Cheap And Efficient Metal Detector

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Abstract-*The electronic industry is the world's largest and fastest growing manufacturing industry in the world. Metal detectors are fascinated electronic device. In the current era , it is most commonly used by many of the people who are just enthusiastic about extolling the virtues of their favorite metal detector as they are about setting off in search of buried treasure.*

The most commonly used metal detection technology is Very Low Frequency (VLF) also known as the known as induction balance . In this type of metal detector, there are two coils : one of which will be the transmitting coil and the another will be the receiving coil. This project aims to design , stimulate ,and construct a simple , cheap and efficient metal detector This metal detector was implemented using LC oscillator. This metal detector will be capable of detecting all the kinds of metals, without any physical contact with the metal. The main objective of this project are focussed on designing a metal detector with the help of the electronic component which are easily available in the market and are not so expensive. The simulation was done using Proteus ISIS simulation software

Keywords-VLF Technology, LC Oscillator, Feedback oscillator , VCO , Direct coupled amplifier

I. INTRODUCTION

(a) VLF Technology

Very low frequency is the most popular detector technology used today. It uses two coils for detection operation. One of the coils has variable magnetic field across it and the other acts as an antenna to pick up and amplify frequencies coming from target objects in the ground. Very low frequency (VLF), also known as induction balance . In a VLF metal detector, there are two distinct coils:

- Transmitter coil - This is the outer coil loop. Within it is a coil of wire. Electricity is sent along this wire, first in one direction and then in the other, thousands of times each second. The number of times that the current's direction switches each second establishes the frequency of the unit.
- Receiver coil - This inner coil loop contains another coil of wire. This wire acts as an antenna to pick up and amplify frequencies coming from target objects in the ground.[2]

(b) LC Oscillator

LC oscillators are widely used to generate high frequency waves(10Khz to 100Mhz)[1], hence these are also called as RF oscillators. It is possible to produce the frequencies at higher range (above 500 MHz) with the practical values of inductors and capacitors. These oscillators use a tank circuit consisting of inductor L and capacitor C elements.

A tank or oscillatory circuit is a parallel form of inductor and capacitor elements which produces the electrical oscillations of any desired frequency. Both these elements are capable of storing energy. Whenever the potential difference exists across a capacitor plates, it stores energy in its electric field. Similarly, whenever current flows through an inductor, energy is stored in its magnetic field. The below figure shows a tank circuit in which inductor L and capacitor C are connected in parallel.[3]

Fig :1 - LC circuit

(c) Feedback Oscillator

Feedback oscillator is a most common type of transistor oscillator which is used to produce undamped oscillation of desired frequency. It consist of mainly two section ,one of which is the amplifier section and the another is the feedback network section, each of these two section will produce a phase shift of 180 degree , i.e overall phase shift of 360 degree , which is the requirement of the oscillator circuit.

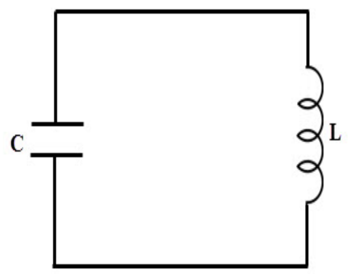

Fig : 2- Feedback oscillator principle

(d) VCO

VCO stands for Voltage controlled oscillator. it is a type of the transistor oscillator whose frequency of oscillation is controlled by the voltage input. Here, a voltage signal is used as control input to vary the output frequency.[1]

(e) Direct coupled amplifier

There are many applications in which extremely low frequency signals i.e. below 10 Hz are to be amplified, for example, amplifying photo-electric current, thermo-couple current etc.In such applications, use of coupling devices such as capacitors and transformers makes such amplifiers bulky due to the large electrical size of these components at low frequencies.Hence, in such cases, one stage is directly connected to the next stage without any intervening coupling device. This type of coupling is known as direct coupling.[4]

II. PRINCIPLE OF OPERATION

Faraday,s law of Electromagnetic induction

(1)Faraday's First Law

Any change in the magnetic field of a coil of wire will cause an emf to be induced in the coil. This emf induced is called induced emf and if the conductor circuit is closed, the current will also circulate through the circuit and this current is called induced current.

