DESIGN AND CONSTRUCTION OF A SOUND-TRIGGERED ALARM

AJIBADE IBRAHIM KAYODE
2000/9788EE

DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

NOVEMBER 2007

DESIGN AND CONSTRUCTION OF A SOUND-TRIGGERED ALARM

AJIBADE IBRAHIM KAYODE
2000/9788EE

A THESIS SUBMITTED TO THE DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING, FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA.

NOVEMBER 2007.

DEDICATION

I dedicate this project to my father, Engineer Y.G. AJIBADE, who has been the pillar of my education and my life as a whole up to this point. May the almighty God reward him in abundance and let him rip the fruit of what he has sown in my life.

DECLARATION

I, Ajibade Ibrahim Kayode declare that this work was done by me and has never been presented else where for the award of a degree. I also hereby relinquish the copyright to the Federal University of Technology, Minna.

AJIBADE IBRAHIM KAYODE
(Name of student)

10/12/2007
(Signature and date)

Engr. Dr. Y. A. Adediran
(Name of supervisor)

9/12/07
(Signature and date)

....
(Name of H.O.D)

....
(Signature and date)

....
(Name of external examiner)

....
(Signature and date)

ACKNOWLEDGEMENT

I hereby acknowledge the contributions of my close pals, John and JB, who spurred and encouraged me at times when I needed it most. I also wish to thank Mr. Seun for his unflinching support and expertise.

I also acknowledge the guidance I received from our supervisor, Engineer Y.A. Adediran. It was a priceless privilege that I had.

ABSTRACT

The aim of the project was to produce a device capable of detecting intrusion in certain areas as a result of sounds made during such intrusions.

To achieve this, I used a microphone to detect such sounds as well as convert the sound to electrical signal. The resulting electrical signal was amplified and passed through an oscillator and mixer latch which combined to produce a desired alarm output.

The final product was able to detect intrusions depending on the intensity of sound made and the distance from the device.

TABLE OF CONTENTS

Chapter 3 Design and Implementation

Chapter 4 Construction and Testing

Chapter 5 Conclusion

List of Figures

List of Tables

CHAPTER 1

INTRODUCTION

1.1 HISTORICAL BACKGROUND

It was said in the past that security alarm systems fall just behind life insurance and cemetery plots as one of the top three most difficult things to sell. Formerly, the public regarded alarm systems as intimidating, complex, and ineffective. They were perceived as necessary only for businesses and very rich people. Commercially, security alarm systems were considered a necessary evil needed by businesses to protect against major losses, and required by insurance companies before coverage would be granted [1].

Residentially, alarm systems were found n a tiny percentage of homes. This tiny percentage comprised the gentry of the society, the glitterati, those with considerably high income, those who have acquired a high level of education, etc.

However, this trend has changed mainly due to technological advancements and increase in the general standard of living of the citizenry. The introduction of new machines such as personal computers, VCRs, and DVD machines, and other electronics, which are affordable by considerable part of the citizenry, has made security, security alarm systems in particular, necessary for that percentage of the citizenry. This trend has led to the increased production of alarm systems, particularly BURGLAR ALARMS.

1.2 OBJECTIVES AND METHODOLOGY

Burglar alarms, as the name implies, are cautions of signals raised at the strike of burglars or intruders. Normally, the burglar alarms are for single point or reason only, that is, raising alarms against intruders, however, these alarms can also be used for other purposes such as fire outbreak detection, safety purposes in factories, etc. Thus the use of these alarms extends from homes to businesses, hospitals, factories, etc.

Basically, these alarms contain a sensor which could be seen as the input unit, which is connected to a control, or processing unit via low voltage hard wires or RF signals, and the output unit, which comprises interactive voice response devices for raising alarms.

Relating the above paragraph to my project, a SOUND-TRIGGERED ALARM, my project consists of three main units.

