actuating current, causing the contacts to buzz (the contacts buzz at line frequency if powered by alternating current) Often these units were anchored to a wall or ceiling to use it as a sounding board. The word "buzzer" comes from the rasping noise that electromechanical buzzers made.

3. CIRCUIT DIAGRAM

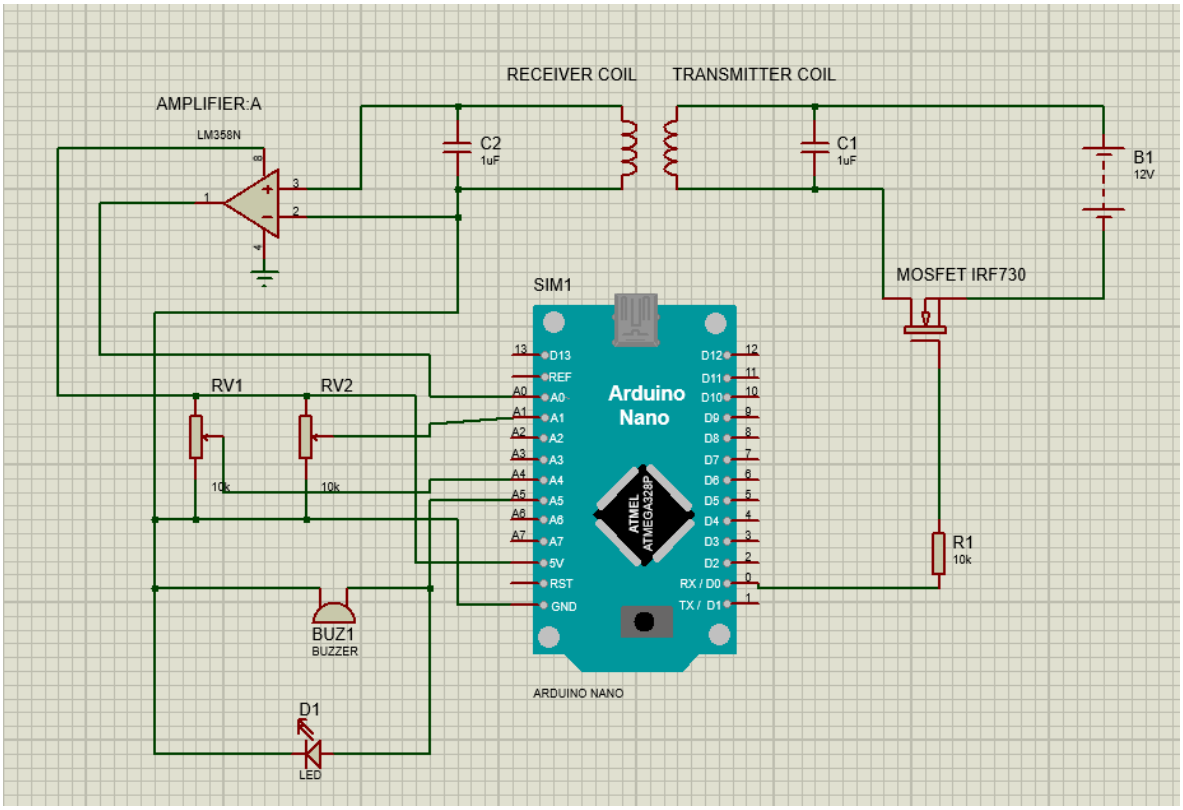


Fig. No. 3. Circuit Diagram

3.1 CIRCUIT DIAGRAM DESCRIPTION

- Select the PCB Board according to circuit diagram and components.
- Connect the MOSFET (Gate terminal to D0 pin of Arduino Nano, Drain terminal to Transmitter coil and Source terminal to negative of Lithium-ion Battery).
- Place a capacitor in between the coils.
- Receiver coils output is connected to input signal for LM358 Signal Amplifier and connect the +5V to Arduino nano. Appropriate connection of Ground and Output of LM358 is connected to A0 of Arduino nano.
- POT is connected to Arduino and LM358 unit.
- Buzzer and LED are connected to A5 pin of Arduino nano for output as Indication of detection of any metal.

4. HARDWARE SPECIFICATION:

4.1 ARDUINO NANO BOARD:

The Arduino Nano is a small, complete, and breadboard-friendly board based on the ATmega328P released in 2008. It offers the same connectivity and specs of the Arduino Uno board in a smaller form factor.

The Arduino Nano is equipped with 30 male I/O headers, in a DIP-30-like configuration, which can be programmed using the Arduino Software integrated development environment (IDE), which is common to all Arduino boards and running both online and offline. The board can be powered through a type-B mini-USB cable or from a 5 V battery.

