

**DESIGN AND CONTRUCTION OF
MULTI-CHANNEL MIXER**

BY

BUKOYE KABIR. O

98/6920EE

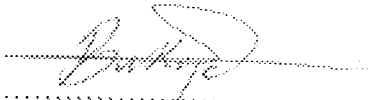
**A PROJECT SUBMITTED TO THE DEPARTMENT OF
ELECTRICAL/COMPUTER ENGINEERING FOR THE
AWARD OF BACHELOR OF ENGINEERING (B.ENG)
IN ELECTRICAL/COMPUTER ENGINEERING
FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA
NIGER STATE.**

NOVEMBER 2004.

DECLARATION

I hereby declare that this project work is my original work and to best of my knowledge.

It has never been presented in any form of award of diploma or degree.



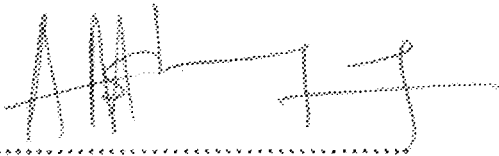
BUKOYE KABIR. O

08/12/2009

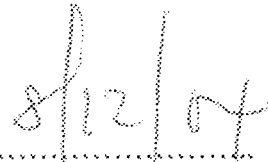
DATE

CERTIFICATION

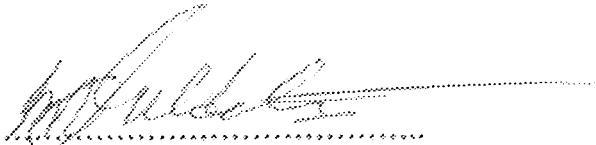
This is to certify that this project titled "Multi-channel Mixer" was carried out by Bukoye Kabir. O. Under the supervision of Engr. M.S Ahmed for award of bachelor of engineering (B.Eng) degree in electrical/computer engineering, Federal University of Technology, Minna, Niger state.



ENGR. M.S AHMED
PROJECT SUPERVISOR



DATE



ENGR. M.D. ABDULLAHI
HOD. ELECT/COMPUTER
ENGINEERING.



DATE

EXTERNAL EXAMINER

DATE

DEDICATION

This project is dedicated to my caring and loving mother Alhaja Amudat Bukoye for her support, courage, kindness and contribution given to me throughout my academic program.

Also to my younger brother Sheriffdeen for his care and love shown to me.

ACKNOWLEDGEMENT

My acknowledgement goes to Almighty Allah, the most high to whom my gratitude is due first, for his sufficient grace, guidance, protection, blessing and infinite mercies

My since gratitude goes to my supervisor Engr. M.S Ahmed for his care, encouragement, patience and guidance during the course of my project. Words to used are not adequate enough to express my appreciation. I'm greatly indebted to you sir. and also to my H.O.D. electrical/computer engineering department, and other lecturers and all the staff of electrical/computer engineering department.

Also my profound gratitude goes to my kind, loving and invaluable parent Alhaji L.J Bukoye and Alhaja Amudat Bukoye for their care, moral and financial support and my step mother Alhaja M Bukoye, Late Alhaji L.A Agboola , Mr & Mrs Marili Rasheed, Alhaja Olarinoye, Mr & Mrs Silifat Olawale.

My gratitude goes to my Sisters and Brothers, Mr. & Mrs. Bisi Amin, Mr. & Mrs. Nike Isioye, Karimat, Sheriffdeen, Joke, Olaitan, Sharafdeen, Kazeem, Bukola, Sherifat, and to my cousine Muji, Lukuman Bukoye, Layi, Omowumi, Lola, Segun Olawale, Dr. & Phar. A. Agboola, Phar. Agboola, Dr. R.A Agboola, Muideen, Kalimat Agboola, Phar. N. Lawal, Risi, Sherif, Engr. Tiaye, Kehinde Olarinoye and all Bukoye's family.

My goes to my colleagues unalloyed appreciation and friends most especially to Tolani Taofiq, Ahmed Aduragba, Dayo Afonja, Wale Alabi, Olanipekun Basir, Ajala Niyi, Abdullahi Afolabi, Kalejaiye Basir, AbdulRaheem Taofiq, Adetoro Maruf, Raji Gbola, Adetayo Tujudeen, Kunle Adeyemo & Adeshina, Iyiola, Arc Niji, Gboyega Akanmu Erin, Authority, Kazeem Folaranmi, Engr. Issa. Olorishade Razak, Sarafa Faleye, Majeed AbdulRaheem, Shittu, Sanni Katuka, and all other that I can not mention thank you all.

Also my appreciation goes to Banji Banwo (M.D. Ecalpemos computer Technology, Kaduna) and to David Kelvin (Chief Engineer of Beulah computer engineering, Kaduna.), and all the staff of Ecalpemos and Beulah computer.

ABSTRACT

This project is to provide a device whereby a mixed music or audio can be recorded either for home consumption or for disco, therefore this project can provide artist or musician a means of mixing music or audio of his choice during recording. The multi-channel mixer is a device that is used to mix two or more music or audio simultaneously without the distortion of the other.

The multi-channel mixer , consist of identical source follower circuits (preamplifier stage) and a summing amplifier. Also incorporated is the power supply unit.

