

**DESIGN AND CONSTRUCTION OF  
A HALF-DUPLEX INTERCOM**

BY

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**DEPT. OF ELECTRICAL/COMPUTER ENGINEERING**

**F.U.T MINNA.**

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**A THESIS SUBMITTED TO THE DEPARTMENT OF  
ELECTRICAL AND COMPUTER ENGINEERING,  
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AND COMPUTER ENGINEERING.**

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## DEDICATION

This project is entirely dedicated to the Almighty God, from whom by his grace and mercy, I have enjoyed divine guidance, provision, protection and inspiration at all time.

## DECLARATION

I (*Okwena Timothy*) declare that this work was done by me and has never been presented elsewhere for the award of a degree. I also hereby relinquish the copy right to the Federal University of Technology Minna.

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(Signature and date)

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## ABSTRACT

The design and the construction of a full-duplex intercom is described in this project. The project is intended to provide an efficient and cheap means of communication in homes and offices.

The methods, procedure and realization of the device to achieve the above set of objectives are contained in this thesis. The modular design, description of components and their relevance in the design as well as test used to verify project's functionality are discussed in this thesis.

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# CHAPTER ONE

## INTRODUCTION

### 1.1 INTRODUCTION

The need for information exchange between people separated by considerable distance led to the need of developing a communication technology which was more pronounced. This has led to the production of several devices such as mobile telephone, intercoms etc.

The Intercom is based on the technology of telecommunication which is an aspect of communication which makes it possible to link areas that are miles away. Until the development of telephone, man ability to communicate was limited to-face-to-face conversation or signaling of various varieties such as the use of light, talking drums and written messages.

The intercom system is a type of wire telephone device for cheap communication over a short distance. The word 'Telephone' is derived from the Greek word 'tele' meaning far and 'phone' meaning sound. Therefore, telephone involves the conversion of sound signals into audio- frequency electrical signal which can then be transmitted to a receiving end. The telephone system has expanded man's capability to communicate over a long distance quickly and inexpensively. The intercom is a cut-down version of the Telephone which relatively cheaper to install and maintain [15].

The Intercom is an efficient and affordable means of transmission of speech to and from a short distance. It is therefore used for used for cheap and fast access to requisite information which is a key ingredient of modern civilization.

## **1.2 THE PLACE OF INTERCOM IN COMMUNICATION**

Communication is implicitly involves the transmission of information from one point to another through a succession of processes such as signal generation, encoding of signal, transmission of amplified signals, decoding, reproduction and recreation of the original signal.

Recent development in electronics, recognized in different levels of specification and complexity has made communication easy, quick and efficient. The intercom is one of this developments meant for audio interaction between two or more points. The intercom which simply means inter-office communication or inter-house communication, is used in homes for different purposes like answering door bells, transfer of communication and data between offices at different distance and the linking of several rooms together even without a telephone [5].

The intercom is a communication system that helps in the efficient transmission, processing and reception of information over a distance. It saves a lot of time and energy required in walking over a considerable distance over and over again to pass information within an organization.

## **1.3 THE INTERCOM [7]**

The intercom which is an important communication device requires simple design and implementation techniques; this makes the intercom a desirable device on the basis of cost effectiveness and efficiency. It uses similar principles of the telephone system; except the transmission and length of area covered differs.

The intercom uses basically two types of transmission namely:-

(i) Simplex

(ii) Duplex

(i) SIMPLEX: - A simplex transmission principle is one which allows signals to travel in one direction only. Devices using this principle can either send or receive data but not at the same time. A good example is the walkie-talkie since although both users can talk and listen, only one can talk at a time.

(ii) DUPLEX:-The duplex transmission principle allows transmission in both direction simultaneously. In other words, it allows the flow of signals between channels in both directions at the same time.

There are two types of intercom which includes

(i) The Wired intercom system

(ii) Wireless intercom

The wired intercom which more popularly used involves circuitry and transmission principles that are relatively cheap and easily achievable.

The wireless intercom does not require any form of wiring and cables because information is transmitted using a combination of transmitter – receiver principles over space at very high frequencies.

#### 1.4 METHODOLOGY

The project is a Wired Intercom that uses the Simplex transmission principle. The project design concept involves the use of two audio amplifiers, one for each communication direction. One microphone is connected to each amplifier input. The microphone acts like a transducer that converts sound to

electrical energy. The resulting weak electric current is strengthened by the corresponding audio amplifiers which are connected to a speaker. Also incorporated is an audio alarm feature used to request the attention of the receiving person on the other end of the station. The communication between the two communication boxes involved involves little complexity and requires little operating experience.

The project involves the following subsection:

- (i) Introduction
- (ii) Literature Review and Theoretical background
- (iii) Circuit Analysis
- (iv) Construction, Tests and Results
- (v) Conclusion and Recommendations.

## 1.5 OBJECTIVES

This project is carried out in order to develop a cheap, affordable and efficient means of communication for local industries or organization. An instance would be taking The Electrical Department in The University of Technology Minna as a case study, in situations where the H.O.D would love to communicate with his or her secretary and staff without the wastage of time and energy.

Research on previous projects led to the inclusion of two tone generators to catch the attention of individuals on both sides of the communication line as well as the use of recent, efficient and cheap IC's which are less susceptible to interference by noise.

# CHAPTER TWO

## LITERATURE REVIEW AND THEORETICAL BACKGROUND

### 2.0 LITERATURE REVIEW

An analogue message is a physical quantity that varies with time usually in smooth and continuous fashion e.g. voice signals, light intensity while a digital message is an ordered sequence of symbol selected from a finite set of discrete element at regular intervals apart.

Digital or Analogue communication can be described as a situation where the data received by a processing unit in either digital or analogue format is transmitted via a communication path in an analogue format. The telephony system whose history and operating principles are extensively discussed later in this chapter basically utilizes the principles of analogue communication. The DSP in digital communication helps in multi-bit digital sampling to generate a pulse of interpolated samples over analogue [5].

The 1960s brought about significant advance in data communication where character coding resulted in the development of 8-bit characters. This coding scheme defined 8-bit characters allowing up to 256 characters to be used. This coding standard known as ASCII (American Standard Code for Information Interchange), or as EBCDIC (Extended Binary Coded Decimal Interchange Code) were adopted in 1963. The early sixties also brought about voice digitization techniques known as Pulse code modulation which was first conceived in 1937 by Alex Reeves was deployed in the United States Public Switched Telephone in 1962 [7].