The input unit consists of sensors in form of transducers, capable of electronically representing or defining the state or position of a system . Transducers basically convert different forms of energy to electrical energy. In this project, a transducer capable of converting sound energy to electrical energy is employed. This function is achieved through the use of a Microphone.

The detection of intrusion is achieved by the production of electrical energy with sound as the input.

The electrical energy or signal is linked to the control unit. Here the signal is amplified and passed through a logic circuit to create a specific response or output.

The output unit consists of alarms, light or audio, or a combination of the both of them. This project employs a combination of both.

Some security systems go as far as generating a feedback action against or to attack the intruders as a measure if defense.

I have used simple electronic components to achieve the above functions in my project. These include an integrated circuit, (IC), to amplify the weak output generated by the microphone, a group of complementary metallic oxide semiconductors, CMOS, for logic control and activation of the alarms, and the alarms are powered by Metallic Oxide Semiconductor Field Effect Transistors, MOSFETS, for increased flexibility.

1.3 SOURCES OF MATERIALS AND ASSISTANCE

The materials used in my project construction can be divided into two, equipment and components. The equipments were easily accessible since other students made use of the some equipment but I had to purchase all the components. a friend of mine, Mr. Seun helped purchase the components and he was of tremendous help during the design and construction stages. So also were my close friends Jubril Adamu and Ogaji John.

1.4 CONSTRAINTS ENCOUNTERED

There are some flaws however n my project. The major one being reliance on the

Power Holding Company of Nigeria, PHCN. The power supply, apart from being erratic in the construction phase, was far above 220V at times and at certain times much below 220V. This made the acquisition of a stabilizer necessary even though it was expensive.

The project however is "supposed" to excel in quiet environment where considerable amount of noise could imply intrusion. Such environments include banks, supermarkets, and other businesses when closed at night. However, I cannot guarantee reliability of my project in critical environment such as banks. This is because the components used are simple and not of the highest quality, hence the alarm cannot be triggered by relatively low sound input. This would not pose a problem for some thieves considering the level of skill, time of practice and dedication put into some robberies today.

CHAPTER 2

2.1 LITERATURE REVIEW

The use of burglar alarms has been in vogue from time immemorial. However the first modern alarm system was the result of modification of thousands of systems invented. Mr.Tidesley, an English inventor, was the first to come out with an acceptable model of burglar alarms. He linked some bells with the door lock and made the system to ring when someone touched or tried to open the door [1].

The next innovation came inform of addition of electricity and use of magnet. In 1850, a Boston inventor, Mr. Augustus Pope made contact points in the burglar alarm system by the use of electricity wires and magnets. At the use of doors, the contacts closed, forming an electric circuit which caused the bell to ring. Mr. Edwin Holmes, an aggressive entrepreneur, got the patent rights of Pope's invention and moved his business to New York in search of a bigger market for the home alarm systems.

With Pope's patent, Holmes sought to promote the concept of electrical security. With no equipment suppliers and the deep distrust of electricity held by the common citizenry, Holmes had his work cut out for him. Eventually he found Hinds and Williams, the only electrical supplier in the country, which eventually became Holmes' new commercial neighbor [2].

In New York, Holmes saw it fit to develop what was the first alarm system demo case, a mini-exhibit he lugged from door to door among New York's wealthiest citizens. News of the new contra0ption spread and Holmes, spurred by his moderate success, delved deeper into the business and developed latching bell circuits, zoning, fault identification , alarm memory, auto arming and disarming, and automatic illumination of violated areas. Holmes built an alarmed jewellery safe which via a direct wire hook up to the police department could silently report attempts at tampering. He staged well publicized events and offered prize money to anyone who could break into the safe without being detected. These promotions became media events and his success grew. By 1872, Holmes Electric Protective was well known and could no longer fill the orders that came from clients.

