

**DESIGN AND CONSTRUCTION OF A
FULL-DUPLEX FOUR WAY
INTERCOM**

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DEPARTMENT**

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**DESIGN AND CONSTRUCTION OF
FULL DUPLEX FOUR-WAY
INTERCOM
BY
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2001/12027EE**

**A THESIS SUBMITTED TO THE
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COMPUTER ENGINEERING.**

**FEDERAL UNIVERSITY OF TECHNOLOGY,
MINNA
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NIGERIA.**

NOVEMBER 2007

DEDICATION

I dedicate this Thesis to the invincible helper, who has been with me through the thick and thins of my studies. You are my every thing (**ALMIGHTY GOD**)

To my beloved and sweet mother **MRS LAMI JACOB MAKAMA** and to my beloved father, late **Mr. JACOB MAKAMA AUTA**. It is unfortunate that you are not alive to see what your son has become. You brought me to this world. I will forever be indebted to you. And finally to my grandma, Late Azuga as you were fondly called, I love you all.

ATTESTATION/DECLARATION

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

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ABSTRACT

An intercom is a telecommunication device, which allows a normal conversation between people separated by certain distance. A sporadic improvement has been registered over the year because of the importance of telecommunication. This project is designed to help in enhancing communication within organization, offices and rooms at a relatively cheaper rate. The Full-duplex four-way intercom is designed with a logical switch over circuit capable of selecting a desired channel operational amplifier (LM 386) is used to amplify the audio input signal for higher audio quality and to reduce noise interference. Digital switch is used to achieve a logical switching between channels (stations). A multivibrator is used to produce equal duty cycle of sound wave generated so that it comes up for a second and goes off for another second. The overall circuit is powered by either 9V d.c battery or main supply. All the components are cased in a plastic casing to prevent electric shock, to beautify the work and easy mobility. The working ability of the circuit is as designed and the cost is relatively cheap.

The circuit will work more effectively on electronic printed circuit board.

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CHAPTER ONE

INTRODUCTION

1.0 GENERAL INTRODUCTION

Intercom uses a simple telephone technology so it is development that uses or utilizes telephone for the purpose of communication within a specified distance and area. In the case of this project (FOUR OFFICES/ROOMS) is our target. Each intercom is a master of its own.

The intercom is a cheap and effective means of communication within organization. The designed is done to solve a particular problem or need of communication in an organization. So it play the role of been the most of internal communication within an organization. The name intercom came from the role it plays (INTERNAL COMMUNICATION) the operation could be either manual or automatic (PABX).

Considering our world today, there are lots of dangers, competitions, information to be passed across, business transaction and accidents. Hence there is need for communication system in order to succeed or pervade (alleviate) this dangers in matter of seconds.

In the past human beings and animal of higher intelligence have communicated before through body movement, Drums beats, Fire, smoke signal, cutting of leaves and use instrument in terms of horns in order to communicate dangers, direction and discovery foot path etc. The revolution of electronics technology has been embraced by man and hence the need for better communication system in line of GSM, Telephone (Intercom), etc.

Alexander Graham Bell (1847-1922) became famous for his invention of the telephone. As a teenager of 18, Bell had been trying to solve human problem of communications by experimenting the idea of transmitting human speech. In 1847 while working on a multiple telegraph he develops the basic idea for the telephone, He and his assistant, Thomas Watson finally proved successful on March 10, 1876. When the first telephone message was transmitted "Watson, come here; I want you" [1] this led eventually to the establishment of the Bell Telephone company still in existence today, which introduce telephone to the world.

Communication has continue to be a back bone of the world economy, social and technological development. And hence the development of communication system in different ways is necessary. This led to the idea of designing and construction of intercom which is just a small aspect or type of communication system? It's used within a particular environment, offices and laboratories. To aid the speed dissemination of information this is important for nation development.

Information may be useful to different people in different ways. it could save lives, it could bring investment opportunity, it could bring joy or sadness and it could it bring development. [2]. But however any information that is not convey from its source to its source to its destination is not useful since it can not achieved it desired goal.

Information could be in two forms; Analogue and Digital considering the scope of this project, analysis is base on analogue, in this case voice signal other examples of analogue signals are: Temperature, Video, Pressure etc.

1.1 OBJECTIVES

The major aim of this work (project) is to make communication easier, cheaper, effective and assessable to small organizations, house hold and ordinary man. The design is to aid communication within offices and also to save the cost of paying BILLS when not necessary. This project finds it application in our local industries and firms.

1.2 METHODOLOGY

The methods employed in the designed of the intercom are analyzed as follow: The circuit is designed using mesh topology and the circuit is designed to be power by both ac main supply and 9 Volt batteries. The source is step down to the desired 9V by the transformer and converted to dc by the rectifying circuit build into the system. The circuit is designed to be dial by a dialing button and as soon as the handset is picked up, the other two stations are automatically cut off from the conversation of the two stations. Digital switching circuit is used to achieve the switching of the stations.

1.3 SCOPE

The scope of this project is a four way intercom system which is a modernization or step higher of two way intercom. It is designed as a full duplex. This means that both people can communicate at the same time. In order to achieved this, the used of two wires to four wire hybrid circuit is used.

The intercom has four stations (users) who can communicate independently. The distance can cover, that is the maximum distance is 1000metres, but can be increased with the help of repeaters. Mesh topology is used to achieve less cost, more effective network and more efficient circuit. It has a digital switching circuit to provide independent communication among users and improved security. It is powered by main

supply and a 9V battery each station is assigned a tone and a number to access the station.

1.4 CONSTRAINTS

The constraints encountered were on the availability of materials such as text books, components for digital switching circuit and financial constraints.

1.5 PROJECT LAY OUT

The project is arranged in five chapters as listed below:

Chapter one: Introduction

Chapter two Literature review/ Theoretical Back ground

Chapter three: Design and implementation.

Chapter Four: Test, Result and discussion of Results

Chapter five: Conclusion and recommendation

CHAPTER TWO

LITERATURE REVIEW/ THEORETICAL BACKGROUND

2.1 HISTORICAL BACKGROUND

The history of communication is as old as man himself. From history past man has been using various means and principle to communicate with his fellow men e.g. using of gun fire, leaves, smokes and horns etc.

Late in 17th century a significance step was made in the in the communication industry, when Robert Hooke proposed a Law called Hooke's law that help in inventing a stringed telephone that could convey sound through an extended wire over a particular distance by means of vibration [4]. With work of other people like Faraday, Davy, Sturgeon and other people in the field of Engineering create and pave way for Graham Bell that make a lead way in the communication industry by inventing the first telephone [1].

In 1877 Graham Bell discovered that is only a steady direct current that could be transmitted in place of a physical human voice. A year later he invented the first telephone that could transmit and receive human voice with high quality efficiency. [5]

Since then technology has been experiences a sporadic development and great improvement has been registered. Graham Bell telephone has the following components, Receiver, Transmitter and connecting wires. Receiver and transmitter were design a like (Identical), they both had metallic diaphragm that were flexible and single horse power Shoe magnet with coil. A provision of sound waves that strike the diaphragm causing it to vibrate in the field generated by the magnet. The vibration in turn generate and electric

Current (D.C) in the coil that is varying in proportion to the level of vibration of the diaphragm. The produced dc traveled in the connecting wires to the receiver where the strength of the magnetic field is at the receiver to vibrate, which in turn reproduced the original sound [6] which complete the cycle of communication as shown in figure 2.1.

