DESIGN AND CONSTRUCTION OF TWO LINE INTERCOM WITH A TELEPHONE CHANGE OVER SWITCH

BY

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DECLARATION

I Awodi Emmanuel Ameh declare that this project was executed by me under the supervision of Engr.R.A Raji, and that the project, to best of my knowledge has not been submitted for any degree elsewhere. All the references extractions were fully acknowledge.

Awodi Emmanuel Ameh	9th nov., 2011.
Student	**Signature and Date**

CERTIFICATION

This is to certify that this project titled **"Design and construction of two line intercom with a telephone change over switch"** has met the requirement governing the award of B.Eng. Electrical and Computer Engineering, Federal University of Technology, Minna,

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DEDICATION

This project is dedicated to the glory of Almighty God, the one whose grace has been sufficient throughout my academic pursuit andto my caring brother Mr.Awodi Ogiri.

ACKNOWLEDGMENT

All praise and glory are due to Almighty God who, in his infinite mercy, protected me from birth till date and gave me the grace of pursuing my course of study.

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ABSTRACT

The design and construction of a two line intercom with a telephone change over switch is presented in this project. The scope of the project is voice communication between two people in different rooms talking to each other over a distance and also includes a changeover circuit that allows the master unit to have a private conversation with any slaves units. The two stations are connected using dedicated telephone cables. The project was achieved using an audio amplifier LM386IC which receives an audio signal from the input transducer; the signalis then amplified and transmitted.The method employed is the sending and receiving of electrical signals varying in accordance with the sound waves impinging on a microphone.The whole process involves production, transmission and reception of messages.

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LIST OF ABBREVIATIONS

[1] PIV ....peak inverse voltage

[2] IC .... integrated circuit

[3] LM....................................Linear monolithic

[4] LW..................................... Long wave

[5] FM.....................................Frequency modulation

[6] a.c......................................alternating current

[7] d.c..................................... direct current

[8] N/O..................................... Normally- open

[9] N/C ....Normally-close

[10] V rms....................................Root mean square voltage

[1I] RL..Load resistance

[12] X...Input impedance

CHAPTER ONE

INTRODUCTION

1.0 PREAMBLE

An "INTERCOM" (internal communication) is a system of communication employing two networks [9]. It is a communication system linking different rooms within a ship or building. It is also a system of speakers and microphones allowing people in different rooms to talk to each other [9]

1.1TYPES OF INTERCOM SYSTEM

There are two types of intercom systems available today: Wired and wireless intercom systems. Each system has their advantages and disadvantages.

- **Wired intercom:**

This is the type of intercom that makes use of telephone cables (wire) to connect one station to another. It is expensive, but does not suffer interference in the network.

- **Wireless intercom:**

This is the second type of intercom network also in use; stations are connected to each other using radio waves [1]. It is cheaper and more easily realizable, but sometimes interference in the network is caused by cordless telephones interfering with each other and lack of privacy caused by two cordless telephones operating on the same frequency [1].

Because of their varying characteristics, intercom networks of different wave lengths are employed for different purposes, and are usually identified by their frequency. An intercom transmits and receives communication at different location frequencies when wireless is employed. Radio is used mostly as relay station for wireless transmission. So it is known as a point-to-point or point-to- multipoint medium. However, radio can also be used for private point-to-point transmissions. Two-way radio, cordless telephones and cellular radio telephones are common examples of transceivers which are devices that can both transmit and receive point-to-point messages. From the foregoing, it can be understood that communication in general is a chain of events in which the most important component is the *message*. The whole process involves production, transmission and reception of messages

1.2 AIM AND OBJECTIVES

The main aim of this project is to design and construct a wired intercom network. It also includes a changeover circuit that allows the master unit to have a private conversation with any of the slave units (slave1 or slave2). To achieve this, the following objectives were set to be carried out:

- Design of power source.
- Design of mouth piece and ear piece (input and output transducers)
- Design of audio amplifying circuit.
- Design of signaling and switching circuit
- Use of quality cable

1.3 MOTIVATION

.The common method of communication in our daily lives is orally from one person to another, or by the use of Frequency modulation (FM), Amplitude modulation (AM), Short wave (SW), Long wave (LW) from transmitting stations to radio stations. These processes make use of antennas and other techniques are very good and effective, an alternate method of communication is proposed in this project namely "Intercom with a telephone change over switch". There are many applications of an intercom, some of which are listed below:

- It can be used in place of a bell to carry out announcements when it is time for an assembly, or top of the hour, e.t.c
- It can connect one room to another, thereby acting as point-to-multipoint network.
- It is also used for security functions, and so on.

Also, replacing telephones with simple INTERCOMS means that the money spent in buying expensive telephones can be saved.

1.4 METHODOLOGY

The project was achieved using an audio amplifier LM386IC which receives an audio signal from the input transducer; the signal is then amplified and transmitted. The two-way station was achieved using three LM386IC coupled with a mouthpiece and earpiece each, and the three circuits were connected in parallel using an electromagnetic relay and a switch which allowed the master unitto have a private conversation with the slave units.

1.5 SCOPE OF STUDY

This work is intended for use by schools, business enterprises, post offices e.t.c, particularly by lecturers, teachers, workers, students, retailers and so on. It involves a brief study of working principles of electronic components like resistors, capacitors e.t.c to bring about a clear understanding of their operation.

1. 6 PROJECT OUTLINE AND ORGANIZATION

This project has five chapters, itemized as follows

- Chapter one comprises ofintroduction, motivation, aims and objectives, methodology, scope of the study and project layout.
- Chapter two talks about literature review, theoretical background of the intercom and principle of operation of components used in the work.
- Chapter three consists of the main design analysis of the intercom and specification
- Chapter four contains details of the construction, testing, results and limitation.
- Chapter five sdeals with conclusions and recommendation based on the work done.

CHAPTER TWO

LITERATURE REVIEW

2.1 LITERATURE REVIEW

Intercomhistory has come a long way since this apparatus was first introduced as acommunication system at the beginning of the 20th century [9]. A descendant of the antique ring system used ontrains, intercoms have evolved a great deal. In the beginning there was use of telephone technologies until eventually intercoms transformed into multi-way, multi-post communications systems and wireless appliances. Intercom systems were quickly put to use in functions that clearly went beyond their original communication role [9]. From 1950's onward, intercom systems became the most ubiquitous access control tool in residential and commercial buildings .We all know the ritual of ringing at a building entry door and waiting for the buzz that will grant us access to the premises, after having dutifully identified ourselves. These entry intercom systems became a part of our everyday life, and helped to improve home security to a large extent. Video intercom was the next to appear. Once reserved only to large corporate customers, video intercom systems have literally conquered the market because they offer the ability to positively identify the person requesting entry greatly improving the security of people equipped with such a device [3].

Nowadays, intercom security solutions no longer require costly maintenance and heavy hard wiring. Wireless intercoms are now available for easy installation and integration, to become at once, a part of a home intercom and entertainment system, a phone intercom, an entry intercom and even ensure that your baby is sleeping tight [9].

2.2 HISTORICAL BACKGROUND

In electrical engineering terms, communication refers to the sending, processing and reception of information using electrical means [5]. The information or message to be sent, processed and received (i.e. to be communicated) may take different forms. It may be voice, picture, written message, electrical signal,etc.

A communication system is therefore, a technique or equipment that is used to send, process and receive messages. This may take the form of telephone network, radiolinks, satellite and optical fibre links, amongst others. Electrical communication started in the 1840s with the discovery of wire telegraphy [5]. The first telegraphy cable was inaugurated in 1850, while the first telephone cable did not appear for another forty years. Radio (wireless) communication did not come into the scene until the beginning of the 20^{th} century when, in 1901, the letter S of the Morse code, transmitted at a pre-arrangedtime from Poldhu in Cornwall (U.K),was heard across the Atlantic in New Foundland (Canada)Since that time, telecommunication systems have gone through many revolutionary stages brought about mainly by dynamic developments in electronics. Hundreds of artificial satellites are now orbiting in space for reception, processing and re-transmission of information either from earth stations or from extra-terrestrial sources [5].

2.3 THE TELEPHONE SYSTEM

Usually, the telephone system comprises of the transmitter, channel, receiver and cable etc.The telephone system operates on the principle of electromagnetism.

When a person speaks into a microphone, he sends sound as air from the mouth into the microphone which is then converted into an electrical signal by the microphone[5]. This electrical signal is converted back into sound by a loudspeaker in the ear piece of a communication system.

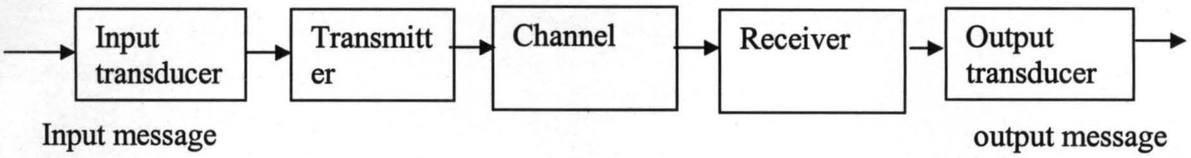


Fig 2.1 A simplified block diagram of a communication system

2.3.1 INPUT TRANSDUCER

The input message, which may be analogue or digital, must be converted from its original form into an electrical signal (message signal) to enable it to be processed by the necessary electrical/electronic equipment [5]. In electrical communication of speech, for example, the sound waves have to be converted to voltage variations by means of a microphone, which is a transducer.

2.3.2 TRANSMITTER

Essentially, the transmitter couples the message to the channel. It is at transmitter that, if necessary, a carrier wave is modulated by the message signal [5]. Modulationmeans modification of one of the parameters (amplitude, frequency, or phase) of the carrier wave, usually of much higher frequency than that of the message signal.

2.3.3 CHANNEL

This is the medium through which the transmitted signal gets to the receiver [5]. It may have many different forms ranging from the ground through underground or overhead cables, to sky and space. The transmitter can be either hard-wired or non-wired (wireless) to the receiver.

2.3.4 RECEIVER

Basically, the receiver in the communication system extracts and processes the desired signal from the various signals received at the channel output [5]. The processing function includes conversion of the selected signal to a form suitable for the output transducer.

2.3.5 OUTPUT TRANSDUCER

This is an element or device that converts the electrical output signal of the receiver into the form desired by the user [5]. For example, a loudspeaker converts electrical signal to sound waves for the user

2.4 MODULATION

In electronics, modulation is the process of varying one or more properties of a high frequency periodic waveform, called the carrier signal, with respect to a modulating signal [7]. In telecommunications, modulation is the process of conveying a message signal, for example a digital bit or an analog audio signal, inside another signal that can be physically transmitted.

2.4.1Methods of Modulation

The methods of modulation are as follows:

- Amplitude modulation
- Frequency modulation
- Phase modulation

2.4.2 Amplitude modulation

This is the type of modulation in which information or audio frequency signal changes the amplitude of the carrier wave without changing its frequency or phase [2]. The process of amplitude modulating is graphically shown below;

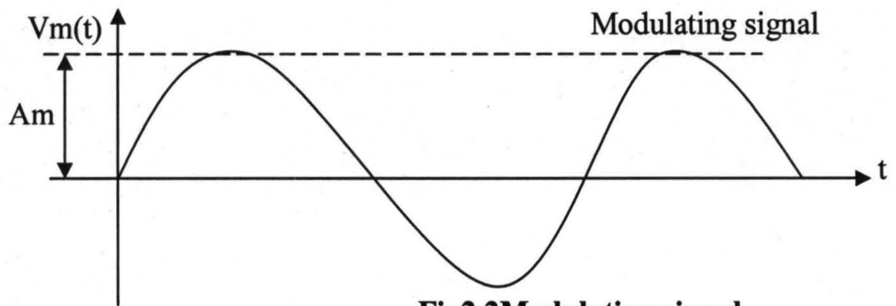


Fig2.2Modulating signal

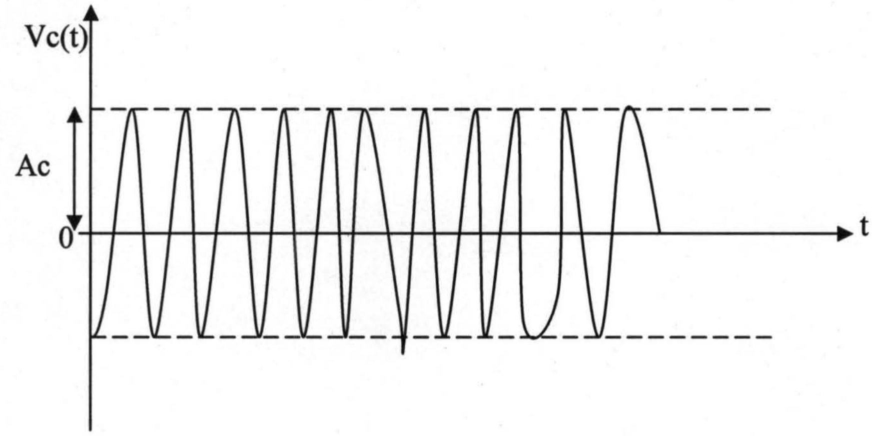


Fig2.3 Carrier signal

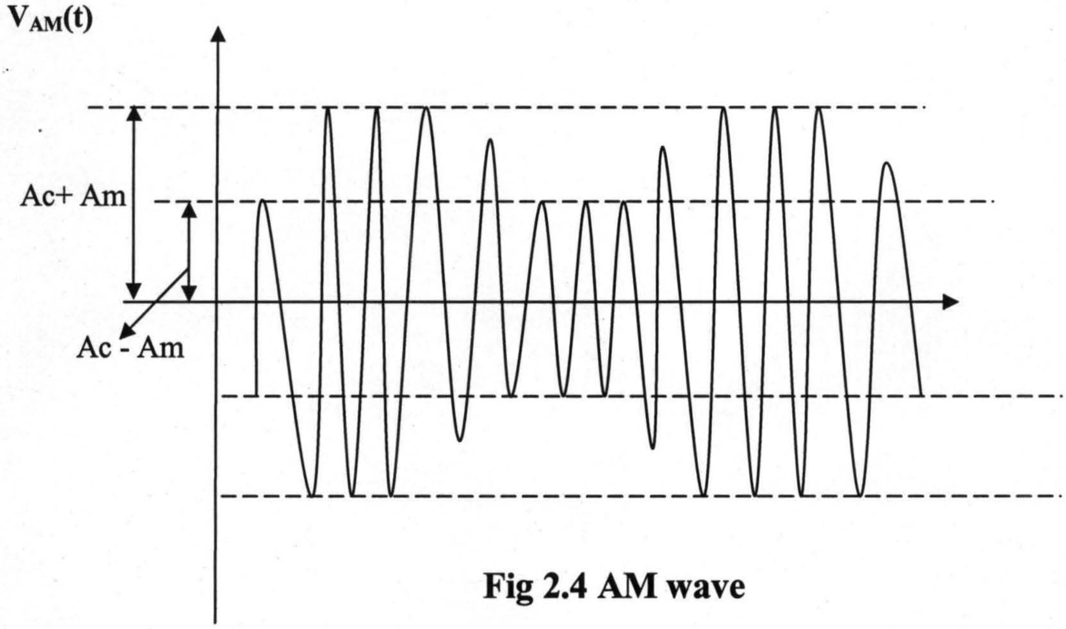


Fig 2.4 AM wave

2.4.3Mathematical expression of amplitude modulation obtained from the graphical representation is shown below;