The use of electricity for street lights in 1880 changed the entire scenario with the common citizenry now accepting electrical models. The American Telephone and Telegraph Company bought the Holmes burglar business in 1905 with linking it to emergency call systems for inviting police and fire fighting personnel.

After World War II, many inventions were brought in home alarm systems. It became less expensive and more versatile. In the 1980s and by the middle 1990s, the system had become a standard feature. After that came wireless system. In the most advanced technology, the use of motion detectors, surveillance equipment and electronic tracking devices are used [2].

2.2 THEORETICAL BACKGROUND

My project is based on the use of sound energy to activate an alarm. This is just one of the many methods of triggering a security alarm. Other methods employ the use of infrared radiation, microwave, wires, laser etc.

Of all these methods, sound activation is just about the most economic. The device only receives sound energy and this does not involve any transmission. The sound energy goes through various stages to trigger the alarm. In these stages, we come across various other system components such as microphone, audio amplifier, latch, oscillators, etc.

Microphones serve as transducers that convert the sound into corresponding electrical energy. They are used in many applications such as telephones, tape recorders, hearing aids, motion picture production, live and recorded audio engineering, etc. In microphones; sound waves are translated into mechanical vibrations in a thin flexible diaphragm. These vibrations are then converted via various methods and processes into electrical signal which varies in voltage amplitude in an analogue of the original sound. The microphone is thus an acoustic wave to voltage modulation transducer [4]. Microphones are of various varieties such as the capacitor microphone, the electrets microphone, the dynamic microphone, etc.

Amplifiers are electrical devices that help to vary the strength of signals. The different types include the power amplifiers, BJT (bipolar junction transistor) amplifiers, and operational amplifiers to mention a few. However the audio amplifier serves to increase the strength of the signal to a certain level where it can trigger the required response from the system.

In circuits employing sequential logic, the output of a circuit depends on the previous inputs as well as the present ones, that is, sequential logic has memory. The simplest devices with this property which can be used to develop more complicated circuits are the flip-flops. The latch is a derivative of the flip-flop. The sequential logic is used to generate a sequence of states in response to a succession of inputs or clock pulses. These sequences can be used to store or read information, to count and possibly to act as a result of these [3]. The latch serves the purpose of storing signal in my project.

Oscillators are unstable amplifiers that convert dc energy to ac energy at very high frequency. They are capable of generating ac output signal without requiring any externally applied input signal [3]. They are of different types such as the RC oscillator, LC oscillators, quartz crystal oscillators, etc

2.3 OPERATION PRINCIPLE OF A TYPICAL SOUND-TRIGGRED ALARM

The alarm is triggered on whenever an unacceptable sound is detected. The alarm uses a transducer to convert related sound energy to electric signal. The leading signal is weak and thus requires an audio amplifier for reasonable, workable resulting signal. This signal interacts with a logic circuit which triggers on an alarm whenever a critical input level is detected. The alarm is held on through a latch or memory technique that retains the signal that triggered the alarm so that the alarm remains on even when the original disturbance fades. The alarm can be manually or automatically triggered off depending on the complexity and usage.

CHAPTER 3

DESIGN AND IMPLEMENTATION

3.1 BRIEF INTRODUCTION

The design consists of various sections and components. However, the design can be categorized into two units

