DESIGN AND CONSTRUCTION OF MICROCONTROLLER BASED CELL PHONE DETECTION SYSTEM

BY

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EE/14/2907

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING, SCHOOL OF ENGINEERING AND ENGINEERING TECHNOLOGY, MODIBBO ADAMA UNIVERSITY OF TECHNOLOGY YOLA

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A PROJECTREPORT SUBMITTED TO THE DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING, SCHOOL OF ENGINEERING AND ENGINEERING TECHNOLOGY, MODIBBO ADAMA UNIVERSITY OF TECHNOLOGY YOLA, IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF BACHELOR OF ENGINEERING

JANUARY, 2020

DECLARATION

I hereby declare that this project was written by me and it is a record of my own research work. It has not been presented before in any previous application for a bachelor`s degree. References made to Published Literature have been duly acknowledged.

……………………………….. Date ….. …………………

ABDULHAMID, MAHMUD

(Student)

The above declaration is confirmed

…………………………… Date……………………

ENGR. I.A USMAN

(Supervisor)

CERTIFICATION

This project entitled "**DESIGN AND CONSTRUCTION OF MICROCONTROLLER CELL PHONE DETECTION SYSTEM"** by **ABDULHAMID, MAHMUD** (**EE/14/2907**) Meets the regulations governing the award of the bachelor`s degree of the Modibbo Adama University of Technology, Yola and is approved for its contribution to knowledge and literary presentation.

……………………….. Date:……………...

Engr. I A Usman

(Supervisor)

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(Head of Department)

27. 01. 2020

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(External Supervisor)

DEDICATION

I dedicated this work to my Parents Alhaji Mahmud Damare, my dear Hon Ahmed Mahmud (bobbo) and Bappa Ibrahim(Elbabs for their directions, protections and supports. Special dedication also to my ever supportive Brother Muhammed Chobadu (Daddy) and his wife Hajjah ummii Mohammed Chubadu for their relentless support and compassion towards me during the course of my studying to this very moment. I will never forget my brothers, Sisters and other relatives and non-relative Friends for their caring attitude and support from the beginning of my pursuit for B.Engr. in Electrical and Electronics Engineering to this point. I thank you all specially to all of my MAJAGASS. I will never forget my dearest brother at the same time my mentor. Jafaru Usman Dan Mallam M.D BUA distribution I love you more. Alhamdulillah for Everything.

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ABSTRACT

Cell phone are widely used in the world while people have to be connected to one another there are situations or places where the usage is a nuisance and hence prohibited either due to security reasons or due to its negative health effective. Cell phone detection has been on investigation for a long time. There are techniques which have been formulated or proposed on how cell phones can be detected. Most of them use features such as audio system RF system and common materials of the phones (such as speaker microphone Earpiece etc} and try these features are the basis of detecting mobile phone. This project utilize the RF system of the cell phone as the features to be used to detect its presence in both on and off condition. A circuit that detects signal in the range of 0.9GHZ to 3GHZ is used to detect a cell phone when in active mode or and switch off mode when the signal is detect an LED blinks to indicate the usage of a cell phone within a radius of 1.5 meters.

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LIST OF ABBREVIATIONS

ADC	Analogue to Digital Converter
AVCC	Analogue Positive Voltage Supply
BSC	Base station Controller
C	Capacitor
CPU	Central Processing Unit.
DAC	Digital to Analog Converter
DC	Direct Current
EIR	Equipment Identity Register
ETSI	European Telecommunication Standard Institute
FPGA	Field Programmable Gate Array
GND	Ground
GSM	Global System for Mobile Communication
GPS	Global Positioning System
IDE	Integrated Development Environment
IMEI	International Mobile Equipment Identity
MIPS	Million Instructions Per Seconpd
MS	Mobile Station
MSC	Mobile Service Center
NEMA	National Emergency Management agency
R	Resistor

RF Radio Frequency

RX Receiver

SIM Subscriber Identity Module

SMS Short Message service

SS Switching Station

TDMA Time Division Multiple Access

TTL Transistor Logic

TX Transmitter

UART Universal Asynchronous Receiver Transmitter

VCC Positive Voltage

CHAPTER ONE: INTRODUCTION

1.0 Background

Due to the advent of wireless communication technology and the recent developments in telecommunications, the use of cell phones (GSM) for different purposes by all categories, classes and ages of people have become common. The abuse of this technology due to its improper usage by some individuals has however been on the high side in recent times and also a thing of great concern. The use of cell phones in both private and public places within and outside the country has generated some problems that if not properly handled may in recent times be difficult to solve [1].

People need to connect all over the world using any easy and available means, cell phones are widely used in every places hence making it an integral part of people lives. Presently cell phones are not only used for communication purposes via short messaging service (SMS), calls, emails and internet but advanced applications such as remote health monitoring systems and security systems have been integrated with the mobile phone. A mobile-phone or a cell phone is an electronic device that has the capability to make and receive phone-calls via a radio-link, while moving around a wide-geographic-area. Due to the availability of cell phones, it is possible for a person located in a remote-place to communicate with a person across the globe in a fraction of a second. It does so by connecting to a cellular-network provided by a mobile-phone-operator, allowing access to a public-telephone- network [2, 3].

In schools, mostly higher institutions students use mobile-phones to store lecture-materials, e-books, tutorials, videos, communicate with their classmates and browse the internet for exceedingly-different-intentions. These projected-advantages provided by mobile phones, however, would have potential-undesirable-effects if mobile-phones are utilized in restricted-premises, such as exam-venues. Noncompliant of students to the general University exam-regulations of not using mobile-phones during lectures and exams has become a thing of great concern to the lecturers and the school management. The rapid-explosion of cell-phones at the beginning of the 21st Century eventually raised problems, such as their potential-use to invade privacy or contribute to widespread academic-malpractice [3].

The advancement and wide-usage of mobile-phones have promoted them to become the learning- media, thereby increasing integration and use of mobile-phones into instruction in the Universities. In spite of the vital-role that is played by mobile-phones as a learning-tool, there are still challenges that could originate from using mobile phones, such as cheating during exams and distraction of students and lecturers during lecture-hours. In our school for example, it can be observed that, there is an overwhelming-increase in the use of mobile phones by students during lectures which has the potential of distracting oneself and the fellow students from learning and as well serves as a means of cheating by the students during examination [3, 4, 5].

The capability of today's mobile phones gives a student numerous ways to cheat in exams. During exams period, a student may constantly-communicate with people outside the exam-room via email and use Short Messaging Services (SMS). Students and outsiders can exchange information (Questions and Answers) via email attachments. Through a mobile-phone-camera, a student can snapshot questions and sends as an email or WhatsApp attachment to outsiders for help, and in the same-way a student can receive answers.

Moreover, as mobile-phone provides internet- connectivity, student can post questions online and receive responses instantly. In addition to that, a student can post their inquiries to search engines and look for answers from many engines. Furthermore, with the storage-capacity that mobile- phone offers, students can pack lecture-notes, e-books and any other unauthorized-materials relevant to the exam in question on their mobile-phones, sometimes before exam period. Other applications installed in a mobile-phone could also be used by a student to commit cheating; such applications include dictionaries and scientific-calculators. As technology keeps advancing, likewise the students get access to multiple-technologies to commit academically dishonest-acts of cheating [3, 6].

In recent years, there has been also an increasing-focus on issues relating to the use of mobile-phones in restricted, prohibited, and unauthorized-areas other than exam halls. The reason for this increased-interest is largely due to disturbance, as well as wrong and inappropriate-usage of mobile-phones by the owners and users alike. Areas like banks, courts of law, churches, mosques, synagogues, offices, private meeting-venues, restaurants/hotels, prisons, airports, theatres, cinemas, conference-facilities, museums, hospitals, examination-halls, defense and security establishments, military and police-base-camps, hospitals; and petrol-stations and depots among others, just to mention a few, are where the use of an active Mobile Communication (GSM) device are prohibited or limited. In recent years, there has been growing recognition of the problem of contraband cell phones inside correctional facilities. These phones can be used to operate both internal and external criminal enterprises, threaten witnesses, harass victims, orchestrate uprisings, and undermine prison security by coordinating the activities of separated inmates. A need clearly exists to monitor and control cell phone use within correctional facilities, lectures and exam halls [1, 3].

1.1 Problem Statement

The rapid-explosion of cell-phones at the beginning of the 21st Century eventually raised problems such as their potential-use to invade privacy or contribute to rampant academic-cheating. One of the existing-approaches to ensure students and individuals are free of mobile-phones in exam-venues and restricted areas is through manual/physical-inspection during exam-venue-entrance, which viewed by some students and lecturers as invasive and sometimes even in-effective. Manual-inspection cannot reveal 100% the presence of mobile-phones and therefore some students may go undetected, especially if they hide a mobile-phone in their private-parts. Taking into consideration that, some unauthorized-users of mobile-phones may not be uncovered by invigilators and security personnel, better-techniques for detecting unauthorized-usage of mobile-phones during examination-time is needed. With the help of cell-phone-detectors the examiner or security personnel can be able to detect the presence of a cell-phone even if it is switched off and can take appropriate-action immediately. This study, therefore, proposes simple mobile-phone-detection systems that has the capability to detect the presence of cell phone both in active mode and when the phone is switched off [1].

1.2 Objective

The objective of this project is to design and construct a cell phone detector that can be able to detect the presence of a cell phone even if the phone is switched off and the battery removed. The system utilizes a low cost electronic components to achieve the required result. In an active mode, the system will constantly search for an RF signal from a mobile phone and will alert the user when there is an active phone communication within the range of the system. In a power off mode, the system will scan for a common components present in all mobile phones and when detected, will alert the user of a hidden phone.

1.3 Significance

The significance of this project benefits institutions, examination bodies, invigilators, organizations, security personnel and individuals to detect the presence of mobile phones in examination, lecture, conference and meeting venues and take appropriate actions. It will also assist security experts to enforce the rule of no cell phone is allowed in a given premises. Also the projects a reference materials for future research purposes.

1.4 Scope

The scope of this project is to design a system that will detect the presence of a cell phone within a range of 1.5meters during an active communication and a close proximity detection if the mobile phone is switched off. The system will not be able to detect any phone outside its range of operation or to disturb any communication using the detected mobile phone.

CHAPTER TWO: LITERATURE REVIEW

2.0 Introduction

Previously, there was no technology to detect the use and presence of cell phones in classes, examination halls and cell phone restricted areas. Students brings their phones to the lecture halls and examination halls while individuals ignores the rules restricting the use of cell phones in restricted areas. In some areas, manual checking for the presence of cell phones are being practiced but there are still the possibility of smuggling cell phones inside if not checked properly. A cell phone detector detects any phone within its range weather in on/off condition. Many researchers has done a considerable work on cell phone detection so as to combat the menaces of smuggling phones beyond restricted areas [7].

This chapter deals with some of the relevant works done by different researchers on the project topic.

2.1 Review of Cell Phone

Cellular telephone is defined as a type of short-wave analog or digital telecommunication device in which a subscriber has a wireless connection from a mobile telephone to a relatively nearby transmitter. The transmitter's span of coverage is called a cell. Generally, cellular telephone service is available in urban areas and along major highways. As the cellular telephone user moves from one cell or area of coverage to another, the telephone is effectively passed on to the local cell transmitter. Cell phones were initially created so that people can carry it along while driving and it was referred to as a car phones. Early cell phones were cumbersome, bulky, and expensive compared to the modernized cell phones. The history of cell phones can be dated back to 1983 due to the development of Motorola DynaTAC 800x which lasted for 30 minutes before dying. Over the years several developments have paved way for the modern cell phones [8]. Mobile wireless communication system has gone through several evolution stages in the past few decades after the introduction of the first generation mobile network in early 1980s. Due to huge demand for more connections worldwide, mobile communication standards advanced rapidly to support more users [9, 10].

2.2 Cellular Phone Technology

Mobile phone uses Radio Frequency RF signals with a wavelength of 30cm and frequency range of 872 MHz to 2170 MHz that is the signal is high frequency with huge energy. When the mobile phone is active, it transmits the signal in the form of sine wave which passes through the space. The encoded audio/video signal contains electromagnetic radiation which is picked up by the receiver in the base station. Mobile phone system is referred to as “Cellular Telephone system” because the coverage area is divided into “cells” each of which has a base station.

When a GSM (Global System of Mobile communication) digital phone is transmitting, the signal is time shared with 7 other users. That is at any one second, each of the 8 users on the same frequency is allotted 1/8 of the time and the signal is reconstituted by the receiver to form the speech. Peak power output of a mobile phone corresponds to 2 watts with an average of 250 milli watts of continuous power. Each handset with in a ‘cell’ is allotted a particular frequency for its use.The mobile phone transmits short signals at regular intervals to register its availability to the nearest base station. The network data base stores the information transmitted by the mobile phone. If the mobile phone moves from one cell to another, it will keep the connection with the base station having strongest transmission. Mobile phone always tries to make connection with the available base station [11].

2.3 Cellular Phone Features

The features of a cell phones are the set of capabilities, services and applications that made up a cellphone. Most of the common features found in all cell phones includes the following;

- A battery providing the power source for the phone functions.
- A circuit board containing the brain of the phone. The circuit board contains the memories and other components that makes the system to functions.
- A keyboard or a means in which the user can input data into the phone.
- A microphone; the microphone piece is near the end of the phone and it picks up the volume of the speaker and transmits it to the listener on the other end of the line.
- A speaker; the speaker is an electromechanical device that is used to pass audio messages from the phone to the user.
- Earpiece; the earpiece is located near the top of the phone and acts as the speaker so that the user can hear the person on the other end of the conversation.
- A displays; the display is a user interface and it displays information from the phone system.
- Antenna; it's found in the network section of the phone and it is made up of metal and non-metals. It searches network and passes forward after tuning.

2.4 Developments of Cell Phone

The stages of cell phone development from the 1G network to the 4G network currently in practice are as explained below.

2.4.1 First Generation Mobile Communication System (1G)

The first generation of mobile network was deployed in Japan by Nippon Telephone and Telegraph Company (NTT) in Tokyo during 1979. This system used analogue signals and some of the major features includes

- Frequency 800 MHz and 900 MHz
- Bandwidth: 10 MHz (666 duplex channels with bandwidth of 30 KHz)
- Technology: Analogue switching
- Modulation: Frequency Modulation (FM)
- Mode of service: voice only
- Access technique: Frequency Division Multiple Access (FDMA)

2.4.2 Second Generation Communication System GSM (2G)

Second generation of mobile communication system introduced a new digital technology for wireless transmission also known as Global System for Mobile communication (GSM). This standard was capable of supporting up to 14.4 to 64kbps (maximum) data rate which is sufficient for SMS and email services. Code Division Multiple Access (CDMA) system developed by Qualcomm also introduced and implemented in the mid-1990s. CDMA has more features than GSM in terms of spectral efficiency, number of users and data rate.

2.4.3 Third Generation Communication System (3G)

Third generation mobile communication started with the introduction of UMTS – Universal Mobile Terrestrial / Telecommunication Systems. UMTS has the data rate of 384kbps and it support video calling. Due to the advent of 3G, Specific applications were developed for smartphones which handles multimedia chat, email, video calling, games, social media and healthcare.

2.4.4 Fourth Generation Communication System (4G)

4G systems are enhanced version of 3G networks developed by IEEE, it offers higher data rate and capable to handle more advanced multimedia services. LTE and LTE advanced wireless technology used in 4th generation systems. Furthermore, it has compatibility with previous version thus easier deployment and upgrade of LTE and LTE advanced networks are possible.

2.4.5 Fifth Generation Communication System (5G)

5G will be using advanced technologies to deliver ultrafast internet and multimedia experience for customers. Current LTE advanced networks will transform into supercharged 5G networks in future. In order to achieve higher data rate, 5G technology will use millimeter waves and unlicensed spectrum for data transmission.