Let the carrier signal be represented by a sinusoidal voltage amplitude V_C and frequency Fc that is;

$V_c = A_c \cos 2\pi f_c t = A_c \cos W_c t$ 2.0

Let the modulating signal of amplitude Vm and frequency Fm be represented by

$V_m = A_m cos 2\pi f_m t = A_m cos W_m t$ 2.1

From the definition of amplitude modulation, the instantaneous voltage of Am signal is

$V_{AM}(t) = A_{AM} Cos 2\pi fct$ 2.2

$A_{AM} = Ac + KV_m$ 2.3

Where A_{AM} is the amplitude of Am signal

Substituting equation 2.1 into equation 2.3 we have

$A_{AM} = A_C + KA_M cos 2\pi f_{mt}$ 2.4

Substituting equation 2.4 into equation 2.2 we have

$VA_M(t) = (Ac + KAmCos 2\pi fmt) \cos 2\pi fct$ 2.5

Where K is the constant of proportionality and a parameter of the circuit

Be factorizing

$V_{AM}(t) = A_C\left(1 + K\frac{Am}{Ac} Cos 2\pi fmt\right) \cos 2\pi fct$ 2.51

Where the ratio

$K\frac{Am}{Ac} = m$ Is known as the modulation depth of the

Am signal.

Hence, asingle-tone (single-frequency) amplitude- modulated wave can be mathematically expressedas

$V_{AM(t)} = A_C(1 + m . cos 2\pi f_m t) cos 2\pi f_c t$ 2.52

$V_{AM}(t) = AcCos 2\pi fct + Ac.m \cos 2\pi fmt . \cos 2\pi fct$ 2.53

Recall from trigonometry functions that;

$$CosACosB = \frac{1}{2}[Cos(A+B)+Cos(A-B)]$$

Applying the trigonometry expression above into equation 2.53

$$V_{AM}(t) = A_C Cos2\pi fct + \frac{1}{2} mAcCos(2\pi fct + Cos2\pi fmt) + \frac{1}{2} mAc(Cos2\pi fct - 2\pi fmt) \ldots\ldots\ldots 2.54$$

$$V_{AM}(t) = A_C cos2\pi fct + \frac{1}{2} mA_C Cos2\pi t(fc+fm) + \frac{1}{2} mA_C Cos2\pi t(fc-fm) \ldots\ldots\ldots 2.55$$

From equation **2.55;**Anunmodulated carrier wave consists of only one single-frequency component of frequency fc. When it is combined with a modulating signal of frequency fm, heterodyning action take place. As a result, two additional frequencies called side frequencies are produced that is (fc-fm) and (fc+fm) with amplitude ½ mAc respectively. The two new frequencies are called the upper- side frequency (fc+fm) and lower- side frequency (fc-fm) respectively and are symmetrically located around the carrier frequency.

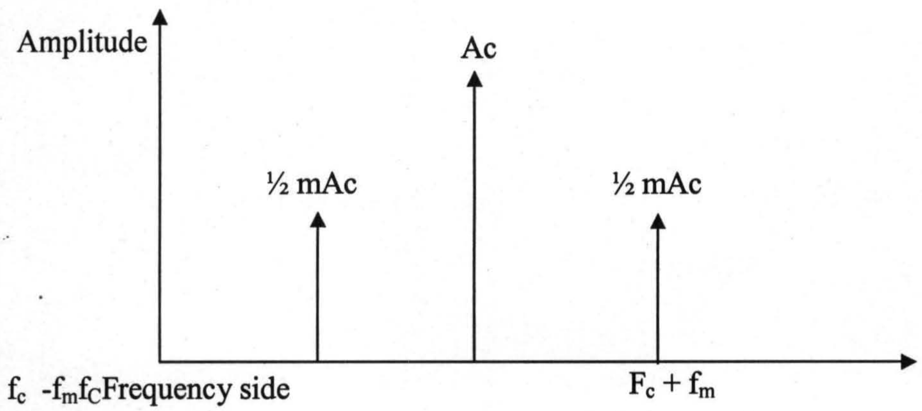


Fig2.5Frequency spectrum of single- tone AM wave

Where

1. A carrier frequency $f_C$with amplitude Ac
2. An upper frequency component (f_c+f_m) with amplitude ½ mAc
3. A lower frequency component (f_c -f_m)with amplitude ½ mAc

2.5 DEMODULATION OR DETECTION

When the RF modulated waves, radiated out from the transmitter antenna, after travelling through space, strike the receiving aerial, they induce very weak RF currents and voltages in them [2]. If these high- frequency currents passed through loudspeakers, they would produce no effect on them because all such sound-producing devices are unable to respond to such high frequencies due to large inertia of the vibrating discs .Neither will such RF currents produce any effect on human ear because their frequencies are much beyond the audible frequencies (20 to 20,000HZ approximately) [2].

This process of recovering AF signal from the modulated carrier wave is known as demodulation or detection. The demodulation of an AM wave involves two operations;

Rectification of the modulated waves and elimination of the RF component of the modulated wave:

For recoveringthe audio frequency(AF)waveform from modulated wave(a mixture of audio frequency and RF carrier), it is essential to find some way of reducing(or better, eliminating) one half of the modulated wave[2]. The result of this elimination (or rectification) would be that the average valve of the wave would not be zero, because now, the impulse would be all in one direction.

2.6 POWER SUPPLY UNIT

The power supply unit is a d.c, power supply[2]. The rectification of a.c power supply is necessary because of its economic advantages over dry cell batteries which are quickly exhausted and need to be changed.

The full wave bridge rectifier diode is used as the rectifier for the power supply unit. The Full wave rectification converts alternating current to direct current.

a.c…d.c.

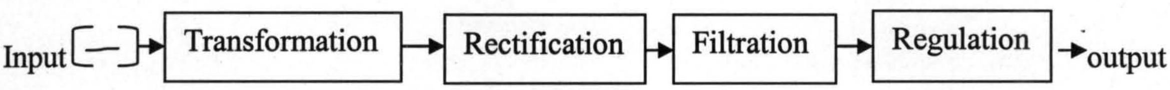


Fig2.6Power supply units

2.6.1 Transformation

This is the process of converting a.c voltage from one form to another (i.e. from a high voltage level to a low voltage level or vice versa) [2]. This is carried out with the use of either a step up or step down transformer. Since the standard power supply in Nigeria has a voltage of 230V, we can make use of a step down transformer of 220/12V 300mA rating for the transformation of the voltage supplied from PHCN.

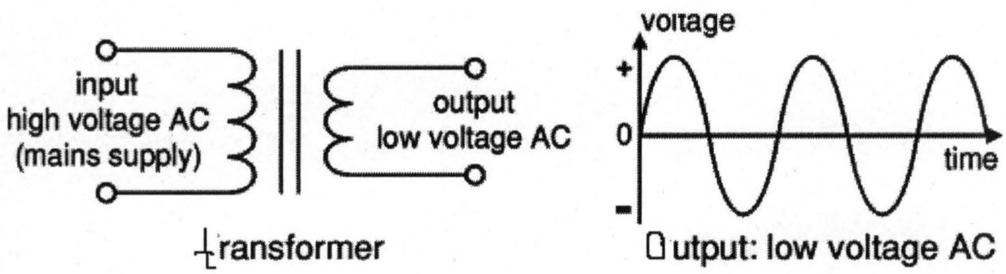


Fig2.7 Step down transformer

E.m.f equation of a transformer is shown below.

Form factor = r.m.s values (V or I)/ Average value (V or I)

$= (1/\sqrt{2})/ (2/\pi)$

= 0.707/0.637 =1.11

Form factor = 1.11……………………………………………………………………………2.0

Since flux increases from its zero value to maximum value (φm) in ¼th of a cycle period, it implies that;

Average rate of change of flux = φm/ (T/4)

= φm4/T =4φm/(1/f)

=4fφm wb or volts.

But rate of change of flux per turn means induced e.m.f in volts.

Therefore, average E.m.f/ turn = 4fφm volt

E/N=4fφm…………………………………………………………………………………2.1

Therefore, E=4fφmN………………………………………………………………………2.2

Where T=period, f=frequency, φm = maximum flux, E =e.m.f.

Since the flux varies sinusoidally, then the r.m.s value of induced e.m.f is obtained by multiplying the average value with form factor.

R.m.s value of e.m.f = 1.11 ×4fNφm

E r.m.s = 4.44fNφm………………………………………………………………………2.3

Therefore, the r.m.s value for the induced e.m.f in the primary and secondary windings will be.

Ep = 4.44fNpφm = 4.44fNp BmA……………………………………………………………2.4

Es = 4.44fNsφm = 4.44fNs BmA……………………………………………………………2.5

Respectively, From equations 2.4and 2.5 we get,

$E_p / E_s = 4.44fN_p\varphi_m / 4.44fN_s\varphi_m = N_p/N_s$

$E_p/N_p = E_s/N_s$……………………………………………………………………………2.6

E.m.f per turn is the same in both primary and secondary windings. In an ideal transformer on no load, $V_p = E_p$ and $E_s = V_s$, where V_s is the terminal voltage.

Also,

$E_s/E_p = N_s/N_p = K$

Where K is known as voltage transformation ratio.

$N_s > N_p$ for a step up transformer $\Rightarrow K > 1$

$N_s < N_p$ for a s

2.6.2 Rectification

Rectification is the process by which an a.c. voltage is converted into d.c. voltage with the use of diode (a bridge rectifier diode in this case) [6].

A rectifier is an electronics device that offers a low resistance to the flow of current in one direction known as the forward bias direction and high resistance to the flow of current in the reverse direction known as reverse bias.

Rectification could be half-wave or full-wave depending on the application. A full wave bridge rectifier is used for this project because of its low peak inverse voltage (PIV). It usually requires four diodes arranged in bridge form.

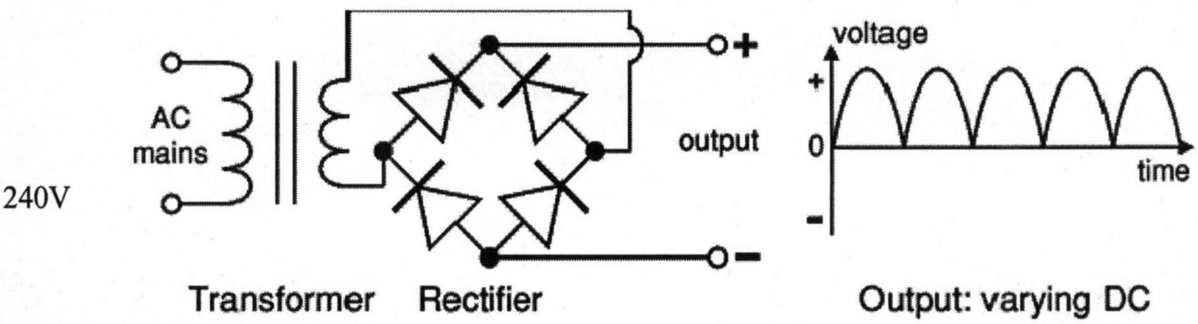
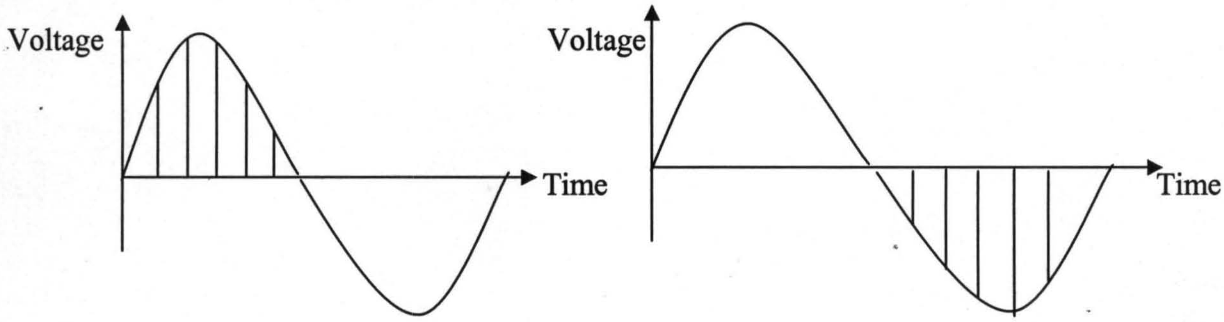