TABLE OF CONTENTS

	Page
Title page.....	i
Declaration.....	ii
Certification.....	iii
Dedication.....	iv
Acknowledgement.....	v-vi
Abstract.....	vii
Table of contents.....	viii-ix
CHAPTER ONE	
GENERAL INTRODUCTION	
1.1 INTRODUCTION.....	1-3
1.2 Aims and objectives.....	4
1.3 Literature review.....	4-5
1.4 Project outline.....	5-6
CHAPTER TWO	
SYSTEM DESIGN AND ANALYSIS	
2.1 Introduction.....	7-8
2.2 Pre-amplifier unit.....	8-11
2.3 Operational amplifier unit.....	11-12
2.3.1 Operational amplifier circuitry (LM 301).....	12-13
2.3.2 Parameters of operational amplifier.....	14
2.4 Mixer stage.....	14-16
2.5 Audio output.....	16-17
2.6 Component used.....	17

CHAPTER THREE

CONSTRUCTION, TESTING AND RESULTS

3.1	Introduction.....	18
3.2	Construction.....	18-19
3.3	Tools used.....	19
3.4	Testing.....	19
3.5	Results.....	20
3.6	Problem encountered.....	20

CHAPTER FOUR

CONCLUSION AND RECOMMENDATION

4.1	Conclusion.....	21
4.2	Recommendation.....	21-22
	References.....	23
	Appendix.....	24

CHAPTER ONE

GENERAL INTRODUCTION

1.1 INTRODUCTION

The effort of the hi-fi enthusiasts, designers and manufacturers of hi-fi equipment have resulted in a single channel or reproducing system of extremely high standard. that is, harmonic distortion has been cut to less than one percent, the frequency response extended well beyond the audible range as a means of improving the transient performance, while the dynamic range and power holding capabilities of modern hi-fi equipment leave little to be desired. However, there is something still looking. What is looking is the promotion of operation sound location sense and that as a result of this illusion, "Perspective and spaciousness" of sound being listened to it lost.

The reason for this is that both ears of the listener collect the sounds coming from the sound source at various angles and the brain being a natural computer, compares several factors of the sounds picked by the two ears and with the information abstracted bring into operation a form of sound location sense.

As far as the brain and ears are concerned and how things are in reality, sounds emanating from the extreme right and left of a listener and dealt with the right and left ears respectively, while sounds from between these two extremes have their position fixed. From the above discussion, it is clear that single or double channel system cannot promote operation of the sound location sense very well.

It should be noted that even if two or more loudspeakers are employed, this short coming will not be obviated but will only help in spreading the sound over a large area provide due to attention given to their phasing. However there are often cases when a simple unit is required to mix three or more inputs perhaps for home recordings or discourse and the unit described here is designed to fill such a function.

The mixer is fed via input logarithmic potentiometers which permits any one or a combination of any two, three or all input when fed at the same time or simultaneously, but these input when fed directly to the mixing deck cannot turn on the input device due to their low output level hence output are fed via pre-amplifiers designed in each case to suit the output to the input equipment.

To achieve this objective I choose to modify the RIAA (Record Industry association of American) pre-amplifier due to the following reasons:-

- (i) Since the output level of a magnetic pick-up is not duly low but varies with frequency. At the top end of the audio spectrum (i.e. 15-20KHZ) the signal is about 40dB up (100 times) that of the lowest end of the range. i.e. the input signal range. I also followed the RIAA (Record Industry Association of America) laid down rules for the frequency response curve so that when designing such a pre-amplifier stage, we did not only calculate suitable feedback loop components but also we should be aiming at a design that has a response which diminishes with increasing frequency over a range of 40db. Hence we are compensating for the response of the magnetic cartridge.

HA
SOFT
COMPUTE
EXTRA CURR
READING AND S

- (ii) The pre-amplifier is expected to operate over a wide range of supply voltage (9-40dc). Hence a reduction in the complexity of power supplies design.
- (iii) The pre-amplifier is built on field effect transistor n-channel, apart from being a dual pre-amplifier; it features low noise, high gain and required frequency response with just a few components. The essential feature of this mixer is that the fading of one input has no effect on the other gains.

The virtual earth acts as an isolating barrier between the inputs of the operational amplifier (adder) and thus provides independent operation. The overall output of the mixer is a well-blended stereo sound.

The power supply owing to the fact that our device can be operate over a wide range voltage (9-40dc) is nothing much to take about. It is simply a full wave rectifier supply with center tap.