2.5 Cellular Phone Communication Standards

Currently the three main technologies used by cellular phone providers are 2G, 3G, and 4G. Each generation of technology uses a different transmission protocol. The transmission protocols dictate how a cellular phone communicates with the tower. Some examples are: frequency division multiple access (FDMA), time division multiple access

(TDMA), code division multiple access (CDMA), global system for mobile communications (GSM), CDMA2000, wideband code division multiple access (WCDMA), and time-division synchronous code-division multiple access (TD-SCDMA).All of these protocols typically operate in the 824 - 894 MHz band in the United States.

Some protocols, such as GSM (depending on the provider) will use the 1800 - 2000 MHz band [12, 13].

2.6 GSM Technology

Global System for Mobile (GSM) is a wireless telephone technology that is used globally in phones. GSM is developed by the European Telecommunications Standards Institute (ETSI) for mobile communications. GSM uses a variation of time division multiple access (TDMA) and is the most widely used of the three digital wireless telephony technologies (TDMA, GSM, and CDMA). GSM digitizes and compresses data, then sends it down a channel with two other streams of user data, each in its own time slot. It operates at either the 900 MHz or 1800 MHz frequency band.

A GSM modem is a specialized type of modem which accepts a SIM card, and operates over a subscription to a mobile operator, just like a mobile phone. GSM (Global system for mobile) uses a process called circuit switching. This method of communication allows a path to be established between two devices. Once the two devices are connected, a constant stream of digital data is relayed .GSM networks consist of three major systems namely the Switching System (SS), The Base Station(BSS) and the Mobile station(MS).

The Switching system SS systems holds the databases within it which performs different functions. SS system performs call processing and subscriber related functions. These databases in SS systems are HLR, MSC, VLR, AUC and EIR. The MSC in cooperation with Home Location register (HLR) and Visitor location register (VLR), take care of mobile calls and routing of phone calls. Authentication center (AUC) is small unit which handles the security end of the system and Equipment identity register (EIR) is another important database which holds crucial information regarding mobile equipment.

Secondary, the base station system (BSS) have very important role in mobile communication. BSS are basically outdoor units which consist of iron rods and are usually of high length. BSS are responsible for connecting subscribers (MS) to mobile networks. All the communication is made in Radio transmission. The Base station System is further divided in two systems. These two systems, they are BTS and BSC. BTS (Base Transceiver station) handles communication using radio transmission with mobile station and BSC (Base station controller) creates physical link between subscriber (MS) and BTS, then manage and controls functions of it.

Lastly the Mobile Station (MS) consist of a mobile unit and a smart card which is also referred as a subscriber Identity Module (SIM) card. This card fitted with the GSM Modem and gives the user more personal mobility. The equipment itself is identified by a unique number known as the International Mobile Equipment Identity (IMEI) [14, 15]

2.7 Cell Phone Detection Techniques

Every mobile phone uses the RF frequency spectrum for communication. Manufacturers use different frequencies in their mobile phones for communication depending on the federal laws of the country and radiation regulations. According to studies, it shows that different phones propagated using different frequency ranges.

- An LG cellular phone had distinctive signals from 260MHz to 300MHz.

- A Motorola cellular phone had distinct signals in the range of 240MHz and 400MHz.
- A Samsung cell phone had distinctive signals between 340MHz and 385MHz.
- Nokia cell phone had distinct signal at 245MHz.

In this detection approach, a passive circuit listens for any emissions from a cellular phone when it is either waiting for a call or transmitting and does not require an external signal to detect the phone. This is advantageous especially in areas where power emissions from electromagnetic sources are highly prohibited[2].

Secondly, all cell phones are made up of one or more electromagnetic component which are usually found in the speaker or the microphone. The system will utilize an electromagnetic detector to sense the presence of an electromagnet usually found in the phones to detect phones when switched off and even if the battery was removed.

2.8 Applications of Cell Phone Detector

Each of the cell phone detectors have been devised to serve distinct purposes at home, in schools and colleges and other places. Some of their uses are mentioned below:

- A cell phone detector could be used by school and college administrations to track certain non-permissible activities by the students in the classroom, mostly during tests and examinations. The students often leverage the capabilities of their highly functional cell phones to transfer the academic notes through calls, SMS, MMS and in other forms. With the help of the specialized cell phone detector circuit, this device detects the transmission of any such data between the cell phones kept within a specified range.

- At places where the cell phones are not allowed at all, a cell phone detector once again is of much use. It could easily sense the presence of a mobile phone inside the restricted area, being carried either intentionally or unintentionally. The places under consideration could be examination halls, conference rooms, operation theaters, police stations etc.
- The company owners and entrepreneurs can also use the cell phone detector to help them track the activities being performed in the cell phones of their employees. This could help them to know if there is some illegal transfer of sensitive data to and from the company premises in the form of text, image, audio or video files being transmitted via cell phones. The detector device being incorporated in the cell phone takes care of that significantly[16].

2.9 Review of Related Literatures

Quite a number of individuals has done a considerable amount of work in the development of a cell phone detector. Some of the major works related to the project being reviewed includes the following;

2.9.1 Mobile Detector Sensing Alarming and Reporting System

A novel mobile-detector-sensing alarming and reporting system had a pivotal role to detect mobile-phones in restricted-areas. Through an antenna, the device detects the presence of a mobile-phone and a signal is sent to PIC16F877A microcontroller which turns ON the buzzer-circuit and sends the message to an LCD-module for display and as well an SMS is sent to the registered mobile-number via GSM module for notification [17, 3].

2.9.2 An Intelligent Mobile Phone Detector

An intelligent-mobile-phone-detector was able to detect the presence of GSM-signals emitted from a mobile-phone within the radius of 1.5 meters. A device had a capability to detect calls, SMS and video-transmission even though a mobile-phone is in silent mode. Moreover, a device was able to restrict the detected-mobile-phone from accessing services through jamming which blocks the desired-frequency. However, the device was unable to discriminate two-distinct-phones operating in the same-frequency [18, 3].

2.9.3 Design and Implementation of Cell-Phone Detection based Line follower Robot

The project was designated to detect the use of mobile-phones in restricted premises. When the robot detects RF-signals transmitted from the mobile-phone, it stops moving and sounds a beep-alarm and the LED blinks for notification until when RF-signals transmission stops. However, the robot cannot tell the exact location of the detected mobile-phone. The robot cannot rotate at any particular-angle which is less than 75 degree. To rotate less than 75 degree angle more sensors and programming would be needed [19, 3].

2.9.4 Mobile Sniffer and Jammer

A mobile-sniffer and jammer has a capability to detect the use of GS mobiles in examination halls and other “do not disturb”-areas. The sniffer-circuit consisted of RF-detector, GSM module and Peripheral Interface Controller (PIC). The device continuously detects the RF-signal level and produces a warning message when the RF-level increases [20, 3].

2.10 Major Components of Cell Phone Detector

2.10.1 Battery

A battery is an electrical device that produces electrical current with collection of cells. Battery, also called electric cell, is a device that converts chemical energy into electricity. Strictly speaking, a battery consists of two or more cells connected in series or parallel, but the term is also used for single cells. All cells consist of a liquid, paste, or solid electrolyte and a positive electrode, and a negative electrode. The electrolyte is an ionic conductor; one of the electrodes will react, producing electrons, while the other will accept electrons. When the electrodes are connected to a device to be powered, called a load, an figure 2. 1electrical current flows. Batteries in which the chemicals cannot be reconstituted into their original form once the energy has been converted (that is, batteries that have been discharged) are called primary cells or voltaic cells. Batteries in which the chemicals can be reconstituted by passing an electric current through them in the direction opposite that of normal cell operation are called secondary cells, rechargeable cells, storage cells, or accumulators [16].

Figure 2.1Battery and the symbol

2.10.2 Voltage regulators

A voltage regulator is simply an electronic device that limits the potential difference at certain levels at the output. Voltage regulators are designed to maintain a constant voltage level despite the changes in the input voltage level or the connected load. A voltage regulator uses a simple feed-forward design or a negative feedback. A voltage regulator operates by comparing the actual output voltage to some reference fixed voltage. Any difference is amplified and used to control the regulation element in such a way as to reduce the voltage error. This forms a negative feedback control loop thereby increasing the open loop gain tends to increase the regulation accuracy but reduces stability. In this project, a voltage regulator will be used to maintain the voltage level being fed into the microcontroller and other parts of the system [21].

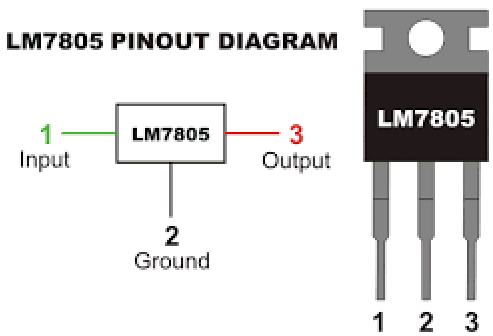


Figure 2.2 A Voltage Regulator

2.10.3 Microcontroller

A microcontroller is a compact integrated circuit designed to govern a specific operation in an embedded system. A typical microcontroller includes a processor, memory and input/output (I/O) peripherals on a single chip.

Sometimes referred to as an embedded controller or microcontroller unit (MCU), microcontrollers are found in vehicles, robots, office machines, medical devices, mobile radio transceivers, vending machines and home appliances among other devices.A microcontroller's processor will vary by application. Options range from the simple 4-bit, 8-bit or 16-bit processors to more complex 32-bit or 64-bit processors. In terms of memory, microcontrollers can use random access memory (RAM), flash memory, EPROM or EEPROM. Generally, microcontrollers are designed to be readily usable without additional computing components because they are designed with sufficient onboard memory as well as offering pins for general I/O operations, so they can directly interface with sensors and other components.

MCUs feature input and output pins to implement peripheral functions. Such functions include analog-to-digital converters, liquid crystal display (LCD) controllers, real-time clock (RTC), synchronous/asynchronous receiver transmitter (USART), timers, universal asynchronous receiver transmitter (UART) and universal serial bus (USB) connectivity. Sensors gathering data related to humidity and temperature among others are also often attached to microcontrollers. Common MCUs include the Intel MCS-51, often referred to as an 8051 microcontroller, which was first developed in 1985; the AVR microcontroller developed by Atmel in 1996; the programmable interface controller (PIC) from Microchip Technology; and various licensed ARM microcontrollers.

A number of companies manufacture and sell microcontrollers, including NXP Semiconductor, Renes as Electronics, Silicon Labs and Texas Instruments[22].

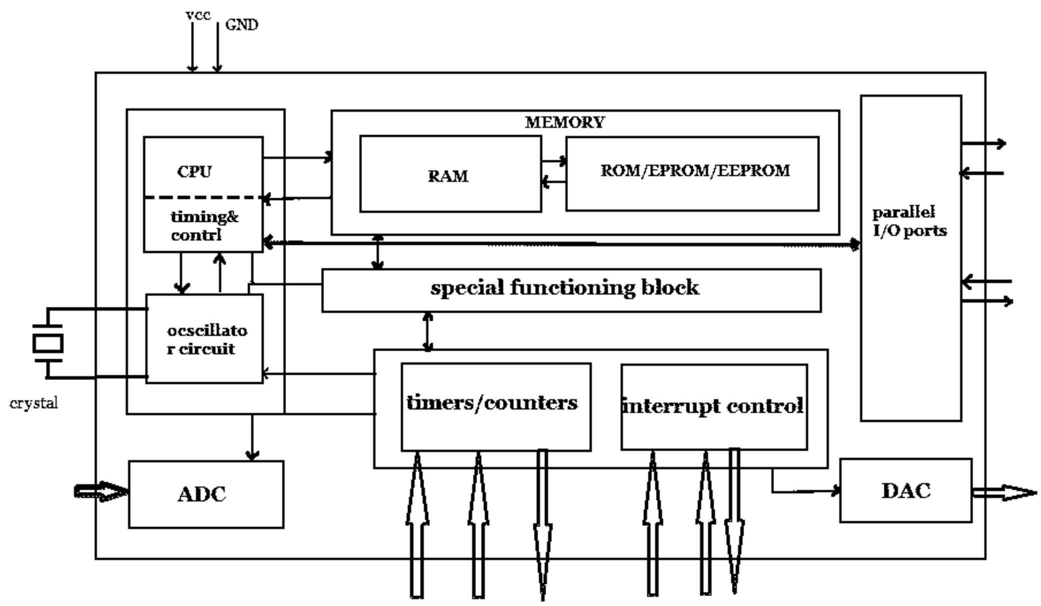


Figure 2.1 1 Microcontroller Block Diagram

2.10.4 Operational Amplifier

An operational amplifier (often op-amp or opamp) is a DC-coupled high-gain electronic voltage amplifier with a differential input and, usually, a single ended output. In this configuration, an op-amp produces an output potential (relative to circuit ground) that is typically hundreds of thousands of times larger than the potential difference between its input terminals.

Operational amplifier is a direct-current coupled high gain electronic-voltage-amplifier with a differential- input and usually a single-ended-output. The Op-amp used in the circuit functions as a current to voltage converter. The Op-amp output becomes high and low alternately according to the frequency of the signal detected from the mobile-phones.

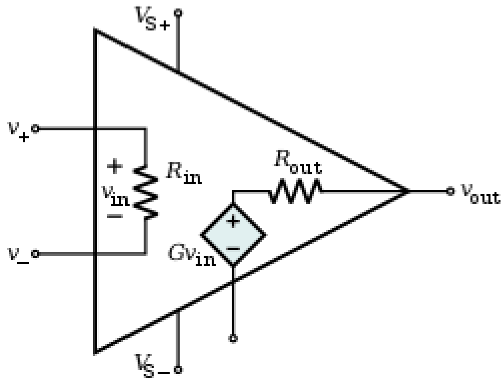


Figure 2.1 2Operational Amplifier

2.10.5 Diodes

A diode is a specialized electronic component with two electrodes called the anode and the cathode. Most diodes are made with semiconductor materials such as silicon, germanium, or selenium. Some diodes are comprised of metal electrodes in a chamber evacuated or filled with a pure elemental gas at low pressure. Diodes can be used as rectifiers, signal limiters, voltage regulators, switches, signal modulators, signal mixers, signal demodulators, and oscillators. The fundamental property of a diode is its tendency to conduct electric current in only one direction. When the cathode is negatively charged relative to the anode at a voltage greater than a certain minimum called forward break over, then current flows through the diode. If the cathode is positive with respect to the anode, is at the same voltage as the anode, or is negative by an amount less than the forward break over voltage, then the diode does not conduct current. This is a simplistic view, but is true for diodes operating as rectifiers, switches, and limiters. The forward break over voltage is approximately six tenths of a volt (0.6 V) for silicon devices, 0.3 V for germanium devices, and 1 V for selenium devices. When an analog signal passes through a diode operating at or near its forward break over point, the signal waveform is distorted. This *nonlinearity* allows for modulation, demodulation, and signal mixing[23].

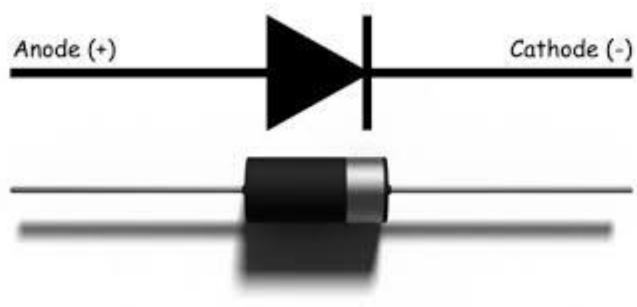


Figure 2.1 3A Diode

2.10.6 Resistors

A resistor is a two-terminal electronic-component that produces a voltage across its terminals that is proportional to the electric-current through it. Resistors are elements of electrical-networks and electronic circuits and are ubiquitous in most electronic-equipment. Practical-resistors can be made of various-compounds and films, as well as resistance-wire (wire made of a high-resistivity-alloy, such as nickel/chrome).The primary characteristics of a resistor are the resistance, the tolerance, maximum working voltage and the power-rating. Resistors are measured in ohms (Ω) and the symbol is as shown below.