Fig.2.8Transformer +rectifier

The varying d.c output is suitable for lamps, heaters and standard motors. It is not suitable for electronic circuits unless they include a smoothing capacitor. During the positive half cycle of the input,D2 and D4 are forward biased and conduct current in the clockwise direction

from ground (point (a) through D2 and D4 to the load resistance (R_L back to ground (at point (b), D1 and D3 are reversed biased. Voltage is developed across R_L



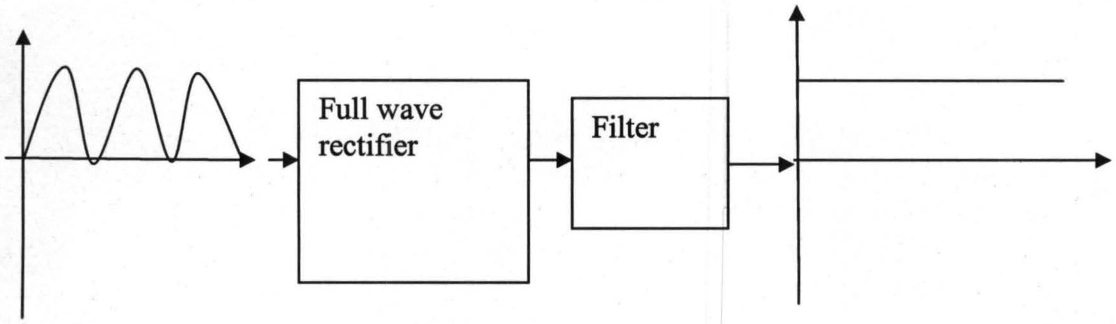
(a)Positive half cycle rectification.(b)**Negative half cycle rectification**

Fig.2.9 Full wave rectification showing the positive and negative half cycle

During the negative half cycle of the input, D1, and D3 are forward biased and conduct current in the anticlockwise direction from ground point (a) through D1 and D3 and back to ground at point (b) through RL. D2 and D4 are reverse biased. A full wave rectified output voltage appears across RL as a result of this action the rectifier diodes used for the bridge rectifier is IN4007 due to its low peak inverse voltage (PIV) of about 50V.

2.6.3 Filtration

A power supply filter ideally eliminates all fluctuations in the output voltage of a half wave or full wave rectifier and produces a constantd.c. voltage, because electronics circuits require only a constant source d.c voltage for power operation. The small amount of fluctuations in the filter output voltage is called ripple [2]. A filter consists of a capacitor connected across pulsating d.c. voltage which smoothens out the voltage this effect is traced to the proper half cycle and to discharge during the non-conducting half cycle.



Pulsating D.C Filtered D.C

Fig.2.10 Filtration process

2.6.4 Voltage Regulation

Some power supply circuits suffer from the drawback that their d.c [2]. Output voltage changes with changes in load or input voltage. Such a d.c power supply is called unregulated power supply. Regulated power supply can be obtained by using a voltage regulation circuit. A source of regulated d.c power is essential for all communication instruments, computers, or any other electronics system.

Therefore a 7812 voltage regulator IC is chosen for this project which will give a fixed position of 12V d.c at the output. The fixed voltage regulator IC usually comes with three lead terminals (i.e. input, common and output voltage terminals respectively).

2.7 OVERVIEW OF THE COMPONENTS USED.

2.7.1 PRACTICAL AMPLIFIER

An amplifier is a device which raises the level of a signal voltage,or power.In this project,the intercom system employs the LM386.So the audio amplifier chosen is LM386[10].

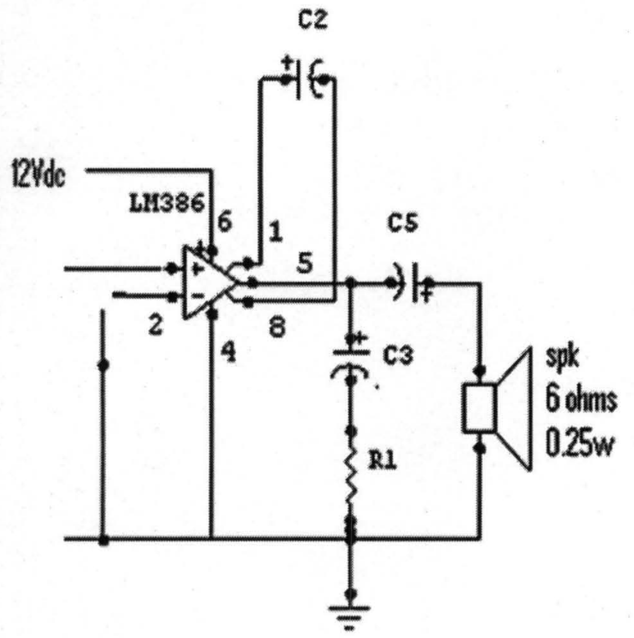


Fig2.11 An audio amplifier circuit.

2.7.1(a) Description low voltage audio power amplifier

The LM386 is an audio power amplifier designed for use in low voltage consumer applications. The inputs are ground referenced while the output automatically biases to one-half the supply voltage. The quiescent power drain is only 24milliwatts when operating from a 6 volt supply, making the LM386 ideal for battery operation [10].

2.7.1(b) Features of the LM386 IC

1- Battery operation

2- Minimum external parts

3- Wide supply voltage range :4V–12V or 5V–18V

4-Low quiescent current drain: 4mA

5- Voltage gains from 20 to 200

6- Ground referenced input

7- Self-centering output quiescent voltage

8- Low distortion: 0.2% (AV = 20, VS = 6V, RL = 8W, PO =

125mW, f = 1 KHz)

9- Available in 8 pin MSOP package

2.7.1(c) Applications of LM386 IC

1- AM-FM radio amplifiers

2- Portable tape player amplifiers

3- Intercoms

4- TV sound systems

5- Line drivers

6- Ultrasonic drivers

7- Small servo drivers

8- Power converters

2.7.2MICROPHONE

The transmitter is designed to modulate voice signal [4]. Then the voice signal is fed to the circuit through an electrets microphone.

Fig2.12 Speaker

2.7.3 THE CHANGE OVER SWITCH

In electronics, a switch is an electrical component that can break an electrical circuit, interrupting the current or diverting it from one conductor to another [13]. The most familiar form of switch is a manually operated electromechanical device with one or more sets of electrical contacts. Each set of contacts can be in one of two states: either 'closed' meaning the contacts are touching and electricity can flow between them, or 'open', meaning the contacts are separated and the switch is nonconducting. The mechanism actuating the transition between these two states (open or closed) is normally of the toggle (flip switch for continuous "on" or "off") or momentary (push-for "on" or push-for "off") type. Through the use of logic gates, momentary switches can also activate timed-activation circuits [13]. A switch may be directly manipulated by a human as a control signal to a system, such as a computer keyboard button, or to control power flow in a circuit, such as a light switch. A switch that is operated by another electrical circuit is called a relay.

In a push-button type switch, in which the contacts remain in one state unless actuated, the contacts can either be normally open (abbreviated "n.o." or "no") until closed by operation of the switch, or normally closed ("n.c. or "nc") and opened by the switch action. A switch with both types of contact is called a changeover switch. These may be "make-before-break" which momentarily connect both circuists, or may be "break-before-make" which interrupts one circuit before closing the other.

➢ **power switching**

When a switch is designed to switch significant power, the transitional state of the switch as well as the ability to with stand continuous operating currents must be considered. When a switch is in the on state its resistance is near zero and very little power is dropped in the contacts; when a switch is in the off state its resistance is extremely high and even less power is dropped in the contacts. However when the switch is flicked the resistance must pass through a state where briefly a quarter (or worse if the load is not purely resistive) of the load's rated power is dropped in the switch. For this reason, power switches intended to interrupt a load current have spring mechanisms to make sure the transition between on and off is as short as possible regardless of the speed at which the user moves the rocker. Power switches usually come in two types.

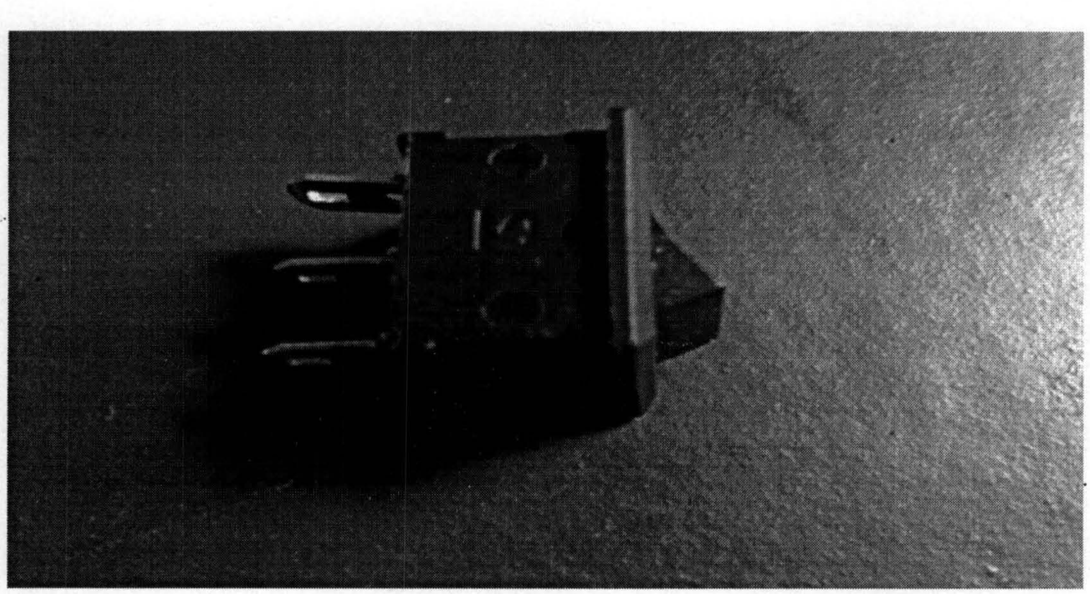


Fig2.13 push- button type switch

2.7.4RELAY

A relay is an electrically operated switch [11]. Many relays use an electromagnet to operate a switching mechanism mechanically, but other operating principles are also used. Relays are used where it is necessary to control a circuit by a low-power signal (with complete electrical isolation between control and controlled circuits), or where several circuits must be controlled by one signal. The first relays were used in long distance telegraph circuits, repeating the signal coming in from one circuit and re-transmitting it to another. Relays were used extensively in telephone exchanges and early computers to perform logical operations. Since relays are switches, the terminology applied to switches is also applied to relays. A relay will switch one or more poles, each of whose contacts can be thrown by energizing the coil in one of three ways:

- Normally-open (NO) contacts connect the circuit when the relay is activated; the circuit is disconnected when the relay is inactive. It is also called a Form A contact or "make" contact. NO contacts can also be distinguished as "early-make" or NOEM, which means that the contacts will close before the button or switch is fully engaged.
- Normally-closed (NC) contacts disconnect the circuit when the relay is activated; the circuit is connected when the relay is inactive. It is also called a Form B contact or "break" contact. NC contacts can also be distinguished as "late-break" or NCLB, which means that the contacts will stay closed until the button or switch is fully disengaged.
- Change-over (CO), or double-throw (DT), contacts control two circuits: one normally-open contact and one normally-closed contact with a common terminal. It is also called a Form C contact or "transfer" contact ("break before make"). If this type of contact utilizes "make before break"functionality, then it is called a Form D contact.

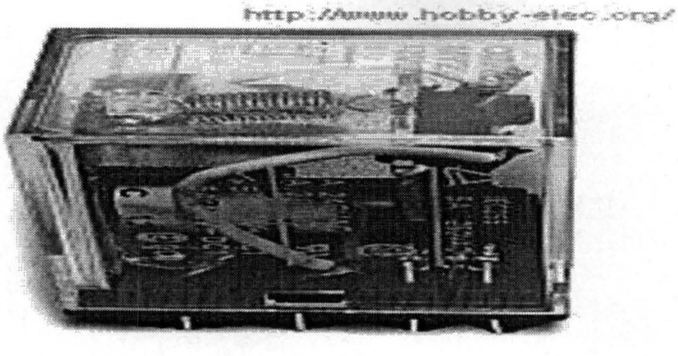


Fig2.14 An electromagnetic relay

2.7.5 LOUD SPEAKER

The loudspeaker is a device that produces sounds of an acoustical nature from pure electrical signal [4]. This signal has itself gone through many subsidiary chains before reaching the terminal of the loudspeaker. In these chains there have been many kinds of links (acoustical, mechanical, electrical and electromagnetic).

There are four basic types of loudspeakers: the dynamic, functioning by interaction of magnetic fields, the electrostatic, functioning by means of electrostatic fields, the crystal, functioning by stresses produced within crystal formations and the ionic, functioning by the electromagnetic pulsing of a gaseous atmosphere [4].