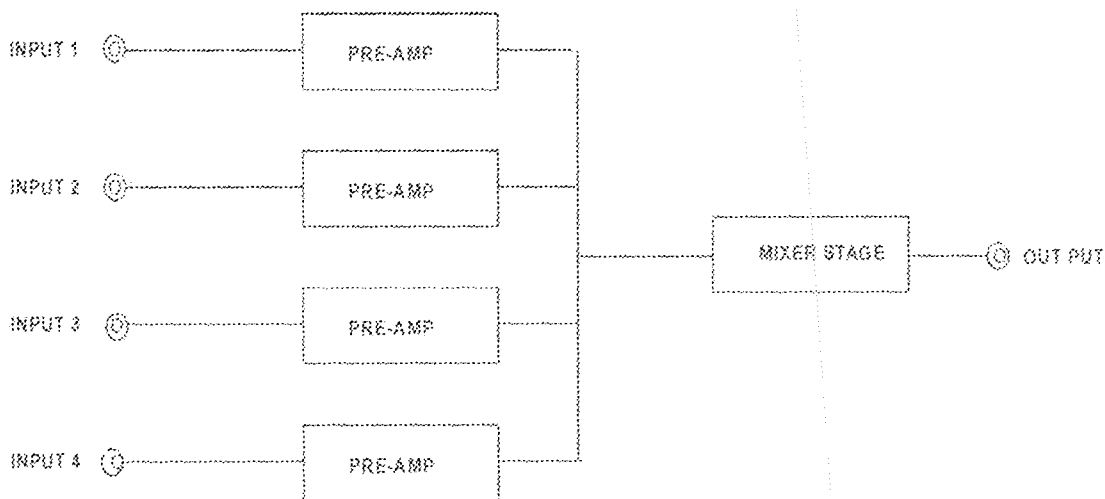


Fig 1.0 Block diagram of multi-channel mixer

1.2 AIMS AND OBJECTIVES

The aims and objectives of this project is to design and construct a device

1. Comprised an electronic circuit that can be used to mix two or more music or audio.
2. That can be used as public address system or device.
3. That can be used for home recordings or disco.

1.3 LITERATURE REVIEW

In the world today, we are expose to difference music of types and kinds, so we need to mix different music and audio of different type, Man has therefore learnt how to mix two or more music or audio together.

The first demonstration of multi-channel mixer was as far back as 1938, when it was find the patent number that was put up it was a large resistor network, later in the 60's various matrix encoding and decoding method came abrat, Unfortunately, the result was less than satisfying from both the performance and marketers standpoint. The early Systems were plagued by poor technical performance. Software of highly variable quality and public indifference. In 1952, this Cinerama debuts, with seven-channel mixer sound, 1953.

The Robe Debuts in cinemascope with four mixer sound, 1957-59, vertex series at Morrison planetarium, using multi-channel mixer system and including seminal tape works by Comper KerlheinZ Stockhausen, Luciano berio, Gyergy ligeti and others, 1958 Rama sender, Terry Ritey and Pauline Oliveros using KPFA as a studio to record improvised music, 1958-59 Composer Stan shaff and Dong Eachern experiment

with multi channel mixer system for sound, designing what will become know as the Audium.

1959 performance of John cage's imaginary loudscape number four for ten radio at UC Bereley, coordinated by lamenta young with a young Terry Riley on the tenth radio, 1960

Robert Erickson organizes the American composer workshops at SF conservatory Raman

Sender starts electronic music concert series, features several multi-channel works, 1965-

70 Audium's first theater, weekly performance for 3.5years, some of the speaker were suspended with cables above the audience and made to swing to create a Doppler effect.

1965-66 Donald Buchla begins development of his first voltage controlled music

instrument, working closely with Sender and Subotrick, 1972-75 John chrowning

together with James A Moorer and John Grey from a research group at Stanford in

psychoacoutics analtsis, digital recording and digital synthesis, formally established in

1975 as CCRMA(Center for computer research in music and acoustics).

We were listening to different type of music of kind from different people culture and

country which we need to mix some together for betterment of human.

Hence the multi-channel mixer cannot be over emphasized. For this reason this project is

necessary for the sustenance of man.

1.4 PROJECT OUTLINE

This project write up is a technical report describes in detail about Multi channel Mixer,

the report consists of four chapters which is as followed;

Chapter one gives a general introduction of the project, the literature review of the past

project, the aims and objectives of the project.

Chapter two gives the description of the design and analysis. It involves the calculations and determination of values of components used in the project. It also explains the overall circuit operation the module.

Chapter three presents the general construction technique the module construction and testing of each module that makes up the overall system circuit.

Chapter four includes the conclusions, recommendation and references.

Appendix A shows the circuit diagram of multi channel mixer.

CHAPTER TWO

SYSTEM DESIGN AND ANALYSIS

2.1 INTRODUCTION

The multi channel mixer work as mixer of music or audio together, It is a common practice in Electrical, electronic and computer engineering to always describe systems with the aid of block diagram. Therefore, the block diagram of the system under design is hereby presented in Appendix A

The power supply unit: This is the source of electrical energy or power to the system and its indispensability can be appreciated from the fact that without it the system will not be able to perform its functions. The unit provides direct voltage with a common ground to other units of the system.

Operational amplifier unit (mixer stage): In this unit, the operational amplifier mix (i.e. summing) the our input resistor R_{13} - R_{16} that are connected to lower to some extent the input level. If the input level a. not the same, the value R_{13} - R_{16} can be changed to lower the highest signal, all the input are connected to the inverting terminal, the operational amplifier mix the input and provide one output, anyone to listen to from the input of individual, swinging from one to another at will.

Pre-amplifier unit: This is built on F245 FET and $1M\Omega$ pots (R_5), since the input impedance of a FET is very high the alternation is also for controlling the level of input signal for each audio or music input. The stages are directly coupled the operational amplifier that amplifier the respond to very low frequency signal.

Amplifier unit: - The amplifier unit basically entails an npn transistor which is biased by a base resistor in the collector feedback biased configuration. This unit helps to amplify the voltage to higher level that is audible.

