DESIGN AND CONSTRUCTION OF A HAND-HELD METAL DETECTOR

By
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DEDICATION

This project is dedicated to the Almighty Allah, the most beneficent the most merciful. And also to my lovely parents: Alhaji (Dr.) Abdulrahim Mamman and Hajiya (Mrs.) Abdulrahim R.O .

DECLARATION

I, ABDULRAHIM MOH'D SALISU, declare that this work was done by me and has never been presented elsewhere for the award of a degree. I also hereby relinquish the copyright to the Federal University of Technology Minna.

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ABSTRACT

This thesis presents all the work done towards designing and constructing a metal detector. The metal detector is a digital electronic based project. The basic underlying principles for designing a hand held metal detector are the physical properties of metals. The device is reliable, efficient, portable and environmentally independent.

The hand-held metal detector could detect metals of reasonable size at the specified distance (50mm). A sound was always heard at the buzzer anytime a metal comes close to the inductor coil. The inductor coil is always maintained at a constant frequency before detection can be achieved.

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CHAPTER 1

INTRODUCTION

The project is aimed at the design and construction of a hand-held metal detector. It is to detect any form of metallic material of reasonable size. It was developed as a result of research of the properties of metals. Metals are materials that possess the following physical properties:

- Malleability: the ability of a metal to be hit or pressed into different shapes easily without breaking and cracking.
- Ductility: the ability of a metal to be beaten into thin wires.
- Color: they are colored and can be polished.
- Good conductors of heat and electricity.
- Metals are lustrous.

Examples of metals include iron, copper, aluminum, zinc, brass, gold, silver, etc.

The detection goes alongside both audio alarm and light indicator. It involves merely just placement of the metal detector few centimeters to the target item (metal) and it detects it by making an alarm alongside with a light signal.

1.1 AIM AND OBJECTIVE OF THE HAND HELD METAL DETECTOR

The project's objective is to provide a formal or un-embarrassing manner of checking people or light packages for offensive materials or weapon. History has shown that no weapon can be made without involving metallic components. So, this device can be used to detect the weapons of metallic structure. The device is attributed to small size and it is battery powered.

The metal detector has many areas of applications in different fields of human endeavors. They include security at airports, border ports, embassies, and custom checkpoints and sometimes in locating buried drains and underground pipes, and in tracing conduit network inside a wall.

1.2 METHODOLOGY

The basic concept of the device involves digitally sampling of the frequency of an LC oscillator with an exposed inductor. The design follows mere inductor principle. The metal sensor is a wound of coils around a non-metallic platform. The coil is simply the inductive component of an LC oscillator. The capacitor is usually constant. The operating frequency of the oscillator is determined by the value of the capacitor and inductor through a familiar relationship. It is basic that metallic material influences the inductive value of a coil. Therefore, whenever a metallic material is near the search or sensor coil, its value changes.

Normally its inductance increases. The result in the LC oscillator is a drop in operating frequency. This technique simply defines the basic mode of metallic detection by the device. The design features a logical sampler. The logical device is a simple frequency meter. The unit monitors the output frequency from the LC oscillator; the unit also passes logical output, which defines the situation of the search or sensor coil, and the LC oscillator in general. The leading output is logic 0 whenever the LC oscillator is stable. The situation changes to logic 1 whenever metal detection occurs. This logical output is used for switching on the alarm.

1.3 SCOPE OF THE PROJECT

The operation of the device is merely of a digital form. The core design is built up of complementary metallic oxide semiconductor (CMOS) integrated circuits. The device is 9V battery powered. Therefore low power consumption electronic components are really of great importance. The sensitivity is aimed at 50mm. The main result of detection is an alarm. It is designed to trigger on whenever a device is detected.

1.4 LIMITATION OF THE PROJECT

The device is limited to simple searching applications. The major one is body search. It is not easy to adapt the device for more advanced applications. Also, due to the oscillator part of the design, the involved circuit produces electromagnetic disturbance or interference.

Moreover, the sensitivity cannot be applicable in certain deep-searching conditions or operations.

The most difficult part of the design and construction is the timing of the LC oscillator to a particular referenced frequency. This frequency is needed to be in a specific range of the sampler for result. Therefore, due to this difficulty in accessing an oscilloscope, the frequency adjustment is performed manually.

CHAPTER TWO

LITERATURE REVIEW

In 1881, Alexander Graham Bell invented the first metal detector. As President James Garfield lay dying of an assassin's bullet, Alexander Graham Bell hurriedly invented a crude metal detector in an unsuccessful attempt to locate the fatal slug. Bell's metal detector was an electromagnetic device he called the induction balance. The German physicist Heinrich Wilhelm Dove invented the induction balance system. Early machines were crude and used a lot of battery power, and only worked to a very limited degree.

Metal Detectors evolved in the form of the rectangular gantry now standard in airports. In common with the developments in other uses of metal detectors both alternating current and pulse systems are used, and the design of the coils and the electronics has moved forward to improve the discrimination of these systems. In 1995 systems such as the Metor 200 appeared with the ability to indicate the approximate height of the metal object above the ground, enabling security personnel to more rapidly locate the source of the signal. Smaller hand held metal detectors is also used to locate a metal object on a person more precisely.

