DESIGN AND CONSTRUCTION OF MICROCONTROLLER BASED METAL AND MOBILE PHONE DETECTOR

BY

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EEE/12/0847

A PROJECT REPORT SUBMITED TO DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING FEDERAL UNIVERSITY OYE EKITI

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF BACHELOR OF ENGINEERING (B.ENG) DEGREE IN ELECTRICAL AND ELECTRONICS

NOVEMBER 2017

DECLARATION OF ORIGINALITY

I declare that this project report entitled "Microcontroller based Metal and mobile phone Detector" is my own work except as cited in the references. The report has not been accepted for any degree and is not being submitted concurrently in candidature for any degree or other award. As such, all use of previously published work (from books, journals, magazines, internet, etc.) has been acknowledged within the main report to an entry in the References list.

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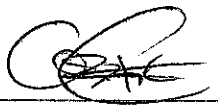
CERTIFICATION

This project work titled "Metal and Mobile Phone detector" by Muhammed Olayinka Anuoluwapo, meets the requirements for the award of Bachelor of Engineering (B.Eng.) degree in Electrical and Electronics Engineering Department, Federal University Oye-Ekiti.



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ENGR. ADEDAYO BABARINDE Date

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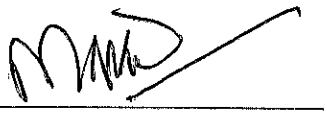

08/12/17

DR. ENGR. OLAITAN AKINSANMI Date

(Head of Department)

EXTERNAL EXAMINER Date

DEDICATION

This project is dedicated to Almighty God, the Giver of life, for His countless blessings, mercies and grace upon my life Academically, physically and financially, and for giving me the privilege to be a student ,and also to my entire family for their love and support.

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I thank my lecturers for their impact on my life, educationally and morally.

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I want to also appreciate my level mates and final year engineering ladies and

To all my relatives, my friends and others who in one way or the other for share their support, love and care during my five years program.

Above all, my sincere gratitude goes to the Almighty God, for the successful completion of my five years program at FEDERAL UNIVERSITY OYE EKITI (FUOYE).

ABSTRACT

This project present the design and construction of a micro-controller based metal and mobile phone detector for security and control purposes. The metal detecting systems is a microcontroller based system. This metal detector make use of microcontroller for it operation as well as other components such as: comparator, voltage regulator, operational amplifier, transistors etc.. For this project, the metal detector is built in a way that a metal sensor (culprit oscillator) senses any electrically conducive metal or metallic object brought close to it. The sensor sends the signal to the microcontroller which processes the signal and turns on the driver (a dc motor) connected to the door. Also present is an alarm and a Liquid Crystal Display (LCD) indicating the status of operation of the system. The power supply unit is dual in the sense that the circuit can be powered by electricity or battery and the battery charges when the circuit works with electricity.

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LIST OF ABBREVIATIONS

IC - Integrated Circuit

RF – Radio Frequency

AM – Amplitude Modulation

LCD – Liquid Crystal Display

AC – Alternating Current

PIC – Peripheral Interface Controller

DC – Direct Current

LED – Light Emitting Diode

AWG – American Wire Gauge

CHAPTER ONE

1.0 INTRODUCTION

Metal detectors have become an essential component in today's society and widely used not only for hobbyists but also for safety purpose. For Safety purpose, Metal detector can be used in airport, shopping malls, hotels, cinema halls to ensure that person is not carrying any explosive metals or illegal things like guns, knives, bombs etc. In technical area, people use metal detector to search for the underground pipe or cable before digging in walls and floors. Besides that, many people enjoy in discovering hidden treasure or valuable metal like gold and silver by using metal detector.

Likewise, The Mobile phone detection project is an advanced device which finds various applications in the modern fields of communication and surveillances. This work is very useful for the private meetings, examination hall, defense establishments, military camp, Hospitals; Petrol pumps etc., where the uses of an active Mobile Communication (GSM) device are prohibited.

In these days, most of metal detectors can only detect metal but not this types of detected metal indicated on the LCD the types of metal such as non-ferrous metal are copper, aluminum, zinc, gold, platinum, bass, bronze and etc... Ferrous metals are all metals which have iron properties. The whole system is controlled by the microcontroller. And they usually indicate by turning on the alarm or LEDs whenever the metal target is detected. In this system, not only detects metal target but also detects mobile phones.

In Africa today, especially Nigeria, there are contentions as to the effective functionality of National Security systems. Security is an encompassing phenomenon that is paramount to individuals, entities, communities and even nations. Security has to do with self-preservation which is the first law of existence. It implies a stable, relatively predictable environment in which

group may pursue its ends or objectives without disruption, harm, danger or fear of disturbance or injury. A country's national security is therefore concerned with the well-being, welfare and interest of her citizens. It is also concerned with the preservation of her sovereignty and territorial integrity against external aggression. The importance of security to the economic well-being of a country and her citizens was amply highlighted by a former American Secretary of Defense, Robert McNamara, when he stated that security is development and development is security. This means that, "without security there cannot be any development" (Guèhenno, 2004). The importance attached to security was well captured in the Nigerian Constitution of 1999: Section 14 (2) (b) where it is stated that: "The security and welfare of the people shall be the primary purpose of Government". Invariably, the Constitution has saddled the Government with the responsibility of safeguarding lives, property and welfare of Nigerians against both internal and external threats including other form of danger. However, everybody has a role to play at enhancing our National security as security is and should be everybody's business. Security is both a prerequisite for and a critical aspect of development. At high levels of insecurity, development is impossible: Economies fail, States go into negative economic growth; societies lose cohesion while health and education status drop (Paul, Anke, & H., 2004). Security has become a very worrisome situation in our contemporary society. Items worth millions are reportedly lost or stolen regularly. People have become more aware of the unreliability of Government-provided security operatives. They are also aware that developed countries where technology-based Security systems are in use, suffer less loss than developing countries like Nigeria and many other African countries. (Toochi, 2014)

Metal detectors are used in the food, pharmaceutical, beverage, textile, garment, plastics, chemicals and packaging industries. Contamination of food by metal shards from broken processing

machinery during the manufacturing process is a major safety issue in the food industry. Metal detectors for this purpose are widely used and integrated into the production line.

Current practice at garment or apparel industry plants is to apply metal detecting after the garments are completely sewn and before garments are packed to check whether there is any metal contamination (needle, broken needle, etc.) in the garments. This needs to be done for safety reasons.

In civil engineering special metal detectors 'cover meters' are used to locate rebar. Rebar detectors are less sophisticated, and can only locate metallic objects below the surface. Metal detectors are applicable both in the civilian and military for security purposes. Metal detectors are also used for security purposes in civilian and military applications. The simplest form of a metal detector consists of an oscillator producing an alternating current that passes through a coil producing an alternating magnetic field. If a piece of electrically conductive metal is close to the coil, eddy currents will be induced in the metal, and this produces an alternating magnetic field of its own. if another coil is used to measure the magnetic field (acting as a magnetometer) the change in the magnetic field due to the metallic object can be detected (S. Yamazaki, 2001) (I. Rezic and I. Steffan, 2007). Due to the high level of insecurity in our society, organizations, banks and especially in places where there is high attraction and inflow and out of different kinds of people, the lives and properties of citizens is threaten by other citizens who are well armed with metallic weapons and explosives. The unarmed citizens lives in fear of being attacked or victimize. Except a device that will detect these weapons and explosives carried around by these traitors is produced, our society will continue to live in fear and insecurity

1.2 BACKGROUND OF THE PROJECT

The industrial revolution began, and the needs for metal in factories increased due to the increase of its uses. This increasing demand leads scientists and engineers to think about inventing a machine that can detect metal for security purposes and to reduce the rate of harm in food processing industry to ensure safety and save time wasted in detection of metal. In 1830 metal detectors appeared. From that time until now the applications of metal and mobile phone detectors have been rapidly increased and critical applications was included, which has led to variety in types, sizes and applications of metal and mobile phone detectors. This project will provide a simple design and implementation of metal detectors.