a) The alarm unit

b) The power supply unit

3.2 THE ALARM UNIT

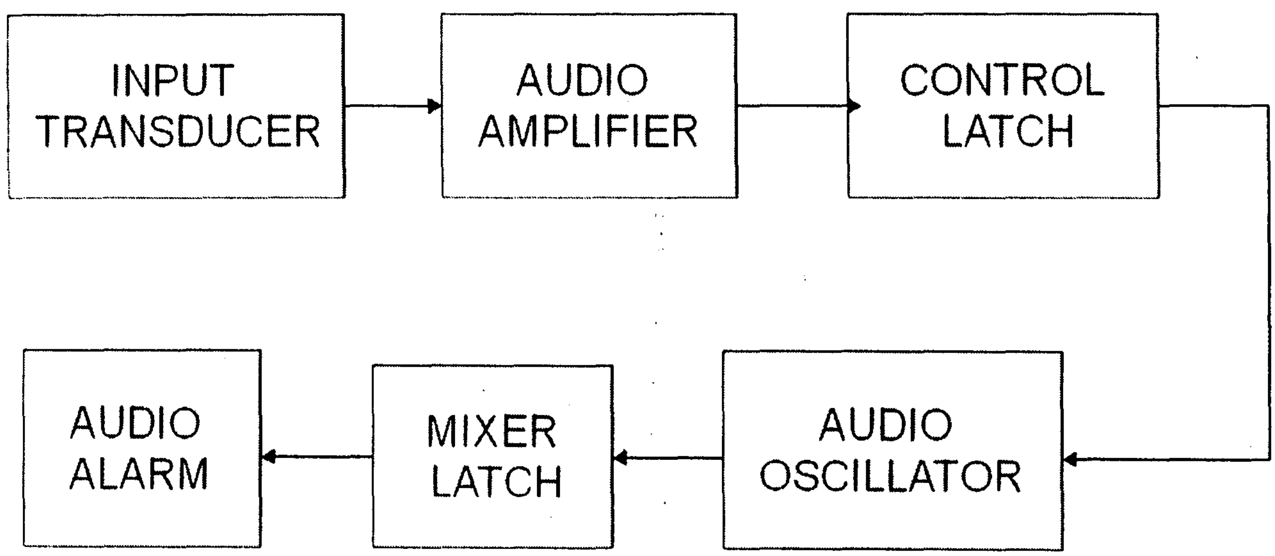

Fig 3.1 Block diagram of the alarm unit

The different block diagrams are explained below

3.21 INPUT TRANSDUCER

A transducer is a device that converts one form of energy to another. In this case, the transducer converts sound energy to electrical energy or signals. The device that suits this purpose is the microphone. There are different types of microphone with varying qualities. The qualities that determine the choice of microphone include sensitivity, frequency response, and impedance.

The sensitivity in this case is with respect to the direction of the source of sound. A microphone may produce larger voltage output for sound coming from certain directions than sounds coming from other directions.

The frequency response refers to the range of frequencies to which the microphone responds.

The basic audio range is between 20Hz and 16.5 KHz. The microphone should be sensitive to frequencies in this range.

Impedance is basically the opposition to the flow of current. For maximum power transfer, it is necessary that the impedance of the microphone is equal to or closely matched to the input impedance of the connected amplifier.

Putting the above qualities onto consideration, the choice of a 600 ohm, unidirectional moving coil microphone was made.

For a moving coil microphone, the dynamic principle is exactly the same as in a loudspeaker, only reversed. A small movable induction coil, positioned in the magnetic field of a permanent magnet, is attached to the diaphragm. When sound enters through the windscreen of the microphone, the sound wave moves the diaphragm. When the diaphragm vibrates, the coil moves in the magnetic field, producing a varying current in the coil through electromagnetic induction

[4].

An added advantage of the moving coil microphone is that it can be used at the end of a considerable length of cable without the need for amplifiers [7].

3.22 THE AMPLIFIER STAGE

The basic function of this stage is to amplify the input signal from the microphone and pass it to the latch section of the alarm circuit for further processing. The circuit arrangement is such that it can amplify the input signal up to 200 times its original value. The device performing this function is the LM386 CMOS operational amplifier.