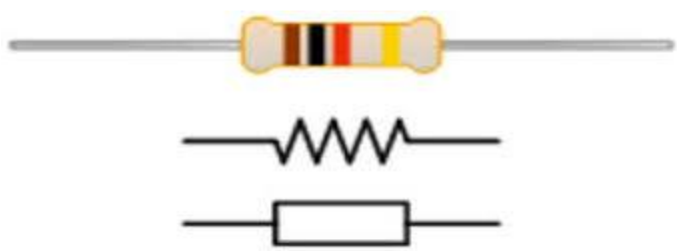


Figure 2.1 4: A Resistor

2.10.7 Capacitors

Capacitor is a passive-electronic-component consisting of a pair of conductors separated by a dielectric. When a voltage-potential-difference exists between the conductors, an electric-field is present in the dielectric. This field stores energy and produces a mechanical-force between the plates. Capacitors are widely used in electronic-circuits to block the flow of direct-current while allowing alternating-current to pass, to filter out interference, to smooth the output of power supplies, and for many other purposes. Capacitors are measured in farad and the symbol is as shown below.

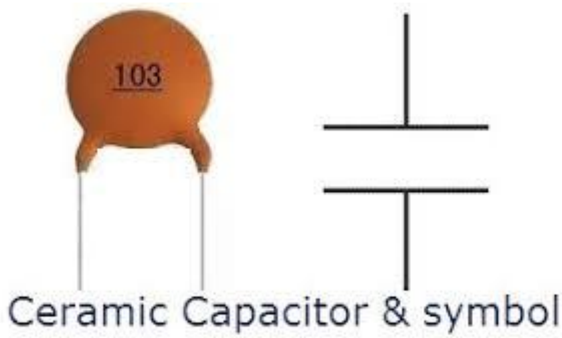


Figure 2.1 5 Ceramic Capacitor

2.10.8 Light Emitting Diode (LED)

Light-emitting diode is an electronic-light-source. LEDs are used as indicator-lamps in many kinds of electronics and increasingly for lighting. LEDs work by the effect of electroluminescence, discovered by accident in 1907. LEDs are based on the semiconductor-diode. When the diode is forward-biased (switched-on),electrons are able to recombine with holes and energy is released in the form of light. This effect is called electroluminescence and the color of the light is determined by the energy-gap of the semiconductor.

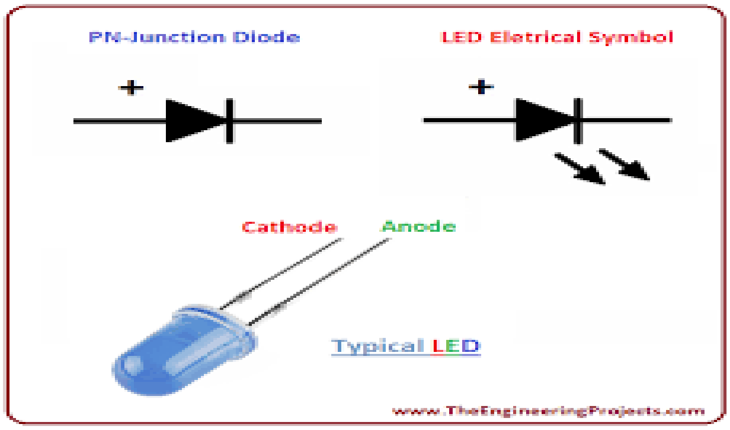


Figure 2.1 6 Light Emitting Diode (Led)

2.10.9 Buzzer

A buzzer or beeper is an audio signaling device, which may be mechanical, electromechanical, or piezoelectric. Typical uses of buzzers and beepers include alarm devices, timers and confirmation of user input such as a mouse click or keystroke. It has a signaling apparatus similar to an electric bell but without hammer or gong, producing a buzzing sound by the vibration of an armature. Its positive pin is marked by a + symbol on both the top and bottom of the buzzer. The negative pin is connected to ground. A buzzer operates between 2-5V as such can be driving by a microcontroller

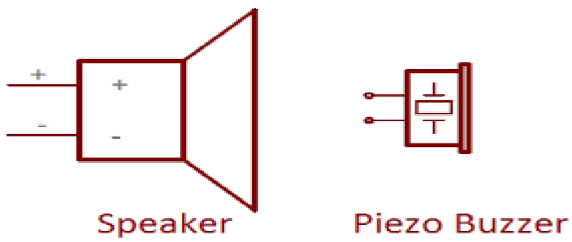


Figure 2.1 7 A Buzzer

2.10.10 Switches

A switch is a device for making or breaking the connection in an electric circuit. A switch allows a control over the current that flows in a circuit without having to manually do it. It is a critical component in any circuit which requires user interaction or control. A switch can exist in one of two states: open and closed. In the off state, a switch looks like an open gap in the circuit. This in effect looks like an open circuit there by preventing current from flowing. In the other hand, in the on state, the switch acts just like a piece of perfectly conducting wire. This closes the circuit and turning the system on and also allowing current to flow through the rest of the circuit.

2.10.11 Reed switches

Reed switch is actuated by magnets, and commonly used in mechanical-systems as proximity-sensors. The reed-switch is an electrical-switch operated by an applied magnetic-field. A magnetic-field (from an electromagnet or a permanent magnet) will cause the reeds to come together, thus completing an electrical circuit. The stiffness of the reeds causes them to separate, and open the circuit, when the magnetic field ceases. Good-electrical-contact is assured by plating a thin layer of non-ferrous precious-metal over the flat-contact-portions of the reeds. Since the contacts of the reed-switch are sealed away from the atmosphere, they are protected against atmospheric-corrosion. The hermetic-sealing of a reed-switch make them suitable for use in explosive-atmospheres where tiny sparks from conventional switches would constitute a hazard. Reed switches senses the presence of a magnet in the cell phones and closes.

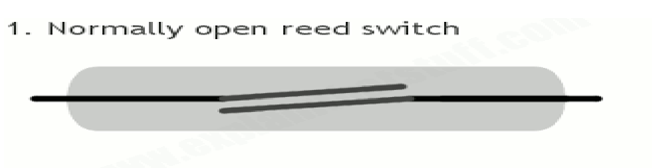


Figure 2.1 8 A Reed Switch

2.10.12 Antenna

The antenna is used to sense the RF-signals that is being transmitted or received through the mobile phones. Antenna is a transducer that converts radio frequency (RF) signals into alternating current and vice versa. There are both receiving and transmission antenna for sending and receiving radio transmission. Antennas have an arrangement of metallic conductors with an electrical connections to receivers or transmitters. Current is forced through these conductors by radio transmitters to create alternating magnetic fields. These fields induced voltage at the antenna terminals which are connected to the receiver input.

Figure 2.1 9 An Antenna

2.10.13 Mobile phone

A wireless communication device through which the RF-signals are transmitted or received and whose presence is to be detected by the mobile-phone-detectors. It is a hand held wireless device that allows user to make and receive calls and to send text message among many features. A mobile phone may also be known as a cellular phone or simply a cell phone. A mobile phone with an advanced feature similar to a computer is called a smart phone, while a regular mobile phone is known as a feature phone.

Figure 2.1 10 Mobile Phone.

CHAPTER THREE: DESIGN AND CONSTRUCTION PROCEDURES

3.0 Introduction

This chapter deals with the design and construction procedure of a cell phone detector that detects cell phones both in on and off condition. The chapter deals with the design procedure, the block diagram description, hardware and software designs and other aspects of the design and construction procedures. It details the step by step, the theoretical analysis, choice of components and values, construction and packaging materials carried out to achieve the expected results. It as well indicates the calculations involved, schematics and drawings of the circuits and other necessary parts.

3.1 System Description

The system is a close range cell phone detection security scanner for concealed mobile phones whether turned on or off and even if the cell phone battery is removed. The system differs from traditional metal detectors as it scans for specific components common to all mobile phone and not just metals. It is a perfect tool for any security details tasked with rapid scans of many targets including people, packages, briefcases and boxes.

Mobile phone detector circuit can detect both the incoming and outgoing calls, SMS and video transmission even if the mobile phone is kept in the silent mode. The moment the system detects RF transmission signal from an activated mobile phone, it start sounding a beep alarm and the LED blinks continuously. The alarm continues until the signal transmission ceases. The transmission frequency of mobile phones ranges from 0.9 to 3 GHz with wavelength of 3.3 to 10 cm. So a circuit detecting gigahertz signals and ferromagnetic materials was used for the mobile phone detection technique.

3.2 System Block Diagram

The system block diagram refers to the various blocks of units that works together to achieve the required result. The various sections of the system includes the power supply, the radio frequency section, the alarm section, the microcontroller section, the indicator section, the display section and the ferromagnetic detector section.

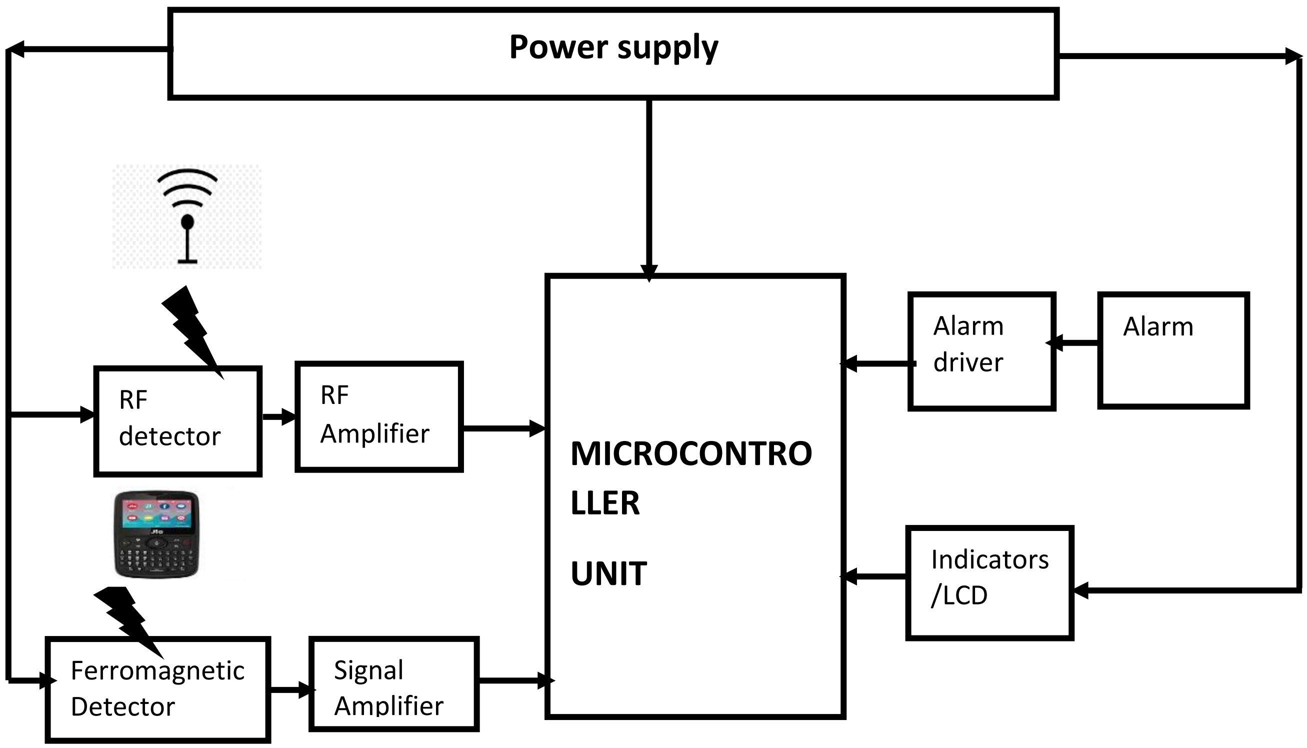


Figure 3 1: System Block Diagram

3.2.1 The Power Supply

The power supply unit is the section that provides and regulates the power needed by the device to function properly. The unit comprises of the power source and various power regulators that maintains the system required power. The system functions based on a 9V battery which powers the various sections of the system. The power supply section comprises of the battery source, the voltage regulator, control switch and the power indicators.

3.2.2 The RF Detector Unit

This section of the system detects the radio frequency signal emitted from a cell phone during active phone communication. The section constantly searches for an RF signal and sends a command to the microcontroller whenever it detects a high frequency RF signal. The RF signal is further amplified by an RF amplifier before sending it to the microcontroller.

3.2.3 The Microcontroller

The microcontroller is the brain of the system. It is responsible for coordinating the activities of the system. The microcontroller receives information from the input devices such as the RF detector and the ferromagnetic detectors, processes the information and gives command to the output peripherals. Every activity of the system depends on the action and command of the microcontroller.

3.2.4 The Ferromagnetic Detector

A ferromagnetic detector is a device that detects the presence of a ferromagnetic materials and gives command to the microcontroller. The section is used to detect the presence of the mobile phone concealed in an object. The section detects of a common object present in every mobile phones which includes the phone speaker and microphones and sends command to the microcontroller.

3.2.5 The Alarm Unit

The alarm unit comprises of a buzzer and a buzzer driver. This section alerts the user whenever there is an active cell phone communication or a concealed mobile phone is detected.

3.2.6 The Indicator and Display Unit

The indicator and display unit is similar to the alarm unit. The indicator and display unit comprises of light emitting diodes and a Liquid Crystal Display (LCD) which is used to notify the user of the status of the system at all time. The indicator indicates whether a cell phone is detected or an idle mode of the system. The indicator unit comprises of several LEDs interfaced to achieve the required result.

3.3 Hardware Design

The hardware design involves the design of the various sections of the system which includes the power supply, the detectors, the controllers and the output units. The design comprises of the analysis and choice of the components, calculations required about the values of the components and the various connections established.

3.3.1 Power Supply Design

As stated earlier, the power supply unit deals with the system source of power and it regulation. The system being hand held is powered with a battery power supply. The system functions based on a non-rechargeable 9V battery. The battery along with other components of the power supply supplies the required power to the various parts of the circuit. From the datasheets of the various components, the minimum voltage required for smooth operation is 7V hence, the choice of 9V battery. Secondly, the 9V battery is widely available in the market. The summary of the systems power consumption is as shown in the table below.

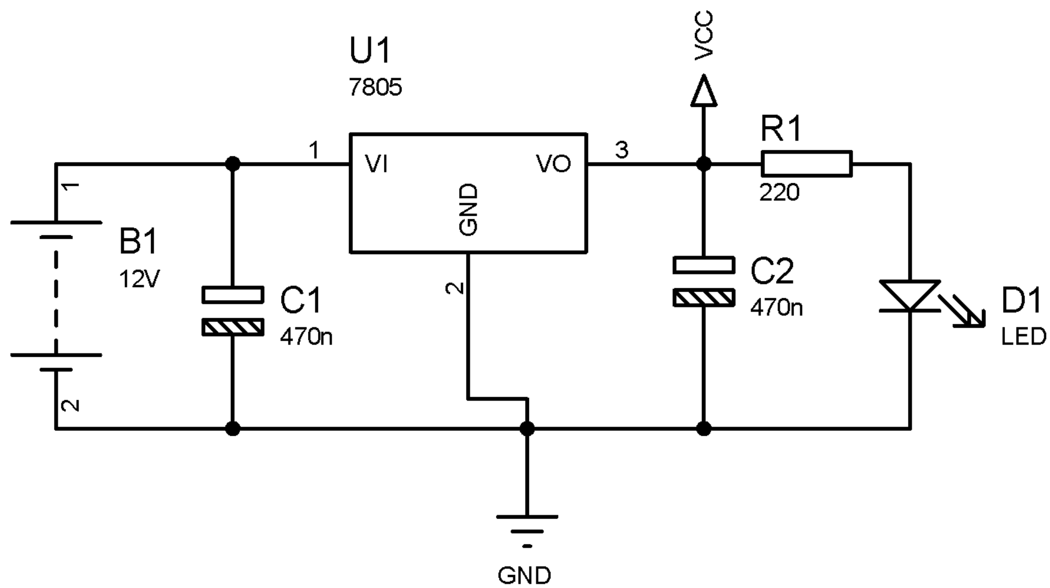


Figure 3 2 Power Supply Unit.