Audio output unit: This is summary either uses a speaker headphone or a loudspeaker for the audio able output.

2.2 PREAMPLIFIER STAGE

The pre-amplifier is built on field effect transistor (FET). The preamplifier is built to amplify the input signal that is very small before it is fed to the amplifier.

The preamplifier has the characteristics of rejecting ripples on the supply line by about 100dB; hence it greatly reduced the quality of the power supply. It has a current consumption of 16mA. The unit is desired to have a gain of 40dB at THE 0dB reference frequency at 1kHz.

The amplification of the preamplifier is not up to the hearing of the human ears, therefore, there is a need to amplify the signal at around the frequency to which the human ear is sensitive to, the generally acceptable frequency range between 20Hz to 20 kHz. Therefore the source follower circuits are connected in parallel and their output are tied together and fed to a summing amplifier. The source follower circuit is intended to match the input impedance of the inverting input of summing amplifier to that of desired source. The source follower presents higher input impedance in a way to avoid losing most of the voltage across the audio-source.

In this application the input impedance of the mixer is that of the attenuation, the 1M Ω pots since the input impedance of a FET is very high.

The preamplifier are four identical, all the four therefore contain the source component.

The circuit of the preamplifier is shown below fig. 2.1

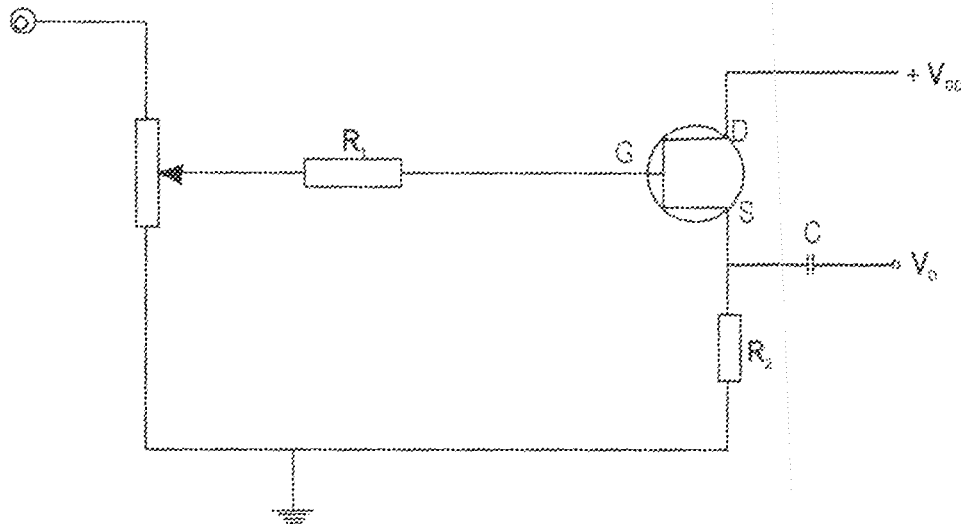


Fig 2.1 Pre-amplifier

All calculations are based on the following figures:-

Type	Construction	P_T	V_P	V_{DSS}	I_{DSS}	G_{SS}	Substitute
F245	NJD	200mV	8V	25V	2mA	8pf	BF244 or 245

V_{DS} = Maximum permissible drain source voltage

I_{DS} = Maximum permissible drain current

T_{Jm} = Maximum permissible junction temperature

NJD = N = Channel, J = Junction gate, D= Depletion

In addition to the above parameter value, the following assumptions were made:

$$I_s = 1.2 \mu\text{A} \text{ where } V_{GS} = 12\text{mV}$$

$$I_s = 0.9\text{mA} \text{ where } V_s = 9\text{V}$$

Also the desired input voltage $V_i = 3.2 \text{ mV}$ and the voltage gain 10

$$\text{From } A_v = \frac{-V_o}{V_i}$$

$$10 = \frac{-V_o}{V_i}$$

$$V_o = 3.2 \times 10 = 32\text{mV}$$

$$\text{Since } R_1 = \frac{V_{GS}}{I_G}$$

Putting the value into the equation expression

$$R_1 = \frac{12 \times 10^{-2}}{1.2 \times 10^{-6}} = 10\text{k}\Omega$$

Considering when $V_{DD} = 9\text{V}$ and $I_s = 0.9 \text{ mA}$

$$R_2 = \frac{V_{DD}}{I_s}$$

Substituting the values into the above equation

$$R_2 = \frac{9}{0.9 \times 10^{-3}} = 10\text{k}\Omega$$

2.3 OPERATIONAL AMPLIFIER UNIT

An operational amplifier is a monolithic integrated circuit amplifier, which has a very high voltage gain, a high input impedance and for most types a low output impedance. Typically the Op Amp. Has two (2) inputs, the inverting and non-inverting input as shown in fig 2.2 below:-