Basically, the dynamic loudspeaker is made up of the following components:

- The voice coil
- The voice coil former
- The centering spider
- The magnet
- Magnet circuit
- The diaphragm(core)
- The apex radiator

2.7.6 DIODE

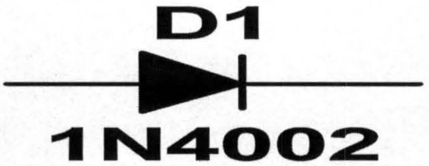
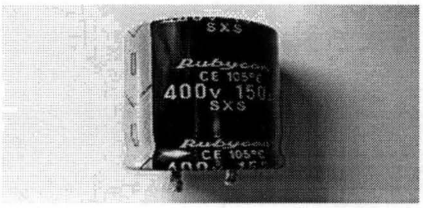


Figure 2.15 Diode

- In electronics, a diode is two terminal electronic components [14]. A semiconductor diode, the most common type of diode today, is a crystalline piece of semiconductor material connected to two electrical terminals. A vacuum tube with two electrodes, a plate and a cathode[14]
- The most common function of a diode is to allow an electric to pass in one direction (called the diodes forward direction), while blocking current in the opposite direction (the reverse direction). This unidirectional behavior is called rectification and is used to convert alternating current to direct current, andto extract modulation from ratio signals in ratio receivers [14].
- However, diodes canhave more complicated behavior than the simple on-off action. Semiconductor diodes do not begin conducting electricity unit a certain threshold voltage is present in the forward direction (a state in which the diodes is said to be forward biased). The voltage drop across a forward biased diode varies only a little with the current, and is function of temperature, this effect can be used as a temperature sensor or voltage reference.
- Semiconductor diodes have non-linear electrical characteristics, which can be tailed by varying the construction of their P-N junction. These are exploited in special purpose diodes that perform many different functions. For example, diode are used to regulate voltage (zener diode), to protect circuits from high voltage surges (avalanche diode) to

electronically tune ratio and TV receivers (varactor diodes), to generate ratio frequency oscillations (tunnel diode, gunn diode, IMPATT diode), and to produce light emitting diode[14].

2.7.7 CAPACITOR



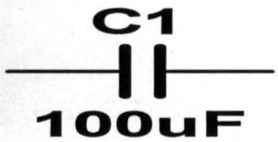


Figure 2.16 Electrolytic capacitor symbol of capacitor

A capacitor (formally known as condenser) is a passive electronic component consisting of a pair of conductors separated by a dielectric (insulator), when there is a potential difference (voltage) across the conductors; a static electric field develops across the dielectric, causing positive charge to collect on one plate and negative change on the other plate. Energy is stored in the electrostatic field. An ideal capacitor is characterized by a single constant value, capacitance, measured in farads. This is the ratio of the electric charge on each conductor to the potential difference between them.

Capacitors are widely used in electronic circuits for blocking direct current while allowing alternating current to pass, in filter networks for smoothing the output of power supplies in the resonant circuit diode that tune ratios to particular frequencies and for many other purposes [6]

2.7.8 RESISTOR

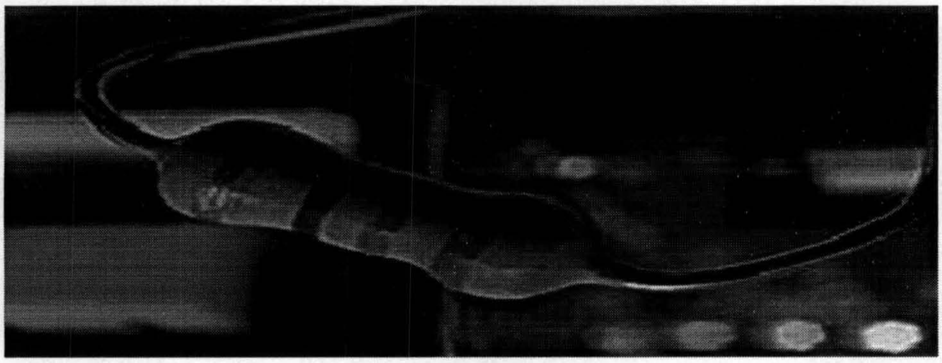


Figure2.17 Resistors

A resistor is a two terminal passive electronic component that implements electrical resistance as a circuit element when a voltage “V” is applied across the terminals of a resistor, a current “I” will flow through the resistors in direct proportion to that voltage resistors are also specified as having a maximum power rating which must exceed the anticipated power dissipation of that resistor in a particular circuit: this is manly concern in power electronics applications. Resistors with higher power rating s are physically larger and may require heat sinks. In a high voltage circuit, attentionmust sometimes be paid to the rated maximum working voltage of the resistor [12].

2.7.9 BUZZER

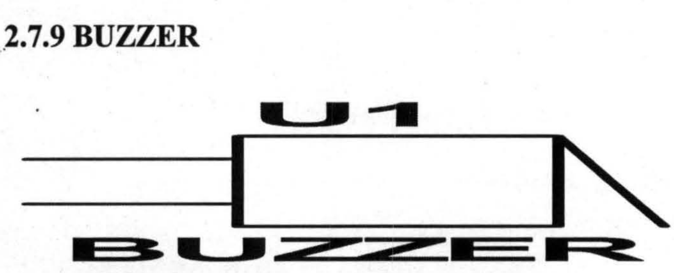


Figure 2.18 symbol of buzzer

A buzzer or beeper is an auction signaling device which may be mechanical, electromechanical or piezoelectric. Typically uses of buzzers and beepers include alarms, timers and confirmation of user input such as a mouse click or keystrokes [6]

CHAPTER THREE

DESIGN AND IMPLEMENTATION

3.1 DESIGN ANALYSIS

The design of the intercom system with a changeover switch was carried out analytically and by selection of the components based on their characteristics, affordability and availability.

The circuit arrangement is divided into five sections that is power supply unit, the audio signal input, the audio signal amplifier, the changeover circuit as well as the output signal

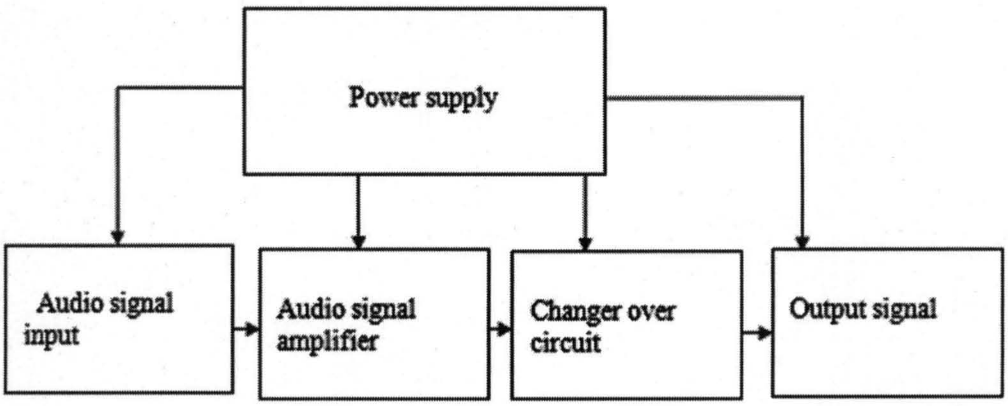


Fig.3.1 Block diagram of an intercom system with changeover switch.

3.2 DESIGN OF POWER SUPPLY CIRCUIT

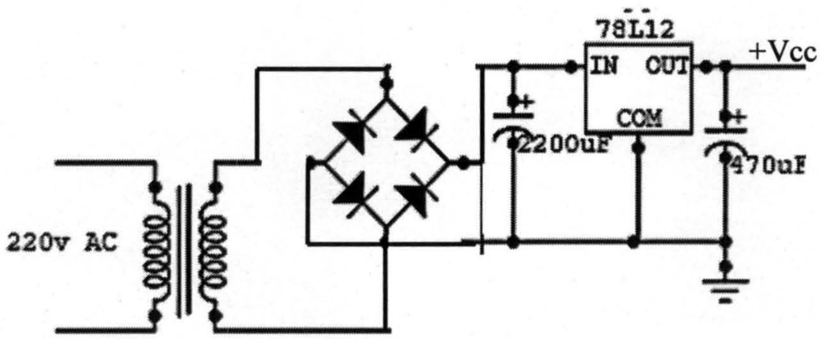


Fig 3.2 Power Supply Circuit

The power supply comprises basically about four (4) components:

- Transformer
- Rectifier
- Filter
- Regulator

3.2.1SELECTION OF TRANSFORMER

Since thea.c power supply rating of Nigeria is 220-240V,50HZ, a step down transformer of 230V primary voltage and 12V secondary voltage with secondary current rating of 300mA (a.c to d.c rectified voltage, 12V) rating is used.

R_L = V/I = 12/0.3 = 40Ω

Turns ratio (k) = Vs/Vp = 12V/240V = 1/20 = 1:20

Or = 0.05< 1 => a step down transformer

d.c current Id.c = (2Irms√2)/π

d.c current Id.c= $(2\times300mA\times\sqrt{2})/\pi$

Id.c. approx. = 270mA is the maximum secondary current that can flow.

The voltage across the bridge diode is Vdc, where Vd.c= Vrms$\sqrt{2}$. But since

Vs = Vrms; Therefore

V d.c. = $12\sqrt{2} = 16.97$

3.2.2 SELECTION OF RECTIFIER DIODES

The diode used is IN4007 because of its low peak inverse voltage (PIV) of about 50V. and a bridge rectifier is used because it helps to further lower the PIV.

Because in either positive or negative half cycle we have two diodes, the diodes forward voltage (Vf) or the d.c. across the rectifier (Vd.c.) diodes is multiplied by 2, i.e.,

PIV = 2× Vd.c = 2× 17 = 34V

PIV=34V is used for the design which is less than the 50V rated PIV. Note Vf is taken as 0.7V for general design calculation and is less than 1.1V i.e. Vf = 0.7V and Vf<1.1V.

The peak inverse voltage is the maximum reverse voltage a diode can withstand before it breaks down since the output voltage of the transformer is 12V with d.c. voltage of 17V, the bridge rectifier diode of PIV above Vd.c (17V) is needed which can handle 500mA. IN4007 diodes are selected to achieve this PIV (PIV of IN4007 = 50V)

3.2.3SELECTION OF FILTERING CAPACITOR

The output of the bridge rectifier has ripples whose voltage V_R is calculated as,

$V_R = V_{PP} - V_{RMS}$..3.0

Where V_{PP} = peak voltage of the secondary

V_{rms} = root mean square voltage

Also $V_r = I_{d.c} / 2fc$...3.1

Where f = Frequency of the power supply in HZ

C_1= capacitance in farad, Capacitor C_1 should have the capability to filter all ripples voltages in the supply.

I.d.c=d.c current

$V_{PP} - V_{RMS}$ = I.d.c/2fc...3.2

C_1 = I.d.c/2f(V_{PP}-V_{RMS})...3.3

I.D.C=300mA, f = 50Hz, V_{PP} =17V, V_{RMS} = 12V

C_1 =300mA/ (2×50(17-12))

C_1 = 600 μF

Hence, an electrolytic capacitor of capacitance greater than 600μF (i.e. 2200μF,35V) was selected for better filtration, bearing that the higher the value of the capacitor the lesser the ripples.

3.2.4 SELECTION OF VOLTAGE REGULATOR

For optimum operation of the circuit, it is necessary to have a good regulated voltage. Therefore 7812 regulator IC was selected for the purpose because of its high quality precision.

3.3 DESIGN OF THE MODULATION CIRCUIT

The design of the modulation circuit would involve analysis of microphone operation. The transmitter will be designed to modulate voice signal the voice signal will be fed to the circuit through an electrets microphone. This is shown below

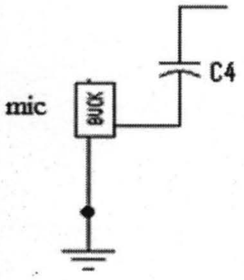


Fig. 3.3 Electrets microphone

There is need for a coupling capacitor to couple microphone with the modulator.

$$X_C = \frac{1}{WC_4} \qquad \text{.......... 3.4}$$

$$C_4 = \frac{1}{WX_C} = \frac{1}{2\pi f X_C} \qquad \text{.......... 3.5}$$

$$C_4 = \frac{1}{2 \times 3.142 \times 50 \times 600}$$

Xc = input impedance of the electrets microphone (600Ω)

$C_4 = 2.2\mu f$

3.4 DESIGN OF AMPLIFIER CIRCUIT

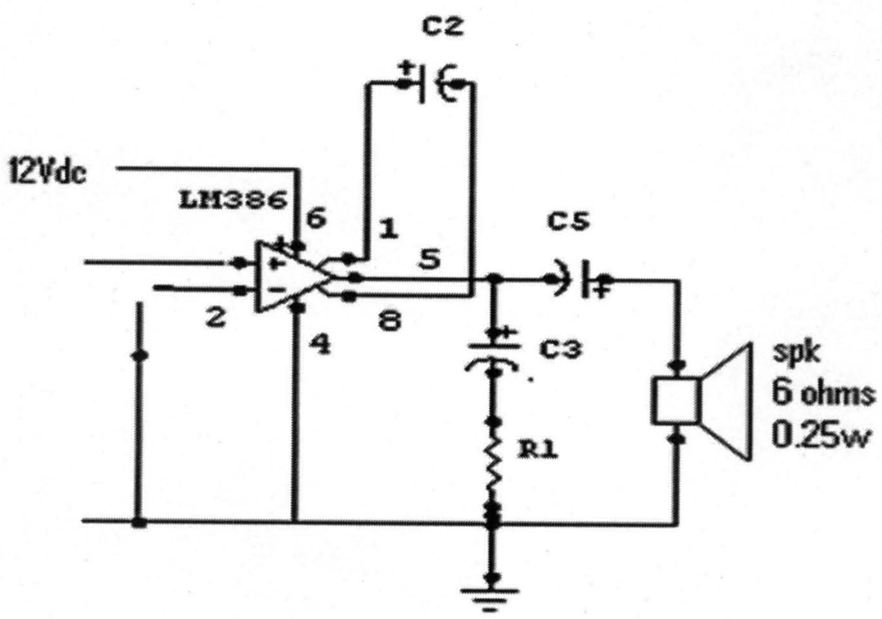


Fig.3.4 An audio amplifier circuit

General description low voltage audio power amplifier

General description low voltage audio power amplifier

The LM386IC is an audio power amplifier designed for use in low voltage consumer applications. The inputs are ground referenced while the output automatically biases to one-half the supply voltage. The quiescent power drain is only 24milliwatts when operating from a 6 volt supply, making the LM386 ideal for battery operation.