A L7805 voltage regulator regulates the power to a constant +5V power supply. The +5V maintains a constant voltage supply to the circuit irrespective of the battery voltage above the threshold. The features of the regulator that prompted for its use is as stated below.

3.3.1.1 The L7805 Regulator

The main function of the voltage regulator is to keep the terminal voltage of the output constant even when the input voltage varies above the specified voltage value. The regulator used in this project is L7805 for regulated 5V dc power supply. The connection of the regulator is as shown in the figure 3.9. The L78XX series according to the datasheet has a maximum output current of 1.5A but can still be adjusted to produce a variable output current. It has a maximum voltage drop of 2.5V at 25^0C and a resistance of 17mΩ at 1

KHz. The special features of L7805 voltage regulator includes the following as captured from the datasheet[24].

- Output current up to 1.5 A.
- Output voltage of 5V.
- Thermal overload protection.
- Short circuit protection.
- Output transition with SOA protection.
- 2 % output voltage tolerance.
- Guaranteed in extended temperature range.

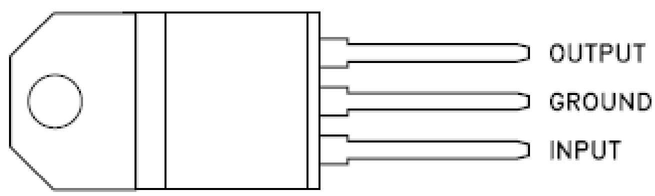


figure 3.3: L7805 Voltage Regulator

3.3.2 The microcontroller

A microcontroller is a compact integrated circuit designed to govern a specific operation in embedded circuits. A typical microcontroller includes a processor, memory and input/output (I/O) peripherals on a single chip. A microcontroller is embedded inside a system to control the function of the system. It does this by interpreting data it receives from its I/O peripherals using its central processors. The temporal information that the microcontroller receives is stored in its memory, where the processor access it and uses the instructions stored in its program memory to decipher and apply the incoming data.

In this project, microcontroller is the brain of the whole system. It coordinates the activity of the system. It receives information from the input peripherals, processes it and gives command to the output peripherals. The microcontroller receives command from the RF detector unit and the ferromagnetic detector units, decodes the information received and gives command to the alarm and the indicator unit. The operation of the system basically depends on the microcontroller and the program that runs in the microcontroller. The choice of microcontroller was based on the ability of the controller to interface the required peripherals, easy to be programmed, availability in the market, ability to retain the programmed information while consuming the required amount of power.

There are a wide variety of microcontrollers in the markets which includes PIC microcontrollers, AVR microcontrollers, ARM microcontrollers etc. ATMEGA328P microcontroller of the AVR family was utilized in the project due to its ability to achieve the desired goals. Some of the features and characteristics of ATMEGA328P is as explained in the subsequent sections below.

3.3.2.1 ATMEGA328P Microcontroller

ATMEGA328P is a high performance microchip Pico power 8-bit AVR RISC-based microcontroller. It combines 32KB ISP flash memory with read-while-write capabilities, 1024B EEPROM, 2KB SRAM, 23 general purpose I/O lines, 32 general purpose working registers, three flexible timer/counters with compare modes, internal and external interrupts, serial programmable USART, a byte oriented 2-wire serial interface, SPI serial port, a 6-channel 10-bit A/D converter (8-channels in TQFP and QFN/MLF packages), programmable watchdog timer with internal oscillator, and five software selectable power saving modes. The device operates between 1.8-5.5 volts.

By executing powerful instructions in a single clock cycle, the device achieves throughputs approaching 1 MIPS per MHz, balancing power consumption and processing speed.

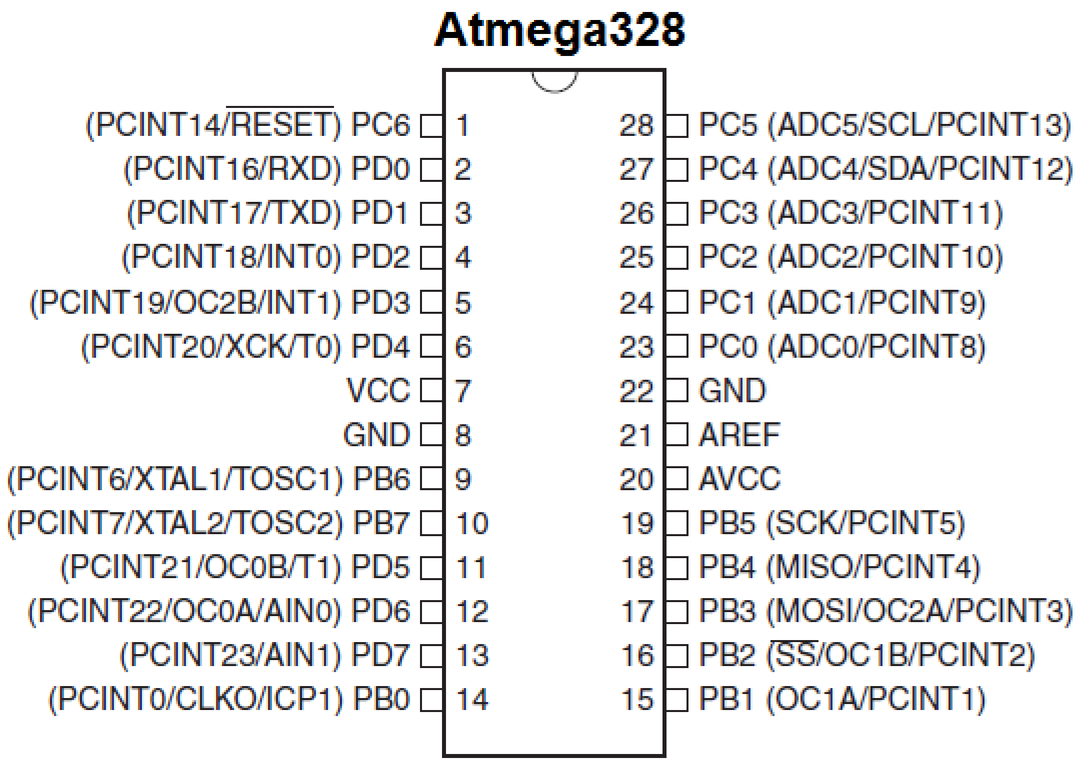


Figure 3 .4 Atmega328p Pin Configuration

The table below gives a description for each of the pins, along with their function.

Table 3.1: ATMEGA328P pin description

Pin Number	**Description**	**Function**
1	PC6	Reset
2	PD0	Digital Pin (RX)
3	PD1	Digital Pin (TX)
4	PD2	Digital Pin

5	PD3	Digital Pin (PWM)
6	PD4	Digital Pin
7	VCC	Positive Voltage (Power)
8	GND	Ground
9	XTAL 1	Crystal Oscillator
10	XTAL 2	Crystal Oscillator
11	PD5	Digital Pin (PWM)
12	PD6	Digital Pin (PWM)
13	PD7	Digital Pin
14	PB0	Digital Pin
15	PB1	Digital Pin (PWM)
16	PB2	Digital Pin (PWM)
17	PB3	Digital Pin (PWM)
18	PB4	Digital Pin
19	PB5	Digital Pin
20	AVCC	Positive voltage for ADC (power)
21	AREF	Reference Voltage
22	GND	Ground
23	PC0	Analog Input

24	PC1	Analog Input
25	PC2	Analog Input
26	PC3	Analog Input
27	PC4	Analog Input
28	PC5	Analog Input

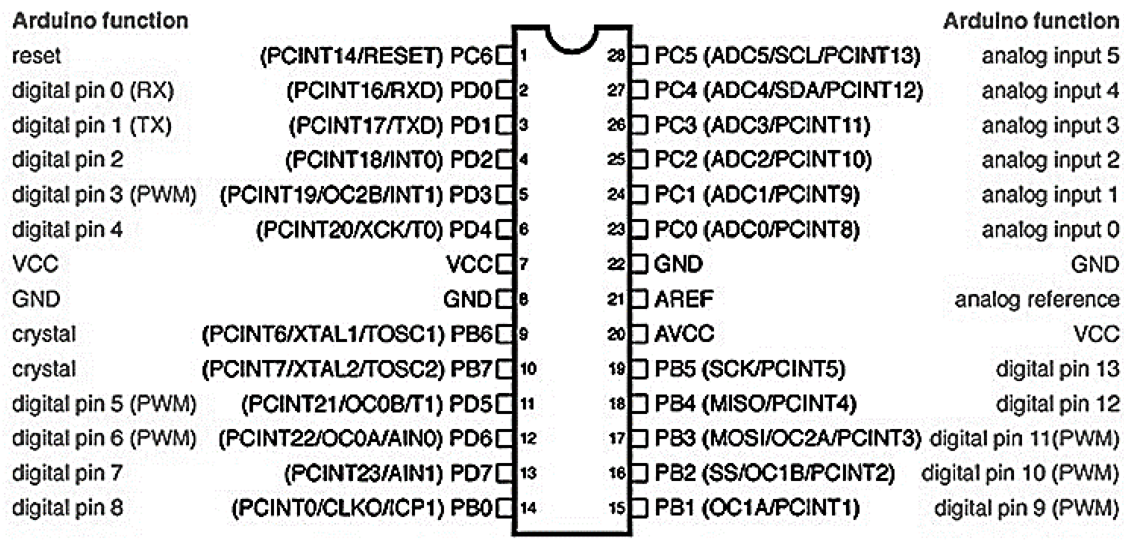


Figure 3. 5 Atmega328p pin summary.

The Atmega328 has 28 pins of which 20 of the pins function as I/O ports. This means they can function as an input to the circuit or as output. 14 of the pins are digital pins, of which 6 can function to give PWM output while the remaining 6 of the pins are for analog input/output. 2 of the pins are for the crystal oscillator which provides a clock pulse for the Atmega chip. A clock pulse is needed for synchronization so that communication can occur in synchrony between the Atmega chip and a device that it is connected to. Two of the pins, Vcc and GND, provides power to the chip so that it can operate. The Atmega328 is a low-power chip, so it only needs between 1.8-5.5V of power to operate.

The Atmega328 chip has an analog-to-digital converter (ADC) inside of it. This must be or else the Atmega328 wouldn't be capable of interpreting analog signals. Because there is an ADC, the chip can interpret analog input, which is why the chip has 6 pins for analog input. The ADC has 3 pins set aside for it to function- AVCC, AREF, and GND. AVCC is the power supply, positive voltage, that for the ADC. The ADC needs its own power supply in order to work. GND is the power supply ground. AREF is the reference voltage that the ADC uses to convert an analog signal to its corresponding digital value. Analog voltages higher than the reference voltage will be assigned to a digital value of 1, while analog voltages below the reference voltage will be assigned the digital value of 0. Since the ADC for the Atmega328 is a 10-bit ADC, meaning it produces a 10-bit digital value, it converts an analog signal to its digital value, with the AREF value being a reference for which digital values are high or low. Thus, a portrait of an analog signal is shown by this digital value; thus, it is its digital correspondent value. The last pin is the RESET pin. This allows a program to be rerun and start over.

The microcontroller was connected to the circuit by connecting it to a 5V dc power supply. The various peripherals were connected accordingly as stated in the subsequent sections.

Clock oscillator circuit. In general, oscillators are used to generate clock signals. Clocks in microcontroller helps it to work together, it also increases the speed of the microcontroller. Atmega328P have a built in 1MHz oscillator. Increasing the oscillator speed increases the speed of the microcontroller operation. External oscillator is normally connected to the XTAL pins (pin 9 and pin 10) of the microcontroller. External oscillator is connected to the microcontroller as shown in the diagram below. The oscillator used is 16MHz oscillator with 22pF capacitors as stated in the datasheet. The connection of the oscillator circuit to the microcontroller is as shown below.

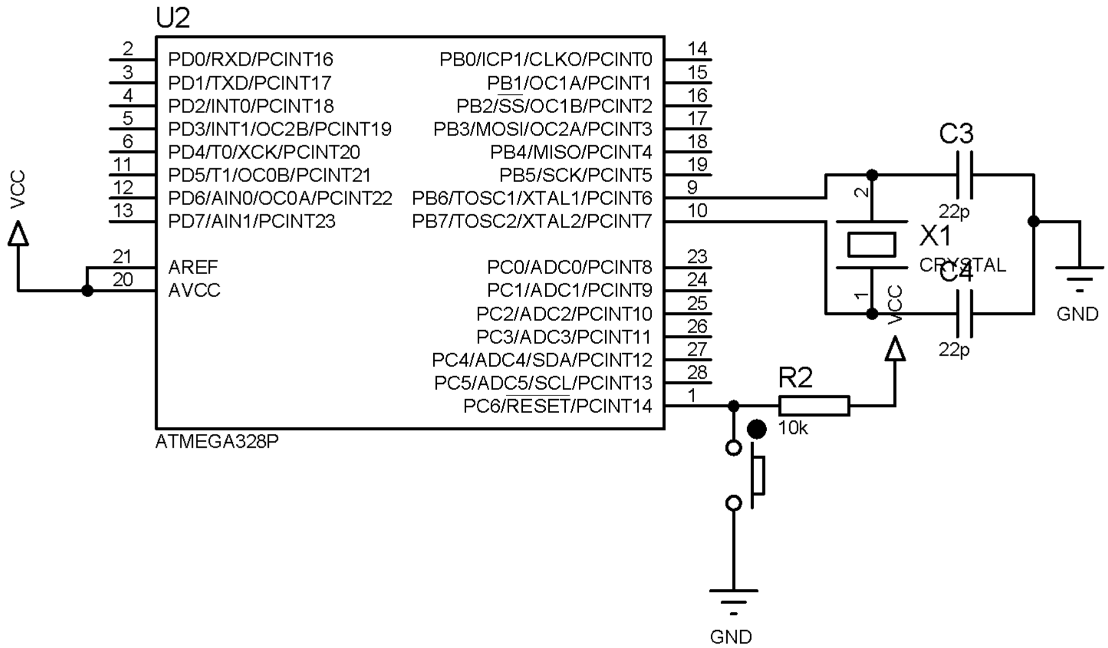


Figure 3. 6: Microcontroller Configuration

3.3.3 The RF Receiver

Mobile phone uses RF with a wavelength of about 30cm at frequency of 872 to 2170 MHz. When the mobile phone is active, it transmits the signal in the form of sine wave which passes through the space. The encoded audio/video signal contains electromagnetic radiation which is picked up by the receiver in the base station. The transmitter power of the modern 2G antenna in the base station is 20-100 watts. Peak power output of a mobile phone corresponds to 2 watts with an average of 250 milli watts of continuous power. The mobile phone transmits short signals at regular intervals to register its availability to the nearest base station. The network data base stores the information transmitted by the mobile phone. If the mobile phone moves from one cell to another, it will keep the connection with the base station having strongest transmission. Mobile phone always tries to make connection with the available base station. AM Radio uses frequencies between 180 kHz and 1.6 MHz, FM radio uses 88 to 180 MHz, TV uses 470 to 854 MHz Waves at higher frequencies but within the RF region is called Micro waves. Mobile phone uses high frequency RF wave in the micro wave region carrying huge amount of electromagnetic energy. The strongest radiation from the mobile phone is about 2 watts which can make connection with a base station located 2 to 3 km away.