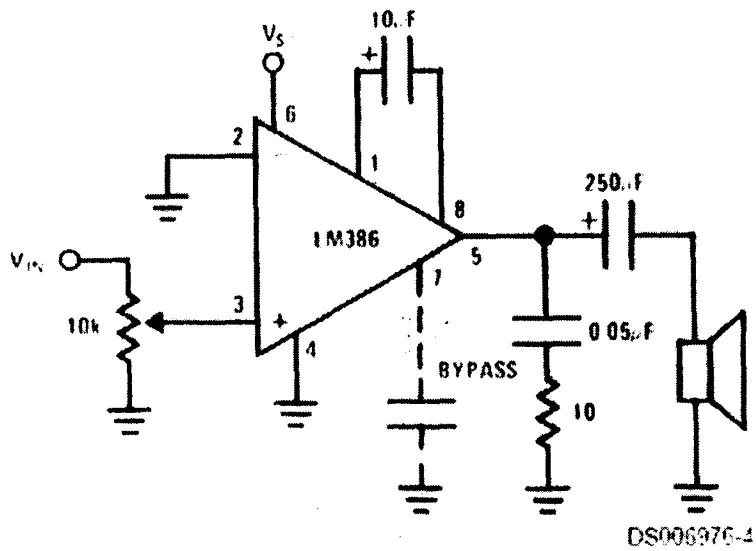

Fig 3.2 Circuit Design for an LM386 Low signal amplifier with gain = 200

The choice of the LM386 CMOS operational amplifier was influenced by certain qualities which

include its voltage gain which is up to 200, its wide supply voltage range, its low quiescent

current drain of 4mA, and its 8pin MSOP packaging which makes for easy interfacing.

3.23 SENSITIVITY CONTROL

The purpose of this section is to regulate the sensitivity of the microphone to sound inputs. This is because it might be desired to set the minimum amount of sound input the device responds to in order to forestall false alarm.

This purpose is achieved with the aid of variable resistors. The principle is that the sensitivity of the microphone is increased by reducing the value of the variable resistor and vice versa.

3.24 THE LATCH STAGE

The purpose of this stage is to preserve the input signal until the reset button is pressed. This ensures that the alarm keeps ringing until attention is drawn. The devices capable of this function employ sequential logic.

Sequential logic is used to generate a sequence of states in response to a succession of inputs or clock Pulses [3]. These sequences can be used to store or read information. The basic devices with this property are called flip flops. In digital circuits, a flip-flop is a kind of bistable multivibrator, an electronic circuit which has two stable states and thereby is capable of serving as one bit of memory [4]. The latch is a derivative of flip flops and it serves the purpose of storing or preserving the input signal in my project. The latch stage basically built around the CD4013B CMOS dual D-type flip-flop. The CD4013B dual D-type flip-flop is a monolithic CMOS integrated circuit constructed with N- and P-channel enhancement mode transistors [5].

3.25 THE OSCILLATOR STAGE

Oscillators are unstable amplifiers that convert direct current to alternating current at very high frequency. They are capable of generating ac output signal without requiring any externally applied input signal [3].

On receiving the output of the latch stage, the oscillator produces two outputs at different frequencies. The device used here is the CD4060B CMOS integrated circuit.

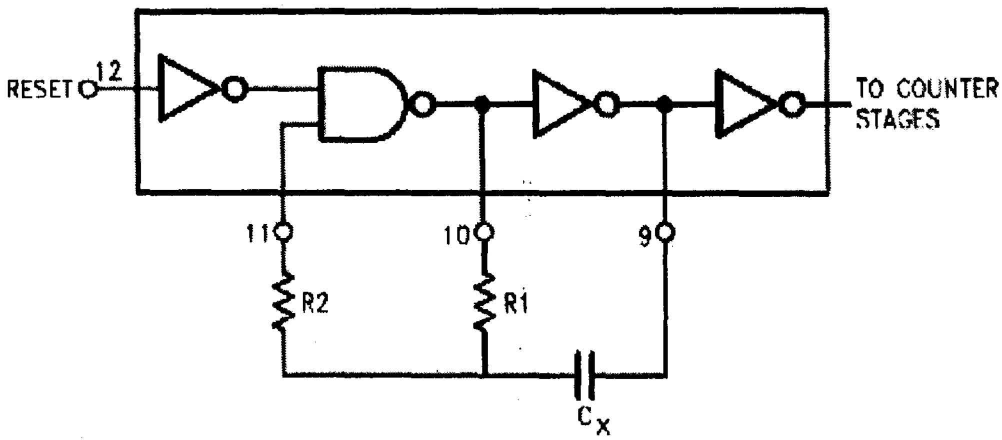

Fig 3.3 Oscillator connections for the CD4060B integrated circuit

The factors that influenced the choice of this device are its wide voltage supply range and its high noise immunity.