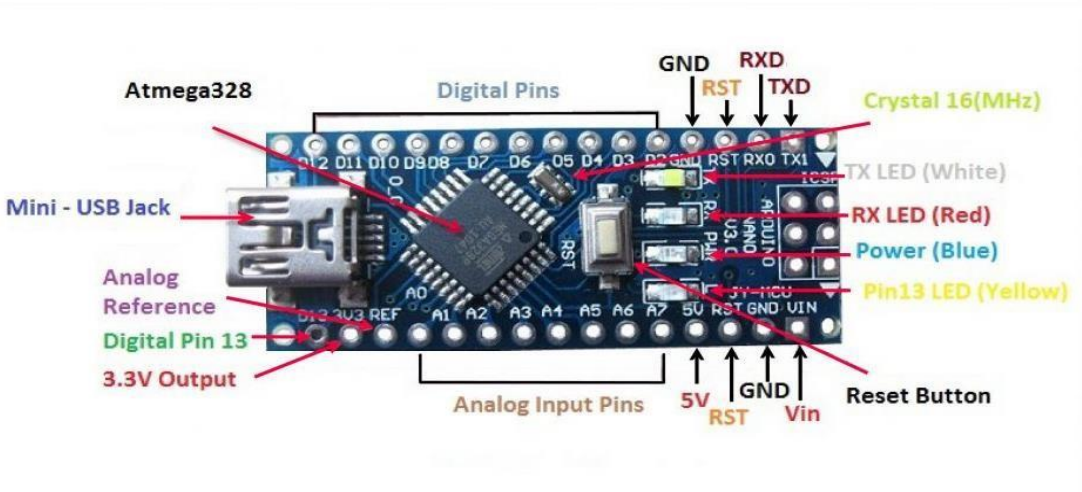


Fig. No. 4.1 Arduino NANO

4.1.1 ATMEGA 328:

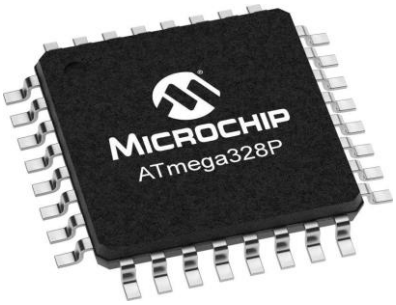


Fig. No.4.1.1 ATMEGA 328

ATmega328 is an 8-bit and 28 Pins AVR Microcontroller, manufactured by Microchip, follows RISC Architecture, and has a flash type program memory of 32KB.

It has an EEPROM memory of 1KB and its SRAM memory is of 2KB.
It has 8 Pin for ADC operations, which all combines to form Port A (PA0 – PA7).
It also has 3 built-in Timers, two of them are 8 Bit timers while the third one is 16-Bit Timer. You must have heard of Arduino NANO; NANO is based on atmega328 Microcontroller. It is NANO's heart. It operates ranging from 3.3V to 5.5V but normally we use 5V as a standard. Its excellent features include the cost efficiency, low power dissipation, programming lock for security purposes, and real timer counter with separate oscillator. It's normally used in Embedded Systems applications. You should have a look at these Real-Life Examples of Embedded Systems; we can design all of them using this Microcontroller.

4.1.2 SPECIFICATIONS:

Parameters	Value
MICROCONTROLLER	ATmega328
ARCHITECTURE	AVR
OPERATING VOLTAGE RANGE	1.8V to 5.5 V
FLASH MEMORY	32 KB of which 2 KB used by bootloader
SRAM	2 KB
CLOCK SPEED	16 MHz
ANALOG IN PINS	8
EEPROM	1 KB
DC CURRENT PER I/O PINS	40 mA (I/O Pins)
INPUT VOLTAGE	7-12V
DIGITAL I/O PINS	22 (6 of which are PWM)
PWM OUTPUT	6