(2)Faraday's Second Law

It states that the magnitude of emf induced in the coil is equal to the rate of change of flux that linkages with the coil. The flux linkage of the coil is the product of number of turns in the coil and flux associated with the coil.[5]

Lenz law

Lenz's law states that when an emf is generated by a change in magnetic flux according to Faraday's Law, the polarity of the induced emf is such, that it produces an current that's magnetic field opposes the change which produces it.

III. DESIGN METHODOLOGY

There are a number of ways to detect a metal object and alter the operation of a circuit so that an output is produced. Metal detectors will detect ferrous (iron, steel, stainless steel) as well as non-ferrous (copper, tin, gold, lead, silver, aluminium) as well as alloys (brass, cupro-nickel, pewter etc). Depending on the complexity of the circuit, a metal detector will be able to discriminate between a lump of gold and an aluminum ring-pull from a drink-can.

The circuit we have presented in this project is very simple and works on the principle of detecting the change in the amplitude of a waveform generated by the principle of Faraday's law of electromagnetic induction and Lenz law. This is called AMPLITUDE MODULATION.

Design was done based on the principle of operation keeping in mind availability of components and getting the output in tangible manner. and hence the components used are:

1 – 18 ohm R , 2 - 330 ohm R, 1 - 390 ohm R , 2 - 1k ohm R, 1 - 1k ohm R, 2 - 10k ohm R, 1 - 56k ohm R, 1 - 220k ohm R, 1 - 270k ohm R , 1 - 500R mini pot, 2 - 10n ceramics, 1 - 47n ceramic or poly, 1 - 100n ceramic, 1 - 100u electrolytic, 1 - 30 metre 0.25mm enamelled winding wire, 1 - 1N4148 signal diode, 1 - 5v6 zener diode, 1 - 3mm red LED, 3 - BC 547 transistors, 1 - BC 557 transistor, 1 - BC 338 transistor, 1 - 8R mini speaker &1 - 9v battery.

Now let have a look over the circuit.This circuit consists of three building blocks:

1. The first block is a FEEDBACK OSCILLATOR, consisting of the first transistor, 70 turn coil 47n and the 50 turn coil.
2. VCO (Direct coupled high gain amplifier) - transistors 3 and 4.
3. THE DRIVER TRANSISTOR [6]

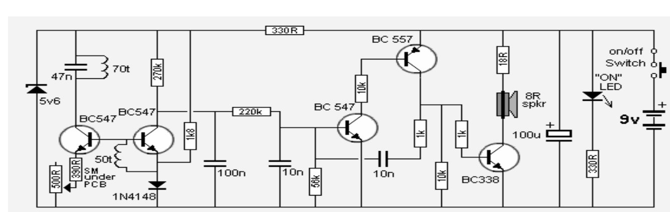

Fig :3- Metal Detector

Working:

When the switch is closed , 9V DC supply is applied to the circuit. As soon as the power supply is switched ON , the LED starts glowing since here the LED is acting as a power indicator. At the same time zener diode provides 5.6V regulated voltage supply to all the circuit components. The first transistor is turned on via the diode in the emitter of the second transistor. This diode receives its turn -on bias from the 1k8 resistor. The resistance of the Rx (receiving coil) is very small and the base of the first transistor sees a "turn-on" voltage from the voltage across the diode. The variable resistor in the emitter starts at a low value for our description of the circuit. The first transistor has a high gain at this point in time and the Tx (transmitting coil) and 47n form a tuned circuit with a frequency of approx 15 kHz. The power rail is stabilized by the 5v6 zener and a small amount of noise is always present in any circuit and causes a small waveform to be produced by the coil and capacitor. This waveform is passed to the receiving coil (through the air) and a small voltage is produced across it. Since the end of the receiving coil connected to the diode, it is fixed and rigid and the signal produced by the coil is passed to the base of both transistors. The coil is connected so the voltage it produces turns the first transistor ON harder and thus the waveform produced by the tuned circuit is increased.