3.26 THE MIXER LATCH

The output from the oscillator is passed to this latch which produces an alarm signal which goes high and low repeatedly [8]. The CD4013B flip flop used again for this purpose.

3.27 THE AUDIO ALARM

This consists of the speaker and its transistor driver. The transistor serves a switching purpose. The speaker used has an 8ohm, 1watt rating while the transistor is a 2SD400 transistor. The output of the mixer latch, through the transistor causes the alarm to beep.

3.3 THE POWER SUPPLY UNIT

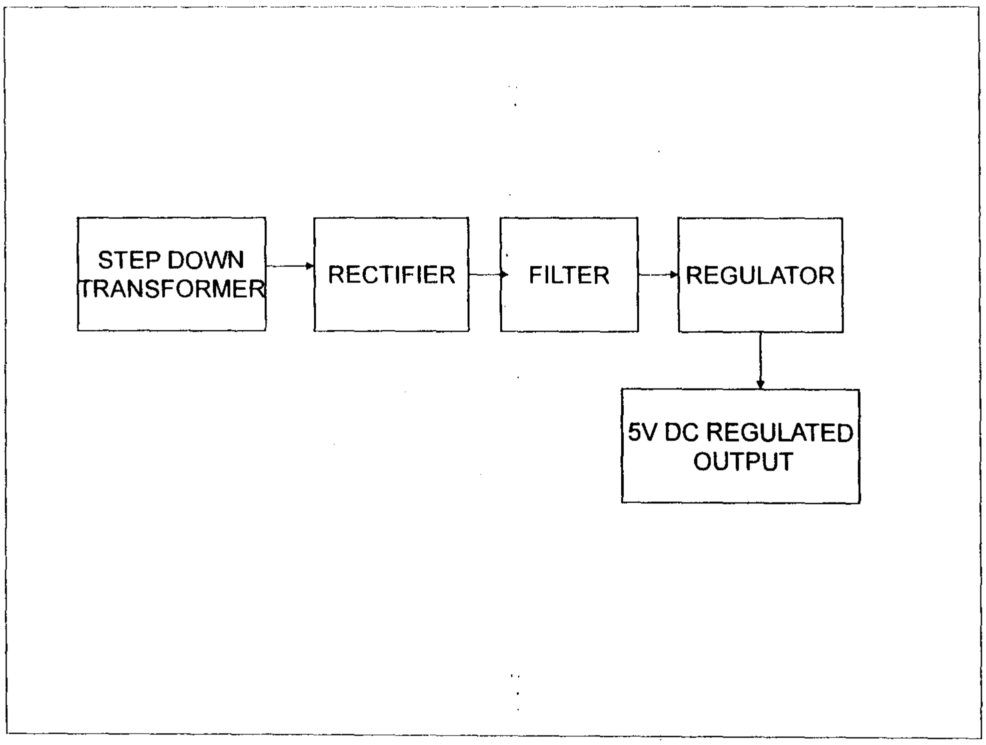

Fig 3.4 the block diagram of the power supply unit

This unit provides a regulated 5V supply to the alarm unit. The unit begins with a step-down transformer which steps the 220V supply from the mains to 12V. This 12V is passed to the rectifier which converts it to dc with some high frequency components. The rectified supply is then filtered to rid it of the high frequency components. The filtered component is then passed through a regulator that produces a constant 5V dc supply at its output. This is what powers the alarm circuit.