Data-phone Digital Service (DDS) was invented in 1974 around the time where was a development in Integrated Technology, thus bringing about digital transmission facilities to the consumer as well as the conversion to digital networking within the Bell System. The 1980s brought about rapid development of Dial modem technology used for FAX transmission and Local Area Network deployment. Thus an ability to access anything from anywhere as well as standardized connectivity was conceived.

The 1990s came along with enormous developments in digital communication, enhanced PBX network services have evolved such as Virtual Private Networks (VPN).The VPN have given customers better options for voice services, higher speed in digital access capabilities as well as an integration voice and data over networks[11].

Recent developments in our day and time have brought about an explosion into wireless communication which is a type of communication that got rid of wires and cables during communication.

A brief history of wireless communication is discussed below-

Wireless communication first evolved during 1831 when J. Maxwell demonstrated electromagnetic induction as it relates to the theory of electromagnetic field and wave equations. Development remained stagnated until 1895 when Guglielmo Marconi first demonstrated wireless telegraphy, long wave transmission and the reflection of short waves at the ionosphere [13]. This brought about commercial transatlantic connections with the fabrication of high antenna deployed in Wireless voice transmission in 1920. The eighties and

nineties brought an advent of analogue voice transmission; data transmission, voice encryption and authentication over a 100 – 500m range within 120 duplex channels of about 1880 to 1900MHz. The late nineties have brought about rapid evolution from analogue communication into digitalized wireless communication. the development of a mobile telecommunication system and better specifications for GSM technology in line with the invention of 66 satellites with a bandwidth of 1.6GHz [6]

## 2.1 THE HISTORY AND DEVELOPMENT OF COMMUNICATION SYSTEM.

The communication system evolved from early primitive sign language, pounding drum, smoke signal fire signal signals to an age of modern telegraph, telephone, wireless communication and the latest satellite communication. But the ease at which it is done varies with a particular medium.

Moreover every reasonable or modern communication system including home medium, originated from research and experiment carried out many decades ago. The most noticeable development in communication involves the “telephone”. It was invented by Alexander Graham Bell in the 1800s. Thomas Watson fashioned the device itself, a crude thing made of wooden stand, a tunnel a cup of acid and some copper wire. At the same time, Elisha Gray (Bell’s competitor) gave many ideas on the telephone development [11].

Telephone came from the Greek word Tele which means from afar and Phone meaning voice or sound. Generally a telephone is any device which

conveys sound over a distance. A string telephone a megaphone or a speaking tube might be considered telephonic instruments.

The standard dictionary defines the telephone as "an apparatus for reproducing sound, especially that of a voice at a great distance by means of electricity consisting of transmitting and receiving units connected by a line or wire which conveys the electric current.

Telephone history begins perhaps at the start of human history. Man has always to communicate from afar. People have used smoke signal, mirror, jungle drums carrier pigeons and sema-phone to get a message from one point to another. But the invention of the phone was something new and operated with ease. Some say Francis Bacon predicted the telephone in 1627; however his book *New Utopia* only described a long speaking tube. A real phone could not be invented until the electrical age began. The electrical principles needed to build a telephone were known in 1831 but it wasn't until 1854 that Bourseul suggested transmitting speech electrically. And it wasn't until 22 years later in 1876 that the idea becomes a reality. Telephone development didn't proceed in an organized line like with one inventor after another working to realize a common goal, rather it was a series of disconnected events mostly electrical some accidental that made the telephone possible [15].

The first record of electrical signals transmission involved the English Chemist Stephen Gray who transmitted electricity over a wire. He sent charges nearly 300 feet over brass wire and moistened thread. An electrostatic generator powered device. The then power supply was real problem for performing



experiment. But, power supply was developed later by Dutchman Pieter Van Musschenbroek and Germans Edward Von Kleist and Alessandro Volta. And a more advanced power supply or source was invented by Michael Faraday in 1821. Power supply (Electricity) is the back bone of the telephone system today. Therefore its development gave way to reasonable electric powered communicating devices [4].

In 1837 Samuel Morse invented the first workable telegraph. Joseph Henry helped Morse build a telegraph relay (repeater) that allowed long distance operation. The telegraph was a useful easily communicating medium through Morse code system or signal. Towards the end of 18<sup>th</sup> century the world still didn't have a working telephone. Inventors focused their efforts on telegraph improvement since these had a waiting market.

Moreover, as early stated the principle of the telephone was uncovered in 1874, but it was the unique combination of electricity and voice that led to Bell's actual invention of the telephone in 1876. Bell considered his invention's of greatest advantage over other form of electrical apparatus to be the fact that could be used by anyone, as " all other telegraphic machines produces signals which require experts to translate it and such instruments are therefore extremely limited in their application but the telephone speaks and for this reason it can be utilized for nearly every purpose for which speech is employed" [ from an address Bell made in 1878 as cited in YOUNG , 1991, page 6 ]

The first permanent out door telephone wire started in 1877. It covered a distance of three miles. Bell could be credited with the anticipated fiber optics

because he worked on a principle called a 'photo phone' which could actually transmit sound for a short distance over a beam of light. Commercial telephone service began in the United States in 1877 with a workable exchange developed in 1878; it enabled calls to be switched among any number of subscribers rather than requiring direct lines. Exchanges were handled manually, first by boys then by the famous women operators [2].

The dial phone was invented in the 1880s by Almond Brown Stronger who lived in Kansas City. Stroger invented the dial telephone and installed automatic exchanges in the US and Europe.

War-time experiments, innovations and inventions brought Bell to the forefront of telecommunication in the post-war era. The first commercial mobile telephone service was put in service in 1946, linking moving vehicles to telephone network by radio. The same year brought transmission via coaxial cables, resulting in a major improvement in services as they were less likely to be interrupted by other electrical interference. Microwave radio transmission was used for long distance telephony in 1947. The transistor, a key to modern electronics, was invented at Bell's laboratory in 1947. A team consisting of William Schockley, Walter Brattain and John Bardeen demonstrated the "transistor effect" using a germanium crystal that they had set-up in contact with the wires two-thousandth of an inch apart[2].