Features of the LM386 IC

1- Battery operation

2- Minimum external parts

3- Wide supply voltage range: 4V–12V or 5V–18V

4-Low quiescent current drain: 4mA

5- Voltage gains from 20 to 200

6- Ground referenced input

7- Self-centering output quiescent voltage

8- Low distortion: 0.2% (AV = 20, VS = 6V, RL = 8W, PO = 125mW, f = 1 KHz)

9- Available in 8 pin MSOP package

Applications of LM386 IC

1- AM-FM radio amplifiers

2- Portable tape player amplifiers

3- Intercoms

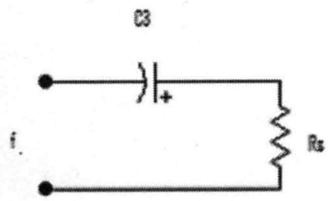
4- TV sound systems

5- Line drivers

6- Ultrasonic drivers

7- Small servo drivers

3.4.1 DETERMINATION OF CAPACITOR C3 (2.2μF) AT THE OUTPUT OF THE SPEAKER.



C_3 is a low pass RC filter.

$f = 1/(2\pi R_s C_3)$ = 1KHz =output frequency of the astable...3.6

Rs = speaker resistance (6Ω,0.25W)

$C_3 = 1 / (2\pi \times 1000 \times 6)$

$C_3 = 0.265\mu F$ (10uF, 25V preferred value for volume control).

C_3 is connected to ground from pin 5 to eliminate any internal noise.

For this amplifier, to calculate the values of components connected to it:

Having decided on 0.25W output and 6Ω speakers the required output current and voltage can be calculated. If P and V denotes the rms power and voltage, respectively, then,

$P = V^2/R_L$..3.7

Gives $V = \sqrt{PR}$..3.8

Therefore V, $= \sqrt{(0.25\times6)} = \sqrt{1.5} \Rightarrow V=1.22V$

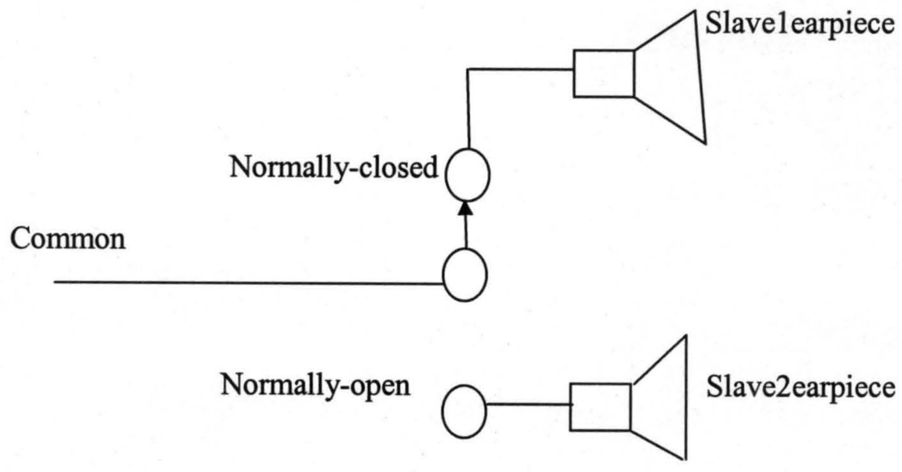
Therefore the voltage across the loudspeaker is 1.22V

3.5 SELECTION OF RELAY

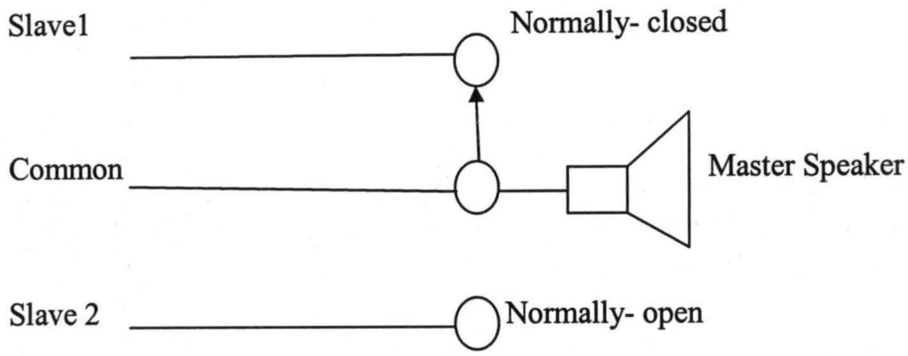
A relay is an electrically operated switch controlled by one signal. The first relays were used in long distance telegraph circuits, repeating the signal coming in from one circuit and re-transmitting it to another. Relays were used extensively in telephone exchange. Hence the relay chosen is 12V, 10A

3.6 WORKIKG PRINCIPLE

The design of two- line intercom system with a telephone changeover switch was achieved using two electromagnetic relays and a change over switch. This project was designed for one master and two slaves that is slave 1 and slave 2.The changeover switch is responsible for changing between slave 1 and slave 2, the switch was connected to the two relays wired parallel to each other. When the switch is closed, it allows current to flow through the coil of the two relays and cause them to switch from normally-closed (NC) to normally-open (NO).The first relay which is normally –closed is shown below;



The normally- closed is connected to the slave 1 earpiece while the normally- open is connected to slave 2 earpiece and the common is the output of the master audio amplifier to determine whether slavel or slave 2 is hearing from the master and the second relay was wired as shown below;



The common connected to the earpiece of the master while the normally-closed was connected to the output of the audio amplifier of the slave 1 and normally open is connected to the audio amplifier of slave 2 to determine who is speaking to the master depending on the condition of the changeoverswitch. The switch 1 is the press- to-push switch on the power supply unit and its used to power ON/OFF the intercom system.

More so, two buzzers and two push button switch was also incorporated for the master to alert his slaves any time he want to communicate with them ,each switch work for a buzzer while each buzzer for each slave. Whenever master push button 1, buzzer 1 sound to alert slave 1 and when he pushes button 2, buzzer 2 sound to alert slave 2 that the master want to have conversation with him.