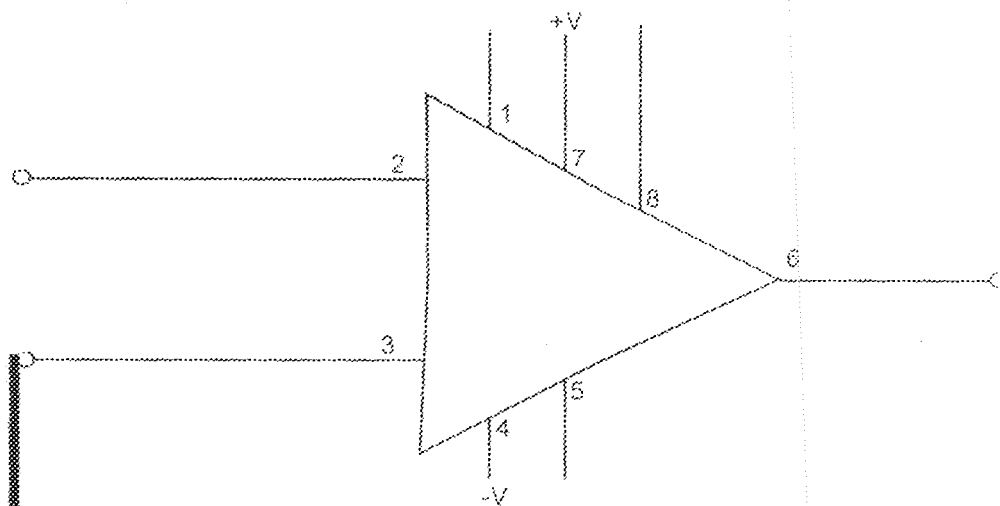


fig 2.2 Operational amplifier

Operational Amplifier has two (2) input terminal 2 and 3, one of them labeled is known as the inverting terminal since a voltage applied to this terminal appears at the output terminal with the opposite polarity, i.e. a sinusoidal input signal will experience a phase shift of 180°. The other input terminal is labeled +, this is the non-inverting terminal, A signal applied to it is applied with zero phase shift. Only a very small difference in potential between the two inputs is need to produce a large output voltage.

When this difference is equal to zero, the output voltage should also be zero but this not always the case. The voltage gain is large unpredictable and is always reduced by negative feedback, when the device is used as an amplifier.

The two terminals, four (4) and seven (7) are provided for the connection of positive and negative power supply voltages. Another terminal, five (5) is provided to which the mid-point of the power supplier must be connected, in most case this point is the earth potential. Terminal, 1, 8 and 9 may be provided for the connection of external frequency compensation components.

M 52204

2.3.1 OPERATIONAL AMPLIFIER CIRCUITRY (LM 301)

The Op-Amp comes in numerous kinds from different manufacturers, the one used for this design is LM 301 Op-Amp and its circuit diagram is shown in fig.2.3 below followed by manufacturer's specification for it.

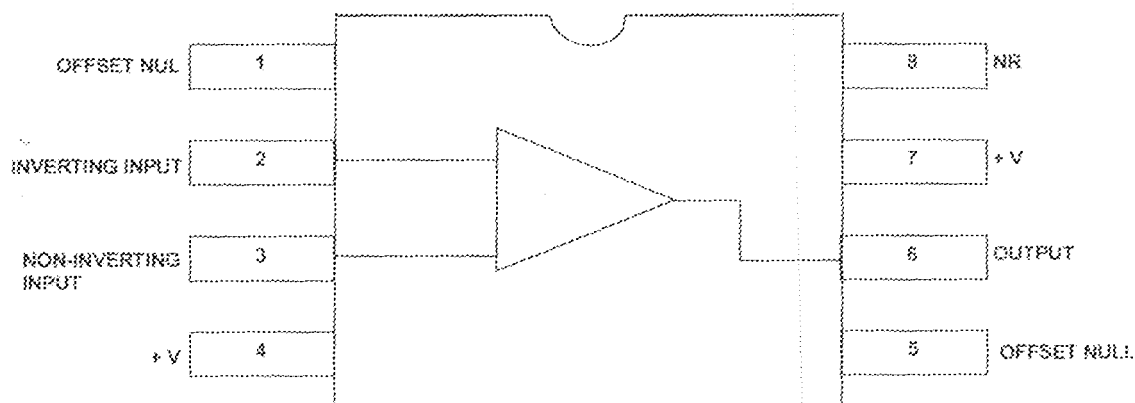


Fig 2.3 Operational amplifier circuitry

Table 2.0

452242

The characteristic of LM 301 Op-Amp from manufacturers data sheet are: -

PARAMETERS	VALUE	UNIT
Saturated voltage, V_{sat}	15	V
Saturated current, I_{sat}	2	mA
Slow Rate, SR	0.4	V/us
Bias current, I_b	70	nA
Offset current, I_{os}	30	nA
Input offset voltage, V_{os}	2	mV
Input resistance, R_i	3	$m\Omega$
Out resistance, R_o	80	Ω
Differential gain, A	200	V/mV (dB)
Common mode rejection ratio, CMRR	90	dB
Gain bandwidth product, B	10	MHz

For the purpose of this design, an Op-Amp LM 301 was cascaded to have a reference voltage. Basically the inverting input has a 4.7 μ f capacity in series with 10k Ω resistor which is used to the inverting input. Then the non-inverting input has a 10k Ω resistor connecting to the ground.