Telstra, the world's first international communication satellite was fired into orbit on July 10, 1962, with collaboration between NASA and the Bell System. Satellites in geosynchronous orbit are used mostly for long distance

service. Videophones, developed in the mid-1960s were becoming more affordable and practical with the combination of devices that eased the transmission and reception of both audio and video signals over telephone lines.

Fiber Optic cables developed in the early 1980s, offered the potentials to carry greater volumes of calls than satellite or microwave links. Electrical telephone signal are fed into tiny semiconductor lasers which produces pulses of light in response to incoming signals and are bounced down the inside of extremely thin glass fibers. Today's cellular mobile telephones rely upon a series of 'cells' each with its own central radio transmitter and receiver. Each cellular telephone unit also has its own central transmitter-receiver, permitting it to receiver seamless transmission as they enter and exist from a cell [11].

The impact of the telephone has been described as both positive and negative. The invention of the telephone has resulted in the rapid dissemination of technical and scientific information, lives are saved through links made to emergency services made possible in modern cities through telephonic connections.

The home or office-intercom is a simplified telephone system that shares the same history and development. The intercom has the same operating principles as the telephone network system the distinguishing factor being the type of transmitter employed in intercom. An intercom is desirable mainly for its simplicity and cost effectiveness.

## 2.2 THEORETICAL BACKGROUND

Since the project is an analogue design, the knowledge of the analogue electronics to achieve its implementation is a necessity. The knowledge of some of the theories that support this project was derived from extensive research through the study of textbooks, magazines, journals and web pages. Some of these theories include -:

### 2.2.1 THE TELEPHONE PRINCIPLE [7]

The telephone system which is the basis of the Intercom comprises the transmitter, receiver, channel, cables and other components like switches, alarm and power source. It works on the principle of electromagnetism brought about by varying air pressure. When a person speaks into a microphone it is then converted into an electrical energy by the microphone at the receiving end. The electrical energy is converted back to sound by the loudspeaker in the earpiece. The following is the simplified block diagram of a communication system.

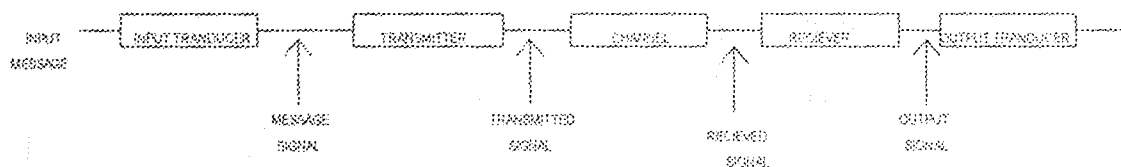


Fig 1.1 The block diagram of the communication system.

INPUT TRANSDUCER: A Transducer is a device that converts one form of energy to the other. The input transducer converts sound waves in the frequency

range of 0.3 – 3.4 KHZ to electrical signal which is fed by wires through the transmitter. Here the microphone acts as the input transducer. [8]

TRANSMITTER: The transmitter couples the messages to the terminal. It is the transmitter that modulates (I avoided modulation by using wired intercom system). The telephone transmitter contains tiny particles of carbon called carbon granules which are closely held in small compartment between a piece of carbon which is cup shaped and another piece is dome shaped with the aid of moving front electrode which moves only when the diaphragm converges as a result of changes in the air pressure. The carbon granules composite increases their contact area which causes the resistance of the circuit to reduce thereby giving rise to a high flow of current.

It is necessary that necessary that sound waves are passed through the transmitter for the following reasons

- For channel assignment each messages signal is transmitted at a unique frequency band to avoid mix-up with other signals.
- To reduce noise and interference especially at low frequencies
- To overcome equipment limitations e.g. size and weight [8]

CHANNEL: This is the medium through which the transmitted signals get to the receiver. It may have many differences from ranging from the ground or underground cables to stay and space. It could be wired or a wireless channel. The common characteristics of all channel is that signal passing through it undergoes degradation which may be due to noise or interface, fading and multiple paths for video signals etc

RECEIVER: This extracts and processes the desired signal from the received signal at the output. Amplification of poor signal and weak signals is performed. Delaying of the received signal is also performed. A good signal should be able to select well the desired signal and reject well the unwanted signal.

OUTPUT TRANSDUCER: This is the device that converts the received electrical output signal into the desired form by the user, hence sound. The output transducer hence is the loudspeaker that converts electrical energy to sound waves. Other examples are CRT (cathode ray tube) meter, oscilloscope.

OPERATIONAL AMPLIFIER: [9]