3.31 THE STEP-DOWN TRANSFORMER

A transformer is a device that transfers electrical energy from one circuit to another through inductively coupled wires [4]. A changing current in the first circuit (the primary) creates a changing magnetic field; in turn, this magnetic field induces a changing voltage in the second circuit (the secondary).

The secondary induced voltage V_S is scaled from the primary V_P by a factor ideally equal to the ratio of the number of turns of wire in their respective windings:

(Vs/Vp) = (Ns/Np)..........................3.31

The step-down transformer thus transforms the 220V coming from the mains to 12V which goes to the rectifier.

3.32 THE RECTIFIER

A rectifier is an electrical device that converts alternating current to direct current or at least to current with only positive value, a process known as rectification [4]. Rectifiers are used as components of power supplies and as detectors of radio signals. A suitable diode, the IN4001 , was used for the rectification purpose.

3.33 THE FILTER SECTION

Electronic filters are electronic circuits which perform signal processing functions, specifically intended to remove unwanted signal components or enhance wanted ones and because capacitors pass AC but block DC signals (when charged up to the applied dc voltage), they are often used to separate the AC and DC components of a signal. This method is known as AC de-coupling [4].

The filter used is an electrolytic capacitor with a value enough to suppress the ripple voltage of the supply to the barest minimum. An electrolytic capacitor is one whose dielectric is soaked with a liquid electrolyte [4].

To determine the value of the required capacitor, the following formula was used:

$C = 1 / (2 * f * Vr)$....................3.33

Where C = capacitance

Vr = ripple voltage

f = supply frequency which is 50Hz

The required capacitor should possess a ripple voltage tolerance of at least 20% [6]. Hence the choice of the 2200ųF capacitor with voltage rating of 25V.

3.34 THE REGULATOR

An electronic device designed to automatically maintain a constant voltage level. The regulator in the circuit provides a constant 5V since most components in the circuit can operate that at that voltage level. The 7805 regulator was used in the circuit for the voltage regulation.

CHAPTER 4

CONSTRUCTION AND TESTING

4.1 PROJECT CASING

The casing of a motorcycle headlamp was used to house the project construction. It is a black plastic with reasonable amount of space within to house the construction.

The fact that it is black did not play a major role in my choice of casing although the black color would make it stain resistant. However, the plastic nature provides reasonable insulation and its light weight is an added advantage.

I also found it easy creating holes on the plastic casing for the power cable, power LED, speaker, and switch and reset buttons. Necessary holes were also made to provide ventilation to the transformer in order to prevent overheating.

The plastic nature and light weight however make the casing vulnerable to excessive pressure which might result to cracking or breakage.

4.2 CONSTRUCTION

The following equipment and components were used in my construction

1. soldering iron and soldering lead
2. sucker
3. digital multimeter
4. plug and cord for connection to AC mains
5. diodes for rectifier
6. red LED for power indicator
7. unidirectional 600 ohm impedance microphone
8. variable resistors: (a) one 2Kohm, (b) one , 10Kohm
9. 220V/12V, 500mA transformer
10. switch for mains
11. 7805 regulator
12. matrix board
13. one loudspeaker 8ohm, 1watt
14. resistors: (a) two, 10Kohm, (2)1000µF,16V,(c)one 33Kohm,(d)one 100Kohm

15. capacitors: (a)100μF,16V,(b)1000μF,16V,(c)1μF,16V,(d)two, 47μF,

16. 116V,(e)2200μF,25V,(f)ceramic, 0.01μ,(g)ceramic, 0.022μF,(h)ceramic, 0.001μF

17. four,IN4001 diodes

18. integrated circuit chips:(a)LM386 low signal amplifier,(b)two,CD4023B dual type flip flop,(c) CD4060 ripple carry binary counter

The alarm circuit was first simulated on electronic workbench software to confirm its correctness and functionality before construction began on the Vero board. The components were positioned on the board by poking their leads through the holes from the opposite side of the copper tracks. All the components were placed on the board in their respective position before soldering in order to avoid soldering wrong linkages between components and also to ensure a neater work.