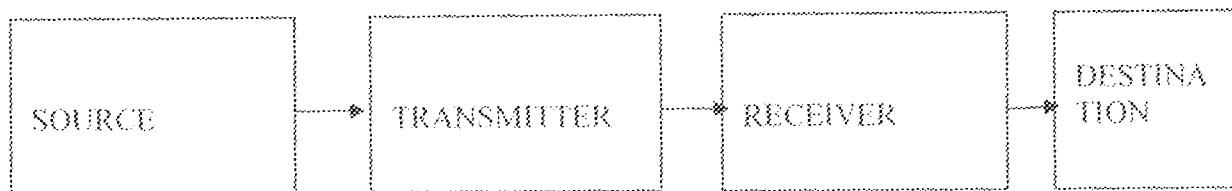


Figure 2.1 Block diagram of communication system

The idea came to lime light on March 10, 1876, when the first telephone message was transmitted "Watson, come here, I want you" which led to the establishment of Bell Telephone company still existence today and this introduced telephone to the world. [1]

2.2 LITERATURE REVIEW

Presently a lot of works have been carried out in the field of intercom. A work was done on four way intercom in the department, but it was not a full duplex. It was done by Alhassan P.S.N. 98/7233EE. Titled FOUR WAY INTERCOM TELEPHONE SYSTEM WITH EXCHANGE another work was done by a student in Kaduna Polytechnic on VERSATILE INTERCOM department of electrical and electronics. With the experiences gained from previous work a challenge of designing a Full Duplex with logic circuit and a tone generator which were not in the previous work. So this work is a modernization (Improved technology) of normal intercom.

2.3 THEORETICAL BACKGROUND

Generally, this project is a combination of basic electrical components ranging

from Transformer, operational Amplifier, Capacitors, Resistors and small scale integrated circuit. Arrange to establish a communication link between two stations.

For effective and good understanding of the project circuit there is need to know the theory behind some of the components.

2.4 TRANSFORMERS

Transformer could described as a static (Stationary) piece of apparatus which electric power which electric power in one circuit is transformed into electric power of the same frequency in another circuit. [3] It can be either step up or step down transformer, which has corresponding increase or decrease current.

The physical operation of a transformer is mutual induction between two circuits linked by a common magnetic flux. The figure 2.2 shows a simple transformer.

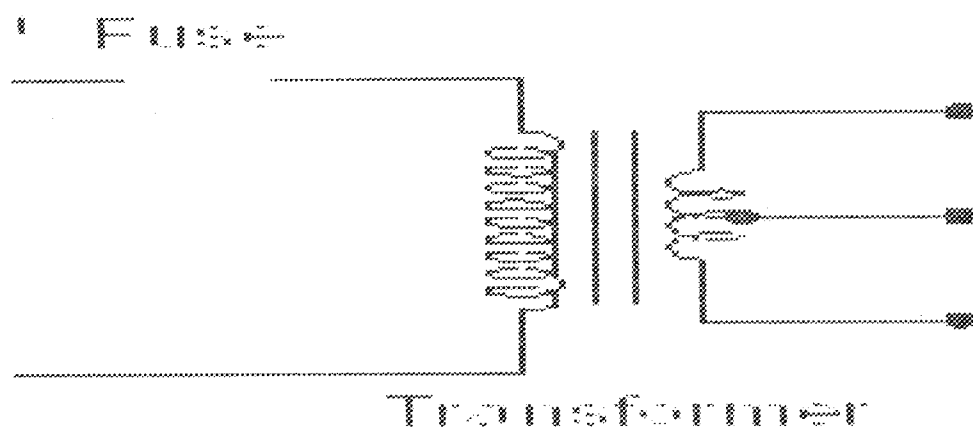


Figure 2.2 transformer

The transformer is given as; $E_2/E_1=N_2/N_1$

Where the terms are defined as;

E1-Primary EMF (Voltage)

E2- Secondary EMF (Voltage)

N1- Primary Windings

N2- Secondary Windings

2.5 OPERATIONAL AMPLIFIER

Operational Amplifier is a very high gain, high –input impedance directly coupled negative feedback amplifier which can amplifier signal having frequency ranging from 0Hz to some where beyond 1MHz. it has two inputs an inverting input pin and non-inverting inputs pins, it is so called because it was designed to performed mathematical operation like summation, multiplication, subtraction, differentiation and integration. The operational amplifier has it application as the building block of electronics system, the components of operational amplifier have been change over the years but the name Operational amplifier still continues, that is, it has found a wider usage. [7]

2.6 USES OF OPERATIONAL AMPLIFIER

- ◊ Scale changer
- ◊ Analogue Computer
- ◊ Instrumentation
- ◊ Control system
- ◊ Summation Integrator
- ◊ Differentiator
- ◊ Audio Power amplifier as used in this project.

The symbol of Op – amp as well as circuit symbol and connection are shown

Below:

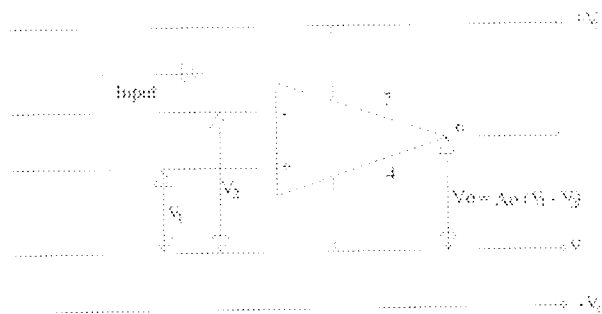
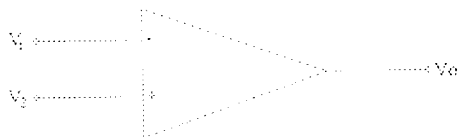


Fig 2.1 The Symbol of Op-amp.

Fig 2.2 The Circuit Connection.

2.7 AUDIO AMPLIFIER

As a matter of fact, in most communication receivers the final output stage is the Audio amplifier, the ideal audio amplifier will have the following characteristics.