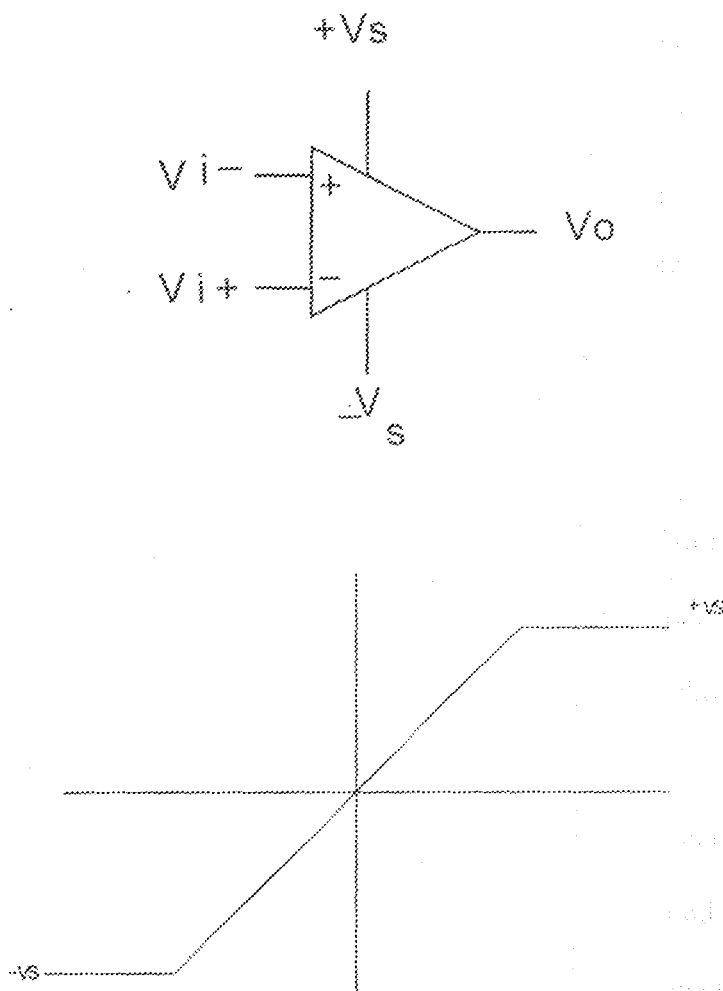


Fig 1.1 The Diagram showing an Op-amp

The basic amplifier has two input which are denoted by  $V(i+)$  and  $V(i-)$  and a signal output  $V(o)$ . The positive and negative power supplies of equal magnitude are normally used although single supply operation is possible. These are shown as  $+V(s)$  and  $-V(s)$ . For simplicity these connectors are not normally shown on circuit diagram. The ideal operation of the amplifier is shown in the transfer characteristics above whose  $V(i)$  represent the difference between the voltages applied to the two inputs ( $V(i+)$  and  $V(i-)$ ). If  $V(i)$  is positive then the supply voltage (or the output saturation voltage). In practice a finite change in  $V(i)$  will be needed in order to change  $V(o)$  from one level to another as shown in dotted lines. For a transfer characteristics having a finite slope the input/output relationship is written as

$$V(o) = A(V(i+) - V(i-)) \quad \text{equation 1.1}$$

Where  $A$  is the open loop gain ( i.e. a gain without feedback) or the gain of the amplifier in the region between the two output saturation voltages. For practical amplifier  $A$  is usually more than 50000 and theoretically infinite ideal lines.

### 2.3 FREQUENCY RESPONSE (OPEN LOOP BEHAVIOUR COMPENSATION) [4]

The circuit described earlier depend on the assumption that the open loop gain  $A$  remained very large (ideally infinite) under all operating conditions. This can't be done for all frequency. For stable operation a feedback configuration is used. The high gain must be preserved for low frequencies including Direct Current.

Also for stable operation under all conditions, the gain must be made to fall or roll off at high frequency this will occur in any case due to stray capacitance but additional capacitance is also needed in order to define the frequency at which roll-off starts to occur. Roll-off is desirable not only to ensure stability but also to avoid amplification of signals outside the required range of frequency. Since this would increase the noise content. This additional capacitance maybe internal to the IC amplifier or external (internal or external compensation). The internal compensation has the advantage that stability generated under all operating condition and external capacitor is not required. The disadvantage is that the open loop bandwidth by the manufacture cannot be changed by the user. The widely used UA741 -amplifiers of this type external compensation gives greater flexibility but care should be taken as suitable choice of compensating capacitor can cause instability.



# CHAPTER THREE

## DESIGN ANALYSIS

### 3.0 INTRODUCTION

The study of the principles of operation of various components needed in the construction of the intercom was carefully done. A thorough appraisal of the theory behind most components used in the circuit design helped in choosing the ideal material needed for the perfect and enhanced construction of the project.

Technical decisions of this magnitude was backed with facts, this chapter discusses some theoretical aspects considered and some calculations considered in choosing the ideal components for the circuits. The communication device described extensive in this chapter provides optional performance with merits such as low power consumption, high flexibility, low cost, high availability, increase simplicity and lots more. The ICs used are CMOS (complimentary metal oxide semiconductor) which provides better performance than other type TTL (transistor-transistor logic) used in previous construction.

### 3.1 THE COMPONENTS CHOICE AND DESCRIPTION

The project involves the use of a reasonable number of components and reduced number of transistors. The simplicity of the design indicates the economic importance of the project. Also the limited number of components involved provides low power consumption in the circuit.

The project involves the following main components

- (i) LM 386 (Audio Amplifier)
- (ii) 4060B (Alarm Oscillator)

(iii) 25040D (Switching Transistor)

### 3.1.1 THE LM 386[8]

The LM386 is a low power, high gain audio amplifier that produces an output of about 1 watt which forms the basis of choice in the Intercom construction. It can work within a voltage range of 4 to 15V.

The Alarm Section is built around a 25040D CMOS oscillator which is a better choice than the 4011 CMOS oscillator because it's a cheaper, more available choice when compared to other oscillator (e.g. 4011 CMOS oscillator). The 25040D is a better switching device with collector current around 900mA (0.9A) and a typical voltage gain of 100 especially with the addition of resistors and capacitors between Pin 1 and Pin 8. The choice of the 25040D IC is due to its better frequency response when compared to the 4011 CMOS oscillator.

Two of this device is used in the circuit for amplifying audio signal from corresponding microphones. Each serves a particular communicating line. The device has reasonable low power consumption. Therefore, it is suitable even for battery powered applications.

**Some features of the LM386 includes:**

- Self Centering output quiescent voltage
- Battery Operation
- Minimum External Part
- Wide Supply Voltage 4-12 or 5-18
- Low quiescent current drain 4mA

- Voltage gains from 20 to 200
- Ground reference input
- Low distortion
- Available in 8pin CMOS package

Some of its Applications includes:

- AM-FM Radio Amplifier
- Portable Tape Player Amplifier
- Intercom
- TV Sound System
- Power Converter