Larger portable metal detectors are used by archaeologists and treasure hunters to locate metallic items, such as jewelry, coins, bullets, and other various artifacts buried shallowly underground.

Metal detectors have come a long way, from the simple device, to today's sophisticated machines. Modern top models are fully computerized, using microchip technology to allow the user to set sensitivity, discrimination, track speed, threshold volume, notch filters, etc, and hold these parameters in memory for future use. Compared to just a decade ago, detectors are lighter, deeper-seeking, use less battery power, and discriminate better. We can expect to see more improvements as designers continue to apply the latest Electronics and Computer technologies to the task of making ever better metal detectors [1].

New genres of metal detector have made their appearance. BB (Beat Balance) and CCO (Coil Coupled Operation) were unveiled by the electronics press in 2004. Both were invented by electronics writer and designer Thomas Scarborough, and combined unprecedented simplicity with good sensitivity.

Based on reasonable and reliable observation, a good number of past projects relating to metal detection had certain degrees of demerits which are carefully considered during the course of the design of this project. The project is aimed at modifying of dozens of early works.

The most evident feature of the design is the use of complementary metallic oxide semiconductor (CMOS) integrated circuits. The 4000 series CMOS integrated circuits are intensively used in the involved circuit. The major advantage of these devices is high compatibility in which the result is reasonable portability. The other attachments are low power consumption, wide supply voltage range, widely available logic functions, high flexibility, etc. The CMOS design is quite better than the transistor. Transistor- Transistor Logic design is seen in most old related projects.

Transistor- Transistor Logic (TTL) devices are merely made for high speed and laboratory applications. They consume relatively high power in contrast to CMOS devices. Their usage doesn't encourage the application of battery for circuit designs.

Moreover, the project was achieved with incredibly small number of components. The circuit holds just two transistors as compared to dozens of such devices in some old related projects. Most duties were taken care of by single integrated circuits.

The circuit design is quite simple. It involved frequency alteration through metallic inference. A simple circuit monitors the frequency from an RC oscillator. The diversion of the frequency output from a particular range triggers on both the light and alarm outputs. This design is quite comprehensive.

Most metal detector designs are quite complicated. They involved the usage of advanced frequency analysis devices for reasonable result, although their results are attributed to more accuracy. The project merely provides a means of achieving metal detection through a cheap and acceptable technique.

This project involves a basic metal detecting technique. It involves a coil of wire wound around a flat platform. The coil is the inductor of an LC oscillator. The frequency output of such oscillator is determined by the value of both inductor and capacitor in the circuit. Whenever the capacitance is constant, the only frequency inference is the inductor.

Moreover, every coil has a particular inductance. The value of the inductance is inference by a close metallic material. The inductance of a coil increases with the close metallic material.

The inductance reduces whenever the metallic materials are put at far distance. This basic principle is used for basic metal detecting.

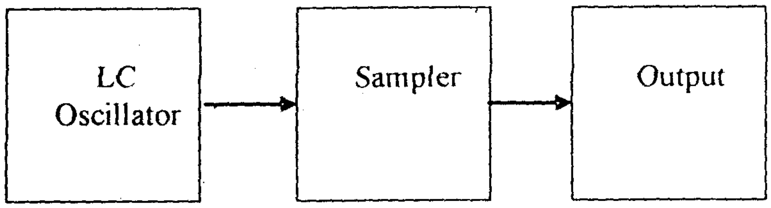

Fig 2.1 Block diagram of a typical metal detector.

It is a common practice to connect the LC oscillator to a sampler. This circuit is usually logical or digital in nature. It is designed to define the frequency output from the LC oscillator. The unit is attributed to logical output. It is either logic 1 or 0. Whenever the frequency of the LC oscillator is normal or high, the sample provides logic 1 output. There is no metal detection but, in a situation whenever the frequency is low showing the detection of metallic material, the output of the sample is logic 0. The output's states are interchanged in certain situations.

The major or conventional metal detectors are Pulse Induction and Beat Frequency Oscillator techniques.The most common way to detect metal uses a technology called beat-frequency oscillator (BFO). In a BFO system, there are two coils of wire. One large coil is in the search head, and a smaller coil is located inside the control box. Each coil is connected to an oscillator that generates thousands of pulses of current per second. The frequency of these pulses is slightly offset between the two coils.

As the pulses travel through each coil, the coil generates radio waves. A tiny receiver within the control box picks up the radio waves and creates an audible series of tones (beats) based on the difference between the frequencies.

If the coil in the search head passes over a metal object, the magnetic field caused by the current flowing through the coil creates a magnetic field around the object. The object's magnetic field interferes with the frequency of the radio waves generated by the search-head coil. As the frequency deviates from the frequency of the coil in the control box, the audible beats change in duration and tone. The simplicity of BFO-based systems allows them to be manufactured and sold for a very low price.

A less common form of metal detector is based on pulse induction (PI). Unlike VLF, PI systems may use a single coil as both transmitter and receiver, or they may have two or even three coils working together. This technology sends powerful, short bursts (pulses) of current through a coil of wire. Each pulse generates a brief magnetic field. When the pulse ends, the magnetic field reverses polarity and collapses very suddenly, resulting in a sharp electrical spike. This spike lasts a few microseconds (millionths of a second) and causes another current to run through the coil. This current is called the reflected pulse and is extremely short, lasting only about 30 microseconds. Another pulse is then sent and the process repeats. A typical PI-based metal detector sends about 100 pulses per second, but the number can vary greatly based on the manufacturer and model, ranging from a couple of dozen pulses per second to over a thousand.