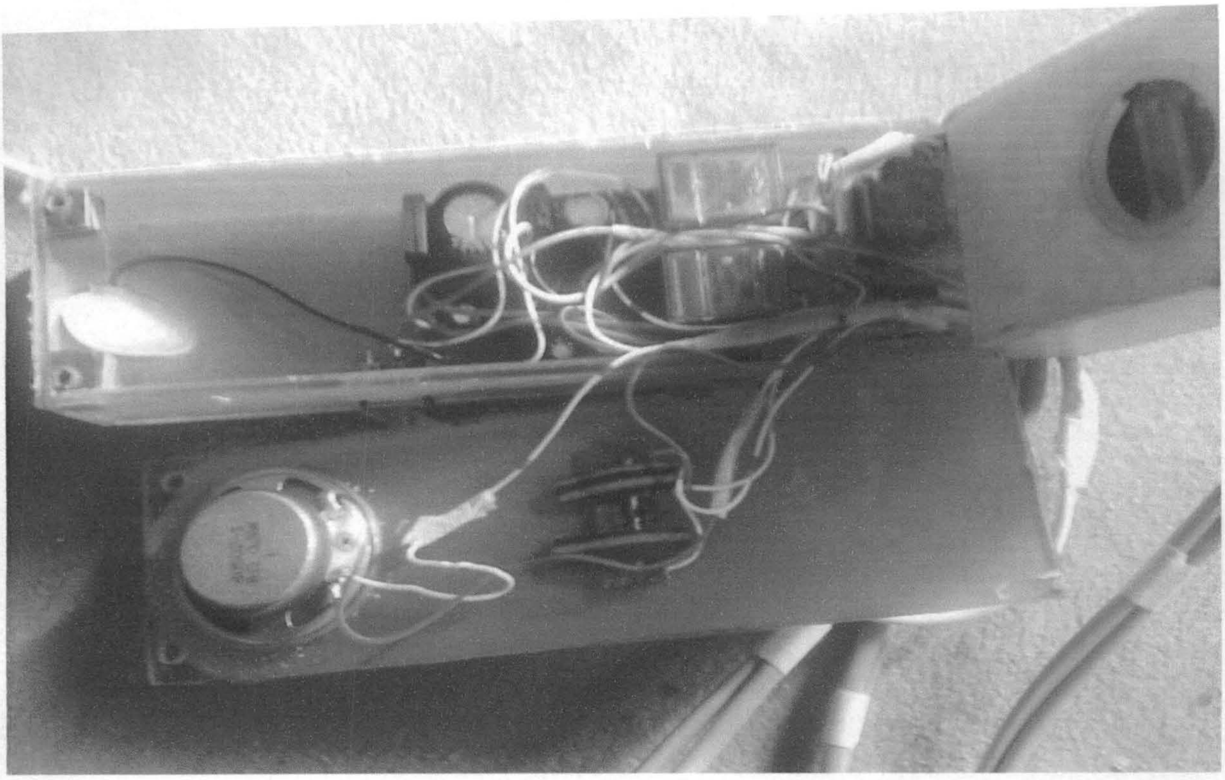


Fig 3.5 Internal circuitry of the master unit

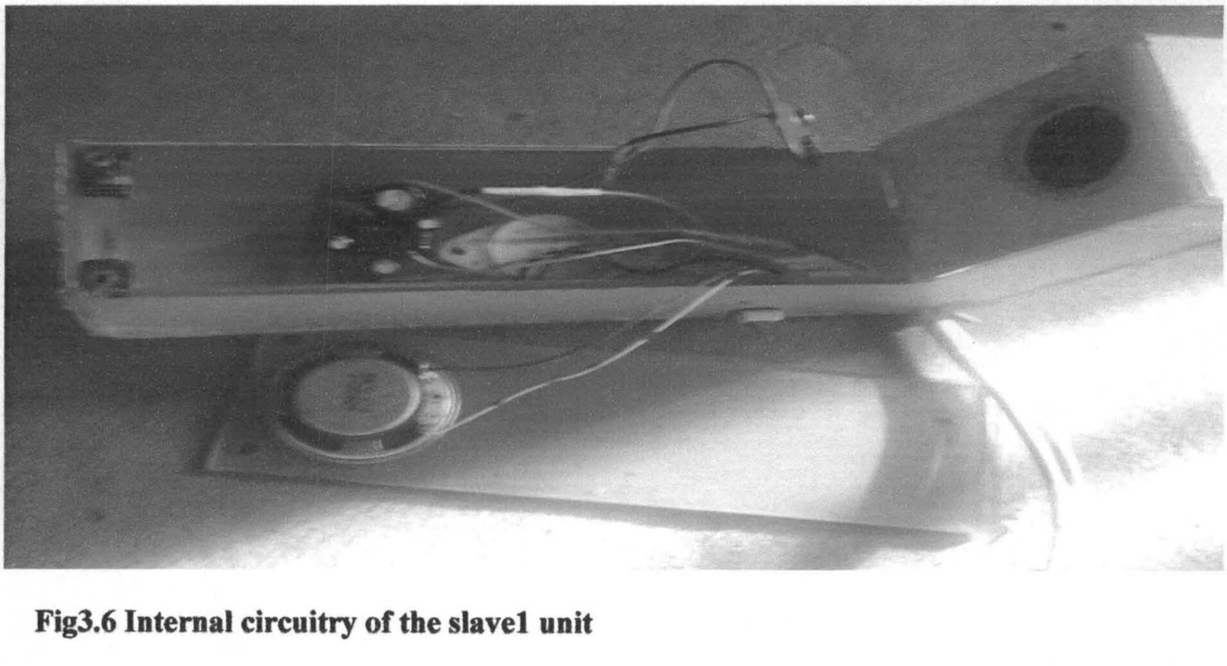


Fig3.6 Internal circuitry of the slave1 unit

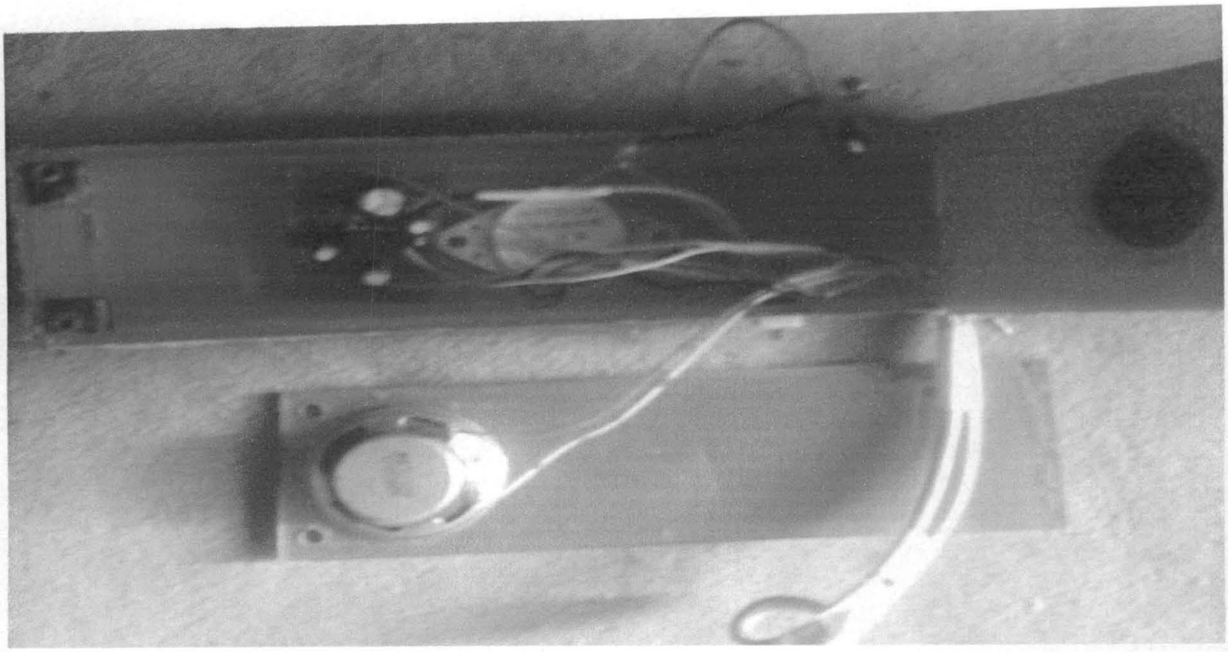


Fig3.7 Internal circuitry of tphe slave 2 unit

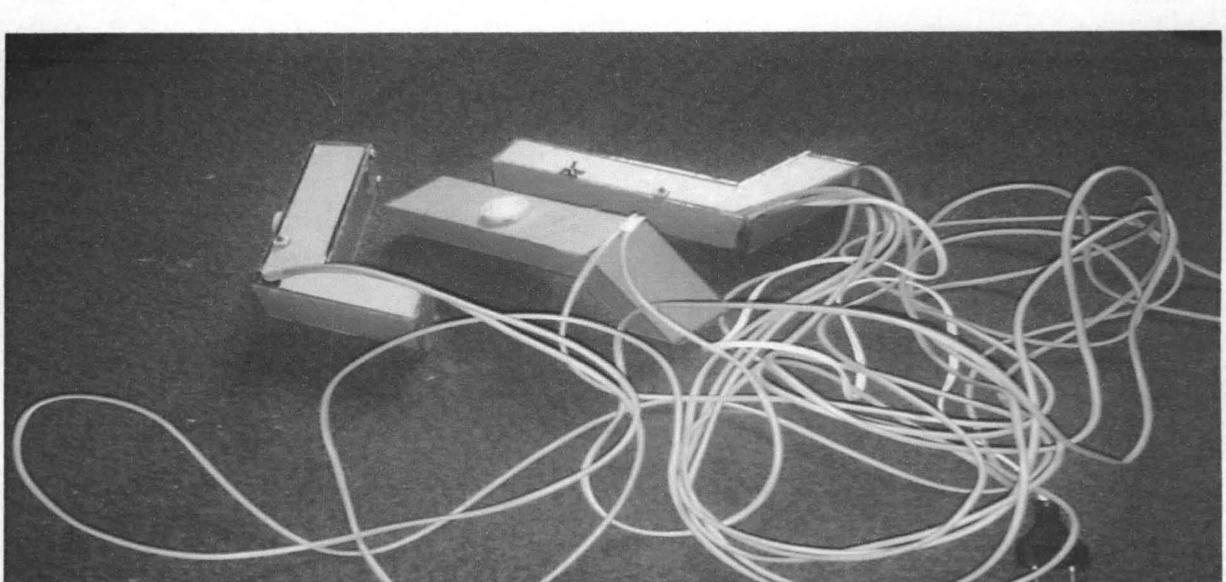


Fig3.8 General casing of the construction

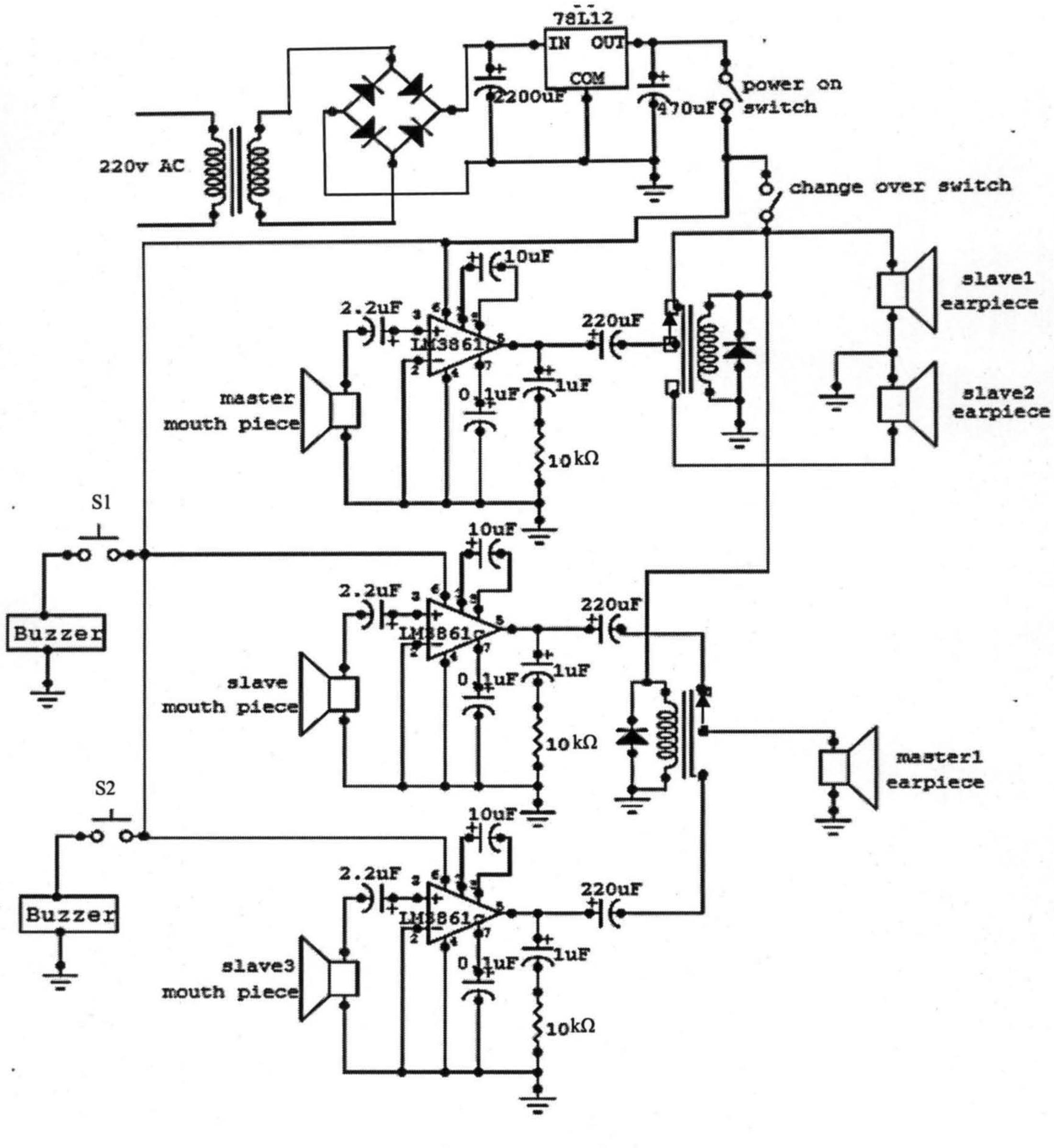


Fig 3.9 Complete circuit Diagram of two- line intercom system with Telephone change over switch.

CHAPTER FOUR

CONSTRUCTION, TESTING AND RESULTS.

4.1 CONSTRUCTION

The construction of this project was in several parts: the main circuit which comprises of the audio signal input, audio signal amplifier, change over circuit, output signal and power supply circuit. The construction of the circuit was implemented by fixing various components and units as shown in the previous chapters. The whole circuit was soldered on veroboard using 40W soldering iron and 60/40 flux cored soldering lead.

The Veroboard is an insulator strip comprising several parallel tracks of strips with small holes drilled along its length, giving a matrix format. It is made of plastic, and provides adequate insulation between connected components. The components are fixed to the veroboard by placing each pin of the component in accordance with the specified design This is to ensure immovability of the components; hence this stage of construction is referred to as the final circuit construction. Soldering the component was done with care to prevent damage to the components. The tip of the soldering lead was used.

Uniformity of the arrangement of components with the tested design was ensured to eliminate the need to remove components for the purpose of correction, after the circuit would have been completely soldered. Also, the concept of the conventional telephone casing was considered for the design of the project casing. The choice material was transparent plastic because of its light weight and transparency. The dimensions of the casing were considered withrespect to the size of the components, and space was given for subsequent additions. The casing was first designed and implemented on paper using the knowledge of engineering drawing and necessary modification was made before the actual construction was carried out to ensure that the finished work closely resembled what was conceived.

The various components of the intercom system were put together by fixing them in their appropriate places on the constructed plastic casing.

4.2CONSTRUCTION MATERIALS

- Soldering iron
- Lead alloy solder
- Vero board
- Connecting wires
- Multi-meter
- Circuit components
- Bread board

4.3TESTING

Since a unit by unit approach was used in the construction, each of the units was simulated on electronic work bench software and tested afterwards on bread board to certify that they work independently and correctly. Each unit was tested one after the other as the project implementation proceeded.

- The switching circuit was implemented and tested on the breadboard
- The audio amplifiers circuits were tested to ensure that they worked without any noise
- The changeover switch circuits were tested and then coupled to ensure that they were able to switch ON/OFF, the voice circuit was then addressed.
- The signal circuit was also tested.

4.4 RESULTS

4.4.1POWER SUPPLY CIRCUIT

Table 4.0 power supply circuit Result

PARAMETER TESTED	MULTIMETER READING
Main Power source	219.72 V
Secondary Voltage of transformer	11.51V
Rectified Voltage	16.95V
Filtered Voltage	14.85V
Regulated Voltage	11.65V

The results from Electronic Workbench software is shown below;