2.3.2 PARAMETERS OF OPERATIONAL AMPLIFIERS

The ideal Op-Amp would have the following parameters

- (i) Infinite input impedance
- (ii) Zero output impedance
- (iii) Infinite voltage gain
- (iv) Infinite bandwidth
- (v) Zero output voltage equal voltage are applied to its two input terminals.

In practice of course, the ideal Op-Amp does not exist and practical devices have various limitations.

2.4 MIXER STAGE

The Op-Amp LM301 is used in this project as mixer, typically this design in the "MIXER" show in fig2.4 below

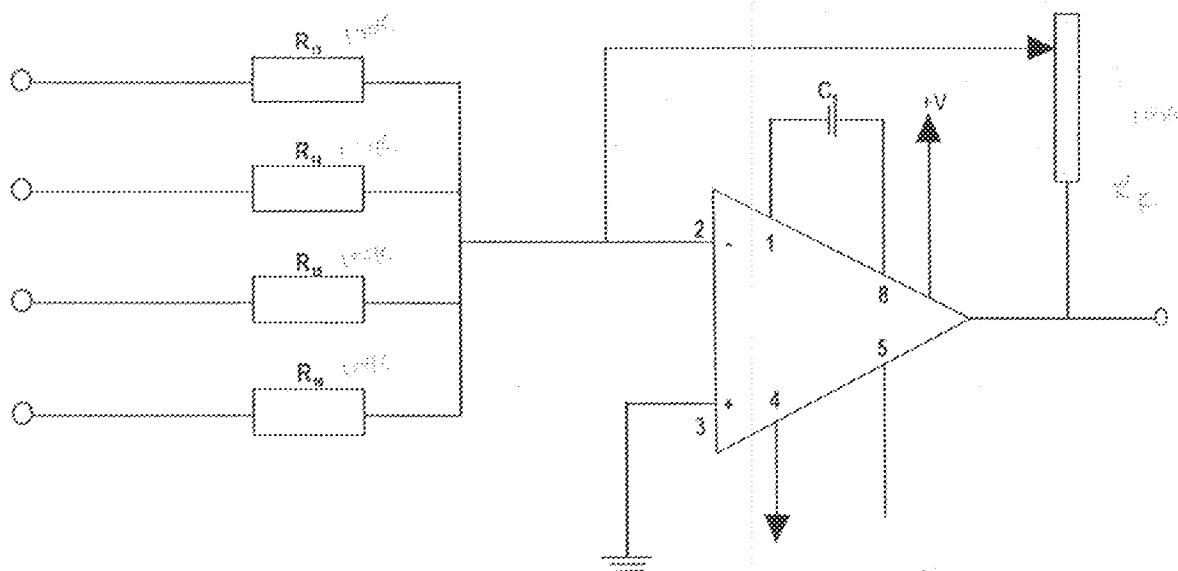


Fig 2.4 Op-Amp use as mixer

The fig2.4 above shows a typical Op-Amp constructed with LM301 used as a mixer.

Since I am concerned with only the summing of four input resistor R_{13} - R_{16} , they are connected to lower some extent the input level. If the input levels are not the same, the value of R_{13} - R_{16} can be changed to lower the highest signals, this can be achieved by increasing the value of R_{13} , R_{14} , R_{15} and R_{16} has a minimum values of $10k\Omega$ and should not go below this value as it will affect the sensitivity of the mixer.

With the arrangement of the figure in page 13 all the inputs are connected to the inverting terminal via a volume control or fader which is regarded as the master - volume, which enables us to select inputs required for mixing and so with this provision we can listen to anyone of the inputs individually, or changing from one to another at will.

The input impedance at any point is practically the value of the input resistor ($10k\Omega$). The overall gain of the mixer stage is control by R_V which also provide the feeder.

The close loop voltage gain of the amplifier can be expressed

$$A_v = - \frac{R V_1}{R} = - \frac{R_V}{R}$$

Where $R = R_{13} = R_{14} = R_{15} = R_{16}$

The output voltage V_o is given by

$$V_o = - \left[\frac{R_V}{R_1} V_1 + \frac{R_V}{R_2} V_2 + \frac{R_V}{R_3} V_3 + \frac{R_V}{R_4} V_4 \right]$$

$$V_o = - \frac{R_V}{R} [V_1 + V_2 + V_3 + V_4]$$

Since $R = R_1 = R_2 = R_3 = R_4 = 10k\Omega$

$R_1 = R_2 = R_3 = R_4 = 10\text{k}\Omega$ (Minimum value of resistance we can used)

R_v is a $100\text{k}\Omega$ by single slide

$$V_o = -\frac{100}{100} [V_1 + V_2 + V_3 + V_4]$$

$$= -10 [V_1 + V_2 + V_3 + V_4]$$

Assume $V_1 = V_2 = V_3 = V_4 = 4\text{V}$

Therefore the output level of each pre-amp feeding the mixer

$$V_o = -10(4)$$

$= -40\text{V}$ (-ve sign means that the output voltage is 180 out of phase with the input).

$$\text{Gain} = 20 \log_{10} 40 = 32 \text{ dB}$$

C_5 is include in the Op-Amp to effect frequency compensation to ensure that the desired closed loop response is stable.

2.5 AUDIO OUTPUT

This is finds the relevance in the circuit when audible frequency components re fed in the speaker. For the purpose of this design, a 8Ω ohms speaker was used to detect that output of the mixer to its audible to the human ears i.e. audible range is 0.3kHz to 3.9kHz .