In this project, an electronic system will be considered using a metal detector which after detecting the presence of a metal or mobile phone it sends a signal to the buzzer which will the trigger the alarm to make sound. The data cable acts as an interface between the microcontroller and the cell phone, there is also an interface between the microcontroller and a Liquid Crystal Display (LCD) (Wilmshurst, 2007)

1.3 STATEMENT OF PROBLEM

Consider a situation where an intruder enters an environment with a harmful metal hidden somewhere. A security personnel stationed at the entrance may not find the metal even after searching, due to a number of reasons. This may eventually lead to loss of property, and even lives because the entire environment will be taken unawares. With this type of metal detector, the metal will be automatically detected and an alarm will be raised, but in this case, through a GSM cell phone.

1.4 PROJECT MOTIVATION

Due to the increase in the rate of robbery, malpractice, need for mining etc. the need for metal and mobile phone detectors arises so as to improve the security rate in some areas such as banks, airport, shopping malls, hotels, cinema halls to ensure that person is not carrying any explosive metals or illegal things like guns, knives, bombs etc. and in and exam hall to prevent a student from carrying a mobile phone into and exam hall to prevent exam malpractice.

1.5 PROJECT AIM

Project aim the aim of this project is to design and construct metal and mobile phone detector. This detector should be capable of detecting metal pieces and mobile phones near to its region.

1.6 PROJECT OBJECTIVES

- ✓ To design a metal detecting project using microcontroller PIC 16F84A.
- ✓ To design a system that can provide maximum security.
- ✓ To design a system that detects metals and phones while walking through the door with the help of a culprit search coil.

1.7 IMPORTANCE OF THE PROJECT

Due to increasing in activities in the country and the increase in prices of metal detectors the need for simple and cheaper metal detectors appears It is necessary to remove Remnants of war especially Land mines, metal detectors can help in detecting land mines. Metal detectors are also important to prevent sensitive and highly populated places from terrorists and other criminals. Since all weapons are made partially or completely from metal then metal detectors can help to identify and confirm

the presence of metallic objects on persons and their belongings hence help security to protect important places.

1.8 SCOPE OF WORK

This project is limited to

- ✓ Detection of a cell phone that is in use; on call, communication via short messaging service and internet access.
- ✓ The detection of cell phones that are on standby mode, switched off or on airplane mode will not be included in this project.
- ✓ It cannot distinguish between several types of metals.
- ✓ Its detection region is small.
- ✓ This metal and mobile phone detector is a mini and portable project.
- ✓ It cannot differentiate between object detected
- ✓ It is not battery power.
- ✓ It is not solar powered and solar charged.

1.9 PROJECT OUTLINE

This thesis consists of five chapters which contain: Chapter 1; Introduction which contains general idea about the project such as its aim and its importance; Chapter 2; Literature review contains history of metal detectors and its development since invention until now. Chapter 3: Methodology (analysis) contains the basic unit of metal detectors and the block and circuit diagram. Chapter 4: Result and Discussion contains the design parameters of the constructed metal detector and results. Chapter 5: Conclusion: entails discussion of performance and recommendations.

CHAPTER TWO
LITERATURE REVIEW

2.1 THE REVIEW OF THE RELATED LITERATURES

A metal detector is a device which responds to metal that may not be readily apparent. The simplest form of a metal detector consists of an oscillator producing an alternating current that passes through a coil producing an alternating magnetic field. If a piece of electrically conductive metal is close to the coil, eddy currents will be induced in the metal, and this produces an alternating magnetic field of its own. If another coil is used to measure the magnetic field (acting as a magnetometer), the change in the magnetic field due to the metallic object can be detected.

The pioneer if anyone could be regarded as the inventor of metal detectors, he will be English geologist and mining engineer R. W. Fox. It was Fox who first discovered that electricity will flow through metallic ores as well as solid metal objects. He devised a simple metal locator which consist of nothing more than a battery, several metal rods and a suitable length of wire. His first method of detection was as follows: one metal rod would be driven into the earth where the suspected vein of ore was located; it was connected to one terminal of the battery. The other battery terminal was connected to a floating wire. Other metal rods were driven into the ground at several different points and successively touched with the floating wire. Where a spark occurred, it was an indication that metal was present. Circa 1870, this device was modified to two rods insulated from each other in a common probe and connected via battery to a bell and plunged into the earth. When contact was made by metallic ore, nugget or metal pipe, the bell rang, thus indicating the presence of a conductive object. (Grosvenor, 1997).

A gold metal detector for example is designed to locate gold underground. There are many types of metal detectors with varying degrees of refinement and complexity but they all operate on the same basic operation.

The induction balance since 1879, Professor D.E. Hughes demonstrated to the Royal Society in London his Induction Balance (I.B.). Its purpose was to study the molecular structure of metals and alloys. However, Hughes and his instrument maker, William Groves, soon recognized the potential of the I.B. as a metal locator. The Royal Mint used the Induction Balance for assaying metals and detecting forgeries. The well- known American inventor George Hopkins modified the I.B. for locating metallic ores, treasure chests and the like. In fact, the Induction Balance forms the basis of most metal detectors used today.

The wireless age with the very rapid development of wireless techniques during World War I, it was only natural that this technique would be adapted to metal locators and prospecting equipment. One of the first pioneers to exploit this technology for locating buried treasure was English man George Williams, Being fully conversant with wireless techniques, and seeing the somewhat primitive treasure locators available then, he decided he could improve the existing technology by designing a Radio-Locator. The first industrial metal detectors were developed in the 1960s and were used extensively for mining and other industrial applications. Uses include de-mining (the detection of land mines), the detection of weapons such as knives and guns, especially in airport security, geophysical prospecting, archaeology and treasure hunting. Metal detectors are also used to detect foreign bodies in food, and in the construction industry to detect steel reinforcing bars in concrete and pipes and wires buried in walls and floors.

Further refinements many manufacturers of these new devices brought their own ideas to the market. Whites Electronics of Oregon began in the '50s by building a machine called the Ore-master Geiger counter. Another leader in detector technology was Charles Garrett, who pioneered the BFO (Beat Frequency Oscillator) machine. With the invention and development of the transistor in the '50s and '60s, metal detector manufacturers and designers made smaller lighter machines with improved circuitry, running on small battery packs. Companies sprang up all over the USA and Britain to supply the growing demand. 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.

2.2 MOBILE PHONE DETECTION

Detectability of Mobile phones the versatility of mobile phones cannot be underestimated. They are very portable and compact and can perform an array of functions ranging from a simple call, SMS, data services, a simple digital organizer to those of a low end personal computer. Most mobile phones have a basic set of comparable features and capabilities. Exploring the features of most cell phones show that they have a microprocessor, a read only memory (ROM) that provides a storage for the operating system, a random access memory (RAM) that temporarily provides storage for data when the cell phone is powered, a radio module, a digital signal processor, a microphone, a speaker, a variety of hardware keys and interface and a liquid crystal display (LCD). A focus to detect mobile phones has therefore to focus on these features to determine the potential vulnerability as entry points. Tests were carried at Pacific Northwest National Laboratories (USA) to determine the potential vulnerability of the microphone, speaker and RF system as entry points for detection. (Christian, 2012)

The RF System The first part on determining the RF system as potential detection point was carried out by looking for the internal oscillators necessary to operate the microprocessor and RF synthesizer. The results were not satisfactory and it was established that the cell phones had been designed to meet the electromagnetic interference specifications. The second part of the experiment was carried out to detect the cell phone by detecting the RF transmitted. This was done by the use of an RF signal strength meter, an amplifier, a mixer and a filter. They found out that since the mobile phone keeps a continuous communication with the tower, this technique was successful,

Combined Audio and RF Signals The combined audio and RF signal tests were done by carrying out a magnetic coupling test. The cell phones presence or position relative to either coil made no change in the observed signal from the second coil.