Since the resistance of the pot is a minimum, the amplitude of the waveform will be a maximum and this will have the effect of turning ON the second transistor so the voltage on the collector will be very low. The signal on the collector will be a waveform but this is smoothed by the 100n capacitor. As the resistance of the pot is increased, the voltage on the emitter will increase and the base -to- emitter voltage will be LESS, so the transistor will not be turned on as much. The waveform produced by the tuned circuit will reduce. This will be reflected in the receiving coil and the second transistor will also get turned off slightly. The voltage on the collector will rise and this will be passed to the second building blocks. When a voltage appears on the base of the third transistor, it turns ON and this turns on the PNP transistor. The voltage on the collector of the PNP transistor rises and this pulls one end of the 10n capacitor (via a 1k resistor) towards the positive rail. The other end of the capacitor is connected to the base of the third transistor. This turns ON the third transistor.

They keep turning ON until both are fully saturated (turned on). This happens very quickly and during this time the 10n capacitor starts to charge. The charging current flows through the base -emitter junction of the third transistor and as the capacitor charges, it develops a voltage across it. This causes the charging current to reduce. The third transistor gradually turns off and this turns the fourth transistor off slightly. The voltage on the collector of the fourth transistor drops and the voltage across the 10n capacitor causes the third transistor to turn off completely. This turns off the fourth transistor and now both are fully turned off. The 10n discharges through the 56k and the cycle repeats. The capacitor takes a very short time to charge and a longer time to discharge. This is why the output consists of very short spikes.

The output of the oscillator is connected to a driver transistor via a 1k resistor. This resistor prevents high currents flowing when both transistors are turned on. The driver transistor is directly connected to an 8 ohm speaker. The 18R resistor reduces the volume and prevents large spikes appearing on the power rails. The result is a clicking sound. For this type of circuit to be successful, the supply voltage must be maintained absolutely rigid for the detecting section. The diameter of the wire and the size of the coil is not critical however our prototype was 0.25mm enamelled wire wound on a 70mm diameter former. Unwind the wire you have received and place it along the floor in a long line so it can turn around on its axis when winding the coils. This will prevent the wire twisting on -itself and kinking. The two coils must be placed on top of each other and changing the number of turns of the receiving coil does not alter the sensitivity of the circuit. The transmitting (oscillating) coil is 70 turns and the detecting coil is 50 turns.

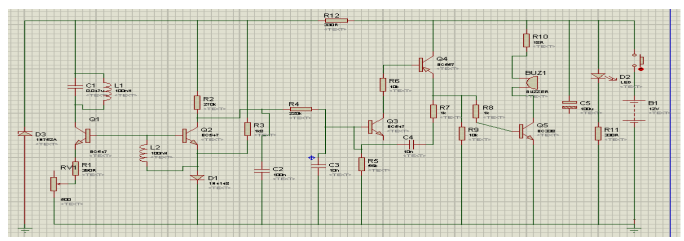

Fig:4 **-** Simulation circuit

This simulation circuit of the metal detector was constructed using the Proteus ISIS Simulation software,

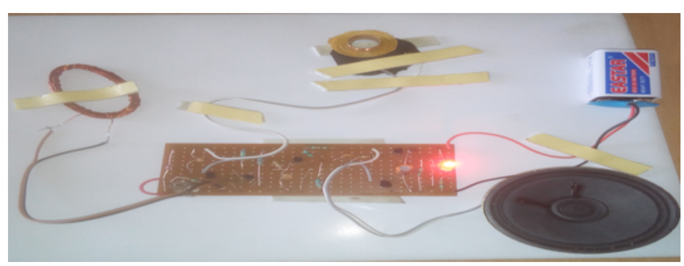

Fig: 5 **-** Full view of overall circuit(Realizing circuit)

IV. CONCLUSION

There are a number of ways to detect a metal object and alter the operation of a circuit so that an output is produced.

Metal detectors will detect ferrous (iron, steel, stainless steel) as well as non-ferrous (copper, tin, gold, lead, silver, aluminium) as well as alloys (brass, cupro-nickel, pewter etc).

Depending on the complexity of the circuit, a metal detector will be able to discriminate between a lump of gold and an aluminium ring-pull from a drink-can.

It has certain limitations which can be removed by little enhancement in the above shown circuit of metal detector.some of those limitations are : It cannot distinguish between several types of metals. Its detection region is small.This metal detector is not so portable.

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