Main power source 219.72

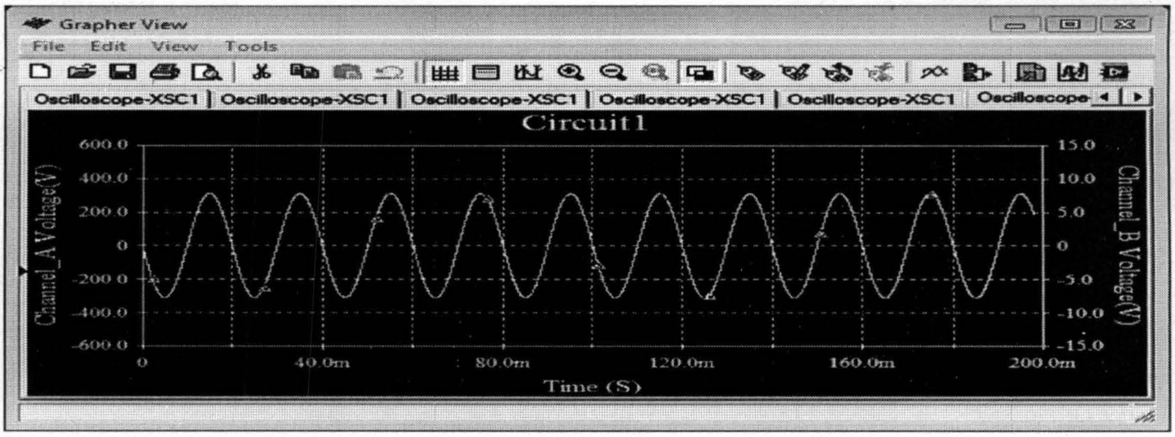


Fig4.0 A simulated main power source

Secondary Voltage of Transformer, 11.51V

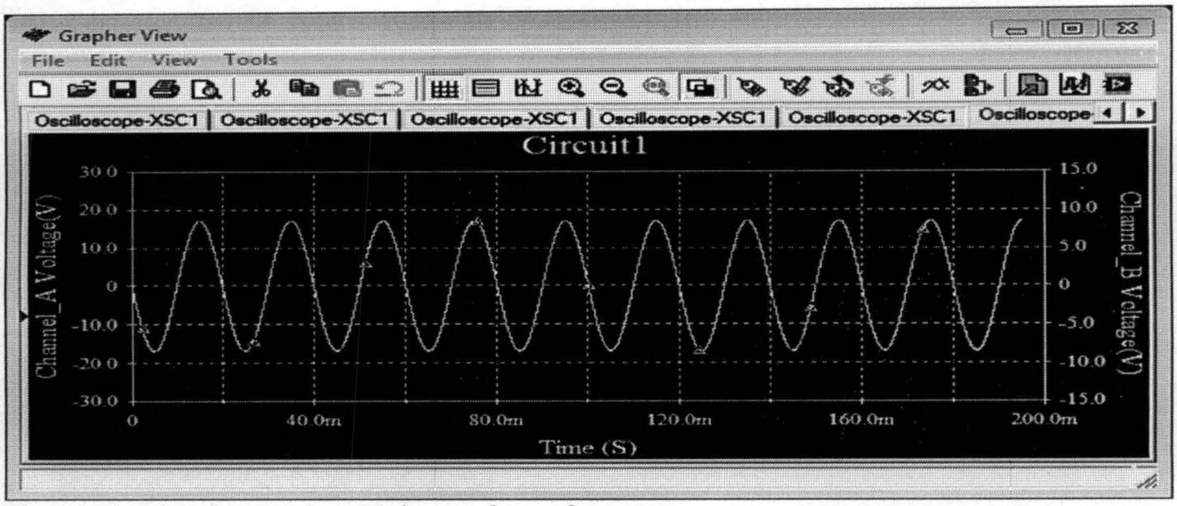


Fig 4.1 simulated secondary Voltage of transformer

Rectified voltage, 16.95V

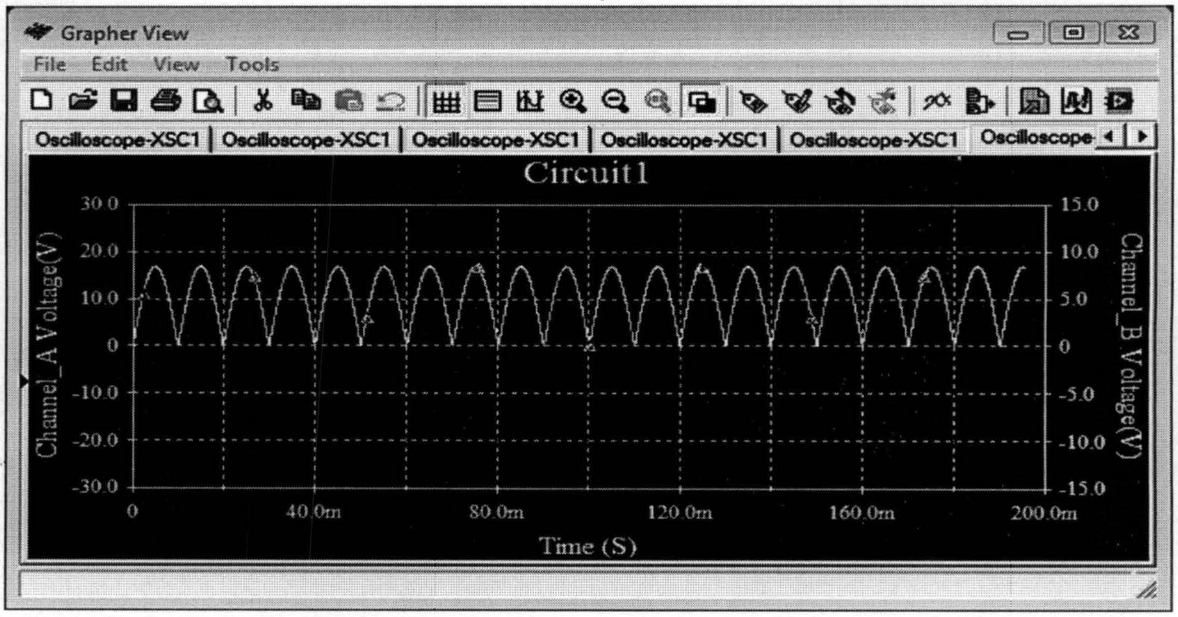


Fig 4.2 Simulated Rectifier Voltages

Filtered voltage, 14.85V

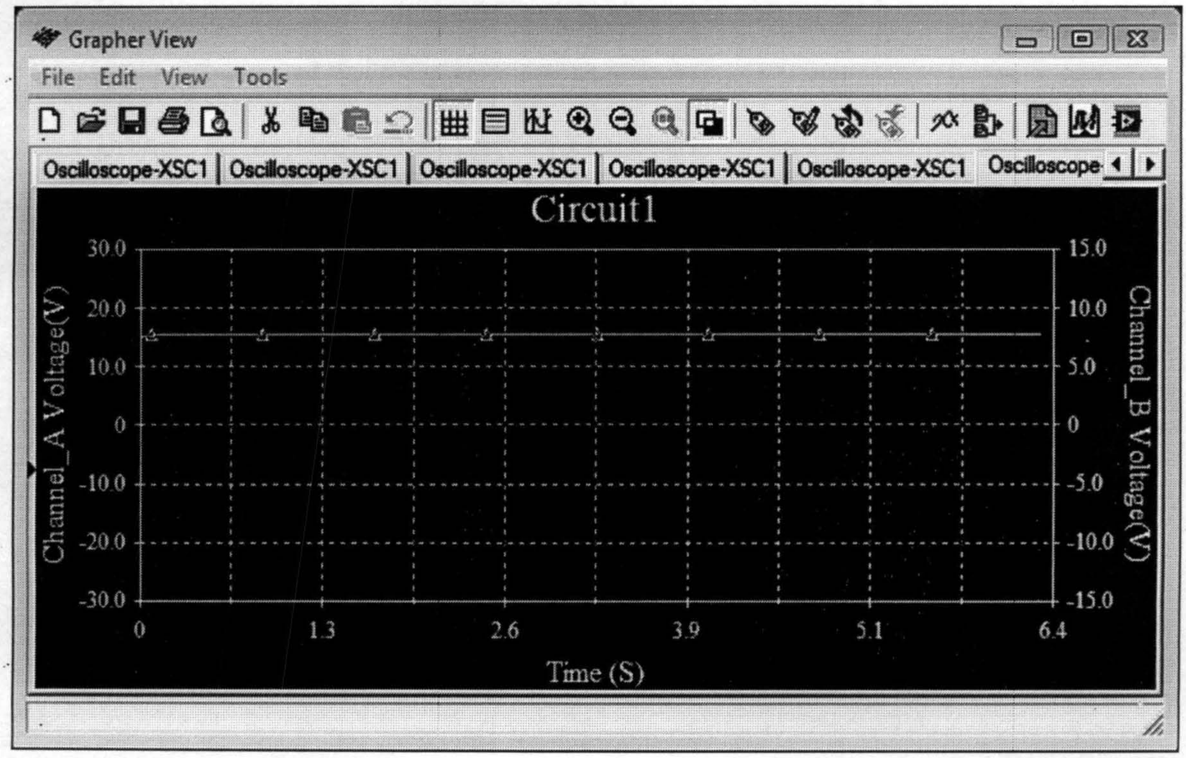


Fig4.3 Simulated Filtered Voltage

Regulated voltage, 11.65V

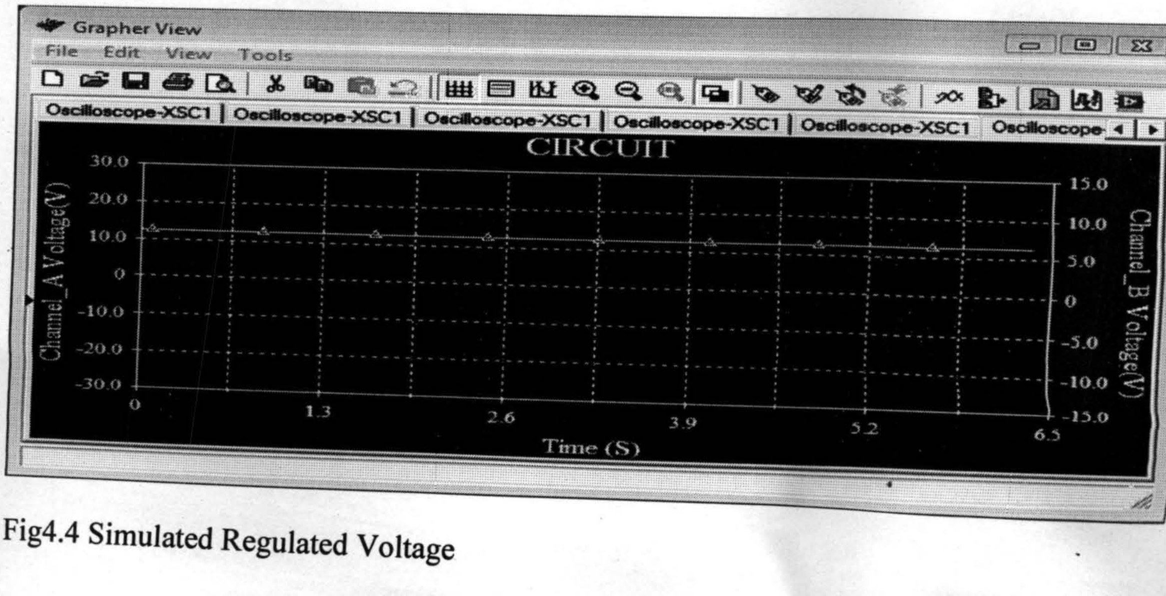


Fig4.4 Simulated Regulated Voltage

4.4.2 AUDIO AMPLIFIER CIRCUIT

Audio amplifier Gain Results;

Voltage gain was set at 100

Table 4.1 Audio Amplifier gain Result

Vin	Vout
1mV	0.1V
5mV	0.5V
10mV	1V

The simulation results from Electronic Workbench software is shown below;