A modification was made that incorporated an audio speaker to make the cell phones microphone or speakers react to the audio signal with an RF spectrum analyzer configured to demodulate AM signals.

Commercial Cell Phone Detectors Cell phone detectors have been in the market for many years. They have been in use in prisons and correctional institutions to ensure that inmates do not smuggle or use cell phones in the facility, in government institutions and security teams in the USA for long. In this section we give a summary of some of the recent cell phone detectors in the market and their outstanding features. (Mohan Kumar, 2008)

2.3 MICROCONTROLLER UNIT

Microcontrollers are one-chip computers designed to control other equipment, and almost all electronic equipment now uses them. The average American home now contains about 100 computers, almost all of which are microcontrollers hidden within appliances, clocks, thermostats, and even automobile engines.

A microcontroller can be considered to be a self-contained system comprising a processor, memory modules and peripherals. Hence, a microcontroller can be used as an embedded system. The majority of microcontrollers in use today are embedded in other machinery such as automobiles, telephones, appliances and peripherals for computer systems. Embedded systems usually have no keyboards, input processes according to instructions stored in its memory and provides results as output. It is an example of sequential digital logic, as it has internal memory. (Alexander, 2000) Microprocessors operate on numbers and symbols represented in the binary numeral system. The first single-chip microprocessor was the 4-bit Intel 4004 released in 1971 with the Intel 8008 and other more capable microprocessors becoming available over the next several years. "TI (Texas Instruments) Engineers, Gary Boone and Michael Cochran were the first to successfully create the first microcontroller in 1971". The result of their work was the TMS 1000 which went commercial in 1974. This combined a ROM (Read-Only Memory) unit, a RAM (Random Access Memory) unit, a processor and a clock on one chip and was targeted at embedded systems (Augarten, 1983).

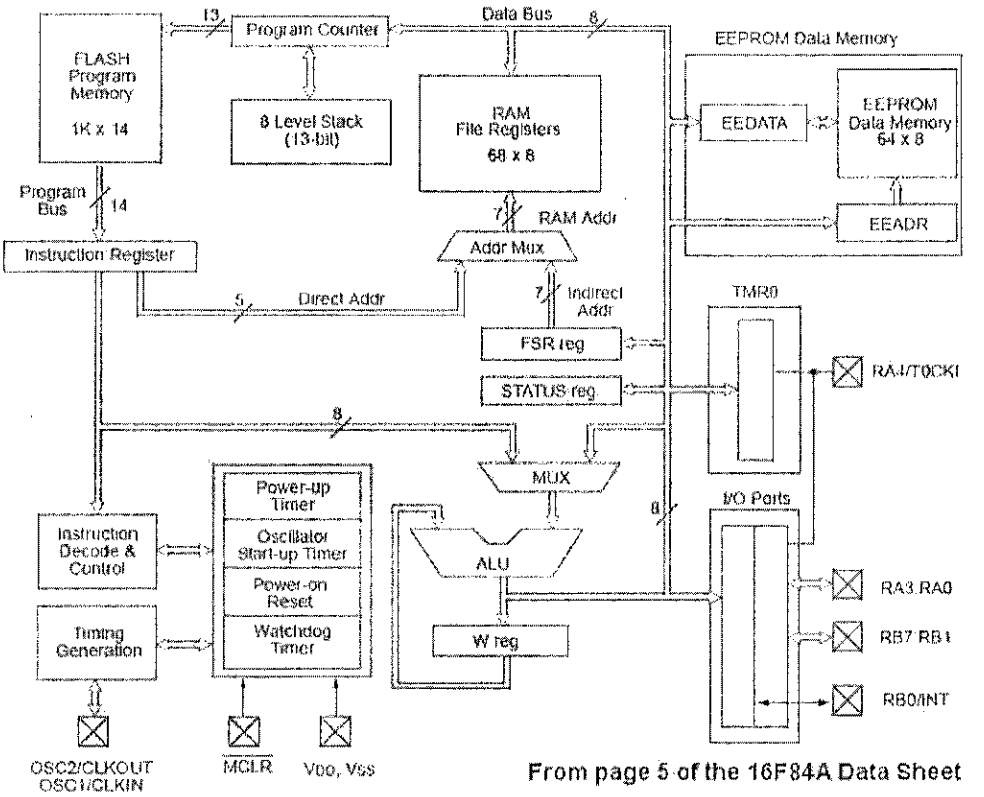

Figure 2.1-General Purpose Microcontroller.

It contains an ALU (Arithmetic and Logic Unit), a PC (Program Counter), an SP (Stack Pointer), some working registers, a clock timing circuit and an interrupt circuit. The key term in describing the design of the microprocessor is "General-purpose".

The hardware design of a microprocessor is arranged such that a small or very large system can be configured around it. The prime use of a microprocessor is to fetch data, perform extensive calculations on that data and store the results of these calculations on a mass storage device or display the result for human use (Ray, 2008).

2.3.1 PIC 16F84 MICRO CONTROLLER

Peripheral Interface Microcontroller (PIC) the PIC16F84 is the most well known and most well used of all the PIC microcontrollers - it is used in numerous projects that you can find across the web. Even though the 16F84 is getting on a bit, it is one of the most popular of the PIC microcontrollers and there are hundreds of circuits for it on the web but it does have limited memory, RAM and peripherals (See diagram below). As of 2015 microchip are recommending that you use 16F84A instead of 16F84 with the only difference being that the A-version runs at 20MHz using a 20MHz crystal (the non-A version runs at 10MHz crystal speed only).

It is an 8 bit mid-range microcontroller having 1024 words of program memory, 68 bytes of RAM and 64 bytes of long term EEPROM storage and a single peripheral - an 8 bit timer - Timer0. The real innovation of this device is that it can be re-programmed using ICSP in circuit - and the interesting thing is that this same scheme is used in all PIC devices proving that the design was and is good from the start. The same can be said of Timer0 which is also used throughout the PIC family ranges, although in 18F devices you can set a control bit that turns it into a 16-bit timer. Of course the 8-bit implementation in that device is still the same as the 16F84A (Wikipedia , 2017)

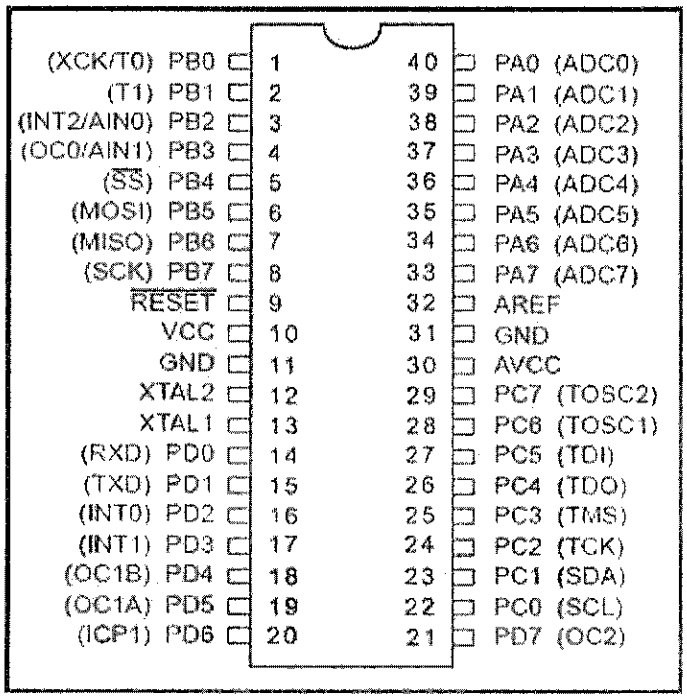

Figure 1.2-Microcontroller PIC 16F84A.