Table No. 4.2

4.1.3 PIN DIAGRAM:

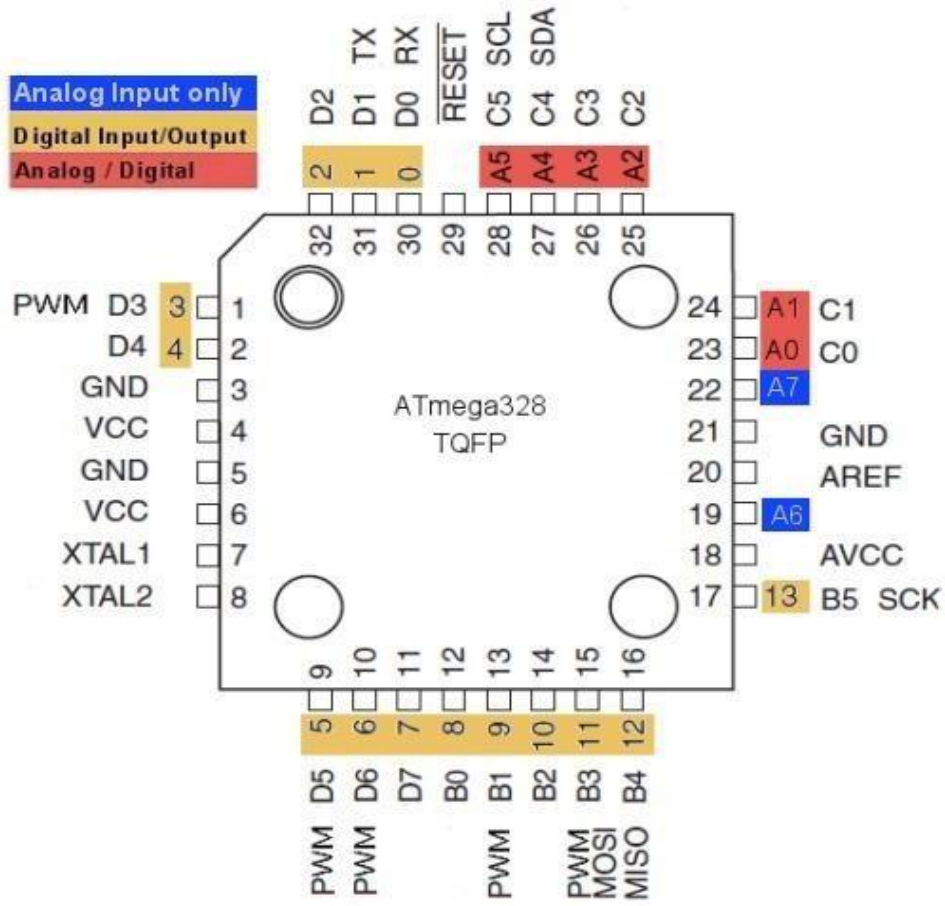


Fig No. 4.1.3

4.1.4 PIN DESCRIPTIONS:

- **VCC:** Digital supply voltage.
- **GND:** Ground.
- **Port A (PA7-PA0)**: Port A services as the analog inputs to the A/D converters. Port A also services as an 8-bit bi-directional I/O port, if the A/D converter is not used. Port pin can provide internal pull-up resistors (selected for each bit). The Port A output buffers have symmetrical drive characteristics with both high sink a source capability. When pins PA0 to PA7 are used as inputs and are externally pulled low, they will source current if the internal pull-up resistors are activated. The Port A pins are tri-stated when a reset condition becomes active, even if the clock is not running.

- **Port B (PB7:0)**: Port B is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The Port B output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port B pins that are externally pulled low will source current if the pull-up resistors are activated. The Port B pins are tri-stated when a reset condition becomes active, even if the clock is not running. Depending on the clock selection fuse settings, PB6 can be used as input to the inverting Oscillator amplifier and input to the internal clock operating circuit. Depending on the clock selection fuse settings, PB7 can be used as output from the inverting Oscillator amplifier. If the Internal Calibrated RC Oscillator is used as chip clock source, PB7...6 is used as TOSC2...1 input for the Asynchronous Timer/Counter2 if the AS2 bit in ASSR is set.

- **Port C (PC5:0)** Port C is a 7-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The PC5...0 output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port C pins that are externally pulled low will source current if the pull-up resistors are activated. The Port C pins are tristate when a reset condition becomes active, even if the clock is not running.

- **Port D (PD7:0)** Port D is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The Port D output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port D pins that are externally pulled low will source current if the pull-up resistors are activated. The Port D pins are tri-stated when a reset condition becomes active, even if the clock is not running.

- **PC6/RESET**: PC6 is used as an I/O pin. Note that the electrical characteristics of PC6 differ from those of the other pins of Port C. If the RSTDISBL Fuse is unprogrammed, PC6 is used as a Reset input. A low level on this pin for longer than the minimum pulse length will generate a Reset, even if the clock is not running. Shorter pulses are not ensured to generate a Reset.

- **XTAL1:** Input to the inverting oscillator amplifier and the input to the internal clock operating circuit.

- **XTAL2:** output from the inverting oscillator amplifier.

- **AVCC:** AVCC is the supply voltage pin for the A/D Converter, PC3:0, and ADC7:6. It should be externally connected to VCC, even if the ADC is not used. If the ADC is used, it should be connected to VCC through a low-pass filter. Note that PC6...4 use digital supply voltage, VCC.

- **AREF:** AREF is the analog reference pin for the A/D Converter.

- **ADC7:6**: ADC7:6 serve as analog inputs to the A/D converter. These pins are powered from the analog supply and serve as 10-bit ADC channels.