Below is the description of speaker used

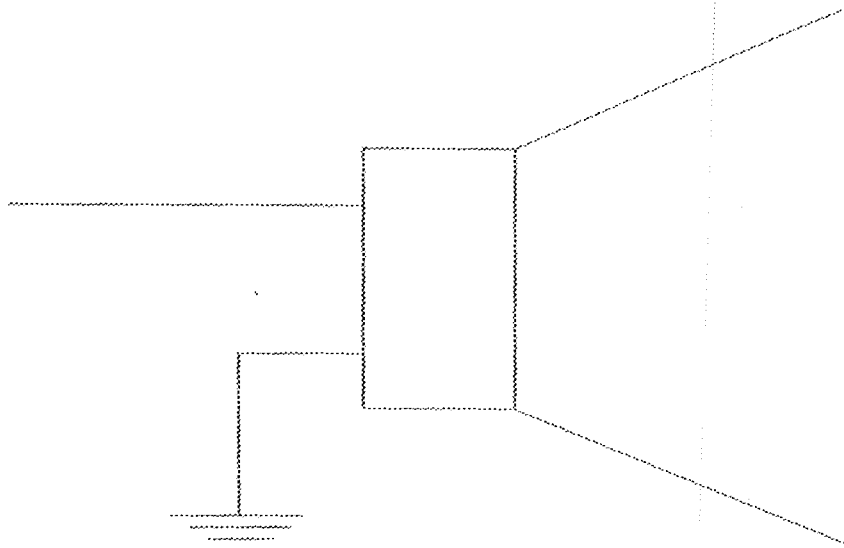


fig 2.5 8Ω speaker

2.6 COMPONENT USED

- Capacitors: - 1000uF/25V, 25uF/16V, 4.7uF/16V
- Resistors: - 10KΩ
- Diodes: - IN4001
- Transistors: - F245
- Speaker - Headphone
- Transformer: - 9-0-9V Transformer
- I.C: - LM301

CHAPTER THREE

CONSTRUCTION, TESTING, AND RESULT

3.1 INTRODUCTION

The hardware design was done in modules. The module was constructed and tested during and after each stage of the construction.

The circuit diagram was first analyzed on paper and all design analysis was done to determine the values of the components required to be used.

The module on the paper analysis was transferred to the electronics workbench for stimulations. After obtaining satisfactory simulation results the component required were known and the components were purchased, the circuit prototype was made on breadboard and again tested.

The modules were then cascaded and the overall system was tested and modifications were made where necessary, until satisfactory results were obtained.

3.2 CONSTRUCTION

After constructing the prototype of the design on the breadboard, the next stage involves construction on the Vero board.

On the opposite side of copper strips of the Vero board, the layout plan was made the components were placed in accordance.

The discrete components: - capacitor and resistor were soldered accordingly including the IC to the Vero board. Where continuity was not required or desired, the copper strips were cut off using a sharp razor blade. Connecting wires were soldered firmly in place.

A digital multi-meter was used for testing the continuity between interconnected points. Also for checking short circuit, which may occur accidentally while soldering. The construction was tested and troubleshooting was made to remove excessive hum and unwanted feedback. High impedance leads were kept as short as possible and all ground returns were made to a common point. A ground therefore made between the circuit board and the metal chassis. The construction was implemented on Vero board and then assembled in a casing.

3.2 TOOLS USED

The tools during the construction includes:-

Breadboard, Vero board, brush, razor blade, cutter, soldering iron, soldering lead, disordering pump. The instrument used was digital multi-meter and analogue multi-meter and a headphone.

3.4 TESTING

Testing was carried out at all stage of stimulation, prototyping and construction. The most crucial testing was carried out during the prototyping with actual physical components.

Each of the prototyping components was tested using the digital and analogue multi-meter to ascertain the value, after testing them individually, they were then coupled together onto a breadboard with the speaker used for the desired output and the desired output was obtained.

3.5 RESULTS

The results obtained during the testing at prototyping were satisfactory. In the final testing of the multi-channel mixer, the inputs were fed with signal and a good output was obtained. The results of the test shows that the multi-channel mixer could mix music or audio together and heard the output from the headphone as the input in fed in.

3.6 PROBLEM ENCOUNTERED

- (i) Difficulty in obtaining a certain component like the amplifier and transistor which results in the equivalent type which is not as effective.
- (ii) Difficulty in obtaining manufacturers data sheet of the component used
- (iii) Time constraint
- (iv) Damaging of some of the component during soldering
- (v) Difficulty in obtaining up to date reference materials.

CHAPTER FOUR

CONCLUSION AND RECOMMENDATION

4.1 CONCLUSION

The design and construction of multi channel mixer was the aim of this project. The principle of the project which was stated in the theory has been practicalised. The device mixer, mix music or audio together through the mixer and the speaker indicate the output of the mixer.

This project has brought to us the simple technique of building, cheaper, and reliable mixer for home recording or disco use and as well as public address system, thus a great success.