2.4 CRYSTAL OSCILLATOR

The 16 MHz Crystal Oscillator module is designed to handle off-chip crystals that have a frequency of 416 MHz. The crystal oscillators output is fed to the System PLL as the input reference. The oscillator design generates low frequency and phase jitter, which is recommended for USB operation. This document contains an overview of the on-chip oscillator design and parameters for the crystal model, which are derived from both simulation and empirical data analysis. Recommendations and requirements for selecting a 16 MHz crystal are also covered. Finally, the document has guidelines and a detailed description of oscillator circuit design and PCB layout. It is strongly recommended that you follow the crystal specification and crystal PCB layout guidelines in this document.

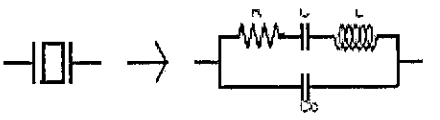

Figure 2. 2-Schematic Diagram of a Crystal Oscillator.

2.5 VOLTAGE REGULATOR

Voltage regulator is to keep the terminal voltage of the dc supply constant even when ac input voltage to the transformer varies (deviation from 220v are common) and also when the load varies. It can be viewed as a dc steady state voltage shaper. Depending on the value of voltage needed to enter a respective circuit after rectification and filtration, a regulator is used to reduce the value of the supply to the needed value. For the 5V dc supply needed in some subunits of this system, the correct size and value of the regulator needed is 7805 to avoid damages as a result of excessive voltage.

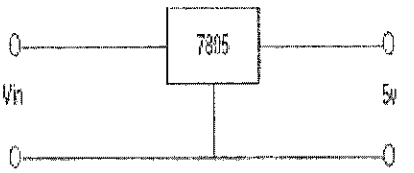

Figure 2.3-Voltage Regulator Circuit.

2.6 DIFFERENT TYPES OF METAL DETECTING TECHNOLOGIES.

- ✓ Beat Frequency Oscillator (BFO)
- ✓ Pulse Induction (PI)
- ✓ Very Low Frequency (VLF)

It is the most basic type of metal detector. This type uses two coils each coil is connected to an oscillator which generates a steady frequency, with each coil having a slightly different frequency. This difference in frequencies will cause a steady "beat" which can be picked up by the receiver in the control box. Any metal or mineral in range of the signal will interfere with the frequency in the search coil, causing a change in the duration and tone of the beat frequency. The Beat Frequency Oscillator (BFO) operates in the range of 100s kHz.

Pulse induction (PI) it is less common form of metal detectors. It is based on VLF but it uses single coil for detection operation .The field here comes from current pulses applied on the coil. The Pulse Induction (PI) operates in the range of 100s Hz

Very low frequency (VLF) 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) operates in the range of 3-30 kHz. Among these technologies, VLF technology is the most popular type of metal detecting technology. In this system, the VLF technology is also used because it has the ability to discriminate different metals according to their phase shifting.

RF oscillators Resonant-frequency oscillators are the simplest type of metal detector. It uses one coil for the detection operation. It is the cheapest and simplest technology for building a metal detector. This technology is used in this project.

2.7 USES AND ADVANTAGES OF METAL DETECTORS

- ✓ Pursuing of hobbies such hobbies may include coin shooting activities, beach combing, and detection of buttons, bullets and exe heads.
- ✓ Security screening: They are used in airports to screen passengers, checking bags in public places and in public events.
- ✓ Food Processing: They are used in food processing industries to detect fragments of metal so as to avoid food contamination.
- ✓ Civil Engineering: They are used in finding reinforcement bars inside the walls.

2.8 DISADVANTAGES OF METAL DETECTORS

- ✓ False alarm Metal detector may give a false alarm in case an individual carries a metal object such as phone, watch or a toy causing unnecessary panic.
- ✓ Interference Metal detectors may interfere with personal devices such as magnetic recording gadgets like CD or a cassette.

2.9 APPLICATION OF METAL DETECTOR

Metal detectors are used for various applications in the food, plastics and pharmaceutical industries. Classic fields of application include the protection of machines, i.e., damage to tools, mills, automats etc., from metallic pieces, object counting or sensing in automated manufacturing. The use for quality control processes is quickly becoming more and more important in the plastics industry (control of purity of materials and products), in the food industry (consumer protection) and in the pharmaceutical industry. (Microcontroller-Based Metal Detection System with GSM, 2015)

We provide the right solution for each application. In order to achieve optimum results our team will collect all the facts that should be taken into consideration prior to the use of any metal detector. High-sensitivity sensors have to be applied accurately to tap their full potential. Our sales engineers will be at your disposal - on-site if necessary. For those difficult applications it is possible to use machines on a "trial basis" in order to collect and to take into account important criteria previous to purchase.

- ✓ Security of buildings Metal detector is very useful to screen people entering a particular building or place, such as airport, office, school, prison, etc. Mounted detectors (unmovable) usually use some variation of Pulse Induction (PI) technology. The portable handheld metal detectors usually use Beat Frequency Oscillation (BFO) technology.
- ✓ Search for Lost items if someone search for a lost item, such as precious piece of jewelries, thanks to metal detector that can help them searching their metal lost items. Thus, people will not spend so much time in searching their metal lost items because of metal detector.

- ✓ Detection of Antiquities Since the ability of metal detector to detect the metal object, it can use to detect the antiquities that made of metal, such as a Greek gold crown, or an iron tempered war-clothes from China. Therefore the archaeologist can found the antiquities in the certain historical places easily.

- ✓ Food processing during the fabrication process of food in the industry maybe there are a metal object accidentally mixed with the food. This food contained metal is very dangerous and harmful for the people when they eat that food. Metal detector can be installed to detect the food contained metal, so it can be removed automatically before the packaging process

- ✓ Geological detection Metal detector also can detect the metallic composition of soil or rock formations within the certain area of interest. It also can be used to help searching the mine location of certain of certain metal.

- ✓ Plastic processing our metal detectors can rid your process line of both ferrous and non-ferrous contaminants down to 0.02" found in free falling material, vacuum conveying lines, and on belt conveyors. Once detected, the metal is separated before the material is processed, helping you to protect your equipment and improve the quality of your product.

- ✓ Pharmaceutical Processing Nowhere is the detection of metal contamination more important than in the making of tablets and pills. The making of tablets and pills requires strict monitoring to avoid metal contamination and to meet strict hygienic requirements. To this end all of o9ur machines are easy to clean and maintain.

CHAPTER 3

METHODOLOGY (ANALYSIS & DESIGN)

The model and methodology, considerations/specifications of the detection system and its functional components are well detained. The development stages and modes of operation of the software application developed for the hardware are also reported here. The design of the metal and detector mobile phone detector involves two main stages which are the hardware and the software.

3.1 PRINCIPLES OF OPERATION OF THE DESIGN

A metal detector operates by generating an electromagnetic field which is swept along the Ground. As it does so, any metal found will affect the electromagnetic field by changing it and this change will be displayed for the operator to see and also may be indicated by an audible sound produced by the metal detector. Inside a metal detector there are two sets of copper wire windings. An electrical current is passed through one of the windings and this creates the electromagnetic field. This is called the transmit winding. As metal conducts electricity, any metal object brought into the field will alter it and this alteration is picked up by the second winding, known as the receive winding. This is then sent to the control box which the operator can use to control the types of metals he or she wants to detect. This information is then displayed through a meter or LCD display and, often, with an alarm signal. The more sophisticated the detector the more information is displayed. There are various refinements to metal detectors designed to filter out unwanted metals and give a signal on the wanted metals only. This is called discrimination and is achieved by the detector being set for a specific level of conductivity. Different metals conduct electricity in different degrees. Silver is an excellent conductor of electricity for example whereas nails are a very low conductor of electricity. Conductivity of each metal is known of course and so a metal

detector can be set to detect gold or silver and reject any others. The size of the metal found is not particularly important in this case. It is just the ability or the „willingness" of metal to conduct electricity that is detected. A detector will often react to minerals in the ground or "mineralized ground" as it is called. These cause false signals and is referred to as "ground noise". Any metal detector should have a "ground balance" control to tune out ground noise. The best metal detectors can eliminate virtually all ground noise. Some detectors can detect metal quite deep. This will depend on the quality of the detector as well as the way it is used. It also depends on the size of the object. Large nugget of metals deeper underground will be detected whereas a small speck might not be detected.