4.1.5 ATMEGA 328 ARCHITECTURE:

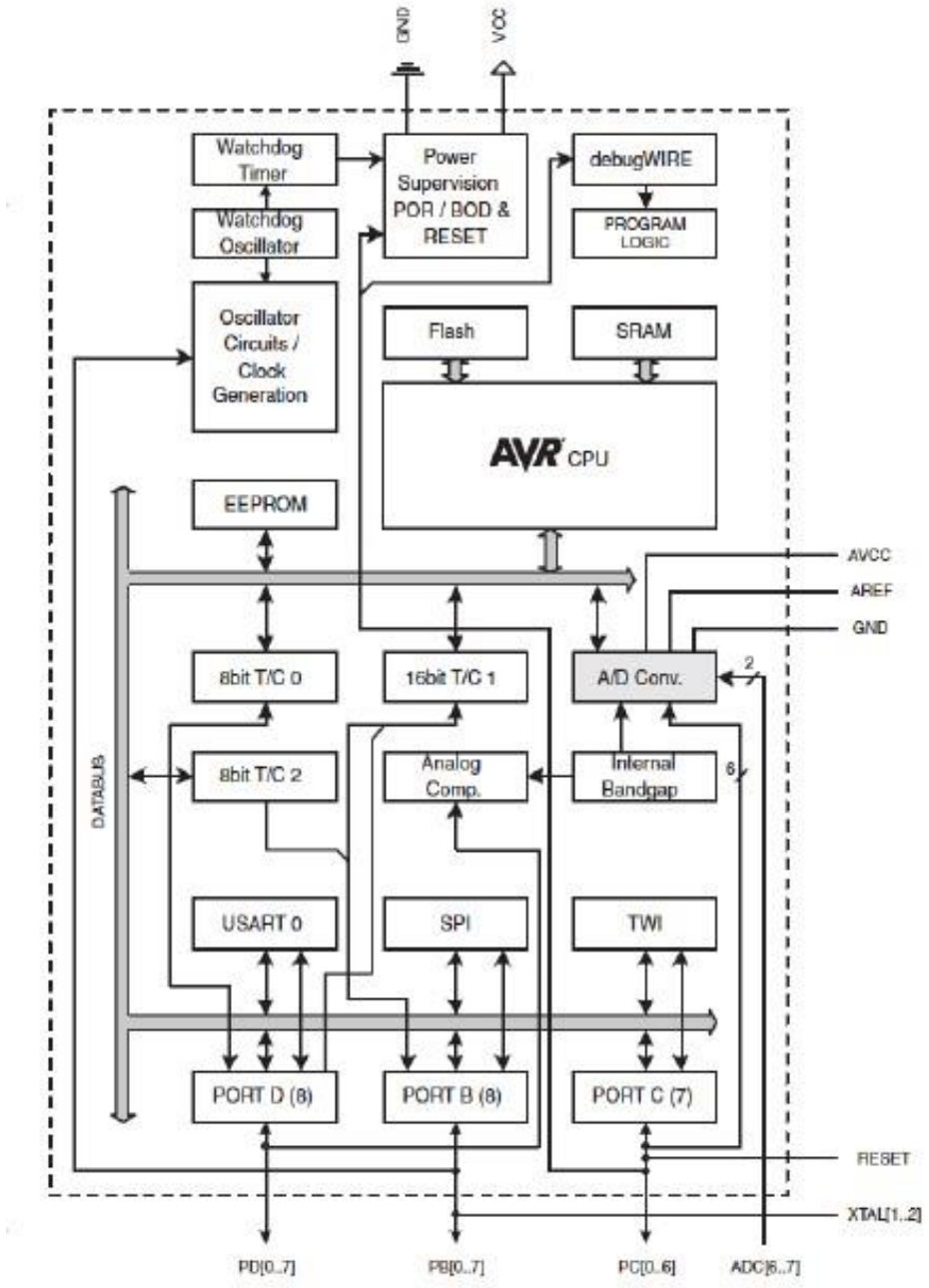


Fig. No.4.1.5 Architecture of ATMEGA328

4.2 LM358 SIGNAL AMPLIFIER:

Fig No. 4.2 LM358 Amplifier

LM358 is a type of operational amplifier. It consists of two independent, high gain, frequency-compensated operational amplifiers designed to operate from a single supply over a wide range of voltages. When your project calls for a traditional op-amp function, now you can streamline your design with a simple single power supply. Use ordinary +5VDC common to practice any digital system or personal computer application, without requiring an extra 15V power supply just to have the interface electronics you need.

4.2.1 SPECIFICATIONS/FEATURES:

- Onboard LM358 Chip
- 100 times gain circuit design
- On-board 10K adjustable resistor, could adjust amplifier times
- On-board power indicator lamp
- All pins lead, directly Input/output signals
- Working voltage: 5V-12V DC
- PCB size: 32.7mm x 13.3mm

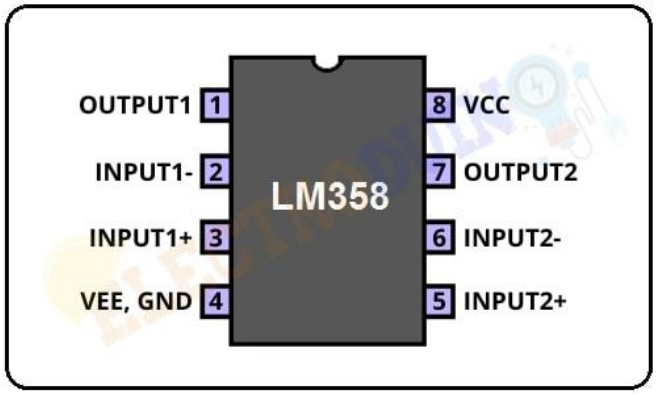


Fig No. 4.2.1 LM358 Pin Configuration

4.2.2 Schematic Diagram:

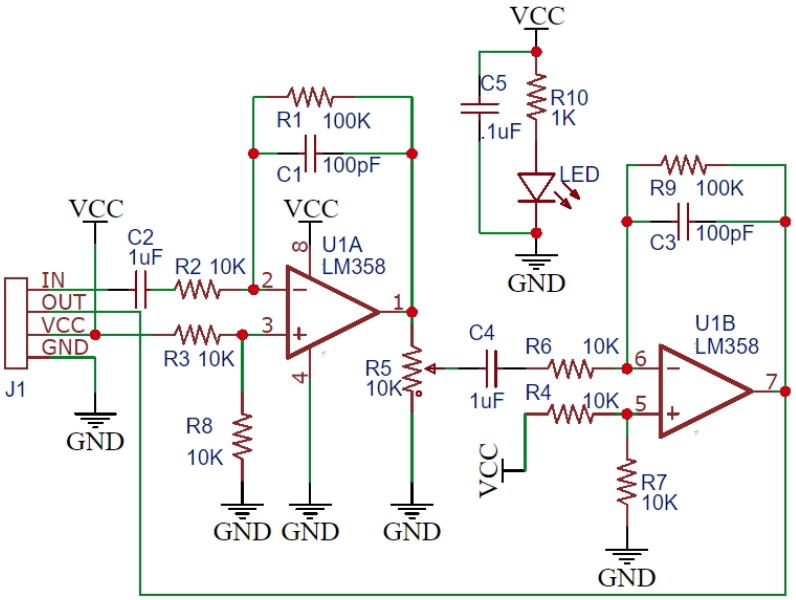


Fig No. 4.2.2 Schematic Diagram

4.3 IRF730 MOSFET:

Fig No.4.3 IRF730

Third generation power MOSFETs from Vishay provide the designer with the best combination of fast switching, ruggedized device design, low on-resistance, and cost-effectiveness. The TO-220AB package is universally preferred for all commercial-industrial applications at power dissipation levels to approximately 50 W. The low thermal resistance and low package cost of the TO-220AB contribute to its wide acceptance throughout the industry.