3.3.4 The RF Detector Antenna

Antenna is an electrical device that converts radio frequency into alternating current. In this project a dipole antenna intercepts an electromagnetic signal emitted from the mobile phone and converts it into alternating current. The antenna is used to sense the RF-signals that is being transmitted or received through the mobile phones. Here the length of the antenna is 5-inches (around 13 cm).Capacitors (22pF) was connected in series with the antenna to filter out the alternating current from the direct current that may be present. A capacitor has two electrodes separated by a ‘dielectric’ like paper, mica etc. The non-polarized disc capacitor is used to pass AC and not DC. Capacitor can store energy and pass AC signals during discharge. Ceramic disc 22pF capacitor is selected because it is a low value one and has large surface area to accept energy from the mobile radiation.

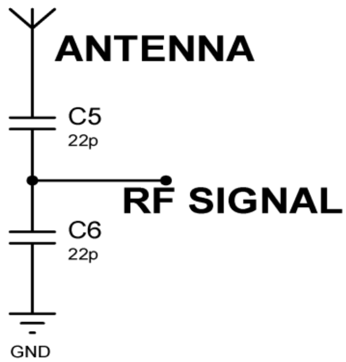


Figure 3. 7 RF Antenna Configuration

3.3.5 HOW THE CAPACITOR SENSES RF?

One lead of the capacitor gets DC from the positive rail and the other lead goes to the negative input of operational amplifier. So the capacitor gets energy for storage. This energy is applied to the inputs of comparator so that the inputs of the comparator are almost balanced with 1.4 volts. In this state output is zero. But at any time, the comparator can give a high output if a small current is induced to its inputs. When the mobile phone radiates high energy pulsations, capacitor oscillates and release energy in the inputs of the comparator. Capacitor carries energy and is in an electromagnetic field. So a slight change in field caused by the RF from phone will disturb the field and forces the capacitor to release energy.

3.3.6 CA3130 Operational Amplifier.

Operational Amplifier (Op-Amp)-A direct-current coupled high gain electronic-voltage-amplifier with a differential- input and usually a single-ended-output. The Op-amp used in the circuit functions as a current to voltage converter. The Op-amp output becomes high and low alternately according to the frequency of the signal detected from the mobile-phones.

The op amp part of the circuit acts as the RF signal detector while the transistor part interfaces it to the microcontroller. The op amp with the capacitor (0.22uF) connected between its inverting and non-inverting inputs reads the signals by converting the rise in current at the input to voltage at the output. The capacitorC3 22pF in conjunction with the lead inductance acts as a transmission line that intercepts the signals from the mobile phone. This capacitor creates a field, stores energy and transfers the stored energy in the form of minute current to the inputs of the operational amplifier. This will upset the balance inputs of comparator and converts the current into the corresponding output voltage.

Capacitor C4 100uF along with high value resistor R1 2.2M keeps the non-inverting input stable for easy swing of the output to high state. Resistor R2 100K provides the discharge path for capacitor C4. Feedback resistor R3 2.2M makes the inverting input high when the output becomes high. Capacitor C5 47pF is connected across strobe (pin8) and null (pin1) for phase compensation and gain control to optimize the frequency response.

When the cell phone detector signal is detected by C3, the output of the OP amp becomes high and low alternately according to the frequency of the signal as indicated by the LED. This triggers mono-stable timer of the microcontroller through capacitor C7. Capacitor C6 maintains the base bias of transistor T1 for fast switching action.

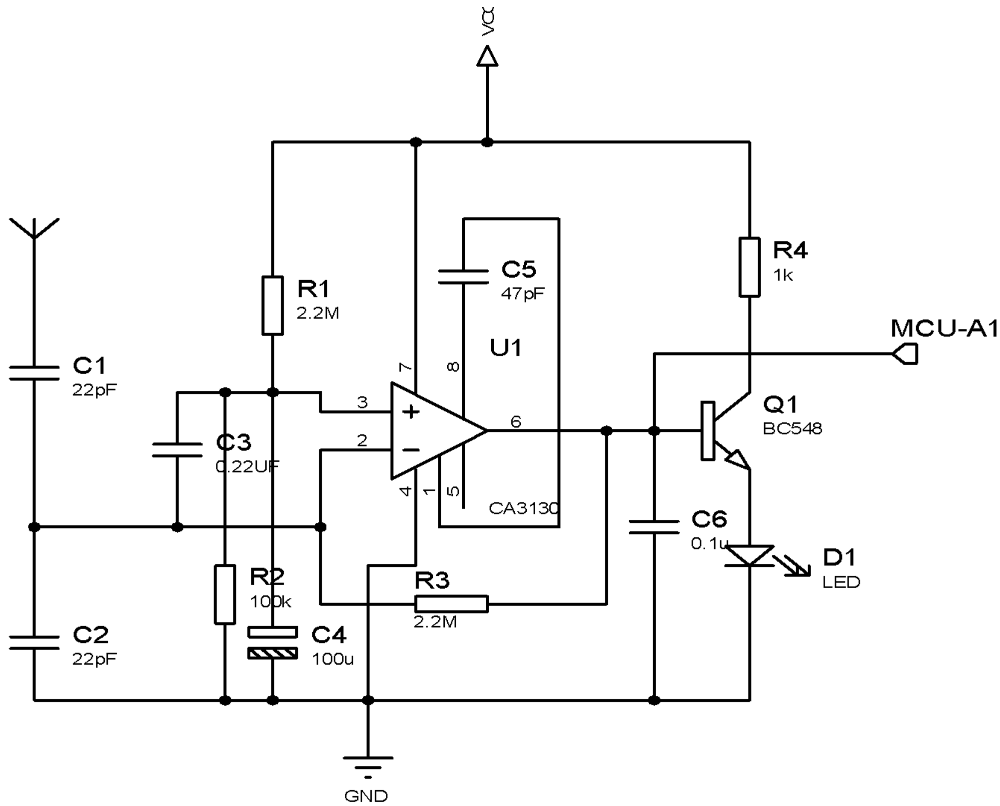


Figure 3. 8: CA3130 Configuration

Transistor T1 is used to amplify the signal obtained at pin 1 of the operational amplifier. The transistor interfaces the output of the RF section the digital pin of the microcontroller.

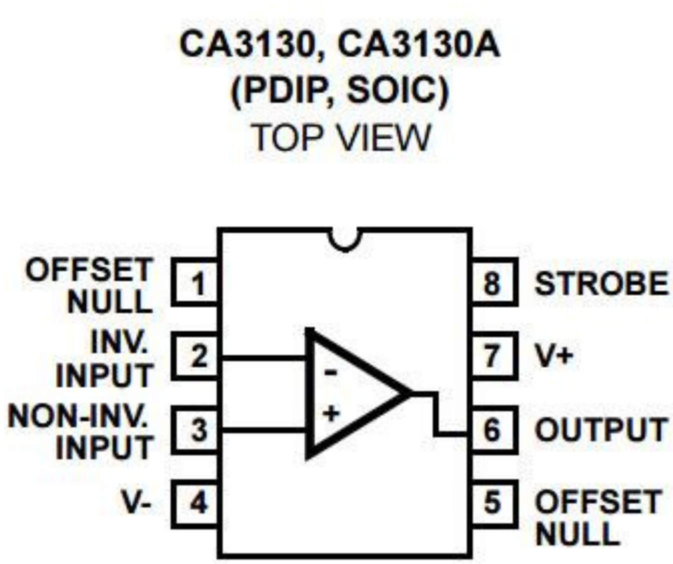
3.3.7 CA3130 OP AMP Feature

The **CA3130** is a **BiMOS Operational Amplifier with MOSFET.** The term BiMOS implies that it combines the advantage of both Bipolar and CMOS op-amp technology. Bipolar op-amps perform well under high bandwidths (fast switching) and CMOS op-amps perform well by consuming less current. So the CA3130 being a BiMOS op-amp has the advantage of high bandwidth operation and less current consumption.

T**he op-amp is built using MOSFETS** and hence it has high input impedance. Meaning, when a sensor's output voltage is connected to the inverting or non-inverting pin of the op-amp, the op-amp will not act as a load to the sensor and thus the output voltage from sensor will not be disturbed. So the Op-amp has a high bandwidth, fast sample rate, less power consumption and high input impedance which makes it the right choice for the operation.

Like all voltage Comparators the **CA3130** also has an Inverting Pin and a Non-Inverting Pin. If the voltage at the Non-Inverting Terminal (pin 3) is high than the Inverting Terminal (pin 2) the output (pin 7) will also be high else the output will be low.

The **CA3130** can work in a Single supply voltage or in a dual supply mode. In this design the single voltage supply was employed. In this type, the VCC+ (pin 8) is connected to +5V supply voltage and the VCC (pin 4) is grounded to hold it at 0V potential.



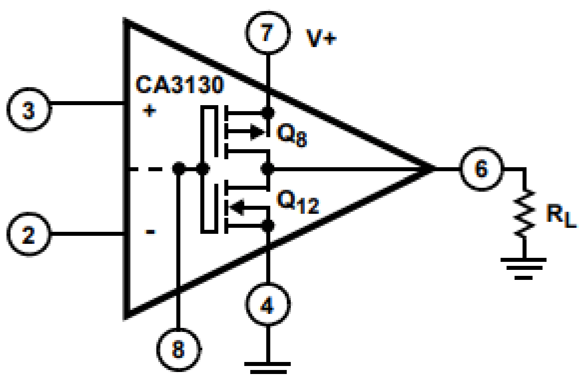


Figure 3 .9: CA3130 RF detector.

The OP amp is an 8pin integrated circuit. The description of the pins are as summarized in the table below.

Table 3.2: Pin Configuration

Pin Number	**Pin Name**	**Description**
1,5	Offset Null Pins	Optionally used to remove the offset voltage at the output pin to make it perfect 0V during off state.
2	Inverting Input (IN-)	The Inverting pin is also given a fixed voltage which is compared with the (IN+)
3	Non-Inverting Input (IN+)	The Non-Inverting Pin of the comparator is give a variable voltage to compare
4	Ground (VCC-)	This pin is connected to the ground of the system (Negative voltage can also be used)
6	Output	This is the output pin of the op-amp
7	VCC+	Provide the operating voltage for the Op-Amp. For CA3130 it is up to +16V.
8	Strobe	Allows you to turn off output stage

Figure 3.10: CA3130 Pin Configuration Summary

3.3.8 CA3130 Specifications

- Op-amp coupled with MOSFET at output
- Wide power supply Range

1. Singe supply – 5V to 16V
2. Dual supply – ±2.5V to ±8V

- Input Terminal current: 1mA
- Maximum Output Voltage: 13.3V
- Maximum source current: 22mA
- Maximum sink current: 20mA
- Supply current: 10mA
- Common Mode Rejection Ration (CMRR): 80dB

The output of the comparator was fed to the microcontroller through the bipolar junction transistor BC547 NPN transistor.

A BJT 547 is used in common emitter mode to amplify the signal. The output signal of the OP amp is of low value. In this project, the transistor acts an amplifier. It amplifies the output voltage of the comparator and then feeds it to the microcontroller.

Table 3.3: Pin Configuration

Pin Number	**Pin Name**	**Description**
1	Collector	Current flows in through collector
2	Base	Controls the biasing of transistor
3	Emitter	Current Drains out through emitter

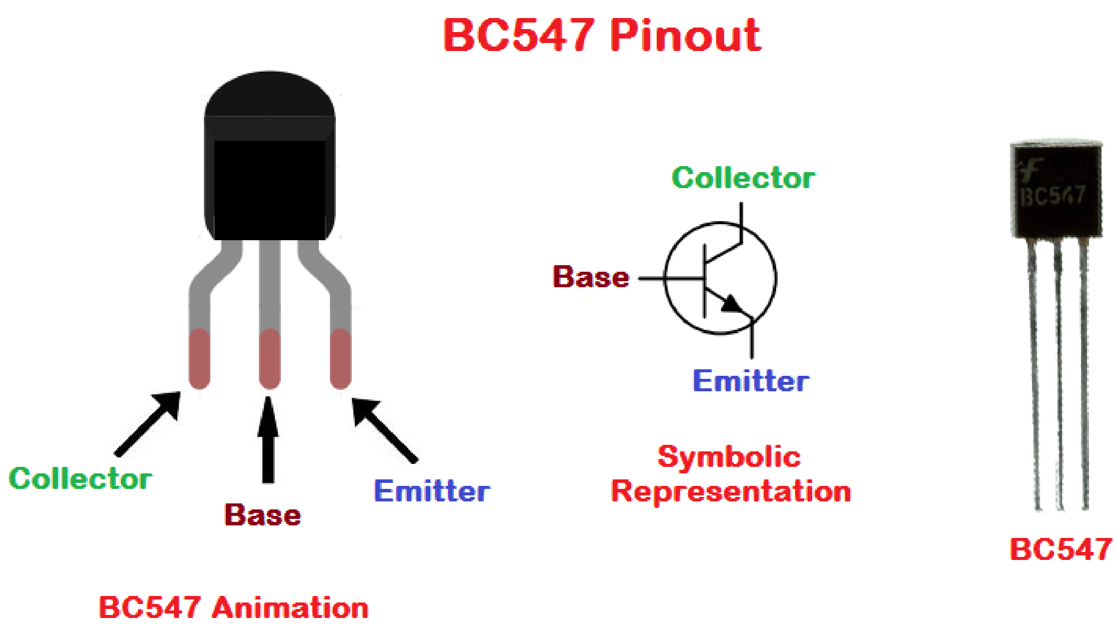


Figure 3 .10: BC547 NPN transistor.

BC547 Transistor Features

- Bi-Polar NPN Transistor
- DC Current Gain (h_{FE}) is 800 maximum
- Continuous Collector current (I_C) is 100mA
- Emitter Base Voltage (V_{BE}) is 6V
- Base Current(I_B) is 5mA maximum
- Available in To-92 Package

3.3.9 The Ferromagnetic Detector

A ferromagnetic material are those substances which exhibit strong magnetism in the same direction of the field when magnetic field is applied to it. In cell phones, one or more ferromagnetic materials are always present. The ferromagnetic material in a cell phones includes the speaker output, the ear piece and the microphone unit. This materials exhibit a strong magnetic properties in the presence of a magnet.

In order to detect the presence of a mobile phone when switched off even if the battery was removed, a ferromagnetic detector will be utilized. A ferromagnetic detector is a device that detects the presence of a magnet. In this project, the ferromagnetic detector employed is a reed switch. A reed switch is a mechanical device that allows electricity to pass through in the presence of a magnet by closing the circuit and do not conduct by opening the circuit in the absence of a magnet.

Reed Switch: is actuated by magnets, and commonly used in mechanical-systems as proximity-sensors.

The reed-switch is an electrical-switch operated by an applied magnetic-field. A magnetic-field (from an electromagnet or a permanent magnet) will cause the reeds to come together, thus completing an electrical circuit. The stiffness of the reeds causes them to separate, and open the circuit, when the magnetic field ceases. Good-electrical-contact is assured by plating a thin layer of non-ferrous precious-metal over the flat-contact-portions of the reeds. Since the contacts of the reed-switch are sealed away from the atmosphere, they are protected against atmospheric-corrosion. The hermetic-sealing of a reed-switch make them suitable for use in explosive-atmospheres where tiny sparks from conventional switches would constitute a hazard.