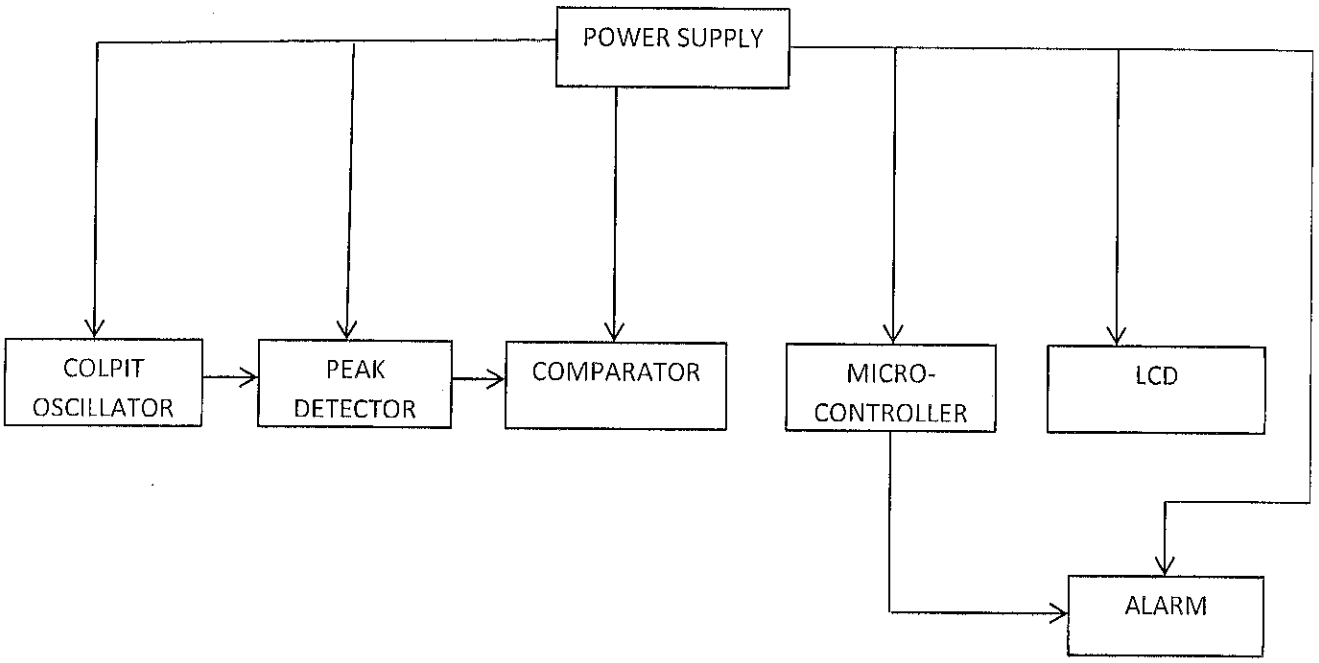

Figure 3.1-Block Diagram of the System.

3.2 DESIGN SPECIFICATION

The frequency range up to which the detector is able to detect signals is about 9-14 KHz. Interfacing is done via **PIC16F84A microcontroller**. Which is 16-bit microcontroller with 16KiloBytes In-System Programmable Flash. 32 × 8 General Purpose Working Registers. Up to 16MIPS Through put at 16MHz.

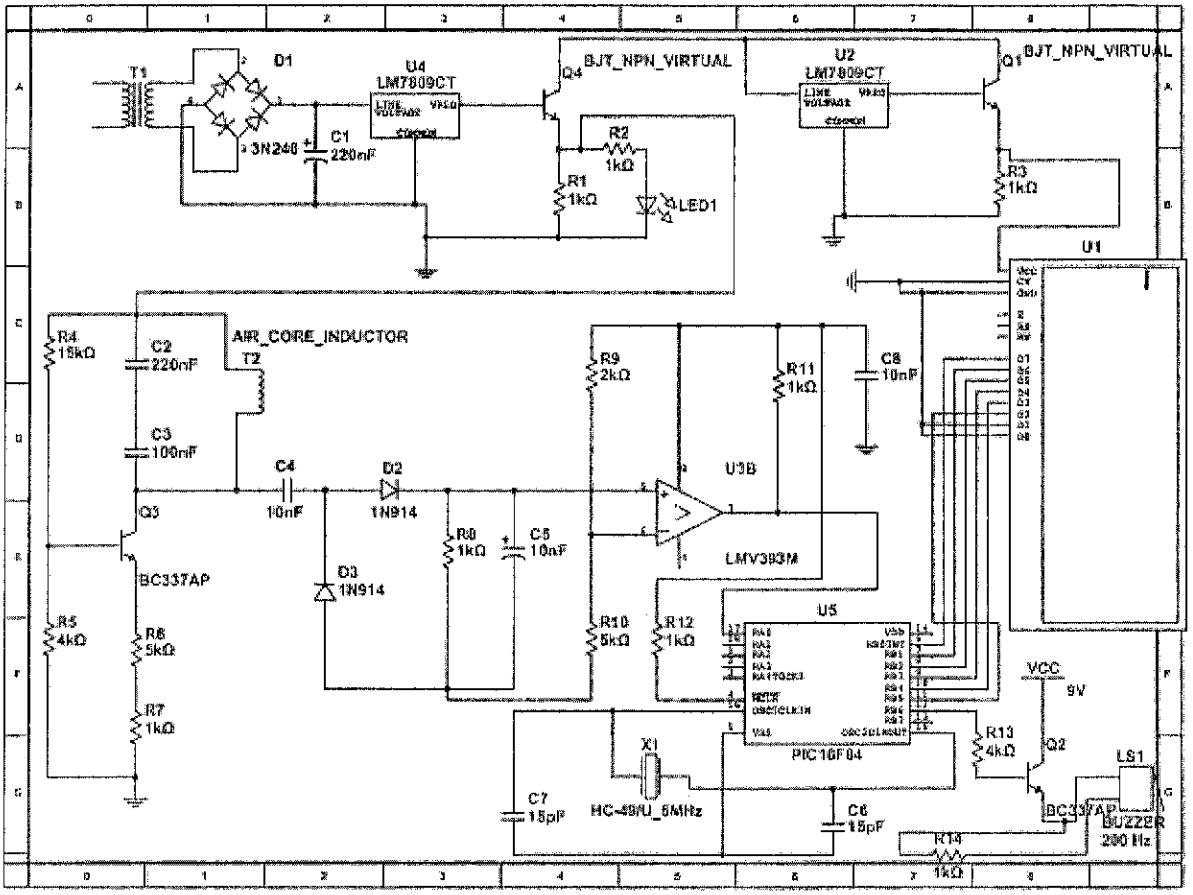

Figure 3.2-Circuit Diagram of the System.

3.3 THE DESIGN OF THE HARDWARE

The hardware consists of the following units namely: the power supply unit, sensing unit, the triggering unit, display unit and the alarming unit.

3.3.1 THE POWER SUPPLY UNIT

The power supply unit is not dual in the sense that the circuit cannot be powered by electricity and battery for places having epileptic electricity supply. The circuit is designed to use +5V DC supply with is a linear power supply type which involve step down transformer, Rectifier, Filter capacitor, and a voltage regulator, to give the regulated DC voltage.

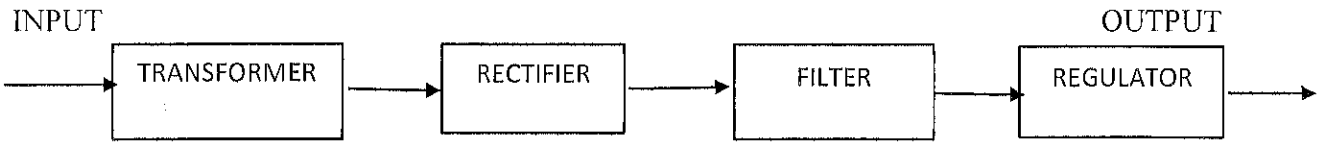

Figure 3.3-Circuit Diagram of the System.