4.2 RECOMMENDATION

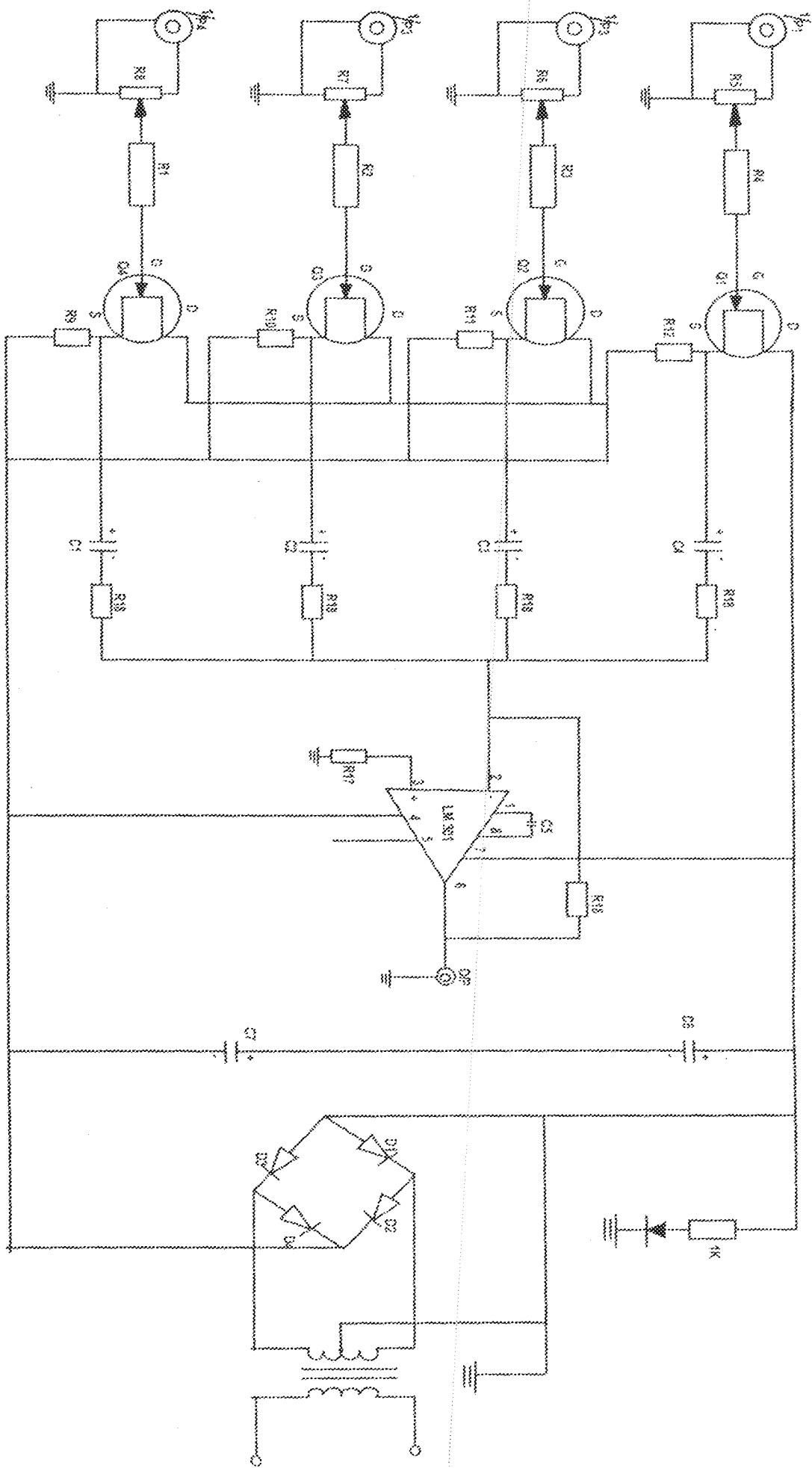
This project could be used as public address system. There are often cases when a simple units is required to mix two or more music of home recording or disco use by musicians where different inputs of their choice are mixed to bring out a composite output. Therefore I will like to recommend that:-

- (i) Further section of this project may include tone control stage and input control stage.

- (ii) Include an amplifying stage to be able to use loudspeaker to make the project more versatile.
- (iii) The use of electronic work bench should be encourage so that students will be familiar with designing and stimulation of circuits diagram.
- (iv) Department in the university should be encourage to help each other when dealing with project aspect, for example in the construction of casing (mechanical engineering) e.t.c.

REFERENCES

- (i) Ahmed M. S. (2004): Advance circuit techniques lecture notes. Federal university of technology, Minna. (Unpublished).
- (ii) Gramy Tobey (1981): Operational amplifiers. Mc Graw Hill, Singapore.
- (iii) Green D.C (1983): Electronic Technique, Pitman Barks Limited London
- (iv) Horowitz P. (1995): The art of electronics, Cambridge university press, London.
- (v) Milliam H. (1999): Integrated Electronic analogue and digital circuits and system, International student edition, Mc Graw-Hill, U.S.A.
- (vi) Ritche G.J (1992): Electronic design with intergrated circuit, Pitman education limited.
- (vii) William D. S (1989): Intergrate amplifier circuits, Merry publishing company, New york.
- (viii) Microsoft Encarta Encyclopedia(2004)
- (ix) WWW.HOWSTUFFWORKS.COM



SCHEMATIC DIAGRAM