- ◊ High gain
- ◊ Minimum distortion
- ◊ High input resistance (impedance)
- ◊ Low output resistance to provide optimum coupling to the speaker [8]

The figure below shows the circuit diagram of audio operational amplifier

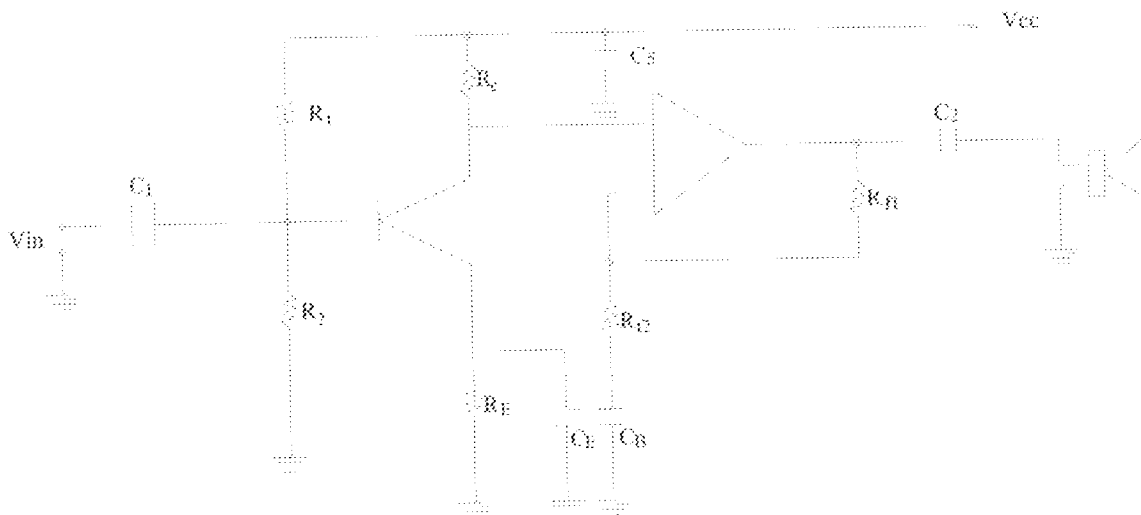


Fig 2.3 Audio Operational amplifier

The amplifier is supplied by only positive voltage power supply, the negative terminal is grounded. Because of this the output will be between the limits of -1V and +1V approximately. Notice the use of capacitor C2 which is used as a coupling capacitor between the operational amplifier and the speaker. It is necessary in order to reference the speaker signal around ground. C3 is also included in VCC line to prevent the transient current caused by operational amplifier. From being coupled back to Q1 through the power supply.

The high gain required is accomplished by the combination of two amplifiers stages. [9]

SOURCE: The signal source is human voice (Sound signal) which is converted by an input transducer in this case an electrets microphone.

AMPLIFIER STAGE: The amplifier stage is made of two stages namely pr---

amplification and audio power amplification stage.

The pre-amplification is done after the audio signal have been converted into electric signal. The signal is amplify a little bit and reason is to reduce noise due system components. A transistor voltage divider amplifier is used.

Audio power amplifier stage is a stage that amplified the pre amplifier signal into the required signal for transmission using a LM 386 an operational amplifier with a voltage gain of 20.

SWITCHING CIRCUIT: This is a digital logic circuit that is design to switch individual subscriber to there desired channel (stations) of call. A CD 4066 is used to achieved this, because it has a high switching speed.

TONE GENERATOR: Tone generator is a circuit design to generate ringing tones when a call is initiated by any subscriber and this tone continue to ring until a handset is picked up by the desired station or subscriber. This is achieved with the used of CD 4047.

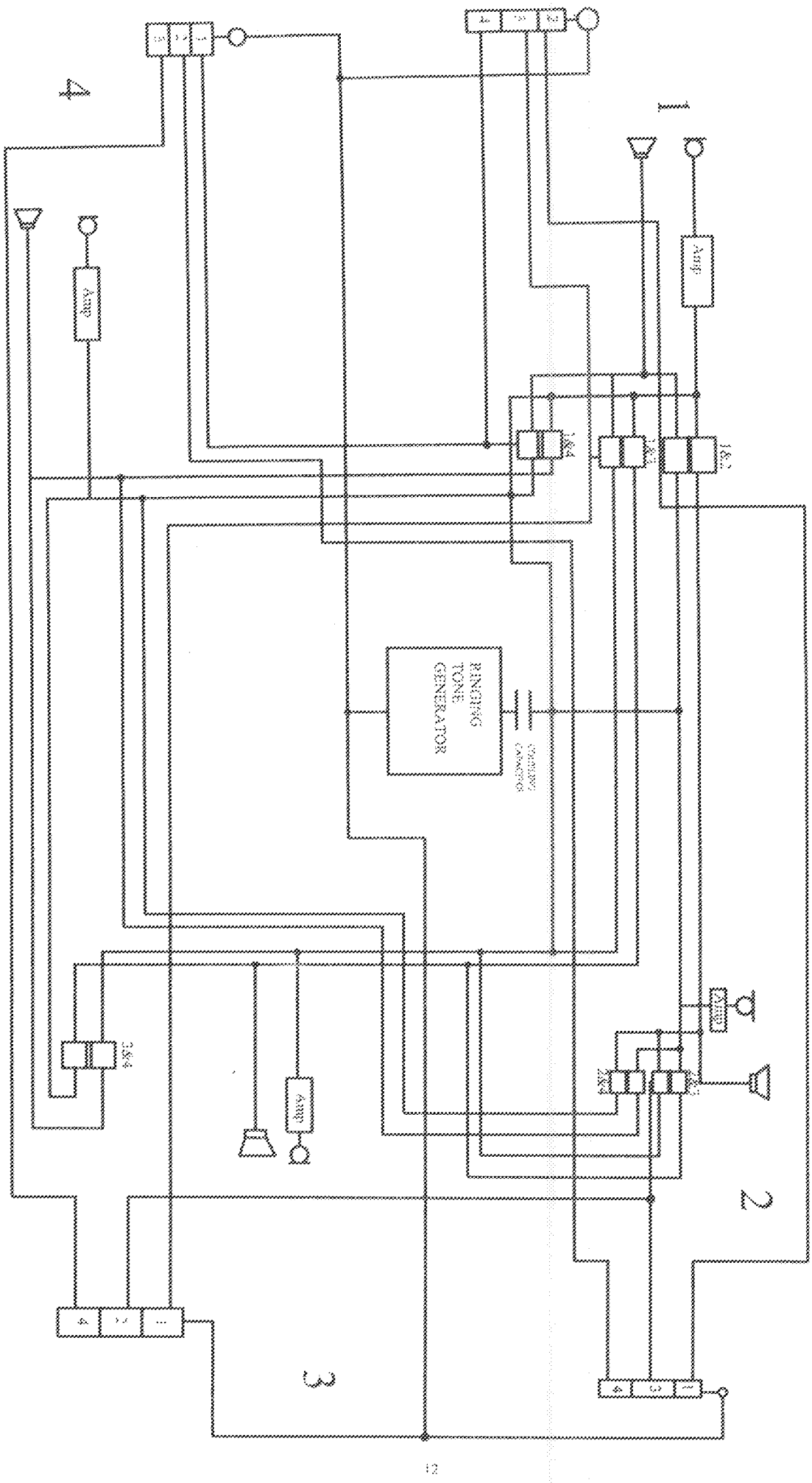


Figure 1.3 Sound Diagram

CHAPTER THREE

DESIGN AND IMPLEMENTATION

3.0 DESIGN CONSIDERATION AND SPECIFICATIONS

For effective functioning of the system (four channel intercom) the following consideration and specification were used.

- The intercom is meant for short distance coverage maximum of 100metres
- Four channels are considered in the network and they can communicate independently.
- The network topology used is the mesh topology which proves to more effective for this project.
- Digital switching is incorporated to provide independent switching and communication among the subscribers in the network and also provide security.
- Tone generation circuit is considered in order to alerts subscriber of an incoming call.
- The system is powered by both mains supply and a back-up 9V battery.