If the metal detector is over a metal object, the pulse creates an opposite magnetic field in the object. When the pulse's magnetic field collapses, causing the reflected pulse, the magnetic field of the object makes it take longer for the reflected pulse to completely disappear. This process works something like echoes. In a PI metal detector, the magnetic fields from target objects add their "echo" to the reflected pulse, making it last a fraction longer than it would without them.

A sampling circuit in the metal detector is set to monitor the length of the reflected pulse. By comparing it to the expected length, the circuit can determine if another magnetic field has caused the reflected pulse to take longer to decay. If the decay of the reflected pulse takes more than a few microseconds longer than normal, there is probably a metal object interfering with it. [2]

CHAPTER THREE

DESIGN AND IMPLEMENTATION

This chapter is mainly concerned with the designing of the circuit, components put together to form a unit and several units to bring out the complete unit of the device. The circuit mainly involves six (6) units which are illustrated by the following block diagram shown in Fig 3.1:

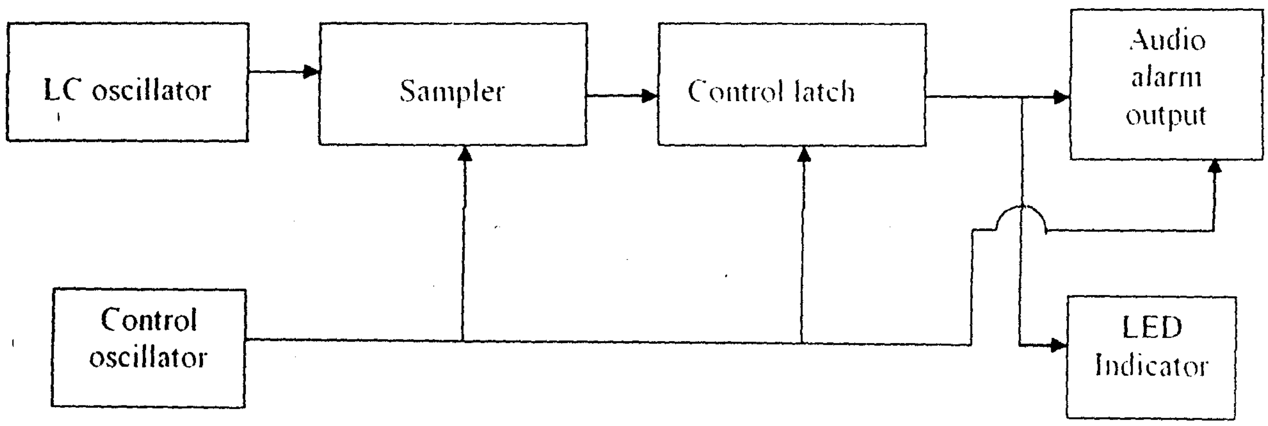

Fig 3.1 Complete block diagram of a metal detector

Another part of the design is the power supply unit, which is the 9Volts, supply battery. Its function is to supply power to the circuit to make it function.

In the block diagram of Fig 3.1, some blocks are electronic circuits (comprising of sub components) while others are mainly integrated circuits (ICs). The LC oscillator is an electronic circuit. The sampler, control latch and the control oscillator are ICs while the audio output (speaker) and the light emitting diode (LED) indicator are electronic components.

3.1 OSCILLATOR

An oscillator is an electronic circuit whose function is to produce an alternating e.m.f of a particular frequency and waveform. The oscillators used in the design of this project (LC oscillator and the control oscillator) are oscillators that generate outputs of sinusoidal waveform, which rely upon the application of positive feedback to a circuit that is capable of providing amplification. [3]

3.1.1 LC OSCILLATOR

The LC oscillator is the inductance-capacitance oscillator which is a frequency determining circuit used for the generation of very high frequency (about 13 kHz). The oscillator consists of an inductor which is a coil of wire wound round an insulator (platform).

The value of the inductance coil determines the frequency at which the signal generator operates. The frequency changes as soon as a metallic object is brought close to the device. When the metal comes close to the coil, the inductance value increases leading to a corresponding decrease in the frequency value. This can be mathematically explained from the expression

$$F = \frac{1}{2\pi\sqrt{LC}}$$

Where F = frequency generated as soon as the metal is brought close to the LC oscillator

L = value of the inductance in the coil wire

C = capacitance value which in this case is kept constant.