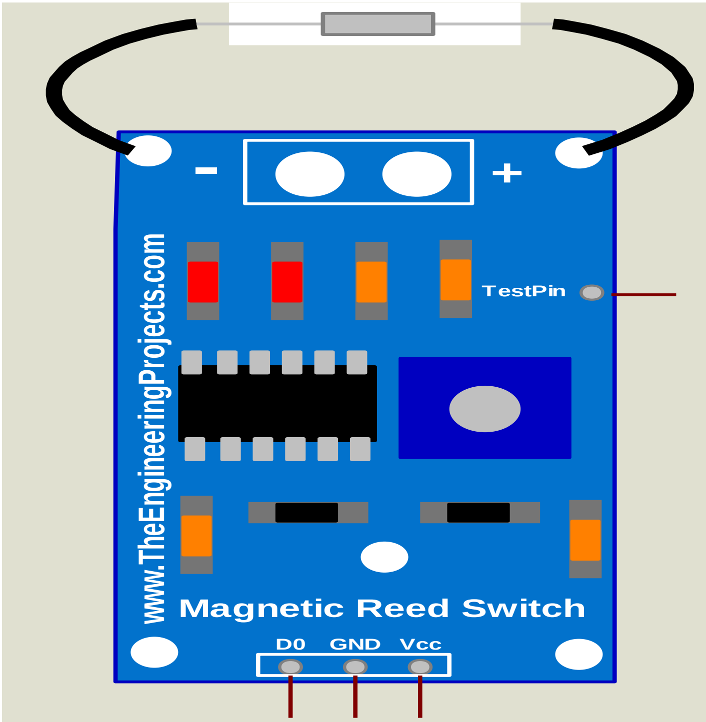


Figure 3 .11: Magnetic reed switch module.

3.3.10 Interfacing Reed Module to the Microcontroller

In this project, the reed module used is the KY-021 mini reed switch module. The device is a small electrical switch operated by an applied magnetic field commonly used as proximity sensor. The module has both digital and analogue outputs. The module consist of a 2X14mm normally open reed switch, a LM393 dual differential comparator, a trimmer potentiometer and other electronics devices. The modules operates on a dc voltage of 3.3V to 5.5V. In this project the digital output of the module was connected to digital pin 3 of the microcontroller. The power pins of the module which comprises the VCC and the GND were as well connected to the 5V dc power supply and the ground terminal respectively. The interface of the module to the microcontroller is as shown in the diagram below.

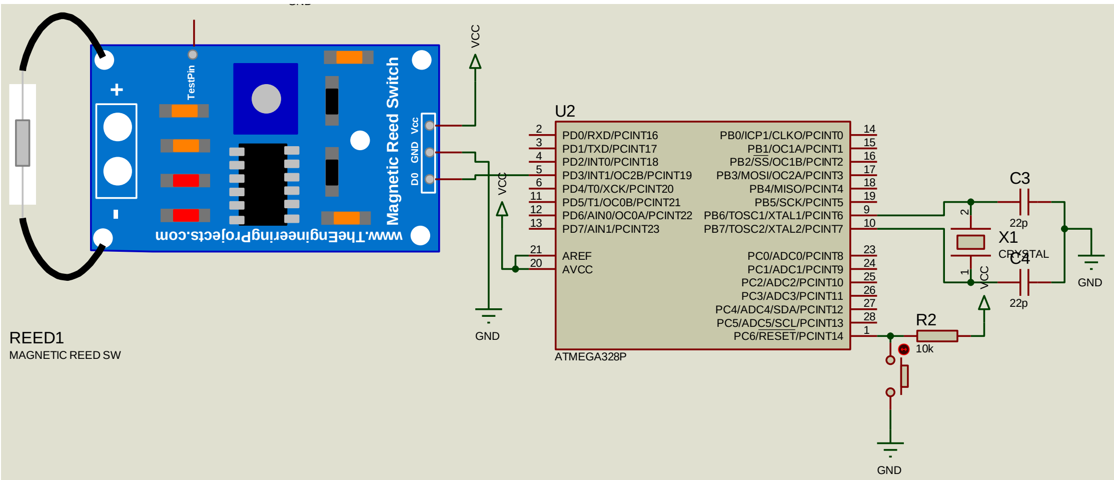


Figure 3 .12: Magnetic reed switch interface to microcontroller.

3.3.11 The LED Indicator

Indicator is a devices that notifies the user of the change of the status of something. It is used to shown warning or the occurrence of an action. An indicator tells the user of the status of the device at any period in time. In this project, the main objective of the indicators is to differentiate during an active communication and non-active communication. To alert the user of the presence of a phone or when a communication is detected. The type of indicator used in this project is LED indicators. Two LED indicators red and green differentiates between active communication and when no cell phone is detected.

Light-emitting diode (LED) is a two-lead semiconductor light source. LEDs are mostly used for power indication, pin status, optoelectronic sensors, and fun blinking displays. It has a typical forward voltage of 2.0V and a rated forward current of 30mA. The basic features of LED are high luminous intensity output, low power consumption, versatile mounting on PCB or panel. Some of the special features of LED indicator includes the following;

Absolute Maximum Ratings at Ta=25℃

Continuous Forward Current IF ------------------30 mA

Peak Forward Current (Duty /10 @ 1KHZ) IFP-------- 100 mA

Reverse Voltage VR ------------------5 V

Operating Temperature Topr -------------- -40 ~ +85 ℃

Storage Temperature Tstg --------------------- -40 ~ +100 ℃

Soldering Temperature (T=5 sec) Tsol-------------260 ± 5 ℃

Power Dissipation Pd-------------------100 mW

Figure 3 .13: LEDs

3.3.12 Interfacing of LEDs to the Microcontroller

Light Emitting Diode (LED) is a semiconductor device that illuminates when electrical charges passes through it. LED are of different colours which includes red, orange, green, blue, white etc. In this project, two LEDs were used to indicate the two possible statuses of the system which includes cell phone detected and when no cell phone is detected. When the system detects a mobile phone, the red LED lights up and remains on throughout the period of the cell phone communication. On the other hand, the green led remains on whenever there is no cell phone active communication or no cell phone is detected.

The two LEDs were connected directly to the pins of the microcontroller through a current limiting resistor of 220Ω as specified in the datasheet of the microcontroller. The red LED was connected to digital pin 5 while the green was connected to digital pin 6 of the microcontroller.

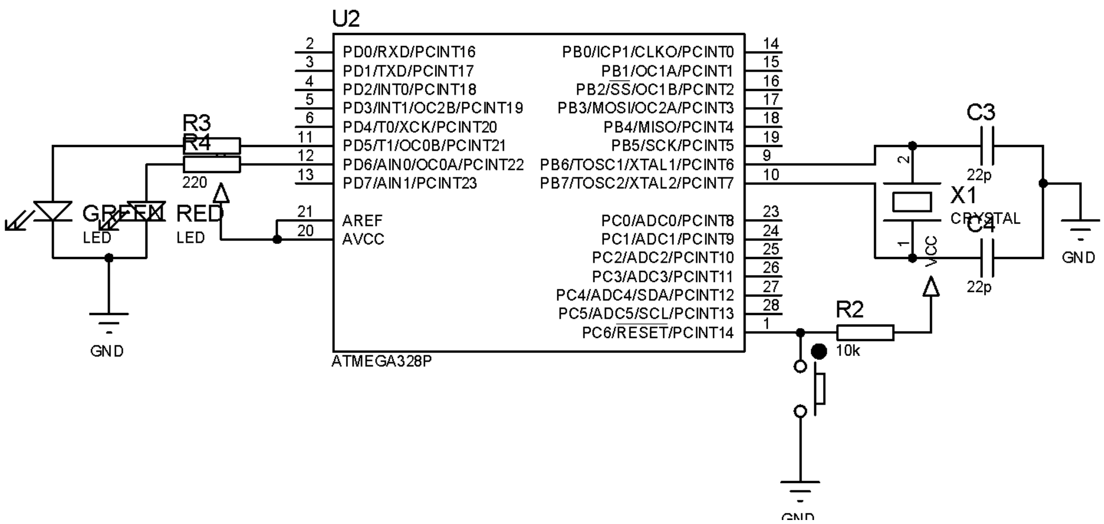


Figure 3. 14: LEDs Indicator interfaced with Microcontroller

The value of the resistor used can be calculated using the equation below.

$$R = \frac{Vs - Vf}{I} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(3.1)$$

Where

R is the current limiting resistor

V_s is supply voltage (Arduino outputs 5 V)

V_f is LED forward voltage drop

I is the current required by for the LED (5- 20 mA depending brightness required)

From LED datasheet,

$$R = \frac{(5-2)V}{15mA} = 200\Omega \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(3.2)$$

We can increase the resistant to one of the standard resistor value and still keep the current within the stipulated range: R= 220Ω

When connecting the LED, the cathode is connected to ground and the anode is combined in series with a resistor and connected to the I/O pin of the controller.

The LEDs are used together with 220Ω resistors in series. The interface of the leds to the microcontroller is as shown above.

3.3.13 Display Unit

LCD stands for **L**iquid **C**rystal **D**isplay. LCD components are "specialized" for being used with the microcontrollers, which means that they cannot be activated by standard IC circuits. They are used for writing different messages on a miniature LCD.

In this project, LCD display is an output module which is being controlled by ATMEGA328P[25, 26]. In this project, the LCD indicates the status of the system. Whenever the system detects a mobile phone or there is an active cell phone communication within its range, the LCD will display some messages to notify the user of the presence of a mobile phone. Also the LCD also displays a message to indicate the status of the system such as standby mode. The LCD is interfaced with the microcontroller and it receives command from the microcontroller.

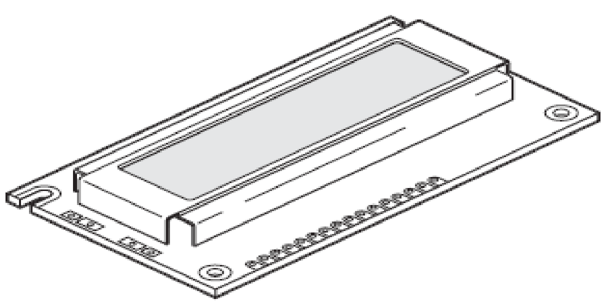


Figure 3. 15:16X2 LCD display hardware.

3.3.14 Features of 16X2 LCD Module

- Display format: 16 characters ´ 2 lines

- Construction: TN/STN LCD panel, Bezel, Zebra and PCB.
- Optional Edge/Array LED or EL back-light.
- Controller: SED1278 or Equivalent.
- 5V single power input with supply current of 2mA and back light current of 20mA.

Table 3.4: Summary of LCD configuration with the microcontroller.

No.	Symbol	Function	Connection
1	VSS	Ground (0V)	Ground
2	VDD	Supply voltage	5V
3	V0	Control adjustment	10K pot
4	RS	Data instruction select	8
5	E	Enable signal	9
6	R/W	Read/Write select	Ground
7	DB4	Data bus	10
8	DB5	Data bus	11
9	DB6	Data bus	12
10	DB7	Data bus	13
11	LED_K	Led power supply (0V)	Ground
12	LED_A	Led power supply (5V)	5V

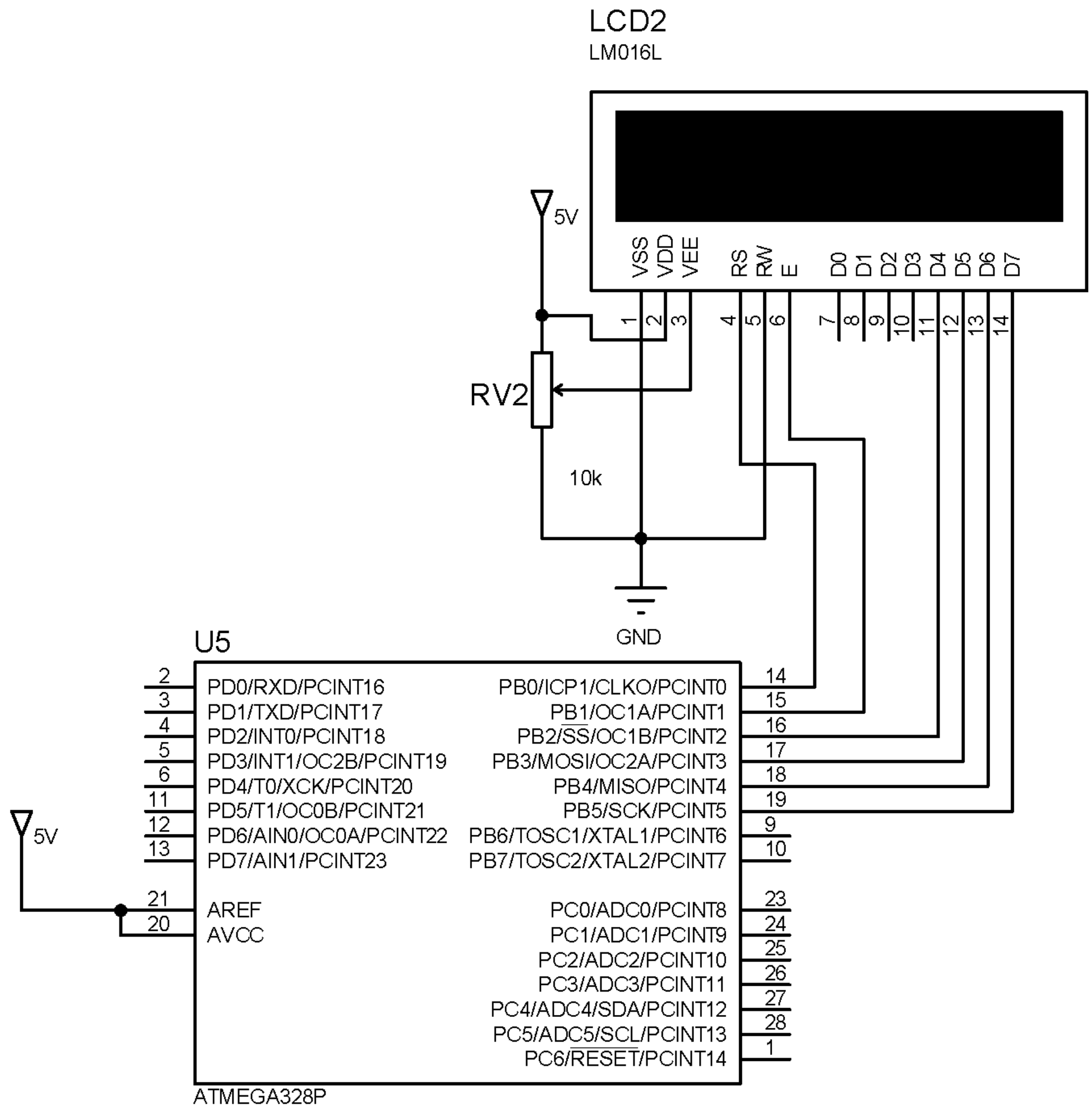


Figure 3 16: 16X2 LCD interface to the microcontroller.

A 10KΩ variable resistor was connected to the VEE terminal of the LCD to control its brightness as stated in the datasheet.

3.3.15 The Alarm Unit

The alert unit alerts the user whenever a cell phone is detected. The alert unit is made up of a buzzer and a buzzer driver. The buzzer driver interfaces the buzzer to the microcontroller.

Buzzer is a device that produces a sound electronically when an electrical current passes through it. In this project, a small 5volts. The buzzer is driven by an NPN transistor BC548 and controlled by the microcontroller. The buzzer is interfaced to the microcontroller digital pin 8 which corresponds to the pin number 14. The buzzer driver provides the required current to the buzzer.

The general purpose NPN transistor BC548B is used to drive the buzzer. The buzzer has a peak current consumption of 30mA with a supply voltage of 5vdc according to measurement. The resistance of the buzzer is calculated from the equation.