3.1 THE OPERATION OF THE SYSTEM

When a subscriber want to initiate a call, he presses a button corresponding to the number of the station he want to call, then a ringing is generated to alert the desired station and LED will also indicate the number where the caller want to call and equally at the receiver side the light LED shows the number where the call is coming from. In order to answer the call, an answer button is pressed, then the ringing tone will stop and the two subscribers can now talk b(communicate) to each other. When the communication is

over, the answer button is depressed again to be ready for receive call.

However, due to digital switching independent communication can be made within the network. This means that more than two subscribers can communicate to their targeted subscriber without each group hearing what other group are talking or without interruption to other group. This independent communication makes this project quite different from ordinary intercom others have done in the past.

3.2 POWER UNIT

The unit consists of battery and a.c main supply, which has a transformer to step down the voltage from 240V to desired 9V for the circuit.

From the a.c main supply after the voltage has been step down it is the pass through rectifier circuits which converts the a.c to d.c equivalent for the proper or desired form for the circuit. The diagram of simple transformer is shown above in figure 2.0. And below is the diagram of a 9V D.C battery.



Figure 3.0 9V D.C Battery

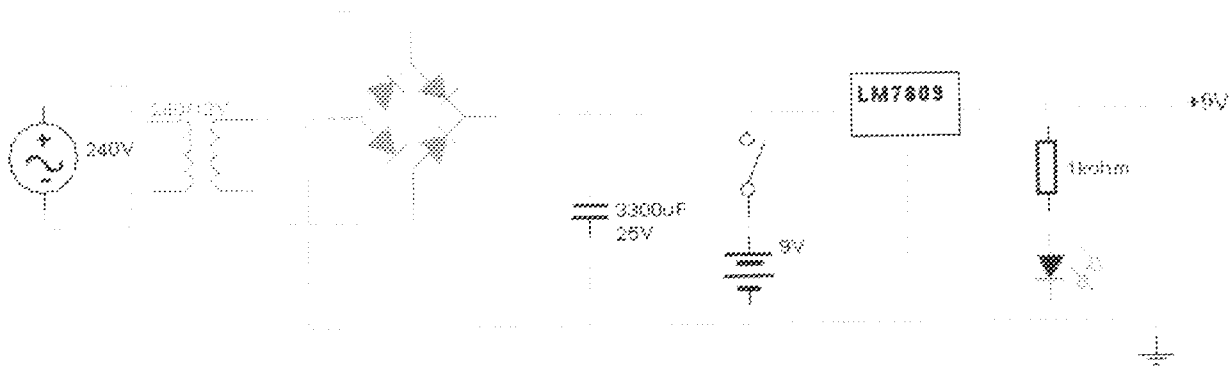


Figure 3.1 AC Power unit

3.3 THE AUDIO INPUT

To get audio sound into the system, an electrets microphone is used. 38KΩ pull up resistor R1 is used to bias the electrets microphone in order to convert audio sound to electrical signal. The circuit is shown below in figure 3.1

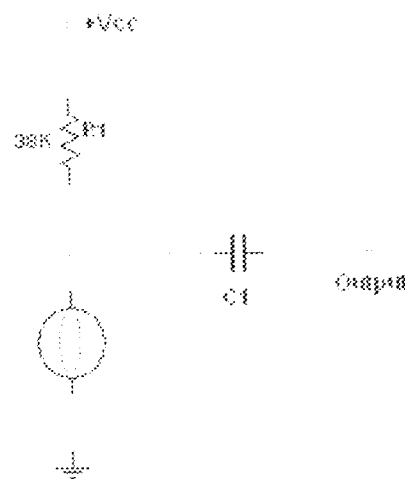


Figure 3.2 Audio Input circuit.

3.4 THE AUDIO PRE-AMPLIFIER CIRCUIT

Having converted the audio source sound into the corresponding electrical signal, the audio signal is pre-amplifier circuit is used to amplify the signal a bit in order to reduce Interference and noise before the signal is finally amplified by power

amplifier. The noise sources are the circuit components. In the pre-amplification stage the used of Transistor voltage-divider amplifier is used as shown in the diagram below:

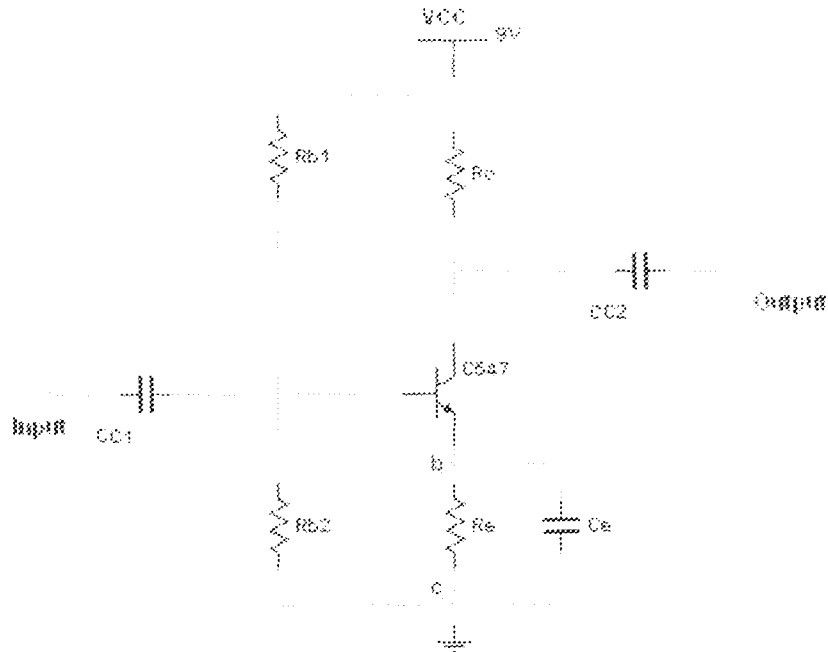


Figure 3.3 Audio pre-amplifier circuits.

3.5 CALCULATIONS OF COMPONENTS VALUES

To calculate values of Ce, Cc2, Rb1, Rb2, Rc and Re respectively, that will give the desired amplification required by the input signal without distortion.

Let Vcc=9V

Transistor used is C547 with hfe (gain) of 250.

Let IC=2.5mA Let hfe= 200 the desired gain from the configuration Ref [1].

Using transistor equation

$$Hfe = I_c / I_b \dots\dots\dots 1$$

But hfe is taken to be 200 and Ic is 2.5mA

From equation 1 it implies that,

$$200 = 2.5 \text{mA} / I_b \Rightarrow I_b = 2.5 / 200 = 1.25 \times 10^{-5}$$

1.25×10^{-5} is the base current required to give a gain of 2000 when the transistor is biased.

The voltage across node "b" and "c" which is the emitter voltage V_{re} which by design should be 20% of V_{cc} .

i.e.

$$V_{re} = 20\% v_{cc} = 20\% / 100\% \times 9\text{v} = 1.8\text{V}$$

$$V_{re} = 1.8\text{v}$$

$$\text{But } V_{re} = I_e R_e \dots\dots\dots 2$$

$$\text{Where } I_e \approx I_c = 2.5\text{mA}$$

$$V_{re} = 2.5\text{mA} \times R_e \Rightarrow R_e = 1.8 / 2.5 \times 10^{-3} = 720\Omega$$

$$R_e = 720\Omega$$

Hence the value of the required $R_e = 720 \Omega$ which is across nodes b and c.