From above, $$2\pi F = \frac{1}{\sqrt{LC}}$$

$$4\pi^2 F^2 = \frac{1}{LC}$$

$$4\pi^2 F^2 C = \frac{1}{L}$$ And $4\pi^2 C$ is another constant value say X

$$\therefore XF^2 = \frac{1}{L}$$

$$F^2 \alpha \frac{1}{L}$$

Depending on the value of the constant X, the inductance (L) is inversely proportional to the square of the frequency. This signifies that when the value of the inductance increases as soon as a metal is brought close to it, the value of the frequency decreases. Although, when there is no metal around the coil, the device has a stable frequency. [3]

The LC oscillator operate at high frequencies of about 13 kHz

To determine the value of inductance and capacitance that would give this frequency, we have

$$F = \frac{1}{2\pi\sqrt{LC}}$$

$$L = \frac{1}{4\pi^2 F^2 C}$$ And value of capacitance = 0.1μf (constant)

$$L = \frac{1}{4 \times \pi \times (13 \times 10^3)^2 \times 0.1 \times 10^{-6}}$$

$$= 0.0014984$$

$$\approx 0.0015$$

$$\approx 1.5mH$$

To give the 13 kHz frequency of the LC oscillator, an inductor (coil of wire) with inductance of 1.5mH was employed.

3.1.1.1 TRANSISTORS

The transistor, which is a 3-terminal, 2-junction semiconductor device, is used for the amplification of the generated input signal after damping occurs. Damping of signals leads to generation of signals with smaller amplitude. The transistor is then used to amplify the signal back to a larger form. [4]

3.1.1.2 RESISTORS

A resistor is a current limiting device. They can either be fixed or variable resistors.

Fixed resistors in Fig 3.2 used in the LC oscillator (10kΩ) were used to limit the amount of current flowing through the emitter, base and collector region of the transistors and stabilize temperature to prevent damage to the component due to excess heat.

The variable resistor (50kΩ) in Fig 3.2 was used to set the frequency to a particular range.

3.1.1.3 CAPACITORS

A capacitor is a device used to store charges. They usually have a positive and a negative terminal.

The 0.001μF capacitor in Fig 3.2 used served as a blocking capacitor. Its function was to block any form of DC current flowing into the sampler.

Fig 3.2 is a typical diagram of an LC oscillator used in the design of this project. [5]

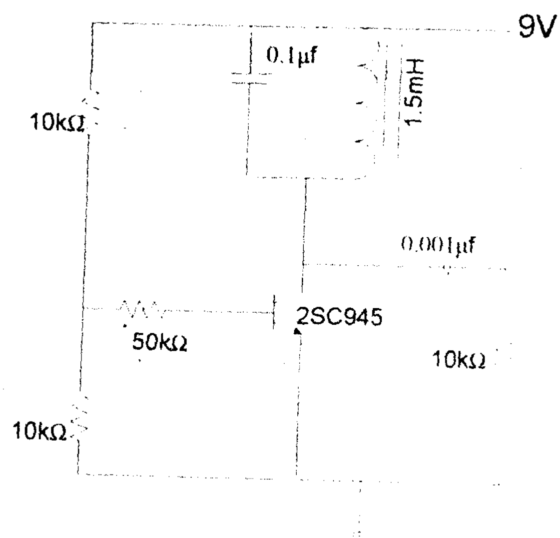

Fig. 3.2 A typical LC Oscillator

3.1.2 CONTROL OSCILLATOR

The control oscillator is also known as the RC oscillator. It is usually an integrated circuit (4060B) operating within the range of 1 – 100 kHz. The IC is a 14-stage binary ripple counter with an on-chip oscillator buffer. The oscillator configuration allows the design of the RC oscillator circuit. The function of the RC oscillator is to allow signals to be sent to the sampler, control latch, alarm latch from their respective proceeding units. It enables the sampler to engage in sampling operation. [6]

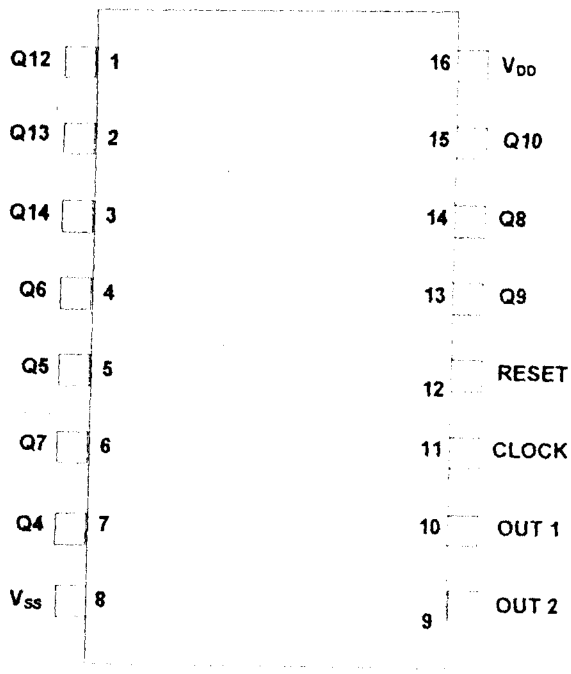

Fig 3.3 Pin Assignment diagram of MC4060B

The RESET function is also included in the chip, which returns all the output into zero state and disables the oscillator. The state of the counter is advanced one step to the next stage on the negative transition on the clock. Schmitt trigger action on the input line permits very slow input rise and fall times. The application of the 4060B includes time delay circuits, counter control and frequency division circuits.

The chip also supports fully static operation diode protection on all inputs; common reset line and can also supply voltage range from 3 to 18Volts.

In the system, the 4060B IC passes frequency division in which 10 lower frequencies are attributed to the same IC.