4.3.1 SPECIFICATIONS/FEATURES:

• Dynamic dV/dt rating
• Repetitive avalanche rated
• Fast switching
• Ease of paralleling
• Simple drive requirements

4.4 Buzzer:

Fig No. 4.4 Buzzer

A buzzer or beeper is an audio signalling device, which may be mechanical, electromechanical, or piezoelectric. Typical uses of buzzers and beepers include alarm devices, timers, and confirmation of user input such as a mouse click or keystroke.

It generates consistent single tone sound just by applying D.C voltage. Using a suitably designed resonant system, this type can be used where large sound volumes are needed. At Future Electronics we stock many of the most common types categorized by Type, Sound Level, Frequency, Rated Voltage, Dimension and Packaging Type.

4.4.1 SPECIFICATIONS:

- Rated Voltage: 6V DC
- Operating Voltage: 4 to 8V DC
- Rated Current*: ≤30mA
- Sound Output at 10cm*: ≥85dB
- Resonant Frequency: 2300 ±300Hz
- Tone: Continuous
- Operating Temperature: -25°C to +80°C
- Storage Temperature: -30°C to +85°C
- Weight: 2g

*Value applying at rated voltage (DC)

4.5 LED

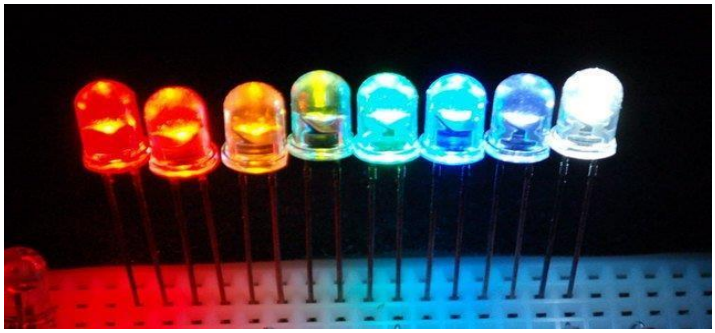
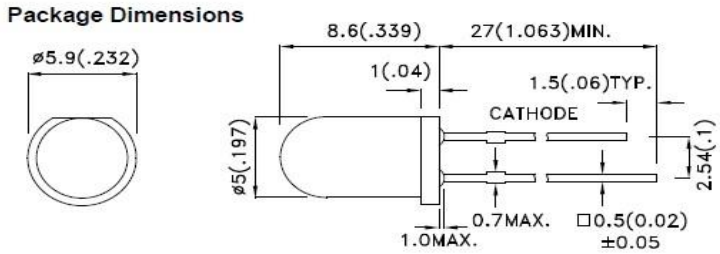


Fig No. 4.5 Light Emitting diode

The first useful thing you'll find is the dimensional 'package' information. The 'package' here is the LED itself.



As you can see, the main diameter of the LED is 5mm (it's a '5mm LED') and there's a lip that makes it around 6mm. The lip can make it handy if you're gluing the LED into a drilled hole, so it doesn't fall through. The datasheet also tells you which pin is the cathode and other lengths and sizes. Note that the figures are in mm with the inches in ()'s afterwards.

4.5.1 PINS FUNCTIONS:

A really nice thing about LEDs is that they are very simple. Unlike some chips that have dozens of pins with names and special uses, LEDs have only two wires. One wire is the anode (positive) and another is the cathode (negative). The two wires have different names because LEDs only work in one direction and we need to keep track of which pin is which. One goes to the positive voltage and the other goes to the negative voltage. Electronic parts that only work in 'one direction' like this are called Diodes, that's what the last letter of LED stands for.

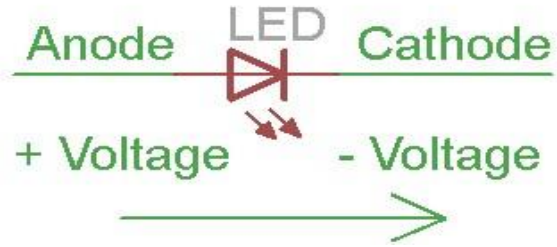


Fig No. 4.5.1

- The longer lead goes to the more-positive voltage
- Current goes in one direction, from the anode (positive) to the cathode (negative)
- LEDs that are 'backwards' won't work - but they won't break either

4.6 RESISTOR:

Fig No. 4.6 Resistor

A resistor is a passive two-terminal electrical component that implements electrical resistance as a circuit element. In electronic circuits, resistors are used to reduce current flow, adjust signal levels, to divide voltages, bias active elements, and terminate transmission lines, among other uses. High-power resistors that can dissipate many watts of electrical power as heat may be used as part of motor controls, in power distribution systems, or as test loads for generators. Fixed resistors have resistances that only change slightly with temperature, time, or operating voltage. Variable resistors can be used to adjust circuit elements (such as a volume control or a lamp dimmer), or as sensing devices for heat, light, humidity, force, or chemical activity.

Resistors are common elements of electrical networks and electronic circuits and are ubiquitous in electronic equipment. Practical resistors as discrete components can be composed of various compounds and forms. Resistors are also implemented within integrated circuits. The electrical function of a resistor is specified by its resistance:

common commercial resistors are manufactured over a range of more than nine orders of magnitude. The nominal value of the resistance falls within the manufacturing tolerance, indicated on the component.

270-ohm 2w high quality carbon film resistor (cfr) with ±5% tolerance and tin-plated copper leads. 270-ohm resistor colour code: red, violet, brown, golden.
Resistance: 270-ohm

Power rating: 2 watts

Approximate maximum current: 86.07ma.