The stability factor (s) of the system S is given by

$$S = R_b / R_e = 10 \dots\dots\dots 3$$

$$\text{Where } R_e = 750, S = 10$$

$R_b = 10 \times 720 = 7200 \Omega$ which is the net base resistor formed by R_{b1} and R_{b2} , from the figure R_{b1} and R_{b2} are connected in parallel and the resultant resistance is $7.2\text{K}\Omega$.

From transistor equation. [10]

We have that

$$V_{BB} = I_b R_b + I_e R_e + V_{BEQ} \dots\dots\dots 4$$

Where V_{BE0} is given as 0.7V for NPN silicon transistors. Subtracting the calculated values of I_b , I_e , R_b and R_e into equation (4)

$$V_{BB} = (1.25 \times 10^{-5} \times 7.2 \times 10^3) + (2.5 \times 10^{-3} \times 7.2 \times 10^2) + 0.7$$

$$V_{BB} = 0.09 + 1.8 + 0.7 = 2.59V$$

$$V_{BB} = 2.59V$$

R_{b1} is given by

$$R_{b1} = V_{cc}/V_{BB} \times R_b \dots \dots \dots 5$$

$$R_{b1} = 9/2.59 \times 7200 = 25019 \Omega$$

$$R_{b1} = 25K \Omega$$

$$R_{b2} = V_{cc}/(V_{cc} - V_{BB}) \times R_b \dots \dots \dots 6$$

$$= 9/(9 - 2.59) \times 7200 = 10K \Omega$$

$$R_{b1} = 25K, R_{b2} = 10K \Omega.$$

Solving for the collector resistor R_C

$$R_C = V_{cc}/I_c + V_{RE}/I_e \dots \dots \dots 7$$

$$R_C = 9/2.58 \times 10^{-3} + 1.8/10^{-3} = 4320 \Omega$$

$$R_C = 4.3K \Omega$$

Solving for emitter capacitance, C_e the capacitance of a capacitor is given as

$$X_e = 1/5 R_e \dots \dots \dots 8$$

$$\text{But } R_e = 720 \Omega$$

$$X_e = 1/5 \times 720 = 144$$

$$X_e = 1/2\pi F C_e \text{ Capacitance impedance}$$

$$X_e = 1/2\pi F C_e \dots \dots \dots 9$$

$C_e = 1/2\pi F X_e$ since the system is dealing with audio frequency, which is between

the range of 100Hz to 10 KHz

Let F be 100Hz. Substitute into equation (9)

$$C_e = 1/2\pi * 100 * 144 = 0.0000110F = 11.1 * 10^{-6} \mu F.$$

$$C_e = 11 \mu F.$$

For the coupling capacitor C_c

$$C_c = 1/2 \pi f X_c \dots\dots\dots 10$$

$$\text{Where } X_c = R_s + \gamma \dots\dots\dots 11$$

And

$$\gamma = R_b + h_{fe} \dots\dots\dots 12$$

$$h_{ie} = 1.5R_b [10]$$

$$\gamma = (R_b + 1.5R_b) = 2.5R_b$$

$$\gamma = 2.5 * 7200 = 18000$$

R_s is the source resistance of the microphone and it is equal to 600

Substituting the value of γ

$$X_c = 600 + 18000 = 18600$$

Equation 10 becomes,

$$C_c = 1/2\pi * 100 * 18600 = 0.00000008F$$

$$C_c = 8 * 10^{-8} = 8 * 10^{-2} \mu F$$

$$C_c = 0.1 \mu F$$

3.6 THE AUDIO POWER AMPLIFIER

The audio power amplifier is configured using LM 386. The amplification of LM 386 is controlled by connecting a certain value of capacitor between pin 1 and 8. According to manufacturer's specification and data sheet, connecting a 10

The switching circuit of the intercom is configured using CD 4066, it is a bilateral switch. It is quite suitable for audio switching because it has a high switching speed, unlike electromechanical relays and it equally has no resistance to the electrical signal [11] its pin configuration is shown below,

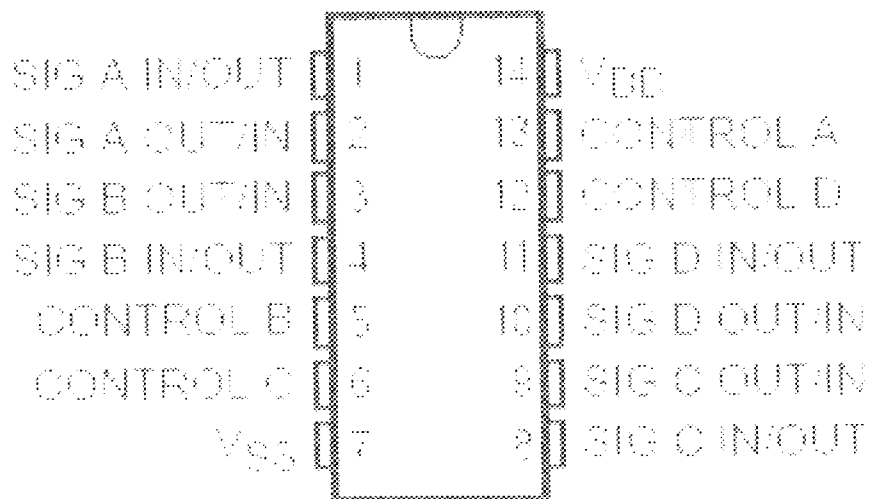


Figure 3.6 Diagram of switching IC (CD 4066)

When input signal terminal is connected to the input pin and the output signal terminal is connected to the output pin; the control pin is used to connect the input signal and output signal terminals when the voltage at the control pin is positive (+). The input signal terminal and the control pin of 4066 is negative (-) or zero.

However, in order to make a noise less full duplex communication among the four subscribers in the intercom network the amplifier mouth piece of a particular subscriber is connected to the ear-piece of another subscriber via the bilateral switch CD4066. So that when a is talking to B, the audio output of A is going straight to the ear- piece of B and the audio output of B is equally going to straight to the ear -piece of A. This is done to avoid side tone effect. Side-tone

effect is a situation in which, when A speaks, the amplified audio signal hits back to the ear of A, making A to feel uneasy due to large amplified audio signal in his ear.

3.8 THE RINGING TONE

Ringtone is included to alert a subscriber about an incoming call. When the button corresponding to the subscriber intended to be called is pressed, the ringing tone is activated and it continues to ring. The receiving station picks up the call by pressing the answering button.