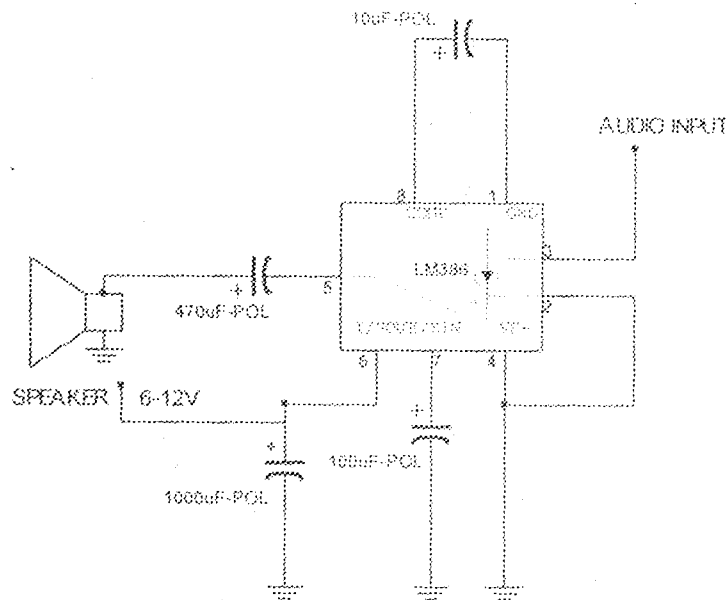


Fig 3.1 A diagram showing a typical circuit of the LM 386

### 3.1.2 THE 4060B [1]

The 4060B is unique oscillator whose outputs are buffered for pins protection and high current driving ability. It is CMOS IC designed as a 14-stage binary ripple counter with an on-chip buffer. It is an important oscillator and divider Integrated Circuit (IC). It operates in both RC and Crystal modes. In this circuit we are interested in the RC configuration since sound is involved. Also in the chip is a reset function which places all output into Zero state and thus disables the oscillator. It is also capable of driving a 2-low power TTL load where applicable

The oscillator produces ten frequencies at a time. A negative transition of the clock will advance the counter to the next state. The Schmitt trigger action on the input line permit very slow input rise and fall times. This IC is used instead of its alternative in 555 timer because of its stability and total implementation circuit in which reduced number of the 555 timers are involved. For instance an estimate of five 555 timers would have been used, thus creating a complex circuit diagram. Another reason for using the 4060B over the 555 timer IC is because it provides excellent noise immunity and can operate over a wide voltage range. The 4060B is used in the alarm section for generating audio alarm frequencies for the circuit.

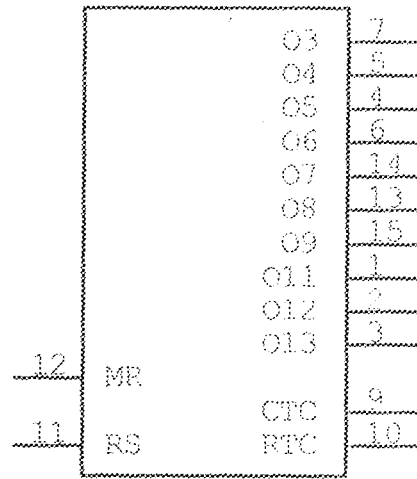


Fig 3.2 A diagram showing the pin arrangement of the 4060B

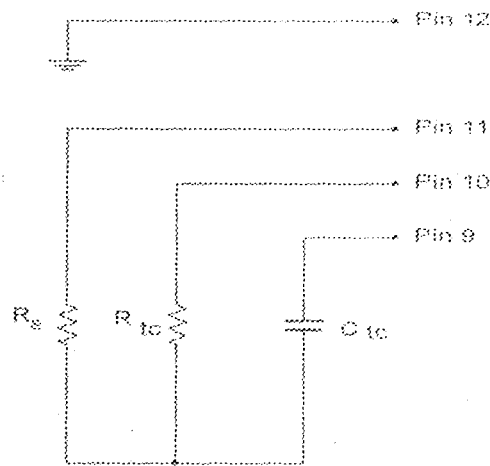


Fig 3.3 A diagram showing the RC configuration of the 4060B oscillator

The integrated circuit generates a main frequency ( $f_m$ ) for a particular RC configuration. This frequency is divided fourteen times through internal divide-by-2 flip-flops. Ten outputs from the division flip flop are fed to the output.

The RC configuration is determined by the following relationship

$$F_m = 1 / (2.3 R_{tc} C_{tc})$$

The frequency at output at a particular pin is given by:-

If  $1 \text{ KHz} \leq f \leq 100 \text{ KHz}$

And  $2R_{ic} < R_s < 10R_{ic}$

The recommended maximum value for resistor is  $1\text{M}\Omega$

Where  $R_s = 100\text{k}\Omega$

$$R_{ic} = 3\text{k}\Omega$$

$$C_{ic} = 0.001\mu\text{f}$$

$$F_{qx} = f_m / 2^x$$

where  $x$  = the Q value of the particular output

For example assuming that  $f_m = 512 \text{ KHz}$  and  $x = 2$

Then  $F_{qx} = 512 / 2^2 = 128 \text{ KHz}$

Similar procedure can be applied to related conditions.

### 3.1.3 THE 25040D

The 25040D is a NPN transistor. It is designed for audio frequency amplification and low speed switching. It has a maximum power of 900 mw at 25V. The choice of the 25040D IC is due to its better frequency response when compared to the 4011 CMOS oscillator. It is used in the construction for fast switching for communication when the handset is picked at the receiving end.

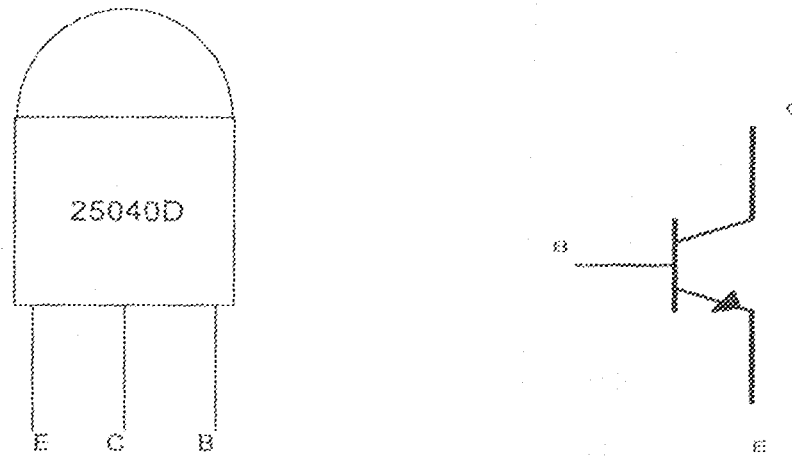


Fig 3.4 A diagram showing the pin configuration of the 25040D

### 3.1.4 OTHER COMPONENTS

Other components used include resistors, capacitors, loudspeakers, microphones and diodes. The Loudspeakers help in converting electrical impulses into audio sounds. It has a coil that in a magnetic field that moves when current is applied to it. The loudspeakers used in this project have an impedance of 8  $\Omega$  each.

While the capacitors are used in storing electrical charges and help within the circuit for filtering unwanted frequencies in audio amplification and the elimination of ripple in the DC circuit.