100-ohm 1w high quality carbon film resistor (cfr) with ±5% tolerance and tin-plated copper leads.100-ohm resistor colour code: brown, black, brown, golden.
Resistance: 100 ohms

Power rating: 1 watt

Approximate maximum current: 100ma

2.2k ohm 0.5w carbon film resistor (cfr) with ±5% tolerance.

2.2k ohm resistor colour code: red, red, red, golden.

Resistance: 2.2k ohm

Power rating: 0.5 watt,

Approximate maximum current: 15.08ma

4.7 Rotary Potentiometer:

Fig No. 4.7 Rotary Potentiometer

A potentiometer is a three-terminal resistor with a sliding or rotating contact that forms an adjustable voltage divider. If only two terminals are used, one end and the wiper.
The measuring instrument called a potentiometer is essentially a voltage divider used for measuring electric potential (voltage); the component is an implementation of the same principle, hence its name.

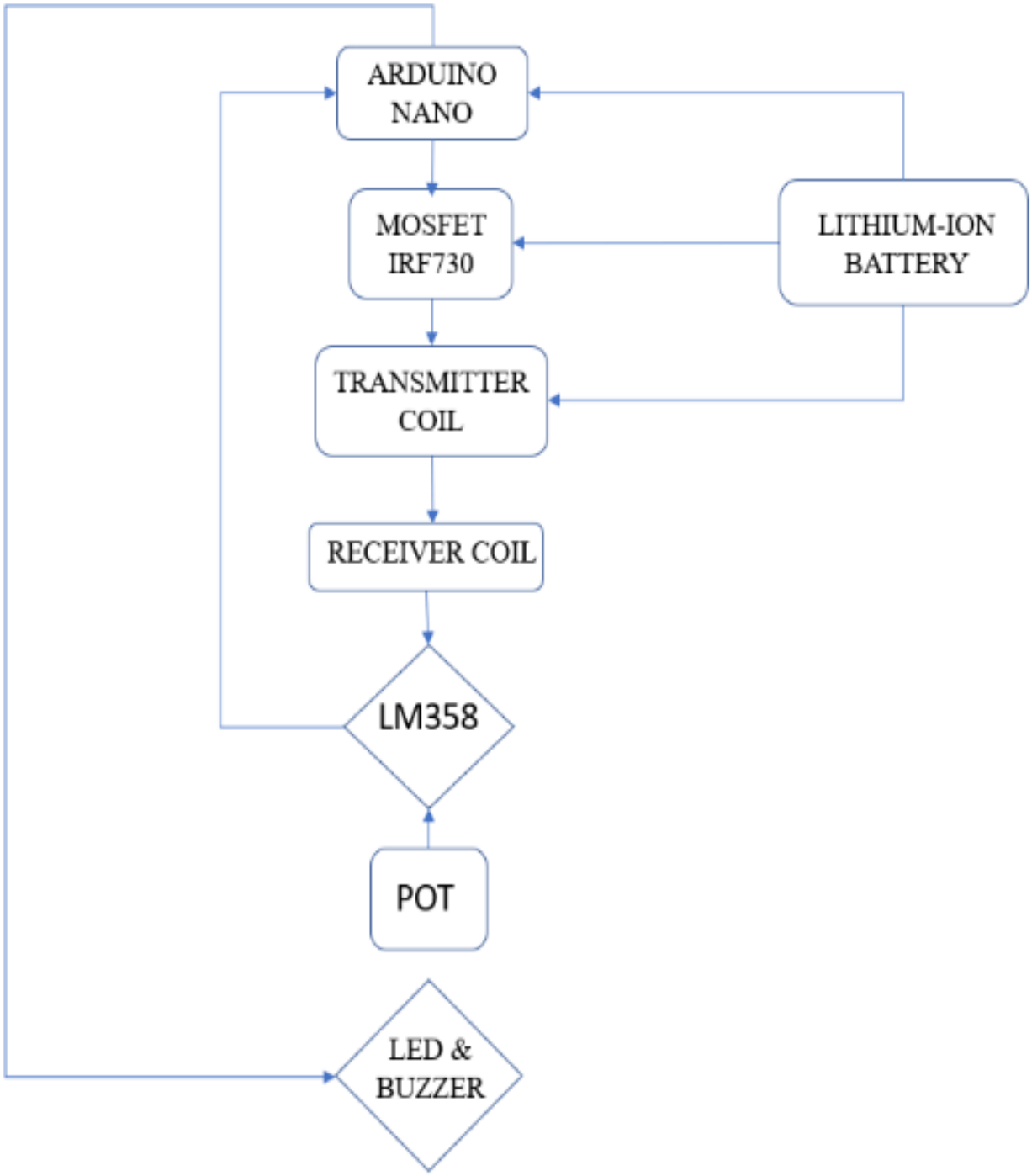
Potentiometers are commonly used to control electrical devices such as volume controls on audio equipment. Potentiometers operated by a mechanism can be used as position transducers, for example, in a joystick. Potentiometers are rarely used to directly control significant power (more than a watt), since the power dissipated in the potentiometer would be comparable to the power in the controlled load.

4.8 Lithium-ion Battery:

Fig No. 4.8 Lithium-ion Battery

A lithium-ion or Li-ion battery is a type of rechargeable battery which uses the reversible reduction of lithium ions to store energy. The anode (negative electrode) of a conventional lithium-ion cell is typically graphite made from carbon. The cathode (positive electrode) is typically a metal oxide. The electrolyte is typically a lithium salt in an organic solvent.