$V = IR$…………….(3.3)

Where V is the applied voltage, I is the current rating and R is the resistance.

Given V as 5V and I as 30mA, therefore, $R = \frac{V}{I} = \frac{5}{30\times10^{-3}} = 167\Omega$ ……………(3.4)

From the datasheet and measured value of the transistor, the current gain of the transistor is 365 i.e. the β of the transistor based on the BC548B datasheet was in between 200 to 450. In this case, the transistor operates as an electronic switch.

The value of resistor is computed as follows.

Similarly, $V_{CE(sat)}$ was given as 600mV for base current of I_B = 5.0 mA and collector current of I_C = 100 mA. Therefore $I_{C\ (sat)} = \frac{V_{cc}-V_{CE(sat)}}{R_L}$ …………………..(3.4)

$I_{C\ (sat)} = \frac{5-0.6}{167} = 26.4mA$ …………………..(3.3)

For a load of 167**Ω** the saturation collector current will be 26.4mA. For the transistor to operate in the saturation region, the equation must hold hence, $I_B > \frac{I_C}{\beta}$ …………….(3.5)

From the datasheet, the base voltage required to operate the transistor in the saturation mode is I_B = 5mA. Therefore $V_B = I_B R_B + V_{BE}$ …………………..(3.6)

$R_B = \frac{V_B - V_{BE}}{I_B} = \frac{5-0.7}{0.005} = 860\Omega$ ……………………….(3.7)

Therefore since the value of the resistor 860Ω is not usually available, 1KΩ resistor biases the transistor[27]. The buzzer driver and the buzzer connection were as shown in in the figure 3.13 below.

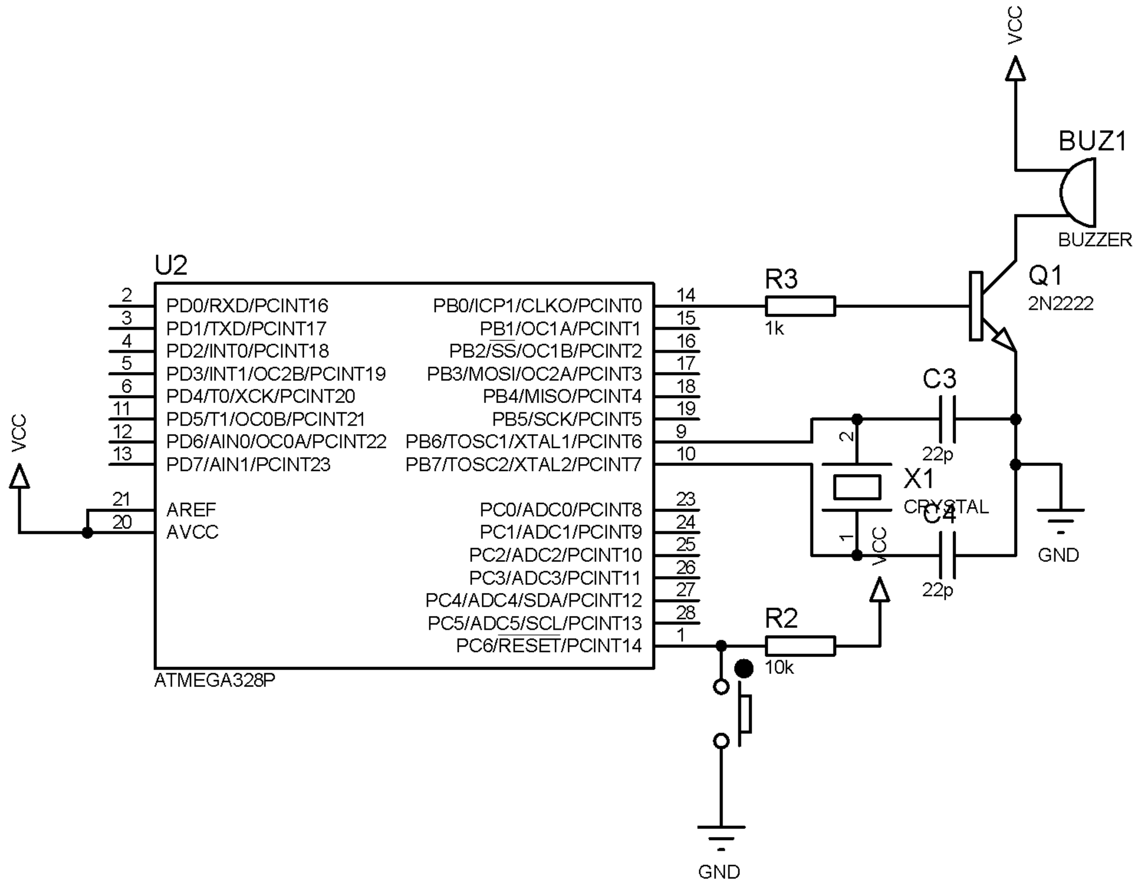


Figure 3.17: Buzzer interface to microcontroller.

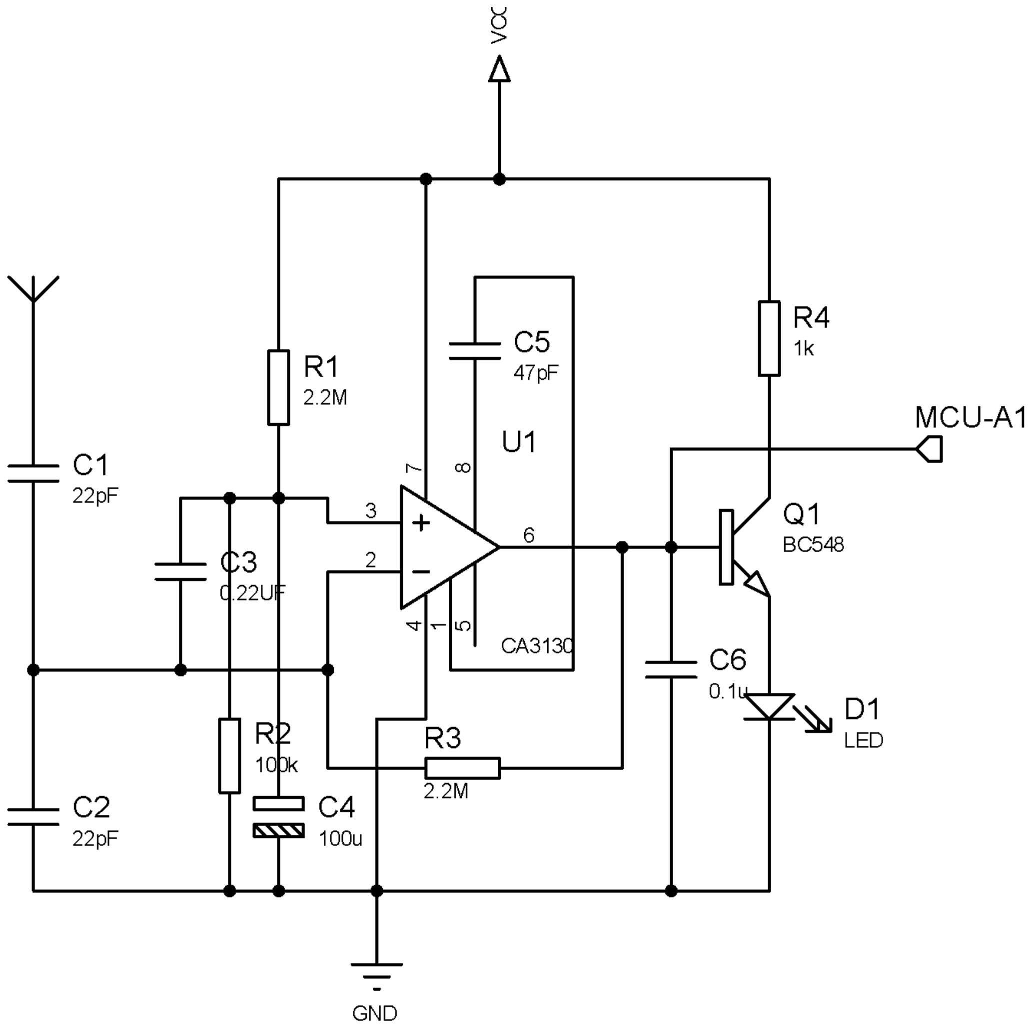


Figure 3 .18: RF detector circuit.

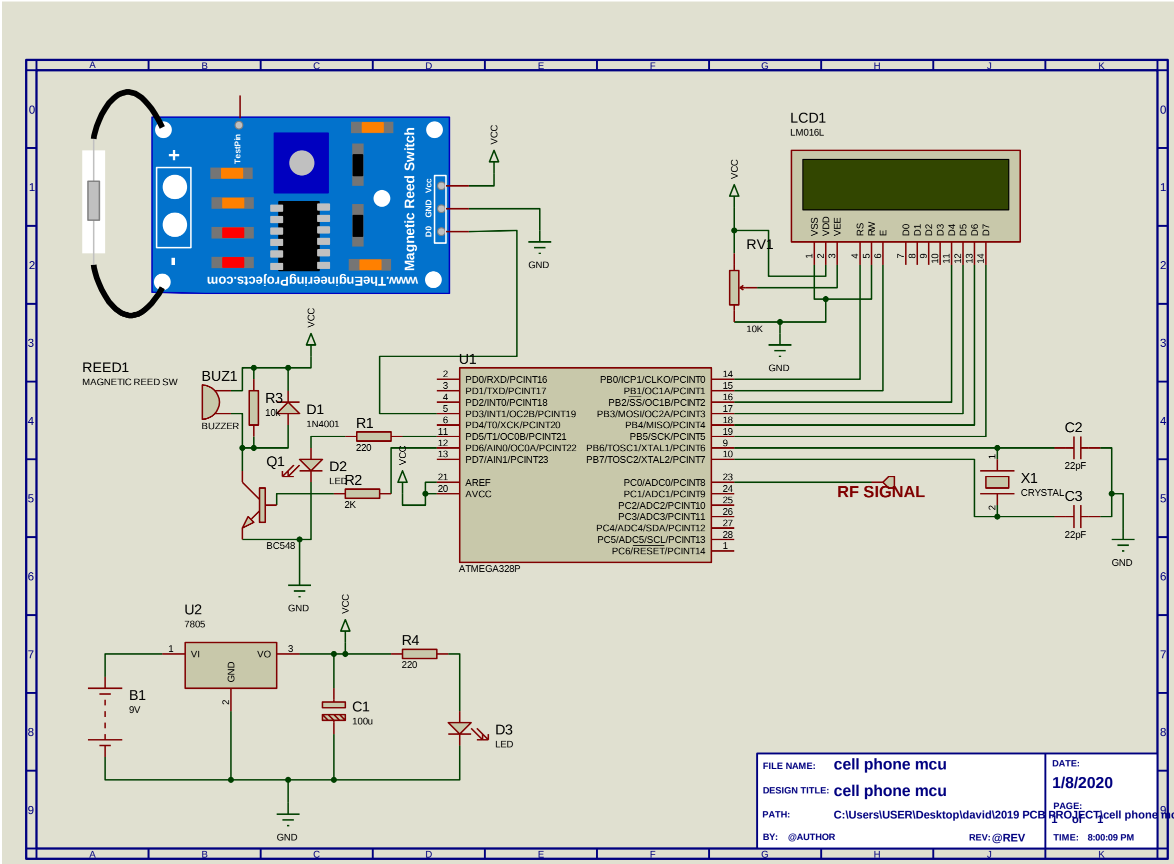


Figure 3 .19: systems circuit diagram.

3.4 Software Design

The software design is the process of envisioning and defining software solutions to one or more sets of problem. It transforms user requirements into some suitable form which he lps the designer in software coding and implementation. Software involves understanding the problem, developing strategies to solve the problem, implementing the developed strategies, coding the program and then test running the coded programs. The steps carried out to achieve the desired result includes designing and drawing the flow charts and then coding the programs using Arduino IDE.

3.4.1 The Flow Chart.

A flowchart is a type of diagram that represents a workflow or process. It's a diagrammatic representation of an algorithm, a step by step approach to solving a task. It shows steps as boxes of various kinds connecting one another with an arrow. Each step in the process is represented by a different symbol and contains a short description of the process step. The flowchart process are linked together with arrows showing the process flow direction. The systems flow chart was designed and drawn with a schematic editor.

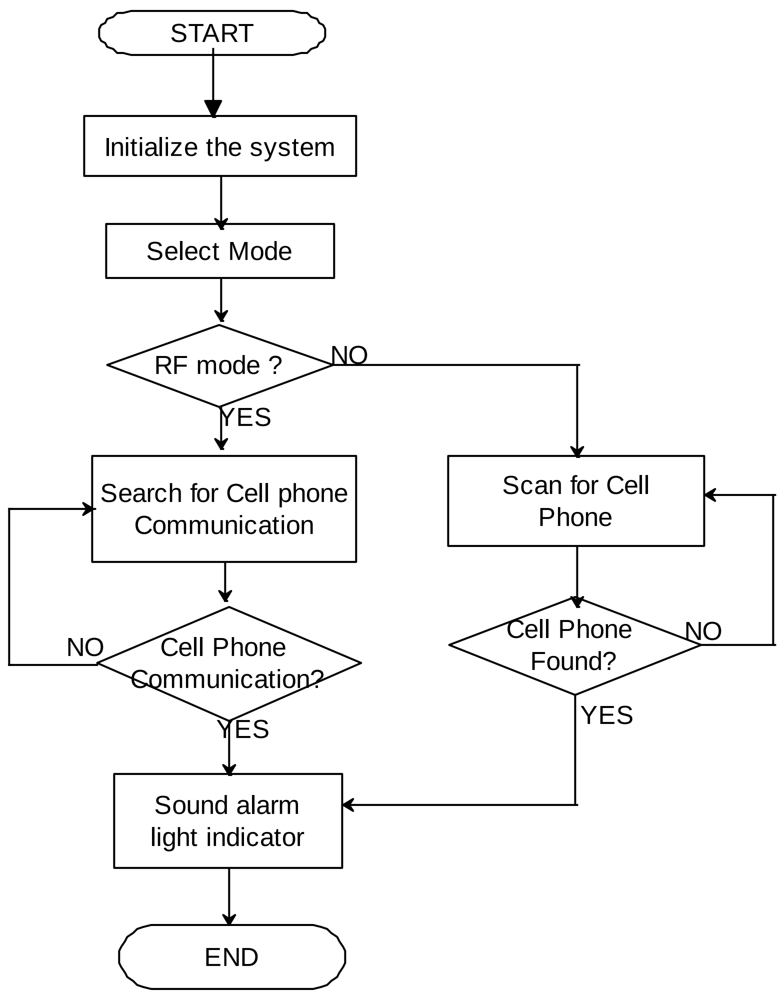


Figure 3. 20: systems flowchart.

The system starts and initializes all the interfaces connected to the microcontroller. The user then selects the mode in which the system is to operate either in scanning mode or RF searching mode. If the RF mode was selected, the system constantly searches for an active cellphone communication. If there is an active communication detected, the system sounds the alarm and lights on the indicators, if there is no active communication, the system keeps on searching until the system is powered off. If on the other hand, the scanning mode is selected, the system keeps on scanning for hidden cell phone. If any ferromagnetic material is detected, the system sounds the alarm and lights on the LEDs else, the system keeps on scanning until powered off.

3.4.2 The Arduino IDE

The Arduino integrated development environment (IDE) is a cross plat-form application that is written in the programming language JAVA. It is used to write and upload programs to Arduino compatible boards. The Arduino IDE supports the languages C and C++ using special rules of code structure. The Arduino IDE supplies a software library from the wiring project, which provides many common input and output procedures.