- ✓ Transformer The transformer is an electrical device that transforms energy from one circuit to another by magnetic coupling with no moving parts. A transformer comprises two or more coupled windings or single tapped winding and in most cases, a magnetic core to concentrate magnetic flux. Transformers are used to convert between high and low voltages, to change impedance, and to provide electrical isolation between circuits.

  If a time-varying voltage, V_p is applied to the primary winding of N_P turns, a current will flow in it producing a magneto-motive force (**mmf**). Just as an electromotive force (**emf**) drives current around an electric circuit, so **mmf** drives magnetic flux through a magnetic circuit. The primary **mmf** produces a varying magnetic flux ϕ_p in the core, and with an

open circuit secondary winding, induces a back electromotive force in opposite to V_p. In accordance with Faraday's law of induction, the voltage induced across the primary winding is proportional to the rate of change of flux.

$Vp = Np \frac{\partial \phi t}{\partial t}$ And $Vs = Ns \frac{\partial \phi s}{\partial t}$

V_p and V_s are the voltages across the primary and secondary windings.

N_p and N_s are the number of turns in the primary and secondary windings.

- ✓ Rectifier The rectifier is an electrical device comprising one or more semiconductor devices (such as diodes) or vacuum tubes arranged for converting alternating current to direct current. When one diode is used to rectify AC (by blocking the negative or positive portion of the waveform) it is called a rectifier. The difference between the term diode and the term rectifier is merely one of usage. For example the diode retains its name when used in DC to block flow of current. In this design, a full-wave rectifier (bridge rectifier) was used.
- ✓ Filter is a circuit used to remove AC components from pulsating DC just after rectification. There are several filtering techniques used in electronic power supply circuits. In this work, a capacitive filter was used.
- ✓ Regulator various kinds of regulators are used for voltage regulation in electronic power supply circuits. IC regulator units contain the circuitry for reference source, comparator amplifier, control device and overload protection all in a single IC. IC regulators provide regulation of a fixed positive voltage, fixed negative voltage, or an adjustable set voltage. For this project, a three terminal IC regulator unit providing regulation of a fixed positive voltage is used. Various models of IC voltage regulators exist by virtue of the regulation provided. So, positive voltage regulators in 7800 series include 7805, 7806, 7808, and 7810

and so on. In this project, we used 7805, 7812 and LM317 since 5V, 12V and 3.3V are required to power the metal detectors, microcontroller and LCD respectively.

3.3.2 SENSORY/OSCILLATOR DESIGN

The inductance to be used is calculated using Where L is inductance in S is the depth of turn, R represents the radius of coil, while N is the number of turns. For the purpose of this project, the sensor (coil) is desired to be reasonably small. So, radius R and length S is chosen to be 0.04 and 0.004 respectively. The frequency of the oscillating discharge current depends on two factors;

- ✓ Capacitance of the capacitor to be used.
- ✓ Self-inductance of the coil to be used.

To realize the oscillation of 9.34MHz, the oscillatory tank was considered. The choice of 10nF and 2.2nF was considered in such a way that their equivalent capacitance when combine with the inductor using equation 1 gives the frequency of oscillation to be 9.34MHz as calculated below.

3.3.3 TRIGGERING UNIT

A shaping circuit that is capable of converting sinusoidal wave to rectangular wave is desired, and to adequately give a low or high output, CD4093 was the choice. CD4093 is a quad 2 input Nand gate Schmitt trigger, but only two Nand gate were required; first for converting the sinusoidal waveform to square and the second for converting the square waveform to either a low or high output.

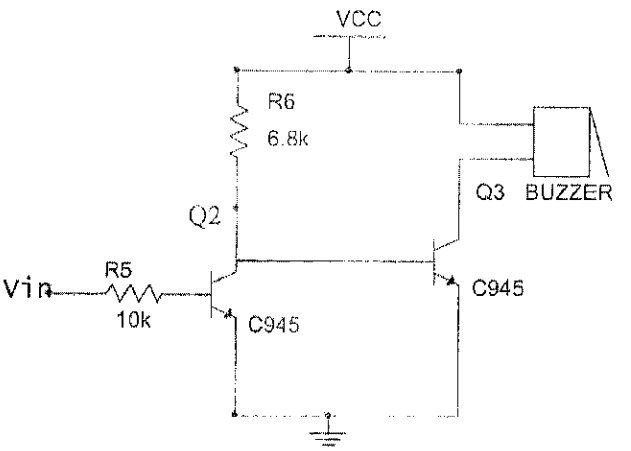

Figure 3.4-Alarm Unit.

Since the output of the triggering unit is either high or low, a transistor switch arrangement is required to properly power the buzzer.

DESIGN CALCULATIONS

Capacitor, C= $10nF$

Number of turns,$N = 14$

Diameter of the coil, $D = 22cm$

Radius of the coil, r = $\frac{D}{2} = 11cm$

Length of the coil, l =7.4cm = 0.074m

The cross-sectional area of the coil, which is circular is given by

$A = \pi r^2$

In accordance with electromagnetic theory, the inductance of an inductor is given by

$A = \pi \times 11^2 = 380.13cm^2 = 0.038013m^2$ (2)

In accordance with electromagnetic theory, the inductance of an inductor is given by

$$L = \frac{N^2 \mu A}{l}$$

Where μ *is the permeable area of the coil* $\mu = 4\pi \times 10^{-7}$

$$L = \frac{14^2 \times 4\pi \times 10^{-7} \times 0.038013}{0.074}$$

$$= 1.265 \times 10^{-7}$$

$$\omega = \frac{1}{(\sqrt{LC})} \quad \omega = 2\pi f$$

$$f = \frac{1}{(2\pi\sqrt{LC}}$$

$$Ceq = \frac{C^2}{2C}$$

$$Ceq = \frac{10^2}{2 \times 10nf}$$

$$= 5nF$$

Therefore $f = \frac{1}{2\pi \times \sqrt{(5 \times 10^{-9} \times 1.265 \times 10^{-4})}}$

$$=200119.71\text{Hz} \approx 200kHz$$

3.4 IMPLEMENTATION

Each section/unit making up the system to implement the microcontroller based metal detector using PIC16F84A as the counter were coupled together: the hardware of each section of the circuit were implemented separately and later combined to make a complete system that would be able to accomplish the desired result.

3.4.1 POWER SUPPLY IMPLEMENTATION

This unit was the first unit implemented after getting to know the minimum and the maximum voltage, current and power rating of the various sections of the circuit. After which it was first

connected on the bread board, to check if it meets the working ability required and finally transferred to a permanent board and soldered.

3.4.2 SENSORY UNIT

Colpitts oscillator (LC oscillator) was used as the sensor. The coil of the sensor is 8cm (0.08m) in diameter and having 16 turns. After which it was constructed on the bread board and finally soldered on a permanent board.

The data-lines of the Liquid Crystal Display were connected to port C of the microcontroller while the control lines were connected to RB0, RB1 and RB2 of the microcontroller. A variable resistor of 10k ohms was also connected to the LCD for controlling the back-light of the LCD.

3.5 SOFTWARE CONFIGURATION

Microcontroller Program Implementation

In this implementation, it is important to assign the reference value. This reference value is the input voltage of the microcontroller and it is the output of the phase detection circuit when there is no metal detected. And then, it is to get the input voltage value from the phase detection circuit. If the input voltage changes, the metal is detected and the alarm system will be ON. If the input voltage increases when compared to the reference voltage, this metal is non-ferrous metal. If the input voltage decreases when compared to the reference voltage, this metal is ferrous metal.