Vin=1mV

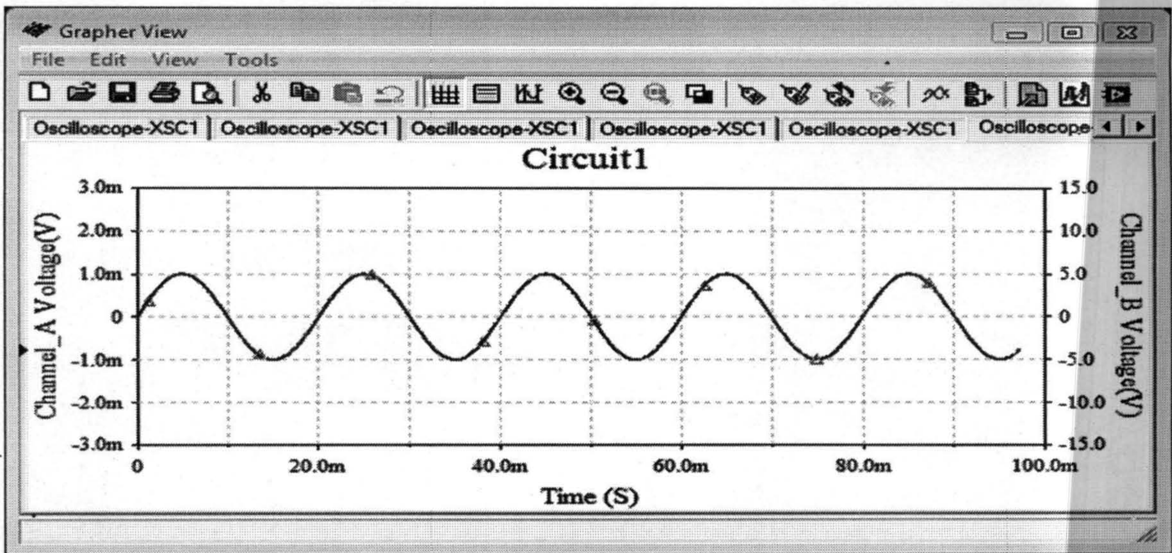


Fig4.5 Simulated input voltage

Vo=100mV

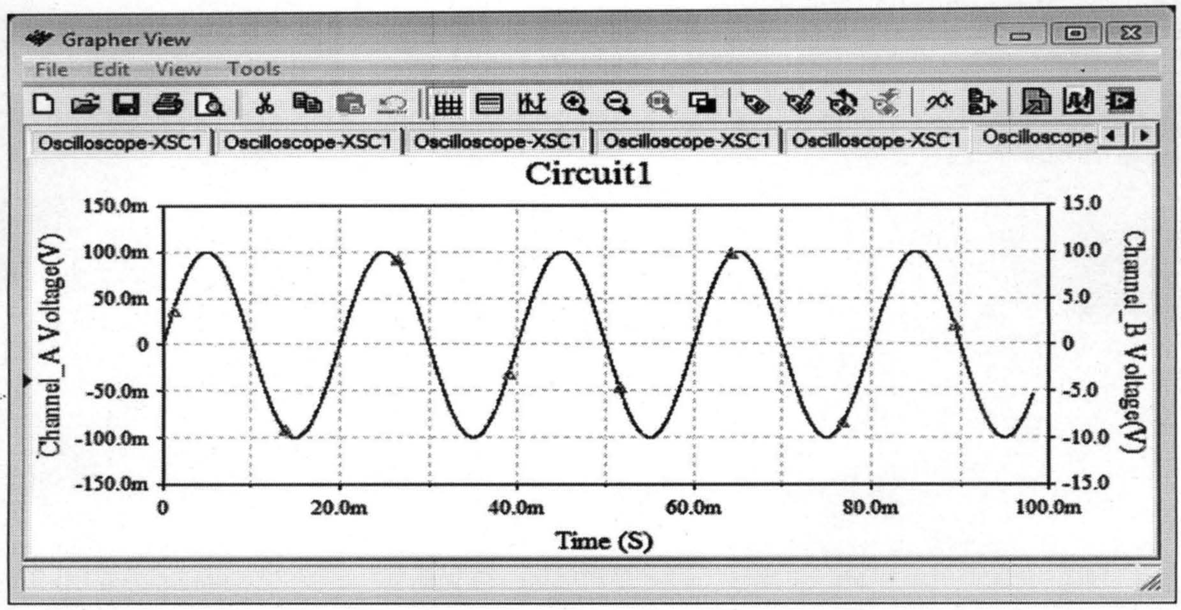


Fig4.6 Simulated output voltage at100mV

Vin=5mV

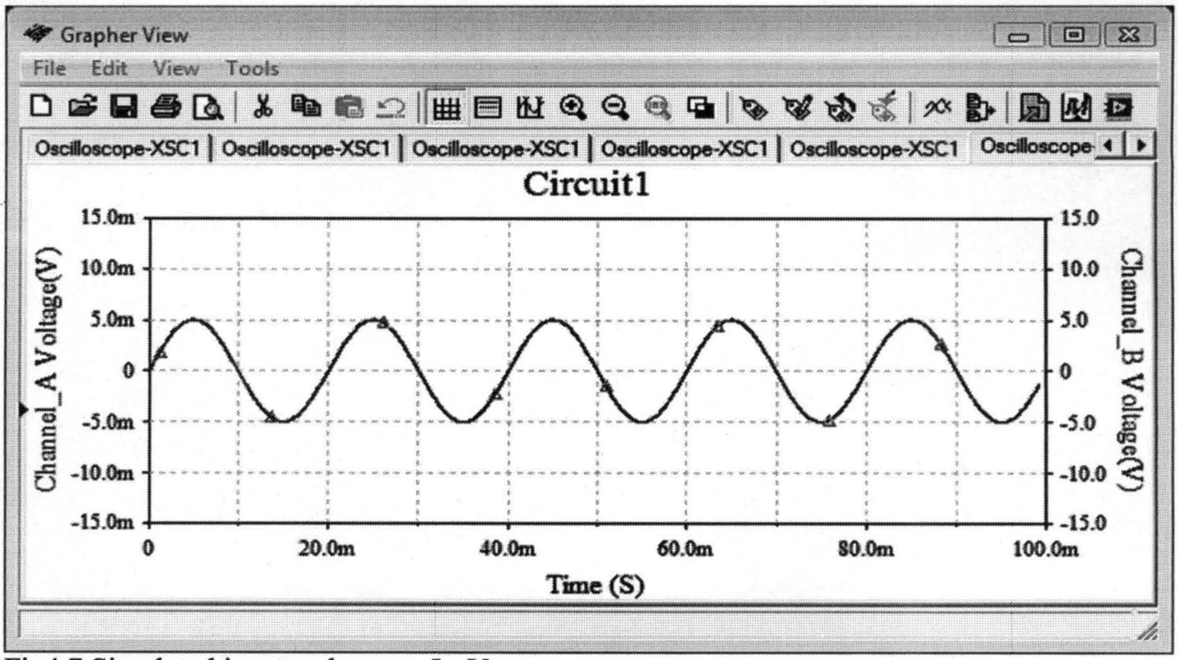


Fig4.7 Simulated input voltage at 5mV

Vo=500mV

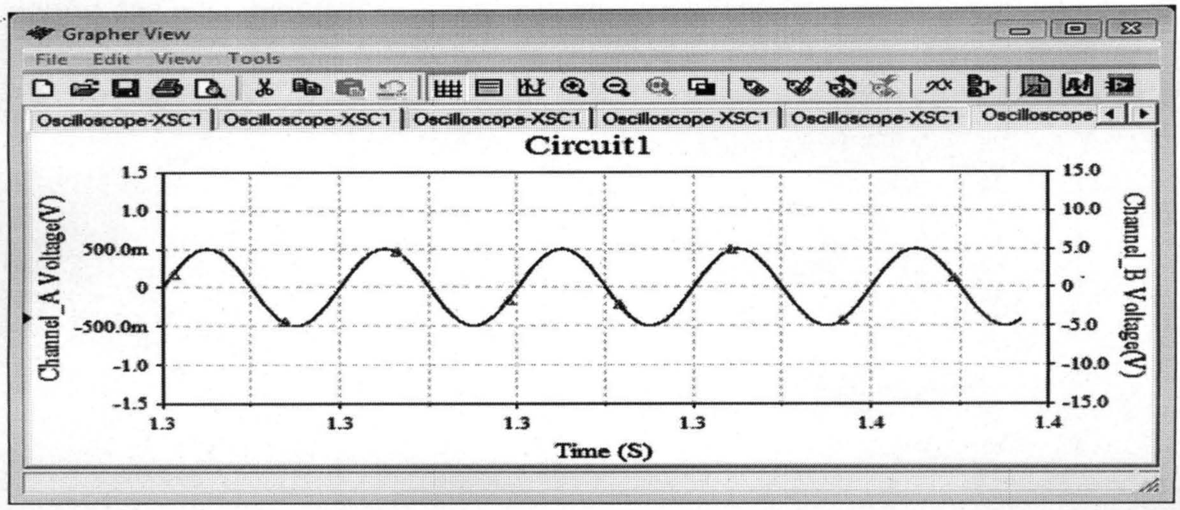


Fig4.8 Simulated output voltage

Vin=10mV

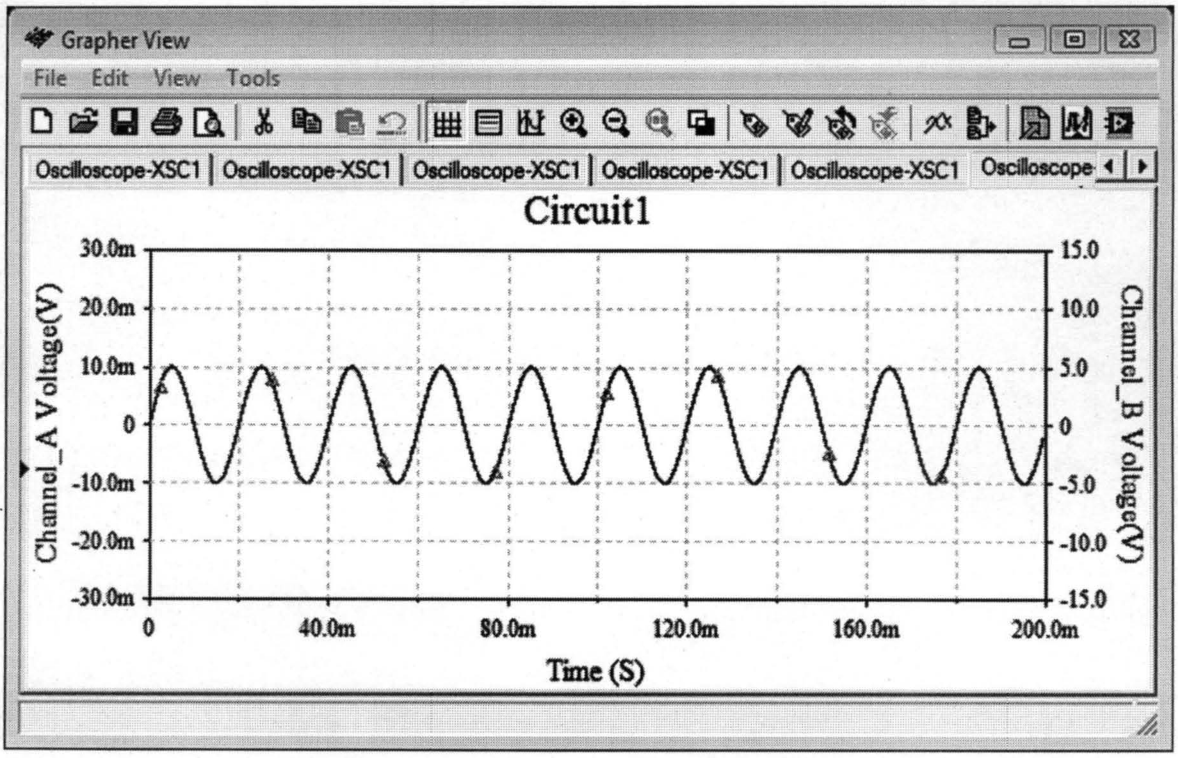


Fig4.9 Simulated input voltage.

Vo=1V

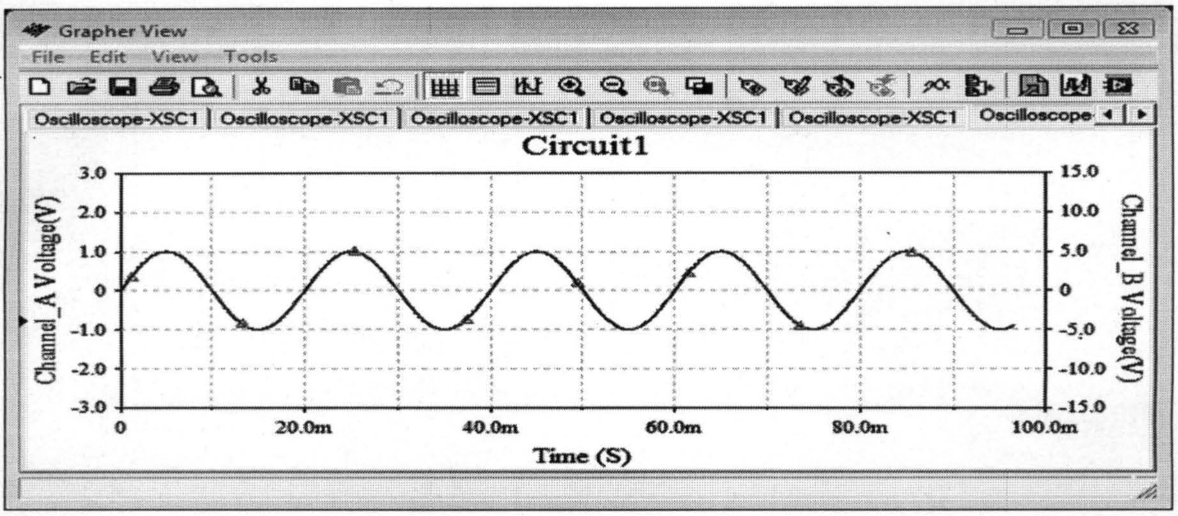


Fig4.10 Simulated output voltage

4.4.3 ACTUAL GAIN RESULTS FROM THE CIRCUIT

The actual gain results determined from actual measurements of the circuit is tabulated below:

Table 4.2 Actual gain results

Vin	Vout
1.3mV	98mV
4.7mV	540mV
9.6mV	960mV

Table 4.2 Actual gain results

The actual gainresult wasplotted as shown below;

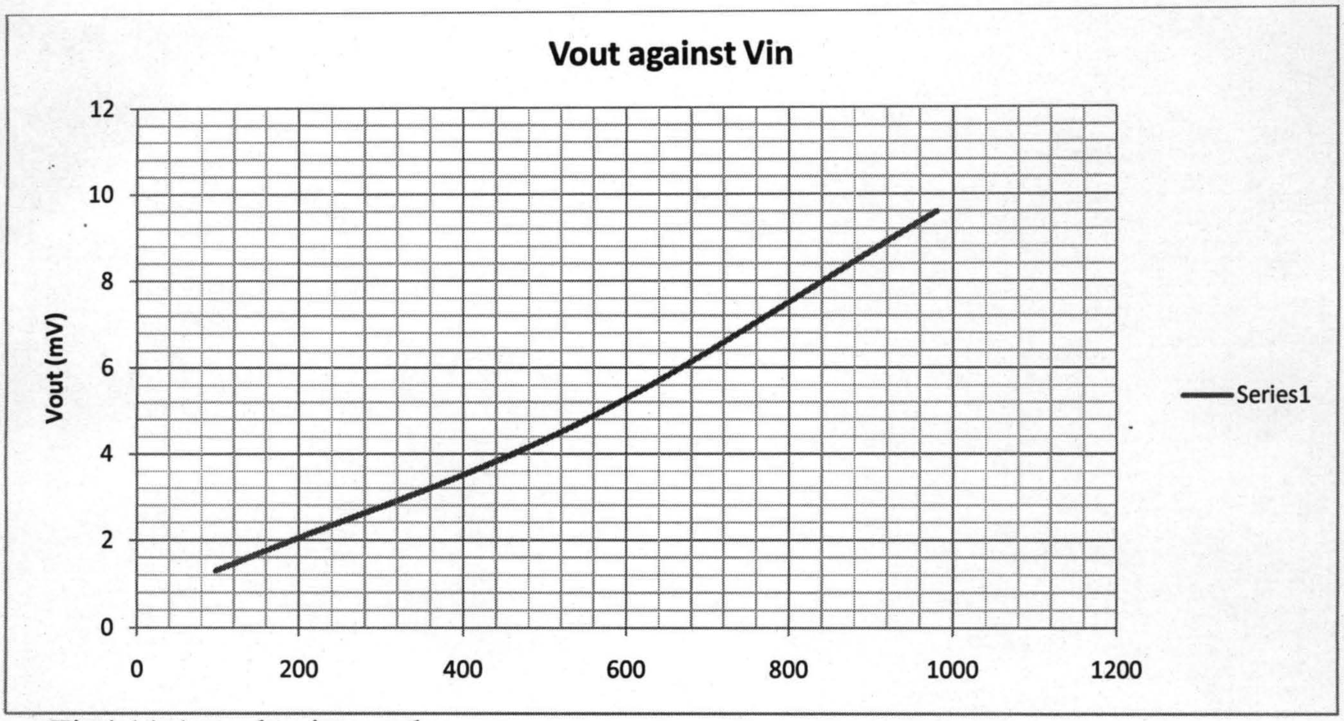


Fig4.11 Actual gain graph

- **Determination of the actual gain results.**

The gain slope= $\frac{\Delta Vo}{\Delta Vin}$

Gain slope □$\frac{Vout2-Vout1}{Vin2-Vin1}$

Gain1 $= \frac{540-98}{4.7-1.3} = 130$

Gain 2 $= \frac{960-540}{9.6-4.7} = 85$

The average sum of the gain slope $= \frac{G1+G2}{2} = 107.5$

The actual gain =107.5

Expressing the actual gain in terms of decibel (G_{dB}) = $20\log_{10}{}^{107.5}$=40.6dB

4.4. 4 DISCUSSIONOF THE ACTUAL GAIN RESULTS

The actual gain results from the circuit were calculated as 107.5 and the ideal gain of the audio amplifier from the manufacturer data sheet range from 20 to 200. Therefore, the calculated actual gain from the circuit falls within a range.

4.4.5 CHANGE OVER SWITCH

Table 4.4 Change over switch Result

RELAY	MULTIMETER READING
Relay input voltage	12V
Relay Resistance	400Ω

4.6 LIMITATIONS

COST; The telephone cable that connects the master unit to the slaves unit, ideally should be made very long but since the telephone cable is expensive so, 5 metres long was used.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1CONCLUSION

This project covers the design and construction of the two-line intercom system with a telephone change over switch. The system was designed primarily to enhance internal communication within a home, school, small offices and factories. The design and construction of an intercom system was chosen for its ability to provide ease of communication and performance of the circuit was satisfactory.

5.2RECOMMENDATIONS

The following are steps that can be taken to upgrade this project;

- The power of the audio amplifier can be increased by cascading two or more LM386IC to increase the range of transmission.
- The telephone cable/ wire should be made longer in order to have long distance of communication. And thicker wires should be used to produce good audio output.
- It is necessary to improve on the modulation unit, so that the voice signal would be clearer.
- The circuit can be modified to suit the requirements for larger places or organizations.

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