The sound from the ringing tone is intended to come up for a second and goes off for another one second continuously as shown in the wave

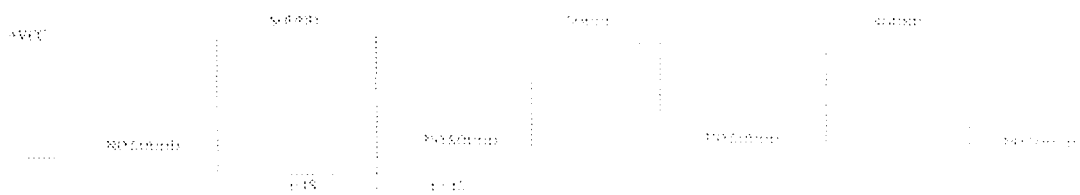


Figure 3.7 Wave form of the ringtone

To configure such a wave form with equal duty cycle of such accuracy, CD 4047 is preferred. Because it is configured on equal duty cycle and it has no internal circuitry oscillation. CD 4047 is a multivibrator [11].

The diagram is shown below,

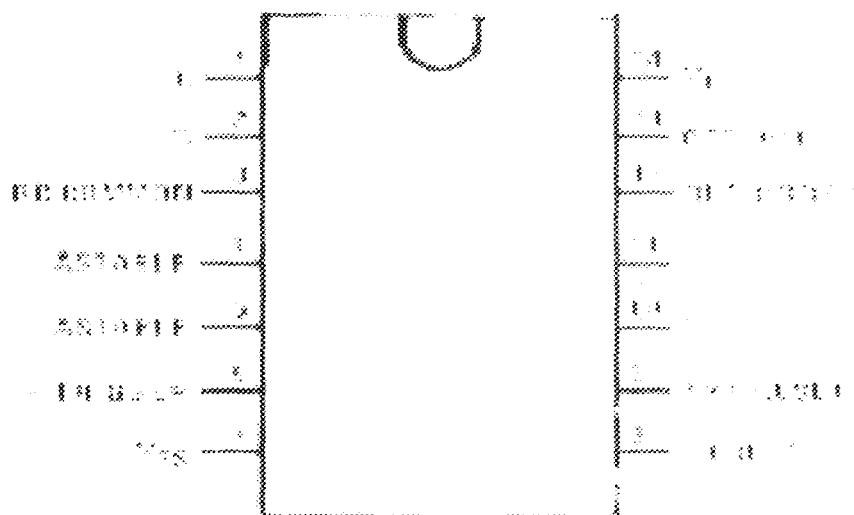


Figure 3.8 Pin-out of CD4047

To configure CD 4047 as a stable Multivibrator, the configuration is shown below.

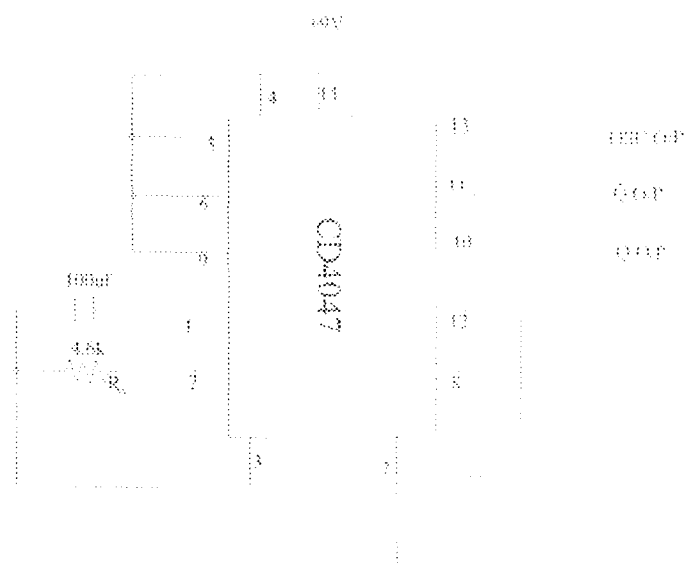


Figure 3.9 CD 4047 as stable Multivibrator.

The period of oscillation of CD4047 configuration as a stable multivibrator is given by

$$T_A = 4.4RACA \dots\dots\dots 13$$

Where T_A is the period of oscillation

R_A is the oscillating resistor

C_A is the oscillating capacitor

Since the sound is required to come up at 1 second and goes off at another 1 second, then the complete period is given as

$$T_A = 1 + 1 = 2s$$

Let $C_A = 100 \mu F$

$$T_A = 4.4RACA$$

$$2 = 4.4 * R_A * 100 * 10^{-6}$$

$$R_A = 2 / (4.4 * 100 * 10^{-6}) = 2 * 10^4 / 4.4 = 4545$$

$$R_A = 4.55K = 4.6K$$

$$C_A = 100 \mu F, R_A = 4.6K$$

The output pin 11 is connected to the reset pin 9 of another CD4047 configuration as high frequency oscillator, which will be given audio sound when the output wave of CD4047 clock is HIGH.

A frequency of 2000Hz is considered pleasant to ear. And this second CD4047 is configured to oscillate at this frequency and controlled by the first CD4047.

Applying above equation $T_A = 4.4RACA$

$$\text{Similarly, } T_B = 4.4RBCB \dots\dots\dots 14$$

But the relationship between frequency F_B and the period of oscillation T_B is given as,