In this case, pulse width of the pulse generator as the receive coil sensor is greater than the pulse width of the pulse generator as the transmit coil sensor. So, the phase difference between these two signals is phase lead. And then, the increasing voltage is inputted to the microcontroller. Microcontroller determines that it is nonferrous metal and at the same time, buzzer is activated

and the green LED is ON. Result when ferrous metal is detected. In this case, pulse width of the pulse generator as the receive coil sensor is less than the pulse width of the pulse generator as the transmit coil sensor. So, the phase difference between these two signals is phase lag. And then, the decreasing voltage is inputted to the microcontroller. Microcontroller determines that it is ferrous metal. At the same time, buzzer is activated and the red led is ON. Result when disallowable non-ferrous metal is detected. In this case, pulse width of the pulse generator as the receive coil sensor is greater than the pulse width of the pulse generator as the transmit coil sensor. So, the phase difference between these two signals is phase lead. And then, the increasing voltage is inputted to the microcontroller.

3.6 HARDWARE CONFIGURATION

3.6.1 OSCILLATOR CIRCUIT DESIGN

Oscillator Circuit Design 4.86 kHz frequency range is designed to operate the transmitter circuit. For low frequency, oscillator based R-C circuit can be used. In this system, Wien Bridge Oscillator, one of R-C oscillator circuit is used. The dual power supply for this circuit is designed as ±5V.

3.6.2 INDUCTION COIL SENSOR DESIGN

In this system, concentric coil design is used to sense the metal target. It transmits coil, receive coil and feedback coil. Transmit coil and receive coil are wound in the same direction but the bucking coil is in the reverse direction of these two coils and wound over the receive coil to cancel the external noise of the transmit coil. An AWG 28 is used for the transmit coil and feedback coil. An AWG 30 is used for the receive coil. Discriminating system by using microcontroller. In this system, there are three parts: the input, the processing and the output. It is composed of power supply, sensing circuit, phase detecting circuit, microcontroller, light emitting diode (LED) and buzzer. Microcontroller is used to control the overall system. The sensing value

from the sensing circuit is inputted to the phase detection circuit. The sensing value is the frequency coming from the metal. The frequency changes are depended on the various types of metals. And then, the frequency changes is inputted to the phase detection circuit. Depending on the output voltage from the phase detection circuit, the microcontroller determines whether the detected metal is ferrous metal or non-ferrous metal and it is displayed on the personal computer (PC). In this system, buzzer is used to alarm that the metal is detected. In the case of LEDs, two LEDs: green and red are used to notify that the metal is ferrous or non-ferrous. If the discriminated metal is prohibited metal, the webcam will capture this type of metal.
In this system, various types of metal such as iron, copper, aluminum, gold and platinum can be sensed by the induction coil sensing circuit. And the maximum distance that the coil sensor can sense is about 8cm to 9cm. The buzzer is activated whenever the metal is detected. When the ferrous metal is detected, the red LED is ON. In the case of nonferrous metal, the green LED is ON. And this message is also displayed on the personal computer (PC). Moreover, if the detected metal is disallowable metal, the webcam will capture this object. By this way, the security personal can get the photo records from this type of metal detector.

3.7 MODE OF OPERATION

Metal detectors basic operation depends on Ampere's and Faraday's laws. It works on the principle of transmitting a magnetic field and analyzing a return signal from the target and environment. The transmitted magnetic field varies with time. This transmitted magnetic field creates electric current to flow in metal targets. These electric currents are called eddy currents, which in turn generate a weak magnetic field, but their generated magnetic field is different from the transmitted magnetic field in shape and strength. The regenerated magnetic field from the eddy currents causes an alternating voltage signal at the receive coil. Depending on the alternating voltage signal at the

receive coil, we can decide whether the metal target is detected or not. Metal detecting sensor is the most essential component in metal detectors. In this system, induction coil sensor is used. Metal detecting capabilities are vary according to coil sensor shapes, sizes and coil configurations. (Yin Min Theint, 2015)

There are three types of coil shapes

- ✓ Round shaped coil
- ✓ Elliptical shaped coil
- ✓ Open-web coil

The most common types of coil configuration are-

- ✓ Concentric coil
- ✓ Double-D coil
- ✓ Mono loop coil

CHAPTER FOUR

RESULT ANALYSIS AND DISSCUSSION

This design was done based on the principle of operation keeping in mind availability of components and getting the output in tangible manner i.e. using LED, So two circuits was to be used, first the circuit which produces the magnetic field and second the circuit that monitors the output. After design was done block diagram was used to simplify the problem, simulation was done and the circuit was constructed and tested. Description of operation is shows flow chart of the mechanism used by the metal and mobile phone detector for object detection.

4.1 TESTING

When testing the constructed metal detector, it was found that: The LED is ON when there is no metal near to the search coil. The LED's light intensity decreases when a metallic object comes near to the search coil and the LED becomes OFF when the object gets very closer from the search coil i.e. the circuit field decreases. This is an agreement with principles of electromagnetic. The field of the search coil is more concentrated at its center and decreases with the distance from it. From the equation it could be noticed that, the frequency of oscillation will be determined by the resonance frequency of the parallel-tuned circuit. It is found that the effect of metallic objects increases as the size of this object increase, also the effect of the metallic objects increases as the distance between it and the center of the search coil decrease; this because the field becomes more concentrated. In general, the suitable size of the search coil is about 9.5"-11.5" diameter However the search coil used in this project is smaller than this size; this because the power is small and to use larger search coils higher power is needed. The size of the search coil used was determined after performing several experiments. PC power supply was used in order to get high power, but

the power we get from it was not high enough to increase detection region and search coil size. In simulation the problem was that no metallic object exists in the simulation software and as the circuit the field to detect objects this problem was solved using AM source i.e. to simulate the existence of the metallic object.

4.2 ANALYSIS

Since the electromagnetic principles support the fact that whenever there is a metallic object in an electromagnetic field there would be an electric current flowing in this object and via versa, based on this fact the design was started and the first step in the design was to introduce an electronic circuit that produces an electromagnetic field. Search was done and the best choice found was the Colpitts oscillator, it was found that the Colpitts oscillator can produce the required magnetic field, the output ac voltage of the circuit change when circuit field change i.e. when there is a metallic object near to the circuit the field decreases. After the circuit was chosen the problem was how to monitor the output to do this another circuit was to be used and the simplest circuit found was a circuit consists of MOSFET, LED and power supply.

COST EVALUTION OF THE PROJECT

S/NO	COMPONENT/ITEMS	QUANTITY	AMOUNT (=N=)	TOTAL AMOUNT
1	Transformer 12Vac/22Vac	1	600	600
2	Voltage regulator 7809	1	120	120
3	Voltage regulator 7806	1	150	150
4	Transistor TIP4IC	2	130	260
5	Amplifier Transistor BC3372	2	200	400
6	Voltage comparator L393	1	150	150
7	Microcontroller PIC16F84	1	400	400
8	Spin IC Socket	1	50	50
9	Buzzer	1	150	150
10	LCD	1	120	120

11	Crystal 4MHZ	1	100	100
12	IN4007	4	20	80
13	Switching diode IN914	2	100	200
14	Vero board	1	150	150
15	Main cable	1	200	200
16	Switch	1	200	200
17	Resistor 100Ω	2	20	40
18	LEDs 3mm	2	20	40
19	Resistor 15k	2	20	40
20	Resistor 2kΩ	2	20	40
21	Resistor 5kΩ	2	20	40
22	Capacitor 15pf	2	20	40
23	Capacitor 10nf	2	20	40
24	Capacitor1k	7	20	140
25	Capacitor 220nf	1	50	50
26	2,200µf	1	150	150

27	Casing	1	3000	3000
	TOTAL			7320

4.3 DESIGNING STAGES AND PROCEDURE

STAGE ONE

- ✓ The first step was to determine the types of the circuits that are to be used in the project, and the needed frequency was calculated to determine the values of the components used. Simulation was done to ensure that circuit can work.