### 3.2 MODULAR DESIGN

The construction involves two main circuits, the amplifier and alarm circuit. A power circuit is also added to reduce operational cost.

The diagram above below shows a block diagram of the home or office intercom

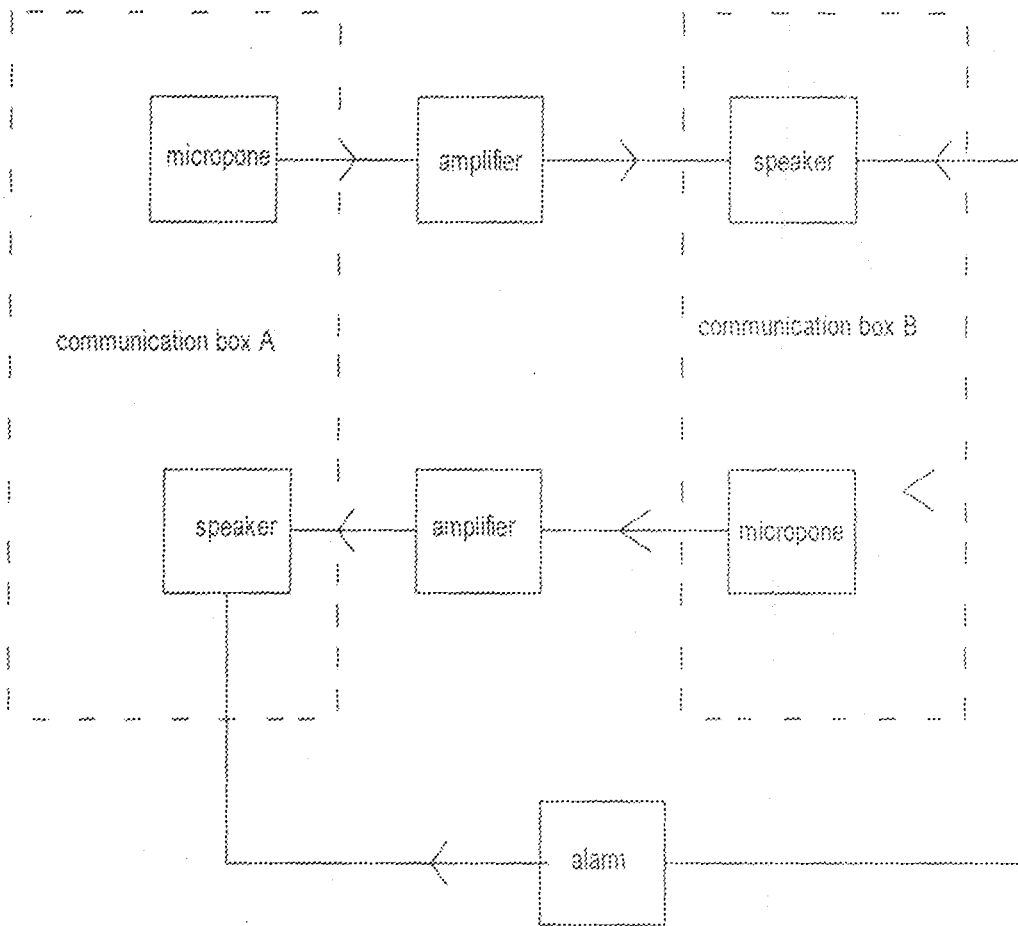


Fig 3.5 Modular Design of the Intercom

### 3.2.1 THE AUDIO AMPLIFIER UNIT

The audio amplifier is built around the LM386 IC. Two audio amplifier integrated circuits(IC) carry the bulk duty in the circuit. Each of them serves a particular communication line. There are two communication lines in the circuit. A particular audio amplifier is connected to a microphone and a speaker. The microphone converts audio energy into corresponding electric audio signal into the input of the amplifier. A speaker is always connected to the output of a particular audio amplifier.



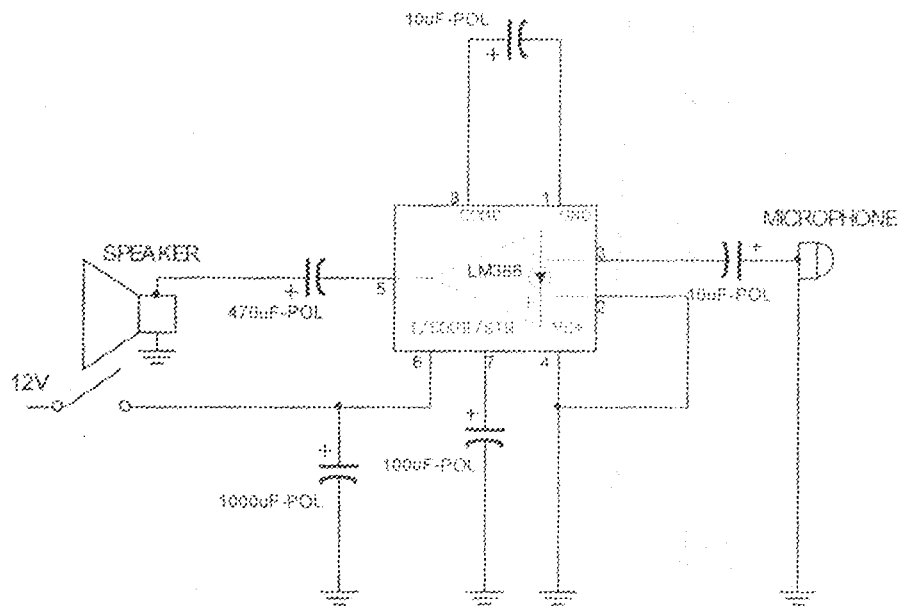


Fig 3.6 A diagram showing the single audio amplifier circuit

The value of the involved components in the audio amplifier circuit is based on the manufacturer's data sheet. The amplifier is designed with an internal gain of 20. The connection of 10µf 16V capacitor between terminals 1 and 8 increases the gain to 200. The integrated circuit is powered with 12V supply from the power rectifier.

The two amplifiers are logically connected with their external components. Microphone B is connected to amplifier A. The output is speaker A. The microphone B is used in the indoor or in-office communication box. So that, for example when a house owner speaks into microphone B it would be heard at the speaker A. This is one communication line.