5. FLOWCHART:


ARDUINO NANO
MOSFET IRF730
LITHIUM-ION BATTERY
TRANSMITTER COIL
RECEIVER COIL
LM358
POT
LED & BUZZER

6. SOFTWARE DESCRIPTION:

The Arduino Integrated Development Environment or Arduino Software (IDE) - contains a text editor for writing code, a message area, a text console, a toolbar with buttons for common functions and a series of menus. It connects to the Arduino and Genuine hardware to upload programs and communicate with them. Cut a small piece of PCB board according to the circuit.

Writing Sketches:

Programs written using Arduino Software (IDE) are called **sketches.** These sketches are written in the text editor and are saved with the file extension. Ino. The editor has features for cutting/pasting and for searching/replacing text. The message area gives feedback while saving and exporting and also displays errors. The console displays text output by the Arduino Software (IDE), including complete error messages and other information. The bottom right hand corner of the window displays the configured board and serial port. The toolbar buttons allow you to verify and upload programs, create, open, and save sketches, and open the serial monitor.

Additional Commands:

Additional commands are found within the five menus: **File**, **Edit**, **Sketch**, **Tools**, **and Help**. The menus are context sensitive, which means only those items relevant to the work currently being carried out are available.

Sketch:

- Verify/Compile

  Checks your sketch for errors compiling it; it will report memory usage for code and variables in the console area.

- Upload

  Compiles and loads the binary file onto the configured board through the configured Port.

- Upload Using Programmer

  This will overwrite the boot loader on the board; you will need to use Tools > Burn Boot loader to restore it and be able to Upload to USB serial port again. However, it allows you to use the full capacity of the Flash memory for your sketch. Please note that this command will NOT burn the fuses. To do so Tools -> Burn Bootloader command must be executed.

- Export

  Compiled Binary Saves a .hex file that may be kept as archive or sent to the board using other tools.

- Show Sketch Folder

  Opens the current sketch folder.

- Include Library

  Adds a library to your sketch by inserting #include statements at the start of your code. For more details, see libraries below. Additionally, from this menu item you can access the Library Manager and import new libraries from .zip files.

- Add File.

  Adds a source file to the sketch (it will be copied from its current location). The new file appears in a new tab in the sketch window. Files can be removed from the sketch using the tab menu accessible clicking on the small triangle icon below the serial monitor one on the right side of the toolbar.

Tools:

- Auto Format**:** This format your code nicely: i.e., indents it so that opening and closing curly braces line up, and that the statements inside curly braces are indented more.
- Archive Sketch: Archives a copy of the current sketch in .zip format. The archive is placed in the same directory as the sketch.
- Fix Encoding & Reload: Fixes possible discrepancies between the editor char map encoding and other operating systems char maps.
- Serial Monitor: Opens the serial monitor window and initiates the exchange of data with any connected board on the currently selected Port. This usually resets the board, if the board supports Reset over serial port opening.
- Board: Select the board that you're using. See below for description the various boards. Port. This menu contains all the serial devices (real or virtual) on your machine. It should automatically refresh every time you open the top-level tools menu.
- Programmer: For selecting a hardware programmer when programming a board or chip and not using the onboard USB-serial connection. Normally you won't need this, but if you're burning a boot loader to a new microcontroller, you will use this.
- Burn Bootloader: The items in this menu allow you to burn a boot loader onto the microcontroller on an Arduino board. This is not required for normal use of an Arduino or genuine board but is useful if you purchase a new ATmega microcontroller (which normally comes without a bootloader). Ensure that you've selected the correct board from the Boards menu before burning the boot loader on the target board. This command also set the right fuses.

Help:

- Here you find easy access to a number of documents that come with the Arduino Software (IDE). You have access to Getting Started, Reference, this guide to the IDE and other documents locally, without an internet connection. The documents are a local copy of the online ones and may link back to our online website.

Sketchbook:

- The Arduino Software (IDE) uses the concept of a sketchbook: a standard place to store your programs (or sketches). The sketches in your sketchbook can be opened from the File > Sketchbook menu or from the Open button on the toolbar. The first time you run the Arduino software, it will automatically create a directory for your sketchbook. You can view or change the location of the sketchbook location from with the Preferences dialog.

Tabs, Multiple Files, and Compilation:

- Allows you to manage sketches with more than one file (each of which appears in its own tab). These can be normal Arduino code files (no visible extension), C files (.c extension), C++ files (.cpp), or header files (.h).

Uploading:

- Before uploading your sketch, you need to select the correct items from the Tools>Board and Tools > Port menus. The boards are described below. On the Mac, the serial port is probably something like /dev/tty. usbmodem241 (for an Uno or Mega2560 or Leonardo) or /dev/tty.usbserial-1B1 (for a Demilune or earlier USB board), or /dev/tty. USA19QW1b1P1**.1** (for a serial board connected with a Key span USB-to-Serial adapter). On Windows, it is probably COM1 or COM2 (for a serial board) or COM4, COM5, COM7, or higher (for a USB board) - to find out, you look for USB serial device in the ports section of the Windows User.
- Device Manager. On Linux, it should be/dev/ttyACMx**,**/dev/ttyUSBx**or** similar. Once you have selected the correct serial port and board, press the upload button in the toolbar or select the Upload item from the File menu. Current Arduino boards will reset automatically and begin the upload. With older boards (pre-Decimal) that lack auto reset, you will need to press the reset button on the board just before starting the upload. On most boards, you will see the RX and TX LED blink as the sketch is uploaded. The Arduino Software (IDE) will display a message when the upload is complete, or show an error.