The pin circuit diagram for the 4060B is illustrated in the Fig 3.4

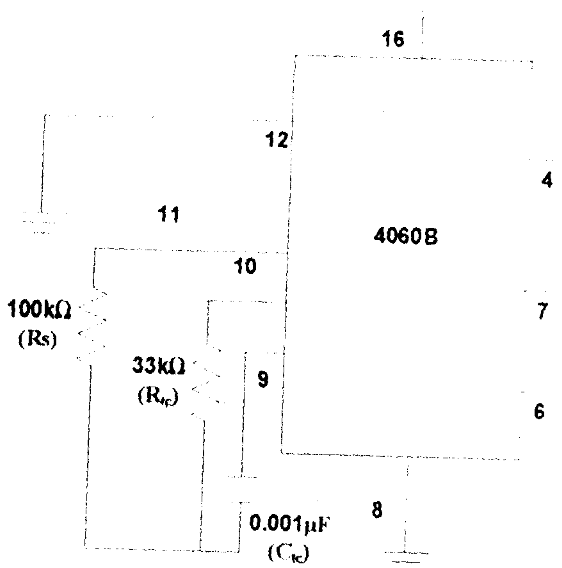

Fig 3.4 Pin Circuit diagram for the control oscillator

Since RC oscillator operates within the range of 1- 100kΩ and for an RC oscillator

$$F = \frac{1}{2.3R_{tc}C_{tc}}$$ And $C_{tc} = 0.001\mu f$ from the data sheet

The frequency of the RC oscillator i.e. 13 kHz was also employed.

To calculate the value of R_{tc}

$$R_{tc} = \frac{1}{2.3C_{tc}F} = \frac{1}{2.3 \times 0.001 \times 10^{-6} \times 13 \times 10^{3}}$$

$$= 33444.816 \approx 33445\Omega$$

$$\approx 33.5k\Omega$$

A resistor of 33kΩ was used and to satisfy the condition of

$$10R_{tc} \geq R_s \geq 2R_{tc} \quad \text{i.e.}$$

$$10 \times 33k\Omega \geq R_s \geq 2 \times 33k\Omega$$

$$330k\Omega \geq R_s \geq 66k\Omega$$

A 100kΩ resistor was used to satisfy the condition. [7]

3.2 SAMPLER

The sampler used in the design of this project is the 4017B IC, which in this case is capable of working as a counter. The main function of a sampler is to determine the state of a generated signal (whether high or low) and mixing them together to form one signal.

Counters are flip-flops with feedback connected together to perform counting operations. The way the counters are connected determines the number of steps as well as the specific sequence of states that the counter goes through during each complete cycle. The number of flip-flops also determines the specific sequence of states. Depending on the function to be executed, counters can be classified as asynchronous and synchronous counters. Their difference comes in the way they are clocked.

- In asynchronous counters, the first flip-flop is clocked by external clock pulse and each other successive flip-flop is clocked by the output of the preceding flip flop.
- In synchronous counter, the clock input is connected to all the flip-flops so that they are clocked simultaneously.

The counter used in the design of this project is the synchronous type with five flip-flops in its internal circuitry. It is a 5-stage Johnson decade counter having ten decoded outputs, which are clocked simultaneously. The output exists in two states, which are the high state (1) or the low state (0). The ten decoded outputs are normally low and go high at their respective decoded time slots. The high state of the clock pulse is normally a positive value ranging from 3 – 18 volts.

Inputs of the counter include the RESET, CLOCK, and CLOCK INHIBIT. Schmitt trigger action in the clock input provides the pulse shaping that allows unlimited clock input pulse rise in fall times. The RESET signal always clears the counter to its low count (zero state).

The clock inhibit signal is low when the counters are advanced one count at the positive clock signal transition and vice versa for when the clock inhibit signal is high (counter advancement via the clock line is inhibited)

The pin diagram for the 4017B is illustrated in Fig 3.5

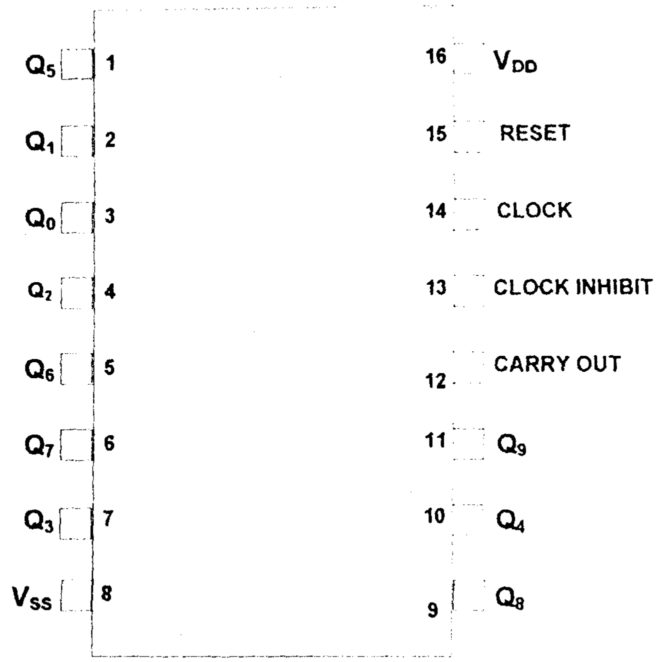

Fig 3.5 Pin assignment diagram of MC 4017B

From Fig 3.5, each of the ten decoded outputs remains high for one full clock cycle and the carry out signal completes one cycle every ten clock input cycles and it is used to ripple clock the succeeding device in a multi device counting chain. The IC functions as a decade stepper for the 10 decoded outputs.