The other communication line involves speaking into microphone A and amplification takes place in audio amplifier B. The output is at speaker B. This explains simply the communication between the two boxes.

### 3.2.2 ALARM UNIT [8]

The Alarm unit mainly consists of the 4060B integrated circuit. The Oscillator generates the required audio frequency for the alarm. The frequency of the signal can be calculated using the frequency formula of the integrated circuit.

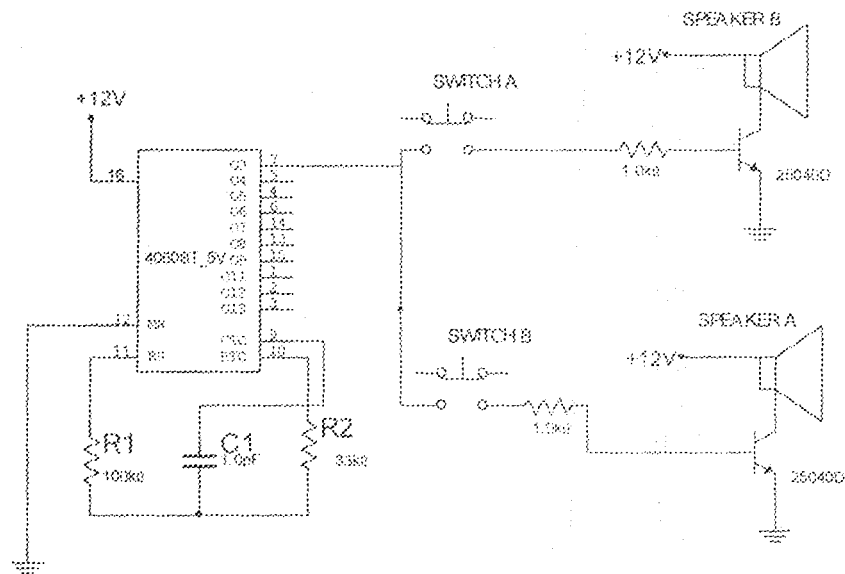


Fig 3.7 A diagram showing the Alarm Unit

The main frequency of the Oscillator is given by

$$R_{tc} = 3.3 \text{ K}\Omega$$

$$C_{tc} = 0.001 \text{ uf}$$

$$f_m = 1 / 2.3 \times 3.3 \times 10^3 \times 0.001 \times 10^{-6}$$

$$= 13.2 \times 10^3 \text{ Hz.}$$

This gives better output frequencies than other constructions observed which have frequencies between the ranges 48Hz to 9.89 KHz found by using other ICs.

The 33kΩ and 0.001uf of the RC constant is quite typical or common to a wide range of circuit application.

The frequency output at Pin 7 is given below

$$\begin{aligned}
 f_{\text{pin 7}} &= f_m / 2^4 \\
 &= 13.2 \times 10^3 \text{ Hz} / 16 \\
 &= 825 \text{ Hz}
 \end{aligned}$$

The Audio Alarm frequency is 825Hz.

The Audio Alarm signal requires amplification for reasonable use. Therefore, a NPN transistor (25040D) is incorporated into the design for the alarm to be heard of a particular or corresponding speaker.

The 25040D is a better switching device when the collector is current is around 900mA (0.9A). It has a typical current gain of 100.

Therefore,

$$\begin{aligned}
 I_{Ba} &= I_{Ca} / 100 \\
 &= 0.9 / 100 \\
 &= 0.009\text{A}
 \end{aligned}$$

$$\begin{aligned}
 R_a &= 12 - 0.7 / 0.009 \\
 &= 1255.5 \\
 &= 1.255\text{k}\Omega
 \end{aligned}$$

A 1k $\Omega$  is used in the design. It provides similar performance as the calculated value.

Switches A and B are incorporated into Communication Box A and b respectively. When the switches are pressed an audio alarm is heard at the corresponding speaker. This connection allows the attention of a particular box to be achieved through the other box.

### 3.3 IMPLEMENTATION [4]

The power system supply power to the amplifier section and alarm section, it supplies 9V to the circuit by converting a 220V AC mains to a 12V DC with the aid of a Iron-Core transformer and a bridge rectifier which is made of four IN 4001 diodes and a 1000uf capacitor to remove ripple and distortion.

The Amplifier section is found in the transmitter and receiving end, it is built around a Lm386 operation Amplifier with the input gotten from the microphone while its output is connected to the speaker of the receiving section. The LM386 in this circuit is used as a gain amplifier with Pin 8 and Pin 1 used to provide gain. At the receiving section the input, the inputs of the amplifier are filtered with the help of a capacitor and the output via a coupling capacitor. This coupling capacitor makes the output clearer and helps to eliminate high frequency oscillation at the output as well as to prevent feed-back into the input stage. The Alarm Section is built around a 4060B CMOS oscillator which is a better choice because it's a cheaper, more available choice when compared to other oscillator (e.g. 4011 CMOS oscillator and the 25040D CMOS oscillator) The 4060B is used to replace the 4011 and 25040D CMOS oscillator as used in previous Intercom constructions. The 4060B supplies a pulsating sound to the input of the LM386 operation amplifier where the alarm button is pressed. This pulsating sound is amplified by the LM386 and this amplified sound is heard at the receiving section. When the button is pressed power is supplied to the 25040D IC and the output is connected the 4060B oscillator which is connected to the positive input of the LM386 and when the button is released power is cutoff from

the 25040D and the circuit returns to its default state. This helps in the switching process. The output from the LM386 is supplied to the transmitter section in the receiving section. An added advantage in this section is addition of alarm at both sides of the communication line and an added advantage of fast switching for quick communication, so that when the alarm button is switch is released and the receiving handset containing the earpiece and the mouthpiece or microphone instant connection is achieved.

# CHAPTER FOUR

## CONSTRUCTION, TESTS AND DISCUSSION

### 4.0 INTRODUCTION

This chapter gives an overview of the general layout of the construction of the various parts that make up the communication boxes, the assembling of those parts to give a functional intercom system. It also deals with the testing of the system by the use of breadboard before final design were placed and soldered on a Vero board.

This chapter also deals precautions taken during the construction as well as troubleshooting techniques used in sorting out the problems faced during construction. After carrying out proper design analysis the project is done proper testing is required to ensure that it suits the purpose for which it was design for.