In this project, the coding of the program was carried in the Arduino IDE. After writing the program, it was then compiled using the IDE compiler and uploaded to the microcontroller via an Arduino Uno board. The interface of the IDE is as shown in the figure below.

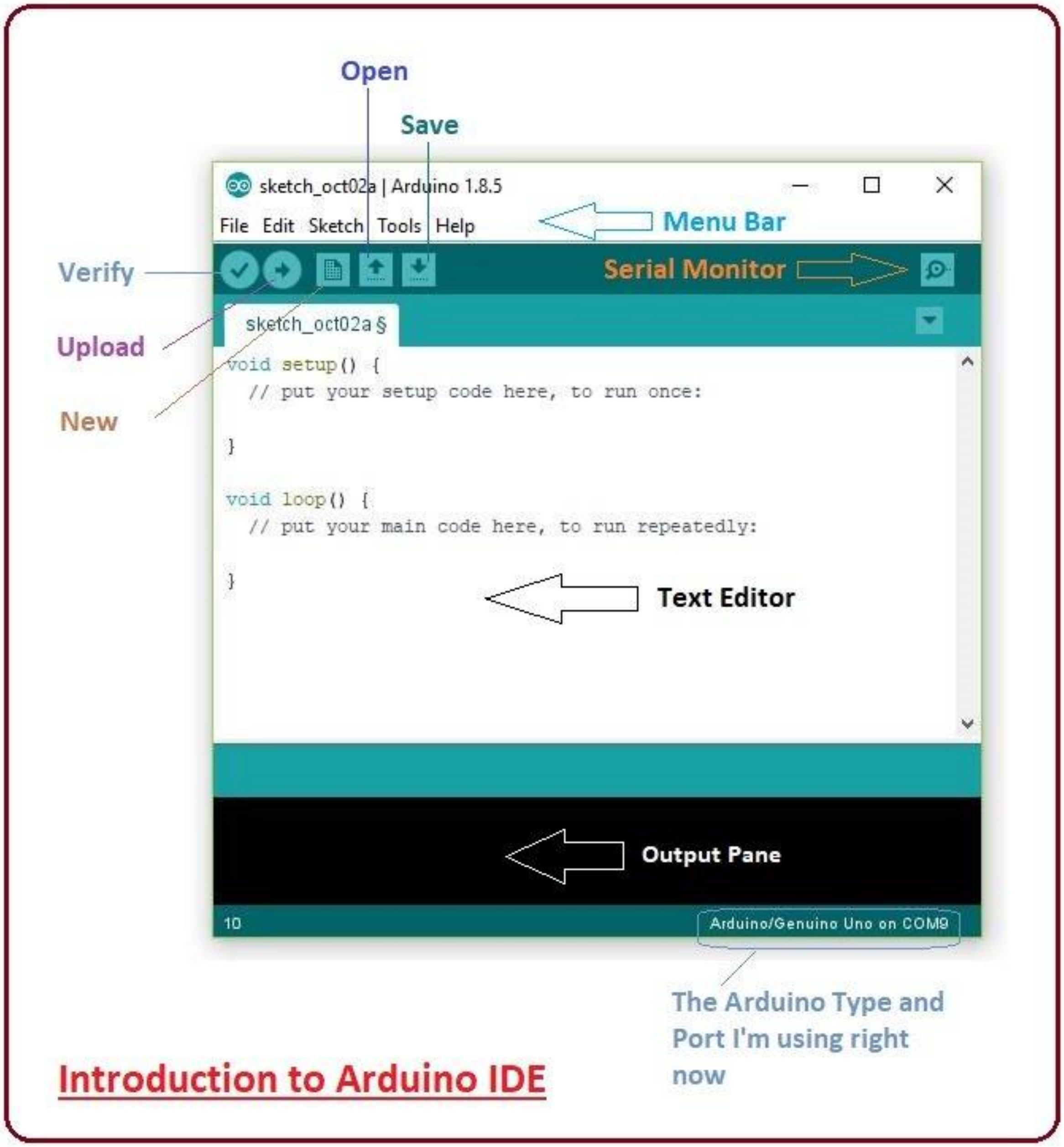


Figure 3. 21: Arduino IDE.

3.5 Construction Procedure

The construction procedures deals with the actual joining of the various sections of the system to become one. The construction procedure deals with the PCB designing, assembly of the components on the PCB, soldering of the assembled components and then designing the casing of the whole system.

3.5.1 PCB Designing and Printing

A printed circuit is an electronic circuit consisting of thin strips of materials such as copper, which have been etched from a layer fixed to a flat insulating sheet called a printed circuit board, and to which integrated circuits and other components are attached. A printed circuit board mechanically supports and electrically connects electronic components or electrical components using conductive tracks, pads and other features etched from one or more sheet layers of copper laminated onto and/or between sheet layers of a non-conductive substrate. Components are generally soldered onto the PCB to both electrically connect and mechanically fasten them to it.

The steps of PCB manufacturing process are as follows

- Designing the PCB
- Printing the PCB design
- Etching the unneeded part of the copper
- Inspection and layer alignment
- Laminating the PCB
- Soldering the components and lastly
- Testing the board

In this project, the printed circuit was designed using proteus8 circuit editor. The designed circuit was then printed on a glossy paper. Using heat transfer method, the design was transferred to the board. A mixture of diluted hydrochloric acid and hydrogen peroxide in the ratio of 2:1 was used to etch the board. Etching is the process of removing the unwanted parts of the board. After etching of the board, a cleaning agent was used to clean the inks on the circuit board. The pictures below shows the designed circuit and the printed circuit board.

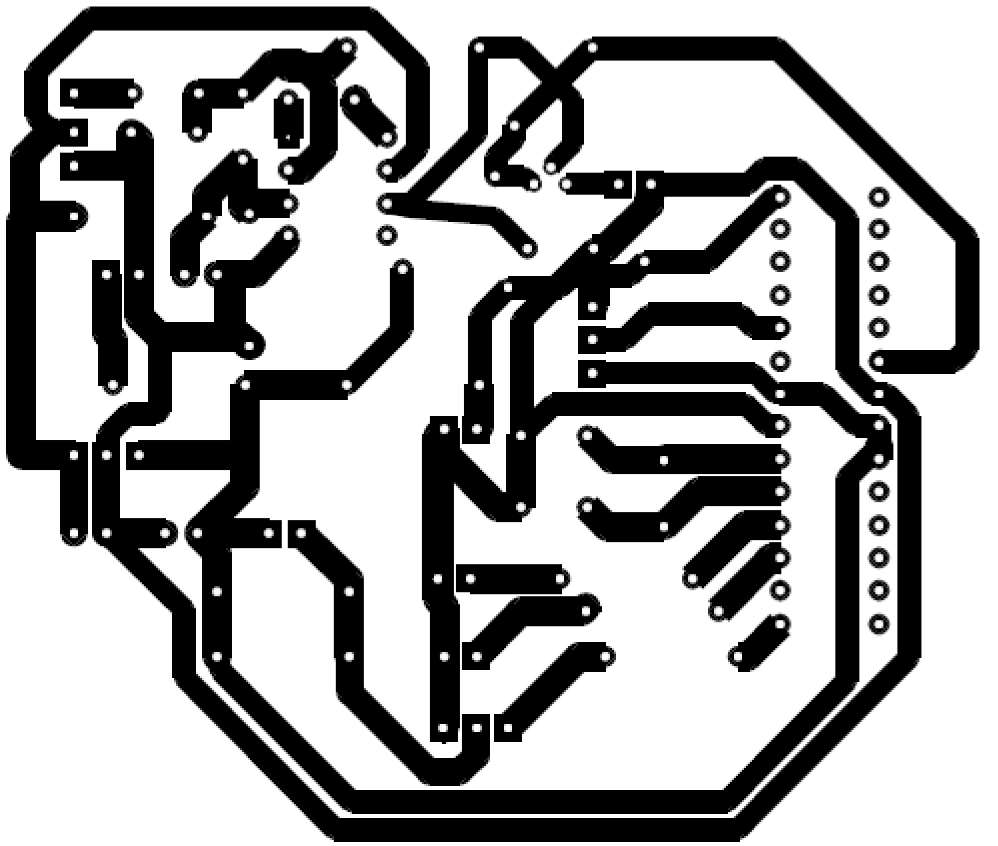


Figure 3. 22: Printed Circuit Board

3.5.2 Component Soldering and Assembly

After the design and printing of the PCB, the components were assembled on the board. The schematic of the circuit was used as a guide to assemble the components. The circuit board was taken to the work station and the components were soldered to the printed circuit board. The soldering was done in such a manner as to avoid partial contact of the terminals. After the soldering was completed, the board was tested of any possible short circuit by testing the continuity between two or more closed terminals or links.

CHAPTER FOUR: PERFORMANCE AND COST EVALUATION

4.0 Performance Evaluation

This chapter describes the evaluations carried out on the system from simulation to the final construction and testing of the system. It details the results during simulation and real life applications obtained and also the cost evaluation for each unit component of the system.

4.1 Performance Evaluation

The system cell phone detection system is a mobile phone detection system that detects the presence of a mobile phone within the range of about three meters during an active communication and also a range of five inches during scanning for concealed phones. This system is a security device as it helps security personnel to curb the menaces of using mobile phones in restricted places such as exam halls, banks and as well meeting room. The system operates in two modes which includes the active communication and as well scanning method. During an active communication, the system detects the RF signal being emitted by the mobile phone and notifies the user of the presence of a mobile phone. Similarly, during scanning method, the user moves the system uniformly across the suspected body at a close range of about five inches from the body. The system constantly scans for a common object which can be found in all mobile phones. When found, the system alerts the user of the presence of a mobile phone either through a beep or through an indication on the LCD and the LEDs.

The system has been tested using several types of phones such as Itel phones, Nokia phones, LG phones, Samsung e.t.c. and was found to functions more properly in small phones compared to the modernized android phones.

4.2 Summary of Results

From the analysis being carried out after the construction of the system, RF technology is a versatile area of study that still needs a lot of research to be carried out on it. The system responds properly to some certain mobile phones while it do not respond at all to certain mobile phones owing to the type of technology being used by the manufacturer. The system is a good device that can be used to some extent to curb the challenges of exam malpractices by the use of mobile phones in our contemporary society.

The system when power on shows the powered LED and the signal LED will be off. The LCD displays the welcome message to the user. Whenever there is an active communication, the red LED starts to blink continuously depending on the distance of the mobile phone from the system or the strength of the transmitted signals. Also, the buzzer also sounds out an audible sound to alert the user of the presence of a mobile phone. The LCD on the other hand displays the status of the system at any point in time. On the other hand, during scanning method, the magnetic reed switch when it comes across the cell phone's speaker or microphones causes the system to send out signal to alert the user of a concealed mobile phone.

Figure 4.1: Picture of the System

4.3 Cost Evaluation

This section deals with the analyses of the expenses incurred to produce a unit cost of a cell phone detector though the cost may be reduced when producing a larger quantity of the of the system. Some of the expenses includes the cost of purchasing the materials, the cost of transportation, casing and as well the labour cost. The cost evaluation is as summarized in the table below.

Table 4.1: evaluation of price

S/N	ITEMS	DESCRIPTION	QUANTITY	RATE(₦)	AMOUNT(₦)
1	ATMEGA328P	MICRCONTROLLER	2	2000	4000
2	CA3130	OP AMP	1	500	500
3	LCD MODULE	LCD MODULE	1	1,500	1,500
4	BUZZER	BUZZER	1	1000	500
5	BATTERY	9V	1	200	200
6	BC 547	TRANSISTOR	1	50	50
7	L7805	VOLTAGE REGULATOR	2	200	400
8	PIN SOCKET	IC SOCKET	4	100	400
9	REED SWITCH	REED SWITCH	1	500	500
10	CAPACITORS.	CAPACITORS	7	50	350
11	LED	LED	5	40	200
12	16MHz CRYSTAL	OSCILLATOR	1	50	50
13	JUMPERS	CONNECTORS	-	-	150
14	RESISTORS	RESISTORS	10	30	300
15	PCB	BOARD	1	5000	5000
16	AERIAL	AERIAL	2	300	600
17	CASING	PACKAGING	-	4000	4000
18	GUM	GUM	10	200	2000
19	CABLES	POWER CORD	-	150	150

20	**MISCELENOUS**				**12,000**
			TOTAL		**30,000**

CHAPTER FIVE: CONCLUSIONS

5.0 Summary

This chapter deals with the conclusion and recommendation of a cell phone detection system in both on and off conditions. The cellphone detector is a hand held security device that can be used to monitor the use of mobile phones in restricted places. The system uses an LCD to display information to the user when it detects a mobile phone or the buzzer to alert the user of the presence of a mobile.

This write up comprises of five chapters from chapter one through chapter five. Chapter one discuss the introduction to the system, the aims and objectives and the statement of the problem. Chapter two deals with some of the related literatures in relation to the topic. It discusses some of the major works done in cell phone detection system and as well the review of the major components. Chapter three is the major stage in the work as it discusses the construction procedure of the system. It deals with the design and the construction procedures. Both the hardware and the software design procedures has been fully discussed. The chapter four deals with the performance and cost evaluation. The chapter illustrates the test analysis and also the cost of producing the unit cost of the project. Chapter five deals with the summary and conclusion of the project.

5.1 Conclusions

The aim of the project which is to design and construct a cell phone detection system in both on and off condition has been achieved. The system when switched on will continuously search for RF signal and notifies the user when detected. The system is a security system that can be implemented in schools to monitor exam malpractices or in restricted areas to control the use of cell phones.

5.2 Recommendation

Due to the construction of the system, the following recommendation can be

- The sensitivity of the system can be improved upon so that it can be able to detect cell phones at a faraway distance.
- Secondly the system should be improved upon so that it can be able to transmit signals that blocks cell phones communication or simply cell phone jammer.

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APPENDIX

PROGRAMING SOURCE CODE

```
#include <LiquidCrystal.h>


const int rs = 2, en = 13, d4 = 9, d5 = 10, d6 = 11, d7 = 12;
LiquidCrystal lcd(rs, en, d4, d5, d6, d7);


int ferroSensor = 3;
int buzzer = 8;
int yLed = 5;
int wLed = 6;


void setup()
{
  Serial.begin(9600);
  lcd.begin(16, 2);
  pinMode(ferroSensor, INPUT);
  pinMode(buzzer, OUTPUT);
  pinMode(yLed, OUTPUT);
  pinMode(wLed, OUTPUT);


  lcd.clear();
  lcd.setCursor(0, 0);
  lcd.print("Initializing.....");
  delay(2000);
  lcd.clear();
  lcd.setCursor(0, 0);
  lcd.print("   CELL PHONE    ");
```

```
  lcd.setCursor(0, 1);
  lcd.print("   DETECTOR      ");
  delay(3000);
}

void loop()
{
 int val = digitalRead(ferroSensor);
 delay(200);
 if (val == 0)
 {
  digitalWrite(yLed, HIGH);
  digitalWrite(wLed, LOW);
  beep(200,2);
  lcd.clear();
  lcd.setCursor(0, 0);
  lcd.print("   CELL PHONE    ");
  lcd.setCursor(0, 1);
  lcd.print("   DETECTED      ");
  delay(500);

 }

 else
 {
  digitalWrite(yLed, LOW);
  digitalWrite(wLed, HIGH);
  lcd.clear();
  lcd.setCursor(0, 0);
```

```
  lcd.print("   NO PHONE     ");
  lcd.setCursor(0, 1);
  lcd.print("  CHECKING....     ");
  delay(500);
 }

}

void beep(int duration, int times)
{
  for(int i = 0; i < times; i++)
  {
    digitalWrite(buzzer, HIGH);
    delay(duration);
    digitalWrite(buzzer, LOW);
    delay(duration);
  }
}
```