The 4017 IC is activated in the system by the signal from the control oscillator, which is fed through the RESET pin (pin 15). When the RESET pin based on the design is logic 1, the device stops operation and only starts to operates when logic 0. The sampler produces an output which can be either K when the LC oscillator is operating normally without no metal or K' when a metal is brought closer to the oscillator. The output signal is then clocked into the control latch. [6]

3.3 CONTROL LATCH

The control latch is a bi-stable storage device that is placed in a separate category from that of a flip-flop. They are similar to flip-flop in that they are both storage devices which are bi-stable in nature and basically have feedback arrangement i.e. they reside in either of the two states in which the outputs are connected back to their corresponding opposite inputs. The main function of the control latch is to store the output frequency from the sampler (whether high or low). It stores the initial sampling from the sampler before another fresh sampling takes place. The main difference between the latch and the flip-flops is the method used for changing their states.

We have two types of latches: the S-R type latches and the D-type latches. The latch used in this particular project is the D-type latch. The D-type latch is constructed with the MOS-channel and the N-channel enhancement mode devices in a single monotholic structure. Each flip-flop has independent data (D), Direct SET (R) and clock (C) input and complementary outputs (Q and Q'). The device may be used as shift register element or as a T flip-flop for counter and toggle application.

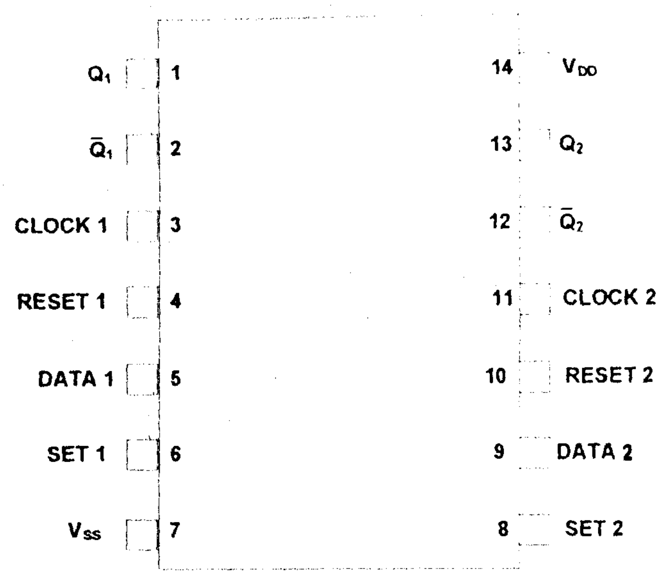

Fig 3.6 Pin assignment diagram of MC 4013B

The 4013B also functions in static operation, logic edge-clocked flip flop design and also supports voltage range of 3-18V. [6]

Fig 3.6 shows the pin assignment for the control latch used in this project. The block diagram for the control latch is illustrated in fig 3.7.

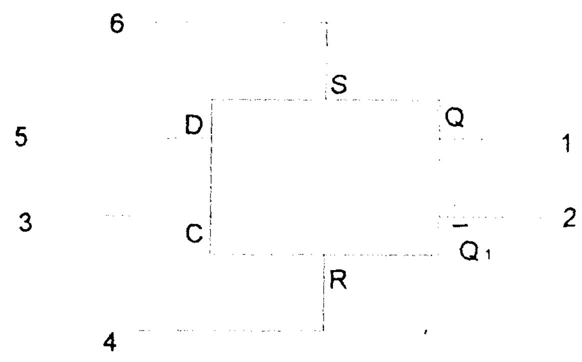

Fig 3.7 Block diagram of a control latch

The 4013B IC is clocked by the sampler output and the D input from Fig 3.7 is the signal from the control oscillator. The output Q gets its signal during the positive going transition of the clock pulse from the logic level present at the D input. When a high level is on the set pin, the IC sets the signals and does the same for the RESET pin. For the complementary output Q' it is vice versa.

The LED indicator is connected to the Q output so that when Q is logic 1, the LED is turned on to indicate the presence of a metal; otherwise it is off with logic 0.

The control latch stores logical level for smooth operation to the output part of the circuit. This unit behaves like a digital buffer.[8]

3.4 ALARM LATCH

The Alarm latch used in the design of this project is the 4013B IC just as the control latch. Its main function is to control the flow of signal to the sound buzzer. The RC oscillator is clocked to the IC to Alarm latch to enable it respond to the control latch.

Whenever a metal is around the inductor, signals are sent, step by step, up to the control latch and Q in the control latch is logic 1. The Alarm latch sends a signal via a transistor to the sound buzzer and a sound is heard.

The pin configuration for the Alarm latch is the same with that of the control latch.

3.5 SEMI CONDUCTOR DIODES

A diode is a two terminal semi conductor device with one junction and is used mostly as switches and rectifiers.