4.3 TESTING AND RESULTS

The effectiveness of the different units was tested at different stages of the construction. The power supply unit was tested using the digital multimeter. A power off test was carried out test for continuity and power on test to check the output voltage level at the transformer and regulator.

The output voltage of the amplifier stage was measured using the multimeter as well. The amplifier was thereafter connected to the speaker through a 47μF capacitor and tested for output sound from the microphone.

The latch and oscillator stages were tested by making sound of reasonably high intensity close to the microphone when the circuit was connected. The alarm responded to confirm that the latch and oscillator stages were working.

Table 4.1 Alarm sensitivity for different sound intensities

ACTIVITY	**MAXIMUM DISTANCE(cm)**
Clapping of hands	100
shout	1000
Stamping of foot	150

4.4 DISCUSSION OF RESULTS

From the results above, it is apparent that the project is ideal for quiet environments where intrusion is unwanted. It can detect sounds of reasonable intensity as low as clapping of hands within a 100cm radius. Although my project would not be reliable in critical environments were where low sound intensities are important, it can however be used at home for security purposes.

4.5 SHORTCOMINGS AND LIMITATIONS

There are some flaws however in my project. The major one being reliance on the power holding company of Nigeria for power supply. The power supply is was erratic during construction and testing. At times the voltage levels were way above 220V and at times way below 220V. This made the acquisition of a voltage regulator necessary despite its expense.

Another shortcoming is the overall quality of the project. The project is only of moderate quality and this is due to the mediocre quality of the components used. This can be linked directly or indirectly to finance.

CHAPTER 5

CONCLUSION

5.1 SUMMARY OF PROJECT WORK

After going through the design and construction stages, a device capable of alerting environs on intrusion based on the sound produced within prohibited areas was arrived at. This device has a defined range though but the aim of the project has been achieved and I would consider the project a success based on the results obtained from the tests conducted.

5.2 RECOMMENDATIONS FOR IMPROVEMENT

Considering the flaws of my project and the technology available today, it would be reasonable to include features that would enable the sensitivity of the device to be varied between wide ranges.

To improve the portability of the alarm sensor (microphone), it is recommended that the microphone be separated from the rest of the circuit by incorporating a radio based transmitter and receiver circuit connected to the microphone and the rest of the alarm circuit respectively. The microphone can be connected at the area that needs to be protected while the rest of the alarm circuit can be connected to a security room to alert security personnel. All external wires and cables used within the circuit should be concealed within the building.

It would also be ideal to add motion detectors to increase the overall versatility of the device.

REFERENCES

[1] http://digitalcontentproducer.com

[2] http://buzzle.com/articles/burglar-alarms-home-burglar-alarm-systems.html

[3] Warnes L., Electronics and Electrical Engineering: principles and practice, 2nd Edition Macmillan Press Ltd. London, pp. 136-157, 1998.

[4] http://wikipedia.org

[5] Horowitz P., The art of electronics, 2nd Ed., University Press, Cambridge-Great Britain, pp. 28-34, pp. 46-58, 1995.

[6] Talbot-Smith M., Audio explained, Reed Educational and professional publishing Ltd, pp. 1-68, 1997.

[7] Jones L., Basic Electronics for tomorrow's world, Low price Ed., University Press, Cambridge-Great Britain, pp. 55-87, pp. 102-122, 1996.

USER'S MANUAL

1. Plug the device to a voltage outlet via the power cable.

2. Insert the two microphones in their respective ports using the respective colors.

3. Push the power switch to switch on the device and the device is ready for use.

4. If the alarm comes up automatically when switched on, push the reset button and the device is ready to work.