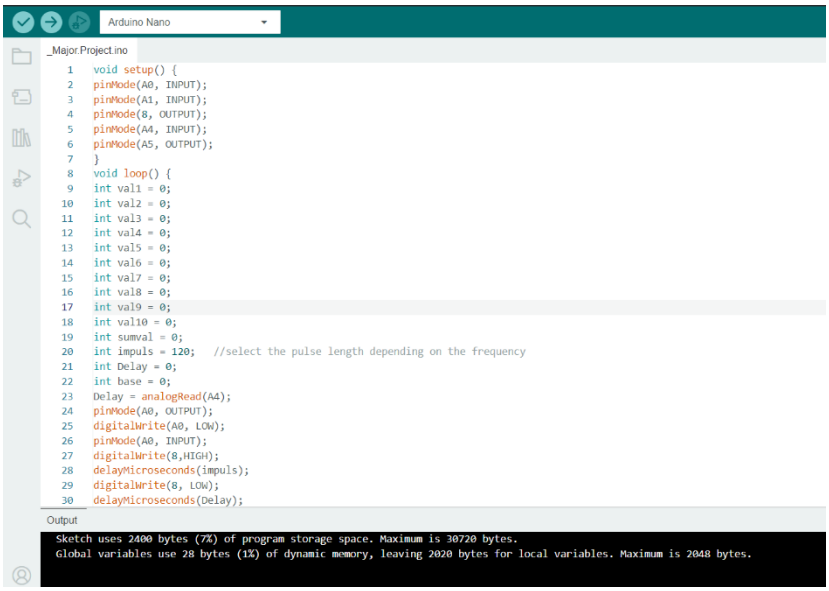


Fig No. 6.1 Verification of Program

- When you upload a sketch, you're using the Arduino bootloader**,** a small program that has been loaded on to the microcontroller on your board. It allows you to upload code without using any additional hardware. The bootloader is active for a few seconds when the board resets; then it starts whichever sketch was most recently uploaded to the microcontroller. The bootloader will blink the on-board (pin 13) LED when it starts (i.e., when the board resets).

Boards:

- The board selection has two effects: it sets the parameters (e.g., CPU speed and baud rate) used when compiling and uploading sketches; and sets and the file and fuse settings used by the burn bootloader command. Some of the board definitions differ only in the latter, so even if you have been uploading successfully with a particular selection, you'll want to check it before burning the bootloader.
- Arduino Software (IDE) includes the built-in support for the boards in the following list, all based on the AVR Core. The Boards Manager included in the standard installation allows adding support for the growing number of new boards based on different cores like Arduino Due, Arduino Zero, Edison, Galileo and so on.

7. LIST OF COMPONENTS:

SR.NO.	COMPONENTS	SPECIFICATION	QUANTITY
1	Arduino NANO	ATmega328p	1
2	LED	White	2
3	Resistor	10K	3
		1K	3
		500	2
5	MOSFET	IRF 730	1
6	Buzzer	Geneal	1
7	Coil	Copper (60 turns each)	2

Table No. 7

8. ADVANTAGES:

- Better sensitivity.
- Light weight.
- Adjustable range.
- Range is 20 cm to 80 cm.

9. APPLICATIONS:

- In Archaeological research.
- To find metal components from the scrap/debris.

10. FUTURE SCOPE:

- Using LCD, we can display the type of metal.
- Can be used to find metal ores in the mines.

11. CONCLUSION:

This detector is the most sensitive, but also a big advantage is that it is a standalone instrument and does not use a smartphone. The construction is simple thanks to the microcontroller, but also the module for weak signal amplification with LM358 IC

The Induction Balance principle uses two coils arranged in such a way that there is virtually no inductive pick-up between them. A modulated signal is fed in to one. When metal is brought near, the electromagnetic field is disturbed and the other coil picks-up an appreciably higher signal.

The ability to locate objects buried in the soil are, of course, dependent on soil conditions. Dry sand being the most favourable, and clay is the worst medium.

12. REFERENCES:

https://www.hackster.io/

https://www.wikipedia.org/

https://projecthub.arduino.cc/

https://youtube.com/

13. APPENDIX:

FINAL PROJECT

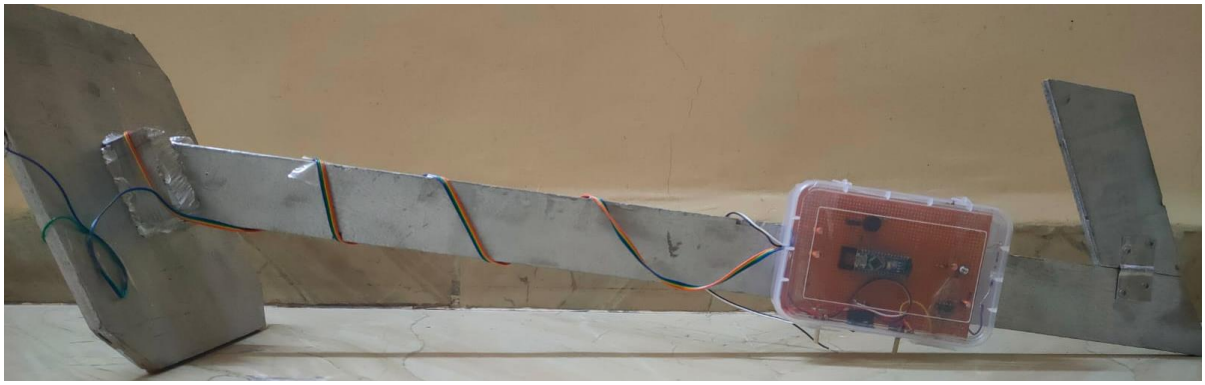


Image No. 13.