They allow flow of current in only one direction. They change alternating current to direct current. They could be signal diodes or power diodes. The difference between the two is that the power diodes have larger power- handling capabilities although their frequency response and switching speed are however low compared to signal diodes.

Examples of diodes are lever diodes, varicap [Variable capacitor diodes] and LED [Light Emitting diodes]. The diodes used in this project are two light emitting diodes.

-The 1st LED in Fig 3.8 is there to indicate that the electronic circuitry has been supplied power, which in this case is a 9v battery.

-The 2nd LED in Fig 3.8 is to serve as an indicator to show when a metal is brought close to the inductor coil.

Different LEDs give out different colors when energized. Examples are

[a] Gallium-Arsenide-phosphide _ Red or Amber [yellow]

[b] Gallium phosphide [GaP] _ Red or green.

[c] Gallium Arsenide infrared radiation [invisible]

LEDs emit no light when reverse-biased and get easily destroyed in the reverse direction.

The voltage level sufficient to trigger on an LED is within the range of 1.5 to 3.3V. To limit the high current from the destroying the component, a resistance is connected across the LED. Maximum current needed for the LED used is 3mA [0.003A]

$$R_{led} = \frac{V_{cc} - V_{led}}{I_{led}} \qquad \text{Where } V_{cc} = \text{Supply voltage} = 5V$$

$$R_{led} = \frac{5 - 2.3}{0.003}$$

$$= \frac{2.7}{0.003}$$

$$= 900\Omega$$

Therefore, the chosen resistance to protect the LED is 1 kΩ for both displays. [9]

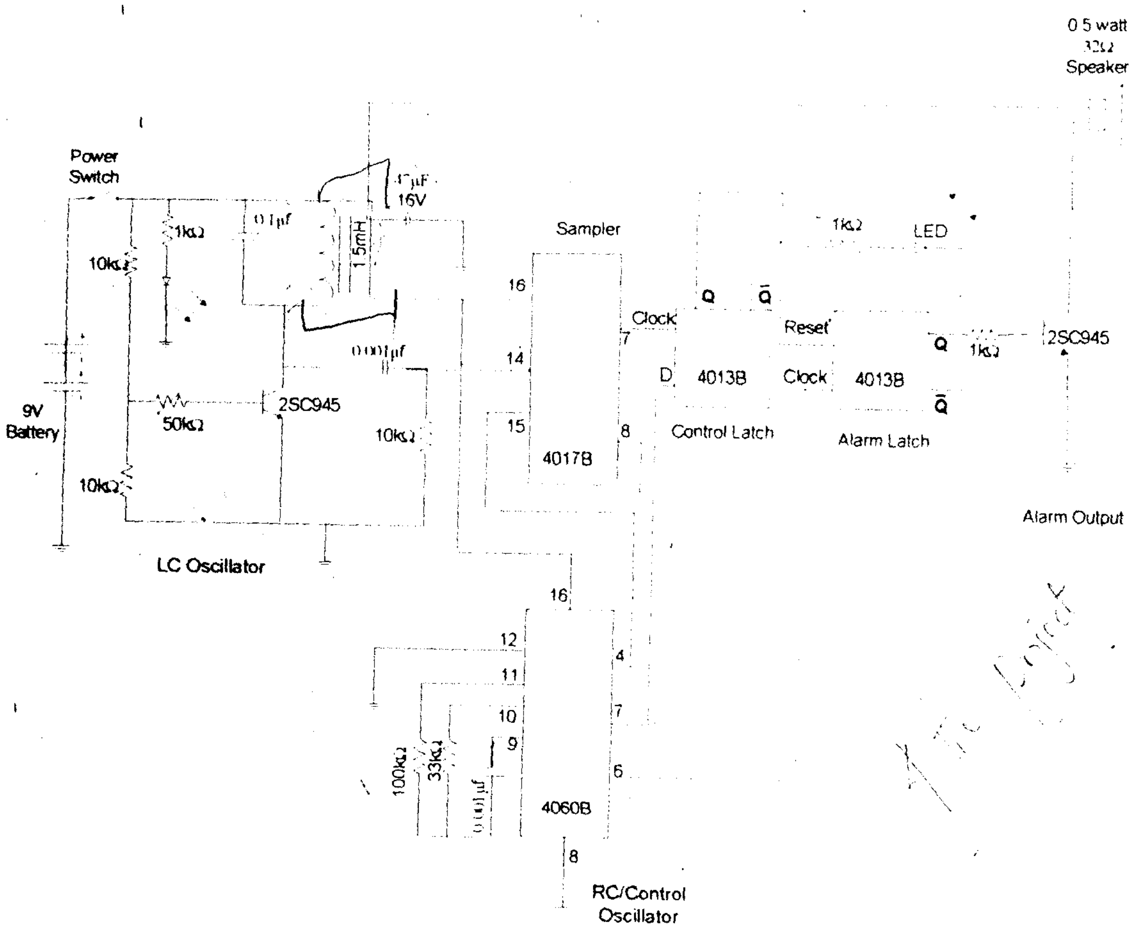

Fig 3.8 Circuit diagram of the Metal Detector

CHAPTER FOUR

TEST, RESULT AND DISCUSSION

4.1 PRINCIPLE OF OPERATION OF THE DEVICE

The metal detector is a digital circuit that makes use of two oscillators: the LC oscillator and the control oscillator. The LC oscillator is the frequency-determining component of the circuit because of the inductor present in the circuit. The LC oscillator operates at a particular frequency (mainly at 13 kHz). The 0.001μF is the coupling capacitor, which couples the signals from the LC oscillator to the sampler.