### 4.1 EQUIPMENTS USED IN CONSTRUCTION AND TESTING

In order test the functionality of each part of the circuit constructed the following equipments were used. They include:-

- Digital Multimeter

Some of the materials and equipments used during construction include

- Breadboard
- Vero board
- Soldering Iron

#### **4.1.1 BREADBOARD**

Breadboard are solder-less prototype board containing well arranged pin sockets for plugging in components during circuit testing or experiments.

The breadboard serves as a temporary construction board for testing the functionality of the components in the system. For this purpose all the components used were laid out on the bread board according to the specification of the project design and necessary adjustments and modifications were made to arrive at the final construction presented.

#### **4.1.2 VEROBOARD**

Vero board consist of a strip of insulator having parallel tracks of strips of conductors etched on one side with holes drilled along each strip length to form a kind of matrix arrangement, the holes provide connection point for components. After satisfactory test, modifications and adjustments were done on the breadboard the various components involved in the project were placed in the appropriate pin hole and the pins soldered into the circuit in accordance to the specified design. Soldering was done with great care to prevent damage to the components. This is referred to the final circuit construction.

#### **4.1.3 DIGITAL MULTIMETER**

In order to achieve proper design the digital multimeter was used in testing at various stages of the construction. It was basically used for measuring -

- The voltages at various pin of the ICs
- The resistances of resistors in the circuits
- The continuity of the wires and of the some pins in the ICs

- The input and output currents of IC's pins and resistors
- The frequency of the 14060B, LM386 IC's and D.C. gain of transistors

## **4.2 CONSTRUCTION OF CASING AND ASSEMBLY OF THE PROJECT**

The concept of conventional casing was involved with little modifications done to give a resemblance of the modern GSM handsets. Therefore electrical socket boxes were used with appropriate allowance included to incorporate the ear piece and mouthpiece.

The dimension of the casing was considered with respect to the size of the Vero board. The various components (like the power circuit, main circuit, ear piece and mouth piece) were kept in their appropriate place within the communication boxes.

The Vero boards were first drilled through at appropriate points and screws used to hold the circuit board in place within the casing.

### **4.2.1 PRECAUTIONS TAKEN DURING CONSTRUCTION**

Quite a number of precautions were observed in the design and construction of this project in order to ensure that the system worked properly and the components were not damaged during construction. Some of these precautions include:

- The circuit design was made easy to understand with major interest in the improvement of exiting intercom this saved time and reduced much experimentation with components.



- The values of the components were chosen close to their calculated values. Proper identification of components and their values both at the point of purchase and during circuit construction was ensured.
- The circuit design was religiously followed during Vero board and breadboard stages of the construction.
- The temperature of the solder was regulated to prevent overheating.
- Soldering-iron (40 W) lead wires were discriminately selected to make for effective soldering. Off target or stray solders were carefully removed to avoid short circuit.
- Power supply was normally put off or disengaged from circuit when plugging or unplugging ICs during test procedures and construction.
- Conducting materials that could bridge the legs of the ICs (like screwdrivers) were kept away.

#### **4.2.2 TROUBLESHOOTING**

During the testing and construction stages a sequence of steps were performed in order to locate the areas of fault and correct them. This organized troubleshooting procedure includes

- Fault Analysis
- Equipment Inspection
- Voltage and resistance measurement
- IC and capacitor testing
- Equipment Performance tests

### 4.3 TEST AND RESULTS

Most of the required testing was done during the breadboard stage where each of the output was measured and monitored using the oscilloscope, this was to ascertain if the necessary gain was achieved.

Initial testing was also done using software called multisim to check the overall functionality of the design. The final stage testing was performed when the various parts that made up the intercom system were coupled. This was done by testing the alarm circuit, power circuit as well as the main circuit to make sure they were working properly.

Also testing was done to make sure that communication existed between the two communication boxes. This was done by speaking into the mouthpiece at one end and having someone listen at the other end to see if my voice would be heard from the earpiece at the other end. This process was repeated on both communication boxes, test for voice clarity as well as noise interference from stray signals was also done.

The output of the two units gave reliable result with minimum distortion with negligible noise interference.

# CHAPTER FIVE

## CONCLUSION AND RECOMMENDATIONS

### 5.0 INTRODUCTION

Working on this project was challenging, but I can honestly say it turned out interesting and very enlightening. The project was designed under the consideration of some vital factors, such as economy, availability, compatibility and durability of components, efficiency of the design as well as the availability of research materials. The performances of this design after testing met the design specifications. The system designed can be said to be reliable, satisfactory with good sound quality and low noise output as well as user friendly.

### 5.1 LIMITATIONS AND PROBLEMS ENCOUNTERED

Some of the problems encountered during the course of the designing and construction of this system are as follows:

- The initial design we had was designed using a TDA 2030 IC for audio amplifier but this IC consumes about 15W of power and generated enormous amount of heat. So the TDA 2030 was replaced by the LM386. As a result of this the cables between the two communications boxes can only go for a few meters, since the output of the LM386 are just about 4W.
- It was observed when the communication boxes were positioned very close to each other, there was a noisy sound due to feedback as a result of sensitivity of the microphone.

- The original design did not have switching circuits and this reduced privacy. Therefore switches had to be incorporated during case construction so that only when the switches are pressed can proper communication occur.

## **5.2 CONCLUSION**

The aim of this project which is the design and construction of a 2-way full-duplex intercom was practically achieved as demonstrated by the results discussed in chapter four.

The simple wired intercom designed in this project is a precious commodity for profit oriented organization. It can be used as an inter-office intercom or as a door-phone to screen visitors. Its application could also extend to TV and stage productions but it is usually modified into headset type and connected in party-line arrangement.

In addition, the construction and casing was done in such a way that could easily be maintained and repaired. It should also be stated that the reliability and performance of this design would also depend on the users despite that the overall design is user-friendly with good , low noise voice output.

## **5.3 RECOMMENDATIONS**

This project portrays the application of the very basis of communication, in an age of rapid developments and inventions, I suggest more research could be done to improve the project and make it more efficient and simplified.

Some improvements include:

- Additional circuits could be added to make a modernized digital camera intercom system

- The sound IC used could be replaced with better and recent ones that give melodious ring tones
- The circuit design could be expanded so that more channels and stations can be interconnected.

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