$$T = 1/F \dots\dots\dots 15$$

$$TB = 1/FB$$

$$FB = 1/TB \dots\dots\dots 16$$

Substituting equation 14 into 16

$$FB = \frac{1}{\frac{1}{0.4RBCB}} = 0.4RBCB \dots\dots\dots 17$$

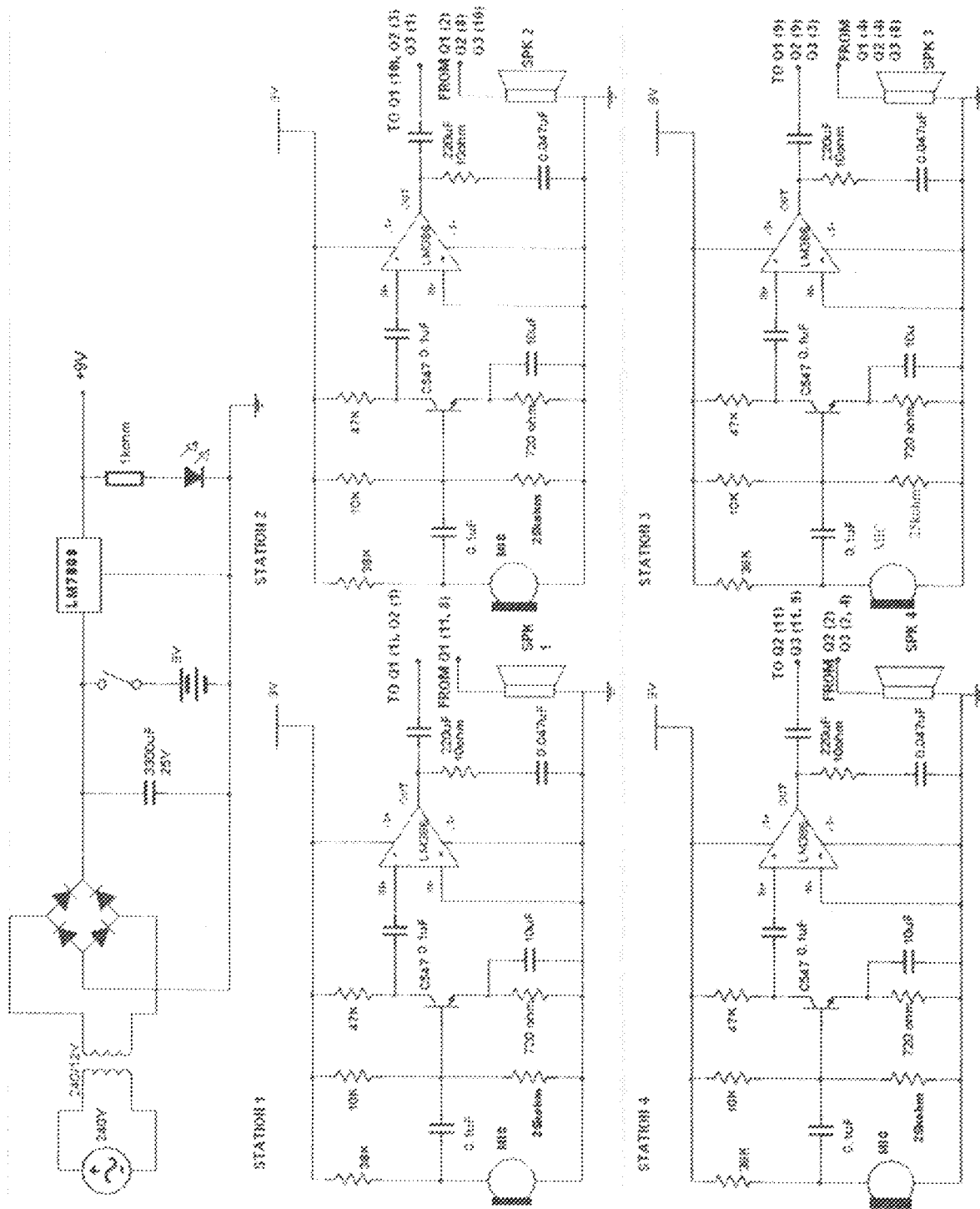


Figure 3.10: Circuit Diagram

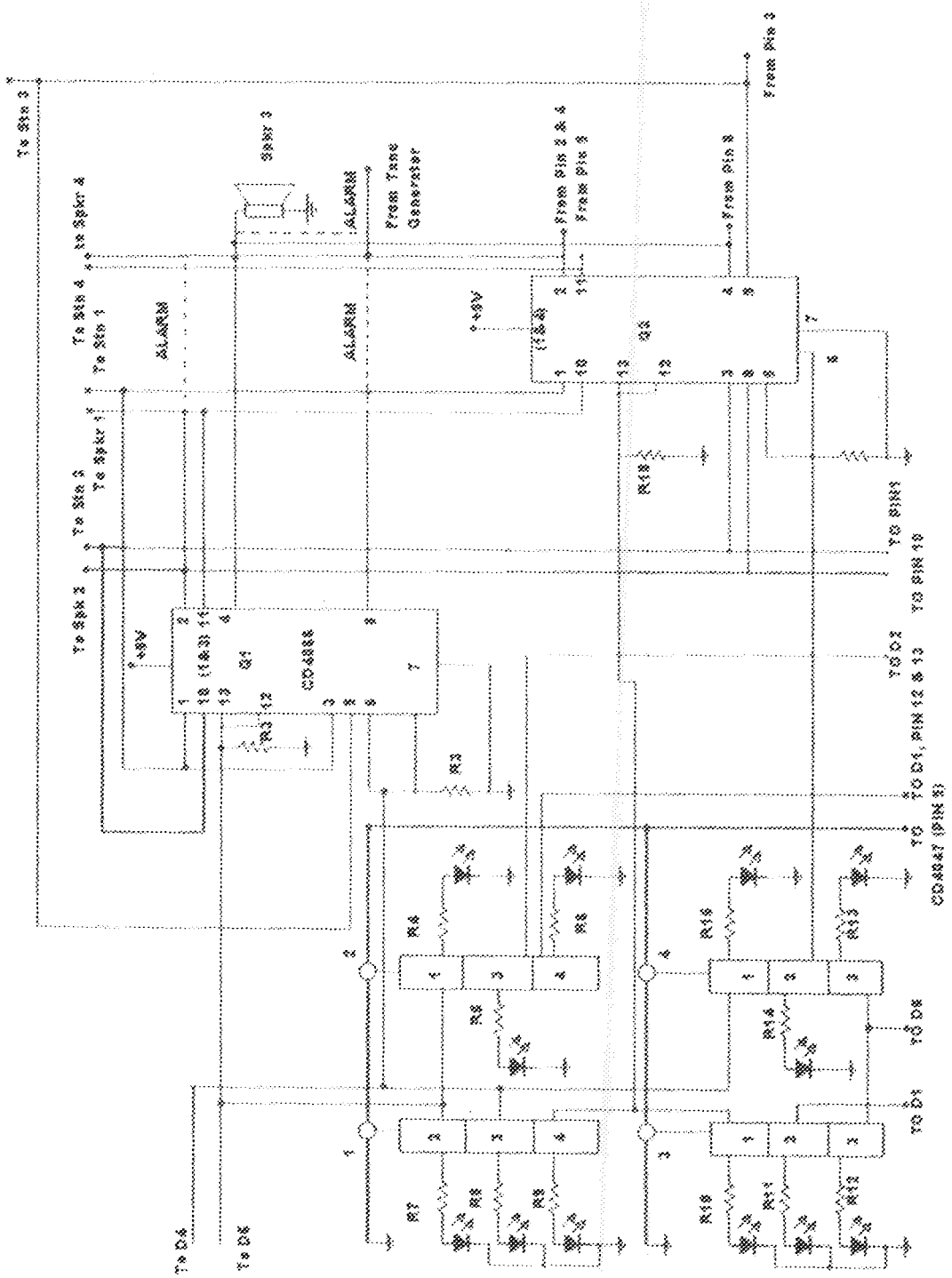


Figure 3.18: Circuit Diagram

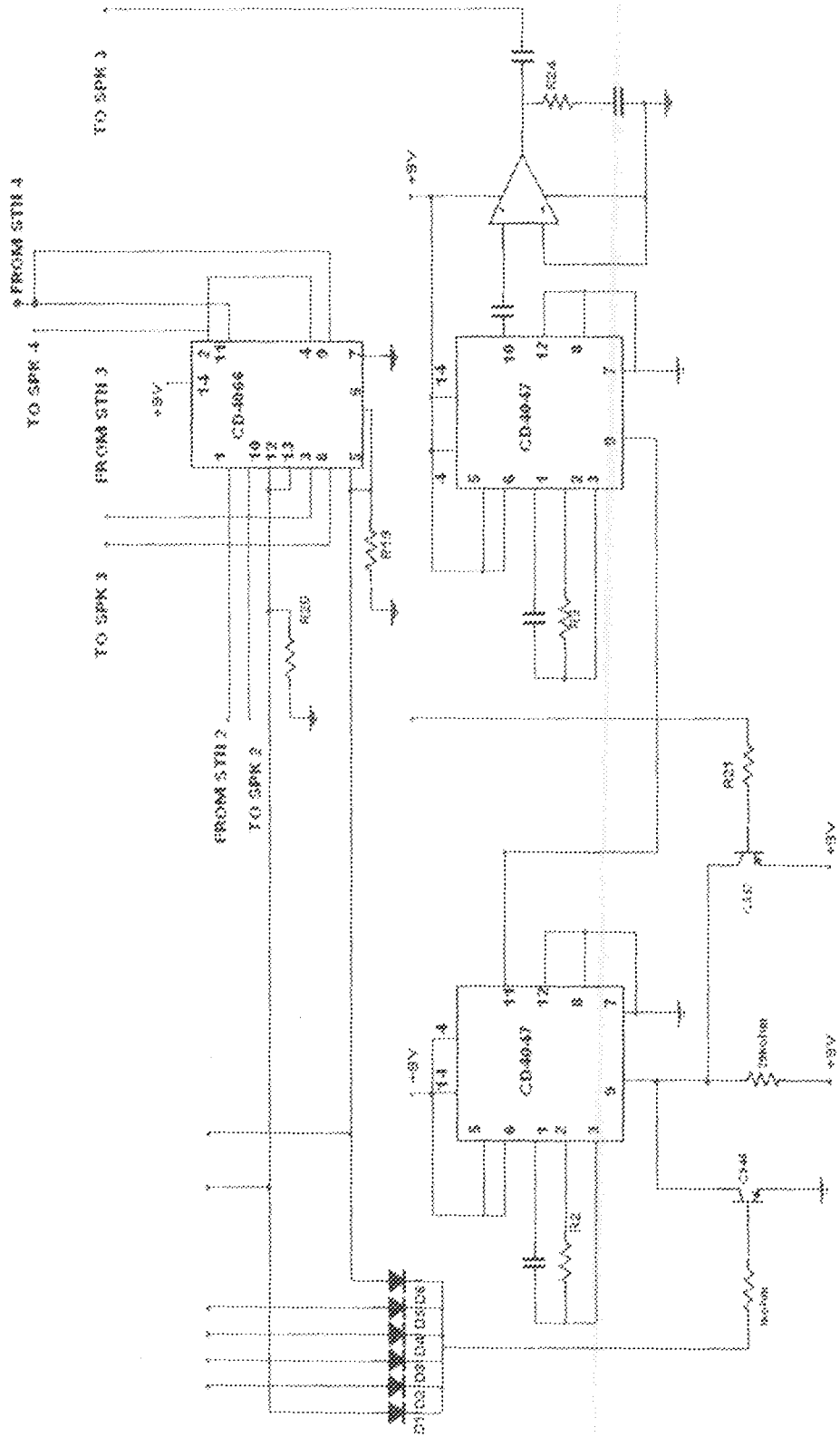


Figure 3.10 circuit Diagram

CHAPTER FOUR

TEST, RESULTS AND DISCUSSION OF RESULT

This chapter gives a breakdown of the construction of both circuit and its Packaging, test carried out, discussion of results and opinion offer base on the results obtained.

4.0 CONSTRUCTION

The construction of the designed circuit was done using a bread board for a trial process and it was then stimulated. The construction was then transfer to Vero board for soldering of the components.

4.1 PACKAGING

The packaging and casing was design following the concept of packaging of normal or conventional telephone system. A normal telephone hand piece is used to case the mouth piece, ear piece and audio pre-amplifying circuit.

A small transparent plastic is used to case the main circuit (design)

4.1 TESTING AND RESULTS

The circuit was tested as many times as possible to determine it working ability. And it was successful. It was tested by initiating calls from different stations and receiving from the corresponding stations. A tone was generator was used as an alert to alert different subscriber on the network.

Test carried out with results obtained are as listed in table 4.0

Table 4.0

COMPONENTS	TEST	RESULTS
General components test	Continuity	There was continuity in all the circuit connection or between the components in the Vero board.
Stations	Calling difference stations	Connected
	Station 1 to station 2	Connected
	Station 2 to station 3	Connected
	Station 3 to station 4	Connected
	Station 1 to station 4	Connected
	Station 2 to station 4	Connected
	Station 2 to station 3	
Transformer	Voltage output	9V
Battery	Voltage output	9V
Capacitors	Interference	There was an interference from Capacitors
Tone generator	Alert	A tone was generated

4.2 RESULTS

The result were obtained as listed above in the table

4.3 DISCUSSION OF RESULTS

The circuit functioned in accordance with the aims and objectives of the design as stated in the chapter one of this report. Except for the interference encounter from the capacitors which causes wanted noise signal.

4.4 SHORTCOMINGS/LIMITATIONS

- ◊ There were some short coming emanating from the design and components used.
- ◊ There was an effect of stray capacitance, which result in the interference on difference signal and thereby causing a noise to be heard at the ear piece resulting in poor audio quality.
- ◊ Assigning different ringing tone to individual stations was not achieved as the circuit was becoming more complex and there making the circuit to look clumsy.