The sampler couples the output frequency from the LC oscillator; that is, it determines the state of the frequency whether high (1) or low (0), when the output at 7 (from the circuit diagram in Fig 3.8) is high, a metal is around the inductor coil and low when there is no metal.

The control latch holds the frequency and gives its output based on whether the value of the input frequency changes or remains the same with the output frequency. The control latch stores one output frequency signal at a time. It stores the initial sampling from the sampler before another fresh sampling is done in the sampler. The control latch is synchronized with the sampler so that the latch recognizes a particular output frequency value from the sampler.

The control oscillator is so called because it engages and controls all the activities in the sampling operation of the signal and allows the alarm latch to respond to the sampler and the sampler to respond to the LC oscillator. The control oscillator senses any changes in the output frequency of the LC oscillator through the response of both the sampler and the control latch.

Resistors coupled with the control oscillator determine the timing or frequency of signals. The 47µF/16 volts capacitor serves as a filter and reduces the ripple content of the circuit. Whenever a metal is brought close to the inductor coil of the LC oscillator, there will be a magnetic field generated around the metal, which will distort the original magnetic field around the inductor. This will cause the frequency of the LC oscillator to change. The control oscillator is sensitive to any change in the sampler and the control latch will trigger the alarm by transmitting a signal to the output device and the light comes on.

4.2 COMPONENT SPECIFICATION

RESISTORS	QUANTITY
10kΩ	3
Variable 50kΩ	1
33kΩ	1

1kΩ	2
100kΩ	1
CAPACITORS	
0.001µF	2
0.1µF	1
47µF	1
LIGHT EMITTING DIODE (LED)	2
ICs	
MC4017B	1
MC4013B	2
MC4060B	1
TRANSISTORS	
2SC945	2
INDUCTOR	
1.5mH	1

4.3 CONSTRUCTION

The construction of the metal detector involved two stages.

The first stage was the construction done on the breadboard. This involved arrangement of components according to the circuit diagram. Power was supplied using a 9 volts dry cell battery and tested to confirm whether it works or not.

The second stage was transferring of the components from the breadboard permanently to a Vero board through a technique called soldering.

The components and apparatus used were:

Soldering iron

Soldering lead

Multi meter

Soldering sucker

Vero board

Breadboard

Cutter

Sockets

4.3.1 STEPS CARRIED OUT IN THE FIRST STAGE

- The coils were wound on a non metallic object, say, plywood
- The terminals of the coils were then connected to the LC oscillator circuit which is connected to the breadboard according to the circuit diagram in the Fig 3.8.
- The sampler IC circuit was arranged on the breadboard by connecting the legs of the 4017B to the appropriate place.
- The control unit was arranged by connecting the control oscillator, the 4060B on the breadboard.
- The alarm latch unit, which is another 4013B is connected to the appropriate place.
- The LED and sound buzzer were also connected according to the circuit diagram.
- The resulting circuit was powered using a 9volts battery.

4.3.2 STEPS CARRIED OUT AT THE SECOND STAGE

All the units connected on the breadboard were transferred permanently onto the Vero board accordingly. The power LED and knobs were extended out for easy access.

4.4 TESTING

Before the soldering of components on the Vero board, a lot was actually done. Circuit components were tested to confirm ratings. Resistors, transistors, LEDs etc were tested using a multimeter to confirm their working conditions and ratings. Data sheet was consulted for pin assignment of ICs. Inductors were tested to ensure continuity.

The component used in the testing of the project was any metallic object. Before connecting the coils, some parts of the Vero board were checked for correct operation.

The buzzer and LED were used as the output devices from which we can hear the alarm sound, while the metallic object served as the object to be detected using the metallic detector for security purposes. The knob, which is a variable resistor, was used to control sensitivity until no more sound is heard. When a metal is placed close to the coil, a sound was heard from the buzzer and a light alarm from the LED indicating the presence of a metal.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1CONCLUSION

At the end of the design, the handheld metal detector was constructed successfully. Whenever a metal is brought close to its inductor coil, a sound was heard and a light displays which indicates that there was a change in the operating frequency of the digital circuit.

5.2 RECOMMENDATION

The project was quite a challenging task and recommendations made with respect to the difficulties during the project work, some of which are;

- Regulating the frequency while maintaining constant amplitude especially when one considers the way of coupling the capacitors acted in reducing the amplitude of signals and generating harmonic frequency.
- No preparation was practiced before the project. There was no proper project course schedule in the university syllabus to get students prepared for their final project work.

- Getting information about the components used like constructing the coil to get the required inductance value needed to trigger the buzzer when a metal was brought close
- The total cost of constructing the device is quite on the high side for a student although still cheaper than that sold in the market.

To improve on the reliability of the device, further research can be carried out on how to stabilize the frequency at the output stage so that a particular type of metal could be known.

Research can also be done to increase the sensitivity of detecting a metal so that metals could be detected at a farther distance than the designed range of the project.

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