STAGE TWO

- ✓ After the simulation work, components were brought search coil was made using copper and the main circuit was constructed, it was tested and the output of this circuit was monitored at that time using oscilloscope and digital multimeter, after making sure that main circuit works properly the indicator circuit was connected and tested using voltage from the power supply to ensure that it was working well.

STAGE THREE

- ✓ The output of main circuit was connected to the indicator circuit then a number of experiments were done to suite the voltage of power supply (which supplies the main circuit) such that the output when there is no metal in coil's field to be slightly more than and less than when there is a metallic object in that field.

STAGE FOUR

- ✓ When voltage more than is applied to the gate the drain and source will be connected i.e. the LED is OFF and When the gate voltage value is less than drain and source will be isolated i.e. the LED becomes ON.

STAGE FIVE

- ✓ It was seen that when a metallic object comes near to the coil the LED was turned ON and when there was no metallic object in the field the LED was OFF.

4.4 RESULT

The prototype was designed and implemented. The results obtained from the combination of various detection system components and corresponding constructions are evaluated and some observation were made during the different stages of testing. Some distances were taken so as to ascertain the workability of the intrusion detection system. The best line-of-sight is about 100cm the distance from the transmitter to the receiver. The picture of the completed project shown below.

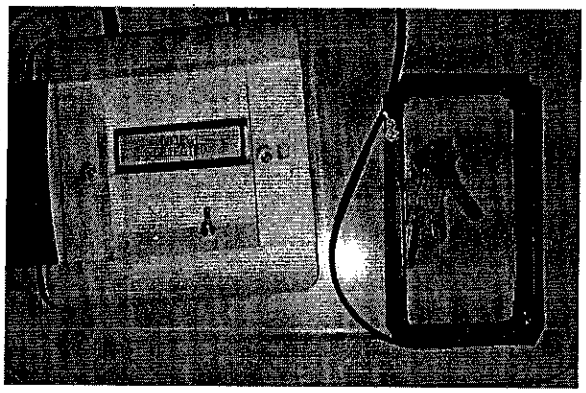

Figure 4.1-Metal and Mobile Phone Detecting Device Detecting a Metal Piece.

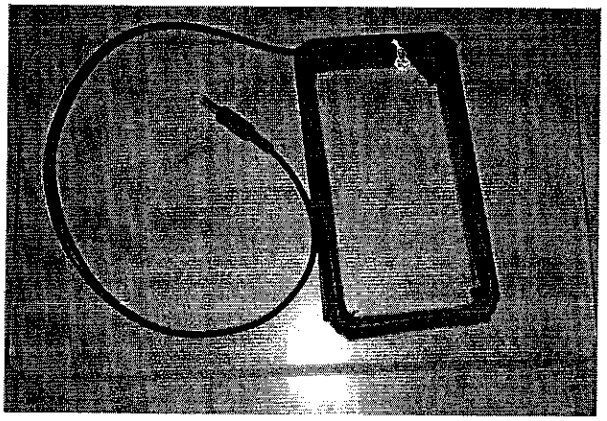

Figure 4.2-Metal and Mobile Phone Detecting Device Search Coil.

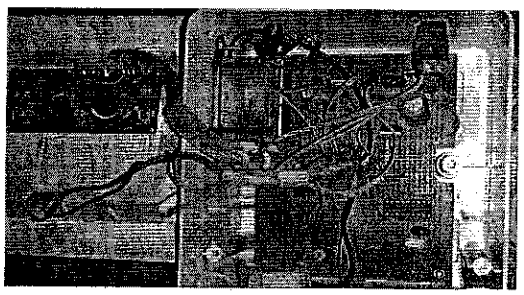

Figure 4.3-Metal and Mobile Phone Detecting Device Component Setup.

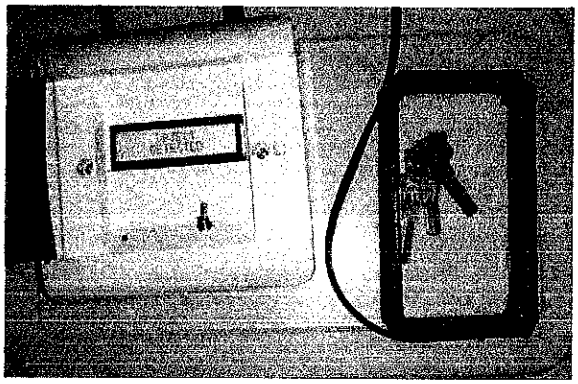

Figure 4.1-Metal and Mobile Phone Detecting Device Detecting a Metal Piece.

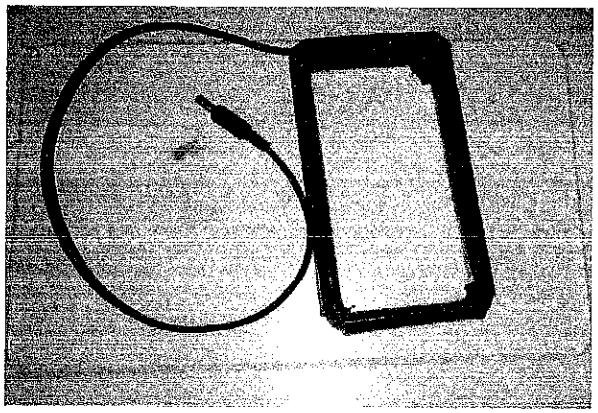

Figure 4.2-Metal and Mobile Phone Detecting Device Search Coil.

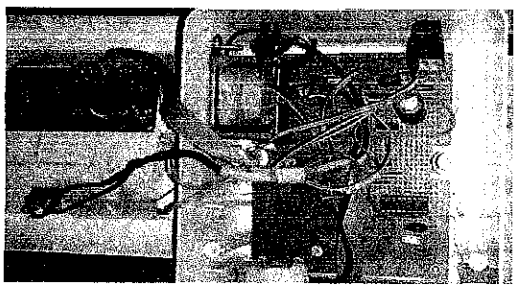

Figure 4.3-Metal and Mobile Phone Detecting Device Component Setup.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 CONCLUSION

This project will demonstrate how a metal detector could be designed with some special features as enumerated above. Consequently calculations and assumptions were made for the various choices of components and the circuit designs. However, the performance of the individual units that made up the system will help to make the project achievable.

5.2 LIMITATIONS

This detector are limited to:

- ✓ Detection of a cell phone that is in use; on call, communication via short messaging service and internet access.
- ✓ The detection of cell phones that are on standby mode, switched off or on airplane mode will not be included in this project.
- ✓ It cannot distinguish between several types of metals.
- ✓ Its detection region is small.
- ✓ This metal and mobile phone detector is a mini and portable project.
- ✓ It cannot differentiate between object detected
- ✓ It is not battery power.
- ✓ It is not solar powered and solar charged.

5.3 FUTURE WORK

There are many updates which could be applied to this detector in the future in order to solve the limitations of this detector and get detector that can be practically used. Possible modifications are:

- ✓ Increase the detection region of the detector; this may be done using high power to supply the circuit.
- ✓ Use LCD or headset as indicator, this also needs increasing the power.
- ✓ Make it portable by using portable supply such as mobile battery.
- ✓ Update this detector and let it determine the type of metal it detects, to do this another technology is to be used.

5.4 RECOMMENDATIONS

Although the main objectives of the project were achieved, it is still subject to further improvement.

i) I recommend that any further work on this project, there should be a solar panel on the system to serve as an alternative power supply.

ii) The use of Bluetooth should be adopted to send signal on the display unit.

iii) I recommend that further work could be done to make the project work better by increasing the range of detection.

iv) Update this detector and let it determine the type of metal it detects, to do this another technology is to be used.

Task 1-project approval

Task 2- collection of materials for project

Task 3- Design of project circuit

Task 4- Programming of code

Task 5- Acquisition of components

Task 6- soldering on a Vero board

Task 7- designing of circuit diagram using software

Task 8- Testing and casing of the project