4.5 SOLUTION REFERED

All of these shortcomings can be overcome if an electronics printed circuit board is used to cut the used of many wires as connectors. This was not done due to non availability of such facilities.

BILL OF ENGINEERING MATERIALS

COMPONENTS	QUANTITY	PRICES
CD4047	2	₦ 500.00
CD4066	3	₦ 750.00
HANDSET	4	₦ 800.00
CAPACTORS	10	₦ 300.00
RESISTORS	50	₦ 300.00
LED	20	₦150.00
TRANSFORMER	1	₦ 200.00
DIODES	15	₦150.00
PLUG	1	₦ 100.00
BATTERY	1	₦ 100.00
CASING	1	₦ 1000.00
MOUTHPIECE	4	₦ 600.00
EAR PIECE	4	₦ 800.00
LM 386	1	₦ 250.00
TRANSISTOR	7	₦ 500.00
	TOTAL	₦ 6500.00

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.0 CONCLUSION

The four ways intercom was achieved and a better understanding of the role of communication in nation building.

Working on a project like this was really a challenging one. And an interesting experience worth knowing. It has clearly shown that there is a difference between theory and practical work. As some calculated values could not give the real practical output

5.1 RECOMMENDATION

The work can be done more effectively using electronics printed circuit board and mass produced to be sold to the teeming population of Africa and generate income to the department and in turn alleviate communication problem in our small companies.

The work can be expanded further by designing an eight (8) ways intercom or n-ways intercom to serve different numbers of offices required.

Improvement can be done on the alert (tone) generation to see how they individual tone can be separated by assigning tone to each station.

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OPERATIONAL MANUALS

The project is operated as follow; A call is initiated by a caller by pressing the desired station dialing button. An alert ringing tone is triggered on, to alert the receiving station about an incoming call. The alert comes up for a second and goes off for another second. The receiving station answer by pressing the receiving button on his hand piece and the put it on his ear and mouth to talk to the caller. After the conversation is over the receiving station depressed the answering button to end the call, preparing for any other incoming call or the station to equally call out.

TROUBLESHOOTING

Incase the tone does not come up, check one of the answering button, one might be pressed. Incase of one been pressed, depressed and redial the required station. Or it might be as result of weak power supply in time of using battery. Replaced the battery by a new one. If the problem persists refer to a qualified technician.

OPERATIONAL MODE

The system is designed to work within the temperature range of 22 to 50. it should not be used with temperature above the specified range.

Thanks for using our product.